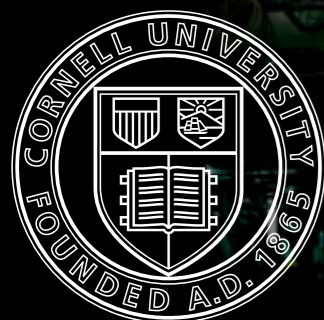




RECENT RESULTS FROM CMS

Symposium: 25 Years of the LHC Experimental Programme



Louise Skinnari (Cornell U.), on behalf of the CMS Collaboration

CERN, December 15, 2017

Introduction

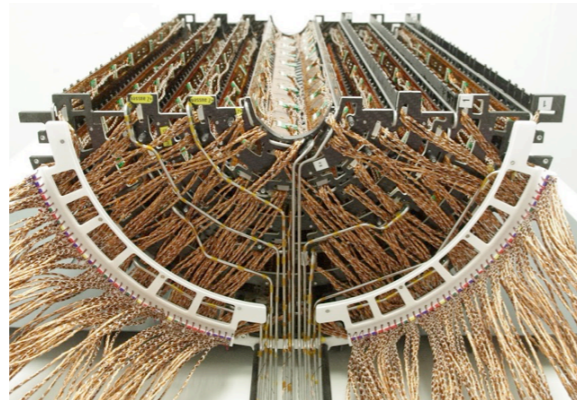


Another successful year of CMS physics!

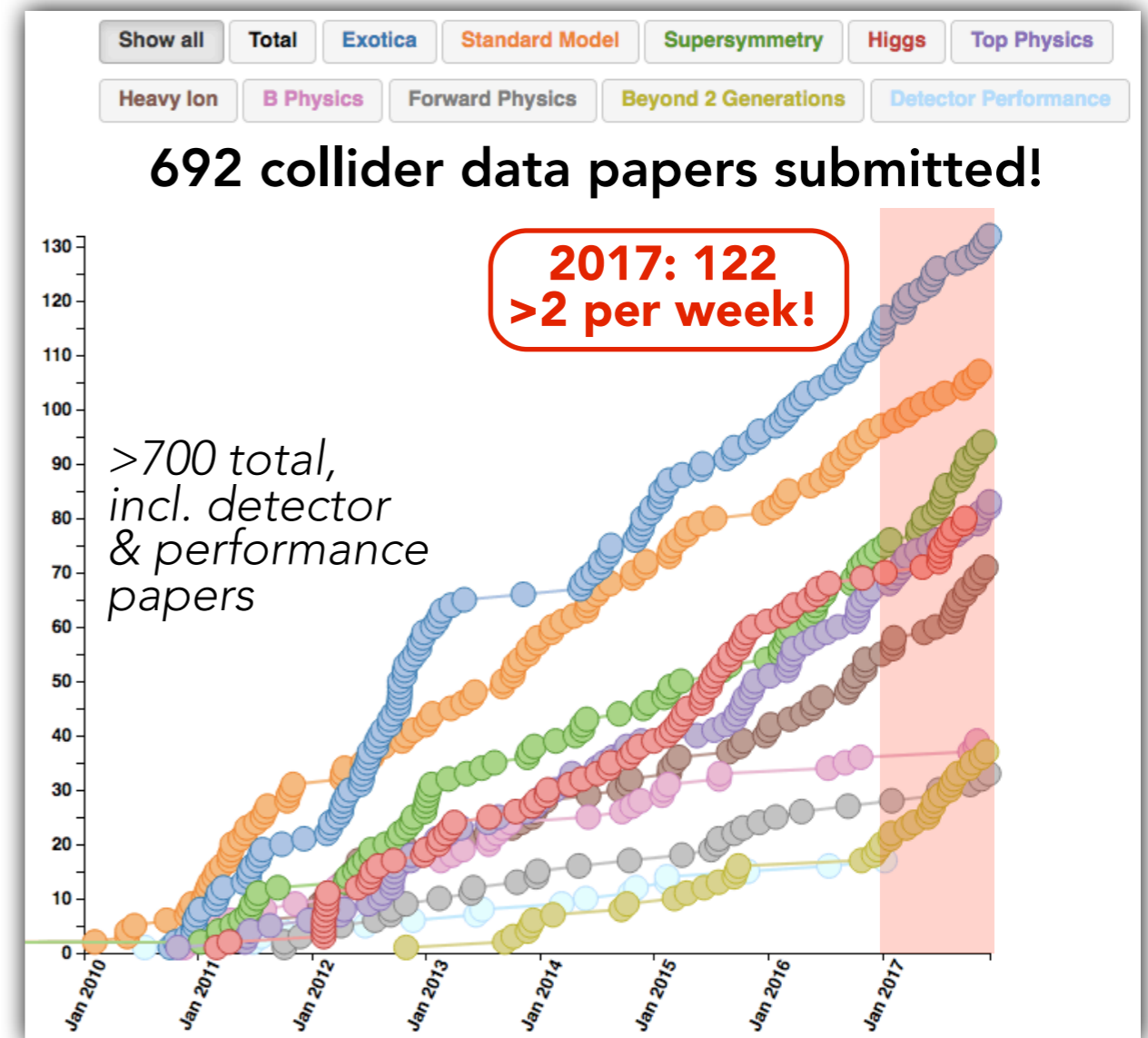
2017: A busy year

- ◆ Replace the “heart” of CMS

*new pixel detector
to maintain excellent
performance*



- ◆ Prepare CMS for record-setting 2017 data taking
- ◆ Analyze large 2016 datasets
- ◆ Submit 4 (+2) Technical Design Reports Technical + Technical Proposal on MiP timing layer for High-Luminosity LHC upgrade

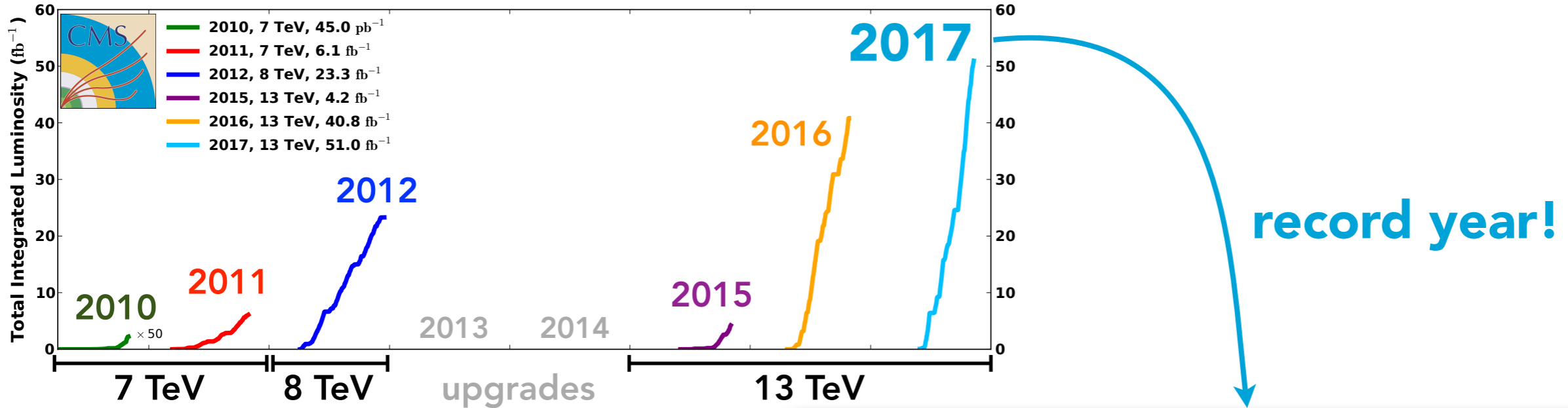


2017 operation



CMS Integrated Luminosity, pp

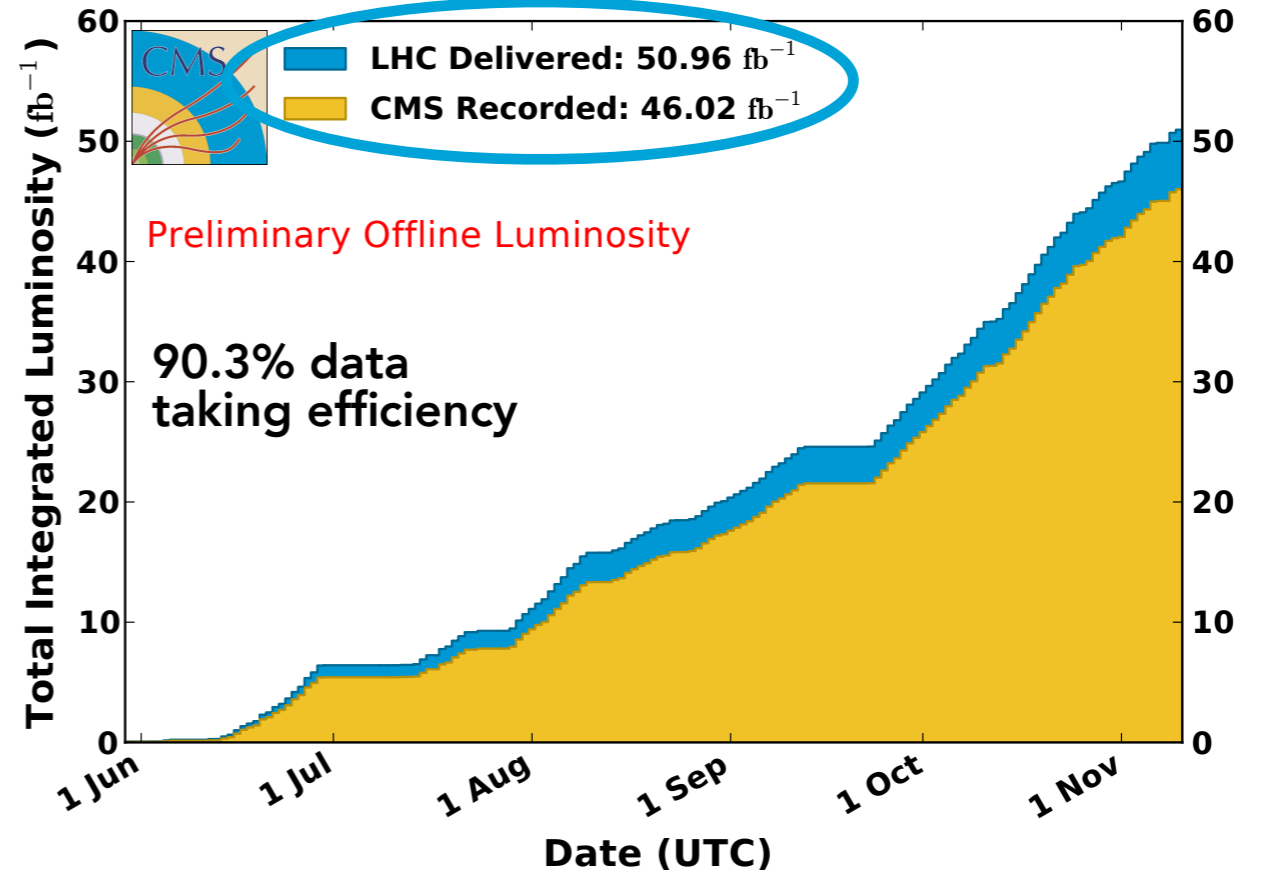
Data included from 2010-03-30 11:22 to 2017-11-10 14:09 UTC



Thanks to the LHC team for the outstanding accelerator performance!!

