Rencontres de Moriond 2026
60 years discussing physics

Experimental Summary

F. Cerutti LBNL

Preamble …

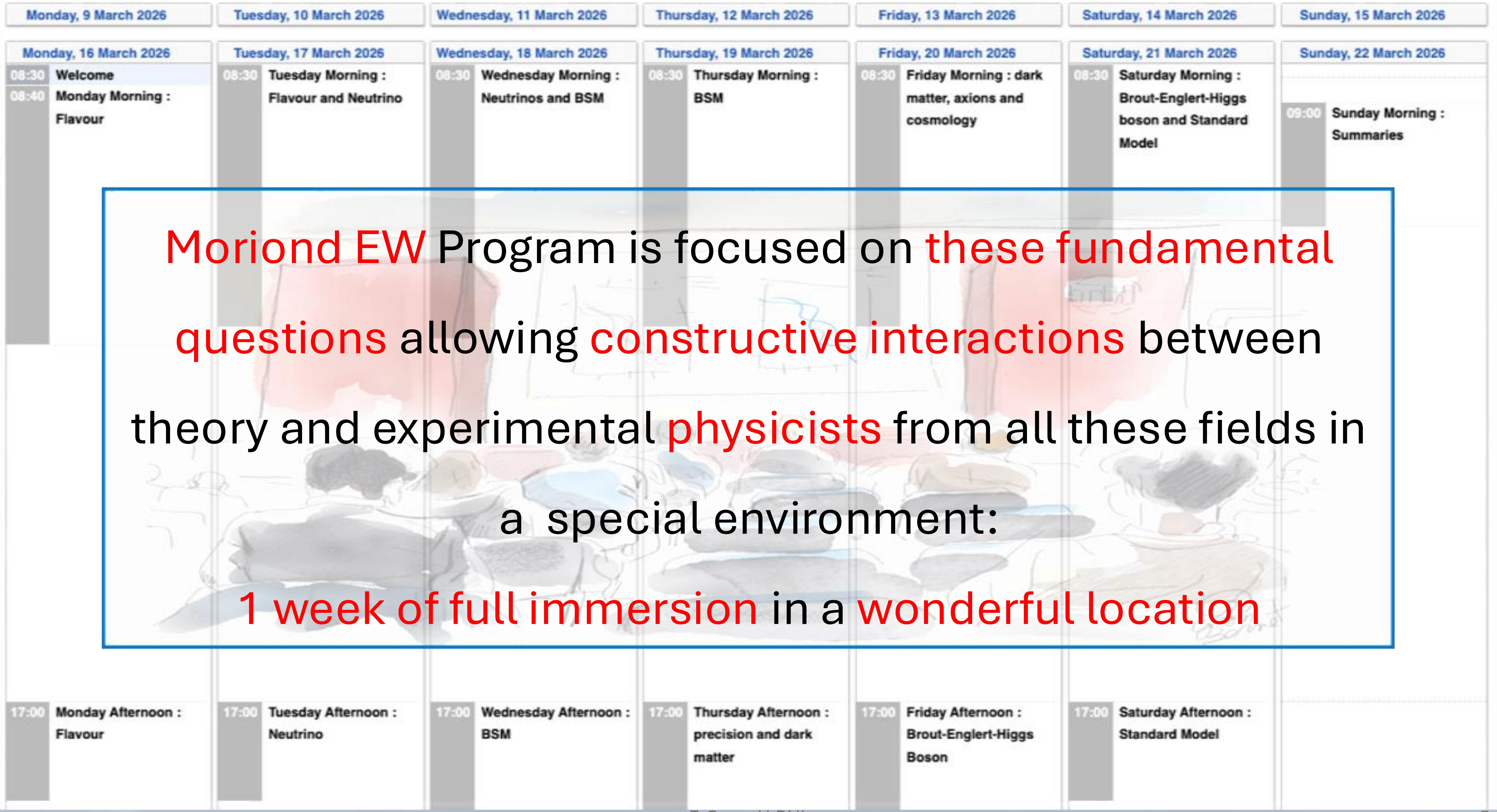
It is for me an immense honor (and responsibility) to summarize the experimental results of the 60th edition of this conference, Les Rencontres de Moriond are part of the history of HEP

Current Landscape …

- ✓ We have models (SM and ΛCDM) that can describe (almost) all the available experimental data but there are unanswered fundamental open questions when trying to put all ingredients together
- ✓ Major issues comes when trying to merge particle physics and cosmology
- ✓ Even taken separately they have internal "tensions" and/or "missing pieces"

Just a few examples …

- Particle Physics SM:
  - Hierarchy problems: light Higgs boson mass, large spread of Yukawa couplings
  - Origin of flavor (too many "free" parameters?), accidental symmetries (LNC, BNC), flavor anomalies?
  - Neutrino masses: absolute values, neutrino nature (D vs M), CP violation → need to extend the SM to include them, exitance of (additional) sterile neutrinos?
- Cosmology ΛCDM:
  - Hubble tension (time dependent cosmological constant, modified GR?)
  - Tension in ν masses between cosmological bounds and oscillation measurements
- Cosmology + particle physics:
  - Matter/Antimatter asymmetry (SM Higgs potential + CPV don't work)
  - Nature of Dark Matter (field, particle, macroscopic)
  - Nature of Dark energy: $\rho_\Lambda <<(<<) \rho_{SM\text{-}VEV}$
  - Inflation



Monday, 9 March 2026	Tuesday, 10 March 2026	Wednesday, 11 March 2026	Thursday, 12 March 2026	Friday, 13 March 2026	Saturday, 14 March 2026	Sunday, 15 March 2026
Monday, 16 March 2026	Tuesday, 17 March 2026	Wednesday, 18 March 2026	Thursday, 19 March 2026	Friday, 20 March 2026	Saturday, 21 March 2026	Sunday, 22 March 2026
08:30 Welcome 08:40 Monday Morning : Flavour	08:30 Tuesday Morning : Flavour and Neutrino	08:30 Wednesday Morning : Neutrinos and BSM	08:30 Thursday Morning : BSM	08:30 Friday Morning : dark matter, axions and cosmology	08:30 Saturday Morning : Brout-Englert-Higgs boson and Standard Model	09:00 Sunday Morning : Summaries
17:00 Monday Afternoon : Flavour	17:00 Tuesday Afternoon : Neutrino	17:00 Wednesday Afternoon : BSM	17:00 Thursday Afternoon : precision and dark matter	17:00 Friday Afternoon : Brout-Englert-Higgs Boson	17:00 Saturday Afternoon : Standard Model	

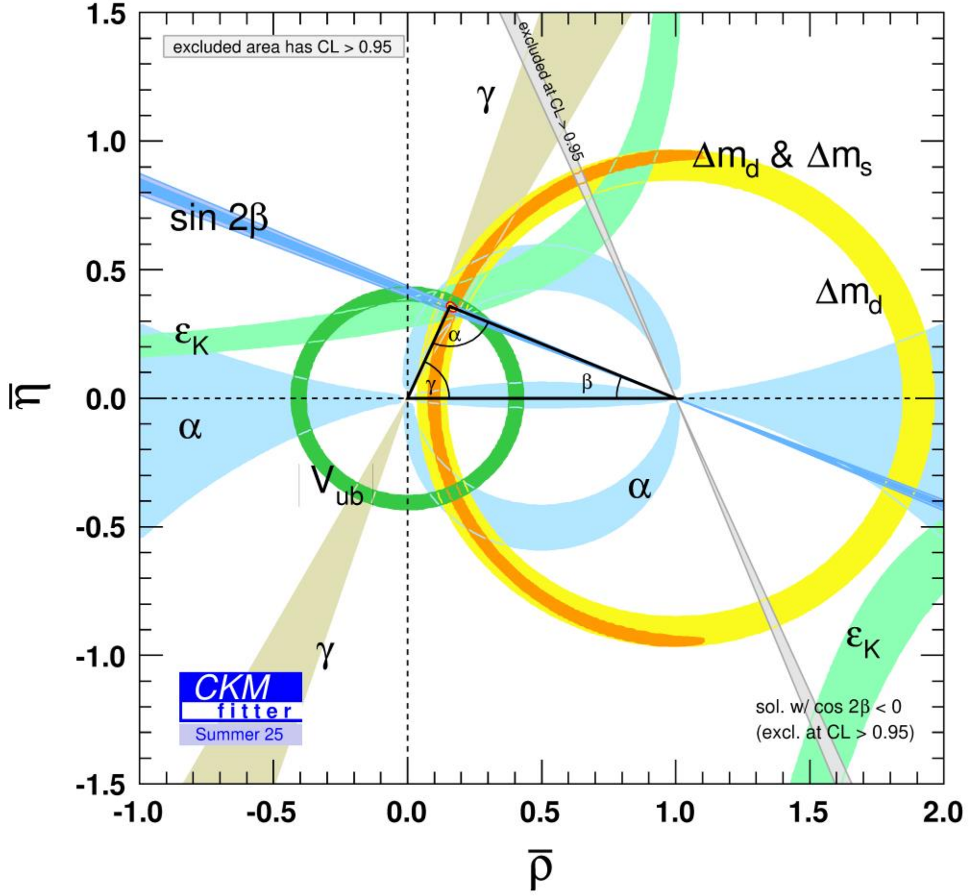
Moriond EW Program is focused on these fundamental questions allowing constructive interactions between theory and experimental physicists from all these fields in a special environment:

1 week of full immersion in a wonderful location

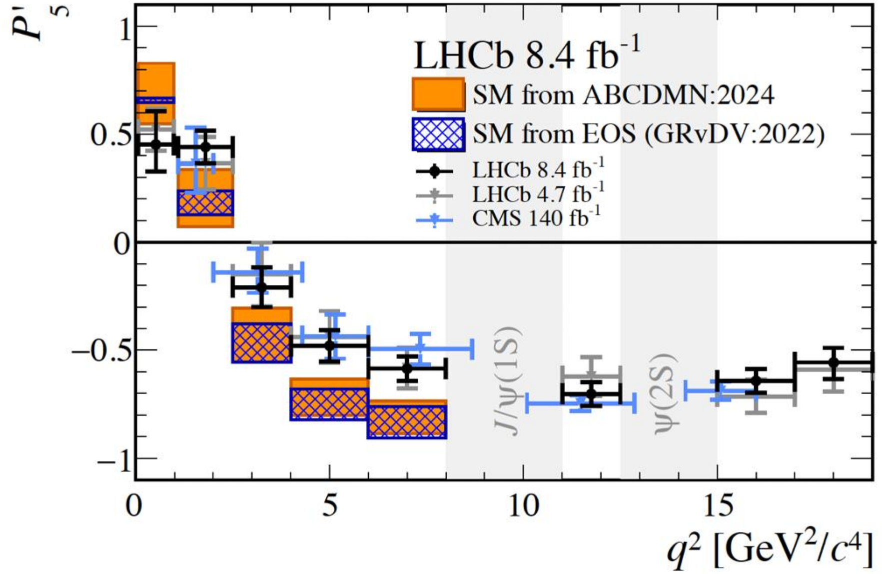
Usual disclaimer …

- Not possible (nor useful) to rush through the huge number of very interesting results: more than 100 **excellent** experimental and theory talks
  - Try to focus on what is **NEW** for this conference
  - For each subject try to highlight results linked to the **main "open questions"** in HEP
  - The summary will be for sure biased and miss some important results: my apologies in advance
  - Much more is in the backup slides (you may find there your **favorite result**)

Flavor physics



- Over constrain the CKM parameters measuring different processes, particularly those linked to CP violation
- Study of highly-suppressed SM processes (rare decays), possibly with small theoretical uncertainties
- Tests of accidental SM symmetries
- Investigate **Flavor anomalies**



First LHCb CP measurement with Run 3 data!

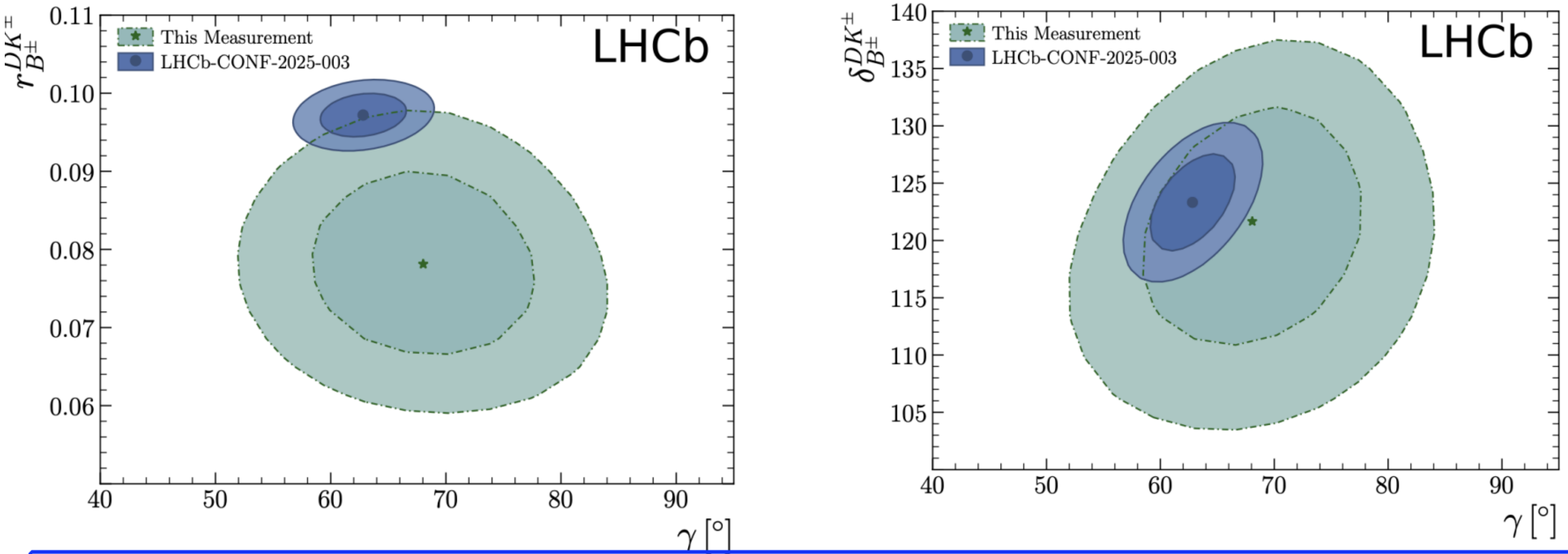
Halime Sazak

Measurement of γ using $B^\pm \to DK^\pm$ and $B^\pm \to D\pi^\pm$ decays with $D \to K^0_S\pi^+\pi^-$ and $D \to K^0_S K^+ K^-$ with Run3

- **Comparison with Run1+Run2 measurements:**
  - Consistent γ , δ_B^{DK}, $\delta_B^{D\pi}$ values, smaller r_B^{DK} larger $r_B^{D\pi}$
  - Higher γ uncertainty from changed strong-phase inputs and a smaller r_B^{DK} valUe
- **Comparison with LHCb γ combination :**
  - good agreement with a p-value of 12% in 5D parameter space

NEW!

5.8fb-1 at 13.6 TeV



✦ **Physics parameters:**

$$\gamma = (68.1 \pm 6.7)^\circ,$$
$$r_B^{DK} = 0.0781^{+0.0078}_{-0.0079},$$
$$\delta_B^{DK} = (121.5^{+6.9}_{-7.4})^\circ,$$
$$r_B^{D\pi} = 0.0073^{+0.0016}_{-0.0015},$$
$$\delta_B^{D\pi} = (286^{+20}_{-23})^\circ,$$

✦ **It is the first γ measurement with Run3 !**

✦ **Higher signal yields observed with less integrated luminosity**

✦ **These results show good agreement with the previous measurement**

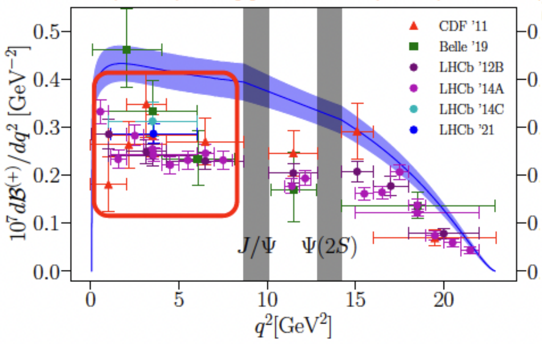
The b → s$\ell\ell$

Christoph Langenbruch

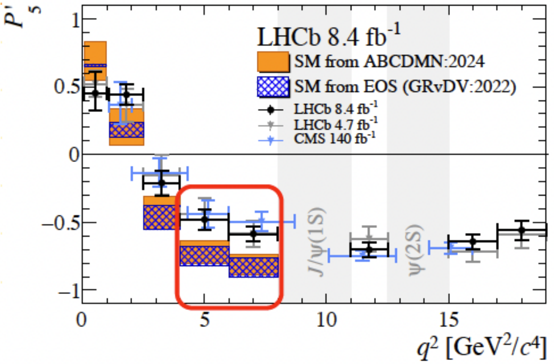
$b \to s\ell\ell$ Observables

Increasing precision of SM prediction

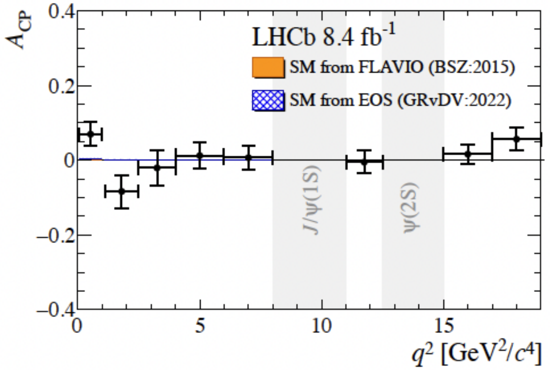
[JHEP 06 (2014) 133] [PRD 107 (2023) 014511]

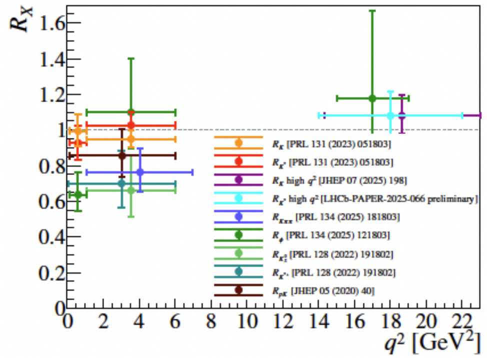


[arXiv:2512.18053]



[arXiv:2512.18053]





Branching fractions
affected by form-factors
and $c\bar{c}$-loop

Angular observables
affected by $c\bar{c}$-loop

CP-asymmetries
clean

Lepton Universality Tests
clean

Strongly suppressed in the SM very sensitive to BSM effects

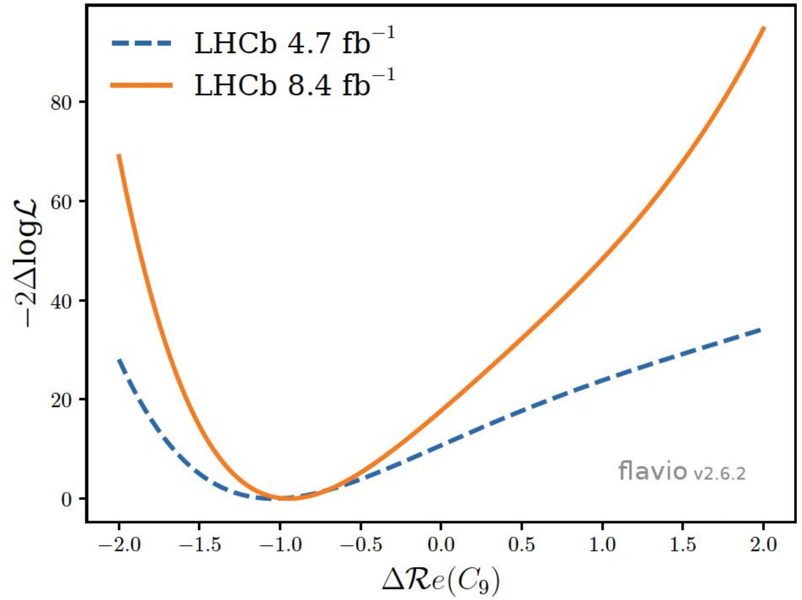
Consistent deviations from SM measured in several obs. (though cleanest R(K) now in agreement with SM)

Major theory uncertainties on the predictions comes from **hadronic form factors** and **charm loops**

The legacy analysis LHCb $B \rightarrow K^{*0}\mu^+\mu^-$

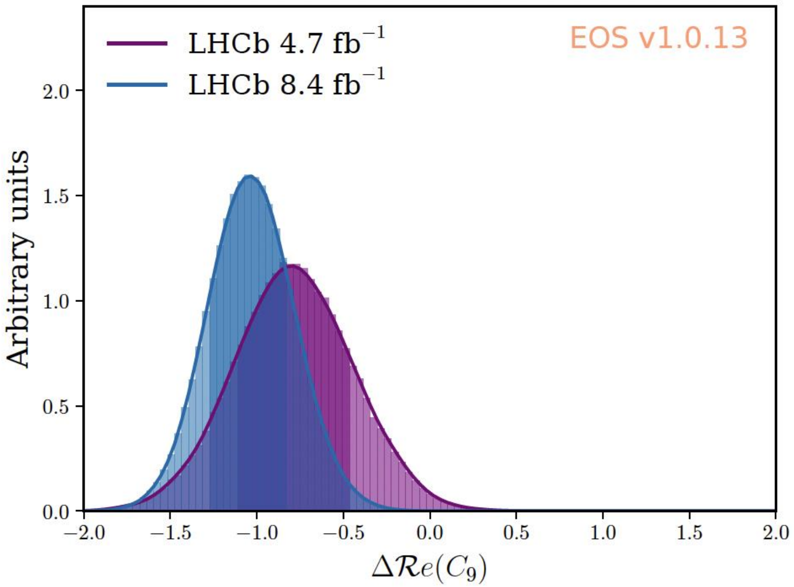
Christoph Langenbruch

[arXiv:2512.18053]



$$\Delta\mathcal{R}eC_9 = -0.93^{+0.18}_{-0.16}$$

Significance $4.1\,\sigma$



$$\Delta\mathcal{R}eC_9 = -0.94^{+0.22}_{-0.22}$$

Significance $4.0\,\sigma$

- Combine angular obs. and branching fraction up to $8\ \mathrm{GeV}^2$
- Use two different theory packages with different approaches *e.g.* different (non-local) FFs, very consistent results
- Open question: NP or underestimated hadronic effect ($c\bar{c}$-loop)?

- LHCb: Legacy analysis of $B \rightarrow K^{*0}\mu^+\mu^-$ with full Run 1+2 data 8.6fb^{-1}
- Significance of a of BSM C_9~4σ , are theory uncertainties under control?

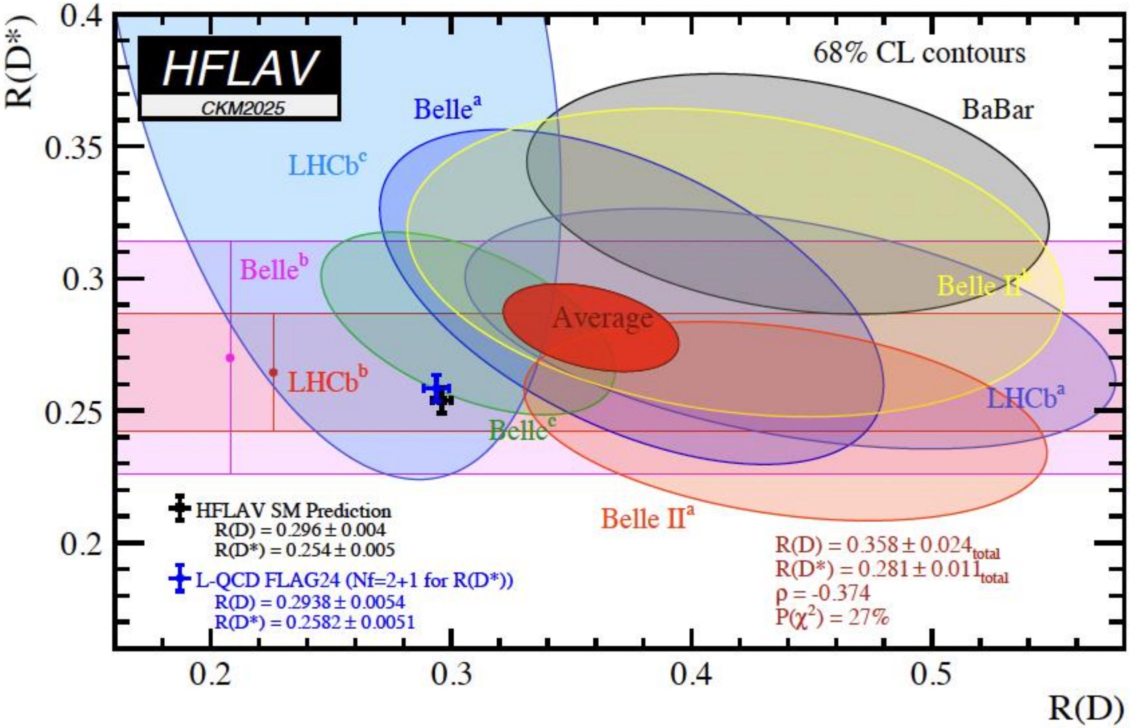
R(D/D*) studies at Belle II

Raynette van Tonder

$b \to c l \nu$ transitions

Currently intriguing discrepancies exist:

- 3.8 σ in $R(D^{(*)})$ measurements



- ➢ Test of LFU, tension for 3rd generation (process at tree level in SM) τ/(e or μ)
- ➢ NEW result from Belle II using hadronic tag

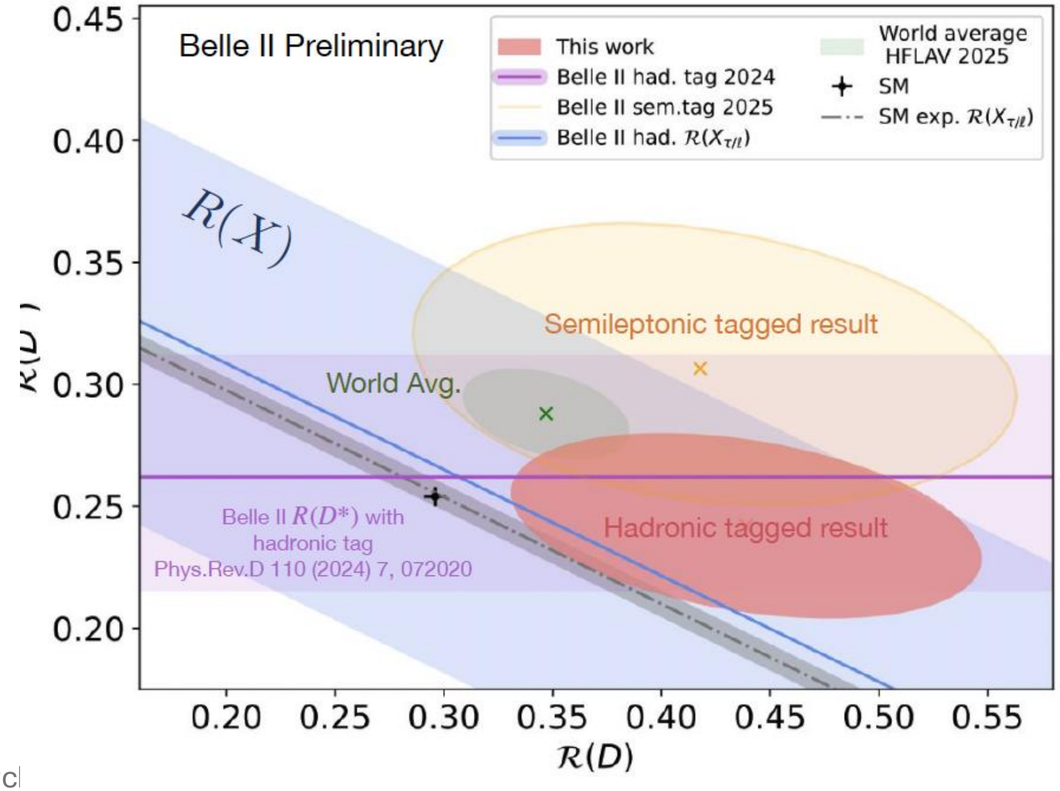
Raynette van Tonder

Most precise determination of $R(D^{(*)})$ with hadronic tagging!

$$R(D) = 0.439 \pm 0.055(\text{stat.}) \pm 0.045(\text{syst.})$$

$$R(D^*) = 0.242 \pm 0.019(\text{stat.}) \pm 0.016(\text{syst.})$$

$$\rho = -0.52$$



SM prediction: $R(D^*) = 0.254 \pm 0.005$
HFLAV 23: $R(D^*) = 0.284 \pm 0.013$
Eur. Phys. J. C 81, 226 (2021)

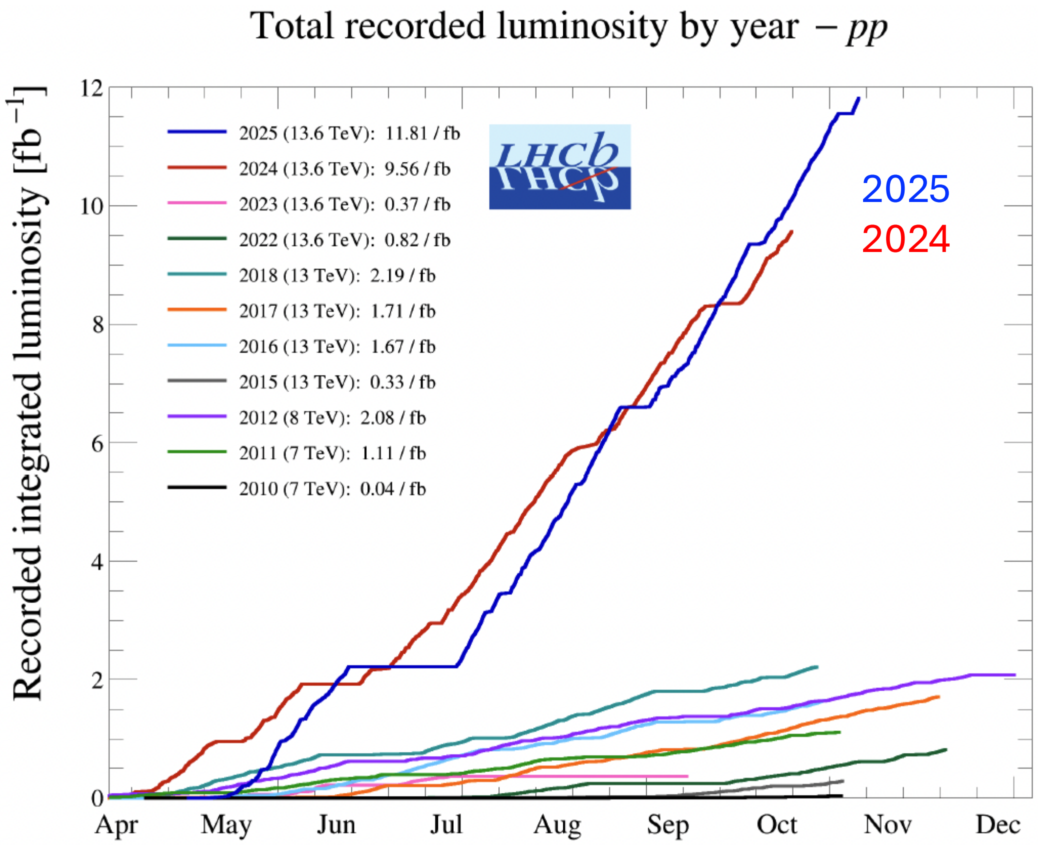
- $R(D)$ consistent with SM within 2σ
- $R(D^*)$ consistent with SM within 0.5σ
- Consistent with SM expectation within 1.5σ
- Consistent with world average within 1.3σ

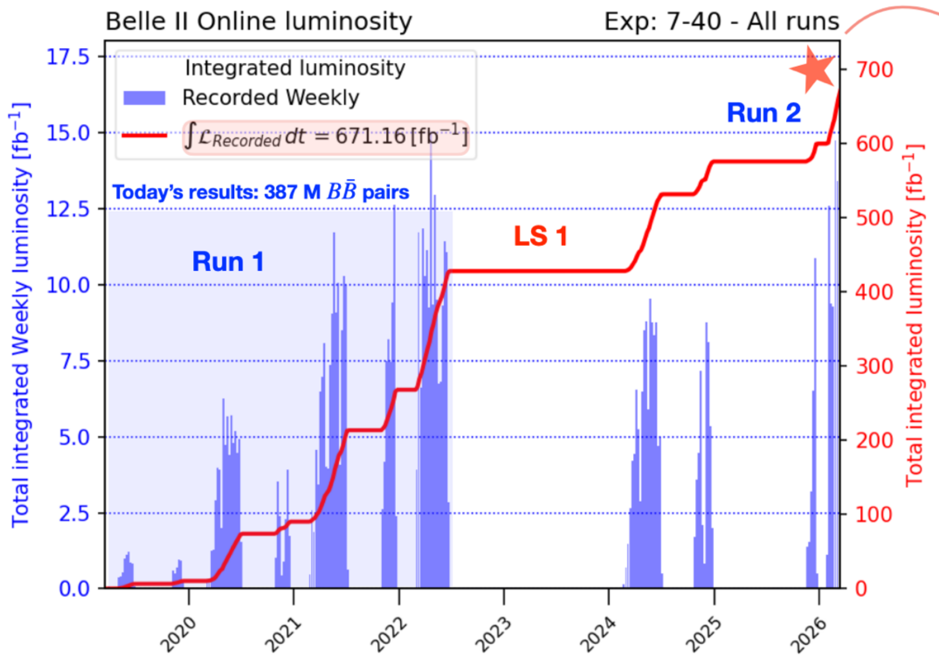
NEW!

Supersedes previous hadronic tag $R(D^*)$ result by using the full Run 1 dataset:

- Previous Belle II $R(D^*)$ result used only **half of the dataset** (189 fb^{-1}) PRD 110 (2024) 7, 072020
- Identify lepton from $\tau \to \ell\nu\bar{\nu}$
- **Efficiency is maximised** by reconstructing all D^* decay modes and 13 D decay modes
  - $D^{*\pm} \to D^0\pi^\pm, D^\pm\pi^0$
  - $D^{*0} \to D^0\pi^0, D^0\gamma$ ⟵ New mode for this analysis!
- Extend analysis to include $R(D)$

Prospects for flavor anomalies





World record!

Instantaneous luminosity:
$L_{\text{peak}} = 5.1 \times 10^{34}$ cm^{-2} s^{-1}

Integrated luminosity (so far):

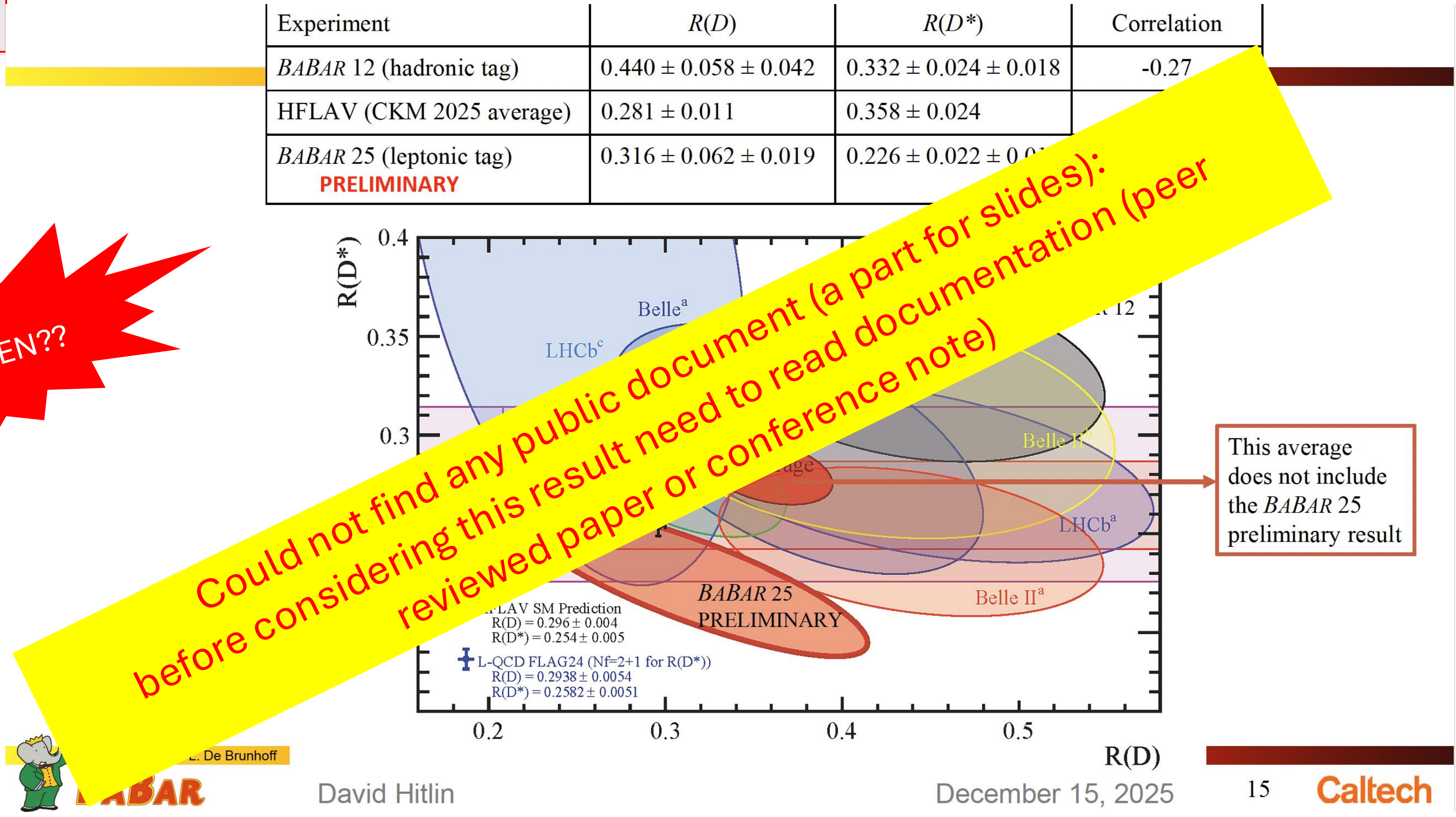
~519 fb^{-1} recorded at $\Upsilon(4S)$

~59 fb^{-1} recorded 60 MeV below $\Upsilon(4S)$ (background studies)

~19 fb^{-1} recorded at 10.8 GeV (exotic hadron searches)

Both LHCb and Belle II will largely increase available data samples

R(D$^{(*)}$)



Experiment	$R(D)$	$R(D^*)$	Correlation
BABAR 12 (hadronic tag)	0.440 ± 0.058 ± 0.042	0.332 ± 0.024 ± 0.018	-0.27
HFLAV (CKM 2025 average)	0.281 ± 0.011	0.358 ± 0.024	
BABAR 25 (leptonic tag) **PRELIMINARY**	0.316 ± 0.062 ± 0.019	0.226 ± 0.022 ± 0.0	

This average does not include the *BABAR* 25 preliminary result

. De Brunhoff

BABAR

David Hitlin

December 15, 2025

15

Caltech

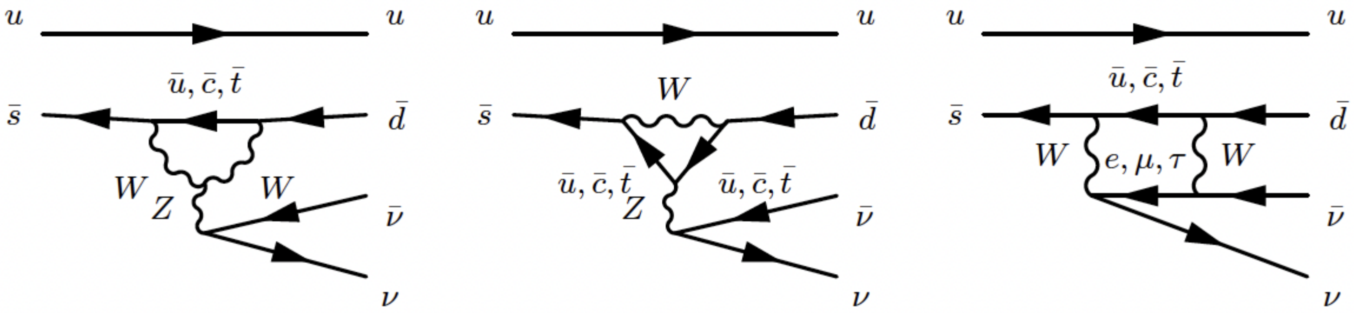
Could not find any public document (a part for slides): before considering this result need to read documentation (peer reviewed paper or conference note)

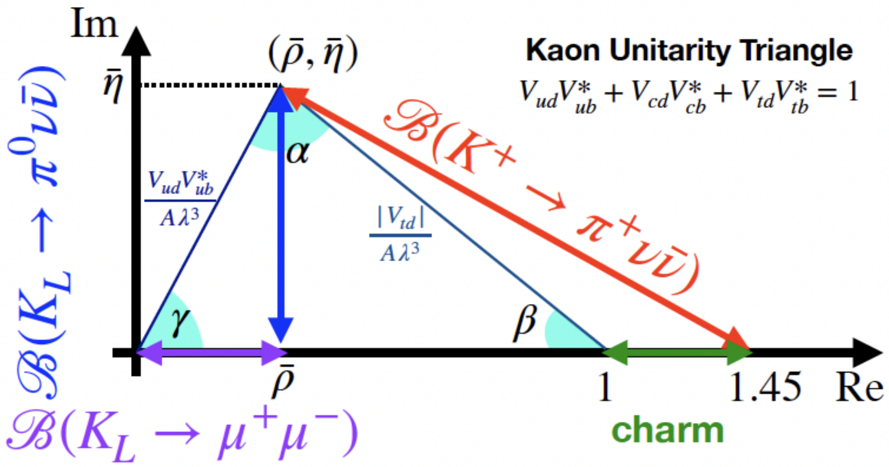
??WHEN??

Alejandro Vaquero slide taken from https://indico.fnal.gov/event/71119/contributions/325774/

$K \to \pi\nu\bar{\nu}$: a golden channel in flavor physics

Xiafei Chang





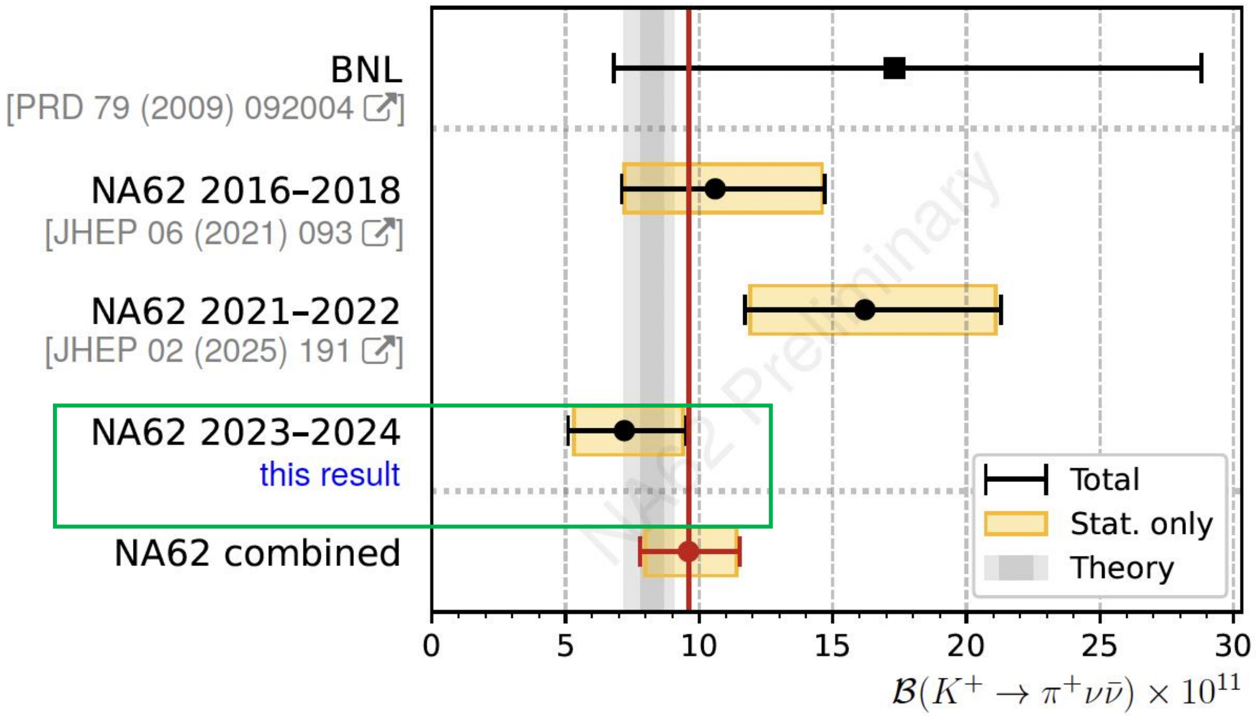
- Flavor Changing Neutral Current;
- $\mathcal{B}(K \to \pi\nu\bar{\nu})$ highly suppressed in SM:
  - GIM mechanism + CKM matrix element suppression
- Theoretically clean:
  - Dominated by short distance contributions;
  - Hadronic matrix element extracted from $K \to \pi\ell\nu$.

