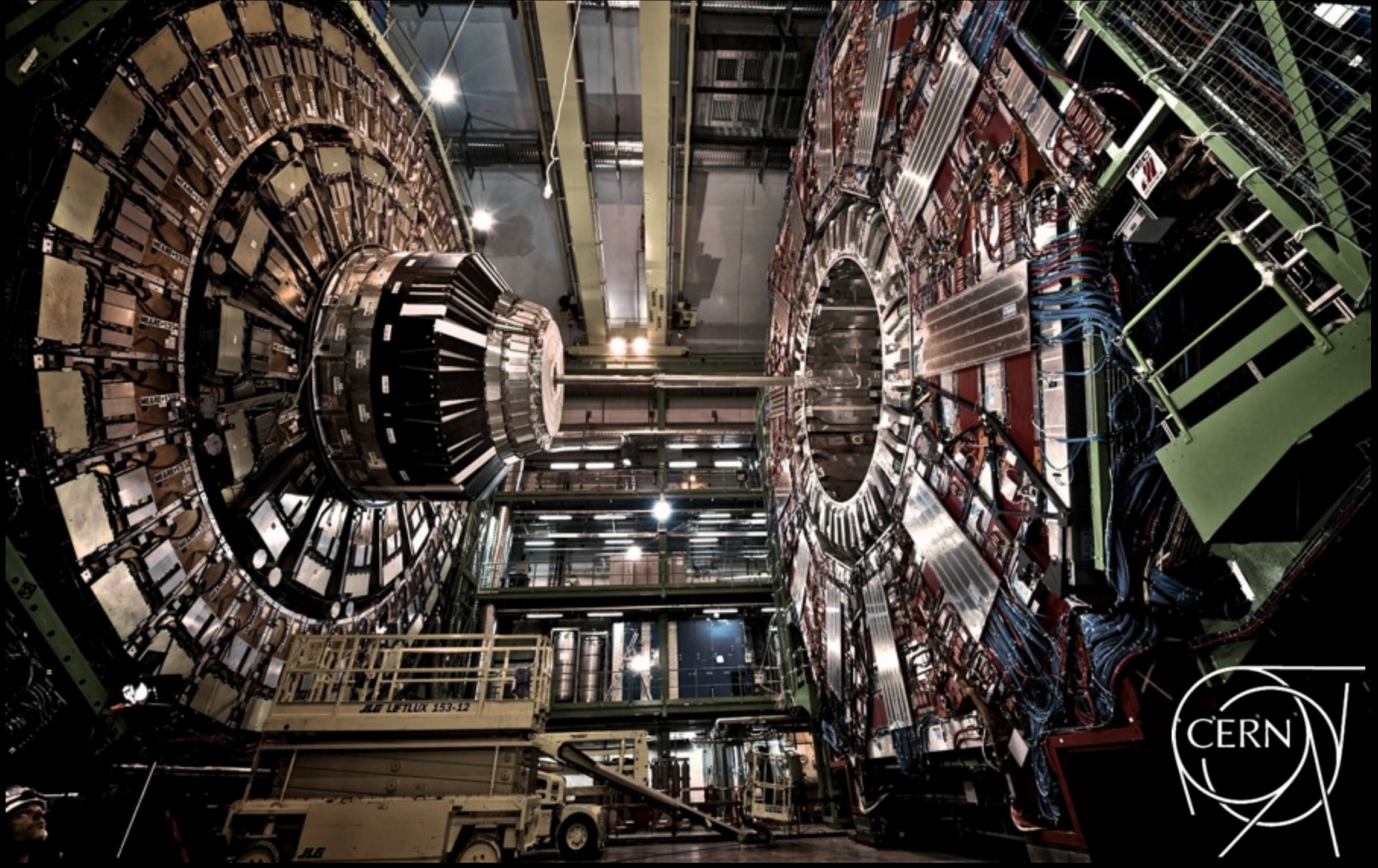

CMS Status Report

G. Cerminara (CERN) on behalf of the CMS Collaboration

117th LHCC Open Session - 5th of March 2014 - CERN

Outline

Three main fronts of activity during LS1

- consolidation and preparation for RunII
  - both detector hardware and offline workflows
  - this is actually entangled with preparation for PhaseI detector upgrades
- squeezing the most out of the RunI data
  - pick some of the latest results (just an overview, not meant to be comprehensive)
- PhaseII upgrade preparation
  - Technical Proposal preparation

Outline

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  - both detector hardware and offline workflows
  - this is actually entangled with preparation for PhaseI detector upgrades

LS1 2013-14

LS1 consolidation: Complete/consolidate for nominal LHC beam conditions:
Prepare for: 13 TeV, 10^{34} Hz/cm^2 , Ave. Pileup (<PU>)~25

- Complete Muon system (4th endcap station) and improve readout electronics
- Replace HCAL photo-detectors and backend electronics in a couple of regions
- Make it possible to operate the Tracker -20◦C (almost 25 C colder than before)

LS2 2018

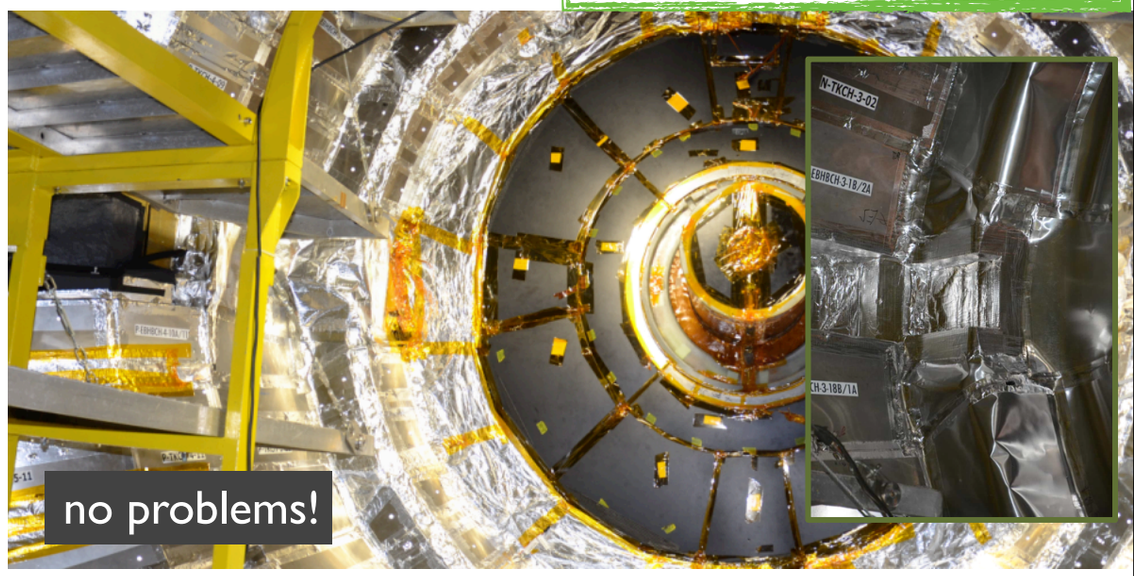
Phase 1 upgrades: Prepare for 1.6 x 10^{34} Hz/cm^2 , <PU> ~40, ≤ 200 fb^{-1} by LS2
Prepare for 2.5 x 10^{34} Hz/cm^2, <PU> ~ 60, ≤ 500 fb^{-1} by LS3

- New L1-trigger system ready for 2016 data taking
- New Pixels ready for installation in 2016/17 Year End Technical Stop (YETS)
- Install new HCAL photodetectors and electronics in 2015 YETS and LS2

Tracker Cold Test

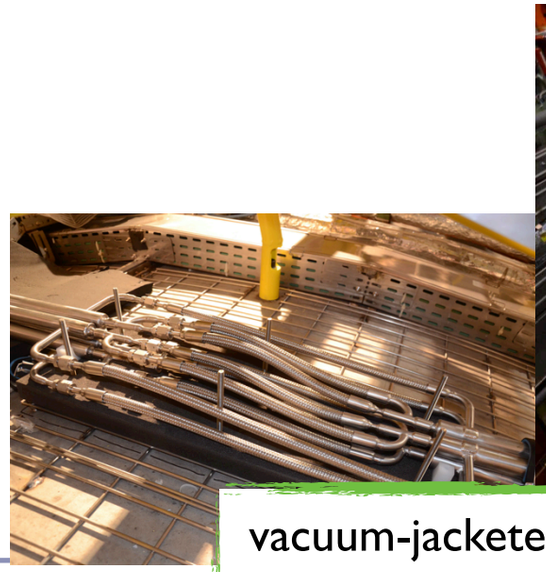
- Major Milestone completed: Tracker Master Cold Test
  - SiStrip @-20°C; Thermal Screen @-10°C and pixel lines @-25°C
  - Environment good for -25°C operation!
  - No bad surprises with steady operation or transients
- **A good working point until LS3**
- Lot of work on services and sensors
  - some of this pre-requisite for Pixel Phase I (2017) installation
    - Vacuum jacketed CO_2 pipes installed!
    - Add. power cables installed!

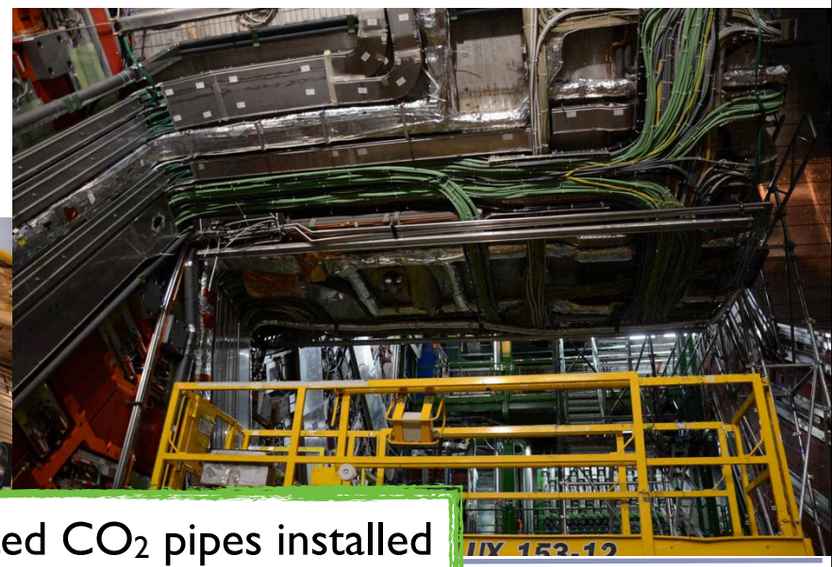
Sealing concept successful



Several hundred new RH and T sensors –inside and outside

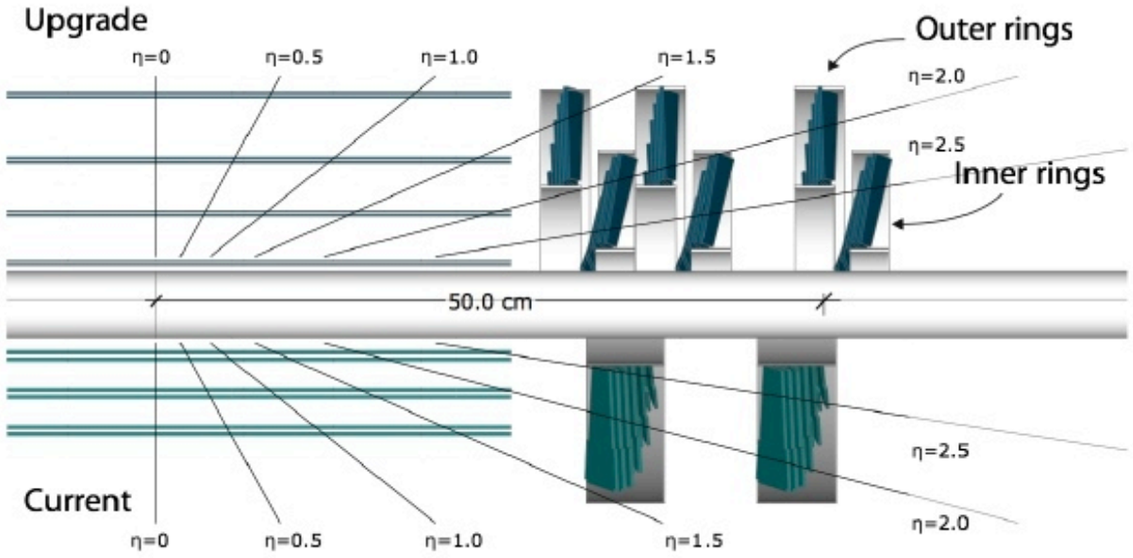
* Cooling bundle repair successful
+ heater wires
+ flushing
+ T sensor

