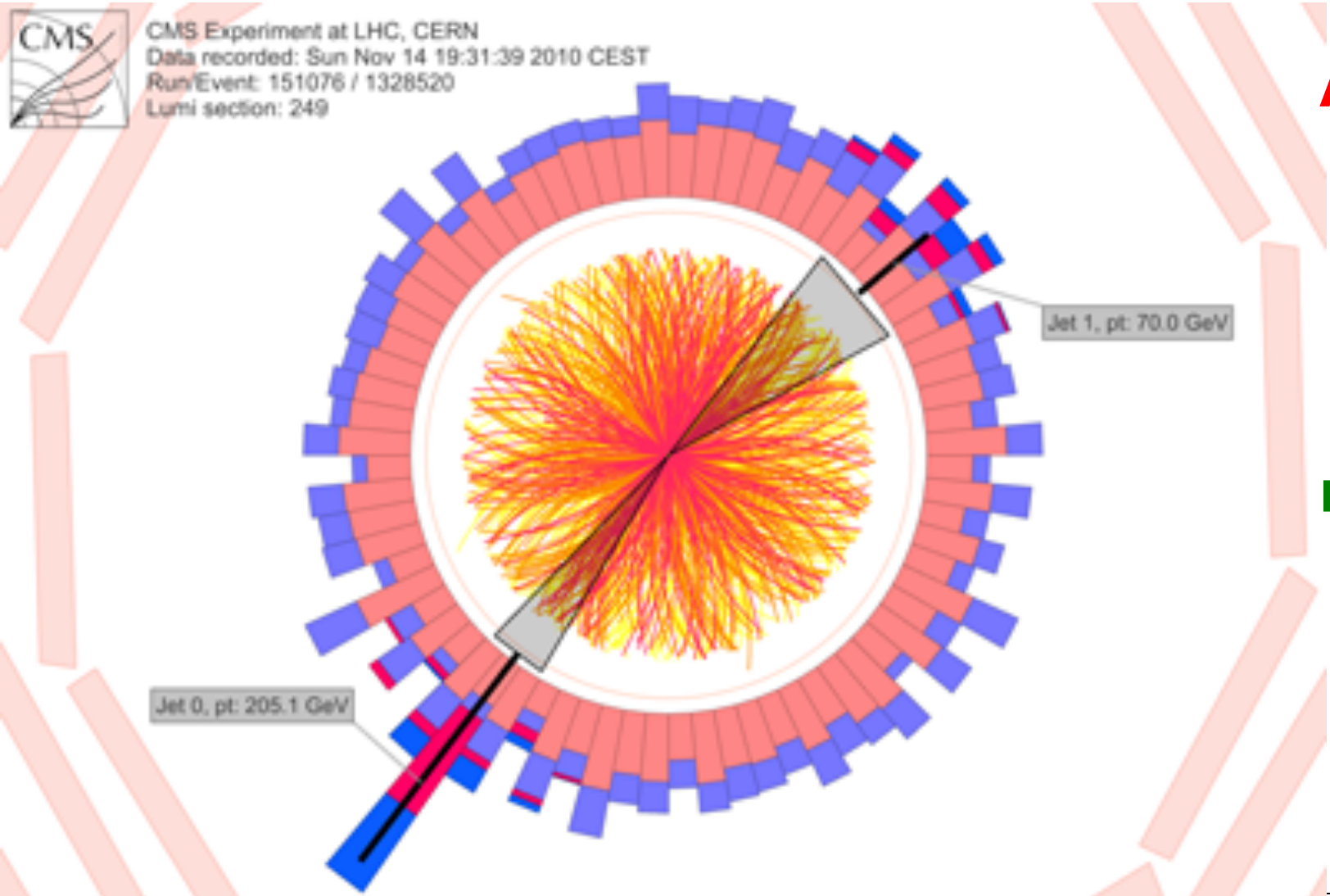
PNPI and CMS Physics

Victor Kim PNPI, Gatchina



PNPI HEPD
Annual Session
Dec. 28, 2010

PNPI CMS
Physics Team:
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I. Smirnov
V. Sulimov
V. Oreshkin
V. Murzin
S. Evstyukhin

Outline

- CMS physics results on collisions data (end of 2010):
  - EW: 2 papers
  - QCD: 9 papers
  - BSM: 5 papers

- CMS physics outlooks 2011(-2012?)

- PNPI @CMS:
  - VBF Higgs boson
  - Dijet K-factor at large rapidities (search for BFKL)

- Conclusions

CMS Physics Objectives

- Re-discovery of Standard Model

- Search for new dynamics of Standard Model at new energy domain

- Search for new physics beyond Standard Model

CMS physics papers on collision data: QCD

QCD papers:

1. **Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at sqrt(*s) = 0.9 and 2.36 TeV*** *J. High Energy Phys. 02 (2010) 041*
2. **First Measurement of Bose-Einstein Correlations in proton-proton Collisions at sqrt(s) *=0.9 and 2.36 TeV at the LHC*** *Phys. Rev. Lett. 105 (2010) 032001*
3. **Transverse-momentum and pseudorapidity distributions of charged hadrons in *pp collisions at sqrt(s) = 7 TeV*** *Phys. Rev. Lett. : 105 (2010) 022002*
4. **First Measurement of the Underlying Event Activity at the LHC with sqrt(s) *= 0.9 TeV*** *Eur. Phys. J. C 70 (2010) 555*
5. **Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC** *J. High Energy Phys. 09 (2010) 091*
6. **Prompt and non-prompt J/ production in pp collisions at sqrt(*s) = 7 TeV*** CERN-PH-EP-2010-046
7. **Charged particle multiplicities in pp interactions at sqrt(*s) = 0.9, 2.36, and 7 TeV*** CERN-PH-EP-2010-048
8. **Measurement of the Isolated Photon Production Cross Section in pp Collisions at sqrt(s) = 7 TeV** CERN-PH-EP-2010-053
9. **Upsilon Production Cross Section in pp Collisions at sqrt(s) = 7 TeV** CERN-PH-EP-2010-055

CMS physics papers on collision data: EW and BSM

ElectroWeak (EW) papers:

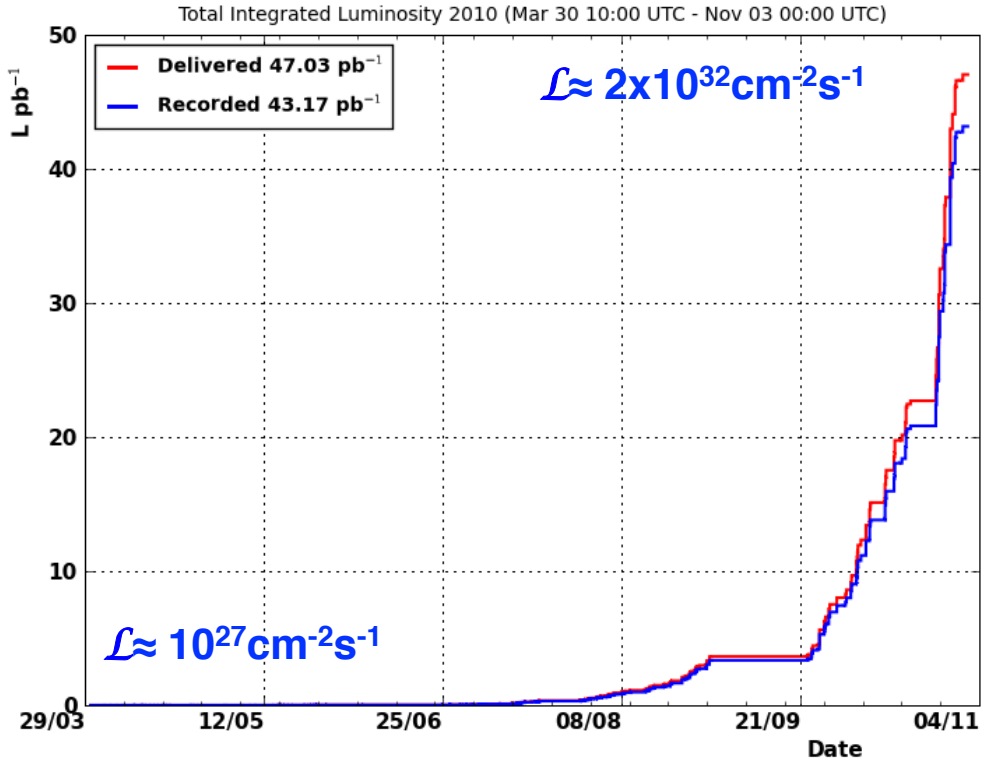
1. **First Measurement of the Cross Section for Top-Quark Pair Production in Proton-Proton Collisions at sqrt(*s*)= *7 TeV*** *CERN-PH-EP/2010-039 26p.*
2. **Measurements of Inclusive W and Z cross sections in pp Collisions at sqrt(*s*) = *7 TeV*** *CERN-PH-EP/2010-050 36p.*

Beyond Standard Model (BSM) papers:

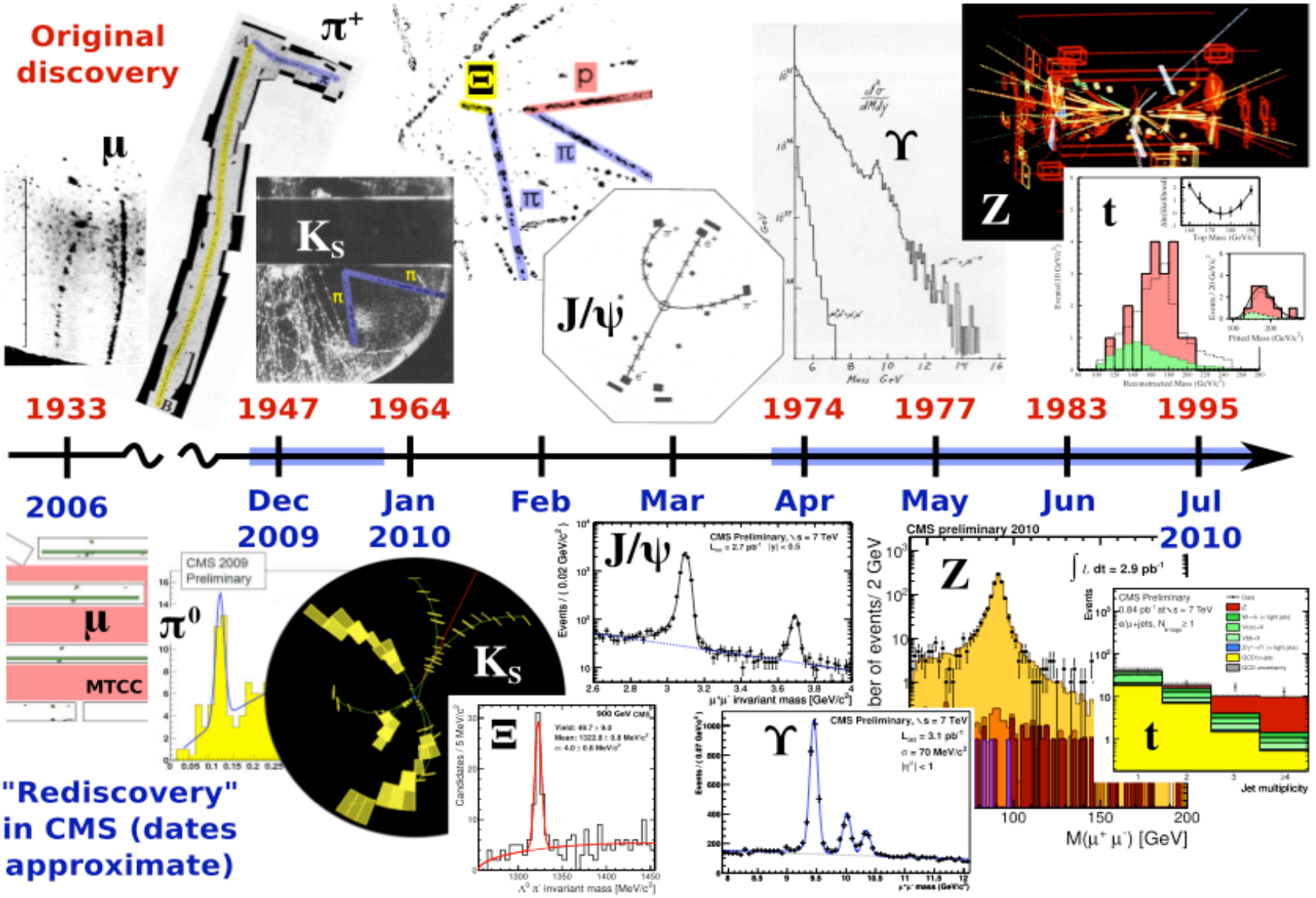
1. **Search for Dijet Resonances in 7 TeV pp Collisions at CMS** Phys. Rev. Lett. 105 (2010) 211801
2. **Search for Quark Compositeness with the Dijet Centrality Ratio in pp collisions at *sqrt(s) = 7 TeV*** *Phys. Rev. Lett. 105 (2010) 262001*
3. **Search for Stopped Gluinos in pp Collisions at sqrt(*s*) = *7 TeV*** CERN-PH-EP/2010-049
4. **Search for Microscopic Black Hole Signatures at the Large Hadron Collider** CERN-PH-EP/2010-73
5. **Search for Pair Production of First-Generation Scalar Leptoquarks in pp Collisions at sqrt(*s*) = *7 TeV*** CERN-PH-EP/2010-052
6. **Search for Pair Production of Second-Generation Scalar Leptoquarks in pp Collisions at sqrt(*s*) = *7 TeV*** CERN-PH-EP/2010-052

LHC and CMS operations in pp collsions

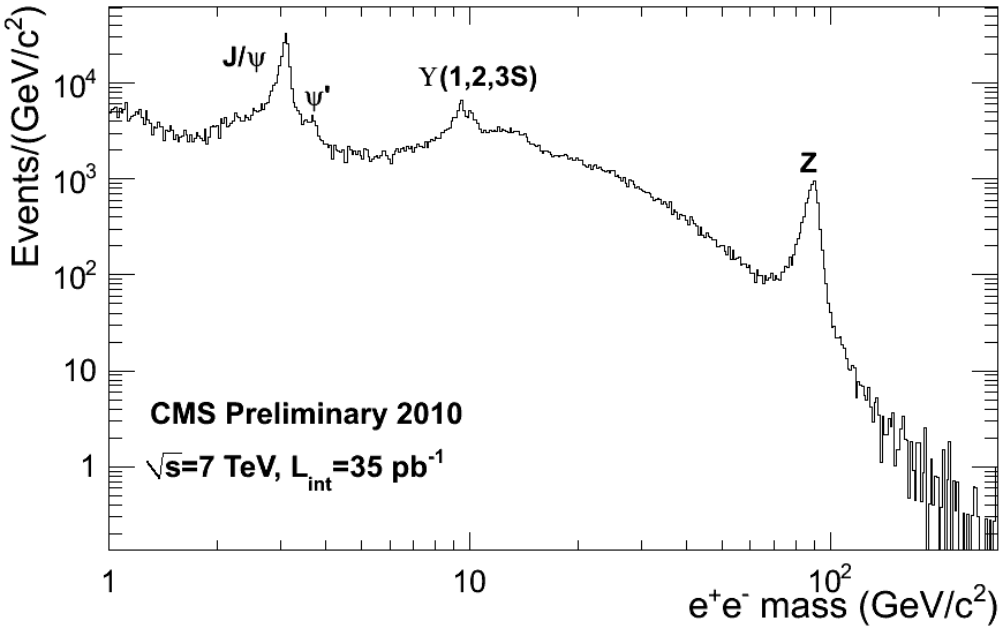
About **47pb^{-1}** delivered by LHC and **~43pb^{-1}** of data collected by CMS. Overall data taking efficiency **~92%.** Excellent performance in coping with more than 5 order of magnitude increase in instantaneous luminosity.

