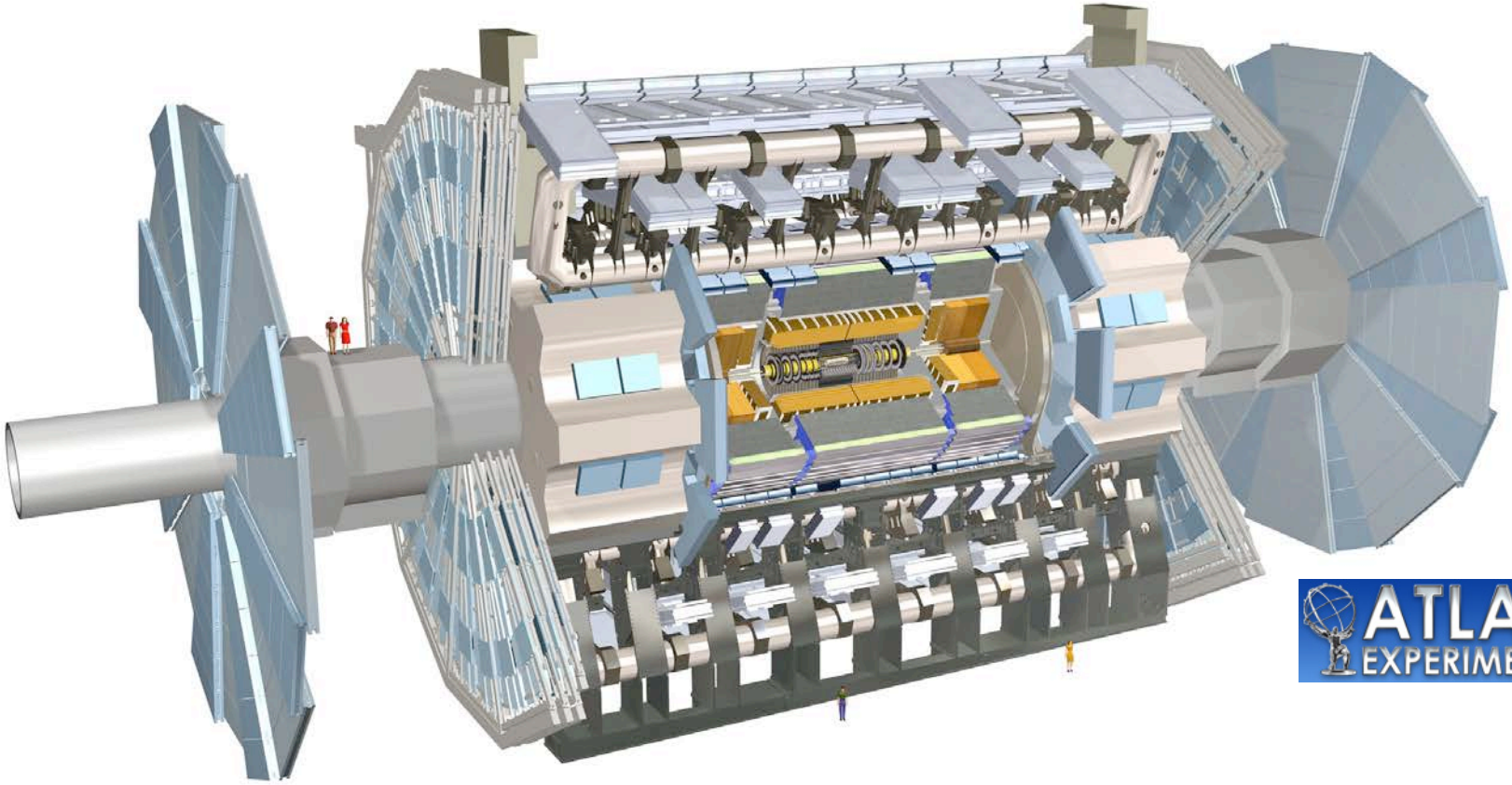
The ATLAS group @ LPNHE



LPNHE - Tristan Beau

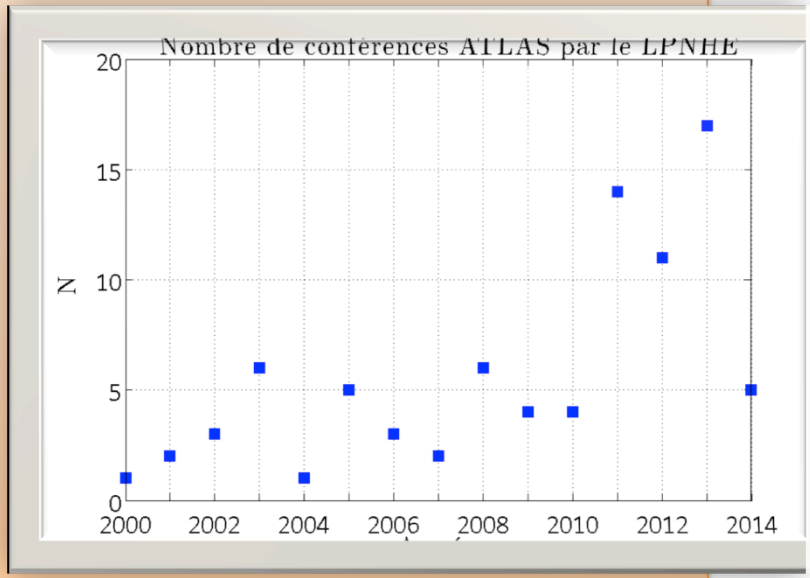
20th of june 2014

Outline

- Local LPNHE ATLAS team, PhD subjects
- Few words about the detector
- Two main fields of studies : Higgs & Top quark
- General common detector tasks
- Few words about R&D

ATLAS team @ LPNHE

- 17 permanent physicists (9 from university, 8 from CNRS)
- 3 Post-docs, 6 PhD students
- 8 tecnicians or engineers
- About 20 undergraduate student trainings
- ~150 days of invited collaborators
- 17 seminars, 47 conferences in 2011-2014



Defended PhD

2011

- **Stefania Bordoni** : Mesure de la section efficace de production des quarks beaux et charmes a partir de leur desintegration semileptonique en electrons avec l'experience ATLAS dans les collisions protons-protons a sqrt(s) = 7 TeV au LHC.
- **Li Yuan** : Mesure de la section efficace de production de paires de photons et étude de sensibilité de recherche du Higgs dans le canal H->gammagamma avec le détecteur ATLAS

2012

- **Timothée Theveneaux-Pelzer** : Mesure de la section efficace de production de paires de quarks top dans les canaux multileptons dans l'expérience Atlas

2013

- **Olivier Davignon** : Recherche du Boson de Higgs de basse masse dans le processus de production de Fusion de Bosons Vecteurs avec lexpérience ATLAS au collisionneur LHC
- **Nicolas Meric** : Etude des corrections électrofaibles aux processus QCD, théorie+expérience
- **Camila Rangel** : Search for Higgs boson in H->gamma gamma channel in ATLAS experiment
- **Heberth Torres** : Mesure de la production de photons dans l'expérience ATLAS. Application á la recherche du boson de Higgs se désintégrant en deux photons
- **Liwen Yao** : research on Higgs to di-photon

PhD to be defended

2014

- **Aurelien Demilly** : Mesure de la masse du quark top dans le canal dileptonique eμ avec le détecteur ATLAS au LHC
- **Guillaume Lefebvre** : Mesure de la section efficace de production de paires ttbar avec le détecteur ATLAS au LHC
- **Kun Liu** : Photon efficiency measurement and search for Higgs boson from H->γγ and H->Zγ with ATLAS

2015

- **Sylvestre Pires** : Mesure de la masse du quark top dans les canaux en dileptons avec l'experience ATLAS

2016

- **Carlo Pandini** : FASTRACK et Higgs dans le canal VH->bb
- **Yee Yap** : Recherche d'un boson de Higgs supplémentaire dans le cadre de modèles à deux doublets de Higgs, à l'aide des désintégrations A->Zh, h->γγ, avec le détecteur ATLAS.

LPNHE ATLAS scientific studies : two main fields

Top properties and measures :

- Cross section
- Mass

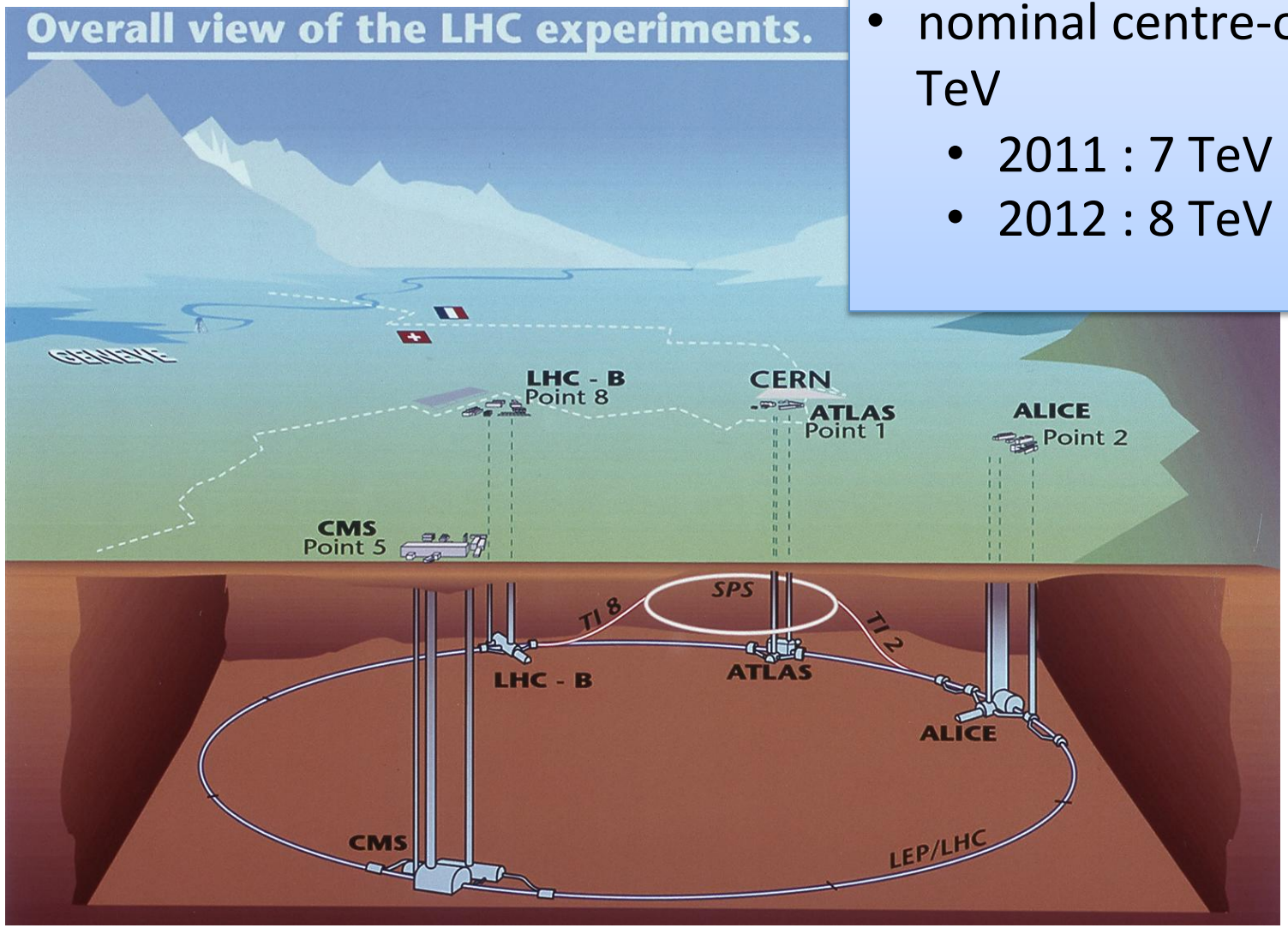
Higgs :

- Search
- Measurements

Few words about the LHC…

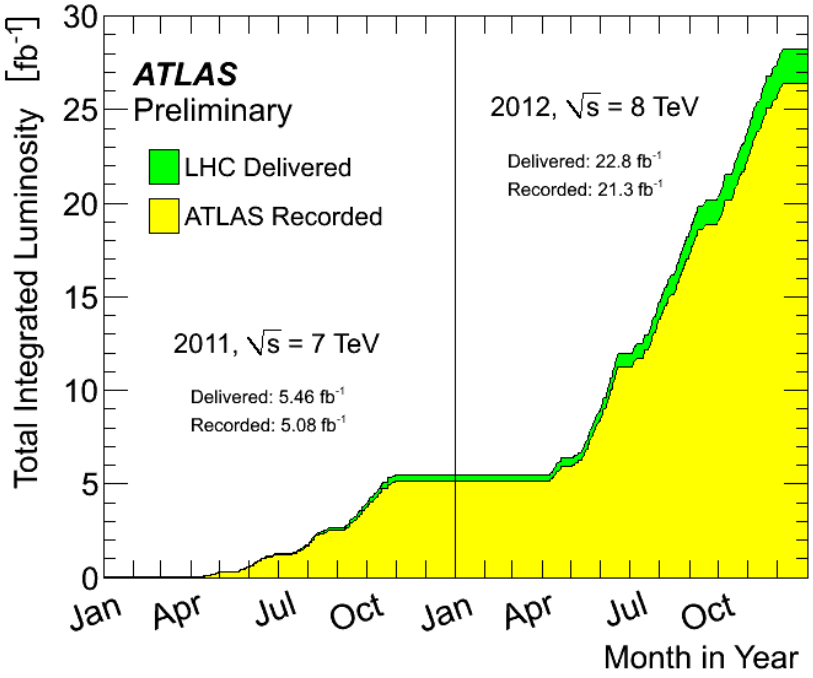
The Large Hadron Collider (LHC) :

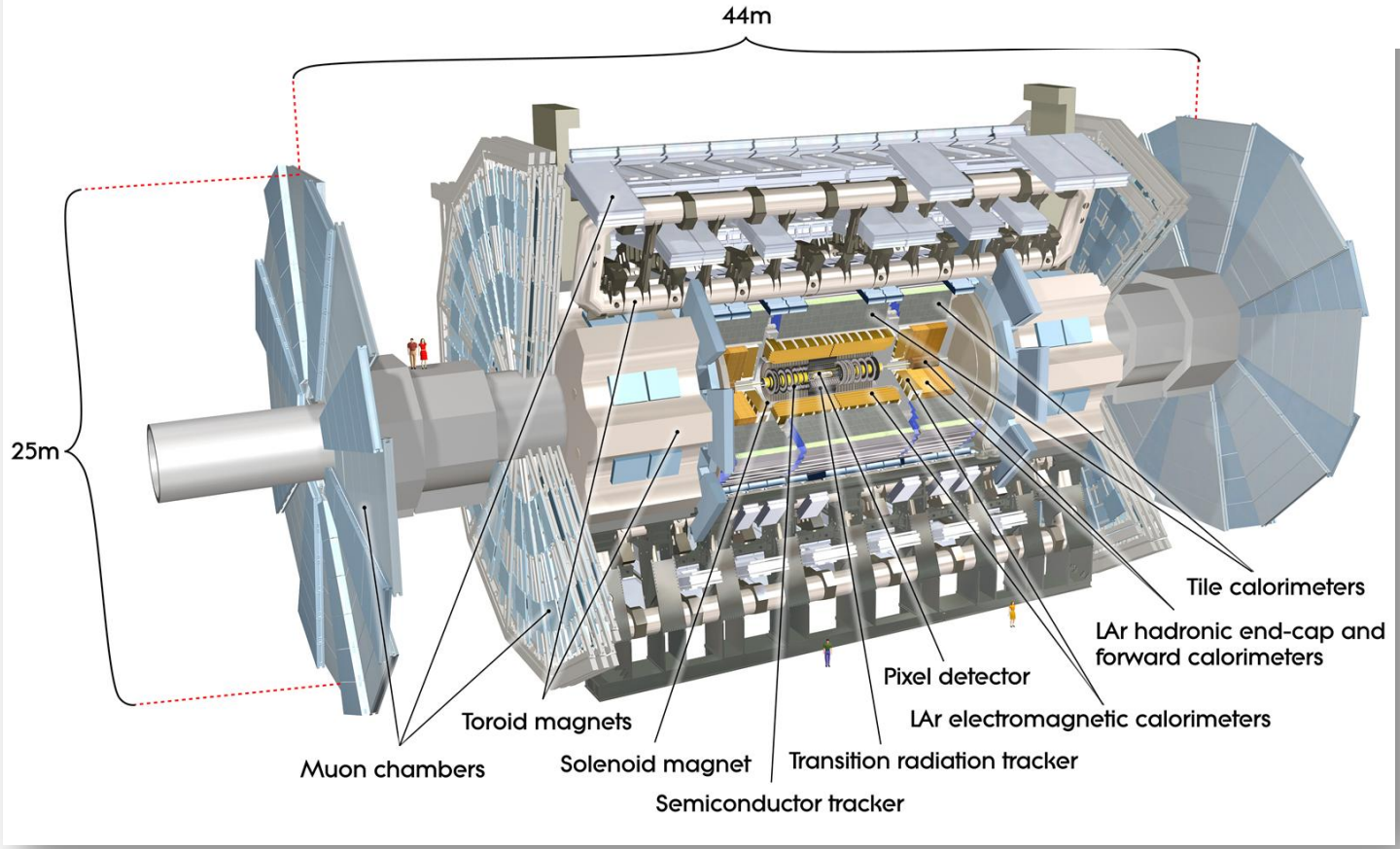
- 27 km long, circular, close to Geneva
- mainly pp collisions
- nominal centre-of-mass energy 14 TeV
  - 2011 : 7 TeV
  - 2012 : 8 TeV



