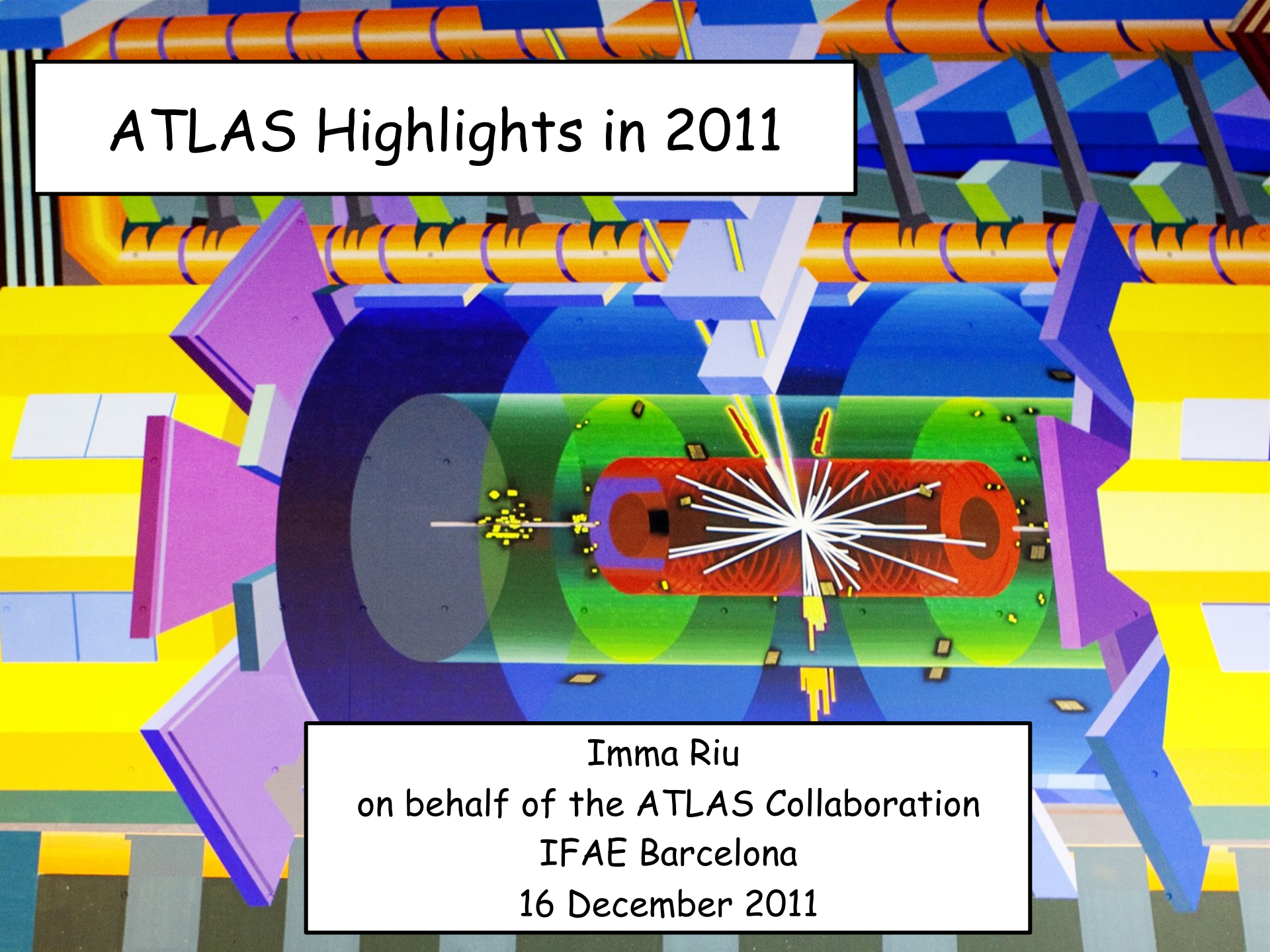
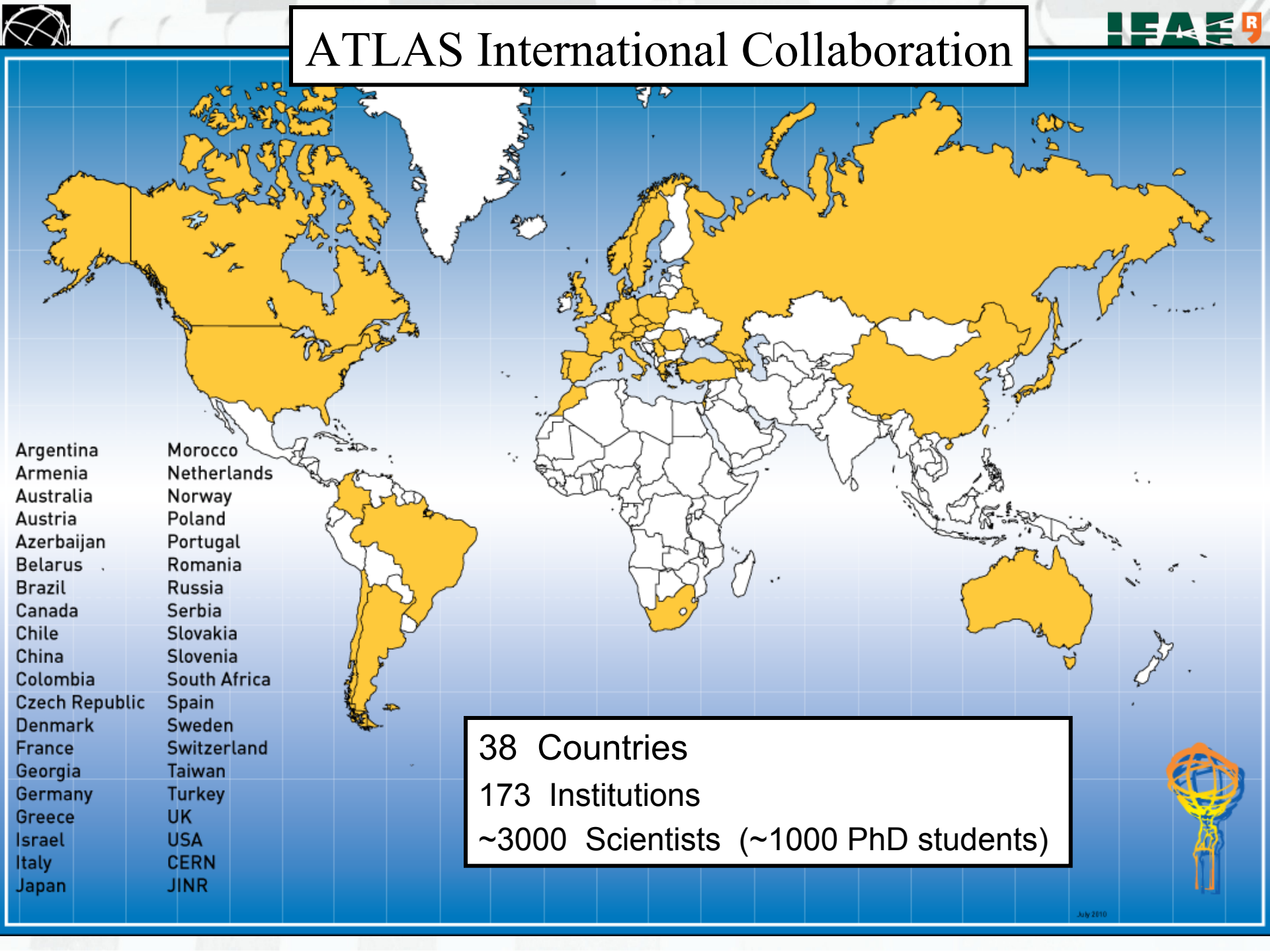
ATLAS Highlights in 2011



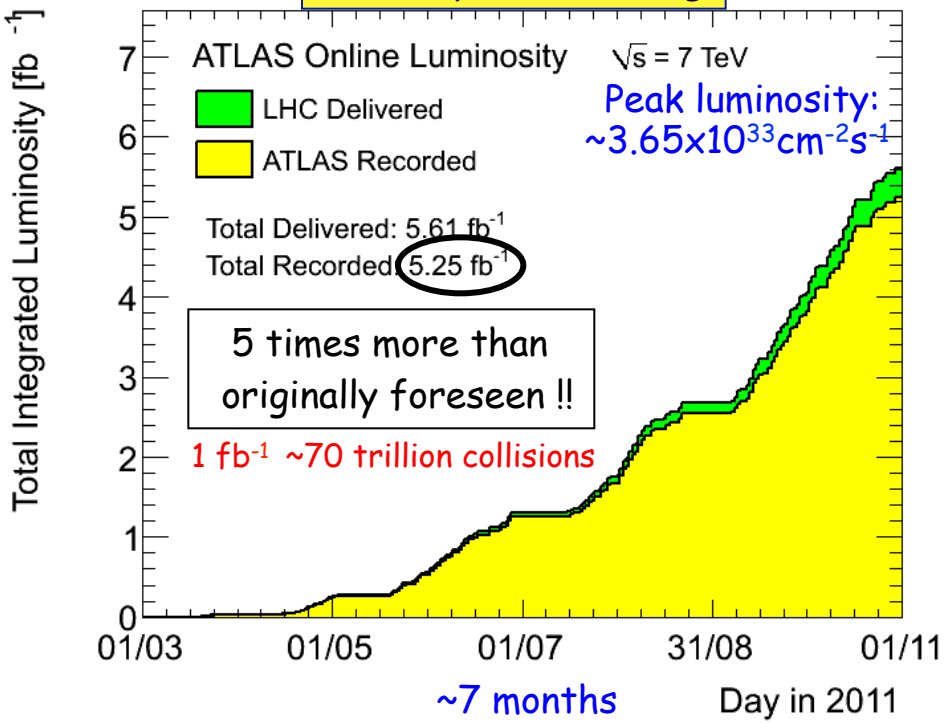
Imma Riu
on behalf of the ATLAS Collaboration
IFAE Barcelona
16 December 2011

ATLAS International Collaboration

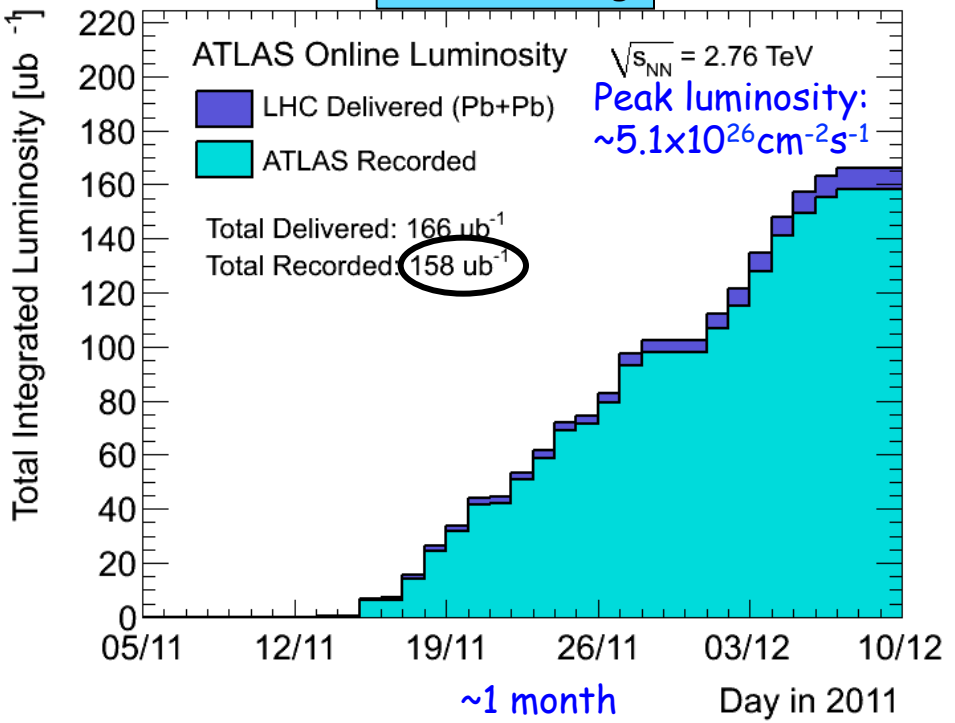


ATLAS collected data in 2011

Proton-proton running



Pb-Pb running



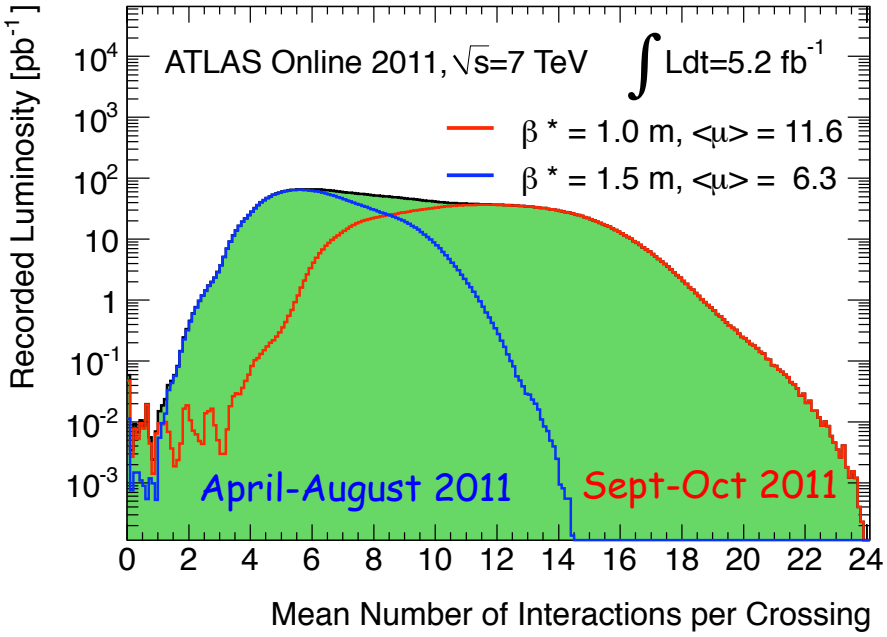
- **≥100 times more** proton-proton collisions:
  - 45 pb^{-1} in 2010
  - 5250 pb^{-1} in 2011
- Excellent recording efficiency: **~94%**

