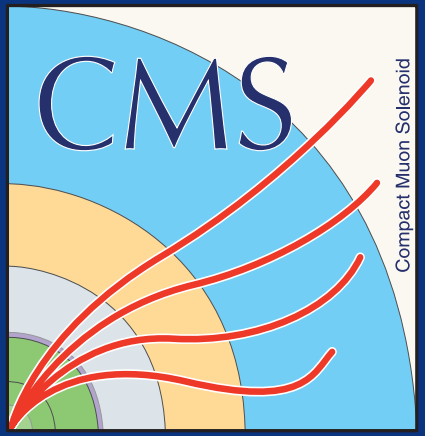
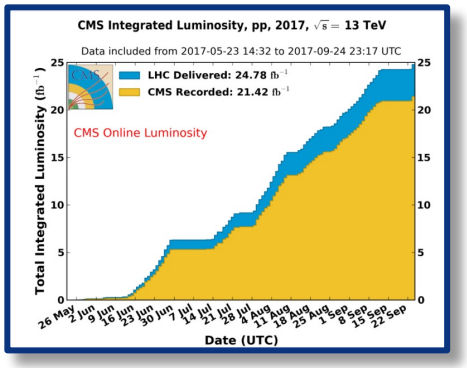
CMS
Status Report



G. Dissertori*
SPC Meeting
CERN
25.09.2017

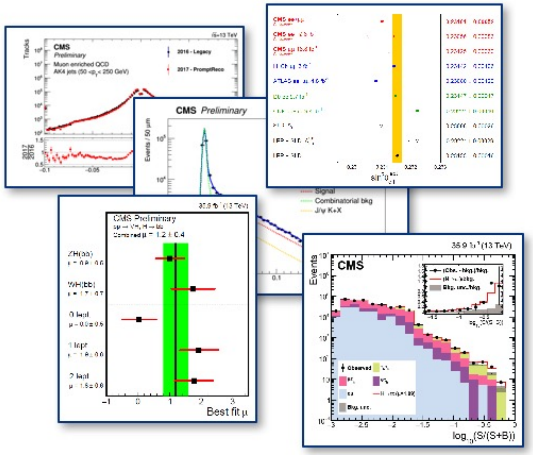
*ETH Zurich

Contents

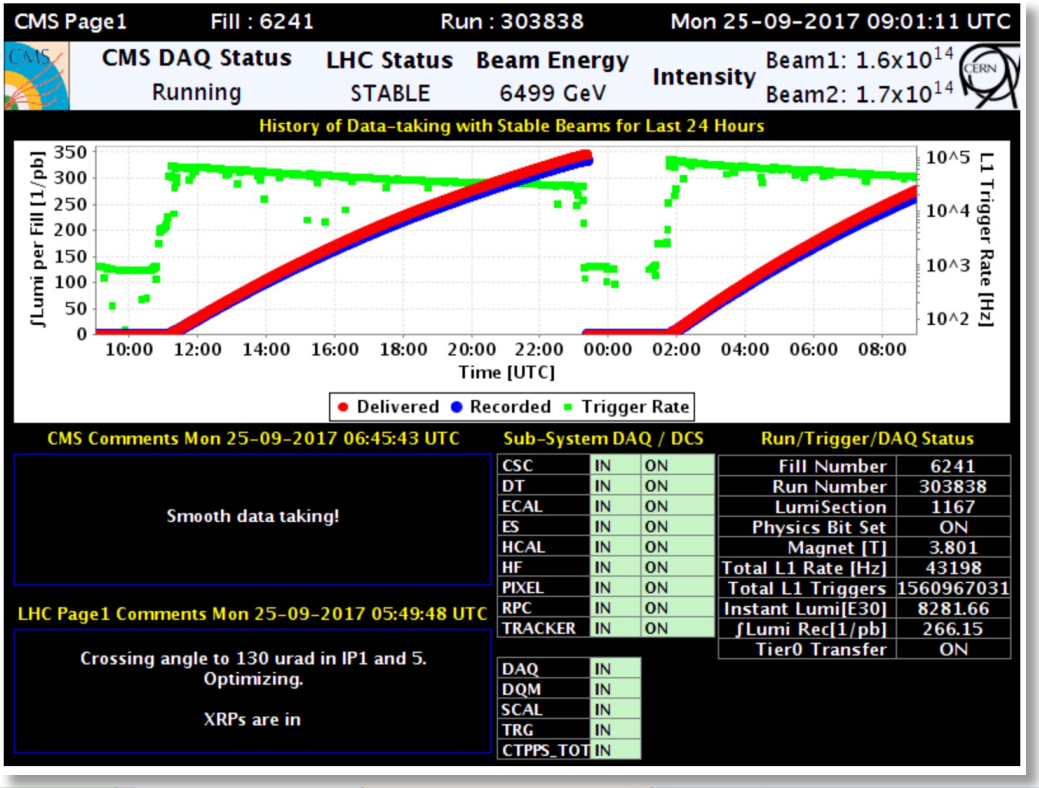


Operations

Physics Highlights

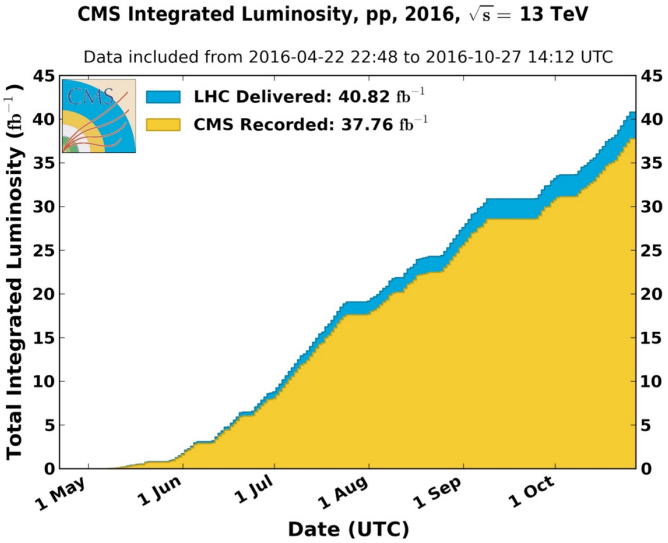


Operations


CMS Page1
Fill : 6241
Run : 303838
Mon 25-09-2017 09:01:11 UTC
CMS DAQ Status
Running
LHC Status
STABLE
Beam Energy
6499 GeV
Intensity
Beam1: 1.6x10^14
Beam2: 1.7x10^14
History of Data-taking with Stable Beams for Last 24 Hours
∫Lumi per Fill [1/pb]
L1 Trigger Rate [Hz]
Time [UTC]
Delivered
Recorded
Trigger Rate
CMS Comments Mon 25-09-2017 06:45:43 UTC
Smooth data taking!
LHC Page1 Comments Mon 25-09-2017 05:49:48 UTC
Crossing angle to 130 urad in IP1 and 5.
Optimizing.
XRPs are in
Sub-System DAQ / DCS
CSC IN ON
DT IN ON
ECAL IN ON
ES IN ON
HCAL IN ON
HF IN ON
PIXEL IN ON
RPC IN ON
TRACKER IN ON
DAQ IN
DQM IN
SCAL IN
TRG IN
CTPPS_TOT IN
Run/Trigger/DAQ Status
Fill Number 6241
Run Number 303838
LumiSection 1167
Physics Bit Set ON
Magnet [T] 3.801
Total L1 Rate [Hz] 43198
Total L1 Triggers 1560967031
Instant Lumi[E30] 8281.66
∫Lumi Rec[1/pb] 266.15
Tier0 Transfer ON

Data taking in 2016

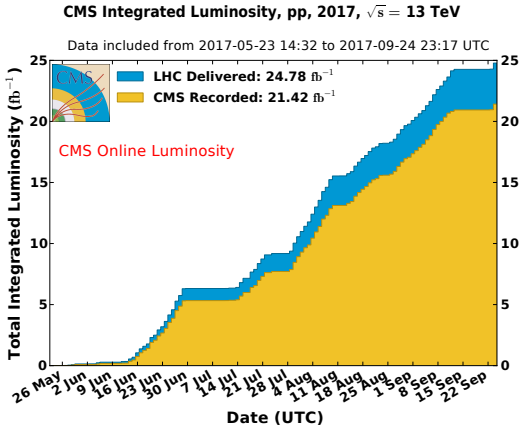
- LHC has exceeded design luminosity
  - 2016 maximum peak lumi 1.5×10^{34} cm^{-2} s^{-1} **with pileup ~ 45**
  - With 2208 colliding bunches
- LHC had much higher availability, ~50%, than expected
- CMS recording efficiency held steady at **92.5%**
- Each CMS sub- detector had **>96%** of all channels working

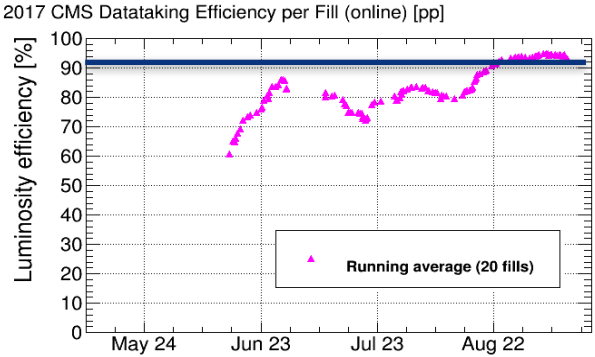


Data validated for all detectors is ~95% of the data recorded ➜ **35.9 fb^{-1} to analyze**

Data taking in 2017

- The recording efficiency so far **for all 2017** is ~88%, as compared to 92.5% for 2016.
  - **This reflects the period of commissioning the new pixel detector, addressing a number of unexpected issues.**
- This has improved lately, albeit at "low" luminosity running of ~ $1x10^{34}cm^{-2}s^{-1}$, to **~94%**
  - Pixels are no longer the big contributor to downtime
- **Further upgrades in 2017 (besides the Pixel system):**
  - Forward Hadron Calorimeter (HF) readout
  - One phi-wedge of HCAL Endcap (HPDs → SiPMs)

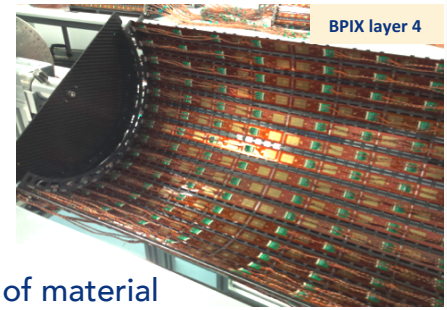


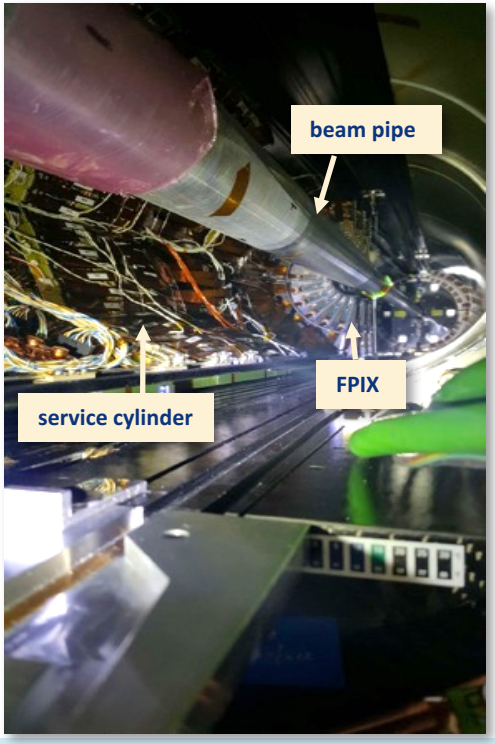


A New Pixel Detector

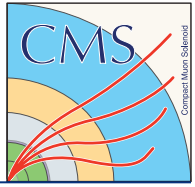
New pixel detector installed in EYETS 2016/17
twice number of channels & active area ($2m^2$)

- Number of barrel layers 3 ➔ 4 and 2 ➔ 3 in endcaps
  ➢ more robust tracking & seeding
- Innermost layer moved closer to beam pipe (4.4cm ➔ 2.9cm)
  ➢ improved vertex reconstruction and b-tagging
- New readout chips for barrel layers 2-4 + FPIX (PSI46dig) and barrel layer 1 (higher rates, PROC600)
  ➢ less dynamic inefficiency at high instantaneous luminosity
- DC-DC conversion powering system & CO_2 cooling system
- New μTCA DAQ system
- Significantly reduced amount of material





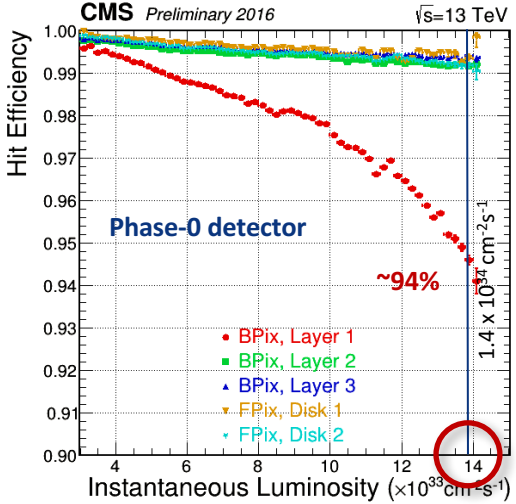
Pixel Detector Performance

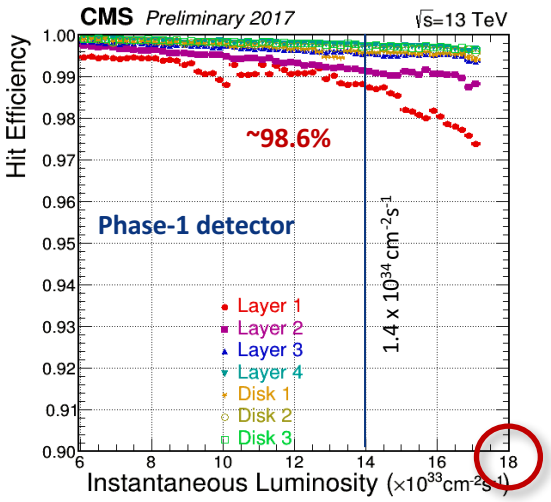


- **~95% good channels**, losses mainly due to few power & readout groups
- **Resolutions** in L2-4 & FPIX match simulations (eg. σ~12 μm in barrel layer 3)

