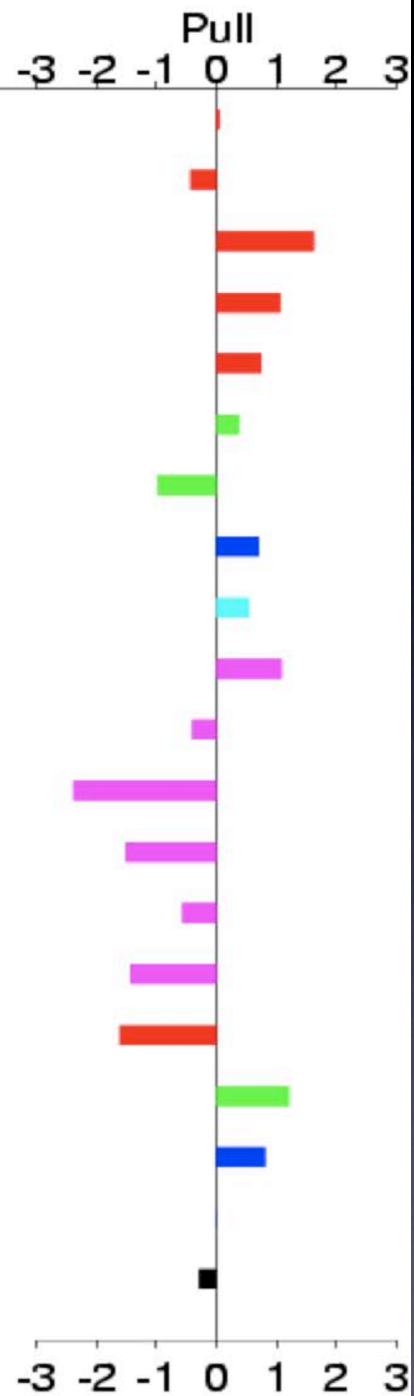
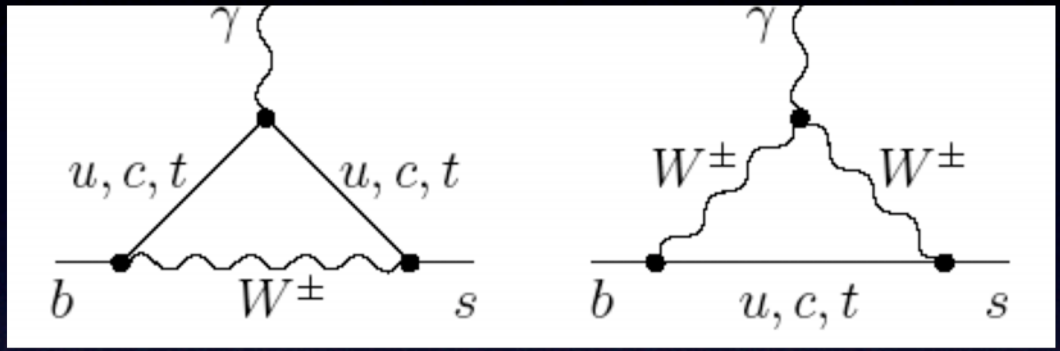
2010

Сравнение Стандартной Модели с экспериментом

	Measurement	Pull
m_Z [GeV]	91.1875 ± 0.0021	.05
Γ_Z [GeV]	2.4952 ± 0.0023	-.42
σ^0_{hadr} [nb]	41.540 ± 0.037	1.62
R_l	20.767 ± 0.025	1.07
$A^{0,l}_{fb}$	0.01714 ± 0.00095	.75
A_e	0.1498 ± 0.0048	.38
A_τ	0.1439 ± 0.0042	-.97
$\sin^2\theta^{lept}_{eff}$	0.2321 ± 0.0010	.70
m_W [GeV]	80.427 ± 0.046	.55
R_b	0.21653 ± 0.00069	1.09
R_c	0.1709 ± 0.0034	-.40
$A^{0,b}_{fb}$	0.0990 ± 0.0020	-2.38
$A^{0,c}_{fb}$	0.0689 ± 0.0035	-1.51
A_b	0.922 ± 0.023	-.55
A_c	0.631 ± 0.026	-1.43
$\sin^2\theta^{lept}_{eff}$	0.23098 ± 0.00026	-1.61
$\sin^2\theta_W$	0.2255 ± 0.0021	1.20
m_W [GeV]	80.452 ± 0.062	.81
m_t [GeV]	174.3 ± 5.1	-.01
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02804 ± 0.00065	-.29



B->$X_s\gamma$



СМ

$$Br(B \to X_s\gamma) = (3.15 \pm 0.23)\cdot 10^{-4}$$

Эксп

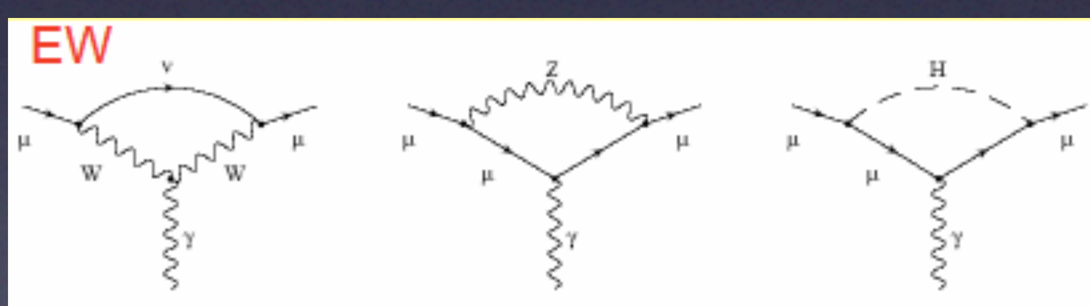
$$Br(B \to X_s\gamma) = (3.55 \pm 0.24)\cdot 10^{-4}$$

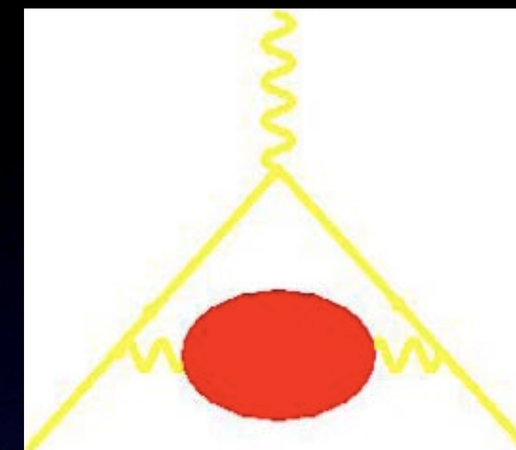
g-2

$$a_\mu^{exp} = 11\,659\,202\,(14)(6)\cdot 10^{-10}$$
$$a_\mu^{SM} = 11\,659\,159.6\,(6.7)\cdot 10^{-10}$$

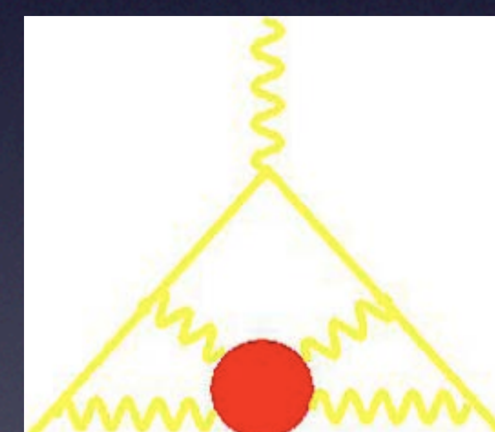
$$a_\mu^{exp} - a_\mu^{SM} = (\,27\pm10\,)\cdot 10^{-10}$$

$$a_\mu^{QED} = 11\,658\,470.56\,(0.29)\cdot 10^{-10}$$
$$a_\mu^{weak} = 15.1\,(0.4)\cdot 10^{-10}$$
$$a_\mu^{hadr} = 673.9\,(6.7)\cdot 10^{-10}$$





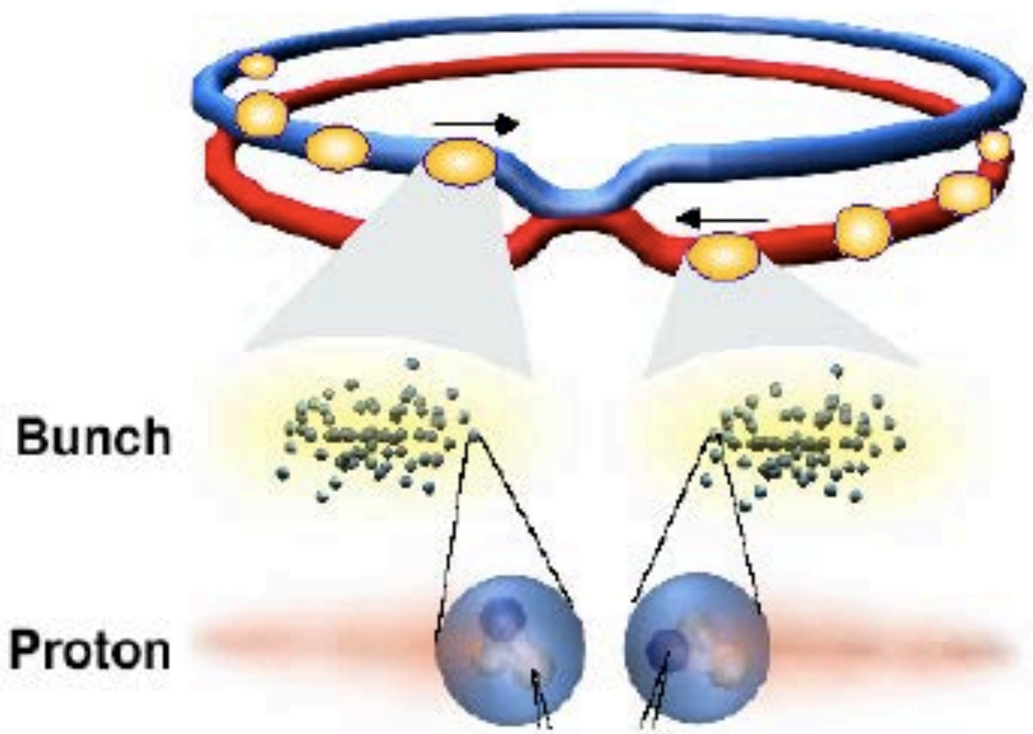
Поляризация адронного вакуума



Рассеяние света на свете

LHC Performance in 2010

Collisions at the LHC: counter-rotating, high-intensity bunches of protons or heavy ions.



The rate of **new particle's production** is proportional to the **luminosity**:

$$\mathcal{L} \propto \frac{N_1 N_2 n_b}{\sigma^2}$$

Key parameters:

- N_i = bunch intensity
- n_b = number of bunches
- σ = colliding beam size

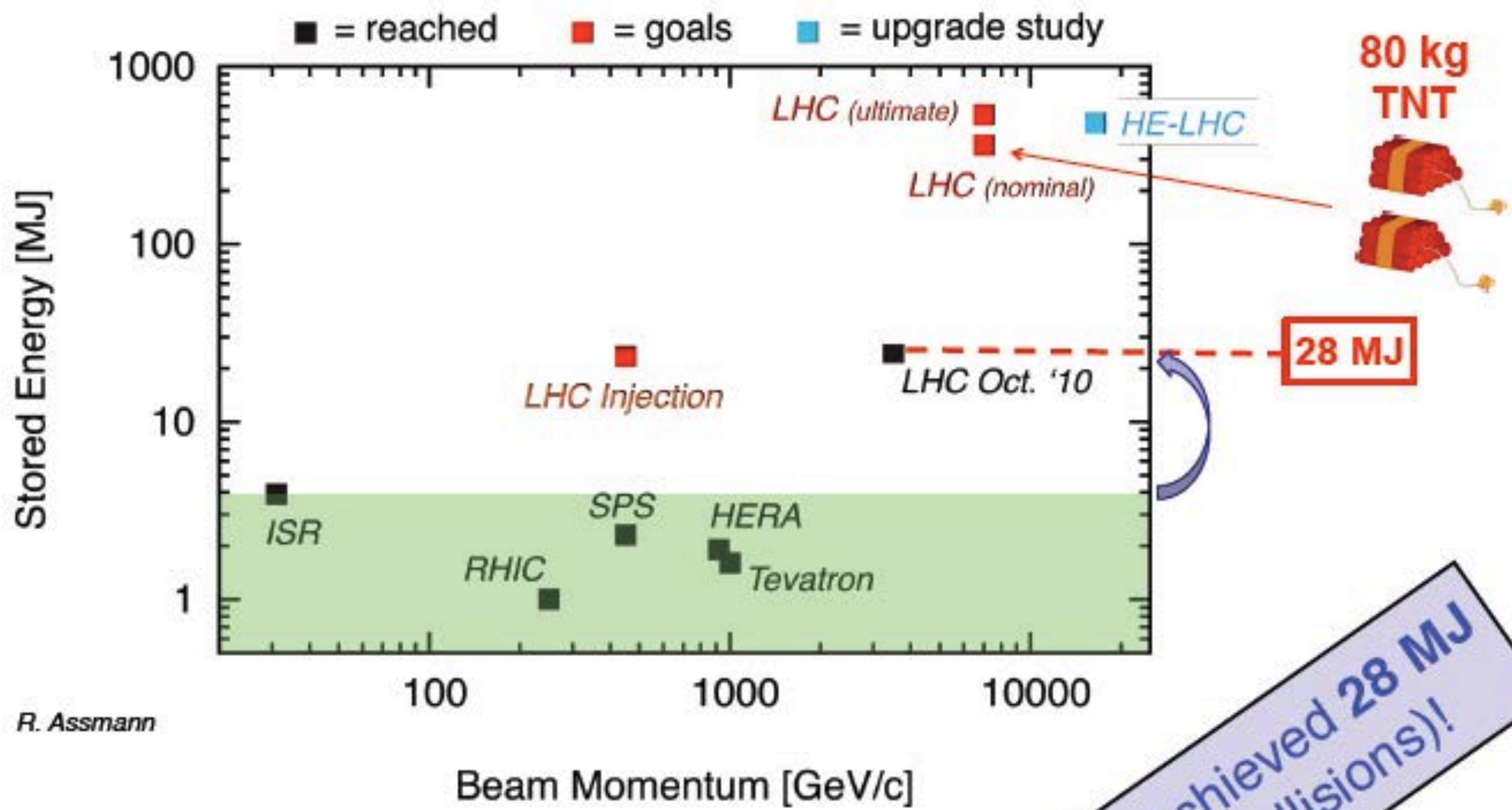
*Nominal LHC parameters (7 TeV): **2808** bunches of **1.1x10^{11}** protons, **0.000016** m size.*

Units for the luminosity:

Peak luminosity given in event rate per unit of area $cm^{-2}s^{-1}$: ***2010 goal = $10^{32}cm^{-2}s^{-1}$***

Integral luminosity (prop. to number of collisions) fb^{-1} : ***2011 goal = 1 fb^{-1}***

What does this means in practice?



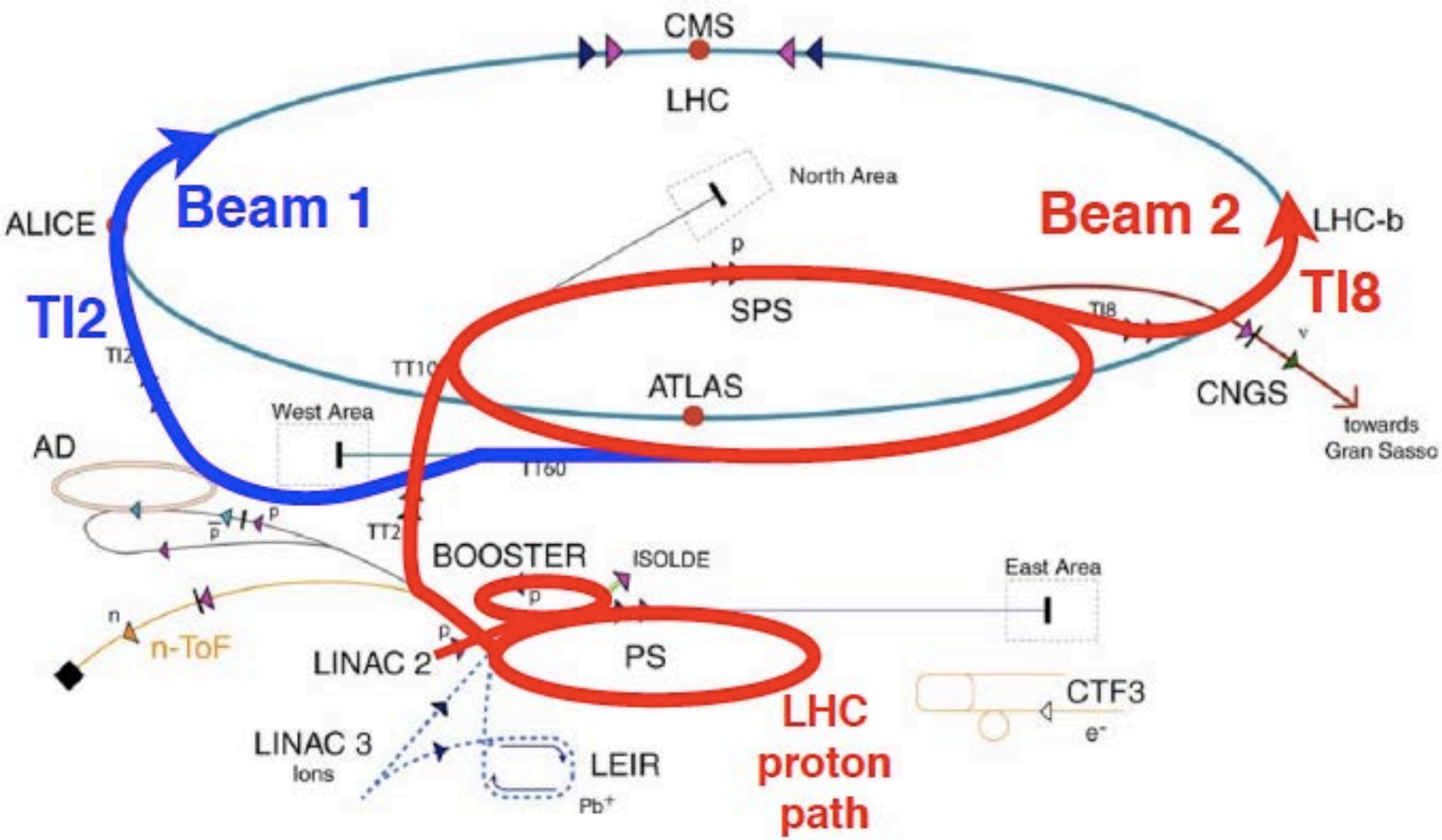
In the first year of operation we needed to achieve:

Factor ~10 above state-of-the-art.

Factor ~15 above the Tevatron.

We made it! Achieved **28 MJ**
(24 MJ with collisions)!

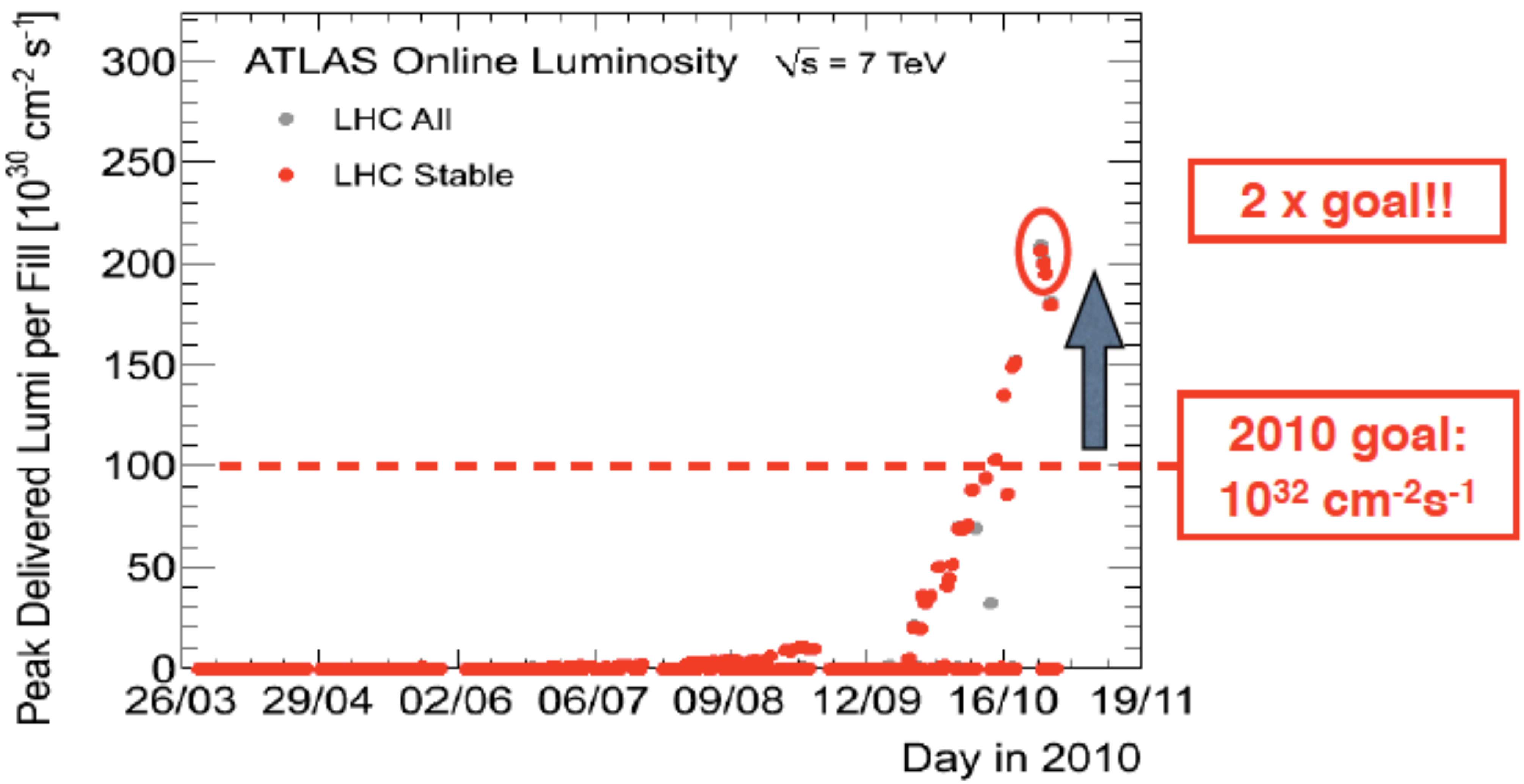
LHC injectors: excellent performance!



<u>Excellent performance</u> <u>of the LHC injection chain:</u>

- Provided the variety of beams needed for commissioning and physics;
- Bunch intensities and beam sizes better than nominal.

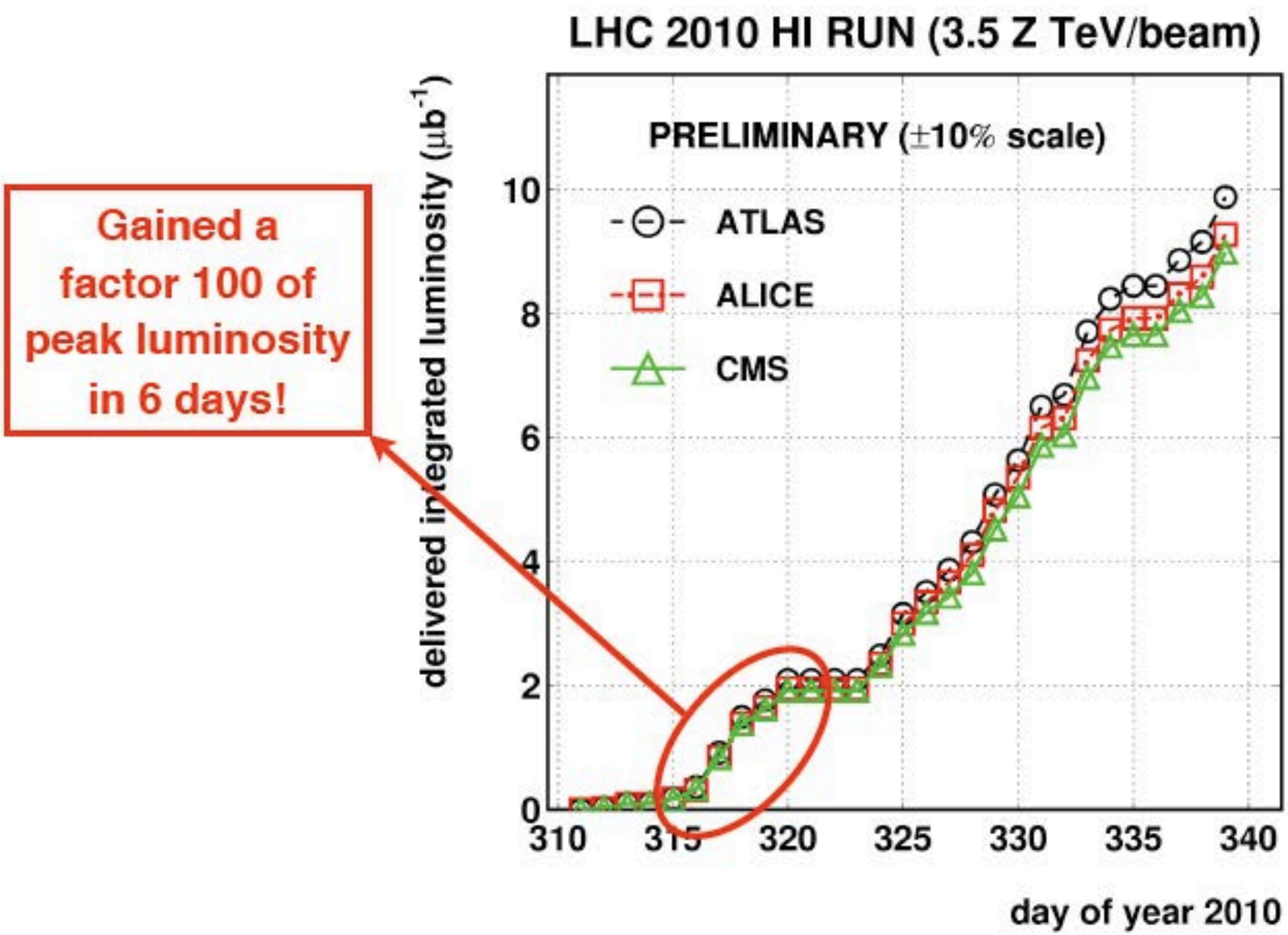
Peak luminosity performance



Main parameters: 368 bunches of 1.2×10^{11} protons.

Colliding beam sizes = 0.00004 metres.

Ion luminosity performance



M. Ferro-Luzzi

1 month

четверг, 23 декабря 2010 г.

Potential performance range

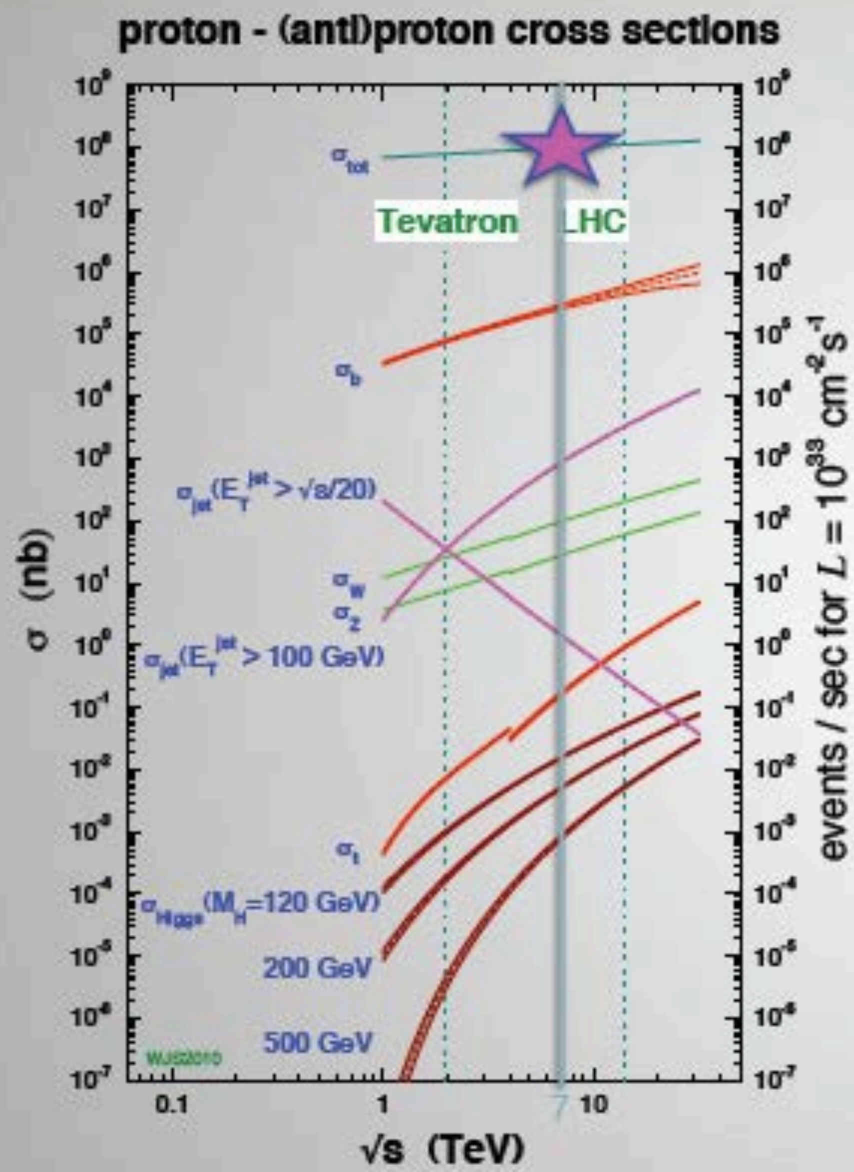
Goal: 1 fb^{-1}

- **Energy: 3.5 TeV to 4 TeV**
  To be decided at the Chamonix workshop in Jan. 2011.
- **Bunch intensity**
  Baseline 1.2×10^{11} protons, higher possible from injectors.
- **Number of bunches**
  450 to 930 bunches (75 ns spacing): potential **factor 2**.
- **Colliding beam sizes**
  Maintain excellent beams from injectors: **50% smaller** than nominal
  Possible to “squeeze” beams further: another **50% gain**!
- **Peak luminosities in the range of 6 to 16 x 10^{32} $cm^{-2}s^{-1}$ could be possible.**
  At least 3 times more than what we have seen in 2010!
- **Integrated luminosity between 1 and 3 fb^{-1} would appear feasible.**

Conclusions

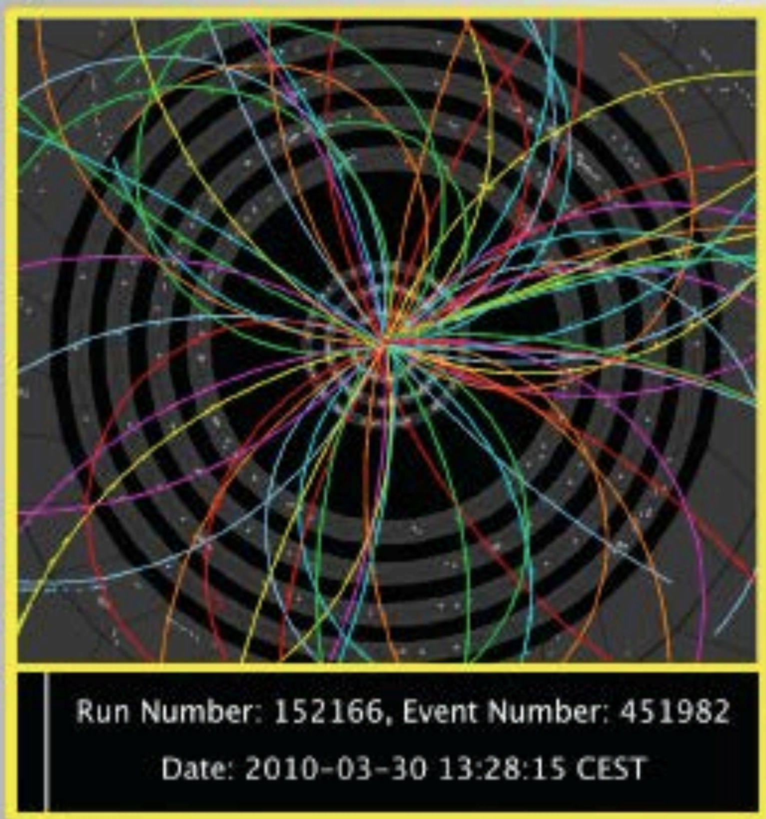
- ☑ Excellent first year of operation for the LHC!
- ☑ We achieved a peak luminosity twice the target for the year.
- ☑ Smooth transition to ion operation (collisions in 3d!)
- ☑ Excellent performance of key accelerator systems and injector chain.
- ☑ Very good machine availability (65%).
- ☑ Solid foundation for 2011 operation: the target for the next year is very much within reach.
- ☑ Potential improvements from smaller colliding beam size and more bunches.