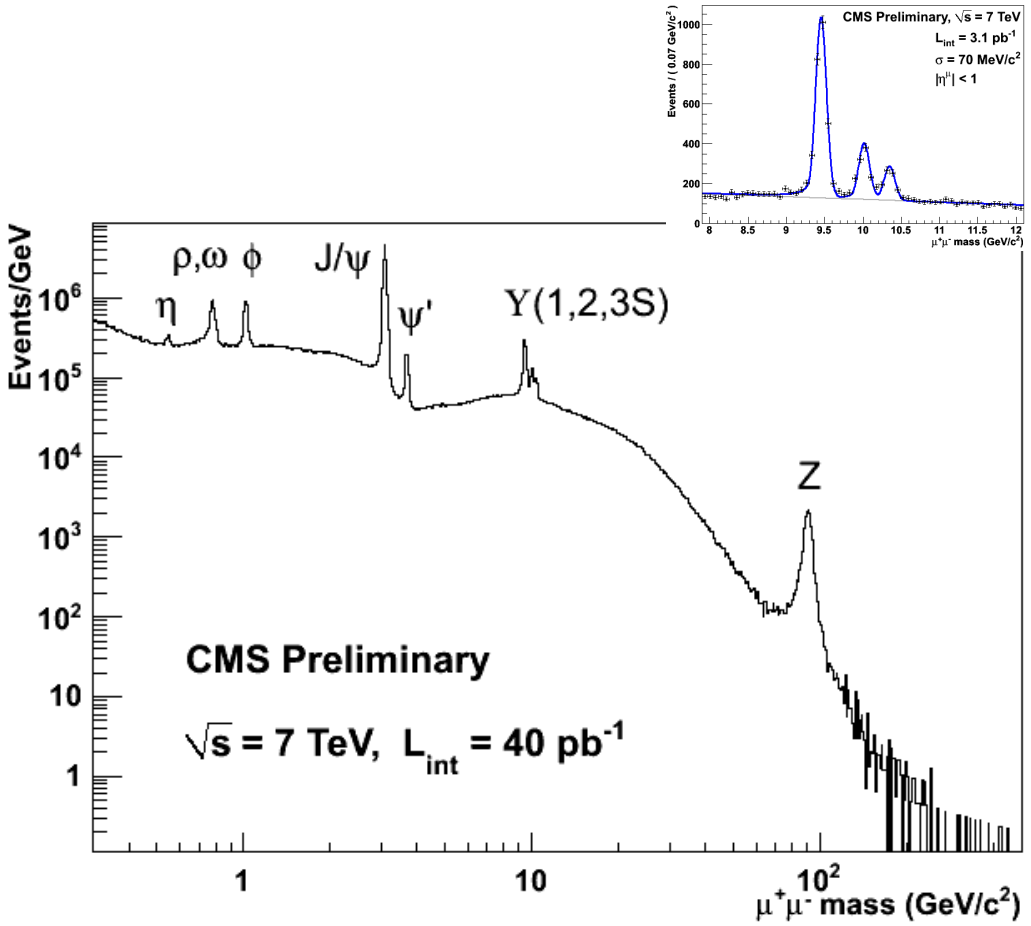


Re-discovery of Standard Model at CMS



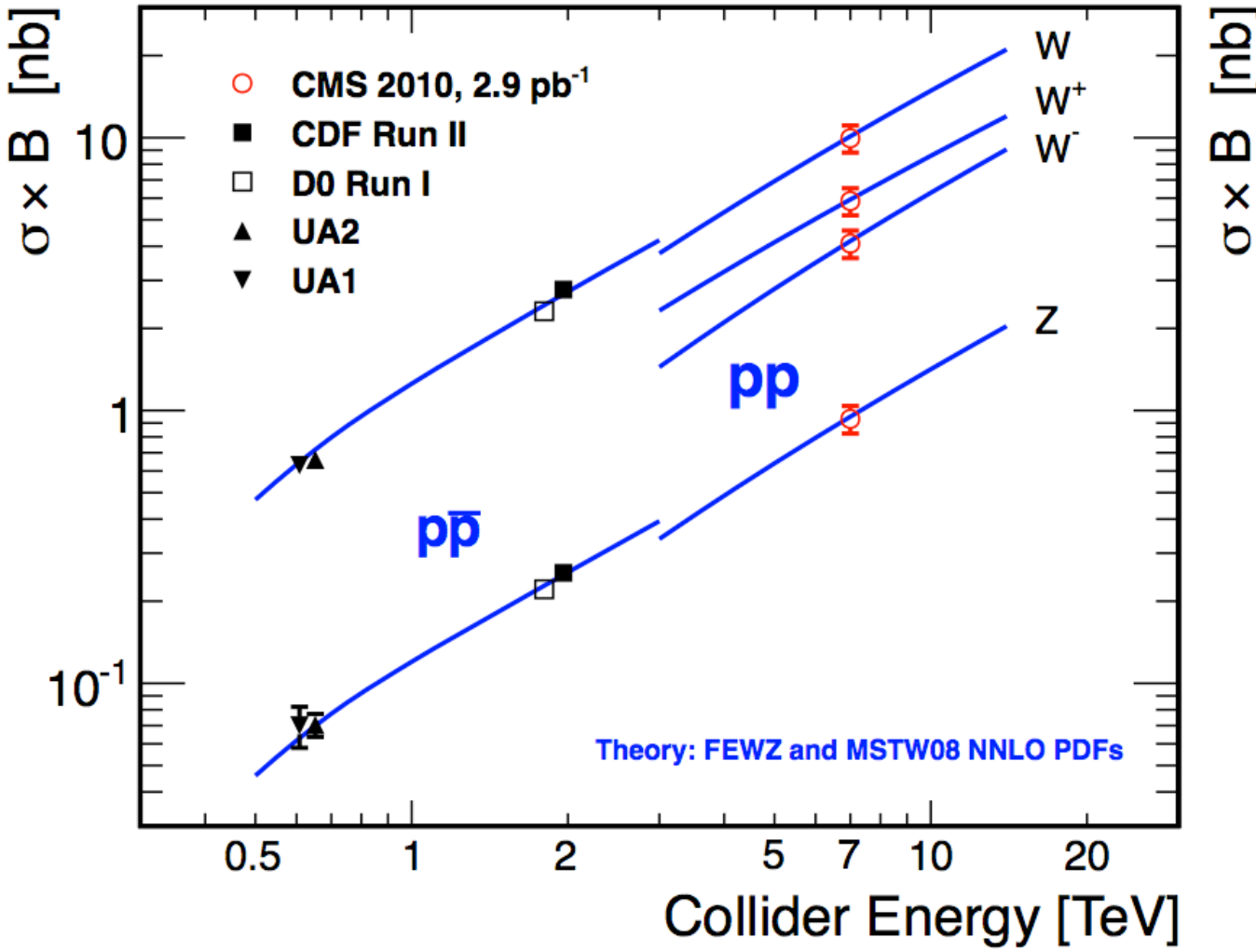
The Standard Model at 7TeV



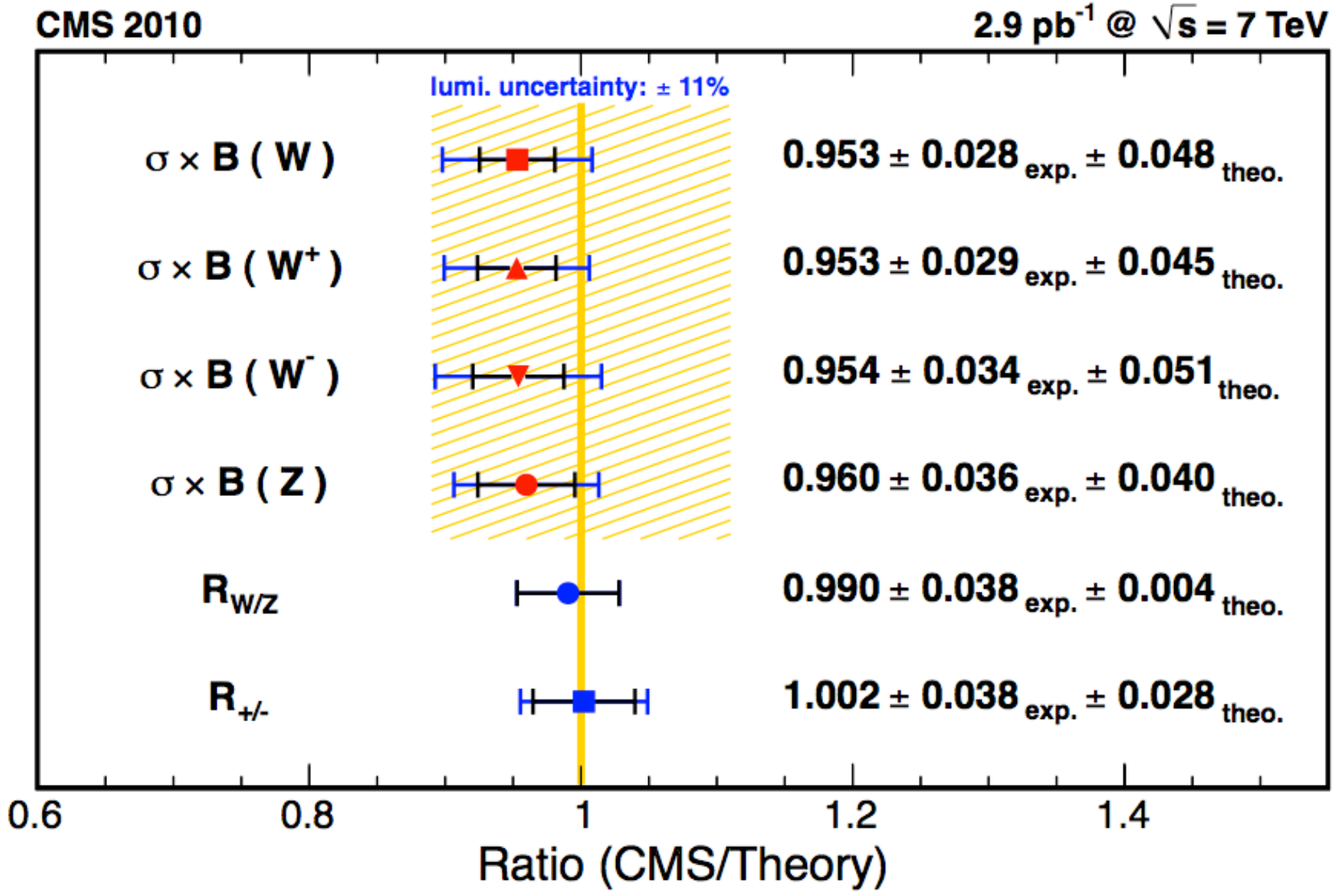


EW: precise and complete measurements

CERN-PH-EP/2010-050
ArXiv: 1012.2466

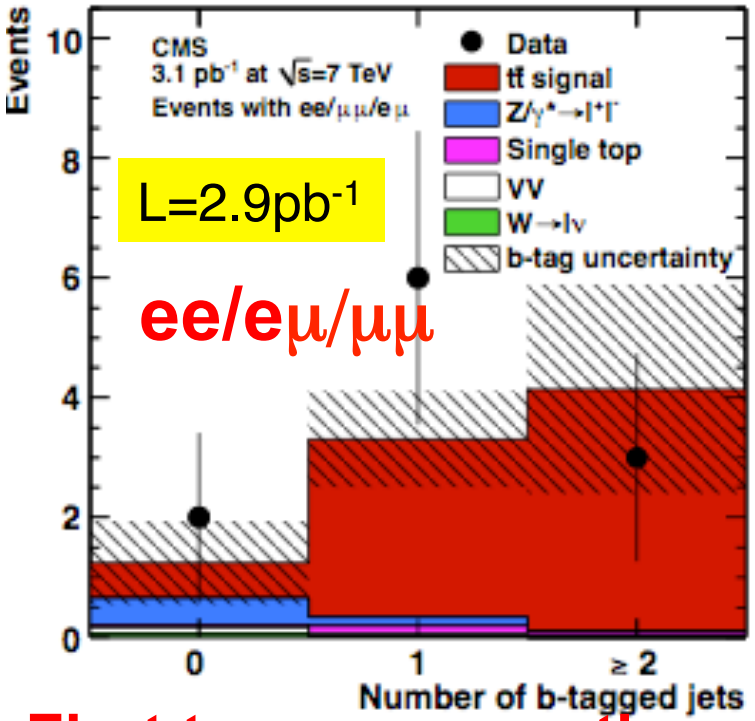


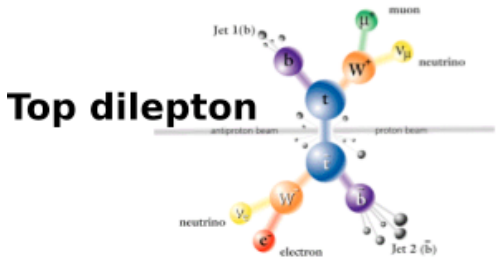
EW: precise and complete measurements



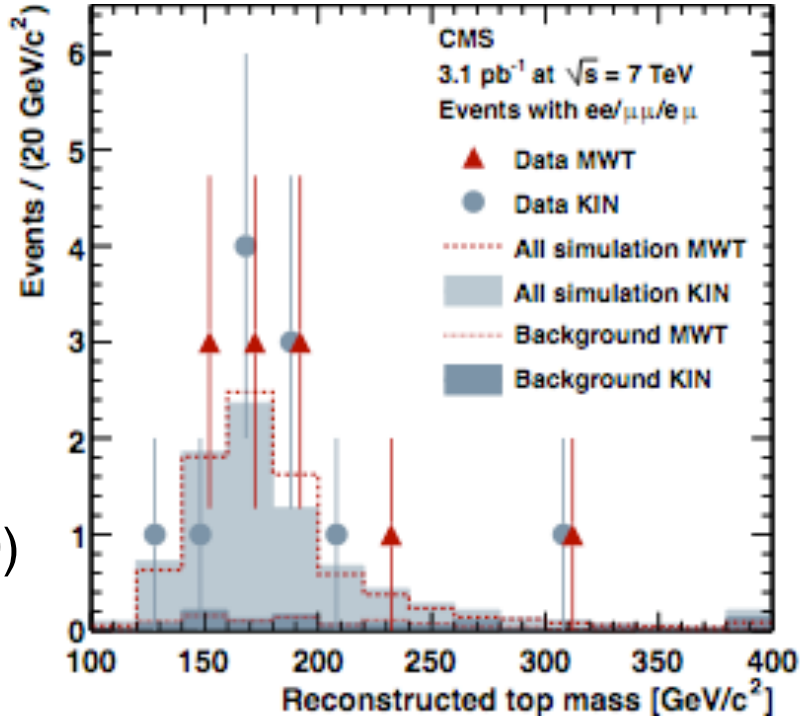
Top: dileptons+jets

- Full selection applied: Z-bosonVeto, |M(ll)-M(Z)|>15 GeV
- MET >30 (20) GeV in ee,μμ, (eμ); N(jets)≥2





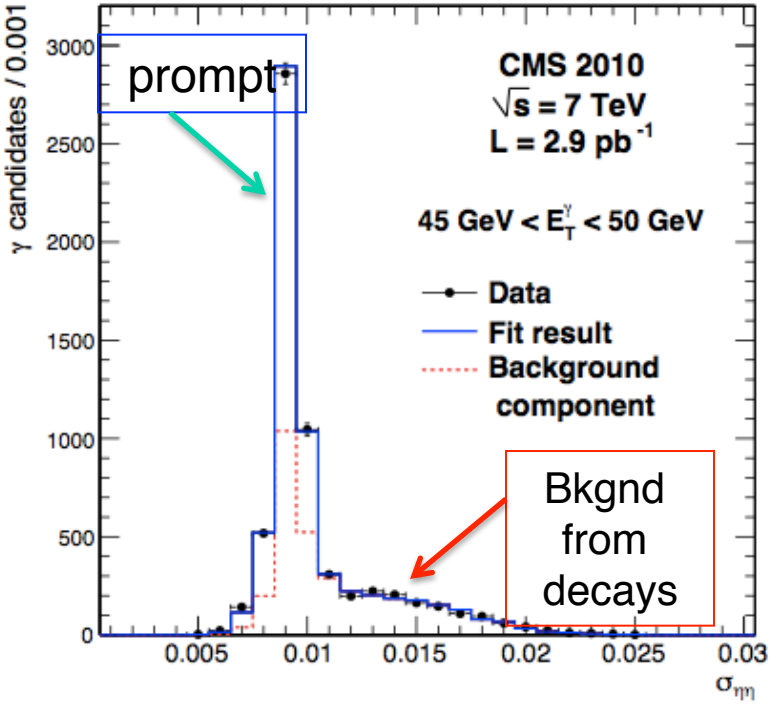
Phys. Lett. B (2010)
arXiv:1010.5994