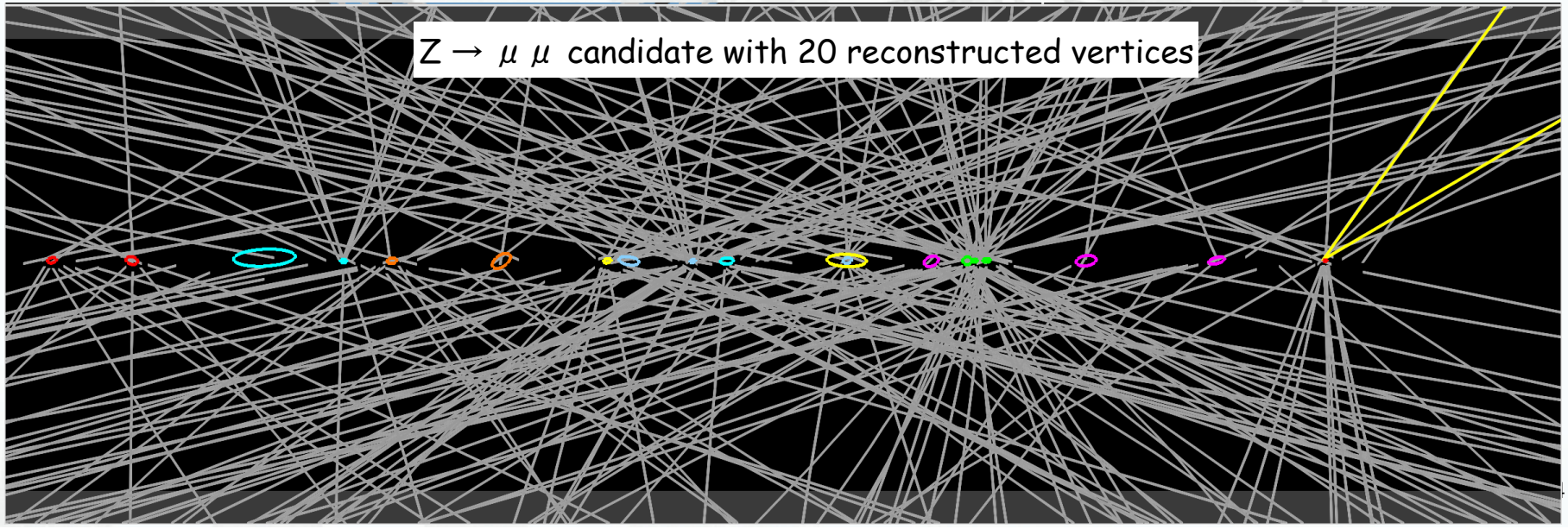
- **17 times more** Pb-Pb collisions:
  - 9 μb^{-1} in 2010
  - 158 μb^{-1} in 2011
- Excellent recording efficiency: **95%**

~90-96% of good quality data for physics analysis

The challenge of pile-up

- Pile-up:
  - Number of simultaneous interactions per crossing
  - Challenges the selection, computing resources and reconstruction of physics objects
- Result in 2011:
  - Observed events with as many as 23 simultaneous interactions:
    - Larger than expected at this early stage





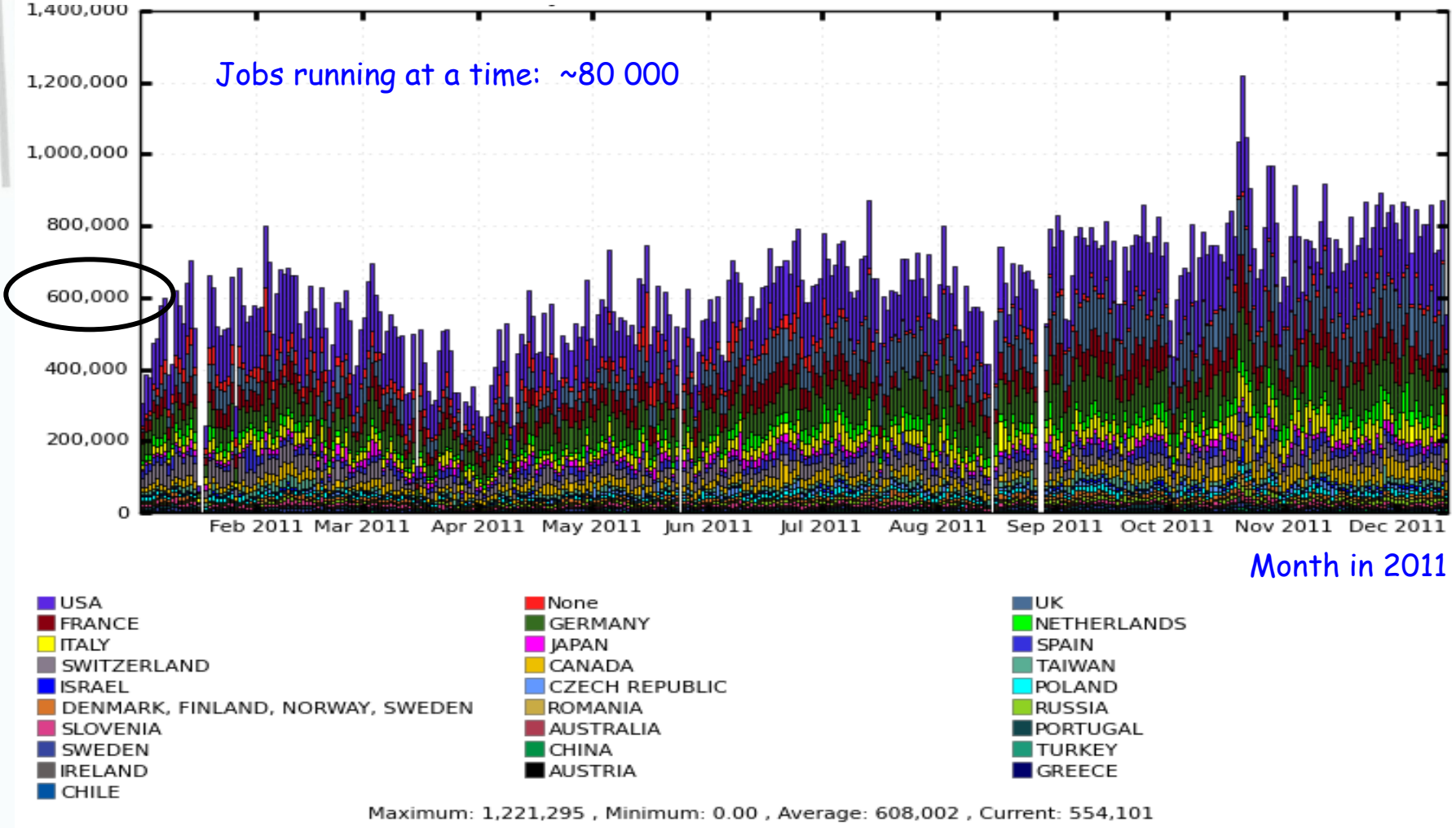
ATLAS physics

- Reminder:
  - ATLAS is a general-purpose experiment

- Main Physics goals:
  - Comprehensive measurement of known physics processes:
    - Lays the foundation for searches
  - Investigation of the origin of mass of particles:
    - Existence of the Higgs boson?
    - Any other mechanism?
  - Investigation of the origin of Dark matter:
    - ~25% of the universe consists of dark matter
    - Origin of this matter? Super Symmetry (SUSY)?
  - Look for new physics at a TeV scale:
    - Existence of extra-dimensions? New forces?
    - New unexpected physics?

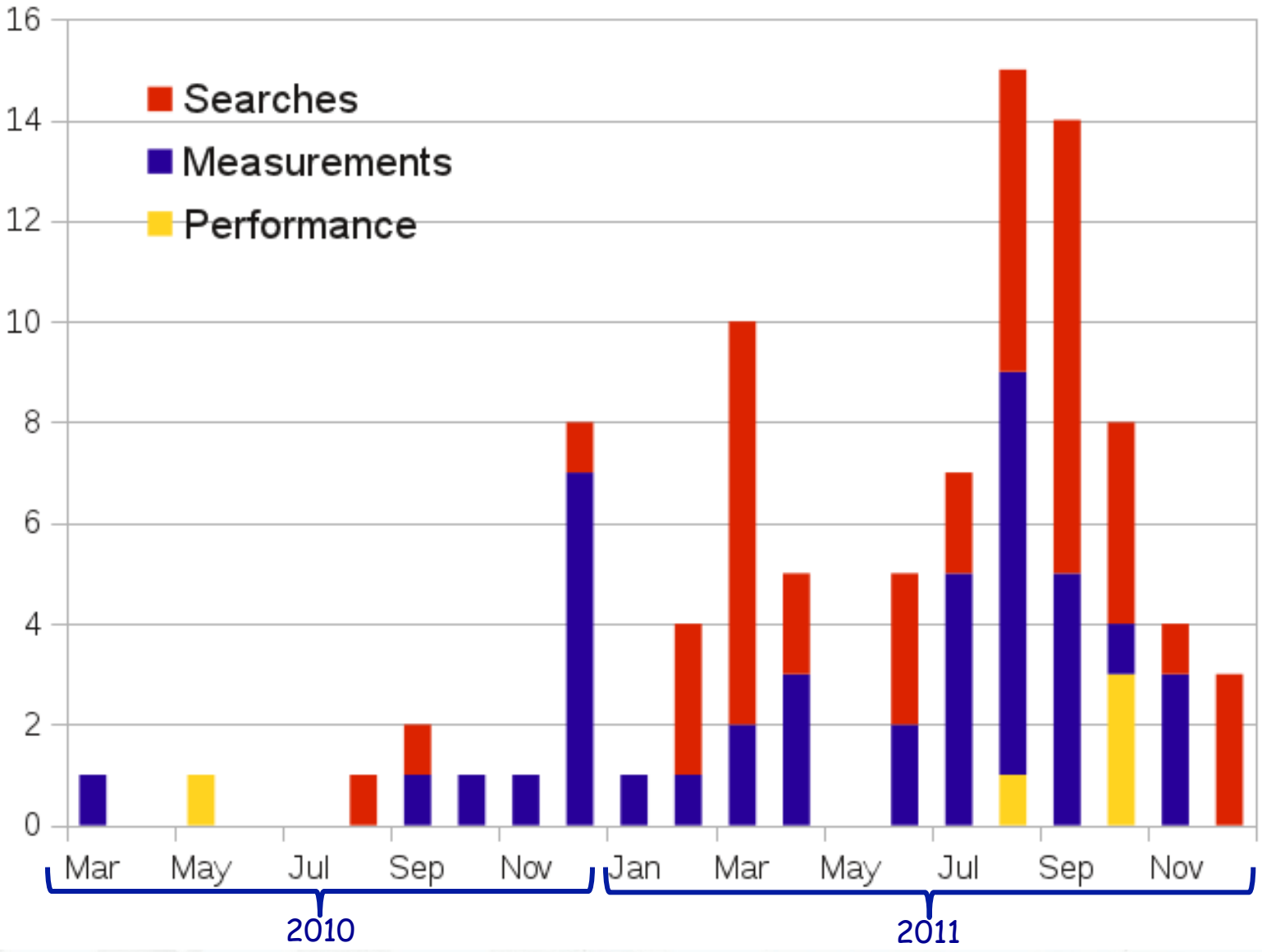
Operating computing resources

Simulation production, event reconstruction and physics analysis jobs per day in the Grid



Truly international collaborative effort in computing resources to perform physics analysis. The Worldwide LHC Computing Grid is instrumental to deliver fast physics results.

