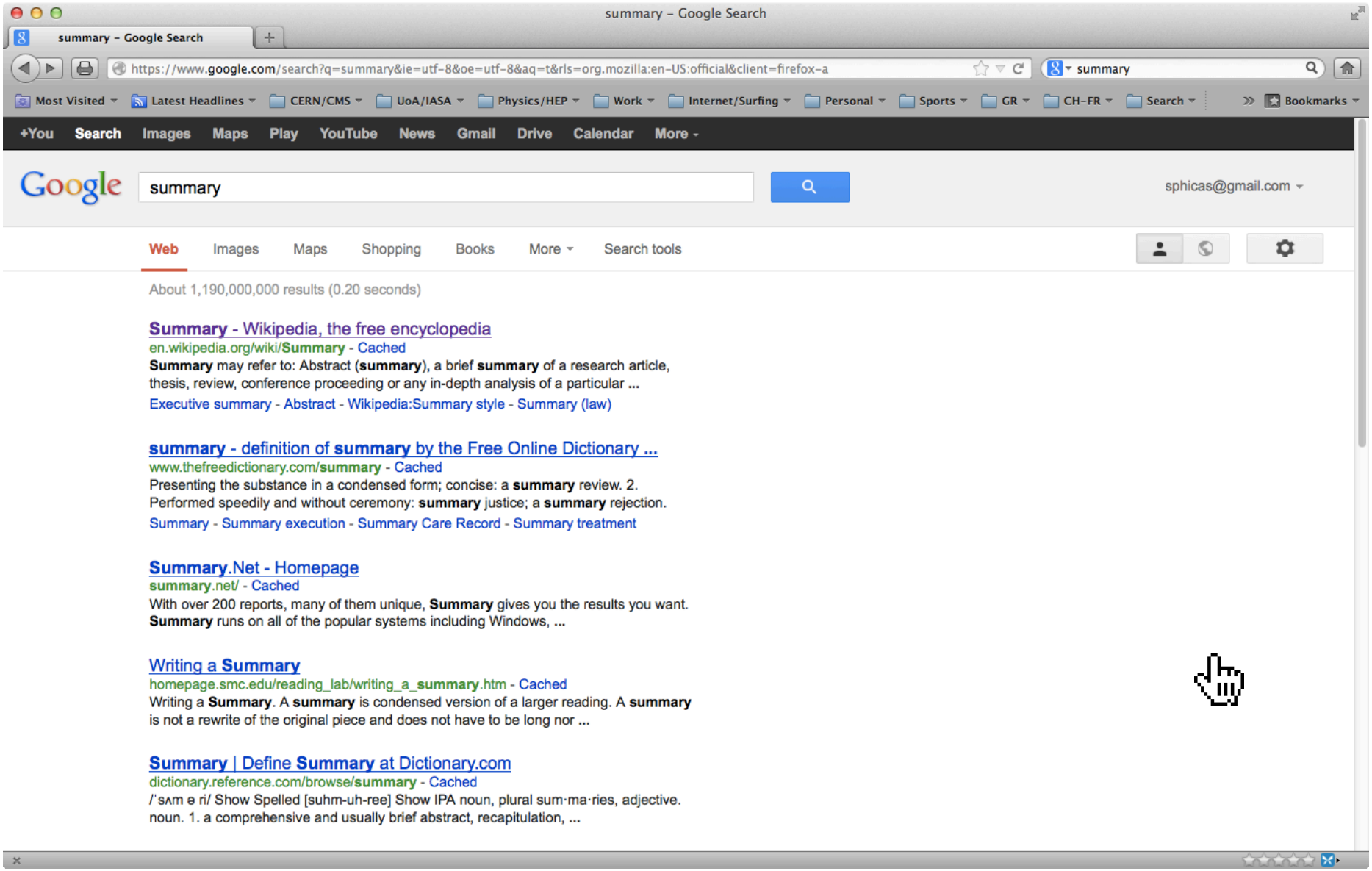
Experimental summary

Paris Sphicas
CERN & University of Athens
ElectroWeak Interactions and Unified Theories
48th Rencontres de Moriond, March 09, 2013

- **The charge**
- **Bread-and-butter physics (aka Standard Model physics)**
- **The dark sector**
- **Nu physics**
- **The SMS-like boson**
- **Searching for New Physics**
- **Some parting thoughts**

www.google.com



Wikipedia/Online dictionary on “summary”

- Abstract (summary), a brief summary of a research article, thesis, review, conference p eding or any in-depth analysis of a particular su scipline…

- Executive summary, a sh or section of a document, produced f urposes, that summarizes a long oposal or a group of related reports, i that readers can rapidly become acqu arge body of material without ha all

- Online Dict enting the substance in a condensed form; concise. a summary review

Clearly, way too hard (impossible)

Advice on “summary”

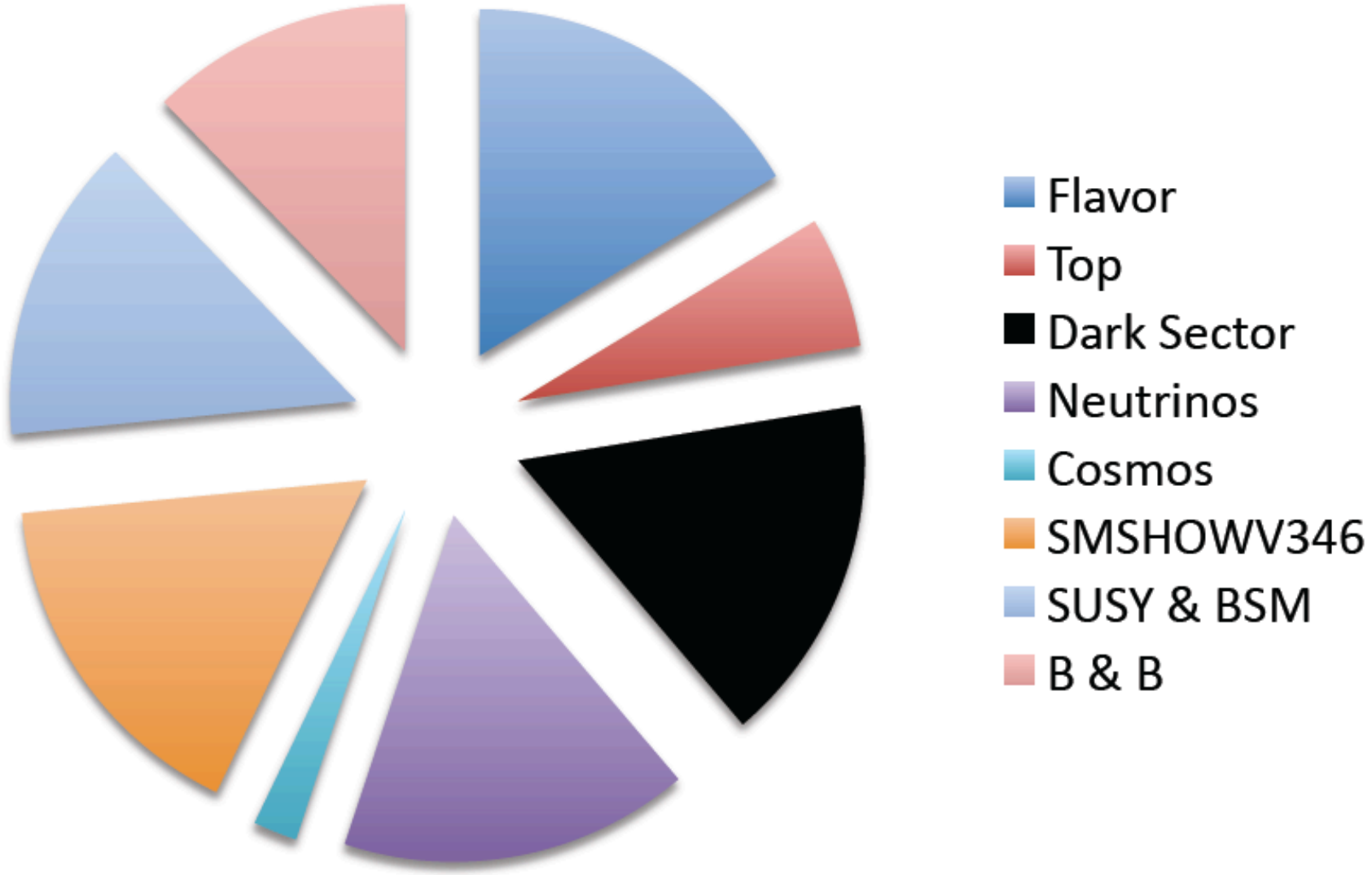
- **Org Committee Member #1: please don’t summarize**
- **Attendee (esteemed colleague): summaries are either boring or provocative**
- **Org Committee Member #2: talk about the future**
- **Attendee (another est. coll.): do the vision thing**
- **Attendee (another est. coll.): I feel so sorry for you**
- **Attendee (highly est. coll.): Pontificate!**

Ad hoc redefinition of talk

Moriond EWK 2013: experimental highlights, lots of opinions, some summaries some observations, free advice

Note added to proof:

Moriond EWK 2013



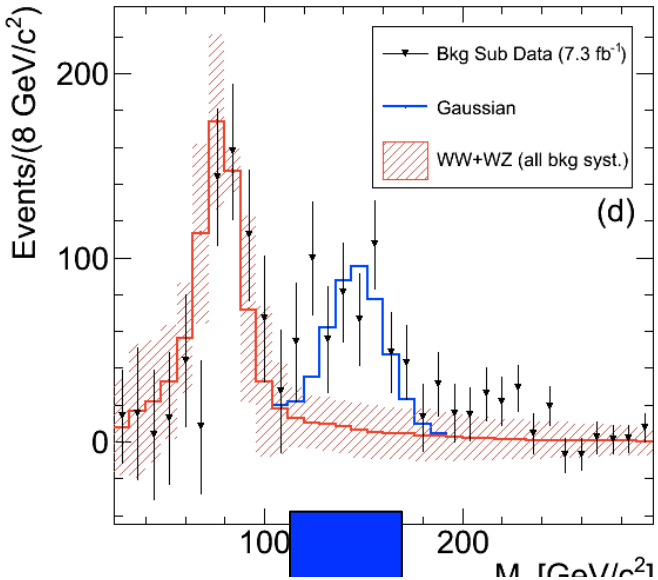
Summary

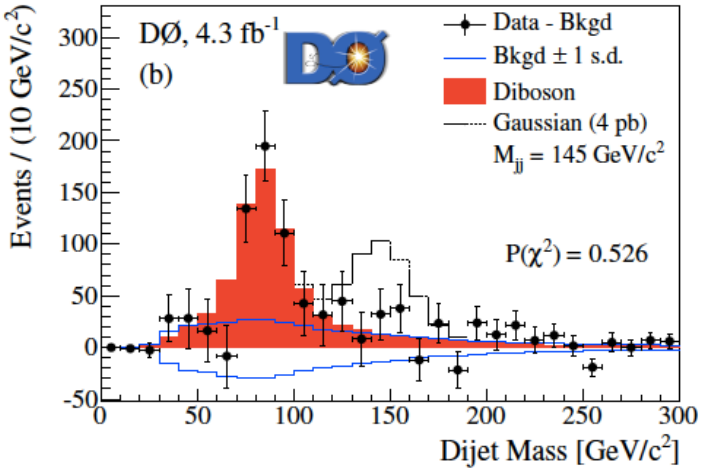
- A very large number of new physics results
- Including many results on nu physics
- But no new physics
  - All discrepancies of the past are either gone or moving towards their politically correct values
  - The new boson looks (decays), sounds (yields), smells (no new smells), tastes ((no new flavors) and feels (0^+…) like the SMS (WHOAVO246GEV)
  - No signs of SUSY
  - No signs of any exotica
- To this day, reasons for believing in accessible Physics BSM are both
  - Real (experimental): dark matter and neutrino masses
  - Virtual (theoretical): natural explanation of nature

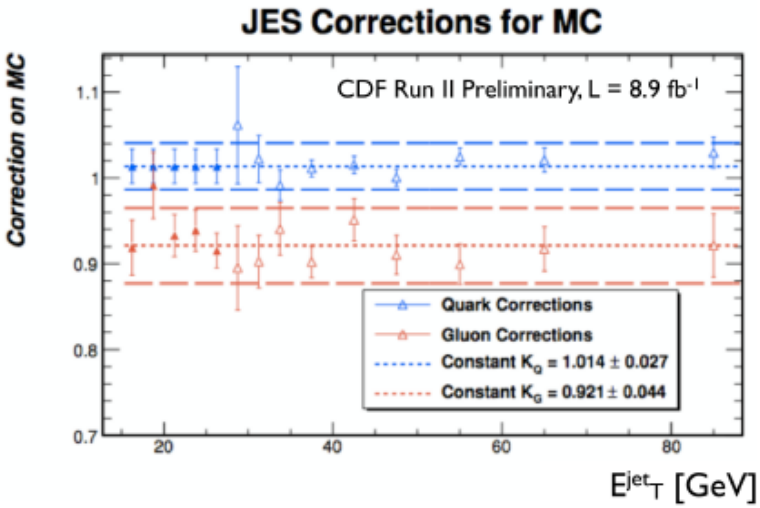
Cool physics

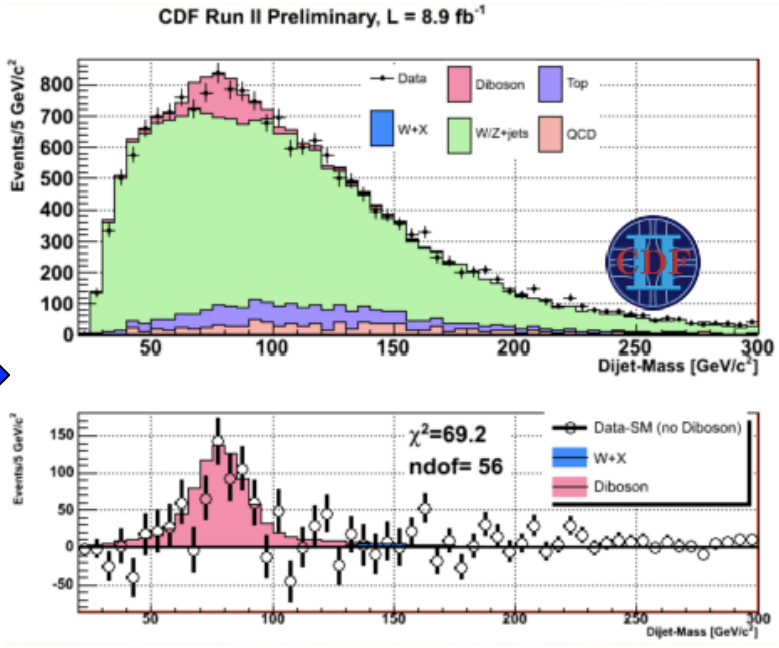
The W+jj emergency is officially closed

Hang Yin





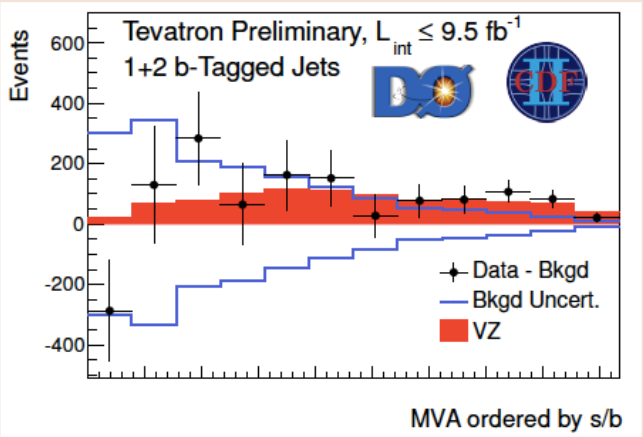




Dibosons @ TeV

Hang Yin

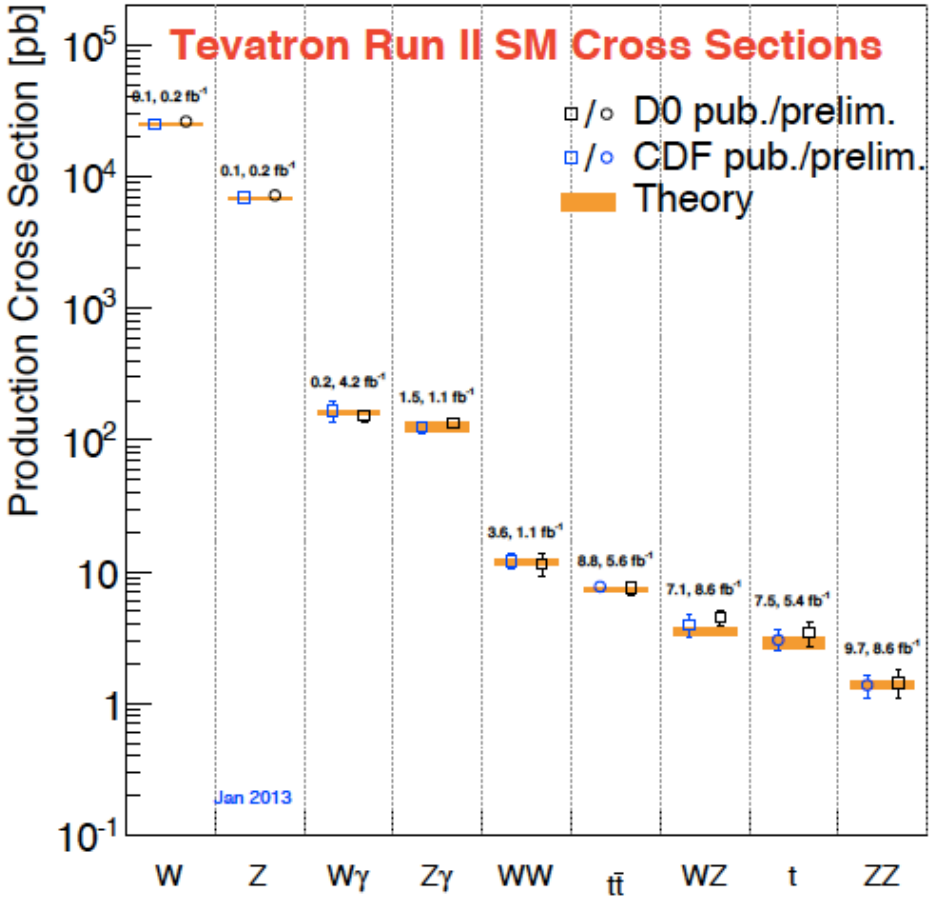
CDF and D0 diboson heavy-flavor final states combination (exploit MVA information)



$\sigma(WZ + ZZ) = 4.47 \pm 0.64(stat.) \pm 0.72(syst.)$ pb

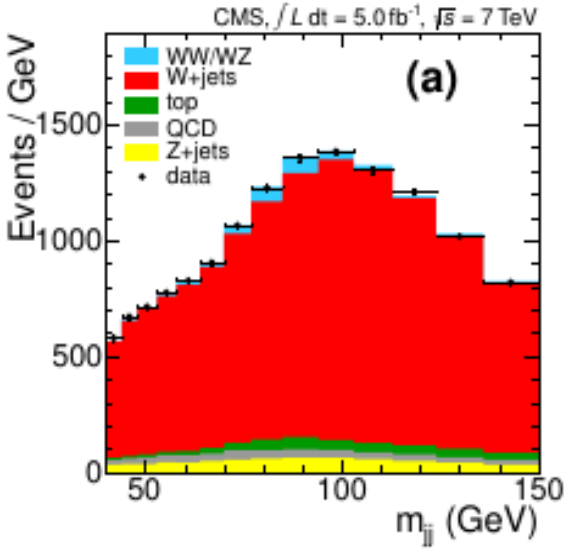
observed with 4.6 s.d.

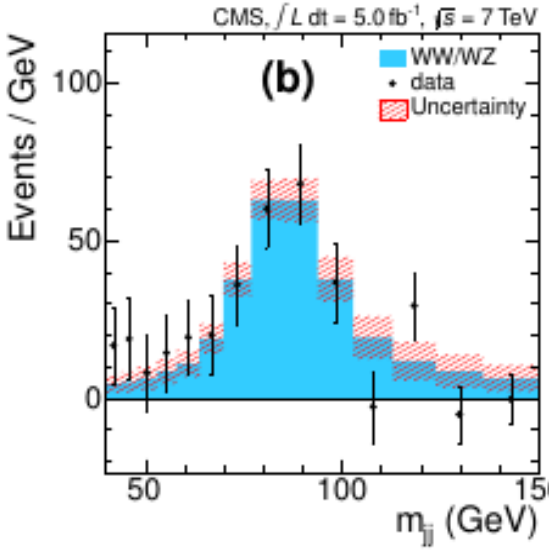
arXiv:1203.3782 (2012)

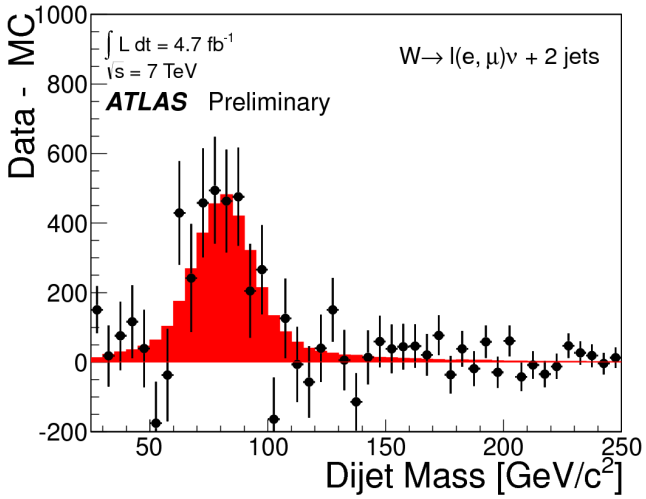


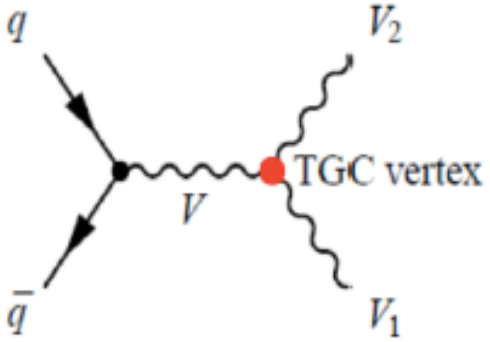
Dibosons @ LHC

Samira Hassani





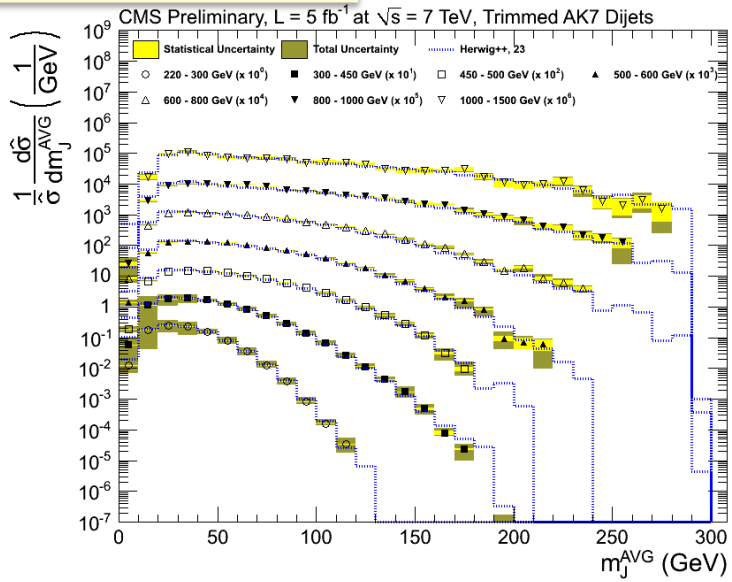


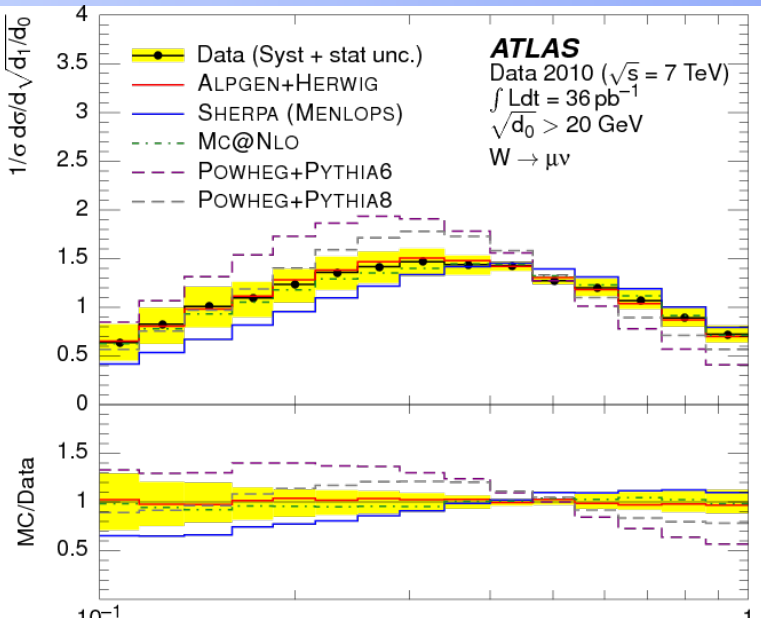


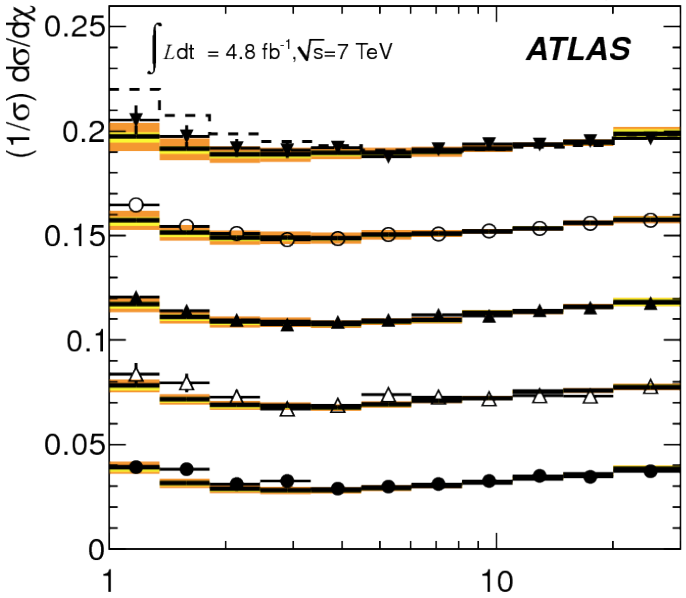
95% C.L.	$\Delta\kappa^{\gamma}$	λ	Δg_1^Z
$W\gamma \rightarrow l\nu\gamma$	[-0.38, 0.29]	[-0.05, 0.037]	-
$W^+W^- \rightarrow l\nu l\nu$	[-0.21, 0.22]	[-0.048, 0.048]	[-0.095, 0.095]
$W^+W^-+WZ \rightarrow l\nu jj$	[-0.111, 0.142]	[-0.038, 0.030]	-

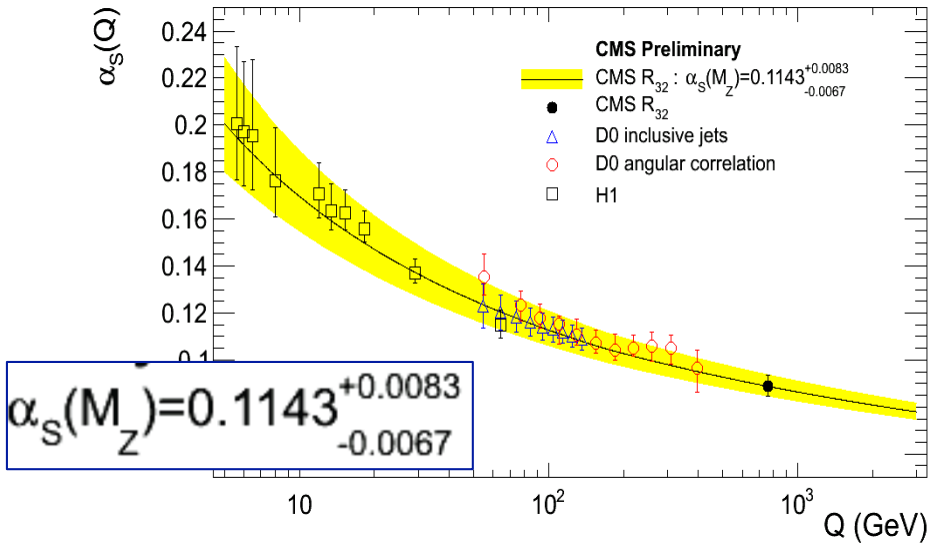
QCD at work

Niki Saoulidou







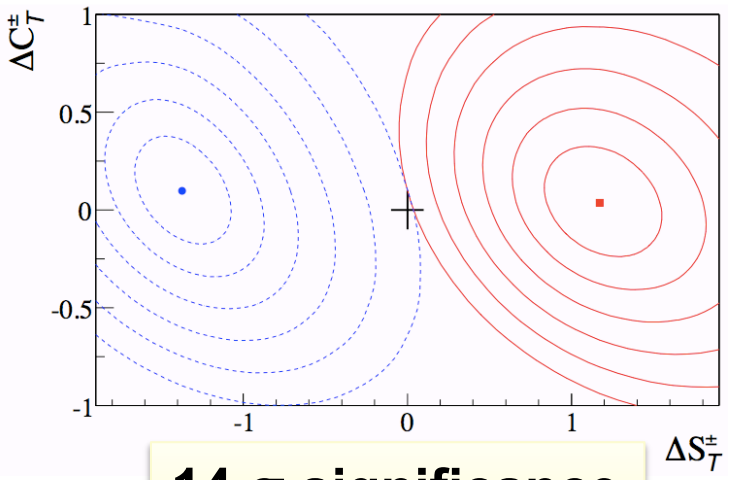


$\alpha_s(M_Z)=0.1143^{+0.0083}_{-0.0067}$

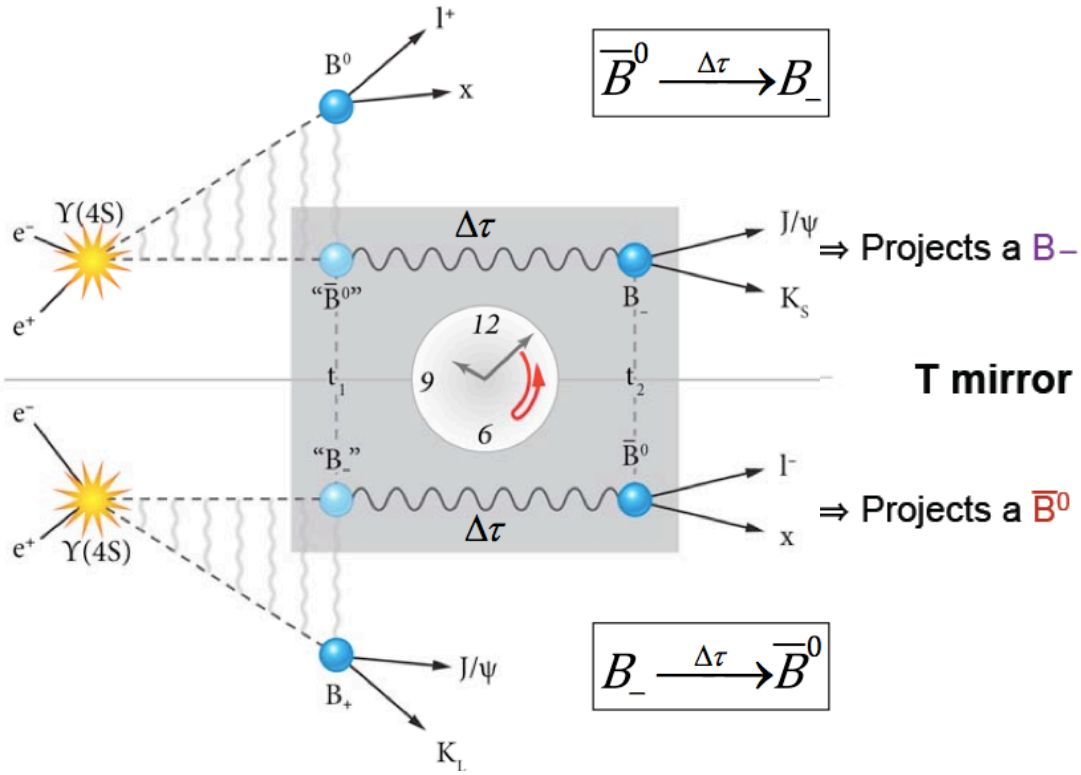
Flavor physics
(aka new physics
at very, very high scales)

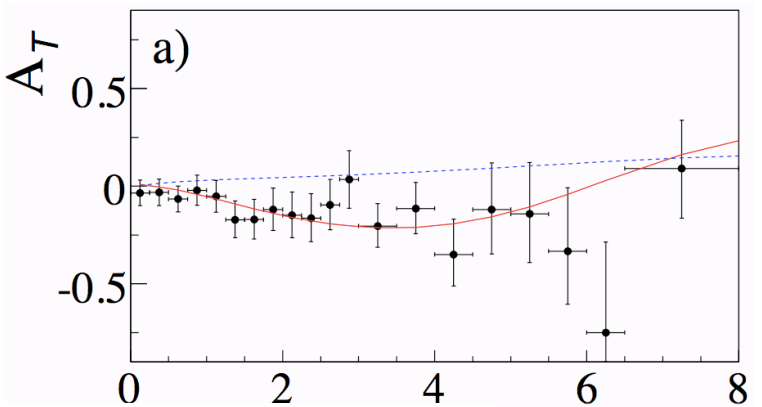
T violation (Babar)

- **Beautiful measurement (though not the first T-violation one; yet, it's very direct and clear one …)**



14 σ significance





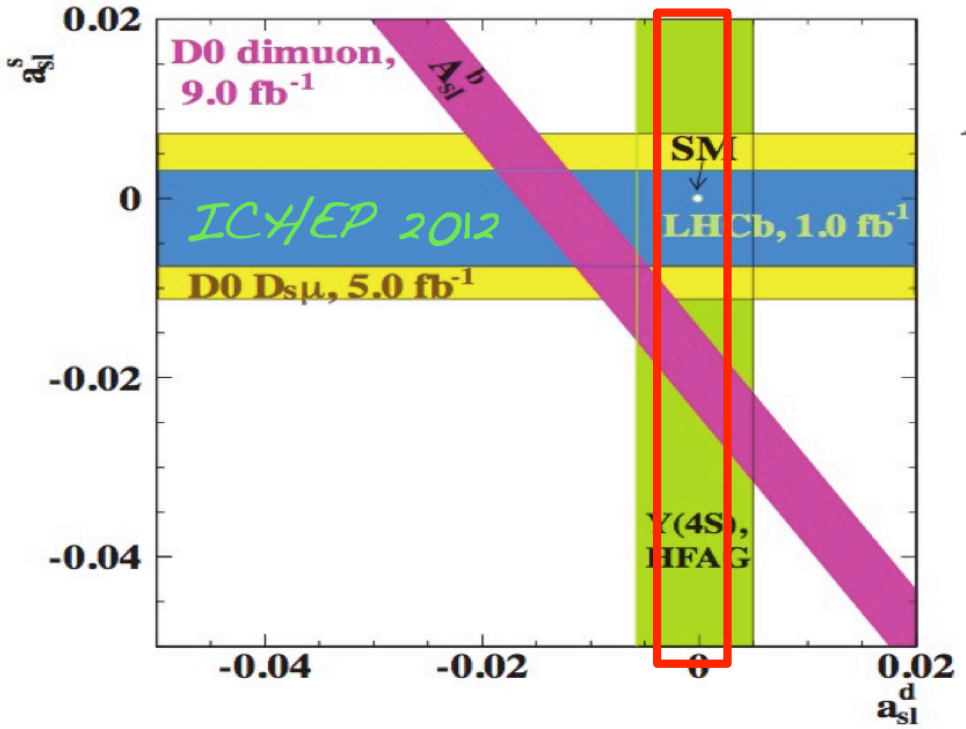
$$g^{\pm}_{\alpha,\beta}(\Delta\tau) \propto e^{-\Gamma\Delta\tau}\{1 + S^{\pm}_{\alpha,\beta}\sin(\Delta m_d\Delta\tau) + C^{\pm}_{\alpha,\beta}\cos(\Delta m_d\Delta\tau)\}$$

