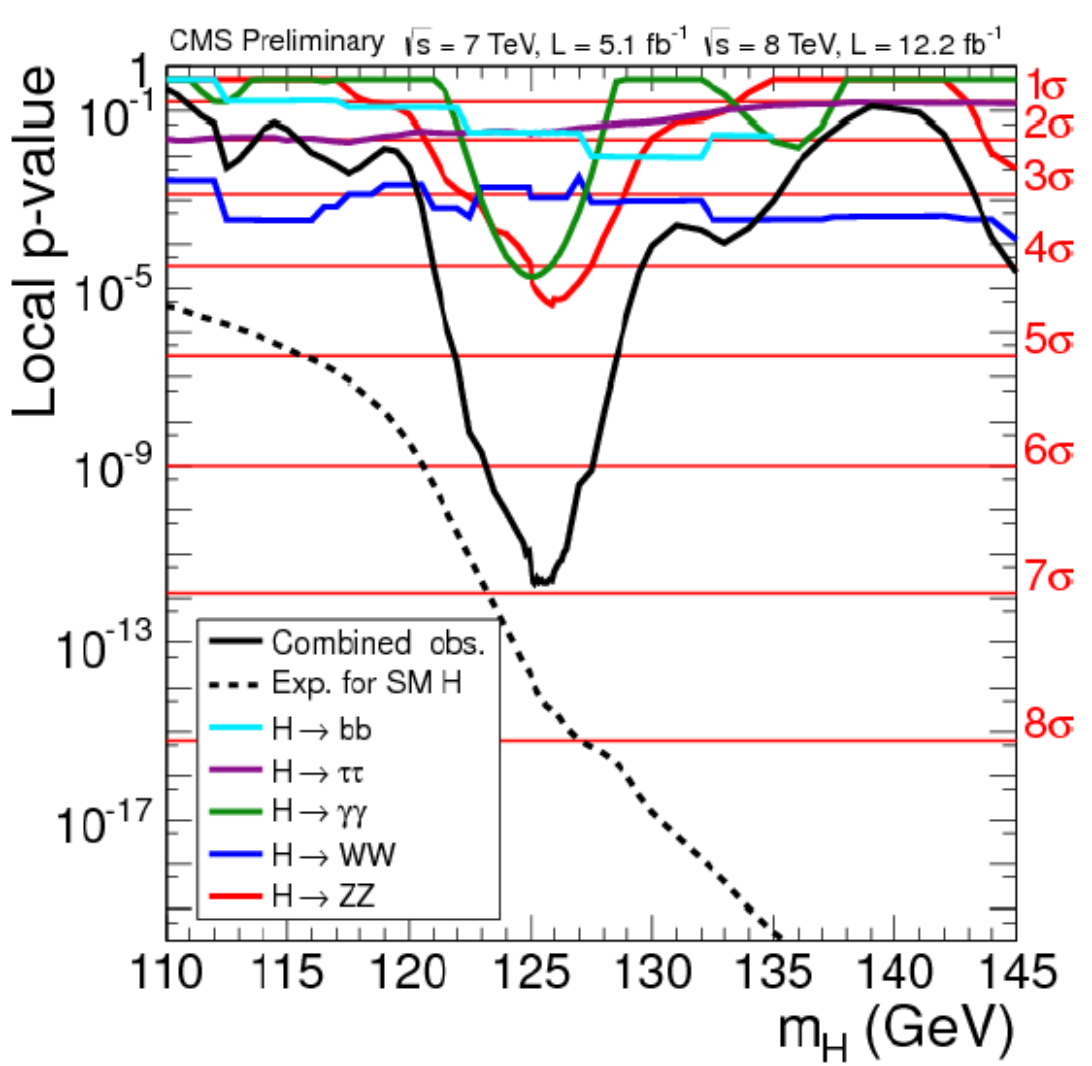
Summary of 2012 CMS results

S.Bolognesi (Johns Hopkins University)
on behalf of CMS Collaboration

CERN Council meeting – December 2012

Higgs's year!

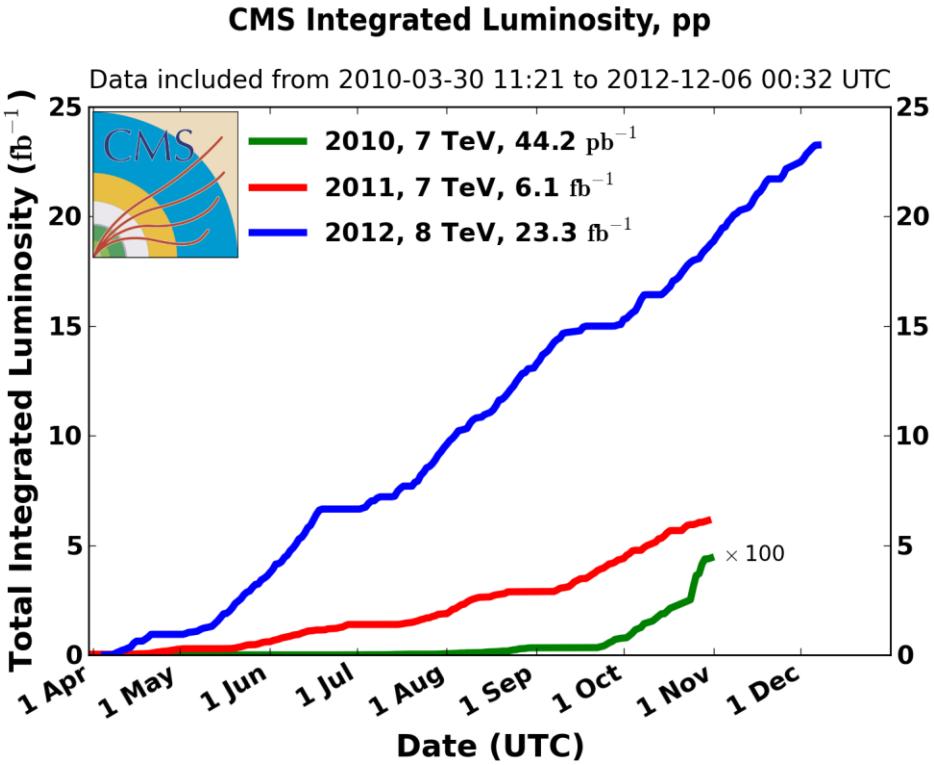


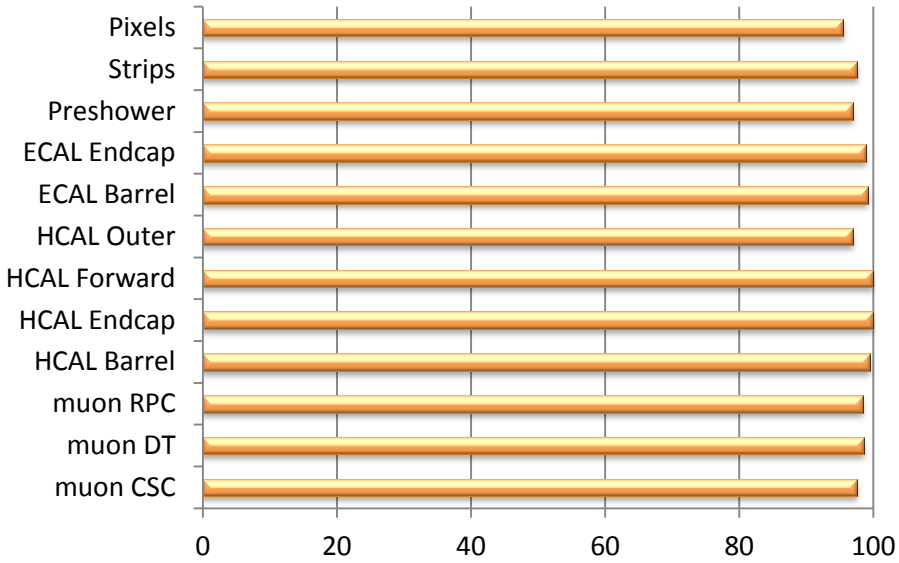
p-value = probability of observing such a result if the Higgs was not there
-> ~10^{-12}

Is like flipping a coin 40 times and getting 40 heads

Recipe for a success

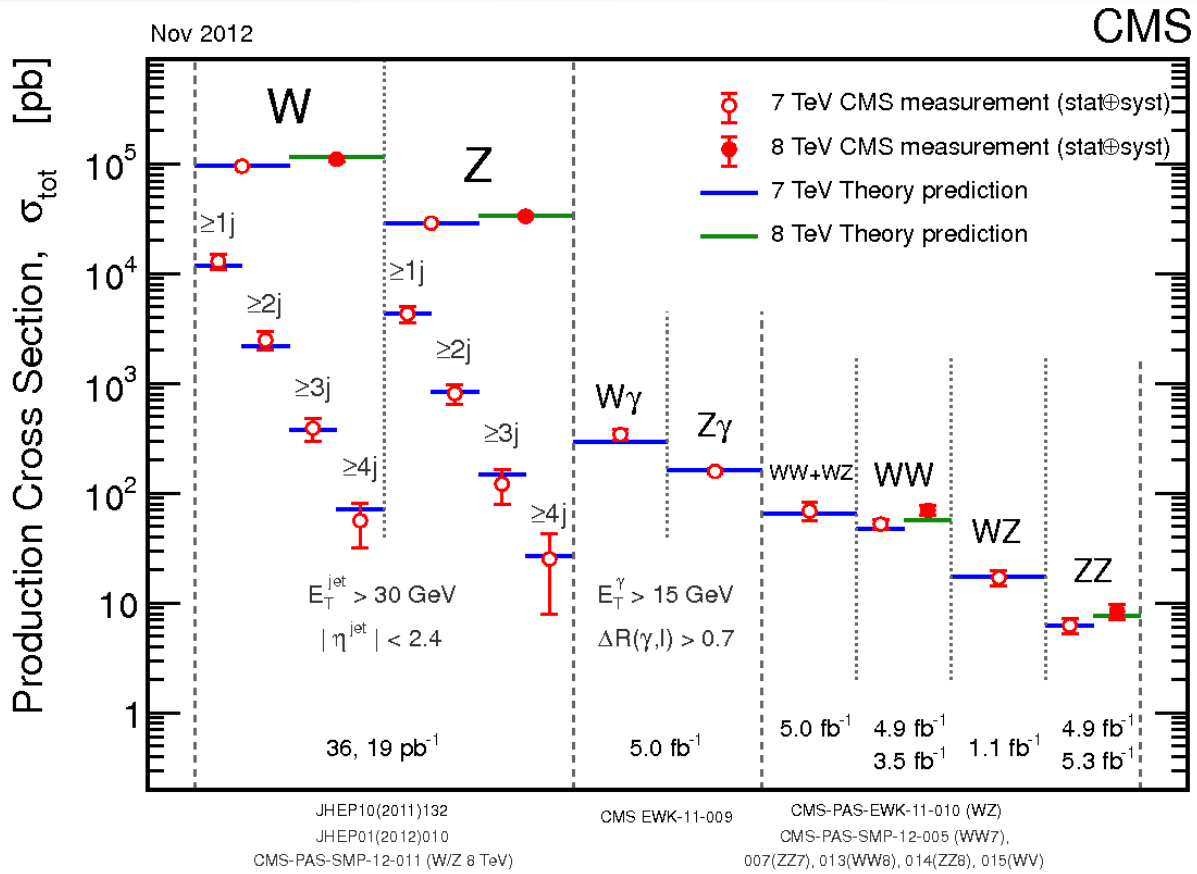
- **High luminosity from LHC and CMS amazing performances**





