Report from Collider & Particle Physics Workpackage

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ENIGMASS General Meeting

28/04/2017

Main Axes

Theory:
Precision calculations for SM and new physics processes, model building, development of tools for interpretation of the LHC results, new ideas for searches & experiments.

nEDM

Hightlights 2012-2017

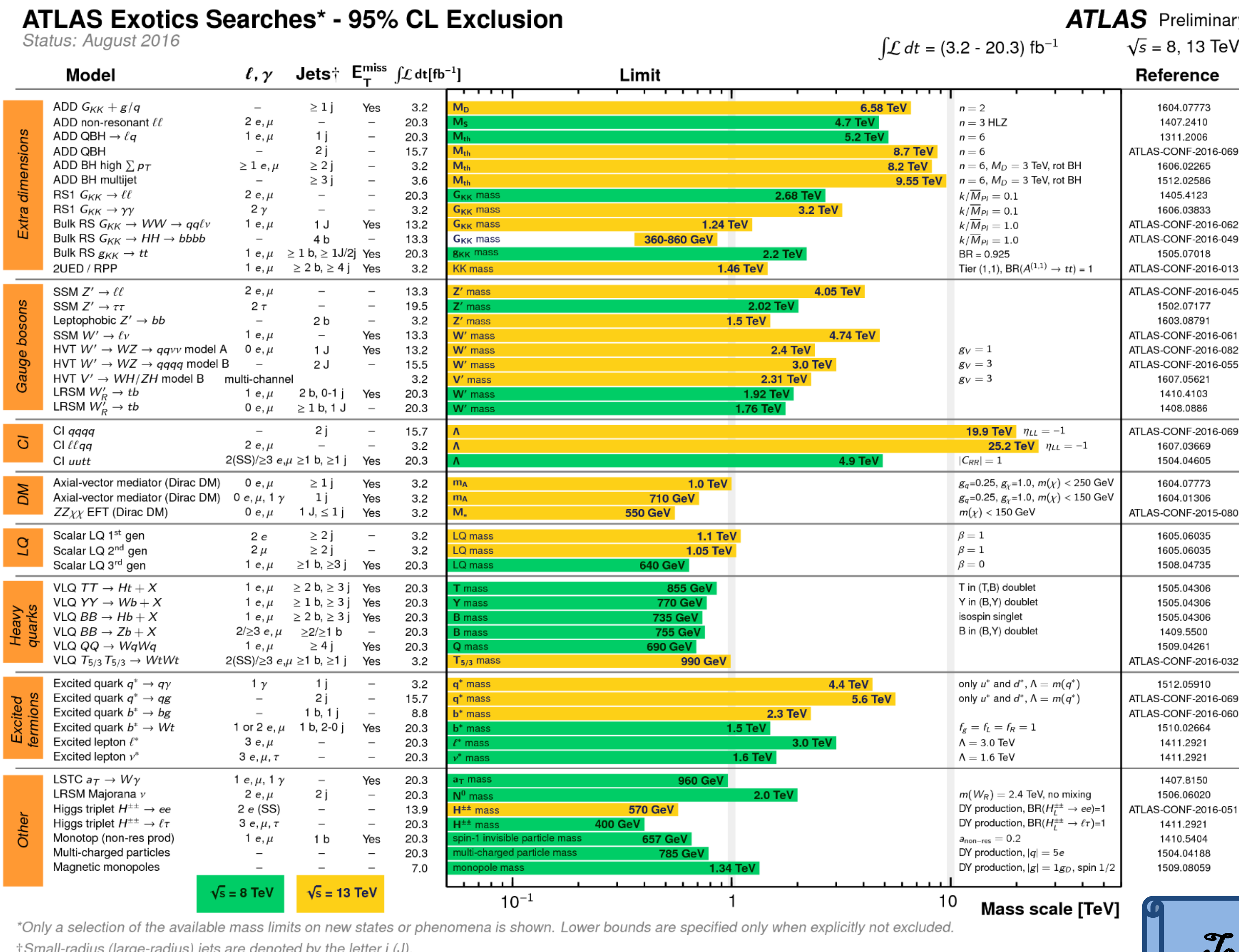
Higgs Discovery 2012

Nobel Prize
(Physics) 2012

Add Higgs
Discovery plot
+ Higgs
Measurements

No New Physics yet 2017

Our searches: $\gamma\gamma$, γ+MET, ll, tb, tt, etc.

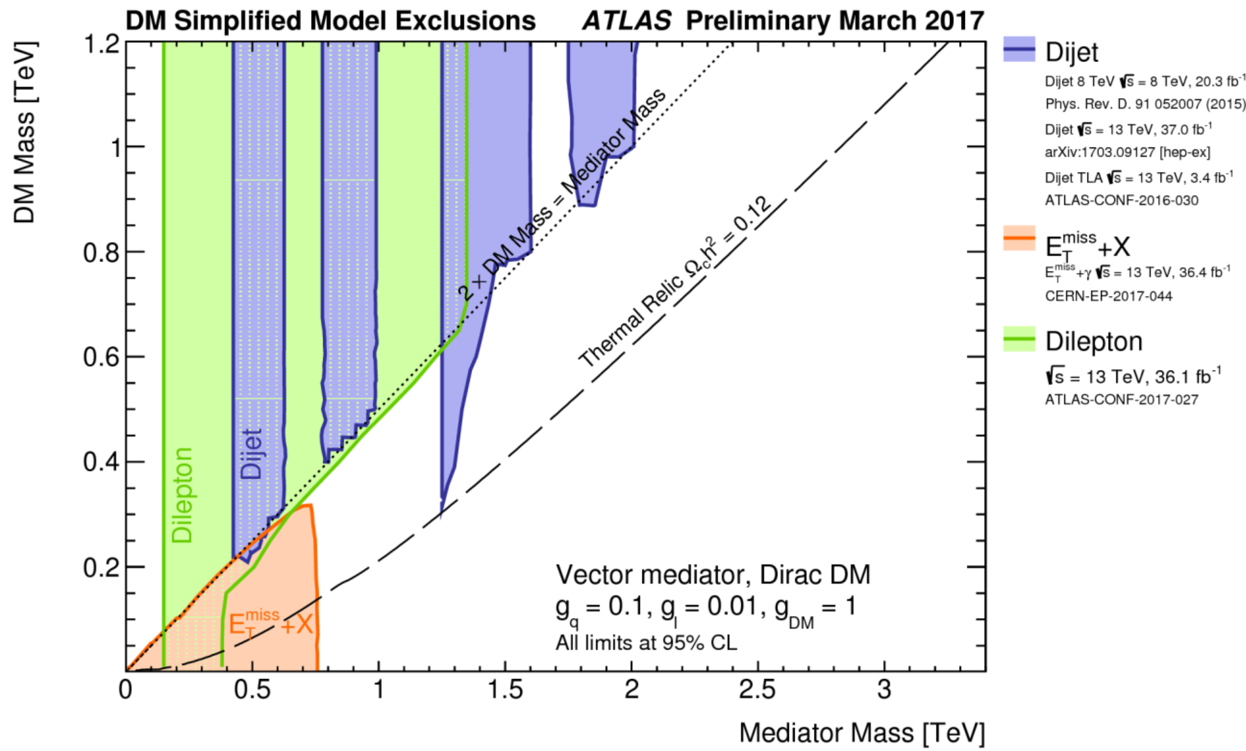


Searches will continue!

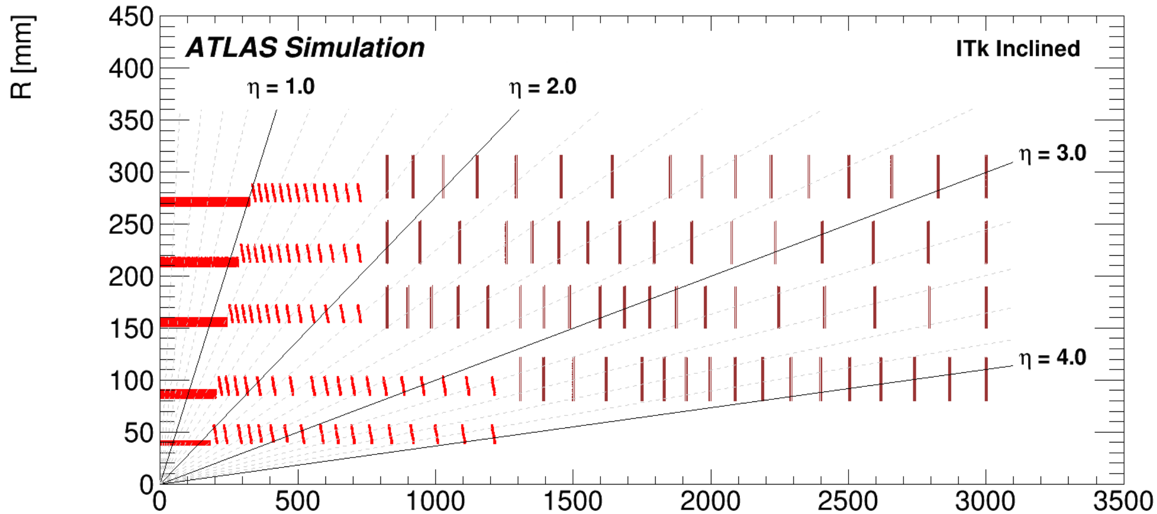
To Do

Searches Theory (& Experiment)

- BSM phenomenology: SUSY@NLO, Composite Higgs, Dark Matter…
- Tools: SModels, MadAnalysis5, Lilith…
- Forums: Interpretation of the LHC results for BSM studies, Dark Matter WG



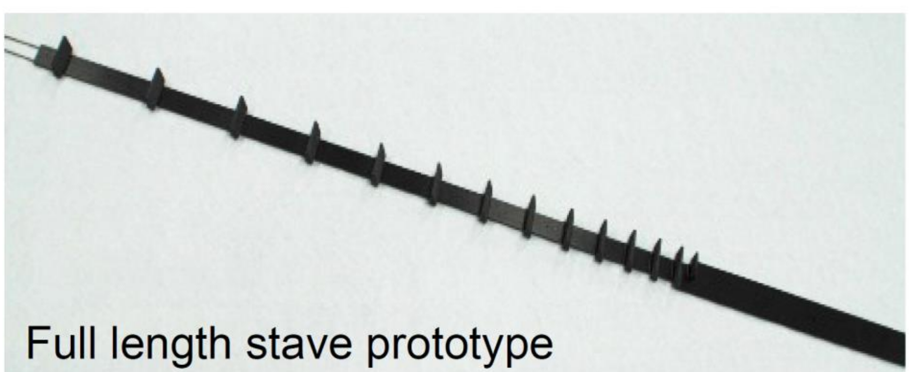
ATLAS Tracking Upgrade (2024-25)

