ATLAS : results and future

1 - History (and archeology) of LHC

2 - Status and recent results

3 - Short term prospects

4 - Long term prospects

Louis FAYARD *(LAL Orsay)*

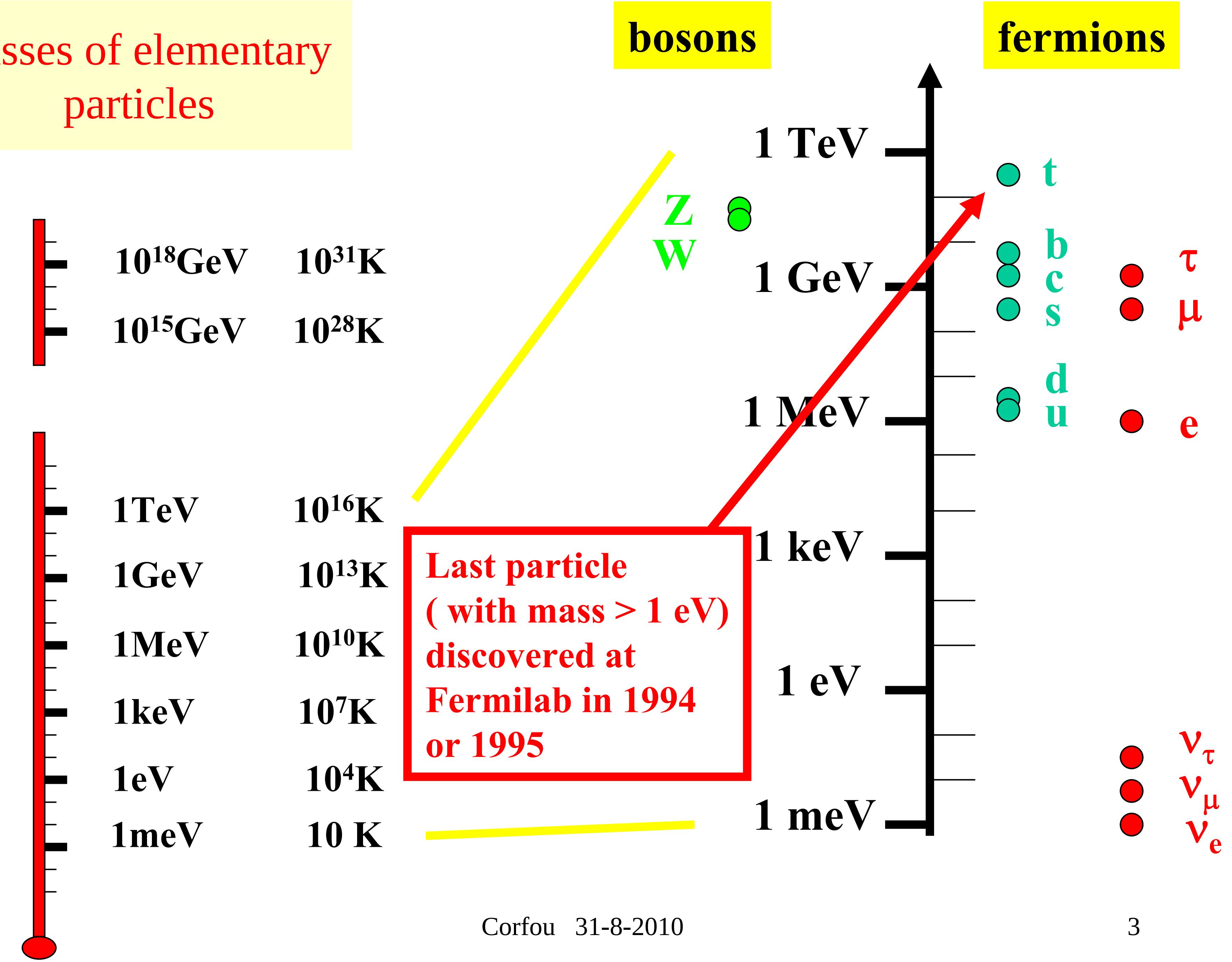
Complementary with IWS : here emphasis on photons, top , SM Higgs , prospects

(because of time and competence)
Very incomplete !