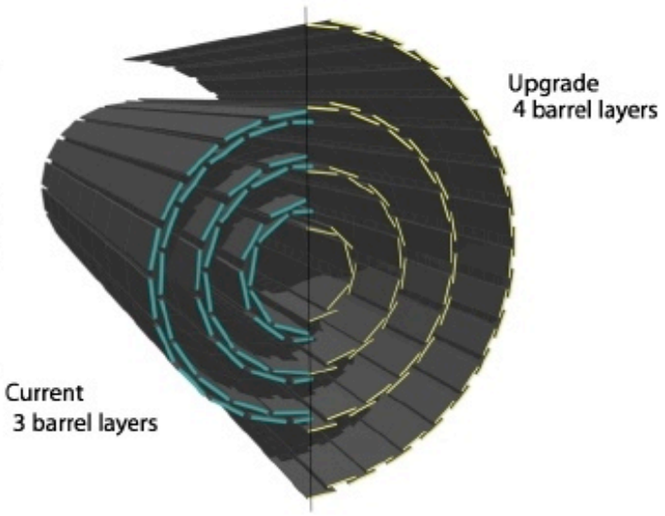




vacuum-jacketed CO_2 pipes installed

2016 Pixel Detector

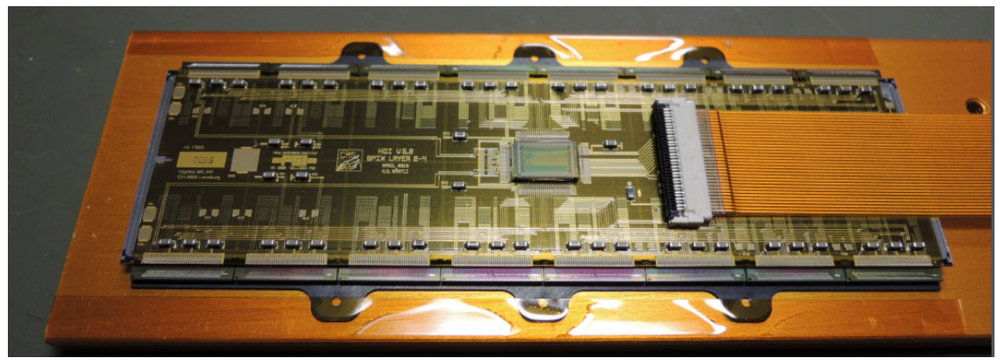




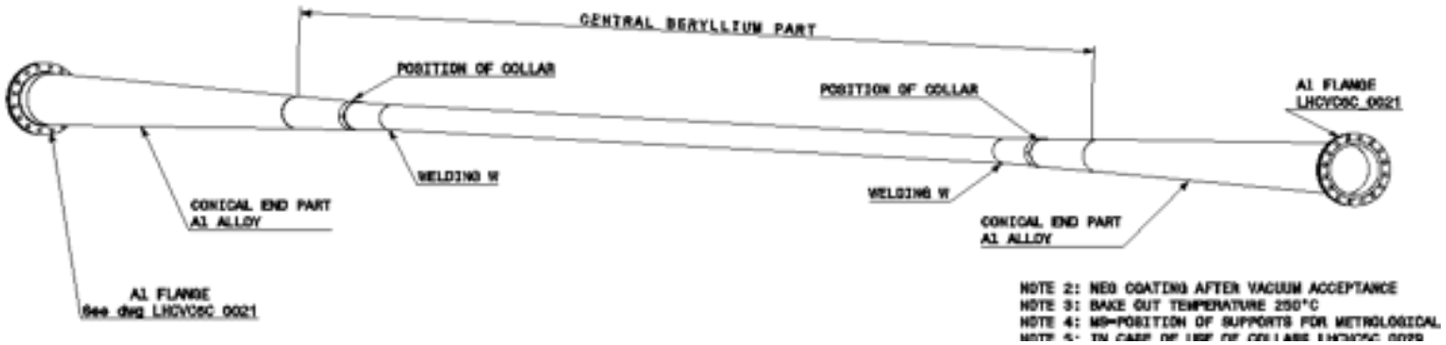
CMS-TDR-011

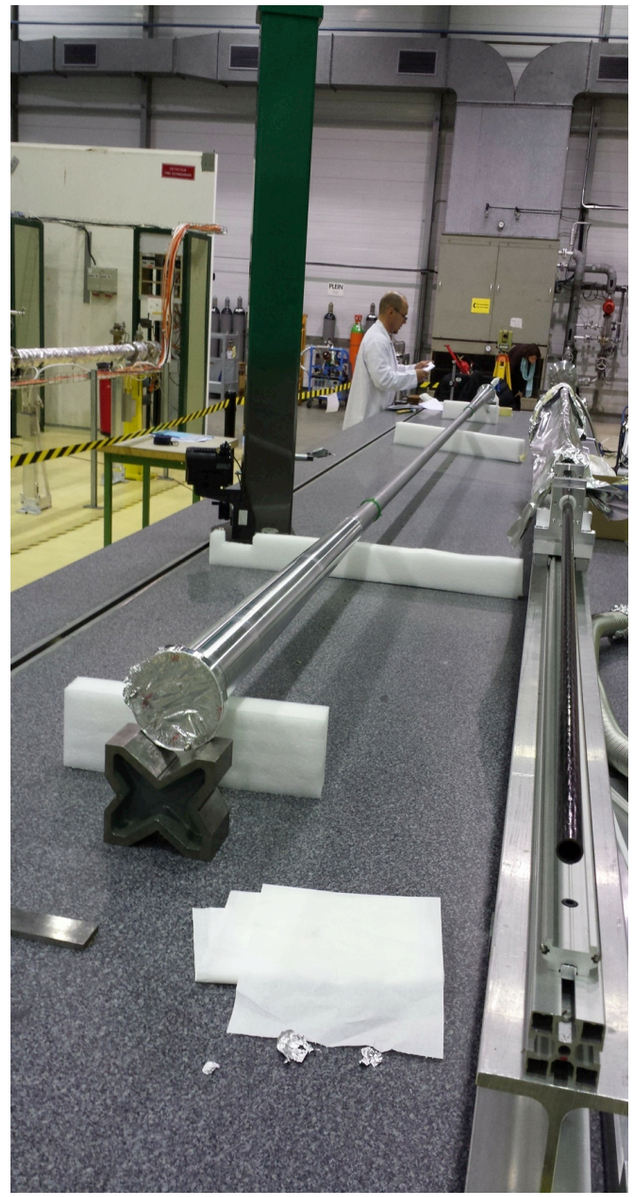
- 4 layers / 3 disks
  - one more space point: smaller inner radius (3 cm)
- new readout chip
  - recovers inefficiency at high rate and PU
- less material
  - CO_2 cooling, new cabling and powering scheme (DC–DC)
- longevity
  - tolerate 100 PU and survive to 500 fb^{-1}, possibly with exchange of innermost layer
- status: first modules of barrel and forward detector produced.
  Project PASSED a 2-day Engineering Design Review (EDR) in December
  - Pilot Blade with final Readout Chip to be installed in August 2014

new module



New Beam Pipe



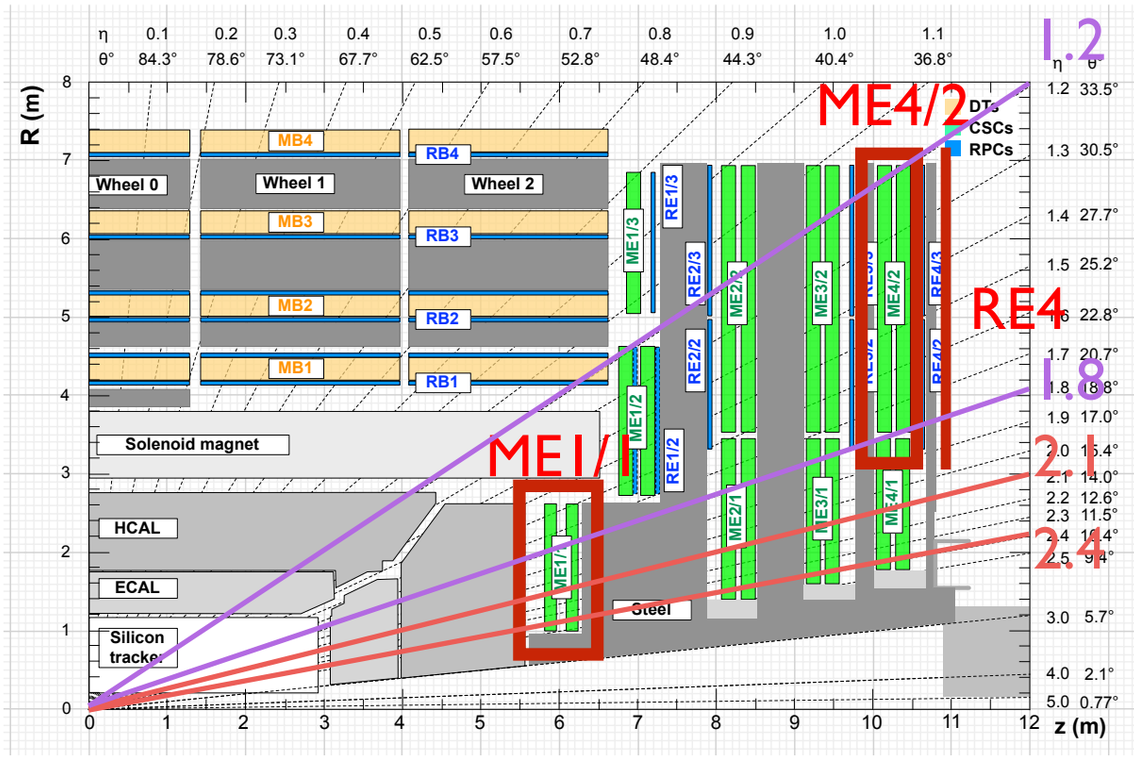


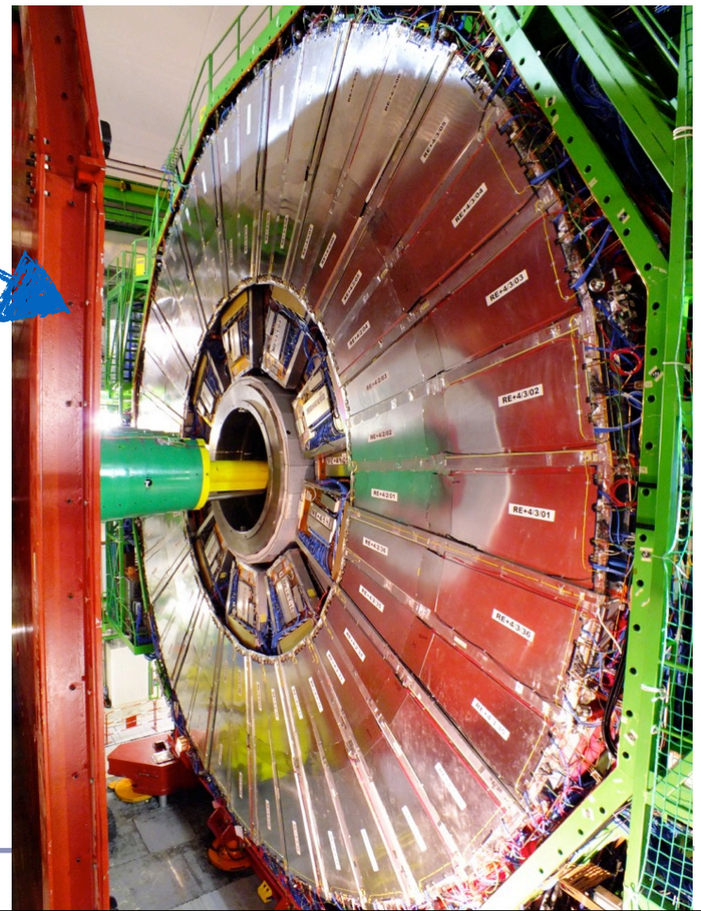
- New 45mm diameter Beryllium beam-pipe in preparation of Pixel Phasel upgrade
  - Be-welding problems finally solved
- The beam-pipe is now @ CERN being tested/measured
  - excellent results for the Vacuum test:
    leak rate < 3 x 10^{-14} mbar l $s^{-1}cm^{-2}$
  - slightly out of spec geometrically at one end
    (distortion due to repair): will smartly use gravitational sag to compensate

Muon Consolidation

Muon **Endcap** system

- optimize usage of $2.1 < |\eta| < 2.4$
  - CSC ME1/1 being refurbished with new electronics for finer granularity (+ side installed)
- completion of muon coverage as in TDR ($1.2 < |\eta| < 1.8$)
  - 4th station of CSC and RPC chambers ⟶ completed on + side, - side by May
  - new shielding (+ side installed)



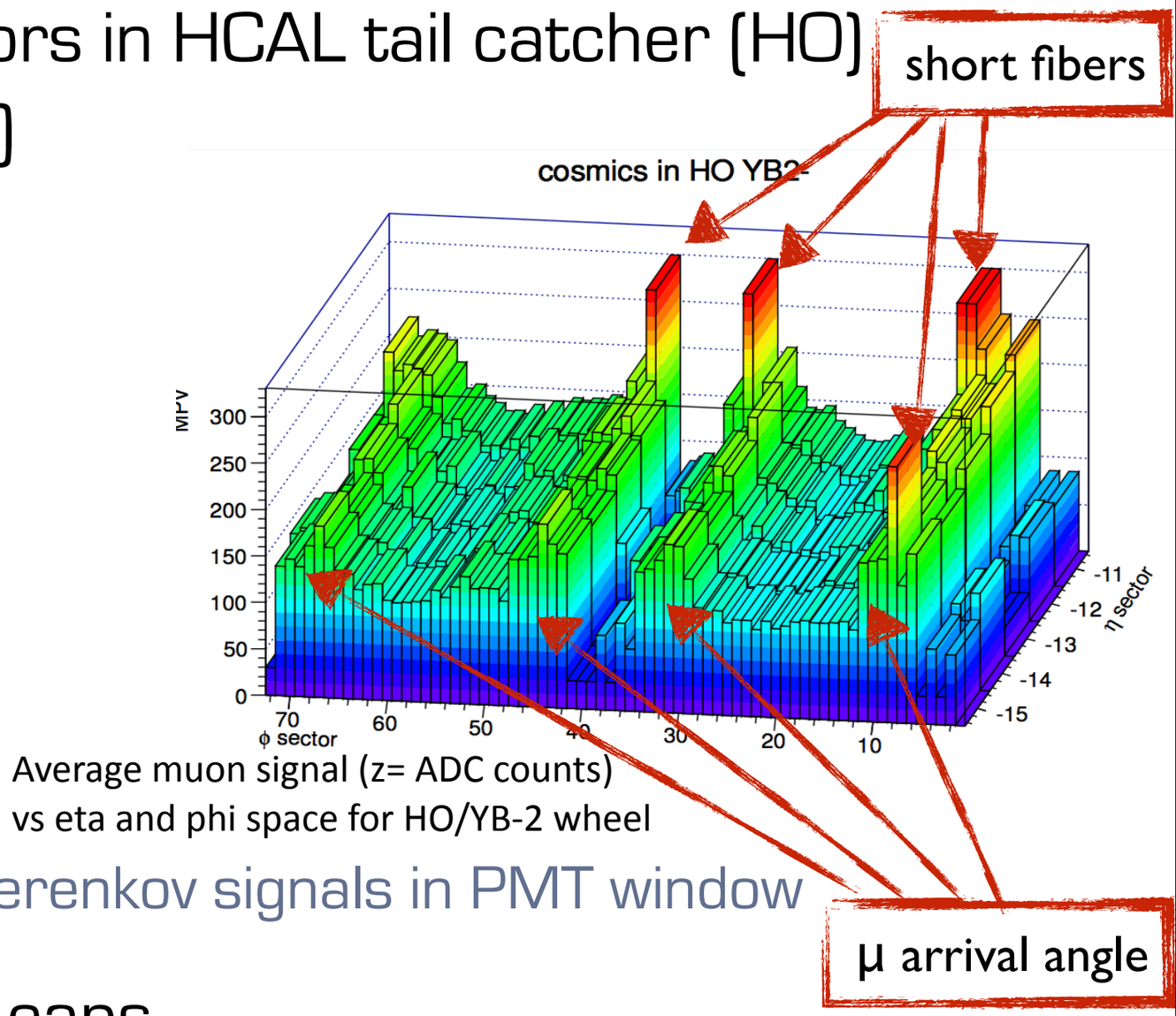


Muon **Barrel** system

- relocation of detector electronics from experimental to service cavern to allow for trigger flexibility (to be completed by August)