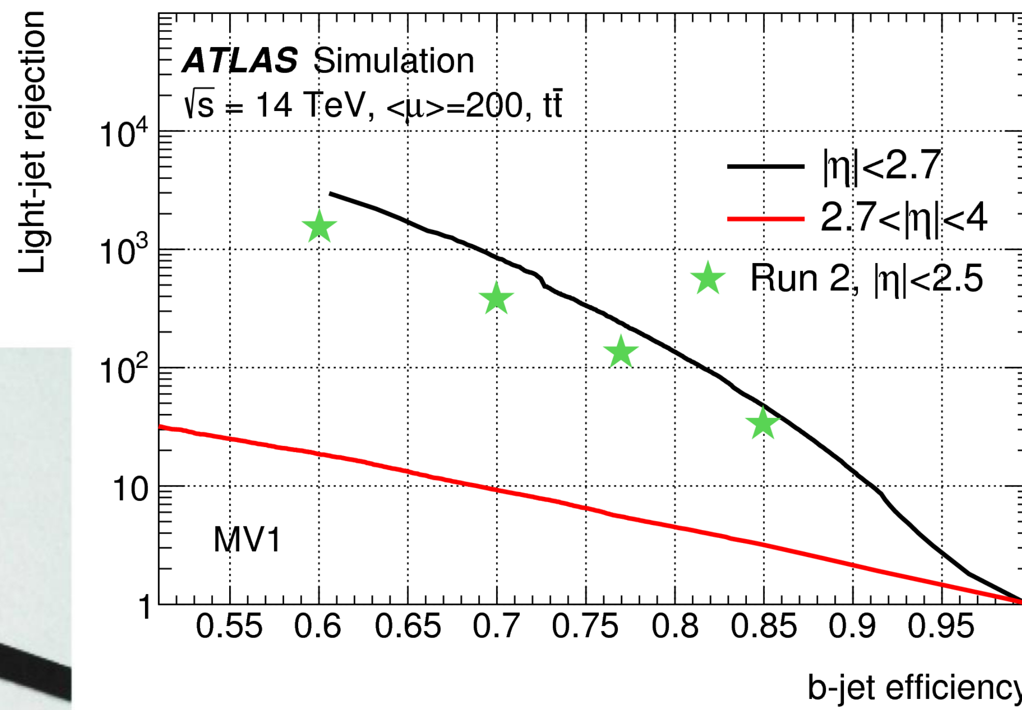


Goals: improved tracking performance in higher pile-up & radiation environment

Inclined Layout
Idea initiated at LAPP:
less material, less silicone

LAPP & LPSC: Layout Simulation, Thermal & Mechanical tests, Electronics (Services),.. Future construction


Full length stave prototype



Next 10 years

Beyond Standard Model

Search for any deviations from Standard Model predictions

Direct observation:

In-direct observation:

LHC

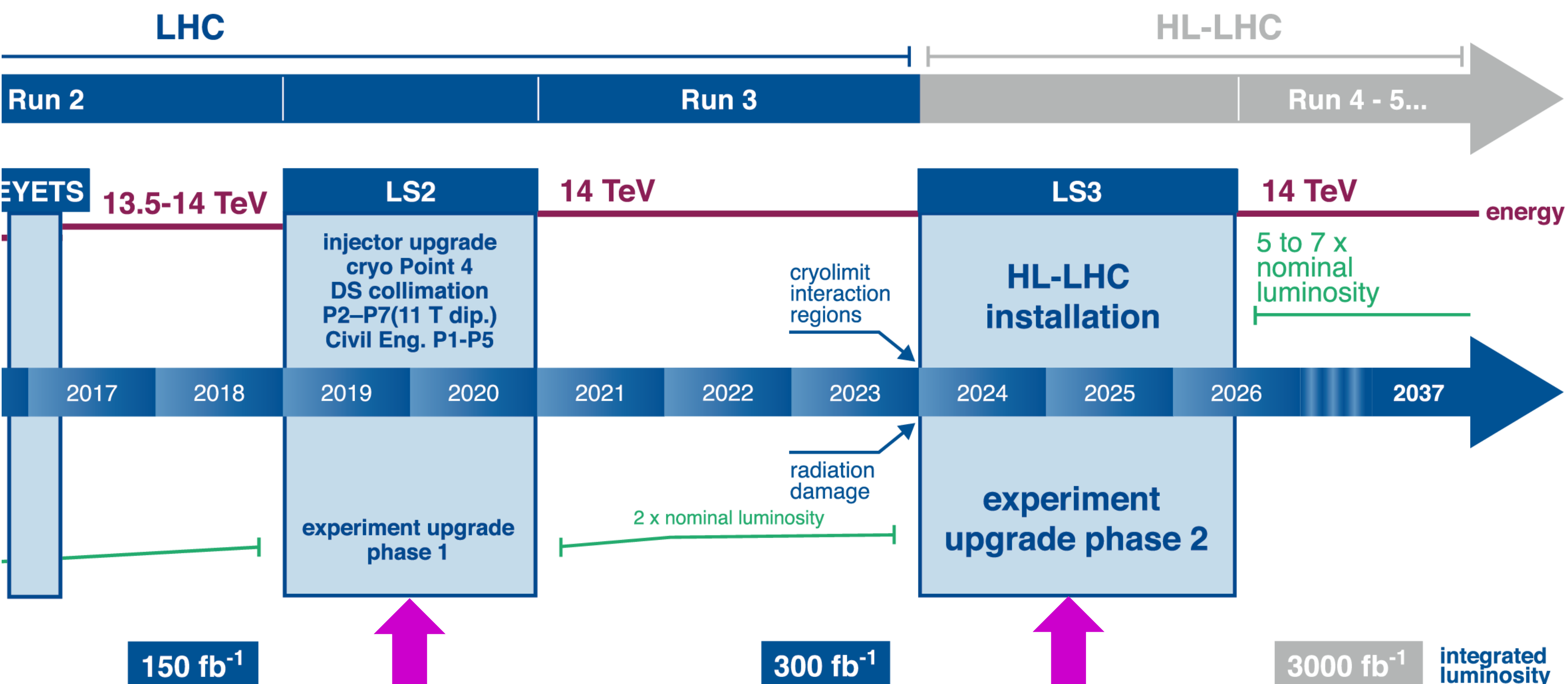
Our searches: $\gamma\gamma$, γ+MET, ll, tb, tt, etc.

Diboson measurements (VBS),
Double Higgs production,
Measurements of CKM angles,
Flavour anomalies,
Precision QCD...

Non-LHC

Measurrement of neutron electric dipole moment,
Measurement of magnetic resonant transitions between neutron quantum states in the gravity field, etc… Future collider experiements.

LHC Timeline

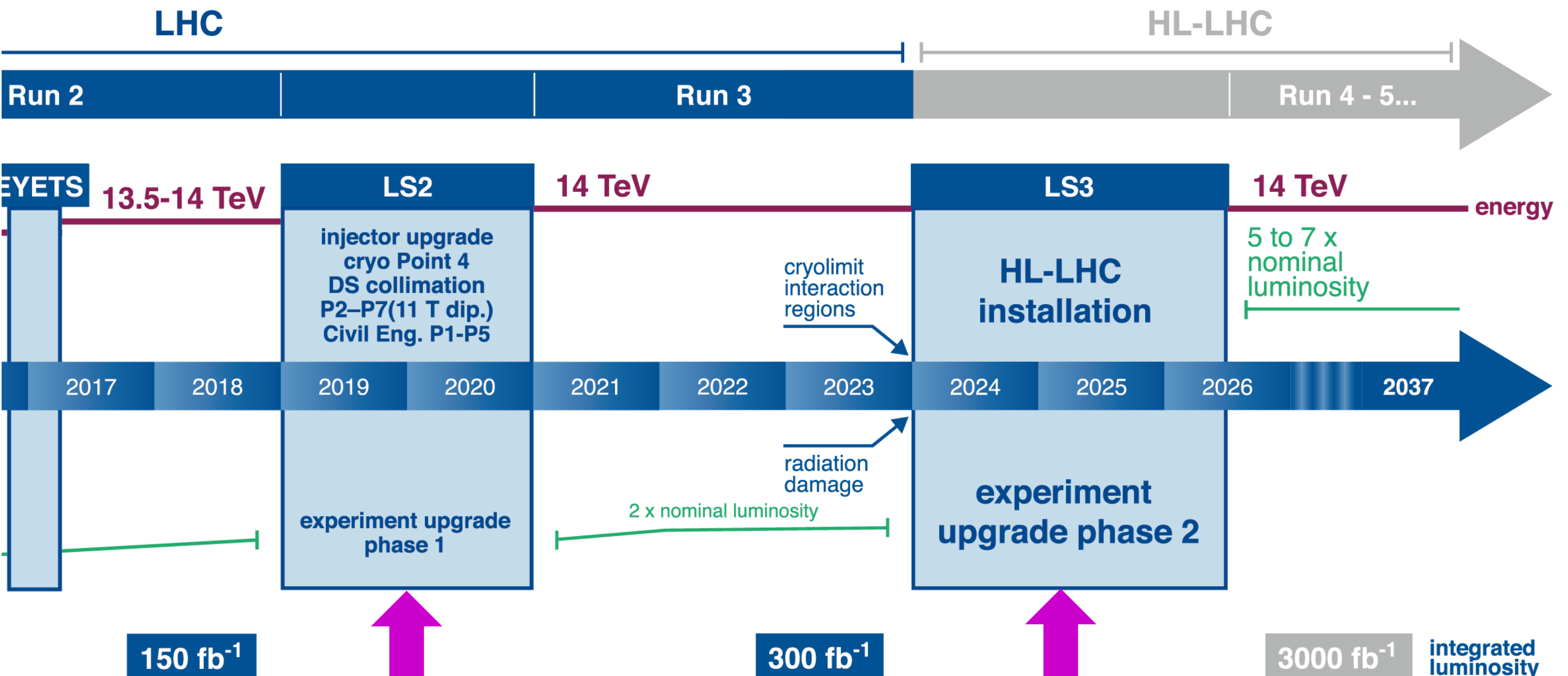


Upgrades:
ALICE Inner Tracking
ATLAS LAr Electronics
LHCb DAQ

Upgrades:
ATLAS LAr Electronics
& Inner Tracker
? LHCb Calorimeter ?

