Overview (Welcome)

KEK & IPMU
Mihoko M. Nojiri

Welcome to IPMU

- IPMU(Institute of Physics and Mathematics of the Universe started Oct 1st 2007 (initially 5+5years)
- University support (permanent positions through TODIAS)
- March 2015 Kavli IPMU has been **nominated for a 5-year extension,** as a "highly exceptional case whose achievements are far beyond the very high WPI standard".
- Good start up to the transition to the long term future
- **First IPMU workshop is on LHC** Dec 17 2007, even before "Opening Symposium
- Since then, we have been interested in the physics relevant to the collider physics

Thanks to Durham and KIAS

Focus week : Facing LHC data

Dates: Dec 17 to 21, 2007

Contact: Mihoko M. Nojiri (nojiri _at_ kek.jp)
(_a_ should be replaced by @)

The meeting aims to discuss the issues related to the discovery of the new physics signature at LHC, ideas to measure the parameters, identify
experimental and theoretical reality that should be overcome by the start of the experiments. Following researchers are agreed to come.

Teruki Kamon (Texas A&M)
Tomasso Lari (Milan)
Patrick Meade (Harvard)
Tilman Plhen (Edinburgh)
Giacomo Polesello (Pavia)
Maxim Perelstein (Cornell)
Steffen Schumann (Edinburgh)
Jay Wacker (SLAC)
C.-P. Yuan (Michigan State)

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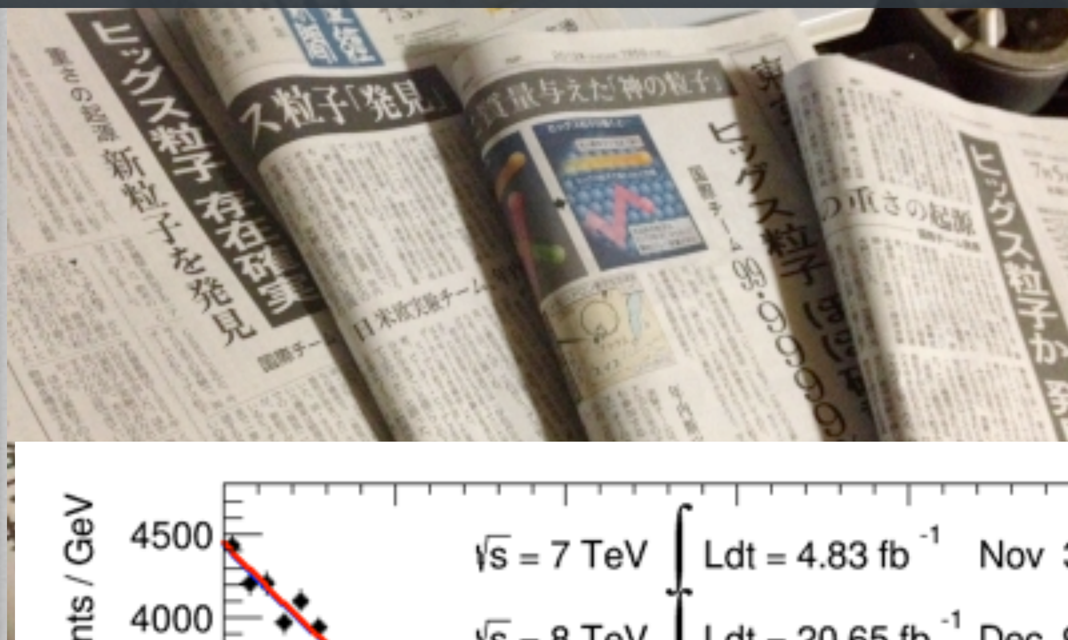
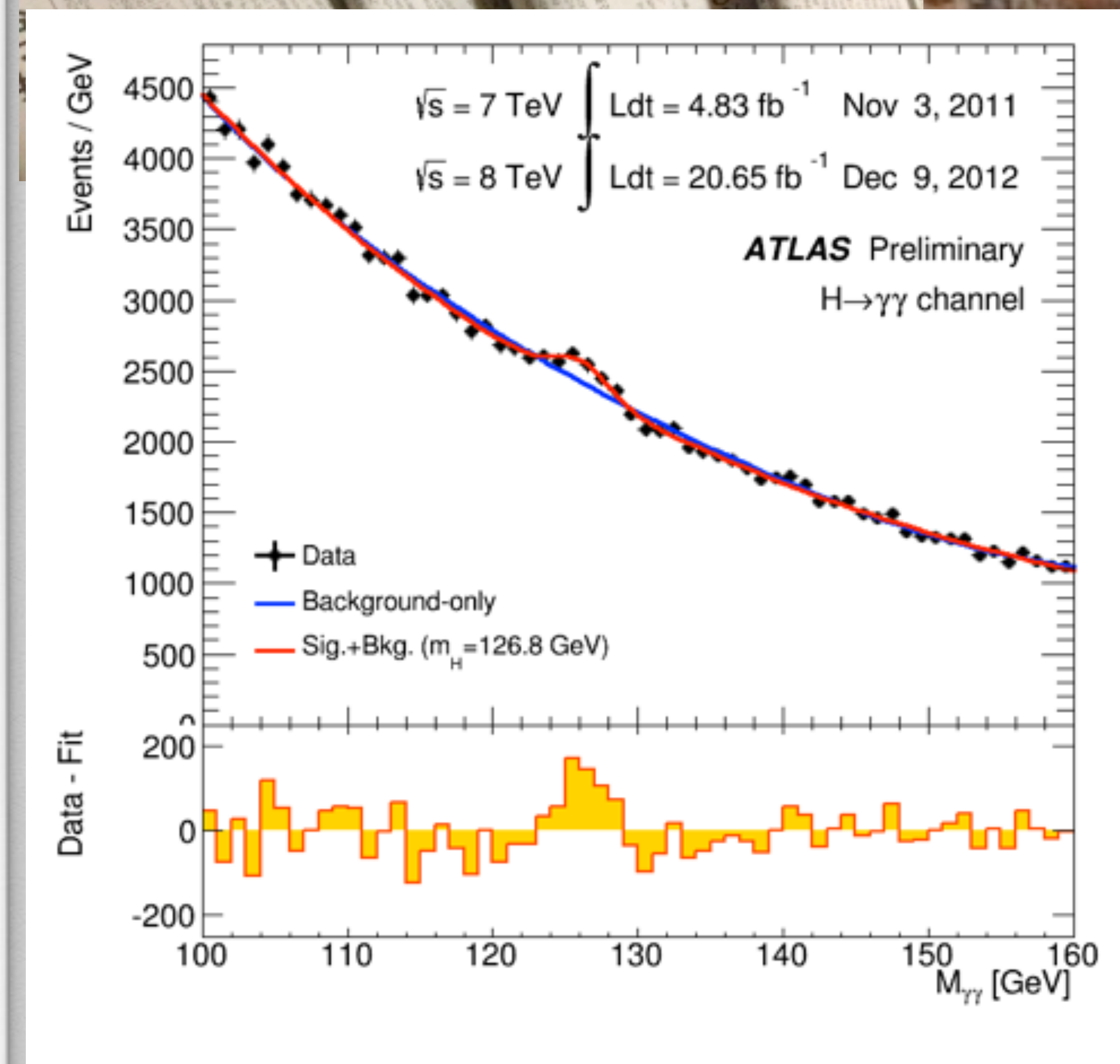
LHC Run I achievement Higgs discovery





Physics 2013

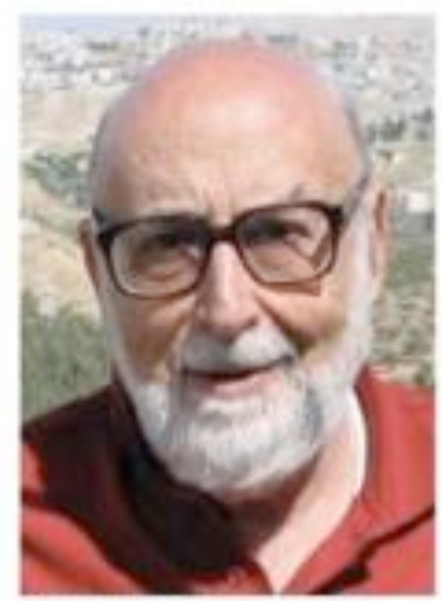


Photo: Pnicolet via Wikimedia Commons

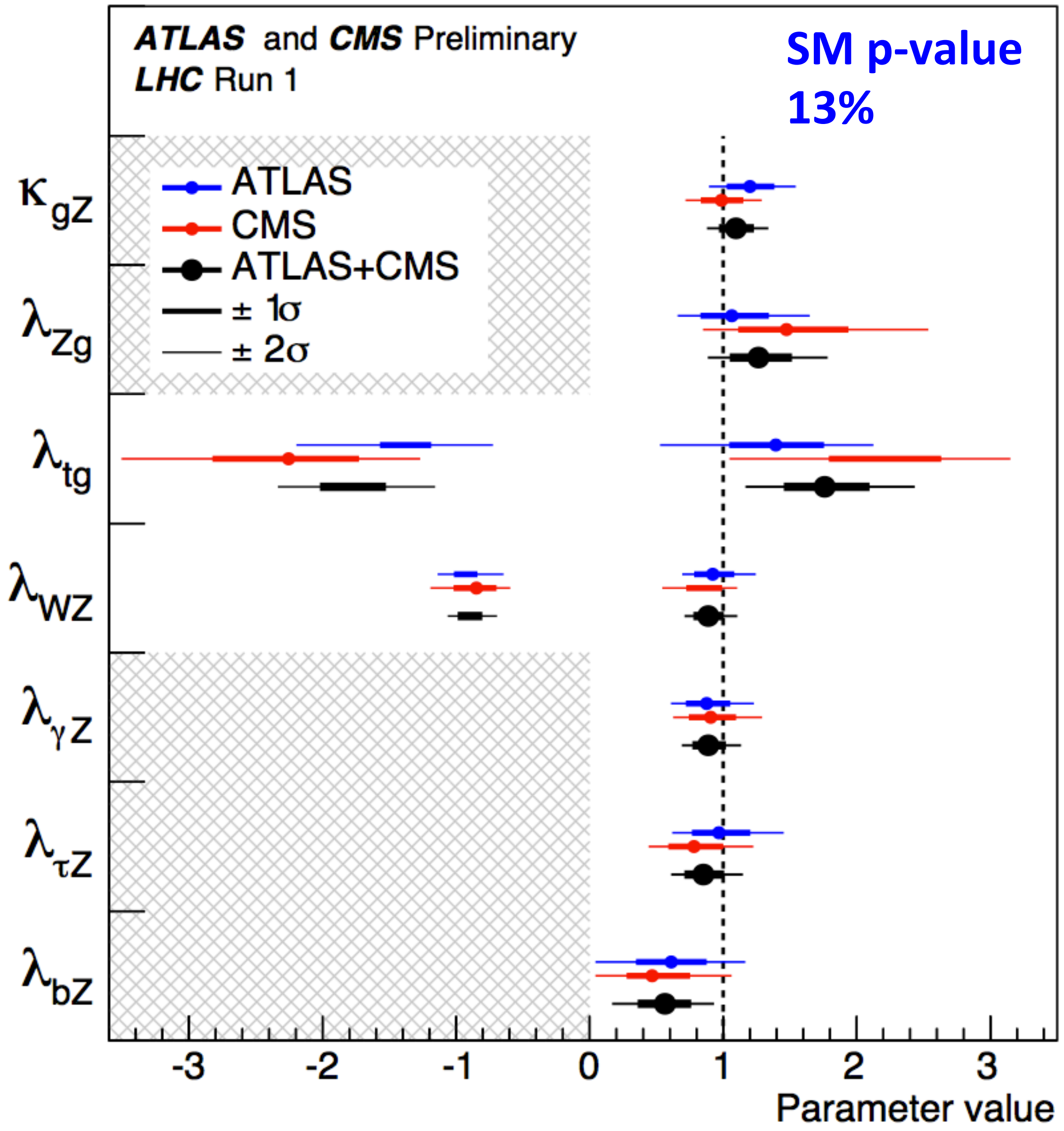
François Englert

Photo: G-M Greuel via Wikimedia Commons

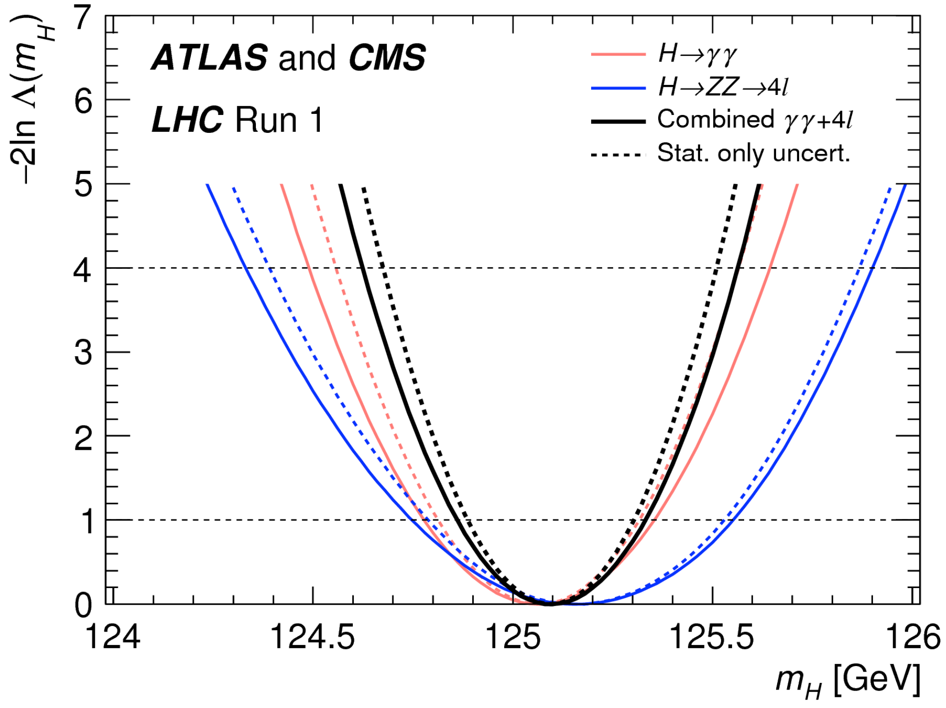
Peter W. Higgs

8TeV achievement (cont)

effective theory approach to parametrize statistical significance of each measurements



