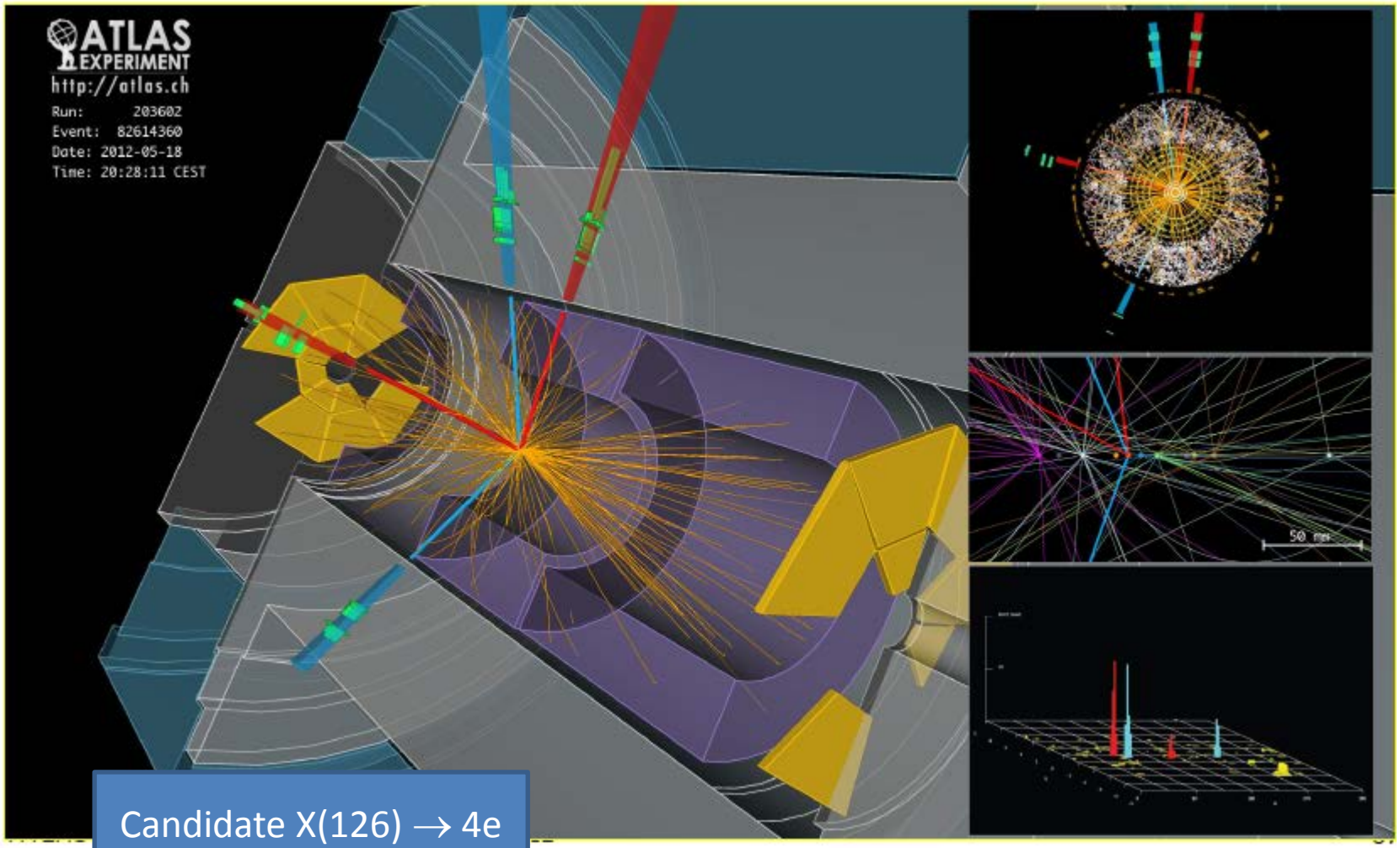
Report on the workpackage « Physics at colliders »

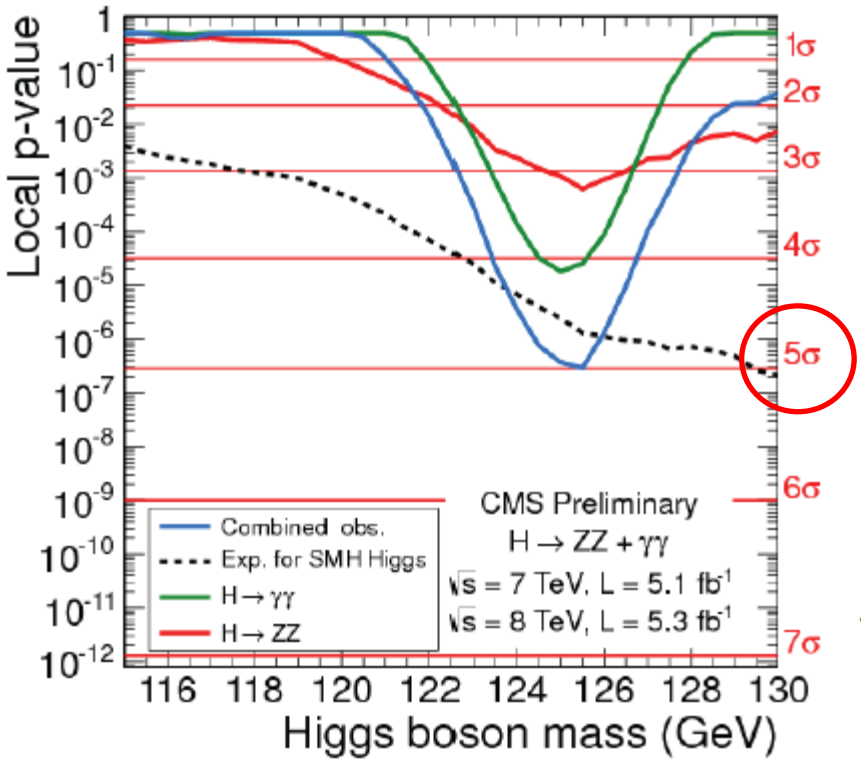
Biased towards Higgs physics

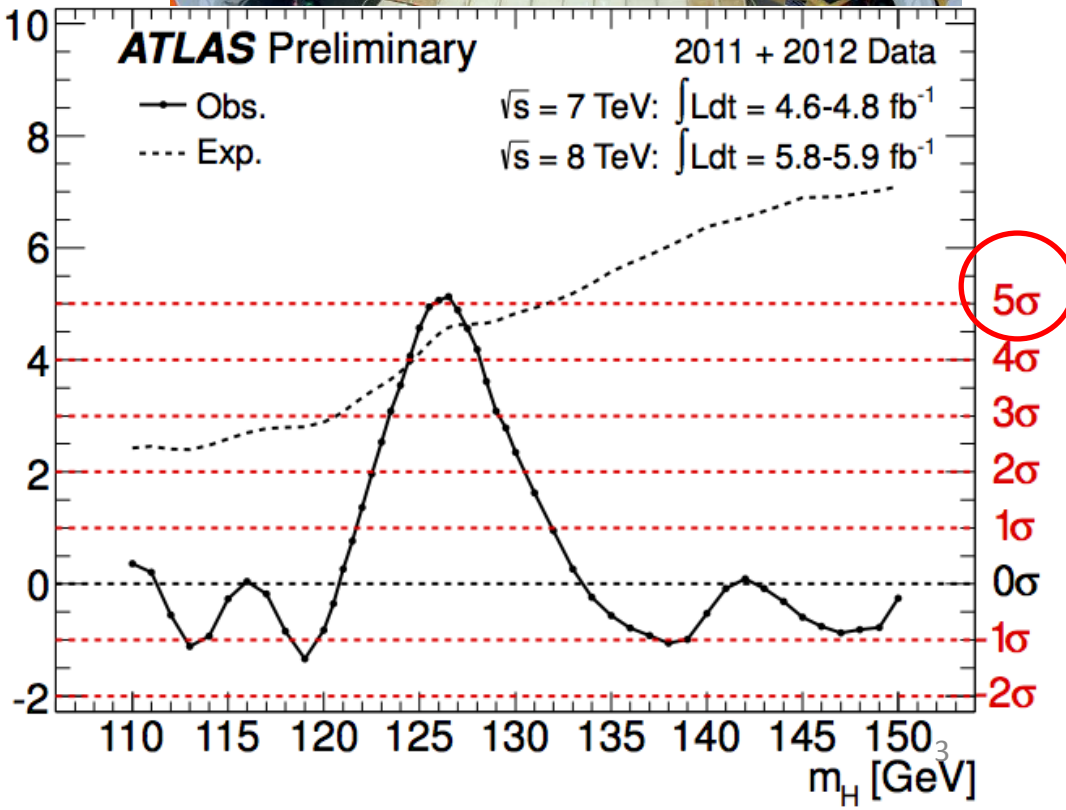
Corinne Goy – LAPP
with contributions from several persons

The 4th of July 2012



Candidate X(126) → 4e


Local p-value
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
1σ
2σ
3σ
4σ
5σ
6σ
7σ
Combined obs.
Exp. for SMH Higgs
H→γγ
H→ZZ
CMS Preliminary
H → ZZ + γγ
√s = 7 TeV, L = 5.1 fb^{-1}
√s = 8 TeV, L = 5.3 fb^{-1}
116 118 120 122 124 126 128 130
Higgs boson mass (GeV)


10
8
6
4
2
0
-2
ATLAS Preliminary
2011 + 2012 Data
Obs.
Exp.
√s = 7 TeV: ∫Ldt = 4.6-4.8 fb^{-1}
√s = 8 TeV: ∫Ldt = 5.8-5.9 fb^{-1}
5σ
4σ
3σ
2σ
1σ
0σ
1σ
2σ
110 115 120 125 130 135 140 145 150
m_H [GeV]

Physics Letters B 716 (2012) 1–29

Contents lists available at SciVerse ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC ☆

ATLAS Collaboration *

This paper is dedicated to the memory of our ATLAS colleagues who did not live to see the full impact and significance of their contributions to the experiment.

Contents lists available at SciVerse ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC ☆

CMS Collaboration *

CERN, Switzerland

This paper is dedicated to the memory of our colleagues who worked on CMS but have since passed away. In recognition of their many contributions to the achievement of this observation.

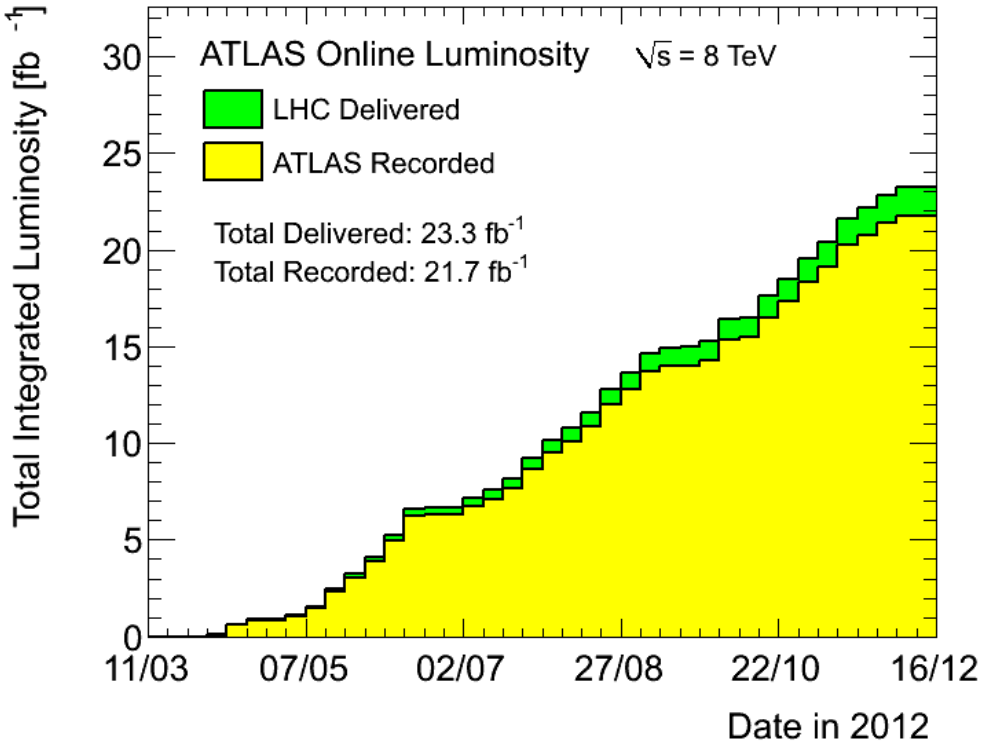
Higgs-like nature of X(126) ?