… and ATLAS

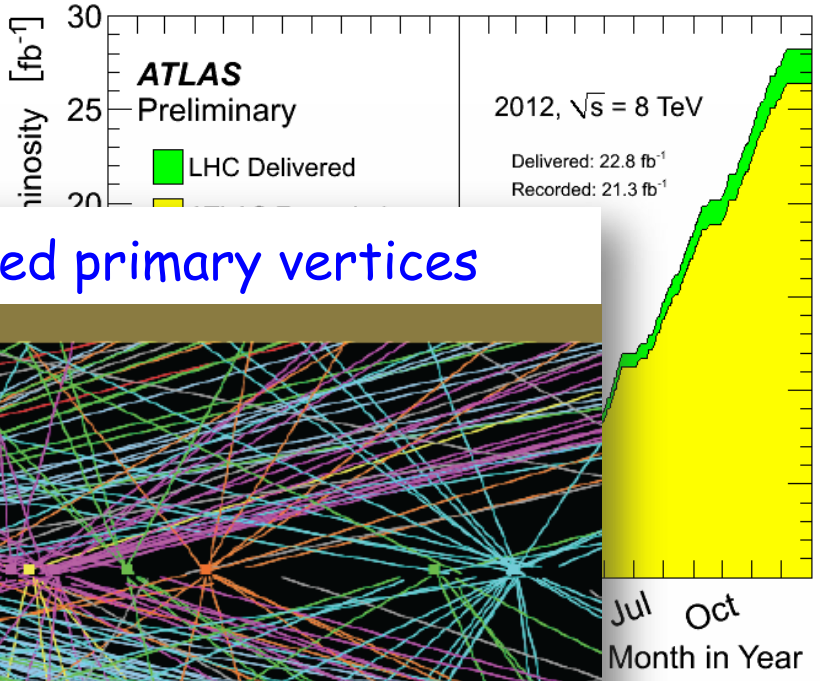
- Designed for Higgs discovery, new physics searches
- High performance in vertexing, tracking, calorimetry, muon coverage



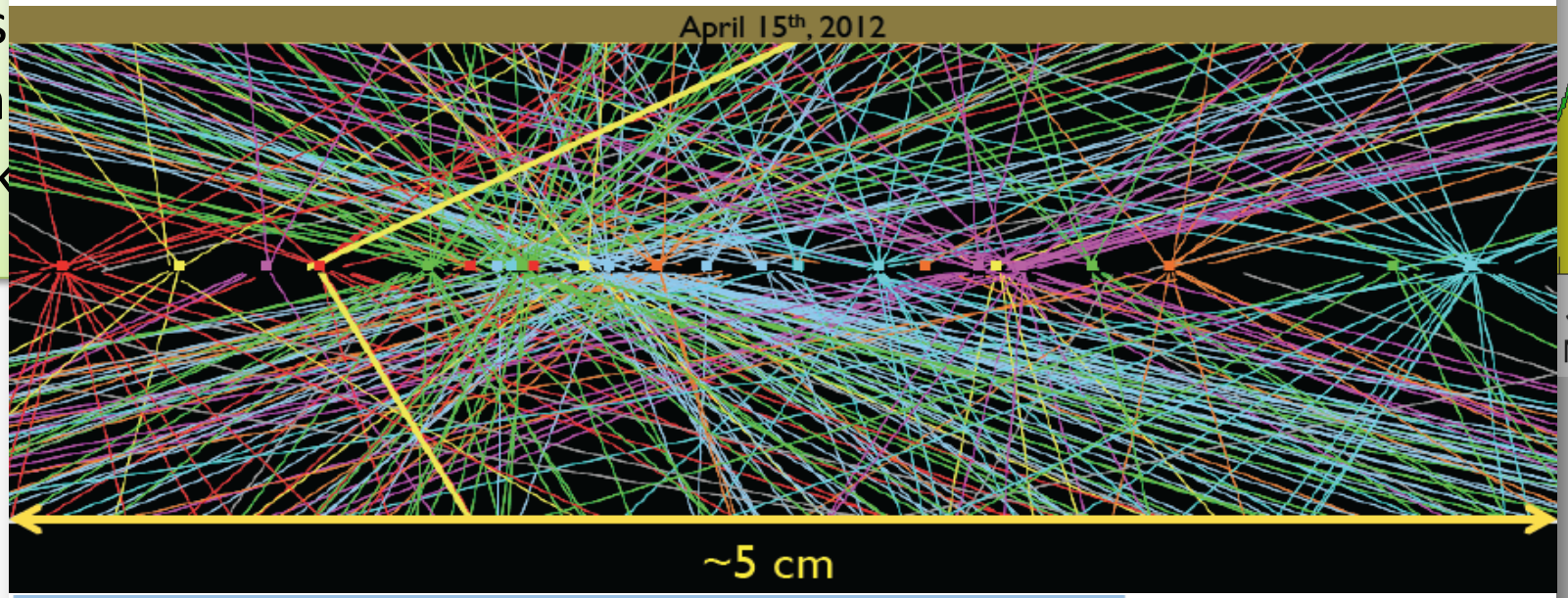


… and ATLAS

- Desig
  phys
- High
  track



Z -> μμ event with 25 reconstructed primary vertices



ATLAS p-p run: April-Sept. 2012

Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
100	99.3	99.5	97.0	99.6	99.9	99.8	99.9	99.9	99.7	99.2

All good for physics: 93.7%

Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at √s=8 TeV between April 4th and September 17th (in %) – corresponding to 14.0 fb-1 of recorded data. The inefficiencies in the LAr calorimeter will partially be recovered in the future.

~90% of delivered luminosity in 2011 and 2012 recorded for physics analysis

"all good for physics"
89.9% 2011, 93.7% 2012

4

Muon chambers | Solenoid magnet | Transition radiation tracker
Semiconductor tracker

First field of study : the Higgs ?

- Postulated mecanism and existence in 1964 (Brout, Englert, Higgs)
- The quest (till mid 2012) :
  - LEP (1989-2000) : m_H>114.4 GeV
  - @Tevatron : excluded m_H between 156 and 177 GeV, indications between 115 and 140 GeV
  - @LHC : excluded m_H between 127 and 600 GeV, indications around 125 GeV
- 4th of july, 2012 : observation ATLAS and CMS observation announcement of a Higgs compatible particle
- 24th of july : “evidence" of the decay of that particle in b-bbar pair by CdF and D0
- 14th of march, 2013 : the discovered particle is A Higgs boson, m_H ~ 125.5 GeV
- 8th of octobre, 2013 : Nobel price in physics for François Englert and Peter Higgs

First field of study : the Higgs ?

- Postulated m… Higgs)
- The quest (til…
  - LEP (1989…
  - @Tevatro… ndications between 115 and 140 G…
  - @LHC : ex… tions around 125 GeV
- 4th of july, 201… nouncement of a Higgs compatible pa…
- 24th of july jui… b-bbar pair by CdF and D0
- 14th of march… n, m_H ~ 125.5 GeV
- 8th of octobre… glert and Peter Higgs

The Nobel Prize in Physics 2013
François Englert, Peter Higgs

Share this: 1.8K

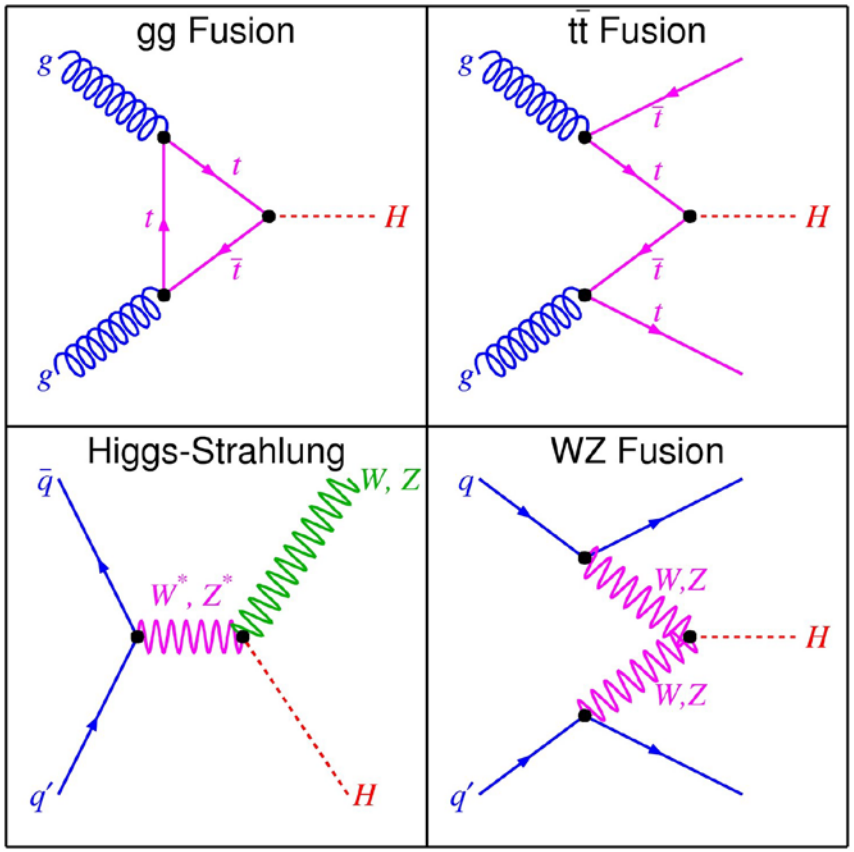
The Nobel Prize in Physics 2013

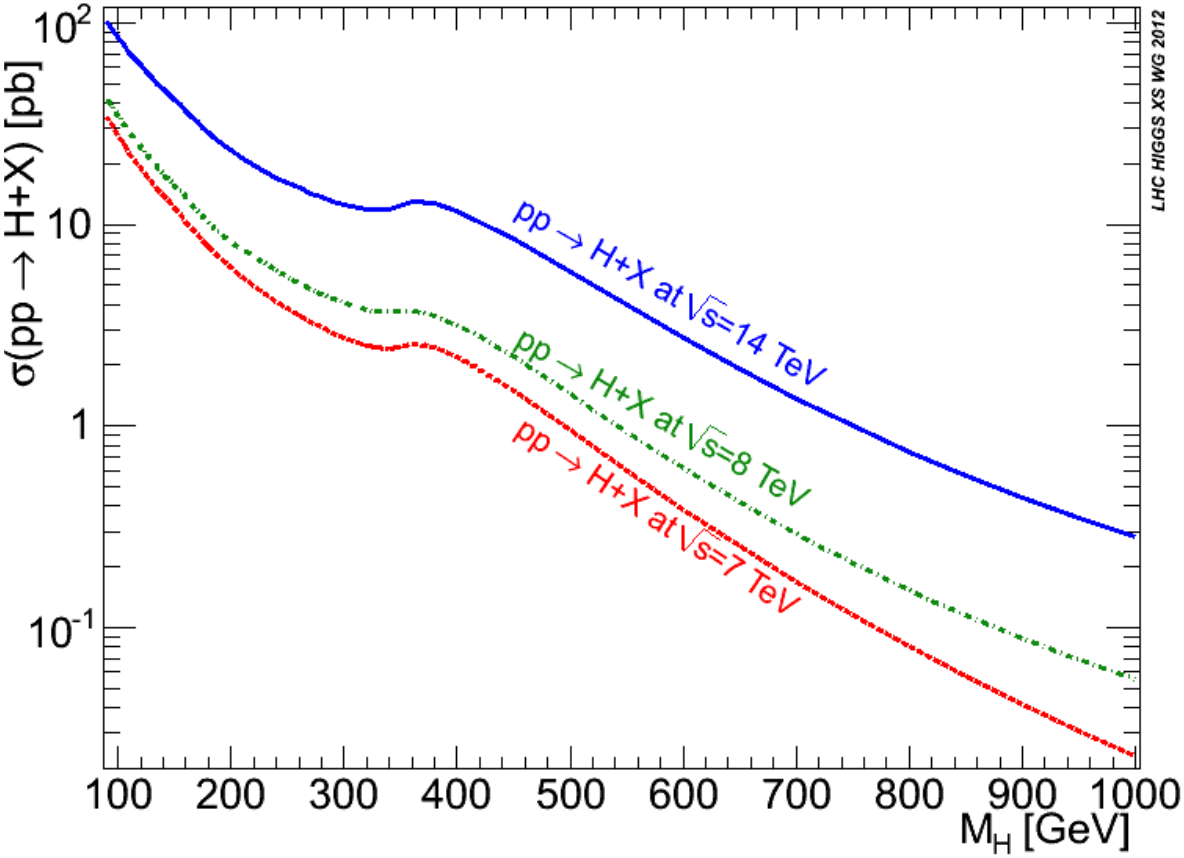
Photo: A. Mahmoud
François Englert
Prize share: 1/2