Soft physics

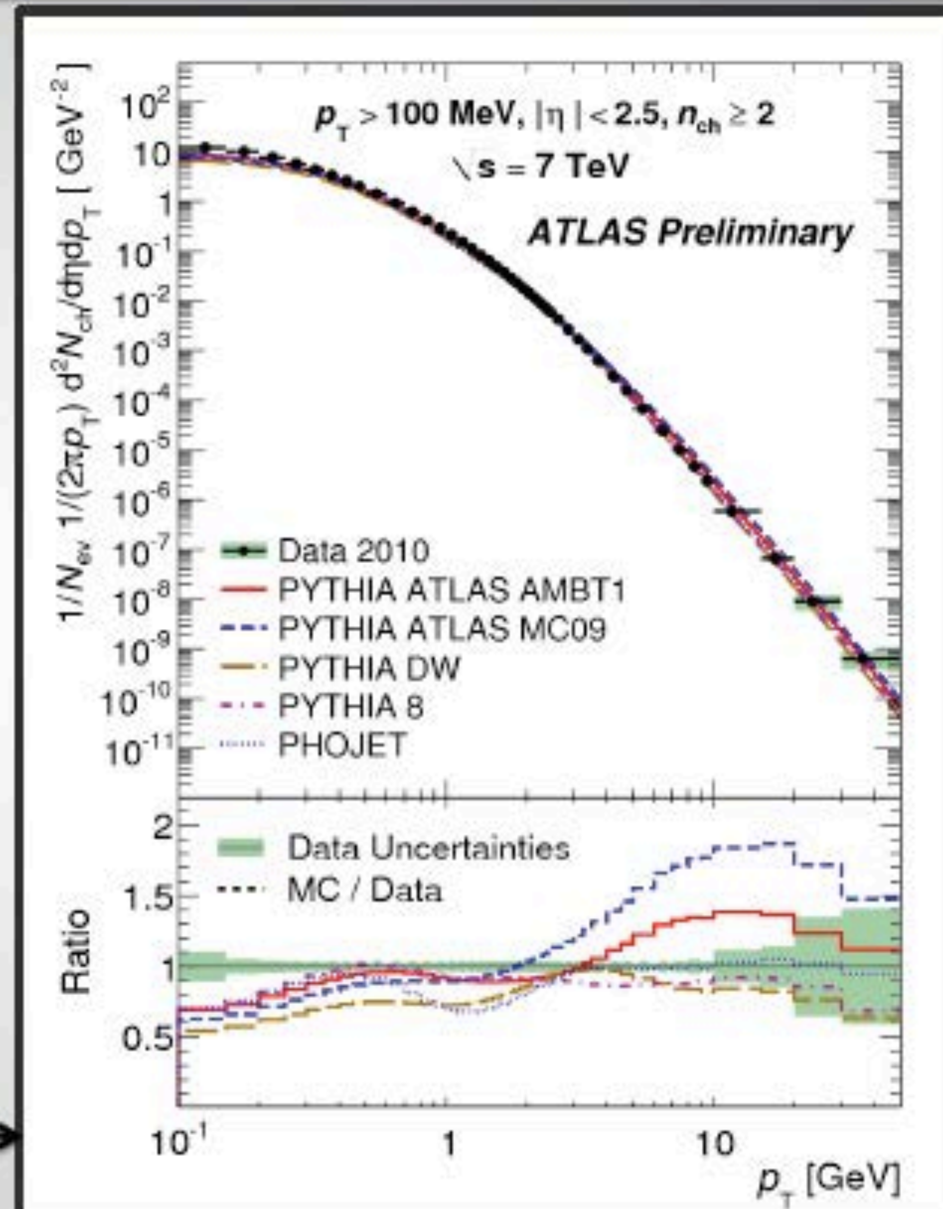


Soft physics

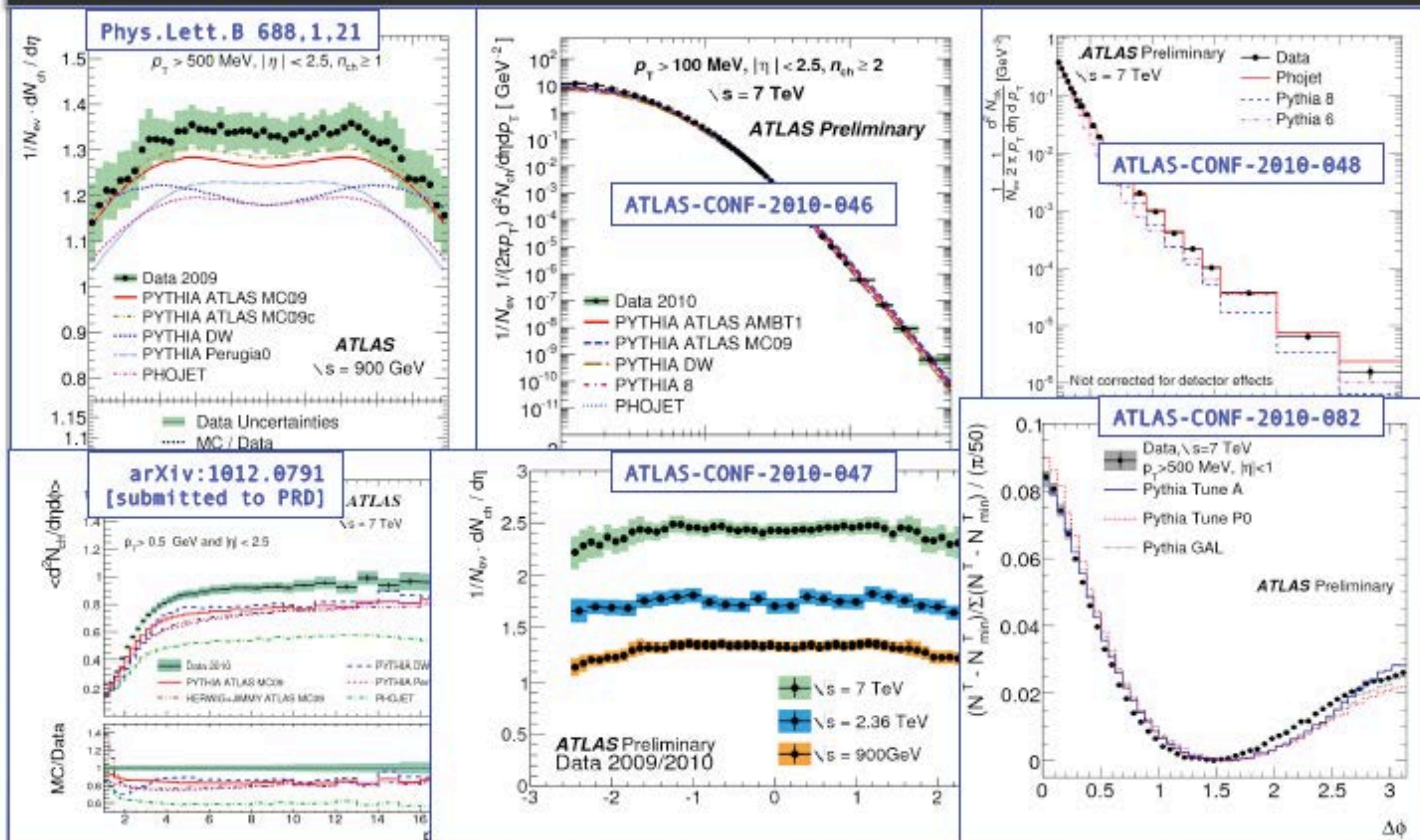
soft charged particles bend a lot in magnetic field



p_T = momentum component transverse to the beam

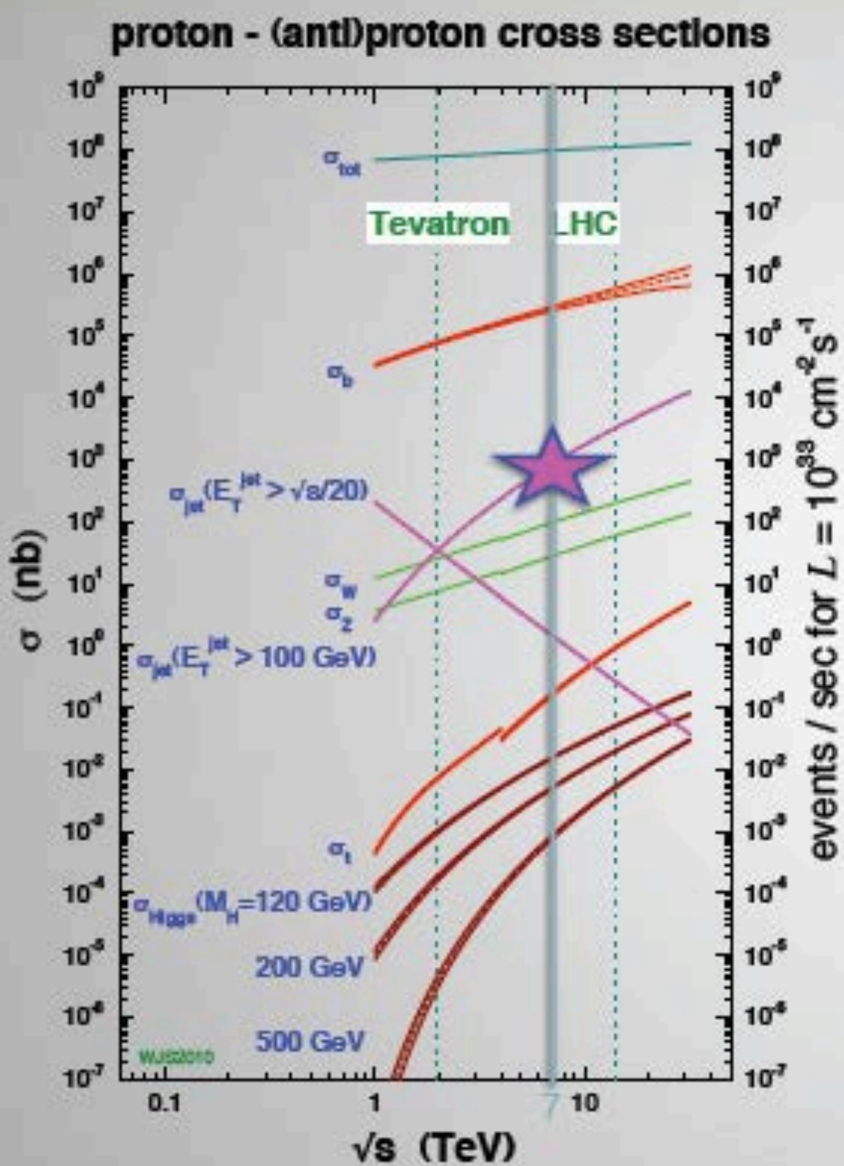


Soft Physics Measurements



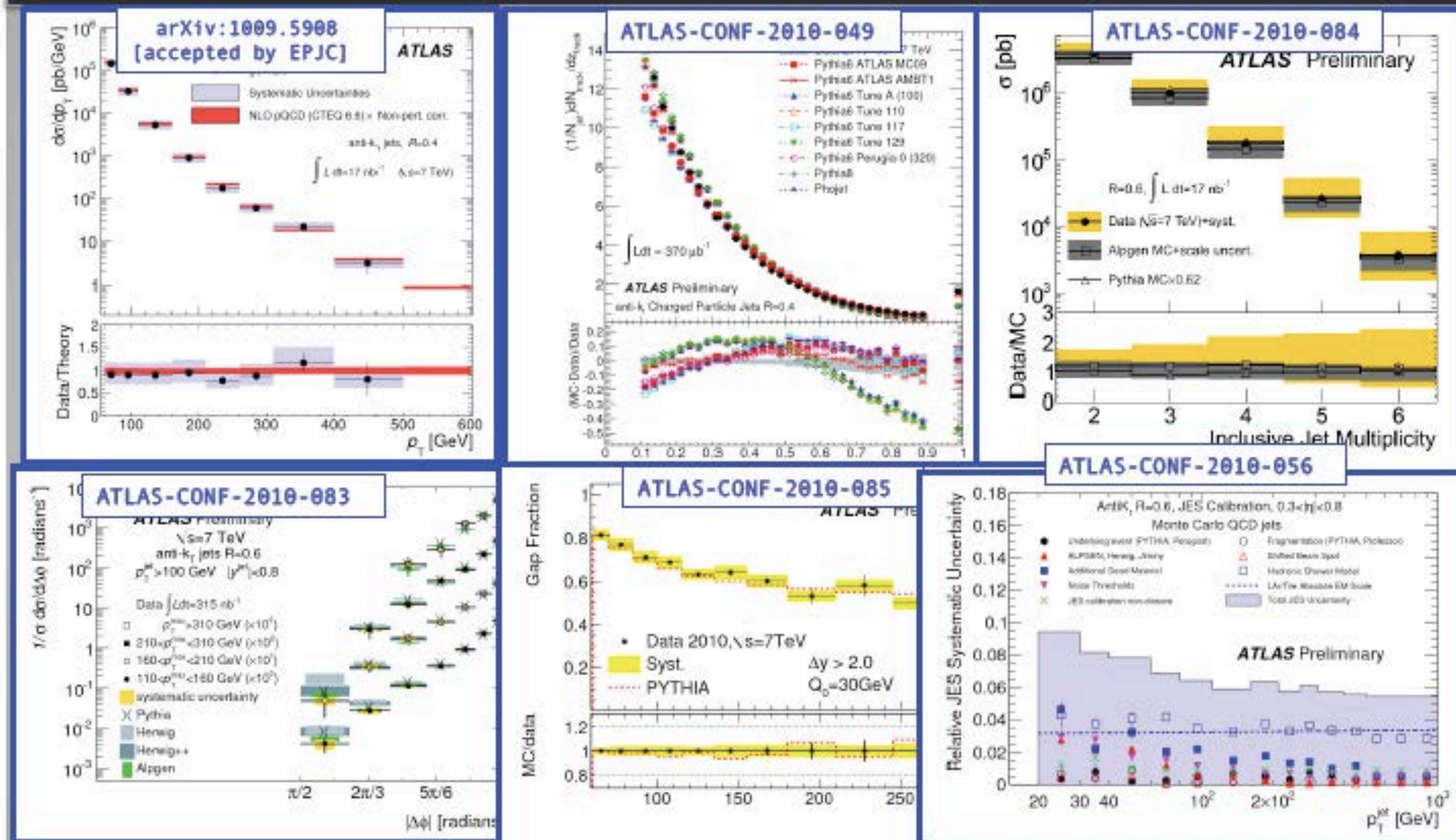
четверг, 23 декабря 2010 г.

Jets

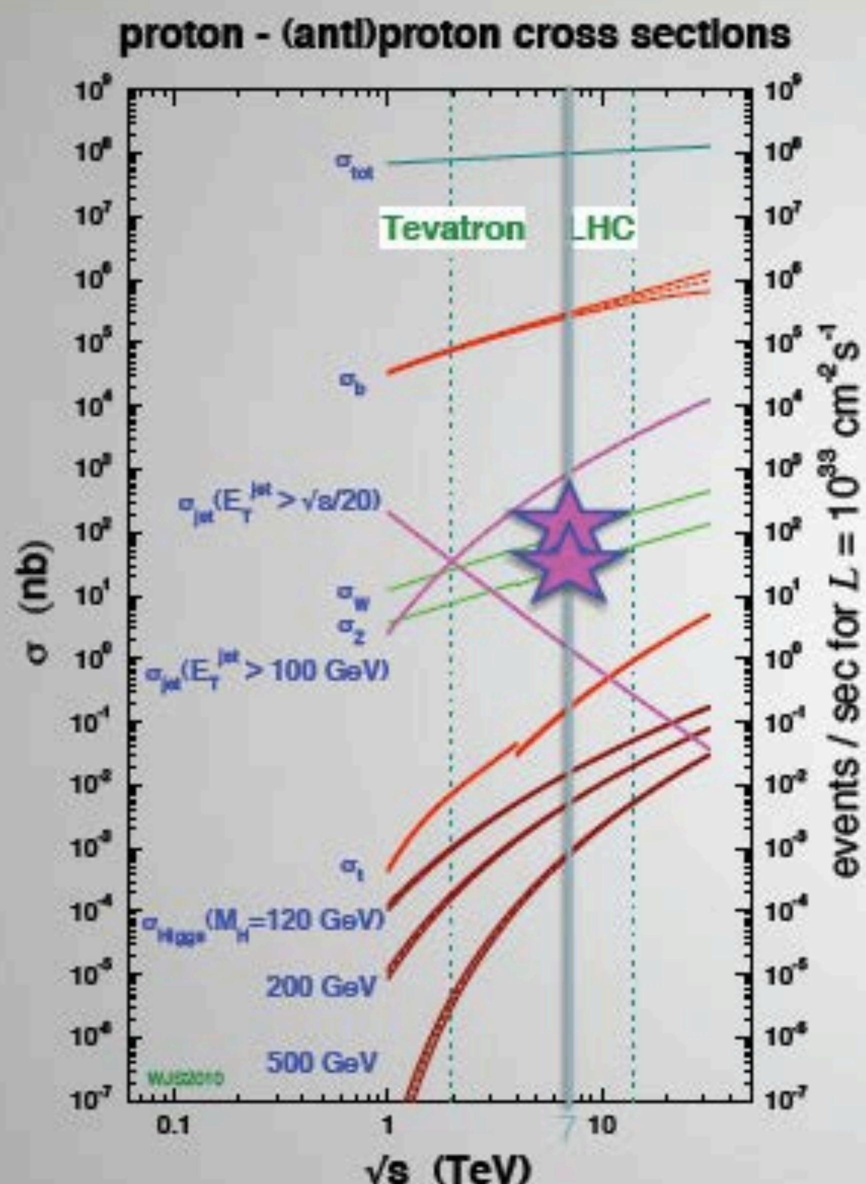

proton - (anti)proton cross sections
Tevatron
LHC
σ (nb)
√s (TeV)
events / sec for L = 10^33 cm^-2 s^-1
σ_tot
σ_b
σ_jet(E_T^jet > √s/20)
σ_W
σ_Z
σ_jet(E_T^jet > 100 GeV)
σ_t
σ_Higgs(M_H=120 GeV)
200 GeV
500 GeV


p
p

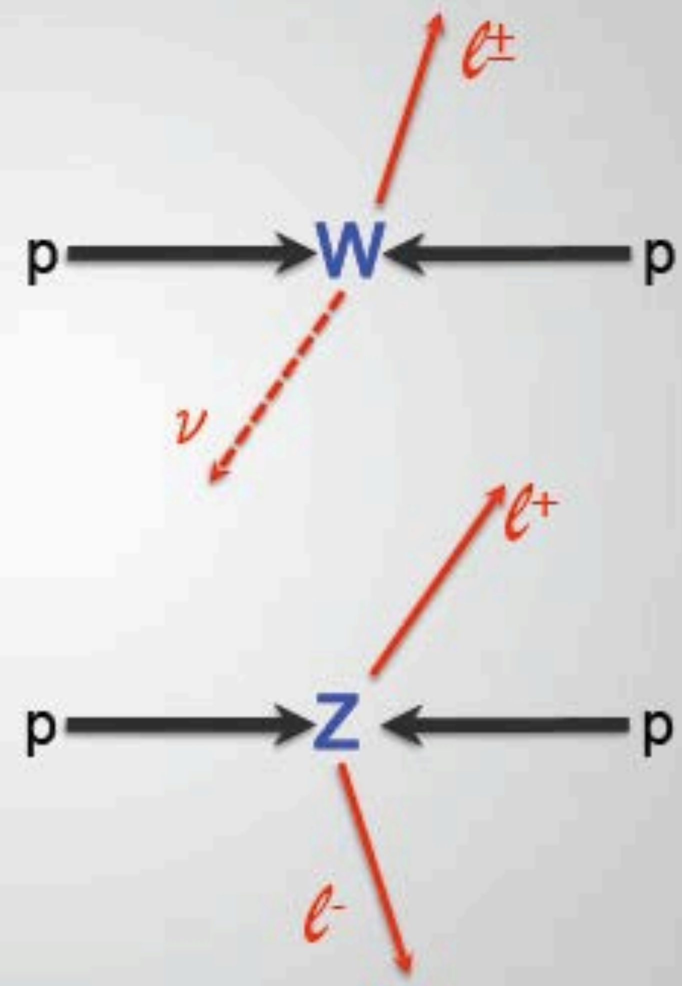
Jet measurements



W and Z physics

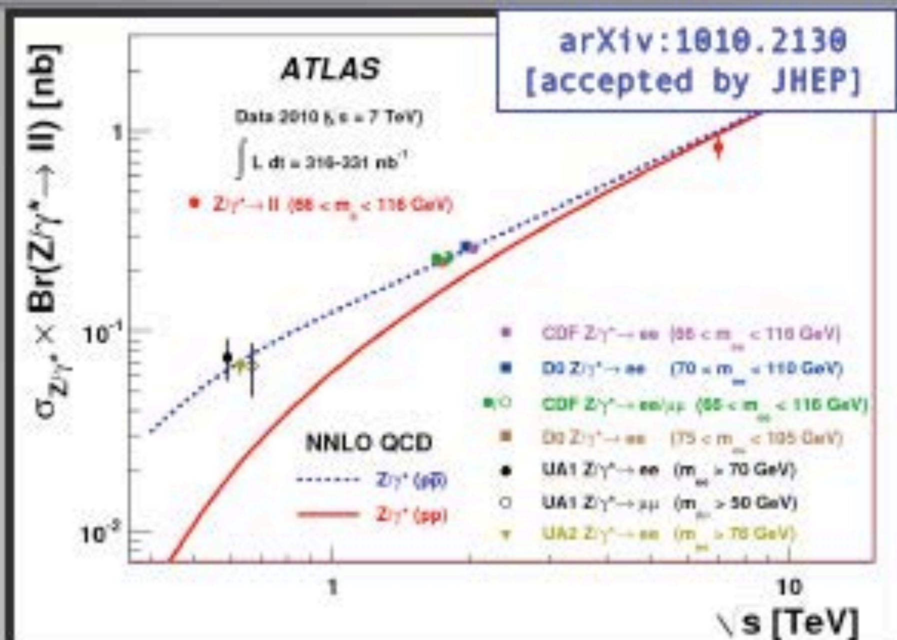


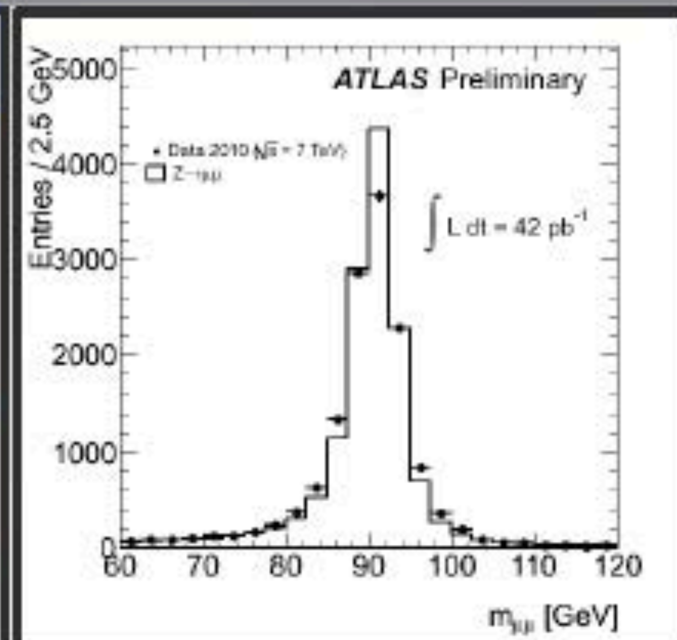
W,Z bosons : mass ~100 times the proton mass



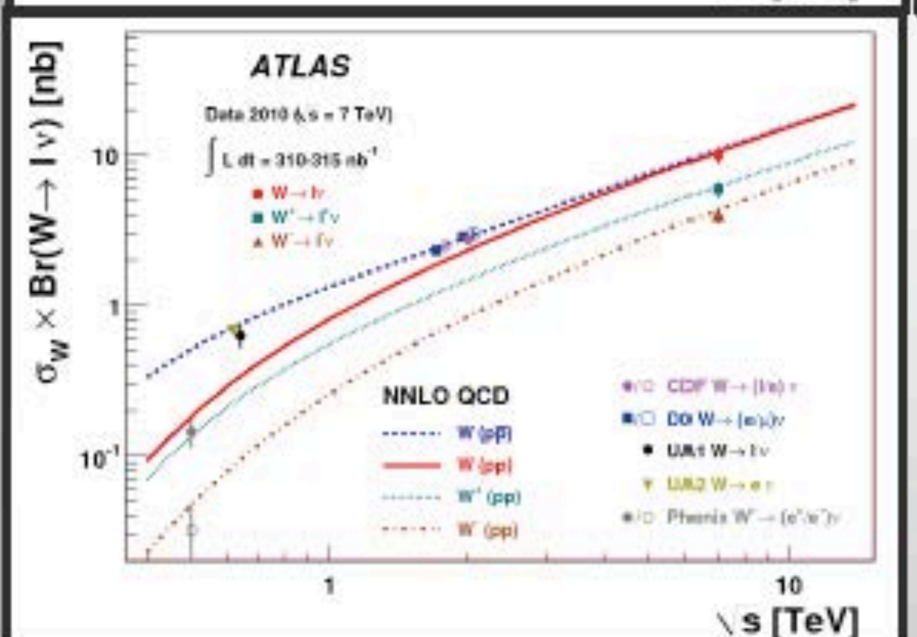
Discovered at CERN in the early 1980s

W and Z physics

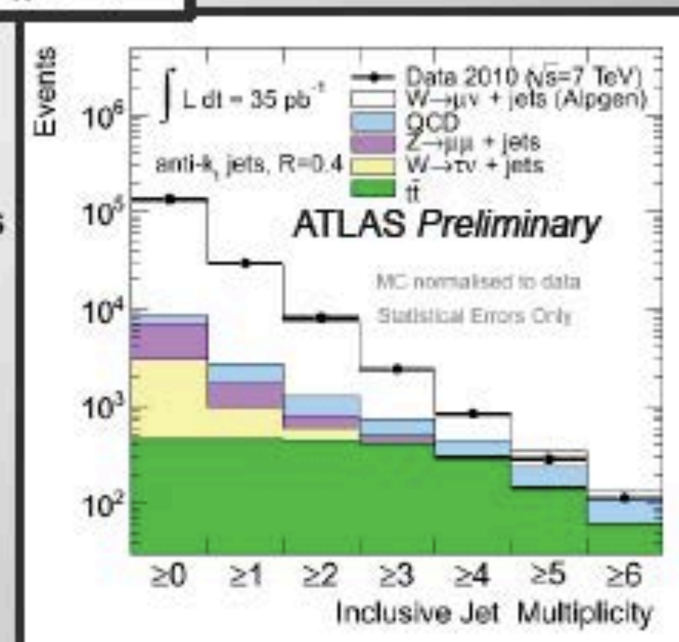




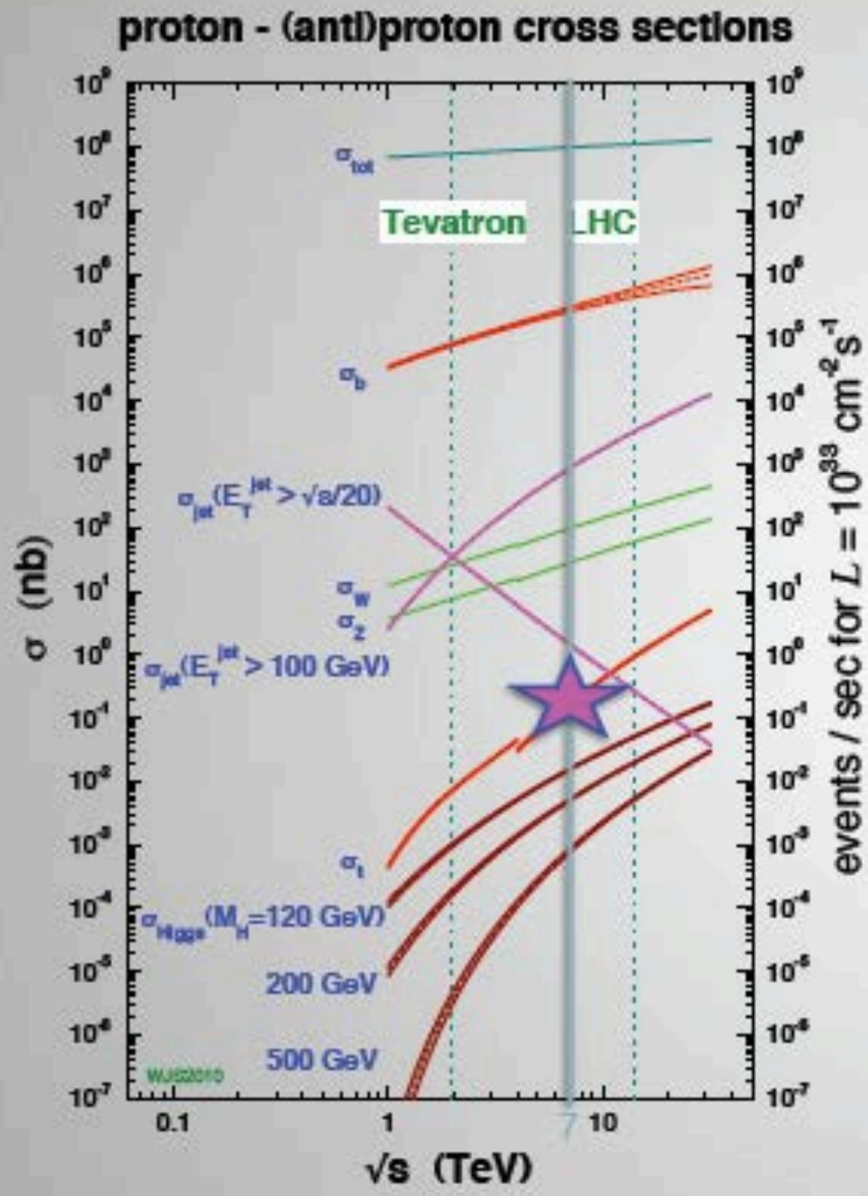
We now have:
250,000 W→μν,eν events
23,000 Z→μμ, ee events