- Mass :
  - Only unknown in the SM

- Other properties :
  - Spin
  - Parity
  - Couplings to bosons & leptons.

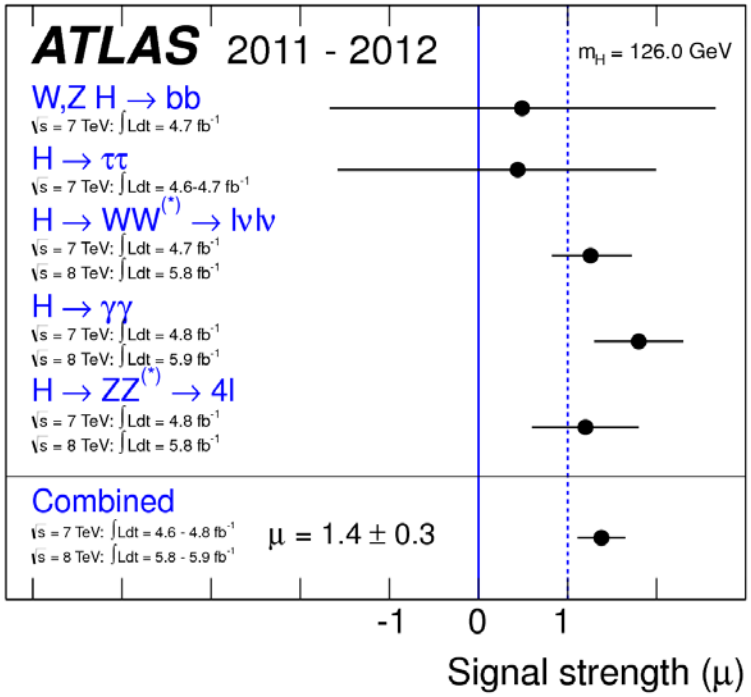
$\rightarrow$ Status (ATLAS biased)

2012 data taking



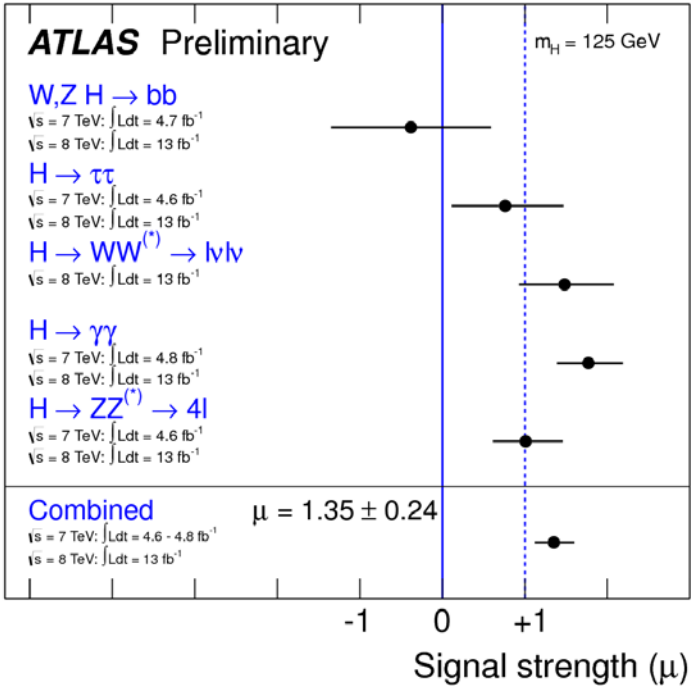
- Following the discovery, the pp LHC run was extended to mid December
- ~ 21 fb^{-1} in 2012
- ~ 5 fb^{-1} in 2011

From the July publication to latest results



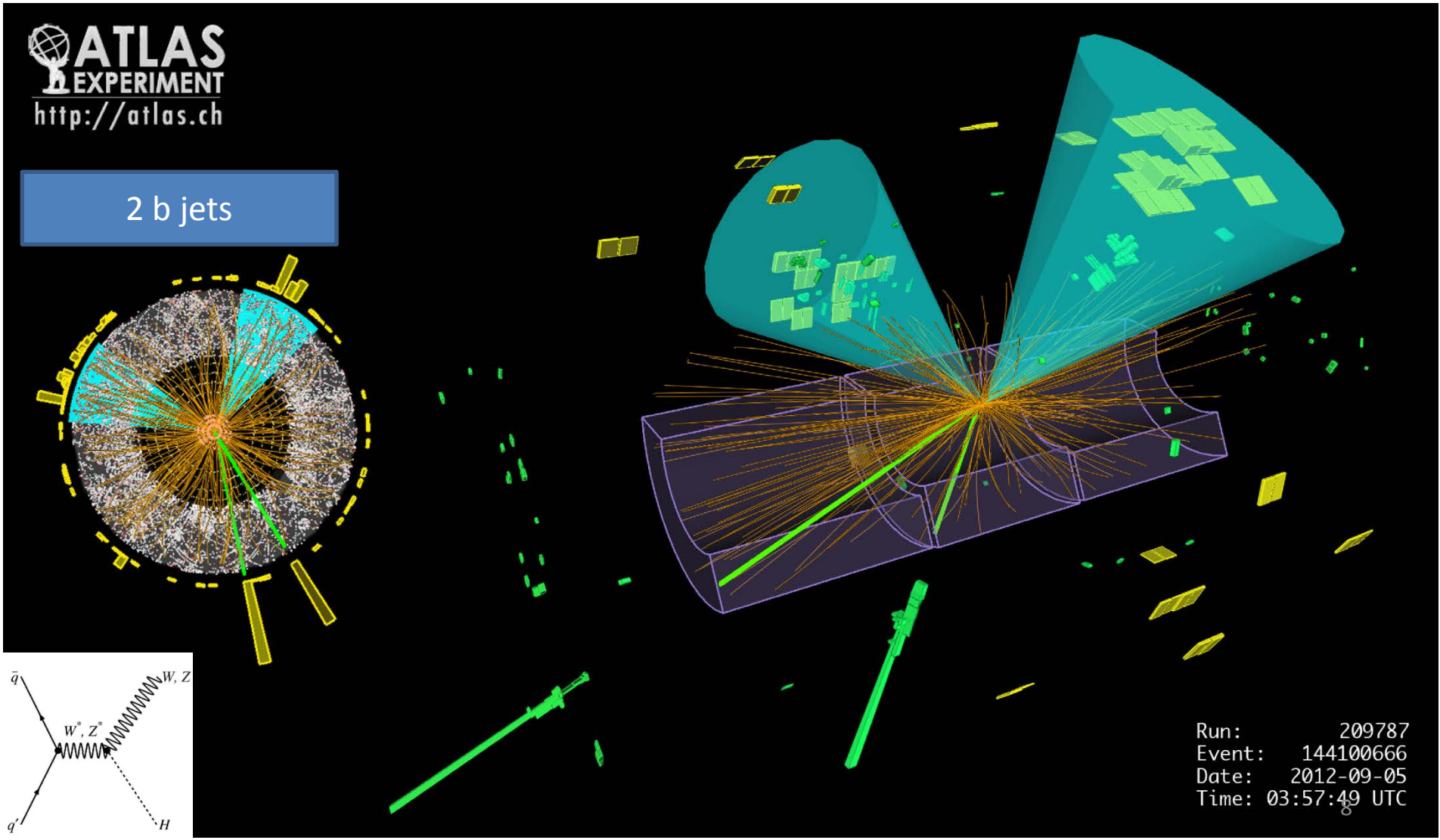
μ is the ratio of the number of observed signal events to the one expected in SM

NB : 13 fb^{-1}



Update with full statistics ongoing for the Winter conferences

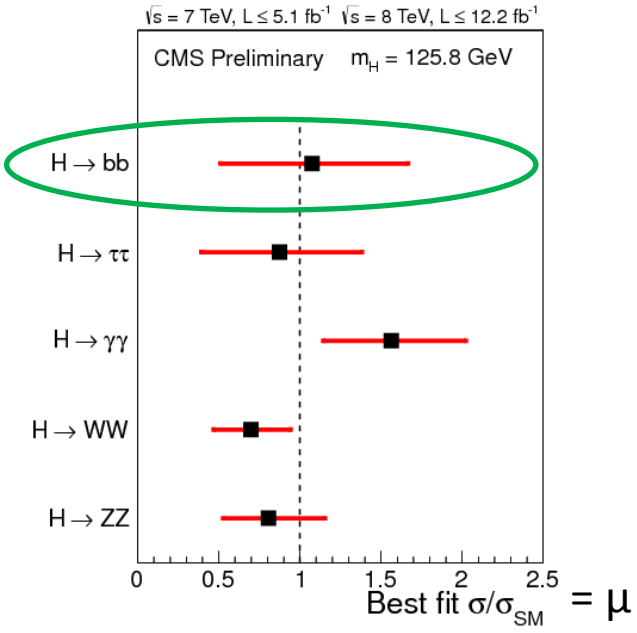
A H → bb candidate in association with a Z →ee



