New Results from CMS

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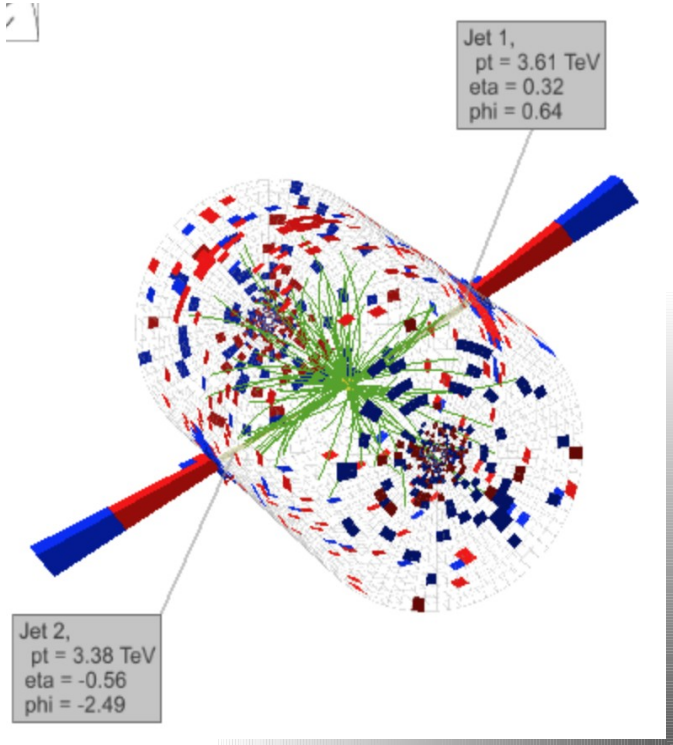
CERN

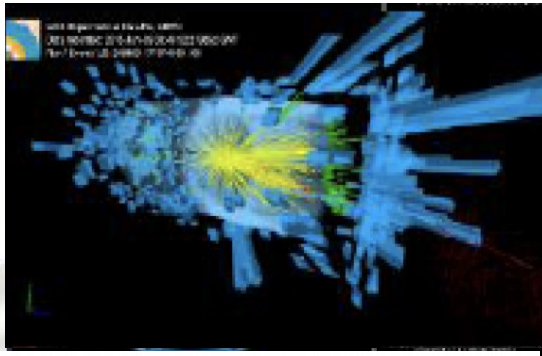


- Introduction
- Physics results
  - The Standard Model
  - The Higgs particle
  - Searches for New Physics
  - Searches for Exotic Particles in the Detector
- Summary/Outlook

Bird-eyes view on new results

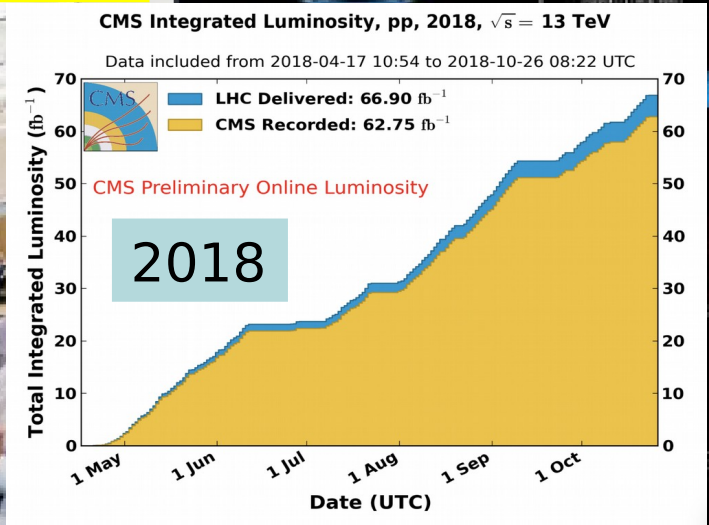
LHC experiments are back in business at a new record energy 13 TeV

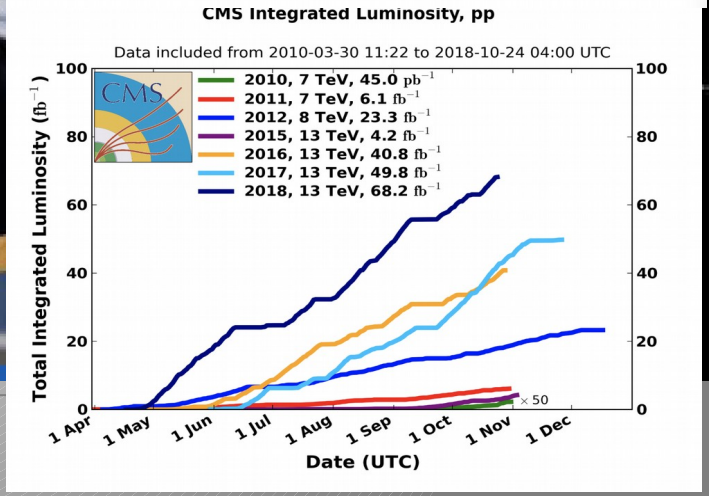
3rd June 2015 Run-2 starts



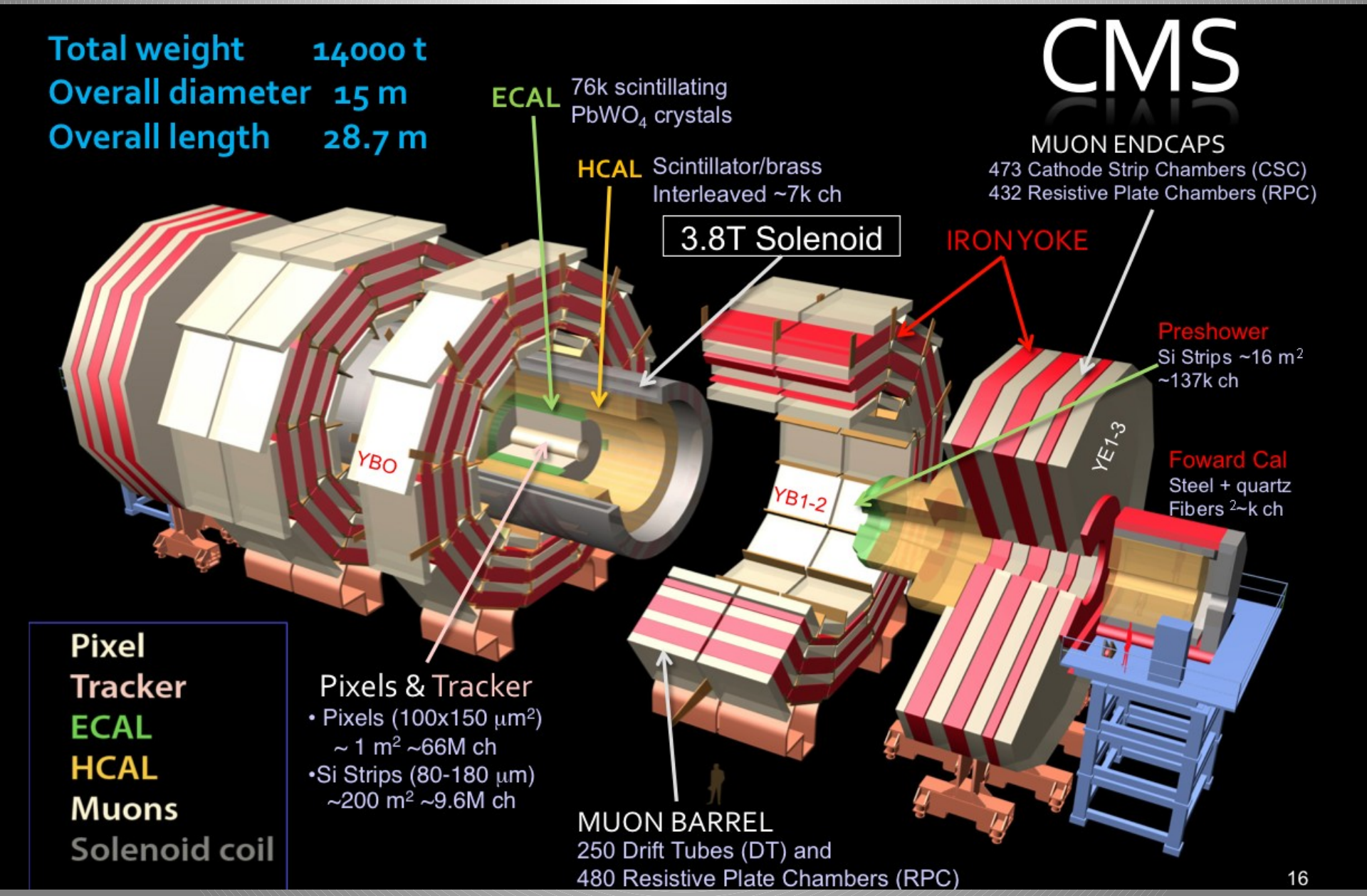
proton-proton Run-2 finished 24/10/18 6:00am

- 2010-2012: Run-1 at 7/8 TeV CM energy
  - Collected ~ 27 fb^{-1}
- 2015-2018: Run-2 at 13 TeV CM Energy
  - Collected ~ 140 fb^{-1}





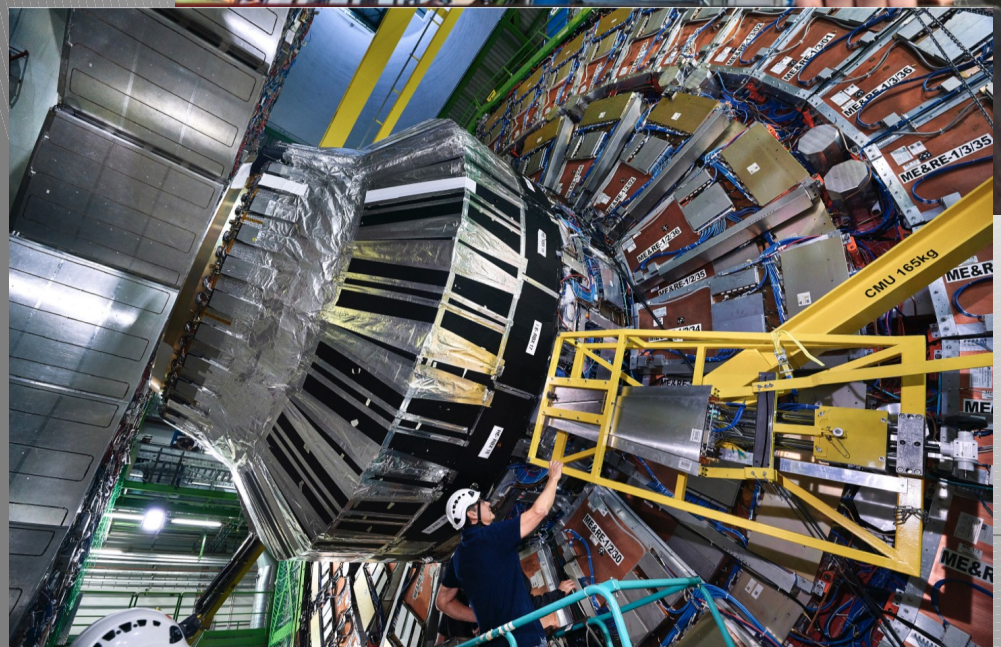
The CMS Detector



NOW:
Long Shutdown 2
till start of 2021

Scenic pictures from the present shut-down and opening of the experiment

CERN open door days
14-15 September



Next Spring: 10 years of LHC Operation

- LHC switched on at 7 TeV in March 2010

  ->The highest energy in the lab!
- LHC @ 13 TeV from 2015 onwards
- Most important highlight so far:

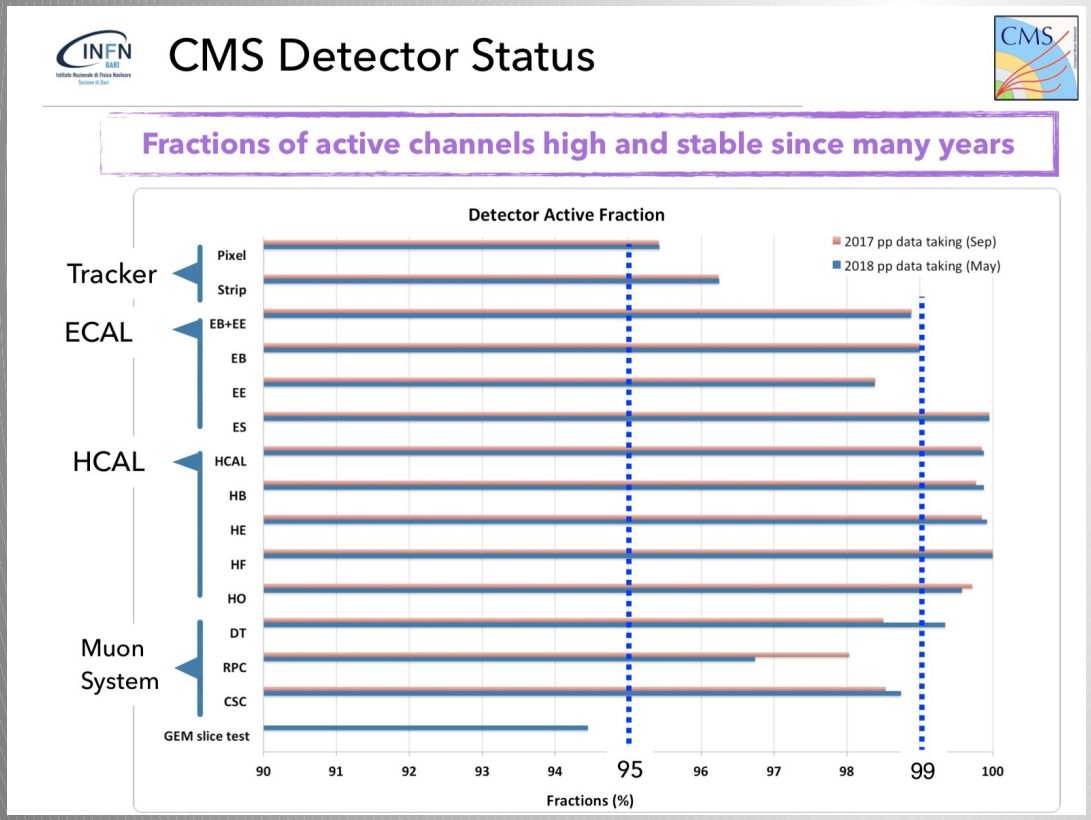
  The discovery of a Higgs boson
- Many results on Standard Model process measurements, top-physics, b-physics, heavy ion physics, searches, Higgs physics
- Waiting for the next discovery…

  -> Searching beyond the Standard Model

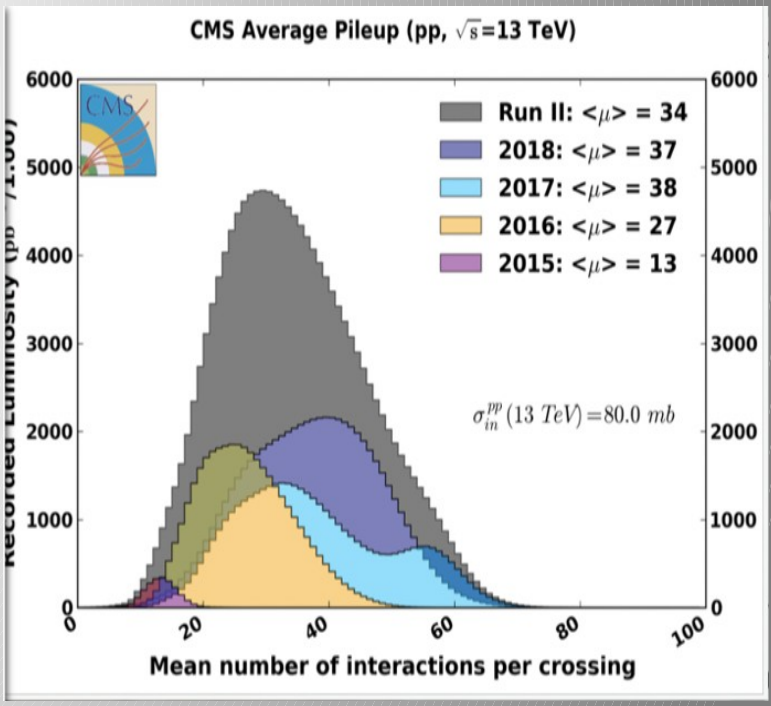
March 30 2010 …waiting..
…since 4:00 am

12:58 7 TeV collisions!!!

CMS Detector Status



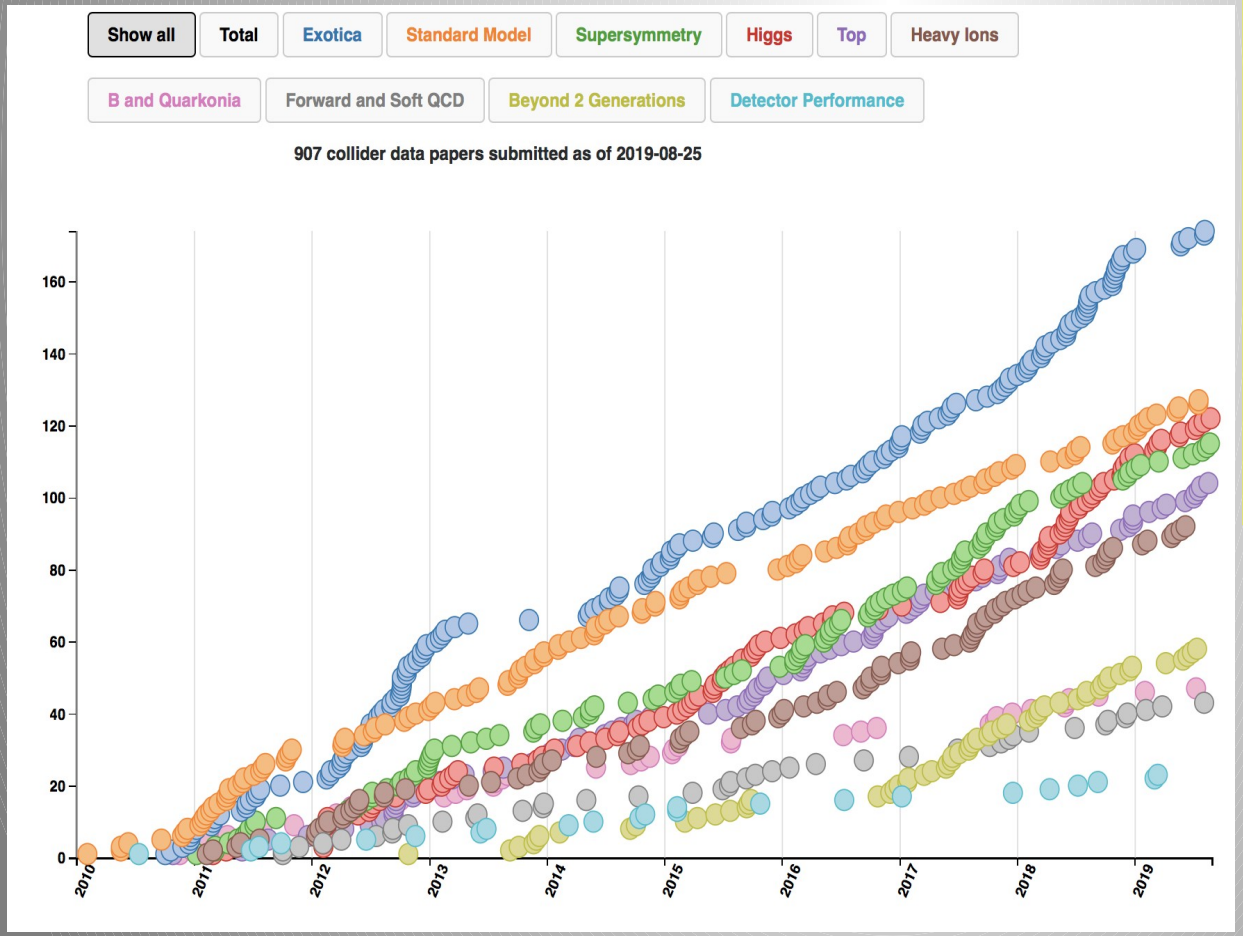
Pile-up during run-2



Run 2 pp data taking efficiency 92.3%
with 2018 data taking efficiency 94%

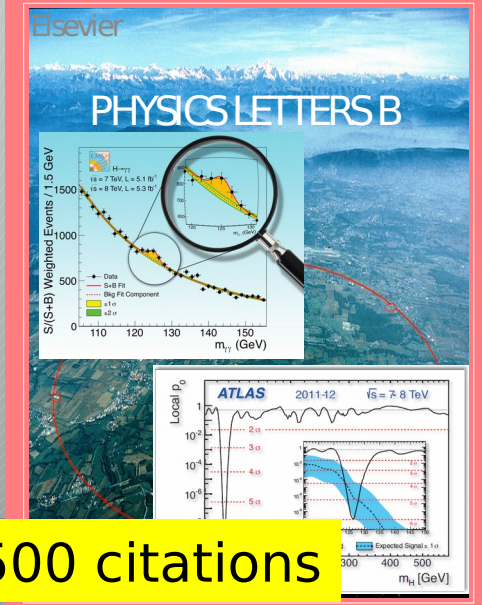
CMS experiment is in a very good shape
We can successfully deal with pile-up ~ 40 events per bx

LHC Publications in CMS



~ 900 publications on pp (and pPb/PbPb) physics since 1/2010

About 100 papers on Higgs studies!!
Paper 16 was the discovery paper!



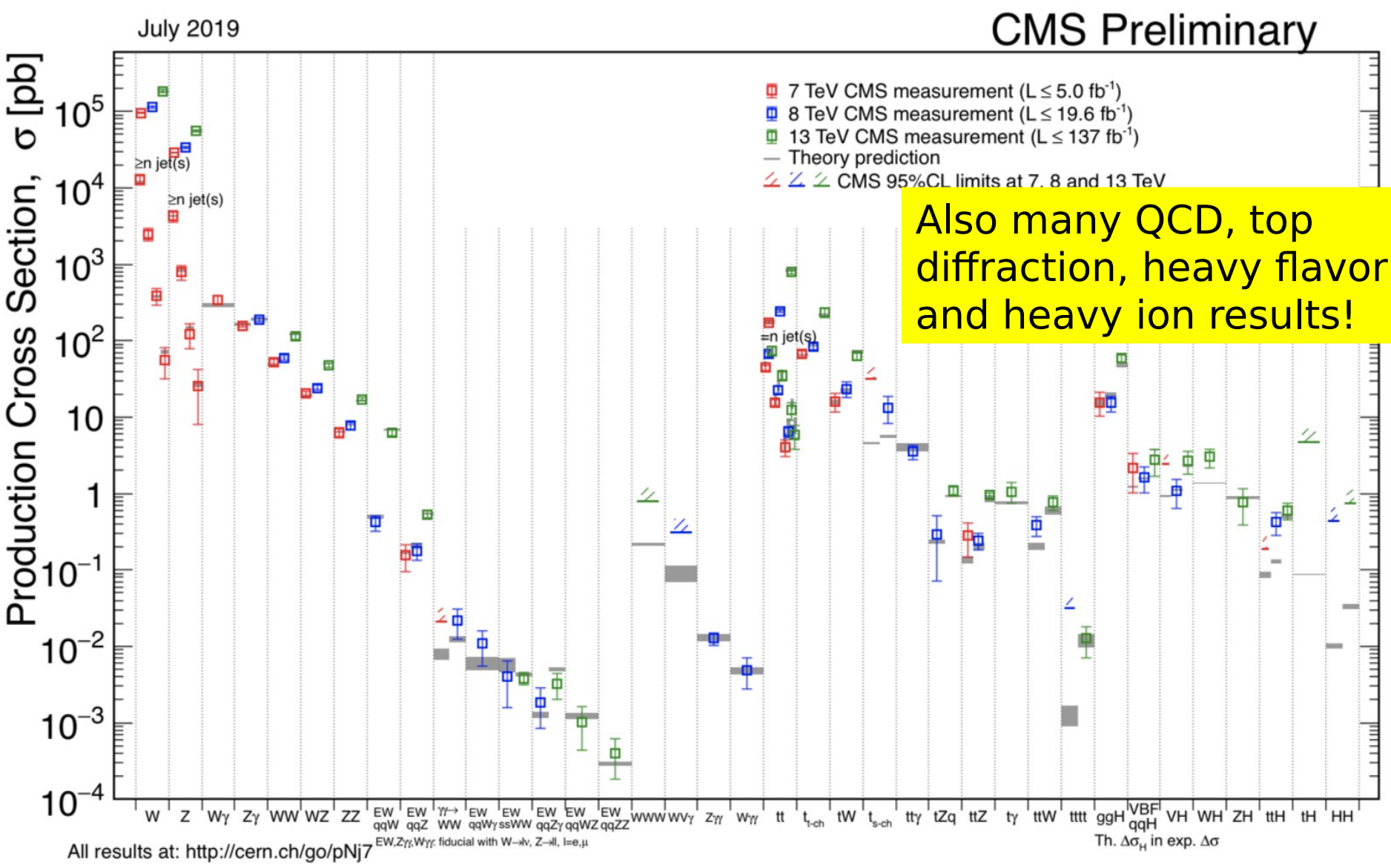
http://cms-results.web.cern.ch/cms-results/public-results/publications-vs-time/

About 120 more since September last year

~9500 citations

Standard Model Measurement

Standard Model Measurements

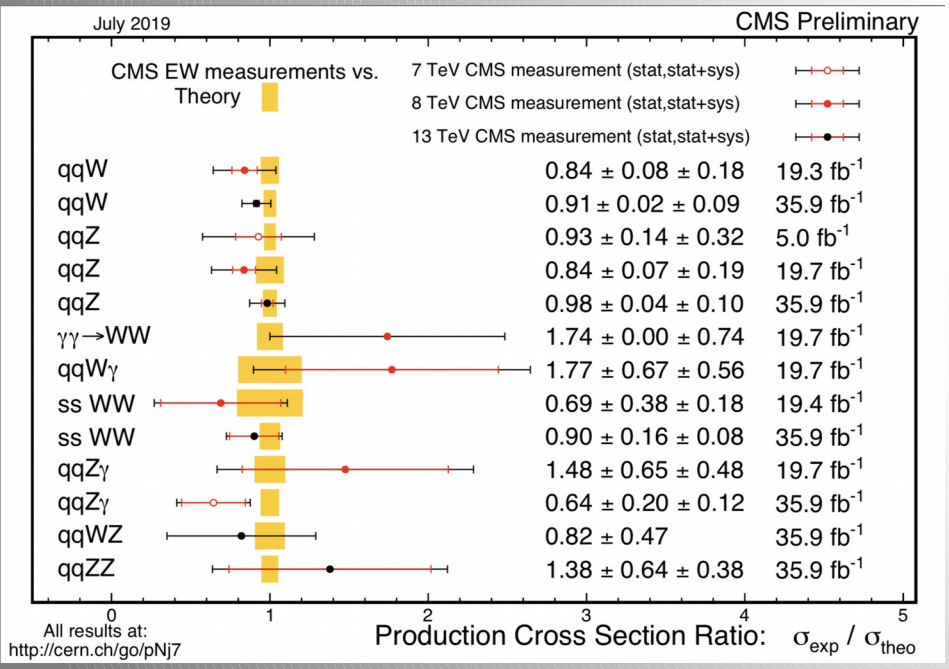


Also many QCD, top diffraction, heavy flavor and heavy ion results!

