



Status of the CMS experiment



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On behalf of the CMS Collaboration
(CIEMAT-Madrid)

IV CPAN days
26-28/Nov/2012 - Granada



**Signalizing topics with Spanish
contribution with the symbol**

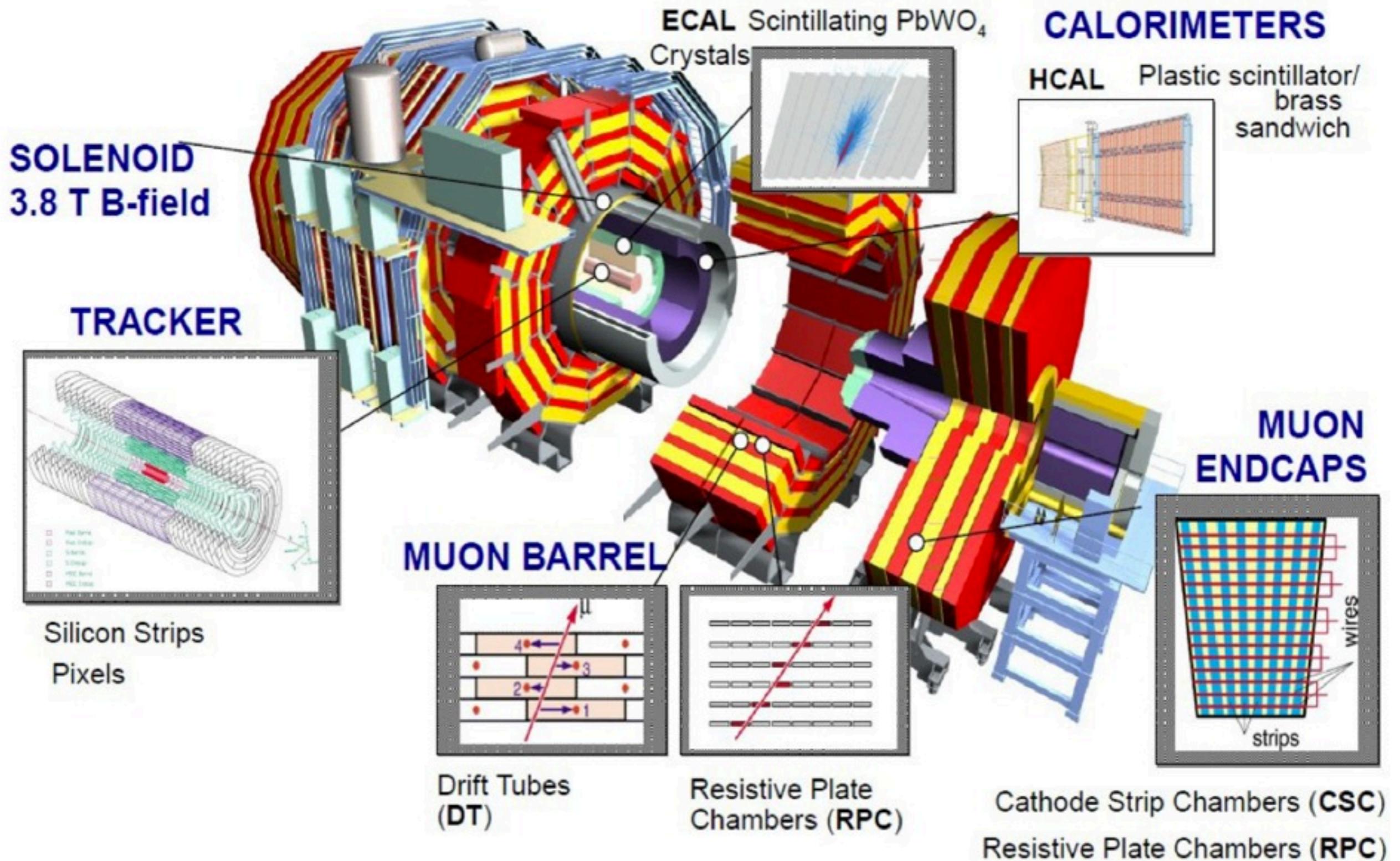




Detector performance in 2012

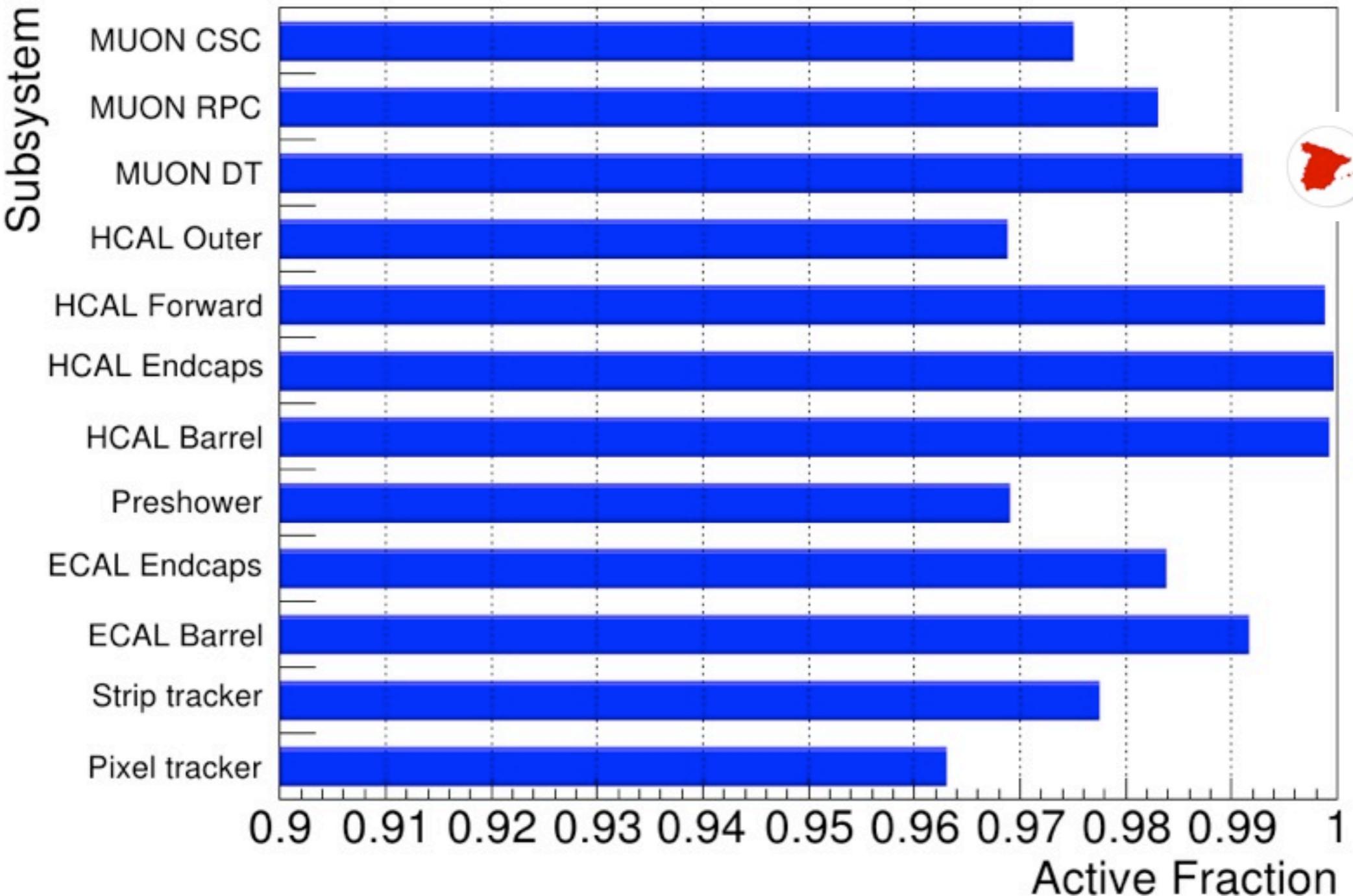


CMS detector



Sub-detector activity fraction

CMS Preliminary - June 2012



excellent performance

all detectors functioning at **>96%** capacity, after ~3 years with no access to CMS internal detector

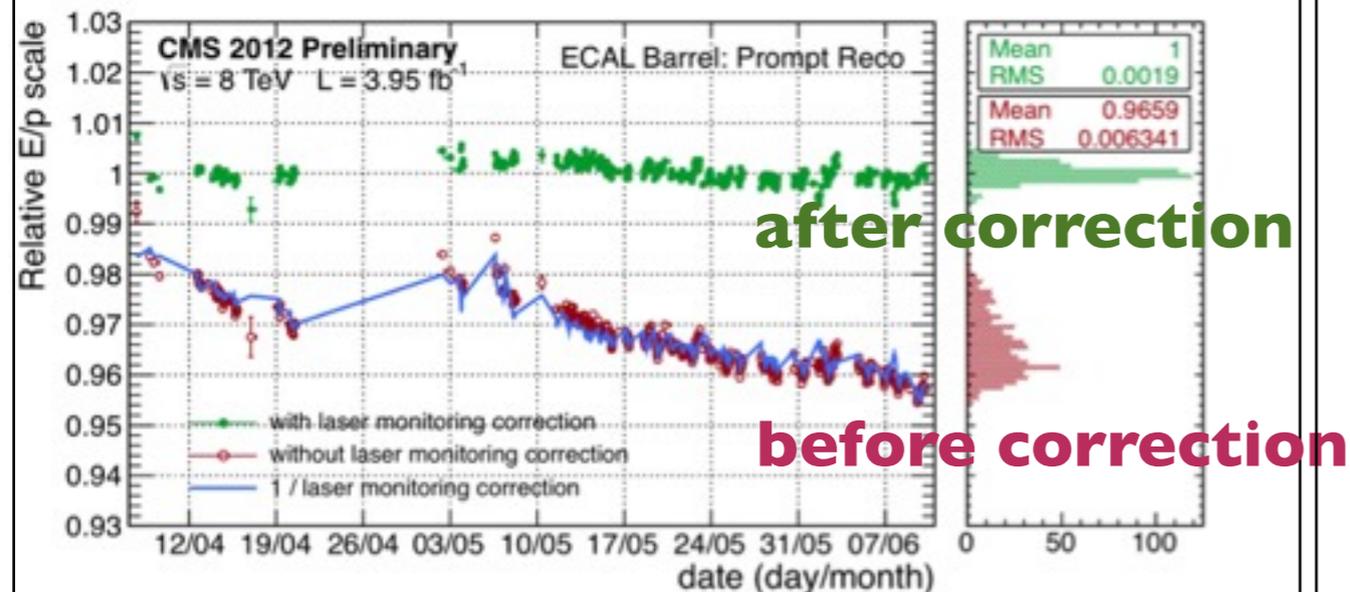
and only few months before LHC shutdown

Detector performance (examples)

CMS DP-12-015

ECAL performance

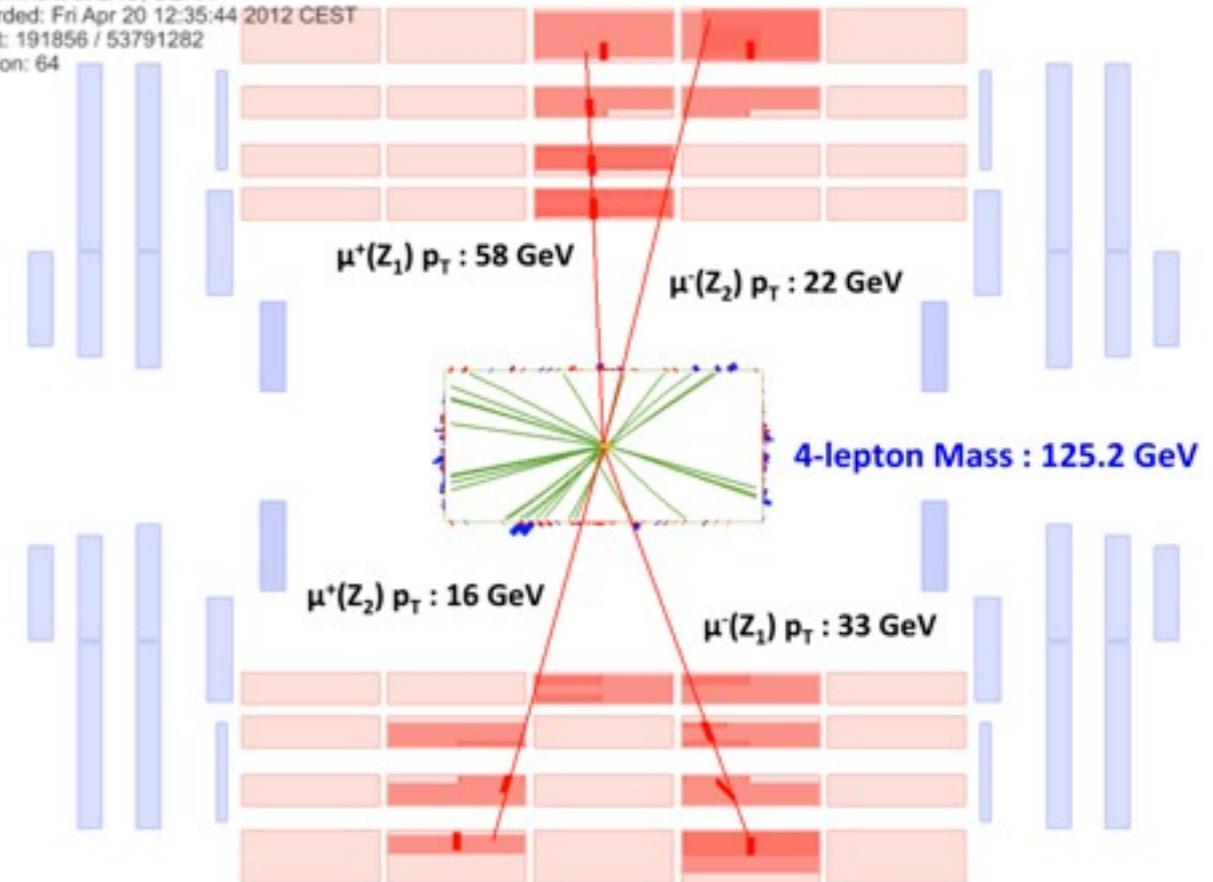
- Light system implemented: crystal response measured using laser monitoring calibration
- Raw data affected by dose rate, integrated charge on VPT photocathode (ECAL): corrections ready in 48h
- 25% improvement on diphoton mass resolution



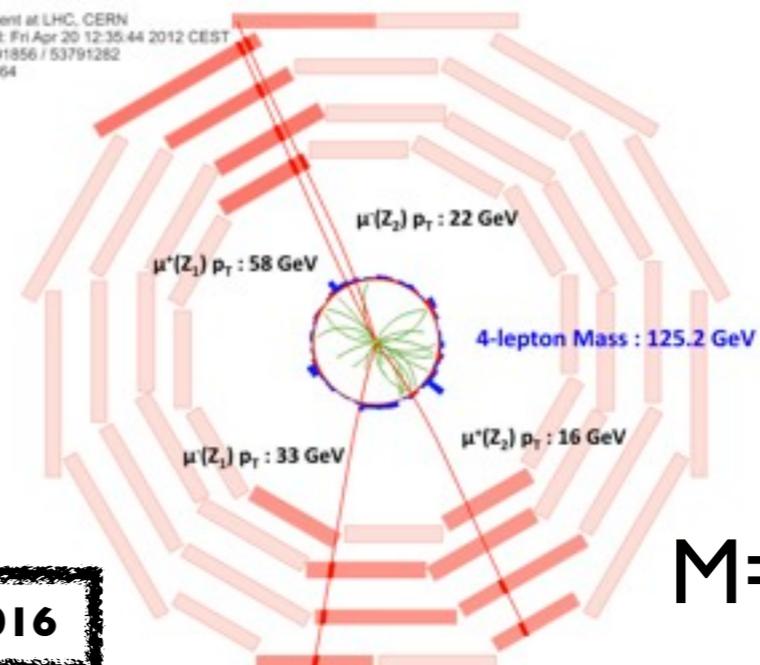
- Single electron E/p stability (ECAL Barrel)

Muon Drift Tubes (DT)

CMS Experiment at LHC, CERN
Data recorded: Fri Apr 20 12:35:44 2012 CEST
Run/Event: 191856 / 53791282
Lumi section: 64



CMS Experiment at LHC, CERN
Data recorded: Fri Apr 20 12:35:44 2012 CEST
Run/Event: 191856 / 53791282
Lumi section: 64



A Higgs candidate:
 $ZZ \rightarrow 4\mu$

$M = 125.2 \text{ GeV}^2$

PAS HIG-12-016

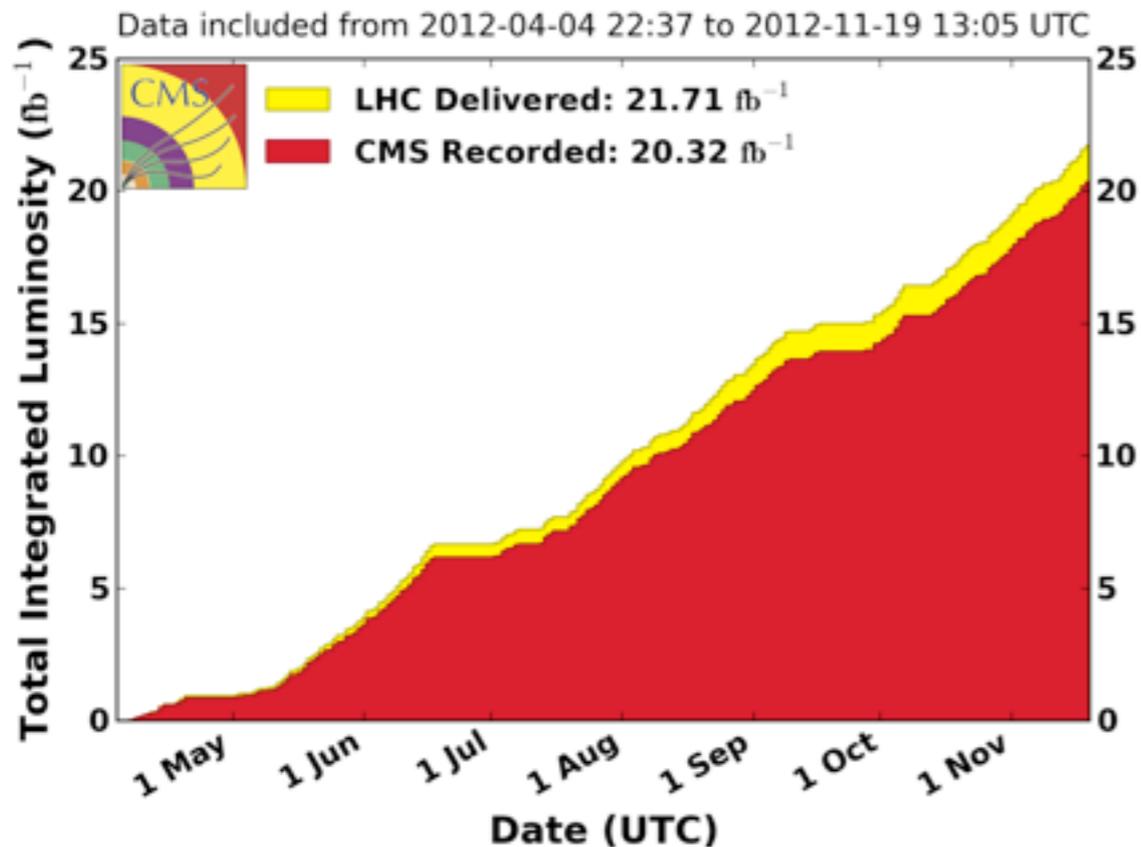


LHC performance



Luminosity, trigger impressive numbers

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



Reaching 10^{34} cm⁻²s⁻¹: **10⁹ collisions/s**

Trigger: decides if the event is worth keeping
 ↗ discard it otherwise

Two steps:

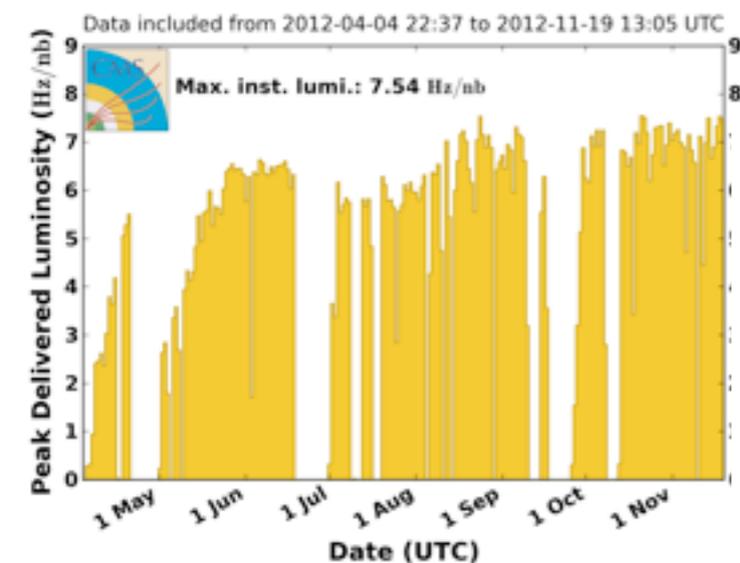
- . LI - fast decision, simple algorithms
- . HLT - computer farm where fast processing is possible; event 'partially' reconstructed

Goal:

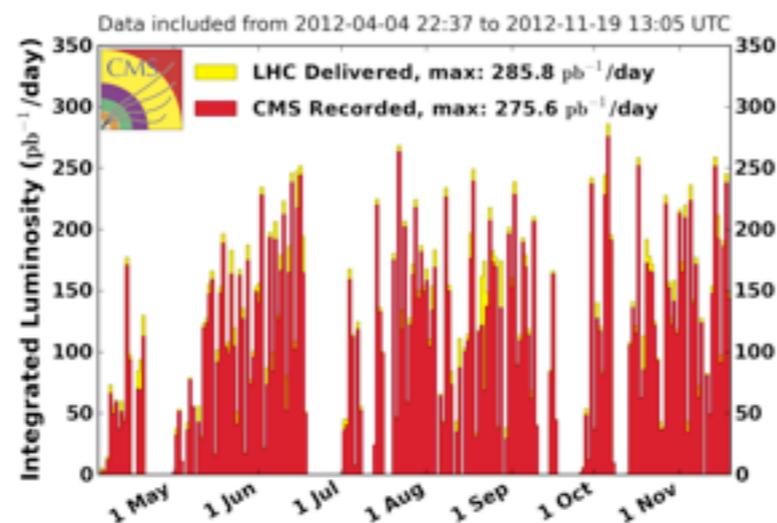
- . HLT gets ~100kHz ("good events")
- . store typically **a few 100 Hz** from those, high-p_T objects ("worth keeping" - should contain the physics we want to see!)