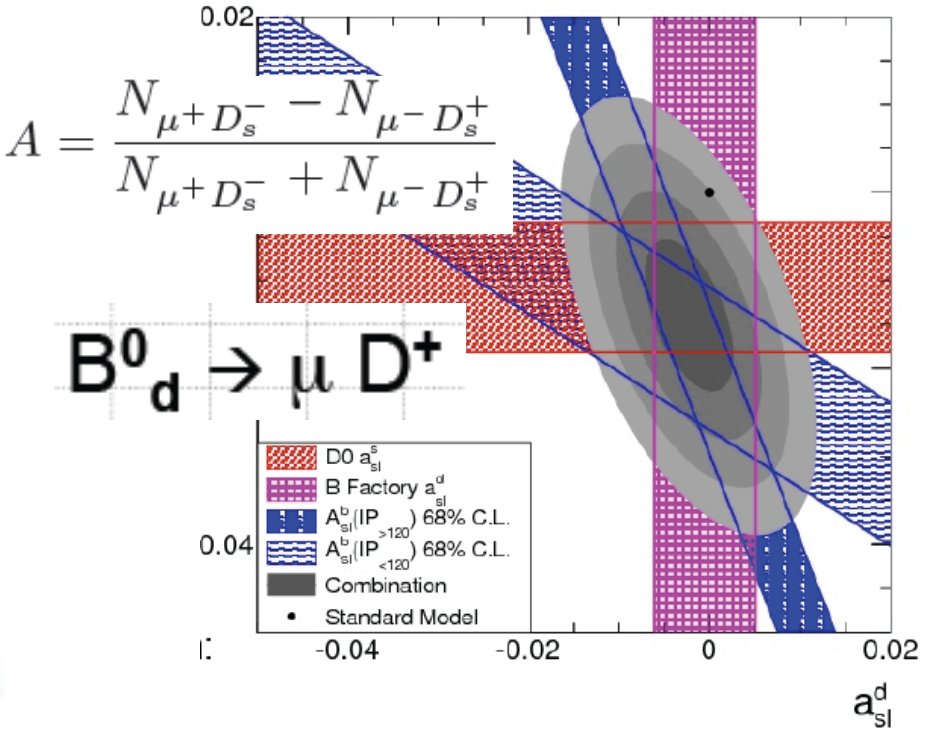
CP violation in B^0 mixing

$$\mathcal{A}_{CP} = (0.06 \pm 0.17^{+0.36}_{-0.32})\%$$

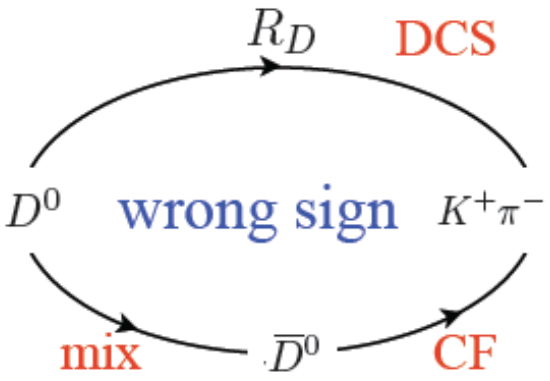
$$1 - |q/p|$$

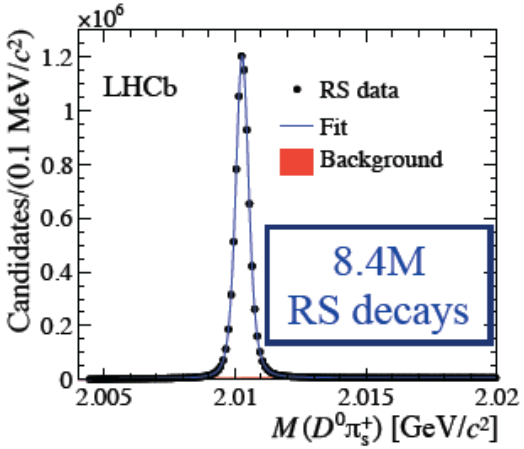
$$= (0.29 \pm 0.84^{+1.78}_{-1.61}) \times 10^{-3}$$

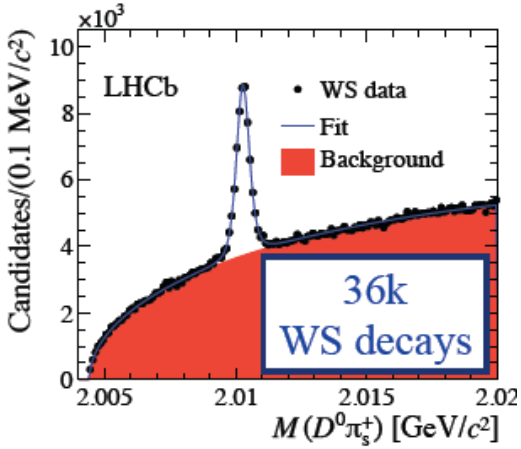


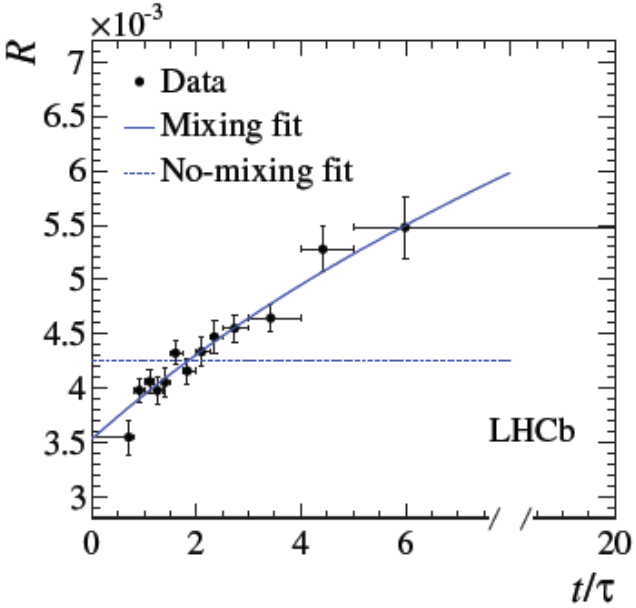


D^0 mixing (LHCb-and-c)

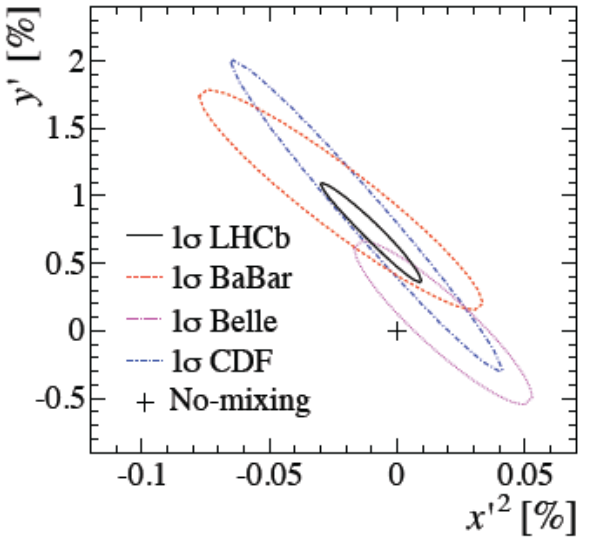








No mixing: Excluded at 9.1σ



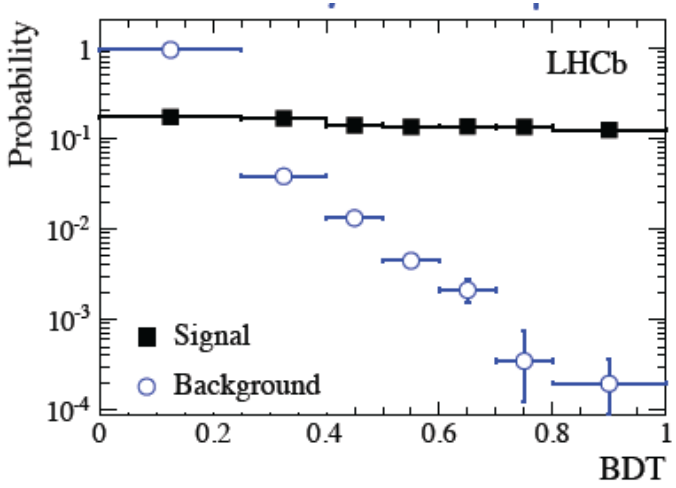
$$R(t) \approx R_D + \sqrt{R_D}\, y' \frac{t}{\tau} + \frac{x'^2 + y'^2}{4} \left(\frac{t}{\tau}\right)^2$$

$B_s \to \mu\mu$

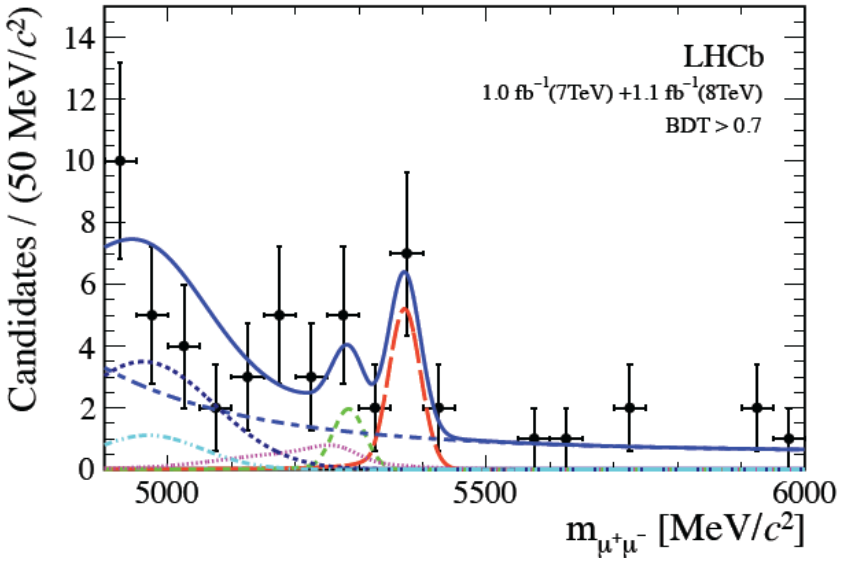
$$\mathrm{BR} = \mathrm{BR}_{\mathrm{cal}} \times \frac{\epsilon_{\mathrm{cal}}^{\mathrm{REC}}\,\epsilon_{\mathrm{cal}}^{\mathrm{SEL|REC}}\,\epsilon_{\mathrm{cal}}^{\mathrm{TRIG|SEL}}}{\epsilon_{\mathrm{sig}}^{\mathrm{REC}}\,\epsilon_{\mathrm{sig}}^{\mathrm{SEL|REC}}\,\epsilon_{\mathrm{sig}}^{\mathrm{TRIG|SEL}}} \times \frac{f_{\mathrm{cal}}}{f_{B_q^0}} \times \frac{N_{B_q^0\to\mu^+\mu^-}}{N_{\mathrm{cal}}} = \alpha_{\mathrm{cal}} \times N_{B_q^0\to\mu^+\mu^-}$$

Combined result at 7 TeV

$$f_s/f_d = 0.256 \pm 0.020$$



$$\alpha_{B_s^0\to\mu^+\mu^-} = (2.80 \pm 0.25) \times 10^{-10}$$



$\mathrm{BR} = (3.2^{+1.4}_{-1.2}\,(\mathrm{stat})\,^{+0.5}_{-0.3}\,(\mathrm{syst}))\times 10^{-9}$

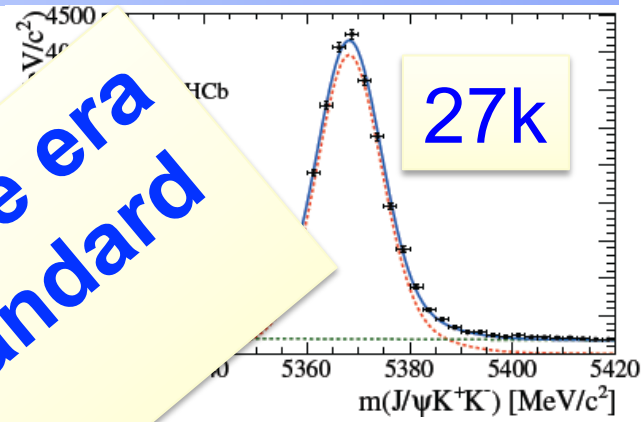
Note: stat ≈ 3 x syst

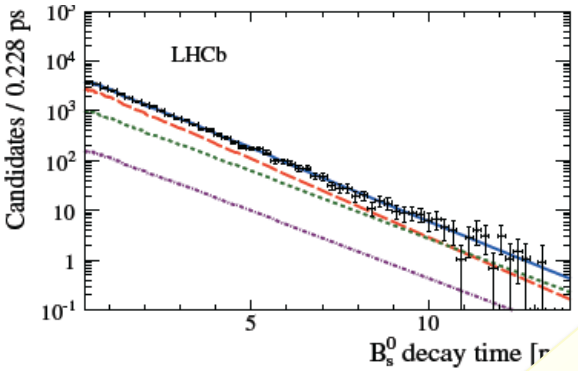
SM expectation
$(3.54\pm0.30)\times10^{-9}$

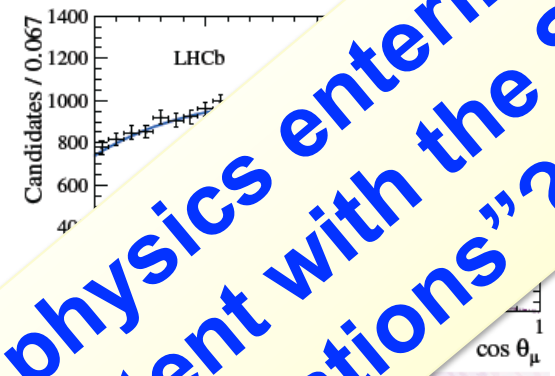
CP violation in B_s (I)

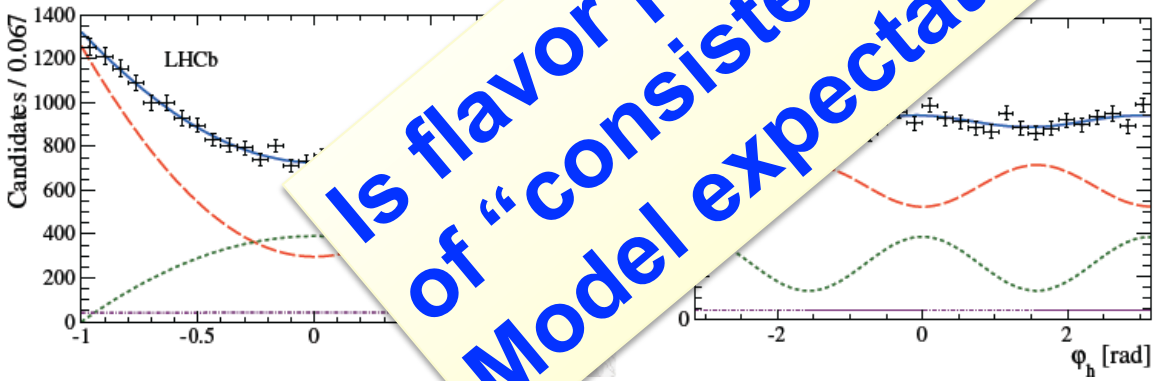
$\phi_s = -2\ \arg(V_{ts}\, V_{tb}^*/V_{cs}\, V_{cb}^*) \sim -0.04$

Charles *et al.* (2011) Phys. Rev **D84** 033

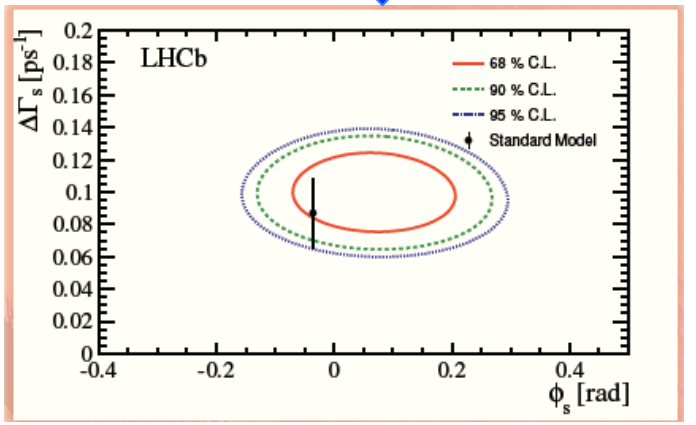








Is flavor physics entering the era of "consistent with the Standard Model expectations"?



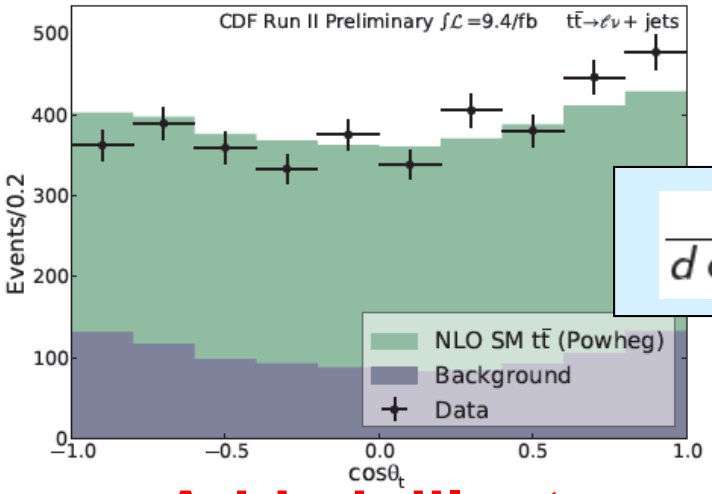
Truly Heavy Flavor
(“top”, or “truth”, quark)

Forward-backward asymmetry

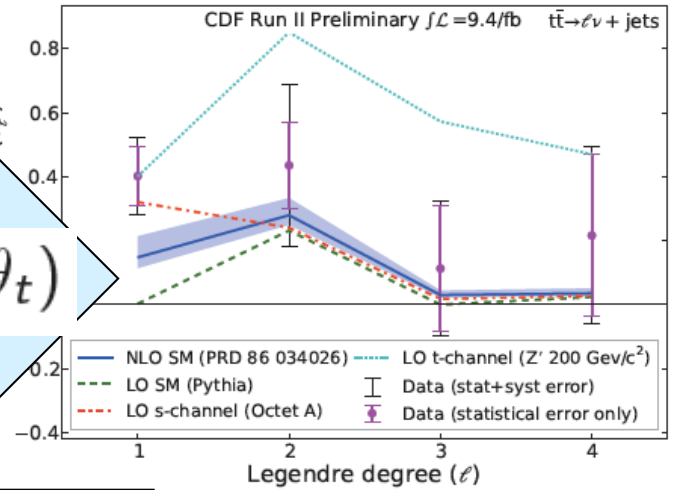
Jonathan Wilson

- **Full $\cos\theta_t$ distribution (A_{FB}: 2 bins)**
  - **Expand in Legendre polynomials:**

a_1 accounts for A_{FB}

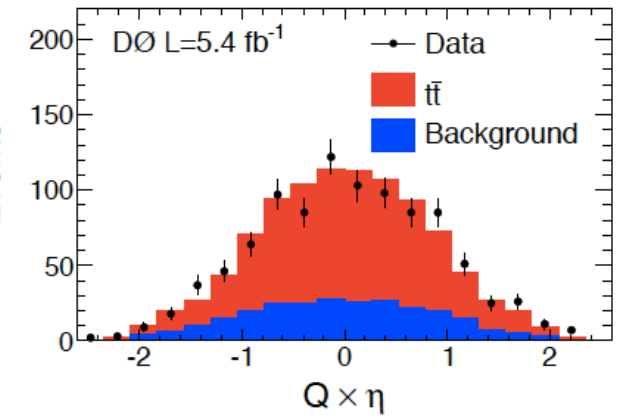


$$\frac{d\sigma}{d\cos\theta_t} = \sum_\ell a_\ell P_\ell(\cos\theta_t)$$



- **Added dileptons:**

$$A_{FB}^{\ell} = \frac{N(q_\ell\eta_\ell>0) - N(q_\ell\eta_\ell>0)}{N(q_\ell\eta_\ell>0) + N(q_\ell\eta_\ell>0)}$$



=0.058±0.053

- **Then lepton+jets**

$$A_{FB}^{\ell} = 0.094^{+0.032}_{-0.029}$$

Expected from A_{FB}: ~0.76

Forward-backward asymmetry at LHC

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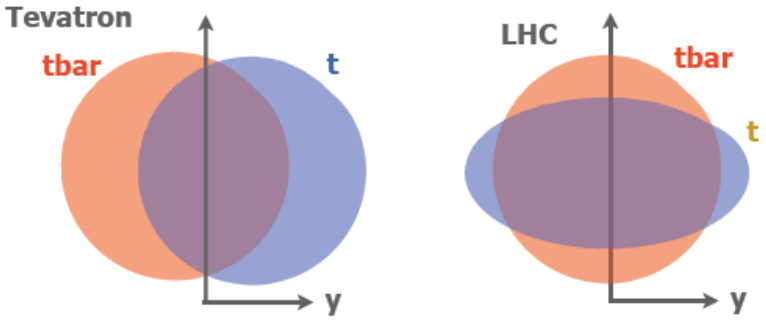


Reconstructing $t\bar{t}$: $\Delta|y| = |y_t| - |y_{\bar{t}}|$

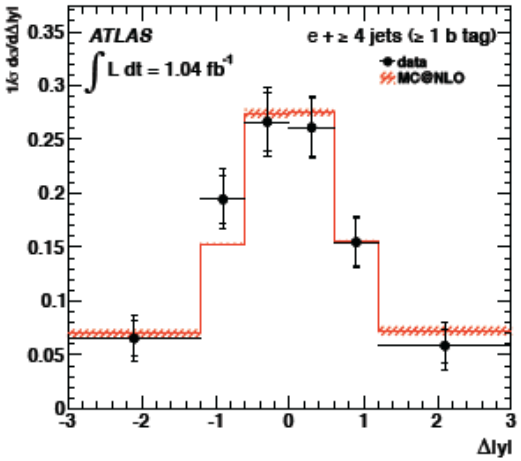
$$A_C = \frac{N(\Delta|y|>0) - N(\Delta|y|<0)}{N(\Delta|y|>0) + N(\Delta|y|<0)}$$

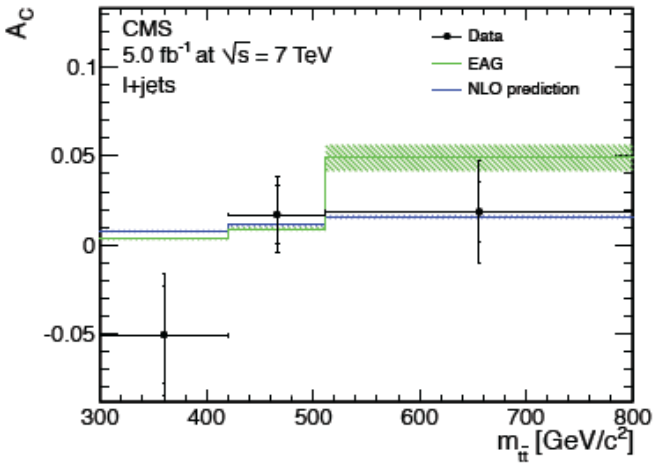
In dilepton decays can also use: $\Delta|\eta| = |\eta_{l+}| - |\eta_{l-}|$

$$A^{ll}{}_C = \frac{N(\Delta|\eta|>0) - N(\Delta|\eta|<0)}{N(\Delta|\eta|>0) + N(\Delta|\eta|<0)}$$

ATLAS Combined [ATLAS-CONF-2012-057]:

$A_C = 0.029 \pm 0.018_{(stat)} \pm 0.014_{(syst)}$





Top studies

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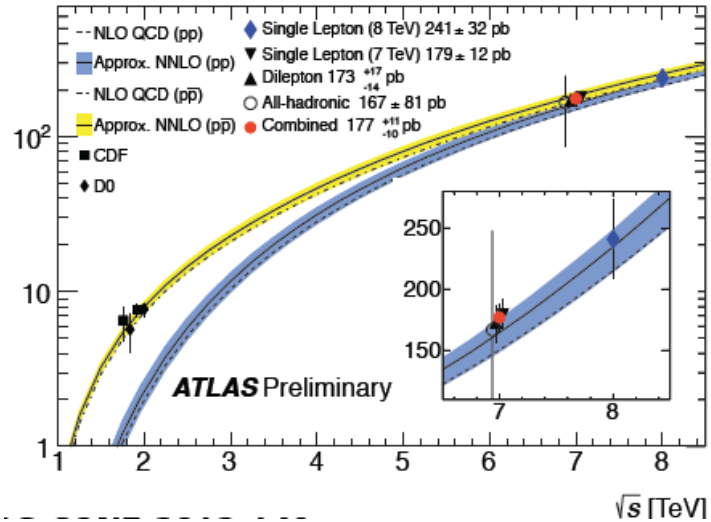
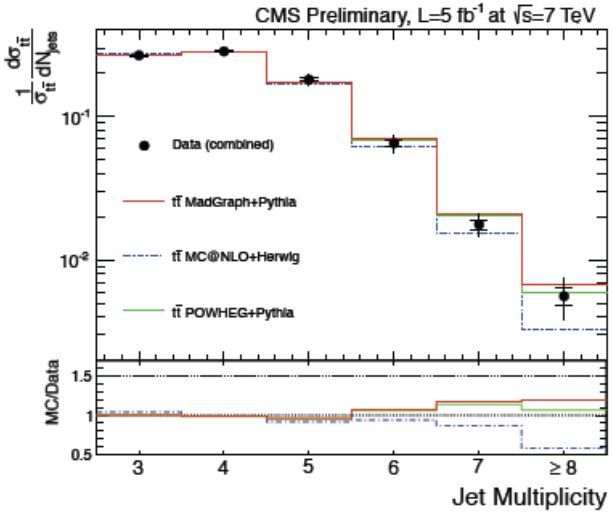
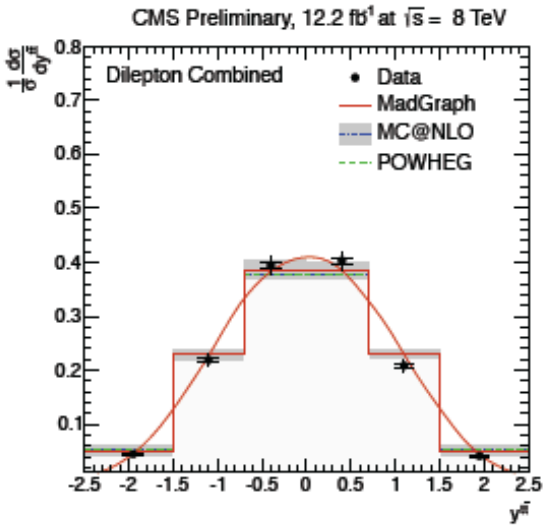
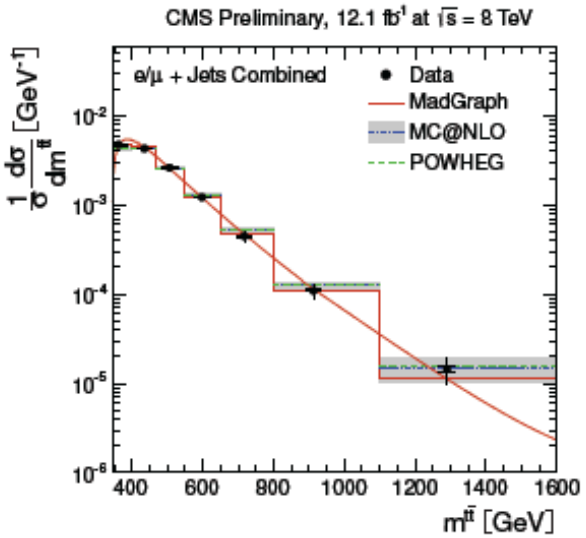
- **Beyond cross section: kinematic/topological analysis**

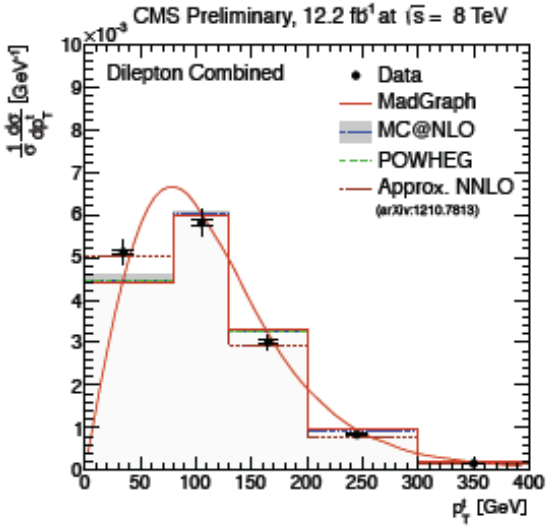




CMS New







Top mass

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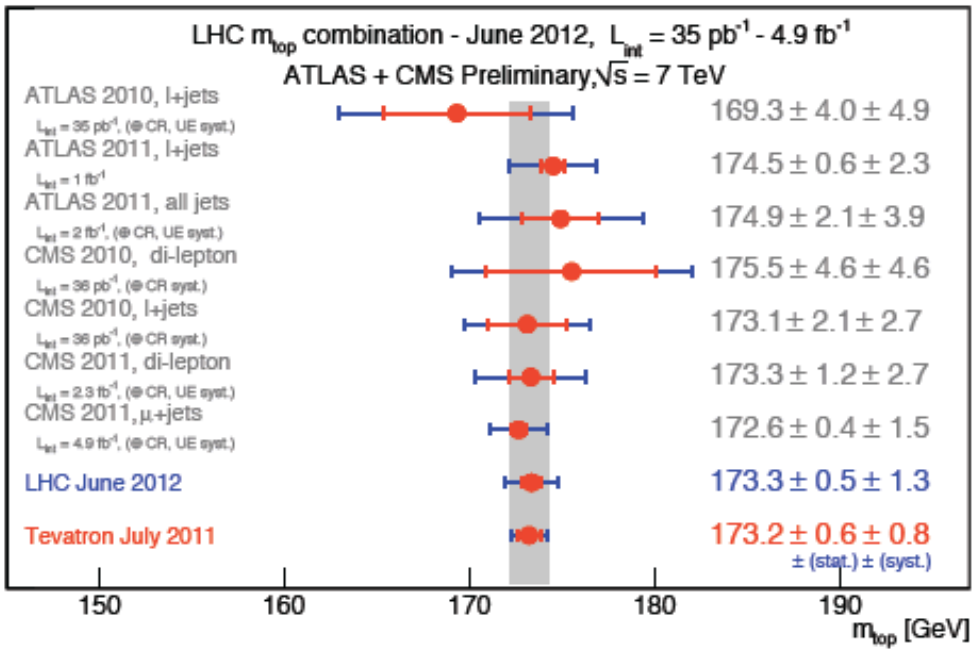
Methods used

- **Template Fit Method**
  - select reconstruct
  - build template fits
    m_t) and for bkg, t
- **Analytical Matrix Wei**
  - used for dilepton
  - reconstruct analyt
    possible m_t values
  - assign a weight b
    m_t the one with la
  - get m_t from likelih
- **Ideogram Method**
  - reconstruct $m_{t\text{-fitte}}$
  - ev. by ev. likelihoc
  - based on the p(m
    accounts all differ
- **In-situ Jet Energy Sc**
  - impact m_t measur
  - use m_W constraint
    measurement itse

not covered here)

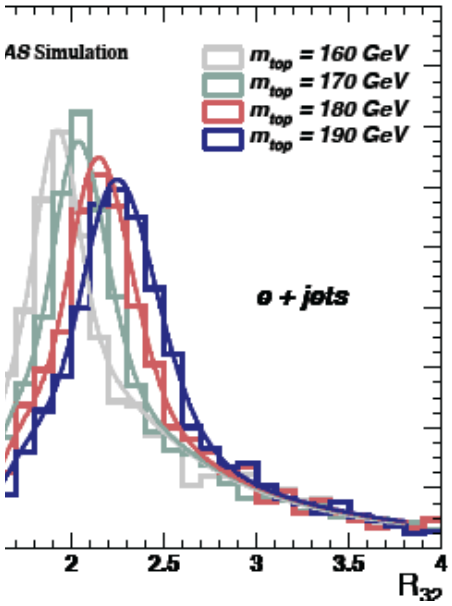


Tevatron

m_t^{comb} = 173.18 ± 0.56(stat) ± 0.75(syst) GeV
= 173.18 ± 0.94 GeV

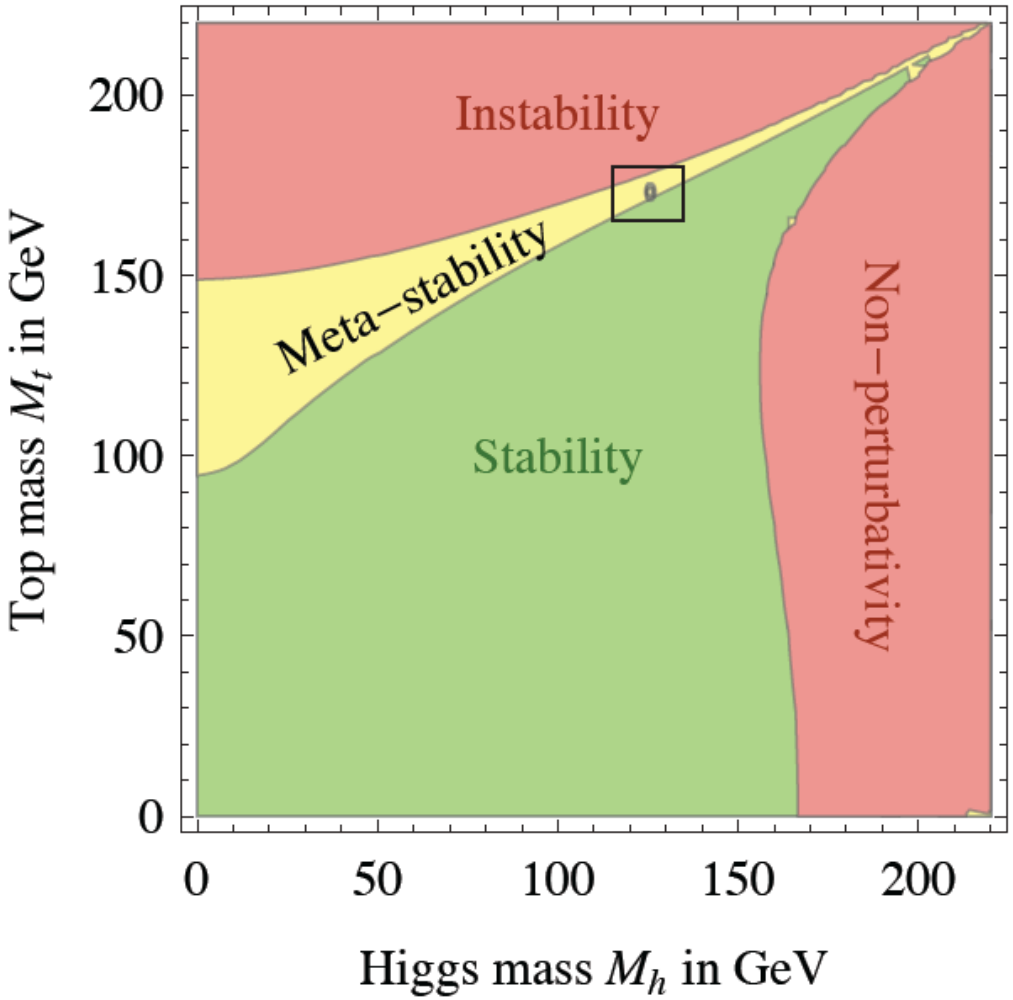
CMS

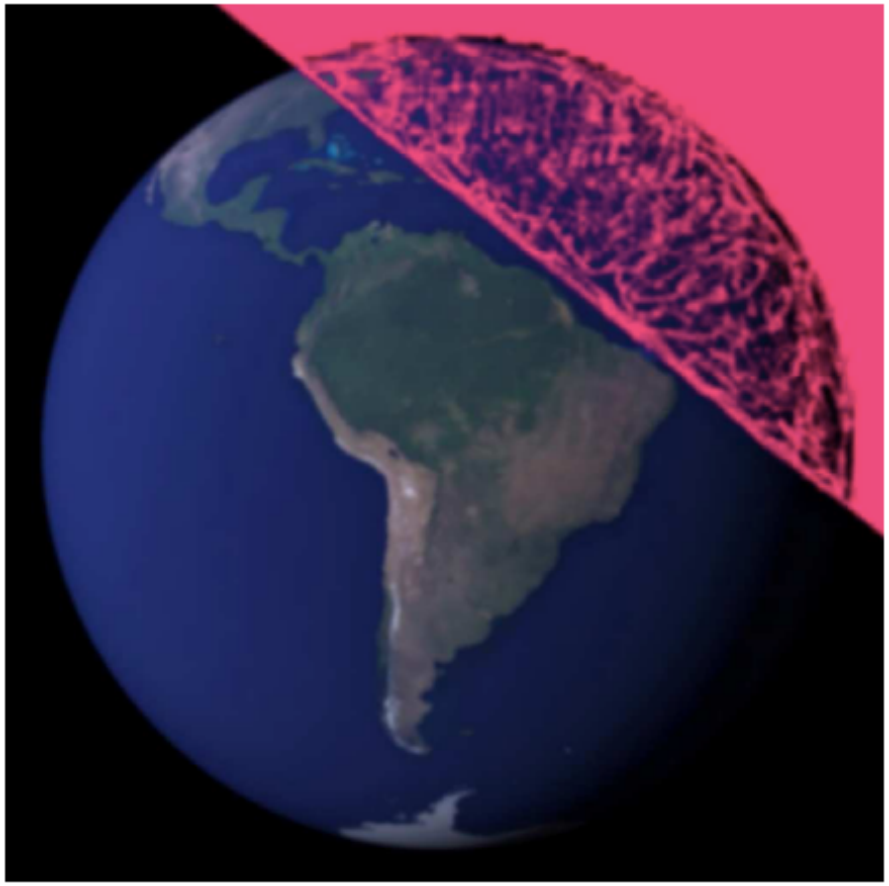
m_t^{comb} = 173.36 ± 0.38(stat) ± 0.91(syst) GeV
= 173.36 ± 1.10 GeV



Top mass: an important parameter

- **Perhaps even more important than originally thought**





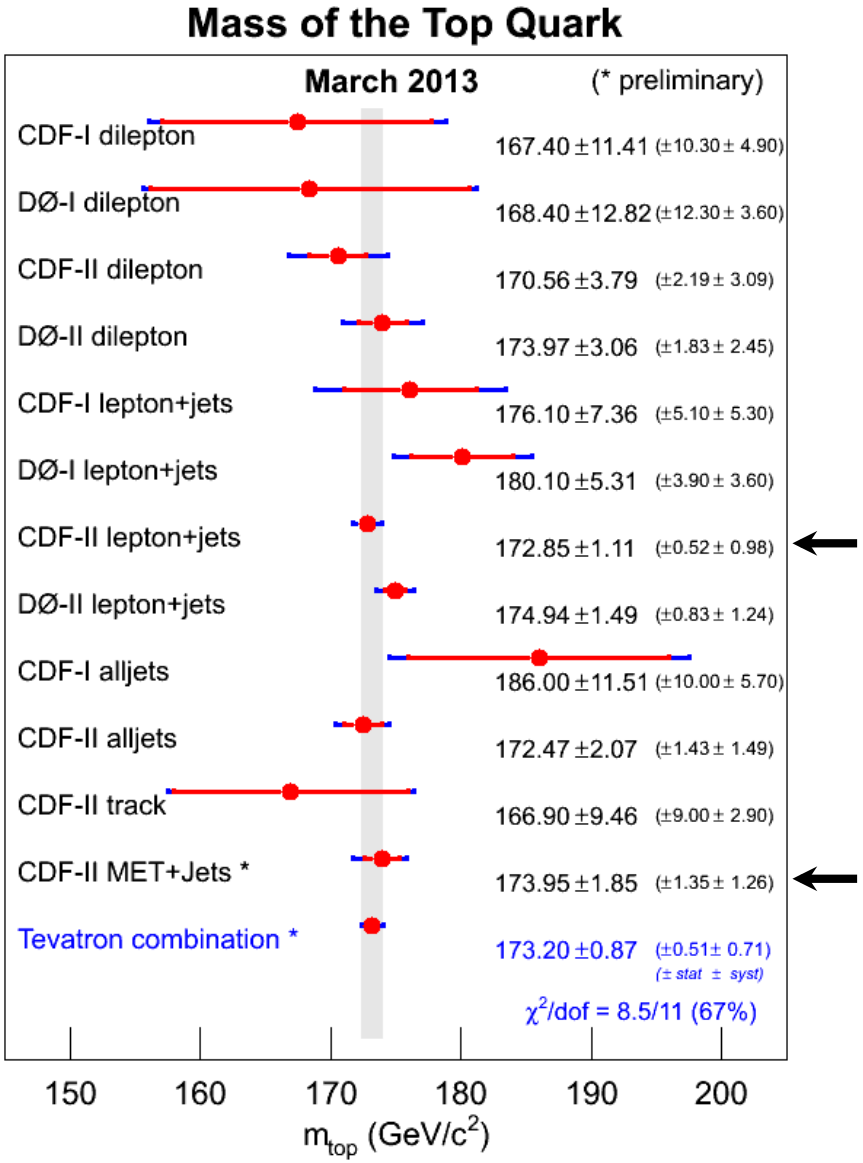
Tevatron Top Quark Mass Combination March 2013