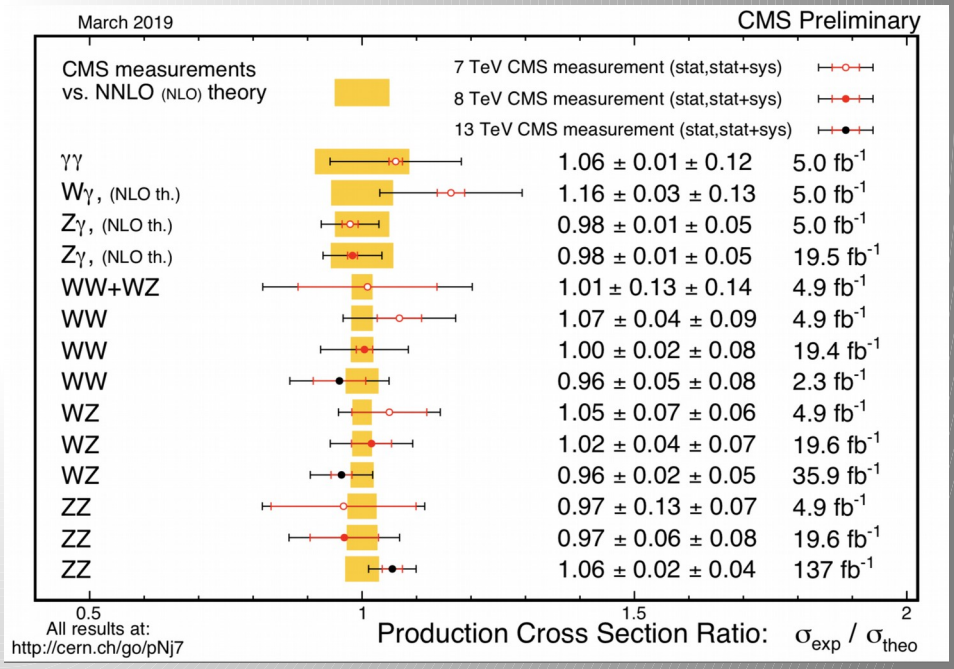
l measurements in good agreement with the Standard Model predictions

Standard Model Measurements

EWK Measurements

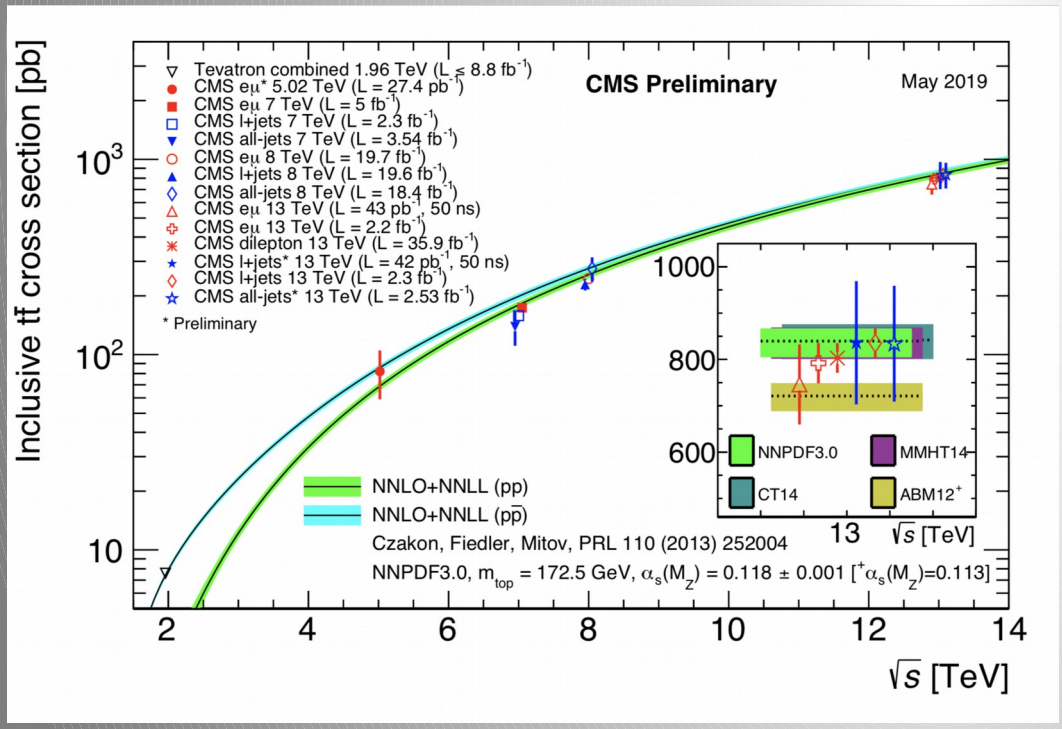


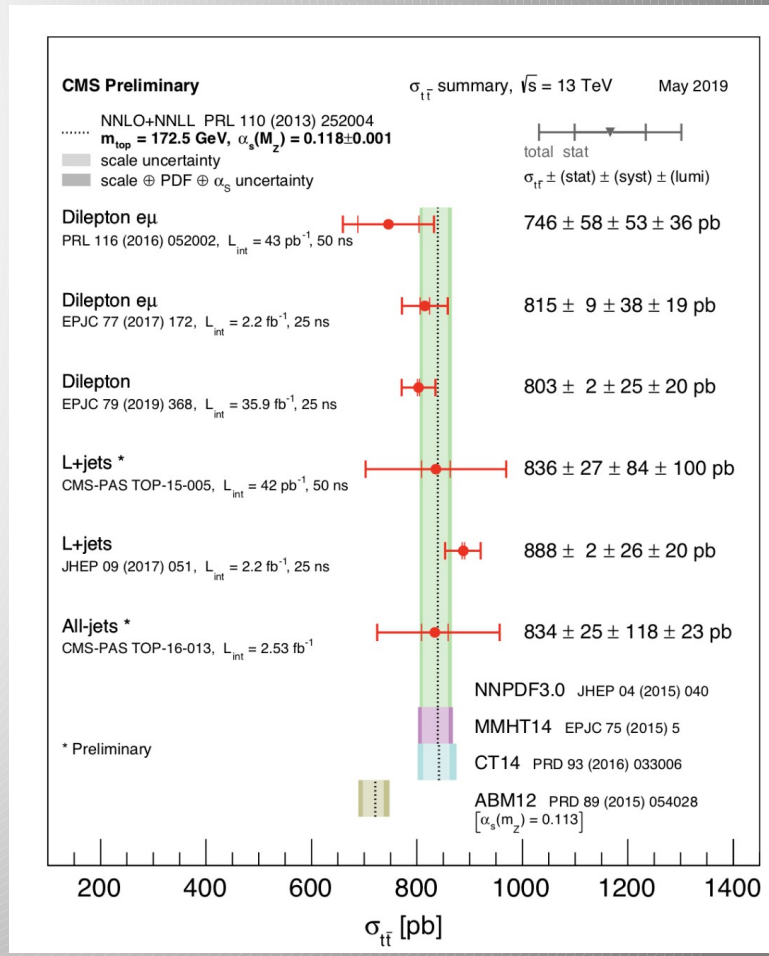
Measurements vs NNLO Theory



measurements in good agreement with the Standard Model predictions

Top Cross Sections

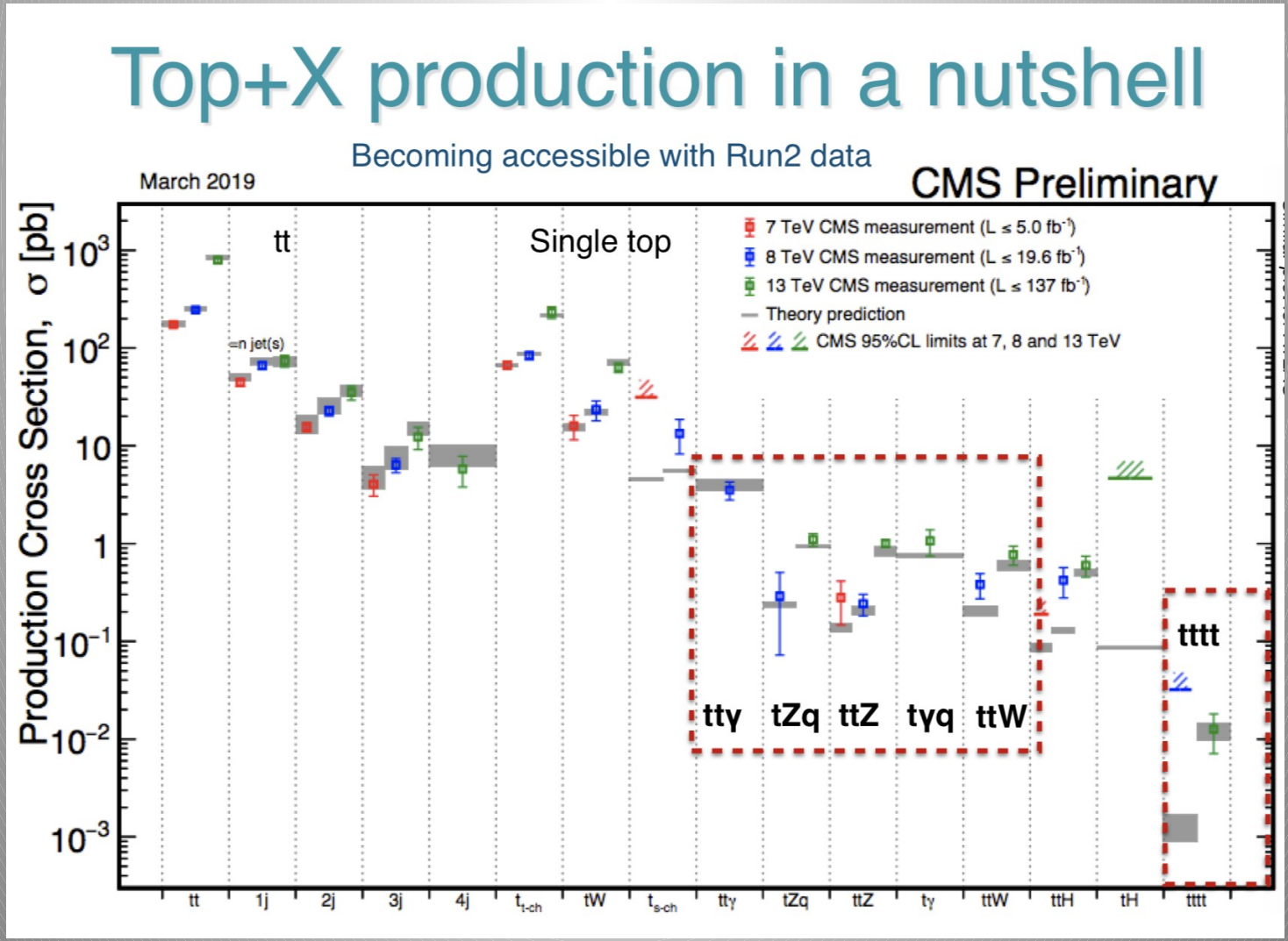




Many detailed top studies ongoing

Measurements in good agreement with the Standard Model predictions!

Top Poduction



Access to measurements of rare processes

Running of the Top Mass

TOP-19-007

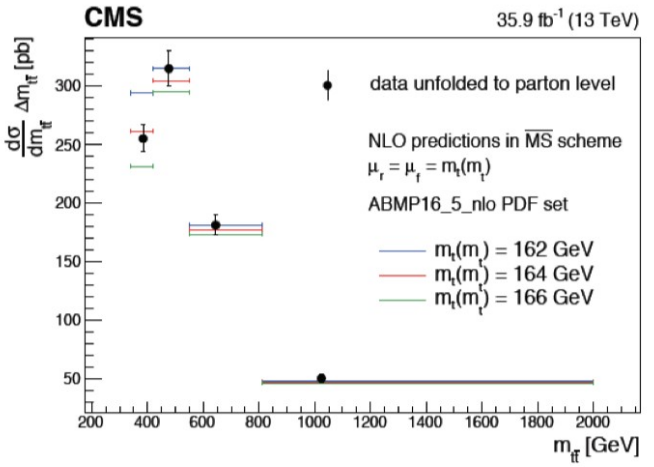
preliminary

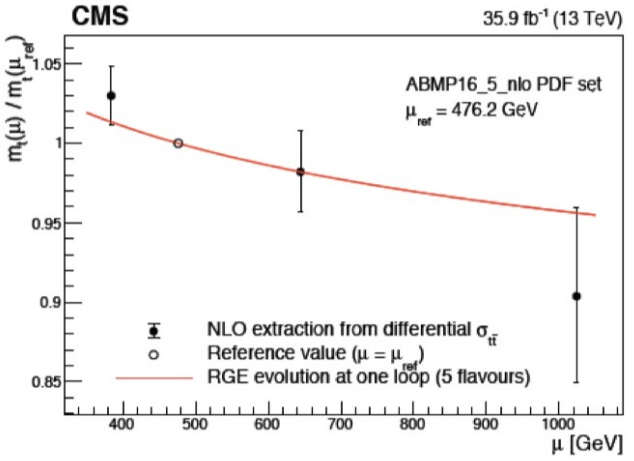
- The running mass m_t of the top quark mass is extracted from the differential $t\bar{t}$ cross section as a function of the invariant mass of the $t\bar{t}$ system
  - in the modified minimal subtraction ($\overline{\text{MS}}$) renormalization scheme

$$\mu^2 \frac{\mathrm{d}m(\mu)}{\mathrm{d}\mu^2} = -\gamma(\alpha_S(\mu))\, m(\mu)$$

- $t\bar{t}$ candidate events with the $e^{\pm}\mu^{\mp}$ final state
- The differential cross section is measured using a maximum likelihood fit
- χ^2 fit to next-to-leading-order differential theory predictions
- The observed running is compatible with scale dependence predicted by the renormalization group equation.
  - Agreement with RGE prediction at one-loop precision: 1.3 s.d.
  - 2.6 s.d. from a no-running hypothesis

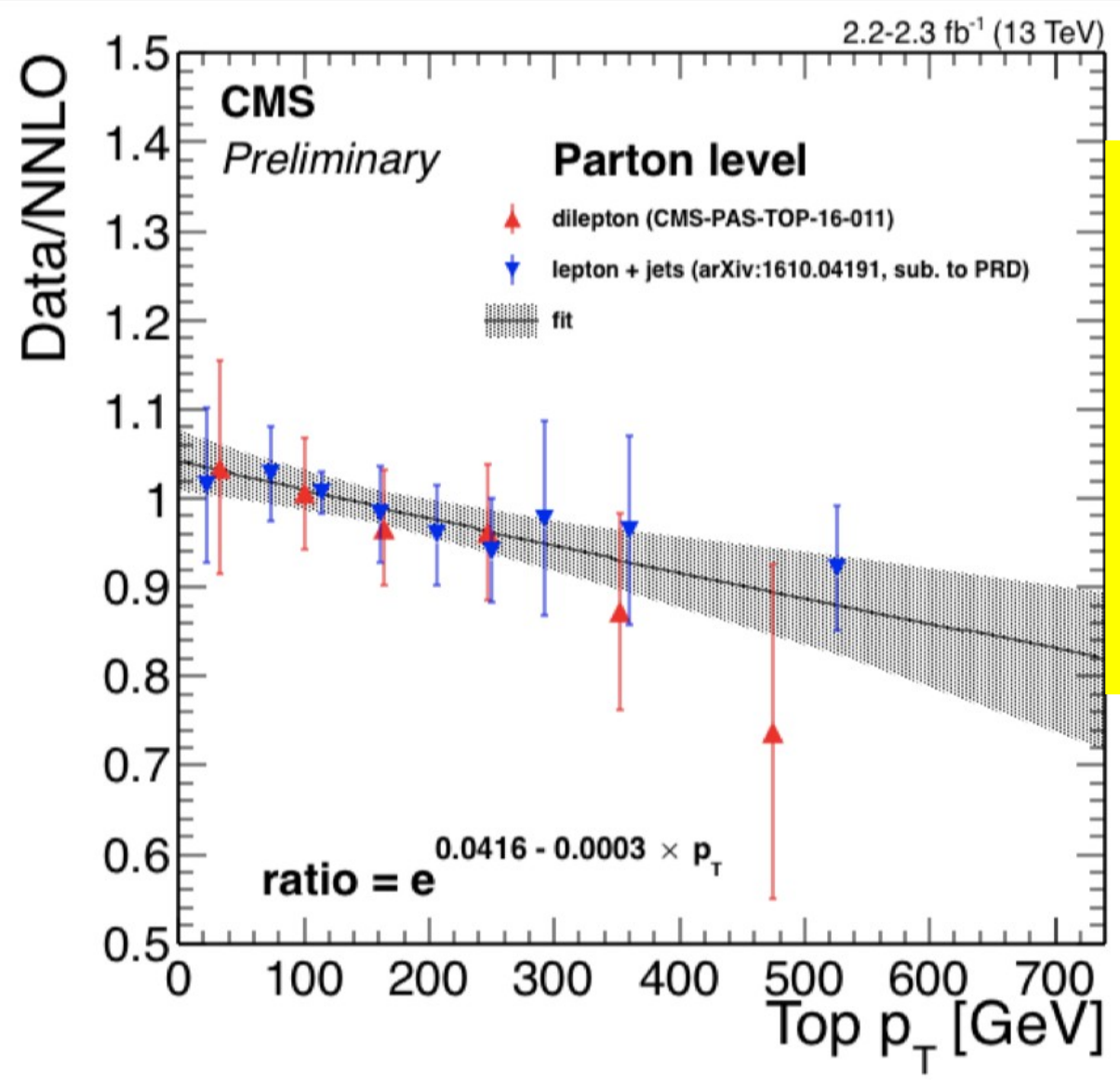
Similar method as for running mass of charm





indication of the running of the top mass

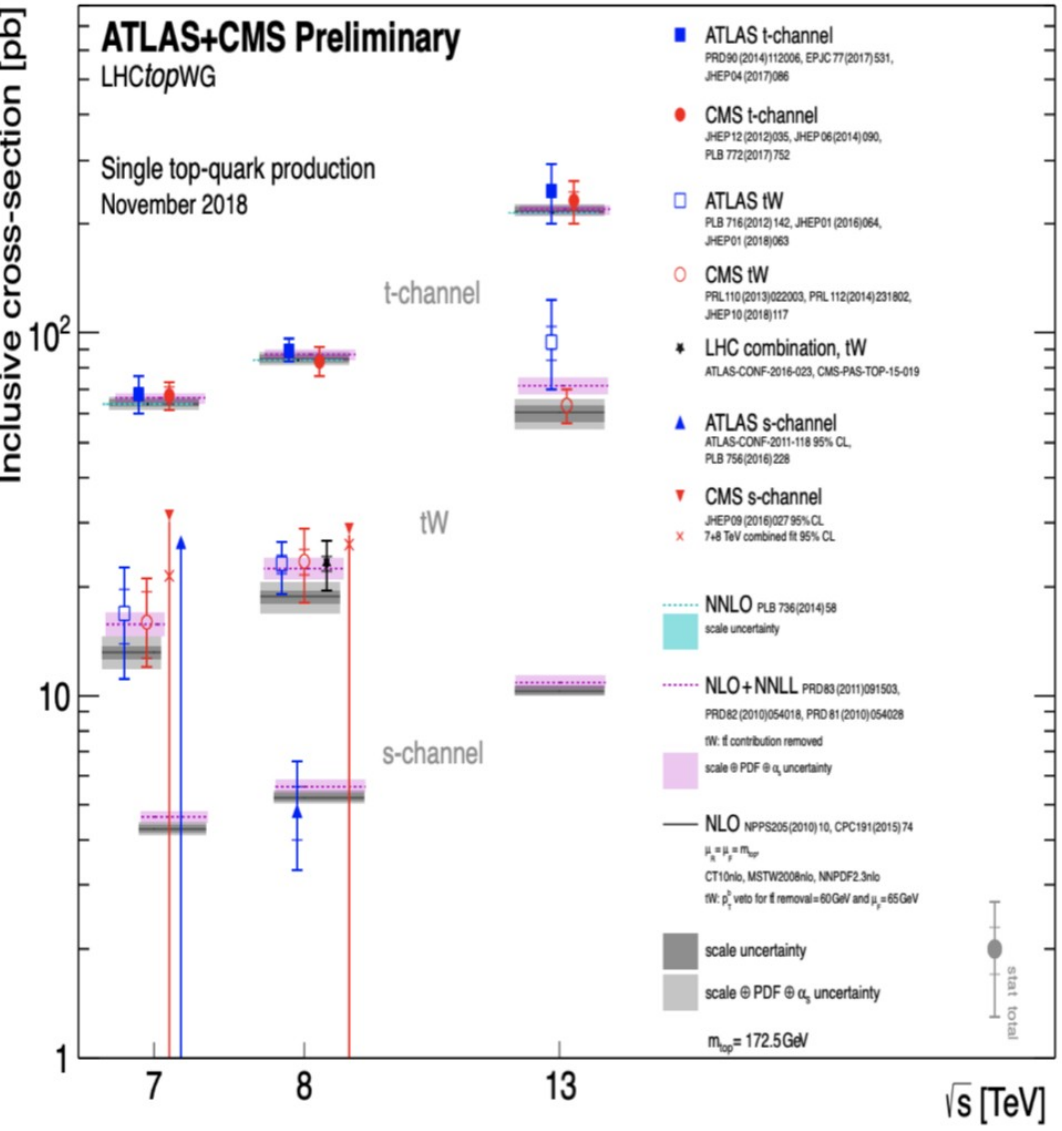
Top p_T Spectra



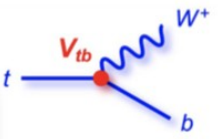
A long standing discrepancy between Data and MC:
-> Data is softer than the predictions

Even NNLO seems not entirely able to fix this

Single Top Production



- **Run1** legacy ATLAS+CMS cross sections and V_{tb} combinations **JHEP 05 (2019) 088**
  - Probing the Wtb vertex: best direct V_{tb} determination to date!

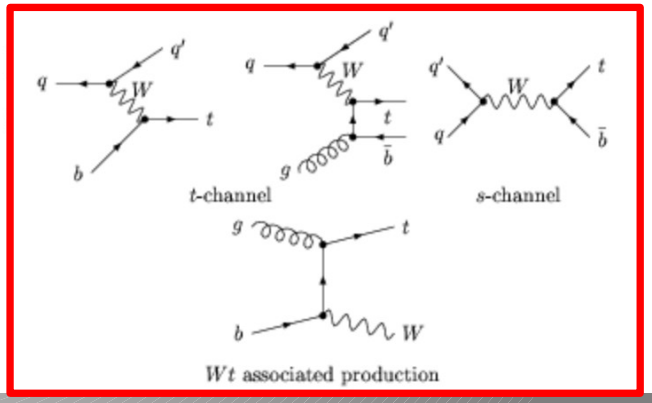


$$|f_{\mathrm{LV}} V_{tb}| = \sqrt{\frac{\sigma_{\mathrm{meas.}}}{\sigma_{\mathrm{theo.}}\ (V_{tb}=1)}}$$

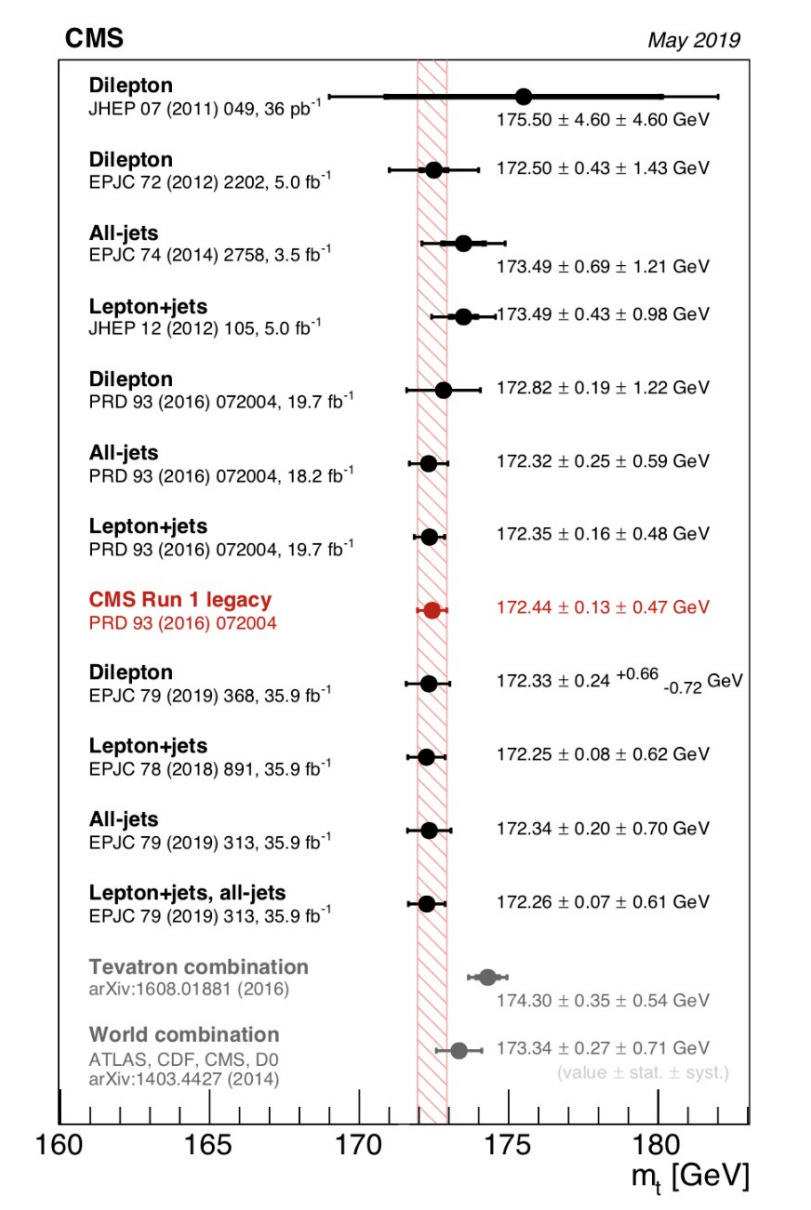
(assume $|V_{ts}|$, $|V_{td}| << |V_{tb}|$) In SM: $f_{LV} = 1$

$$|f_{\mathrm{LV}} V_{tb}| = 1.02 \pm 0.04\ (\mathrm{meas.}) \pm 0.02\ (\mathrm{theo.})$$

(3.7%)



Top Mass Determination



Steady improvements over the last years in Run-1

Precision now better than 0.3%

Hadronization model uncertainties one of the main limitations

Several alternative methods have been and are being explored using J/ψ, secondary vertices,...
This is not the final word yet

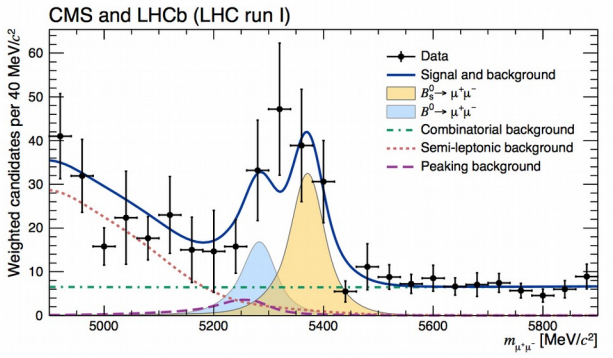
Experiment combination under wa

Note: the average value at LHC somewhat lower than Tevatron one: 174.30 ± 0.64 GeV

Measurements of $B_{s(d)} \to \mu\mu$

arXiv:1411.4413
Published in Nature

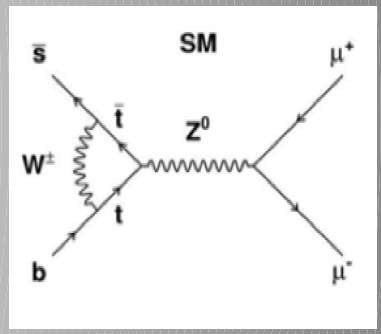
Three B_s particles in a billion will decay into two muons. This decay has been chased for 30 years!!