Setback: events not stored are lost forever
(what if we missed new physics?)

CMS Peak Luminosity Per Day, pp, 2012, $\sqrt{s} = 8$ TeV



CMS Integrated Luminosity Per Day, pp, 2012, $\sqrt{s} = 8$ TeV



To know how impressive those numbers are, compare:

- RunII period (2002-2011), Tevatron collected **10.5 fb⁻¹**
- LHC 2010 year, collected ~**40 pb⁻¹** (PicoBarns!)
- LHC 2011 year, collected >~ **5 fb⁻¹**



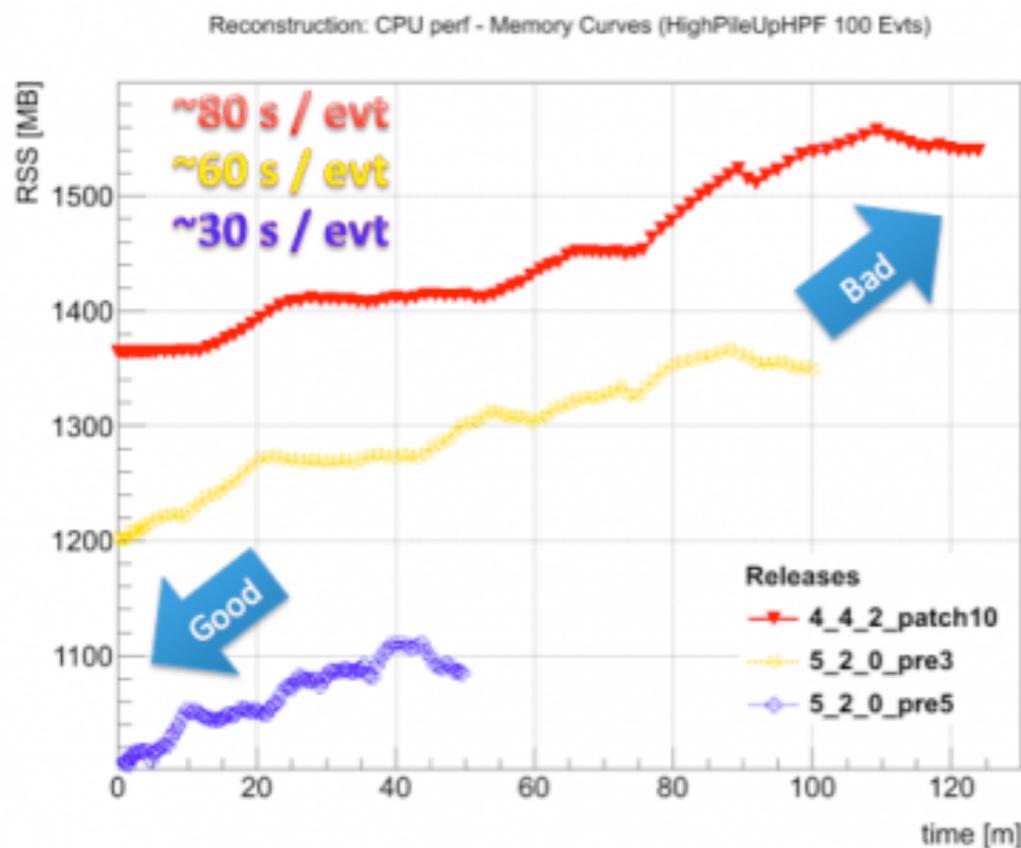
Surviving in high-luminosity and high pile-up scenario

CMS 2012 strategy



Data handling: software

- **Handling such enormous amount of data is a real challenge!**
- First action: optimize the software performance, both online and offline
 - improvements on software algorithm, expanded HLT farm



additional CPU power, updated Linux kernel&compilers..., better algorithms:

more than double speed/event

over 33% memory reduction

- But... actually, **processing** the data much more costly than **collecting and storing it**, so...
- Why not increase recorded data beyond current ability to process it?
 - collect much more data now - no immediate processing possible
 - reconstruct and analyze when computing resources are available (e.g. long shutdown starting in 2013)

Data Parking

- As in August/2012
 - Trigger Rate for “Prompt-reconstruction”: 405 Hz
 - **Trigger Rate for “Parked data”: 304 Hz (now: 600 Hz)**
 - *Keeping almost x2 of additional data that before was discarded!*
- “Prompt-reco”: data ready for analysis within a day
- “Parked data”: to be reconstructed next year. *Small fraction already being processed.*

Data scouting

However: must make sure additional data is not worthless

- Open the box in 2013 only **but monitor it now!**
- Take stream of data at very large rate but storing minimal information: **reduced event content** ✂ **ok for quick reprocessing : immediate reconstruction**
- Within that data: which info builds the **expected signal** (e.j. *monojet*), store only **that** information (e.j.: **only jets+MET** instead of all raw info: clusters, tracks, electrons, muons, jets, MET,...)
- If something really interesting is found on data scouting, may consider to implement looser trigger on main stream (for fast & full reconstruction)



Data scouting

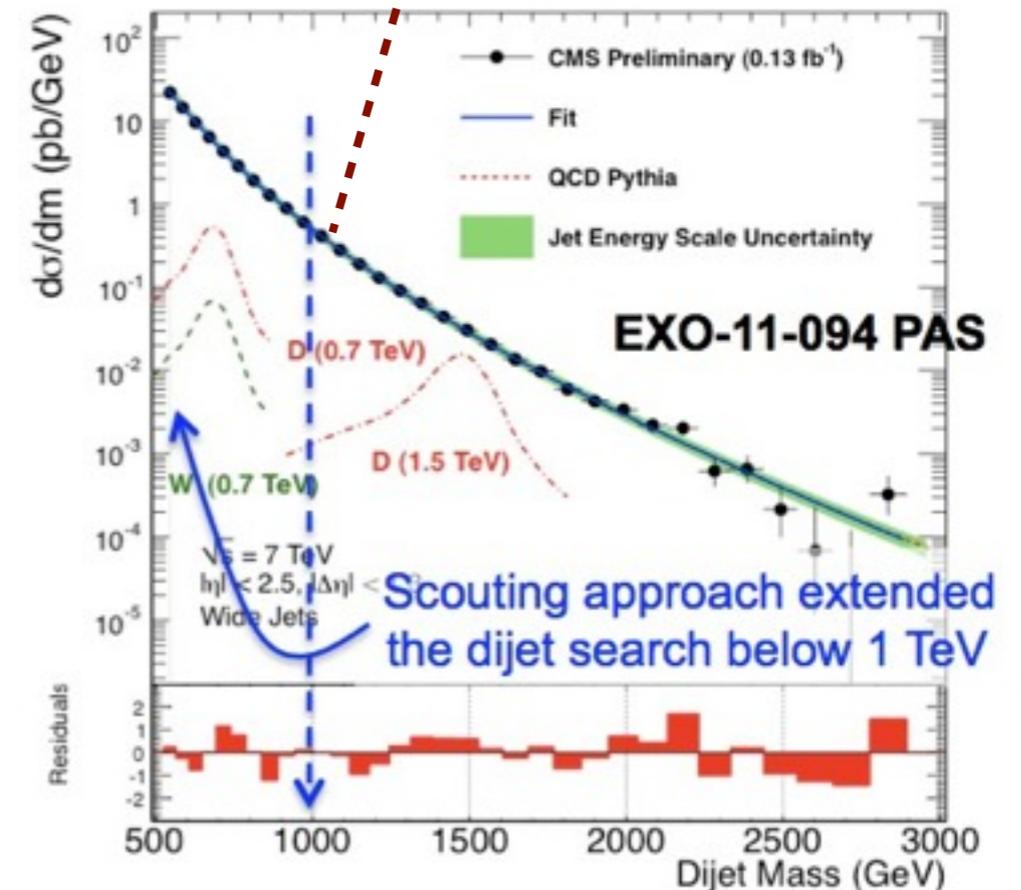
- **Scouted data actually used for analysis!**

First real case:

- search for new physics in hadronic final states (resonances on dijet mass spectra)
- Event selection: 2 jets with low transverse momentum (p_T)
- **Trigger:** overwhelmed by enormous amount of QCD events \Rightarrow **huge rate: $\sim 10^3$ Hz**
- \Rightarrow impossible to maintain all data in 'normal' format
- **Scouting: store** only 4p of the "particle-flow" **jets** reconstructed during High Level Trigger online processing. **Nothing else!**

Only 0.13 fb^{-1}

hypothetical scalar di-quark signals
at different masses

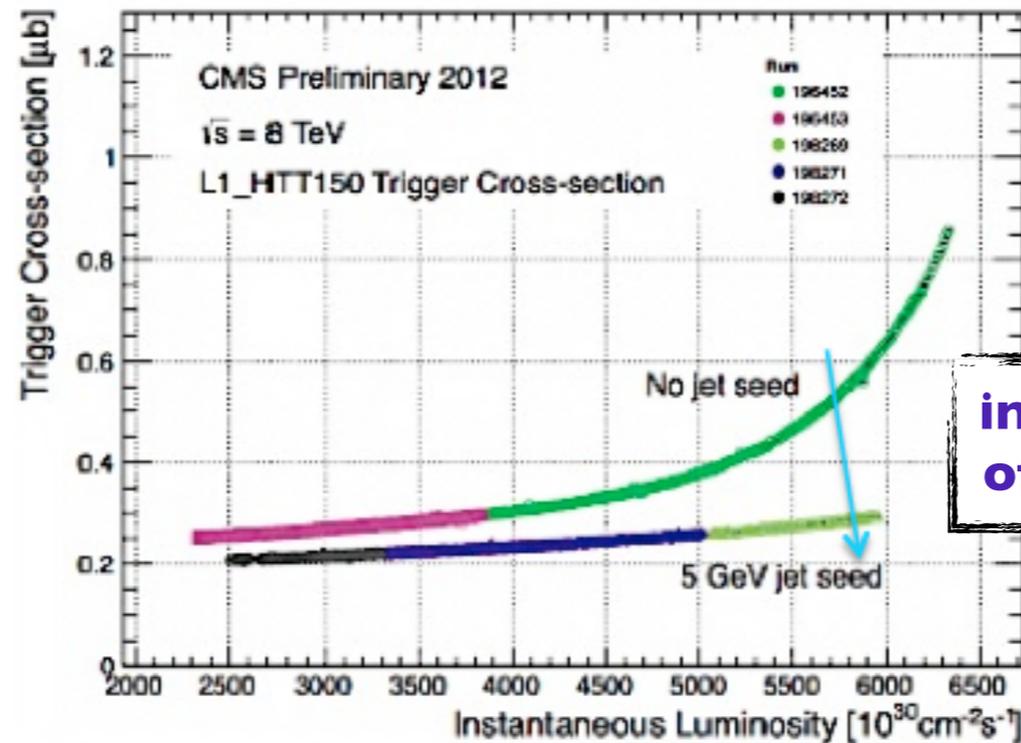
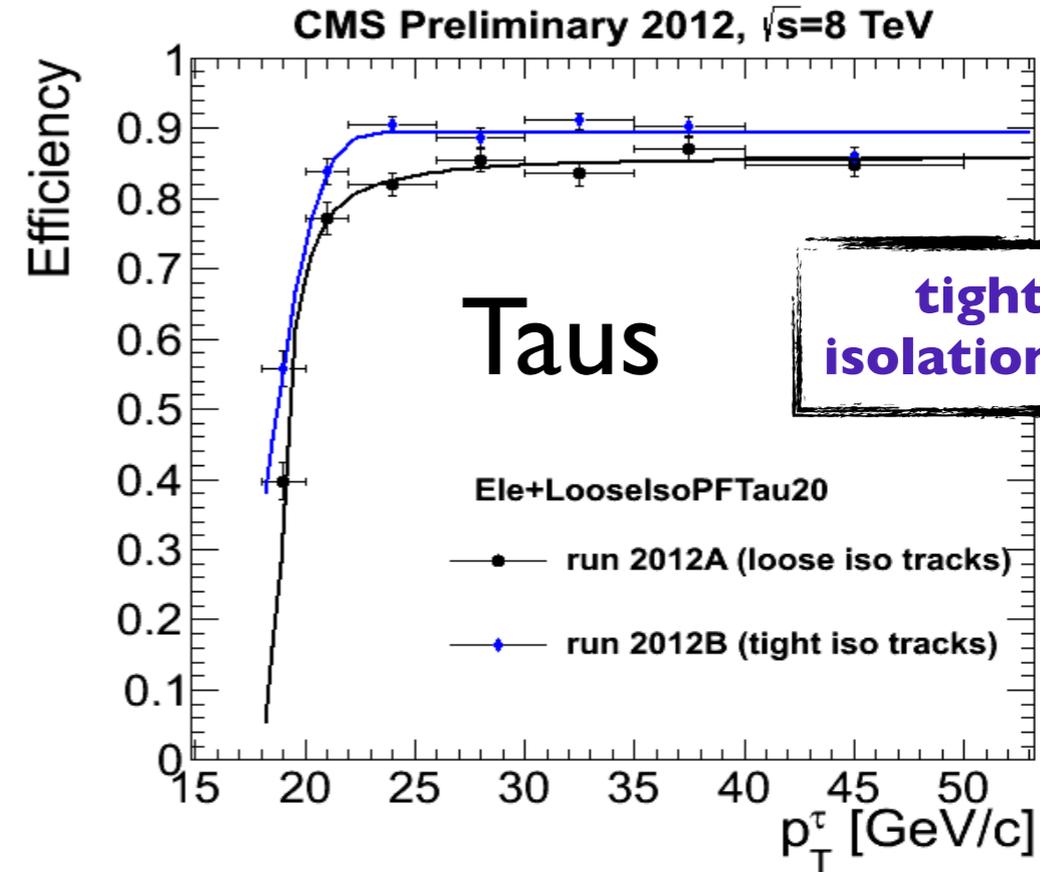
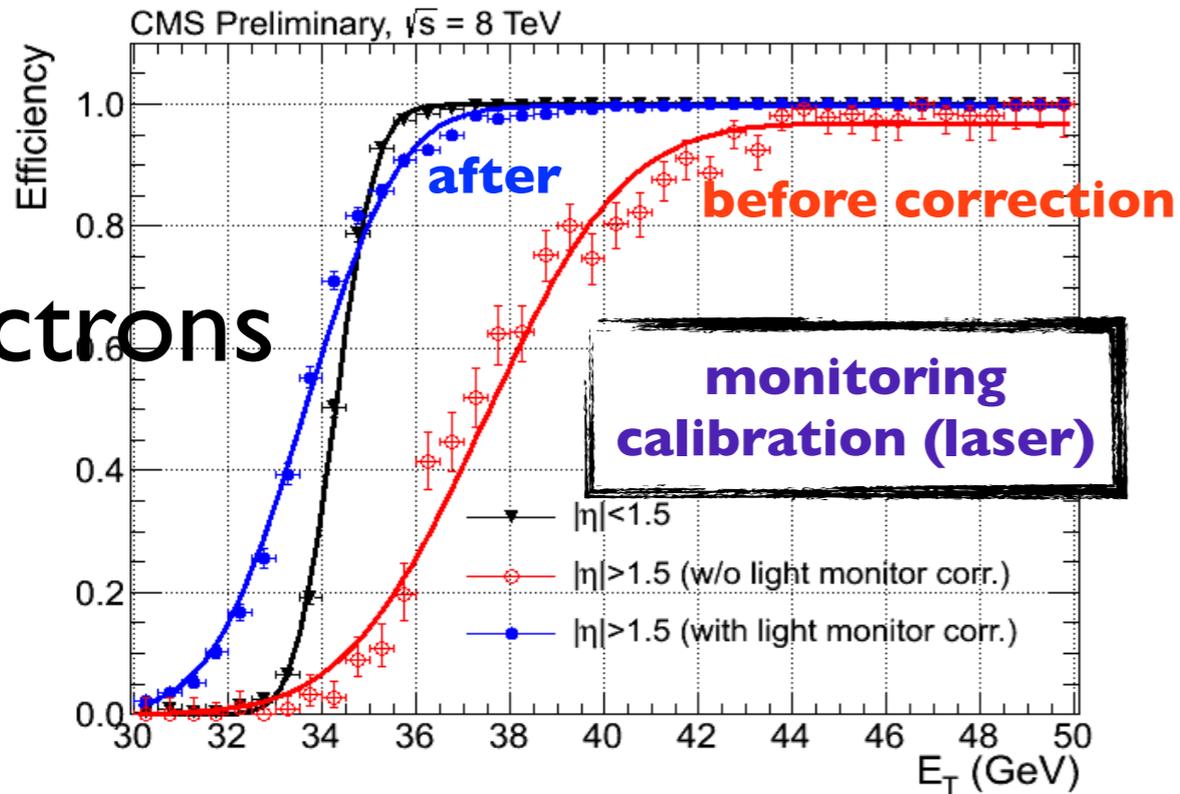


In 2012, we can benefit from almost the full integrated luminosity ($> 15 \text{ fb}^{-1}$)

(resolution $\sim 1.05x$ worse wrt offline reconstruction)

Trigger improvements

Electrons

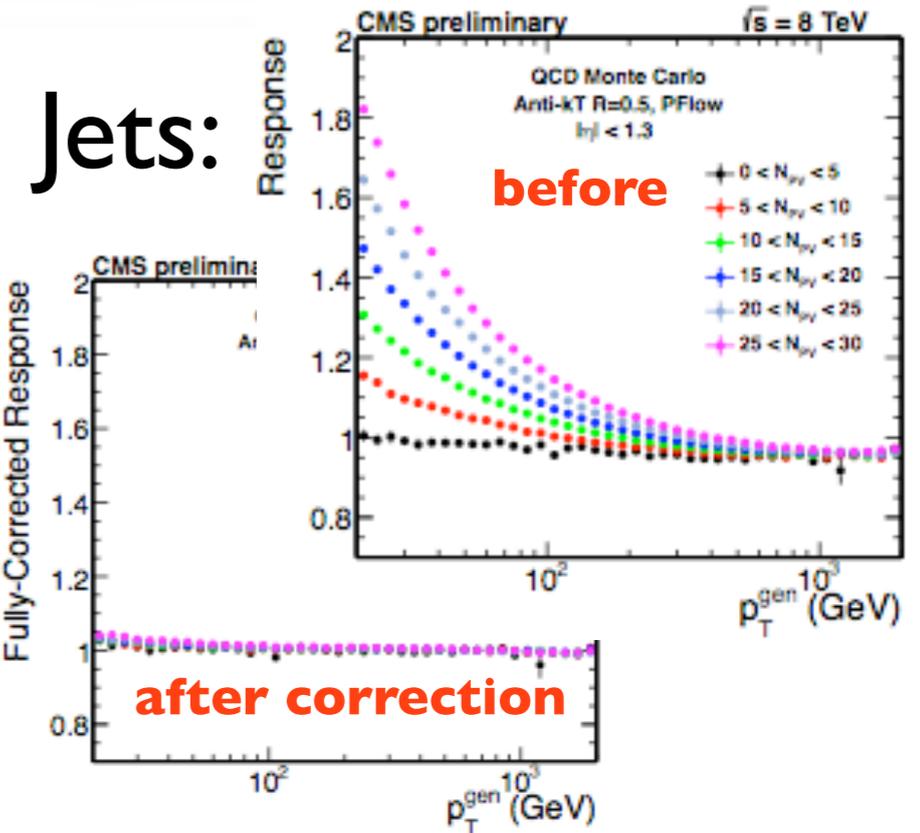
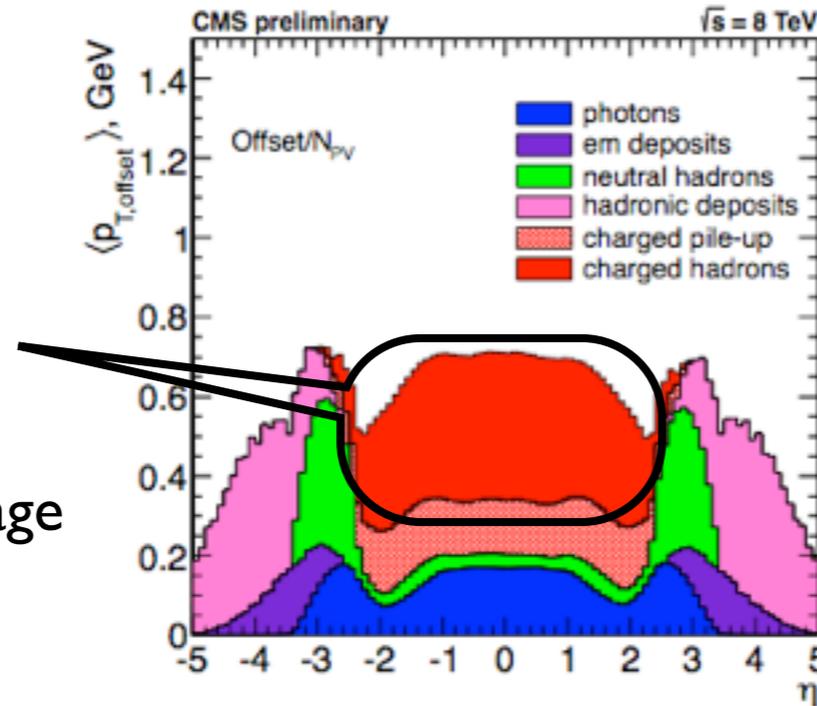


Jets

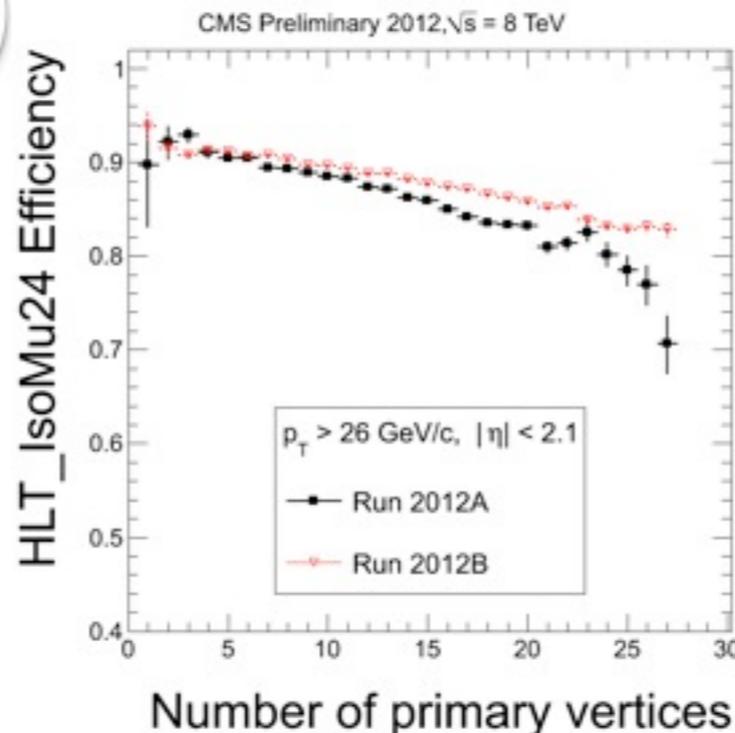
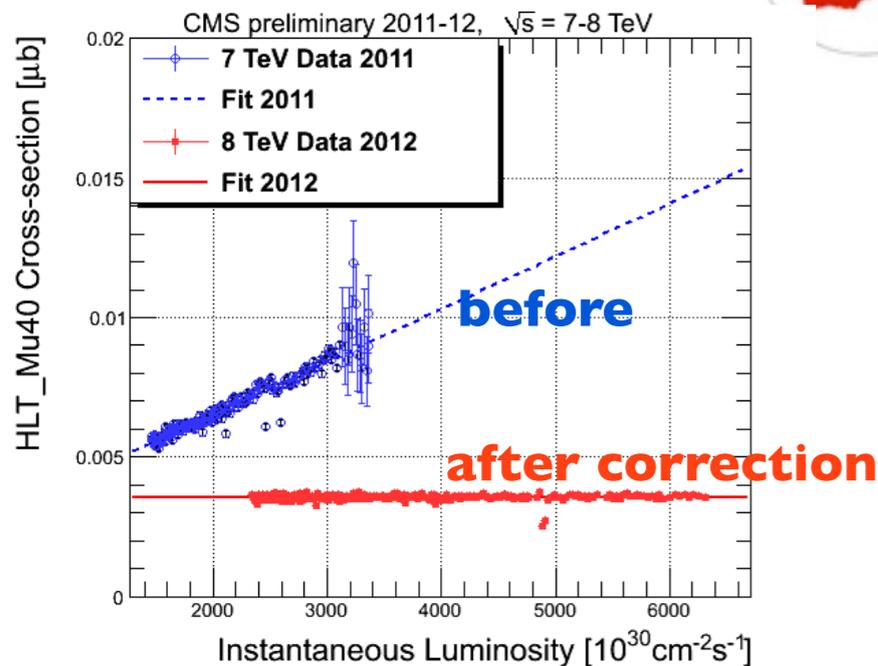
increasing threshold of jet seed to 5 GeV

Pile-Up : simultaneous pp interactions \propto InstLumi

- excellent tracking: identify track \leftrightarrow vertices
- JETS: remove charged particles coming from secondary interactions
- remaining PU: correct average energy/area



Muons



Remarkable improvement on muon triggers:

1. using detector-based relative isolation with PU-corrections
2. improving track quality

Corrected rate dependency with Lumi

50% rate reduction for nearly same efficiency



CMS physics results

HIGHLIGHTS

(apologies for unfairness on highlights choice!)