- **High energy (8 TeV)** -> Larger S/B: fundamental ingredient of the discovery

Re-discovering the Standard Model at 8 TeV



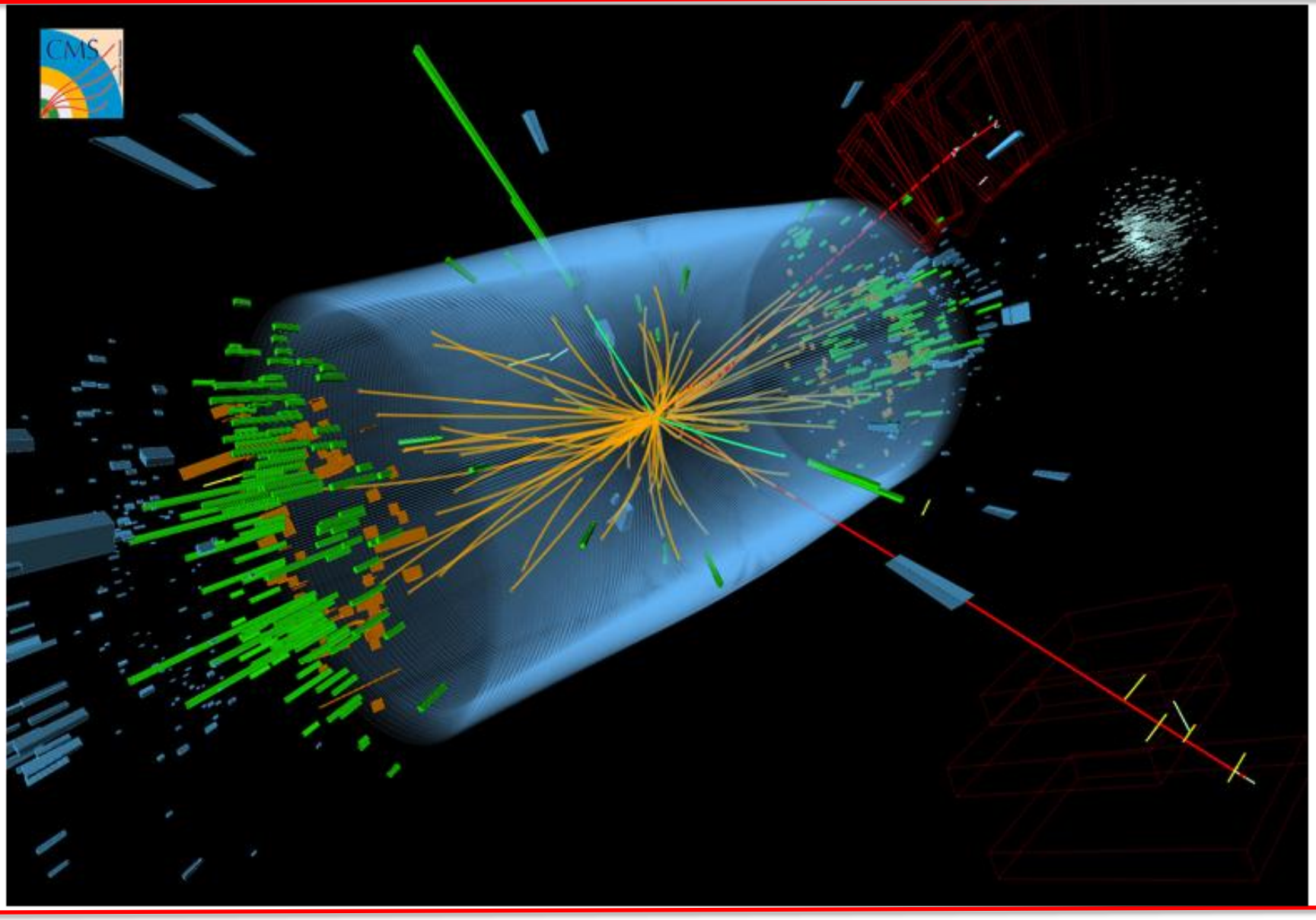
- Perfect control of such a huge and sophisticated system (calibration)

  -> rediscovery of the Standard Model

  -> precise knowledge of background to Higgs search

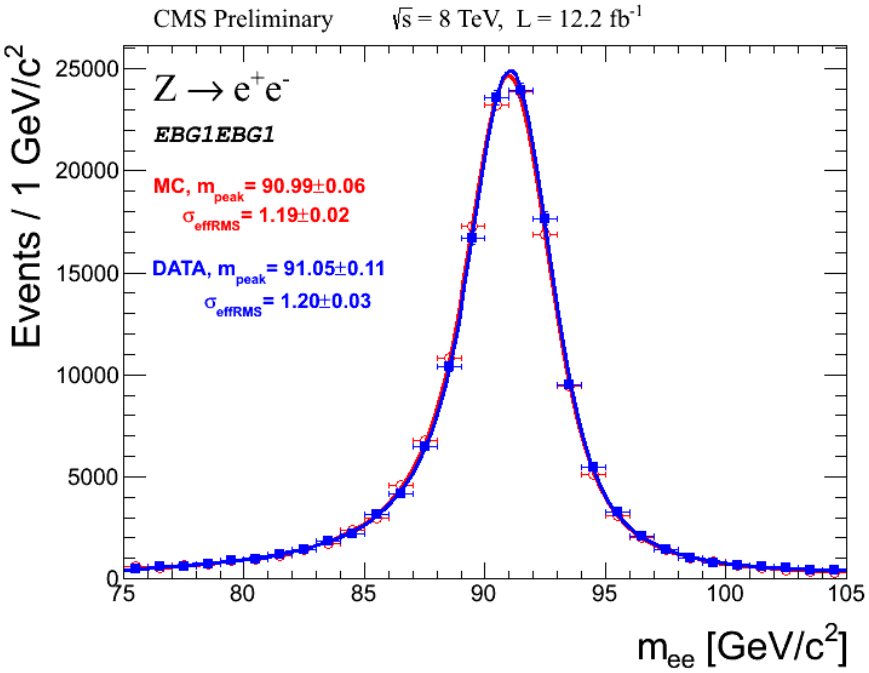
1 Higgs event each 10^{10} events

Event display of a clean Higgs candidate

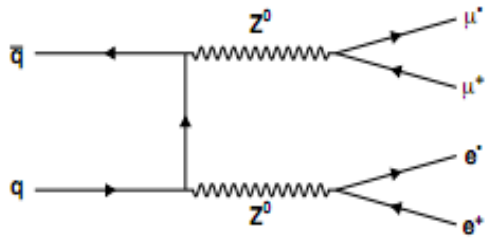


Four-leptons final state

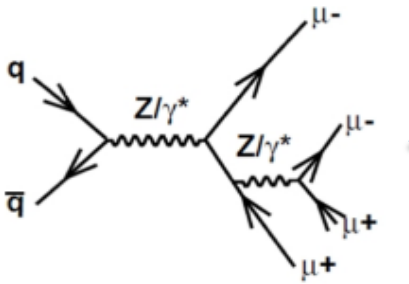
- Good control of detector performances (down to very low pT)