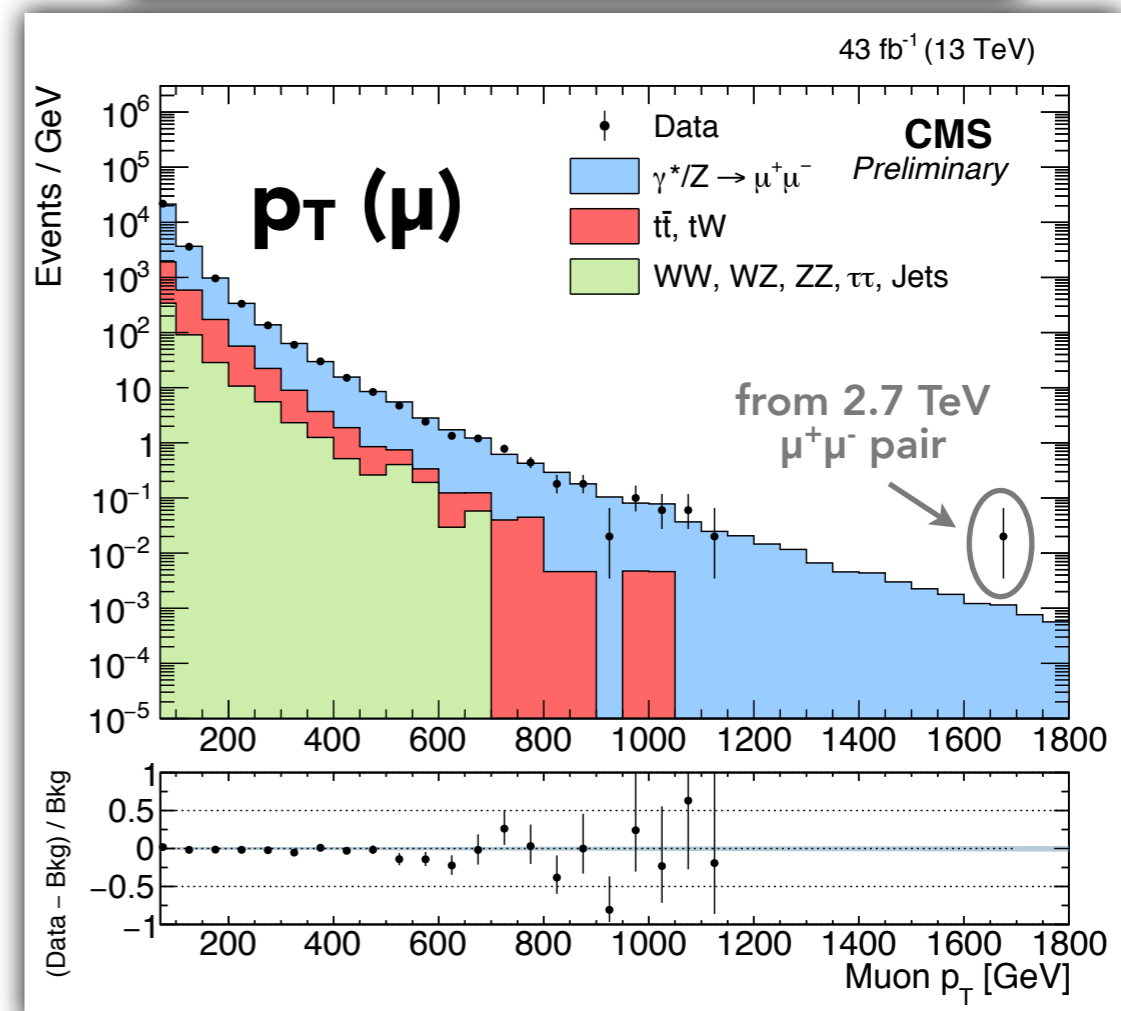
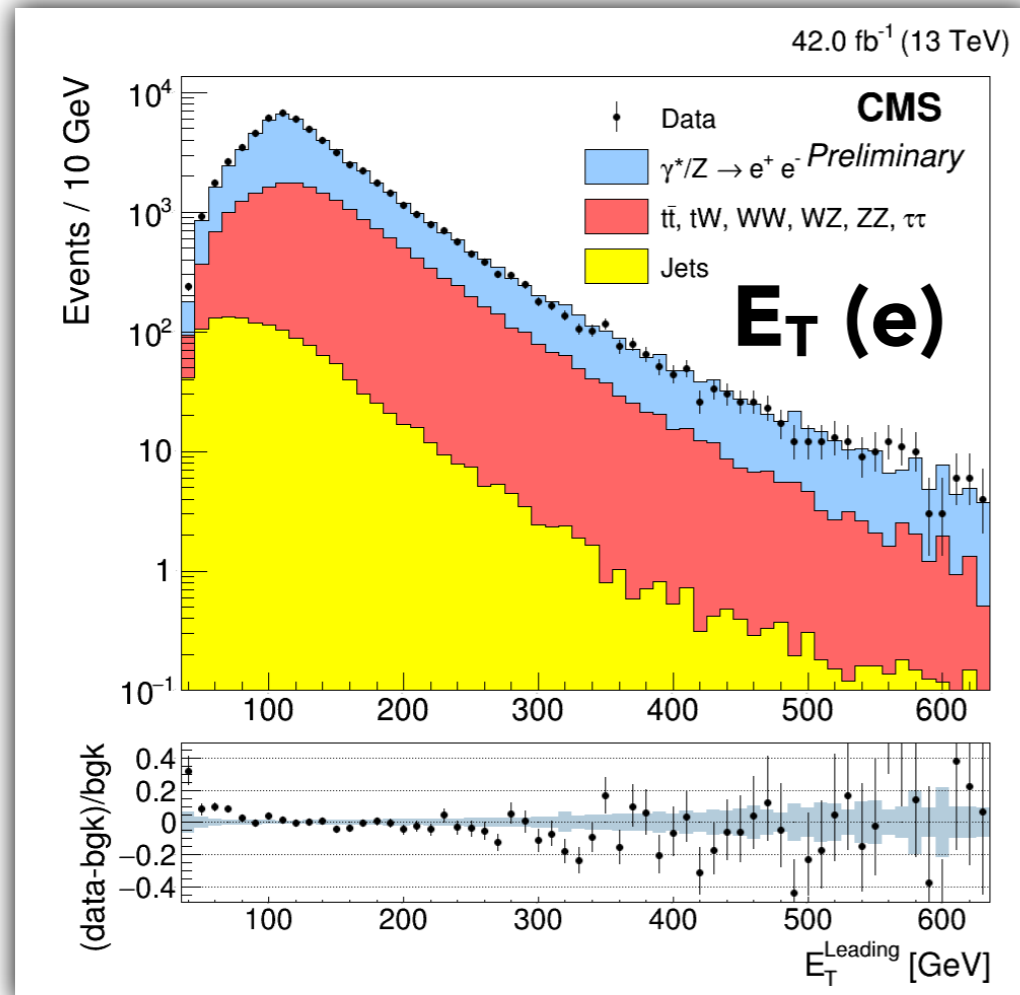
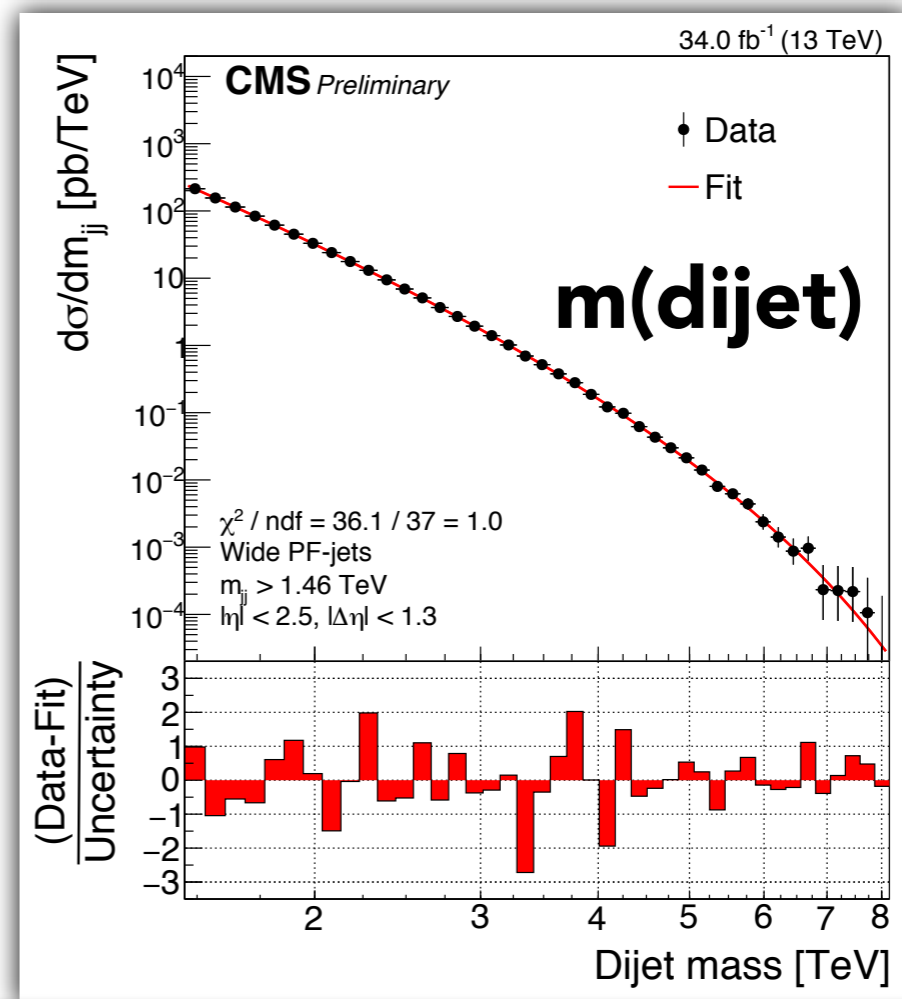
CMS Integrated Luminosity, pp, 2017, $\sqrt{s} = 13$ TeV

Data included from 2017-05-30 08:43 to 2017-11-10 14:09 UTC



2017 data

- 2017 data taking recently ended, first performance studies with full dataset
- Good physics object performance observed