HCAL Upgrade

- Installation of new photo-detectors in HCAL tail catcher (HO) (HPDs being replaced by SiPMs)
  - installation in wheels -2, -1 and 0 completed
  - now re-calibrating using cosmics
- Installation of new multi-anode PMTs and two-anode cables in Hadron Forward
  - resolve issues with anomalous Cherenkov signals in PMT window
- Interventions on barrel and end caps (new Clock and Control Modules)
- New backend electronics (μTCA based) in Hadron Forward
  - aiming to have it commissioned for cosmics ray data taking in July

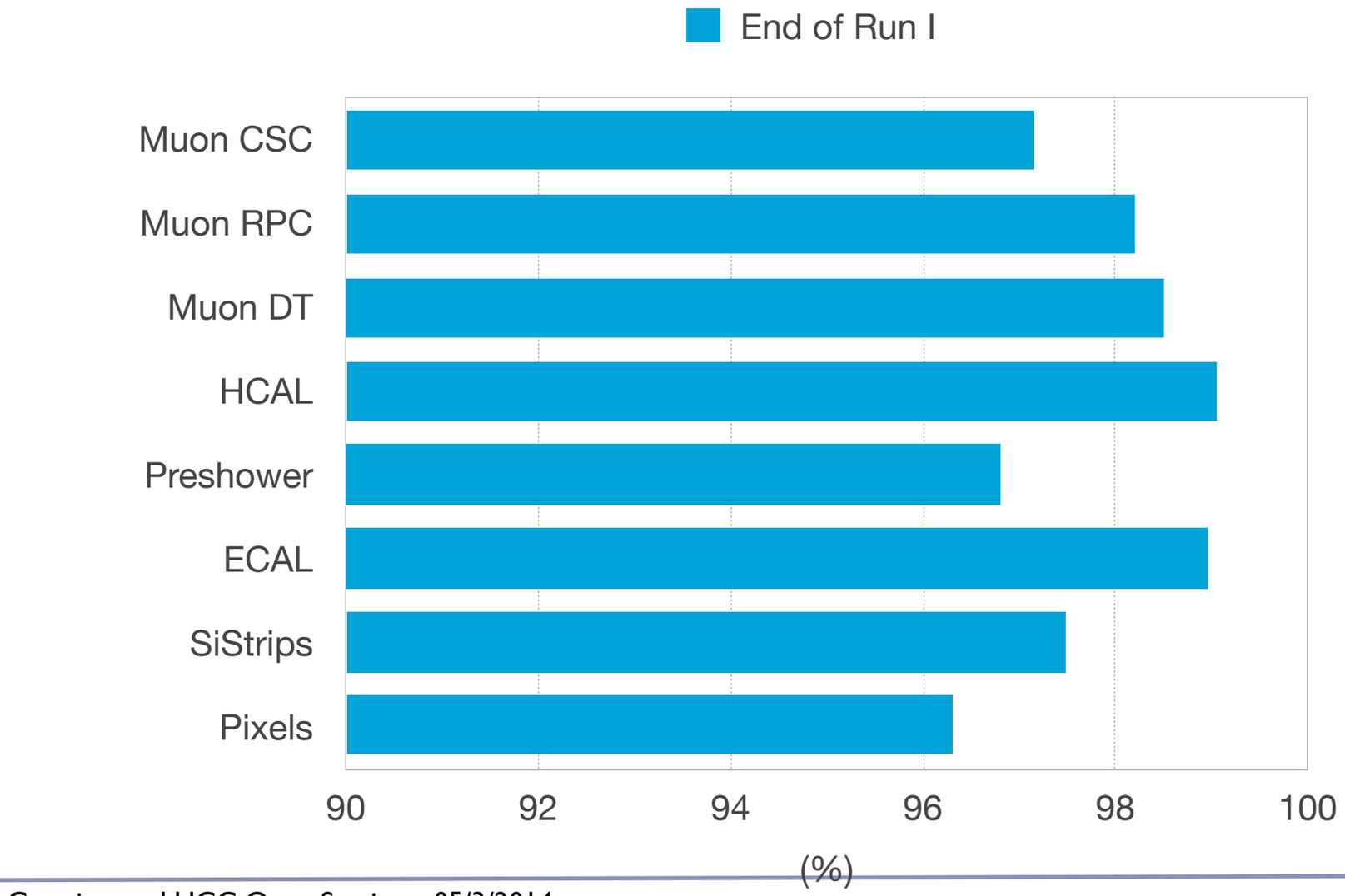


Average muon signal (z= ADC counts) vs eta and phi space for HO/YB-2 wheel

CMS-TDR-10

General Consolidation

- General consolidation/upgrade work on software and services to simplify operations
- an example: maximizing # of working channels



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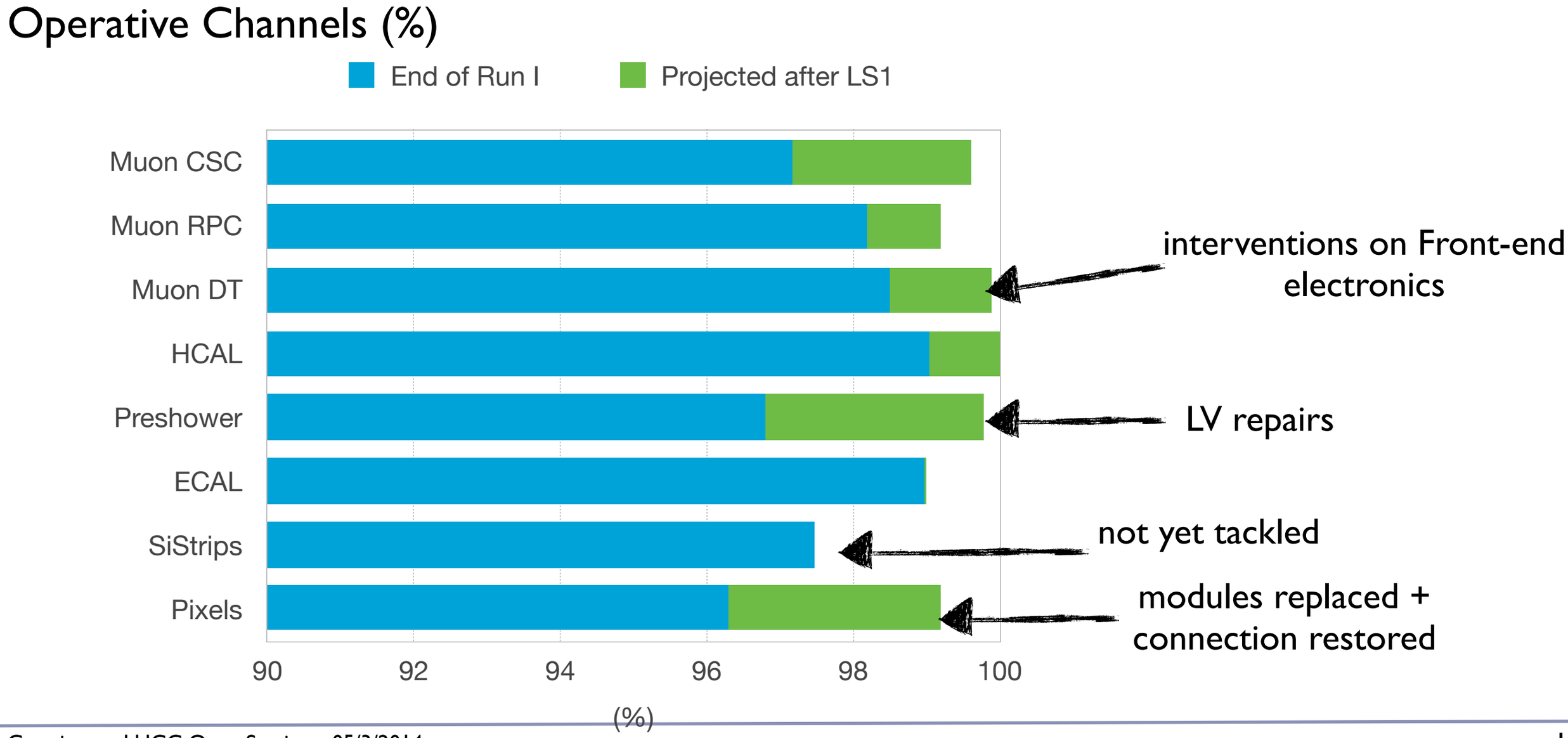
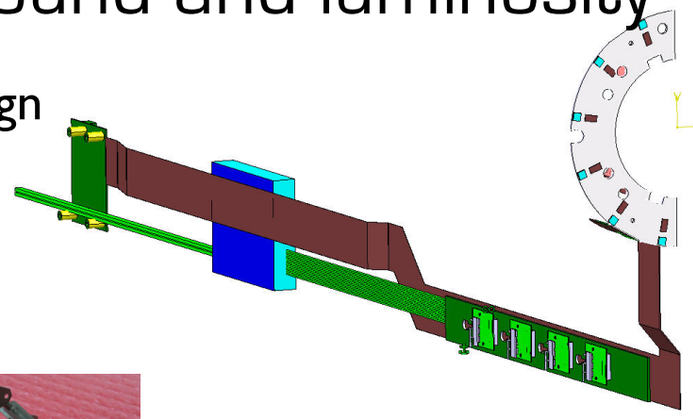


Beam Monitoring & Luminosity

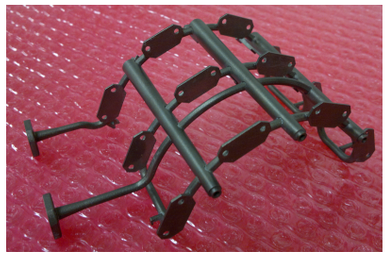
New Beam Radiation Instrumentation and Luminosity (BRIL) Project

- Upgrade Fast Beam Conditions monitor (BCM1F)
  ⟶ new detector/electronics/services for background and luminosity
  - faster and less material

BCM1F design



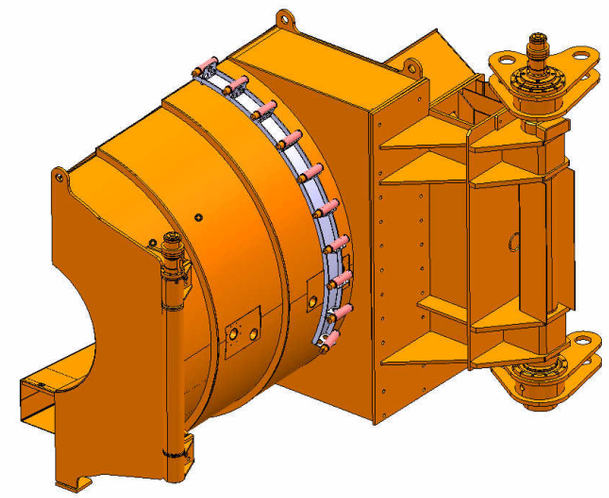
- Silicon Pixel Luminosity Telescope (si-PLT)
  - new dedicated online luminometer for CMS
    ⟶ on track



3D printed Ti cooling structure for Si-PLT

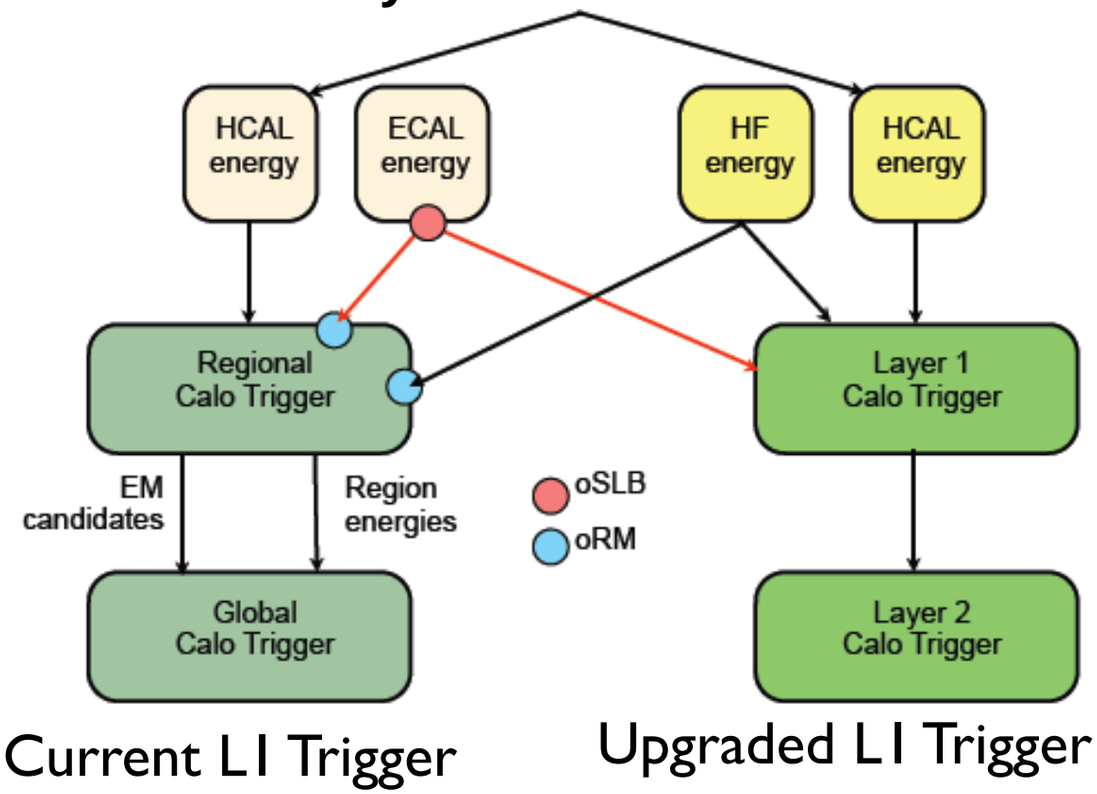
- Beam Halo Monitors (BHM):
  new Cherenkov monitor for incoming background
  - installed on rotating shielding
- BRIL Data Acquisition being written in standard DAQ framework
  - used for "non-event based data" (e.g. Luminosity)

BHM design on rotating shielding



L1 Trigger Upgrade

- Mitigate increase of rates due to luminosity and $\sqrt{s}$
  - muon and e/γ isolation
  - τ ID
  - muon p_T resolution
  - jets with PU subtraction
  - improve flexibility of the L1 menu