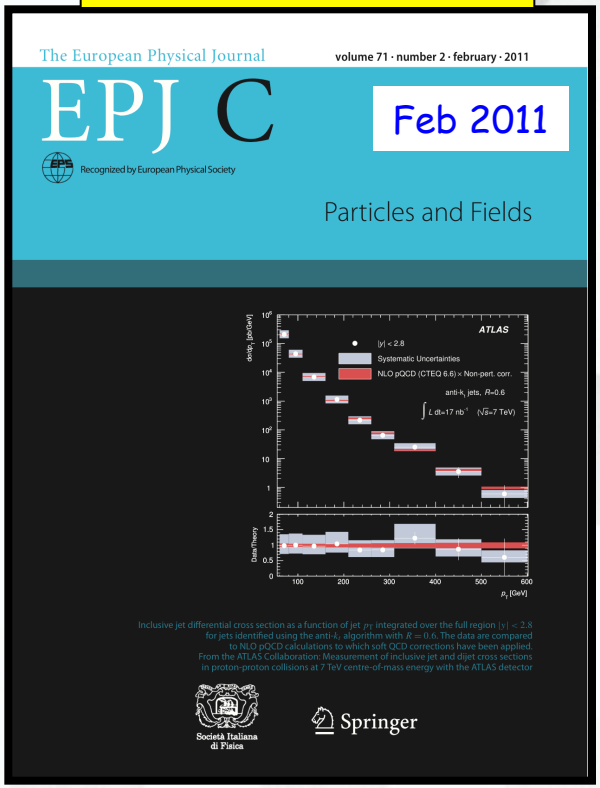
ATLAS publications



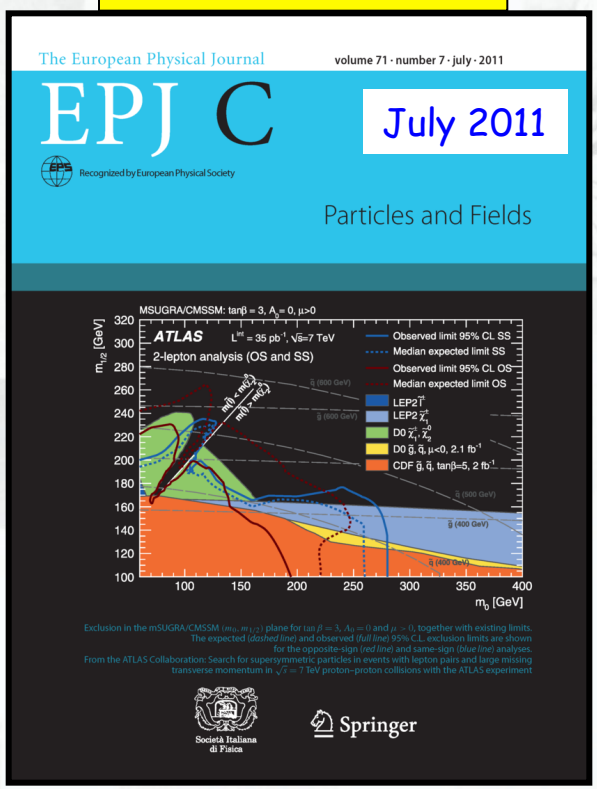
ATLAS publications

- ATLAS papers submitted for publication:
  - In 2010: 16 papers
  - In 2011: 75 papers until today
- Conference notes:
  - 265 since the start of data taking (~50 to summer conferences)

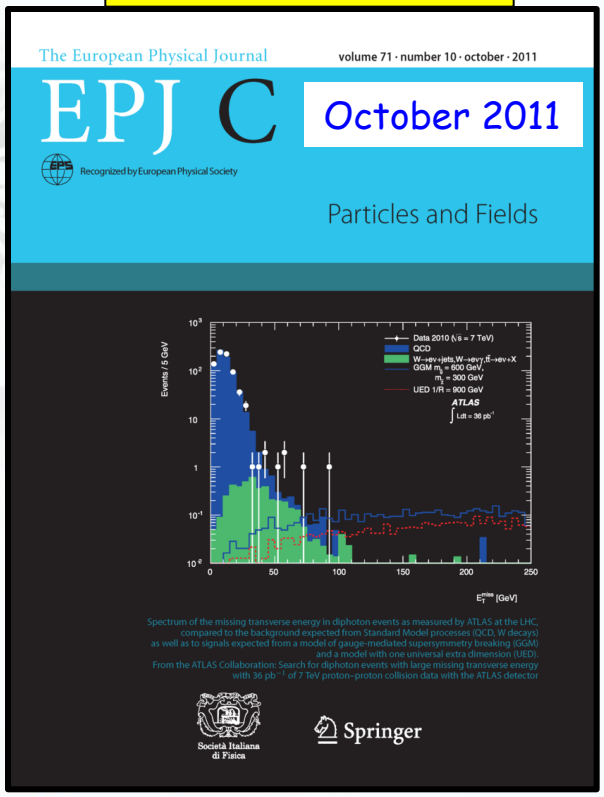
Jet cross-section measurement



SUSY searches in the 2l channel

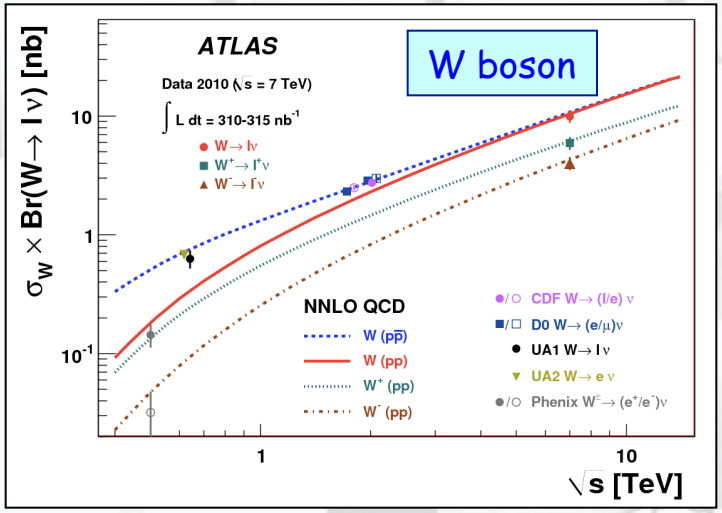


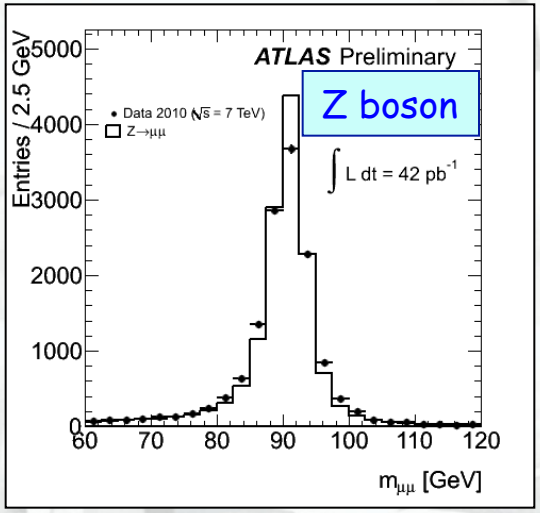
Search for di-photon events

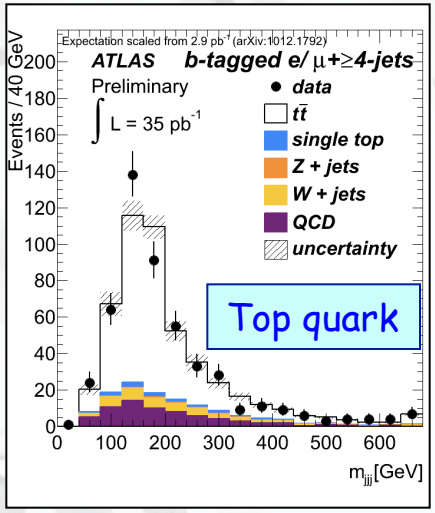


Reminder – ATLAS results in 2010 –

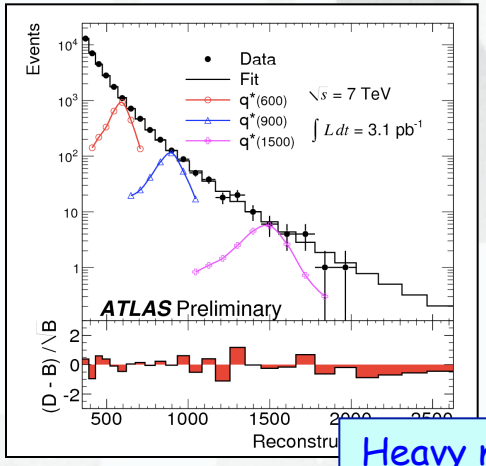
Re-establish the signals from the already known particles of the Standard Model