Inspired by several (ATLAS and non ATLAS) talks, *in particular Fabiola Gianotti @ ICHEP 2010*

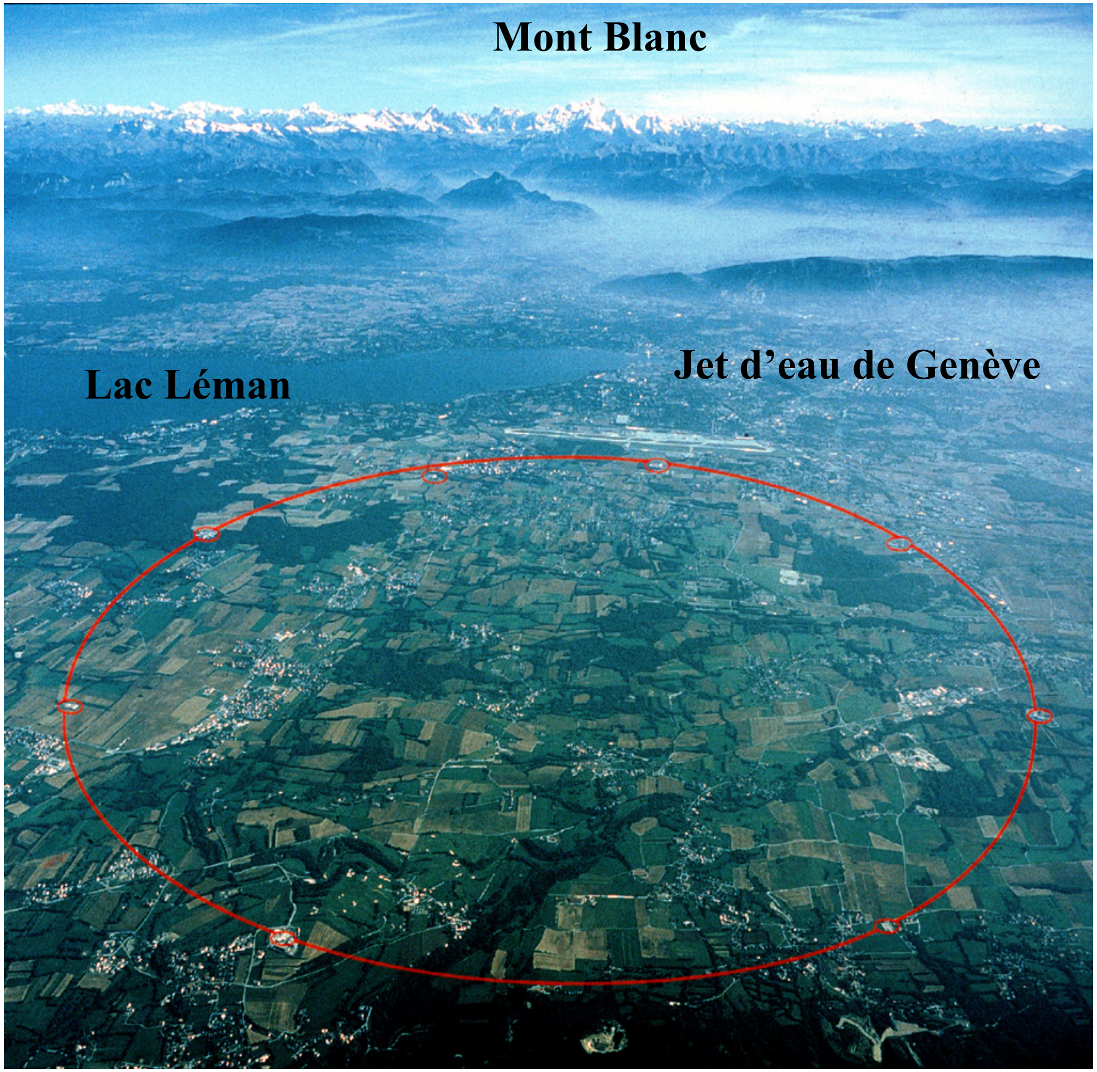
1 - History (and archeology) of LHC

masses of elementary particles



► LHC

LHC is a (mainly) pp collider of 27 km long in a tunnel ~ 100 m underground close to Geneva (tunnel already used by LEP) which should work with a *design* centre-of-mass energy of 14 TeV