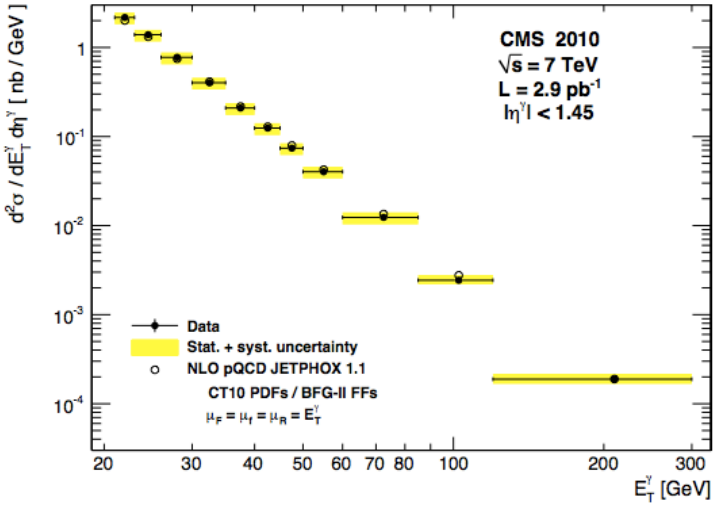
First top cross section measurement at LHC.

$\sigma(pp \rightarrow t\bar{t}) = 194 \pm 72(stat.) \pm 24(syst.) \pm 21(lumi.)$ pb. Consistent with NLO prediction of 157.5 (+23.2 –24.4) pb for a top quark mass of $m_t = 172.5$ GeV/c^2

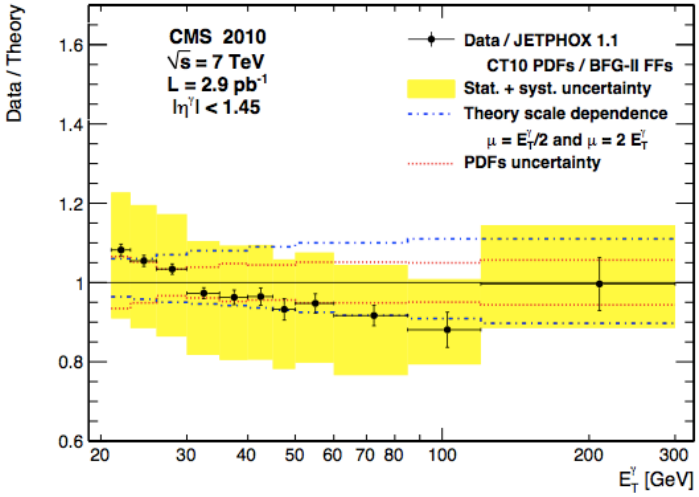
QCD: isolated γ production



Lumi error (11%) not included



Comparison with theory



arXiv:1012.0799
CERN-PH-EP-2010-053

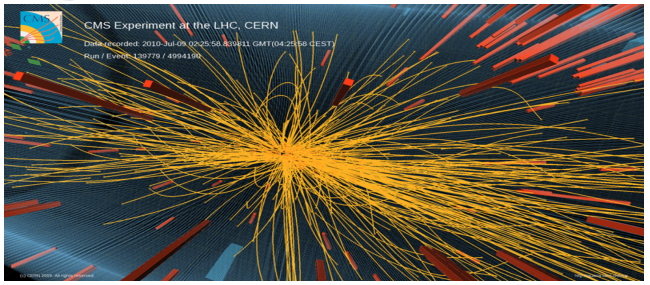
The "ridge": the first surprising result from LHC

High Energy Physics - Experiment arXiv:1009.4122v1 [hep-ex]

Observation of Long-Range Near-Side Angular Correlations in Proton-Proton Collisions at the LHC