- **no changes in the combination method (BLUE) or systematic assignments**
- **2 updated measurements from CDF using their final data set (indicated by arrows)**

	Tevatron combined values (GeV/c^2)
M_t	173.20
In situ light-jet calibration (iJES)	0.36
Response to b/q/g jets (aJES)	0.09
Model for b jets (bJES)	0.11
Out-of-cone correction (cJES)	0.01
Light-jet response (2) (dJES)	0.15
Light-jet response (1) (rJES)	0.16
Lepton modeling (LepPt)	0.05
Signal modeling (Signal)	0.52
Jet modeling (DetMod)	0.08
Offset (UN/MI)	0.00
Background from theory (BGMC)	0.06
Background based on data (BGData)	0.13
Calibration method (Method)	0.06
Multiple interactions model (MHI)	0.07
Systematic uncertainty (Syst)	0.71
Statistical uncertainty (Stat)	0.51
Total uncertainty	0.87

$$M_{\mathrm{t}} = 173.20 \pm 0.87\,\mathrm{GeV}/c^2$$

July 2012: $M_{\mathrm{t}} = 173.18 \pm 0.94\,\mathrm{GeV}/c^2$



Summary

- **Most abnormalities are gone**
  - **CDF W+jj "resonance"**
  - **B semileptonic asymmetry**
  - **B $\rightarrow \tau \nu$ (not shown here, but presented at the conf.)**

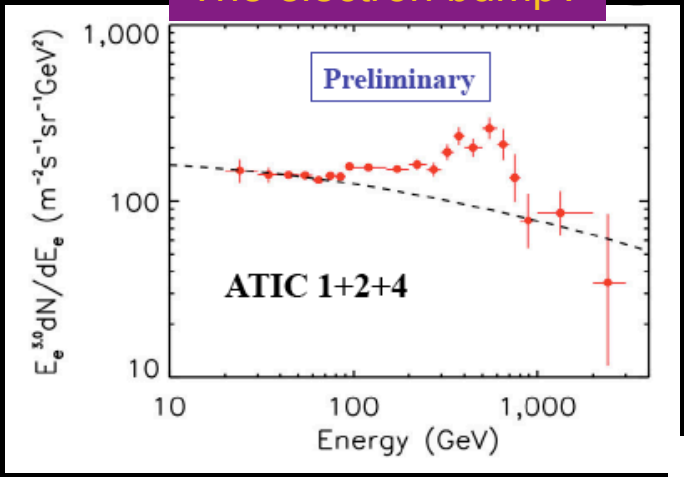
- **Top FB asymmetry still there**
  - **But no additional data expected @ 2TeV**
  - **LHC does not see it – but not quite sensitive yet**
    - **The issue will not be settled "directly" for a while. But direct searches for t-tbar resonances/etc will probably settle this.**

The Dark Sector

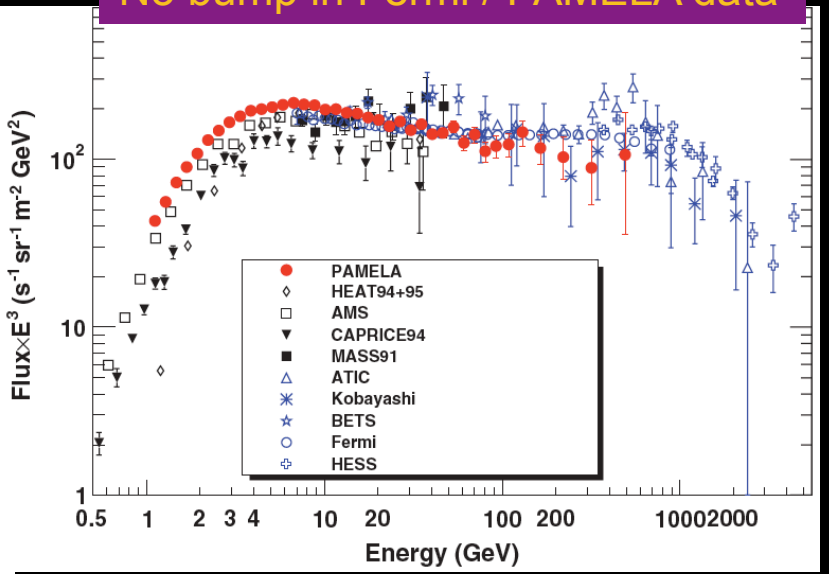
Reasons to attend the AMS talk: experimental input

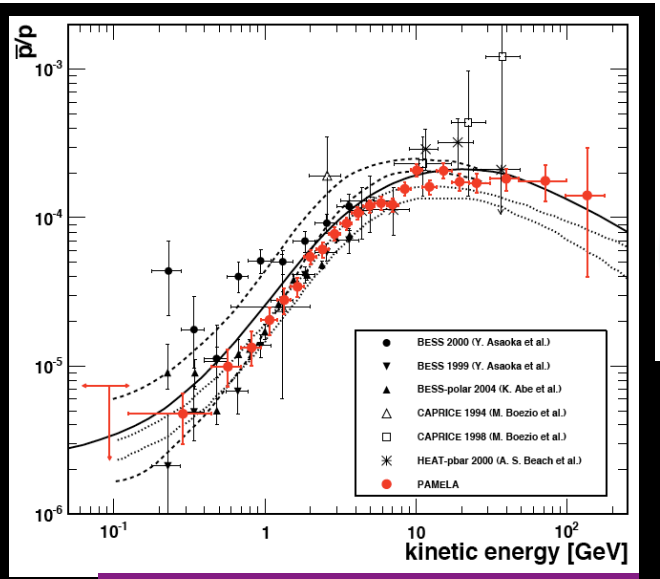
Bruna Bertucci

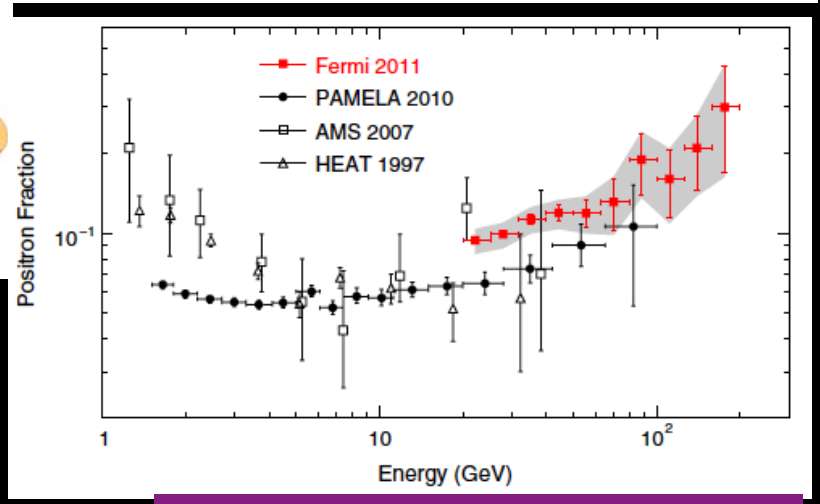
The electron bump?



No bump in Fermi / PAMELA data







No fresh source of anti-p!

A confirmed positron “excess”

Theoretical input

1. Positron yield does not need to be measured.
2. AMS should announce electron spectrum: actual exchange follows: (editorial interventions marked "[ ]")
   - A. Theorist: Your positron fraction will look like PAMELA ['s]
   - B. Bertucci: Hmmm…
   - A. Theorist: It's the electron spectrum which [that] will matter
   - B. Bertucci: What will it look like?
   - A. Theorist: sort of like the positron [one] with a few fluctuations, maybe

- Still: (many people) eagerly awaiting AMS data

Fermi LAT

Gabrijela Zaharijas

- **130 GeV line: one of the current sources of excitement**

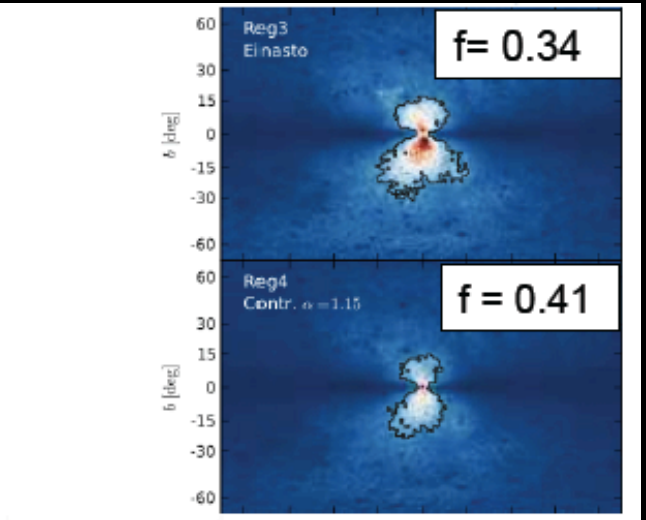
Weniger+ 2012: Evidence for a narrow spectral feature in 3.5 yr data near 130 GeV in **optimized ROIs** near the Galactic center.

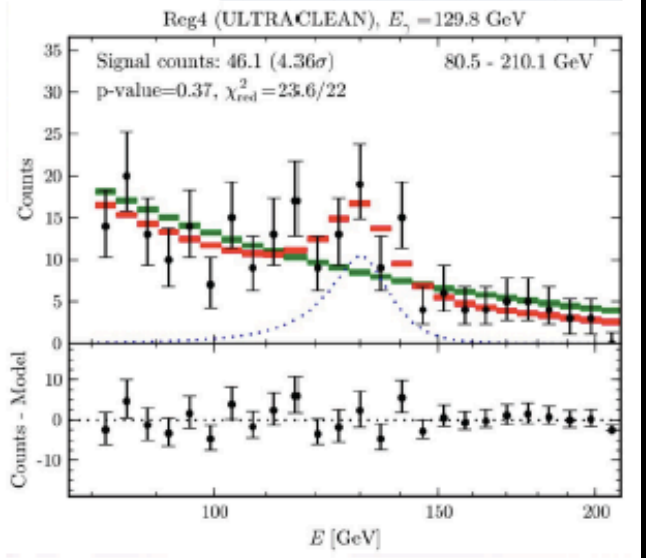
- Signal is particularly strong in 2 out of 5 test regions with

S/N> 30%-60%, with ~>4σ.

- Some indication of double line (111 &130 GeV), Su+, 2012 (1206.1616).

Exciting: 100+ papers since; line-like signature considered a smoking gun of DM!



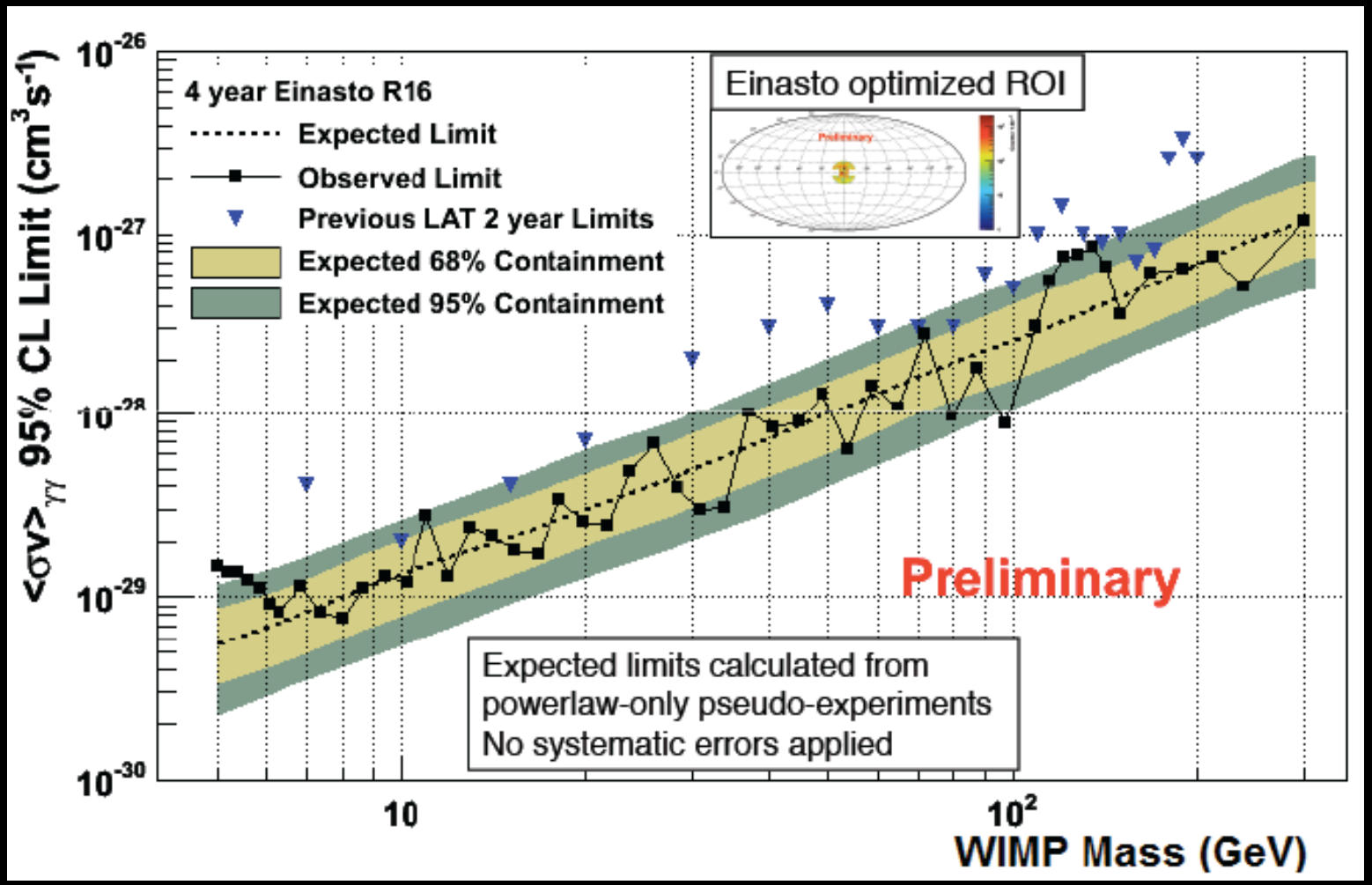


C. Weniger JCAP 1208 (2012) 007 arXiv:1204.2797

Fermi-LAT (II)

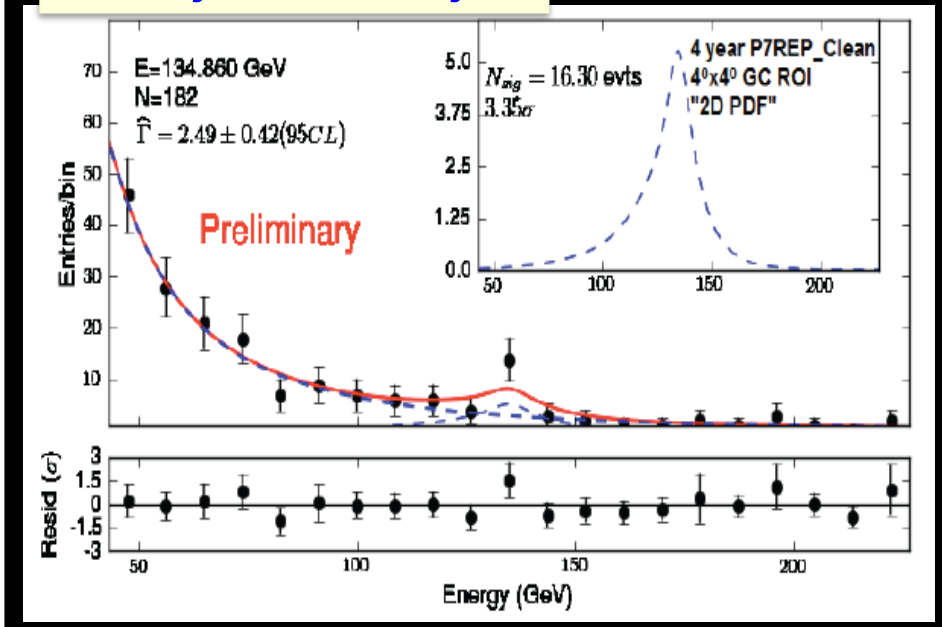
Gabrijela Zaharijas

- **Blind search → no line found**



Fermi-LAT (III)

Gabrijela Zaharijas

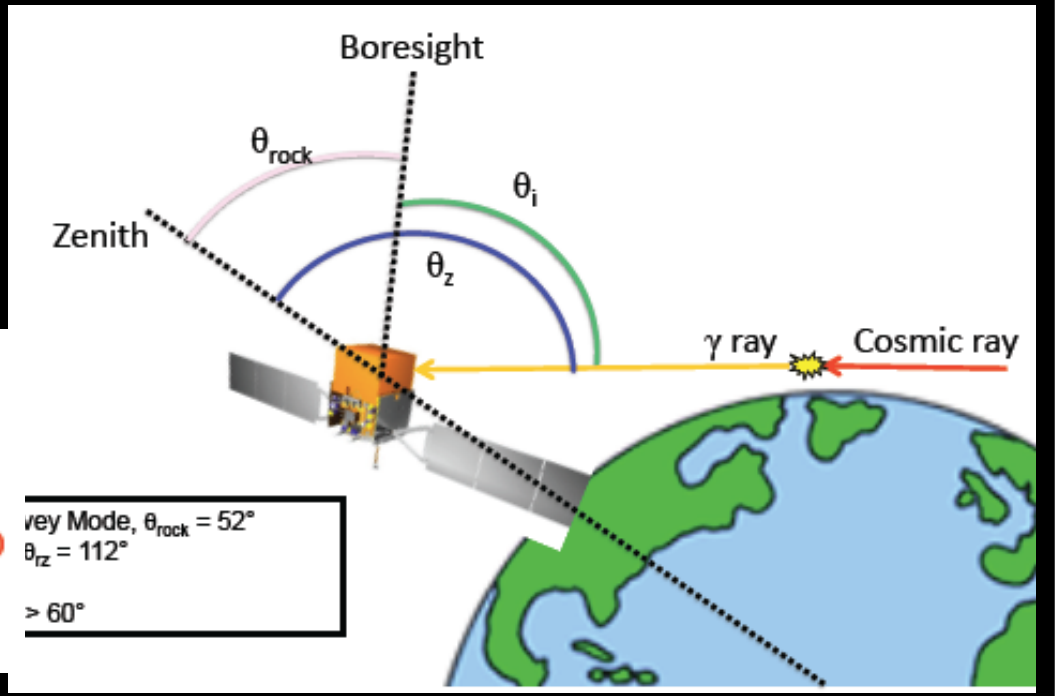


Local 2D fit at 135 GeV 3.35 σ
(4° x 4° window)
Including LEE: < 2 σ

BUT

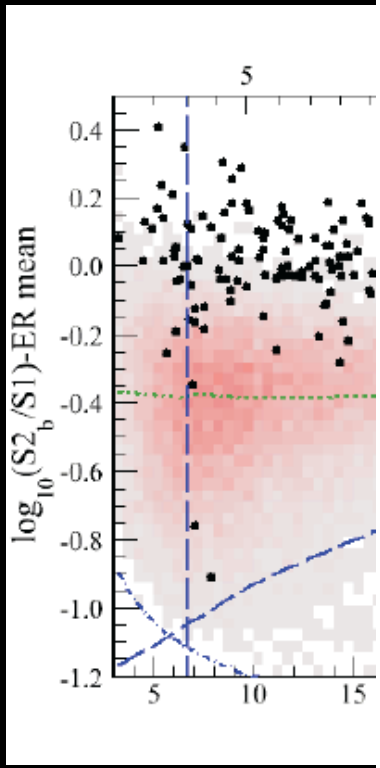
Line-like feature in the limb at 135 GeV, ~2.2σ,

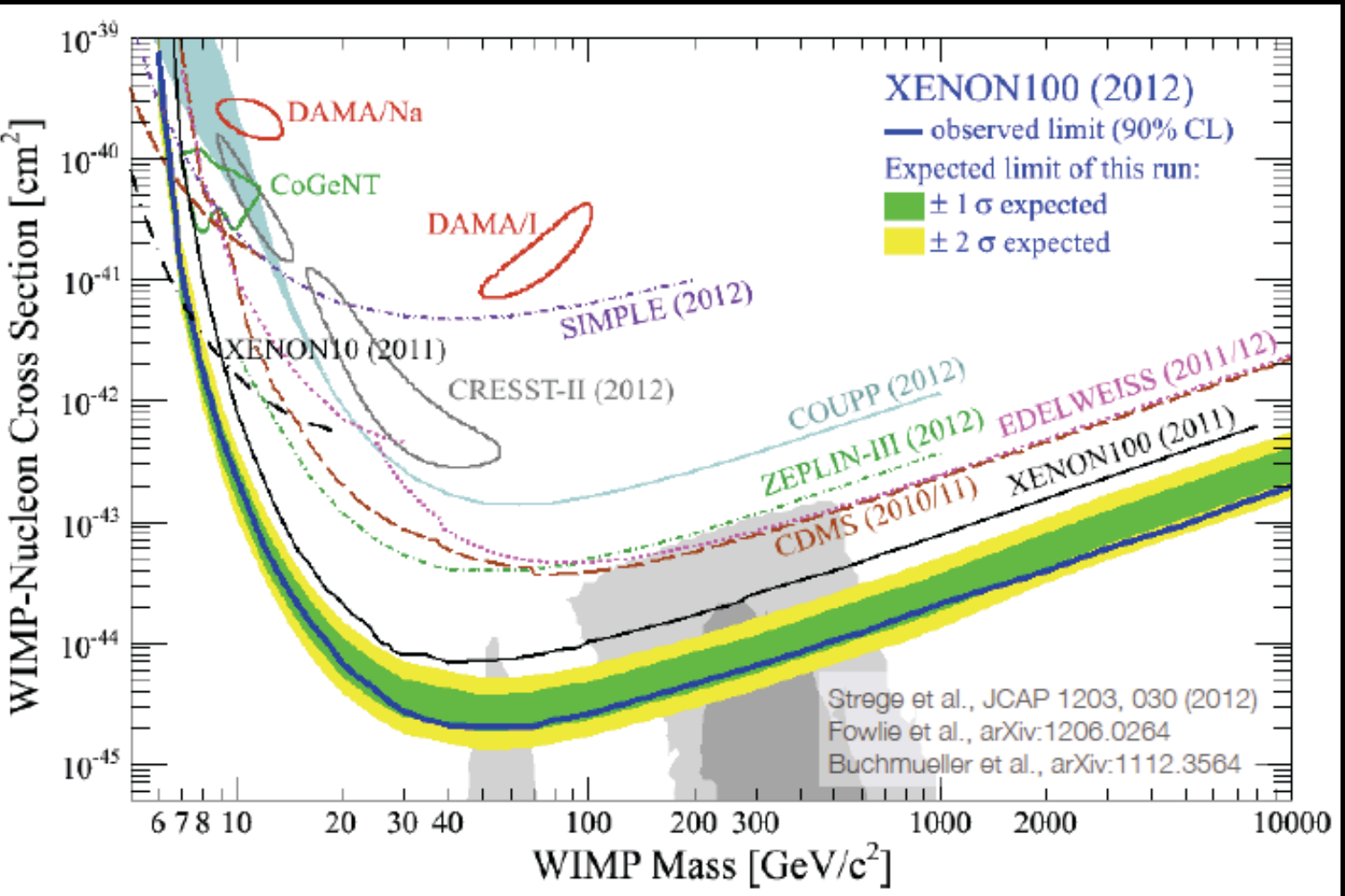
S/N_{limb} ~15%, while S/N_{GC} ~30% - 66%.



Dark Matter: Xenon100

Paolo Beltrame



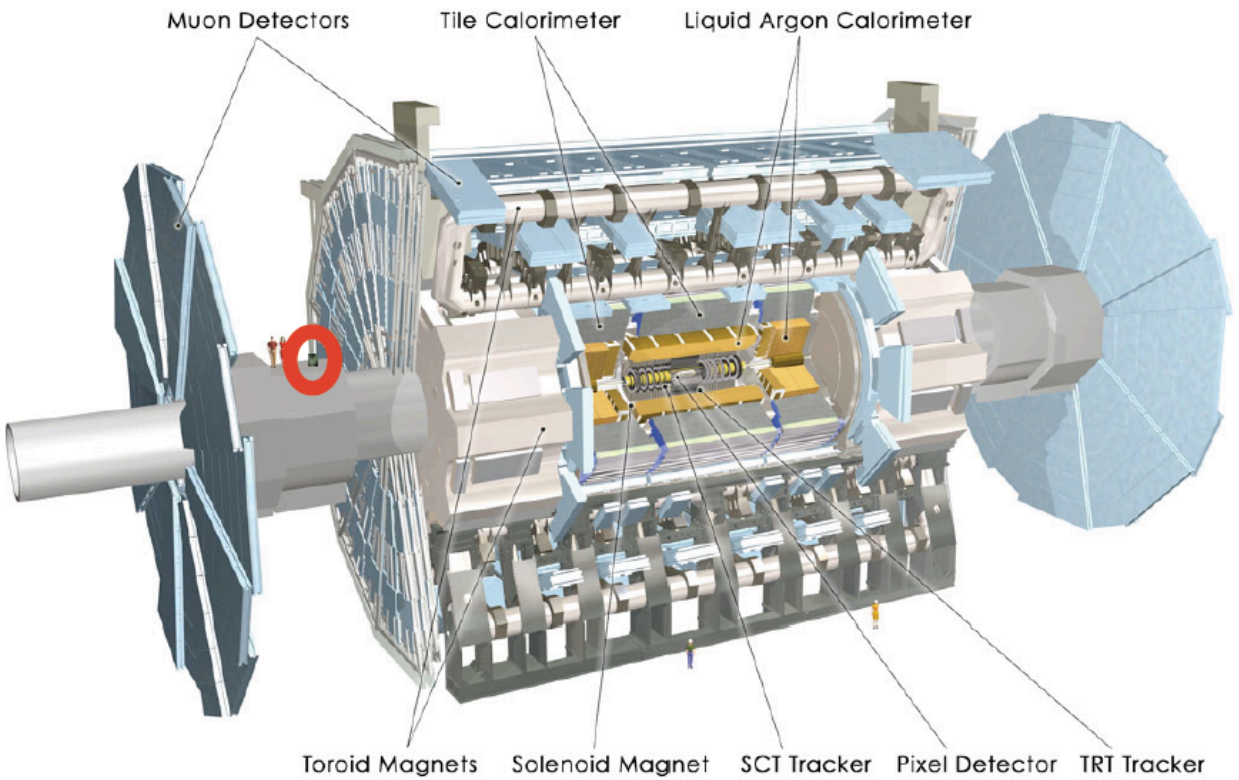


2 events observed

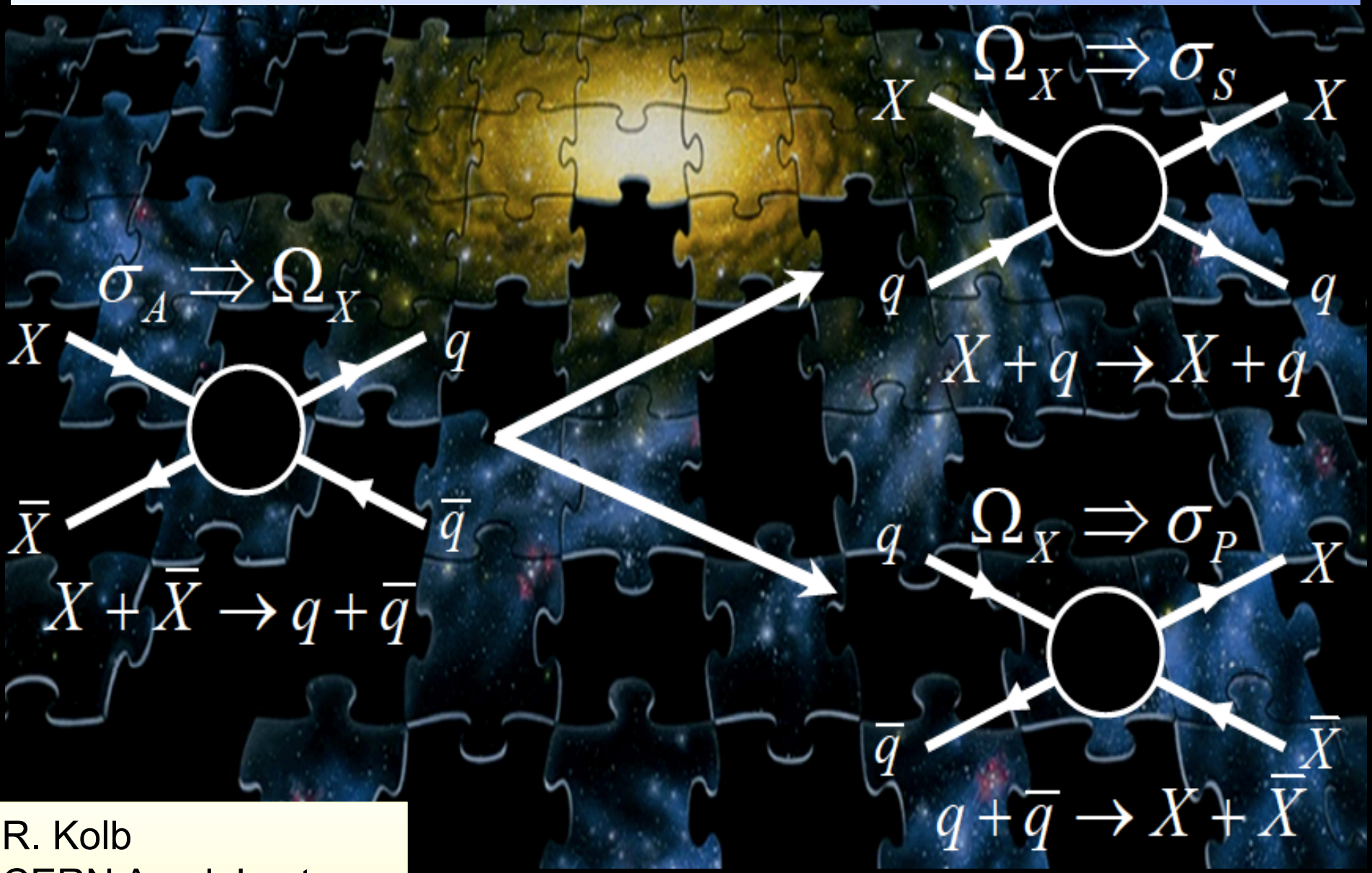
26.4% probability

No significant excess due to signal seen in XENON100 data

Support from the LHC

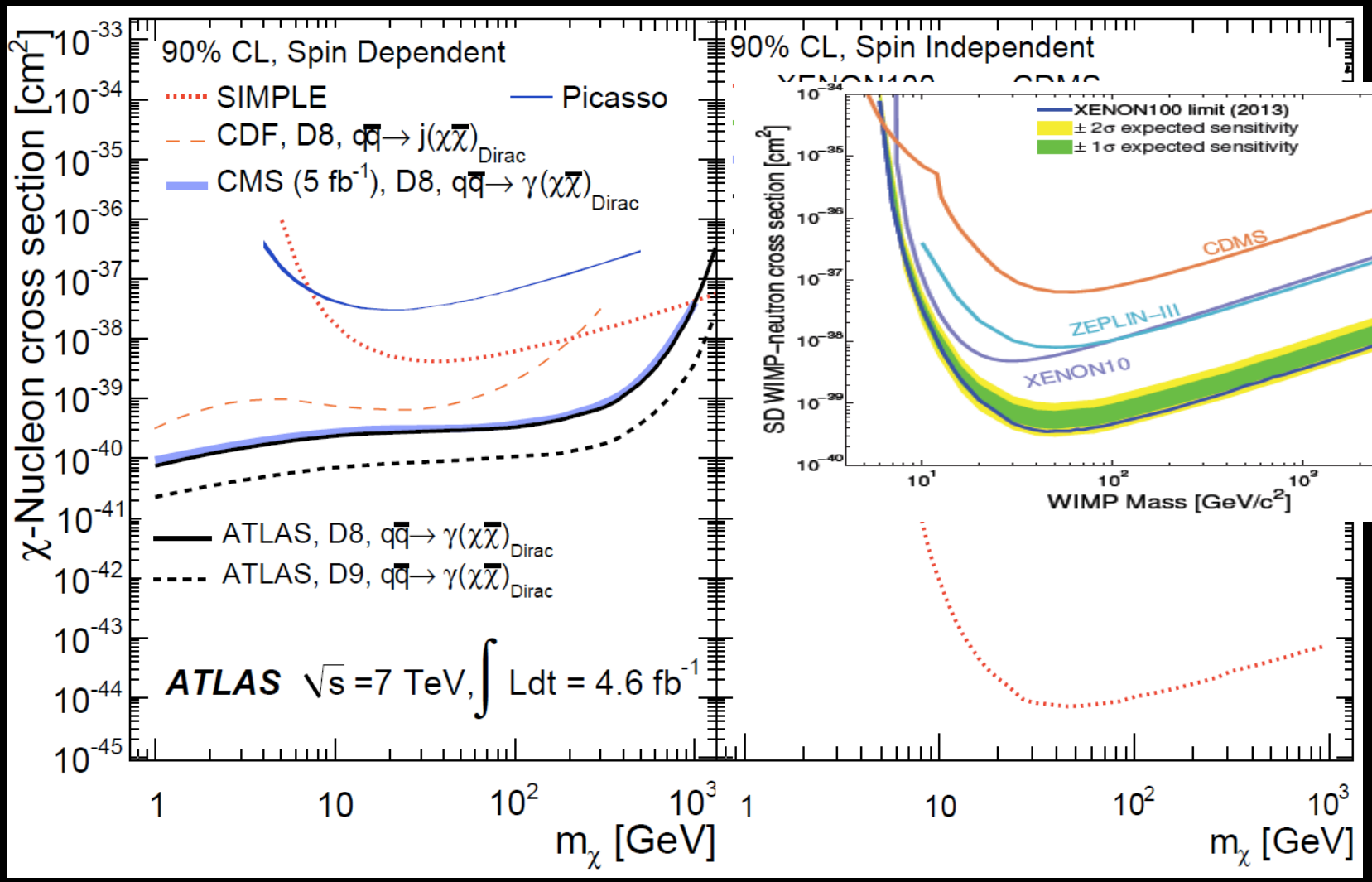


Dark Matter at the LHC

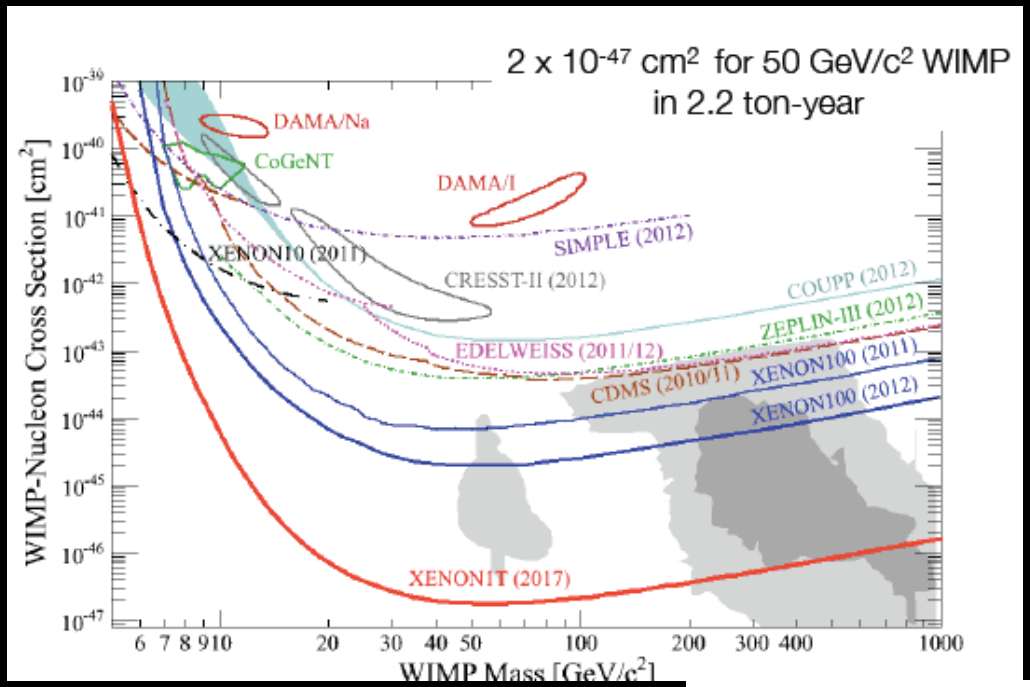


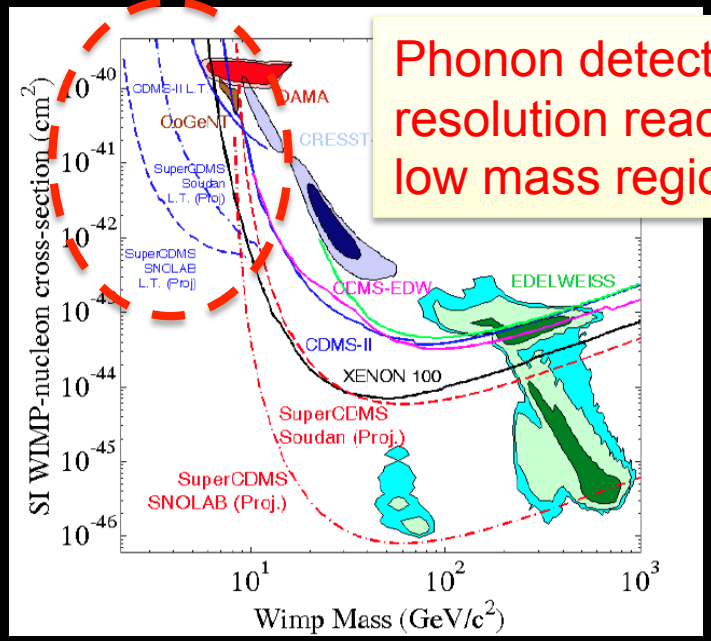
R. Kolb
CERN Acad. Lectures

Dark matter searches += LHC

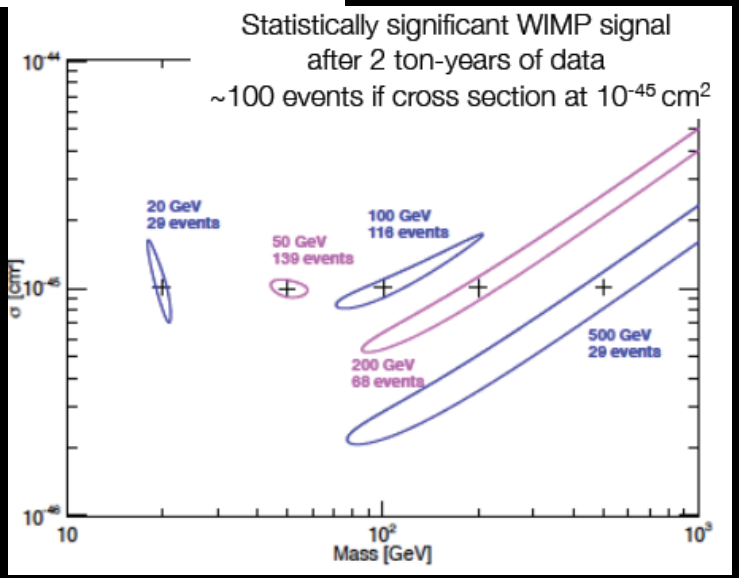


Dark Matter: “bright” future ahead





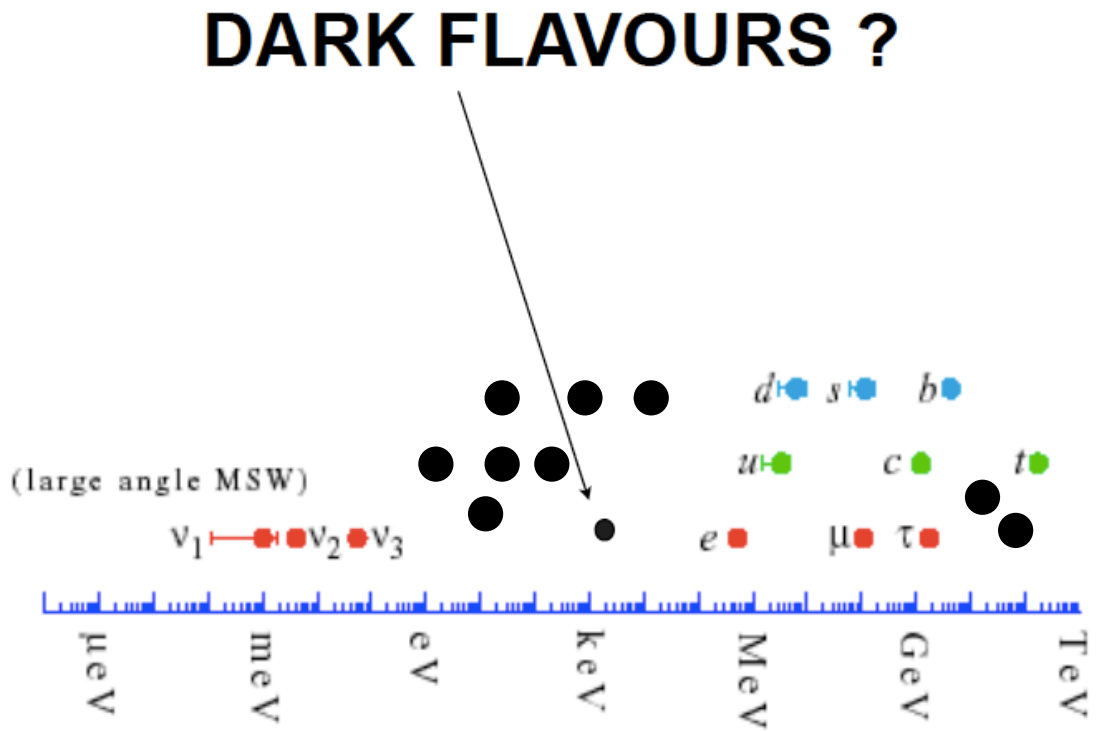
Phonon detection: resolution reaches low mass regions