<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults>

Physics happening of the year

- After many years of high expectancy and hard work

- it finally `arrived`!



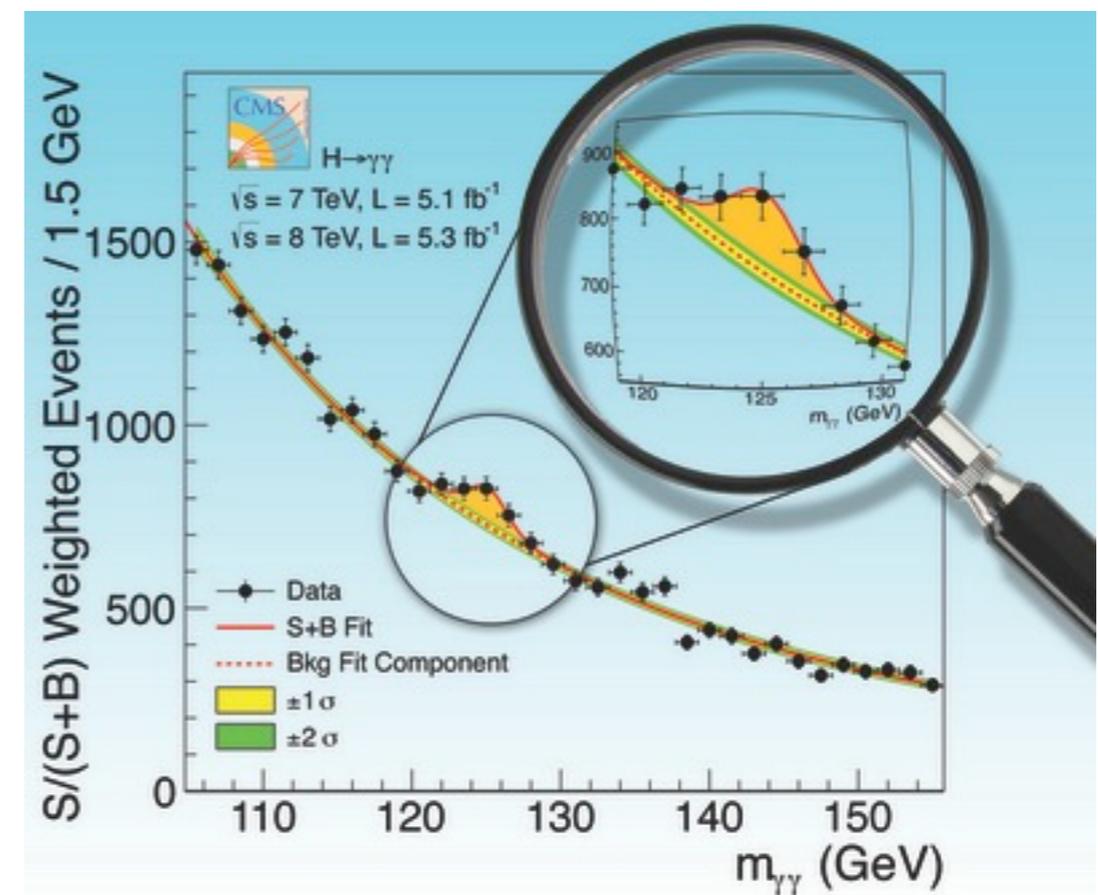
- (spin $\neq 1$, it couples to photons!)

- Will 'it' be responsible

for EWK symmetry breaking ?

Not many details in this talk

See also J.Virdee (plenary) and other CMS talks
on parallel sections



Spanish front pages 05/July/2012

EL MUNDO

LA TEORÍA DEL PROFESOR HIGGS, DEMOSTRADA 48 AÑOS DESPUÉS EN EL CERN

Descubren el 'cemento' de la materia

El acelerador de Ginebra da con el bosón de Higgs, que explica el origen de la masa. El CERN: "Es un hito en la explicación de la naturaleza"



Las partículas elementales de la física de partículas se unen para formar la materia que vemos a nuestro alrededor. El descubrimiento del bosón de Higgs, la partícula que explica el origen de la masa, es un hito en la historia de la ciencia. El CERN, el mayor laboratorio de física de partículas del mundo, ha anunciado el descubrimiento del bosón de Higgs, la partícula que explica el origen de la masa. Este descubrimiento es un hito en la historia de la ciencia, ya que completa el Modelo Estándar de la física de partículas. El CERN, el mayor laboratorio de física de partículas del mundo, ha anunciado el descubrimiento del bosón de Higgs, la partícula que explica el origen de la masa. Este descubrimiento es un hito en la historia de la ciencia, ya que completa el Modelo Estándar de la física de partículas.

La Audiencia dirá si Rato orquestó un engaño masivo al lanzar Bankia

Dimite tras ser incluido entre los 33 imputados el consejero delegado que gobernzó el banco en su cargo



El juez imputa a Rato y a los otros miembros del consejo de administración de Bankia por haber ocultado la verdadera situación del banco. El juez imputa a Rato y a los otros miembros del consejo de administración de Bankia por haber ocultado la verdadera situación del banco. El juez imputa a Rato y a los otros miembros del consejo de administración de Bankia por haber ocultado la verdadera situación del banco.

EL PAÍS

EL PERIÓDICO GLOBAL EN ESPAÑOL

AVIES 12 JULIO 2012 | Nº 5000 | Precio: 1,50 euros

Hallada la partícula clave para la comprensión del universo

El acelerador de Ginebra da con el bosón de Higgs, que explica el origen de la masa. El CERN: "Es un hito en la explicación de la naturaleza"



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La Audiencia Nacional imputa a toda la cúpula de Bankia

El consejero delegado presenta su dimisión. El juez llama como testigo a Ordóñez

Arafat será exhumado para determinar si lo envenenaron

El cuerpo será llevado a un laboratorio en París para ser examinado. El juez llama como testigo a Ordóñez

LA VANGUARDIA

FUNDADA EN 1881 POR DON CARLOS Y DON BARTOLOMÉ CORDA

La 'partícula de Dios' abre nuevas puertas a la física

TENDENCIAS 24 Y 25

El juez imputa a Rato y a los otros miembros del consejo de administración de Bankia

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LA RAZÓN

LA POLICÍA RECUPERA EN UN GARAJE EL TESORO DE COMPTON

El Gobierno obligará por ley a las autonomías a hacer más ajustes

Modificará la legislación básica como ya hizo en el caso del copago sanitario y la reforma educativa. El Ejecutivo llevará al Consejo de Ministros del día 13 una nueva ofensiva antideficit.

«Dios está detrás de la partícula divina»

El descubrimiento del bosón de Higgs, la partícula que explica el origen de la masa, es un hito en la historia de la ciencia. El CERN, el mayor laboratorio de física de partículas del mundo, ha anunciado el descubrimiento del bosón de Higgs, la partícula que explica el origen de la masa. Este descubrimiento es un hito en la historia de la ciencia, ya que completa el Modelo Estándar de la física de partículas.

La anterior cúpula de Bankia, ante el juez

El juez imputa a Rato y a los otros miembros del consejo de administración de Bankia por haber ocultado la verdadera situación del banco. El juez imputa a Rato y a los otros miembros del consejo de administración de Bankia por haber ocultado la verdadera situación del banco.

ABC

Aquí estaba el Códice Calixtino

Encuentran el manuscrito en un garaje, metido en una bolsa, junto a otros libros también robados

El juez cita a Rato, Olivas y Acebes como imputados por el «caso Bankia»

Dimite Francisco Verdú, actual consejero delegado, «para no perjudicar a la entidad»

Zapatero dotó con 60 millones al organismo que ha fichado a Pajín

Encuentran el bosón de Higgs, la partícula que explica el origen de la materia del universo

El Gobierno despedirá a empleados públicos y subirá el IVA para controlar el déficit

Merkel sigue muy reticente a las compras de deuda

El mercado espera que el BCE baje hoy los tipos de interés

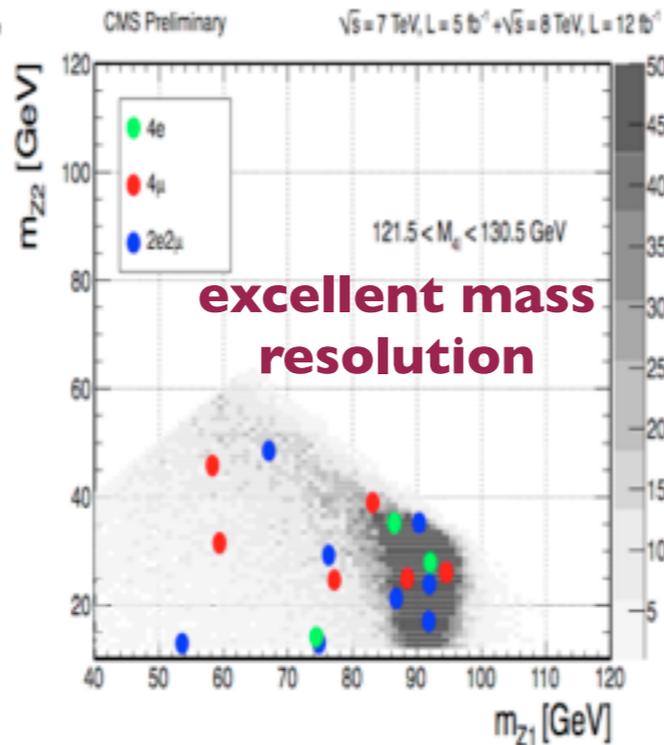
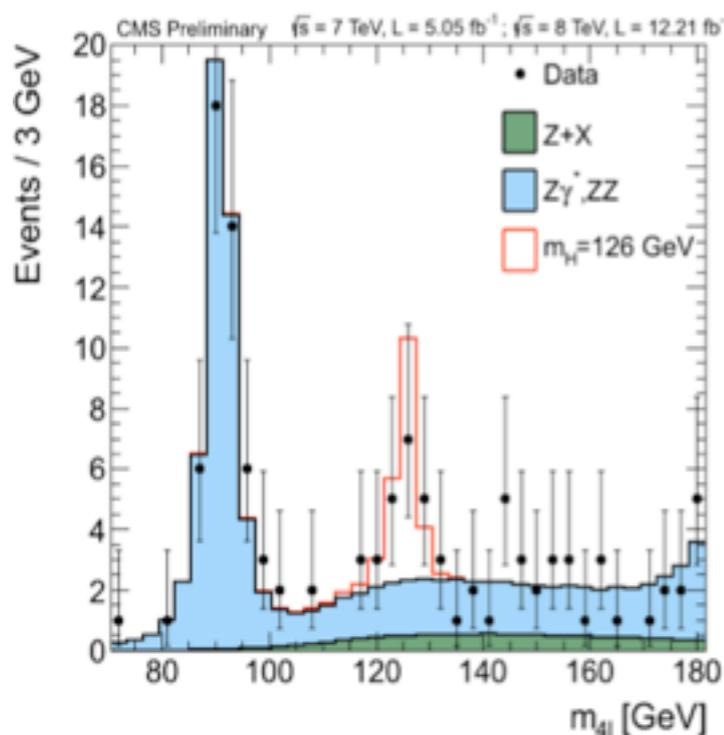
Bankia amplía como diario a Catalunya

RACI cierra la mejor temporada de su historia como líder de la radio catalana con 675.000 oyentes

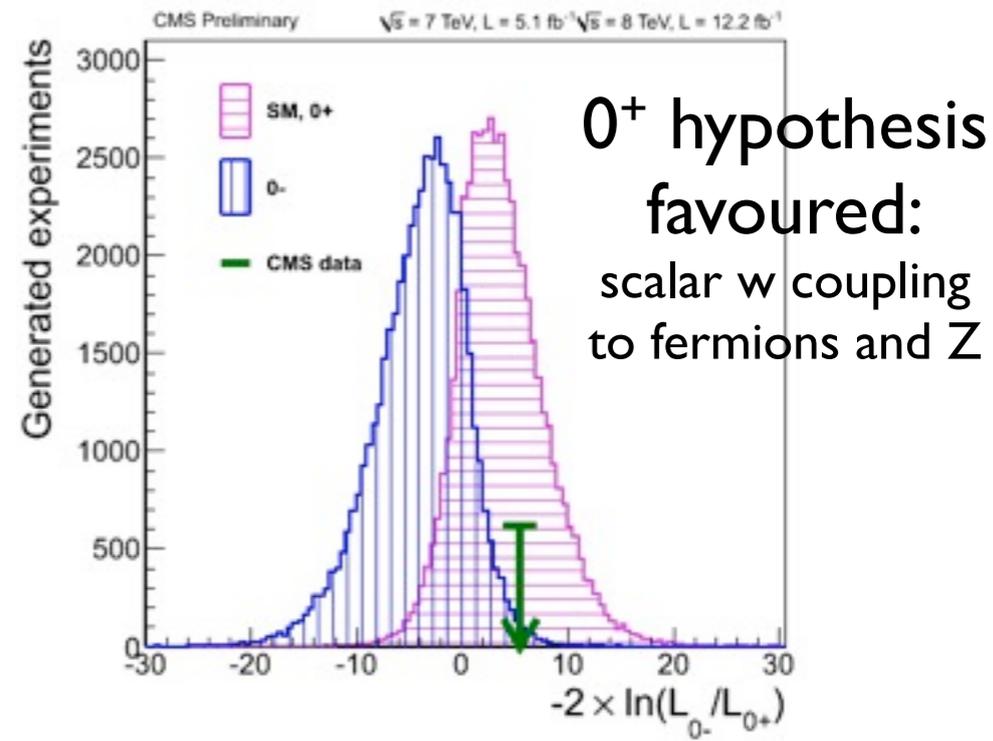
7 TeV: $\mathcal{L}=5 \text{ fb}^{-1}$
 8 TeV: $\mathcal{L}=12 \text{ fb}^{-1}$

New boson discovery

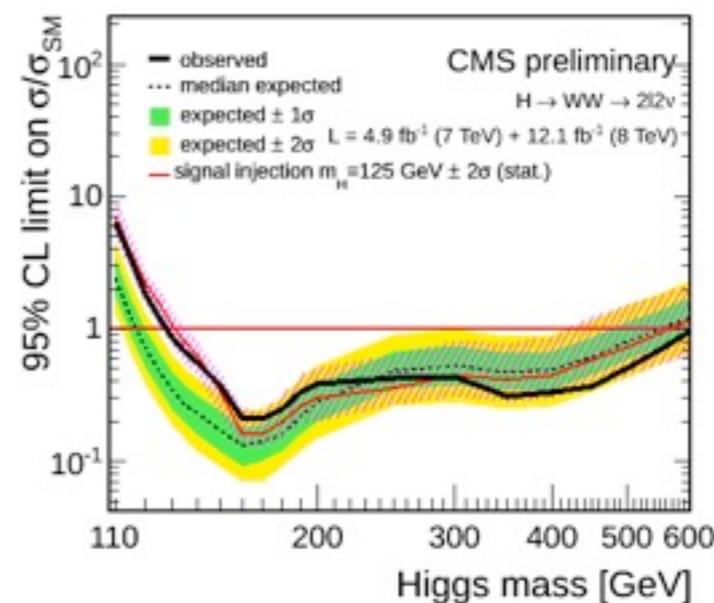
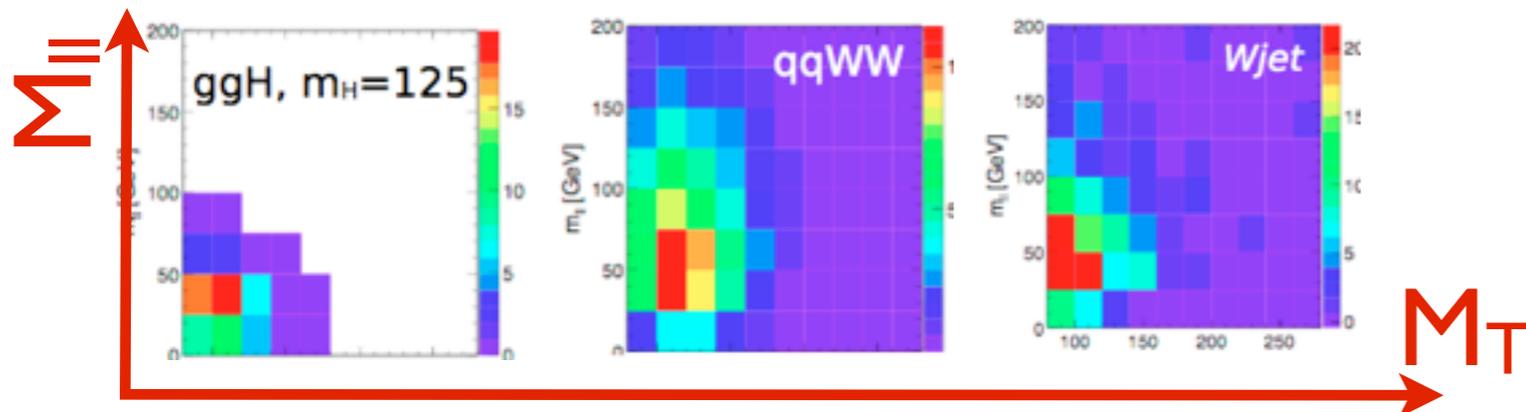
- Updated after July 4th: $H \rightarrow ZZ \rightarrow \ell\ell\ell\ell$



- Spin/Parity test: $J^P : 0^+ \text{ vs } 0^-$



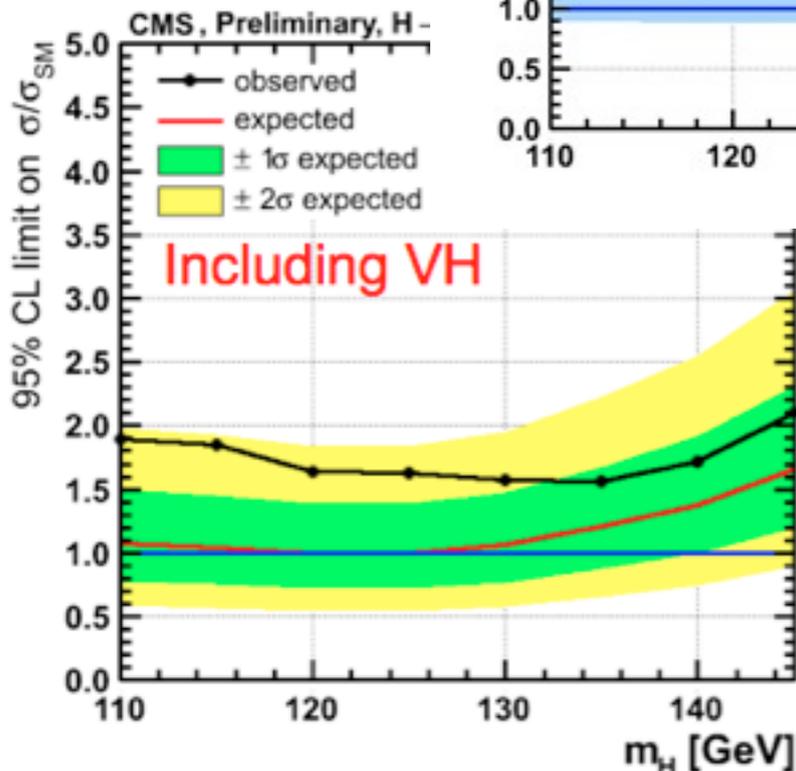
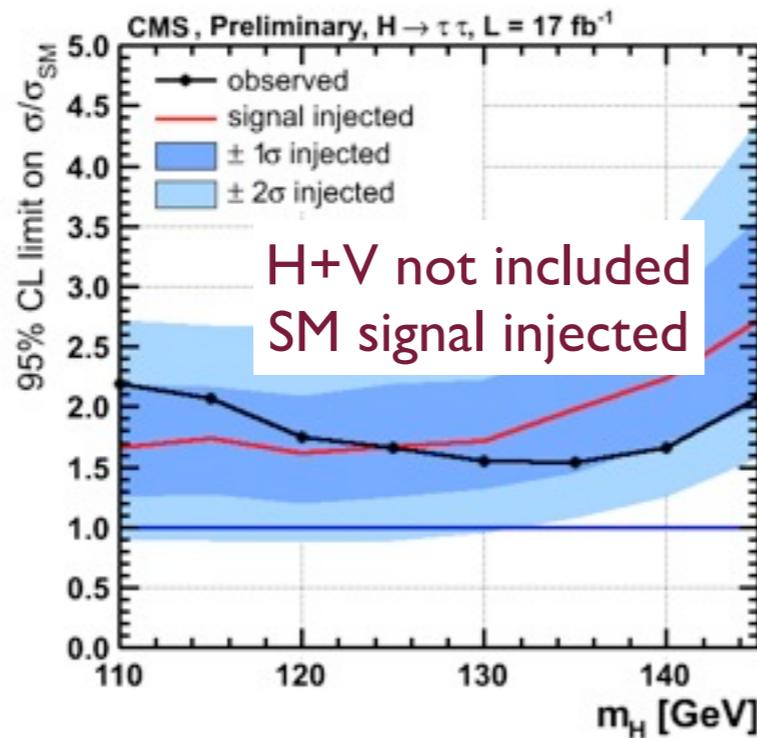
- $H \rightarrow WW \rightarrow \ell\nu\nu$
- New shape analysis (8 TeV)
- signal vs bkg: 2D cut (M_T, M_{ll}) plan



