CMS Status Report

Yves Sirois

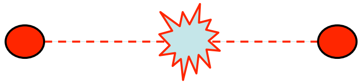
Ecole Polytechnique, IN2P3/CNRS

110th LHCC

On behalf of the CMS experiment

2010

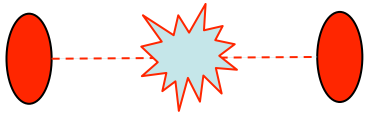
LHC



pp

$\mathcal{L}$ ~ 35 pb^{-1} / exp.

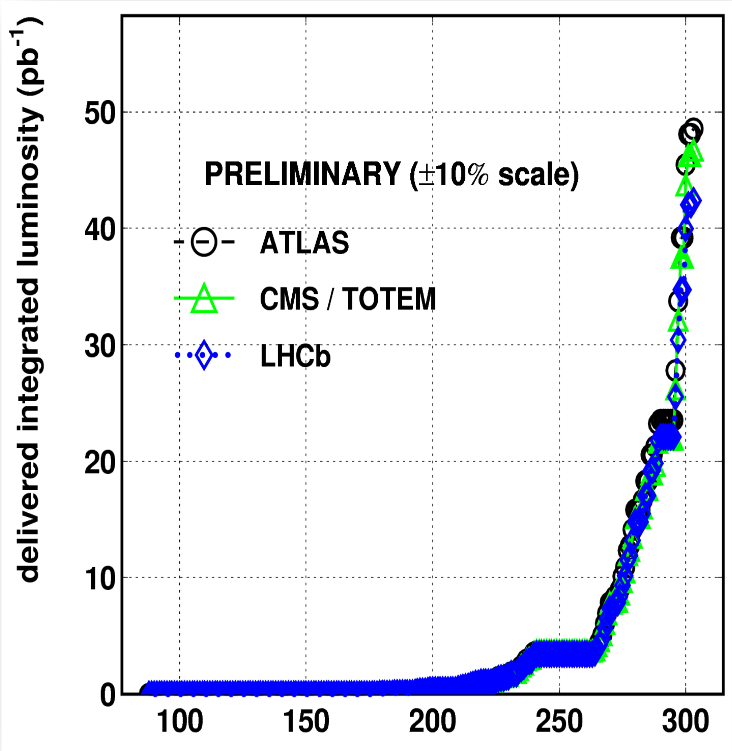
$\sqrt{s}$ = 7 TeV

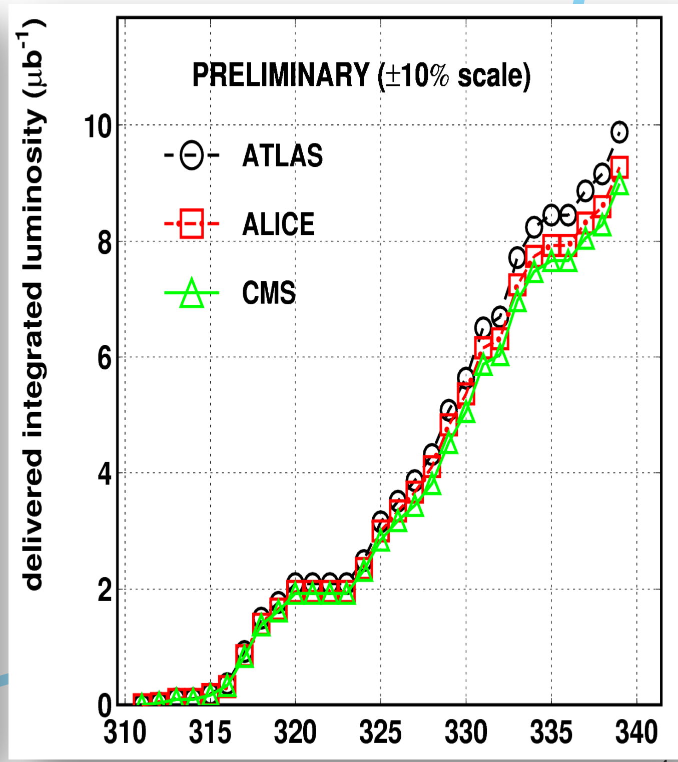


PbPb

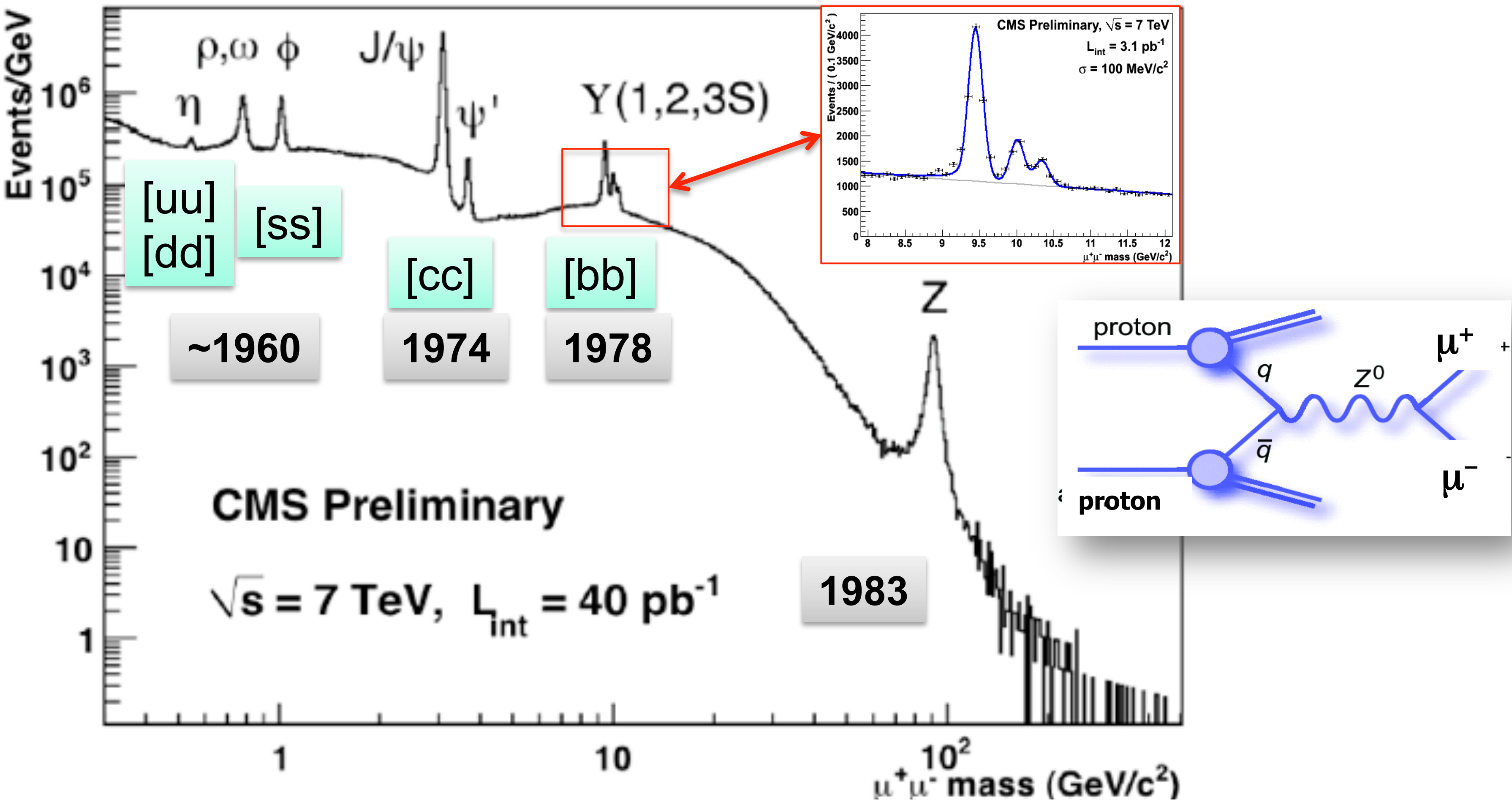
~ 7.3 μb^{-1}/exp.

$\sqrt{s_{nn}}$ = 2.76 TeV

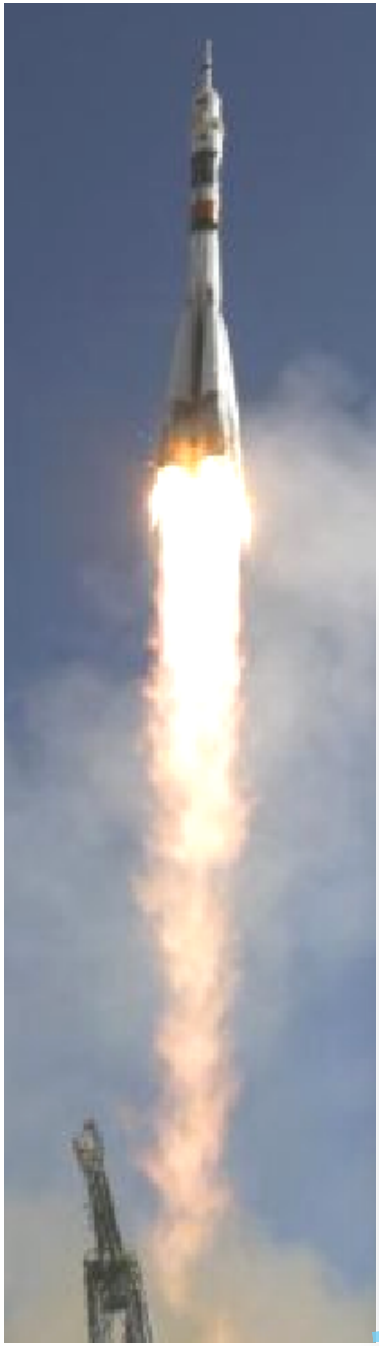




Re-discovery of the Standard Model

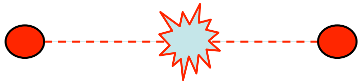


40 pb^{-1} collected in 2010



2011

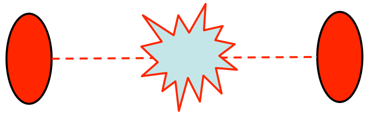
LHC



pp

$\mathcal{L}$ ~ 5 fb^{-1} / exp.

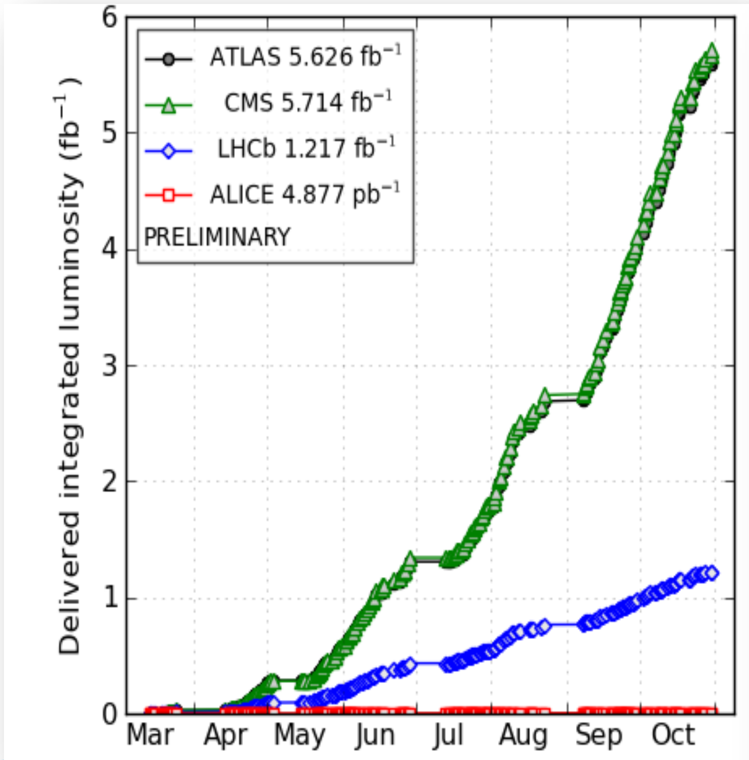
$\sqrt{s}$ = 7 TeV

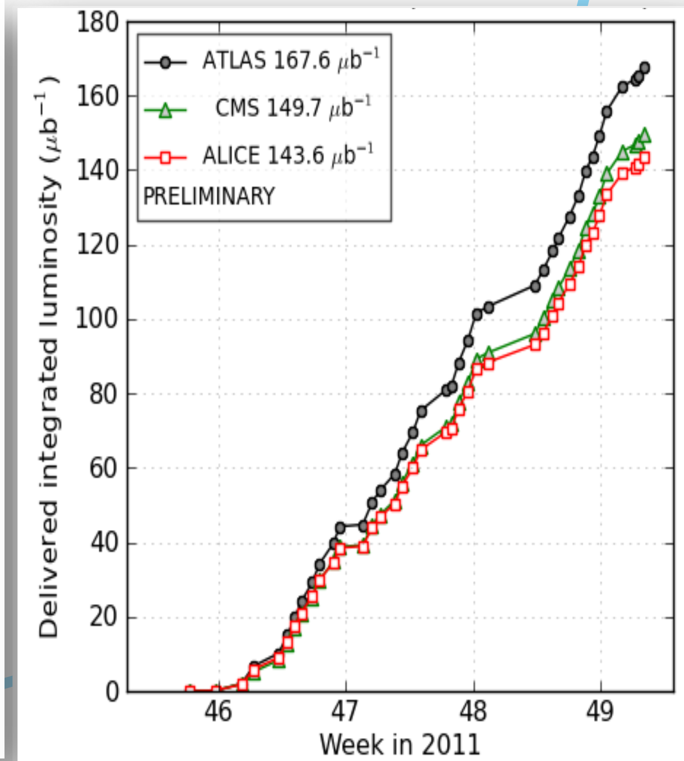


PbPb

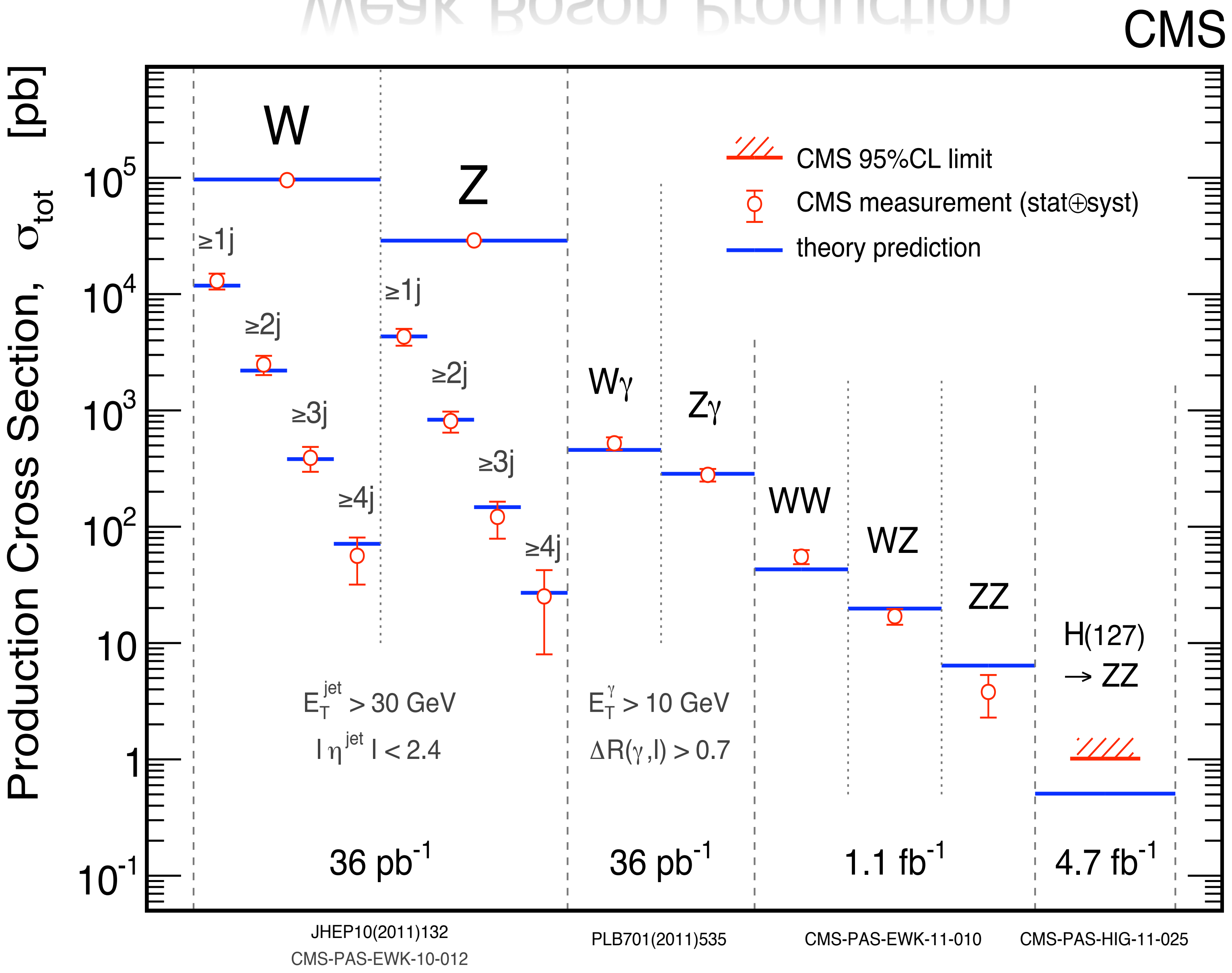
~ 150 μb^{-1}/exp.

$\sqrt{s_{nn}}$ = 2.76 TeV





Weak Boson Production



2012

LHC

CMS Total Integrated Luminosity, 2012, $\sqrt{s}$ = 8 TeV

Data included up to 2012-06-10 07:21:15 UTC

Total Integrated Luminosity (fb $^{-1}$)

*** CMS Hypernews
Discussion title: CMS Commissioning

Jun 11, 2012,

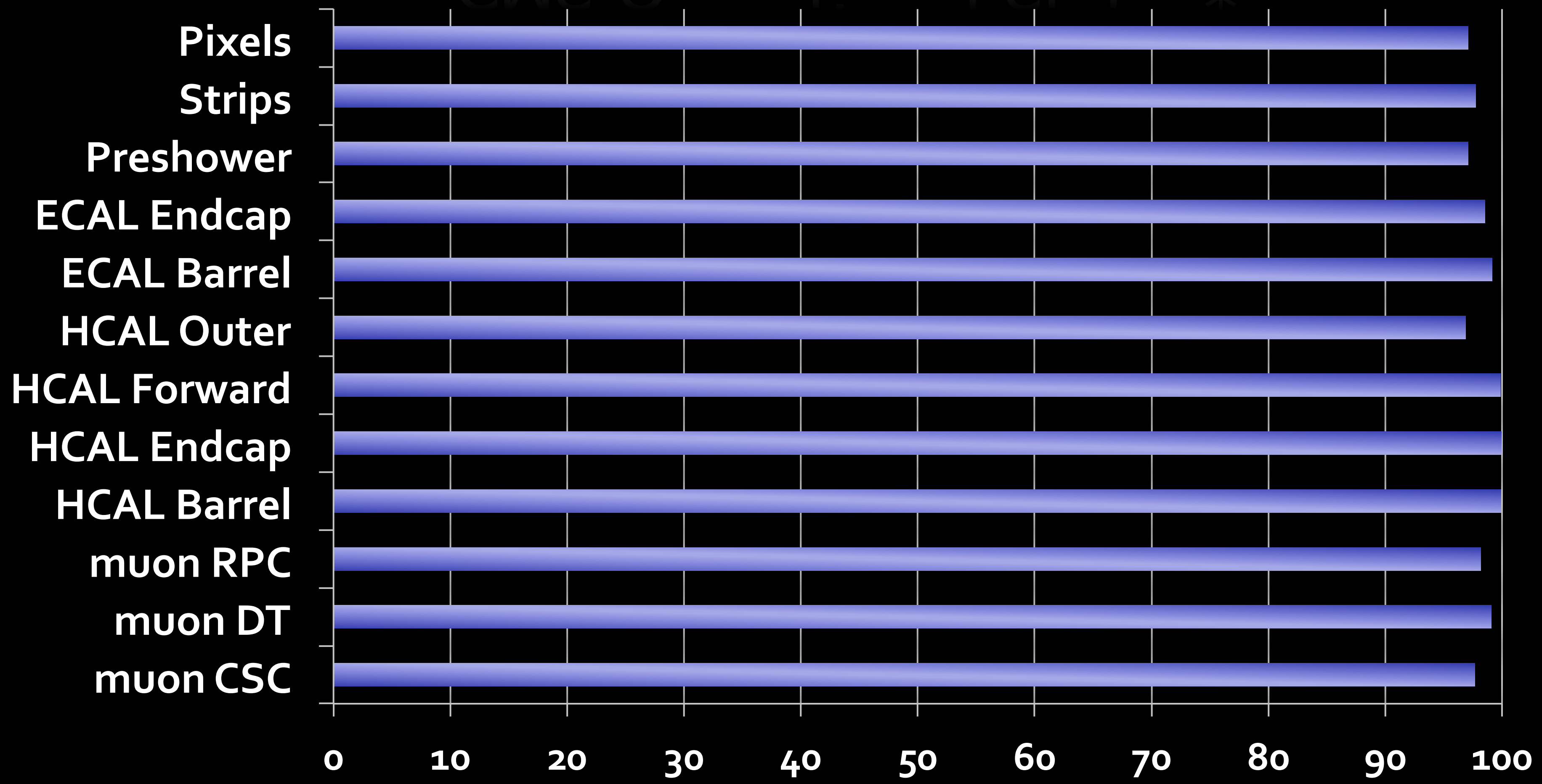
Dear All,

We just crossed the 5/fb recorded.

We would like to invite you for a drink TODAY at 12:00 at P5 as an appreciation of the data taking so far and in anticipation of a whole lot more.