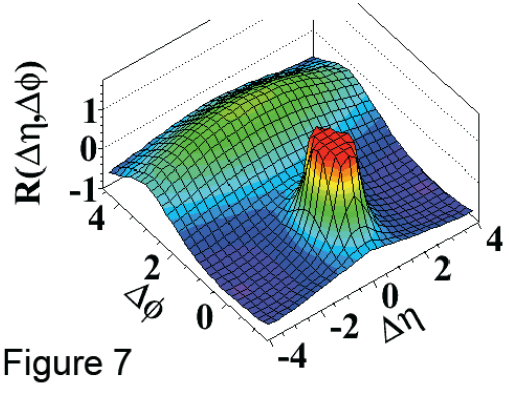
CMS Collaboration

(Submitted on 21 Sep 2010) **JHEP Sep. 27**



MinBias

(b) MinBias, 1.0GeV/c<p_T<3.0GeV/c



high multiplicity (N>110)

(d) N>110, 1.0GeV/c<p_T<3.0GeV/c

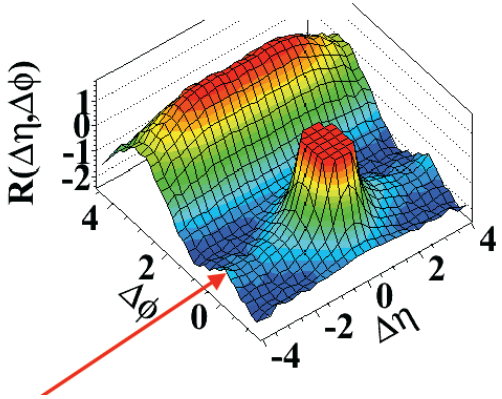
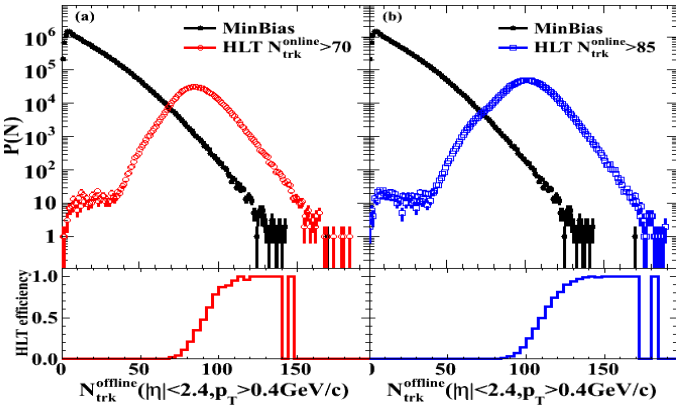


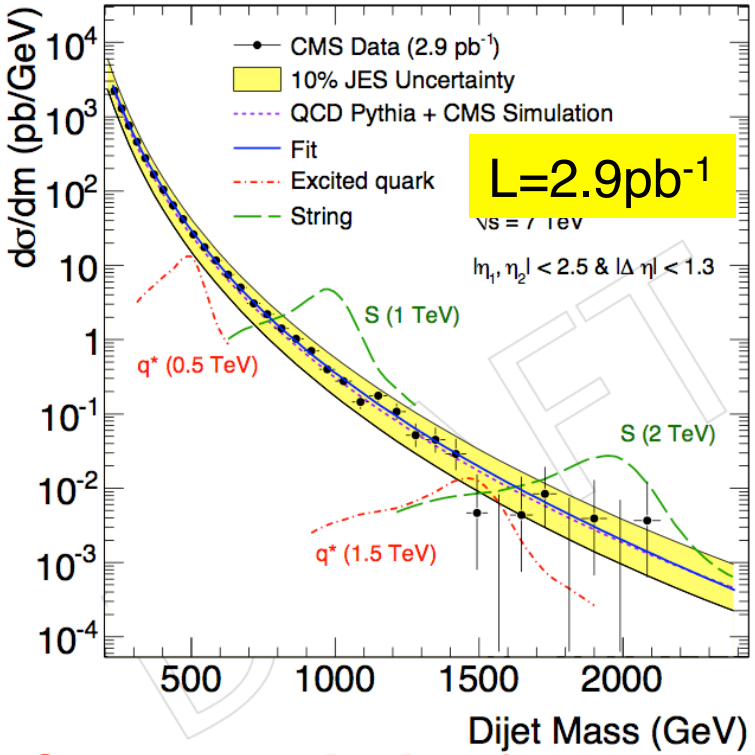
Figure 7

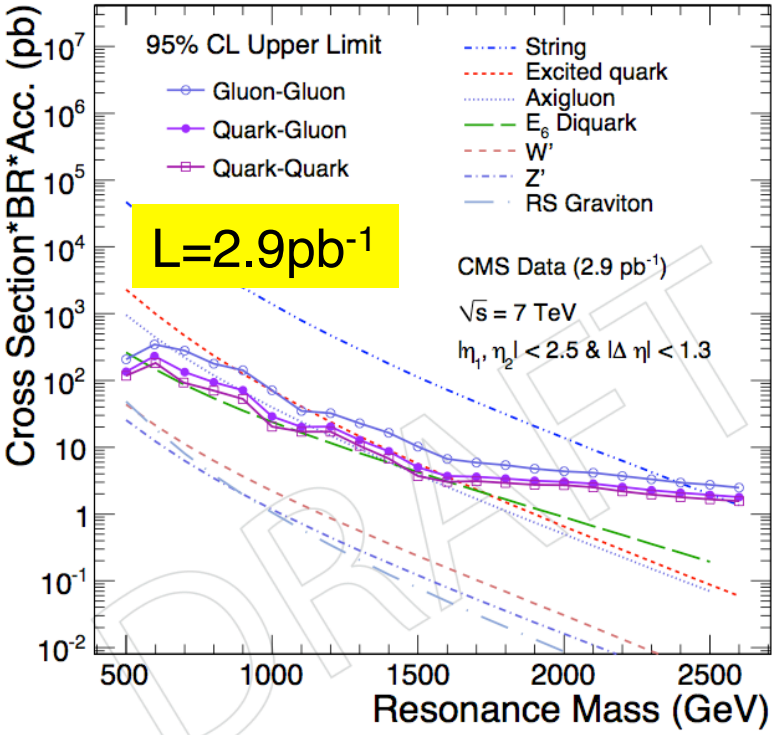


The impact on the scientific community has been sizeable. More than 16 papers on possible interpretations. New set of measurements to understand better the dynamics **but a lot of additional work to do.**

BSM: Search for narrow resonances in dijets

Dijet mass differential cross section for $|\eta_1,\eta_2|<2.5$ and $|\Delta\eta_2|<1.3$, $2.9pb^{-1}$ is sensitive to the coupling of any new massive object to quarks and gluons.
PRL 105 (2010) 211801

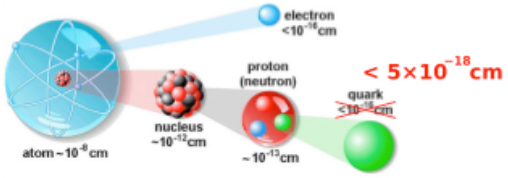


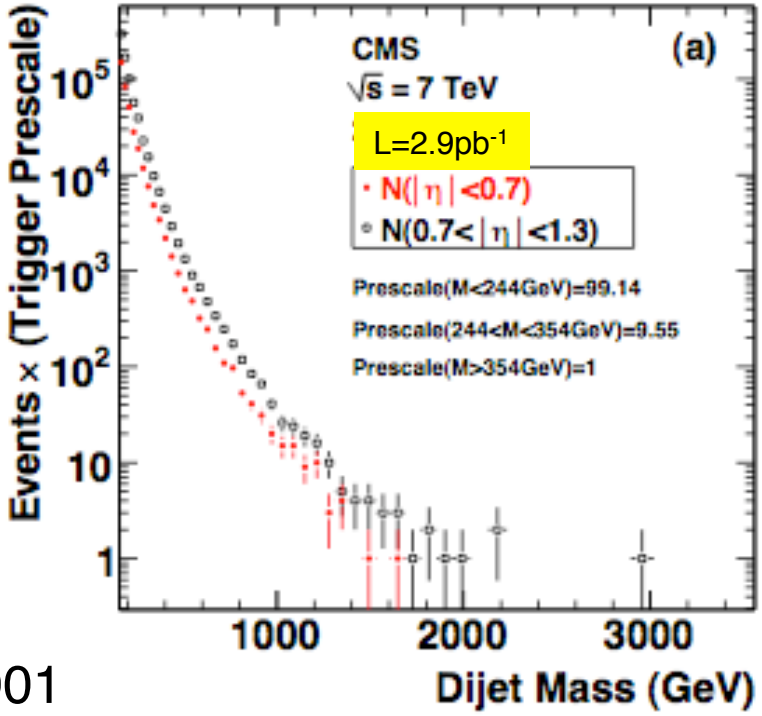


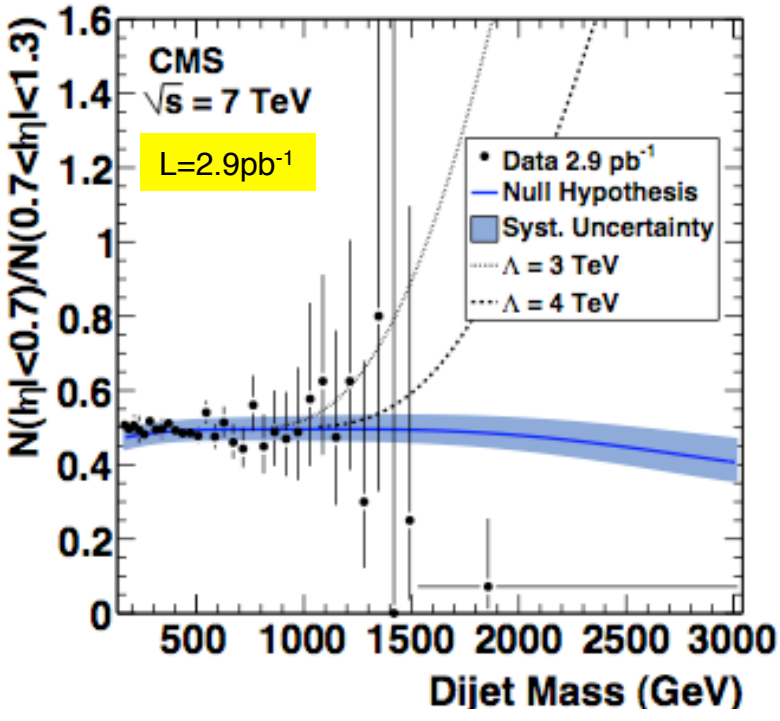
95% CL mass limits for new particles decaying to parton pairs: String resonances >2.5TeV; Excited quarks >1.58TeV….