Significant excess:
 3.1σ (obs) 4.1σ (expected)

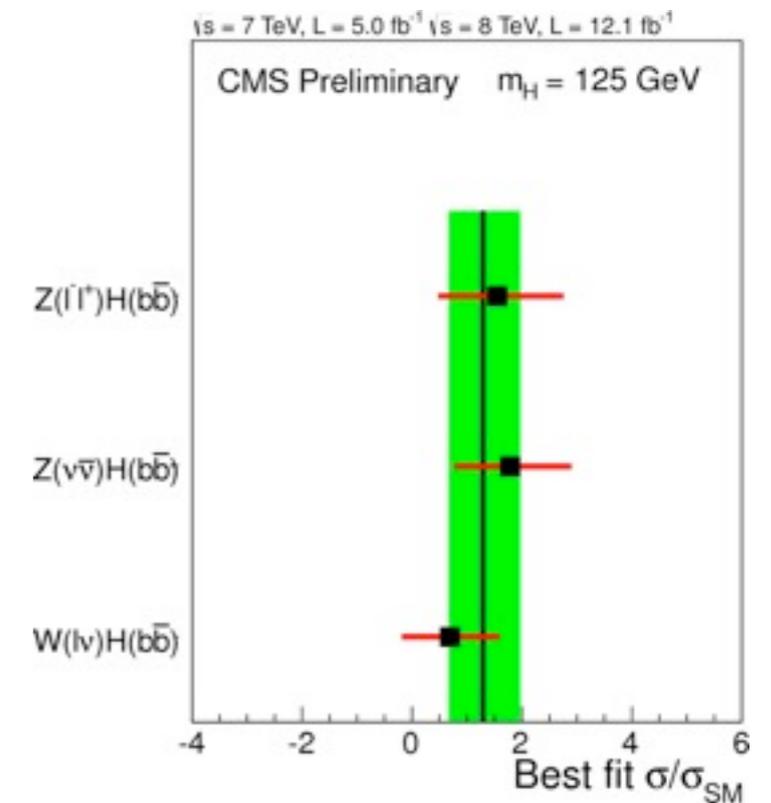
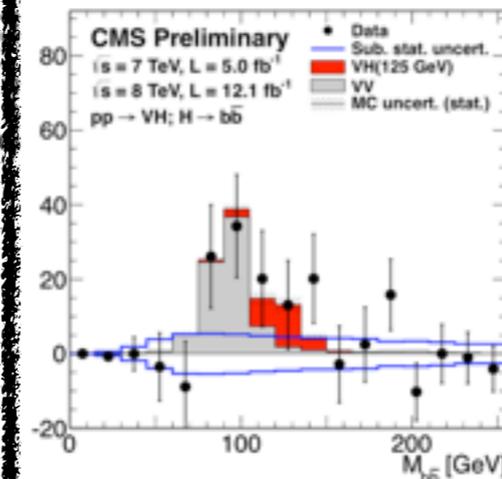
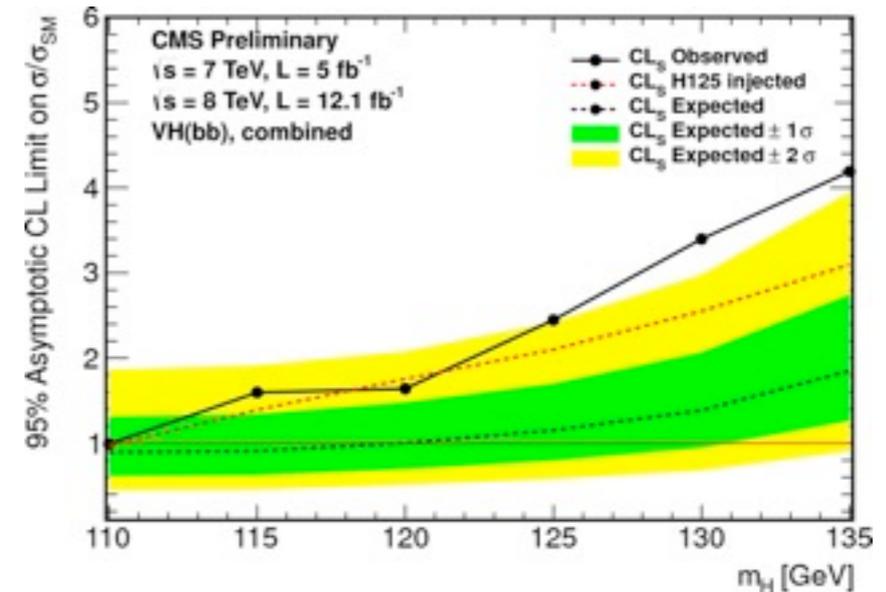
New boson discovery

- Updated after July 4th: $H \rightarrow \tau\tau$
- New after July 4th: $H +$ vector boson



7 TeV: $\mathcal{L} = 5 \text{ fb}^{-1}$
8 TeV: $\mathcal{L} = 12 \text{ fb}^{-1}$

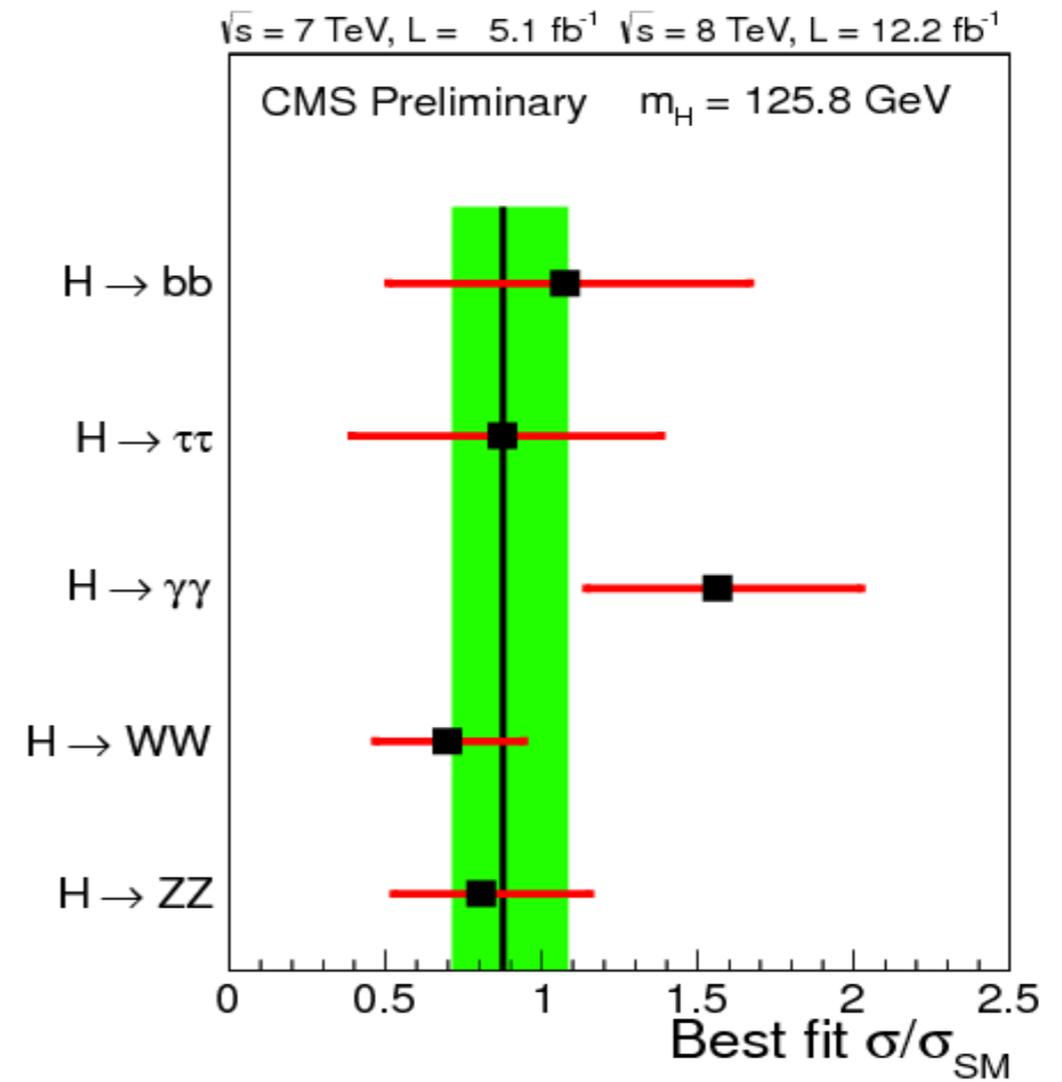
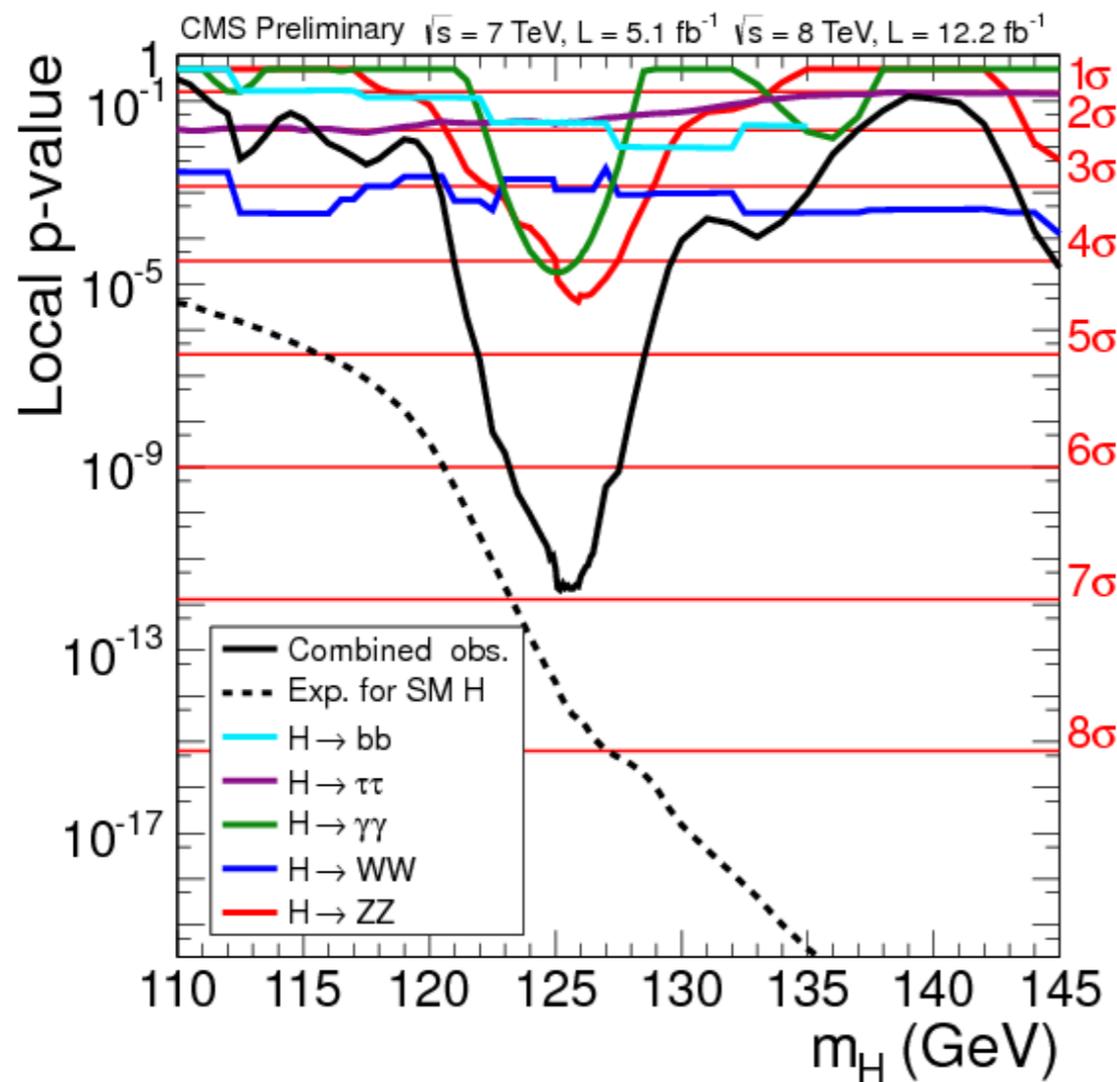
- $VH \rightarrow Vbb$ ($V=W,Z$)



New boson discovery

Nov/2012

Combination of Higgs Results



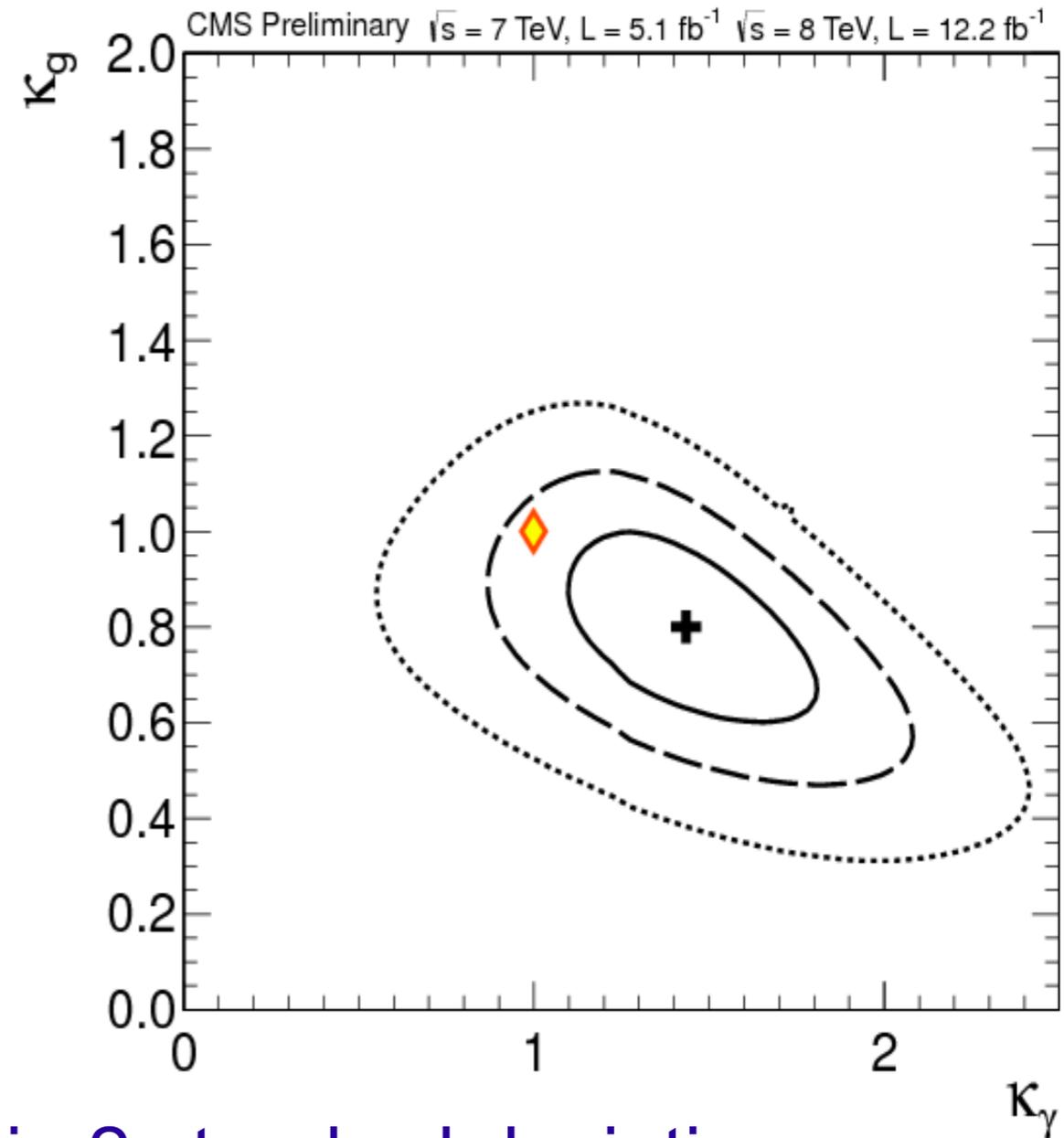
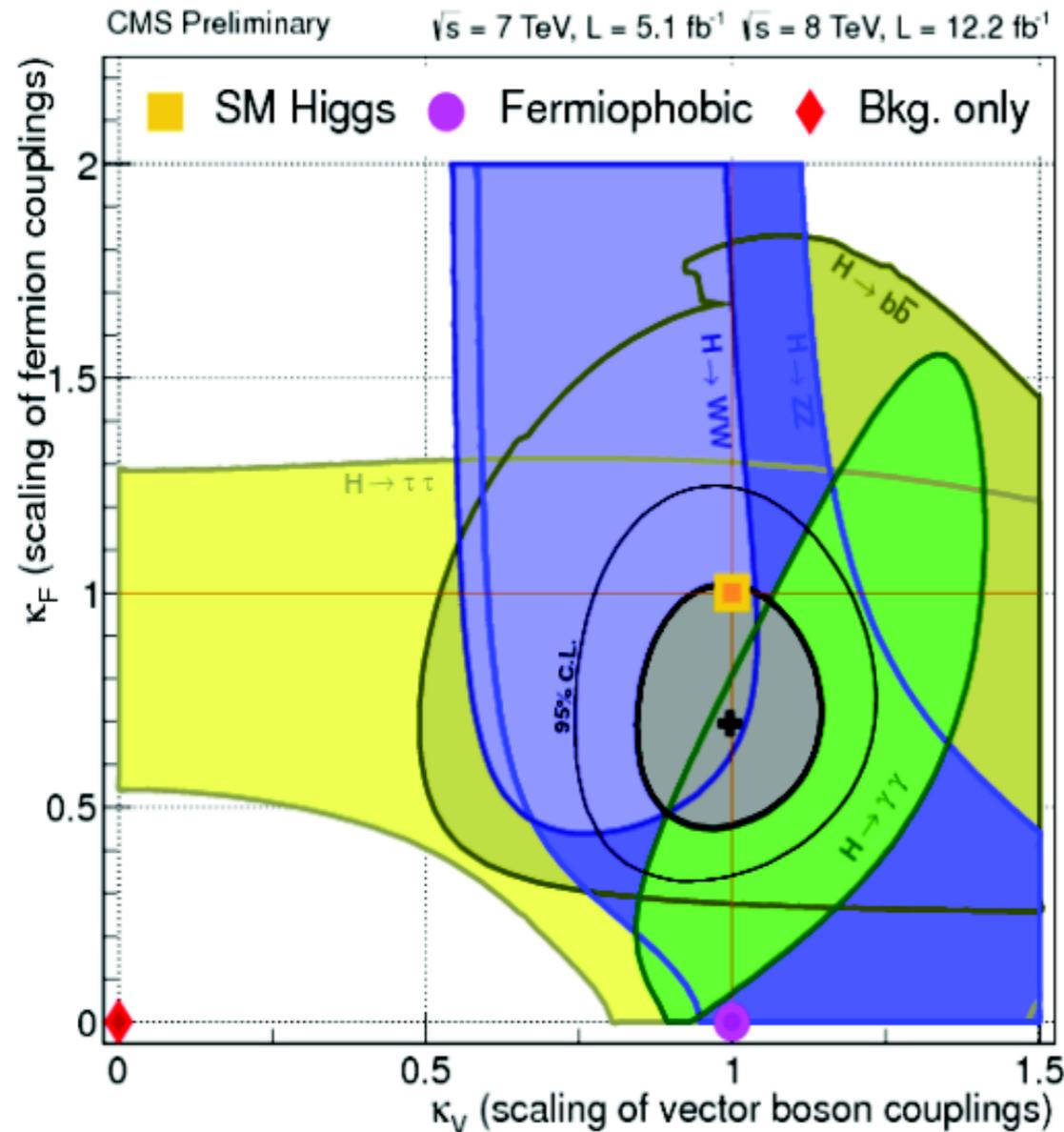
Overall significance and signal strength

— observed: 6.9; expected: 7.8 [signal strength: 0.88 ± 0.21]