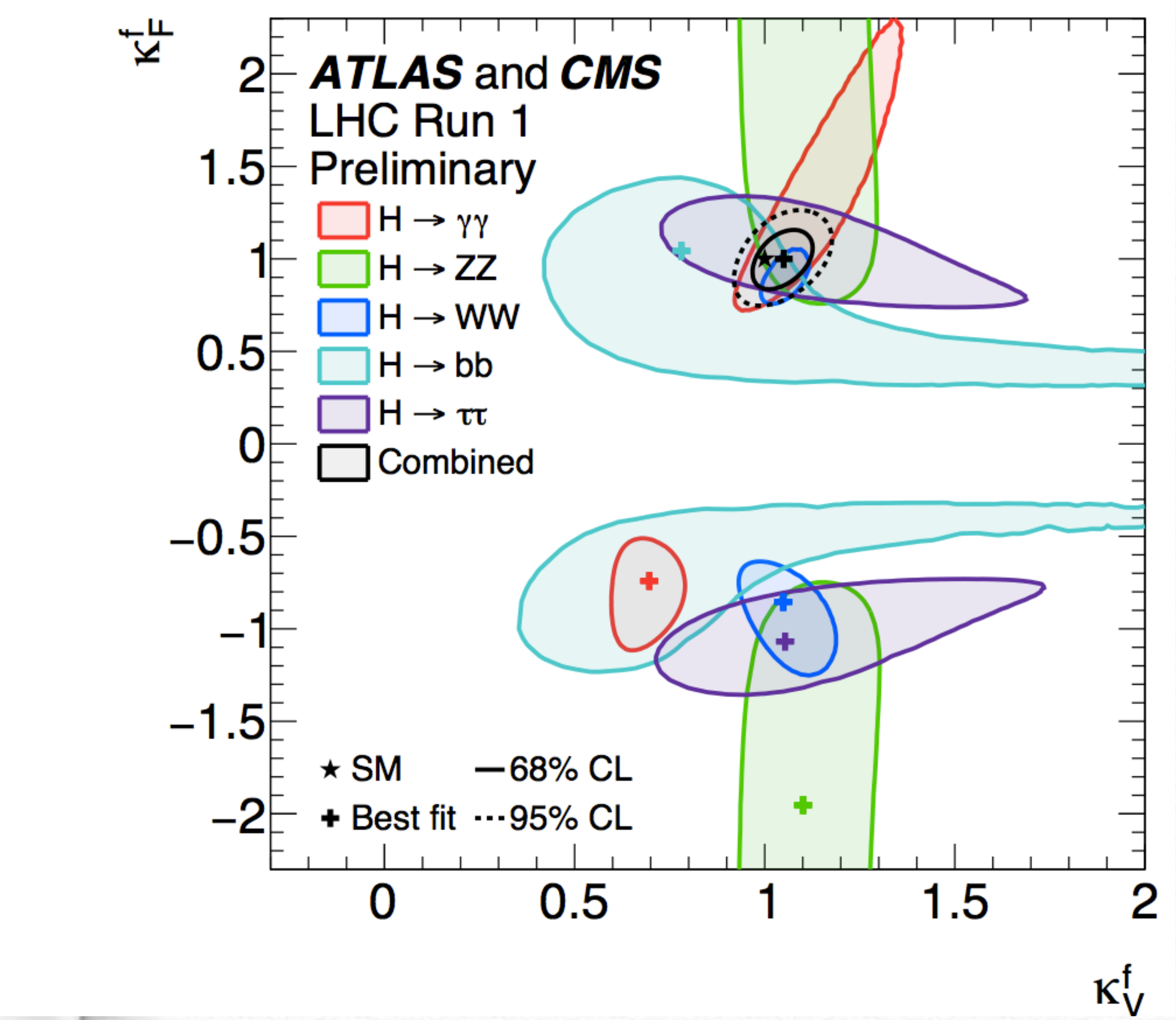
1D scan



mH=125.09 pm 0.24

μ= 1.09 +0.11-0.11

consistency among the channels



Higgs coupling in future

Peskin 1312.4974

μ values	300 fb^{-1} CMS	300 fb^{-1} here	3000 fb^{-1} CMS	3000 fb^{-1} here
$\gamma\gamma$	[6 , 12]	[6.2 , 11.3]	[4 , 8]	[3.7 , 8.0]
WW	[6 , 11]	[7.6 , 12.7]	[4 , 7]	[5.2 , 11.9]
ZZ	[7 , 11]	[6.2 , 12.7]	[4 , 7]	[3.0 , 7.0]
$b\bar{b}$	[11 , 14]	[13.6 , 16.7]	[5 , 7]	[4.7 , 8.6]
$\tau^+\tau^-$	[8 , 14]	[6.2 , 12.0]	[5, 8]	[2.8 , 7.2]
invis.	[11 , 17]	[11.2 , 16.6]	[4 , 11]	[4.1 , 10.9]
κ values	300 fb^{-1} CMS	300 fb^{-1} here	3000 fb^{-1} CMS	3000 fb^{-1} here
γ	[5 , 7]	[5.7 , 9.0]	[2 , 5]	[2.9 , 6.5]
W	[4 , 6]	[4.2 , 5.4]	[2 , 5]	[1.6 , 3.3]
Z	[4 , 6]	[5.7 , 8.5]	[2 , 4]	[2.8 , 6.3]
g	[6 , 8]	[4.9 , 6.9]	[3 , 5]	[2.3 , 4.8]
b	[10 , 13]	[11.4 , 14.9]	[4 , 7]	[4.2 , 8.5]
t	[14 , 15]	[17.3 , 20.5]	[6 , 8]	[5.7 , 12.9]
τ	[6 , 8]	[5.8 , 9.5]	[2 , 5]	[2.7 , 6.5]
inv.	[8 , 11]	[6.3 , 8.0]	[4 , 7]	[2.0 , 4.0]

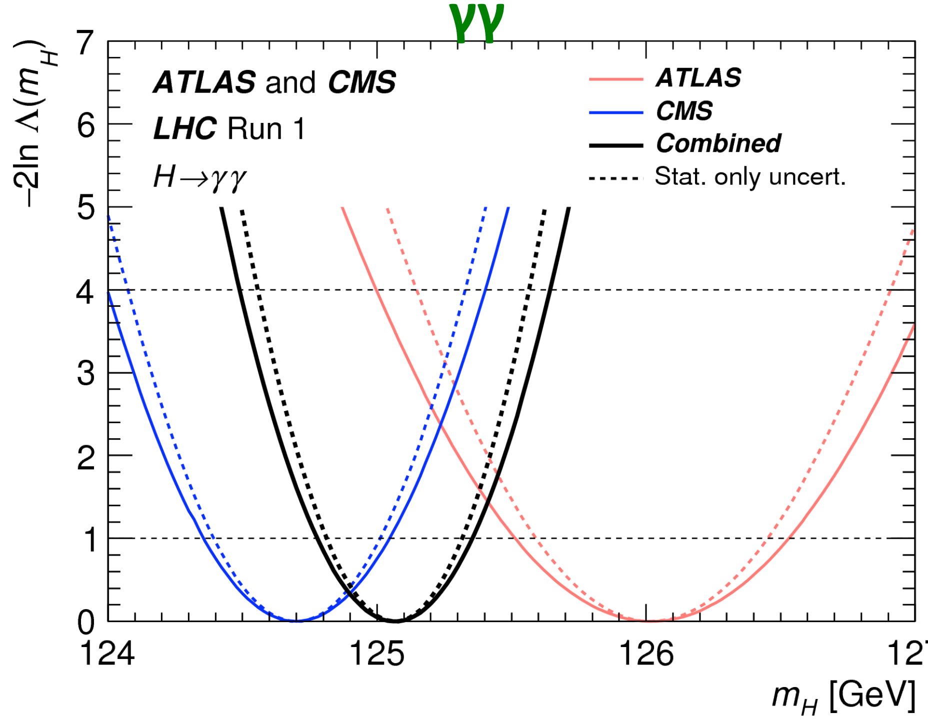
Table 2: Comparison of the results of fits with the inputs in Table 1 to the fit results given in [7]. All numbers are given as 1 σ uncertainties, in %. In expressions in brackets, the first entry is for Scenario 2, the second is for Scenario 1.

4% at 3000fb^{-1}
O(0.1)% at future e+e-

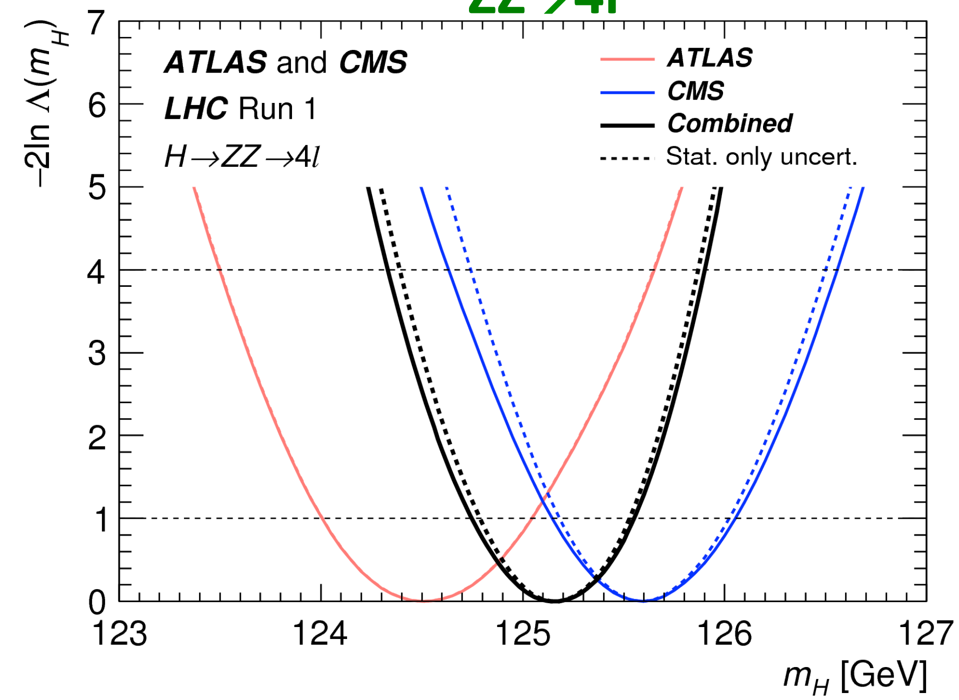
Measurement in the individual channels

- Mass is measured with high precision channels $\gamma\gamma$ and ZZ→4l

γγ



ZZ→4l



Some (opposite) tension between the two channels
but very good agreement in the central values

$$\begin{aligned} m_H^{\gamma\gamma} &= 125.07 \pm 0.29\ \text{GeV} \\ &= 125.07 \pm 0.25\,(\text{stat.}) \pm 0.14\,(\text{syst.})\ \text{GeV} \end{aligned}$$

$$\begin{aligned} m_H^{4\ell} &= 125.15 \pm 0.40\ \text{GeV} \\ &= 125.15 \pm 0.37\,(\text{stat.}) \pm 0.15\,(\text{syst.})\ \text{GeV} \end{aligned}$$

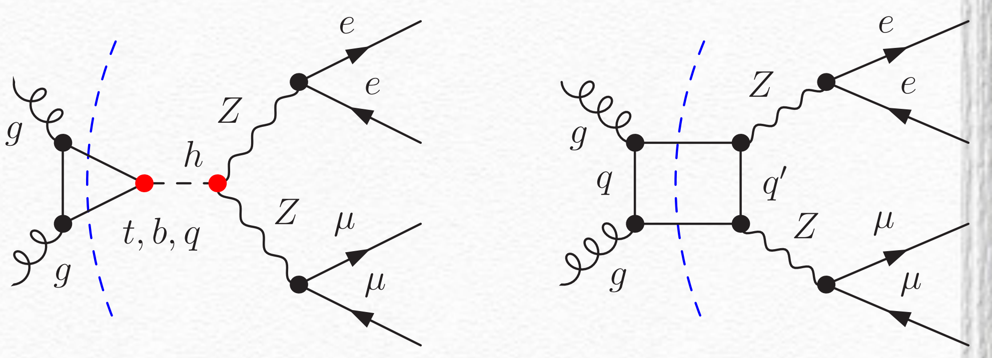
ATLAS γγ 2σ away from the best .
ATLAS 4l best fit is 2σ away from ATLAS 2γ

Is Effective theory always efficient way?

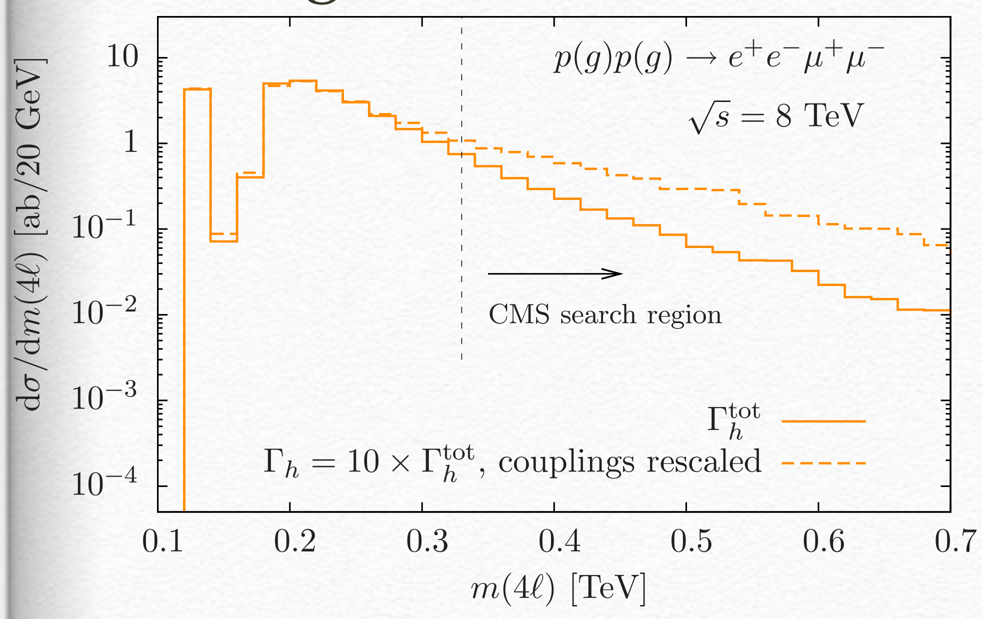
- effective theory approach is often useful to parametrize signal distribution, but the care must be taken so that we do not **misuse it.**

- ex: Higgs width in pp→ ZZ using off shell amplitude

$$\sigma^{\text{on-shell}}_{gg\to H\to ZZ^*} \sim \frac{g^2_{ggH} g^2_{HZZ}}{m_H \Gamma_H} \text{ and } \sigma^{\text{off-shell}}_{gg\to H^*\to ZZ} \sim \frac{g^2_{ggH} g^2_{HZZ}}{(2m_Z)^2}.$$