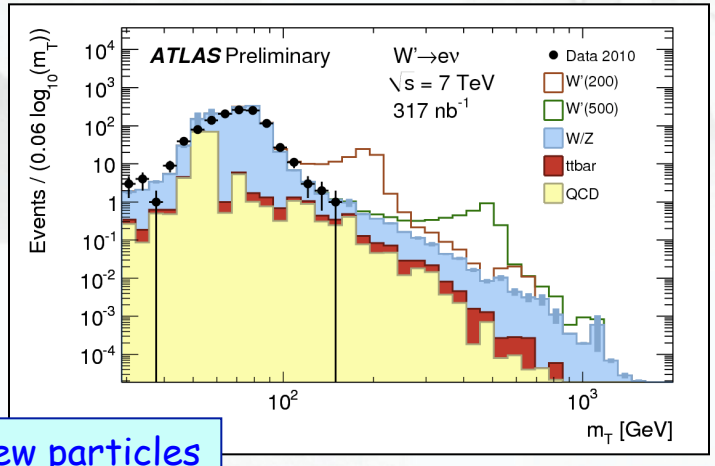




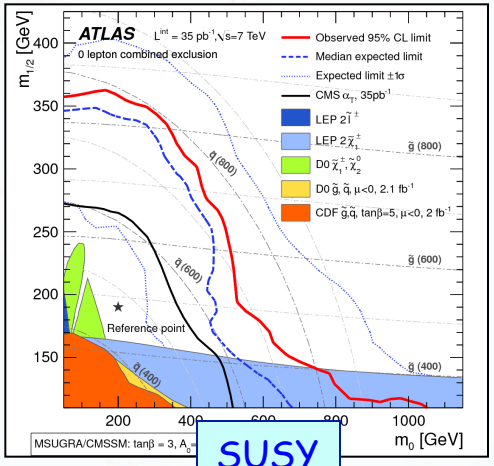


New physics searches at the reach of statistics





Heavy new particles



SUSY

Standard Model cross-section measurements in 2011

Production cross-sections of physics processes background to searches

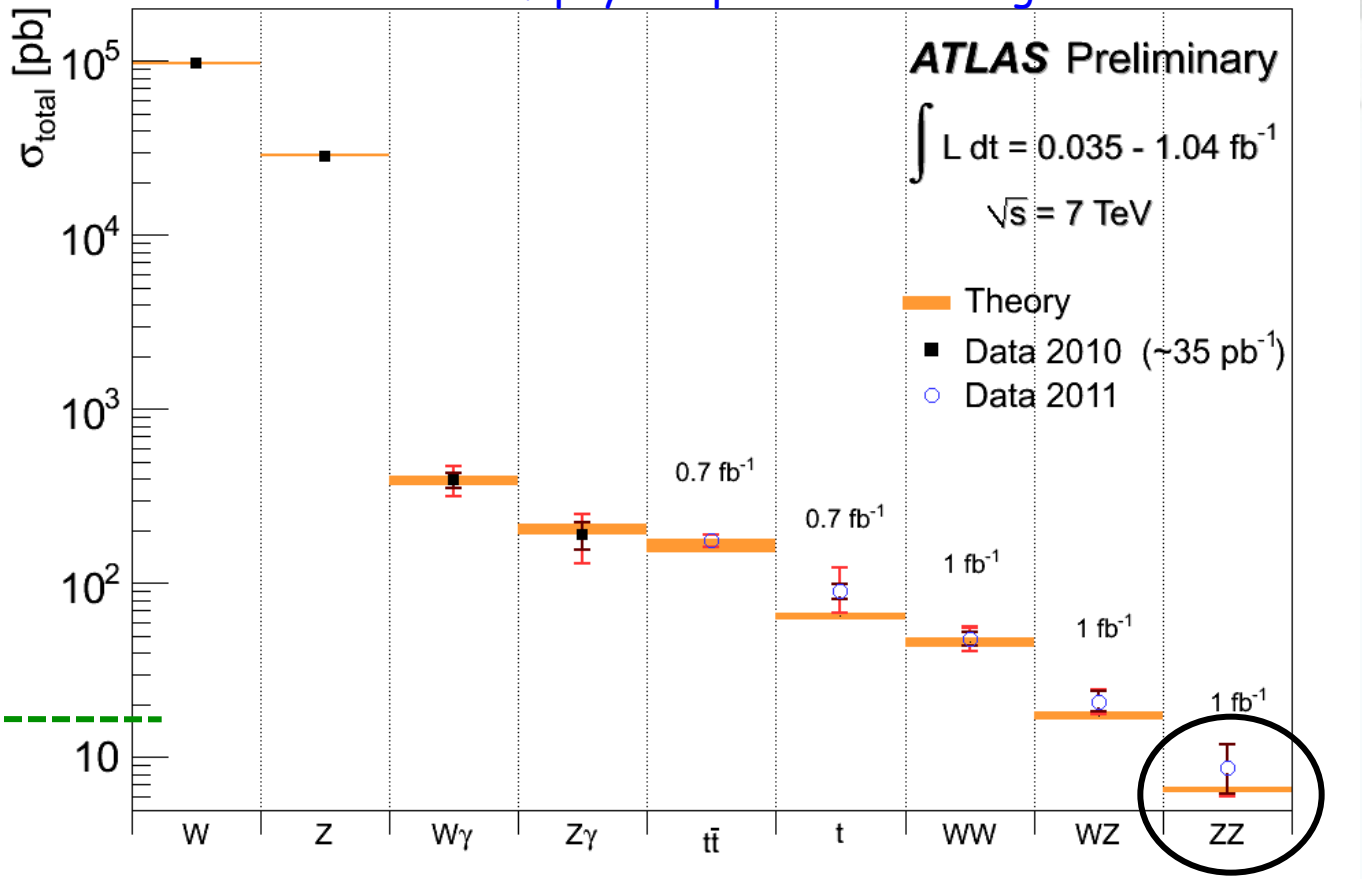
Events after selection cuts

~30M $W \rightarrow \mu\nu, e\nu$

~3M $Z \rightarrow \mu\mu, ee$

~60k top-pairs

$\sigma(pp \rightarrow H)$ m_H=130 GeV

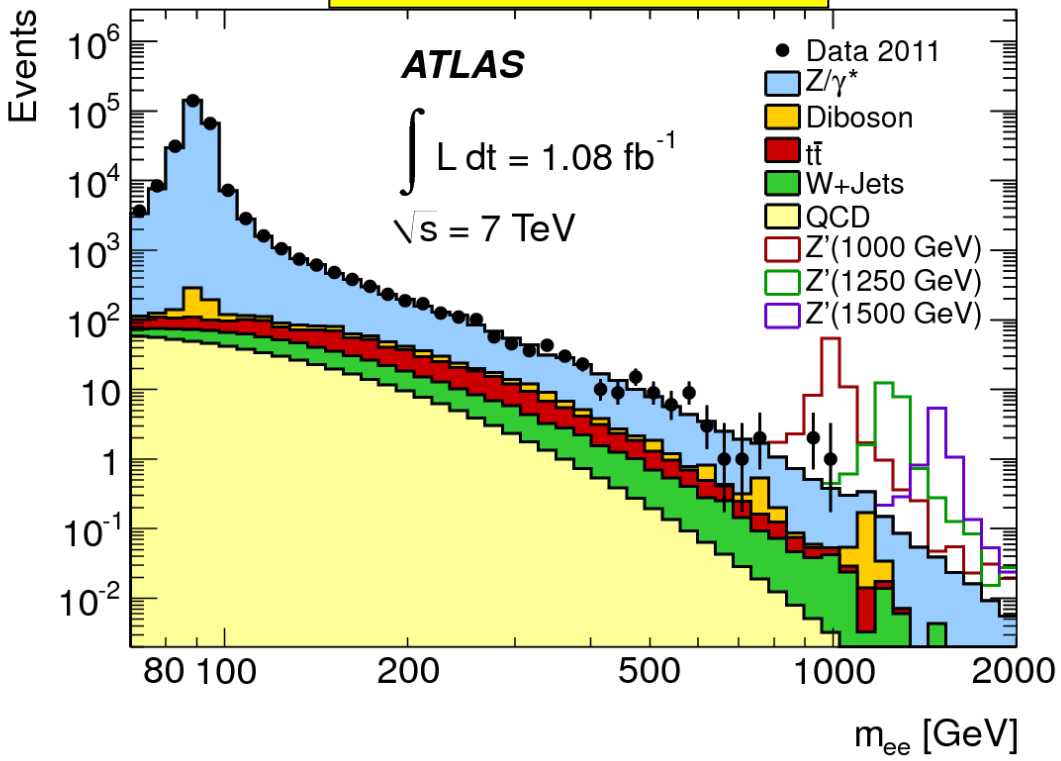


- The amount of data allowed measurements of "rare" physics processes:
  - In ~70 trillion pp collisions, ~40 ZZ → 4l events are produced
- Good agreement with the Standard Model expectations

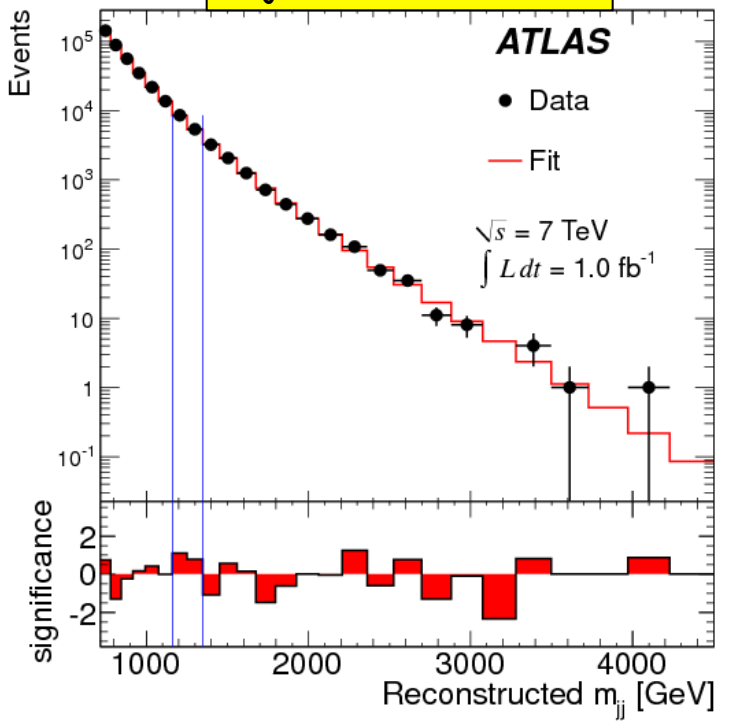
Search for heavy new particles – resonances –

- Search for peaks in different spectra
  - Reached very high masses: ~ 4 TeV (m_{jj}) and 1 TeV (m_{ee})