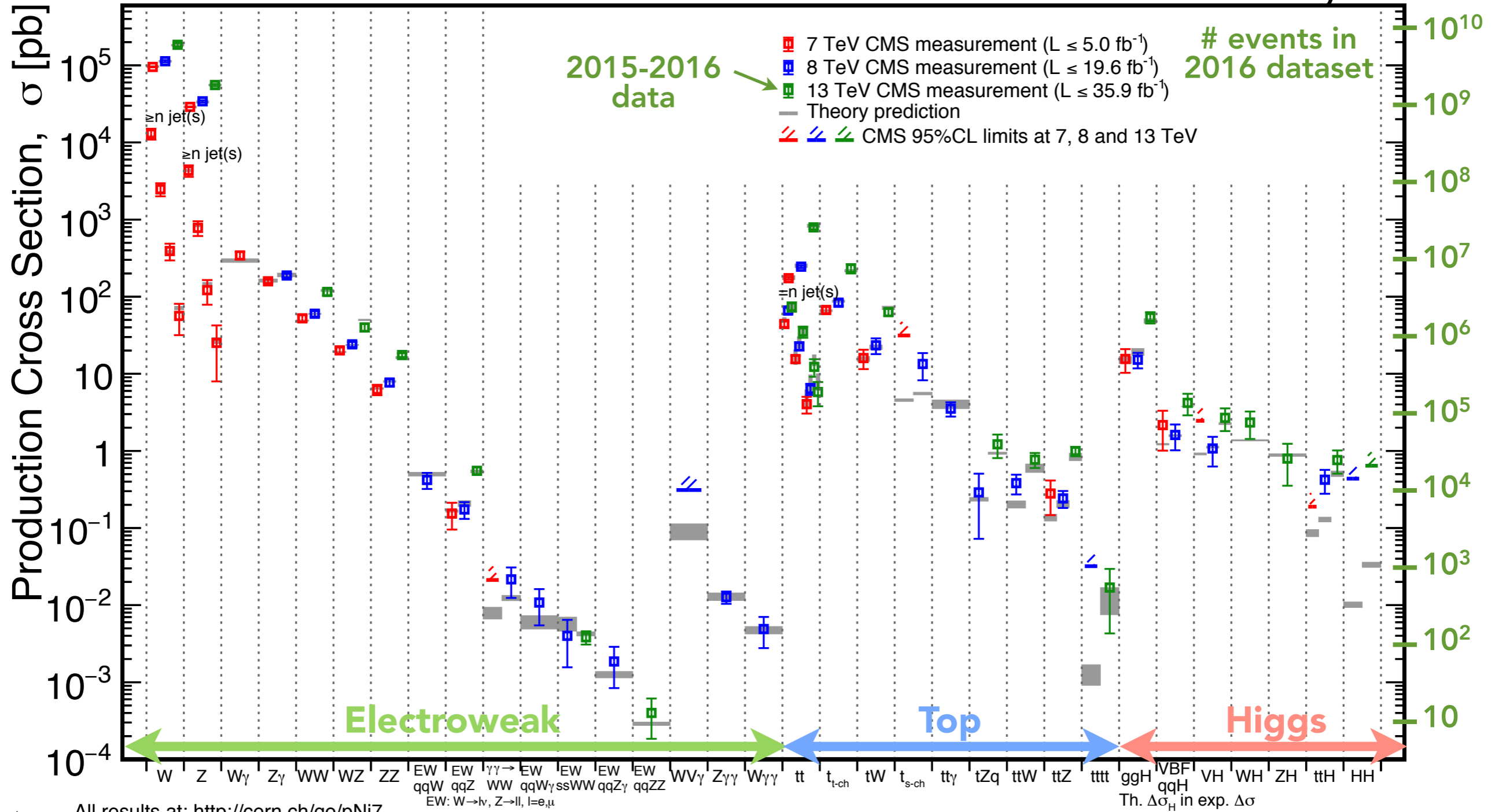


Physics highlights



November 2017

CMS Preliminary



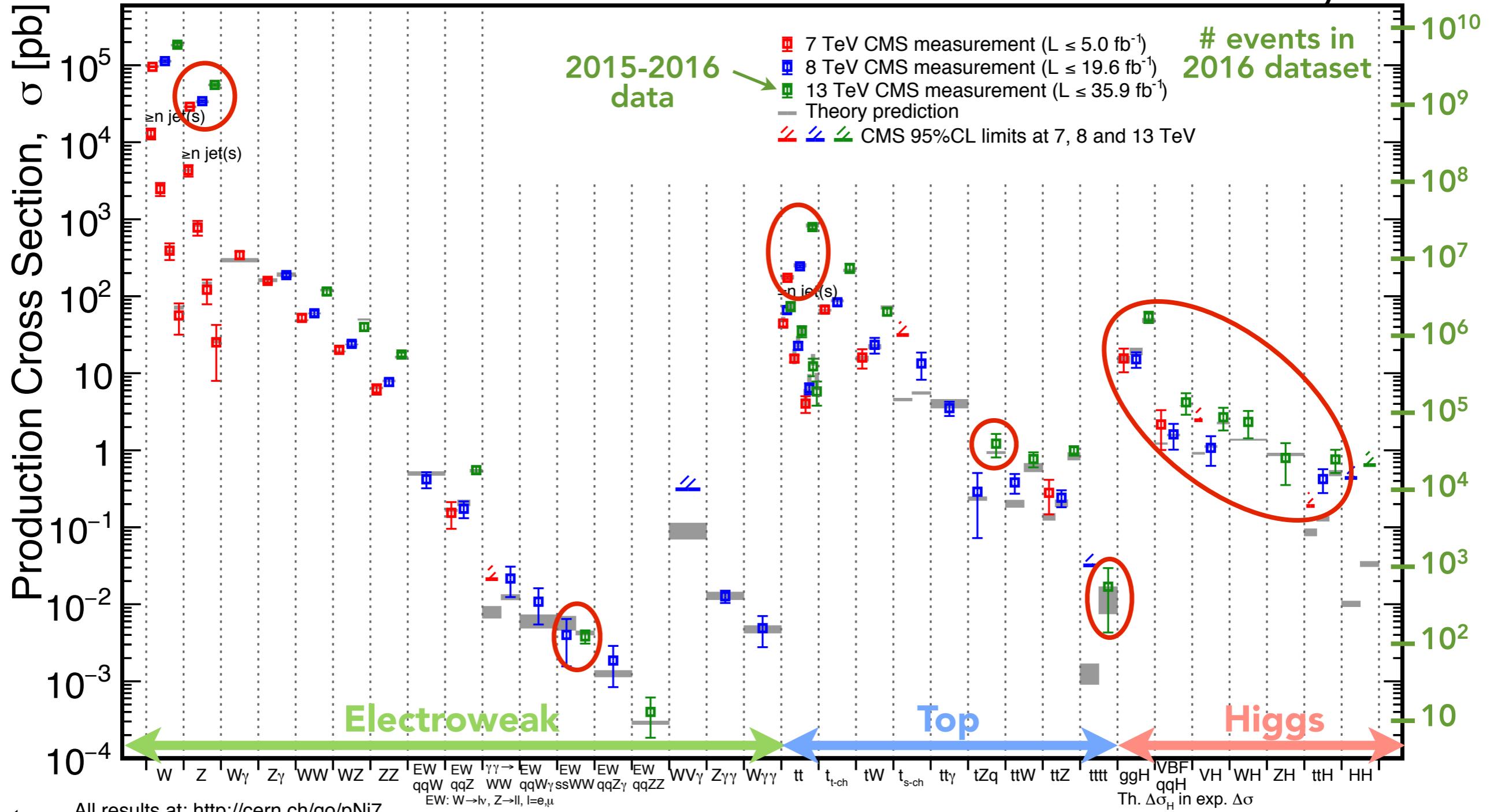
Measurements span **nine** orders of magnitude!

Physics highlights



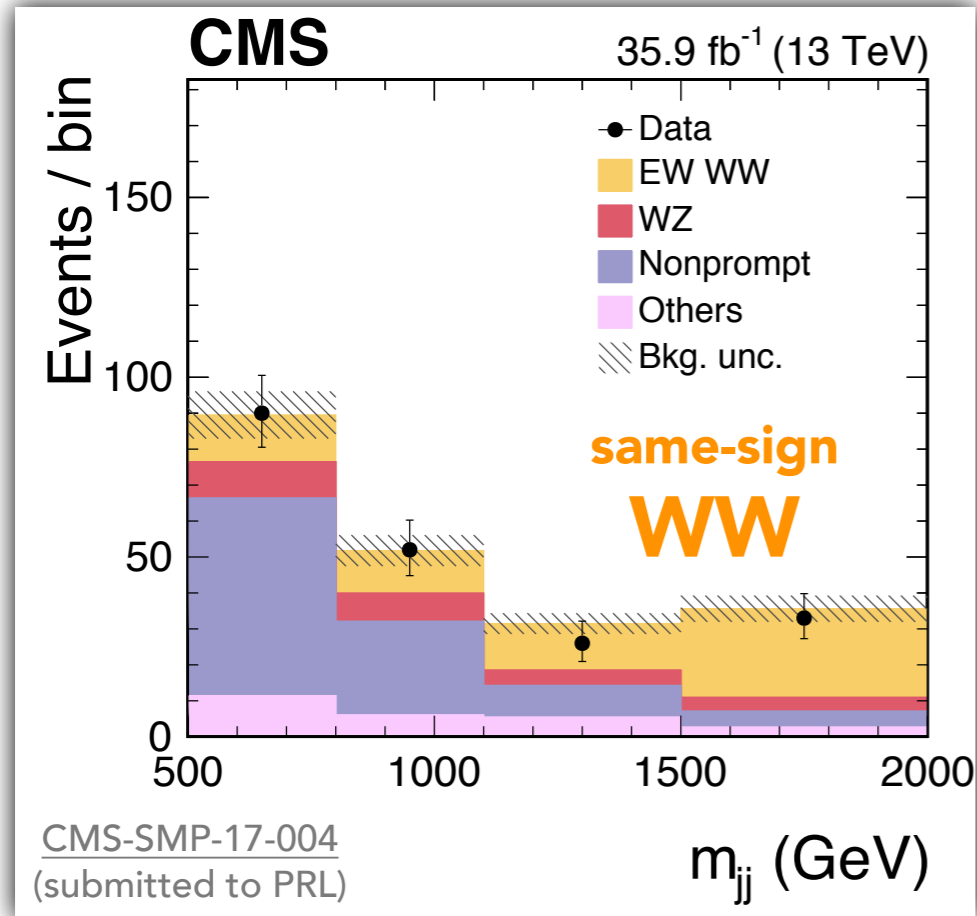
November 2017

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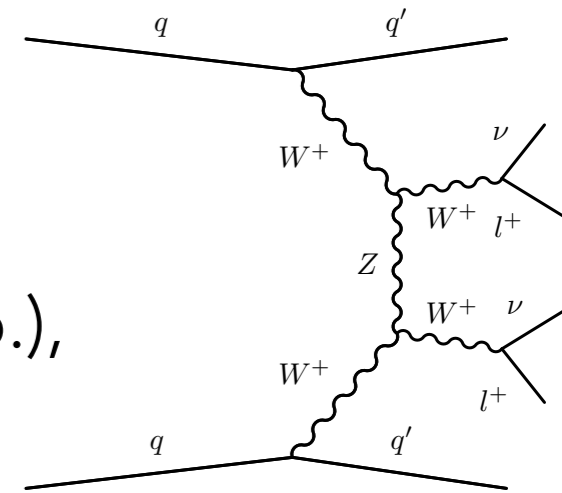
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Electroweak measurements

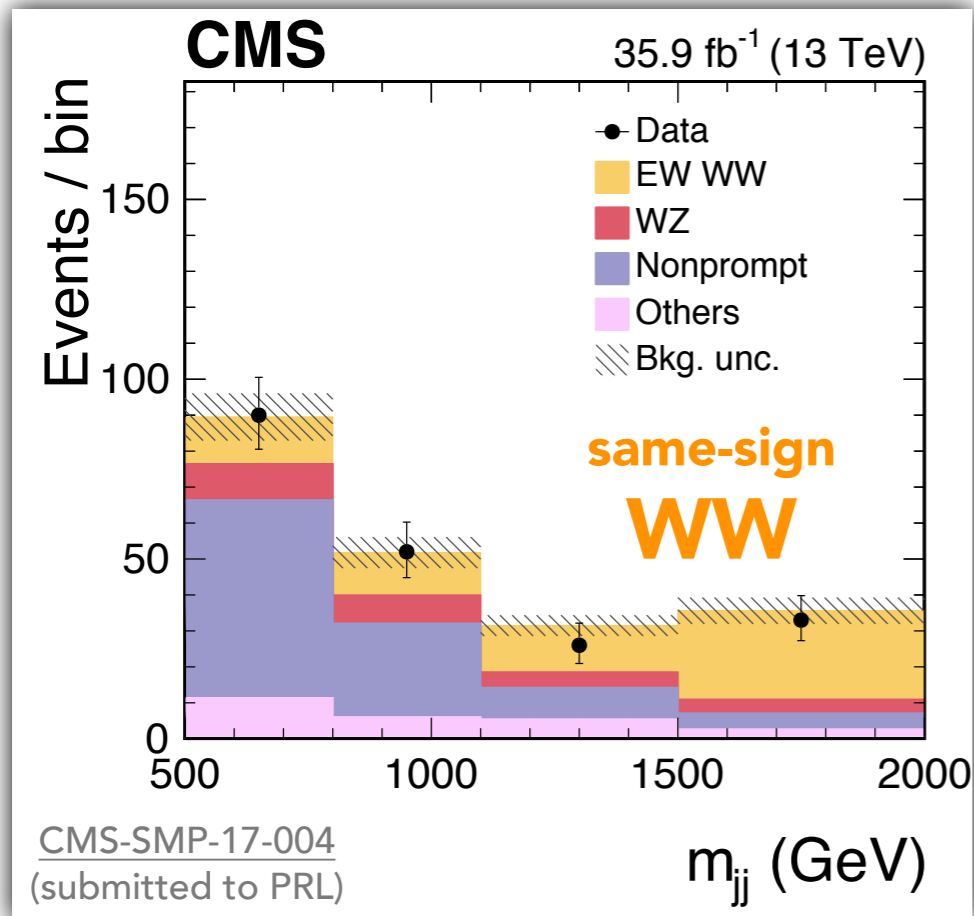


1st observation of same-sign WW

- ◆ Vector-boson scattering
- ◆ Enhanced in beyond-SM scenarios (modified Higgs sector or new resonances)
- ◆ Significance: **5.5 σ** (5.7 σ exp.), in agreement with SM