Paolo Beltrame
Nader Mirabolfathi

A parting thought

Belen Gavela



.... they can be fermions

Straight from Woriond 2013

Nu physics: mixing

Motoyasu Ikeda

Neutrinos and mixing

Flavor (e,μ,τ) Eigenstate

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = U_{PMNS} \times \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

Mass (m_1,m_2,m_3) Eigenstate

$$U_{PMNS} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$c_{ij} \equiv \cos\theta_{ij}$

$s_{ij} \equiv \sin\theta_{ij}$

Current status

Solar and reactor (KamLAND)

$$\theta_{12} = 33.6° \pm 1.0°$$

Atmospheric, accelerator

$$\theta_{23} = 45° \pm 6° \quad (90\%\text{CL})$$

Accelerator, reactor (DayaBay,DoubleChooz,RENO)

$$\theta_{13} = 9.1° \pm 0.6°!$$

Remaining questions:

- Is $\theta_{23} = \pi/4$?
- CP phase (δ) ?
- Mass hierarchy

  $m_1<m_2<m_3$? $m_3<m_1<m_2$?

On autopilot of ever-more-sensitive results

Oscillati **ν osc. analysis (ν_μ disap arance)**

– Near det

– ν_μ disap

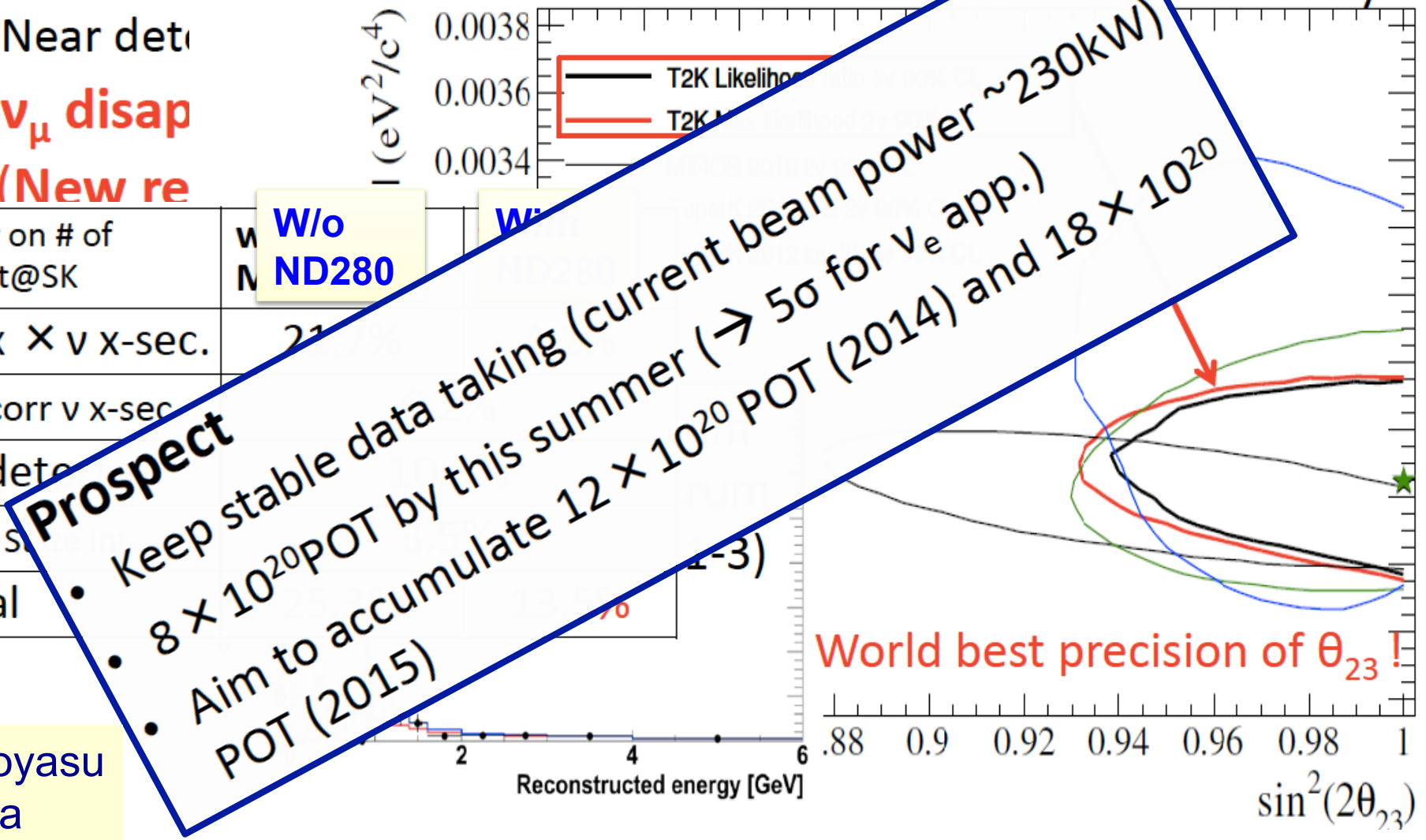
(New re

Preliminary

Error on # of event@SK	W/o ND280	With ND280
Flux × ν x-sec.	21	
Un-corr ν x-sec		
SK dete		
Final S		
Total		

Prospect

- Keep stable data taking (current beam power ~230kW)
- 8×10^{20}POT by this summer (→ 5σ for ν_e app.)
- Aim to accumulate 12×10^{20} POT (2014) and 18×10^{20} POT (2015)

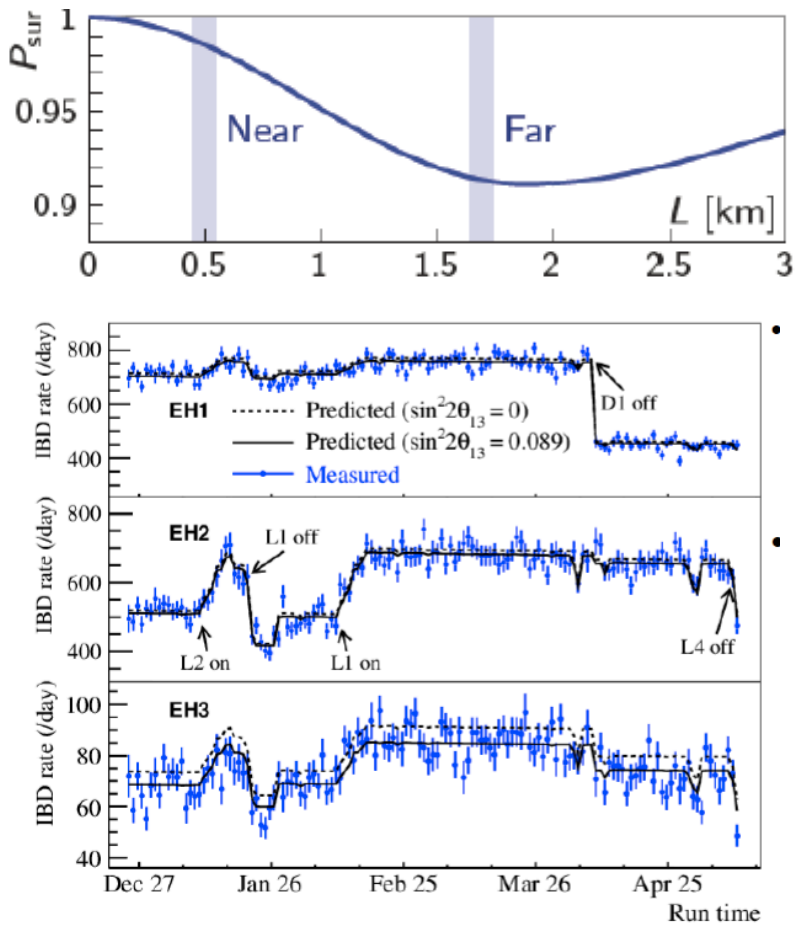


Motoyasu Ikeda

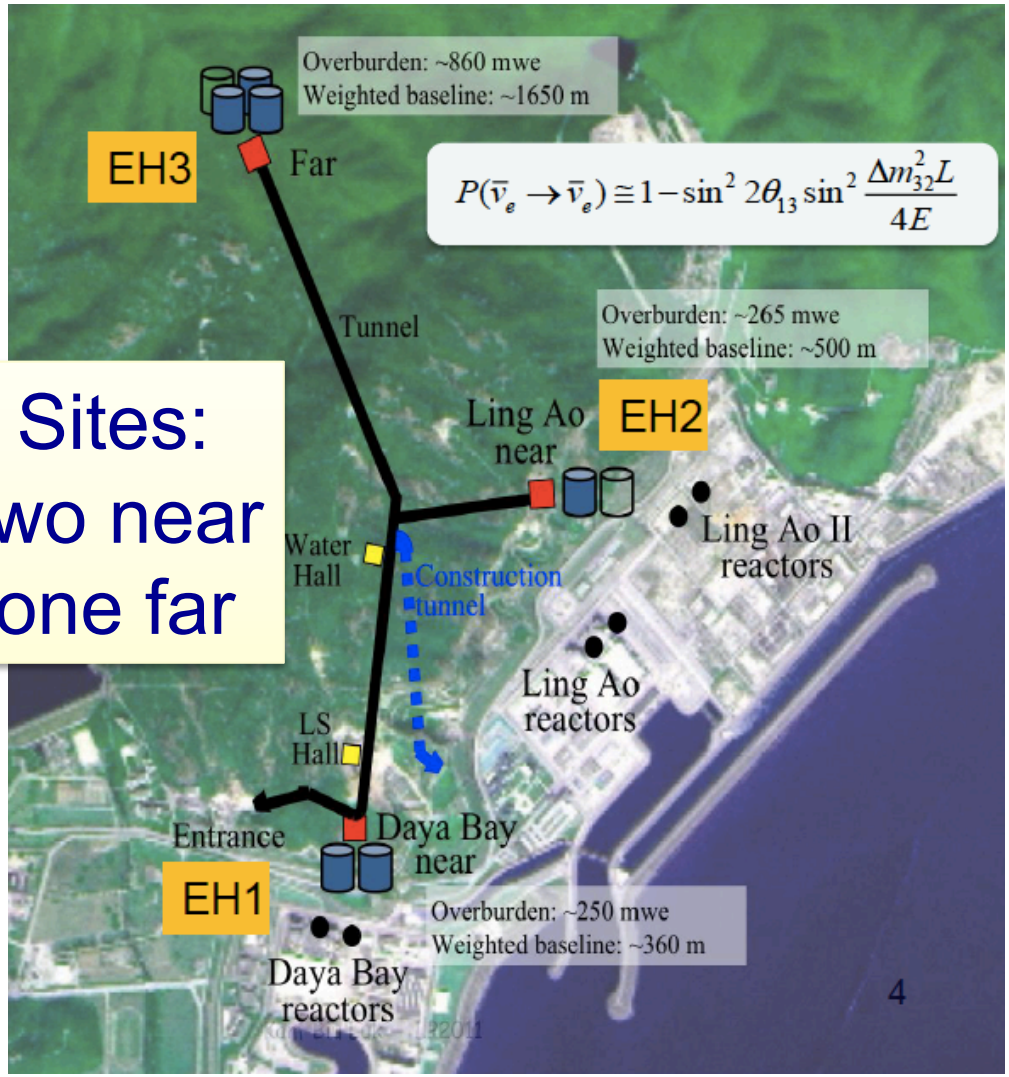
Θ_{13}

Guofu Cao

- **Daya Bay**



Sites: two near one far

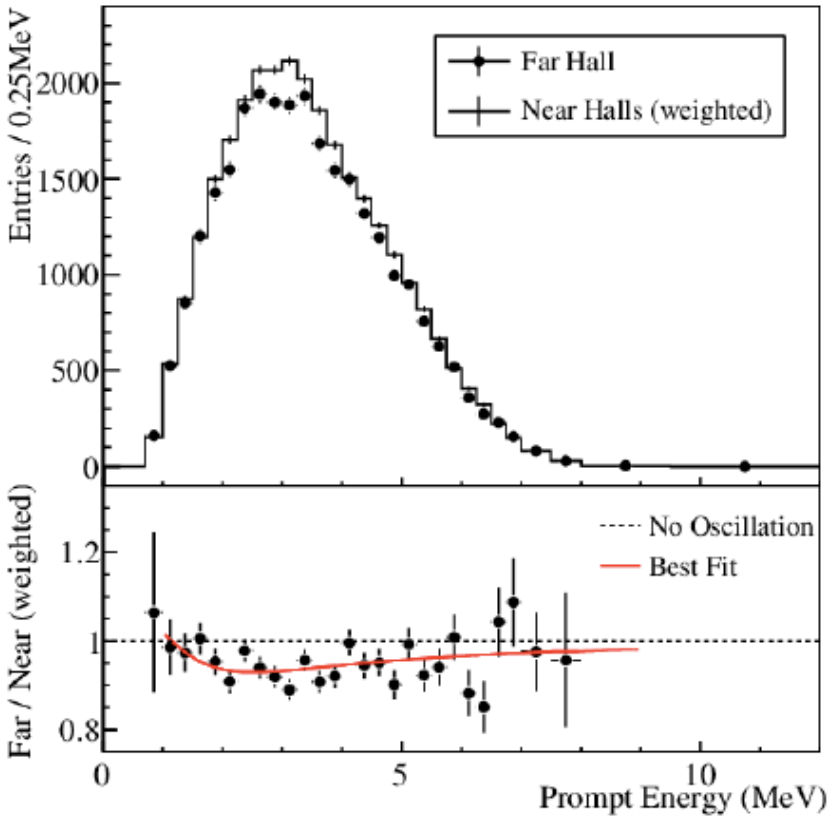


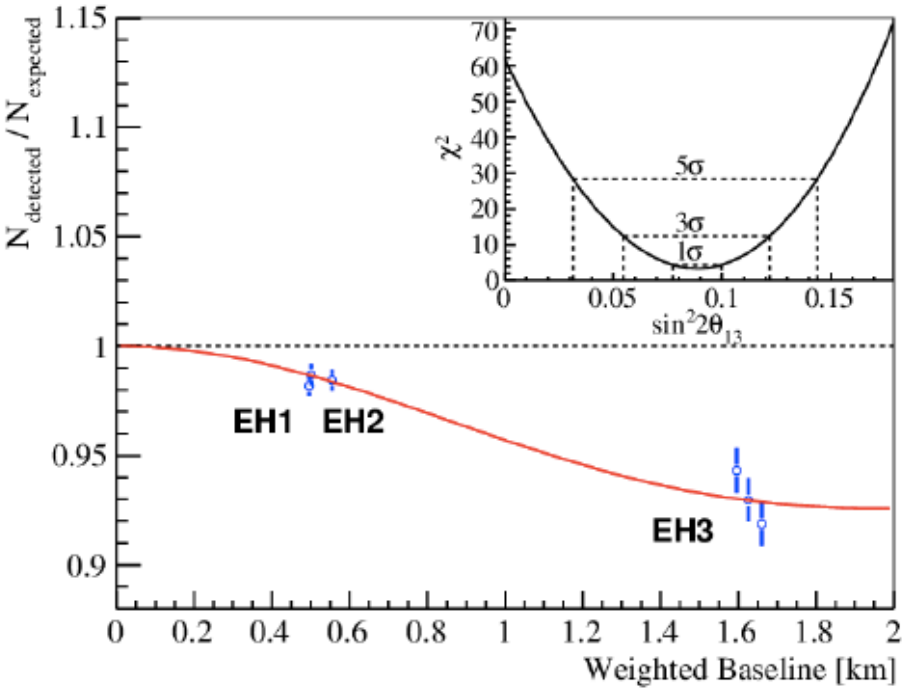
Θ_{13}

Guofu Cao

- **At times t<2011, $\sin^2\Theta_{13} < 0.15$ (90%CL)**

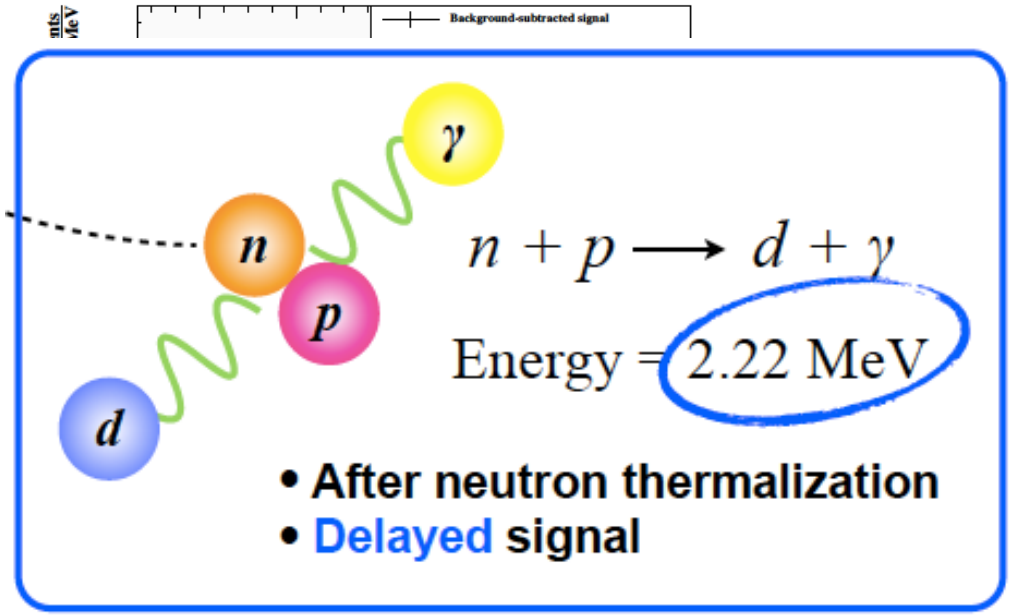
$R = 0.944 \pm 0.007\,(stat) \pm 0.003\,(syst)$



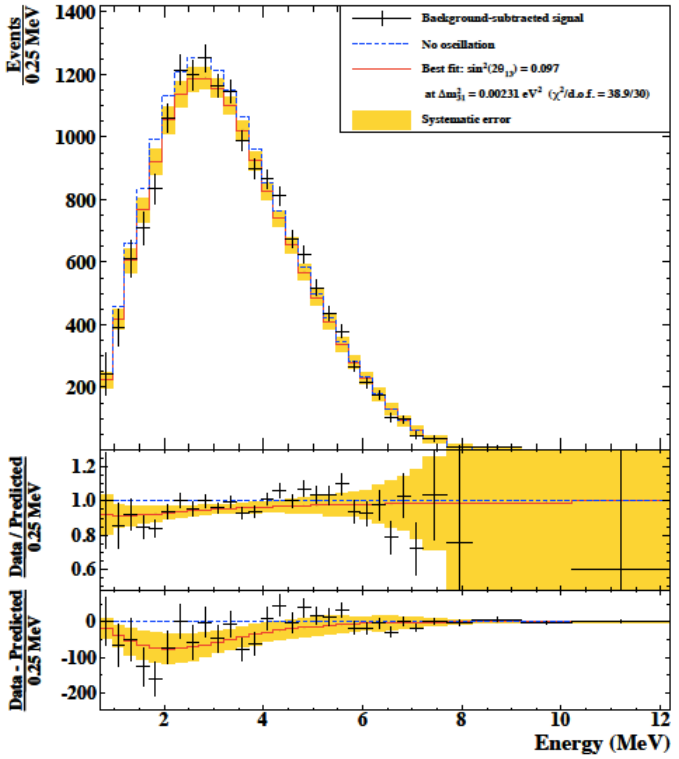


$\sin^2 2\,\theta_{13} = 0.089 \pm 0.010(stat) \pm 0.005(syst)$

Θ_{13}: Double Chooz



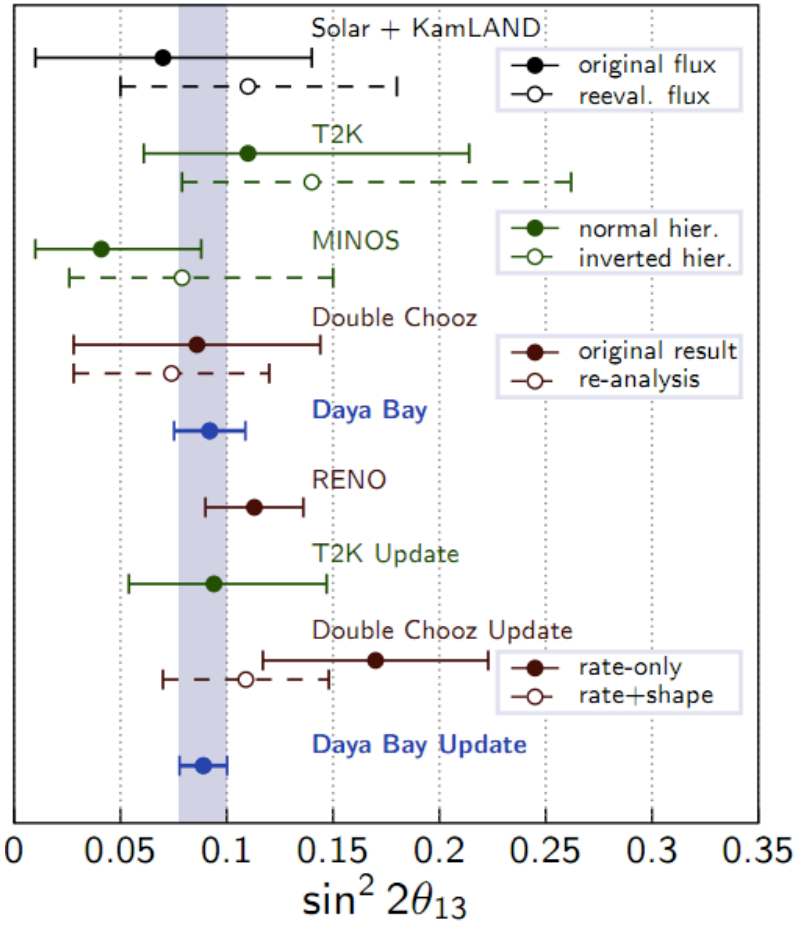
Neutron Capture on Hydrogen



Θ_{13}: Summary

- **Important for CP violation in the neutrino sector:**

$$CPv \propto \sin\Theta_{12} \sin\Theta_{23} \sin\Theta_{13} \sin\delta$$

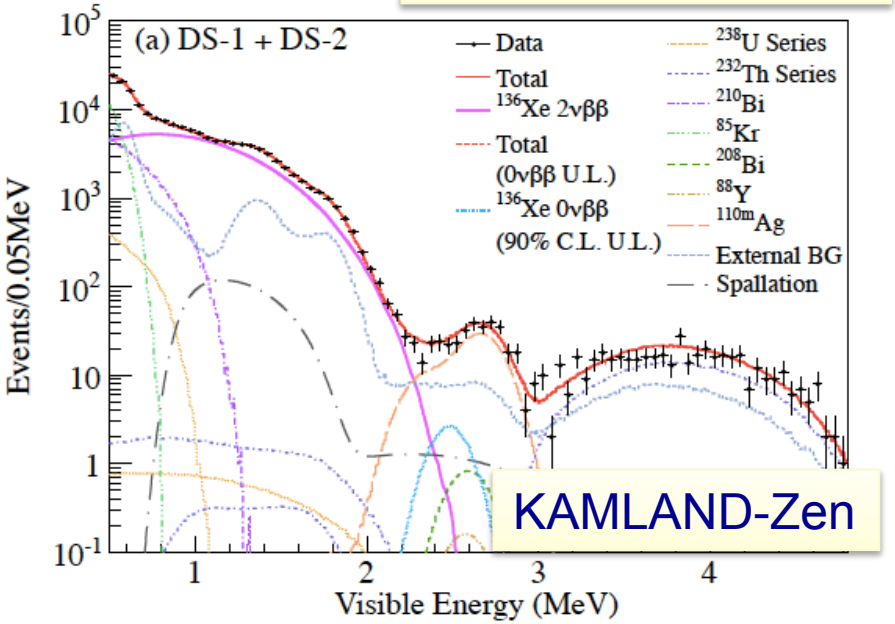


Nu physics: Majorana?

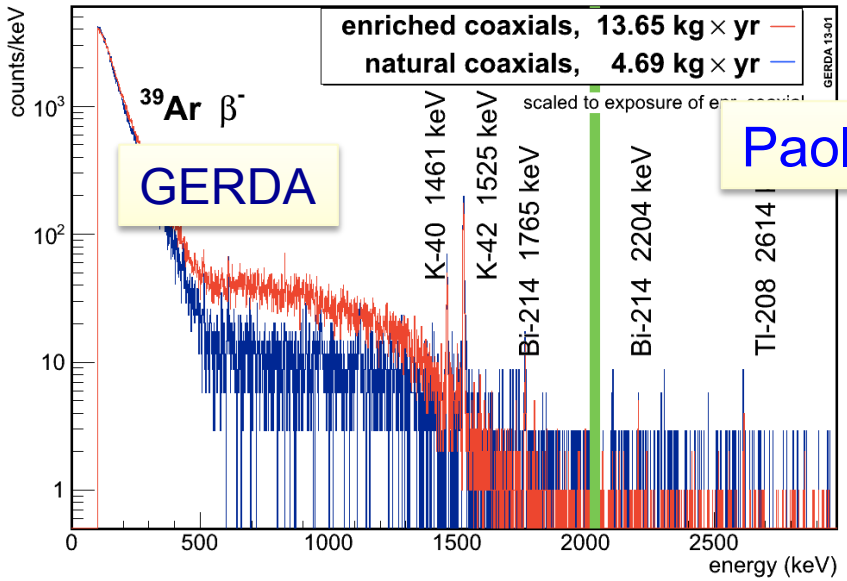
0νββ decay

Thomas ODonnell

Candidate Isotope	Experiment
^{48}Ca	Candles
^{76}Ge	**Gerda**, Majorana
^{82}Se	SuperNemo,Lucifer
^{130}Te	**CUORE**
^{136}Xe	**EXO**, NEXT, **KamLAND-Zen**
^{150}Nd	SNO+



KAMLAND-Zen



GERDA

Paolo Zavarise

Limit with current configuration hit

Phase I exposure goal: 20 kg yr (June/July)

Expected sensitivity:

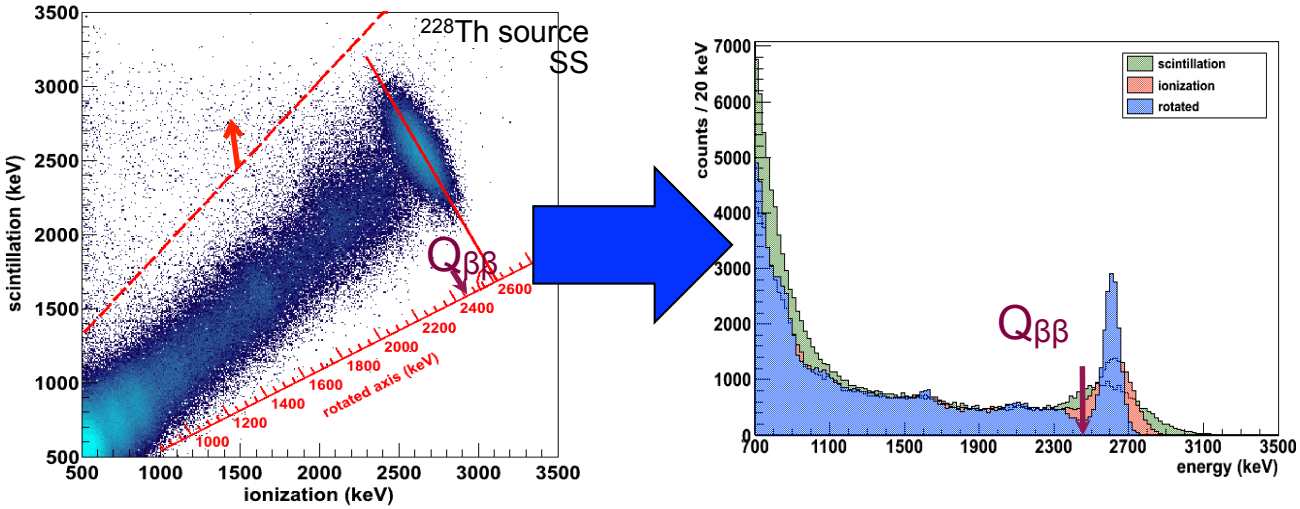
$\sim 2 \times 10^{25}$ years @ 90% C.L. (without p.s.)

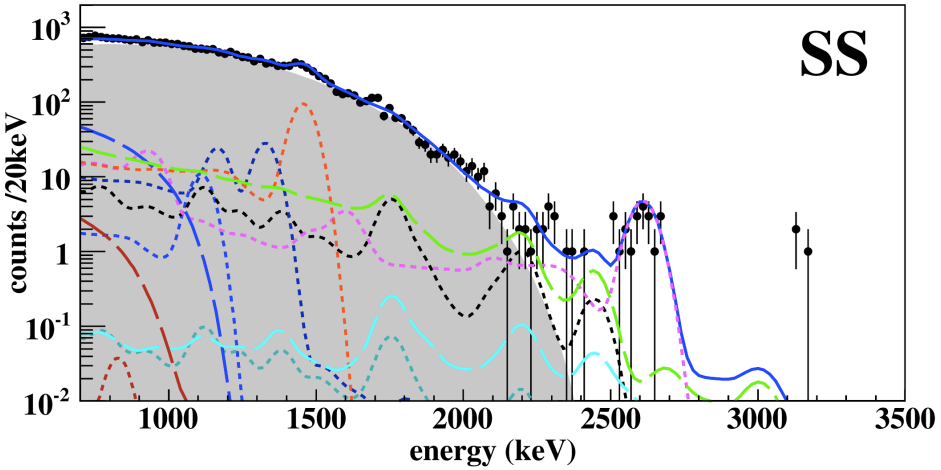
0νββ decay: EXO200

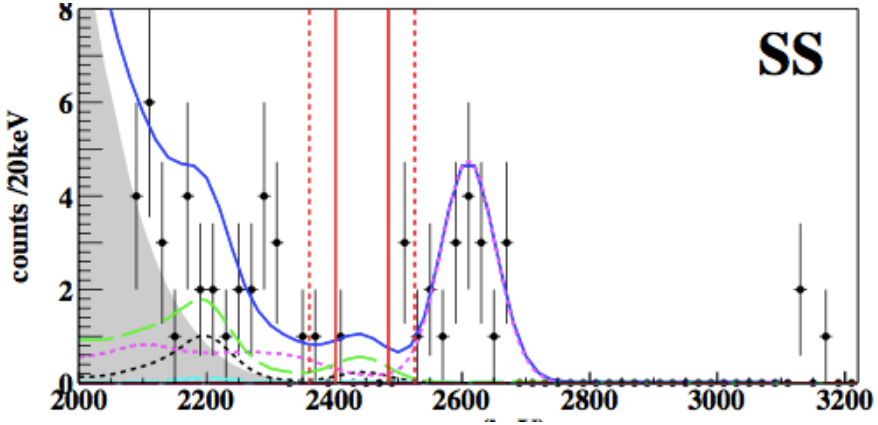
David Auty

Properties of xenon cause increased scintillation to be associated with decreased ionization (and vice-versa)

E. Conti et al. Phys. Rev. B 68 (2003) 054201





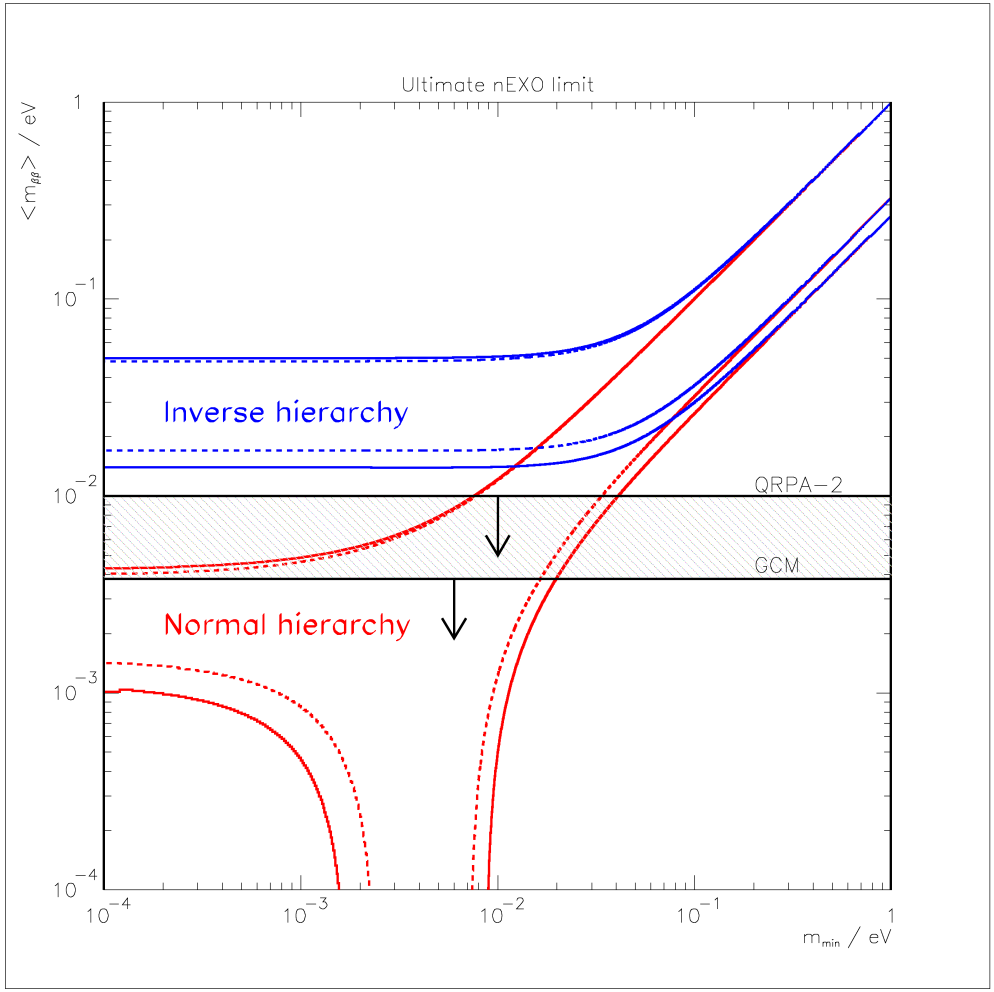


$T_{1/2}2\nu\beta\beta$ (^{136}Xe) x 10^{21} yr = 2.23 ± 0.017 stat ± 0.22 sys

$T_{1/2}0\nu\beta\beta$ (^{136}Xe) x 10^{25} yr > 1.6 (90% CL)

0νββ decay; the future: (n)EXO(200)

David Auty



Neutrino parameters: Forero et al. 1205.4018v4, 95%CL.