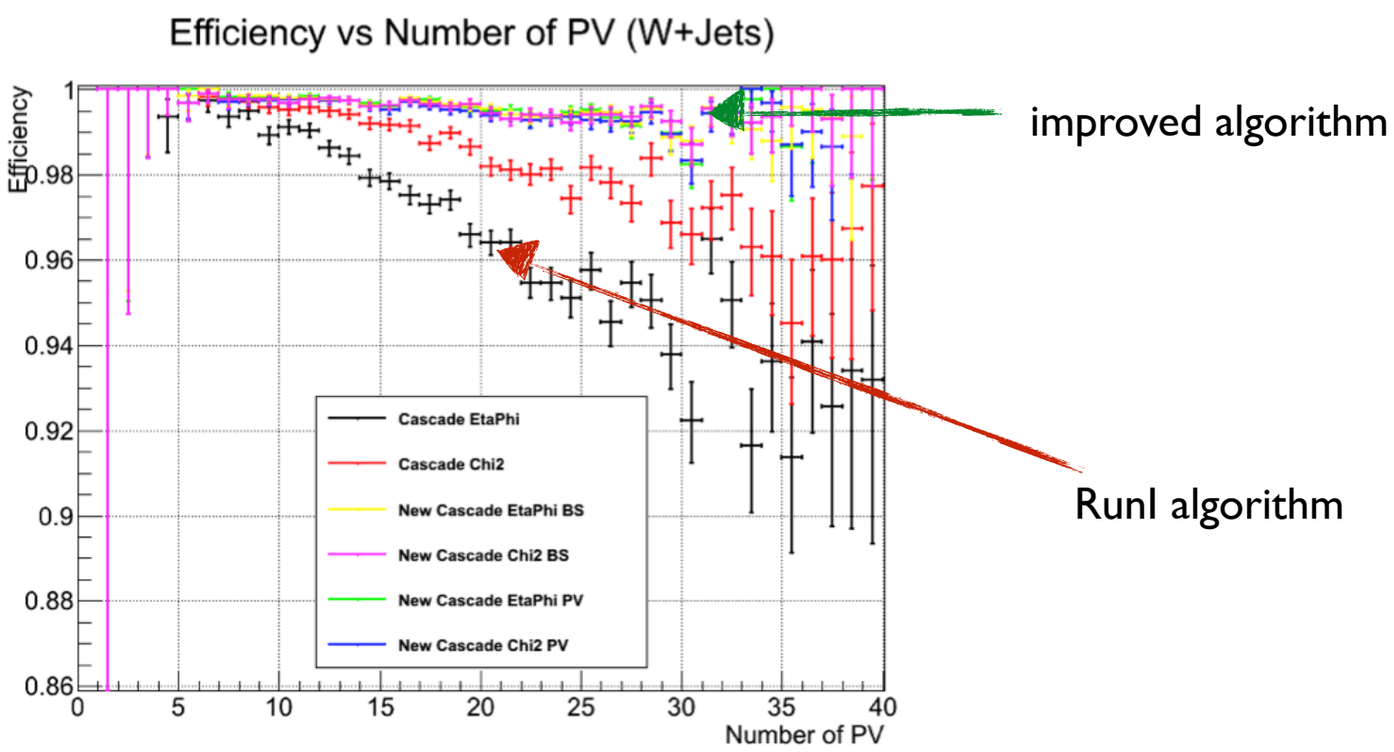
Current L1 Trigger | Upgraded L1 Trigger

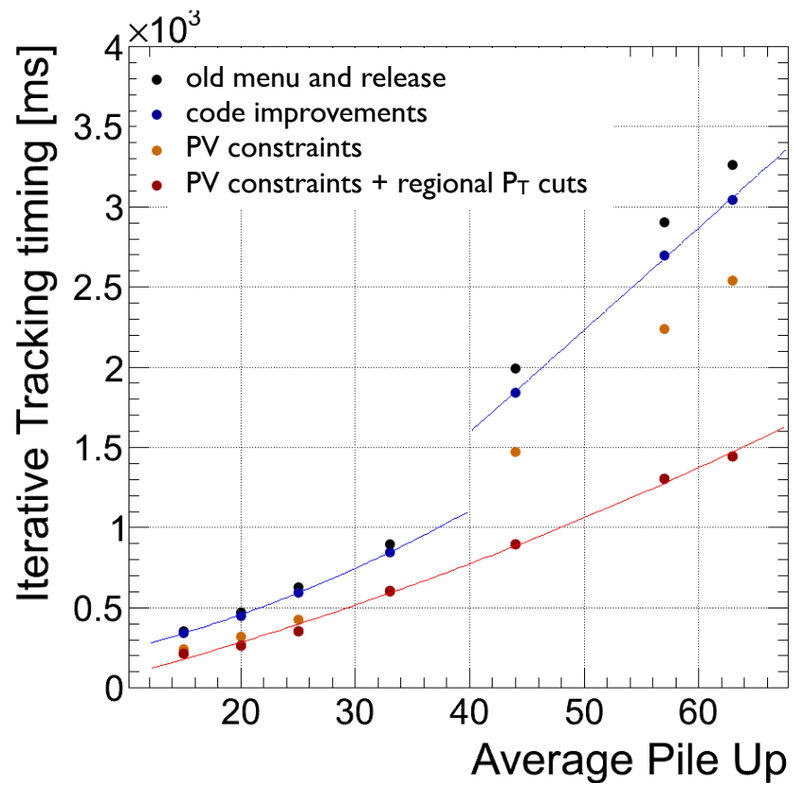
- Build and commission upgrade in parallel with current system in 2015 to decouple from LHC schedule
  - achieved splitting optical signals to legacy and upgraded hardware (being implemented for Electromagnetic Calorimeter)
- Integration tests during Spring and Summer

CMS-TDR-12

Trigger preparation

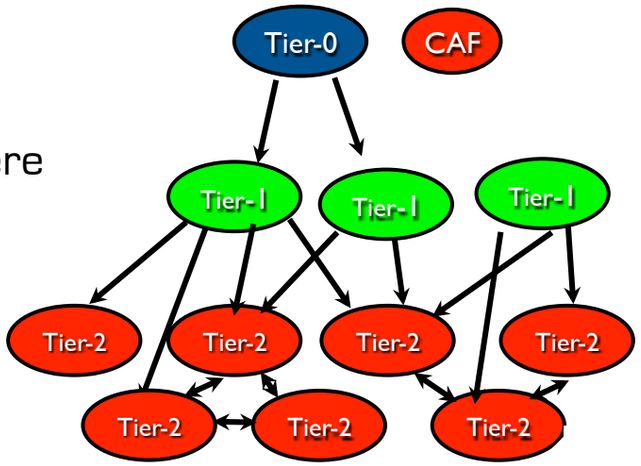
- HLT focusing on robustness and computational performance vs PU
  - started from physics object reconstruction and ID
    - currently focusing on leptons (single, double)
  - moving on with path design once development on basic blocks in advanced stage



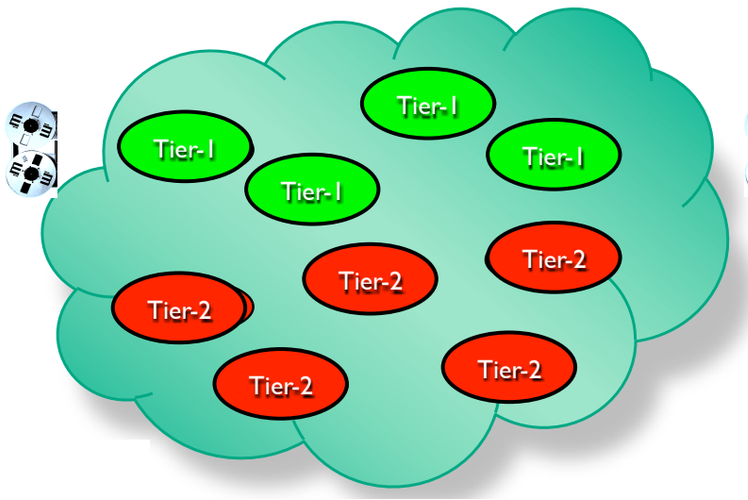


Computing Towards RunII

- The scale of the computing problem increases by factor 6 in 2015
  - a factor 2.5 in event reconstruction time due to higher pile-up and event complexity
  - a factor of 2.5 with 1kHz of prompt reconstruction
- Mitigation assumes less reprocessing, budgeted simulation and maximum flexibility in how we use resources
  - plus foreseen resource increase of about a factor 2
- Computing is evolving during LS1, in particular for:
  - Data Management:
    - transparent access to samples from anywhere for production and analysis over the WAN with **data federation**
  - Workflow Tools
    - Improvements in the distributed analysis tool (CRAB3)
    - make the system as agile as possible and allow highest profile tasks to be executed across sites



Blurring boundaries between sites



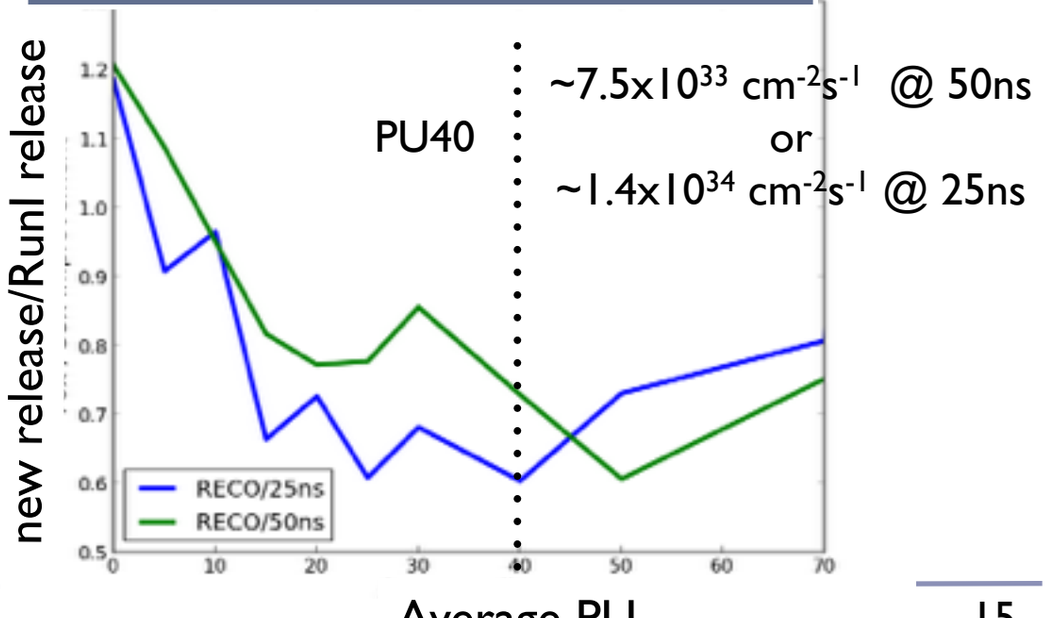
Offline Reco Performance

- Continued progress in reducing resource needs through CMSSW code improvements
  - simulation: deployed method to reduce time spent tracking low-energy neutrons and gammas in GEANT4 (aka “Russian Roulette”)
    ⟶ 35% speed-up
  - steady improvements in RECO performance while incorporating algorithms with improved physics performance
- development for threaded framework and applications ongoing

Simulation time

	Min Bias	TTBar
2012 release	21	86
2014 release	14	56
Improvement	35%	

Reconstruction time

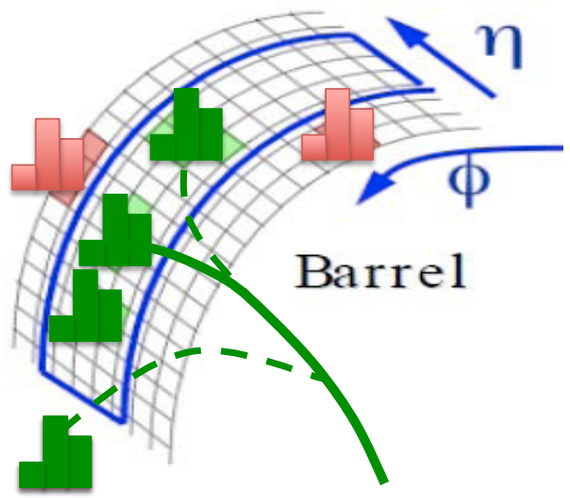


Algorithm Consolidation

General effort to improve robustness of algorithms and Physics Object IDs for 25ns running exploiting Global Event Description (aka Particle Flow)

Consolidation of the Physics Object reconstruction algorithms, some examples:

- exploit ECAL granularity using more advances clustering "shapes" to improve containment of electrons/photons and increase PU rejection
- refined track assignment to electron (electron track, converted brems) or photons (conversion)
  - very low-p_T electrons resolution
  - particle-based isolation
  - Jets/MET resolution and tail control



- evaluating performance of different ΔR size 0.5 (std in RunI) vs 0.4 for AntiKT jets ⟶ smaller PU dependence expected

RunII Readiness: CSA14

Planning integrated exercise in Summer to stress test CMS

→ **Computing, Software and Analysis Challenge 2014** - CSA14

- major milestone for analysis readiness towards data-taking

- Need to assess the preparation on 2 fronts

  - physics performance (object IDs and working points) @ 13TeV, high-PU and realistic "first-data like" calibrations

    - alignment and calibrations for **first few weeks of data @ 50ns**
      → reference Inst. Lumi ~7.5×10^{33} $cm^{-2}s^{-1}$ (PU40)

    - alignment and calibrations for **first 1/fb @ 25ns**
      → reference Inst. Lumi. ~7×10^{33} $cm^{-2}s^{-1}$ (PU20) and ~1.4×10^{34} $cm^{-2}s^{-1}$ (PU40)

    } Simulated samples

  - offline workflows for data processing/handling and automation of calibrations

    - focus on prompt reconstruction performance → analysis level RECO within 48h

RunII Readiness: GRs

- Global Runs (GR): roadmap to test online machinery
  - new DAQ framework (hardware and software): DAQ2
    - related redesign of online Data Quality Monitoring (DQM)
  - cosmics data before beam
    - calibration/alignment
    - operation crew re-training

