Recent results from CMS experiment at LHC

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On behalf of the CMS Collaboration

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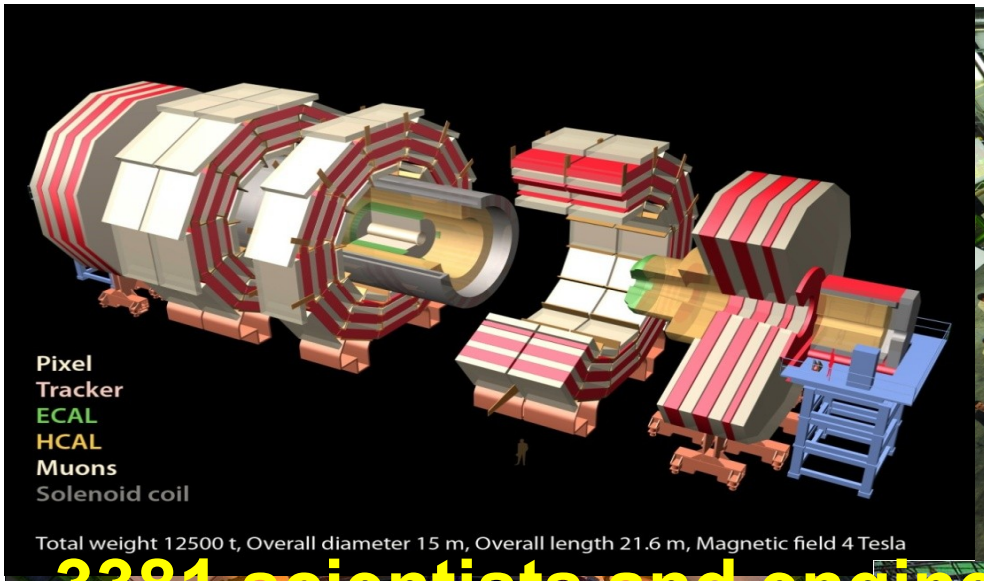
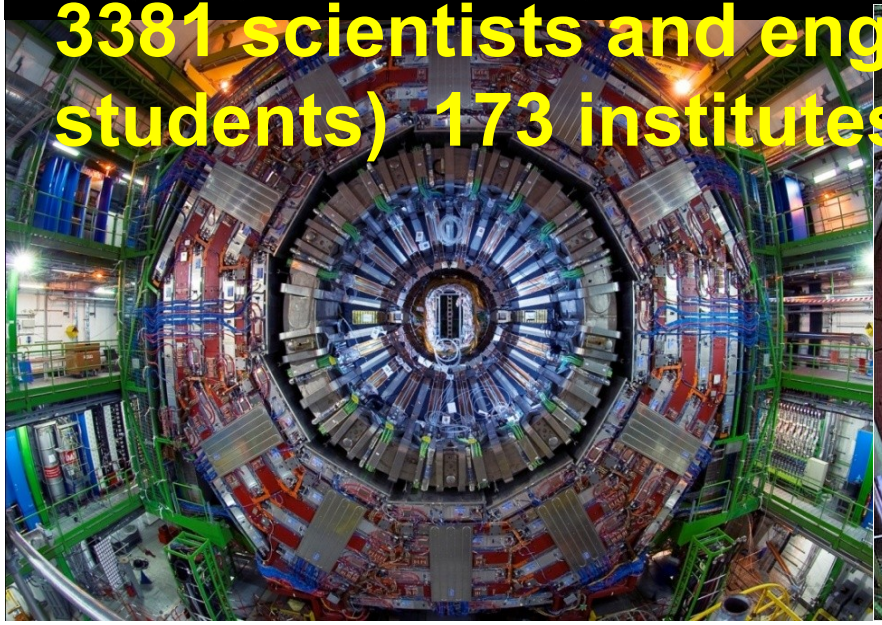
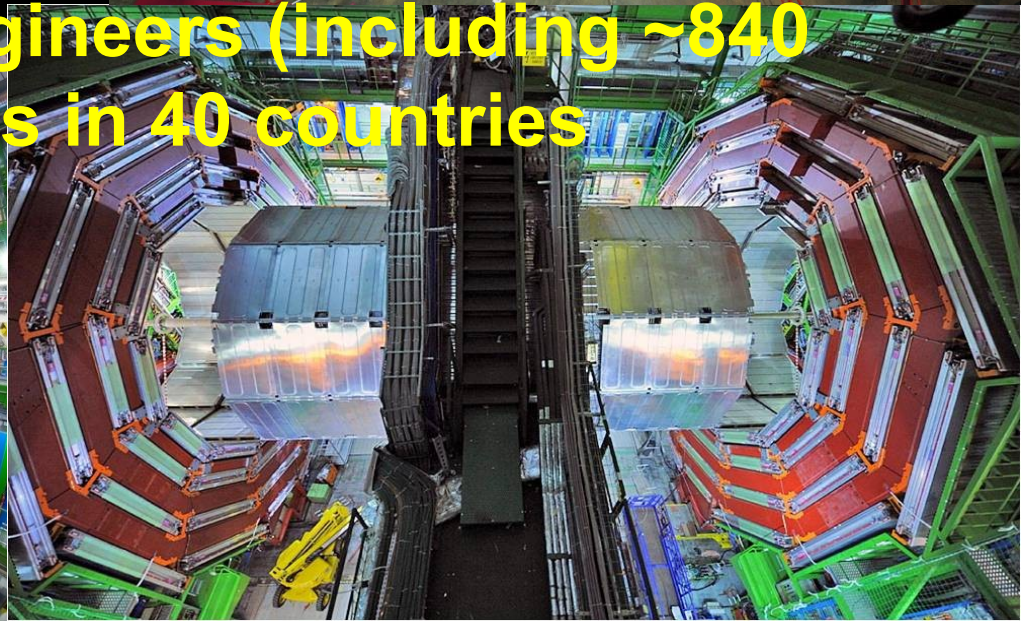
CMS Collaboration



3381 scientists and engineers (including ~840 students) 173 institutes in 40 countries



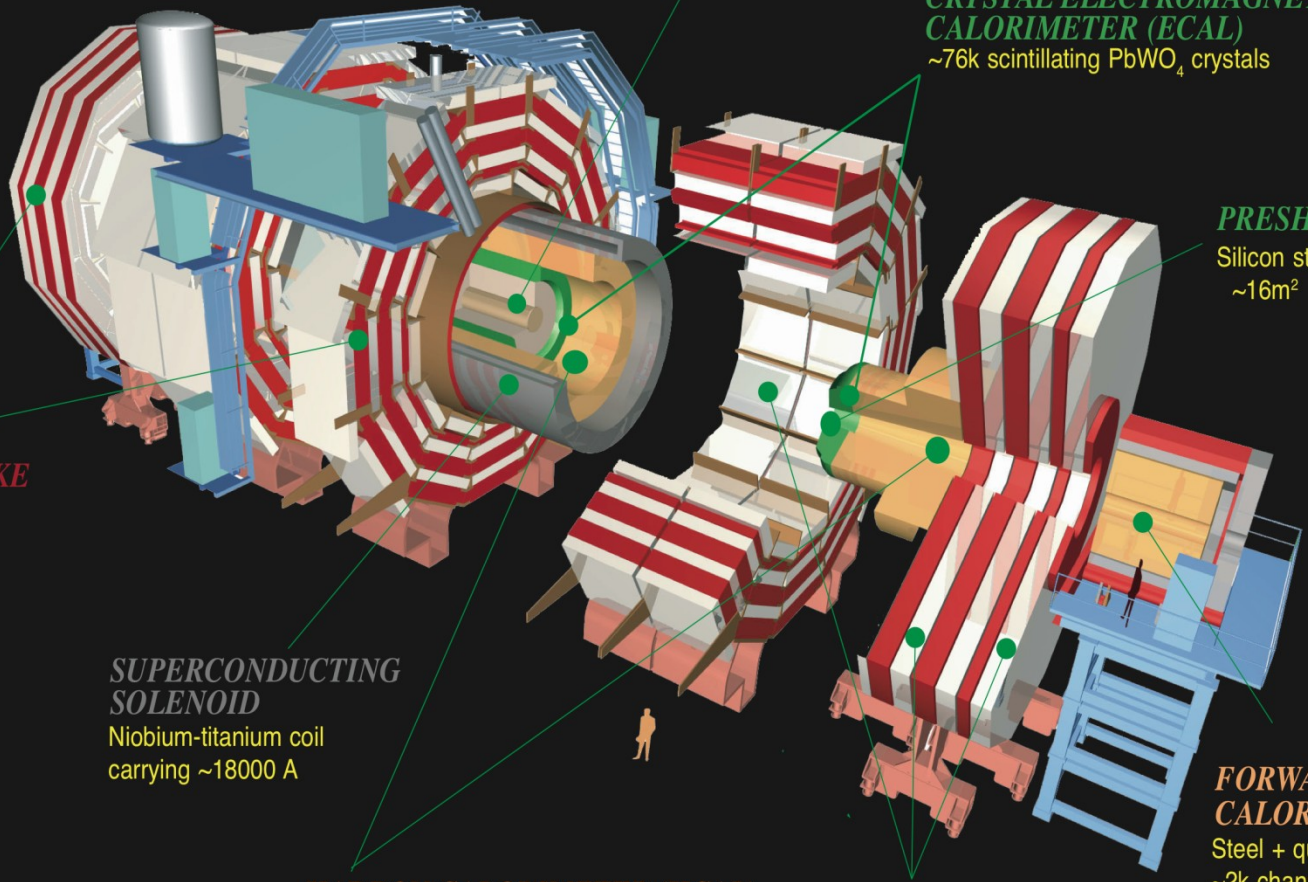


RDMS Collaboration

INR (Moscow)
IHEP (Protvino)
ITEP (Moscow)
LPI (Moscow)
MSU (Moscow)
PNPI (Gatchina)

JINR (Dubna)
JINR Memeber States Instutites

CMS Detector



SILICON TRACKER
Pixels (100 x 150 μm²)
~1m² ~66M channels
Microstrips (80-180μm)
~200m² ~9.6M channels

CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)
~76k scintillating $PbWO_4$ crystals

PRESHOWER
Silicon strips
~16m² ~137k channels

STEEL RETURN YOKE
~13000 tonnes

SUPERCONDUCTING SOLENOID
Niobium-titanium coil
carrying ~18000 A

FORWARD CALORIMETER
Steel + quartz fibres
~2k channels

HADRON CALORIMETER (HCAL)
Brass + plastic scintillator
~7k channels

MUON CHAMBERS
Barrel: 250 Drift Tube & 480 Resistive Plate Chambers
Endcaps: 473 Cathode Strip & 432 Resistive Plate Chambers

Total weight	: 14000 tonnes
Overall diameter	: 15.0 m
Overall length	: 28.7 m
Magnetic field	: 3.8 T