To Do

LHC Timeline



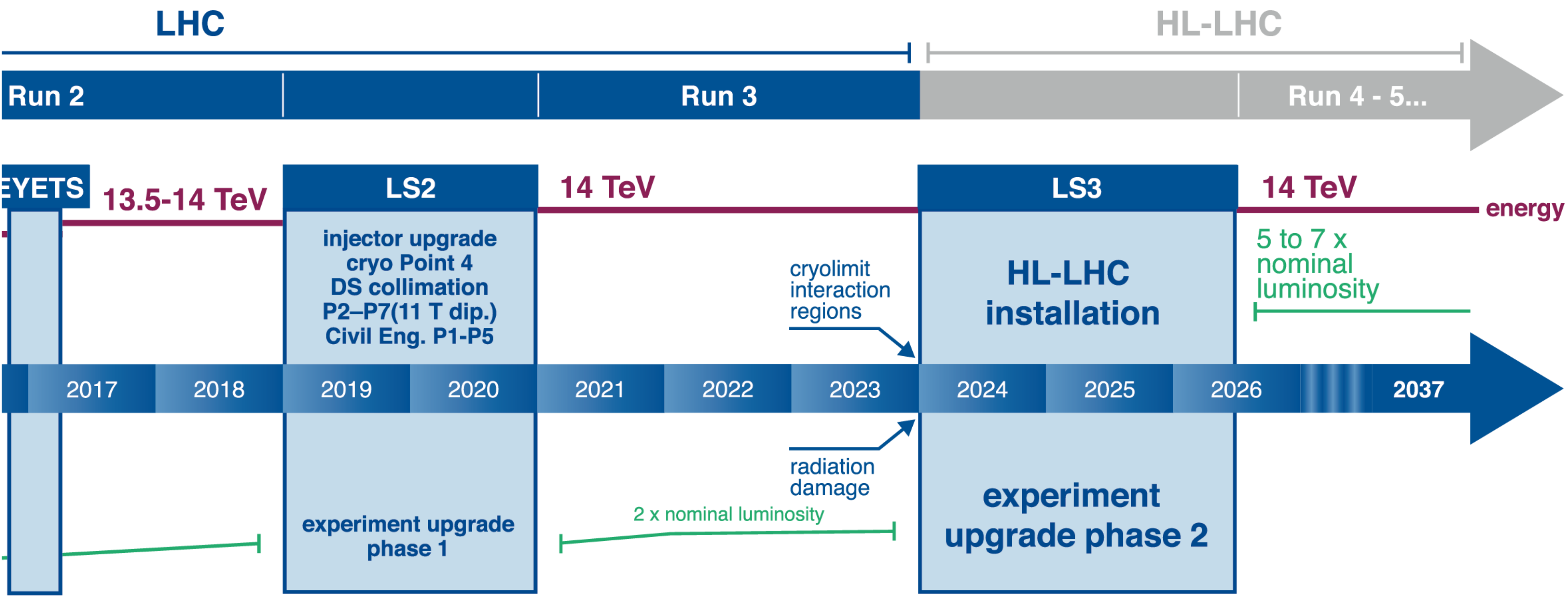
Upgrades:
ALICE Inner Tracking
ATLAS LAr Electronics
LHCb DAQ

Upgrades:
ATLAS LAr Electronics
& Inner Tracker
? LHCb Calorimeter ?

To Do

Operational Responsibilities: Calorimeters & related performance studies, Computing, etc.

LHC Timeline



	ATLAS	LHCb	ALICE (HI)
2017	$40fb^{-1}$	$5fb^{-1}$	$1nb^{-1}$
2019	$150fb^{-1}$	$8fb^{-1}$	
2024	$300fb^{-1}$	$28fb^{-1}$	
2028	$1000fb^{-1}$	$42fb^{-1}$	$10nb^{-1}$

SM EFT

To Do

- SM scale ~ v = **246 GeV**, no BSM physics seen below **Λ ~ 1 TeV**

  $\Rightarrow$parameterize the BSM using an **EFT extension of the SM**

$$L = L_{SM}^{(d\leq 4)} + \boxed{\frac{1}{\Lambda^2}\sum_i c_i^{(d=6)} O_i^{(d=6)}} + \frac{1}{\Lambda^4}\sum_i c_i^{(d=8)} O_i^{(d=8)} + \ldots$$

- Usually(*) leading effect from **interference of d=6 and SM ~(v/Λ)^2** and can **neglect d≥8** and $|c^{(d=6)}|^2$.

$\Rightarrow$ **Report experimental constraints on the c_i, compare to model predictions**

- Straightforward to extend to higher orders in SM couplings
- **Many operators**: **2499** for n_{gen}=3
  - Higgs operators
  - Other EW operators (TGCs)
  - 4-fermion operators (flavour measurements)

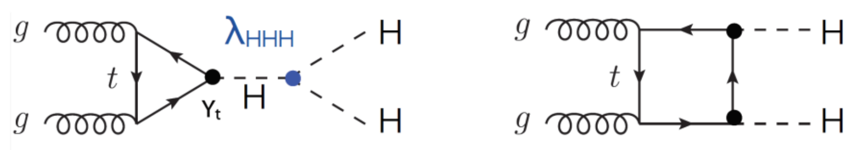
Measu-rements planned ⇔ Theory predictions are crucial.

From N. Berger @ GDR TeraScale 2016

Double Higgs Production

To Do

Direct information on the shape of the scalar Higgs potential



$\sigma_{gg\to HH} = 33.49^{+4.3}_{-6.0}$ (scale) ± 2.1 (PDF) ± 2.3 (α_s) fb

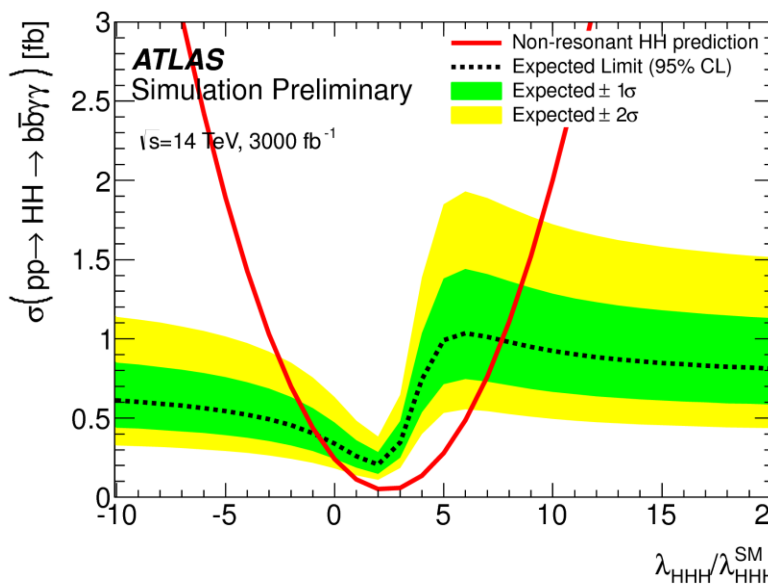
[13 TeV, NNLO + NNLL with top mass effects, HXSWG, arXiv:1610.07922]

Chan.	Obs. (exp.) 95% C.L. limit on σ/σ_{SM} ATLAS EXPERIMENT	CMS
bbbb	29 (38)	342 (308)
bbWW	-	410 (227) ▣
$bb\tau\tau$	-	28 (25) ▣
$bb\gamma\gamma$	117 (161)	91 (90)
$WW\gamma\gamma$	747 (386)	-

2.3-3.2 fb^{-1} | 13.3 fb^{-1} | 35.9 fb^{-1}

▣: Test of anomalous HH couplings

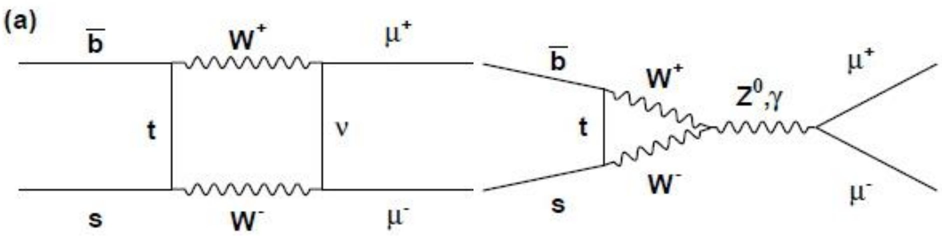
Negative interference between HH production with and w/o HHH vertex.



ATL-PHYS-PUB-2017-001

In $bb\gamma\gamma$ expect 9.5 signal over 90.9 bkg events in 3 ab^{-1} (~1σ) Need to combine with other channels & CMS.

Flavour Anomalies



$BR_{obs}(B_s \to \mu\mu)/BR_{SM}(B_s \to \mu\mu) = 0.76^{+0.20}_{-0.17}$

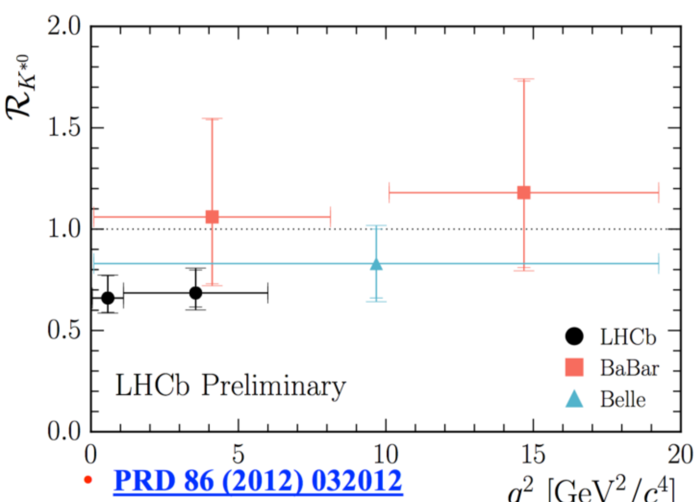
$\Rightarrow$ More precise measurement needed.

LHCb reported 2-3 sigma anomalies in various

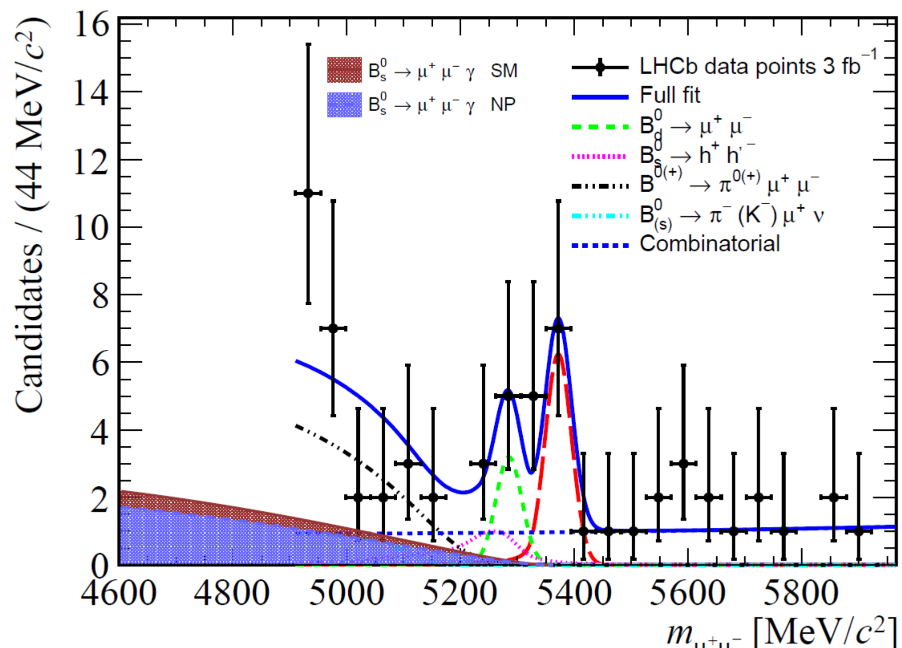
$b \to sll$ measurements (BRs, angular observables, ...) and in $b \to c\tau\upsilon$. FCNC sensitive to BSM contributions through the loops.

