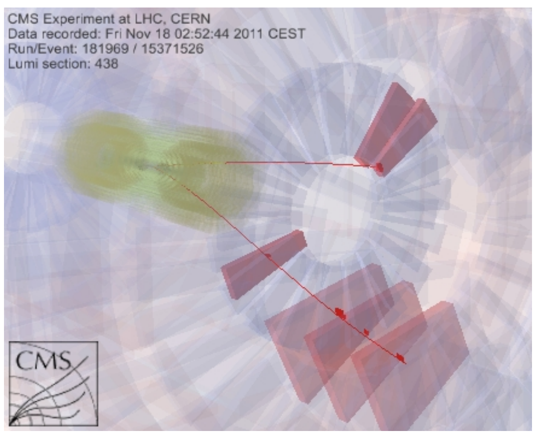
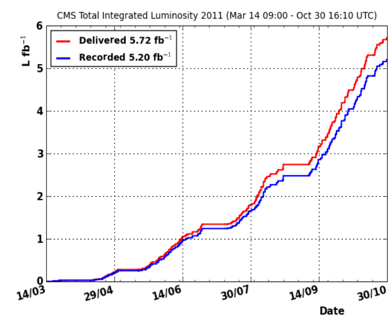
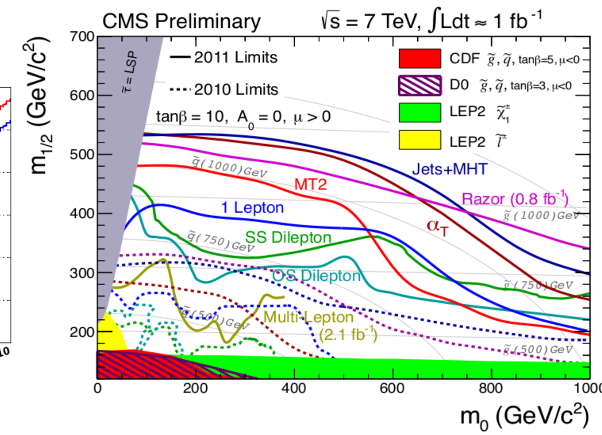
CMS Status Report

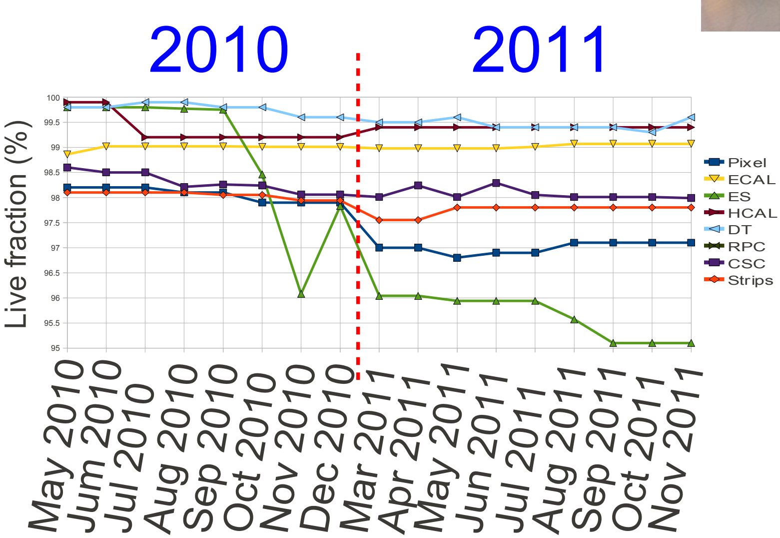
Anders Ryd
Cornell University
On behalf of the CMS Collaboration

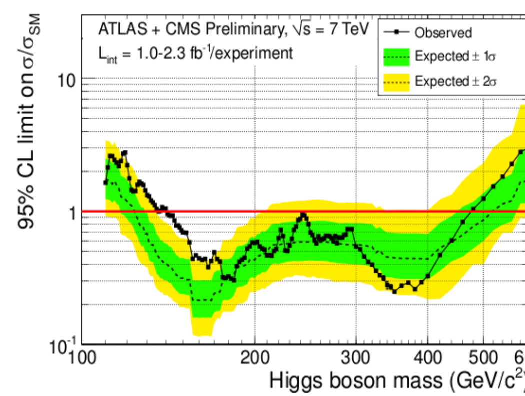
Dec. 7, 2011

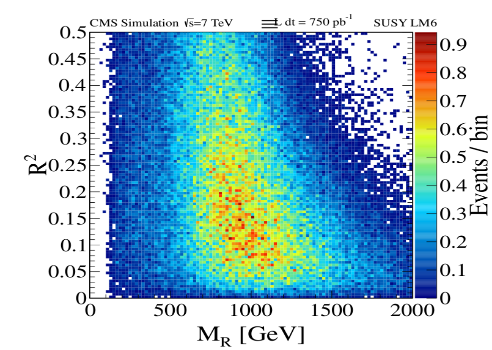


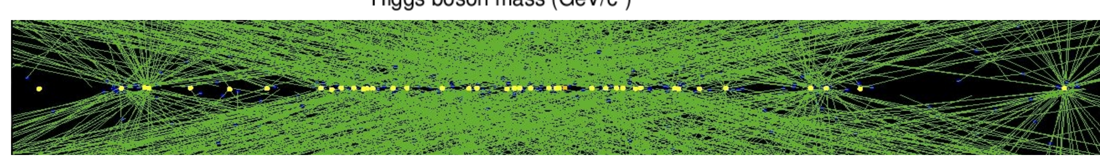












Outline

Detector performance when integrating from 2 to 5 fb-1

Lessons learnt from the high mu operation

Updates on calorimeter and tracking performance

Many (less mundane) physics channels updates

lessons from high beta running

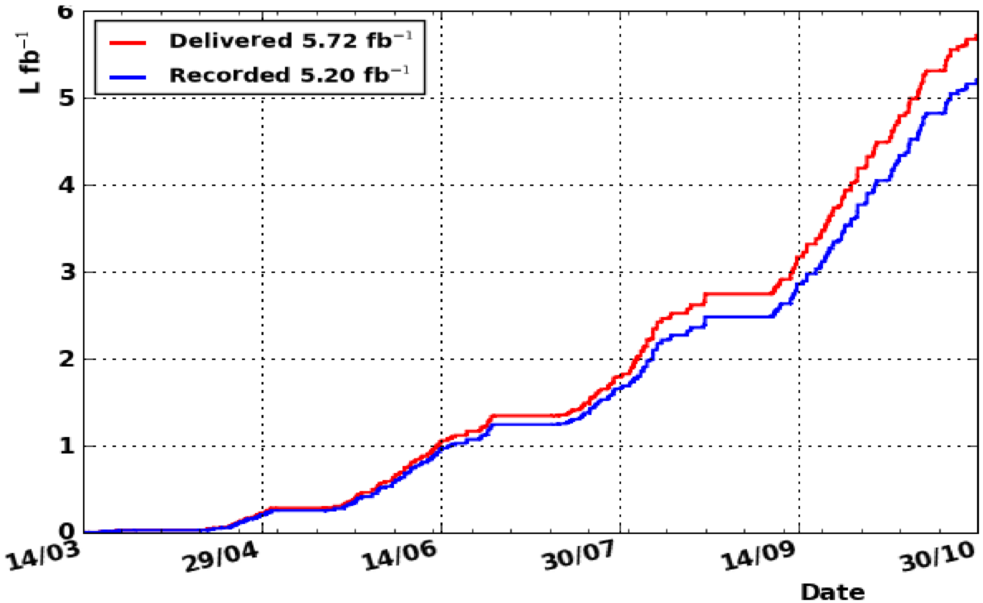
pA and AA running experience and plans

Possibly new insights and wishes for the 2012 running of the LHC

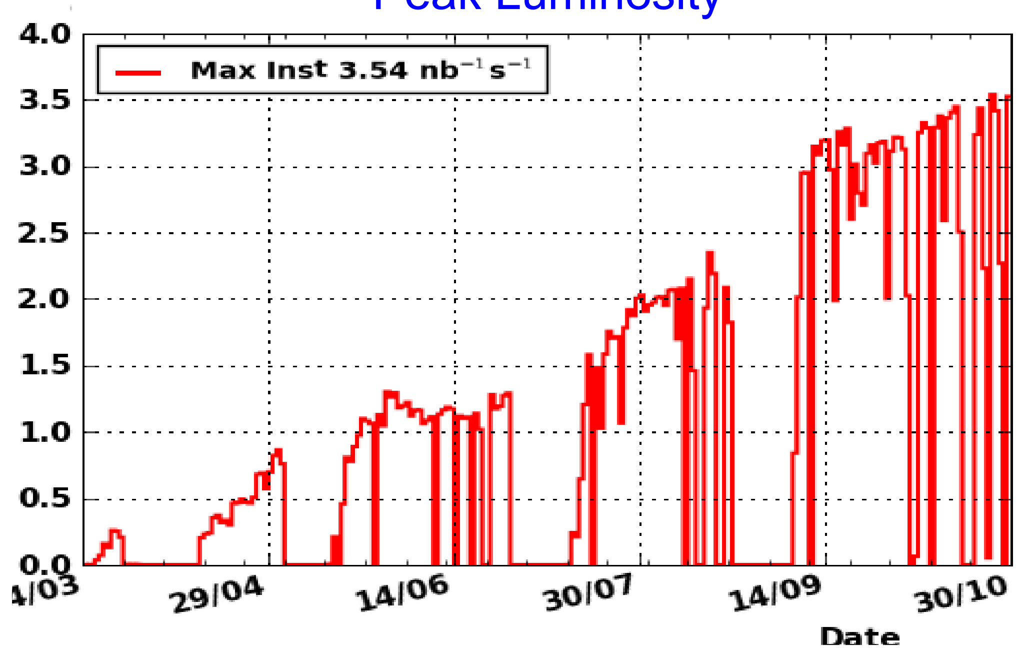
Plans and progress for the upgrades

The 2011 Proton Run

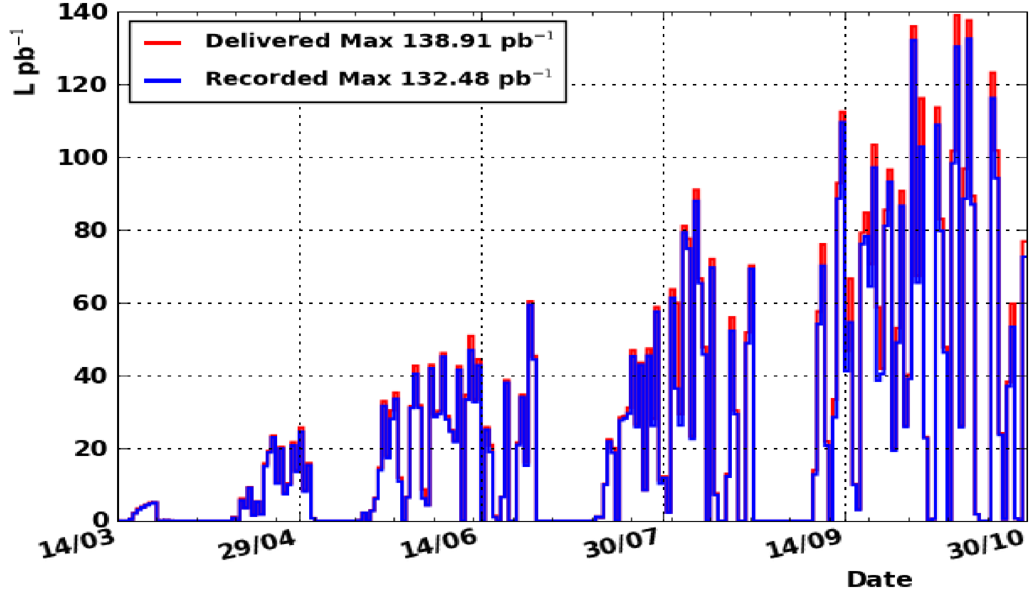
Delivered and Recorded Luminosity



Peak Luminosity

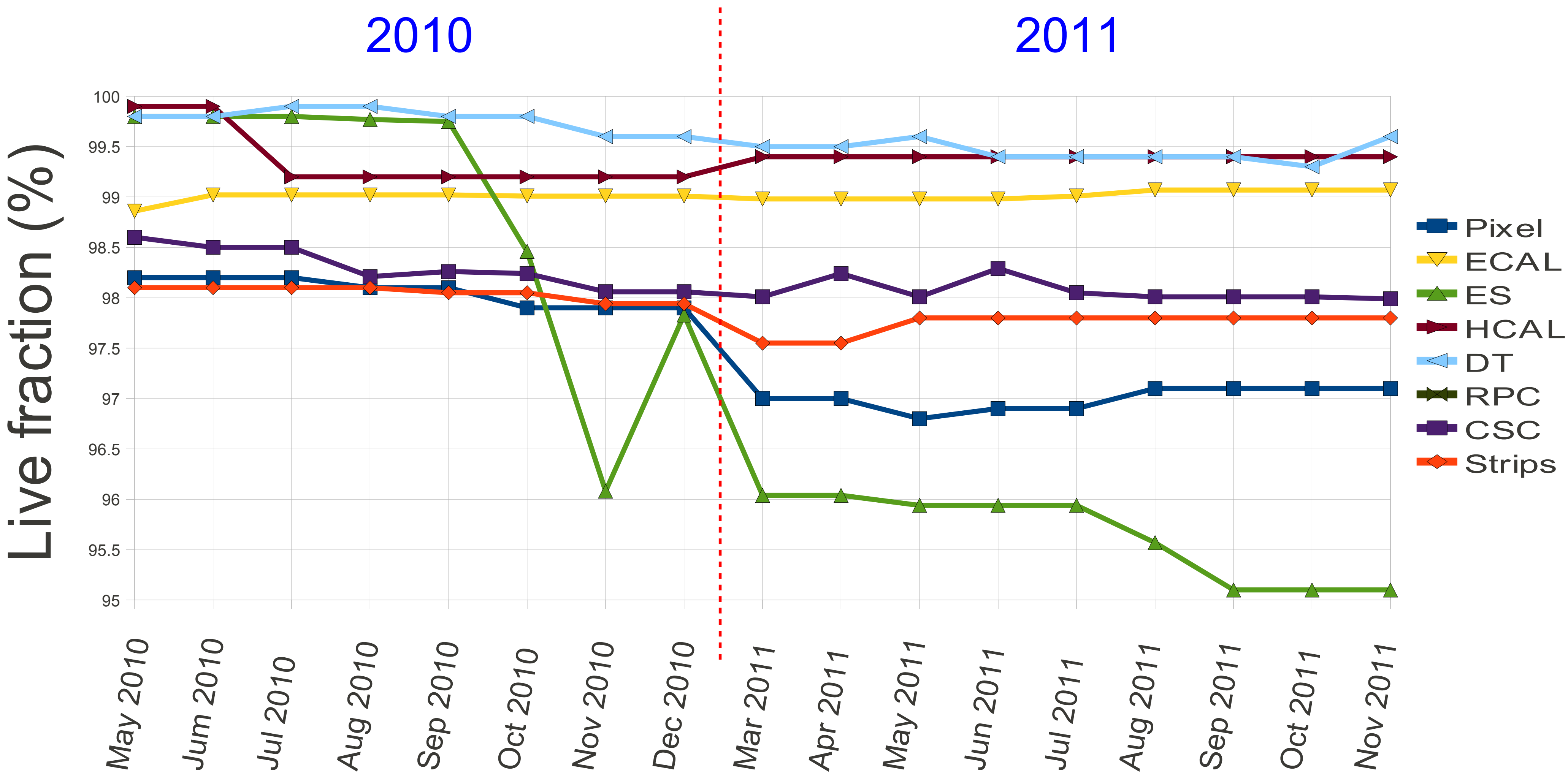


Integrated Luminosity per day



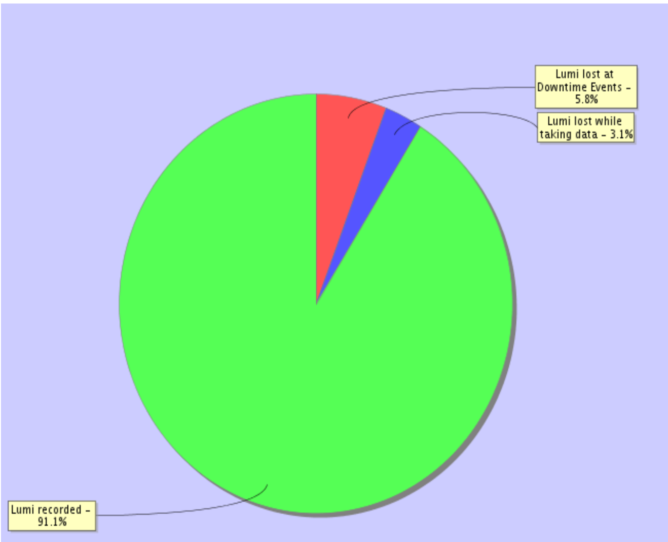
- A very successful run
  - We thank the LHC for their excellent performance!

Very Stable Detector Performance



Most detectors over 97% live – and stable in time

CMS Data Taking Efficiency



LHC delivered 5.72 fb^{-1}

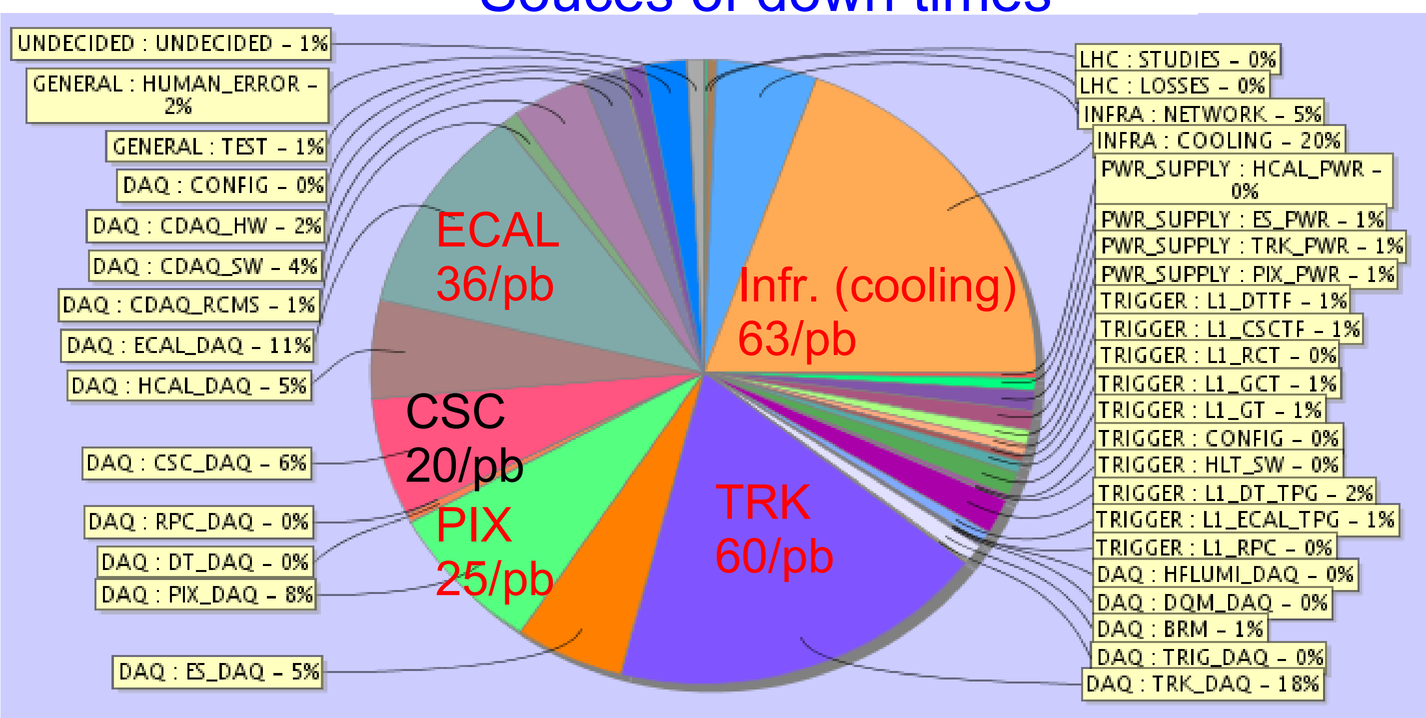
Lost due to deadtime:176 pb^{-1}

Lost due to downtime:325 pb^{-1}

Sources of deatime:

- Trigger rules (~0.7%)
- Partition control (sub detectors ~0.5%)
- HLT at start of runs (~0.5%)
- Short stops that don't count as dowtime.

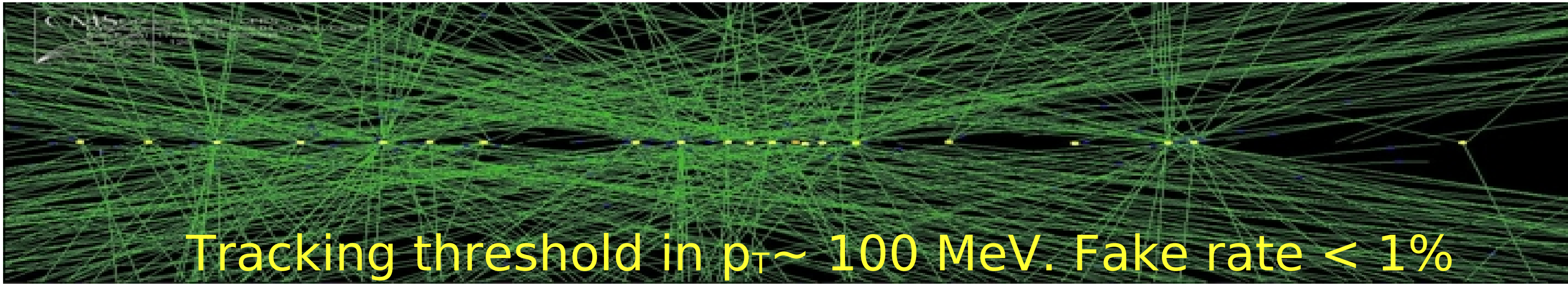
Souces of down times

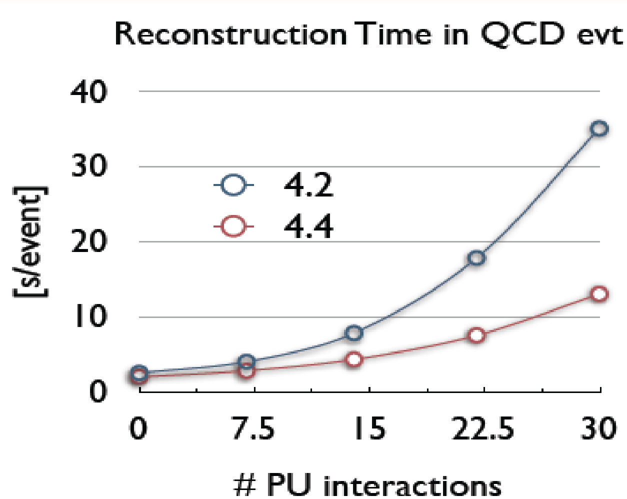


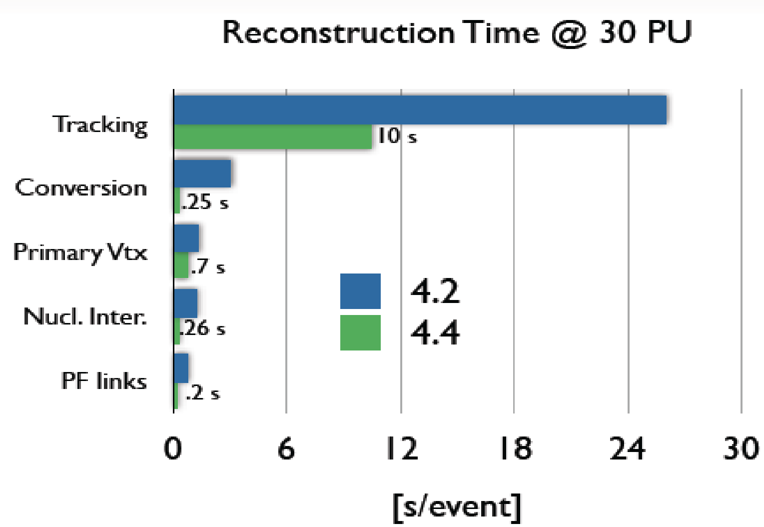
Largest single source of downtime was a cooling failure affecting two fills.

SEUs affecting several subsystems (Pixel, ECAL, CSC, HCAL) has contributed to the downtume.

Tracking Challenges with High PU

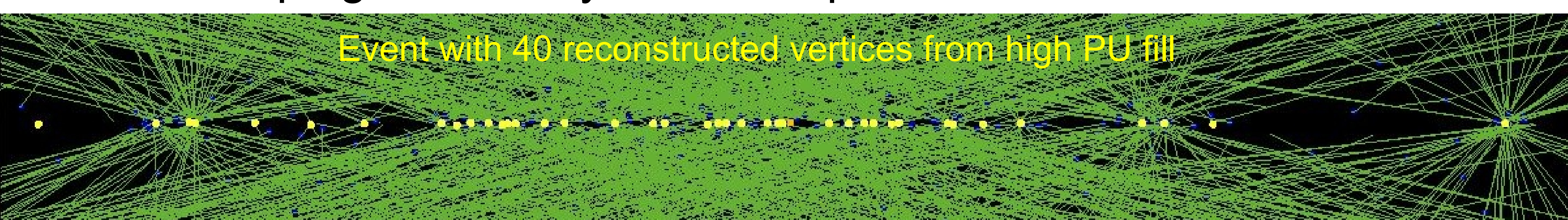






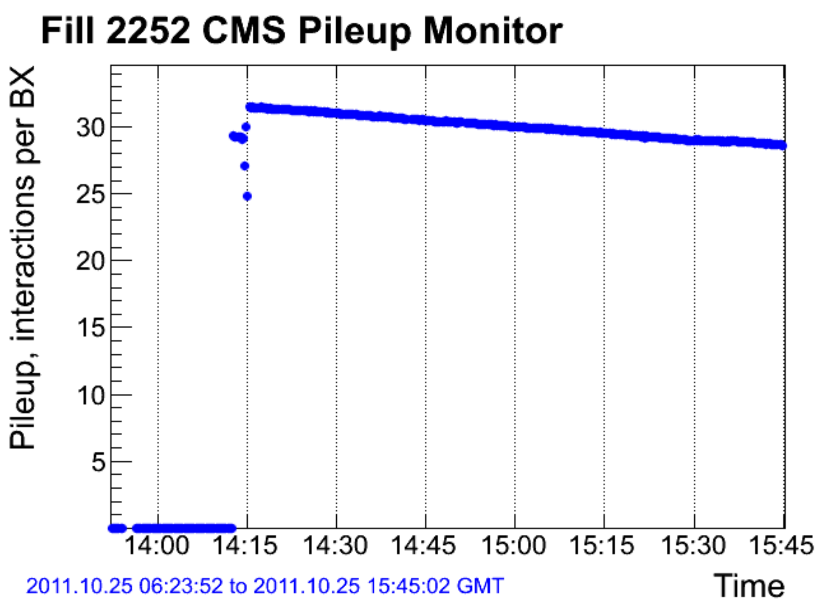
Improved tracking code reduces reconstruction time in high pile-up events by factor or 2

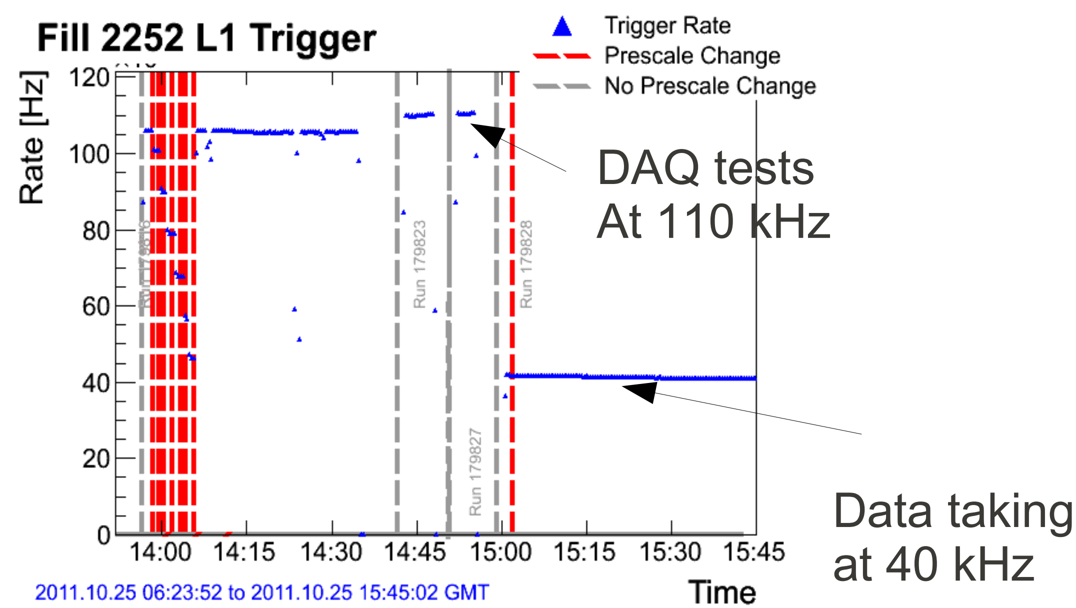
Keeping essentially the same performance



DAQ Bandwidth Studies

- The CMS DAQ was designed to operate at 100 kHz L1 trigger rate with 25 ns bunch spacing at 1e34 Hz/cm2 with a PU of about 20.
  - With higher PU in 50 ns operation the design bandwidth guaranteed by the DAQ would be exceeded at ~4.5e33 Hz/cm^2 – what is the limit?
  - Using the high pileup fill with 10 colliding bunches we can trigger at up to 110 kHz and read out high PU collisions

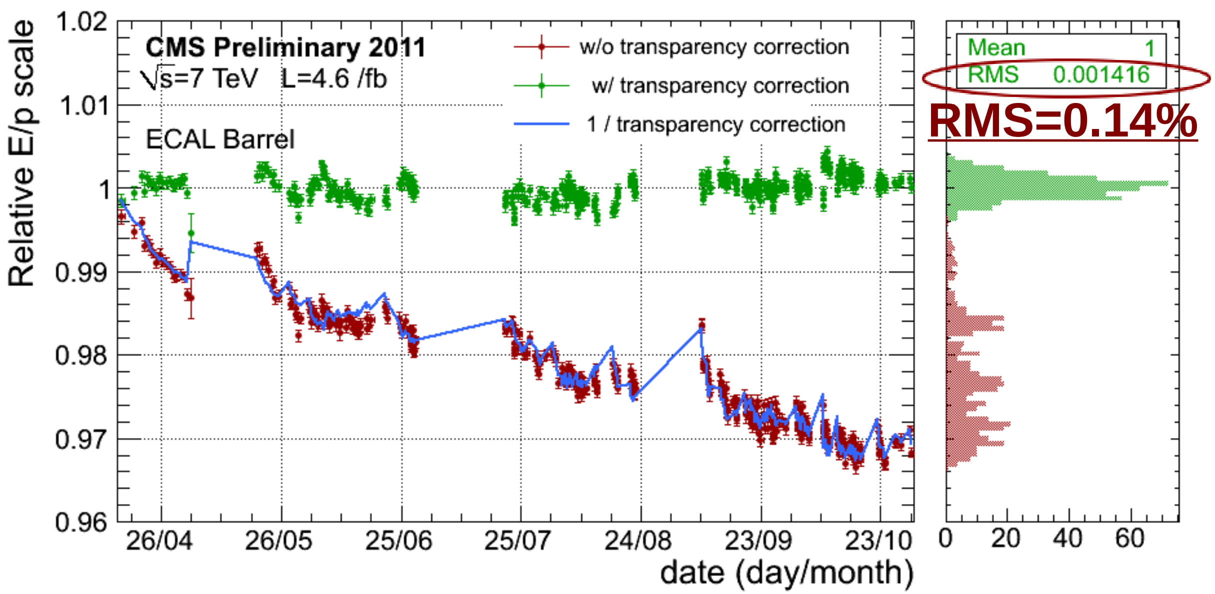




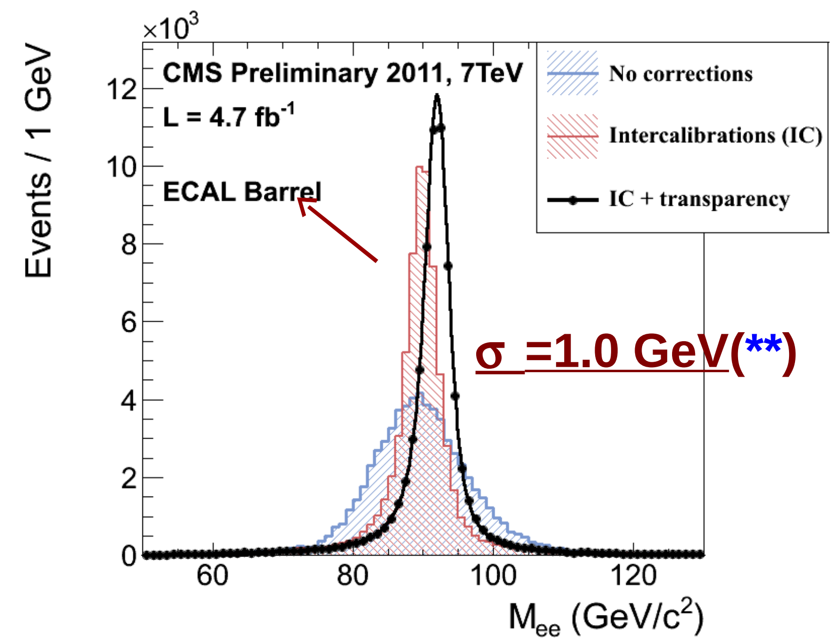
  - With a PU of >30 at the start of the fill we ran at 110 kHz L1 trigger rate – no limitation seen by the DAQ bandwidth.
  - Without modifications to the readout we can operate at 7e33 Hz/cm^2 with 50 ns bunch spacing.

Progress in ECAL calibration

Single electron energy scale (E/p) stability in the ECAL barrel measured using W →eν events



Overall effect of single channel inter-calibration and transparency corrections on the Z→ee invariant mass in the ECAL barrel (*)

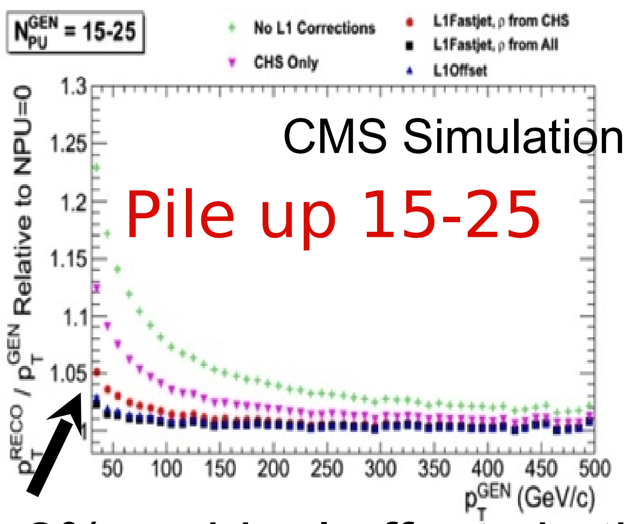


- **Stable energy scale throughout 2011 run after applying laser corrections:**
  - Barrel: average loss ~ 2.5%, RMS stability after corrections 0.14%
  - Endcap: average loss ~ 10%, RMS stability after corrections 0.5%
- **Good energy resolution with preliminary energy calibration for 2011:**
  - Invariant mass resolution on Z → e+e- events: 1.0 GeV in ECAL Barrel (**)

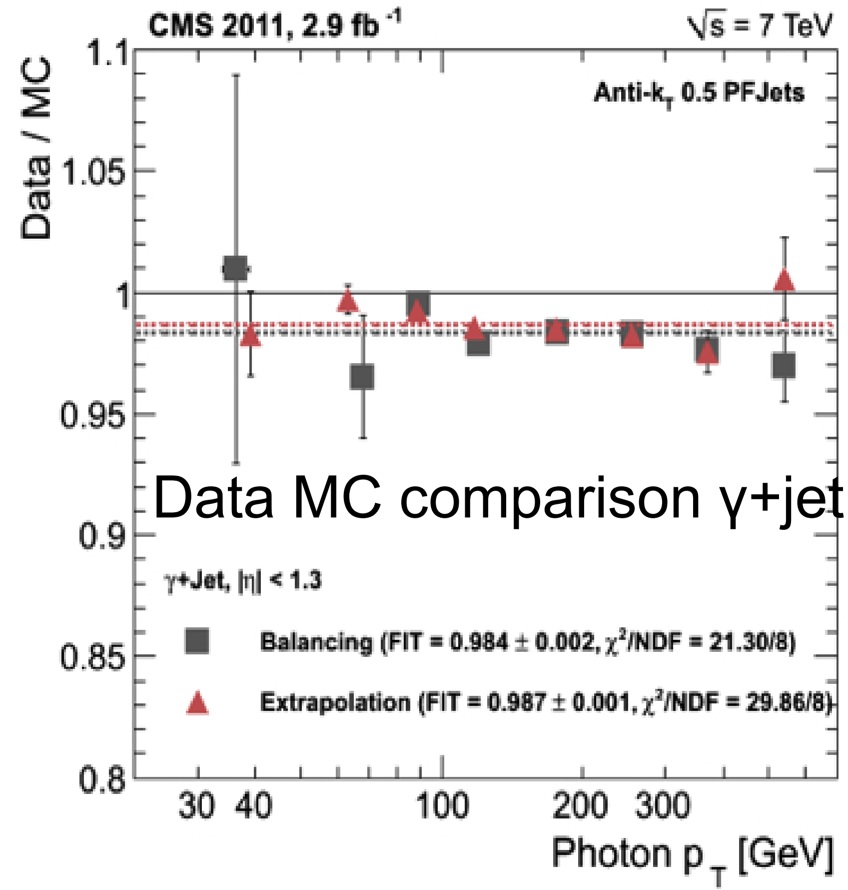
(*) The plot includes only electrons with limited radiation in the CMS tracker

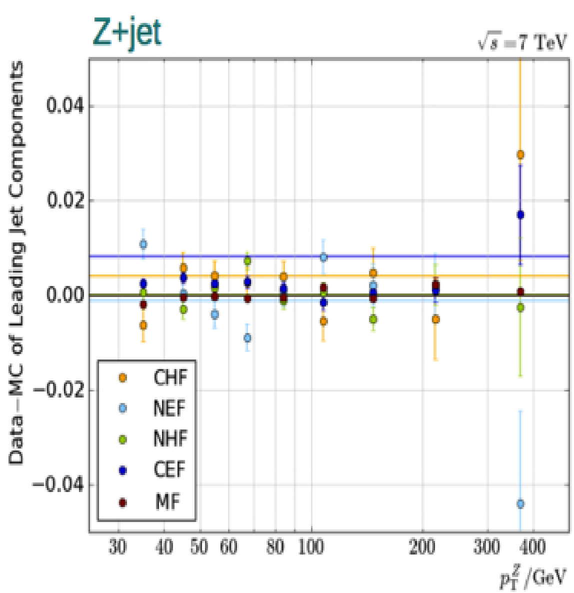
(**) Width of Crystal Ball function convoluted to the Z→ee Breit-Wigner shape

JET Calibration at High Pile-Up



1-2% residual effects in the energy scale

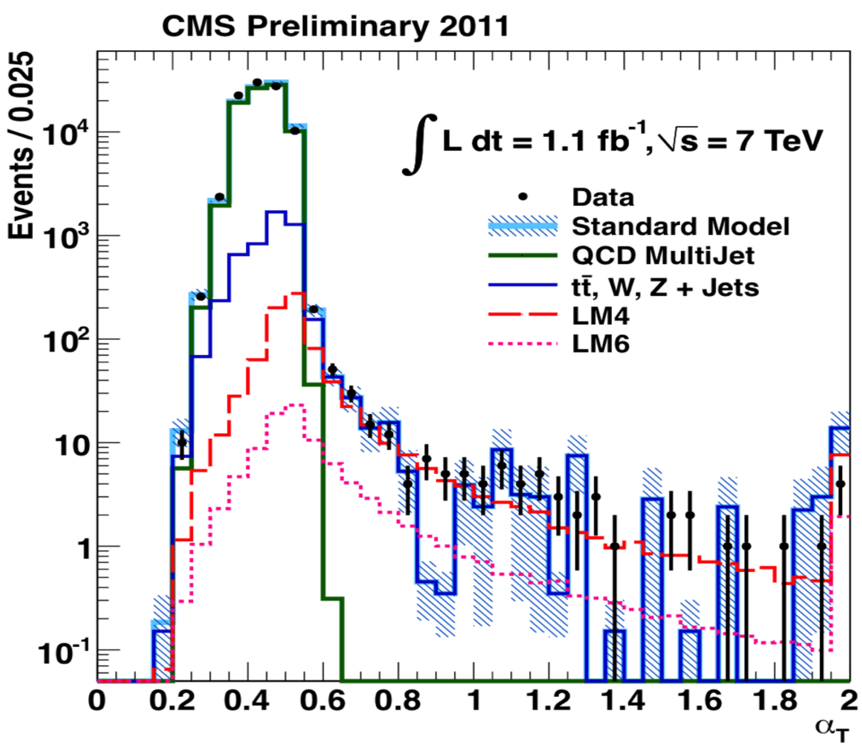


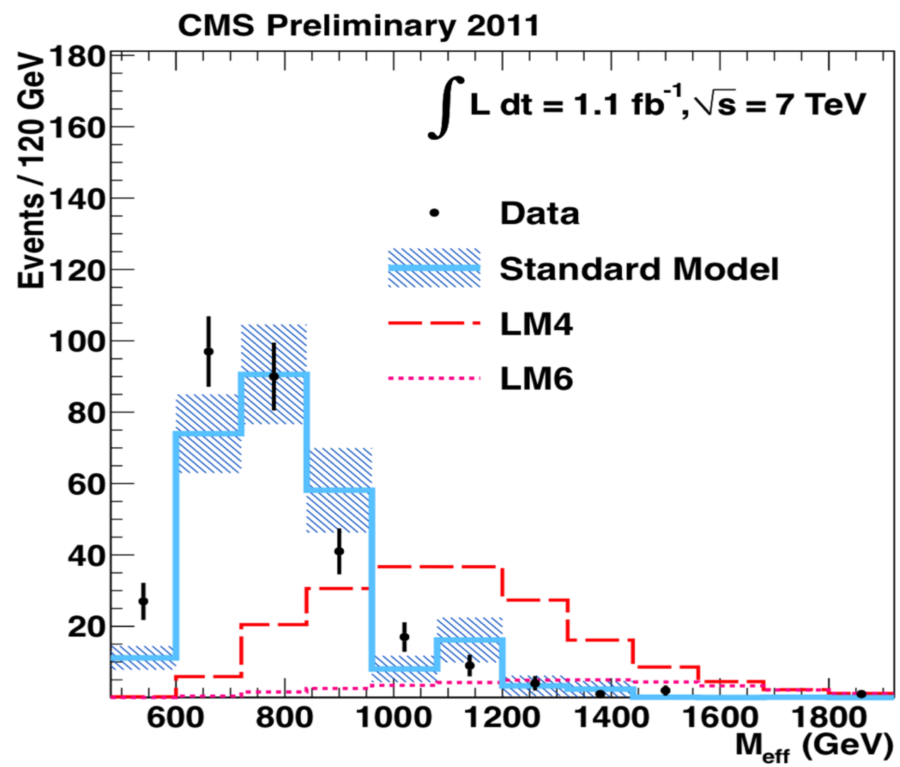


Also the jet composition is very well simulated

Physics Updates

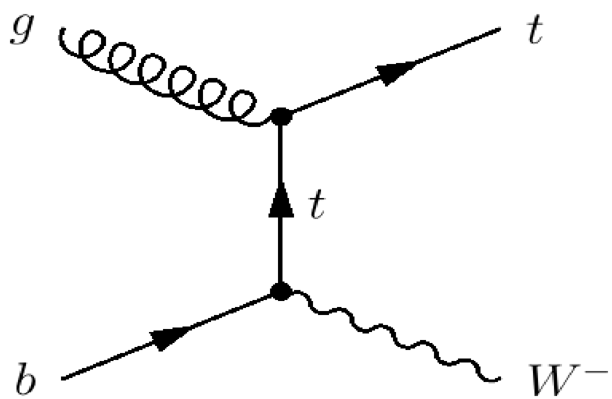
- At the last LHCC on Sept. 21 Darin Acosta gave a detailed overview of many analysis
- In the next few slides some updates on recent results are given

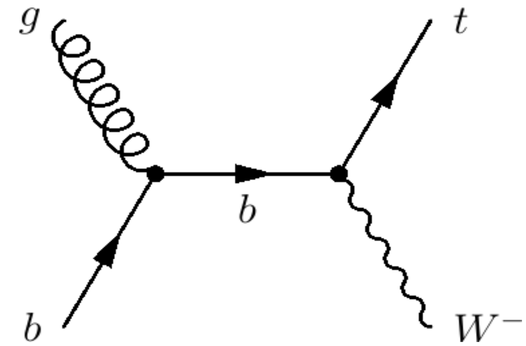


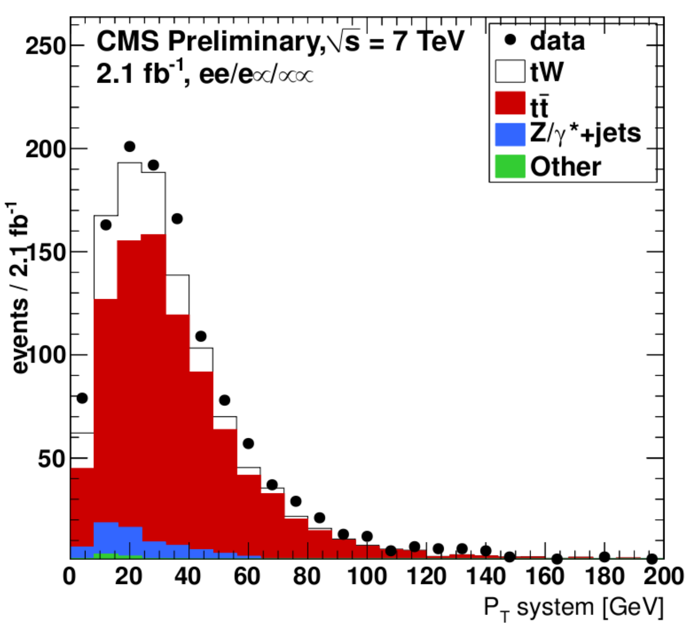


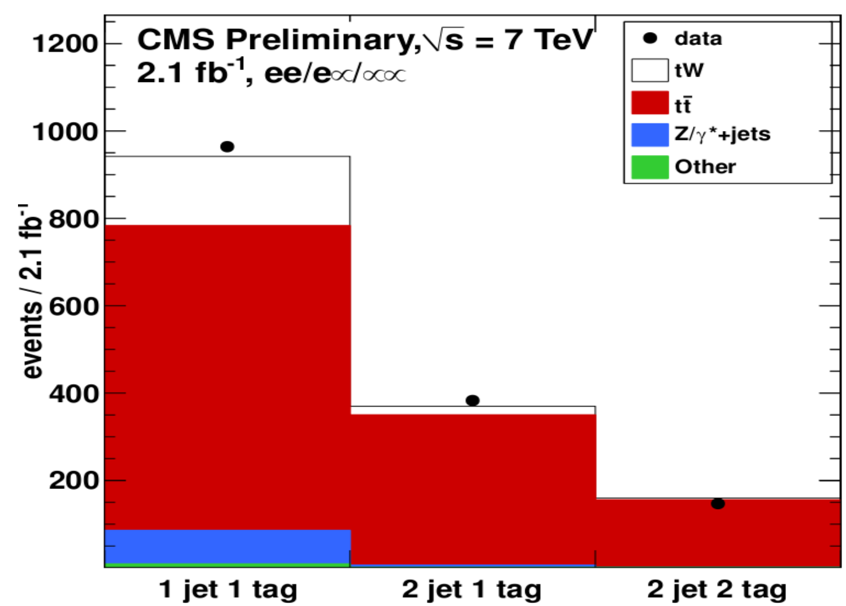
1109.2352 36 citations
1101.1628 141 citations ← Most cited LHC paper on collision data

Single Top+W





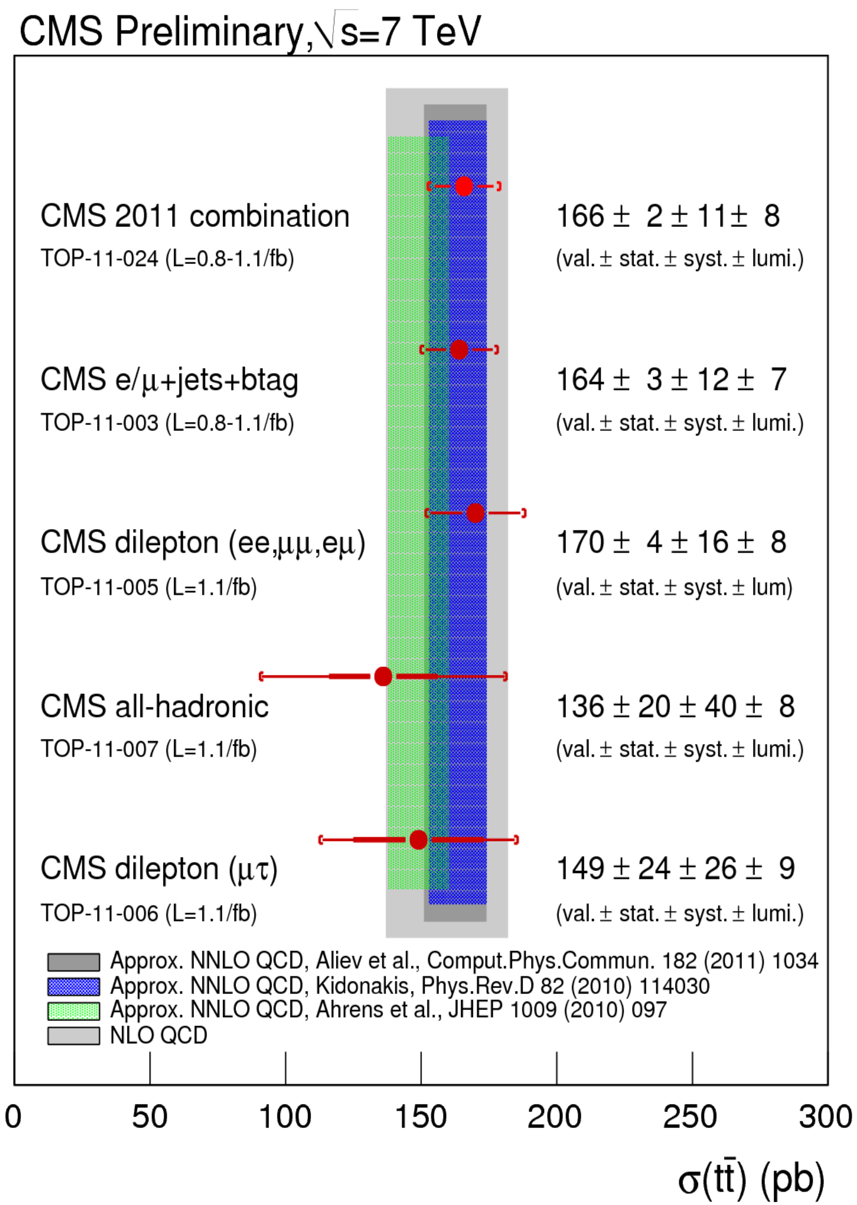




$$\sigma(tW) = 21^{+9}_{-7}\,\mathrm{pb}$$

Consistent with the SM with a significance of 2.7σ

Top Pair Cross-Section



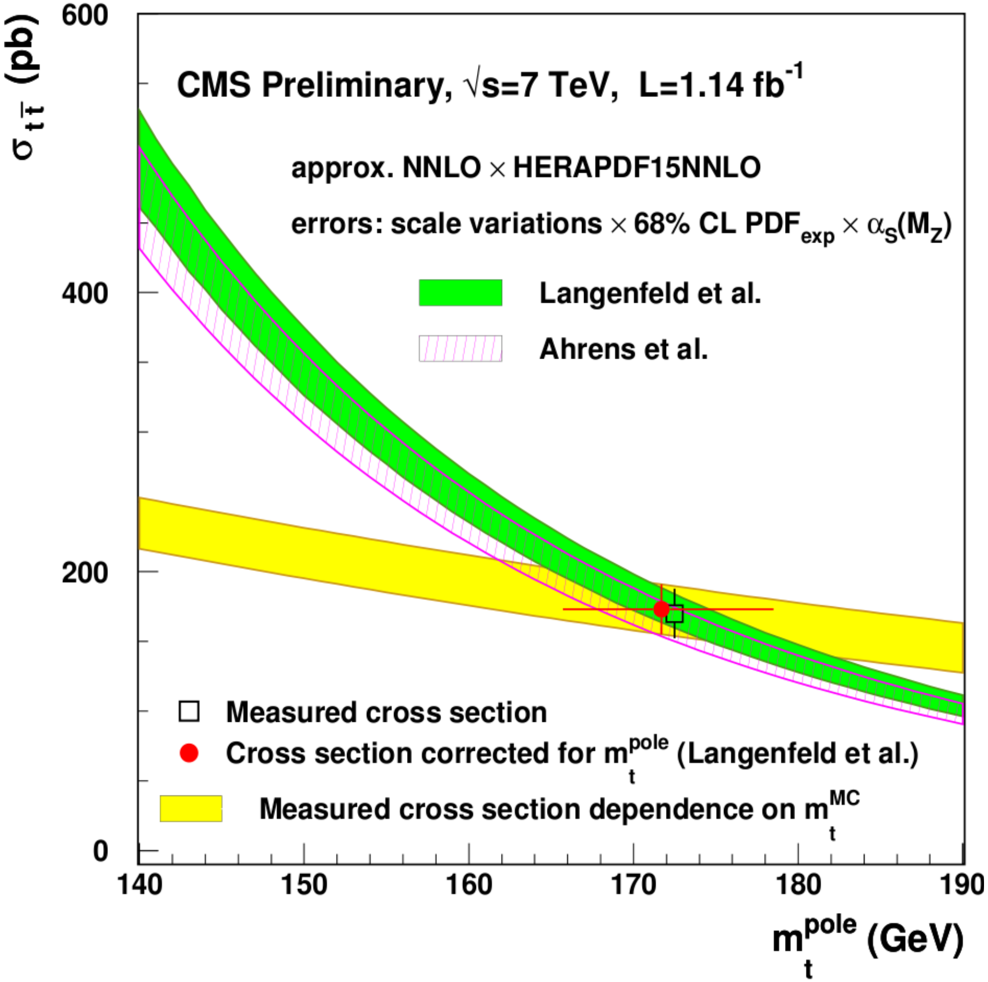
New result for HCP 2011

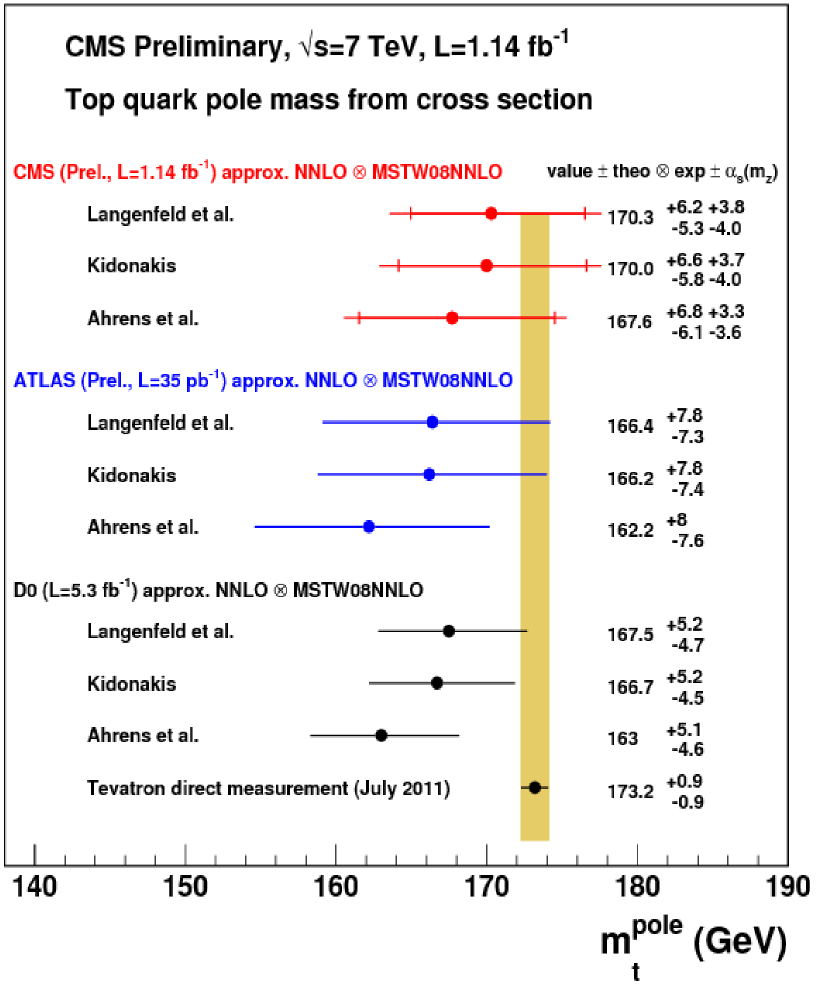
8% precision – systematics limited

Start to be sensitive to different NNLO approximations

systematic source	single lepton	ee	$\mu\mu$	$e\mu$	$\mu\tau$	hadronic
JES	poly	1.9	1.7	1.9	4.4	14.3
b-tag (single)	poly					
b-tag (hadronic)						15.7
b-tag ($\mu\tau$)					5.5	
b-tag (dilepton)		5.0	5.0	5.0		
Pileup	2.6	5.0	5.0	5.0	3.1	0.6
$t\bar{t}$ Q^2	2.8	2.4	2.4	1.8	2.0	10.3
luminosity	4.5	4.5	4.5	4.5	6.0	6.0
Lepton efficiency (single)	3.4					
Lepton efficiency ($\mu\tau$)					2.1	
Lepton efficiency (dilepton)		3.0	1.6	2.3		
W leptonic branching ratio		1.7	1.7	1.7	1.7	
Top quark mass		2.6	2.6	1.5	1.6	5.3
JetMet model		3.2	3.2	0.4	1.0	
ME-PS matching	2.0				1.0	5.2
W+jets Q^2 (single)	poly					
PDF (single)	3.4					
Lepton model (dilepton)		4.0	4.0	4.0		
Decay model (dilepton)		2.0	2.0	2.0		
fake rate ($\mu\tau$)					13.0	
τ jet mis-ID ($\mu\tau$)					7.3	
tau and hadron decay model ($\mu\tau$)					2.0	
MC bkgd ($\mu\tau$)					1.6	
MC tune (hadronic)						8.1
trigger (hadronic)						4.5
bkgd (hadronic)						12.2

Top Mass From Cross-Section

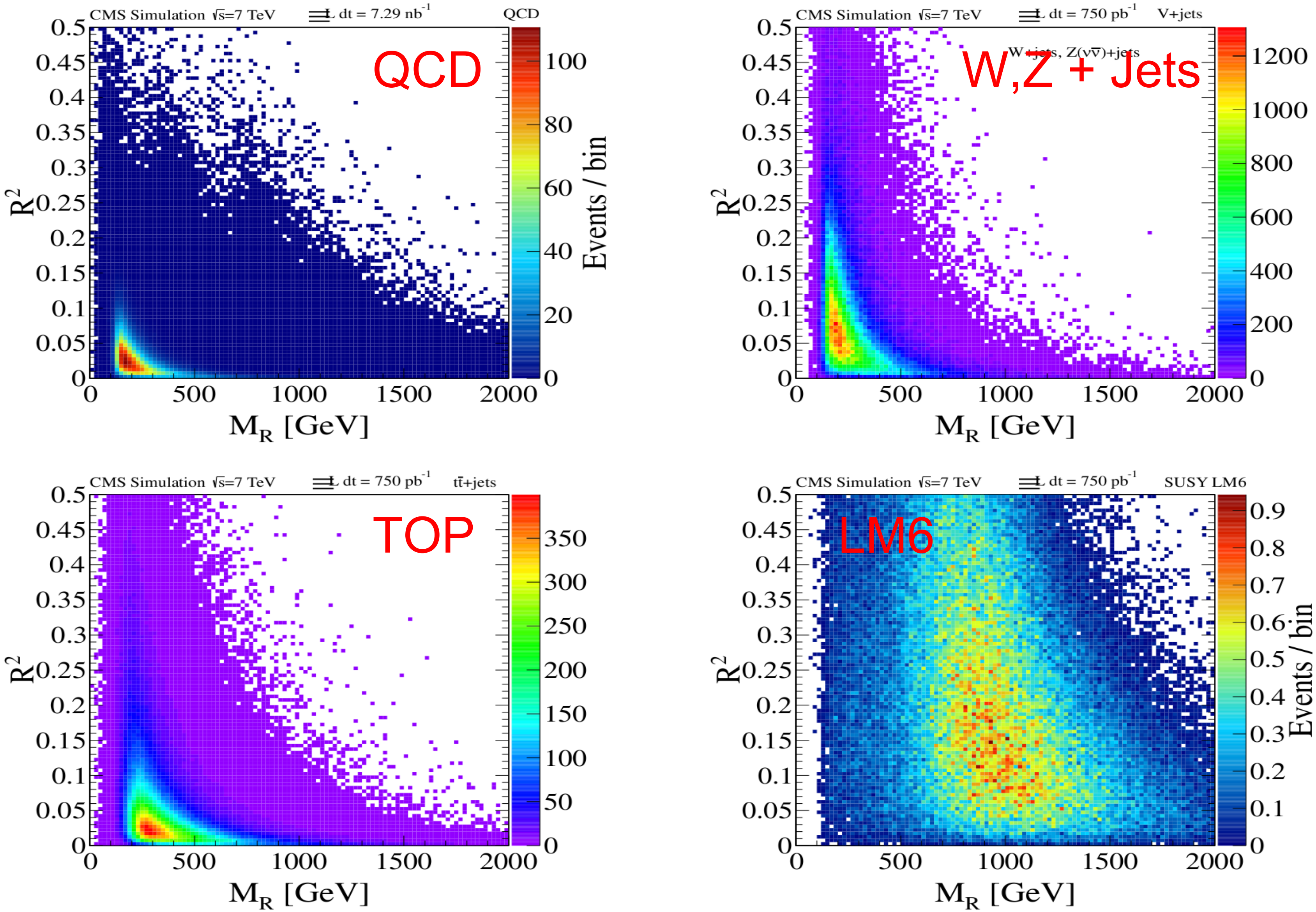




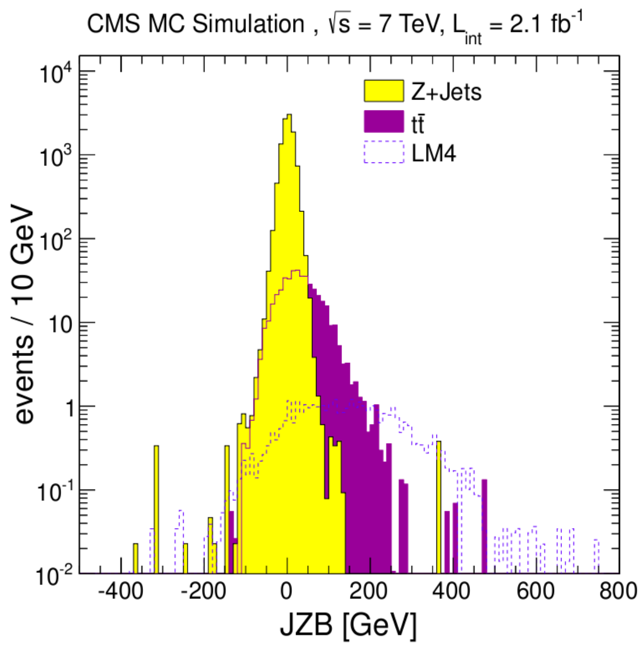
SUSY - Razor

M_R – Estimate of the heavy particle scale
R^2 – Related to the event MET

Perform fits to the M_R vs R^2 distributions
Powerful search based on kinematics

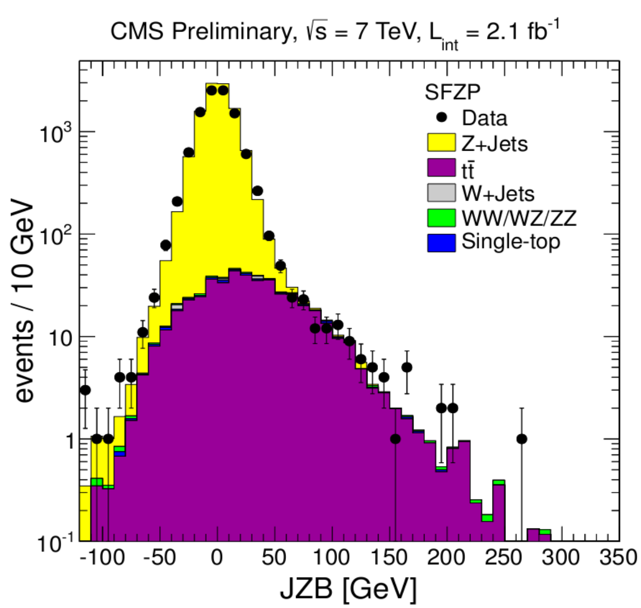


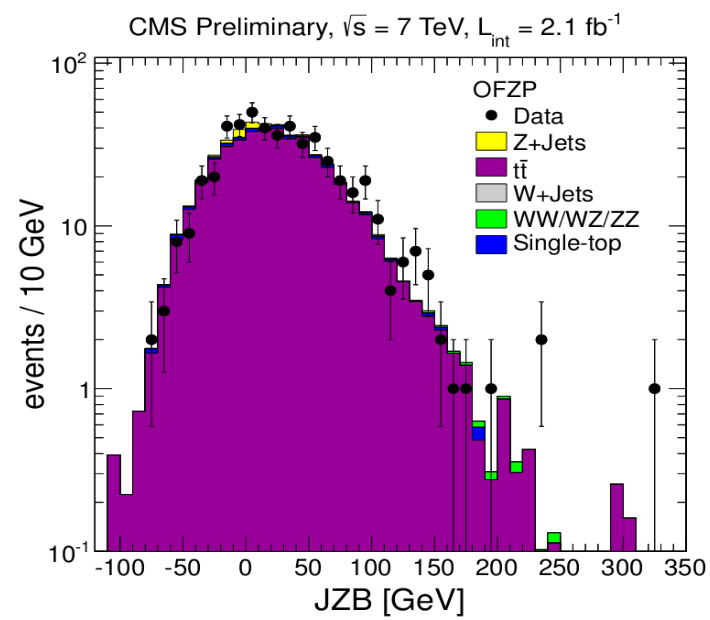
Jet-Z Balance: Jets+Z+MET



$$\mathrm{JZB} = \left|\sum_{jets} \vec{p}_T^{\,\mathrm{jet}}\right| - \left|\vec{p}_T^{\,Z}\right|$$

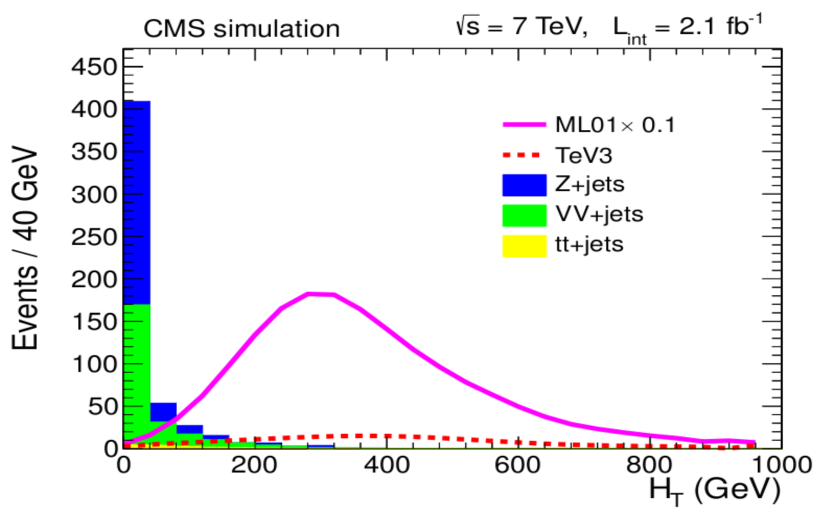
Method allows a very robust prediction for Z+jets background.

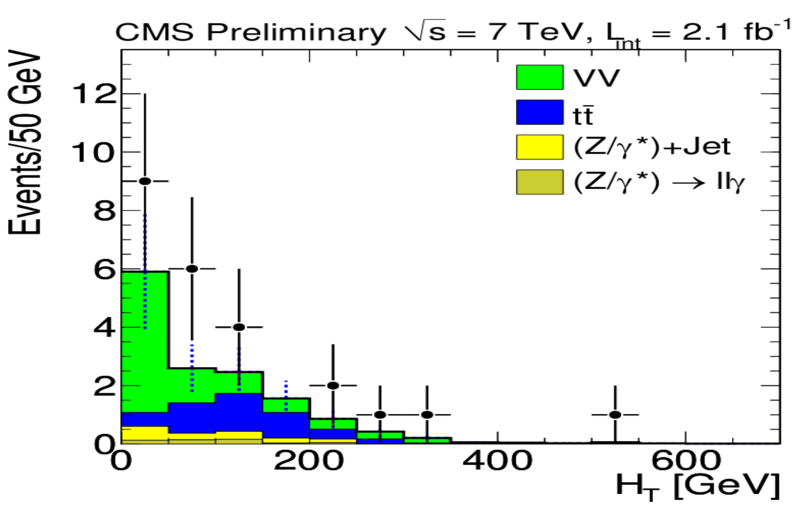


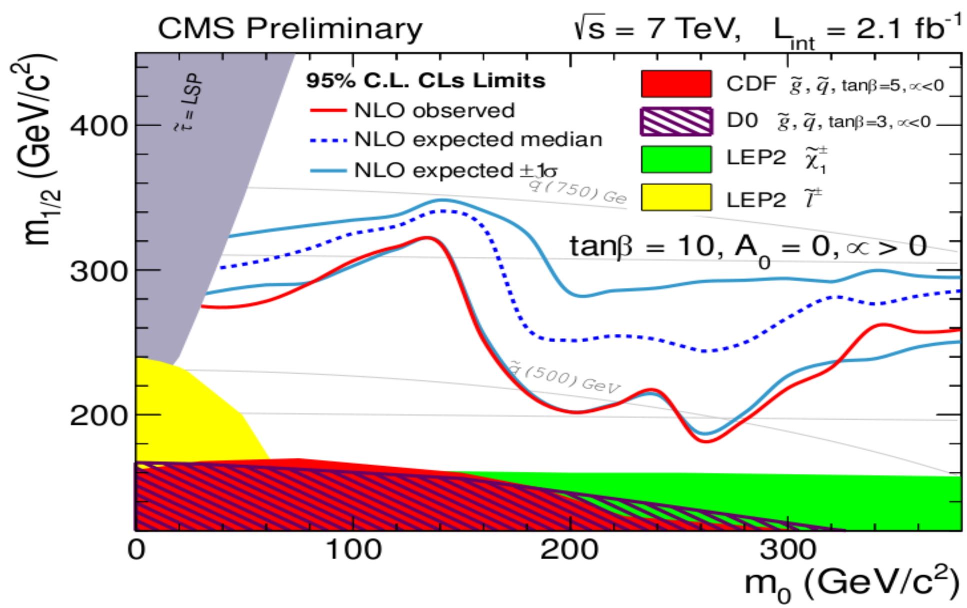


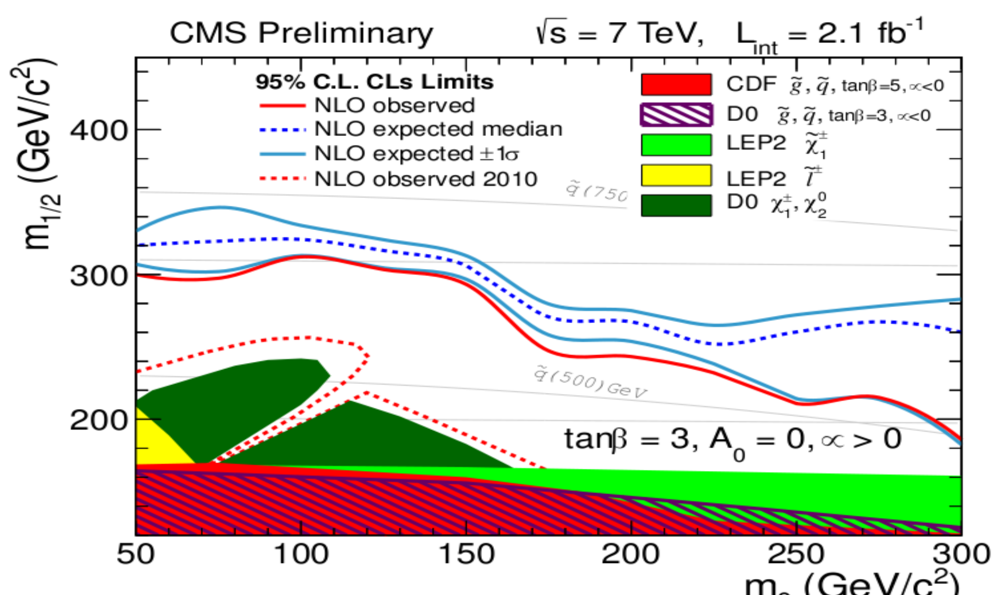
Multilepton SUSY Searches

- At least 3 leptons
- Require MET and veto Z
- Need to understanding backgrounds from internal converions

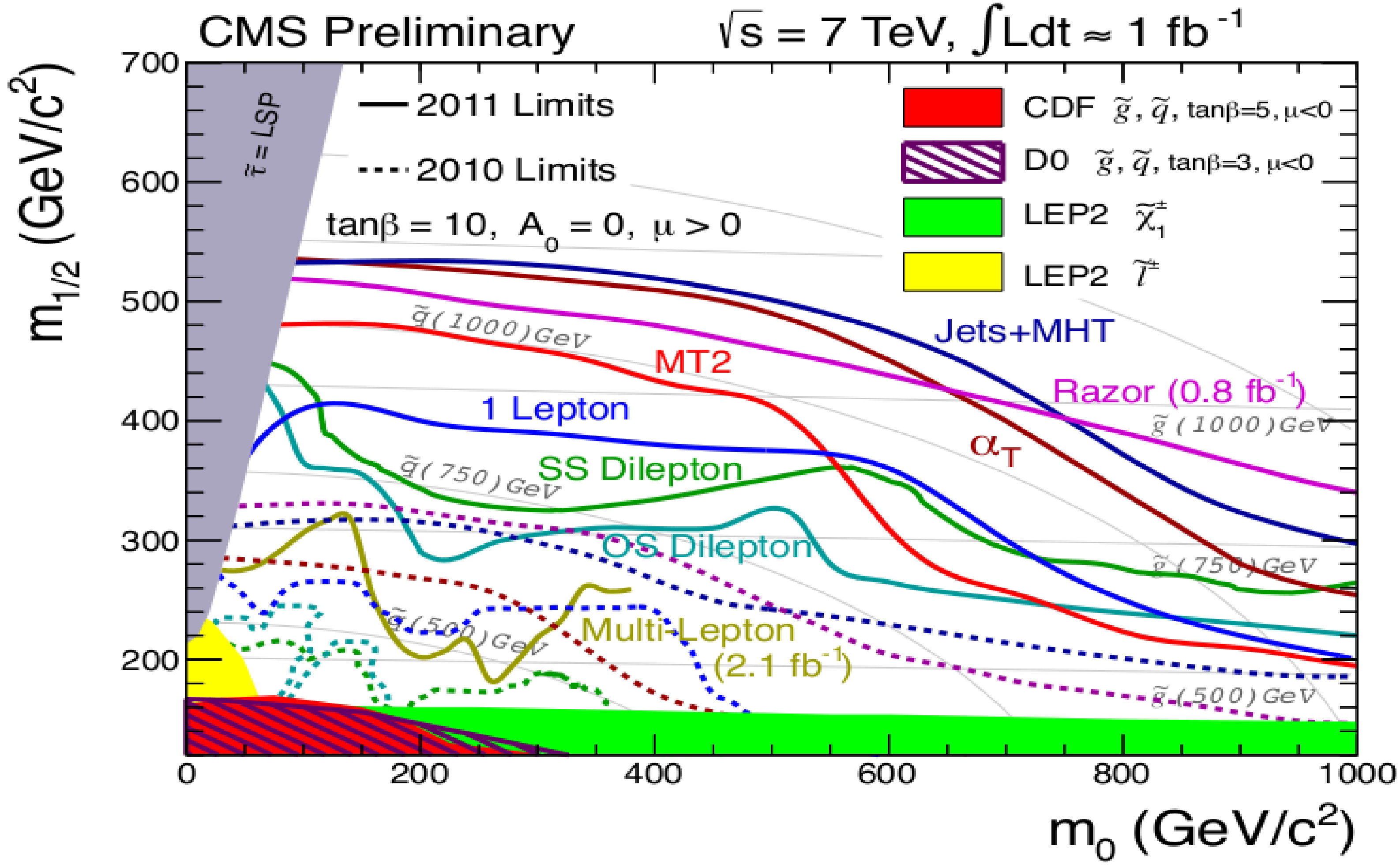






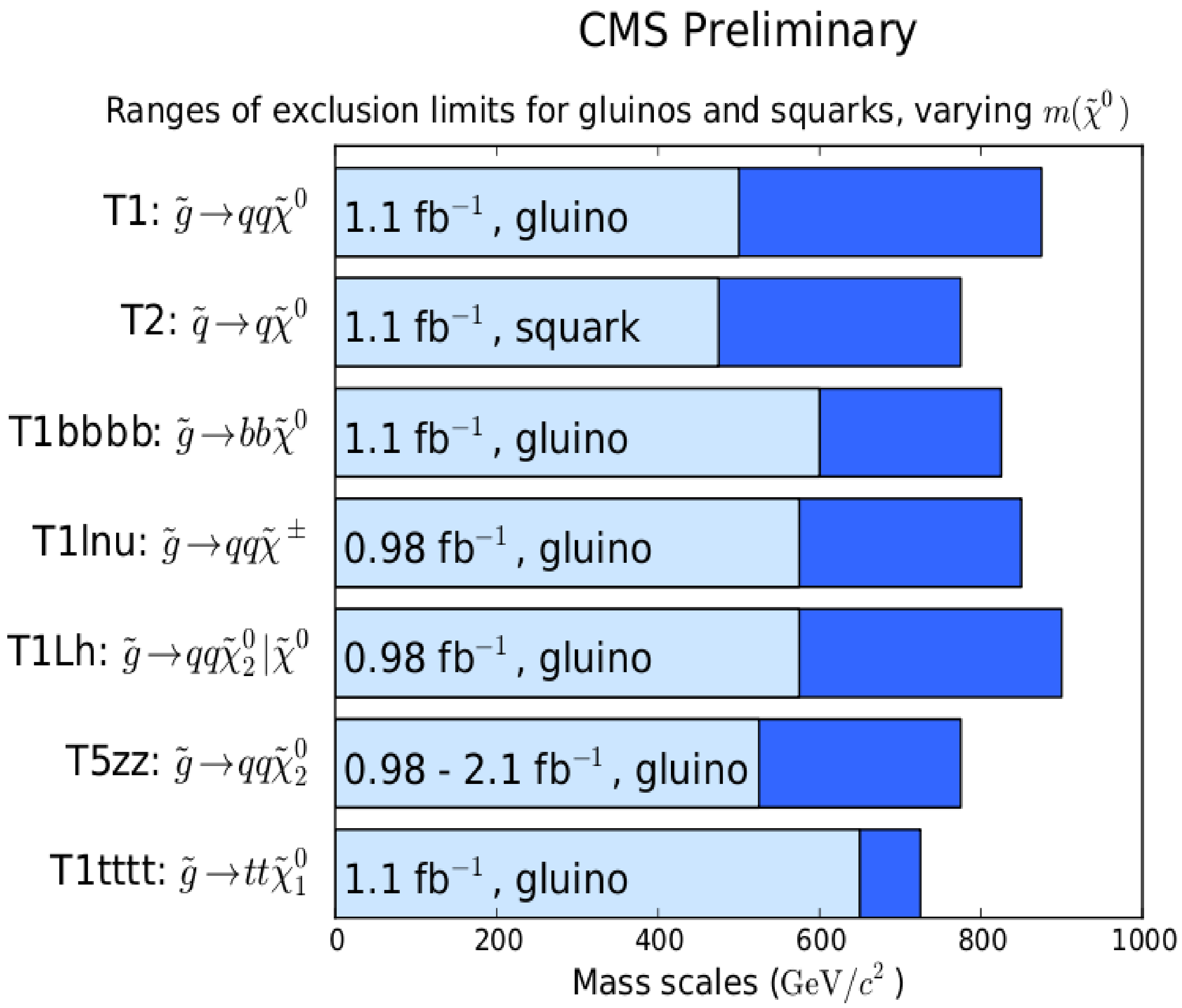


SUSY Summary: CMSSM



Many different search strategies

Simplified Models



The dark blue range corresponds to a range of neutralino masses down to 200 GeV below the gluino mass.

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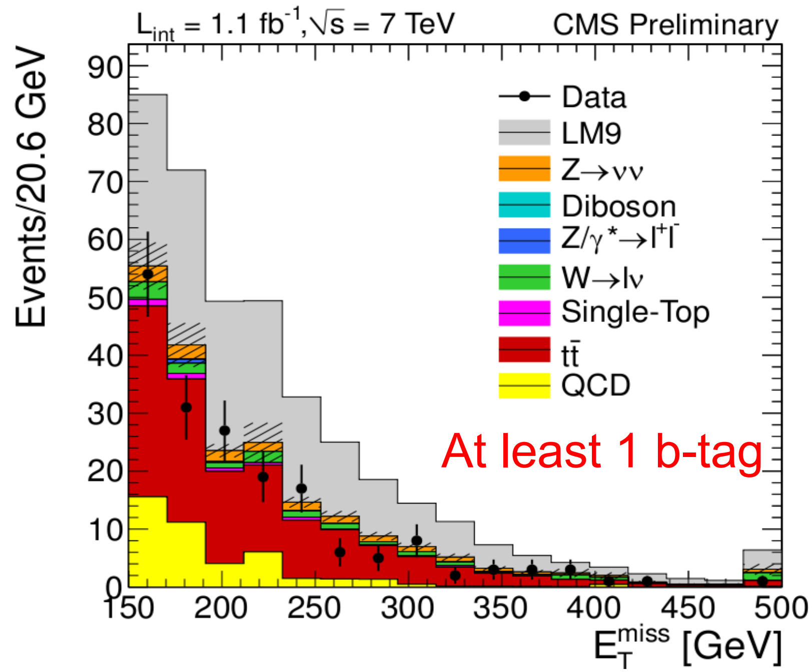
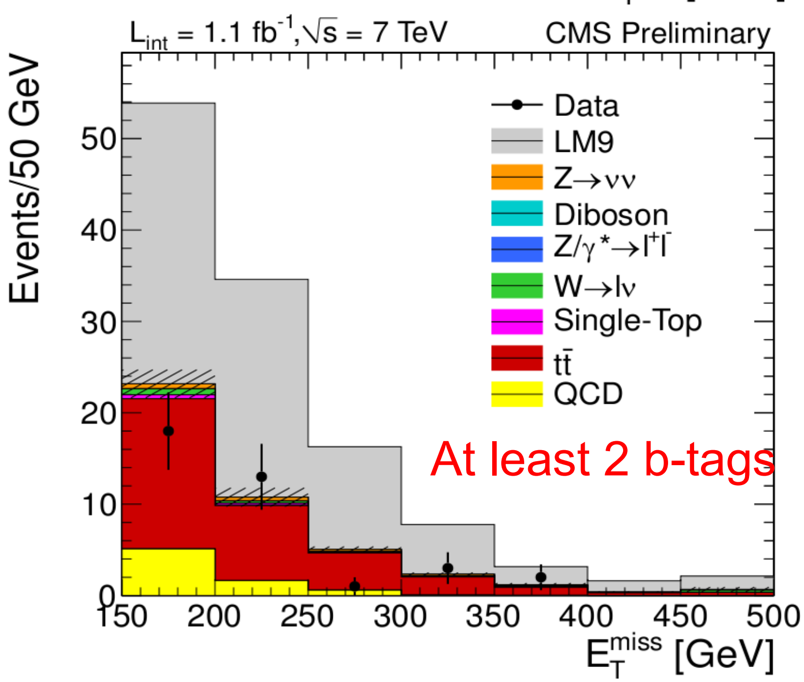
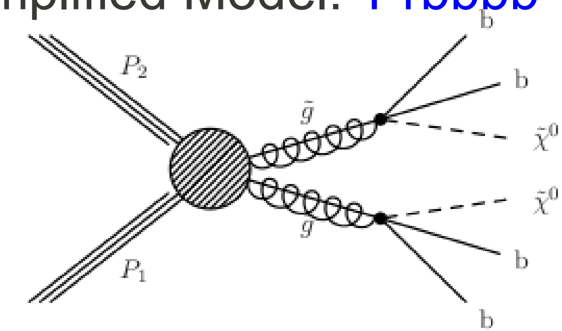
SUSY: MET + jets + b-tags

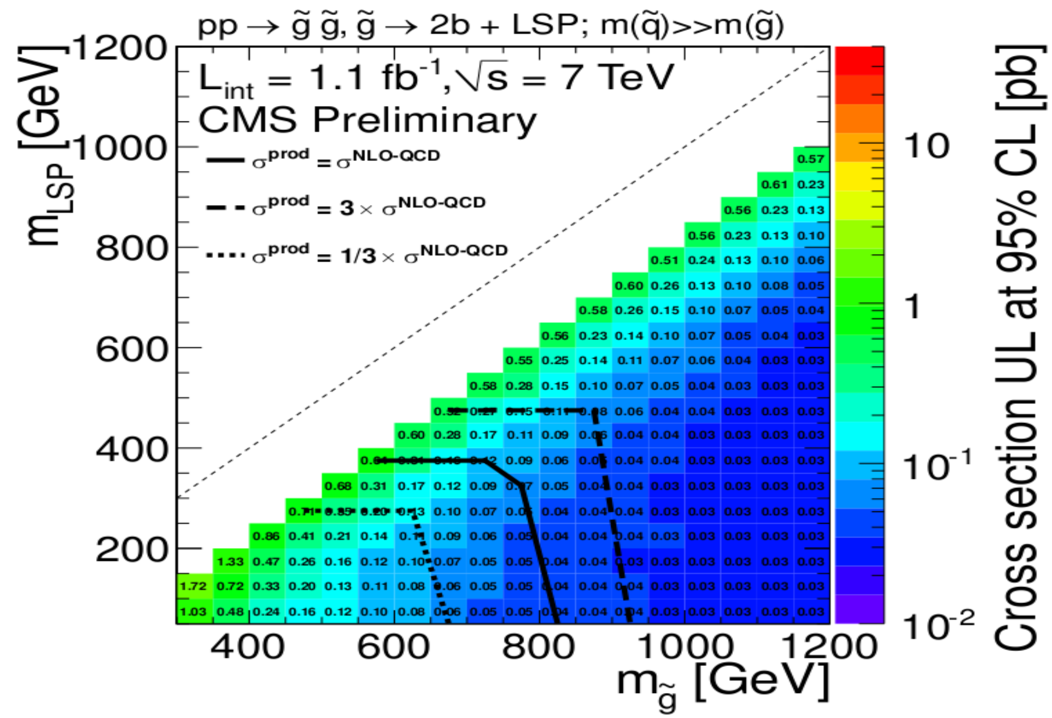




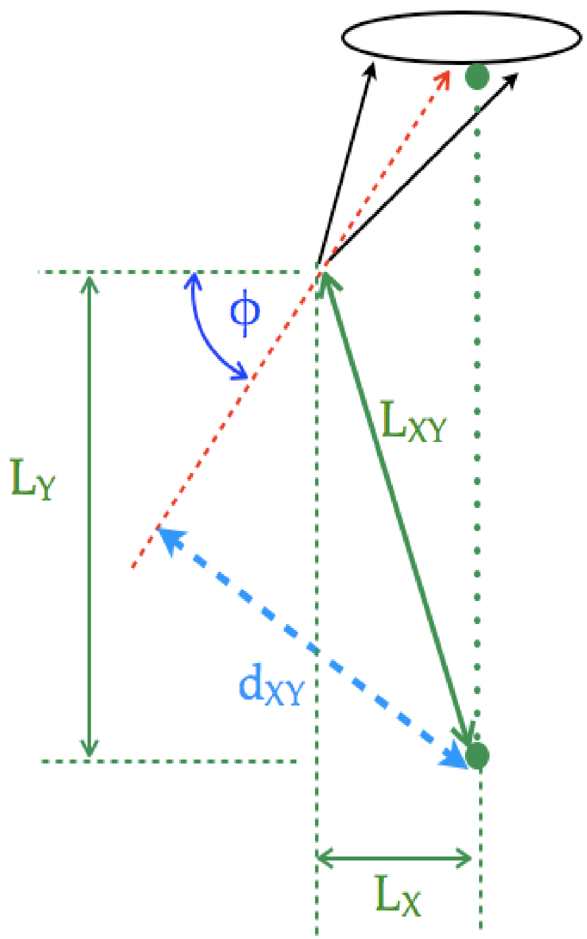
- At least 3 jets + MET
- Greater than 1 or 2 b-tags

Simplified Model: T1bbbb

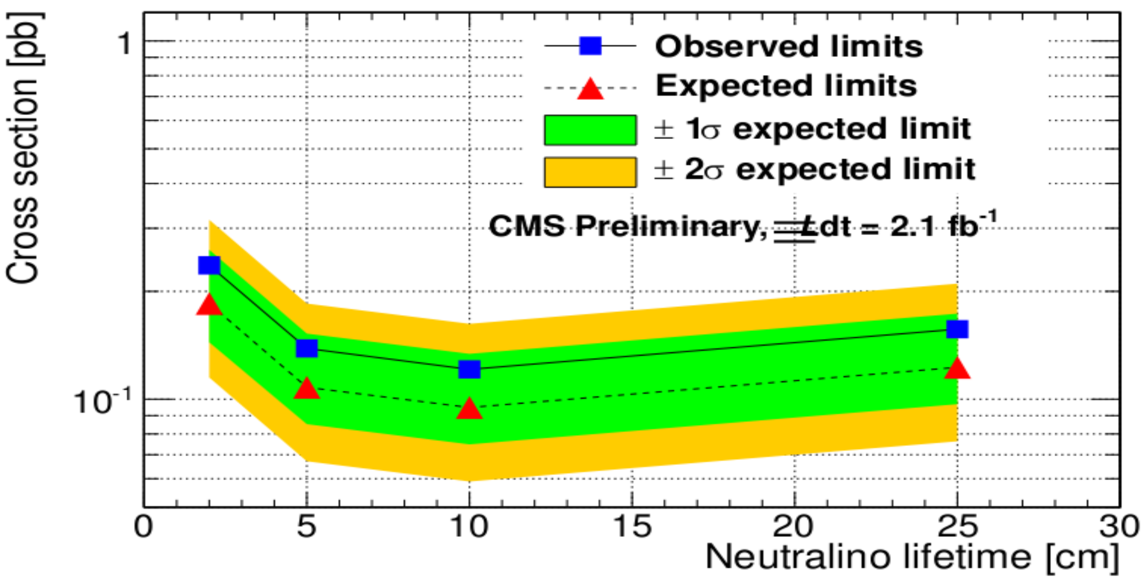




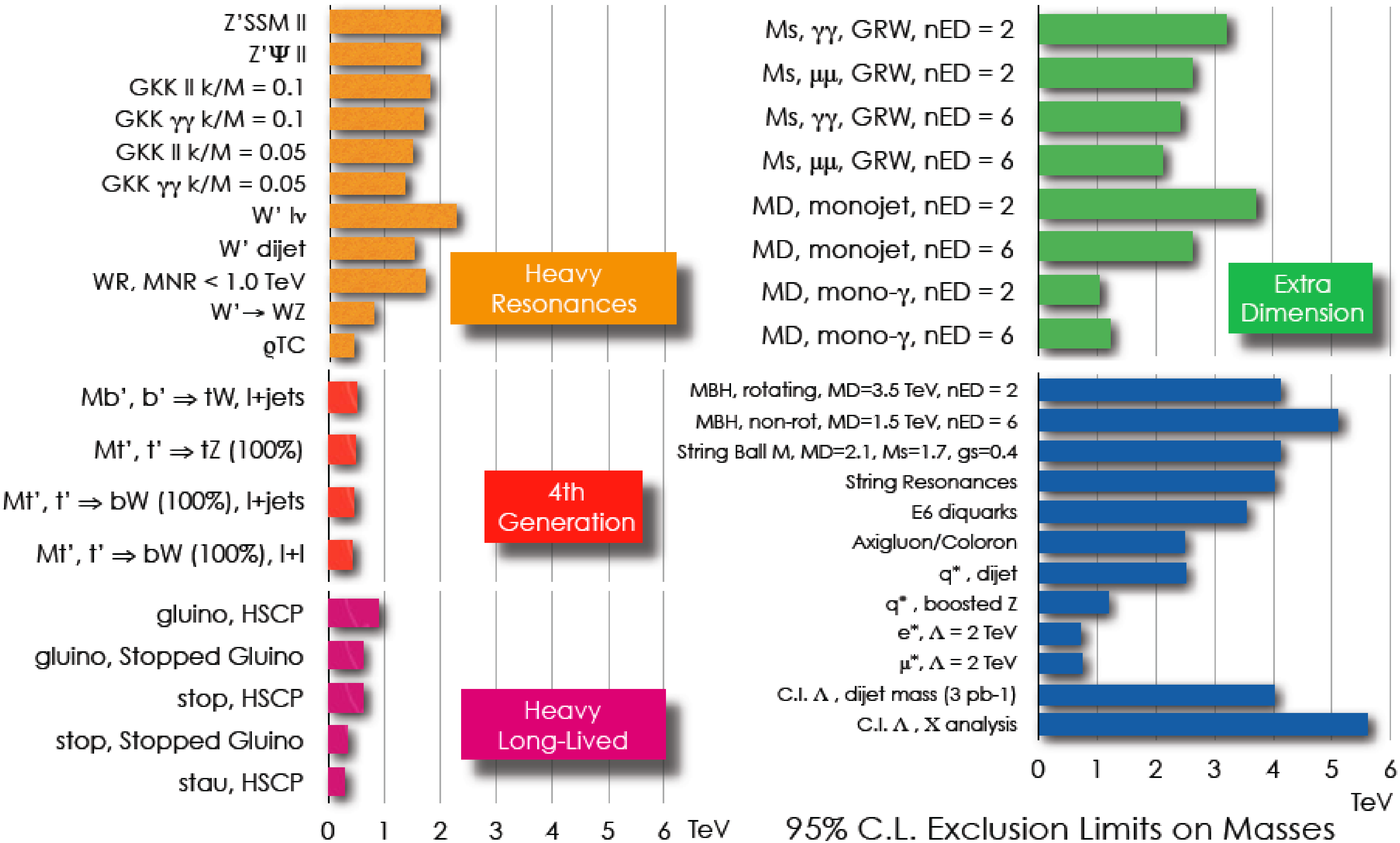
Longlived Particle Decays to Photon+MET



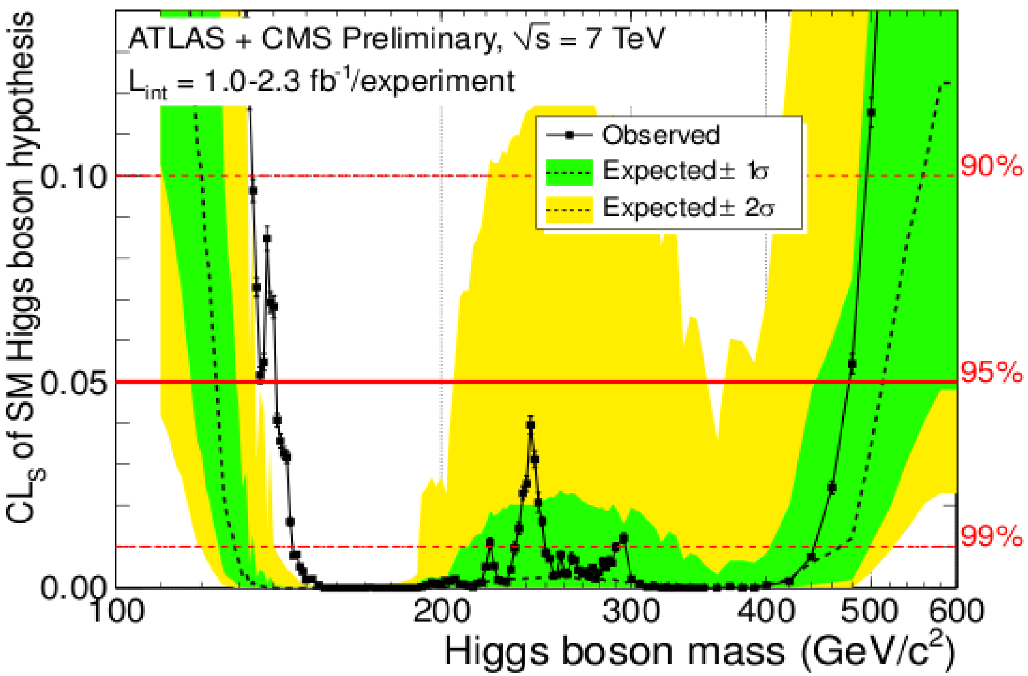
Reconstruct photon conversion to deterimine impact parameter of photon



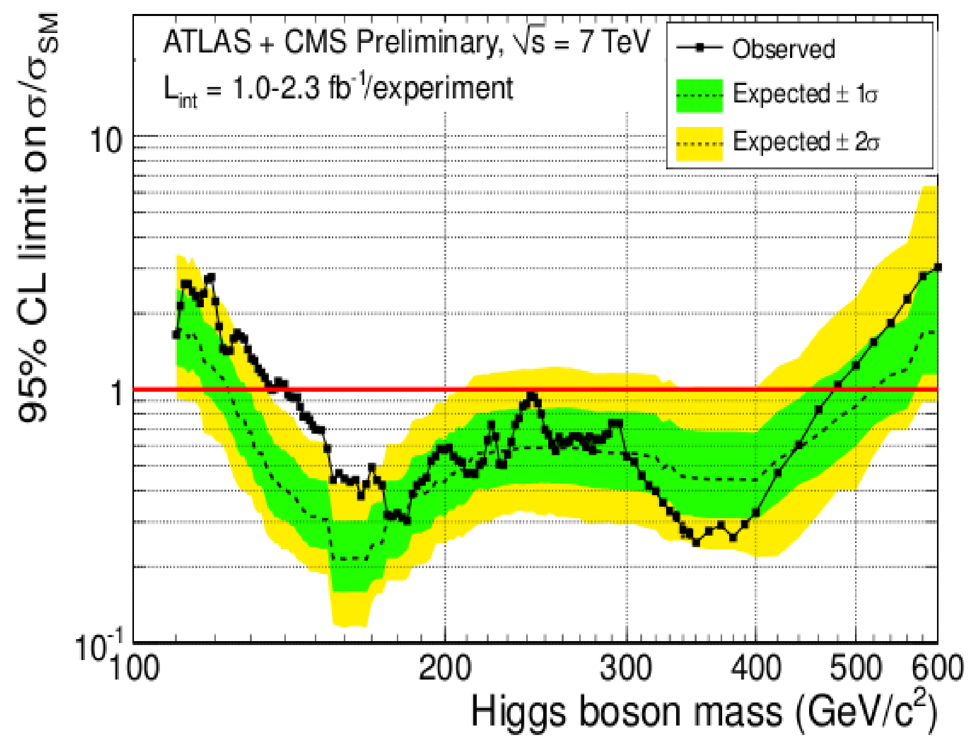
Summary of CMS Exotica Searches



CMS-ATLAS Combined Higgs



Exclude 141 to 476 GeV at 95% C.L.
Most of this range excluded at 99% C.L.

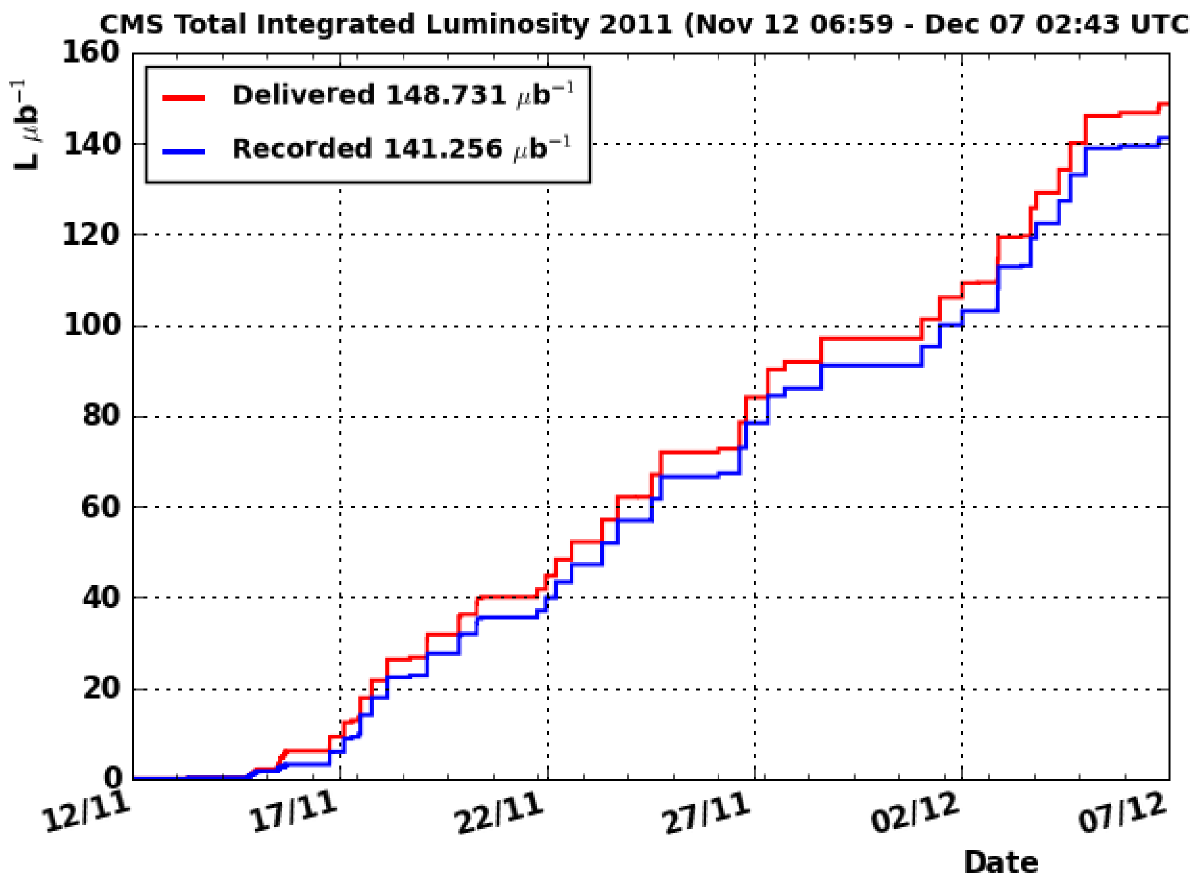


Combines results from:

H->gg
H->bb
H->WW(lnln)
H->tautau
H->ZZ(4l,2l2n,2l2q,2l2tau)

Updates to the Higgs searches with more data on Dec. 13

Pb-Pb Data Taking in 2011



CMS was reconfigured for Pb-Pb data taking in the last Technical Stop

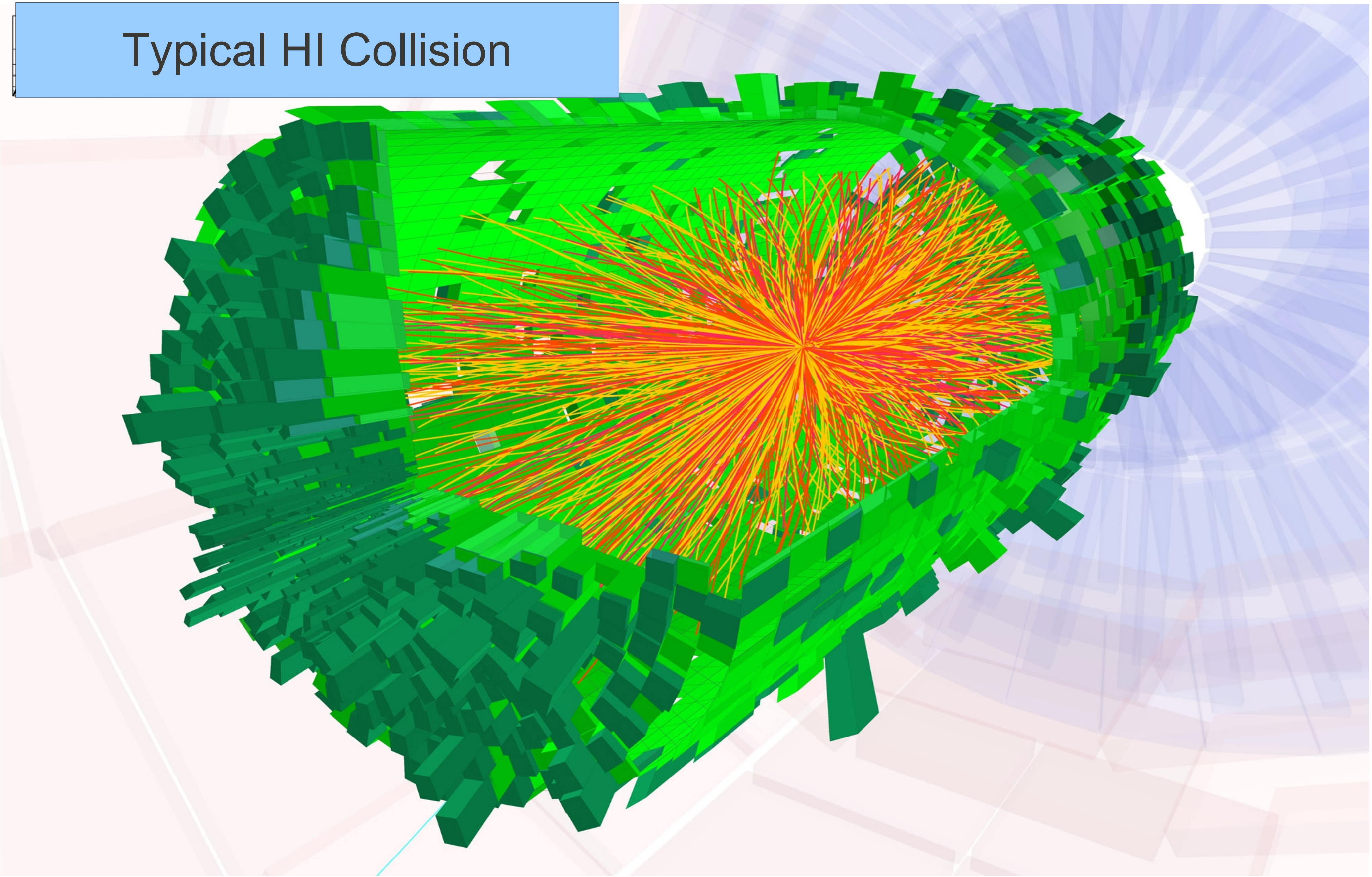
- Non-zero suppressed readout of the strip tracker
- New trigger/HLT configuration

Running with ~2.5 kHz L1 rate has been very smooth

Recorded a factor of 15 more data in 2011 than in 2010

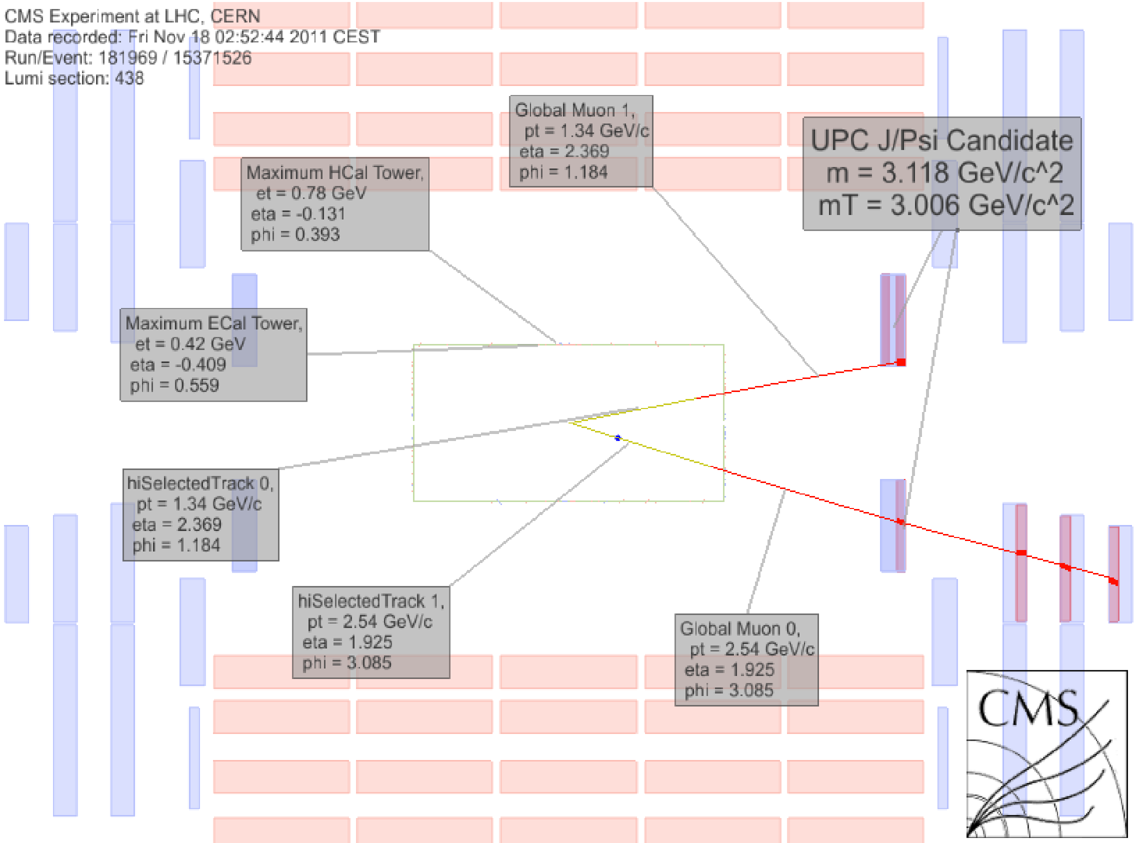
Pb-Pb from the Most Complicated...

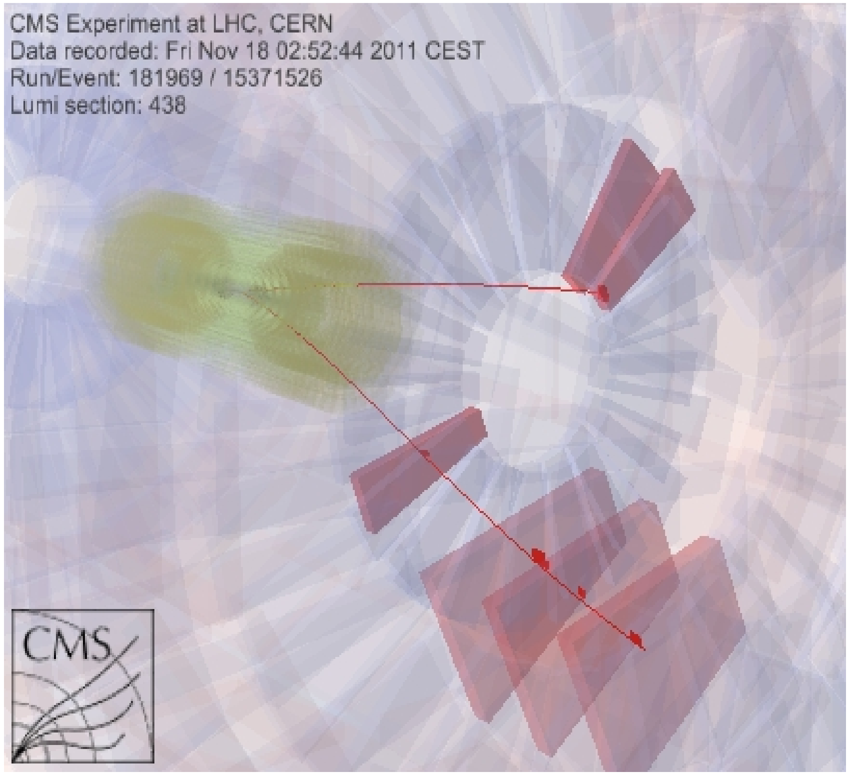
Typical HI Collision



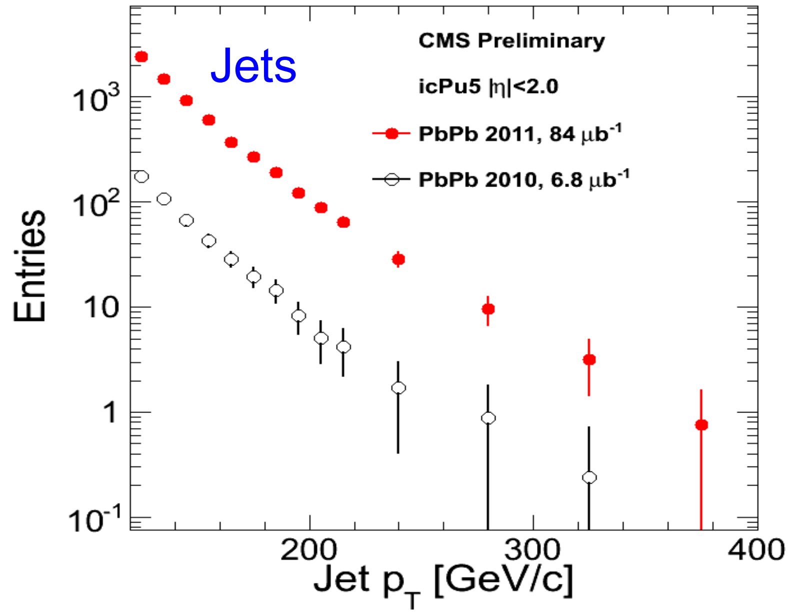
...to the Simplest Final States at the LHC: J/Ψ in an Ultra-Peripheral Event

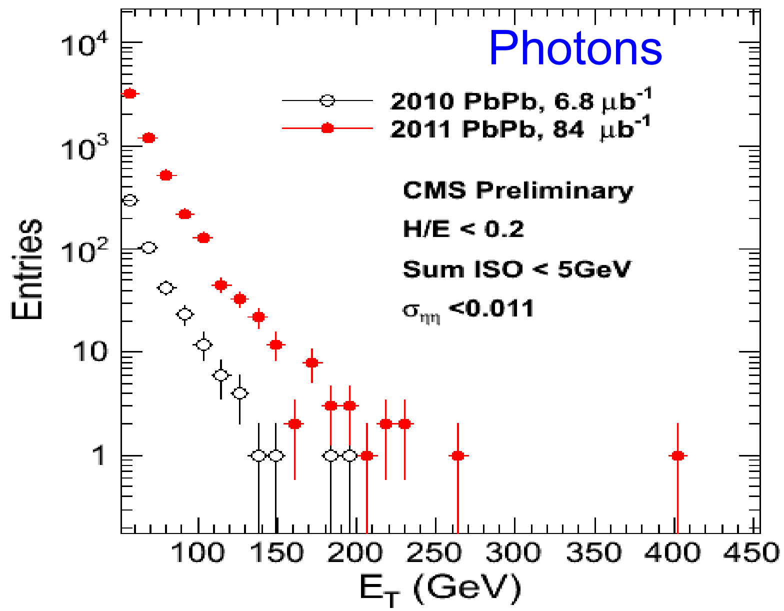
Only two tracks in the event (the two muons), virtually no energy in the Calorimeters, and classified in the 2.5% most peripheral collision bin for heavy ions

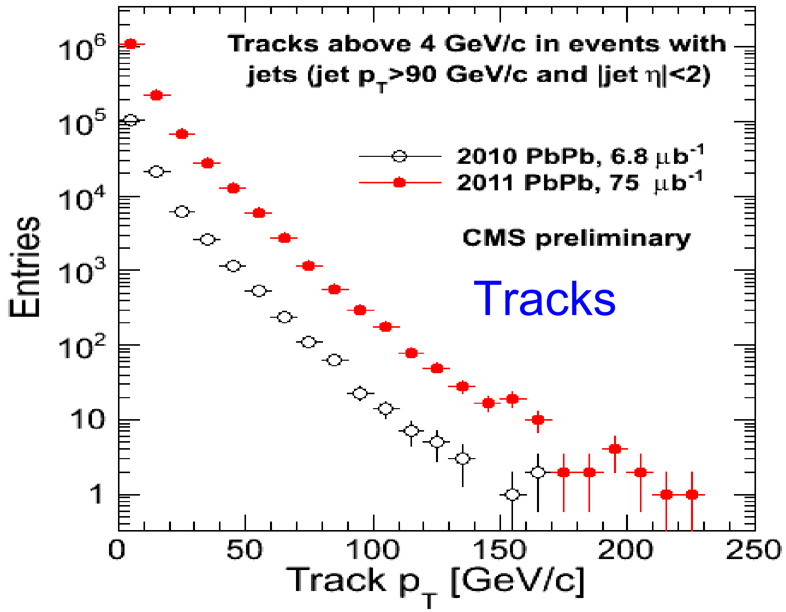




Gains in Statistics



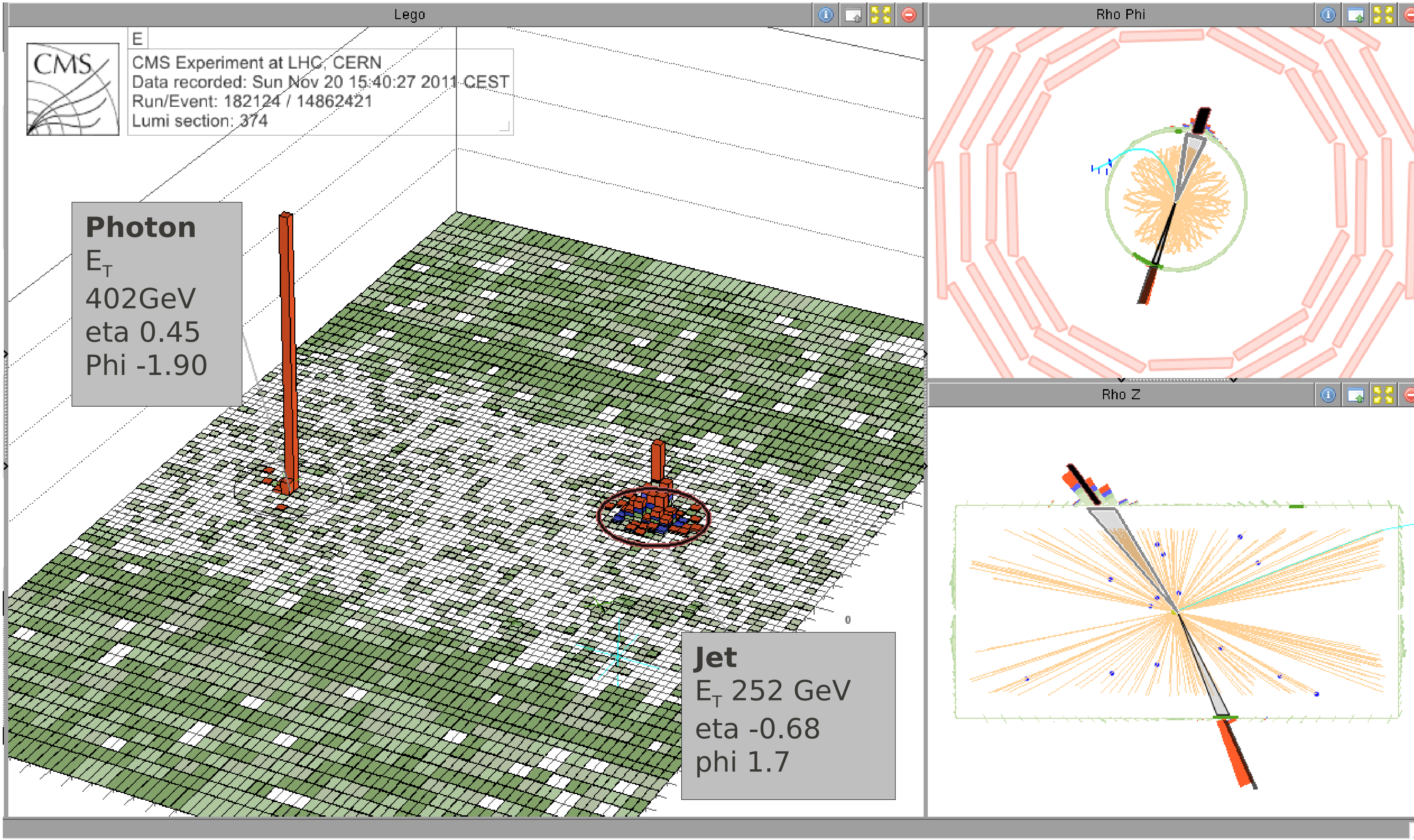




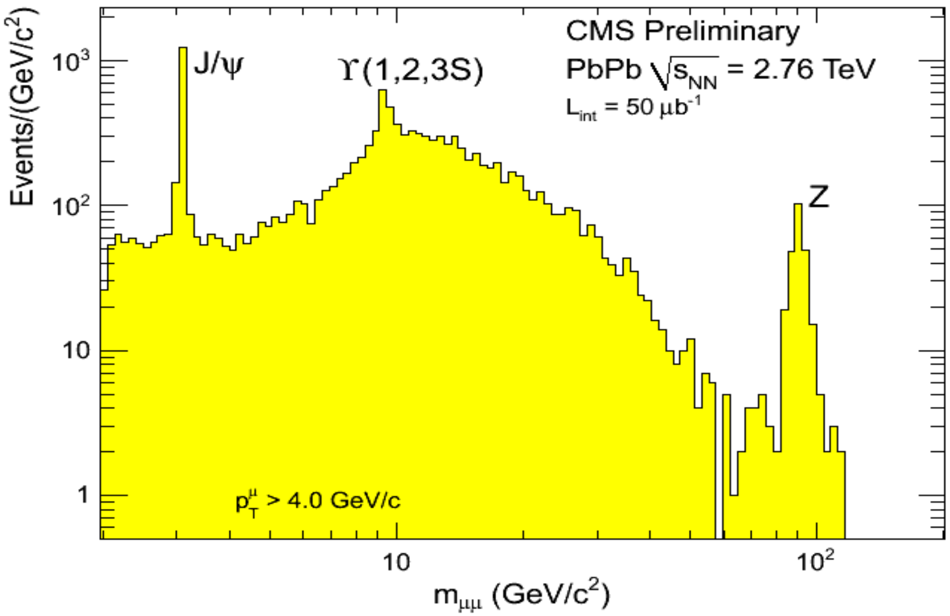
The higher statistics in 2011 allows probing higher energies

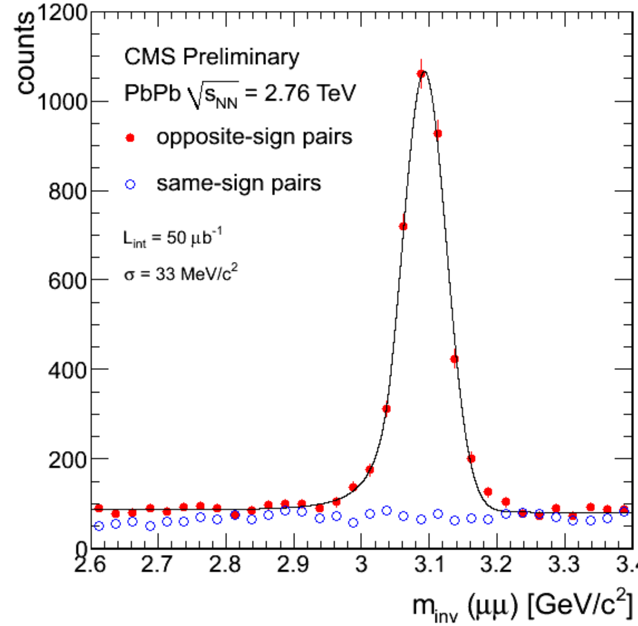
Gamma-jet Event

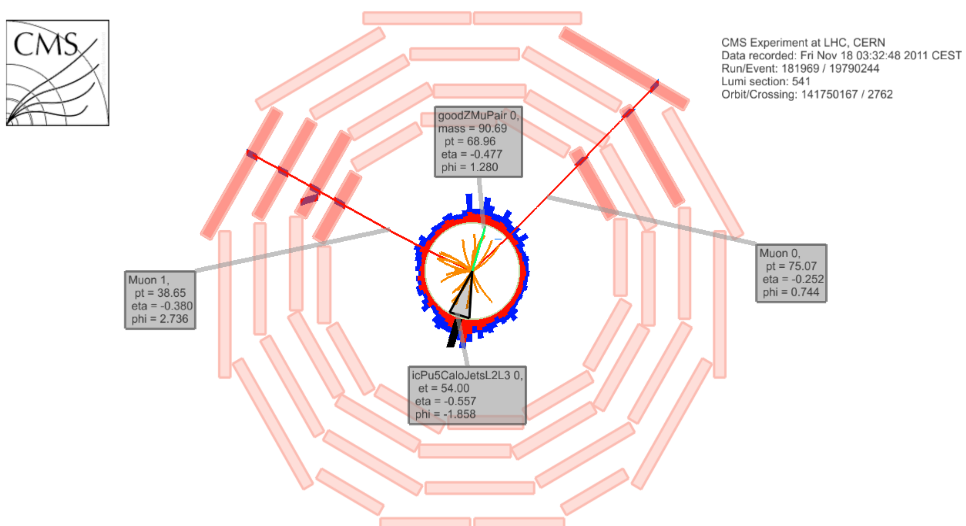
centrality bin 30-40%

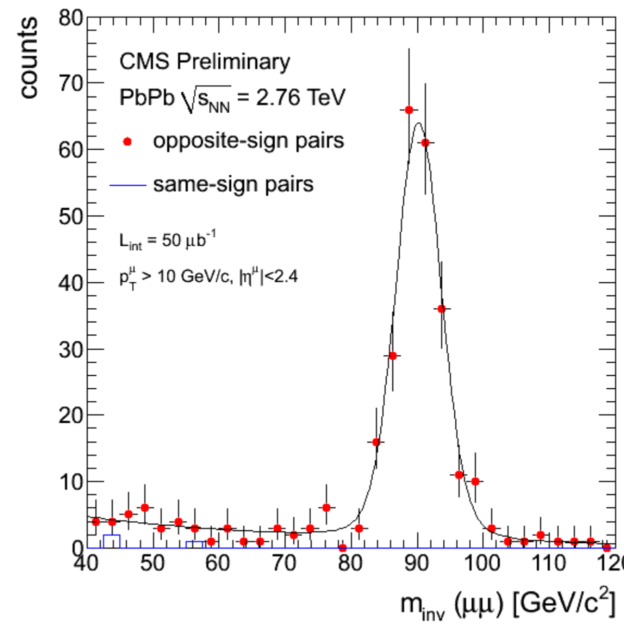


Dimuons in Pb-Pb Collisions

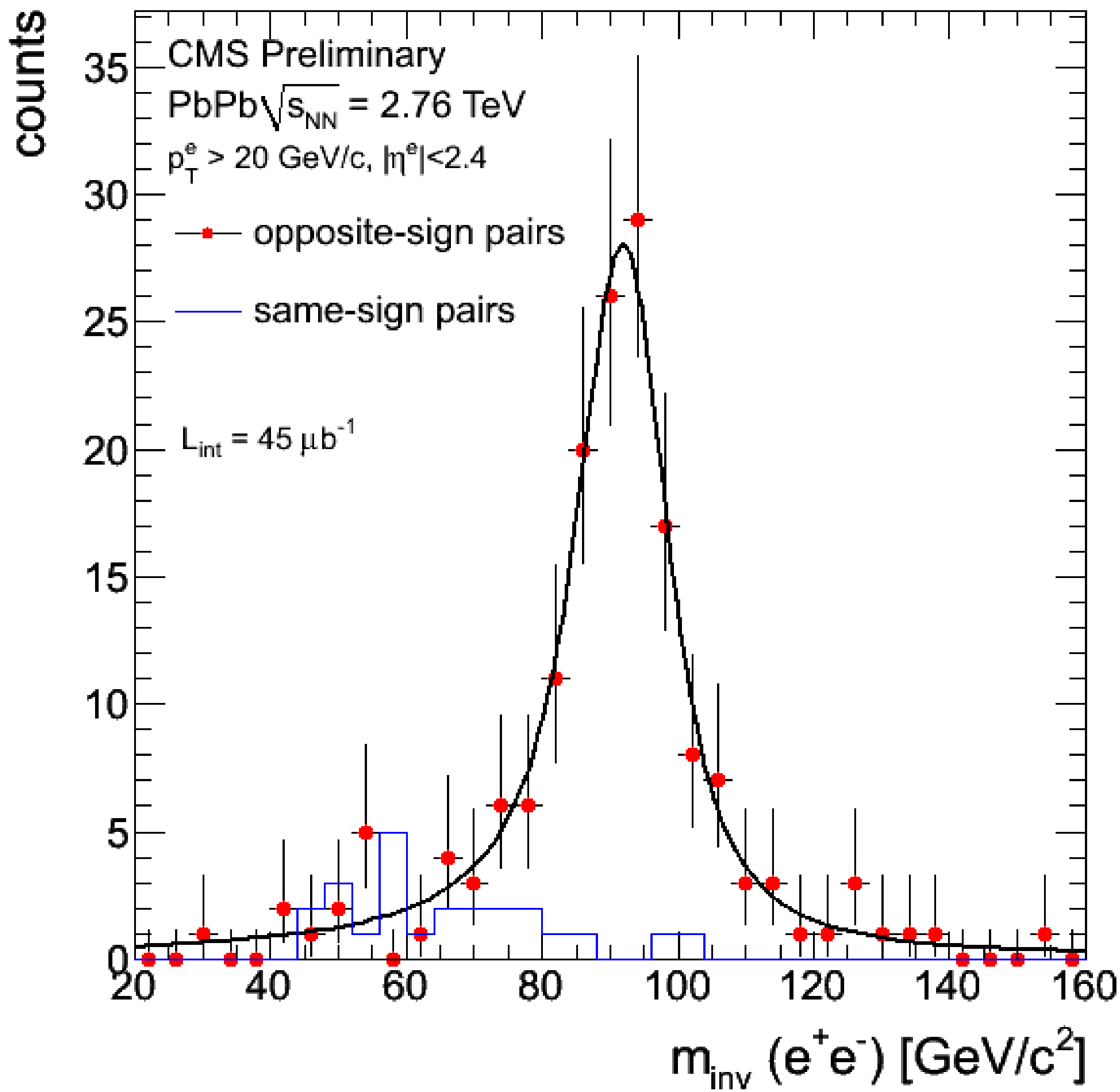








$Z \rightarrow e^+e^-$



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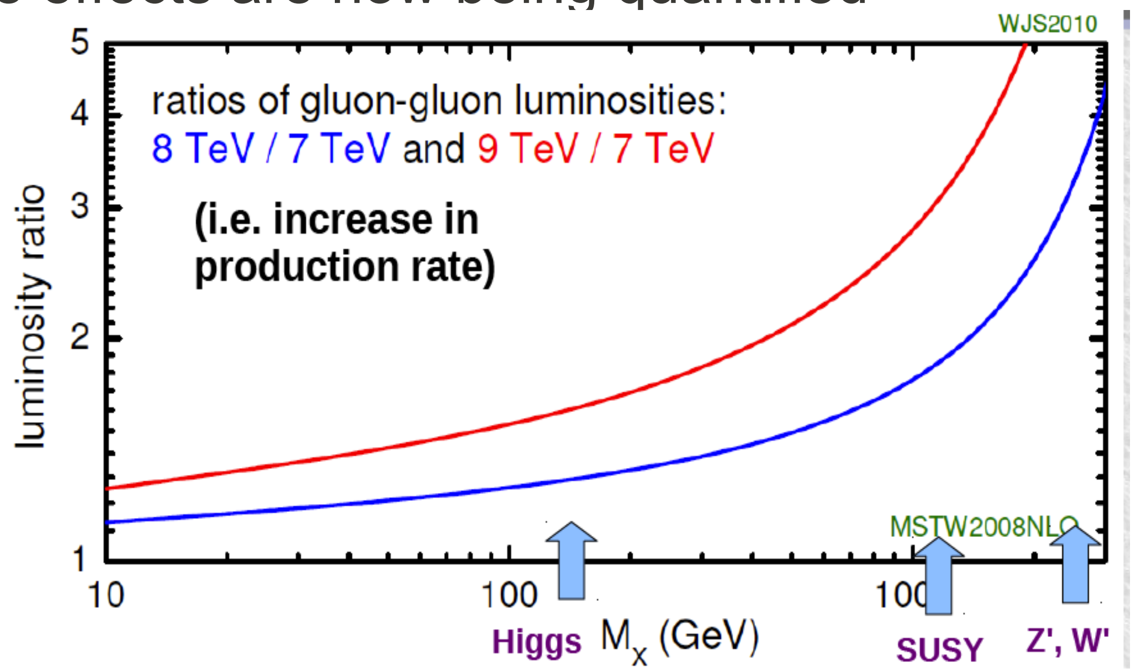
The 2012 Proton Run

- CMS strongly supports 4 TeV in 2012 - enhances discovery portential:
  - Overhead in machine commissioning small
  - Higher luminosity (allows smaller β*)
  - Larger cross-section (gluon-gluon luminosity)
  - MC tuning and production not an issue
- We want the largest usable luminosity possible:
  - Detector and readout OK for both 25 and 50 ns
  - Challenges with physics and trigger for high PU (50 ns)
    - These effects are now being quantified



CMS Upgrade Scope

System	2010-2020	2020-2030
Pixel	New Pixel Detector	
Tracker		New Tracking System (incl Pixel)
HCAL	Back End Electronics + PD replacement	HF/HE?
ECAL	Trigger Primitive Transmission	EE?
Muons	ME4/2, ME1/1 ,RPC endcap, Minicrate spares, some CSC Electronics	Electronics replacement
Trigger	HCAL/RCT/GCT to μTCA	Complete replacement

CSC Factory


B904 hall


Gluing


Winding


Component soldering


Wire soldering


CSC assembly

New Pixel Detector

- It will have the following features
  - 4 barrel and 3 endcap layers (current has 3 barrel 2 ec)
    - Barrel Inner layer closer to the beam
  - Less material in the tracking volume!
  - Capable of handling more hits (Required for luminosity beyond 1 x 10^34)

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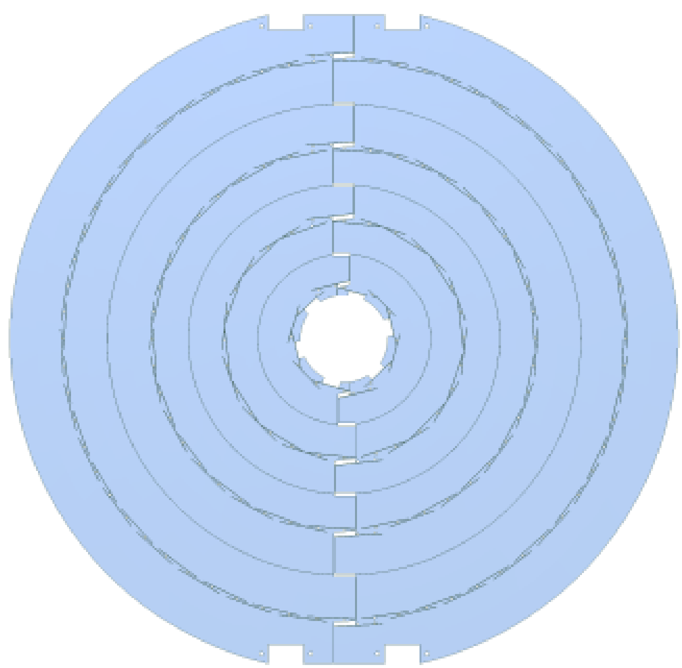
Four layer pixel barrel

100 bar pressure tested
Tubes, 50µ wall thickness



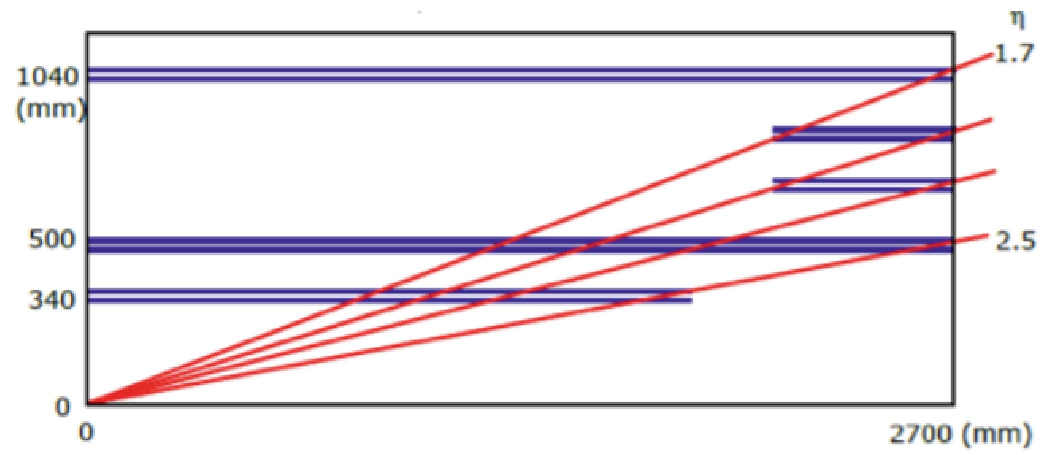
Layer #	Radius	# of faces
4	160	64
3	109	44
2	68	28
1	30	12
	or	
1*	39	16

Baseline: 45 mm Ø beampipe
30 mm radius L1
tight installation tolerances
→ adjustable wheels
1* = backup solution for
old beampipe

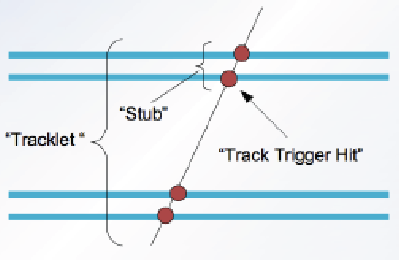
Tracking Trigger Simulations

Need to build candidate layouts to study how much information is needed from the tracker to get reliable trigger information as well as keeping the tracking performance

Long Barrel (LB) Simulation



- Stack separation: 1mm
- Pixel size: 1mm (z) x 100um (phi)
- Module area: ~100 cm^2
- Available alternative: swap SuperLayer 2 and 3 (not covered in this talk)
- Sim hits → ***digi hits*** → ***clusters*** → ***stubs***



E. Salvati

Conclusions

- The 2011 run has been a great success:
  - We thank LHC for the excellent performance!
  - The CMS detector performance has been outstanding
  - Many physics results on 1 to 2 fb^{-1} of data ready
  - Ion run was also very successful
- LHC has provided test fills with high PU and 25 ns has
  - Detectors+DAQ OK for both conditions
  - Trigger and Physics more challenging with PU of around 30
    - We are still working on quantifying the effects of high PU on trigger and physics
- For the 2012 run CMS wishes are:
  - Running at 4 TeV beam energy from the start
    - MC tuning and production for 4 TeV is not an issue for us
  - Record the largest possible data sample before the long shutdown
- Upgrades for the long shutdown progressing well