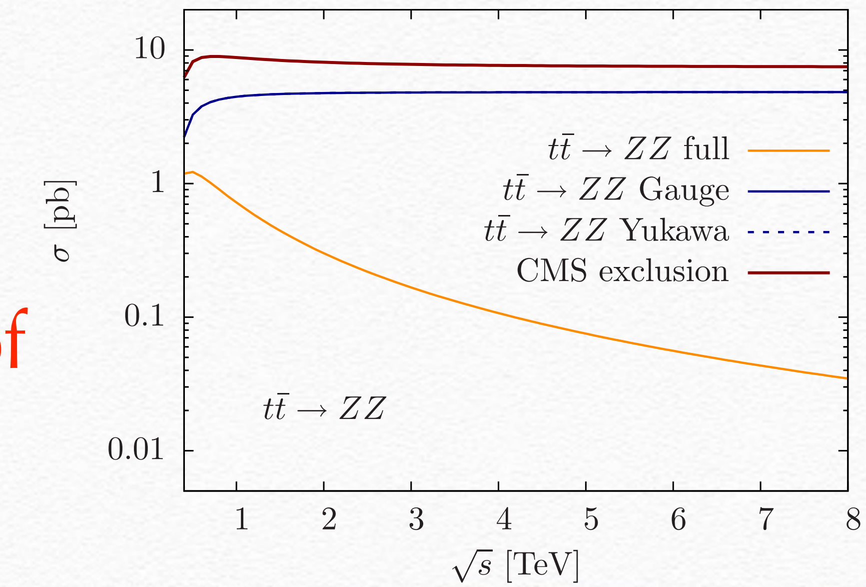


C.Englert et al 1410.5440



ΓH<20MeV

but the result comes from non-Unitarity of the amplitude

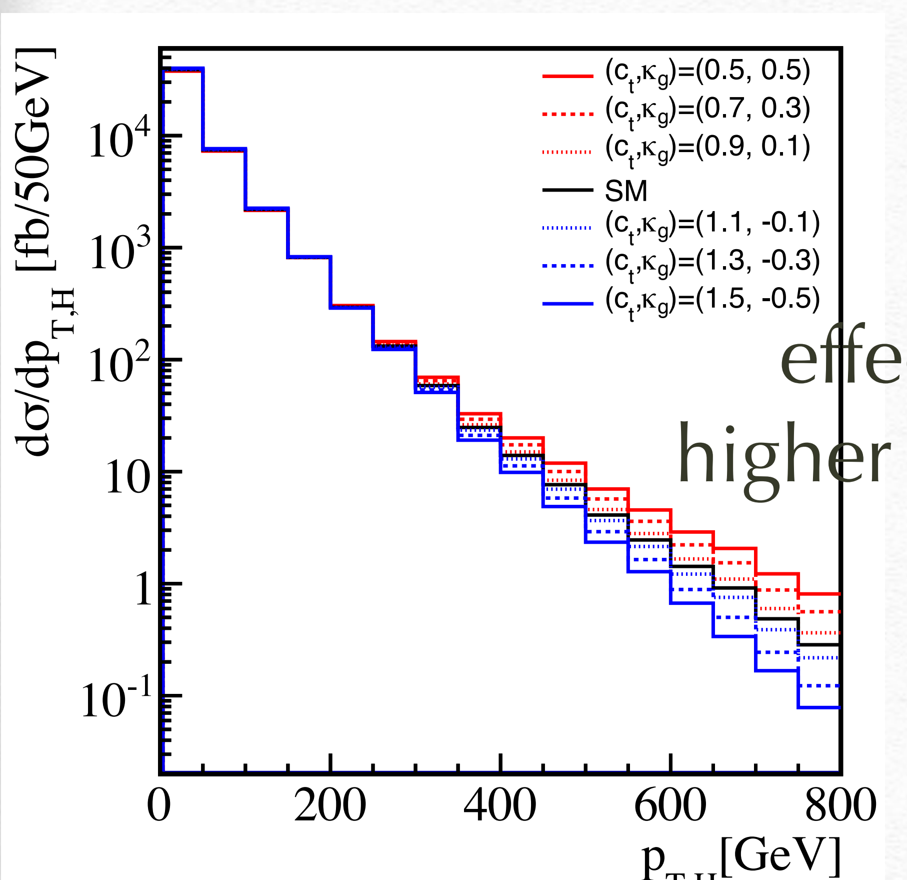


More information in higgs distributions?

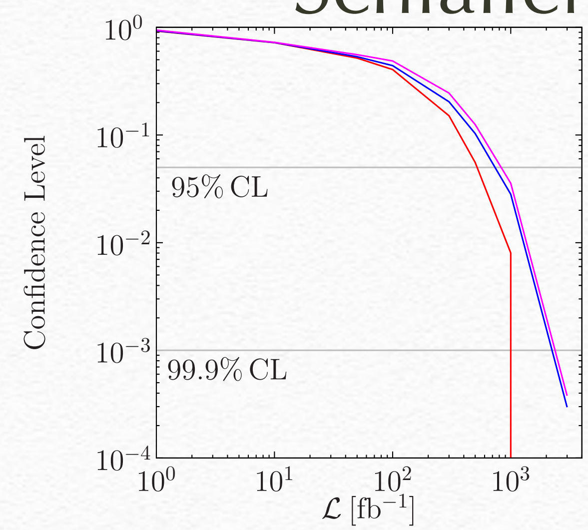
- Higgs boson pT, ttH… typically require high pT

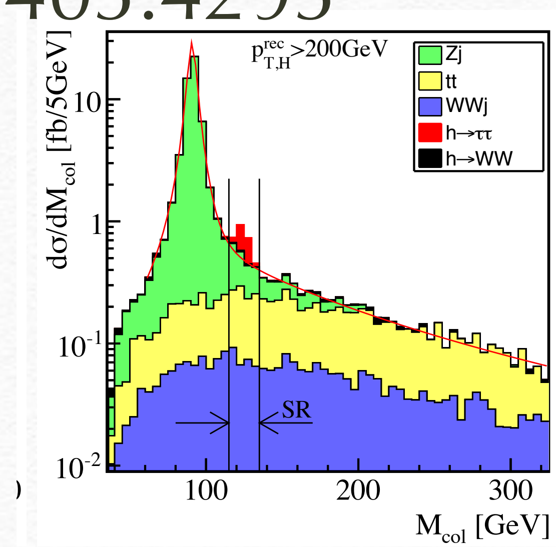
$$\mathcal{L}_{\rm eff} = -c_t \frac{m_t}{v}\bar{t}tH + \kappa_g \frac{\alpha_S}{12\pi}\frac{h}{v} G^a_{\mu\nu}G^{a\,\mu\nu} + \mathcal{L}_{\rm QCD},$$

Schlaffer 1405.4295



effect of higher dim op



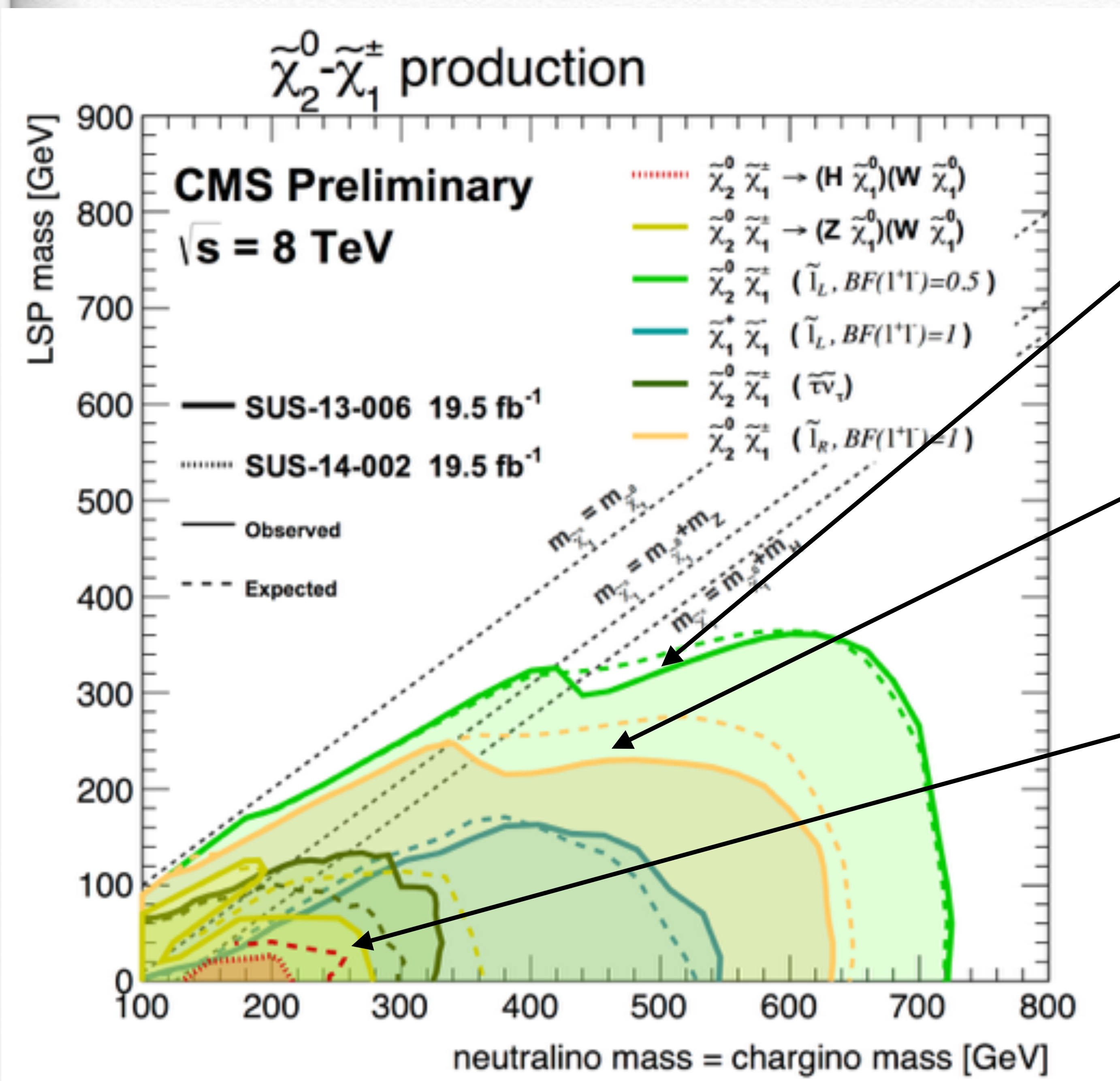


κg=0.5

estimate based on h->**ττ** ->leptonic only

8TeV achievement (New physics)

Assuming wino like NLSP's



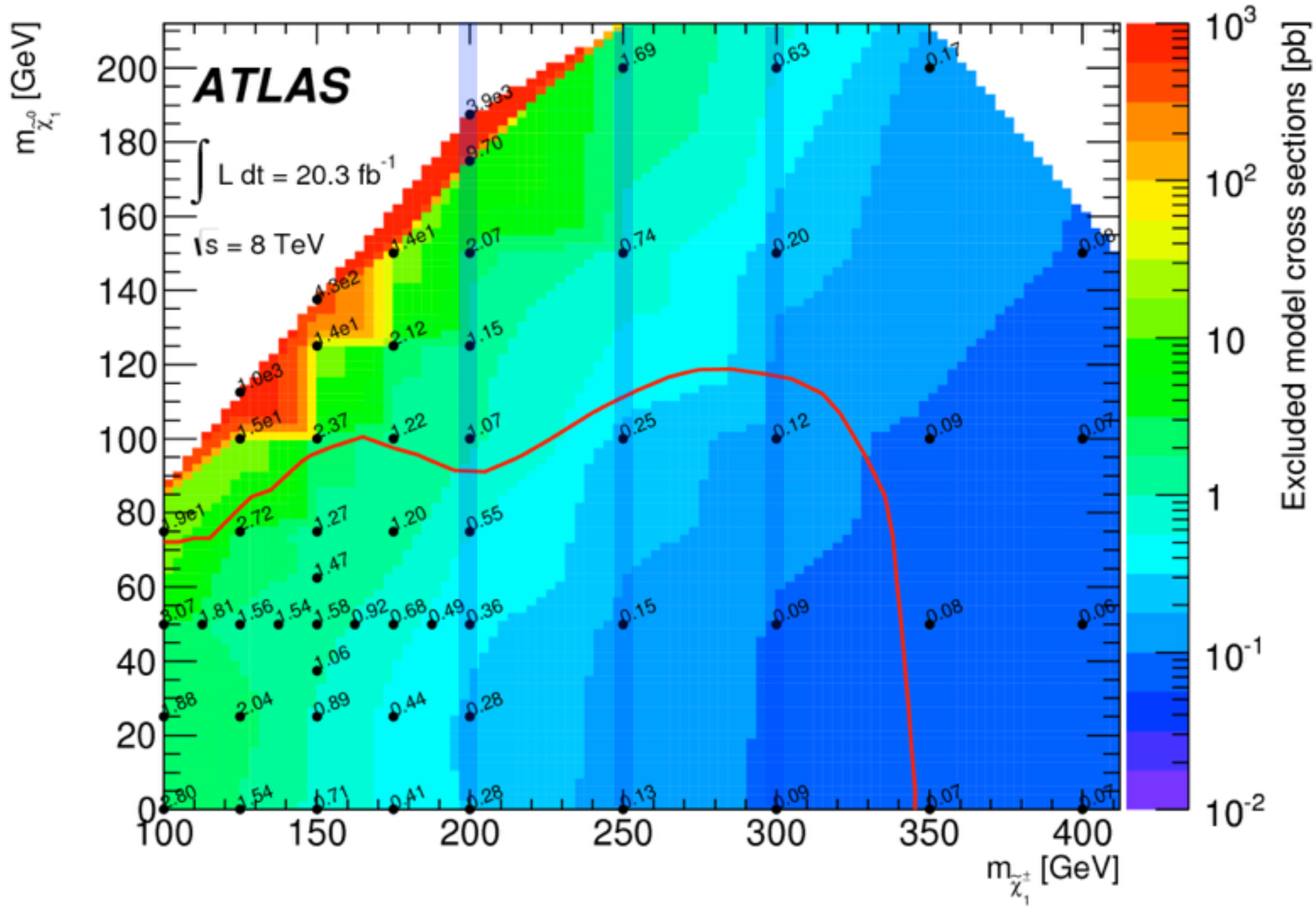
Light slepton and bino LSP is exlclude up to 700 GeV