$BR(B_s \to \mu\mu\gamma)$ ~5 $BR(B_s \to \mu\mu)$, not seen yet. Also interesting to see $B_s \to e\mu\gamma$.

To Do



- PRD 86 (2012) 032012
- PRL 103 (2009) 171801



arXiv:1610.00629

Sign of New Physics? Stat Fluctuations? QCD effects not fully accounted for?

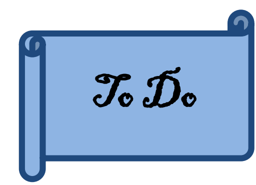
Probing QCD with Quark Gluon Plasma (QGP)

- Study of QGP in **Pb-Pb**: new constraints on strong interaction
- Study of **pp** collisions: baseline for the QGP study and for comparisons with QCD calculations;
- **p-Pb** collisions: cold nuclear effect

ALICE @ LPSC:

Inclusive jets, jet-jet and photon-hadron/jet correlations measurements

→parton fragmentation related observables



→in-medium modification of parton energy loss and energy redistribution at ~ low p_T

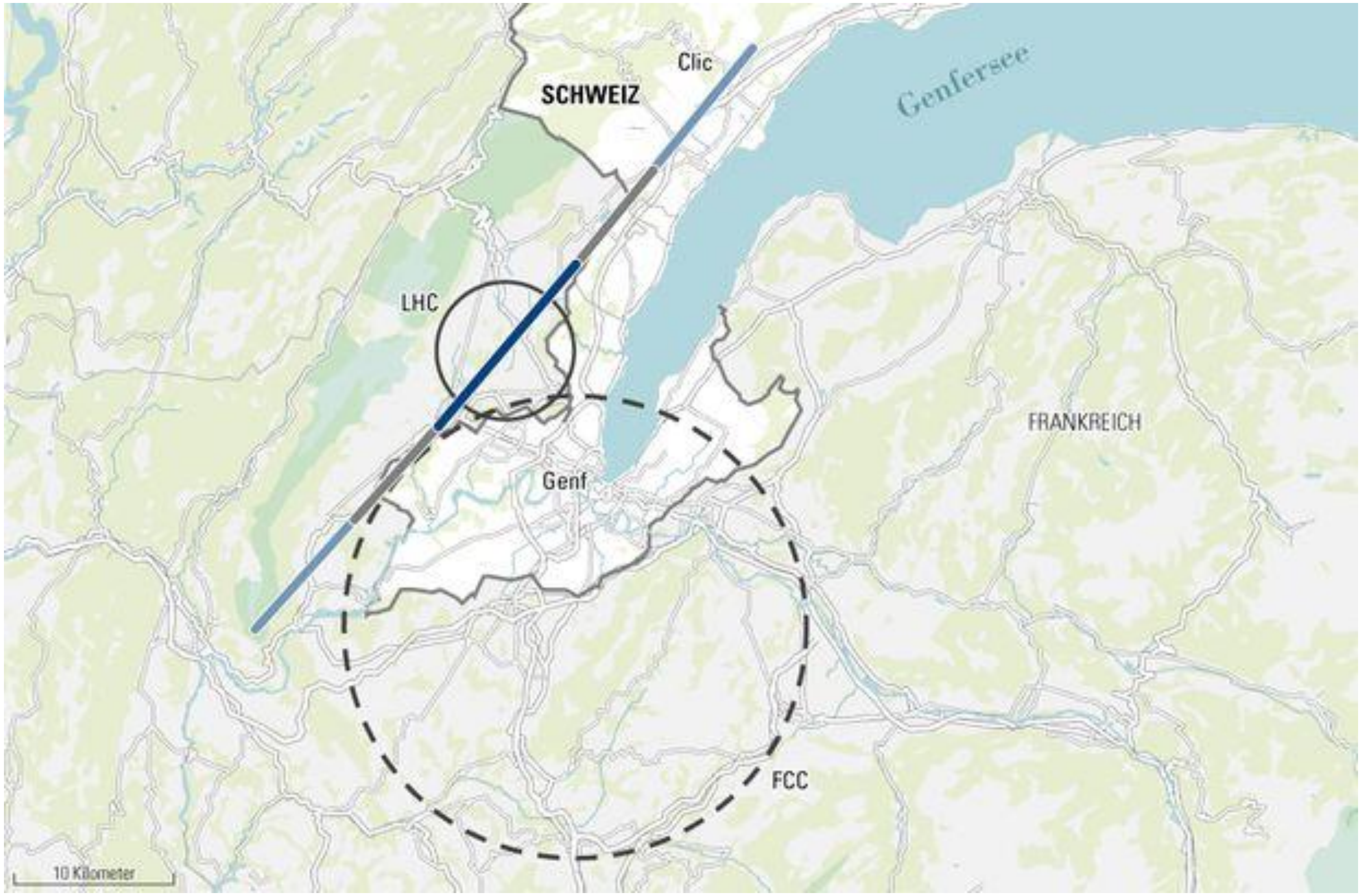
New b-tagging methods for heavy flavour identification in jets:

→ use to study quark flavor dependence of energy loss in QGP: test dead cone effect prediction

Beyond LHC: nEDM

Beyond LHC: GRANIT

Beyond LHC: new colliders

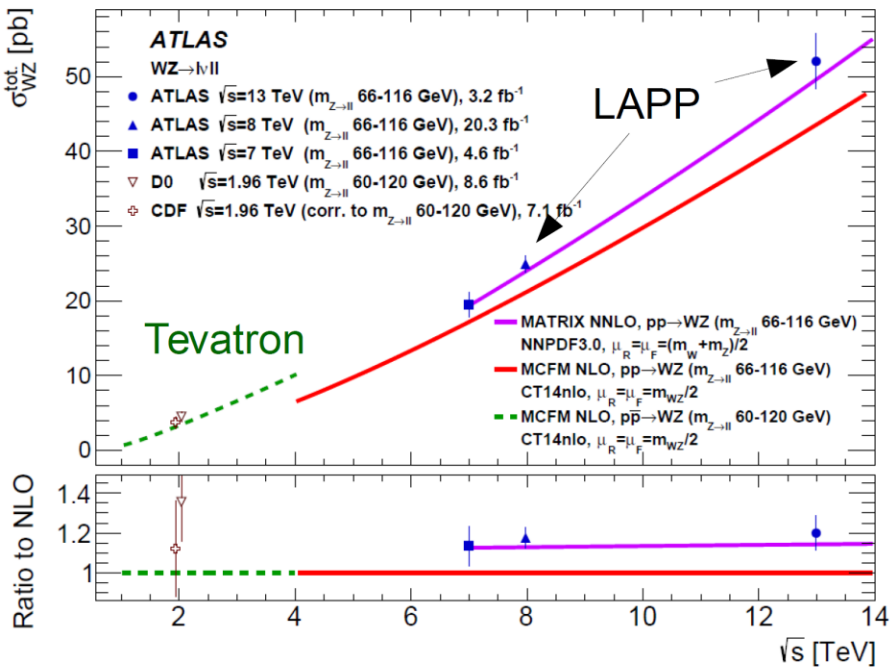


Small ILC groups @ LAPP & LPSC

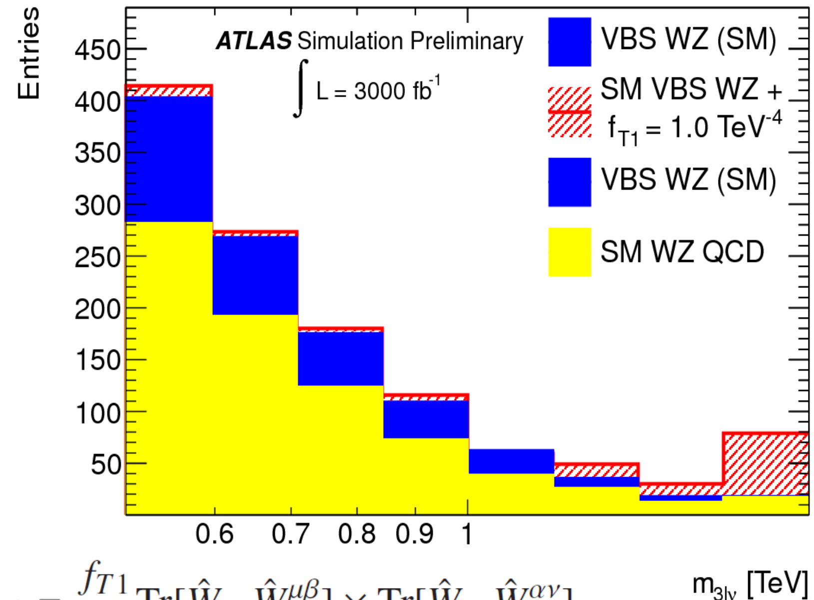
Following developments on FCC, CLIC and ILC.