2 electrons invariant mass

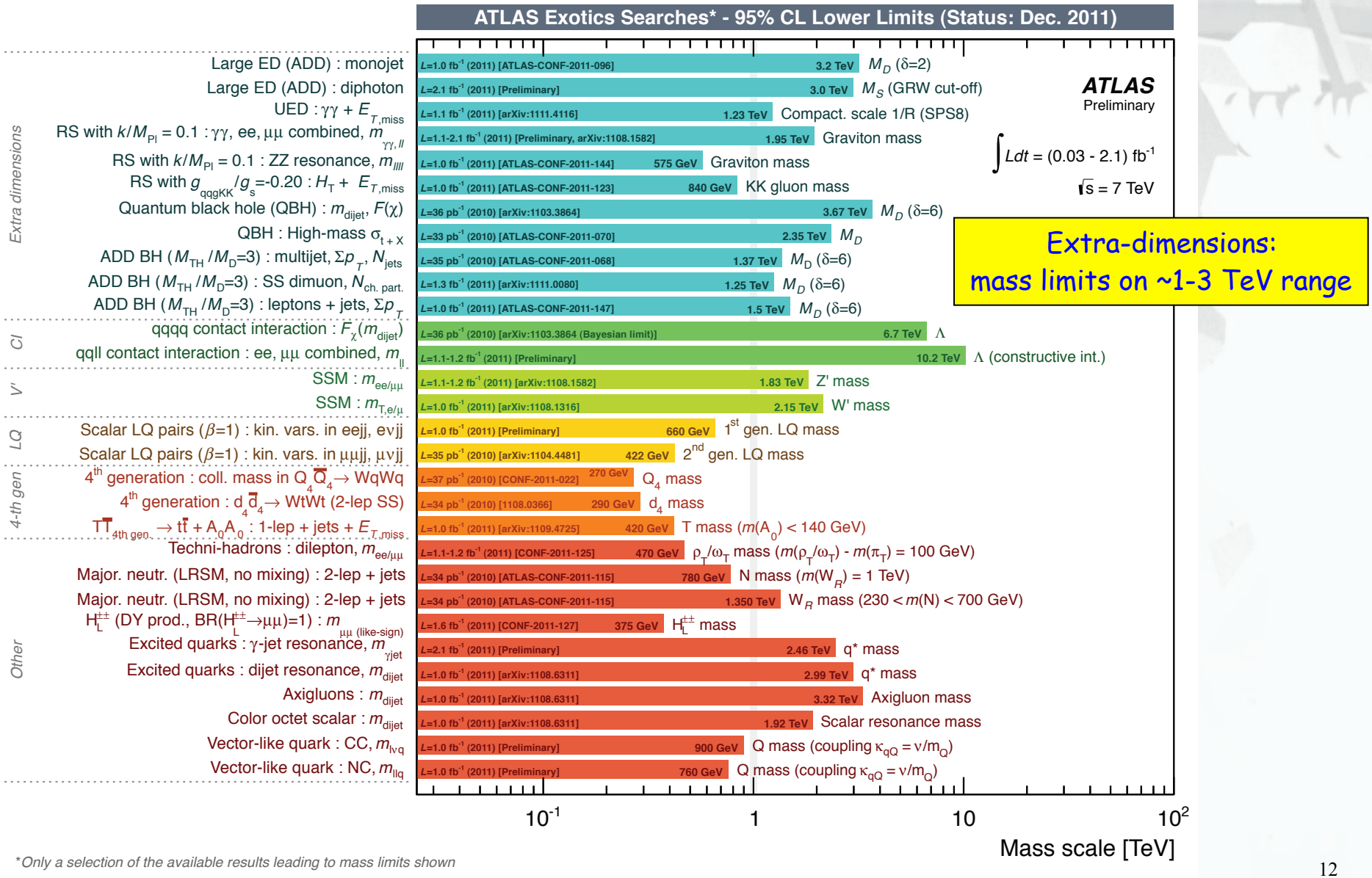


2 jets invariant mass



This allows to put more stringent lower mass limits to heavy new particles

New exotic physics search result summary

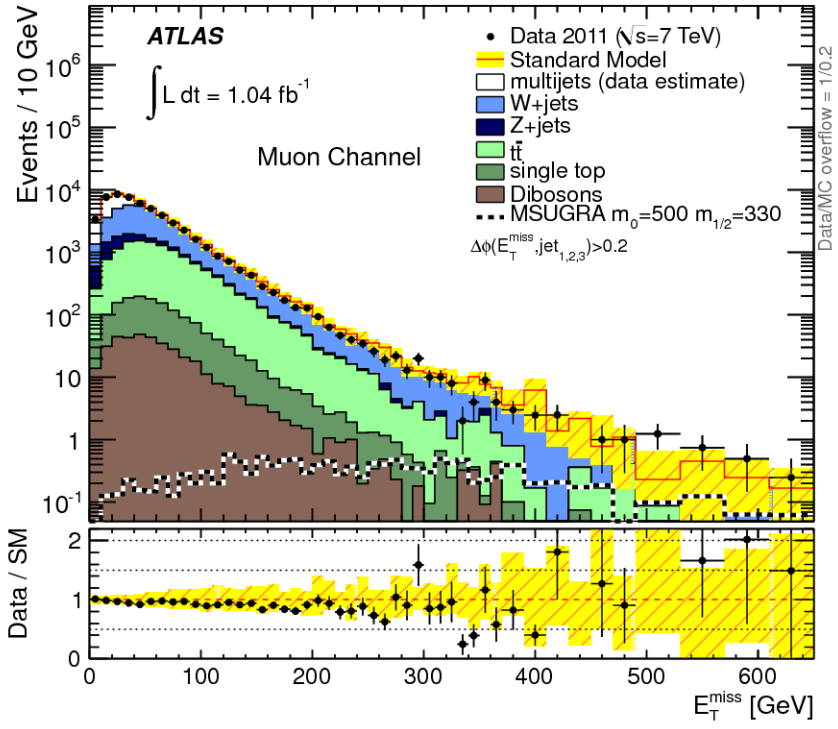


Extra-dimensions:
mass limits on ~1-3 TeV range

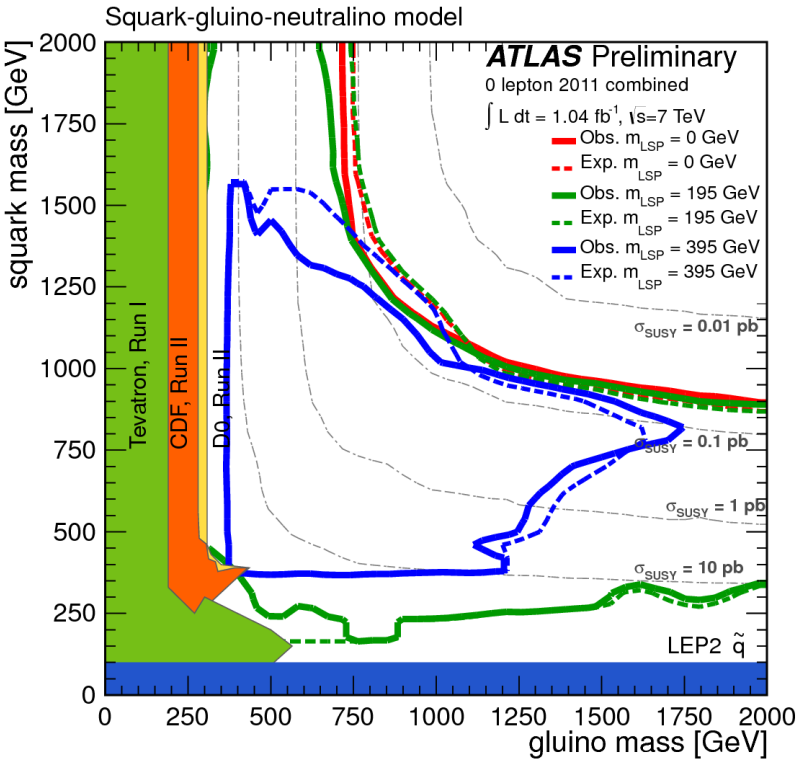
*Only a selection of the available results leading to mass limits shown

SUSY search results

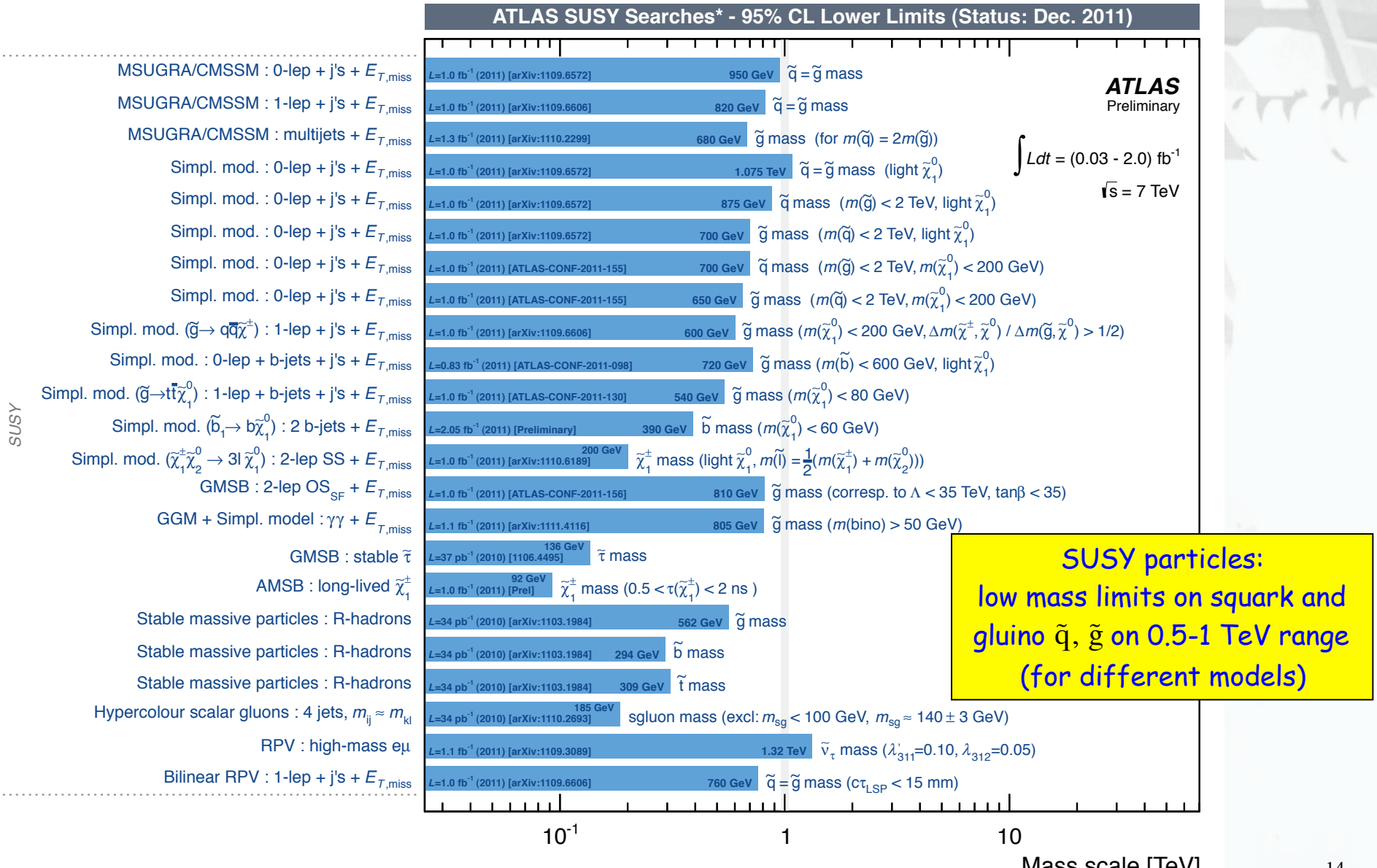
- Searching for SUSY:
  - Sum all energy in the detector
  - Compute the energy balance in the plane transverse to the beam axis (E_T^{miss})
    - Might be due to neutrinos (known that mostly don't interact) or maybe SUSY
- E_T^{miss} distribution well described within 5 orders of magnitude:
  - Very good understanding of the detector !



- Limits on different SUSY particle masses are extracted
- Plot of the exclusion region for squark and gluino masses



SUSY search result summary

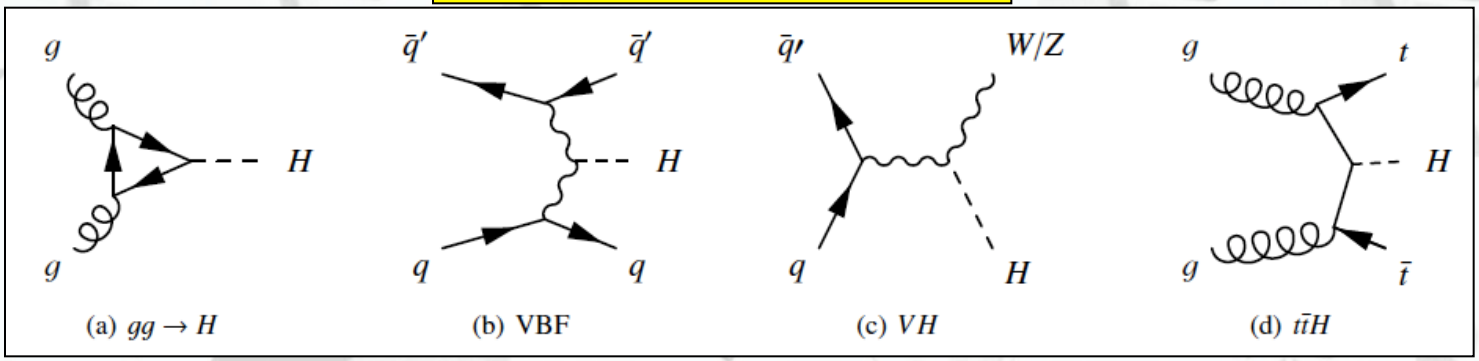


SUSY particles:
low mass limits on squark and gluino $\tilde{q}$, $\tilde{g}$ on 0.5-1 TeV range
(for different models)

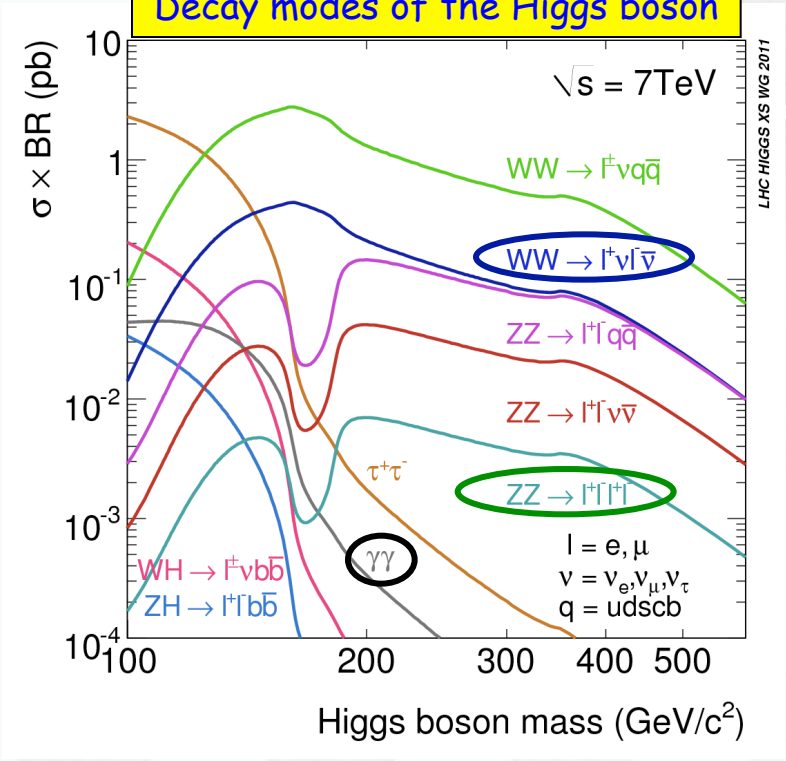
*Only a selection of the available results leading to mass limits shown

The Higgs boson search in ATLAS

Higgs boson production at LHC



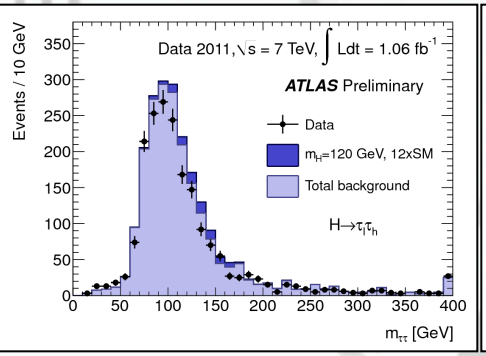
Decay modes of the Higgs boson

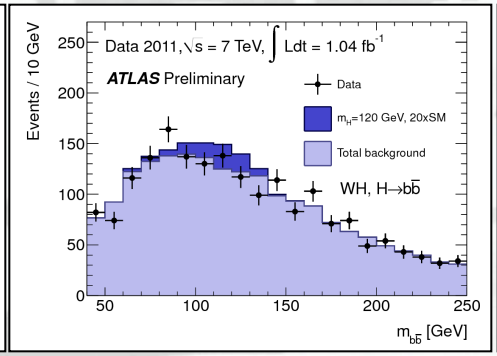


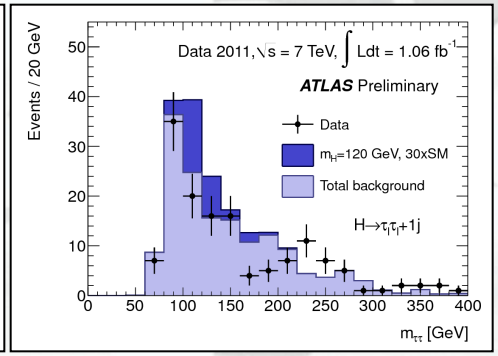
- Sensitivity of a channel to find the Higgs depends on the mass of the Higgs boson, e.g.
  - If $m_H < 130$ GeV: $H \to \gamma\gamma$
  - If $125 < m_H < 180$ GeV: $H \to WW^{(*)} \to l\nu l\nu$
  - If $125 < m_H < 300$ GeV: $H \to ZZ^{(*)} \to llll$
- Results obtained from analysis of each decay mode are combined to constrain the Higgs mass