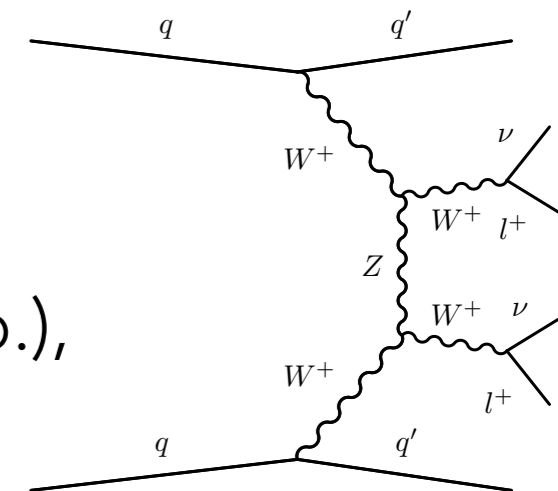


Electroweak measurements



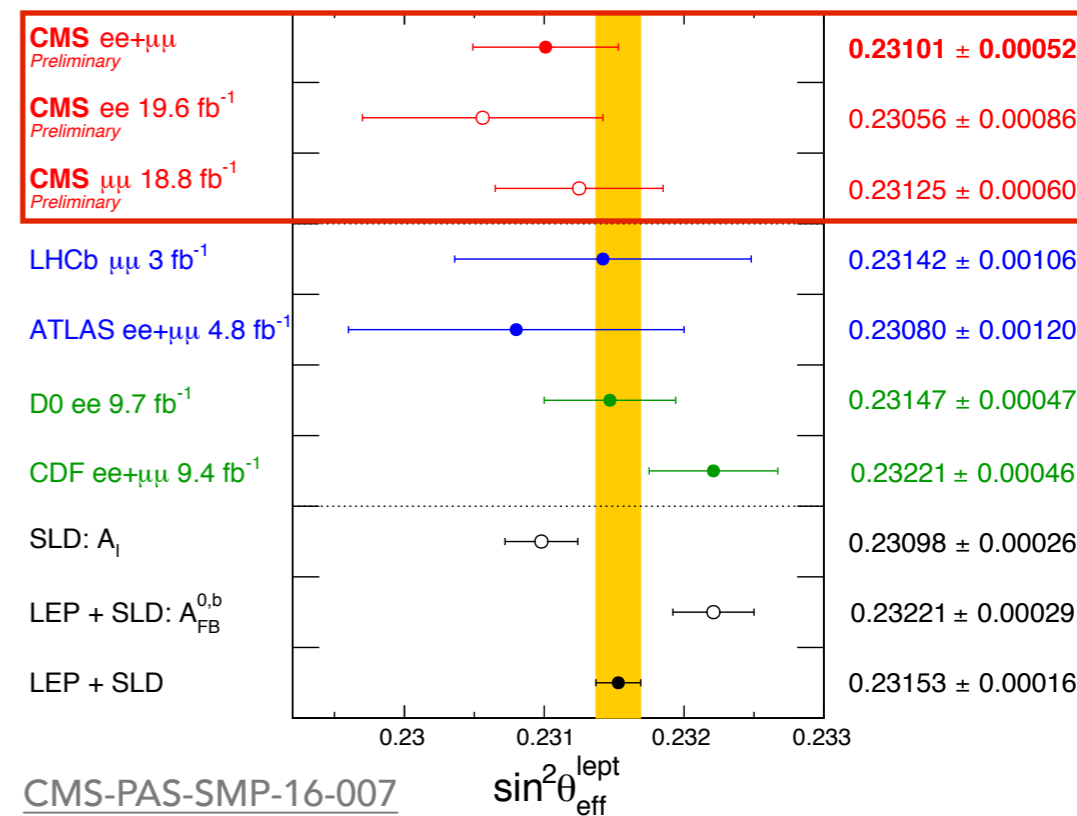
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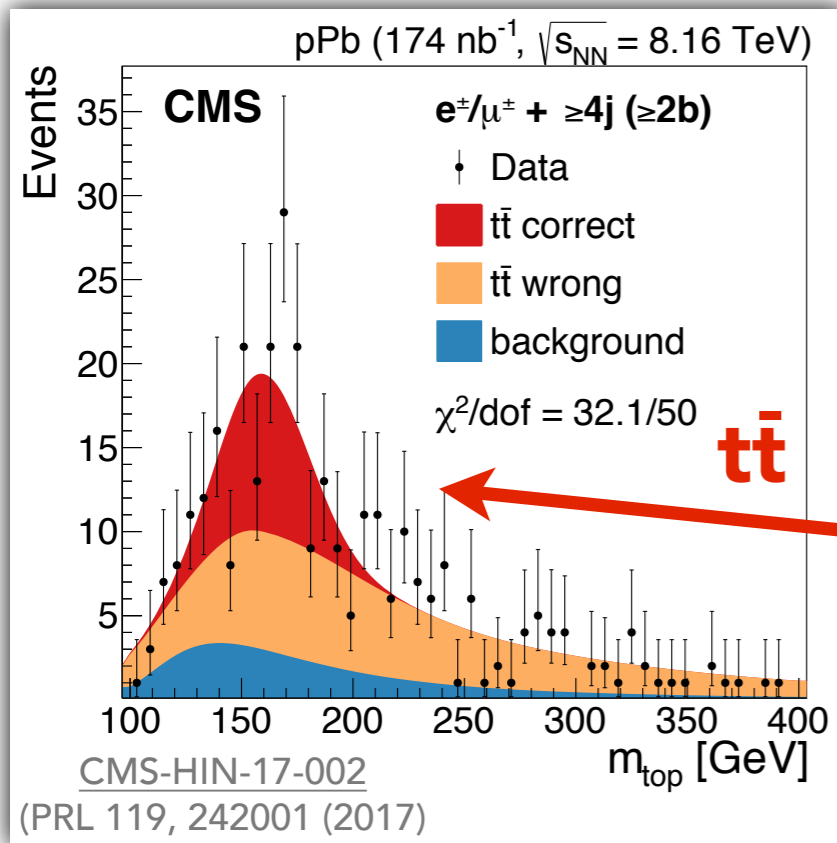


Weak mixing angle

- ◆ Exploit forward-backward asymmetry in Z → ee/μμ events (8 TeV data)
 - $\sin^2\theta_{\text{eff}}^{\text{lept}} = 0.23101 \pm 0.00052$
- ◆ Most precise LHC measurement so far



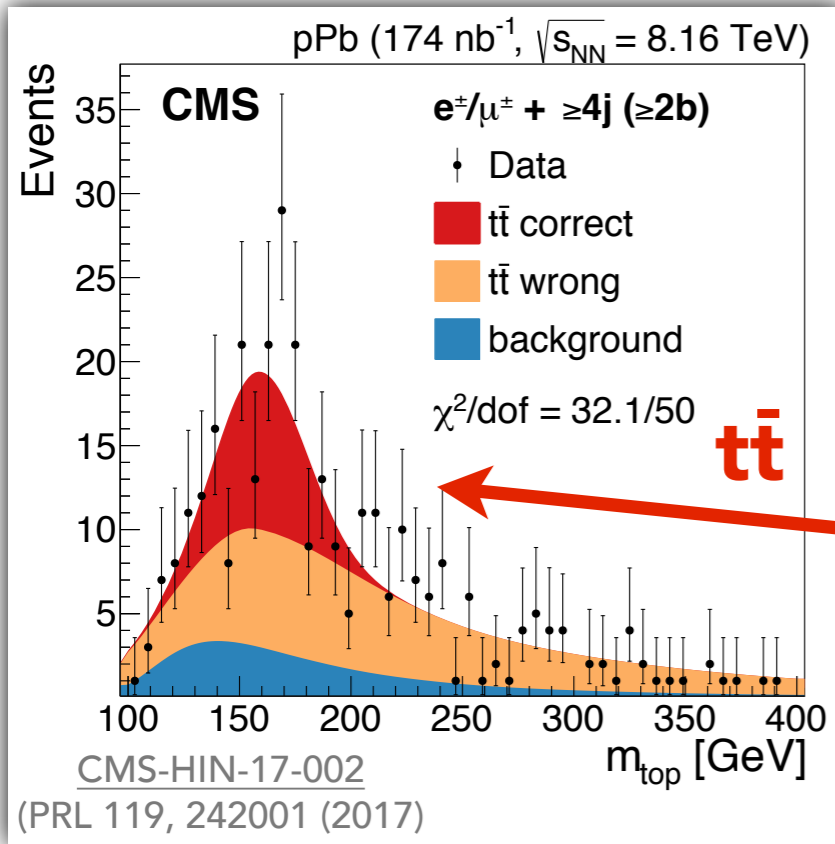
Top quarks



1st observation of tops in proton-lead collisions

- ◆ Precise probe of nuclear gluon density
- ◆ $\sigma_{t\bar{t}} = 45 \pm 8$ nb, consistent with predictions

Top quarks

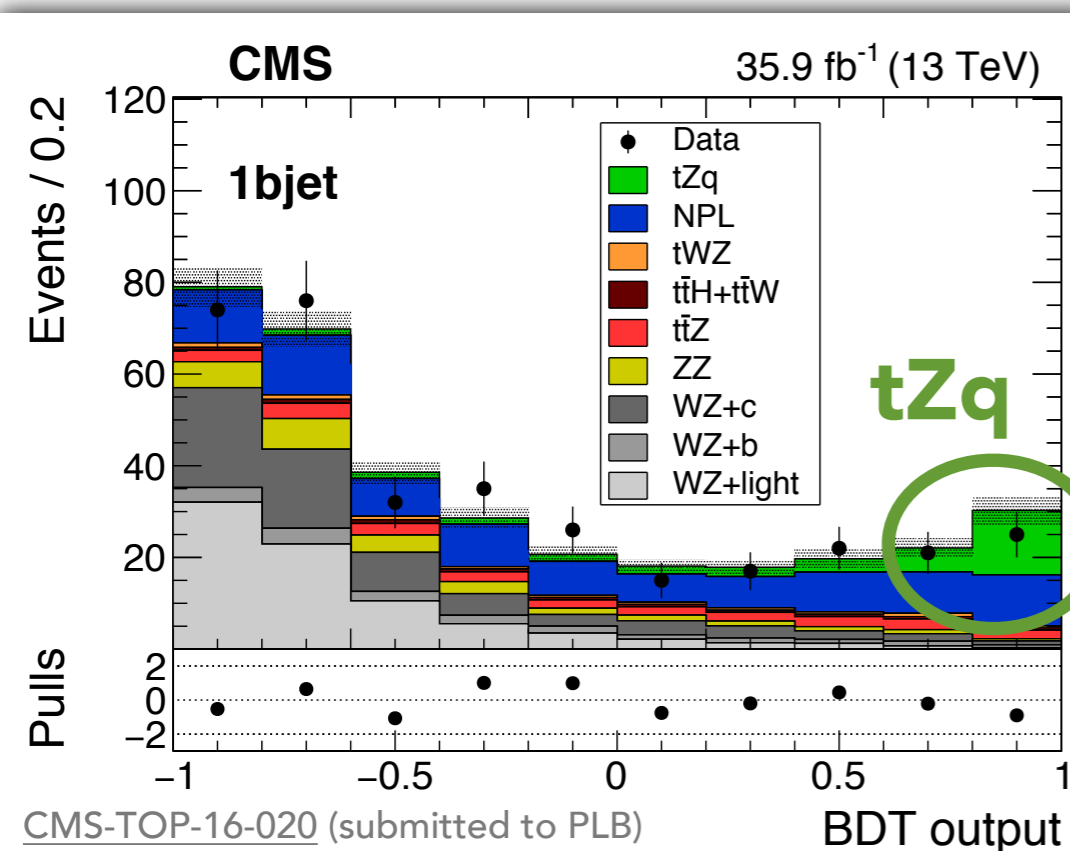


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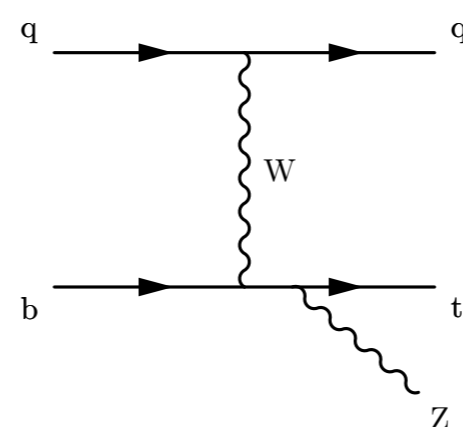
Rare SM processes

Sensitive to new physics effects!