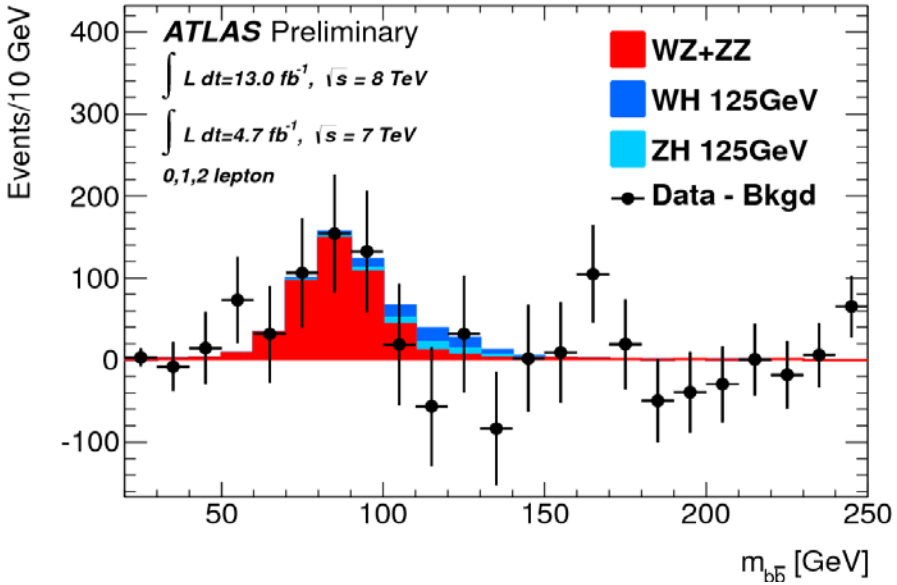
H→bb

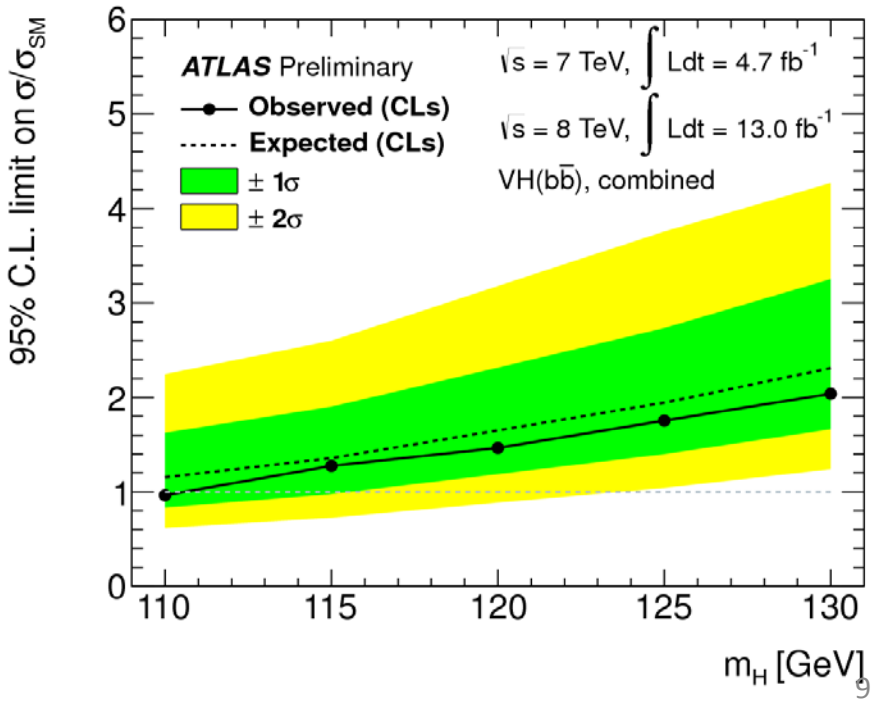
NB :

A 3 σ excess was reported by Tevatron in this channel.



= μ

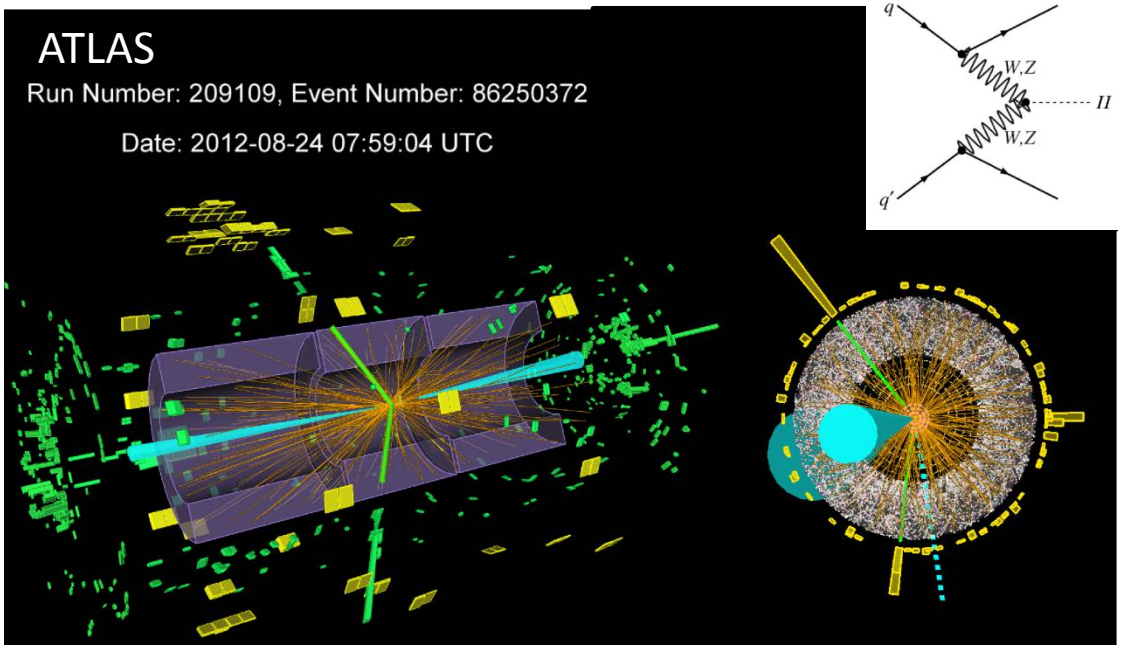


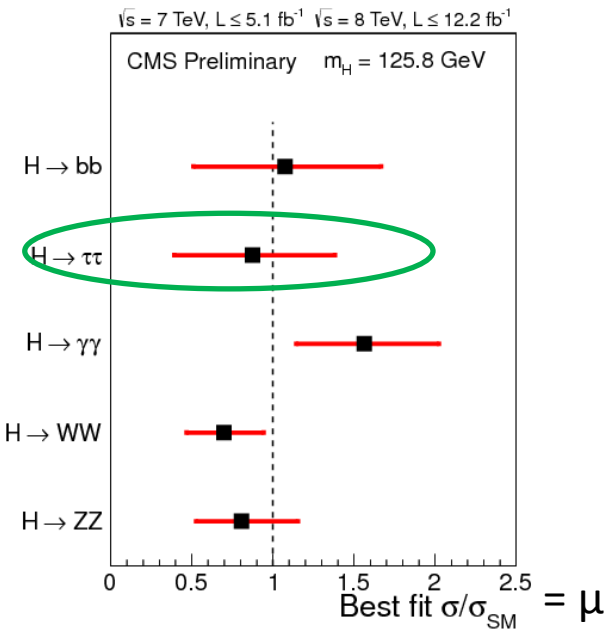


H→ττ

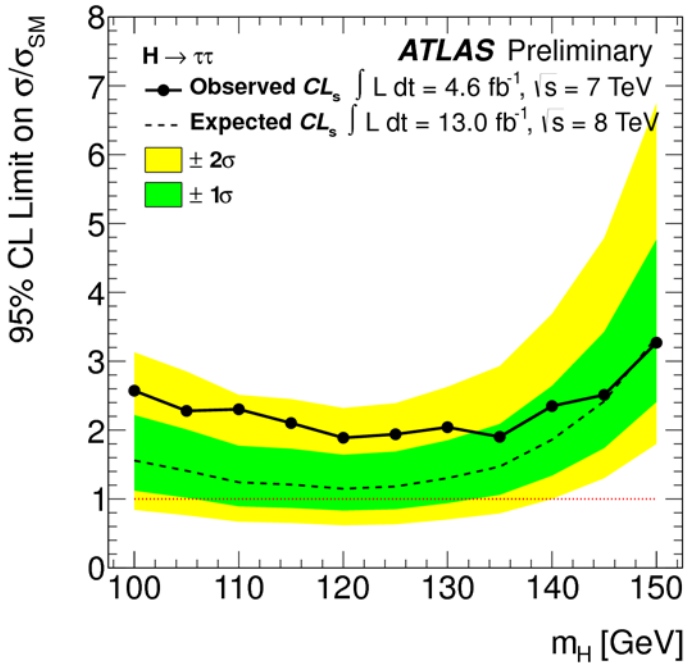
The only measurable coupling to leptons at LHC so far