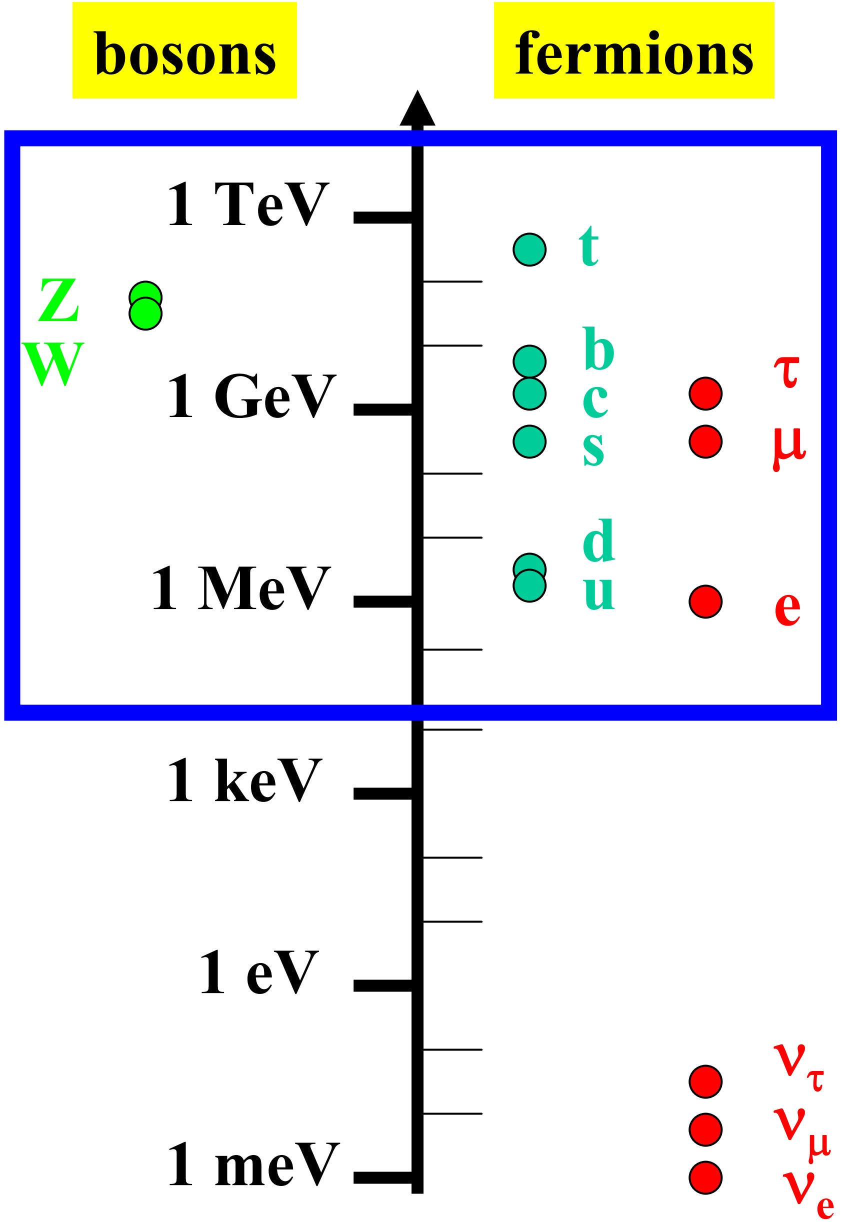


CERN
(Centre
Europeen
de
Recherche
(sub)Nucleaire)

in fact world center

We think that the vacuum is filled by the Higgs field interacting with the particles which therefore get a mass
This Higgs field is part of the Electroweak Standard Model

The Higgs mechanism is a sort of *supraconductivity in the vacuum (cf Meissner effect)*



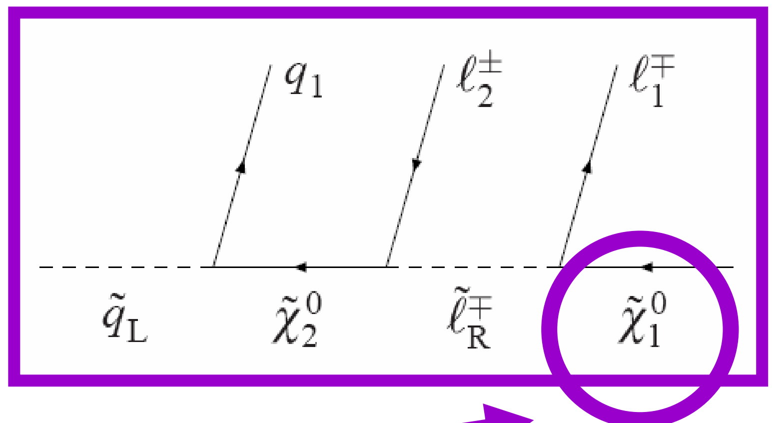
$\Rightarrow$ **field (particle) to find** ***mass of order 100 GeV***

But we all hope that LHC will find something else than the Higgs boson

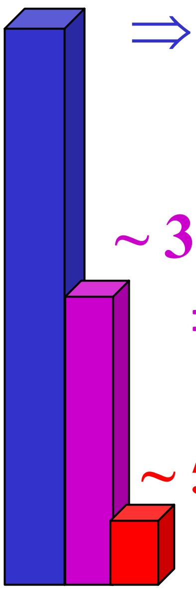
Supersymetry

is the most '*usual*' theory ..

