The Path to Discovery in CMS

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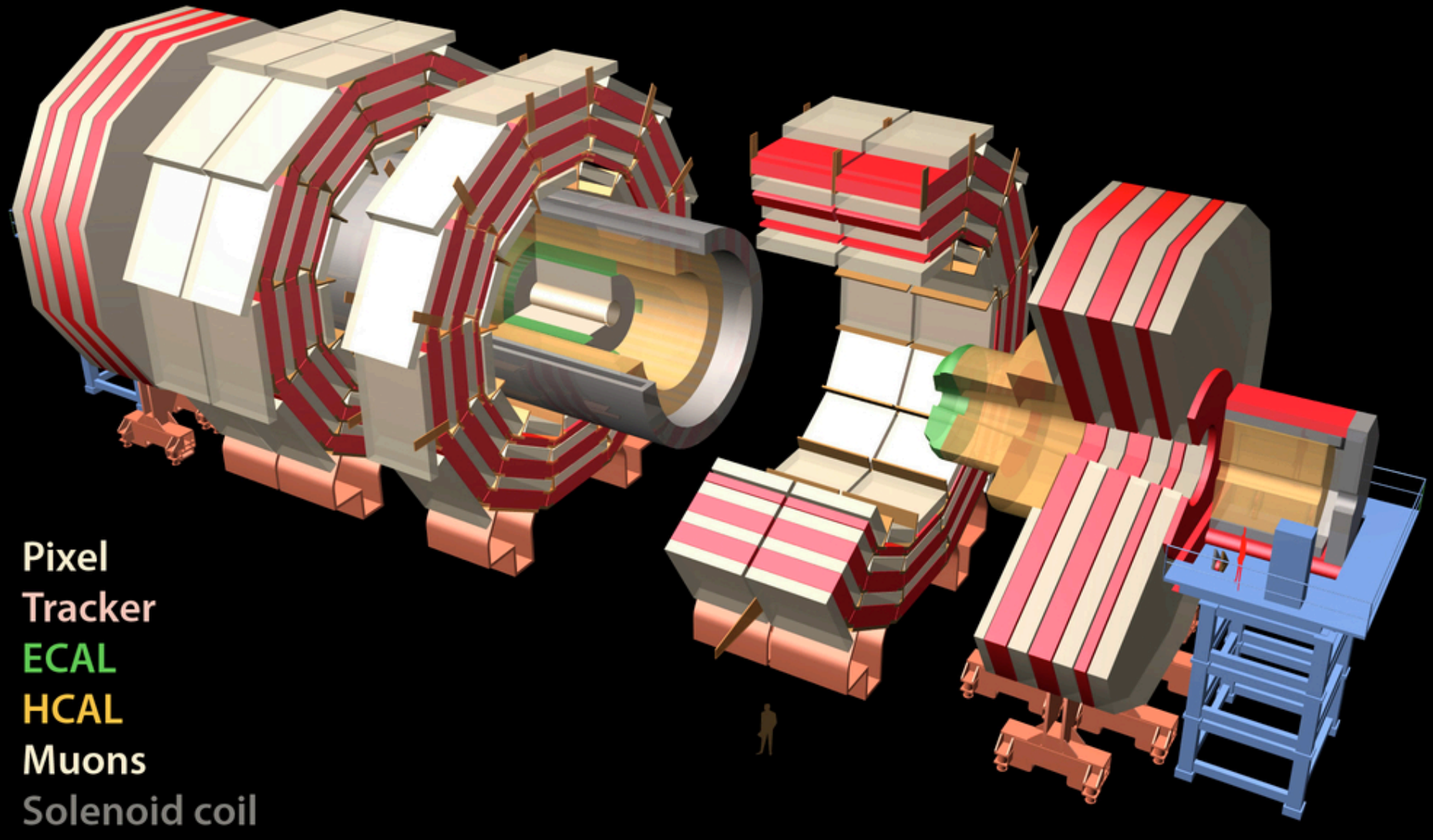
Pheno 2010
UW Madison

The LHC experiments are at last collecting high energy physics data!



Data so far

- CRAFT (late 2008) 600k events
- 900 GeV (Nov. 2009) 300k events
- 2.36 TeV (Dec. 2009) 20k events

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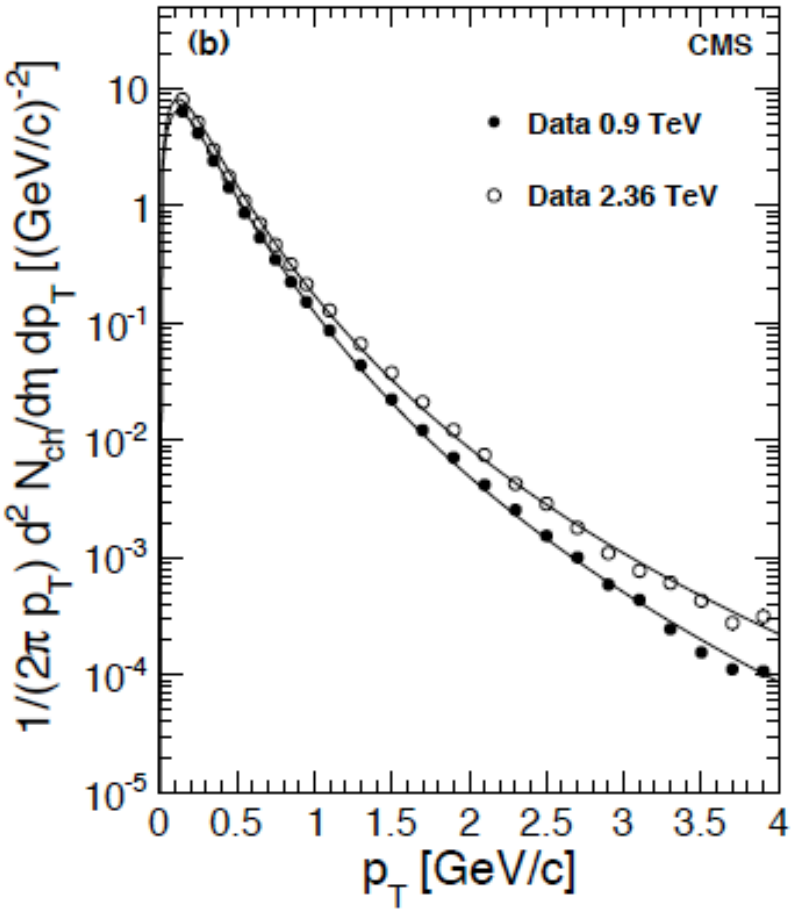
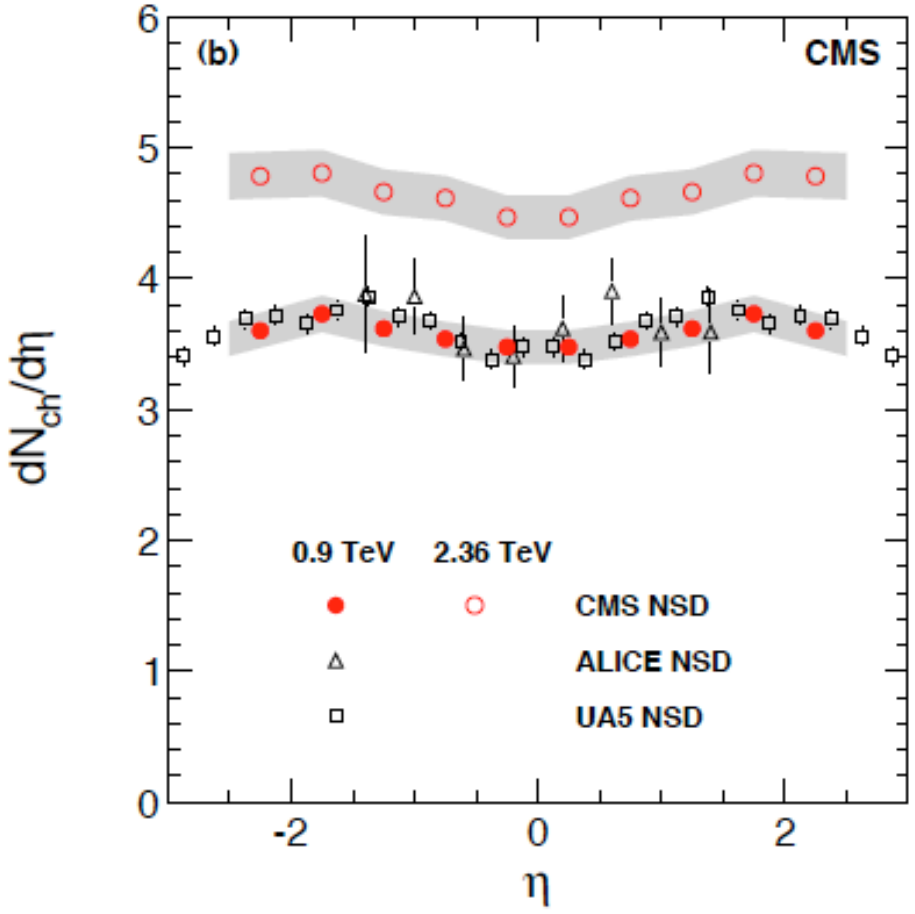
- 2.36 TeV (Dec. 2009) 20k events

  ⇒ the first glimpse of high energy

CMS' First Physics Paper!

- inclusive particle p_T, and pseudorapidity at 900 GeV and 2.36 TeV





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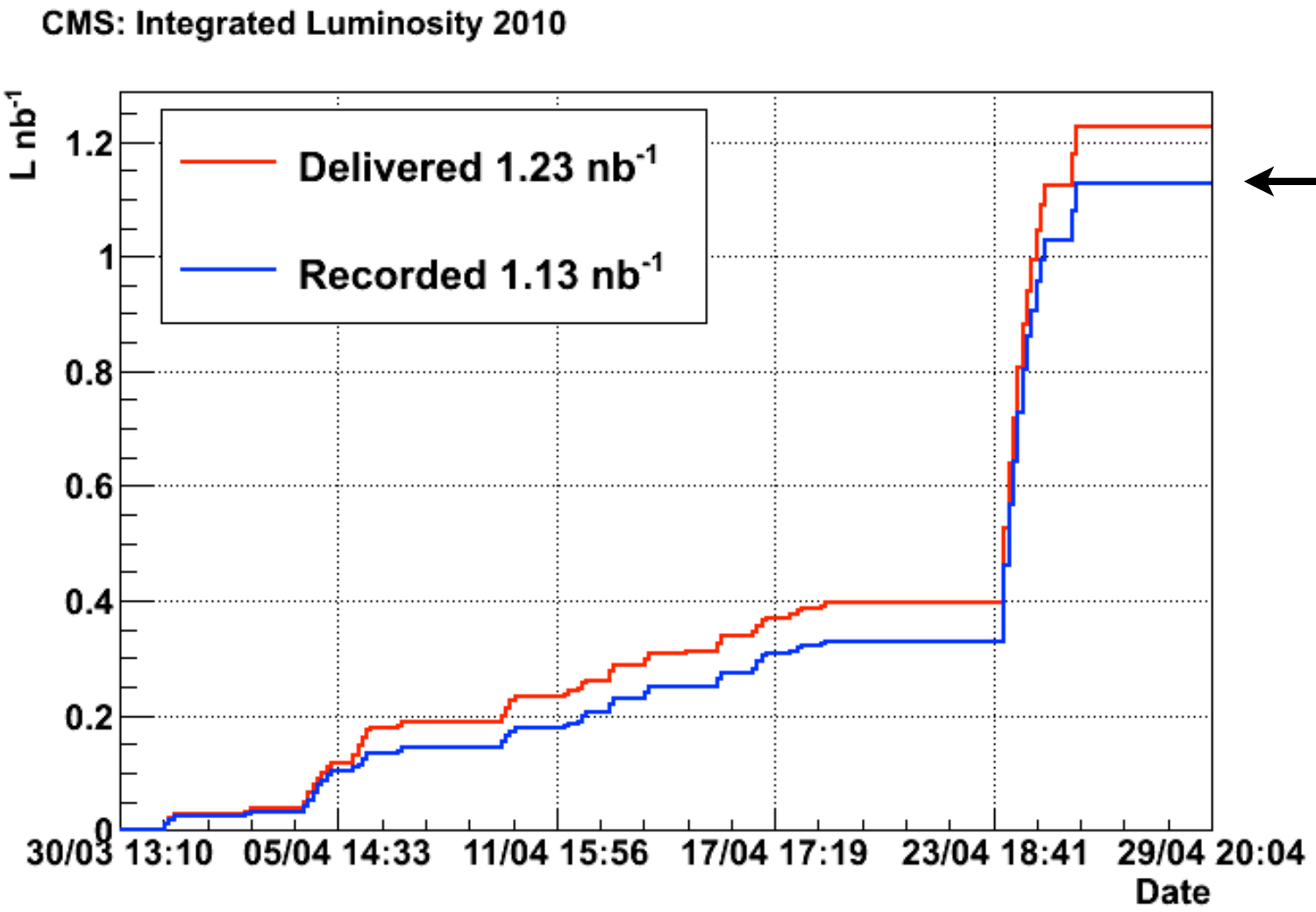
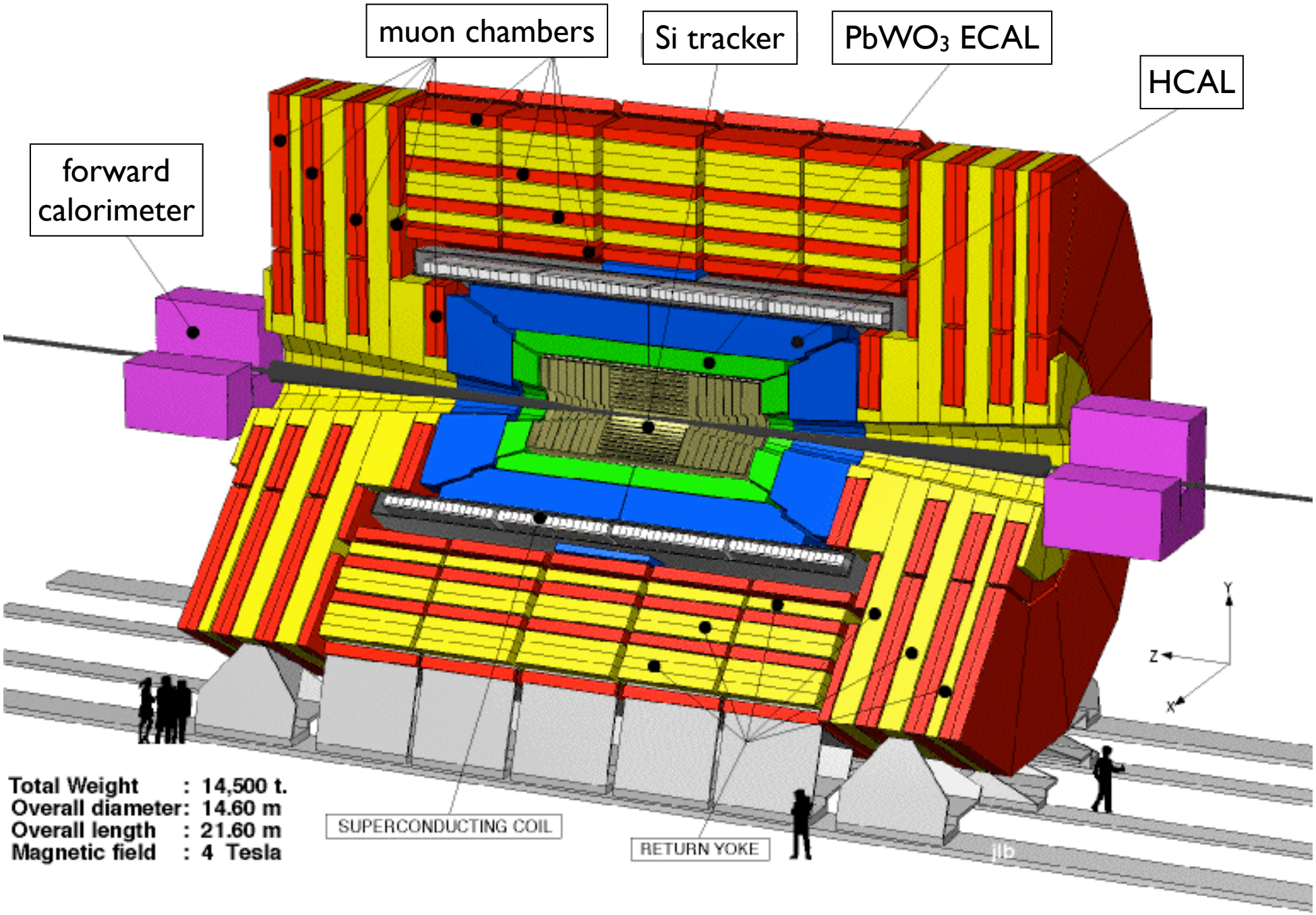
First look at results from 7 TeV running!

LHC has achieved ~10^{28} $cm^{-1}s^{-1}$



← this talk

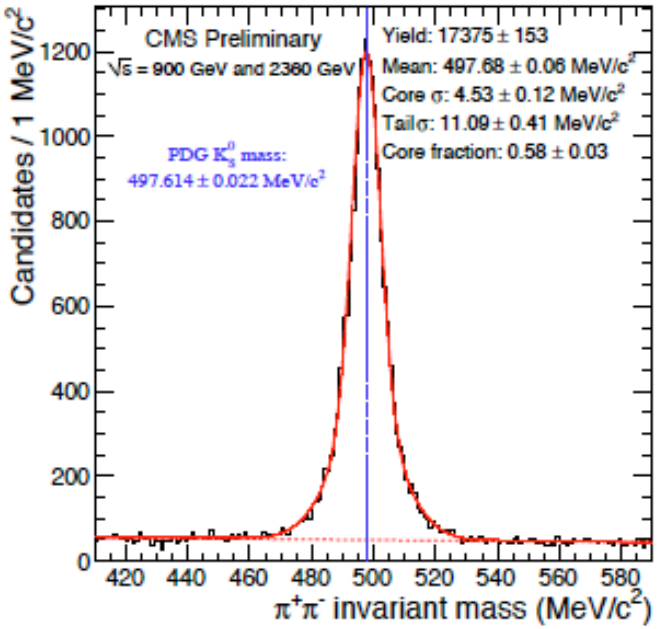
CMS is Performing Well!

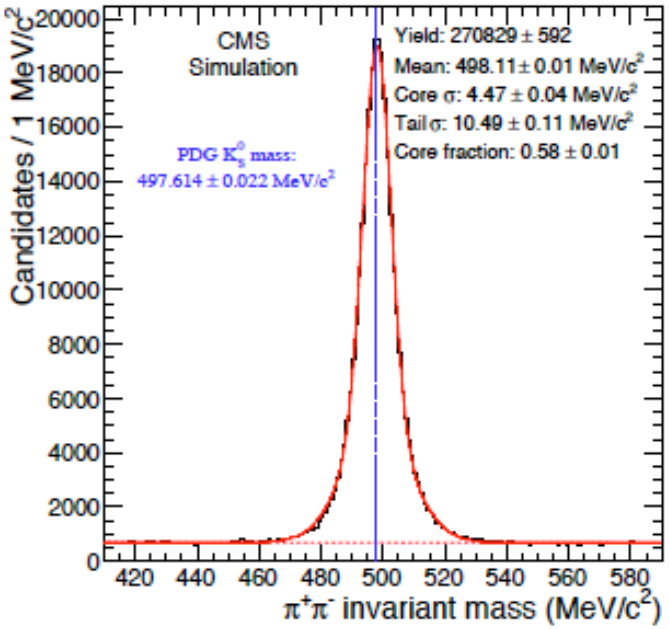


CMS Tracker: Pixels/Strips

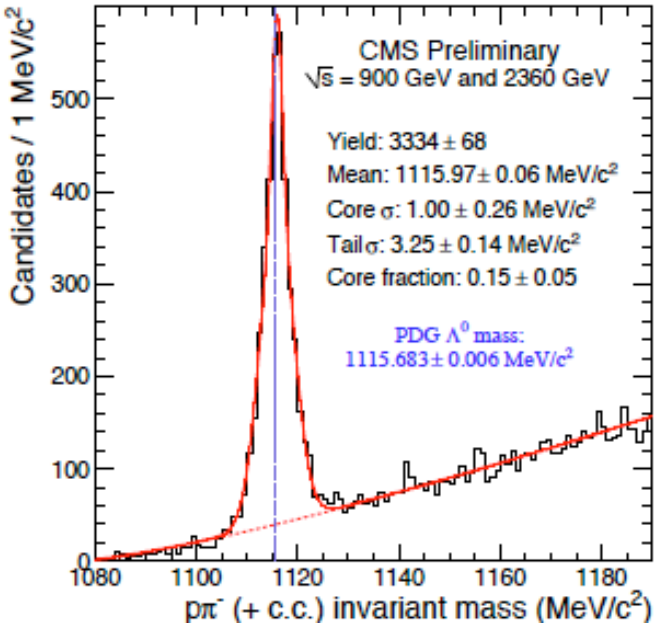
data simulation

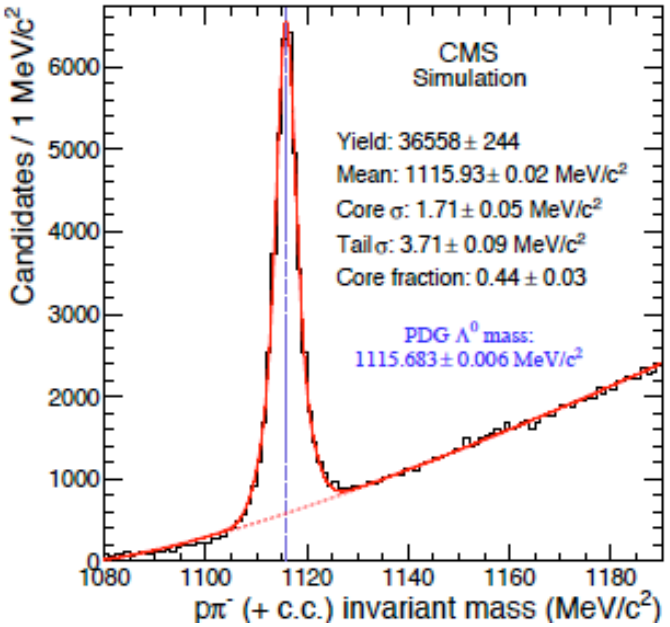
K_s





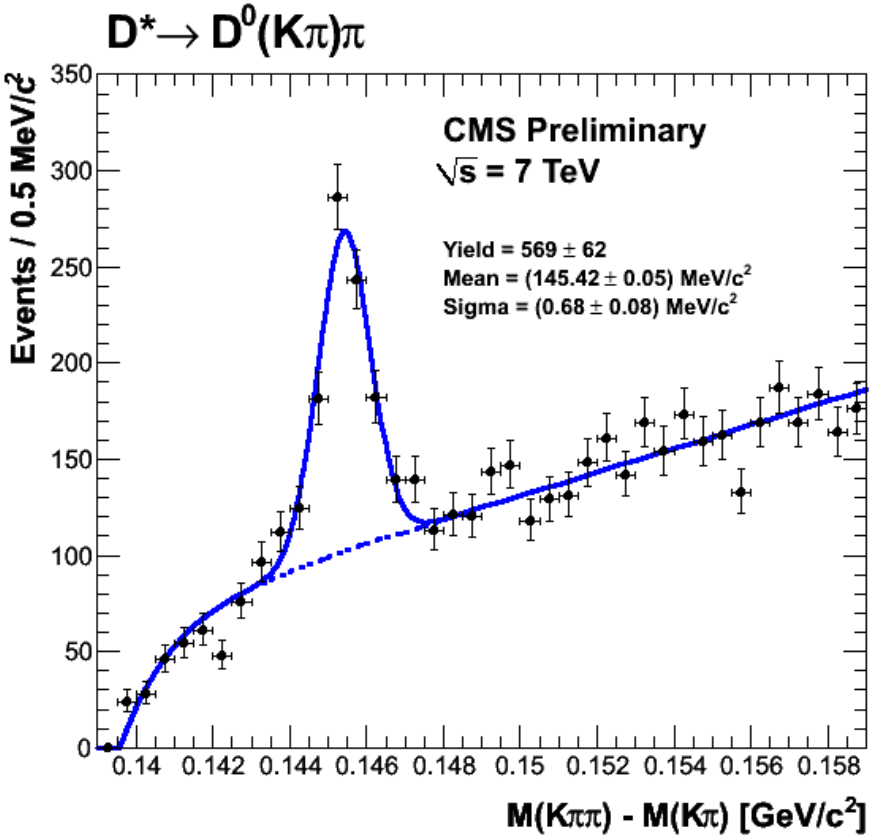
Λ

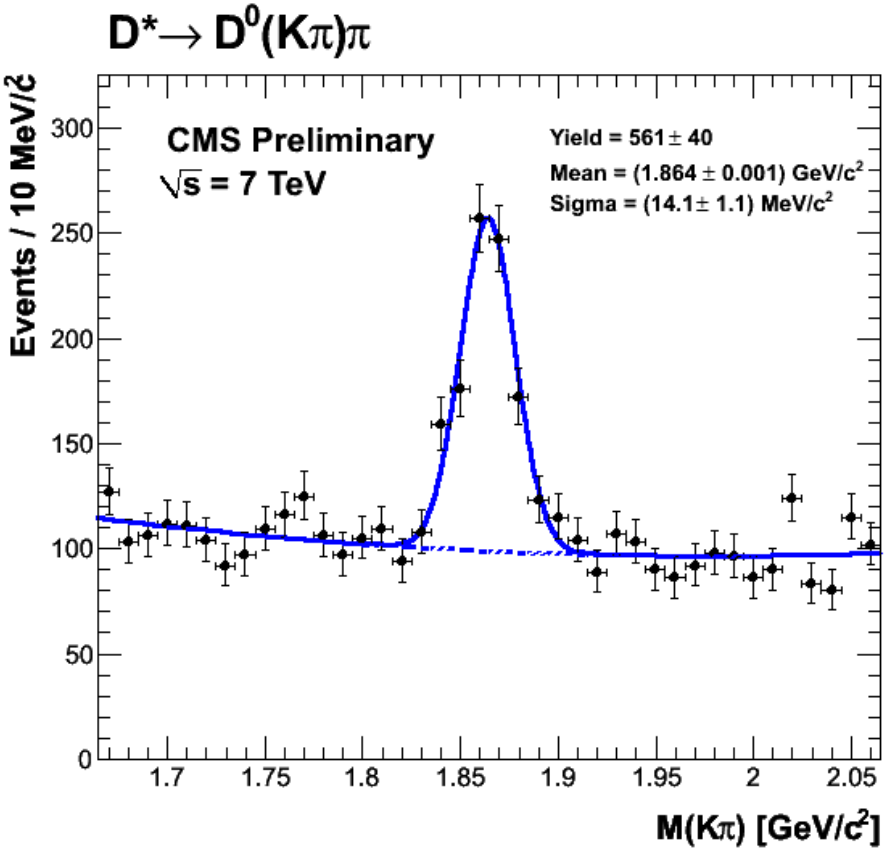




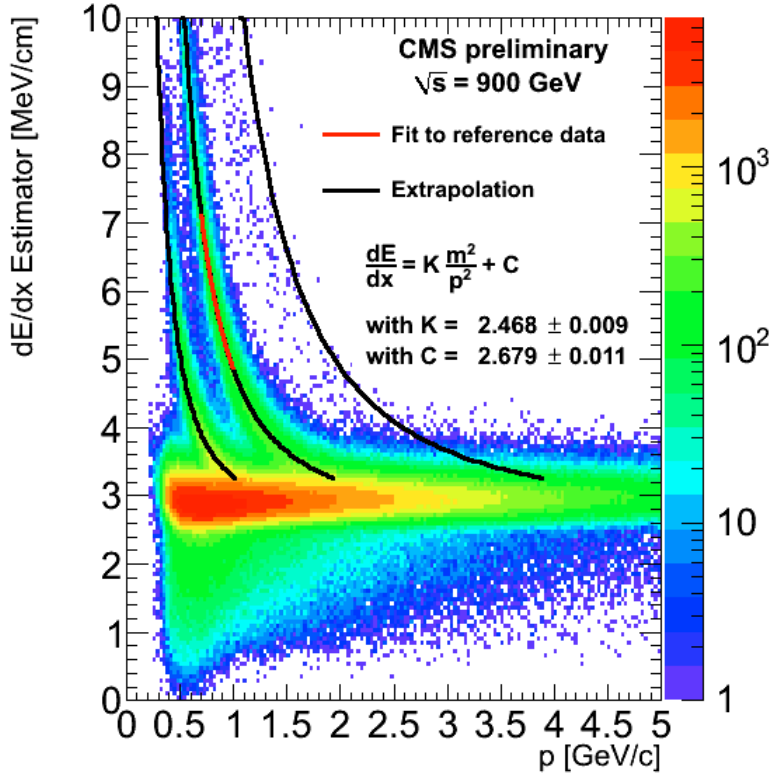
New: D* in 7 TeV data!