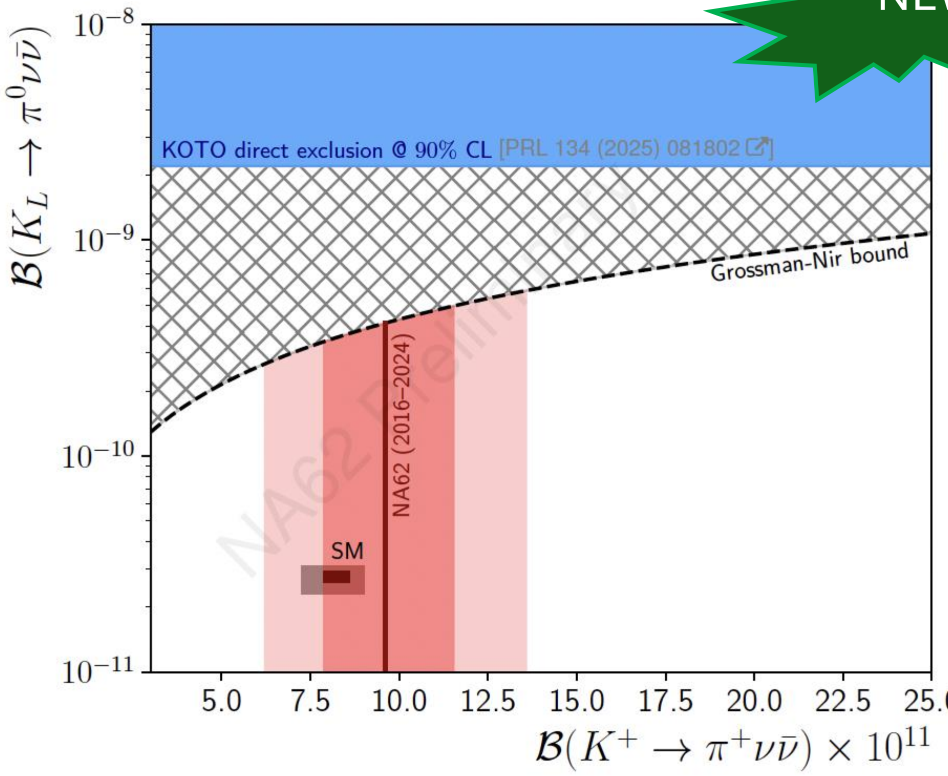
	$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$	$\mathcal{B}(K_L \to \pi^0\nu\bar{\nu})$
Buras et al. [EPJC 82 (2022) 615 ↗]	$(8.60 \pm 0.42) \times 10^{-11}$	$(2.94 \pm 0.15) \times 10^{-11}$
D'Ambrosio et al. [JHEP 09 (2022) 148 ↗]	$(7.86 \pm 0.61) \times 10^{-11}$	$(2.68 \pm 0.30) \times 10^{-11}$
Experimental status	$(13.0^{+3.3}_{-3.0}) \times 10^{-11}$ NA62 2016–2022 [JHEP 02 (2025) 191 ↗]	2.2×10^{-9} @ 90% C.L. KOTO 2021 [PRL 134 (2025) 081802 ↗]

$K^+ \rightarrow \pi^+\nu\nu$ from NA62

Xiafei Chang

NEW





$$\mathcal{B}^{NA62}_{2016-2024}(K^+ \to \pi^+\nu\bar{\nu}) = (9.6^{+1.8}_{-1.6}|_{stat}\ {}^{+0.8}_{-0.6}|_{syst}) \times 10^{-11} = (9.6^{+1.9}_{-1.8}) \times 10^{-11}$$

Improvements: better k/p rejection GTK, CNN calo PID, improved KTAG, better large angle veto, ...

Combined 2016-2024 **>5σ sensitivity** – Result in agreement with SM prediction unc. ~20%

Summary flavor

- Complementarity between B-factories and LHC experiments
- CKM matrix measured at high precision and CP sector deeply studied
- Improved R(D) from Belle II (new Babar result coming soon?)
- Still tensions in the $b \rightarrow s\mu\mu$ measurements: need to improve also on theory side (charm loops)
- BSM physics has high probability to show up in highly suppressed SM flavor processes (FCNC, LFUV, very rare decays, etc.) so worth the effort!

Neutrino Physics

$$U = \boxed{\begin{pmatrix}1 & 0 & 0\\ 0 & c_{23} & s_{23}\\ 0 & -s_{23} & c_{23}\end{pmatrix}\cdot\begin{pmatrix}c_{13} & 0 & s_{13}e^{-i\delta_{\mathrm{CP}}}\\ 0 & 1 & 0\\ -s_{13}e^{i\delta_{\mathrm{CP}}} & 0 & c_{13}\end{pmatrix}\cdot\begin{pmatrix}c_{12} & s_{12} & 0\\ -s_{12} & c_{12} & 0\\ 0 & 0 & 1\end{pmatrix}}\cdot\begin{pmatrix}e^{i\eta_1} & 0 & 0\\ 0 & e^{i\eta_2} & 0\\ 0 & 0 & 1\end{pmatrix}$$

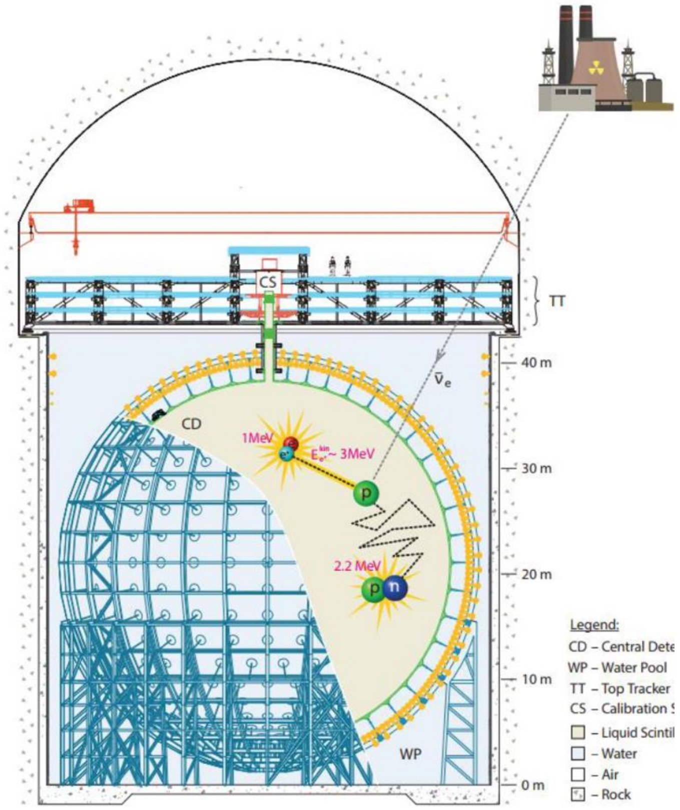
PDG 2025: PMNS review

- Measure missing PMNS parameters, in particular δCP
- Nature of neutrino masses: Majorana vs Dirac via neutrino-less double-β decay
- Mass ordering Normal (m1<m3) or Inverted (m1>m3): via matter effect, partial degeneracy with δCP
- Absolute masse scale: β decay endpoint, several experimental techniques
- Additional (sterile) light neutrinos?

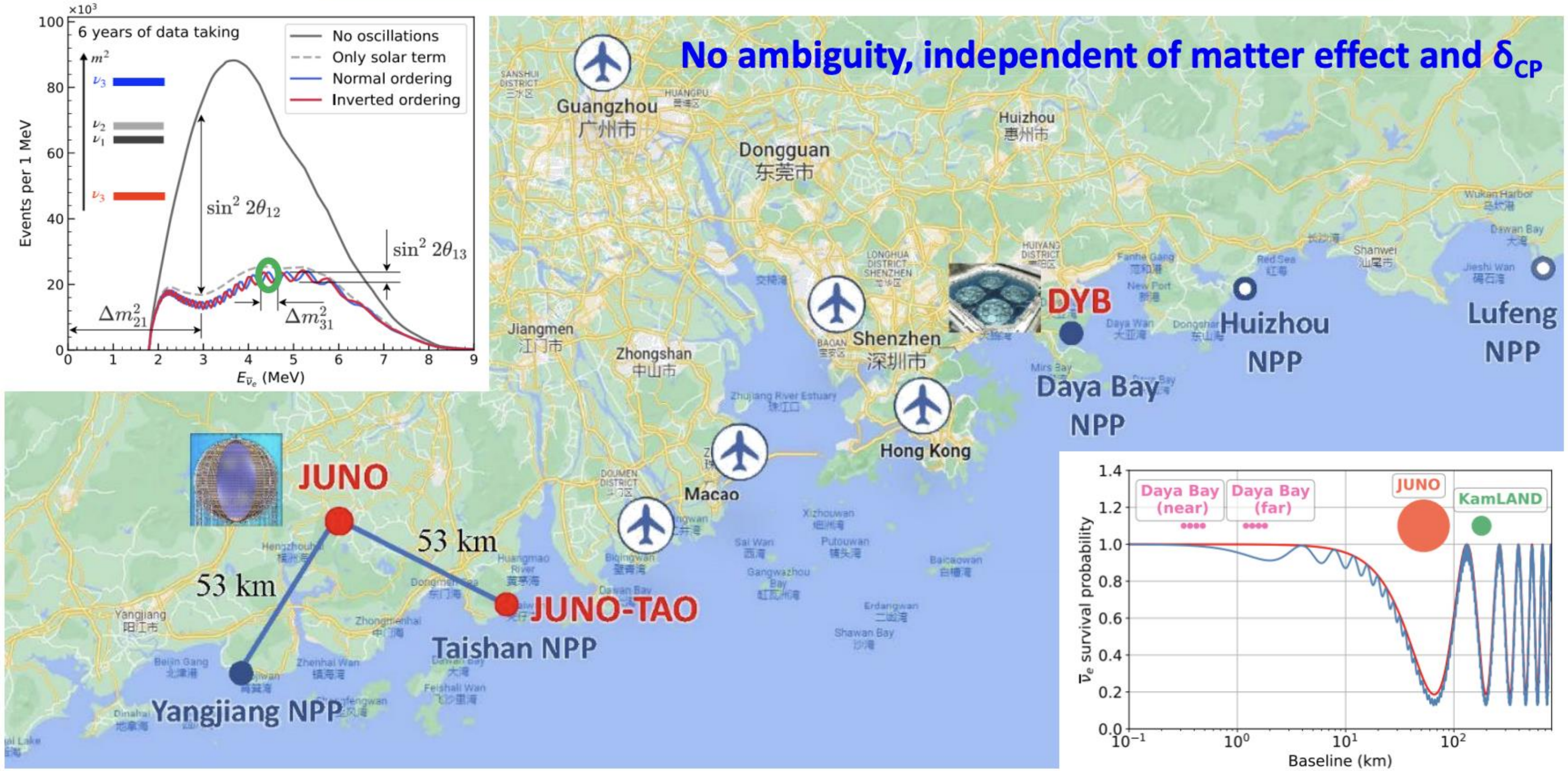
All these ingredients are needed to understand how to “extend” the SM (level of BMS needed) to include neutrino masses

JUNO studies how reactor $\overline{\nu}_e$'s oscillate (disappear) into other flavors

Zeyuan Yu, Mingxia Sun, Mingyuan Wang



$$P_{\bar{\nu}_e\to\bar{\nu}_e}(L,E) = 1 - \boxed{\sin^2 2\theta_{12}\cos^4\theta_{13}\sin^2\frac{\Delta m^2_{21}L}{4E}} - \sin^2 2\theta_{13}\left(\cos^2\theta_{12}\sin^2\frac{\Delta m^2_{31}L}{4E} + \sin^2\theta_{12}\sin^2\frac{\Delta m^2_{32}L}{4E}\right)$$



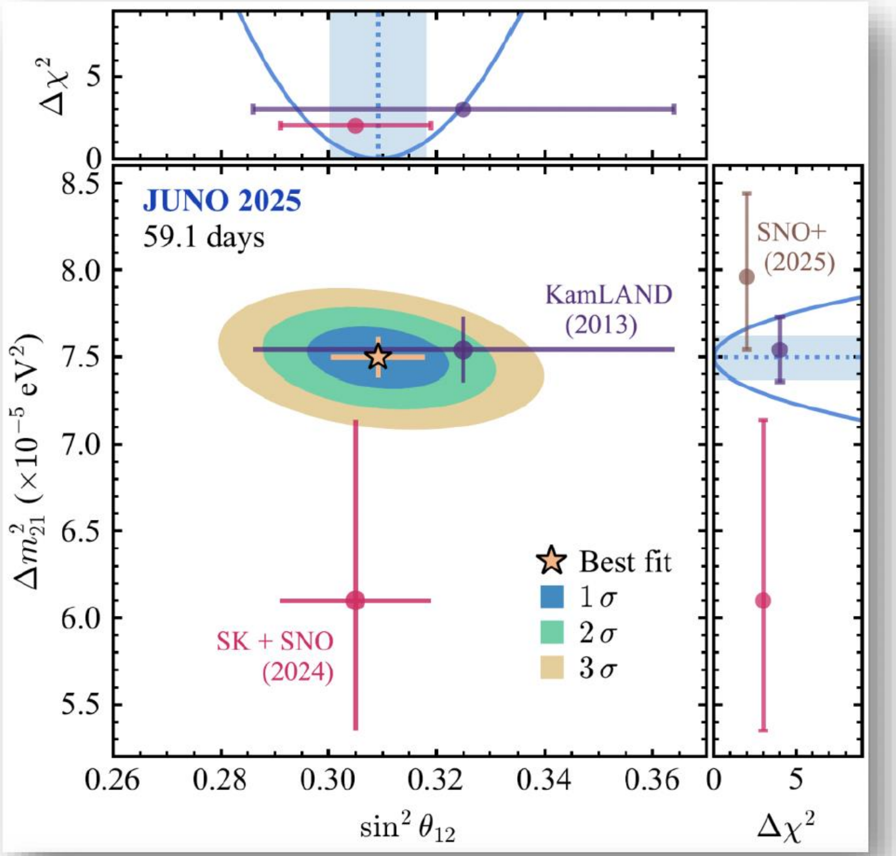
No ambiguity, independent of matter effect and δ_{CP}

Sensitive θ_{12}, Δm^2_{12} main goal is **mass ordering**: need excellent E resolution

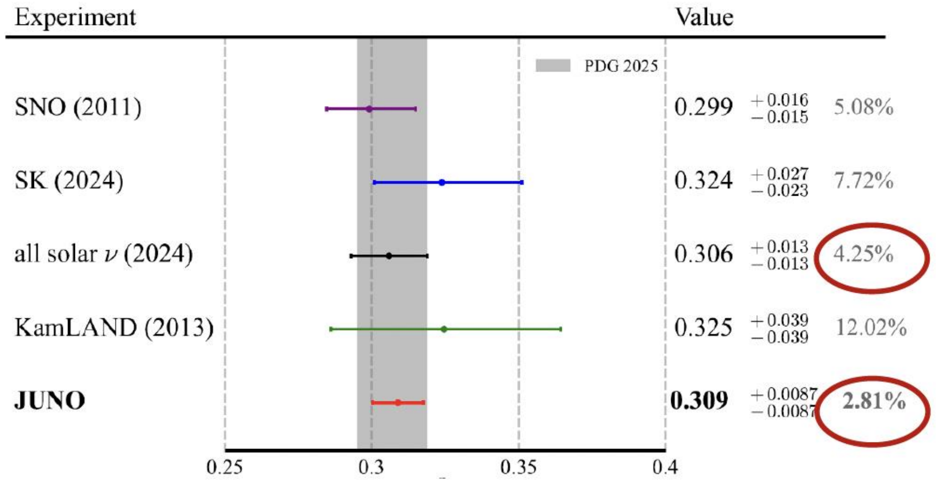
Detector performance very close to design level , very high up time and data taking efficiency

Zeyuan Yu, Mingxia Sun, Mingyuan Wang

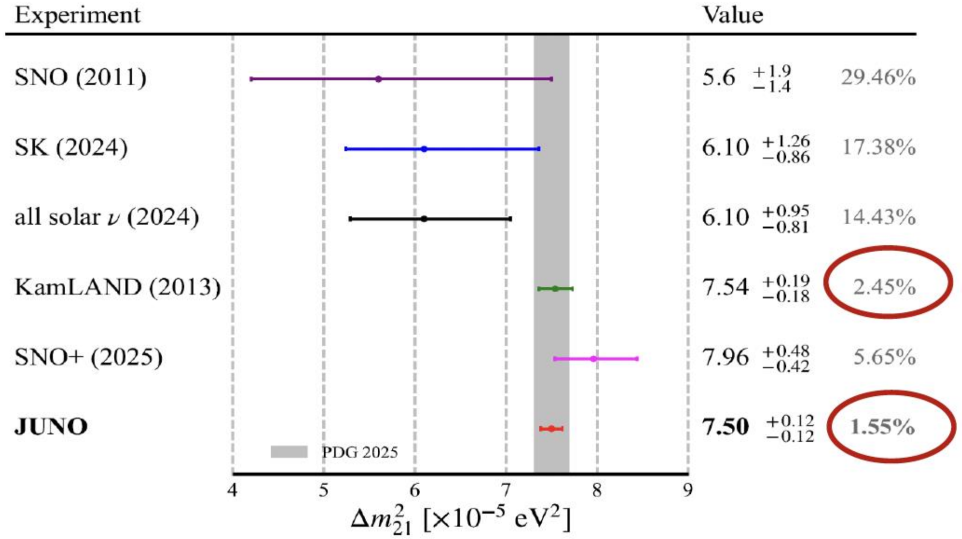
First Juno results



$$\sin^2\theta_{12} = 0.3092 \pm 0.0087\,,$$
$$\Delta m^2_{21} = (7.50 \pm 0.12) \times 10^{-5}\ \mathrm{eV}^2$$



Experiment	Value	
SNO (2011)	$0.299^{+0.016}_{-0.015}$	5.08%
SK (2024)	$0.324^{+0.027}_{-0.023}$	7.72%
all solar ν (2024)	$0.306^{+0.013}_{-0.013}$	4.25%
KamLAND (2013)	$0.325^{+0.039}_{-0.039}$	12.02%
JUNO	**0.309** $^{+0.0087}_{-0.0087}$	**2.81%**



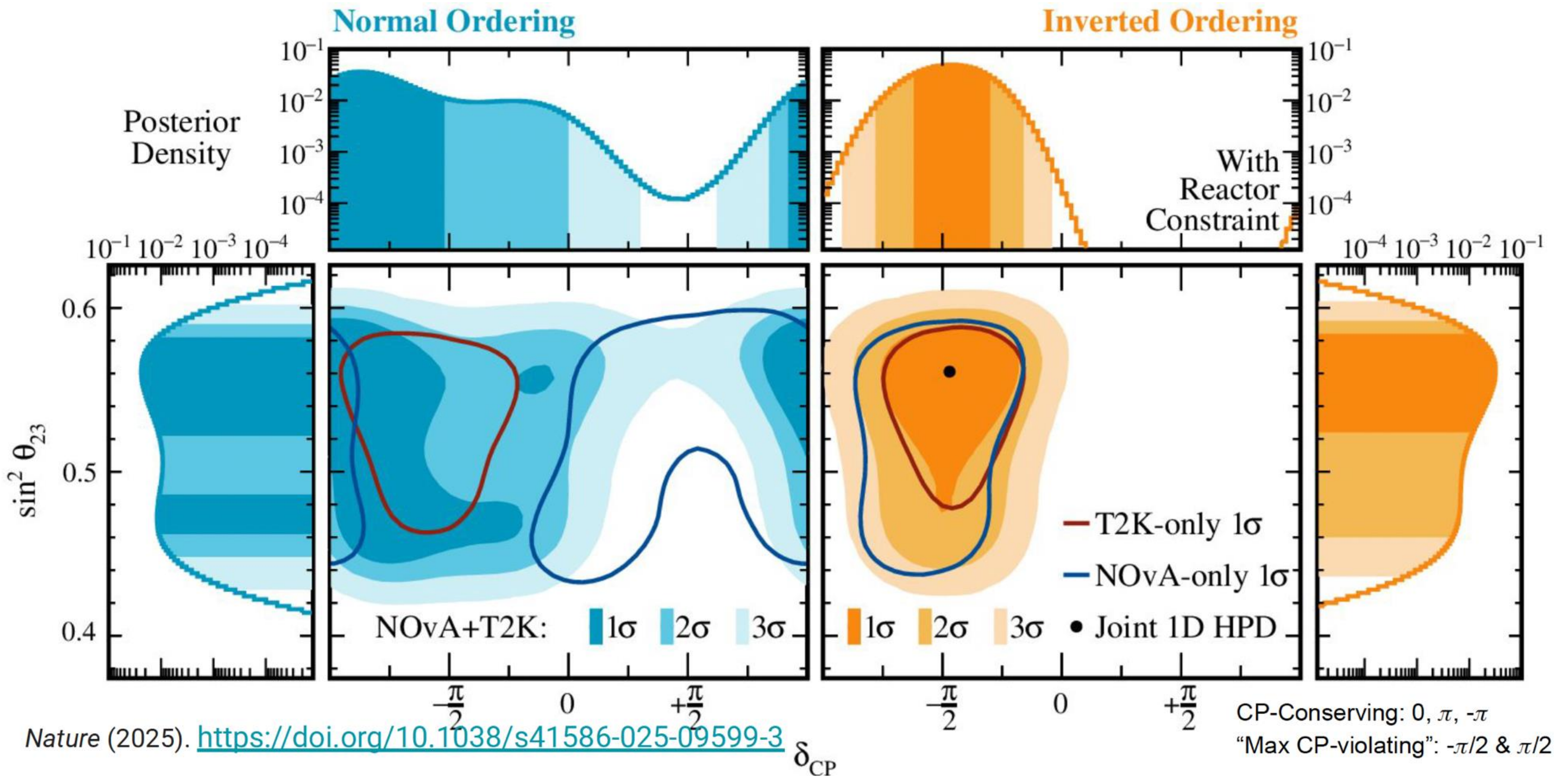
Experiment	Value	
SNO (2011)	$5.6^{+1.9}_{-1.4}$	29.46%
SK (2024)	$6.10^{+1.26}_{-0.86}$	17.38%
all solar ν (2024)	$6.10^{+0.95}_{-0.81}$	14.43%
KamLAND (2013)	$7.54^{+0.19}_{-0.18}$	2.45%
SNO+ (2025)	$7.96^{+0.48}_{-0.42}$	5.65%
JUNO	**7.50** $^{+0.12}_{-0.12}$	**1.55%**

Based on 59 days data taking → **leading results in θ_{12}, Δm^2_{12}**

Mass ordering at 3-4σ need 6-7 years (assuming design energy resolution can be achieved)

Combined T2K and Nova fits

Artur Sztuc

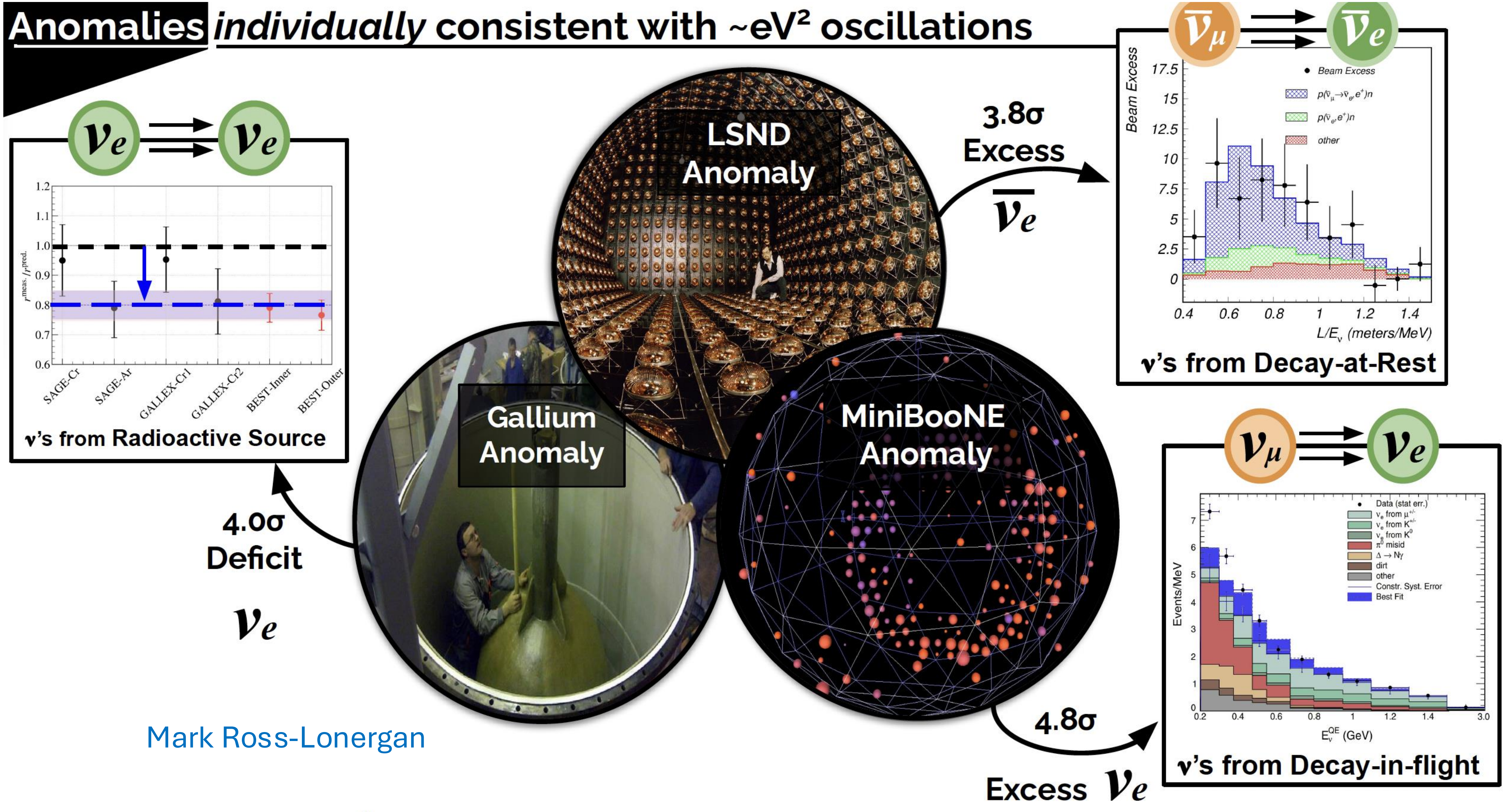


Nature (2025). https://doi.org/10.1038/s41586-025-09599-3

CP-Conserving: 0, π, $-\pi$
"Max CP-violating": $-\pi/2$ & $\pi/2$

Situation **inconclusive** on mass ordering and δ_{CP} due to degeneracy between several effects, limited precision and "tensions" between experimental results

Anomalies *individually* consistent with ~eV² oscillations



ν's from Radioactive Source

4.0σ Deficit ν_e

3.8σ Excess $\bar{\nu}_e$

ν's from Decay-at-Rest

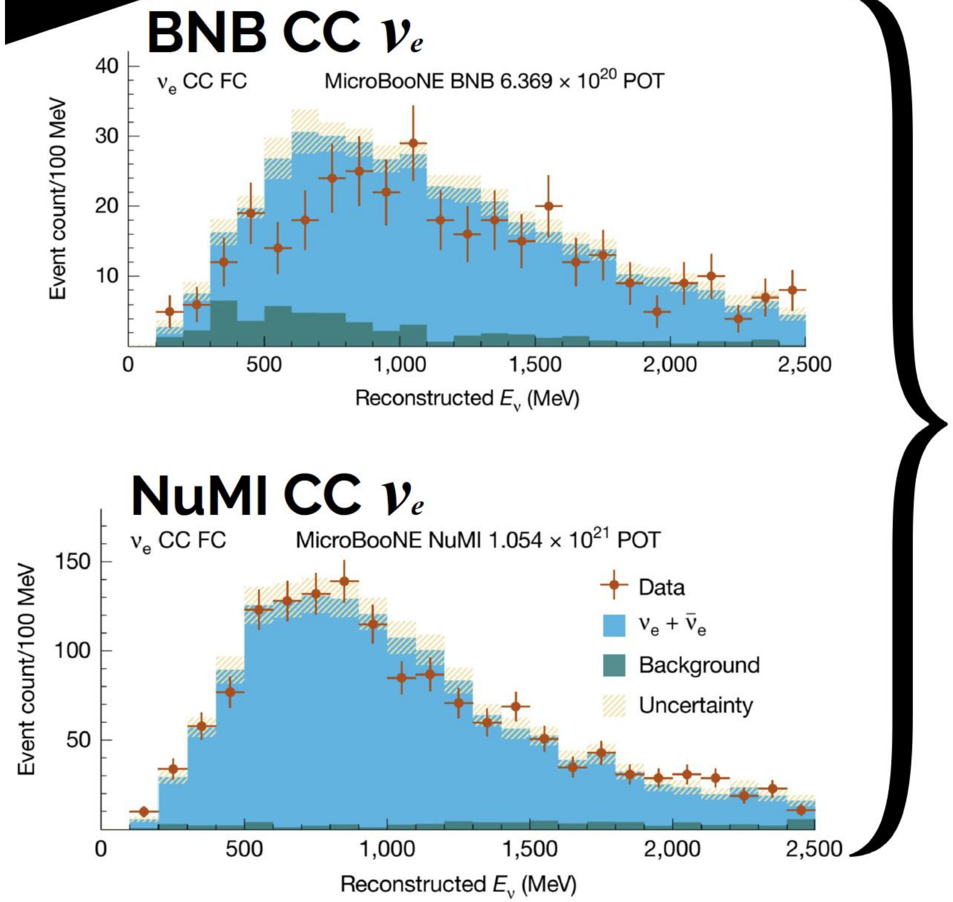
4.8σ Excess ν_e

ν's from Decay-in-flight

Mark Ross-Lonergan

Puzzling "signals" that do not fit the 3ν paradigm: Can be explained with 3+1ν with Δm²~1 MeV

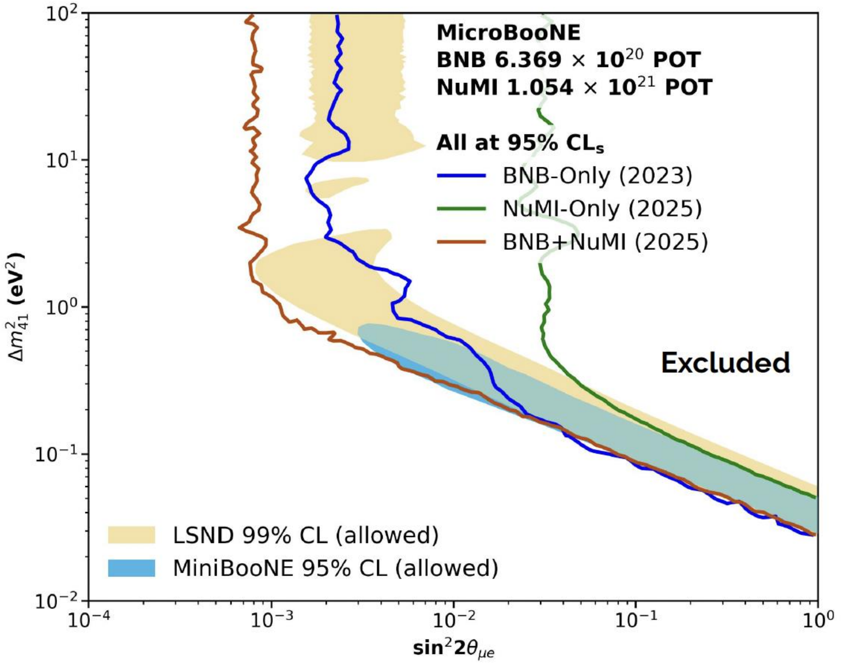
BNB+NuMI, Dual Beam Exclusion Contours



BNB CC ν_e

NuMI CC ν_e

Mark Ross-Lonergan



Combination of 2 beams with different νe contamination strongly improves sensitivity

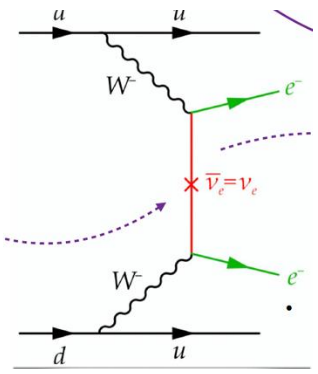
μBooNE LArTPC: profit of 2 ν beams: BNB and NuMI with different energy profile and νe contaminations

Look for νμ → νe appearance → Large Flux systematics constrained including constraints from νμ CC (introducing some model dependency)

Still origin of “MiniBooNE anomaly” not understood: 3+1ν essentially excluded – looking at model independent approach slight excess in single-γ events (2σ level)?

Results from Cuore: νless-ββ decay

Alice Campani



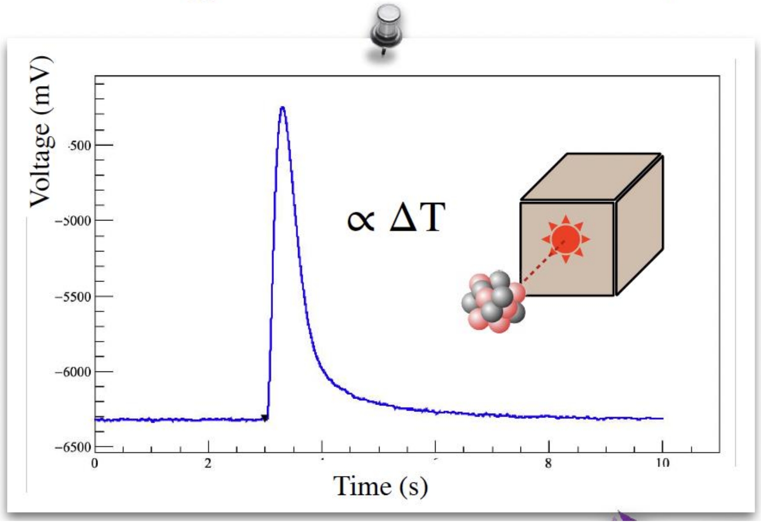
$$S_{0\nu} \propto \eta \cdot \varepsilon \cdot \sqrt{\frac{M \cdot T}{b \cdot \Delta E}}$$

Effective Majorana mass

$$< m_{\beta\beta} > = \left| \sum_{i=1,2,3} |U|^2_{ei}\, e^{i\alpha_i}\, m_i \right|$$

Operating at a temperature of ~10 mK:

1 MeV energy release causes ΔT~100 μK



Double-β decay for isotopes when single β is kinematically forbidden: 0ν only possible if ν are Majorana particles

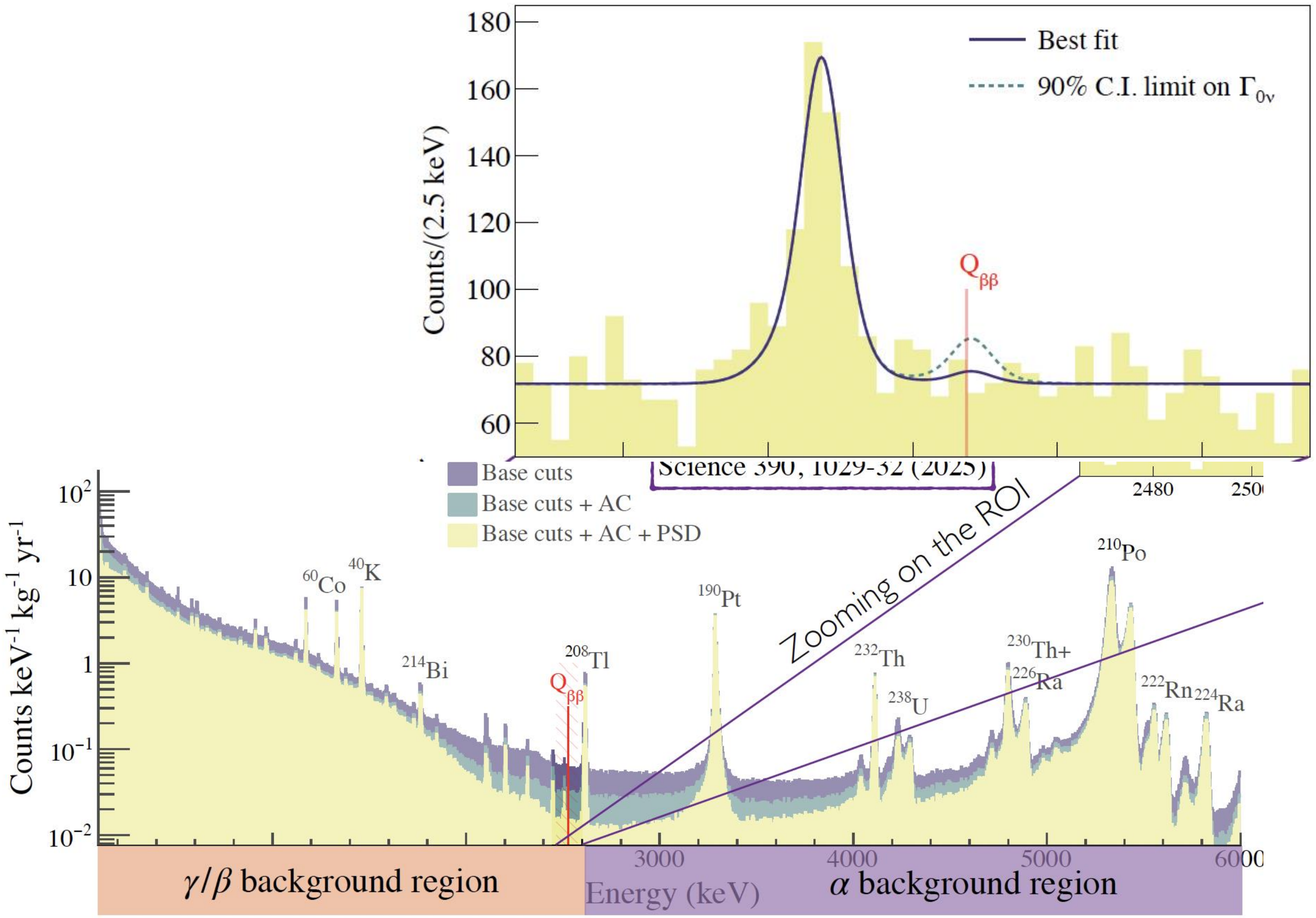
Observation will measure ”effective” mass and ordering, prove Majorana nature and probe Majorana phase!

Several experimental based on different techniques: Cuore largest cryogenic calorimeter ever built (<20mK)

Optimization: careful choice of isotope ^{130}Te, Large active mass, large Q, small bkg., excellent Energy resolution, high detection efficiency

Results from Cuore: νless-ββ decay

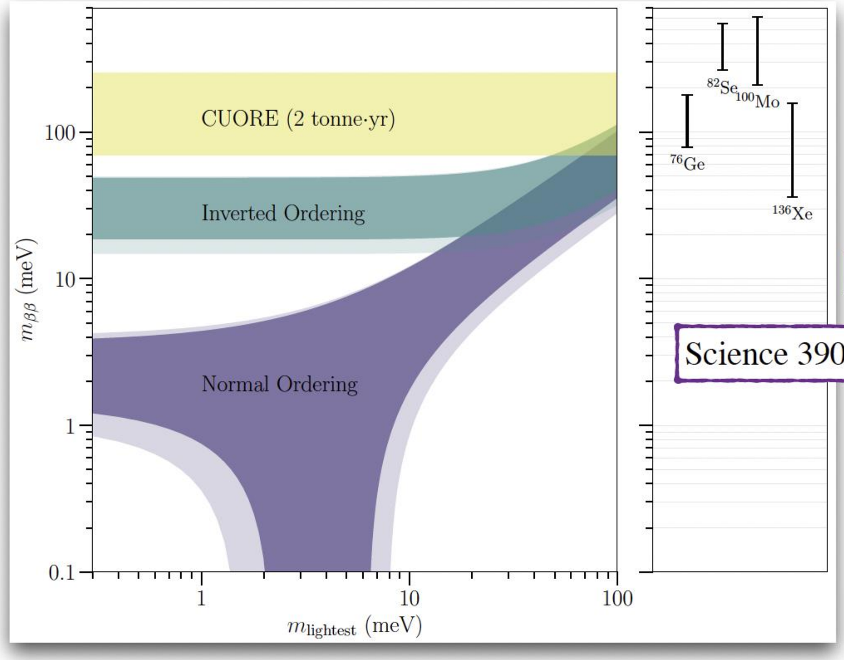
Alice Campani



Frequentist result $T^{1/2}_{0\nu\beta\beta} > 3.4 \cdot 10^{25}$ yr (90 % C . L.)

Assuming the exchange of a light Majorana neutrino
the limit on the effective Majorana mass is

$m_{\beta\beta} < 70 - 250$ meV

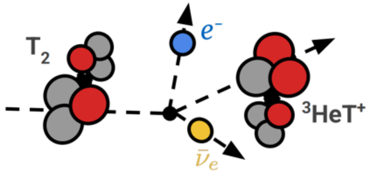


Science 390, 1029-32 (2025)

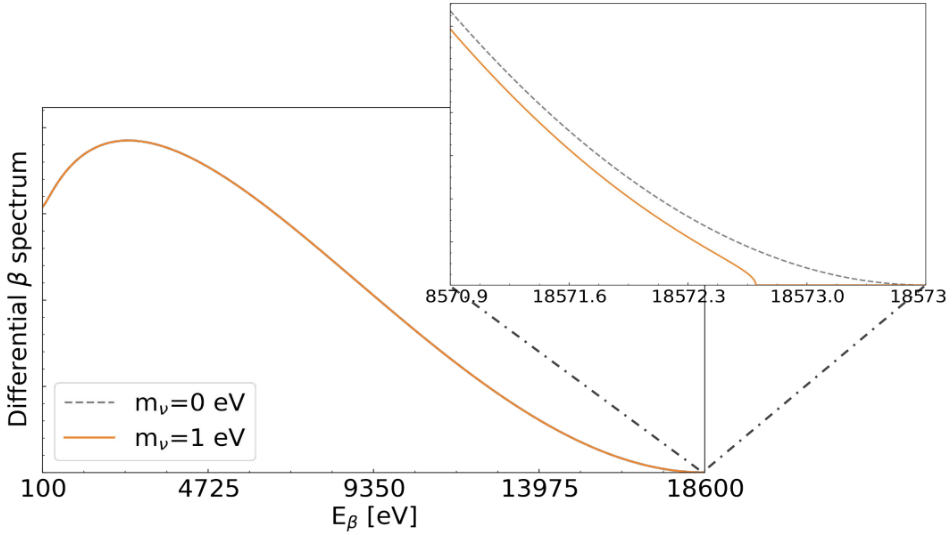
Results based on about 2/3 of the collected data: several experiments entering in the Inverted order area, CUPID (^{100}Mo larger Q + improvements) could go down to 10meV Normal mass ordering very challenging!