Mid-Week Global Run

Cooling maintenance + DAQ2

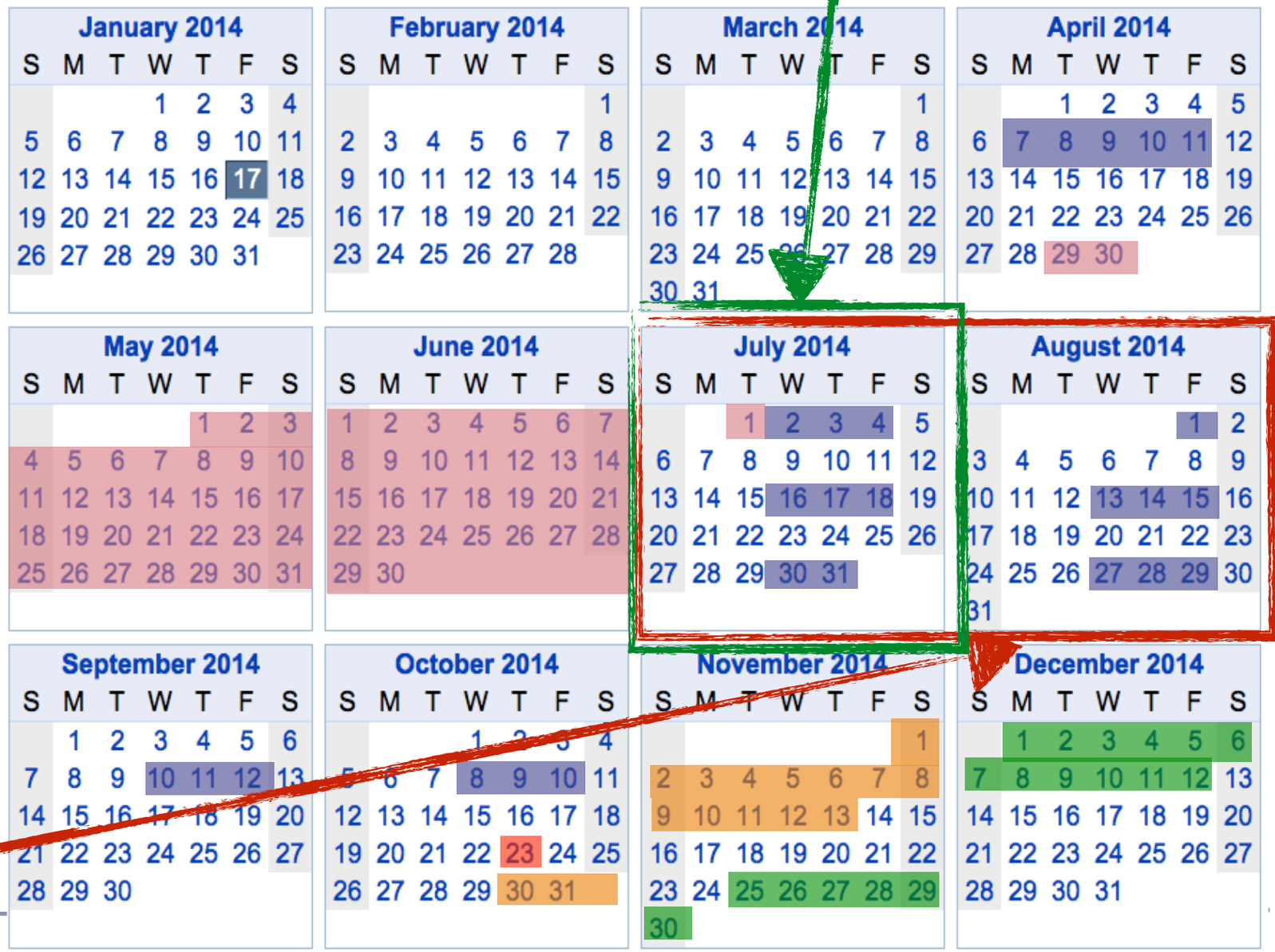
Begin to close CMS

Cosmic Ray Run @ 0T

Cosmic Ray Run @ 3.8T

DAQ2 commissioning

Concurrent to CSA14



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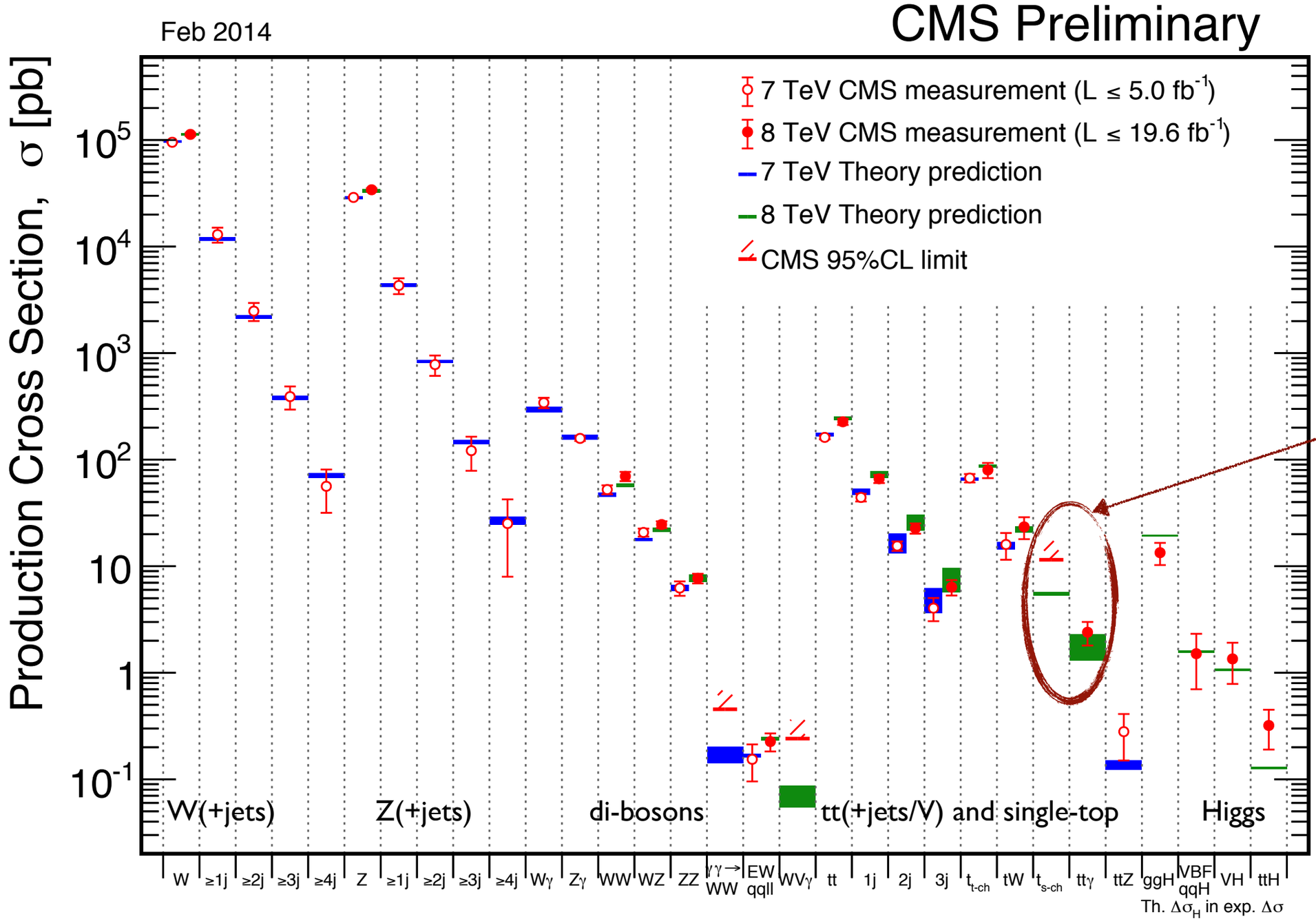
- squeezing the most out of the RunI data
  - pick some of the latest results (just an overview, not meant to be comprehensive)
- upgrade preparation
  - Technical Proposal preparation for PhaseII

Exploring X-sections

- We keep adding pieces to the puzzle



Most recent results:

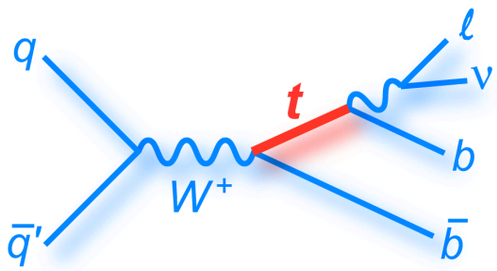
- single-t s-channel
- ttγ

- https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsCombined

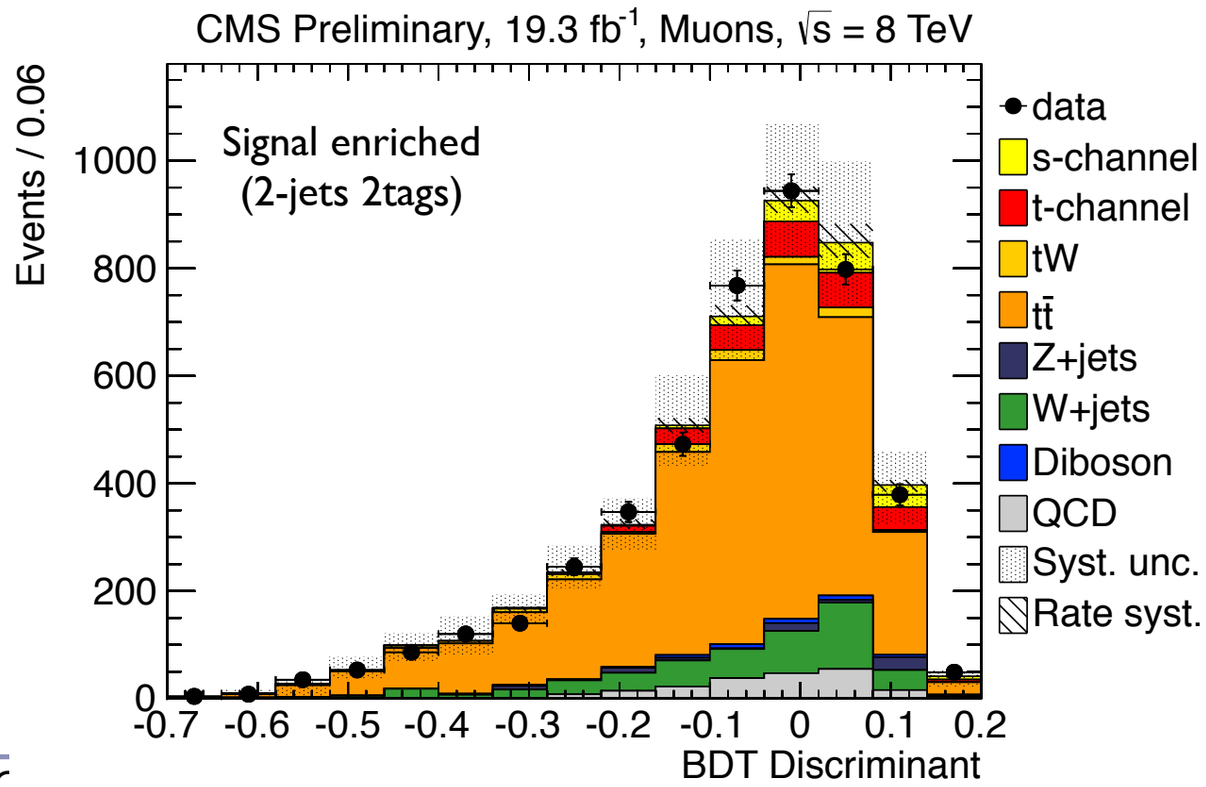
Single Top s-channel

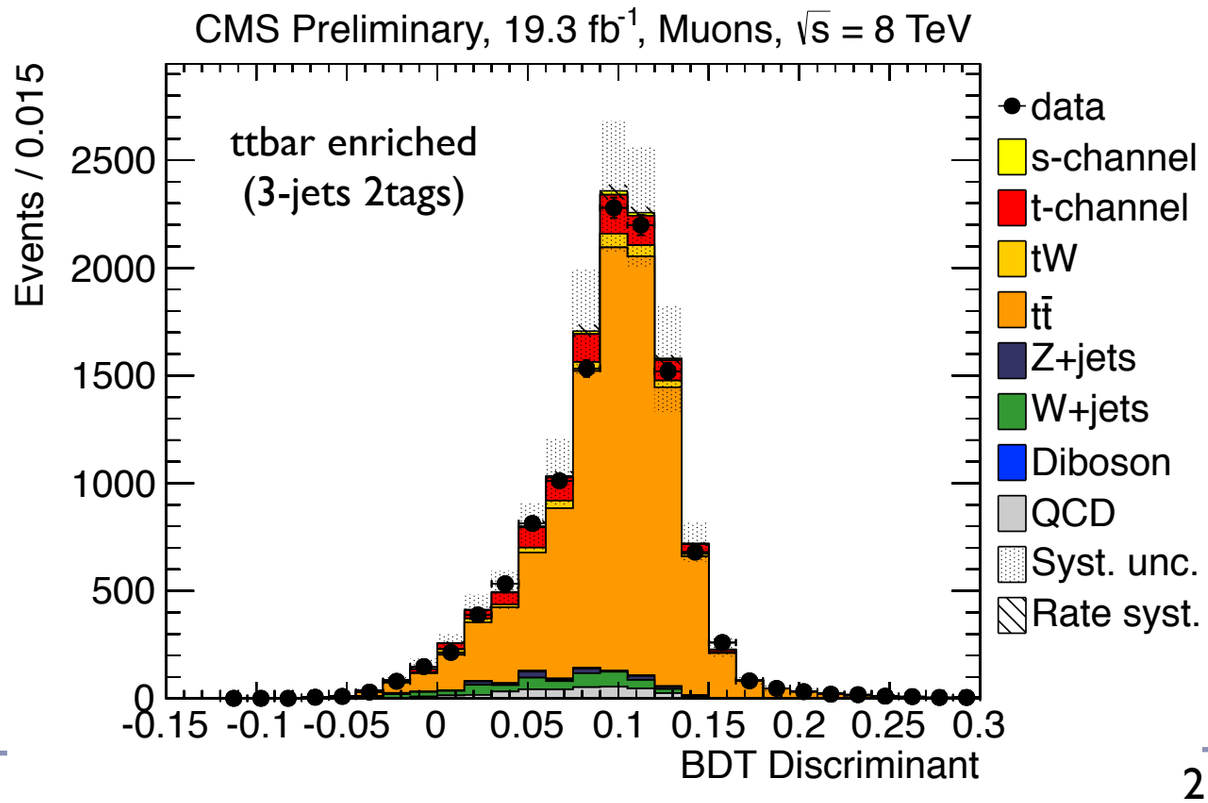
TOP-13-009

- Leptonic (electron or muon) decay modes of the top quark
  - Boosted Decision Trees (BDT) to discriminate signal and background (mainly ttbar and W+jets) topologies