Horizontal bands: envelopes of 90% CL limits expected (or obtained) assuming various NME calculations and assuming that no signal is detected
EXO-200 "Present limit": PRL 109 (2012) 032505

EXO-200 "Ultimate" sensitivity: 4 yrs liveT, new analysis & Rn removal.

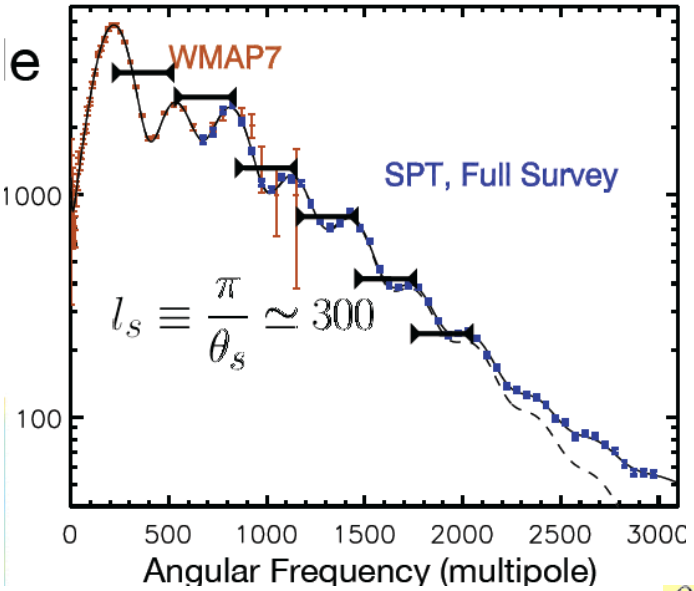
Initial nEXO" band: directly scaled from EXO-200, including measured background and 10yr livetime.

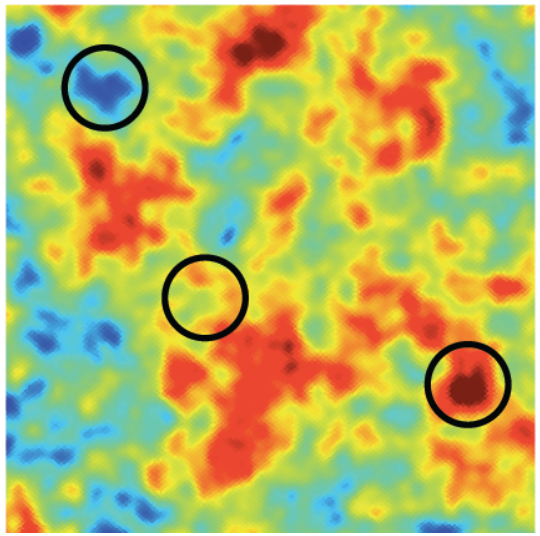
"Final nEXO" band: same detector and no BKG other than 2v

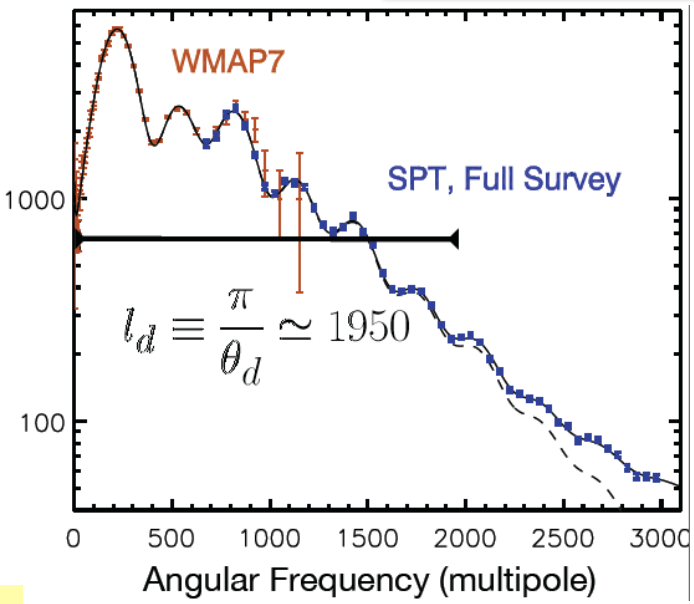
Nu physics: masses?

SPT

Brent Follin







$$\frac{\theta_d}{\theta_s} = 0.1562 \pm 0.0011$$

$$r_s \propto H^{-1}$$

$$r_d \propto H^{-1/2}$$

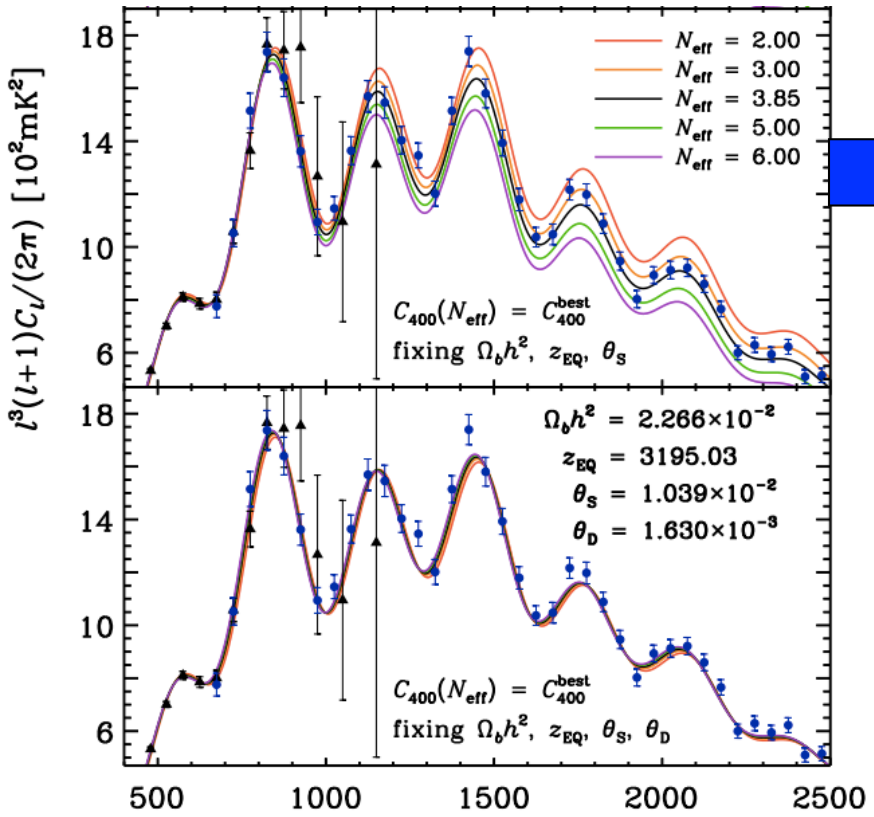
$$\frac{\theta_d}{\theta_s} \propto \sqrt{H}$$

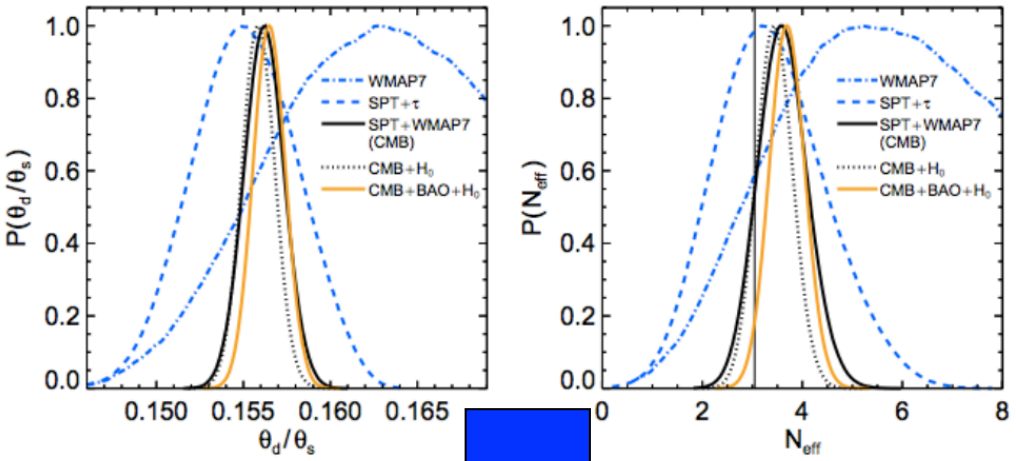
$$H^2(a) = H_0^2 \left(\frac{\Omega_m}{a^3} + \frac{\Omega_\gamma}{a^4} + \frac{\Omega_\nu}{a^4} + \Omega_\Lambda \right)$$

SPT

Brent Follin

$$H^2(a) = H_0^2 \left(\frac{\Omega_m}{a^3} + \frac{\Omega_\gamma}{a^4} + \frac{\Omega_\nu}{a^4} + \Omega_\Lambda \right)$$





Num of Nus:

N_{eff} = 3.62 ± 0.48 (SPT+WMAP7)

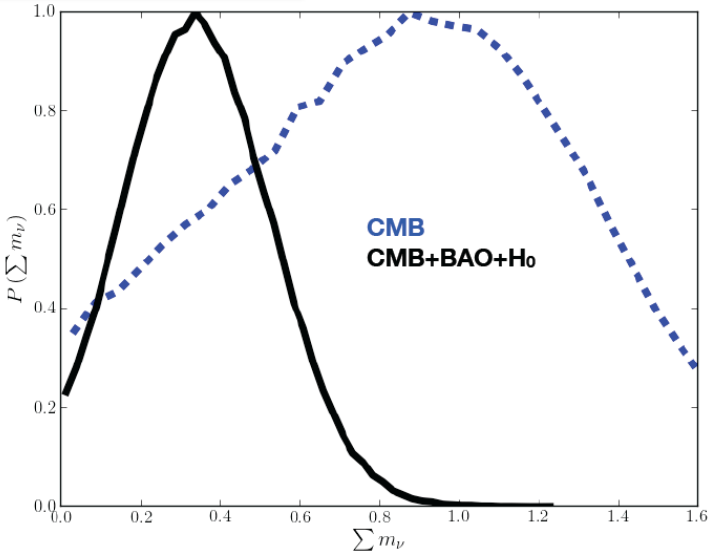
N_{eff} = 3.71 ± 0.35 (SPT+WMAP7+H_0+BAO)

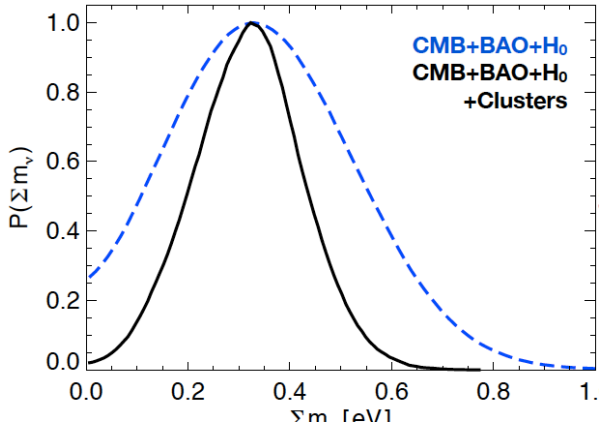
N_{eff} = 2.97 ± 0.56 (ACT+WMAP7)

N_{eff} = 3.50 ± 0.42 (ACT+WMAP7+H_0+BAO)

Neutrino mass

Brent Follin

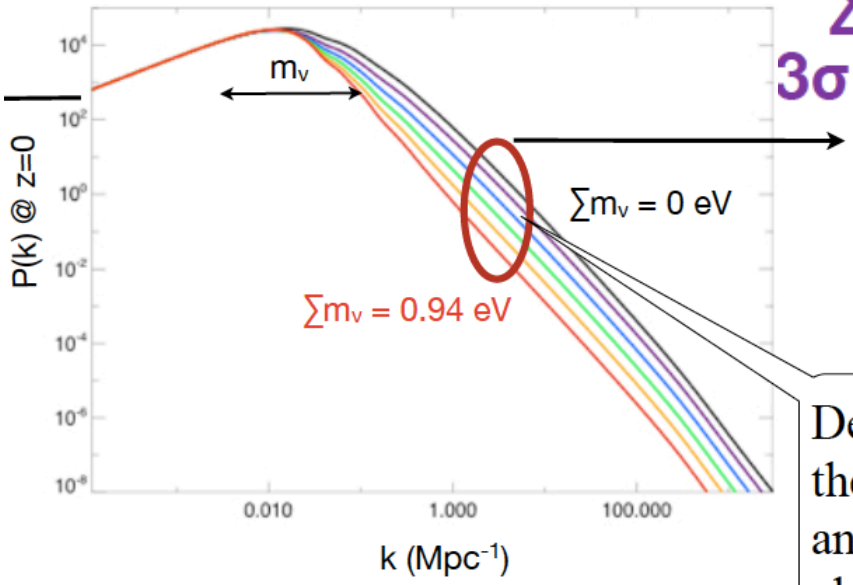




Including everything:

$\sum m_\nu = 0.32 \pm 0.11$ eV

3σ preference for $\sum m_\nu > 0$



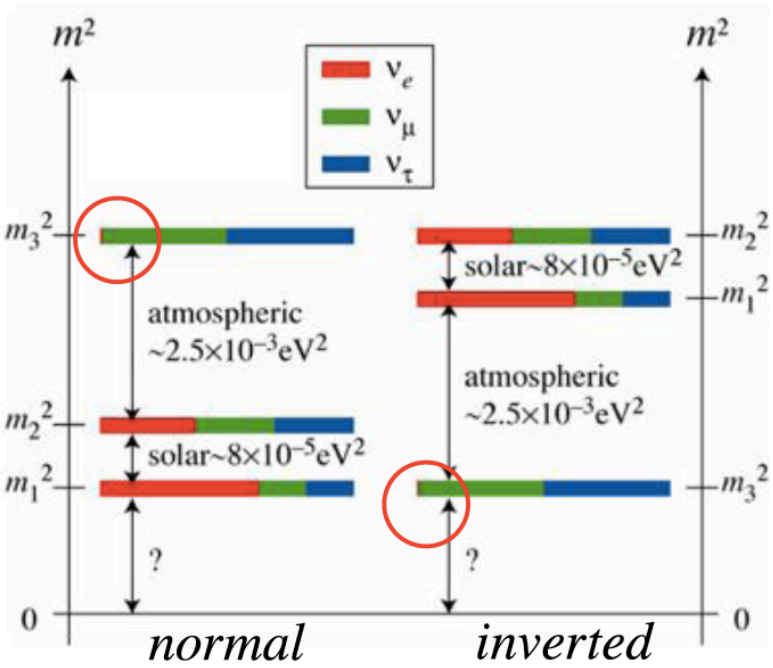
scales:
Faster expansion suppresses structure

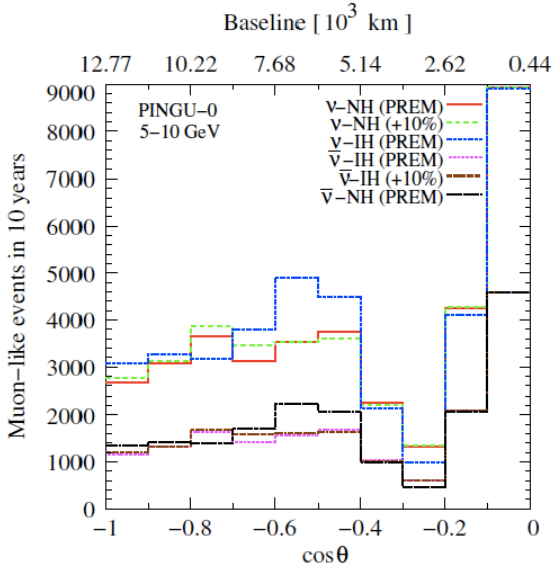
Determines the number and mass of clusters

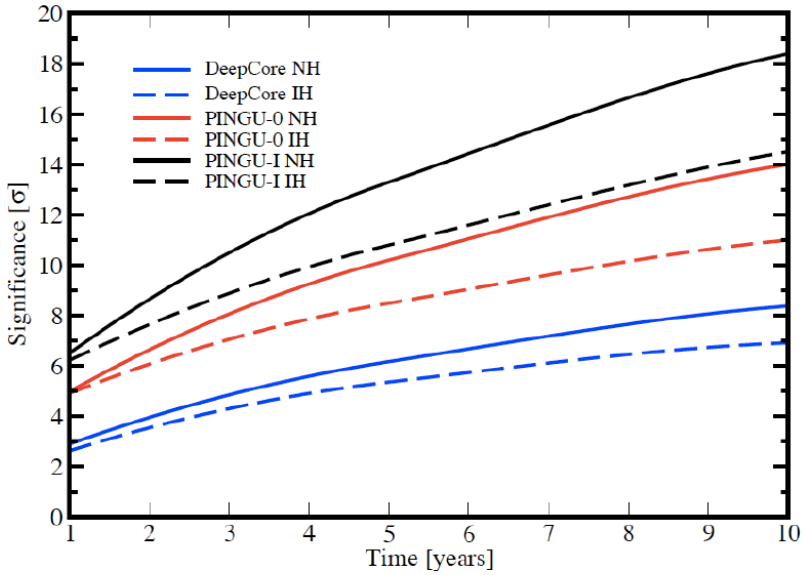
Neutrino mass

- **The future: PINGU & DeepCore**

Mass hierarchy



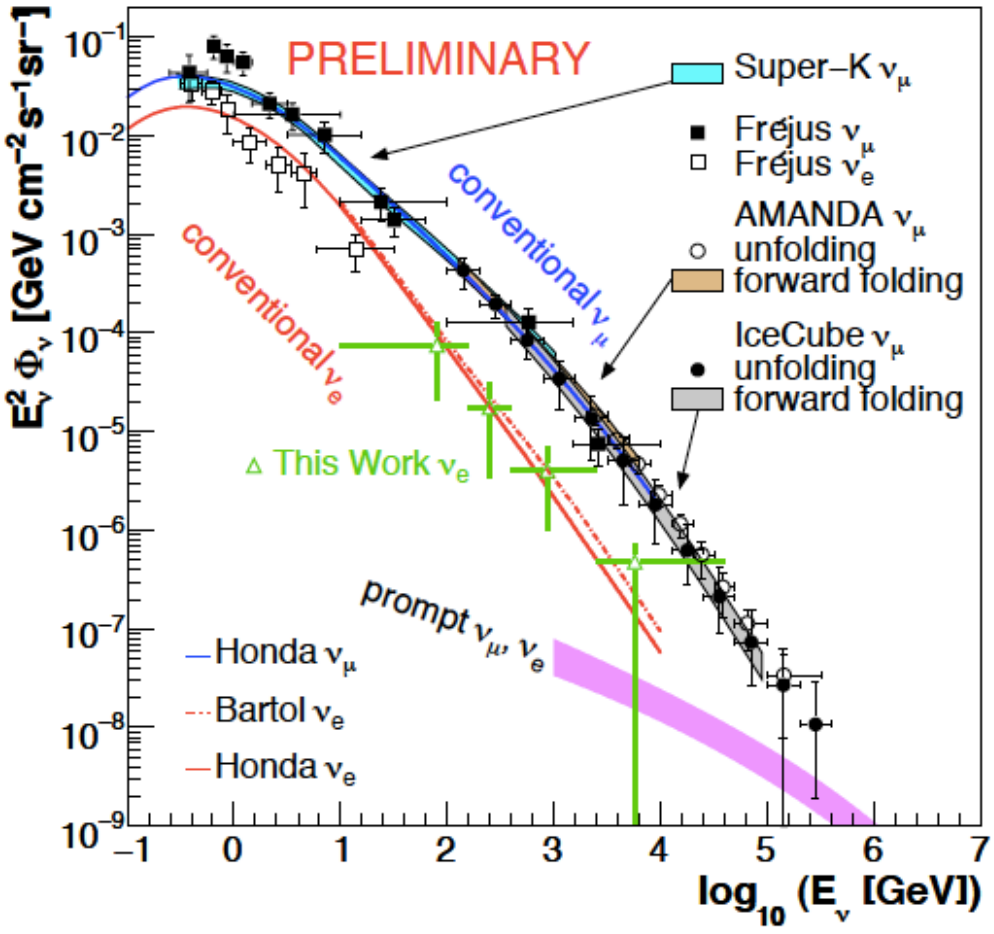


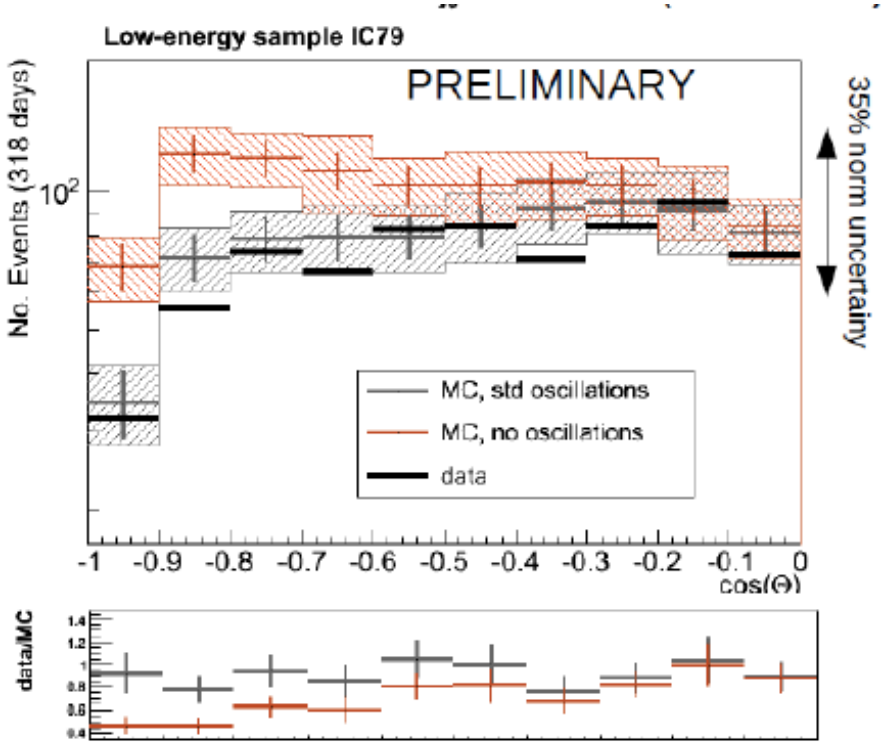


Sergio Palomares-Ruiz

IceCube

N. Whitehorn





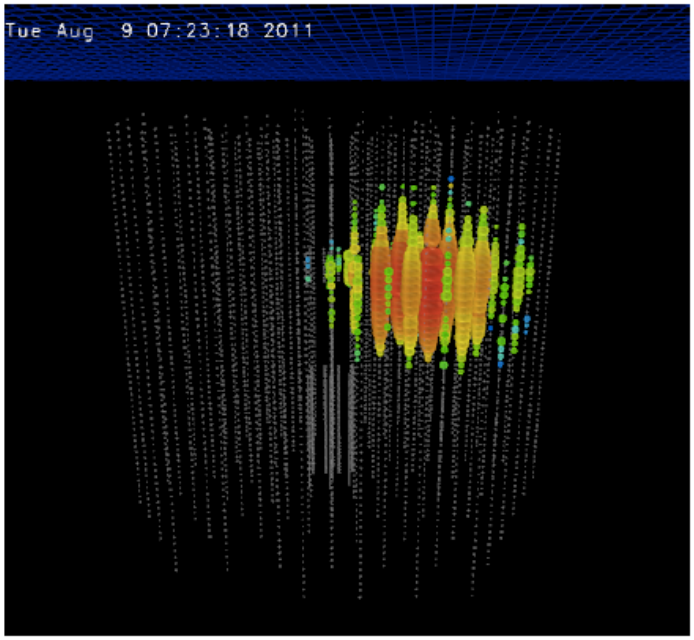
arXiv:1212.4760

IceCube

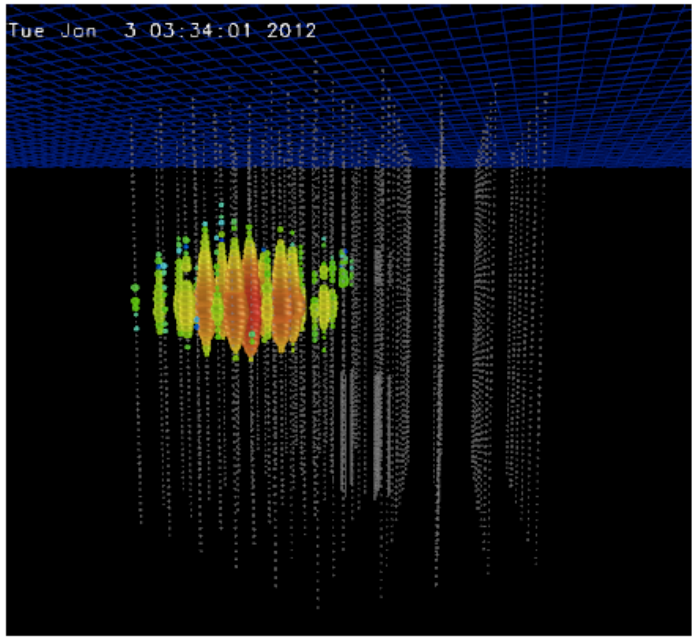
N. Whitehorn

A mystery: PeV neutrinos

Appearance of ~ 1 PeV neutrinos as an at-threshold background in cosmogenic neutrino search – should be $\ll 1$ atmospheric neutrinos per year at these energies



~ 1100 TeV



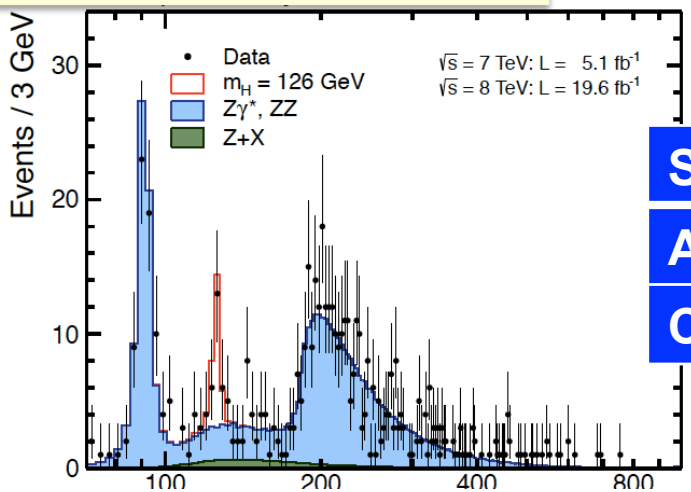
~ 1300 TeV

PRELIMINARY

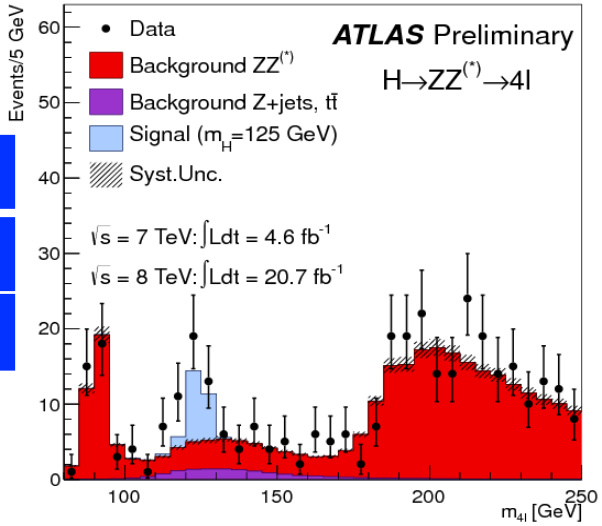
The SMS-like boson

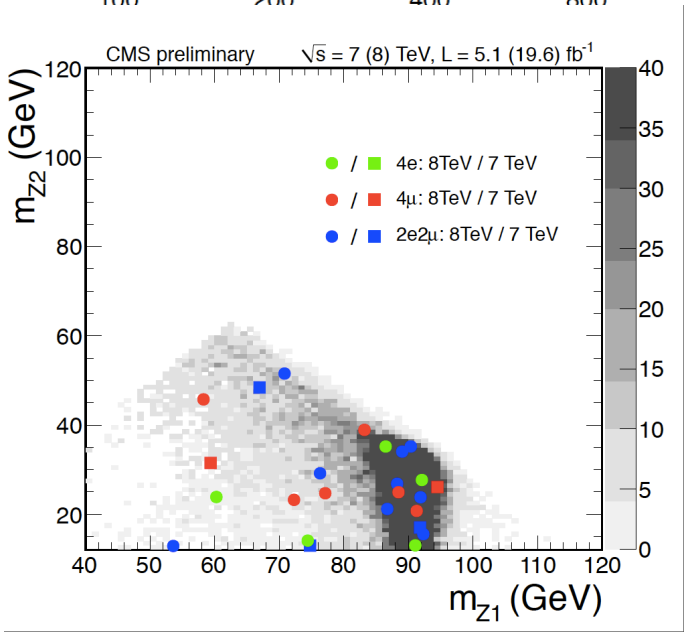
SMS → ZZ → 4leptons

Guillelmo Gomez-Ceballos
Fabrice Hubaut

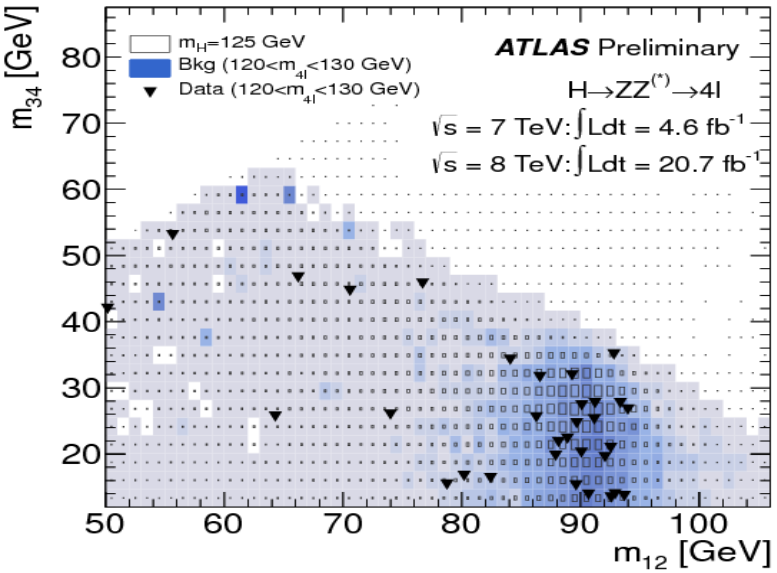


Sign/Exp	Exp	Obs
ATLAS	4.4 σ	6.6 σ
CMS	6.7 σ	7.2 σ



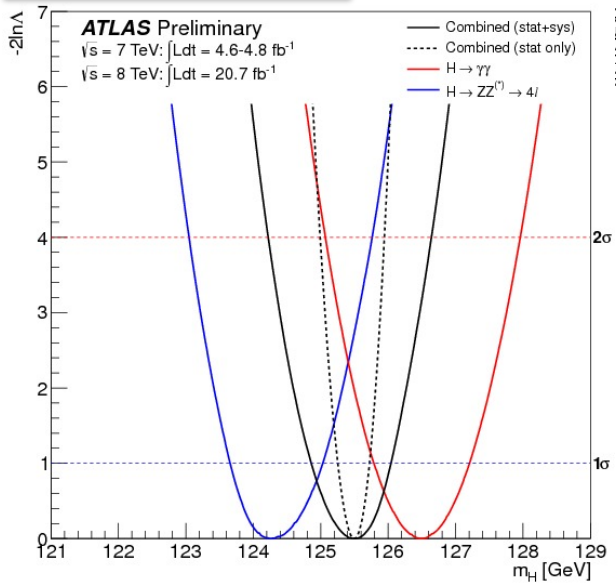


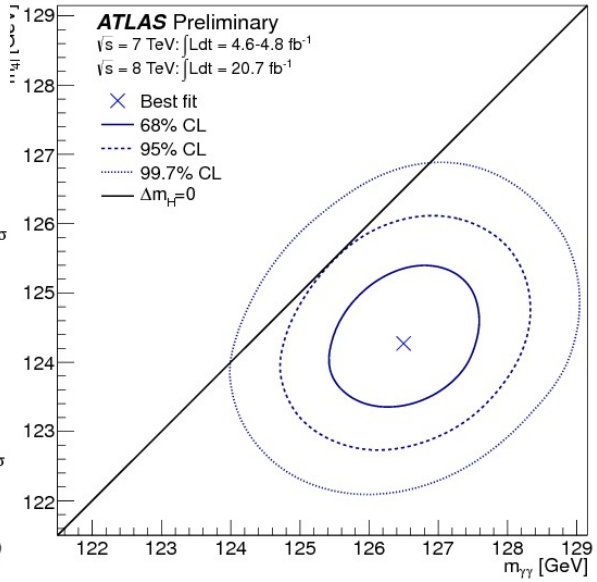
Z_1 Z_2 mass ok



SMS mass (ATLAS and CMS)

Vicky Martin





$m_H = 125.5 \pm 0.2\ (stat)^{+0.5}_{-0.6}\ (sys)$ GeV

$\Delta m_H = 2.3^{+0.6}_{-0.7}(stat)$
$\pm 0.6(sys)$ GeV
$2.4\ \sigma$ wrt $\Delta m_H = 0$ (p=1.5%)

Also: set E-scale, e/γ pdf's to rectangular *[± 1 σ] (material models, calo samplings calibration…)*
p = 8%

BUT

$m_{4e} = 126.2 \pm 1.5$
$m_{4\mu} = 123.8 \pm 0.8$

CMS situation simpler:

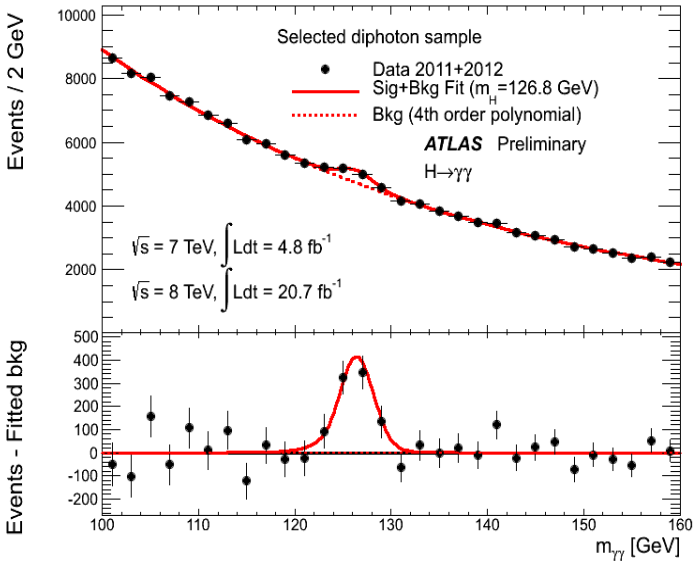
$m_x = 125.8 \pm 0.6$ GeV (±0.5%)
$= 125.8 \pm 0.4(stat) \pm 0.4(syst)$ GeV