New boson discovery

Nov/2012

Combination of Higgs Results



Couplings look consistent within 2 standard deviations

- Fermions versus vector bosons
- effective gluon versus photon couplings (loops)

b-physics

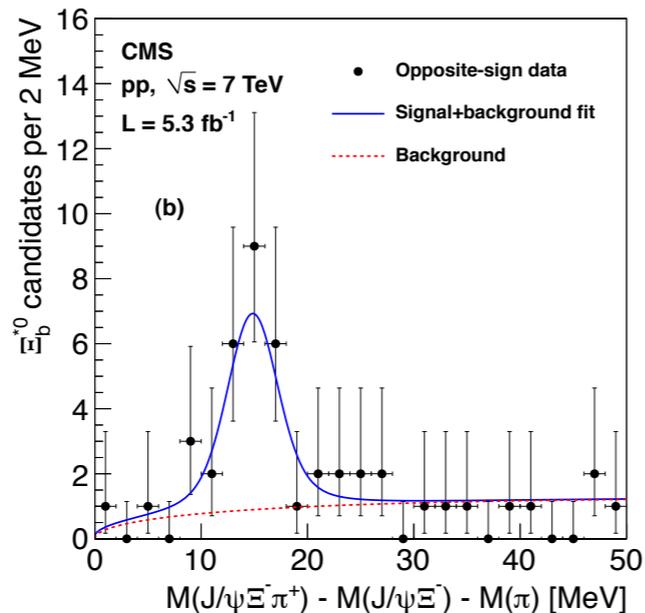
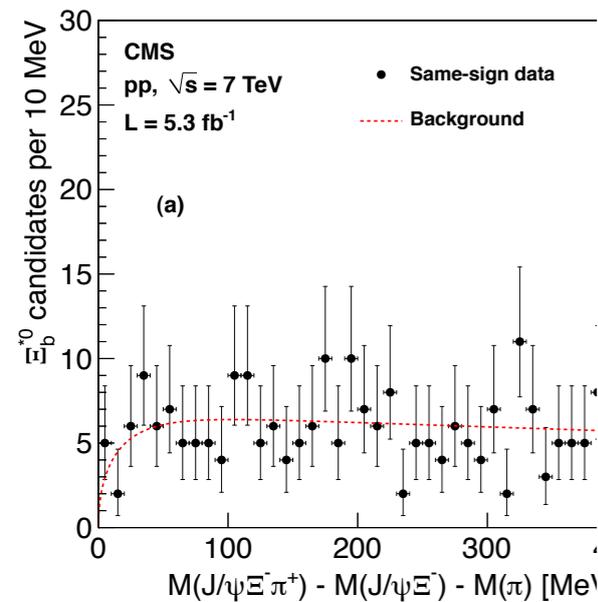
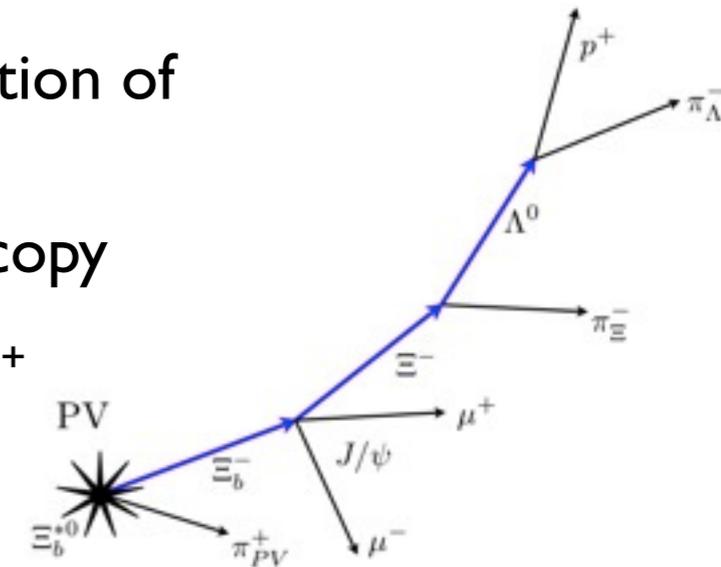
- *Not only new bosons show up in our detector: new baryon*

- $M_{\Xi_b^*} = 5945 \pm 0.3 \pm 0.7 \pm 2.3 \text{ MeV}$

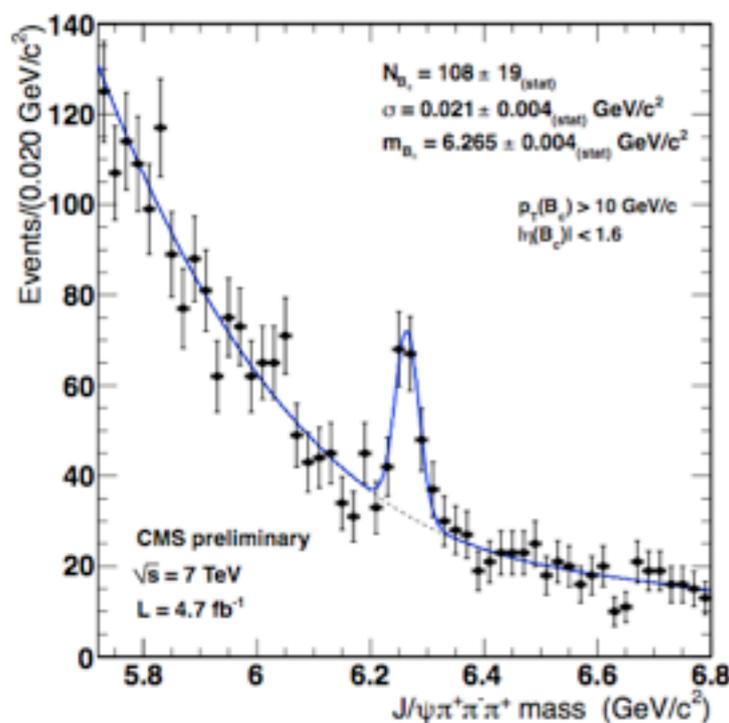
- not as exciting, no indication of new physics

- still working on spectroscopy

- decay chain: $\Xi_b^{*0} \rightarrow \Xi_b^- \pi^+$



- Rare decays: $B_c \rightarrow J/\Psi \pi \pi \pi$ (observed) $B^0, B_s^0 \rightarrow \mu \mu$ (limits)



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

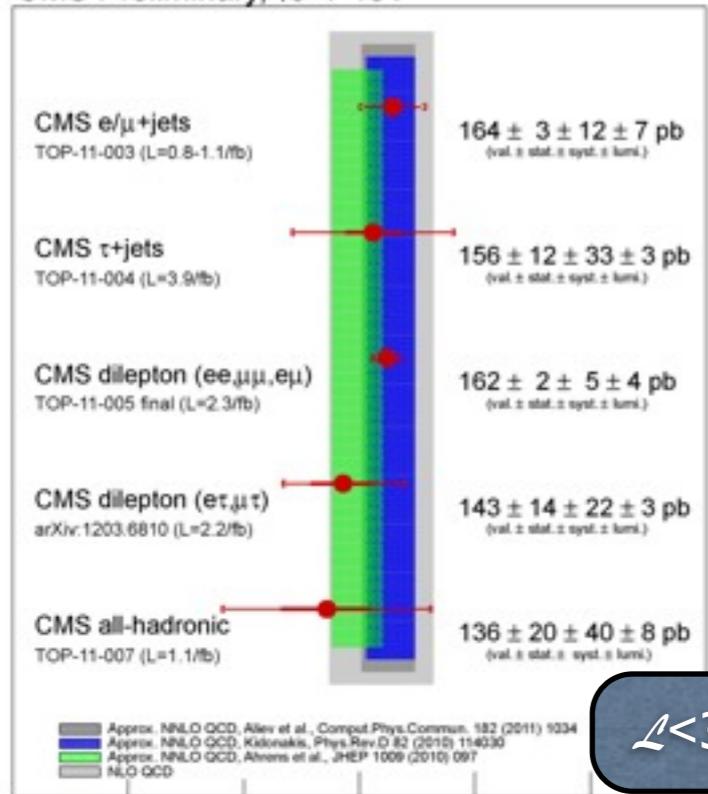
$\mathcal{L} = 5 \text{ fb}^{-1}$

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

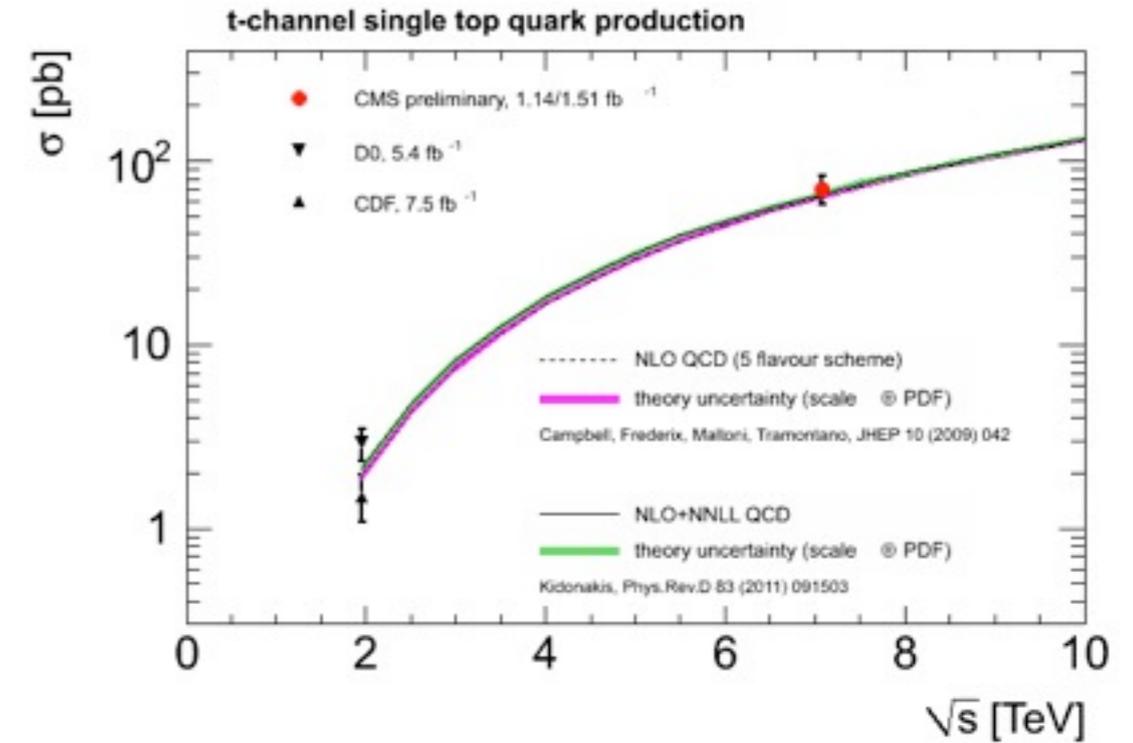
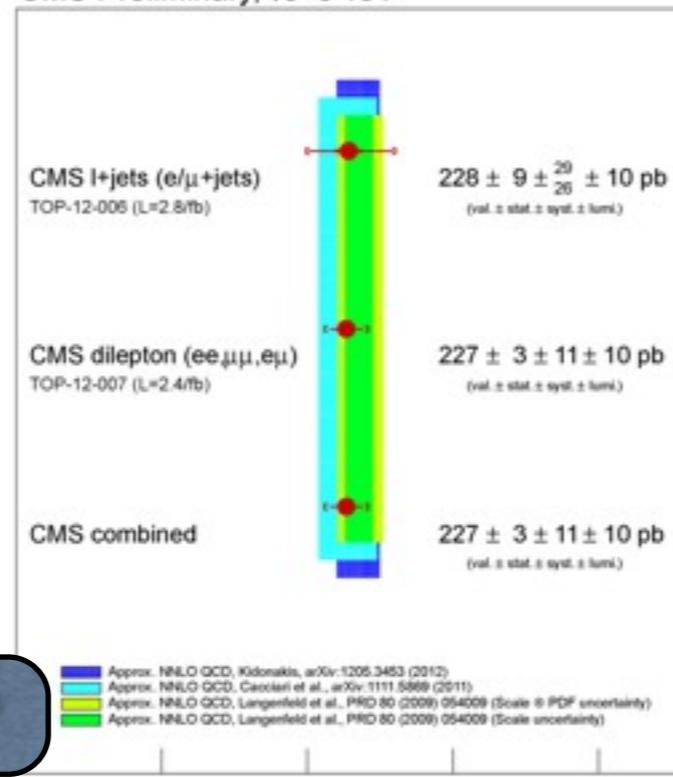
No enhancement indicating new physics: SM holds!

...from b to top physics

CMS Preliminary, $\sqrt{s}=7$ TeV

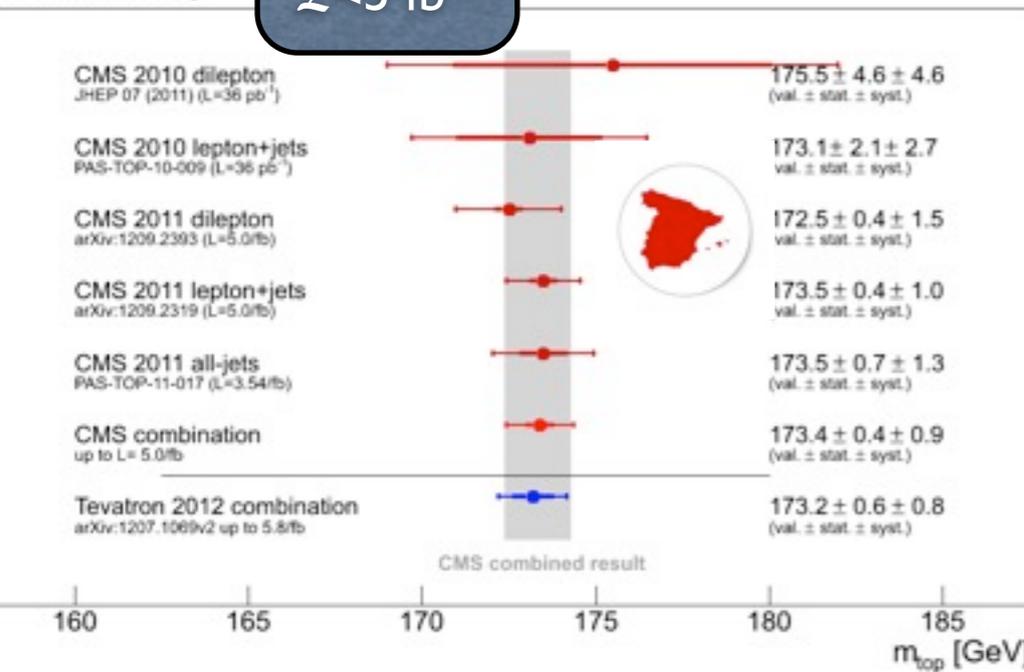


CMS Preliminary, $\sqrt{s}=8$ TeV



CMS Preliminary

$L < 5$ fb⁻¹



- top-pairs cross-section at 7 & 8 TeV
- CMS 2011 alone reaching Tevatron m_t precision!
- Interesting results on single-top (8 TeV):
 - t-channel: 80.1 ± 5.7 (sta) ± 1.1 (sys) ± 4% (lumi) pb
 - tW-channel: 16⁺⁵ -4 pb: ~30% precision!

remarkable agreement with the SM

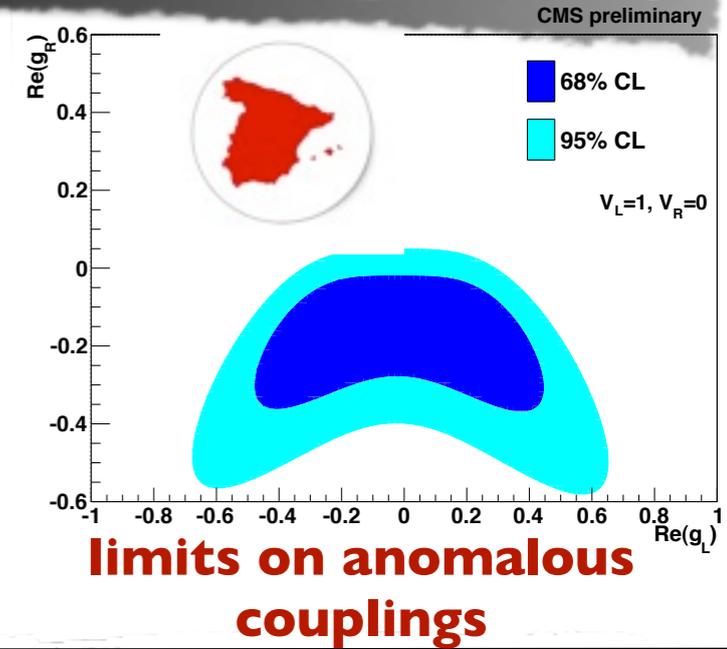
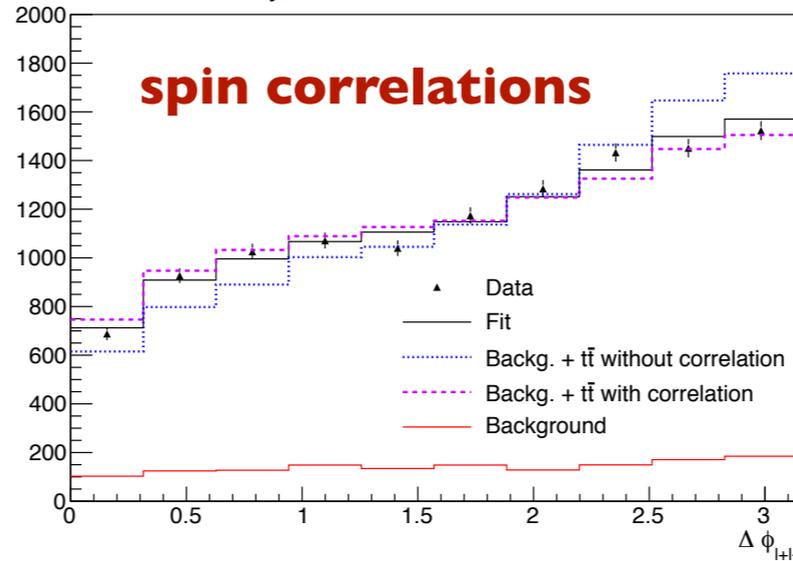
Top properties

Asymmetries

$$A_C = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)}$$

$$A_C = 0.004 \pm 0.010(\text{st}) \pm 0.012(\text{sys})$$

CMS Preliminary, 5.0 fb⁻¹ at $\sqrt{s} = 7$ TeV



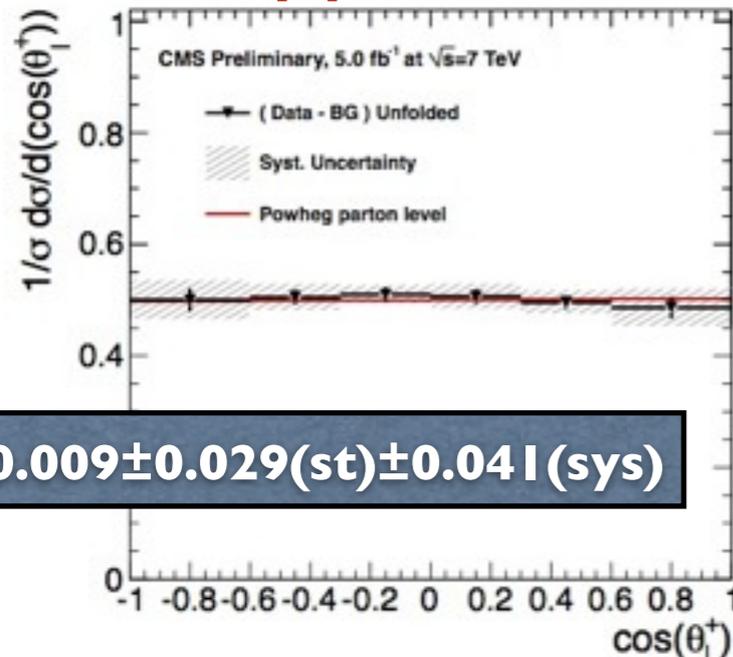
Mass difference:

$$\Delta m_{\text{top}} = -0.44 \pm 0.46(\text{st}) \pm 0.27(\text{sys}) \text{ GeV}$$

(no CPT violation)

tt+V, tt+Higgs

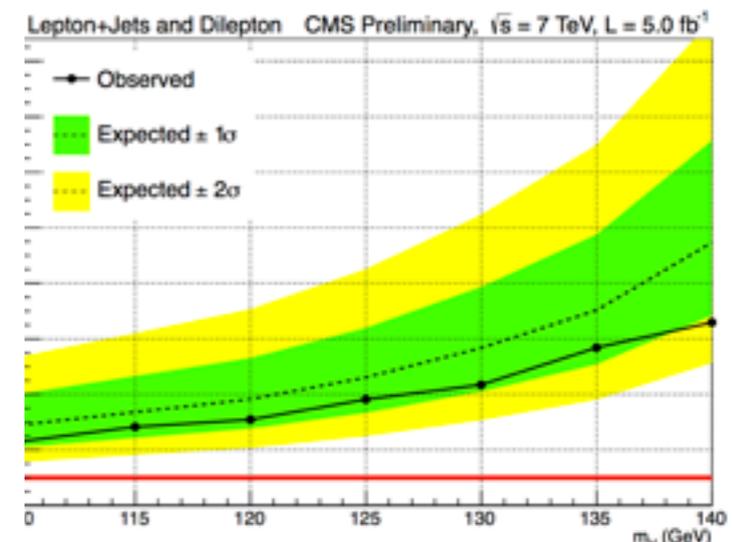
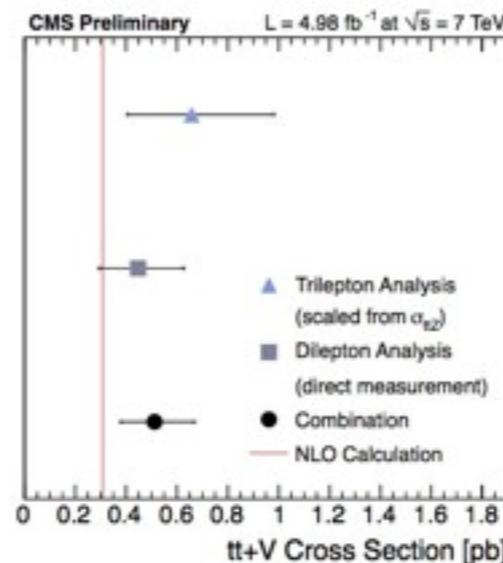
top polarization



$$P_n = -0.009 \pm 0.029(\text{st}) \pm 0.041(\text{sys})$$

	$\sigma(t\bar{t}Z)$ [pb]	$\sigma(t\bar{t}W)$ [pb]	$\sigma(t\bar{t}V)$ [pb]
Trilepton Analysis	0.30 ^{+0.14+0.04} _{-0.11-0.02}	-	0.66 ^{+0.32+0.09} _{-0.25-0.05}
Dilepton Analysis	-	0.28 ^{+0.14} _{-0.12} ± 0.04	0.45 ^{+0.17+0.06} _{-0.15-0.05}
Combined	-	-	0.51 ^{+0.15+0.05} _{-0.13-0.04}
NLO Calculation	0.1387	0.169 ^{+0.029} _{-0.051}	0.308