Photo: A. Mahmoud
Peter W. Higgs
Prize share: 1/2

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*

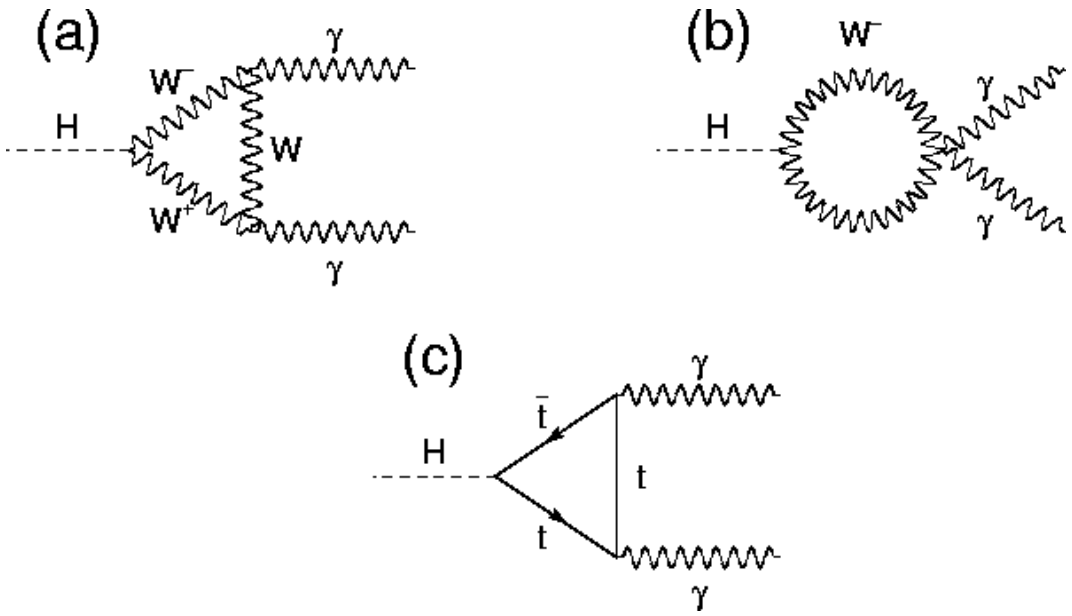
Higgs production @ LHC

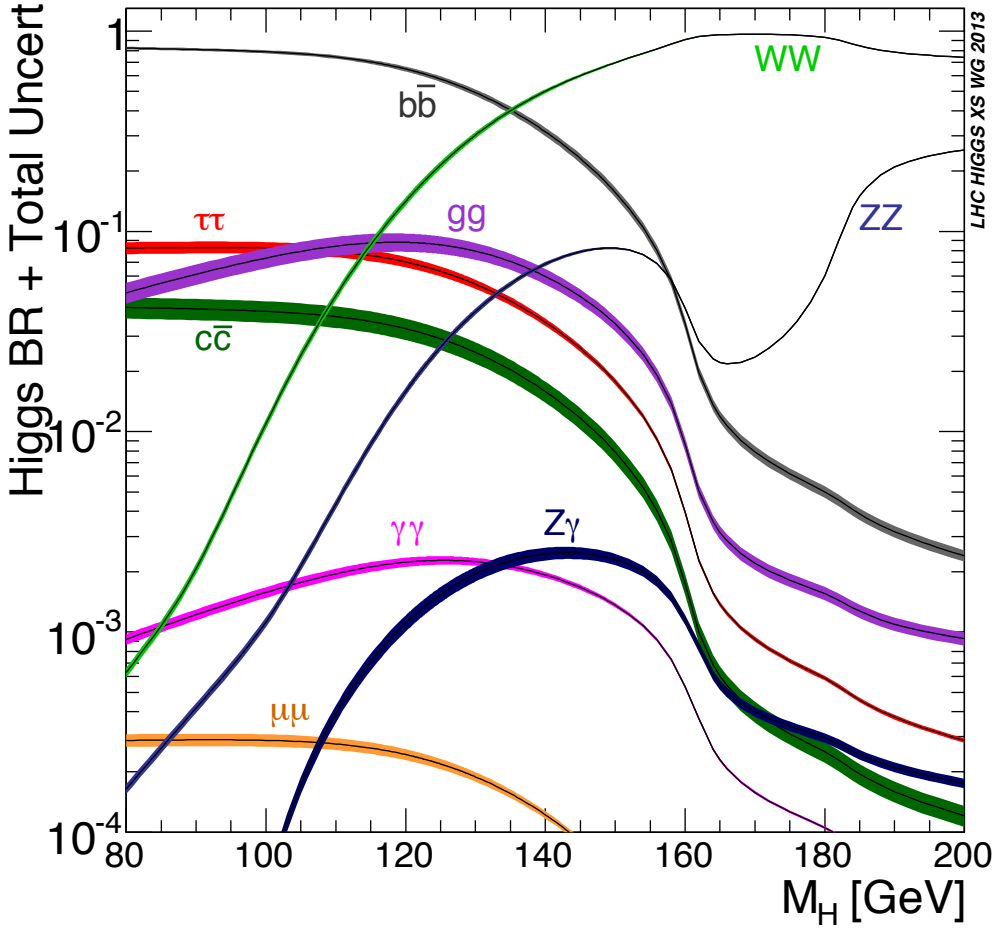




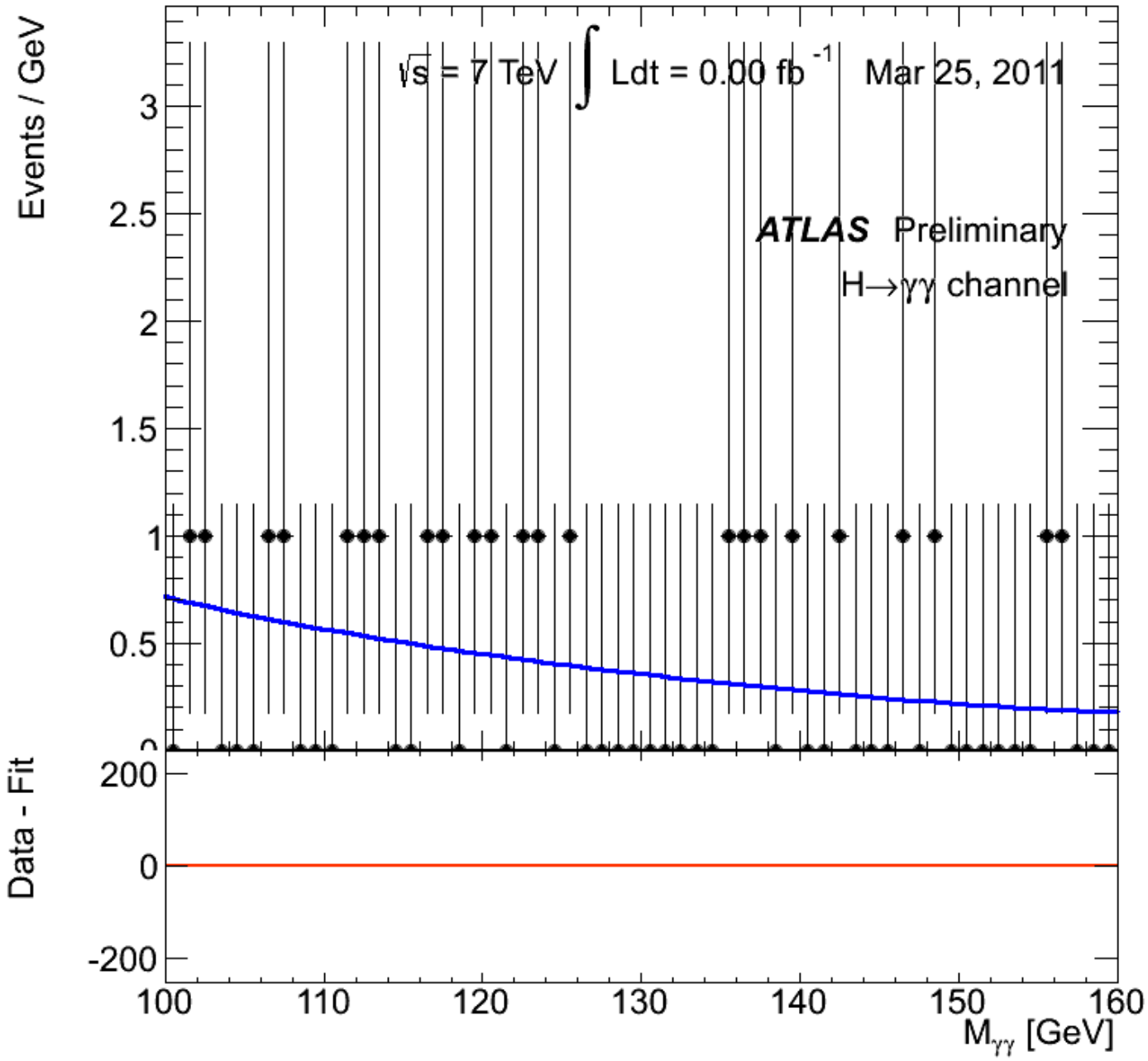
One of the golden channel : H -> γγ

This channel allow to evaluate the Higgs boson mass with a very good precision, and with a clear signature.