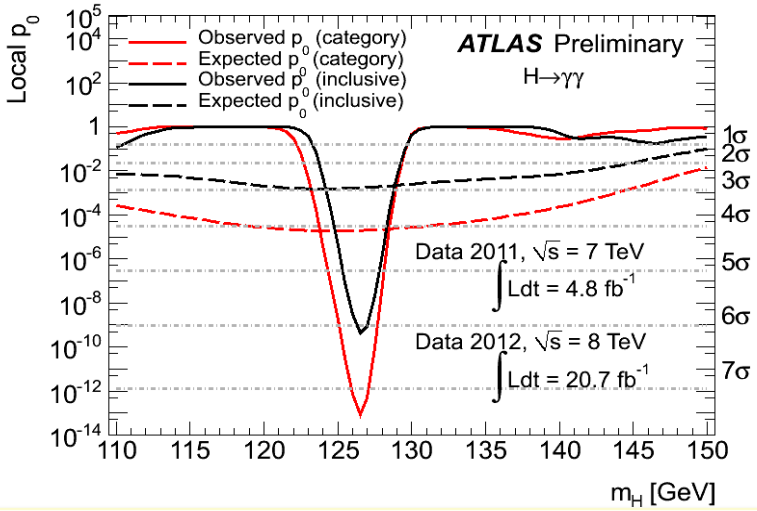
Conclusion: not an issue

H → γγ

Fabrice Hubaut

- **Update from ATLAS**

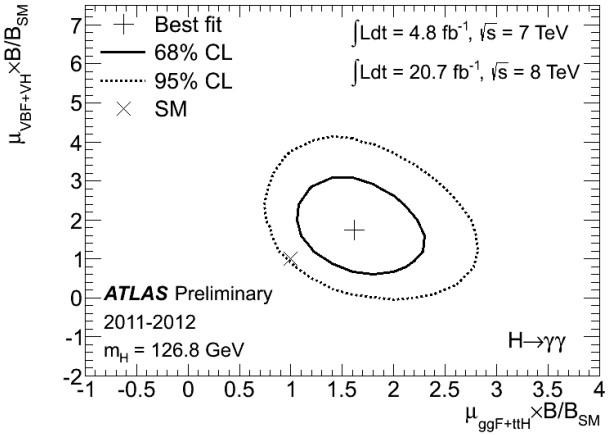




Mass window ~125 GeV with 90% signal: S/B~3%

Significance; obs: 7.4σ; exp: 4.1σ

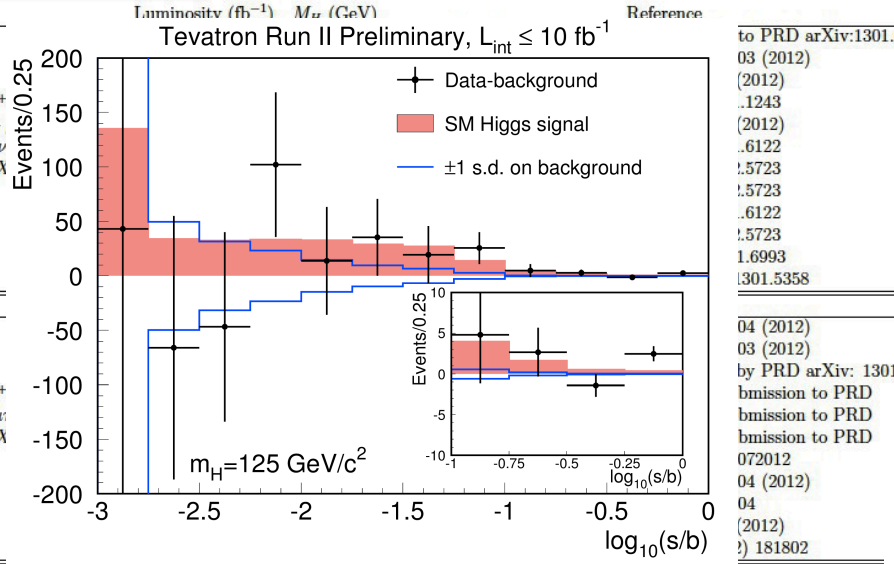
Mass: 126.8 ± 0.2(stat) ± 0.7(sys) GeV

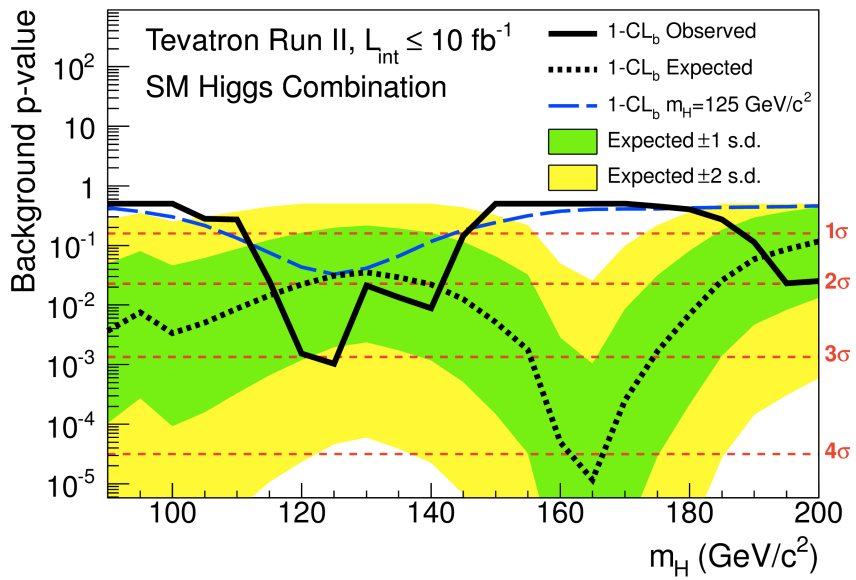


Tevatron legacy

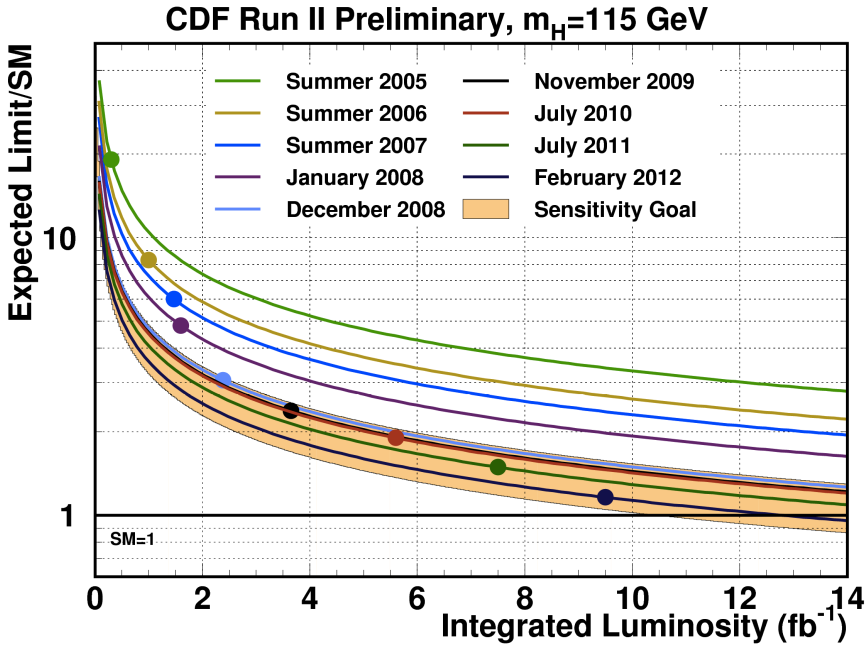
Wei-Ming Yao

DØ	Luminosity (fb^{-1})	M_H (GeV)	Reference
$WH \to \ell\nu b\bar{b}$			to PRD arXiv:1301.6122
$ZH \to \ell\ell b\bar{b}$			03 (2012)
$ZH \to \nu\bar{\nu}b\bar{b}$			(2012)
$H \to W^+W^- \to \ell^+$			..1243
$H + X \to WW \to$			(2012)
$H \to W^+W^- \to \ell\nu$			..6122
$VH \to ee\mu/\mu\mu e + X$			.5723
$VH \to e^{\pm}\mu^{\pm} + X$			.5723
$VH \to \ell\nu q'\bar{q}q'\bar{q}$			..6122
$VH \to \tau_h\tau_h\mu + X$			.5723
$H + X \to \ell\tau_h jj$			1.6993
$H \to \gamma\gamma$			1301.5358
CDF			
$WH \to \ell\nu b\bar{b}$			04 (2012)
$ZH \to \ell\ell b\bar{b}$			03 (2012)
$ZH \to \nu\bar{\nu}b\bar{b}$			by PRD arXiv: 1301.4440
$H \to W^+W^- \to \ell^+$			bmission to PRD
$H \to WW \to e\tau_h\mu$			bmission to PRD
$VH \to ee\mu/\mu\mu e + X$			bmission to PRD
$H \to ZZ \to llll$			072012
$H \to \tau\tau$			04 (2012)
$VH \to jj\bar{b}\bar{b}$			04
$H \to \gamma\gamma$			(2012)
$t\bar{t}H \to WWb\bar{b}b\bar{b}$			) 181802





What to be really proud of



So, is it THE SMS boson?

- **In general, when is a boson the SM Higgs?**
  - spin 0
  - Neutral, CP-even component of complex $SU(2)_L$ doublet with hypercharge 1
  - couplings to SM fermions proportional to masses
- **The "new boson" can have several non-SM properties and still be the Higgs boson of electroweak symmetry breaking:**
  - CP mixture, mixture of two or more weak doublets!
  - Composite!
  - Nonstandard decay to gg or γγ from other colored/ charged exotic particles in loops

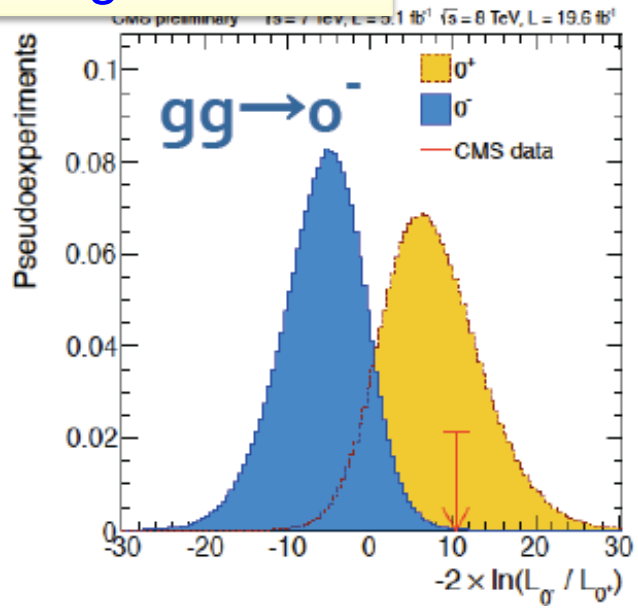
→ Does it couple like a H-boson? (i.e. to mass?)

- Measure couplings to fermions and bosons, and see if they come out right

→ What is its CP?

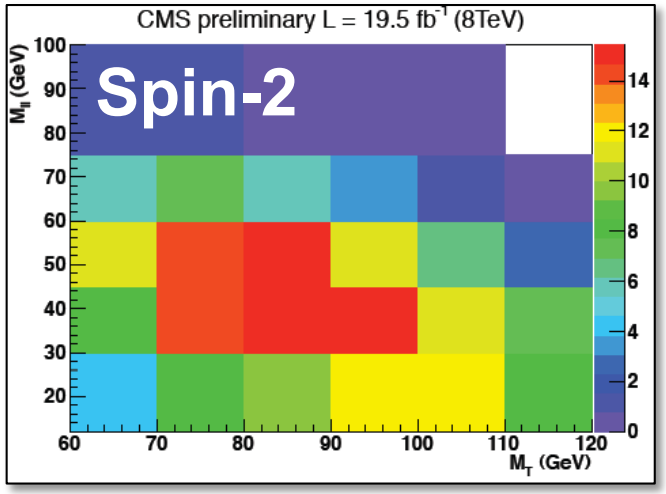
Spin-parity from ZZ* and WW*

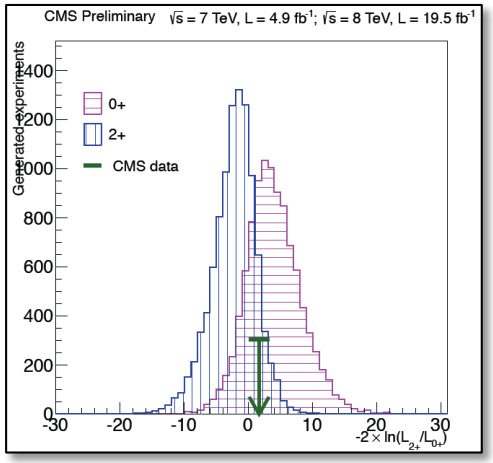
Mingshui Chen

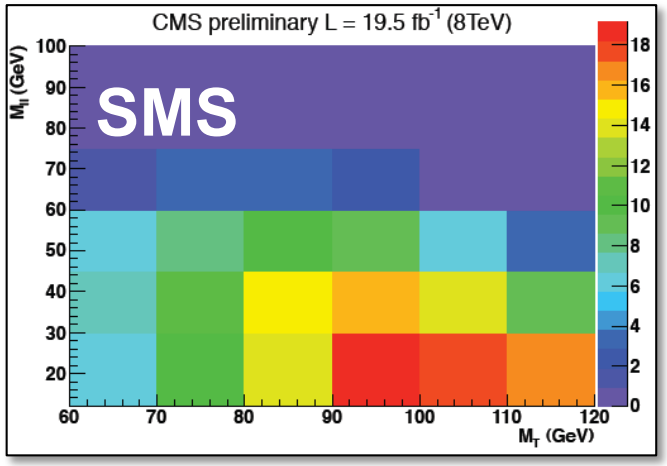


ZZ*:

pseudoscalar, spin-1 and spin-2 cases excluded at ≥ 95% CL







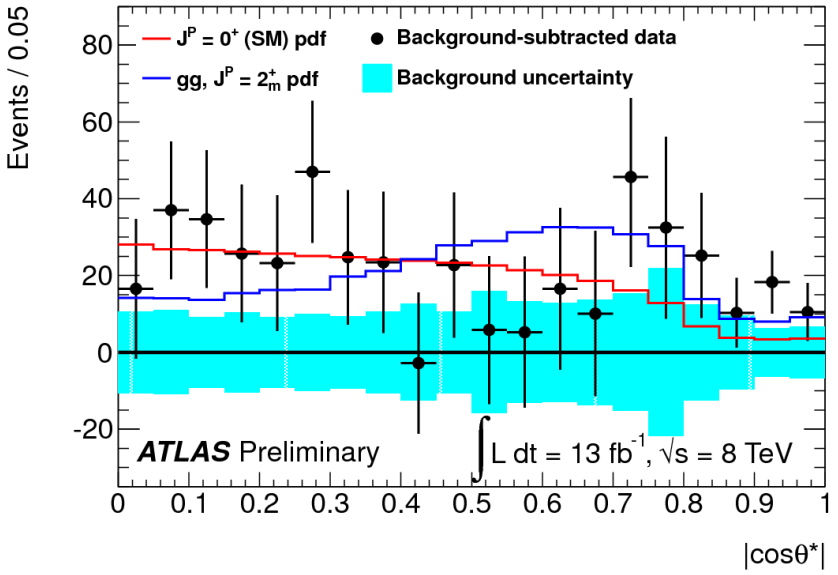
Expected separation ~ 2σ

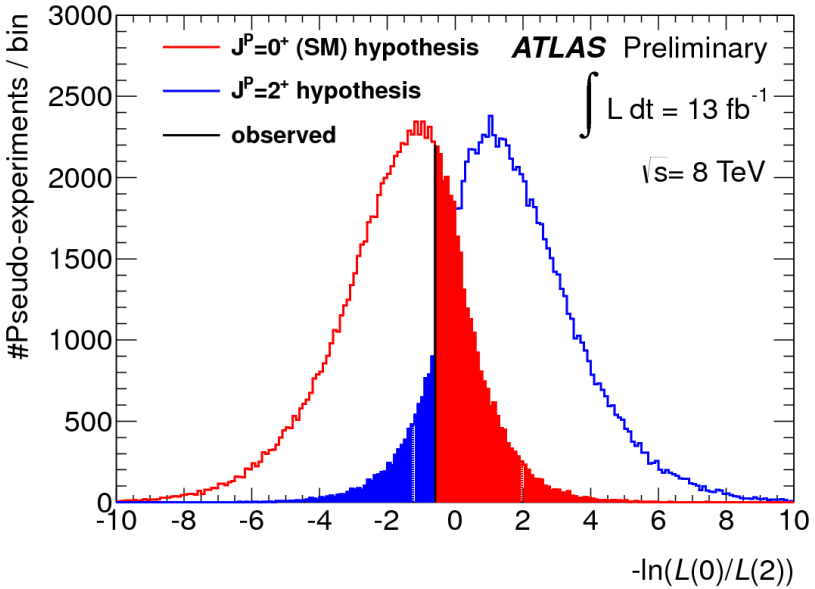
Data: consistent with both hypotheses; favors slightly 0+

Fabrice Hubaut

Spin-parity from γγ

- **Sensitive to spin-0 vs spin-2**



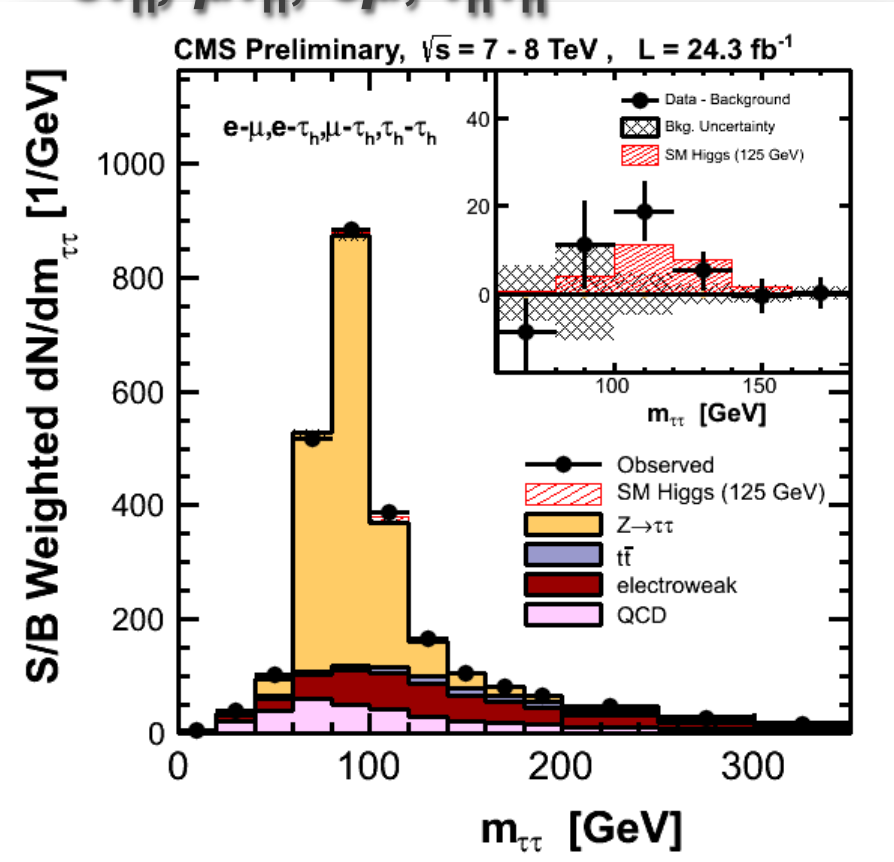


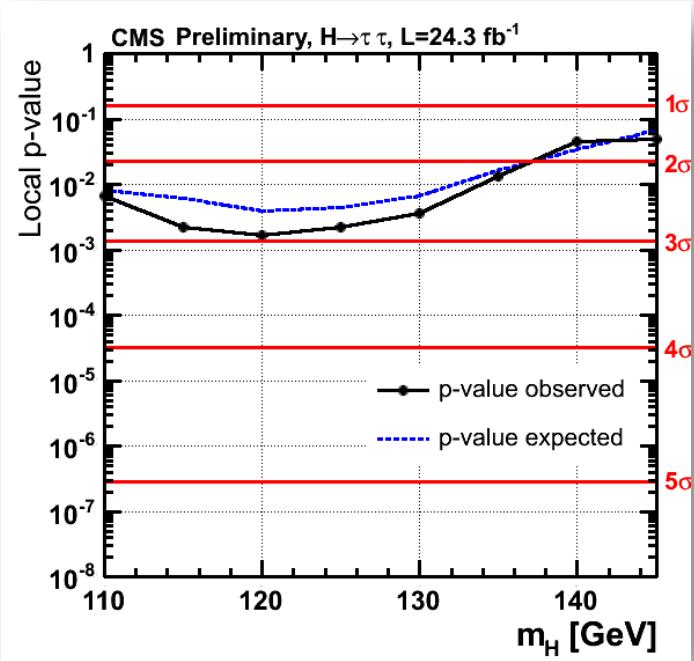
- **Spin-2^+ hypothesis expected exclusion CL_s at 93%**
- **Observation compatible with spin-0^+, slightly favored over spin-2^+ hypothesis**

It decays to taus (and thus, fermions ☺)

Valentina Dutta

$e\tau_h$, $\mu\tau_h$, $e\mu$, $\tau_h\tau_h$



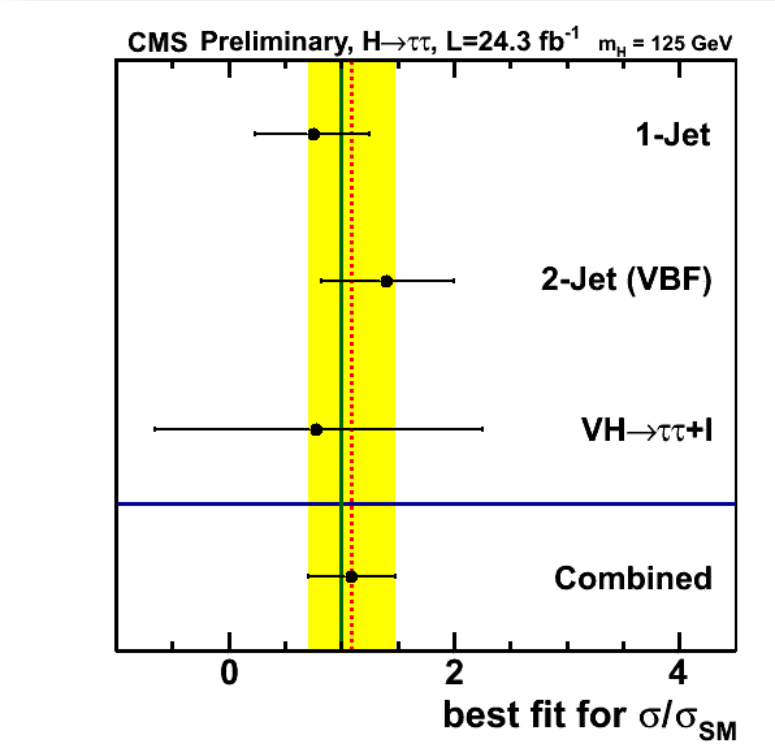


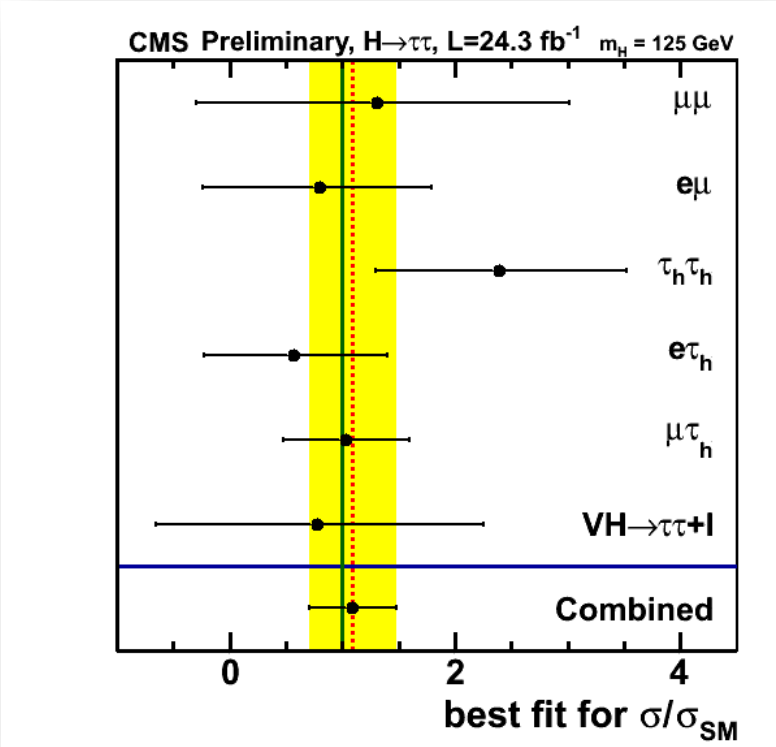
Combined channels and categories, each category in each channel weighted by its S/B

- Maximum local significance @ 120 GeV: **2.93σ**; compatible with 125 GeV SMS boson
- At 125 GeV: observed signif: **2.85σ** (expected: **2.62σ**)

$H \rightarrow \tau\tau$

- **Yields by "type" and by decay channel**





- Consistent picture across channels and categories
- Combined best-fit $\hat{\mu}$ of **1.1±0.4**

ATLAS fermionic summary

Vicky Martin

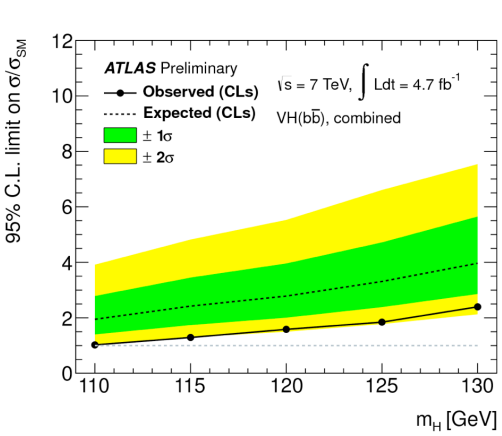
- **No observation of SM Higgs boson production, decaying into fermions or invisibly, in the range $100 < m_H/\text{GeV} < 150$.**

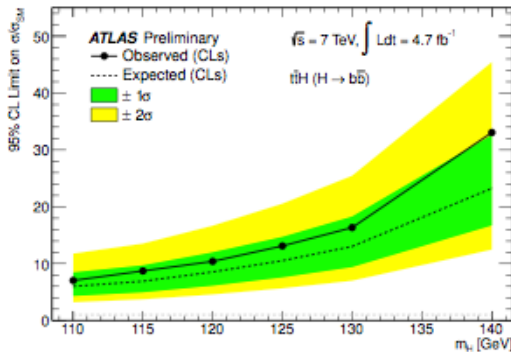
95% CL limits on SM Higgs production, for m_H=125 GeV

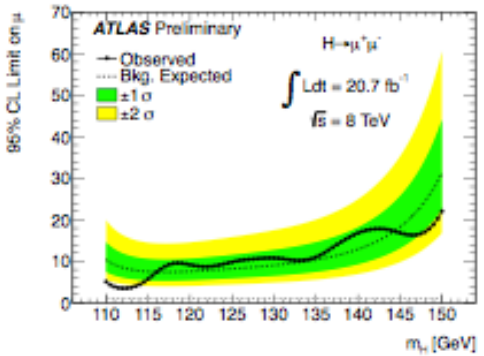
	observed	expected
$VH \to Vb\bar{b}$	1.8	1.9
$t\bar{t}H, H \to b\bar{b}$	13.1	10.5
$H \to \tau^+\tau^-$	1.9	1.2
$H \to \mu^+\mu^-$	9.8	8.2

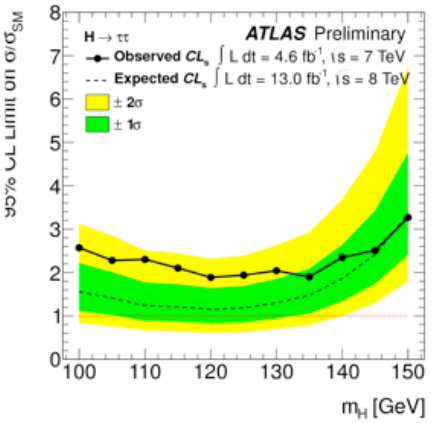
95% CL limits on SM Higgs, for m_H=125 GeV

	observed	expected
BR ($H \to$ invisible)	< 65%	< 84%

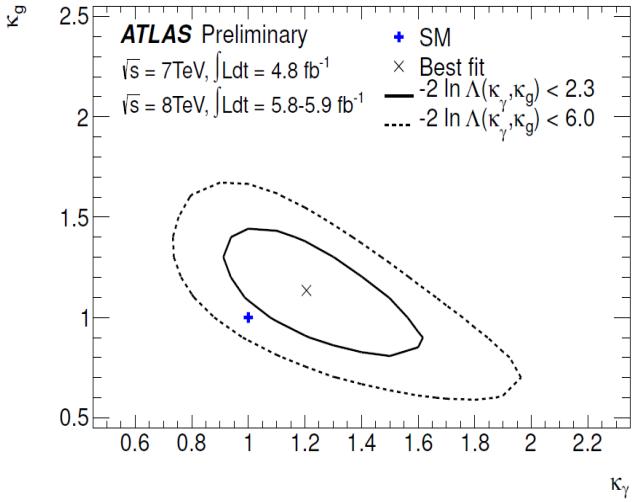


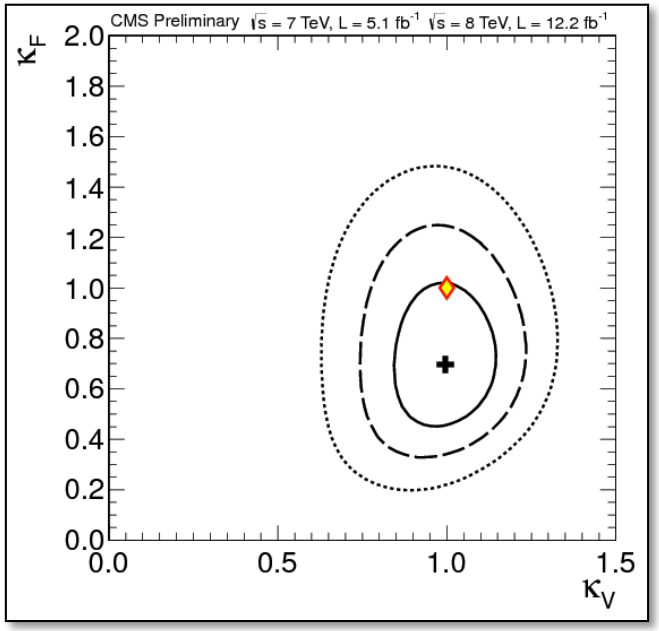




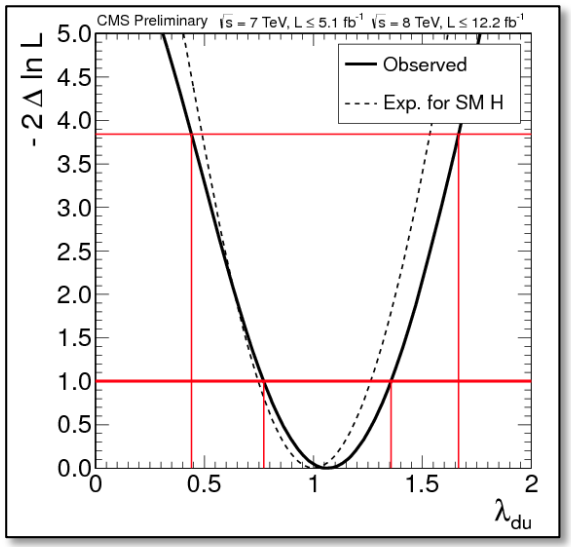


Couplings

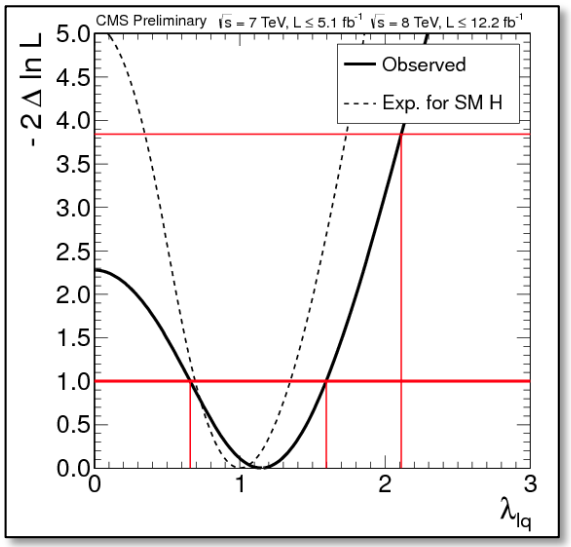




λ_{du}: ratio of couplings between down- and up-fermions



λ_{lq}: ratio of couplings between leptons and quarks



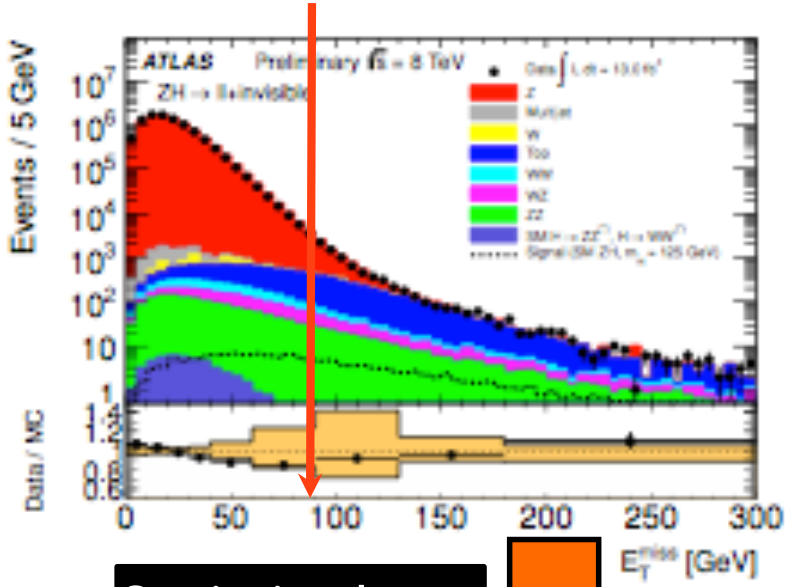
Both ratios consistent with 1

H→invisible search

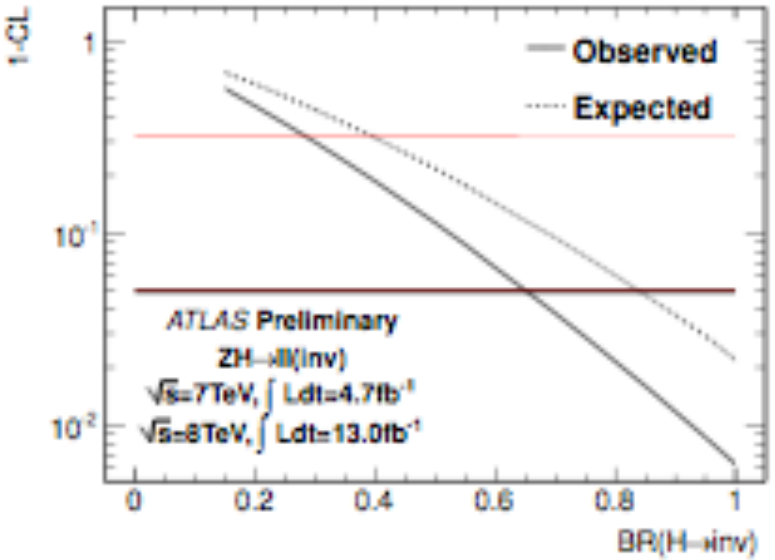
Vicky Martin

- **Z→ee/μμ @ large Etmiss**

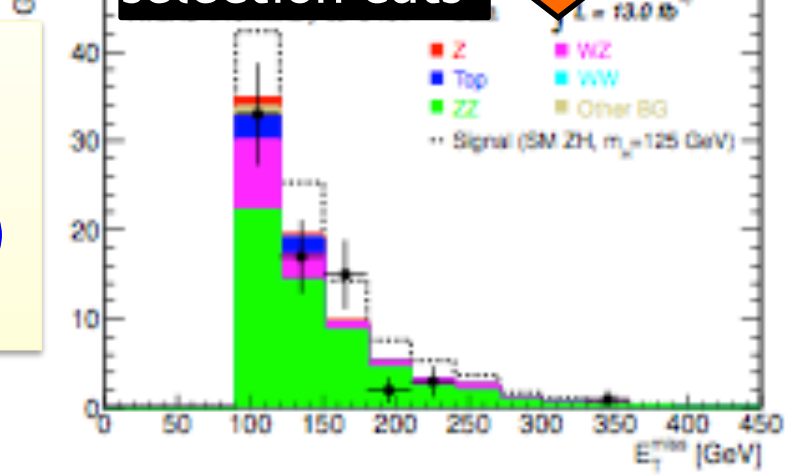
	expected SM backgrounds	observed events
$\sqrt{s} = 7$ TeV 4.7 fb^{-1}	32.7 ± 1.0 (stat) ± 2.6 (syst)	27
$\sqrt{s} = 8$ TeV 13.0 fb^{-1}	78.0 ± 2.0 (stat) ± 6.5 (syst)	71



Optimised selection cuts



@ 95% CL
BR(*H*→inv)
< 65% (obs)
< 84% (exp)



SMS summary

The new boson [is beginning to*]
look (decay modes),
sound (yields ~ok ?!?),
smells (no new modes),
tastes (no extra flavor-dependence)
and feels (0^+…)
like the SMS (WHOI1/2AVO246GEV)

***expresses scientific caution**

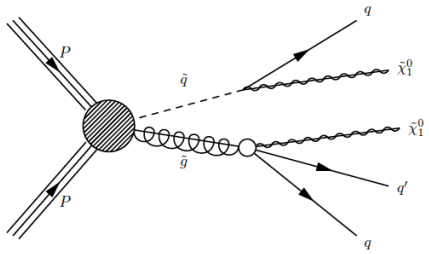
Next (big) jump in confirmation in 2.5 yrs…

Supersymmetry [?]