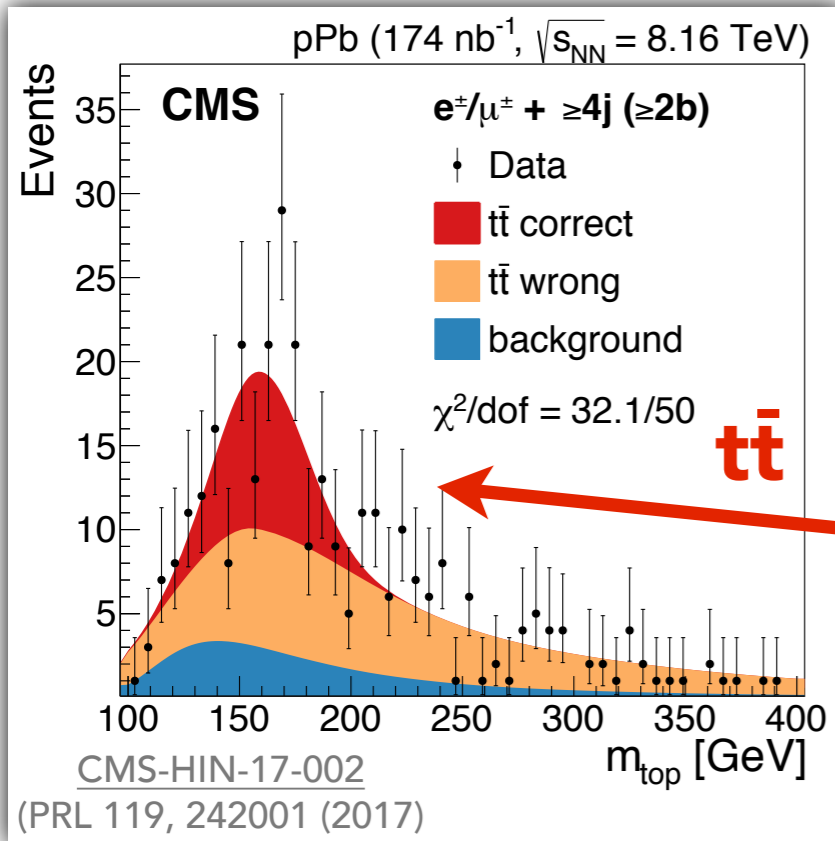


Evidence for tZq

- **3.7σ** significance (3.1 σ exp.)



Top quarks

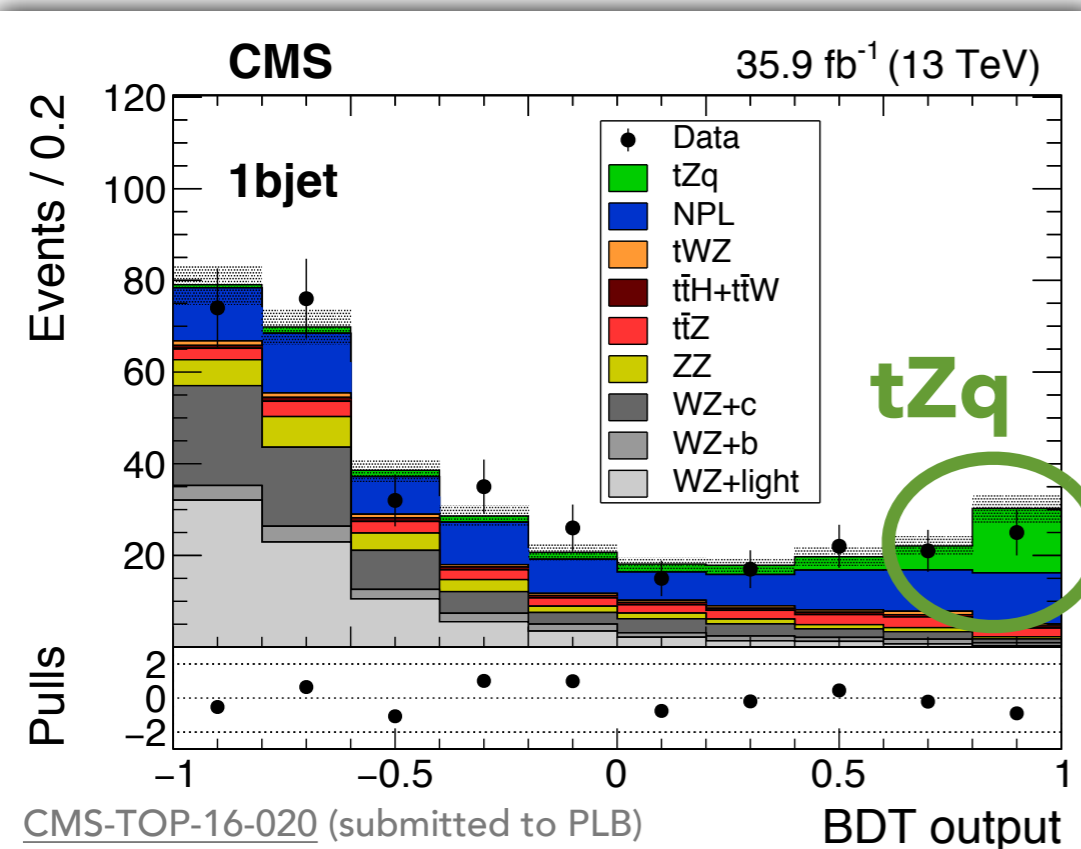


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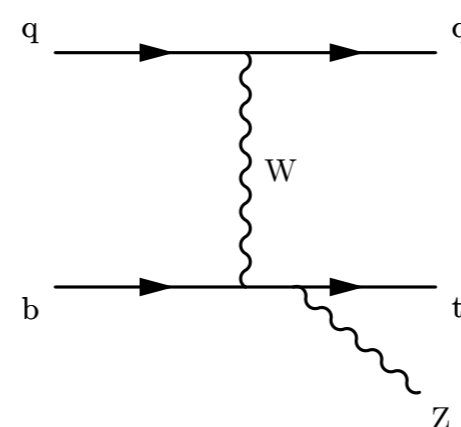
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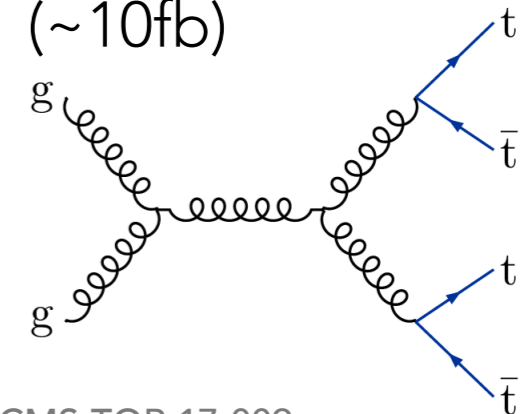
Evidence for tZq

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Search for tttt

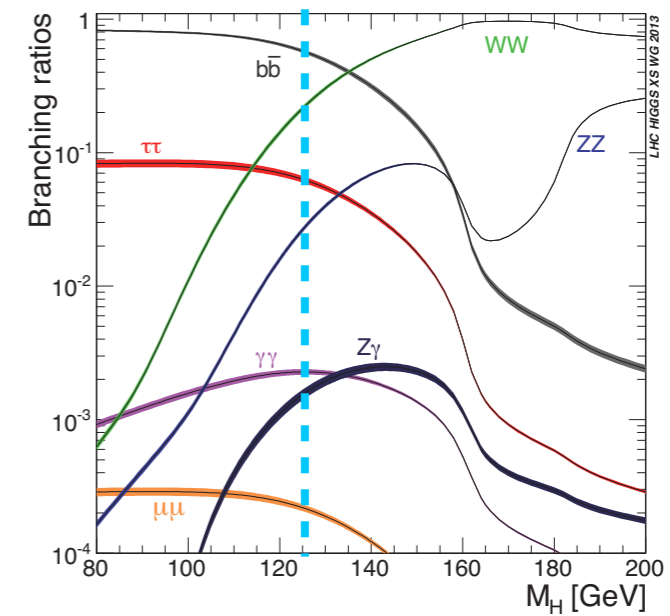
- **1.6 σ** significance, in agreement with SM (~10fb)



CMS-TOP-17-009
(submitted to EPJC)

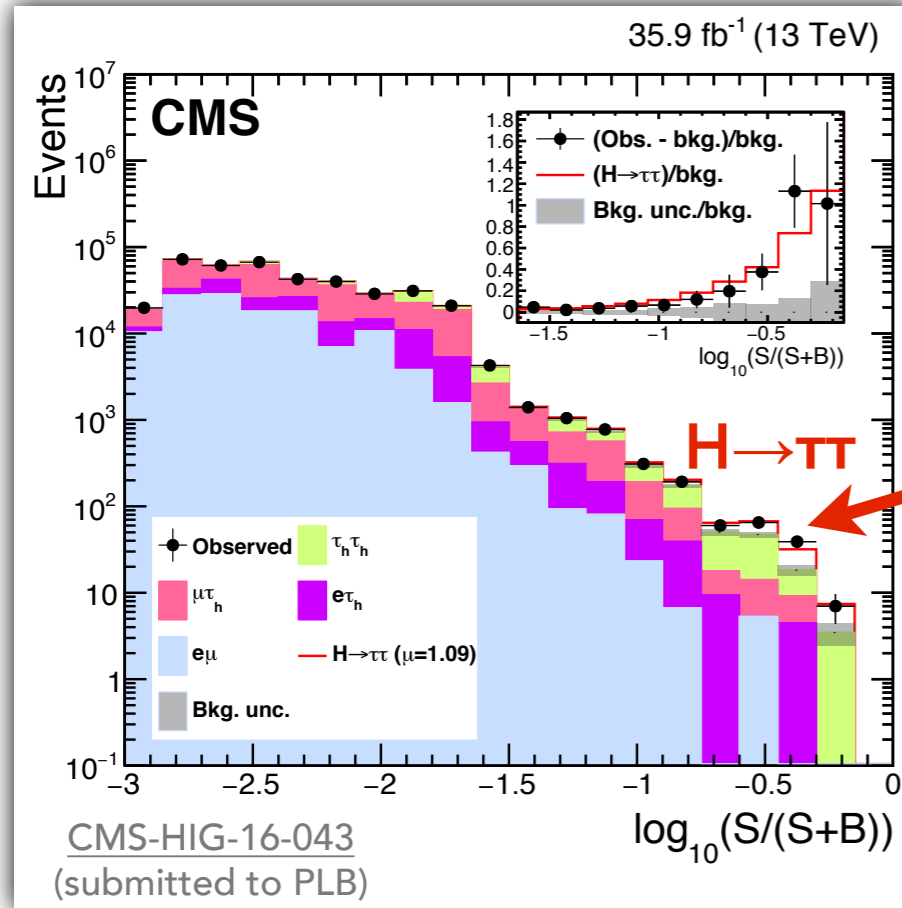
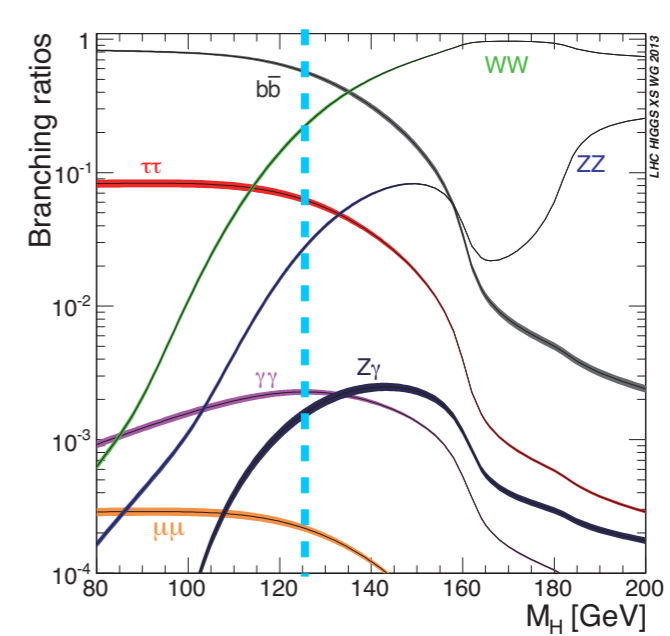
SM Higgs triumph