Data taking

2009

pp 0.45+0.45 TeV

pp 1.18+1.18 TeV

2010

pp 3.5+3.5 TeV 47/43 pb^{-1}

PbPb 1.38+1.38 TeV/N 9.6/8.7 μb^{-1}

2011

pp 3.5+3.5 TeV 6.1/5.6 fb^{-1}

pp 1.38+1.38 TeV 257/247 nb^{-1}

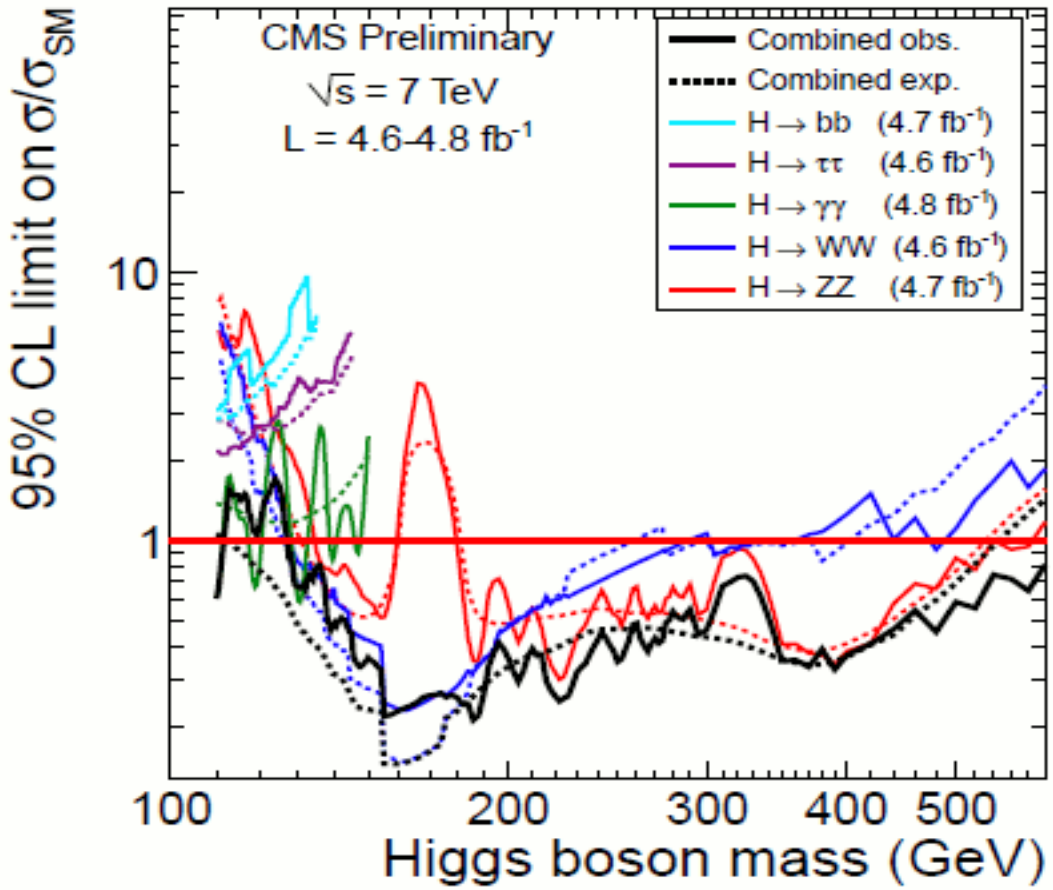
PbPb 1.38+1.38 TeV/N 167/158 μb^{-1}

2012 (up to May 26)

pp 4 + 4 TeV 3.3/3.0 fb^{-1}

Search for the SM Higgs Boson

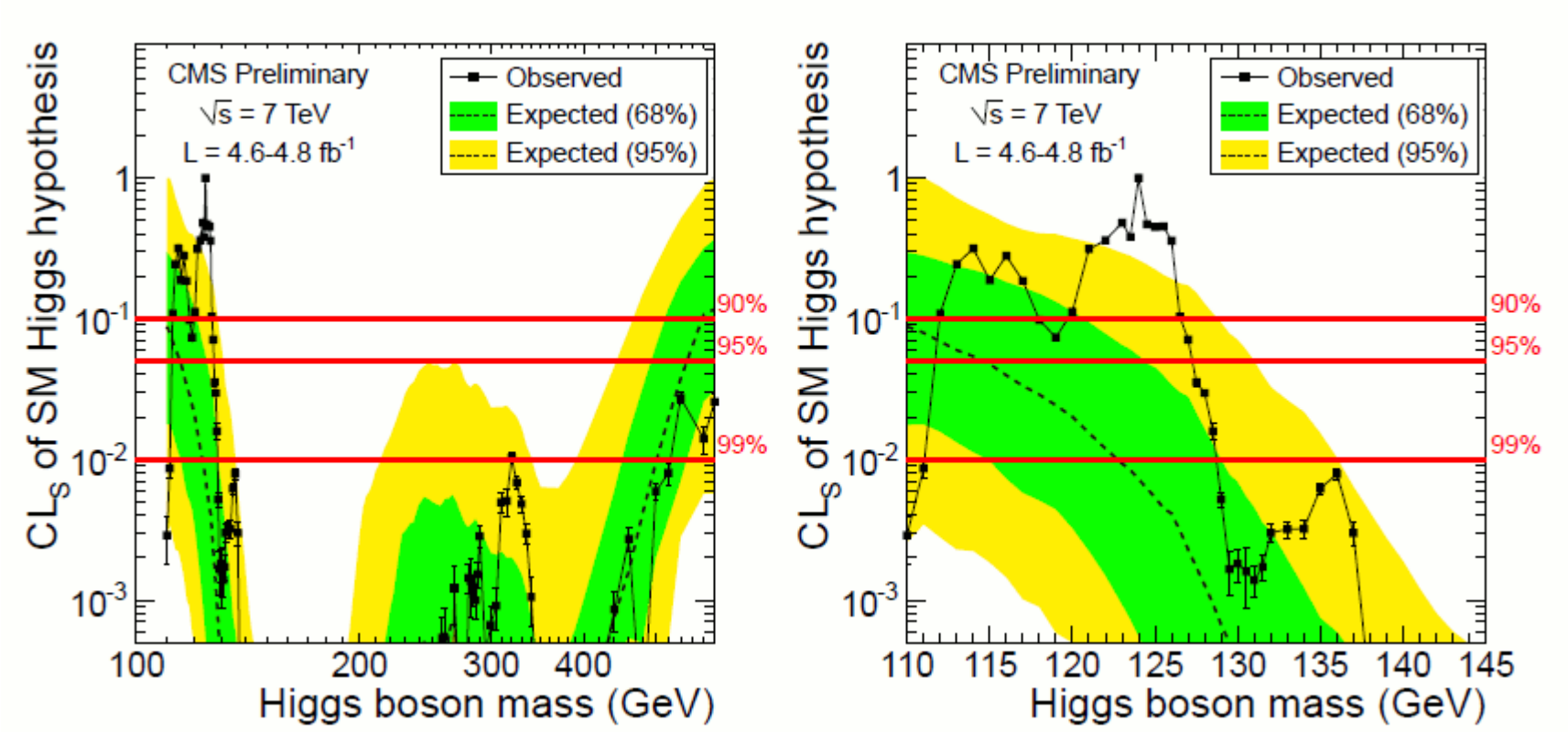
CMS HIG-12-008



Sensitivity for different decay channes

SM Higgs exclusion limits

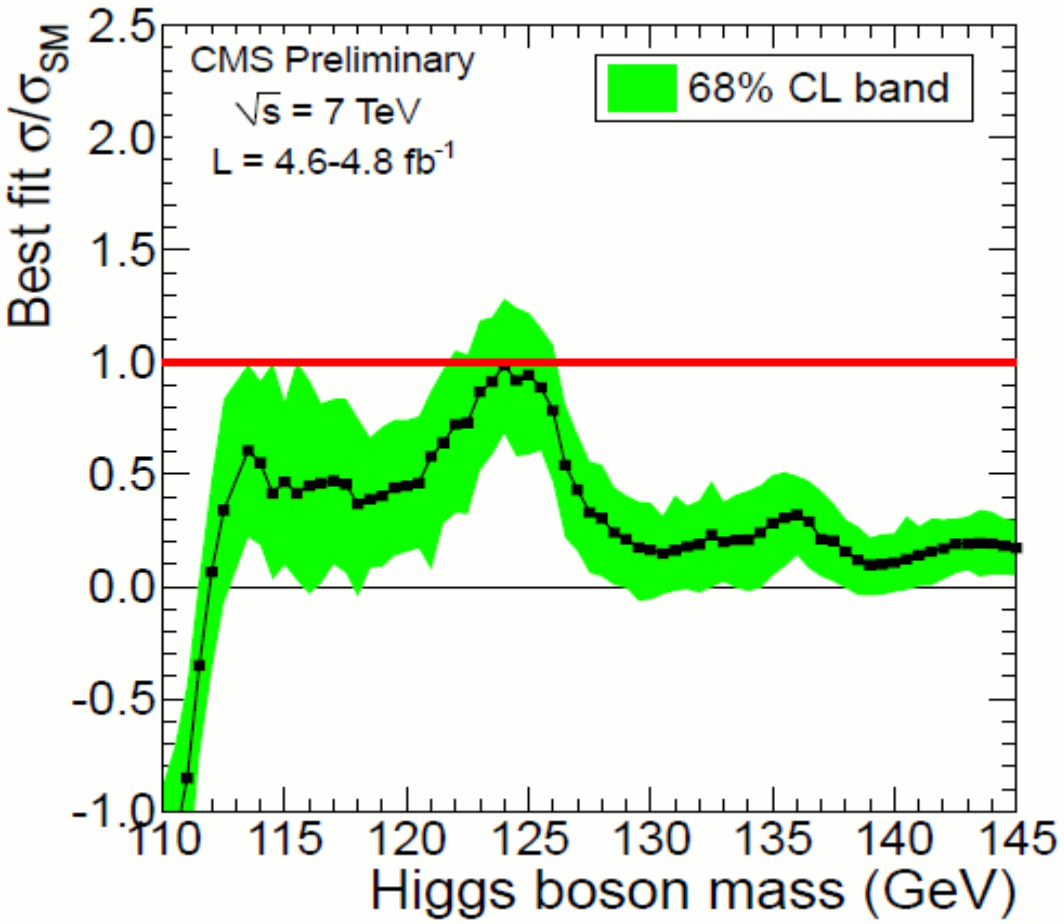
CMS HIG-12-008



SM Higgs boson excluded in mass range 127.5 — 600 GeV at 95% CL

Best fit for σ/σ_{SM}

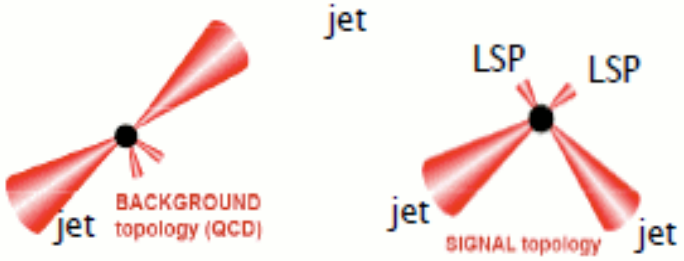
CMS HIG-12-008



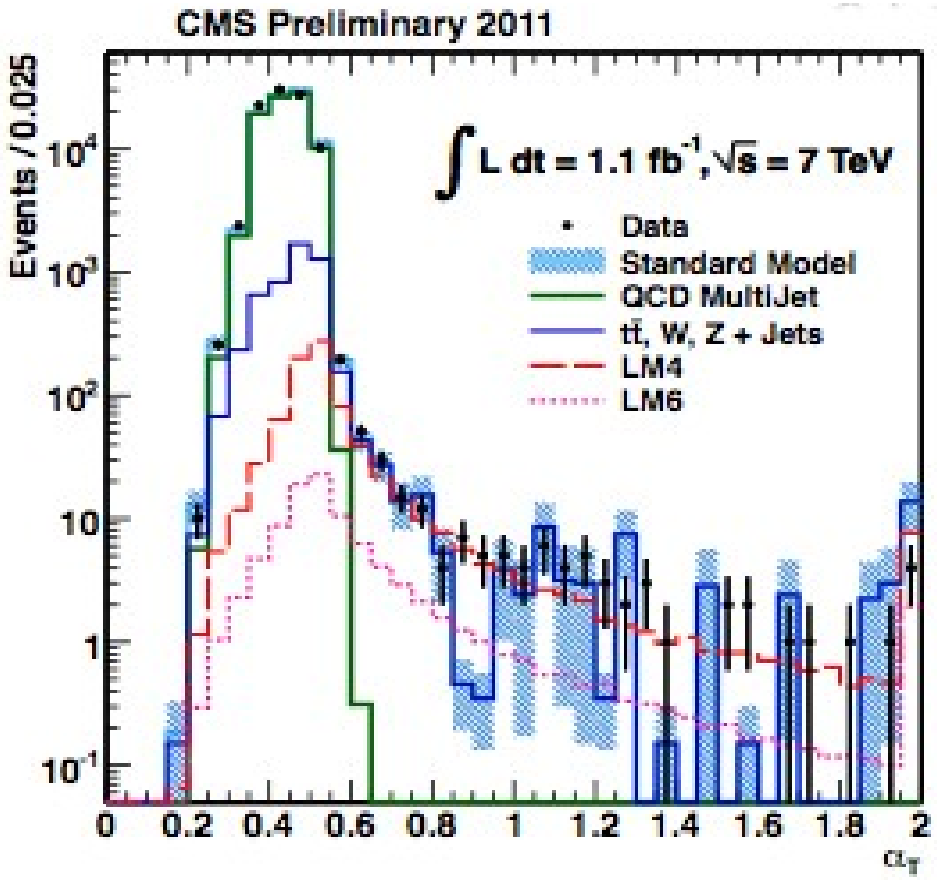
Comparison results with hypothesis of SM Higgs boson of different masses

SUSY – hadrons

Hadronic decays with jets and missing transverse energy using α_t

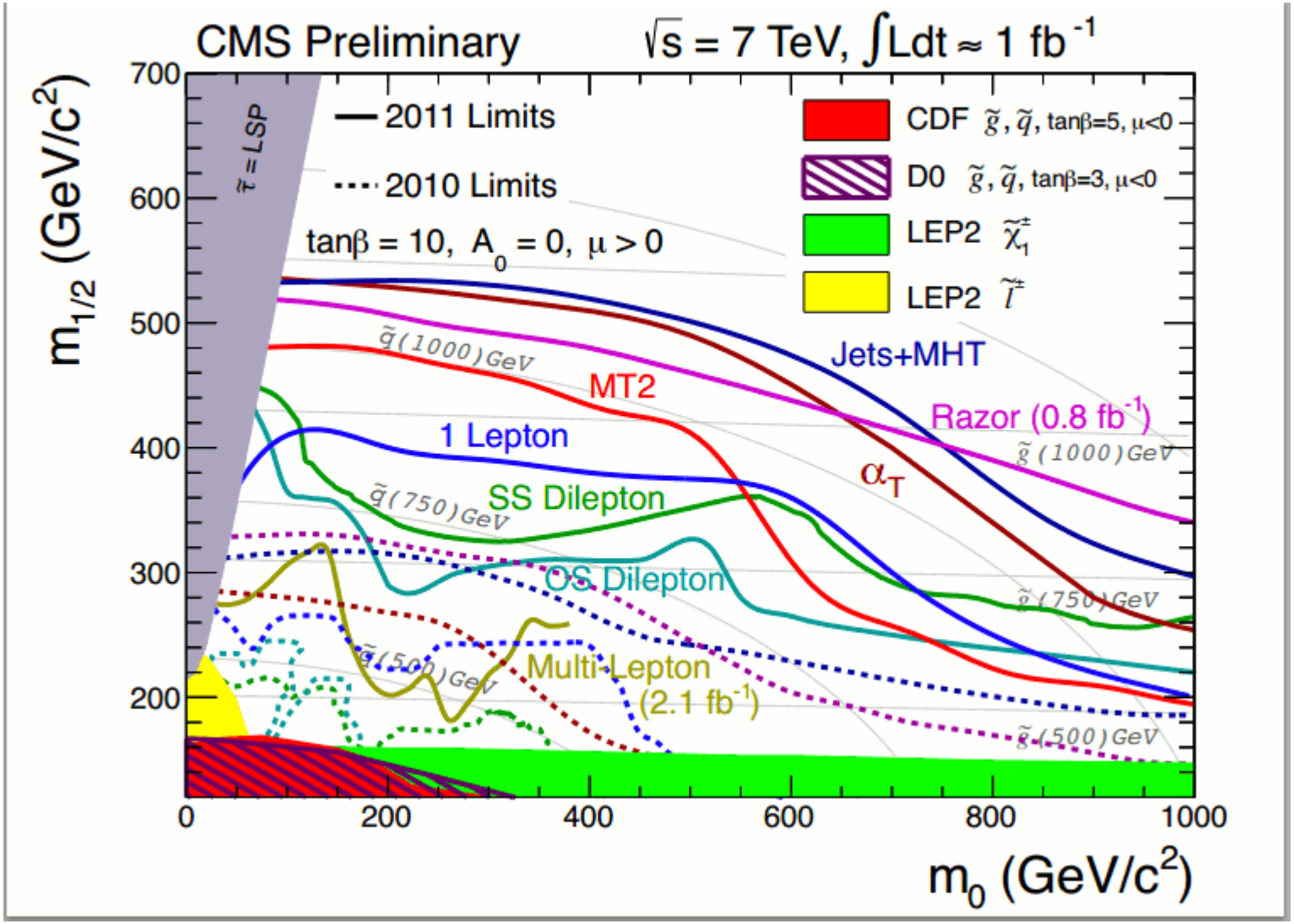


$$\alpha_T = \frac{E_{T\,j2}}{M_{T\,j1j2}} = \frac{\sqrt{E_{T\,j2}/E_{T\,j1}}}{\sqrt{2(1-\cos\Delta\varphi)}}$$



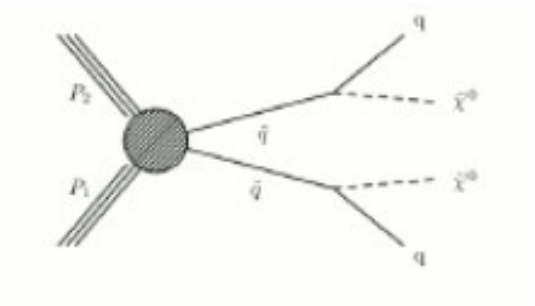
CMS SUS-11-003

SUSY limits



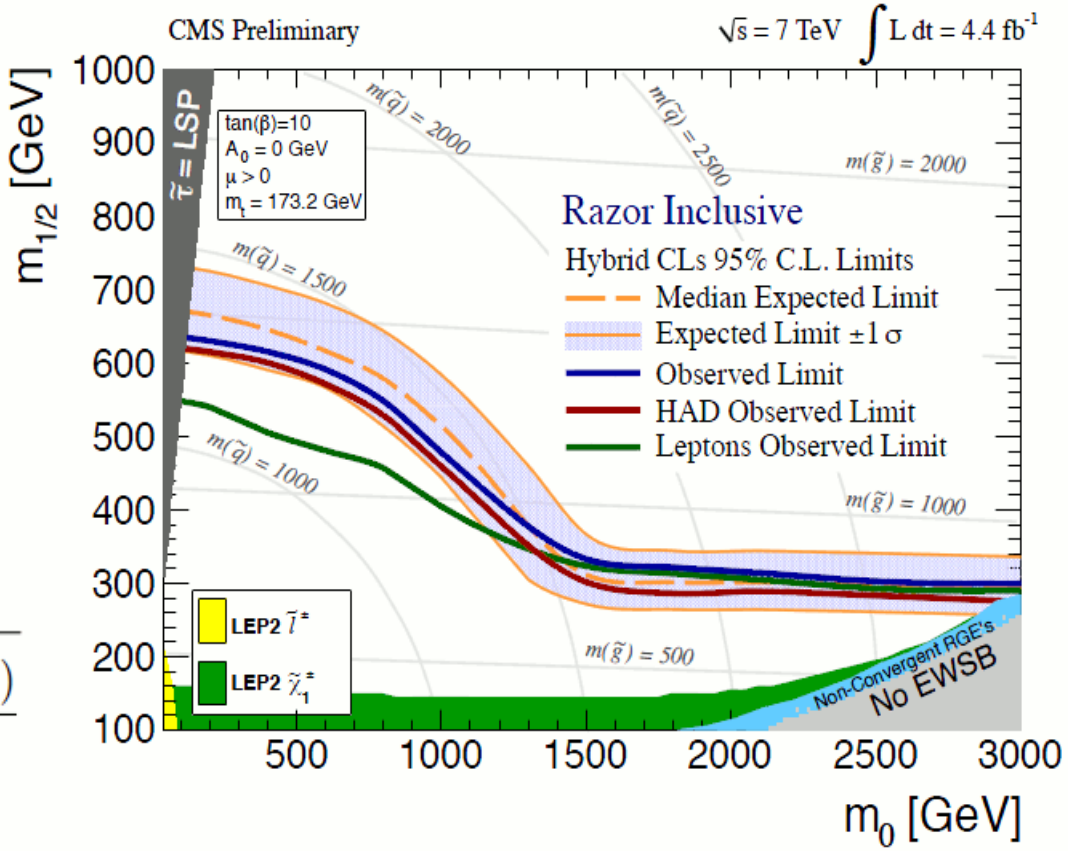
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

Analysis with Razor variables



$$M_R \equiv \sqrt{(E_{j_1} + E_{j_2})^2 - (p_z^{j_1} + p_z^{j_2})^2}\,,$$

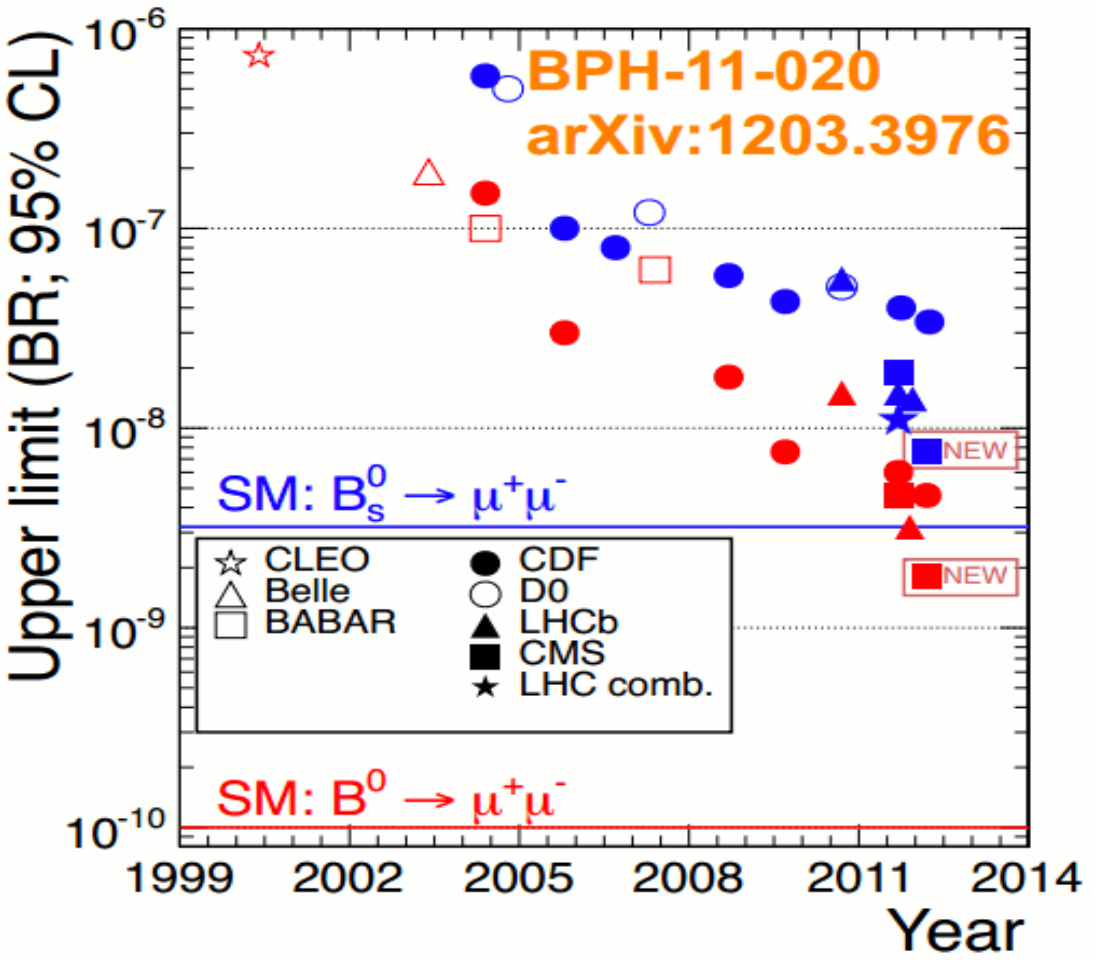
$$M_T^R \equiv \sqrt{\frac{E_T^{miss}(p_T^{j1} + p_T^{j2}) - \vec{E}_T^{miss}\cdot(\vec{p}_T^{\,j1} + \vec{p}_T^{\,j2})}{2}}$$



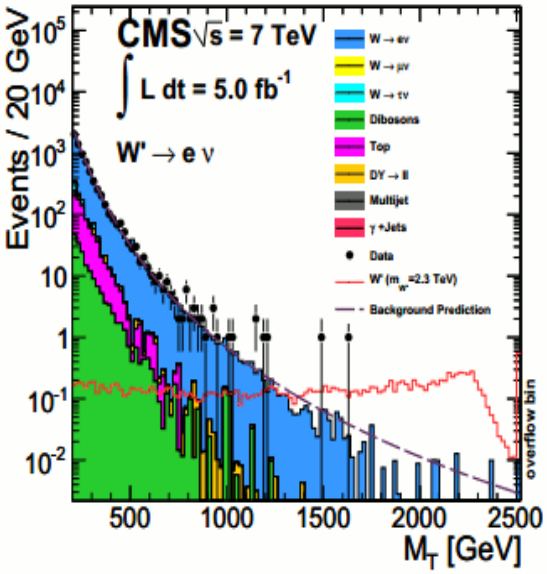
CMS SUS-12-003

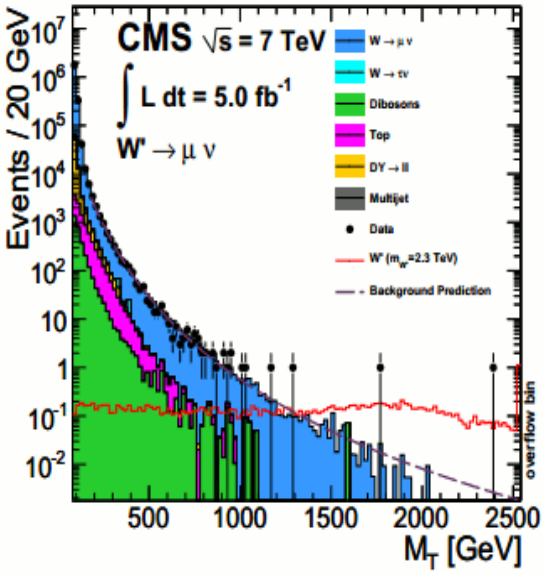
$B_s \rightarrow \mu^+\mu^-$

Indirect sensitivity to new physics
MSSM:BR∝$(\tan\beta)^6$ → sensitivity to extended Higgs boson sectors → additional constraints on parameter region.
$B_s \rightarrow \mu^+\mu^- = (3.2\pm0.2)\times10^{-9}$;
$B_d \rightarrow \mu^+\mu^- = (1.0\pm0.1)\times10^{-10}$

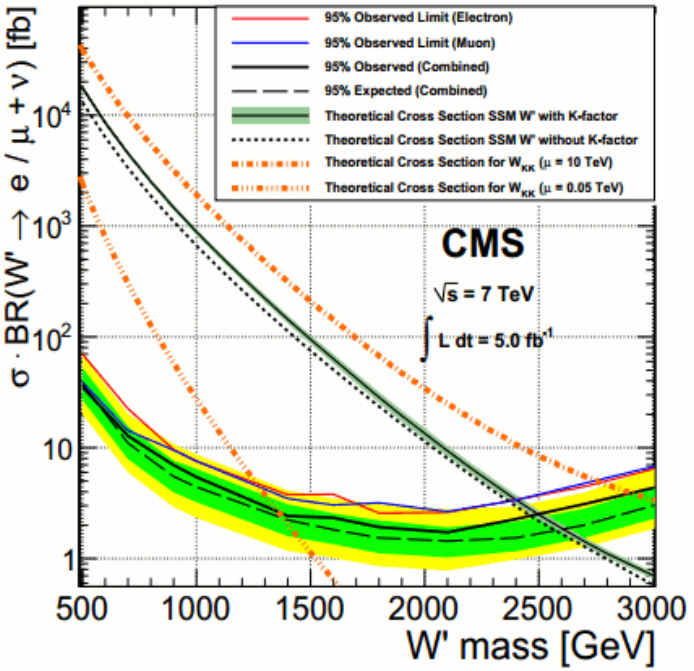


Looking for massive extra W-bosons



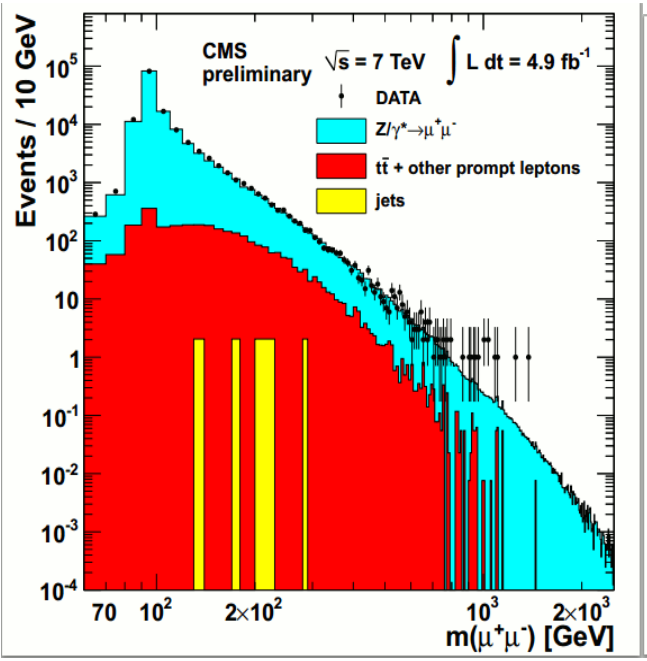


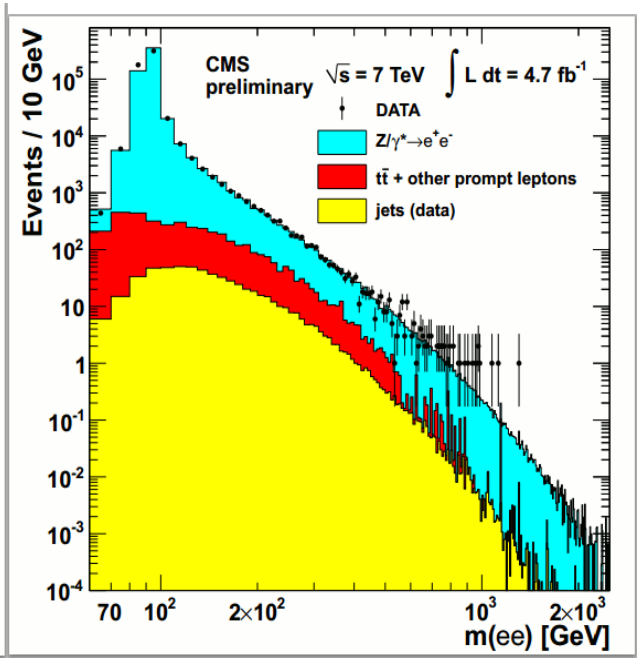
arXiv:1204.4764

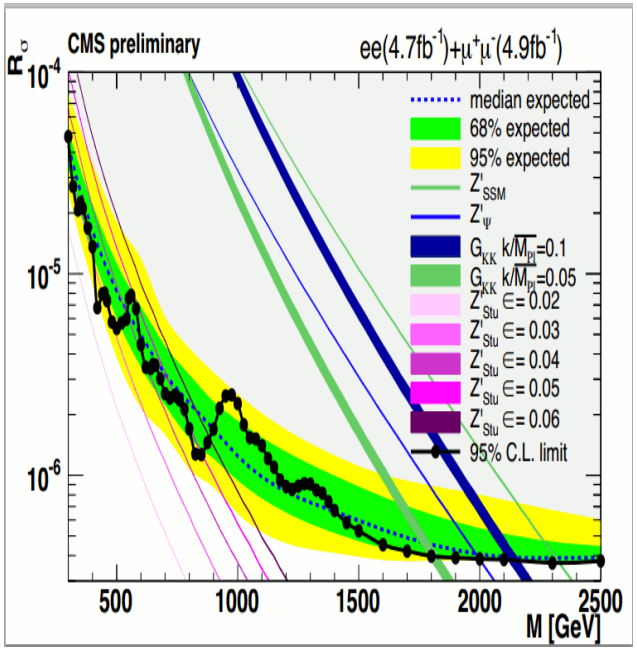


High p_T di-leptons

CMS study in detail the high mass tail of the Z. Since spectra are consistent with known SM processes we extract 95% CL limits.



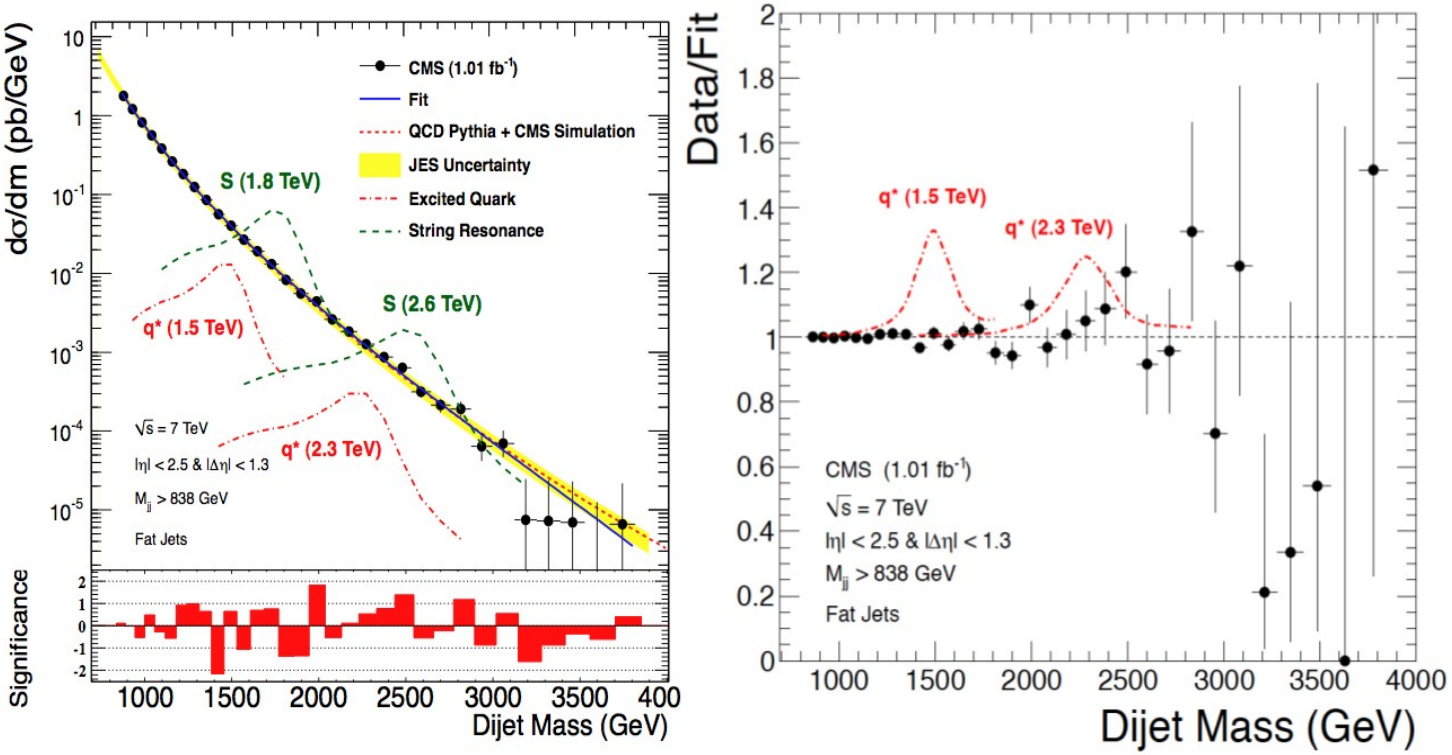




Z'→μ⁺μ⁻ **Z'→e⁺e⁻** **Z'→e⁺e⁻ or μ⁺μ⁻**

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO

Search for di-jet resonances

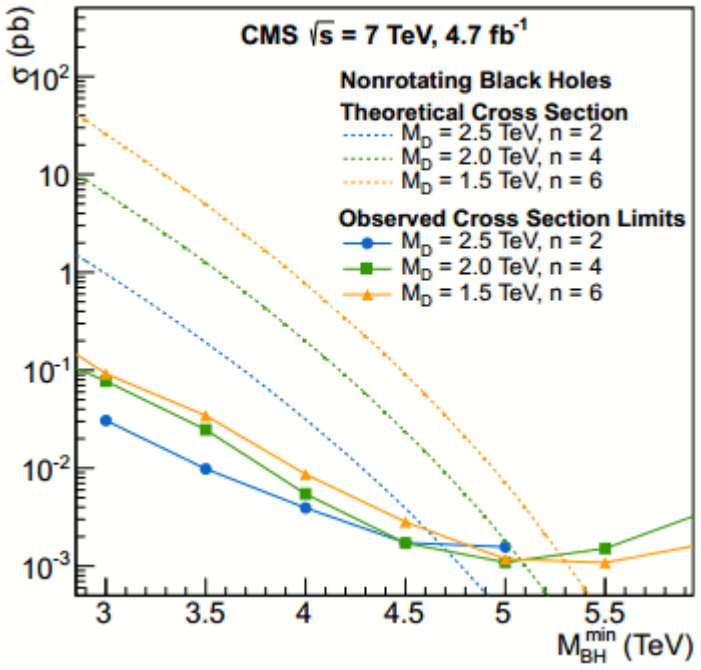


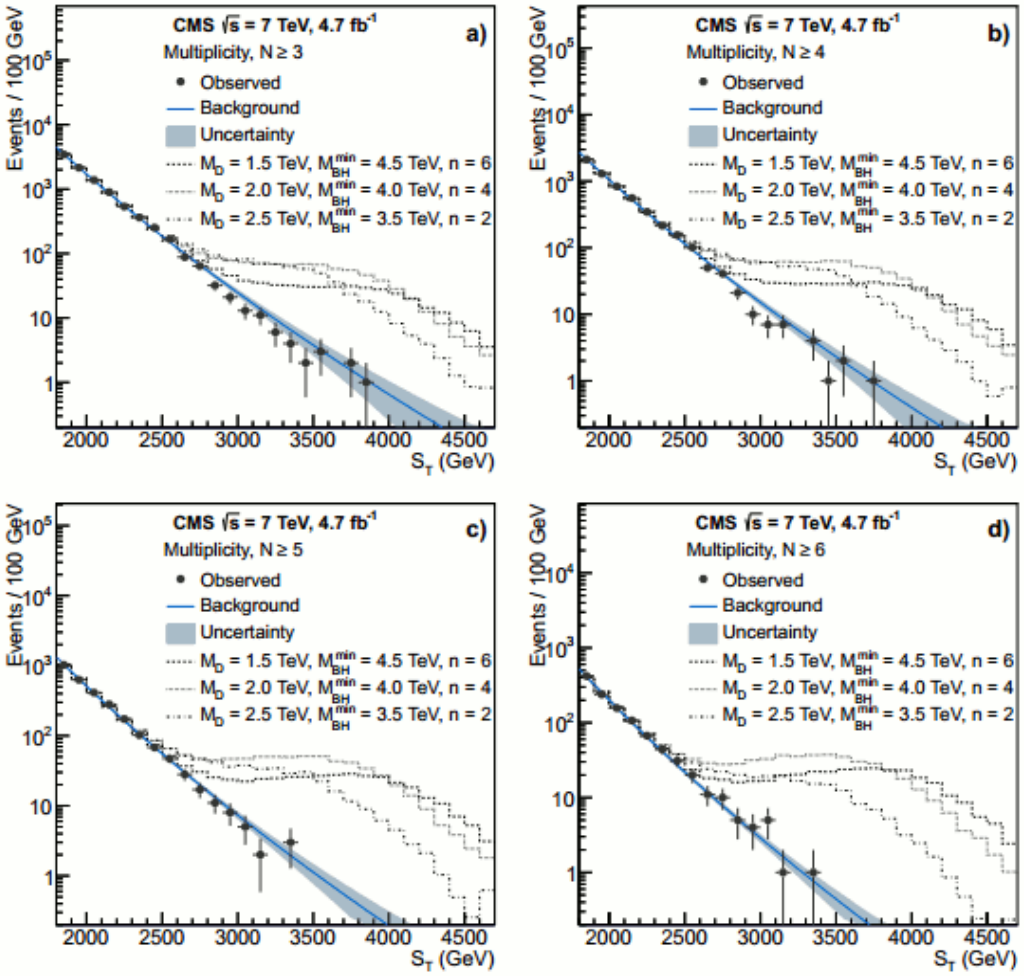
The data can be used to exclude at 95%CL new particles predicted in several models:
excited quarks with M(q∗)<2.49TeV,
string resonances with mass M(S)<4.00TeV et al.

PL B704(2011)123

Black hole search

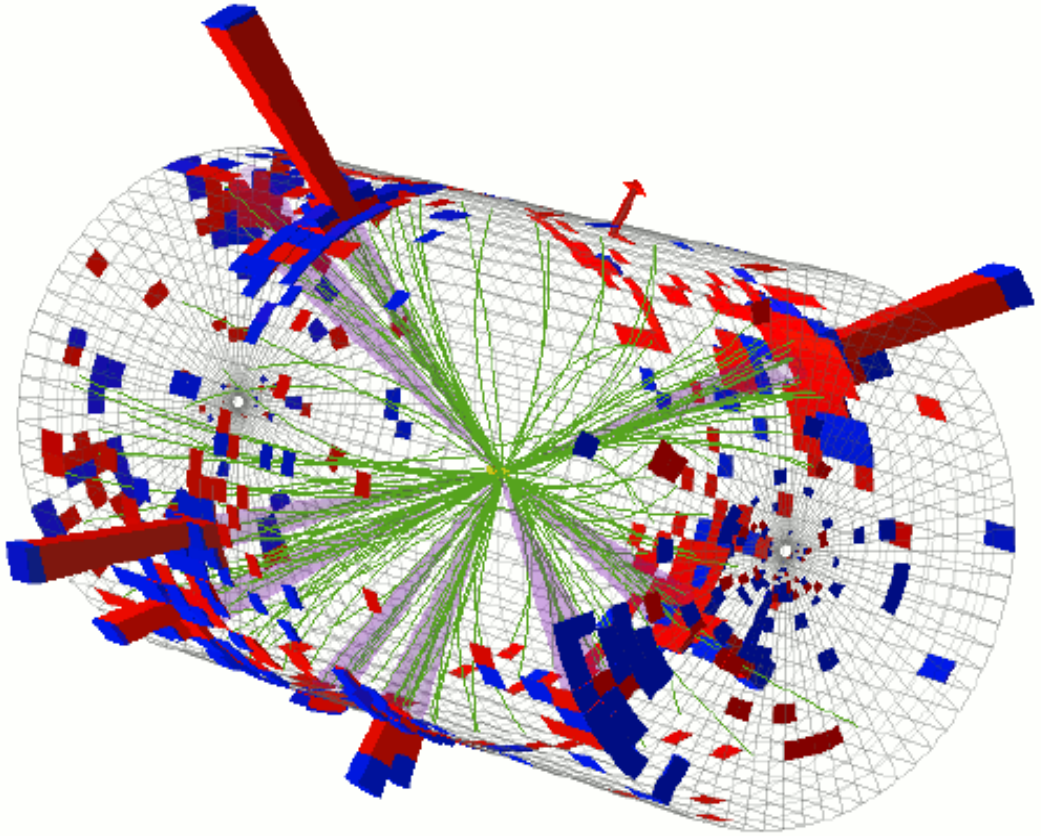
Jets, e, μ, γ
$P_T > 50$ GeV





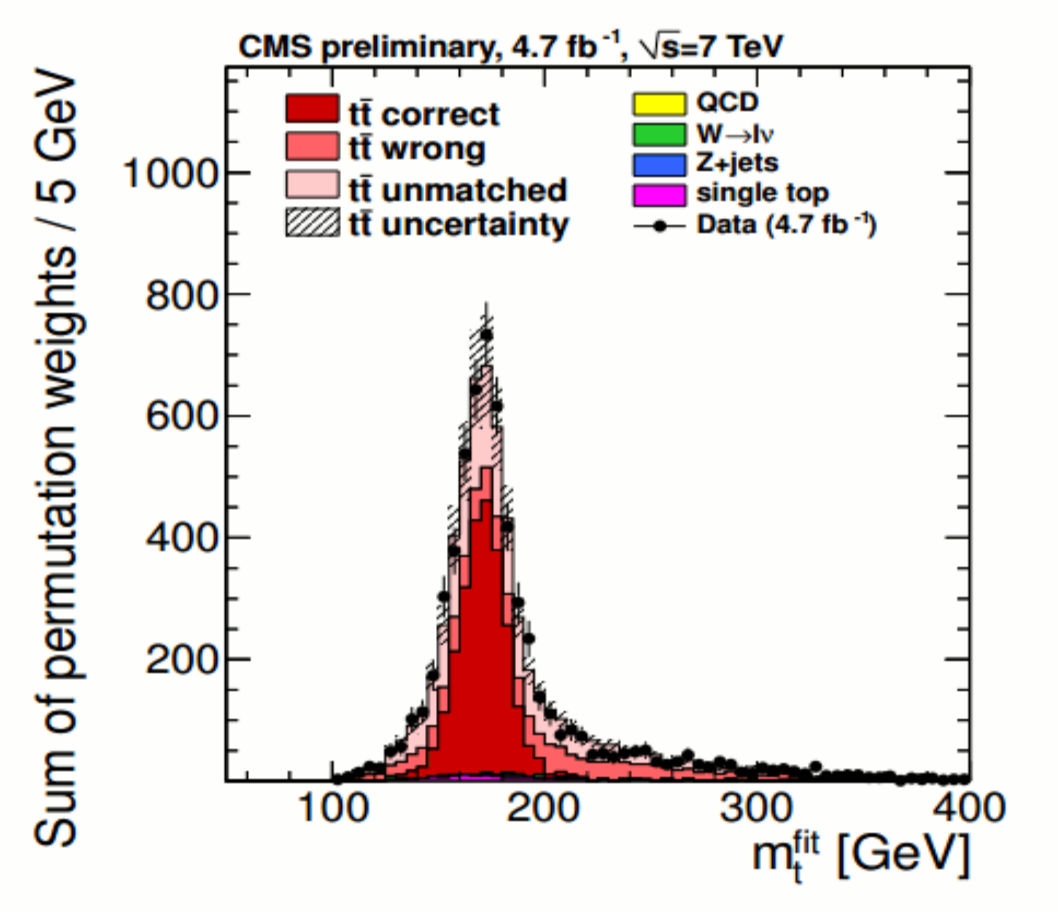
JINR team **JHEP04(2012)061**

Black Hole candidate



CMS Experiment at LHC, CERN
Data recorded: Mon May 23 21:46:26 2011 EDT
Run/Event: 165567 / 347495624
Lumi section: 280
Orbit/Crossing: 73255853 / 3161

Top quark mass

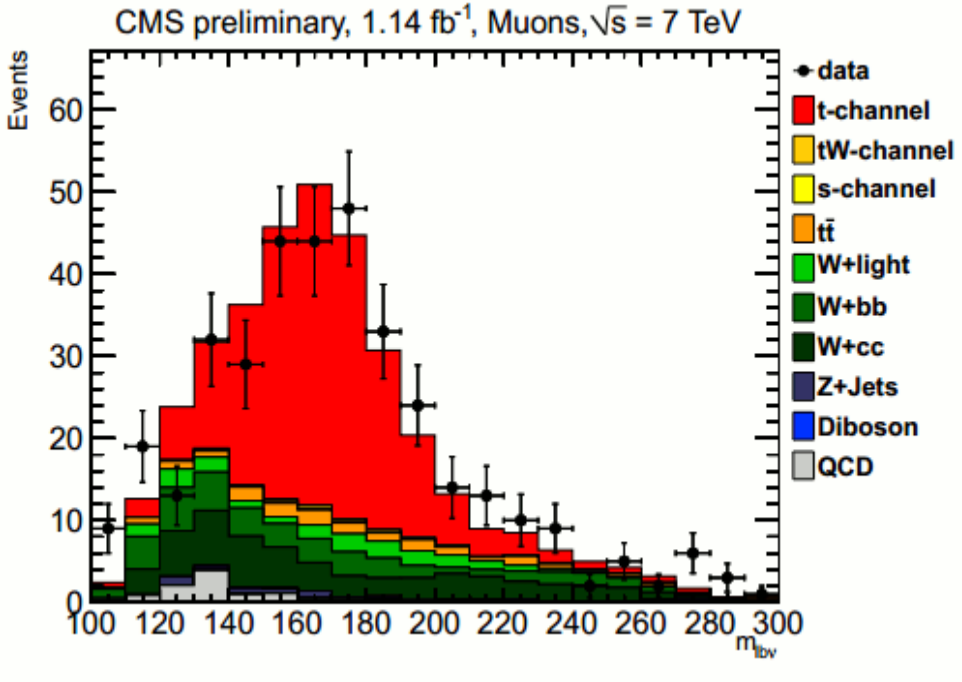


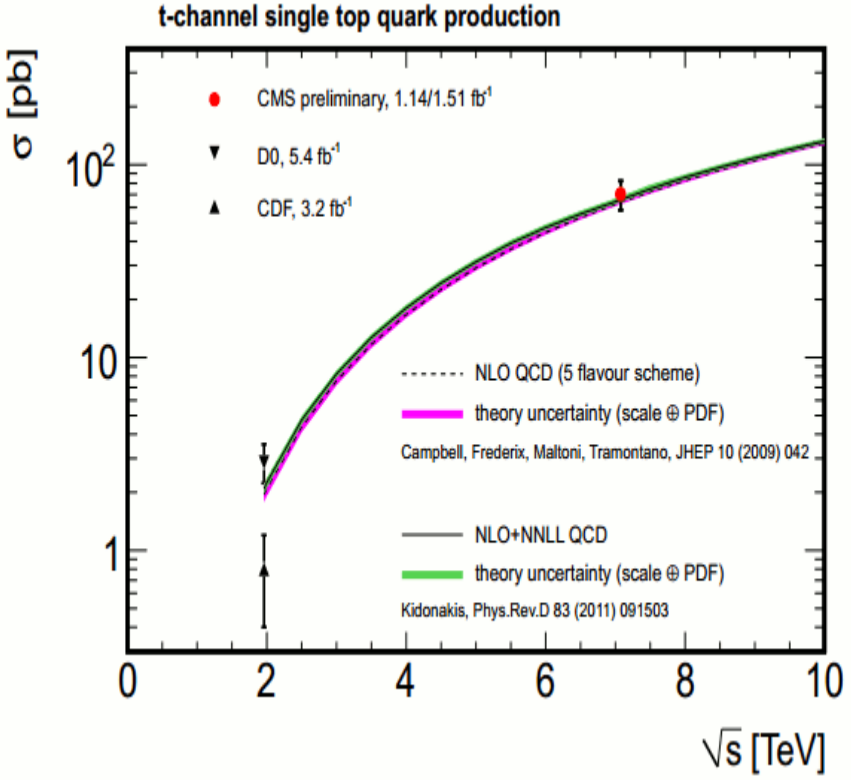
2391 events
μ + 4jets

CMS PAS TOP-11-015

$$m_t = 172.6 \pm 0.6(\text{stat} + \text{JES}) \pm 1.2(\text{syst}) \text{ GeV}.$$

Single top quark production





MSU team **CMS PAS TOP-11-021**

EWK di-boson production

1.1 fb^{-1} **CMS-PAS-EWK-11-010**

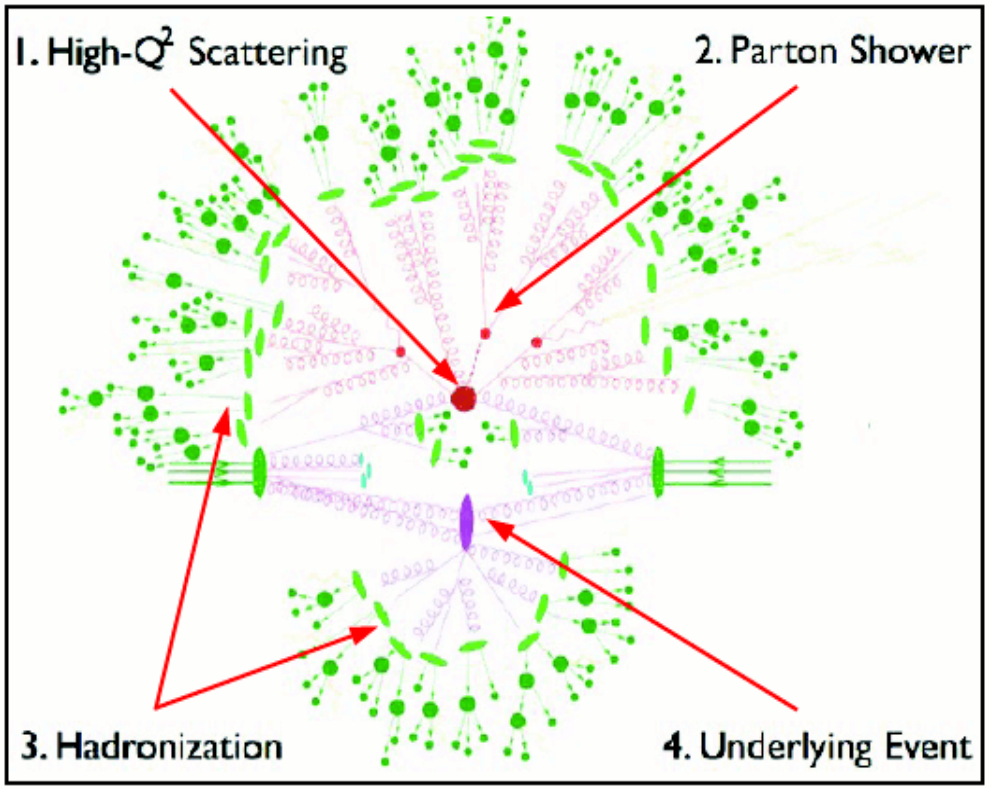
$$\sigma(pp \to W^+W^- + X) = 55.3 \pm 3.3\,(\text{stat.}) \pm 6.9\,(\text{syst.}) \pm 3.3\,(\text{lumi.})\ \text{pb.}$$
$$\sigma(pp \to WZ + X) = 17.0 \pm 2.4\,(\text{stat.}) \pm 1.1\,(\text{syst.}) \pm 1.0\,(\text{lumi.})\ \text{pb.}$$
$$\sigma(pp \to ZZ + X) = 3.8^{+1.5}_{-1.2}\,(\text{stat.}) \pm 0.2\,(\text{syst.}) \pm 0.2\,(\text{lumi.})\ \text{pb.}$$

4.92 fb^{-1} **CMS-PAS-SMP-12-005**

W^+W^- + X

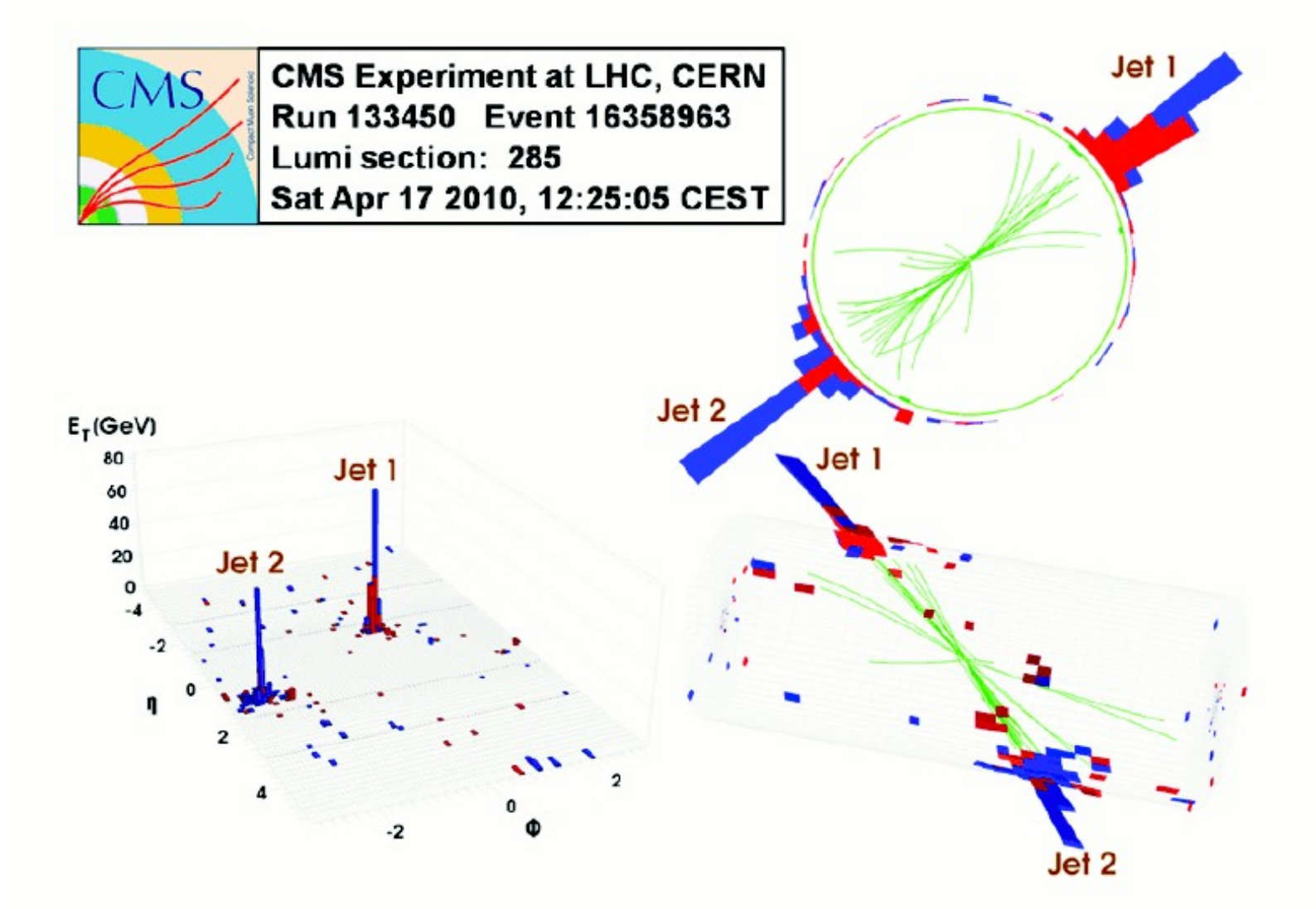
$$52.4 \pm 2.0\,(\text{stat.}) \pm 4.5\,(\text{syst.}) \pm 1.2\,(\text{lumi.})\ \text{pb.}$$

QCD study

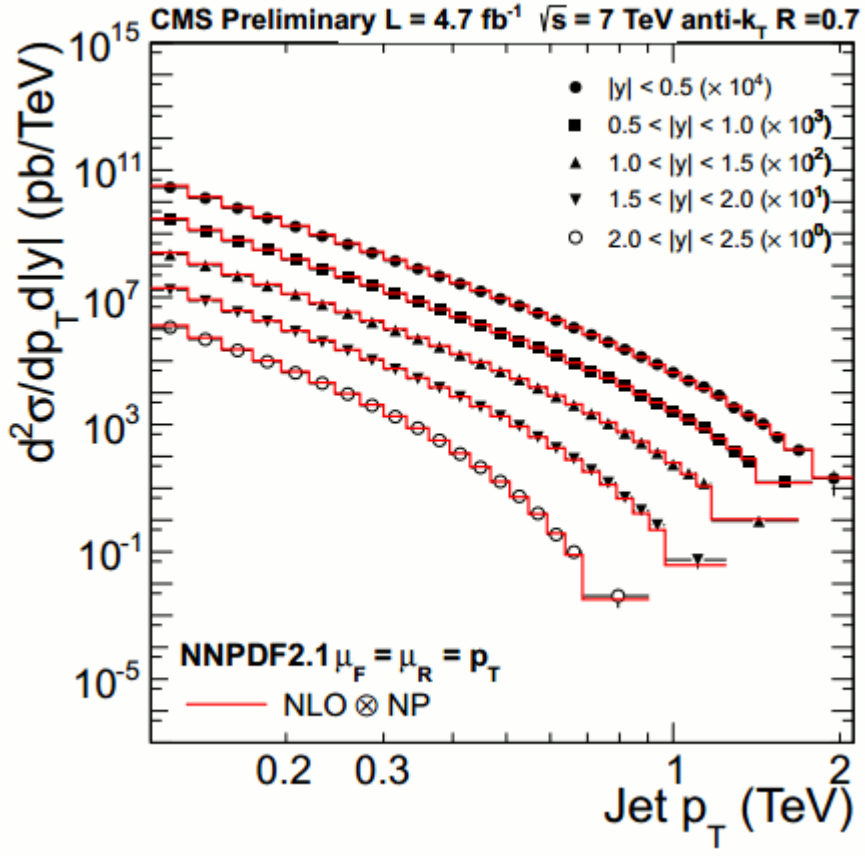


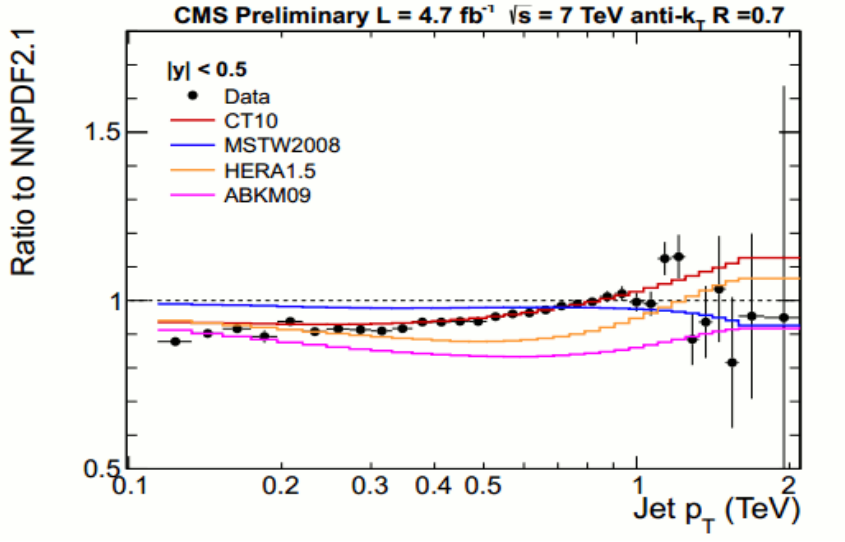
- pp collisions reveal multiple aspects of QCD:
  - perturbative behavior at the hard scattering scale
  - parton showers
  - multiple parton interactions
  - hadronization
  - structure of the proton
- QCD is a remarkable theory which deserves to be explored in detail
- even more important: before we can claim ANY signal of New Physics, we must understand this immensely complicated environment