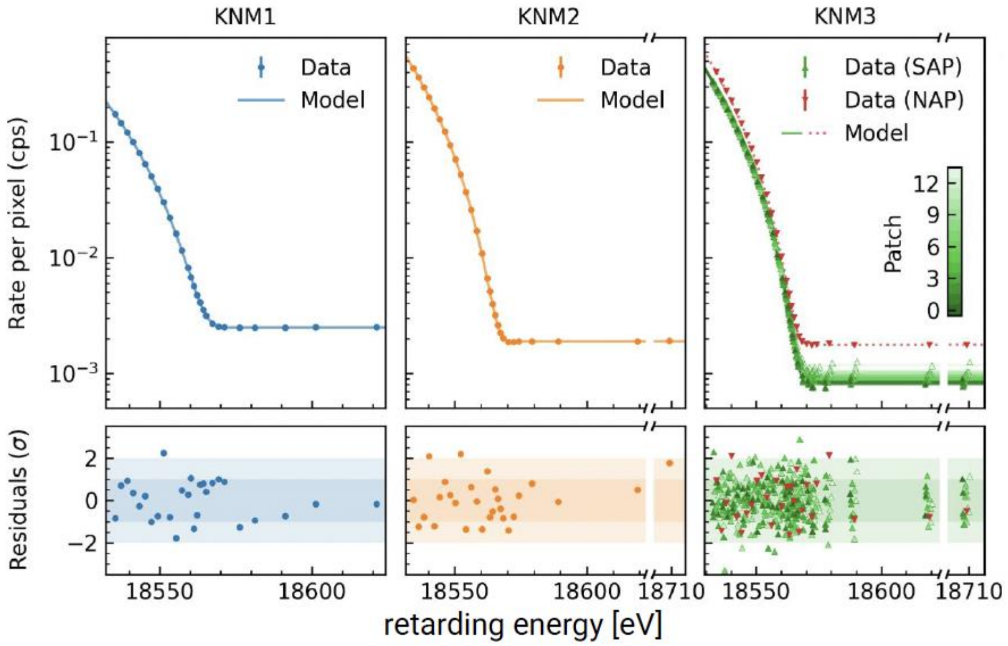
Results from Katrin

Chloé Goupy



$$m_\nu^2 = \sum_{i=1}^{3} |U_{ei}|^2 m_i^2$$





Best fit result (p-value: 0.84): $m_\nu^2 = -0.14^{+0.13}_{-0.15}\,\mathrm{eV}^2$

KATRIN's new upper limit:
m_ν < 0.45 eV (90% CL)

Huge EM spectrometer → energy end-point from β decay → Energy resolution ~1 eV

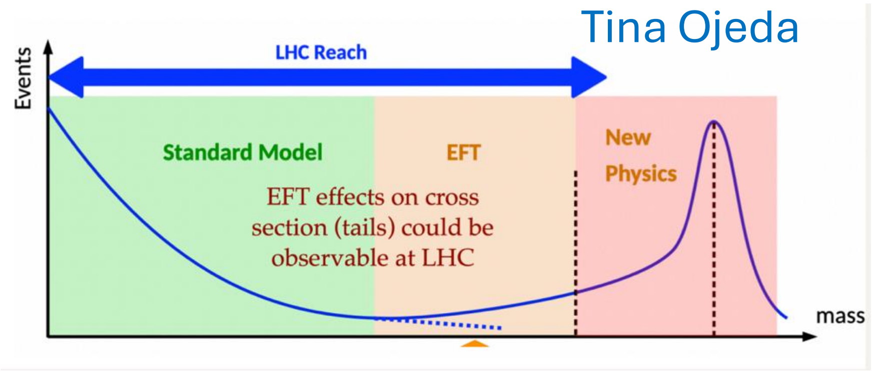
Results based on 260 days, full 1000d coming out soon -> 0.3eV

Can also search for sterile ν in Ga anomaly region -> limits excluding most of the preferred regions

Summary on ν physics

- Several PNMS parameters now measured with high precision, but δ_{CP} and Mass ordering require new generation experiments: JUNO, HyperK, DUNE
- Absolute mass scale and Majorana nature very challenging: good prospects for IO but very challenging for NO
- Results from μBooNE, Icarus and Katrin shed more light on νs "anomalies": 3+1 explanation (almost) excluded

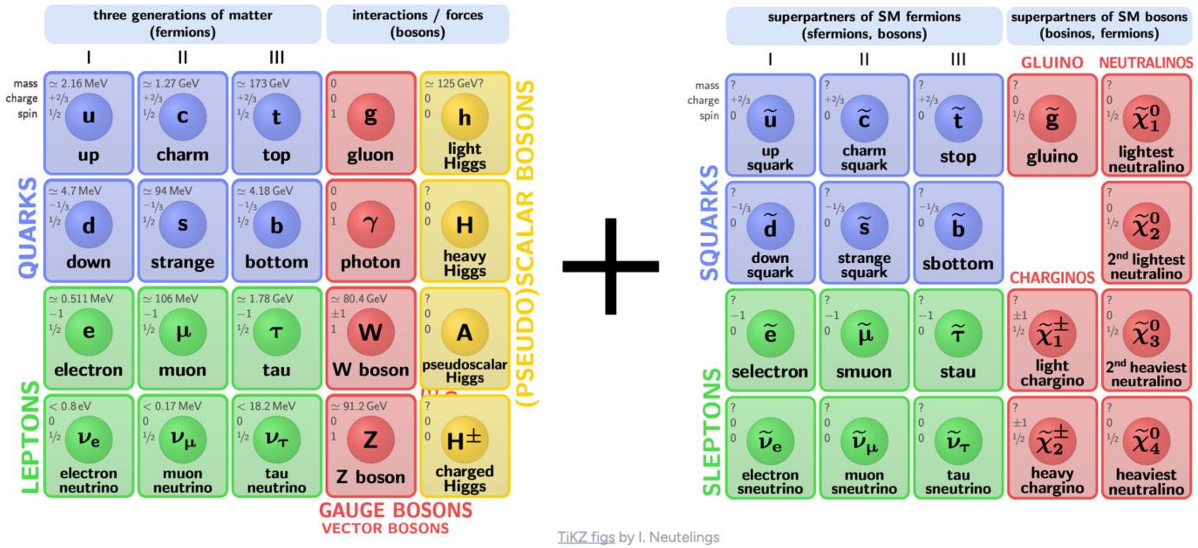
Search for BSM phenomena at colliders



Wilson coefficient c_i

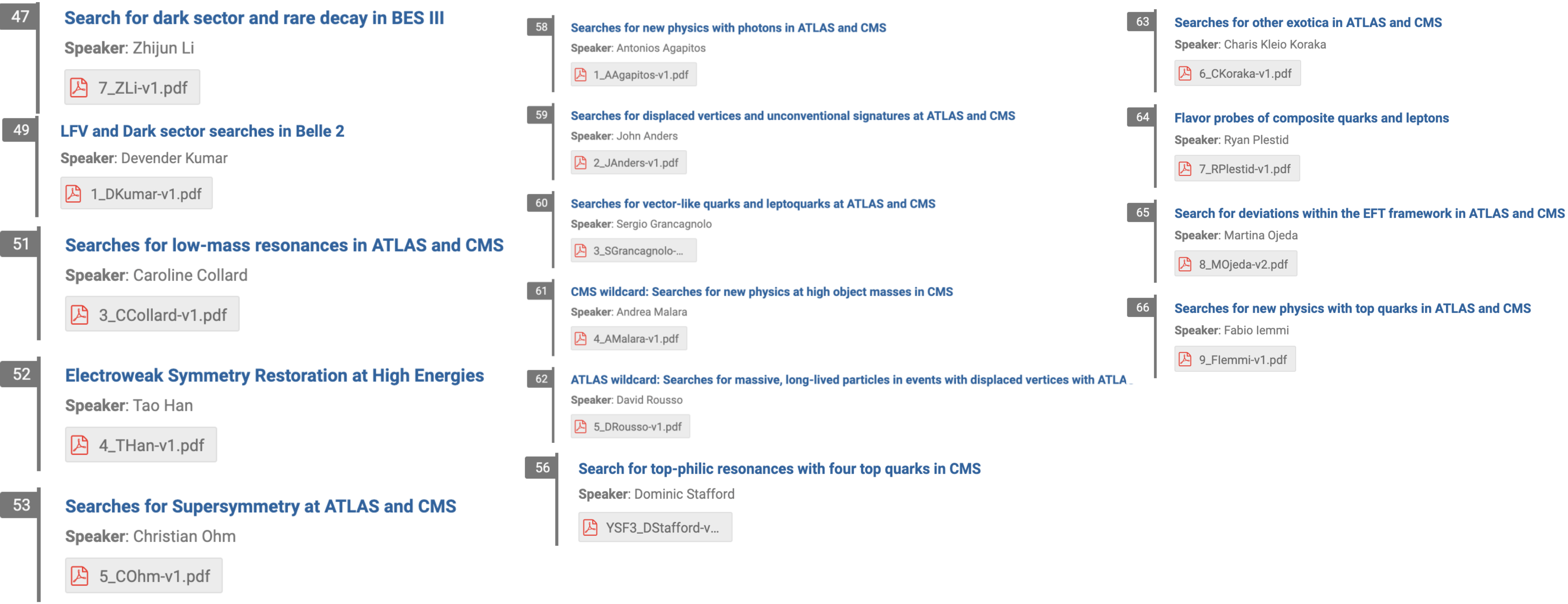
$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \cancel{\sum_i \frac{c_i^{(5)}}{\Lambda} Q_i^{(5)}} + \sum_i \frac{c_i^{(6)}}{\Lambda^2} Q_i^{(6)} + \cancel{\sum_i \frac{c_i^{(7)}}{\Lambda^3} Q_i^{(7)}} + \sum_i \frac{c_i^{(8)}}{\Lambda^4} Q_i^{(8)} + \cdots$$

Scale of "new physics" Λ, usually set to 1 TeV



Complementary approaches developed to look for BSM physics:

- Agnostic Effective Field Theory: most general set of effective operators, fit to all measured observables
- Well motivated UV models: SUSY, Other GUT symmetries, Extra-dimensions, Dark Sector, ...
- Completely model independent/data driven: Topology driven, Anomaly Detection, ...



47 **Search for dark sector and rare decay in BES III**

Speaker: Zhijun Li

7_ZLi-v1.pdf

49 **LFV and Dark sector searches in Belle 2**

Speaker: Devender Kumar

1_DKumar-v1.pdf

51 **Searches for low-mass resonances in ATLAS and CMS**

Speaker: Caroline Collard

3_CCollard-v1.pdf

52 **Electroweak Symmetry Restoration at High Energies**

Speaker: Tao Han

4_THan-v1.pdf

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5_COhm-v1.pdf

58 **Searches for new physics with photons in ATLAS and CMS**

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1_AAgapitos-v1.pdf

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Speaker: John Anders

2_JAnders-v1.pdf

60 **Searches for vector-like quarks and leptoquarks at ATLAS and CMS**

Speaker: Sergio Grancagnolo

3_SGrancagnolo-...

61 **CMS wildcard: Searches for new physics at high object masses in CMS**

Speaker: Andrea Malara

4_AMalara-v1.pdf

62 **ATLAS wildcard: Searches for massive, long-lived particles in events with displaced vertices with ATLA**

Speaker: David Rousso

5_DRousso-v1.pdf

56 **Search for top-philic resonances with four top quarks in CMS**

Speaker: Dominic Stafford

YSF3_DStafford-v...

63 **Searches for other exotica in ATLAS and CMS**

Speaker: Charis Kleio Koraka

6_CKoraka-v1.pdf

64 **Flavor probes of composite quarks and leptons**

Speaker: Ryan Plestid

7_RPlestid-v1.pdf

65 **Search for deviations within the EFT framework in ATLAS and CMS**

Speaker: Martina Ojeda

8_MOjeda-v2.pdf

66 **Searches for new physics with top quarks in ATLAS and CMS**

Speaker: Fabio Iemmi

9_FIemmi-v1.pdf

15 excellent talks covering ~50 analyses!

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3_SGrancagnolo-...

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4_AMalara-v1.pdf

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Speaker:

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Mission Impossible!

15 exce ent talks covering ~50 analyses!

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Speaker:
4_TH

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Highlight new techniques and directions developed in the last years

Missio

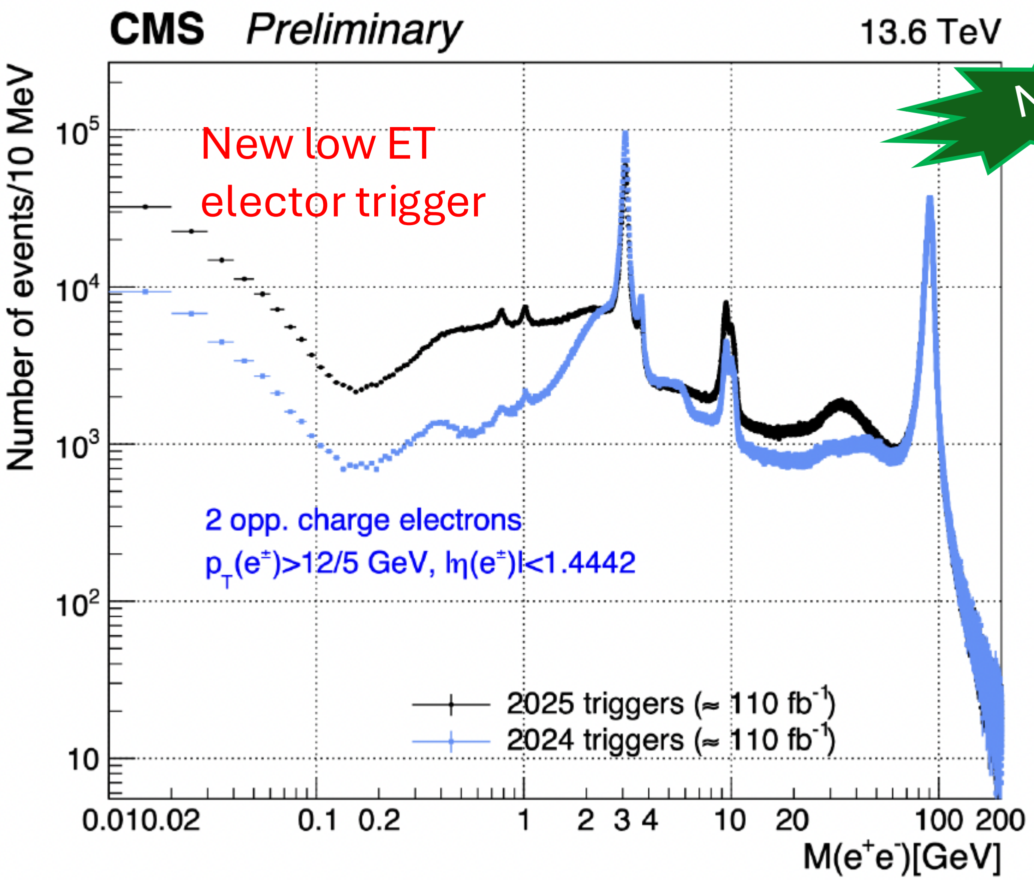
ossible!

15 exce ent talks covering ~50 analyses!

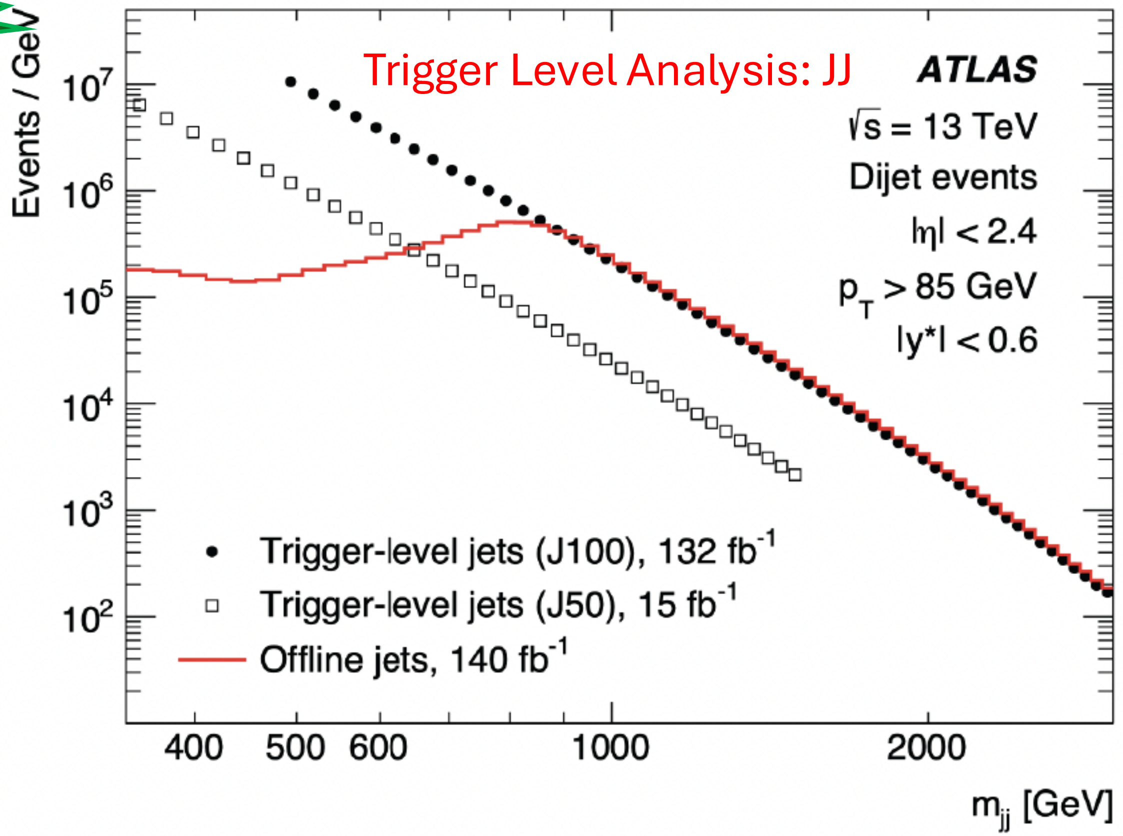
Search for low mass resonances in ATLAS + CMS

Caroline Collard

NEW



New low ET elector trigger



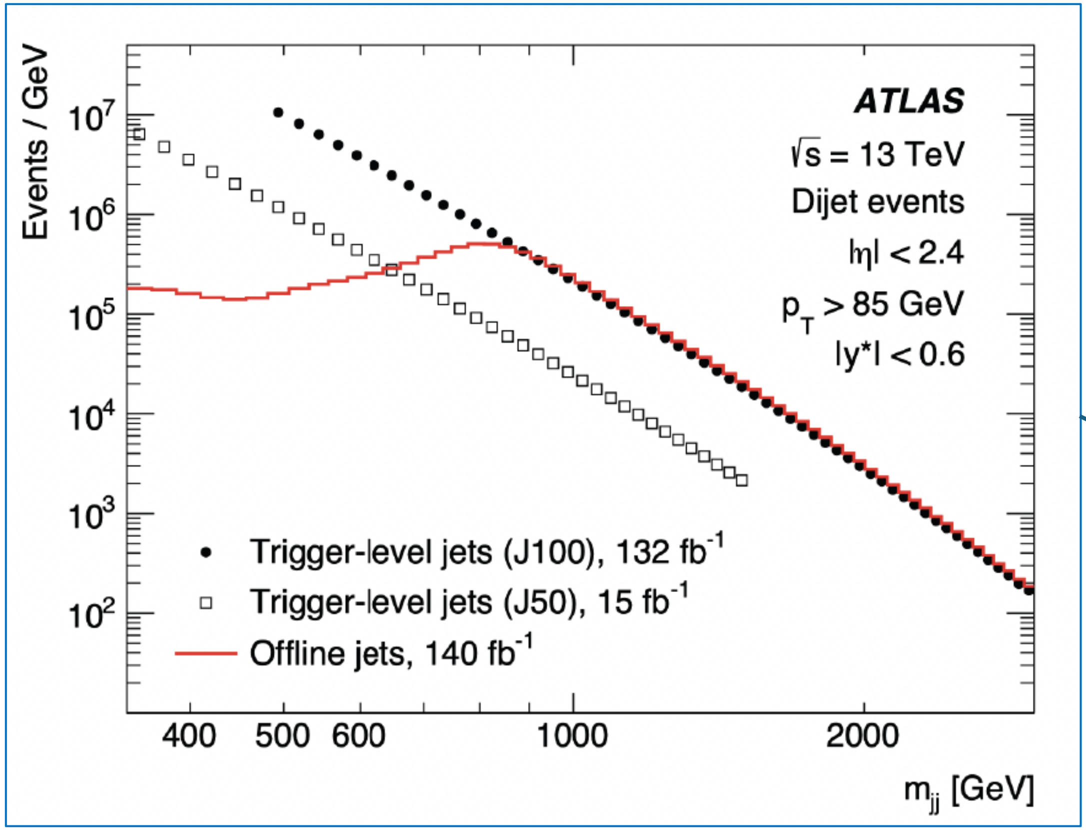
Trigger Level Analysis: JJ

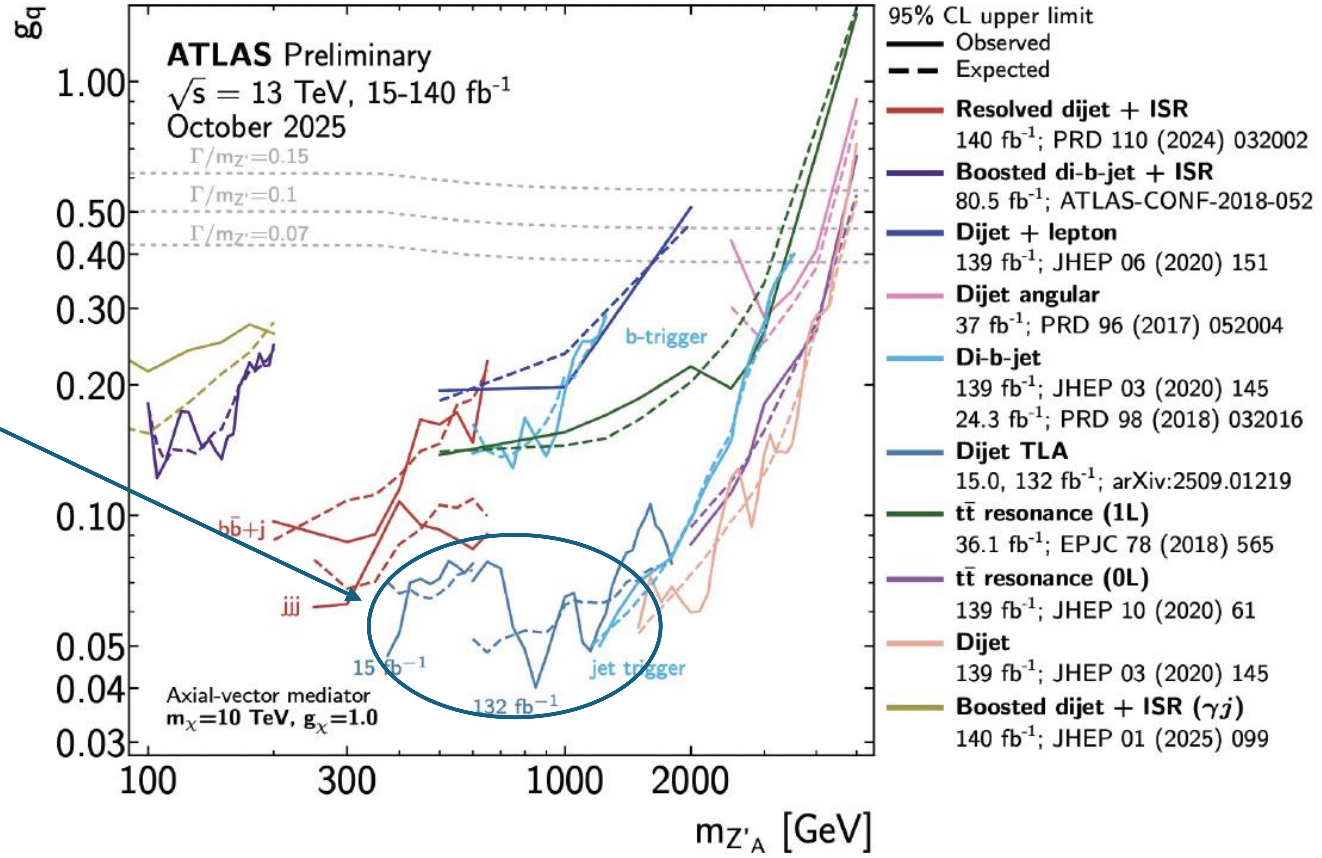
LHC detectors were designed for high energy signatures (Higgs boson, Z’, …)

Low mass regions are very challenging: **NEW** dedicated triggers, calibrations and and reconstruction techniques developed

Search for low mass di-jet resonances in ATLAS

Caroline Collard





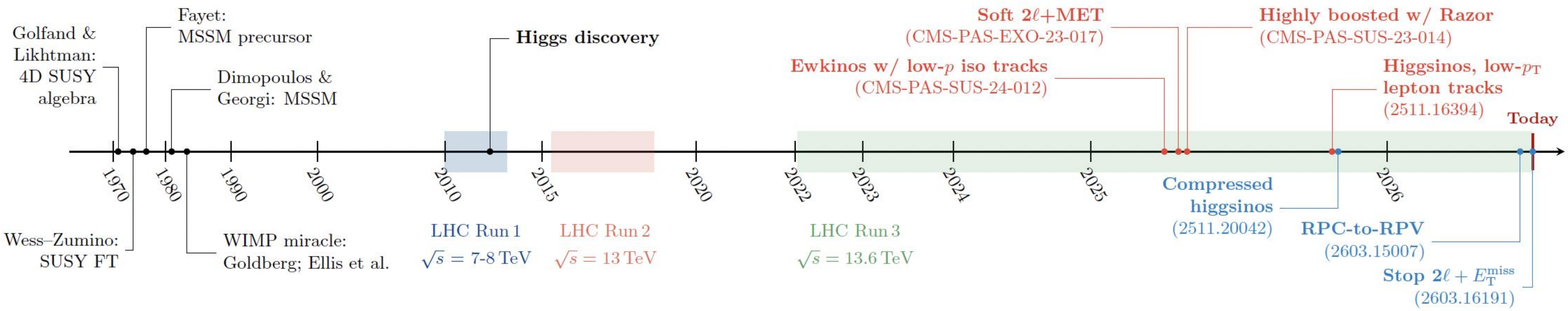
Low mass regions are very challenging at LHC: dedicated triggers and reconstruction techniques

Data Scouting/TLA Write less information at trigger level → Bandwidth=[rate x event size] → small events → high rate!

Search SUSY in ATLAS + CMS

Chris Ohm

- SUSY argued to be last possible additional symmetry, and SUSY models attractive since they can
  - Alleviate ***fine-tuning of Higgs mass*** (naturalness)
  - Improve ***unification of forces*** at GUT scale
  - Provide particles that can make up the ***dark matter***



Golfand & Likhtman: 4D SUSY algebra

Fayet: MSSM precursor

Dimopoulos & Georgi: MSSM

Wess–Zumino: SUSY FT

WIMP miracle: Goldberg; Ellis et al.

Higgs discovery

LHC Run 1 $\sqrt{s} = 7\text{-}8$ TeV

LHC Run 2 $\sqrt{s} = 13$ TeV

LHC Run 3 $\sqrt{s} = 13.6$ TeV

Soft 2ℓ+MET (CMS-PAS-EXO-23-017)

Ewkinos w/ low-p iso tracks (CMS-PAS-SUS-24-012)

Highly boosted w/ Razor (CMS-PAS-SUS-23-014)

Higgsinos, low-p_T lepton tracks (2511.16394)

Today

Compressed higgsinos (2511.20042)

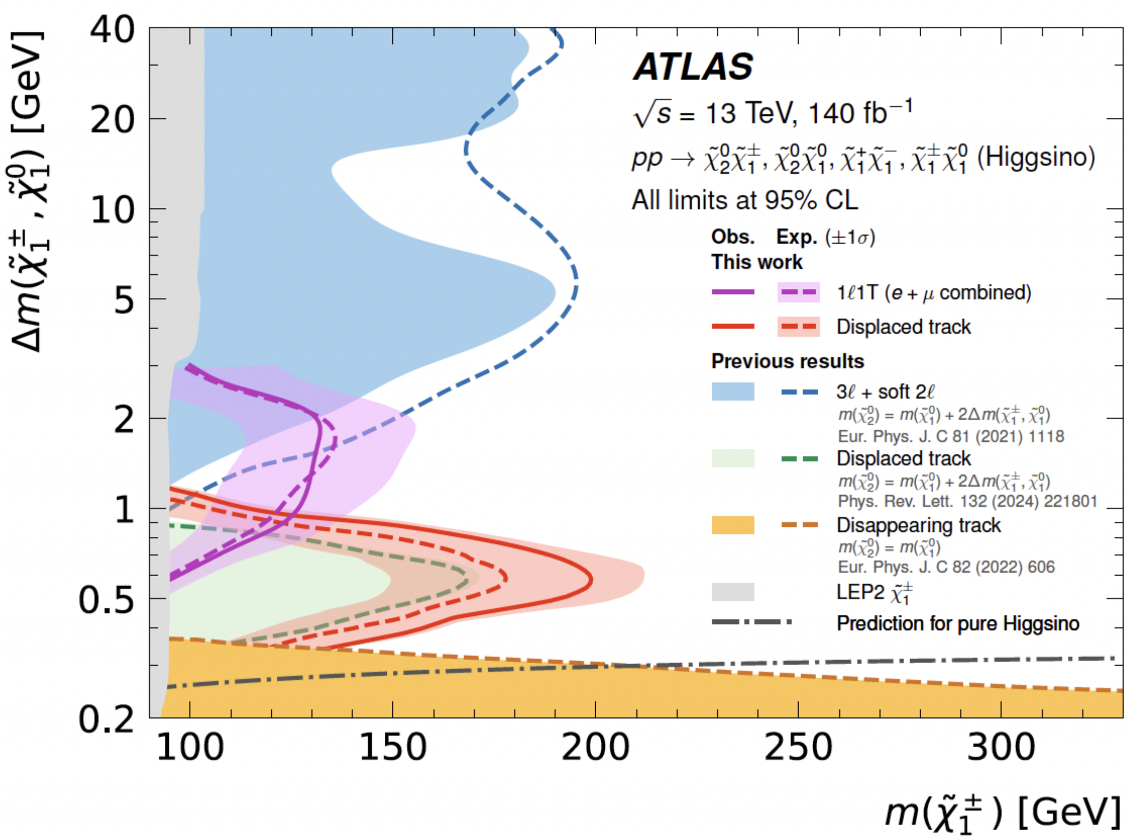
RPC-to-RPV (2603.15007)

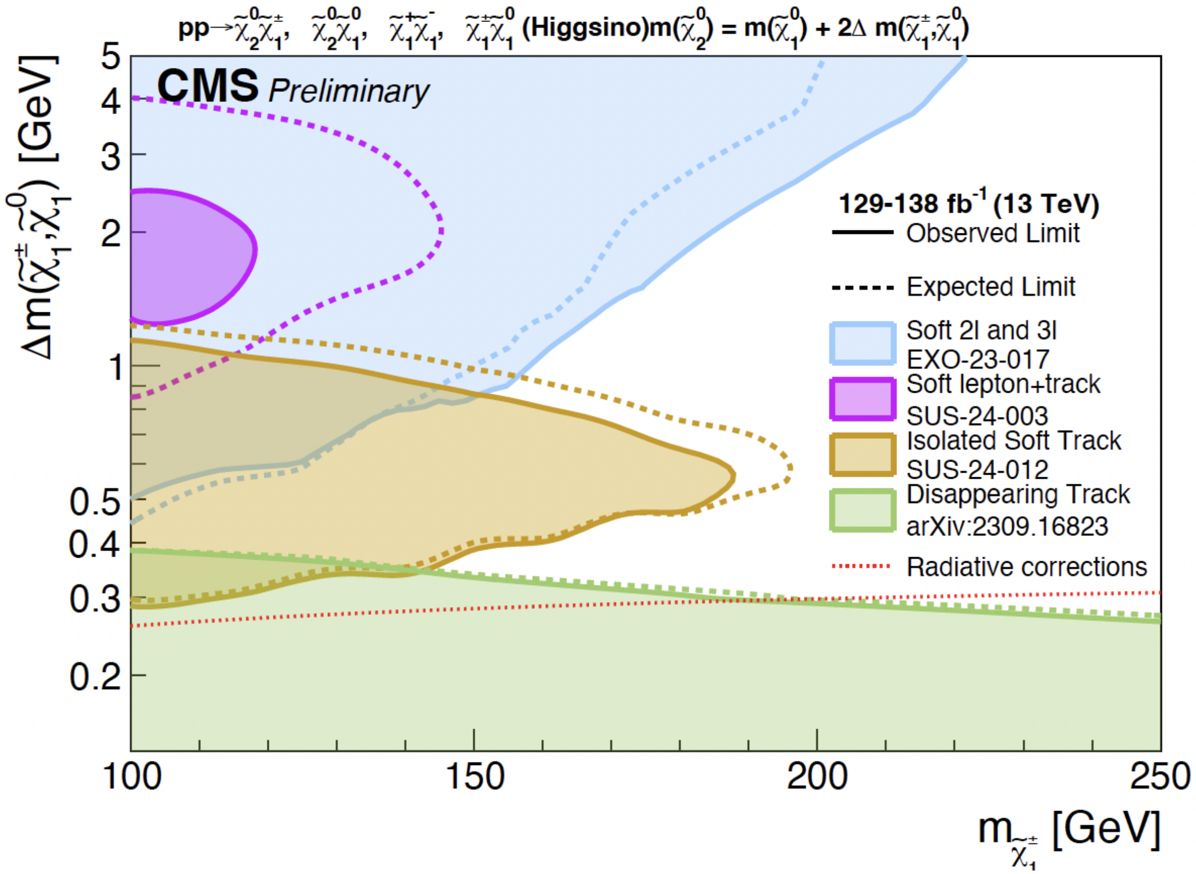
Stop $2\ell + E_T^{miss}$ (2603.16191)

- Run 1: Inclusive/general searches produced powerful exclusion limits
- Now: methodology-driven efforts targeting tricky parts of parameter space
  - LLPs, compressed scenarios + improvements from innovative reconstruction & ML/AI techniques

Search “compressed” EW SUSY in ATLAS + CMS

Chris Ohm





New reconstruction techniques to address low DM electroweakinos regions:

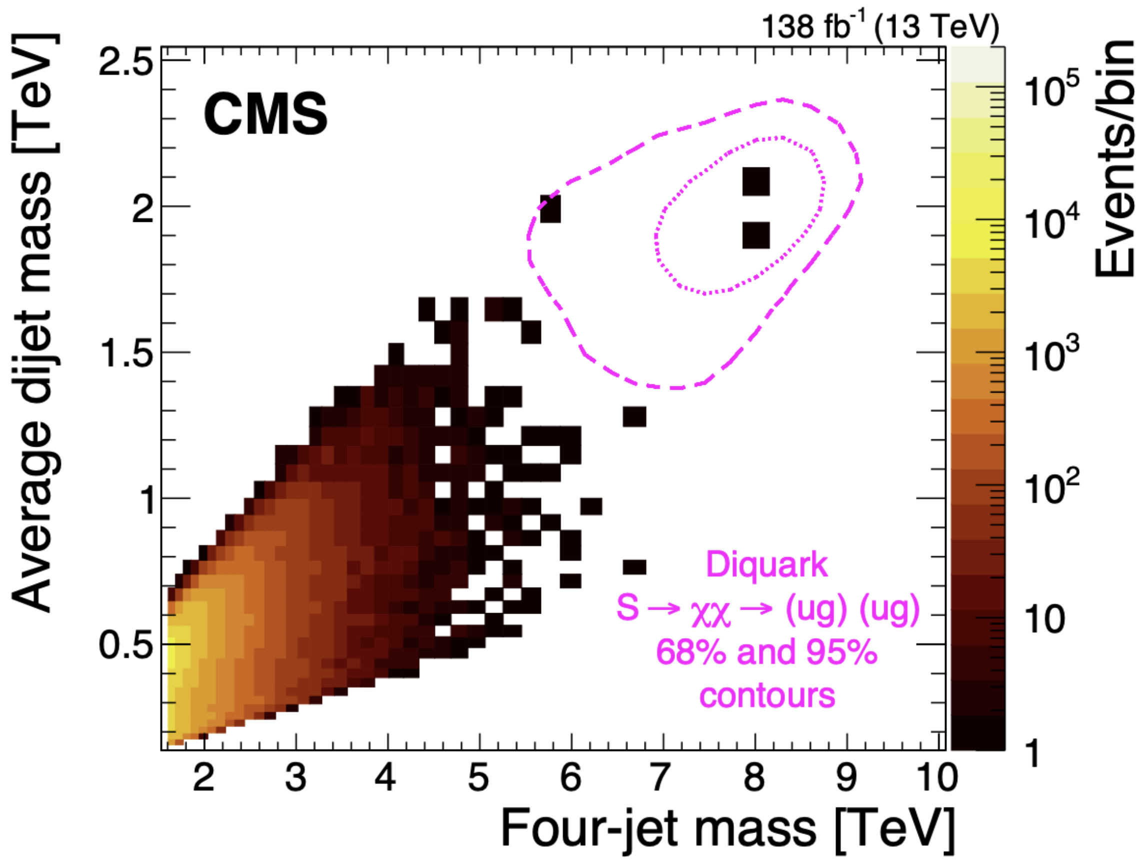
“Soft leptons” dedicated ID

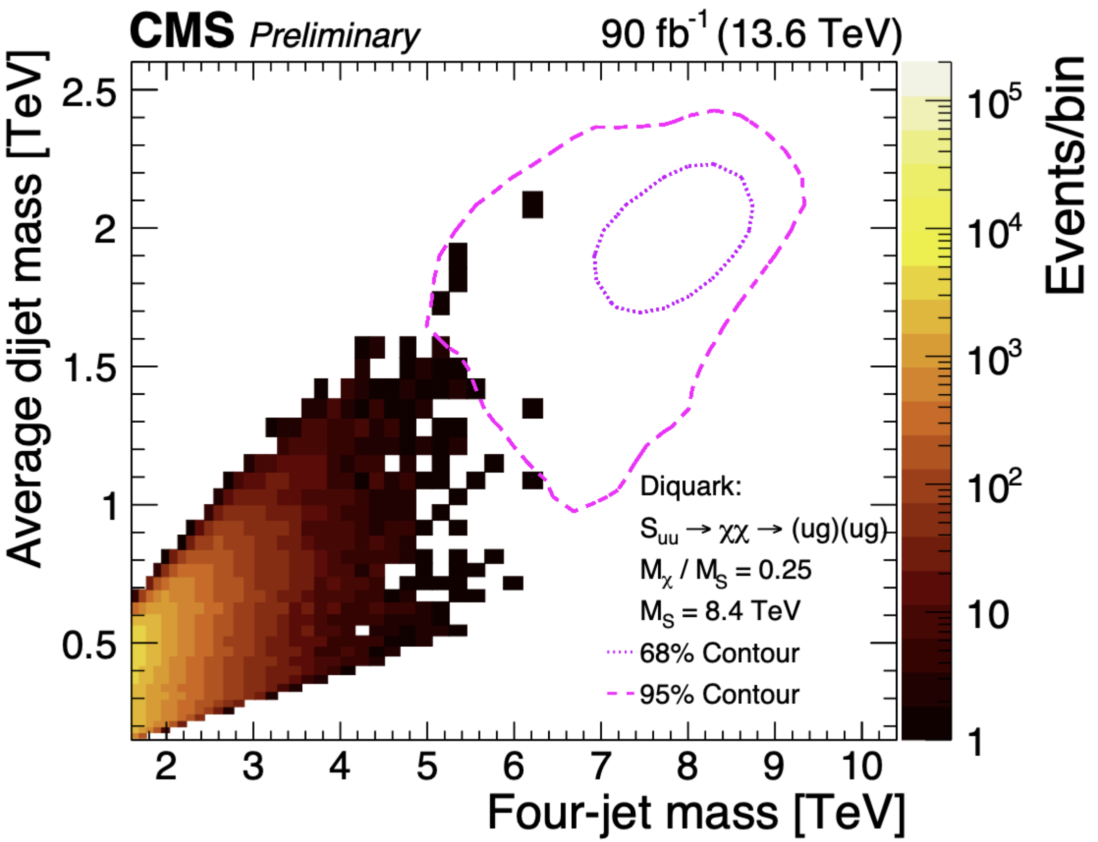
“Displaced” tacks

“Disappearing” tracks

Search for high mass di-jet resonances

Andrea Malara

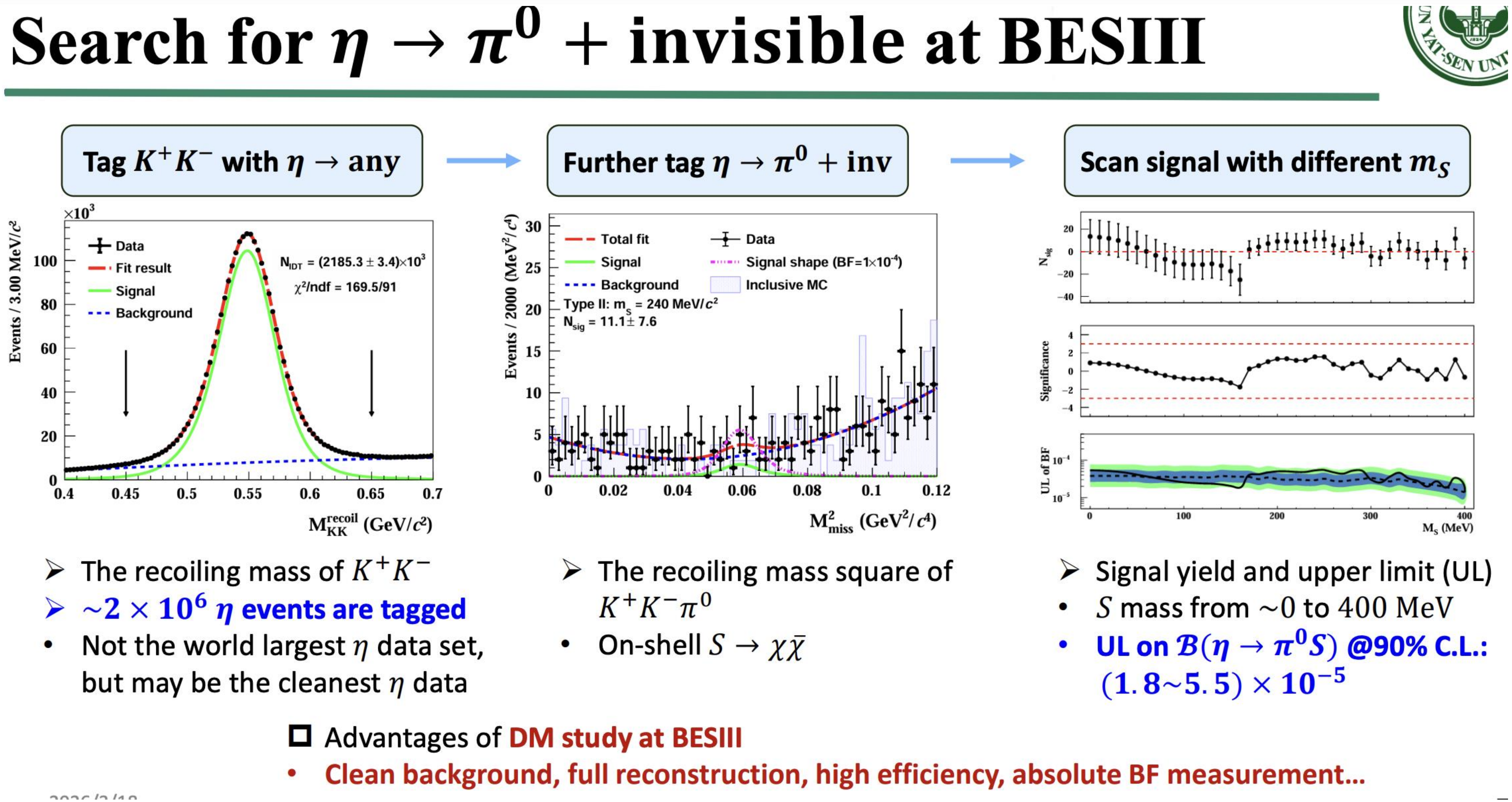




- Stil important to explore the energy frontier with **very high mass searches**
- Follow up of (small) Run 2 excess with **Run 3 data** : not confirmed (see also ATLAS full Run 2)

Search for DM at BES III

Zhijun Li



Search for $\eta \to \pi^0$ + invisible at BESIII

Tag K^+K^- with $\eta \to$ any → **Further tag $\eta \to \pi^0 + \text{inv}$** → **Scan signal with different m_S**

- The recoiling mass of K^+K^-
- **$\sim 2 \times 10^6$ η events are tagged**
- Not the world largest η data set, but may be the cleanest η data

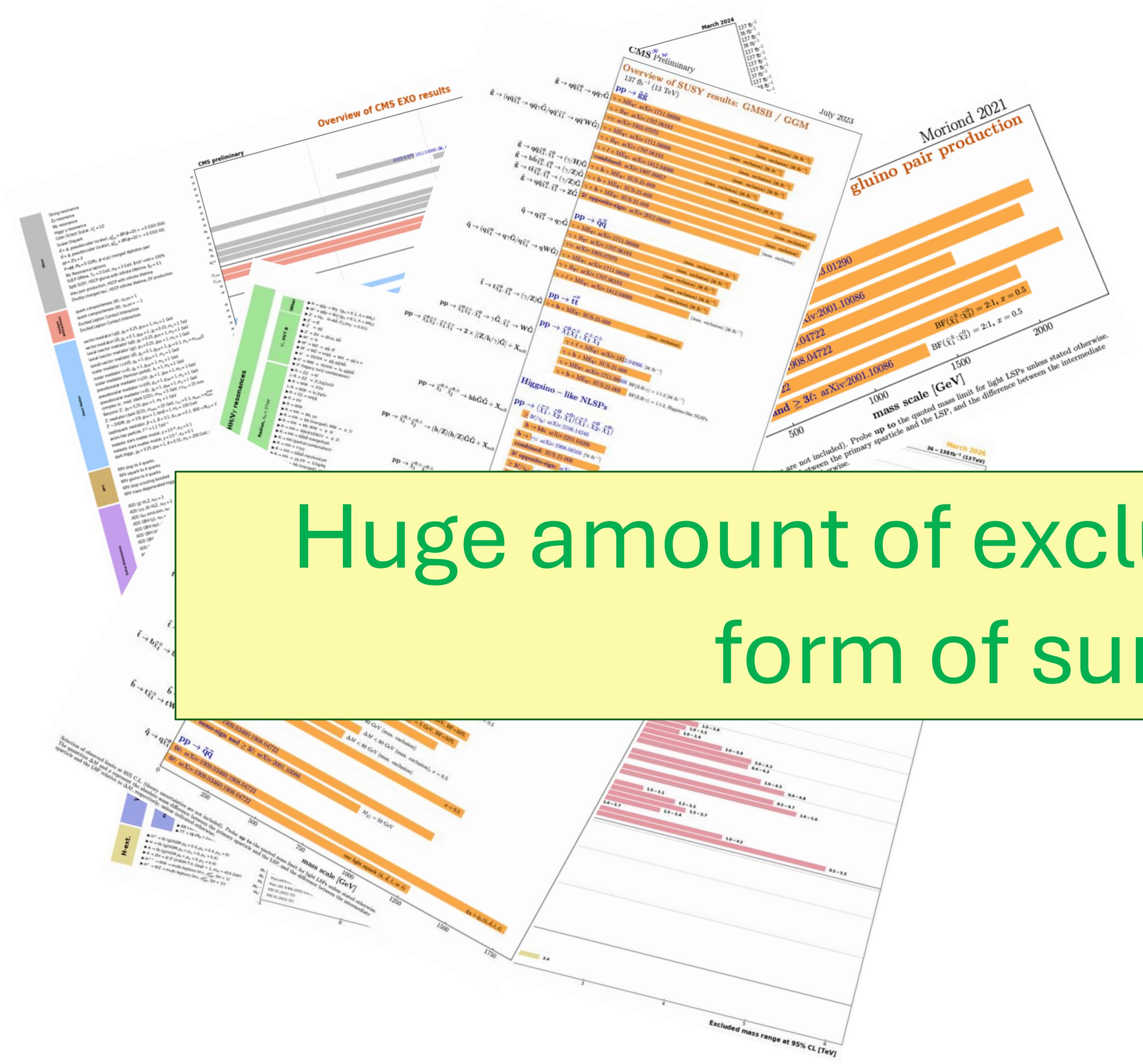
- The recoiling mass square of $K^+K^-\pi^0$
- On-shell $S \to \chi\bar{\chi}$

- Signal yield and upper limit (UL)
- S mass from ~0 to 400 MeV
- **UL on $\mathcal{B}(\eta \to \pi^0 S)$ @90% C.L.: $(1.8{\sim}5.5) \times 10^{-5}$**

☐ Advantages of **DM study at BESIII**
- **Clean background, full reconstruction, high efficiency, absolute BF measurement…**

- Competitive search for **light DM candidates** in the sub-GeV range

- Large n umbers of decays studies



Huge amount of exclusion limits available in form of summary plots!