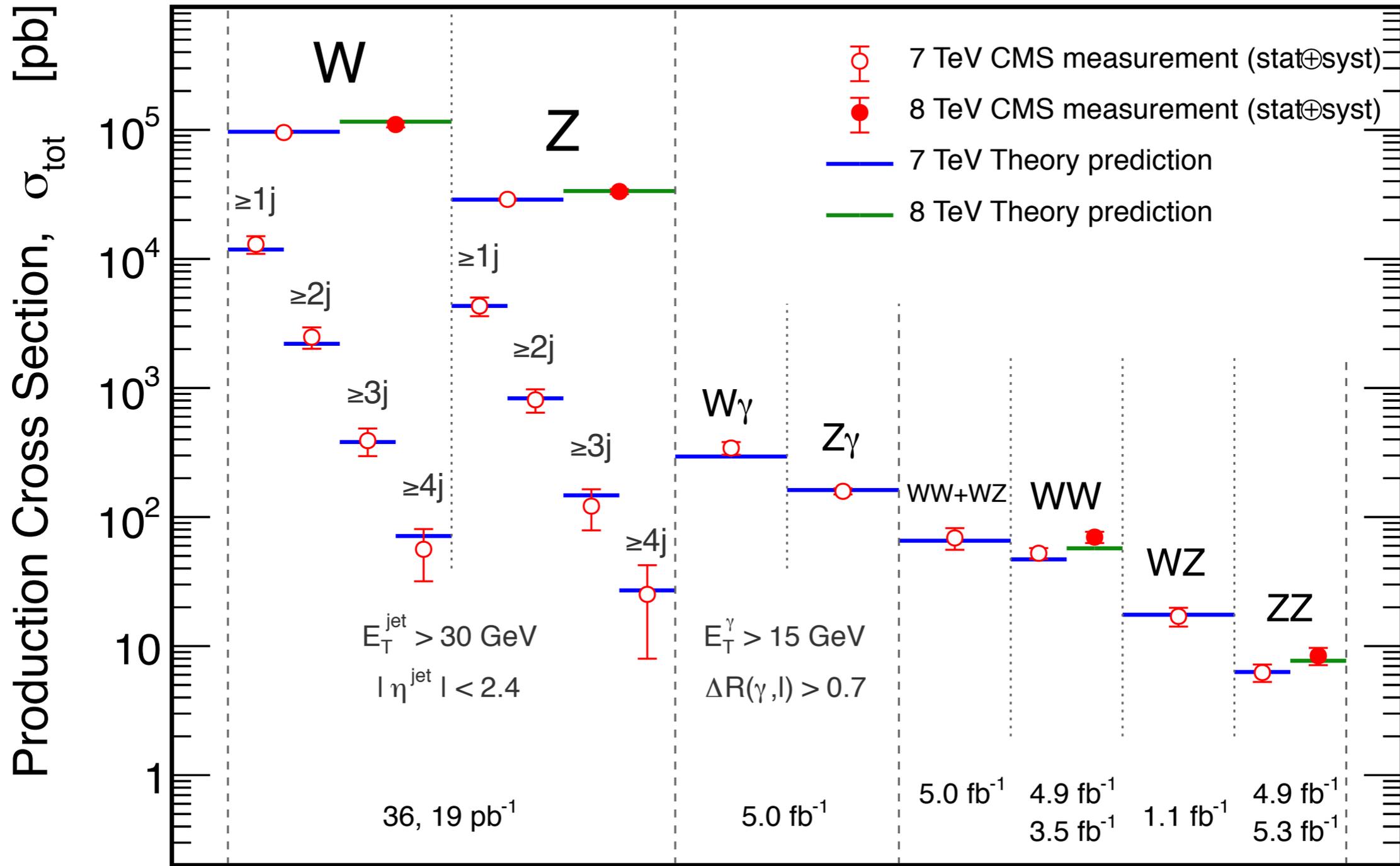
ttH with t → anything
H → bb



Electroweak: cross-sections

CMS

Nov 2012



JHEP10(2011)132
 JHEP01(2012)010
 CMS-PAS-SMP-12-011 (W/Z 8 TeV)

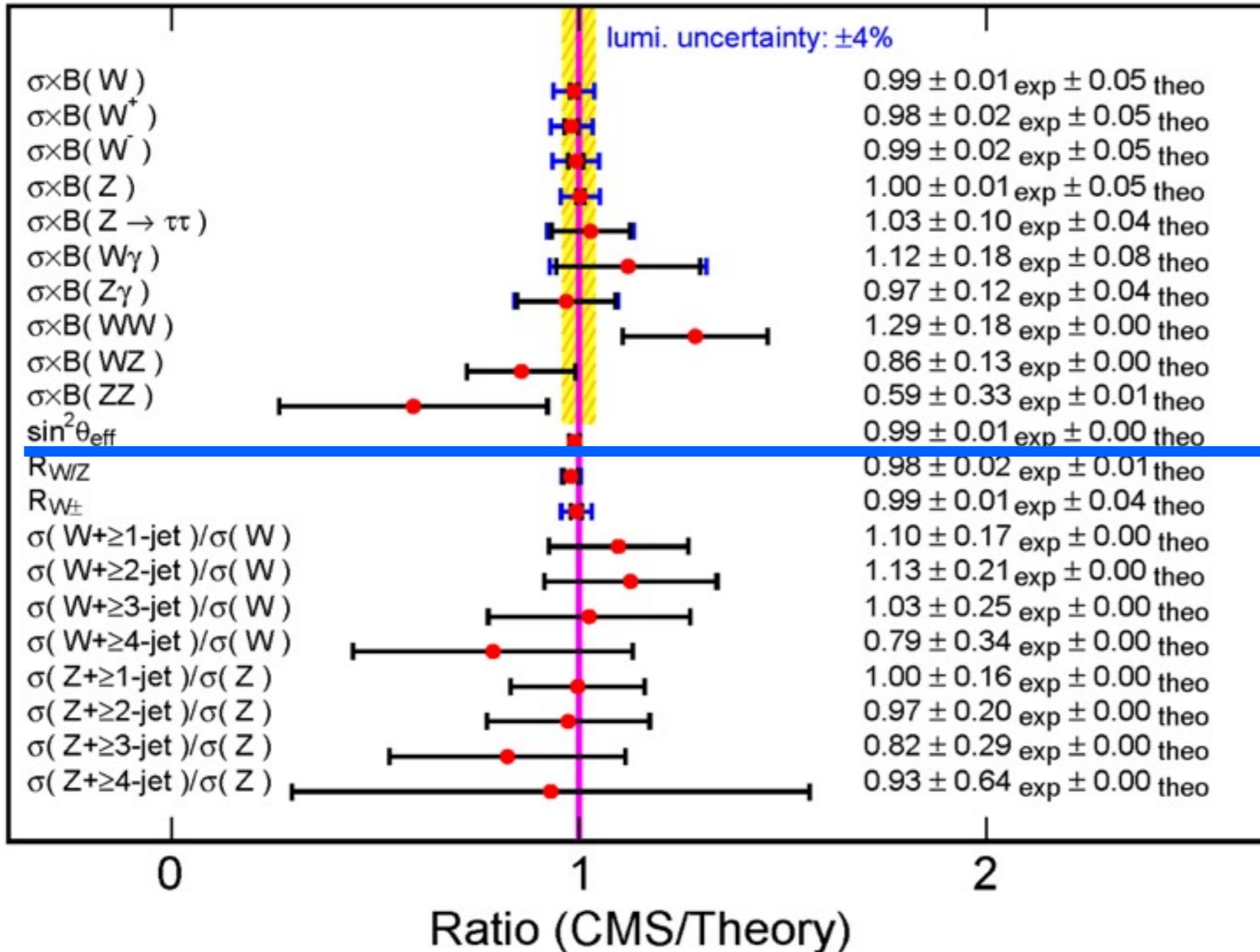
CMS EWK-11-009

CMS-PAS-EWK-11-010 (WZ)
 CMS-PAS-SMP-12-005 (WW7),
 007(ZZ7), 013(WW8), 014(ZZ8), 015(WV)



Electroweak: SM summary

CMS $\sqrt{s} = 7 \text{ TeV}$



cross-sections
and ratios

EWK mixing
angle

- * high-precision
- * compatibility with the SM

Searches for new physics: "exotica"

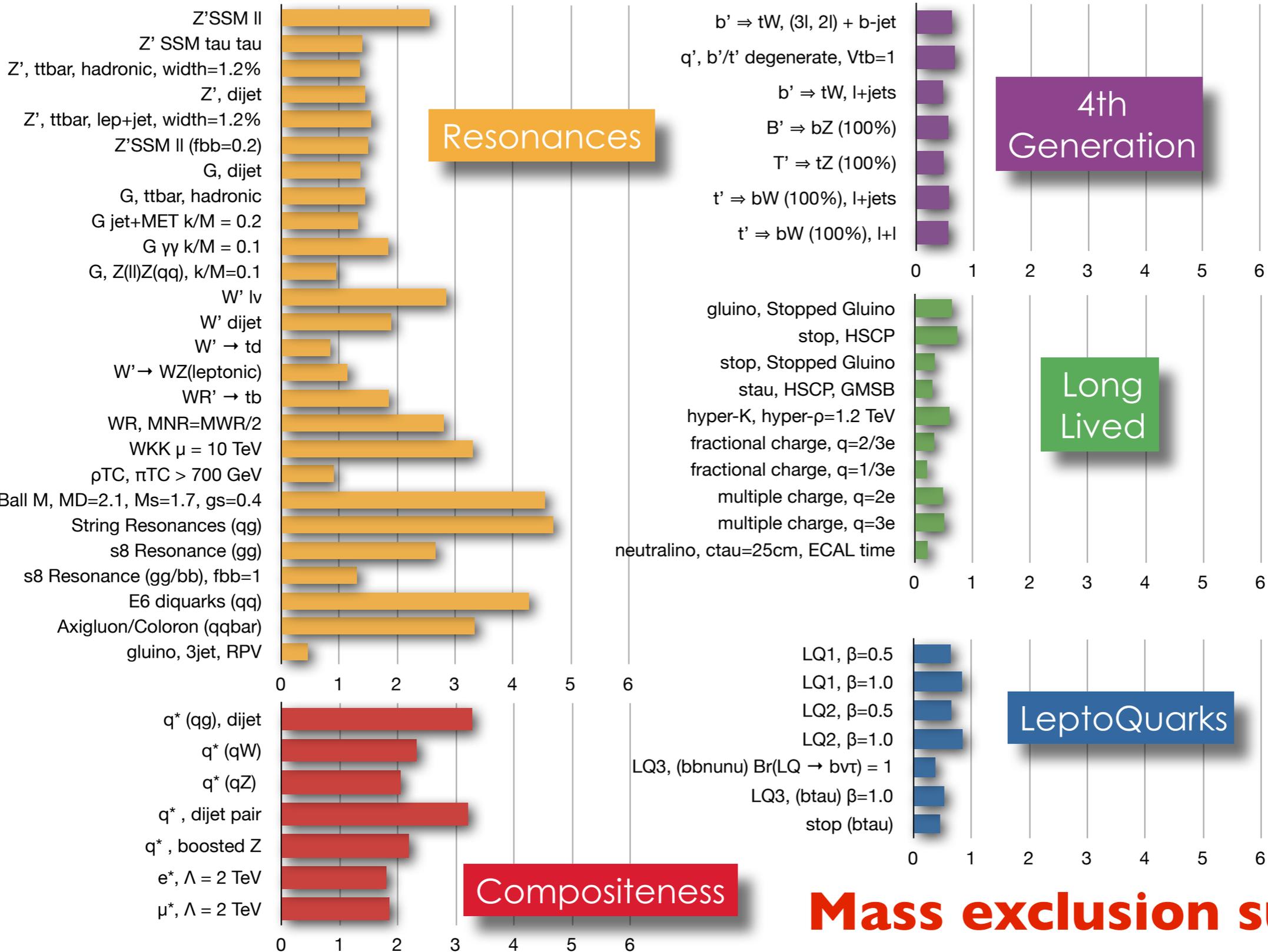
Resonances

Compositeness

4th Generation

Long Lived

LeptoQuarks



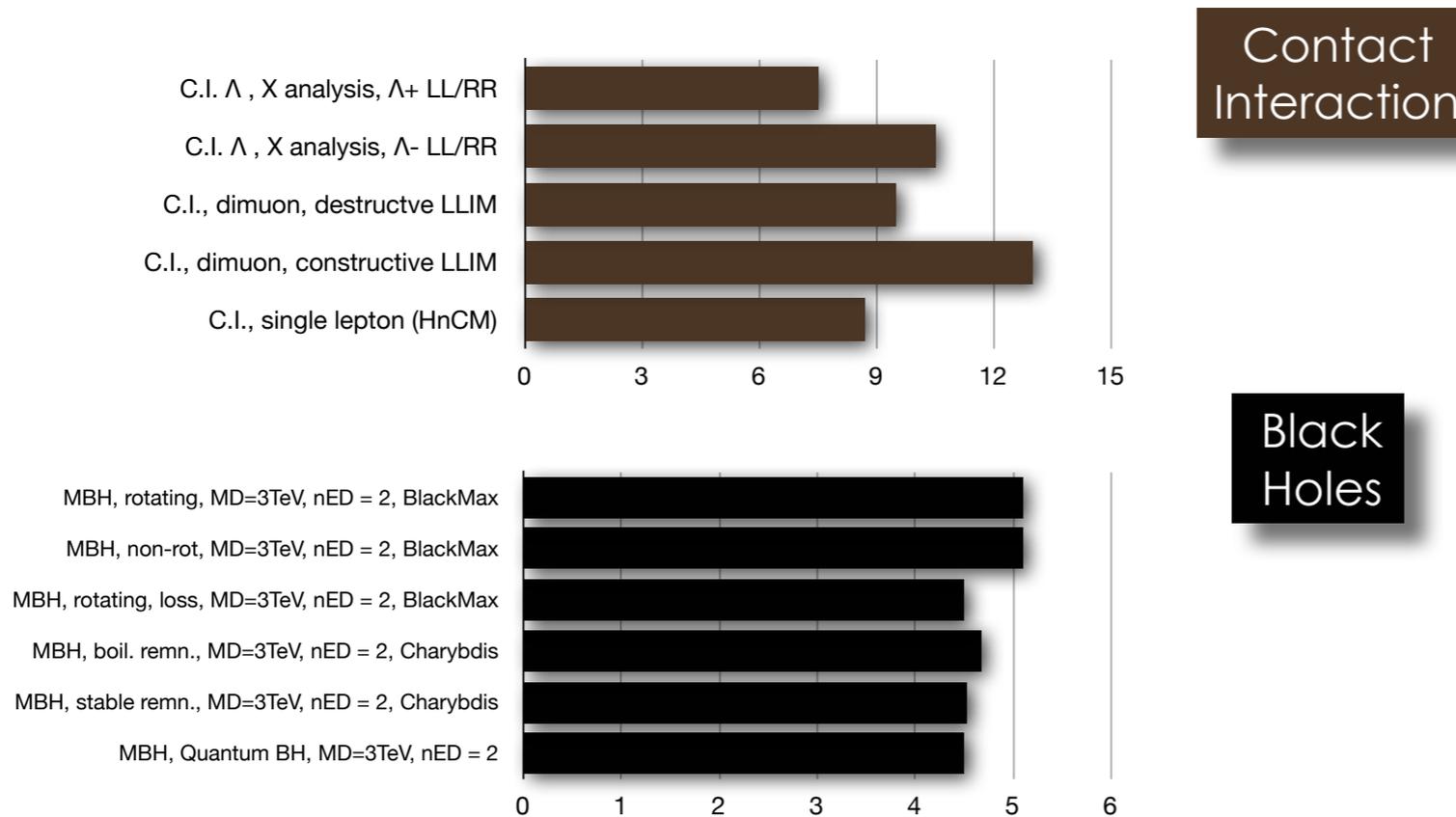
Mass exclusion summary

Searches for new physics: “exotica”

- ...and even more searches
 - no sign of new physics whatsoever

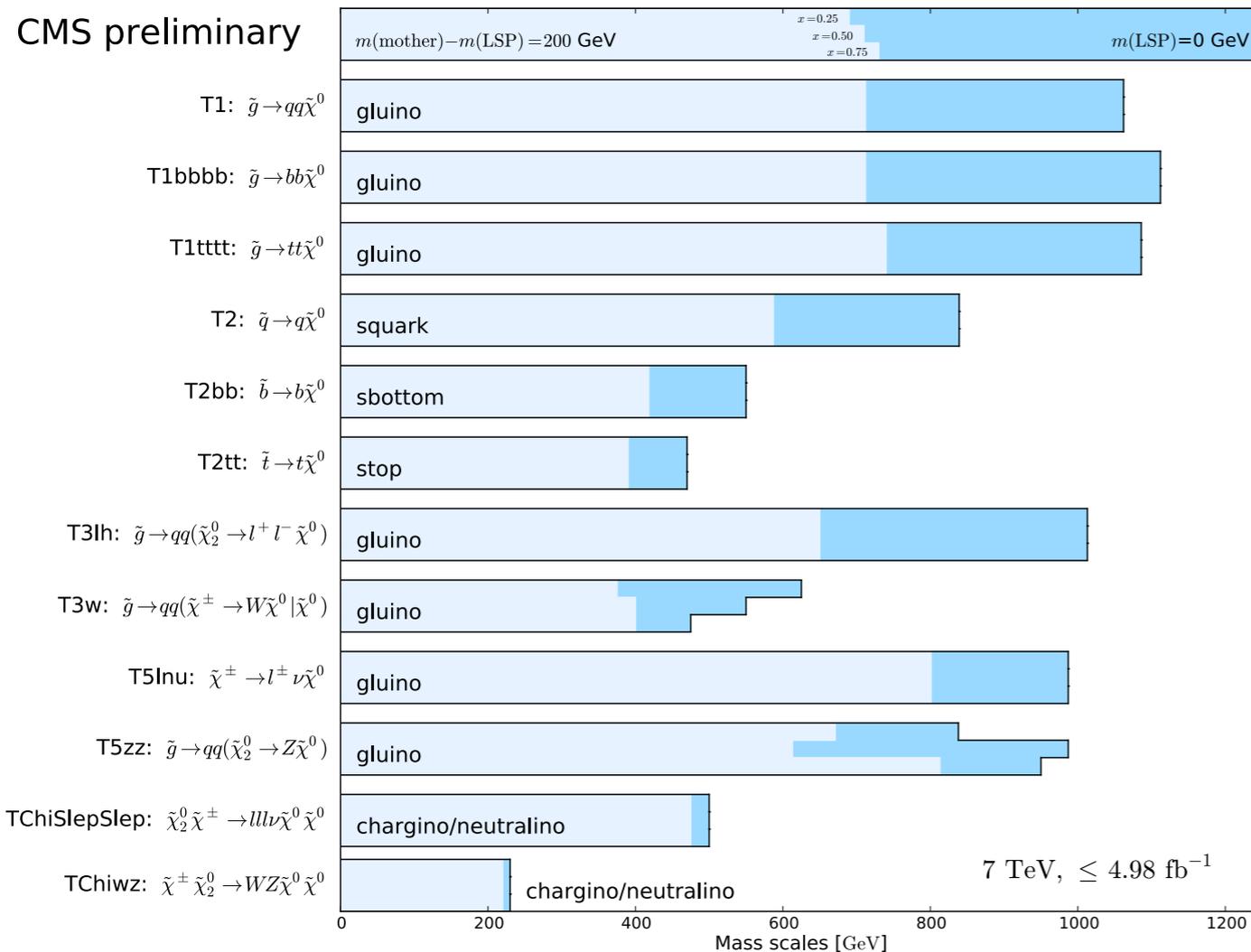
Some of these were updated for HCP 2012, but always the message holds:

**Good-old
Standard Model
doing very well!**

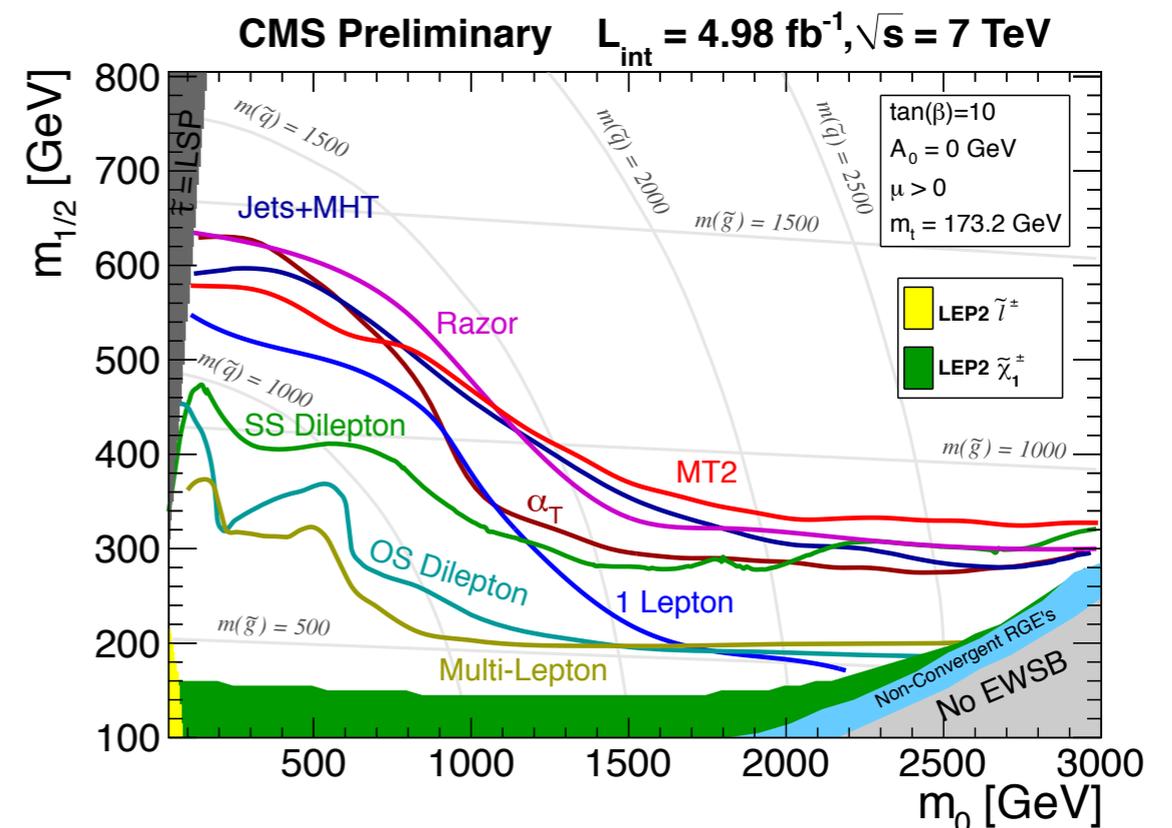


Supersymmetry

- Excellent idea, *hold on to it till the end...*
- easily solves symmetry breaking problem
- lightest SUSY particle (very weakly interacting): good dark matter candidate
- No signs of new physics anywhere else: simple models being squeezed, but parameter space is large



Limits on constrained minimal SUSY:



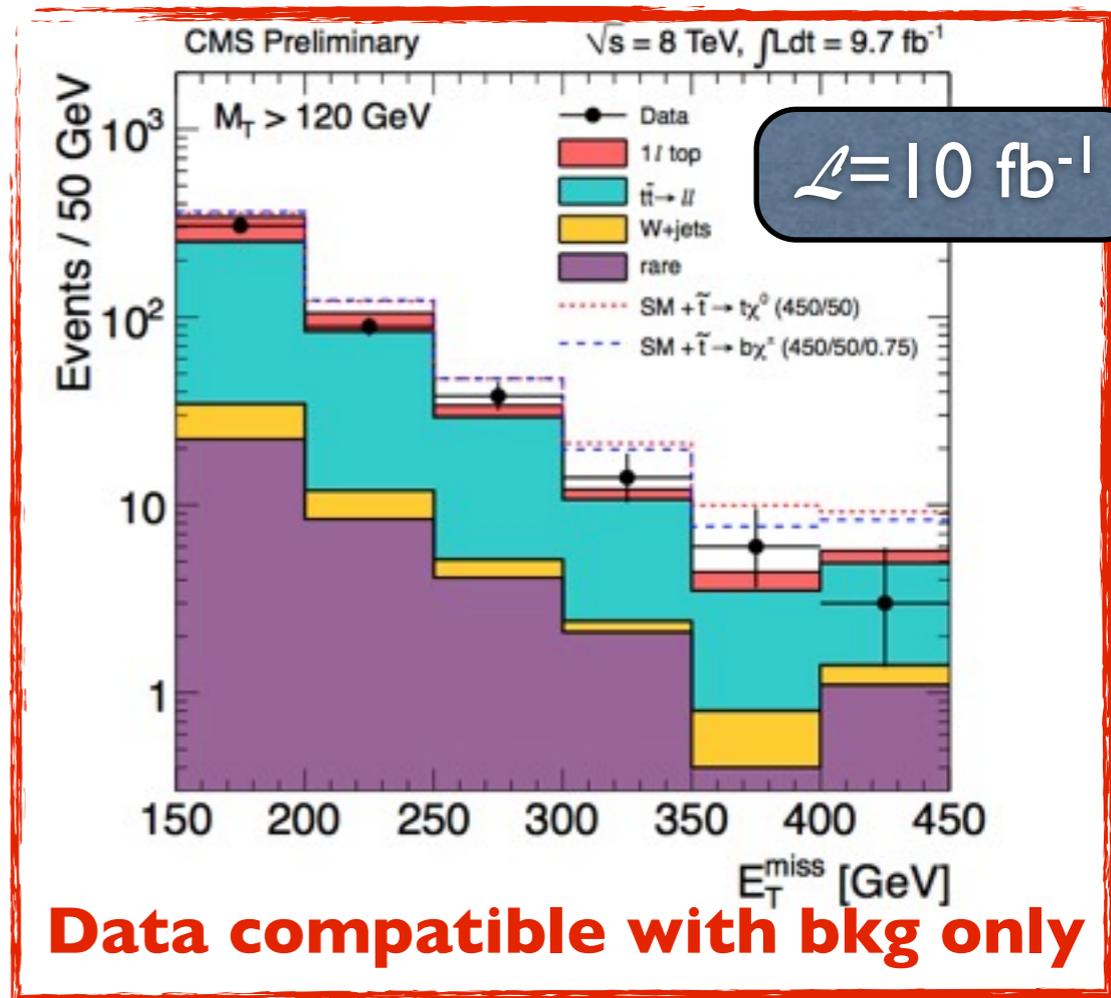
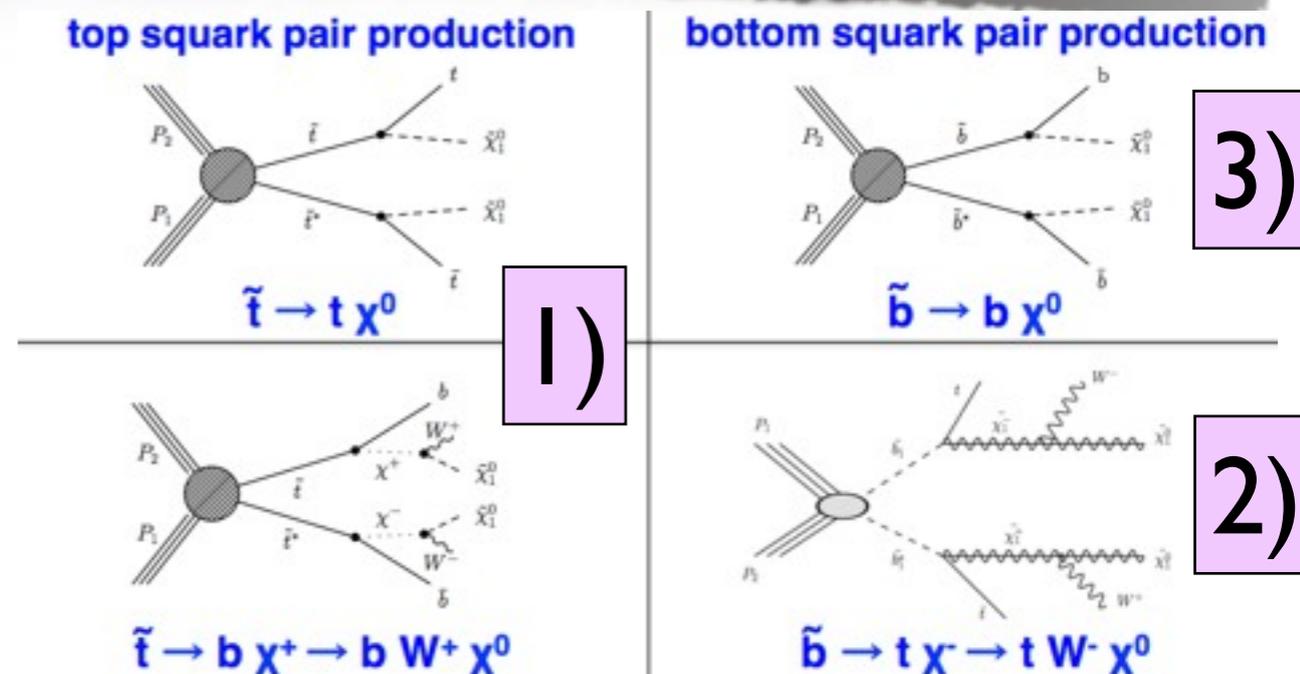
- *What is left to be looked at?*

Supersymmetry: example

- “Natural SUSY” solves hierarchy problem: **one light stop** (and light sbottom by weak isospin symmetry) **cancel top radiative correction to Higgs mass**

Direct searches

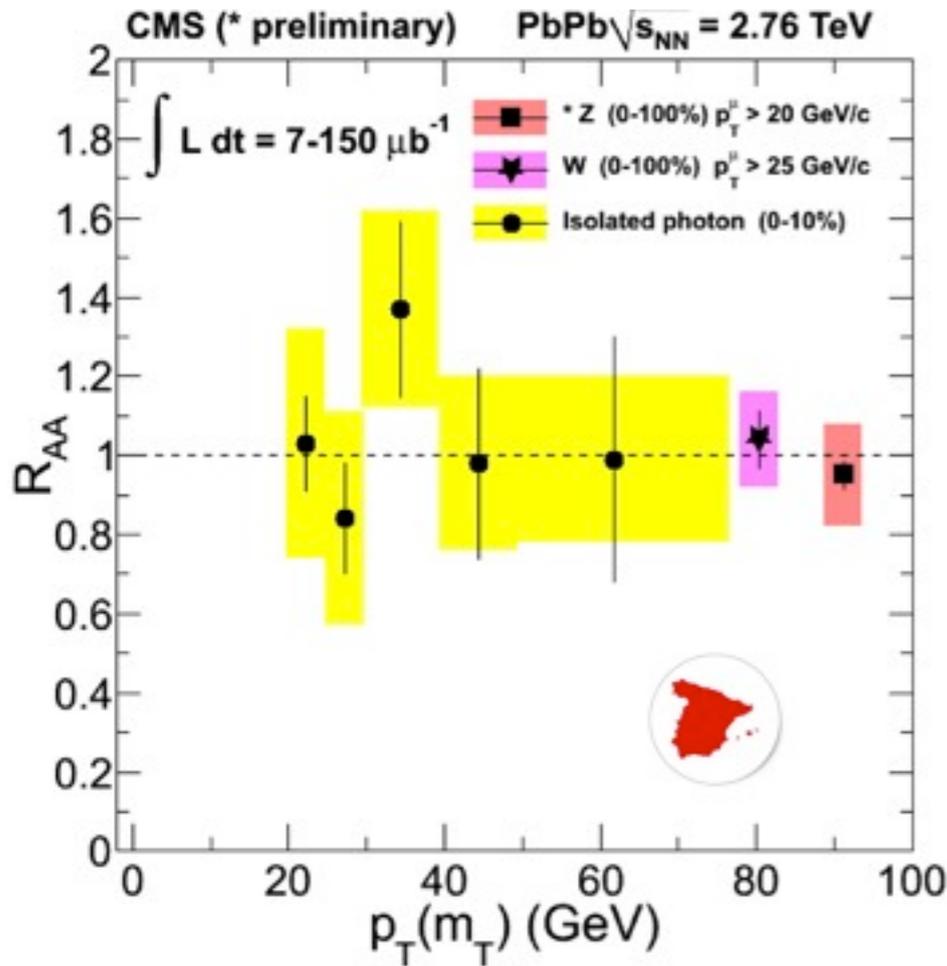
- Search 1: $\tilde{t} \tilde{t} \rightarrow t \chi^0 t \chi^0 \rightarrow tt + MET \rightarrow bWbW + MET \rightarrow b + j + j + b + l + MET$
 ➔ 1 lepton, ≥ 4 jets (1 btagged), MET
- Search 2: $\tilde{b} \tilde{b} \rightarrow t \chi t \chi \rightarrow tW \chi^0 tW \chi^0$
 ➔ 4 W's and 2 b jets in the final state: two leptons of same-sign, ≥ 2 b jets, MET, (signal enhancement:) H_T
- Search 3: all hadronic final state ➔ ≥ 2 b jets, α_T ($=E_T(j_2)/M_T(j_1, j_2)$) optimal var. suppresses fake MET)



Heavy Ions

- EWK bosons production

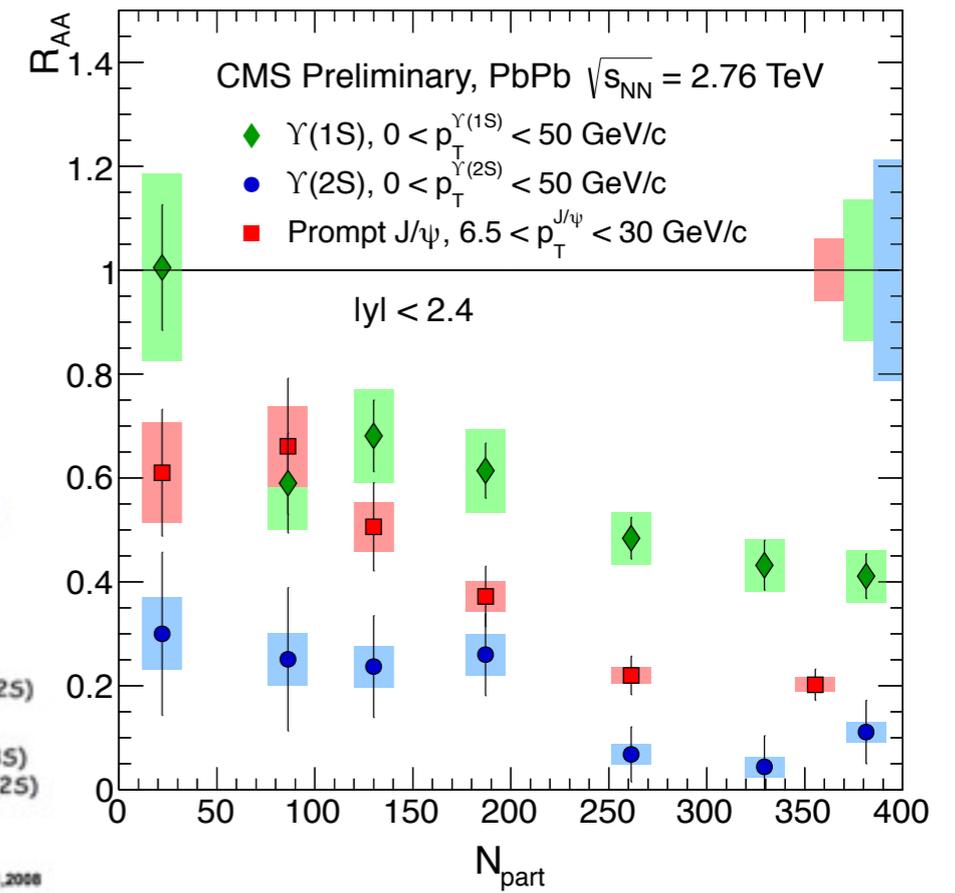
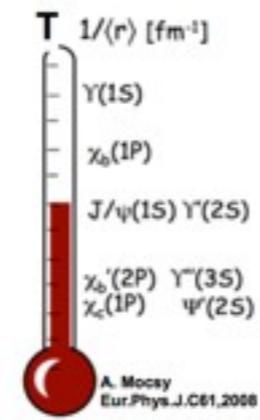
- Onia suppression



nuclear modification factor:

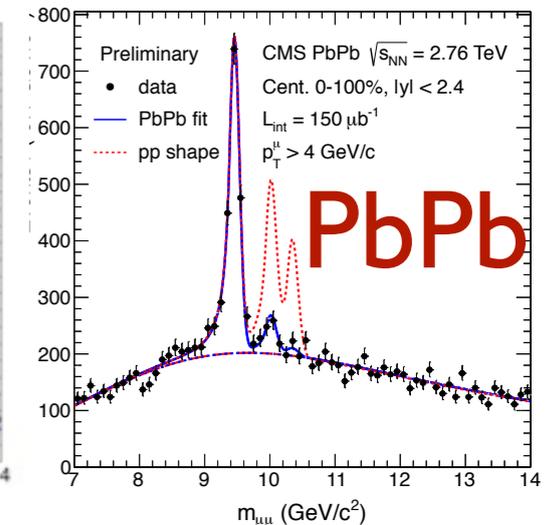
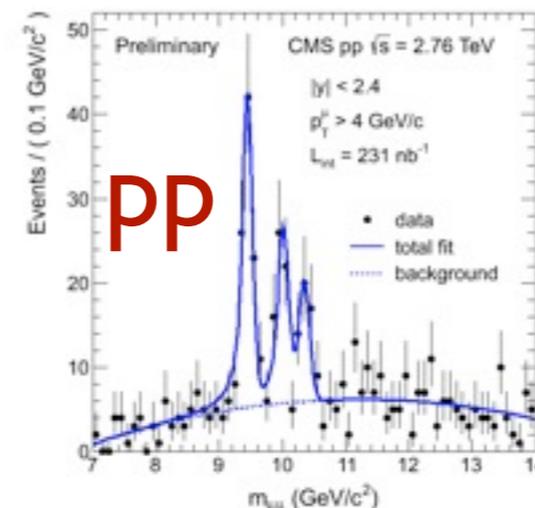
$$R_{AA} = \frac{N_{AA}}{N_{pp}} \frac{1}{N_{coll}}$$

Several probes
different medium



Bosons: $R_{AA} \sim 1$, not modified by the medium

Charm, bottom-onia: Debye screening at different medium temperatures, for different states





Publications

CMS Spain



Number of CMS publications

Show all

Total

QCD

Exotica Searches

Supersymmetry

B Physics

Electroweak

Top Physics

Heavy Ion

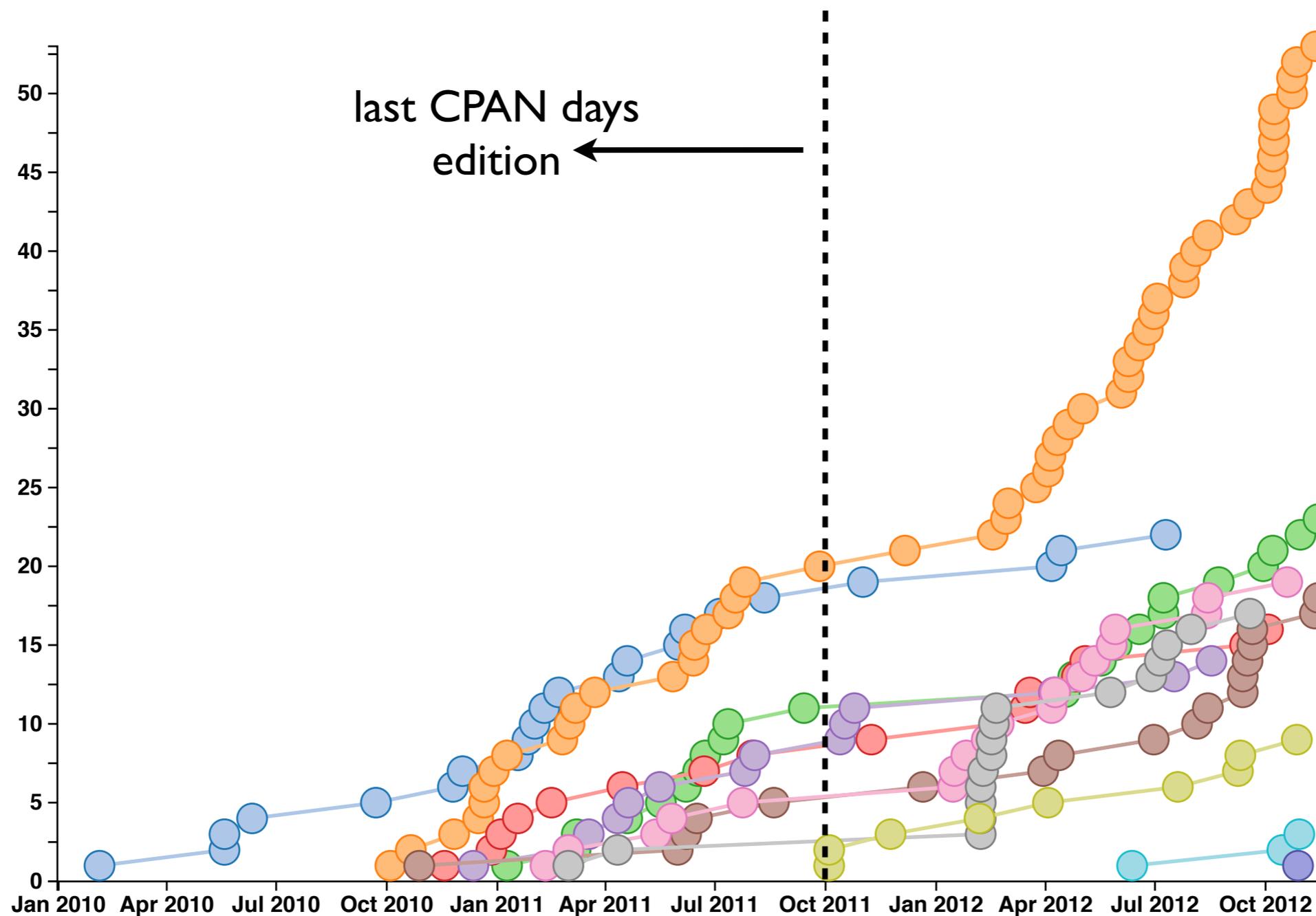
Higgs

Forward Physics

Standard Model

Beyond the SM: B2G

195 papers published



Spanish contribution to CMS **in 2012**

● Higgs

- **IFCA-Oviedo**: $H \rightarrow WW$
- **CIEMAT,UAM**: $H \rightarrow ZZ$

● Electroweak Physics

- **CIEMAT**: $W + \text{charm}$
- **IFCA-Oviedo**: WW and WZ cross-sections

● Top Physics

- **IFCA-Oviedo**: cross-section in ll channels
- **CIEMAT,UAM**: Wtb coupling structure
- **CIEMAT**: combination ATLAS+CMS

● SUSY searches

- **IFCA-Oviedo**: dileptons+MET

● Heavy Ions

- **CIEMAT**: W production in heavy ion collisions

● Muon-related activities

- **CIEMAT**: “Physics-object” group coordinator, “Trigger” coordinator, “DT Technical” coordinator, detector & electronics maintenance (DT)
- **UAM**: LI trigger responsibility
- **IFCA**: DT alignment (link tracker-DT barrel)

● Detector upgrade

- **CIEMAT**: “DT upgrade” coordinator

● B-tagging

- **CIEMAT**: efficiency in data&MC from long-lived J/Ψ
- **IFCA**: “Performance” group coordinator, software management

● Computing

- Resources: Tier-1 (**PIC**), Tier-2 (**CIEMAT,IFCA**);, Tier-3 (**Oviedo,UAM**)
- **CIEMAT**: “Computing Integration” coordinator

● Run Coordinator: (**CIEMAT**)

● Collaboration Board Chair: (**IFCA**)

*These items do not include an extensive list of tasks performed **and finished** by Spanish groups prior to 2012*

Conclusions

- **CMS detector in good shape**

- Excellent performance from LHC startup until now (~ 3 years)
- First long LHC shutdown planned for 2013; intense activities on detector upgrade (not covered)

- **LHC operation smooth, delivering a huge amount of data**

- Pile-up (side effect of high luminosities) taken care of in many fronts
 - data collection, storage and processing:
 - improved triggers (logic and software), data parking (later processing), data scouting (reduced event content)
 - Physics objects definitions improved (area corrections, tracking) to mitigate PU effect in data analysis

- **Physics highlights overshadowed by discovery of a new boson X(125.8)**

- Physics program (primarily) oriented to characterize this new particle
- Updates: 7σ ; small bump starts to build up on $H \rightarrow \tau\tau$; better compatibility with SM Higgs

- **... but not only:**

- interesting searches for new physics: exotic models, SUSY: so far, only standard model results
- precision measurements in top, b- physics, QCD, heavy ions

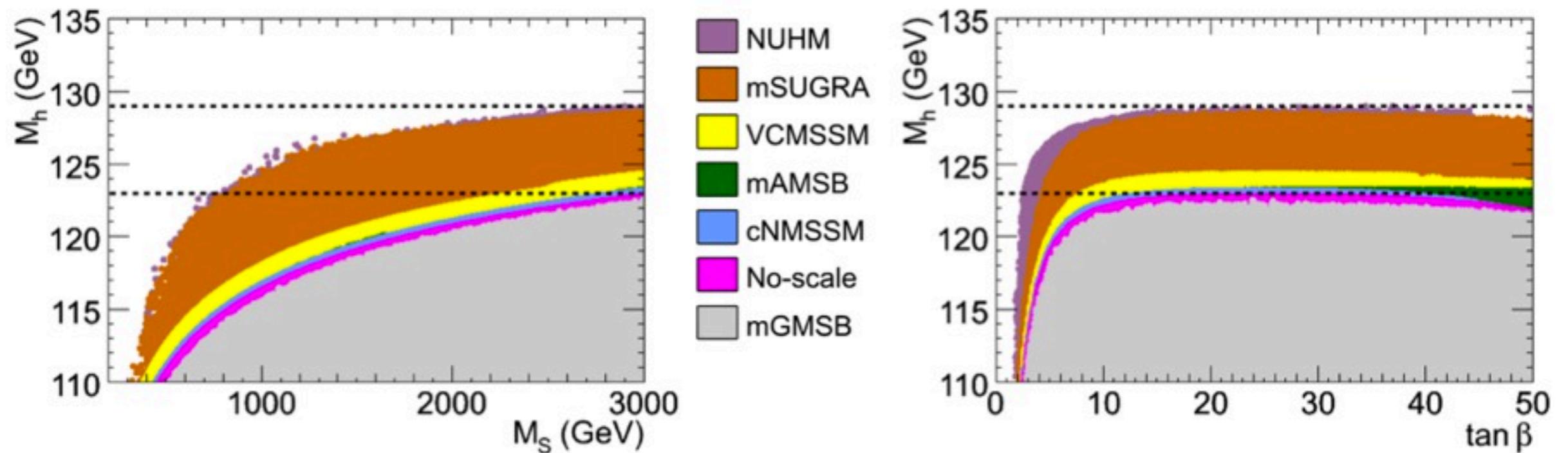
Looking forward to the next big 'advent'!