- Results:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (2.8^{+0.7}_{-0.6}) \times 10^{-9}$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) = (3.9^{+1.6}_{-1.4}) \times 10^{-10}$$

- Observed (Expected) significance
  - B_s: 6.2σ (7.4σ)
  - B^0: 3.2σ [WT], 3.0 [FC]σ (0.8σ)



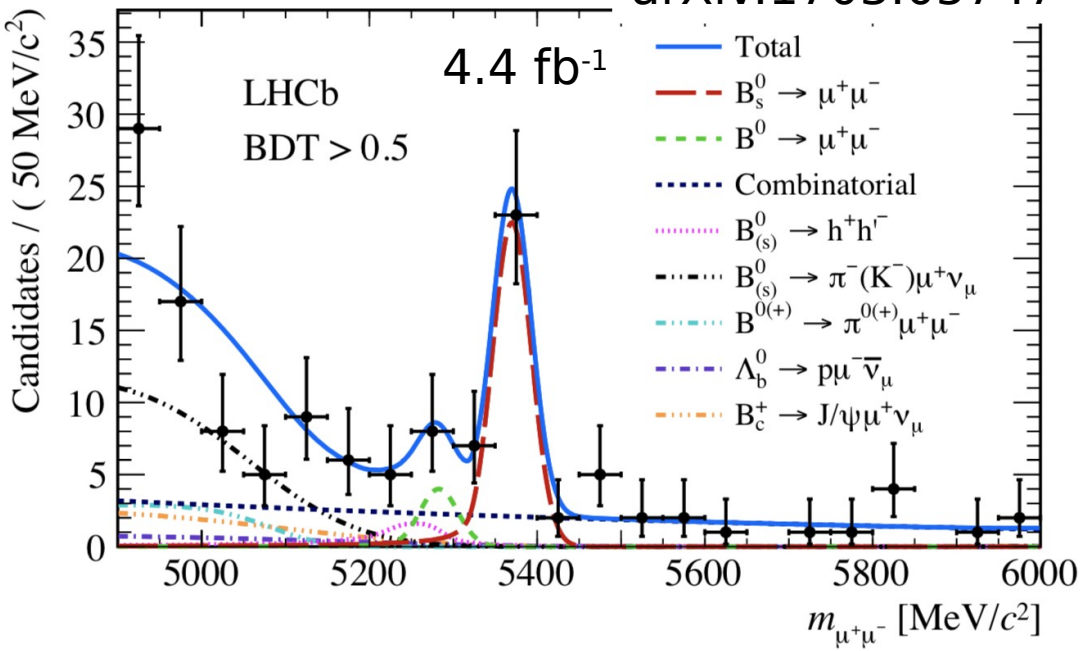
Present most precise results
Significance for B_s to muon decay is 7.8σ

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (3.0 \pm 0.6^{+0.3}_{-0.2}) \times 10^{-9}$$

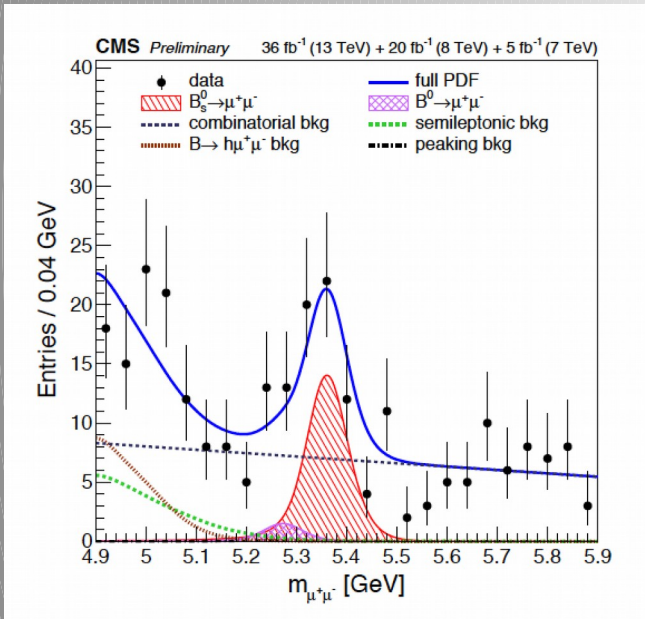
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-)_{\rm SM} = (3.66 \pm 0.23) \times 10^{-9}$$

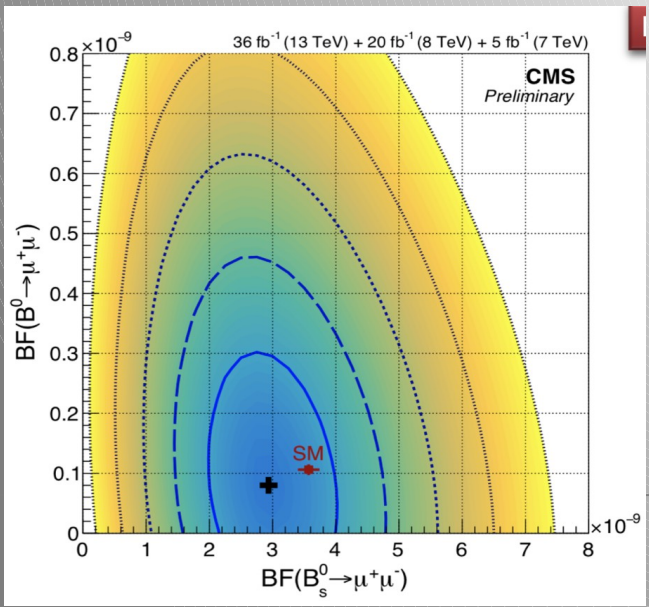
$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 3.4 \times 10^{-10} \text{ at } 95\%$$

arXiv:1703.05747



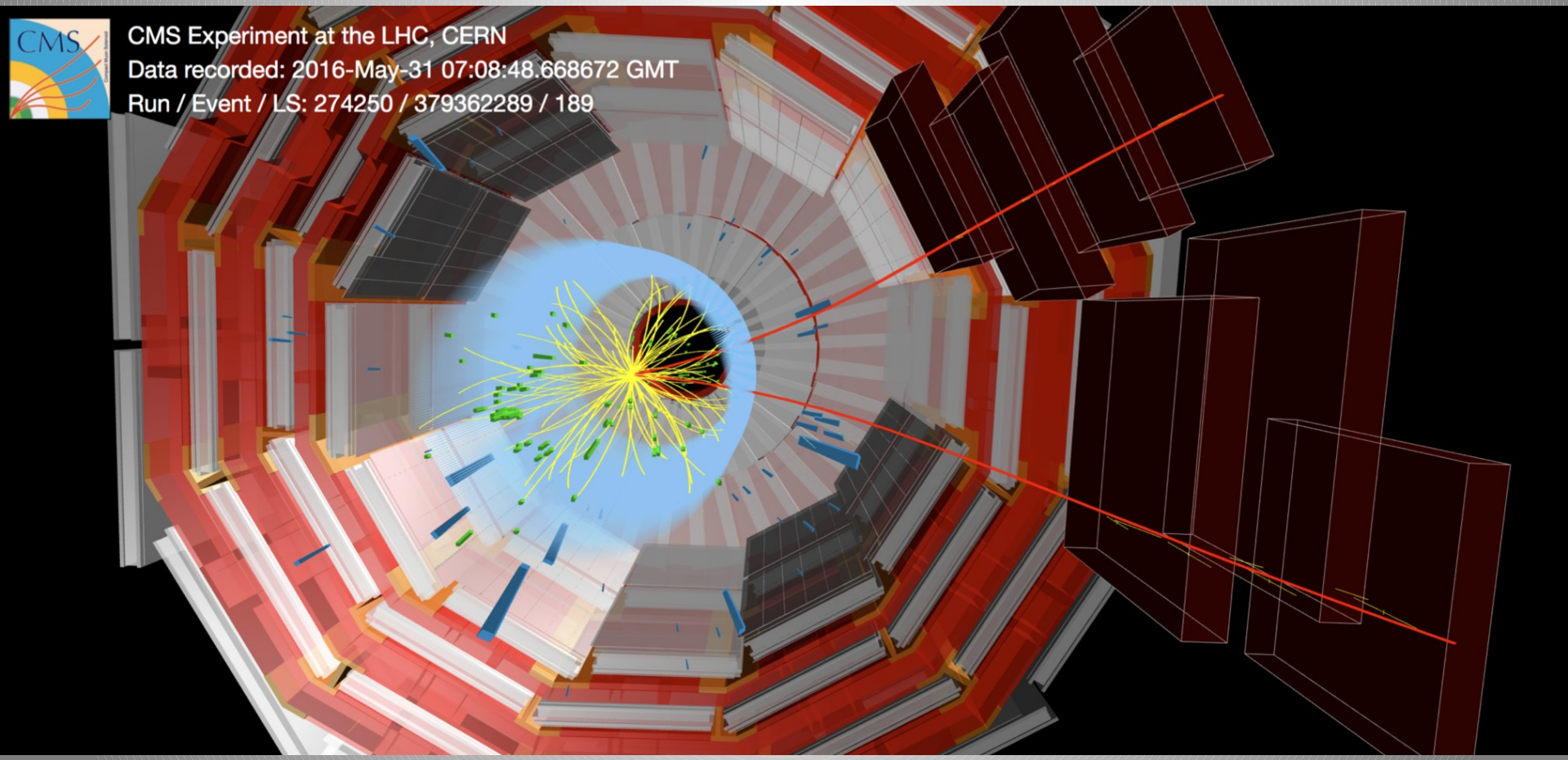
Measurements of $B_{s(d)}^{0} \to \mu\mu$





- The decay $B_s^0 \to \mu^+\mu^-$ is observed with a branching fraction of
  - $\mathcal{B}(B_s^0 \to \mu^+\mu^-) = [2.9^{+0.7}_{-0.6}\,(\text{exp}) \pm 0.2(f_s/f_u)] \times 10^{-9}$
    - Significance $B_s^0 \to \mu^+\mu^-$: 5.6 (6.5) s.d. obs (exp)
  - No significant excess is observed for the decay $B^0 \to \mu^+\mu^-$,
    - Upper limit $\mathcal{B}(B^0 \to \mu^+\mu^-) < 3.6 \times 10^{-10}$ at 95% confidence level
    - Previous CMS result: $\mathcal{B}(B^0 \to \mu^+\mu^-) < 1.1 \times 10^{-9}$ Phys. Rev. Lett. **111**, 101804
  - These results are consistent with standard model predictions

Measurements of $B_{s(d)} \to \mu\mu$

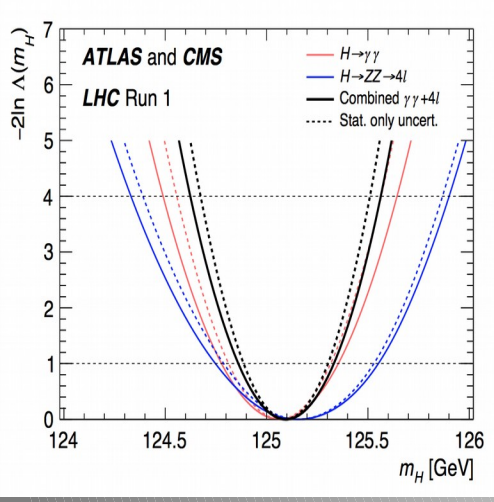


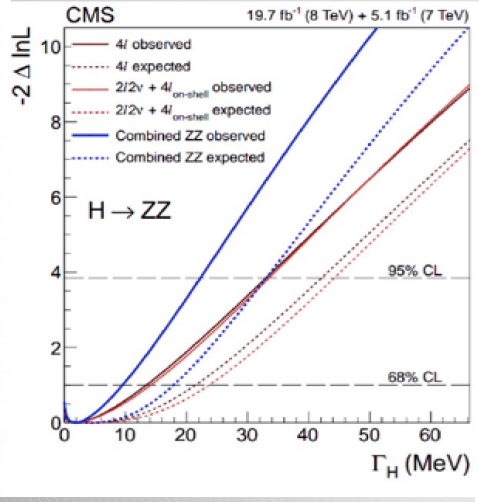
$B_s \to \mu\mu$ candidate

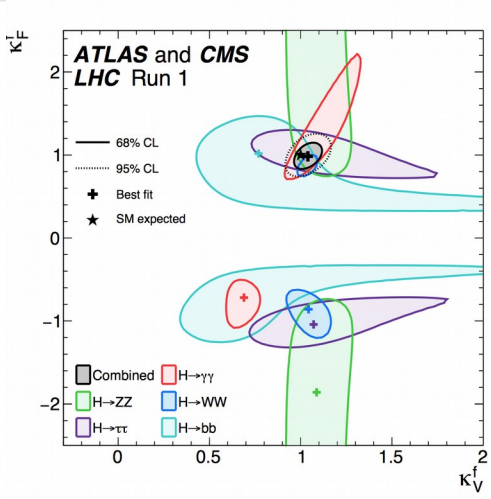
The Higgs

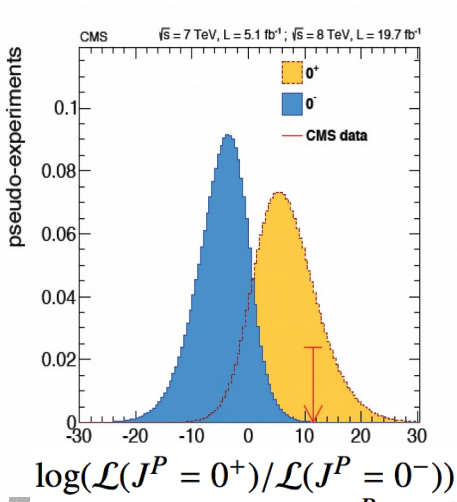
Brief Higgs Summary: Run-1

We know already a lot on this brand New Higgs particle









Mass = CMS+ATLAS 125.09 ±0.21(stat) ±0.11(syst) GeV

Width < 24 MeV (95%CL)

Couplings are within ~10-20% of the SM values

Spin = $0^{+(+)}$ preferred over 0^-,1,2

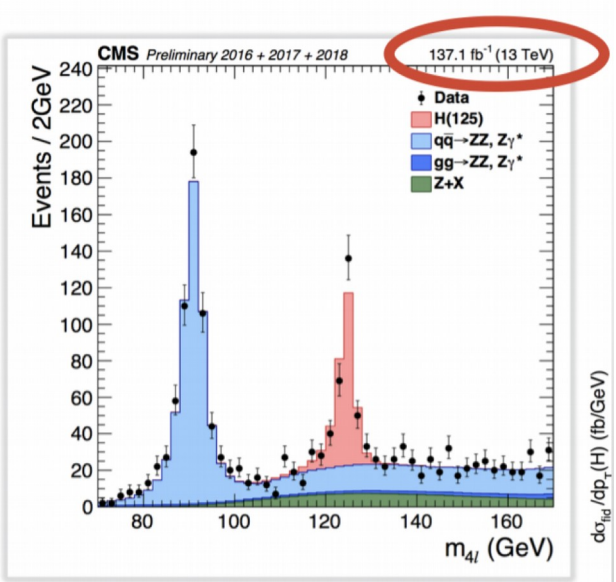
anomalies, i.e. unexpected decay modes or couplin

lti-Higgs production, heavier Higgses, charged Higgses...

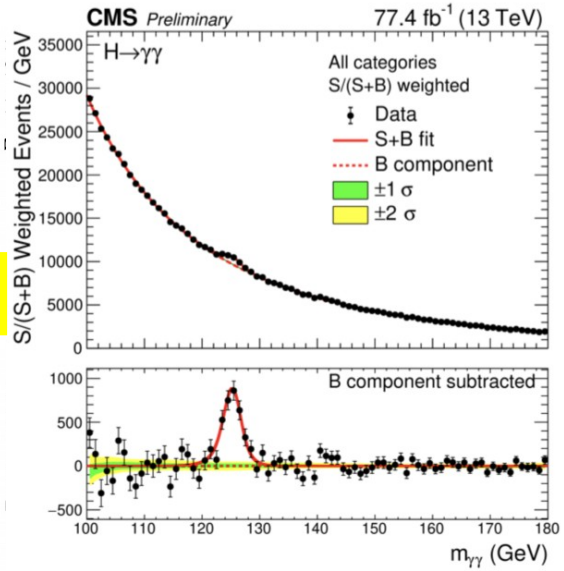
Higgs @ 13 TeV in Run-2

- Higgs particle is still there ! ᴍ

H→ ZZ



H→ γγ



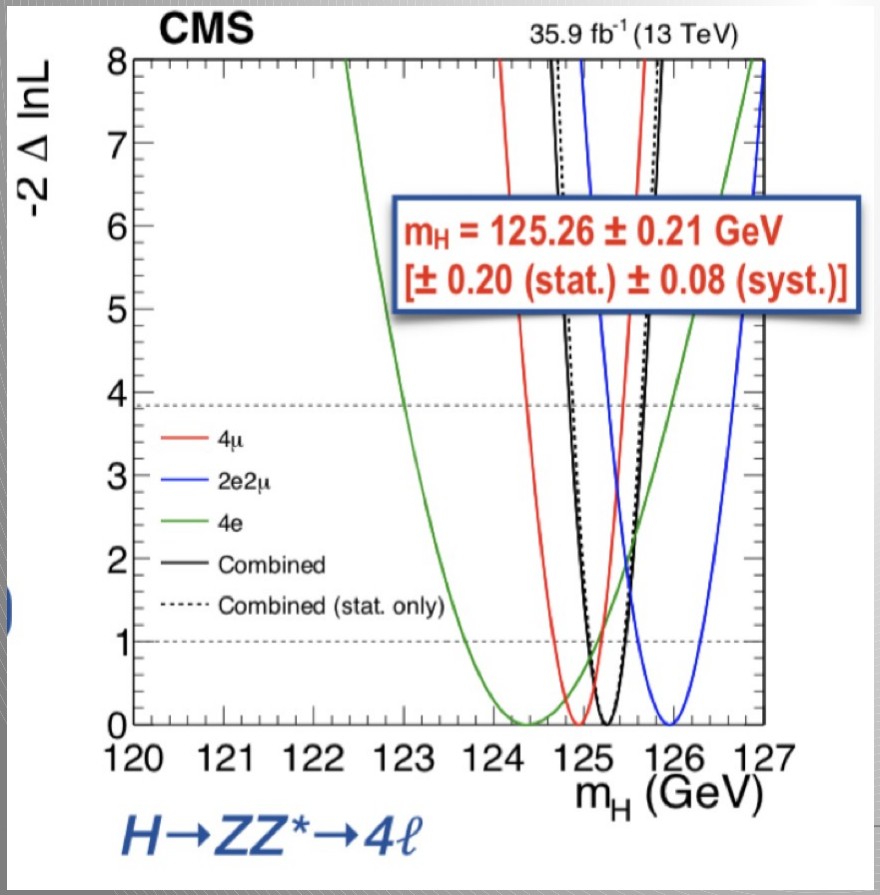
- The mild deviations seen in Run-1 seem to be gone ⊣
- Observation of H→bb in the associated production channel
- Direct observation of ttH production
- No deviations from Standard Model Higgs expectations yet!!

The Higgs Boson is still very much Standard Model-like!

$$\mu = 1.17^{+0.10}_{-0.10}$$

Higgs Mass

- High resolution channels $H \to \gamma\gamma$ and $H \to ZZ^* \to 4\ell$
  - excellent detector performance in lepton/photon energy scale determination
  - single experiments are better than ATLAS + CMS Run I combination
  - still dominated by statistical uncertainties



1706.09936

Only using the ZZ channel and ¼ of the run-2 statistics

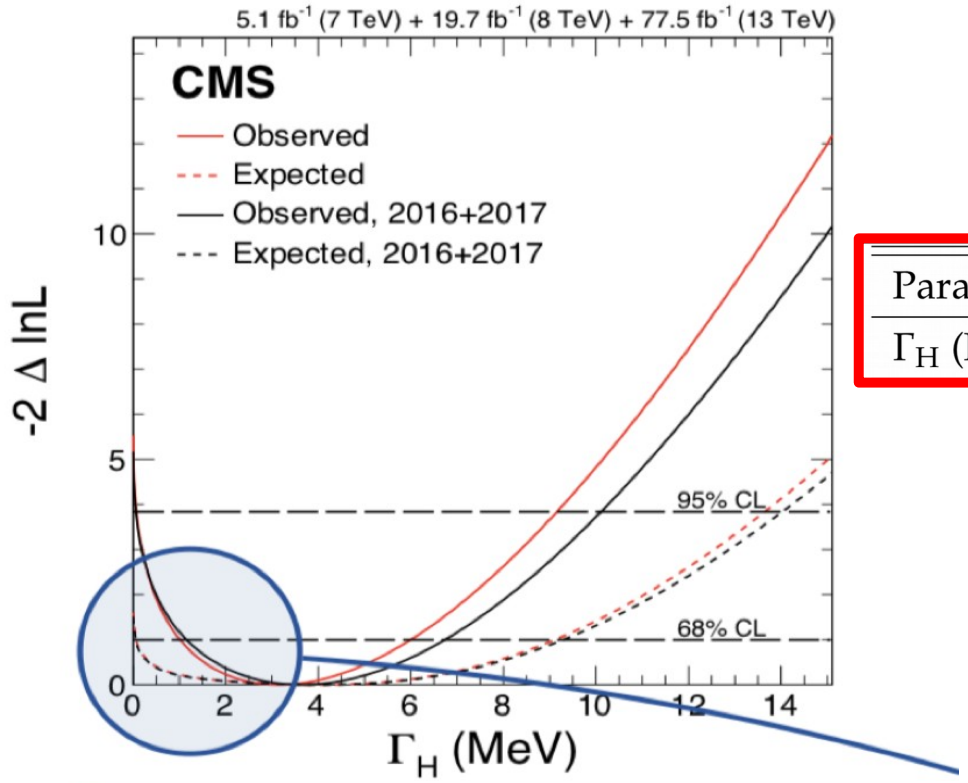
$$m_{\mathrm{H}} = 125.26 \pm 0.21\,\mathrm{GeV}$$

M_H is known to a precision of better than 2 per mille

Higgs Width

Technique: on-shell to off-shell cross section

arXiv:1901.00174



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

Parameter	Observed	Expected
Γ_H (MeV)	$3.2^{+2.8}_{-2.2}$ [0.08, 9.16]	$4.1^{+5.0}_{-4.0}$ [0.0, 13.7]

SM Higgs width =4 MeV

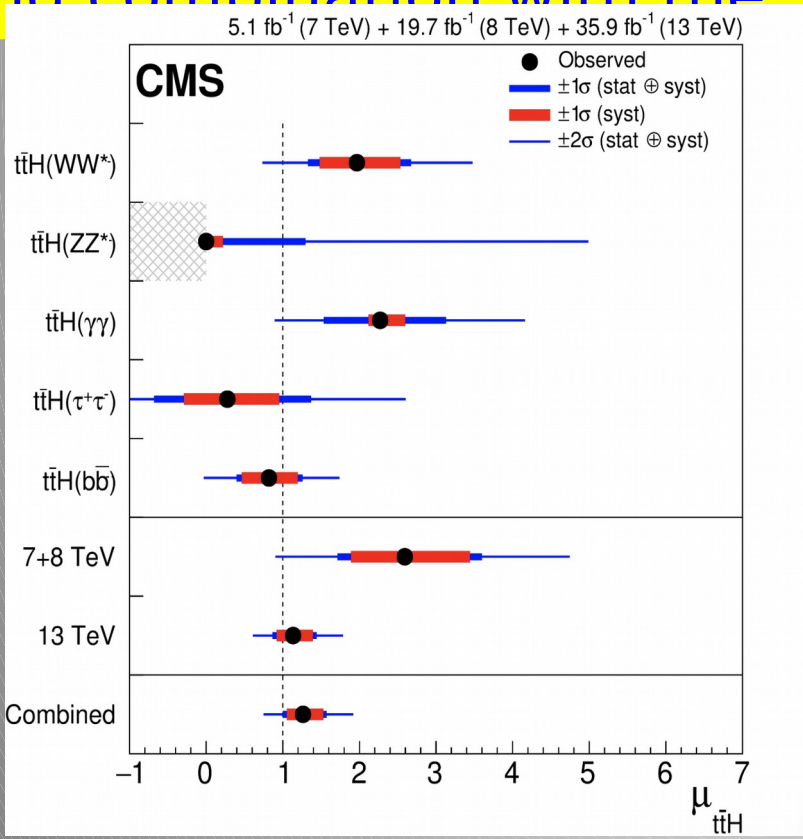
We start to get a lower bound on the Higgs width!

$\Gamma < 9.16$ MeV (13.7 exp.) @ 95% C.L.

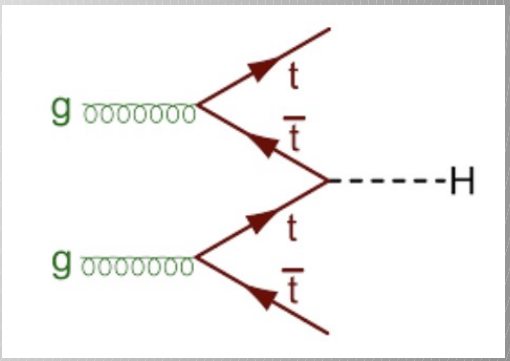
Run1 + Run2, $H \to ZZ^* \to 4\ell$

Higgs ttH Production

ttH production: Combination of all Higgs decay channels
and combination with the 7/8 TeV data of Run-1



arXiv:1804.02610



7+8+13 TeV data

$$\mu_{t\bar{t}H} = 1.26\,^{+0.31}_{-0.26}$$

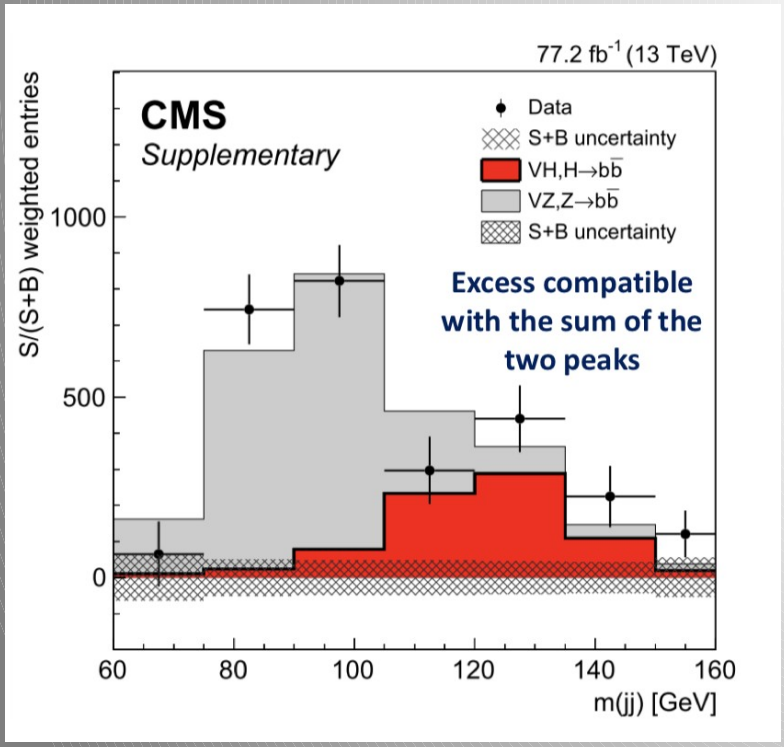
Significance = 5.9σ (exp 4.2σ

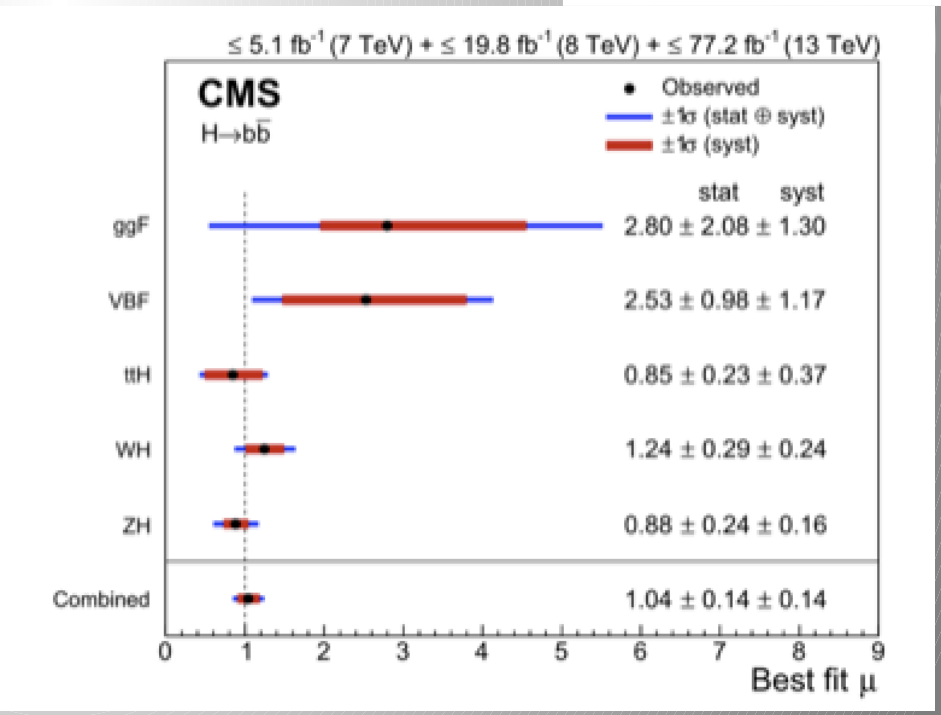
Observation of ttH!
Results in agreement with the Standard Model