Compatible with background only hypothesis or with SM – Higgs

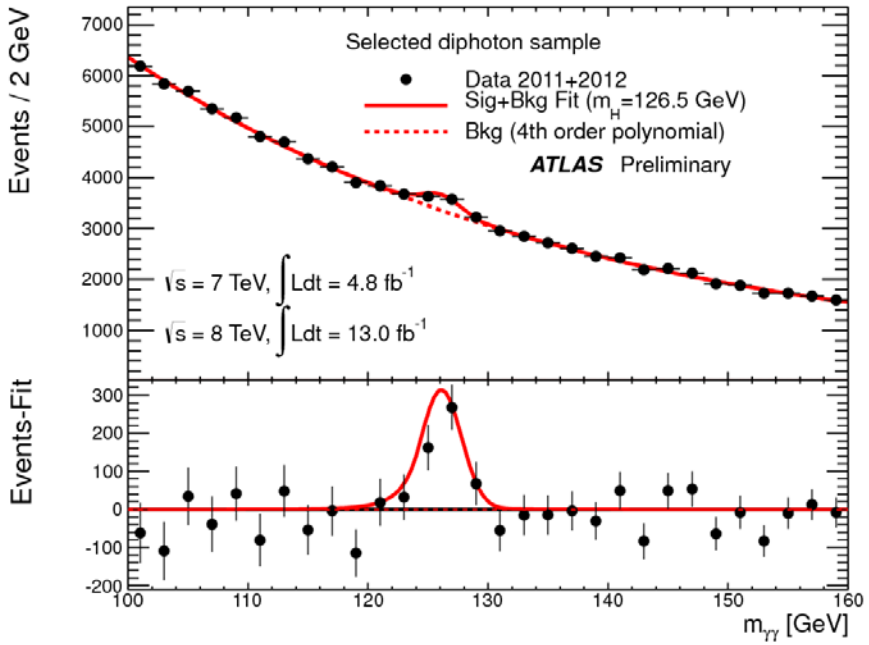


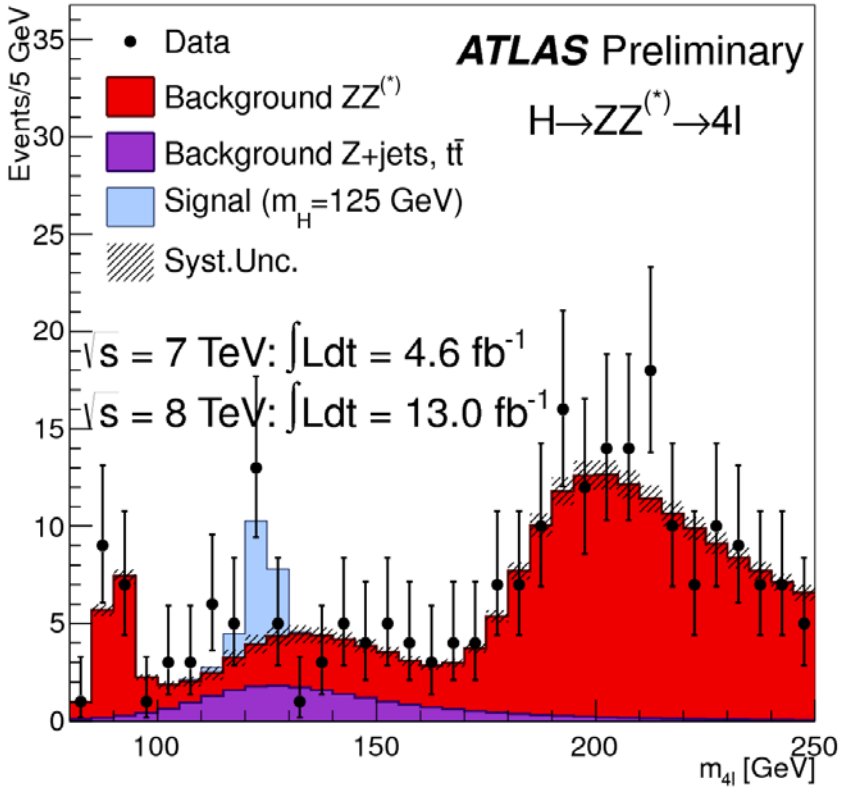


= μ



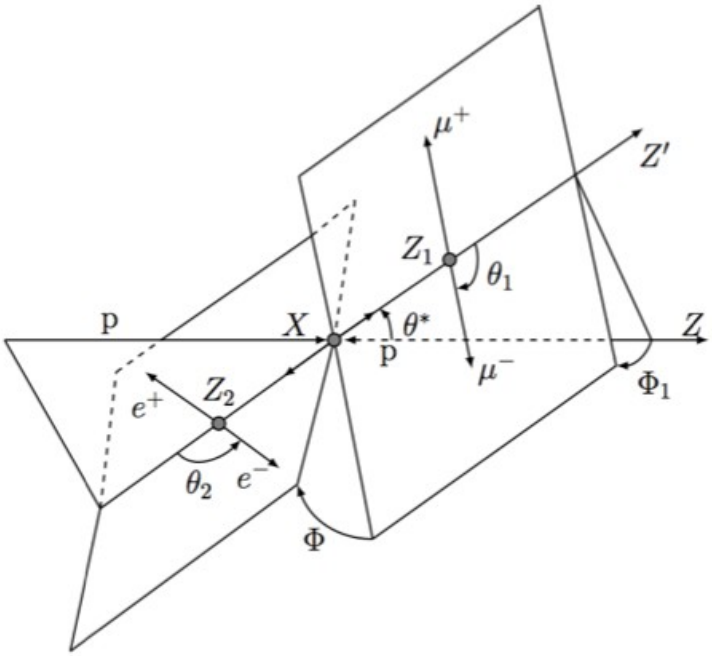
Latest on H→γγ and H→ZZ



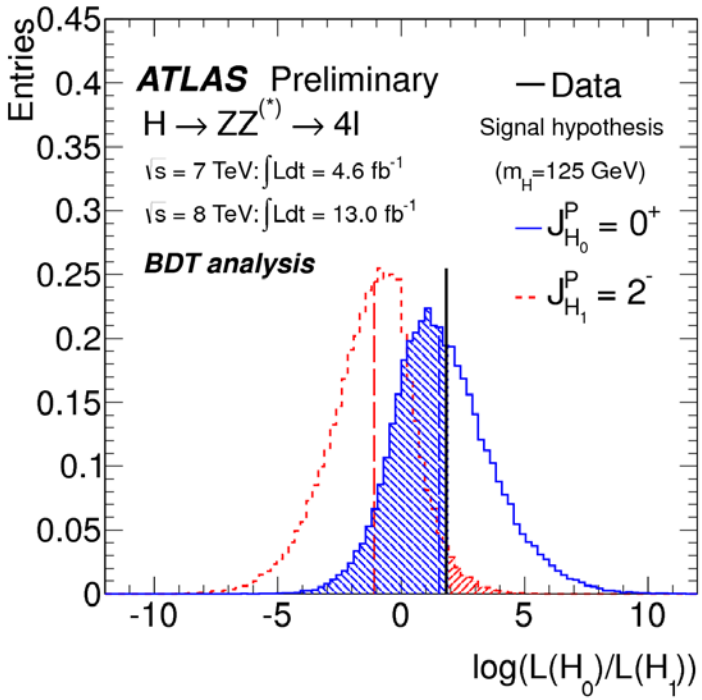


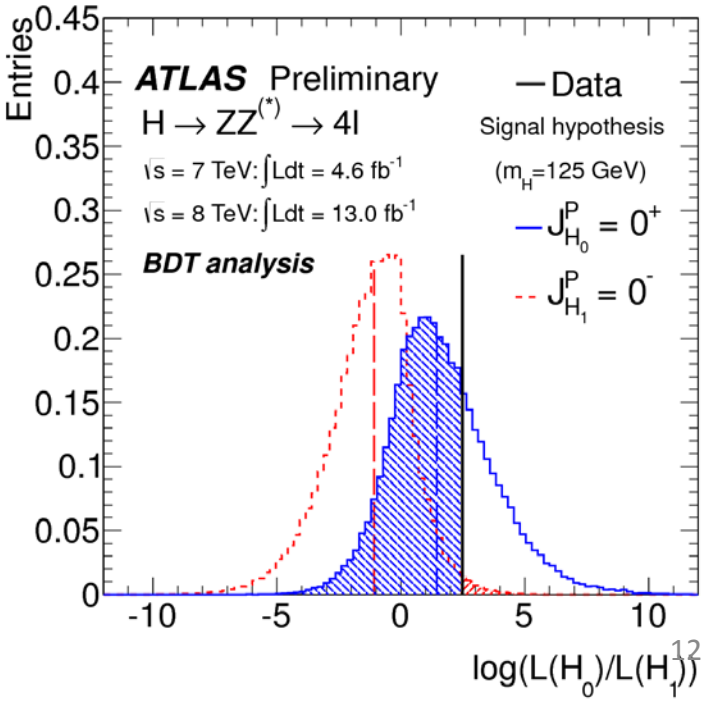
Spin & Parity

Using fully reconstructed final state:
$H \rightarrow ZZ$ or $H \rightarrow \gamma\gamma$



Compatible with 0^+ state



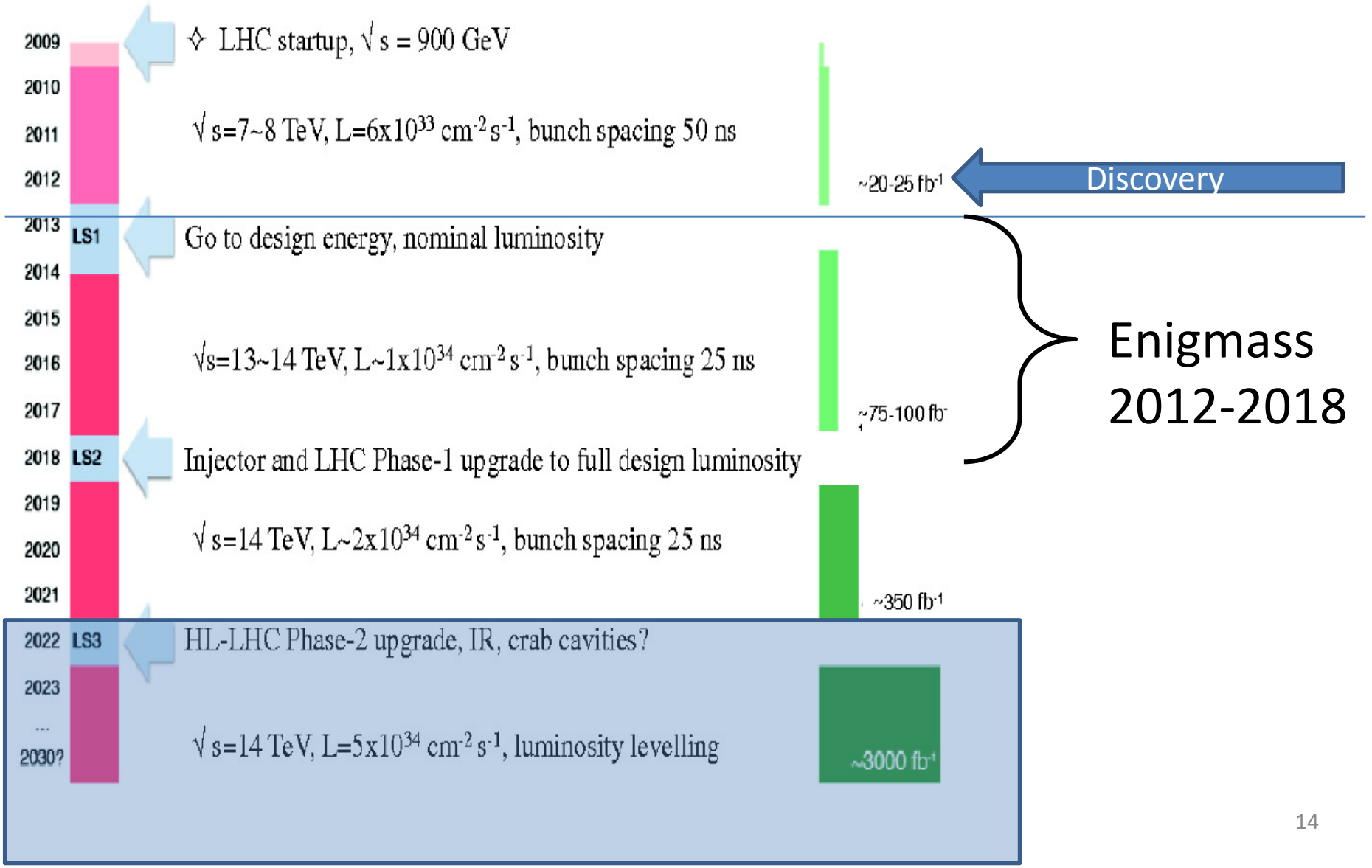


This theme has a clear support from Enigmass

- 1 thesis on $H \rightarrow \gamma\gamma$ (LAPP - Sep 2012)
- 1 post-doc on Higgs phenomenology studies (LAPTH - Oct 2013)
- 1 post-doc on ATLAS upgrade (LPSC- May 2013)

- Les Houches International Workshop
  - Physics at TeV Colliders
  - June 2013

The experimental context



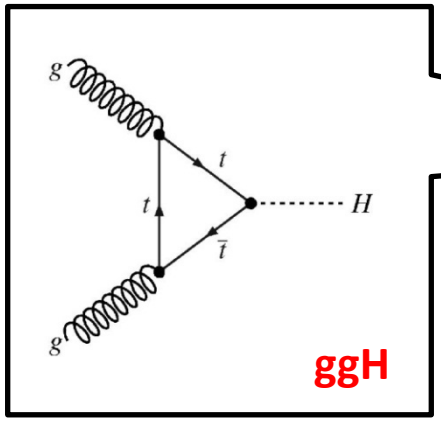
Main tasks

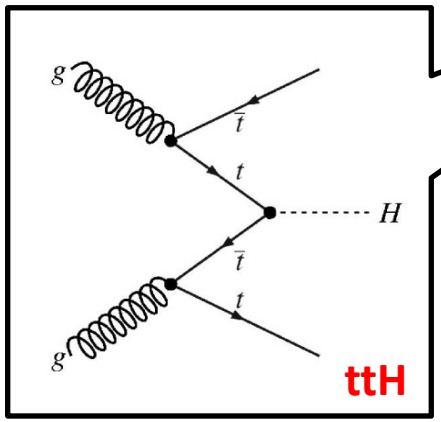
- Data exploitation with ~ 100 fb^{-1} expected (2018)
  - Measurement of the Higgs properties
  - Search for New Physics
    - Direct searches
      - In particular an Extended Higgs sector
      - Top sector/ Exotics
    - Precision measurement in the flavour sector
  - Nature of EWSB breaking : phenomenology approaches