Pixel Detector Performance

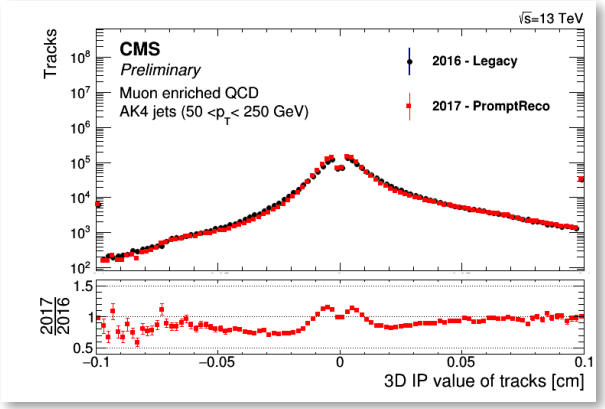
- **~95% good channels**, losses mainly due to few power & readout groups
- **Resolutions** in L2-4 & FPIX match simulations (eg. σ~12 μm in barrel layer 3)
- Significant **reduction of dynamic inefficiency** at high inst. luminosity compared to old detector, with layer 1 closer to beampipe!
- Readout bandwidth **sufficient up to a PU of ~80**





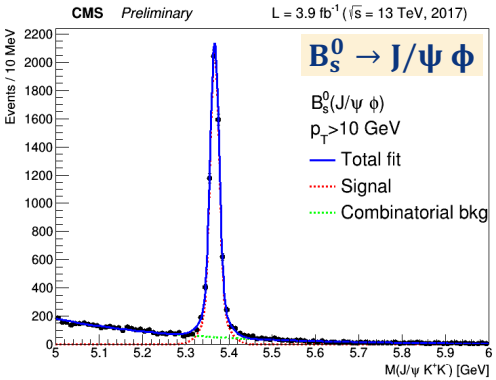
Vertexing and B Physics Performance

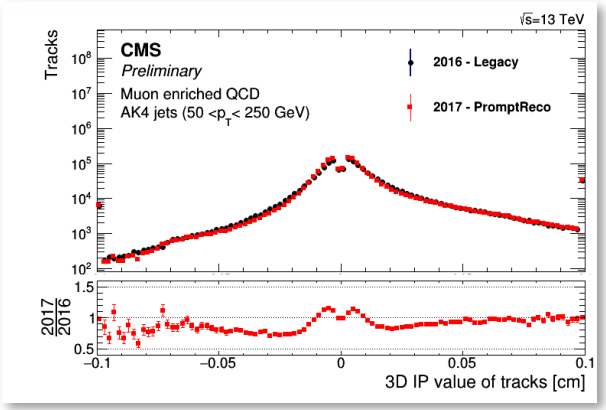
- **Vertexing and b-tagging as good as ultimate 2016** performance, despite higher instantaneous luminosity, and not yet fully optimized settings & reconstruction SW – further improvements expected
- Performance of barrel layers 2-4 and FPIX as envisaged

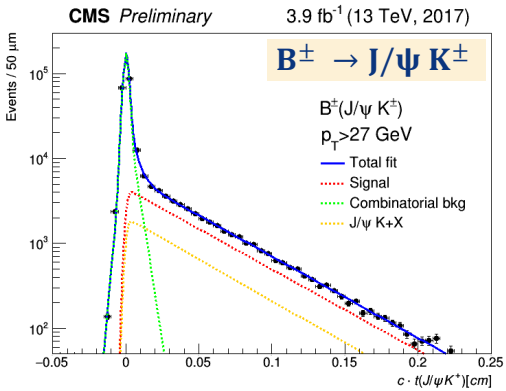


Vertexing and B Physics Performance

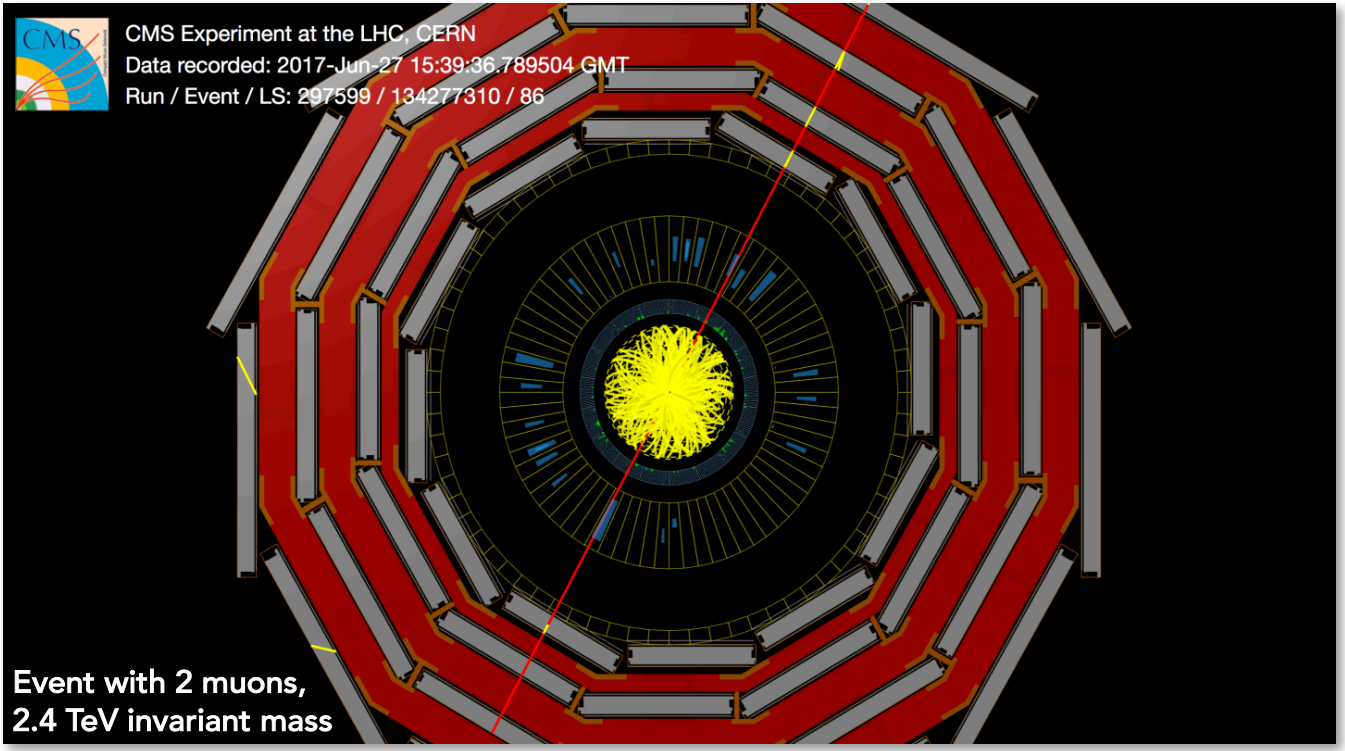
- **Vertexing and b-tagging as good as ultimate 2016** performance, despite higher instantaneous luminosity, and not yet fully optimized settings & reconstruction SW – further improvements expected
- Performance of barrel layers 2-4 and FPIX as envisaged
- Work in progress to improve further the performances of Layer 1, despite of some shortcoming of the layer 1 chip
  - Higher than expected threshold & dynamic inefficiency





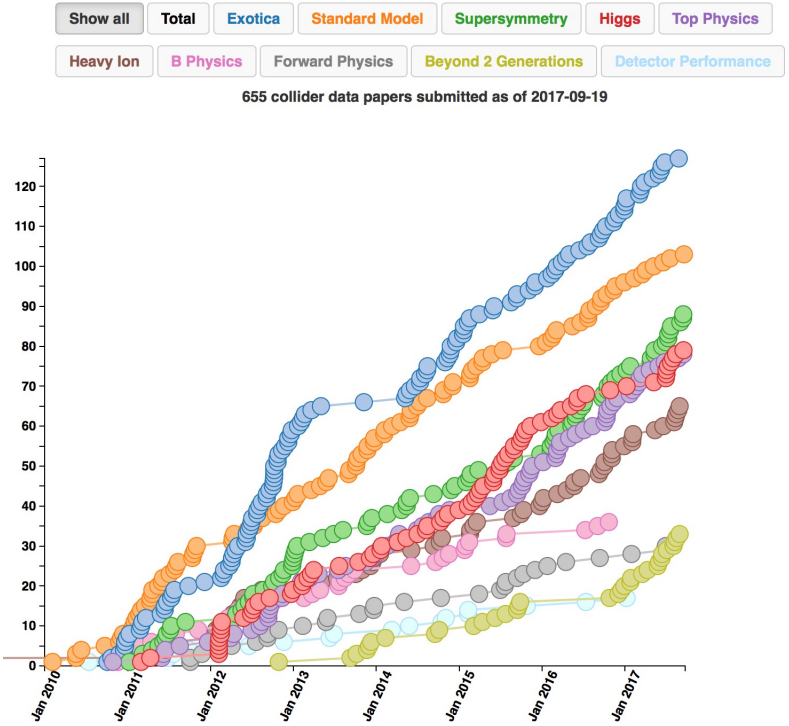


Physics Highlights

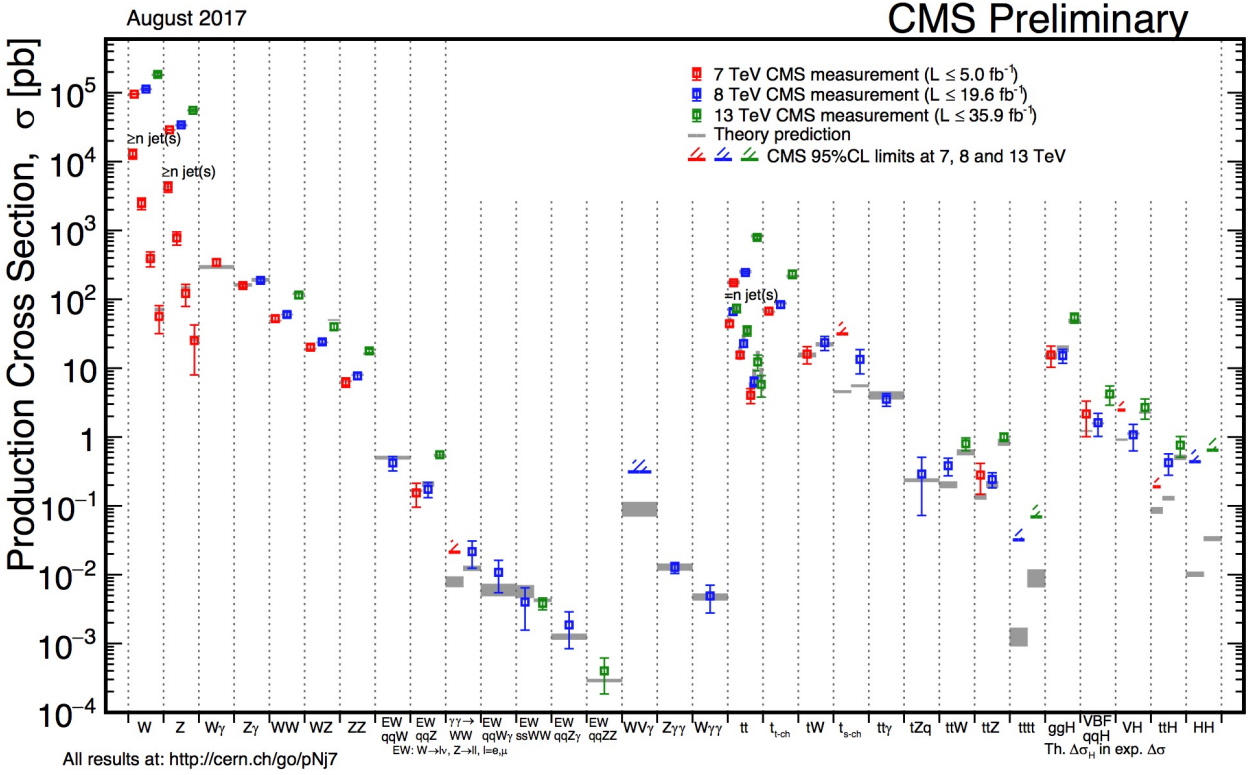


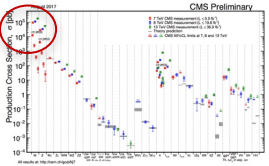
Overview on Publications

- Remarkable output of physics publications
- **655 publications in total** (on collider data)
- Many new results with full 2016 13TeV data set
- Some selected (very) recent highlights in the following



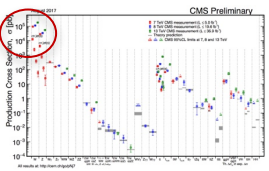
Stairway to…


August 2017
CMS Preliminary
Production Cross Section, σ [pb]
7 TeV CMS measurement (L ≤ 5.0 fb⁻¹)
8 TeV CMS measurement (L ≤ 19.6 fb⁻¹)
13 TeV CMS measurement (L ≤ 35.9 fb⁻¹)
Theory prediction
CMS 95%CL limits at 7, 8 and 13 TeV
≥n jet(s)
≥n jet(s)
≥n jet(s)
W
Z
Wγ
Zγ
WW
WZ
ZZ
EW qqW
EW qqZ
EW: W→lν, Z→ll, l=e,μ
γγ→ WW
EW qqWγ
EW ssWW
EW qqZγ
EW qqZZ
WVγ
Zγγ
Wγγ
tt
t t-ch
tW
t s-ch
ttγ
tZq
ttW
ttZ
tttt
ggH
VBF qqH
VH
ttH
HH
Th. Δσ_H in exp. Δσ
All results at: http://cern.ch/go/pNj7