It predicts in particular a natural candidate to dark matter



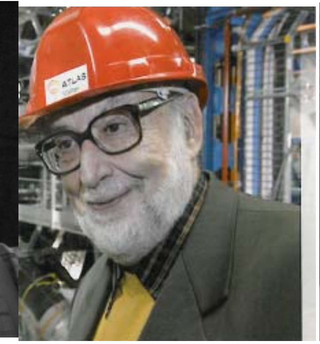
Energy of Universe

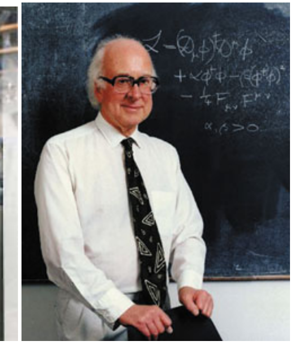


~ 65 % of dark energy
⇒ expansion of Universe speed-up

~ 30 % of dark matter
⇒ rotation of galaxies

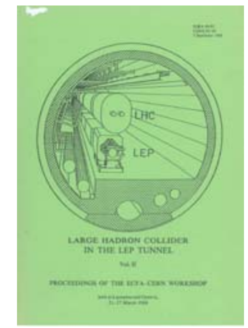
~ 5 % of standard matter





1960 Nambu
1961 Goldstone
1962 Anderson
1964 Brout, Englert, Higgs,Guralnik,Hagen,Kibble
1967 Weinberg, Salam
1970 Glashow, Iliopoulos,
Maiani, ‘t Hooft , …..

1983 *discovery of W and Z at CERN*
1984 Lausanne



1989 construction of the LEP (e+ e- collider) tunnel
beginning of the R & D of LHC experiments

1992 ← LOI of ‘large’ LHC experiments
1994 ← TP of ATLAS andCMS approval of LHC (december)

1996 ← approval of LHC in one step (december)
1998 ← approval of the 4 largest LHC experiments (ATLAS,CMS, *LHCb, ALICE*)
1999 ← ATLAS Physics TDR CERN/LHCC/99-14 CERN/LHCC/99-15

2006 ← CMS Physics TDR J. Phys. G: Nucl. Part. Phys. 34 (2007) 995–1579
2008 ← ATLAS *Expected Performance* arXiv:0901.0512
2010 ← start-up at 3.5 + 3.5 TeV

2008

10th september 2008 : first beams around

19th september 2008 : incident

2009

14 months of major repairs and consolidation

New Quench Protection system

20th november 2009 : first beams around (*again*)

december 2009 : collisions at 2.36 TeV cms

January 2010 : decided scenario 2010-11   7 TeV cms

instead of 14 TeV

2010

30th march 2010 : first collisions at 7 TeV cms

august 2010 : luminosity of 10^{31} cm^{-2} s^{-1}

	design	now
β*	0.55 m	3.5 m
Circumference	26.7 km	
Beam energy at collision	7 TeV	3.5 TeV
Beam energy at injection	0.45 TeV	
Dipole field at 7 TeV	8.33 T	
Luminosity	10^{34} cm^{-2} s^{-1}	10^{31}
Beam current	0.56 A	
Protons per bunch	1.1×10^{11}	10^{11}
Number of bunches	2808	48 (36 colliding in ATLAS)
Nominal bunch spacing	24.95 ns	
Normalized emittance	3.75 μm	
Total crossing angle	300 μrad	
Energy loss per turn	6.7 keV	
Critical synchrotron energy	44.1 eV	
Radiated power per beam	3.8 kW	
Stored energy per beam	350 MJ	
Stored energy in magnets	11 GJ	
Operating temperature	1.9 K	

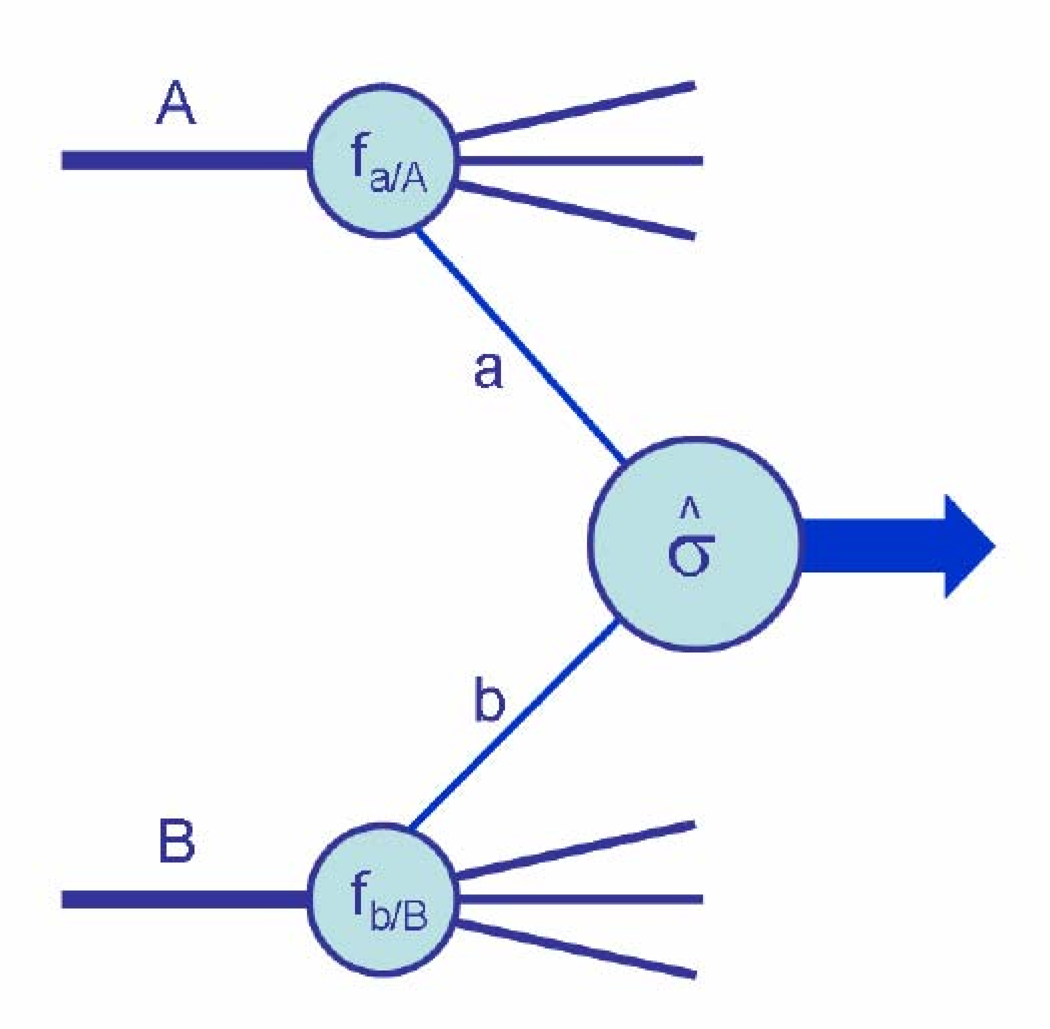
L.Evans *New Journal of Physics* **9** (2007) 335

2 – status and recent results

Very little (or nothing) on trigger ,
soft physics , not too much on detector
(in particular muons and b-tagging)

emphasis on 'hard scattering'

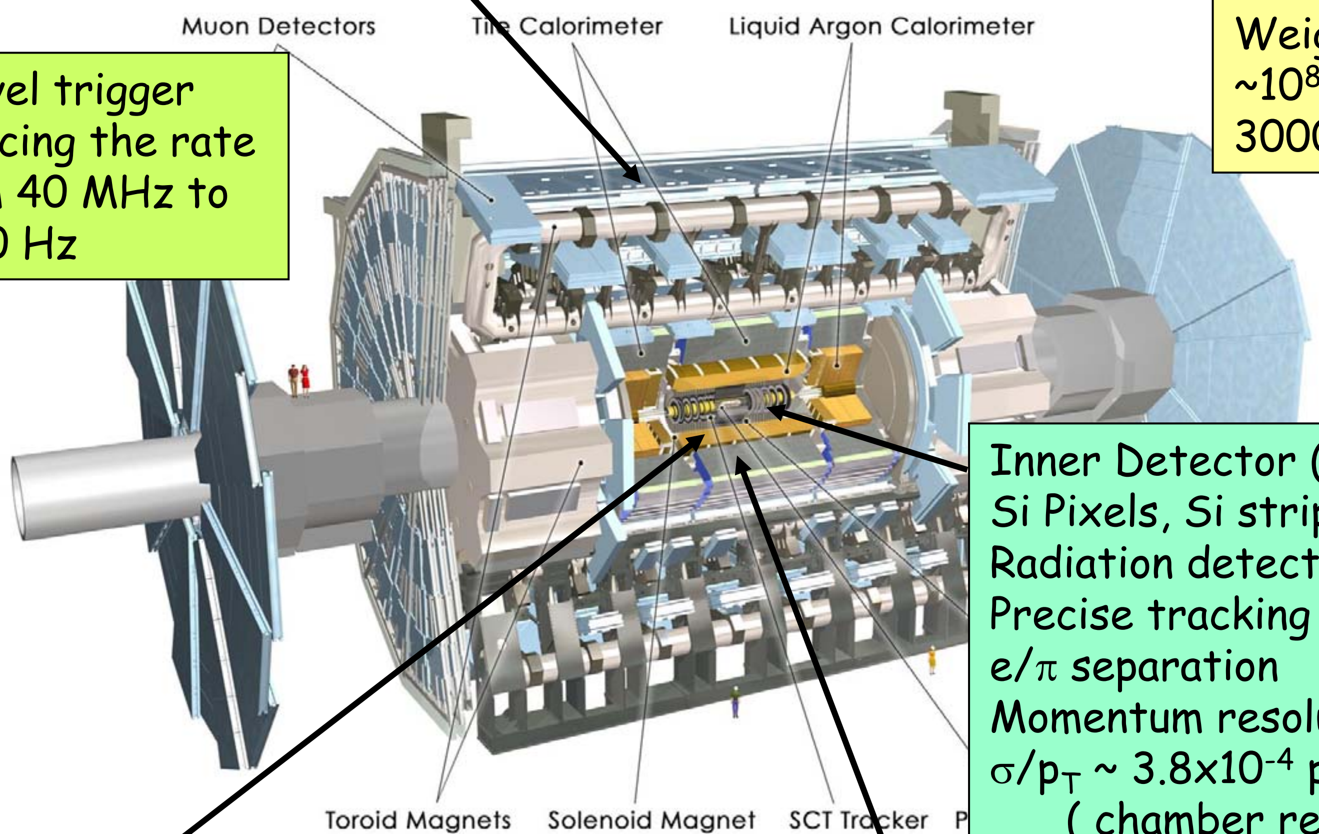
Campbell et al. Rept.Prog.Phys.**70**:89,2007