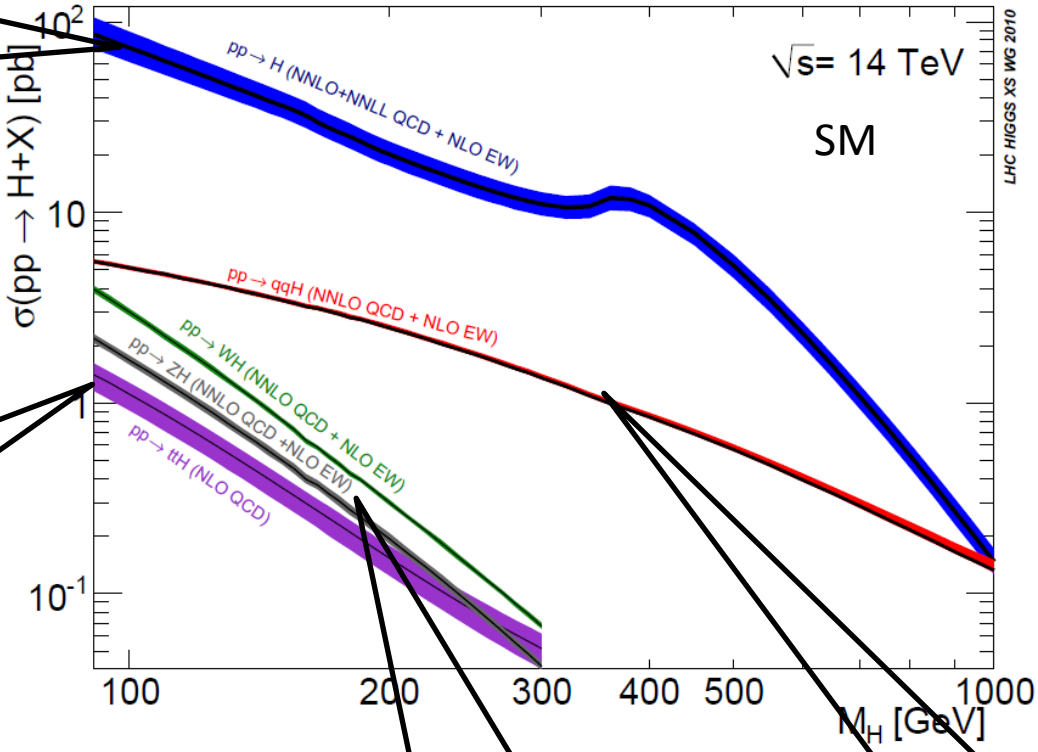
- Preparation of ATLAS Phase I upgrade. (2019)
  - To face a factor 4 increase in instantaneous luminosity : ~2. 10^{34} $cm^{-2}s^{-1}$

- Preparation of ATLAS Phase II upgrade (2022)
  - The Technical Design Report is due by ~2016

Higgs production at LHC

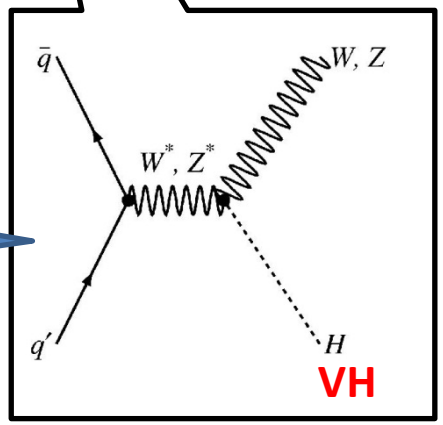


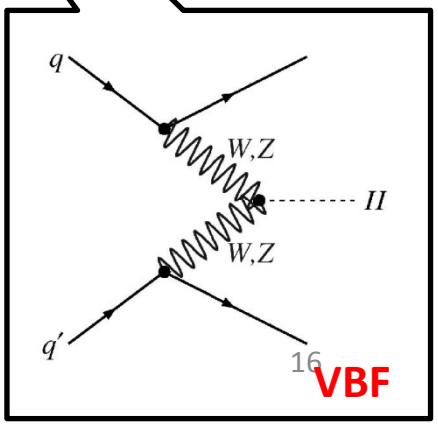




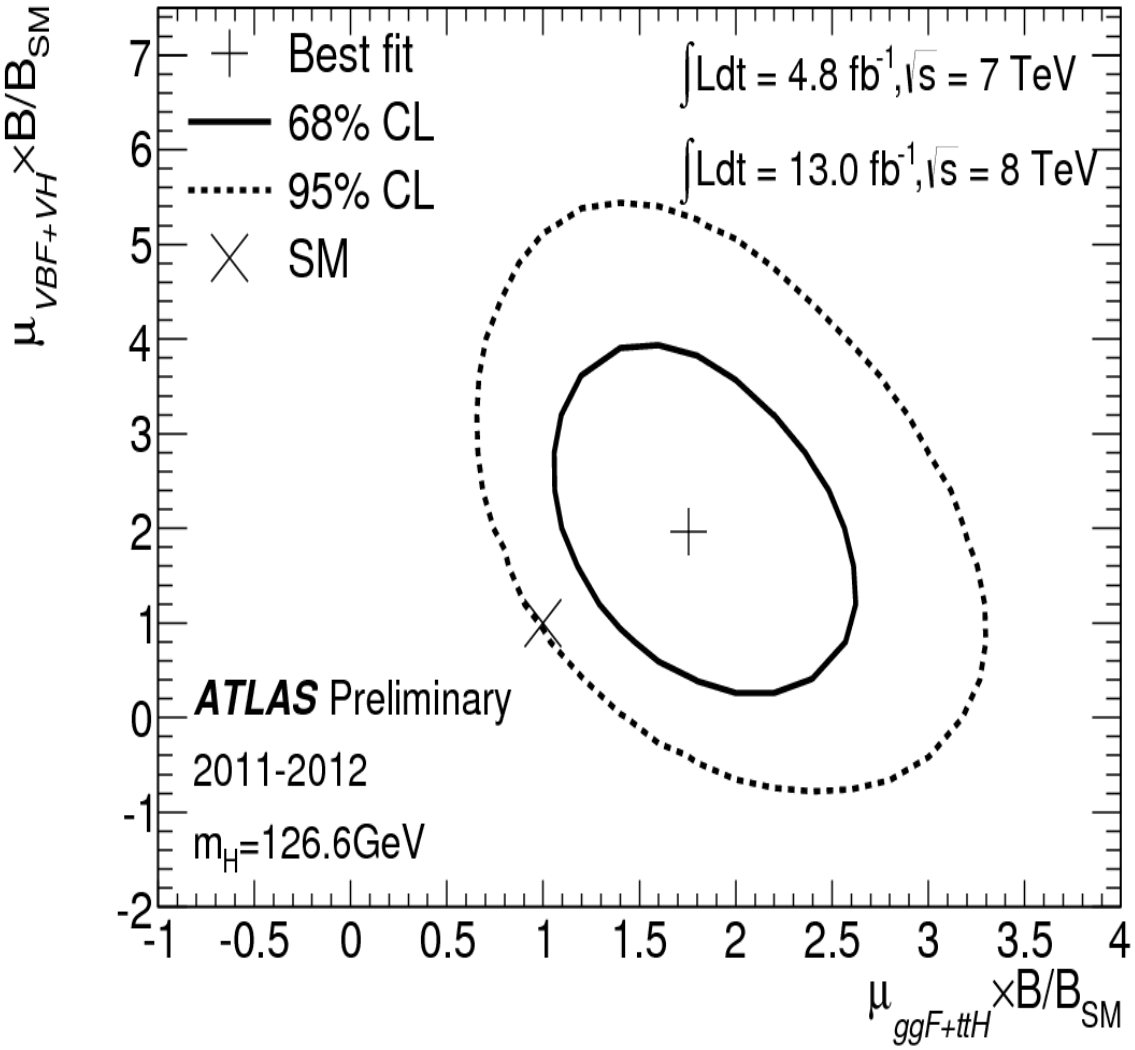
Coupling to top

Coupling to Vector Boson





H→γγ :
ggH VS VBF+VH

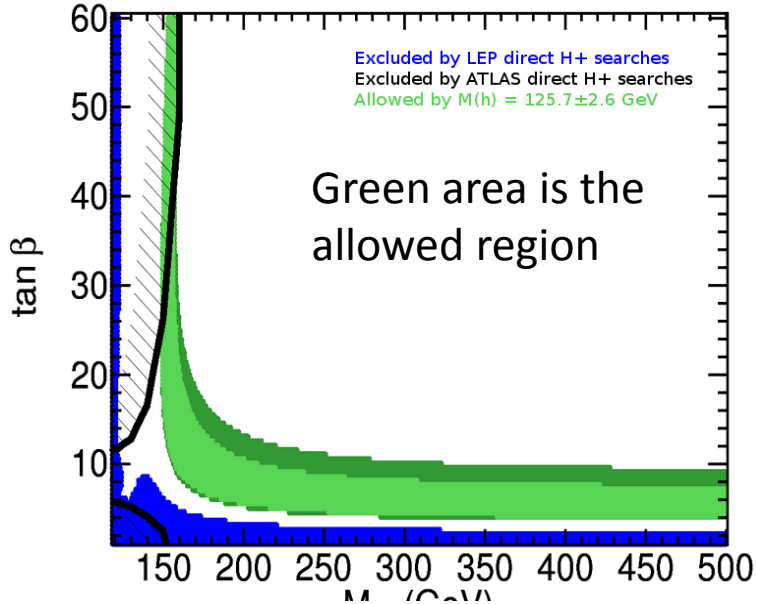


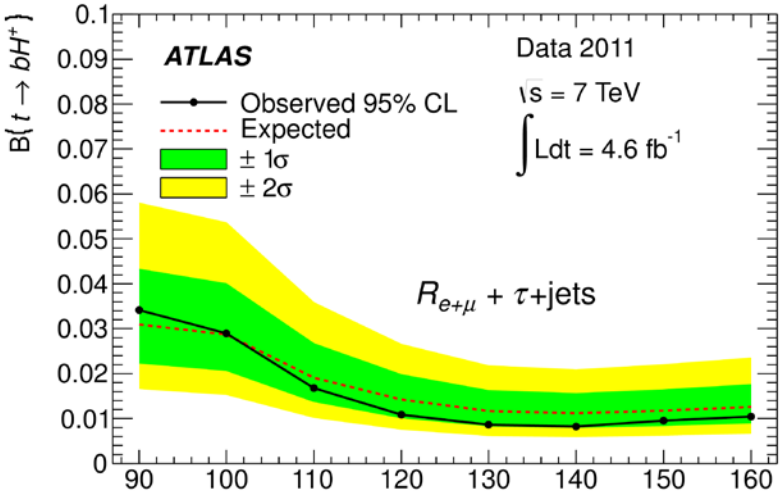
A PhD Student

Beyond a SM Higgs – Exp

- Extented Higgs sector : H^+
- Simplest approach : a 2nd Higgs doublet (2HDM)

- 79 < mH < 160 GeV
  - Using lepton universality to increase sensitivity t→bH w/r t→bW