Higgs to bb Decay

H->bb decay: Combination of all Higgs decay channels
and combination with the 7/8 TeV data of Run 1

arXiv:1808.08242





H->bb observed with 5.6 (5.6) σ observed (expected) significance

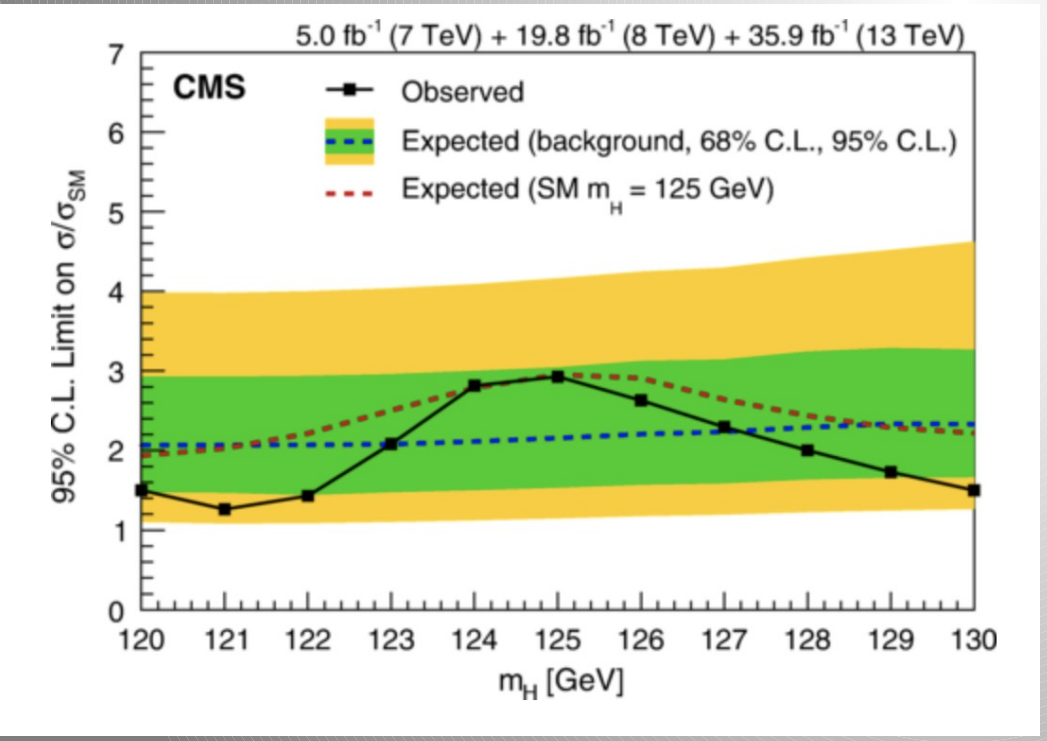
$$\mu = 1.04 \pm 0.20$$

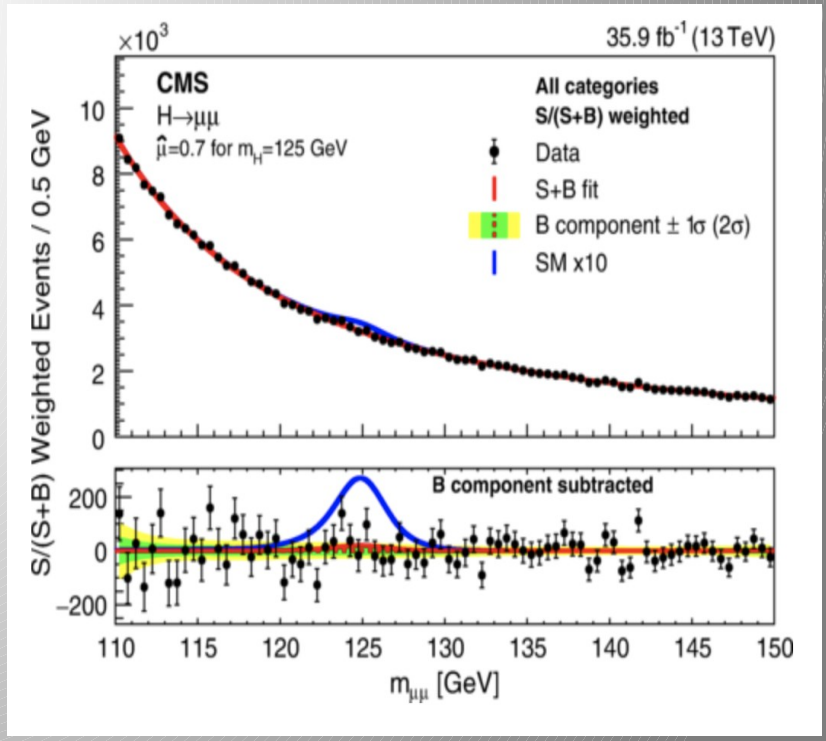
Combined best fit

Di-Muon Analysis

No signal yet but the sensitivity to H->$\mu\mu$ is getting within reach with full run-2/run-3 data

1807.06325



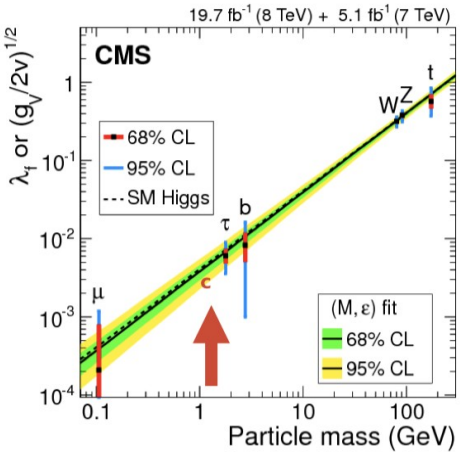


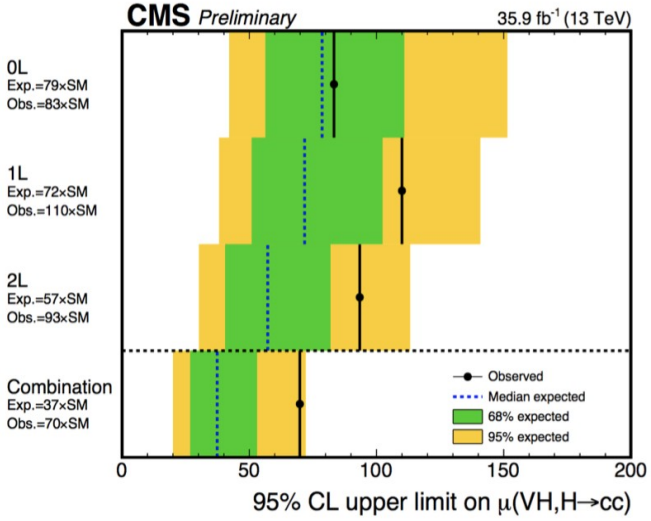
Observed (expected) upper limit is 2.9 (2.2) times the SM expectation

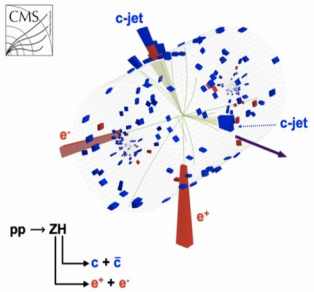
Searching for Higgs -> Charm

- First CMS result on VH, **H→cc**
  - Challenging due to low cross section and need for c-tagging
    - Categorization is done according to lepton multiplicity of V decays
    - Analysis used both resolved (2 c jets) and merged (1 cc jet) cases
    - Use of ML and jet substructure for tagging and classification
  - final results from the combination of resolved & merged jet analyses

HIG-18-031







Combined results for the signal strength:

Obs (exp) Upper Limit: 70 (37) @ 95% C.L.

$$\mu(\mathrm{VH}, \mathrm{H} \to c\bar{c}) = 41^{+20}_{-20}$$

Validate method using VZ production:

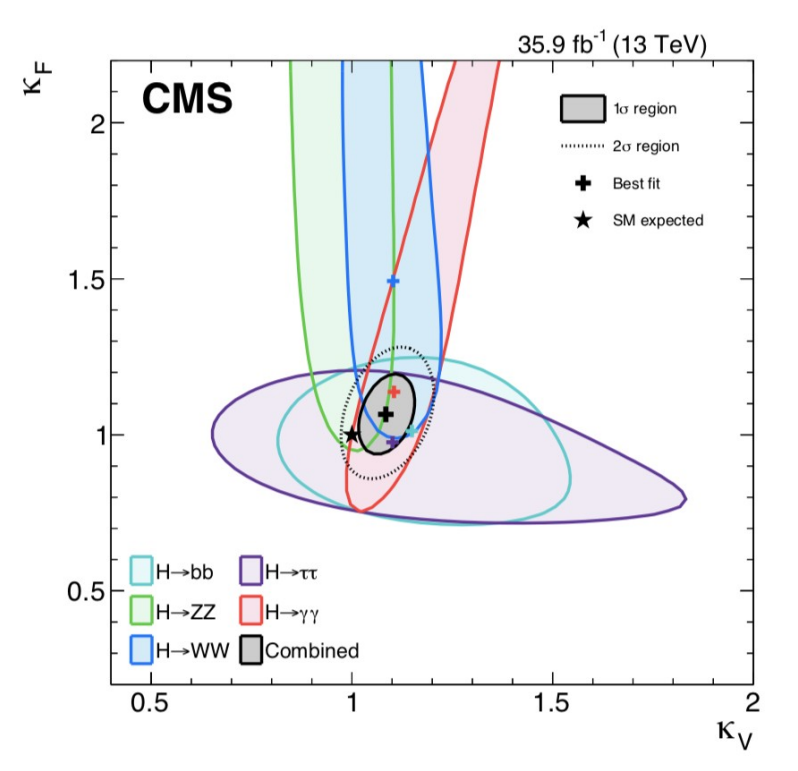
$$\mu(\mathrm{VZ}, \mathrm{Z} \to c\bar{c}) = 0.55^{+0.86}_{-0.84}$$

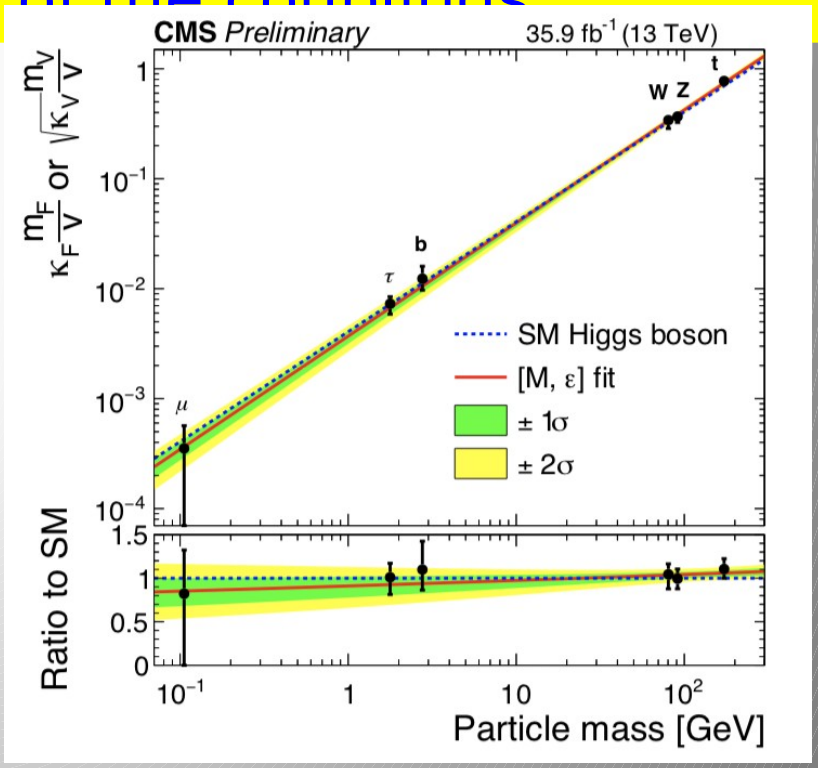
Still far from SM expectation, but no strong anomalous coupling so far

Brief Higgs Summary: Run-2

Combination of all Higgs production/decay channels at 13 TeV

Check of overall consistency of the couplings





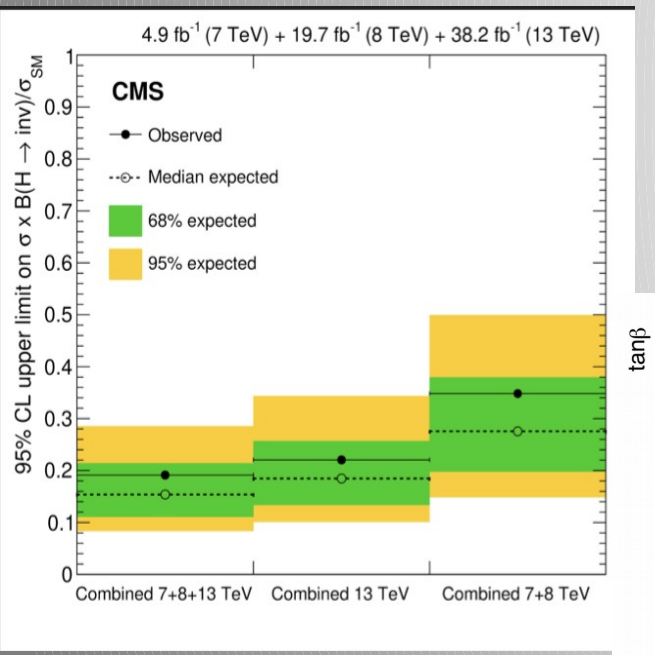
arXiv:1809.10733

Results in agreement with the Standard Model

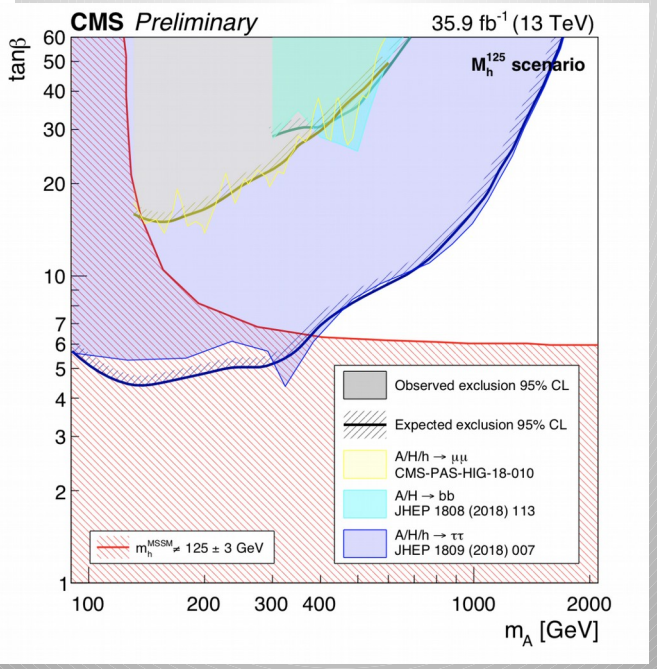
$$\mu = 1.17^{+0.10}_{-0.10}$$

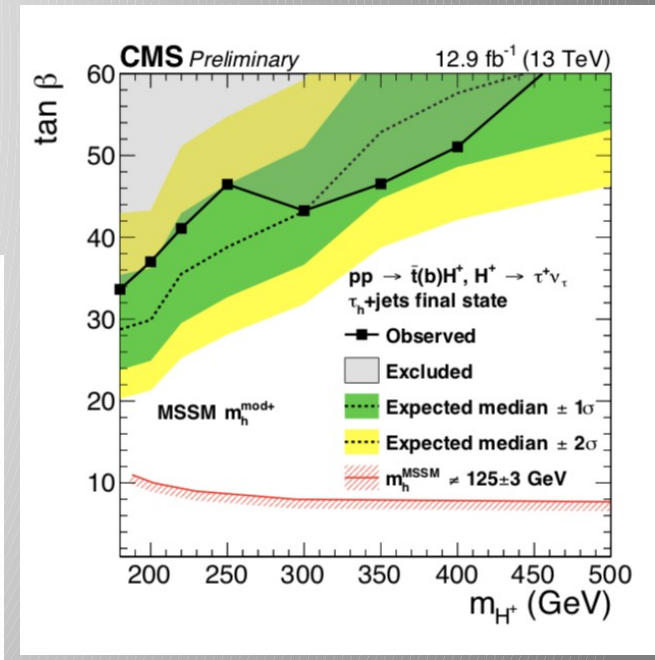
Searches for Exotic Higgses…

No exotic or extra Higgses found so far…



H,A Higgs search in MSSM SUSY scenario





Invisible Higgs searches
BR (H-> invisible) is less than 20%

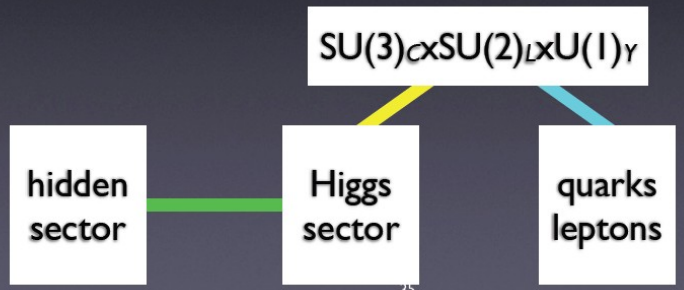
Charged Higgs search

The Future: Studying the Higgs…

- More LHC Data 2021-202
- LHC upgrade ! 2026-203
- Experiment upgrades!!
- Other/new machines?
  -> see later

Higgs as a portal

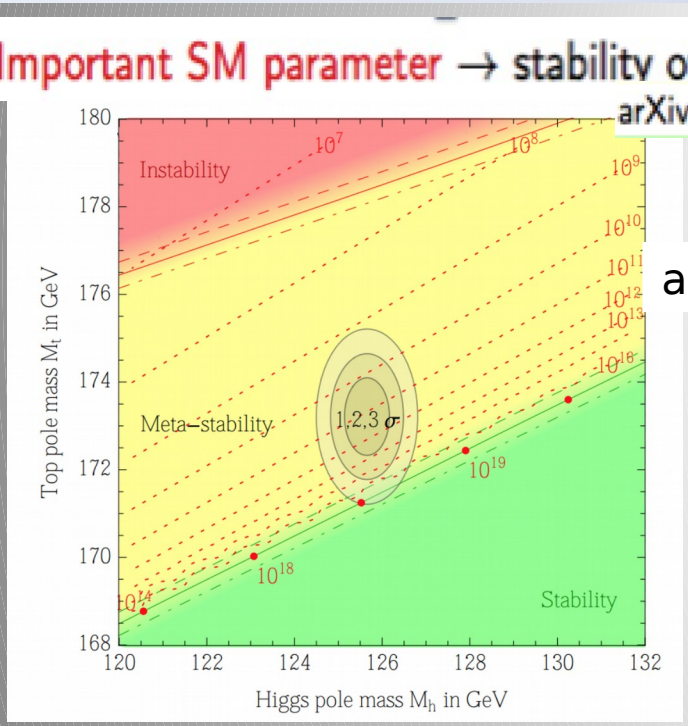
- having discovered the Higgs?
- Higgs boson may connect the Standard Model to other "sectors"



Many questions are still unanswered:

- What explain a Higgs mass ~ 125 GeV?
- What explains the particle mass pattern?
- Connection with Dark Matter?

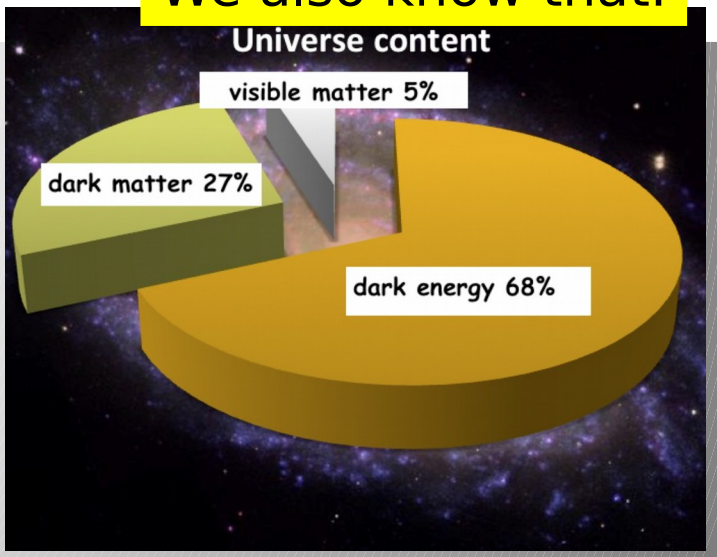
Physics Beyond the Standard Model?



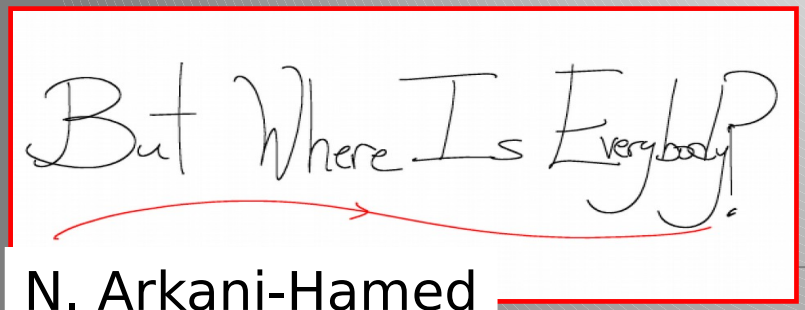
arXiv:1403.6535

A Higgs at 125 GeV
Precise measurements of the top quark and the Higgs mass

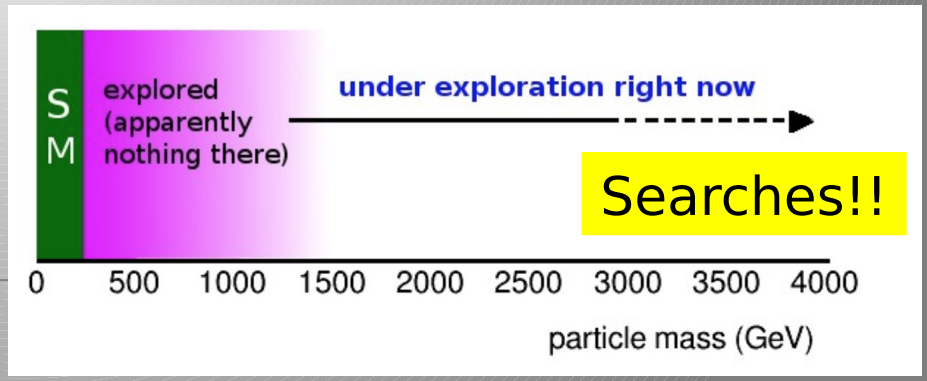
We also know that:



New Physics inevitable?
But at which scale/energy?

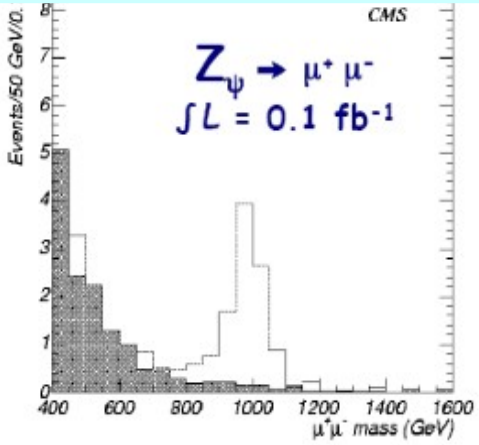


N. Arkani-Hamed

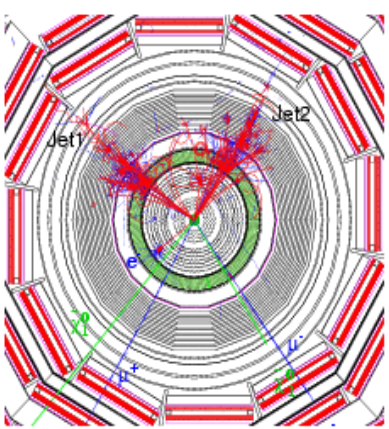


New Physics?

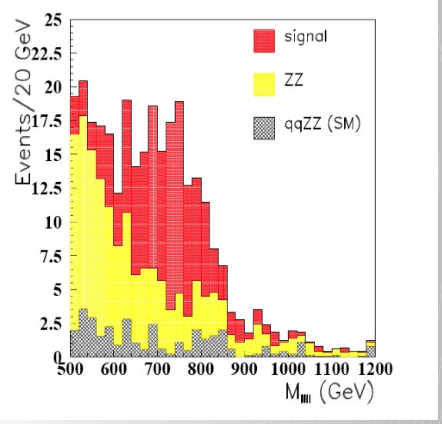
New Gauge Bosons?



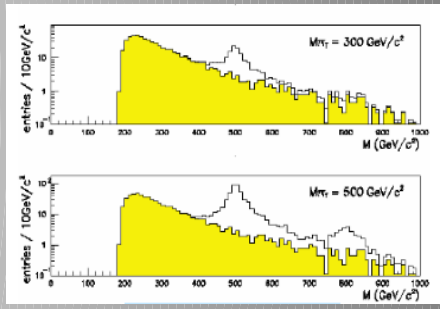
upersymmetry



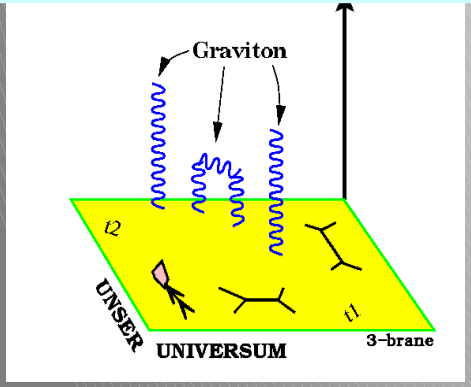
ZZ/WW resonances?



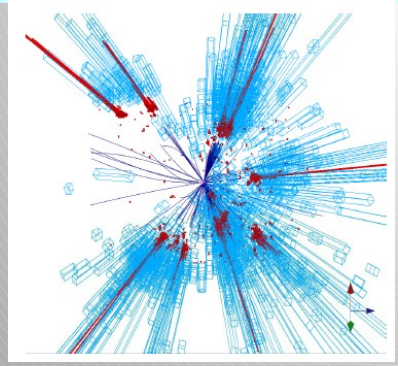
Technicolor?



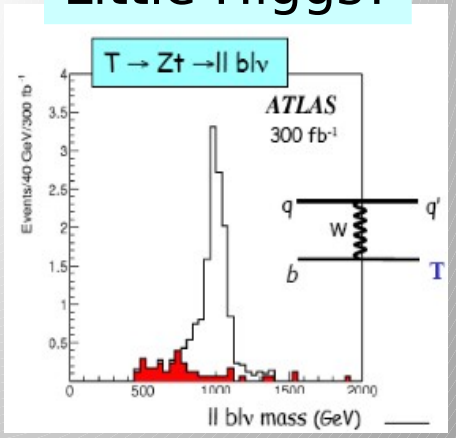
Extra Dimensions?



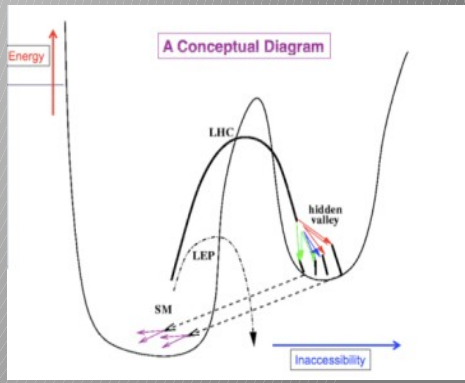
Black Holes???



Little Higgs?



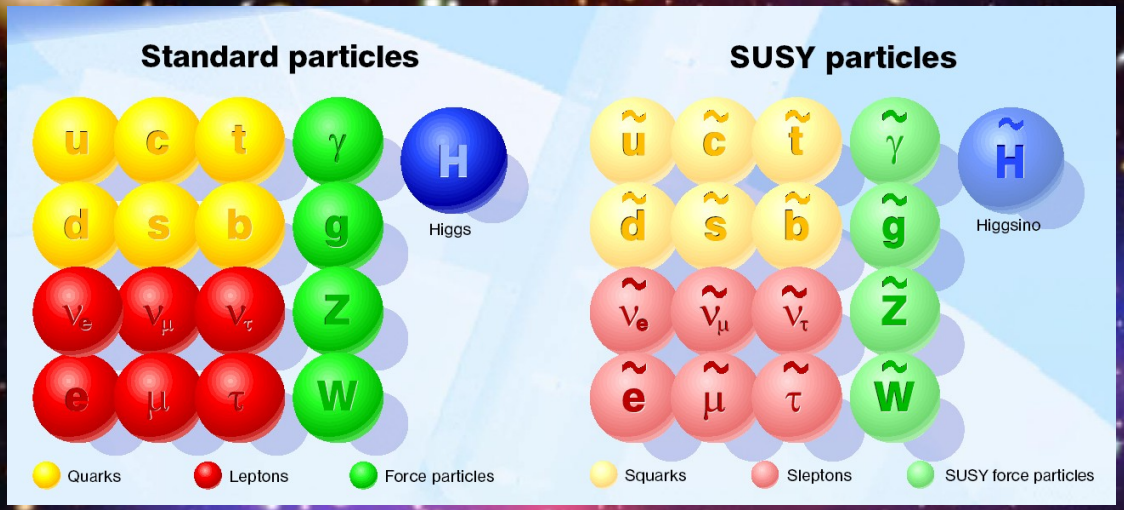
Hidden Valleys?

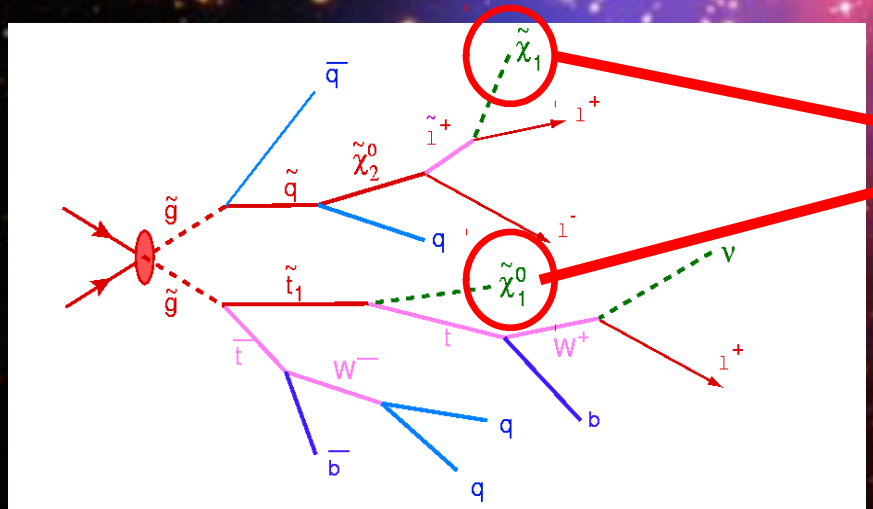


What stabelizes the Higgs Mass? Many ideas, not all viable any more

A large variety of possible signals. We have to be ready for that

Supersymmetry: a new symmetry in Nature?