2012 → 2017: From first discovery with gauge bosons, to confirming fermion couplings



SM Higgs triumph

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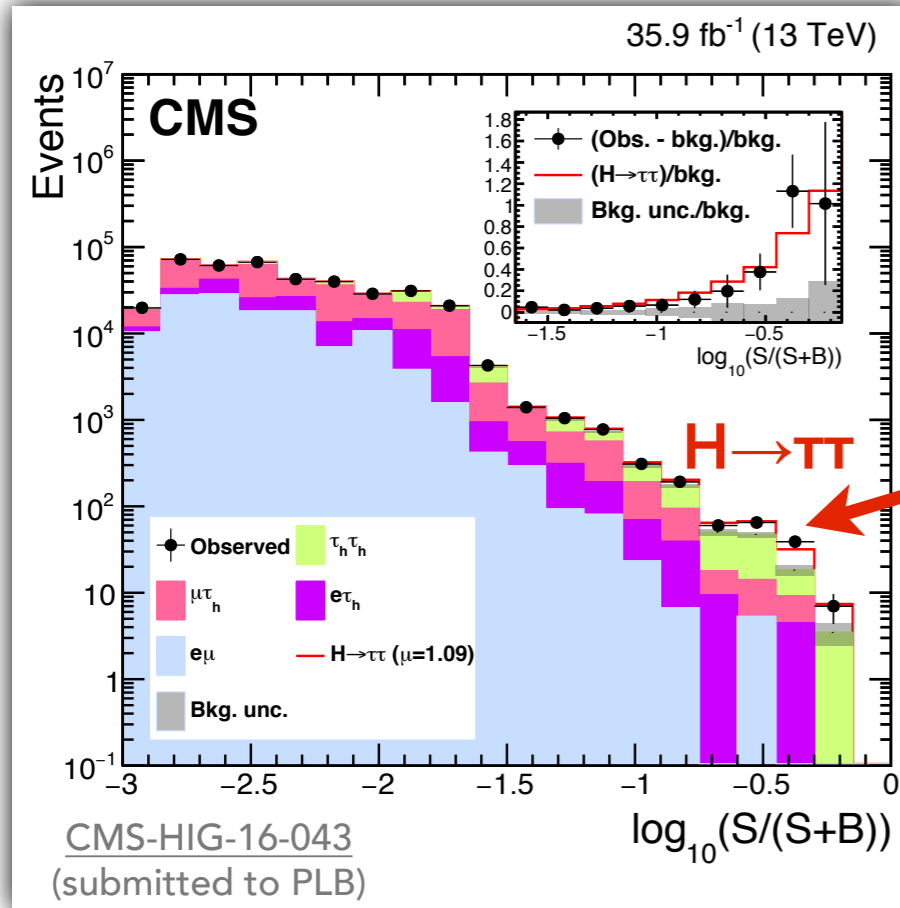
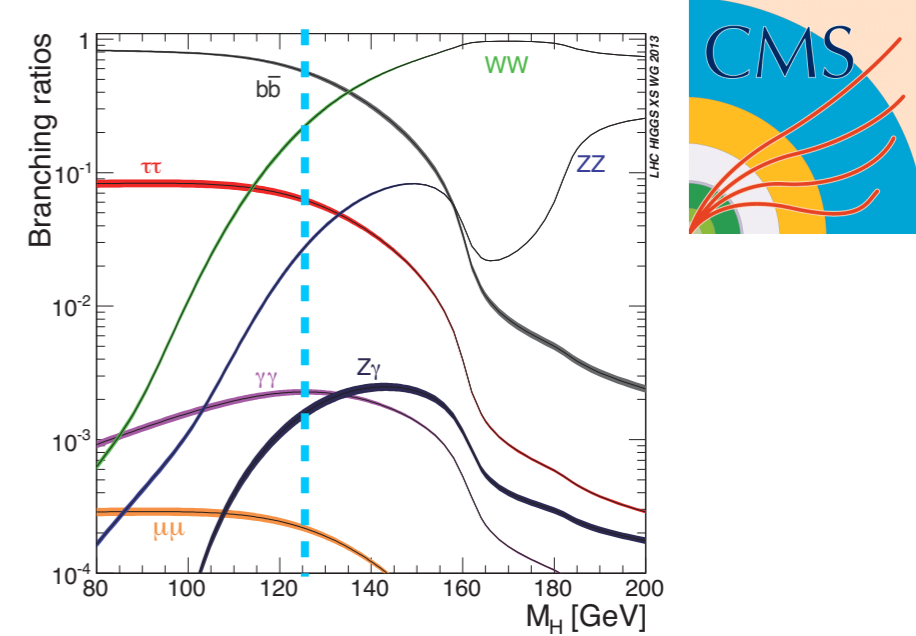


H → ττ observation

- ◆ Combination of 7/8/13 TeV → **5.9σ**
- ◆ 1st single-experiment observation!

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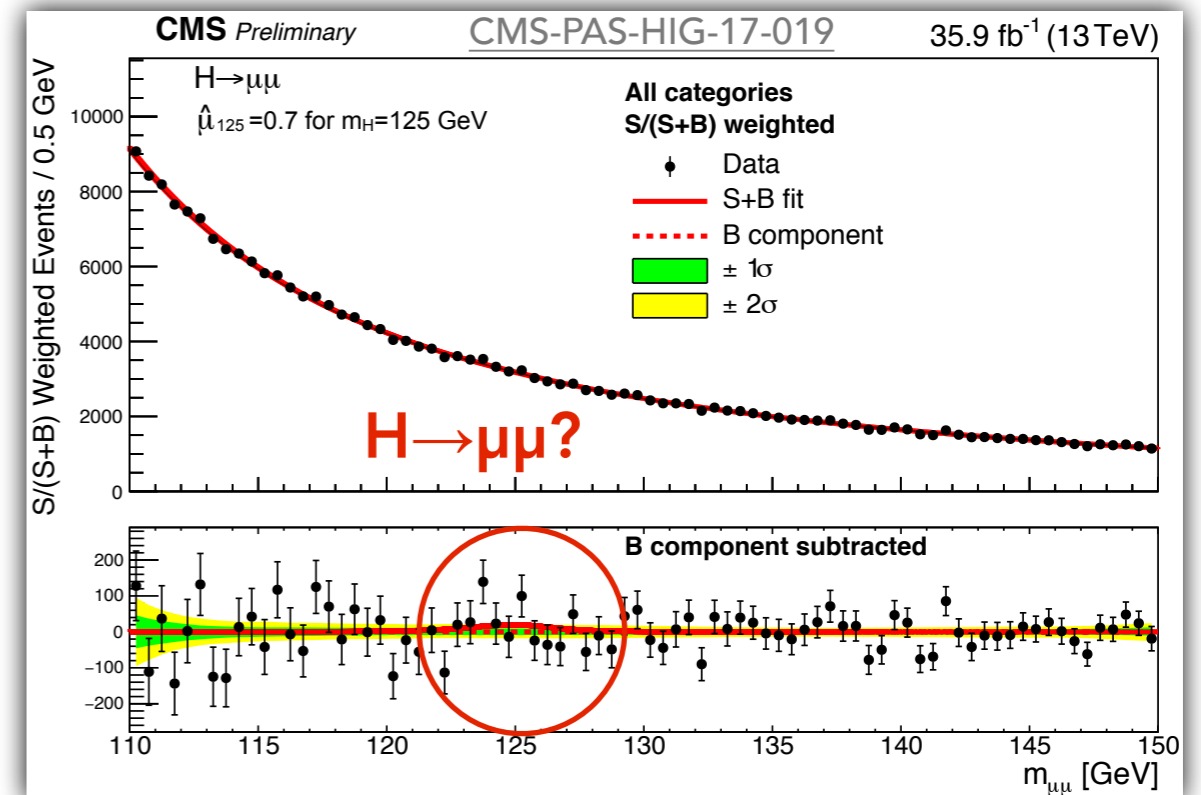
H → ττ observation

- ◆ Combination of 7/8/13 TeV → **5.9σ**
- ◆ 1st single-experiment observation!

Constrain H → μμ

- ◆ Probe 2nd gen. couplings
- ◆ Obs. limit: **2.64xSM** (1.89 exp.) @ 95% CL

Most stringent limit to date!



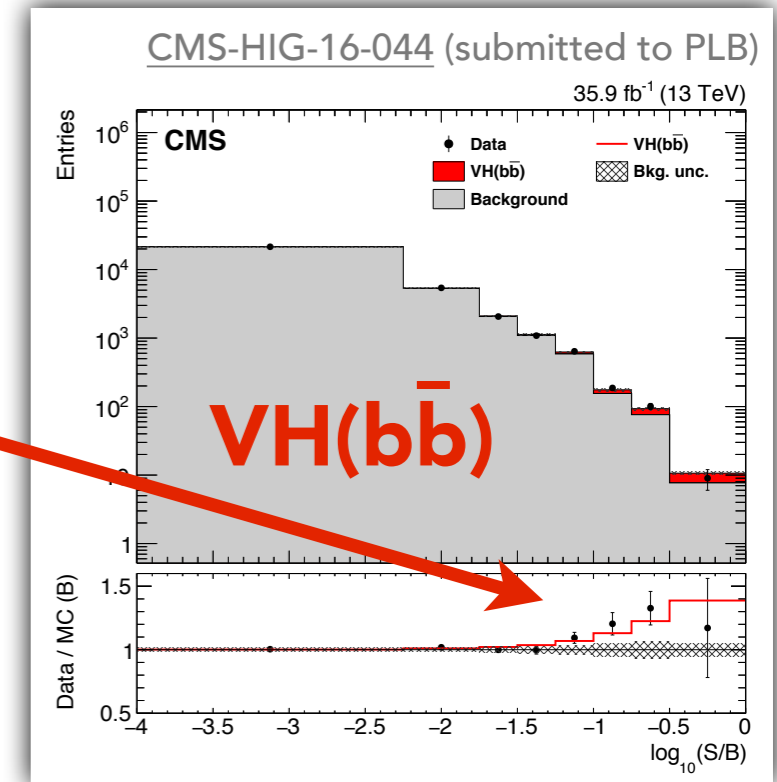
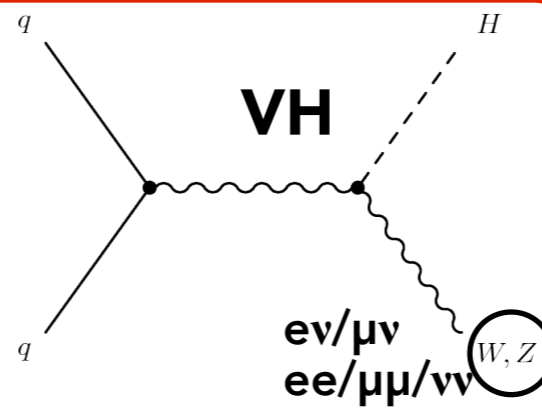
SM Higgs triumph



Evidence for $VH, H \rightarrow b\bar{b}$

◆ Combination of 7/8/13 TeV:

3.8σ

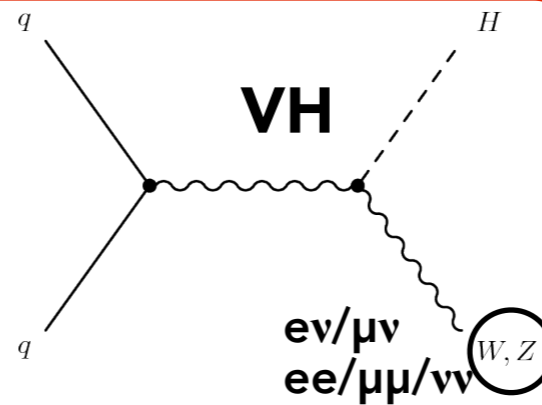


SM Higgs triumph



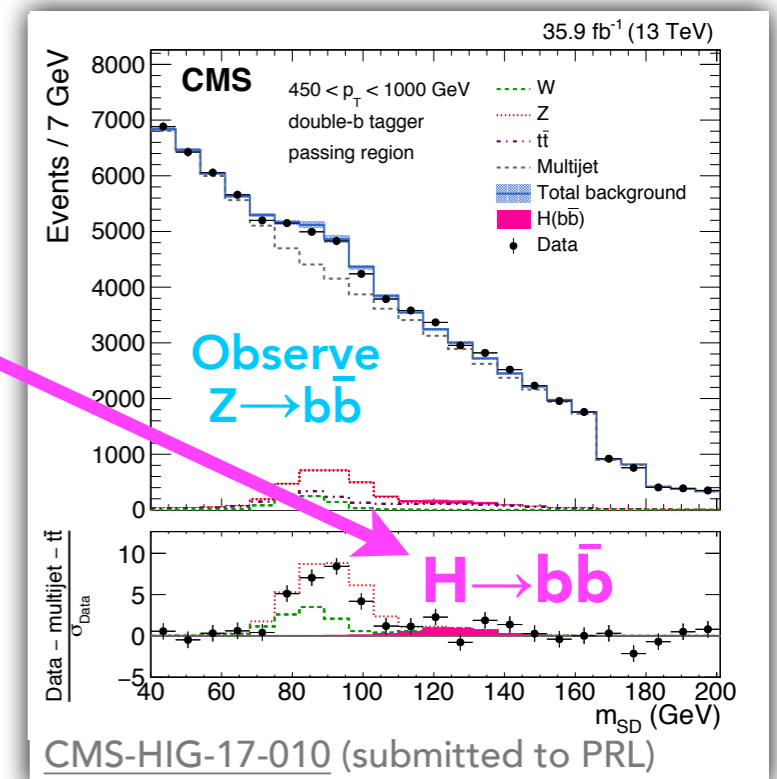
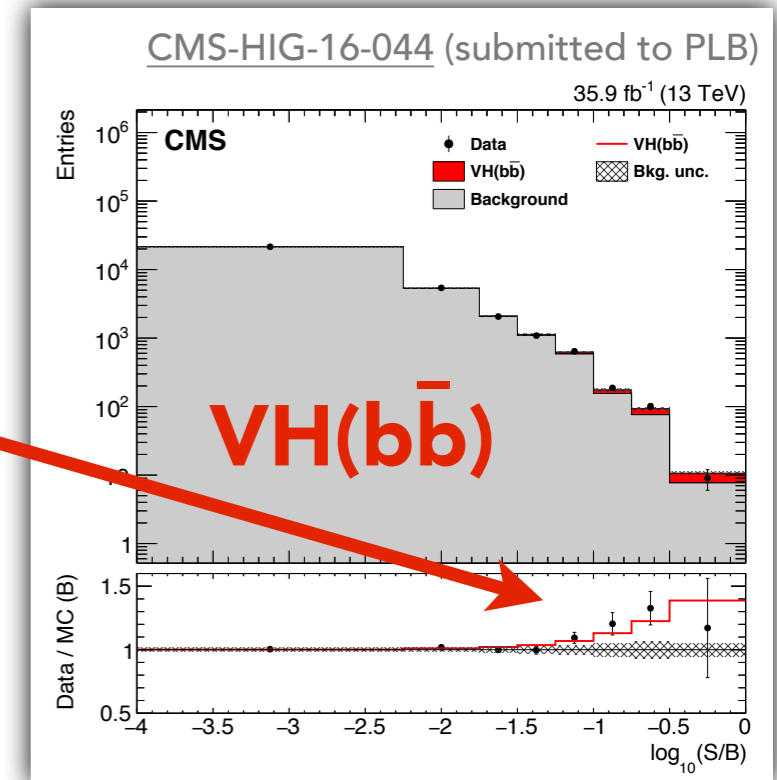
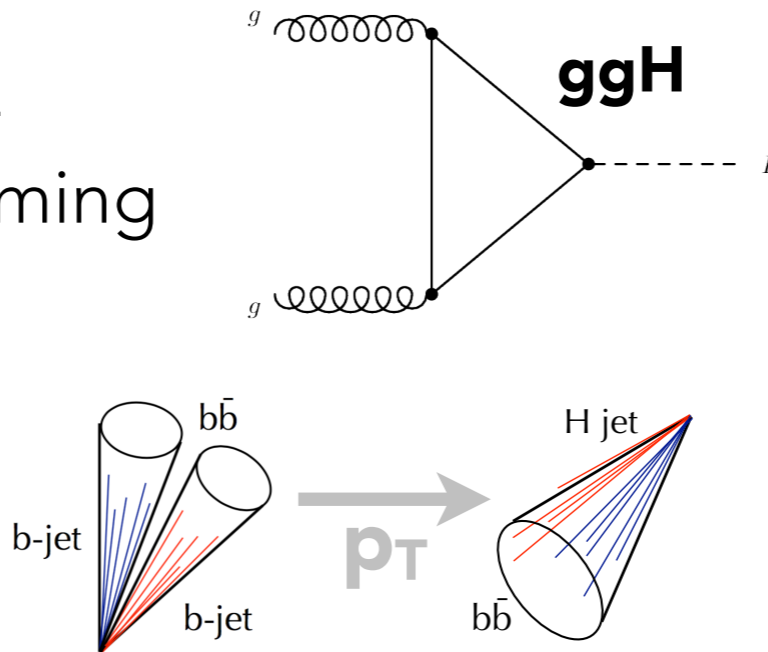
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- Combination of 7/8/13 TeV:
3.8 σ



Inclusive $H \rightarrow b\bar{b}$ search

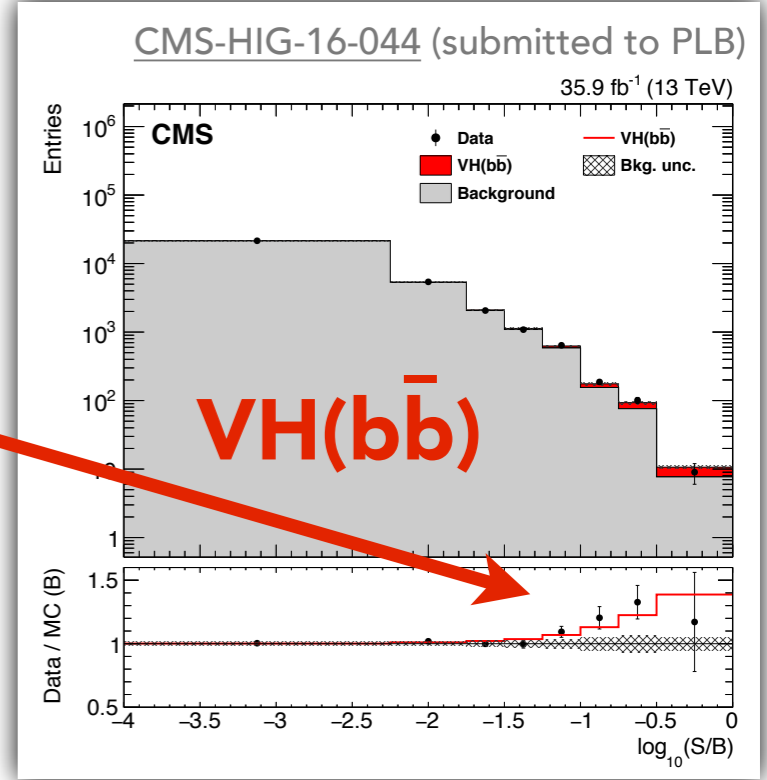
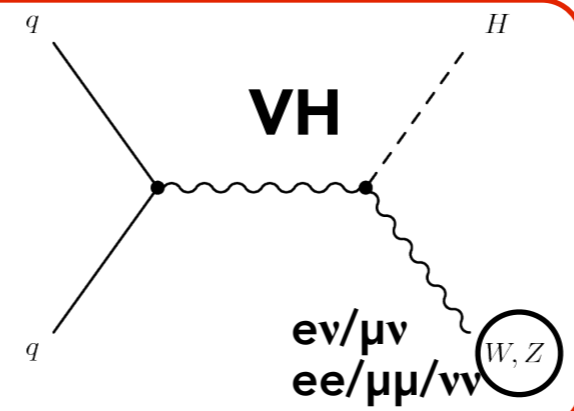
- Distinguish from overwhelming QCD bkg w. "boosted" H
- Significance:
1.5 σ (0.7 σ exp.)



SM Higgs triumph

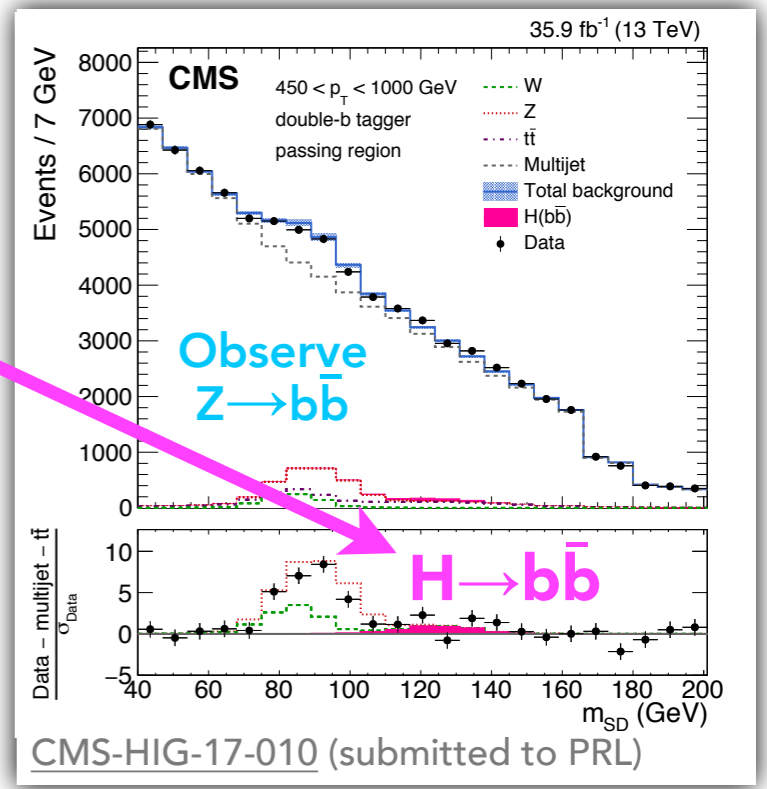
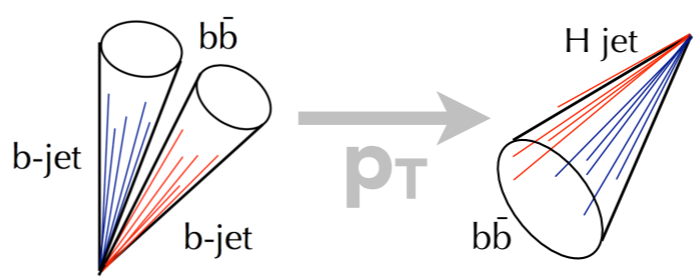
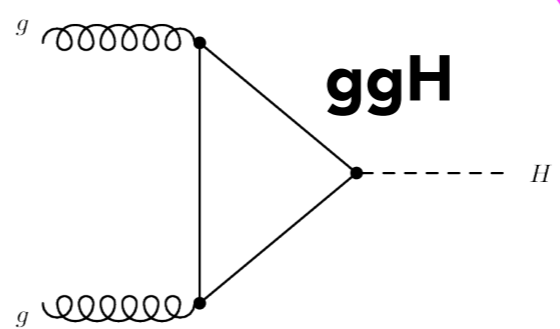
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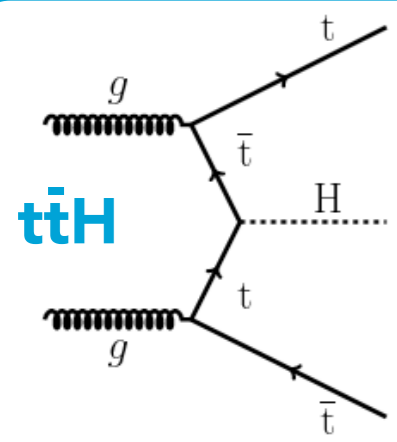
Inclusive $H \rightarrow b\bar{b}$ search

- Distinguish from overwhelming QCD bkg w. "boosted" H
- Significance:
1.5 σ (0.7 σ exp.)