CMS searches summary plots

ATLAS searches summary plots

Summary of searches

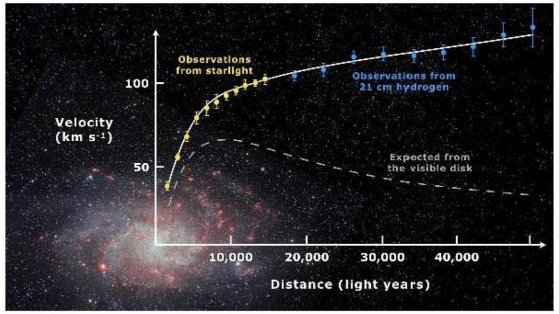
- Wide range of possible BSM signatures covered at colliders motivated by SM short comes (DM, Hierarchy problem, Flavor anomalies, …)
- In addition to “vanilla” topologies (strong SUSY, LQ, …), experiments are investing resources to extend searches in challenging directions: NEW trigger (TLA/Scouting, Long Leaved Particles, …), NEW reconstruction techniques (boosted objects, large IP tracks, dE/dx, TOF, …), heavy use of ML/AI to tackle more challenging signatures and improve objects performance
  - Pushing LHC detector well above their target performances
- No signal yet but it is our duty to make optimal use of large datasets that will be collected in the incoming years (HL-LHC, Belle II, …)

Search for DM

Gian Marco Lucchetti

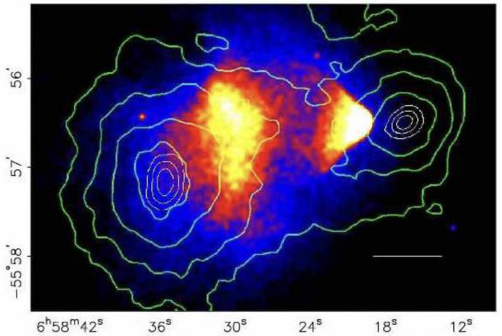
[For a nice review see Dark Matter: Cirelli, Strumia, Zupan]

Galaxy rotation curves



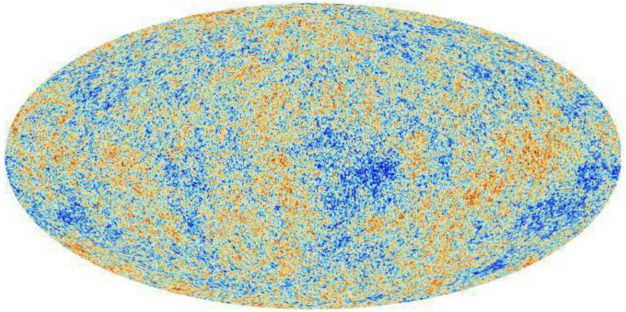
Ram Chandra Gotame

Galaxy cluster collisions



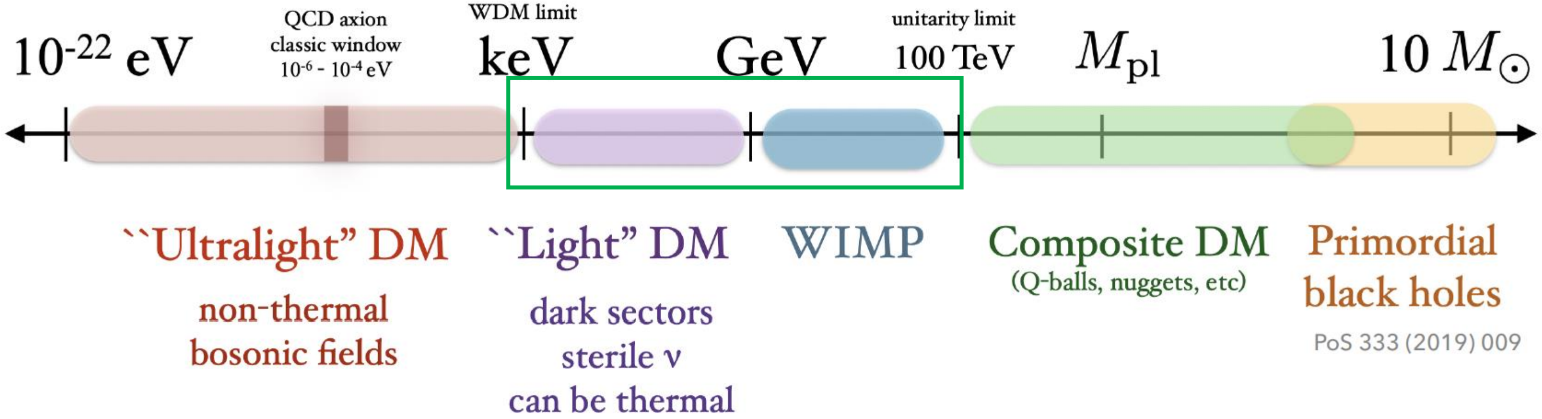
Douglas Clowe *et al* 2006 *ApJ* **648** L109

CMB anisotropies



ESA and the Planck Collaboration

which can be explained by the presence of a new neutral massive particle:



PoS 333 (2019) 009

Overwhelming evidence for DM existence: **Wide range** of DM candidates 10^{-22} eV < M < 10^{37} kg (90 order of magnitudes!)! makes the search extremely challenging

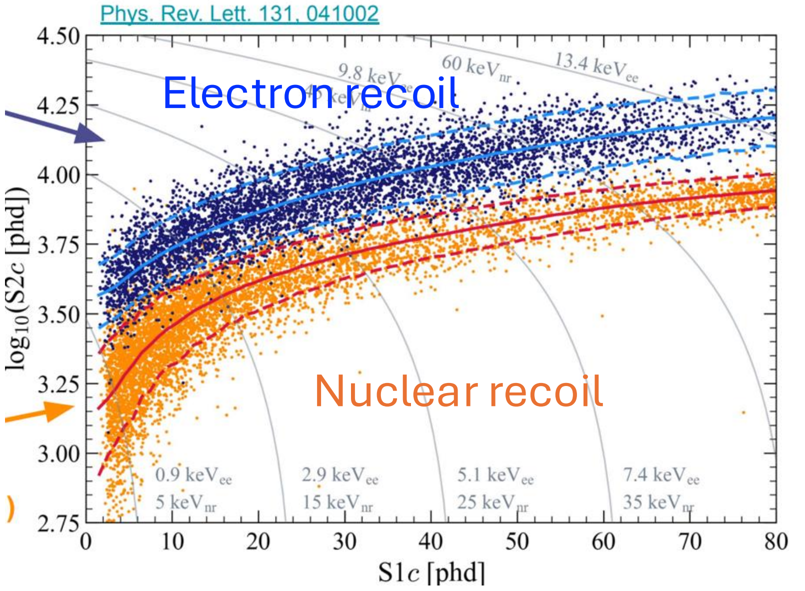
Extension of SM (BSM) provides good candidates: WIMPs, QCD Axions (ALPs), Dark Sector, ...

Complementary searches form **direct detection**, production at colliders, indirect (annihilation signals), ...

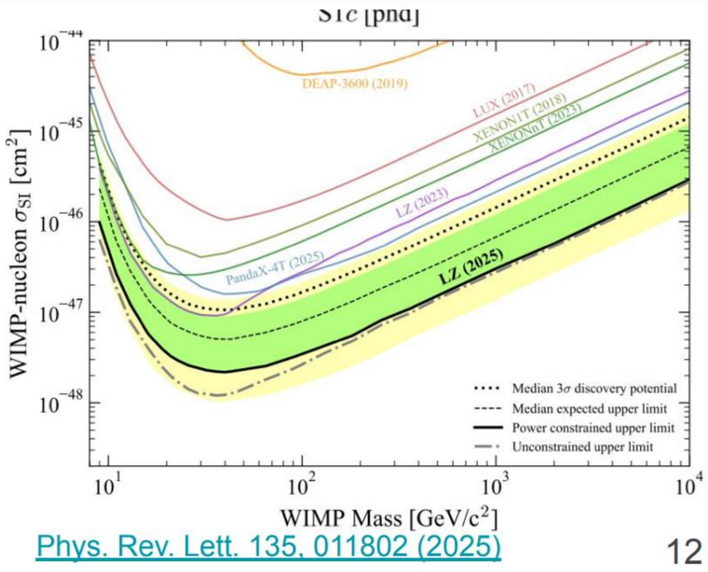
Latest Results from LUX-Zeplin

Bjoern Penning

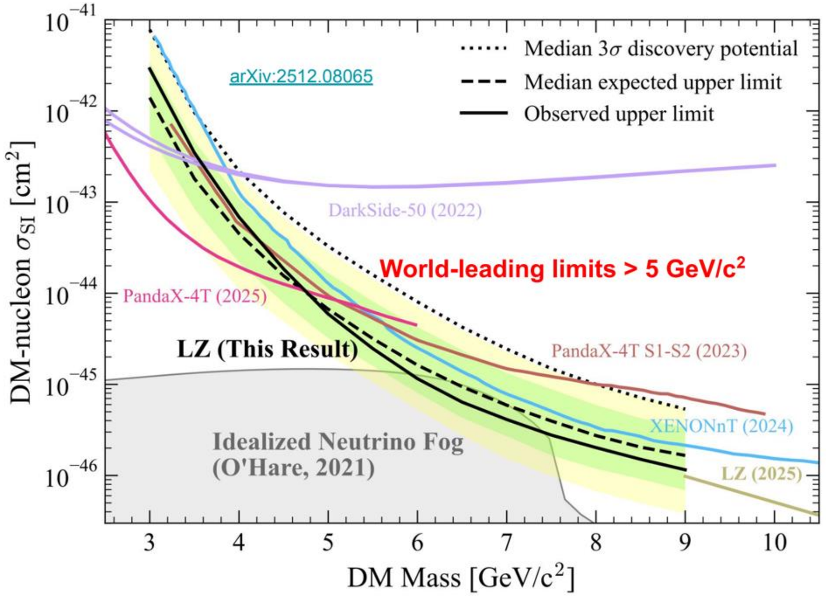
Particle ID



Phys. Rev. Lett. 131, 041002



Phys. Rev. Lett. 135, 011802 (2025)



arXiv:2512.08065

Leading sensitivity >5GeV

Dark matter interactions detected in LiXe Dual-phase TPC with “active” shielding: prompt light signal (S1) + delayed amplified charge (S2)

Analysis extended to lower masses, dominant background accidental coincidences

Sensitive to ^{8}B ν (dominant background for DM in that region):

Bkgds: ~6.6 ± 0.4 events

^{8}B CEvNS: $20.6^{+8.9}_{-6.8}$ events

Obs: 19

Fit: $18.9^{+7.0}_{-5.5}$

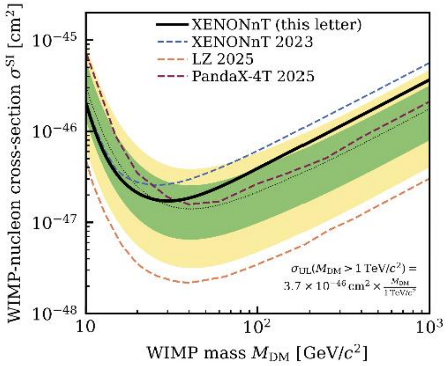
4.5σ

Latest Results from XenonT

Gian Marco Lucchetti

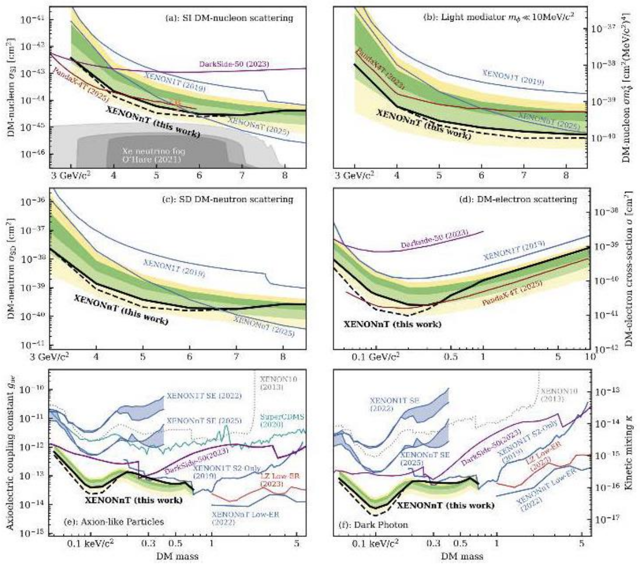
WIMP

- **New limits on WIMP-nucleon cross section:** $\sigma = 1.7 \times 10^{-47}$ cm^2 at m_χ = 30 GeV/c^2.
- Factor **1.8** improvement wrt SR0.



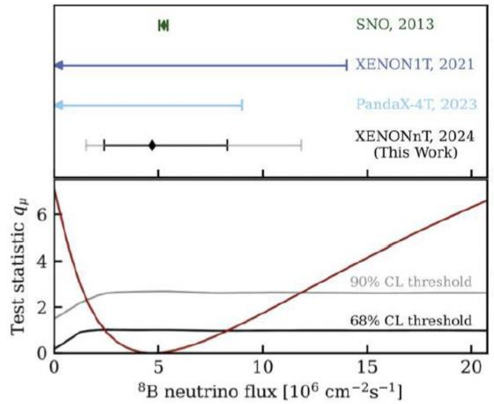
S2-only search

- **New limits on DM-nucleon, DM-e$^-$, ALPs and Dark Photons**



^{8}B CEvNS

- **Observed ^{8}B CEvNS at $2.73\,\sigma$:** 1st observation in a xenon experiment and with astrophysical neutrinos.



LiXe dual-phase TPC surrounded by by "instrumented shielding" (muon and neutron veto)

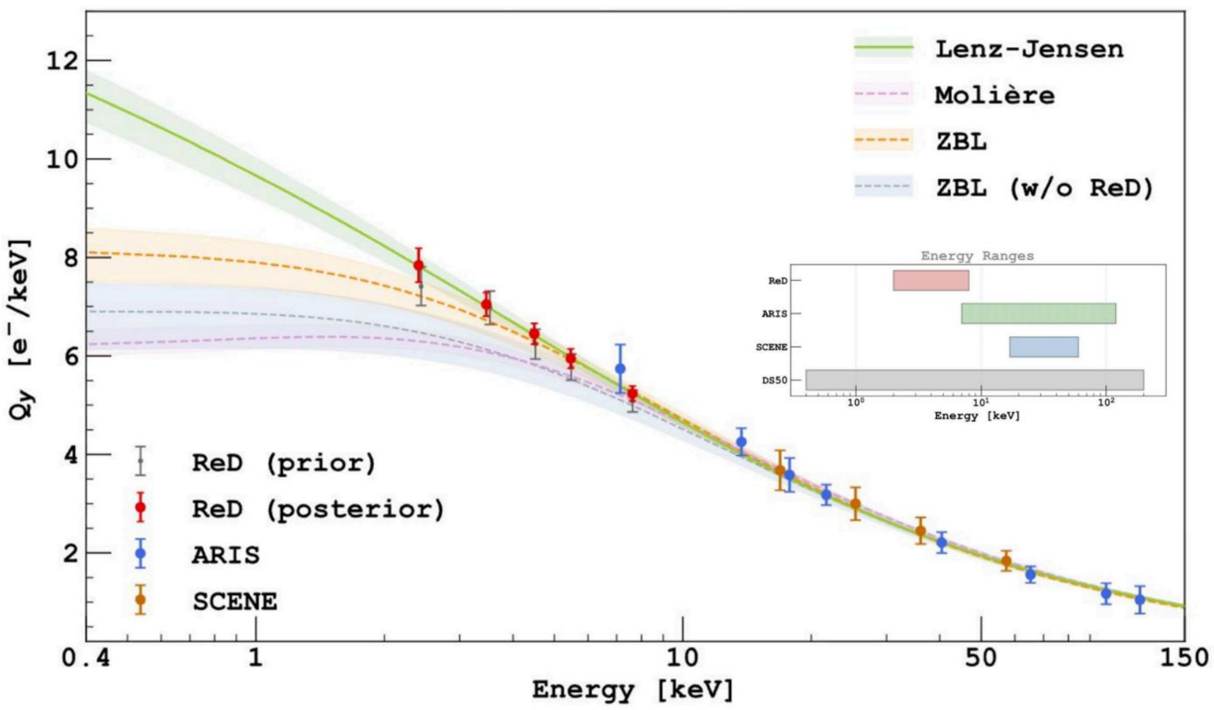
Similarly to LUX-Zepelin 2 search regimes to cover large mass range [S1+S2→NR 10 GeV-TeV] or [S2-only ER sub-GeV] → For S2 only background becomes large (cathode and delayed electrons, will be reduced with current upgrade))

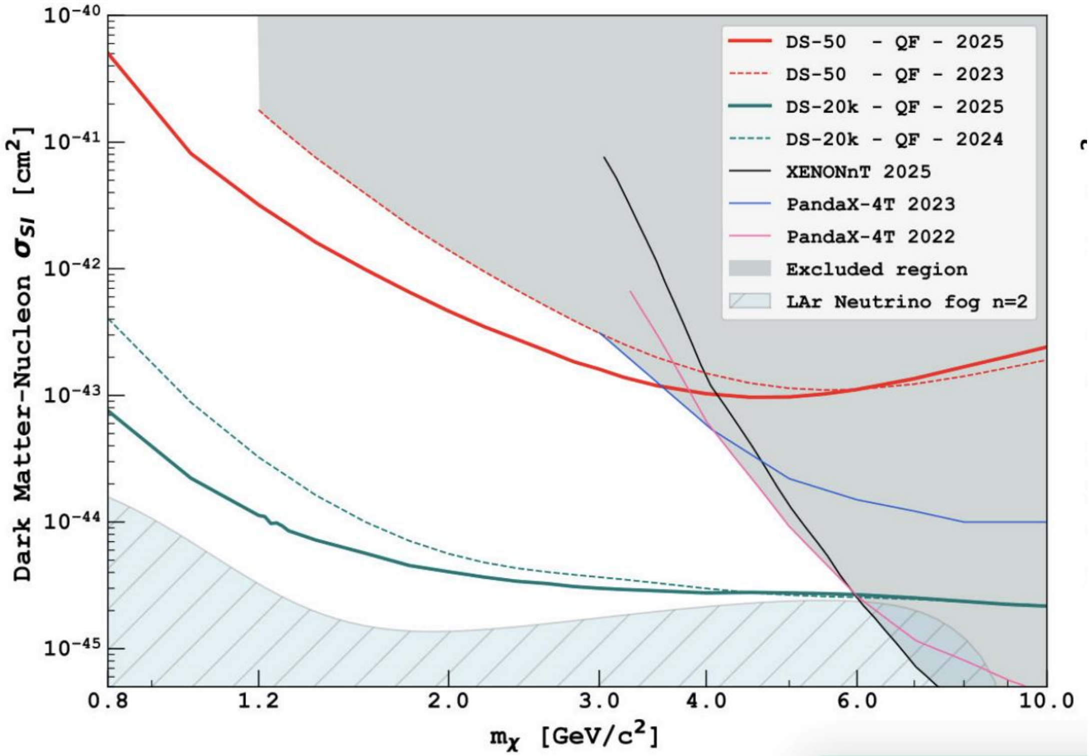
Solar ^{8}B CEvNS give NR signals as DM (irreducible bkg.) 2.7 excess

XLZD: Xenon-Lux Zeplin-Darwin collaboration established to build the next gen-LXe TPC with up to 60t target mass

Latest Results from DarkSide-50

Timothée Hessel





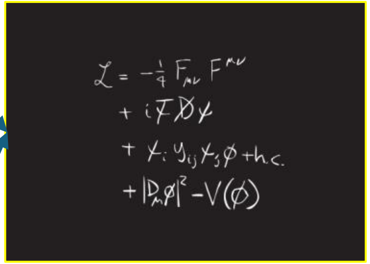
LAr dual-phase TPC, extend the search to low mass using ionization signal only

Need to calibrate ionization model for nuclear recoil used data with n sources (ReD experiment) Lenz-Jensen model, predicts stronger signals for WIMPs

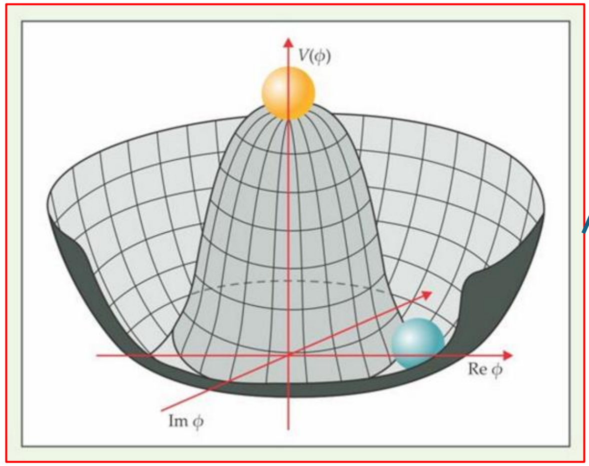
Improved sensitivity at low M and also improved projected sensitivity for upgrade to **Dark-Side20k**

Brout-Englert-Higgs boson physics

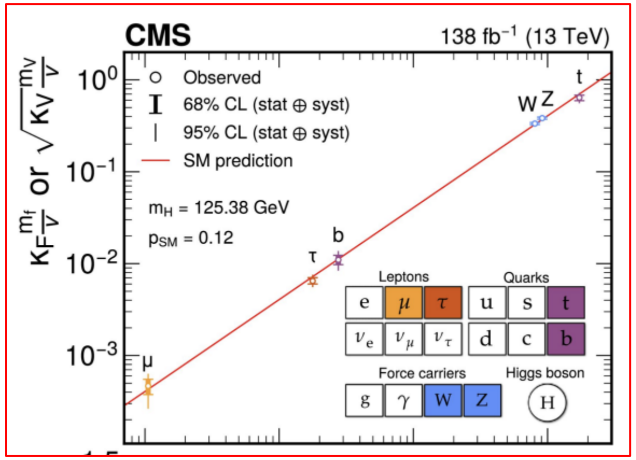
$SU(3)_{QCD} \times SU(2)_L \times U(1)_Y$

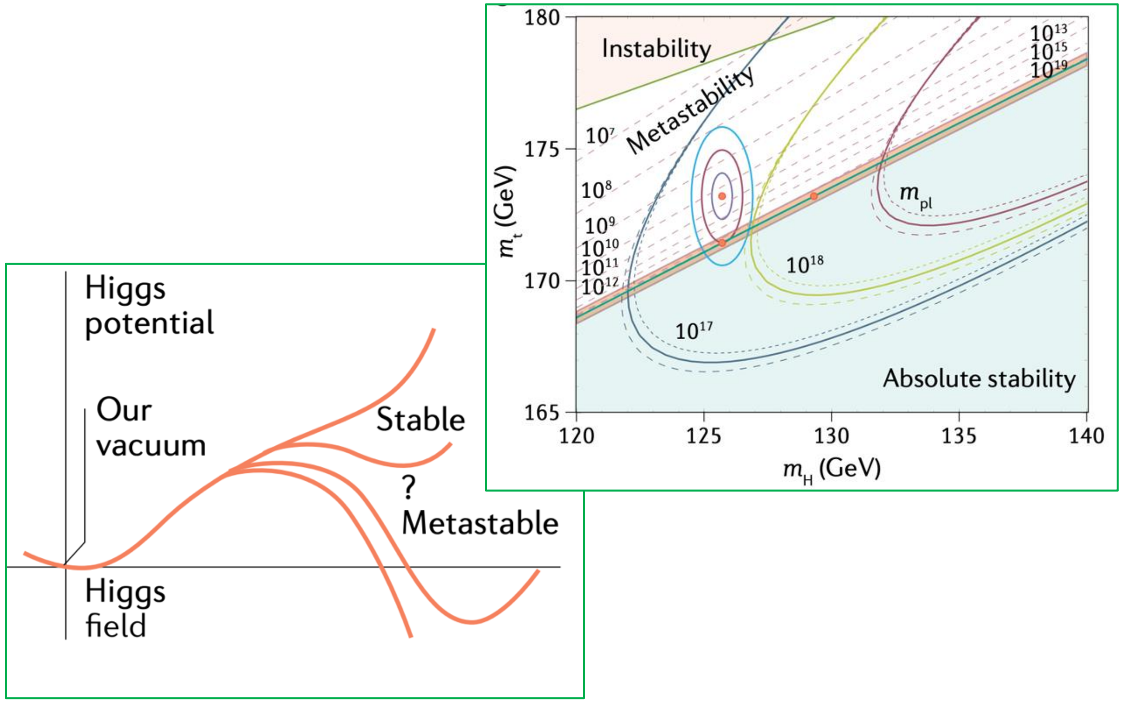


$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + i\bar{\psi}\not{D}\psi + \psi_i y_{ij}\psi_j\phi + h.c. + |D_\mu\phi|^2 - V(\phi)$$



$$V(\phi) = \frac{1}{2}\mu^2\phi^2 + \frac{1}{4}\lambda\phi^4$$





Nature Reviews Physics volume 3, pages608–624 (2021)

The BEH mechanism and Higgs boson play a central role in the SM: Spontaneous EW symmetry breaking via vacuum expectation value → Fermions and boson masses, 16 of the 19 fundamental parameters are related to Higgs boson interactions (masses, flavor)

m_H vs BSM Λ scale (hierarchy problem)

Measure Higgs boson self-interactions → constrain Higgs potential

H → Zγ from CMS

Andrzej Novak

Rare decay loop-suppressed in the SM with BR=$1.5\text{x}10^{-3}$ →

Sensitive to BSM effects

Intriguing ATLAS+CMS in Run 2: $\mu(\sigma/\sigma_{SM})=2.2\pm0.7$ (Obs./Exp.

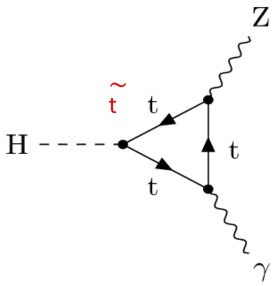
Significance 3.4/1.6s - about 2s above SM prediction) [Phys. Rev. Lett. 132 (2024) 021803]

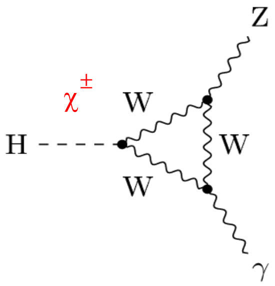
ATLAS updated the results adding 2022-2024 data: Combined

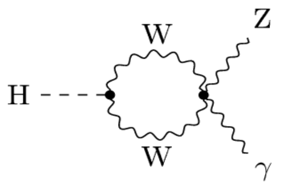
Run2+Run3: $\mu=1.3^{+0.6}_{-0.5}$ significance 2.5σ (exp. SM 1.9σ)

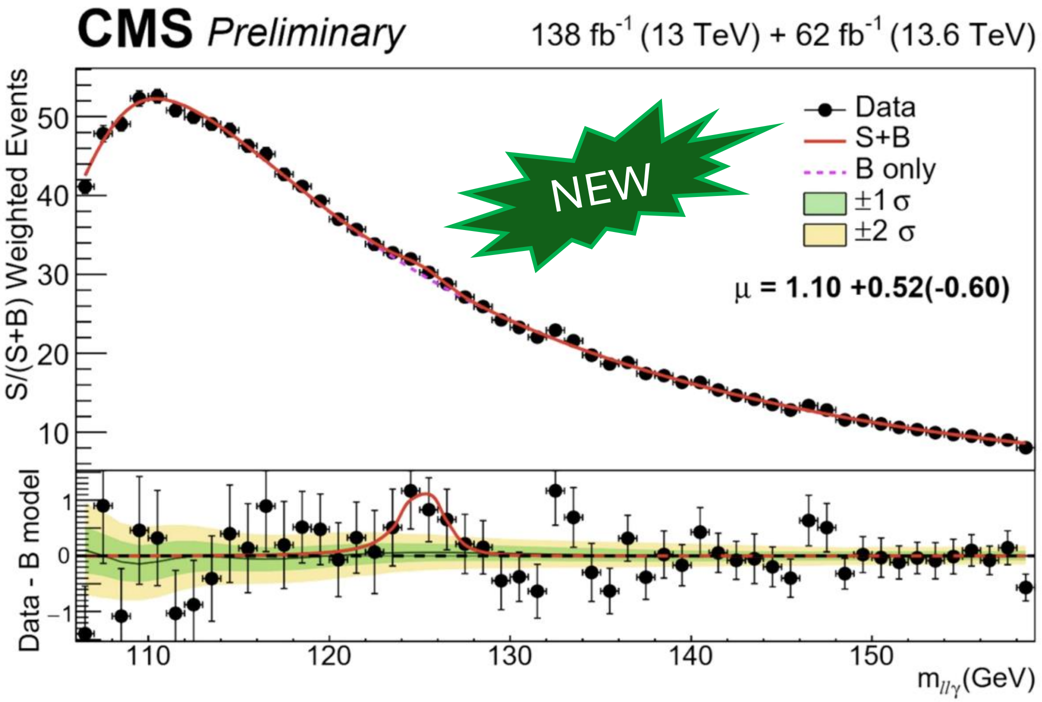
NEW CMS reanalysis of Run 2 + 2022-2023 Data: improved strategy (13 categories) and improved trigger:

Run2+Run3: $\mu=1.10^{+0.52}_{-0.61}$ significance 1.9σ (exp. SM **2.3σ**)



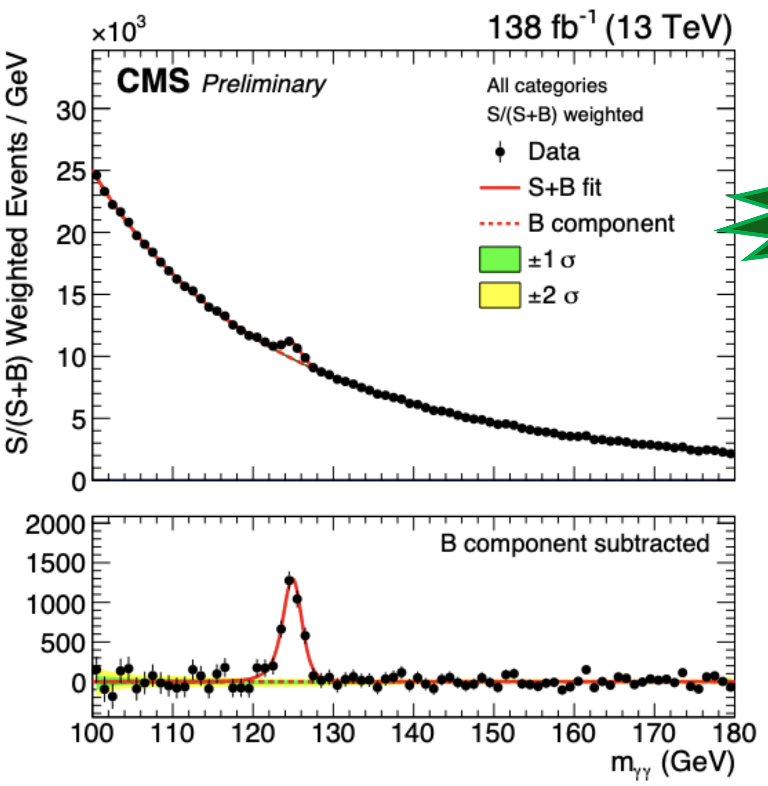




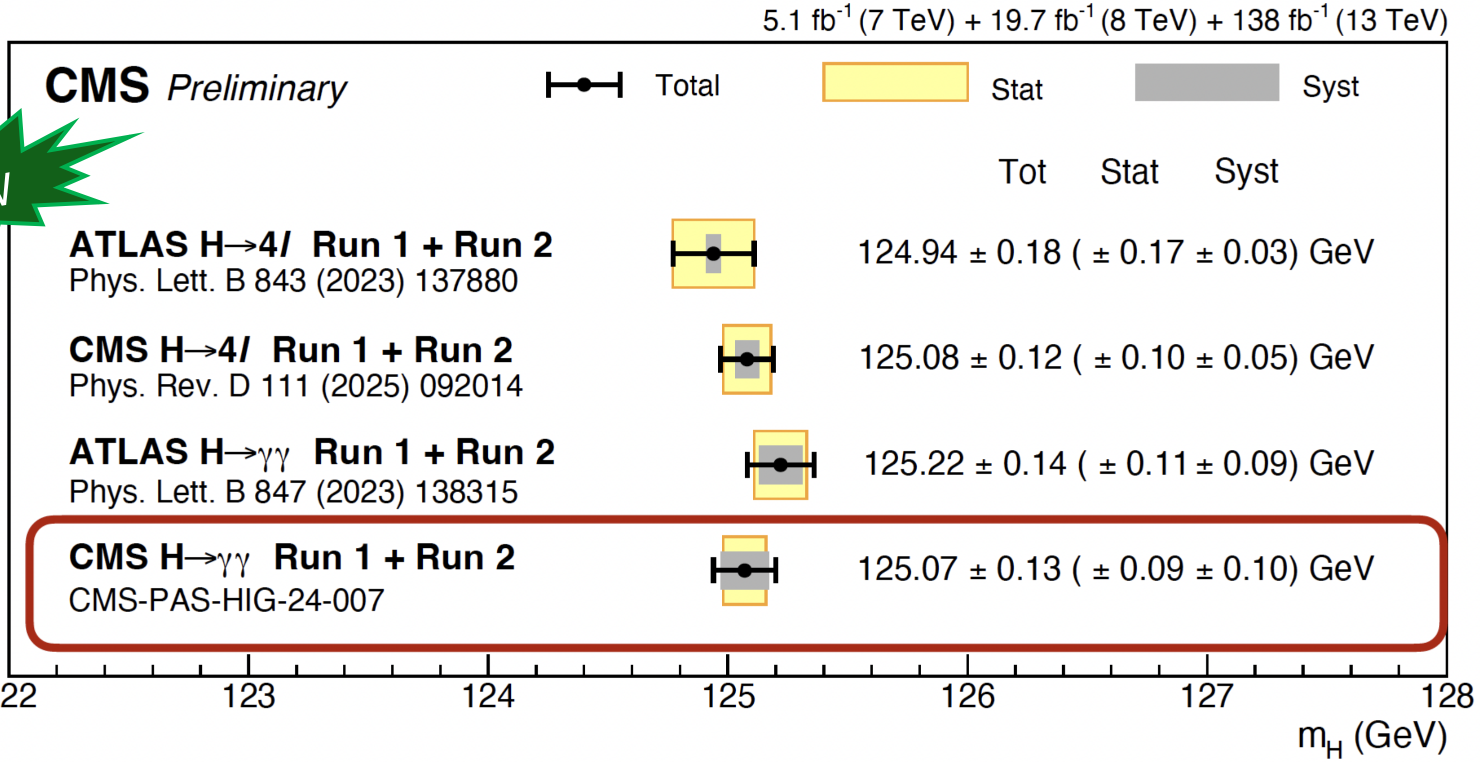


$H \rightarrow \gamma\gamma$ mass

Gaetano Barone



NEW



The Higgs boson mass is a fundamental parameter of the SM (last to be measured)

$H \rightarrow \gamma\gamma$ is very challenging at LHC due to difficulty to calibrate γ E-scale at the LHC

CMS performed an improved calibration of Run2 γ E–scale (adding $Z \rightarrow \mu\mu\gamma$) → Hard work paid off:

NEW Run 2 ***mH* = 125.14 ± 0.10 (stat) ± 0.11 (syst) GeV**

Very consistent set of measurement → next LHC combination will have a precision **~70 MeV**

High-momentum inclusive H→bb

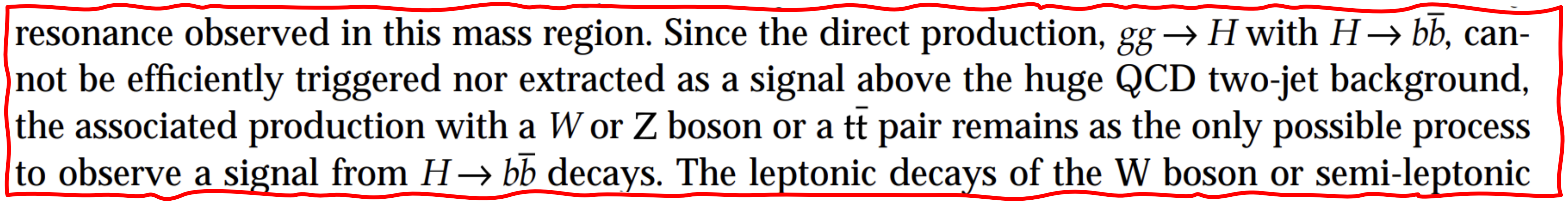
Gaetano Barone

The high pTH regime is very sensitive to BSM physics

gg→H→bb largest σxBR allow to explore extremely boosted production

Considered “impossible” at LHC due to **huge QCD bkg**.