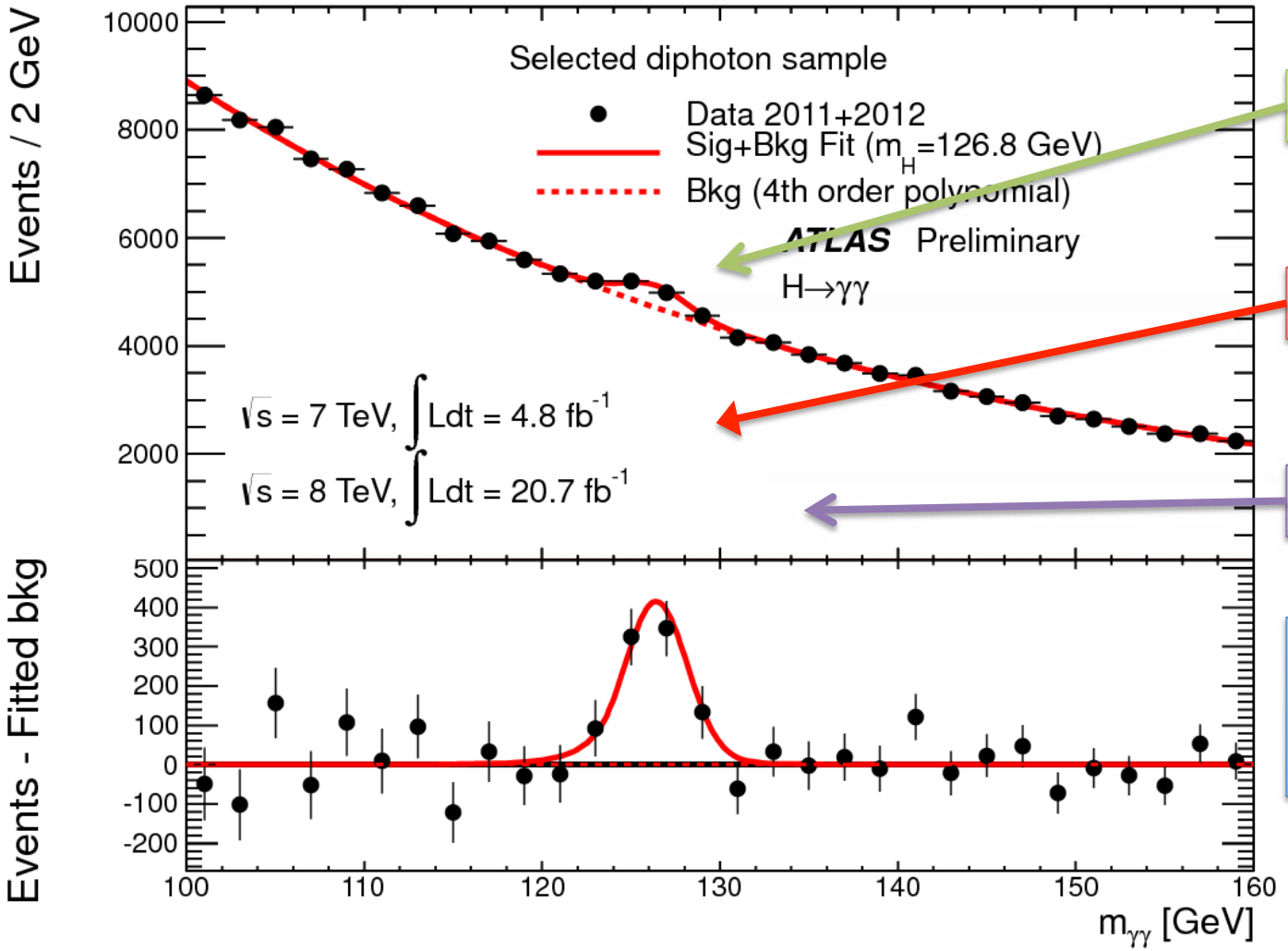




The H -> γγ signal ATLAS



The H -> γγ signal in ATLAS : LPNHE contributions



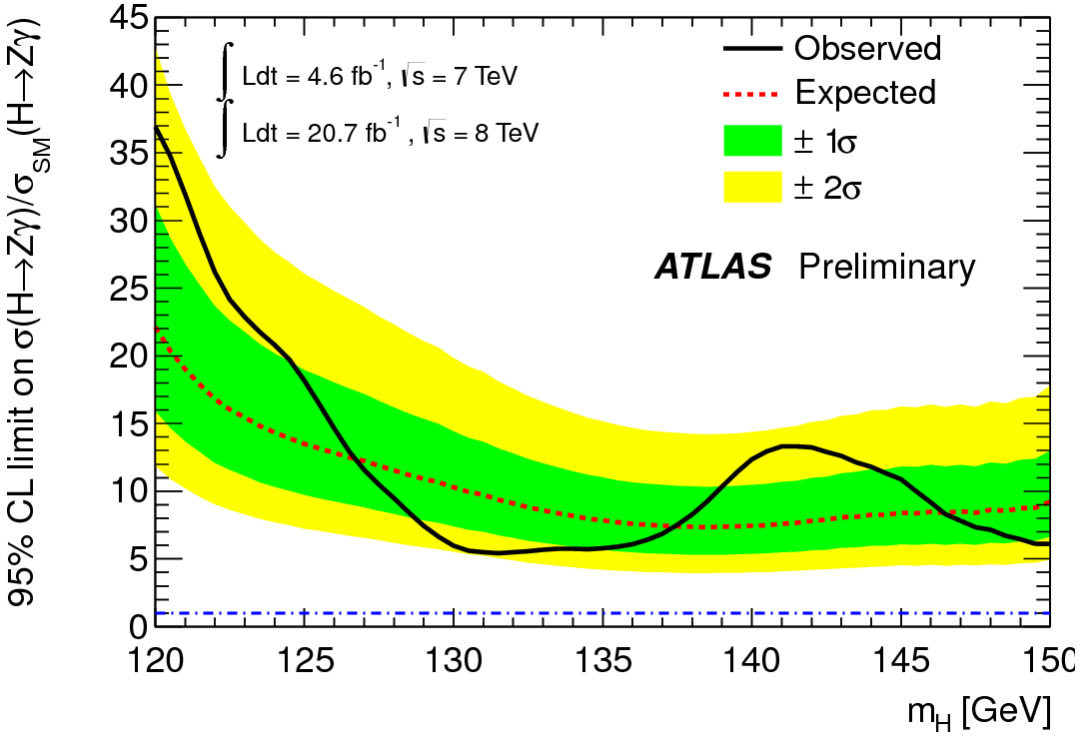
Signal parametrisation

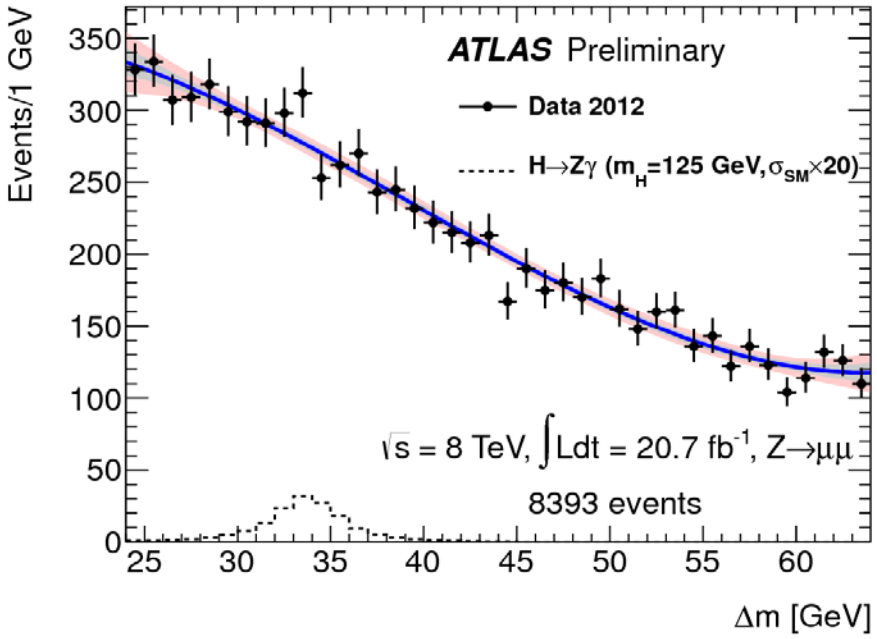
Background parametrisation

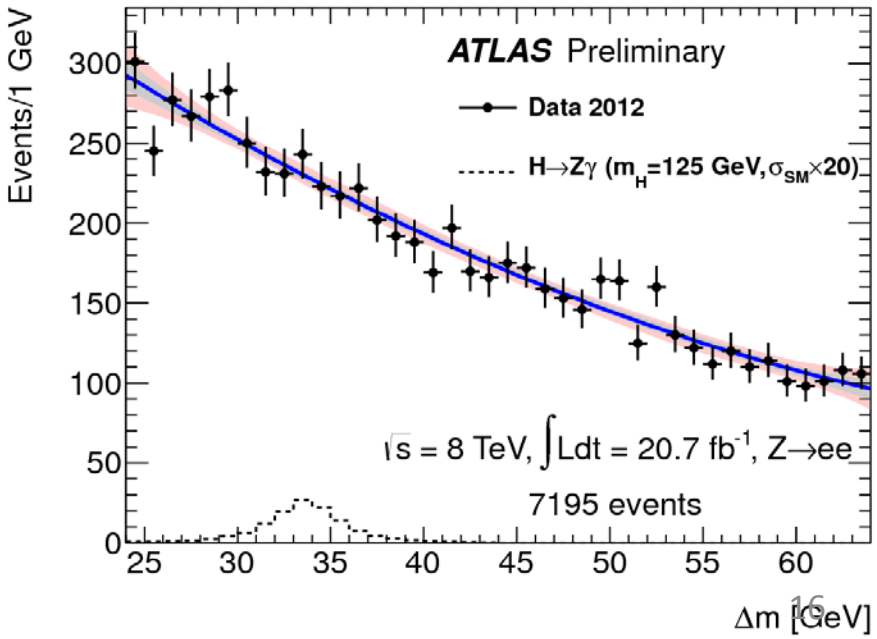
Composition du bruit de fond

Use of extra jet topology to enrich the sample with VBF events

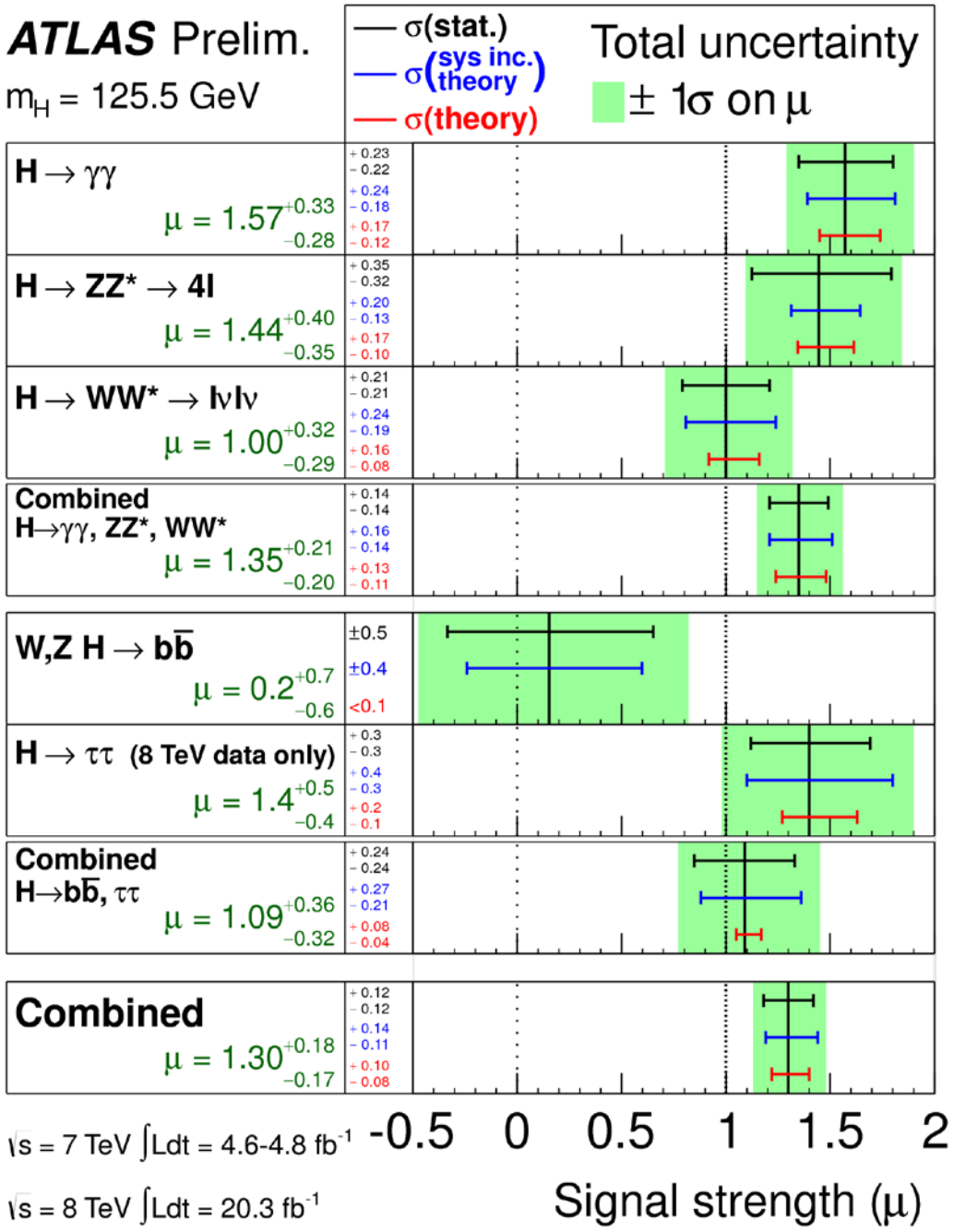
Searches in the H -> Zγ channel







Higgs seen by ATLAS - summary



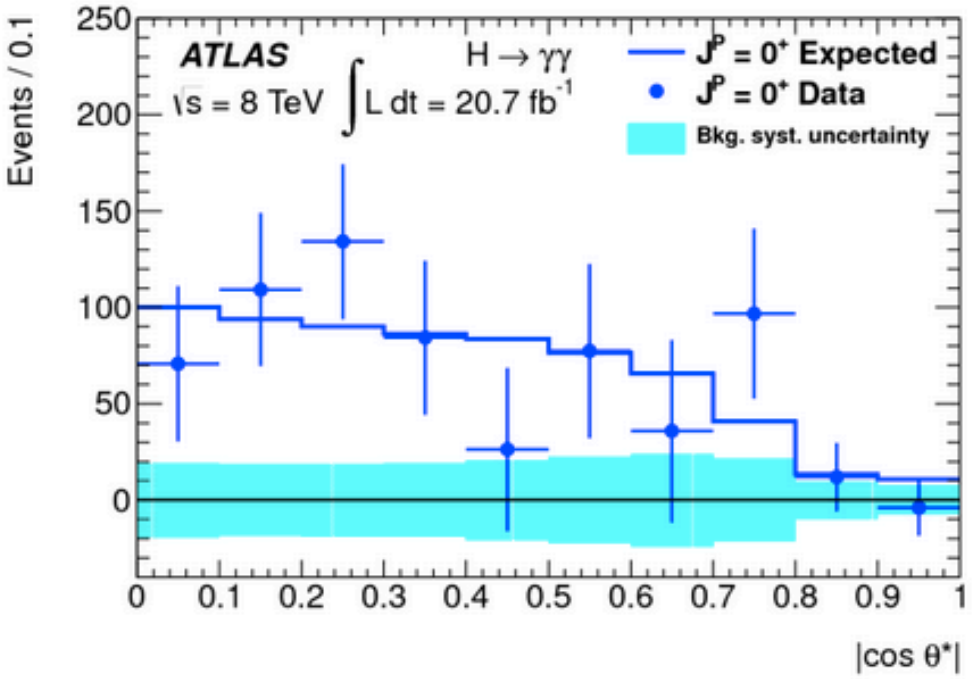
Multi channel measurements of the Higgs signal

Recent activity in the group with H->bb :

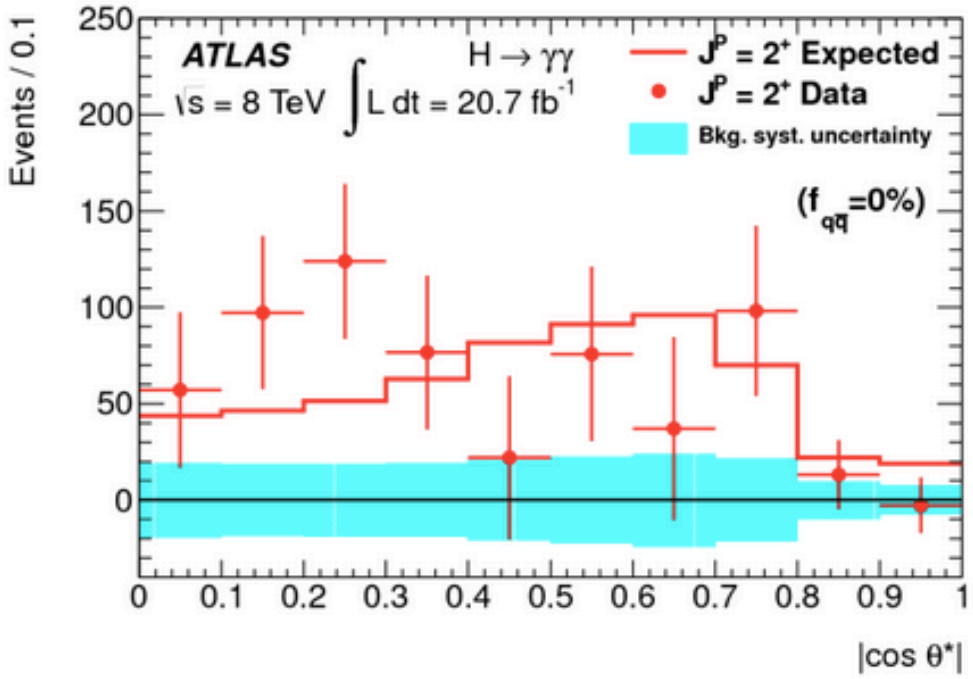
- Analysis optimisation
- Already running for run1

Higgs seen by ATLAS - summary

Spin statistical tests :
-> Spin 2 hypothesis exclusion with confidence level of 99.3 %