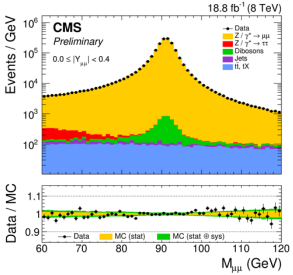


Weak Mixing Angle

- Exploit forward-backward asymmetry A_{FB} in Z/γ^* → ee and μμ Drell-Yan events



Weak Mixing Angle



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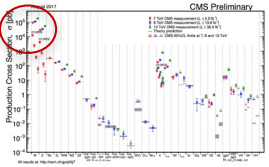

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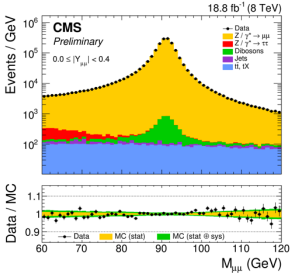
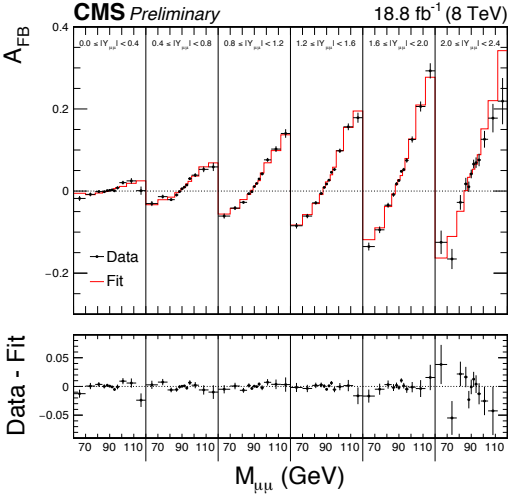
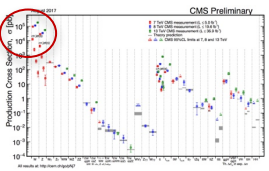
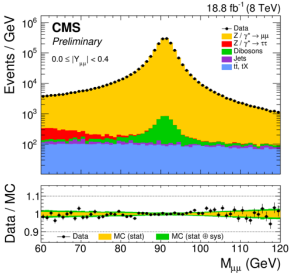


- Exploit forward-backward asymmetry A_{FB} in Z/γ* → ee and μμ Drell-Yan events
- Effective leptonic weak mixing angle $\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$ from minimizing χ^2 between A_{FB} templates and data in **72 bins of dilepton mass and rapidity**





Weak Mixing Angle



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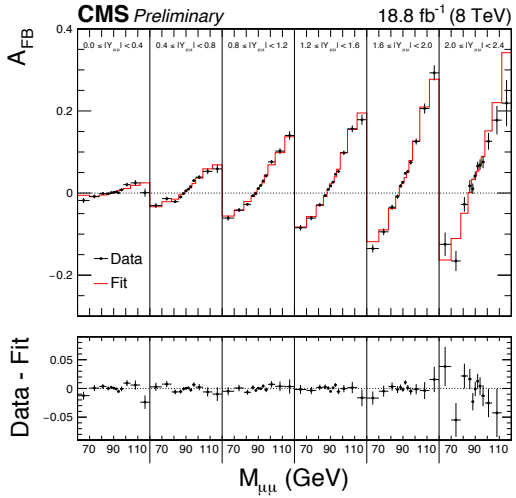
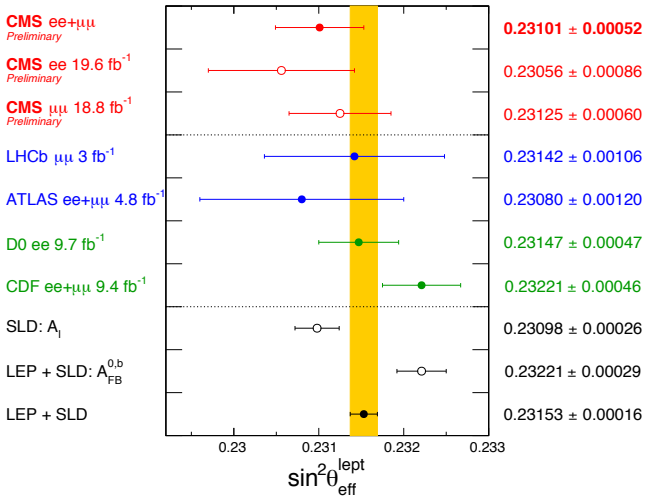
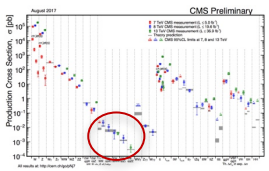
- Effective leptonic weak mixing angle $\sin^2\theta_{\text{eff}}^{\text{lept}}$ from minimizing χ^2 between A_{FB} templates and data in **72 bins of dilepton mass and rapidity**

$$\sin^2\theta_{\text{eff}}^{\text{lept}} = 0.23101 \pm 0.00036\ (\text{stat}) \pm 0.00018\ (\text{syst}) \pm 0.00016\ (\text{theory}) \pm 0.00030\ (\text{pdf}) \quad (\pm 0.00052\ \text{tot})$$

Best LHC measurement so far, approaching precision achieved at the Tevatron



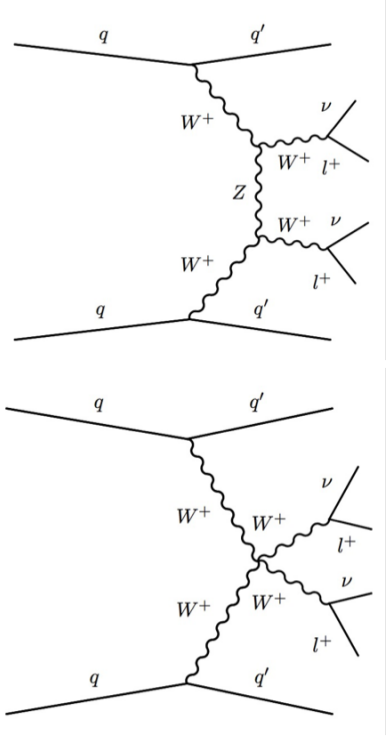


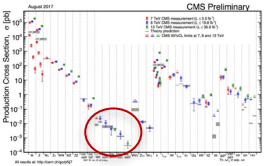


Same-Sign WW prod.

- Search for EWK production of two W bosons of same charge
- Signal: two same-sign leptons and two jets with large rap-separation and large inv. Mass

Submitted to PRL last week!





Same-Sign WW prod.

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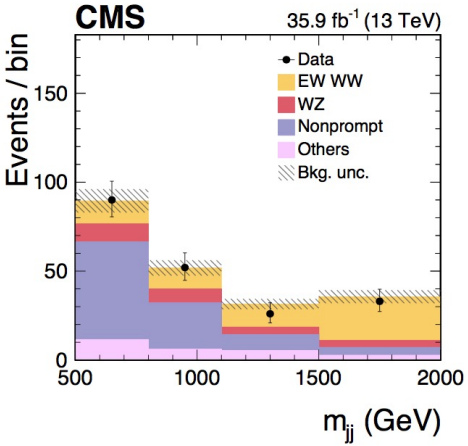
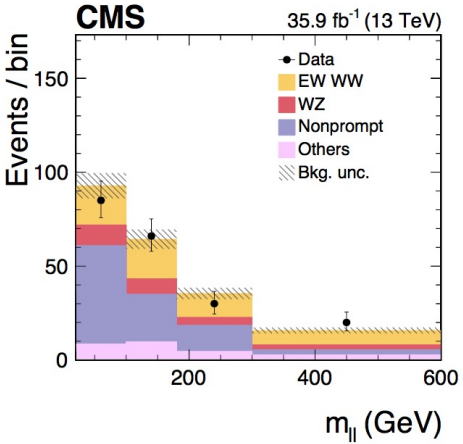
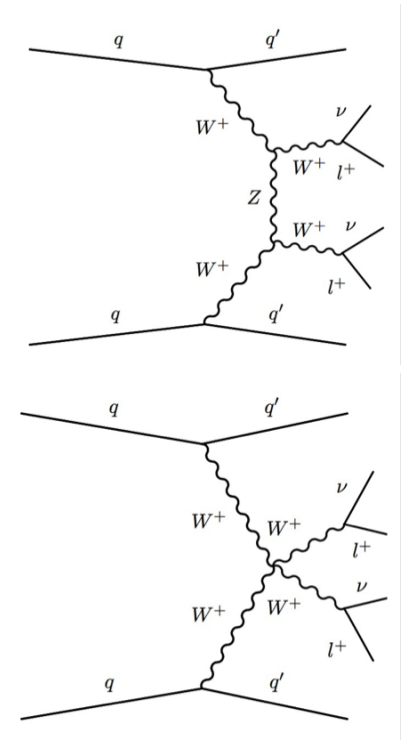
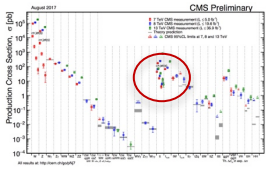
- Search for EWK production of two W bosons of same charge
- Signal: two same-sign leptons and two jets with large rap-separation and large inv. Mass
- **First observation: 5.5 σ (obs), 5.7 σ (exp)**
  fid. cross section in agreement with SM pred. of ~ 4 fb
- Stringent limits on aQGCs and doubly-charged Higgs prod.

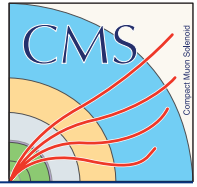






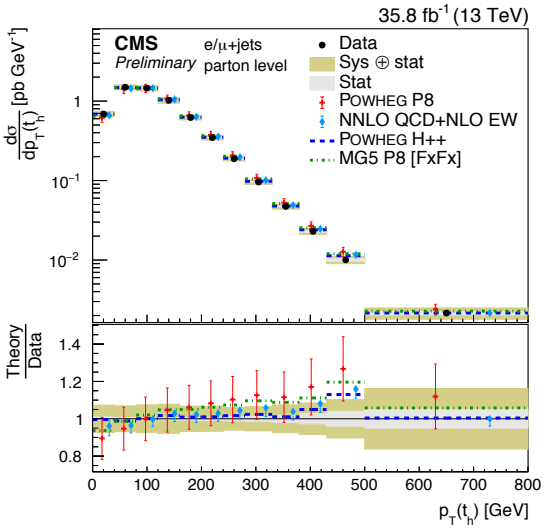


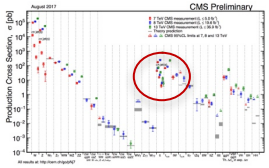
Top quark production



- Recent example from the rich harvesting of top-quark events
- Precise measurements of differential cross sections, as functions of many kin. observables
- Comparisons to modern MC generators

CMS-PAS-TOP-17-002





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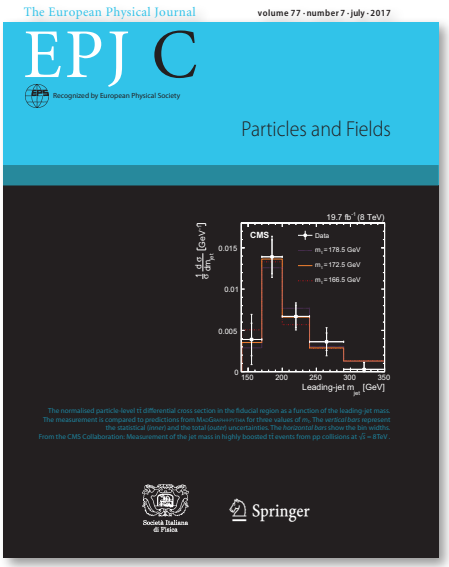
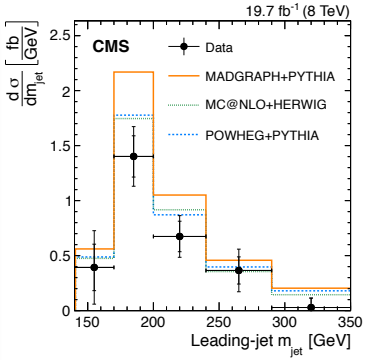
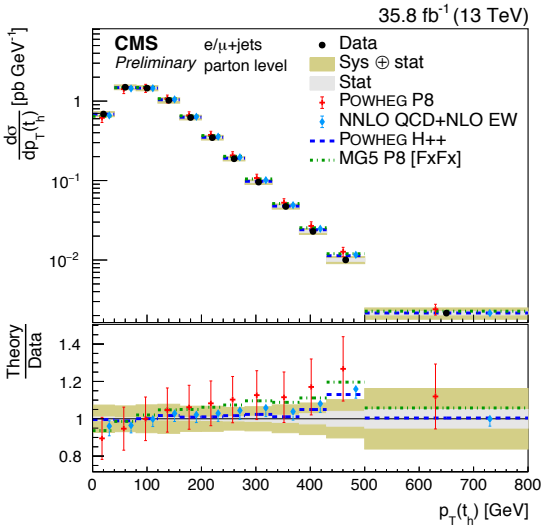
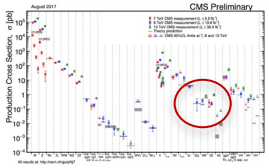
CMS-PAS-TOP-17-002







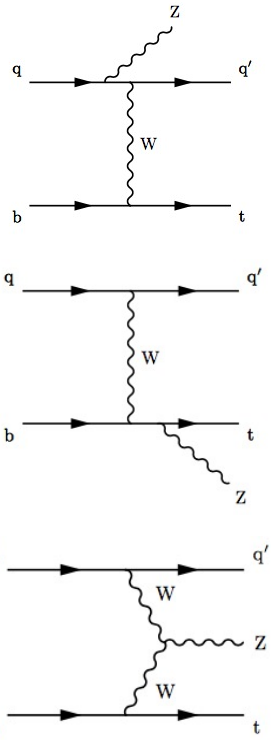
- **First measurement** of the jet mass of the hadr. decaying top quark in highly boosted regime ($p_T > 400$ GeV) !
- Sensitivity to top quark mass
- All these results consistently show **softer top prod.** than predicted by MC generators

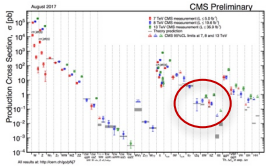


Evidence for tZq prod.