ATLAS Physics TDR May 1995



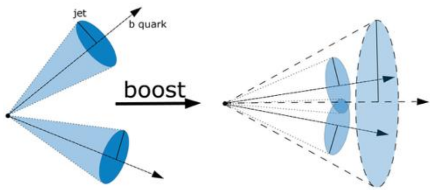
resonance observed in this mass region. Since the direct production, $gg \rightarrow H$ with $H \rightarrow b\bar{b}$, cannot be efficiently triggered nor extracted as a signal above the huge QCD two-jet background, the associated production with a W or Z boson or a $t\bar{t}$ pair remains as the only possible process to observe a signal from $H \rightarrow b\bar{b}$ decays. The leptonic decays of the W boson or semi-leptonic

High-momentum H→bb

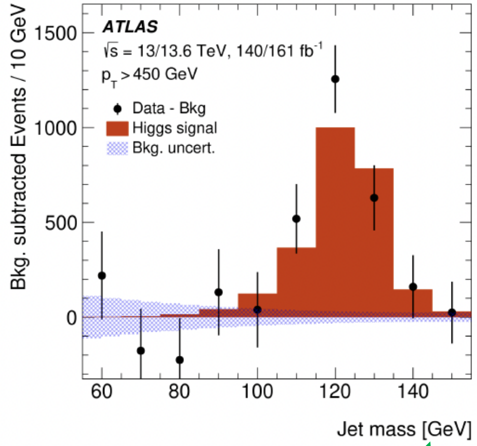
Gaetano Barone

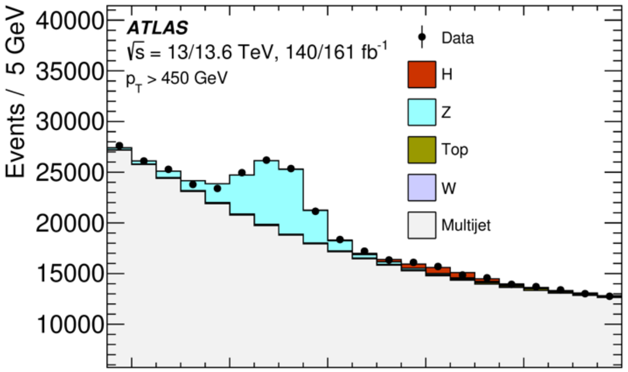
- Exploring high-energy dynamics differentially
  - Boosted bb with Run-2 and Run-3 data, exploring the high p_T^H region
  - Evidence with 3.8 σ for $p_T^H > 450$ GeV,
  - with μ of 1.53 ± 0.27 (stat.) $^{+0.33}_{-0.27}$ (syst.) ± 0.17 (theo.)
  - Improvement of a factor of 10 with respect to previous Run-2 result

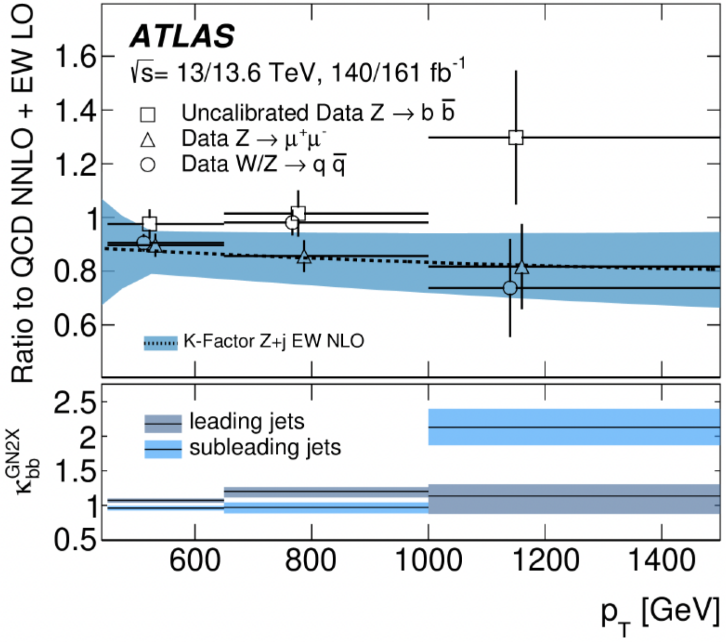
Evidence 3.8σ for inclusive H→ bb pT^H>450 GeV
Measured xs in agreement with SM predictions

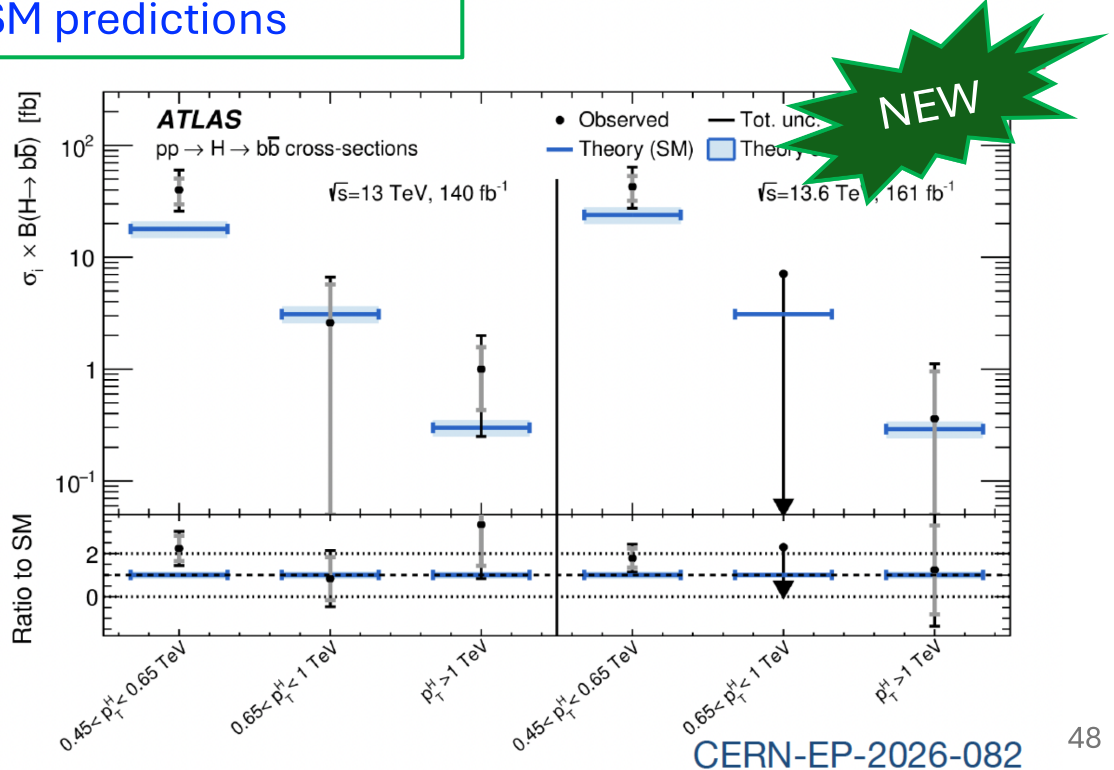


New **GNN based tagger** for large R-jets (H→bb)





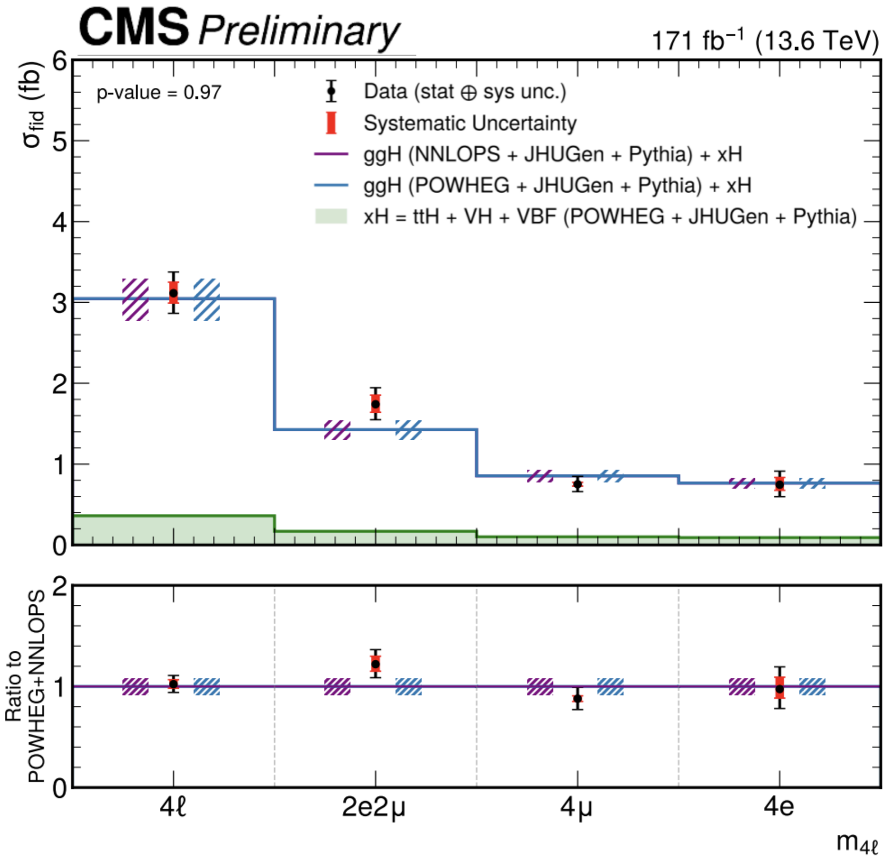




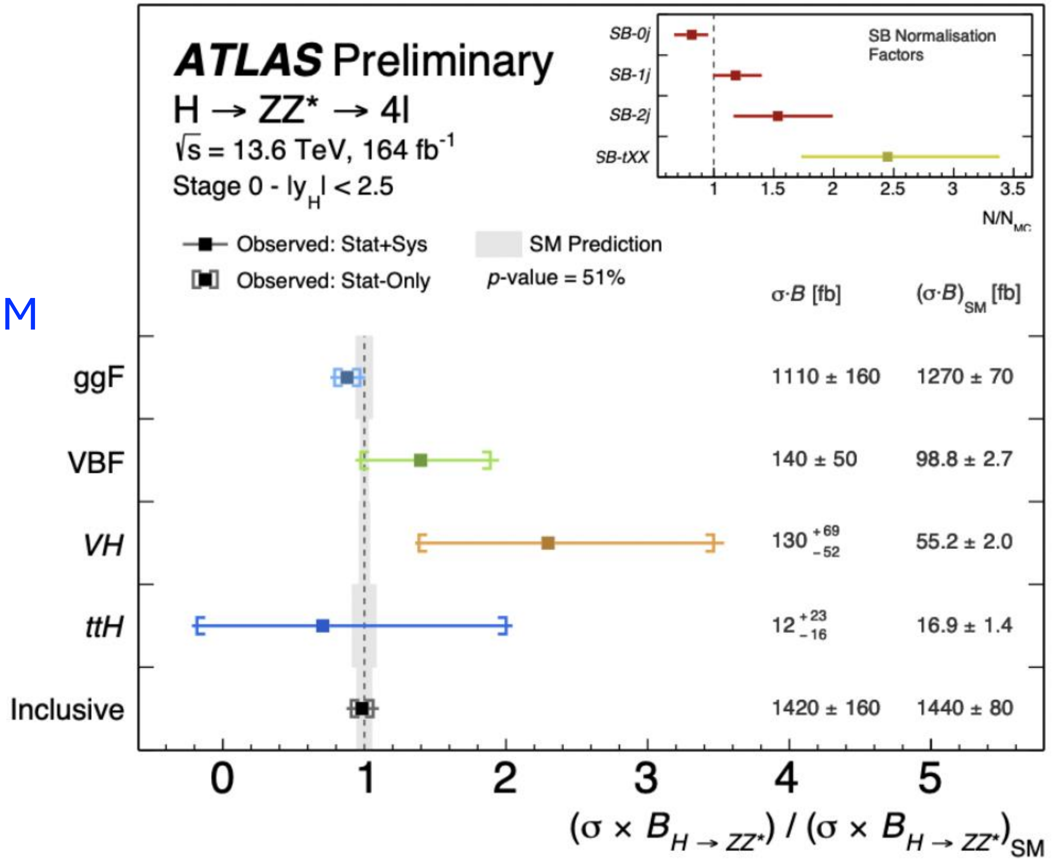
CERN-EP-2026-082

$H \rightarrow ZZ^* \rightarrow 4\ell$

Martina Manoni and Lailin Xu



All in agreement with SM



Both ATLAS and CMS analyzed **Run 3** data **2022-2024** ~**160-170 fb-1**

CMS Fiducial, differential

ATLAS Fiducial, Differential, STXS

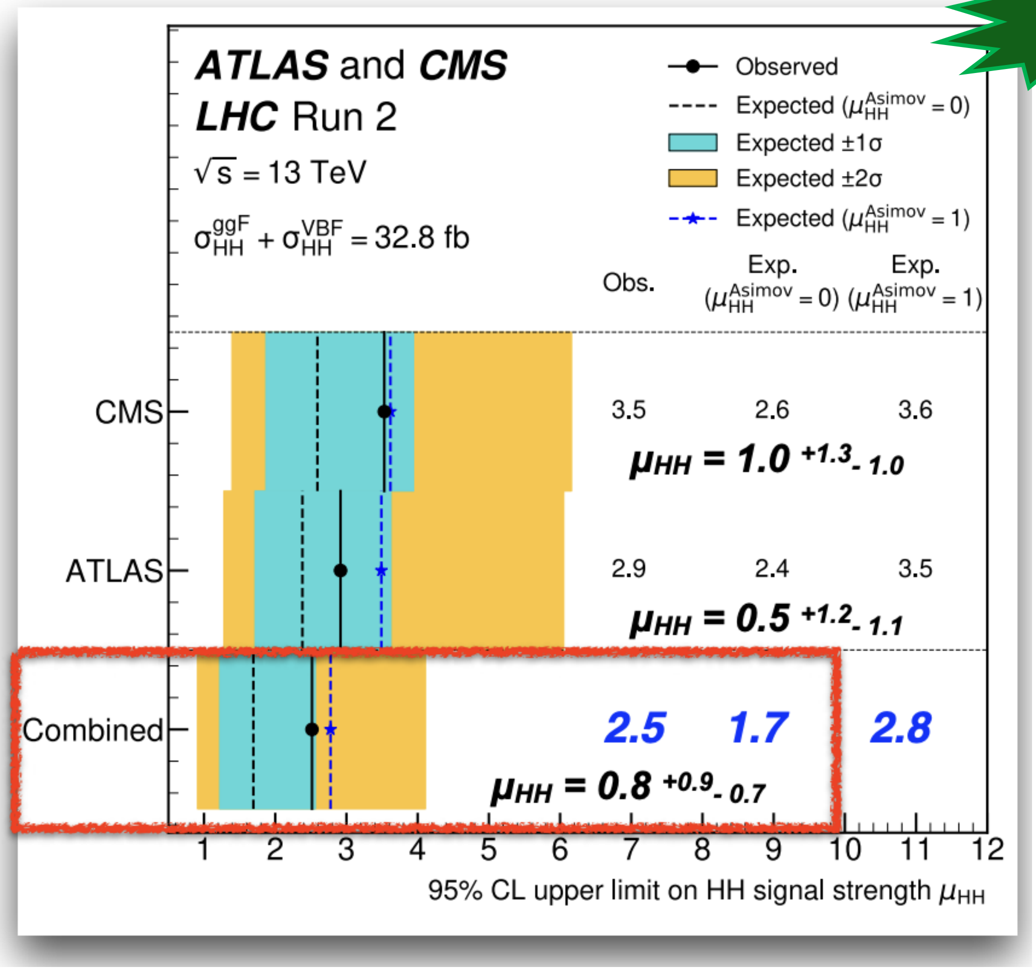
HH production

Valerio Dao

- ***Statistical combination of Run 2 results:***
  - equalising signal predictions among experiments [Powheg as main MC]
  - understanding correlated uncertainty source: *HH XS* (leading contribution), Higgs Br, single H background XS, ggH+HF
  - reproducing results with each-others frameworks
- ***Assuming SM HH prediction:***
  - **best limit on HH XS**: 30% improvement over single experiment results
  - significance: ***1.1** (1.3) **σ obs.** (exp.) ******
  - still statistically limited

CERN-EP-2026-011 (submitted to PRL)

NEW

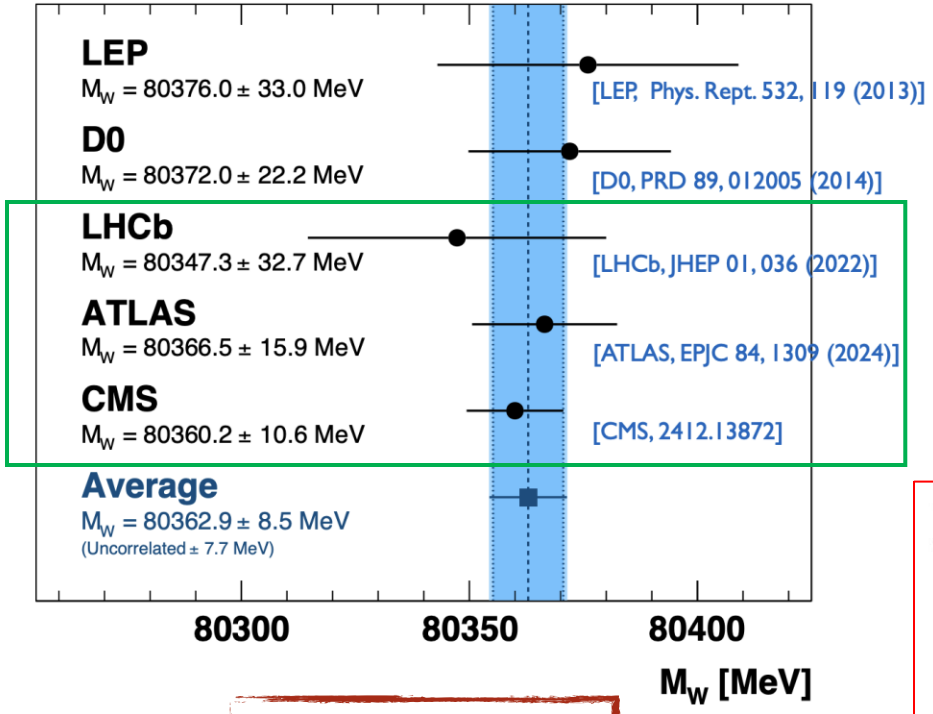


Legacy Run 2 ATLAS+CMS reach better than **1σ sensitivity** for HH production

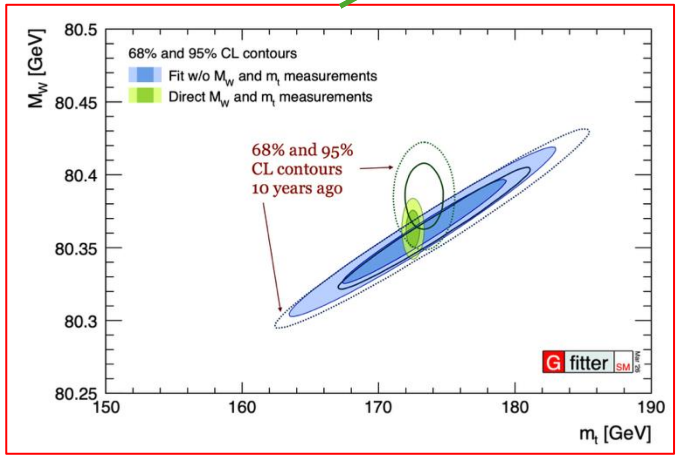
Summary of BEH

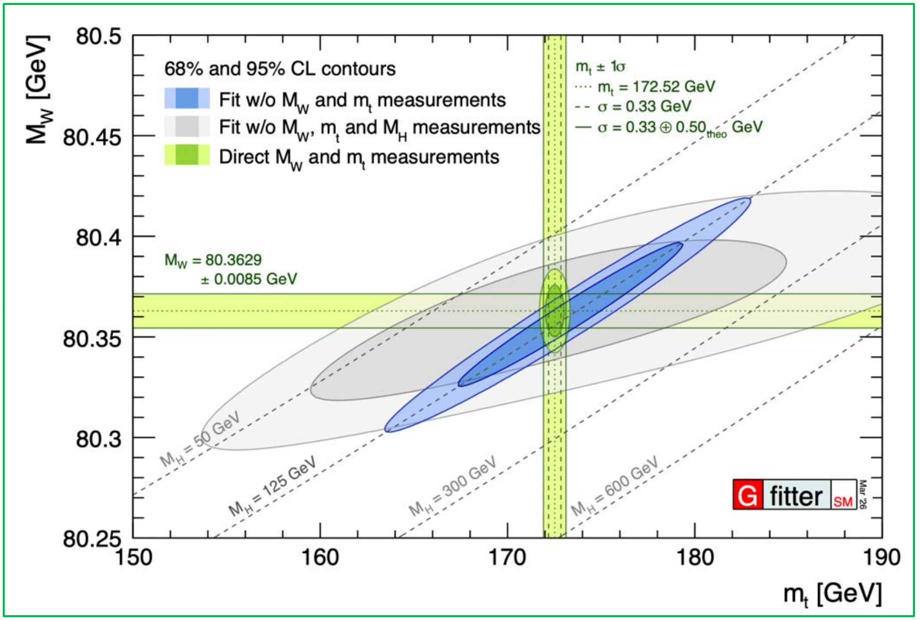
- Couplings, steady improvements: now H->ZZ*->4l below 10% precision with 1/2 Run 3 data! Looking at corner of phase space BSM sensitive
- HH provides portal to Higgs potential: legacy ATLAS+CMS Run 2 sensitivity at 1σ level! Run 3 combined ATLAS+CMS could reach “evidence”!
- CP violation: up to now no sign of CP violation in H interactions
- Rare decays are now accessible: excess on H→Zγ not confirmed, H→μμ will probably be **observed** (if SM-like) in Run 3
- HL-LHC will provides strong tests of SM Higgs sector, coupings at % level, 3σ on Higgs boson self couplings, 2nd F generation, CP violation studies, ...

EW and top-quark physics



Precision on m_W:
15 MeV (2015)
8.5 MeV (today)





Roman Kogler

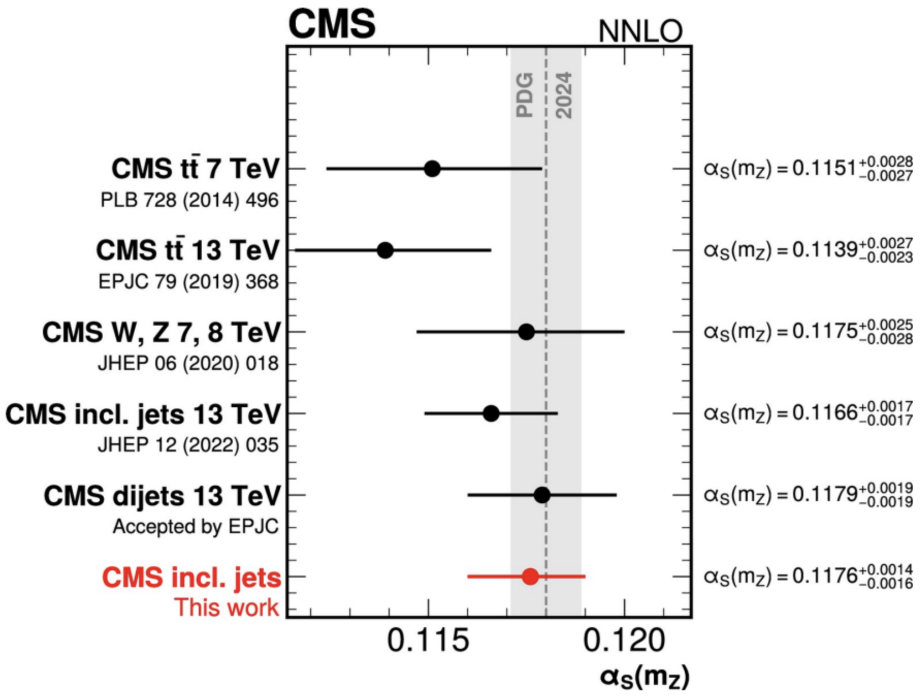
Incredible impact of LHC measurement on EW precision observable and top-quark physics

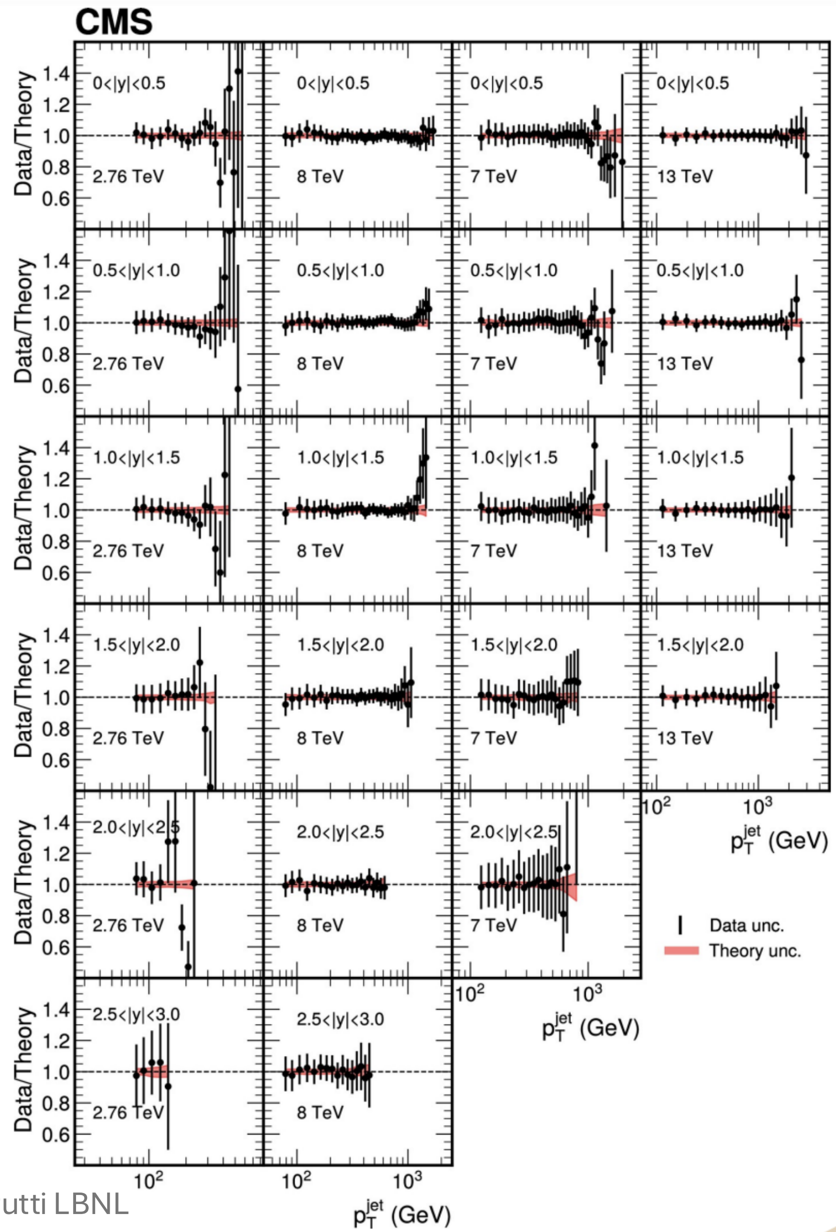
α_s from di-jet cross-section CMS

Stefano Camarda

- Combined QCD analysis of inclusive jet cross sections at 2.76, 7, 8, 13 TeV and HERA DIS data at NNLO
- $\alpha_s(m_Z) = 0.1176 \pm 0.0015$

PDG WA 2025: $\alpha_s(m_Z^2) = 0.1178 \pm 0.0010$

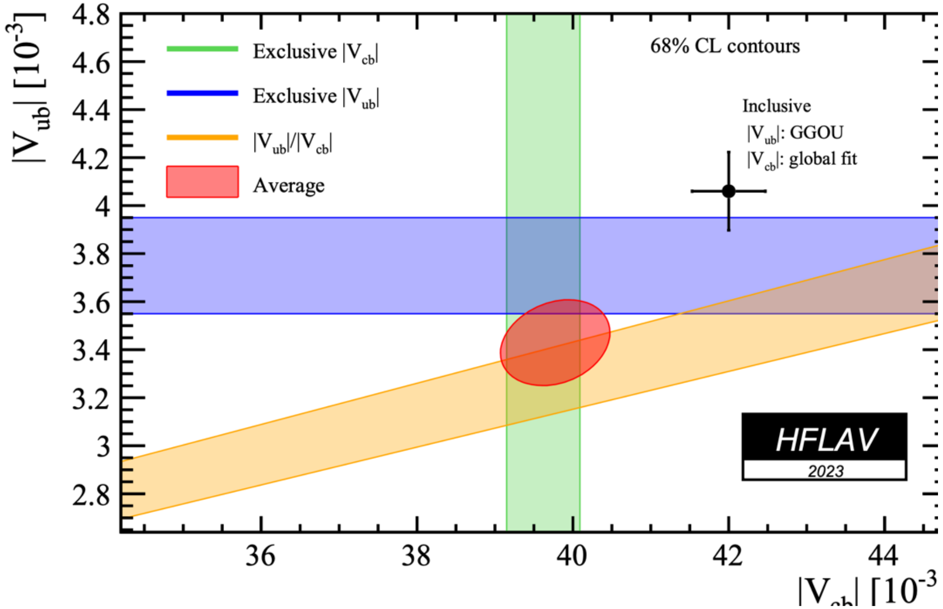




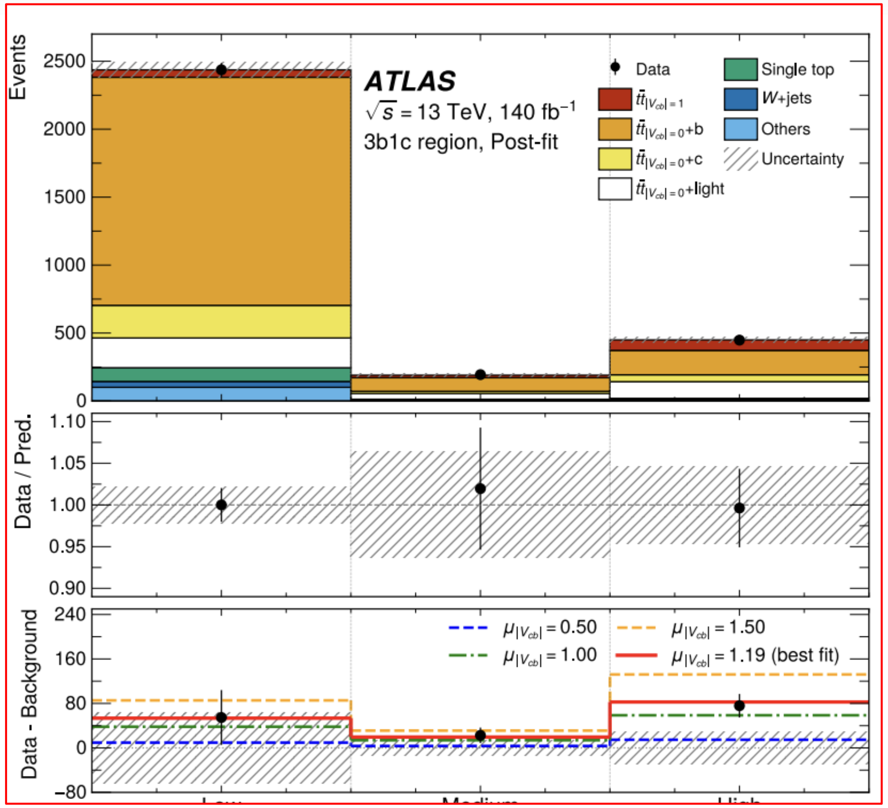
Measurement of |Vcb| from top decays

Adam Warnerbring

arxiv:2411.18639



$$|V_{cb}|_{\text{world avg.}} = (41.1 \pm 1.2) \times 10^{-3}$$



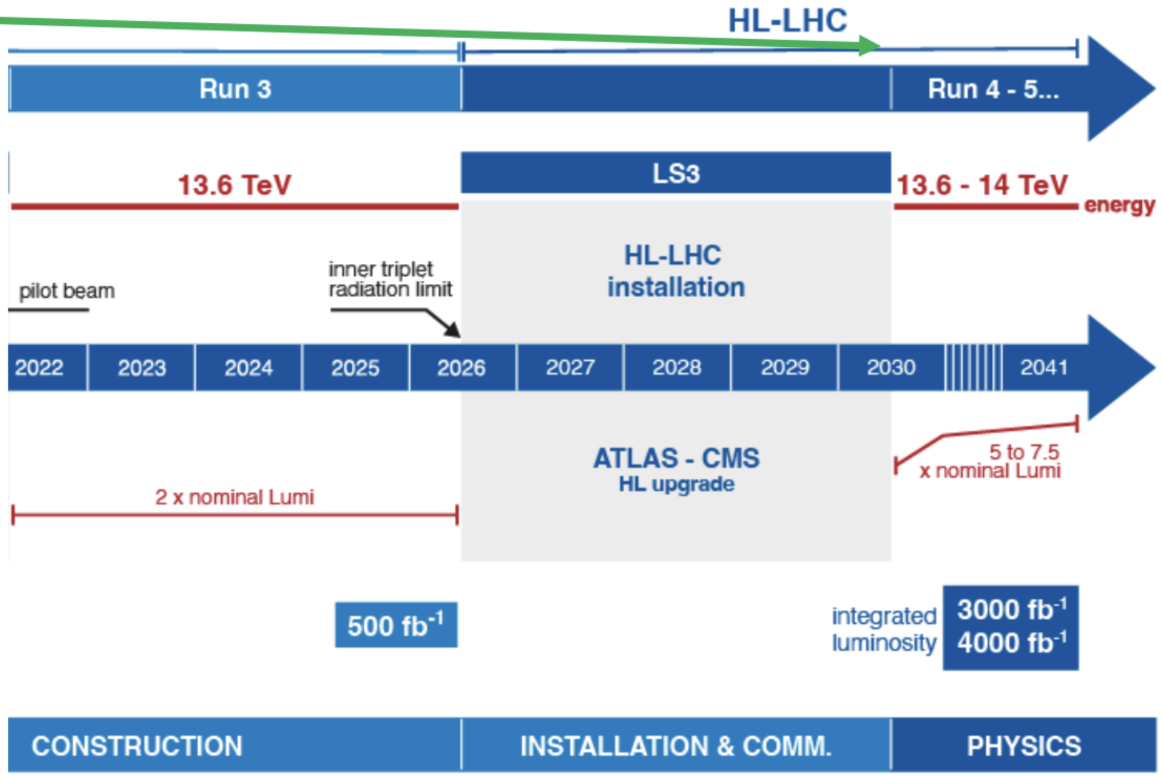
$$V_{cb}| = \left(50^{+11}_{-14}\right) \times 10^{-3} = \left(50^{+7}_{-9}\ \text{(stat.)}\ {}^{+9}_{-10}\ \text{(syst.)}\right) \times 10^{-3}$$

- First analysis using on-shell W decays $|V_{cb}|^2 = \dfrac{\mathscr{B}(W \to cb)}{\mathscr{B}(W \to cq)} = \dfrac{\mathscr{B}(t\bar{t} \to b\,cb, b\,\ell\nu)}{\mathscr{B}(t\bar{t} \to b\,cq, b\,\ell\nu)}$
- Select tt-> W(cb) b W(l nu) b and train a NN to distinguish events containing W->cb, simultaneous fit to tt+c and tt+b

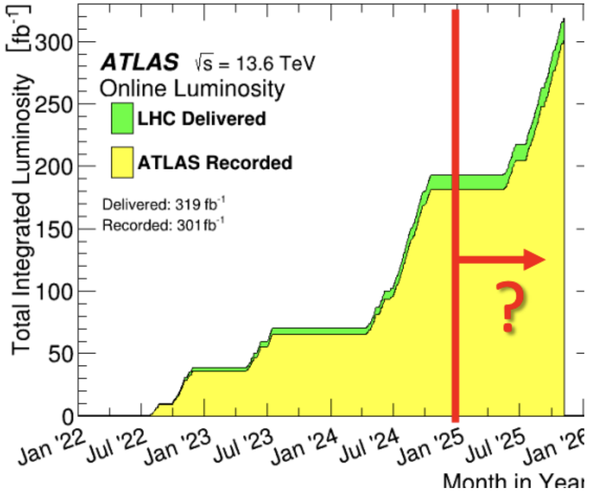
Prospects (HL-)LHC …

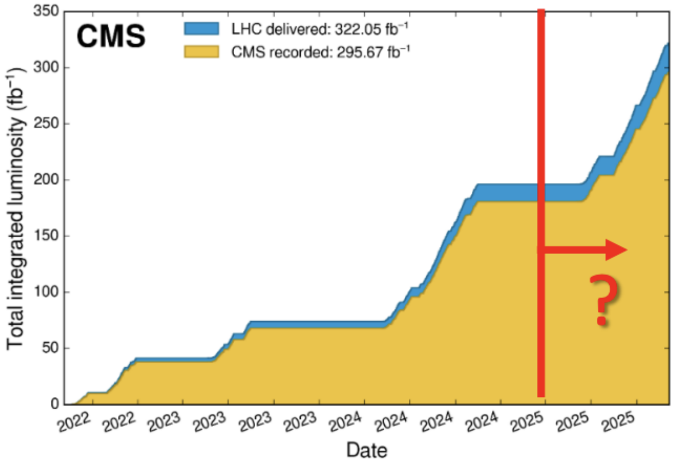
Suzanne Gascon-Shotkin

- Hope for ~350fb^{-1} ➔ ~50% (>=2025) largely unexplored for the moment!
- HL-LHC starts ~2030, expect 3ab^{-1}
- Overall, still plenty of discovery potential at LHC!



https://twiki.cern.ch/twiki/bin/view/CMSPublic/LumiPublicResults#Multi_year_summary_proton_proton





Run 3 → ~double Run 2 (and 13 → 13.6 TeV)
HL-LHC → goal 3ab^{-1} good for physics ~20 time Run 2!

Summary of the summary …

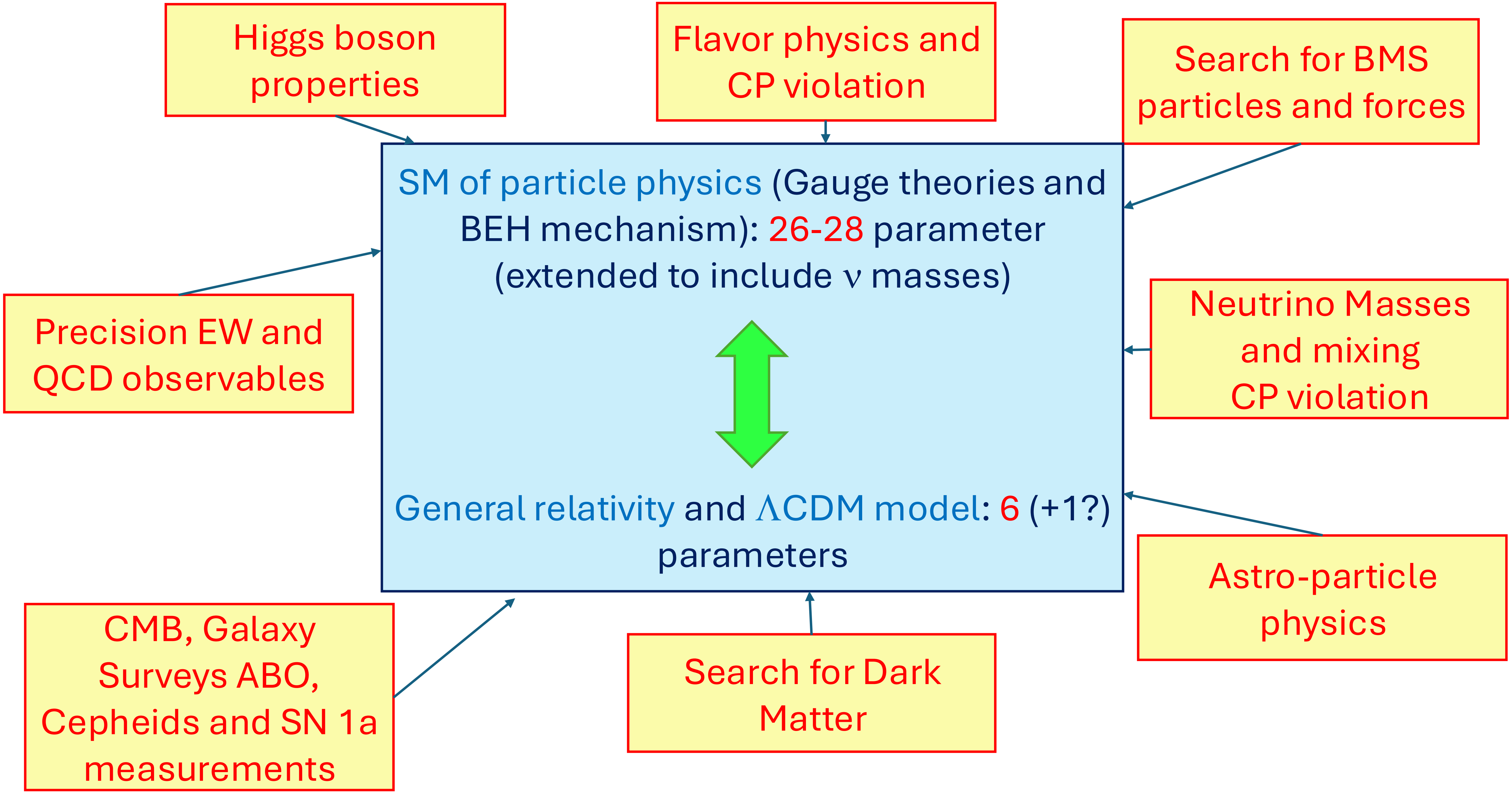
- Progresses are slow due to the complexity of the experimental challenges but **STEADY**: many new results show sizeable improvements
- We have a **comprehensive** and **ambitious experimental program** designed to address the still pending **fundamental questions** in particle physics
- I’ve been **impressed** by the **Young Scientists talks**, good sign for our field since the **future of HEP is in their hands**!
- The future **looks bright** thanks to the existing and future experimental facilities

Thank you to all the people involved in the organization of this wonderful conference (personal remark: this is by far my preferred HEP conference)!

Many discoveries and outstanding achievements in HEP presented in the last 60 years in this conference: see presentations at 60th Annyversary celebration

I wish you another 60 years of big discoveries and success!

Backup



Higgs boson properties

Flavor physics and CP violation

Search for BMS particles and forces

Precision EW and QCD observables

SM of particle physics (Gauge theories and BEH mechanism): 26-28 parameter (extended to include ν masses)

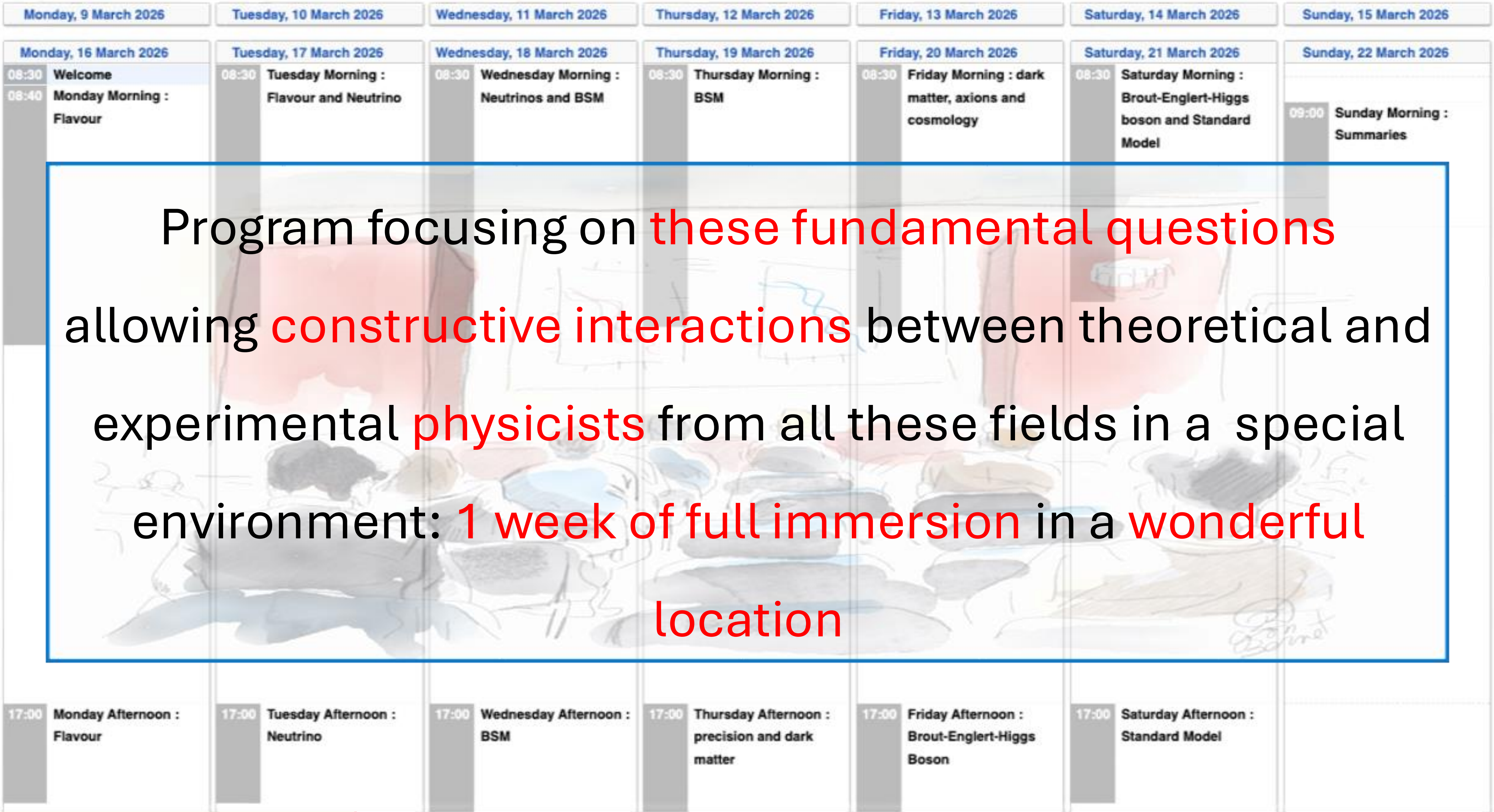
General relativity and ΛCDM model: 6 (+1?) parameters

Neutrino Masses and mixing CP violation

Astro-particle physics

CMB, Galaxy Surveys ABO, Cepheids and SN 1a measurements

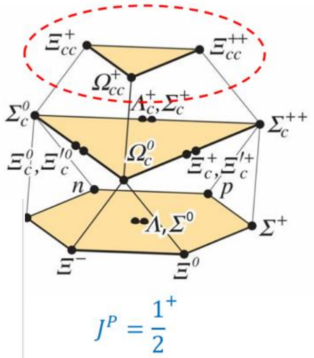
Search for Dark Matter



Monday, 9 March 2026	Tuesday, 10 March 2026	Wednesday, 11 March 2026	Thursday, 12 March 2026	Friday, 13 March 2026	Saturday, 14 March 2026	Sunday, 15 March 2026
Monday, 16 March 2026	Tuesday, 17 March 2026	Wednesday, 18 March 2026	Thursday, 19 March 2026	Friday, 20 March 2026	Saturday, 21 March 2026	Sunday, 22 March 2026
08:30 Welcome 08:40 Monday Morning : Flavour	08:30 Tuesday Morning : Flavour and Neutrino	08:30 Wednesday Morning : Neutrinos and BSM	08:30 Thursday Morning : BSM	08:30 Friday Morning : dark matter, axions and cosmology	08:30 Saturday Morning : Brout-Englert-Higgs boson and Standard Model	09:00 Sunday Morning : Summaries
17:00 Monday Afternoon : Flavour	17:00 Tuesday Afternoon : Neutrino	17:00 Wednesday Afternoon : BSM	17:00 Thursday Afternoon : precision and dark matter	17:00 Friday Afternoon : Brout-Englert-Higgs Boson	17:00 Saturday Afternoon : Standard Model	

Program focusing on these fundamental questions allowing constructive interactions between theoretical and experimental physicists from all these fields in a special environment: 1 week of full immersion in a wonderful location

A new 2-Charmed hadron Ξ^+_{cc} at LHCb



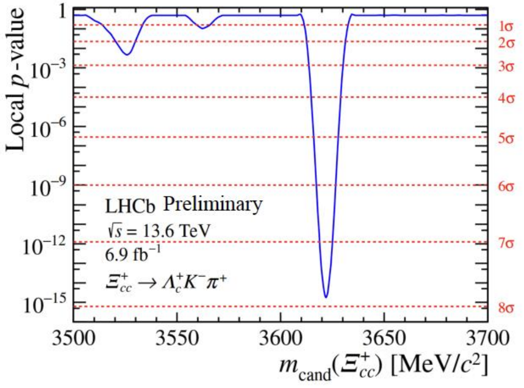
Summary

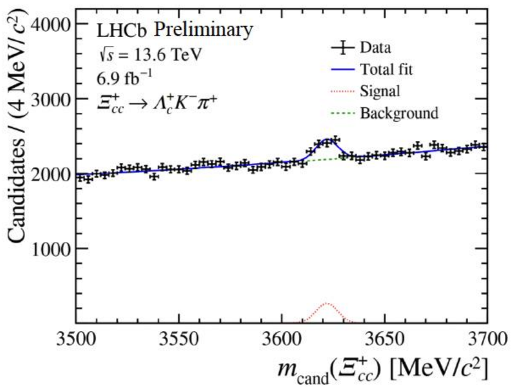
Shuyu Han

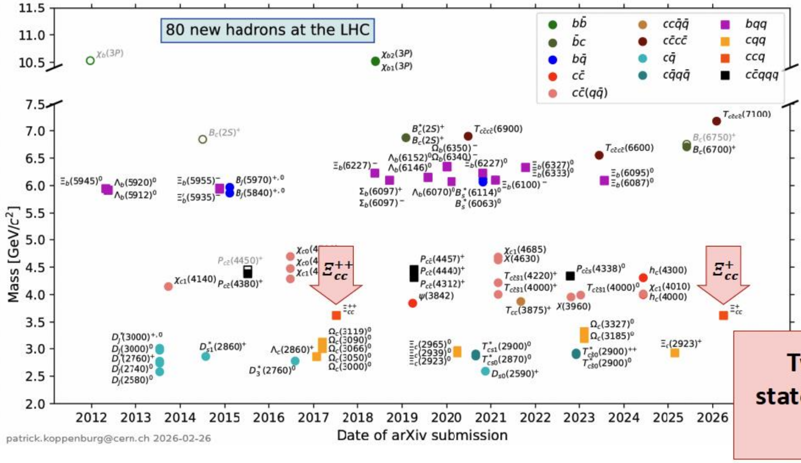
[LHCb-PAPER-2026-009, in preparation]

- Thanks to the enhanced capabilities of the **upgraded LHCb detector** and trigger system, **efficiency of hadronic final states increased** by a factor of 2-4.
- $\boldsymbol{\Xi^{++}_{cc}}$: with a factor of 4 signal yield per fb^{-1} of data, compared with Run 2.
- **$\boldsymbol{\Xi^{+}_{cc}}$: first new particle observed with the upgraded LHCb detector.**
  - Local significance larger than 7σ.
  - Ξ^+_{cc} mass: $\boxed{3619.97 \pm 0.83\,(\text{stat}) \pm 0.26\,(\text{syst})^{+1.90}_{-1.30}\,(\text{lifetime})\,\text{MeV}/c^2.}$
  - Mass difference: $\boxed{\Delta M \equiv M(\Xi^+_{cc}) - M(\Xi^{++}_{cc}) = -1.77 \pm 0.84\,(\text{stat}) \pm 0.15\,(\text{syst})^{+1.90}_{-1.30}\,(\text{lifetime})\,\text{MeV}/c^2.}$
    - Consistent with prediction.