Muon Spectrometer ($|\eta|<2.7$) : air-core toroids (B ~ 0.5 / 1T in barrel/ end-cap) with gas-based muon chambers Muon trigger and measurement with momentum resolution < 10% up to E_μ ~ 1 TeV

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~10^8 electronic channels
3000 km of cables

3-level trigger reducing the rate from 40 MHz to ~200 Hz



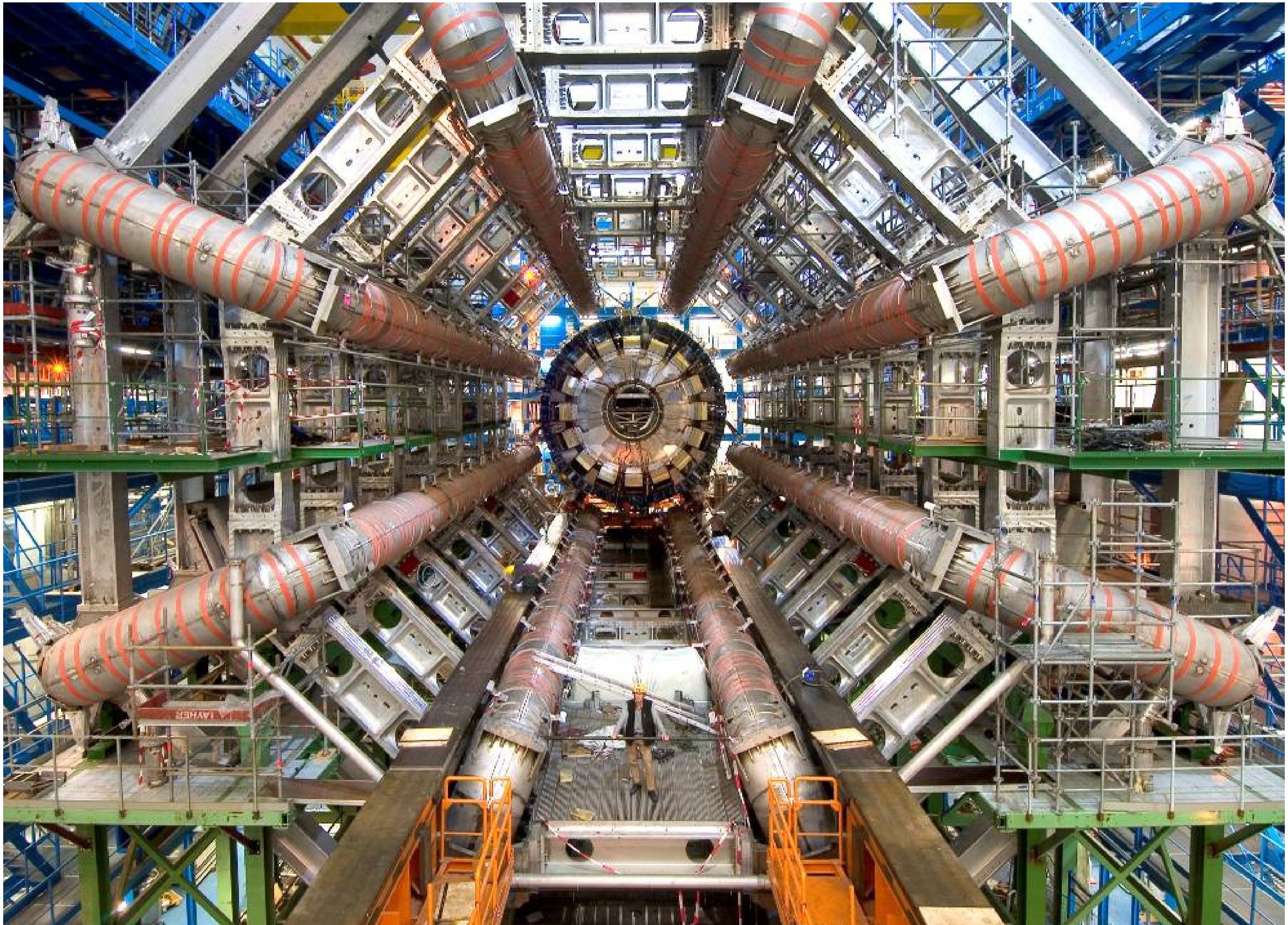
Inner Detector ($|\eta|<2.5$, B=2T):
Si Pixels, Si strips, Transition Radiation detector (straws)
Precise tracking and vertexing,
e/π separation
Momentum resolution:
$\sigma/p_T \sim 3.8\times10^{-4}\, p_T(\mathrm{GeV}) \oplus 0.015$
(chamber resolution ⊕ MS)