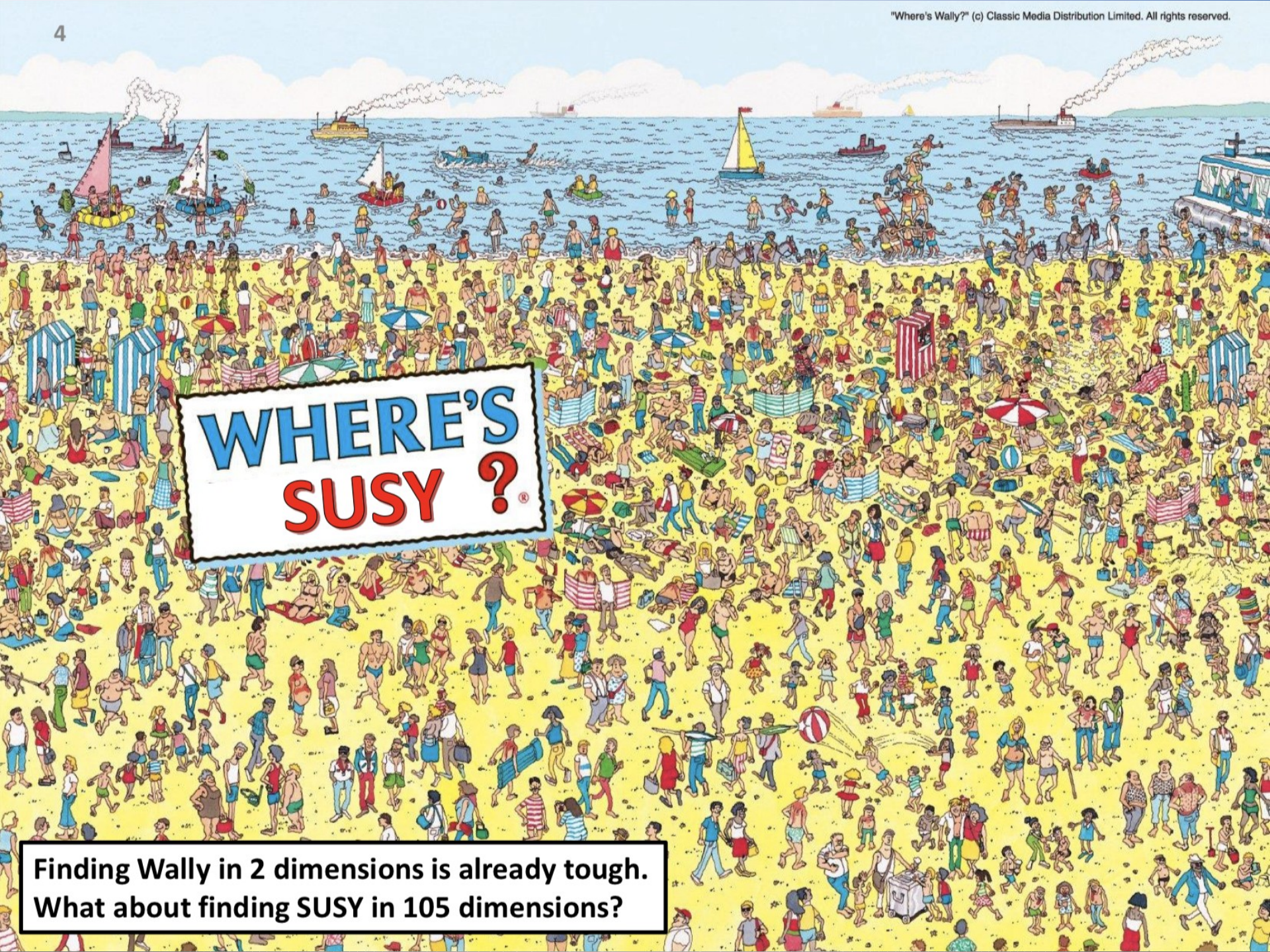




SUSY particle production at the LHC

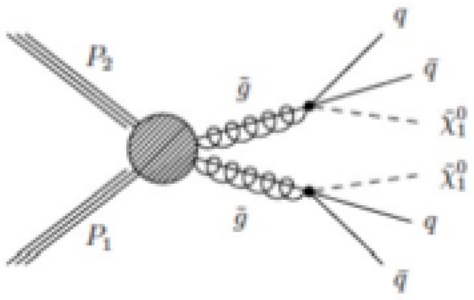
Candidate particles for Dark Matter
⇒ Produce Dark Matter in the lab

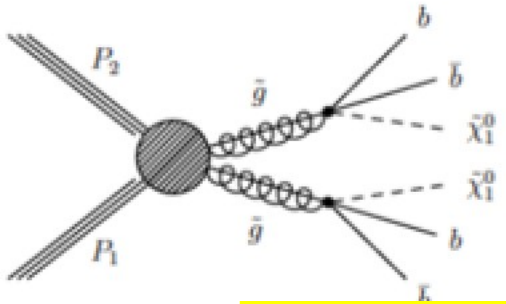
Picture from Marusa Bradac

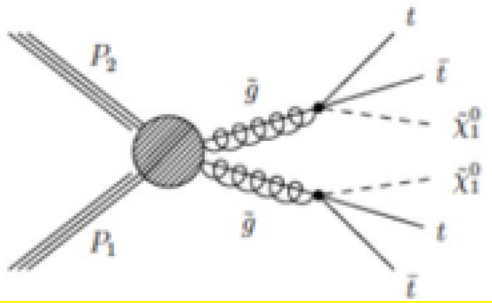


Finding Wally in 2 dimensions is already tough.
What about finding SUSY in 105 dimensions?

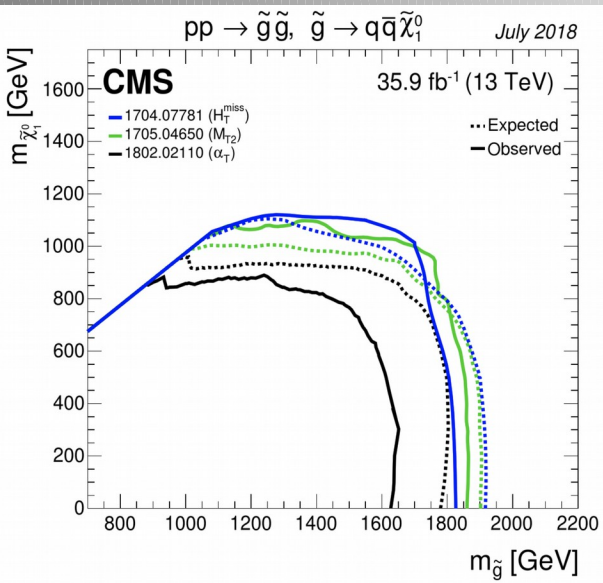
Supersymmetry: Gluinos

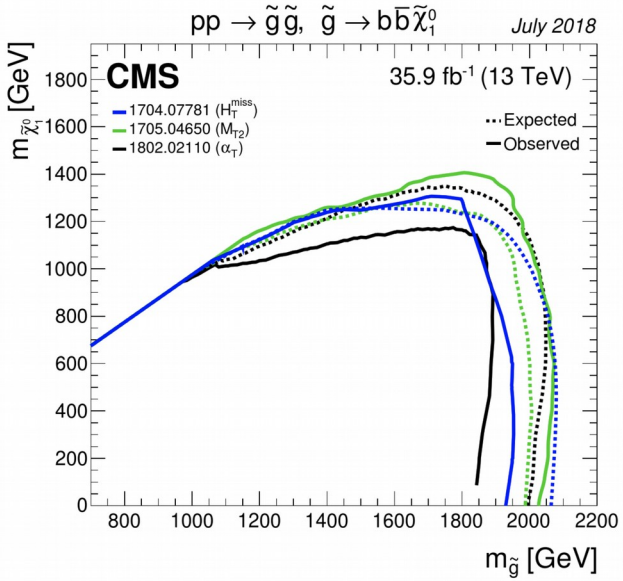


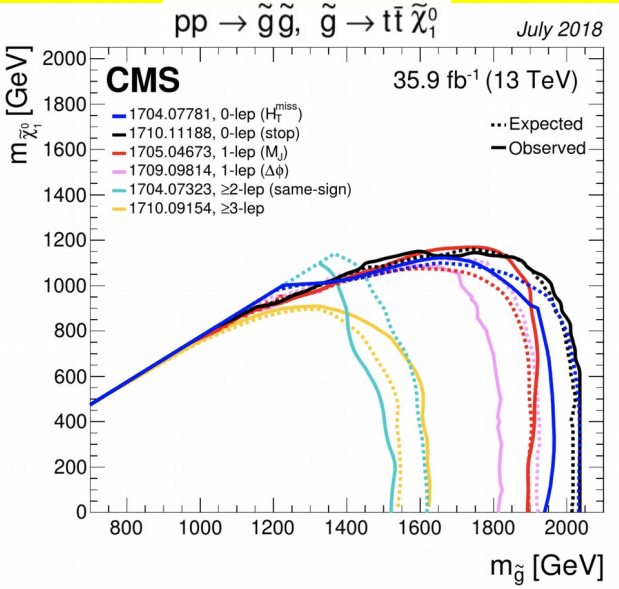




Interpretation in simplified models (SMS





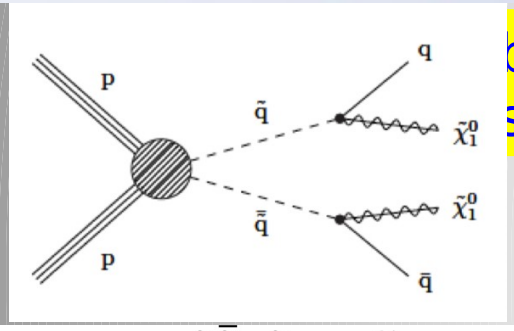


No significant signal to date

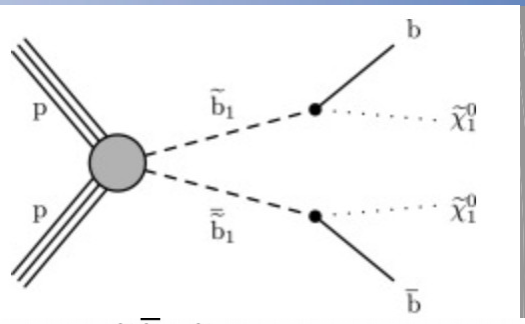
Within the context of the SMS:

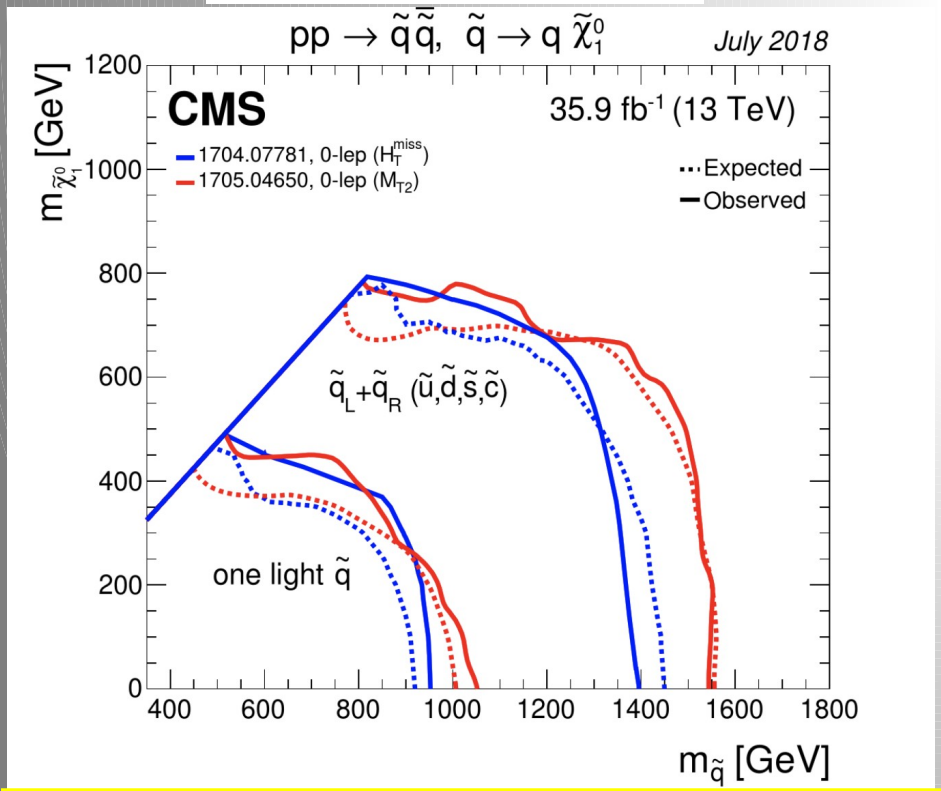
Exclude gluino masses ~ 2200 GeV for neutralino masses up to 800 GeV

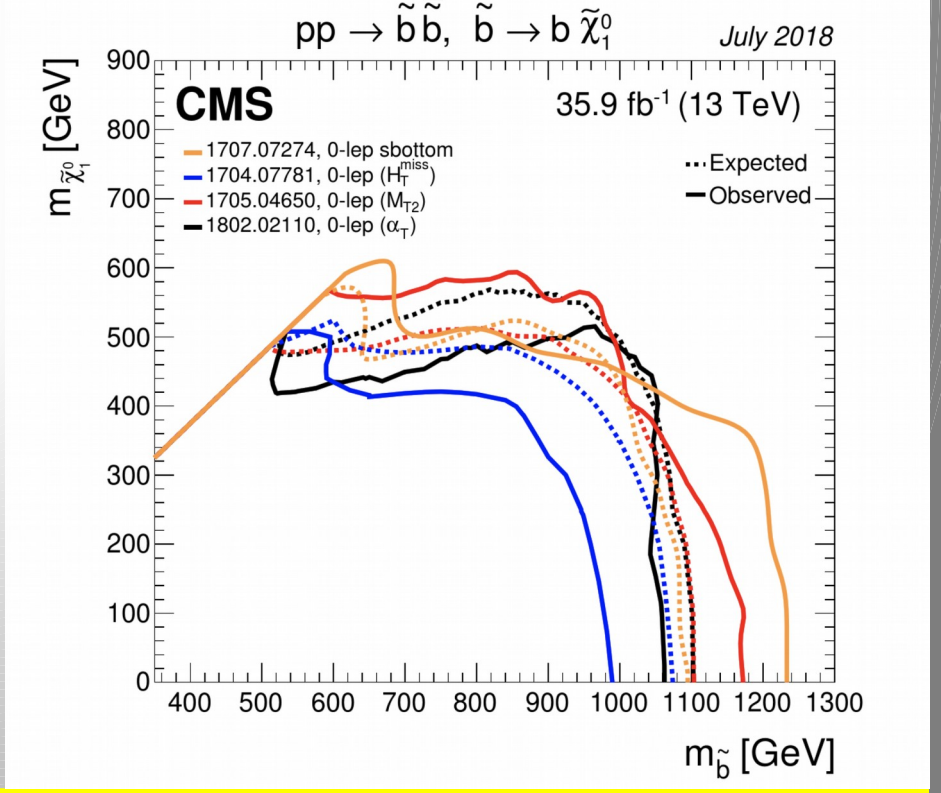
Supersymmetry: Quarks



b-squarks and light squarks



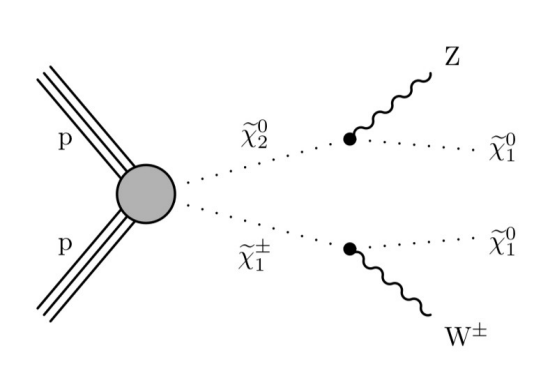




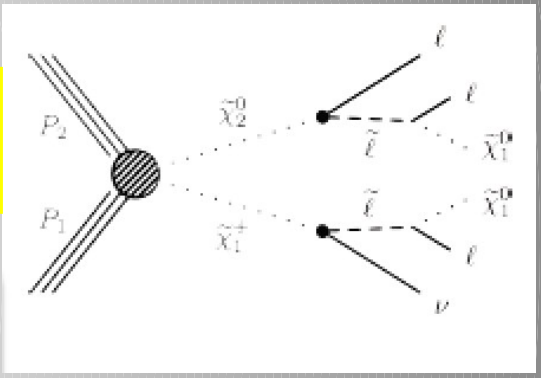
No significant signal to date

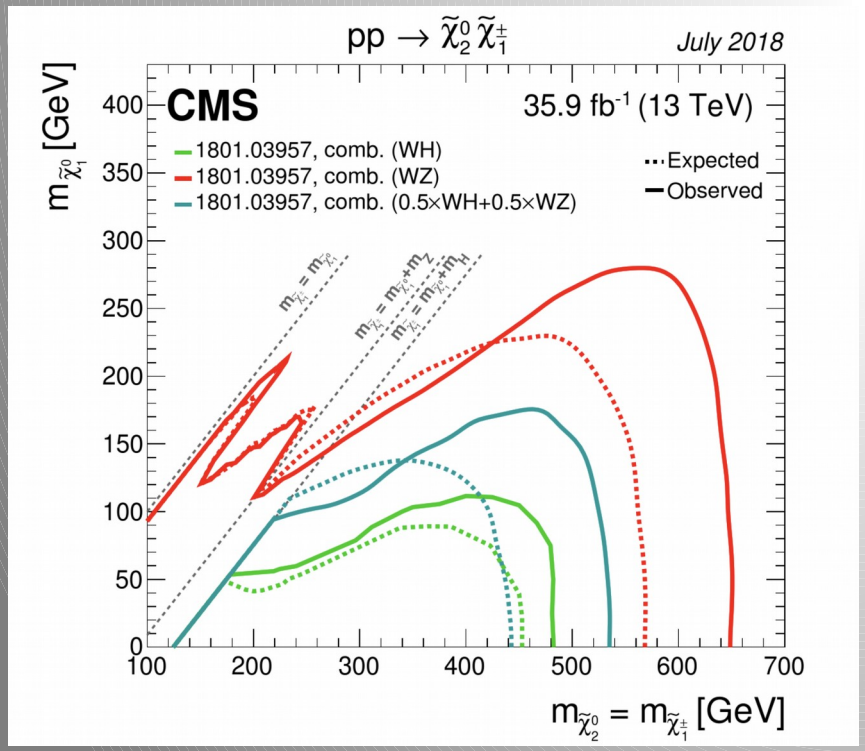
Within the context of the SMS: Exclude squark masses ~ 1500 GeV

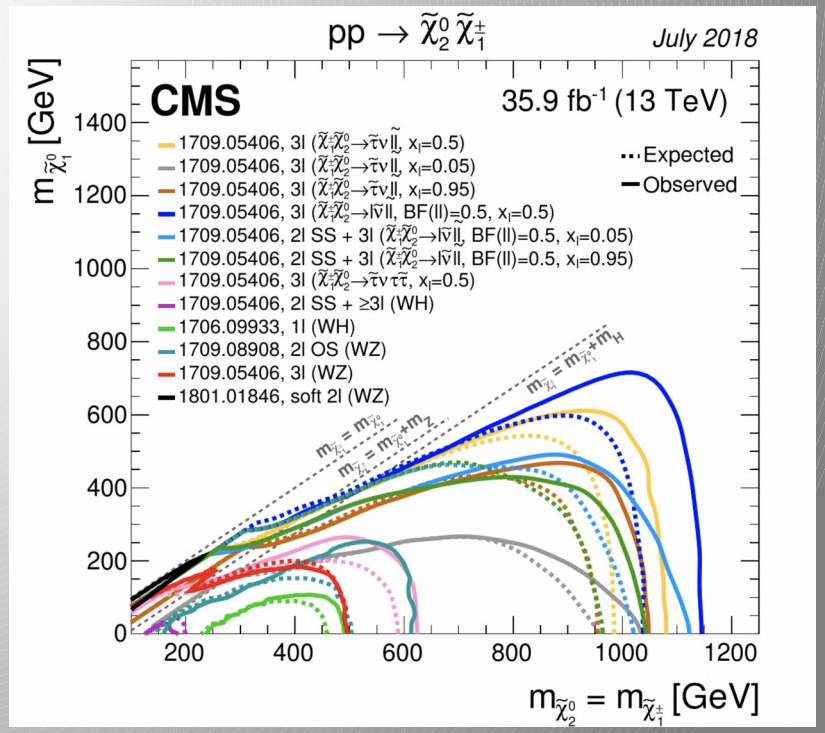
Chargino and Neutralino Production



Direct production of "electroweakino" pairs



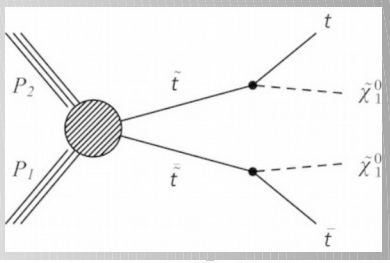


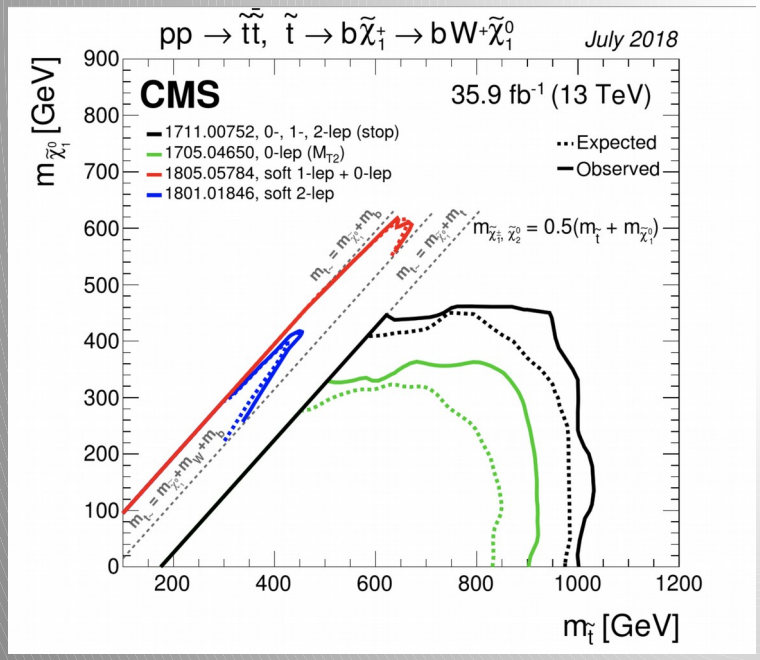


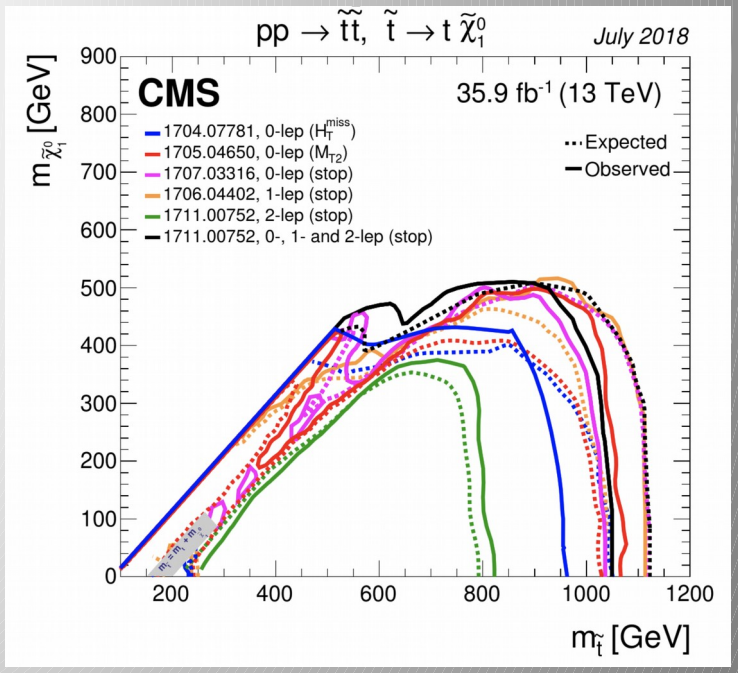
Exclude masses up to 1100 GeV for neutralino masses up to 600 GeV

Top Squark Search Summaries

Partner of the top quark – the stop– plays a prominent role in Natural Models







Within the context of the SMS:

Exclude with masses up to 1100 GeV for neutralino masses up to 500 GeV

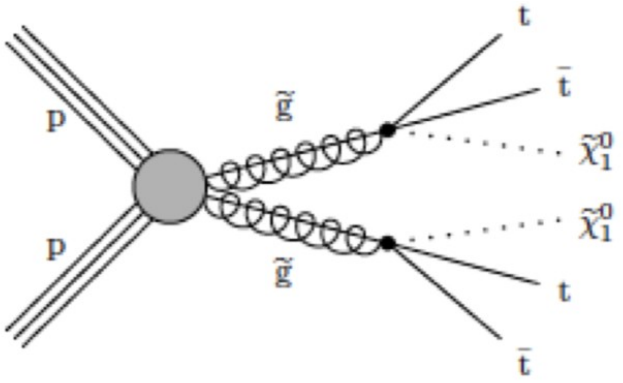
Is this getting critical for Natural Models??