NEW





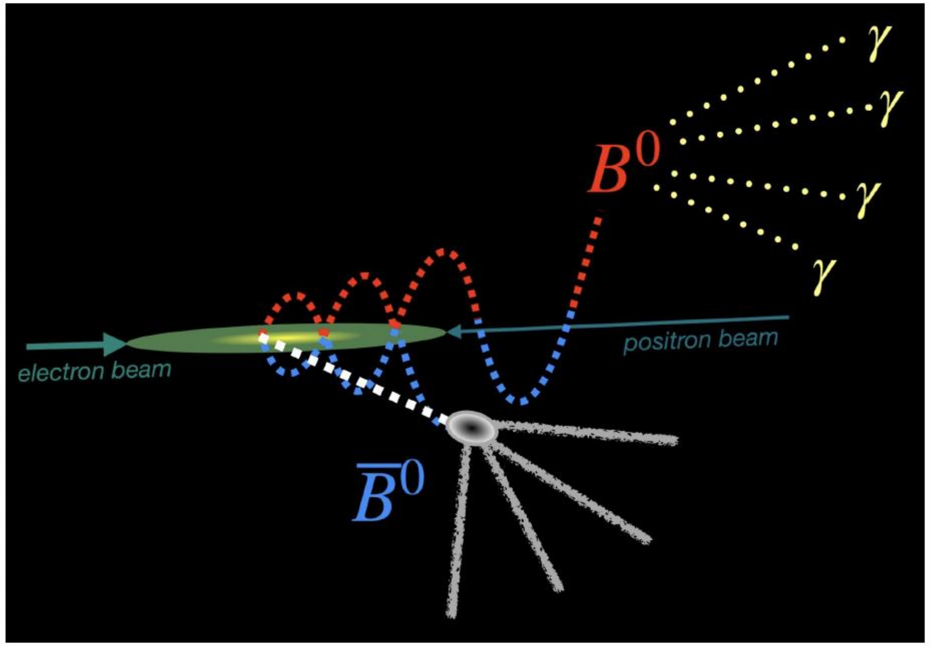


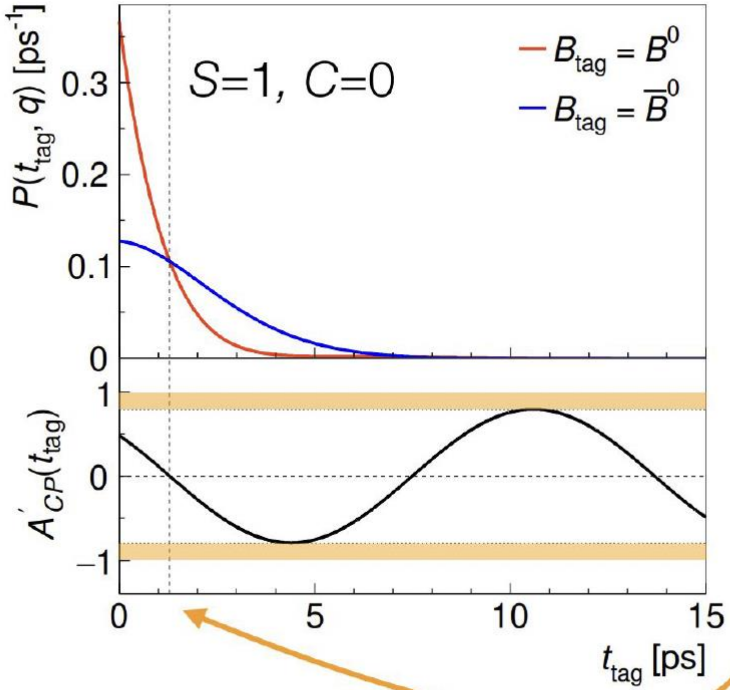
Two weakly decaying states observed at the LHC to date.

CPV in B0 → $\pi^0\pi^0$ at Belle II

Radek Zlebcik

Thanks to $B^0\bar{B}^0$ quantum entanglement, time-dependent flavour asymmetry arises even when measuring a single decay time, such as the tag-B meson decay time t_{tag}, instead of $\Delta t = t_{CP} - t_{tag}$ Phys.Rev.D 112 (2025) 3





$$\mathcal{A}'_{CP}(t_{\text{tag}}) = S'\sin\Delta m(t_{\text{tag}} - t_0) - C'\cos\Delta m(t_{\text{tag}} - t_0)$$

$$S' = -\frac{S}{\sqrt{1+(\tau\Delta m)^2}} \approx \mathbf{-0.8}\ \boldsymbol{S}$$

$$C' = \frac{C}{\sqrt{1+(\tau\Delta m)^2}} \approx \mathbf{0.8}\ \boldsymbol{C}$$

$$t_0 = \frac{1}{\Delta m}\arctan(\Delta m\tau) \approx \mathbf{1.3\ ps}$$

- New approach based on the time decay measurement on only tag side t_{tag}
- Since system is entangled at Y(4S) time dependent asymmetry still exist even after integrating on t_{CP}

CPV in B0 → $\pi^0\pi^0$ → α

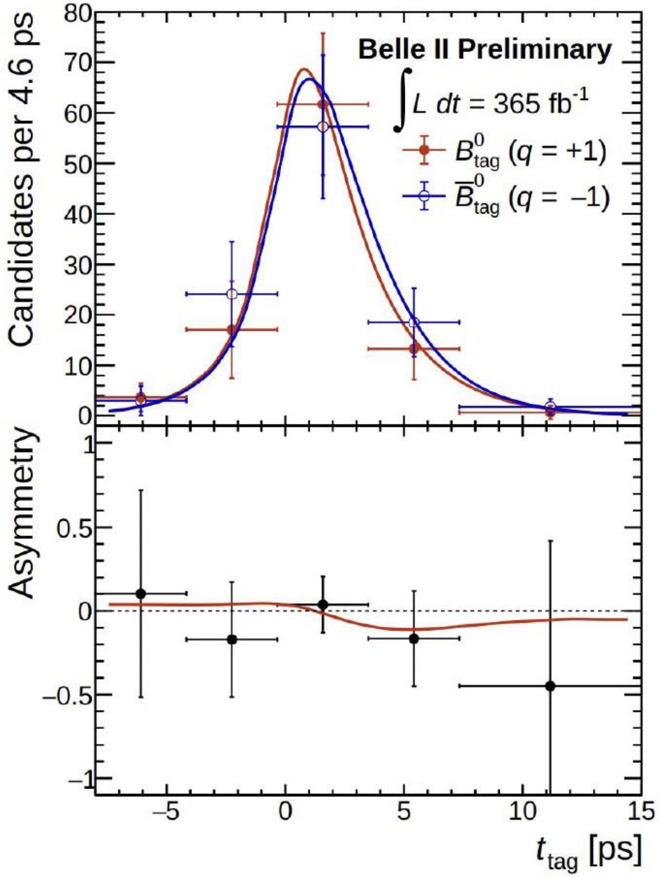
Radek Zlebcik

Results

NEW!

With more precision can reduce 8fold ambiguity in extracting α from B->$\pi\pi$

$$\boxed{\begin{aligned} S_{00} &= 0.61^{+0.75}_{-0.79}\,(\mathrm{stat}) \pm 0.11\,(\mathrm{syst}),\\ C_{00} &= 0.05 \pm 0.28\,(\mathrm{stat}) \pm 0.07\,(\mathrm{syst}). \end{aligned}}$$



Novel approach, along with SKEKB compact interaction region and pixel detector, enable measurement of mixing induced *CP* violation in $B^0 \to \pi^0\pi^0$

Would require 20x more data with conventional approach

Precision limited by sample size. Large margins of improvement

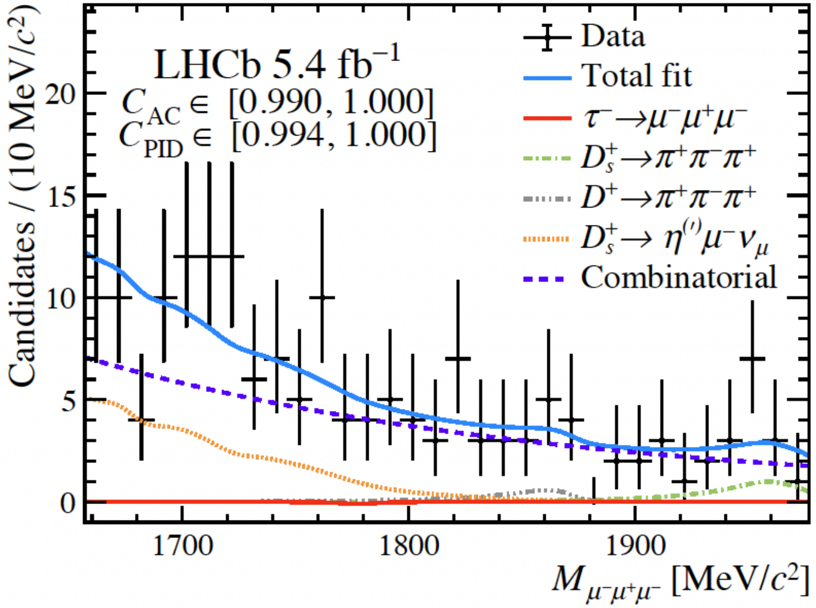
Mixing induced CPV in $B^0 \to \pi^0\,\pi^0$ measured for the first time

LFV at LHCb and Belle II

Hanae Tilquin and Edwin Chow

- Dominant systematic uncertainties due to external factors (such as knowledge of $f^{\tau}_{D_s}$)
- Resulting upper limit similar to that obtained by Belle II

$$\mathcal{B}(\tau^- \to \mu^-\mu^+\mu^-) < 1.9\,(2.3) \times 10^{-8} \text{ @ } 90\% \ (95\%) \text{ CL} \qquad (4)$$



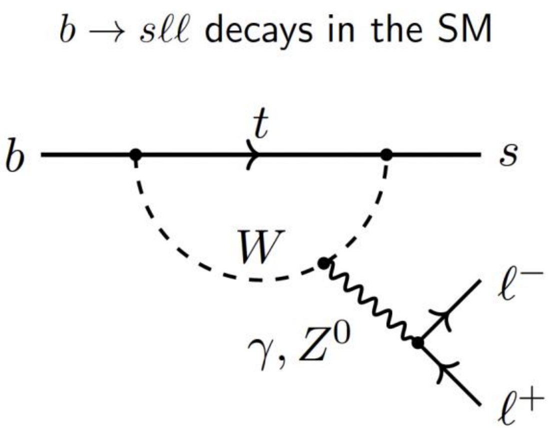
In SM ~ 10^{-55} (via neutrino mixing)

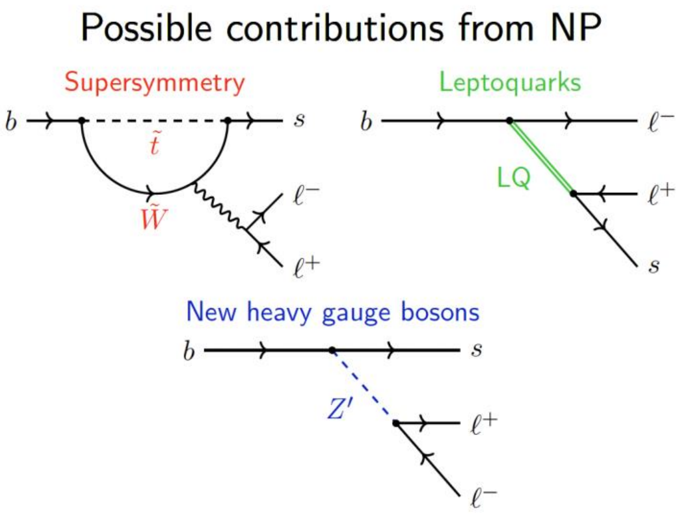
Same result at Belle II $B(\tau \to 3\mu) < 1.0 \times 10^{-8}$ @90% CL
ATLAS presented a NEW results at this conference:
$B(\tau \to 3\mu) < 8.7 \times 10^{-8}$ @90% CL

arxiv:2601.20785

The b → sℓℓ

Christoph Langenbruch



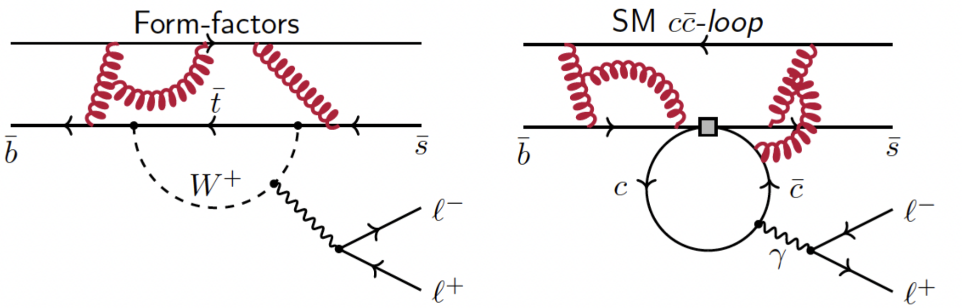


$$\mathcal{H}_{\text{eff}} = -\frac{4G_F}{\sqrt{2}} V_{\text{tb}} V_{\text{ts}}^{*} \frac{e^2}{16\pi^2} \sum_i \boxed{\mathcal{C}_i} \boxed{\mathcal{O}_i}$$

Local operator

Wilson coefficient (“effective coupling”)

Hadronic uncertainties

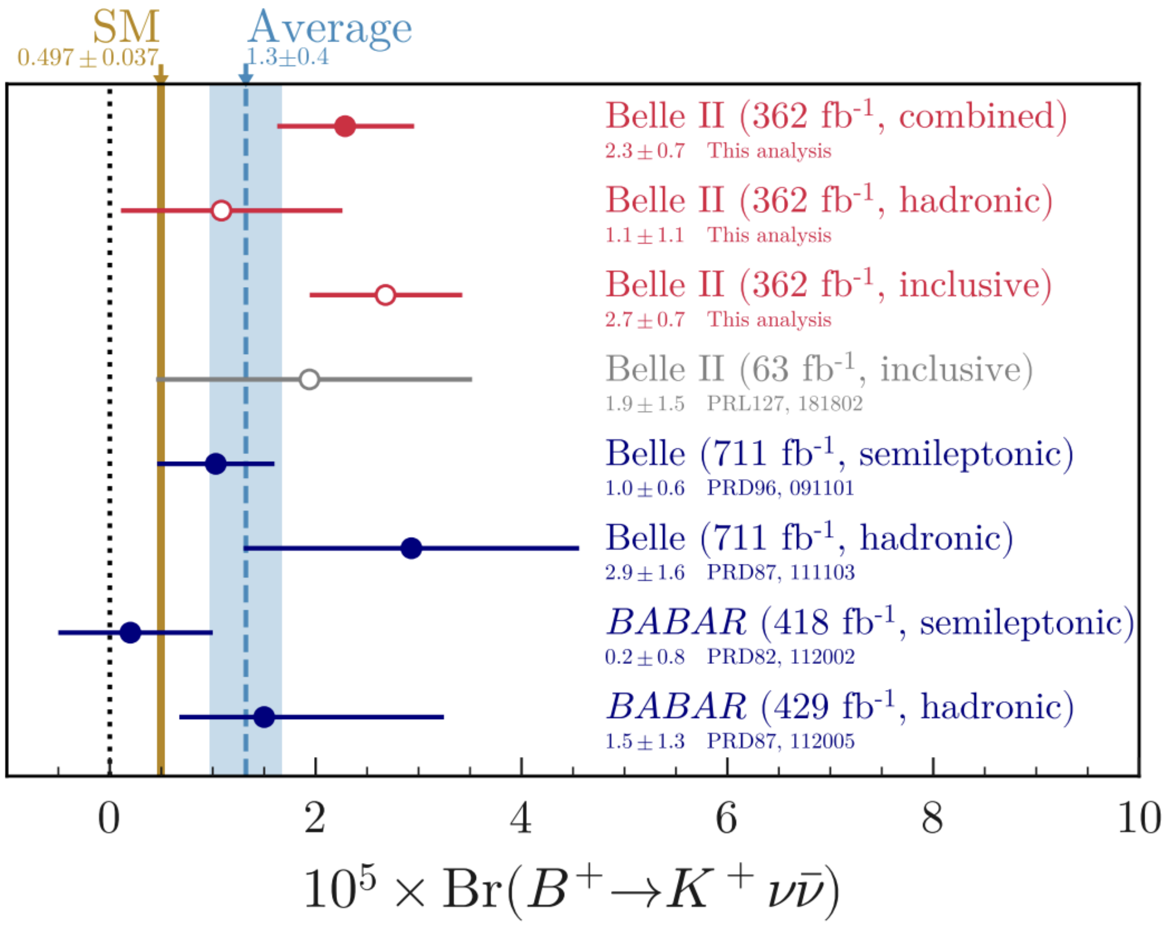


Strongly suppressed in the SM very sensitive to BSM effects

Use model independent approach to study experimental results: major theory uncertainties on the predictions comes from hadronic form factors and charm loops: measure observables with less sensitivity to hadronic uncertainties

b→sνν and b→sττ decays

Meihong Liu



Using hadronic B-tagging, we have..

- Most stringent limit on $B^+ \to K^+\tau^+\tau^-$ decay
- First search and upper limit on $B^0 \to K_S^0\tau^+\tau^-$ decay
- Upper limit on $B^0 \to K^{*0}\tau^+\tau^-$ decay

Additional tagging methods (inclusive and semileptonic tagging) are under investigation to improve efficiency.

- Inclusive+hadronic tagging combined $B^+ \to K^+\nu\bar{\nu}$ result shows 2.7σ tension wrt SM. A model-agnostic likelihood reinterpretation within WET sets constraints on Wilson coefficients.
- Most stringent $B \to X_s\nu\bar{\nu}$ limit using hadronic B-tagging

$R(D^{(*)})$ with hadronic tag

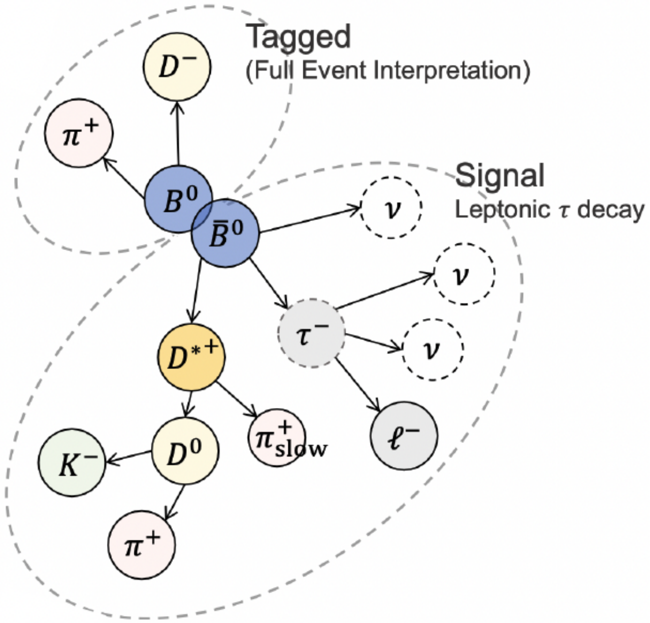
Belle II

To be submitted

Raynette van Tonder

Supersedes previous hadronic tag $R(D^*)$ result by using the full Run 1 dataset:

- Previous Belle II $R(D^*)$ result used only **half of the dataset** (189 fb^{-1}) PRD 110 (2024) 7, 072020
- Identify lepton from $\tau \to \ell\nu\bar{\nu}$
- **Efficiency is maximised** by reconstructing all D^* decay modes and 13 D decay modes
  - $D^{*\pm} \to D^0\pi^\pm, D^\pm\pi^0$
  - $D^{*0} \to D^0\pi^0, D^0\gamma$ ⟵ New mode for this analysis!
- Extend analysis to include $R(D)$



Signal

Normalisation modes

Dominant backgrounds

	D^{*+}	$D^{*}_{[D^0\pi^0]}{}^0$	$D^{*}_{[D^0\gamma]}{}^0$	D^0	D^+
$B \to D^*\tau\nu$	124 ± 10	64 ± 5	107 ± 8	380 ± 30	63 ± 5
$B \to D\tau\nu$	0 ± 0	2 ± 0	32 ± 4	340 ± 43	148 ± 19
$B \to D^*\ell\nu$	2899 ± 66	1417 ± 32	2598 ± 59	10638 ± 235	1624 ± 37
$B \to D\ell\nu$	4 ± 0	7 ± 0	215 ± 7	2882 ± 87	1226 ± 37
$B \to D^{**}\tau/(\ell)\nu$	60 ± 31	29 ± 24	191 ± 58	731 ± 134	294 ± 64
gap modes	21 ± 25	42 ± 15	53 ± 50	240 ± 94	90 ± 46
hadronic B decay	86 ± 25	4 ± 12	166 ± 38	469 ± 95	126 ± 25
continuum	3	2	33	181	84
other backgrounds	0	0	0	1	4
Total	3197	1567	3395	15862	3659

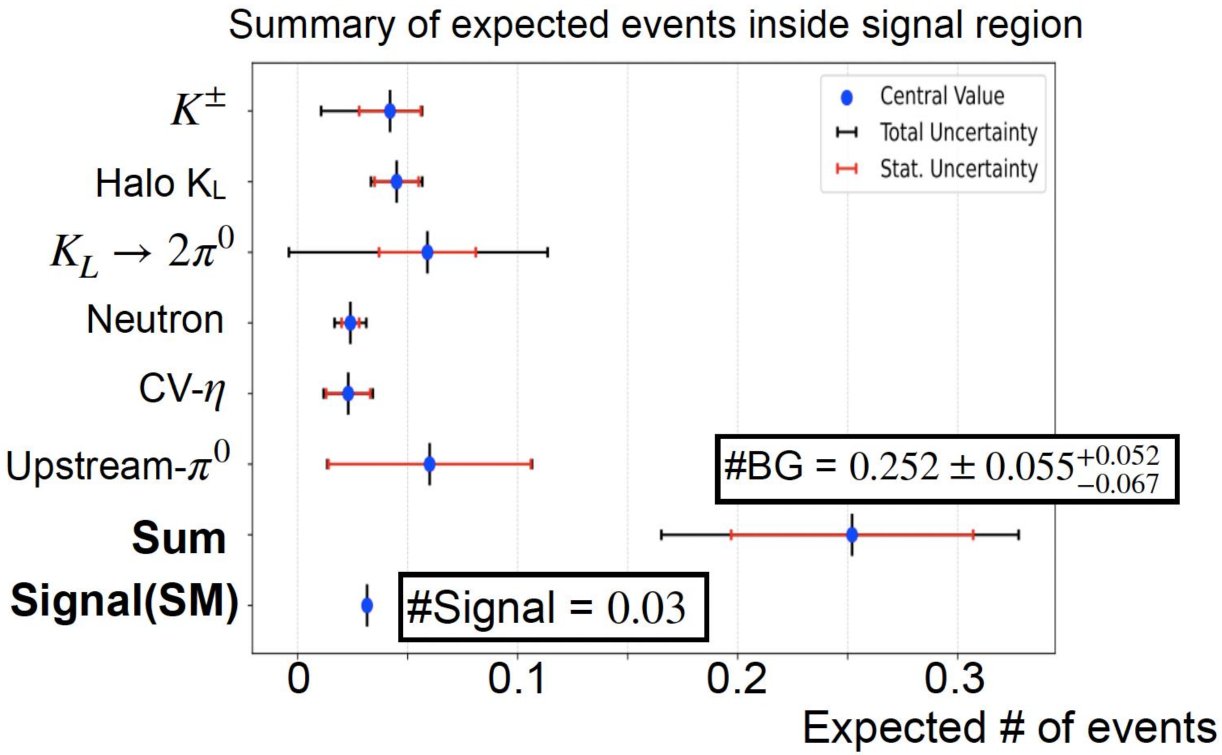
Twice the data!

The $K_L \rightarrow \pi^0\nu\nu$

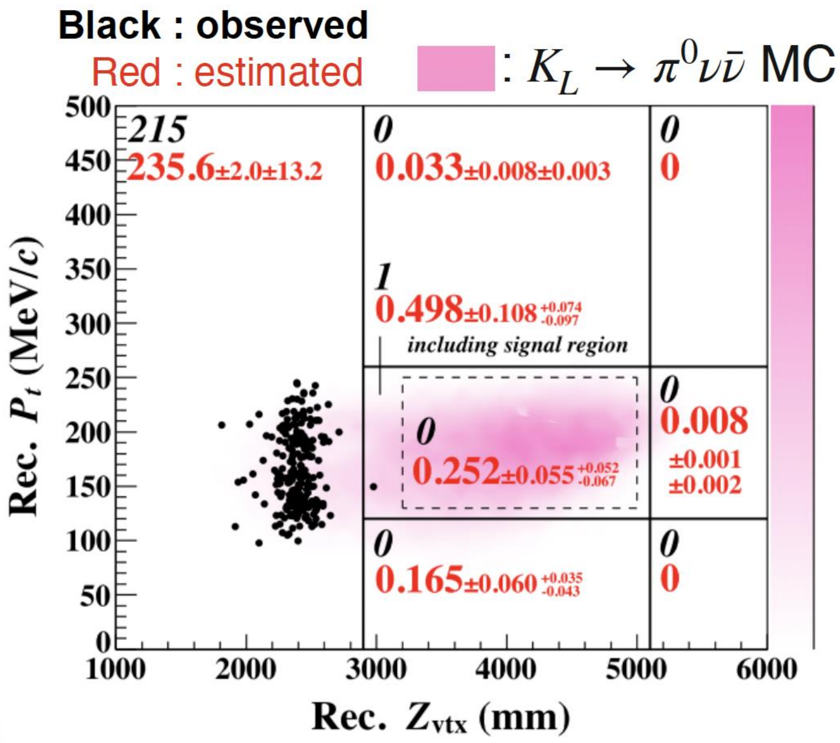
Keita Ono

Single Event Sensitivity (SES) : Branching ratio for which the expected number of observed events is 1

$$\mathrm{SES}_{2021} = (9.33 \pm 0.06_{\mathrm{stat}} \pm 0.84_{\mathrm{sys}}) \times 10^{-10}$$



Summary of expected events inside signal region



- No observed events inside signal region

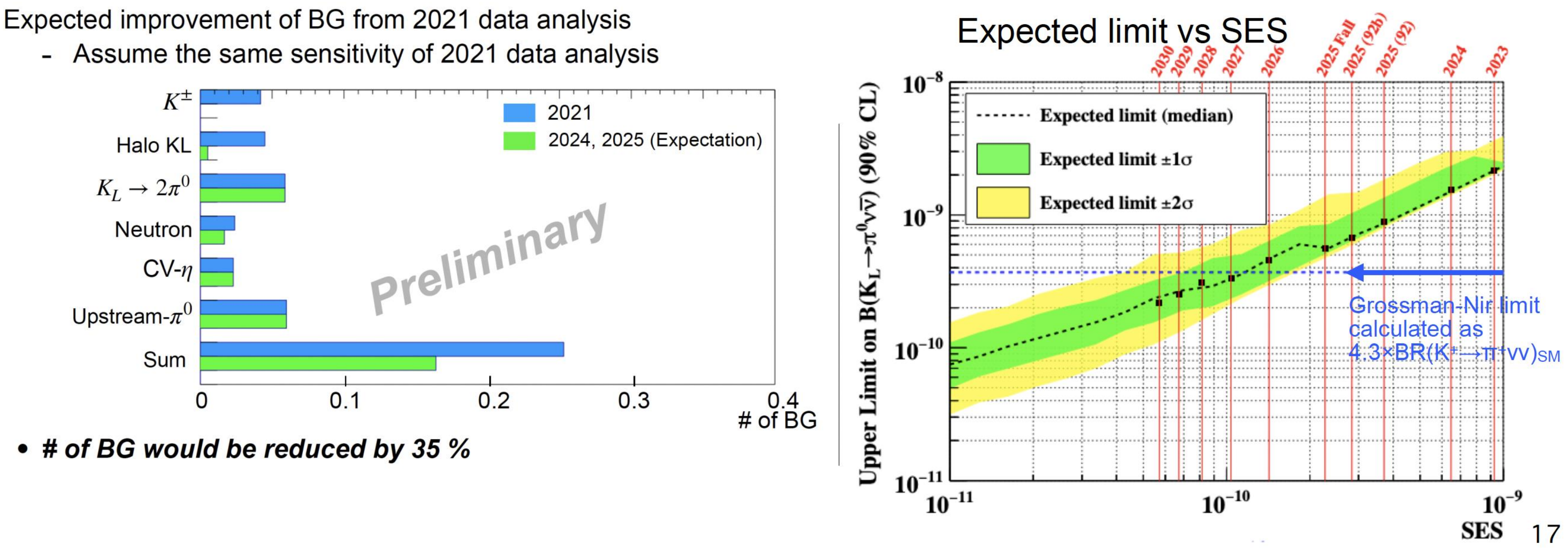
$$\mathscr{B}(K_L \rightarrow \pi^0\nu\bar{\nu}) < 2.2 \times 10^{-9} \text{ (90\% C.L.)}$$

Phys. Rev. Lett. 134, 081802 (2025)

- ➢ Very sensitive to BSM physics, direct CP violation, $\mathrm{BR}_{\mathrm{SM}}$ 3×10^{-11} with <2% unc.

The “golden” $K_L \rightarrow \pi^0 \nu\nu$

Keita Ono



Expected improvement of BG from 2021 data analysis

- Assume the same sensitivity of 2021 data analysis

- ***# of BG would be reduced by 35 %***

Expected limit vs SES

Grossman-Nir limit calculated as $4.3 \times BR(K^+ \rightarrow \pi^+ \nu\nu)_{SM}$

17

Several upgrades of KOTO at JPARK: UCV detector, new dipole, improved DAQ

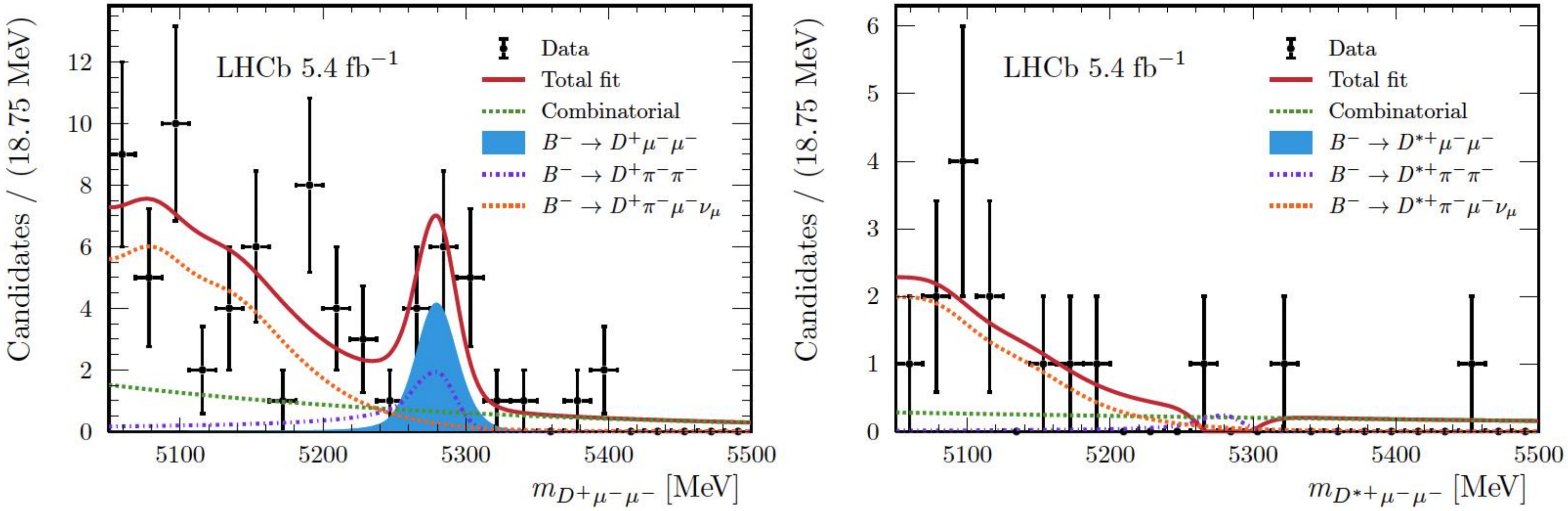
SES < 10^{-10} in 3-4 years

Search for lepton number violation

arXiv:2601.07657

- Dominant systematic stemming from the decay model of the signal, assumed to be generated uniformly in phase-space

$$\mathcal{B}(B^- \to D^+\mu^-\mu^-) < 3.8\,(4.6) \times 10^{-8} \text{ @ } 90\%\ (95\%)\ \text{CL}$$
$$\mathcal{B}(B^- \to D^{*+}\mu^-\mu^-) < 4.5\,(5.9) \times 10^{-8} \text{ @ } 90\%\ (95\%)\ \text{CL} \quad (5)$$

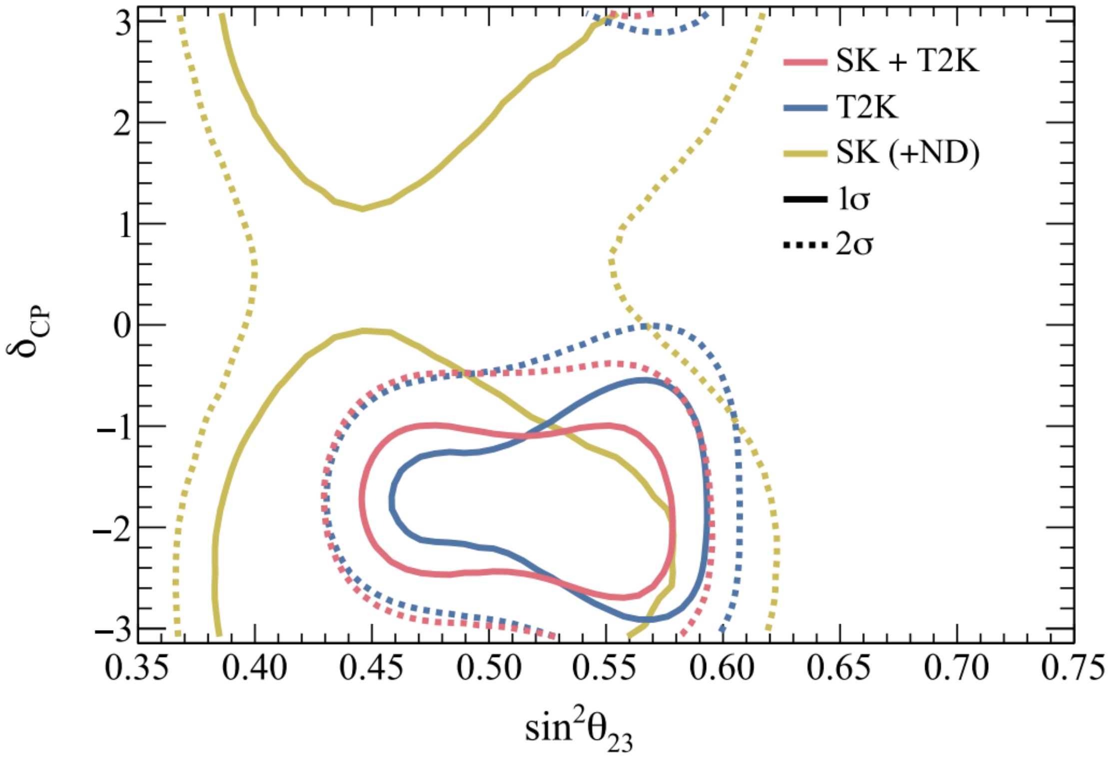


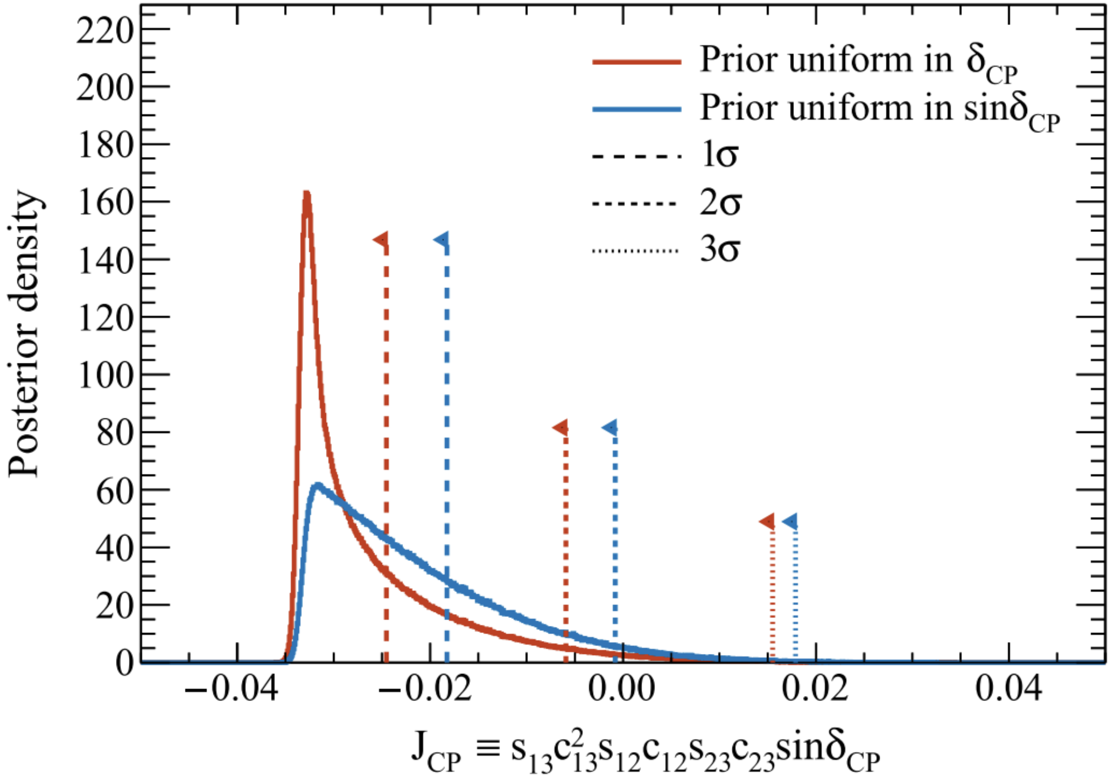
Can only be meditated via Majorana ν□s ~10^{-22}-10^{-23}

Small excess <2σ → Run 3 large increase of sensitivity

Joint SK Atmospheric + T2K analysis

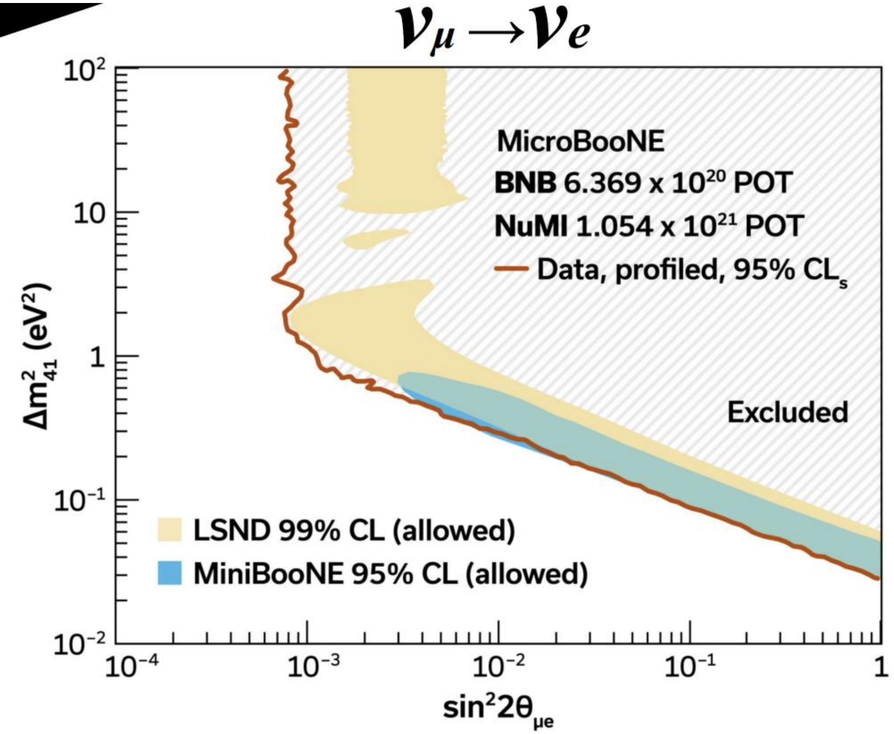
Benda Xu





Atmospheric ν results reduce degeneracy between MO and δ_{CP}

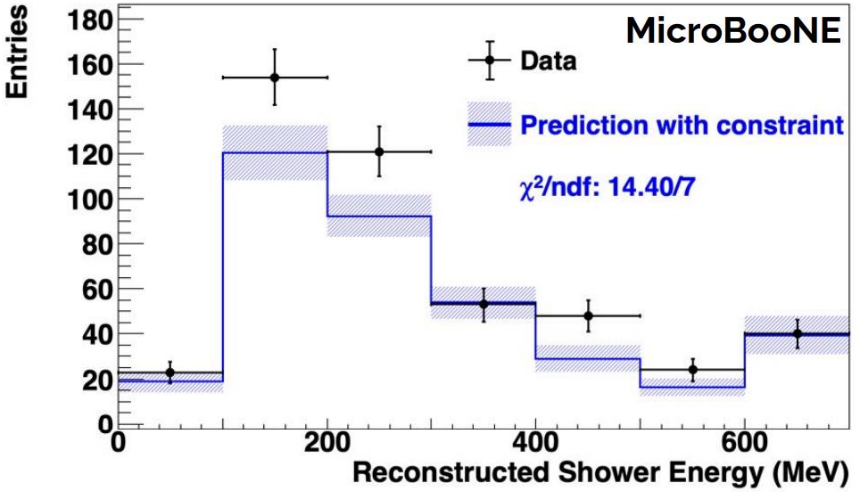
$\delta_{CP}=0$ disfavored at 1.9σ with Mass Ordering marginalized in the fit



- **World's first two beam sterile neutrino search**
- Data consistent with no sterile neutrinos
- **Excludes LSND** 99% allowed region
- **Excludes vast majority of MiniBooNE** 95% allowed region

MicroBooNE: Nature volume 648, 64–69 (2025)

- While the 3+1 sterile neutrino interpretation is **strongly disfavoured, the anomalies themselves remain unexplained!**
- Searches for **single-photon** and **e+e- signatures** continue, with a particular focus on events with **no associated hadronic activity**, one of the last remaining places that the MiniBooNE anomaly could be hiding



Mark Ross-Lonergan

arXiv:2502.06064 [hep-ex] (2025)

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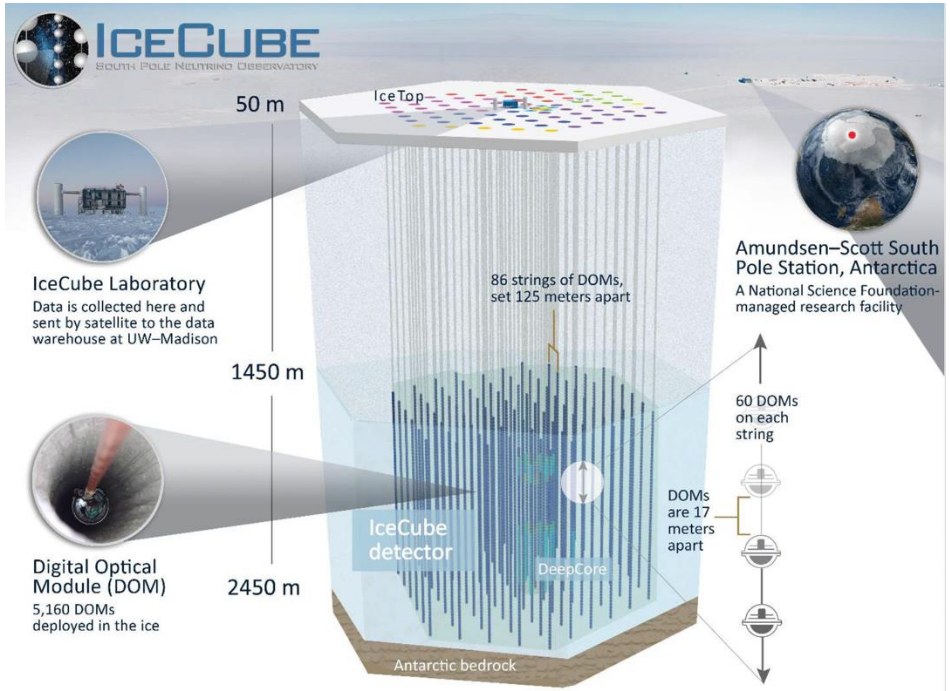
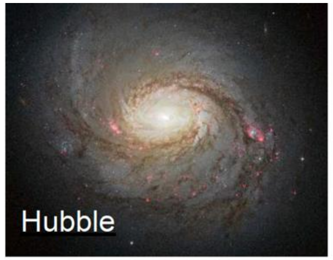
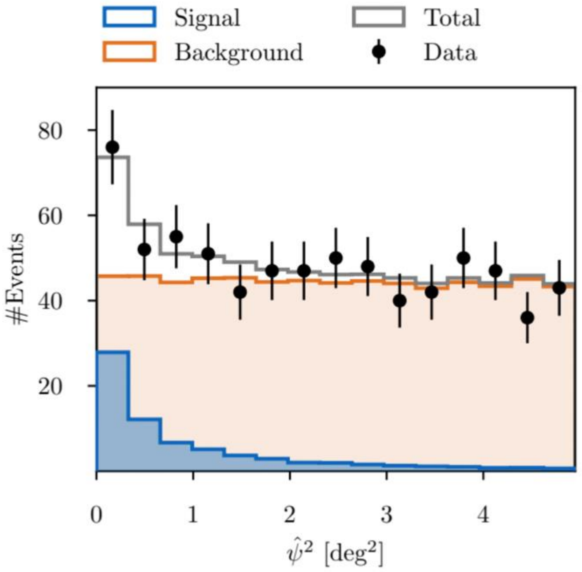
Still origin of "MiniBooNE anomaly" not understood: 3+1ν essentially excluded – looking at model independent approach slight excess in single-γ events (2σ level)?