- Maximum likelihood fit to the BDT to extract the signal
  - upper limit on the cross section @ 95% CL: $\sigma \times BR < 17.0$ pb (expected) and 11.5 pb (observed)



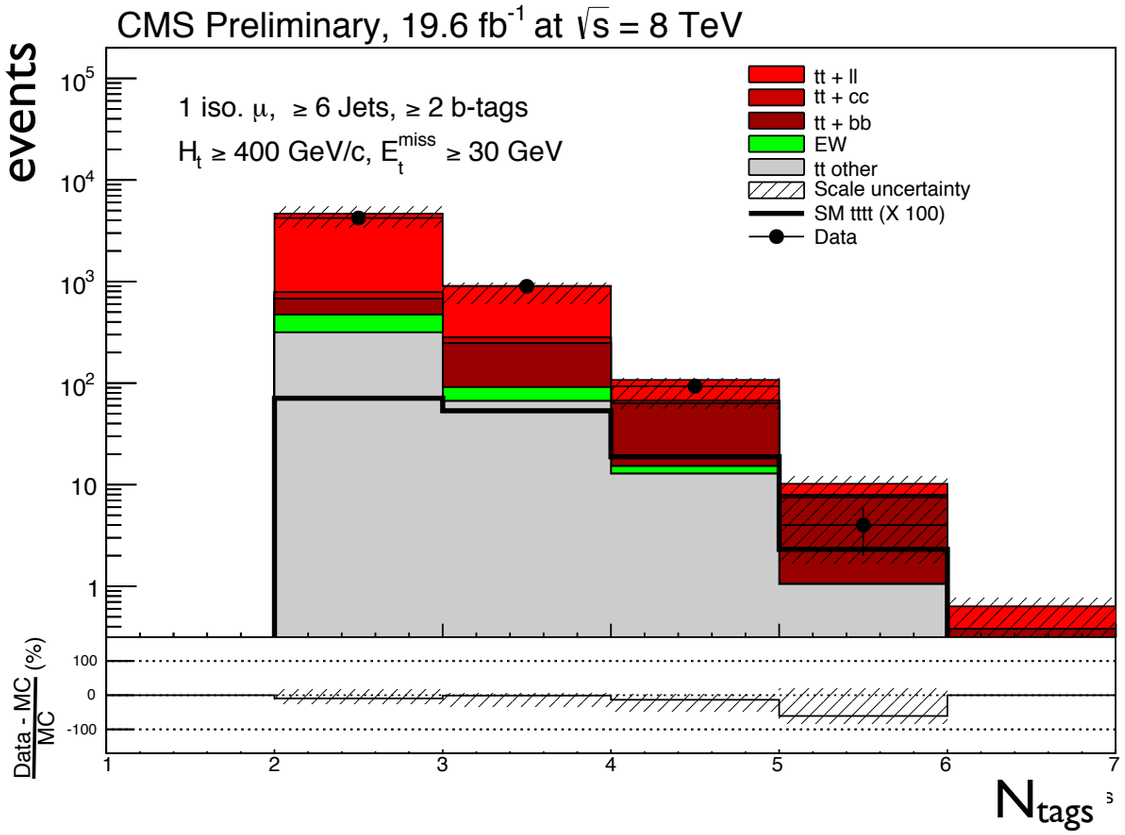


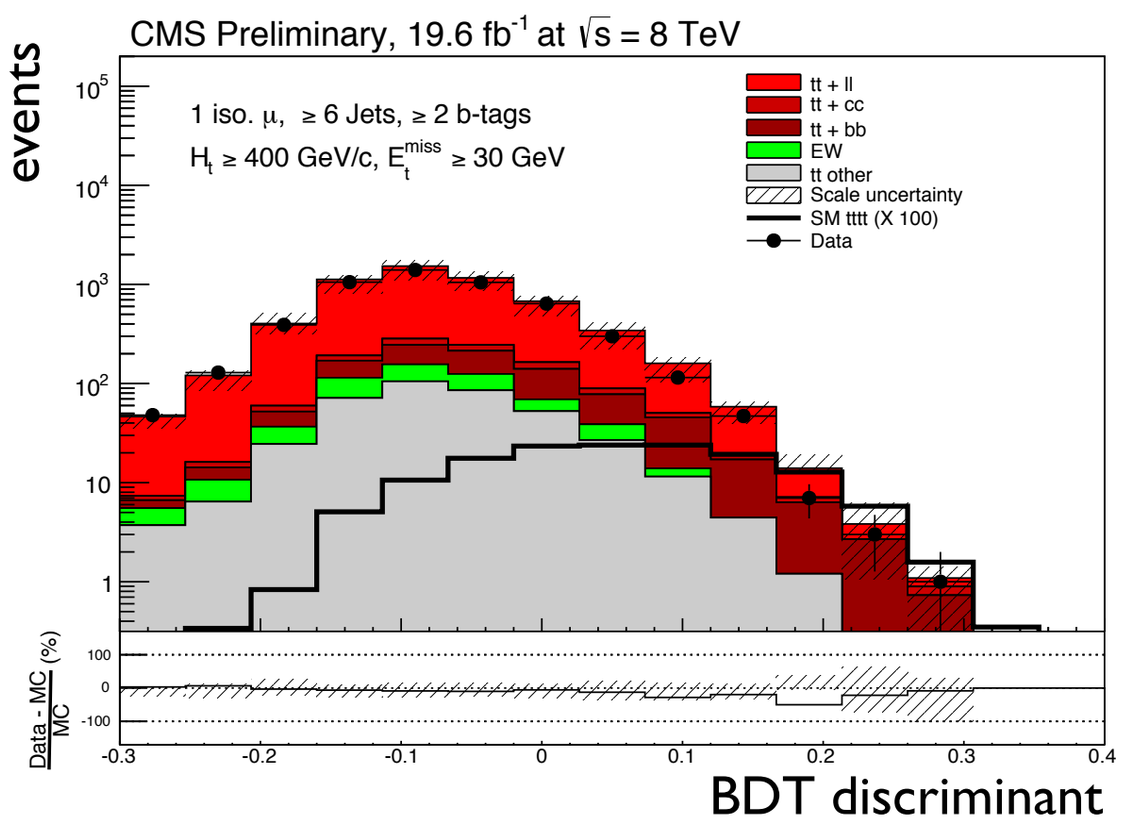
SM 4TOP SEARCH

TOP-13-012

- First direct search for $t\bar{t}t\bar{t}$ production in lepton plus jets channel (SM prediction $\sigma \approx 1$fb):
  - kinematic reconstruction procedure to exploit multiple hadronic tops in signal
  - information from kinematic reco., event activity and b-jet content combined in Bosted Decision Tree ⟶ Limit extracted from template fit
- Combined limits on SM x-section @ 95%CL

$\sigma(t\bar{t}t\bar{t}) < 42$ fb (expected) and 63 fb (observed)

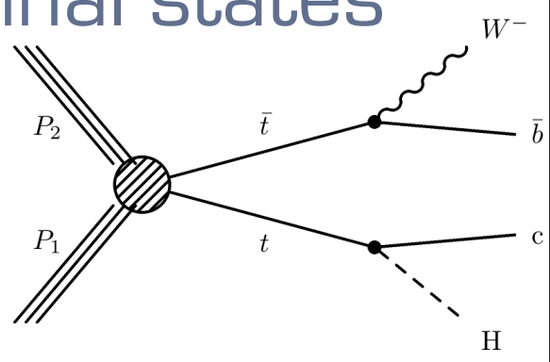




New Higgs Results

HIG-13-034

- Search for t ⟶ cH (FCNC decay, negligible in SM)
  - recasting existing SUSY analysis in multilepton final states and Heavy Higgs searches in leptons + photons
    - BR (t ⟶ cH) 0.56% (observed) and 0.65% (expected)



Higgs Decay Mode	observed	expected	1σ range
$H \to WW^*$ ($\mathcal{B} = 23.1\,\%$)	1.58 %	1.57 %	(1.02–2.22) %
$H \to \tau\tau$ ($\mathcal{B} = 6.15\,\%$)	7.01 %	4.99 %	(3.53–7.74) %
$H \to ZZ^*$ ($\mathcal{B} = 2.89\,\%$)	5.31 %	4.11 %	(2.85–6.45) %
combined multileptons (WW^*, $\tau\tau$, ZZ^*)	1.28 %	1.17 %	(0.85–1.73) %
$H \to \gamma\gamma$ ($\mathcal{B} = 0.23\,\%$)	0.69 %	0.81 %	(0.60–1.17) %
combined multileptons + diphotons	0.56 %	0.65 %	(0.46–0.94) %

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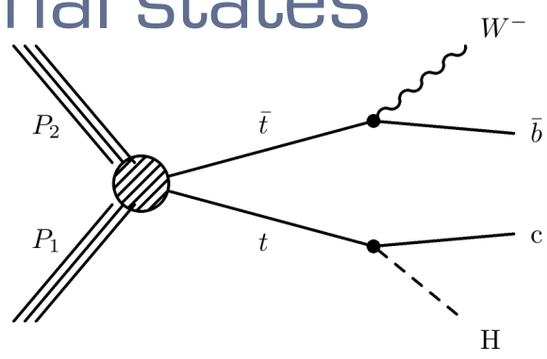
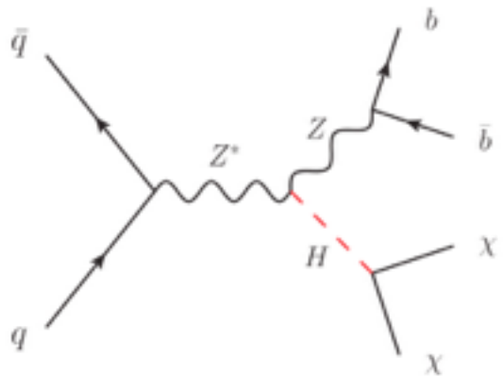
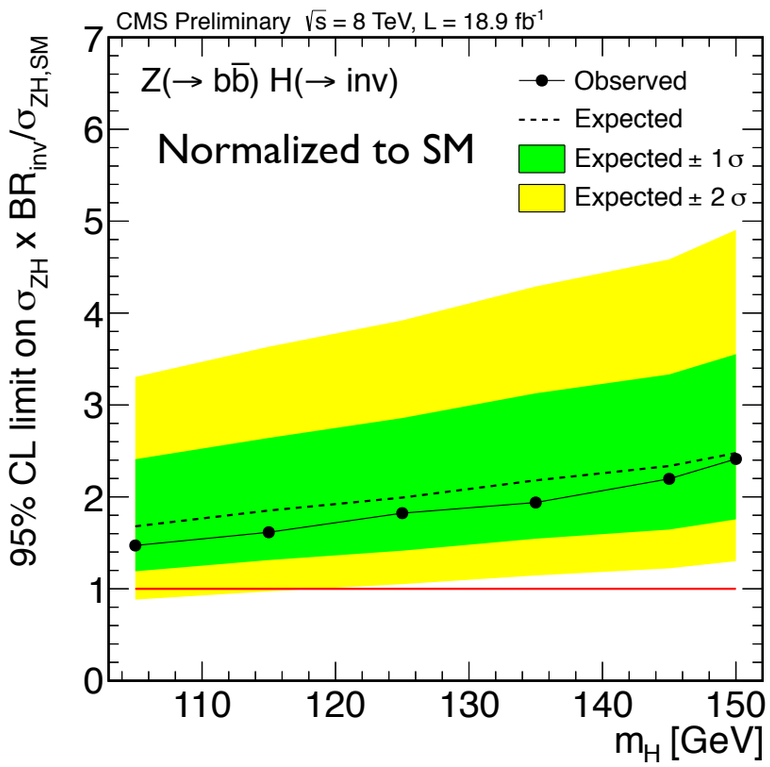


- Search for Invisible Higgs in association with Z boson decaying to b quarks
  - same strategy of VH(bb) with re-optimized BDT
    - σ(ZH)xBR < 1.99 X SM(ZH) (expected) and 1.82 (observed) @ m_H=125 GeV