BSM: search for quark compositeness

The dijet centrality ratio, the ratio of the number of events with the two leading jets within pseudorapidity |η| <0.7 to the number with both leading jets within 0.7<|η| <1.3 is a very sensitive variable to deviations from the Standard Model coming from quark sub-structures.





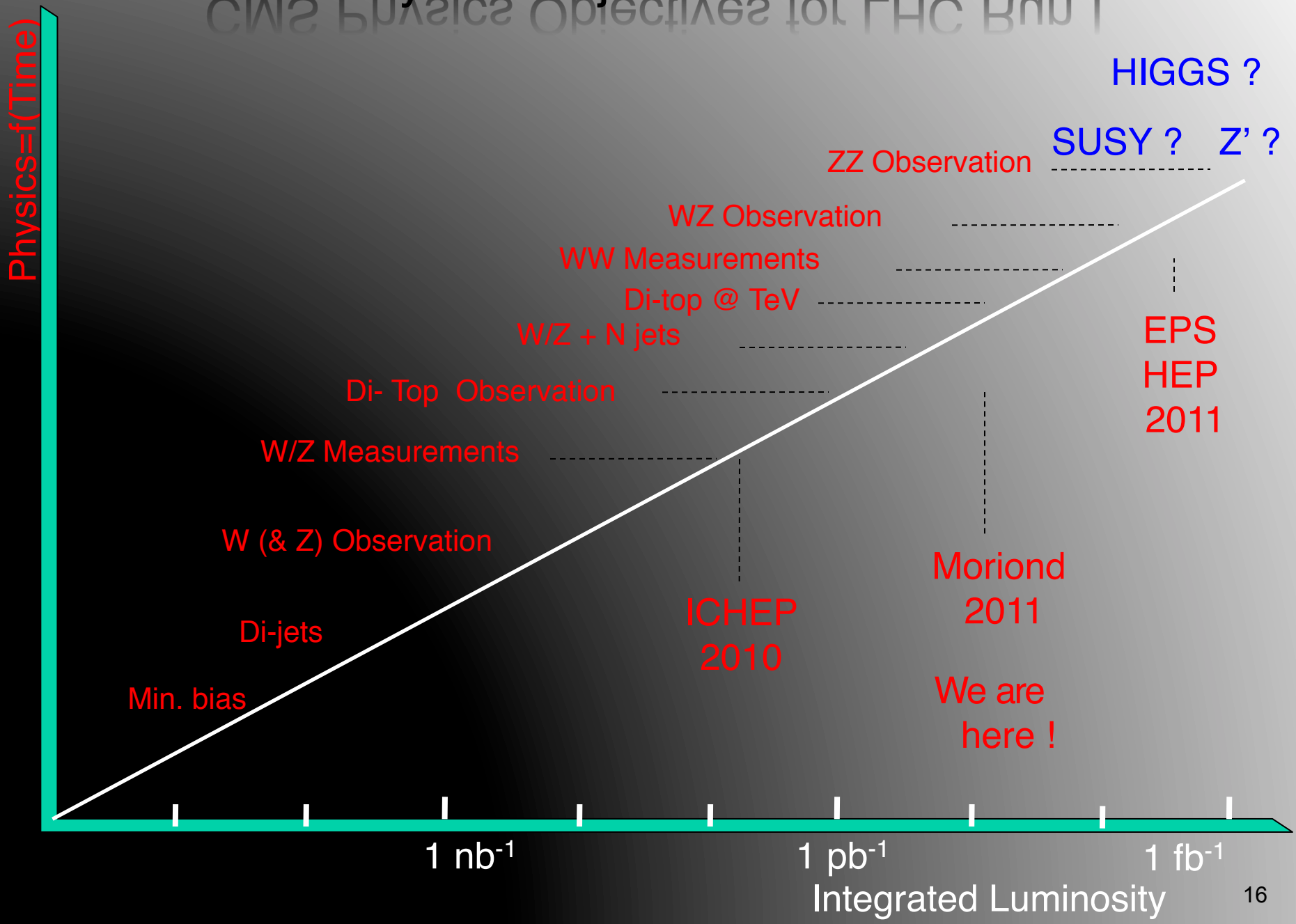


PRL 105 (2010) 262001

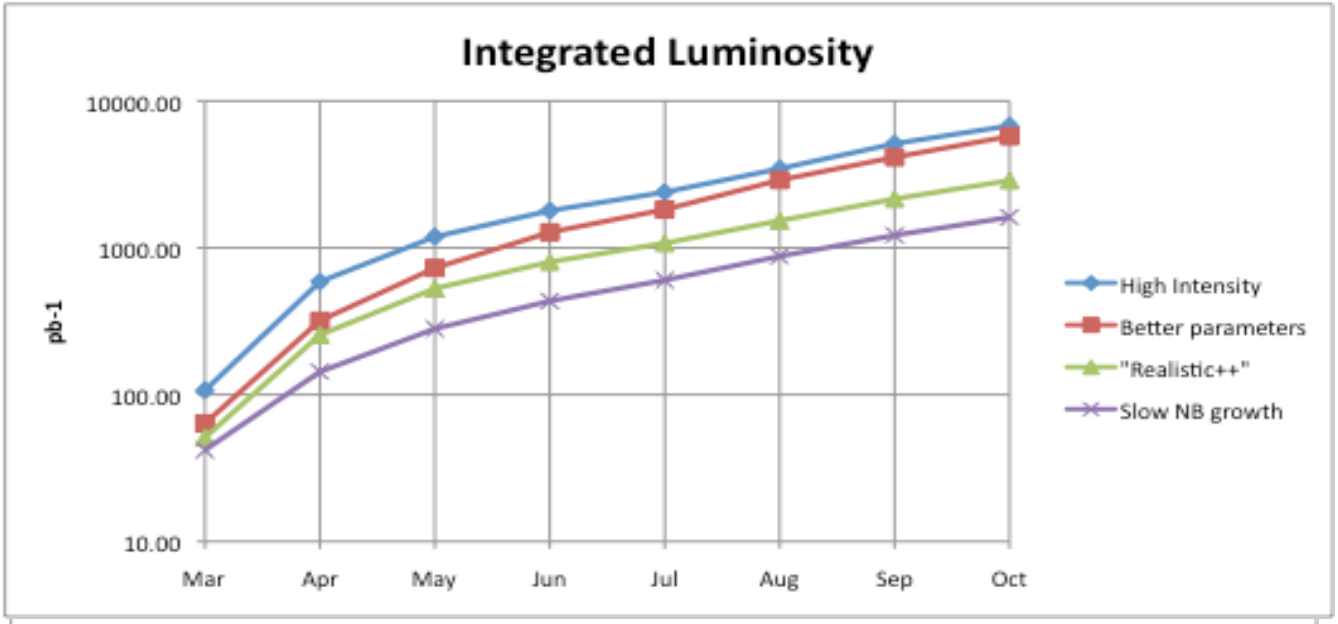
The ratio shows a little dependence on m_{jj} and agrees with the SM expectations.