See very clean $D^* \to D^0\pi$, $D^0 \to K\pi$



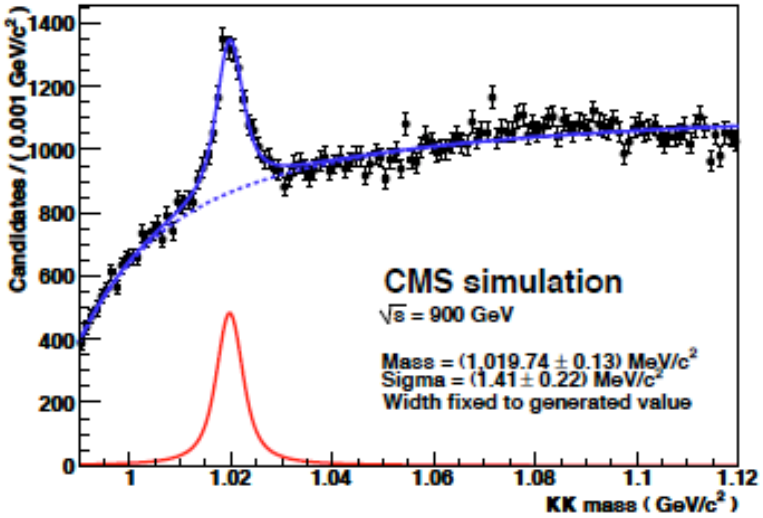


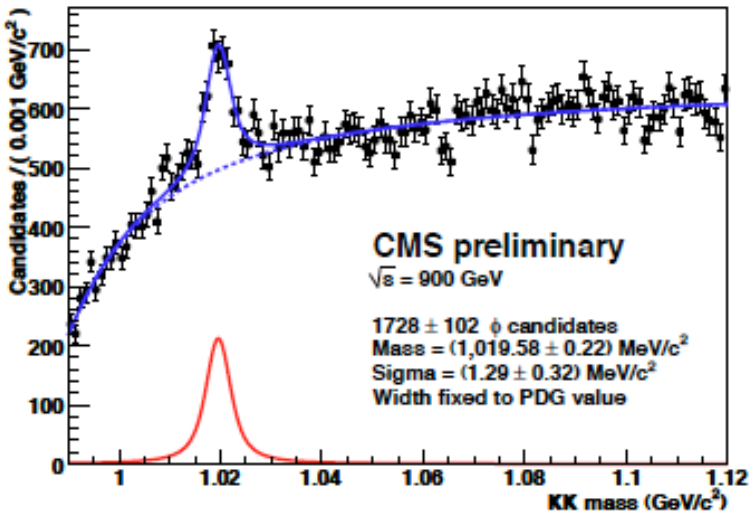
Tracking: dE/dx



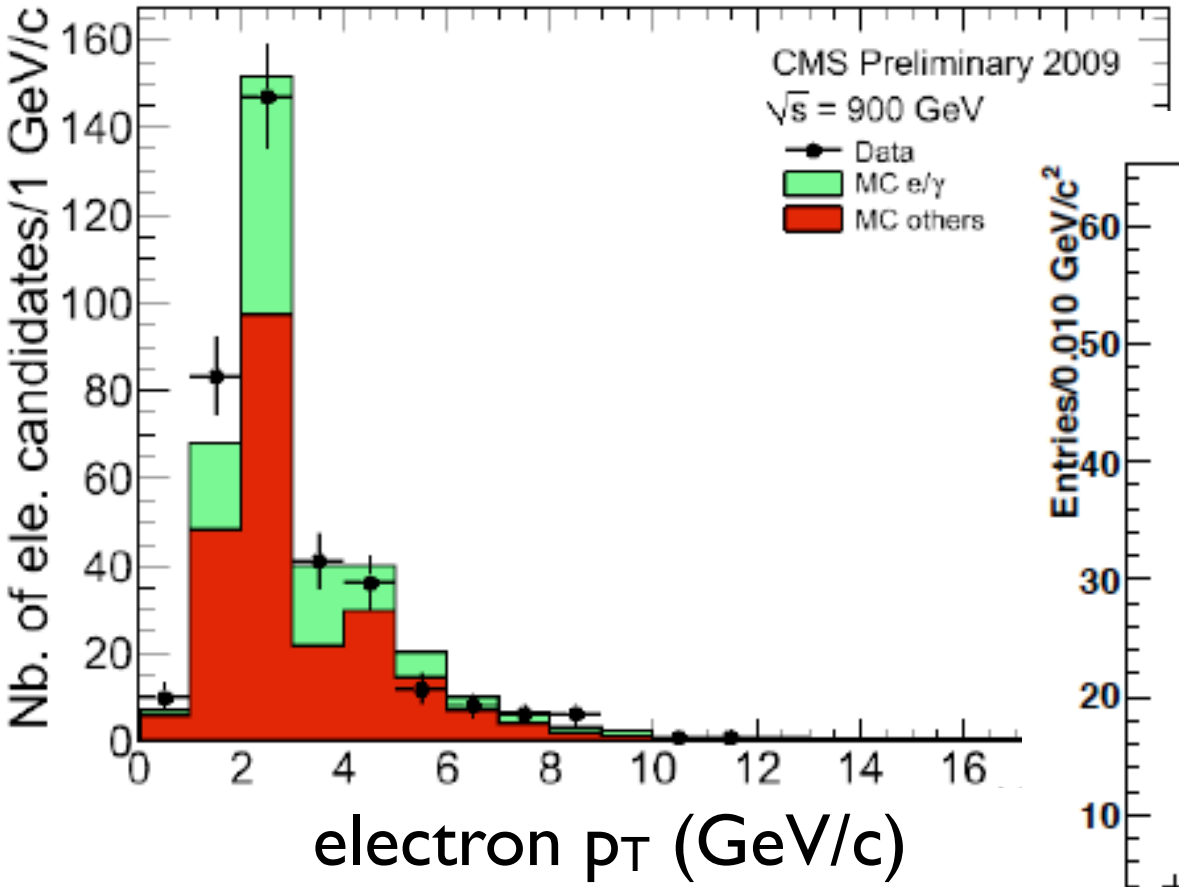
Make use of large number of samples along track to do particle ID with dE/dx

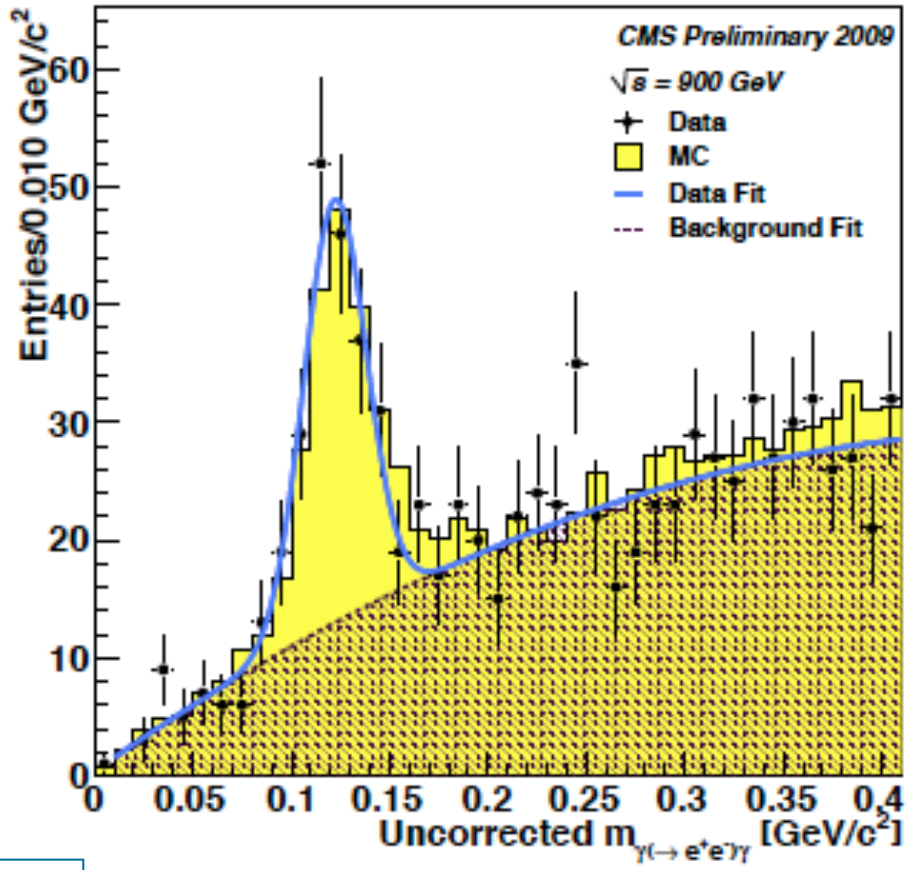
$\phi \rightarrow KK$





Electrons/Photons/Conversions



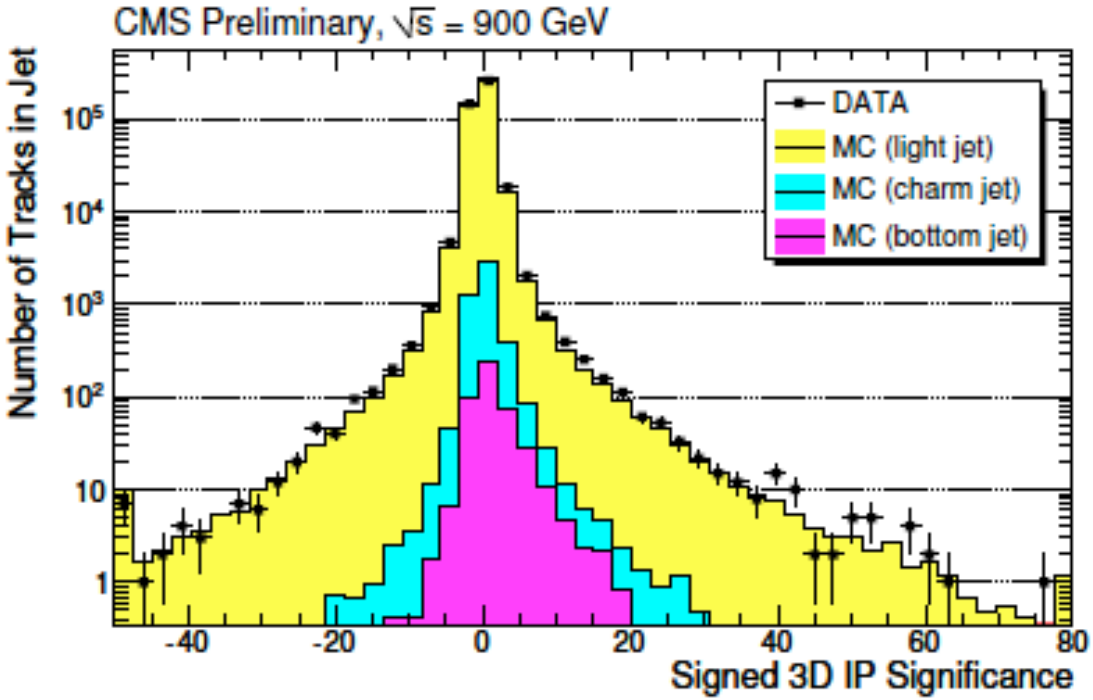


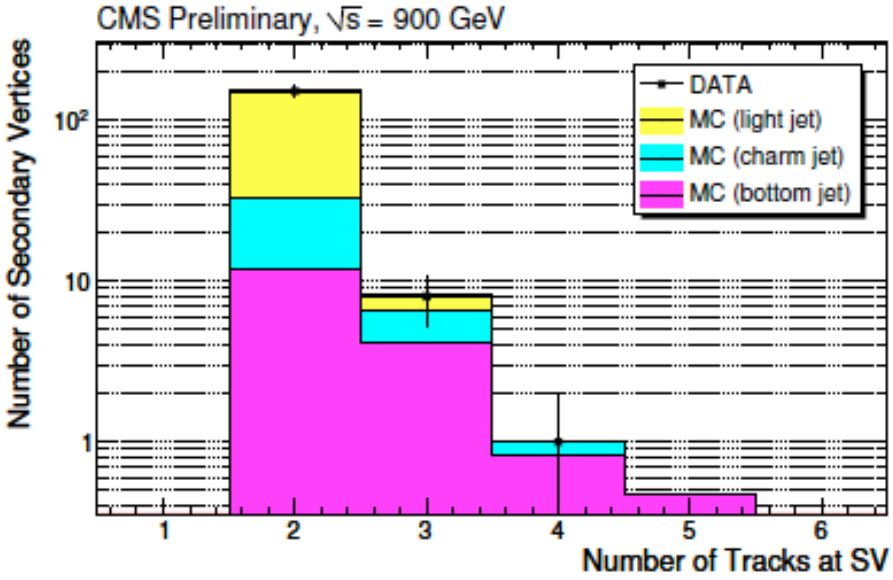
Electron/photon reconstruction working well

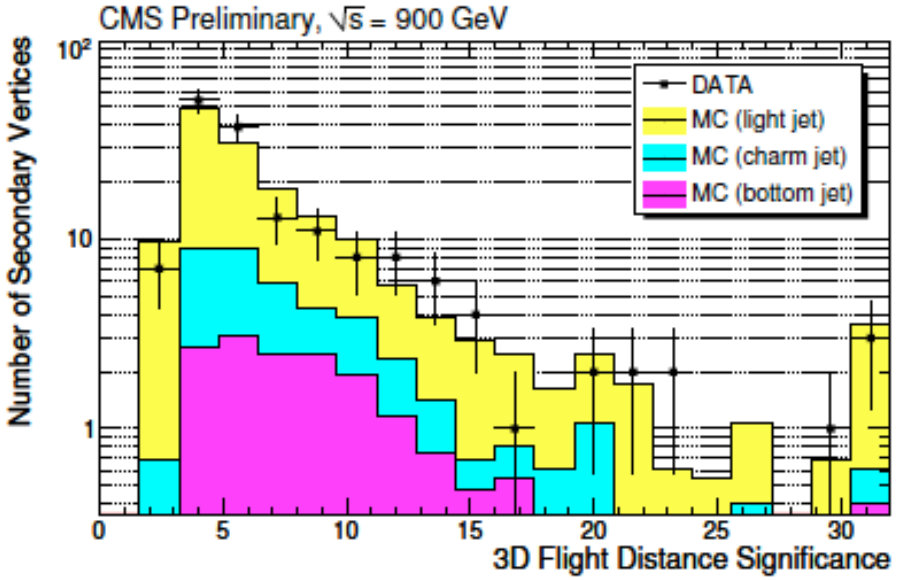
π^0 from γ +($\gamma \rightarrow ee$)

Vertexing and b-tagging

Basic b-tagging variables are well described - need more exposure and tuning with new data