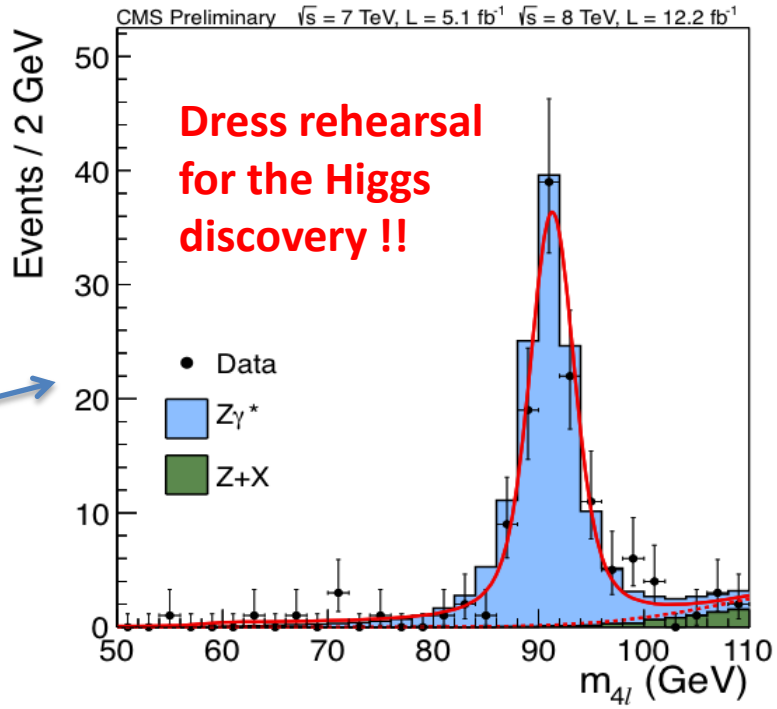


- Measurement of **ZZ → 4l xsec**

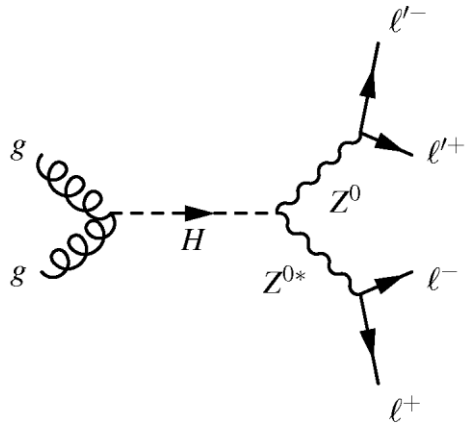


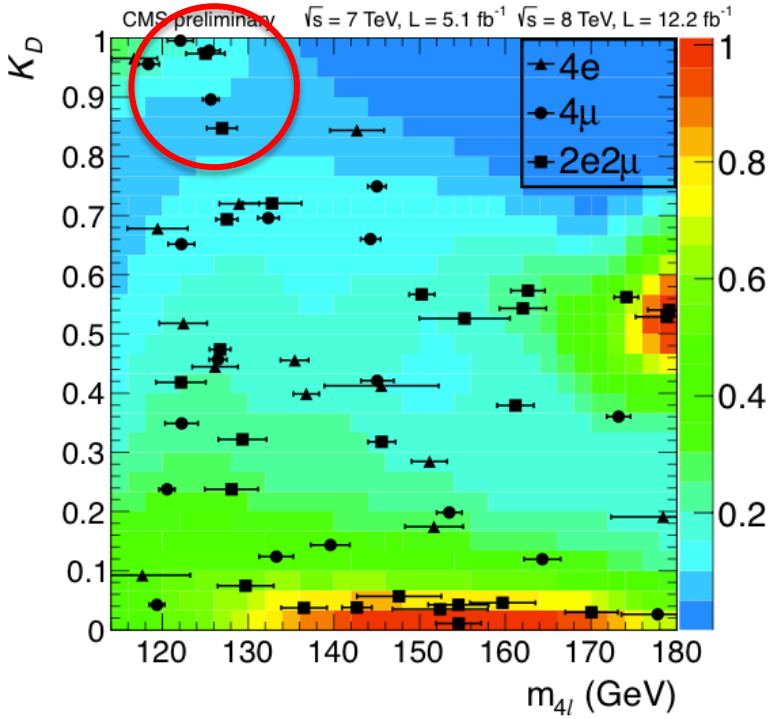
-> even more rare process: **Z → 4l**

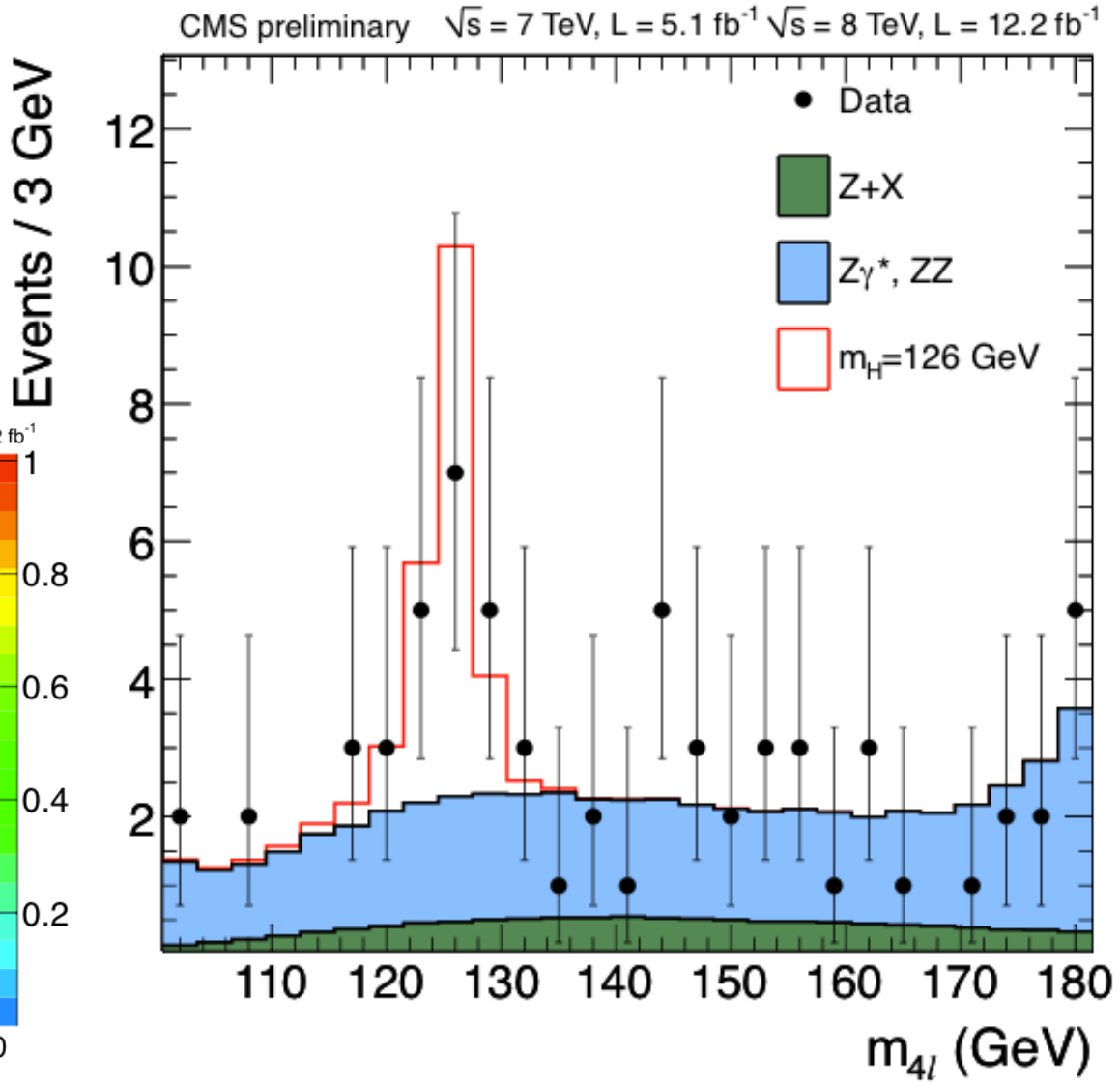




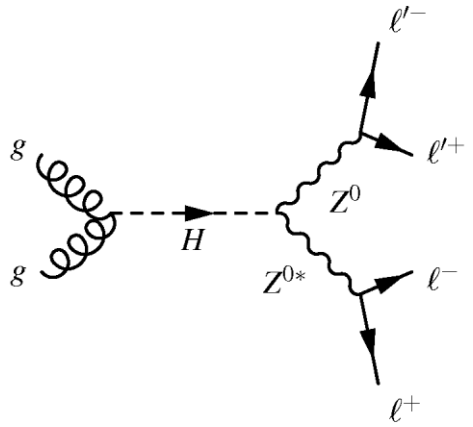
H → ZZ → 4 leptons

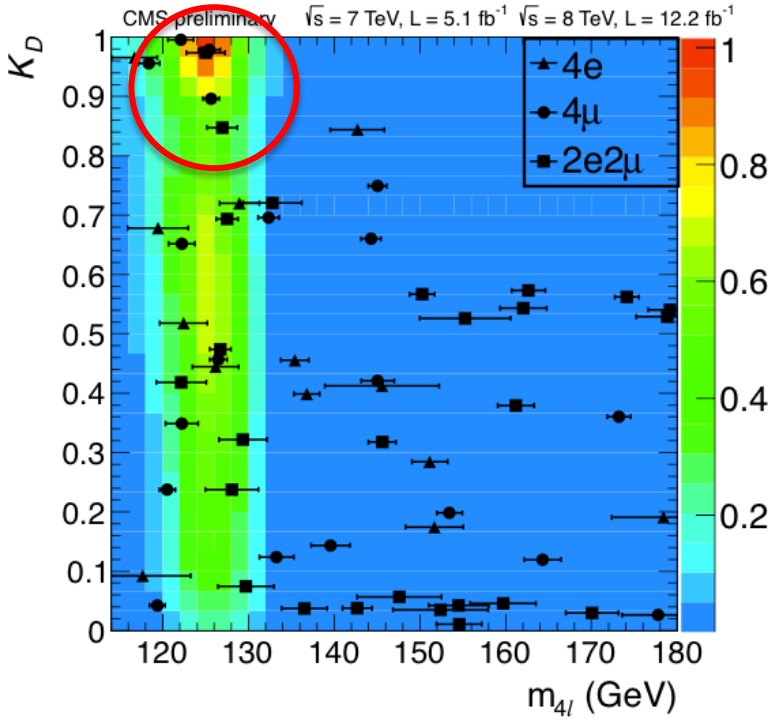


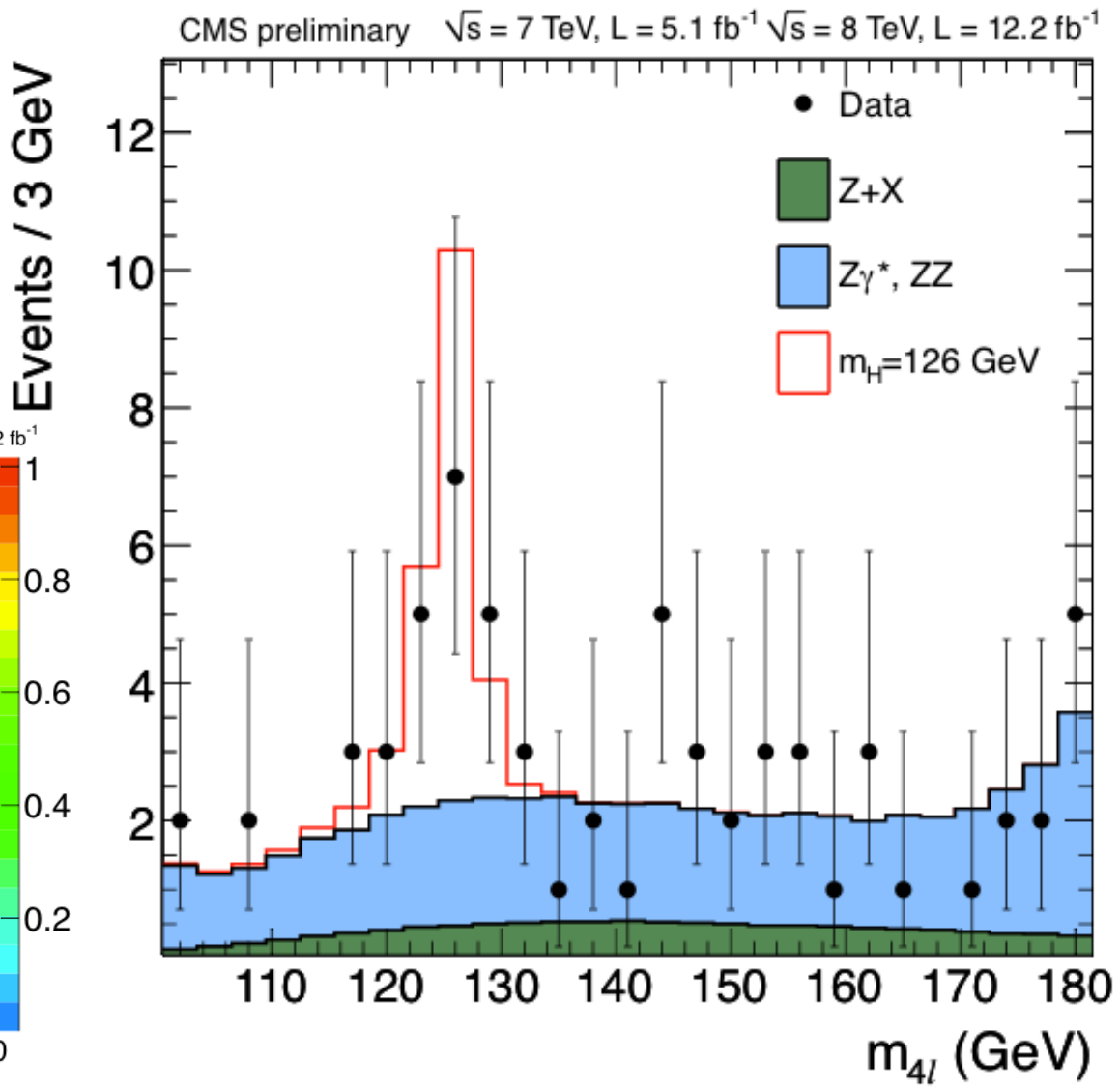




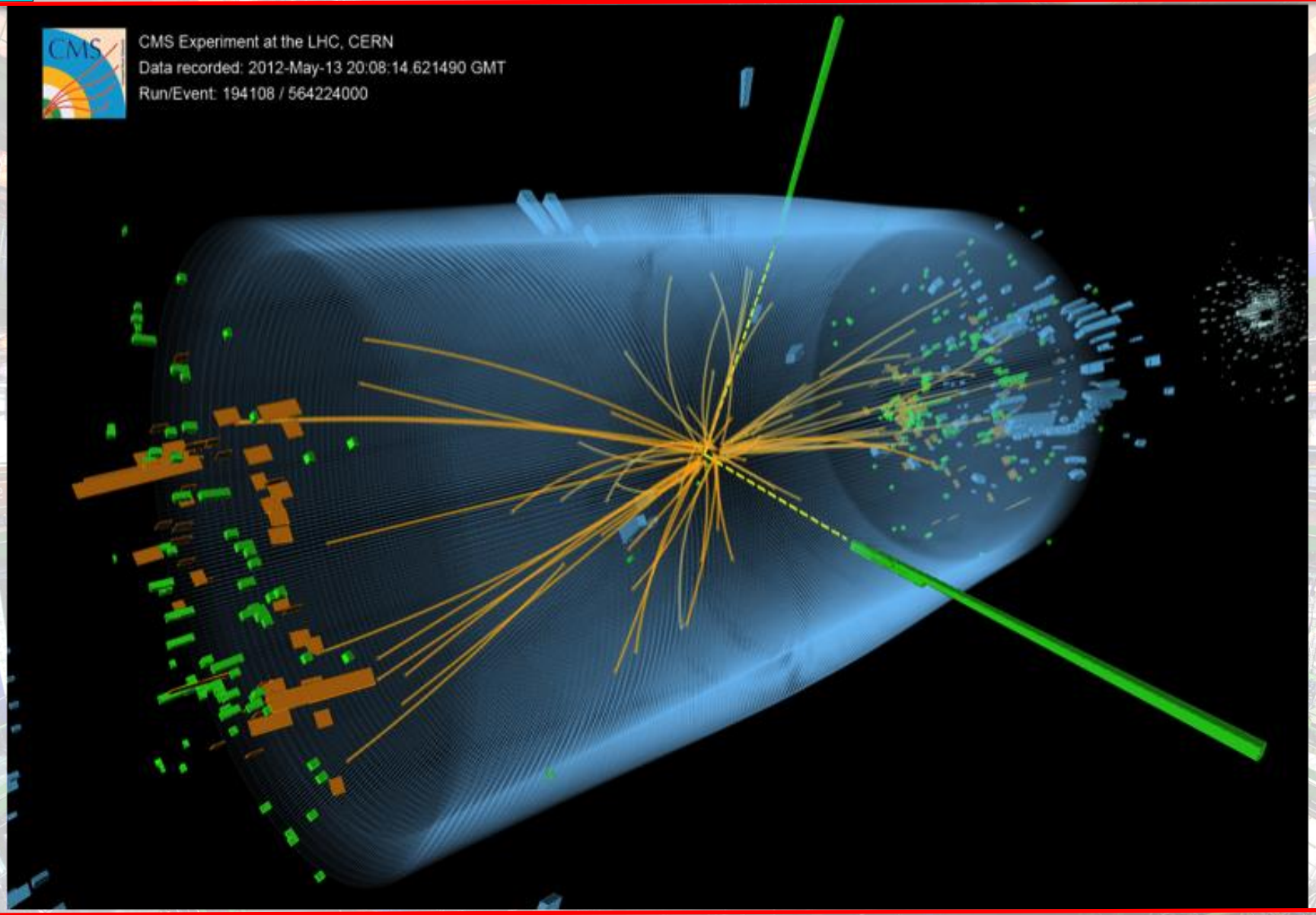
H → ZZ → 4 leptons





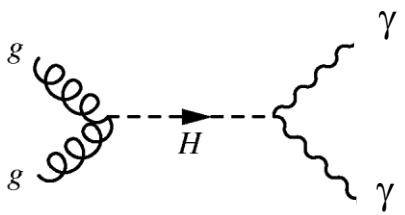


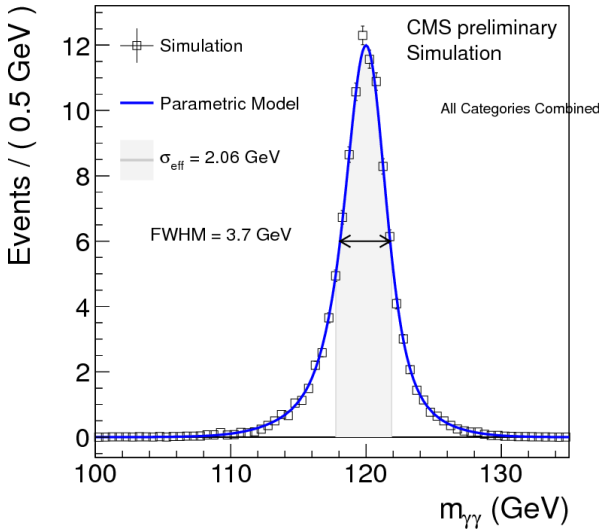
Event display of Higgs → 2 photons candidate