Just released for TOP2017

- Rare SM process (~120 fb)
- Sensitive to **t-Z coupling**, **FCNCs**, **triple WWZ** coupling
- Signal: 3 leptons and at least 2 jets

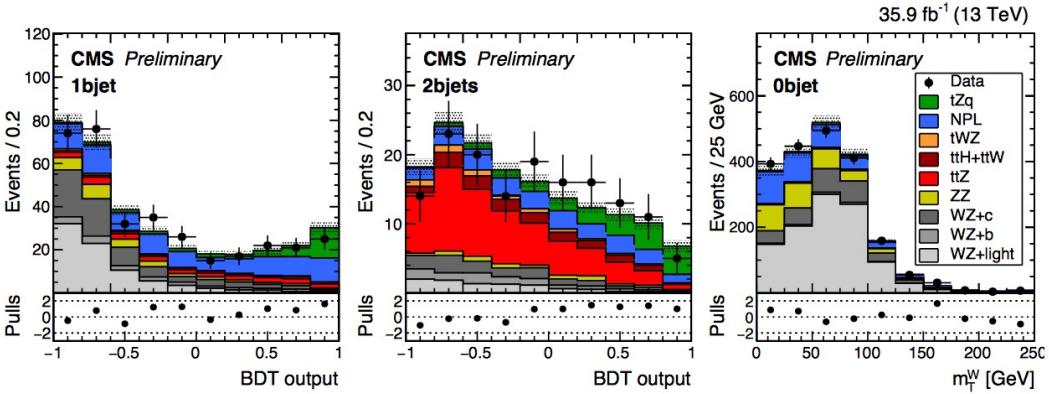


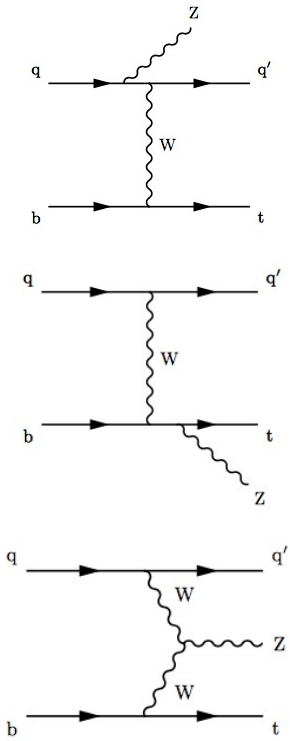


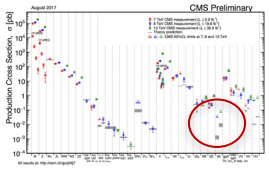
Evidence for tZq prod.

Just released for TOP2017

- Rare SM process (~120 fb)
- Sensitive to **t-Z coupling**, **FCNCs**, **triple WWZ** coupling
- Signal: 3 leptons and at least 2 jets
- **Evidence: 3.7 σ (obs), 3.1 σ (exp)**

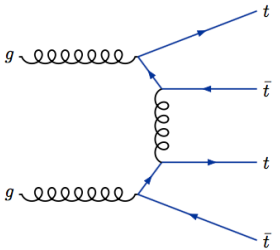


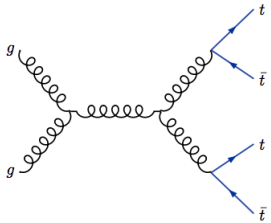


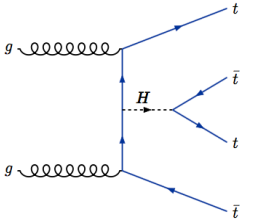


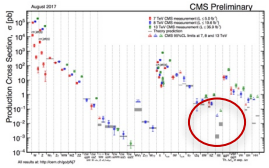
4 top quarks production

- Even rarer SM process (~10 fb)
- Sensitive to **ttH coupling**, enhancement in many BSM models
- Signal: 2 same-sign or at least 3 leptons
  - jet multiplicty and flavour enhance signal sensitivity
  - nice “spin-off” of a BSM search









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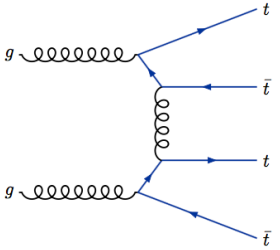
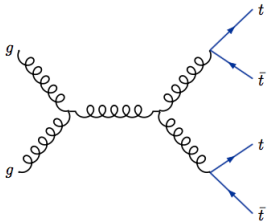
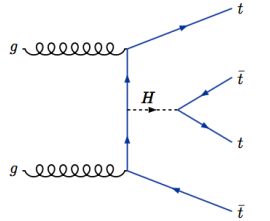
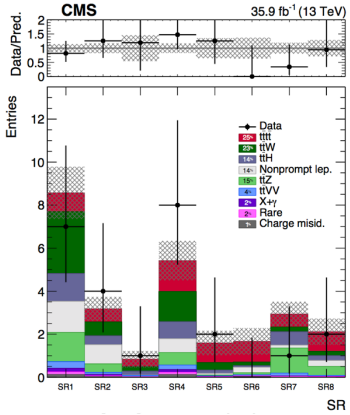
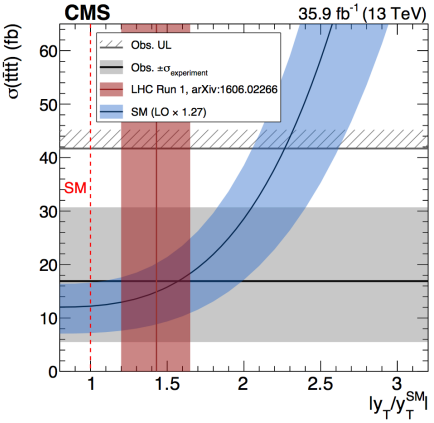
- Sensitive to **ttH coupling**, enhancement in many BSM models
- Signal: 2 same-sign or at least 3 leptons
  - jet multiplicty and flavour enhance signal sensitivity
  - nice “spin-off” of a BSM search
- **1.6 σ significance, meas. cross section agrees with SM pred.**









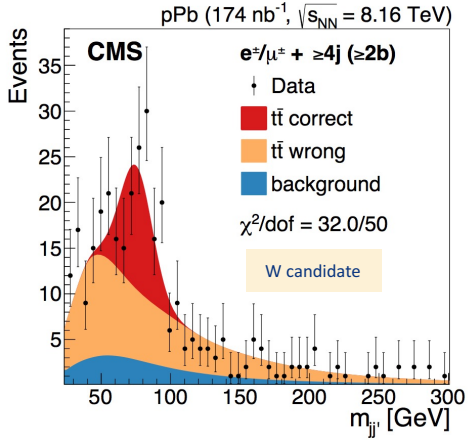


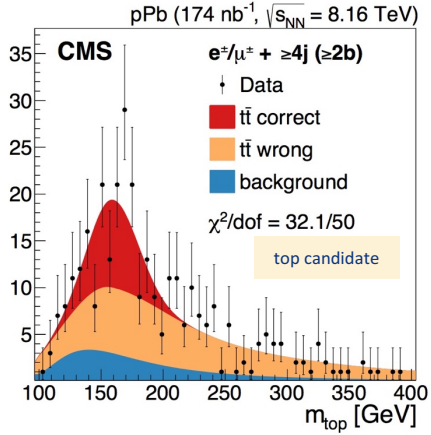
Intermezzo:

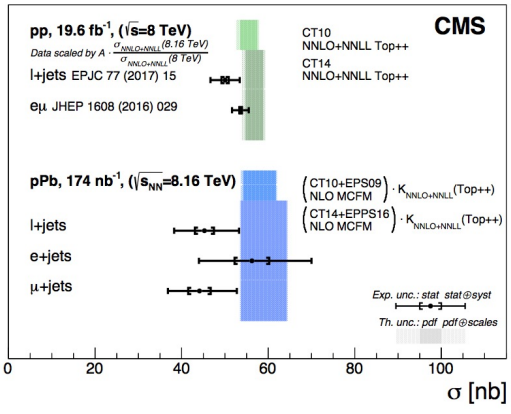
Top in p-Pb Collisions

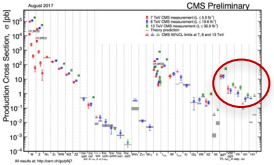
Submitted to PRD last week!

- **First observation of top quark production in proton-nucleus collisions**
- Signal: 1 isolated lepton (el, mu) and at least 4 jets
- 710 signal events, significance above 5 σ
- Cross section 45 ± 8 nb, consistent with pQCD predictions





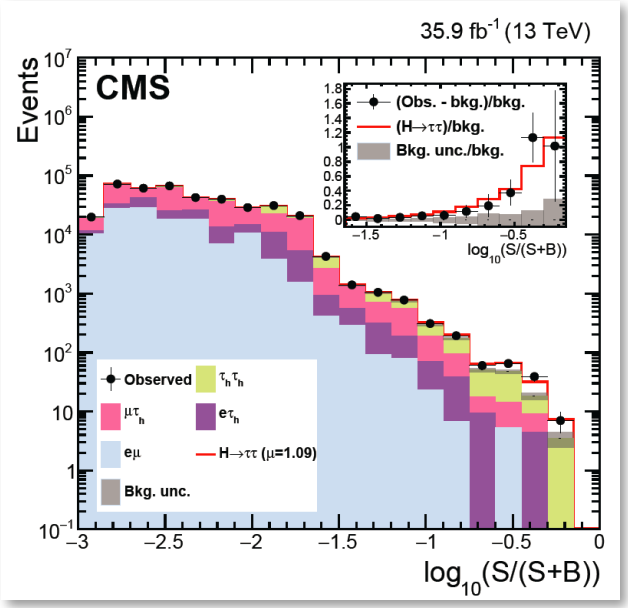


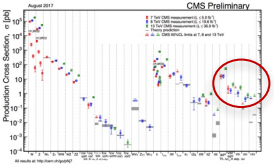


Observation of H → ττ

arXiv:1708.00373

- Branching ratio = 6.3%, best channel to establish coupling of Higgs boson to fermions
- Final states: $\tau_h\tau_h$, $e\tau_h$, $\mu\tau_h$, $e\mu$ → Significance of 4.9σ observed (4.7σ expected) using 13 TeV data
- Combination with 7 and 8 TeV data: **5.9σ obs. (5.9σ exp.)** and **$\mu = 0.98 \pm 0.18$**





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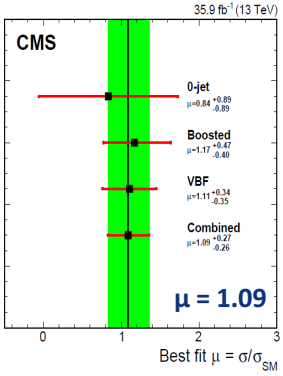

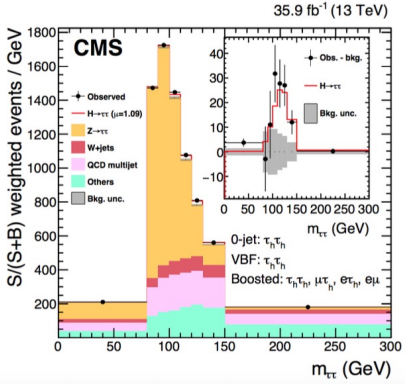

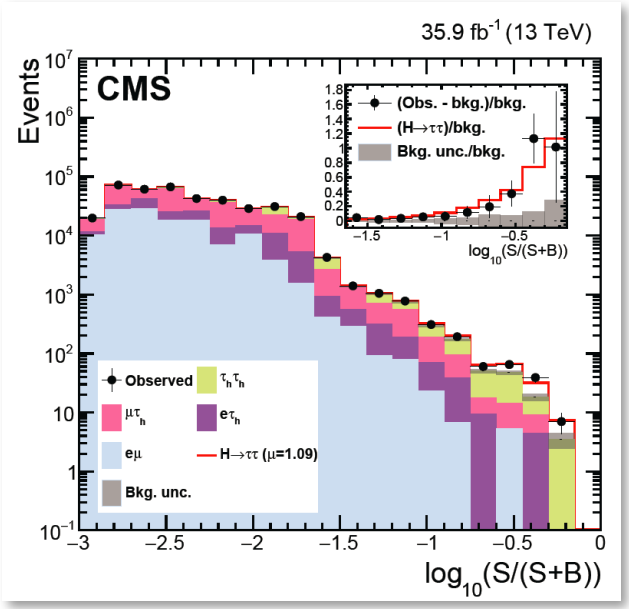

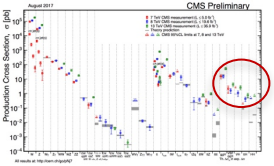

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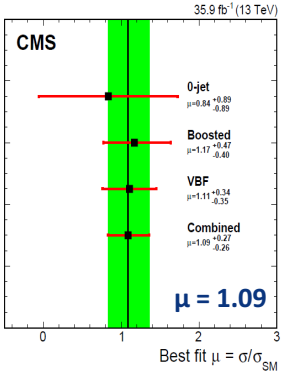
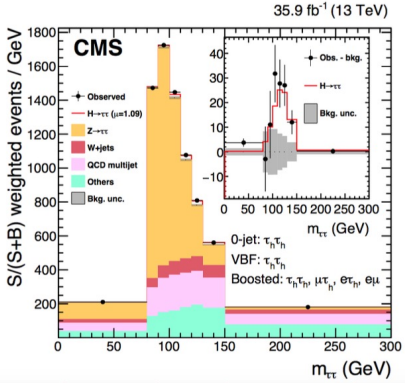
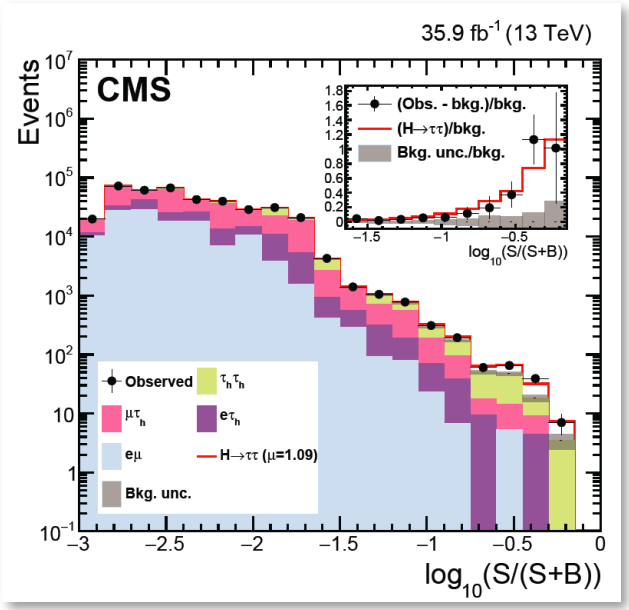
First direct observation by a single experiment of H coupling to fermions!