Backups

Supersymmetry

- If Higgs mass=125 GeV: stronger constraints on SUSY models

F.Mahmoudi et al CERN-PH-TH/2012-307



Simplified Model

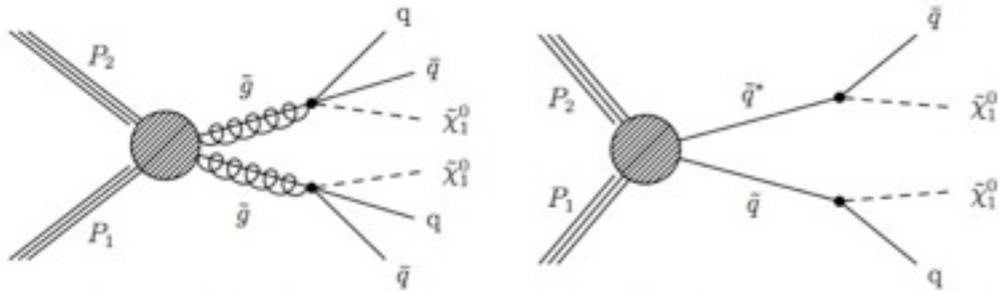


Figure 1: Diagrams of the hadronic models: gluino pair production (T1,left) and squark anti-squark production (T2,right).

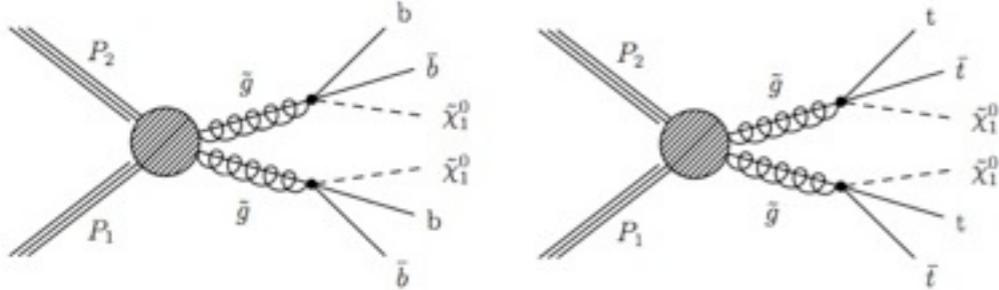


Figure 2: Diagrams of the heavy flavor models: T1bbbb (left), T1tttt (right).

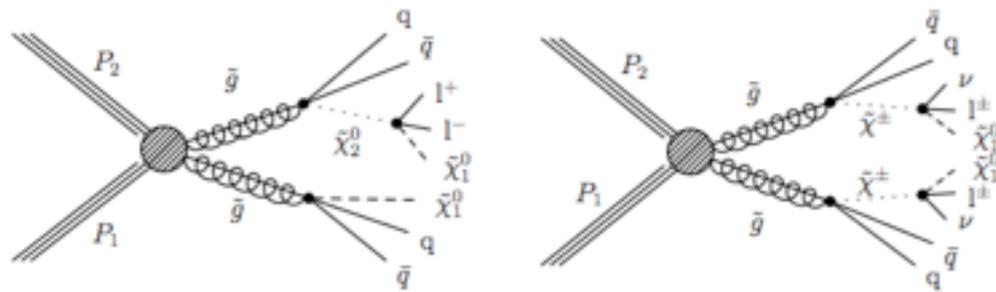


Figure 3: Diagrams of the dilepton models: T3lh (left), T5lnu (right).

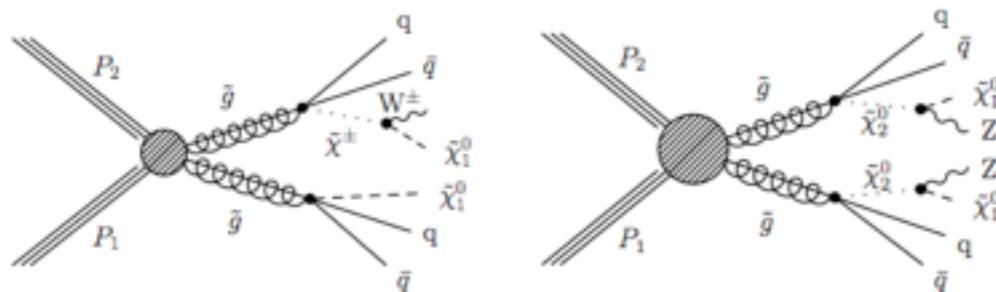


Figure 4: Diagrams of T3w (left), T5zz (right).

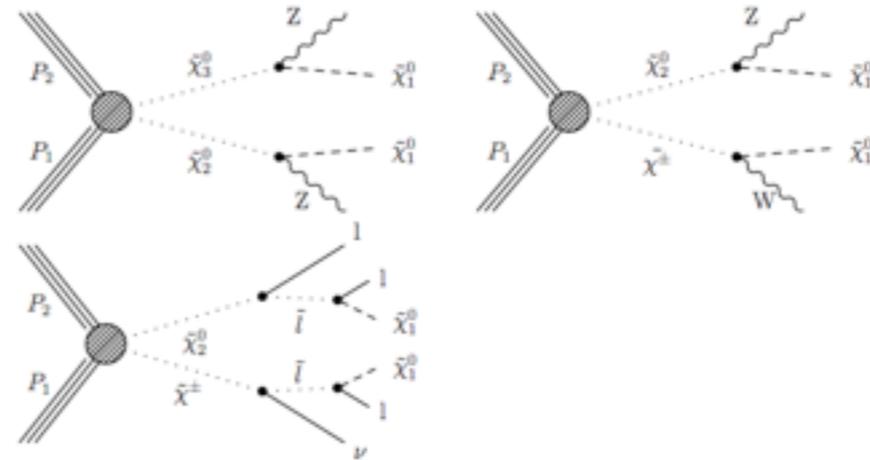


Figure 5: Diagrams of chargino and neutralino production: TChizz (left,top) TChiwz (right,top), and TChiSlepSlep (bottom).

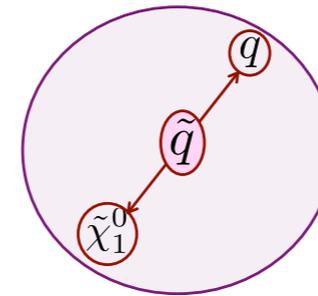
$$m_{\tilde{\chi}_2^0} | m_{\tilde{\chi}^\pm} = x \cdot m_{\tilde{g}} + (1 - x) \cdot m_{\tilde{\chi}^0}$$

Razor variables in SUSY searches

CMS PAS-SUS-11-008

Search for SUSY using Razor variables $\sim 1 \text{ fb}^{-1}$

- Search for pair production heavy particles
 - squarks and gluinos
- Objects grouped into two “megajets”
 - perform event-by-event test that they represent visible portion of decays
- Use two kinematic variables: M_R and R
 - Evaluated in *razor* frame:



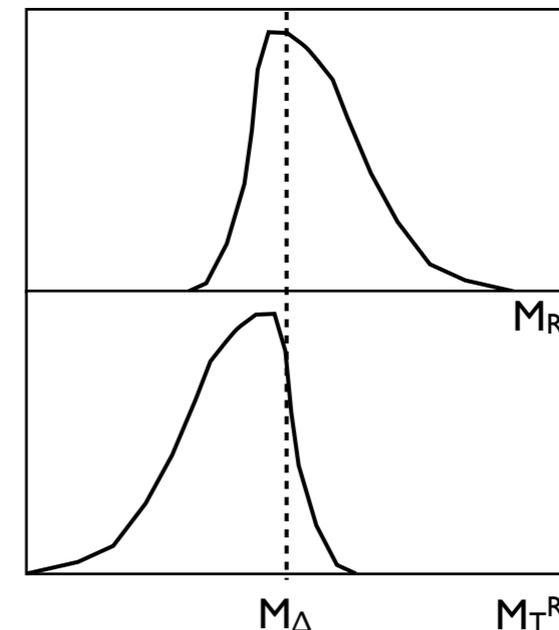
$$M_{\Delta} \equiv \frac{M_{\tilde{q}}^2 - M_{\tilde{\chi}}^2}{M_{\tilde{q}}}$$

M_R is invariant under this longitudinal boost

$$M_R \equiv \sqrt{(E_{j_1} + E_{j_2})^2 - (p_z^{j_1} + p_z^{j_2})^2} \quad \leftarrow M_R \text{ peaks at } M_{\Delta}$$

$$M_T^R \equiv \sqrt{\frac{E_T(p_T^{j_1} + p_T^{j_2}) - \vec{E}_T \cdot (\vec{p}_T^{j_1} + \vec{p}_T^{j_2})}{2}} \quad \leftarrow M_{\Delta} \text{ edge in } M_T^R$$

$$R \equiv \frac{M_T^R}{M_R} \quad \leftarrow R \text{ is ratio of the two and related to MET}$$

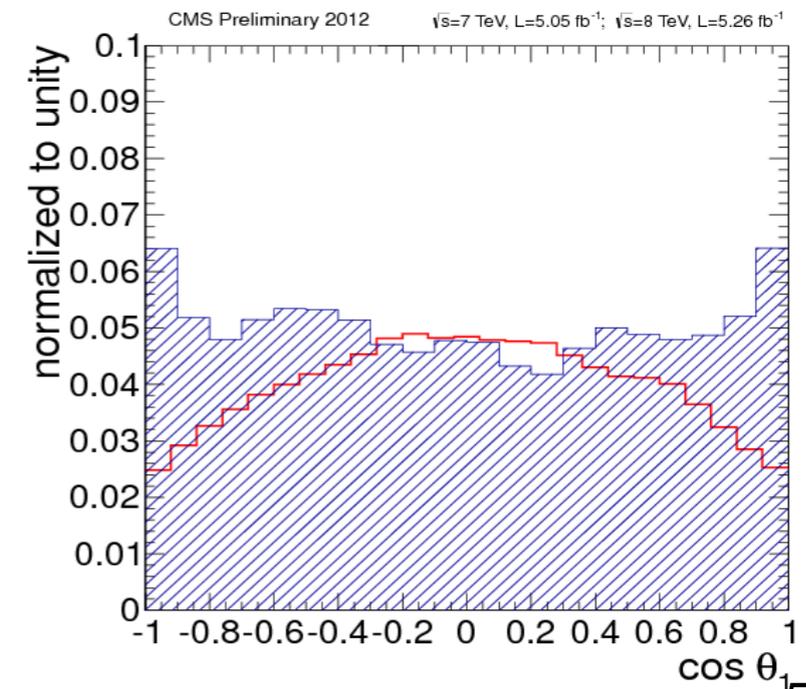
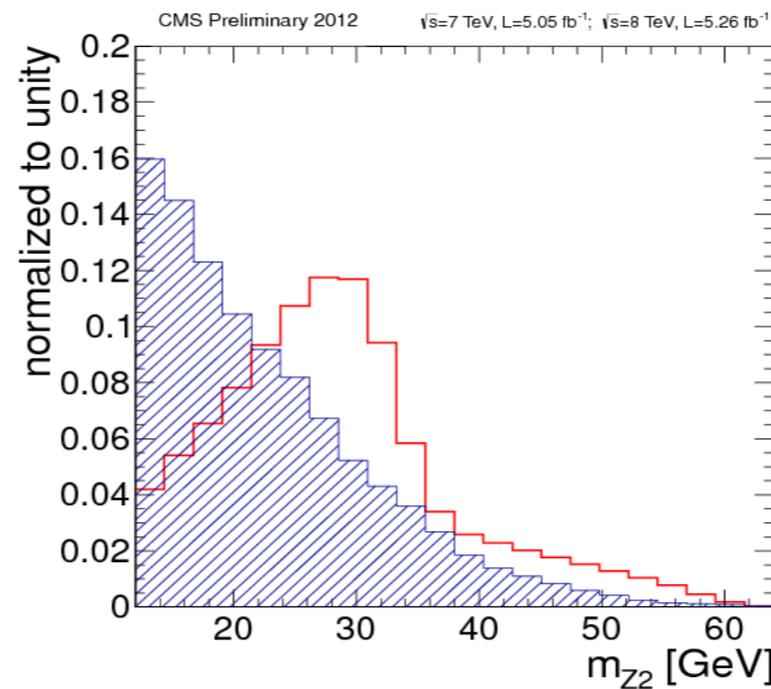
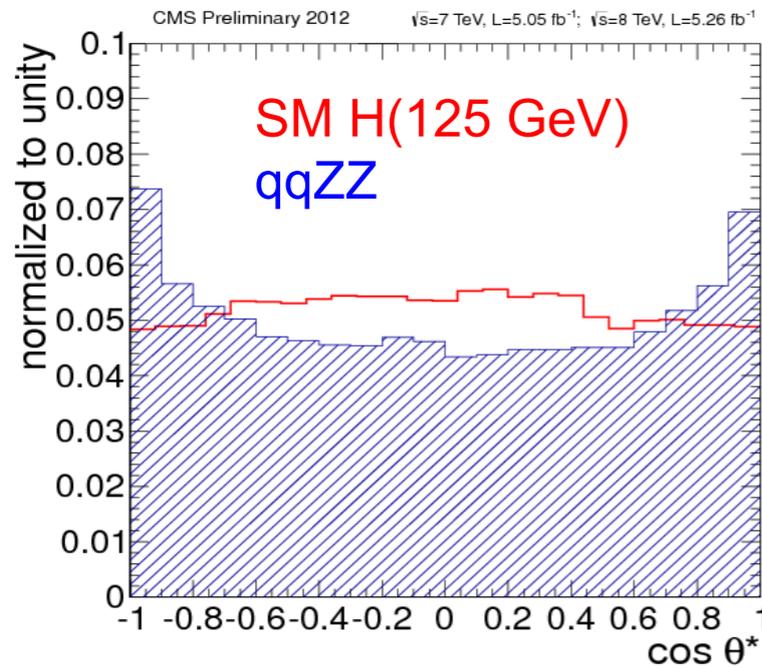
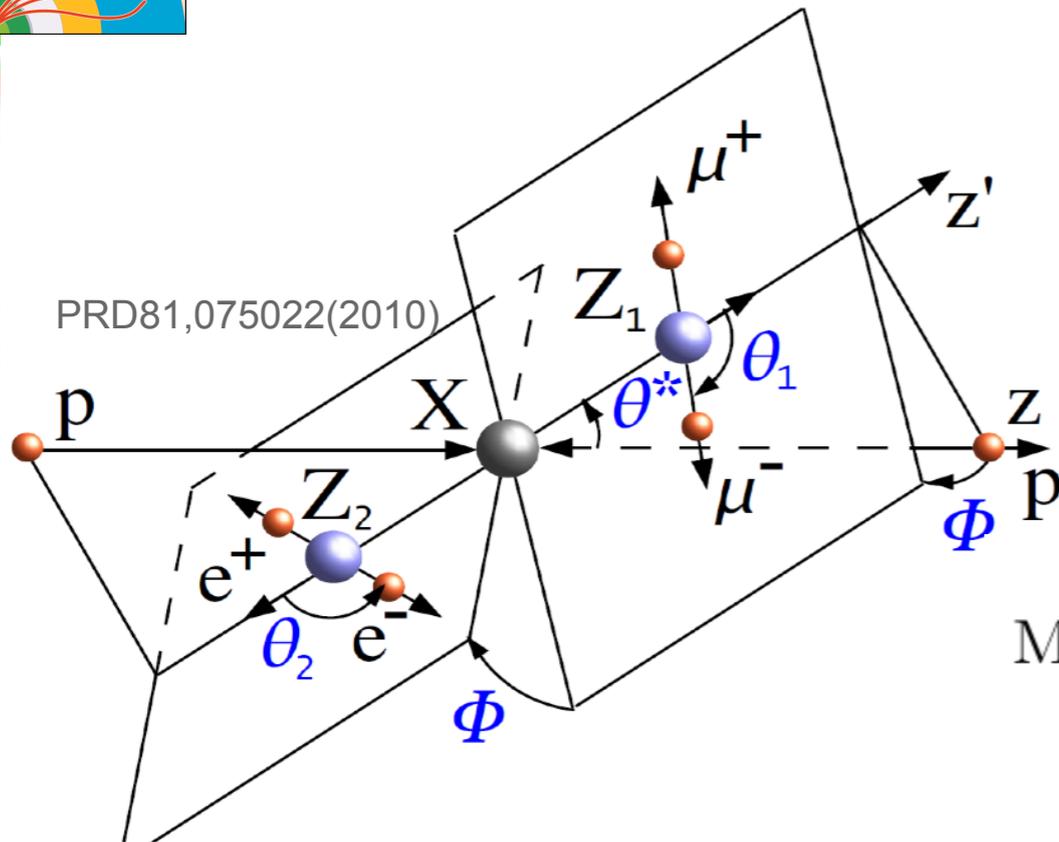




MELA

Matrix **E**lement **L**ikelihood **A**nalysis:
 uses kinematic inputs for
 signal to background discrimination
 $\{m_1, m_2, \theta_1, \theta_2, \theta^*, \Phi, \Phi_1\}$

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



Data scouting

● **Scouted data actually used for analysis!**

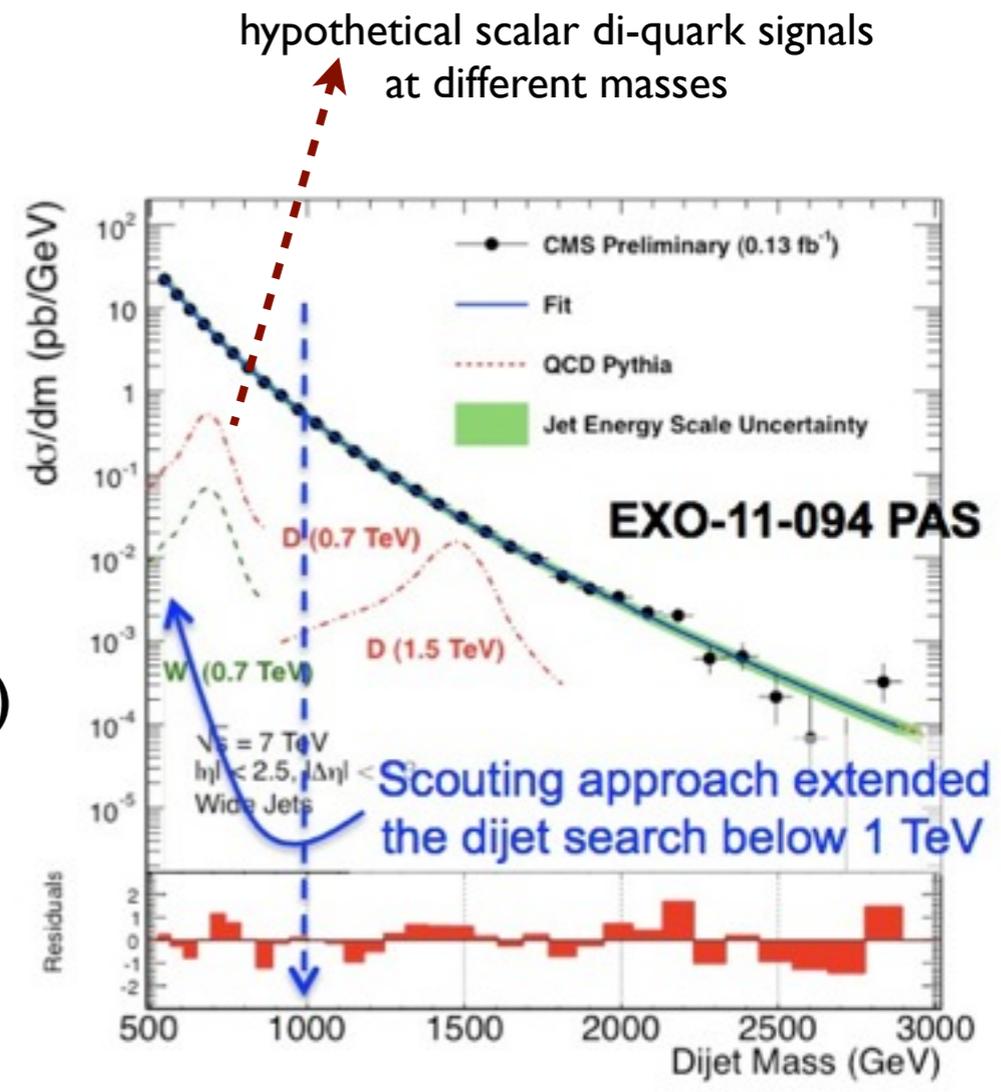
First real case:

- search for new physics in hadronic final states
- Resonances on dijet mass spectra predicted in many models : Z' or W' with SM couplings, Randal-Sundrum gravitons (extra-dimensions), technicolor...
- Event selection: 2 jets with low transverse momentum (p_T) and low H_T ($H_T = \sum p_T$ of all jets with $p_T > 40$ GeV)
- **Trigger:** require $H_T > 350$ GeV (or dijet mass > 400 GeV)
 - ⇒ overwhelmed by enormous amount of QCD events ; **huge rate: $\sim 10^3$ Hz**
 - ⇒ impossible to maintain all data in 'normal' format

● **Scouting: store** only 4p of the "particle-flow" **jets** reconstructed during High Level Trigger online processing. **Nothing else!**

(resolution $\sim 1.05x$ worse wrt offline reconstruction)

Only 0.13 fb^{-1}



In 2012, we can benefit from almost the full integrated luminosity ($> 15 \text{ fb}^{-1}$)

Heavy quarkonia suppression in Heavy Ions

- QGP: deconfining medium
- Screening radius : $\propto 1/\text{energy density}$
 - or $1/(\text{density of colour charge})$
- If screening radius $<$ resonance size : bound state not formed
- Quarkonia “dissolved”, appearing later as open c, b
 - known as Debye screening mechanism