Backup

Dibosons to VBS



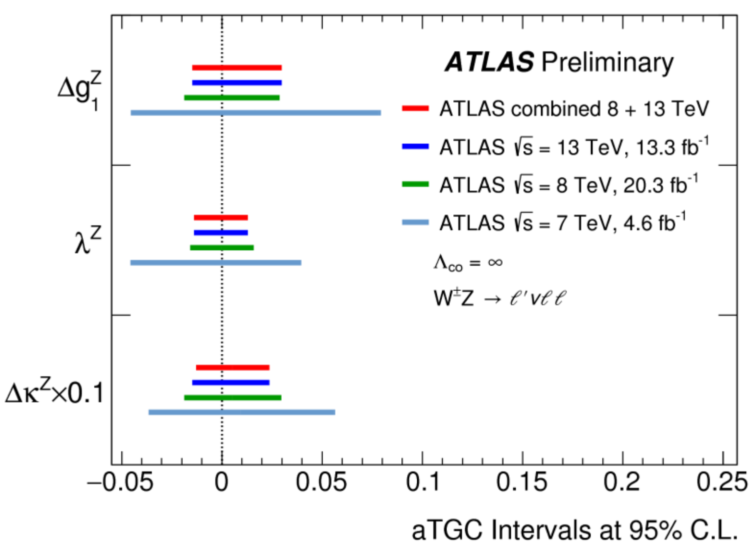
ATL-PHYS-PUB-2013-006

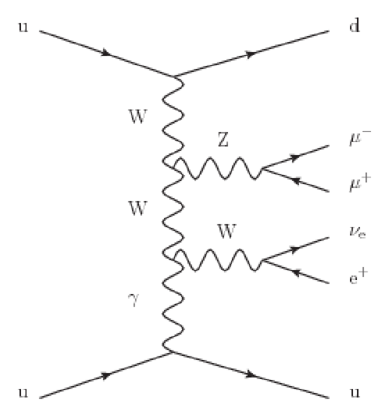


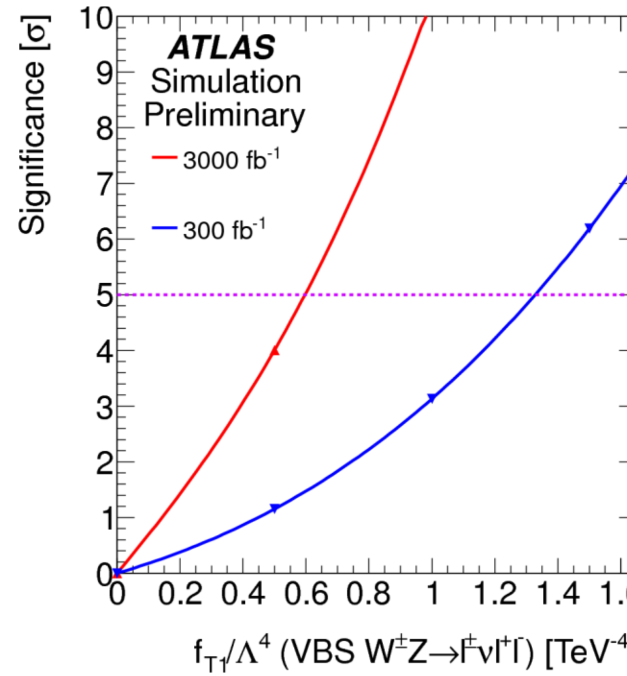
$$\mathcal{L}_{T,1} = \frac{f_{T1}}{\Lambda^4}\mathrm{Tr}[\hat{W}_{\alpha\nu}\hat{W}^{\mu\beta}] \times \mathrm{Tr}[\hat{W}_{\mu\beta}\hat{W}^{\alpha\nu}]$$

To Do

ATLAS-CONF-2016-043

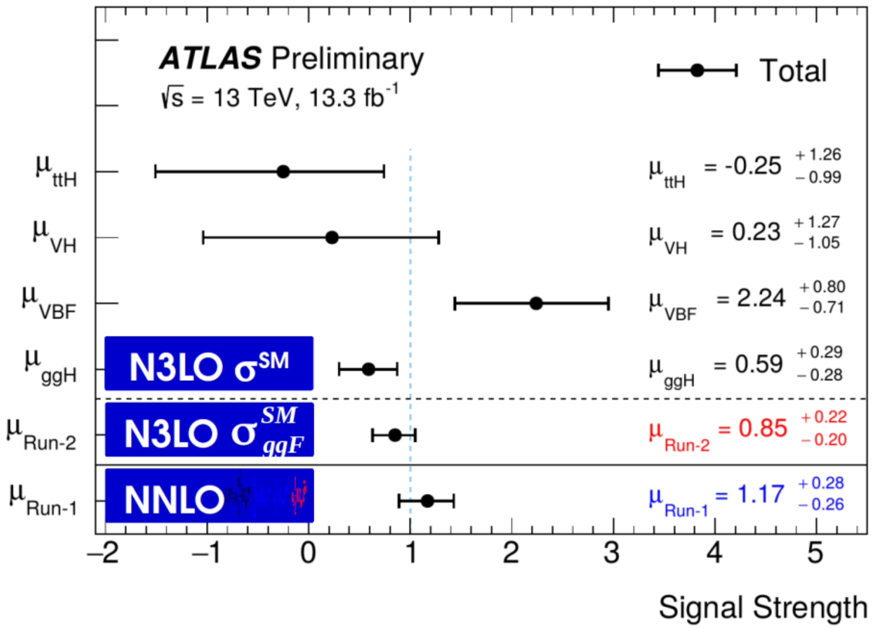






H→γγ couplings

ATLAS-CONF-2016-067

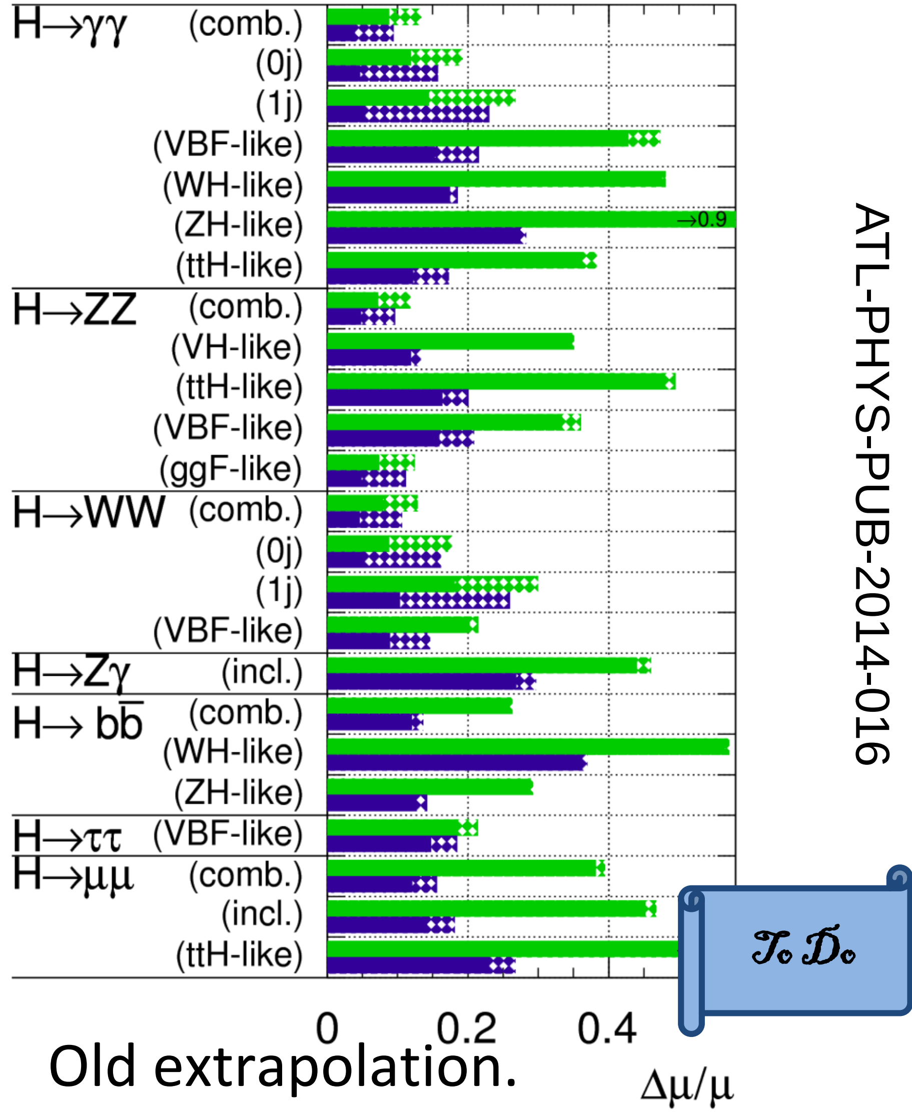


JHEP(2016)058

New ggF N3LO calculation

- +3% change in σ^{SM}_{ggF}
- QCD pert. uncert. 7.8% → 3.8%
- PDF+α_s uncert.: ~7% → 3.2%

Experimental precision needs to catch up with theory!



ATL-PHYS-PUB-2014-016

Old extrapolation.

Analyses improved.

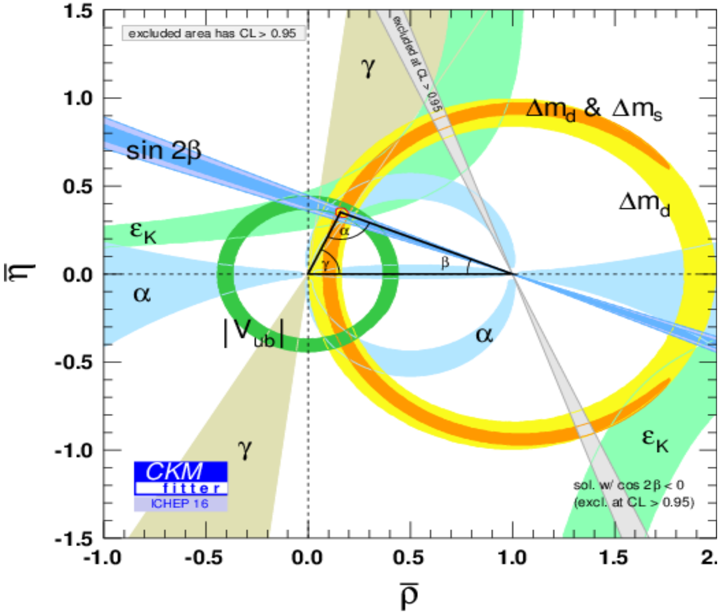
Sizable theory uncertainties!