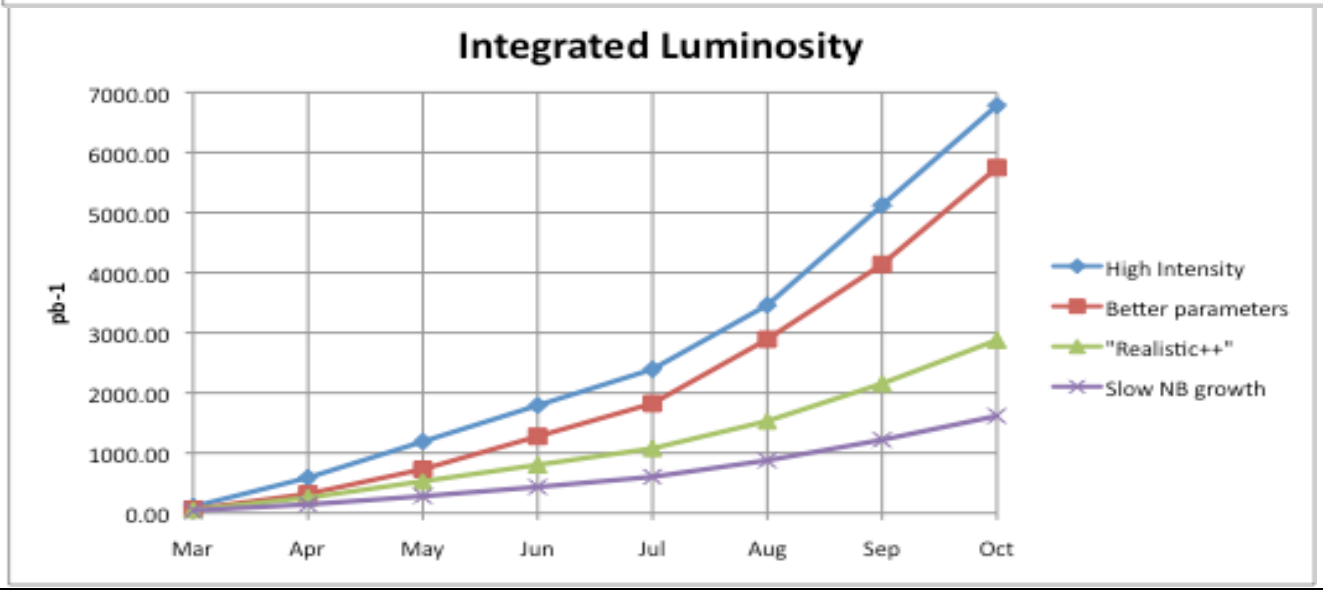
CMS excludes quark compositeness at energy scales of Λ<4.0TeV at the 95%CL.

CMS Physics Objectives for LHC Run I



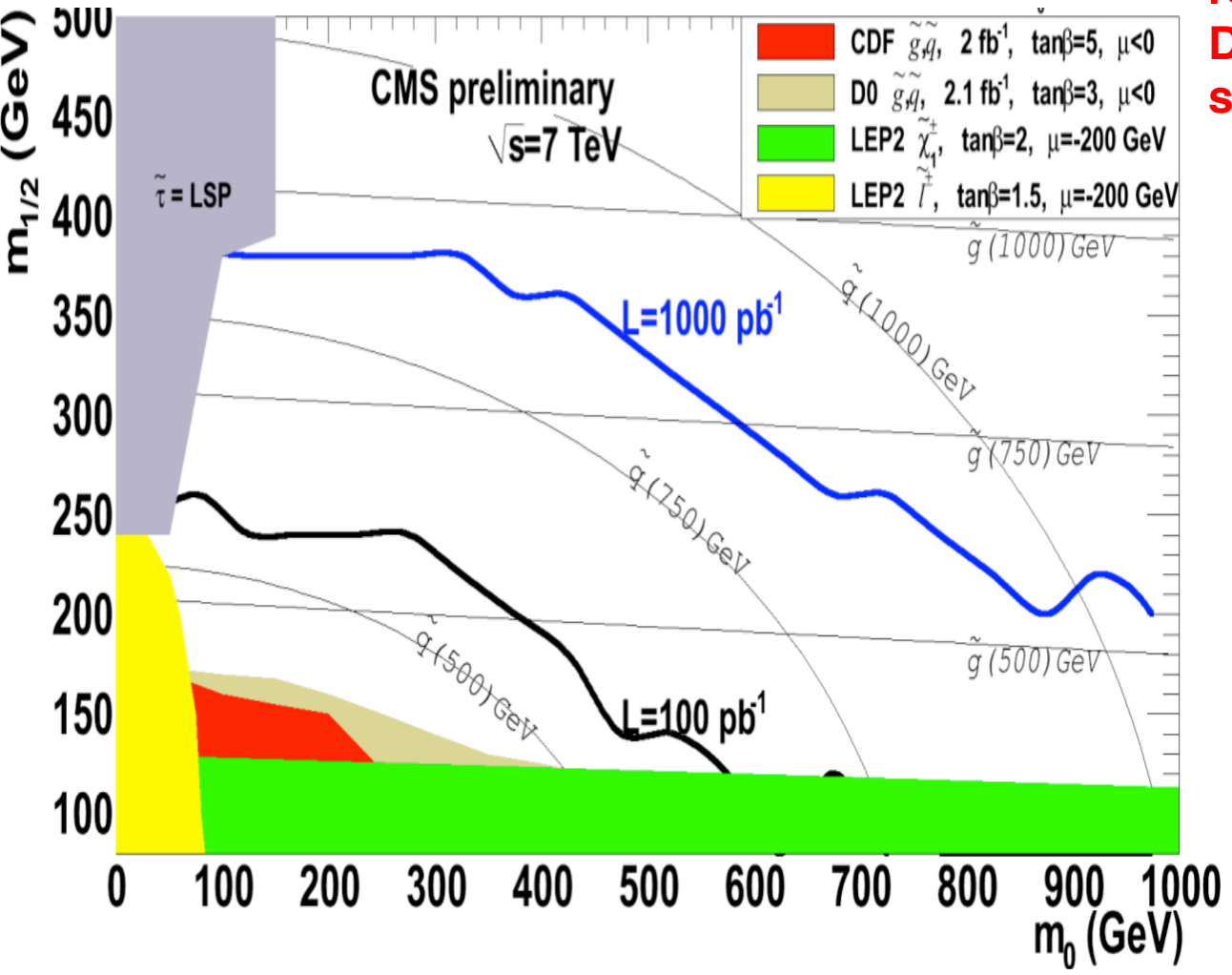
LHC-2011 scenarios: Delivered luminosity

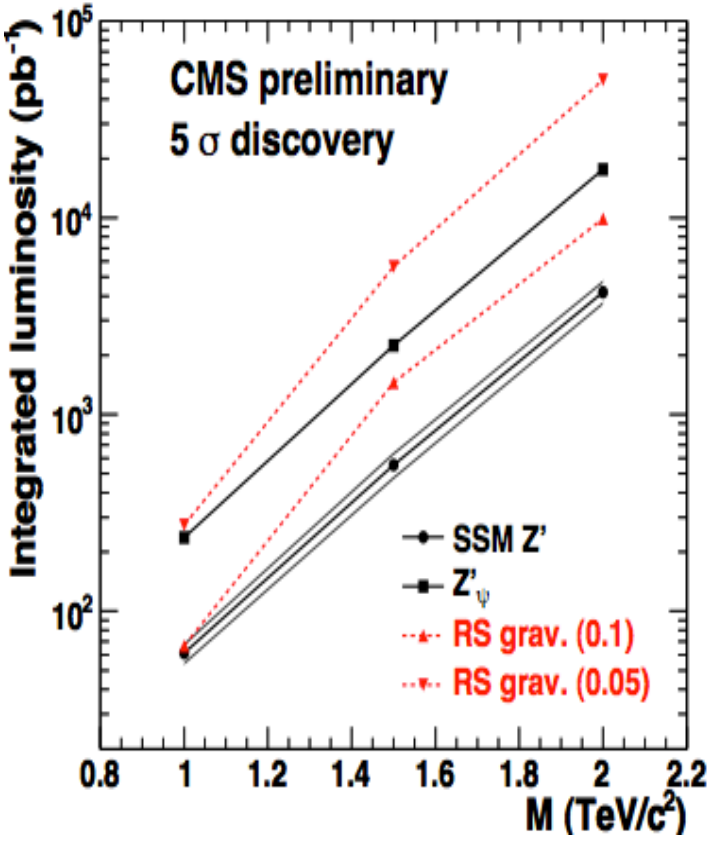




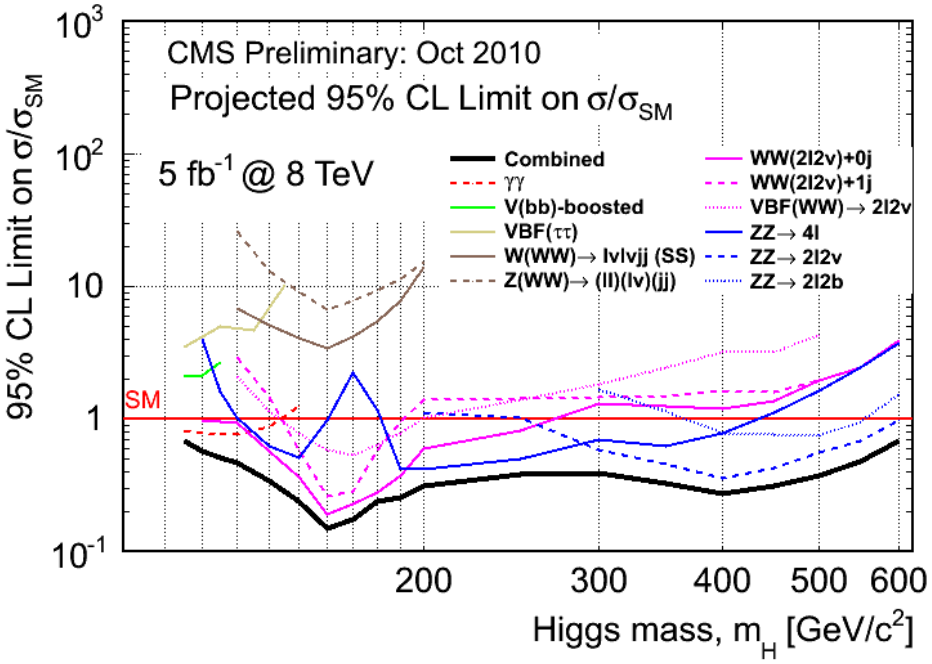
New Physics Prospects for the 2011-12 Run