Limits are weaker for W and Z final state

Higgs or tau final state is difficult

Typical cross section vs cross section limit

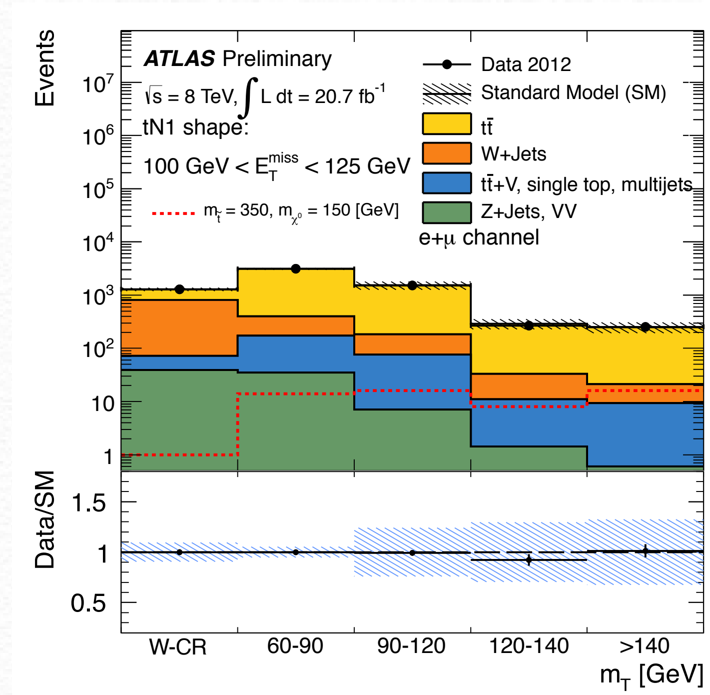
0.8pb 0.32pb 0.15pb

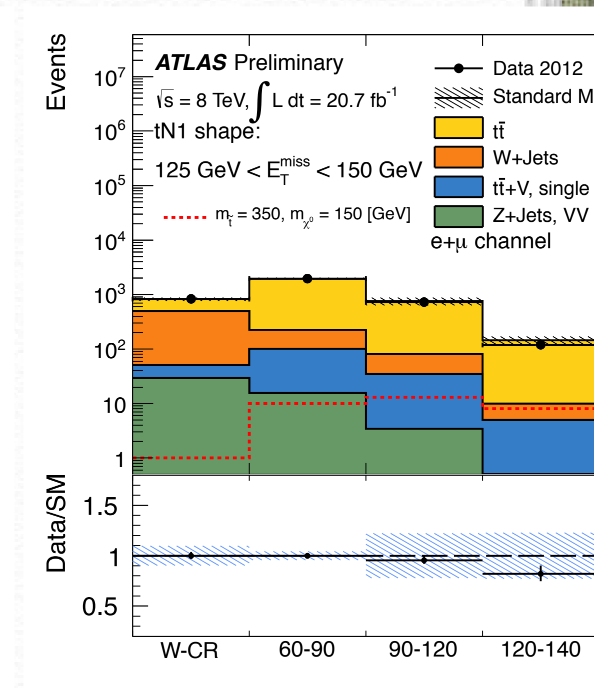


Stop searches
~ theoretical understanding of SM

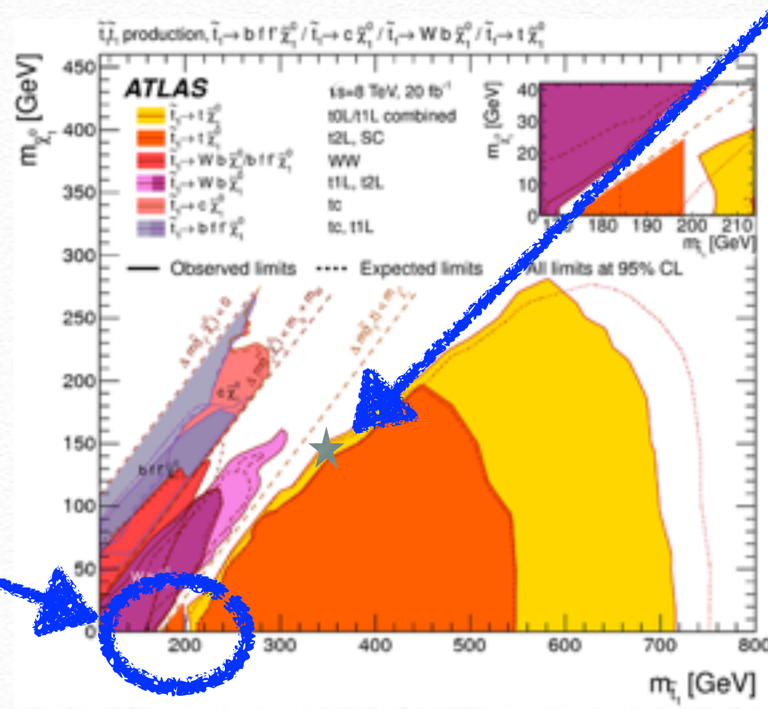
In reality there are
no region with
S/N>0.1 in this plot

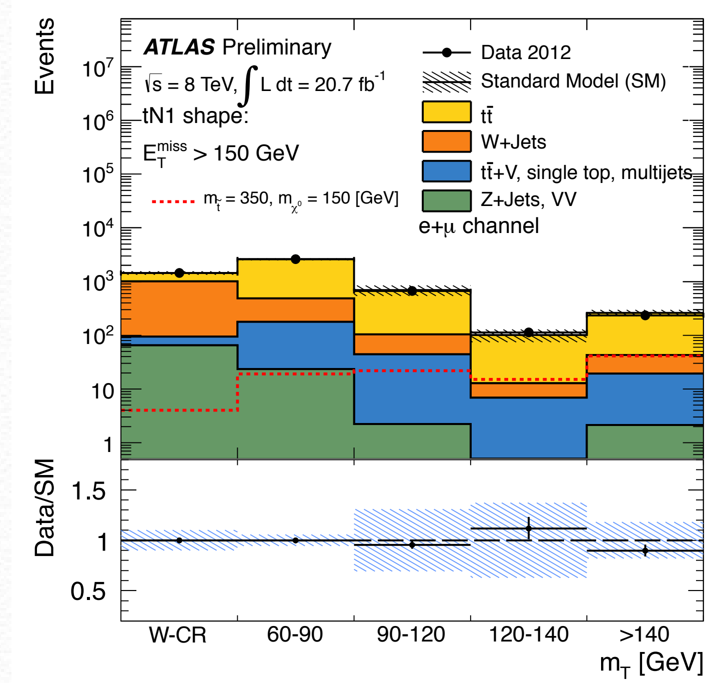
exclude up to the region
where mstop~mLSP+mt +30GeV





ttbar distribution
filling the gap

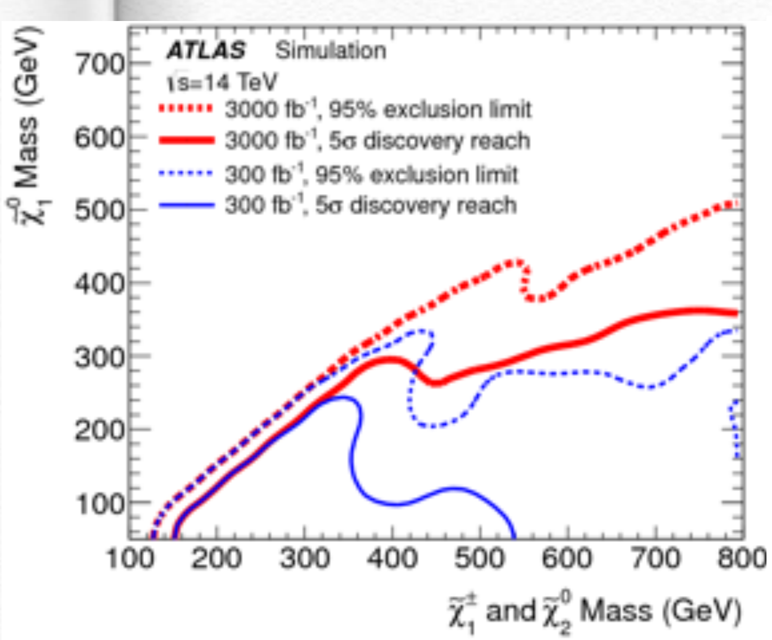


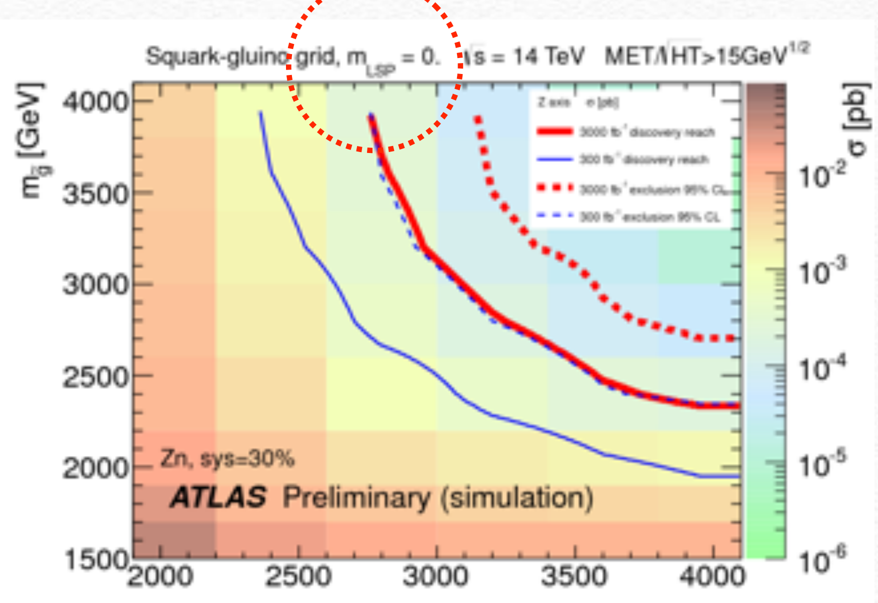


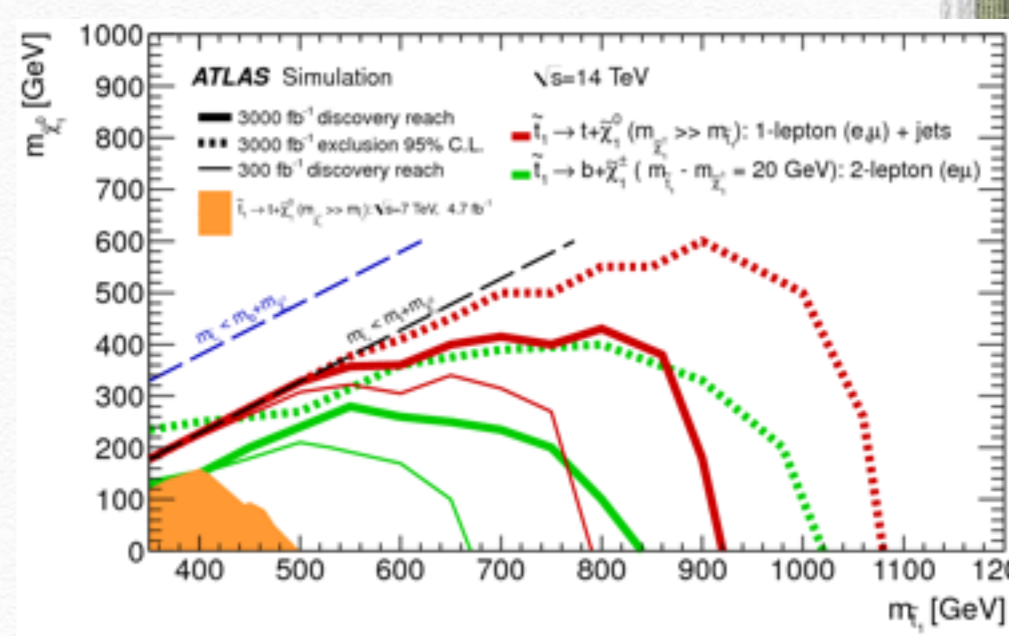
Theory needs to prepare high scale SUSY calculation

- Higgs mass (now much less than 1% error) → SUSY scale, stop mass and mixing, tanβ
  - Higgs mass, Higgs branching ratios (resum large logs and non-decoupling corrections
  - rare decays (public tools mostly uses parameters at mZ…)

ATL-PHYS-PUB-2013-007
(W, Z channel)