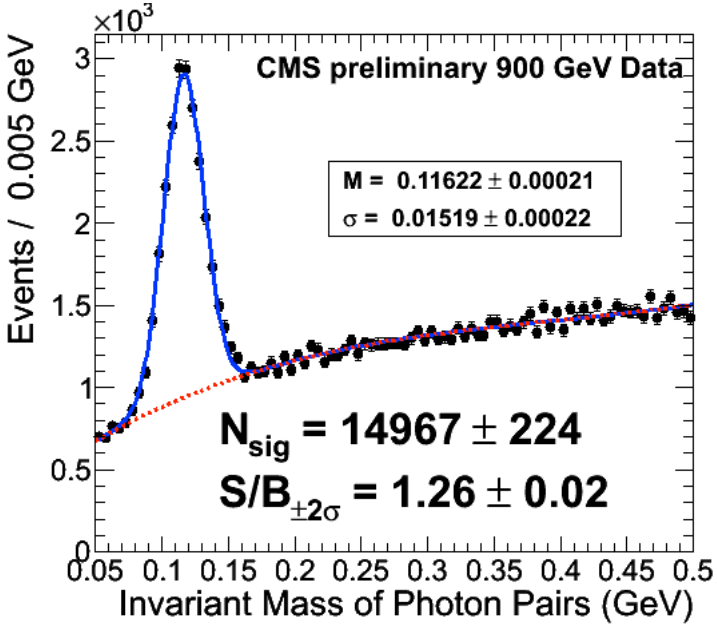


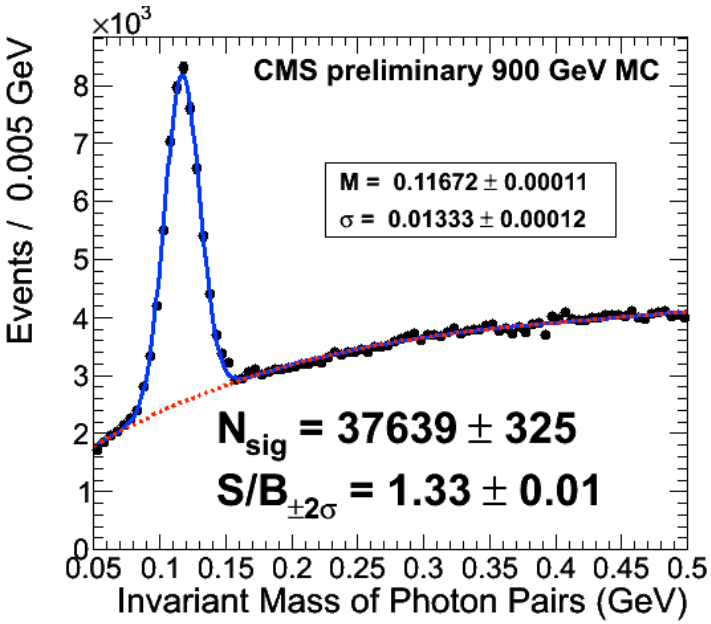
ECAL: π^0 and η

data

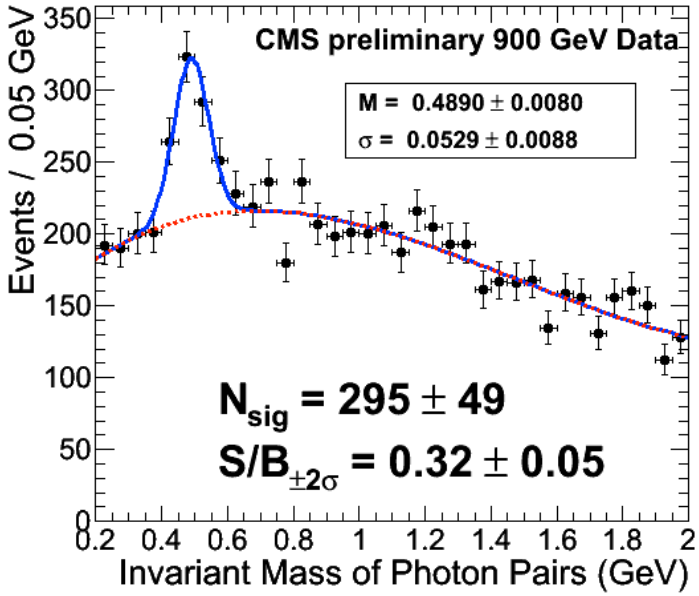
simulation

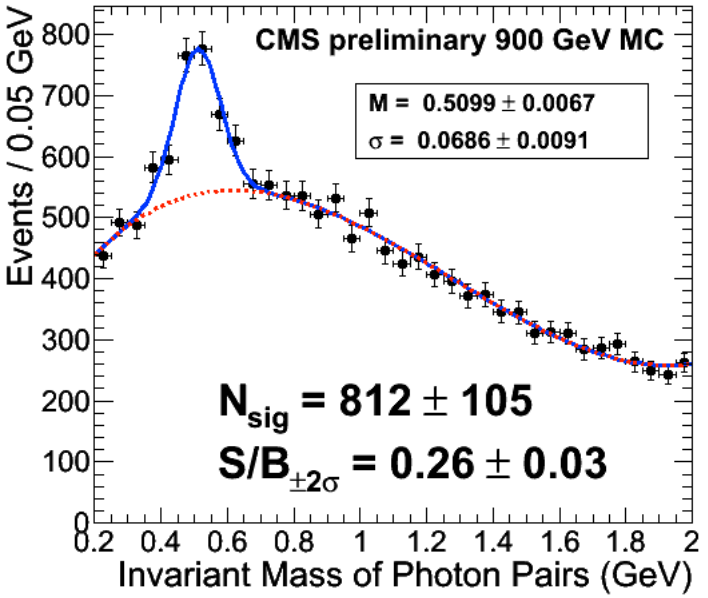
π^0



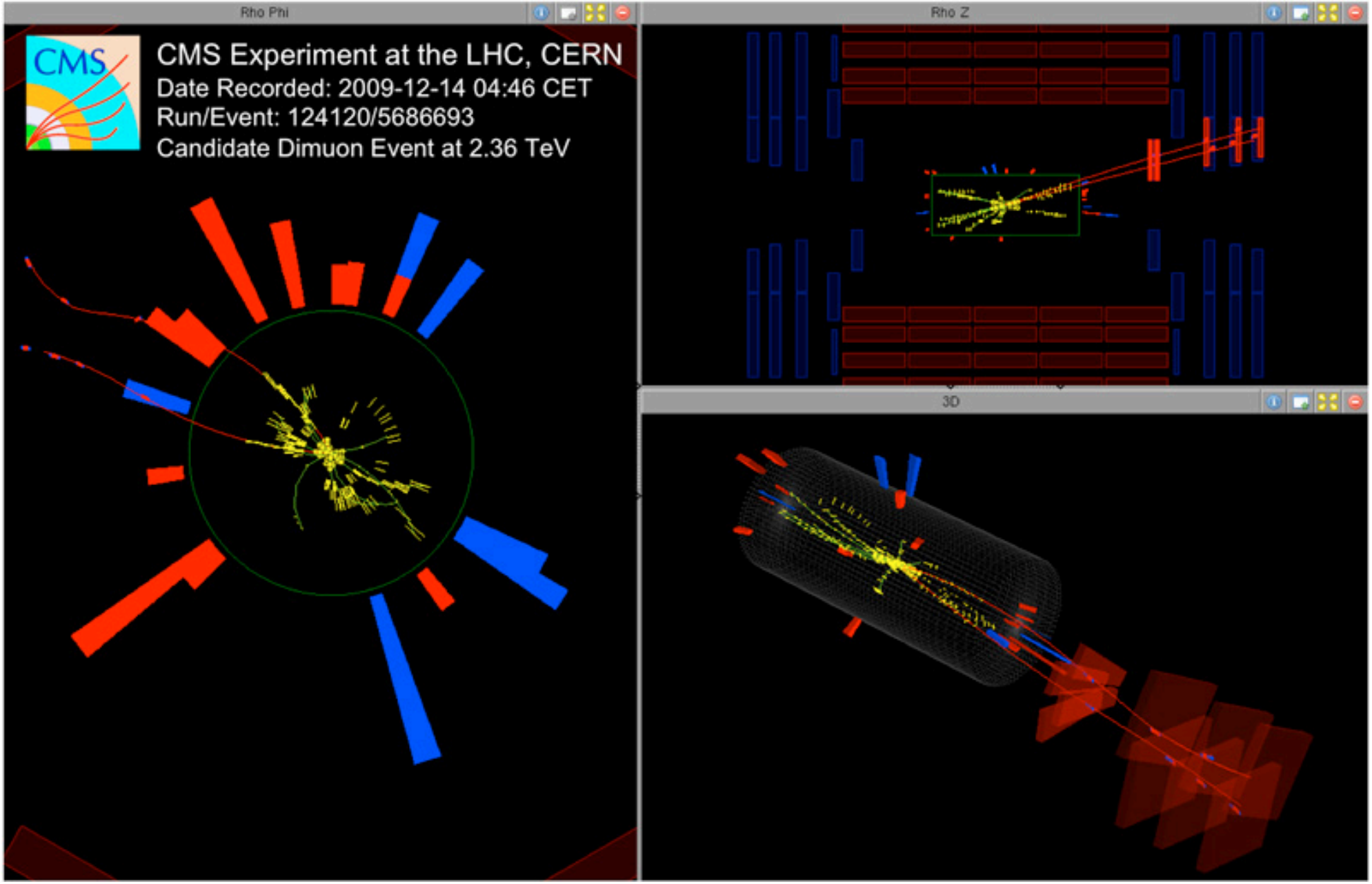


η





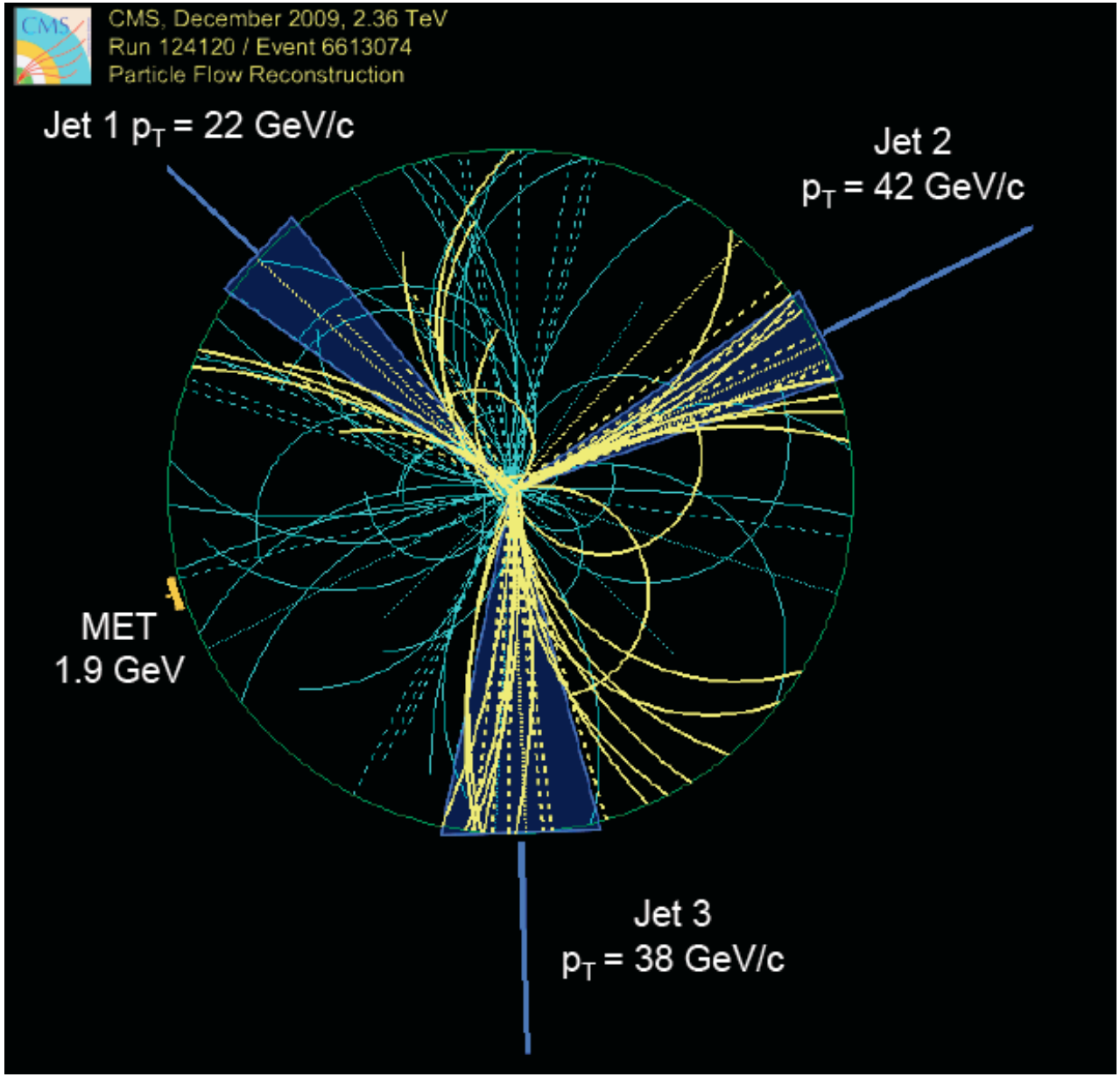
Muon is our Middle Name



Jets, Jets, Jets!

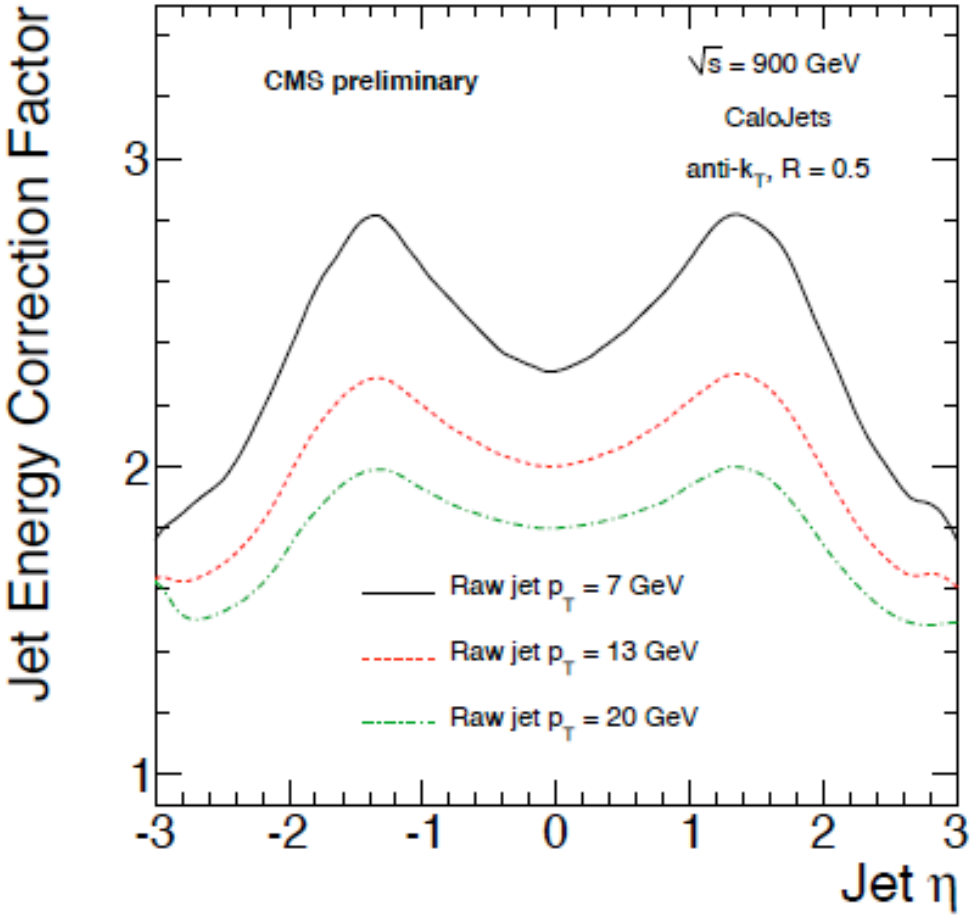
1. calorimeter jets (CALO)
2. "jet plus tracks" jets (JPT)
3. particle flow jets

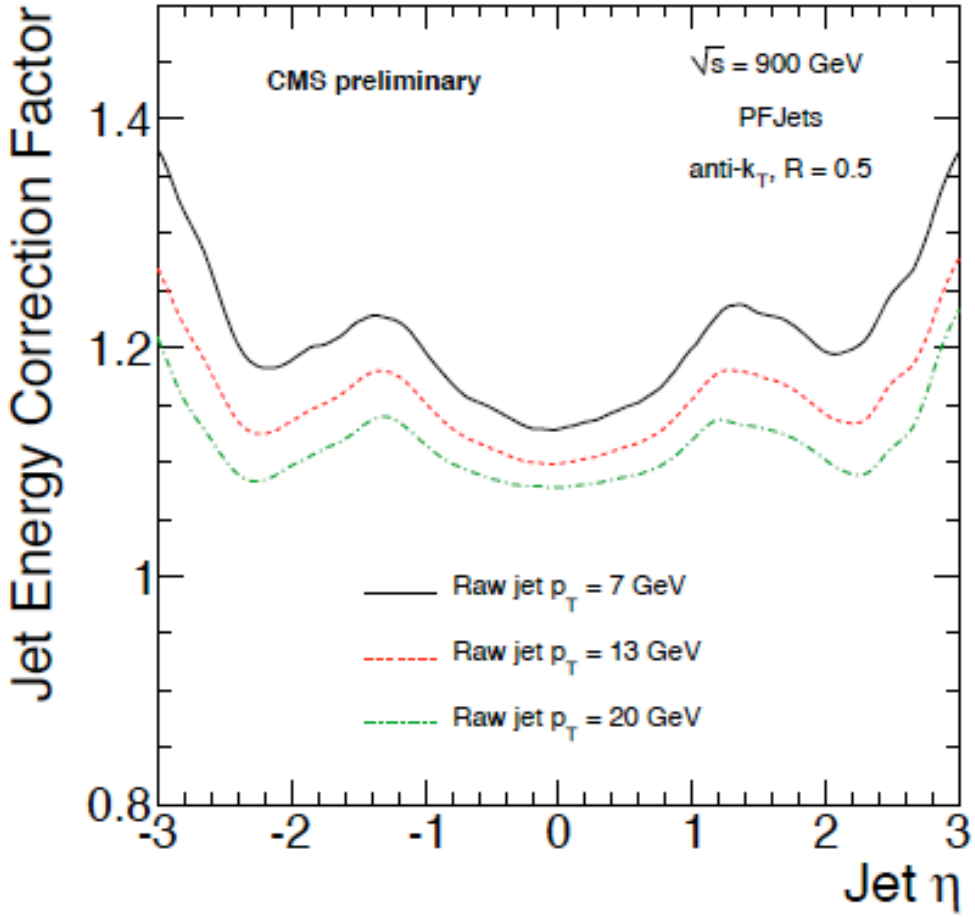
jet algorithm:
anti-k_T, R = 0.5



Jet corrections

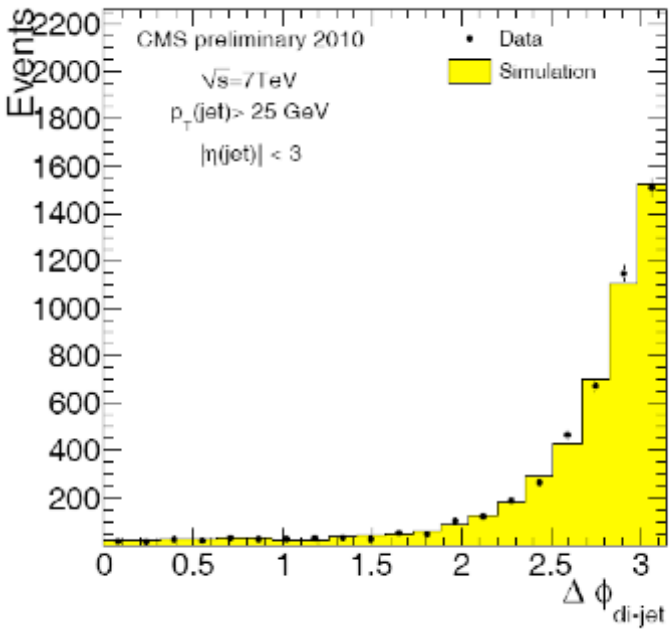
particle flow dramatically reduces magnitude of jet corrections:



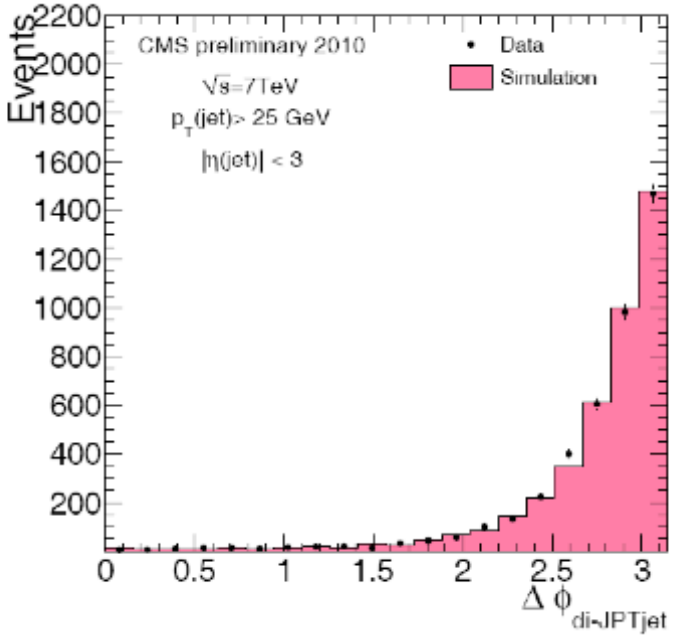


Jets: the first inverse nb at 7 TeV

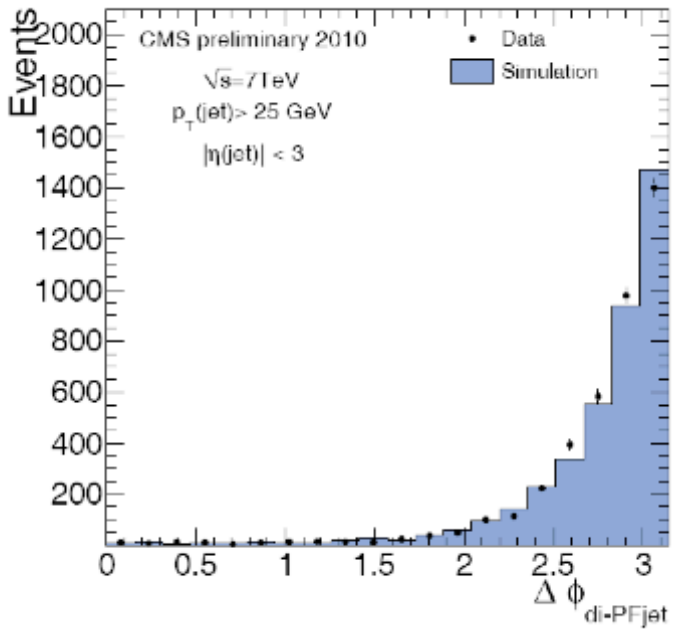
calorimeter



jet plus track



particle flow



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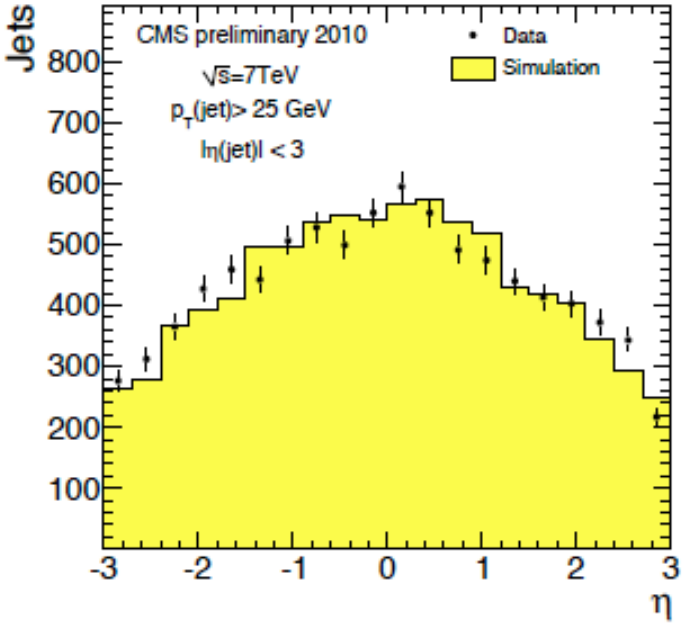

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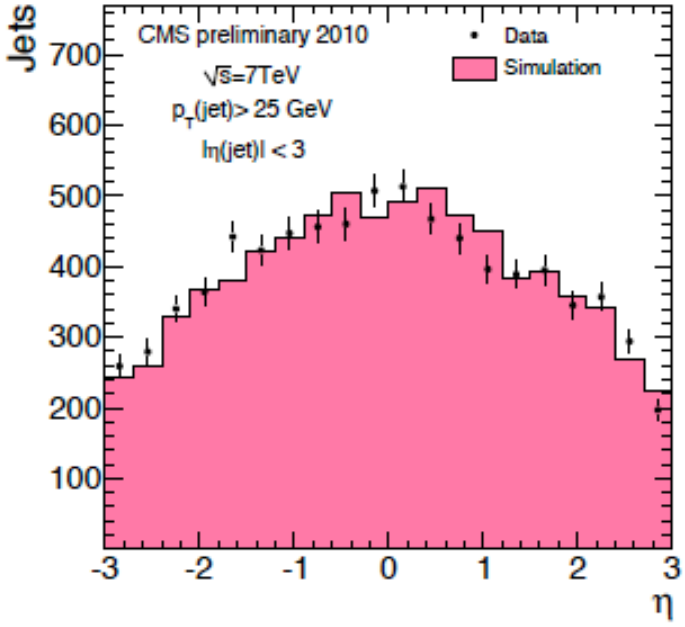
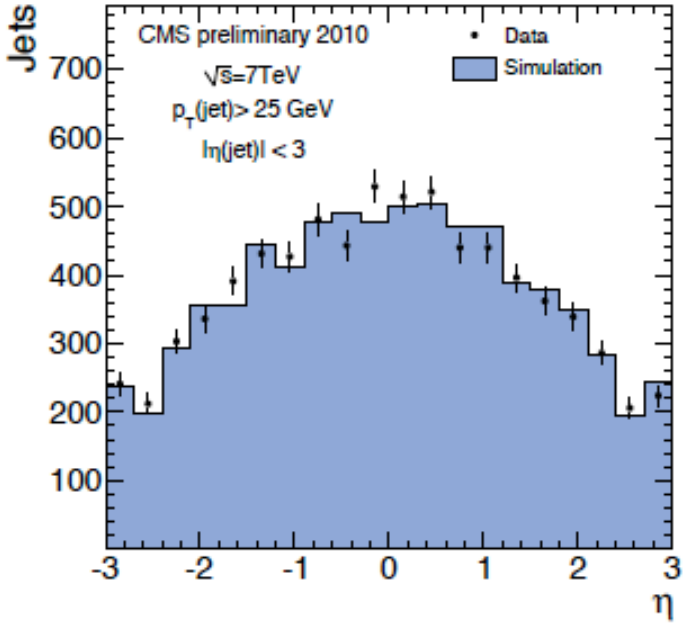
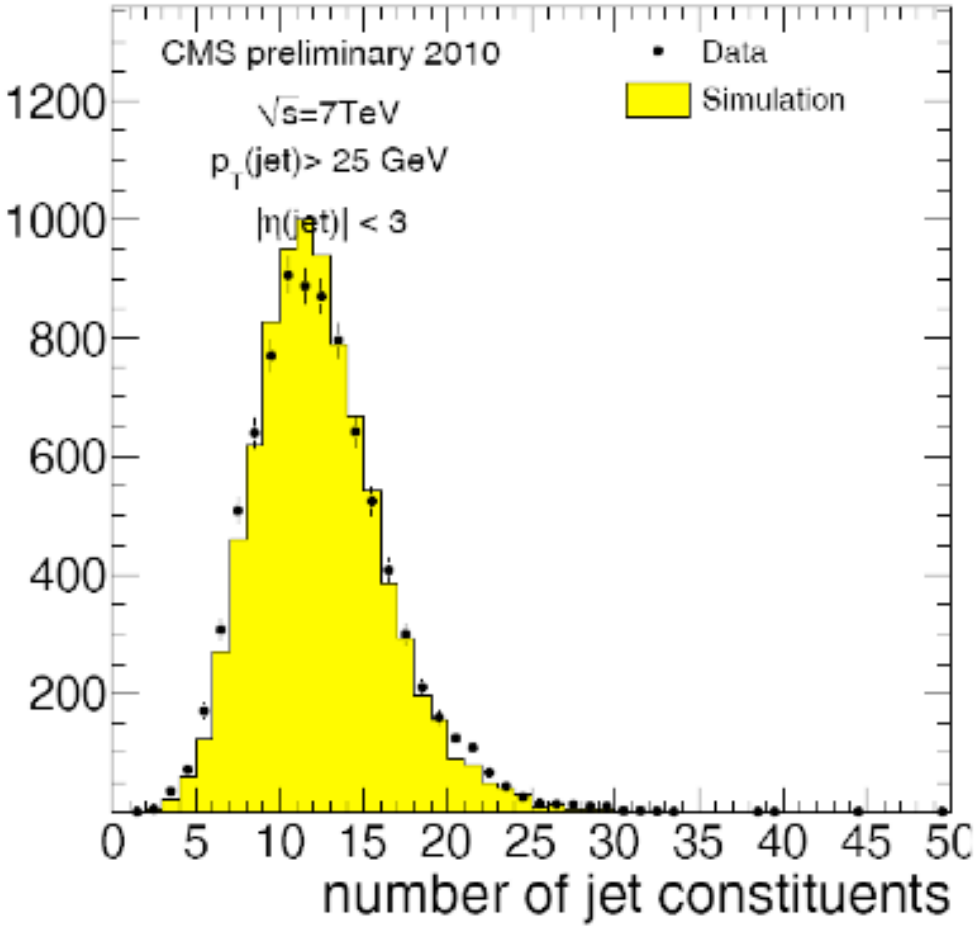


