Fermilab Users' Meeting

CMS Physics from Early LHC Running

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For the CMS Collaboration

Outline

- Status of the LHC accelerator and the detectors.
- The 7 TeV startup of data taking.
- Future plans for the accelerator operations.
- New physics opportunities in 2010, and then 2011.

US HEP and the LHC

US Personnel on LHC Experiments

1,700 scientists, engineers and graduate students from US institutions collaborate on the LHC experiments

ALICE
- 12 US Institutions
- 50+ participants

ATLAS
- 44 US Institutions
- 700+ participants

CMS
- 49 US Institutions
- 900+ participants

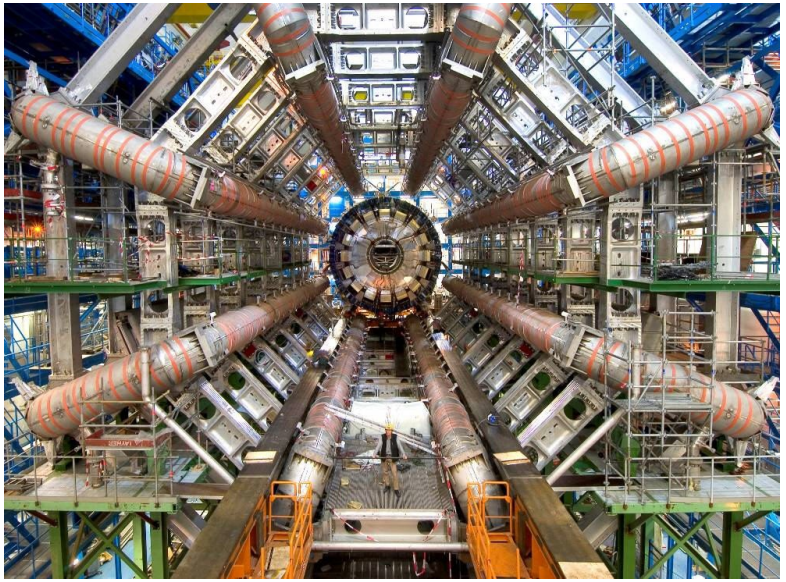
LHCb
- 1 US Institution
- ~15 participants

+ LARP, TOTEM, LHCf

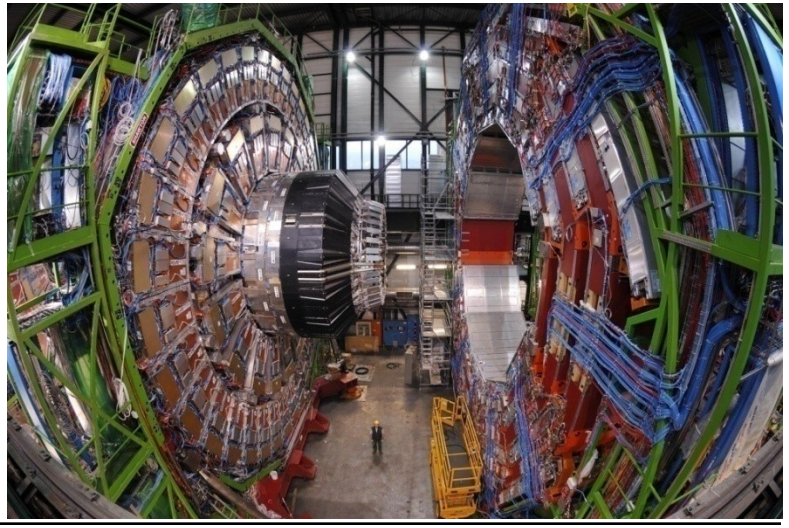
Very significant US participation, 1/3 on CMS, ¼ in ATLAS. Fermilab is the host lab for US CMS – E892.

The ATLAS and CMS Experiments – Status

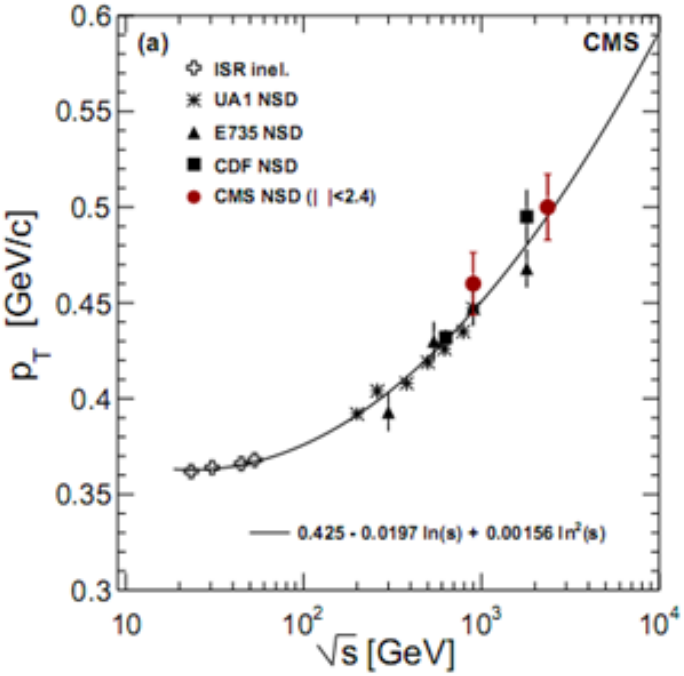
Each detector is like a 100 megapixel camera which takes 40 million pictures per second

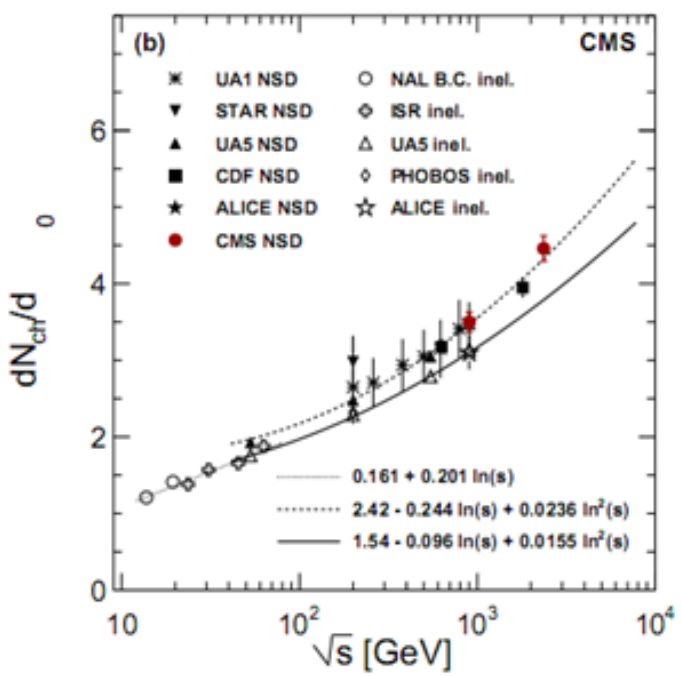


The experiments have been designed, built, assembled and commissioned over the last 15 years. Using test beams, cosmic rays and lower energy data (0.9 TeV, Nov 2009 and 2.36 TeV Dec. 2009) they were initially aligned and calibrated before the 7 TeV startup,



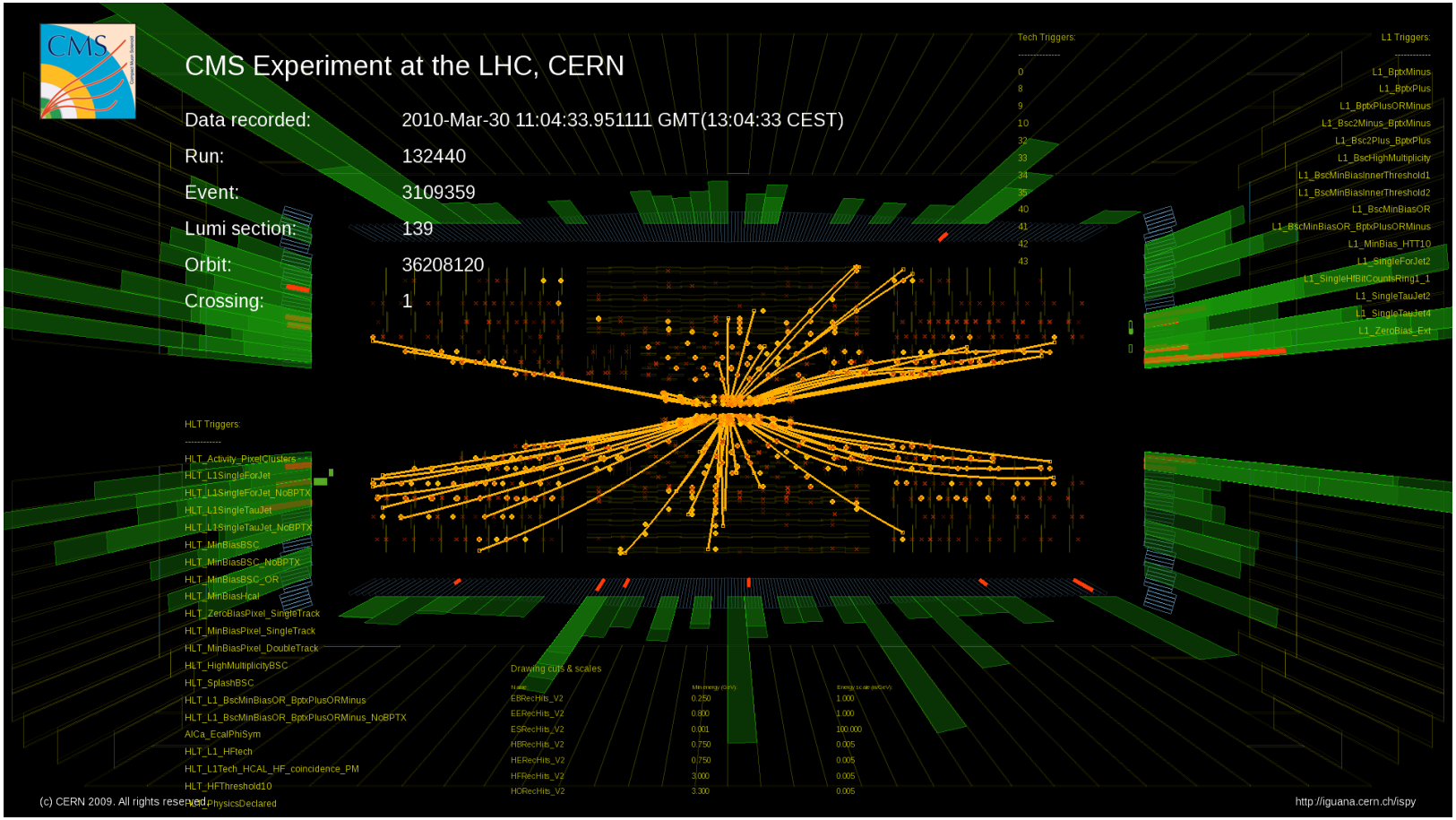
First CMS Publication





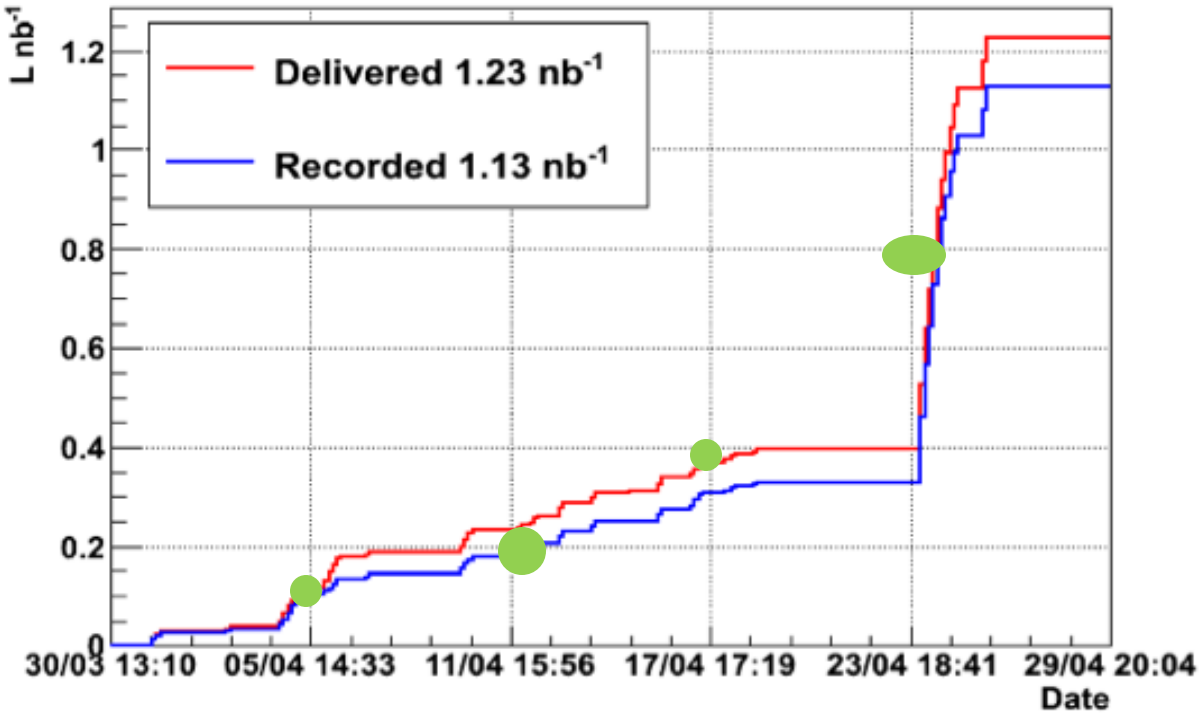
Data taken in Dec., 2009. Published in Feb., 2010. Years of preparation pay off with prompt physics results. Good agreement with previous data. The "re-discovery" of the SM was well launched.

March 30 – First 7 TeV Collisions



CMS is now 2 months into the 7 TeV run

CMS has been Efficient



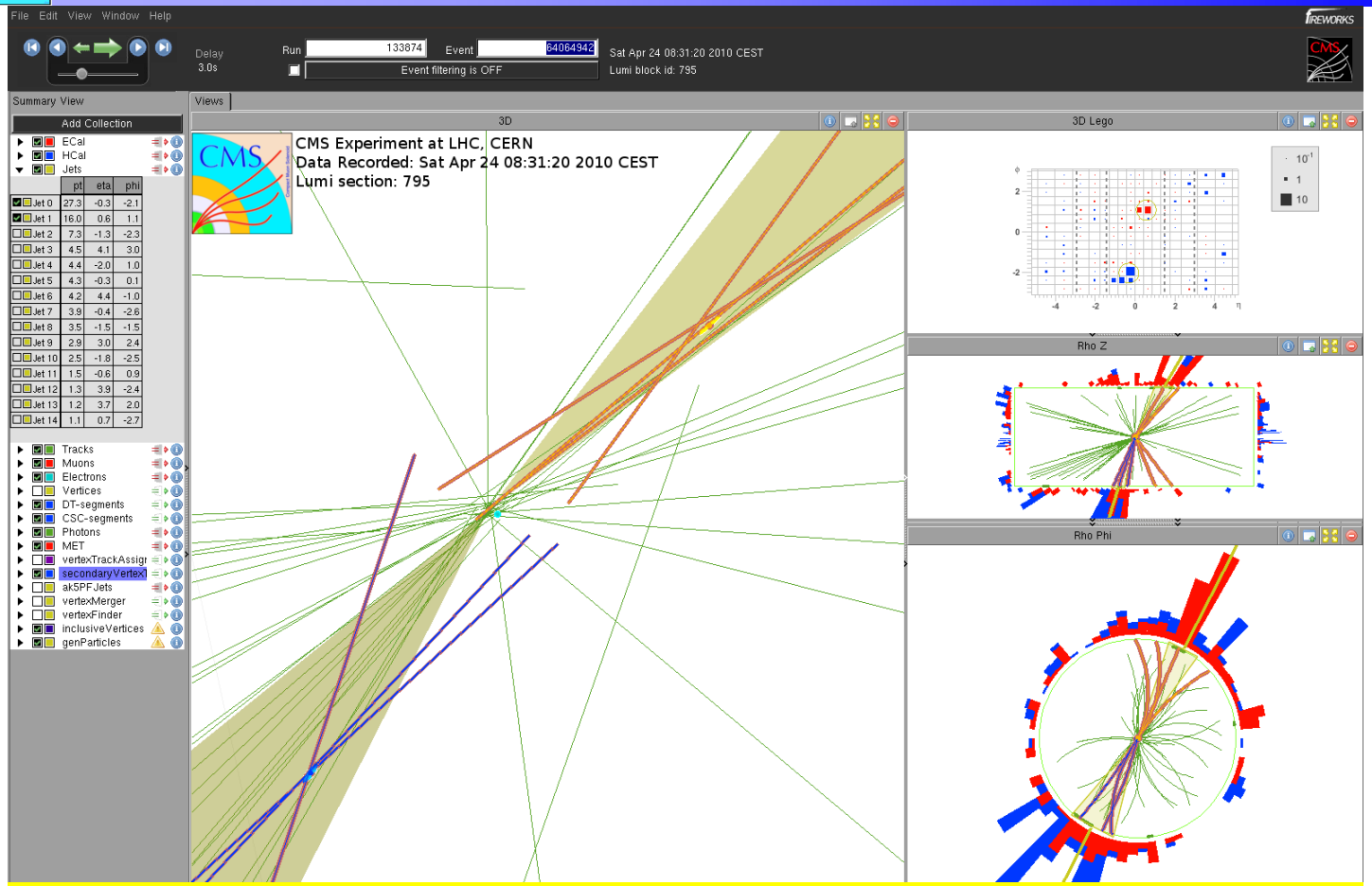
First month of operation – log > 1 nb^{-1} of data. Rise is "exponential" – L doubling time is ~ 1 week, CMS has operated at ~ 90% efficiency.

Plan for 2010, 2011

Integrated L	SM Object	SM Use	Search Strategy
mb^{-1} (1)	UE, MB	Tune MC	
ub^{-1} (10^3)	$K_s, \Lambda, \Xi, \Omega, \phi, K^*$ Jets, π^o, η Heavy flavor ψ, Υ	Align. dE/dx Calib, trigger valid, MET c, b tag leptons	
nb^{-1} (10^6)	W Z	Cross section, charge Mass scale, resolution	
1 pb^{-1} (10^9)	Top pairs	Leptons + J + true MET	Black holes
10 pb^{-1}			Dijet M > 2 TeV HSCP, leptoquarks
100 pb^{-1} (2010)			M > TeV W' , Z' New range for SUSY
1000 pb^{-1} (2011) (10^{12})			SUSY – TeV mass scale Higgs @ 95% CL, (140,190) GeV

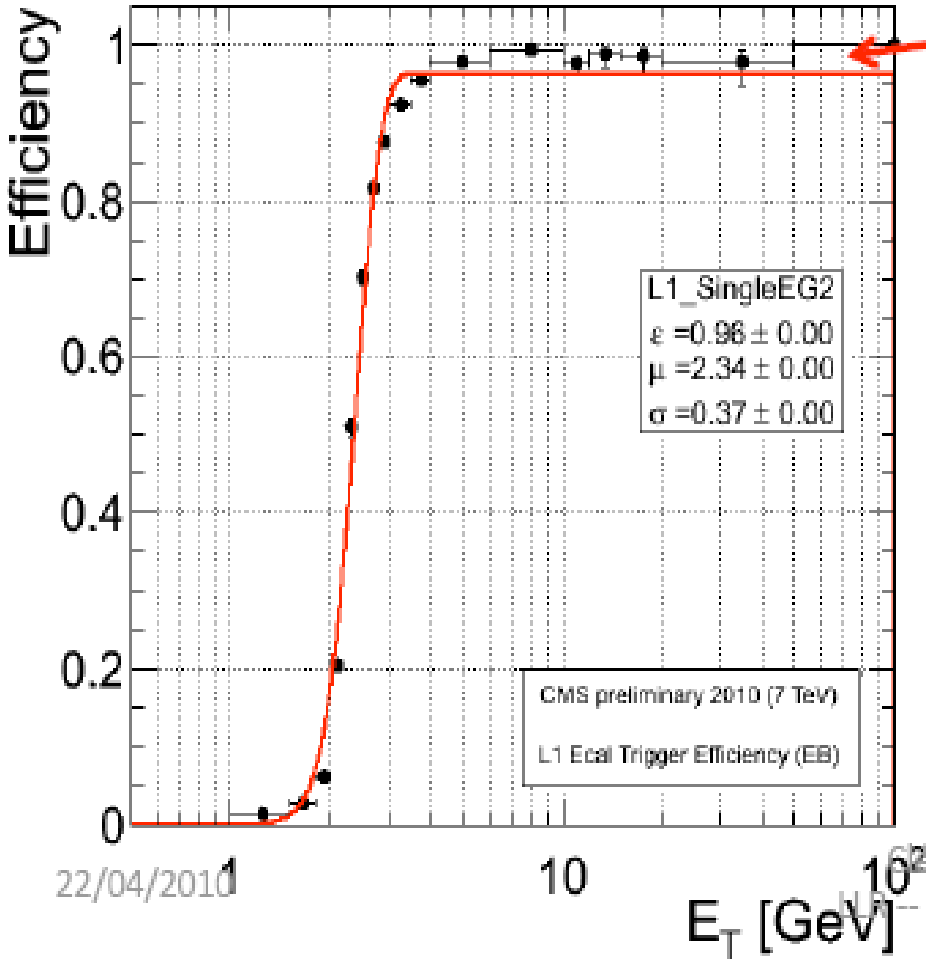
CMS will start by rediscovering the Standard Model and then launch searches, starting with strongly produced final states.

7 TeV – Heavy Flavor



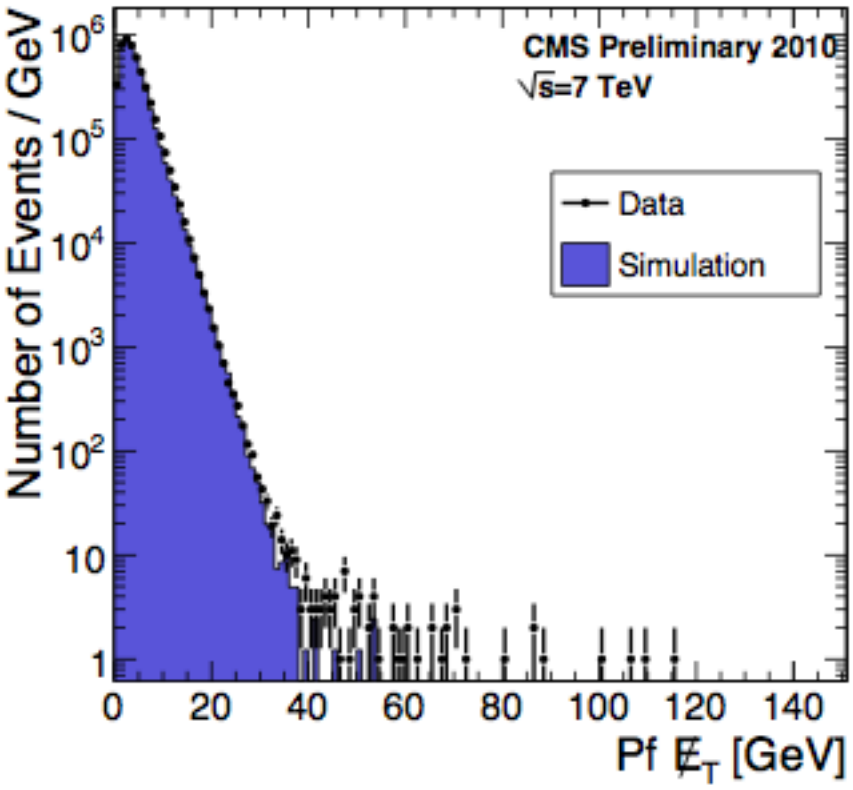
Note error ellipses on the primary and secondary vertices. B tagging is being commissioned. That establishes the fact that CMS tracking is well commissioned.

Commissioning of Triggers with Millions of MB Events



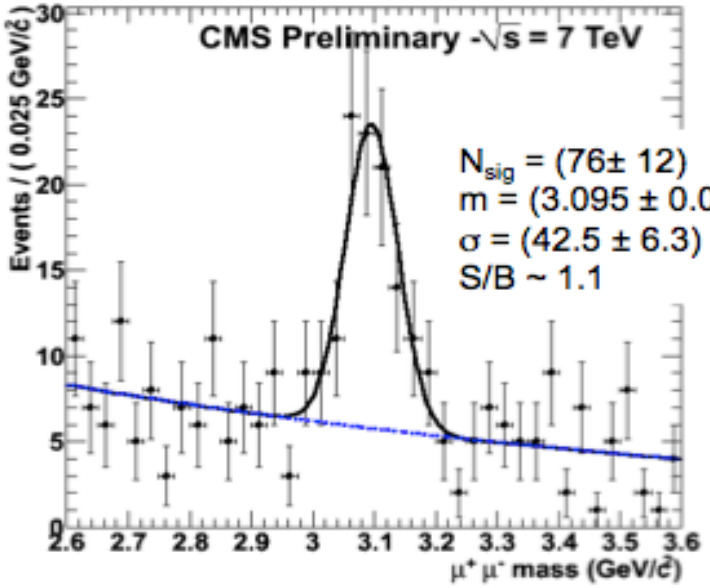
By taking millions of MB events, with the triggers in "mark and pass", the low Pt triggers can be validated. Then when they are implemented at higher luminosity, the higher Pt triggers will, in turn, be put in mark and pass - bootstrap.

MET is Being Commissioned

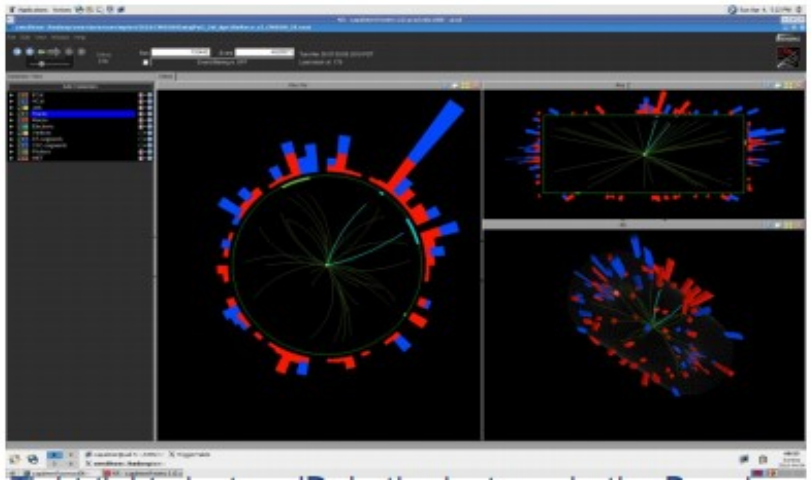


CMS has made a special effort to commission MET as soon as possible since it is crucial to many searches for new physics, e.g. SUSY. In dijet events there is ~ no true MET and there is a ~ 6 order of magnitude smooth fall of the observed MET. The tails are being explored and a successful "cleaning" strategy is in train – in time for ICHEP in July.

Dilepton Resonances

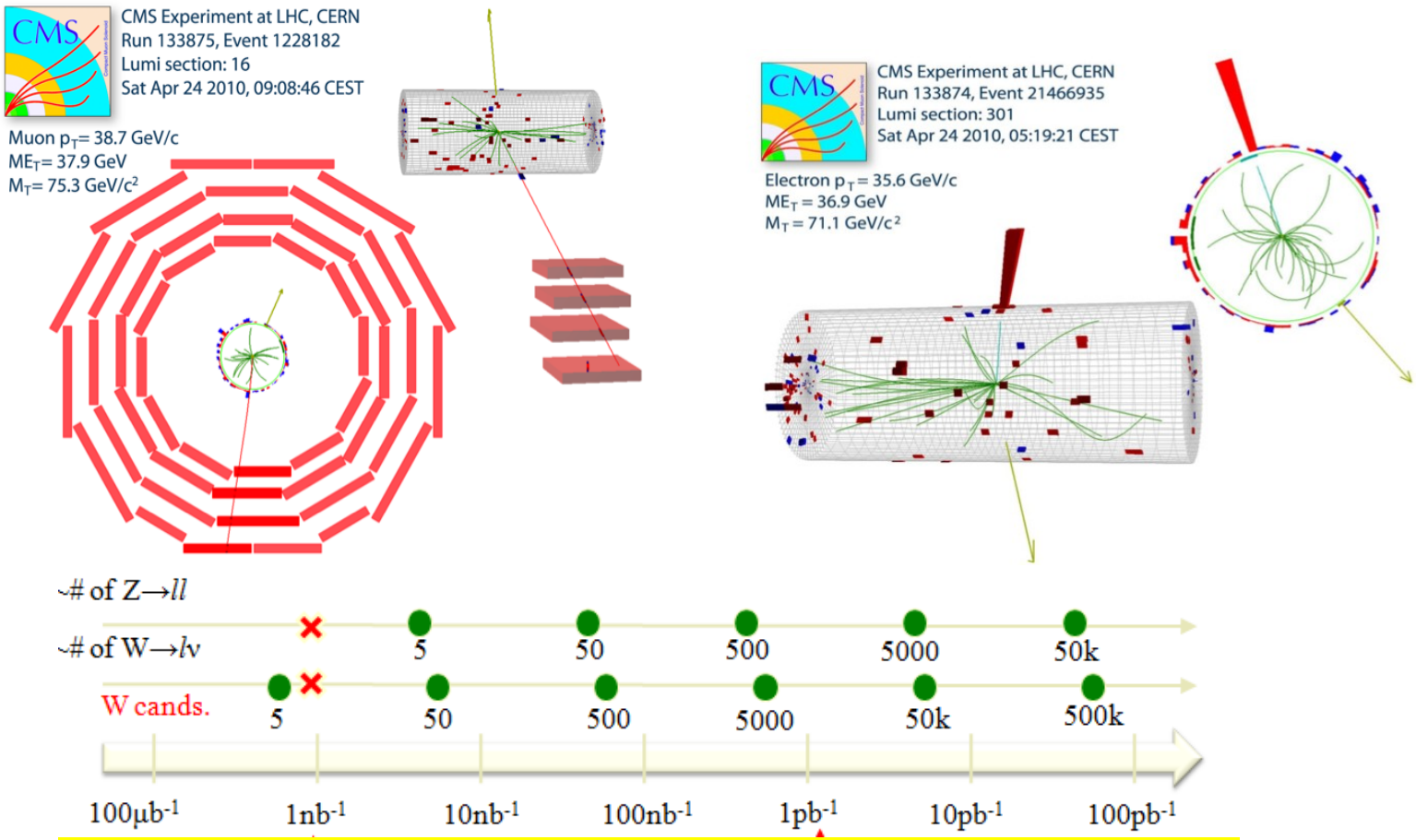


ψ



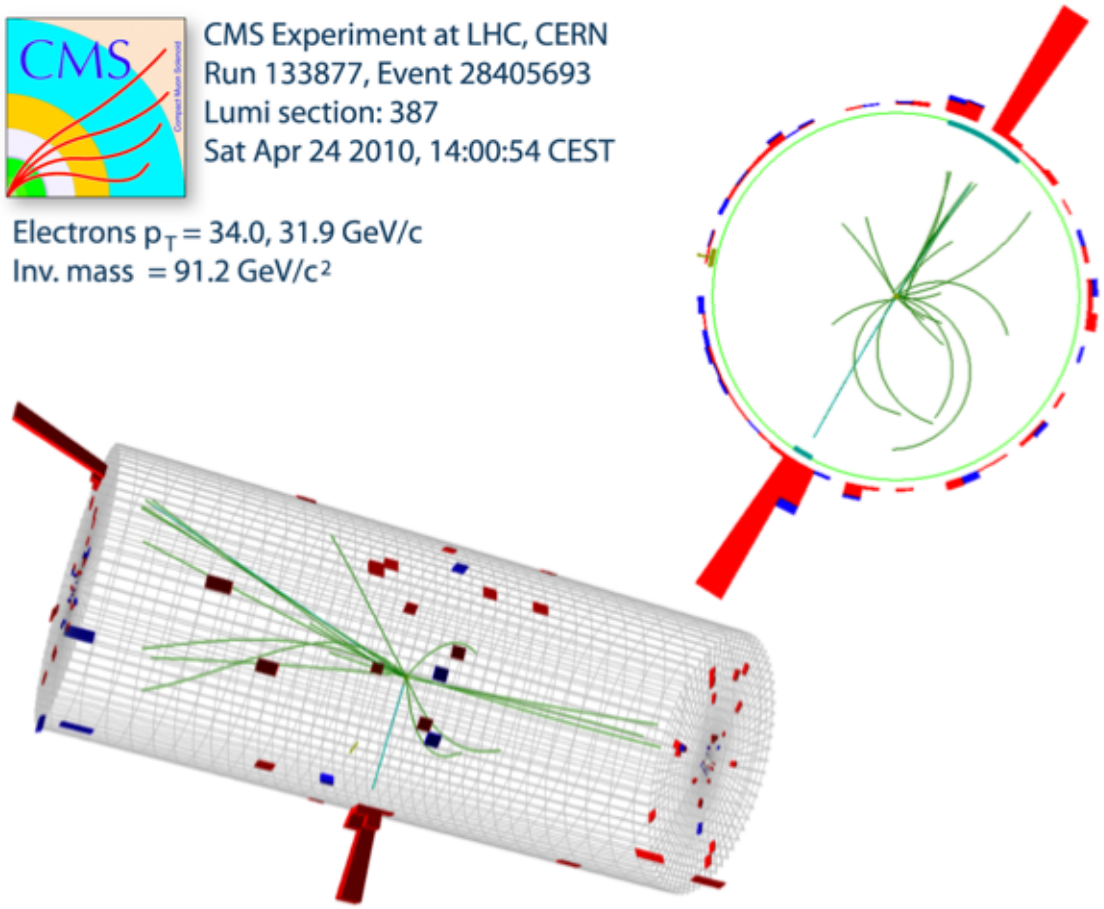
As the integrated luminosity goes up, dilepton resonances begin to be observed. The J/psi into di-electrons has been seen. The Upsilon will be next, followed by the Z. This is a "candelabra" of known "standard candle" resonances to be used for calibration – checking the momentum scale and the momentum resolution.

W to Electron and Muon



Very recently, > 10 nb^{-1} has been delivered. CMS will now move from candidate events to kinematic distributions.

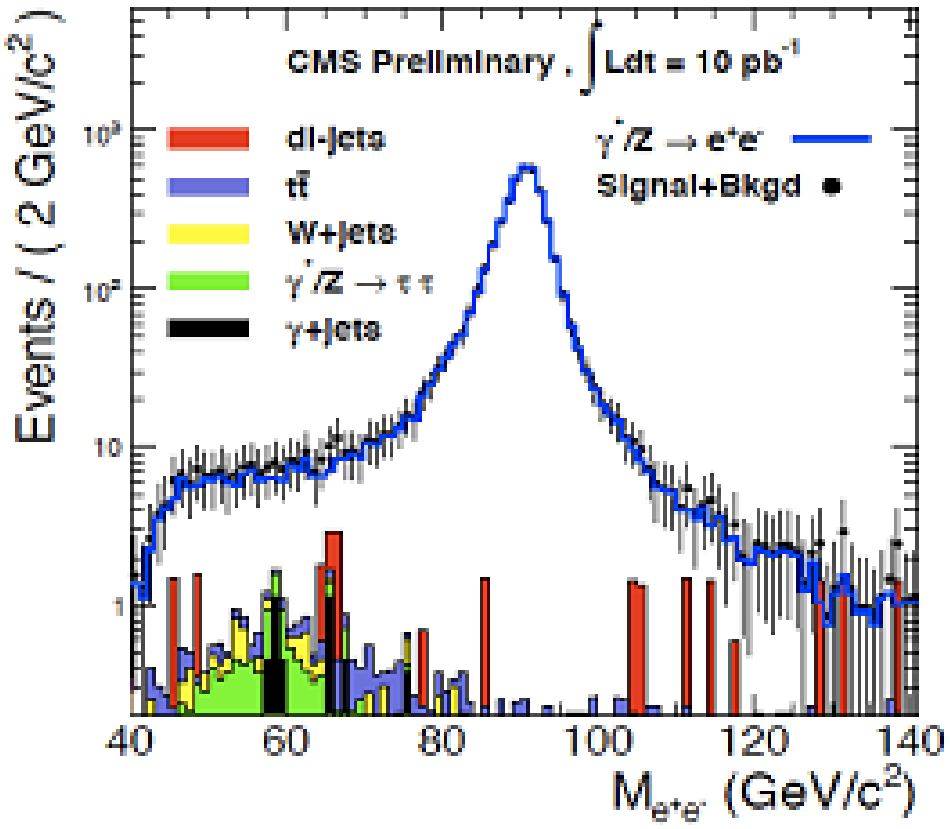
Z to Di-electron



Dilepton Z candidates are beginning to appear. More luminosity is needed to go beyond candidate event searches.

New publications are submitted to PRL. Many abstracts have been submitted to ICHEP

Z Decays into Lepton Pairs

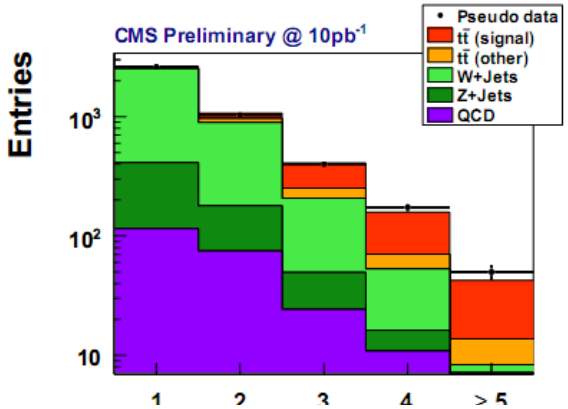


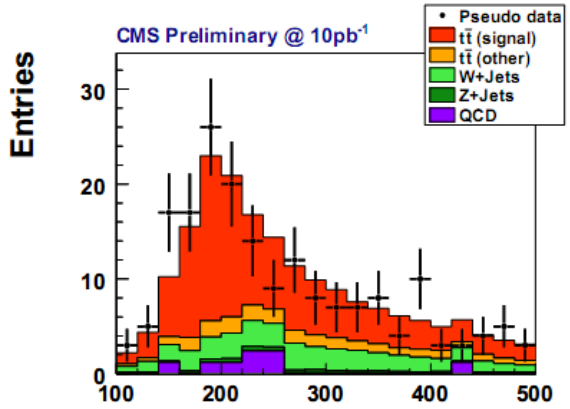
In the near future CMS will complete the rediscovery of the SM.

The dilepton Z "tag and probe" – extract data driven efficiencies for leptons – e.g. e trigger efficiency. Backgrounds are small so purity for clean tagging is very high.

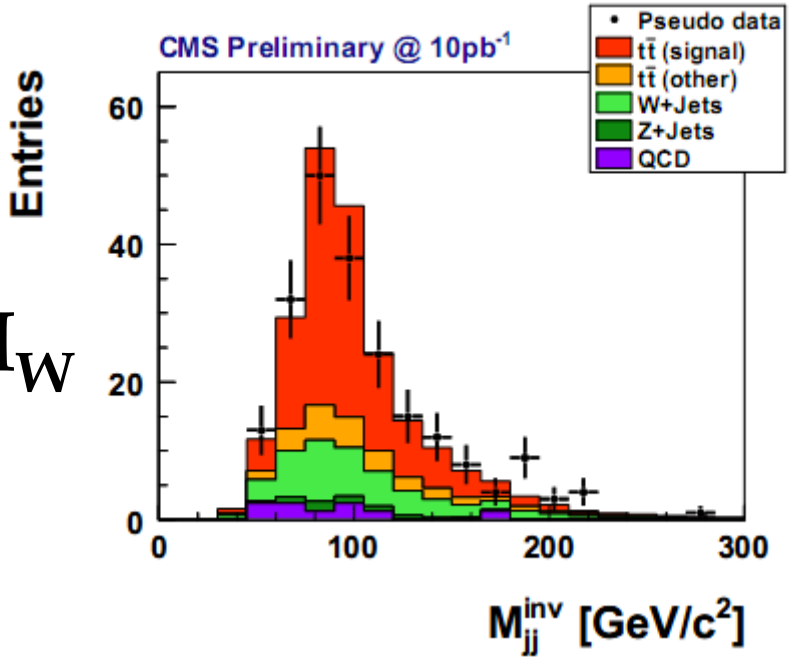
Then look in the high mass tail of the Z and transverse mass for the W…. W, Z recurrence ?

Top – Jets + Leptons + MET





M_t

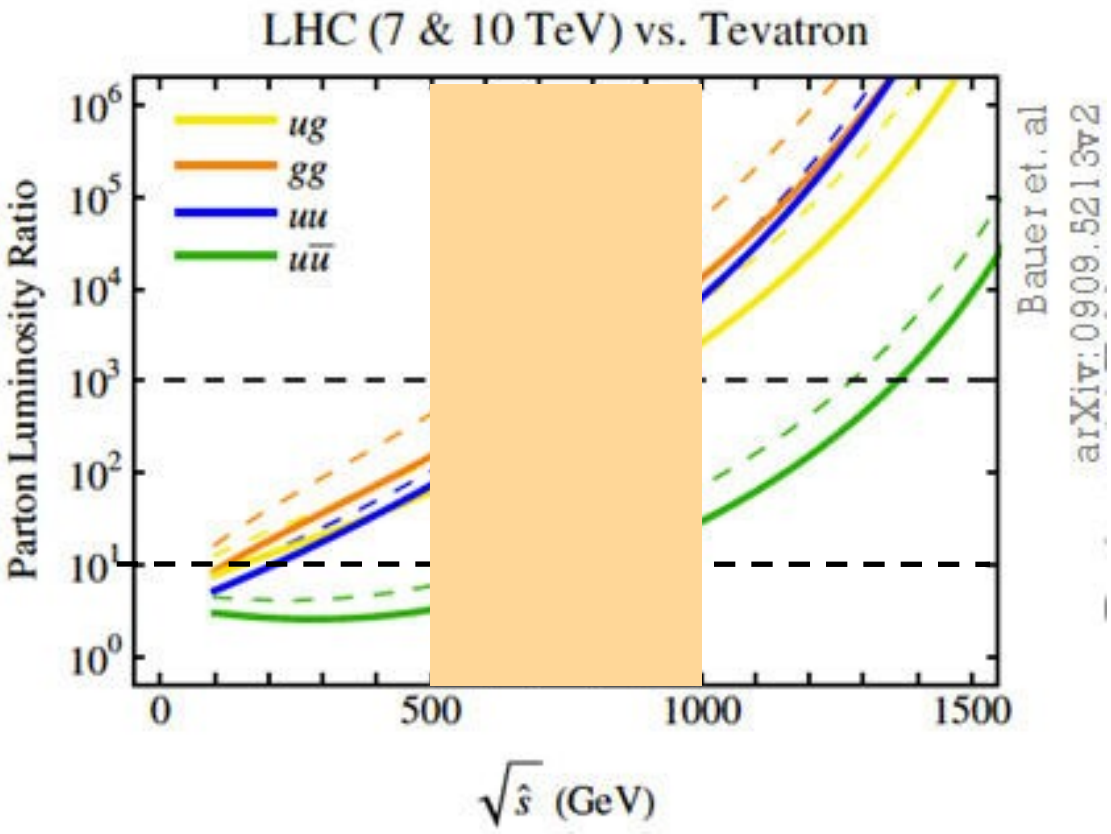


M_W

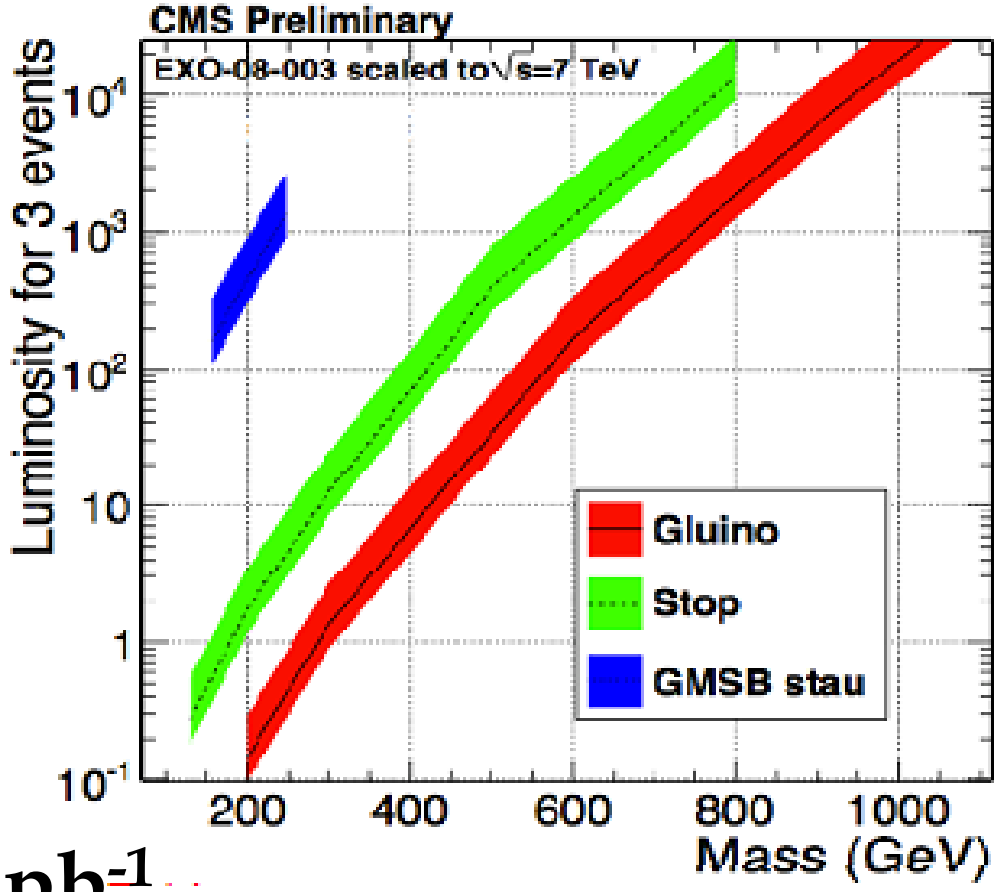
Check jet energy scale with hadronic decay of the W. Check b tag efficiency with 2 b in final state. Establish absolute MET scale. Studying this process largely completes the "rediscovery" of the SM. Top pairs are a pervasive background to searches BSM.

Advancing the Energy Frontier - 2010

The parton luminosity ratio is > 10 at a mass of many of the present Tevatron mass limits. At the TeV mass scale the ratio is large, all else being equal. Truly, the LHC is a machine for discovery and the focus will be on states with ~ (0.5, 1.0) TeV mass scale where the ratio is most favorable.

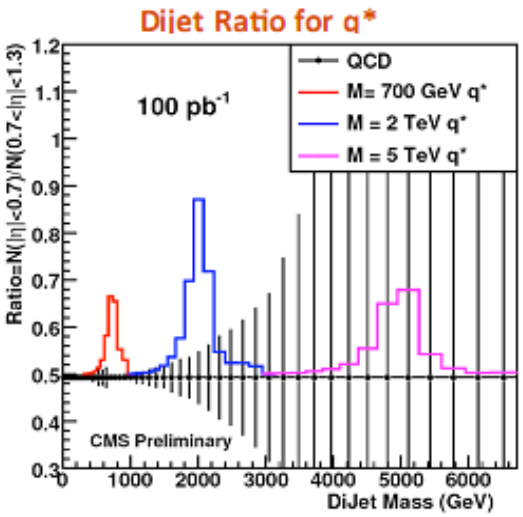


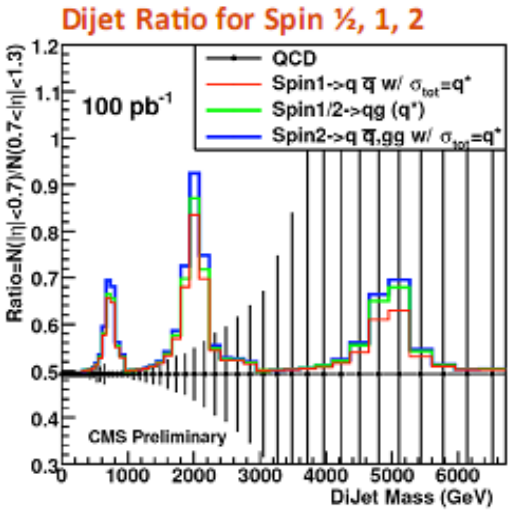
Heavy Stable Charged Particles

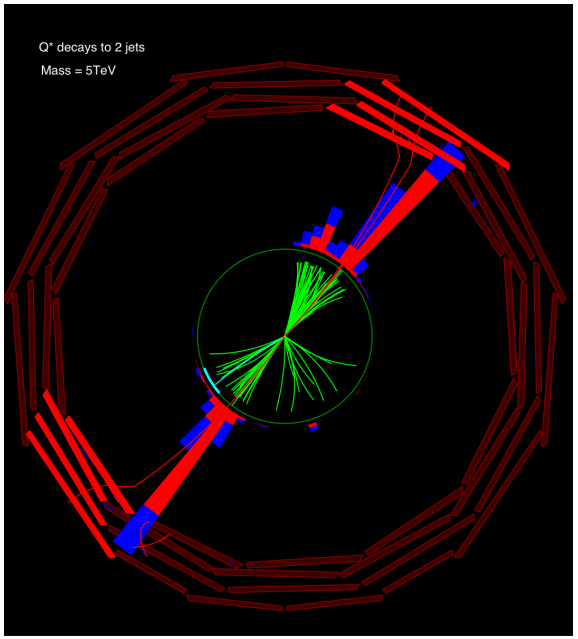


Use dE/dx from tracker and timing in CMS detectors to look for HSCP. At 100 pb^{-1} the explored mass scale is > 0.5 TeV. Gluino (stop) production is a strong process.

Dijet Angular Ratios



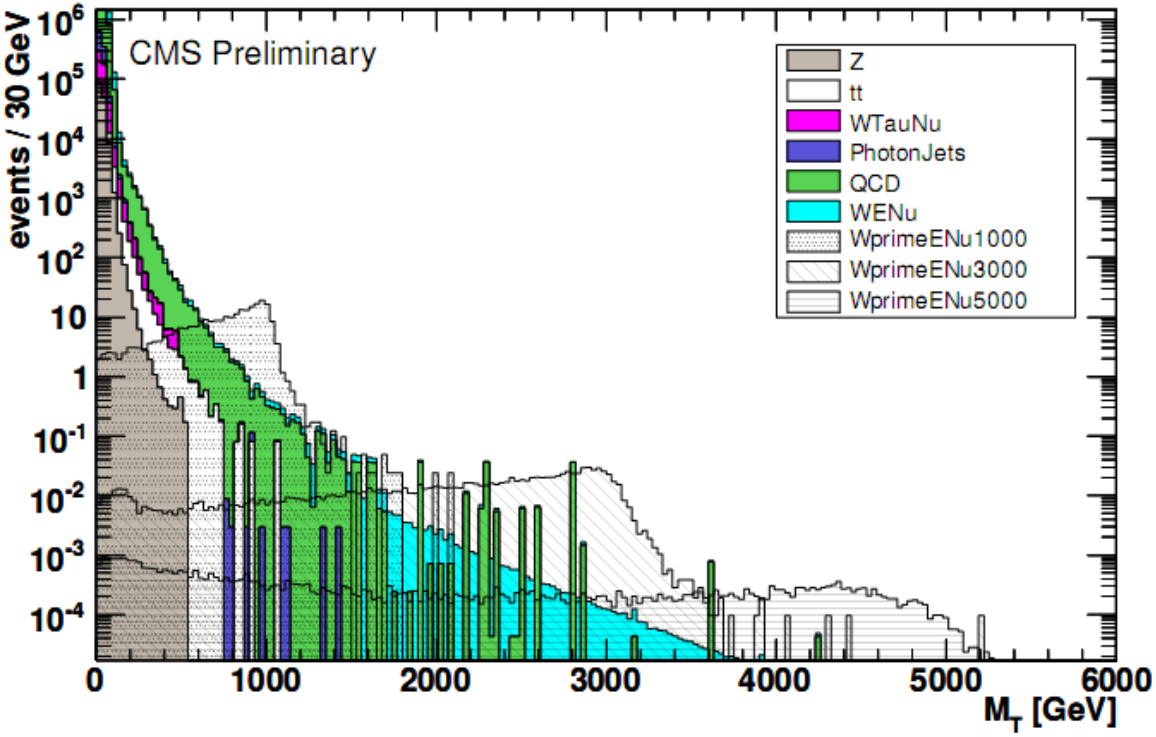




The di-jet mass searches for excited quarks or contact interactions or ? will be one of the earliest (2010) LHC searches – with fairly low luminosity. The angular ratio has some spin discrimination. The dijet spectrum already extends to ~ 1 TeV mass.

Sequential W – Tail of W BW

W′

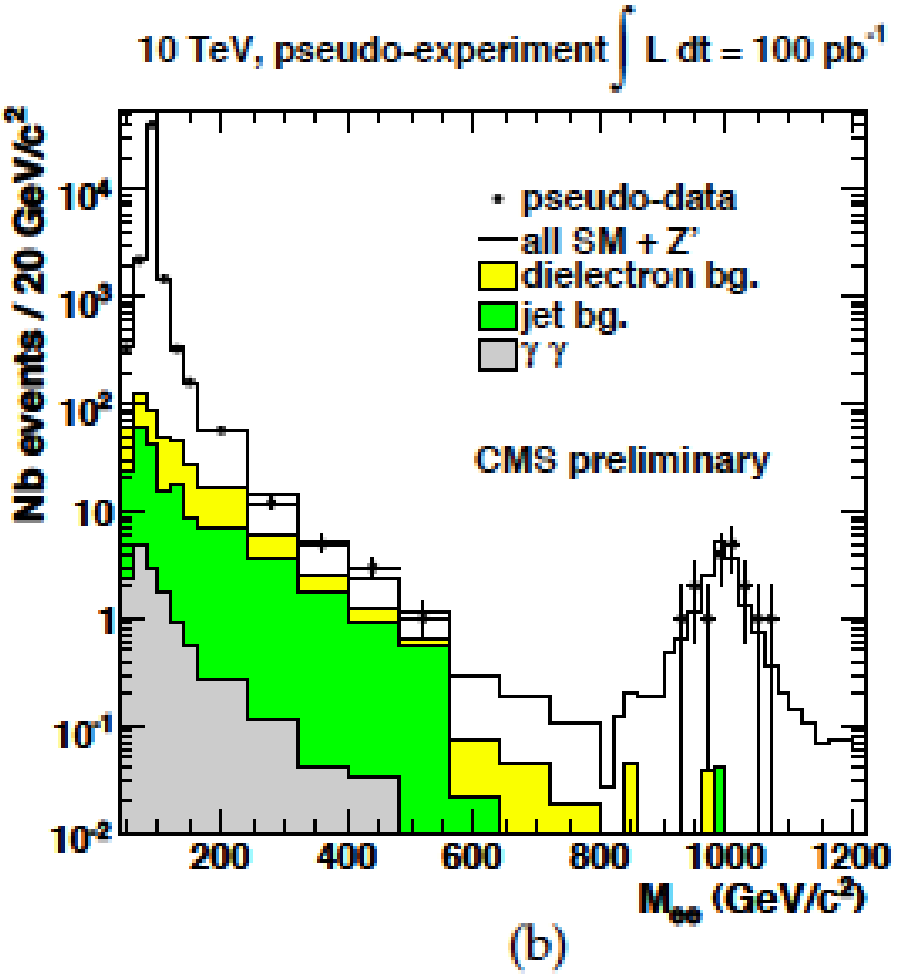


100 pb^{-1}

In the SM there are no states beyond the W and the Z -> look in the BW tails.

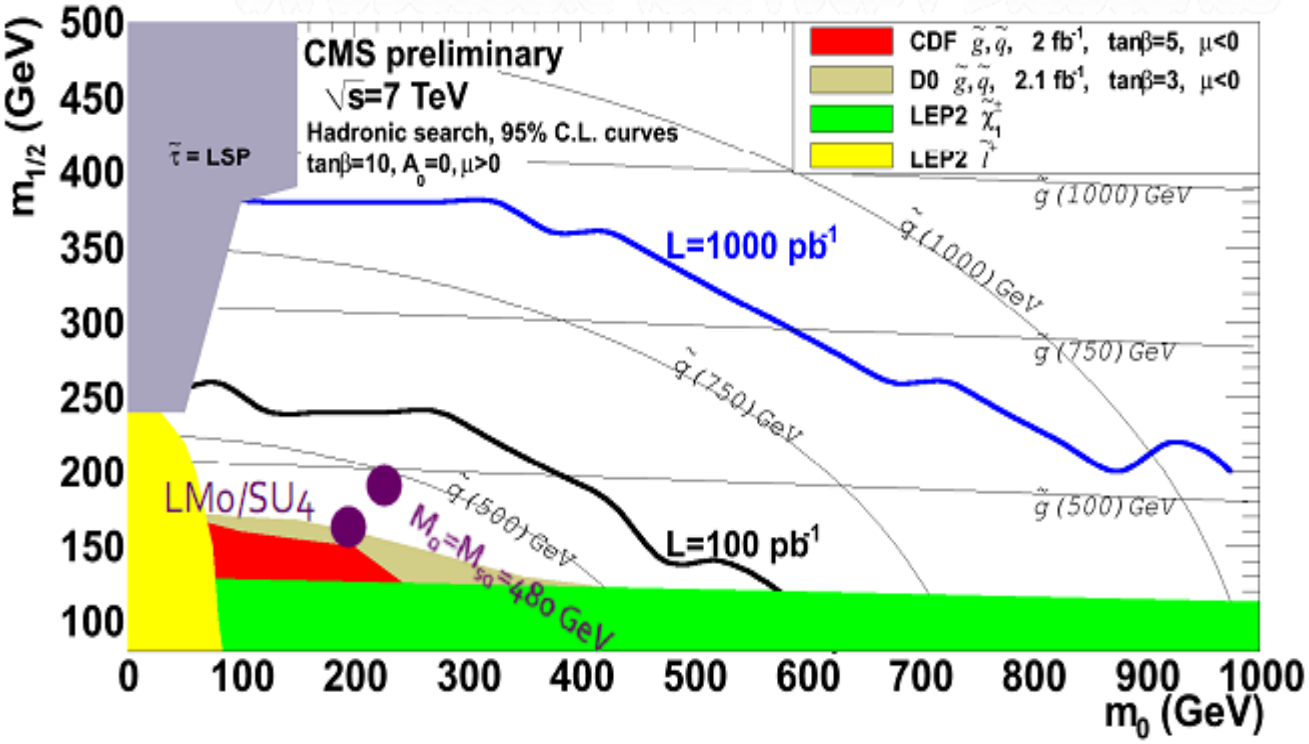
At 100 pb^{-1} the 95% C.L. for > 1.5 TeV sequential W is reached.

Sequential Z in DY + BW Tail



A 100 pb^{-1} the mass reach is > 1 TeV for a sequential Z resonance for a 5 s.d. The discovery. reach is longer for a 95 % C.L. exclusion.

SUSY Reach in J + MET

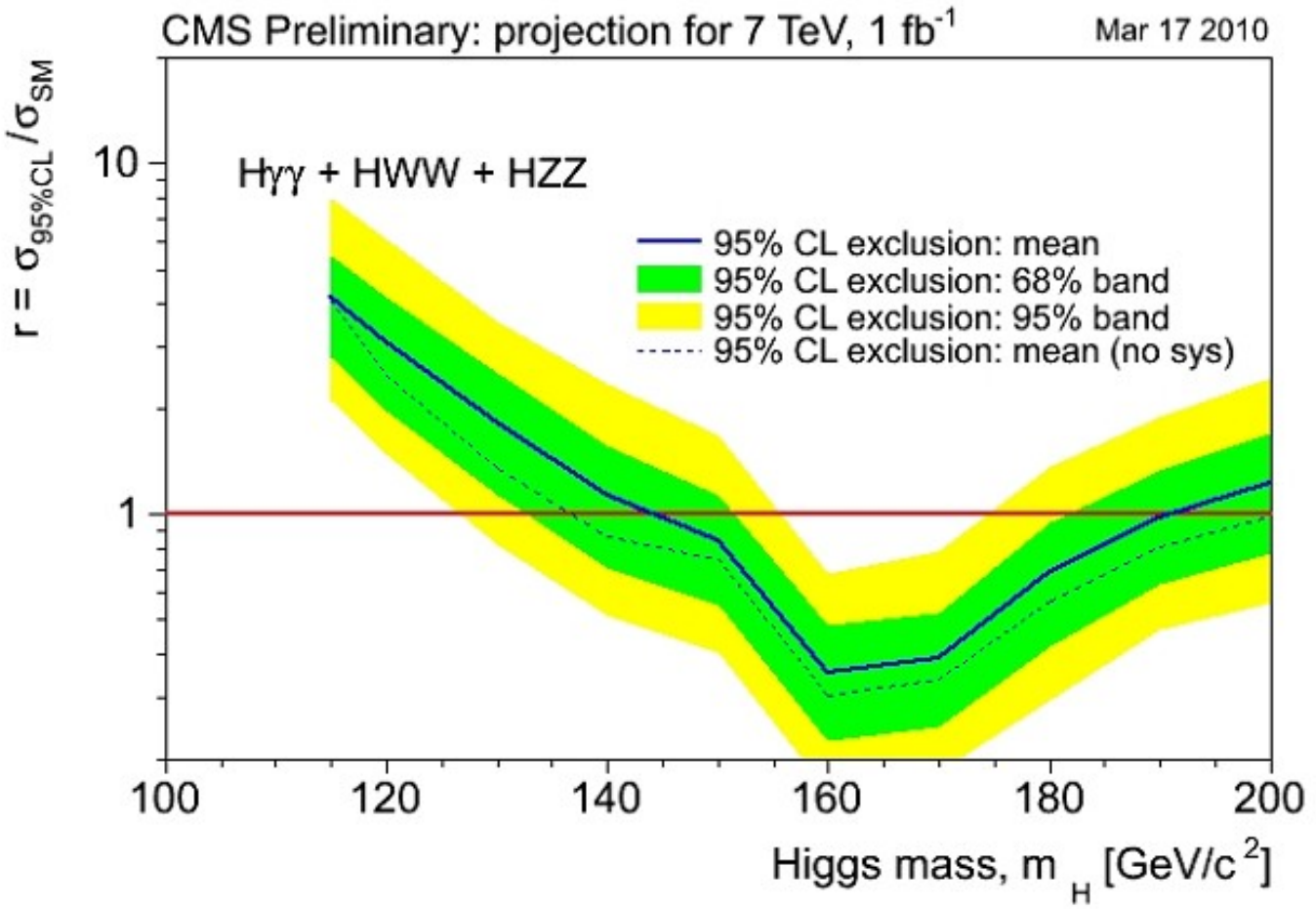


95% CL for all-hadronic search (≥ 3 jets + MET)

Systematic uncertainty of 50% assumed here on backgrounds

Starting in late 2010 the LHC experiments will open up new regions of discovery potential for SUSY. The reach will be greatly extended in 2011.

CMS @ 7 TeV, Reach for Higgs - 2011



In 2011 CMS will delve deeper into the > TeV mass range and begin to make contributions to the Higgs search.

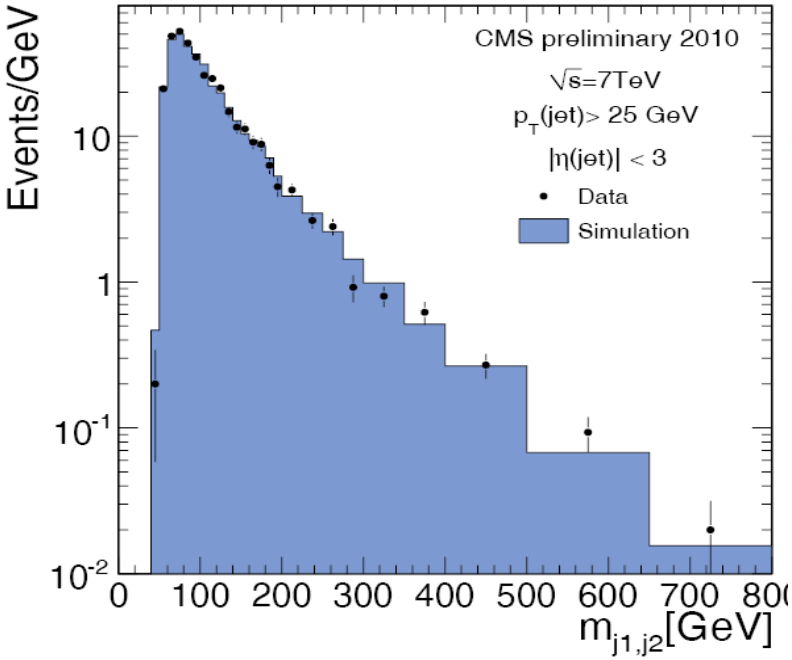
Setting Out into Deep Waters

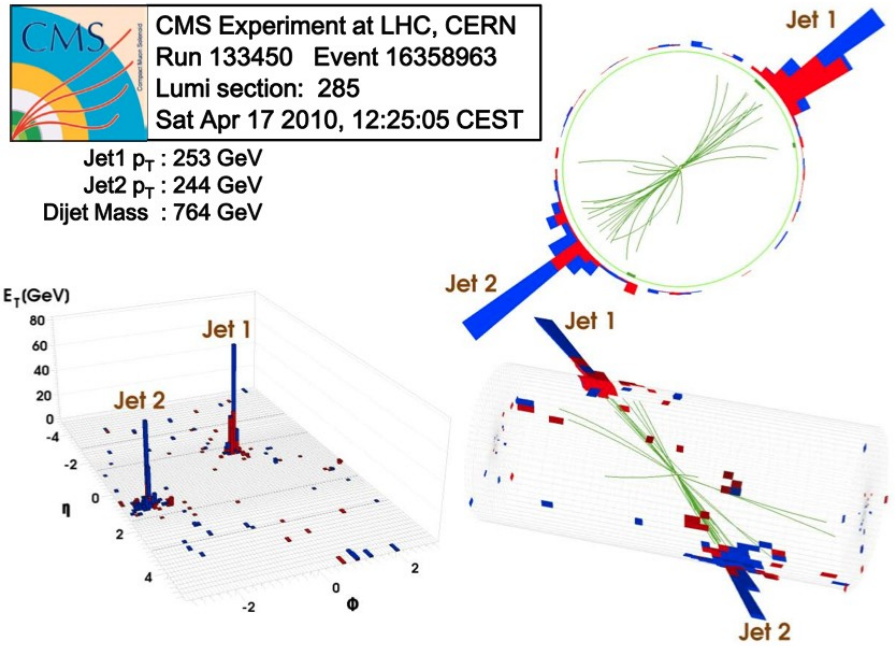
The "take home message" is that 2010 and 2011 will be a great ride for the LHC experiments with "exponentially" increasing integrated luminosity. Buckle up.

"The real voyage of discovery consists… in having new eyes"
Marcel Proust

We have built a magnificent new set of eyes. We have explored the shallows and visited the known islands. Now we will set out into deep and unknown waters.

Dijet Masses





With ~ 1 nb^{-1} of logged data, the dijet mass spectrum is approaching ~ 1 TeV. Strongly produced "new physics" processes will be the first to be searched for – e.g. composite quarks.