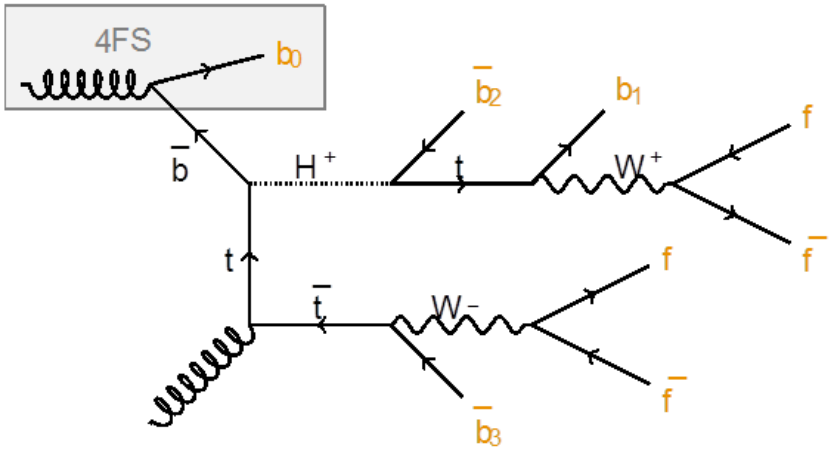


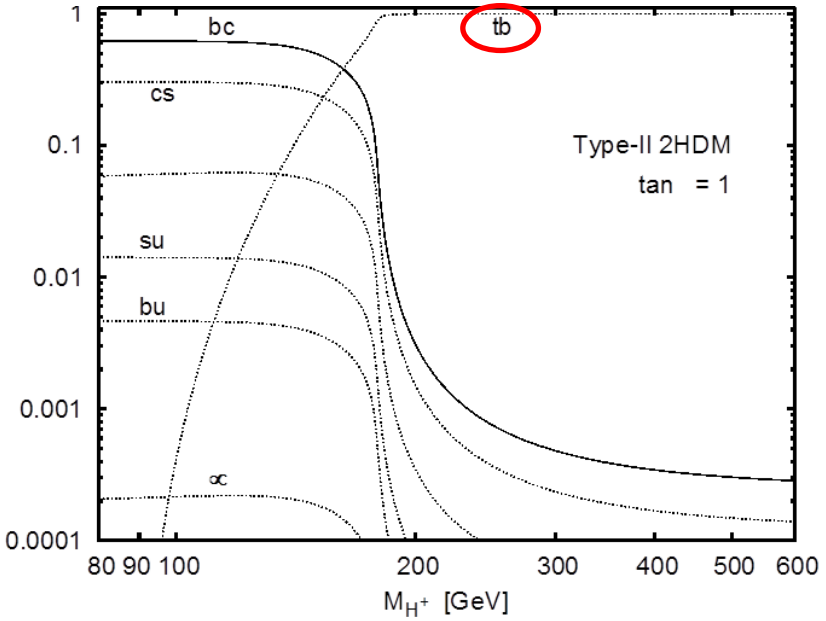


Model independant upper limit on t→BH(→τν)

Future: $H^+ \rightarrow tb$ ($mH > m_{top}$)

- Dominating decay mode above 200 GeV – almost exclusive for low tanβ.
- Very challenging final state with high (b-)jet multiplicity and large irreducible backgrounds.
- Extensive use of MVAs for signal/background discrimination and also event reconstruction.





Naturalness and X(126 GeV)

Is the X(126) natural? Remember for a long time, the naturalness argument behind existence of New Physics

- A--If no new physics, no discovery of new states
  - Are the properties of the Higgs really those of the SM (precision measurements)
  - A new framework for naturalness, scale invariance
- B--If some new physics / new states are discovered
  - Any link to the Higgs?
  - will this help understand naturalness
  - Any link to Dark Matter

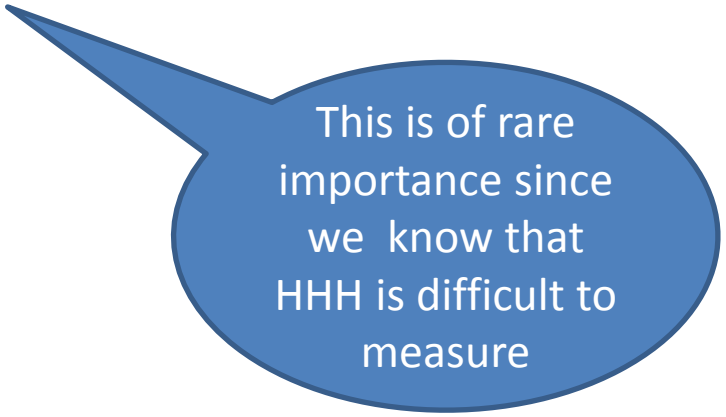
One post-doc

Naturalness: Issue A

- Reconstruction of couplings (standard, invisible widths,..)

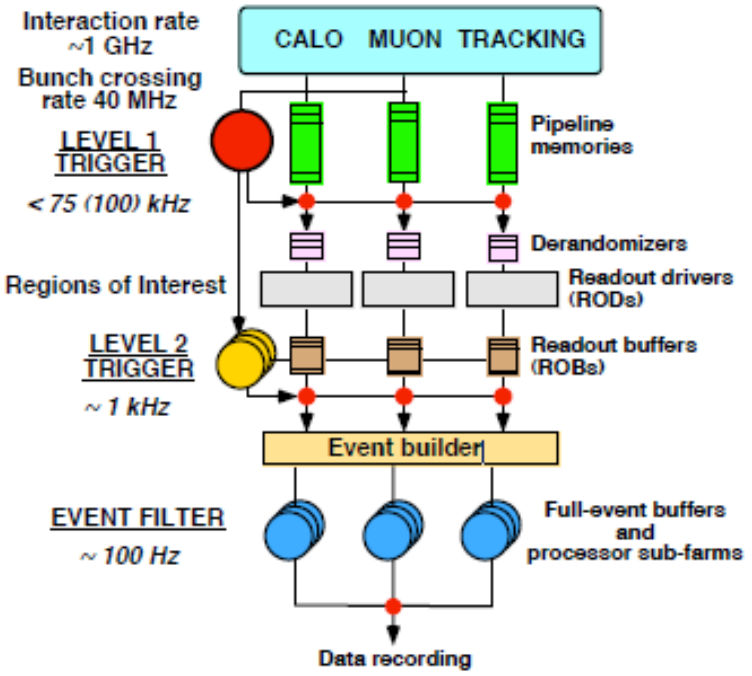
$\rightarrow$ fits to all available data (decays and separate production modes)

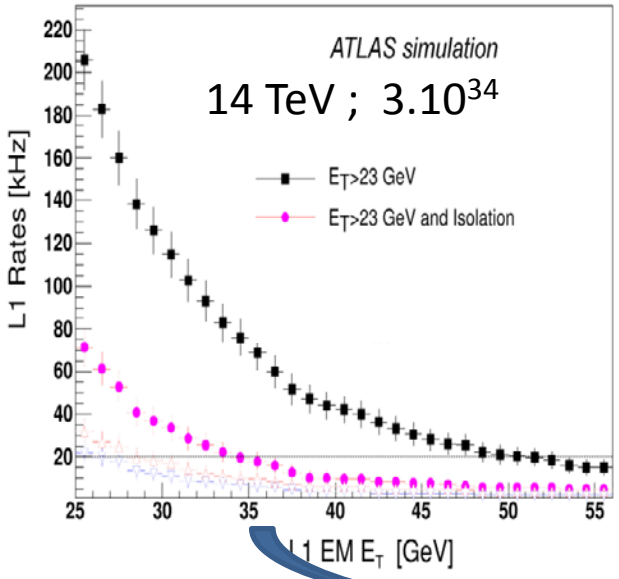
- Reconstruction of Higgs potential, in particular HHH
  - HHH: Studies (all) based on total Xsections of double H production not enough
  - Isolate the H-->HH contribution, spin and kinematics (may even help increase S/B)

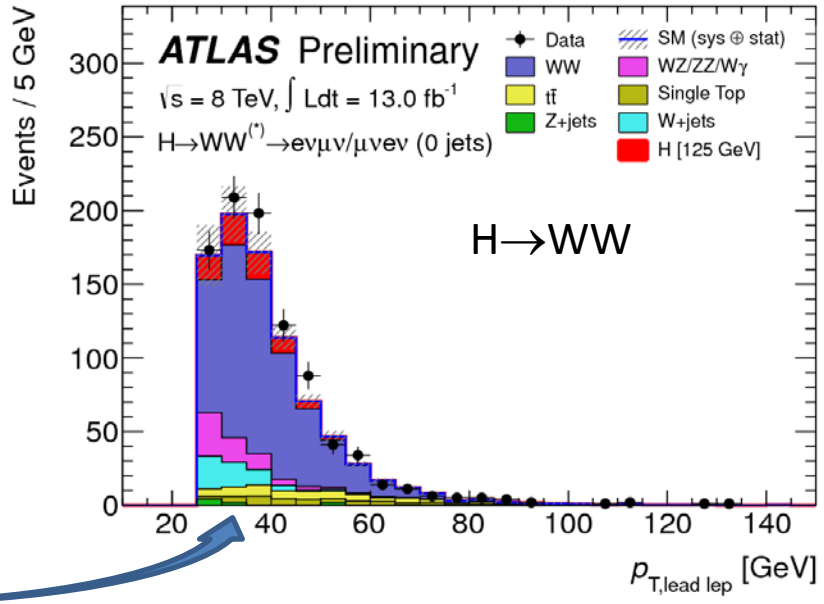


LAr Phase I upgrade (2019)

- Luminosity : ~2. 10^{34} $cm^{-2}s^{-1}$
- (factor ~4 w/r 2013)
- 20 kHz at the Level 1 for Electromagnetic objects.