particle flow

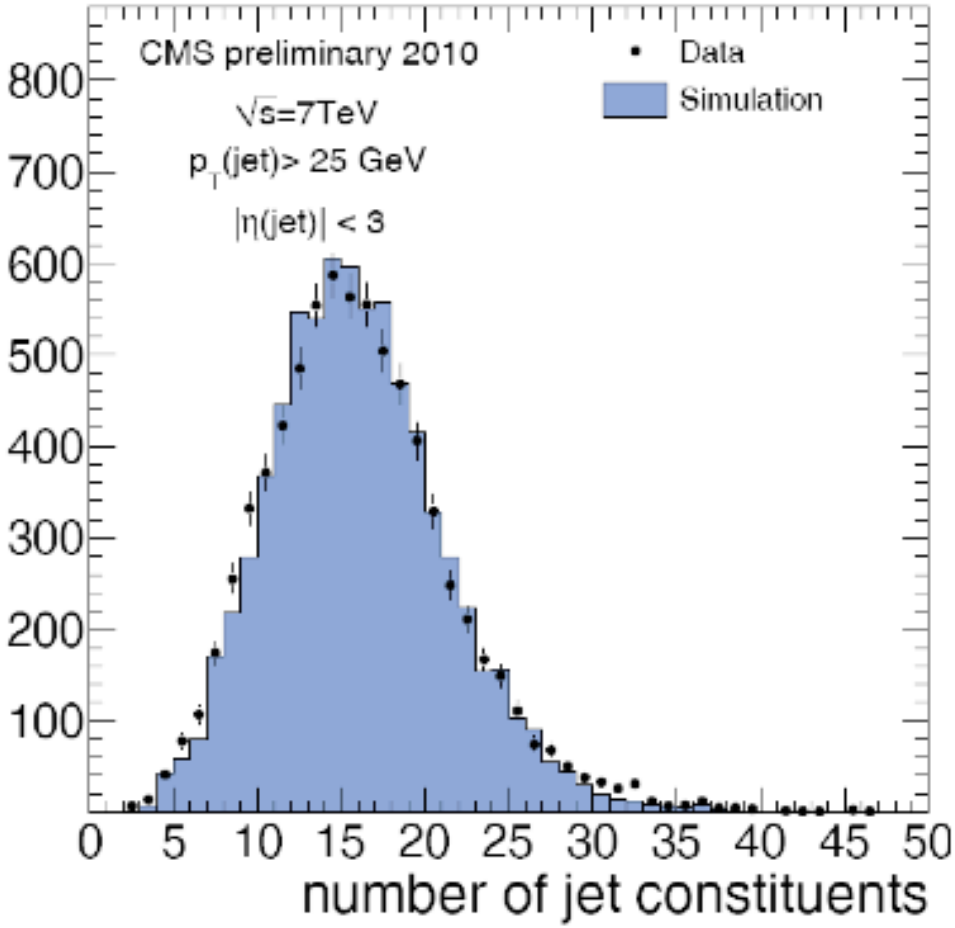


Particle flow jet performance

calorimeter

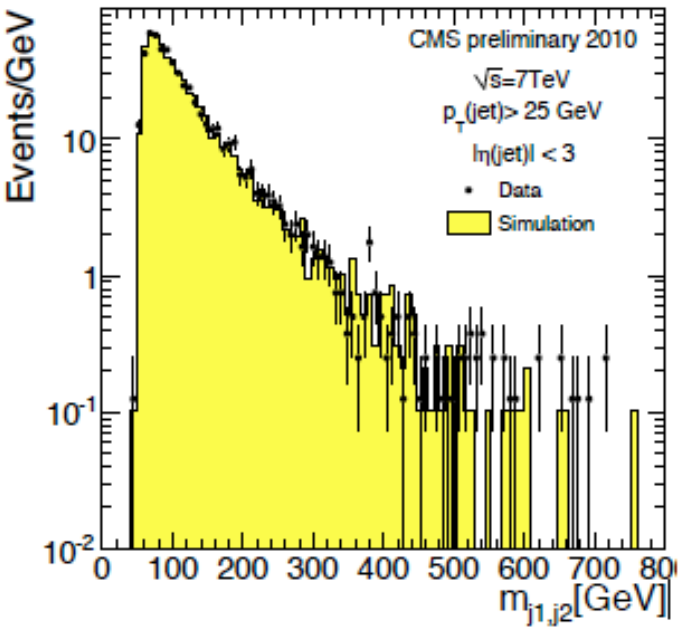


particle flow

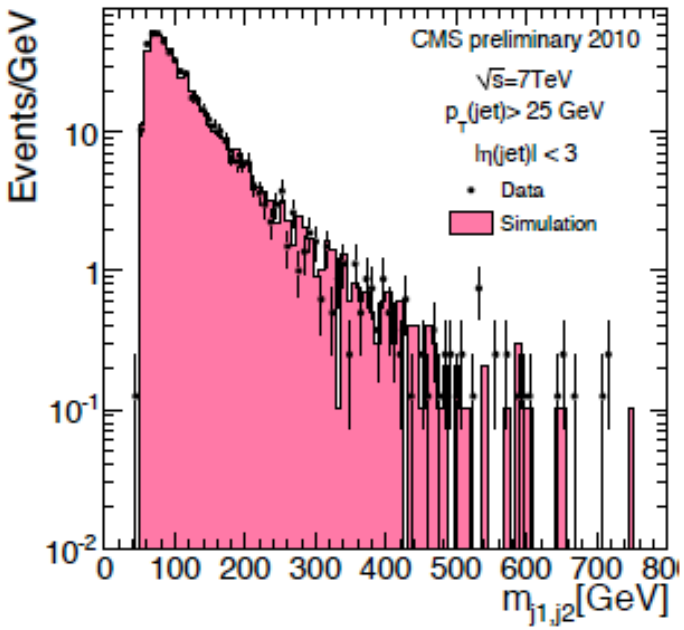


Jets: the first inverse nb at 7 TeV

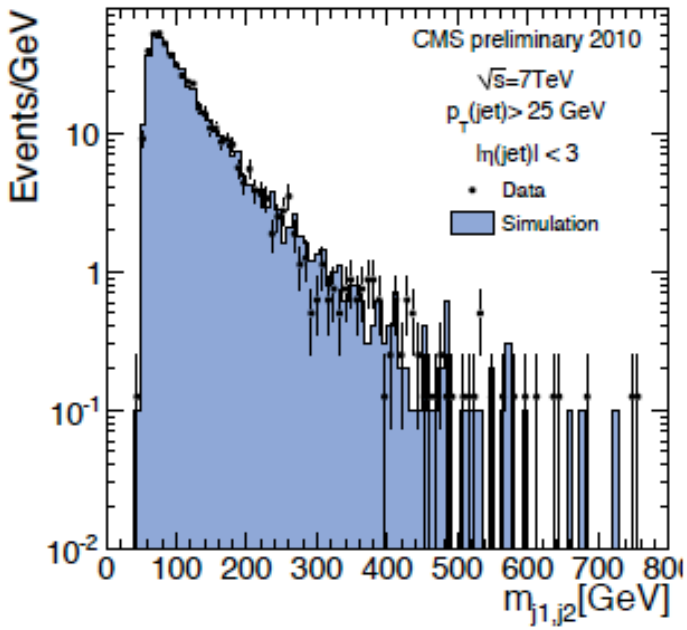
calorimeter



jet plus track



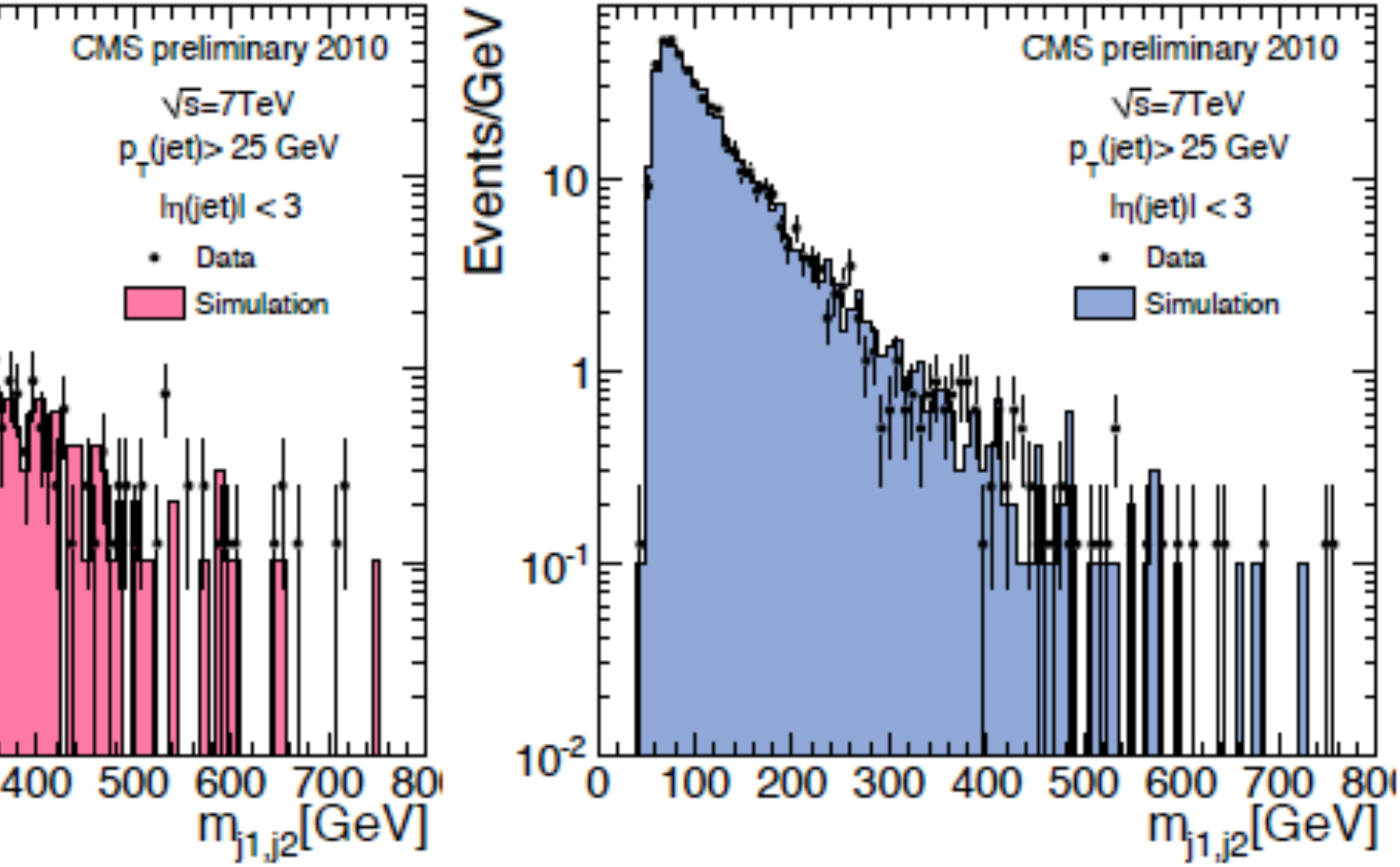
particle flow



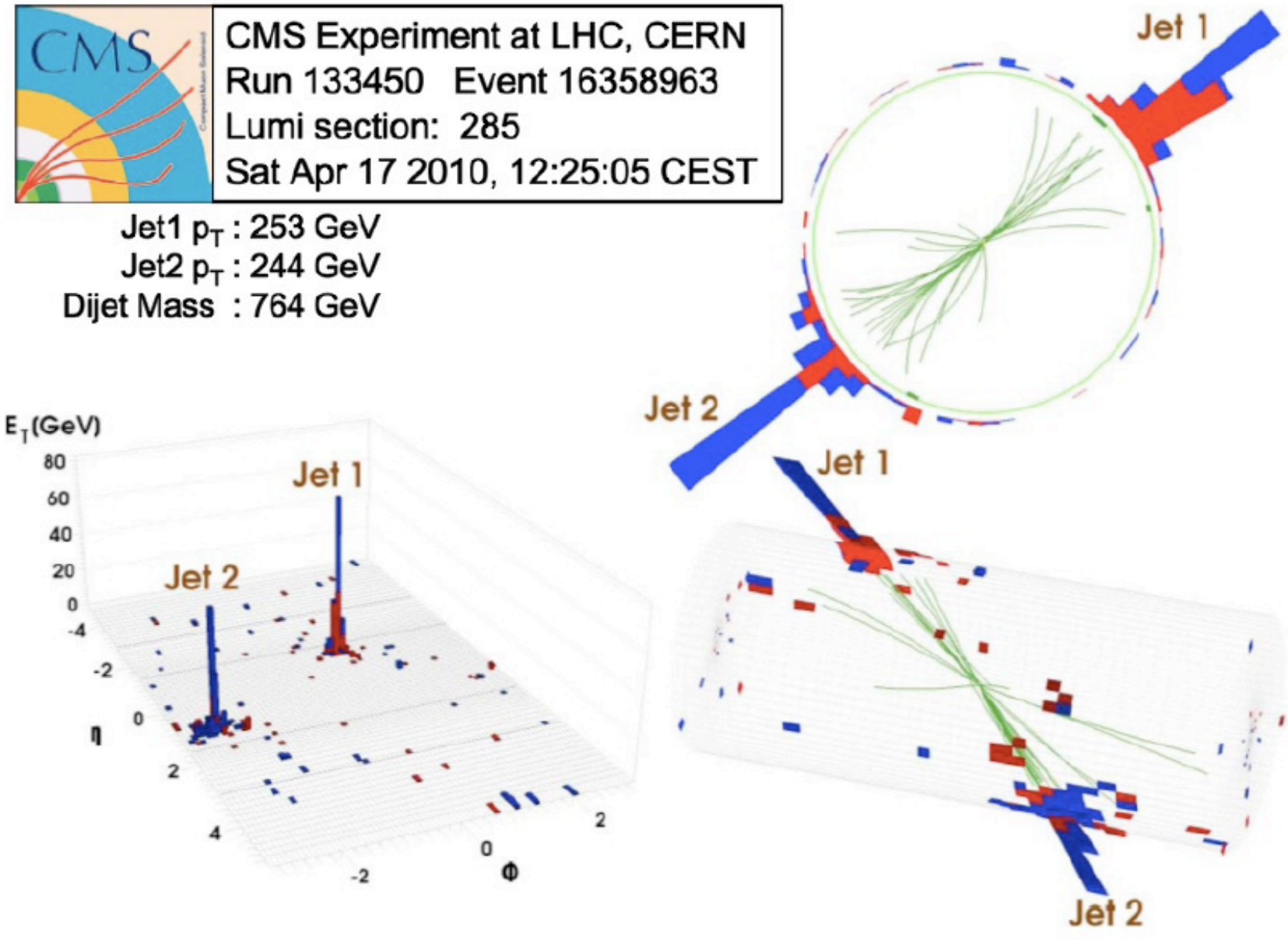
excellent agreement with simulation!

Jets: the first inverse nb at 7 TeV

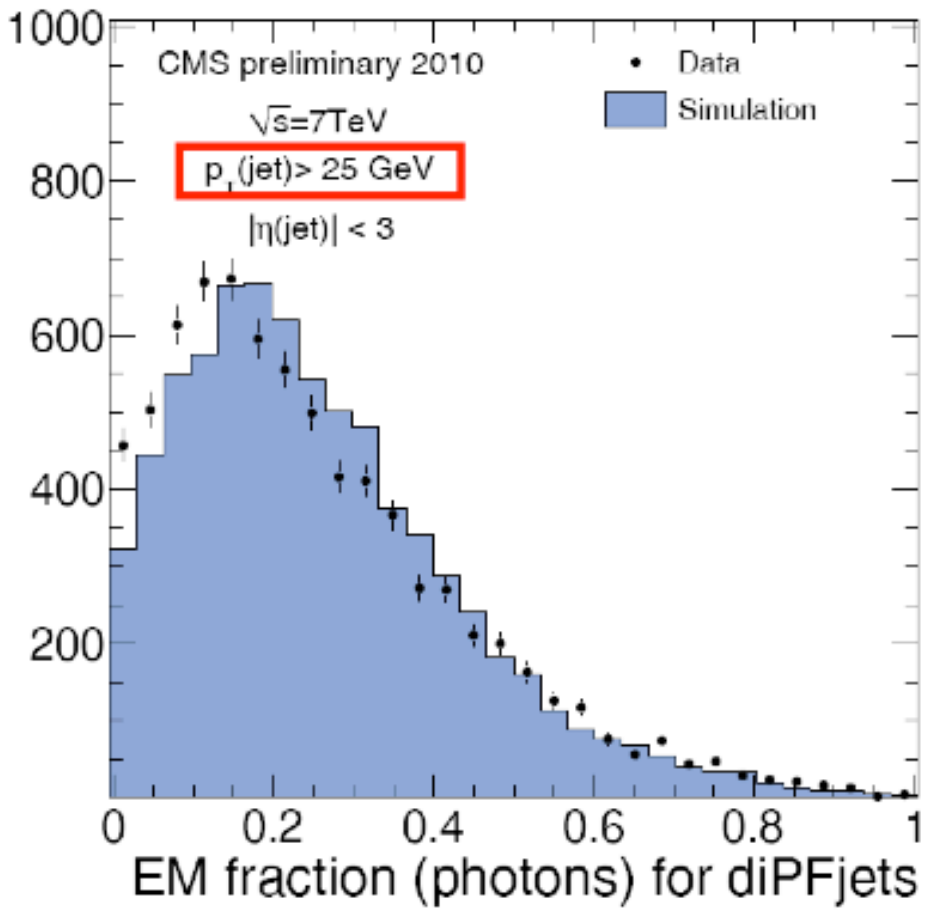
Will surpass Tevatron very soon in dijet searches!

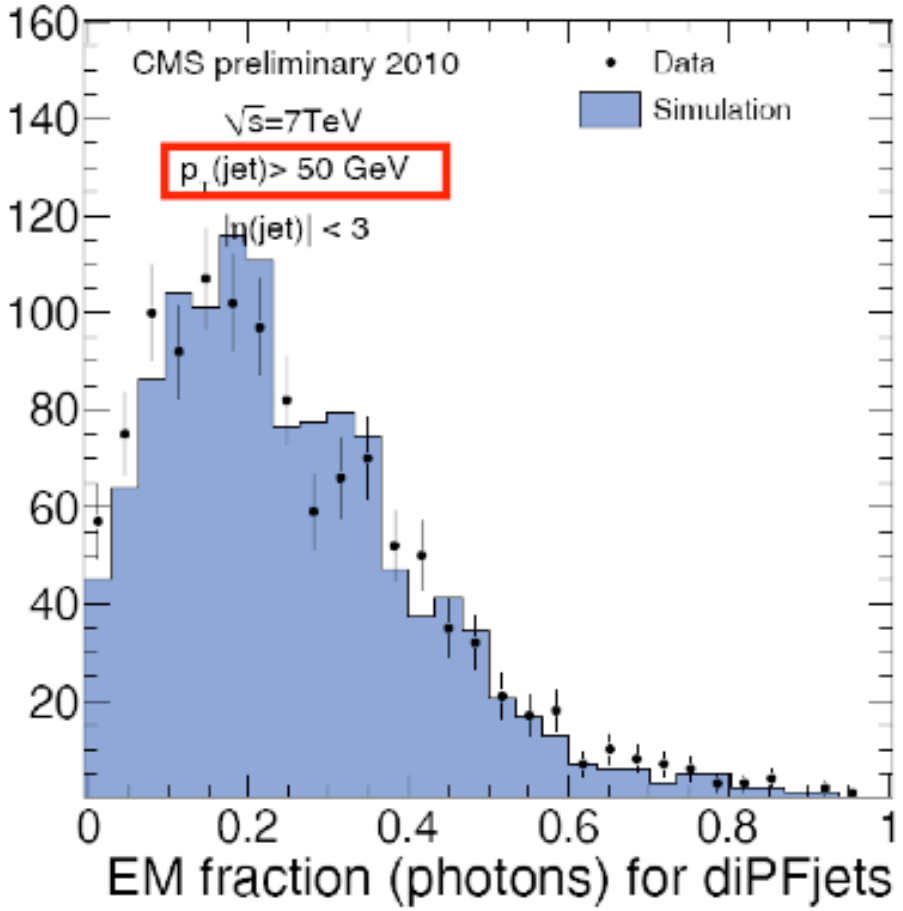


High-mass dijet at 7 TeV



Particle flow jet performance

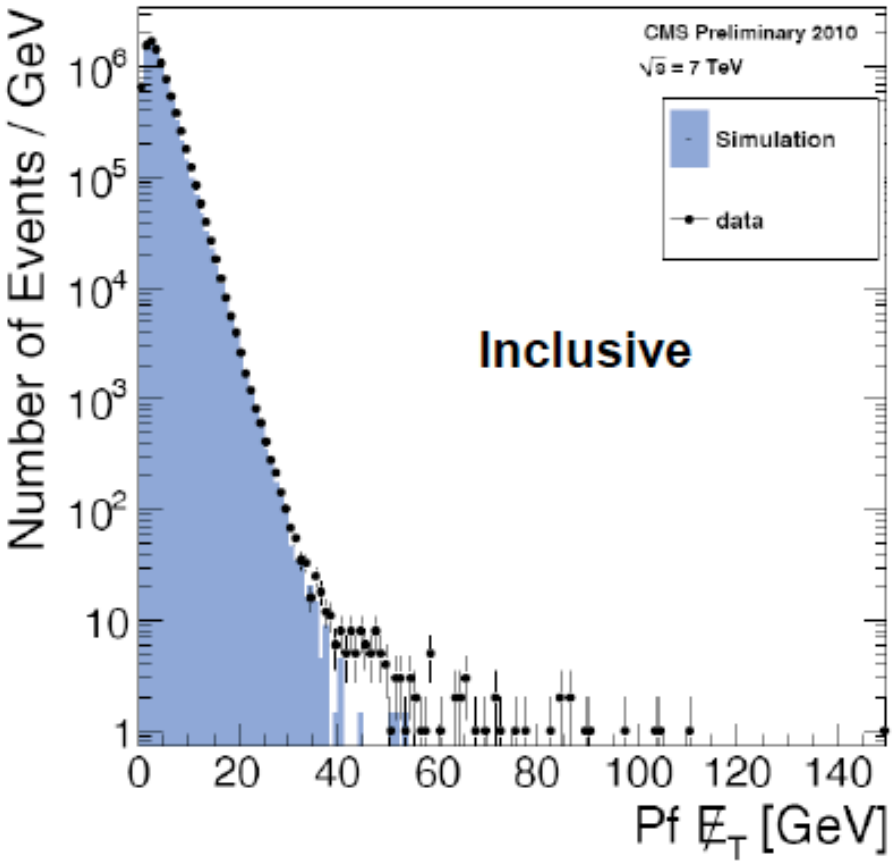


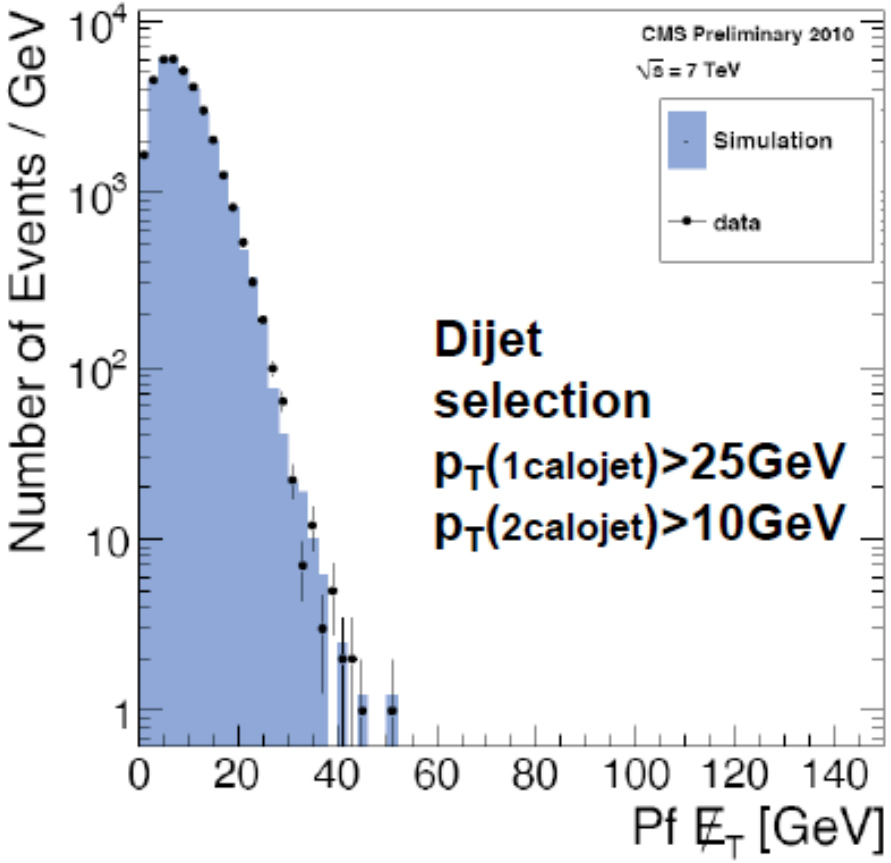


EM fraction better described at higher jet energy

Missing E_T

- need to clean up calorimeter spikes and noise in ECAL, HCAL, and HF

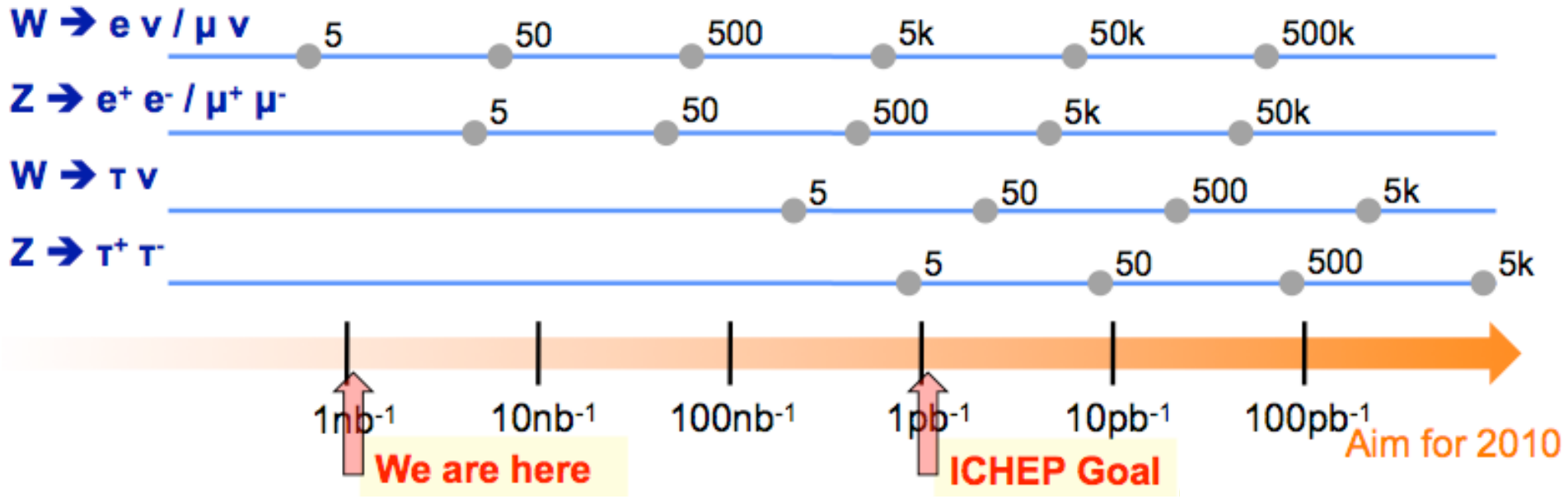




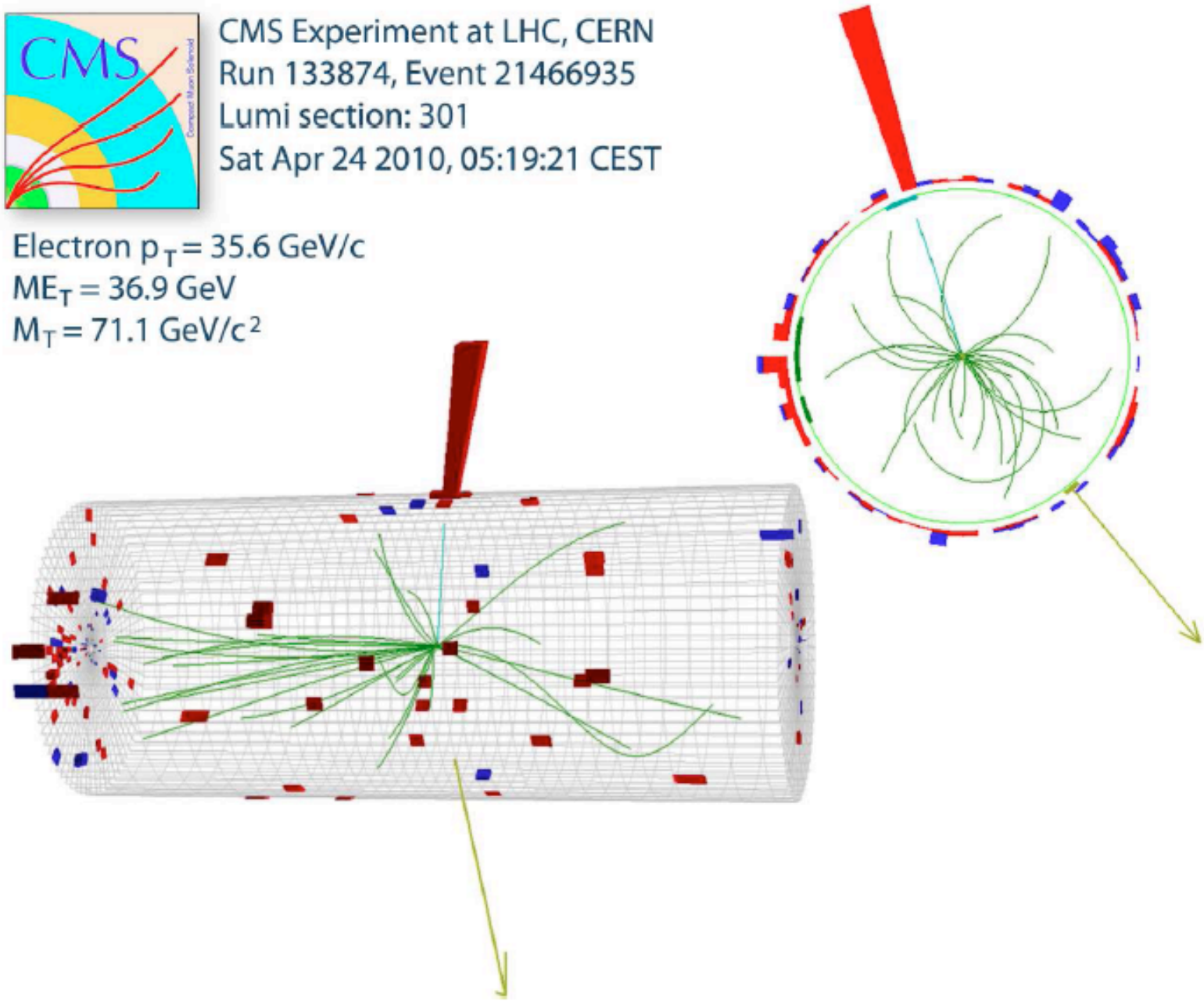
Early Signposts: W and Z

W^+ : 56 nb W^- : 39.5 nb total: 95.5 nb

Z/γ^* : 49.5 nb



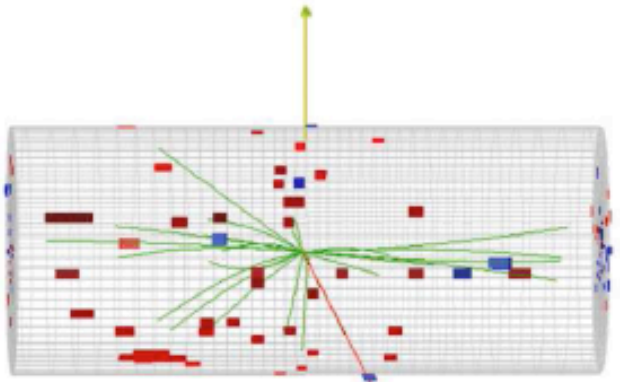
W→eν candidate

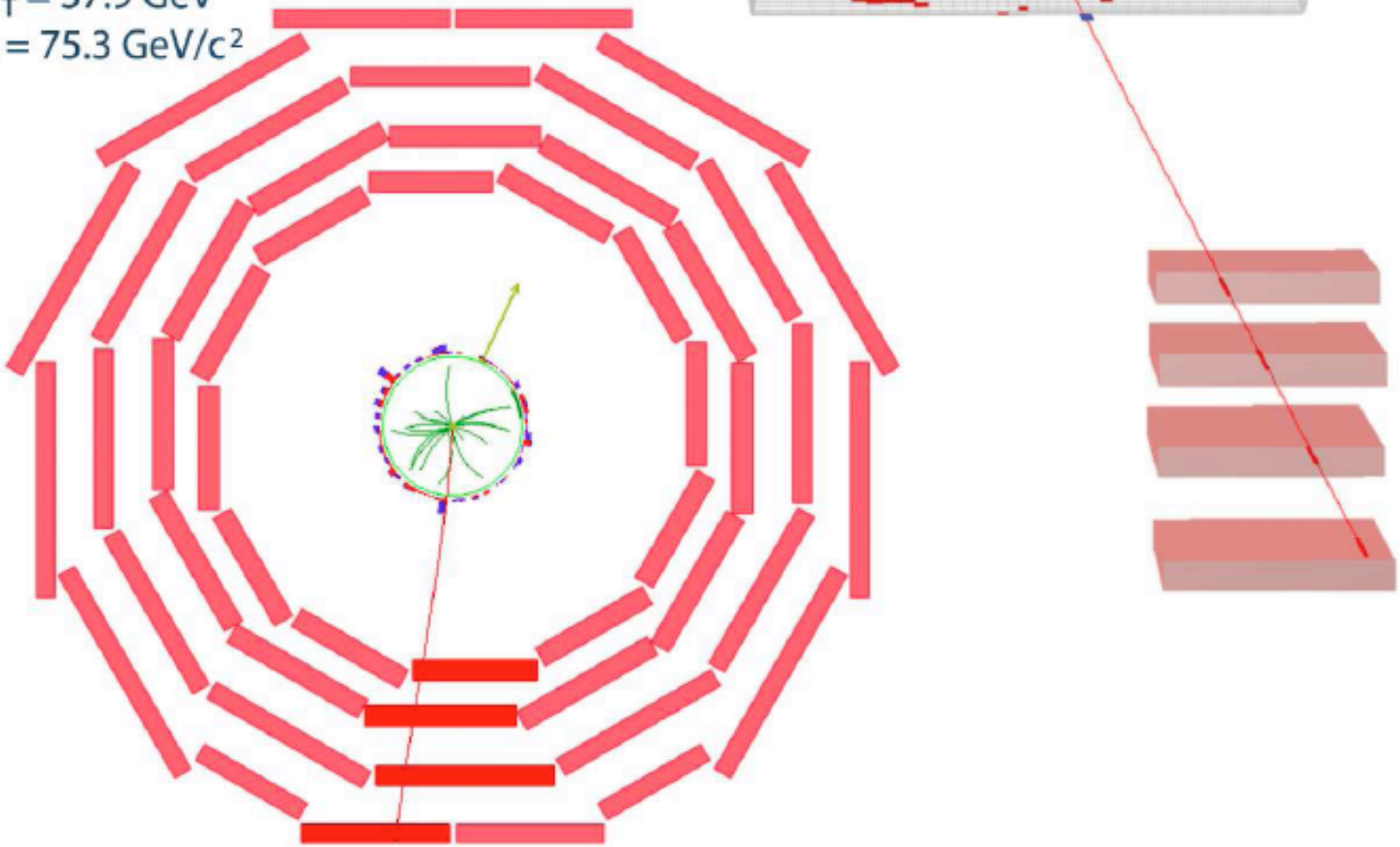


W→μν candidate

CMS Experiment at LHC, CERN
Run 133875, Event 1228182
Lumi section: 16
Sat Apr 24 2010, 09:08:46 CEST

Muon $p_T = 38.7$ GeV/c
$ME_T = 37.9$ GeV
$M_T = 75.3$ GeV/c^2

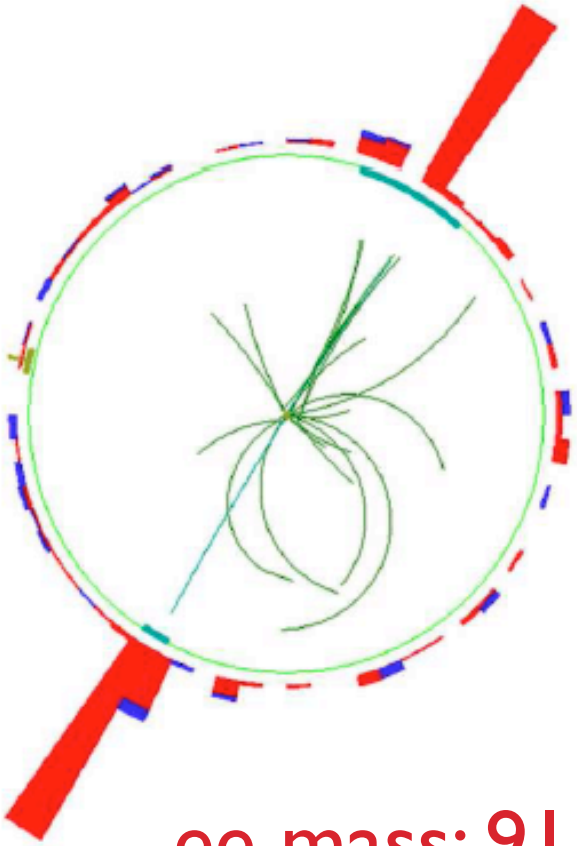


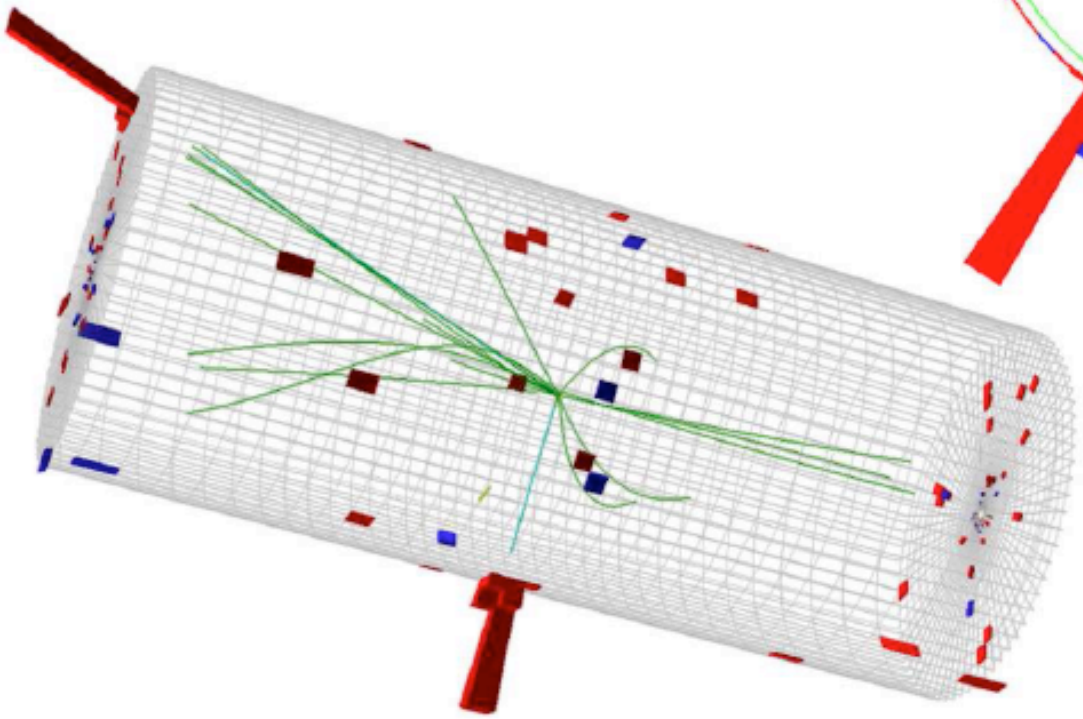


Z→ee candidate

CMS Experiment at LHC, CERN
Run 133877, Event 28405693
Lumi section: 387
Sat Apr 24 2010, 14:00:54 CEST

Electrons p_T = 34.0, 31.9 GeV/c
Inv. mass = 91.2 GeV/c^2

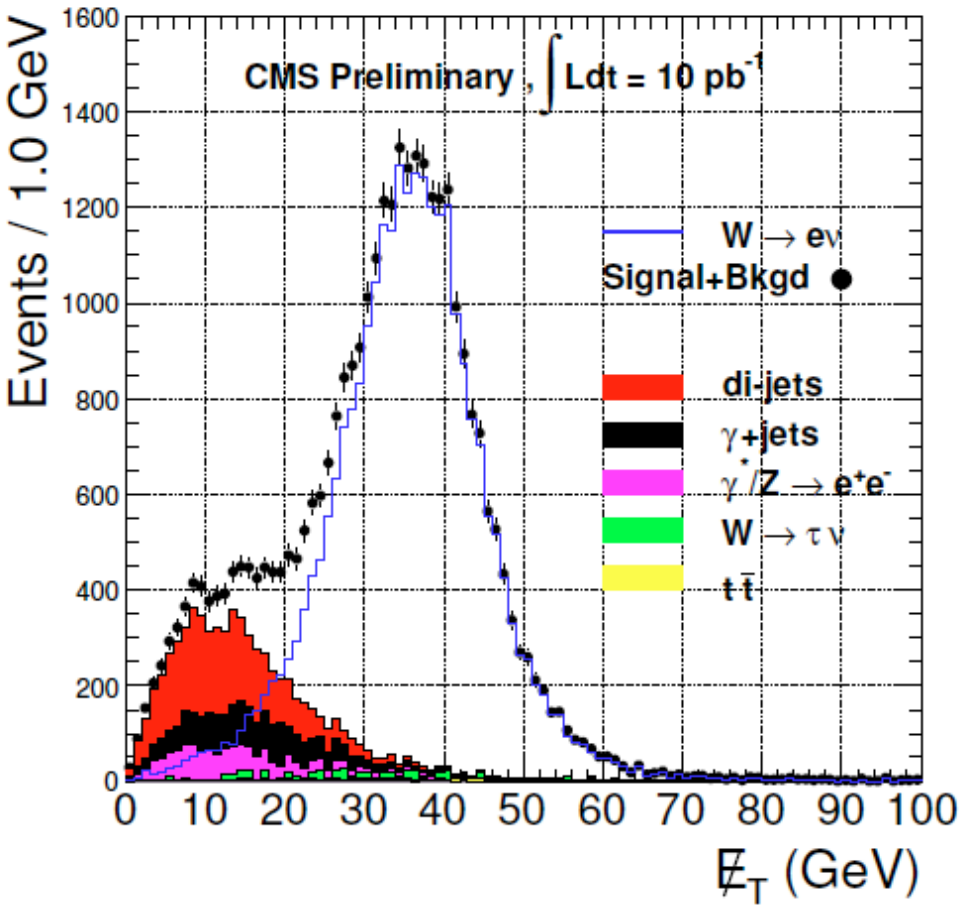




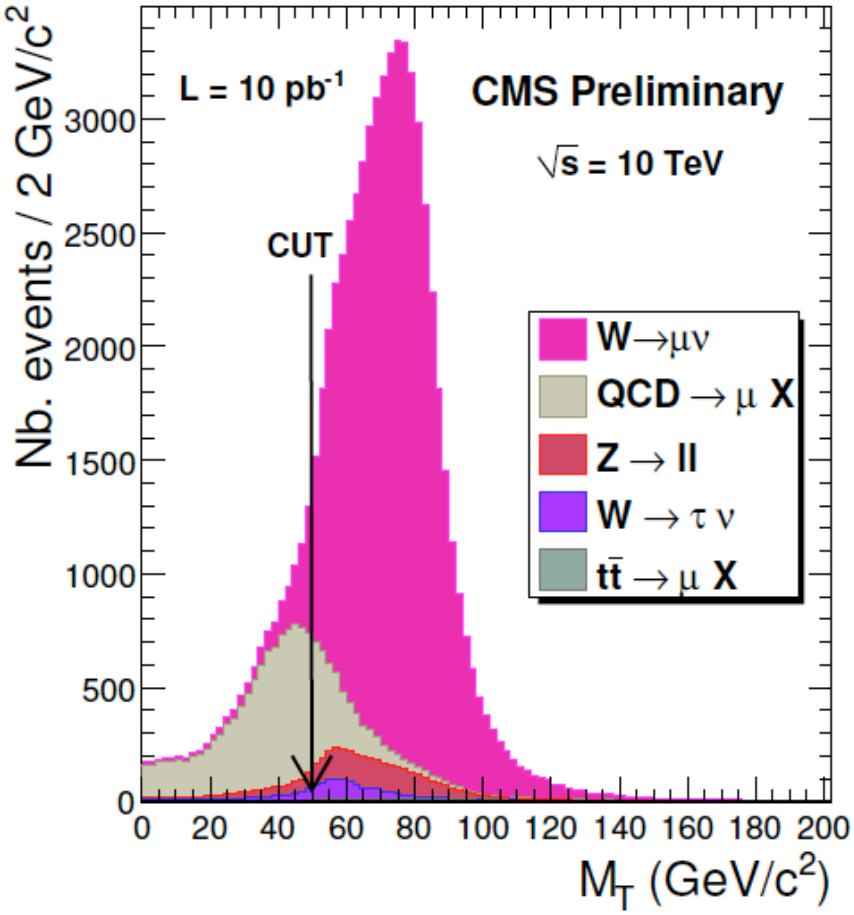
ee mass: 91.2 GeV

Early Signposts: $W \to \ell \nu$

electrons



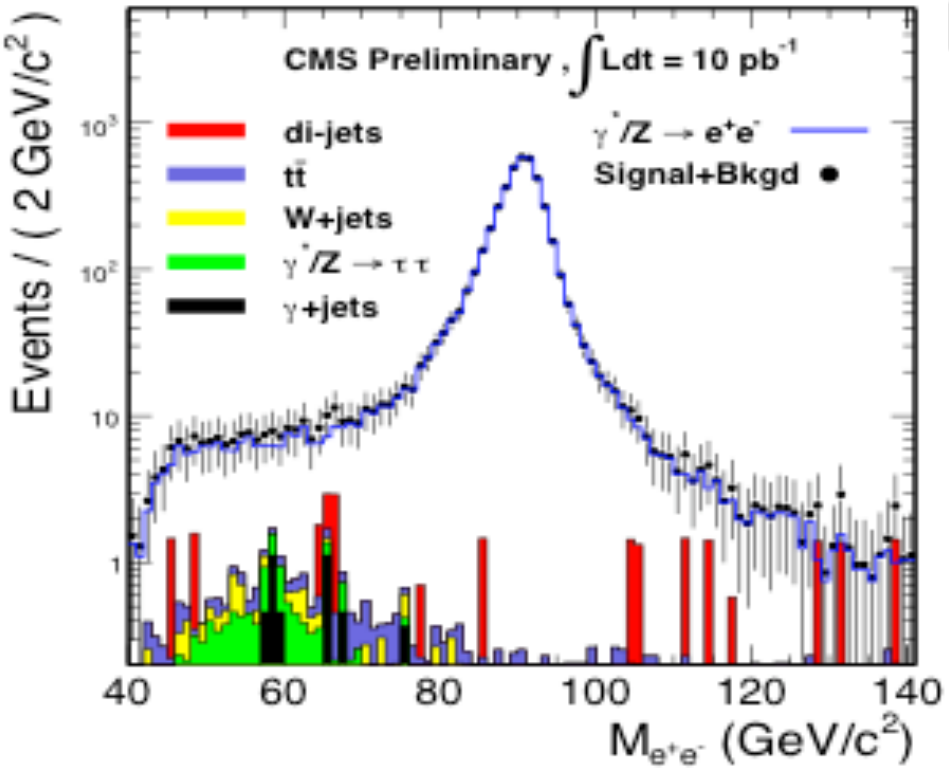
muons



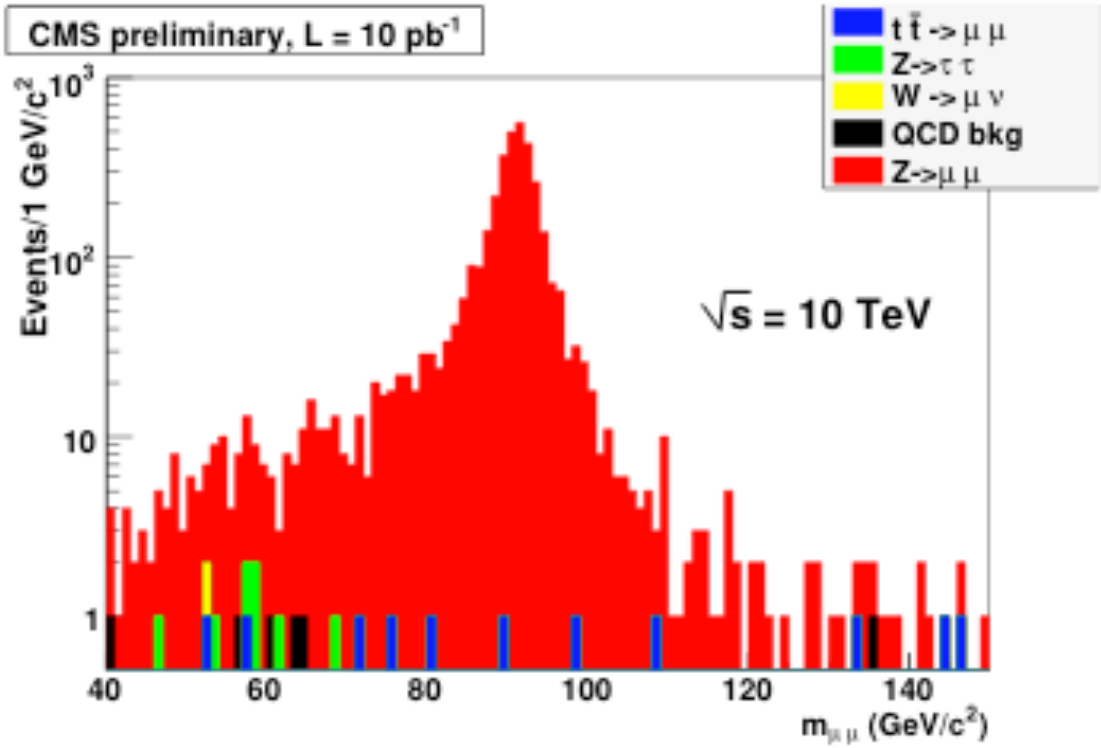
Expect very clean $W \to \ell\nu$ distributions

Early Signposts: $Z \rightarrow \ell\ell$

electrons



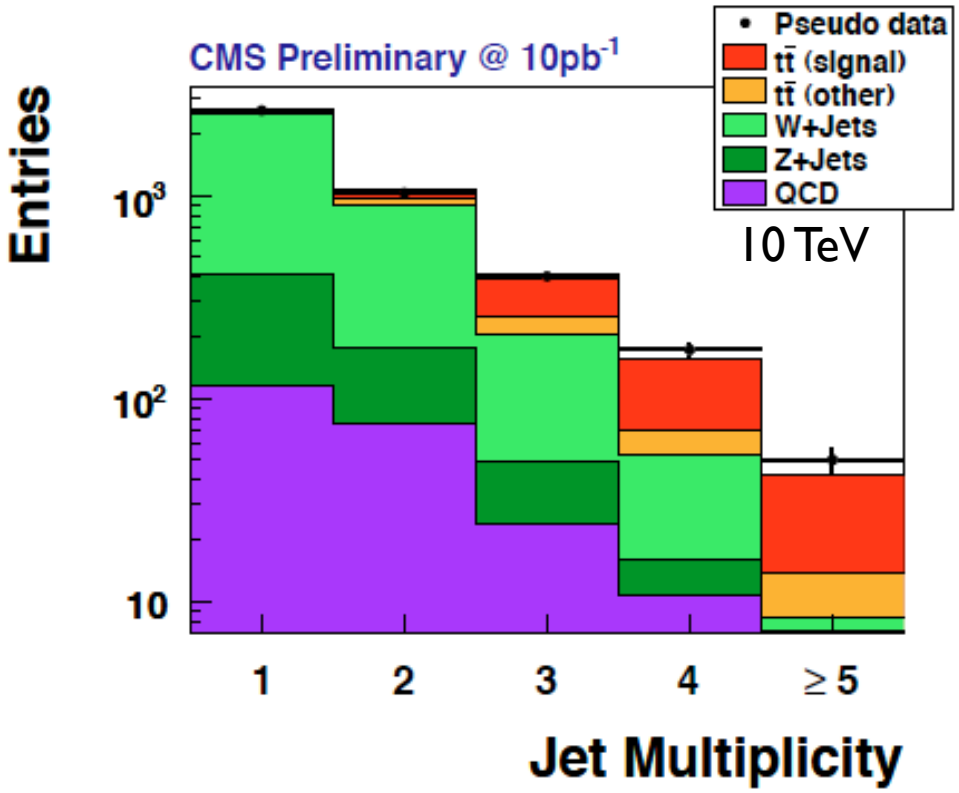
muons

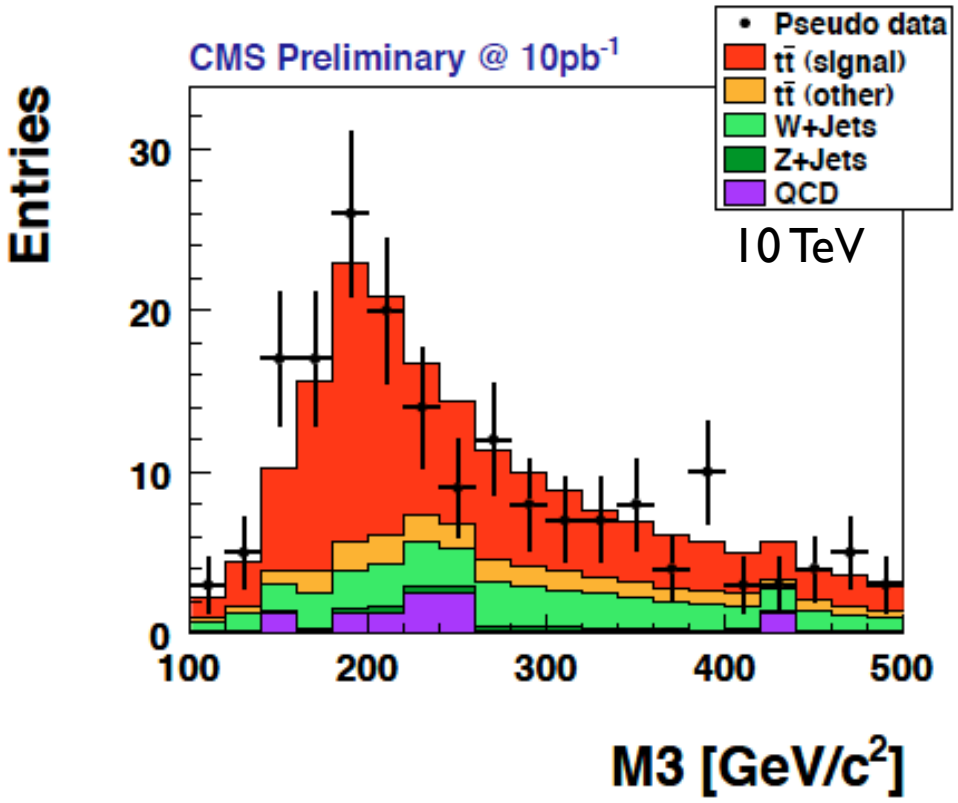


$Z \rightarrow \ell\ell$ is our most important early calibration

significant samples coming very soon!

Early Signposts: top





With ~20 pb^{-1} expect to observe hundreds of ttbar events, and calibrate jet energy scale, b-tagging, MET, and later test boosted top algorithms

"The LHC only has 7 TeV, and will only get one inverse femtobarn...it won't do any better than the Tevatron!"

New 7 TeV BSM projections

Available on CMS information server

CMS NOTE 2010/008

The Compact Muon Solenoid Experiment

CMS Note

Mailing address: CMS CERN, CH-1211 GENEVA 23, Switzerland

5th May 2010

The CMS physics reach for searches at 7 TeV

The CMS Collaboration

Abstract

Some examples of the expected reach of CMS in terms of searches for new physics, for a proton-proton centre-of-mass energy of 7 TeV, are shown. Integrated luminosities between 100 pb^{-1} and 1 fb^{-1} are considered. The prospects are preliminary, and based on existing studies at higher energies.

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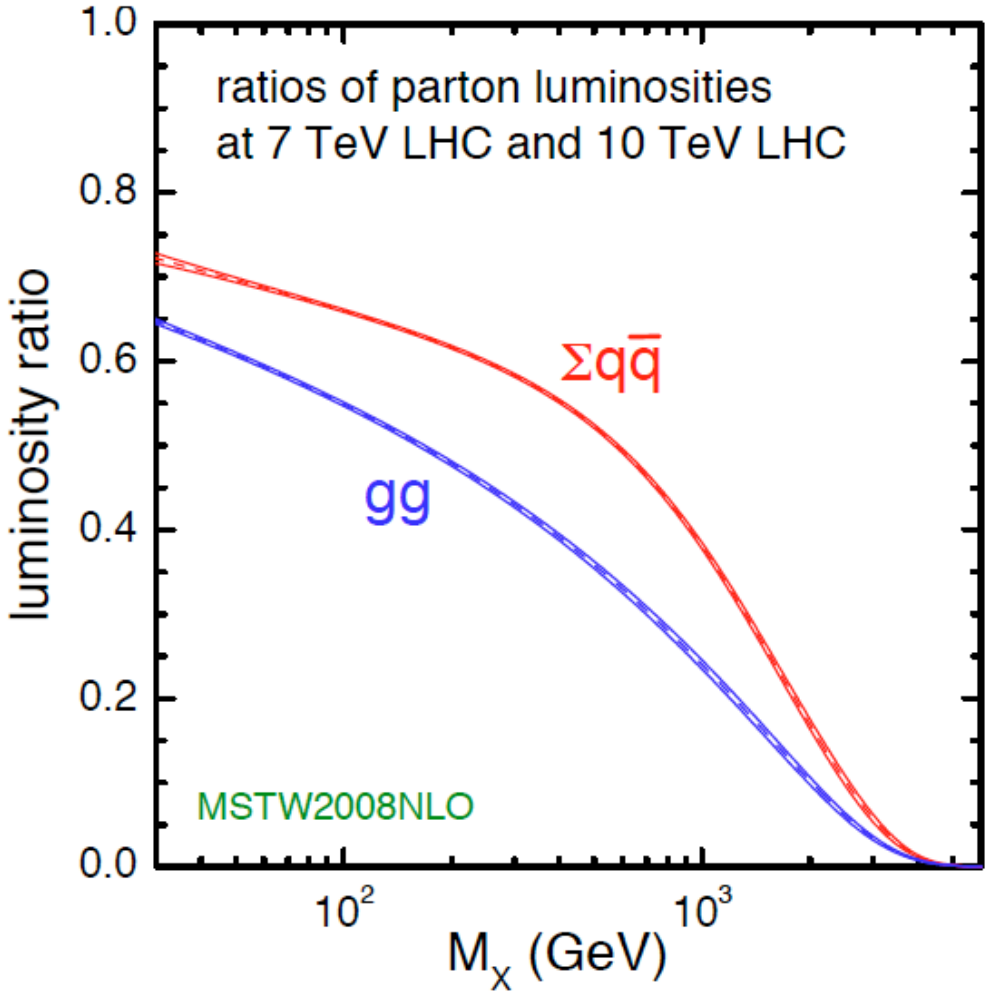
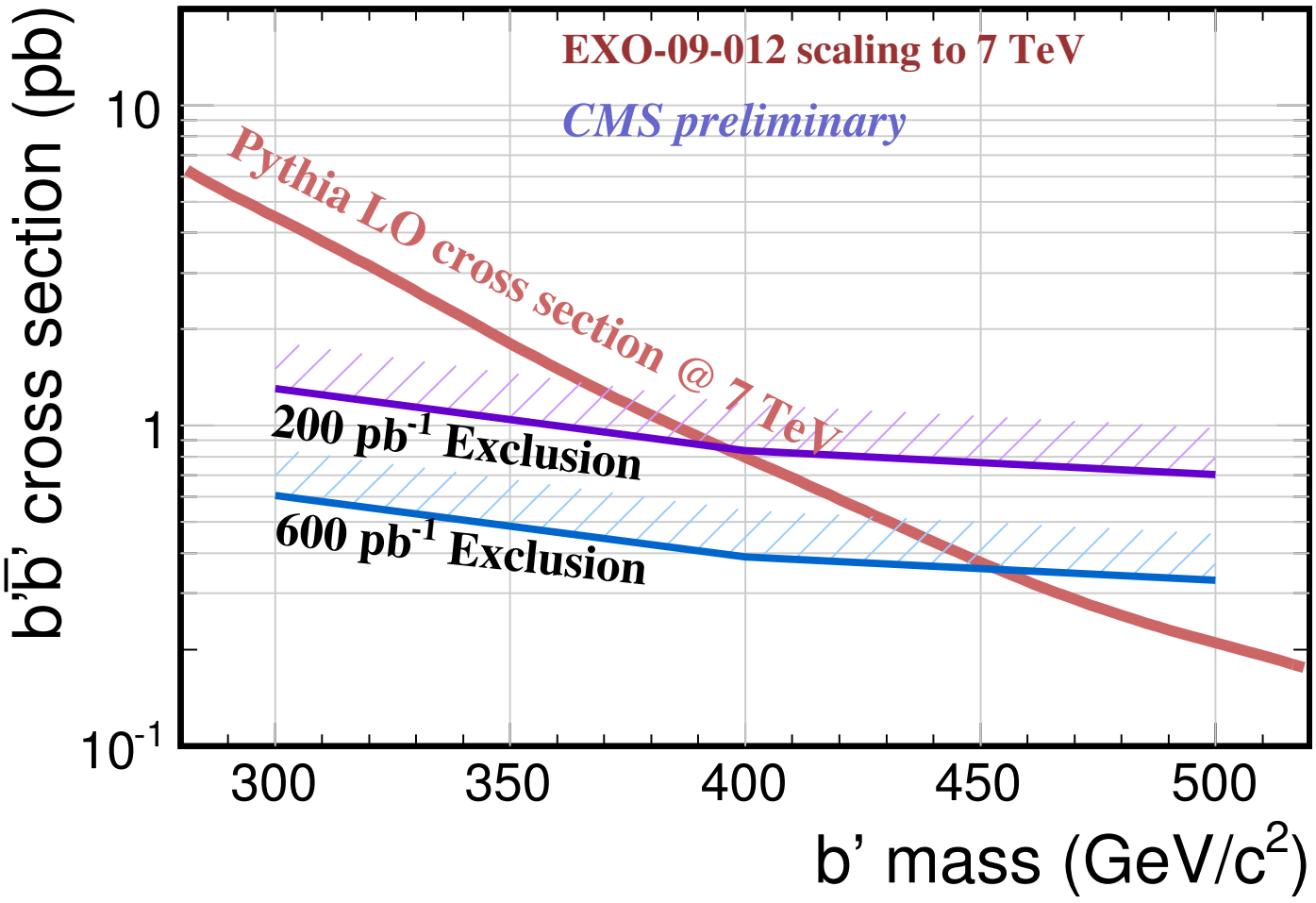
note posted at Pheno 2010 website

Rescaling 10 TeV to 7 TeV

Take 10 TeV results for new particle searches and simply scale by expected qq, gg luminosity ratio (courtesy James Stirling)

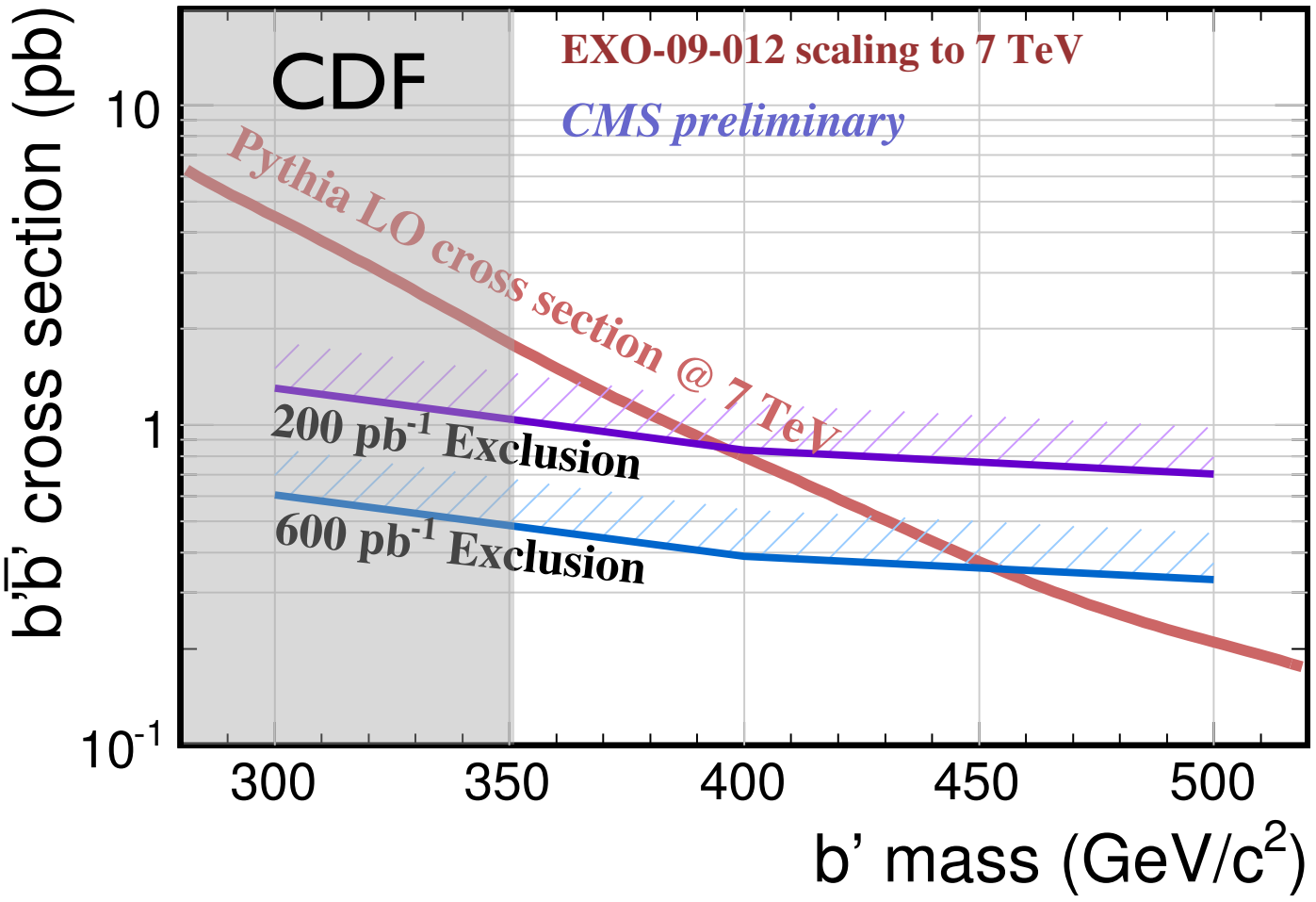


Early new physics: b' search



With ~200 pb^{-1} we can exceed Tevatron sensitivity

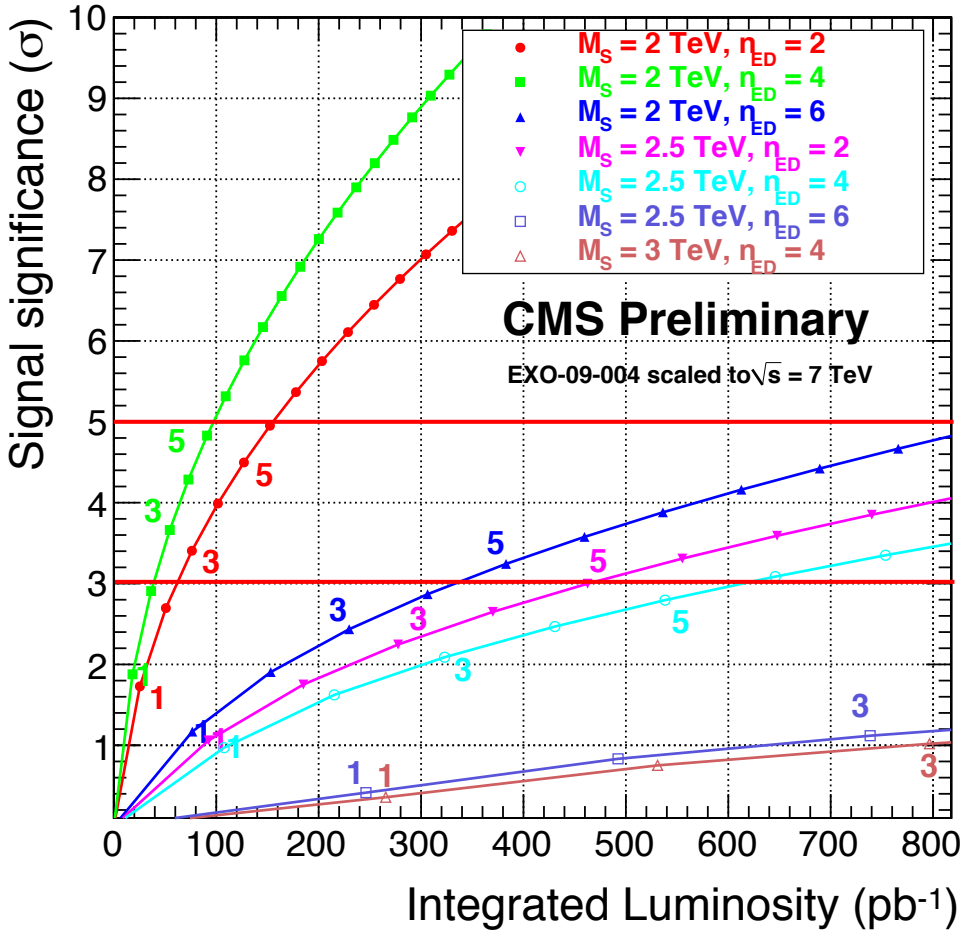
Early new physics: b' search

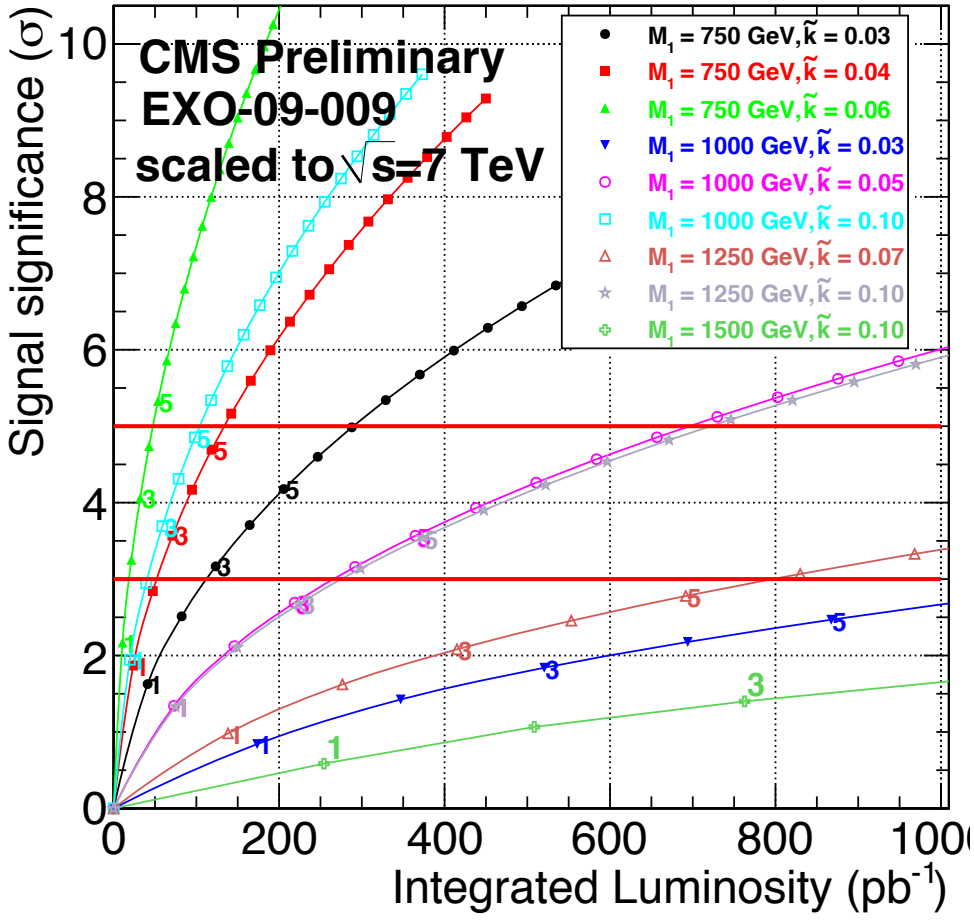


With ~200 pb^{-1} we can exceed Tevatron sensitivity

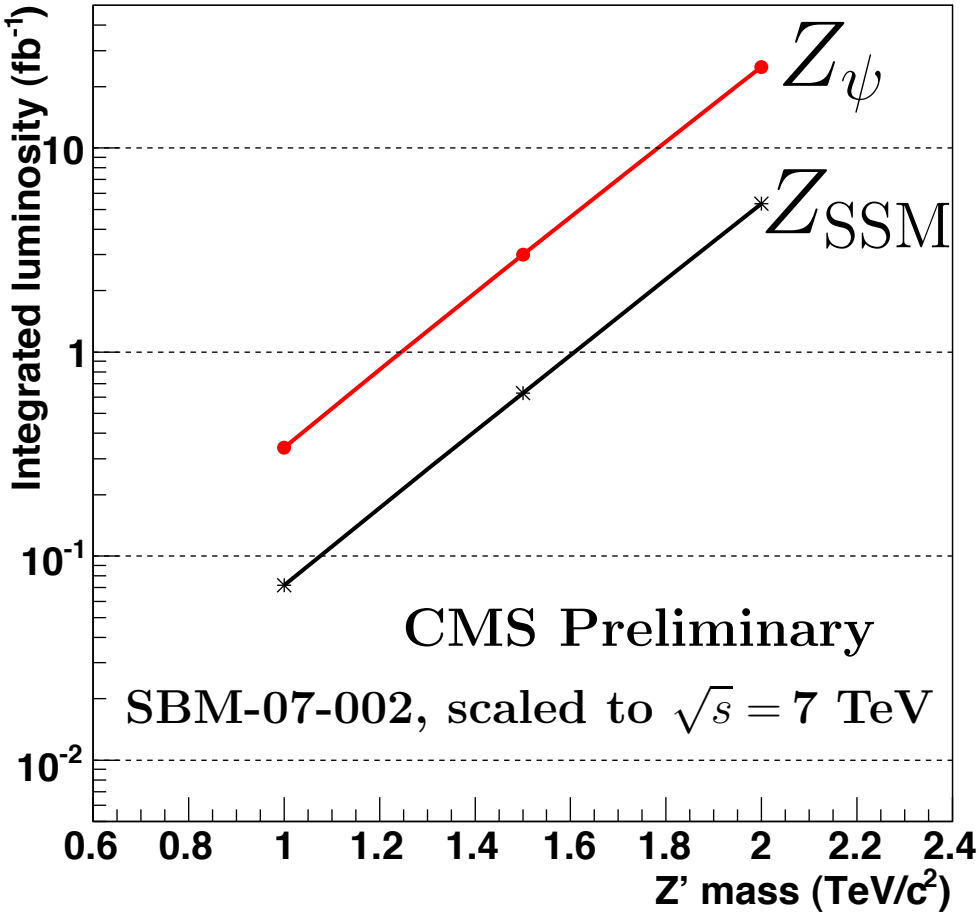
Early new physics: ED in γγ

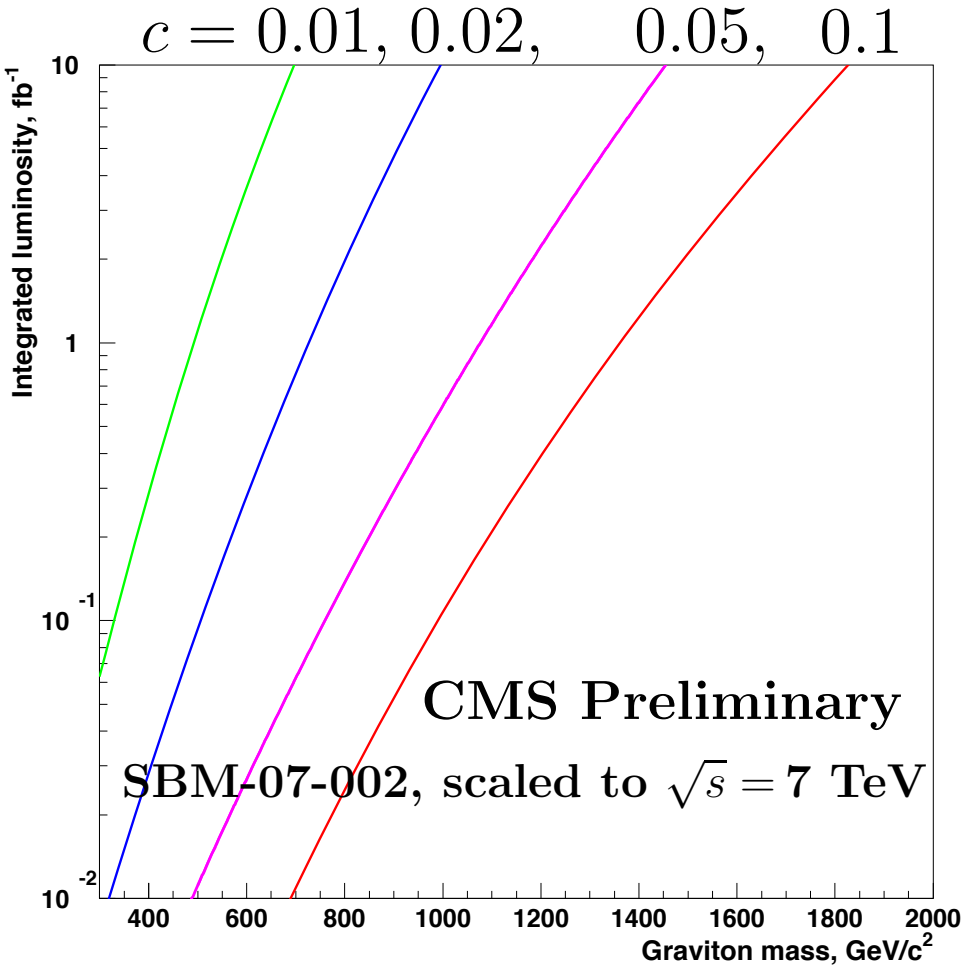
- look for very high mass photon pairs in LED and Randall-Sundrum models respectively:





Early new physics: Z′, ED in μμ

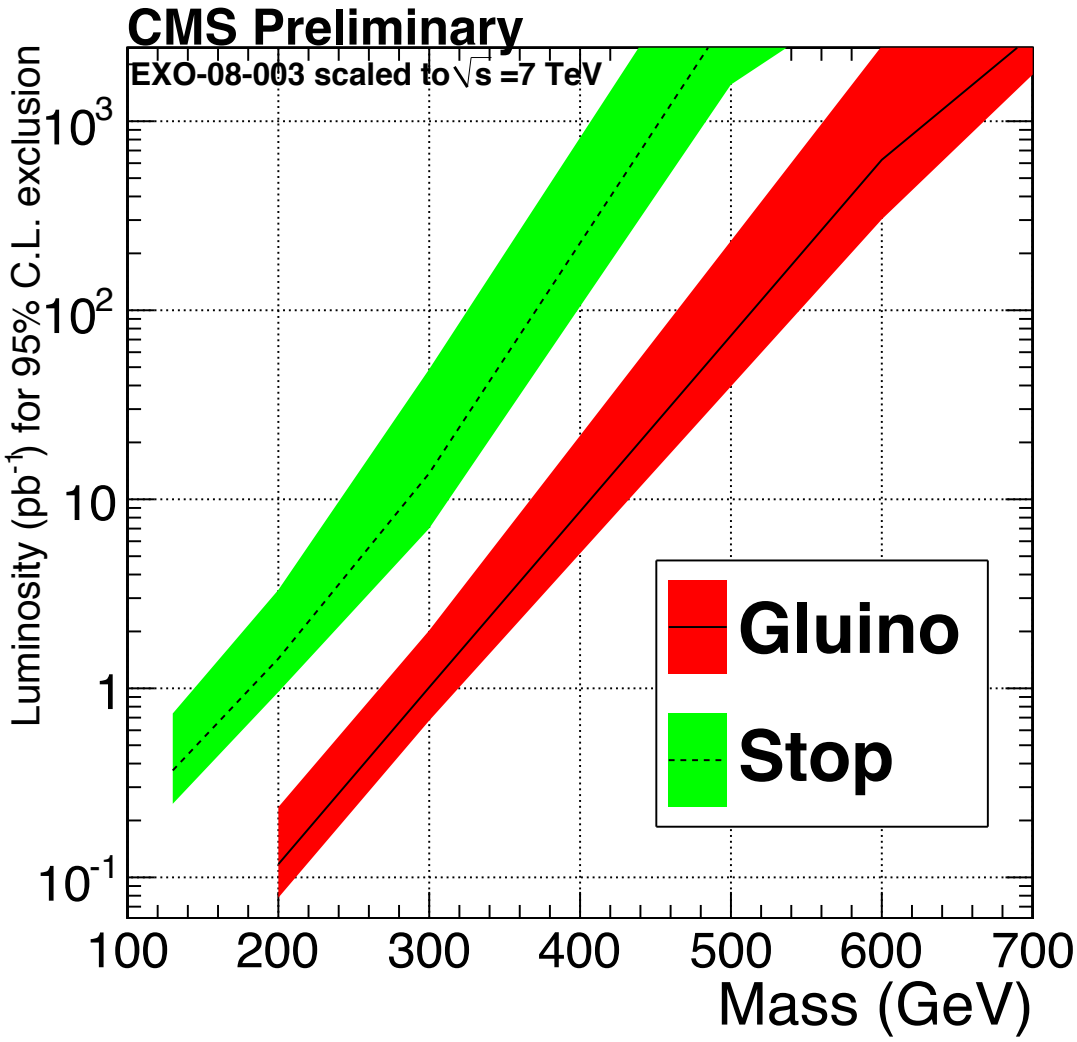




With 1 fb^{-1} will push past Tevatron

Early new physics: HSCP

- heavy stable charged particles:

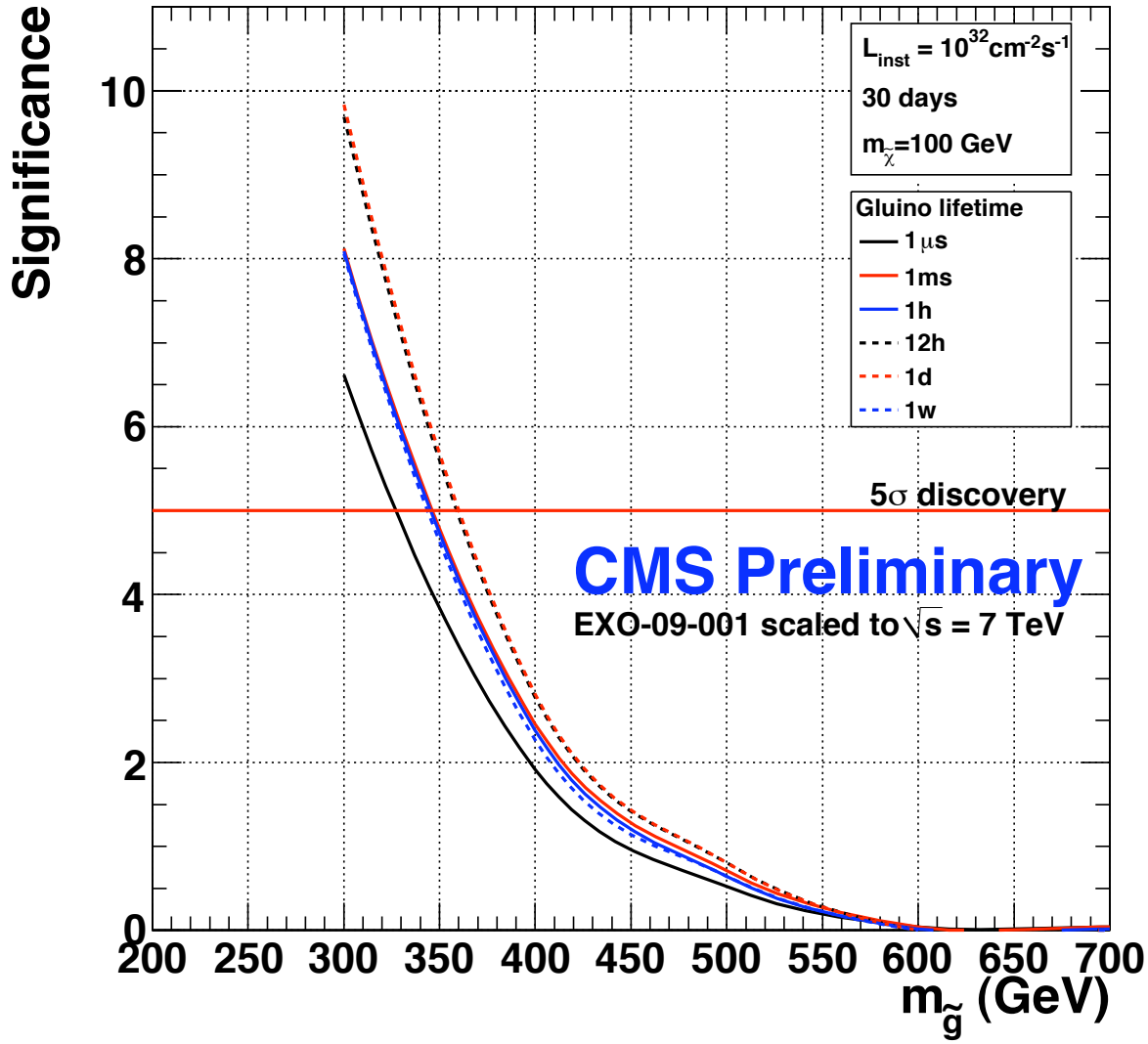


Early new physics: stopped gluinos

look for gluino decays during periods of no beam including

- inter-bunch gaps
- no-beam periods

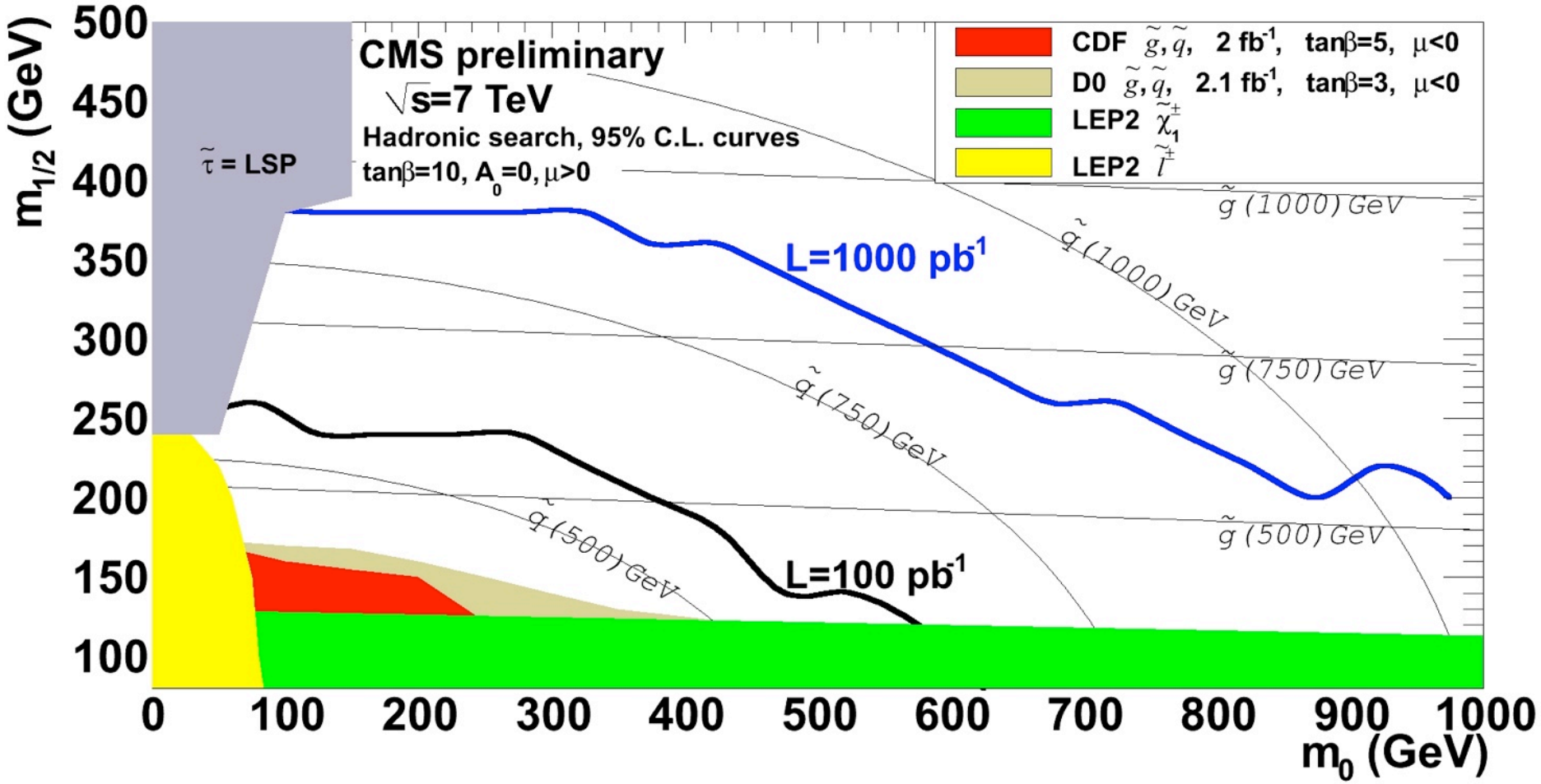
result from 30 days running at 10^{32} $cm^{-2}s^{-1}$



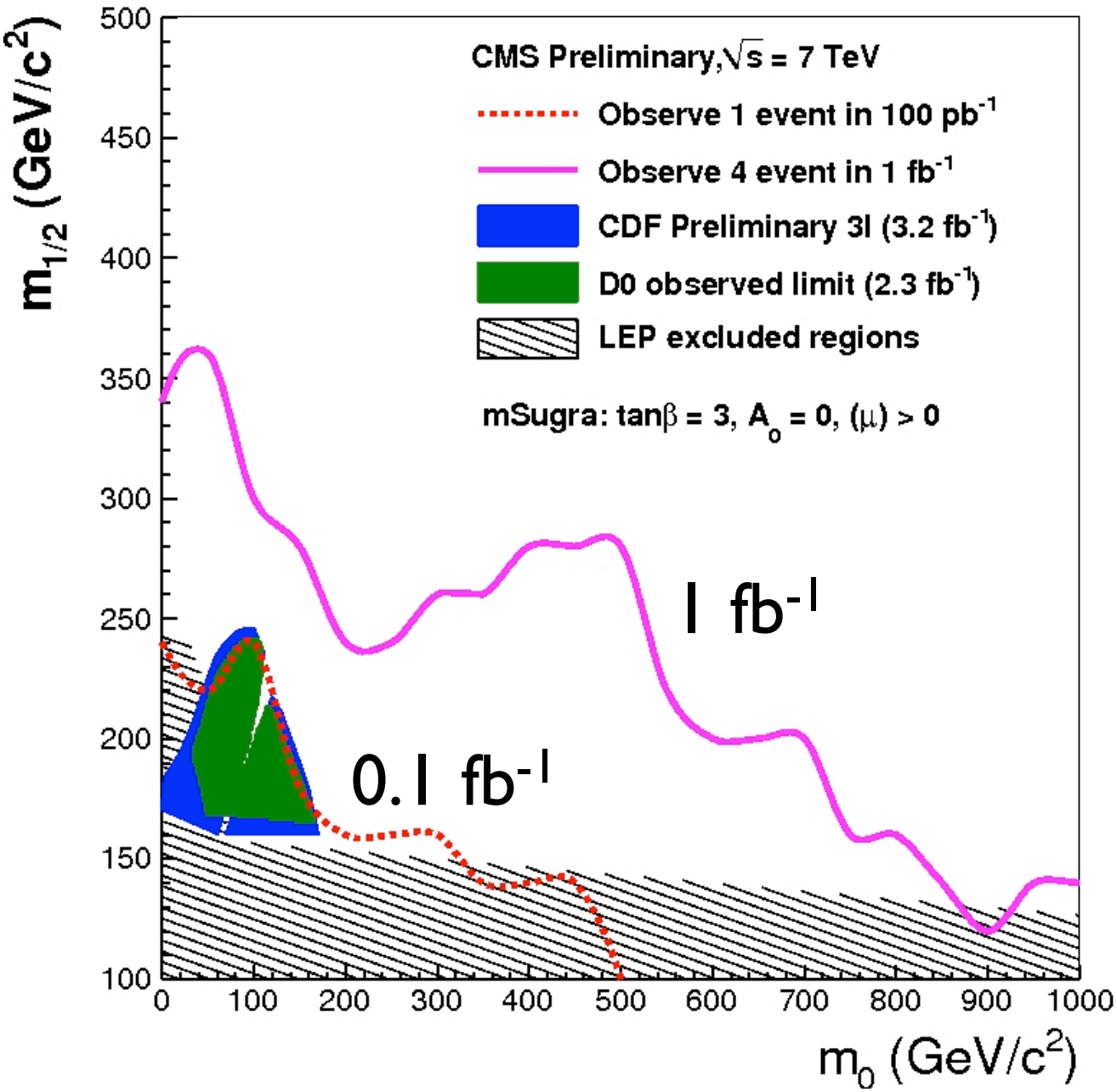
SUSY: jets + missing E_T

"Classic" all-jets search:

- 3 or more jets, E_T > 50 GeV
- missing E_T > 250 GeV
- no leptons

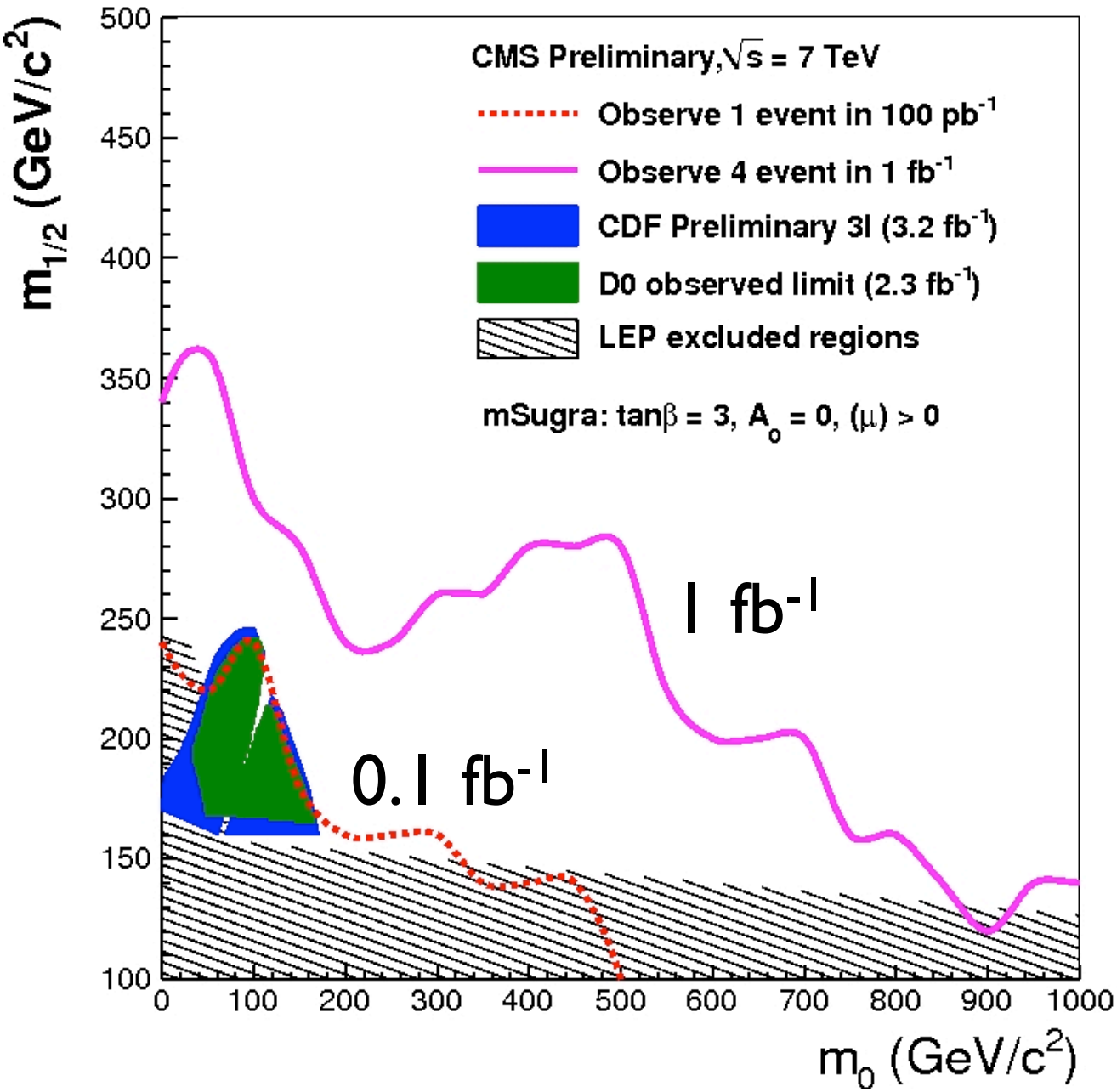


SUSY: like-sign dileptons



Similar sensitivity seen in like-sign dilepton analysis

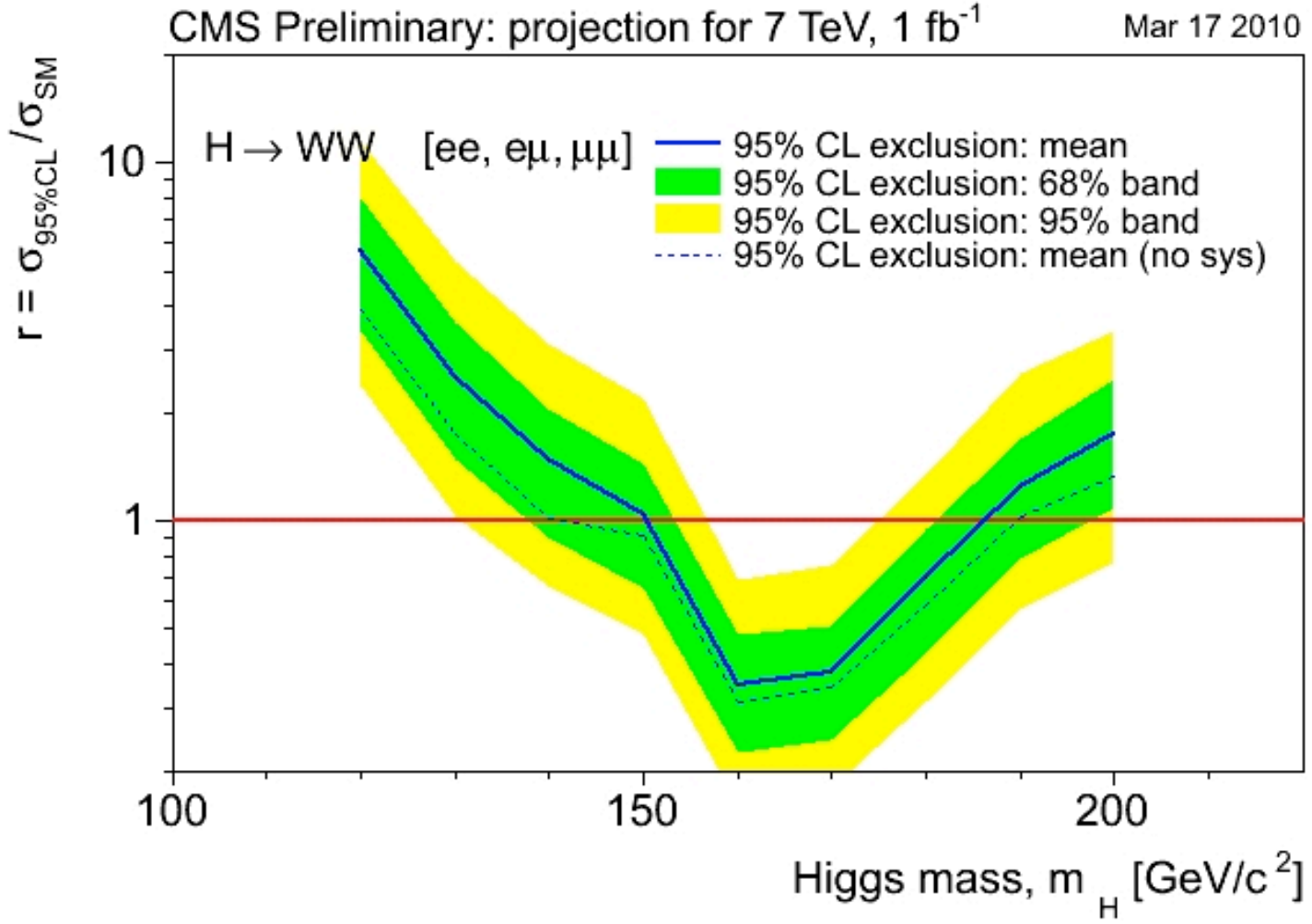
SUSY: like-sign dileptons



Similar sensitivity seen in like-sign dilepton analysis

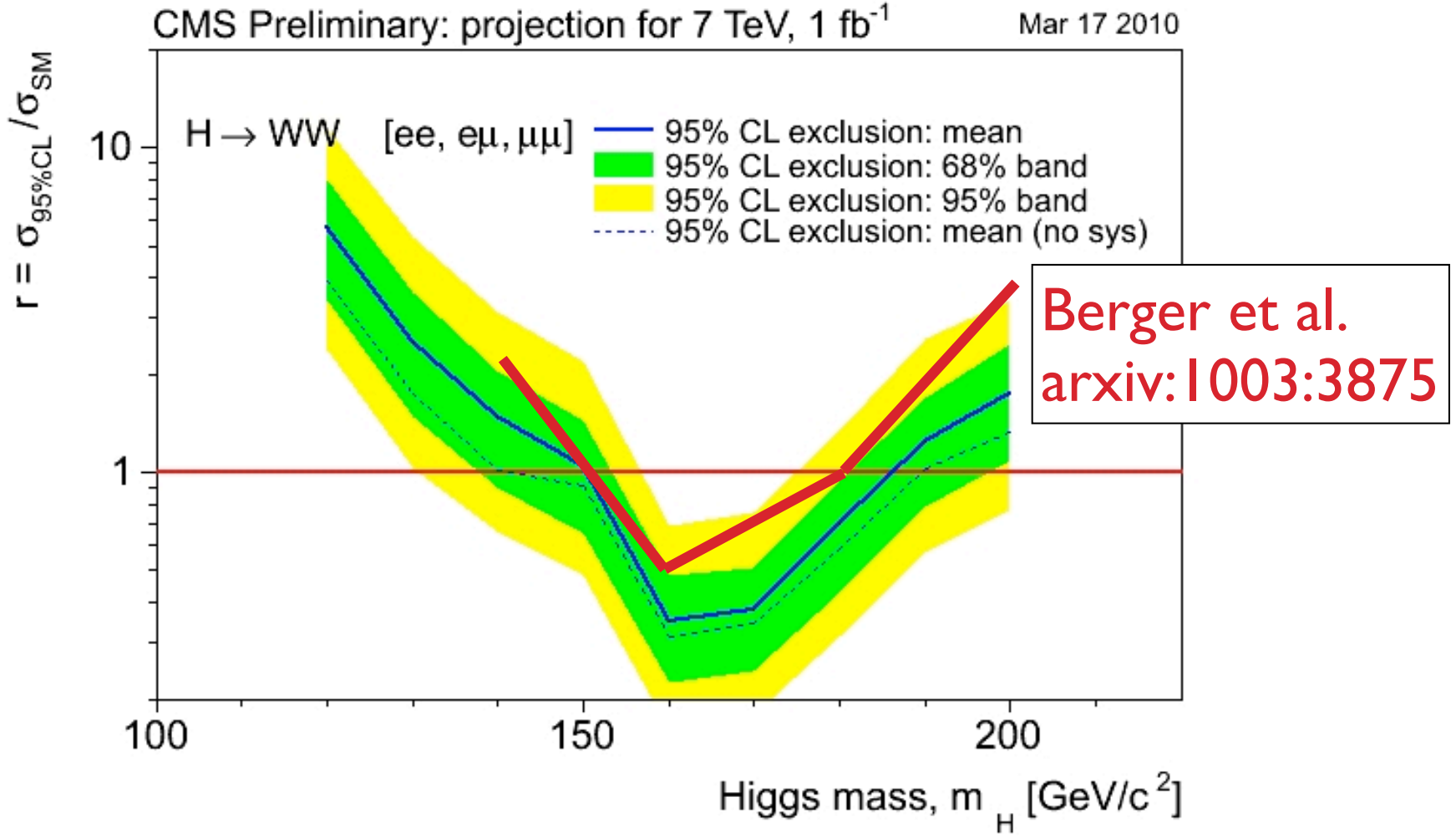
Very soon the LHC will surpass the Tevatron in the search for SUSY