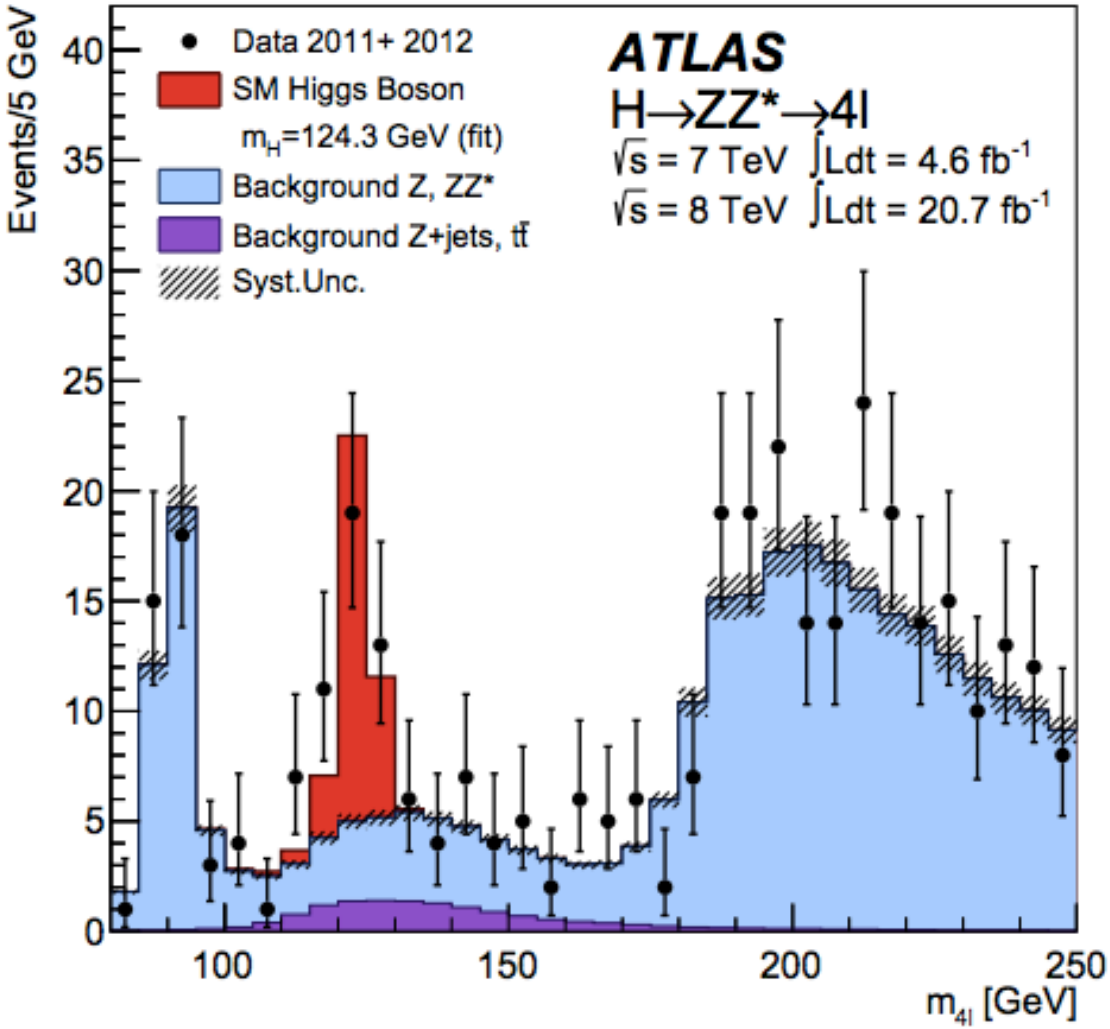


(a) Hypothèse $J^P = 0^+$



(b) Hypothèse $J^P = 2^+$

Higgs seen by ATLAS - summary



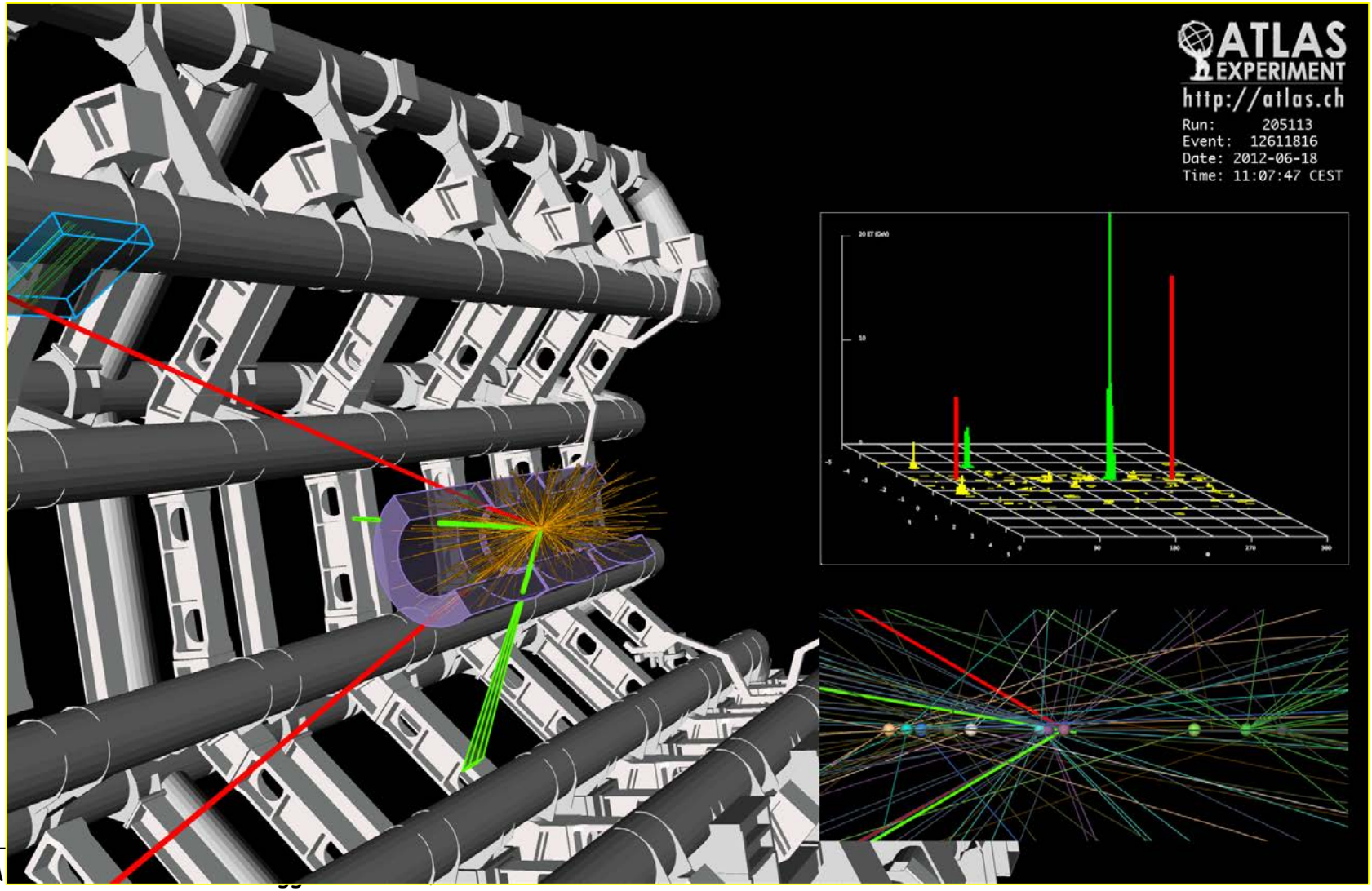
Multi-channel combined mass :

m_H = 125.5 ± 0.2 (stat.) ± 0.6 (syst.) GeV

Some event displays

2e2μ candidate with $m_{2e2\mu}$= 123.9 GeV

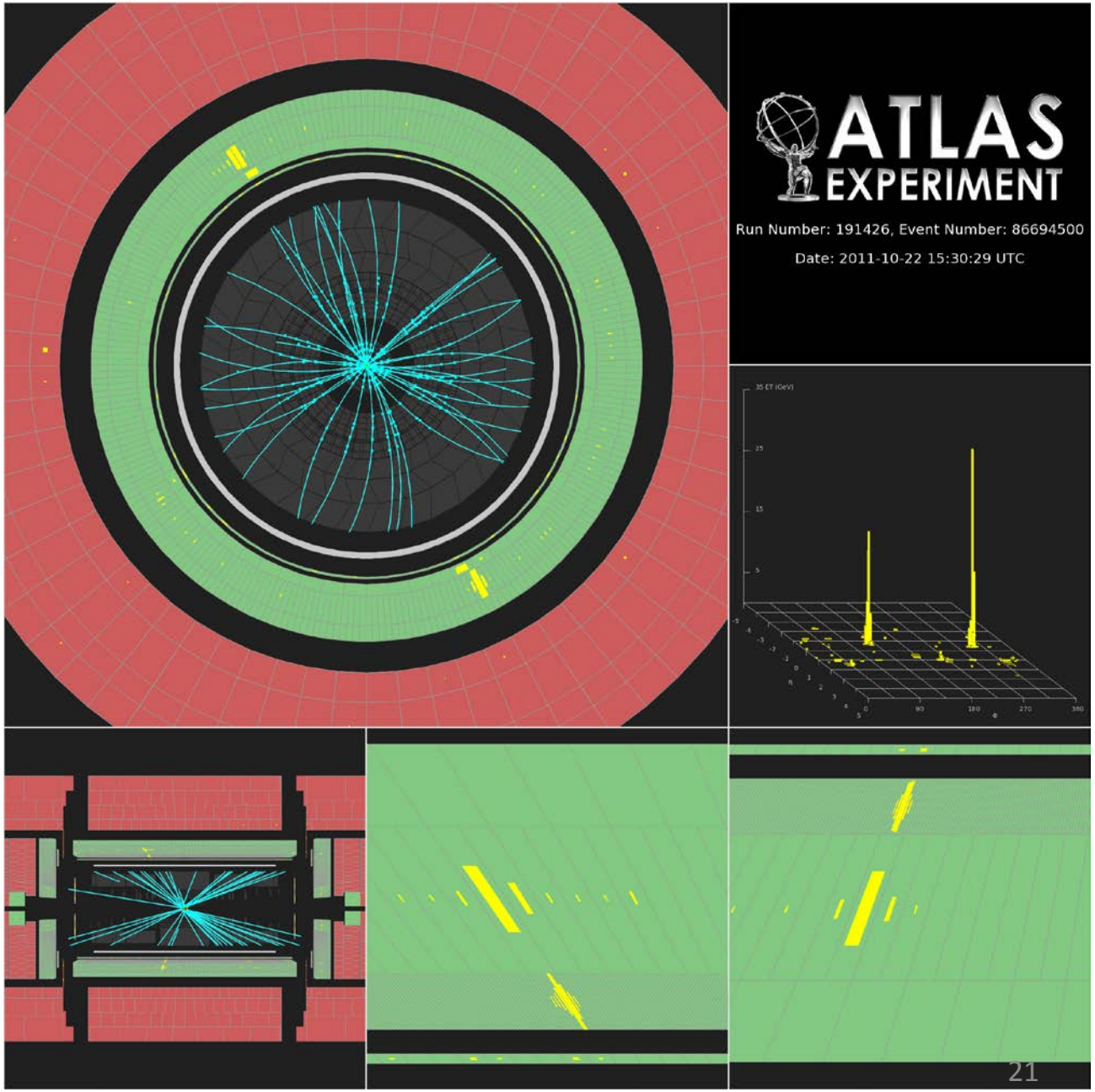
p_T (e,e,μ,μ)= 18.7, 76, 19.6, 7.9 GeV, m (e^+e^-)= 87.9 GeV, m($\mu^+\mu^-$) =19.6 GeV
12 reconstructed vertices



Some event displays

H -> γγ candidate

di-photon
reconstructed mass :
126.6 GeV



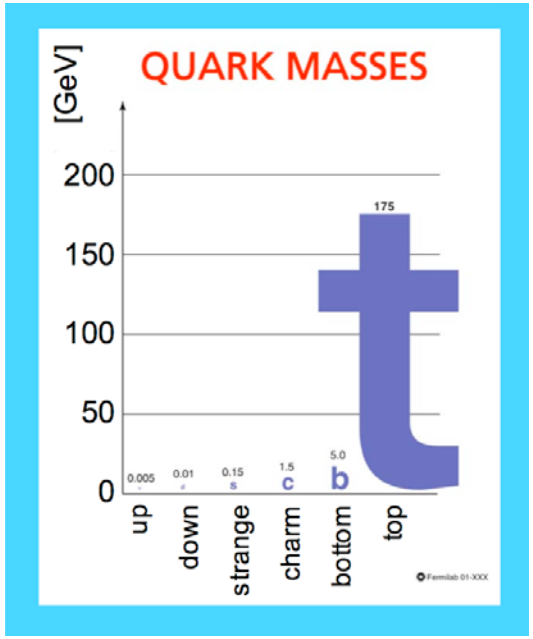
Higgs in ATLAS : what's next @ LPNHE ?

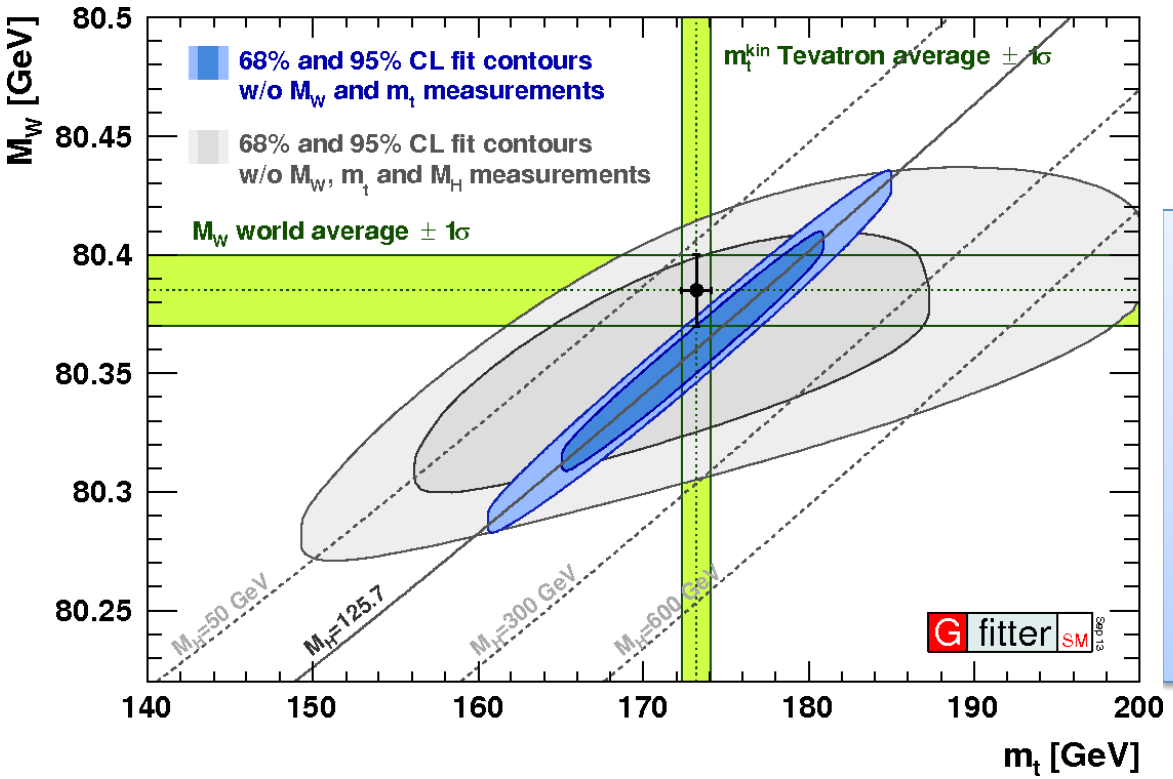
- Extended study channels :
  H->$\gamma\gamma$, H->Zγ, H->bb
- Continuation of spin studies
- Other Higgs candidates searches
- Towards precision measurements

Second field of study : top quark

Observed @ TeVatron in 1995

- Heaviest known elementary particle
- Extra short life time (4.10^{-25} s), it decays before hadronisation

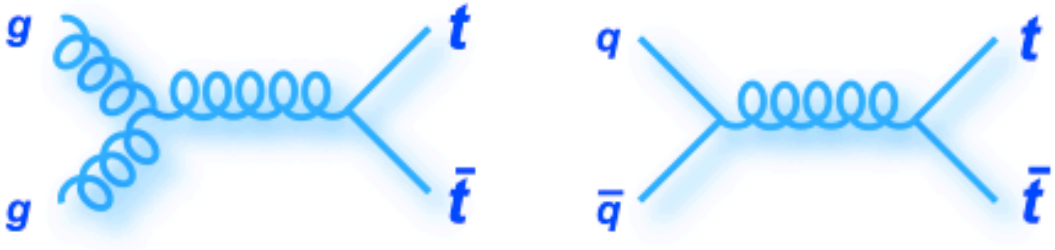




- Detector understanding, top event calibration
- Precision measurements of cross sections, standard Model coherence tests
- Mass measurement, new physics constraints

Top production @ LHC

- QCD production, mainly via gluon fusion
  - NLO (MCFM): σ = 158 pb
  - ~NNLO: σ = 163 pb

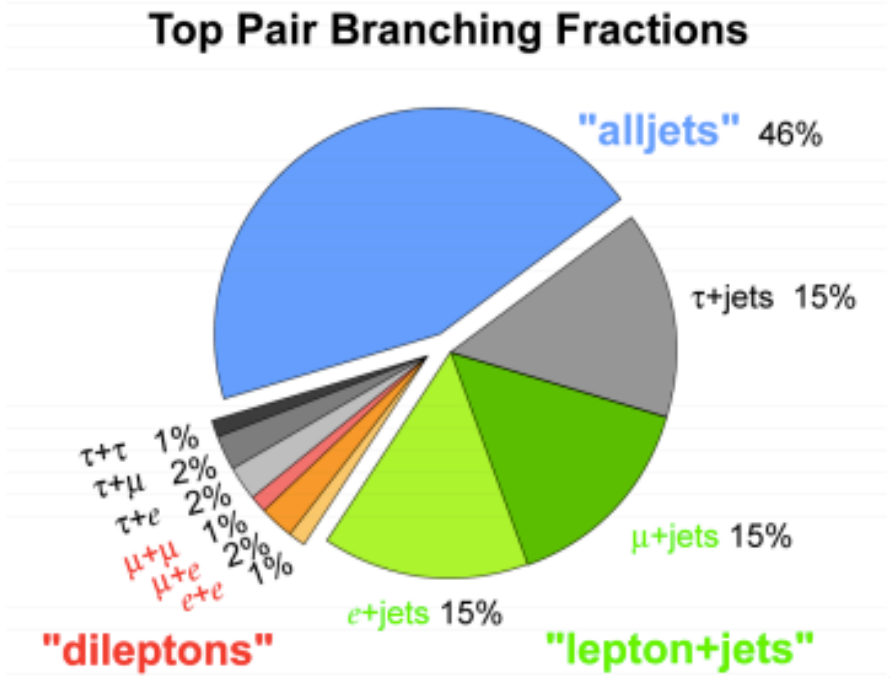


- Top quark decay is driven by the *W* decay (BR(t⟶Wb) ≈1)

Top Pair Decay Channels

W decay	e^+	μ^+	τ^+	$u\bar{d}$	$c\bar{s}$
e^-	$e\tau$	$e\mu$	$e\tau$	electron+jets	
μ^-	$e\mu$	$\mu\tau$	$\mu\tau$	muon+jets	
τ^-	$e\tau$	$\mu\tau$	$\tau\tau$	tau+jets	
$\bar{u}d$	electron+jets			all-hadronic	
$\bar{c}s$		muon+jets	tau+jets		