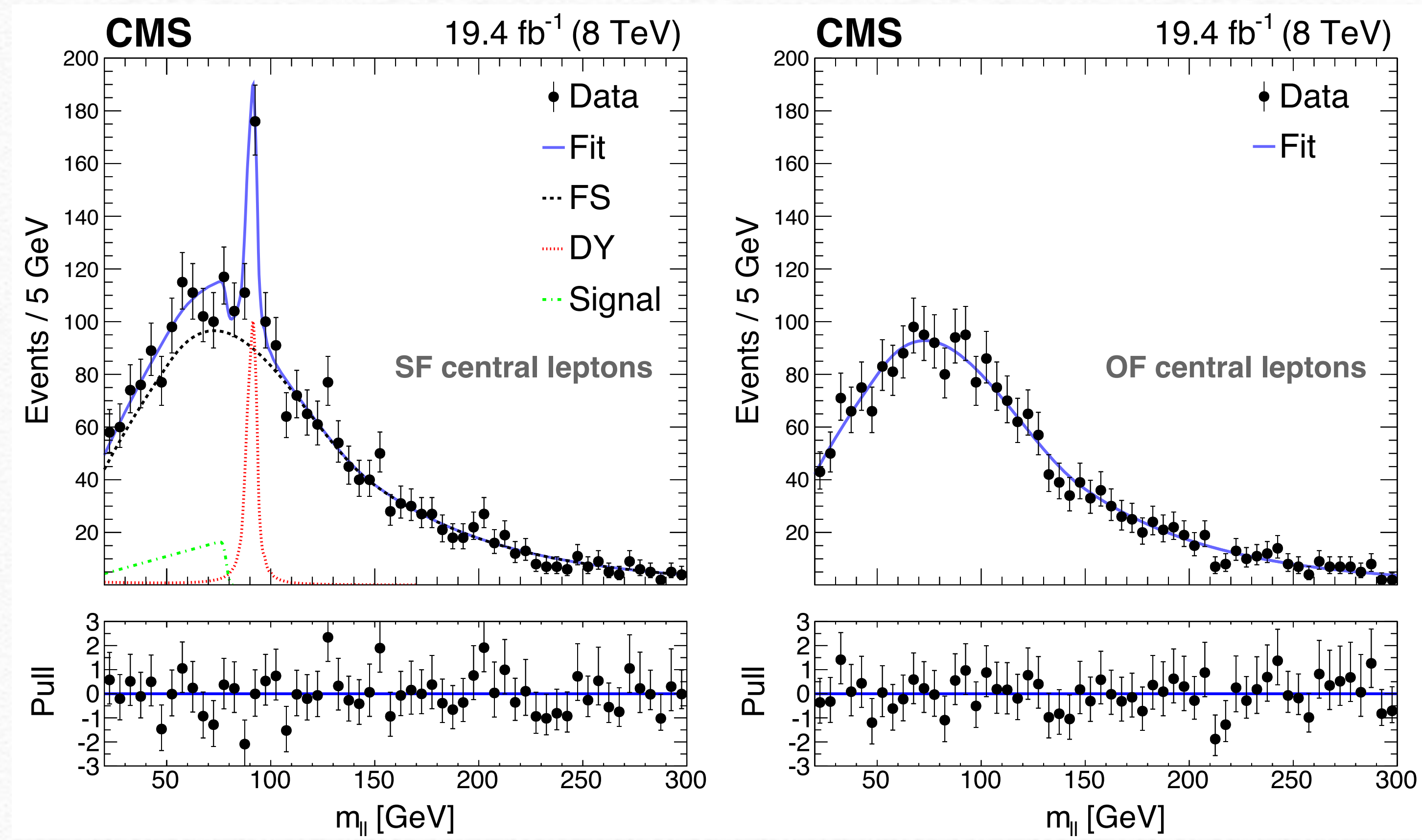


Anomaly driven life

dilepton +jet+ missing ET

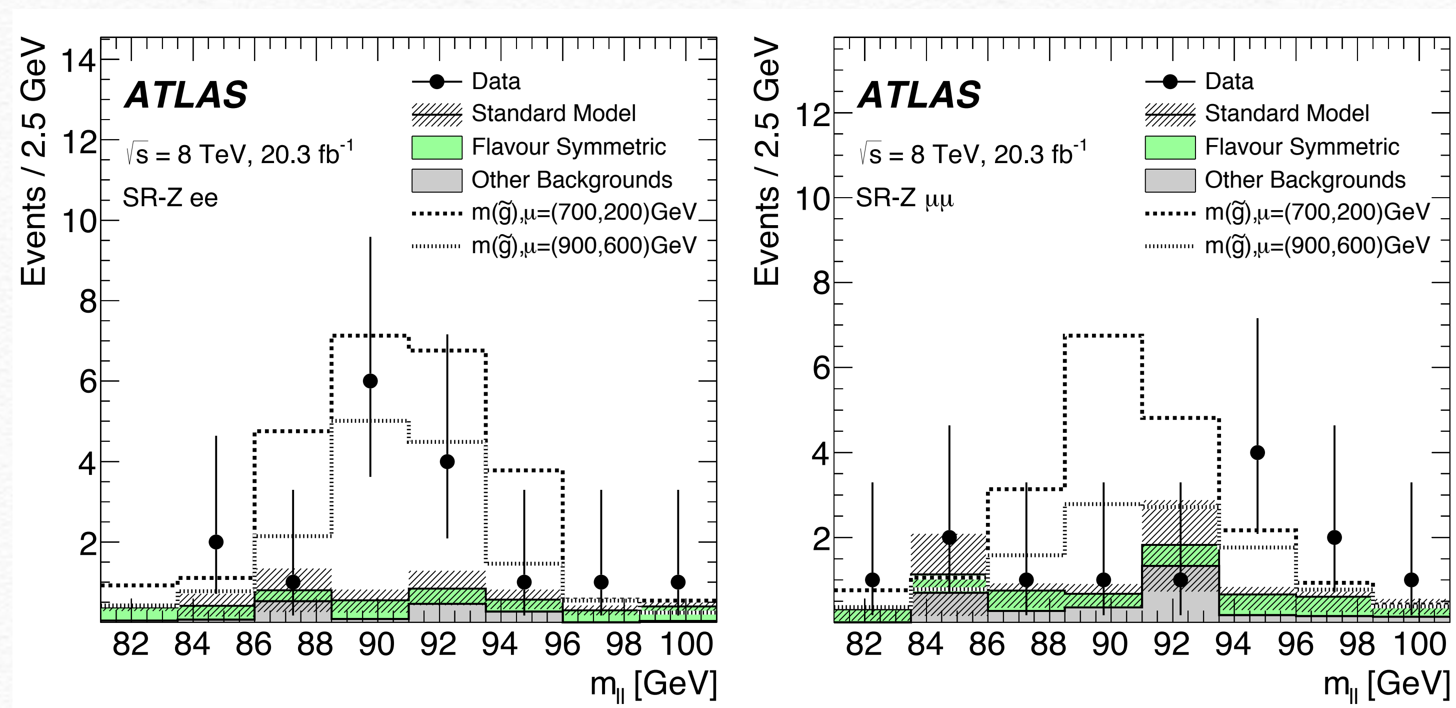
arXiv 1502.06031
arXiv:1503.03290

CMS 2.6 σ



jets + Z +missing Et
arXiv:1502.06031
arXiv:1503.03290

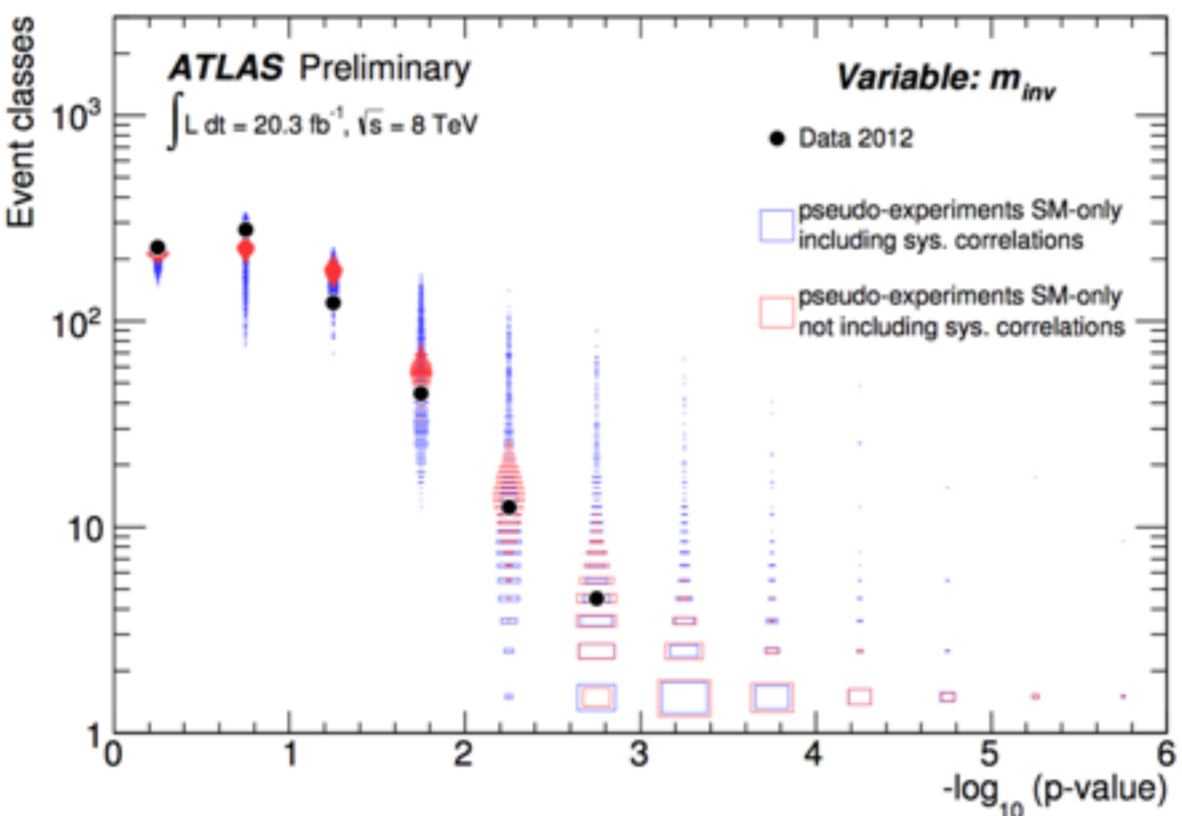
ATLAS 3σ in ee
none in μμ



Stay calm and look

Global search results

4) Compare expected P-value distributions with observed
- channel gets diluted by look elsewhere effect



No deviations with p-value < 10^{-3}

~ 1 expected

- Largest deviation comes from m_{eff} of e + μ + γ + 2 jets
  - P-value of 7E-4

Conclusion : nothing unexpected

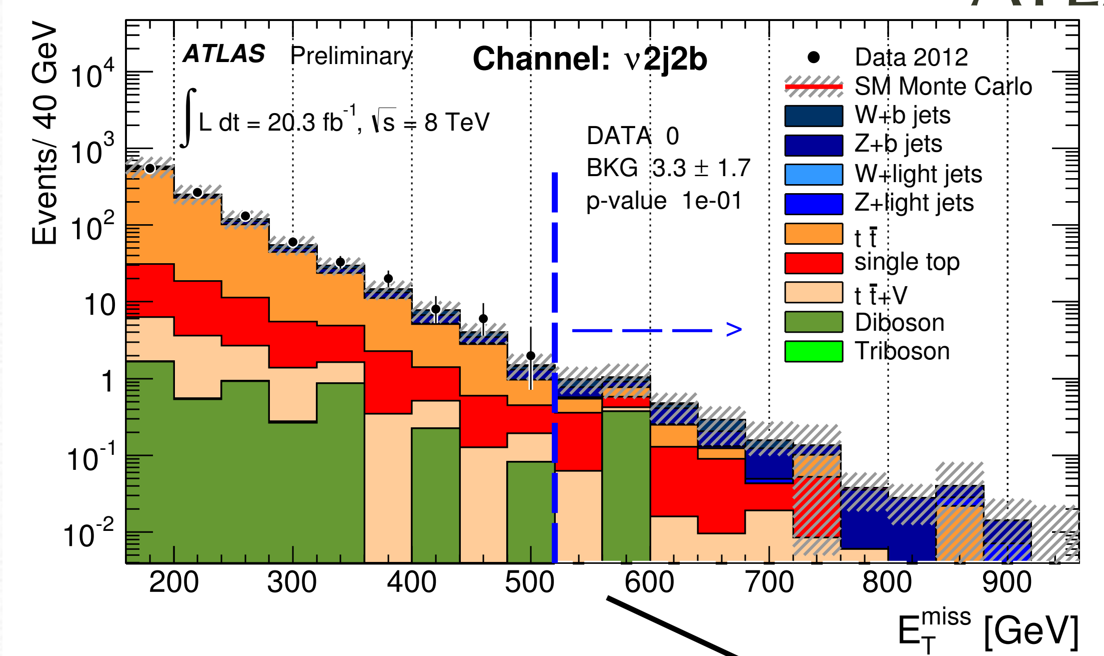
53

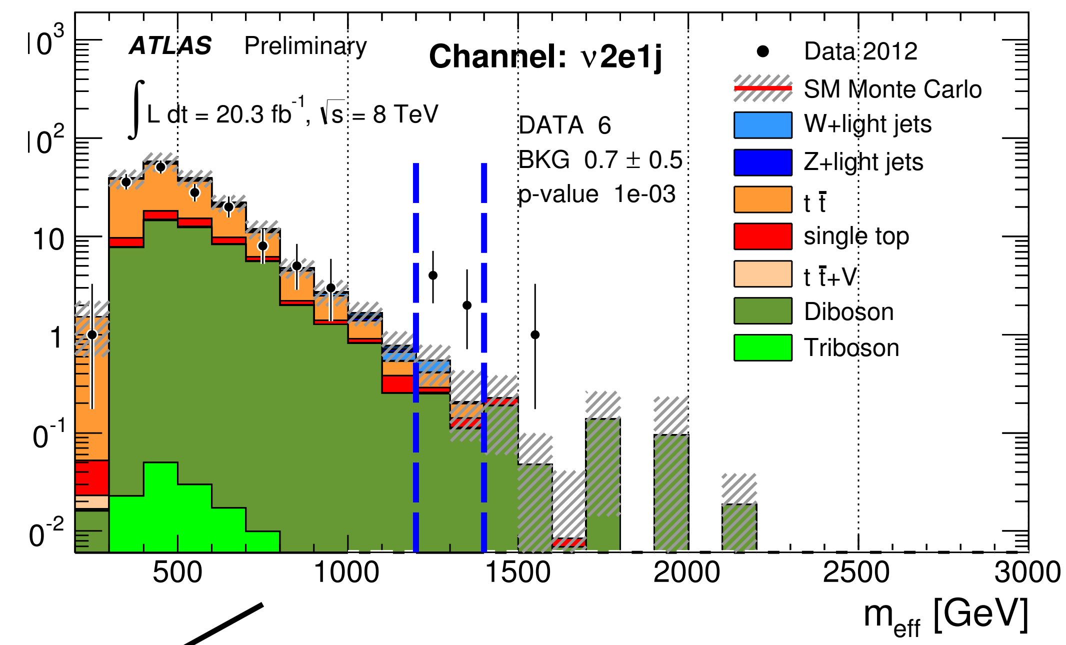
ATLAS-CONF-2014-006
from Ben Kilminster's talk

Use SUSY data, HT, M_event, Etmiss
compare with pseudo experiment and get p-values
compare with 697 class of events with SM bkg>0.1evnets