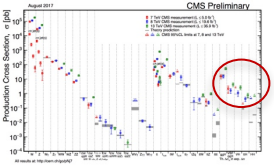
– Observed before in CMS+ATLAS combination

First direct observation of H coupling to leptons and to fermions of the 3rd generation!









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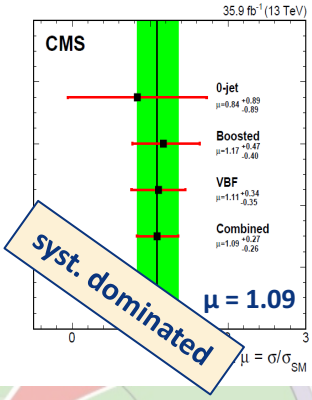

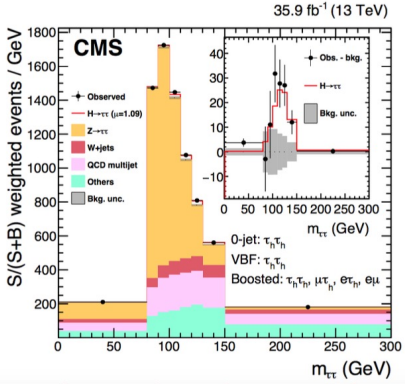

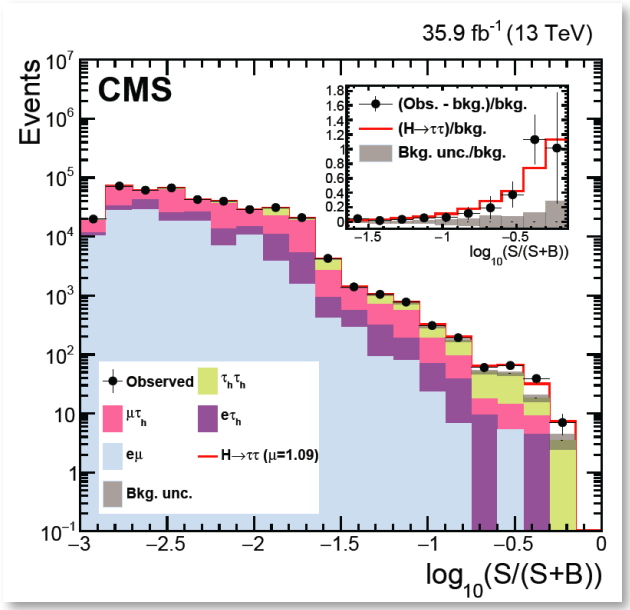

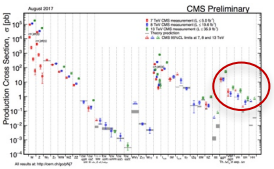

Evidence for H → bb

Submitted to PLB last week!

- BR = 58%, but large backgrounds, not yet observed
- Production of ZH and WH is studied, with Z → ee, μμ, $\nu\nu$ and W → eν, μν
- Significance of 3.3σ obs. (2.8σ exp.) using 13TeV data
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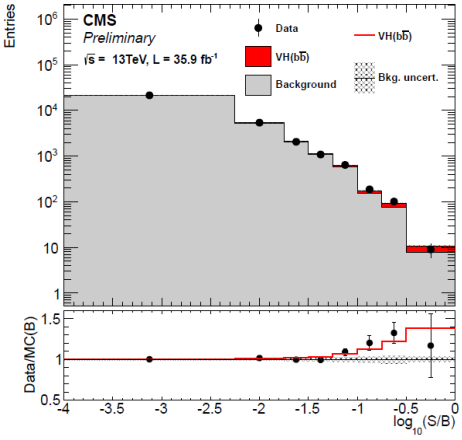

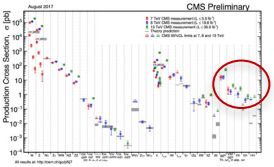

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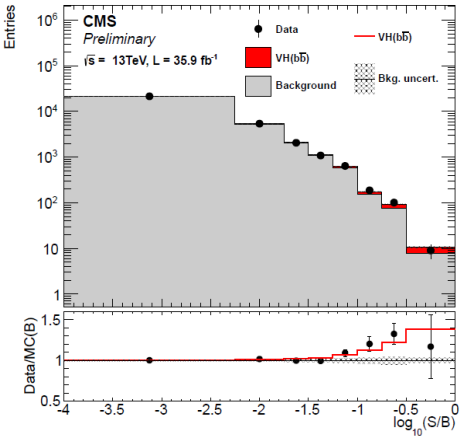

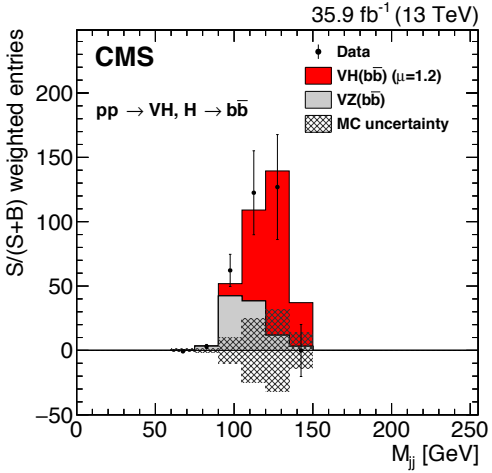

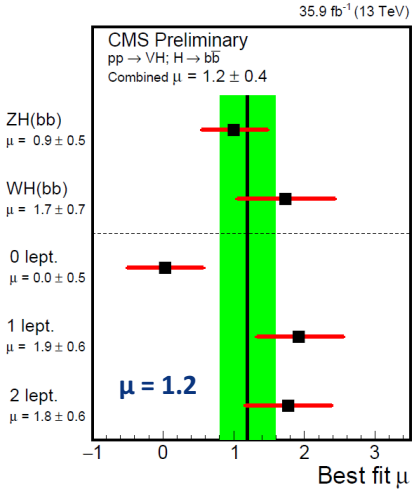

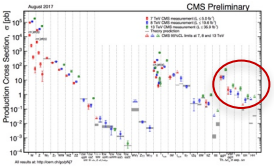

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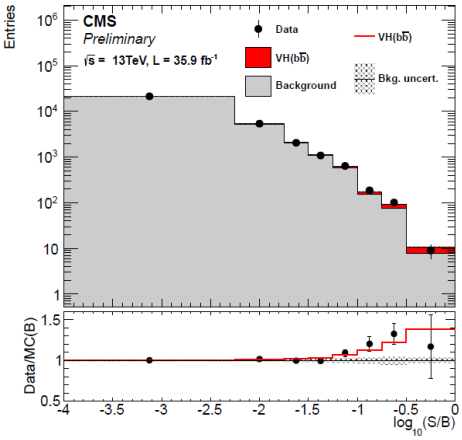

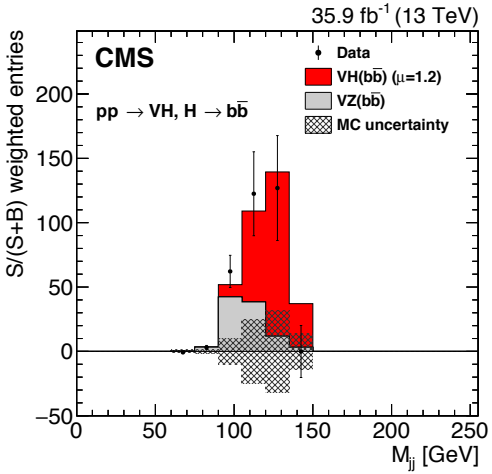

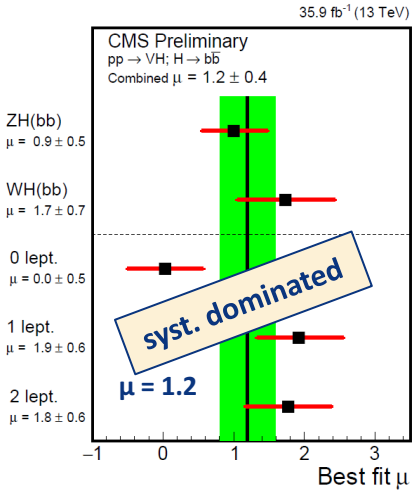

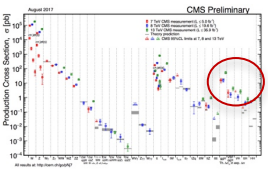

Inclusive boosted H → bb

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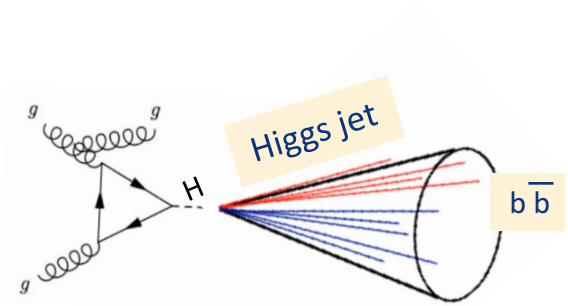
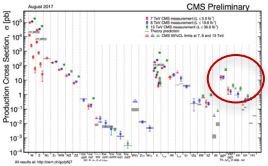
- **First search for incl. gg → H → bb in boosted topology!**
  - was considered impossible.... Because of overwhelming QCD bckg.
- Higgs **p_T > 450 GeV**, reconstructed as single fat jet
  - Using state-of-the-art boosted jet substructure and dedicated b-tagging techniques





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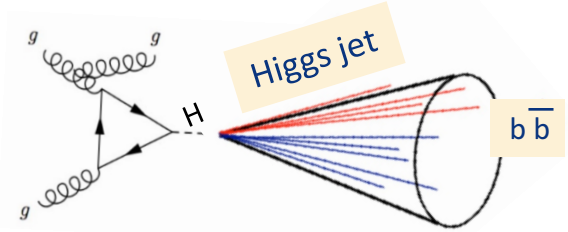
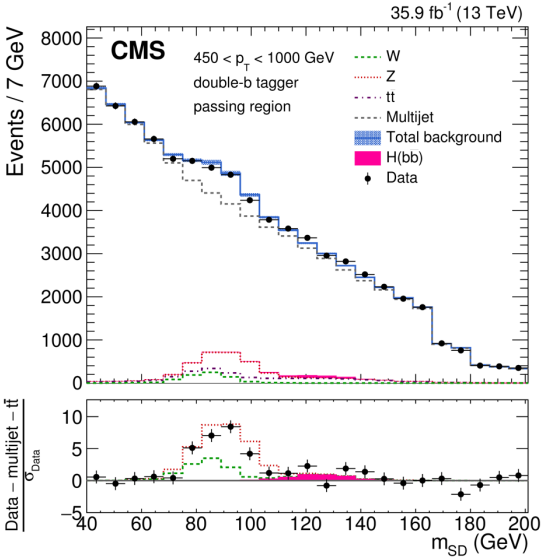
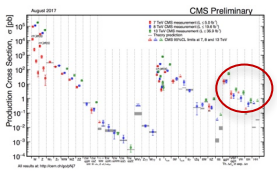
- Higgs **p_T > 450 GeV**, reconstructed as single fat jet
  - Using state-of-the-art boosted jet substructure and dedicated b-tagging techniques
- **Z → bb as control: Significance of 5.1σ obs, first obs. in single-jet topology**
- H → bb at 1.5 σ consistent with SM expectations

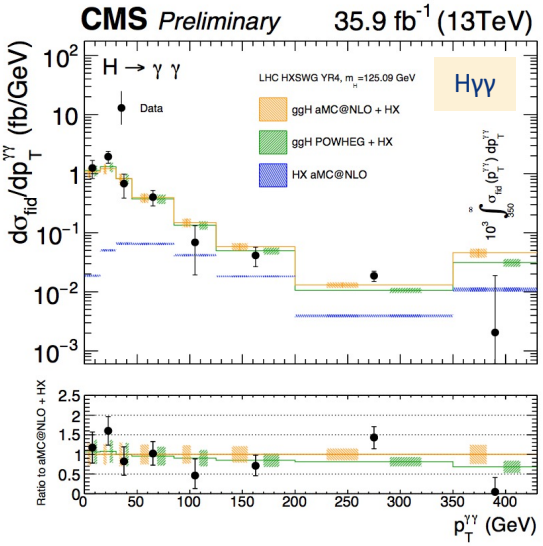


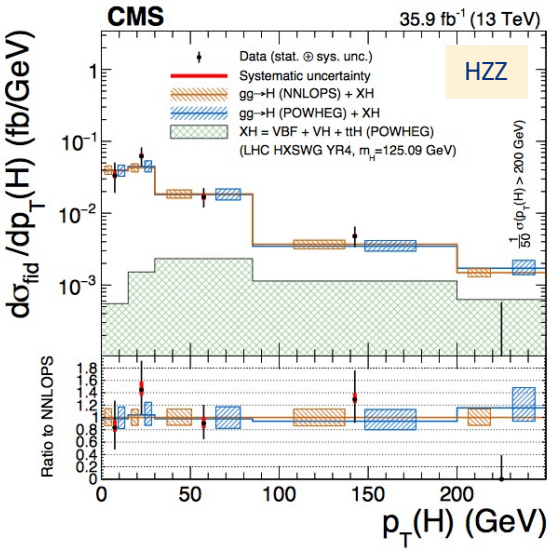


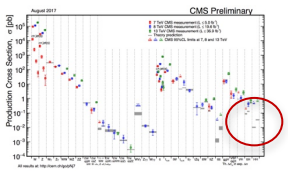


Higgs "differential"