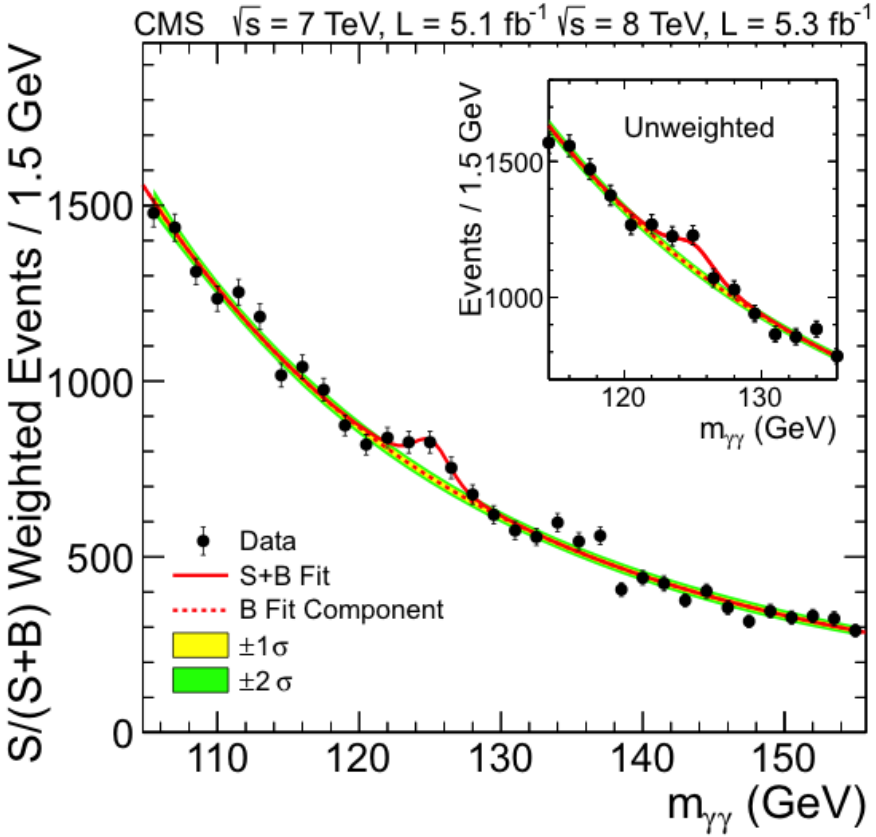


H → photons (γγ)

- Distinguishing between $\pi^0 \to \gamma\gamma$ and isolated γ : multi-variate analysis for **photon identification**
- Very good **mass resolution (~2 GeV)** to identify small peak over large background

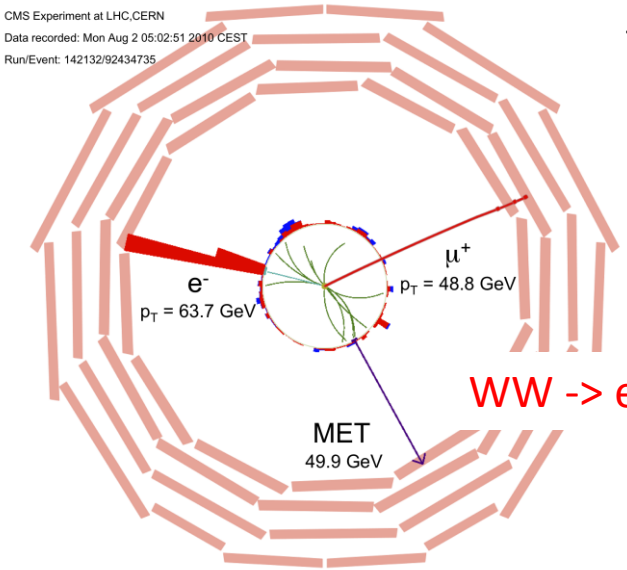






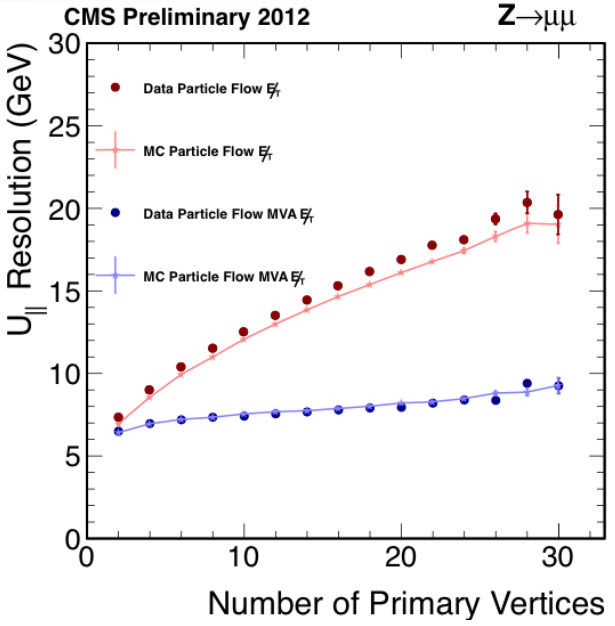
Missing energy and jets

❑ **Very precise energy scale/resolution**



-> good control of missing energy (also at high PU)

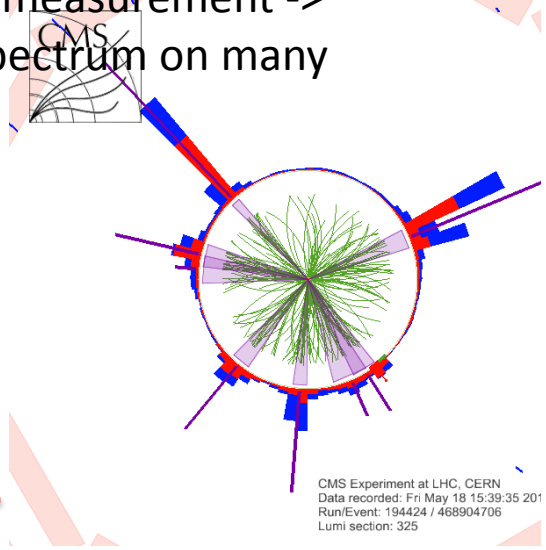
WW -> eνμν event

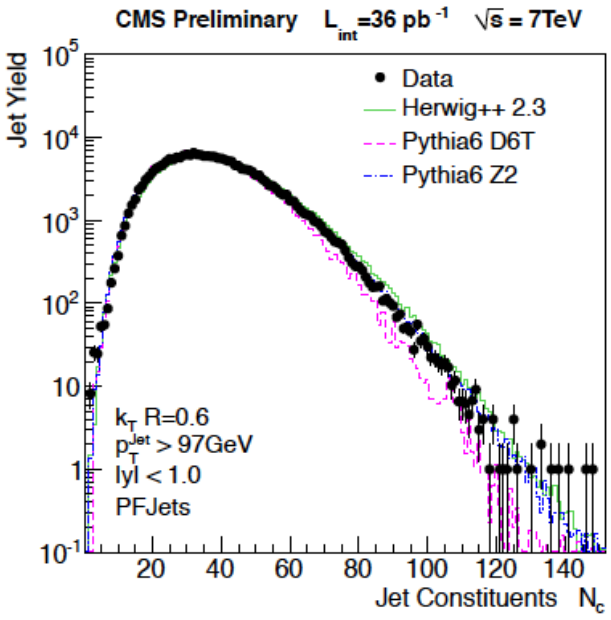


❑ High precision in jet energy measurement -> dijet cross-section and mass spectrum on many order of magnitude

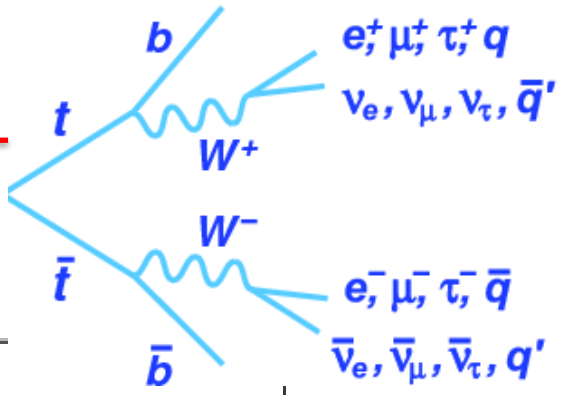
Disentangling fine details of the **jets substructures**

(winning bet: particle flow approach)

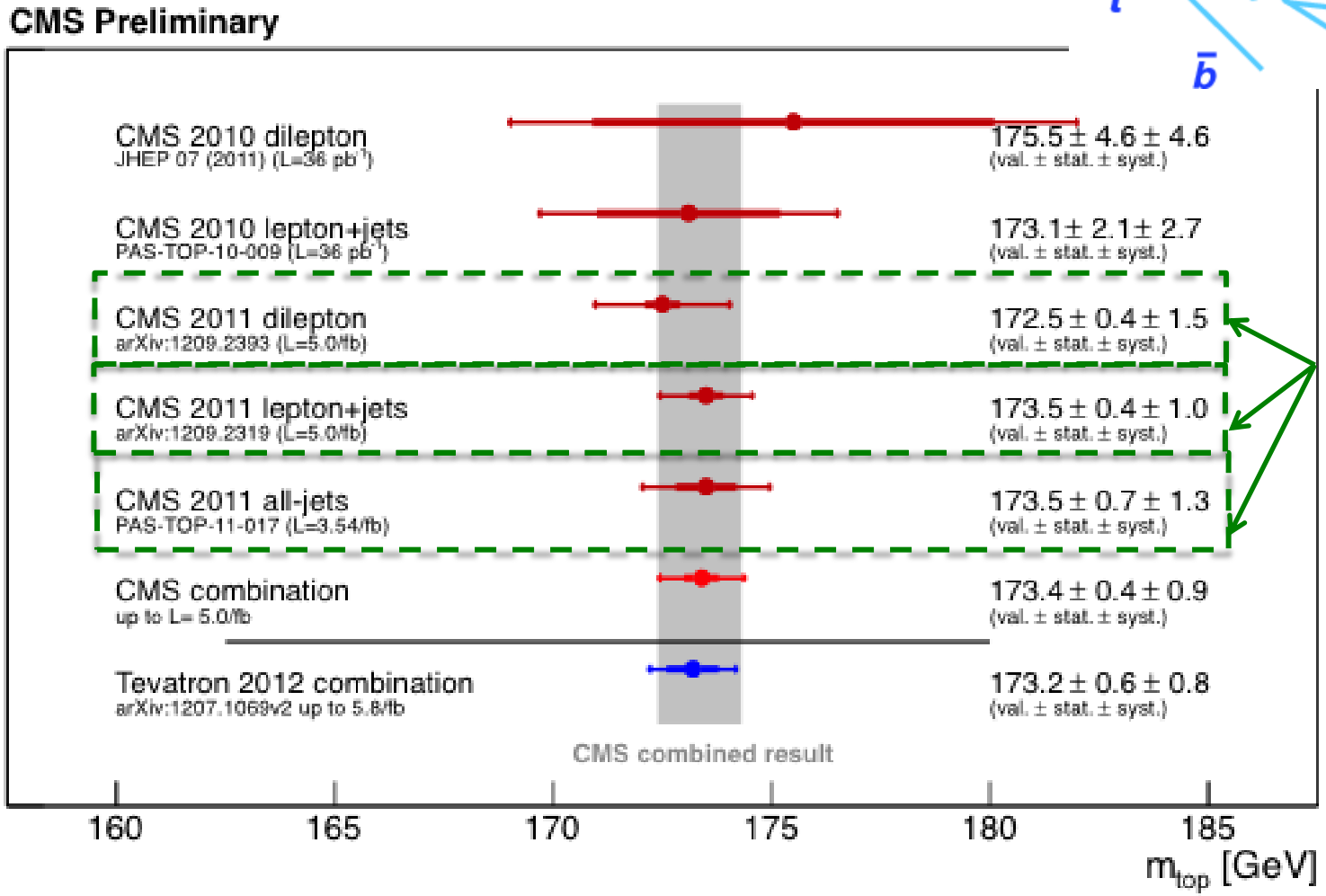




Top mass

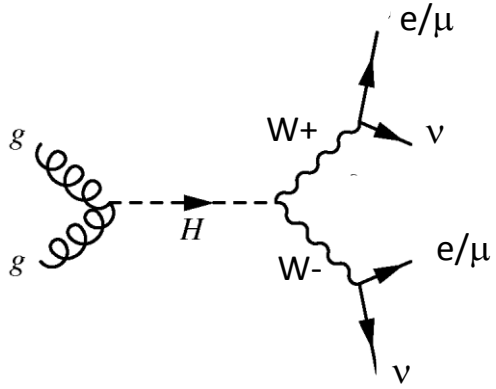


Mass measured in various top-antitop final states:

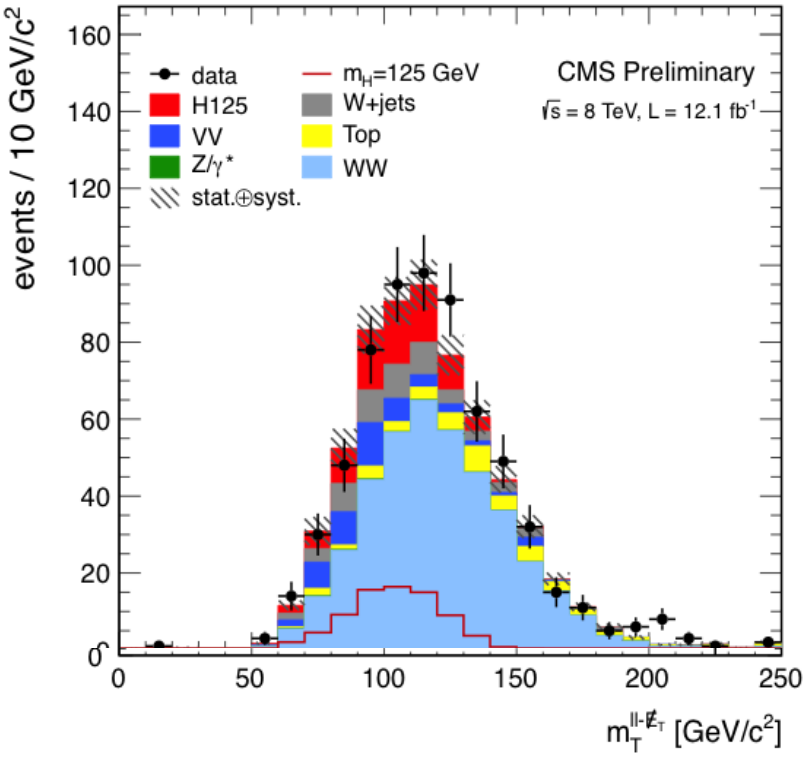


World Best measurements!

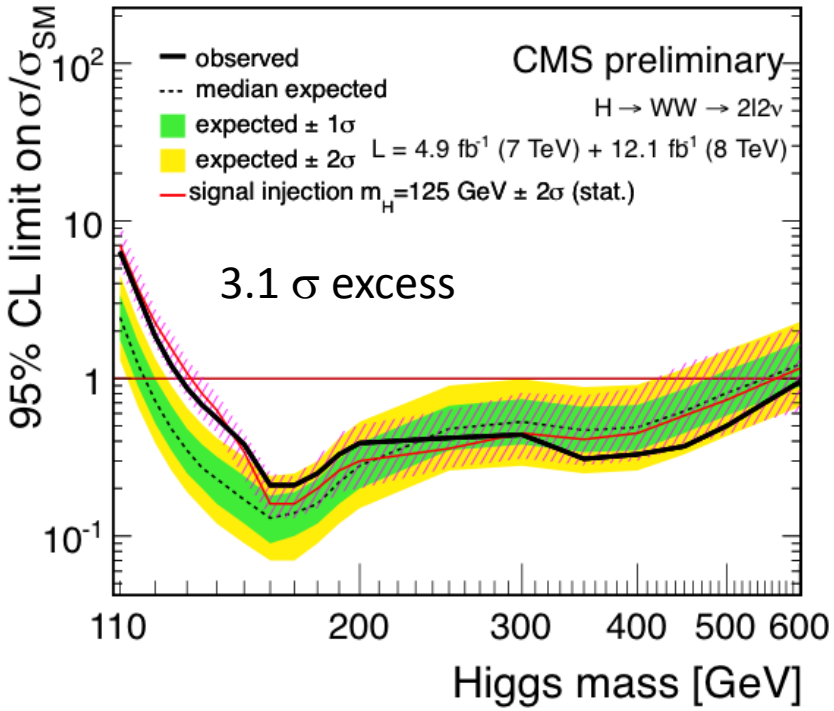
H → WW → lνlν



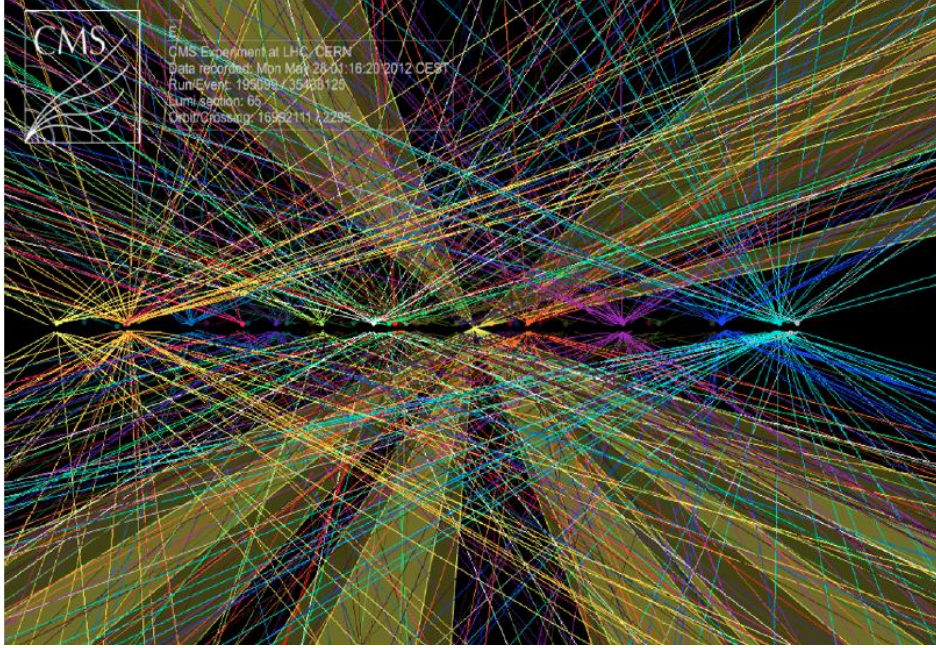
H → WW transverse mass:
critical importance of background control (WW, top)



Comparison of data with background-only hypothesis:



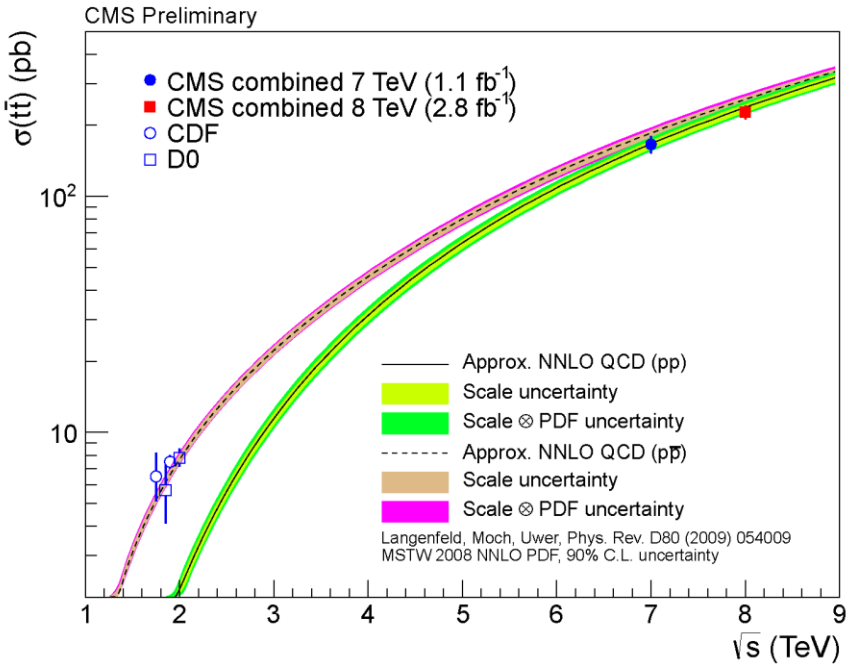
b-jets: top cross-section



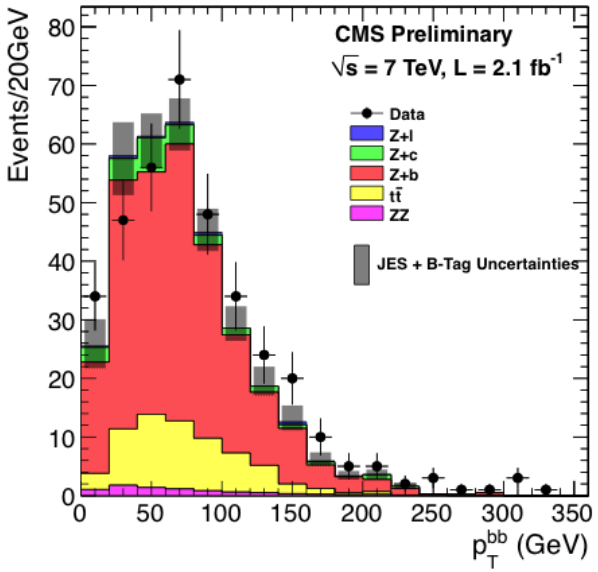
❑ **Jets from b-quark** have peculiar signature:

- B hadrons have long lifetime
  -> secondary vertices
- needs tracking/vertexing in high pile-up

▪ **Top cross section** measured with high precision:



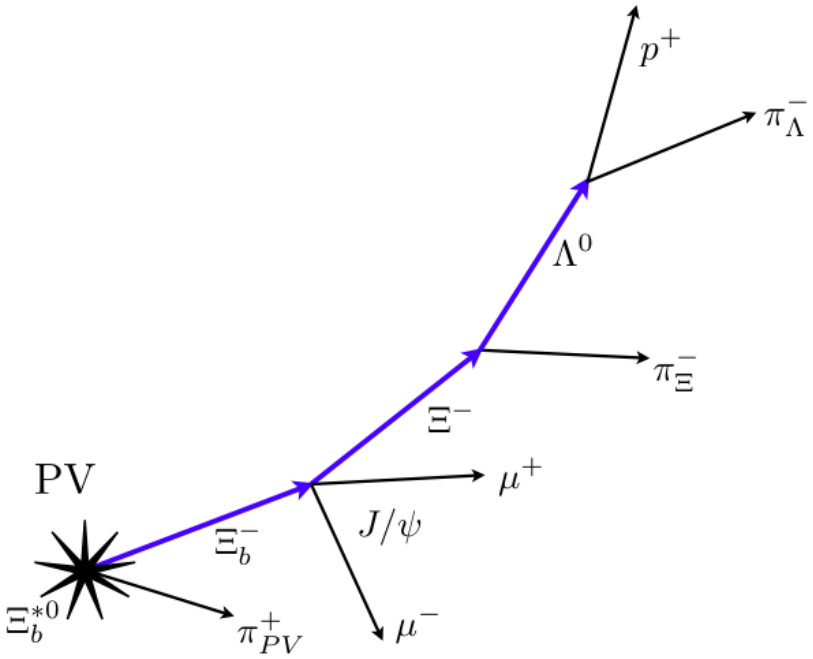
▪ Measurement of **Z+bb jets cross-section**