Anomalies are not significant “looking elsewhere” effect

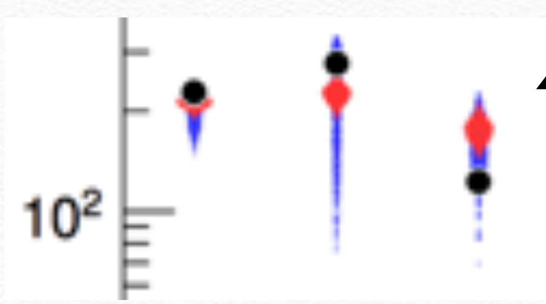
ATLAS-CONF-2014-006

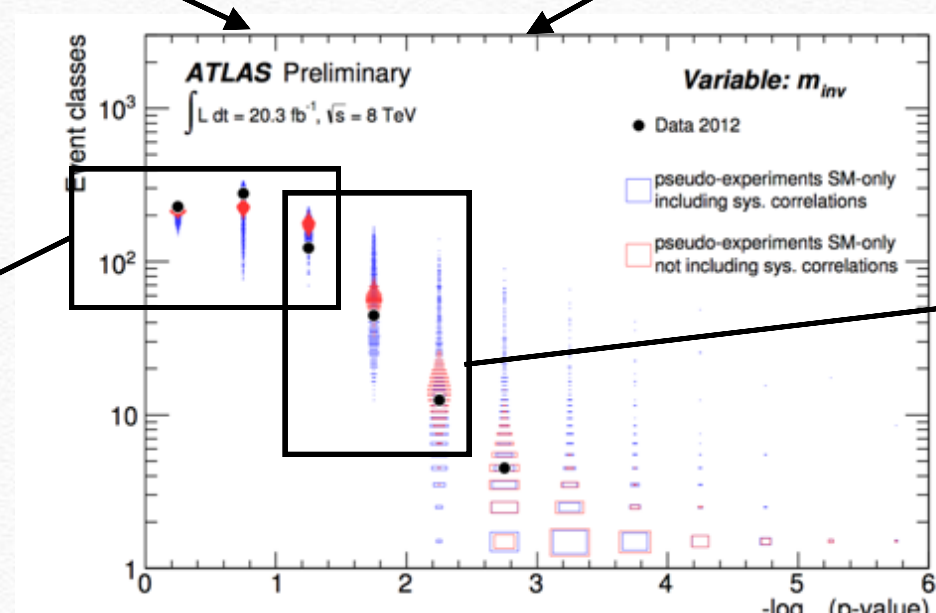


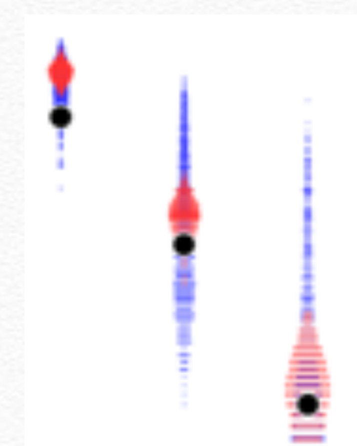


pull to

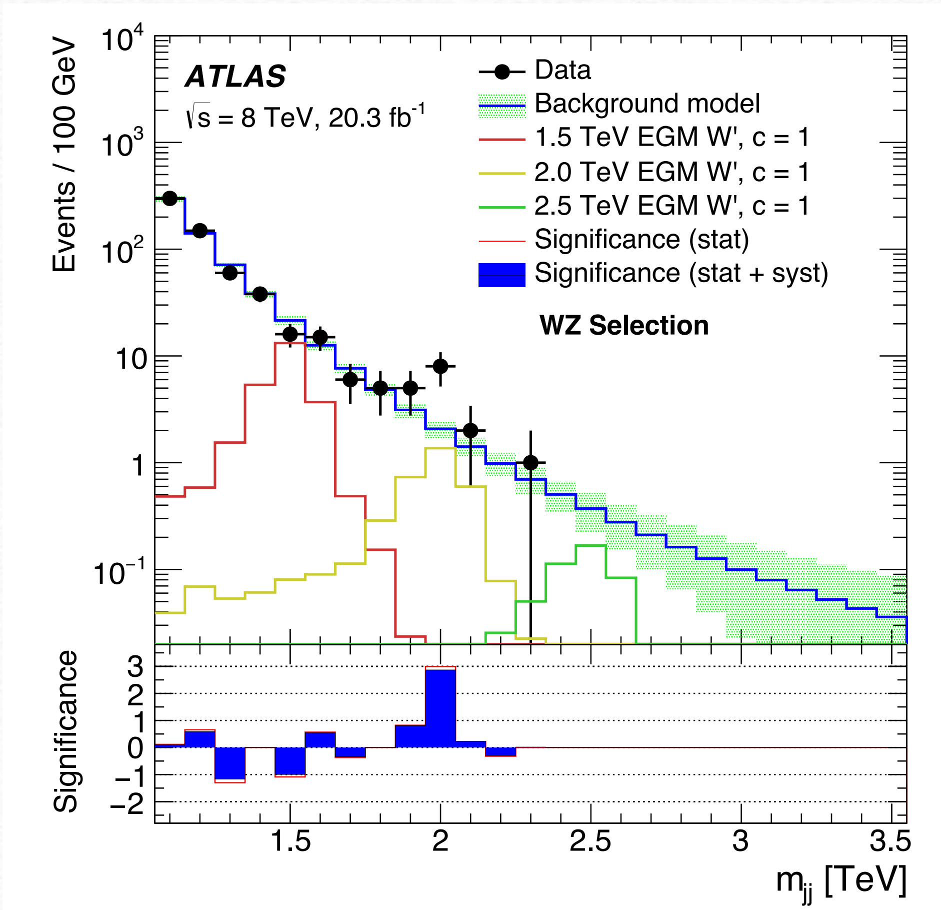
“error overestimate”?

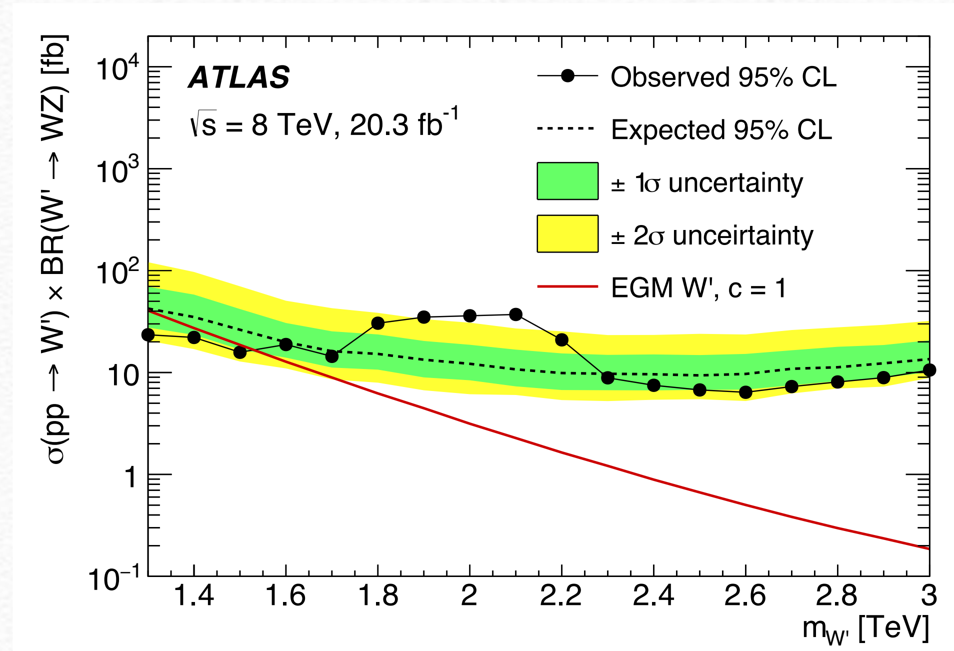


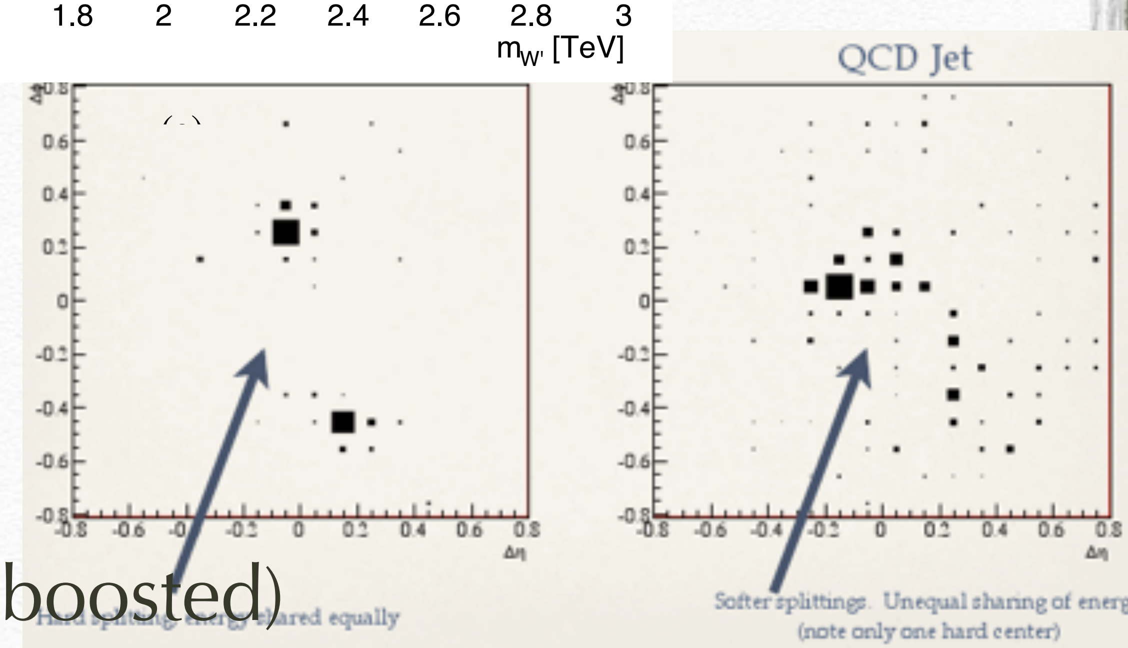




di-boson search







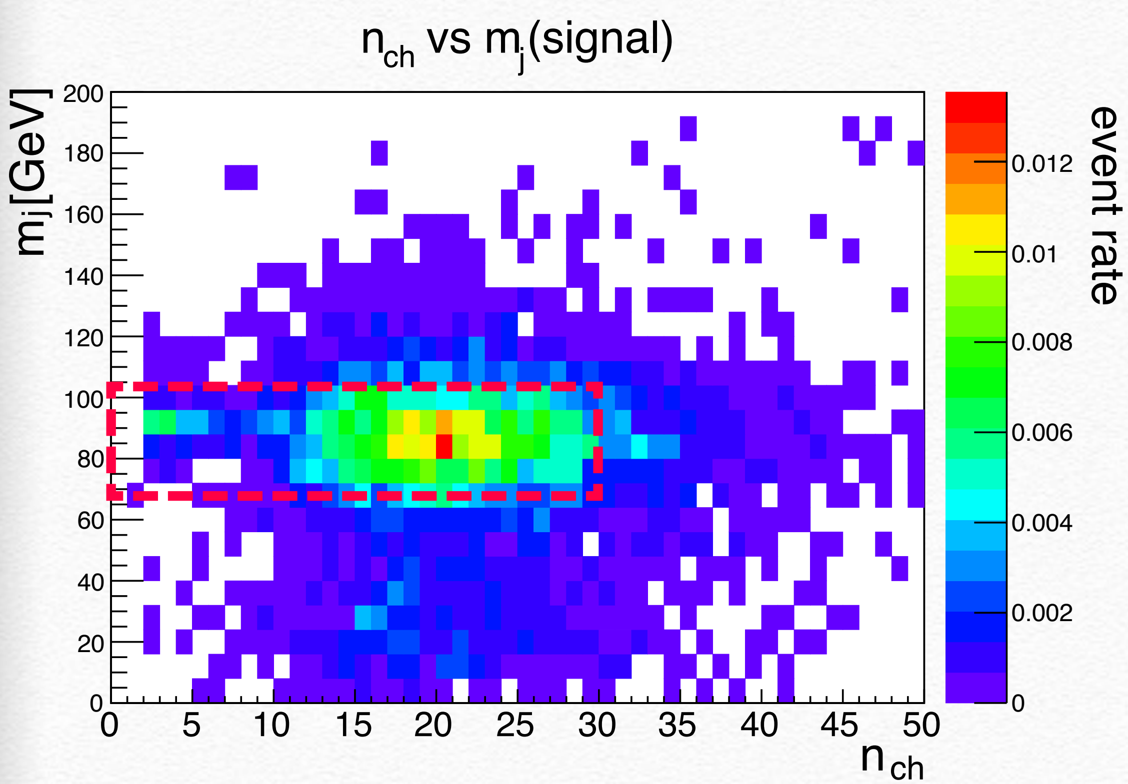
- excess of pp-> W′ Z′-> WW, WZ, ZZ (boosted)
- Jet substructure plays important role

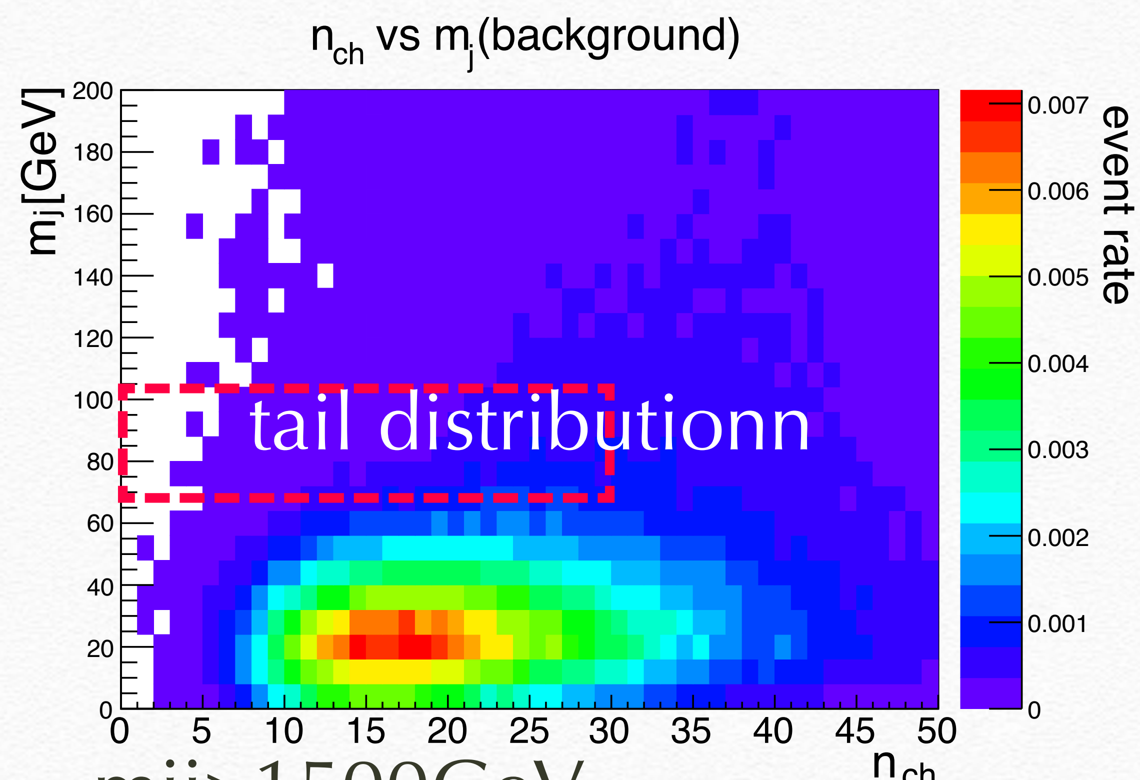
$$\sqrt{y} = \min(p_{T_{j1}}, p_{T_{j2}}) \frac{\Delta R_{(j1,j2)}}{m_0}. > 0.45$$

- tension between width and cross section
- current excess point would be excluded for 10fb^-1 at 13TeV