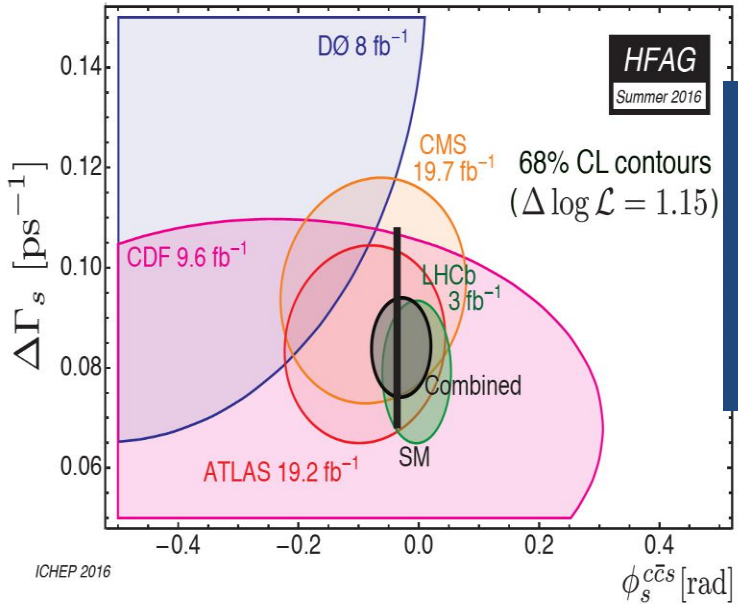
From N. Berger @ [Dissecting the LHC results](#) 2017

CKM angles

To Do

arXiv:1612.07233





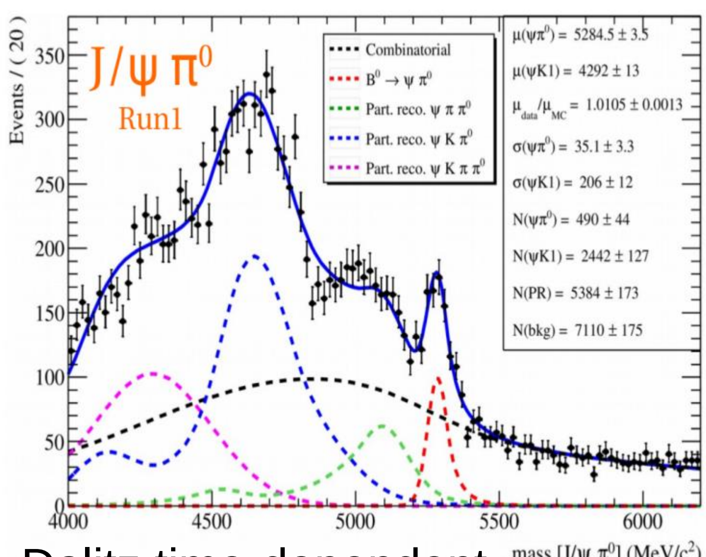
Now (CKMFitter):

$\sin 2\beta = 0.691 \pm 0.017$

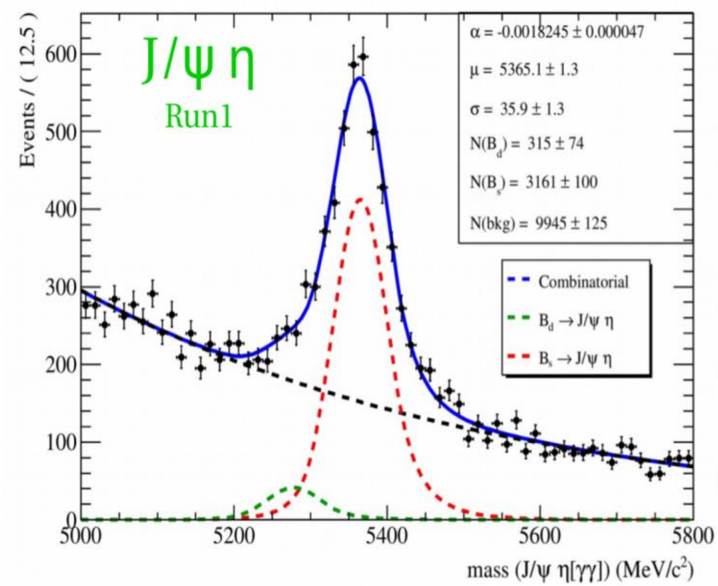
$\gamma = (72.2^{+5.3}_{-5.8})°$

$\phi_s = -0.015 \pm 0.035$rad

	LHCb Uncertainty End of Run 4
β	0.031°
γ	0.9°
ϕ_s	0.009 rad



Dalitz time-dependent analysis for Run 2

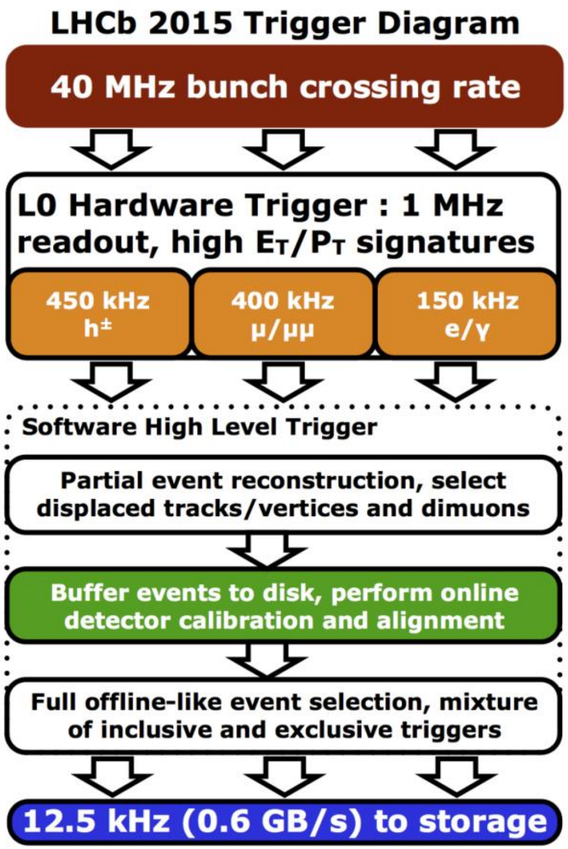


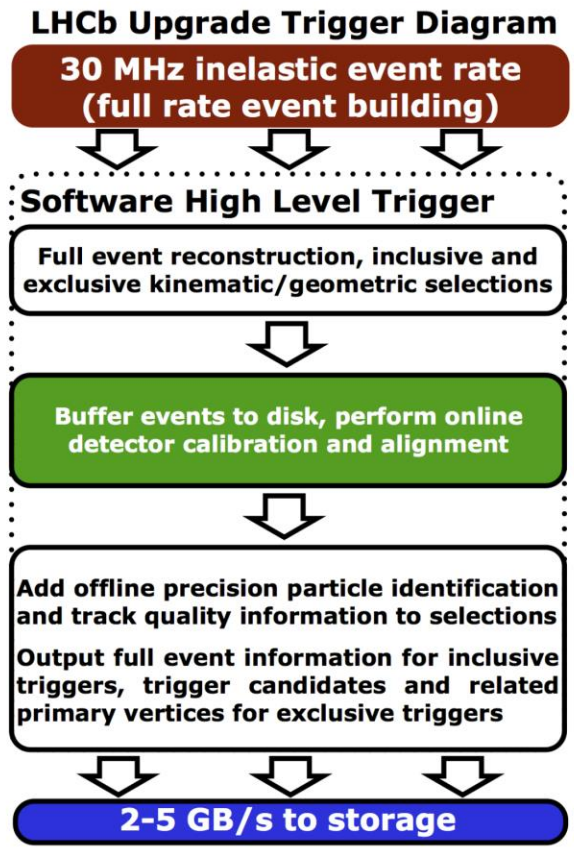
Also $B_s \to J/\psi\eta'(\rho^0\gamma, \eta\pi^+\pi^-)$

Testing SM predictions

LHCb DAQ Upgrade (2019-20)

Goal: Remove Hardware Trigger



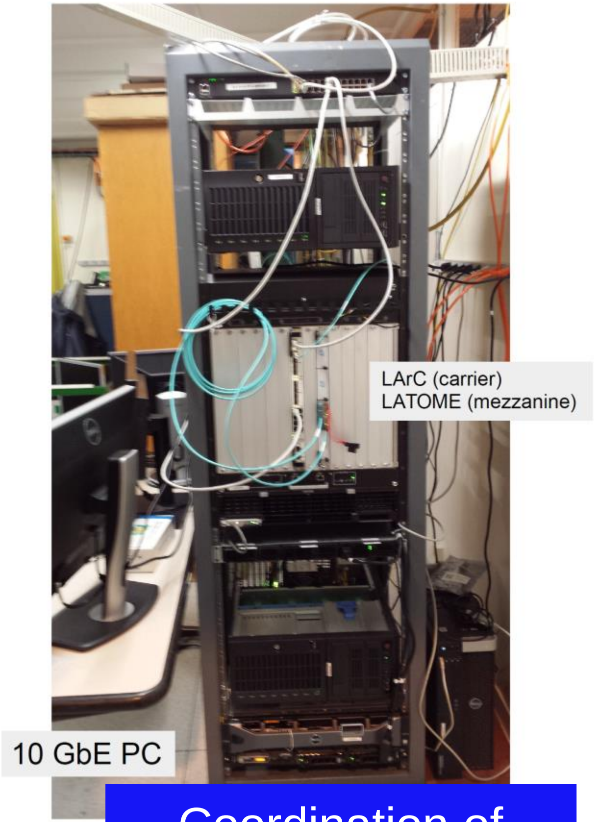


LAPP coordinates firmware development for Prototype Readout Board Used for Event Building

Potential participation in the LHCb Calorimeter upgrade 2024-2025

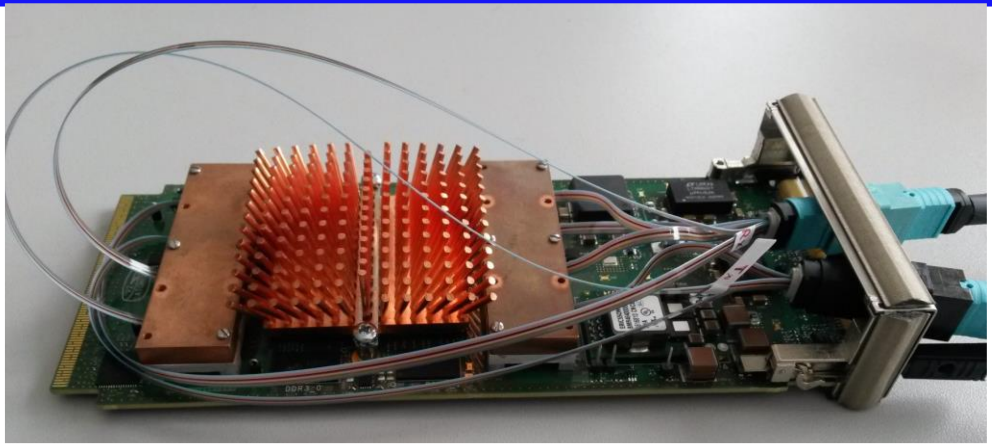
ATLAS LAr Calorimeter Upgrade (2019-20)

Goal: increase calorimeter hardware trigger granularity and to do digitisation at 40 MHz



Coordination of tests at CERN

LAPP developed a fast and dense processing unit (E_T calculation, LHC bunch crossing identification etc.)