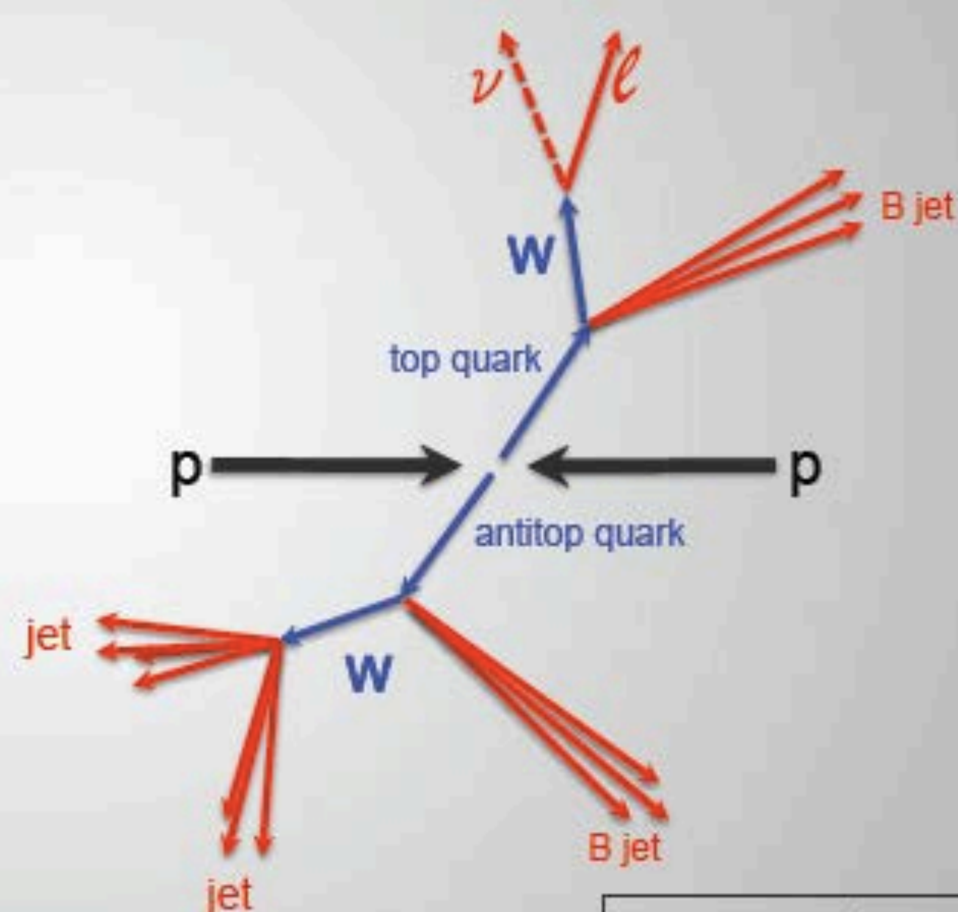
W/Z + jets : important backgrounds to searches



top quark physics

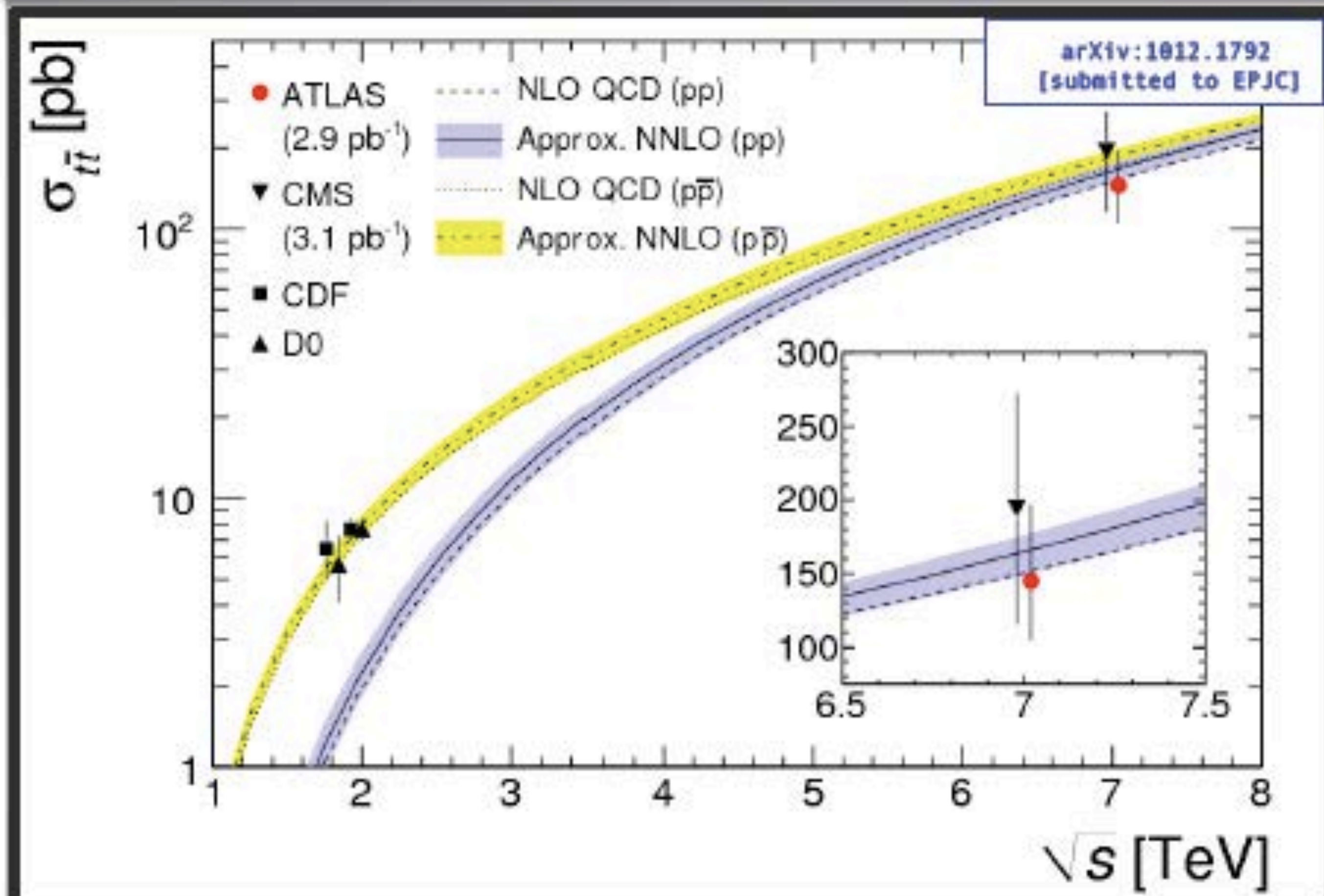


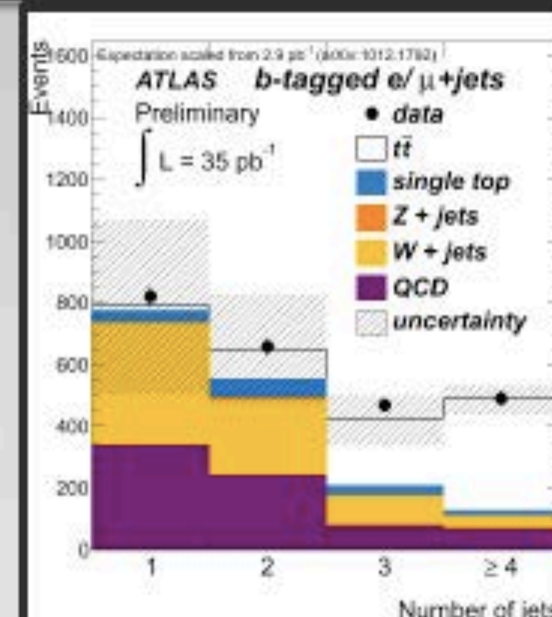
top mass ~200 times proton mass!

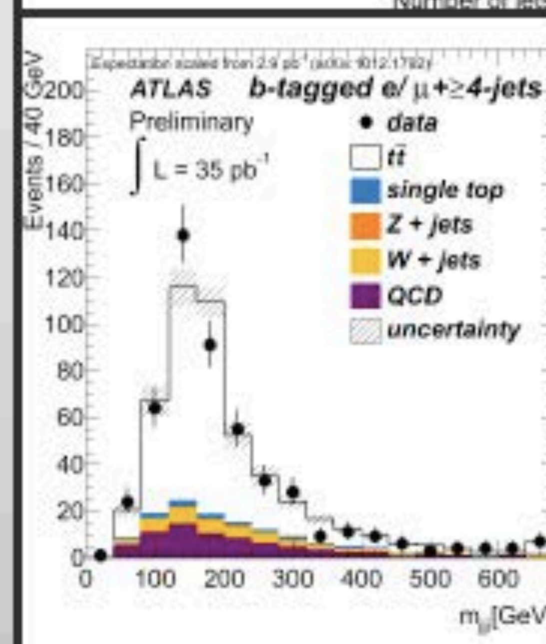


W decays into leptons or jets (hadrons)

top quark physics

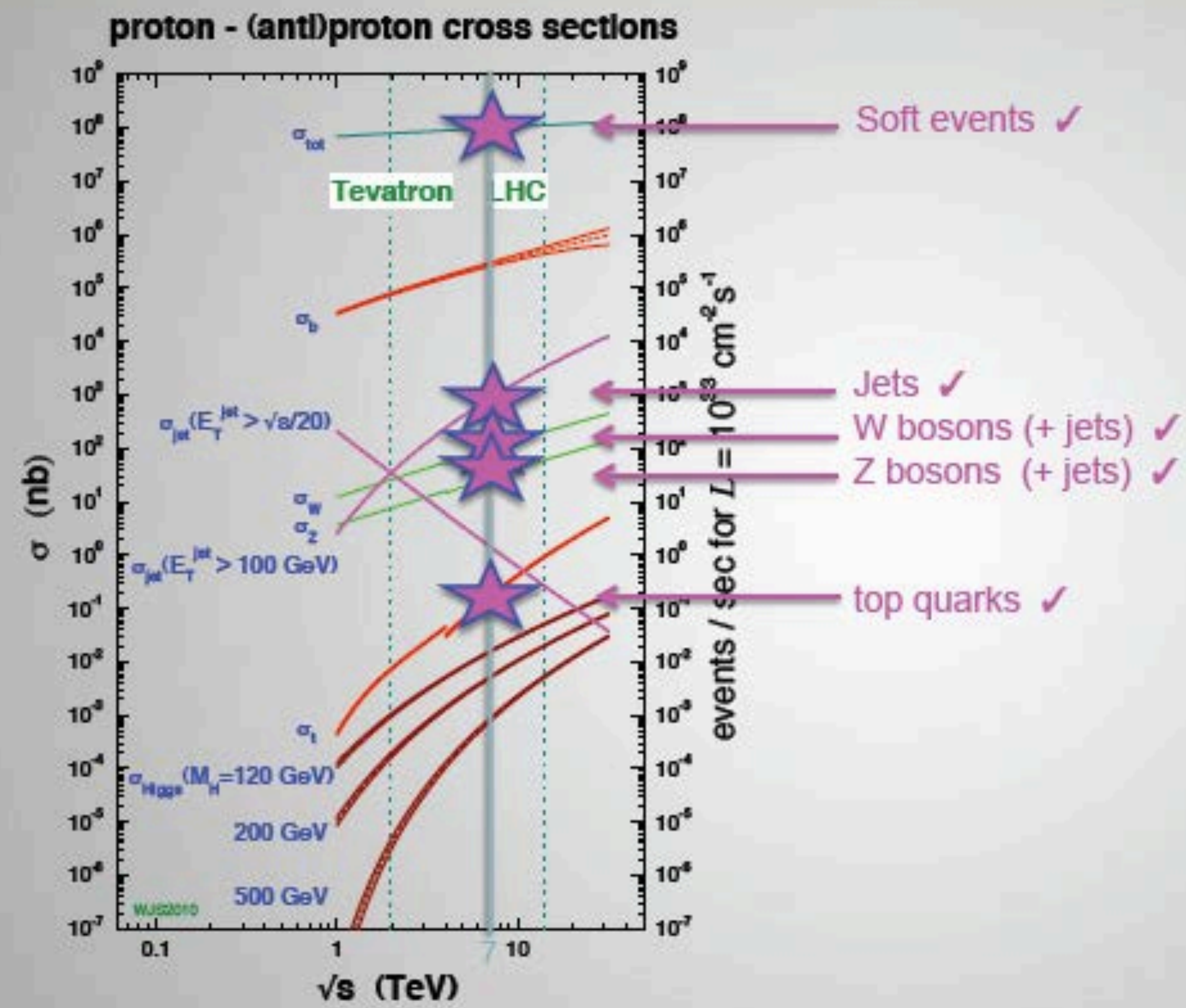






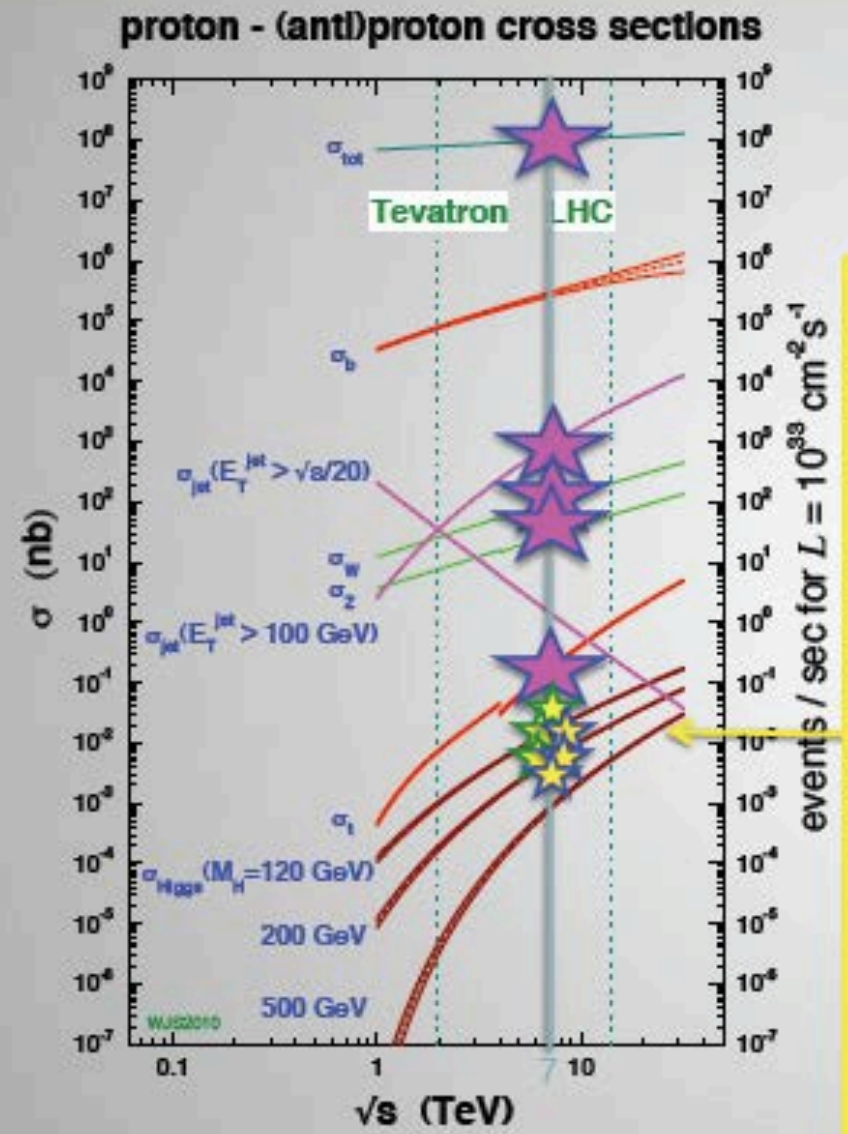
Measurement performed in both single-lepton and di-lepton channels for optimum precision

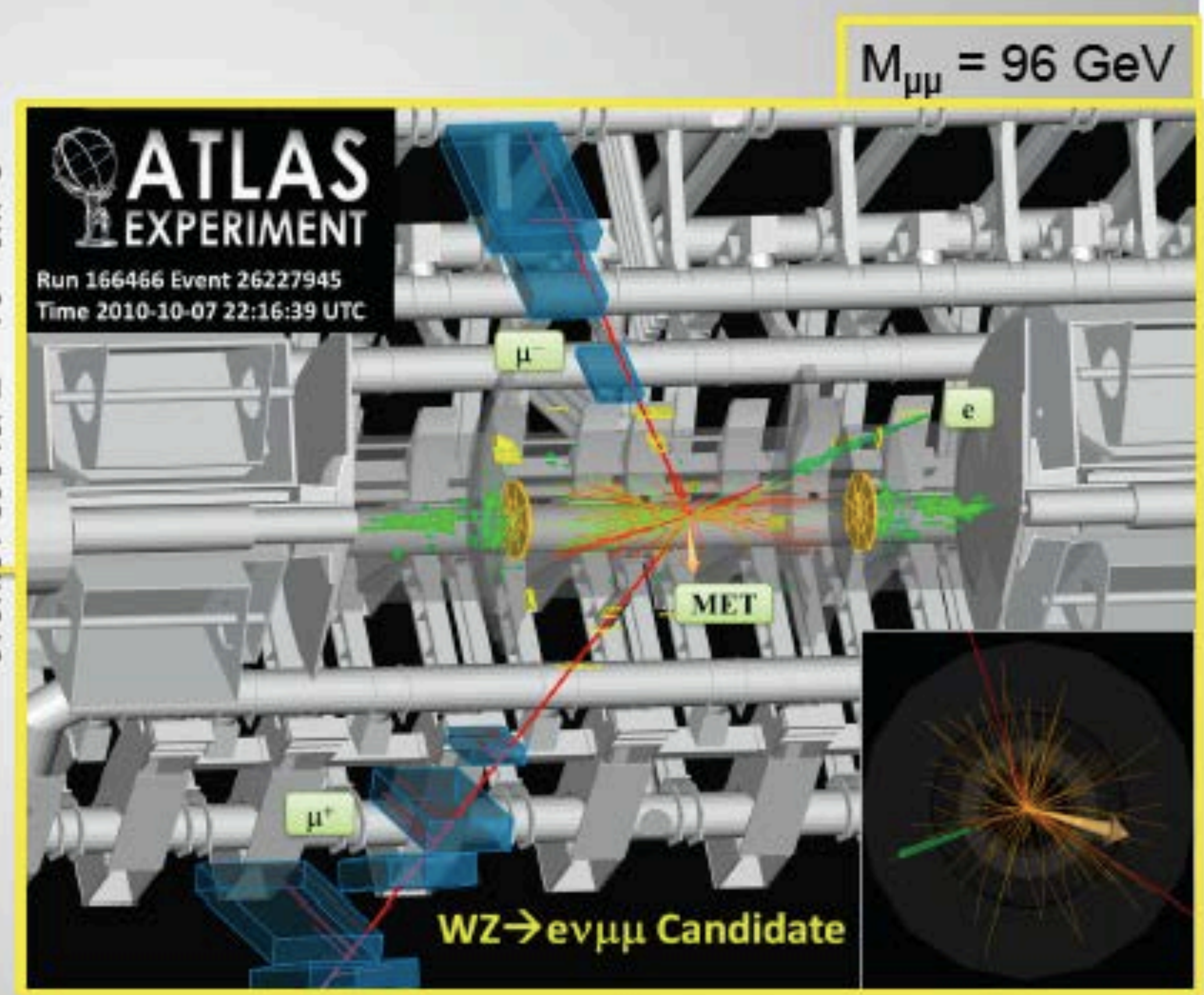
Summary of proton-proton results



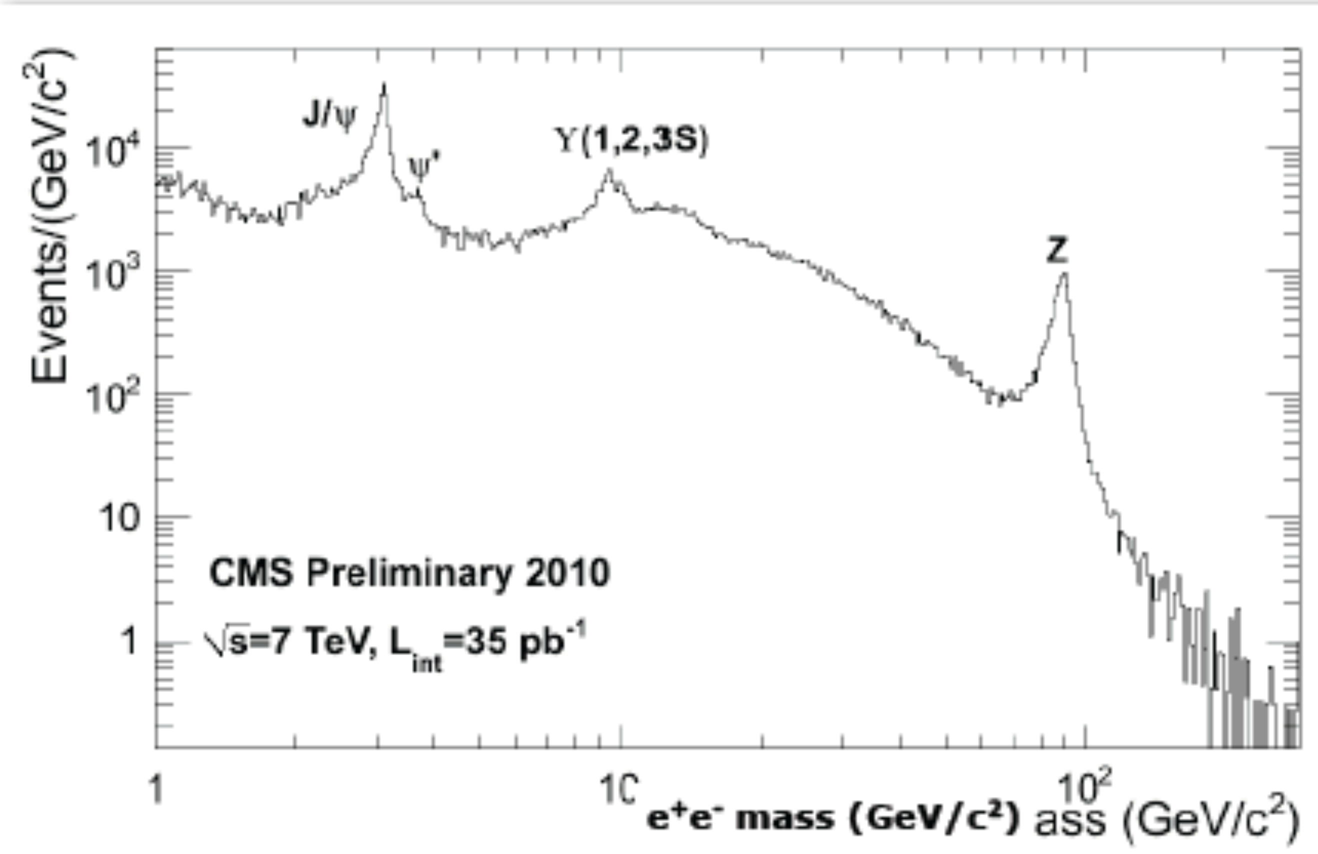
In only 8 months already very well advanced in our SM exploration!

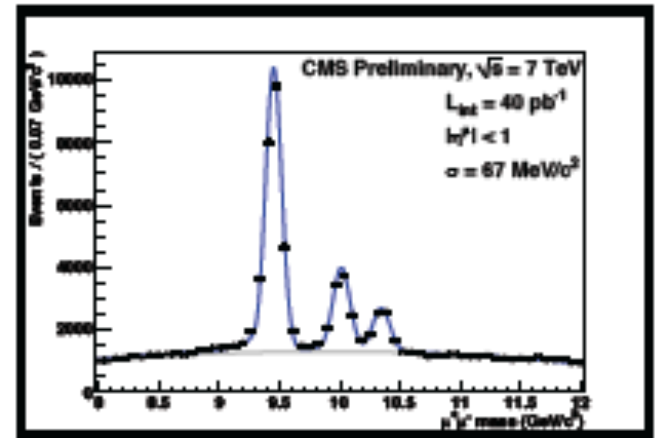
Summary of proton-proton results

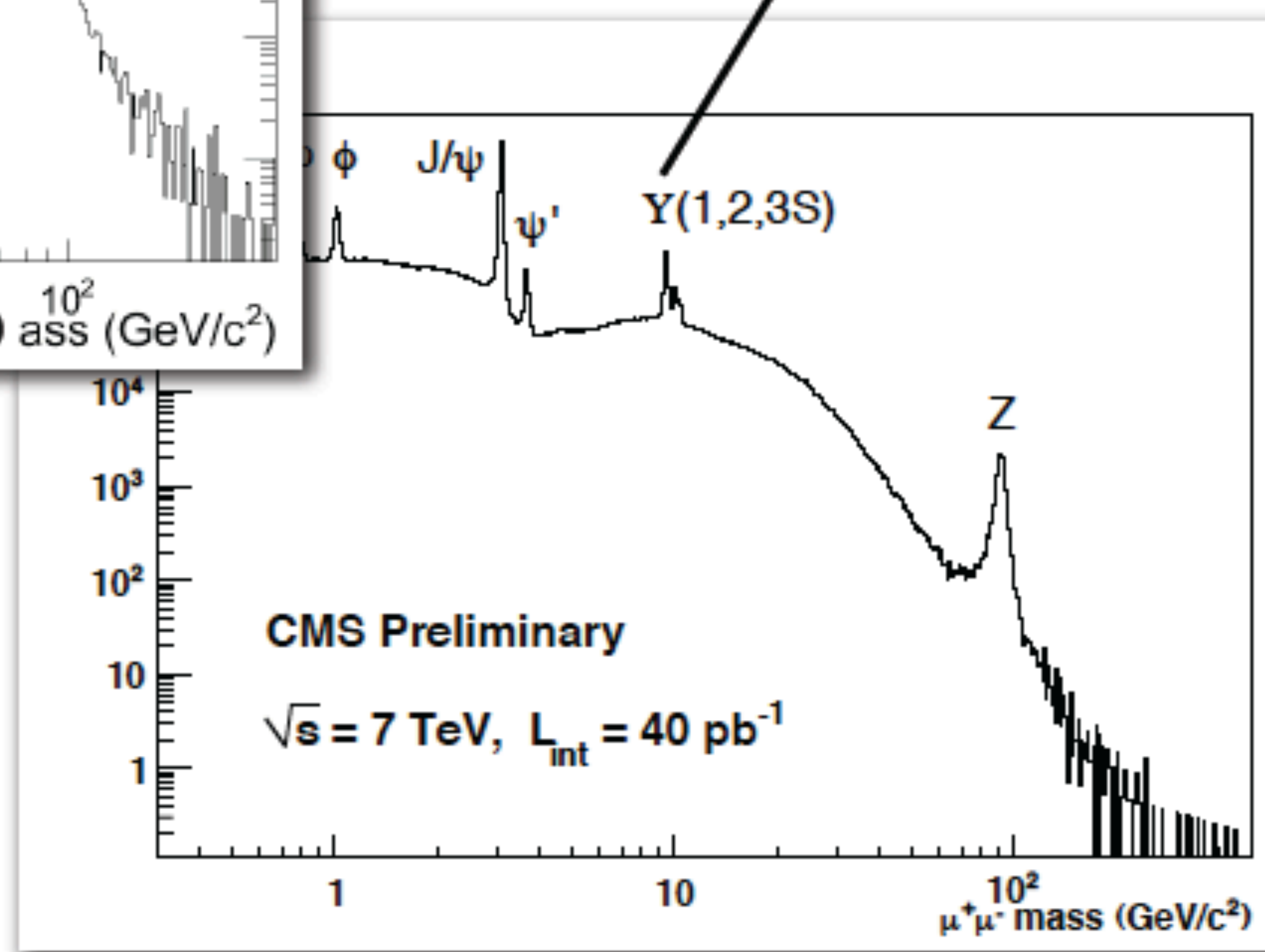




Di-Electron and Di-Muon Spectra



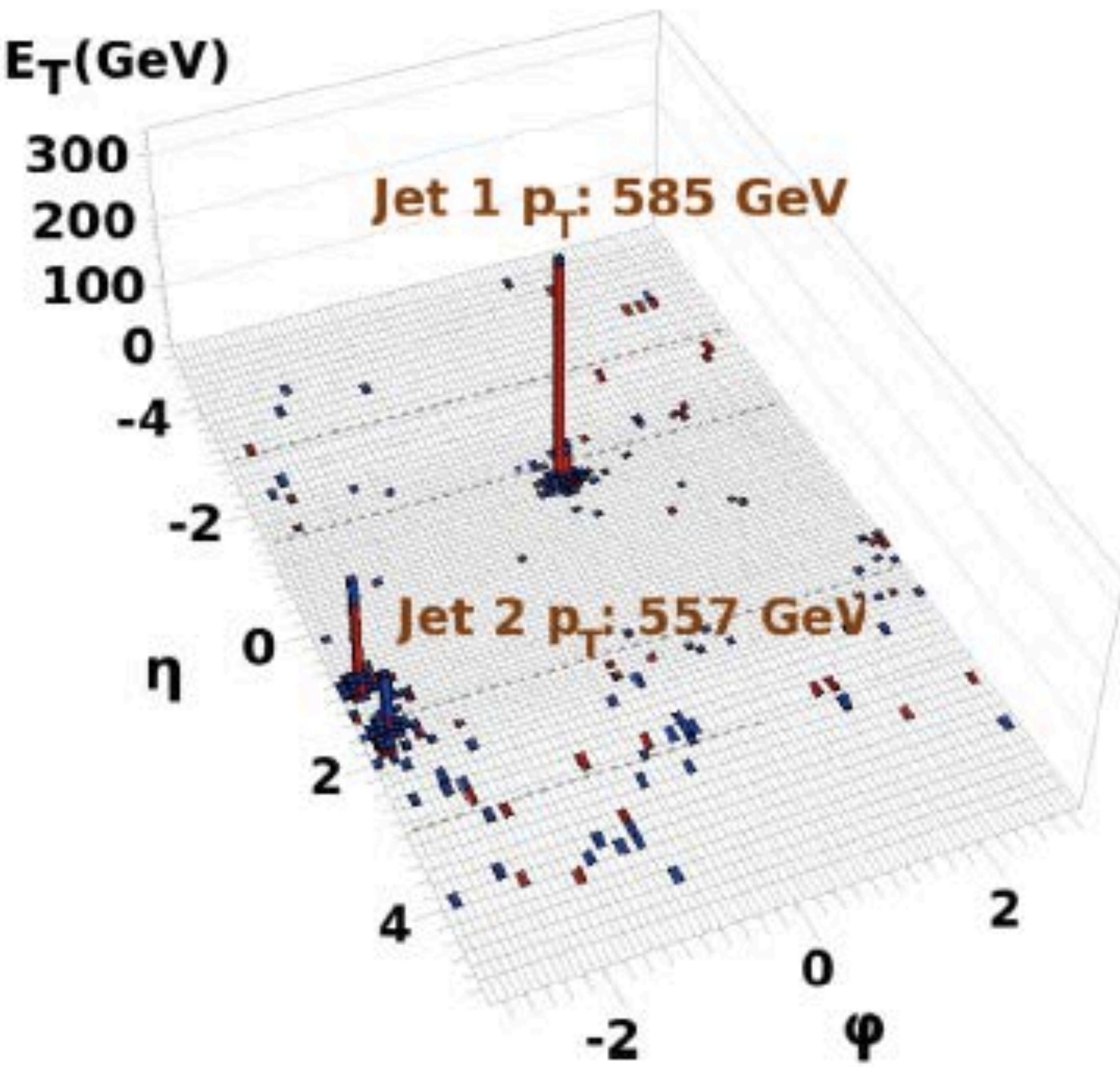


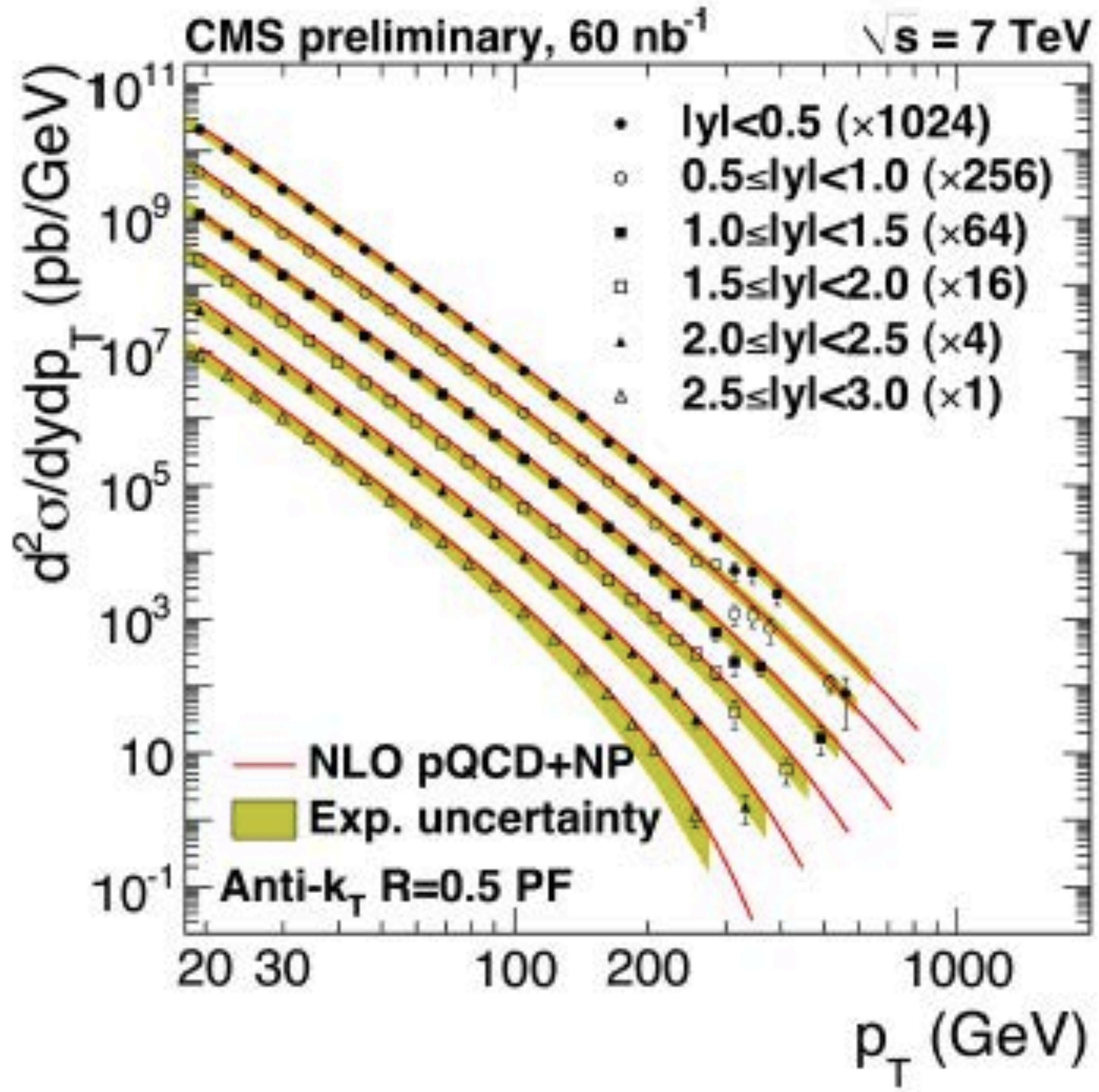


High-Resolution Electron & Muon Reconstruction over full kinematic range

Inclusive Jet Production

Measured Jet Production rate in good agreement within experimental and theoretical uncertainties