EM calorimeter: Pb-LAr Accordion
e/γ trigger, identification and measurement
E-resolution: $\sigma/E \sim 10\%/\sqrt{E}$

HAD calorimetry ($|\eta|<5$): segmentation, hermeticity
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
Trigger and measurement of jets and missing E_T
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$

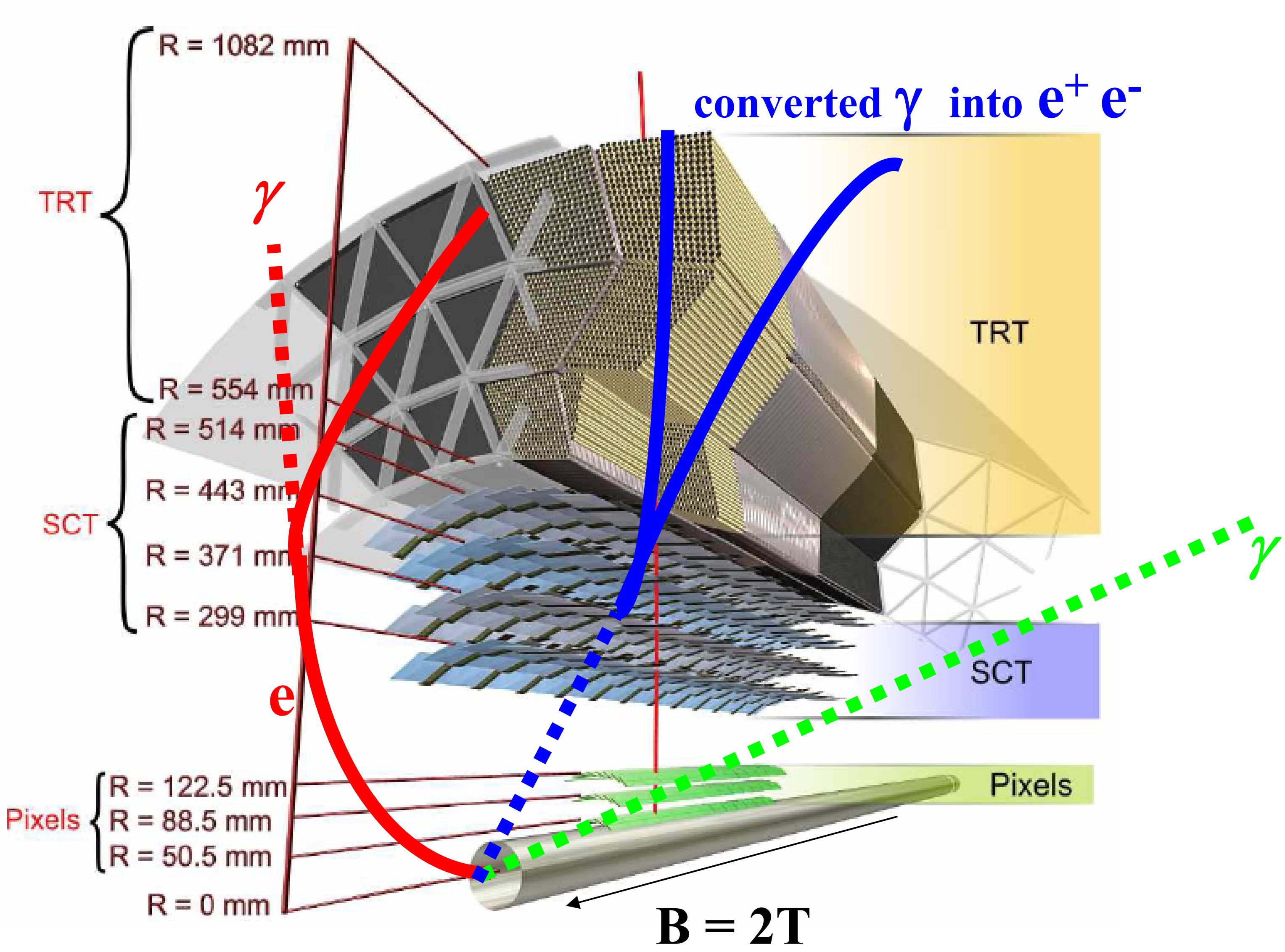
ATLAS detector

The barrel superconducting toroid of ATLAS
(A Toroidal LHC ApparatuS)