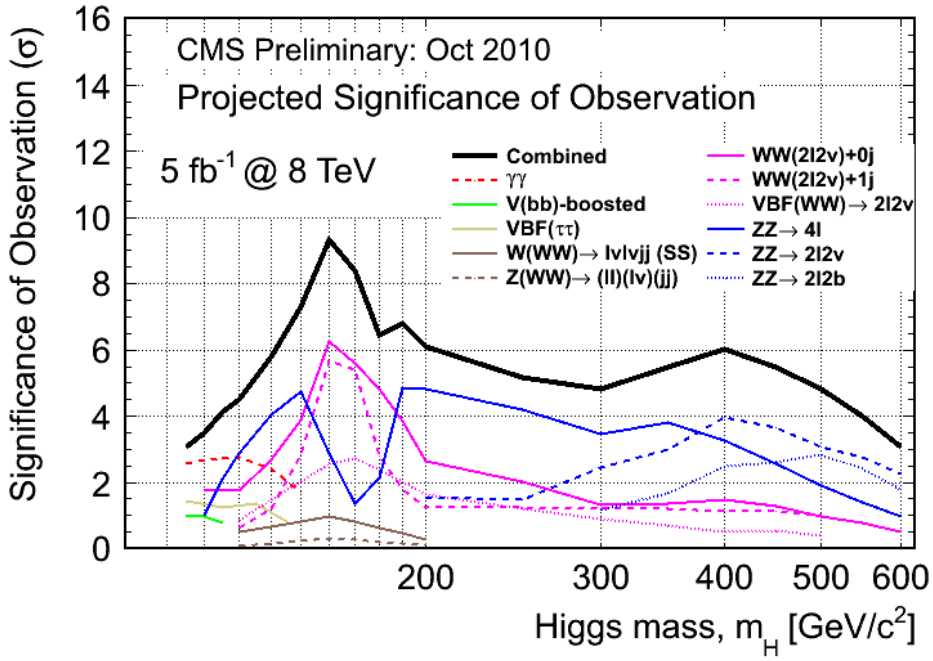
W' and Z' up to the MultiTeV region.
Discover SUSY if masses of squarks and gluinos <1-1.2TeV





Prospects for Higgs boson search in 2011-12

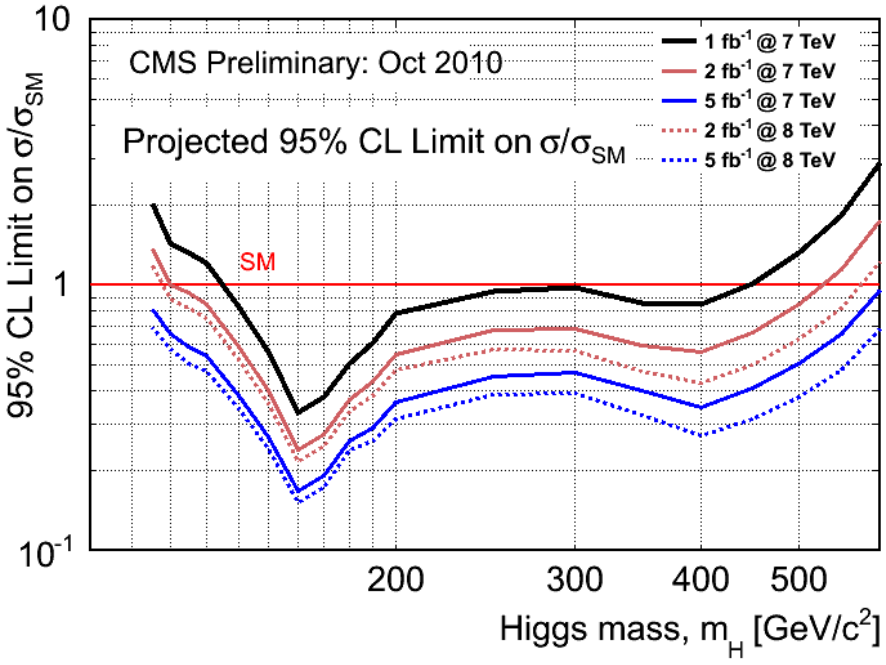


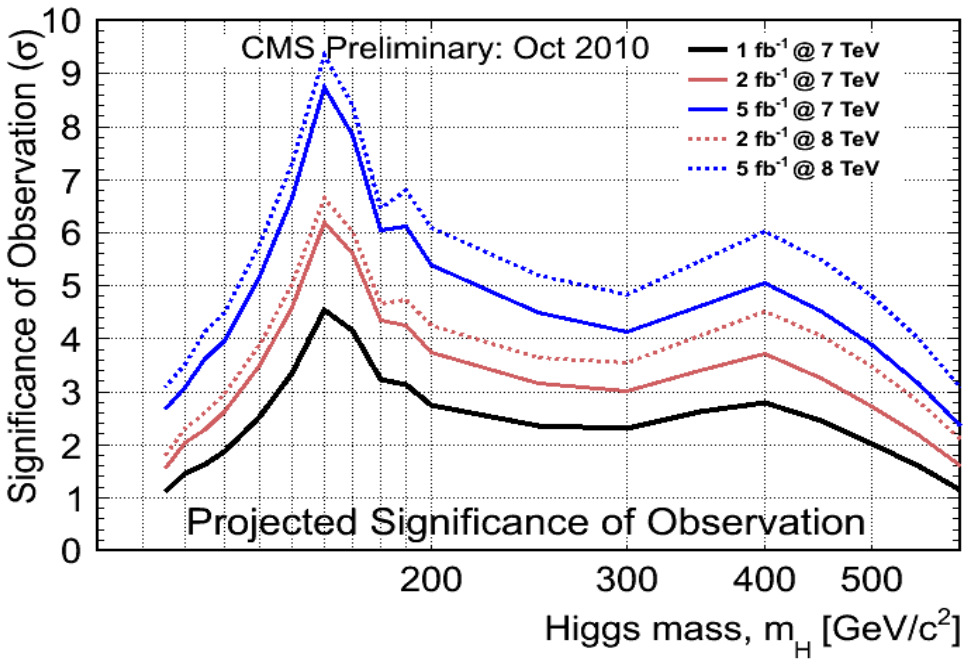


Channels included	Higgs mass range used in analyses (GeV)
H→γγ	115-150
VBF H→ττ	115-145
VH, H→bb (highly boosted)	115-125
VH, H→WW→lνjj	130-200
H→WW→2l2ν + 0/1 jets	120-600
VBF H→WW→2l2ν	130-500
H→ZZ→4l	120-600
H→ZZ→2l2ν	200-600
H→ZZ→2l2b	300-600

LHC 2011-2012:
7 TeV -> 8 TeV ?

Prospects for Higgs boson search in 2011-12





The reach of CMS 2011-12 has been re-evaluated.
Considering for the moment only cut based analysis
and the most promising channels (new preliminary estimates):
with 10fb^{-1} (e.g., with ATLAS) **at 8 TeV one can discover Higgs boson over the mass range between ~115 and ~600GeV**

PNPI @CMS Physics: VBF Higgs boson

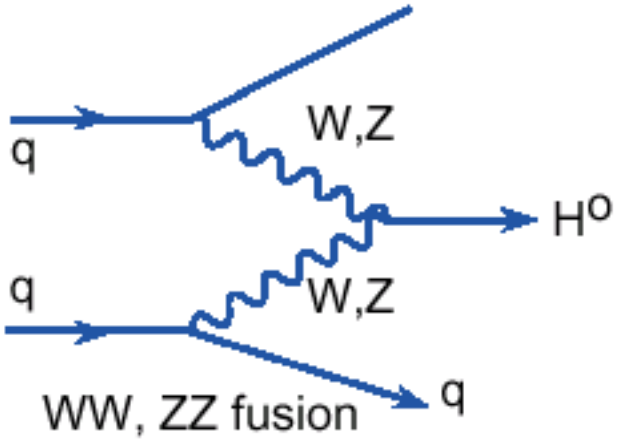
- Higgs boson group: VBF subgroup

  Background studies for

  - Efficiency of jet veto
  - Central jet activity
  - Forward jet tagging

Fully leptonic: qqH → jj WW → jj l ν l ν

Semi-leptonic: qqH → jj WW → jj l ν jj



Signal features semi-and fully leptonic modes:

- forward tagging jets VBF

- central high pT lepton + missing ET W → l ν

- central high-pt dijet W → jj (l ν)

PNPI @CMS Physics: Dijet K-factor

BFKL enhancement for processes with large rapidity intervals between jets ->

-> Dijet K-factor = inclusive dijets / “exclusive” dijets as a function of rapidity

• Forward Physics Group: Forward Jets subgroup
double jet trigger for forward dijets: prescale 3 (jet trigger prescale > 30)

Analysis: systematic uncertainties
MC production for different models
Analysis -> ready for Spring conferences

PNPI team in collaboration with
CERN: G. Brona
ITEP: V. Gavrilov, A. Krokhotin, G. Safronov
INR: G. Pivovarov
UIC: M. Malek

Conclusions

Excellent physics performance at CMS 2010:

- SM tests and searches for new SM dynamics at novel energy domain
- search for new physics beyond SM

2011: even more exciting year at CMS!