QCD backgrounds estimate

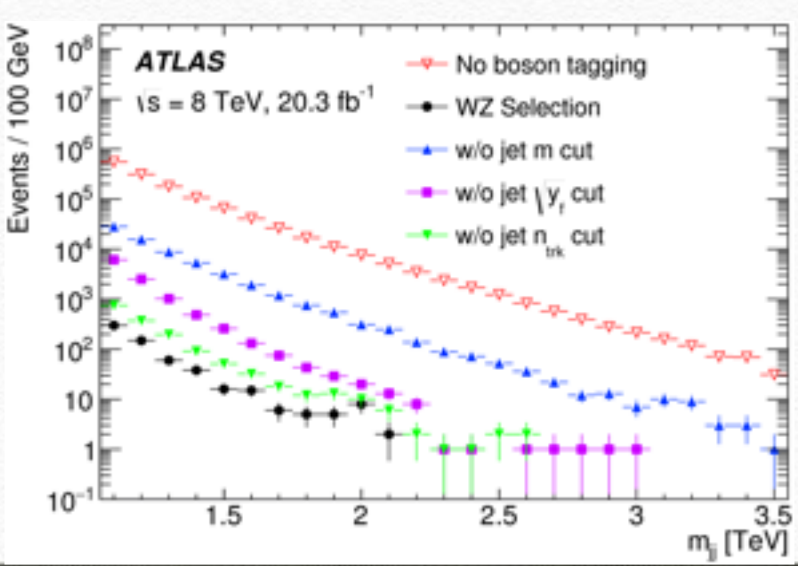
- substructure ←theoretically calculable and MC prediction stable
- number of charged tracks ←large uncertainty in MC prediction for gluon jet (n<30)





mjj>1500GeV

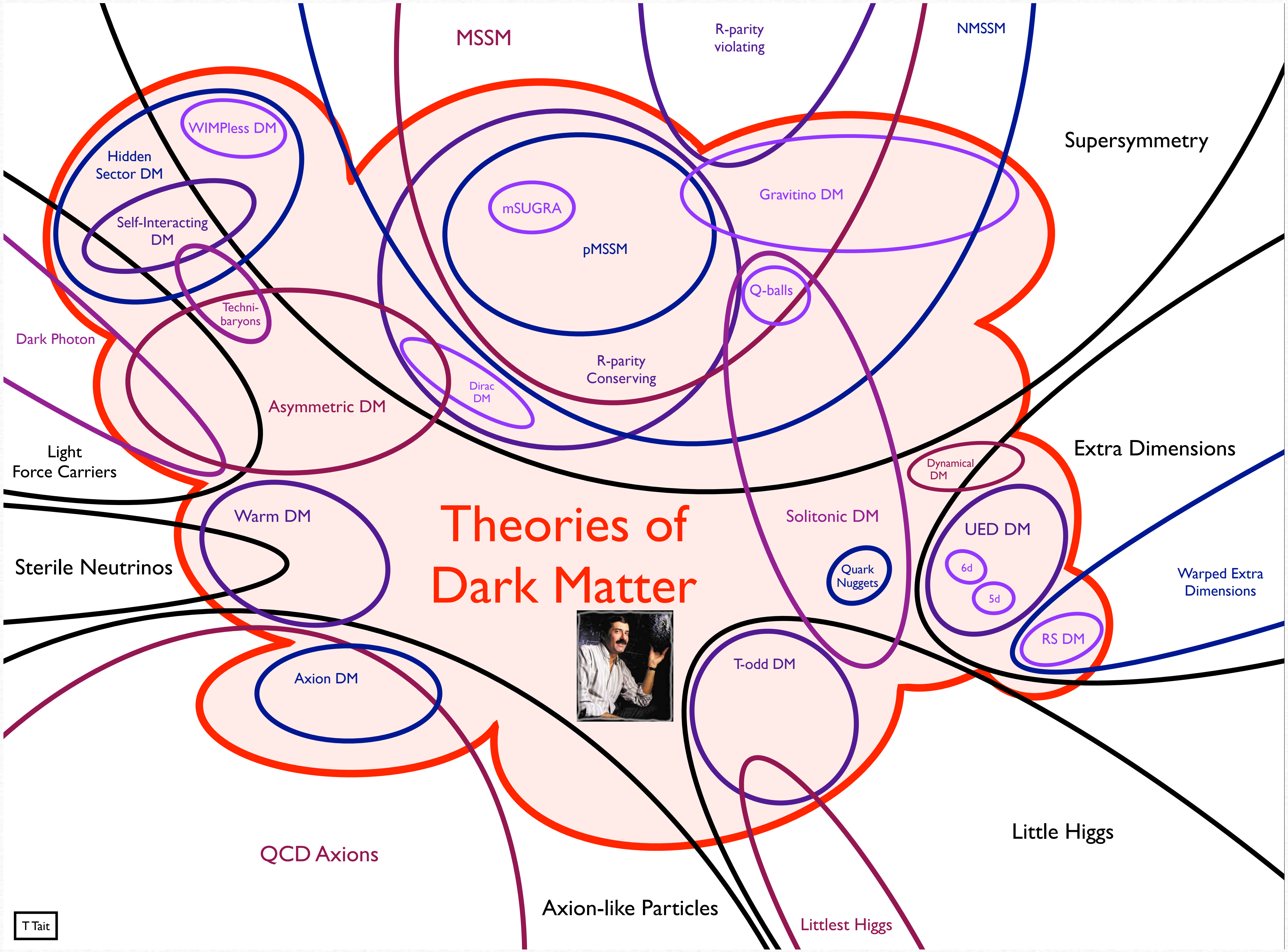
1507.01681 Abe Kitahara Nojiri



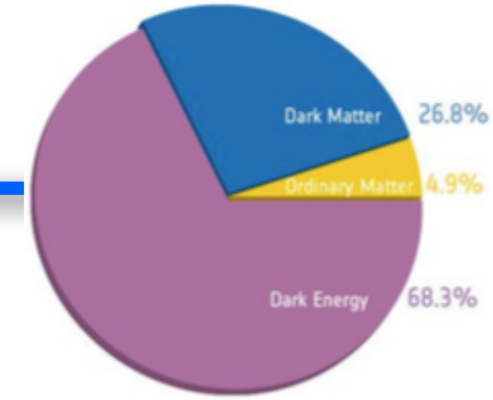
Still something need to be done to understand the cut flow

dark matter at LHC

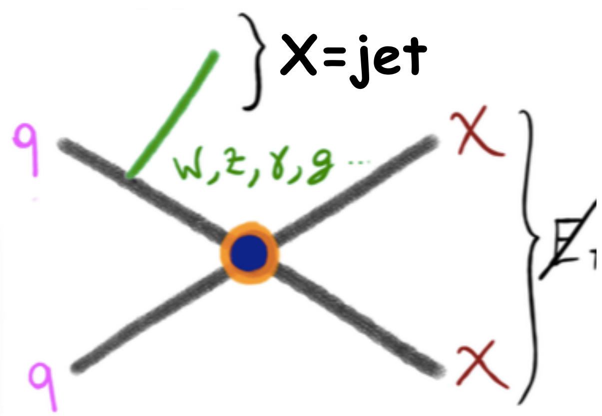
by Tim Tait



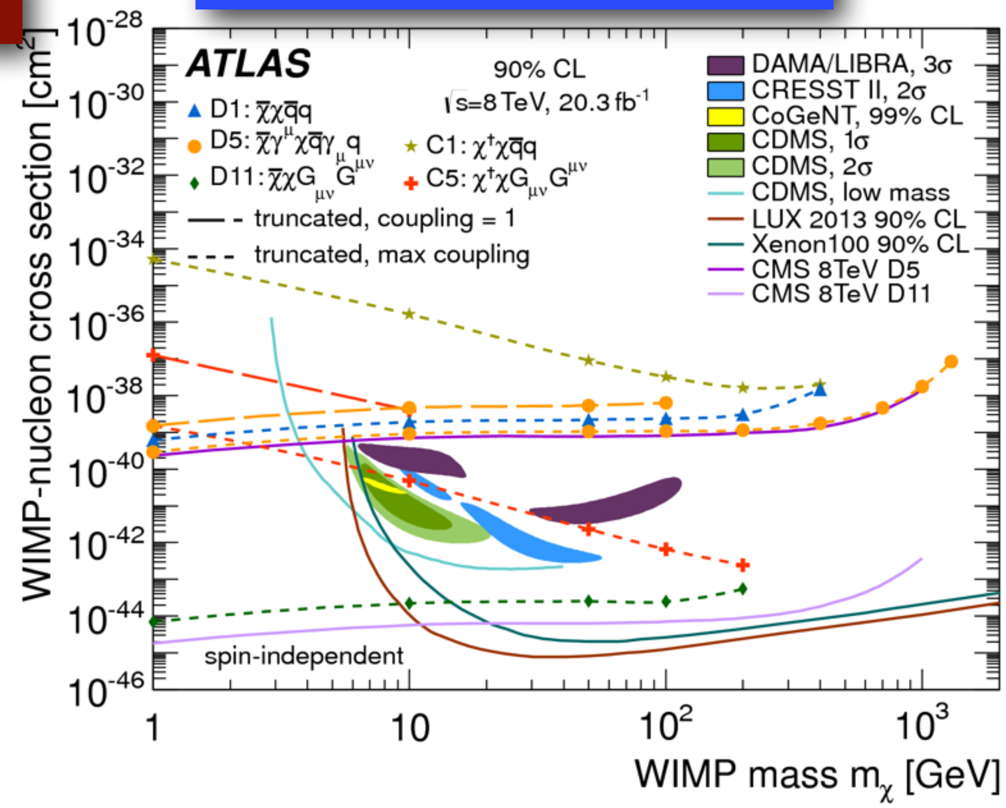
Dark Matter at LHC: Mono-Jet

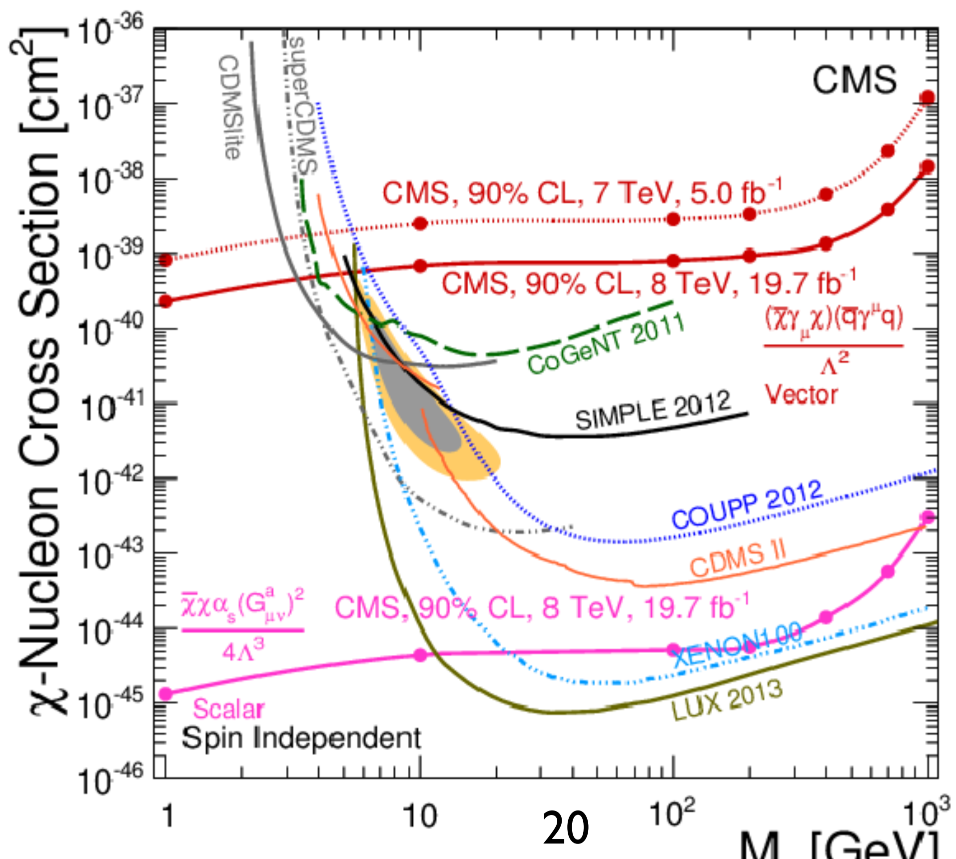


mono-jet + missing E_T

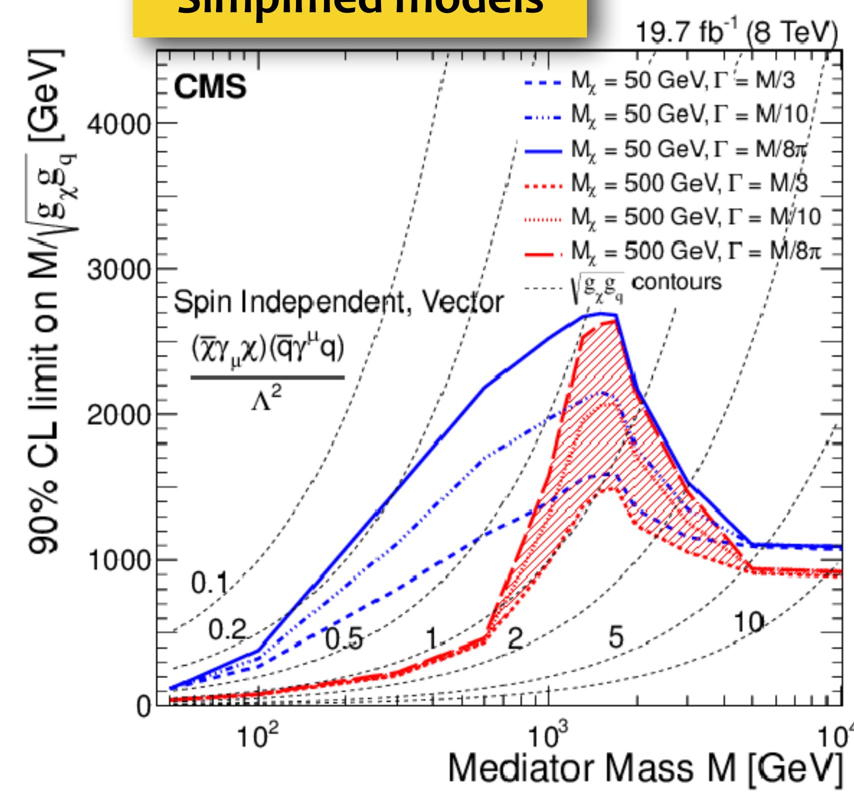


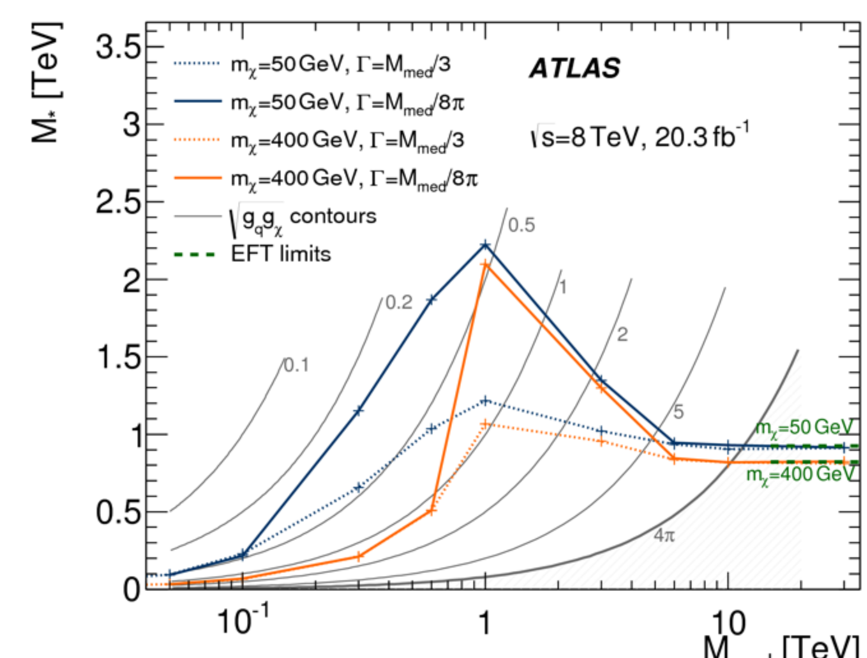
Effective Field Theory





Simplified models





Both EFT and Simplified model(s) analyses applied by ATLAS and CMS

Results interpreted in terms of WIMP-nucleon cross section and effective and mediator mass limits.