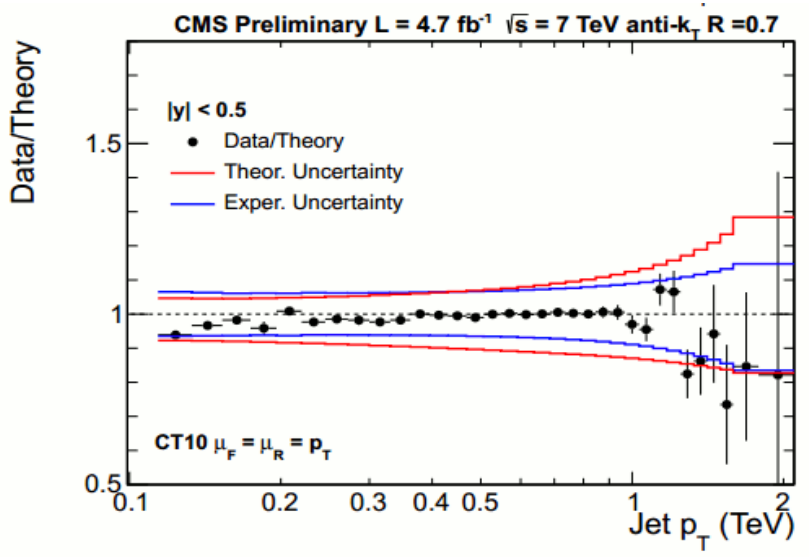
Jet detection at CMS



Inclusive Jets and PDF





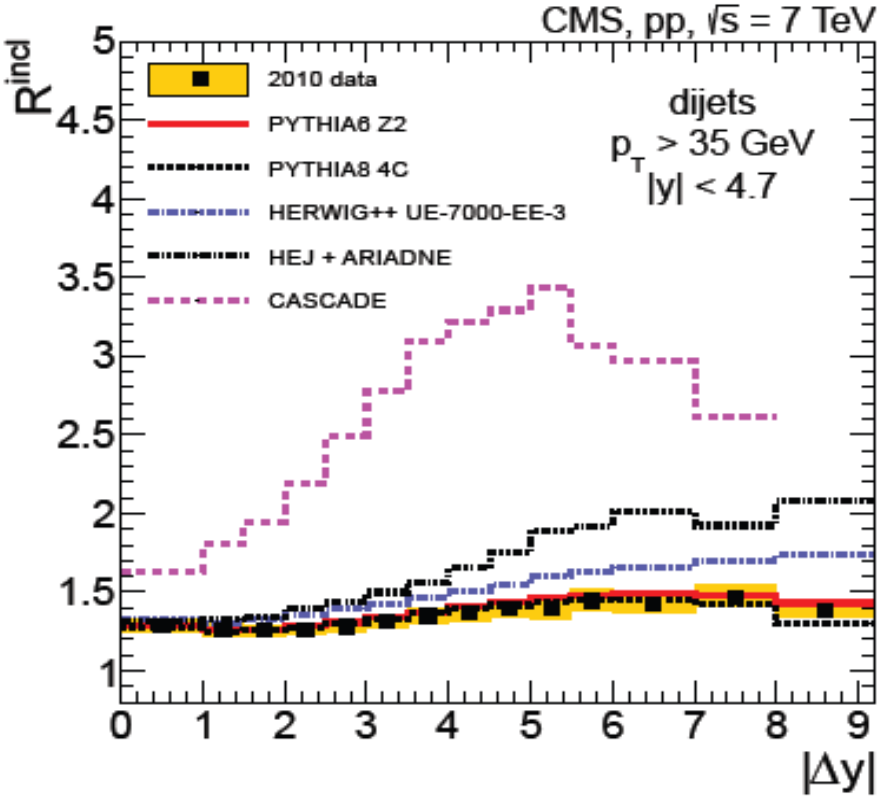


CMS-PAS-QCD-11-004

Di-jet “k-factor”

Inclusive – any pair of jets

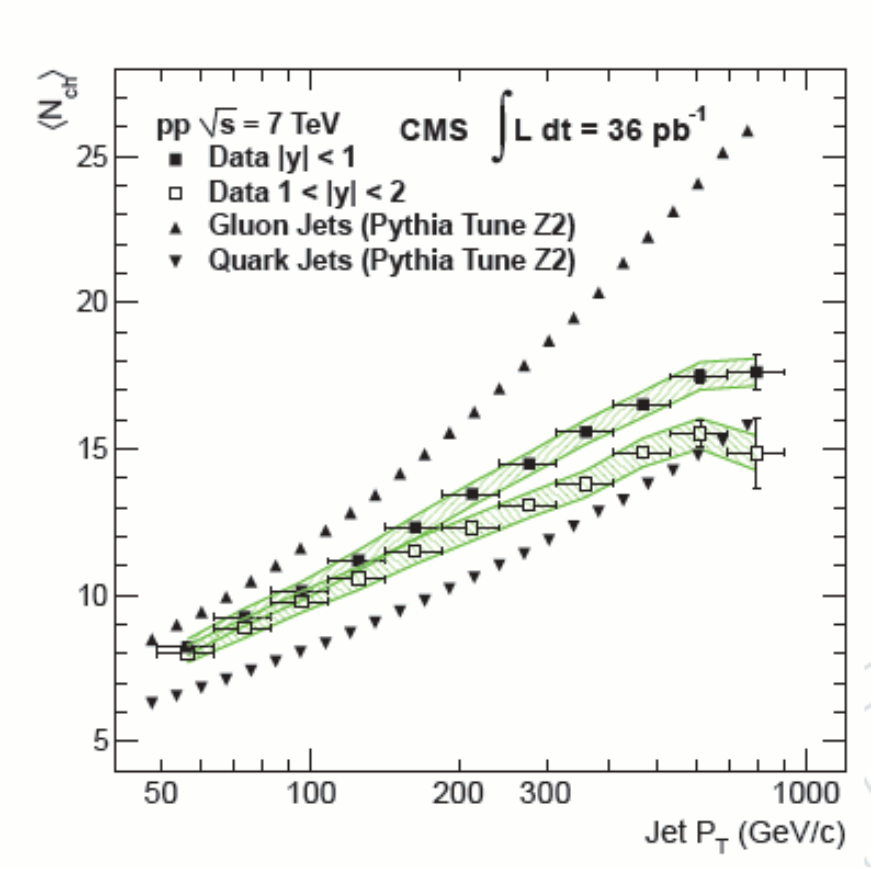
Exclusive – only one pair of jets in event



INR, ITEP, PNPI team

CERN-PH-EP-2012-088

Charge particle multiplicity in Jets



ITEP, MSU team

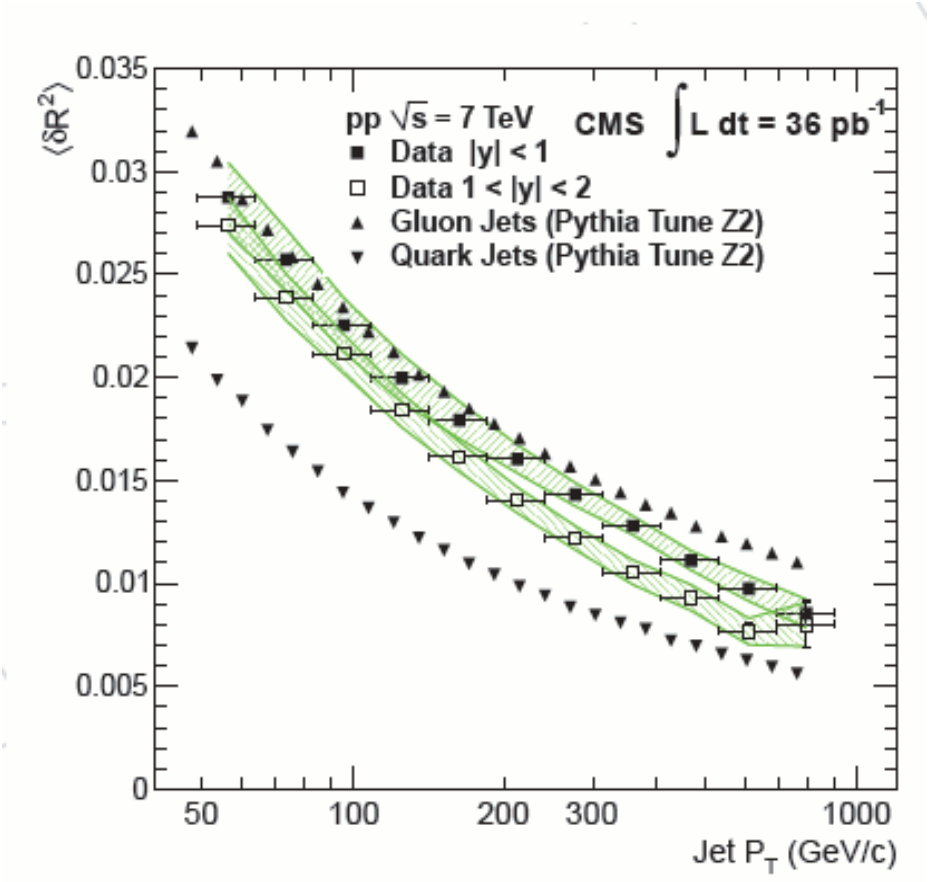
CERN-PH-EP-2012-079

Jet transverse size

$$\langle \delta R^2_{jet} \rangle (p_T) = \langle \delta \eta^2_{jet} \rangle + \langle \delta \phi^2_{jet} \rangle$$

$$\langle \delta \eta^2_{jet} \rangle (p_T) = \frac{\sum_{i \in jet} (\eta_i - \langle \eta_{jet} \rangle)^2 \cdot p_{T_i}}{\sum_{i \in jet} p^2_{T_i}}$$

$$\langle \delta \phi^2_{jet} \rangle (p_T) = \frac{\sum_{i \in jet} (\phi_i - \langle \phi_{jet} \rangle)^2 \cdot p_{T_i}}{\sum_{i \in jet} p^2_{T_i}}$$



ITEP, MSU team

CERN-PH-EP-2012-079

Summary

- **Very successful data taking in 2009-2012**
- **SM Higgs boson excluded in mass range 127.5 — 600 GeV, 2012 data will allow to complete study at lower masses**
- **No SUSY partners and other fundamental particles were observed, exclusion limits were expanded significantly**
- **Many quantitive results for SM processes were obtained**