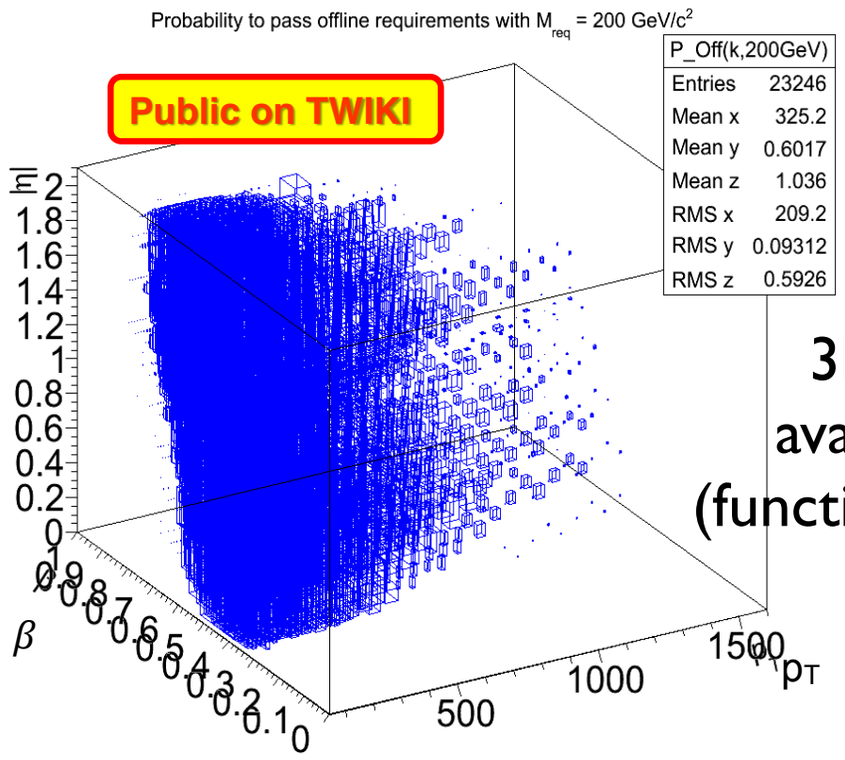


HIG-13-028

Extending Exotica Searches

EXO-13-006

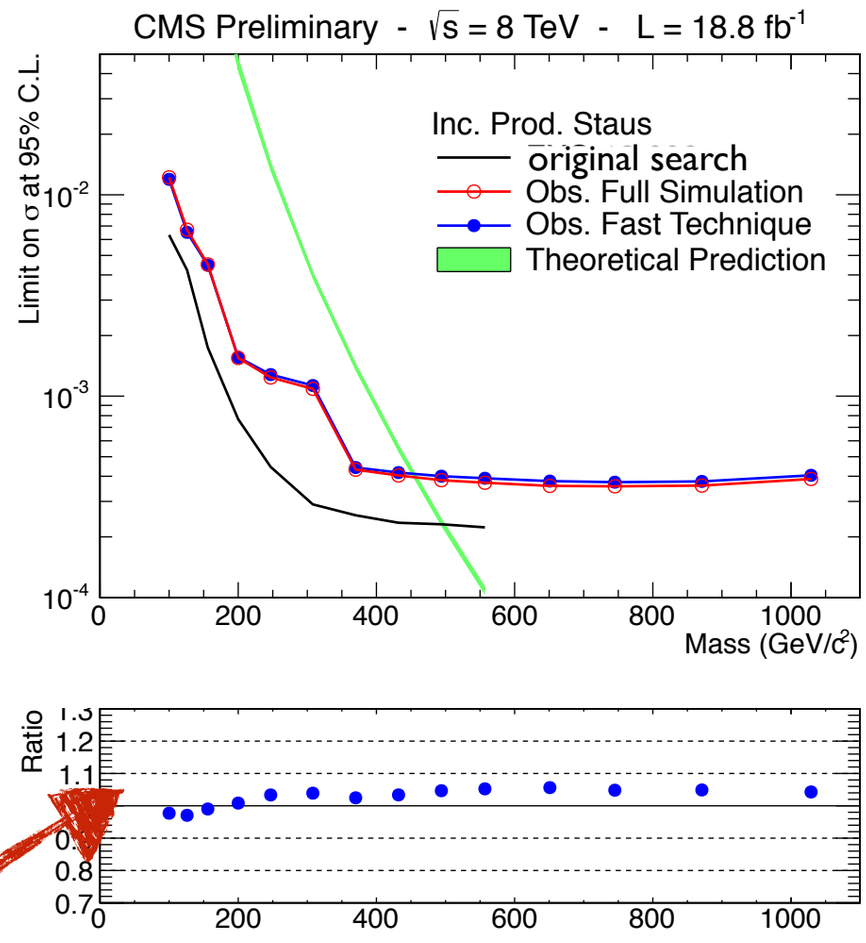
- Proposes a technique for reinterpreting existing HSCP results (based on dE/dX and TOF measurements) for BSM models predicting lepton-like Long Lived particles
  - signal acceptance is estimated based on generated LL particle kinematics (bins of pT,eta and beta)
  - set of "particle based probabilities" made publicly available ⟶ you can accurately estimate the CMS sensitivity to your favorite LL models
  - method validated against existing analysis based on full simulation
- power of technique demonstrated on a complex pMSSM model extending previous results



3D Efficiency Maps available to the world (function of M requirement)

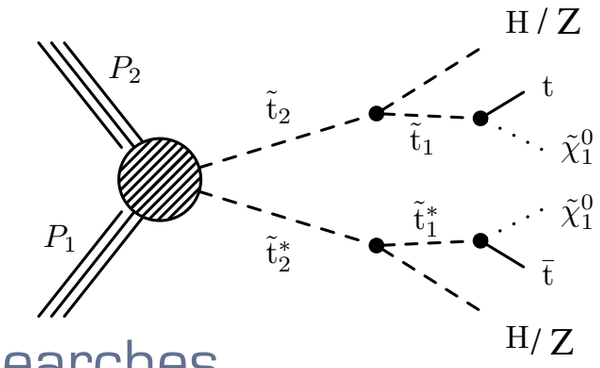
Validation: ratio fast technique / full-SIM

Observed limits on the x-section for the inclusive production of staus

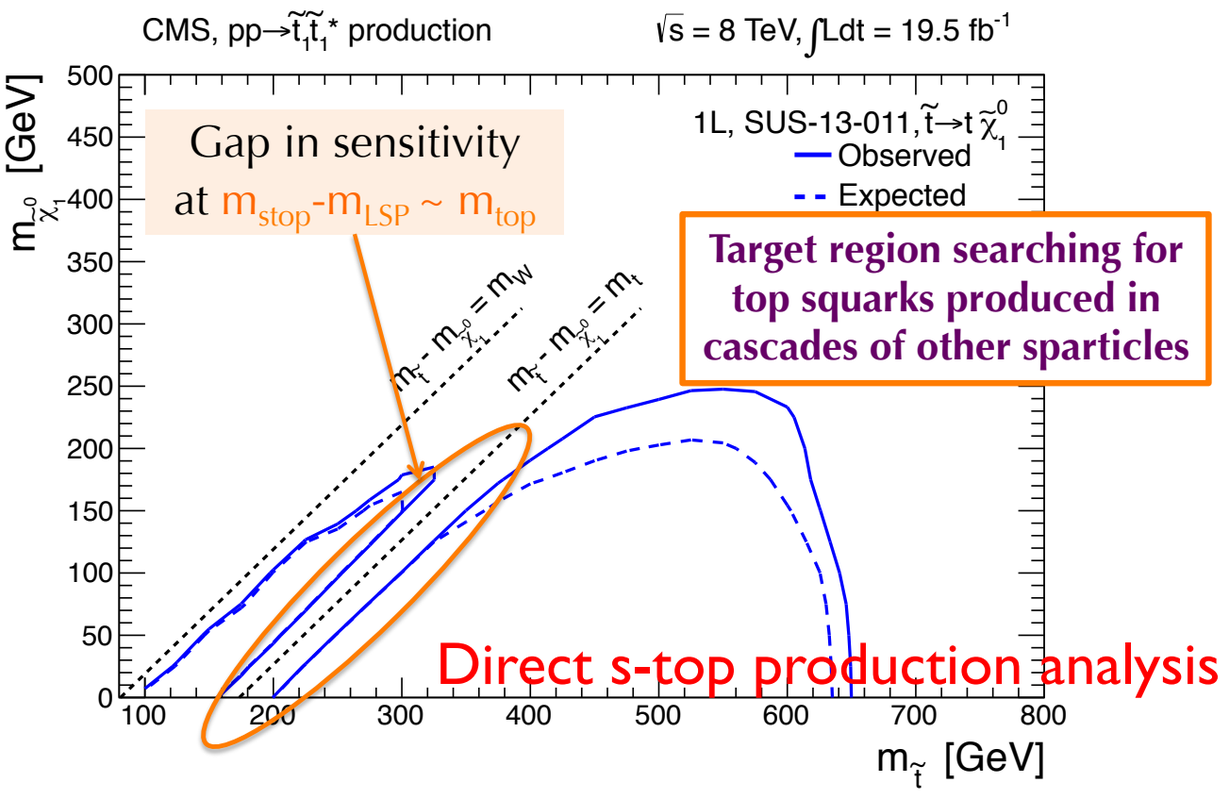


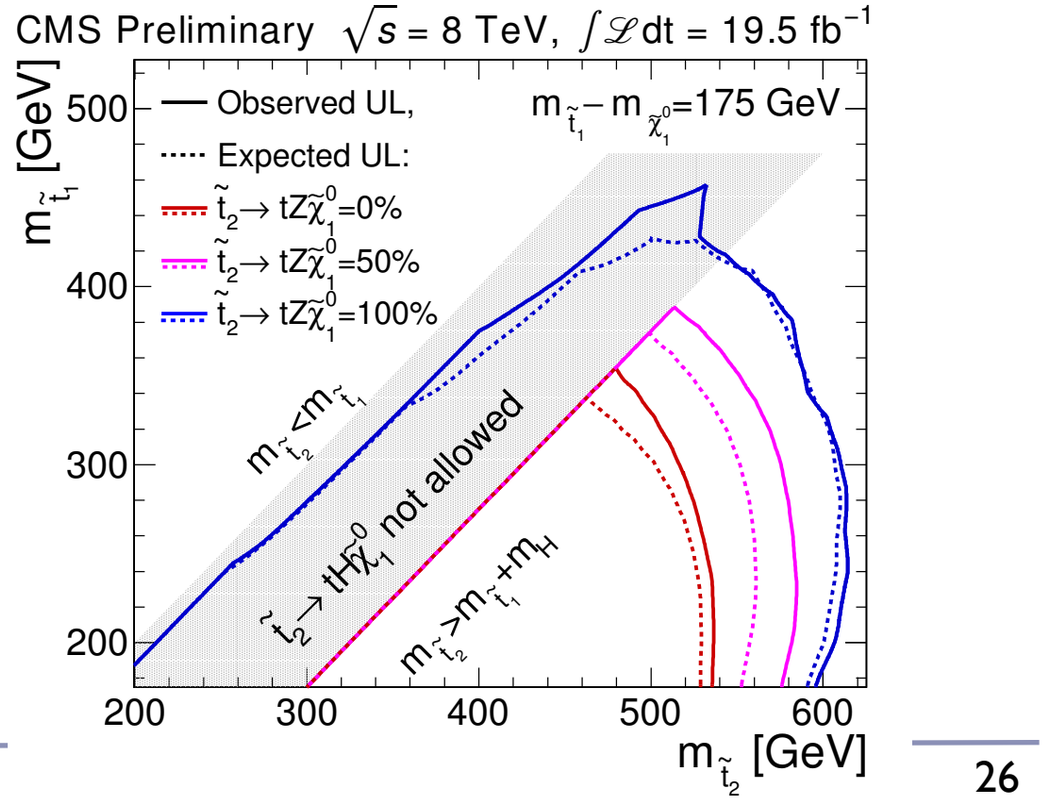
Searches for stop

- Search for top-squark production with H and Z bosons in final state
  - targeting cascade decays from heavier $\tilde{t}_2$ to lighter $\tilde{t}_1$
  - probe region (m_{stop} - m_{LSP}) ≃ m_{top} not covered by standard s-top searches



- Recast previous results in different final states — SUS-13-024
  - "≥ 3 l" - three leptons, "2 SS l" - same-sign di-leptons, "1l / 2 OS l" - single lepton or two opposite-sign leptons
- exclude @ 95%CL ~ $m(\tilde{t}_1) < 400$ GeV and $m(\tilde{t}_2) < 575$ GeV





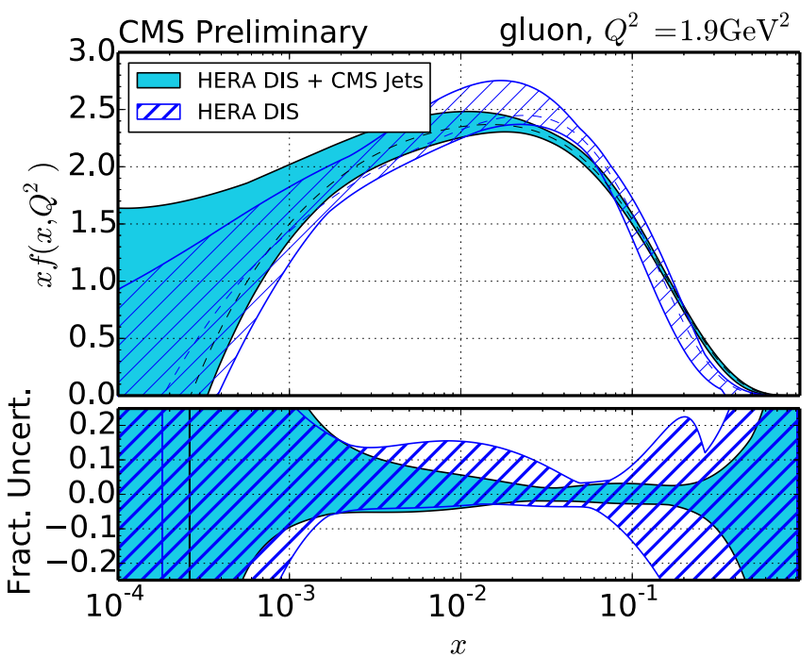
Standard Model

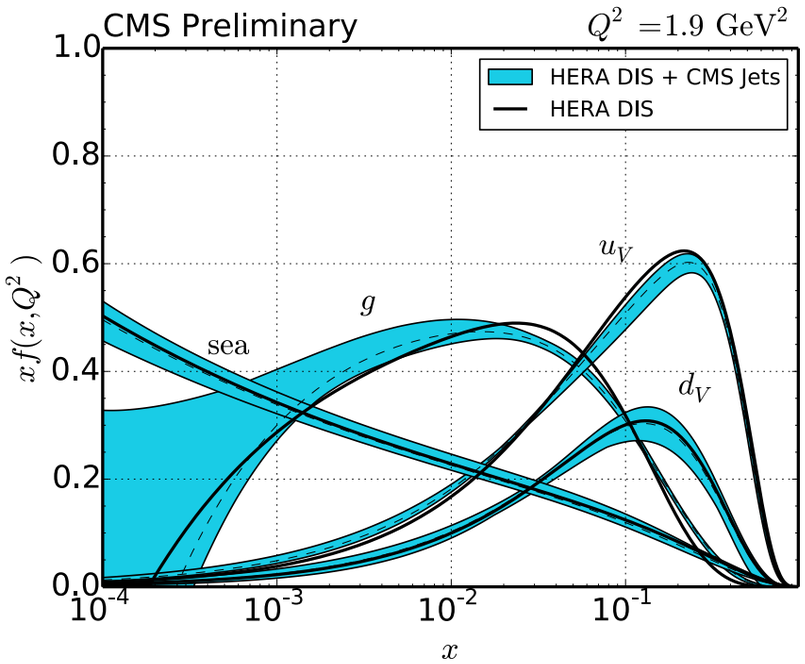
SMP-12-028

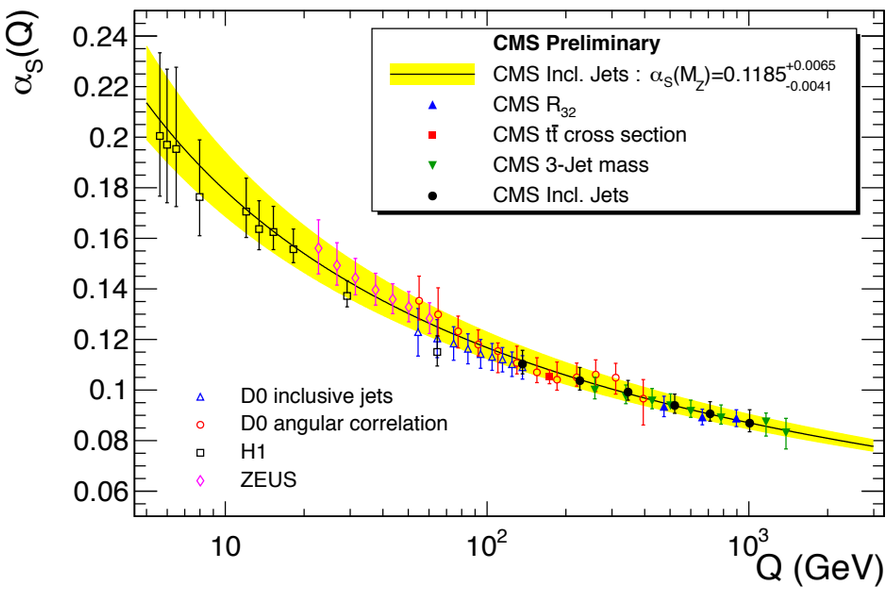
- Use recent measurements of the jet cross section @ 7TeV to investigate impact on PDFs and determine $\alpha_s(M_Z)$
- PDF fits using inclusive HERA DIS & CMS jet data ⟶ significant impact in particular the gluon PDF
  - include electroweak corrections & corrections from matched NLO+parton showers
- New determination of $\alpha_s(M_Z)$ from inclusive jet cross section
  - Result for $\alpha_s(M_Z)$ compatible with previous CMS results and world average

$$\alpha_S(M_Z) = 0.1185 \pm 0.0019\,(\text{exp.}) \pm 0.0028\,(\text{PDF}) \pm 0.0004\,(\text{NP})^{+0.0055}_{-0.0022}\,(\text{scale}).$$

- Running of $\alpha_s(Q)$ demonstrated to be consistent with RGE of QCD



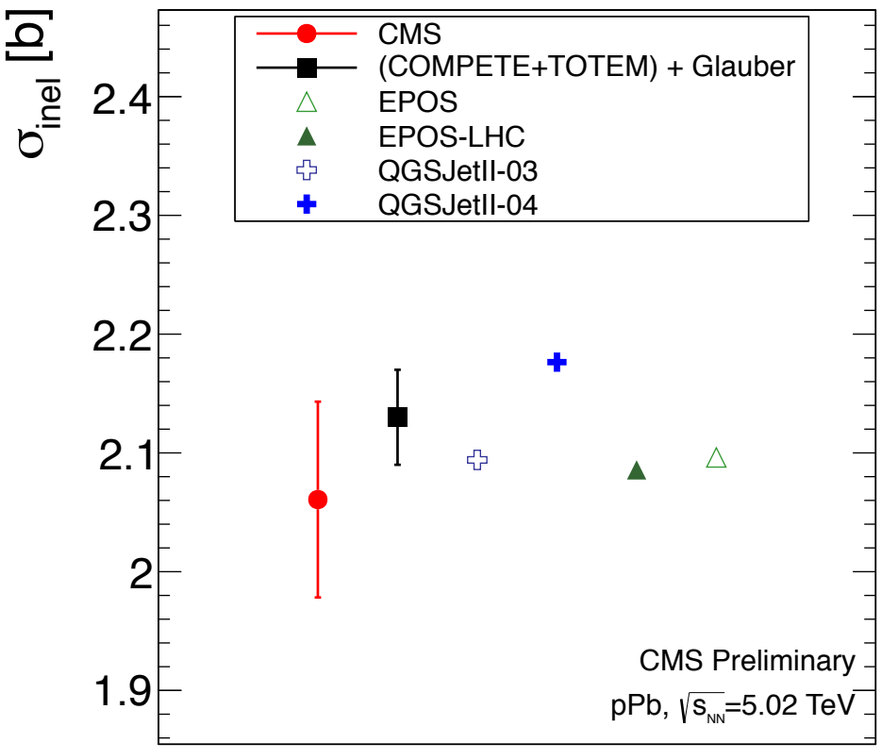


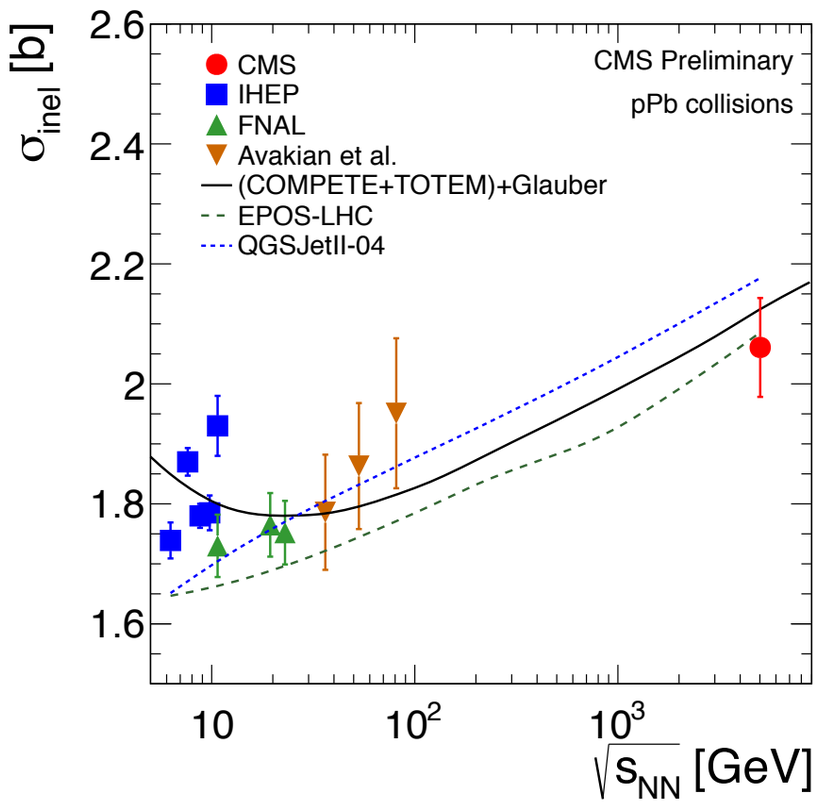


Forward Physics

- pPb Inelastic Cross Section at 5.02 TeV FSQ-13-006
- inelastic collisions are tagged using the forward calorimeters at $3 < |\eta| < 5$
  - measure events single/double armed above certain E in HF
- Lumi measured with VdM scans (3.5% uncert)

$$\sigma_{\text{inel}} = (2.061 \pm 0.003(\text{stat.}) \pm 0.039(\text{syst.}) \pm 0.072(\text{lumi.}))\ \text{b}\ .$$

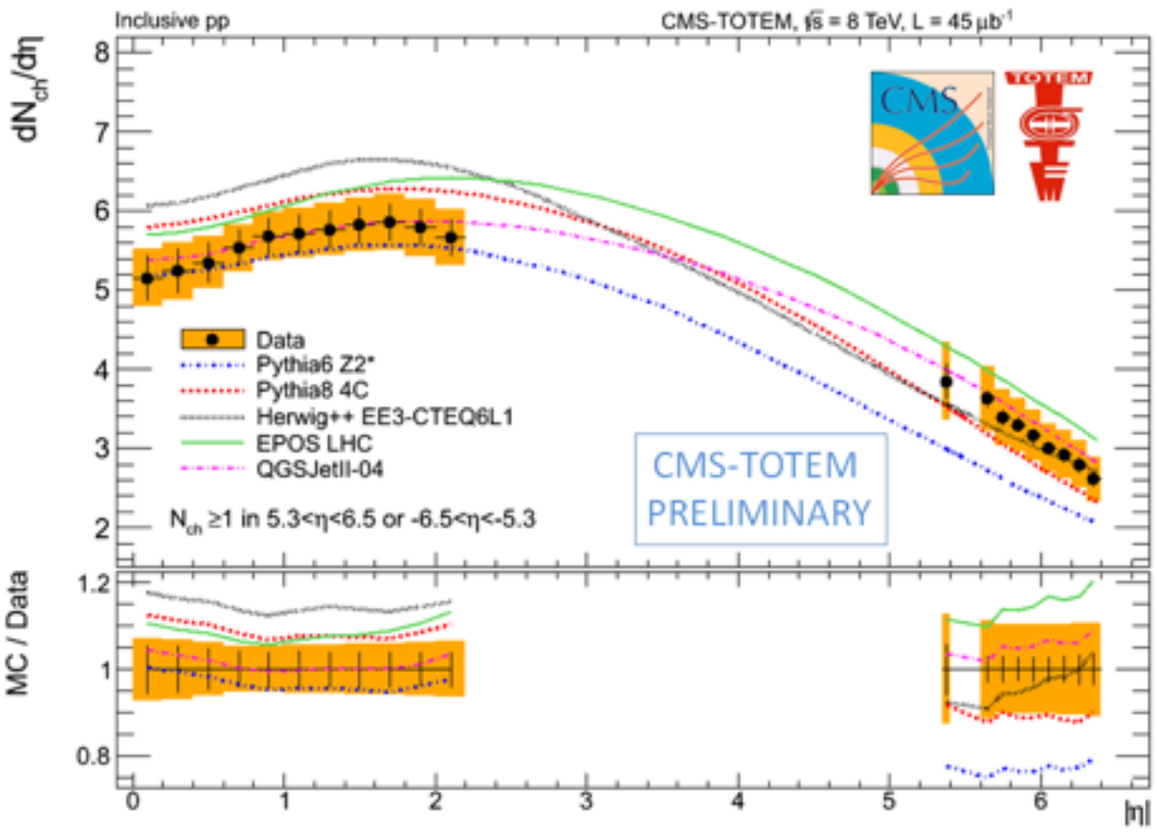


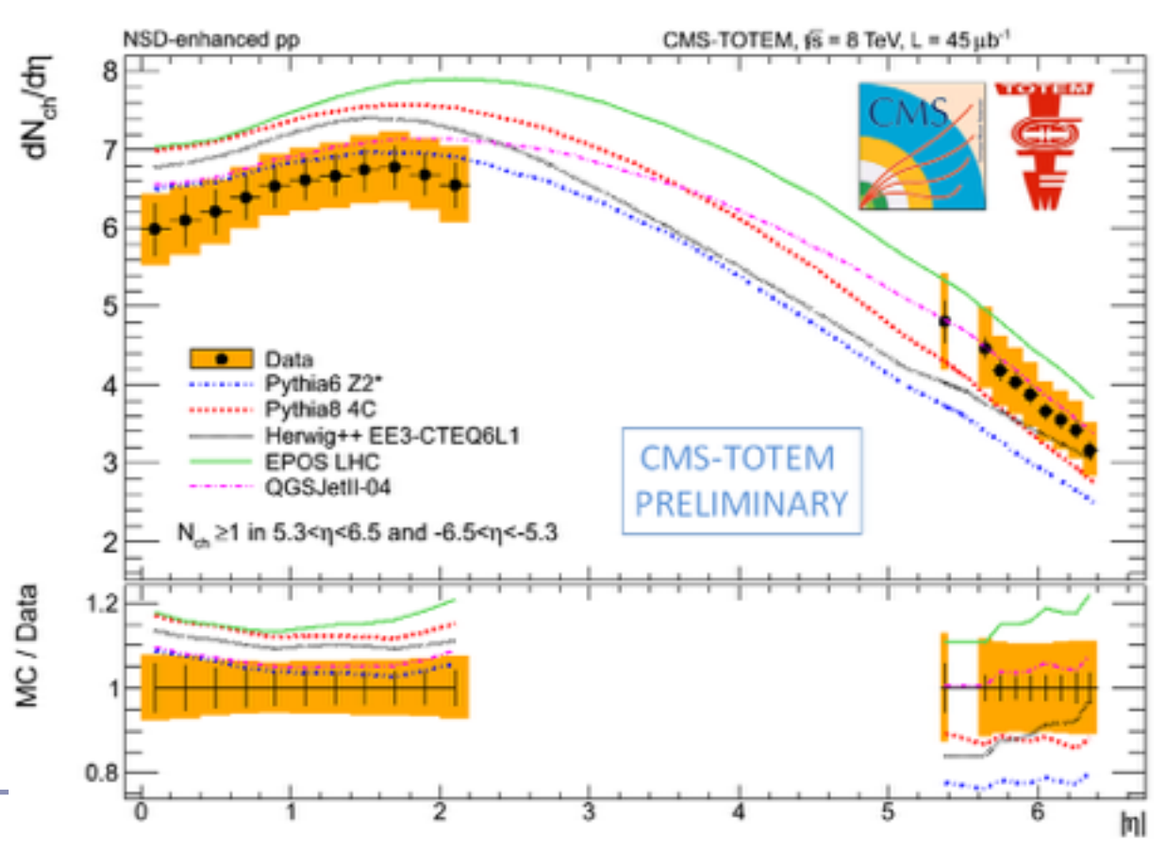


CMS + TOTEM

- Pseudorapidity distributions of charged particles pp collisions at $\sqrt{s}$=8 TeV with CMS and TOTEM experiments
  - inclusive and NSD-enhanced in $|\eta| < 2.2$ and $5.3 < |\eta| < 6.4$
  - common with TOTEM T2 ⟶ common TOTEM trigger in Low PU runs
  - provide useful input for tuning and testing models

FSQ-12-026





Heavy Ions

- Working full steam for more results in time for:

XXIV QUARK MATTER
DARMSTADT 2014

May 19 - 24, 2014

Stay Tuned!

Outline

Three main fronts of activity during LS1

- consolidation and preparation for RunII
  - both detector hardware and offline workflows
  - this is actually entangled with preparation for PhaseI detector upgrades
- squeezing the most out of the RunI data
  - pick some of the latest results (just an overview, not meant to be comprehensive)
- Phase II upgrade preparation
  - Technical Proposal preparation

Upgrade Preparation

LS1 | 13-14 TeV → 1x10^{34} Hz/cm^2 → | LS2 | 2x10^{34} Hz/cm^2 → | LS3 | 5x10^{34} Hz/cm^2

2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026

PhaseII Upgrades: prepare for > 5x10^{34}Hz/cm^2, PU140 to 200
total of 3000/fb in ~10yrs operations

- Replace subsystems no longer performant due to radiation damage
  - tracker including pixels, Endcap calorimeters
- Maintain physics performance at very high PU
  - new electronics and trigger, enhanced detector coverage

Technical Proposal (Fall 2014)

- demonstrate the need for Phasell upgrades
  - detector longevity, performance issues at high luminosity
- describe the detector conceptual designs and performance studies on physics objects, trigger and key physics signals
- demonstrate feasible solutions and present plans for completion of necessary R&D
- present a preliminary production cost and organization plan

Outlook

- Preparation for RunII and PhaseI upgrades is ongoing and we are on track
  - readiness tests in Summer (CSA14 & Global Cosmic Runs) are important milestones
- Work on RunI data is still ongoing:
  - many interesting results still being published
  - more than 100 analysis still ongoing
- Preparing for the future: PhaseII Upgrades & Technical Proposal

CMS is looking forward and will be ready to take the first LHC beam