ATLAS: arXiv:1502.01518, CMS: arXiv:1408.3583

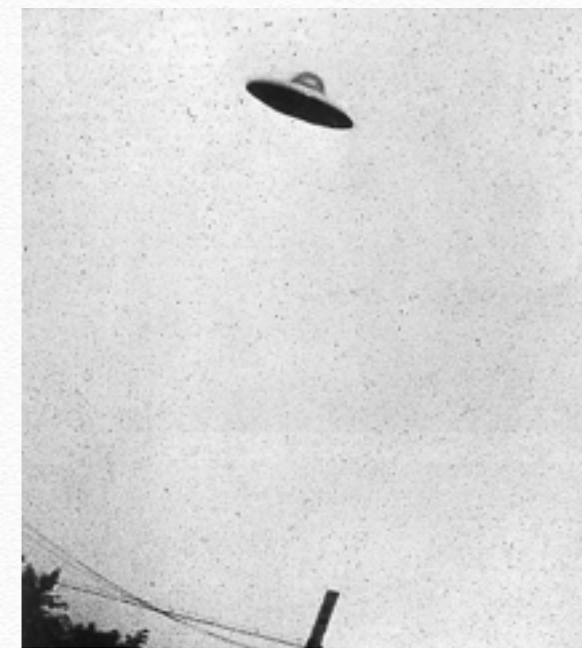
Kersevan LP2015

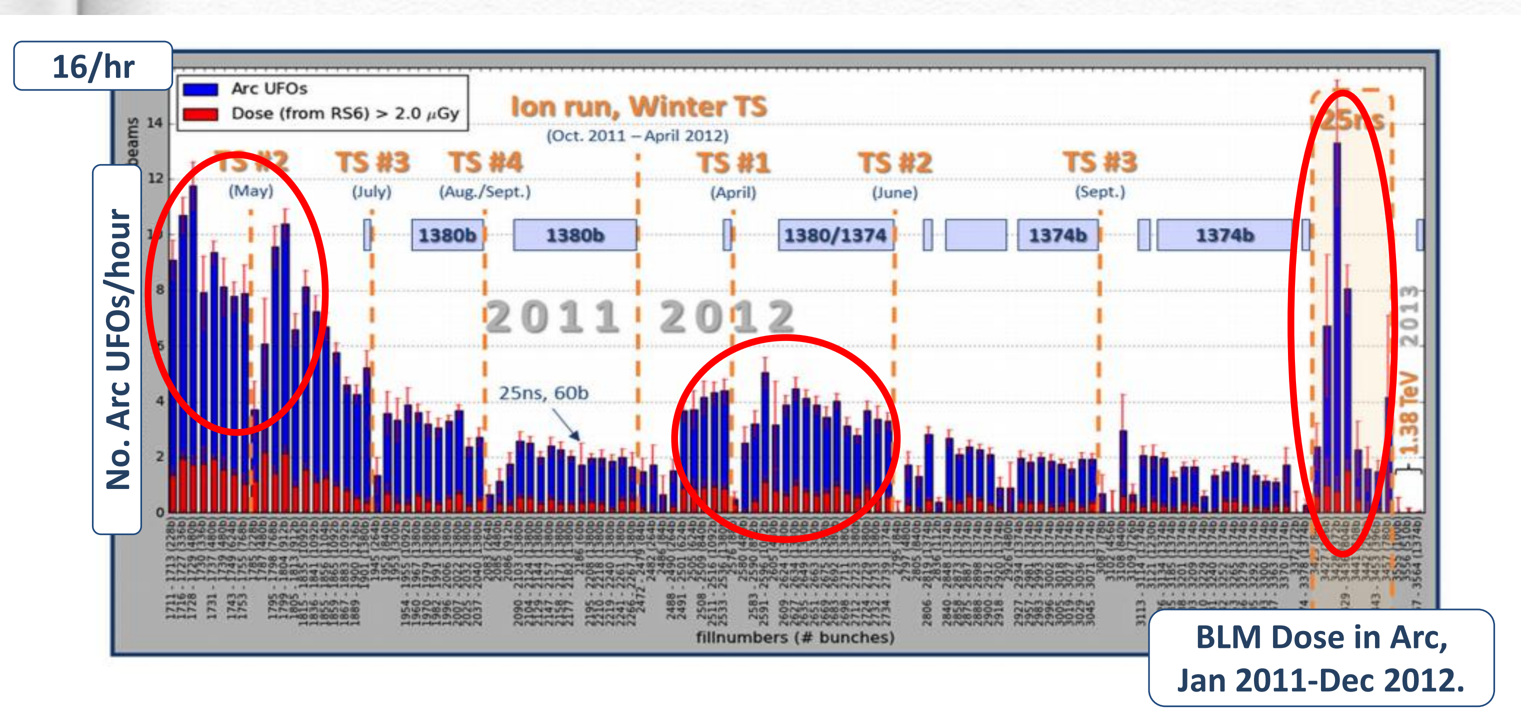
8TeV→Toward original design

- Accident on Sep 19 2008 →half recovered in 2010→ **trying to achieve the original design**
- 4TeV, 50 ns 1380 bunch → 25ns to avoid pile up(experimental request) 2500~2800 bunchs/ring 1.15 10^11 p per bunch
- Higher energy→strong B
- It is not trivial: **Electronic cloud:** more radiation-> more electrons-> more electron acceleration-> more secondary electrons -> heat to cryogenic system-> (><)
  - beam scrubbing (long beam operation to reduce electron clouds) Many ideas are tried

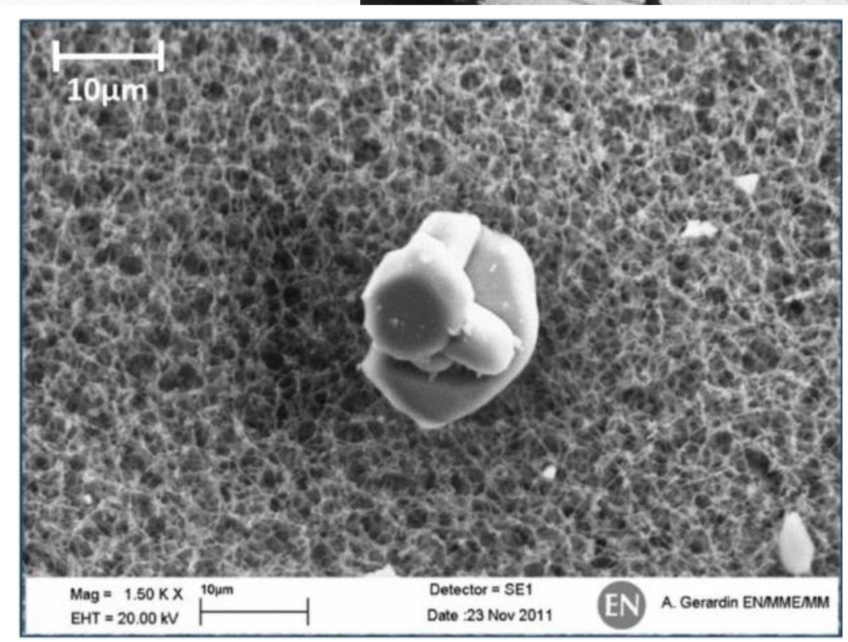
Some issues of machine and experiments

- **Unidentified Falling Objects** (UFO)
    - microparticle falling to the beam, ionized -> beam dump and quench
- … ULO, Earth faults …
- Experimental side: CMS magnet system **(I think having two sound experiments are important)**



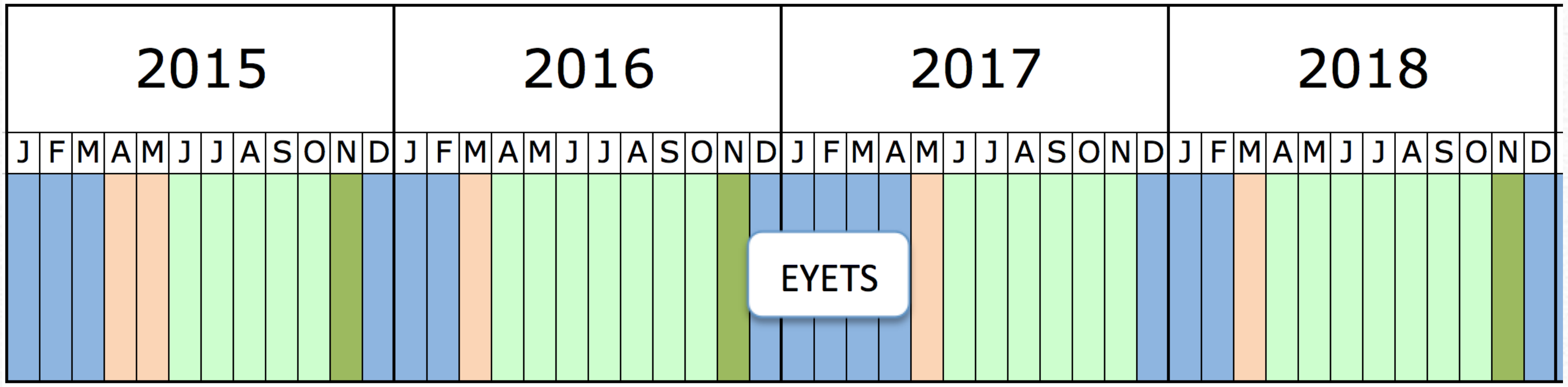


BLM Dose in Arc, Jan 2011-Dec 2012.



T. Baer CERN-THESIS-2013-233

Run 2



Shutdown/Technical stop
Protons physics
Commissioning
Ions

Longer break in 2017

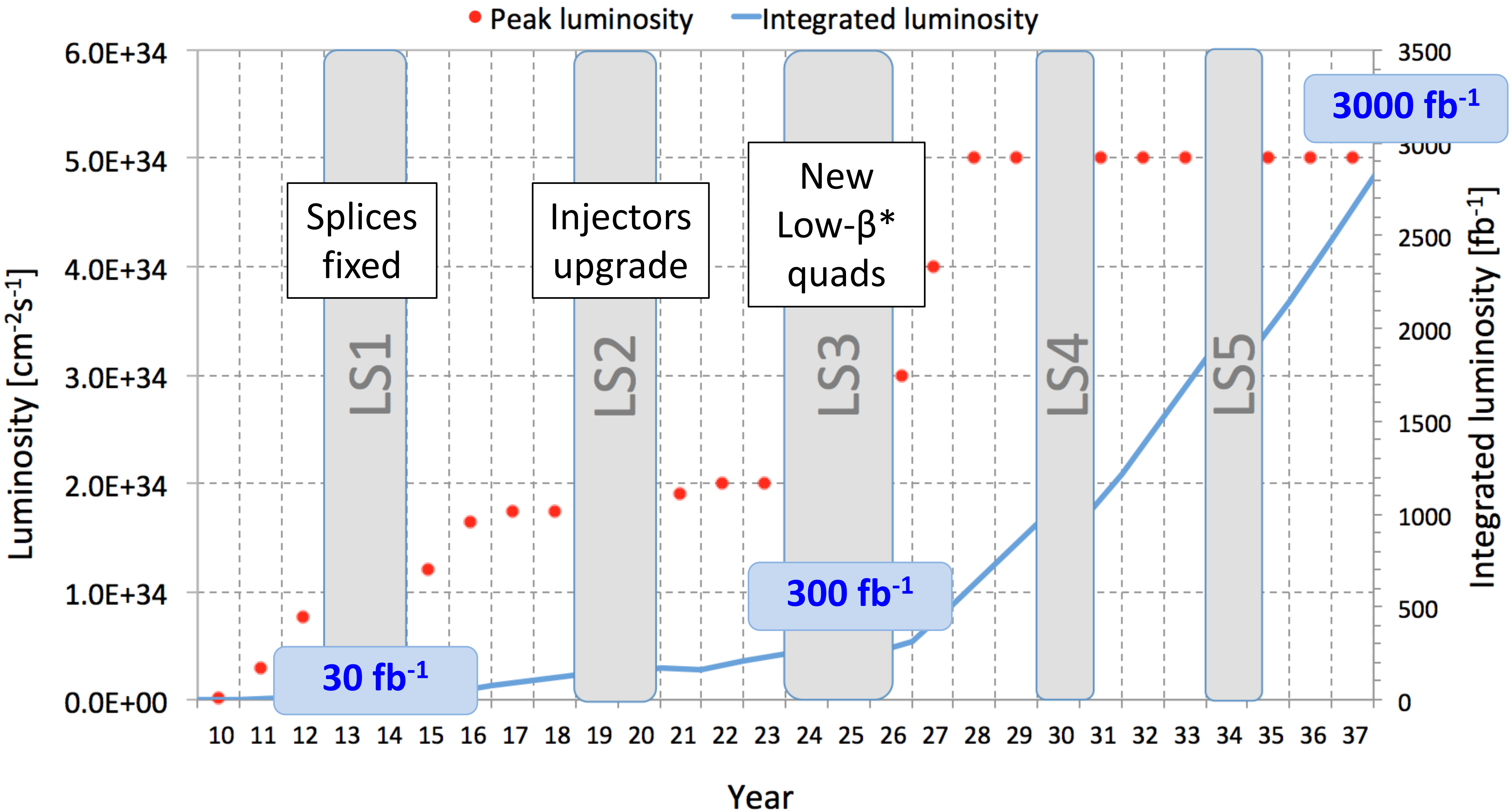
- EYETS – Extended Year End Technical Stop – 19 weeks – CMS pixel upgrade
- Start LS2 at the end of 2018

Very intersting results already and will be reviewed tomorrow

	Peak lumi E34 $cm^{-2}s^{-1}$	Days proton physics	Approx. int lumi [fb^{-1}]
2015	~0.5	65	3
2016	1.2	160	30
2017	1.5	160	36
2018	1.5	160	36

2015 Lum is not as large as we hoped

And beyond



LHC is highest-E, highest-L operational collider → full exploitation ($\sqrt{s}$ ~ 14 TeV, 3000 fb^{-1}) is mandatory:

Overview

- New stage (factor 2 energy and factor 5 luminosity) is ahead.
- Meantime, Theory have gone from **fundamental theory to effective theory.**
- 3000fb-1 ahead? and 100TeV or ILC? **Particle physics need to answer big question to justify its costs.**