- Entering the Higgs precision physics era
- explore new regions of phase space (also in view of systematics…)
- explore Higgs production differentially, eg. at large p_T
  - "precision" vs "sensitivity"

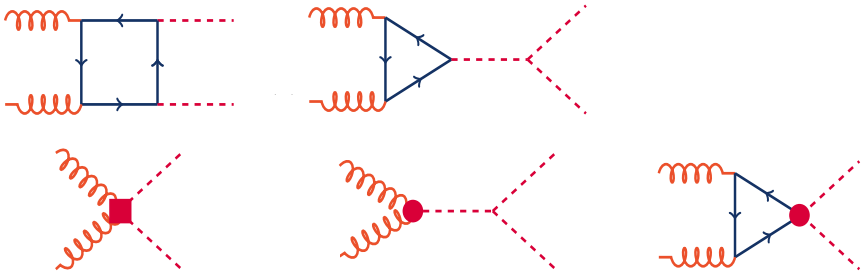


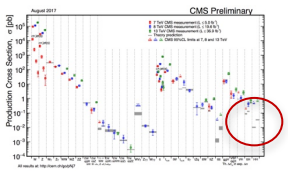




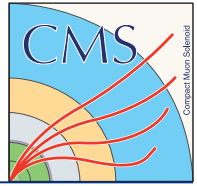
Search for $HH \to b\bar{b}\,\gamma\gamma$

- Study H self coupling in gluon fusion events – very low SM cross section, difficult
- May be enhanced due to anomalous couplings, or new particles produced directly or in loops

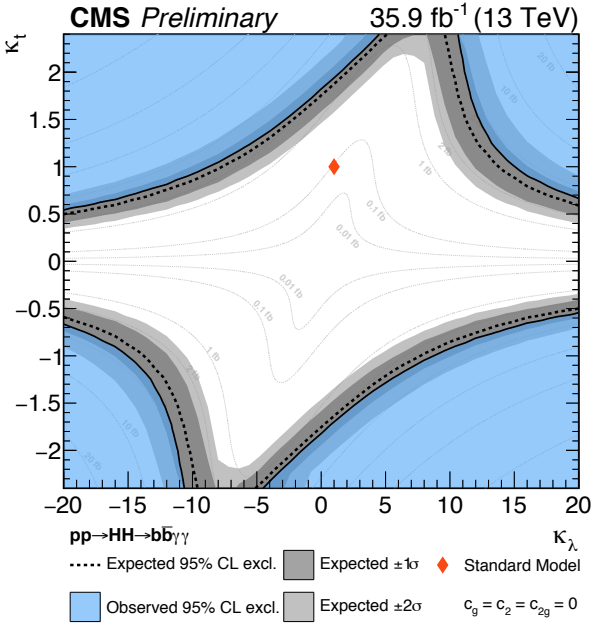


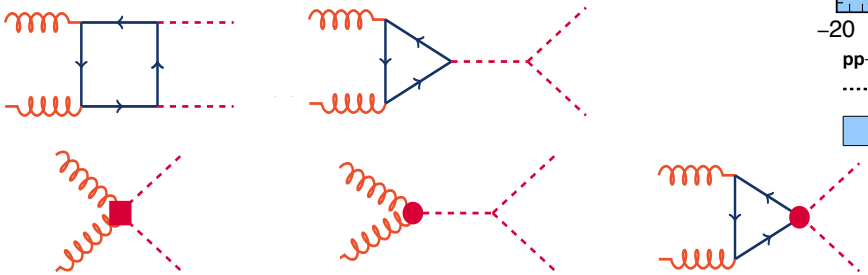


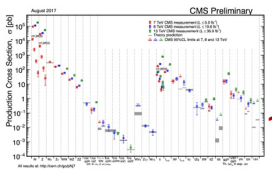
Search for HH → bb̄ γγ



- Study H self coupling in gluon fusion events – very low SM cross section, difficult
- May be enhanced due to anomalous couplings, or new particles produced directly or in loops
- Two-dimensional fits in $M_{\gamma\gamma}$ and M_{jj} invariant masses
- Observed (expected) 95% CL limits on cross section ~ 19.2 (16.5) x SM cross section
  - **Best limits at LHC so far**
- Limits on $\kappa_\lambda = \lambda_{HHH}/\lambda_{HHH}^{SM}$ and $\kappa_t = y_t/y_t^{SM}$ and on radions & KK-gravitons in Warped ED model







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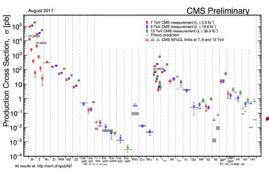
Searches (1)

- Broad program: **23 SUSY searches completed with full 2016 CMS dataset**
- several already submitted to journals
- Probing different models: inclusive production, strong and **electroweak production**, and 3rd generation sparticles (stops, staus), high ΔM, compressed, …



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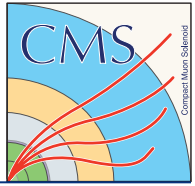

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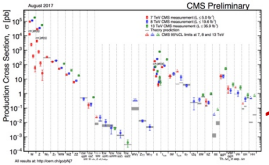
	Signal topology				
Search	WZ	WH	ZZ	ZH	HH
1ℓ 2b		✓			
4b					✓
2ℓ on-Z	✓		✓	✓	
2ℓ soft	✓				
2ℓ SS, $\geq 3\ell$	✓	✓	✓	✓	✓
$H(\gamma\gamma)$		✓		✓	✓



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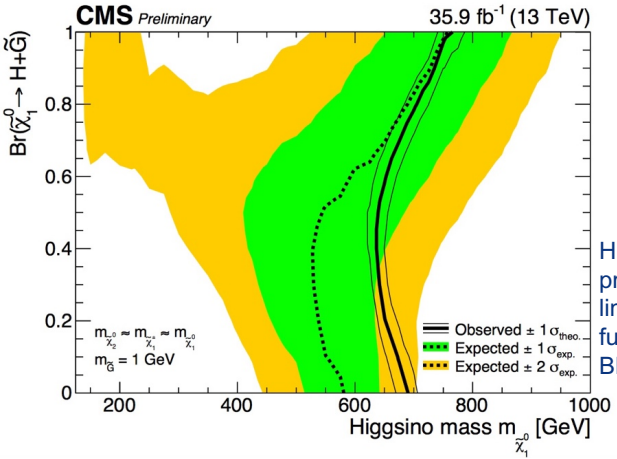
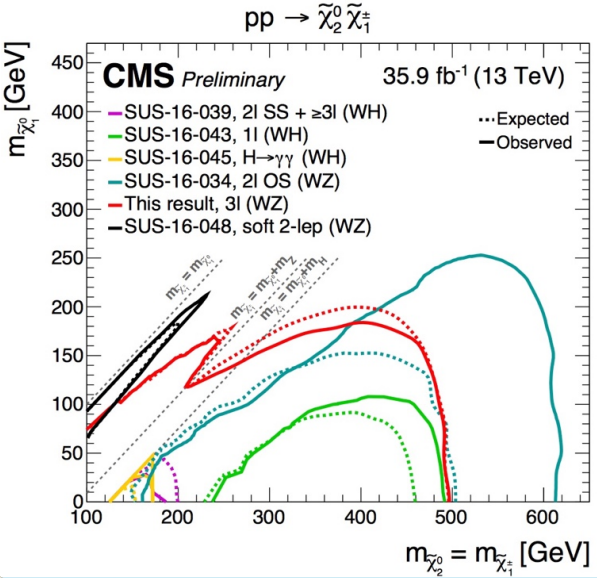
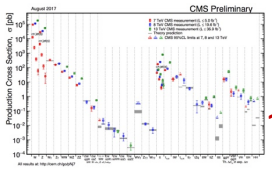


Higgsino-production limits as function of BR(N1→H G~)





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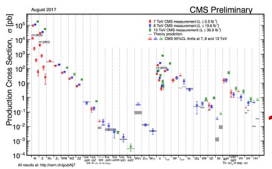
SUSY limits in a nutshell:

- **Gluinos > ~2 TeV**
- **Stops > ~1 TeV**
- **EWKinos > ~0.5 TeV**



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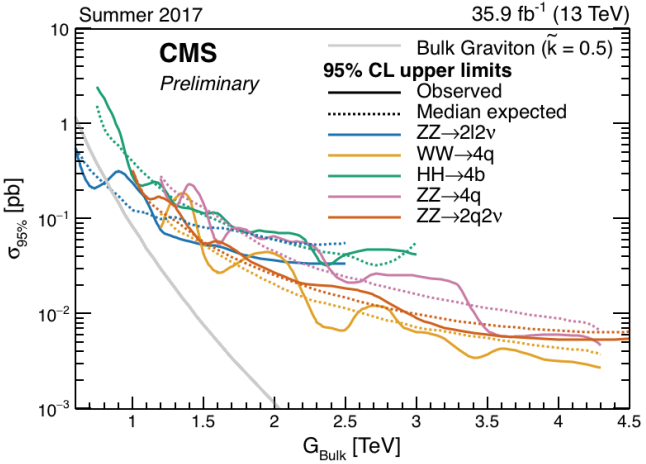

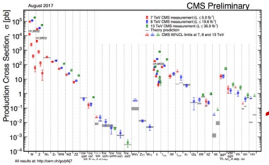

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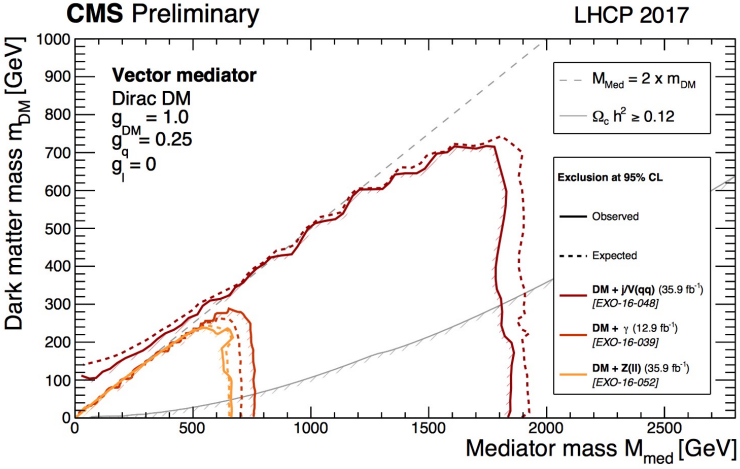
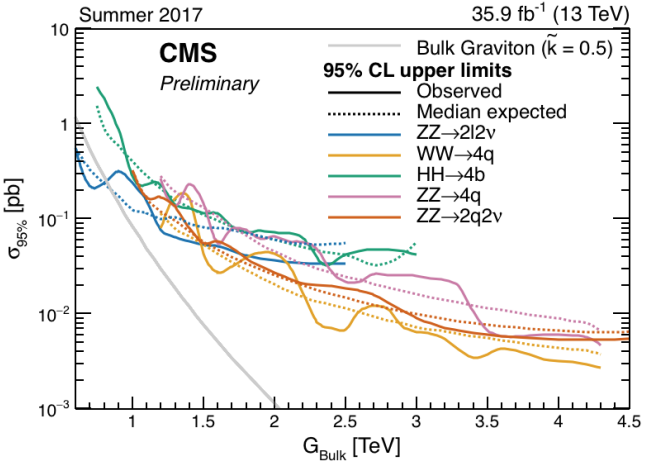
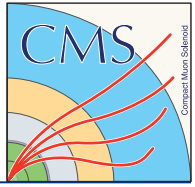
- Also focus on combining searches targeting **DM** (the "mono-X" class)





New Results for LHCP & EPS

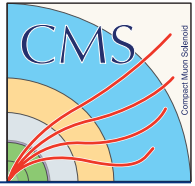


BPH-13-008: Precision lifetime measurements of b hadrons reconstructed in final states with a J/Psi meson
HIN-16-021: Pseudorapidity distributions of charged hadrons in proton-lead collisions at 5.02 and 8.16 TeV
SMP-16-018: Measurement of electroweak production of two jets in association with a Z boson in proton-proton collisions at sqrt(s) = 13 TeV
SMP-16-019: Measurement of ZZ production in association with jets and search for electroweak production of two jets in association with a Z boson in proton-proton collisions at 13 TeV and 8 TeV
SMP-17-004: Observation of electroweak production of same-sign W boson pairs in the two jet and two same-sign lepton final state at a center-of-mass energy of 13 TeV
HIG-17-001: Search for lepton flavour violating decays of the Higgs boson to eτ and μτ at 13 TeV
HIG-17-005: Search for production of a Higgs boson and a single top quark in multileptonγfinal states
HIG-16-040: Measurements of properties of the Higgs boson in thediphoton decay channel with the full 2016 data set
HIG-16-043: Observation of the SM Higgs boson decaying to a pair of τ leptons at 13 TeV
TOP-17-005: Measurement of the top quark pair-production in association with a W or Z boson at 13 TeV
EXO-17-001: Search for light vector resonances decaying to a quark pairproduced in association with a jet
EXO-16-004: Search for stopped long-lived particles produced in pp collisions at 13 TeV
EXO-16-045: Search for heavy neutrinos and W bosons with right-handed couplings at 13 TeV
EXO-16-048: Search for new physics in final states with an energetic jet,or a hadronically decaying W or Z boson with
EXO-16-052: Search for Dark Matter, Invisible Higgs Boson D