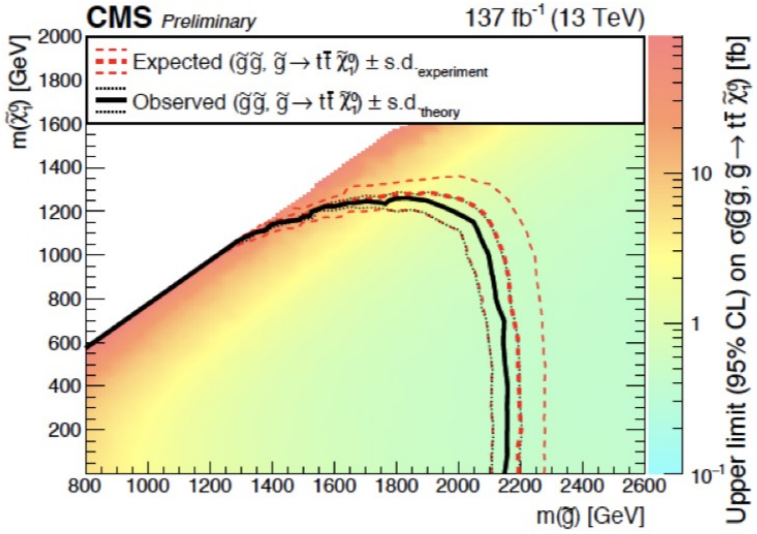
SUSY Searches with the Full Run-2 data

Analyses that have been “completed” and submitted

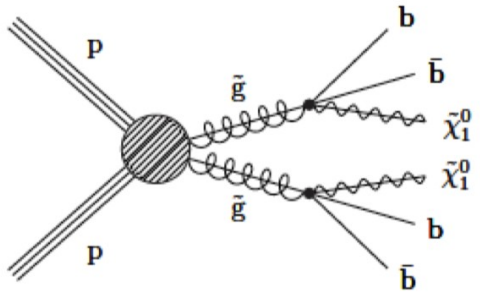
Supersymmetry: Gluinos

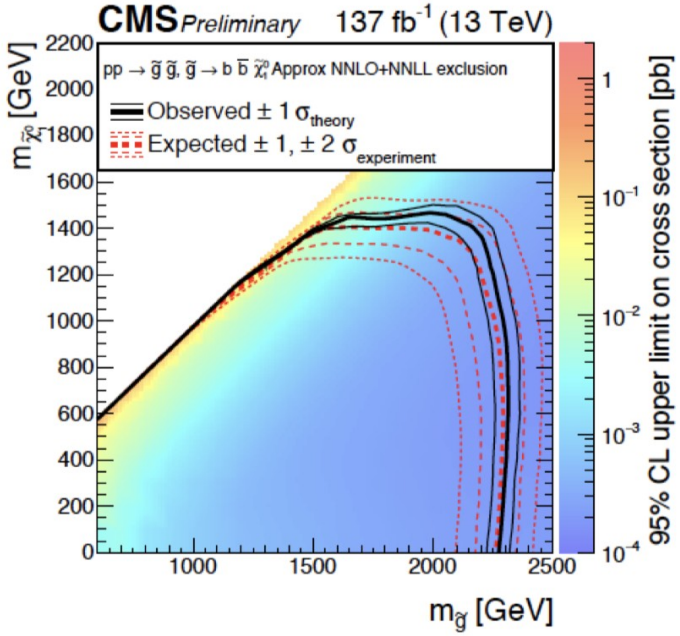
SUSY-19-007





SUSY-19-006

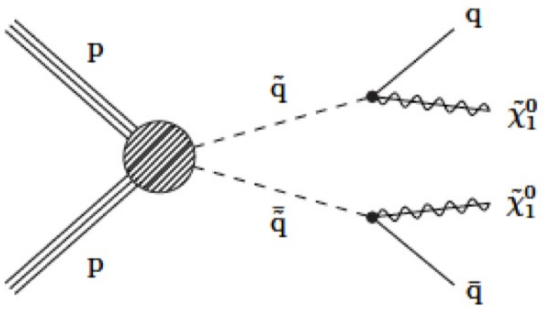


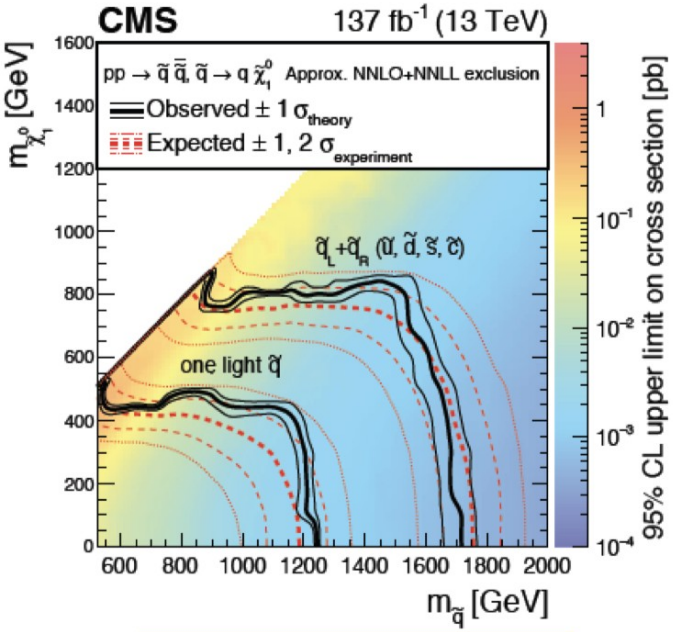


Within the context of the SMS: Exclude gluino masses ~ 2300 GeV

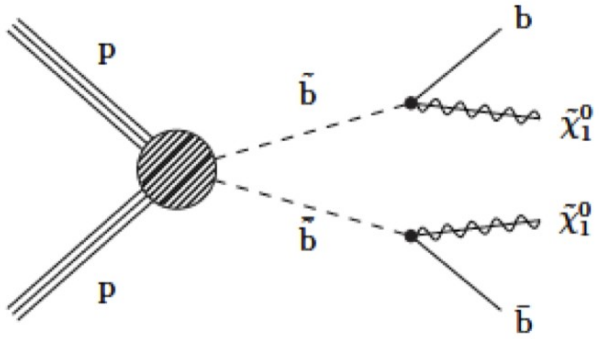
Supersymmetry: Quarks

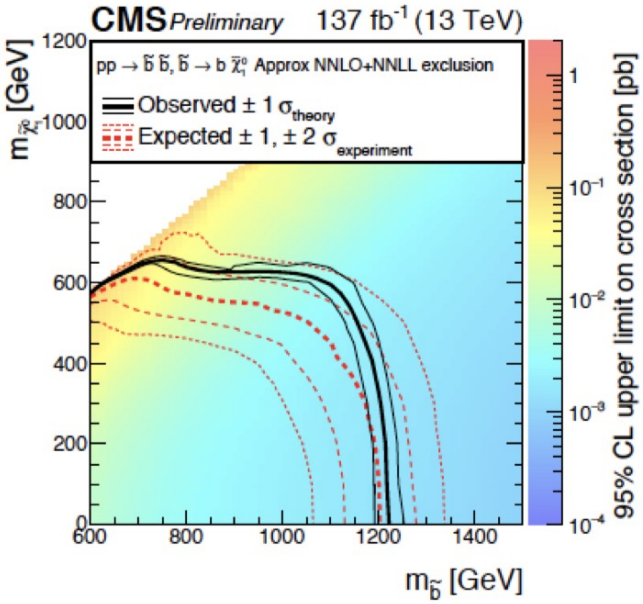
SUSY-19-005





SUSY-19-006

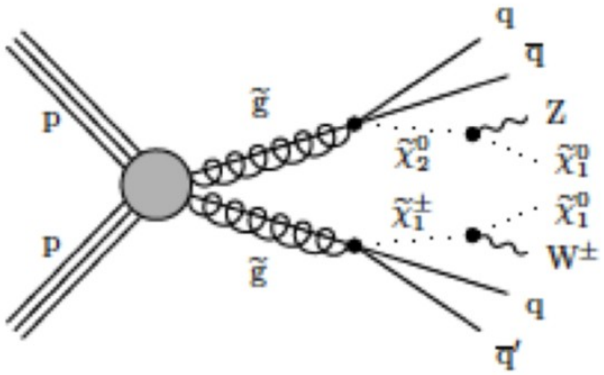


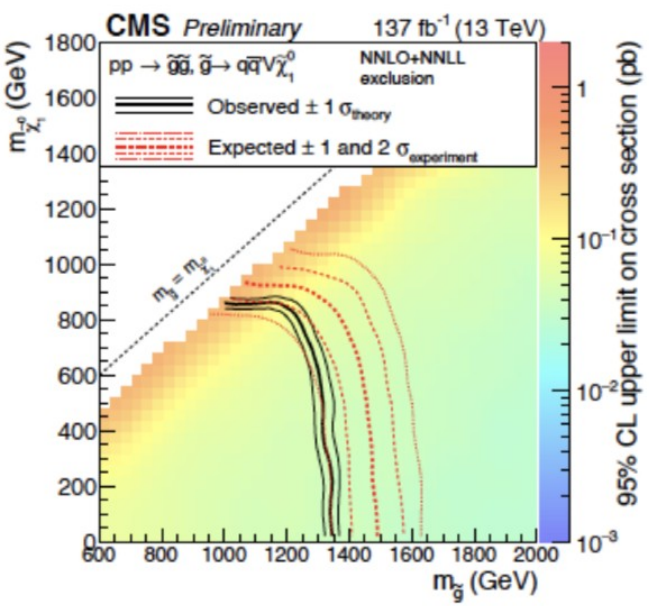


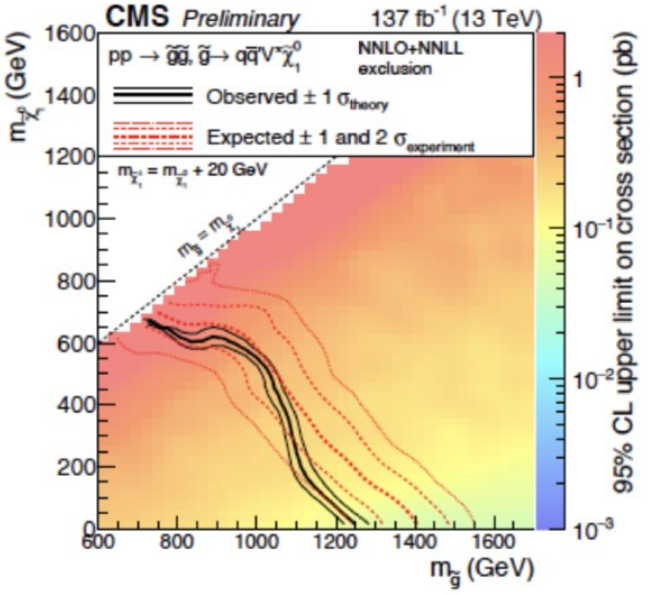
Within the context of the SMS: Exclude squark masses ~ 1700 GeV

SUSY with Dileptons

SUSY-19-008



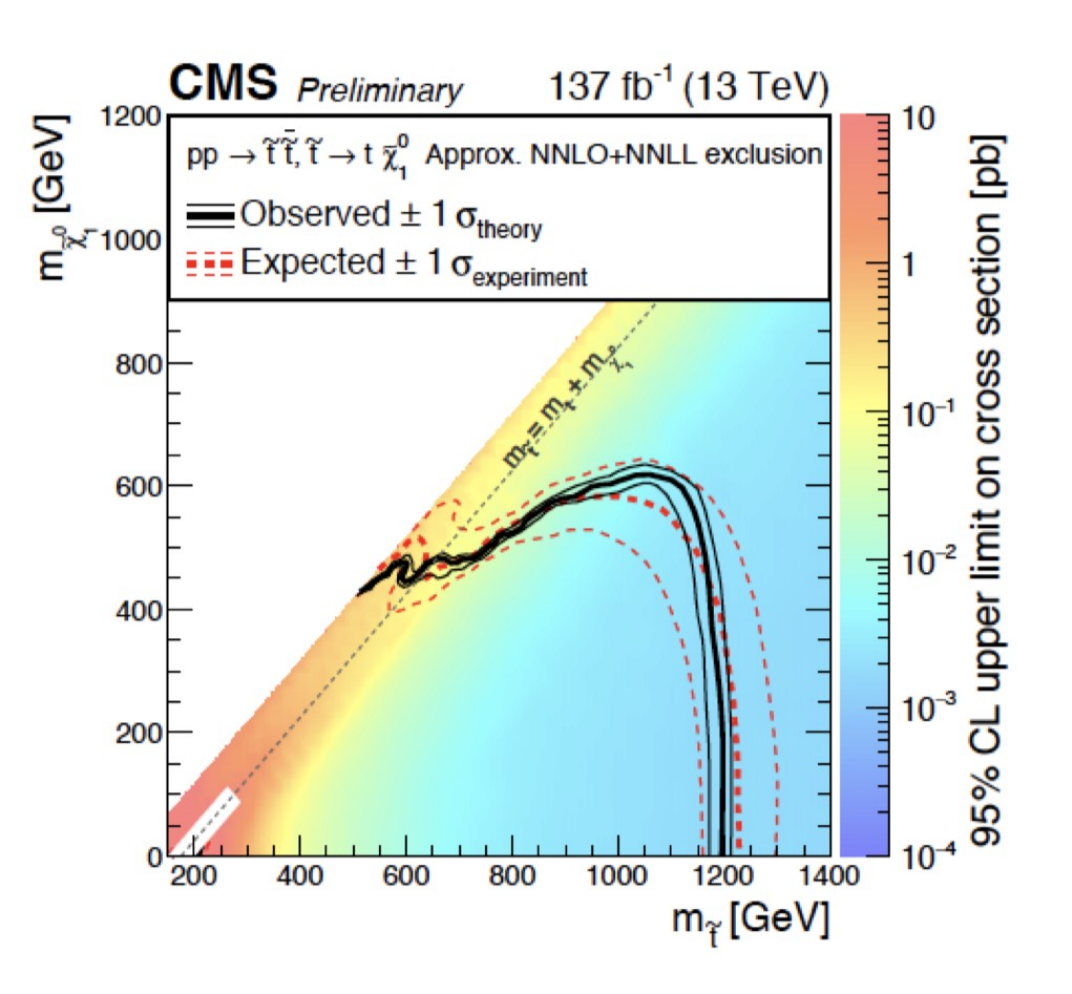


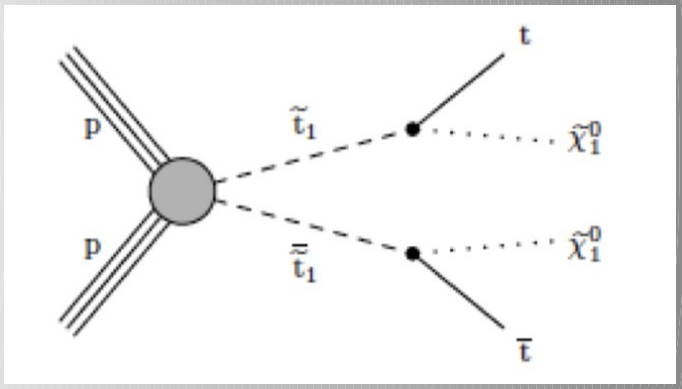


$$m_{\tilde{\chi}_1^\pm} = 0.5(m_{\tilde{g}} + m_{\tilde{\chi}_1^0})$$

$$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0} + 20\,\text{GeV}$$

SUSY Stop Production





SUSY-19-009

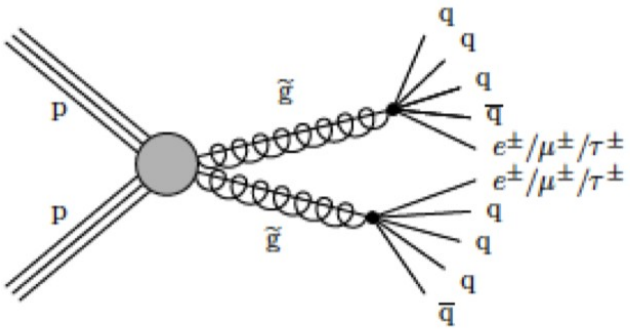
Single lepton analysis

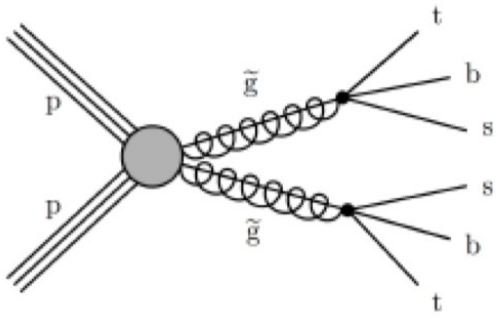
No significant signal to date

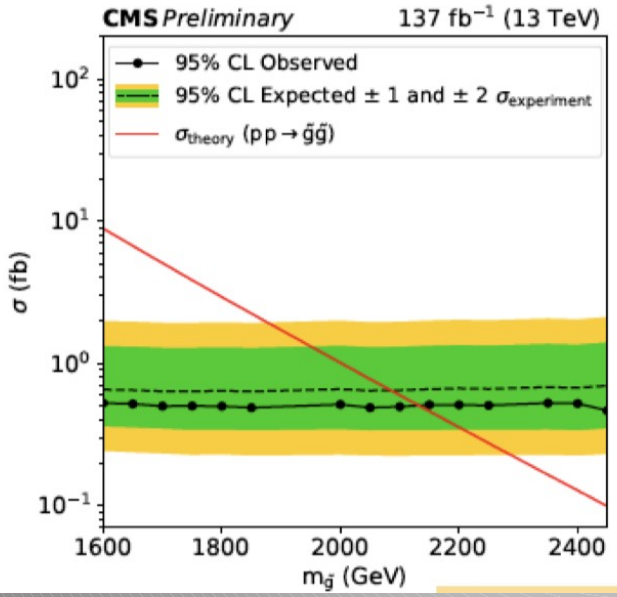
Within the context of the SMS: Exclude stop masses ~ 1200 GeV

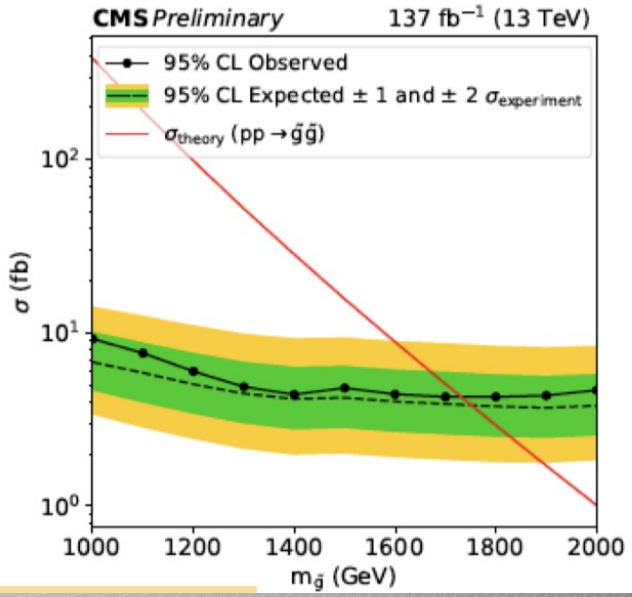
RP-Violating SUSY

SUSY-19-008









Within the context of the SMS: Exclude gluino masses ~ 2100 GeV

Long-Lived SUSY

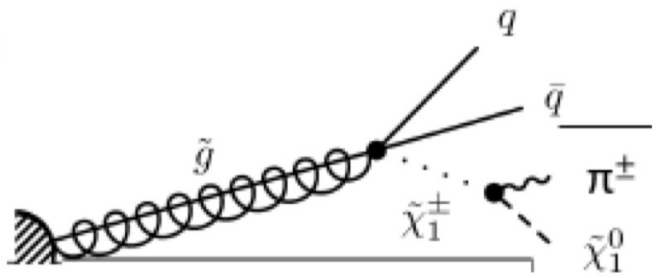
SUSY-19-005

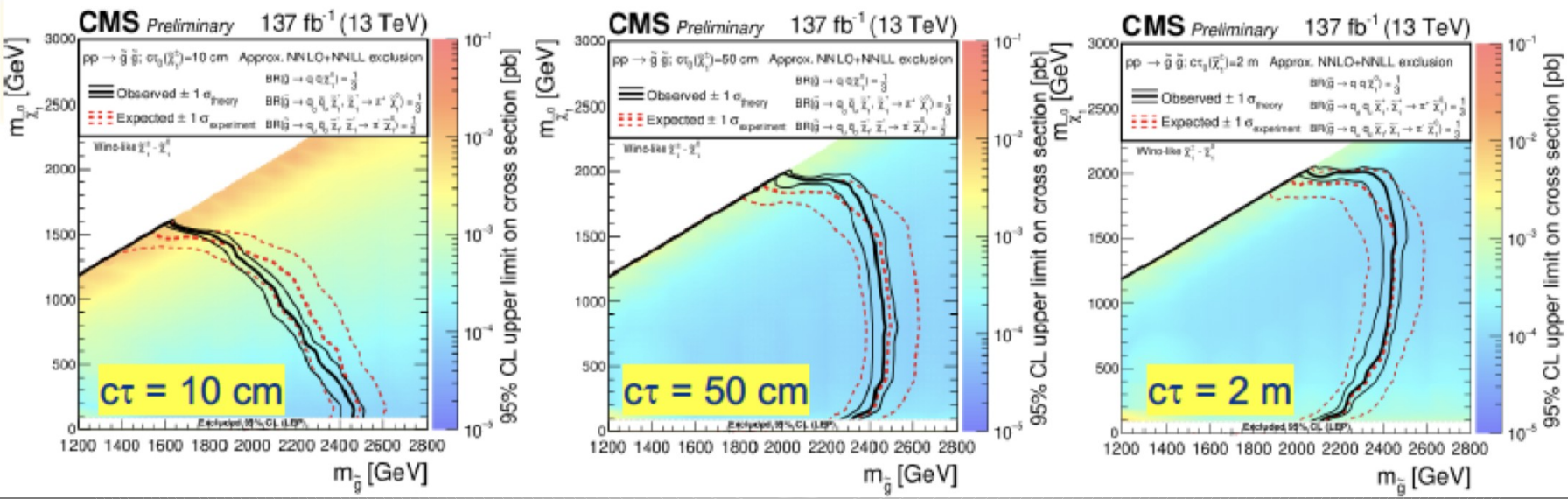
Extension of “classic” hadronic MT2 search

Signal selection:

Binning in H_T, M_{T2}, #jets, #b-jets

Extra categorization in short (pixel-only), medium (< 7 hits) and long (> 7 hits) tracks





No significant signal to date

Within the context of the SMS: Exclude gluino masses ~ 2400 GeV

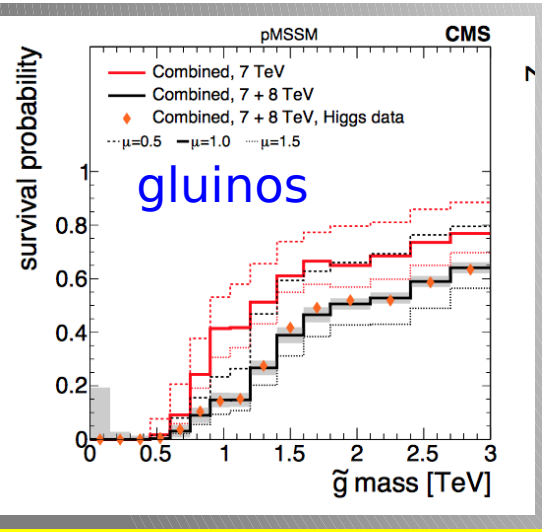
Phenomenological MSSM analysis

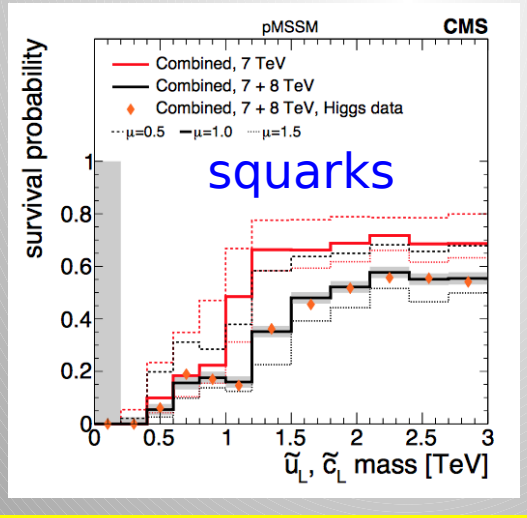
SMS don't always fully cover signatures...
-> the 19 parameter phenomenological MSSM (pMSSM) analyses

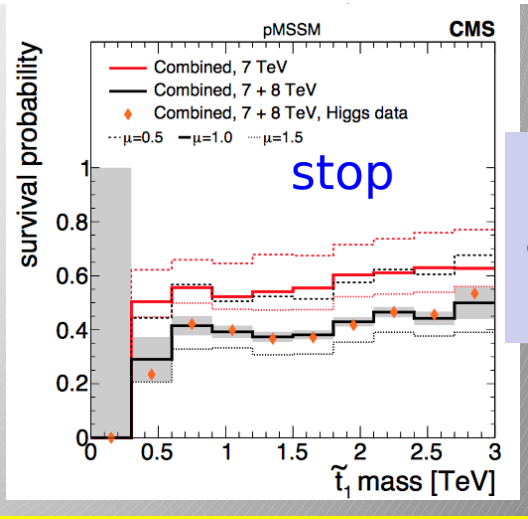
arXiv:1606.03577

- three independent gaugino mass parameters M_1, M_2, and M_3,
- the ratio of the Higgs vacuum expectation values $\tan\beta = v_2/v_1$,
- the higgsino mass parameter μ and the pseudoscalar Higgs boson mass m_A,
- 10 independent sfermion mass parameters $m_{\tilde{F}}$, where $\tilde{F} = \tilde{Q}_1, \tilde{U}_1, \tilde{D}_1, \tilde{L}_1, \tilde{E}_1, \tilde{Q}_3, \tilde{U}_3, \tilde{D}_3, \tilde{L}_3, \tilde{E}_3$ (for the 2nd generation we take $m_{\tilde{Q}_2} \equiv m_{\tilde{Q}_1}, m_{\tilde{L}_2} \equiv m_{\tilde{L}_1}, m_{\tilde{U}_2} \equiv m_{\tilde{U}_1}, m_{\tilde{D}_2} \equiv m_{\tilde{D}_1}$, and $m_{\tilde{E}_2} \equiv m_{\tilde{E}_1}$; left-handed up- and down-type squarks are by construction mass degenerate), and
- the trilinear couplings A_t, A_b and A_τ.

$$
\begin{aligned}
-3 \le\ & M_1, M_2 \le 3\,\text{TeV},\\
0 \le\ & M_3 \le 3\,\text{TeV},\\
-3 \le\ & \mu \le 3\,\text{TeV},\\
0 \le\ & m_A \le 3\,\text{TeV},\\
2 \le\ & \tan\beta \le 60,\\
0 \le\ & m_{\tilde{Q}_{1,2}}, m_{\tilde{U}_{1,2}}, m_{\tilde{D}_{1,2}}, m_{\tilde{L}_{1,2}}, m_{\tilde{E}_{1,2}}, m_{\tilde{Q}_3}, m_{\tilde{U}_3}, m_{\tilde{D}_3}, m_{\tilde{L}_3}, m_{\tilde{E}_3} \le 3\,\text{TeV},\\
-7 \le\ & A_t, A_b, A_\tau \le 7\,\text{TeV},
\end{aligned}
$$







Based on 8 TeV data limits

points sampled: Leads to softer limits on the sparticles masses
nos > 500 GeV, stops > 300 GeV => there is still low mass phase space

SUSY (as seen from outside HEP…)

November ‘16 reported by The Economist (!?!):

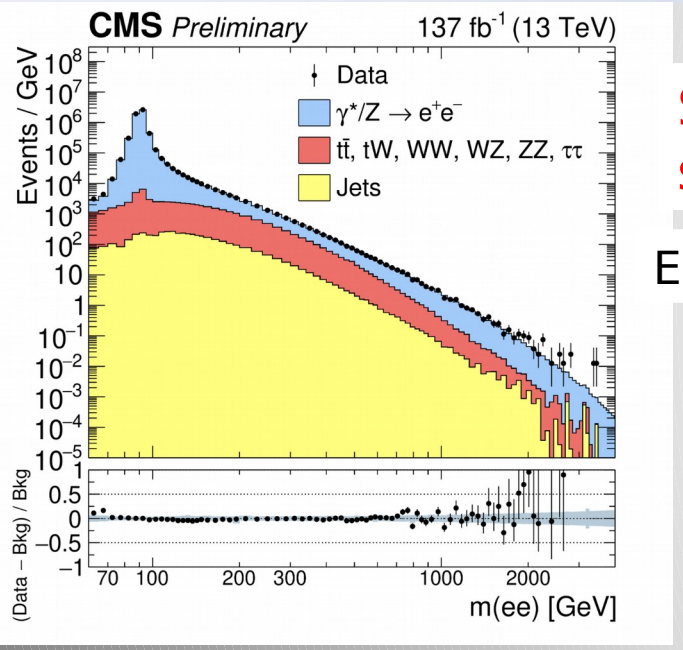
But not giving up as yet!!!
So far 2016 data analysed

Keep the party ready..