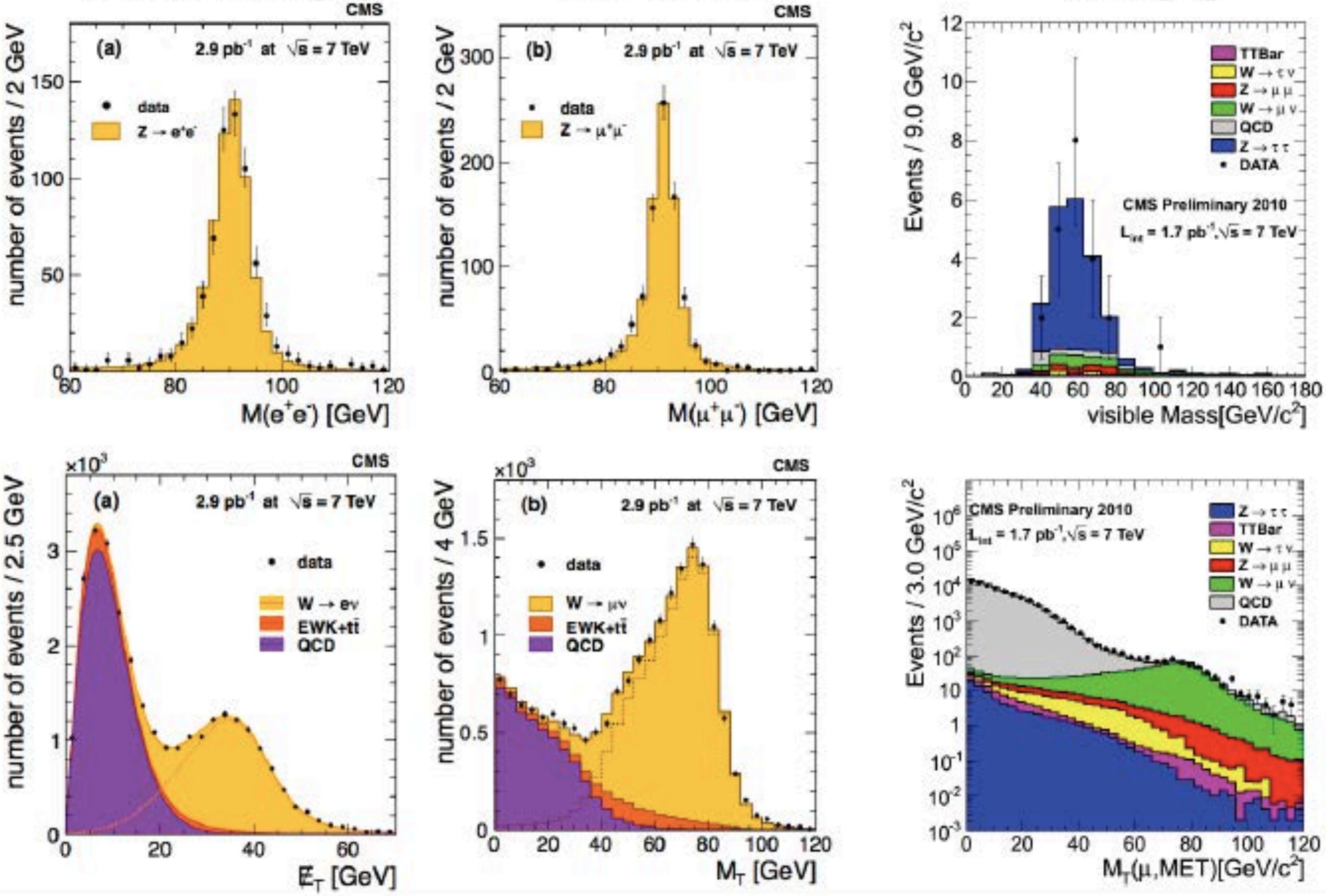


W & Z Boson Production

electron(s) | muon(s) | tau(s)

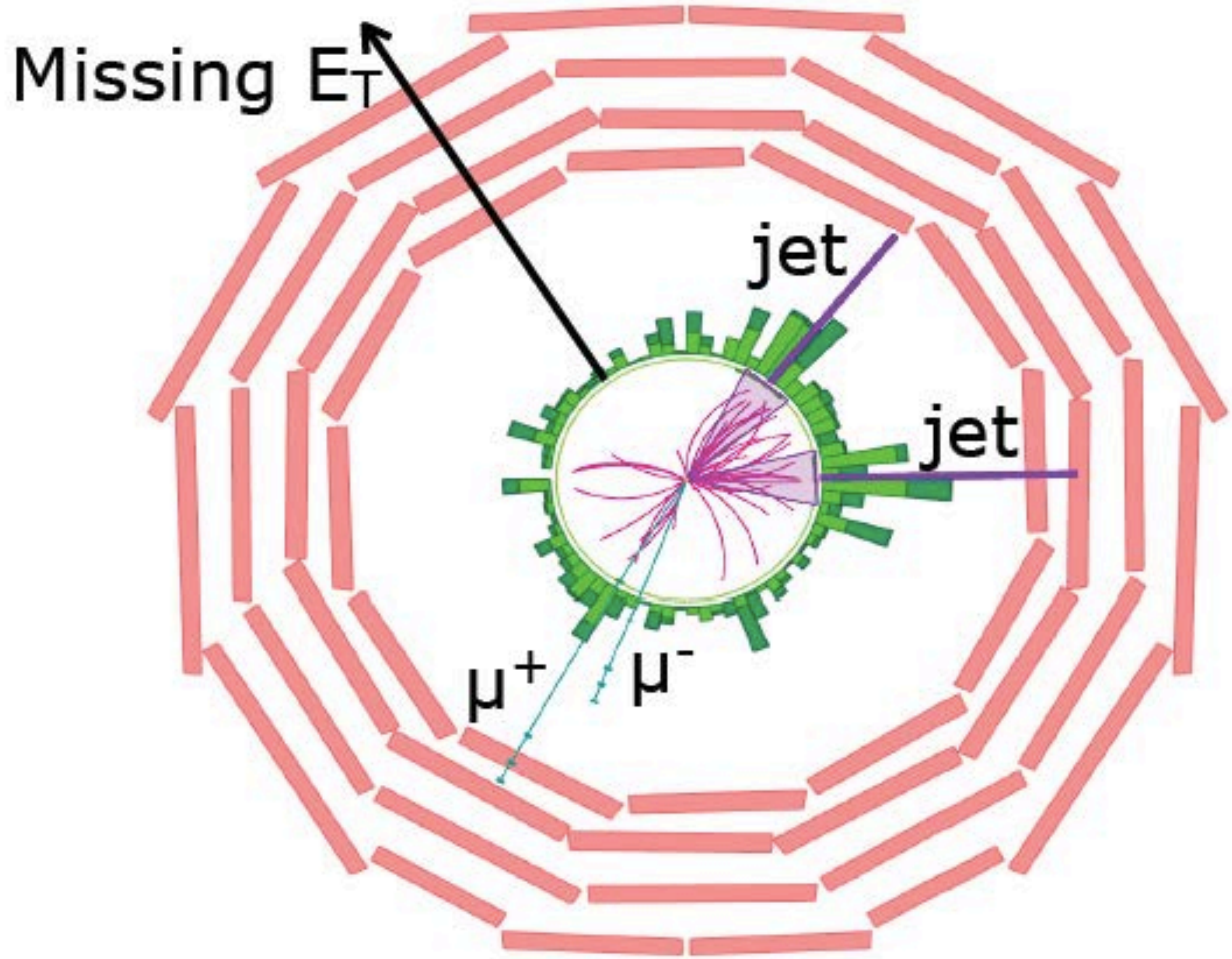
Z Boson

W Boson



четверг, 23 декабря 2010 г.

Top Pair Production



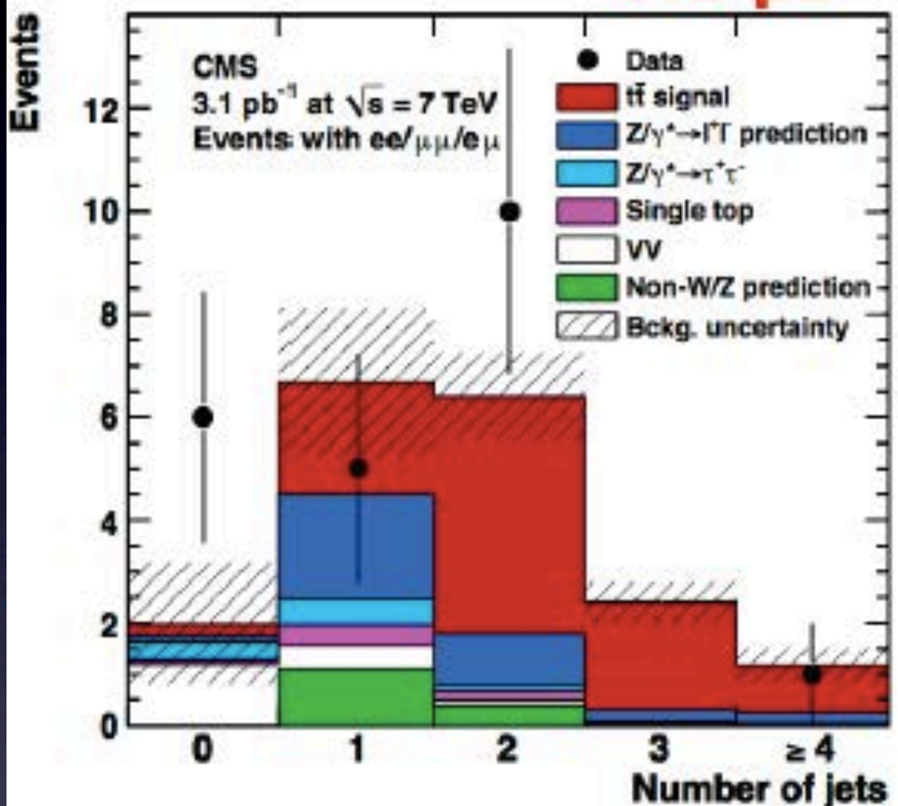
Top Di-Muon Candidate Event

Top Pairs: Dilepton Channel

Accepted by PLB
arXiv:1010.5994 [hep-ex]

3.1 pb^{-1}

2 Leptons, ≥2 Jets , Missing E_T



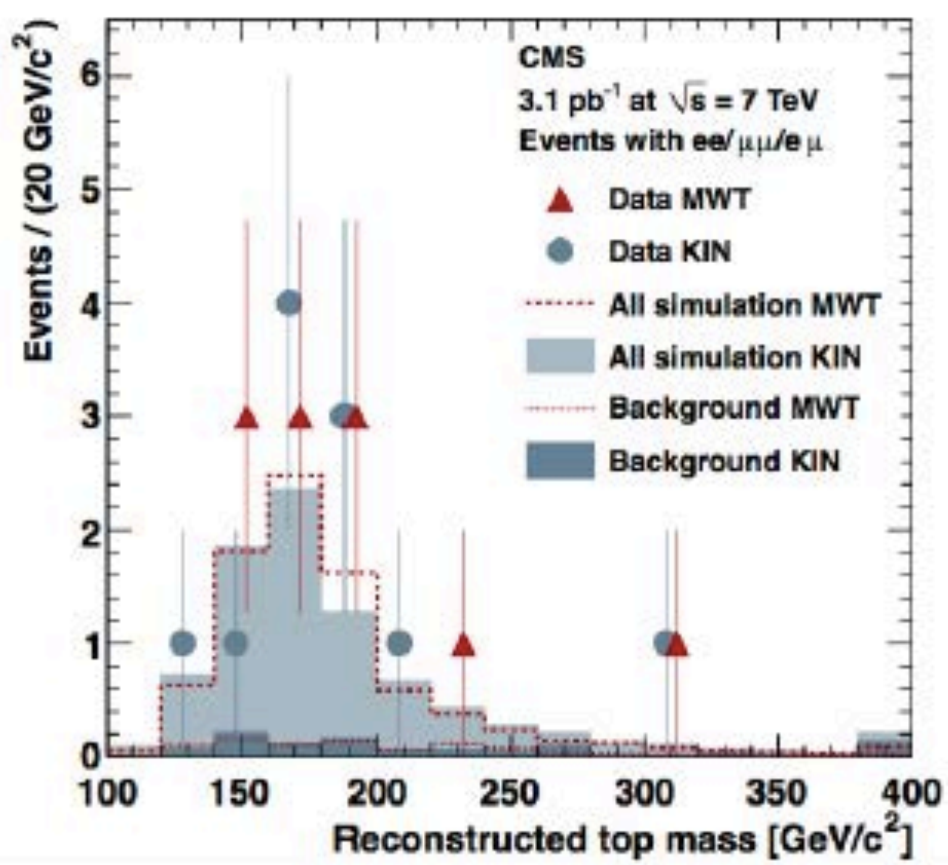
First LHC top pair cross-section measurement:

$\sigma(pp \to tt) = 194 \pm 72(stat) \pm 24(syst) \pm 21(lumi)$ pb

Consistent with theory prediction

Reconstructed Top Mass in good agreement with simulation prediction

Top Mass measurement with full 2010 pp dataset in preparation



четверг, 23 декабря 2010 г.

Two-Particle Angular Correlations

Published in
J. High Energy Phys. 09 (2010) 091

First surprising result from the LHC:
Observation of Long-Range Near-Side Angular Correlations in pp Collisions

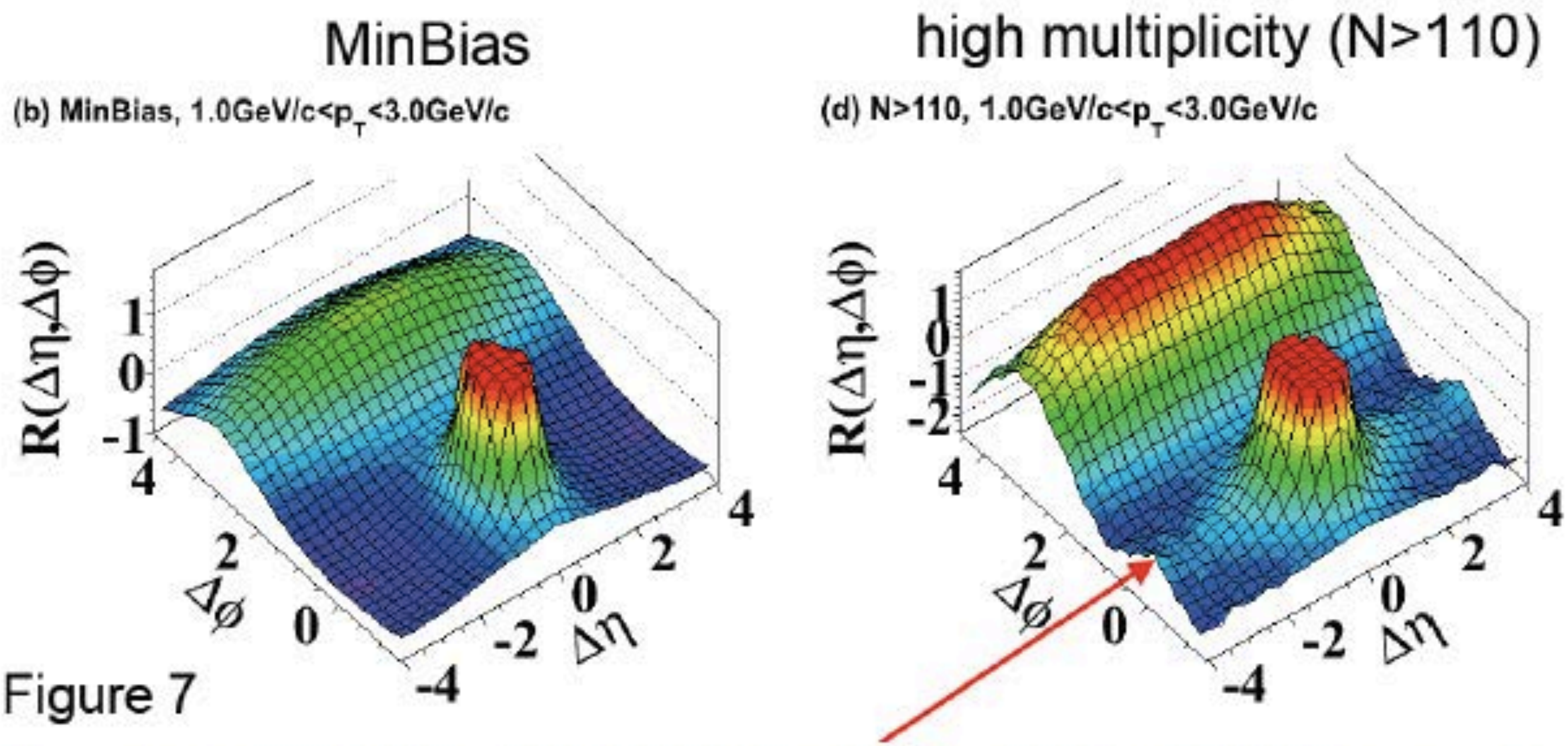
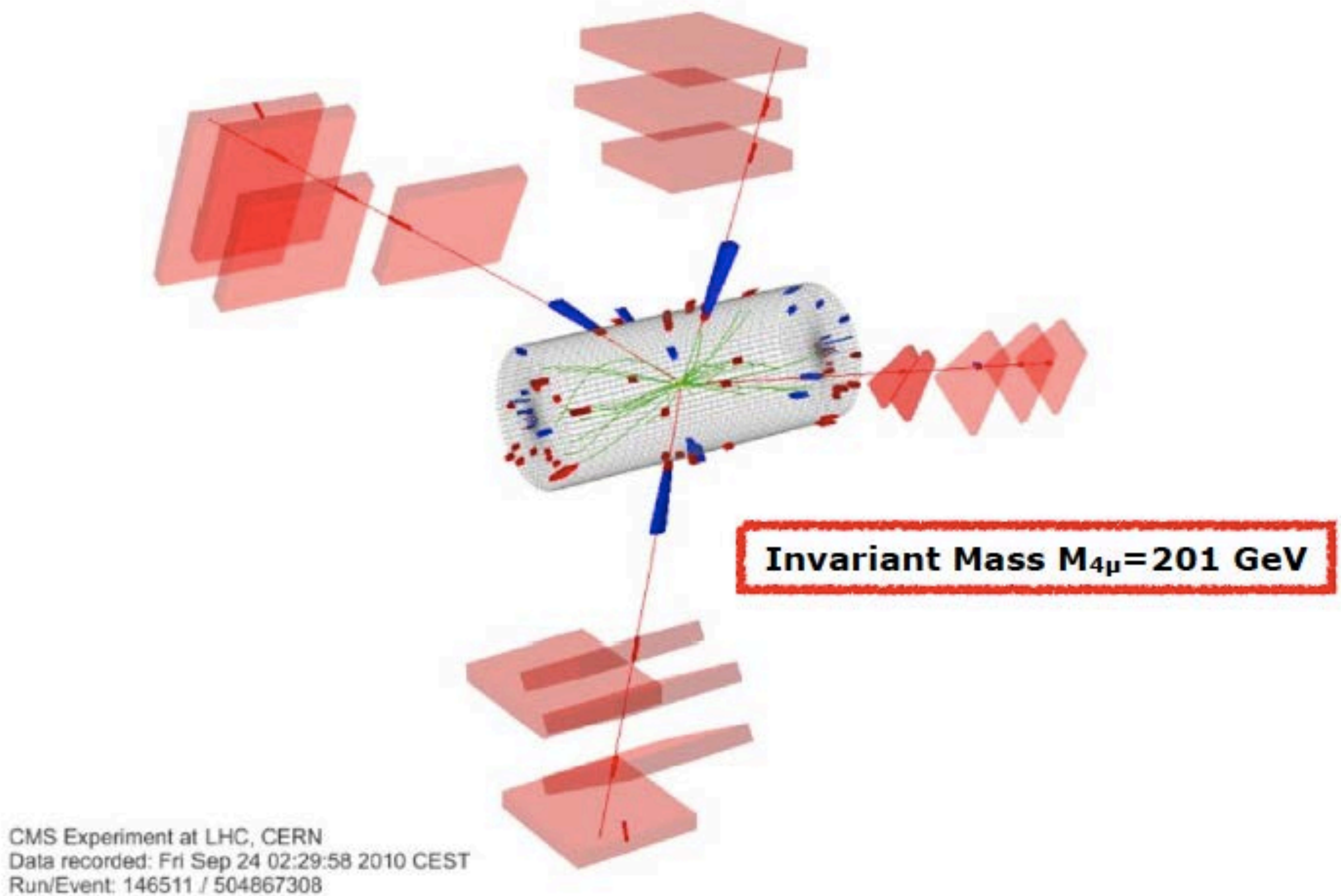
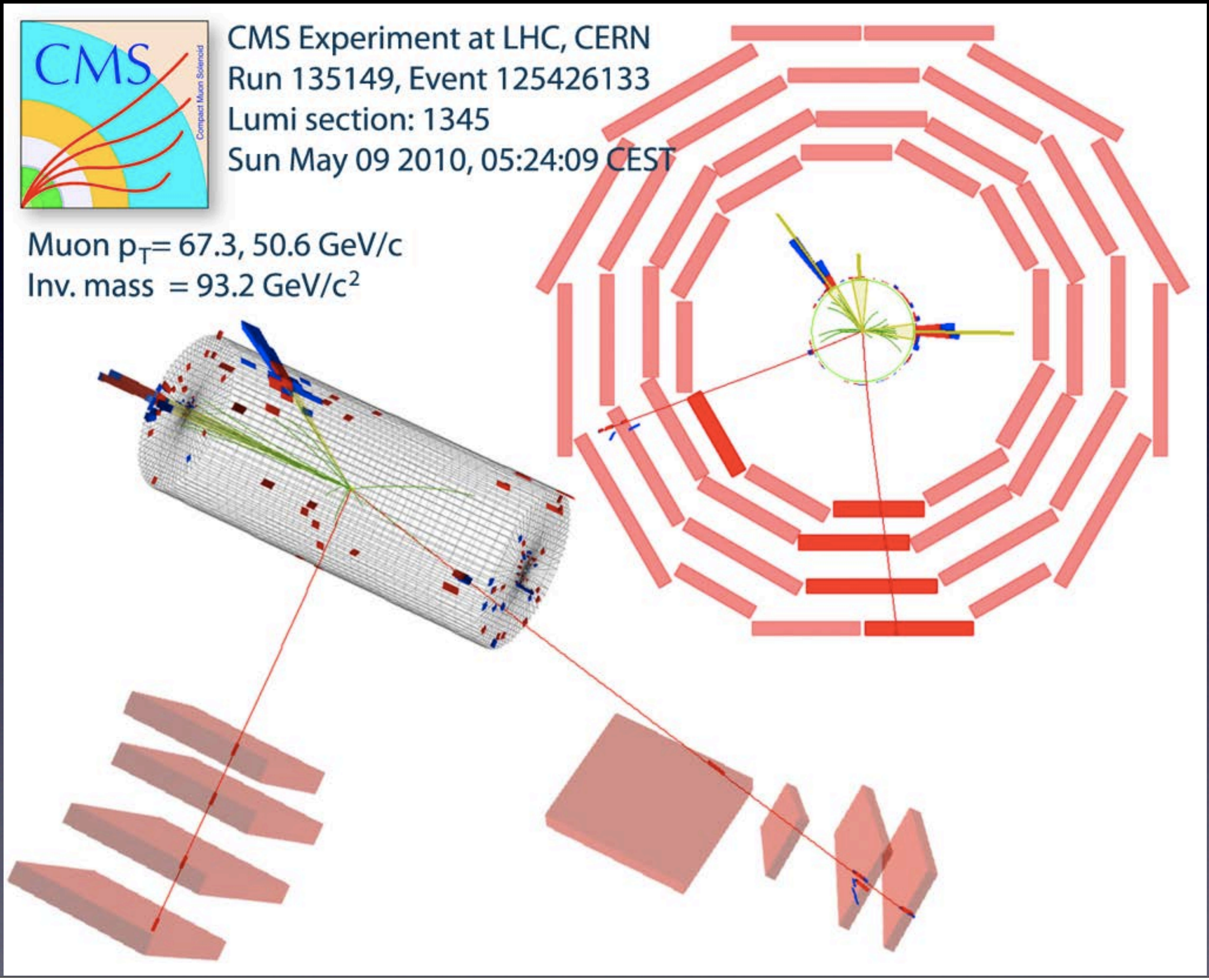


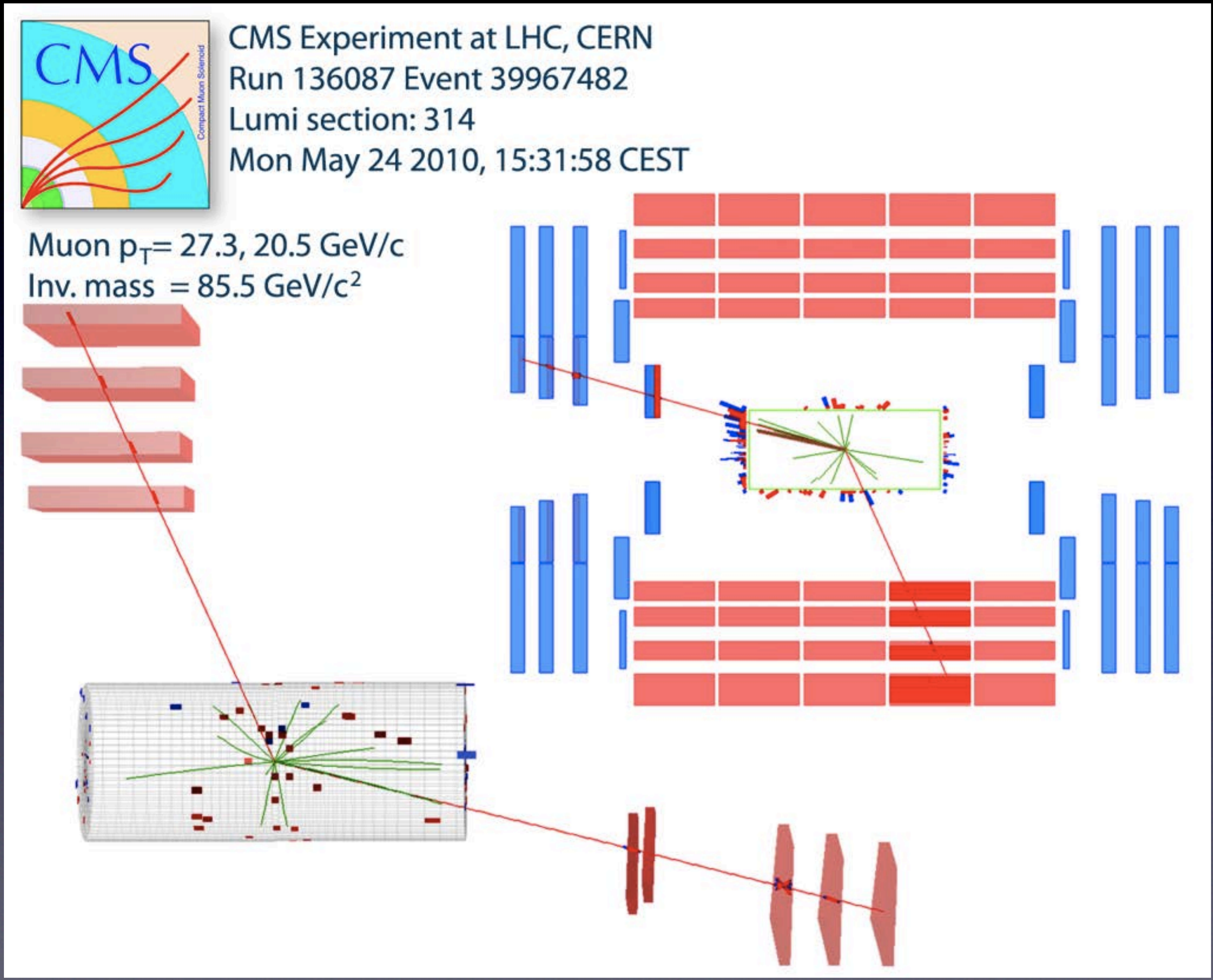
Figure 7

No conclusive explanation yet , sizeable impact on scientific community!