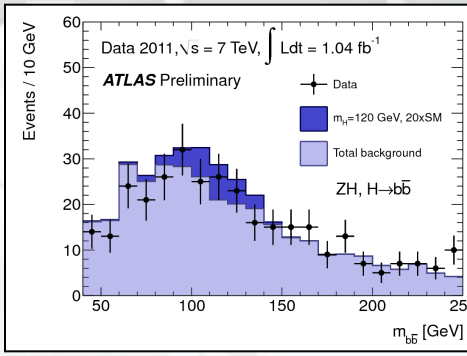
ATLAS analysis of 11 Higgs channels

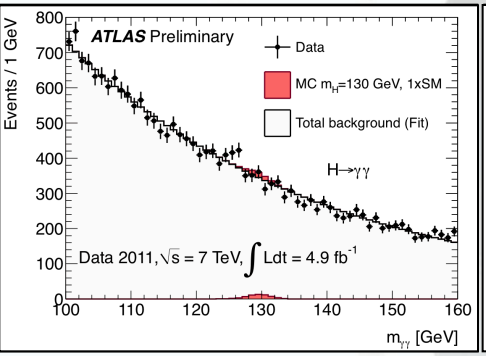
Results shown 13th December 2011

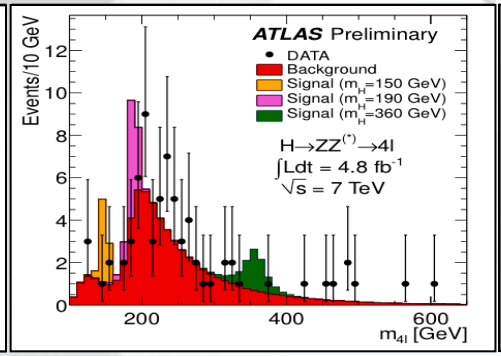


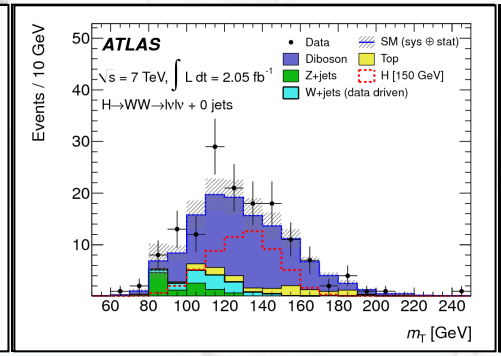


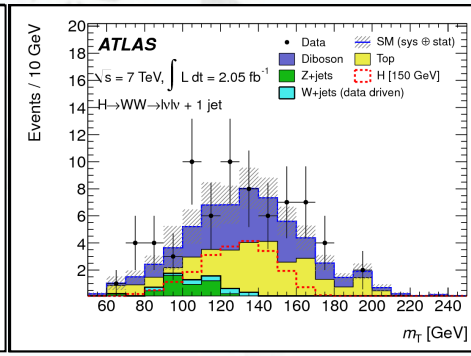


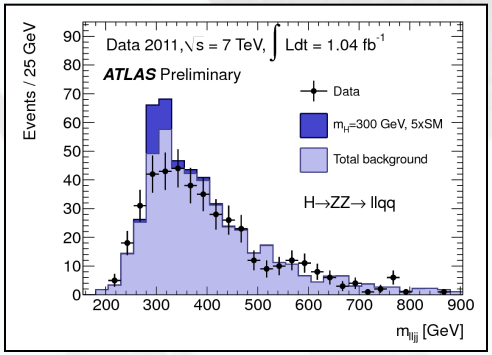


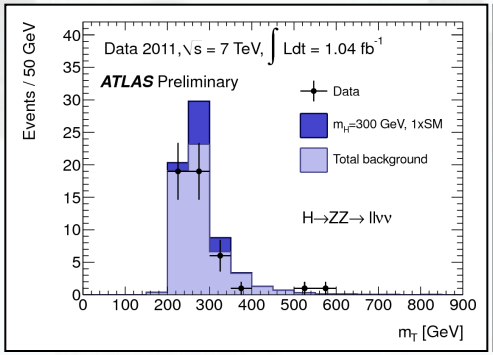


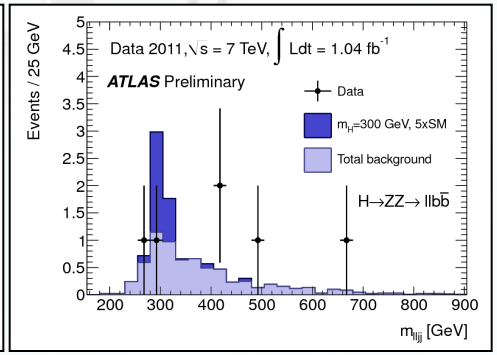






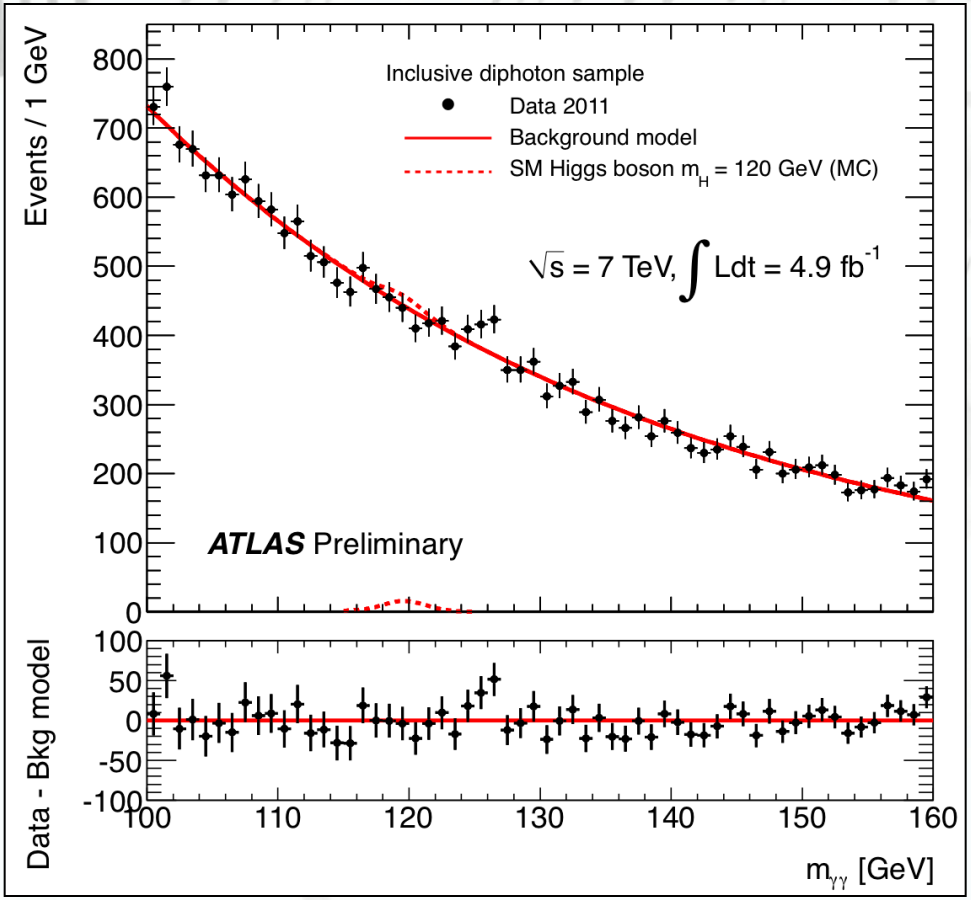




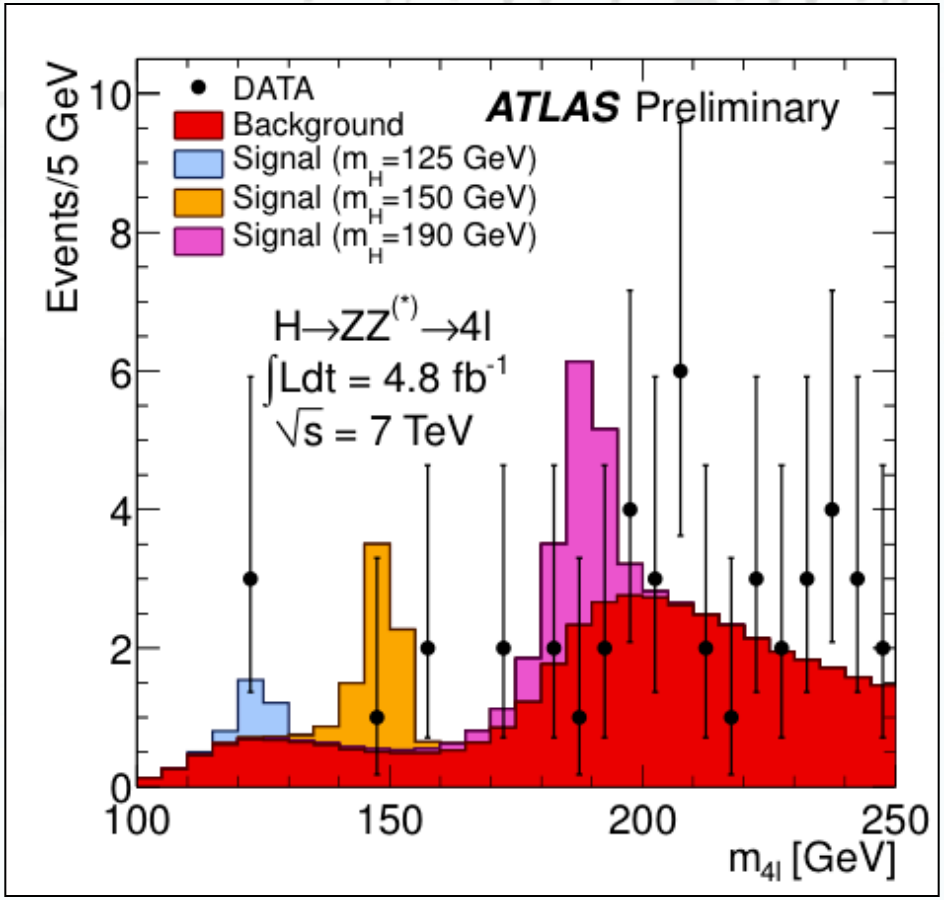


A closer look to two of the channels

H → γγ channel analysis result

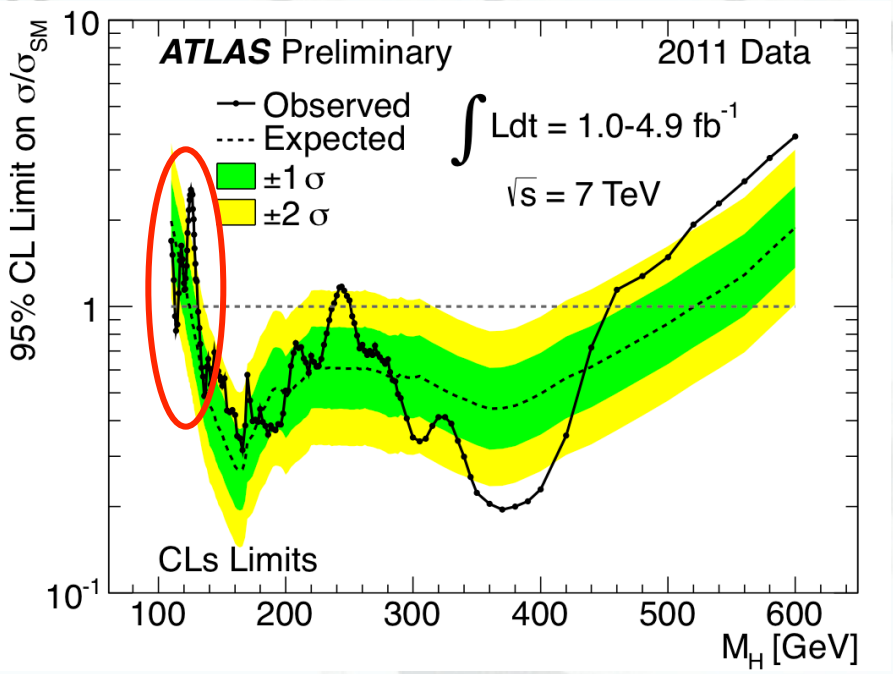


H → ZZ(*)→4l channel analysis result

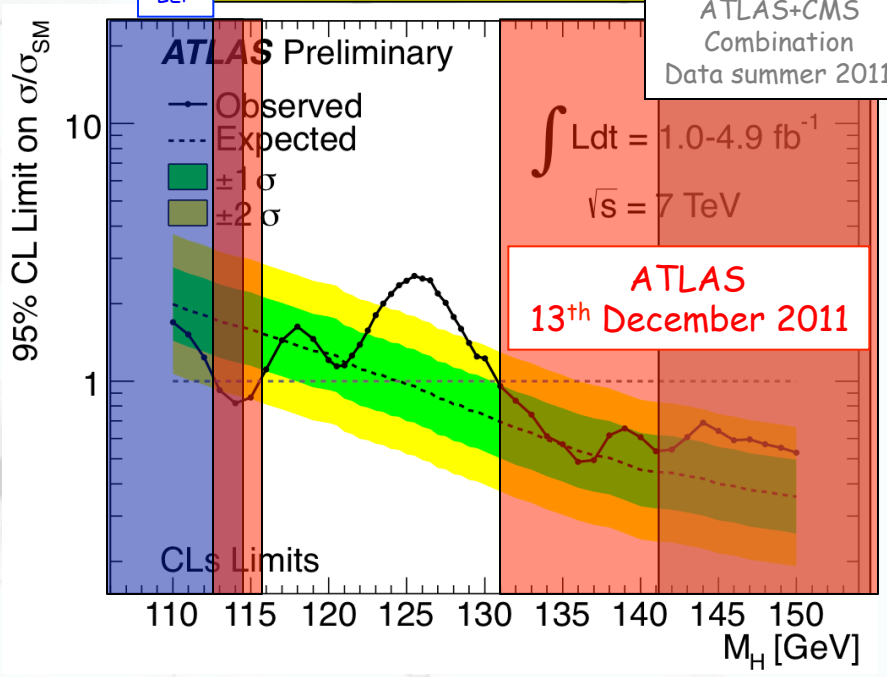


ATLAS exclusion of Higgs masses

Higgs masses with $\sigma / \sigma_{SM} < 1$ excluded at 95%CL



Zoom in the low Higgs mass region



Excluded at 95% CL

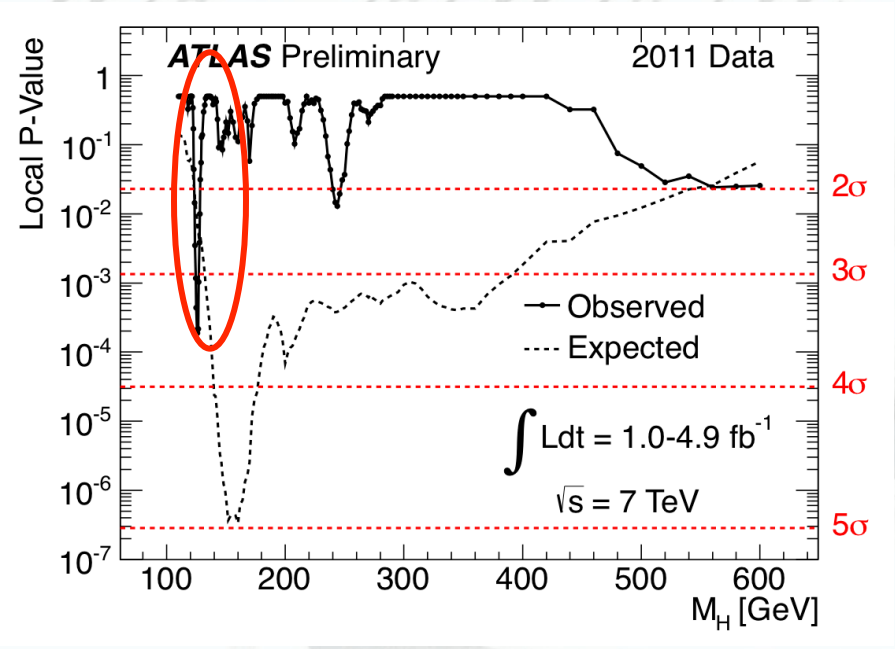
$114.4 < m_H < 115.5$ GeV

$131 < m_H < 453$ GeV, except 237-251 GeV

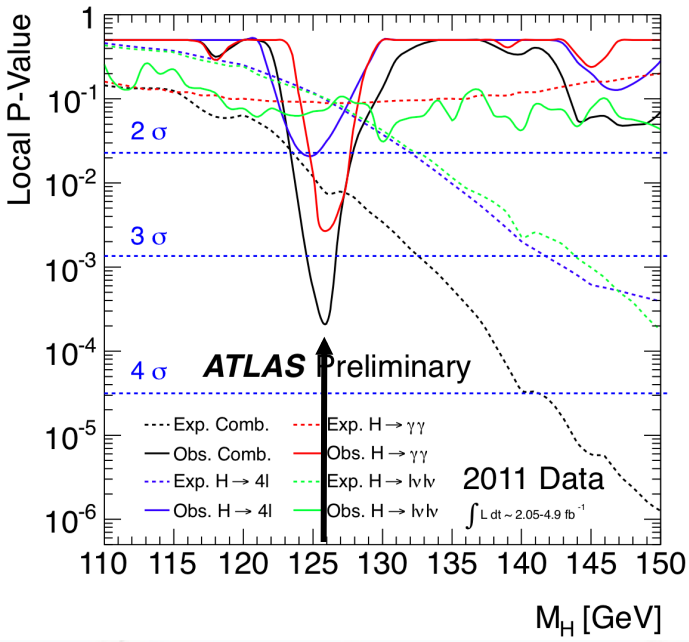
Most likely Higgs mass region at 95% CL: 115.5 – 131 GeV

Data and background only expectation consistency

Probability that the data is compatible with background only expectation

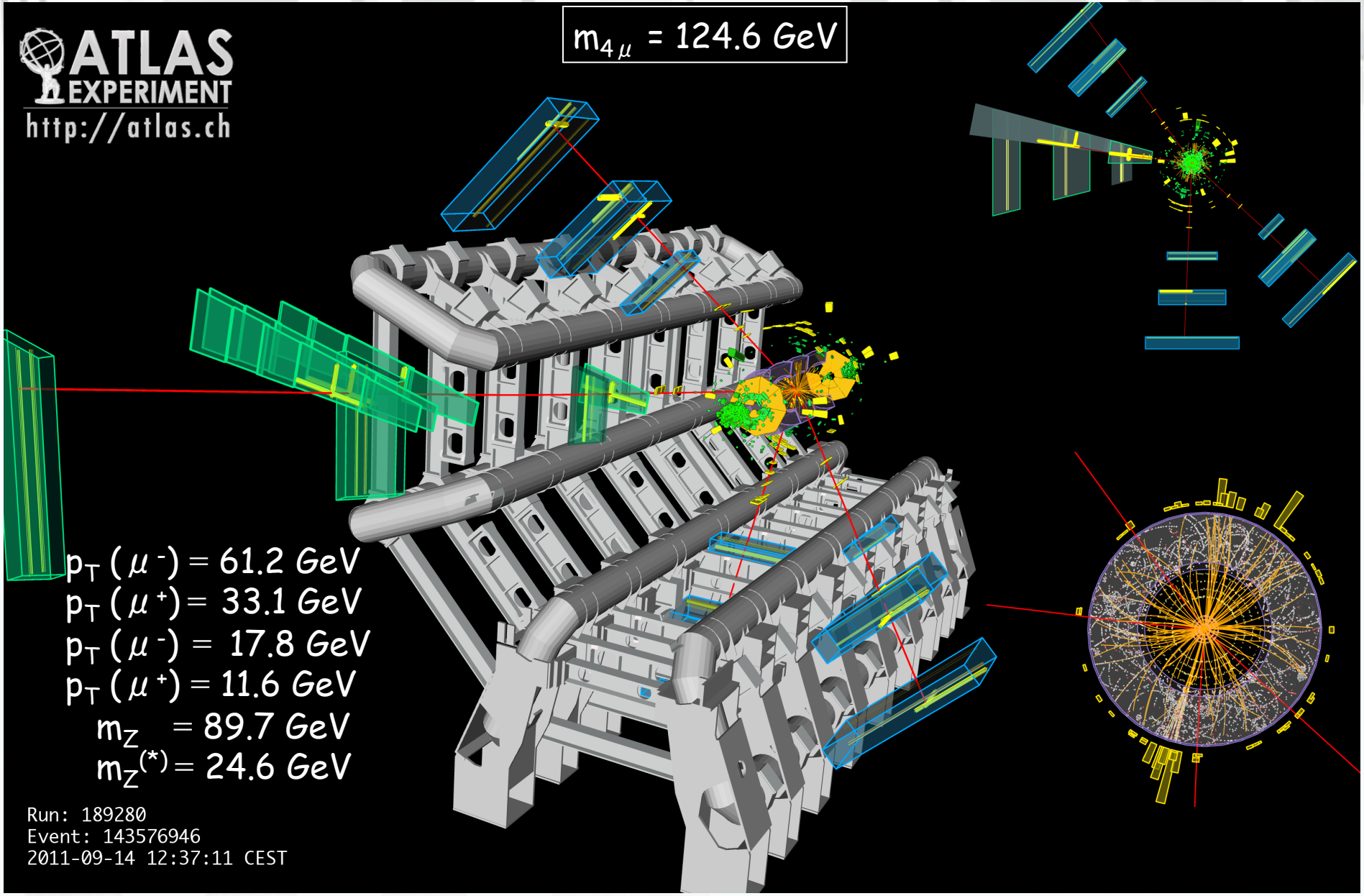


Zoom at the low Higgs mass region

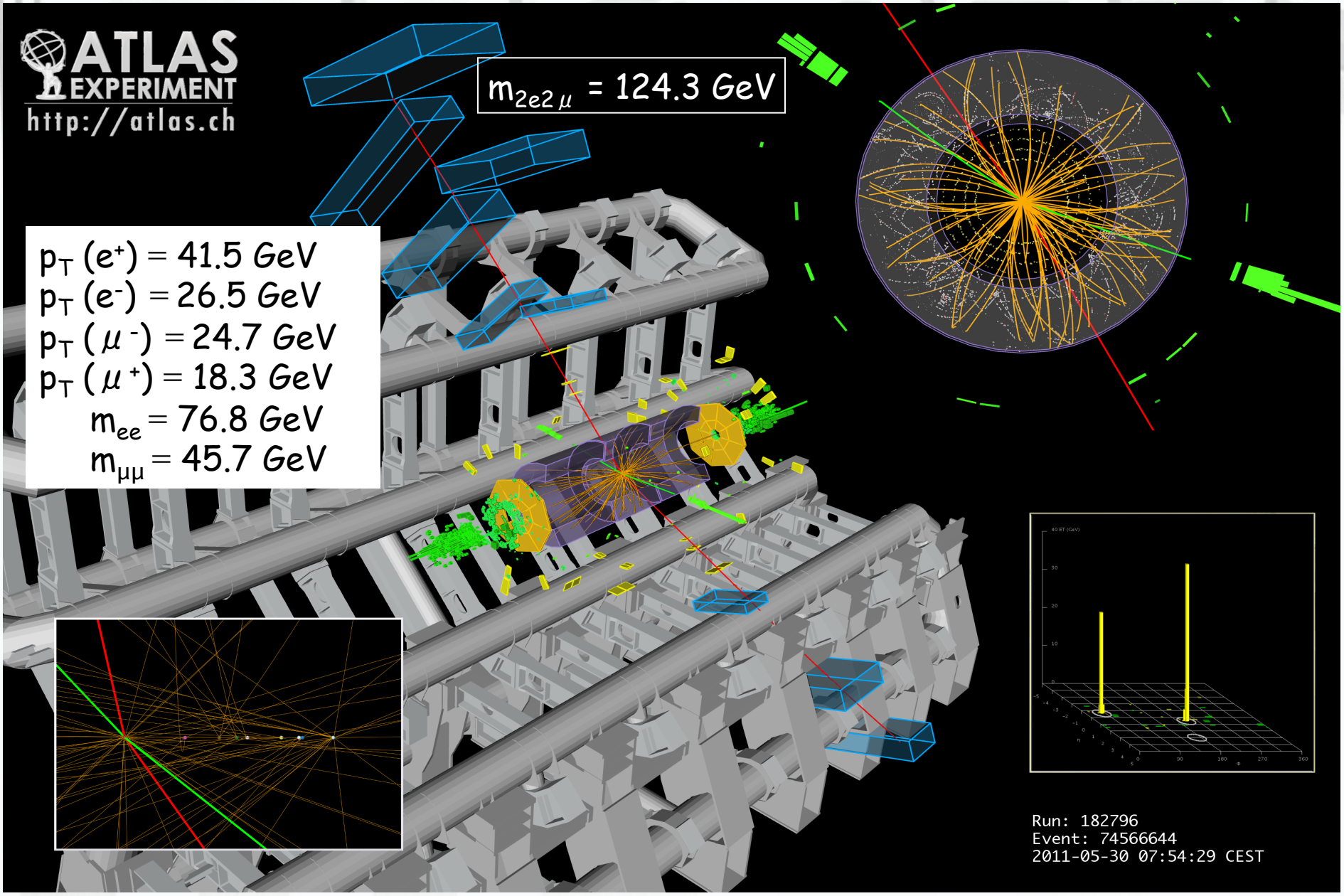


- Maximum deviation from background only expectation observed at m_H ~126 GeV:
  - Local probability (p_0 value) = 0.019% Local excess significance = 3.6 σ
  - Global probability = ~1% Global excess significance = ~2.3 σ
    - Includes the probability for such an excess anywhere in a mass range (LEE)

4μ candidate

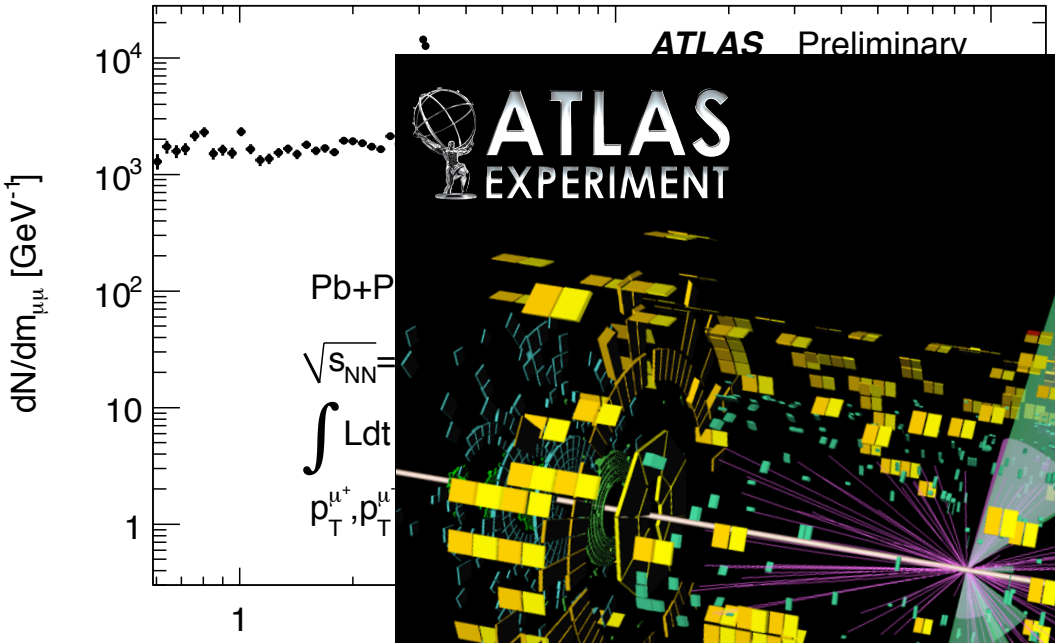


2e2μ candidate



First look at PbPb data taken in 2011

$m_{\mu\mu}$ spectra: J/Ψ , Z particles clearly seen



Conclusions

- Overall, a **fantastic** year thanks to an excellent LHC performance!
- The ATLAS collaboration **has achieved to** do:
  - Multitude of detailed measurements of many known processes in the LHC energy regime.
  - Many searches for new physics including SUSY particles, very heavy bosons, extra-dimensions and many others and put unprecedented limits to many of them.
  - A **search for the SM Higgs boson** in many channels and has restricted the most probable region at the 95% CL to 115.5-131 GeV.
- An excess of events has been observed at **126 GeV** with a local/global significances of 3.6 σ / ~2.3 σ
  - **Is this the Higgs?** We don't know yet – we need more data –.
- Looking forward for an **exciting** *new year* !

THANK YOU !

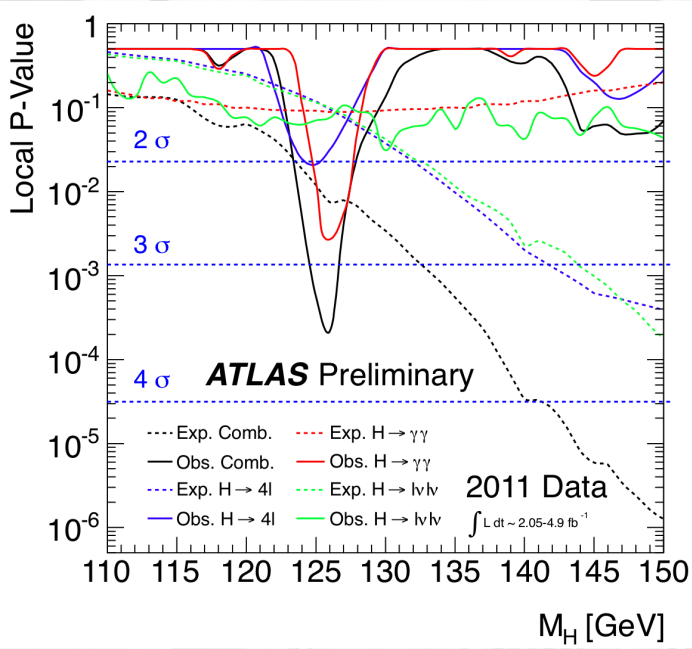
BACKUP

Summary of present Higgs searches in ATLAS

Channel	m_H range (GeV)	Int. lumi fb^{-1}	Main backgrounds	Number of signal events after cuts	S/B after cuts	Expected σ/σ_{SM} sensitivity
$H \to \gamma\gamma$	110-150	4.9	$\gamma\gamma$, γj, jj	~70	~0.02	1.6-2
$H \to \tau\tau \to ll+\nu$	110-140	1.1	$Z \to \tau\tau$, top	~0.8	~0.02	30-60
$H \to \tau\tau \to l\tau_{had}$	100-150	1.1	$Z \to \tau\tau$	~10	~5 10^{-3}	10-25
$W/ZH \to bbl(l)$	110-130	1.1	W/Z+jets, top	~6	~5 10^{-3}	15-25
$H \to WW^{(*)} \to l\nu l\nu$	110-300	2.1	WW, top, Z+jet	~20 (130 GeV)	~0.3	0.3-8
$H \to ZZ^{(*)} \to 4l$	110-600	4.8	ZZ*, top, Zbb	~2.5 (130 GeV)	~1.5	0.7-10
$H \to ZZ \to ll\,\nu\nu$	200-600	2.1	ZZ, top, Z+jets	~20 (400 GeV)	~0.3	0.8-4
$H \to ZZ \to ll\,qq$	200-600	2.1	Z+jets, top	2-20 (400 GeV)	0.05-0.5	2-6
$H \to WW \to l\nu qq$	240-600	1.1	W+jets,top,jets	~45 (400 GeV)	10^{-3}	5-10

Higgs results

Consistency of the data with background only expectation

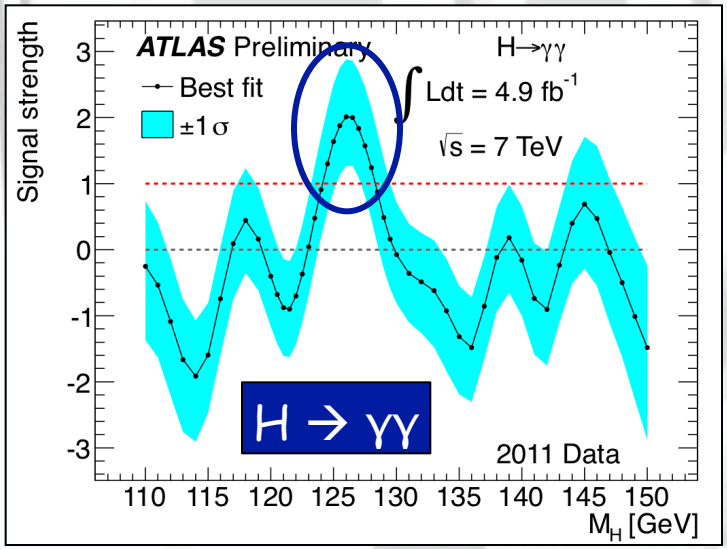


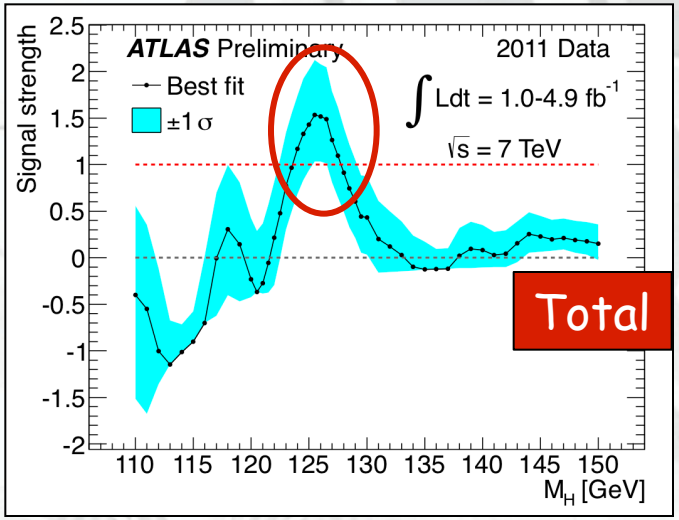
Local p_0-value: 1.9 10^{-4}
→local significance of the excess: 3.6σ
~ 2.8σ H→ γγ, 2.1σ H→ 4l, 1.4σ H→ lνlν

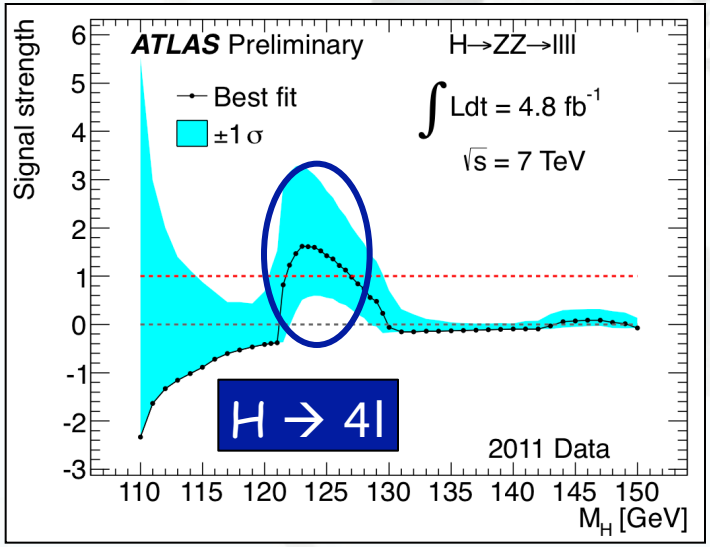
Expected from SM Higgs: ~2.4σ local (~1.4σ per channel)

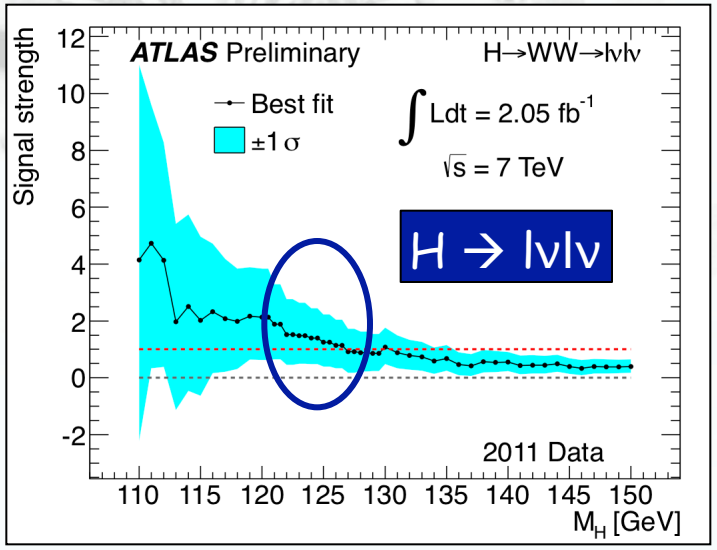
Global p_0-value : 0.6% →2.5 σ LEE over 110-146 GeV
Global p_0-value : 1.4% →2.2 σ LEE over 110-600 GeV

Compatibility of the observation with the expected strength of a SM Higgs signal









The observed excess is slightly larger (2±0.8) than expected in the H→γγ channel and compatible within 1σ for the other channels and the combined result