Maria / Greg/ Christophe

CMS Operational Status*



Pixel Tracker	Strip Tracker	Presh.	ECAL Barrel	ECAL Endcaps	HCAL Barrel	HCAL Endcaps	HCAL Forw.	HCAL Outer	m DT	Muon CSC	Muon RPC
97.1%	**97.75%**	**97.1%**	**99.2%**	**98.54%**	**99.9%**	**99.96%**	**99.9%**	**96.9%**	**99.1%**	**97.7%**	**98.2%**

* As of April 15th 2012

2012

LHC

2011 → **2012**

7 TeV → **8 TeV**
Increased production σ for new physics

β*
1 m → **0.6 m**
Increased d$\mathcal{L}$/dt
Increased PU

50ns bunch spacing
max.: 1318 bunches

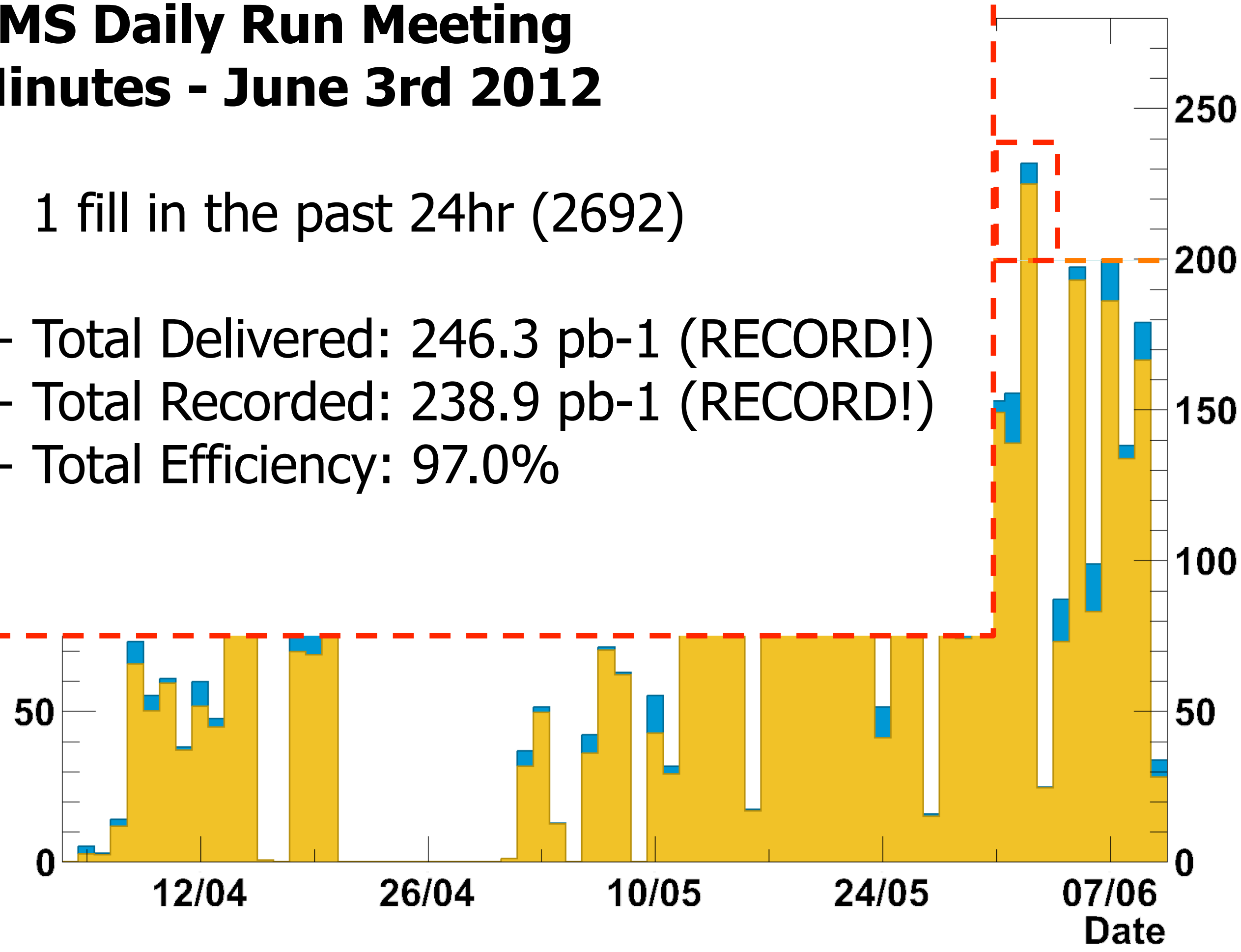
d$\mathcal{L}$/dt (x 10^{33} $cm^{-2}s^{-1}$)
3.5 → **7.0** (goal)

CMS Daily Run Meeting Minutes - June 3rd 2012

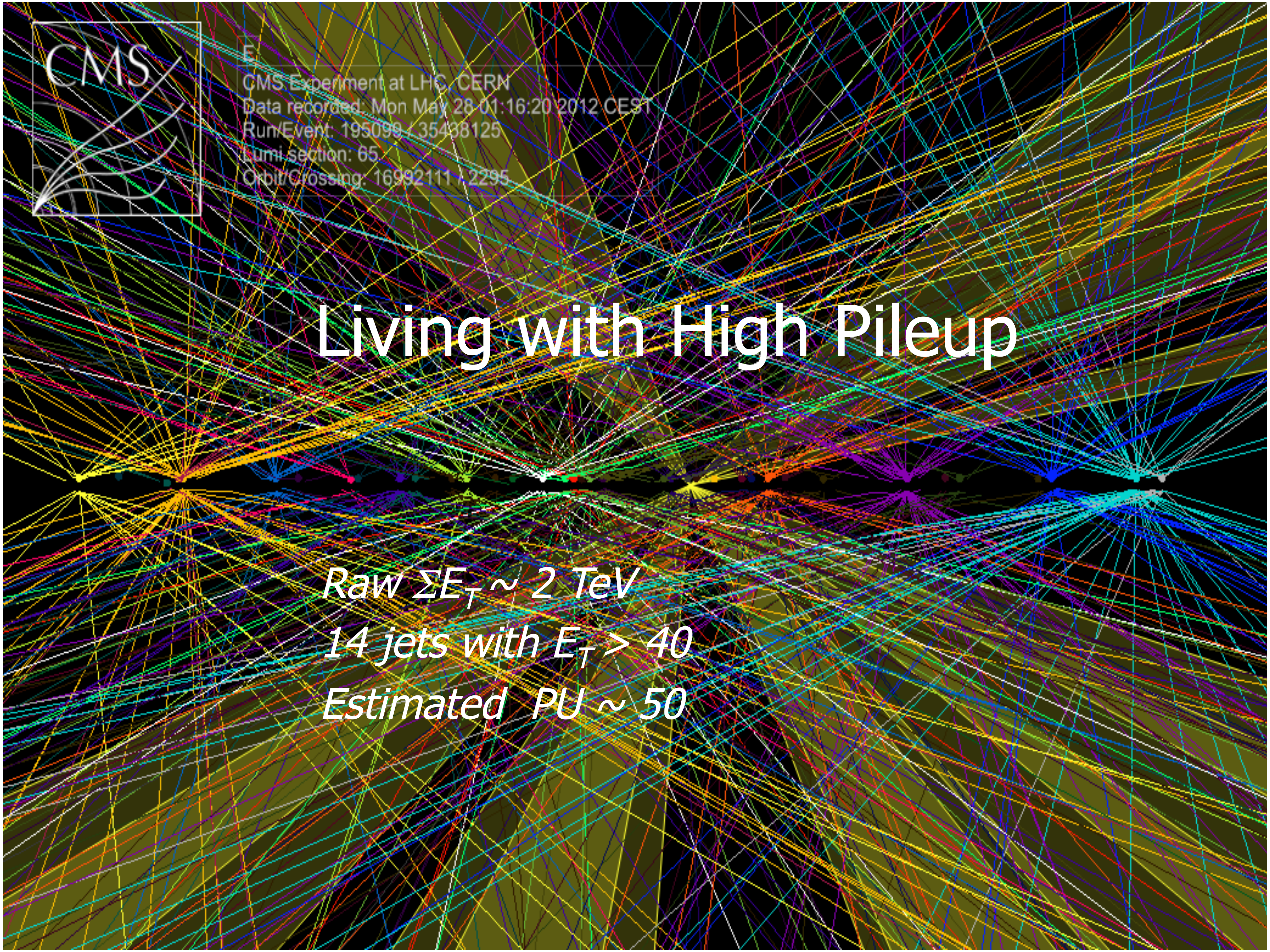
- 1 fill in the past 24hr (2692)

+ Total Delivered: 246.3 pb-1 (RECORD!)
+ Total Recorded: 238.9 pb-1 (RECORD!)
+ Total Efficiency: 97.0%

8 TeV



Living with High Pileup



Raw $\Sigma E_T \sim 2$ TeV

14 jets with $E_T > 40$

Estimated PU ~ 50

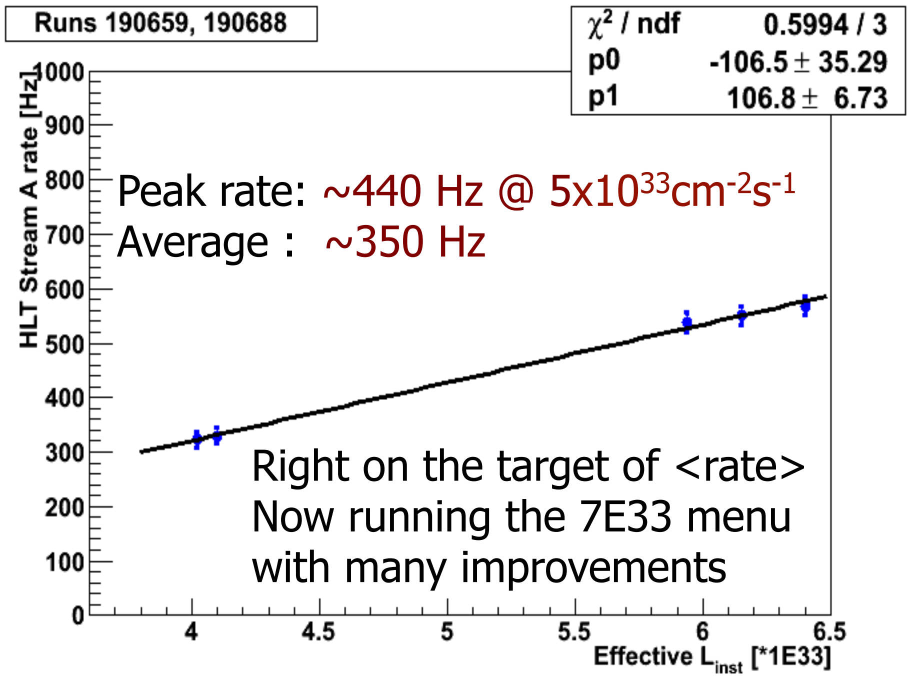
Data Taking Rates

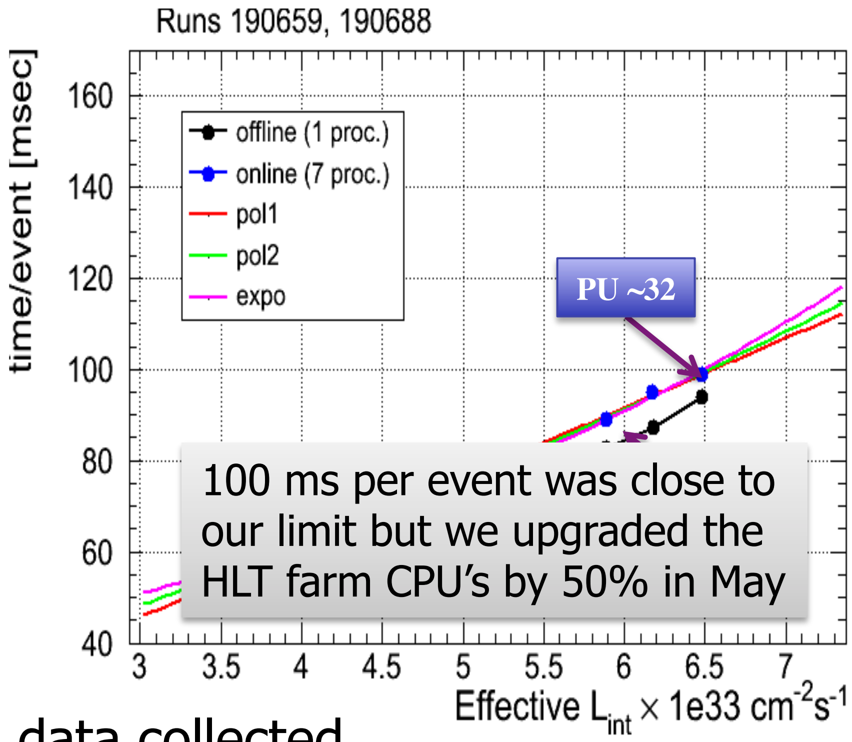
- New CMSSW software (5.X)
  Gain of x 2.5 in speed (~15 s/evt)
  Reduction of > 33% of memory
  → Avoids limitation our data-taking rate from Prompt Reco at Tier-0

Physics performance unchanged !
(or even improved)

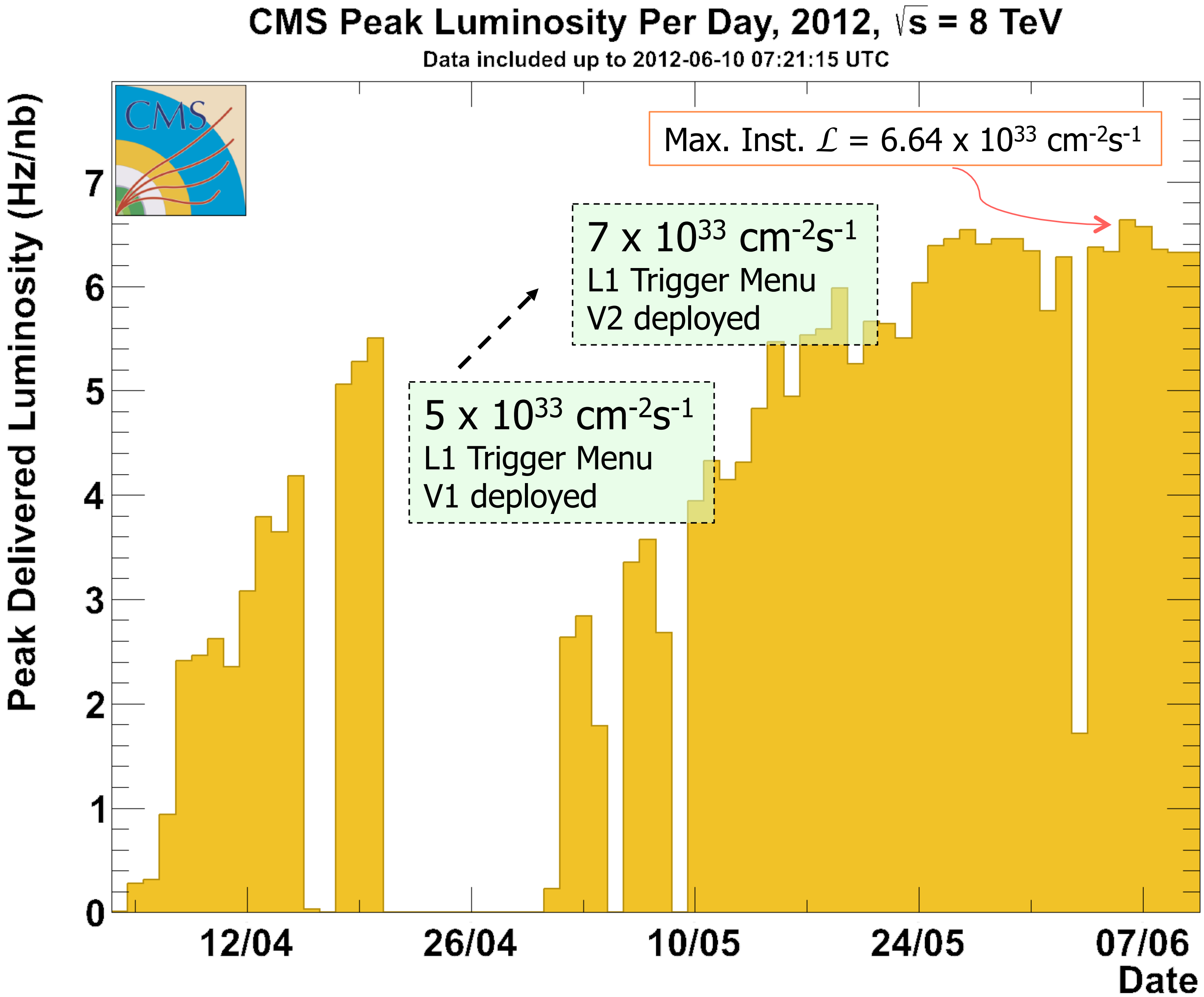
See J. Varela,
109th LHCC – 21 Mars 2012

- Rates and CPU times on the HLT Farm:





- ~ 300 Hz of additional « parked » data collected


CMS Peak Luminosity Per Day, 2012, √s = 8 TeV
Data included up to 2012-06-10 07:21:15 UTC
Peak Delivered Luminosity (Hz/nb)
Date
12/04
26/04
10/05
24/05
07/06
0
1
2
3
4
5
6
7
CMS
Max. Inst. ℒ = 6.64 x 10^33 cm^-2s^-1
7 x 10^33 cm^-2s^-1
L1 Trigger Menu
V2 deployed
5 x 10^33 cm^-2s^-1
L1 Trigger Menu
V1 deployed

HLT Trigger Menu for 6 x 10^{33} $cm^{-2}s^{-1}$

(Unprescaled) Object	Trigger Threshold (GeV) @ 6E33
Single Muon	40
Single Isolated muon	24 (|eta| < 2.1)
Double muon	**(17, 8) [13, 8 for parked data]**
Single Electron	80
Single Isolated Electron	27
Double Electron	**(17, 8)**
Single Photon	150
Double Photon	**(36, 22)**
Muon + Ele x-trigger	**(17, 8), (5, 5, 8), (8, 8, 8)**
Single PFJet	320
QuadJet	80 [50 for parked data]
Six Jet	(6 x 45), (4 x 60, 2 x 20)
MET	120
HT	750

$H \rightarrow \gamma\gamma$

HLT Trigger Menu for 6 x 10^{33} $cm^{-2}s^{-1}$

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Single Muon	40
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Single PFJet	320
QuadJet	80 [50 for parked data]
Six Jet	(6 x 45), (4 x 60, 2 x 20)
MET	120
HT	750

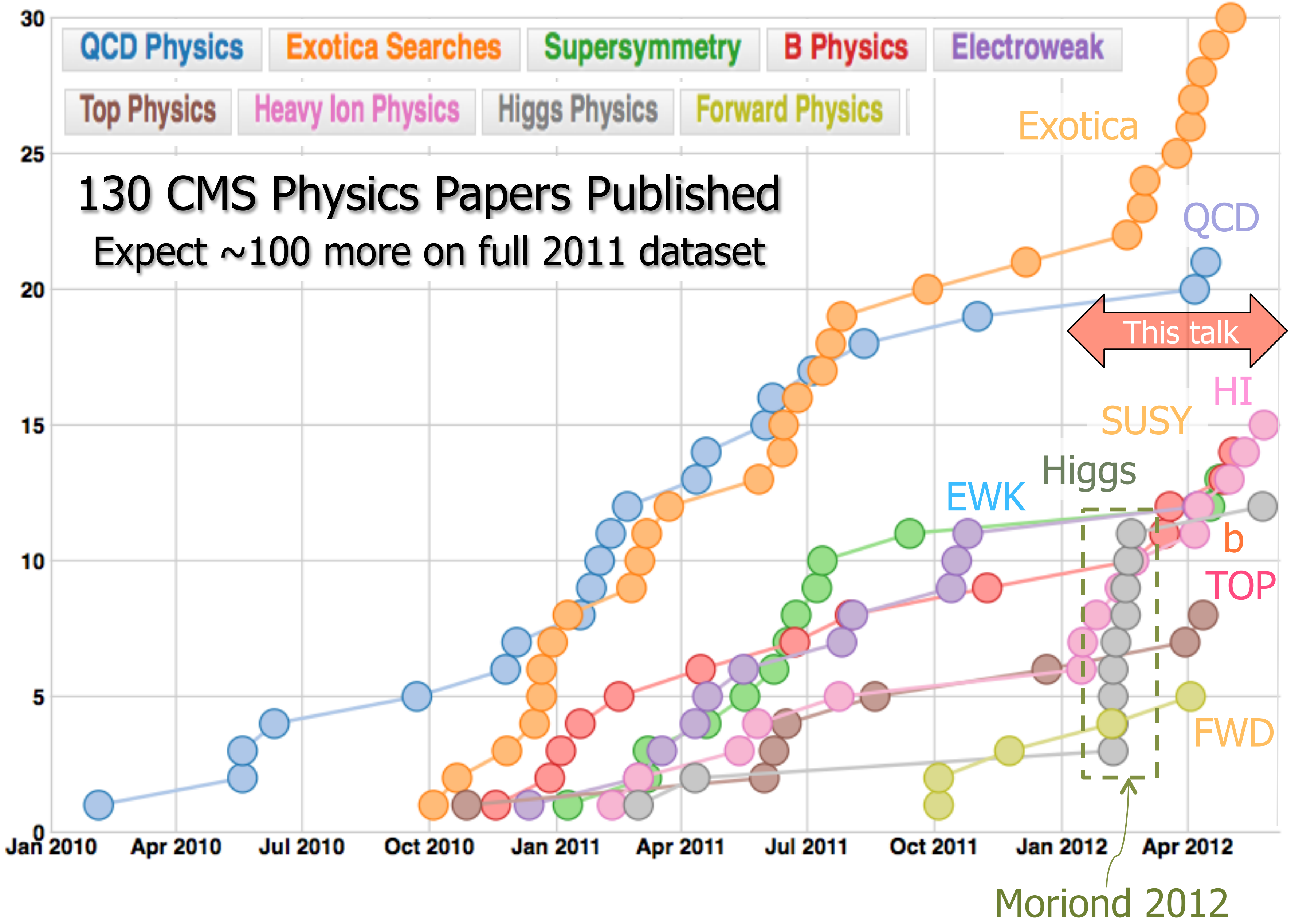
$H \rightarrow ZZ^* \rightarrow 4\ \ell$

Living with Pile-UP

- Increase of <PU> less important than for Chamonix estimations
  $\langle PU \rangle_{2012}$ ~ 13 compare to $\langle PU \rangle_{2011B}$ ~ 9 and $\langle PU \rangle_{2011A}$ ~5

- Meanwhile: continue deployment of PU mitigation techniques for physics analysis and evolve to less sensitive observables
  → event-by-event corrections based on mean jet energy density and/or local track matching at primary vertex
  → rely on « Particle Flow » reconstruction techniques (jets, lepton isolation, etc …) putting more emphasis on « good tracks » which are not affected
  → deployment of MVA techniques validated on SM candles and adjusted on PU-reweighted MC for photon and lepton ID, etc. (e.g. "BDT" now used for photons and electrons in Higgs analyses)

After all the hard work the mean pile-up effects on the physics relying on isolated ℓ's and γ's [e.g. EWK and main Higgs boson decay channels] or high PT jets [e.g. Top physics and BSM at the TeV scale] is well under control (small effects on PU corrected observables or final sensitivity)



QCD Physics
Exotica Searches
Supersymmetry
B Physics
Electroweak
Top Physics
Heavy Ion Physics
Higgs Physics
Forward Physics
130 CMS Physics Papers Published
Expect ~100 more on full 2011 dataset
Exotica
QCD
This talk
HI
SUSY
Higgs
EWK
b
TOP
FWD
Moriond 2012
0
5
10
15
20
25
30
Jan 2010
Apr 2010
Jul 2010
Oct 2010
Jan 2011
Apr 2011
Jul 2011
Oct 2011
Jan 2012
Apr 2012

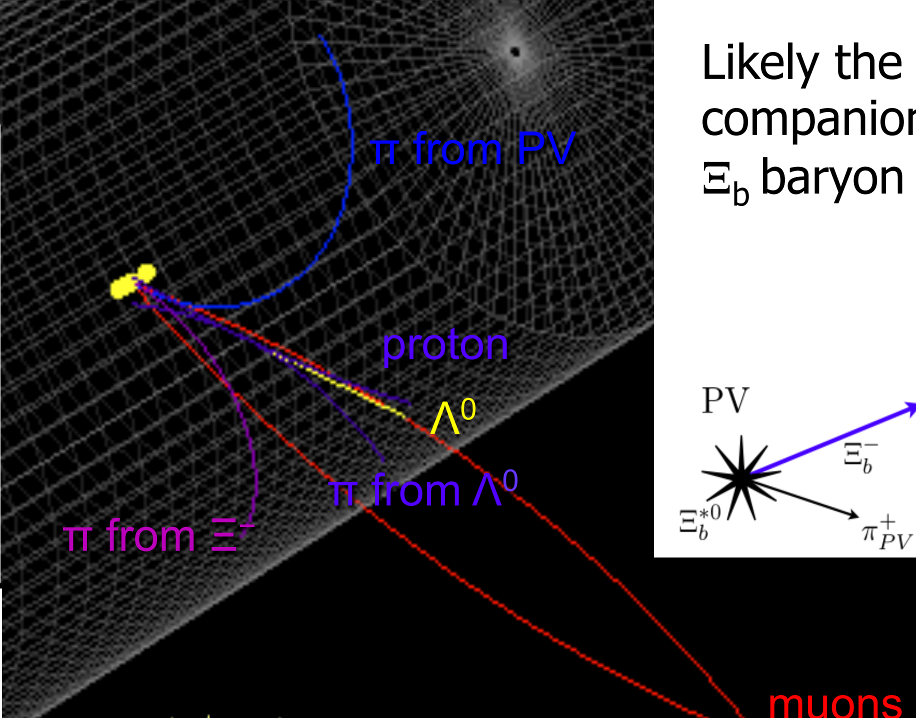
CMS

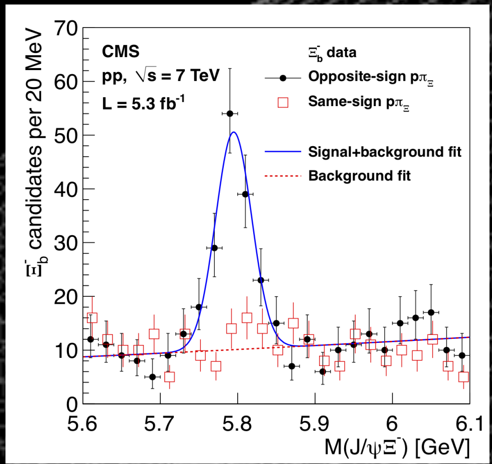
Physics Highlights

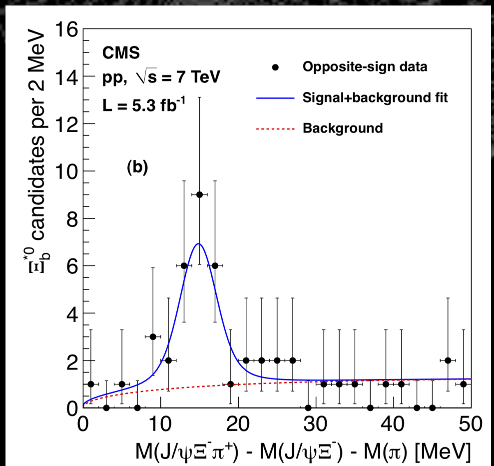
New Particle Discovery

garnered a lot of media attention

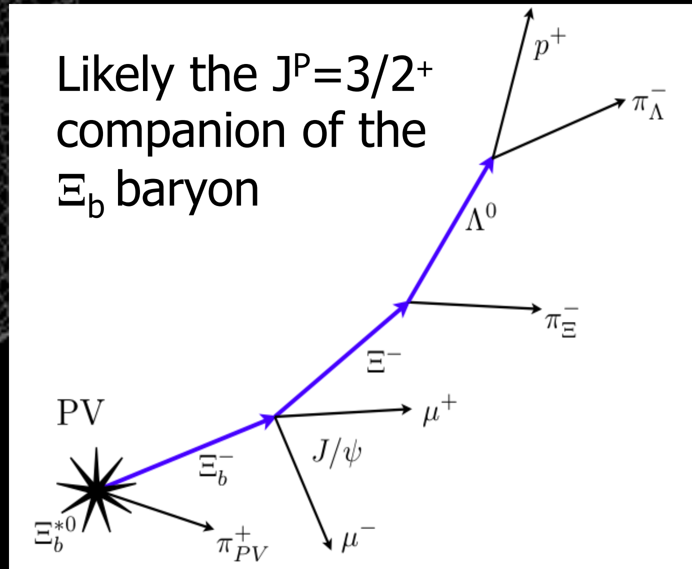
Candidate event display







Likely the $J^P=3/2^+$ companion of the Ξ_b baryon

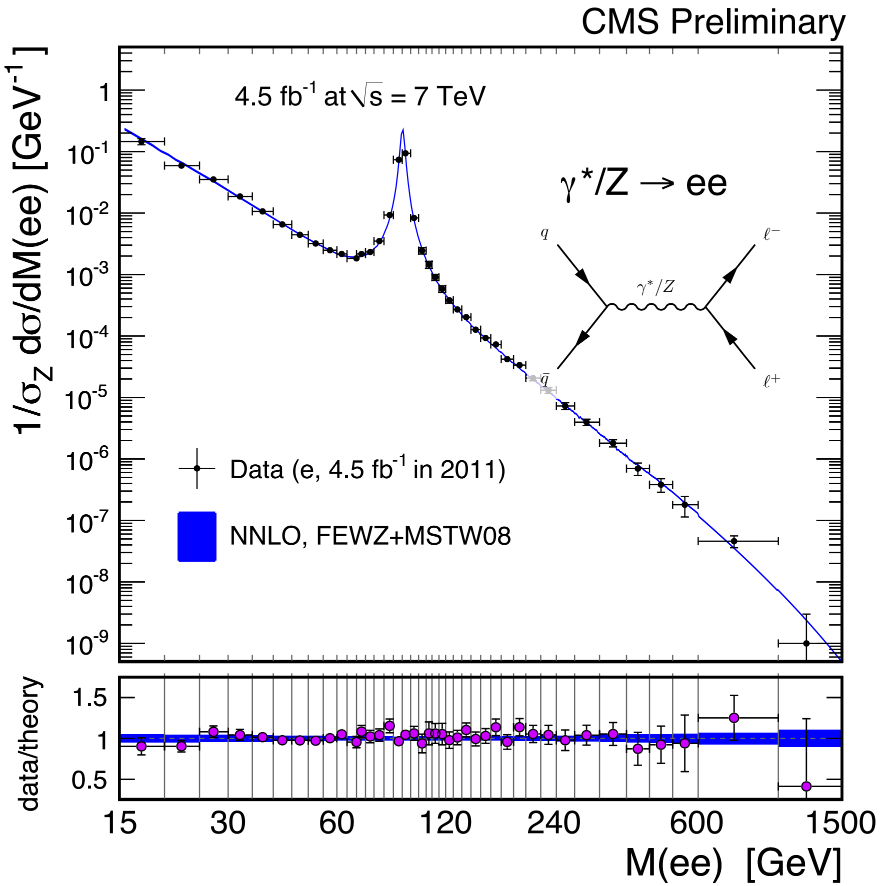


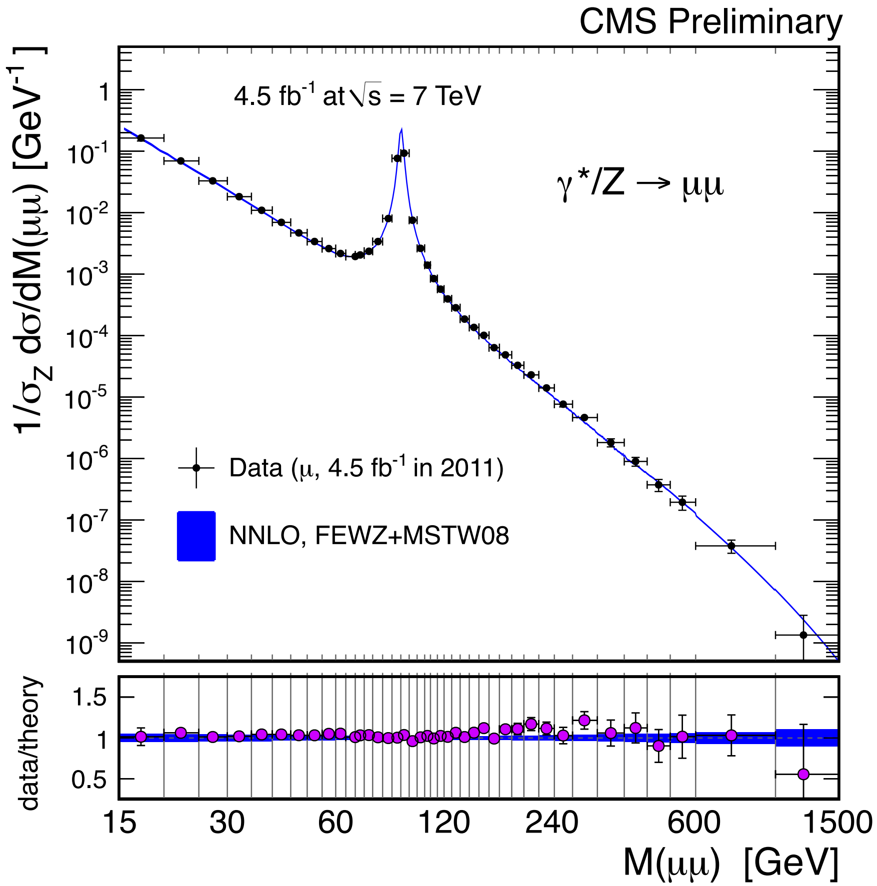
$$M(p^+\pi^-) = 1116.7\ MeV$$
$$M(\Lambda^0\pi^-) = 1315.5\ MeV$$
$$M(\mu^+\mu^-) = 3117.1\ MeV$$
$$M(J/\psi\Xi^-) = 5787.8\ MeV$$
$$Q(J/\psi\Xi^-\pi^+) = 15.7\ MeV$$

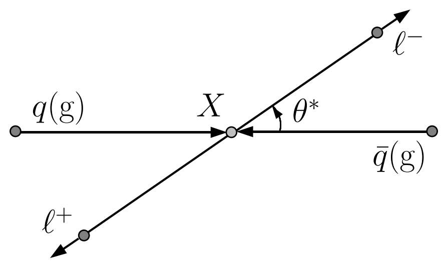
Ξ_b^0 (5945 MEV) $\rightarrow \Xi_b^-\pi^+ \rightarrow \Xi^- J/\psi\, \pi^+ \rightarrow \Lambda\pi^-\mu^+\mu^-\pi^+ \rightarrow p^+\pi^-\pi^-\mu^+\mu^-\pi^+$

CMS-BPH-12-001 arXiv:1204.5955

Measurement of Drell-Yan dσ/dM and d²σ/dMdY







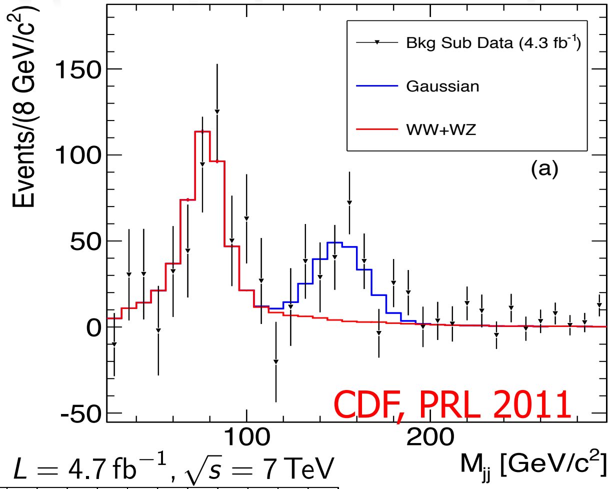
$$\sin^2\theta_{\mathrm{eff}} = 0.2287 \pm 0.0020\,(\mathrm{stat.}) \pm 0.0025\,(\mathrm{syst.})$$

EWK-11-007

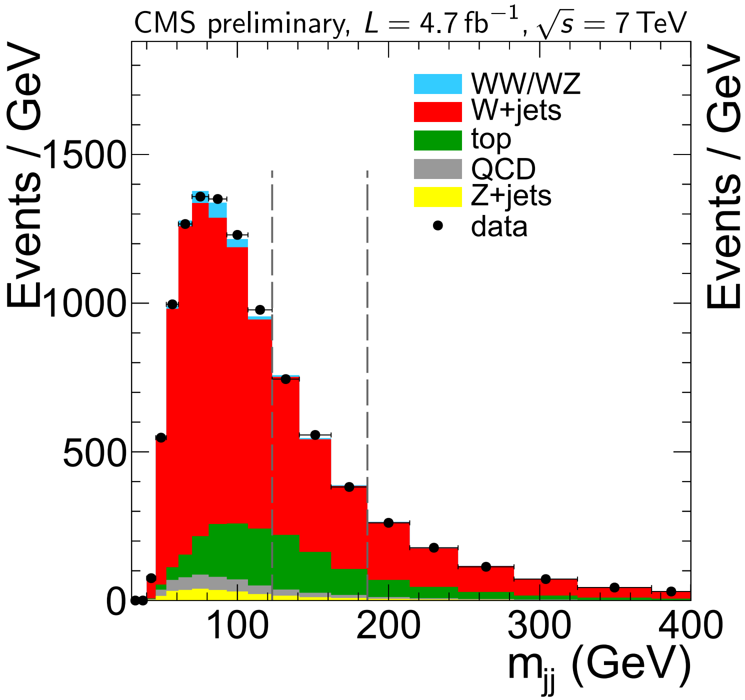
EWK-11-003, PRL

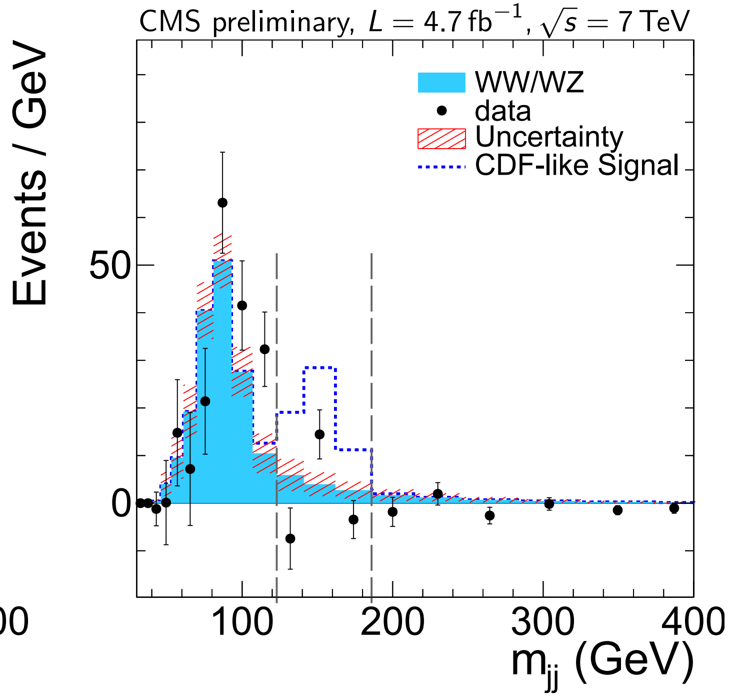
Di-jet Invariant mass in W + jets events

- Important background for Higgs and BSM
- Extented phase space for hard recoiling jets
- Excess observed by CDF at the Tevatron (not confirmed by D0)



Look for a high $P_{T,\ell}$ + E_T^{miss} + 2 or 3 jets

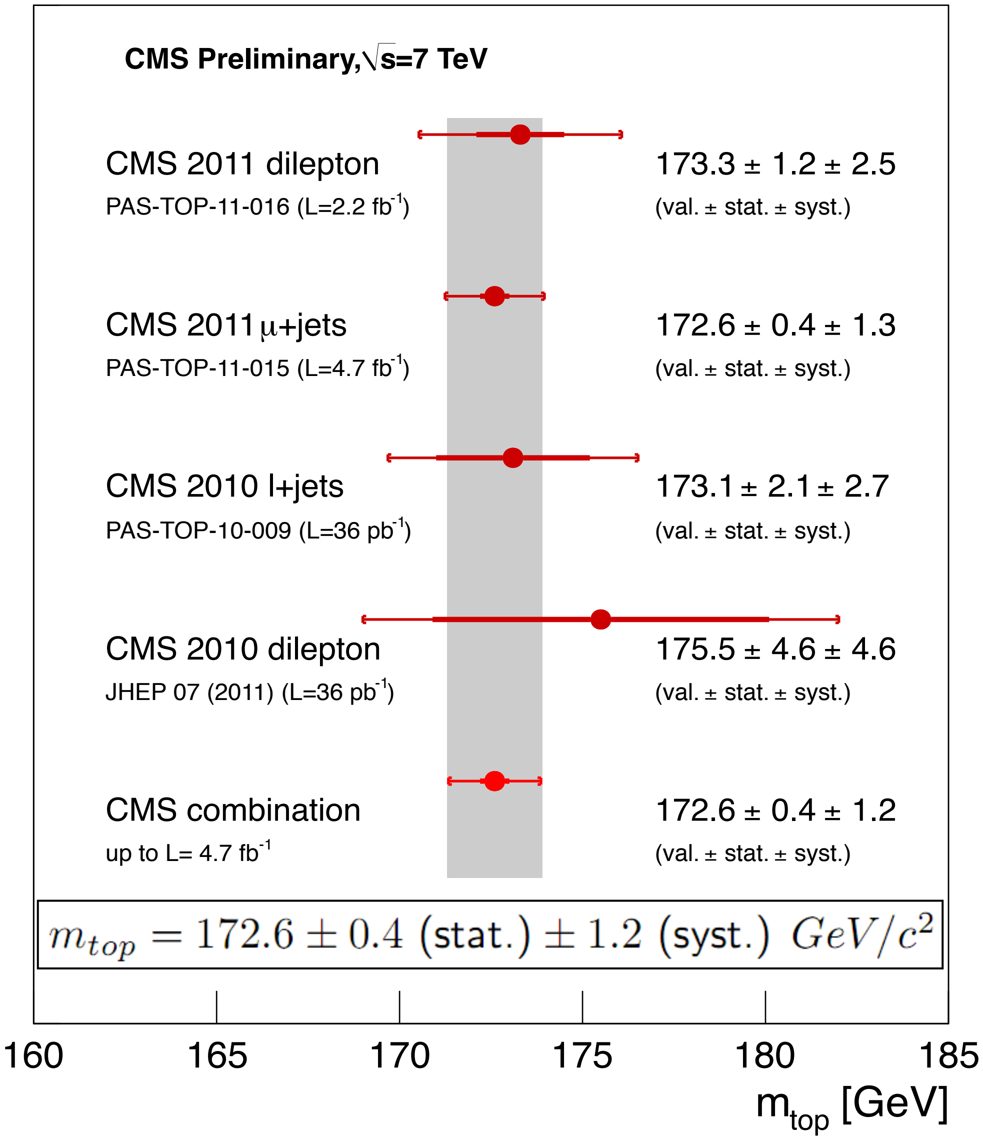




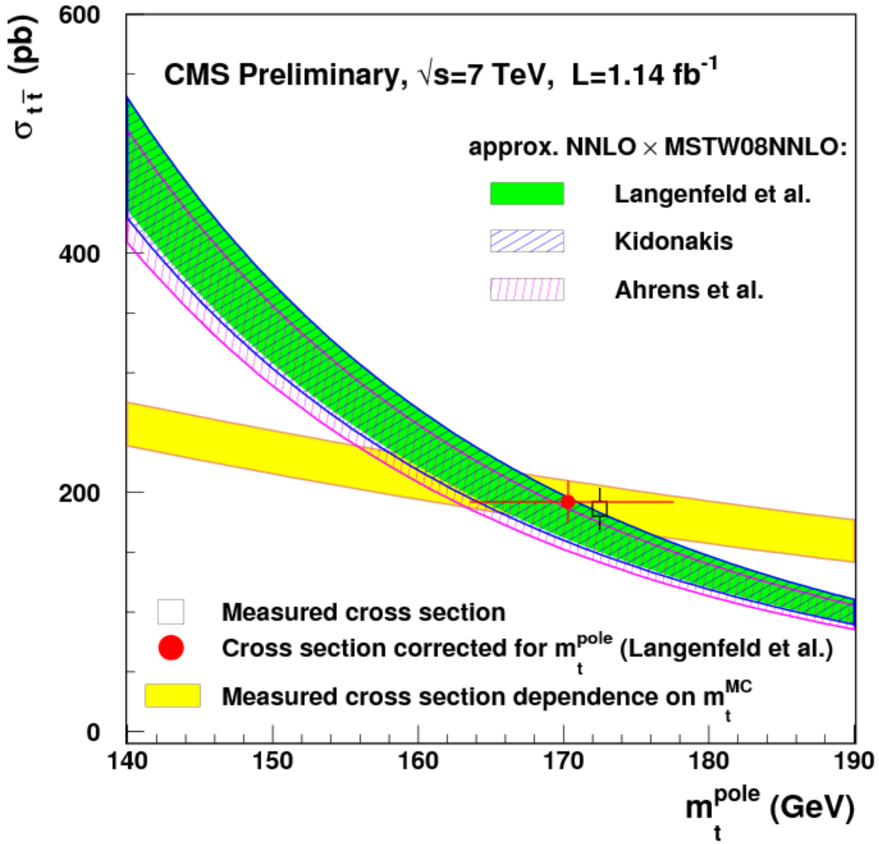
No evidence for a resonance enhancement around M_{jj} ~150 GeV

EWK-11-017

Top quark Mass Measurements



Moriond 2012



	m_t^{pole} / GeV
Langenfeld et al.	$170.3^{+7.3}_{-6.7}$
Kidonakis	$170.0^{+7.6}_{-7.1}$
Ahrens et al.	$167.6^{+7.6}_{-7.1}$

Approx. NNLO × MSTW08NNLO

TOP-11-008

Test CPT invariance in the top sector

$$\Delta M_t = M_{top} - M_{\overline{top}}$$

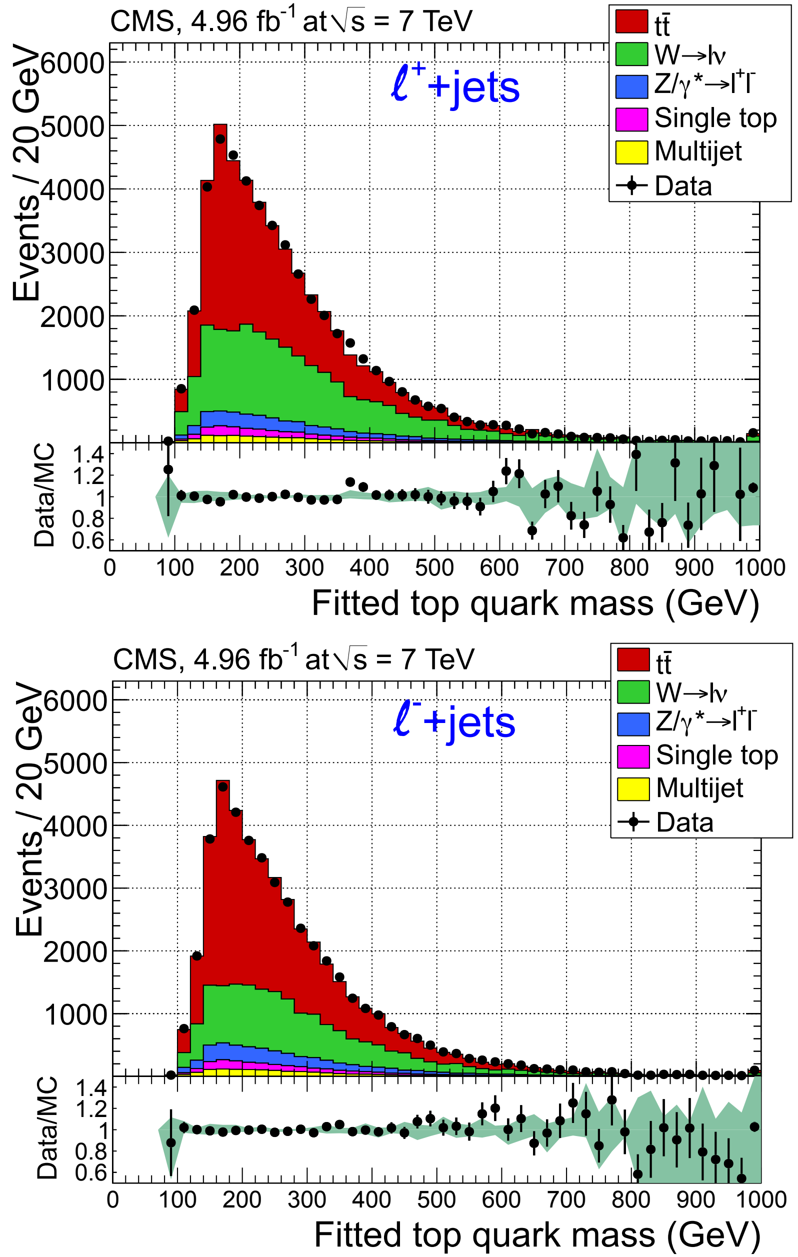
- Reconstruction of the hadronic side: compare ℓ^++jets and ℓ^-+jets events
- Use kinematic fit, and event-per-event likelihood for ℓ^- and ℓ^+ separately

$$\Delta m_t = -0.44 \pm 0.46\ (\text{stat.}) \pm 0.27\ (\text{syst.})\ \text{GeV}$$

Most systematic effects cancel out !
→ the measurement is stat. limited

World's best so far

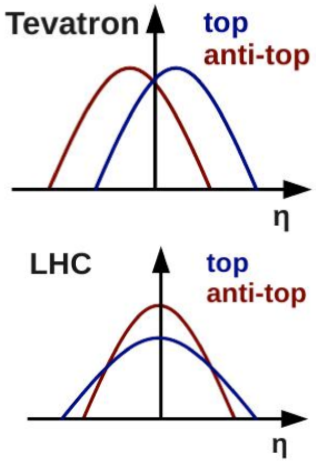
Consistent with SM,
Consistent between e and μ



TOP-11-019

Top Charge Asymmetry Measurements

- Anomalous charge asymmetries observed at the Tevatron CDF PRD83 (2011); D0 PRD84 (2011)



- Different definition possible a the LHC (asymmetry partly diluted) :

$$A_C = \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y > 0) + N(\Delta y < 0)} \qquad \Delta|y| = |y_t| - |y_{\bar{t}}|$$

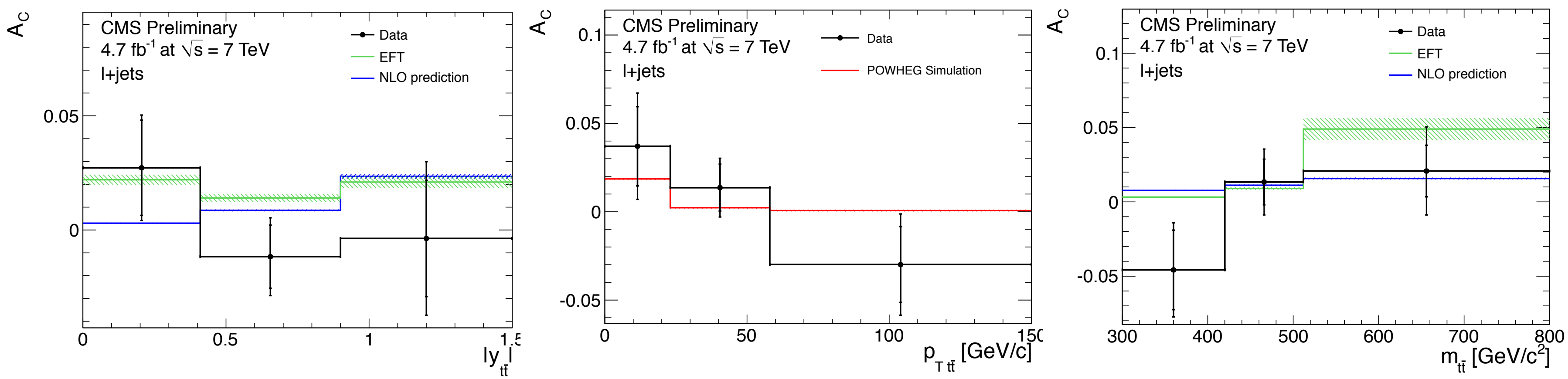
New CMS Measurement:

$A_C = 0.004 \pm 0.010$ (stat.) ± 0.012 (syst.)

Theory Prediction (SM):

$A_C = 0.0115 \pm 0.0006$

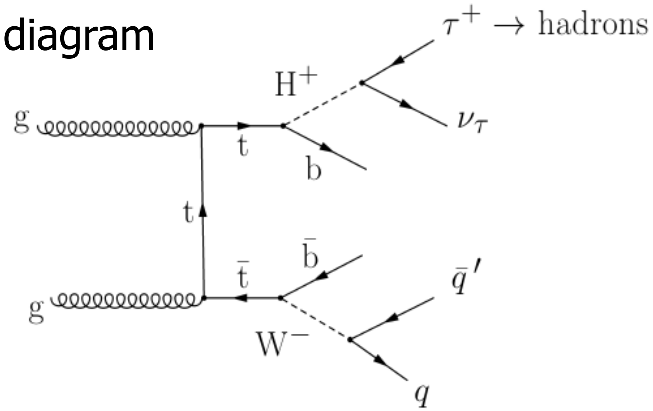
- No dependence on phase space within uncertainties:

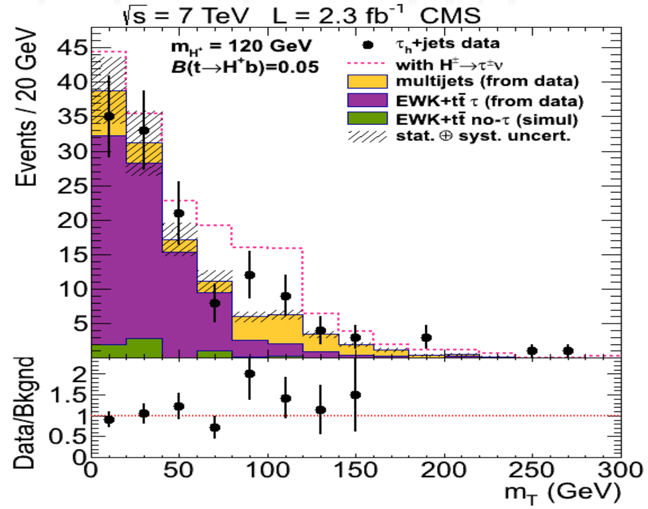


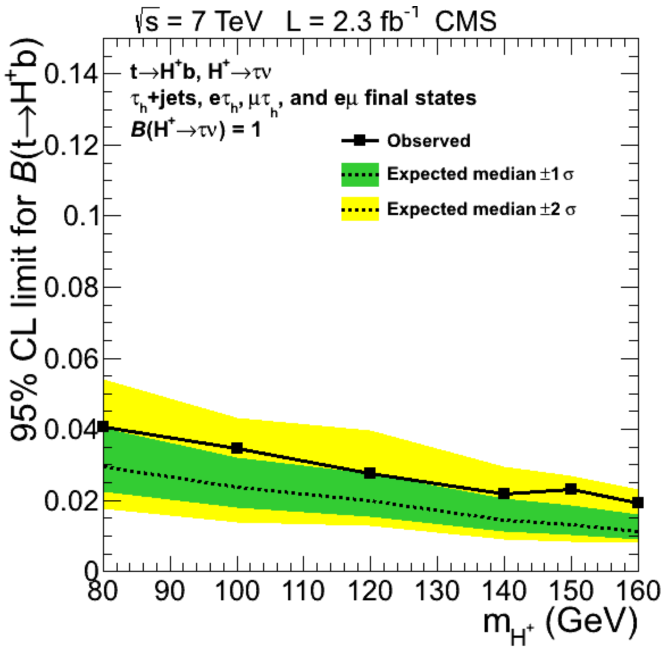
TOP-11-014

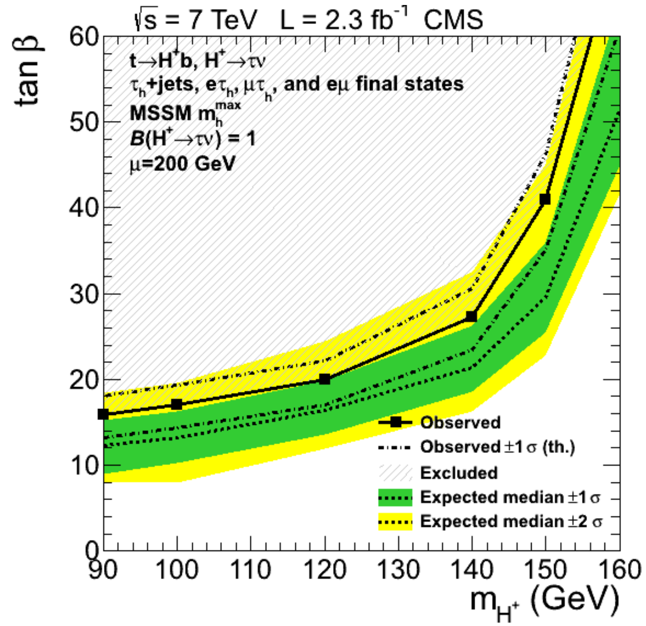
Top Decays: Search for t → H⁺b

e.g. diagram









Improves by an previous Tevatron limits on B (t → H+ b) by ~ O(10)

HIG-11-019

CMS « **Higgs** » Papers Full Datasets at $\sqrt{s}$ = 7 TeV $\mathcal{L} \sim 4.7 - 5\ fb^{-1}$

$H \to 2\gamma$	HIG-11-033	PLB	arXiv:1202.1487v1	Feb. 2012
$H \to ZZ \to 4\ell$	HIG-11-025	PRL	arXiv:1202.1997v1	Feb. 2012
$H \to ZZ \to 2\ell\, 2\tau$	HIG-11-028	JHEP	arXiv:1202.3617v1	Feb. 2012
$H \to ZZ \to 2\ell\, 2\nu$	HIG-11-026	JHEP	arXiv:1202.3478v1	Feb. 2012
$H \to ZZ \to 2\ell\, 2q$	HIG-11-027	JHEP	arXiv:1202.1416v1	Feb. 2012
$H \to WW \to 2\ell\, 2\nu$	HIG-11-024	PLB	arXiv:1202.1489v1	Feb. 2012
$H \to 2\tau$	HIG-11-029	PLB	arXiv:1202.4083v1	Feb. 2012
$H \to 2b$	HIG-11-031	PLB	arXiv:1202.4195v1	Feb. 2012
H Combination	HIG-11-032	PLB	arXiv:1202.1488v1	Feb. 2012
MSSM $H^{\pm}$	HIG-11-019*	JHEP	arXiv:1205.5736v2	May 2012

CMS Physics Analysis Summaries (PAS)		
$H \to 2\gamma$ "MVA"	HIG-12-001	Mar. 2012
H Fermiophobic	HIG-12-002	Mar. 2012
H Combination	HIG-12-008	Mar. 2012
$WH \to \ell\nu\, \tau_\ell \tau_h$	HIG-12-006	Mar. 2012
$H \to 2\tau_\mu$	HIG-12-007	Mar. 2012

CMS Physics Analysis Summaries (PAS)		
MSSM $\Phi \to 2\mu$	HIG-12-011	Jun. 2012
$H \to WW \to \ell\nu 2q$	HIG-12-003	May 2012
VH; $H \to 2\ell\, 2\nu$	HIG-12-014	Jun. 2012
$H^{\pm\pm}$	HIG-12-005	Mar. 2012

* $\mathcal{L} \sim 2\ fb^{-1}$

Summary
Moriond 2012

SM Higgs Boson Searches in CMS

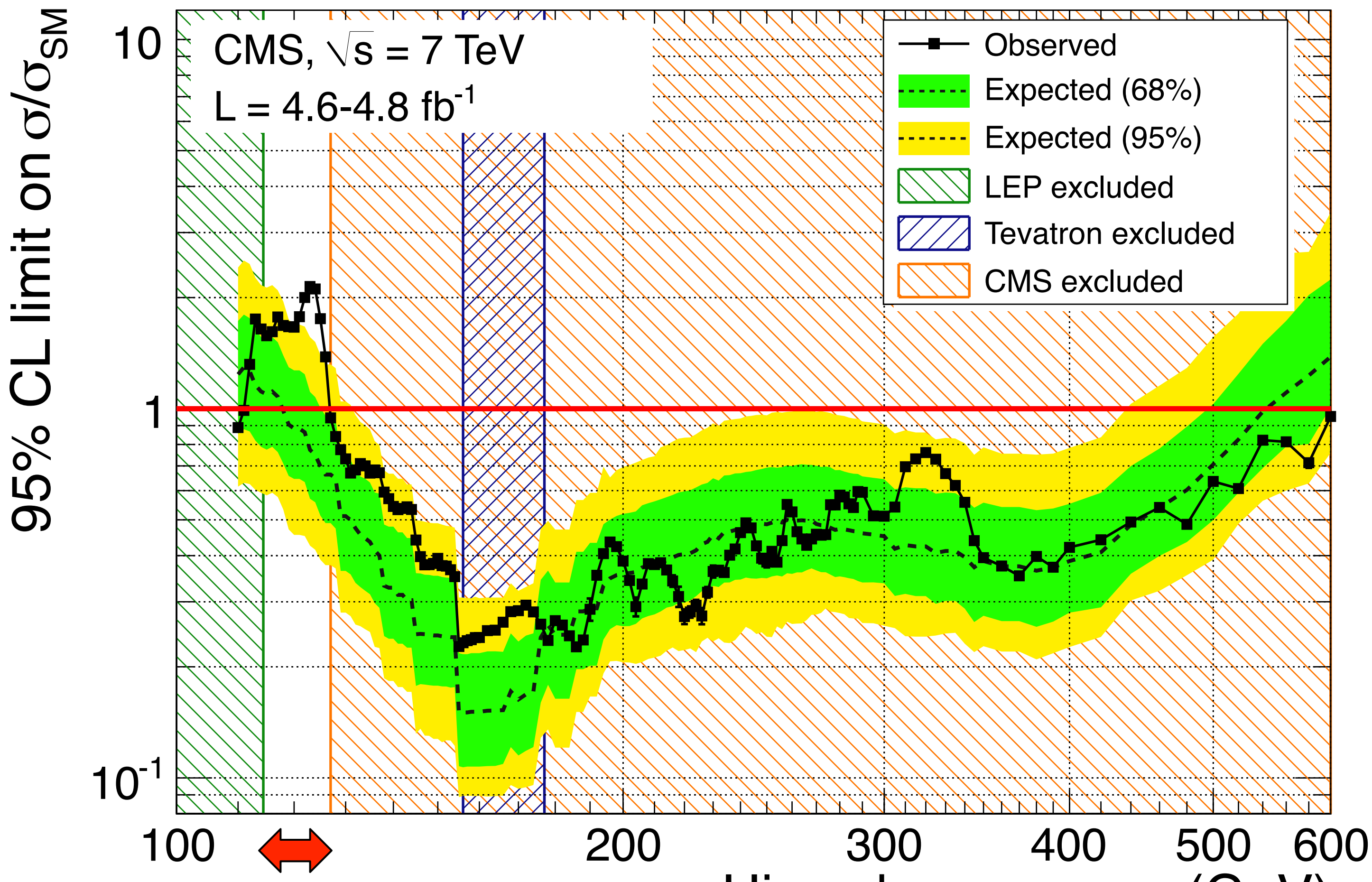
Channel	m_H Range	Lumi	Sub-Channels	m_H Resolution	Main Background	Expected sensitivity	Number of signal events after cuts
$H\to\gamma\gamma$	110-150	4.8	5	1-3%	$\gamma\gamma$ γj jj	1.5-2	~70
$H\to\tau\tau$	110-145	4.6	9	20%	$Z\to\tau\tau$ W+jet QCD	2-3	40-90
$H\to bb$	110-135	4.7	5	10%	V+jet Vbb tt	3-6	0.5-2
$H\to WW\to l\nu l\nu$	110-600	4.6	5	20%	WW DY tt	0.7-7	25-180
$H\to ZZ\to llll$	110-600	4.7	3	1-2%	ZZ Z+jets tt Zbb	0.5-10	1.-16
$H\to ZZ\to ll\tau\tau$	190-600	4.7	8	10-15%	ZZ Z+jets tt	3-12	0.5-2
$H\to ZZ\to ll\nu\nu$	250-600	4.6	2	7%	ZZ WZ Z+jets	0.6-2	3-20
$H\to ZZ\to llqq$	130-164 200-600	4.6	6	3%	Z+jets tt	5-15 1-5	~15 17-70

Background derived from Data

Signal MC: POWHEG, reweighted at NNLO

Background: PYTHIA, MadGraph, etc reweighted at NLO

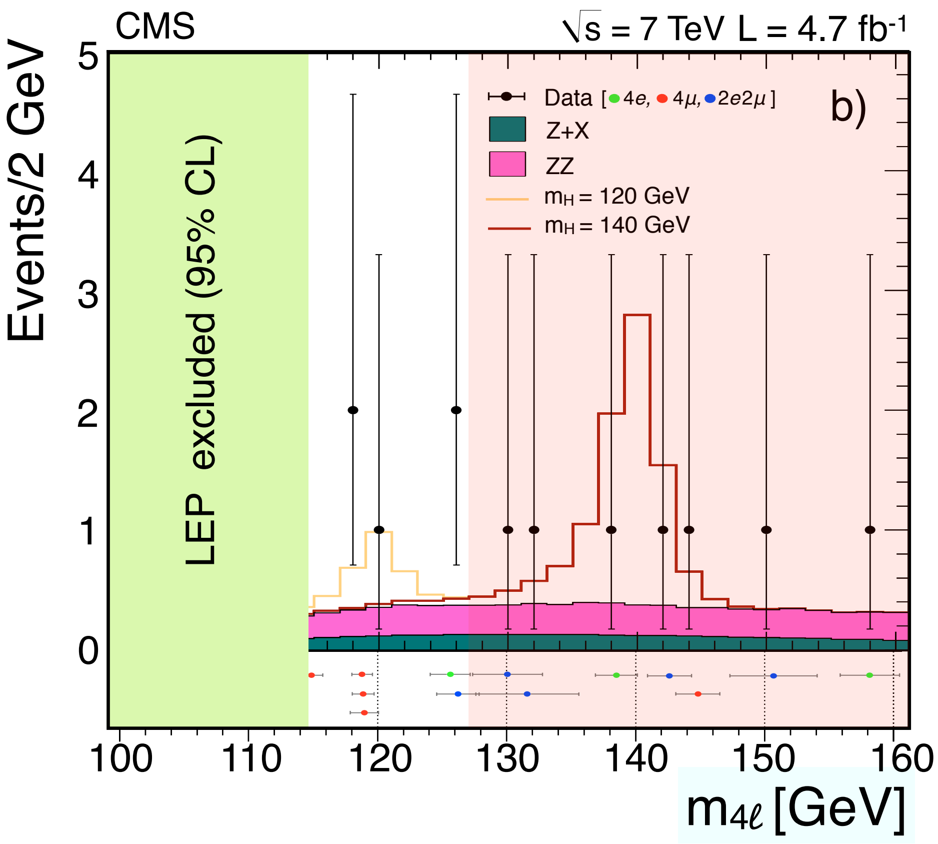
Exclusion Limits: Combined Results



114,4 – 127,0 GeV/c^2

Allowed M_H range for the SM Higgs Boson

Low Masses



Baseline Selection

$50 < M_{Z1} < 120$ GeV/c^2

$12 < M_{Z2} < 120$ GeV/c^2

$\varepsilon(M_H \sim 120) \sim 20\%$ (4e), 40% (4μ), 25% (2e2μ)

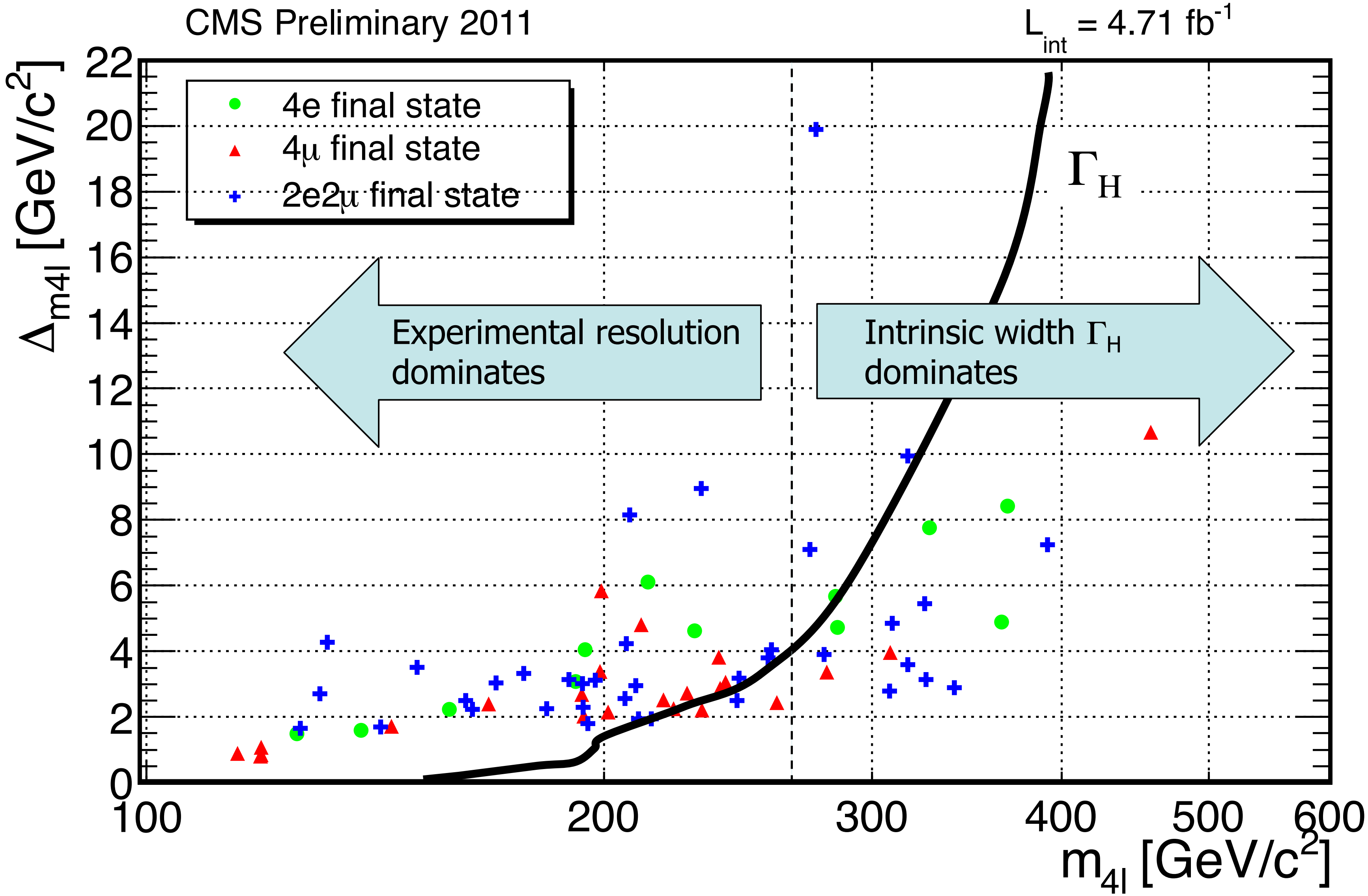
$\varepsilon(M_H \sim 160) \sim 42\%$ (4e), 75% (4μ), 55% (2e2μ)

Event Yields:

Final state:	4e	4μ	2e2μ
Obs. events:	3	5	5
Exp. events:	1.7	3.3	4.5

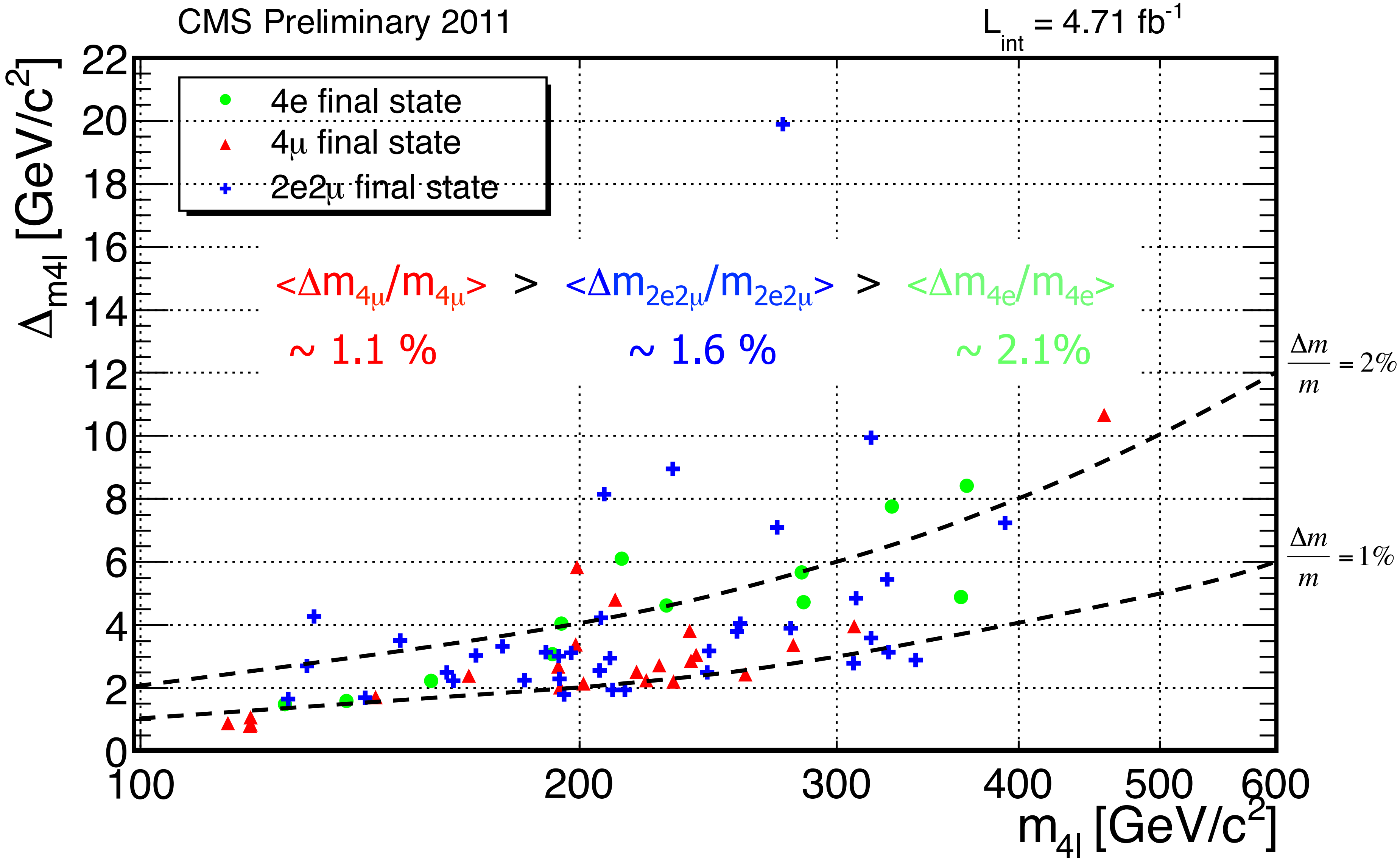
$100 < M_{4\ell} < 160$ GeV/c^2 Observed: 13 Expected: 9.5 ± 1.3 events