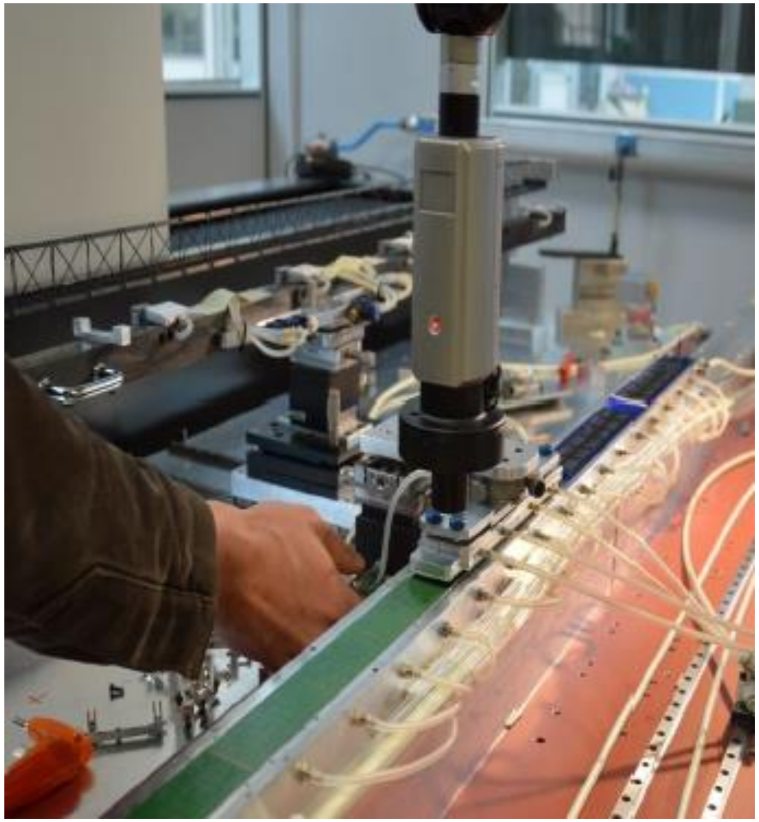


LAPP coordinates firmware development

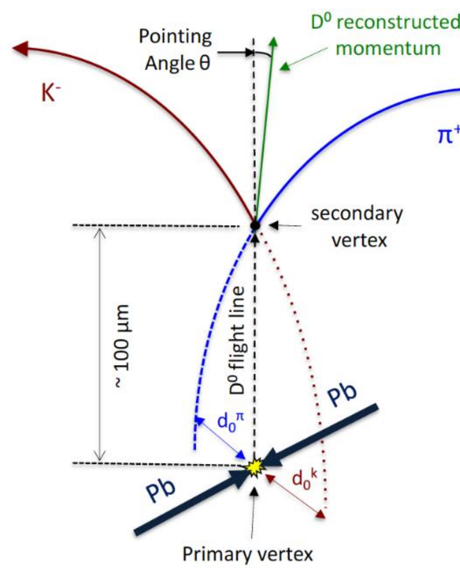
IPMC : ATCA controller card developed at LAPP

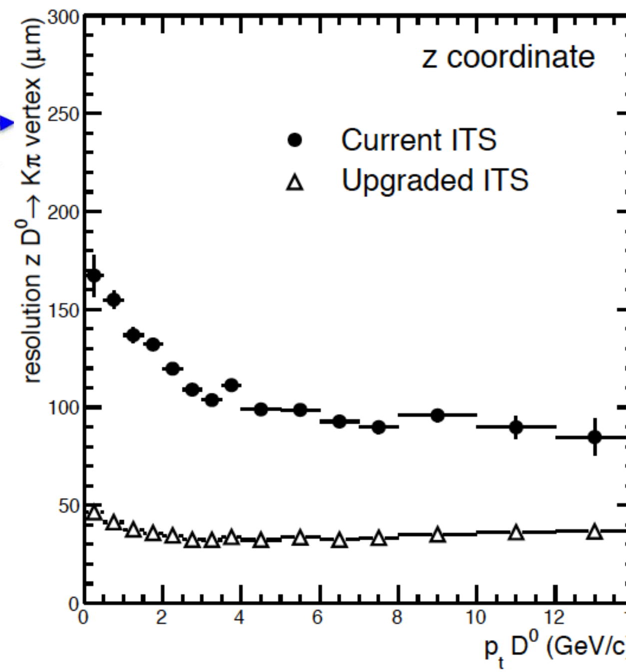
ATLAS LAr Electronics upgrade 2024-2025: back-end & calibration card

ALICE Tracking Upgrade (2019-20)



Goals: improve tracking performance

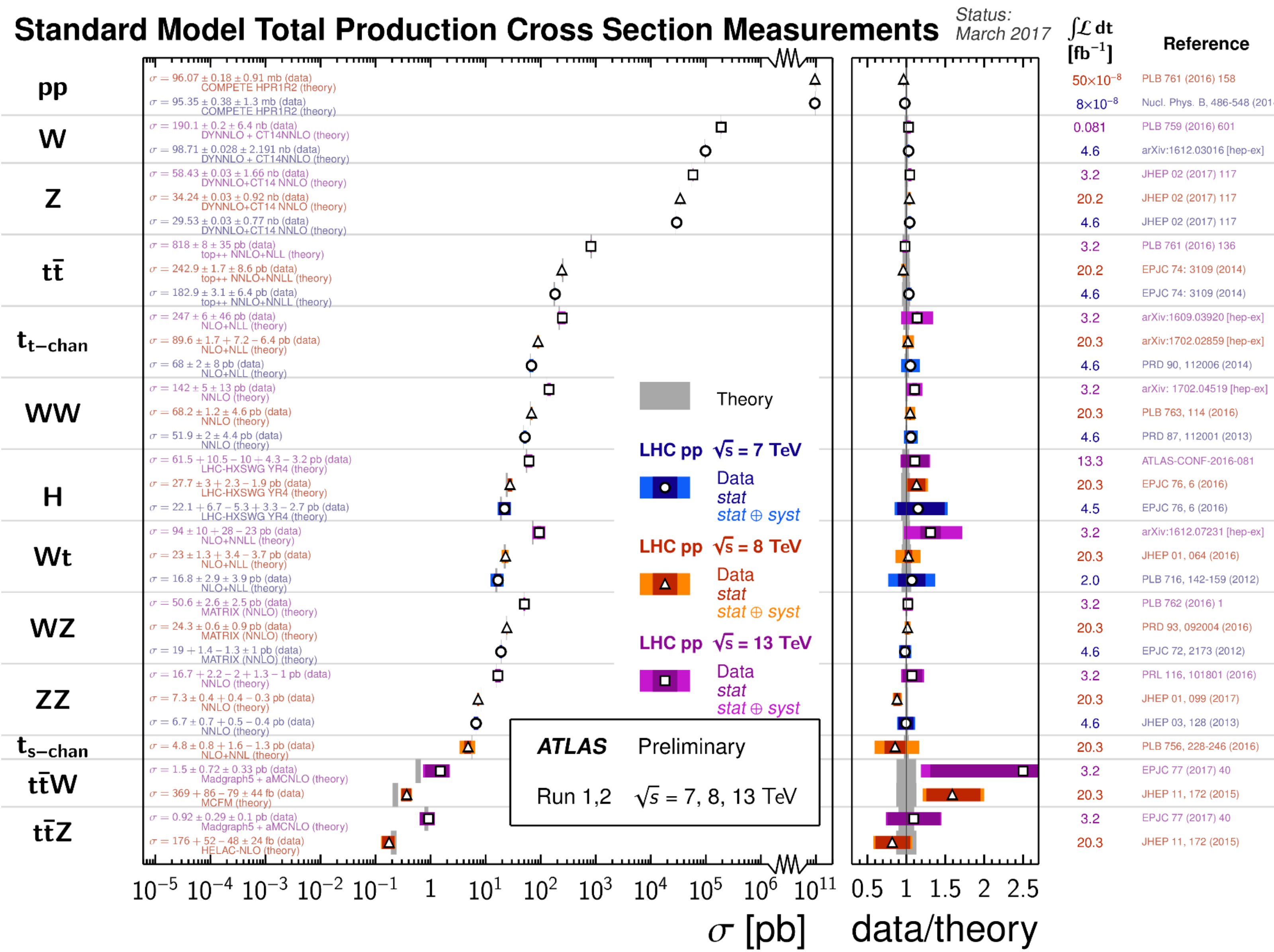




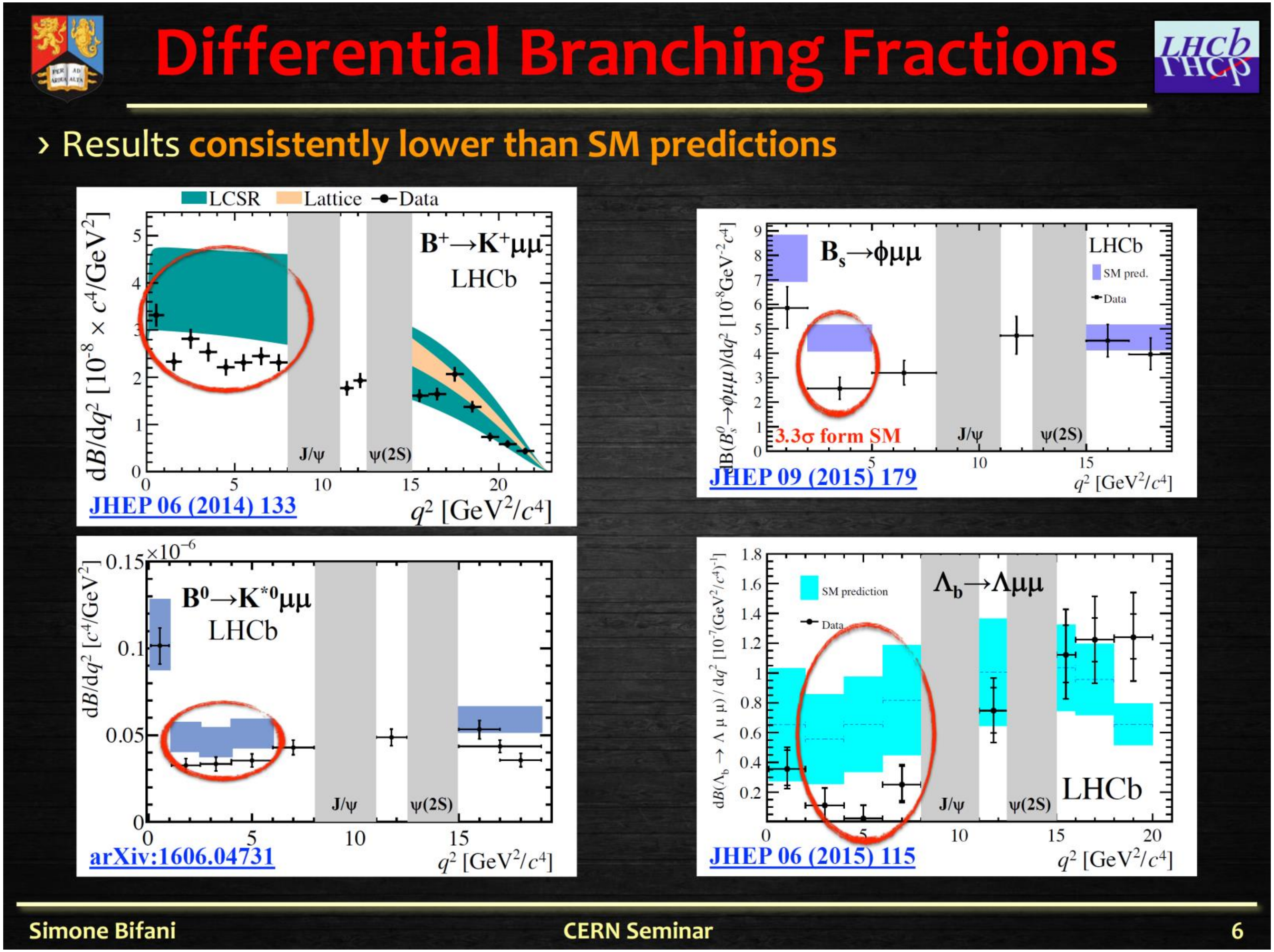
LPSC: Construction of manufacturing molds for staves.
Design and production of the Middle Barrel staves assembly tool.