But no signal in full run-2 data as yet

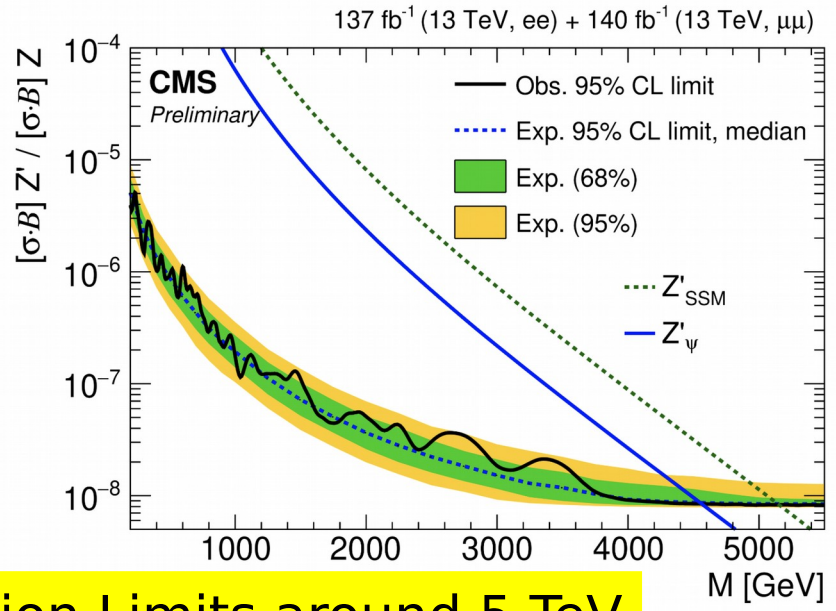
/www.economist.com/news/science-and-technology/21709946-supersymmetry-beautiful-idea-there-still-no-evidence-sup

Search for Dilepton Resonances



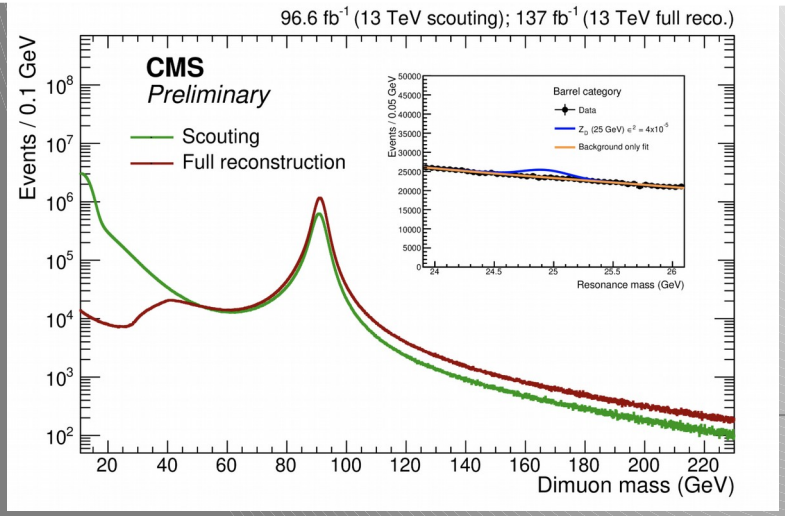
Standard search

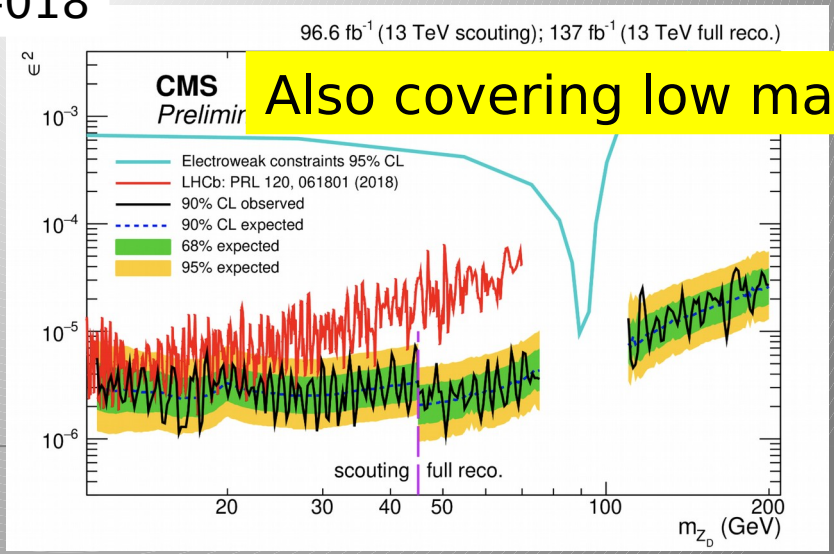
EXO-19-019



Exclusion Limits around 5 TeV

Search with scouting data EXO-19-018



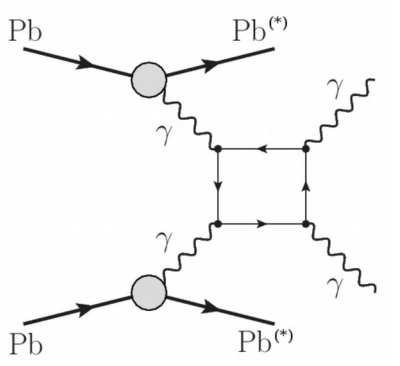


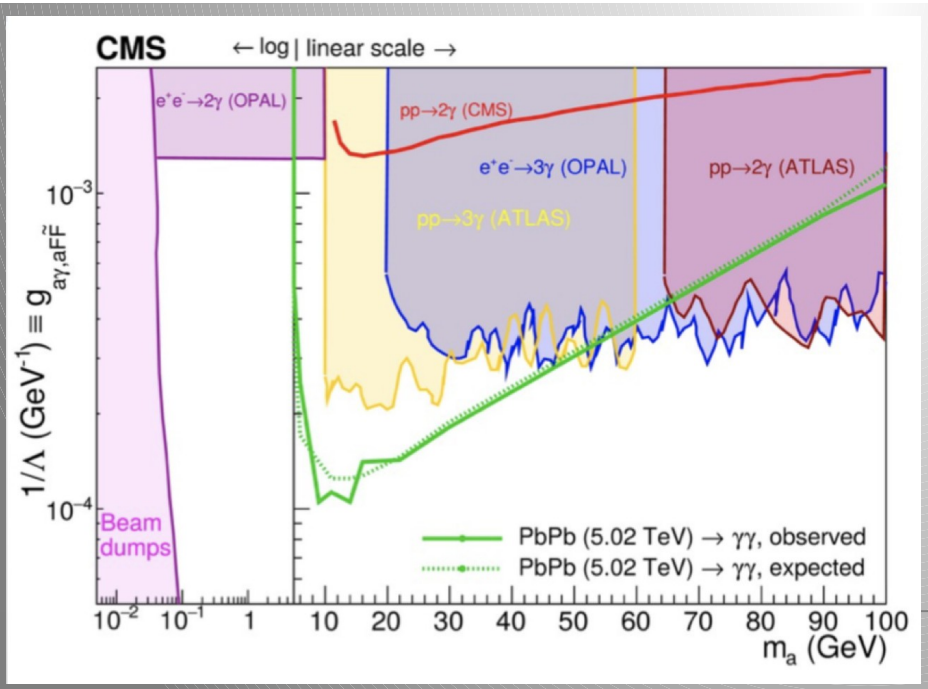
Also covering low mass rang

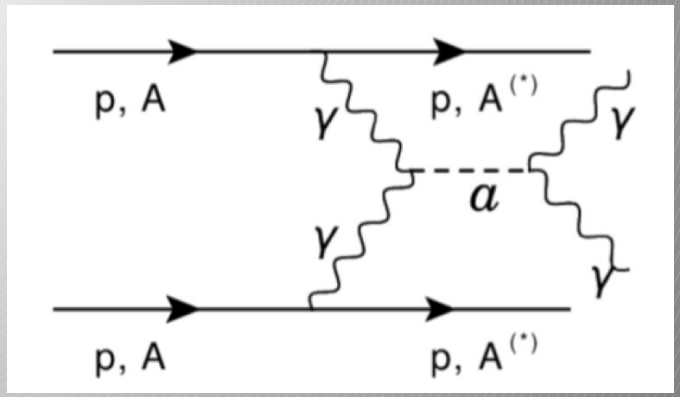
Light-by-light Scattering

- Select ultra-peripheral collisions in PbPb
- Exclusive 2-photon final state selection
- Small acoplanarity (< 0.01)
- Small diphoton p_T (< 1 GeV)
- 14 events found, 3.8 background events est.
- -> set limits on Axion-Like Particle searches

arXiv:1810.04602

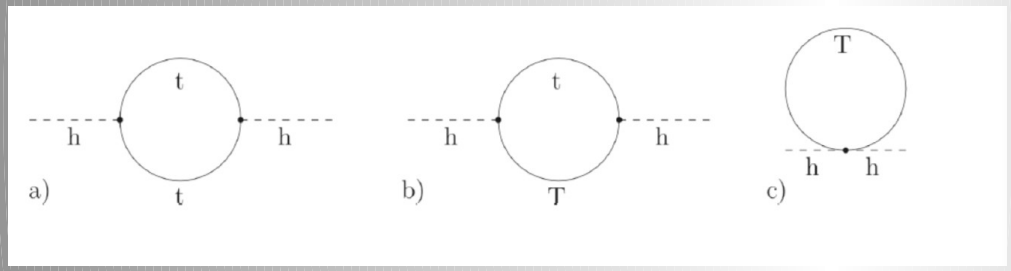


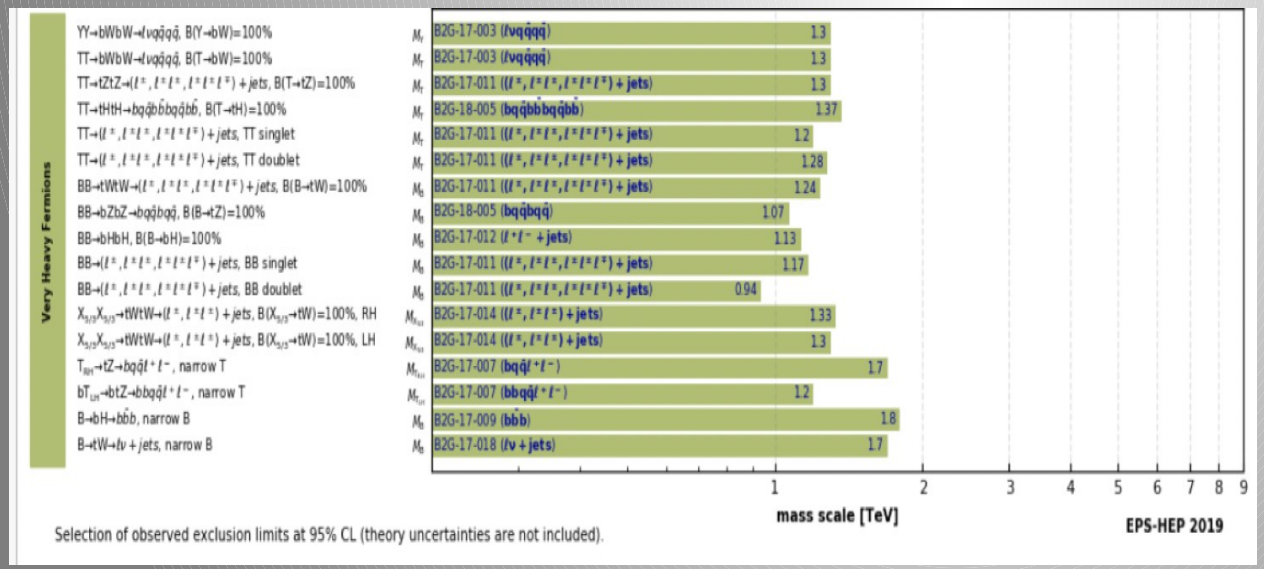




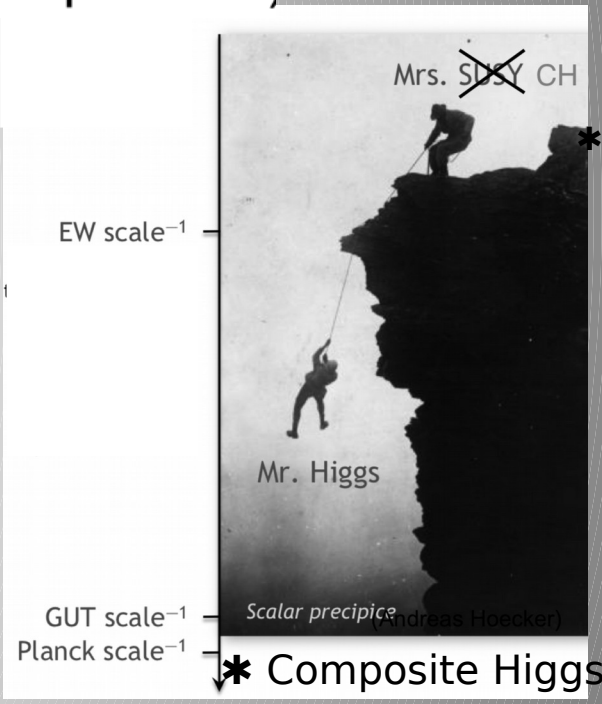
Vector-Like Quarks

VLQ: same electroweak charges for LH and RH components





Selection of observed exclusion limits at 95% CL (theory uncertainties are not included).



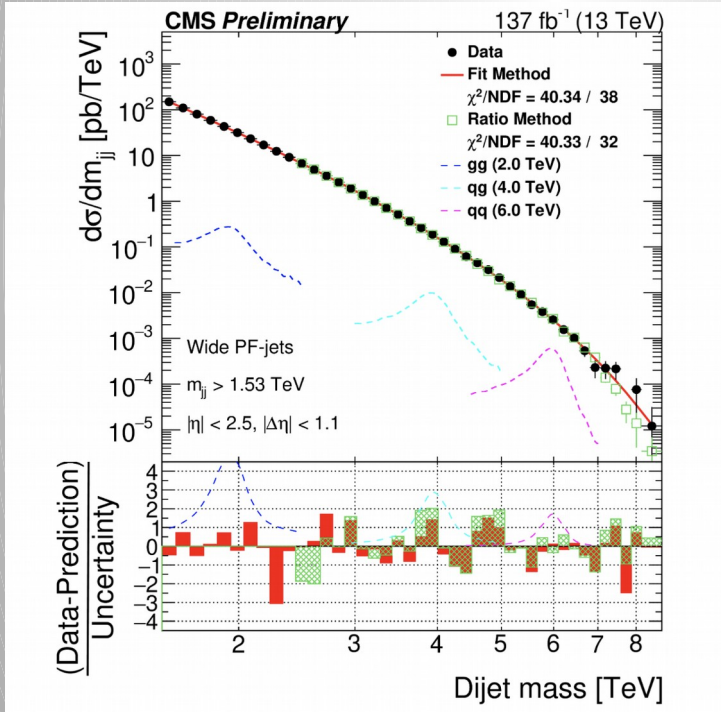
VLQs to tame the quantum corrections

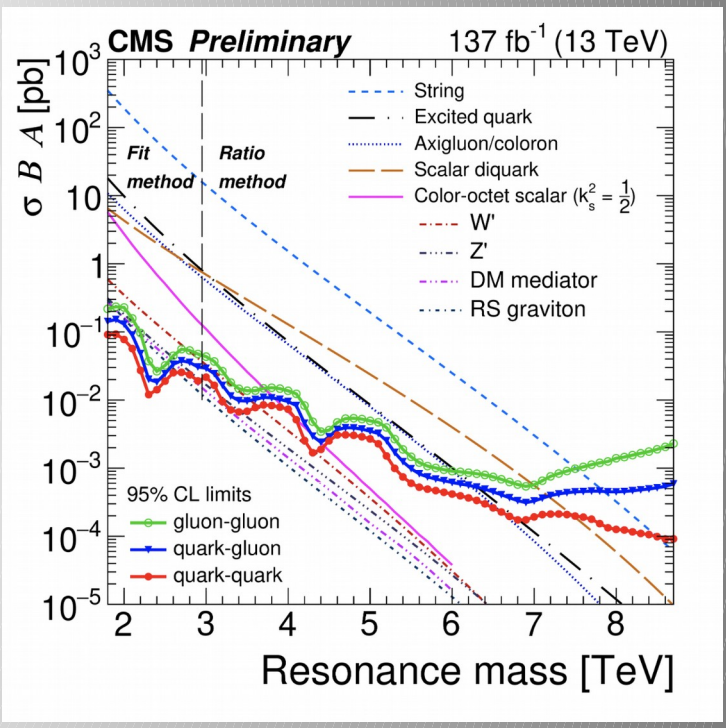
VLQs: Lower limits presently in the 900-1800 GeV range

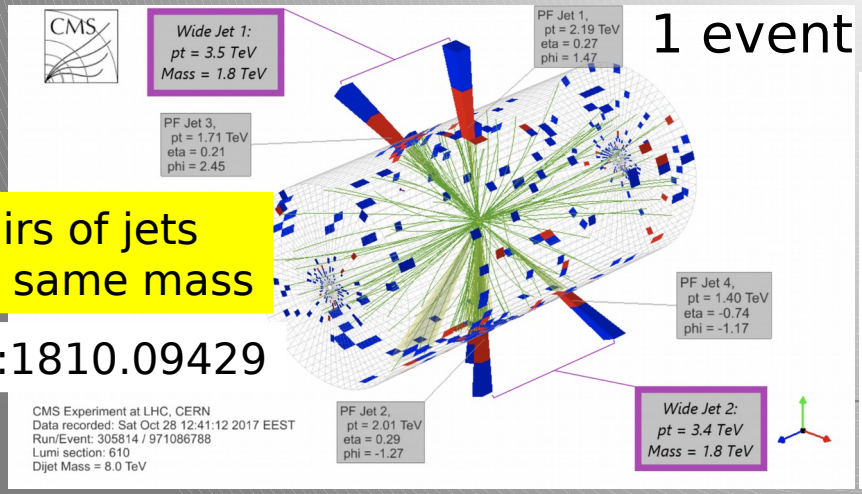
Seach for Di-jet Resonances

EXO-19-012

Search for high mass dijet resonances based on the full run-2 data sample







1 event

2 pairs of jets with same mass

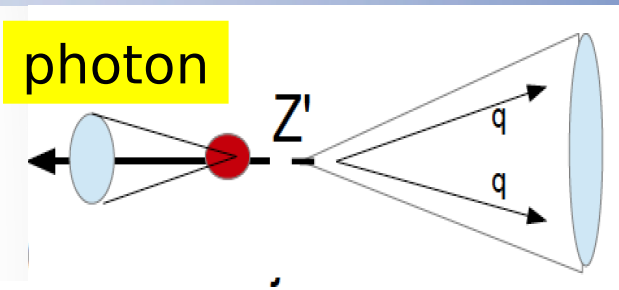
See:1810.09429

Limits on physics scenarios

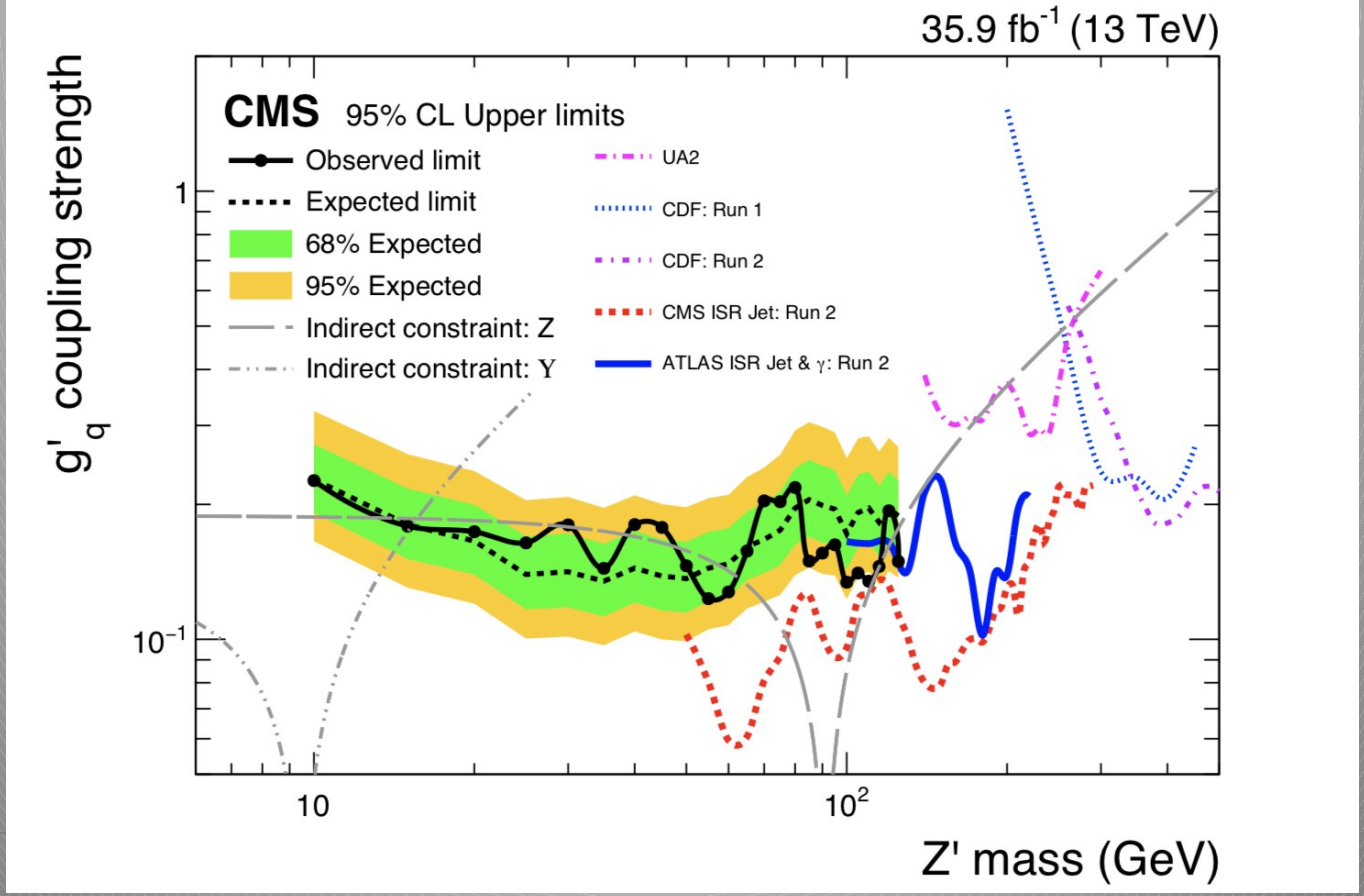
Model	Final State	Observed (expected) mass limit [TeV] 36 fb^{-1} 13 TeV	137 fb^{-1} 13 TeV
String	qg	7.7 (7.7)	7.9 (8.1)
Scalar diquark	qq	7.2 (7.4)	7.5 (7.9)
Axigluon/coloron	$q\bar{q}$	6.1 (6.0)	6.6 (6.4)
Excited quark	qg	6.0 (5.8)	6.3 (6.2)
Color-octet scalar ($k_s^2 = 1/2$)	gg	3.4 (3.6)	3.7 (3.9)
W'	$q\bar{q}$	3.3 (3.6)	3.6 (3.9)
Z'	$q\bar{q}$	2.7 (2.9)	2.9 (3.4)
RS Graviton ($k/M_{PL} = 0.1$)	$q\bar{q}$, gg	1.8 (2.3)	2.6 (2.6)
DM mediator ($m_{DM} = 1$ GeV)	$q\bar{q}$	2.6 (2.5)	2.8 (3.2)

Search for Di-jet Resonances

Access LOWER dijet invariant masses via initial state radiation for the trigger: eg a high p_T photon

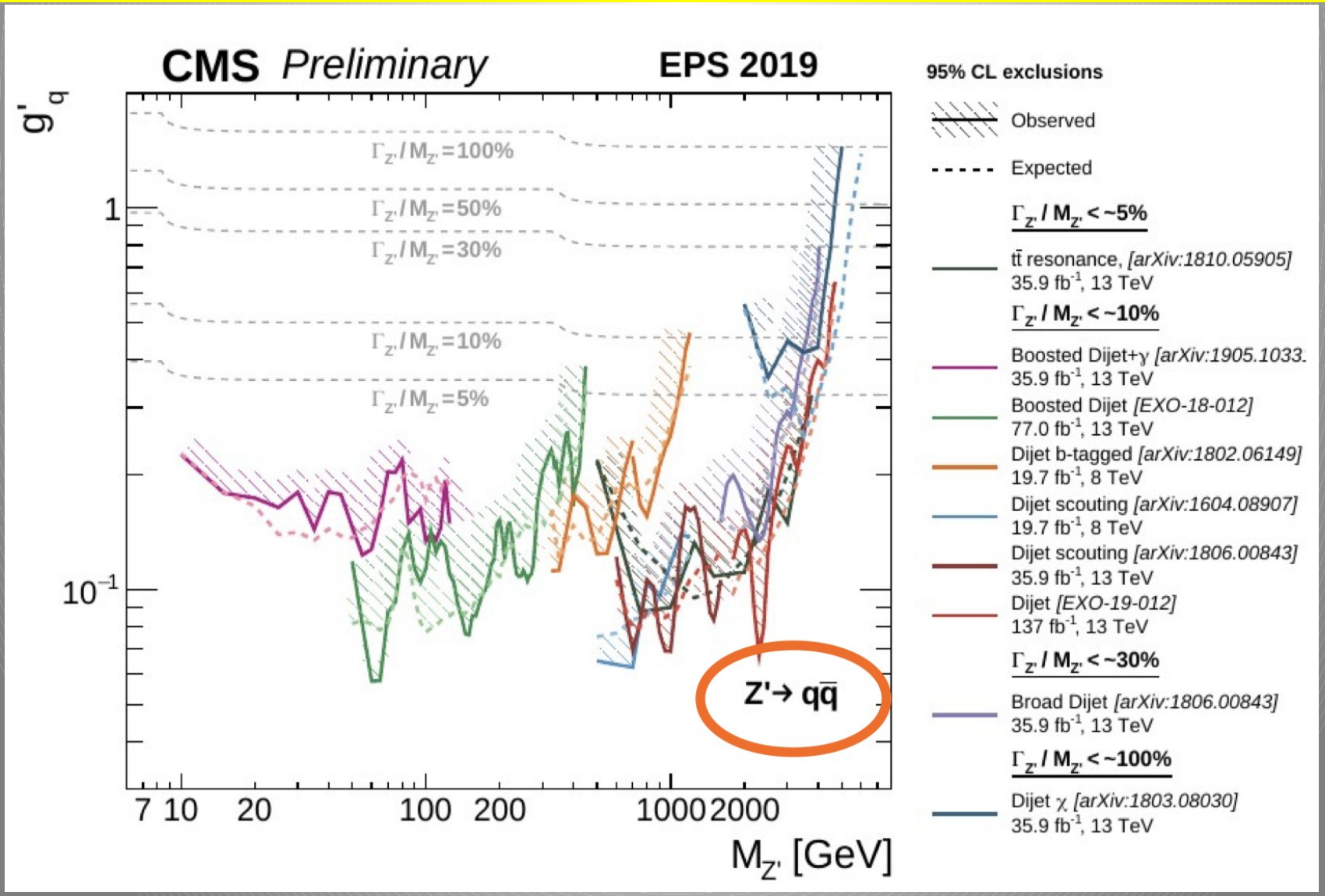


arXiv:1905.10331



Access to Lower Mass Region

Using Initial State Radiation/Boosted and data scouting techniques

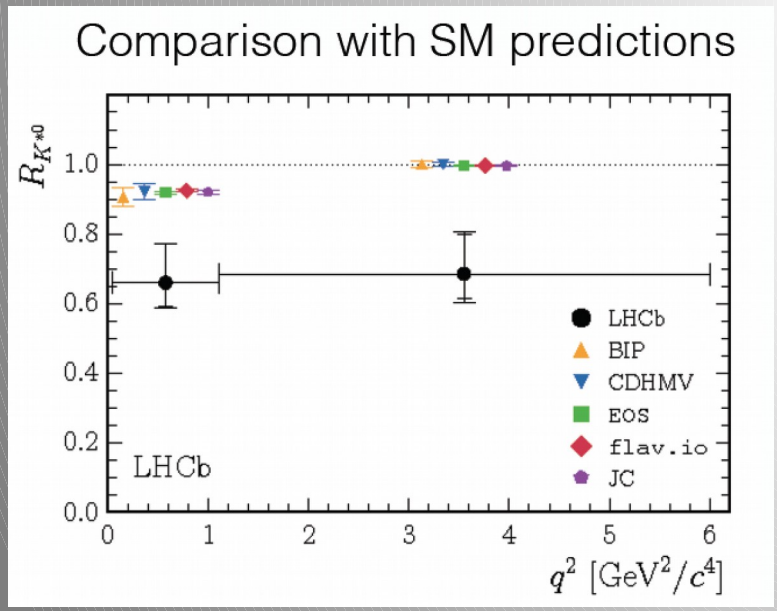


LHCb: Tests of Lepton Universality

A few puzzling results from the LHCb experiment…

Comparing the rates of $B \to H\mu^+\mu^-$ and $B \to He^+e^-$

$H = K, K^*, \phi, \ldots$



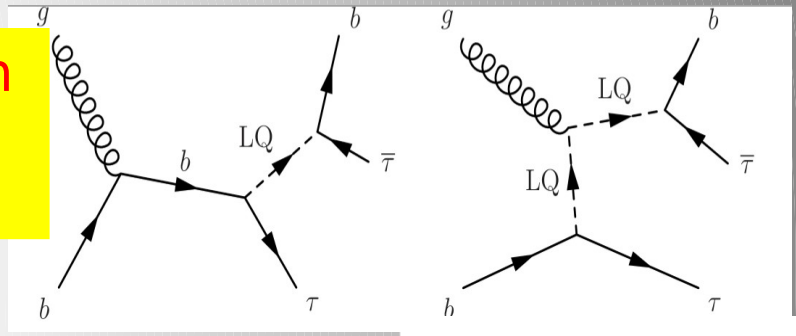
If confirmed, independent checks
will become very important.
Belle II? ->in a few years form now

CMS has installed a special trigger to collect an unbiased b-sample which is active since 2018
-> more than 10^{10} b-pairs collected
during 2018 via parked data stream!

rst LHCb run-2 results did not yet

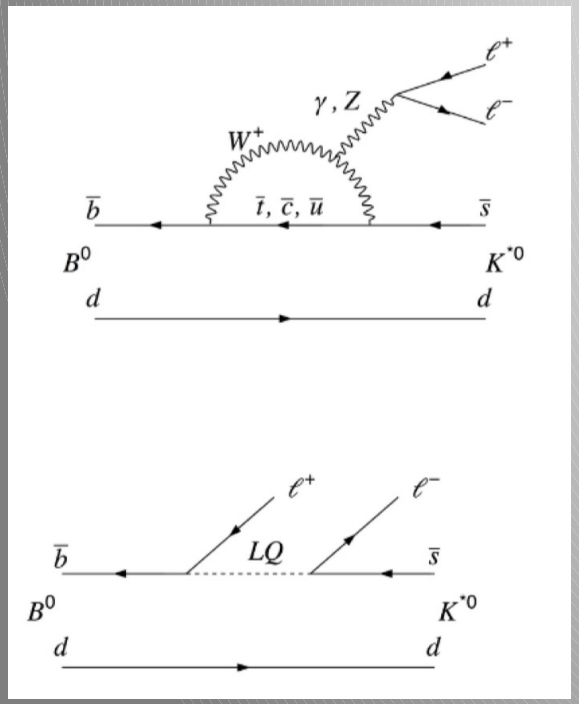
Third Generation Leptoquarks

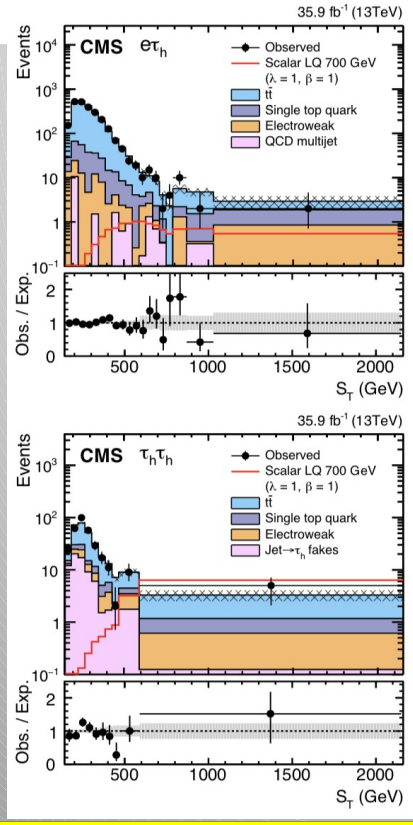
Candidate explanation: Leptoquarks with couplings to second/third generation.
-> Check in ATLAS and CMS