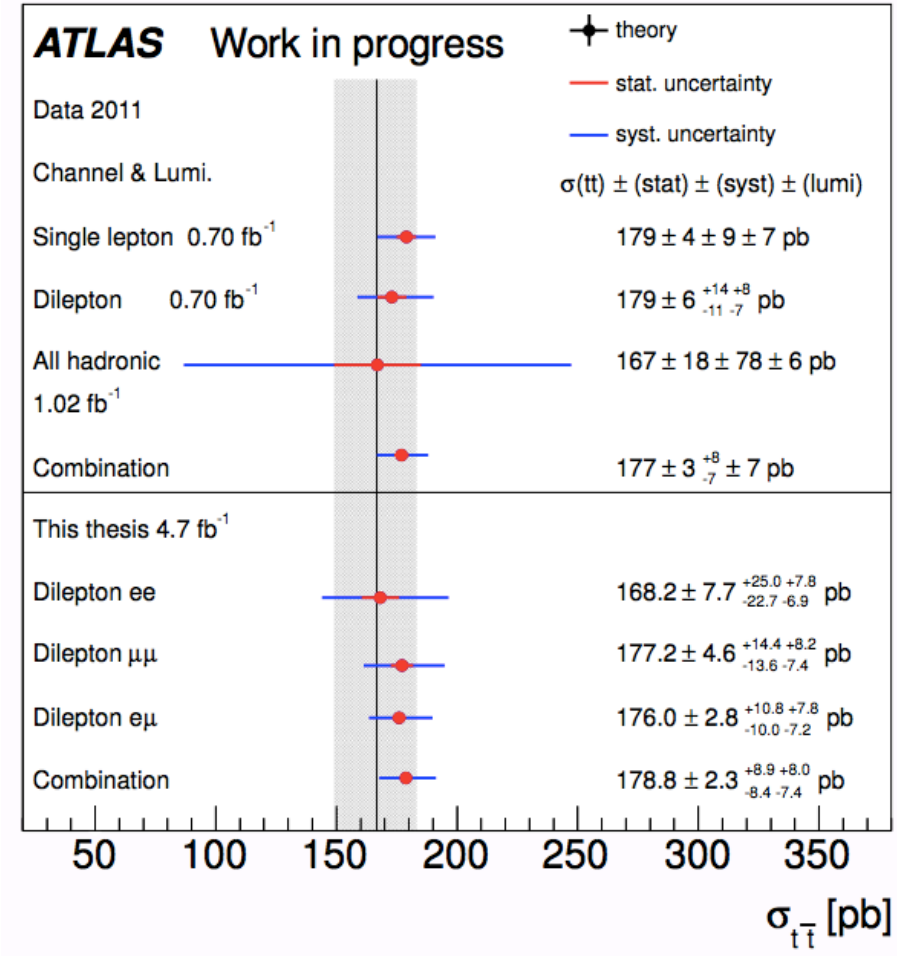
dileptons



Top cross section

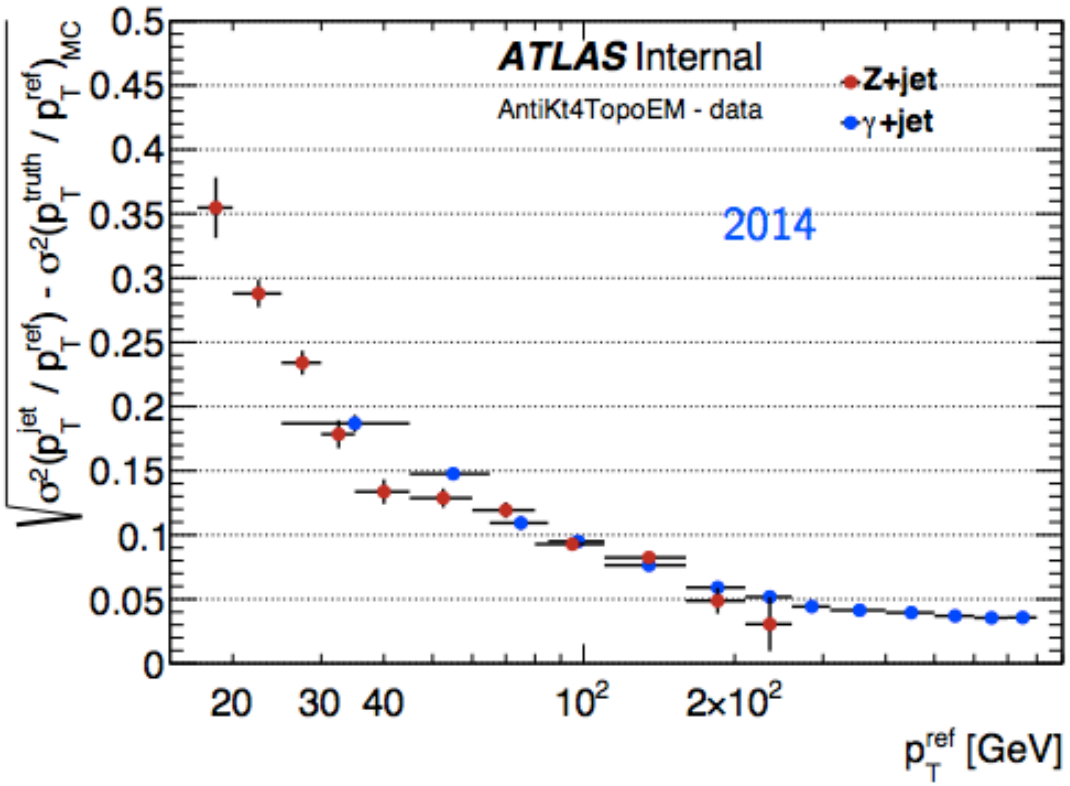
Dileptonic channel (ee, μμ, eμ)

- Real of "fake" objects efficiency estimations
- Standard Model Compatible Modèle
- Precision dominated by systematics and theory



Full hadronic channel :

- JES studies (main systematic)
- JER studies via Z-jets



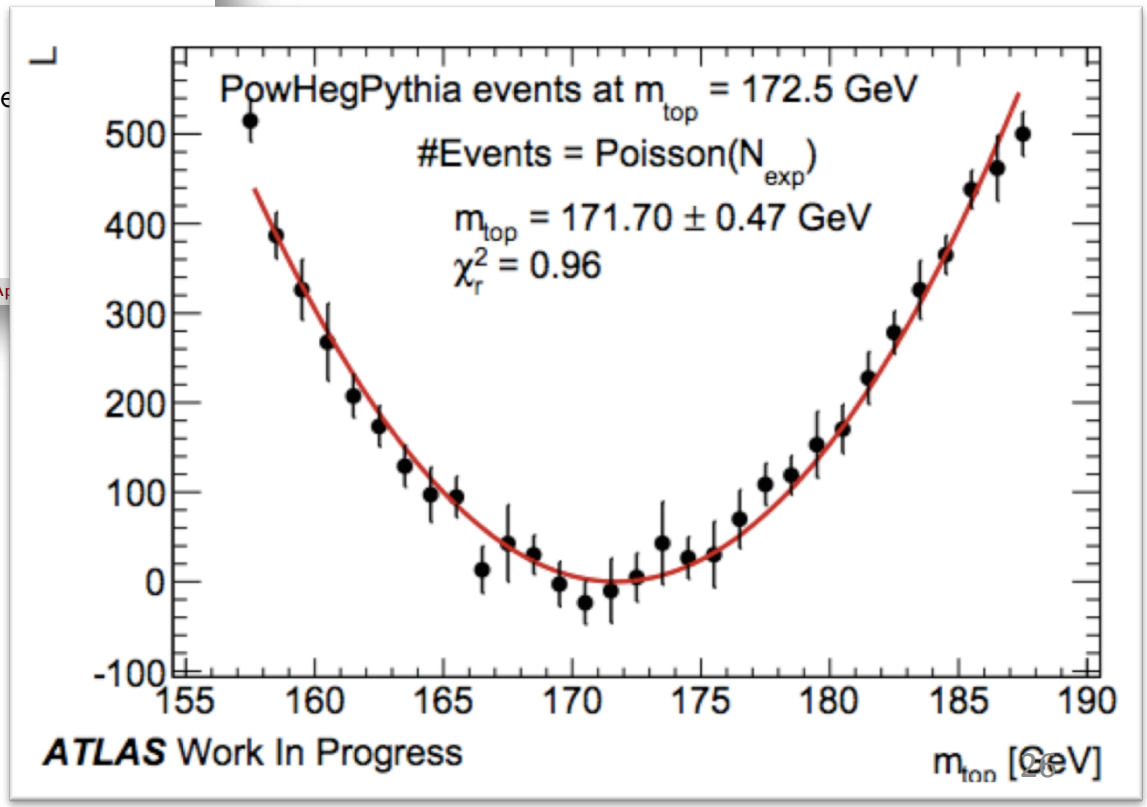
Top mass in dileptonic channel eμ

Matrix Element Method

Computing the differential cross section is the heart of the method:

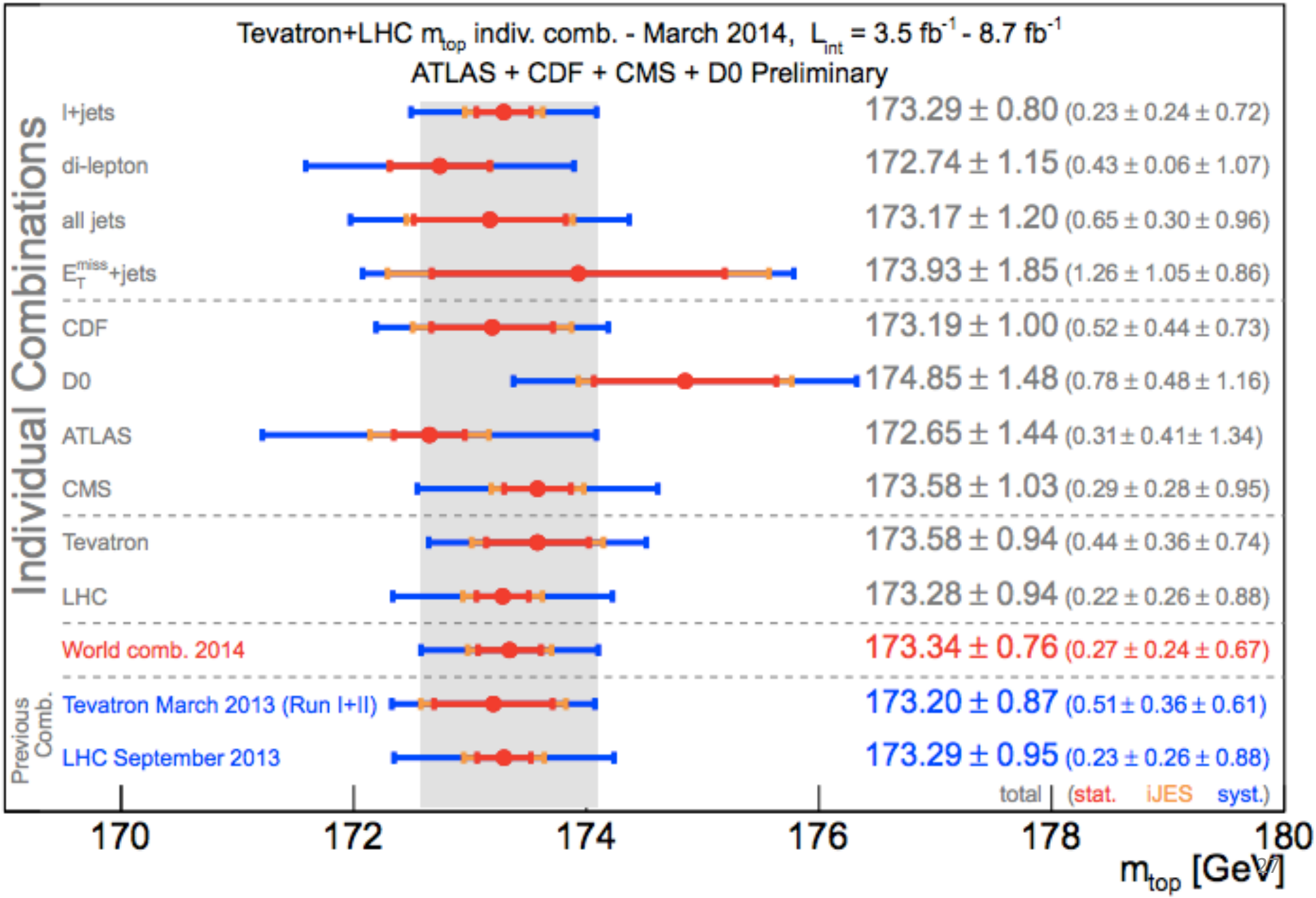
$$\frac{d\sigma}{dx}(m_{top} \mid P) \propto \int dg_1 dg_2 d\Phi |M_{t\bar{t}}(g_1, g_2, x, m_{top})|^2 f_{pdf}(g_1) f_{pdf}(g_2) W(x \mid P)$$

- $|M_{t\bar{t}}(g_1, g_2, x, m_{top})|$: matrix element for $g_1 g_2 \to t\bar{t} \to b\bar{b}e\mu\nu_e\nu_\mu$
- g_1 and g_2: incoming partons
- x: observables of the final state at the parton level
- $d\Phi$: phase space for the $pp \to t\bar{t} \to b\bar{b}e\mu\nu_e\nu_\mu$ process
- f_{pdf}: parton density function
- P: observables of the final state at the reconstructed leve
- $W(x \mid P)$: transfer function from P to x

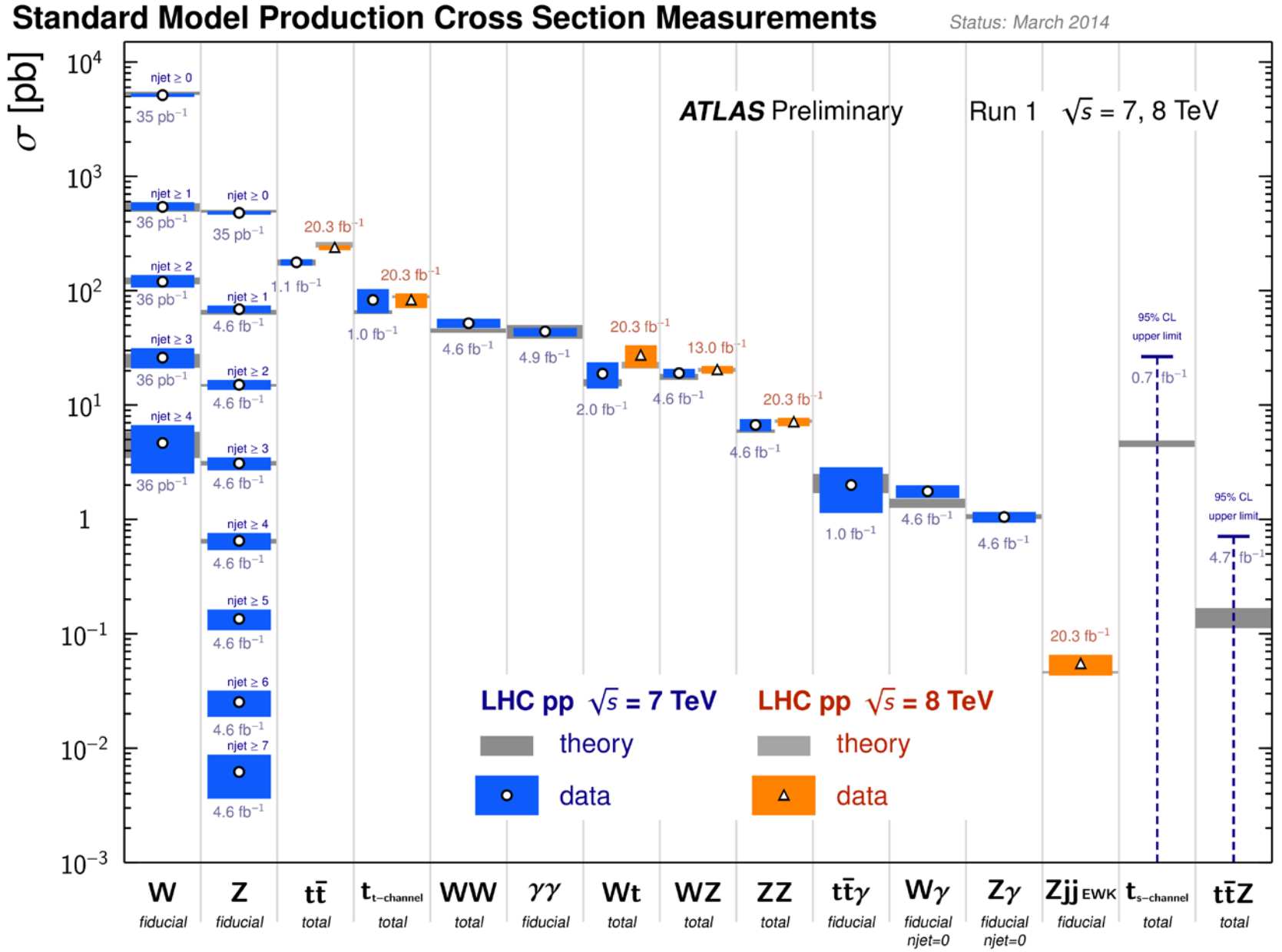


- Final point of the study @ 7 TeV
- Application to 8 TeV data

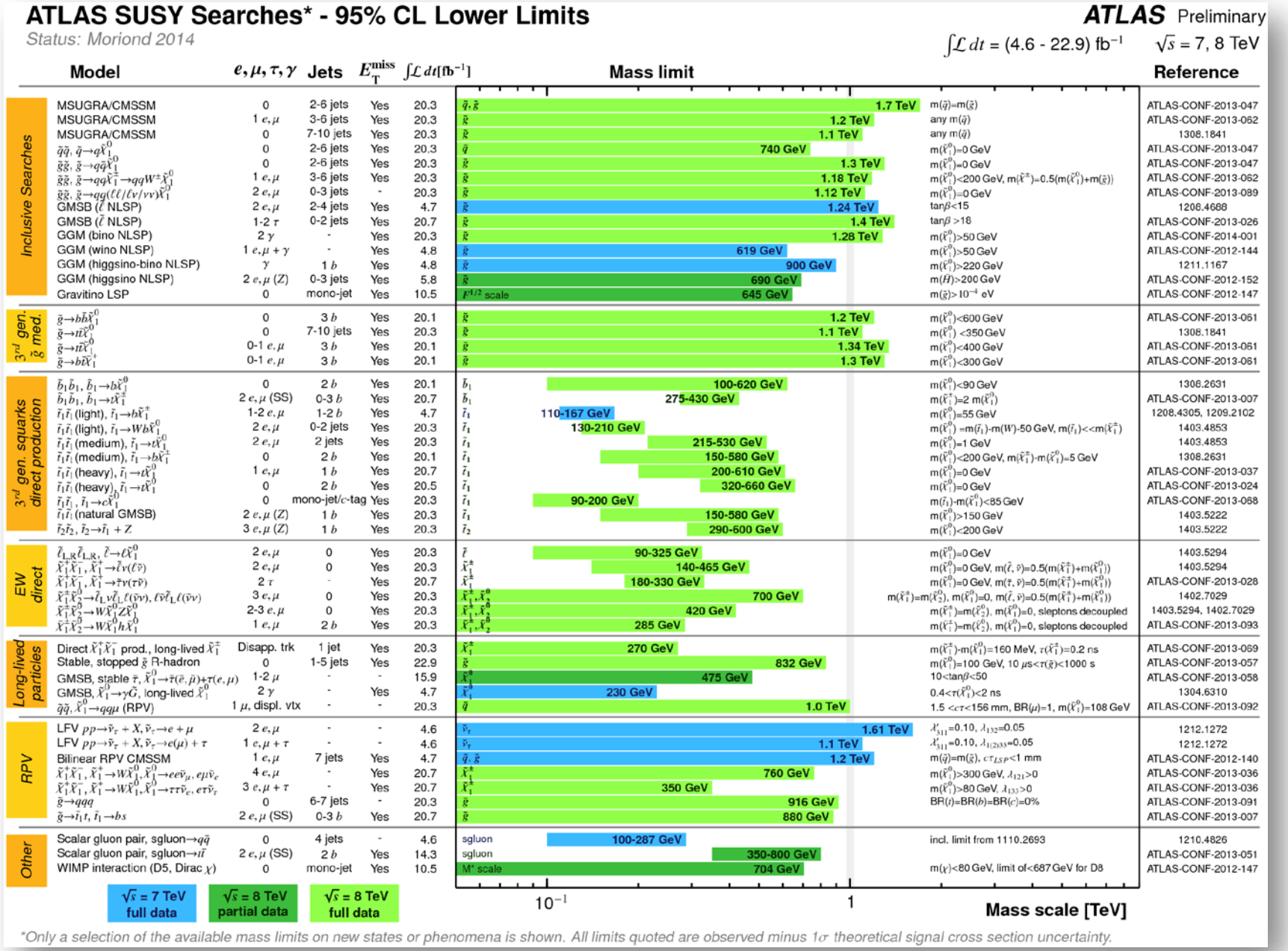
Top mass : combined public results



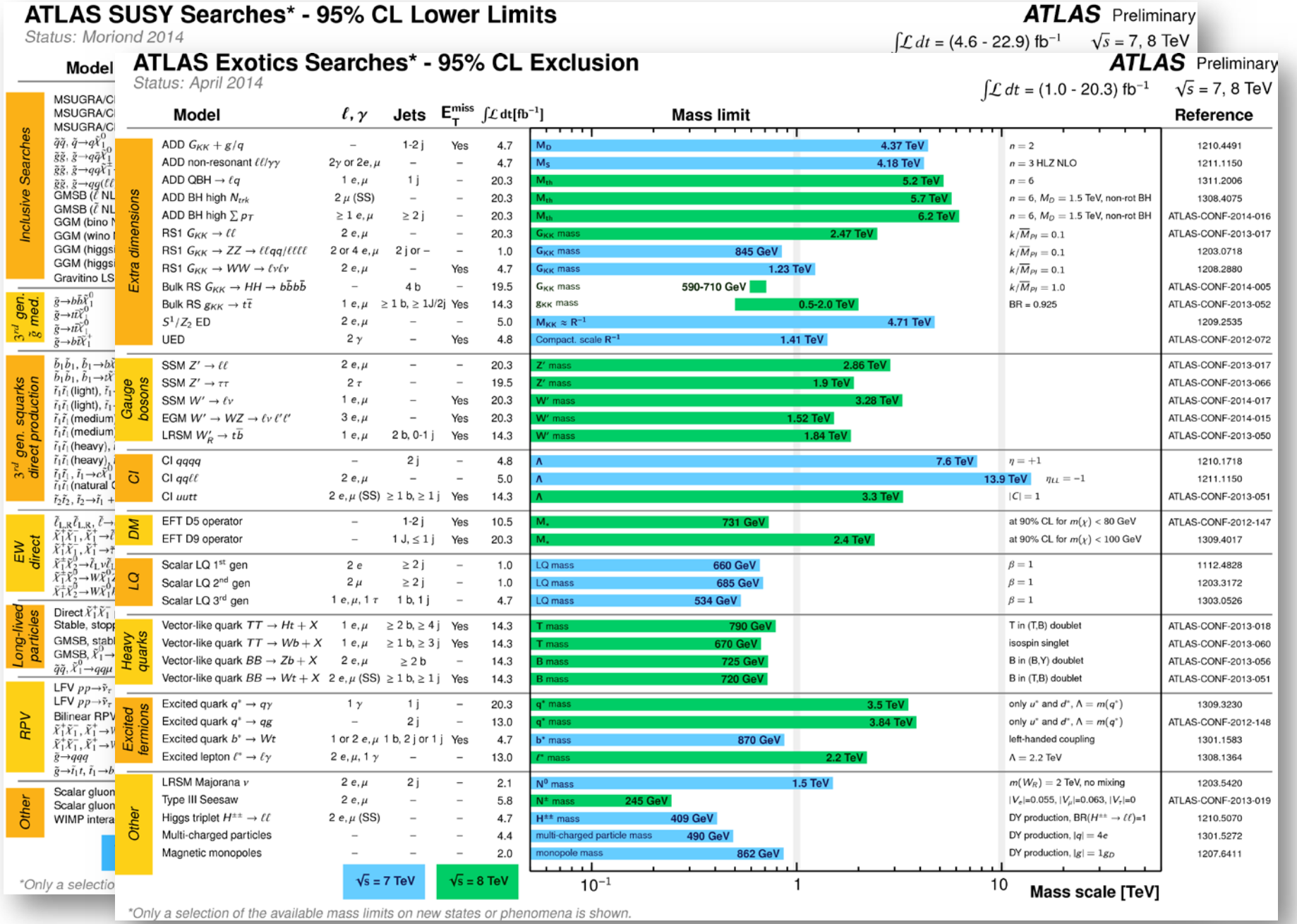
Beyond the top and the Higgs : the success of the Standard Model



Beyond the SM in ATLAS ?



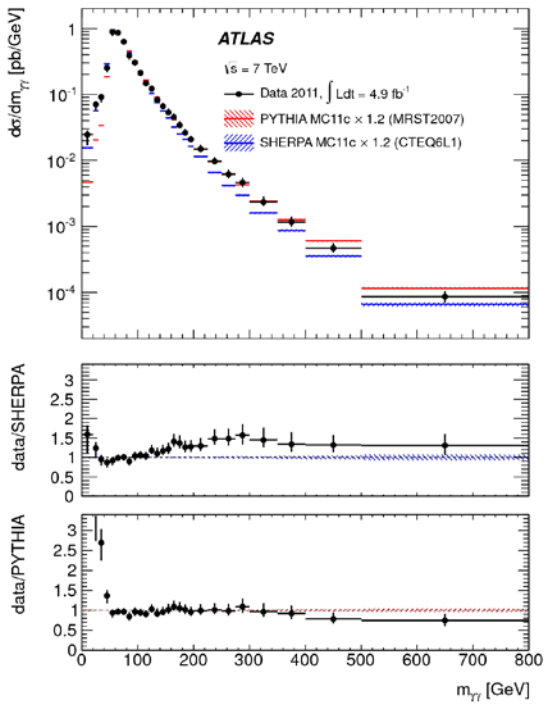
Beyond the SM in ATLAS ?



Performance tasks and detector studies

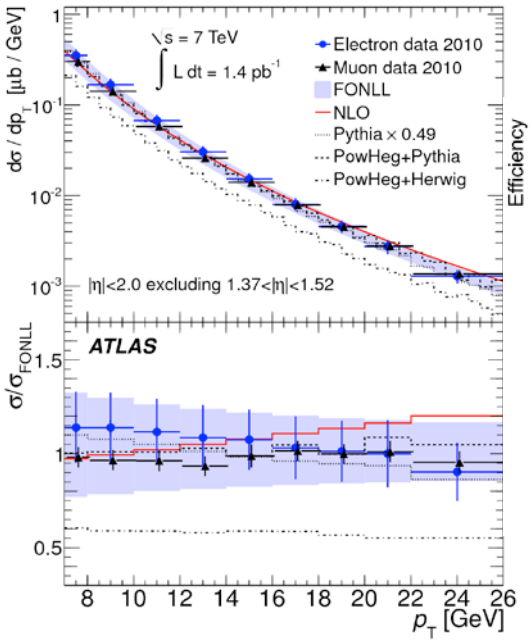
Physics at LHC: ATLAS photons and electrons studies

Comparison of diphoton Production spectra in data and simulation



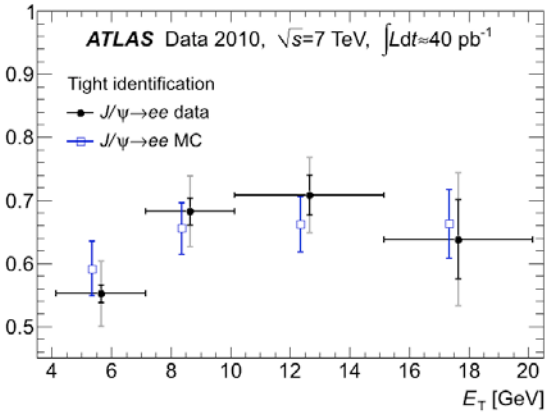
Invariant mass of the diphoton system : main discriminating variable for Higgs search

Differential cross section measurement of the leptons from heavy flavour decay



For electrons and muons as a function of the P_t leptons ratio of measured cross sections over predicted values

Measurement and simulation of identification efficiency of the electrons from the J/Psi ->ee events



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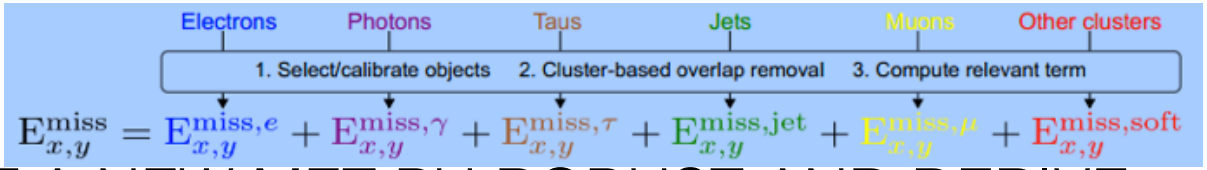
Performance tasks and detector studies

Performances : MET

Widely used in ATLAS, in standard model measurement, and particularly interesting in new physics (SUSY, Dark Matter,…) searches

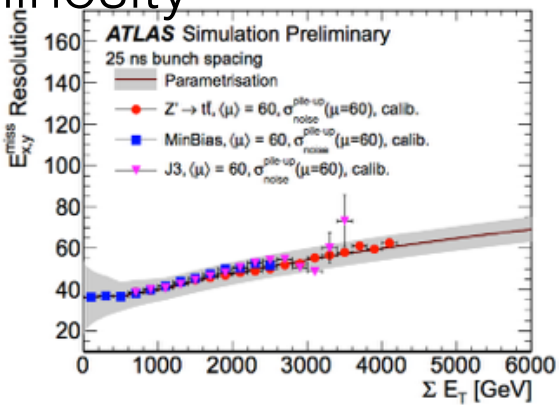
naive definition: measurement of what is missing in the transverse plane to balance the event

more accurate description:
keep correlations with all the other objects in the event



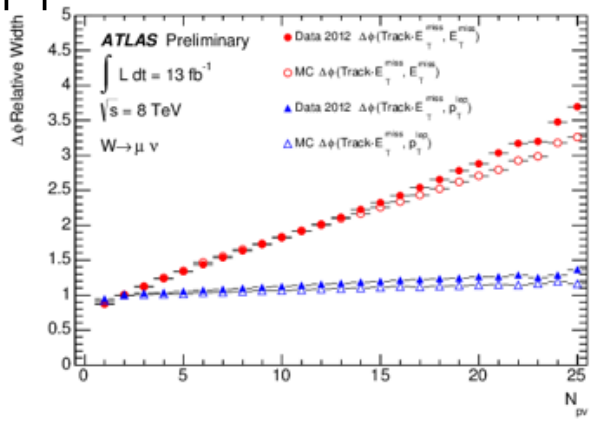
WORKING TO GET A NEW MET PU ROBUST AND DERIVE SYSTATICS

High luminosity



First simulation to get the prospective for MET performance already done.
Optimisation ongoing

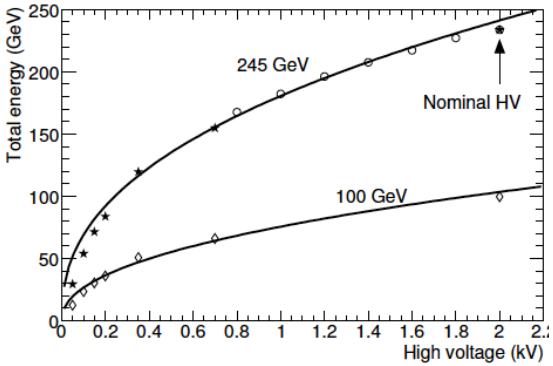
PU suppression



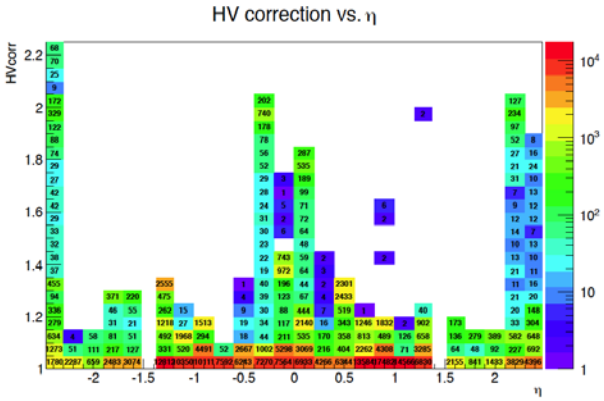
Use of the tracks reduce the dependence on Npv (pileup).

Performance tasks and detector studies

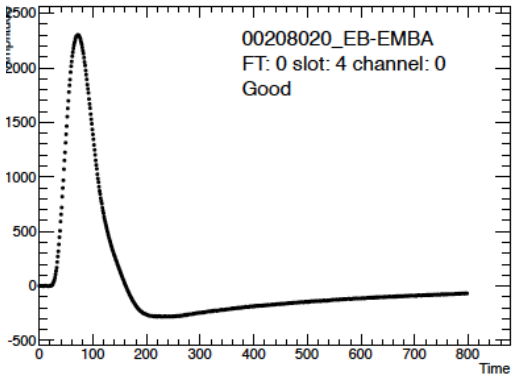
ATLAS Electromagnetic calorimeter studies

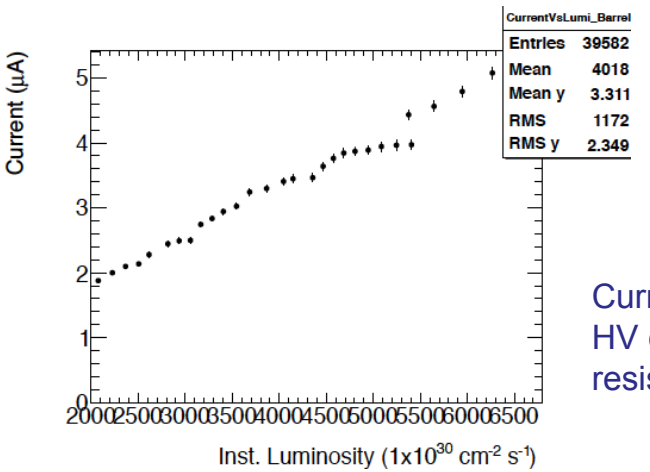


Total measured energy as a function of the high voltage



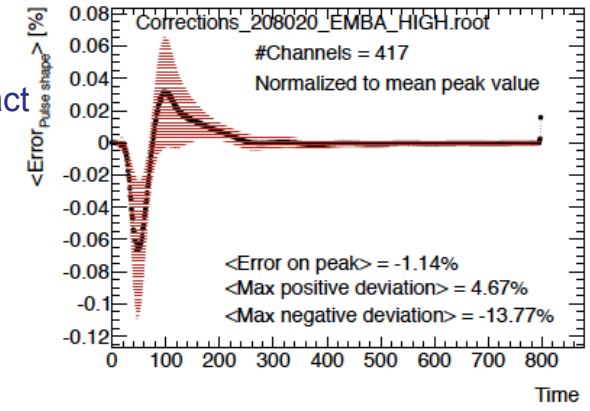
HV correction versus eta and impact on the constant term of the resolution





Current versus luminosity
HV corrections – sensitivity to resistances

Patching procedure impact on the calibration

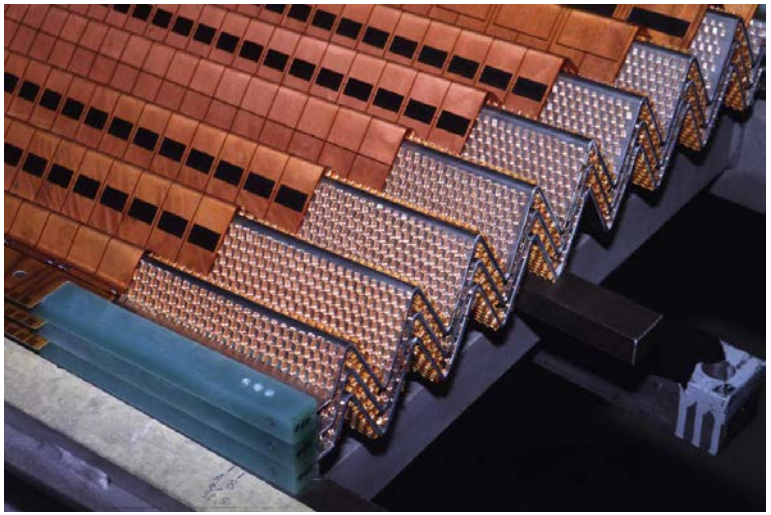


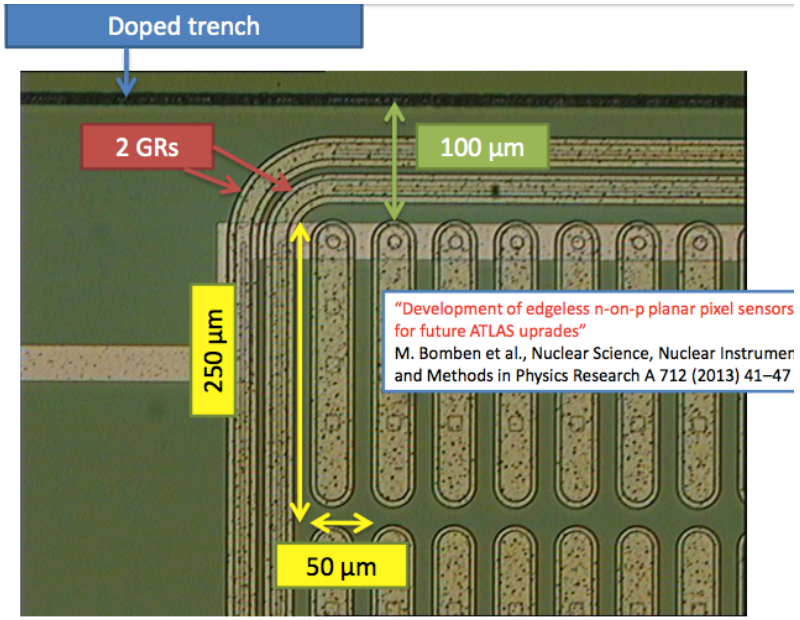
Qualification tasks

- **Aurélien** : Lar channel patching study
- **Camila** : study of impact pf electrode resistors on HV in the calorimeter
- **Carlo :** FTK TDAQ pattern bank for 2015 data taking and performance studies.
- **Guillaume** : EM calorimeter performance, impact of HV corrections on energy resolution
- **Heberth** : Development and optimization of software tools to access calorimeter L1 trigger tower info at L2, documentation of HLT calo monitoring. Develoment of software tool to propagate energy calibration from L1TT to L2TT
- **Kun** : photon medium trigger for 2012 data taking (8 TeV) and measure of the trigger efficiency, mainly used for H->gammagamma analysis.
- **Liwen** : Parametrisation of automatic data checks algo for the whole Calorimeter Trigger HLT.
- **Sylvestre :** B-tagging performances with IBL, simulation for e-gamma
- **Timothée :** calorimeter high voltage studies
- **Yee** : optimisation of converted photon reconstructions with the EM calorimeter for the run2

ATLAS R&D at LPNHE

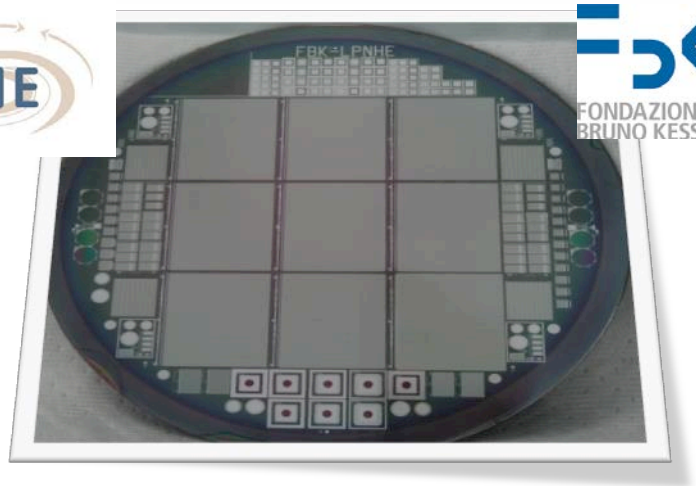
- The LPNHE was largely involved in the Liquid Argon calorimeter building and implementation
- Thermal studies
  - Slaves
  - Silicon buried micro-channels based cooling
- Mechanical studies for the Inserted B-Layer (IBL), which has been inserted last weeks in ATLAS
- Switch to the updates for High Luminosity phasis (internal pixel detector)
  - Edgeless sensors
  - TCAD studies
  - Radiation hardness studies
  - Beam tests

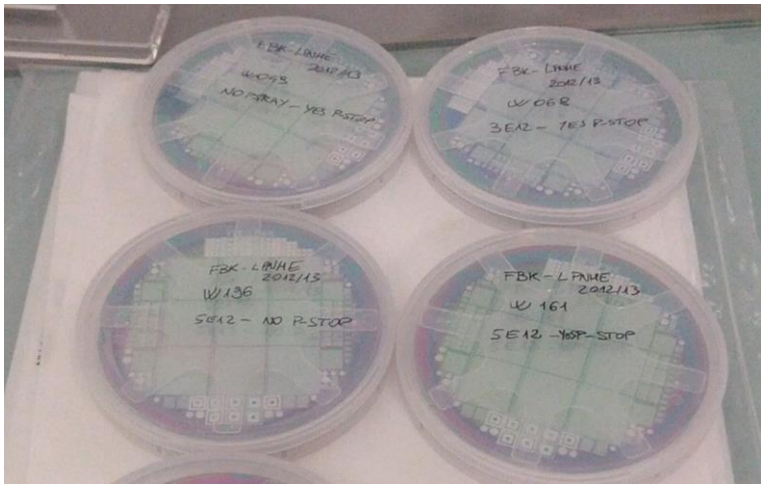




Edgeless pixels @ LPNHE

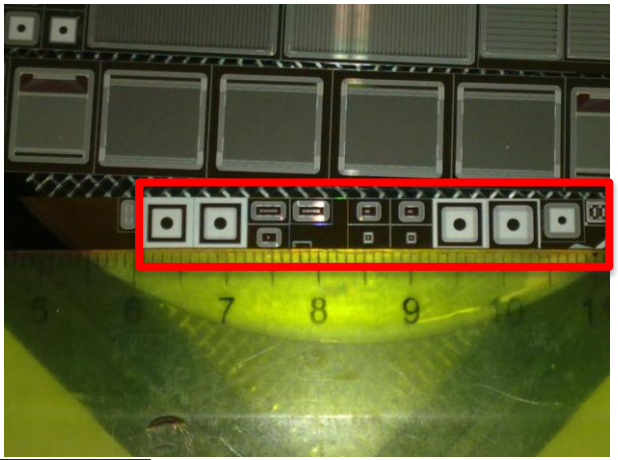
- Joint **FBK-LPNHE** project
  - ➢ Goal: thin, **edgeless** pixel sensors
  - ➢ Target: **intermediate layers**
  - ➢ How: make the **border** a **damage free ohmic contact by DRIE**
- **200 µm thick n-on-p** production
  - 500 µm temporary support wafer
- **Pixel-to-trench distance as low as 100 µm**

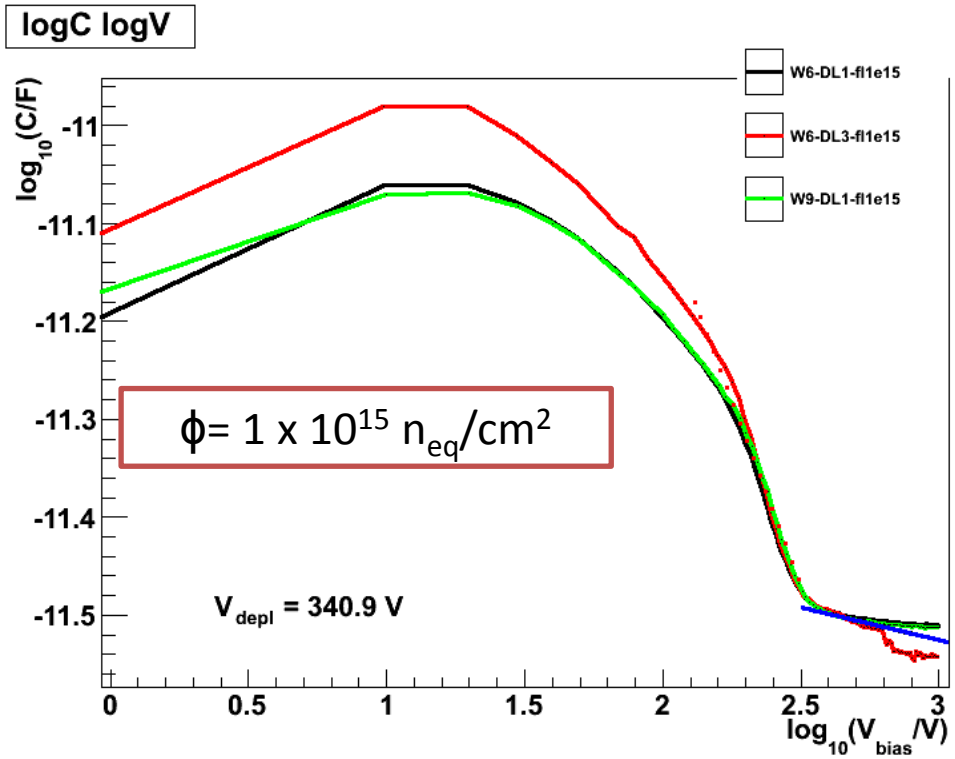


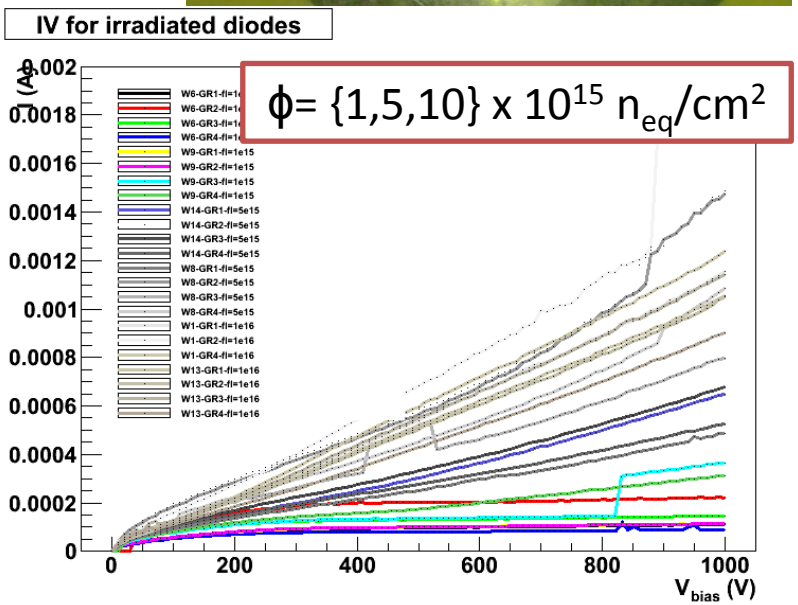


Radiation damage studies

- N-on-p diodes irradiated at CERN with 24 GeV/c protons
- Used to extract information about depletion voltage, current density, etc







Thanks for your attention