SM Higgs: $WW \to 2\ell 2\nu$



No discovery of SM Higgs in first run at 7 TeV...
sensitivity similar to Tevatron with 1 fb^{-1}

SM Higgs: $WW \rightarrow 2\ell 2\nu$



No discovery of SM Higgs in first run at 7 TeV...
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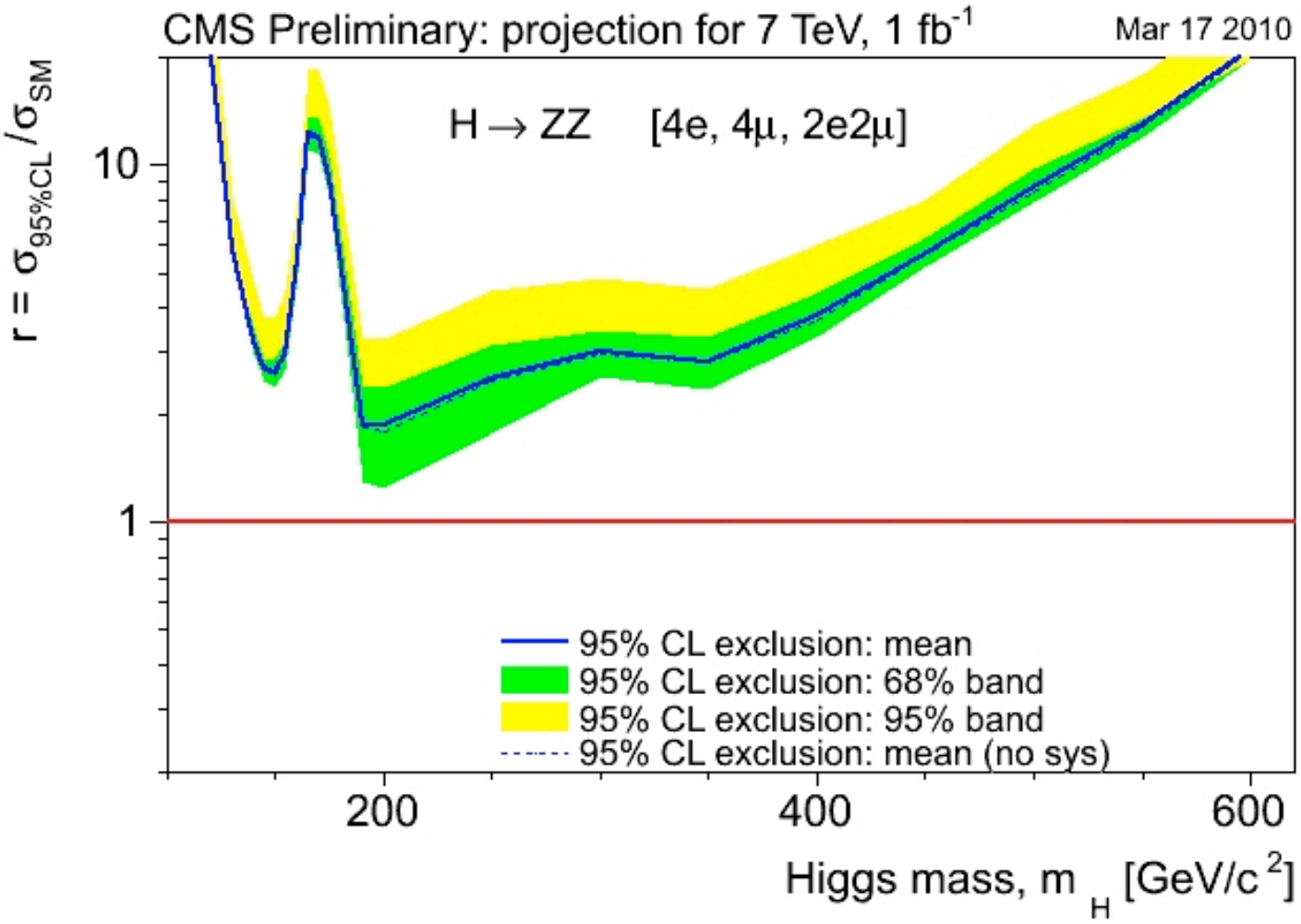
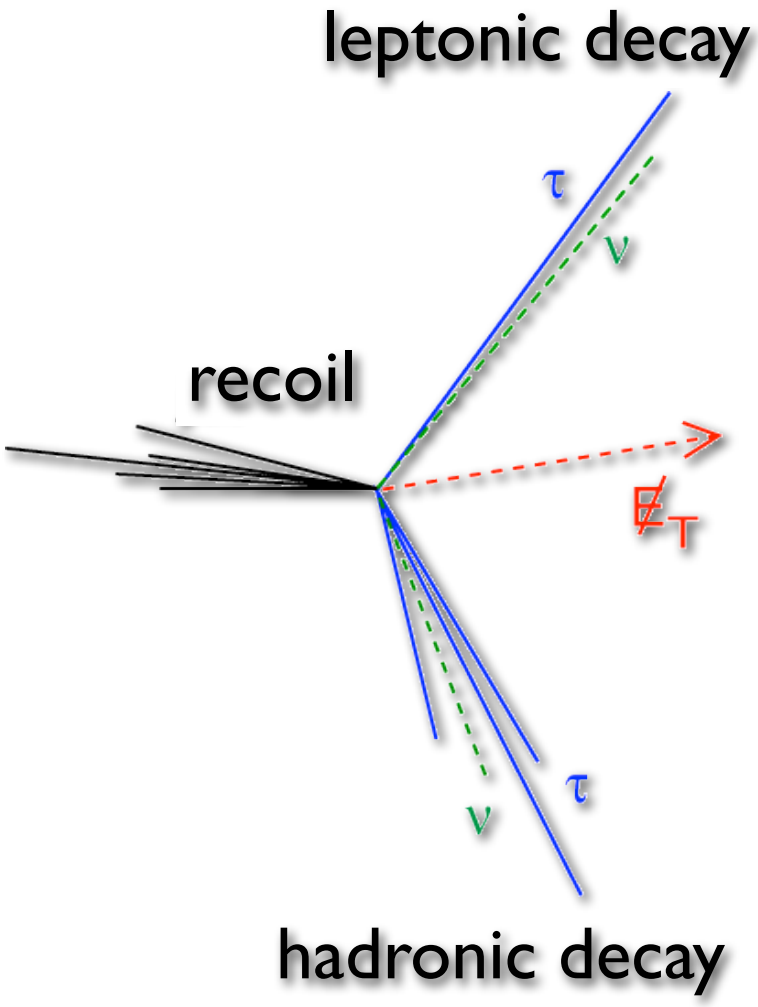
SM Higgs: ZZ→4ℓ

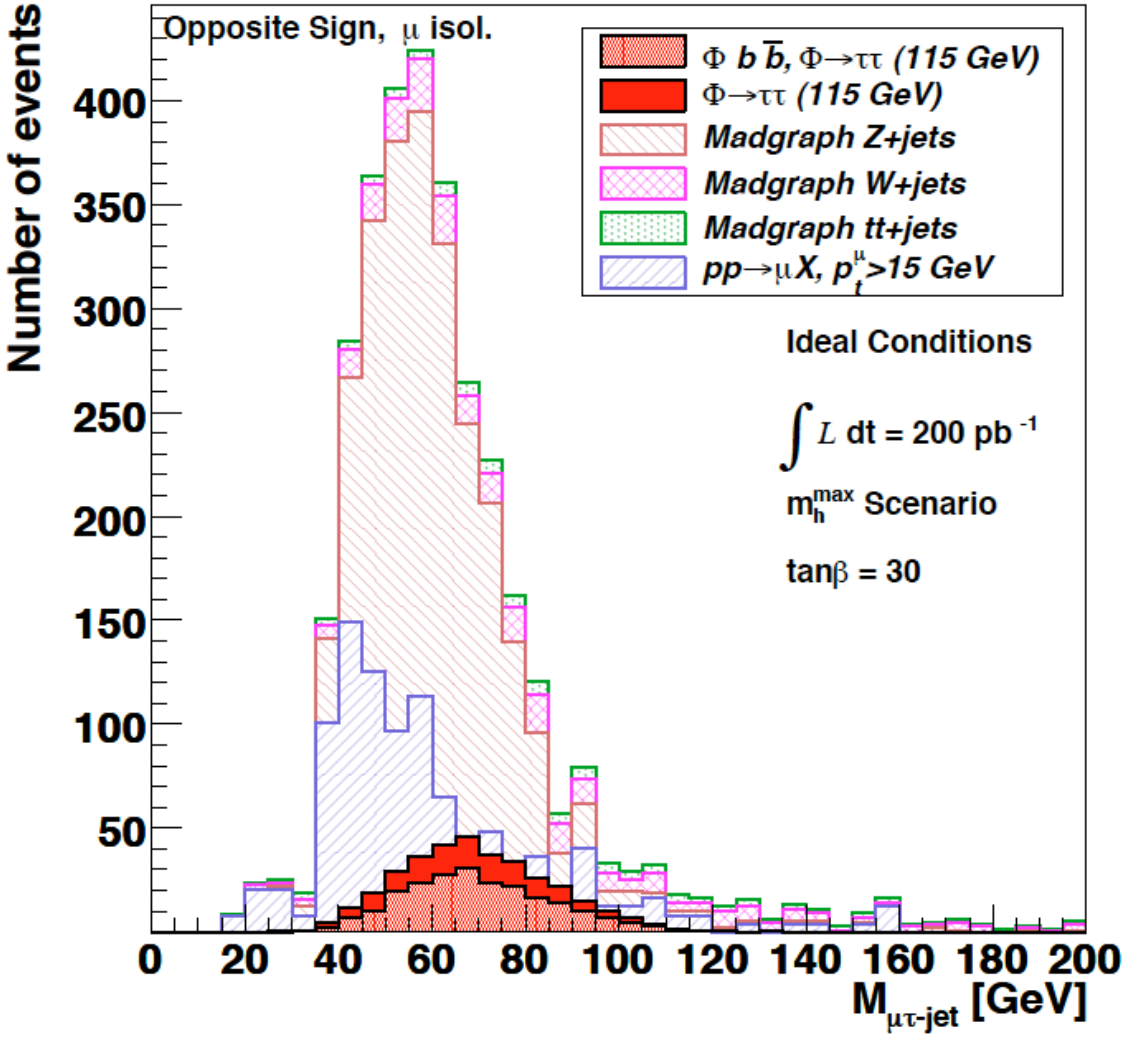


No exclusion of low mass SM Higgs anticipated in first run at 7 TeV

MSSM Higgs

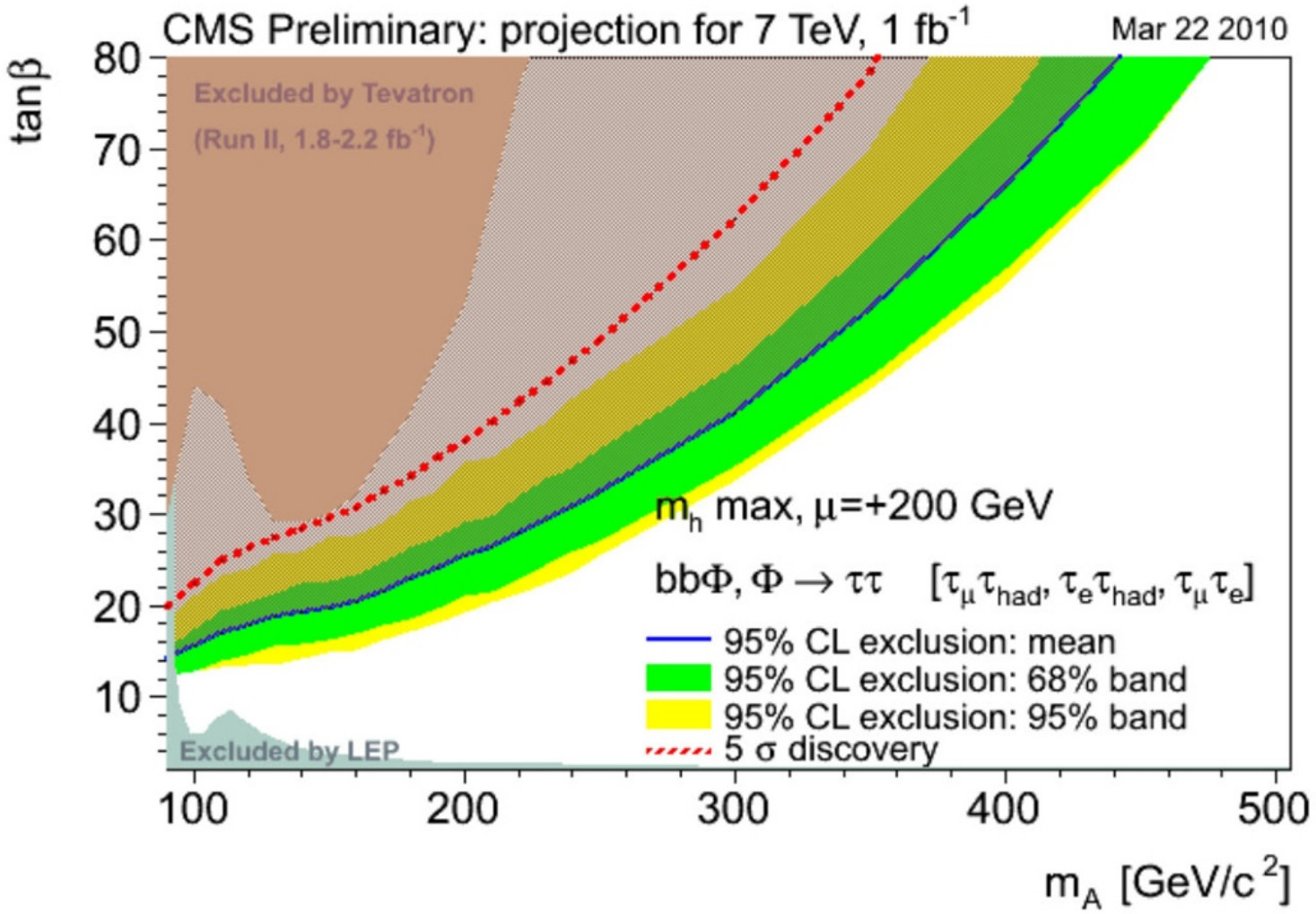
Most sensitive: tau pair decays (~9% BR) of h/H/A





MSSM Higgs

di-tau sensitivity for H/A will soon exceed Tevatron!



(stay tuned: we will do even better than this!)

LHC: the coming weeks

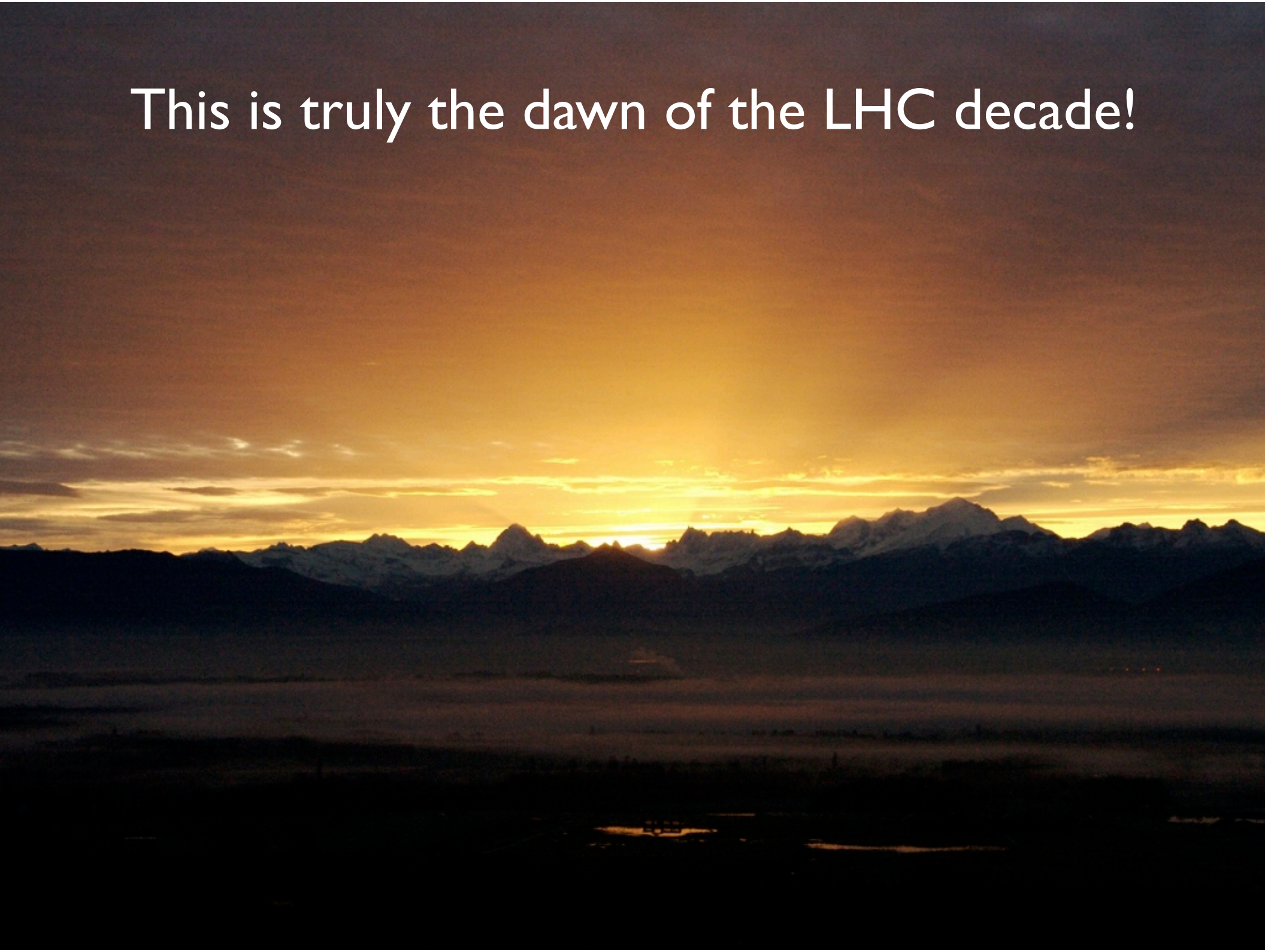
From J. Wenninger, LMC 2010-04-28

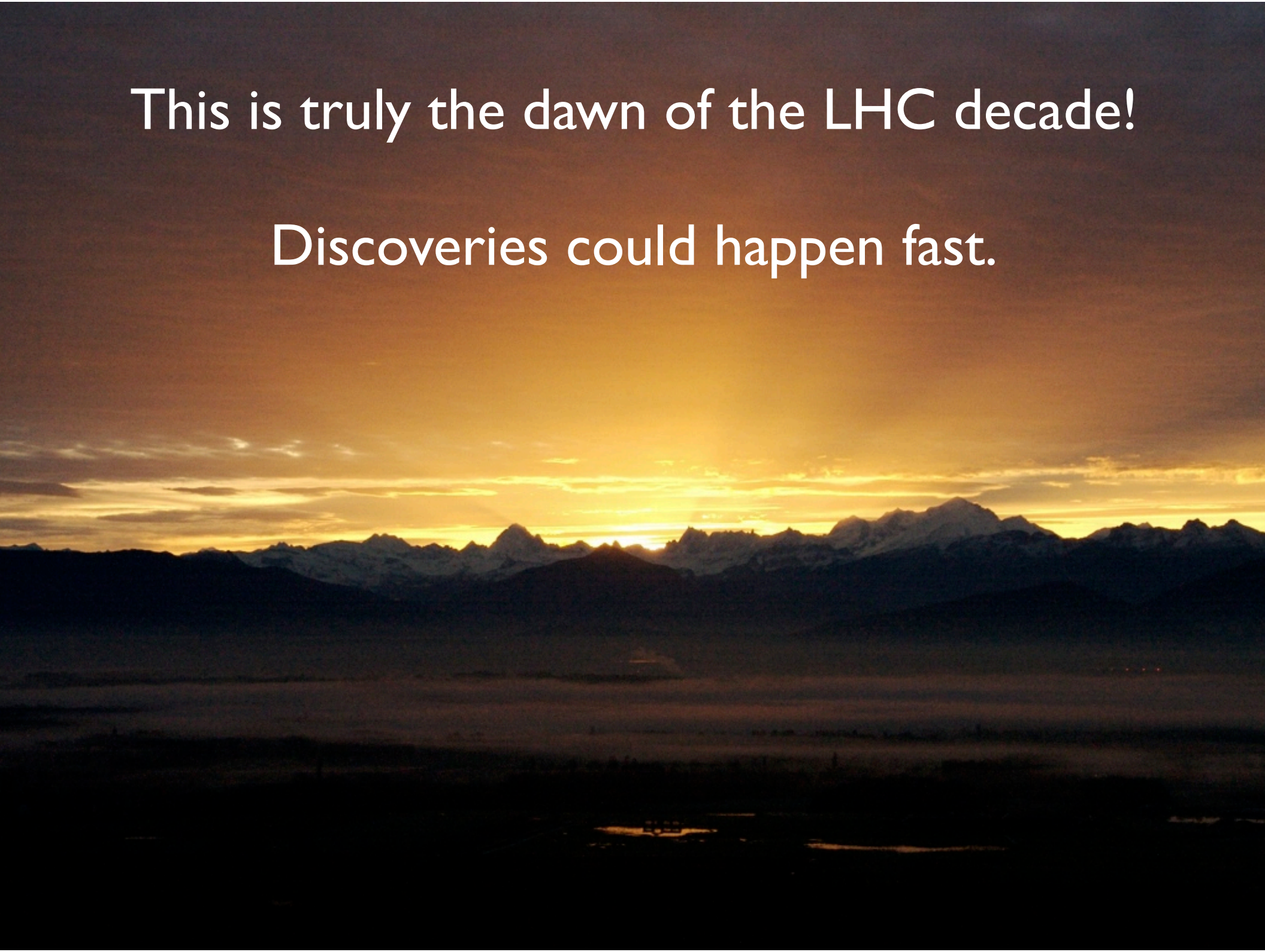
Stage	Ib (protons)	Nb	Stored E (kJ)	Stored E step	Peak L (Hz cm-2)	
3 fat pilots (*)	1.00E+10	3	17	1.00	1.34E+28	Now
4 bunches	2.00E+10	4	44.8	2.60	7.63E+28	
4 bunches	5.00E+10	4	112.0	2.50	4.77E+29	1 pb^{-1}/mo
8 bunches	5.00E+10	8	224.0	2.00	9.54E+29	
4x4 bunches	5.00E+10	16	448.0	2.00	1.91E+30	
8x4 bunches	5.00E+10	32	896.0	2.00	3.81E+30	
43x43	5.00E+10	43	1204.0	1.34	5.13E+30	
8 trains of 6 b	8.00E+10	48	2150.4	1.79	1.33E+31	1 pb^{-1}/day
50 ns trains	8.00E+10	96	4300.8	2.00	2.67E+31	

β* = 2 m, nominal emittance

(*) Initial plan was with 4 bunches of 5E9, L ~ 4E27

Each step requires about 10 fills. Requirement from the Machine Protection Panel.


This is truly the dawn of the LHC decade!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Discoveries could happen fast.


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Fasten your seat belts...