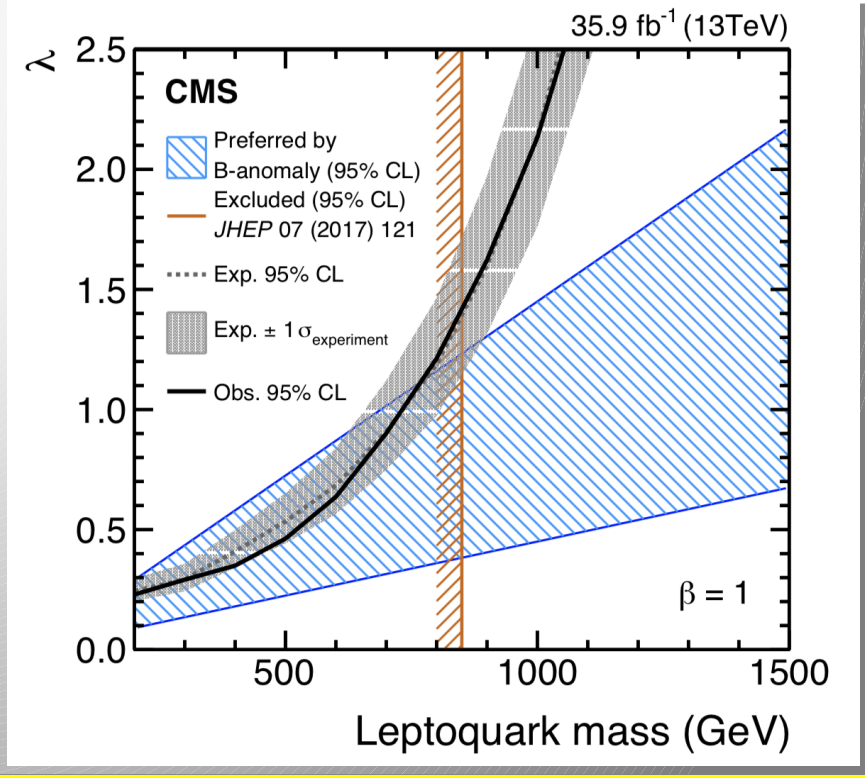


arXiv:1806.03472

Example search in the tau-b final state

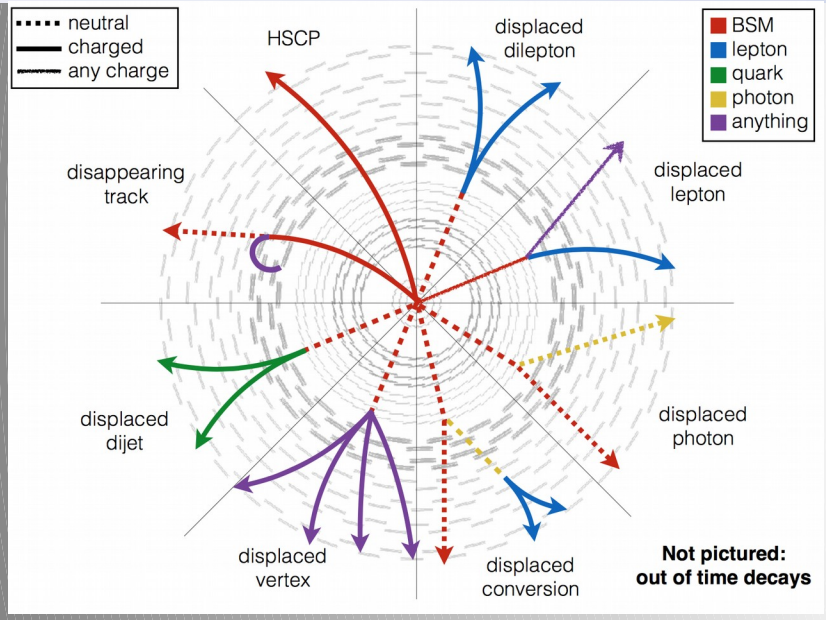






Blue region is preferred by the B-anomalies...

Searches for Long Lived Particles

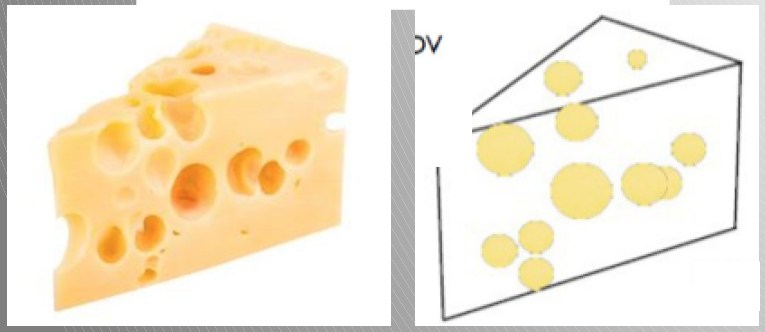


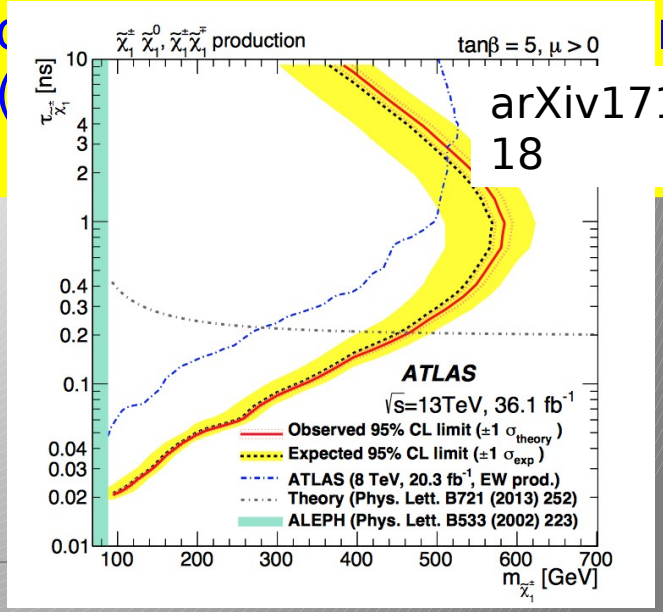
Increasing interest and effort:
Look for unusual signals in the detector from long-lived particles

- Example disappearing tracks ->
- Search for charginos, almost

nos

Present coverage?



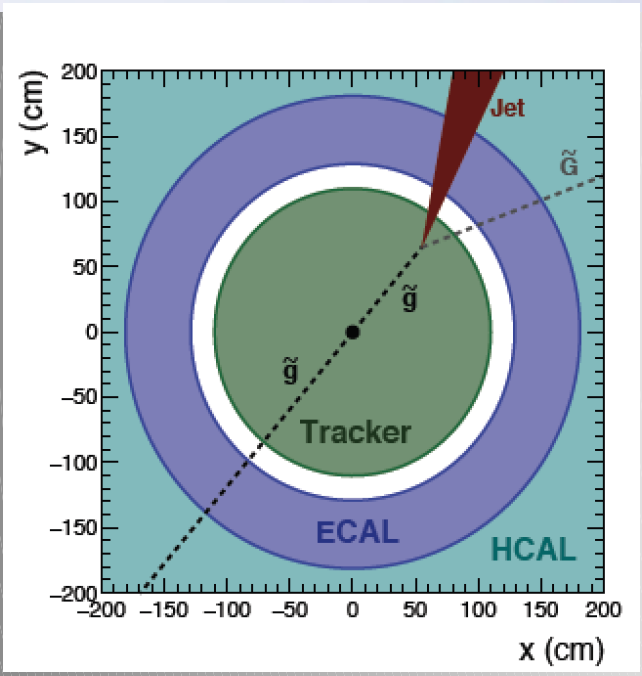


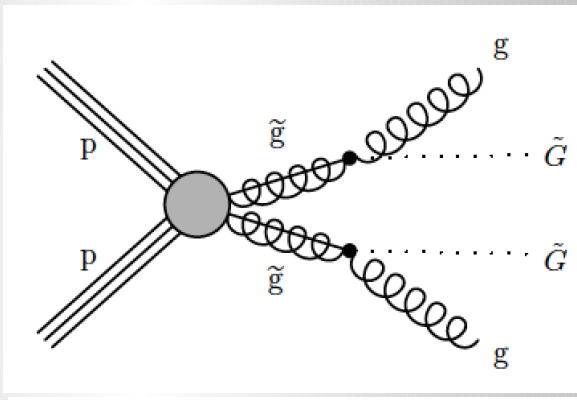
arXiv1712.02118

LHC-wide organized study ->
https://indico.cern.ch/e/LHC_LLP_October_2017

A White Paper in preparation!

Search for Delayed Jets

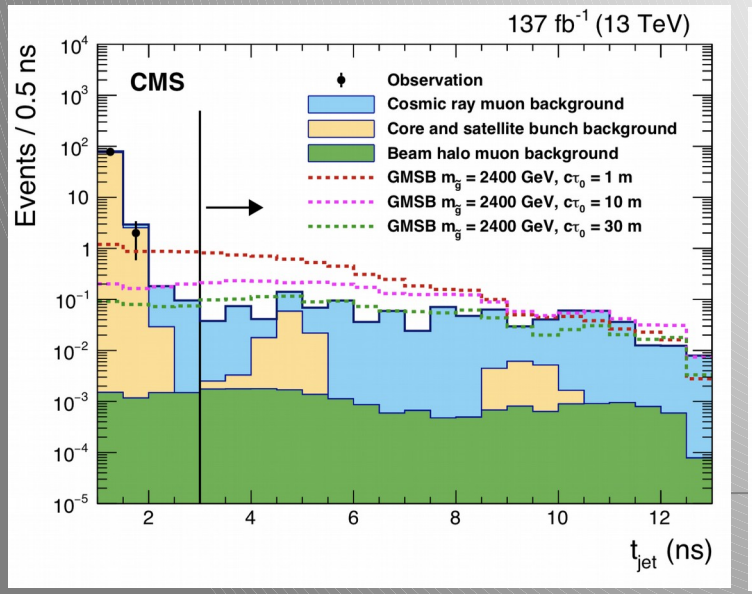


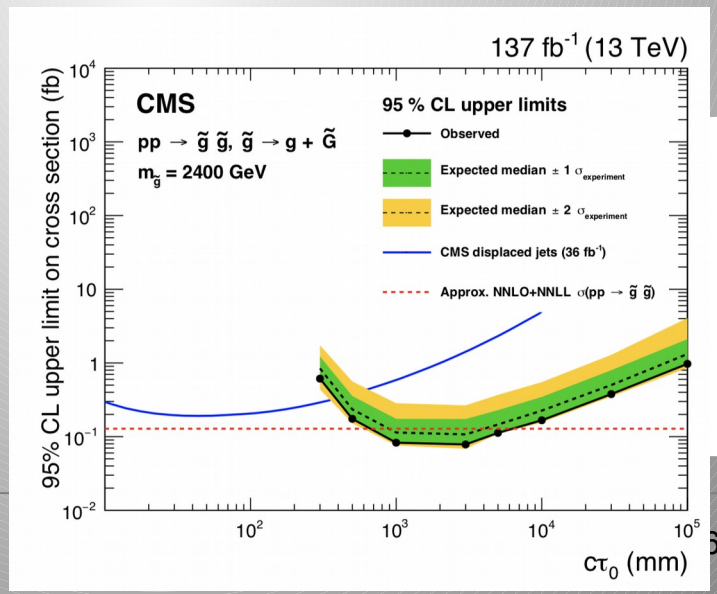


arXive:1906.06441

Background	Prediction
Beam halo	$0.02^{+0.06}_{-0.02}$ (stat) $^{+0.05}_{-0.01}$ (syst)
Core and satellite bunches	$0.11^{+0.09}_{-0.05}$ (stat) $^{+0.02}_{-0.02}$ (syst)
Cosmics	$1.0^{+1.8}_{-1.0}$ (stat) $^{+1.8}_{-1.0}$ (syst)

-Using the ECAL precision timing ~200 ps
-Search for jets not connected to the primary vertex
-Data driven back-ground estimate

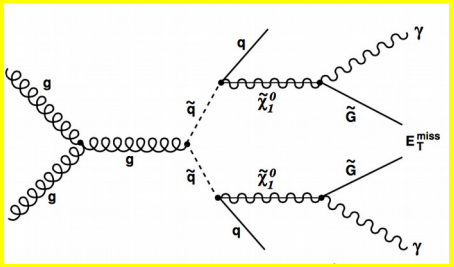


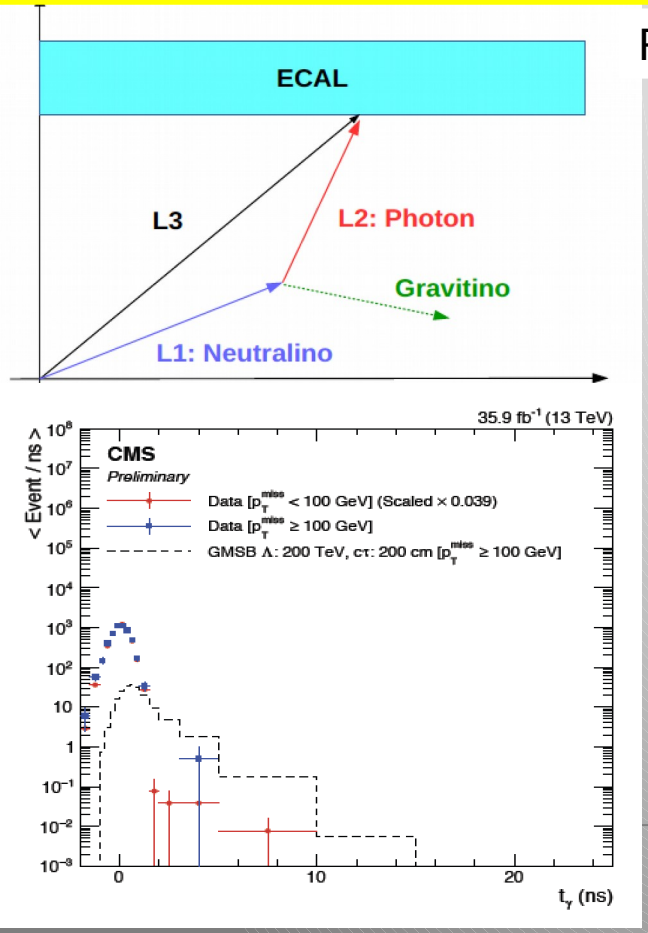


GMSB long-lived gluino model search. Mass limits up to 2500 GeV

Displaced Photons

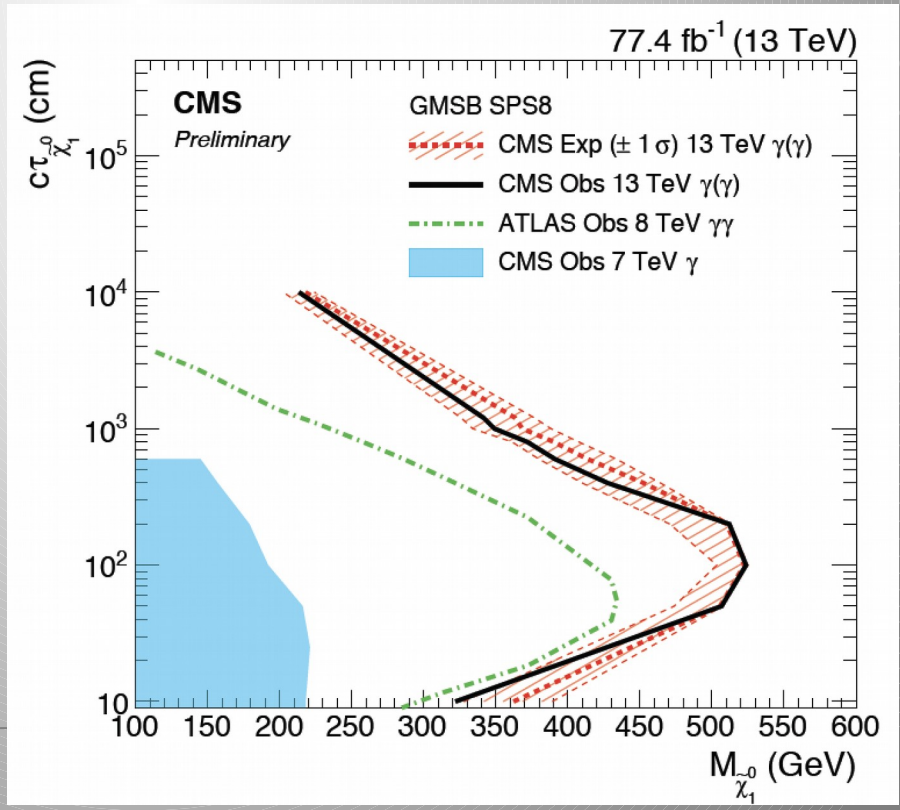
search for long-lived neutral particles decaying to photons, using precis
ming in the ECAL. Eg in GMSB models: $\tilde{\chi}_1^0 \rightarrow \gamma + \tilde{G}$
vens with two photons with p_T> 70 GeV, 3jets
ith p^T> 30 GeV
se timing and shower shape discrimination





Resolution ~ 200 ps

EXO-19-005

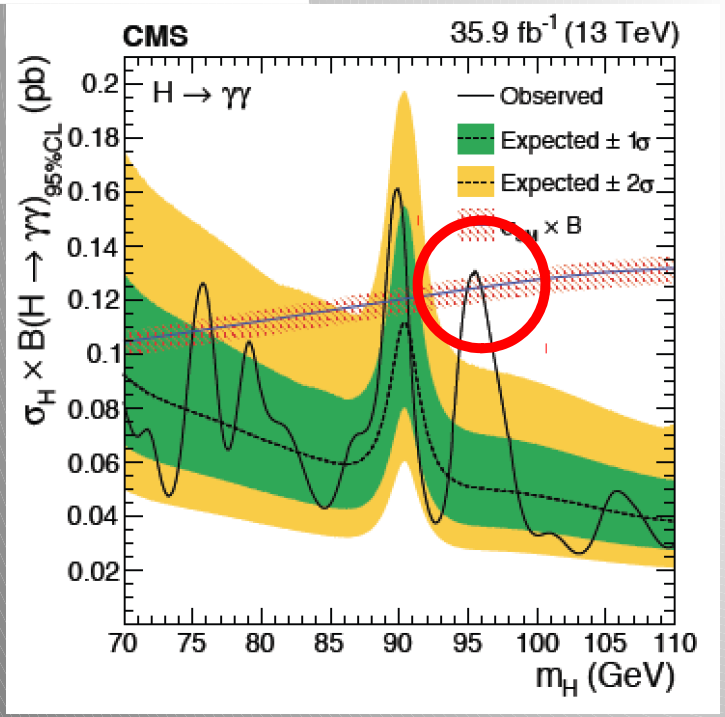


Low Mass Diphoton Spectrum

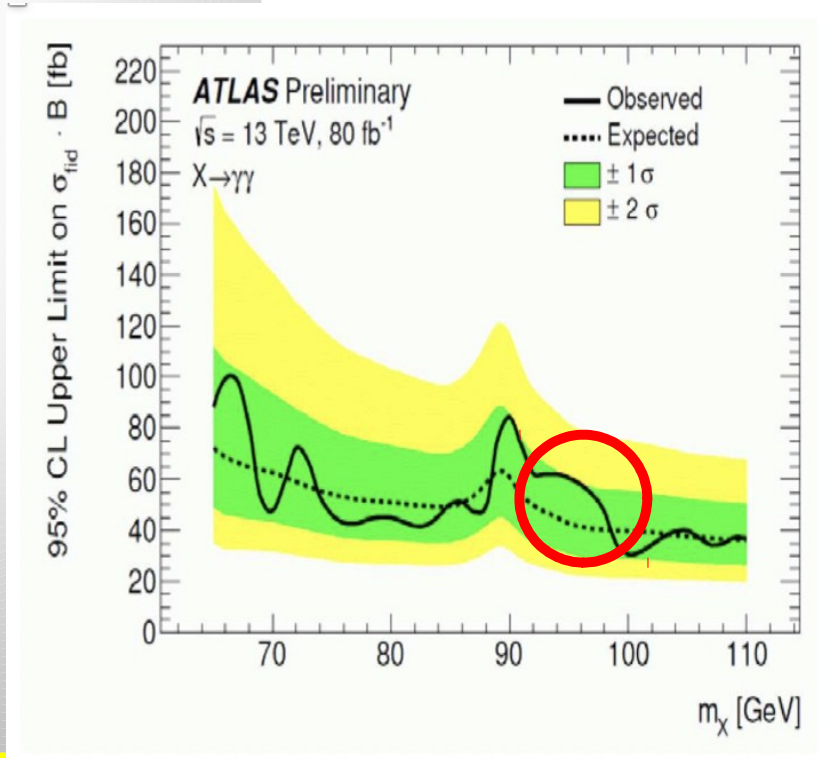
A search for X->γγ at low mass

An excess is observed in the 8 TeV data (2σ at 97.6 GeV) and 13 TeV (2.9σ at 95.3 GeV) -> Combined gives a 2.8σ local excess at 95.3 GeV

arXiv:1811.08459



ATLAS-CONF-2018-025



Probably not ⊣ … ATLAS does not see the same size of effect… Let's see with more data in future…

Search for New Resonances

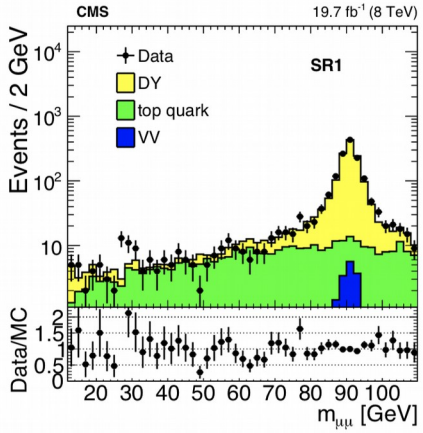
arXiv:1808.01890

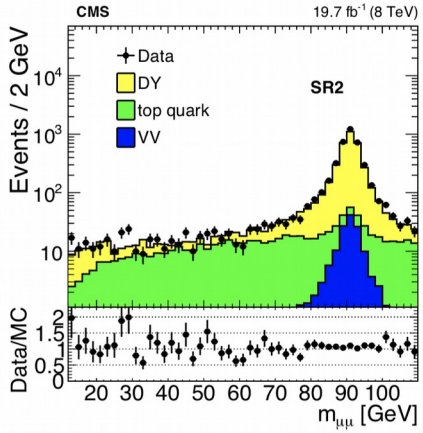
NMSSM Higgs inspired search in mass range 12-70 GeV

-Search for bump in muon pair mass spectrum with associated b-jets

-SR1: 2 muons + one central and one forward jets ($|\eta| > 2.4$), at least 1 b

-SR2: 2 muons + 2 central and no forward jets, at least 1 b

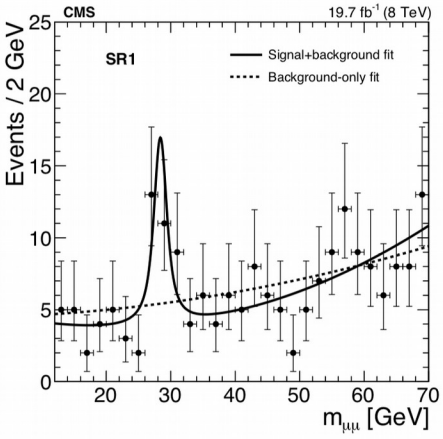


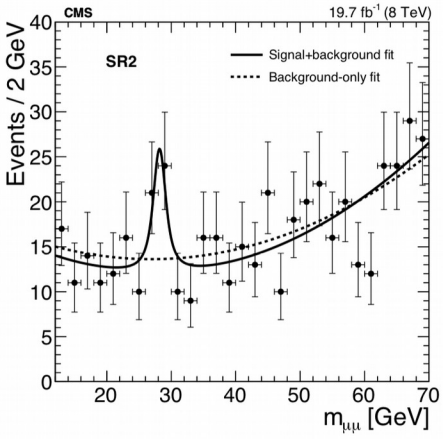


8 TeV Data

Both regions are independent

Excess seen in the both regions around 28 GeV





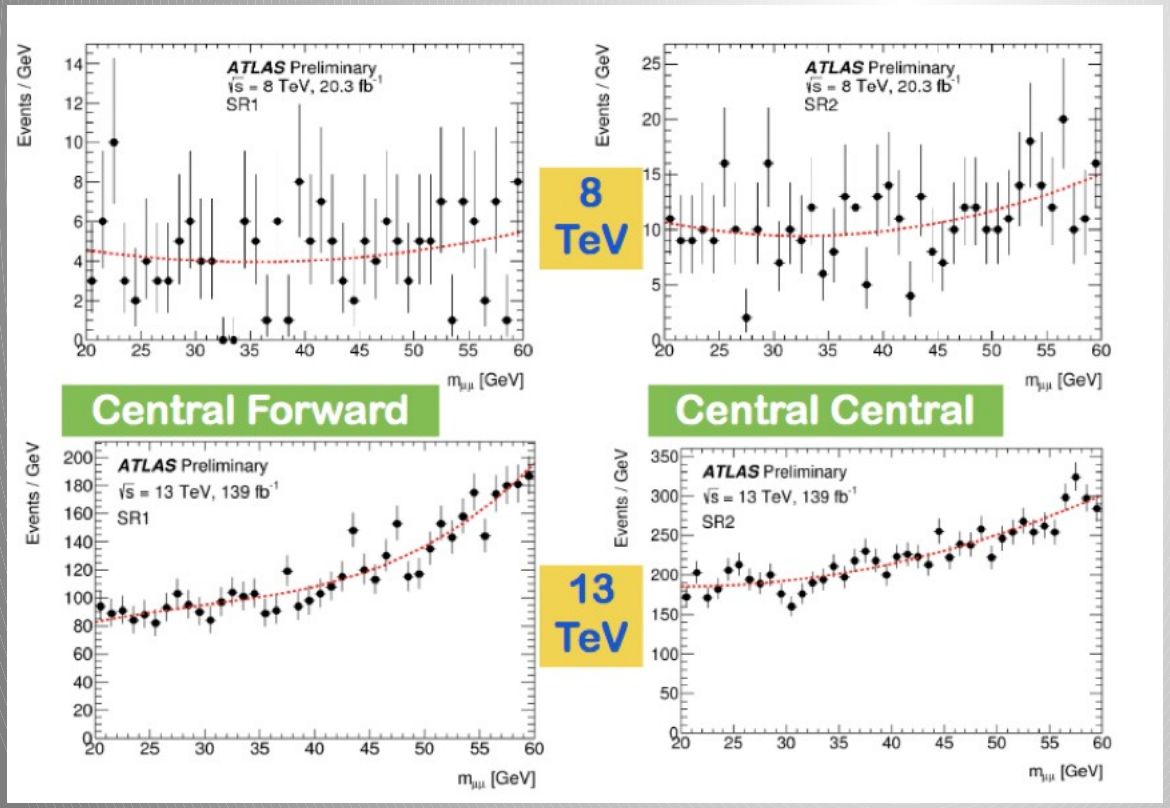
SR1: 4.2σ local significance
(~3.0σ global sign.)
SR2: 2.9σ local significance

No significant excess at 13 TeV
What does ATLAS say?

Search for New Resonances

ATLAS-CONF-2019-36

ATLAS search in this channel



ATLAS: 2 OS μ (leading μ p_T>27 GeV) two SR: one jet barrel one endcap or two in barrel)

No Significant Excess

Local significance and max significance 26-30 GeV in steps of 0.5 GeV

	8 TeV		13 TeV	
Region	SR1	SR2	SR1	SR2
Local significance (28 GeV)	0.5	0.5	0.7	0.2
Max. significance	0.9 (29.5 GeV)	1.1 (29.5 GeV)	0.8 (27.5 GeV)	2.1 (26 GeV)

Summary

- Measurements of Standard Model processes show good agreement with predictions. Precise measurements require precise calculations. New rare processes measured.
- Higgs measurements at 13 TeV. So far the Higgs is very consistent with SM expectations. All main decay and production channels now observed. More precision with run-2.
- No sign of new physics in the 13 TeV data so far in run-2… Many analyses now with full run-2 statistics already,
- Dark Matter and Long Lived Particle searches are being explored in a systematic way. White paper arXiv:1903.04497
- New physics in the flavour sector? New TH para
- The LHC is continuing to explore the Terascale. significant deviation to show the way!!

And hopefully one day soon: