



### CMS STATUS REPORT

A. David (LIP, Lisboa) for the CMS Collaboration



### Data just keeps pouring

2

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

### Thanks to the LHC !

- Doubled the 8 TeV dataset.
- 50% more luminosity in total by now.
- Looking forward to the rest of the year.

CMS Total Integrated Luminosity, p-p otal Integrated Luminosity (fb <sup>-1</sup>) 2011. √s = 7 TeV 16 16 2012. √s = 8 TeV 14 14 12 12 10 10 110<sup>th</sup> 8 LHCC 6 2 02/05 02/07 01/09 Time in year



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

- New online procedures reduced inefficiencies:
  - □ from 7.7% (April-June).
  - **To** 4.9 % (July-Aug).
- Solenoid fast discharge:
  - ~0.5/fb recorded without magnetic field.
  - B=0 collision data used for alignment and calibration.





### Detector channel count

 Largest change:
 Recovery of 75 ECAL endcap channels.



Fraction (%)



#### [CMS-DP-2012-015]

- Reaping the benefits:
  - Automated 48-hour calibration loop.
  - New solid state monitoring laser.
- $\Box$  No surprises with >7e33.



# LHC: now serving up to 7.5e33 cm<sup>-2</sup>s<sup>-1</sup>

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

### Record-breaking fill:

- L1 rate steady near 100 kHz limit.
- 5% dead-time initially but drops very quickly.

### 8e33 trigger menu ready.

 Requires some cutting into the physics.

### Data parking in place.

300+ Hz saved for reconstruction in 2013.

### Data scouting in place.

 High rate, small event content.

![](_page_5_Figure_12.jpeg)

![](_page_6_Picture_0.jpeg)

 Weekly updated corrections for signal response.

Much sharper turn-on in forward region.

![](_page_6_Figure_3.jpeg)

![](_page_7_Picture_0.jpeg)

- Tighter η roads in L1 track finders.
- □ 50% smaller muon rate.
  - With a small efficiency loss.

![](_page_7_Figure_4.jpeg)

![](_page_8_Picture_0.jpeg)

- Increase jet seed thresholds to 5 GeV.
- Much better high-lumi. rate behavior.
  - No physics impact.

![](_page_8_Figure_4.jpeg)

![](_page_9_Picture_0.jpeg)

Tighter quality criteria on isolation tracks.

10

- $\Box$  Higher  $\mathcal{T}$  trigger efficiency.
  - Improvement for  $H \rightarrow \tau \tau$ search.

![](_page_9_Figure_4.jpeg)

![](_page_10_Picture_0.jpeg)

![](_page_10_Figure_1.jpeg)

Since 110<sup>th</sup> LHCC:
35 new submissions for publication
http://goo.gl/7L7vj
75 new public Physics Analysis Summaries
http://goo.gl/VSGw0

![](_page_11_Picture_0.jpeg)

Submitted for publication

12

![](_page_11_Figure_2.jpeg)

Physics Analysis Summaries

![](_page_11_Figure_4.jpeg)

![](_page_12_Picture_0.jpeg)

# **Highlights: B and Forward Physics**

13

#### [BPH-11-003] [arXiv:1209.2922] [arXiv:1209.1666]

![](_page_12_Figure_4.jpeg)

![](_page_13_Picture_0.jpeg)

14

# **Highlights: Heavy-lon physics**

[HIN-10-005, HIN-11-008/002, HIN-12-008/014] [HIN-12-003, 004] [arXiv:1208.2826] [arXiv:1208.2826, HIN-12-007, 014]

![](_page_13_Figure_3.jpeg)

![](_page_14_Picture_0.jpeg)

15

# **Highlights: Electroweak physics**

[SMP-12-005, 007, 011, 013, 014] [SMP-12-009]

![](_page_14_Figure_3.jpeg)

A. David (LIP, Lisboa)

![](_page_15_Picture_0.jpeg)

# Top pair production at 8 TeV

16

![](_page_15_Figure_3.jpeg)

![](_page_16_Picture_0.jpeg)

## Single top production at 8 TeV

#### [TOP-12-011]

![](_page_16_Figure_3.jpeg)

![](_page_17_Picture_0.jpeg)

### Highlights: top properties

18

[TOP-11-018] [arXiv:1207.0065] [TOP-12-019] [arXiv:1208.0957] [TOP-12-024]

### $m_{\rm t} = 173.36 \pm 0.38$ (stat.) $\pm 0.91$ (syst.) GeV

![](_page_17_Figure_5.jpeg)

A. David (LIP, Lisboa) CMS at LHCC 111

Charge asymmetry

![](_page_18_Picture_0.jpeg)

### Highlights: SUSY at 8 TeV

19

[SUS-12-016] [SUS-12-017]

![](_page_18_Figure_3.jpeg)

![](_page_18_Figure_4.jpeg)

![](_page_19_Picture_0.jpeg)

20

# SUSY: CMSSM sweeping

[SUS-11-022, SUS-12-005/010, arXiv:1204.5341/1205.6615/1206.3949/1207.1798/1207.1898]

- The low-hanging fruits of light SUSY have been swept away.
- Next up: naturalness.
  - Search for stops and sbottoms in gluino decays.
  - Direct search for light stop and sbottom.
  - Chargino and neutralino production.

![](_page_19_Figure_8.jpeg)

# Stop and sbottom searches

[SUS-11-020/022/024/027, SUS-12-005/009, arXiv:1207.1798/1208.4859] [SUS-11-022/024, arXiv:1207.1798/1208.4859] [SUS-11-022/024, SUS-12-005]

#### Stop and sbottom in gluino decays

![](_page_20_Figure_3.jpeg)

![](_page_20_Figure_4.jpeg)

### More dedicated searches in the works

A. David (LIP, Lisboa) CMS at LHCC 111

21

![](_page_21_Figure_0.jpeg)

![](_page_22_Picture_0.jpeg)

# Highlights: Exotica reach with 8 TeV

23

#### [EXO-12-015] [EXO-12-010] [EXO-12-016] [EXO-12-009]

![](_page_22_Figure_4.jpeg)

![](_page_23_Picture_0.jpeg)

# **Exotica: Search for Dark Matter**

![](_page_23_Figure_2.jpeg)

- □ Use photon or jet ISR to tag production of DM particles.
  - Process very similar to that assumed in direct detection experiments.
  - Exceeds sensitivity of cryogenic searches for DM in spin-dependent DM couplings.
  - Adds sensitivity to light (M < 10 GeV) DM also for spin-independent couplings (where direct searches are most sensitive due to coherent scattering  $\sim A^2$ ).

![](_page_24_Figure_0.jpeg)

![](_page_25_Picture_0.jpeg)

### Looking up to a new boson

#### 26

![](_page_25_Picture_3.jpeg)

![](_page_25_Picture_4.jpeg)

![](_page_26_Picture_0.jpeg)

#### [arXiv:1207.7235]

27

# □ Highest sensitivity in the channels with the best mass resolution: $H \rightarrow Z Z$ , and $H \rightarrow \gamma \gamma \gamma$ .

![](_page_26_Figure_3.jpeg)

![](_page_27_Picture_0.jpeg)

#### [arXiv:1207.7235]

28

# Background fluctuations cannot explain the data at the 5.0 $\sigma$ level.

Main drivers are the high resolution channels.

![](_page_27_Figure_4.jpeg)

![](_page_28_Picture_0.jpeg)

![](_page_29_Picture_0.jpeg)

30

# Inclusive Higgs m $_{\gamma \gamma}$ resolution

#### [HIG-11-010] [HIG-11-021] [HIG-12-001] [HIG-12-015]

![](_page_29_Figure_3.jpeg)

![](_page_30_Picture_0.jpeg)

### Global significance > $3.2 \sigma$

### Data combined using S/(S+B)

![](_page_30_Figure_4.jpeg)

![](_page_30_Figure_5.jpeg)

![](_page_31_Picture_0.jpeg)

32

CMS Experiment at the LHC, CERN Data recorded: 2012-May-27 23:35:47.271030 GMT Run/Event: 195099 / 137440354

![](_page_32_Picture_0.jpeg)

[HIG-12-016]

### Significance slightly short of expectation

![](_page_32_Figure_3.jpeg)

### **Mass distribution**

![](_page_32_Figure_5.jpeg)

A. David (LIP, Lisboa) CMS at LHCC 111

33

![](_page_33_Picture_0.jpeg)

34

### The low mass resolution channels

#### [HIG-12-

Decay	Production	No. of	$m_{\rm H}$ range	Int. Lum. $(fb^{-1})$	
mode	tagging	subchannels	(GeV)	7 TeV	8 TeV
WW	untagged	4	110–600	4.9	5.1
	dijet (VBF)	1 or 2			
ττ	untagged	16	110–145	4.9	5.1
	dijet (VBF)	4			
bb	lepton, $E_{\rm T}^{\rm miss}$ (VH)	10	110–135	5.0	5.1

![](_page_33_Figure_4.jpeg)

![](_page_34_Picture_0.jpeg)

### **Combined** results

#### [HIG-12-020]

![](_page_34_Figure_3.jpeg)

![](_page_34_Figure_4.jpeg)

![](_page_35_Picture_0.jpeg)

### Mass of the new resonance

36

[HIG-12-020]

Combination assuming SM relative production and decay fractions.

![](_page_35_Figure_4.jpeg)

Model-independent mass measurement from the high-resolution channels:  $m_x = 125.3 \pm 0.6 \text{ GeV}$ 

![](_page_35_Figure_6.jpeg)

![](_page_36_Picture_0.jpeg)

## $\rightarrow$ WW shape-based analysis

#### 7

[HIG-12-038]

- Discovery result used
  - cut-based analysis of
  - same-flavor (ee / μ μ) and different-flavor (e μ) samples.
- Same-flavor DY+MET background hard to model with high PU.
- Shape-based, differentflavor is the basis for future updates.

![](_page_36_Figure_8.jpeg)

![](_page_37_Picture_0.jpeg)

38

# ttH, $H \rightarrow bb$ : the power of tagging

#### [HIG-12-025]

- tt(lepton+jets) and tt(dilepton)
  - Count b-tags
  - Shape analysis

![](_page_37_Figure_6.jpeg)

![](_page_37_Figure_7.jpeg)

![](_page_38_Picture_0.jpeg)

[FIIG-12-020]

39

- Exploit more exclusive channels.
- Characterize the new state with 8 TeV data.
  - How does it couple to other particles ?
  - What are its spin and parity ?

![](_page_38_Figure_6.jpeg)

![](_page_39_Picture_0.jpeg)

### Conclusions

![](_page_39_Picture_2.jpeg)

### **CMS running more efficiently.**

- Unfortunate infrastructure down times.
- Constant adaptation to collision environment.

### Physics analysis proceeding at full speed.

- Impressive description of LHC data by Standard Model.
   A tribute to decades of theoretical work.
- Discovery of new boson is a great accomplishment for the field. Much work ahead to characterize it.
- CMS is working hard to leave no stone unturned.
  - Looking forward to surprises.

![](_page_40_Picture_0.jpeg)

![](_page_41_Picture_0.jpeg)

# Matrix Element Likelihood Analysis

[HIG-12-016]

![](_page_42_Figure_2.jpeg)

Uses kinematic inputs for signal to background discrimination  $\{m_1, m_2, \theta_1, \theta_2, \theta^*, \Phi, \Phi_1\}$ 

$$\mathbf{K}_{\mathsf{D}} = \left[1 + \frac{\mathcal{P}_{\mathsf{bkg}}(m_1, m_2, \theta_1, \theta_2, \Phi, \theta^*, \Phi_1 | m_{4\ell})}{\mathcal{P}_{\mathsf{sig}}(m_1, m_2, \theta_1, \theta_2, \Phi, \theta^*, \Phi_1 | m_{4\ell})}\right]^{-1}$$

- For signal, use fully analytic parameterization
- For BG use a simulation of the process  $q\overline{q} \rightarrow ZZ/Z\gamma$

![](_page_42_Figure_7.jpeg)

![](_page_43_Picture_0.jpeg)

# Results from 2D distributions

#### [HIG-12-016]

- $K_D$  discriminant versus  $m_{41}$
- Data points shown with per-event mass uncertainties
- Six simultaneous two-dimensional maximum likelihood fits for each value of m<sub>H</sub>, in the variables m<sub>41</sub> and K<sub>D</sub>.

![](_page_43_Figure_6.jpeg)

Data w.r.t. background expectation

![](_page_44_Picture_0.jpeg)

# Results from 2D distributions

#### [HIG-12-016]

### 2D fit results:

- The minimum local p -value occurs at m<sub>H</sub> = 125.6 GeV and has a significance of 3.2 (expected 3.8).
- The best-fit signal strength for a SM Higgs boson mass hypothesis of 125.6 GeV is 0.7+0.4-0.3

![](_page_44_Figure_6.jpeg)

Data w.r.t 126 GeV Higgs Expectation