Event-by-event
Mass Measurement Uncertainties



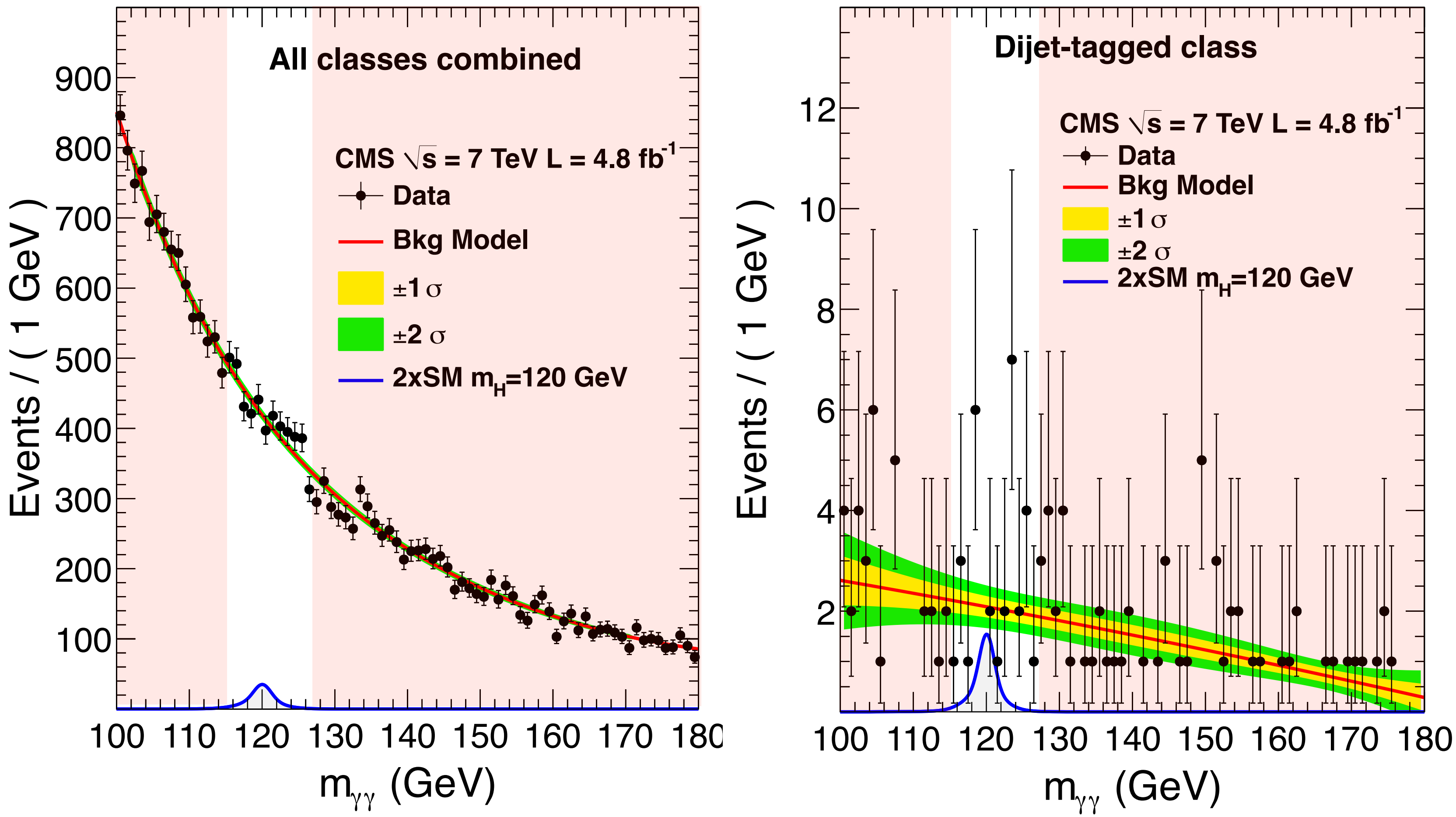
Event-by-event

Mass Measurement Uncertainties

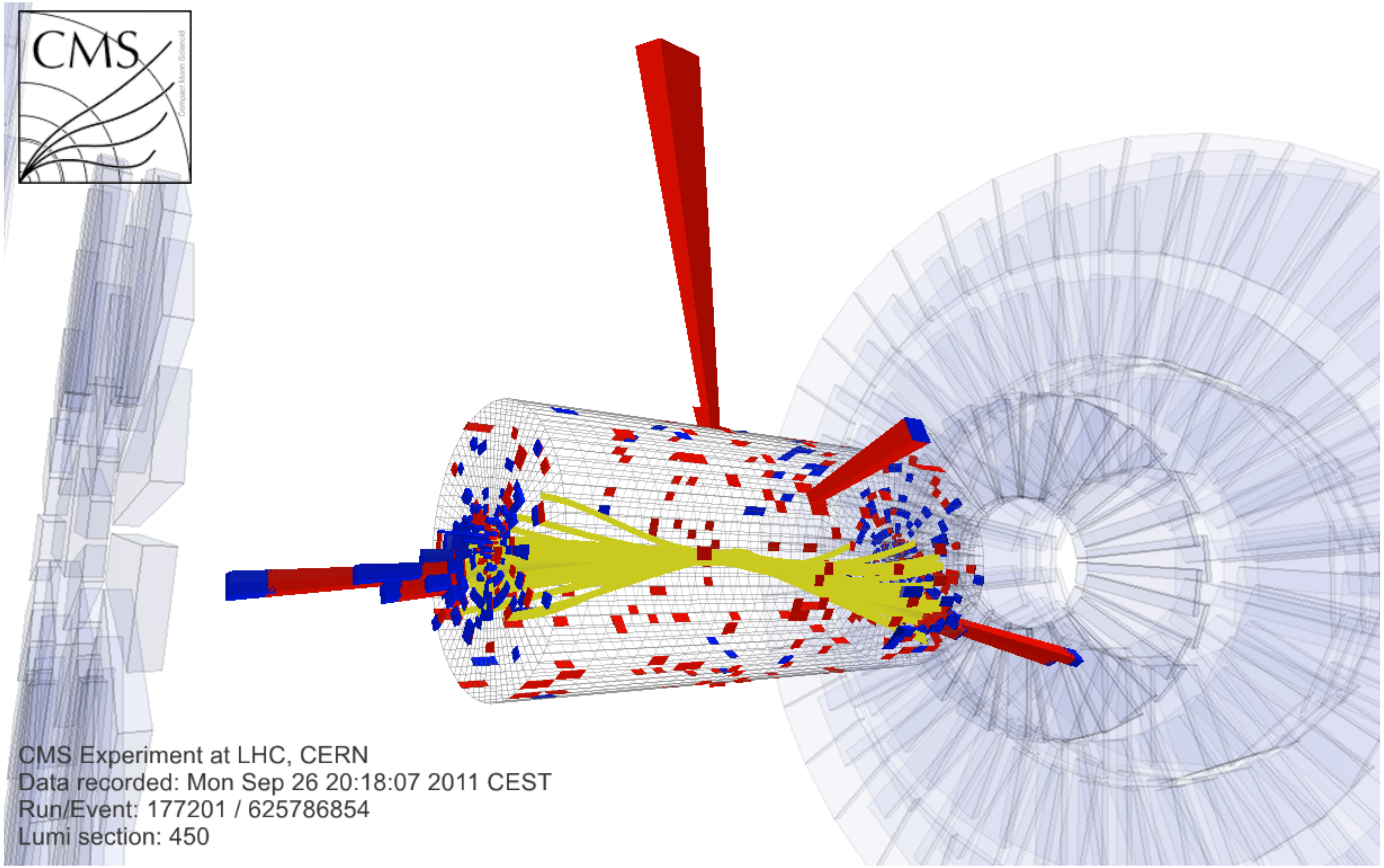


$H \to \gamma\gamma$

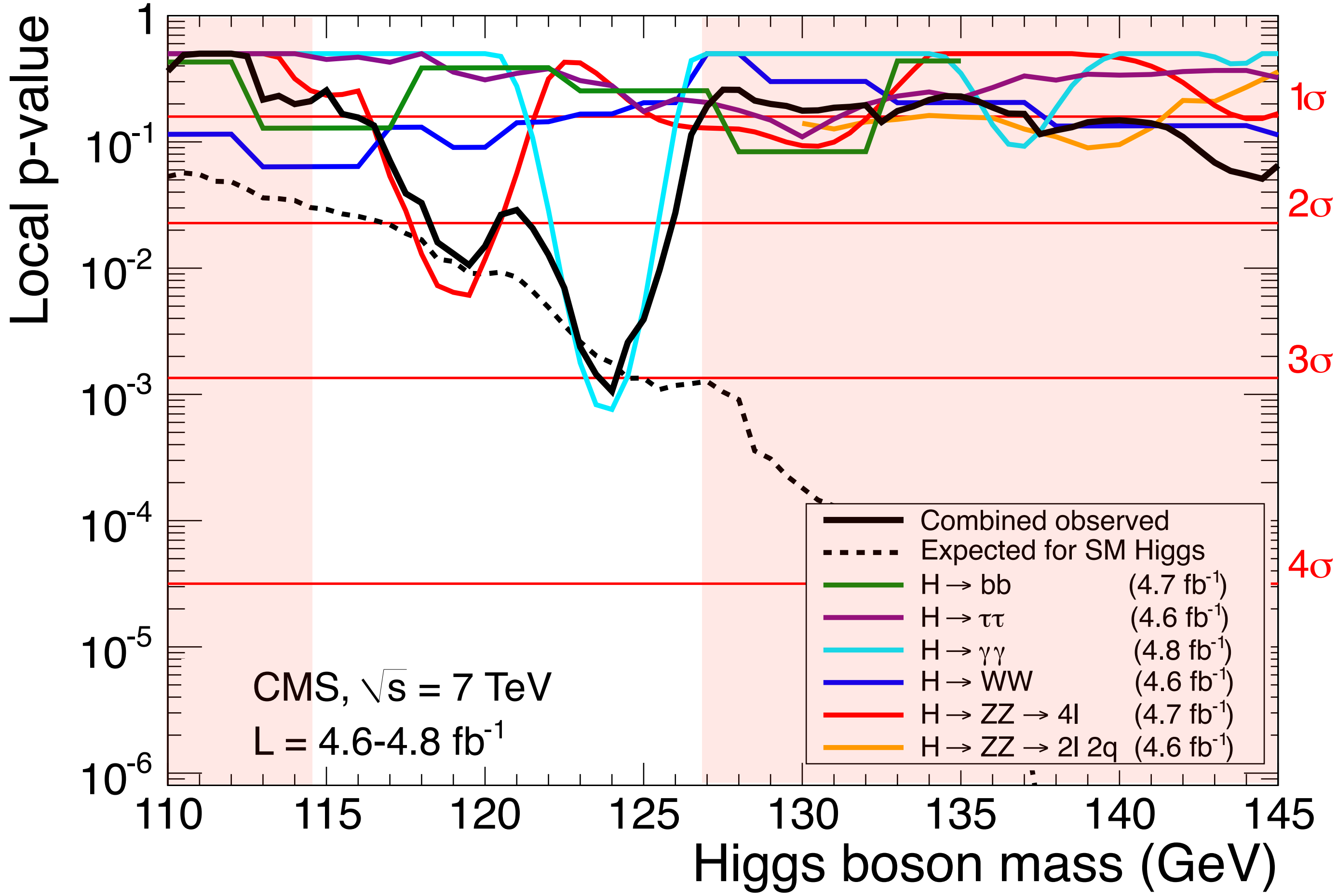
Mass Spectra



$H \rightarrow \gamma\gamma$ Candidate in Dijet-Tag Class



Low Mass Excess: Anatomy



Local Significance

P_{min} = 0.001
Z_{max} = 3.1σ

Global Significance
Full range
110-600 GeV/c²

Z_{max} = 1.5σ

Restricted range
110-145 GeV/c²

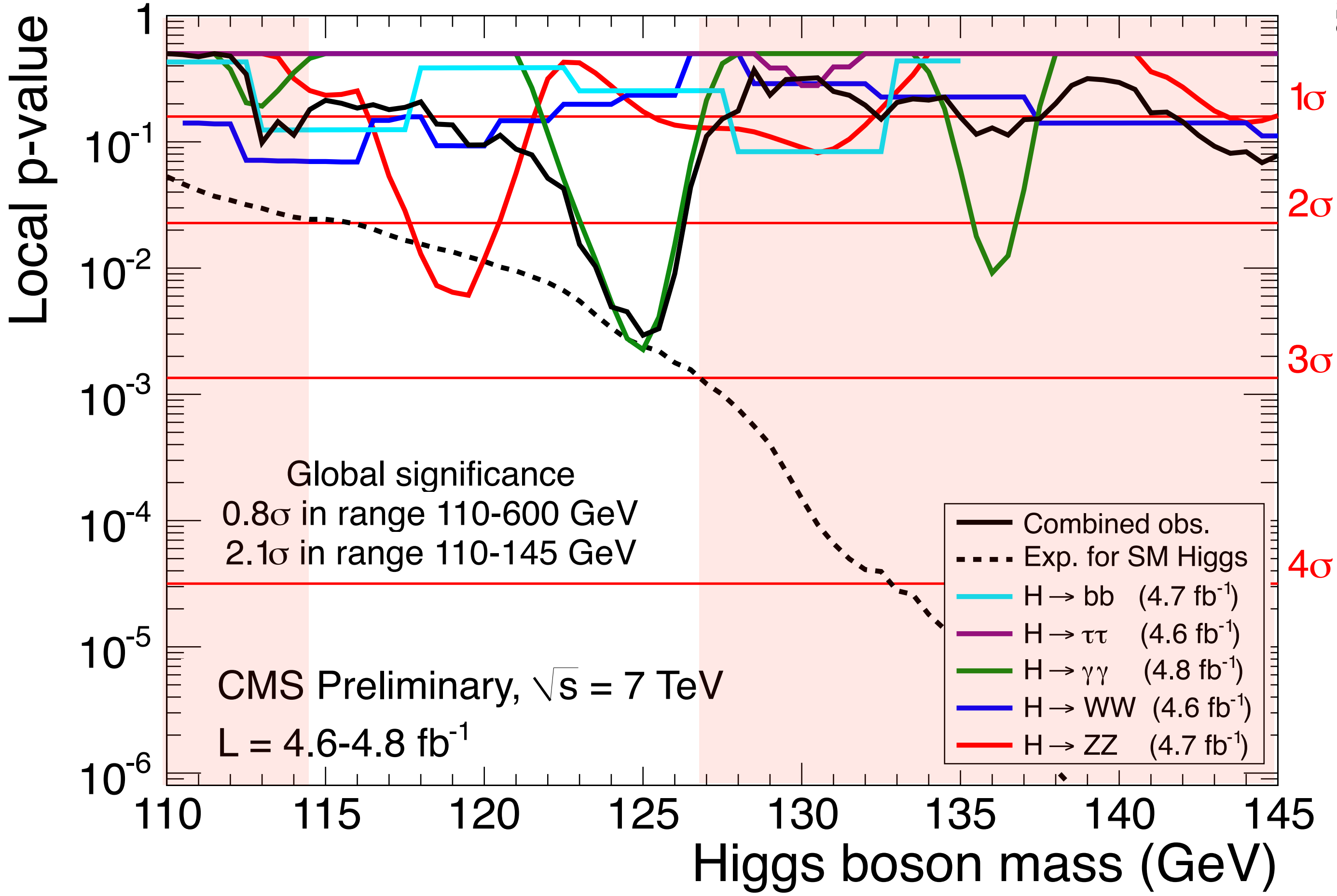
Z_{max} = 2.1σ

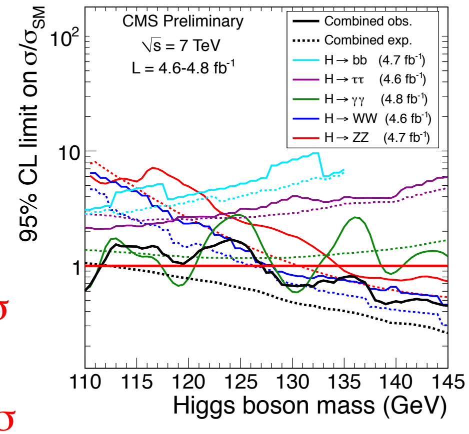
Within 1σ of unity in the mass range 117-126 GeV !

Broad excess at ~ 1σ level from H → bb, ττ, ww complemented by localized excesses from H → 4l and H → γγ

Local p-value = probability of a background fluctuation resembling a signal-like excess for a given value of m_H

Low Mass Excess: Anatomy

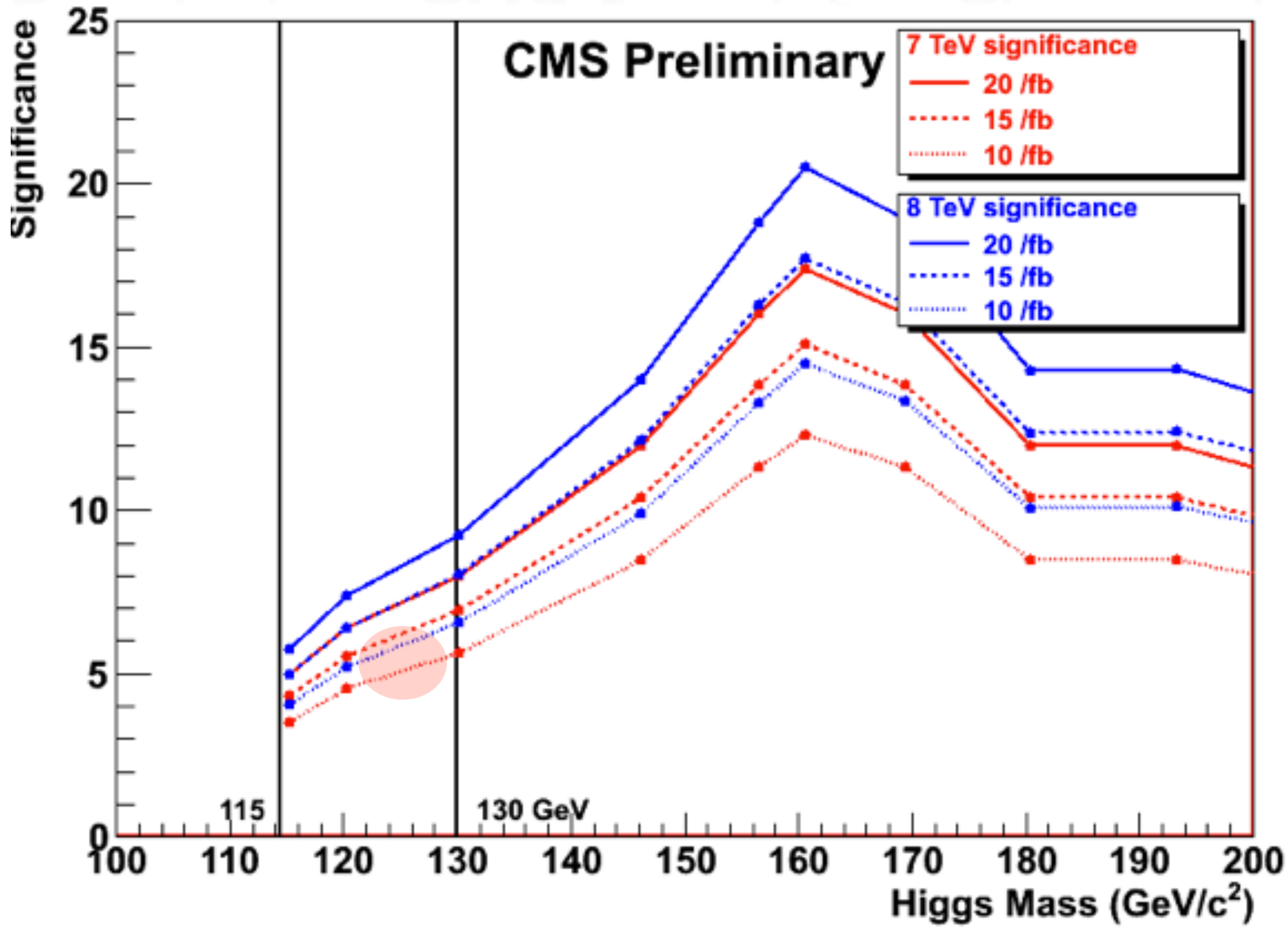




Using new
H → γγ « MVA »

CMS PAS-HIG-12-001 + PAS-HIG-12-008

Reminder: CMS Input for Chamonix



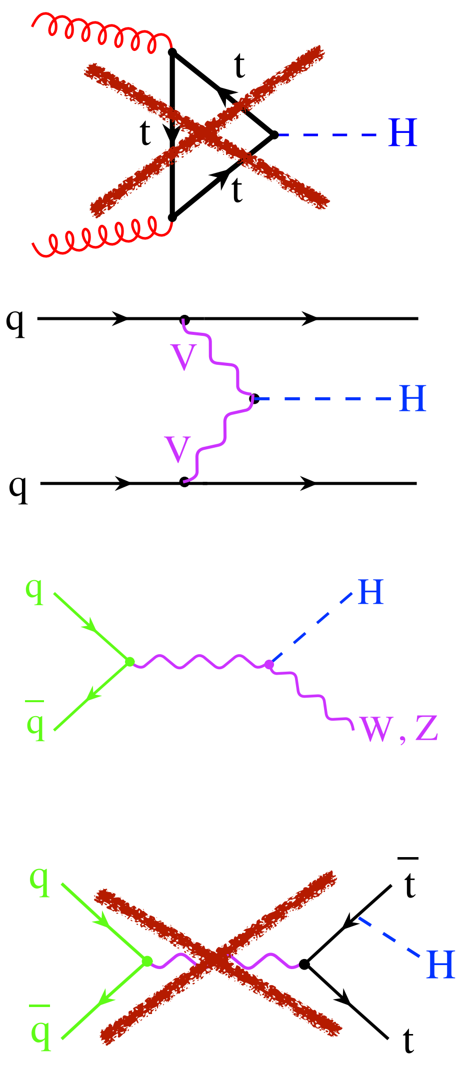
You are HERE ?

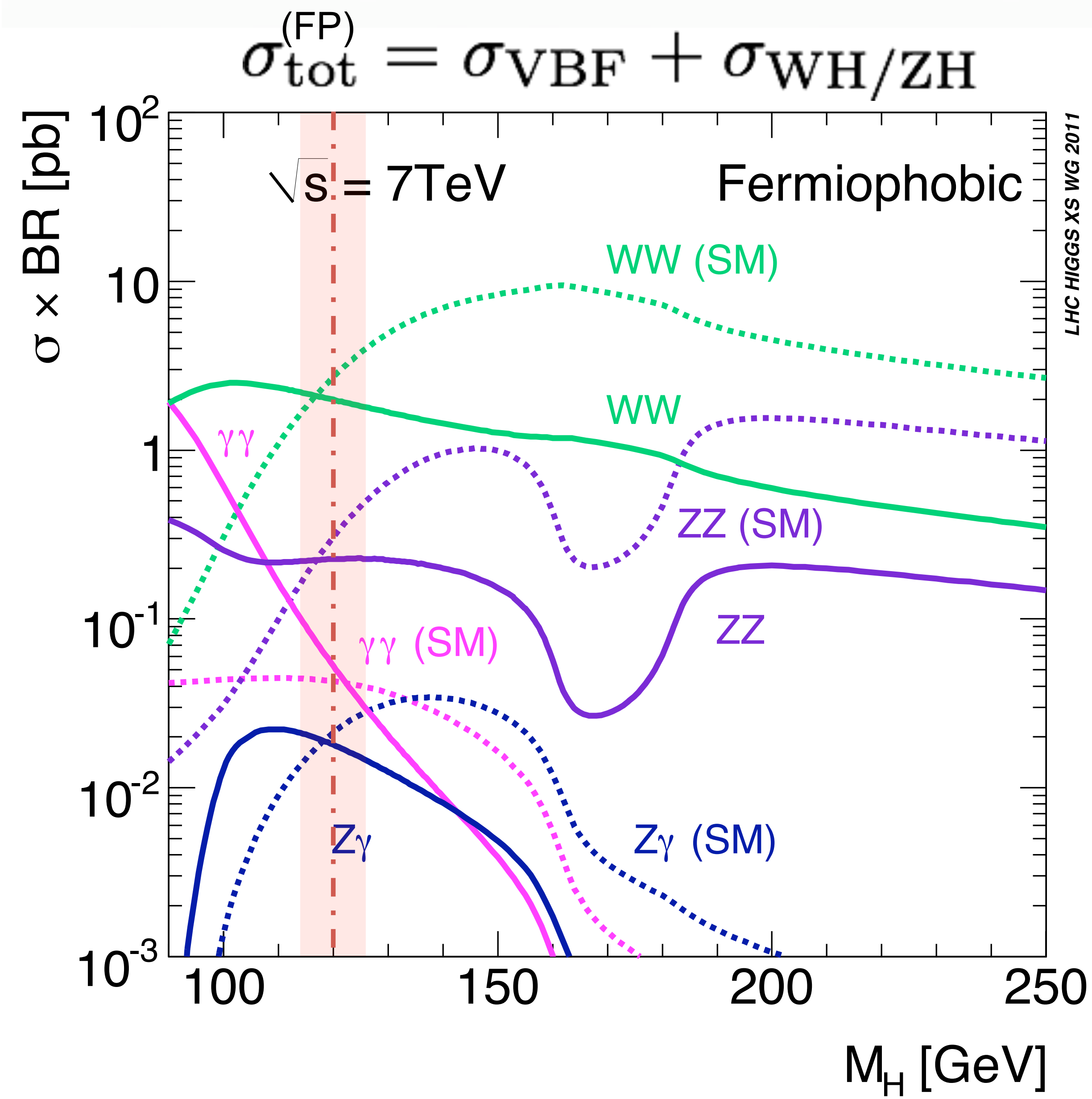
Note: Very roughly, for M_H ~125 GeV, one expects 3 to 4 signal events per 5 fb^{-1} in $H \rightarrow 4\ell$ for a S/B of ~ 2

⇒ Requires about 20 fb^{-1} for 5σ in stand-alone

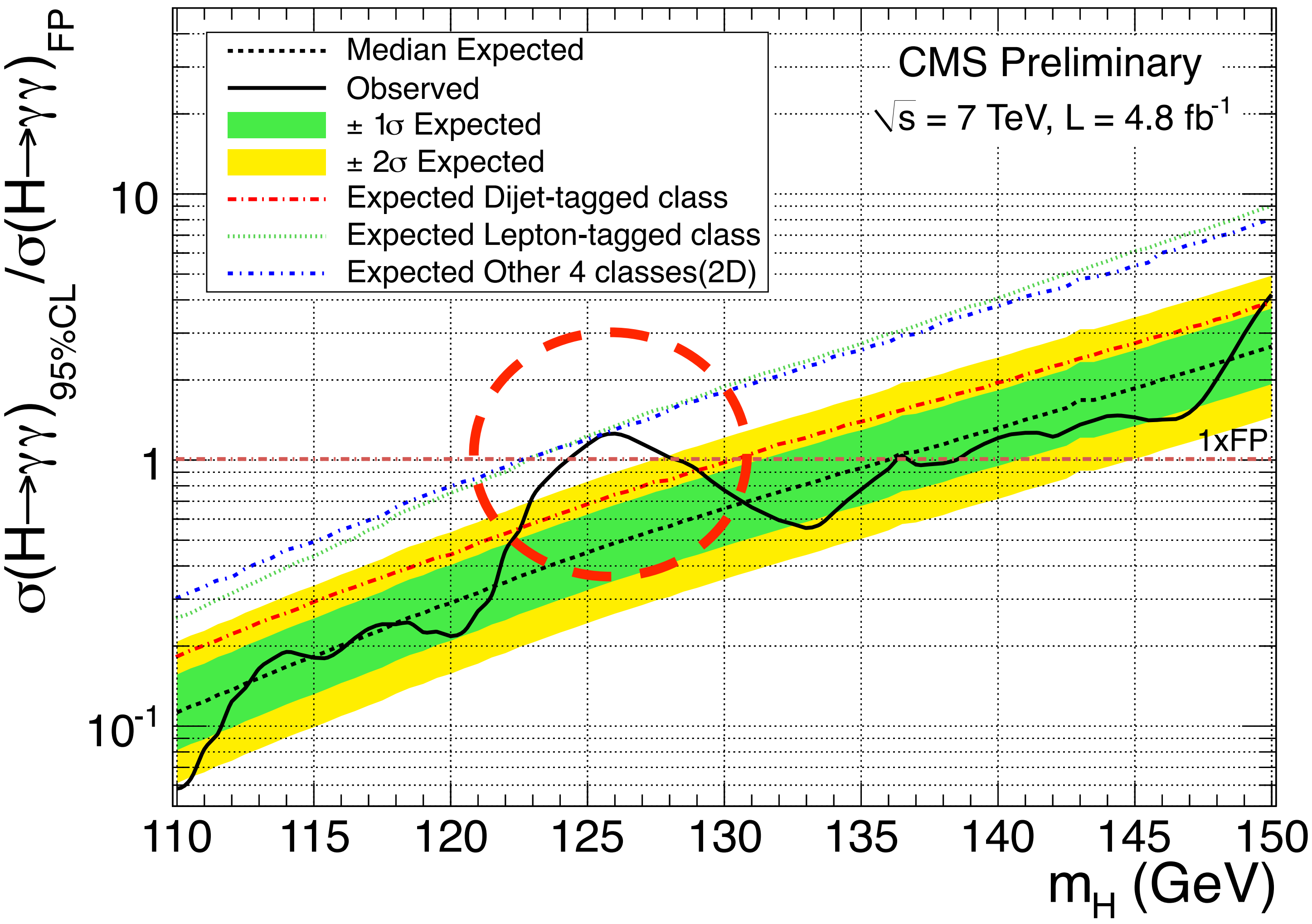
⇒ We should see something starting to build-up already now

Standard Model or Fermiophobic ?



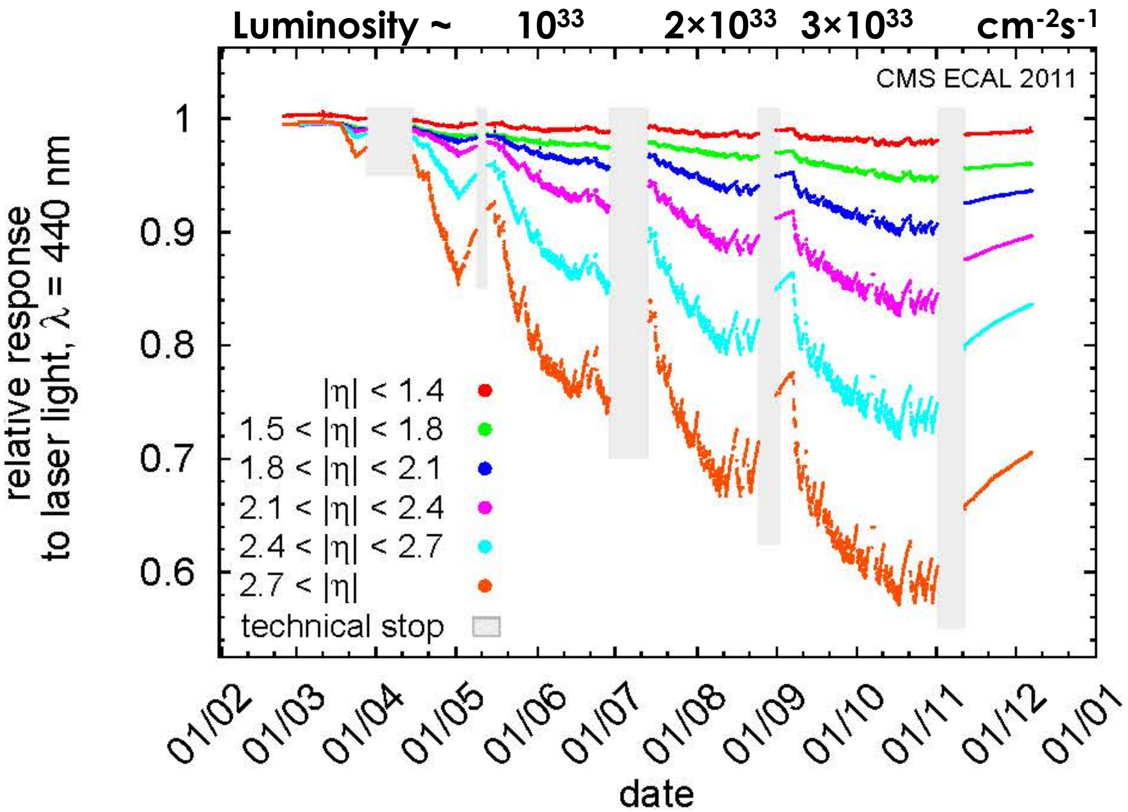


Search for a Fermiophobic Higgs Boson



CMS PAG HIG-12-002

Monitoring of ECAL Response Variations



ECAL Barrel:
crystals qualified for
<6% loss under 0.15 Gy/h

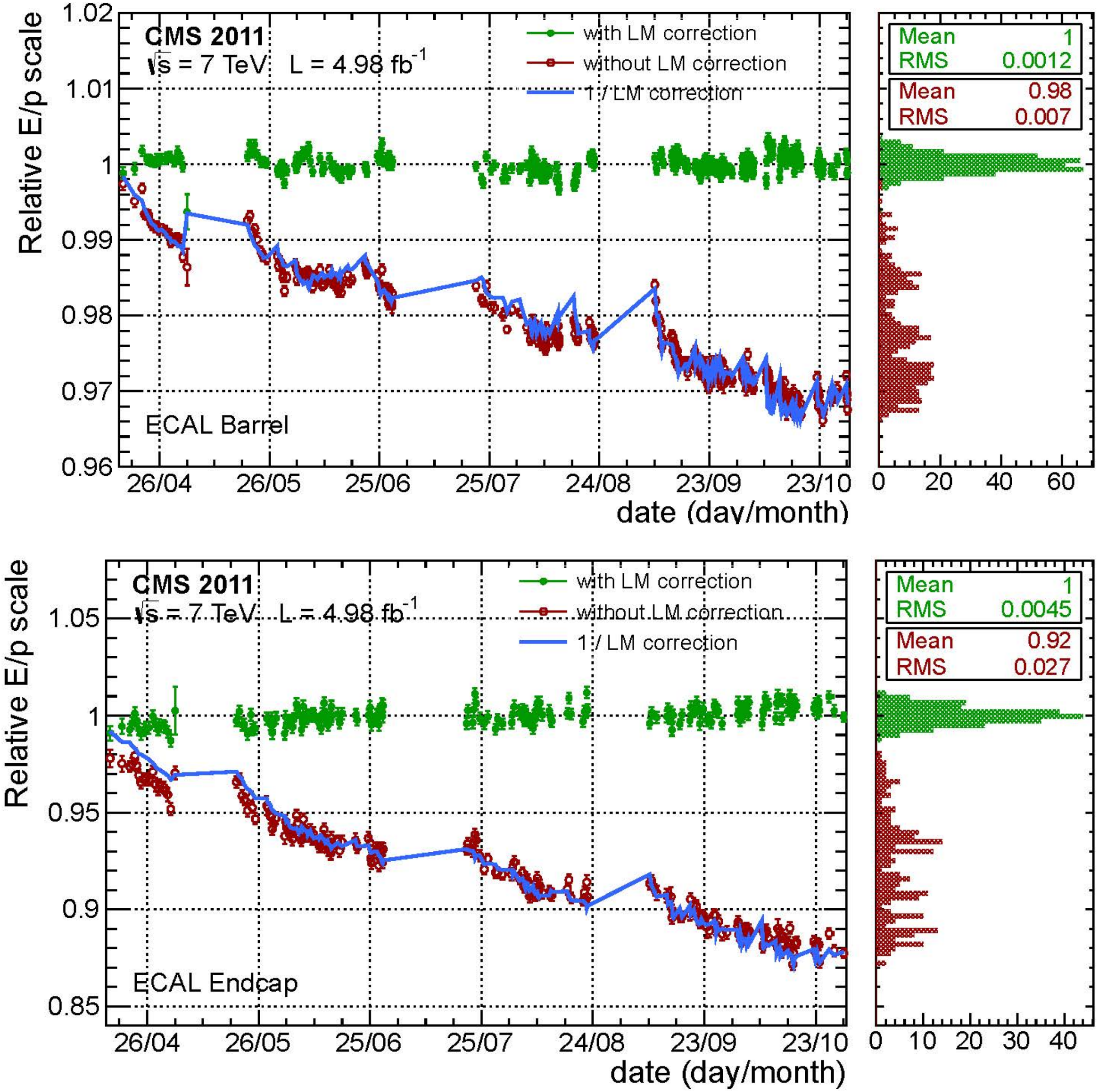
ECAL Endcap:
higher radiation level

- Damage and recovery during LHC cycles
- Steady recovery during Heavy Ion run (low luminosity) and in periods without beam

- Monitoring data: 1 point/channel/40 min
  - Corrections ready for reconstruction in less than 48 h!
  - A few iterations with data reprocessing required in 2011
- New diode pumped laser installed in 2012
  - Less maintenance intensive → reduced medium term instabilities

T. Tabarelli de Fatis, CALOR 2012

Stability of Response for Electrons: $W \rightarrow e\,\nu$



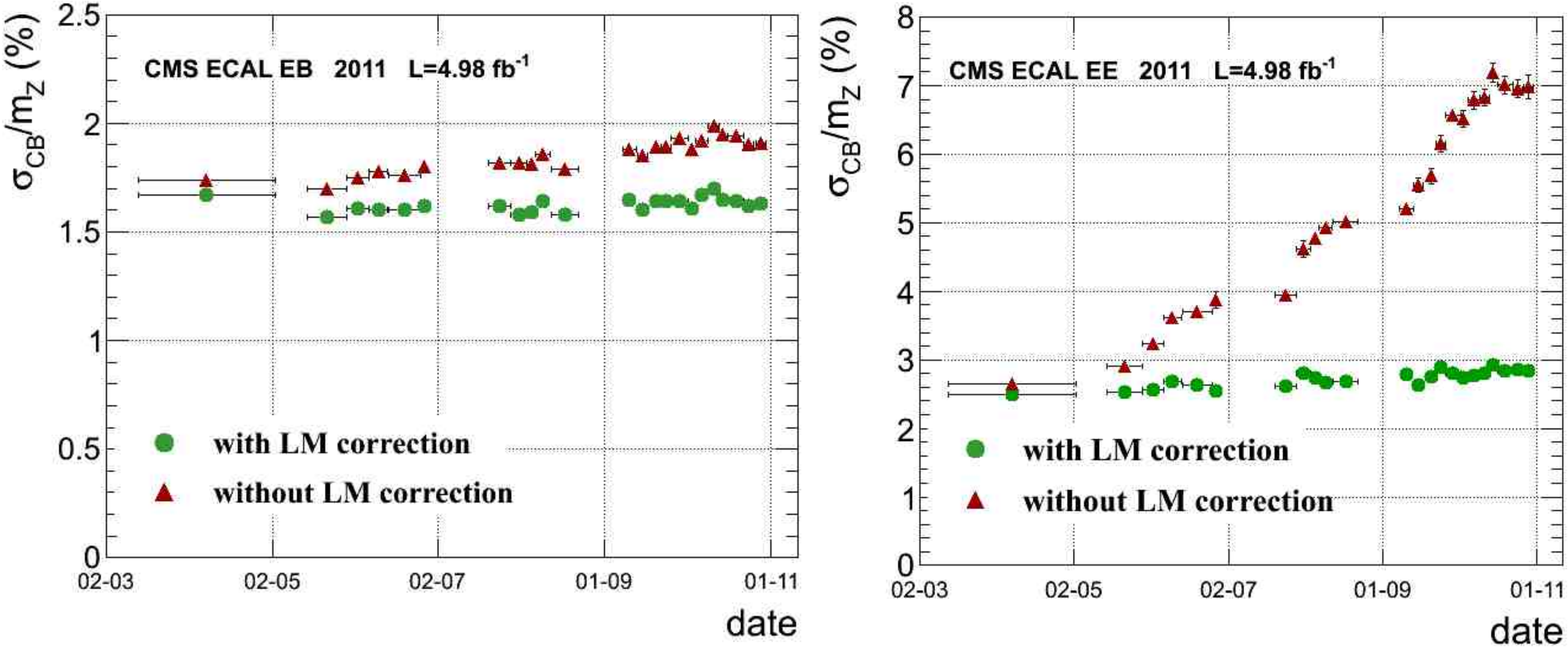
- Stable energy scale after monitoring corrections
  - Barrel:
    - <signal loss> ~ 2.5%,
    - RMS stability ~0.12%
  - Endcap:
    - <signal loss> ~10%,
    - RMS stability ~0.45%
- Corrections include:
  - Barrel : α = 1.52
  - Endcap: $<\alpha>$ ~ 1.28
    - Current loss-dependent optimization for this region
- Further tuning of the corrections in progress:
  - Time-invariance of energy flow: signal loss vs transmission loss at the single crystal level
    - → *In situ* measurement of α

$$(S/S_0) = (R/R_0)^{\alpha}$$

(S/S_0) = relative response to e's

(R/R_0) = relative resp. to laser light

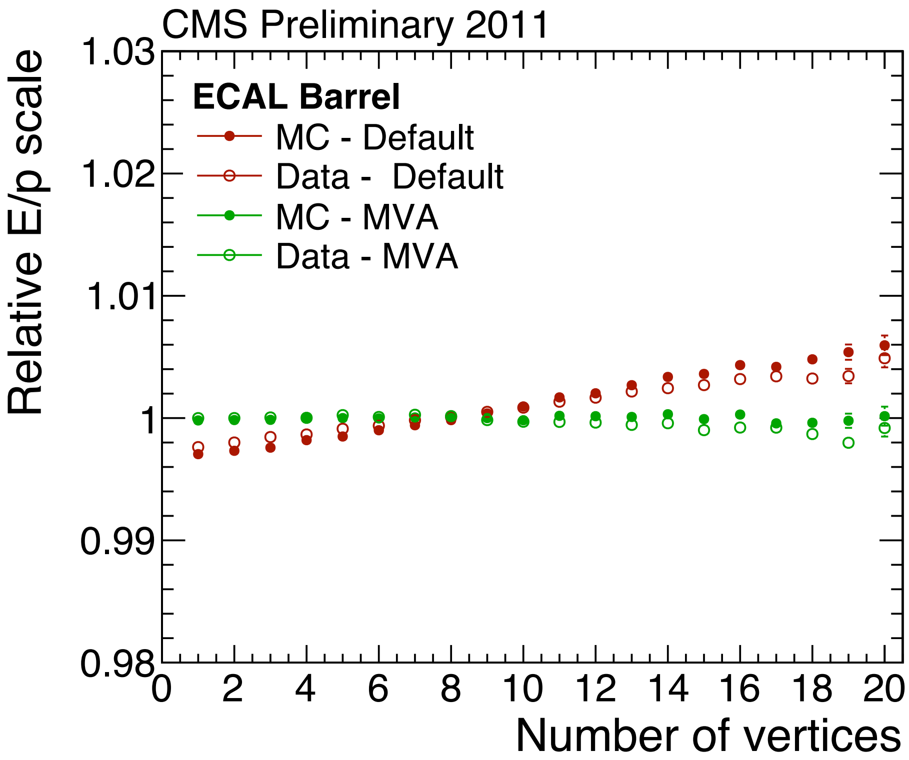
Stability of the Energy Resolution: Z → e e

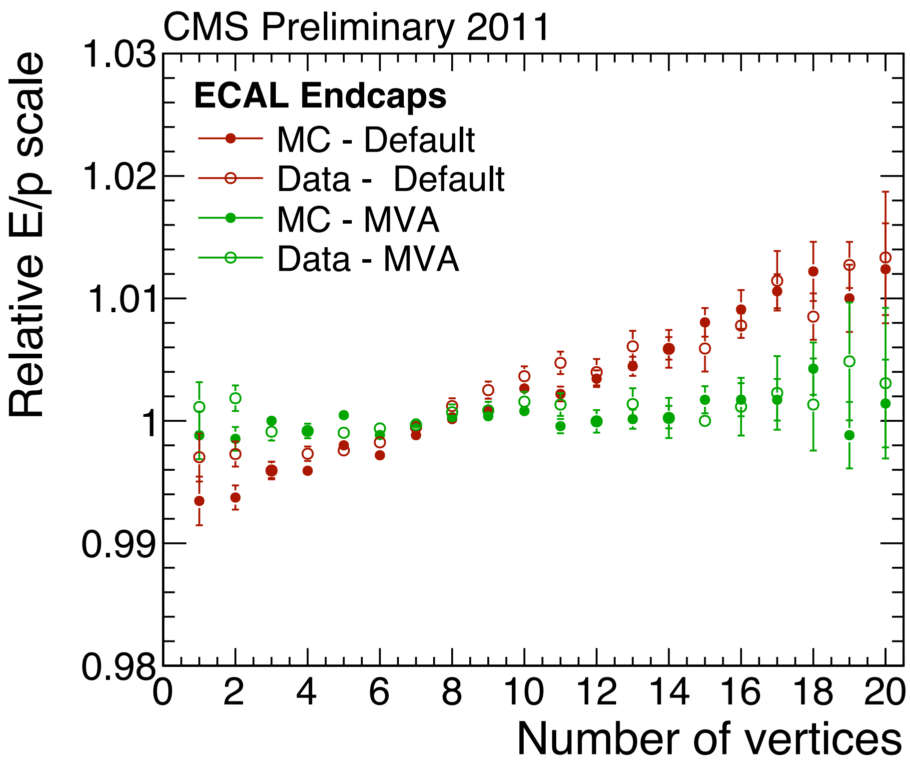


- ECAL resolution (from Z→ee peak width) stability before and after the application of Laser Monitoring corrections (LM):
  - ECAL Barrel: resolution stable within errors
  - ECAL Endcap: resolution worsens by ~1.5% in quadrature

→ Requires further tuning of corrections and/or pile-up effects (e.g. *in situ* measurement of the 'effective α' at single crystal level)

Response dependence on Pile-up





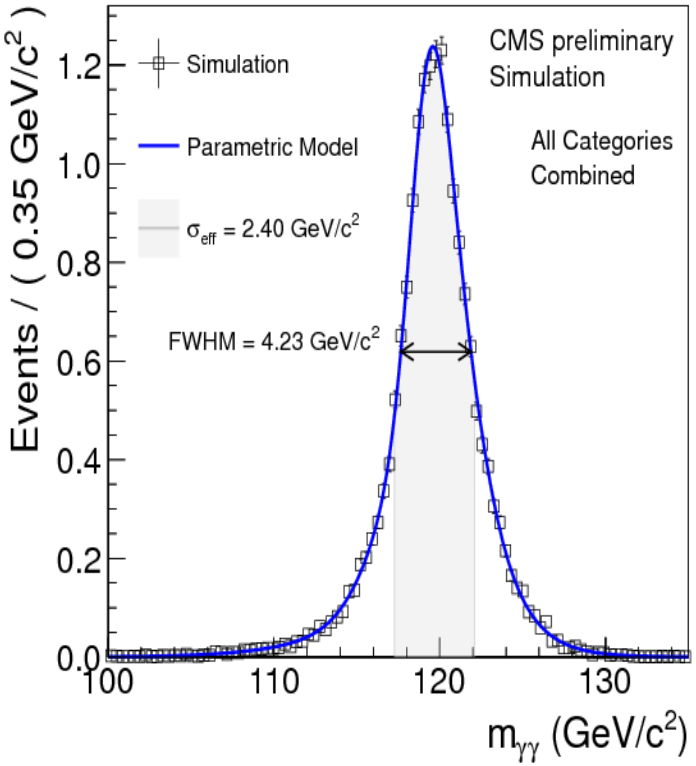
Dependence $E_{reco.}$ on N_{vtx}

Data (open dots) and MC (full dots) are compared for the default reconstruction (red dots) and after MC-driven corrections to the energy based on a multivariate analysis of the energy response including pileup sensitive global event variables

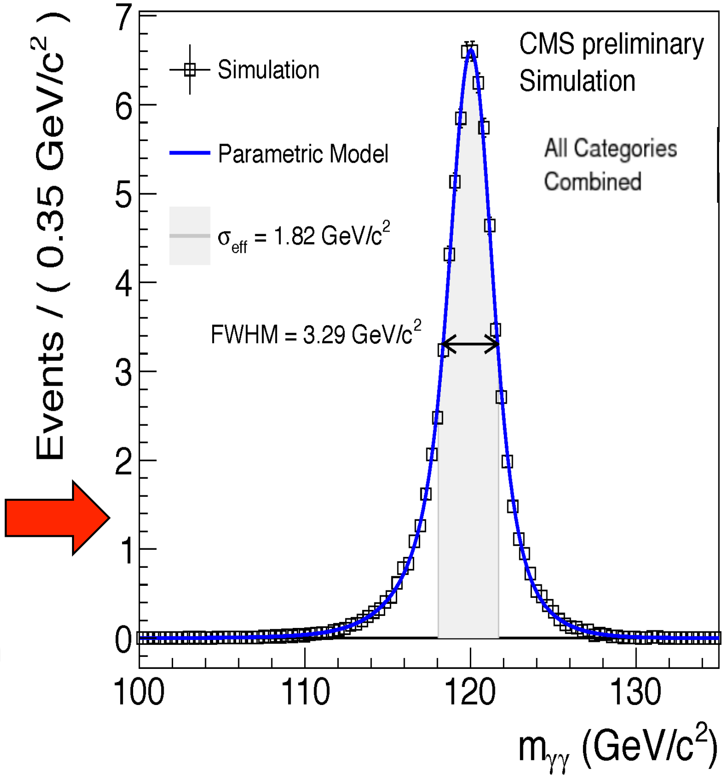
- Pileup-resilient clustering algorithms are under study

Progress in Understanding …

- July 2011 (EPS):
  - FWHM = 4.23 GeV



- March 2012 (Moriond)
  - FWHM = 3.29 GeV



Improved single crystal and cluster corrections

- July 2012 (ICHEP)

Search for SM Higgs: 2011+2012 Data

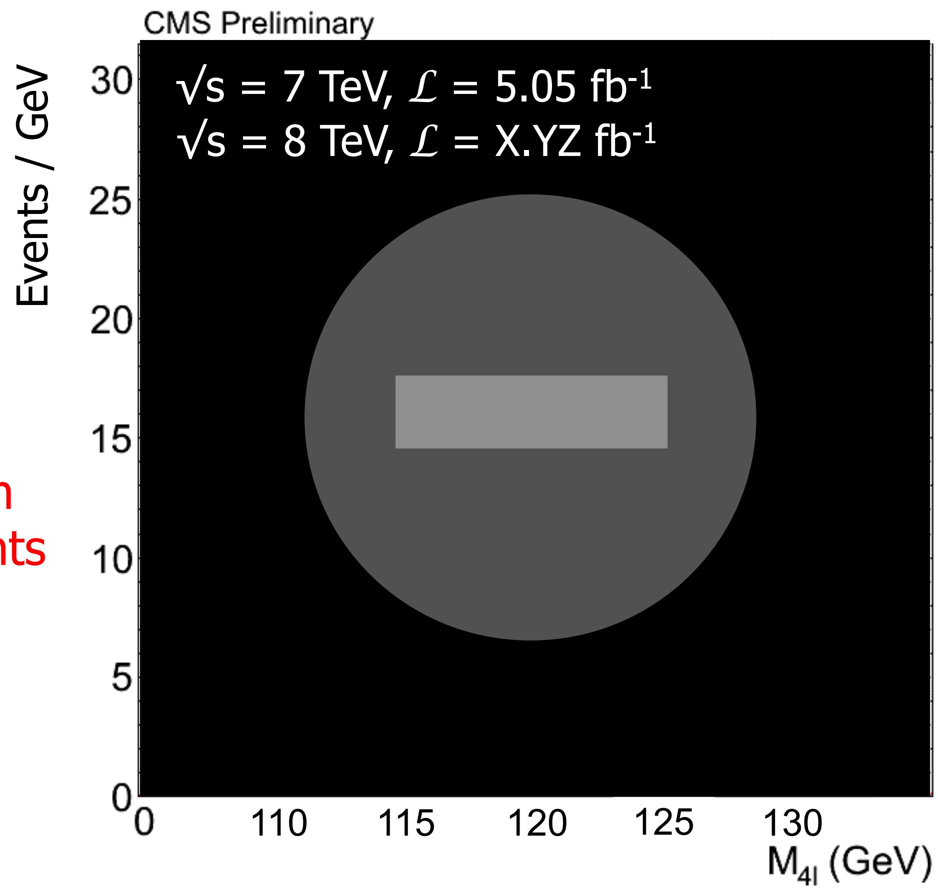
What do we see in the low mass range ?

CMS is blinded

Analysis improvements:

use MC for optimisation +
use DATA only in background
and SM candles phase space

Both 2011 and 2012 data have been
blinded for the analysis improvements

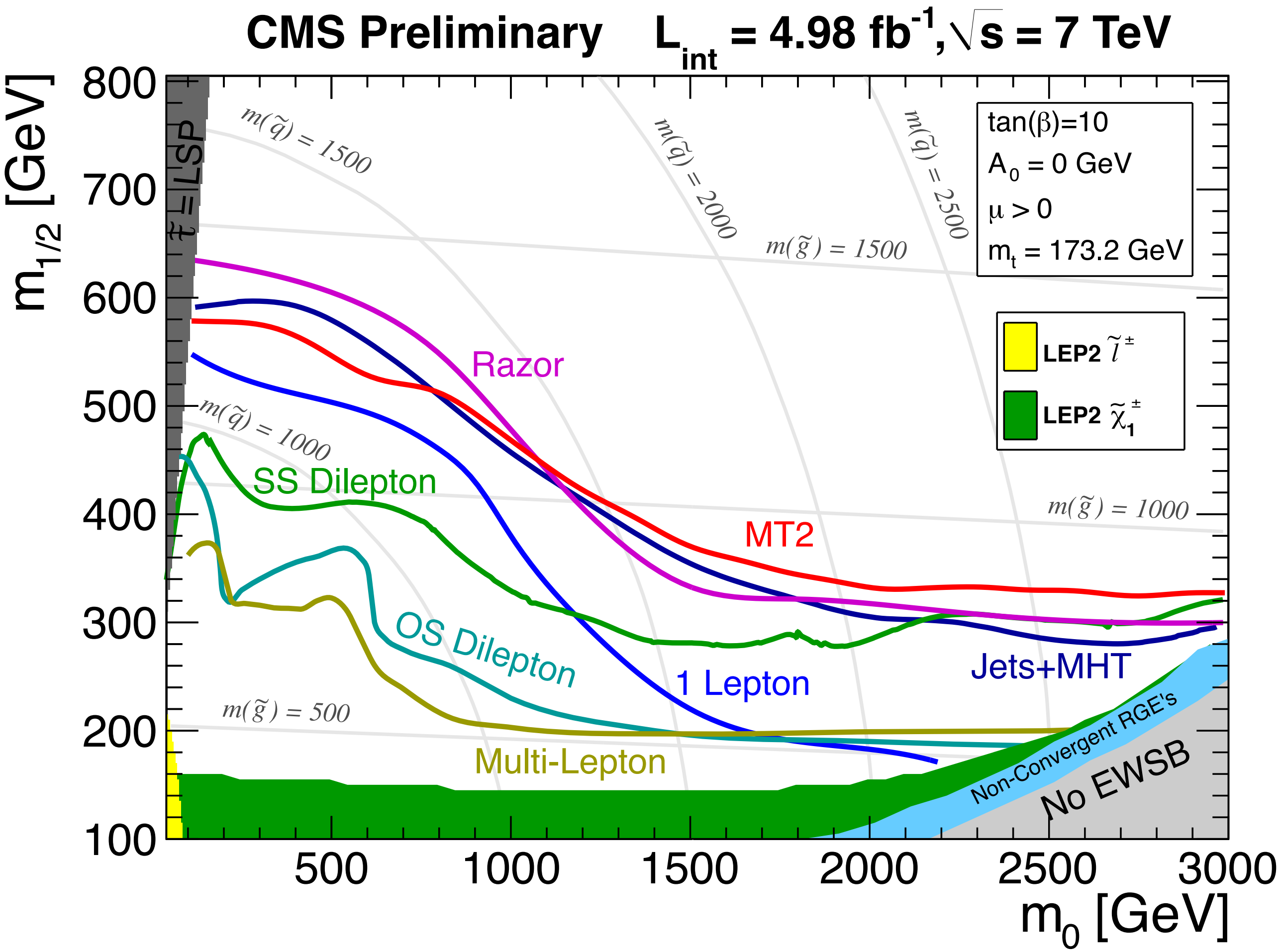


CMS « **SUSY** » Papers	Full Datasets at $\sqrt{s}$ = 7 TeV	$\mathcal{L}$ ~ 4.7 - 5 fb^{-1}	
Z + jets + E_T^{miss}	SUS-11-021	PLB arXiv:1204.3774v1	Apr. 2012
Multileptons	SUS-11-013	JHEP arXiv:1202.5341v1	Apr. 2012

CMS Physics Analysis Summaries (PAS)		
CMSSM l + jets + E_T^{miss} (Templates)	SUS-11-027	May 2012
CMSSM = l + jets + E_T^{miss}	SUS-12-010	May 2012
SUSY l + b-jets + E_T^{miss}	SUS-11-028	May 2012
SUSY Fully hadronic states	SUS-12-002	May 2012
Simplified Models	SUS-11-016	May 2012
CMSSM l + jets + E_T^{miss} (NN)	SUS-11-026	Apr. 2012
GMSB γ's + E_T^{miss}	SUS-12-001	Apr. 2012
CMSSM « Razor inclusive »	SUS-12-005*	Mar. 2012
$\ell^{\pm}\ell^{\pm}$ b-jets + E_T^{miss}	SUS-11-020	Mar. 2012
$\ell^{+}\ell^{-}$ jets + E_t^{miss} (NN)	SUS-11-018*	Mar. 2012

* $\mathcal{L}$ ~ 4.4 fb^{-1} * $\mathcal{L}$ ~ 2.2 fb^{-1}

Supersymmetry: Constrained Models



Minimal Models (e.g. cMSSM) under pressure …

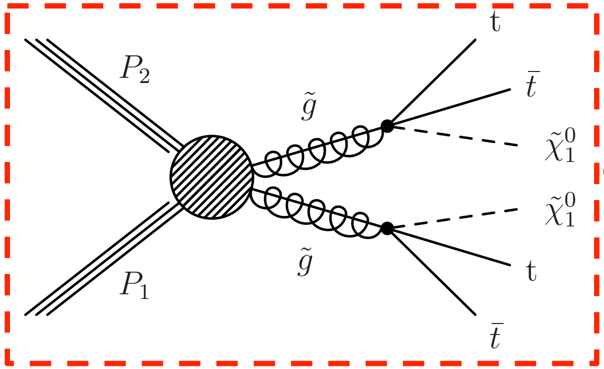
Limits > 1 TeV on squarks and gluinos

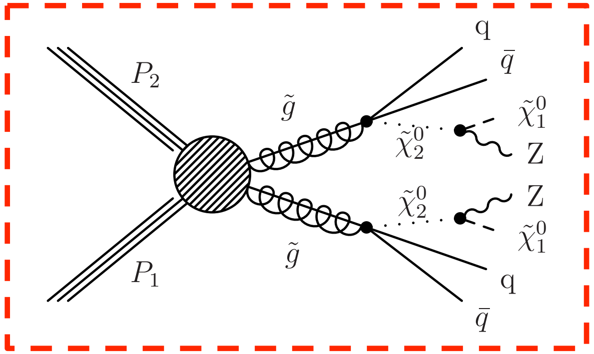
SUSY is not dead yet
115-130 GeV Higgs tailor made for SUSY

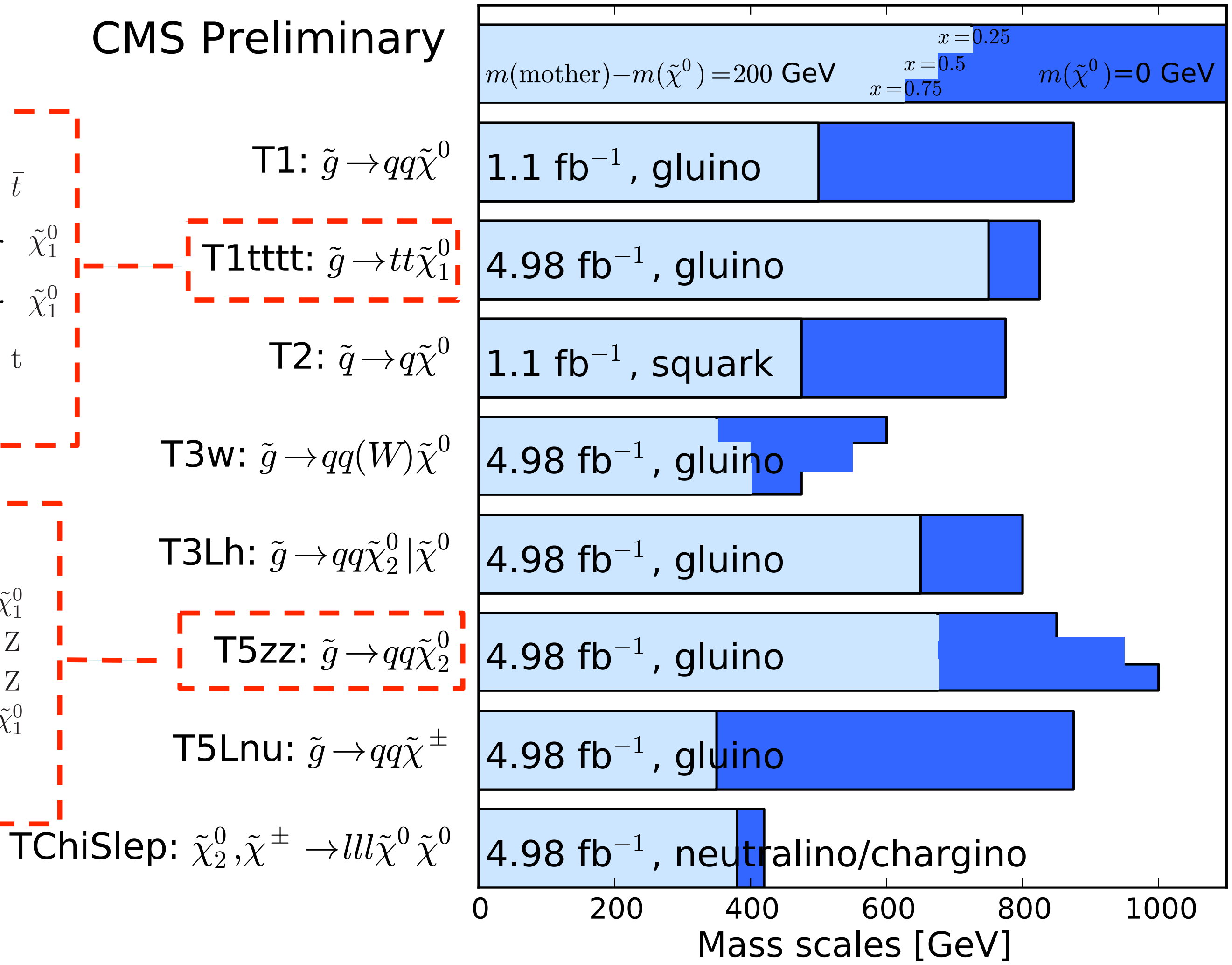
More complicated (and interesting) "natural" SUSY models still plentiful

Explore general mass spectra (e.g. « simplified models ») or exceptional (e.g. multileptons, mono-photons) topologies !

Supersymmetry: Simplified Models



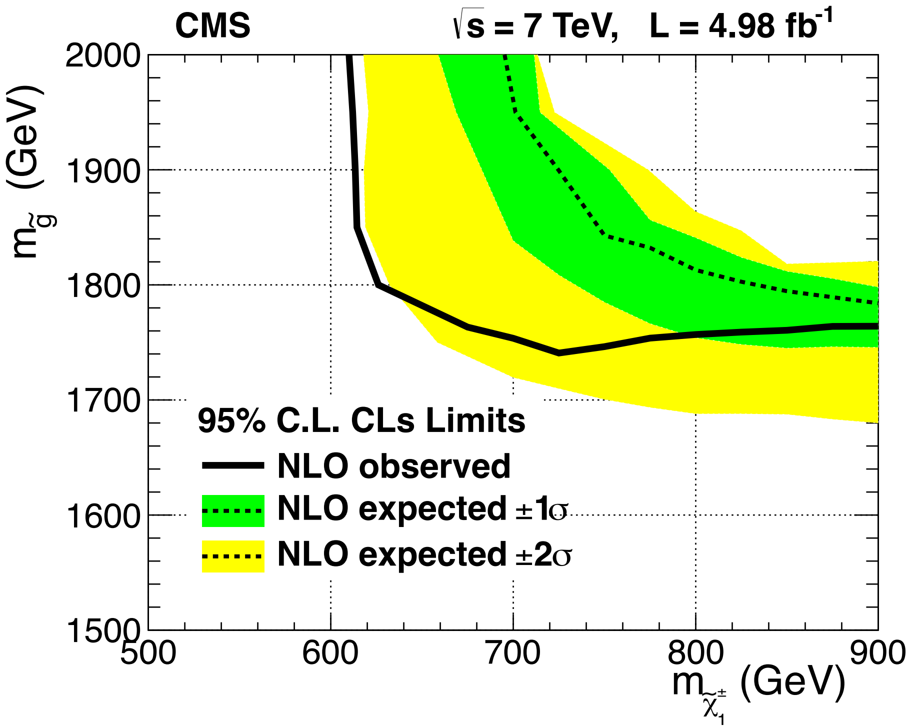




CMS performed a comprehensive search with "Simplified Models"

CMS-SUS-11-021 + CMS-SUS-11-016

Search for Anomalous Production of Multilepton Events



Search for anomalous production of events with 3 or 4 isolated leptons (e, mu, or tau)

cMSSM with neutralino or gravitino LSP

SUSY with R-parity violating couplings

GMSB in the so-called "slepton co-NLSP" scenario

Selection	$N(\tau_h)=0$ obs	$N(\tau_h)=0$ expected	$N(\tau_h)=1$ obs	$N(\tau_h)=1$ expected	$N(\tau_h)=2$ obs	$N(\tau_h)=2$ expected
4 Lepton results						
4ℓ $E_T^{miss} > 50$, $H_T < 200$, no Z	1	0.20 ± 0.07	3	0.59 ± 0.17	1	1.5 ± 0.6
4ℓ $E_T^{miss} > 50$, $H_T < 200$, Z	1	0.79 ± 0.21	4	2.3 ± 0.7	0	1.1 ± 0.7
4ℓ $E_T^{miss} < 50$, $H_T < 200$, no Z	1	2.6 ± 1.1	5	3.9 ± 1.2	17	10.6 ± 3.2
4ℓ $E_T^{miss} < 50$, $H_T < 200$, Z	33	37 ± 15	20	17.0 ± 5.2	62	43 ± 16

CMS-SUS-11-013

CMS « **Exotica** » Papers	Full Datasets at $\sqrt{s}$ = 7 TeV		$\mathcal{L}$ ~ 4.7 - 5 fb^{-1}	
X → $\ell^+ \ell^-$	EXO-11-019	PLB	arXiv:submit/0490787	Jun. 2012
Long lived Q±	EXO-11-022	PLB	arXiv:1205.0272v1	May 2012
W′ → $\ell \nu$	EXO-11-024	JHEP	arXiv:1204.4764v1	Apr. 2012
Z′ → t anti-t	EXO-11-006	JHEP	arXiv:1204.2488v1	Apr. 2012
Heavy b′	EXO-11-036	JHEP	arXiv:1204.1088v1	Apr. 2012
Heavy t′ (pair prod.)	EXO-11-050	PLB	arXiv:1203.5410v1	Mar. 2012
DM and extra-dim.	EXO-11-096	PRL	arXiv:1204.0821v1	Apr. 2012
Large extra-dim.	EXO-11-087*	PLB	arXiv:1202.3827v	Feb. 2012
μ - Black holes	EXO-11-071	JHEP	arXiv:1202.6396v1	Mar. 2012
q*	EXO-11-017*	JHEP	arXiv:1202.5535v1	Feb. 2012

* $\mathcal{L}$ ~ 2 fb^{-1}

Most recent post-Moriond

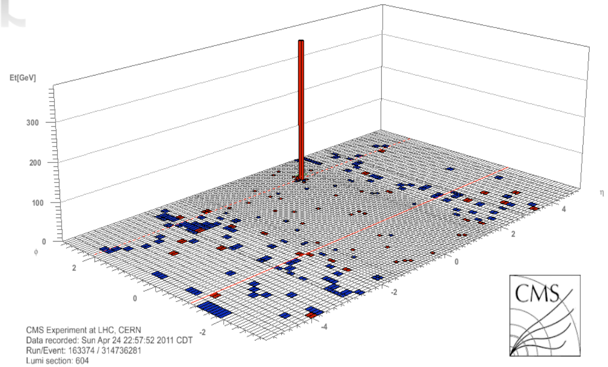
CMS Physics Analysis Summaries (PAS)		
X → t anti-t	EXO-11-093	Jun. 2012
X → Z Z → 4μ	EXO-11-025	May 2012
X → V Z	EXO-11-081	May 2012
G* → ZZ →2l2q	EXO-11-102	May 2012
Contact Int.	EXO-11-009	May 2012

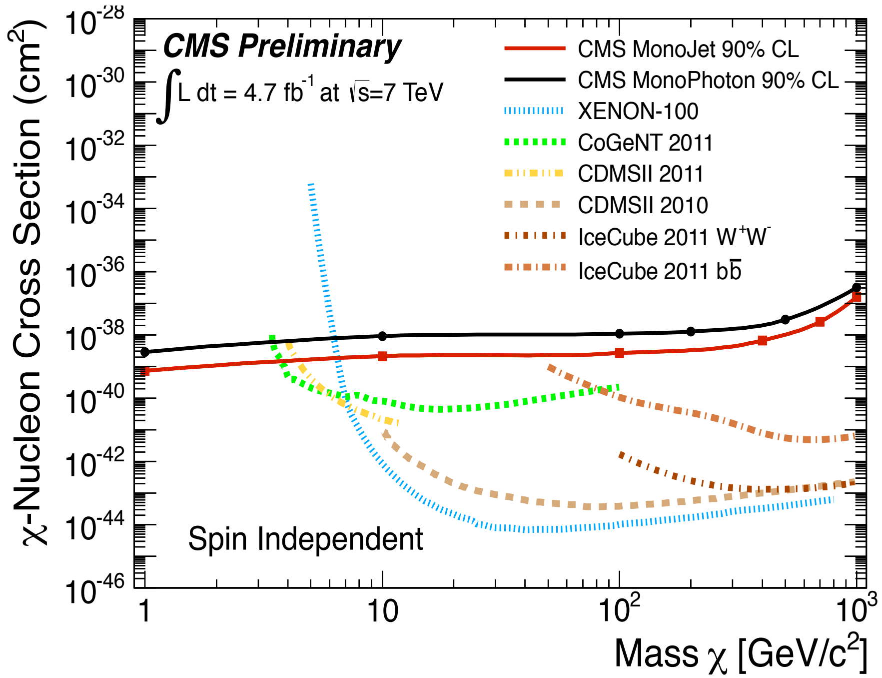
CMS Physics Analysis Summaries (PAS)		
W′ → t b	EXO-12-001	Apr. 2012
W′ → t d	EXO-11-056	May 2012

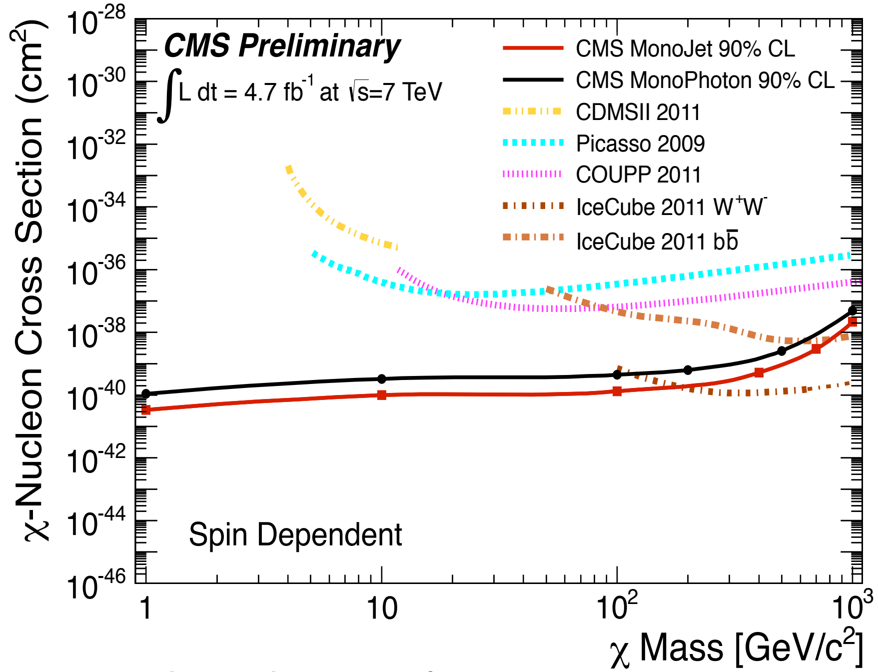
Search for Dark Matter

See J. Varela,
109th LHCC – 21 Mars 2012

- Look for « nothing » + monophoton or monojet
- Probe the same effective operators as in direct detection
- High sensitivity to spin dependent couplings







Spin-independent couplings

Extend limits to low masses where nuclear recoil imposes a threshold for direct detection

Spin-dependent Couplings

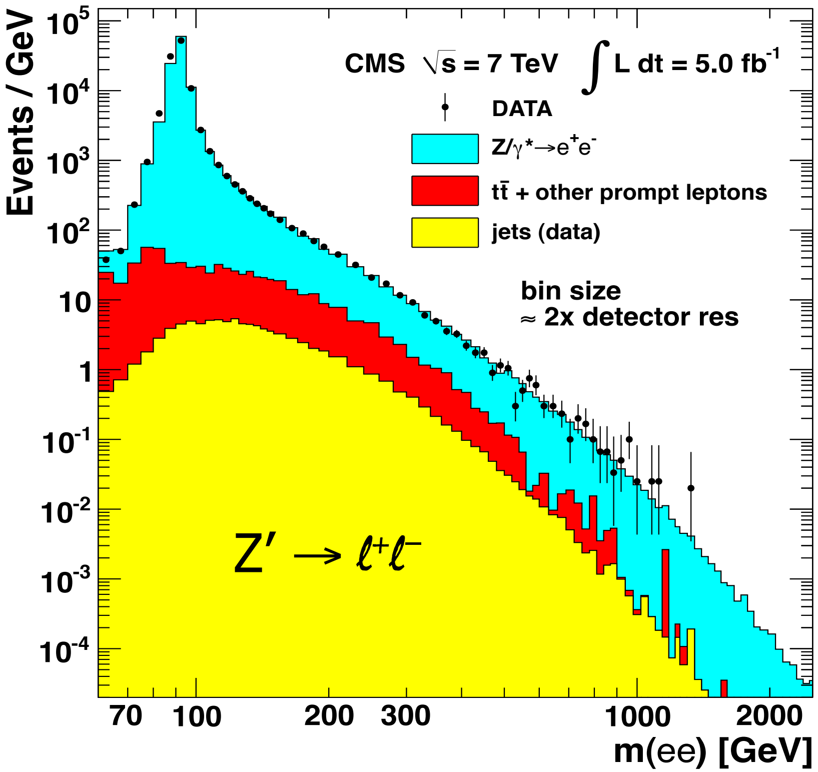
Limits beyond Direct searches

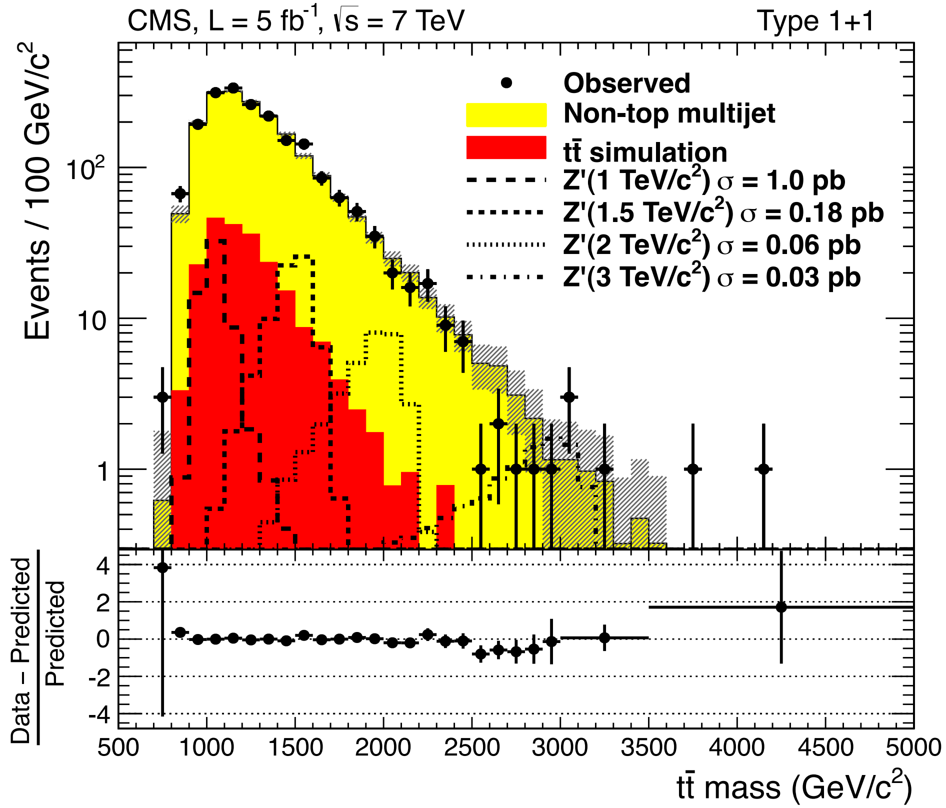
Assume heavy mediator (simple CI assumtion)

Limits weakened for light mediators

EXO-11-096

Search for a Heavy Z′ Boson





Z'_{SSM} > 2330 GeV
Z'_{ψ} > 2000 GeV

G_{KK} > 2140 GeV (k/M_{Pl} = 0.1)
> 1810 GeV (k/M_{Pl} = 0.05)

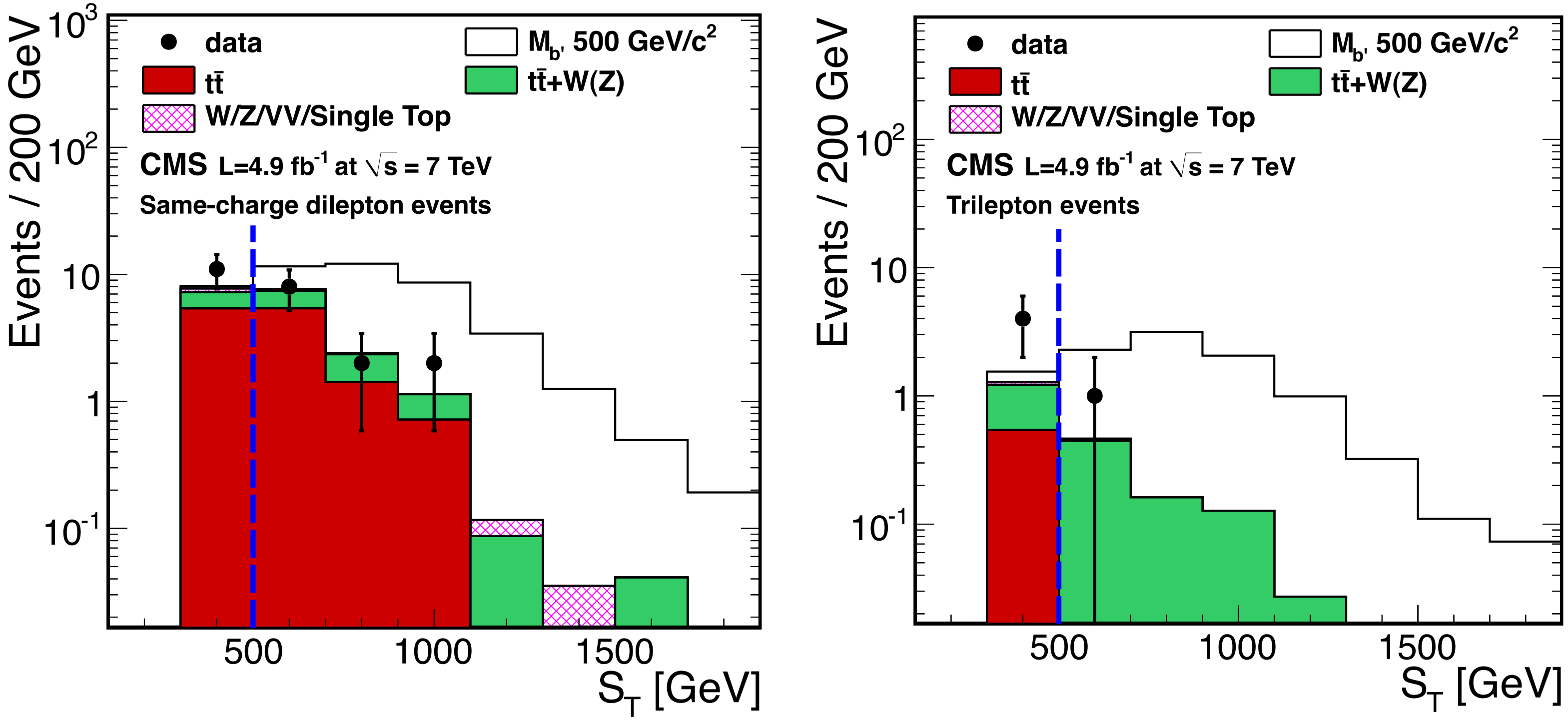
Topcolor Z′
Mass range 1-1.6 TeV
excluded for $\sigma_{Z'}/m_{Z'}$ = 3%

Most stringent constraints to date

EXO-11-019

Search for New Heavy Quarks

e.g. $b'\bar{b}' \to tW^-\bar{t}W^+ \to bW^+W^-\bar{b}W^-W^+$



b' -> tW- : b′ with masses below 611 GeV/c2 excluded at 95% CL
t' -> W+ b : t′ with masses below 557 GeV/c2 excluded at 95% CL
SM-Higgs of the SM4 is excluded now by CMS in the range 120-600 GeV

Have to explore Heavy Q in the context of BSM Physics !

EXO-11-036 + arXiv:1203.5410

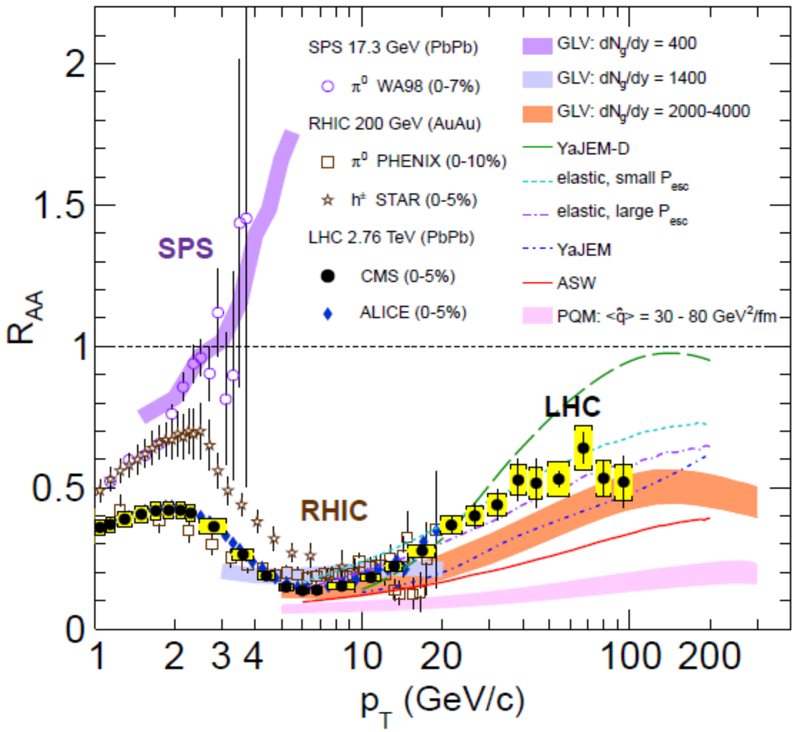
Heavy Ions and the QGP in CMS

15 published papers and a wealth of remarkable results !

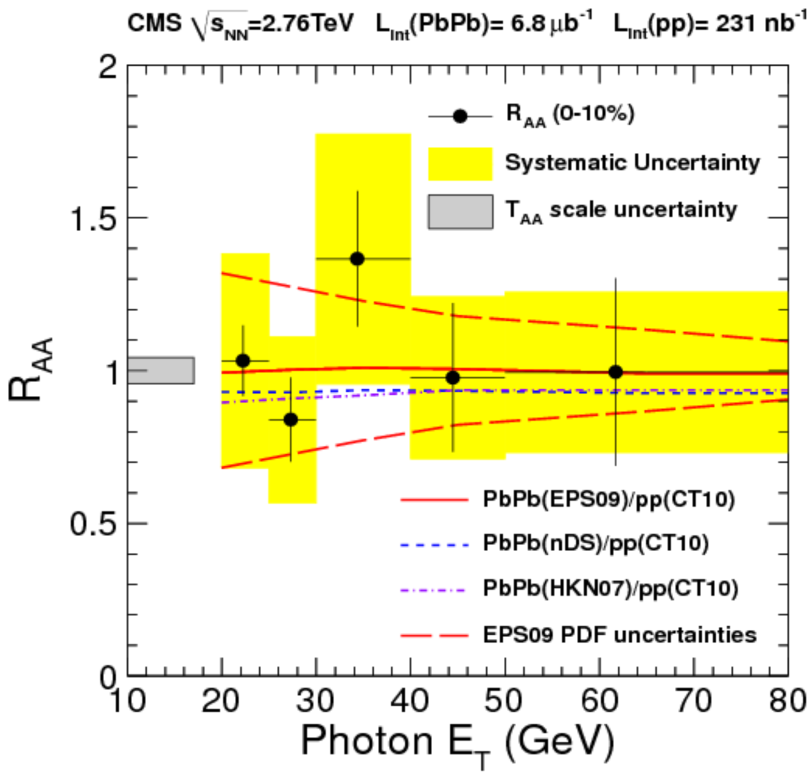
quarkonia suppression, jet quenching, azimuthal and elliptic anisotropy

Recall (J. Varela, 99th LHCC):

EPJC arXiv:1202.2554



PLB arXiv:1201.3093



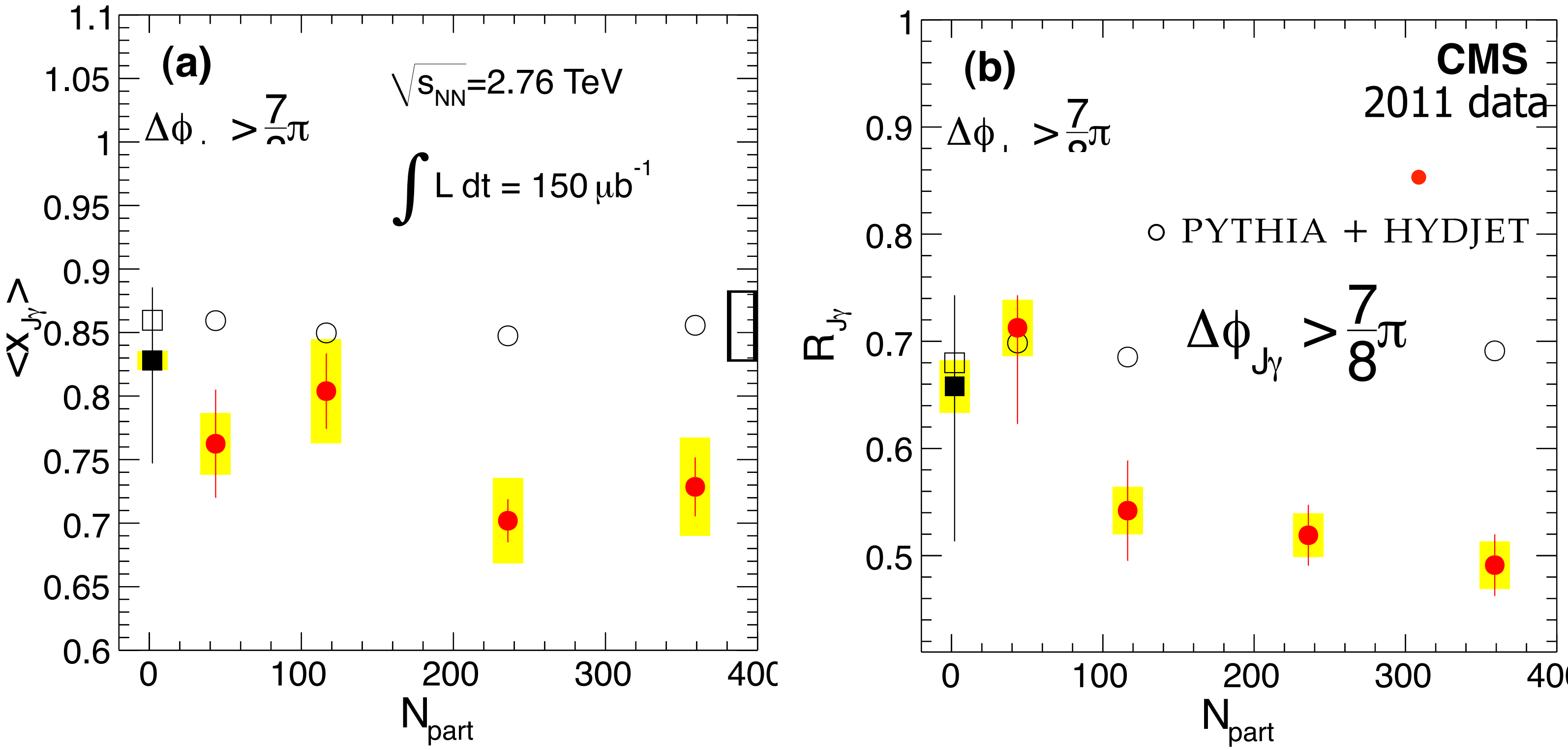
Hadrons up to p_T ~ 100 GeV/c are suppressed … γ's up to E_T 80 GeV are not

R_{AA} = (yield in PbPb) / (N equivalent pp collisions × yield in pp)

$R_{AA} < 1 \rightarrow$ suppression

Jet Quenching Using Isolated γ + jet

Very recent : use isolated γ as a « tag » to probe high p_T quark production and characterize its propagation in hot-dense medium



$$\langle x_{J\gamma}\rangle_{0-10\%} = 0.73 \pm 0.02(\text{stat.}) \pm 0.04(\text{syst.})$$

$$x_{J\gamma} = p_T^{\text{Jet}} / p_T^{\gamma}$$

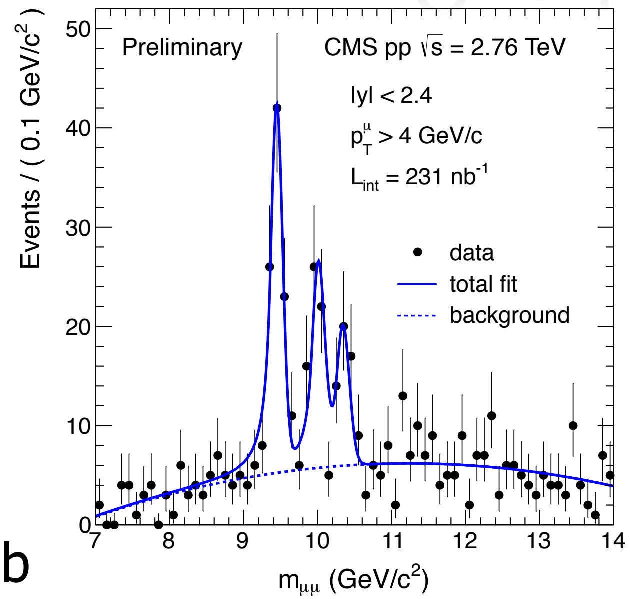
$$R_{J\gamma} = 0.49 \pm 0.03\ (\text{stat.}) \pm 0.02\ (\text{syst.})$$

= fraction of isolated photons that have an associated jet passing the analysis selection

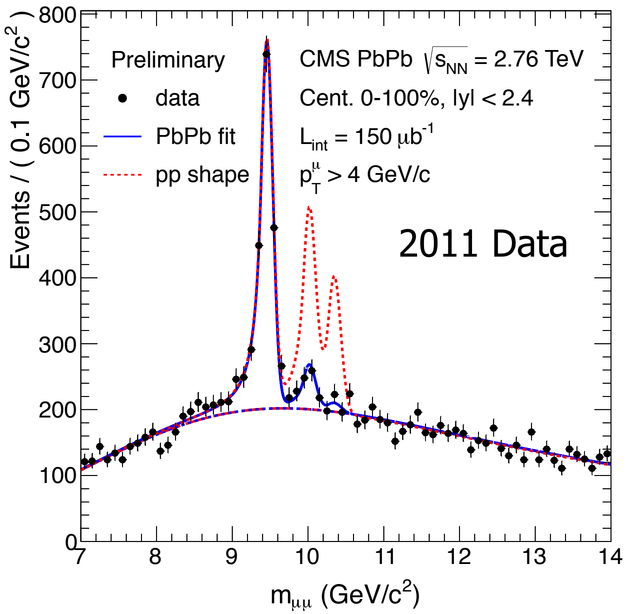
HIN-11-010

Quarkonia Suppression

pp

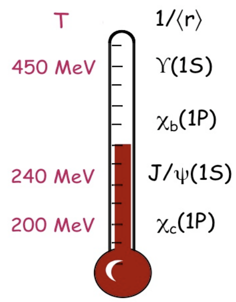


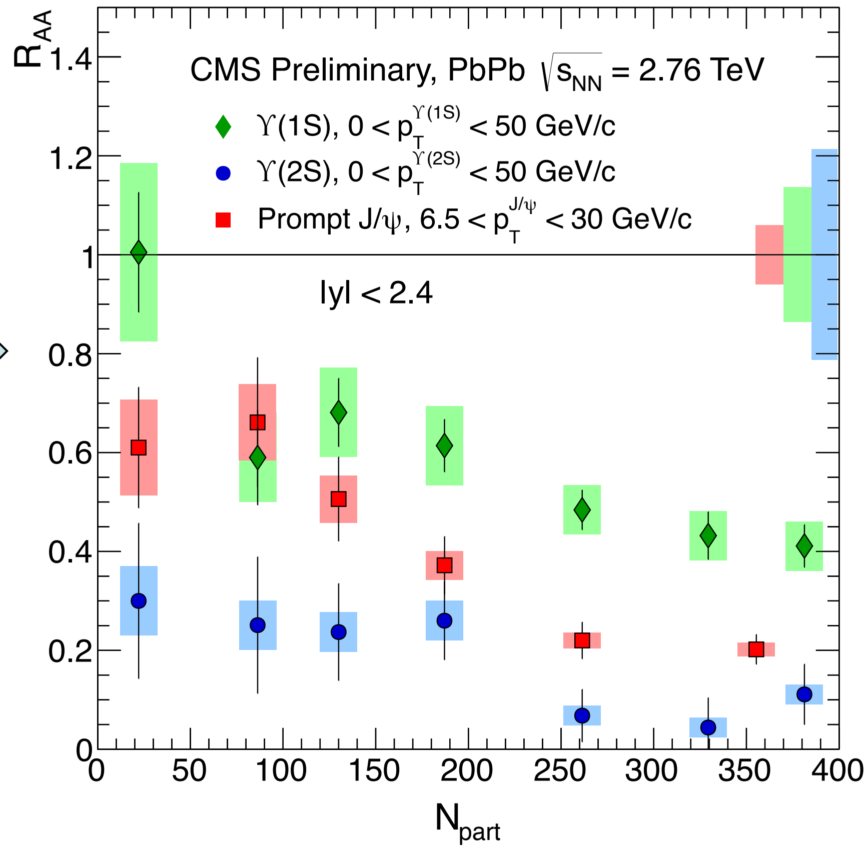
PbPb



Υ excited states and J/ψ are suppressed in PbPb relative to pp

A 'thermometer' of strongly interacting matter





Conclusions

- The CMS experiment experiment is operating at full regime and very high efficiency to collect large amount of data at $\sqrt{s}$ = 8 TeV
  > 2 x $\mathcal{L}_{2011}$ already collected !

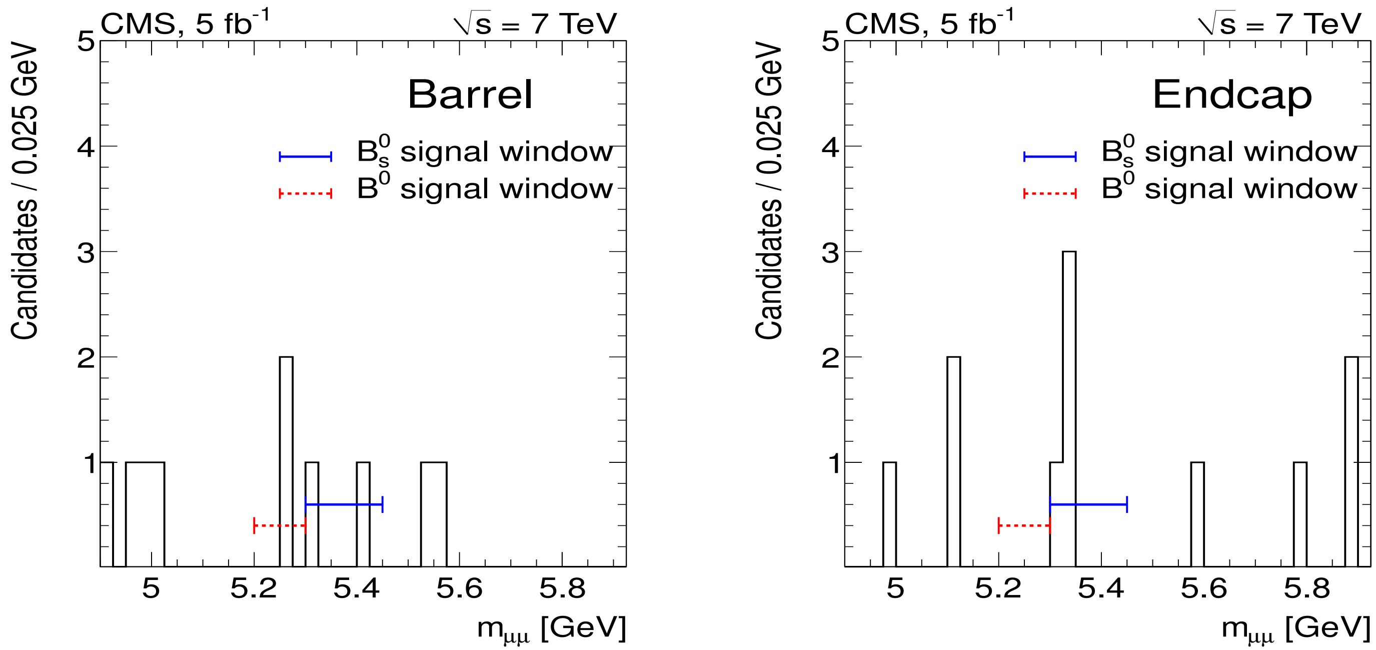
- The discovery (or exclusion) of the SM Higgs boson is in sight
  … the analysis have been improved and re-deployed under a strict blinding policy
  Opening of the « box » this week !

- High precision measurement of SM candles have been performed
  … and stringent constraints on BSM models have been established
  BSM Physics remains out of reach for the moment !
  (better hopes for $\sqrt{s}$ = 13 TeV ?)

And to conclude …

Many thanks to the LHC accelerator teams, and the many other institutes and people who made this possible !

Search for $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ decays



Variable	$B^0 \to \mu^+\mu^-$ Barrel	$B_s^0 \to \mu^+\mu^-$ Barrel	$B^0 \to \mu^+\mu^-$ Endcap	$B_s^0 \to \mu^+\mu^-$ Endcap
$\varepsilon_{\rm tot}$	0.0029 ± 0.0002	0.0029 ± 0.0002	0.0016 ± 0.0002	0.0016 ± 0.0002
$N^{\rm exp}_{\rm signal}$	0.24 ± 0.02	2.70 ± 0.41	0.10 ± 0.01	1.23 ± 0.18
$N^{\rm exp}_{\rm peak}$	0.33 ± 0.07	0.18 ± 0.06	0.15 ± 0.03	0.08 ± 0.02
$N^{\rm exp}_{\rm comb}$	0.40 ± 0.34	0.59 ± 0.50	0.76 ± 0.35	1.14 ± 0.53
$N^{\rm exp}_{\rm total}$	0.97 ± 0.35	3.47 ± 0.65	1.01 ± 0.35	2.45 ± 0.56
$N_{\rm obs}$	2	2	0	4

upper limit (95%CL)	observed	expected
$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	7.7×10^{-9}	8.4×10^{-9}
$\mathcal{B}(B^0 \to \mu^+\mu^-)$	1.8×10^{-9}	1.6×10^{-9}

JHEP04 (2012) 033

Higgs Production and Decay at the LHC