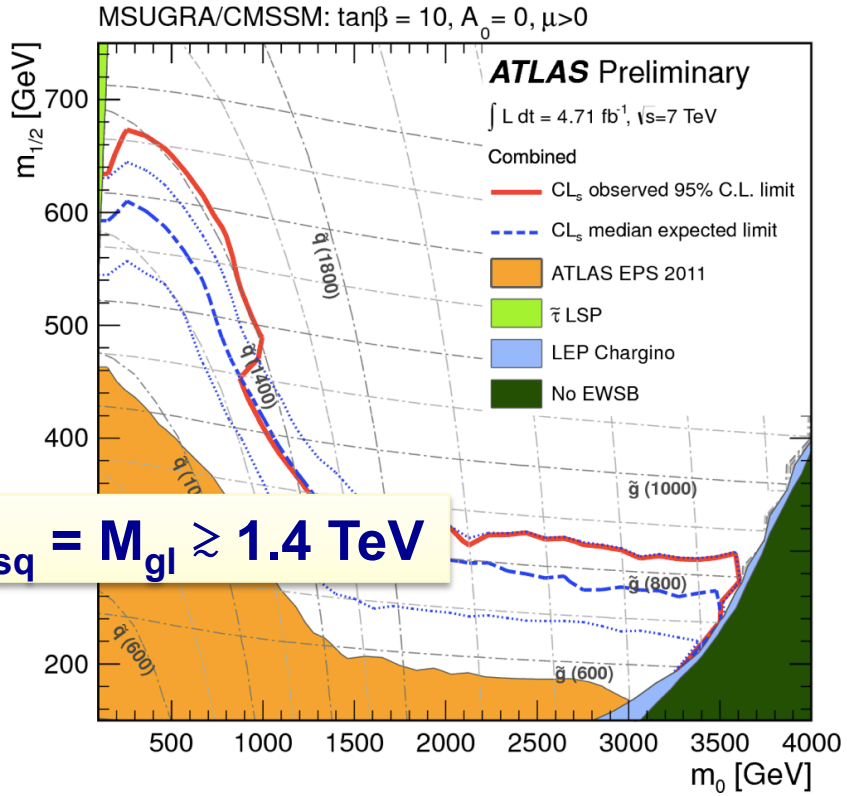
(Still) desperately seeking SUSY

With the full 2011 data (~5 fb^{-1})

- **Example ATLAS SUSY search: 2-6 jets plus MET**
  - **Veto leptons (all hadronic)**

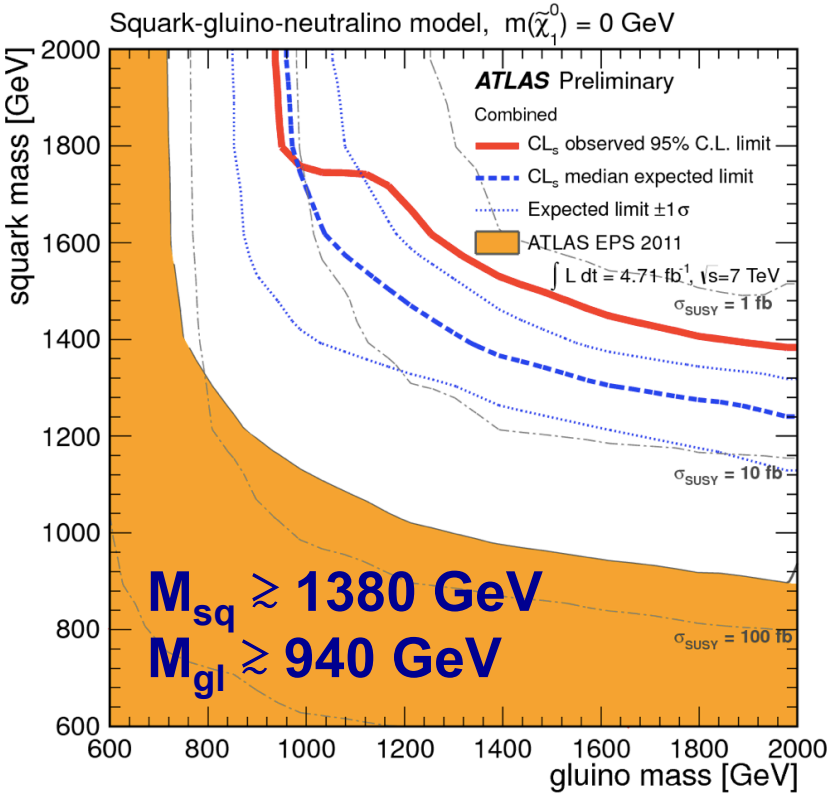


CMSSM



$M_{sq} = M_{gl} \gtrsim 1.4$ TeV

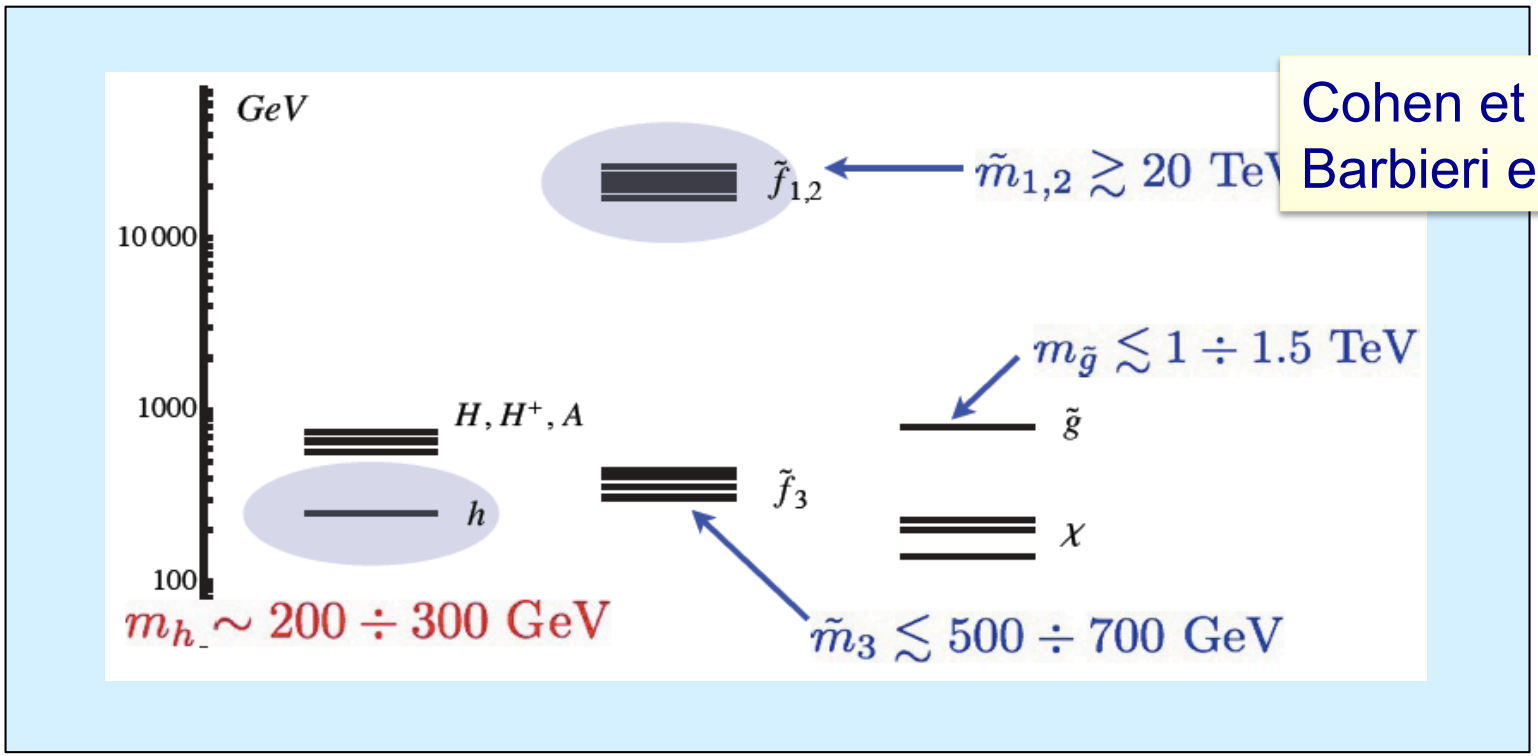
SMS



$M_{sq} \gtrsim 1380$ GeV
$M_{gl} \gtrsim 940$ GeV

Definition of "natural"

- **In theory, it is unnatural not to find what Theory predicts; in practice, of course, it is quite natural*.**
  - **Faced with difference between theory and practice, pursuing "natural-SUSY searches" [vs "natural SUSY searches"]**

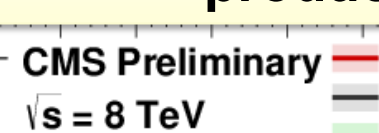


Cohen et al (96)
Barbieri et al (07)

*** For those who only read the transps: this is a joke.**

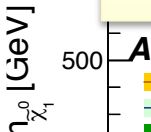
Natural-SUSY searches in SMS

If gluino light enough:
→ gluino induced production



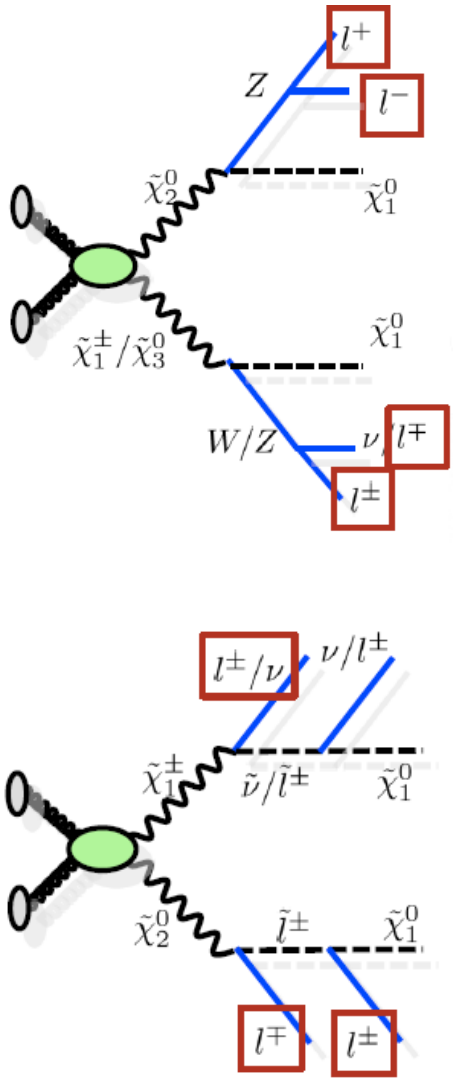
CMS gluino-induced stop production

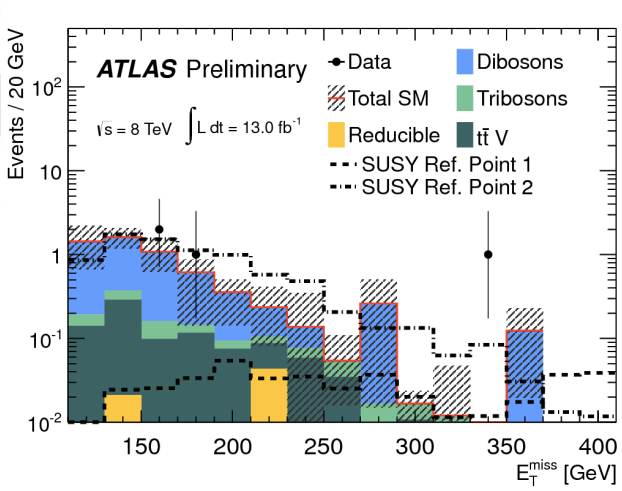
If third-generation squarks light enough:
→ direct production

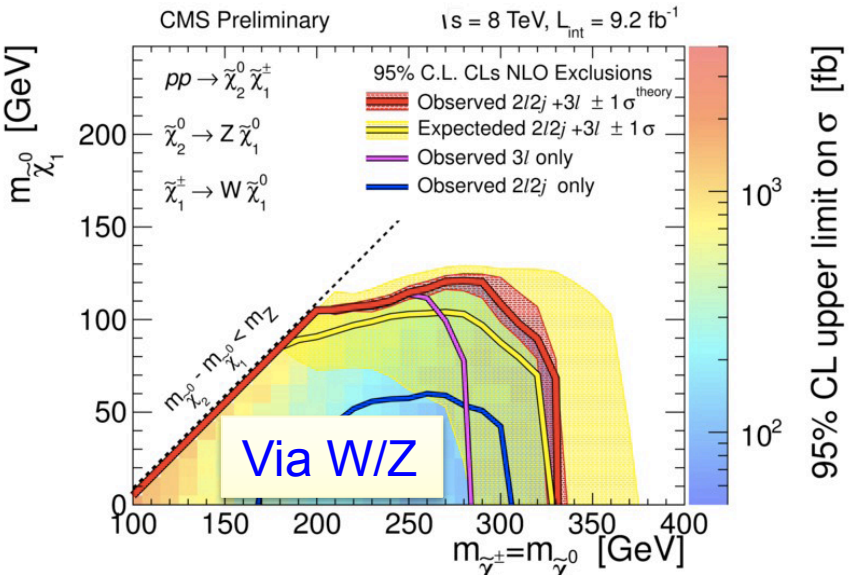


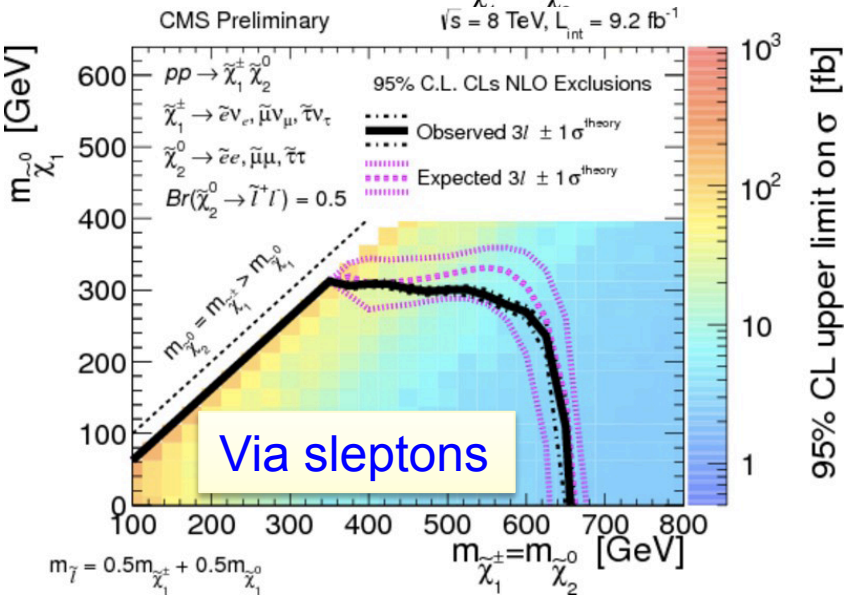
ATLAS direct stop production

Natural-SUSY searches in SMS



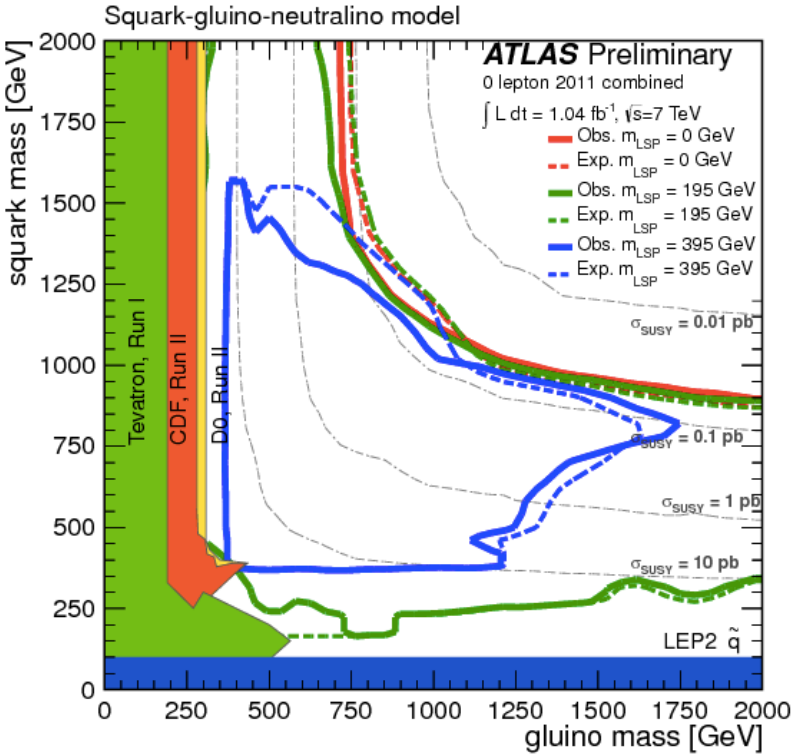


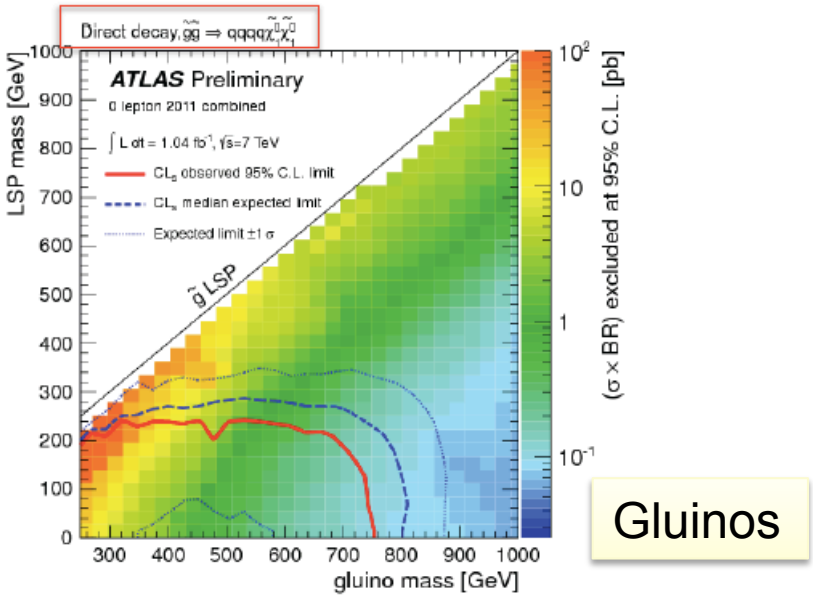




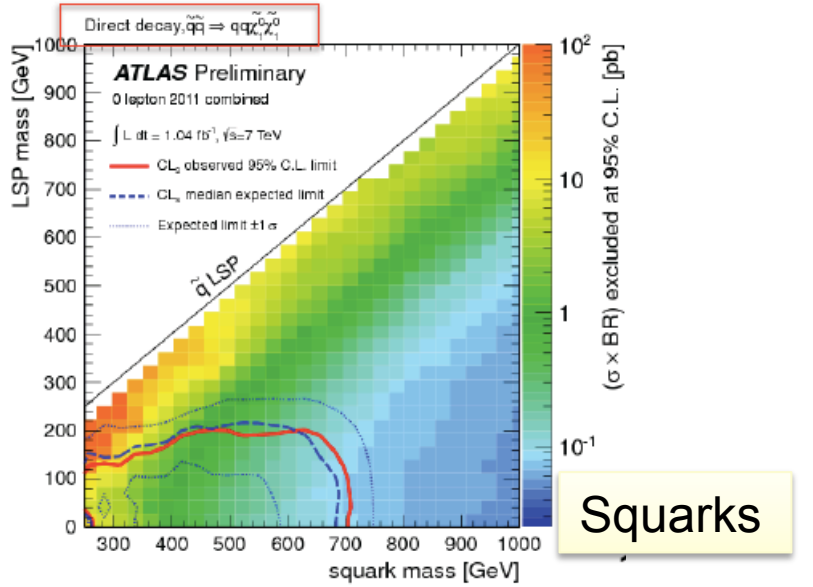
SMS: allow parameter variation

- **Effects can be significant;**
- **e.g. varying M_{LSP}:**
  - **RED: M_{LSP}=0**
  - **Green: M_{LSP}=195 GeV**
  - **Blue: M_{LSP}=395 GeV**





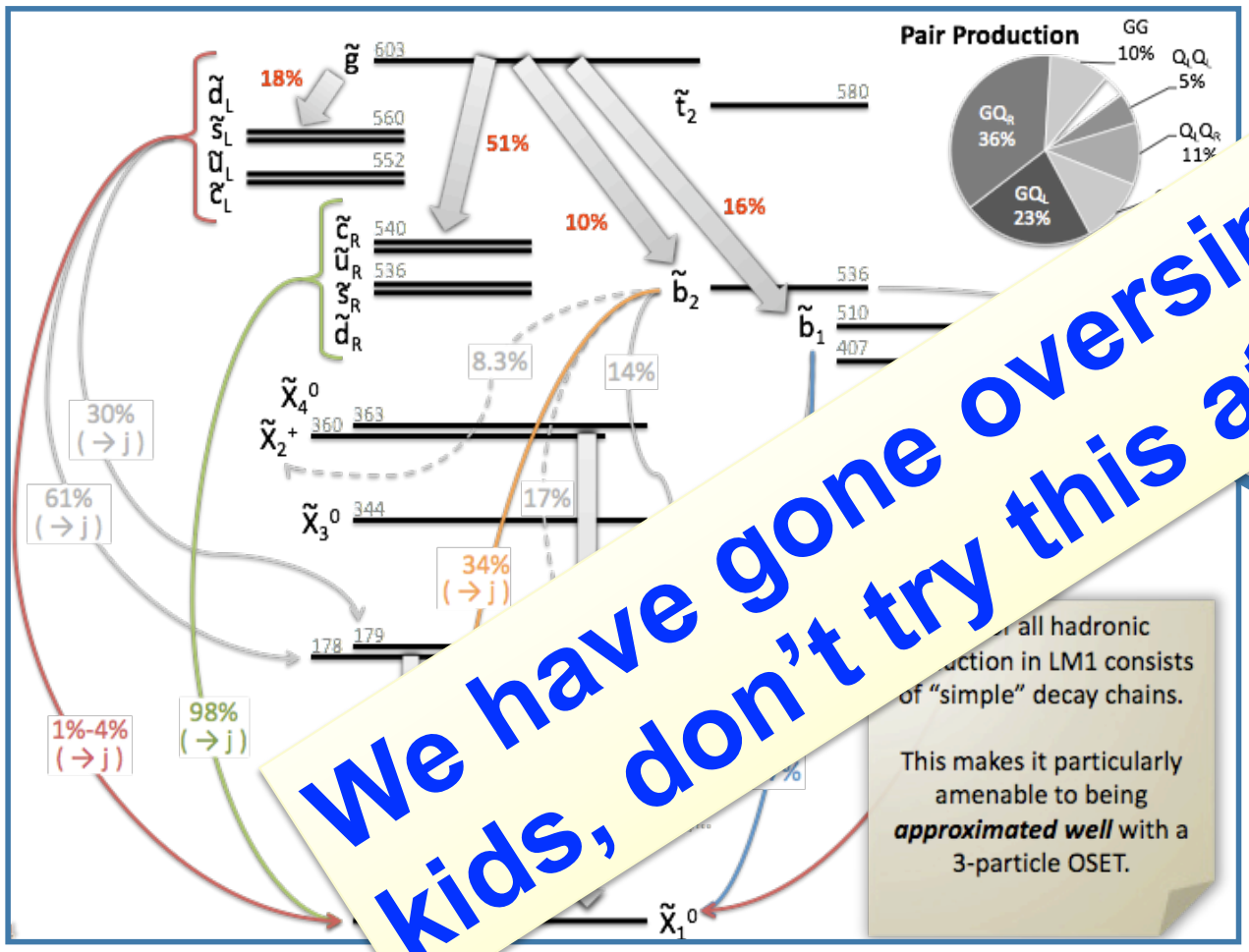
Gluinos



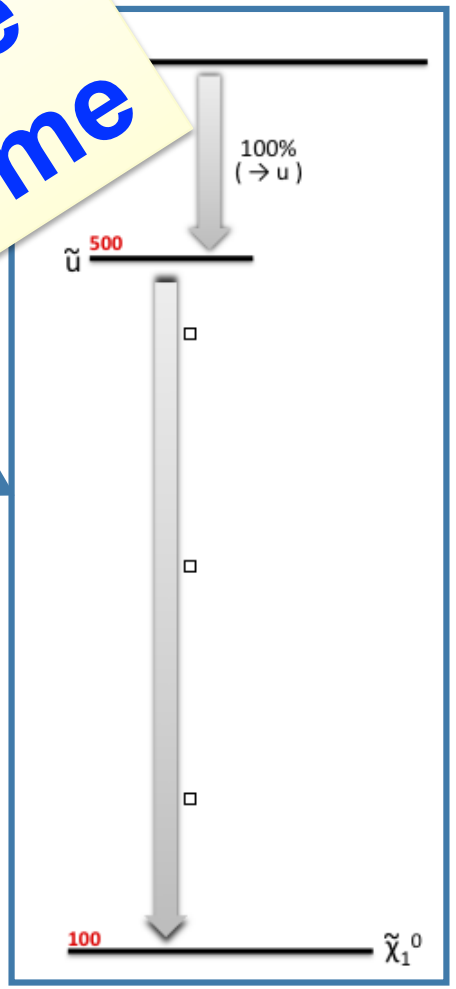
Squarks

Recently: use of simplified models

CMSSM



What we put in:
h simpler…



We have gone oversimple kids, don't try this at home

Simplified Model Spectrum (SMS)
with 3 particles, 2 decay modes

A word on models

It would be useful to have a NatMSSM

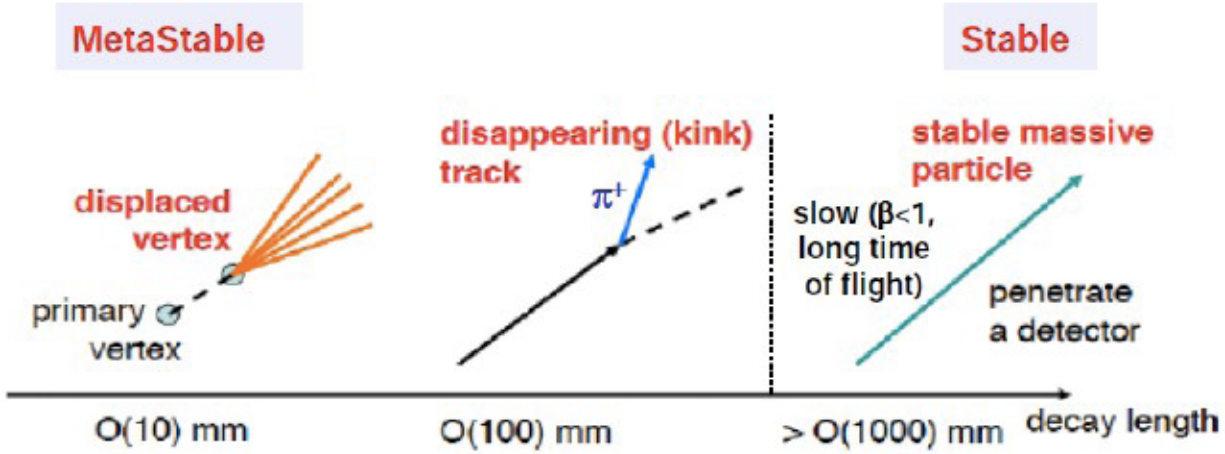
Even if this sounds a bit naïve,

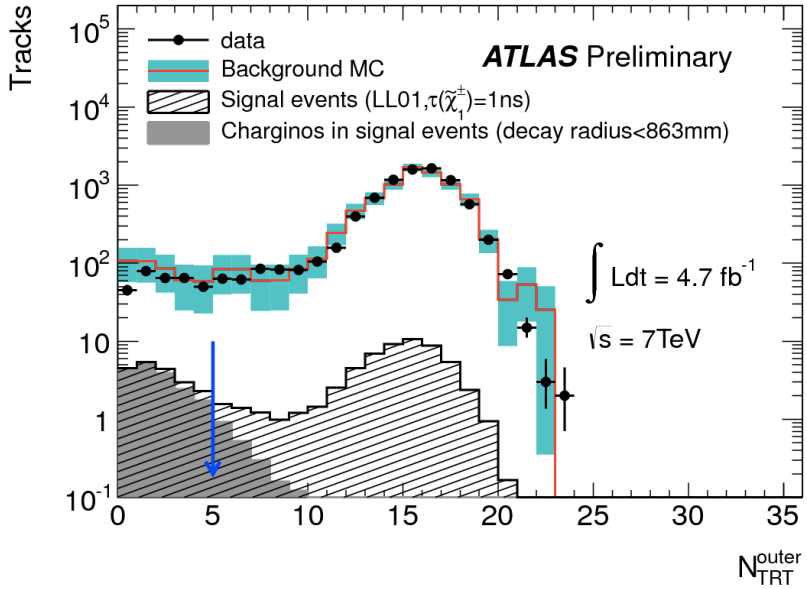
the point is that with the (SUSY) SMS and an accumulating set of limits we have an overall "interpretation issue"

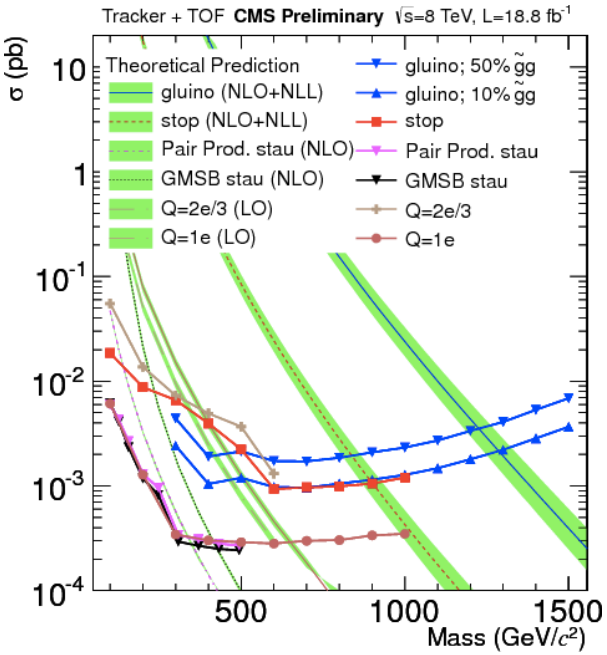
SUSY is far from excluded (let alone dead)

- **Yes, simple models (e.g. universal soft masses) being squeezed. But:**
- **Numerous other scenarii still very much unprobed [thus very unconstrained]. Two examples:**
  - **Low ME_T: not only within R_p-violation; small mass splittings (would be equally lethal to ME_T signature)**
    - **Could even have all sparticles with mass < ~0.5 TeV…**
  - **Large flavor splitting: very heavy squarks [1st, 2nd gen], light 3rd gen (plus gluino at ~1-1.5 TeV). Favored recently…**

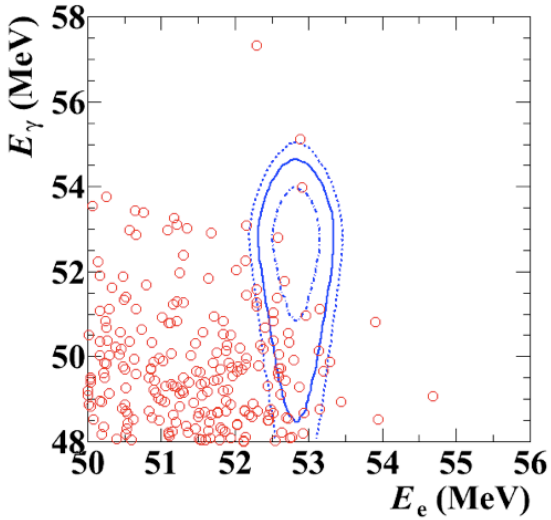
Non-MET SUSY

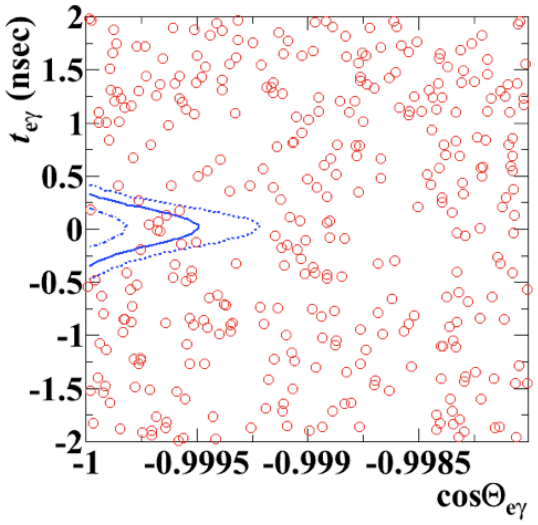

MetaStable
Stable
displaced vertex
primary vertex
disappearing (kink) track
π^+
stable massive particle
slow (β<1, long time of flight)
penetrate a detector
O(10) mm
O(100) mm
> O(1000) mm
decay length

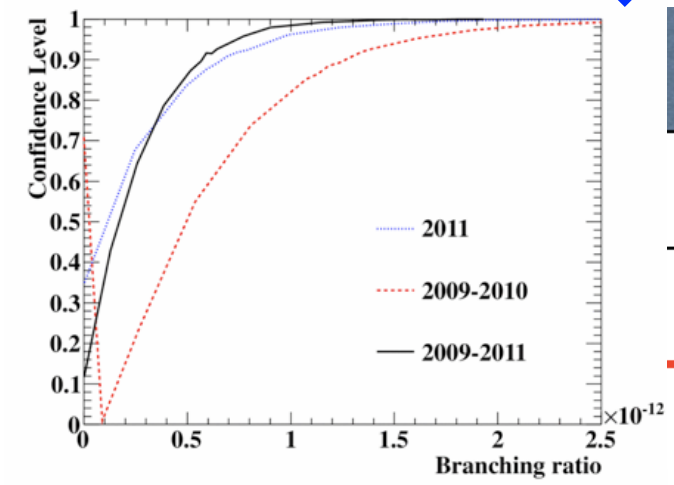

Tracks
data
Background MC
Signal events (LL01,τ($\tilde{\chi}_1^\pm$)=1ns)
Charginos in signal events (decay radius<863mm)
ATLAS Preliminary
∫ Ldt = 4.7 fb^{-1}
√s = 7TeV
N_{TRT}^{outer}


Tracker + TOF CMS Preliminary √s=8 TeV, L=18.8 fb^{-1}
σ (pb)
Theoretical Prediction
gluino (NLO+NLL)
stop (NLO+NLL)
Pair Prod. stau (NLO)
GMSB stau (NLO)
Q=2e/3 (LO)
Q=1e (LO)
gluino; 50% $\tilde{g}\tilde{g}$
gluino; 10% $\tilde{g}\tilde{g}$
stop
Pair Prod. stau
GMSB stau
Q=2e/3
Q=1e
Mass (GeV/c^2)

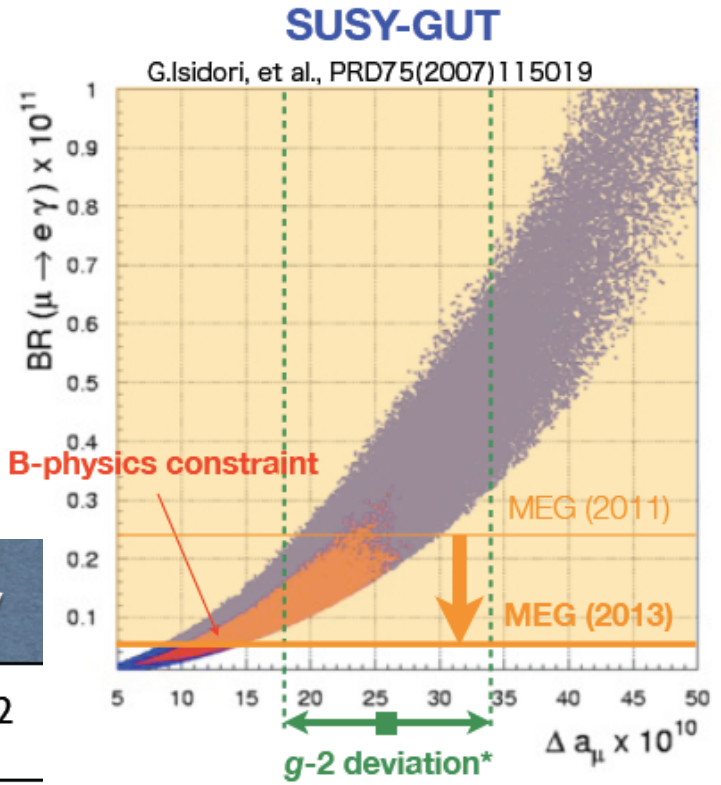
MEG: oh well!







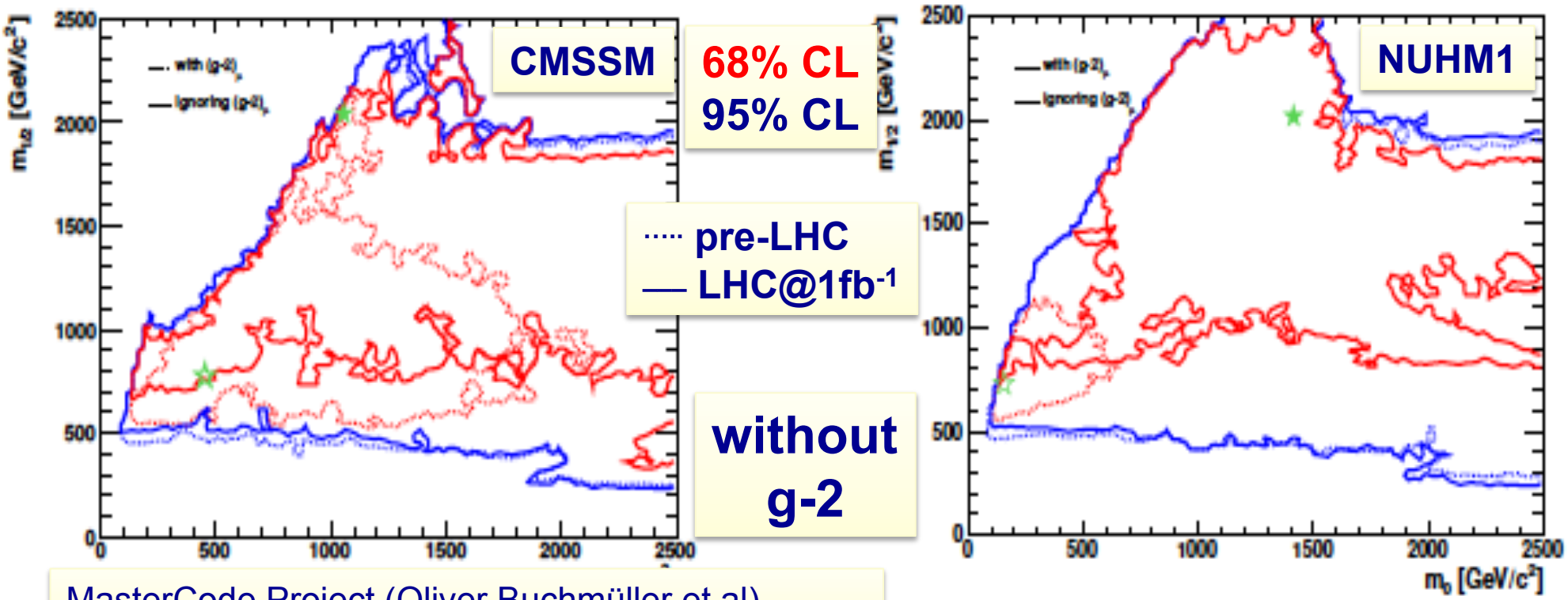
Upper limit (90% C.L.)	Sensitivity
1.3×10^{-12}	1.3×10^{-12}
6.7×10^{-13}	1.1×10^{-12}
5.7×10^{-13}	7.7×10^{-13}



If g-2 in "trouble", so is "upper SUSY bound"

From $\mu \to e\gamma$ to g-2 to SUSY

- Recall: g-2 is (was?) binding SUSY "from above"
- "Obvious SUSY" @ "unnatural" values
  - CMSSM cornered. Not excluded [yet] but looking unlikely [e.g. "high fine-tuning price of the LHC" hep.ph/1101.2195]
- But: (a) effect of g-2 ?! (b) SUSY >> CMSSM



MasterCode Project (Oliver Buchmüller et al)

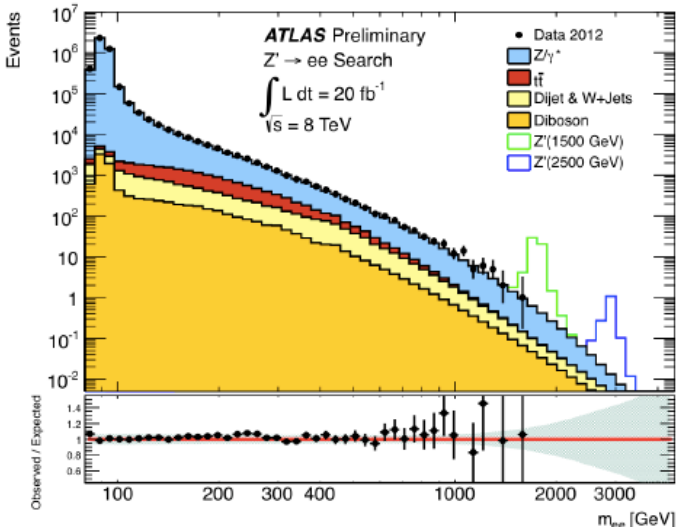
Parting word on SUSY

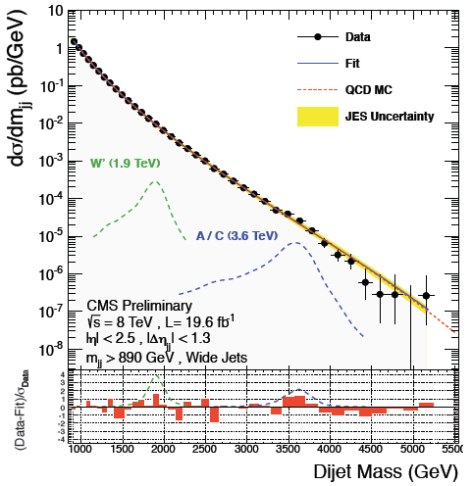
- **Further guidance from theory (heard at Moriond 13):**

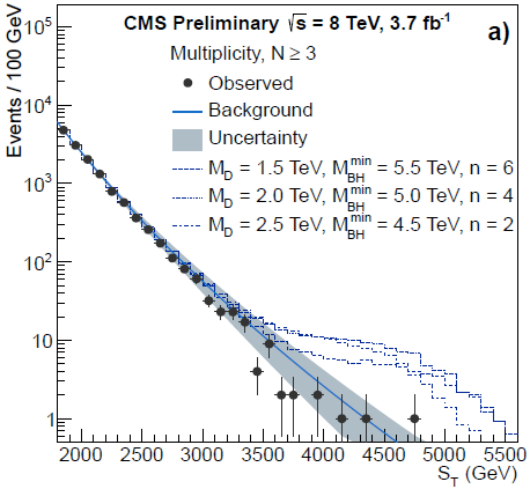
  "Supersymmetry will be alive even if we don't find it at the LHC"

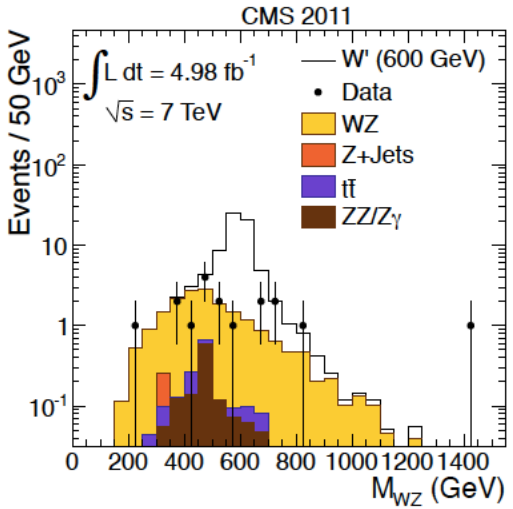
  → My take: sure, but ~ noone will be looking for it.

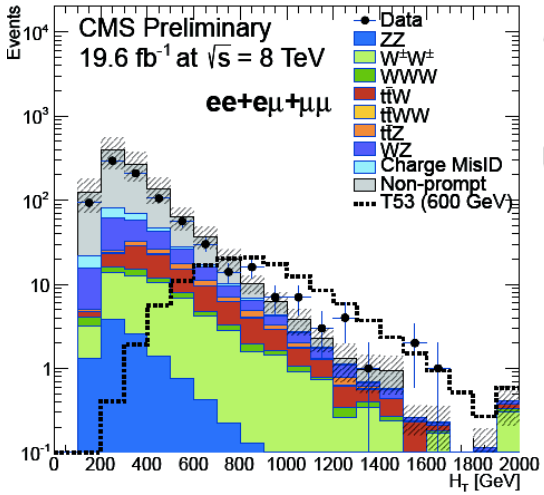
Looking for everything else

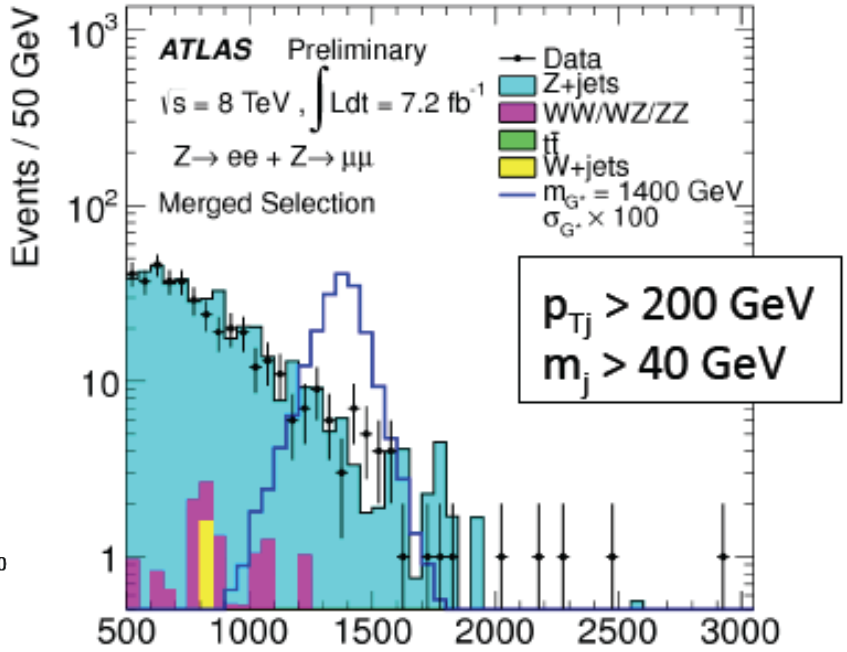










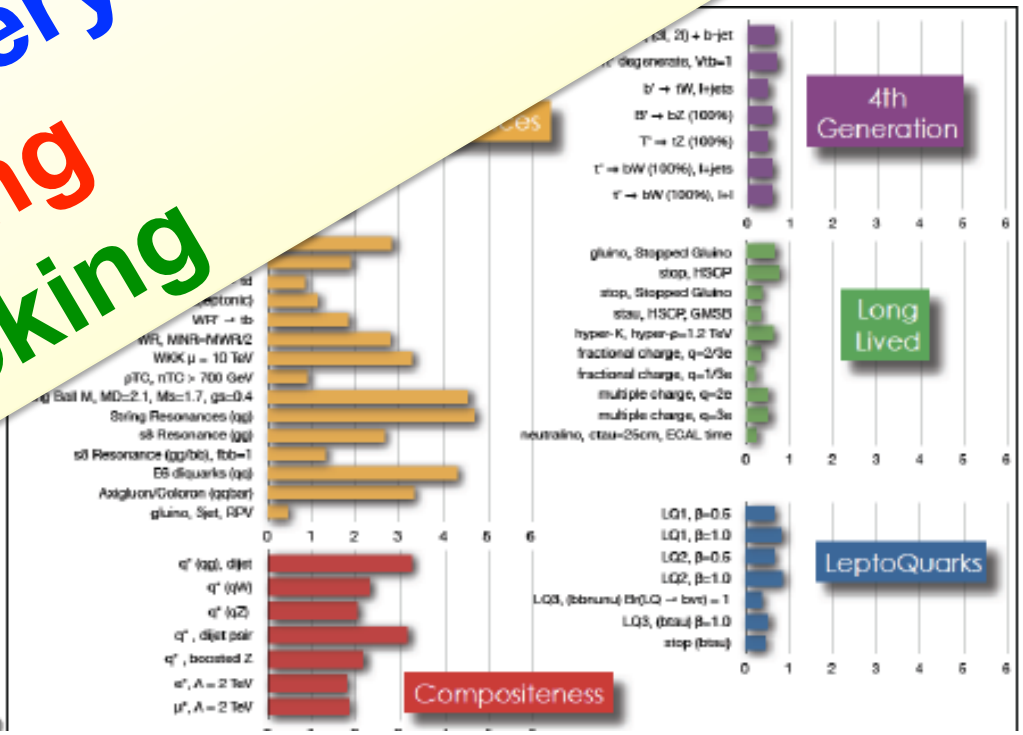


Searches for BSM physics

Looked for everything

Found nothing

But still looking



Actually…

- We have NOT looked for EVERYTHING; the equivalents of the Centauro searches at the SPS is pursued less actively…
  - Our credit-award system does not encourage "looking at everything"
  - Neither does our "funding system"
- There are, of course, good reasons for not looking for all (possibly crazy) things one can think of
- Nota bene: a theoretical paper with a crazy idea goes a long way towards encouraging (aka "justifying") work on an idea. In the absence of a "quantitative limit", it is very difficult to justify the work in front of God and people (promotion committees, funding board, etc)
  - Obviously, we should look for things not predicted as well…

Summary of the experimental summary

Back to Google

- **Searching for "how to summarize without being hated by everyone"**

how to summarize without being hated by everyone - Google Sea

Portal | CADI-An... | CMS Pub... | Rencontr... | Rencontr... | Portal | Courche... | eps-hep... | T30d

https://www.google.com/search?q=Summary&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:en-US:official&client=firefox-a#hl=en&

Most Visited | Latest Headlines | CERN/CMS | UoA/IASA | Physics/HEP | Work | Internet/Surfing | Personal

+You Search Images Maps Play YouTube News Gmail Drive Calendar More

Google how to summarize without being hated by everyone

Web Images Maps Shopping More Search

About 139,000,000 results (0.36 seconds)

WRITING **WITHOUT** PLAGIARIZING
www.buowl.boun.edu.tr/students/avoidingplagiarism.htm
When we paraphrase such a text, we should **summarize** his narrative main points ... The stars, the universe attracted him with **all** their myst

Modern family real-life twins: We **hated being** Lily
womansday.ninemsn.com/.../modern-family-real-life-twins-we-**hated**...
Nov 26, 2012 – Modern family real-life twins: We **hated being** Lily. Mo money they earned went into their college funds." .... Oh **no** Rhonda!

Best, Worst Learning Tips: Flash Cards Are Good, Highli
ideas.time.com/.../highlighting-is-a-waste-of-time-the-best-a...

by ANNIE Murphy Paul - in 267 Google+ circles - More by ANNIE Murphy Paul
Jan 9, 2013 – Although they are common practices, studies show they offer **no** benefit ... rereading and **summarizing** were **all** rated by the authors as **being** of ...

Brilliant: The Science of Smart
By Annie Murphy Paul

EDUCATION

Highlighting Is a Waste of Time: The Best and Worst Learning Techniques

By Annie Murphy Paul | Jan. 09, 2013 | 97 Comments

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In a world as fast-changing and full of information as our own, every one of us — from schoolchildren to college students to working adults — needs to know how to learn well. Yet evidence suggests that most of us don't use the learning techniques that science has proved most effective. Worse, research finds that learning strategies we do commonly employ, like rereading and highlighting, are among the least effective.

Parting thoughts

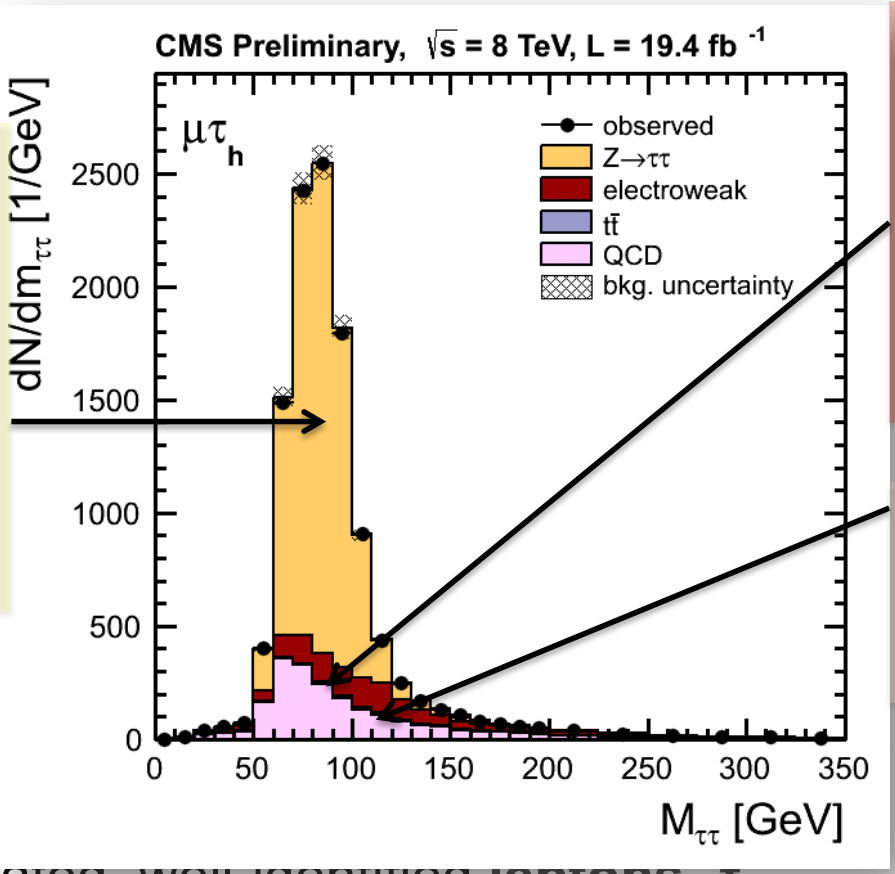
- **J. Iliopoulos (in his dinner speech) mentioned that "the real strength of any conference is its participants"**
  - **How very true for Moriond 2013: superb results, presentations prepared very well. Physics-rich!**

- **We are living in interesting times: the primary "problem" of the summary speaker was/is that there is too much information to "summarize"!**

Backups

It decays to taus (and thus, fermions ☺)

$Z \to \tau\tau$ *Embedding*:
$Z \to \mu\mu$ data, replace μ with simulated τ decay
Normalization from $Z \to \mu\mu$ data

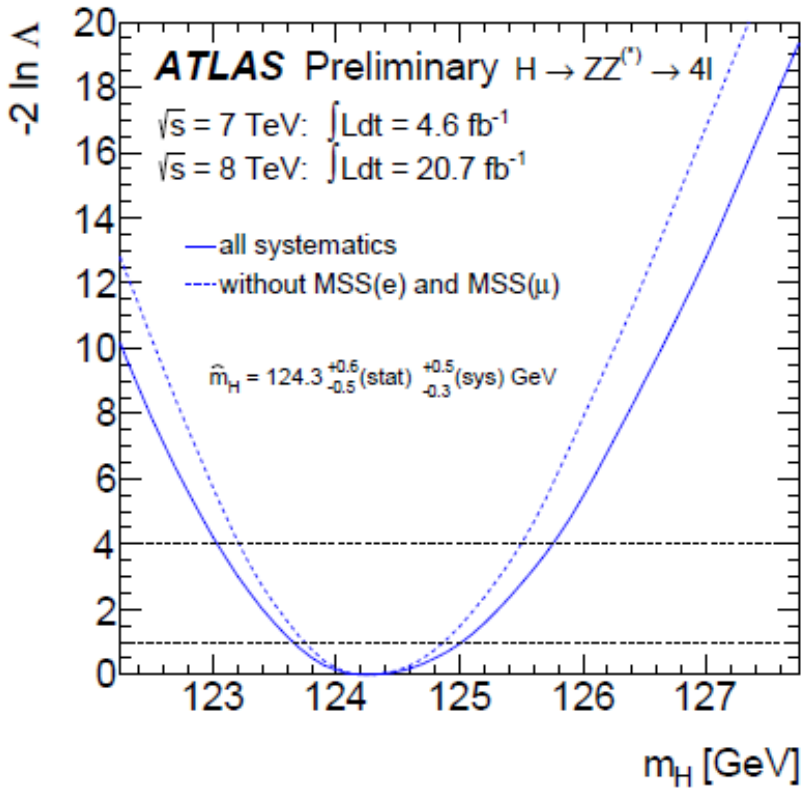


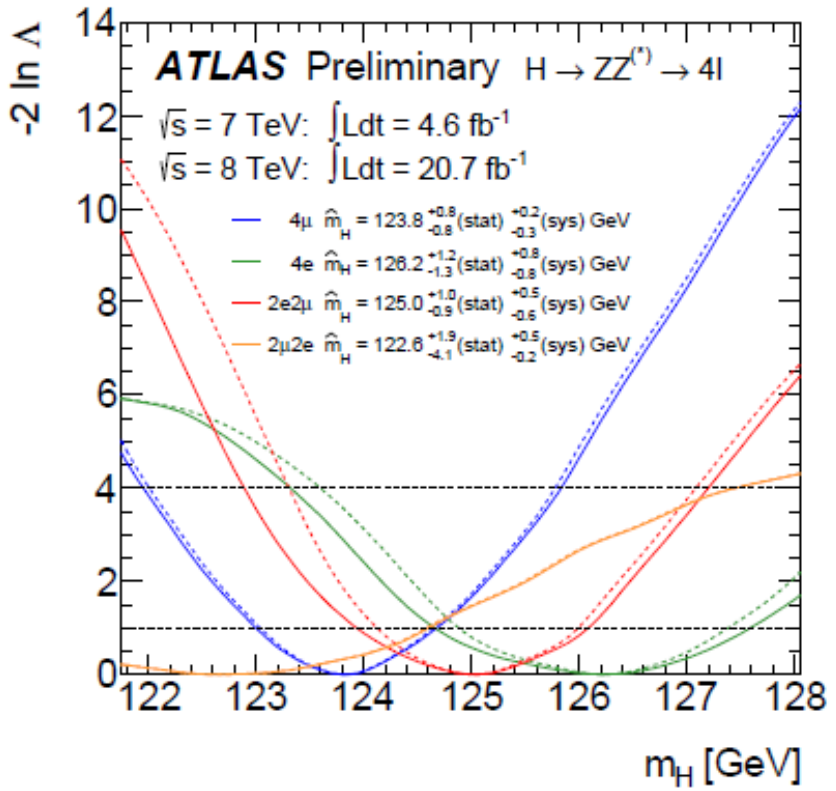
W+jets
Shape from simulation
Normalization from control region

QCD
SS data, corrected for SS/OS ratio

Strategy:

- Select isolated, well-identified leptons, τ_h
- Topological cuts (e.g. m_T in $l\tau_h$) to suppress backgrounds
- Categorize events based on number of jets, τ p_T
- Template fit to m_{TT} shape

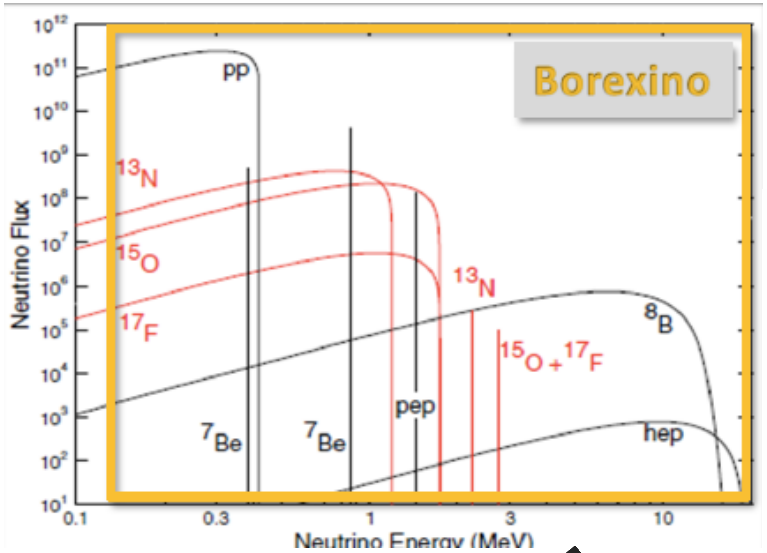

ATLAS Preliminary H → ZZ(*) → 4l
√s = 7 TeV: ∫Ldt = 4.6 fb-1
√s = 8 TeV: ∫Ldt = 20.7 fb-1
all systematics
without MSS(e) and MSS(μ)
m̂H = 124.3 +0.6 -0.5 (stat) +0.5 -0.3 (sys) GeV
-2 ln Λ
mH [GeV]

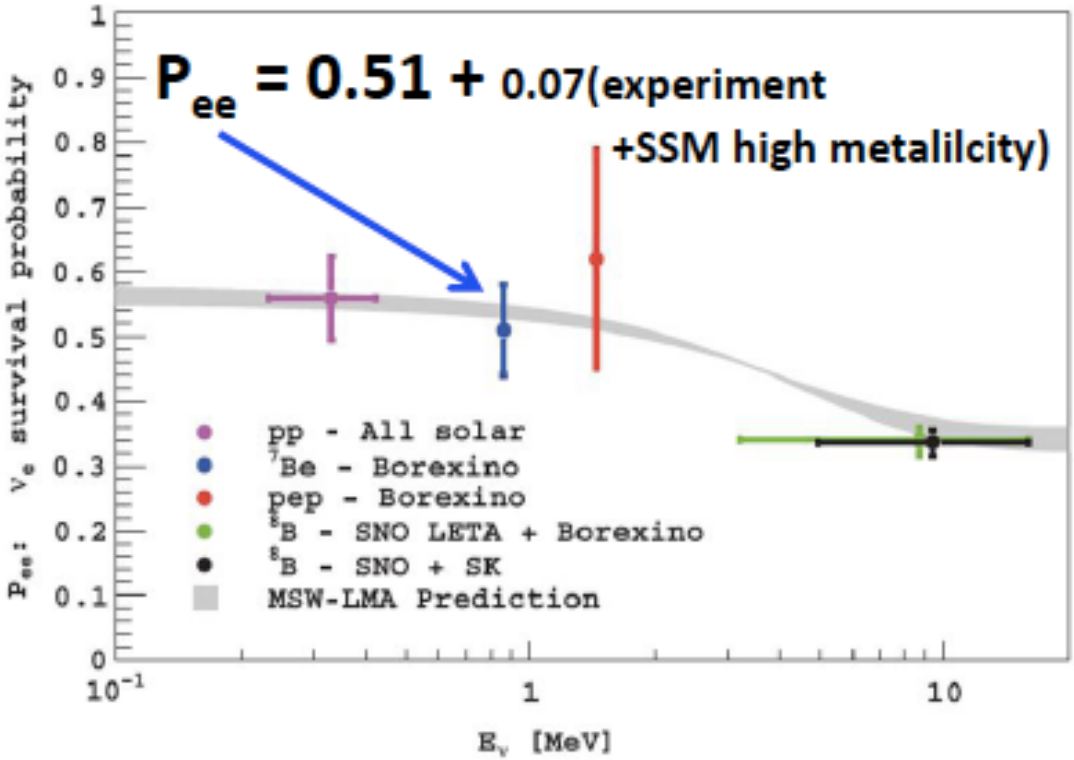

ATLAS Preliminary H → ZZ(*) → 4l
√s = 7 TeV: ∫Ldt = 4.6 fb-1
√s = 8 TeV: ∫Ldt = 20.7 fb-1
4μ m̂H = 123.8 +0.8 -0.8 (stat) +0.2 -0.3 (sys) GeV
4e m̂H = 126.2 +1.2 -1.3 (stat) +0.8 -0.8 (sys) GeV
2e2μ m̂H = 125.0 +1.0 -0.9 (stat) +0.5 -0.6 (sys) GeV
2μ2e m̂H = 122.6 +1.9 -4.1 (stat) +0.5 -0.2 (sys) GeV
-2 ln Λ
mH [GeV]

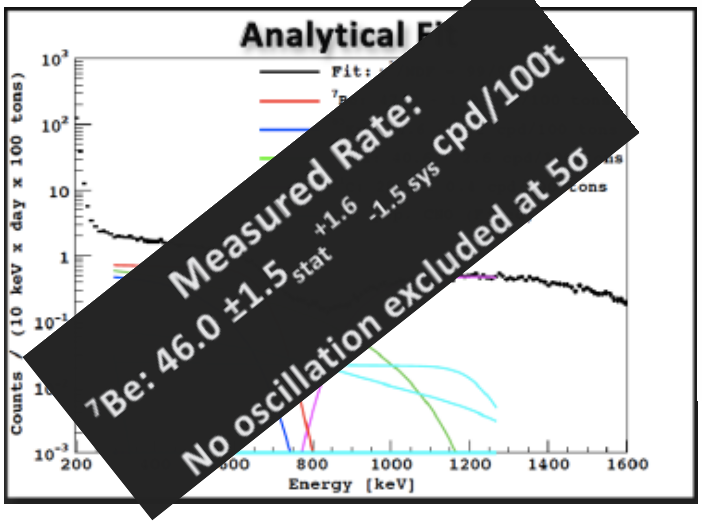
Szymon Manecki

Solar neutrinos: Borexino

- **Reminder: ^{7}Be monochromatic**







"Anomalous" oscillations:
Vacuum : ~~$\sim 1/r^2$~~

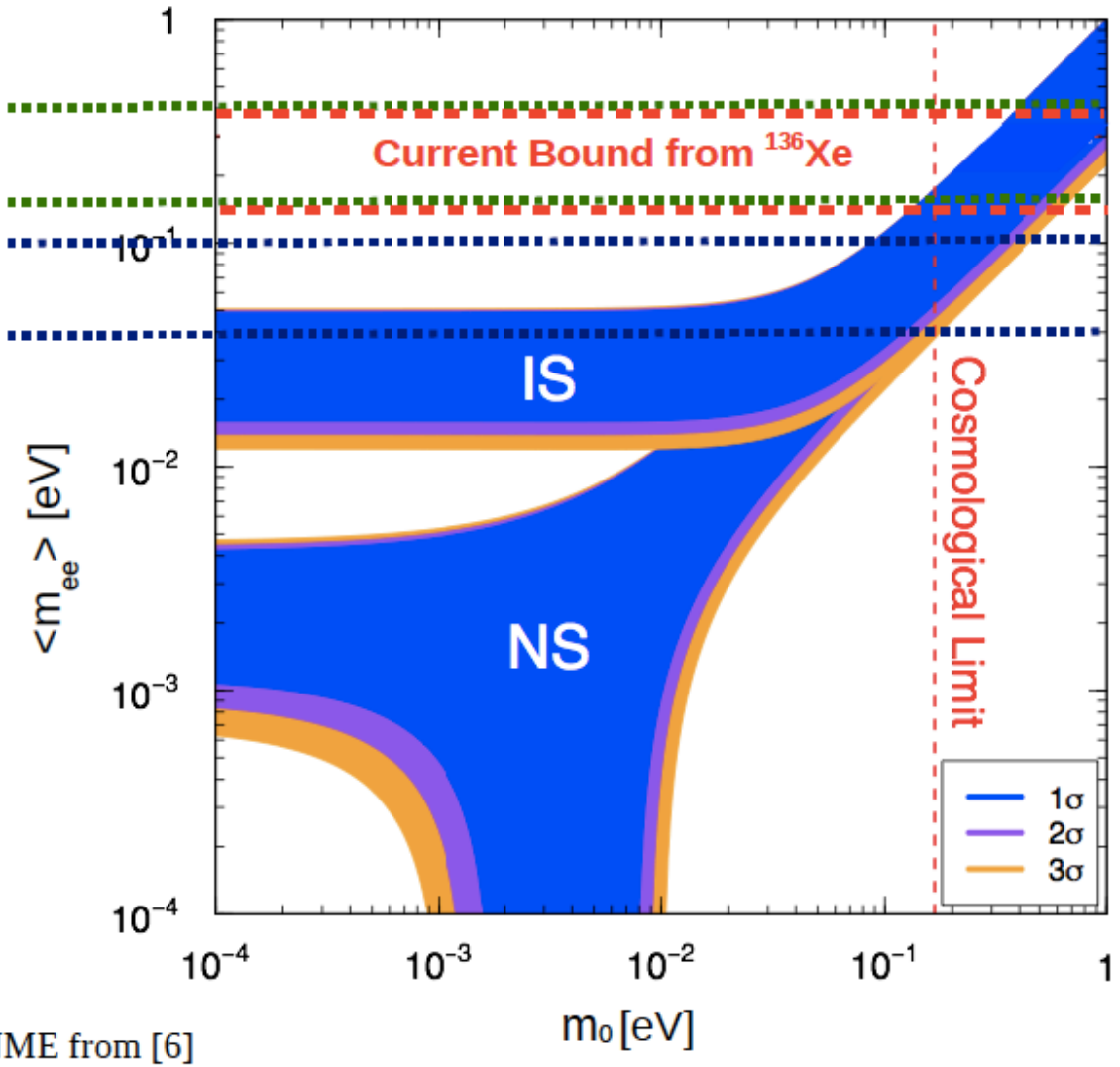
0νββ decay; the future: CUORE

Silvia Capelli

CUORE-0
- worst NME
- best NME

CUORE
- worst NME
- best NME

CUORE-0 and CUORE sensitivity at 1σ CL (*)



* Computation performed with PSF and NME from [6]

OPERA

- $\nu_\mu \rightarrow \nu_\tau$ appearance search:

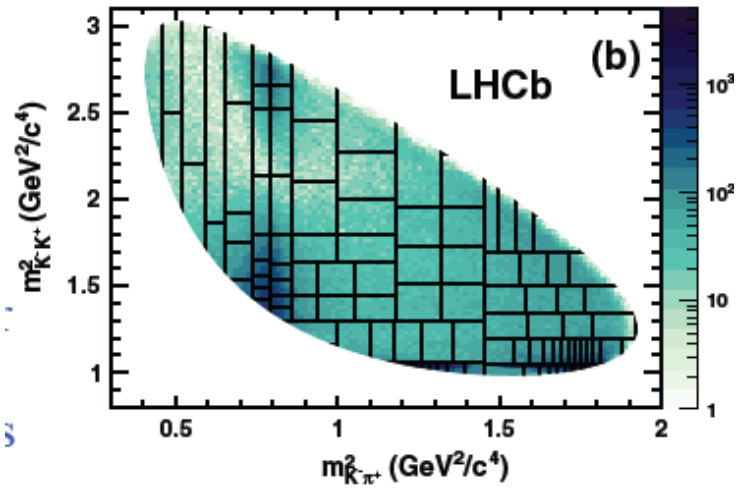
  2 candidates observed, 1.9 signal + 0.2 background expected

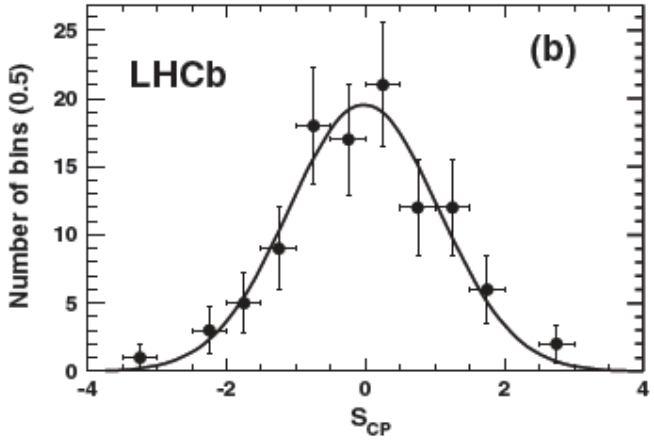
- $\nu_\mu \rightarrow \nu_e$ oscillation search:

  non-standard ν oscillations $\sin^2(2\theta_{new}) < 7.2 \times 10^{-3}$ @ 90% CL

CP violation in the charm sector

- $D^+ \to K^-K^+\pi^+$

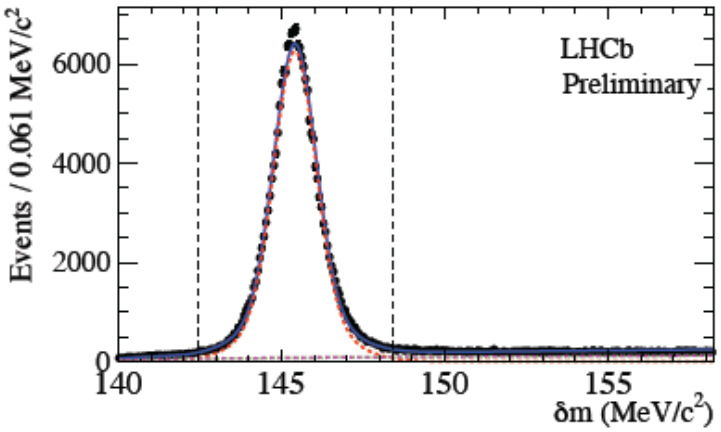


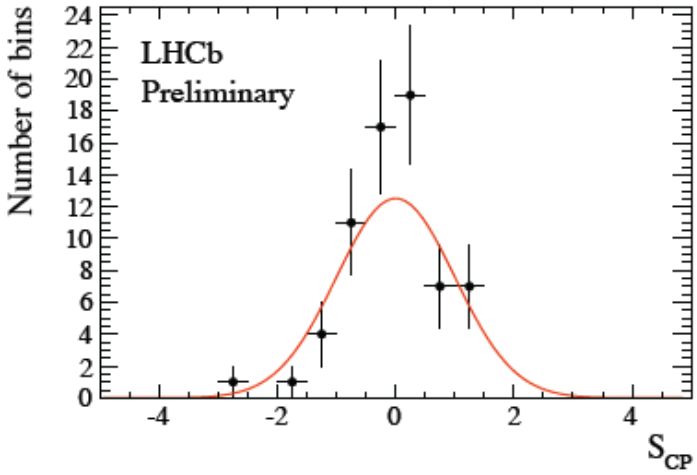


- In each bin, compute

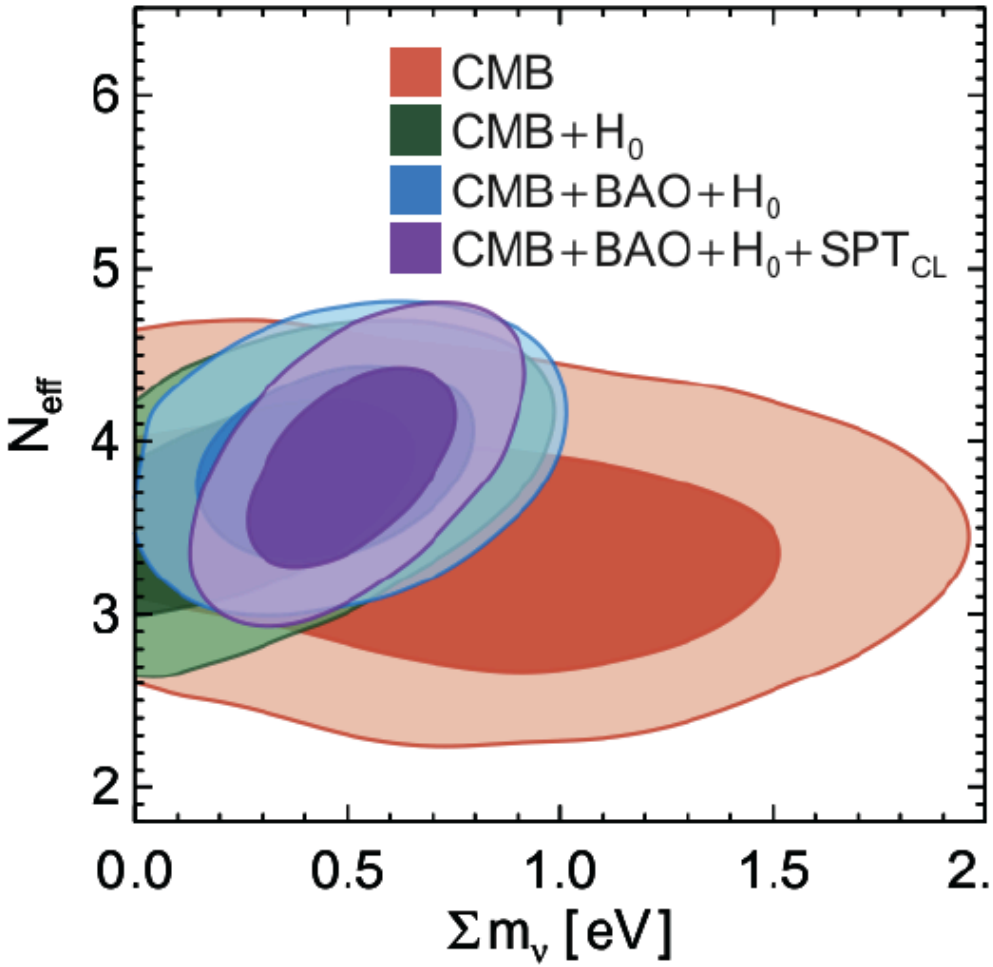
$$\mathcal{S}^{i}_{CP} = \frac{N^i(D^+) - \alpha N^i(D^-)}{\sqrt{N^i(D^+) + \alpha^2 N^i(D^-)}}, \qquad \alpha = \frac{N_{tot}(D^+)}{N_{tot}(D^-)},$$

- New: D^*-tagged $D^0 \to \pi^+\pi^-\pi^-\pi^-$





Neutrino mass



CMB + low redshift geometry:

$$N_{eff} = 3.89 \pm 0.37$$

$$\sum m_\nu = (480 \pm 210)\ \mathrm{meV}$$

CMB+low redshift geometry
+ Large Scale Structure:

$$N_{eff} = 3.86 \pm 0.37$$

$$\sum m_\nu = (510 \pm 150)\ \mathrm{meV}$$