Results from IceCube

Thijs van Eeden







Neutrino emission from nearby active galaxy NGC 1068
Science, 378(6619), 538-543

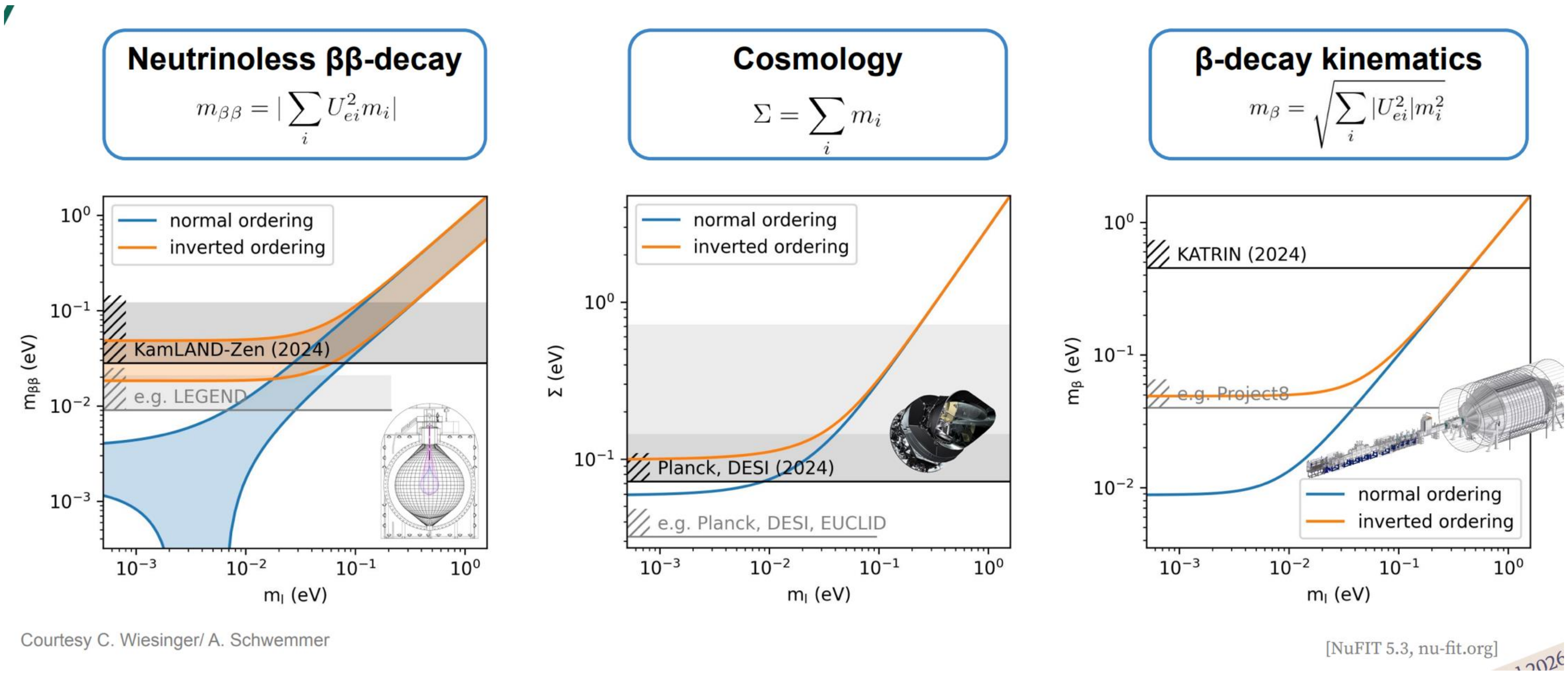
Follow-up on 47 bright X-ray sources

- Submitted to ApJL: arXiv.2510.13403
- NGC 1068: 4σ
  - Soft spectrum: $\gamma = 3.4$
  - Much higher ν flux than γ
- 3.3σ when stacking 11 sources, excluding NGC 1068

Photomultipliers arrays at South Pole photo multipliers that detects Cerenkov radiation from ν interactions
Main goal is to detect astro-physical sources but also reach ν research program (astrophysics n composition, cosmic rays hadrion interactions, search for WIMPs, …)
Example: study of n emission from active Galaxies (NGC)
Proposed upgrade form1 to 8 km^3

Results from Katrin

Chloé Goupy



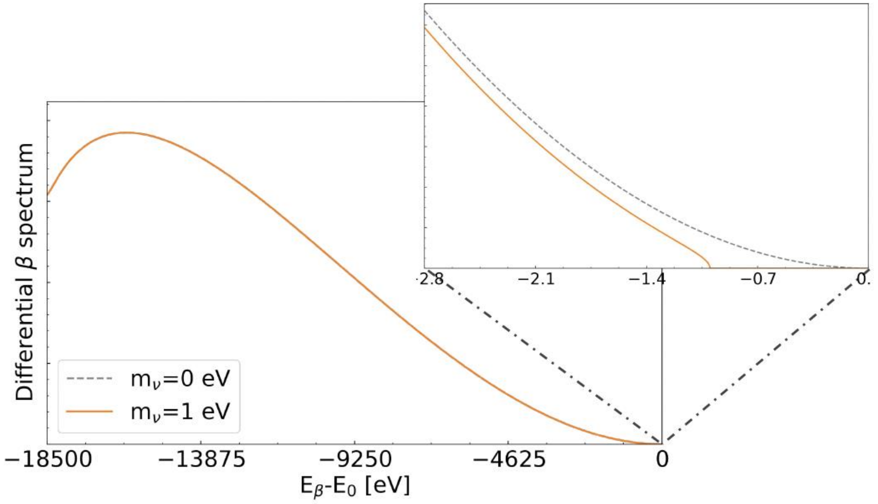
Courtesy C. Wiesinger/ A. Schwemmer

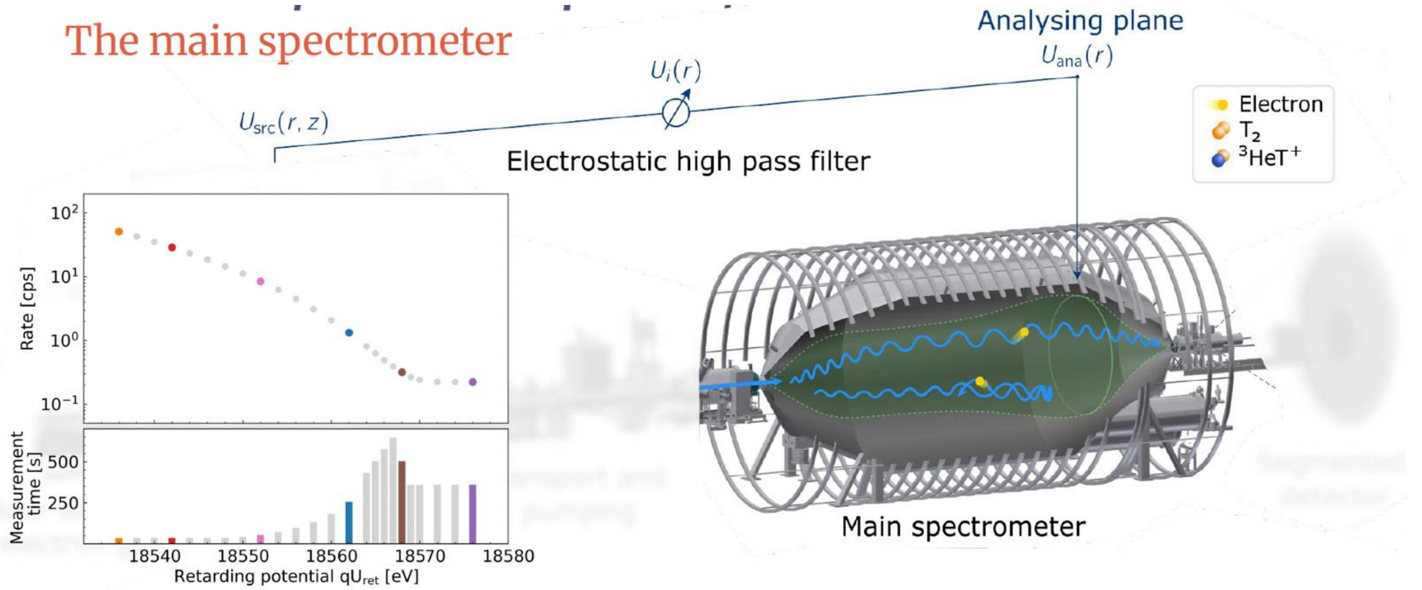
[NuFIT 5.3, nu-fit.org]

Huge EM spectrometer → energy end-point from β decay → Energy resolution ~1 eV
Results based on 260 days, full 1000d coming out soon -> 0.3eV
Can also search for sterile ν in Ga anomaly region -> limits excluding most of the preferred regions

Results from Katrin

Chloé Goupy





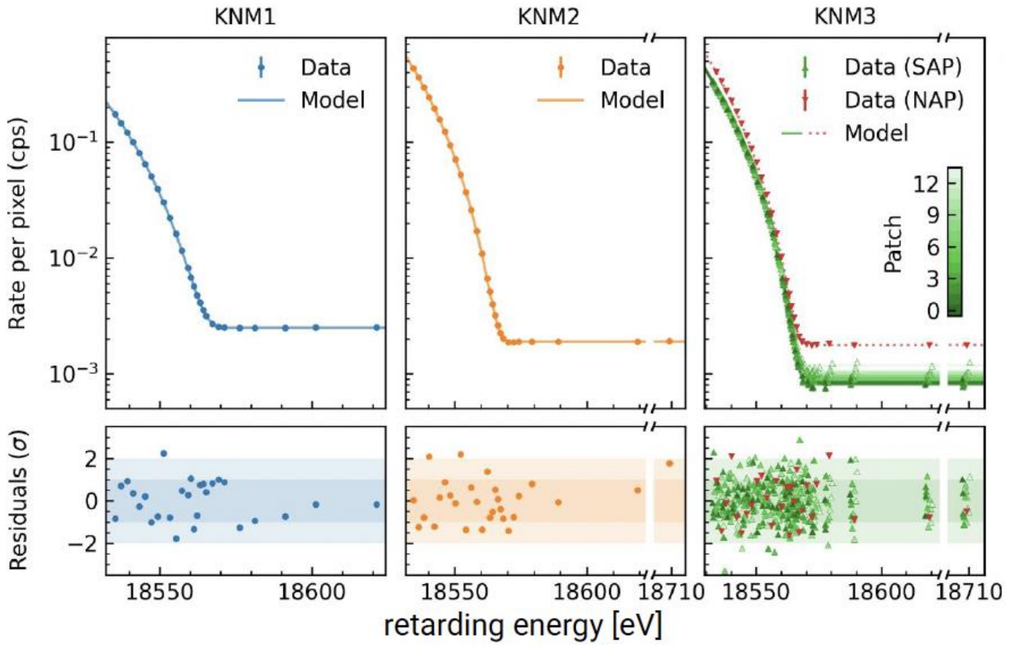
- β-decay with end point E_0: $n \rightarrow p^+ + e^- + \bar{\nu_e}$
- probe **effective electron anti-neutrino** mass $m_\nu^2 = \sum_{i=1}^{3} |U_{ei}|^2 m_i^2$

Huge EM spectrometer to get integral e- energy spectrum 2-3h cycles → Energy resolution ~1 eV

Fit of analytical model of the spectrum + model of experimental response with 4 free parameters + systematics

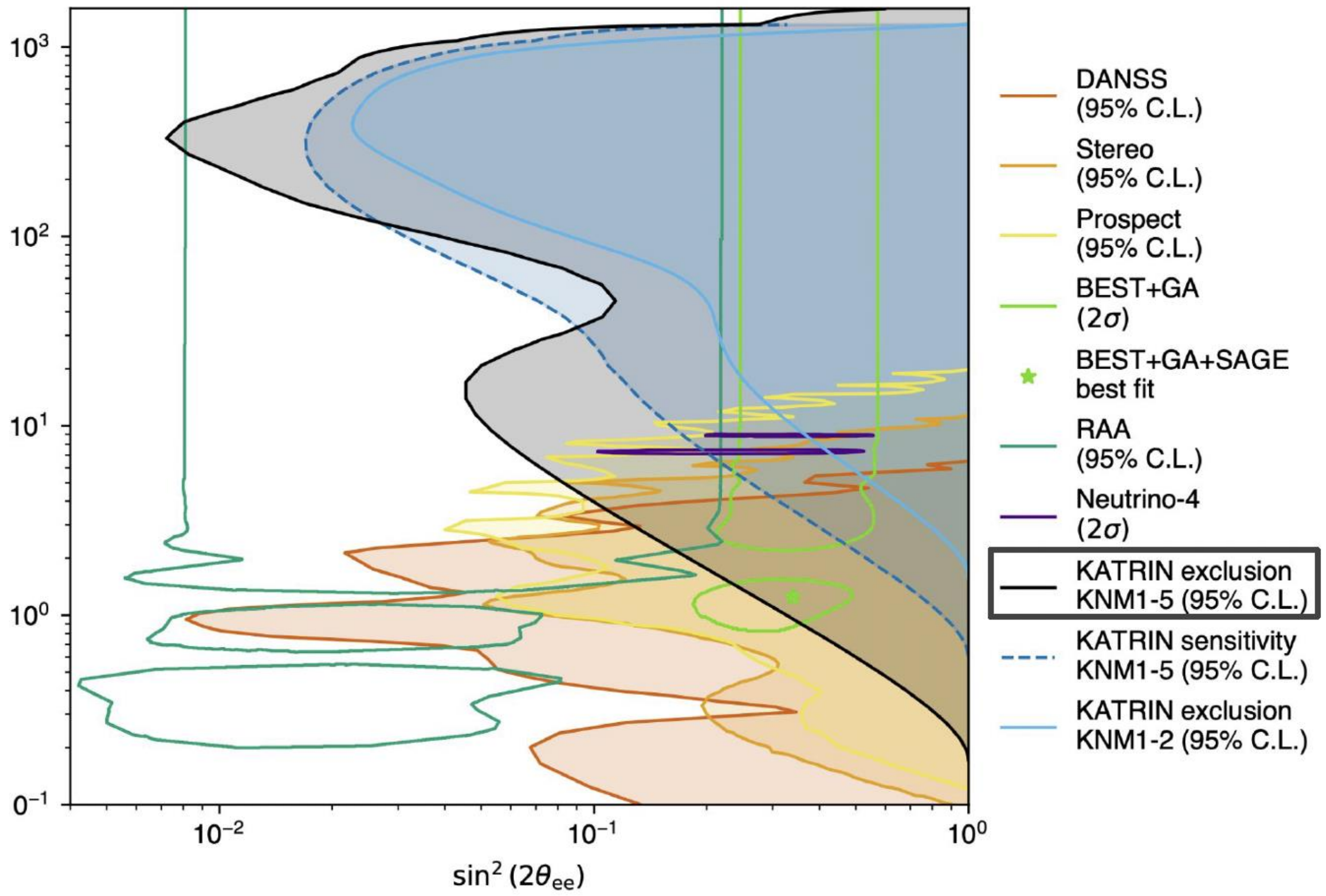
Results from Katrin

Chloé Goupy



Best fit result (p-value: 0.84): $m_\nu^2 = -0.14^{+0.13}_{-0.15}\,\mathrm{eV}^2$

KATRIN's new upper limit:
$m_\nu < 0.45$ eV (90% CL)



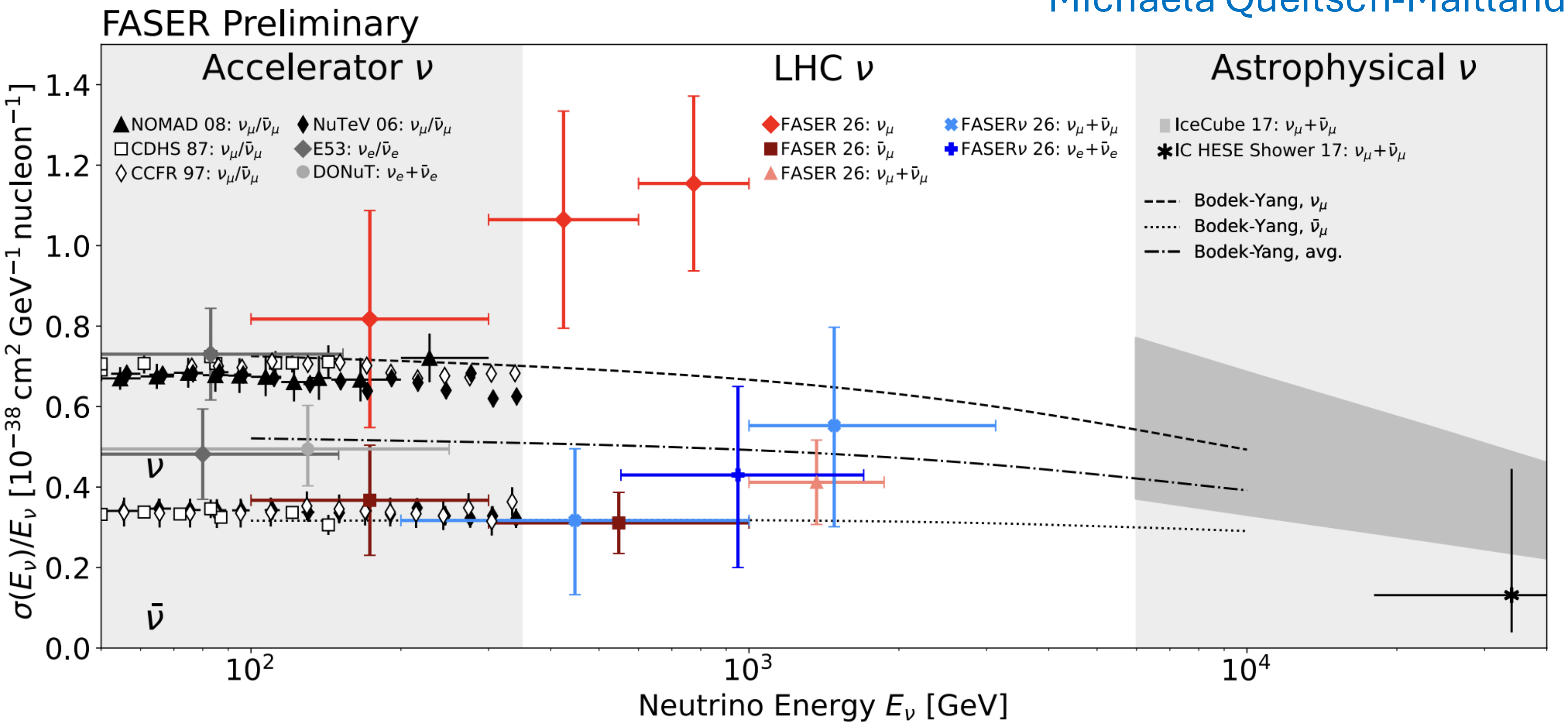
Huge EM spectrometer → energy end-point from β decay → Energy resolution ~1 eV

Results based on 260 days, full 1000d coming out soon -> 0.3eV

Can also search for sterile ν in Ga anomaly region -> limits excluding most of the preferred regions

First results with 2022 data from FASER

Michaela Queitsch-Maitland



Detector with emulsion + electronic detector targeting ν produced in LHC collisions (~300fb^{-1} of data)

Target: ν xs (knowledge of the flux), search for new particles in the MeV-GeV range: dark photons, ALPs

ATLAS - Run 3 Search for Displaced Vertices and Muons (164fb^{-1}) John Anders [2603.01991]

Focuses on neutral LLP decays within the ATLAS innermost detector layers

- One displaced vertex and at least one muon with large transverse impact parameter

Unconventional trigger and tracking

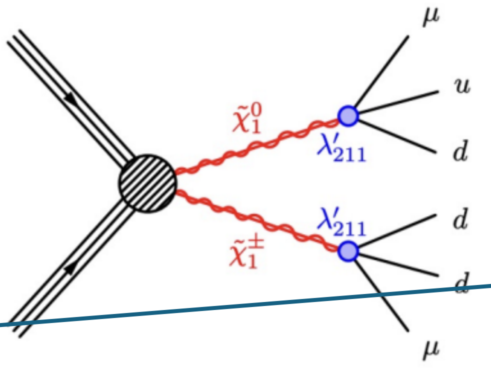
- Trigger uses Muon Spectrometer (MS) information only
- LRT identifies large impact parameter muons

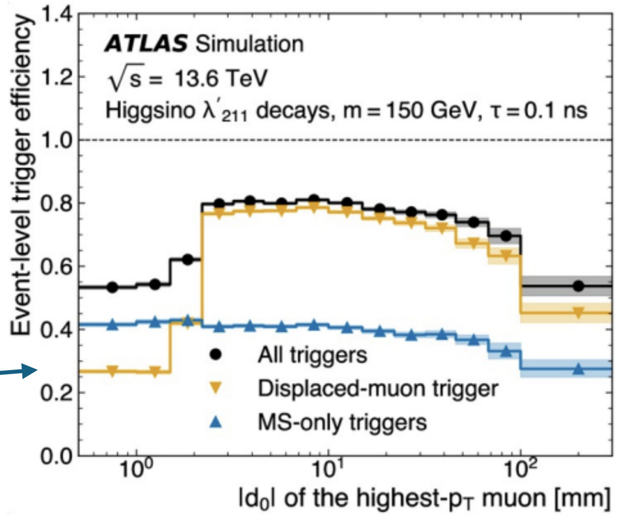
ABCD Method to estimate background

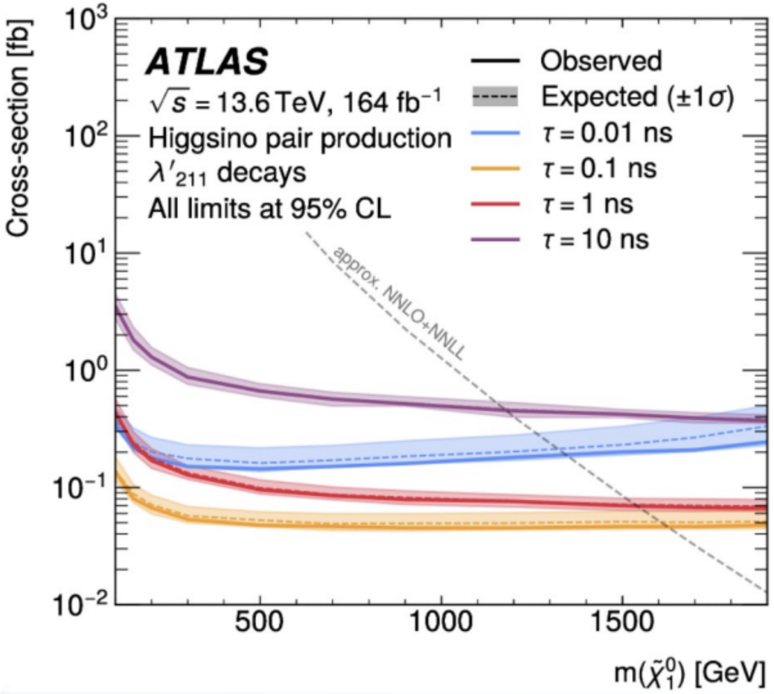
- Mainly arises from tracks reconstructed from coincidental/unrelated hits
- Invert muon-requirements and impact parameter

No significant excess

- Model independent limits and
- Interpretations in multiple RPV SUSY models





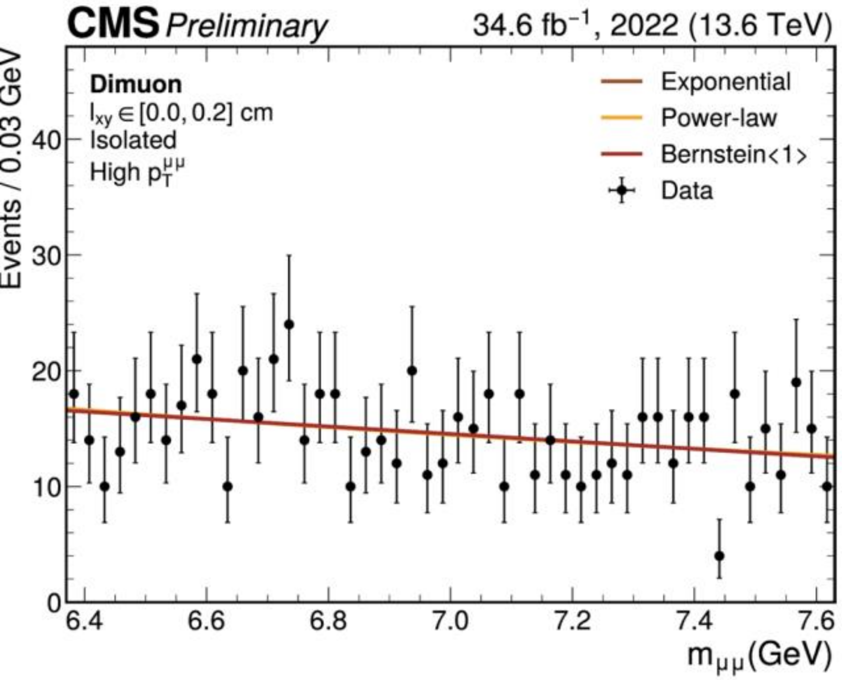


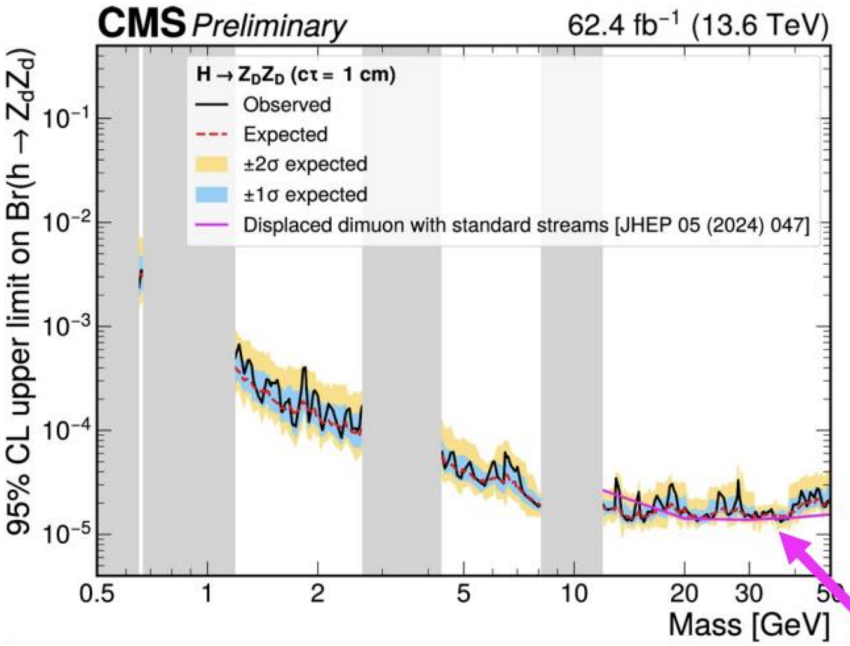
More in David Rousso's talk

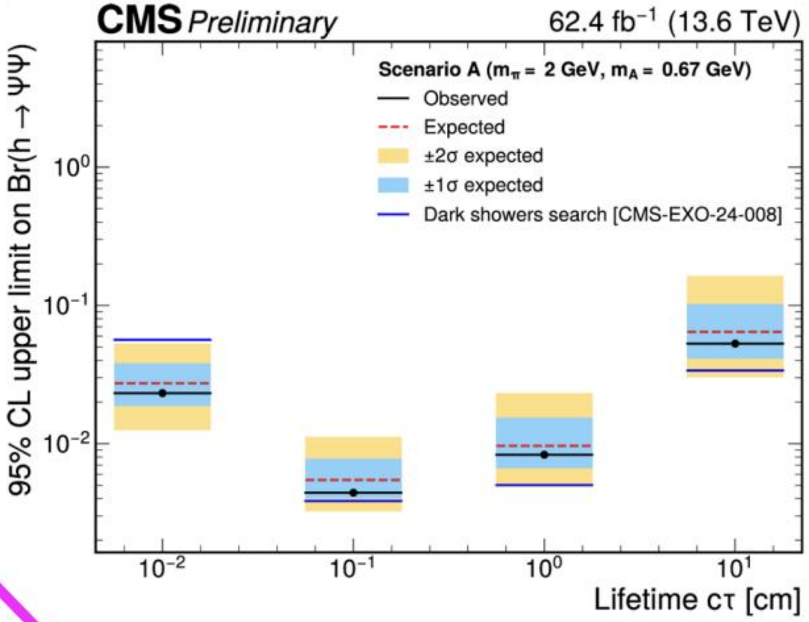
CMS - Run 3 Search for LLPs decaying into Muons ($62 fb^{-1}$) John Anders CMS-PAS-EXO-24-016

Background is taken directly from data

- Fitting analytic functions (Bernstein polynomials, power law and exponential functions) to the $\mu^+\mu^-$ mass spectra





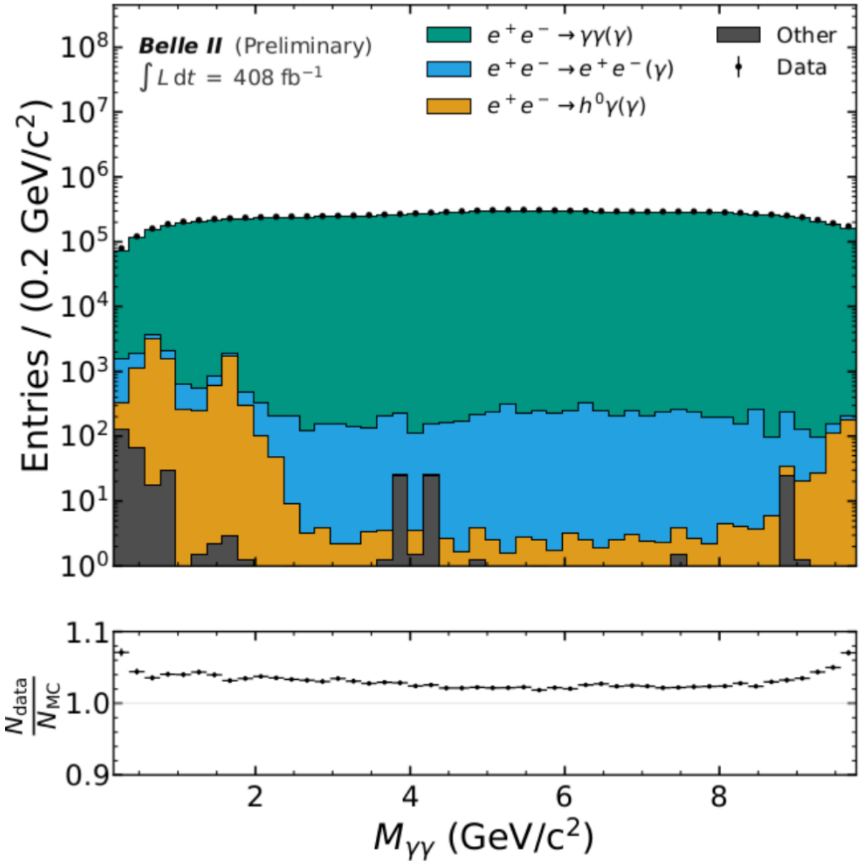


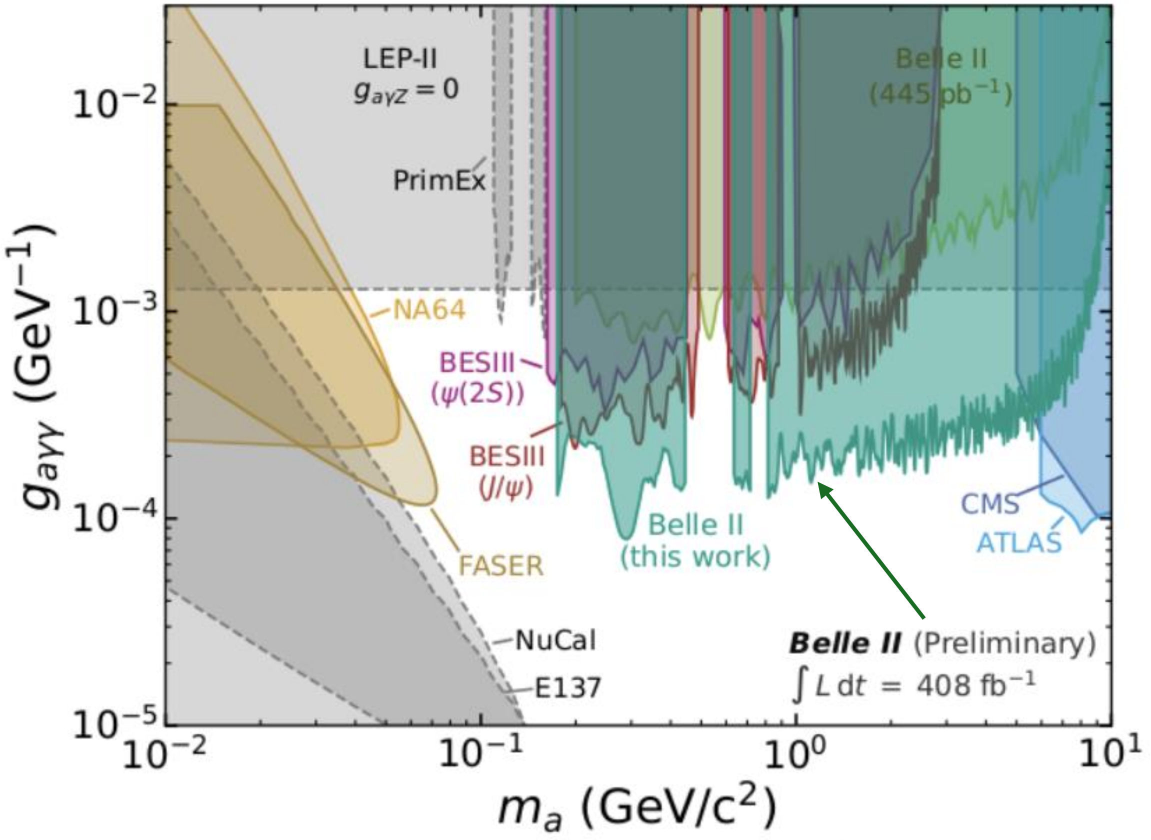
No significant deviations from the background predictions

- Data scouting allows for significantly lower masses to be probed than previously possible!
- Limits placed in dark photon and dark shower models

Search for ALPs in Belle II

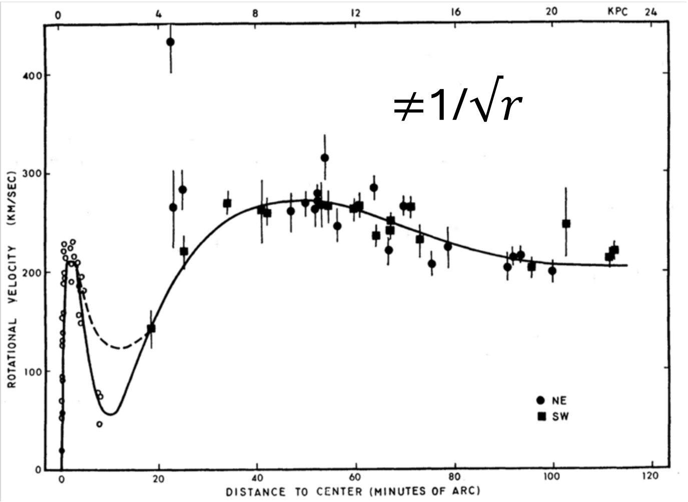
Devender Kuma

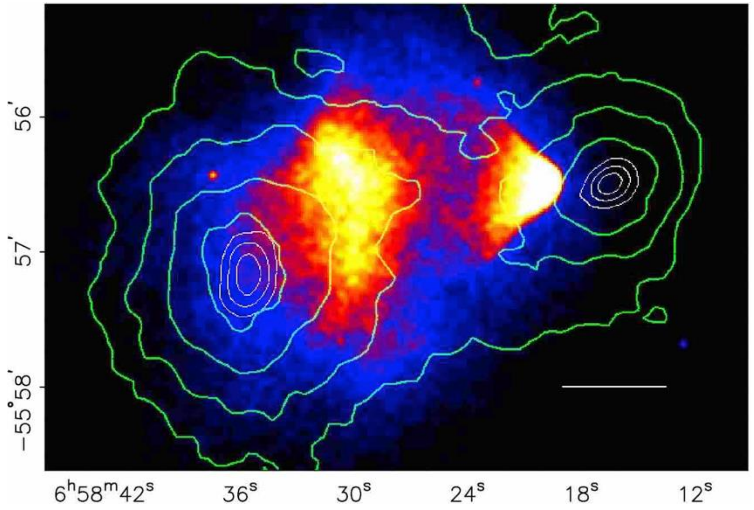


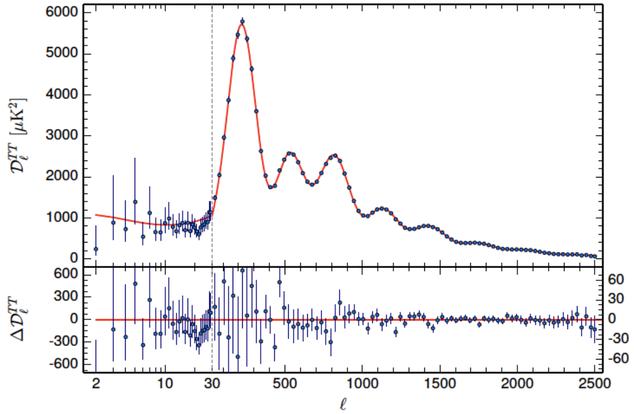


ALPs in e+e → aγ → γγ γ 0.17-9.8 GeV fit to m(a) spectrum: no exces, limits on scan σ(e+e- → aγ)~2-10 fb translated into limits on g_ayy.

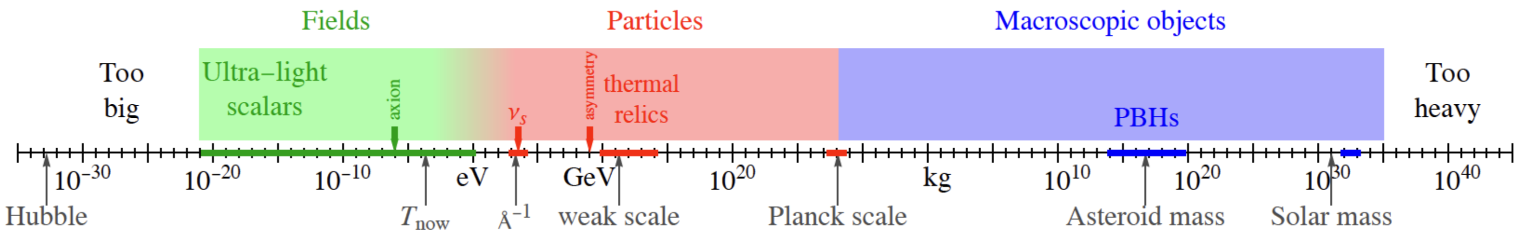
Search for DM

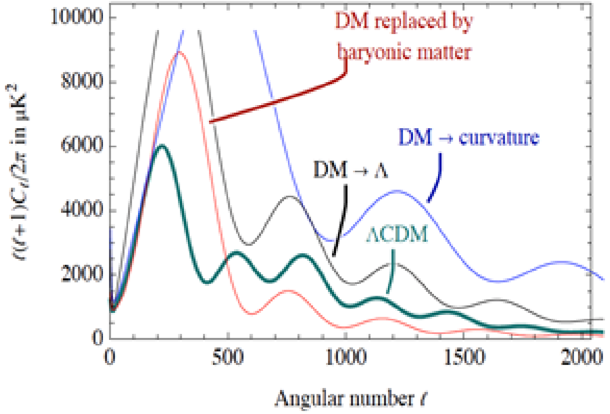






[Dark Matter: Cirelli, Strumia, Zupan]





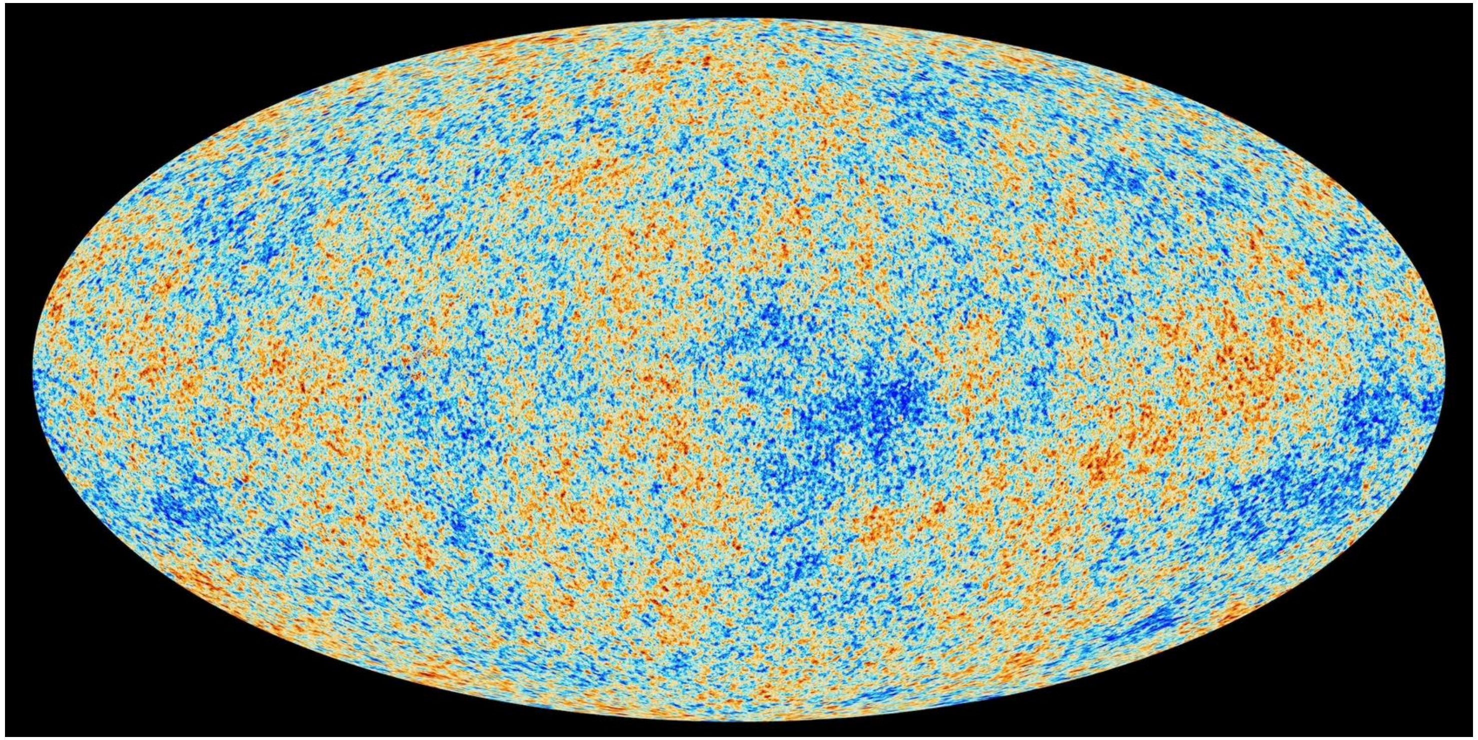
Overwhelming evidence for DM existence: Astrophysics, Weak lensing, CMB acoustic peaks …

Wide range of DM candidates (10^{-21} eV < M < 10^{37} kg!) makes the search extremely challenging

Extension of SM (BSM) provides good candidates: WIMPs, QCD Axions (ALPs), Dark Sector, …

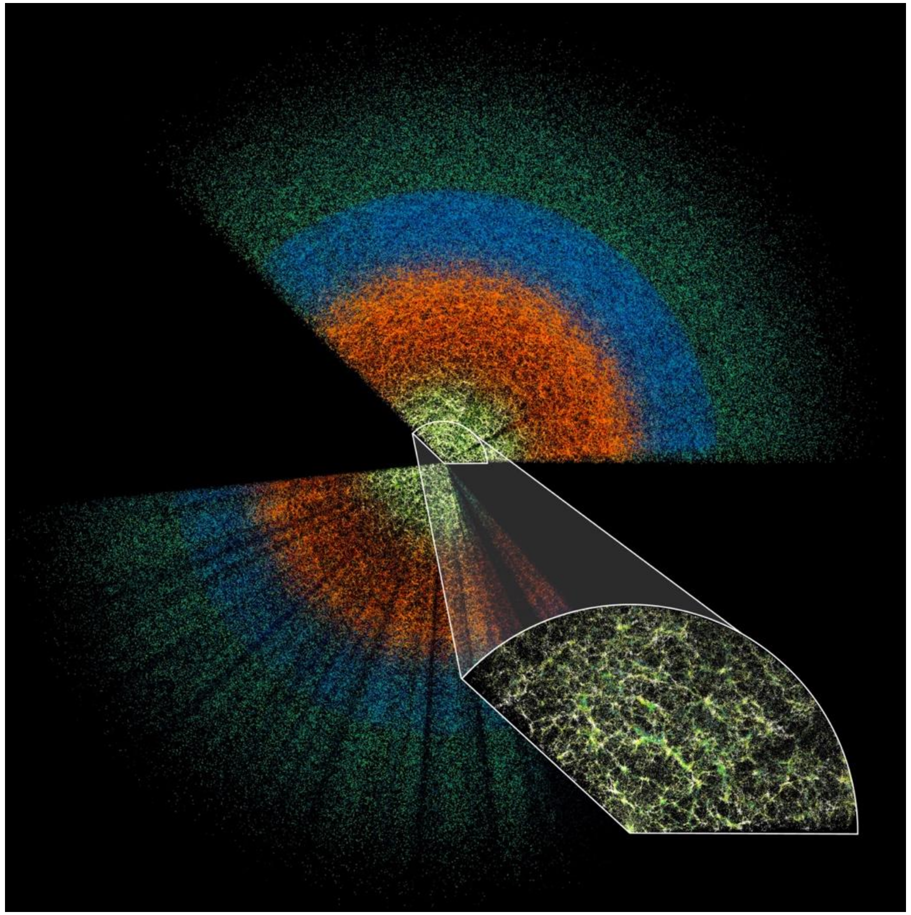
Complementary searches form direct detection, production at colliders, indirect (annihilation signals), …

Cosmology



By ESA and the Planck Collaboration - Cosmic Microwave Background, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=130789180

DES Collaboration/DOE/KPNO/NOIRLab/NSF/AURA/C.Lamman



Very successful model ΛCDM: fit of 6 parameters to a large number of experimental observations: CMB, LSS, ...

Link between DM, Λ, inflation and particle physics need to be clarified

Some tensions emerging between *Early* and *Late* measurements (Hubble tension, S_8 tension, ...)

Neutrino mass limits from Cosmology fits

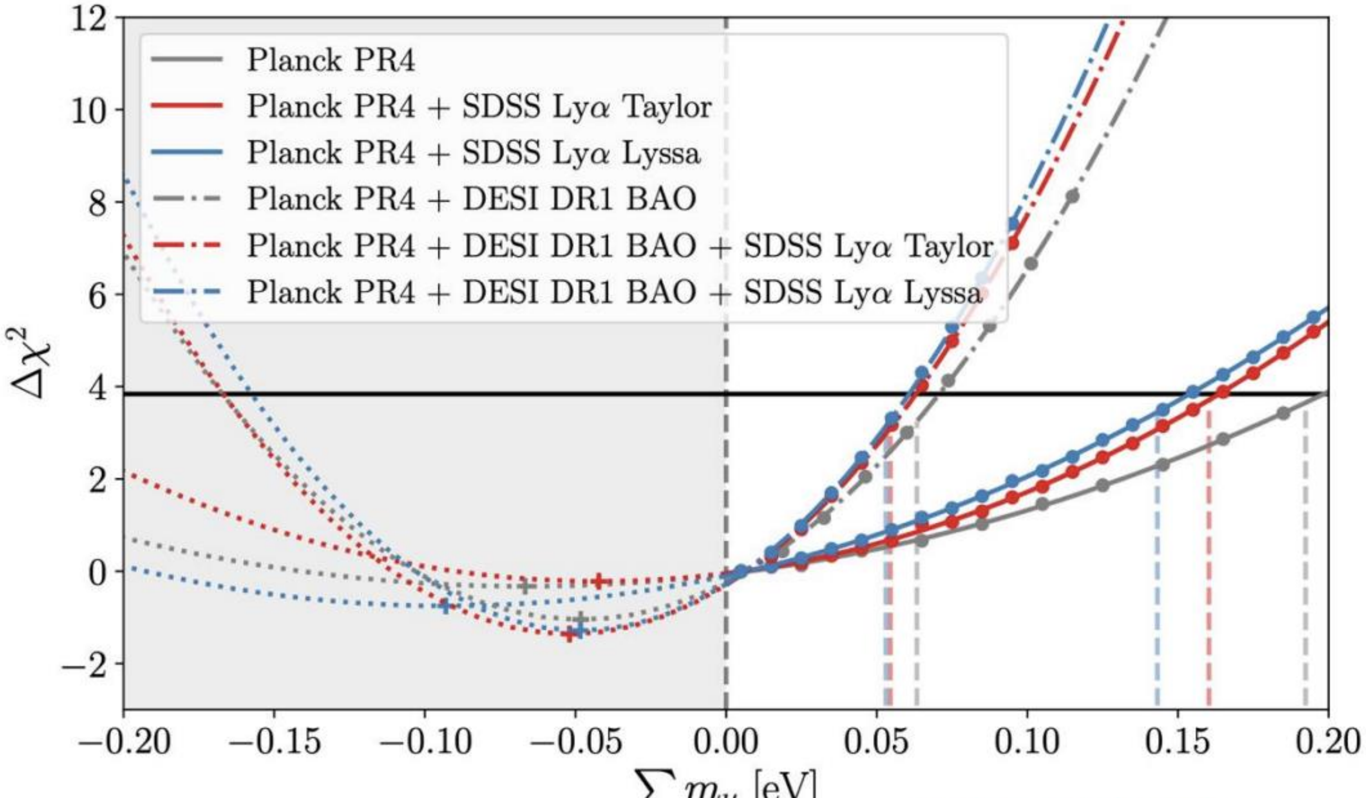
Yvonne Wong

The combination of **DESI+Planck** appears to constrain the neutrino mass sum to an extremely tight $\sum m_\nu < 0.053$ eV (95%) in a ΛCDM+Σm_ν fit.

Elbers et al [DESI]. 2025

- Bound is below the miniumum neutrino mass sum $\sum m_\nu = 0.06$ eV from neutrino oscillations.
- In fact, likelihood peaks in an **unphysical region.**
  - Seen in both Bayesian and frequentist analyses.
- **"Negative neutrino mass"**

Loverde & Weiner 2024;
Craig, Green, Meyers & Rajendran 2024;
Naredo-Tuero et al. 2024; Elbers et al. 2025

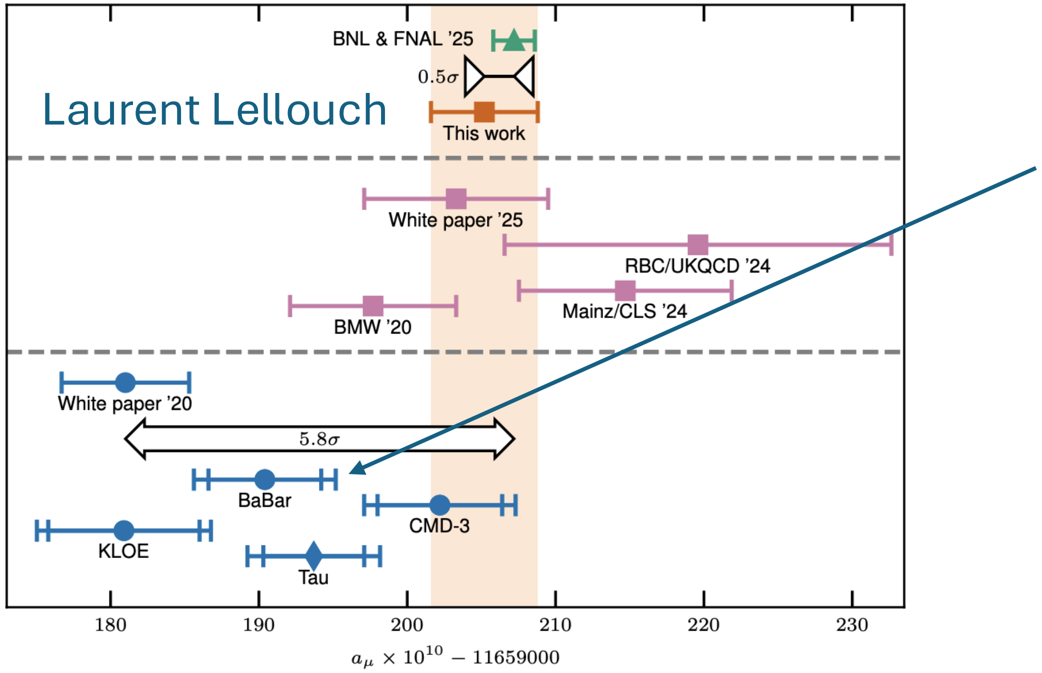


Chebat et al. 2025

Consequence of tension in H0 and ΩM between two measurements (Early vs Late)

The muon g-2 measurement

Leonard Polat



Laurent Lellouch

$\pi\pi$ contributions to a_μ

Energy range [GeV]	2025 $a_\mu^{2\pi}$ ± stat ± syst [10^{-10}]	2009 $a_\mu^{2\pi}$ ± stat ± syst [10^{-10}]
Below 0.5	58.0 ± 5.5 ± 1.7	58.2 ± 0.6 ± 0.6
0.5 - 1.4	456.2 ± 2.2 ± 1.7	455.6 ± 2.1 ± 2.6

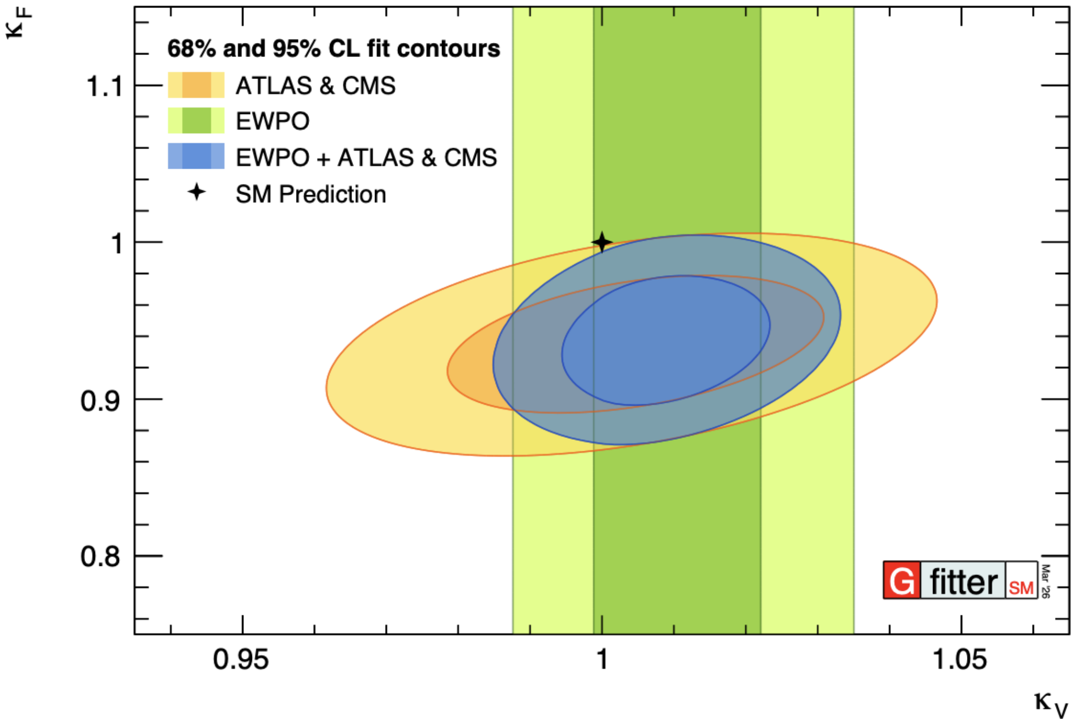
⇒ 2025 and 2009 results are compatible with excellent agreement

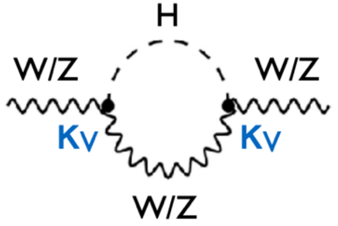
⇒ the averages yield the most precise $a_\mu^{2\pi}$ measurement from a single experiment.

- Great Experimental success latest Fermilab measurement: 127ppb!
- Challenged theory prediction in particular hadronic vacuum polarization that involves low-energy QCD
- Hadronic corrections: tension between "experimentally" and "Lattice based" predictions (but also between "measurements"): new method to measure e+e- → π+π- in Babar use kinematic selection instead of PID for π/μ → Lowered pT cut more stat. and less systematics

Γ_H with EW precision observables

Roman Kogler





$$S = \frac{1}{12\pi}(1-\kappa_V^2)\ln\left(\frac{\Lambda^2}{m_H^2}\right)$$

$$T = -\frac{3}{16\pi c_W^2}(1-\kappa_V^2)\ln\left(\frac{\Lambda^2}{m_H^2}\right)$$

LHC Higgs σxBR $\mu_i^f \equiv \frac{\sigma \cdot \mathrm{BR}}{\sigma_{\mathrm{SM}} \cdot \mathrm{BR}_{\mathrm{SM}}} = \frac{\kappa_i^2 \cdot \kappa_f^2}{\kappa_H^2}$

HVV coupling-only:

$$\Gamma_H = 4.36\ ^{+0.64}_{-0.51}\ \mathrm{MeV}$$

χ^2 / ndf = 28.8 / 28

Effective parameterisation:

$$\Gamma_H = 4.09\ ^{+0.44}_{-0.37}\ \mathrm{MeV} \quad (\delta\Gamma_H \approx 10\%)$$

χ^2 / ndf = 45.9 / 44

All measurements (resolved parameterisation κV, κF):

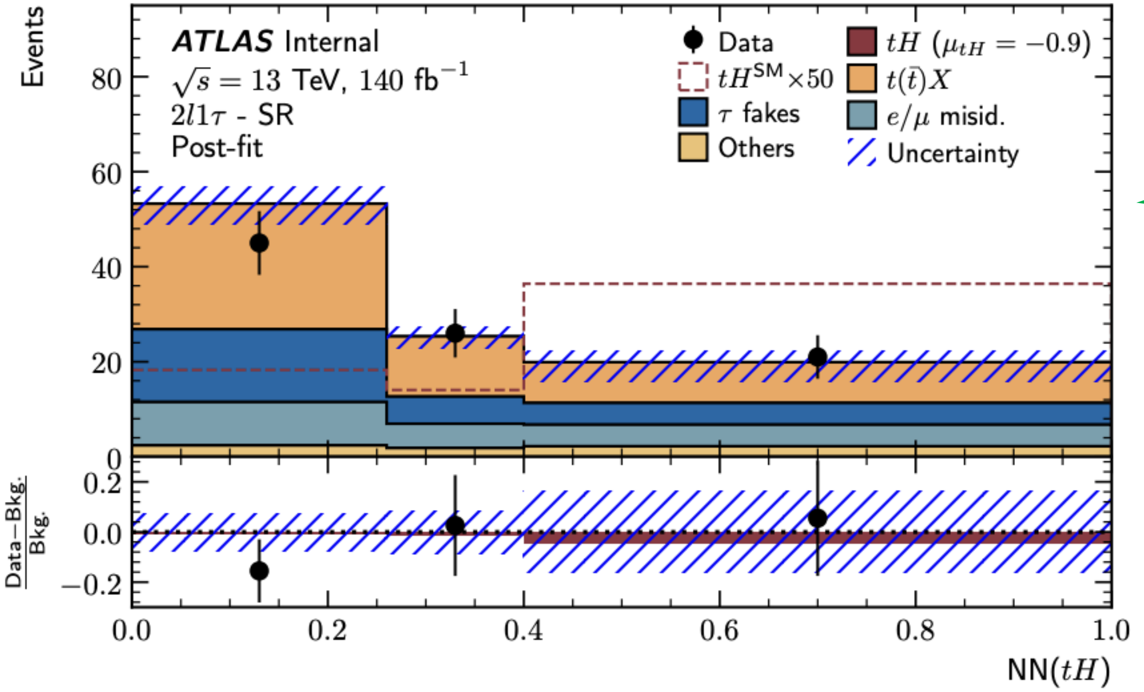
$$\Gamma_H = 3.79\ ^{+0.31}_{-0.27}\ \mathrm{MeV}$$

χ^2 / ndf = 72.9 / 76

$(\Gamma_H^{\mathrm{SM}} = 4.1\,\mathrm{MeV})$

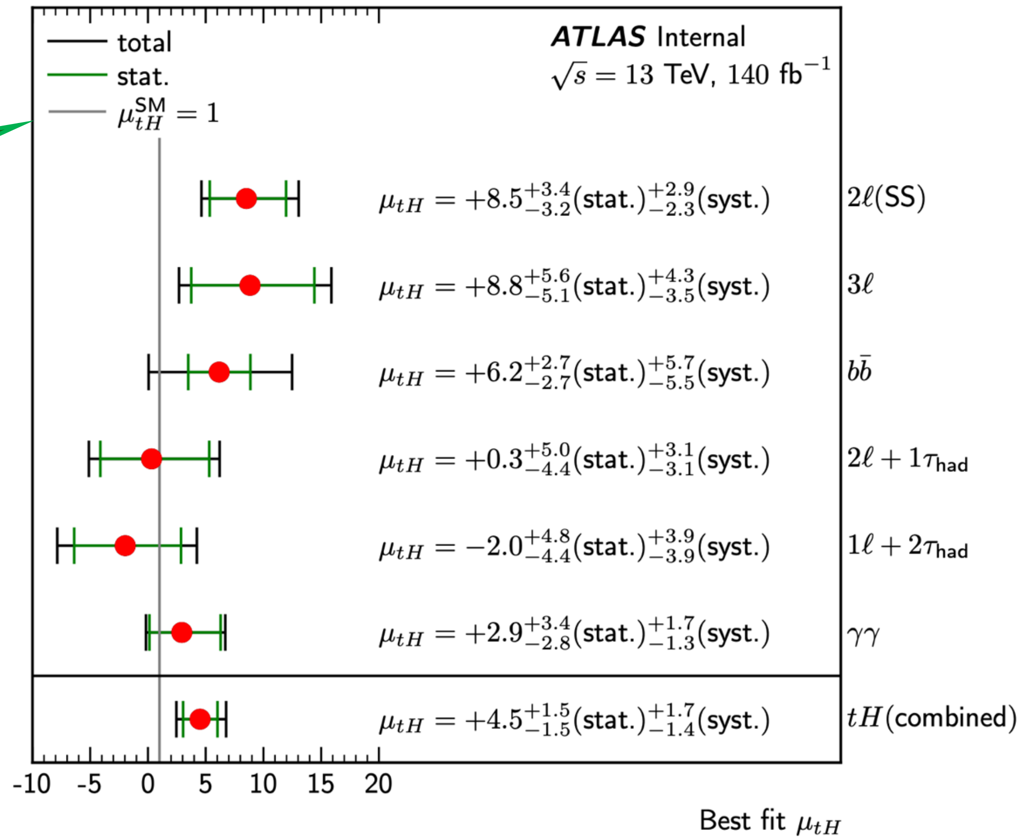
th→ττ and combination

Gaetano Barone



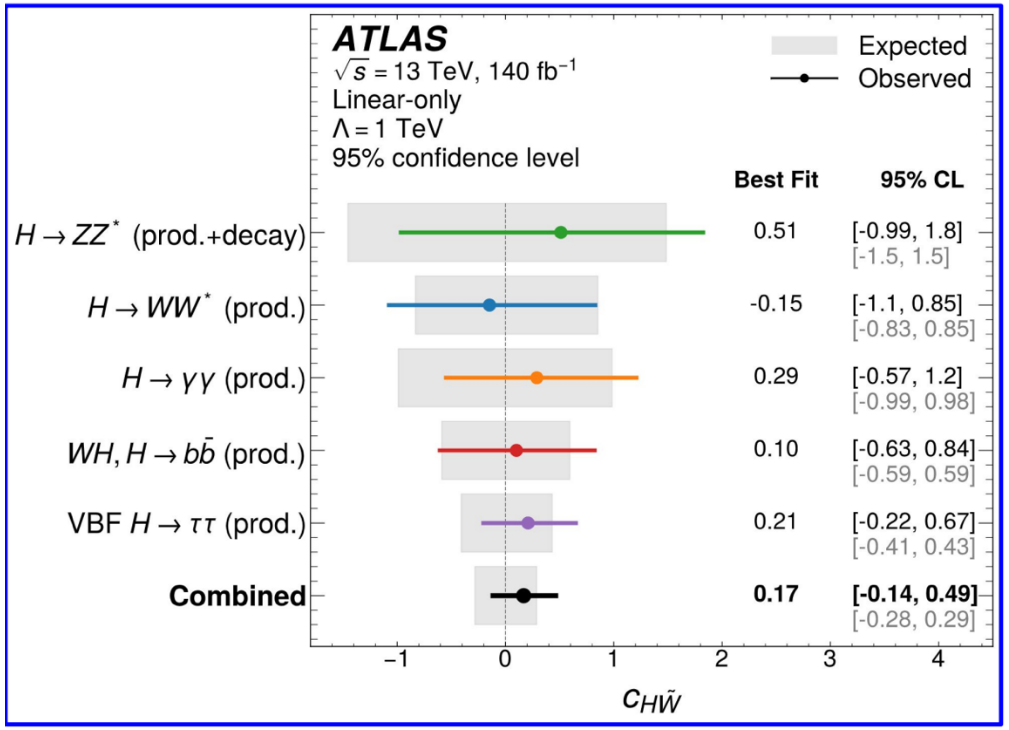
(a) 2ℓ SS + $1\tau_{\text{had}}$ SR

NEW

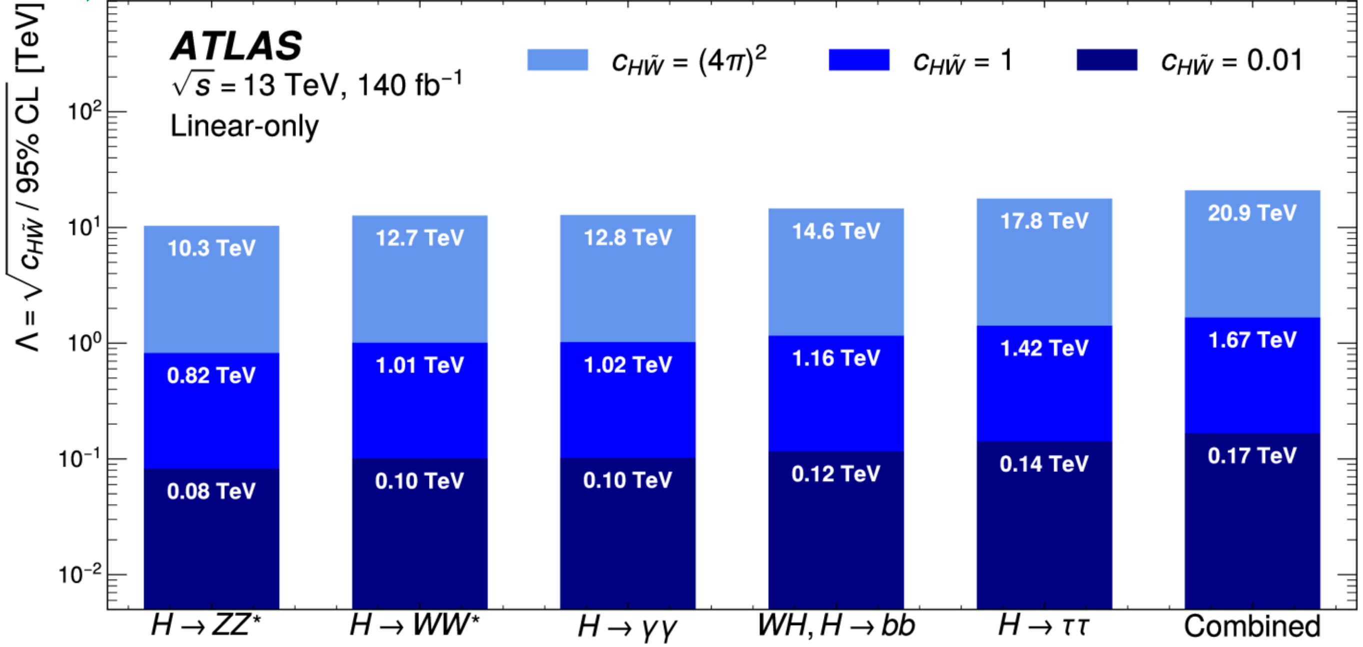


New analysis searching for tH associated production in H→ττ decays from ATLAS
Combined with previous Run 2 analyses

ATLAS CP studies on HVV interaction



NEW

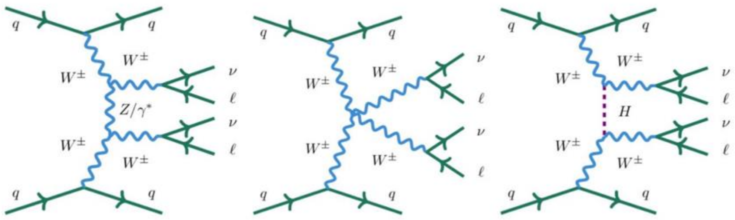


Stringent limits on EFT CP-odd interactions between H and V

Fermion sector even more interesting (CP possible at tree level!)

VBS production ATLAS

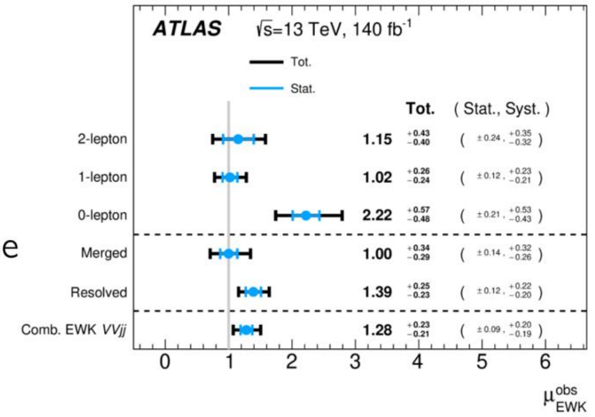
Santiago Folgueras

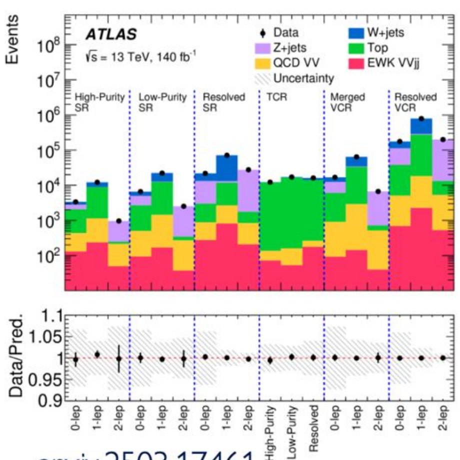


VBS observation in semileptonic modes

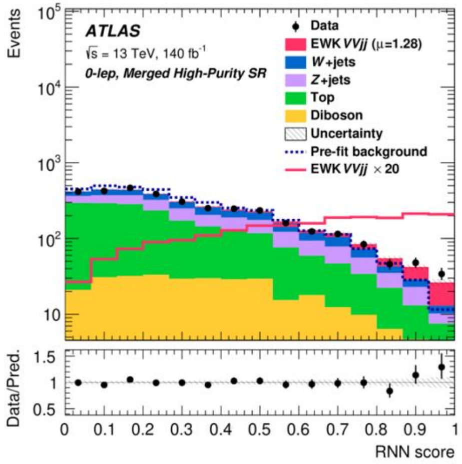
- Combined ℓℓqq / ℓνqq / ννqq (resolved + merged)
- RNN-based extraction

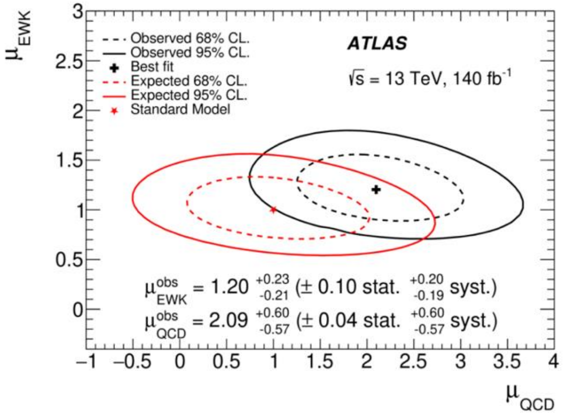
- Observed significance: 7.4σ (expected 6.1σ)
- ATLAS also sees 3.3σ evidence for ≥1 longitudinal W in SSWW: the next VBS frontier [Phys. Rev. Lett. 135 (2025) 111802]





arxiv.2503.17461

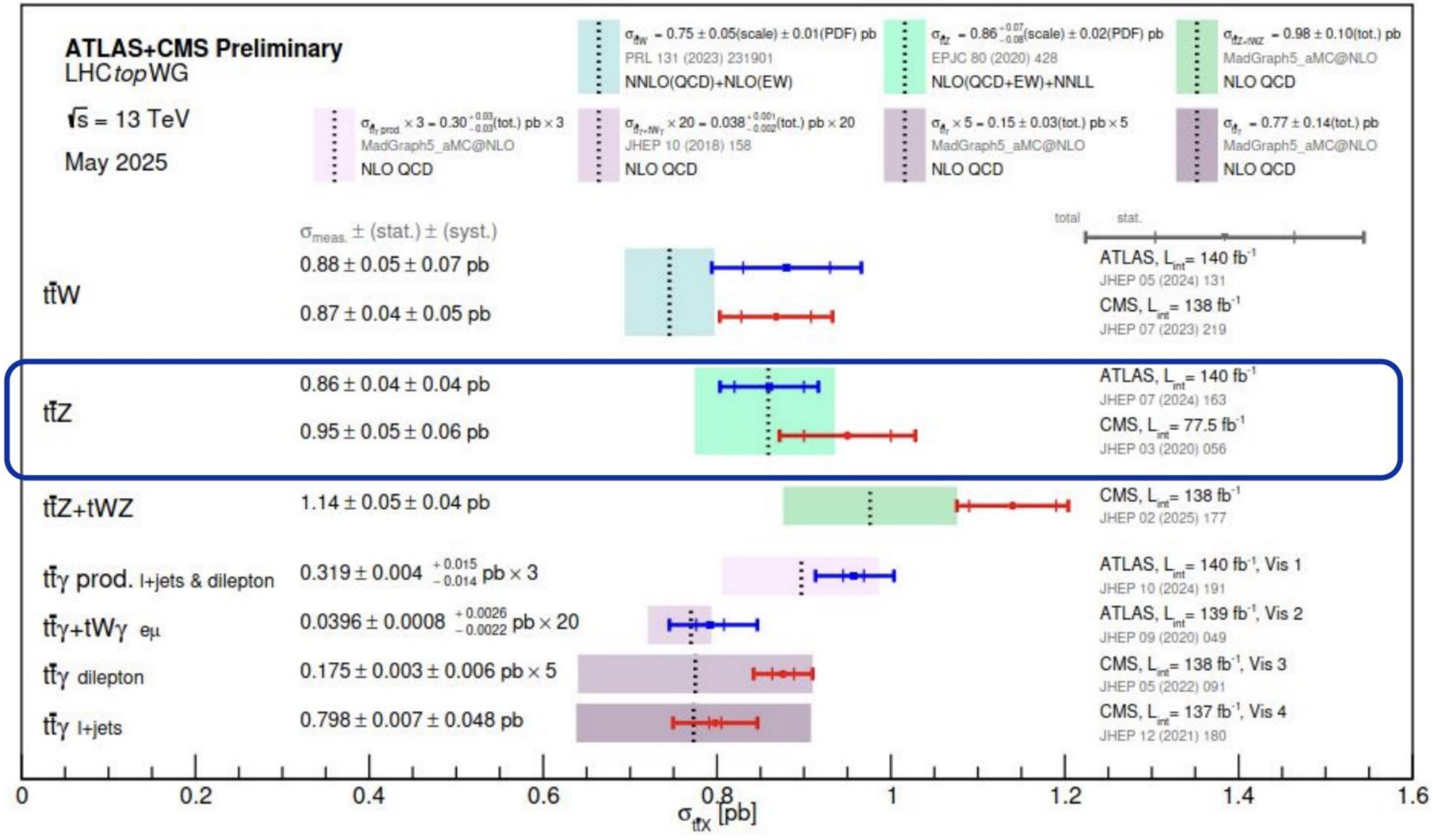




Multi-boson production provides stringent test of EW physics: constraints on anomalous TGC and QGC, test of the EWSB ($W_L W_L$ production)

Rare tt+X processes

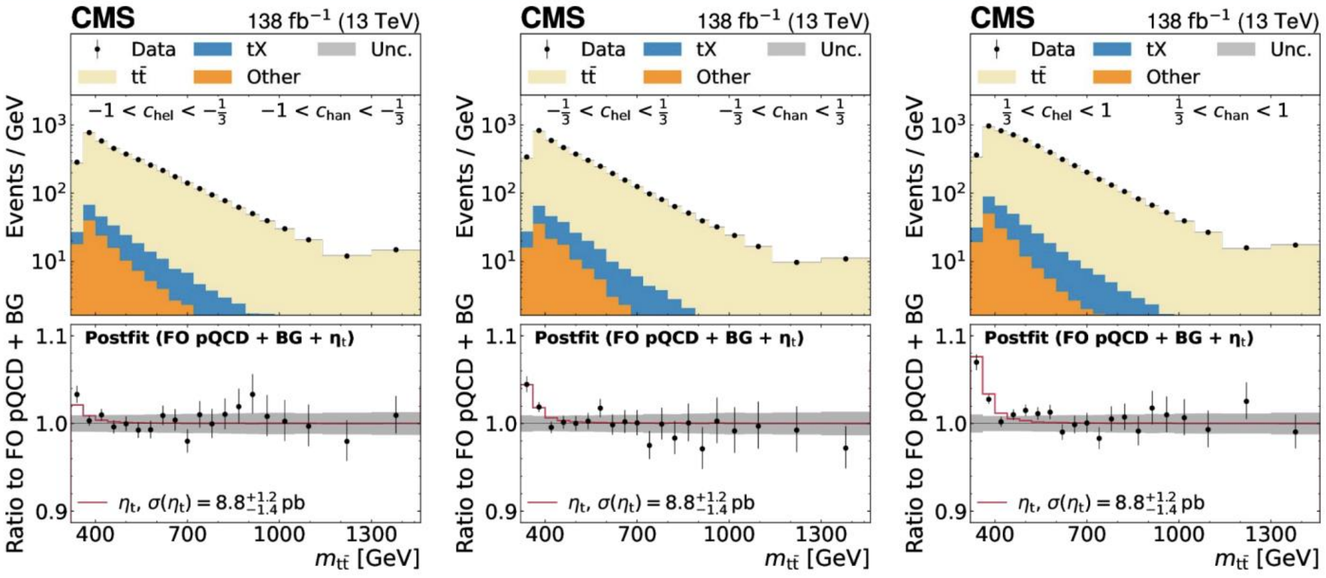
Sergio Sanchez Cruz

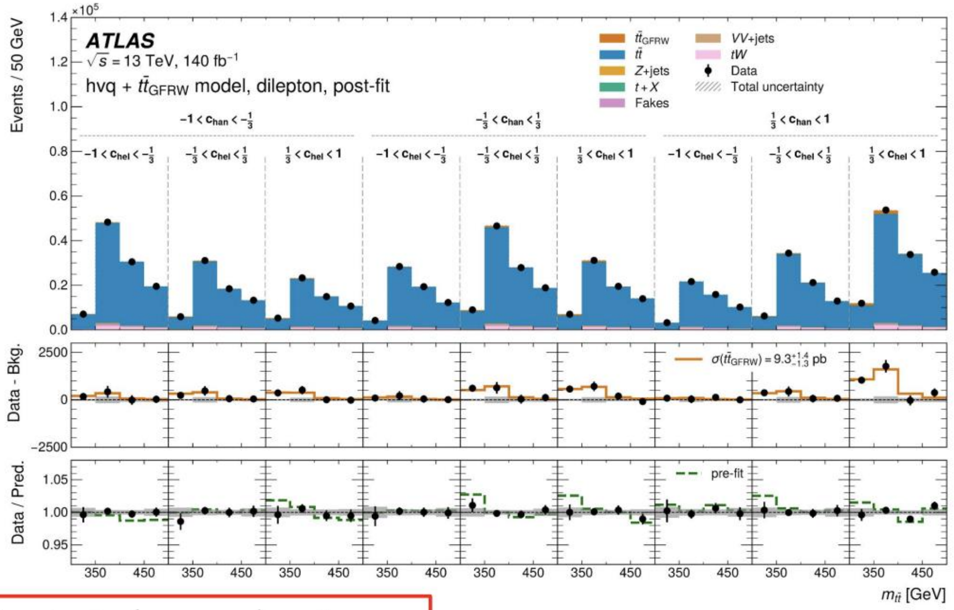


LHC gives access to very rare process with high sensitivity to BSM operators but also very difficult to model

Excess at the threshold: quasi-bound state !

TOPQ-2025-11 ROPP 88 (2025) 087801





$$\sigma(t\bar{t}_{\mathrm{GFRW}}) = 9.3^{+1.1}_{-1.0}\,(\mathrm{stat.})\ \pm 0.8\,(\mathrm{syst.})\,\mathrm{pb}$$

$$\sigma(\eta_t) = 8.8 \pm 0.5\,(\mathrm{stat.})\,^{+1.1}_{-1.3}\,(\mathrm{syst.})\,\mathrm{pb}$$

- Both ATLAS & CMS report a **>5σ excess**, near threshold and behaving like spin-singlet toponium
- Measured cross sections are **compatible with each other** but ~(40±20)% higher than a NRQCD-inspired prediction of 6.43pb. [PRD 104, 034023 (2021)] [Fit with bb4l baseline yield slightly lower cross section.]
- **Large impact of tt̄ modelling systematics on both results!**

Check the backup for further evidence of the signal in tt̄→eμ+bb !