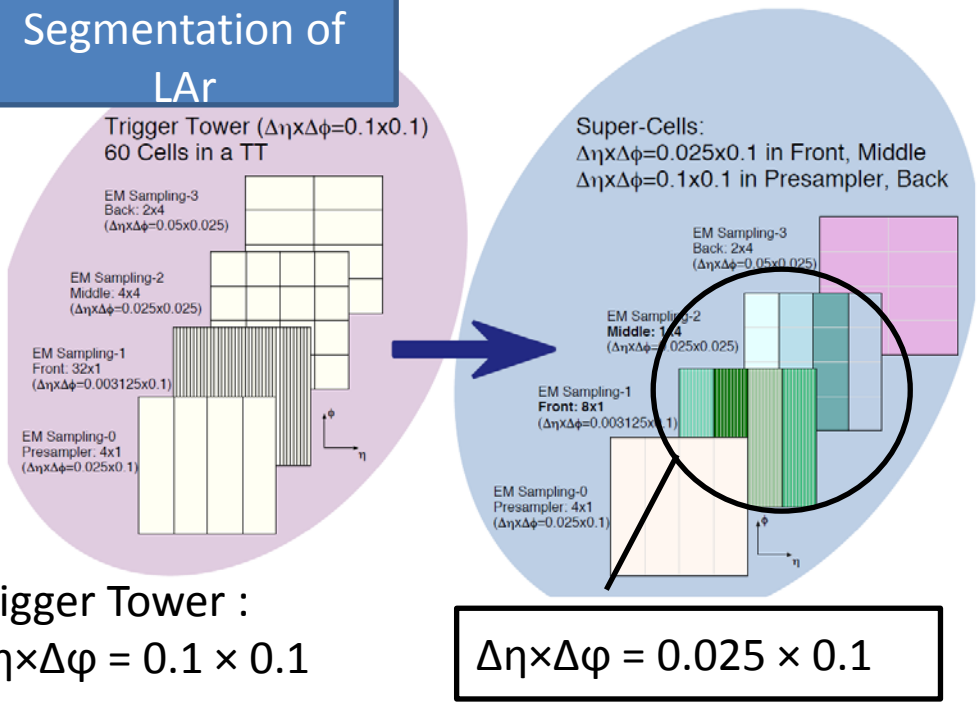






Granularity of the trigger cell

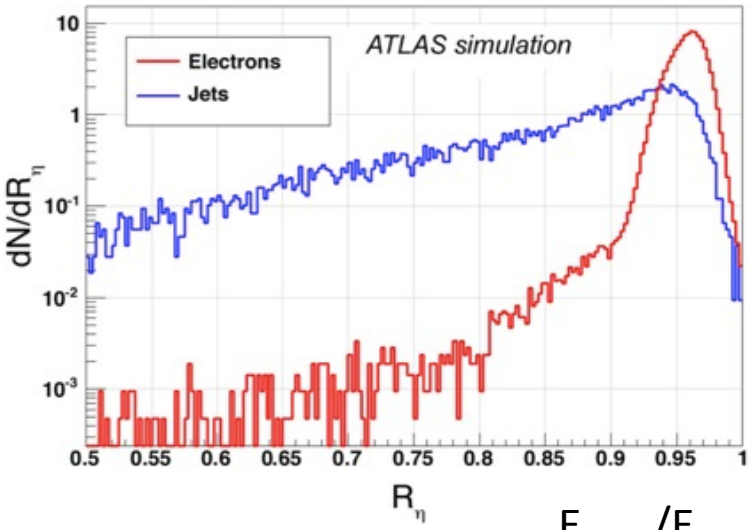
Long. Segmentation of LAr



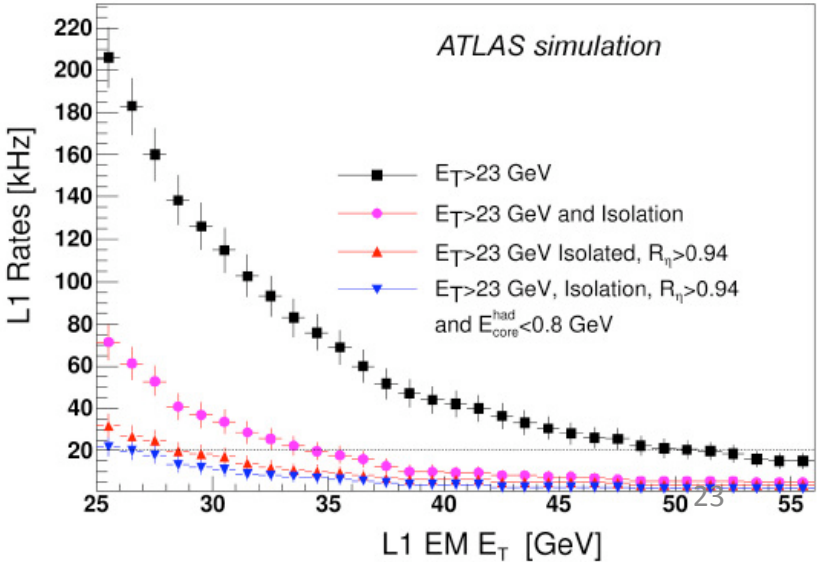
Trigger Tower :
Δη×Δφ = 0.1 × 0.1

Δη×Δφ = 0.025 × 0.1

→ Cut on the shower shape

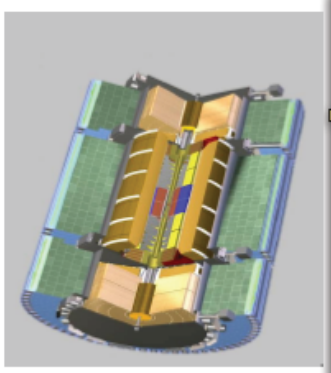


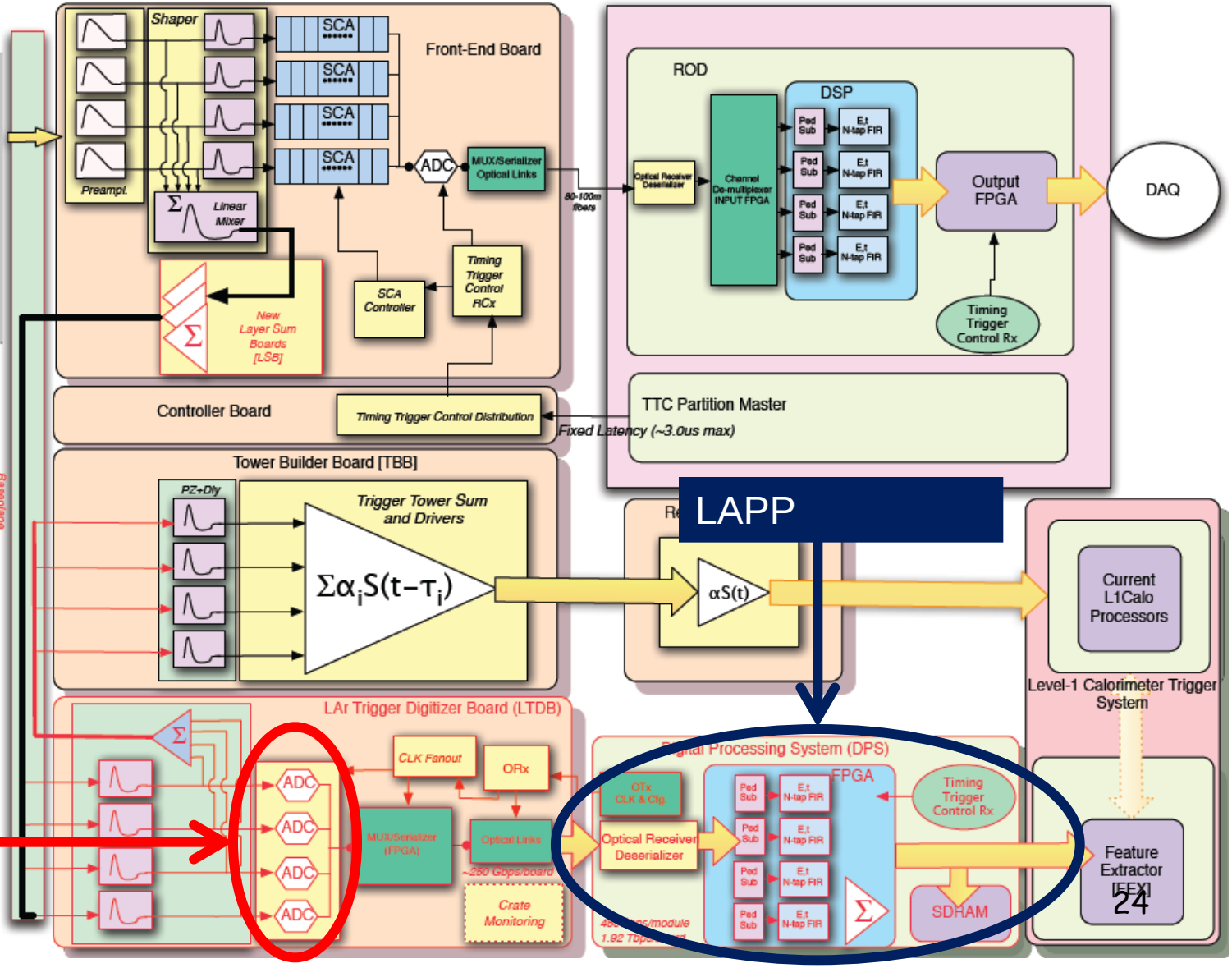
E_{core} /E



One post-doc

LABEX labs commitments





LAPP

LPSC

Possible implementation
$\Delta\eta\times\Delta\phi$=0.025x0.1 1st and 2nd layer EM
$\Delta\eta\times\Delta\phi$=0.1x0.1 elsewhere

Phase II upgrade

- High Luminosity LHC running > 2020 :
  - L_{inst} = 5.10^{34} fb^{-1} with an expected integrated luminosity of 3000 fb^{-1}
  - Not approved
- However appears as a good option in the European strategy
- TDR in 2016

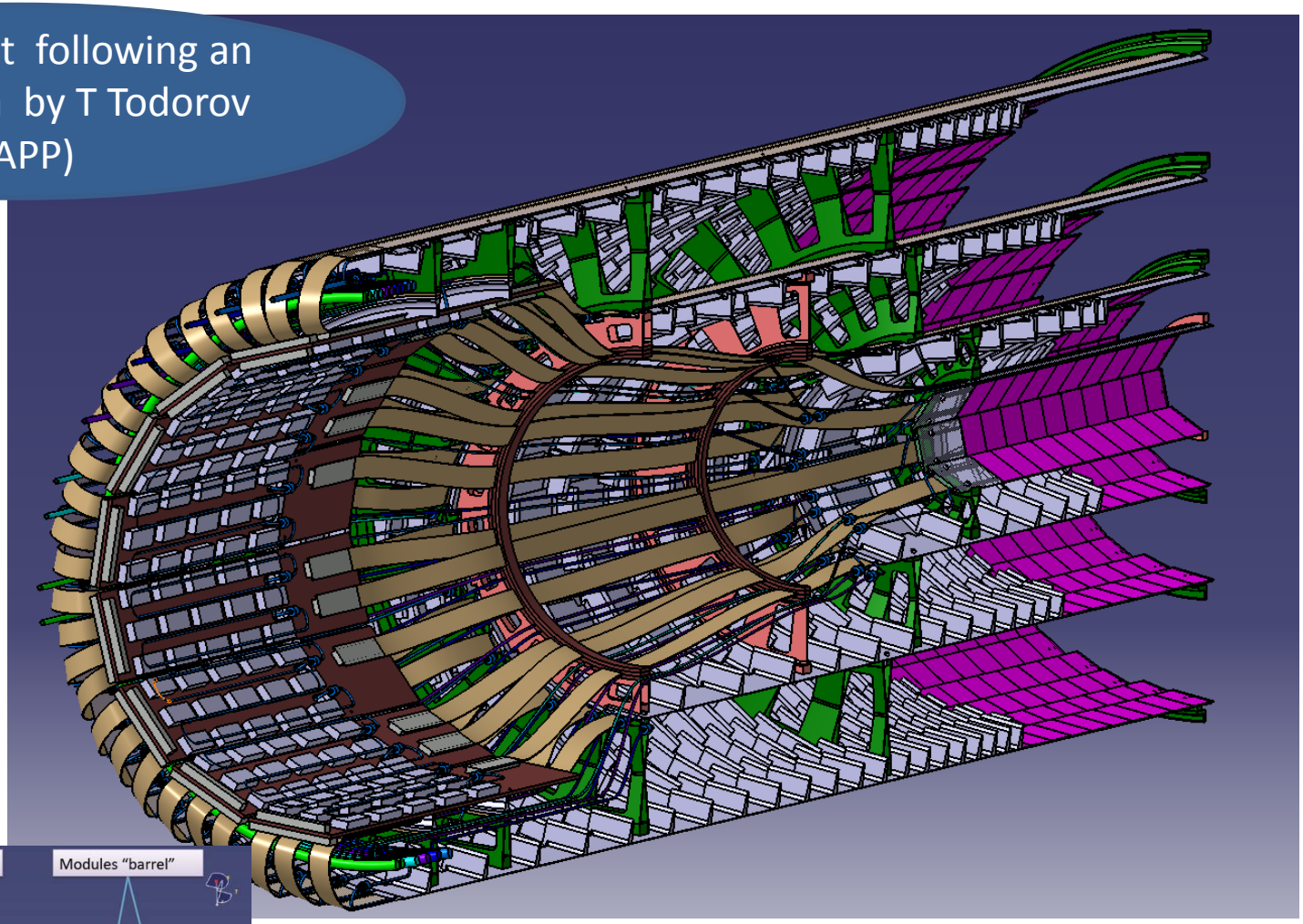
Physics Motivation (H linked) :

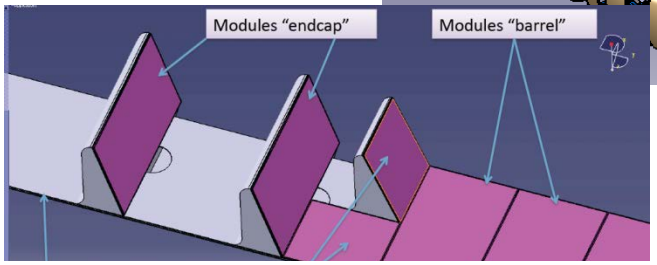
- H couplings to 10% (5% for the best case)
- $H \rightarrow \mu\mu$
- Access to triple coupling HHH
  - Via $bb\gamma\gamma$
- Higgs composite via VV scattering

New Tracker (all Silicon)

- Deterioration of the current tracker due to radiation
- TRT cannot cope with the expected occupancy
- Readout cannot stand a luminosity of 5. 10^{34} $cm^{-2}.s^{-1}$

Alpine layout following an original idea by T Todorov (LAPP)





Carbon foam contributes both to rigidity and heat transport of the stave

- Tracks impinging the pixel with close to ideal incidence.
- Services outside tracker acceptance.
- **Pixel area reduced by a factor 2 compared with a classical design** (barrel + end-caps disks)

- **Base version**
  - Performance of such a design in terms of physics.
  - Thermo – mechanical behavior
    - Monitoring of IBL : in situ test of Carbon Foam
    - Building and Studies of prototypes
    - Cooling
  - Study for a global structure and final assembly
  - Optimization of services
  - Design of an Interface board

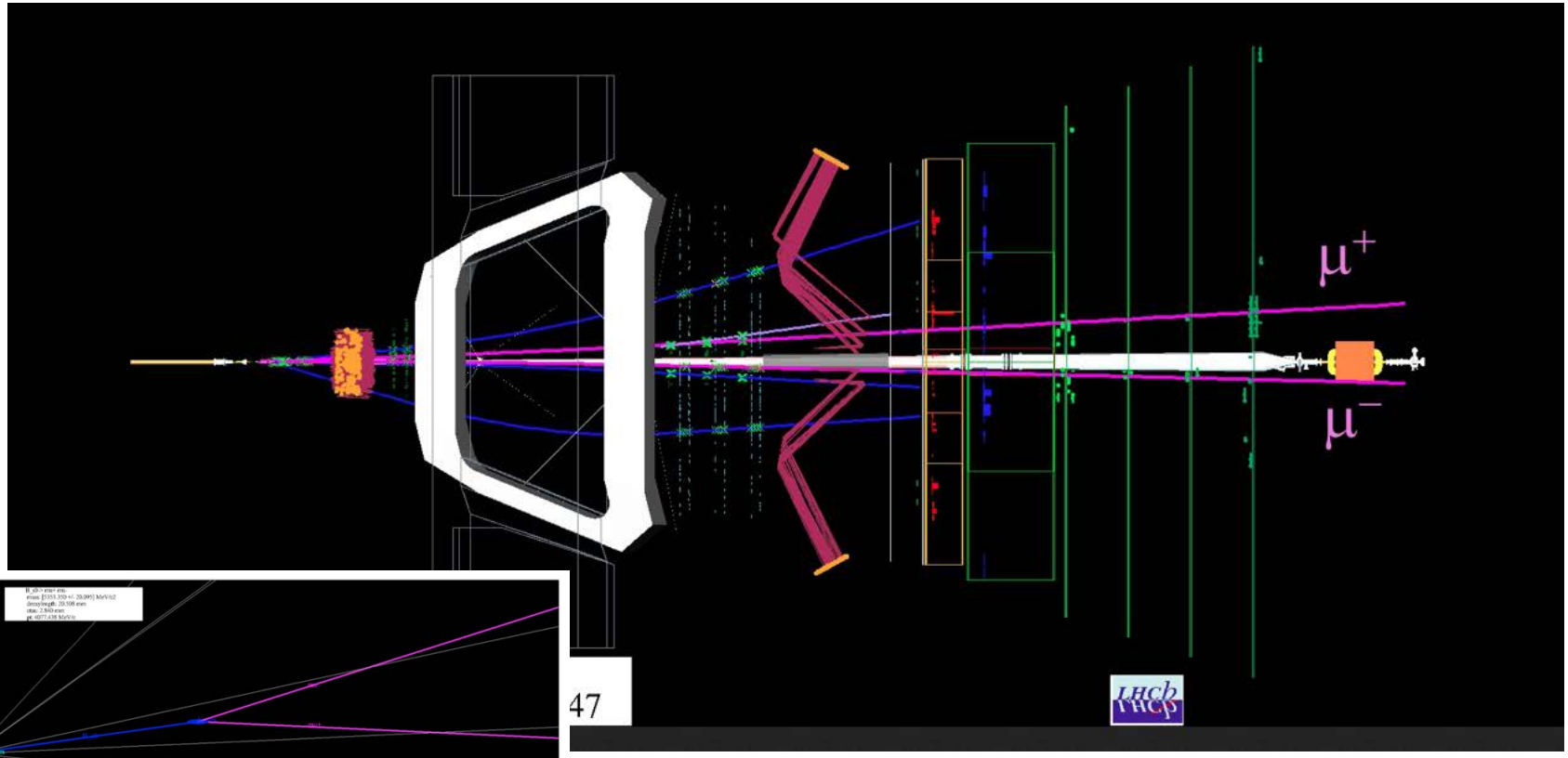
ANR* AlpHiggs
LAPP/LPSC/LAPth

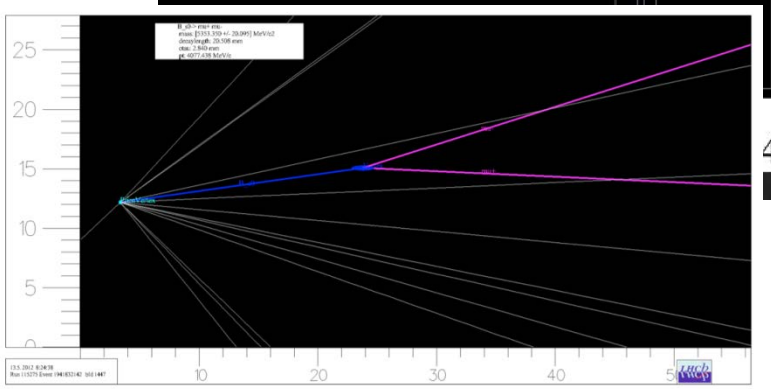
- **Extended to large acceptance (Eta ~ 4.5)**
  - Physics case
  - Validating a conceptual design along the line of the Alpine layout

*ANR : extra source of funding by project

The flavors

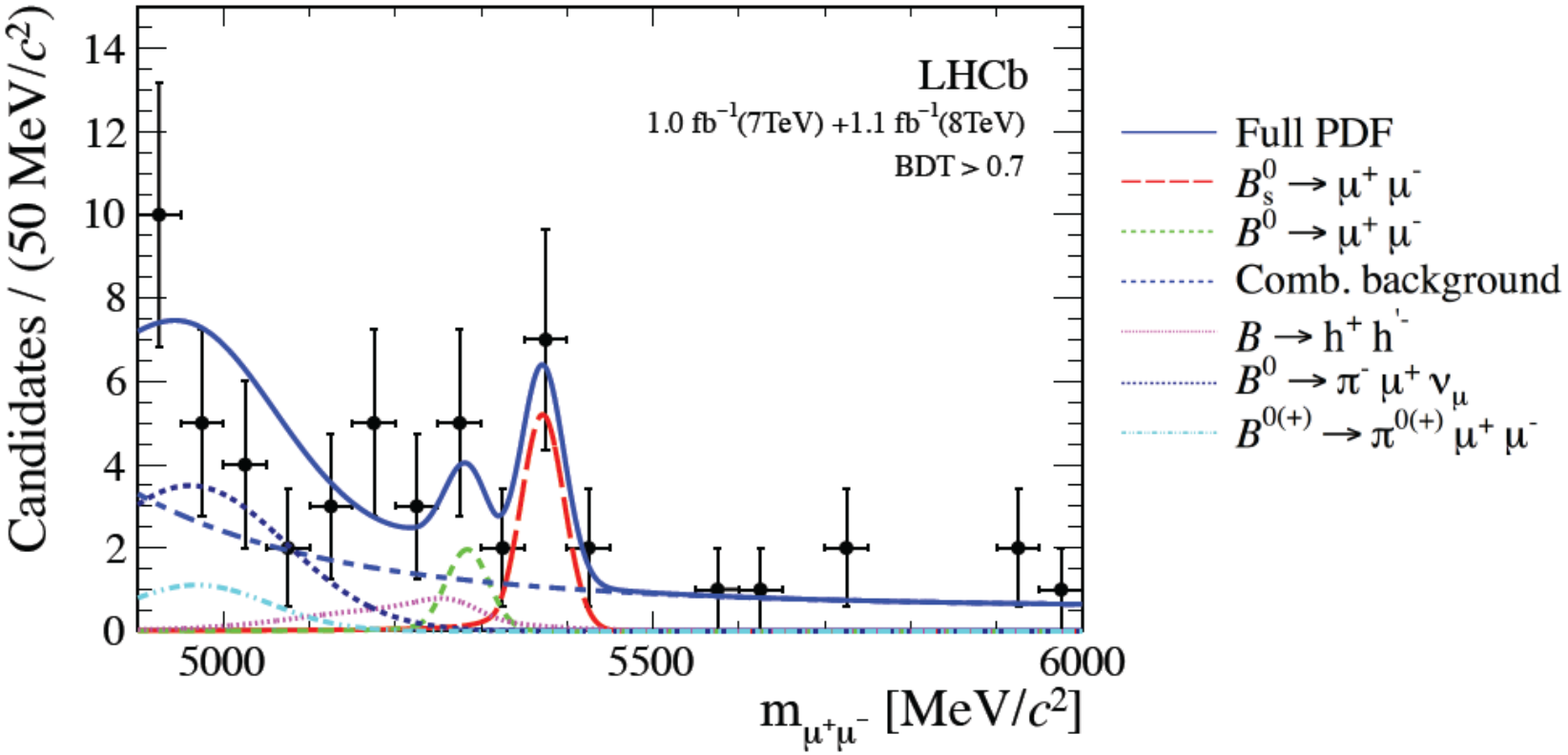
- First evidence of $B^0_s \rightarrow \mu\mu$





$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (3.2^{+1.5}_{-1.2}) \times 10^{-9}$$

In agreement with SM expectations



New Physics in the Flavor sector

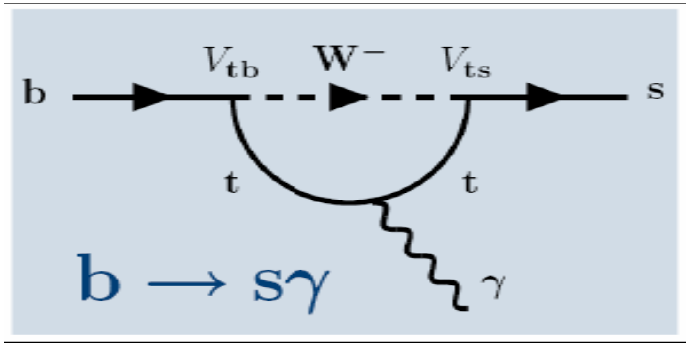
2 ANRs proposed

NewPhysTop (LPSC)

- Precision measurement in the Top Sector
  - Single top cross-sections
  - Polarisation
- Direct search with top in the final states :
  - Complementary aspect to

H+ $\rightarrow$tb

RADIA (LAPP – LHCb ,LAPTH)



- Measurement of the photon polarisation
  - % right component is an indication of New Physics
- Several modes

Conclusion

- To reveal the nature of EWSB is the core of Enigmass:
  - Blessed by the discovery of the X(126) resonance somewhat earlier than expected,

    $\rightarrow$Enigmass gave a priority to this axis of research.

- Measurements and searches linked with the flavor sector contribute as a complementary approach to this aim.

- Hope is that the several ANR demands will bring a synergy into the Enigmass sphere.