- ~40 new results released for LHCP 2017 & EPS-HEP 2017
- Made possible by excellent performance of the detector!
- More data are needed to settle the open questions …

momentum in dijet events at 13 TeV
top quark pair production as a function of kinematic event variables at 13 TeV
Search for Higgs boson pair production in the final state containing two photons and two bottom quarks at 13 TeV
HIG-16-043: Observation of the SM scalar boson decaying to a pair of τ leptons with the CMS experiment at the LHC
HIG-16-021: Higgs to WW measurements at 13 TeV with 2015 and 2016 data
SUS-16-052: Search for supersymmetry in events with at least one soft lepton, low jet multiplicity, and missing transverse momentum at 13 TeV
SUS-17-004: Search for electroweak production of charginos and neutralinos at 13 TeV
SUS-17-003: Search for pair production of tau sleptons in all-hadronic final state
EXO-17-002: Search for excited states of light and heavy flavor quarks in the γ + jet final state at 13 TeV
EXO-16-046: Search for new physics with dijet angular distributions in proton-proton collisions at 13 TeV and constraints on dark matter and other models
EXO-16-051: Search for dark matter in final states with a top quark and missing transverse momentum using new hadronic top quark tagging techniques
EXO-17-004: Search for long-lived particles that stop in the CMS detector and decay to muons
B2G-17-009: Search for a singly produced vector-like quark B decaying to a b quark and a Higgs boson in a fully hadronic final state using boosted topologies
B2G-17-005: Search for heavy resonances decaying into a Z boson and a vector boson in the νν qq̄ final state
B2G-16-025: Search for pair production of excited top quarks in the lepton+jets final state
PPS-17-001: Evidence for proton-tagged, central semi-exclusive production of high-mass muon pairs at 13 TeV with the CMS-TOTEM Precision Proton Spectrometer
FTR-16-002: Projected performance of Higgs analyses at the HL-LHC for ECFA 2016

Summary and Outlook



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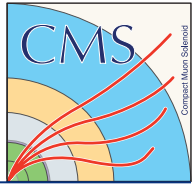

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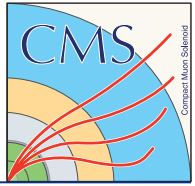

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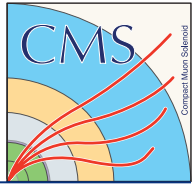
- **Physics results continue to be excellent with much exciting analyses ahead for the 2016 data and with the new data from 2017**

- The collaboration is handling well the "pile-up" of tasks:
  - Data Analysis
  - Efficient data taking, with the related challenges of new detector sub-systems and the running at high luminosity (Trigger, DAQ, computing & SW)
  - Preparation of Phase-2 Upgrade Documents

Thank you for your attention!

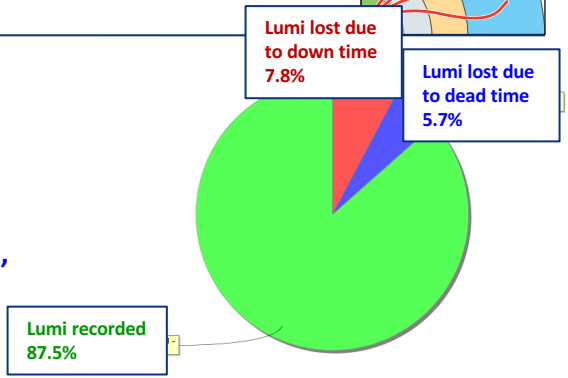
Phase 2 Upgrades

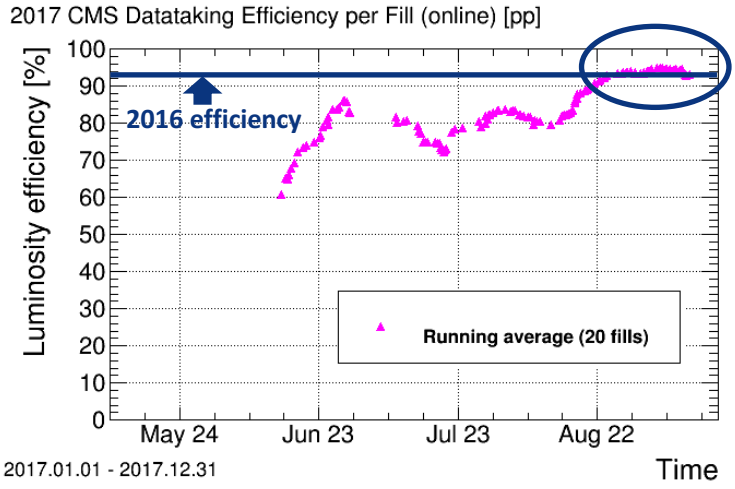


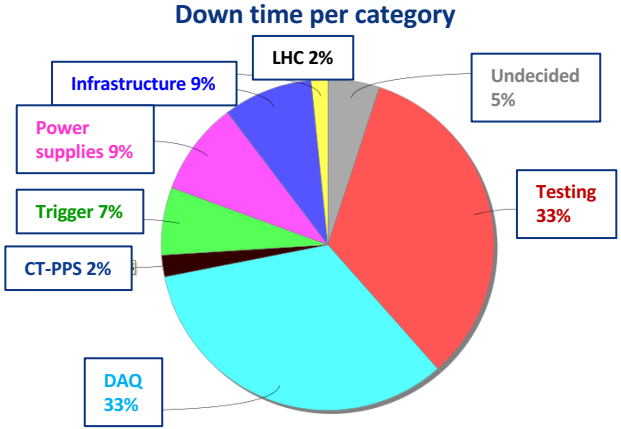
- The CMS Phase II Upgrade is a major construction effort
  - Complexity is very high; **CMS continues to do bold projects with high potential physics payoff**
- **Four major TDRs:**
  - Tracker (submitted, recently reviewed by LHCC)
  - Barrel Calorimeter (submitted)
  - Muon Detectors (submitted)
  - Endcap Calorimeter (end of Nov)
- Three Interim Design Documents:
  - Trigger (submitted)
  - DAQ/HLT (submitted)
  - Common Infrastructure Upgrade and Logistics of work during LS3
- A Conceptual Design document of precision timing, Oct. 30
- Much R&D, design, prototyping, and preproduction work ongoing

2017 Data Taking Overview

- **Dominant reasons for inefficiency:**
  - Commissioning, in particular of the new pixel detector
  - Operational procedures for new pixel detector
- Other sources are mostly related to the usual small intermittent problems and are scattered over the whole detector
- **During last weeks the efficiency reached values well above 92%, and is similar to the efficiency achieved in previous years**

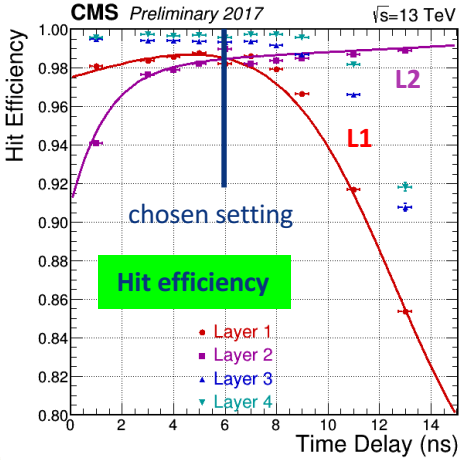




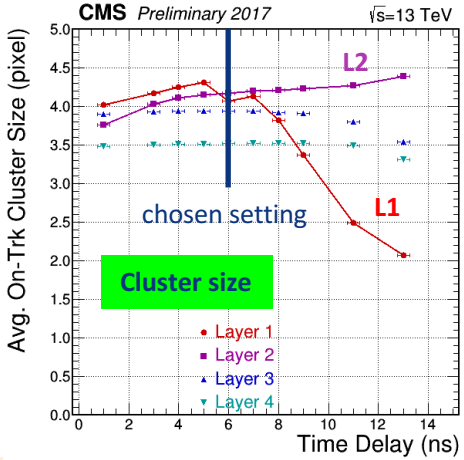


Pixel Detector: Commissioning, Timing, Operations

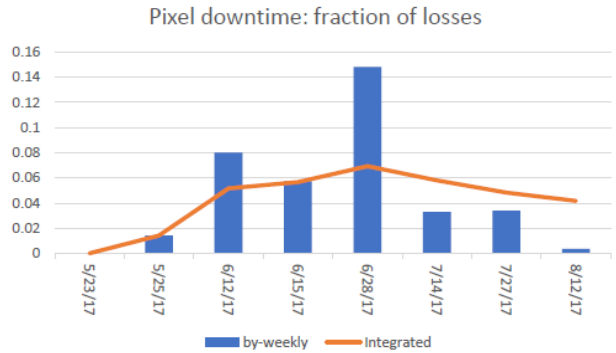
- **Pixel detector commissioning is complex – many parameters to be optimized**
  - Threshold, gain, timing, bias voltage, ...
- **Subtle timing optimization was required to achieve optimal efficiency for all layers**
  - L1 chip is faster than chip for other layers, but clock is common for L1 & L2 (historical reasons)
- **Operational procedures had to be developed and optimized**
  - Periodic reprogramming / power cycling mainly to cure SEUs in a small FE chip (TBM) that organizes module readout, now done automatically and taking few seconds
  - Periodic resets of L1 readout chips to mitigate dynamic inefficiency

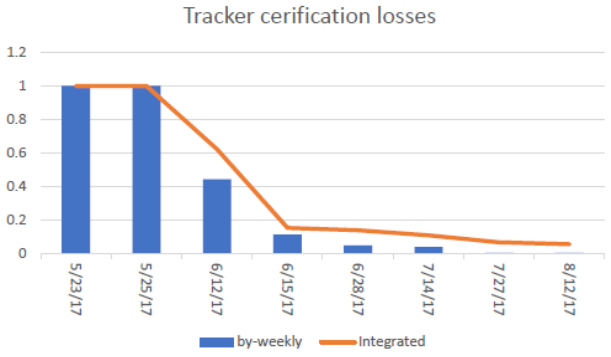


Lines are drawn to guide the eye



Pixel Data Losses

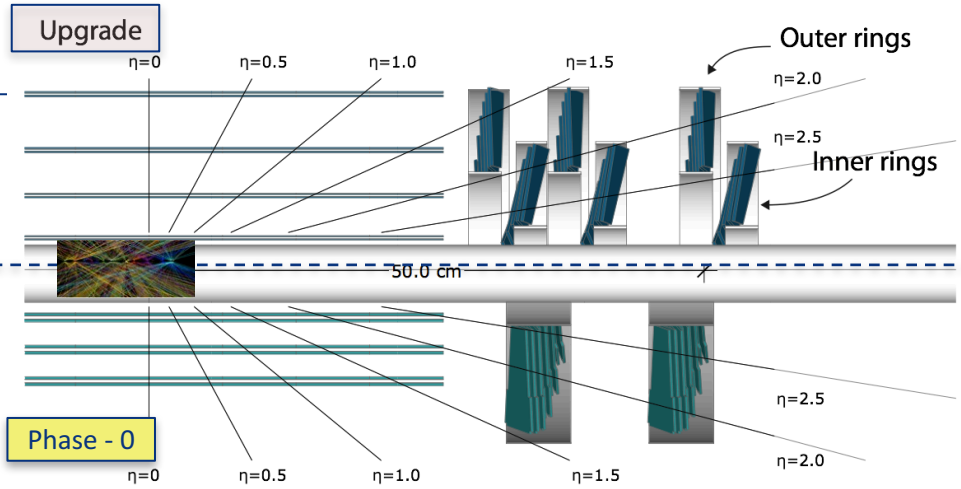




- ~4% of delivered data lost due to pixel downtime
- ~4% of delivered data lost due to pixel data certification
- Both types of losses have gone down to a negligible level

- 2-3% of delivered data lost due to dead time
  - 1.3% dead time due to ROC reset; now decreased to 0.7%
- 1-2% dead time due to mitigation of SEUs; now decreased, need high inst. luminosity to quantify

Phase 1 Pixel Detector

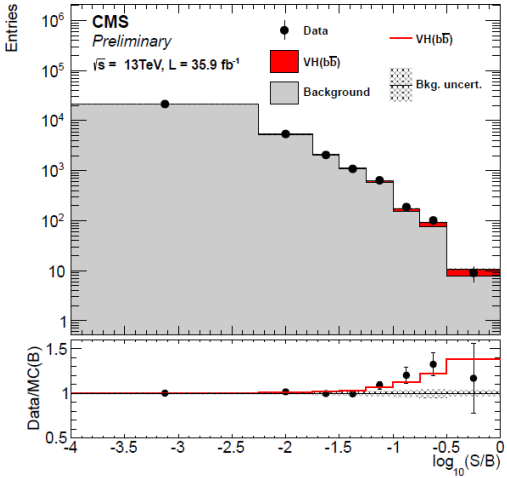


Pixel Upgrade:

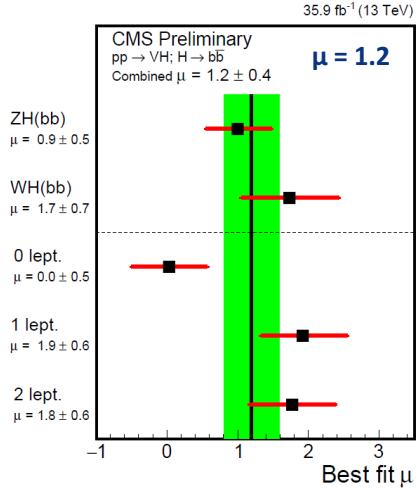
- Baseline L = $2x10^{34}$ $cm^{-2}sec^{-1}$ with 25ns BX → 50 pileup **(50PU) with very small efficiency loss**
- Tolerate L = $2x10^{34}$ $cm^{-2}sec^{-1}$ with **50ns** BX → 100 pileup **(100PU) with reduced performance**
- **Survive Integrated Luminosity of 500 fb^{-1}**
- **Same detector concept**: higher rate readout, data link and DAQ w/ less material forward
- **More Robust tracking** : 4 hit coverage; **3 layers/2 disks to 4 layers / 3 disks** (can compensate point losses in strips)
- Inner layer closer to beam → Better primary and secondary vertex resolution

Evidence for H → bb

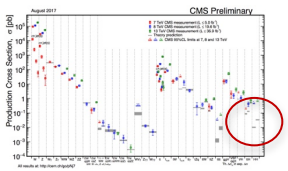
- BR = 58%, but large backgrounds, not yet observed
- Production of ZH and WH is studied, with Z → ee, μμ, $\nu\nu$ and W → eν, μν
- 0-lepton, 1-lepton, 2-lepton channels
- Signal extraction from combined fit to signal & control regions (BDT discriminant, b-tagging variable $CMVA_{min}$)
- Significance of 3.3σ obs. (2.8σ exp.) using 13TeV data
- **Combination with 7 & 8 TeV data: 3.8σ obs. (3.8σ exp.)**



CMS-PAS-HIG-16-044

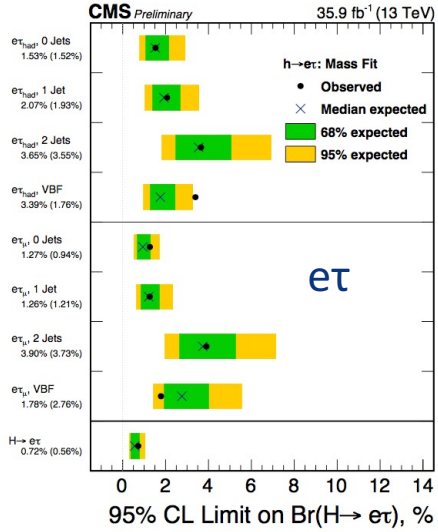


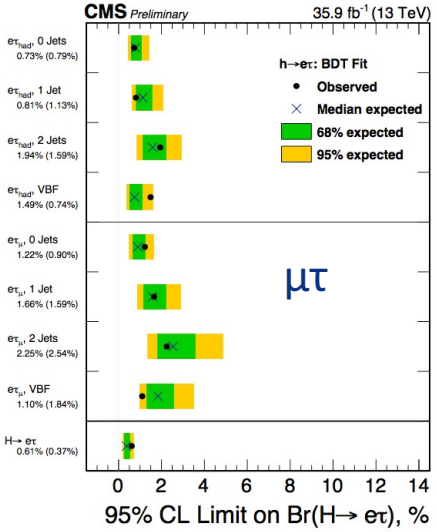
$m_H = 125$ GeV	Significance expected	Significance observed	Signal strength observed
Run 1	2.5	2.1	$0.89^{+0.44}_{-0.42}$
Run 2	2.8	3.3	$1.19^{+0.40}_{-0.38}$
combined	3.8	3.8	$1.06^{+0.31}_{-0.29}$



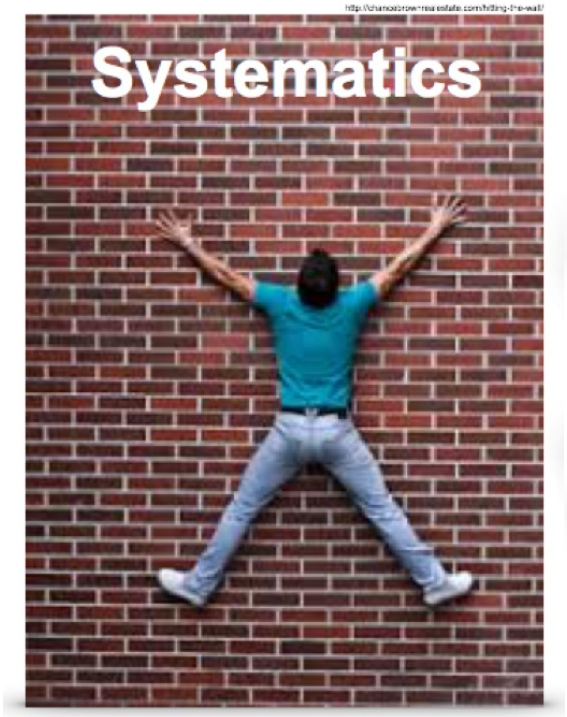
Higgs: going beyond

- **Search for lepton flavour violating decays of the Higgs boson to eτ and μτ**
- Previous 2.4σ hint in H→μτ in Run1 data (*Phys. Lett. B* **749** (2015) 337) **not confirmed with 13 TeV data (2016)**
  - stringent limits set on branching fractions, in few per cent range





Systematic uncertainties



- To be taken note of: already now we are often hitting the "systematics wall"
- Some examples:

overall ATLAS-CMS Higgs combination

$$\mu = 1.09^{+0.11}_{-0.10} = 1.09^{+0.07}_{-0.07}\,(\text{stat})\,^{+0.04}_{-0.04}\,(\text{expt})\,^{+0.03}_{-0.03}\,(\text{thbgd})^{+0.07}_{-0.06}\,(\text{thsig})$$

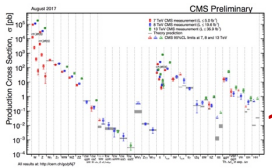
$$\mathrm{H} \rightarrow \mathrm{ZZ} \rightarrow 4\ell \text{ decay ch}$$
$$1.05\,^{+0.15}_{-0.14}\,(\text{stat})\,^{+0.11}_{-0.09}\,(\text{syst})$$

Higgs to tau tau:

$$1.09^{+0.15}_{-0.15}\,(\text{stat})^{+0.16}_{-0.15}\,(\text{syst})^{+0.10}_{-0.08}\,(\text{theo})^{+0.13}_{-0.12}\,(\text{bin-by-bin})$$

Higgs to bb (VHbb) :

$$\mu = 1.19^{+0.21}_{-0.20}(\text{stat.})^{+0.34}_{-0.32}(\text{syst.})$$



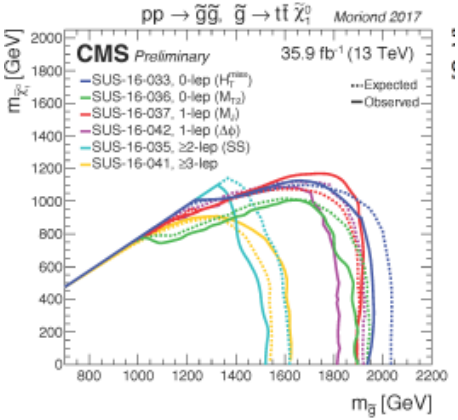
?

Searches

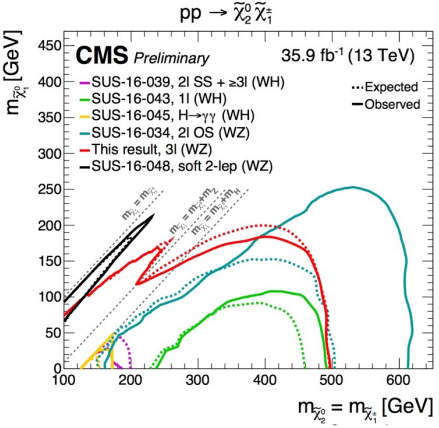
Broad program: 23 SUSY searches completed with full 2016 CMS dataset, with several already submitted to journals

- Probing different models (inclusive production, strong and electroweak production, and 3rd generation sparticles (stops)
- Different final states (with leptons, photons, jets) and analysis techniques

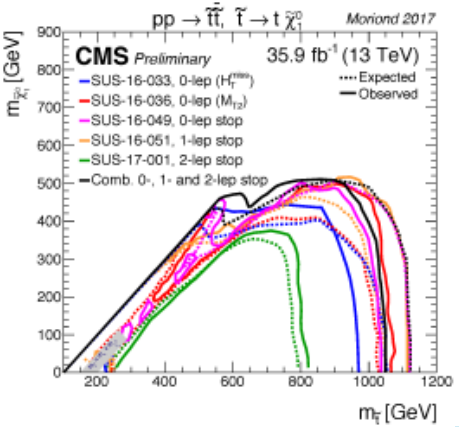
gluinos (inclusive)

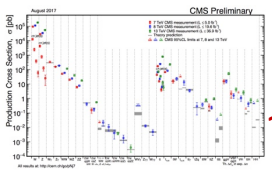


electroweakinos



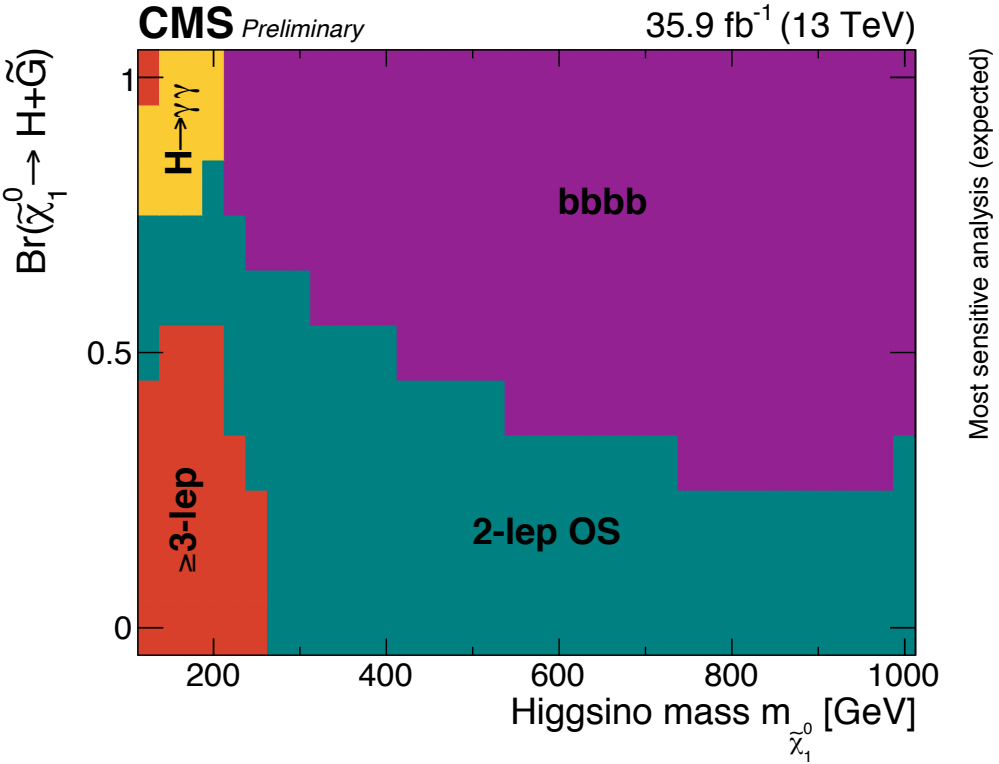
stops (3rd gen)




CMS Preliminary
Production Cross Section, σ [pb]

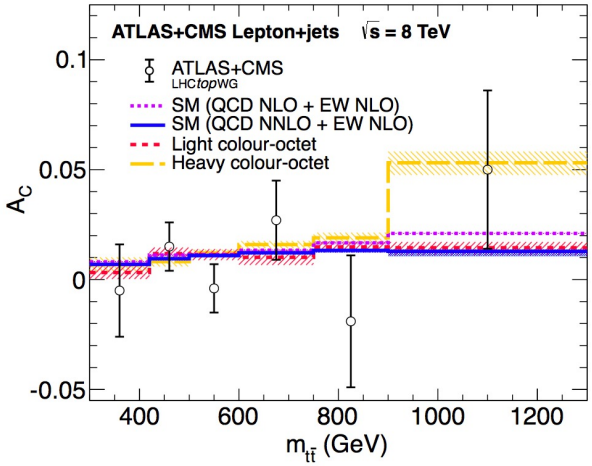
?

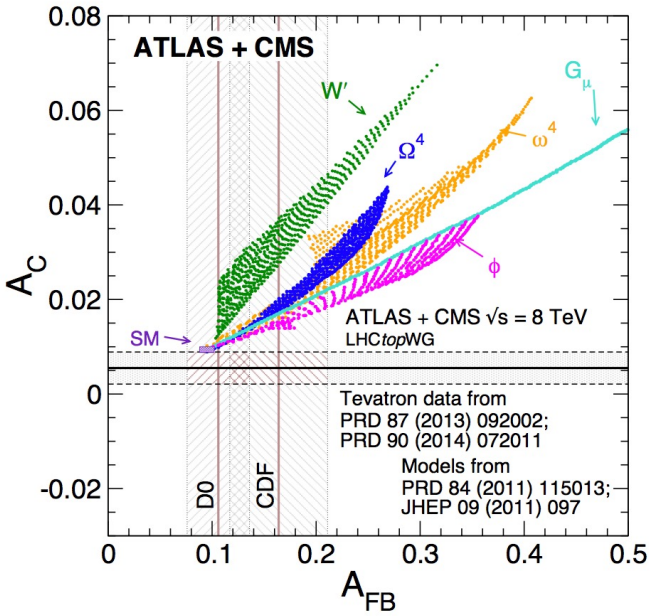
Searches


CMS Preliminary
35.9 fb-1 (13 TeV)
Br(χ̃10 → H+G̃)
H→γγ
bbbb
≥3-lep
2-lep OS
Most sensitive analysis (expected)
Higgsino mass m χ̃10 [GeV]
0
0.5
1
200
400
600
800
1000

Top Charge Asymmetry

https://arxiv.org/abs/1709.05327





Data taking efficiency per fill