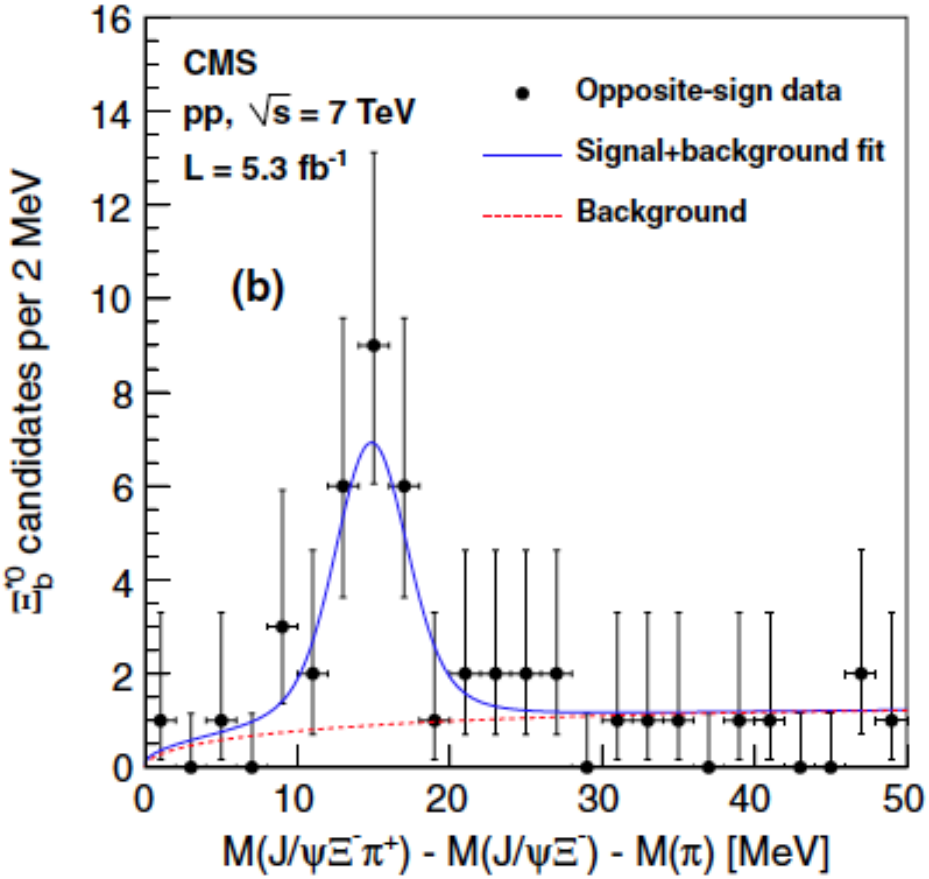


New hadronic resonance

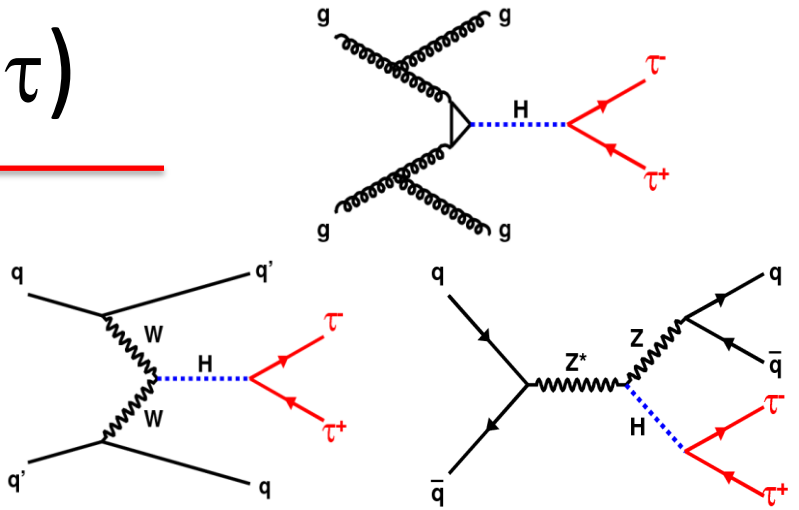
- **New particle discovered: Ξ_b^***

  long chain of EWK decays -> many secondary vertices





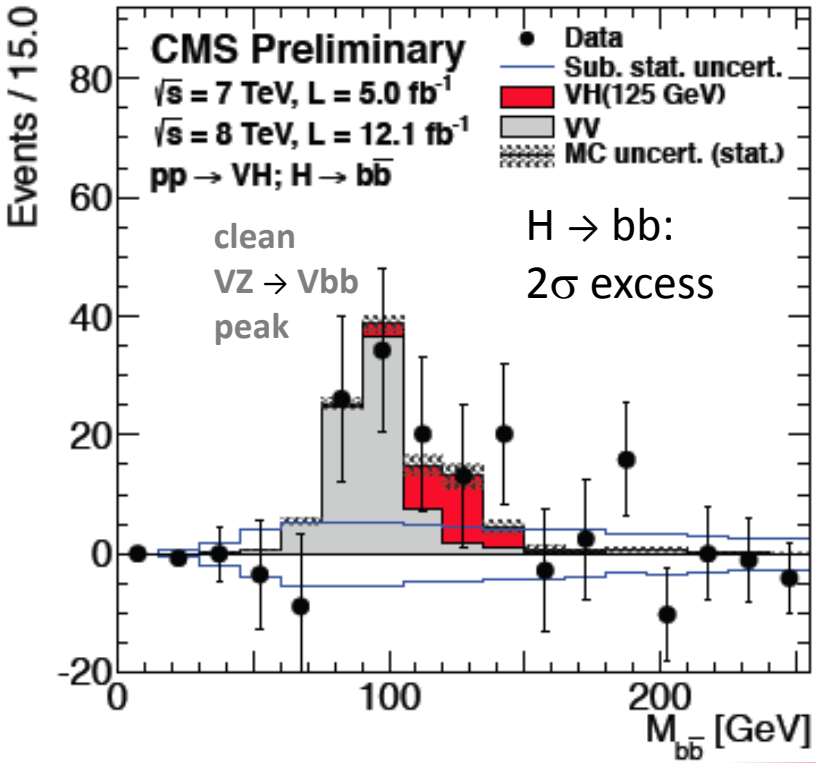
H → fermions (bb, ττ)



Small peak over huge background ->

- associated production: Higgs + something else
- crucial ingredients:

b-tagging and jet energy precision,
Particle Flow for tau reconstruction



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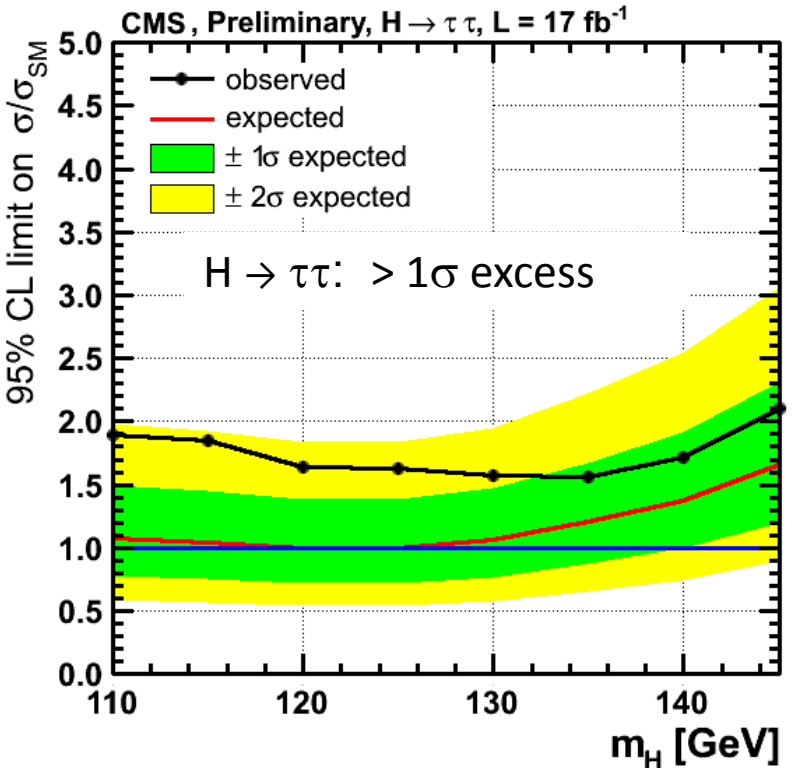
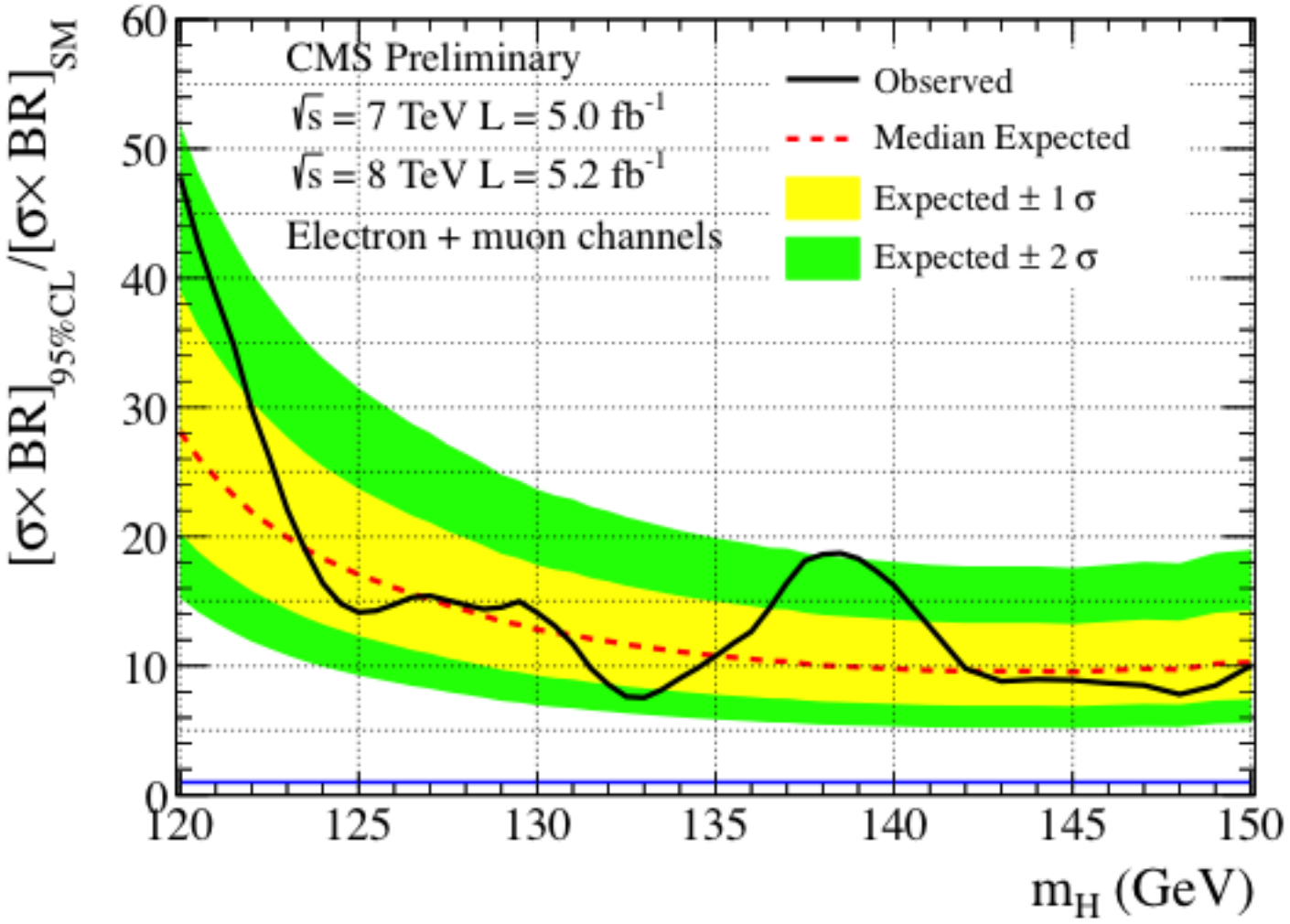


Fresh result: limit on H → Zγ

Large signal enhancement expected in many BSM theories



Is it the long-awaited SM Higgs?

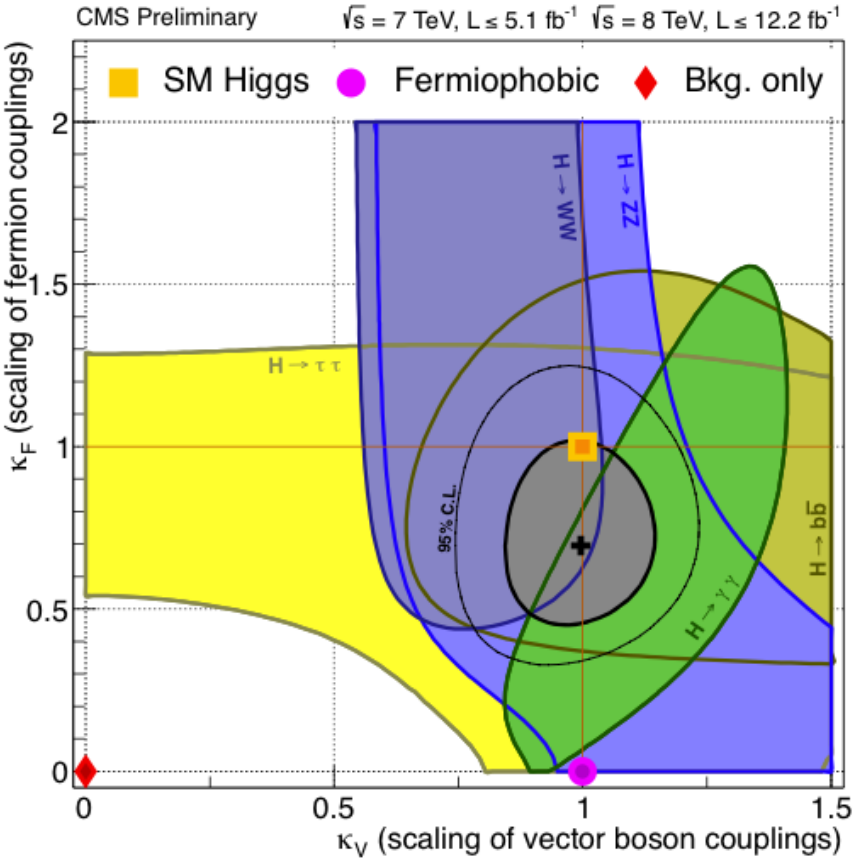
-> measurement of the new boson properties

-> direct search for New Physics

Higgs properties

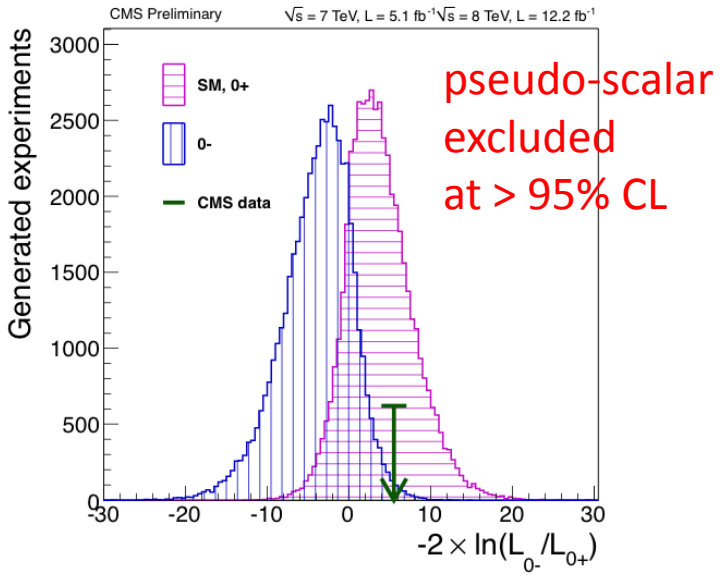
Mass M = 125.8 ± 0.4 (stat) ± 0.4 (syst) GeV

Couplings:



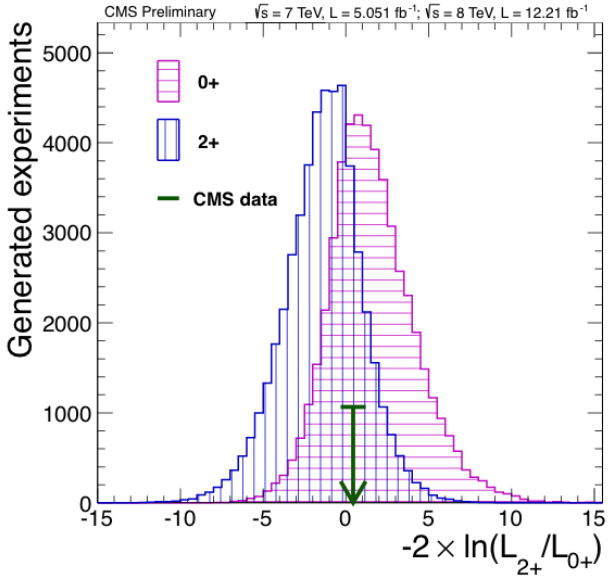
Need high energy and luminosity to reduce the uncertainties

Parity :



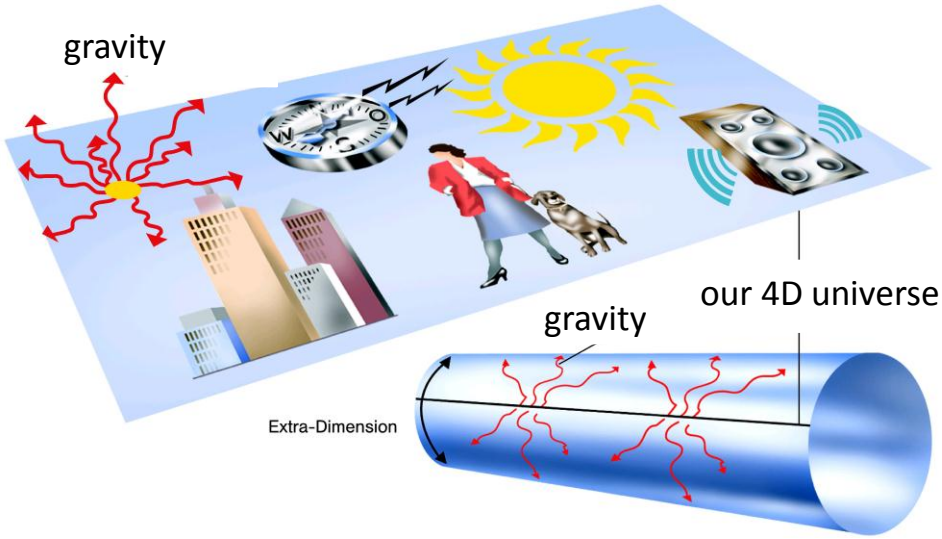
pseudo-scalar excluded at > 95% CL

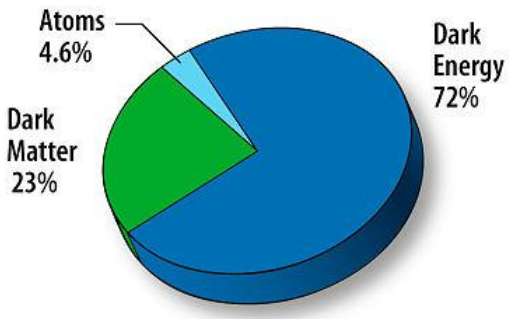
Spin :

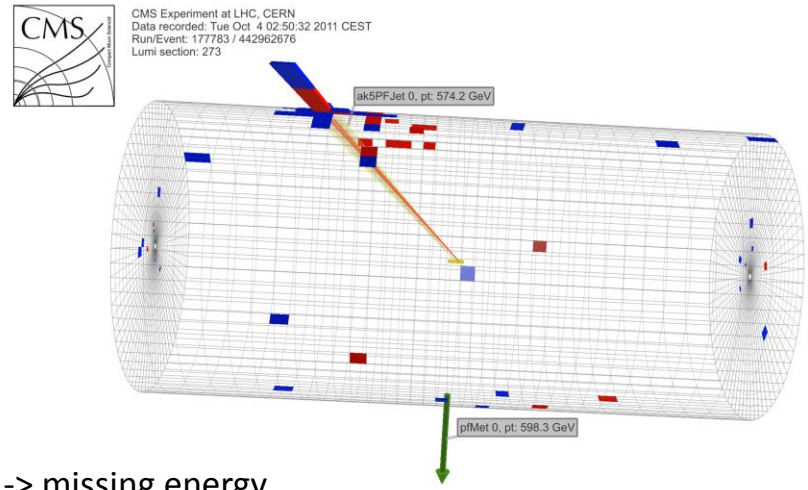


New Physics search: new particles

New unknown/undetectable particles ->
Dark Matter candidate and
Extra-Dimensions models







- Search in 1 jet (or 1 photon) + missing energy

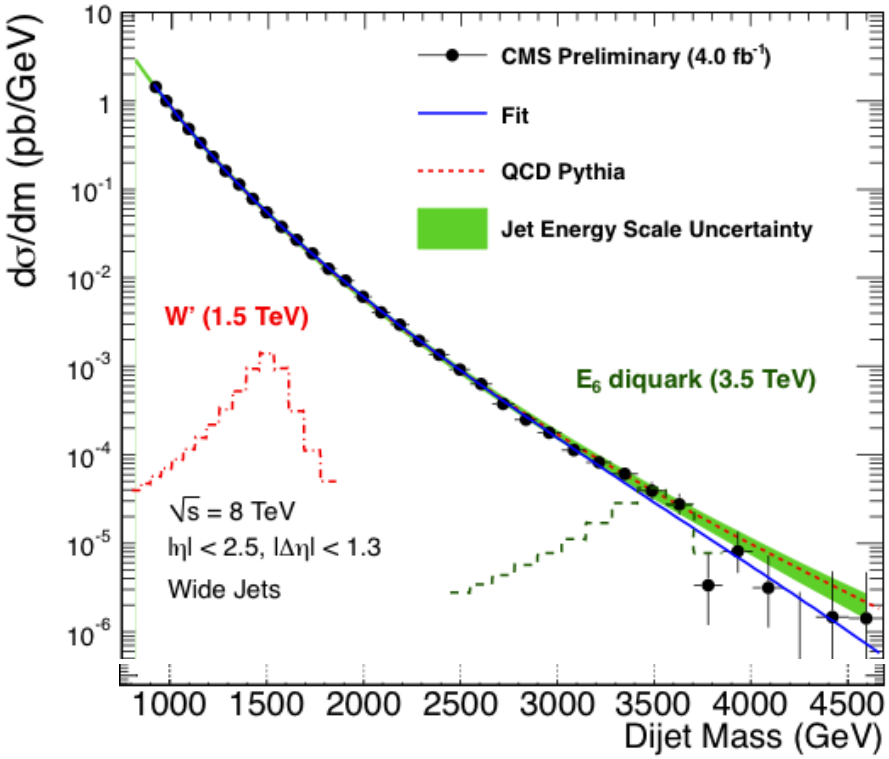
  1 jet recoiling against new unknown/undetectable particle -> missing energy

-> strict limits on Dark Matter competitive with direct search from astro-particle

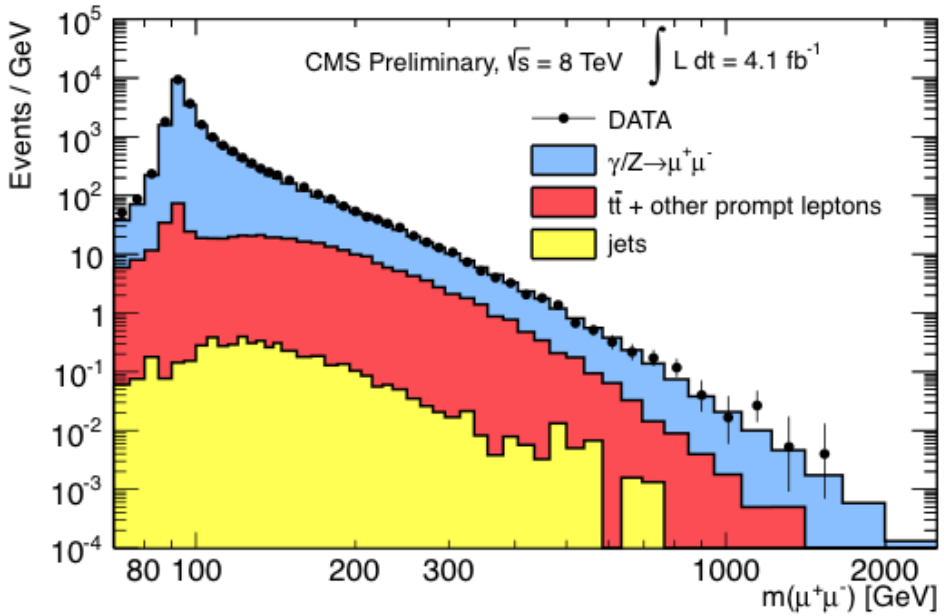
New Physics search: new resonances

Heavy new resonances (eg, graviton or Kaluza-Klein particles in Extra-Dimensions)

Dijets:

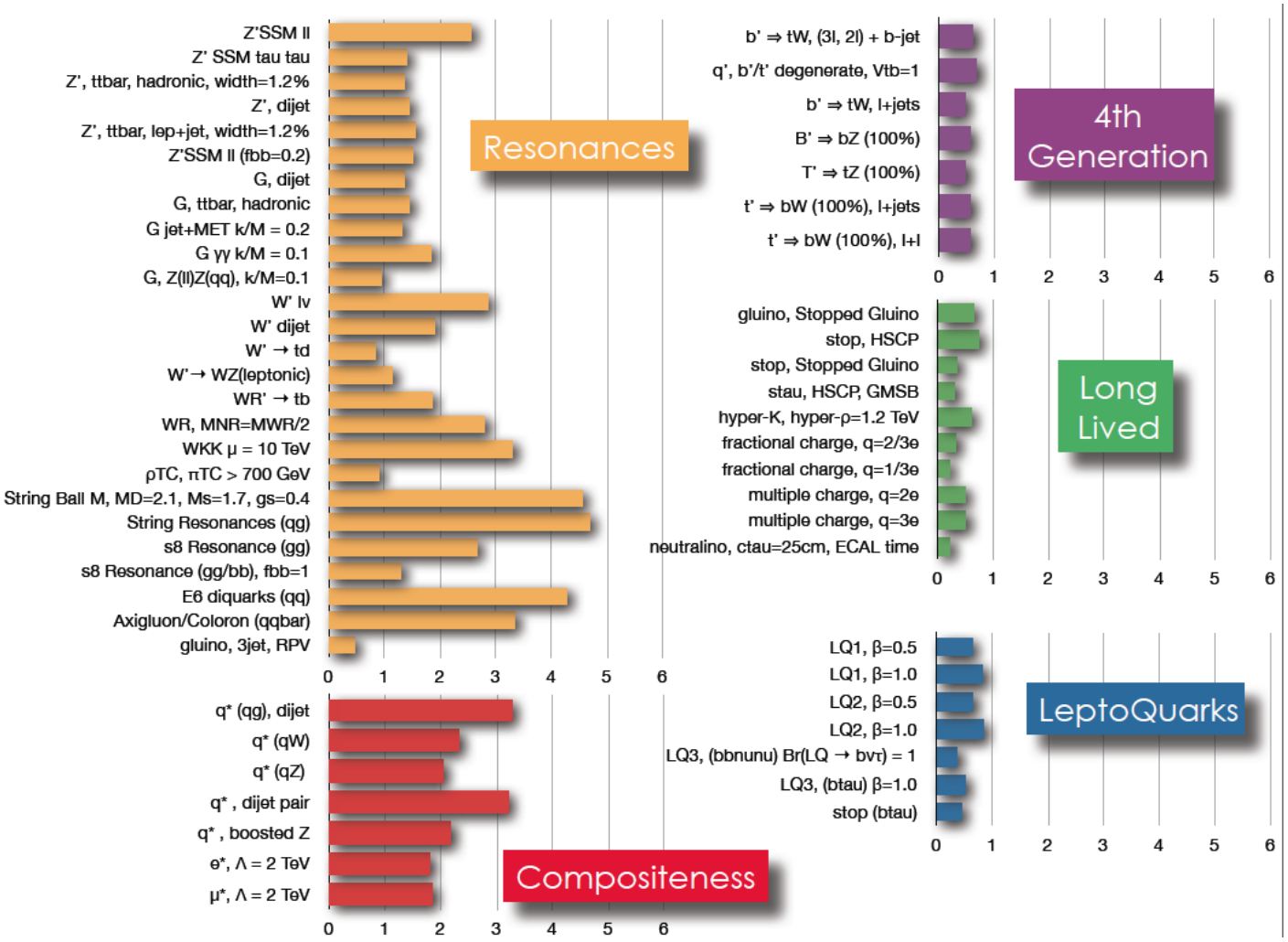


Dileptons



High energy and high luminosity will strongly increase the sensitivity

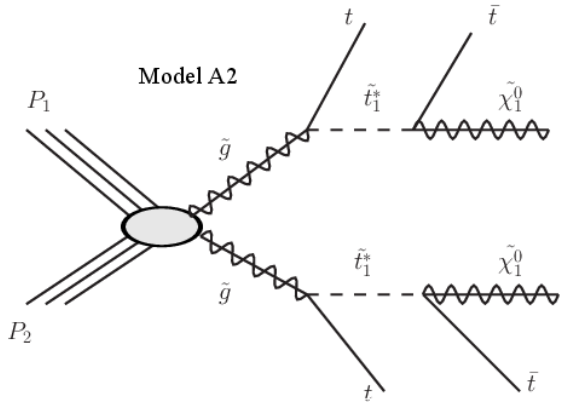
Summary of New Physics limits



SUper-SYmmetry

Very promising model: solution of hierarchy problem, dark matter candidate, …

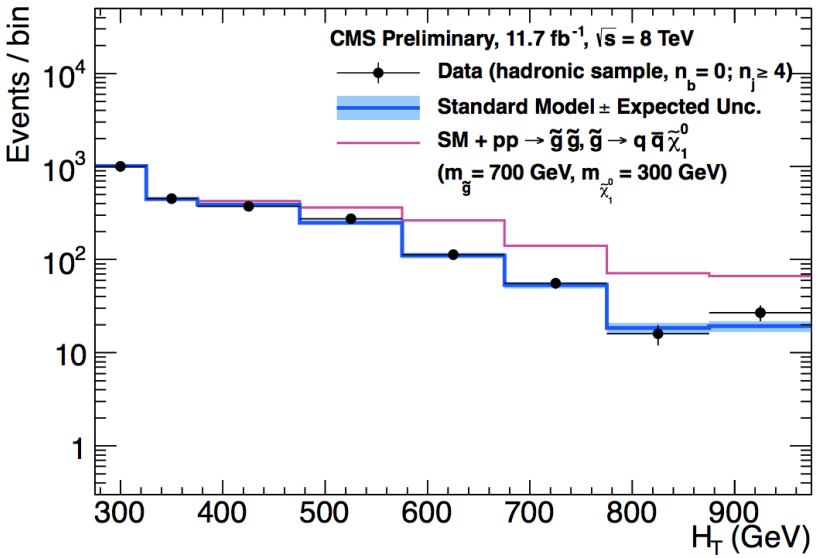
Chain production of **many new particles** (a SUSY partner for each SM particle)
-> crowded final states with (b)-jets, MET, leptons …
-> analysis of inclusive variables (missing energy, H_T)



- **General search for high mass:**
  -> squarks and gluinos: m < 1 TeV excluded

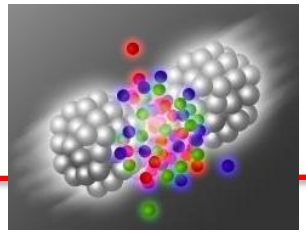
- More **exclusive search for stop, sbottom** (eg, b-tagging):
  -> stop, sbottom: < 300-450 GeV excluded

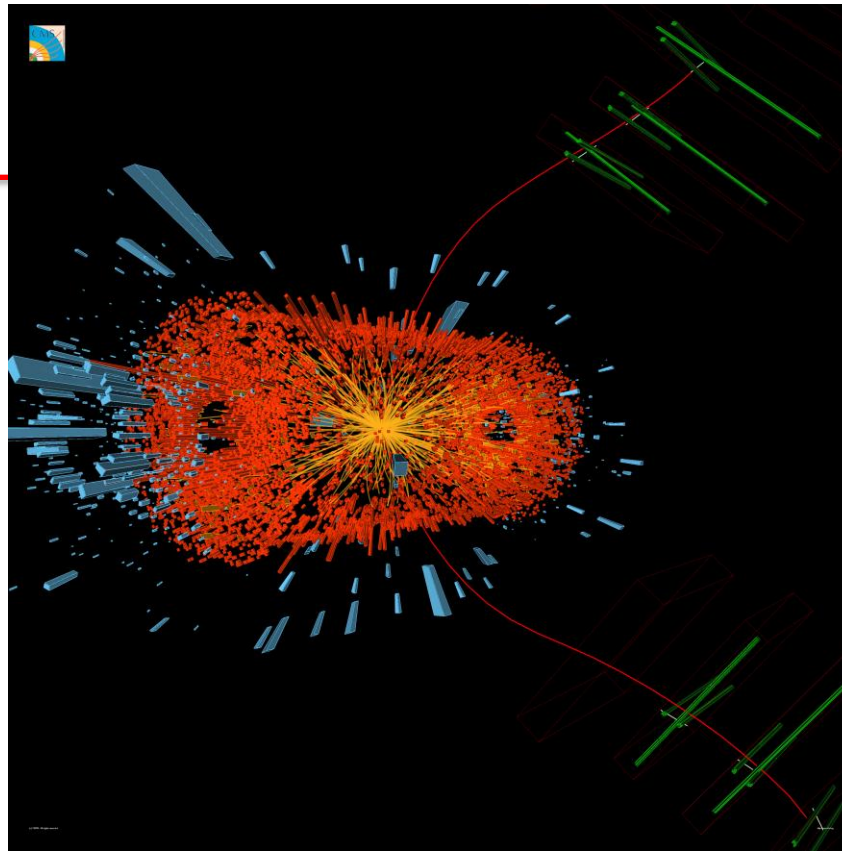
- **Search for ewkinos** (charginos, neutralinos, sleptons) **into rare leptonic final states** (3 leptons, same sign leptons, …)
  -> ewkinos: < 300-700 GeV excluded
  -> very clean but low xsec, strongly profit of high lumi



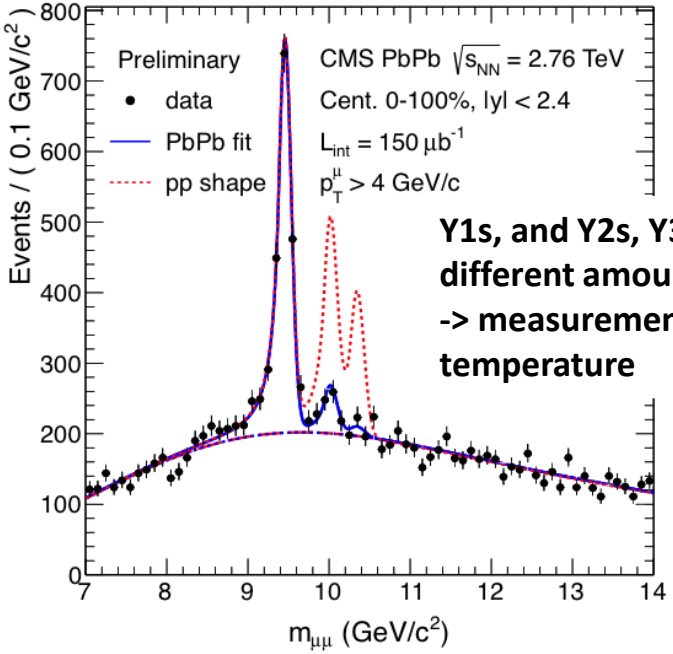
14 TeV will highly increase the sensitivity

Heavy Ions





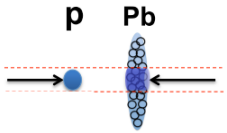
- **Disentangling excited Y states in Heavy Ions for first time !**

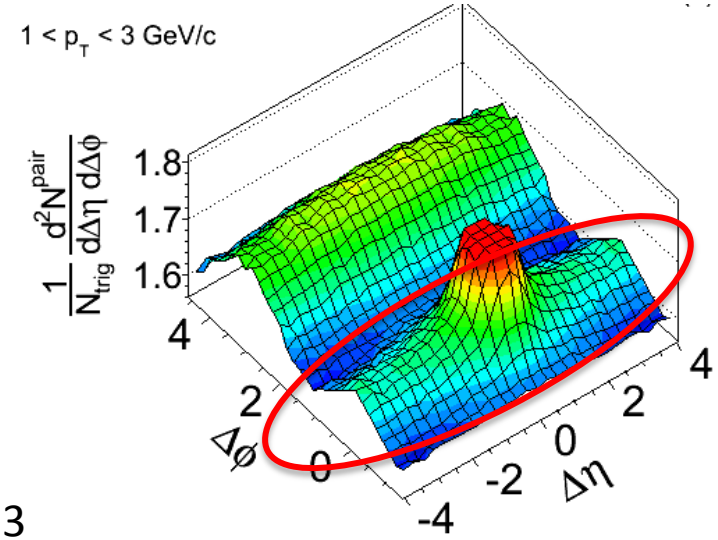


Y1s, and Y2s, Y3s screened by different amount
-> measurement of plasma temperature

- **"The ridge"**: unexpected/unexplained angular correlation observed in pp in 2010 ->

now observed in p-Pb too





Conclusions

2012 was the year of the discovery: new boson at ~126 GeV

- Higgs discovery is the result of a long road of high precision SM measurements
- it is the long-awaited SM Higgs ?
  - **measuring the properties**
  - **direct search for New Physics**

    -> search for new resonances at high mass and non-SM signatures

    -> good control of the detector in very crowded and high energy events

-> we are in good shape to afford the next challenge: eagerly awaiting for high energy and high luminosity