Potential Synergy with ATLAS Tracking Upgrade in LPSC

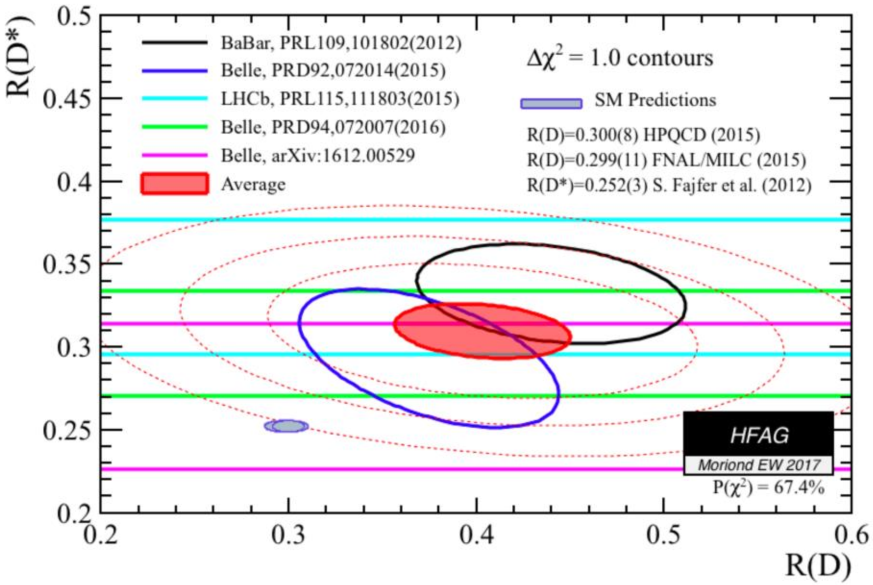
Indirect Searches = Measurements

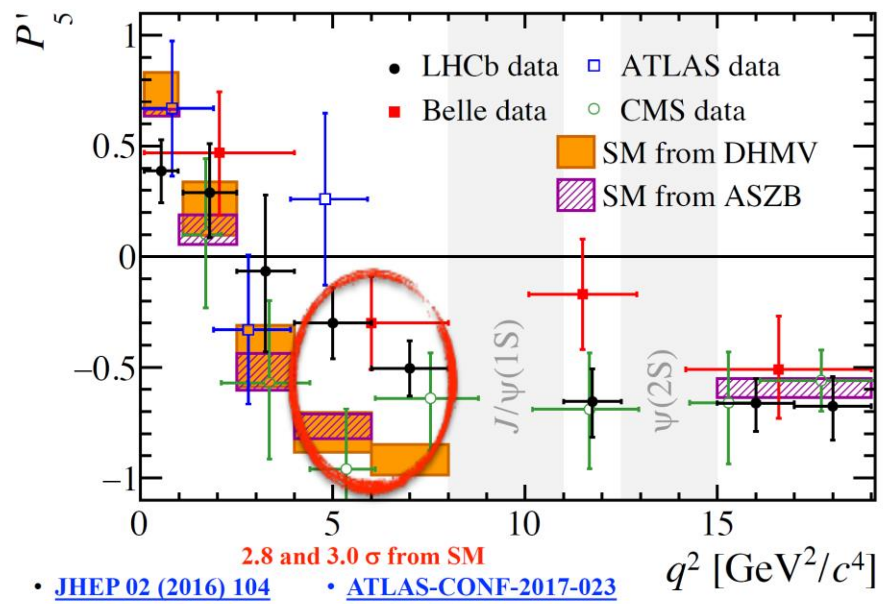


LHCb anomalies (1)



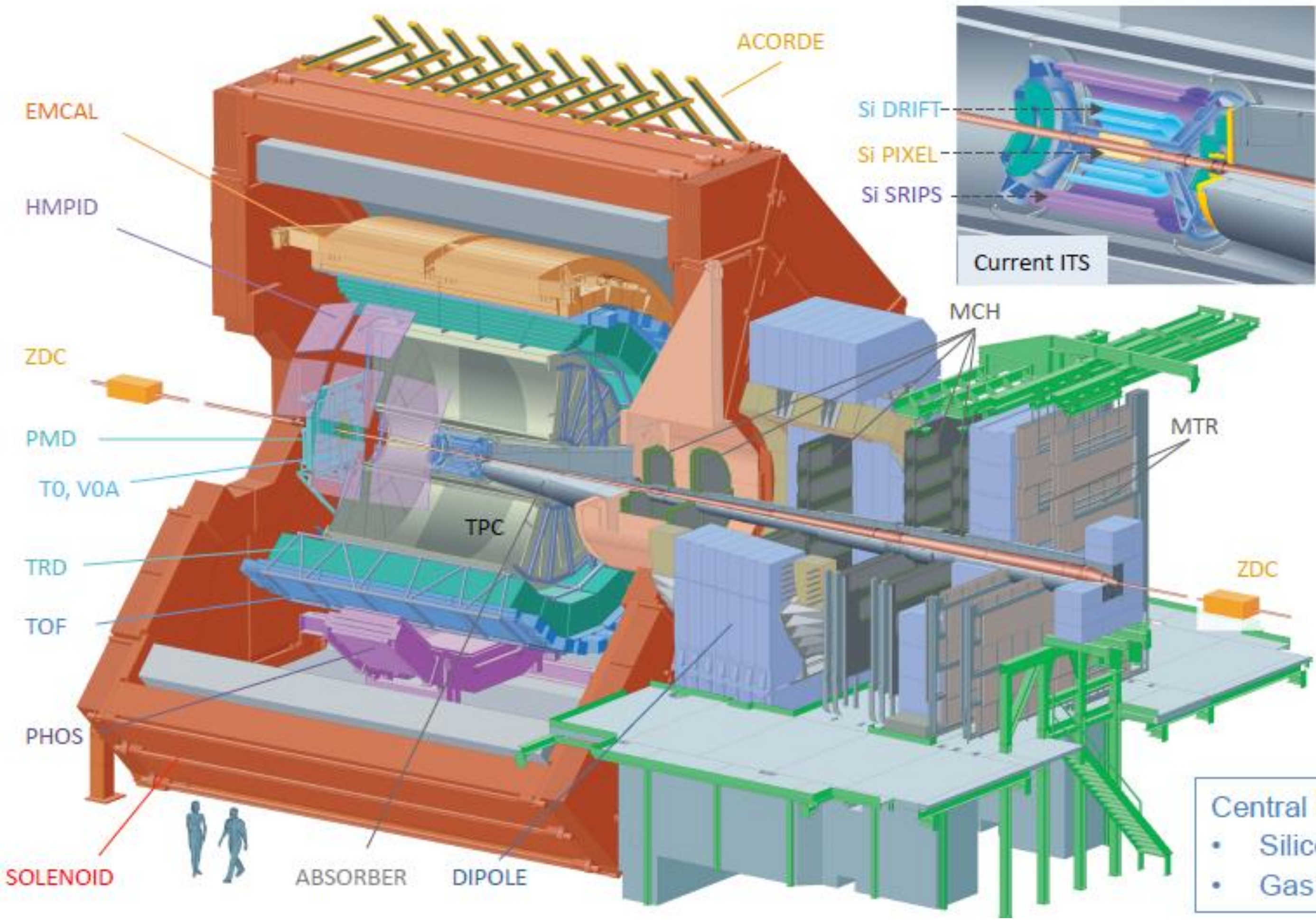
LHCb anomalies (2)

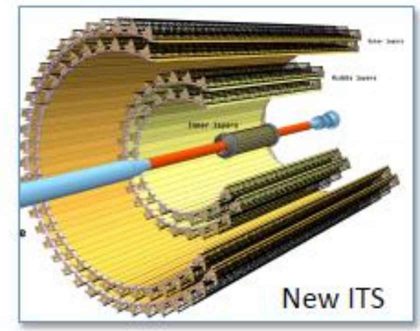




- JHEP 02 (2016) 104
- PRL 118 (2017)
- ATLAS-CONF-2017-023
- CMS-PAS-BPH-15-008

Upgrade d’ALICE run 3&4





Readout rate is currently limited by TPC and ITS (SDD)

~ 1kHz for Pb-Pb

Central Barrel Tracking

- Silicon: 39 – 430 mm
- Gas (TPC, TRD): 88 – 368 cm

- New electronics (TPC, TOF, TRD, Muon spectro…) + New DAQ & HLT (50 kHz Pb-Pb, O2 project)
- New detectors: Internal Tracking System and MFT (Muon Forward tracking)

Quark Gluon Plasma & ALICE experiment

LPSC team:

- **5 permanents :** G. Conesa-Balbastre (CR), J. Faivre (MdC), C. Furget (PR), R. Guernane (CR), C. Silvestre (CR)
- **4 PhD:** A. Vauthier (UGA), H. Yokoyama (Tsukuba/UGA), R. Hosokawa (Tsukuba/UGA), H. Hassan (Liban/UGA)

Physics goals:

- Study of high density deconfined matter like QGP produced in Pb-Pb collision at LHC provides new constraints on strong interaction at the partonic level (95% of the nucleon mass).
- Study p-p collisions as a baseline for the QGP study and for comparisons with QCD calculations; study cold nuclear effect study in p-Pb collisions
- Favoured topics: study of parton energy loss in QGP through jets production and photon-hadron correlations

Technical involvement:

- Electromagnetic calorimeter: assembly, energy calibration, Level 1 trigger, reconstruction+analysis

Projects for run 3&4:

- ALICE upgrade during LS2: improve the tracking performance and increase the statistics by 10
- New jet observables, study of in-medium energy loss for heavy flavours and precise measurements of the parton energy loss through jet-jet and photon-hadron/jet correlations