Evidence for $t\bar{t}H$ production

- Direct access to top Yukawa coupling
- Searches in leptonic final states:
3.3 σ evidence (2.5 σ exp.)



CMS-PAS-HIG-17-004

Direct searches



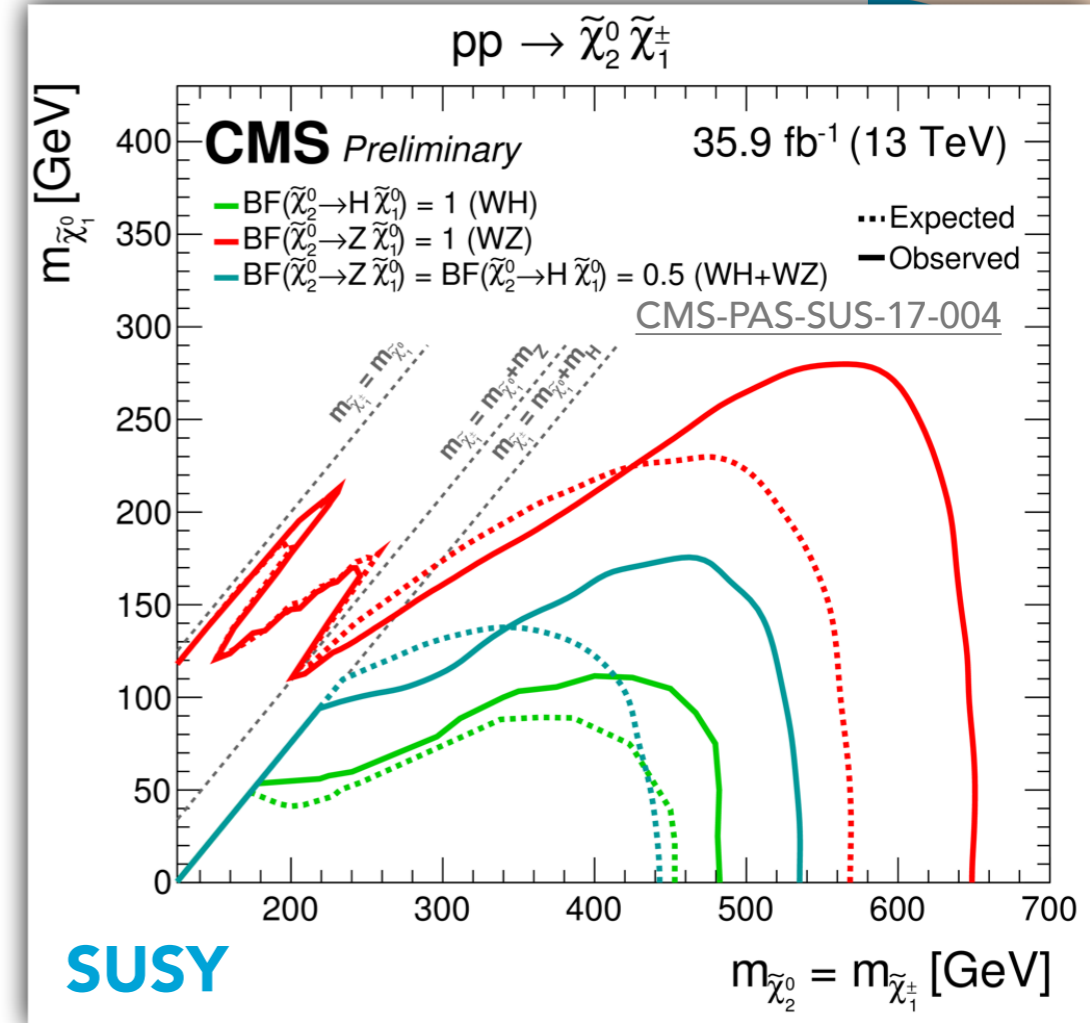
Broad spectrum of new physics searches

- ◆ Probe different SUSY models/phase-space
- ◆ Long-lived particles
- ◆ Dark matter
- ◆ New resonances, ...

Direct searches

Broad spectrum of new physics searches

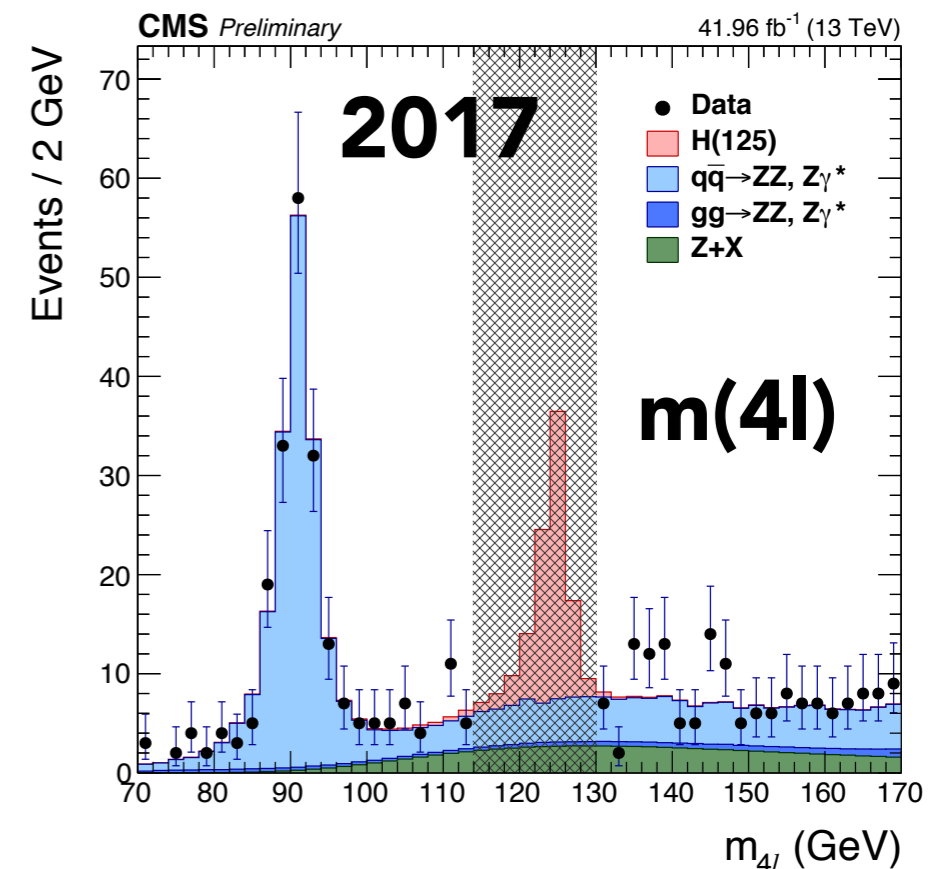
- ◆ Probe different SUSY models/phase-space
- ◆ Long-lived particles
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Conclusions



- Exciting year for CMS physics!
 - ✦ Many new results, primarily analyzing 2016 13 TeV data
 - Unprecedented datasets allow detailed precision measurements & probing very rare processes
 - ✦ Continued triumph of SM Higgs boson
 - Observation of coupling to tau leptons
 - Evidence for coupling to b/top quarks
 - ✦ Extensive program searching for new physics
 - Direct searches
 - Precision SM
 - Rare processes
- Meanwhile, analyses of 2017 data & preparing for 2018 run ongoing!



None of this feasible w/o the >3500 CMS collaborators!



1992

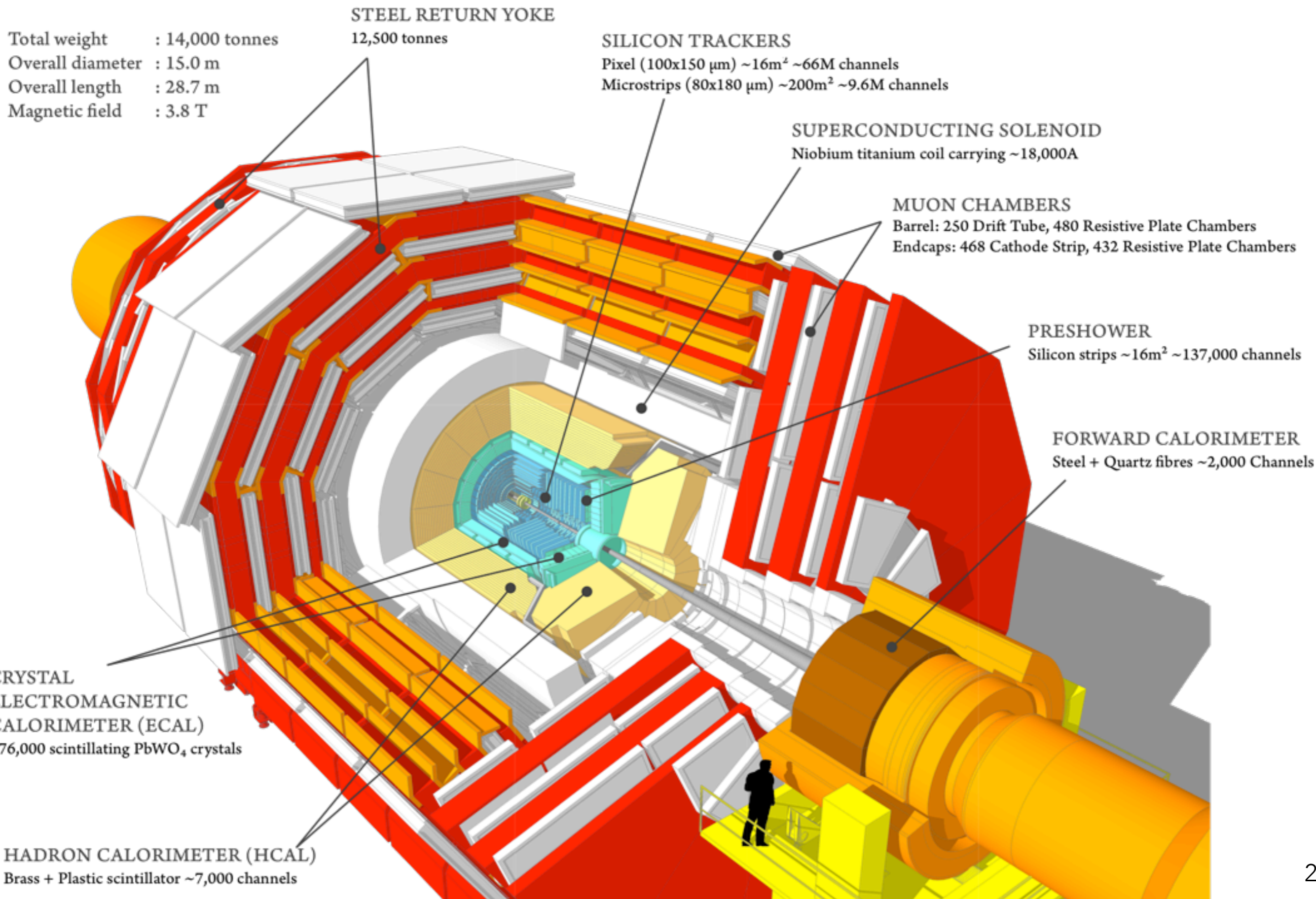


2017

A top-down view of a complex, circular industrial machine, possibly a particle accelerator or a large-scale server array. The machine features a central circular core surrounded by multiple layers of components, including blue and red panels, and a dense network of cables and pipes. The overall structure is highly symmetrical and intricate. The word "BACKUP" is overlaid in the center in a bold, white, sans-serif font.

BACKUP

CMS detector



Upgraded CMS for HL-LHC



New Tracker

- Radiation tolerant - high granularity - less material
- Tracks in hardware trigger (L1)
- Coverage up to $\eta \sim 4$

Muons

- Replace DT FE electronics
- Complete RPC coverage in forward region (new GEM/RPC technology)
- Investigate Muon-tagging up to $\eta \sim 3$

Barrel ECAL

- Replace FE electronics
- Cool detector/APDs

New Endcap Calorimeters

- Radiation tolerant
- High granularity

Trigger/DAQ

- L1 (hardware) with tracks and rate up ~ 750 kHz
- L1 Latency $12.5 \mu\text{s}$
- HLT output rate 7.5 kHz

Other R&D

- Fast-timing for in-time pileup suppression
- Pixel trigger