First $(Z^0 \to \mu^+\mu^-)(Z^0 \to \mu^+\mu^-)$ Candidate

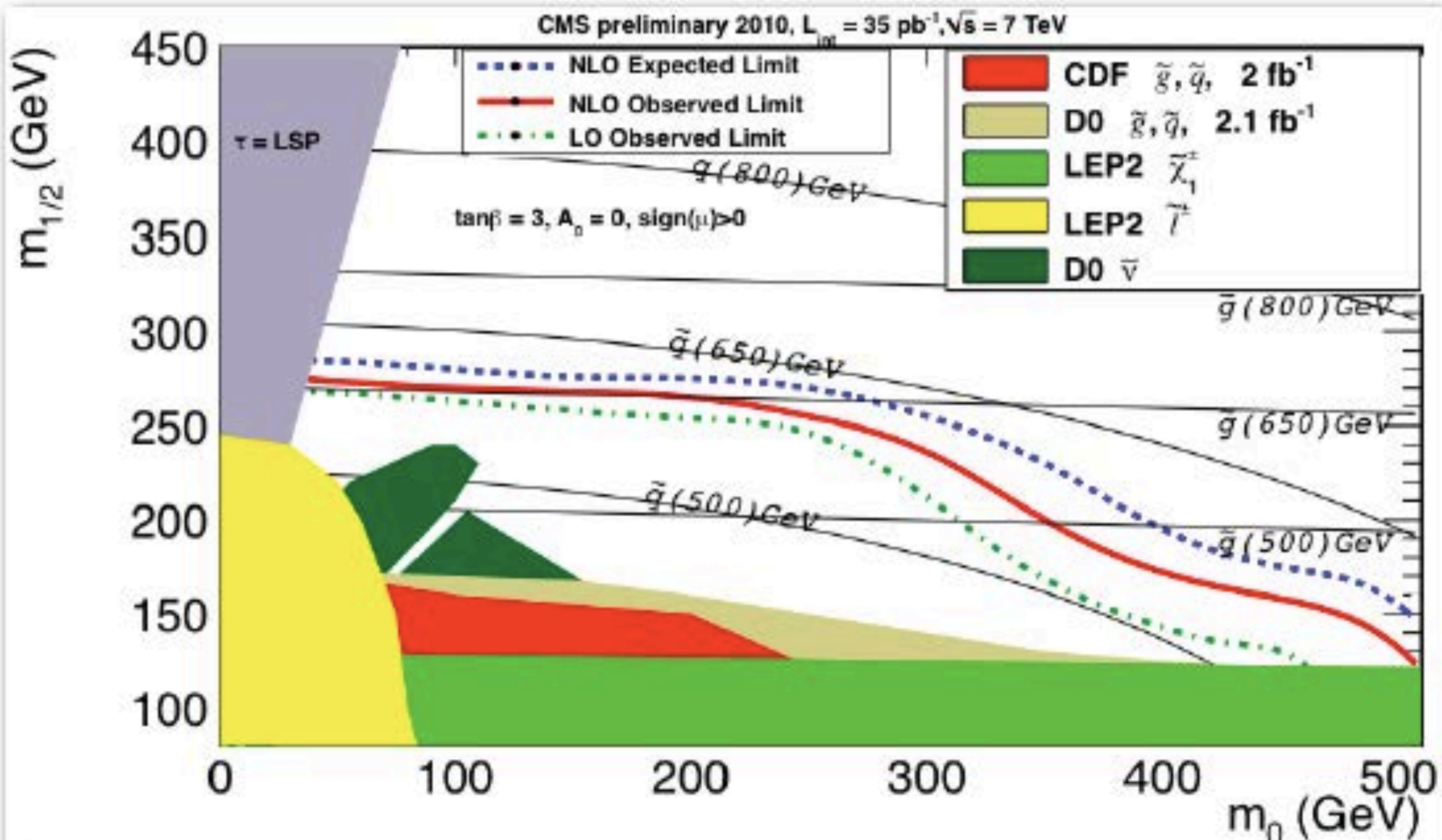



CMS Experiment at LHC, CERN
Run 135149, Event 125426133
Lumi section: 1345
Sun May 09 2010, 05:24:09 CEST
Muon p_T= 67.3, 50.6 GeV/c
Inv. mass = 93.2 GeV/c^2


CMS Experiment at LHC, CERN
Run 136087 Event 39967482
Lumi section: 314
Mon May 24 2010, 15:31:58 CEST
Muon p_T= 27.3, 20.5 GeV/c
Inv. mass = 85.5 GeV/c^2

First SUSY Result at the LHC!

Search for high mass squark & gluino production in events with large missing transverse energy and two or more jets



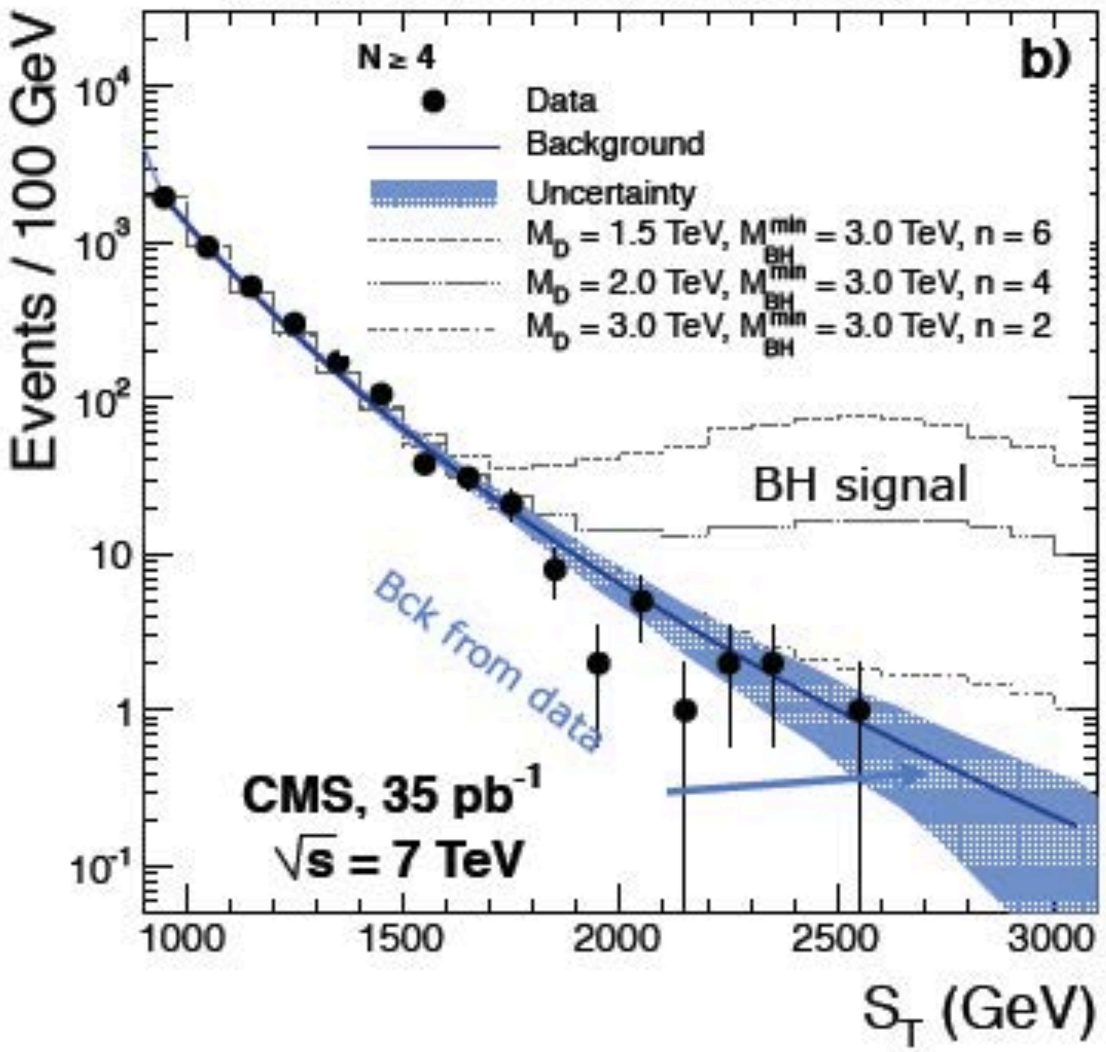
Expanded the excluded range established during the last 20 years (!) by ~factor of two with only 35 pb^{-1}!

Search for Microscopic Black Holes

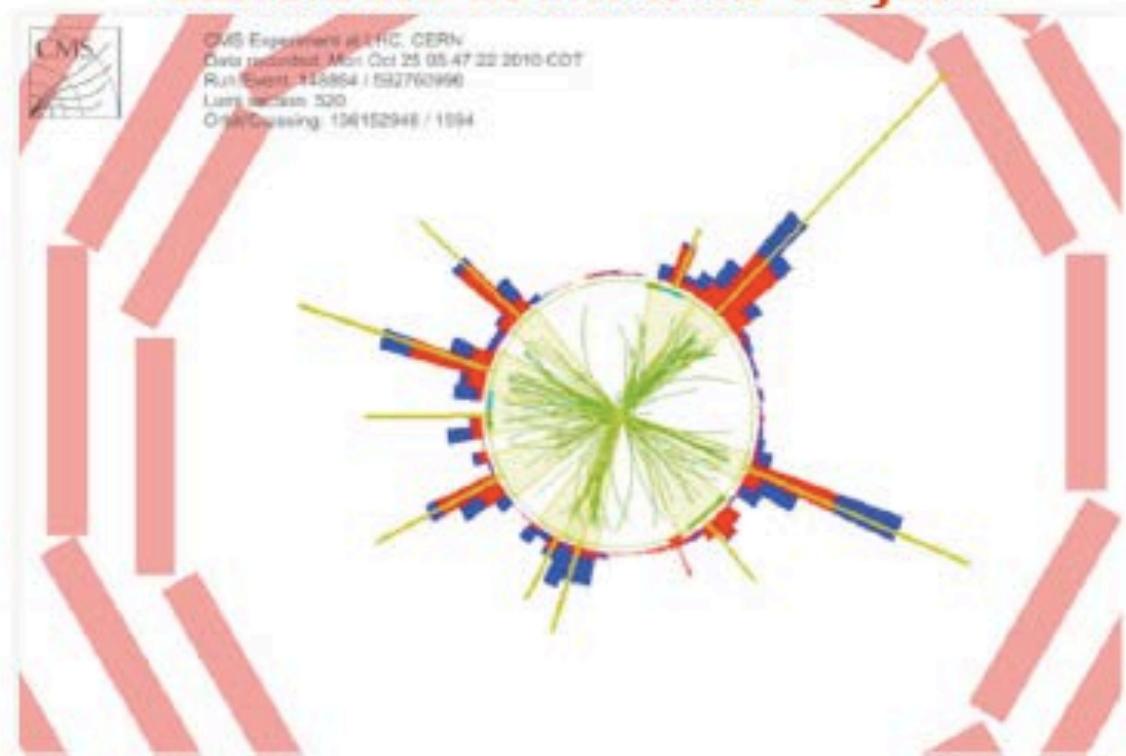
Submitted to PLB
arXiv:1012.3375 [hep-ex]

Extra dimensions?!

Decay into highly-energetic multiparticle final states
The first search for black holes at a particle accelerator

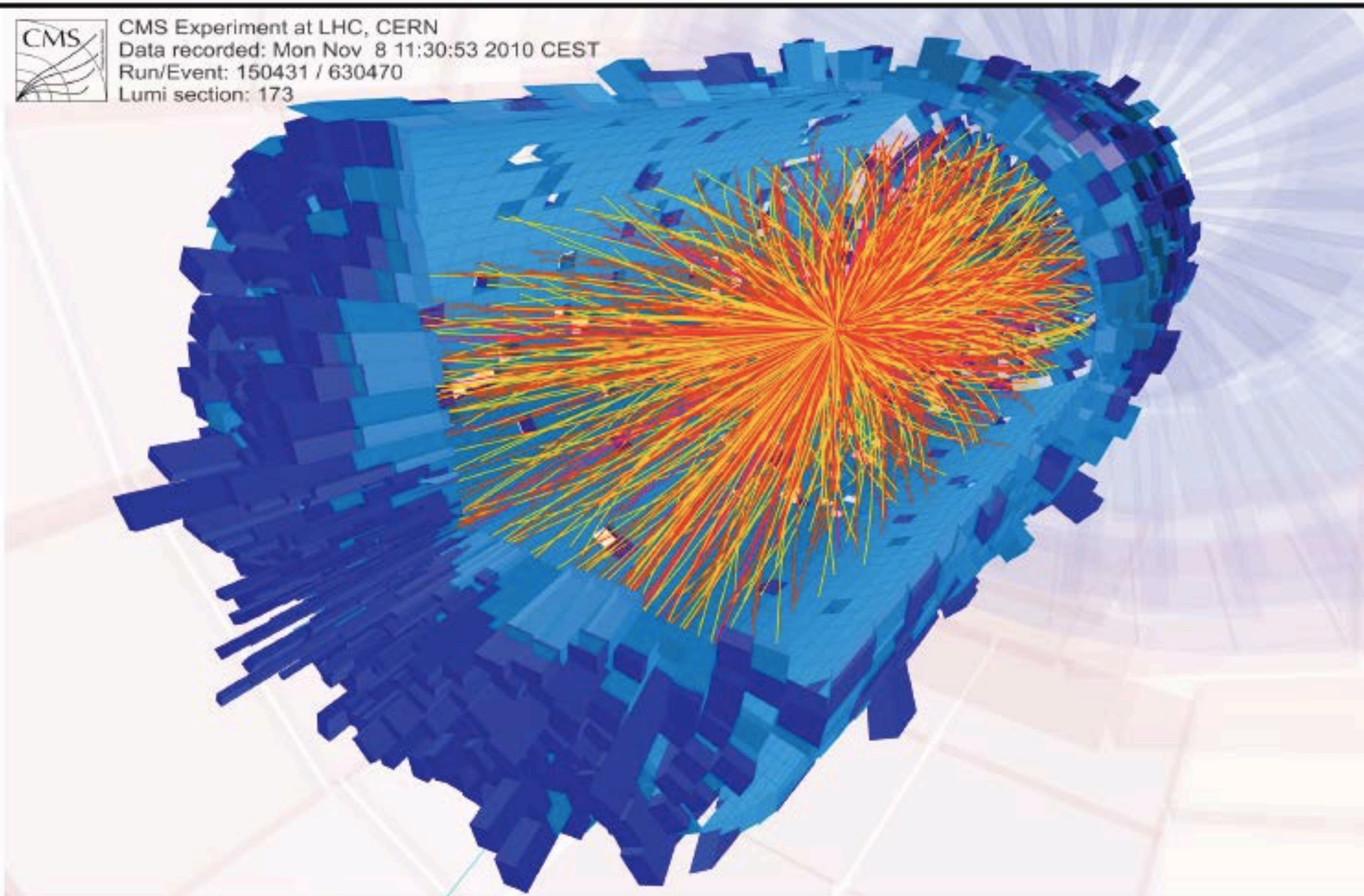


Candidate event with 10 jets



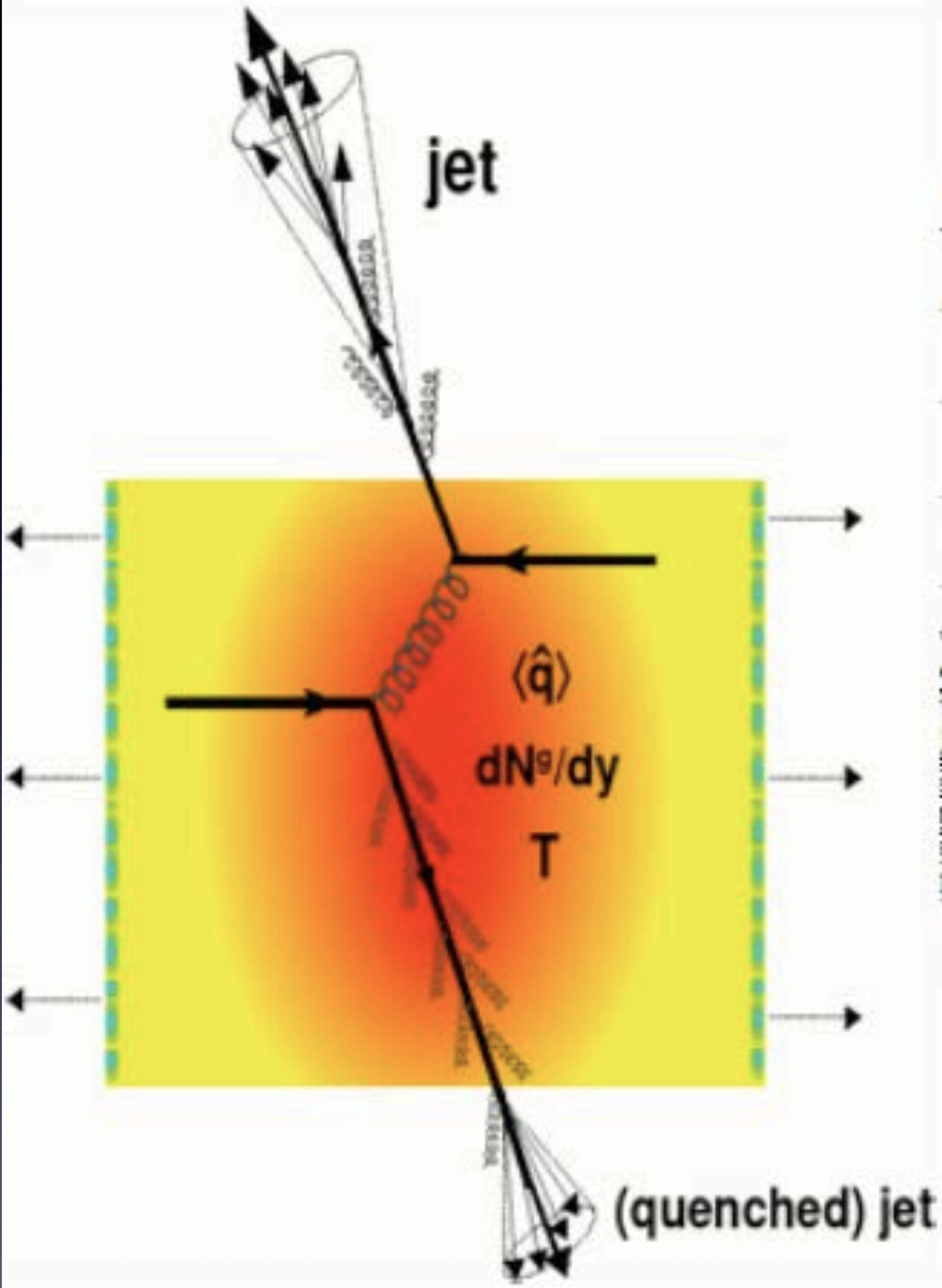
Set limits of 3.5-4.5 TeV on the minimum black hole mass

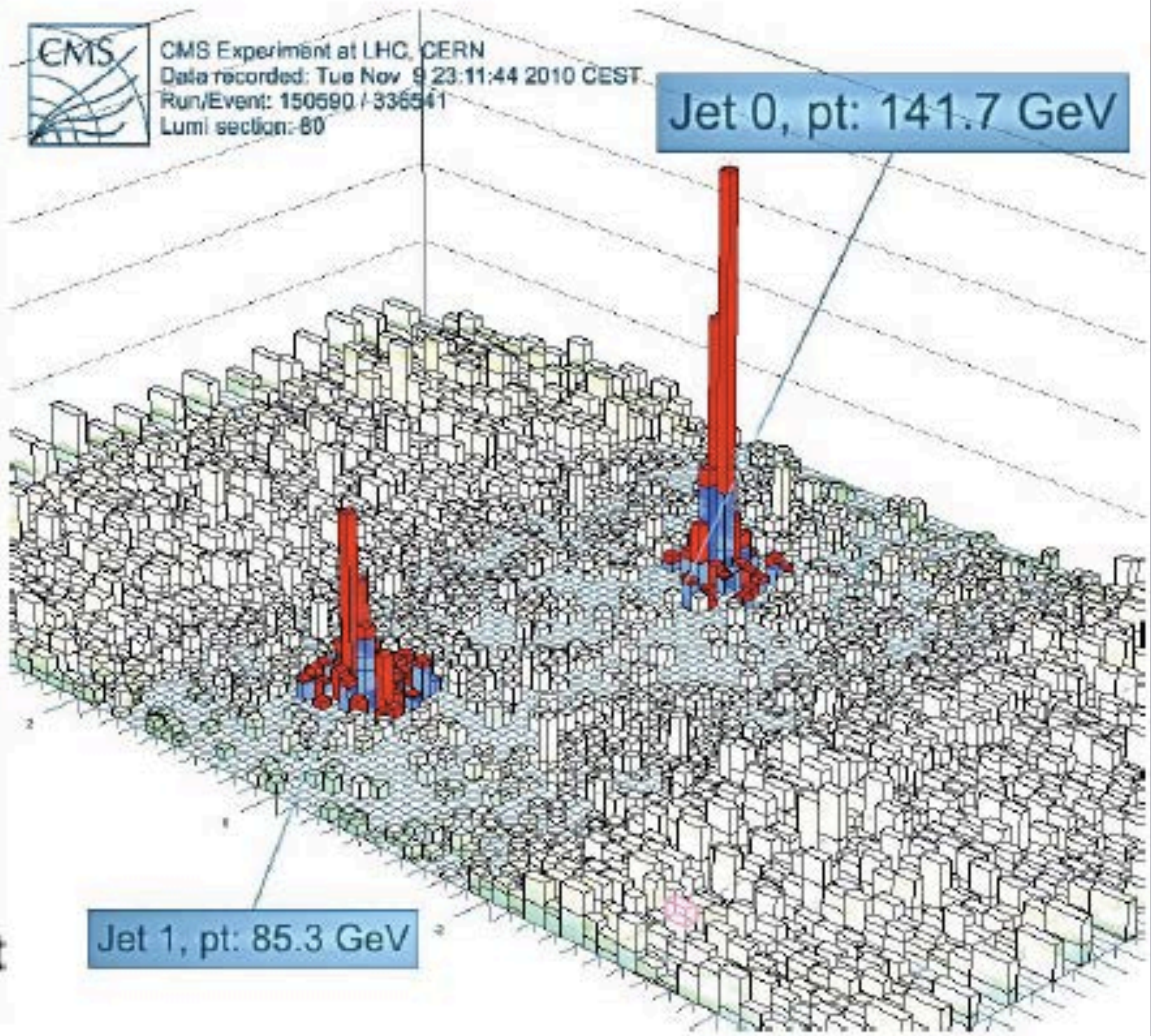
Heavy Ion (Pb-Pb) Collisions



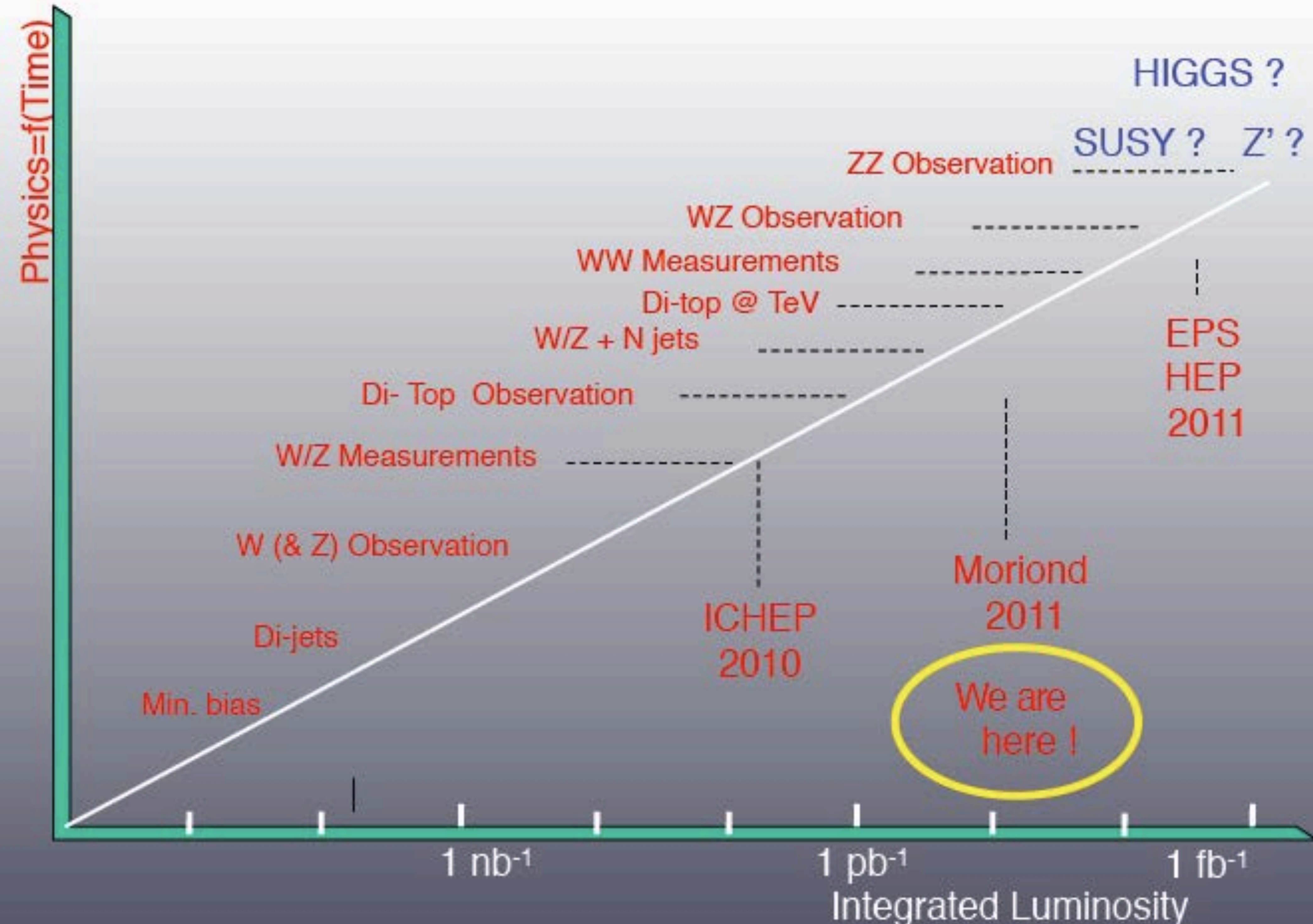
Jet Quenching in HI Collisions

Significant dijet imbalance





CMS Physics Objectives through 2011



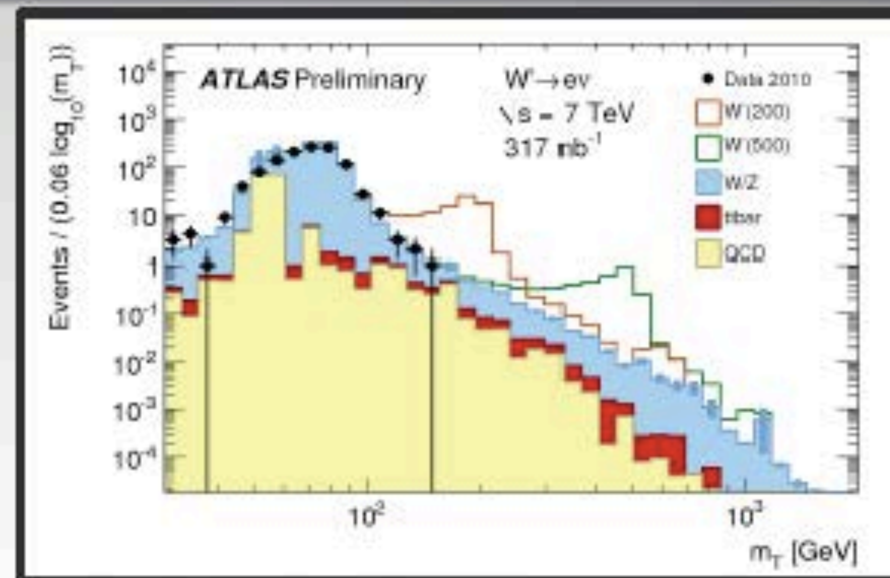
Other search prospects in 2011

Massive W' and Z' particles

Preliminary estimates for 10 events at 7 TeV :

	$1\ fb^{-1}$	$5\ fb^{-1}$
W' mass	2 TeV	2.4 TeV
Z' mass	1.5 TeV	2 TeV

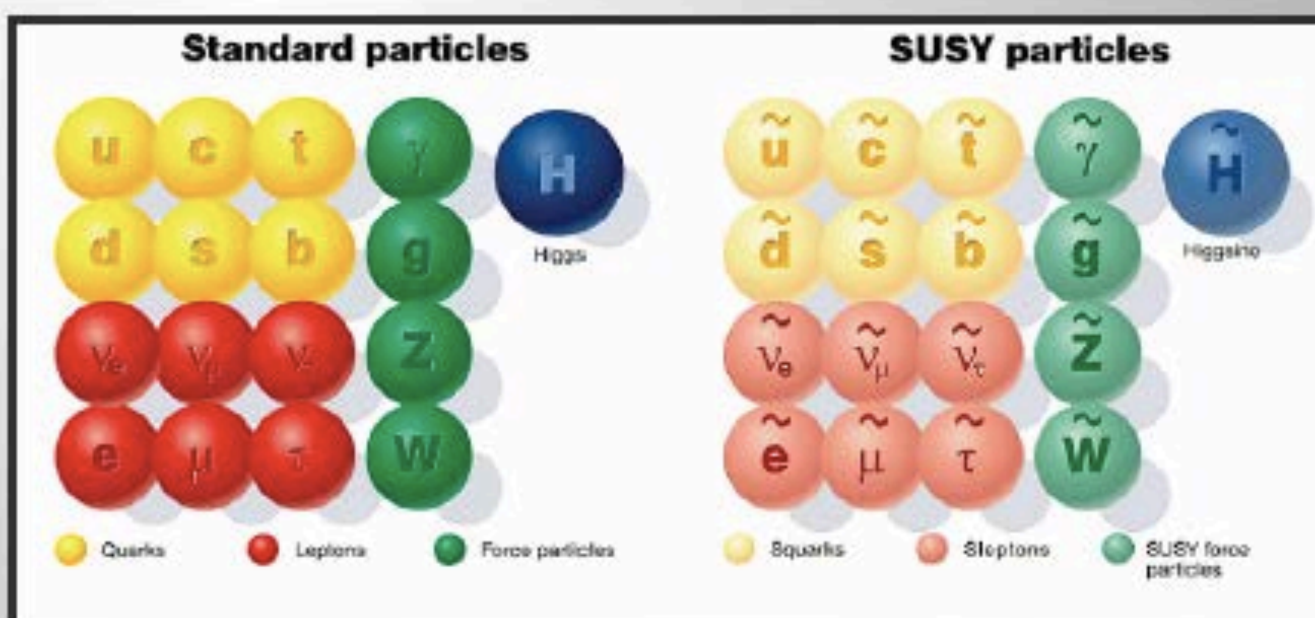
Tevatron limits currently ~1 TeV



SUperSYmmetry (SUSY)

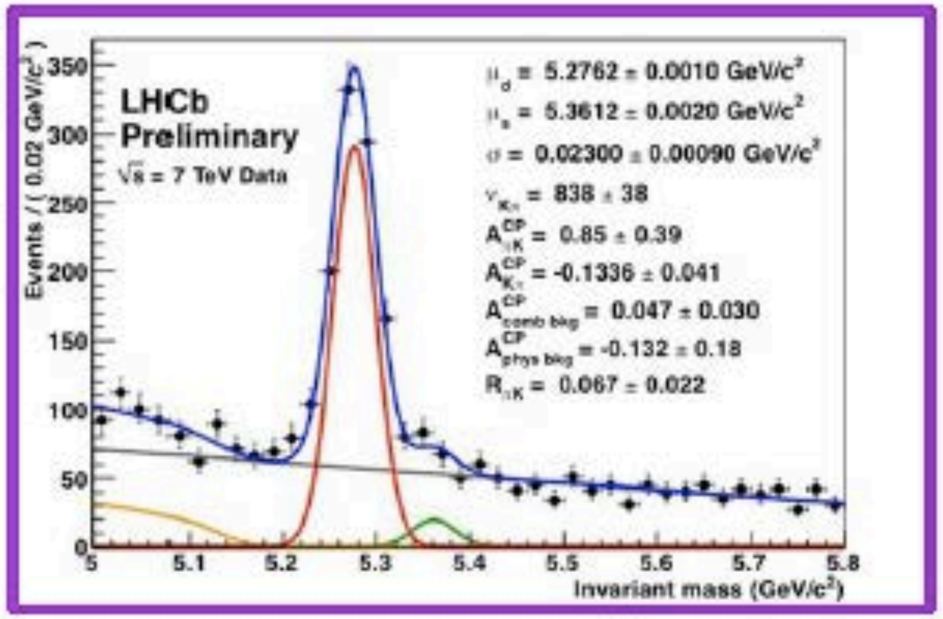
$1\ fb^{-1}$	$5\ fb^{-1}$
0.7 TeV	1 TeV

$\tilde{q}$ mass (~ $\tilde{g}$ mass)



Evidence for CP violation in B-system in first data ?

$B_d^0 \rightarrow K\pi$ &
$B_s^0 \rightarrow K\pi$



B_s^0/B_d^0 yield = (10.7±2.0)%,

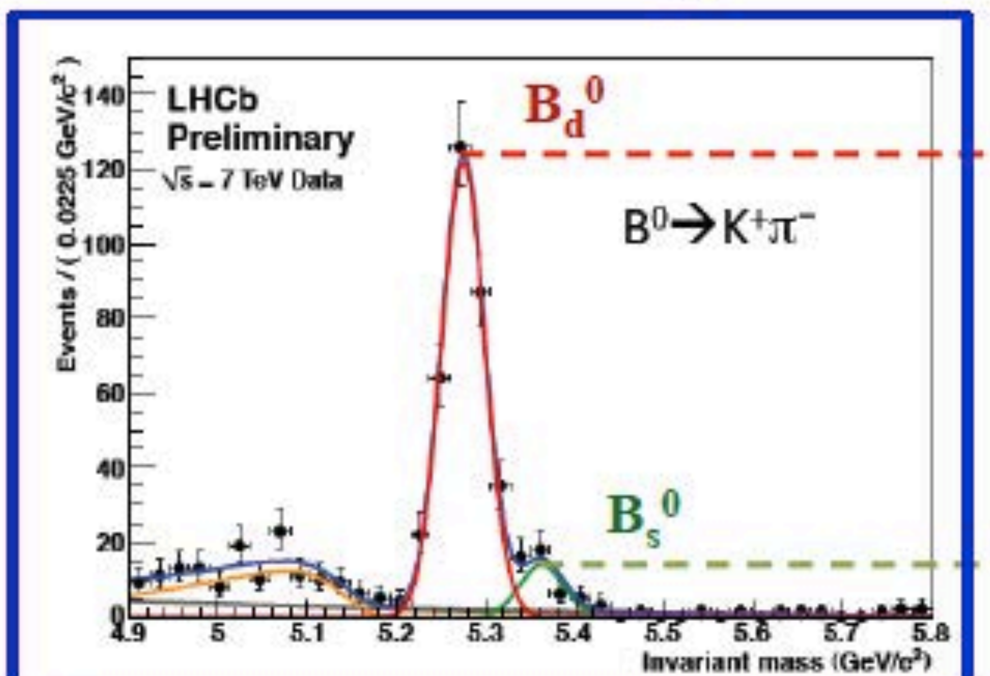
$A_{CP}(B_d^0)$=-0.134±0.041
(HFAG: -0.098±0.012)

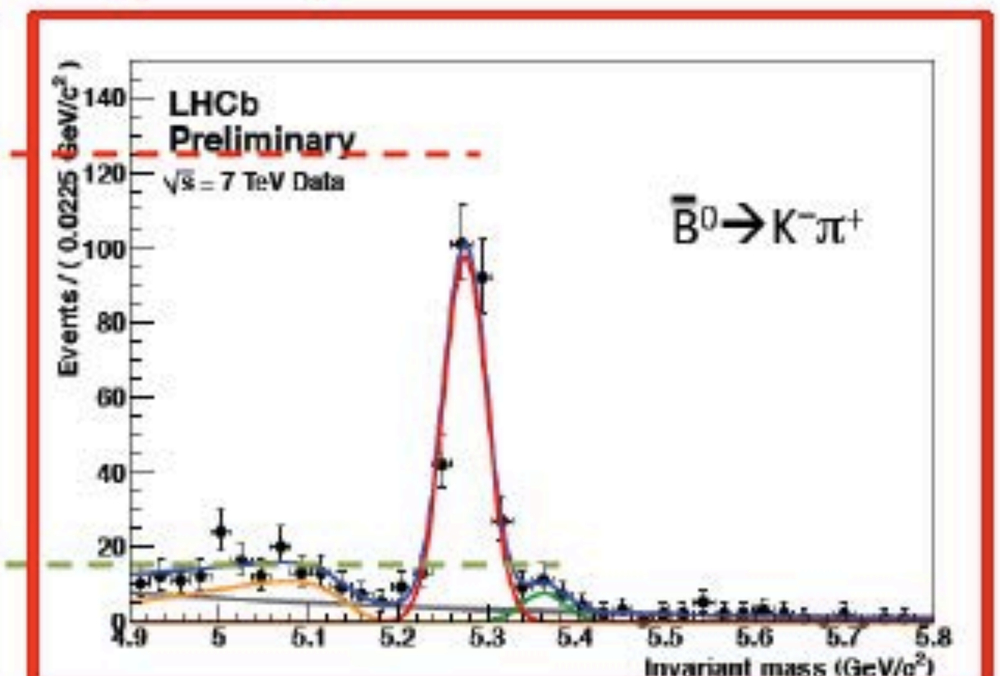
$A_{CP}(B_s^0)$=-0.43±0.17
(CDF: 0.39±0.15±0.08 in 1 fb^{-1})

- ❖ only raw asymmetries
- ❖ not accounted for production & detector asymmetries
- ➢ this is not a physics result yet!

CP violation →
particle and anti-particle
behave differently!

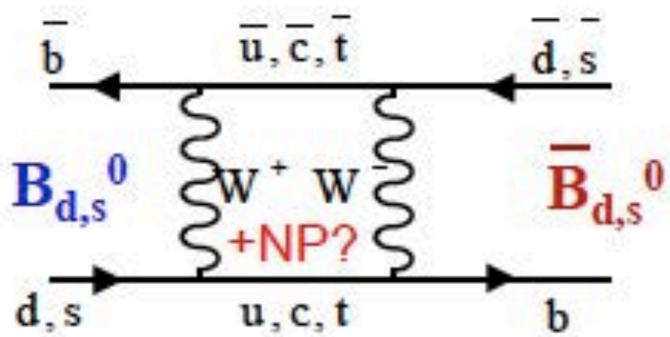
B^0 $\bar{B}^0$

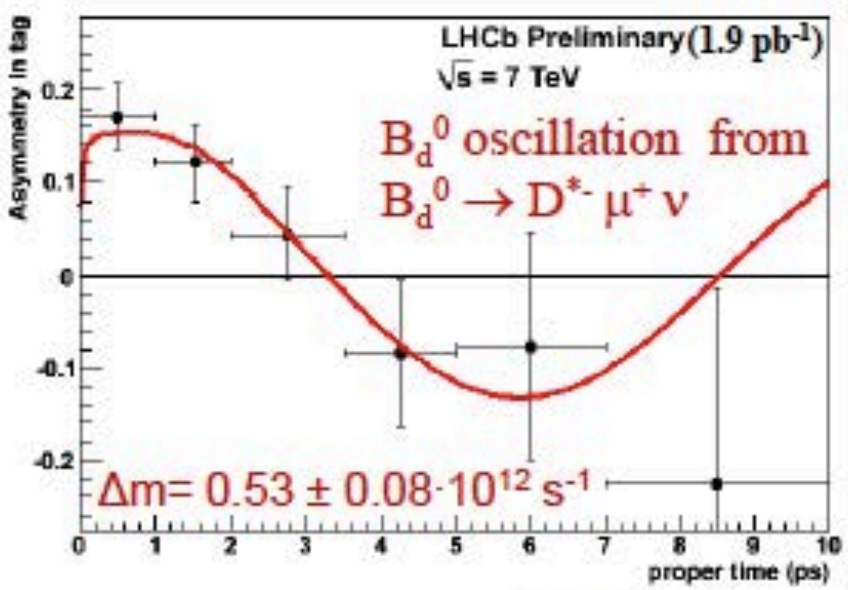




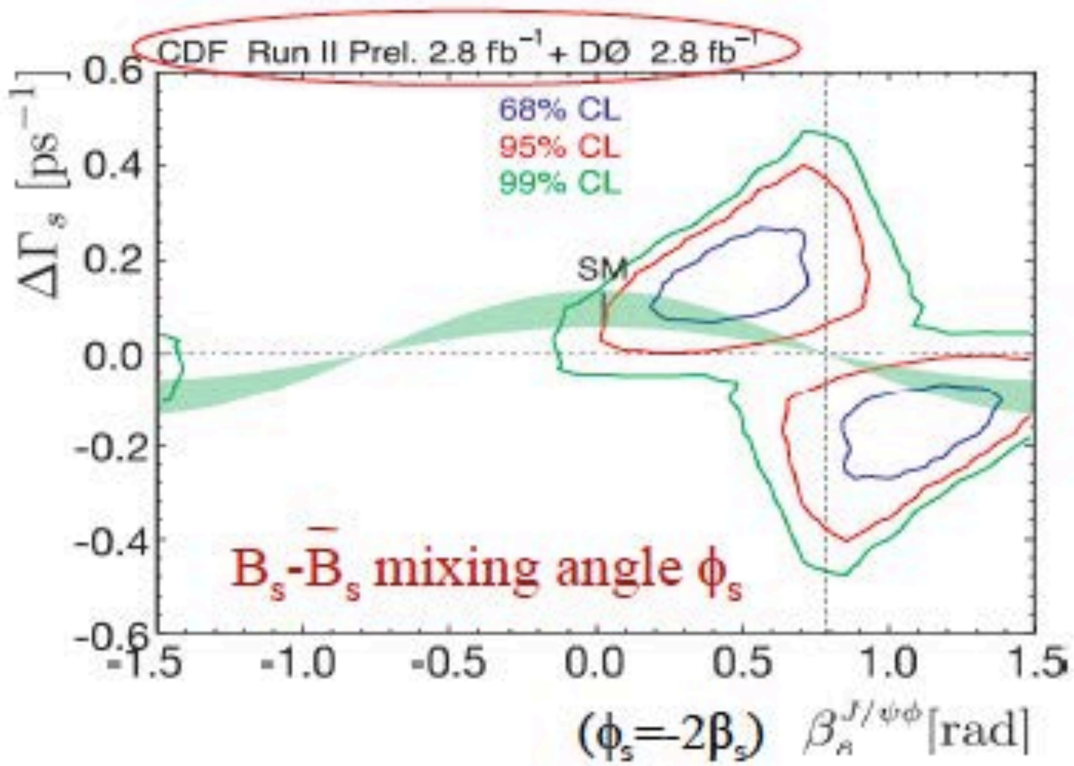
Probing New Physics in loop decays: CPV in $B_s \to J/\psi\varphi$

- ✓ B^0 and $\overline{B}^0$ are mixing via box diagram





- ✓ mixing phase very precisely known in Standard Model: $\phi_s = -2\beta_s = -0.042 \pm 0.0014$
- ✓ sensitive to New Physics effects
- ➢ $\phi_s = \phi_s(SM) + \phi_s(NP)$

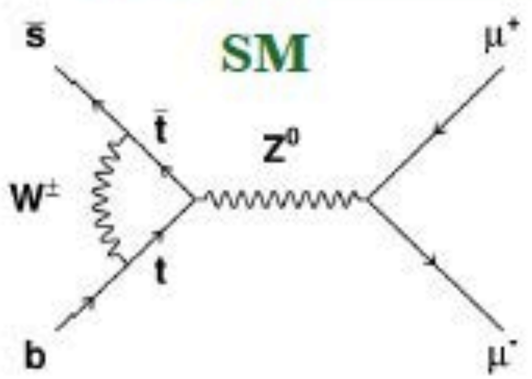


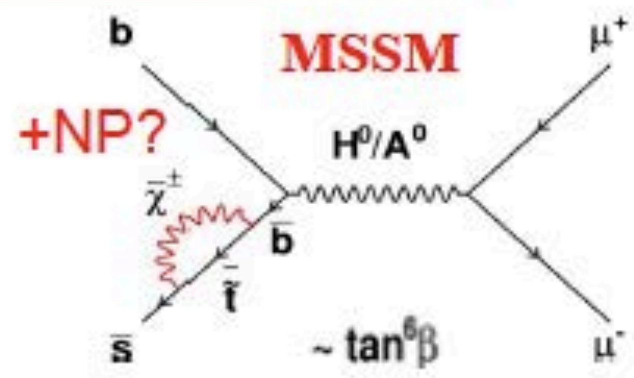
- ✓ measure CP violation in $\overset{(-)}{B}_s \to J/\psi\ \varphi$
- ➢ B_s mixing phase Φ_s is analogous to the measurement in B_d system, with which BaBar & BELLE validated the CKM model

- ➢ first combined Tevatron result showed ~2σ deviation from Standard Model
- ➢ down to ~1σ with 2010 CDF/D0 results

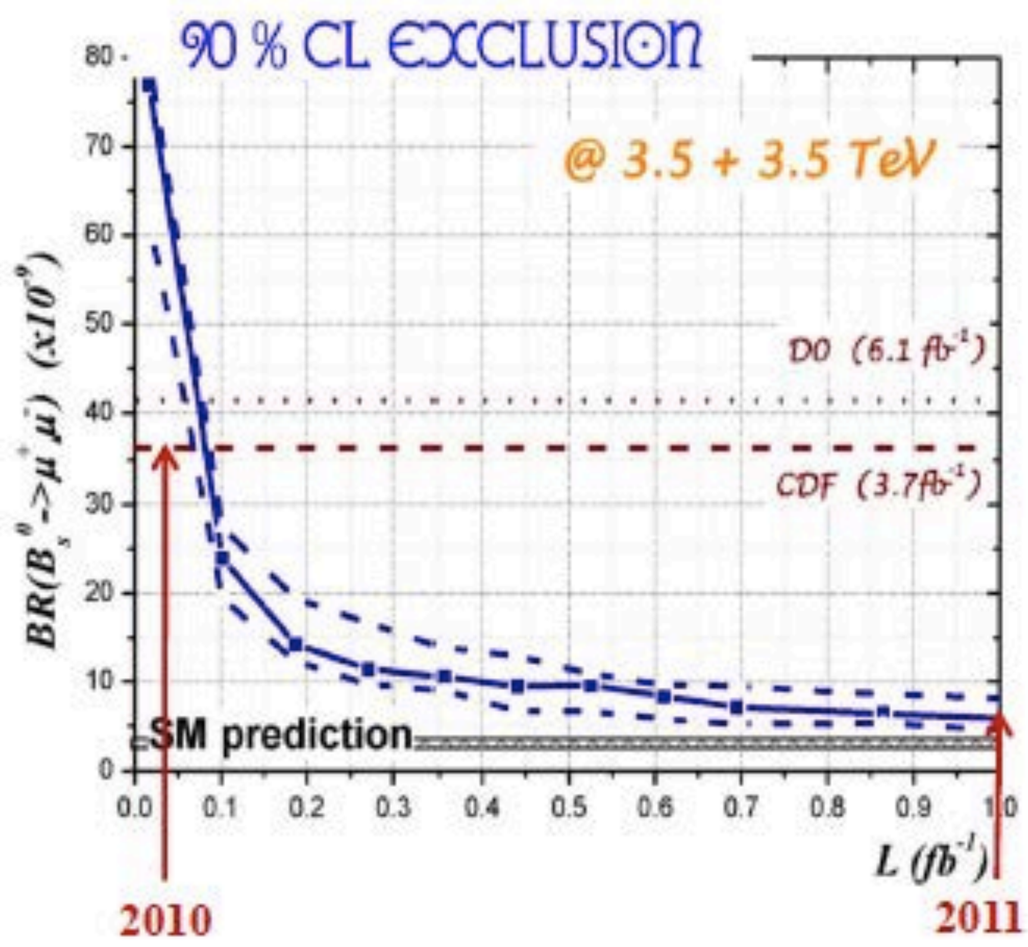
Probing New Physics in loop decays: $B_s \to \mu\mu$

$B_s \to \mu\mu$: the **super** rare loop decay





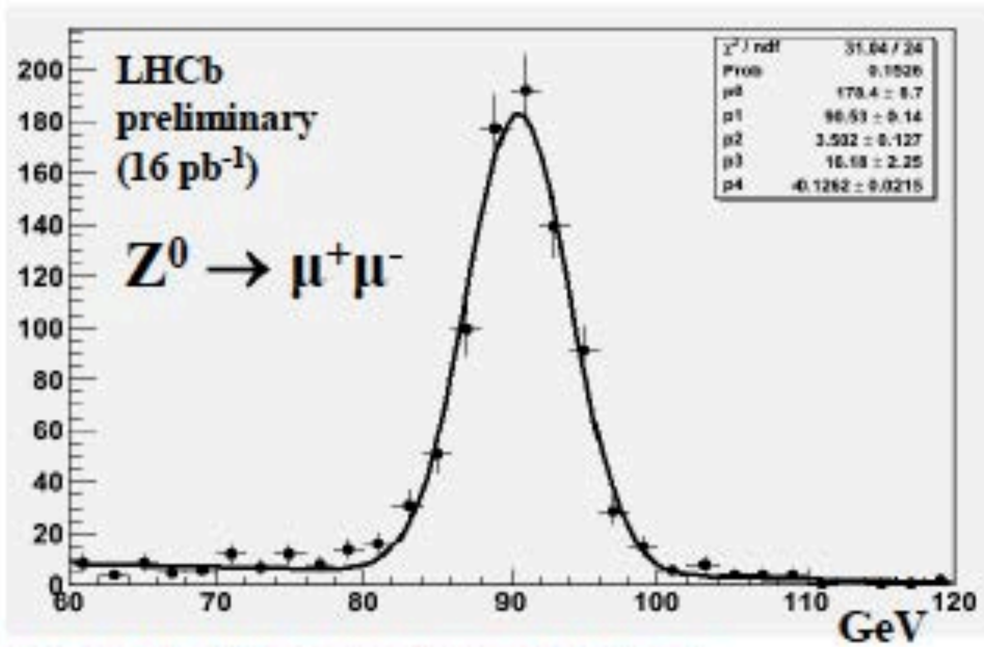
$BR = (3.2 \pm 0.2)\times\mathbf{10^{-9}}$ in SM



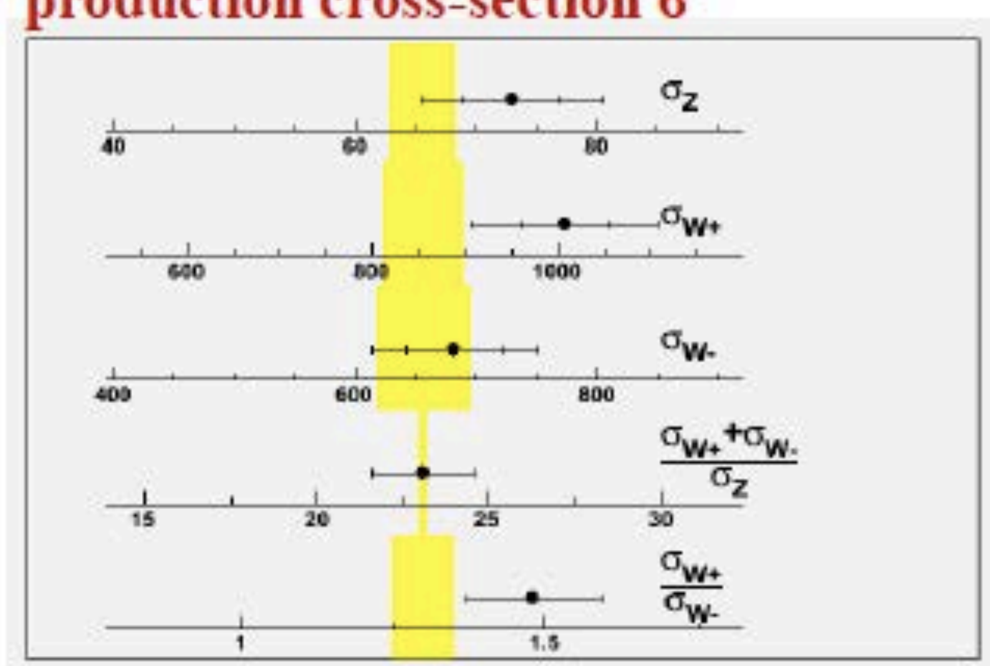
- ✓ sensitive to New Physics, can be strongly enhanced in SUSY with scalar Higgs exchange
- ✓ sensitive probe for MSSM with large tanβ: $B(B_S \to \mu^+\mu^-) \sim \tan\beta^{\,6} / M_A^{\,4}$

- ✓ analysis of 2010 data well advanced, "un-blinding" for winter conferences!
- ➢ expect competitive result with best world measurements, with this years data set
- ➢ potential to discover New Physics down to the SM predictions with next year's data

Production of Z and W in forward direction

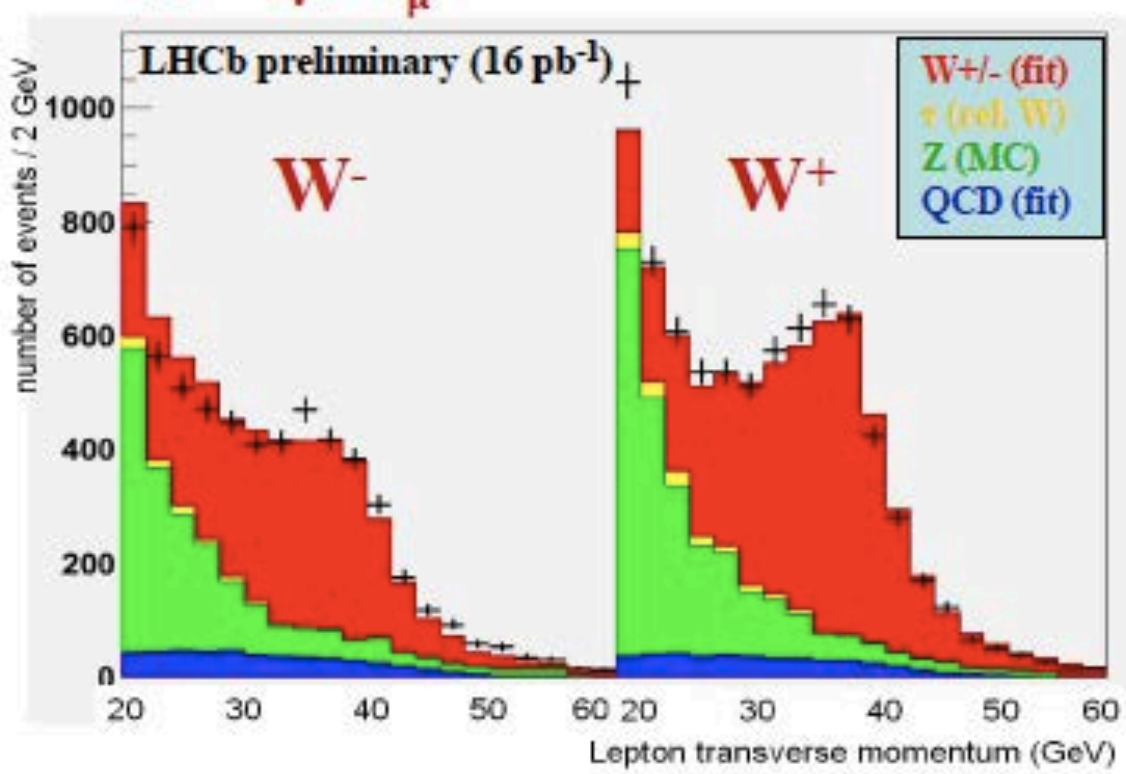


production cross-section σ

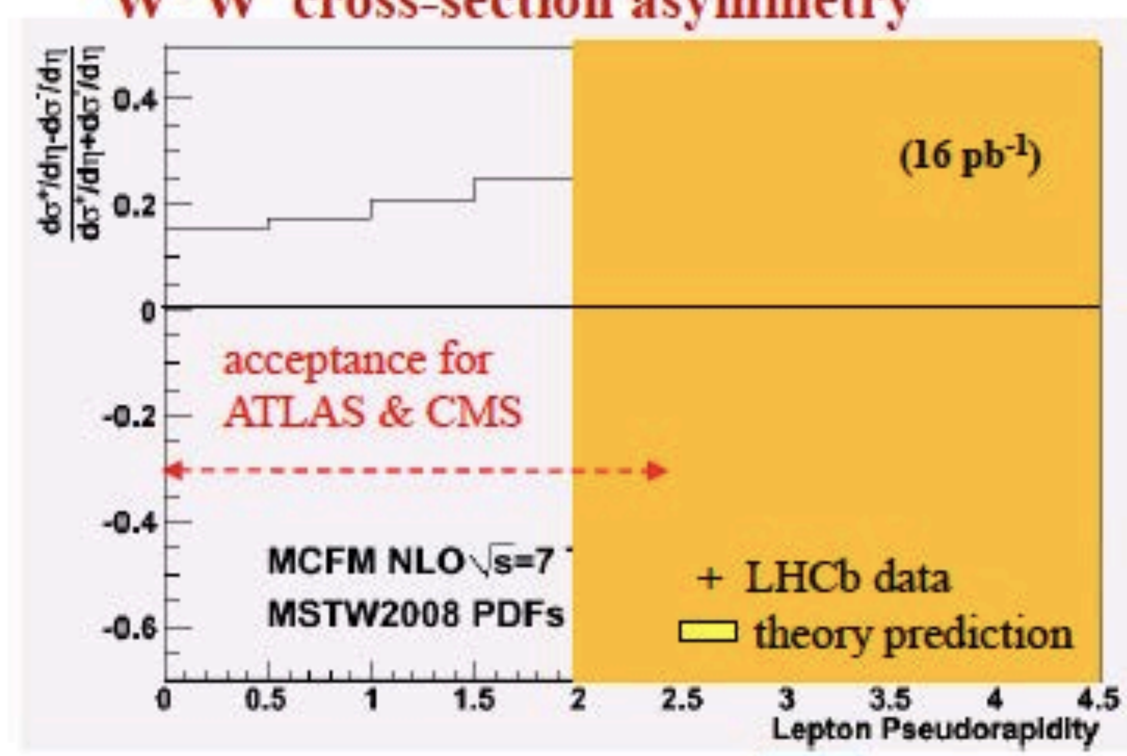


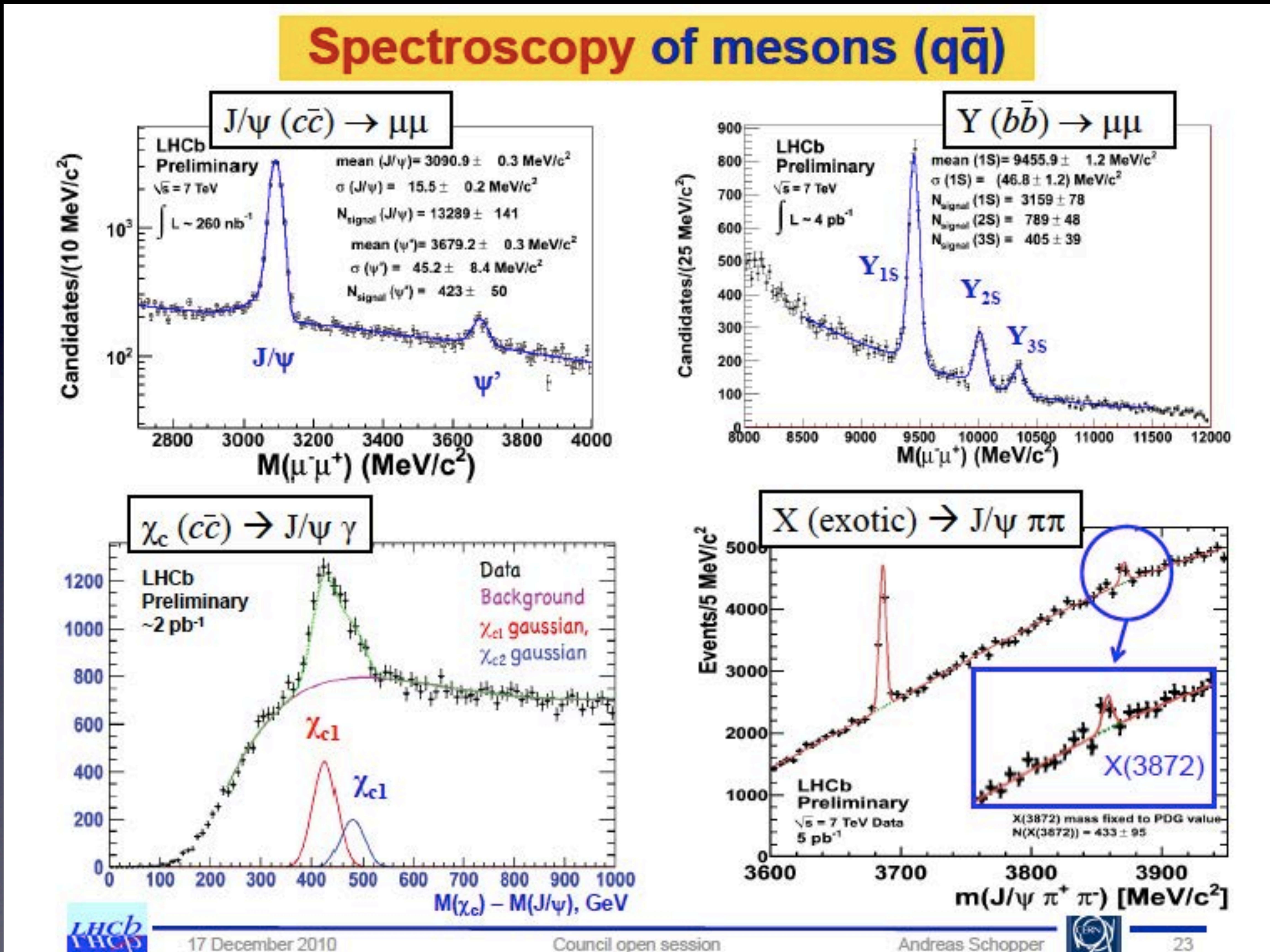
W/Z ratios test SM at 6%

$W^{\pm} \rightarrow \mu^{\pm} \nu_{\mu}$



W+ W- cross-section asymmetry

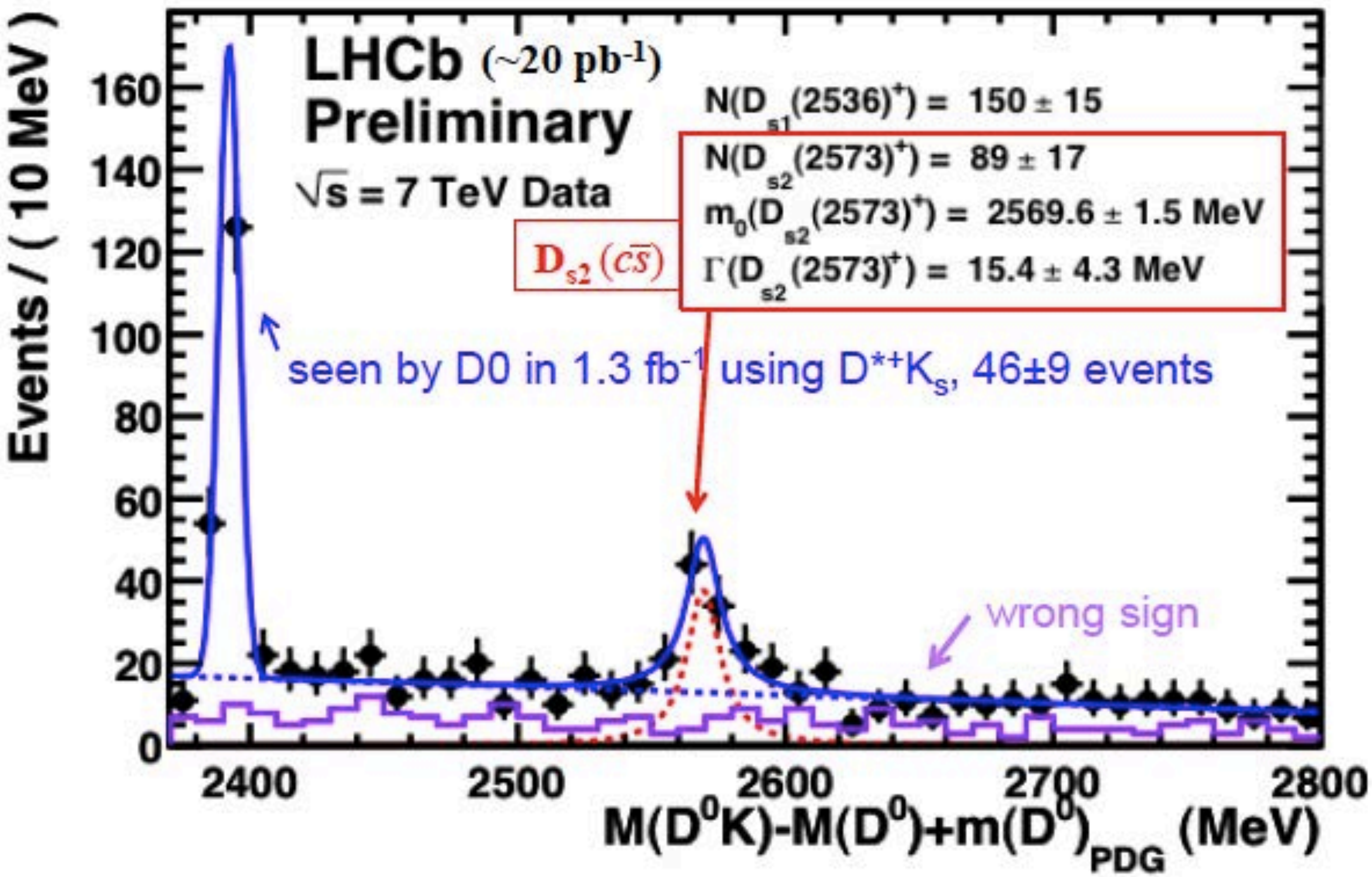




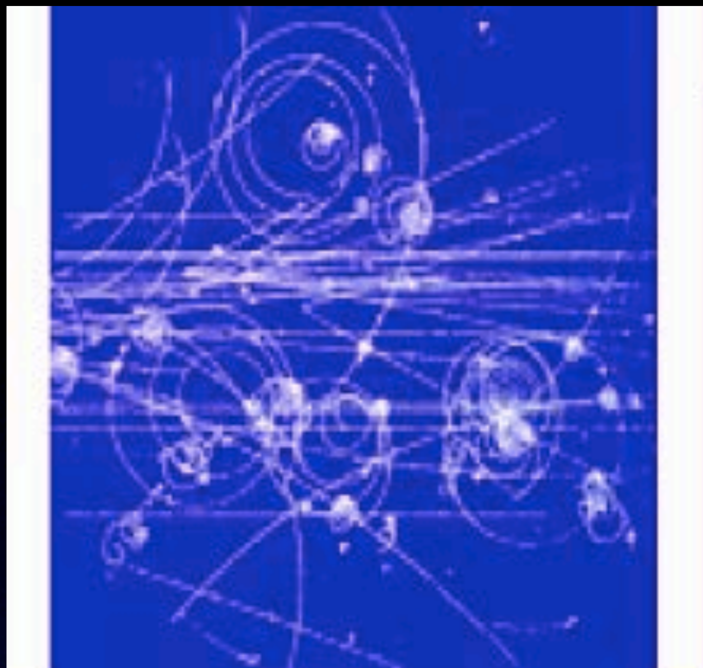
четверг, 23 декабря 2010 г.

First observation of new semileptonic B_s^0 decay

First observation of $B_s \to D_{s2}\, X\, \mu\, \nu$ with $D_{s2} \to D^0 K^+$

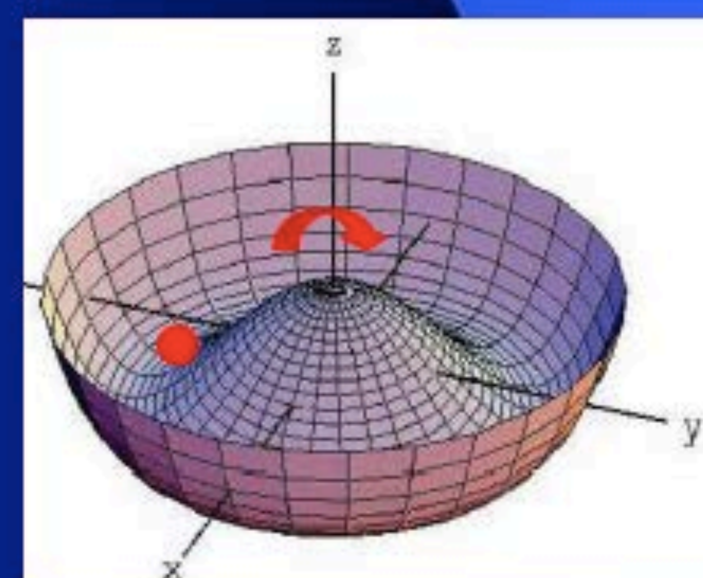


➢ **and more first observations in the pipeline… !**

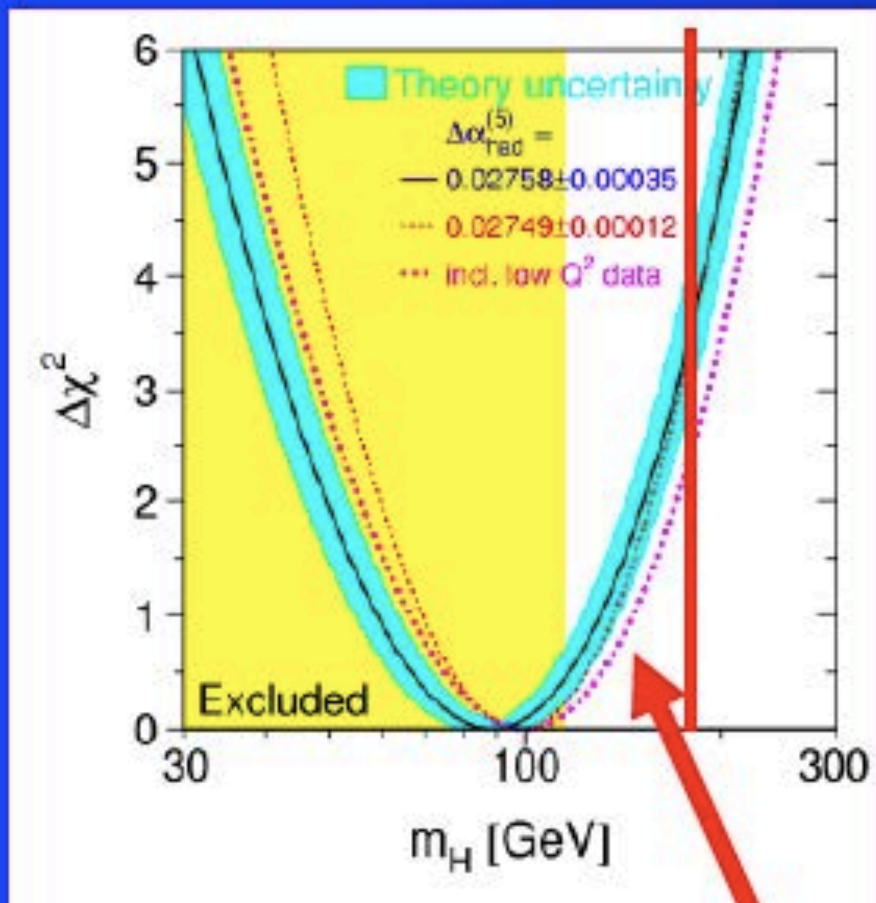


The Run for the Higgs Boson

- Is it there?
- Where is it?
- When and where we find it?



SM Fit to Precision EW Data



χ^2 versus M_H for SM Fit

- M_H=89 +42-30 @68%CL
- M_H < 165 GeV @95%CL

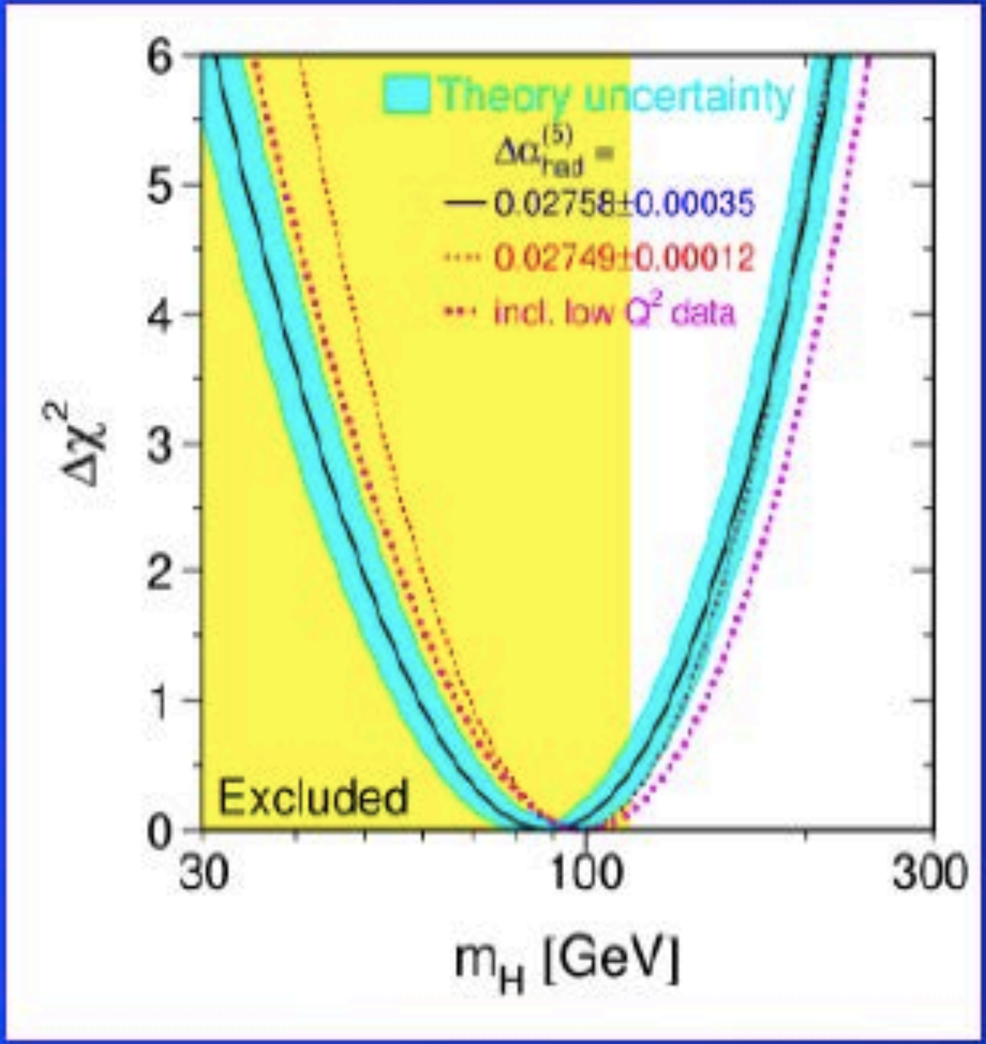
for m_{top}=172.5 GeV

If it is there we may see it soon

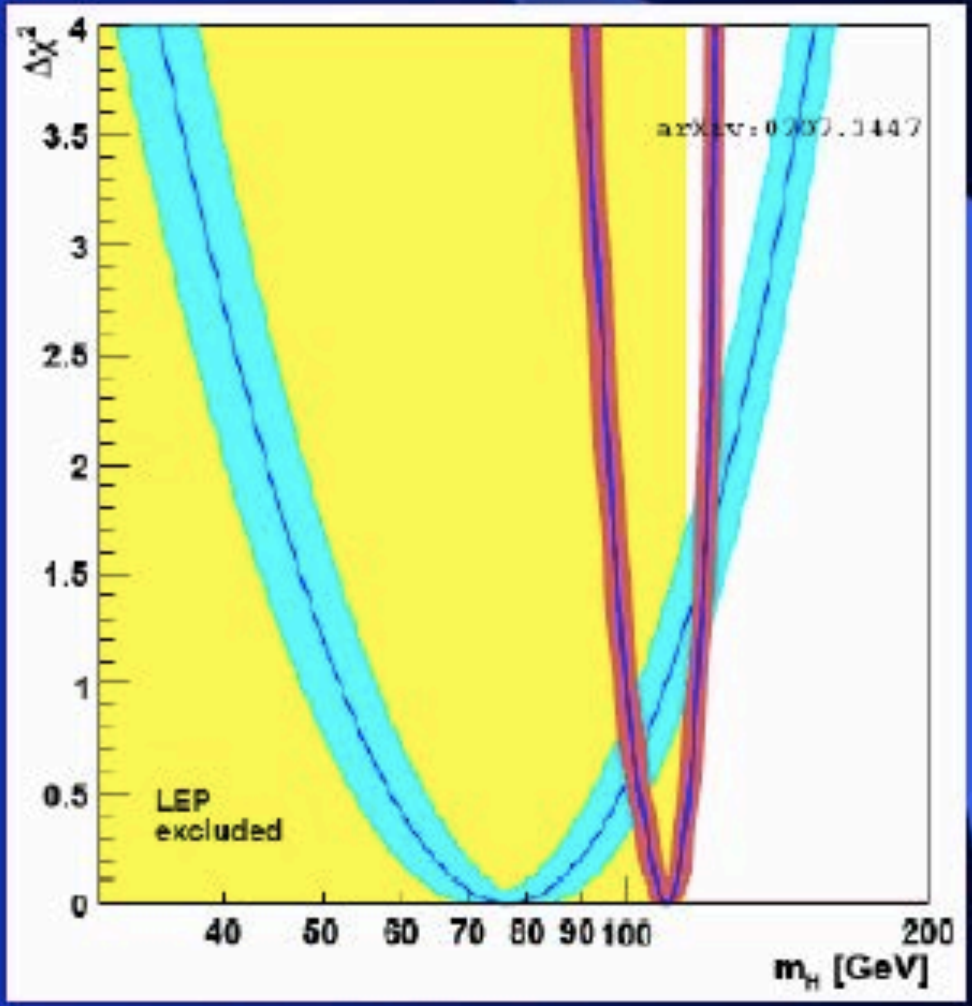
The SM versus MSSM

Fit for the Higgs Boson Mass

SM

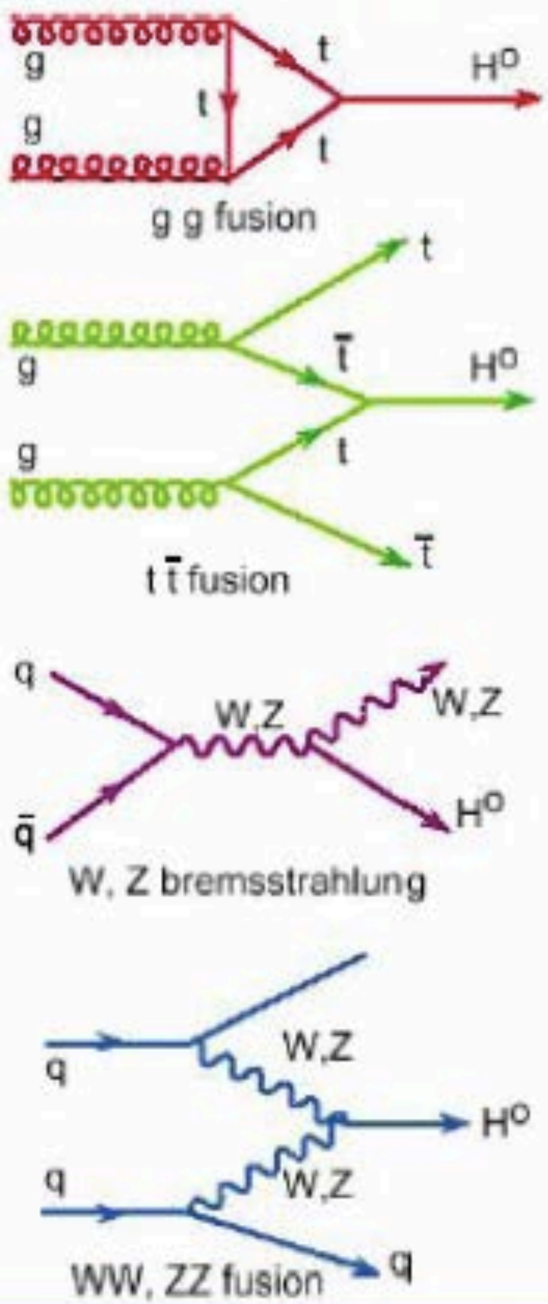


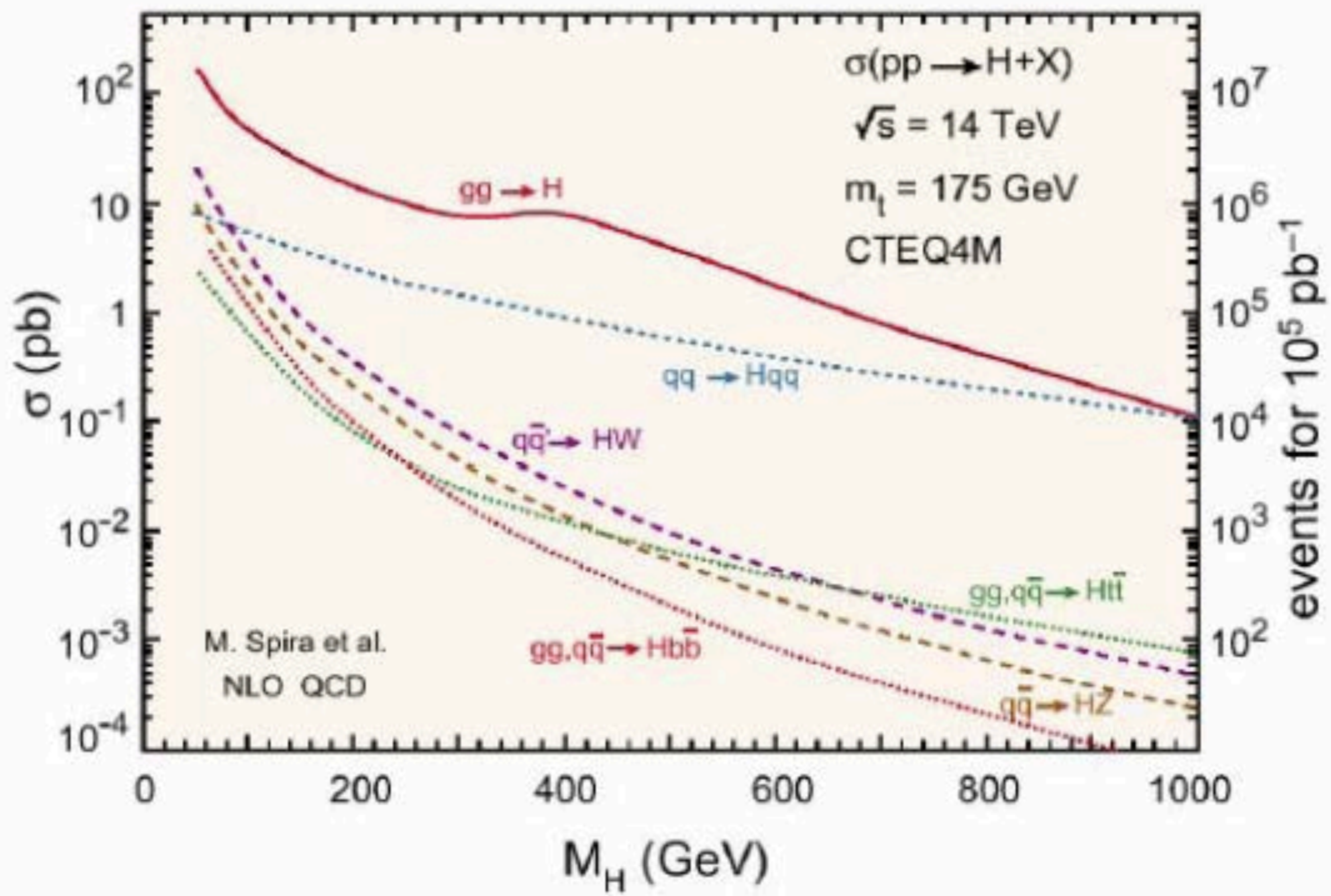
MSSM



Search for Higgs Boson at LHC

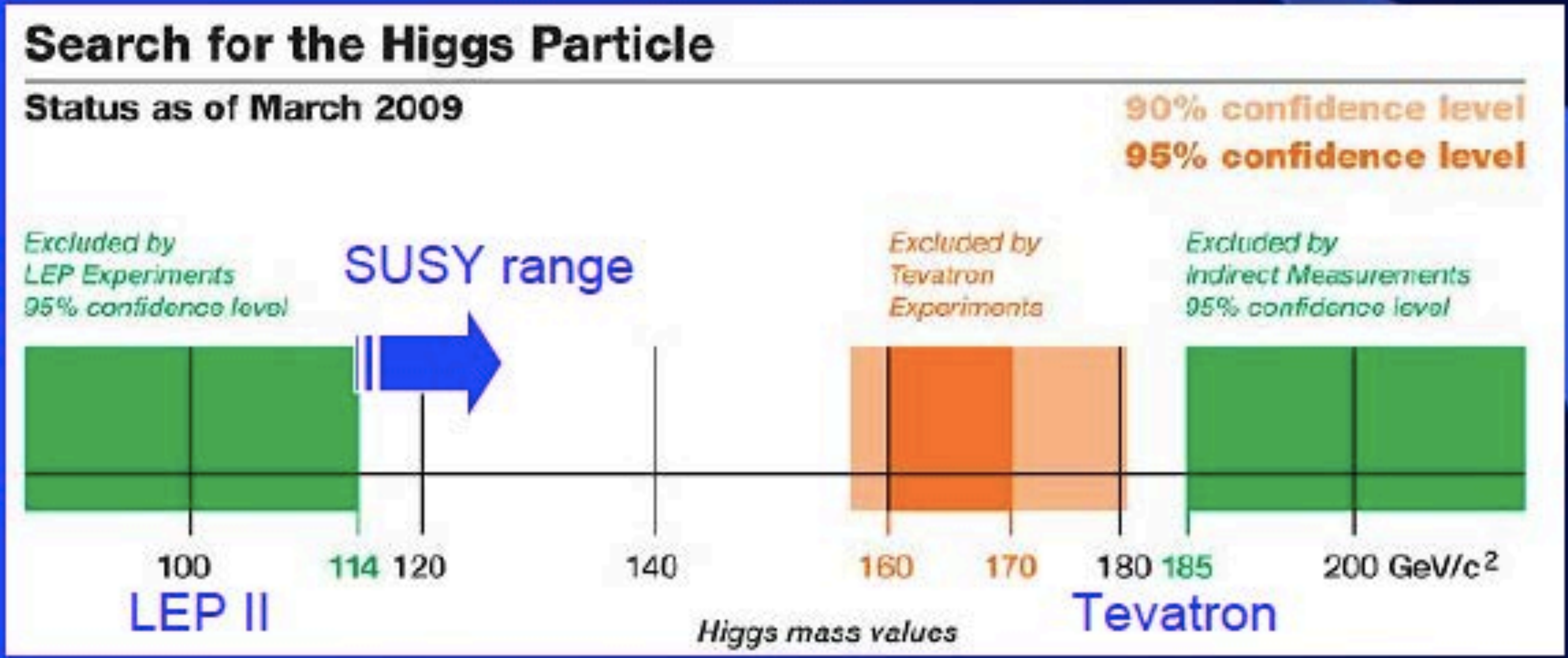
- **Production mechanisms & cross section**



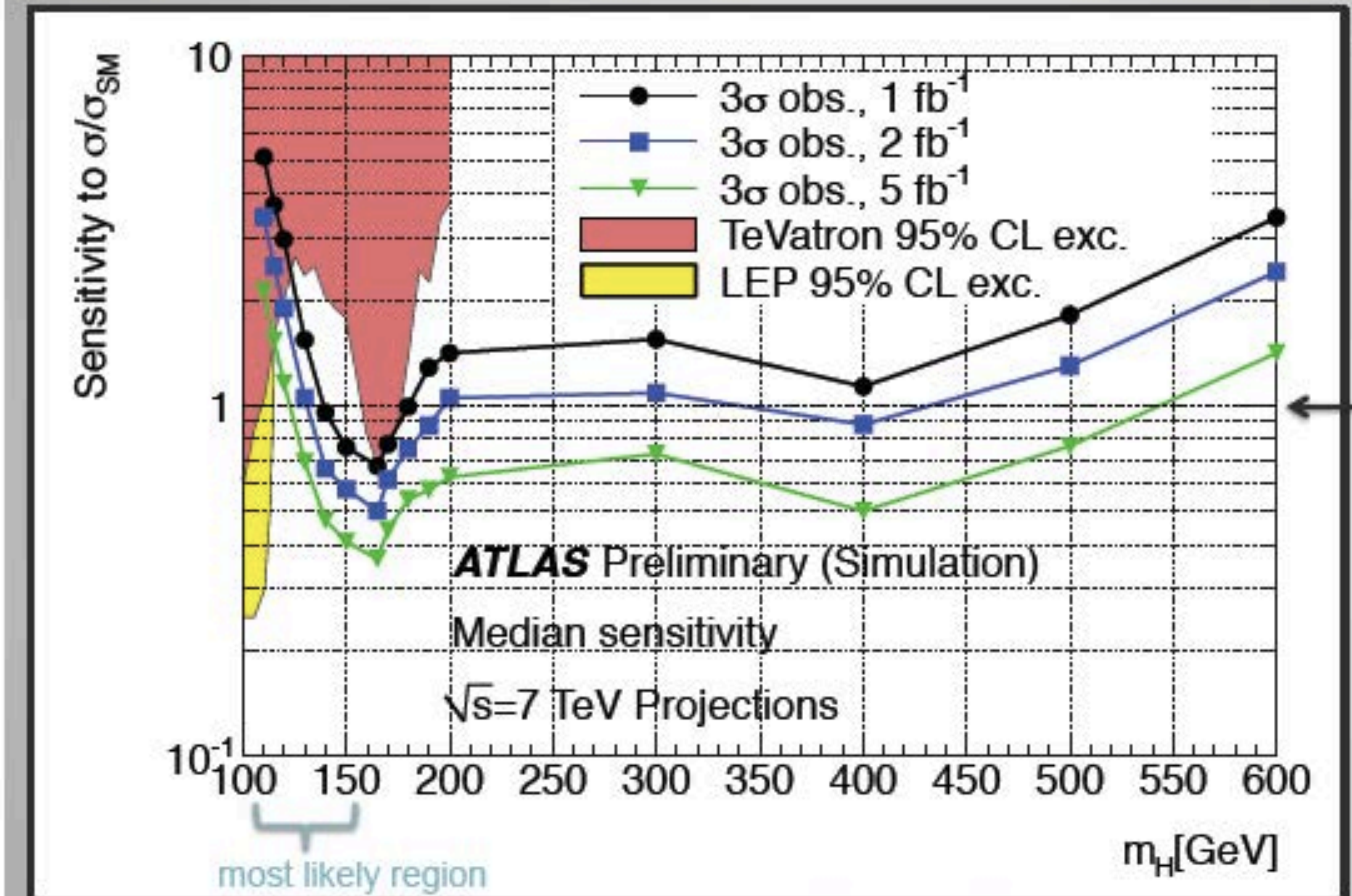


Modern Higgs Window

(Direct Search)



Higgs in 2011?



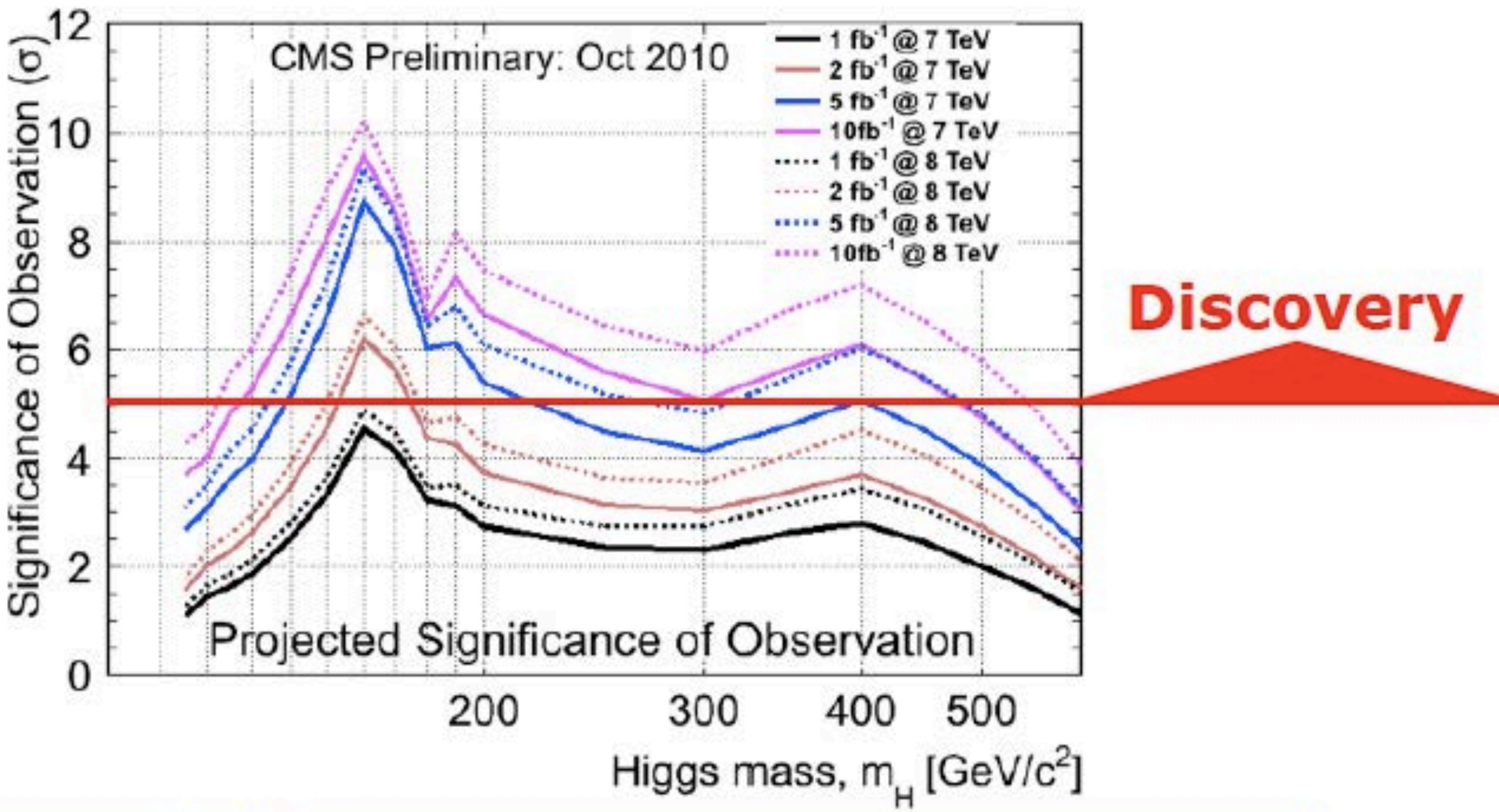
Need 5σ for *discovery*

look at this line

Improvements possible with further optimised analysis techniques

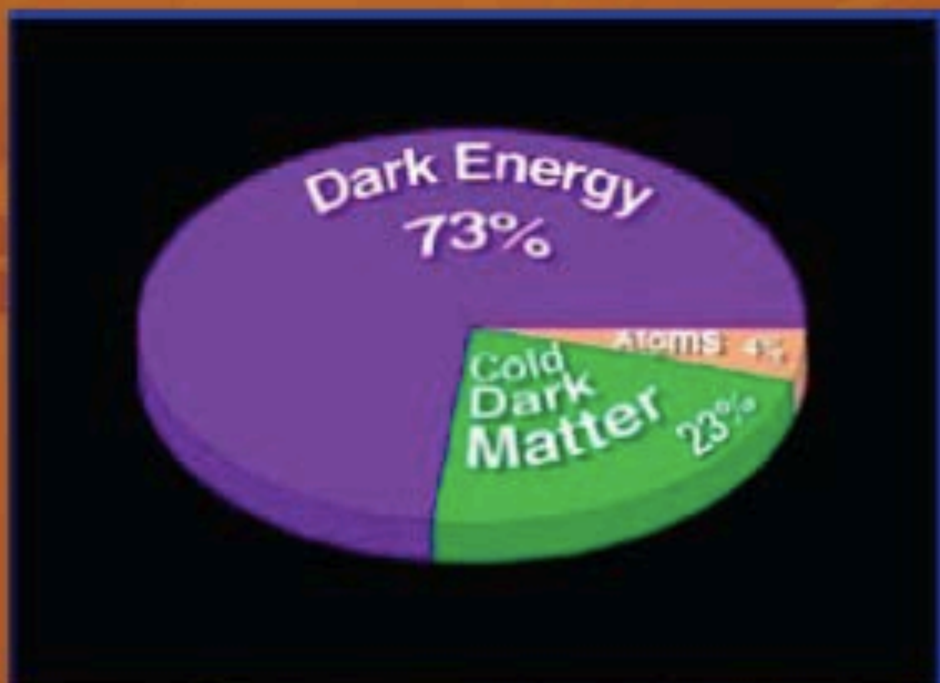
Search for the Higgs Boson

We don't know the mass of the Higgs Boson!
Evaluated the CMS discovery potential 2011 with the simulation



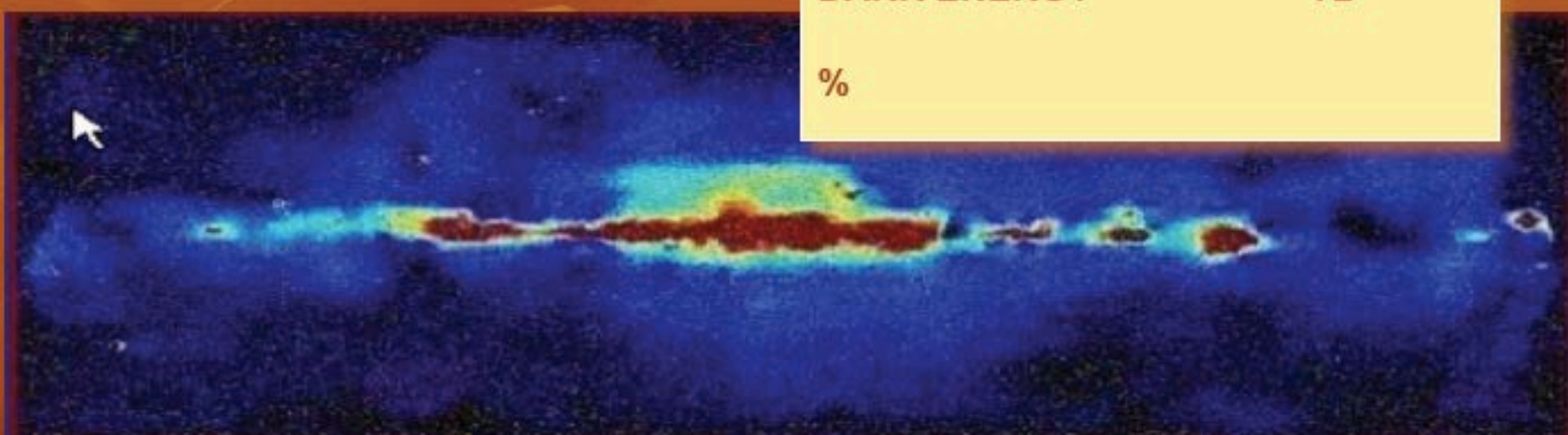
with 10fb^{-1} @$\sqrt{s}$=8 TeV CMS can discover the Higgs Boson in the mass range ~115-600 GeV!

Matter and Energy Content of the Universe

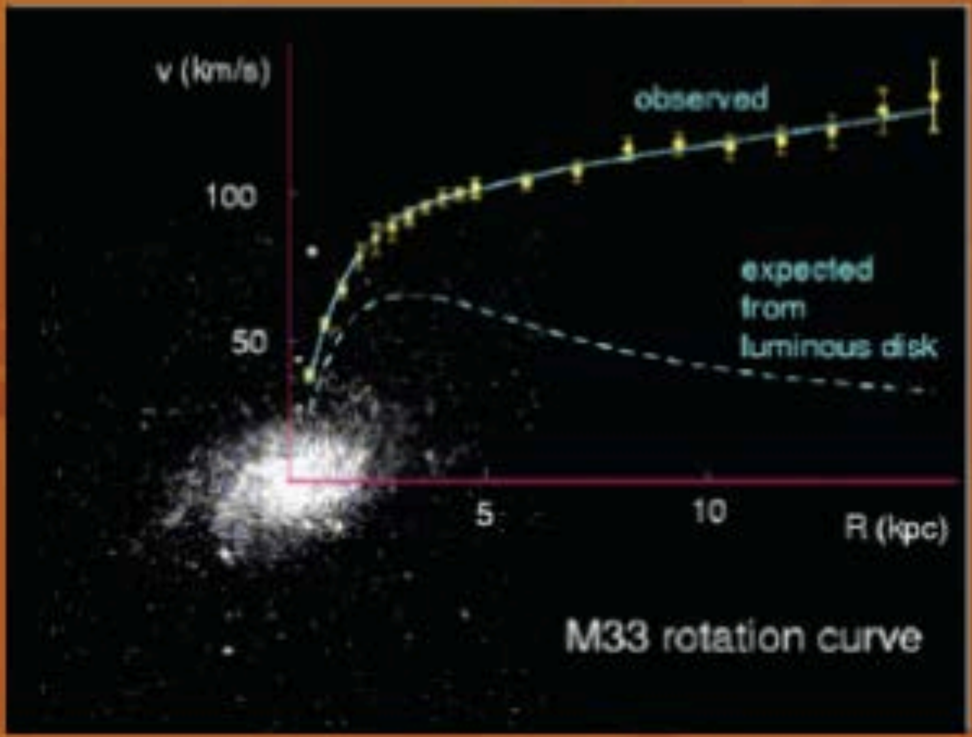


HEAVY ELEMENTS	0.03 %
MASSIVE NEUTRINOS	0.3 %
STARS	0.5 %
H AND He	4 %
DARK MATTER	23 %
DARK ENERGY	72

%



Evidence for the Dark Matter



THE FLAT ROTATION CURVES OF SPIRAL GALAXIES PROVIDE THE MOST DIRECT EVIDENCE FOR THE EXISTENCE OF LARGE AMOUNT OF THE DARK MATTER.

SPIRAL GALAXIES CONSIST OF A CENTRAL BULGE AND A VERY THIN DISC, AND SURROUNDED BY AN APPROXIMATELY SPHERICAL HALO OF DARK MATTER

DM Candidates

The Dark Matter is made of:

- Macro objects – Not seen
- New particles – right-handed neutrino

Non from the SM {
- neutralino
- sneutrino
- axion (axino)
- gravitino
- heavy photon
- heavy pseudo-goldstone
- light sterile higgs

DM Detection

Direct detection

DAMA, Zeplin,
CDMS, Edelweiss

No convincing evidence so far
Hope for new results soon

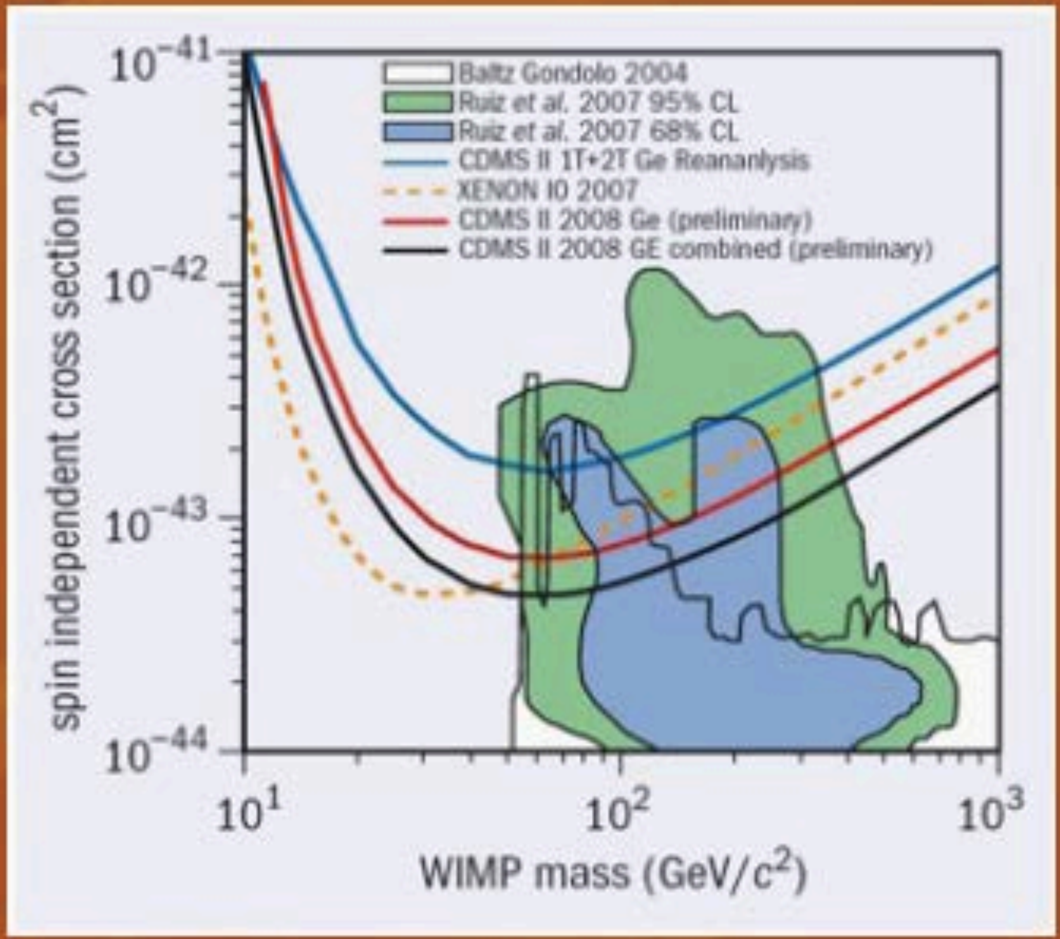
Indirect detection

- EGRET -> GLAST(FERMI)
Diffuse Gamma Rays
- HEAT, AMS01 -> PAMELA
Positrons in Cosmic Rays
- BESS -> AMS02
Antiprotons in Cosmic Rays

First Evidence of DM annihilation ?!

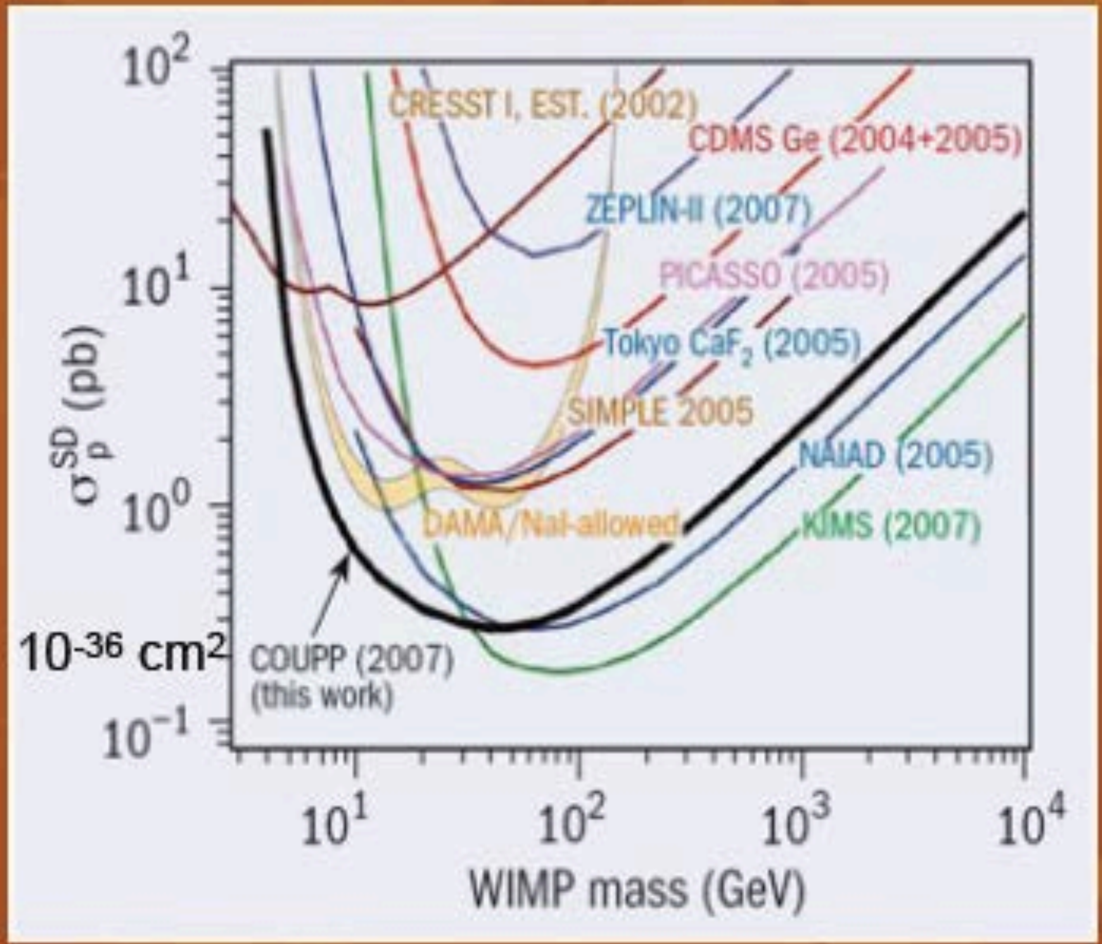
Recent Results on Direct Detection

Spin Independent



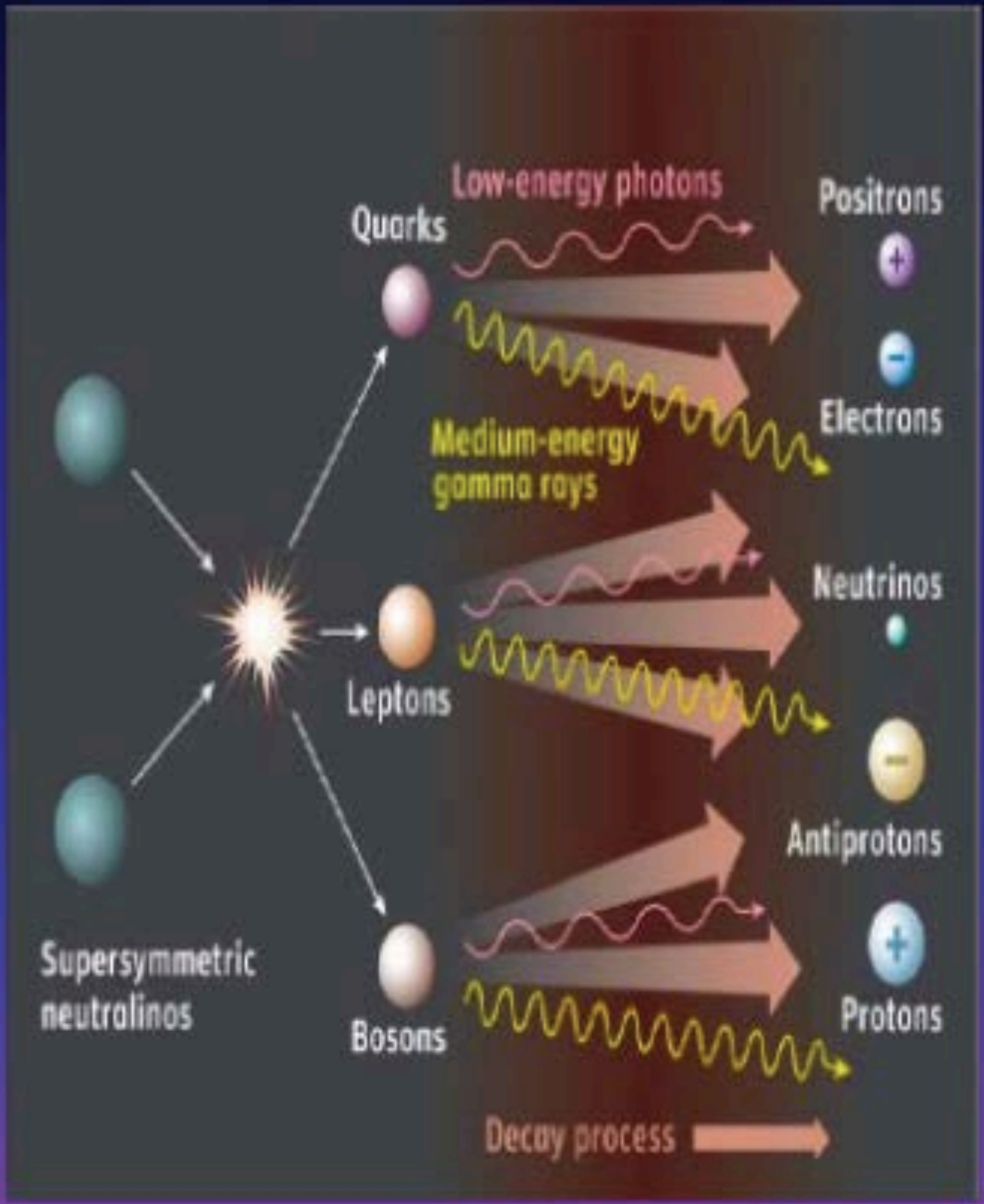
The Chicagoland Observatory for Underground Particle Physics (COUPP)

Spin Dependent



Cryogenic Dark Matter Search (CDMS)

Dark Matter Annihilation



Annihilation products from dark matter annihilation:

Gamma rays
(EGRET, FERMI)

Positrons (PAMELA)

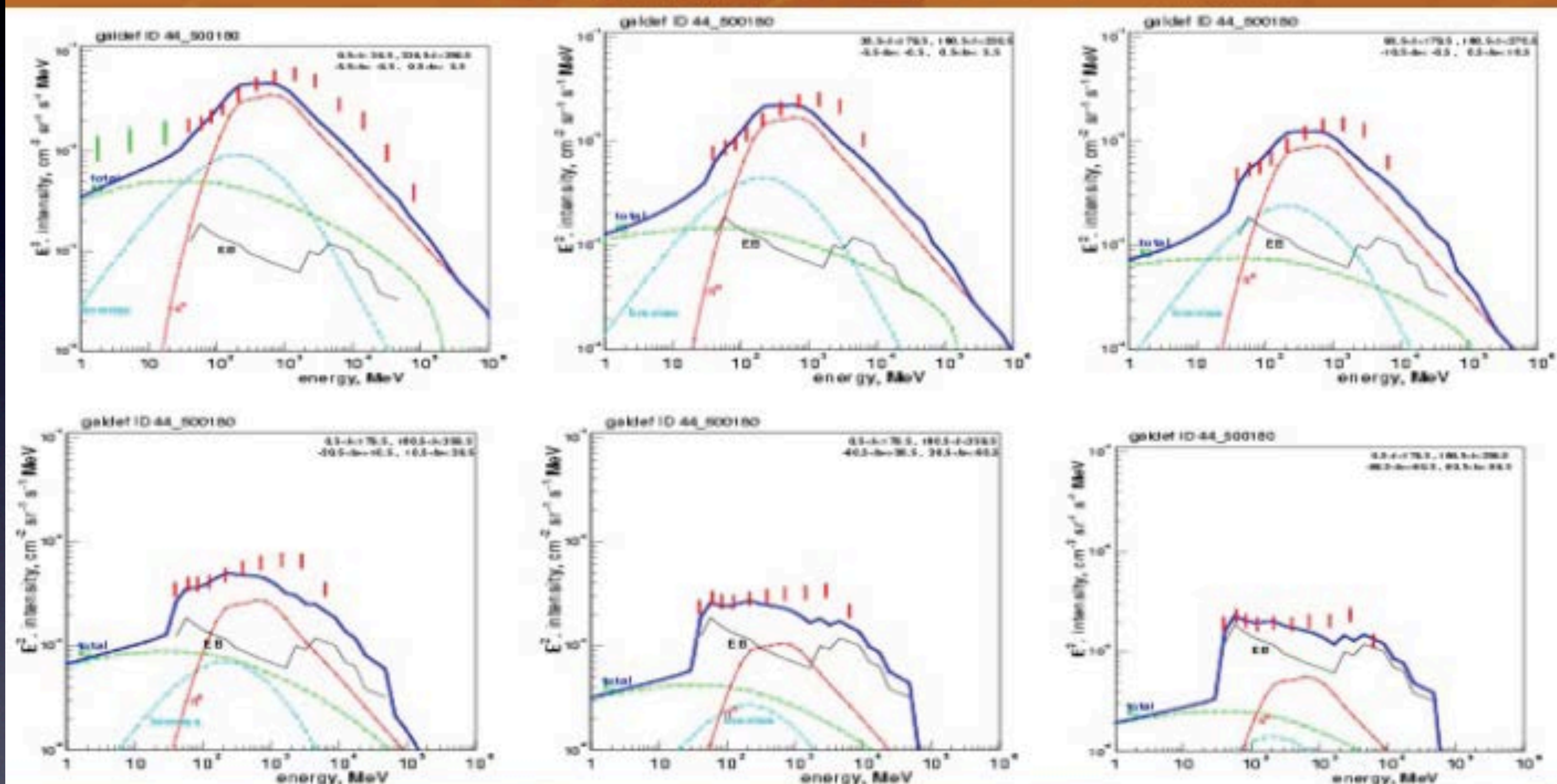
Antiprotons (PAMELA)

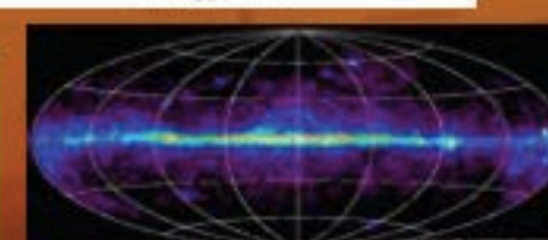
e+ + e-
(ATIC, FERMI, HESS, PAMELA)

Neutrinos (Icecube, no results yet)

e-, p drown in cosmic rays?

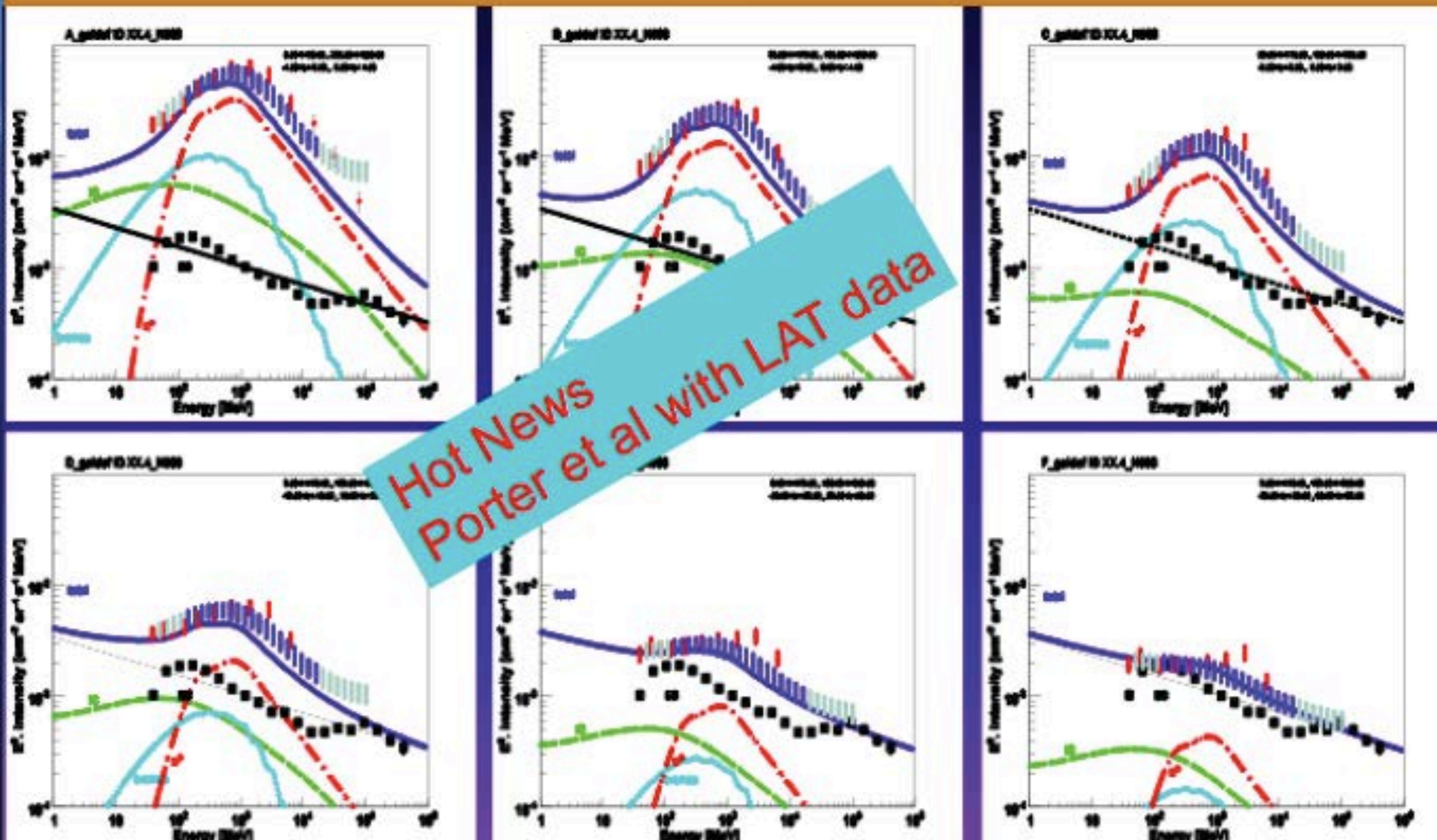
Excess of Diffuse Gamma Rays Above 1 GEV





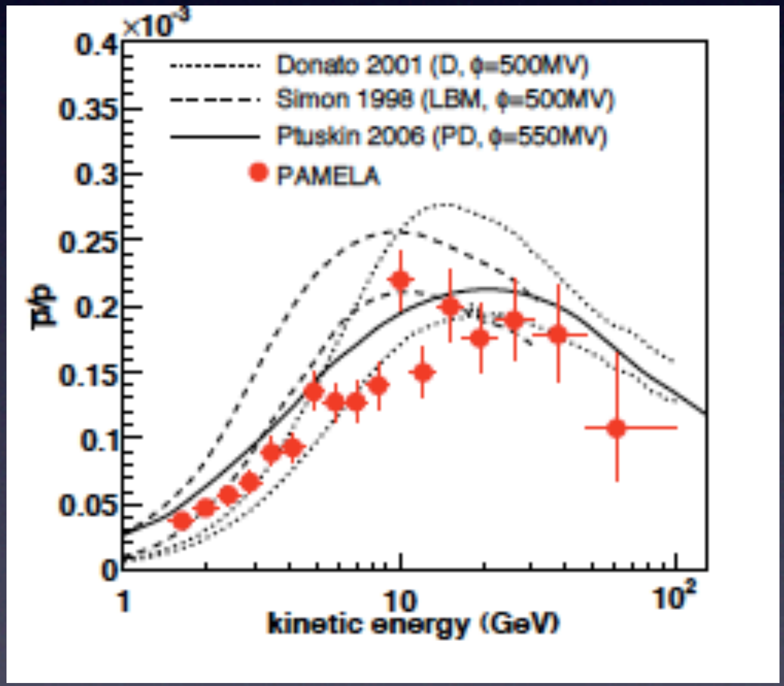
A: inner Galaxy (l=±30^0, |b|<5^0)
B: Galactic plane avoiding A
C: Outer Galaxy
D: low latitude (10-20^0)
E: intermediate lat. (20-60^0)
F: Galactic poles (60-90^0)

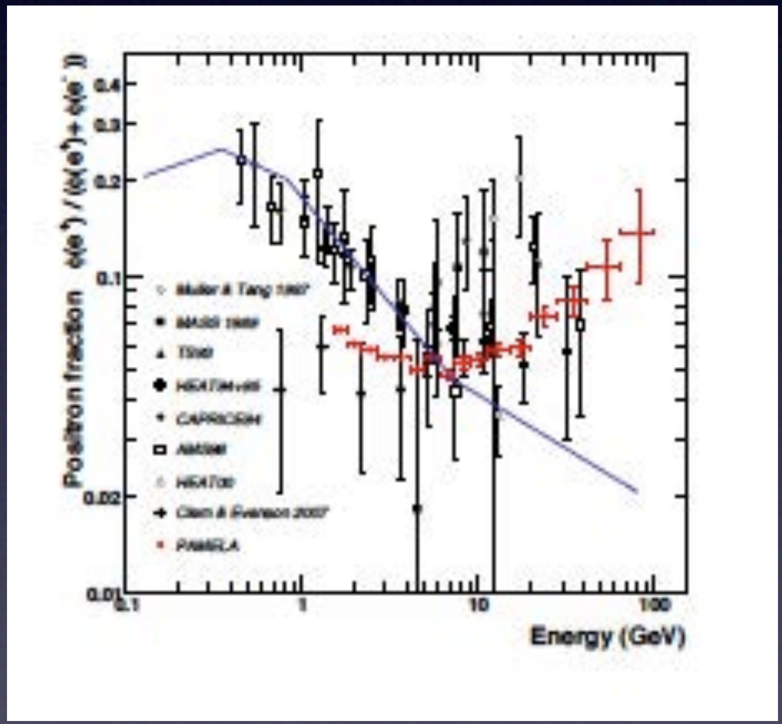
Comparison of EGRET-FERMI Data



Антипротоны

Позитроны





С Новым 2011 годом!