Inner detector

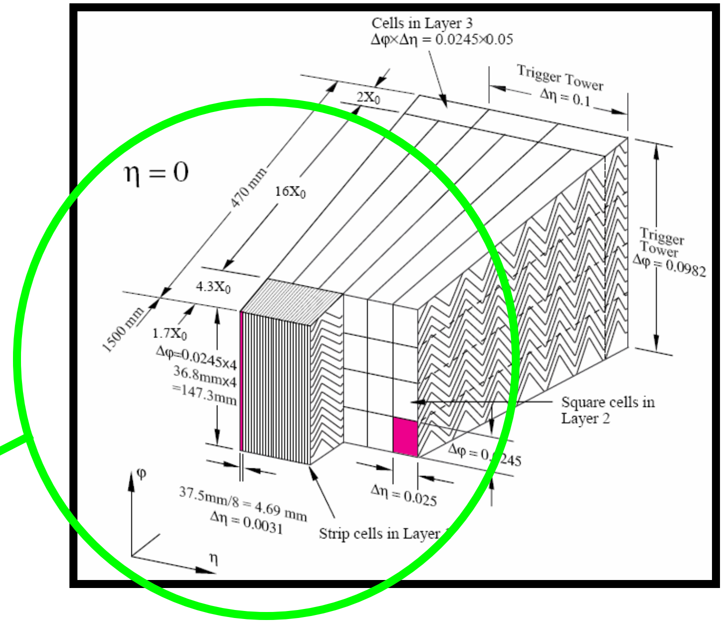
Outside you have the calorimeters and the muon detector

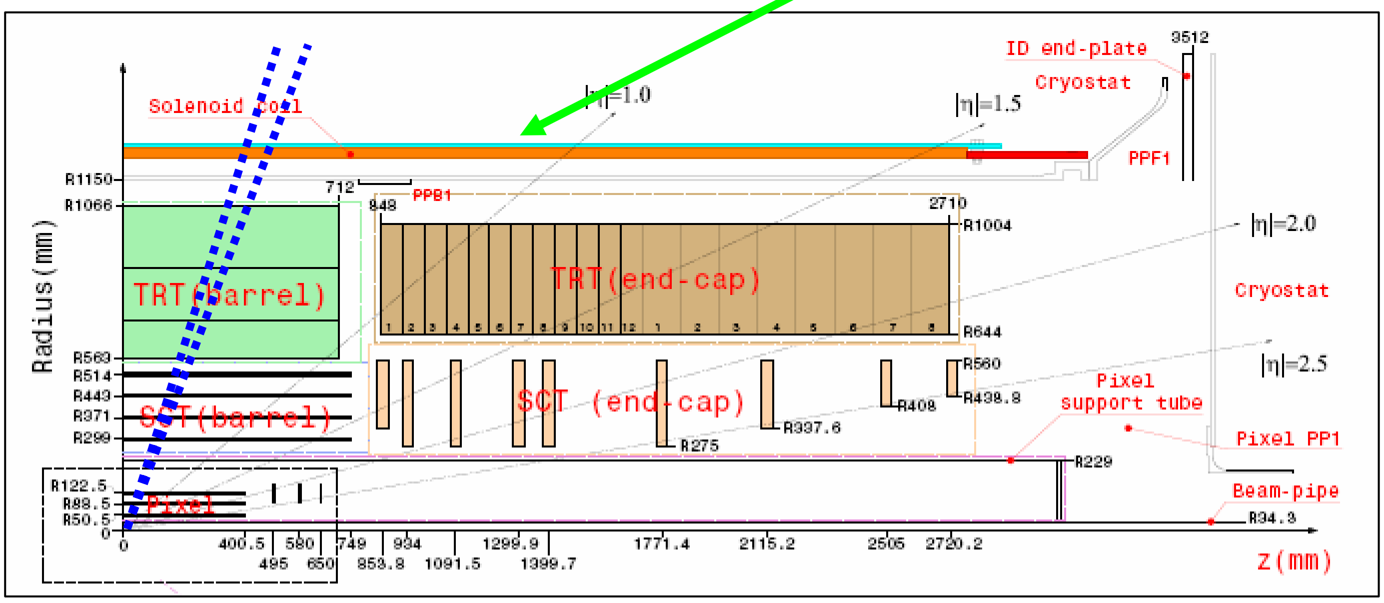


This will be very useful to reject the background from π^0

opening of photons coming from a π^0 (p_T=40 GeV)

$\Delta R > .007$

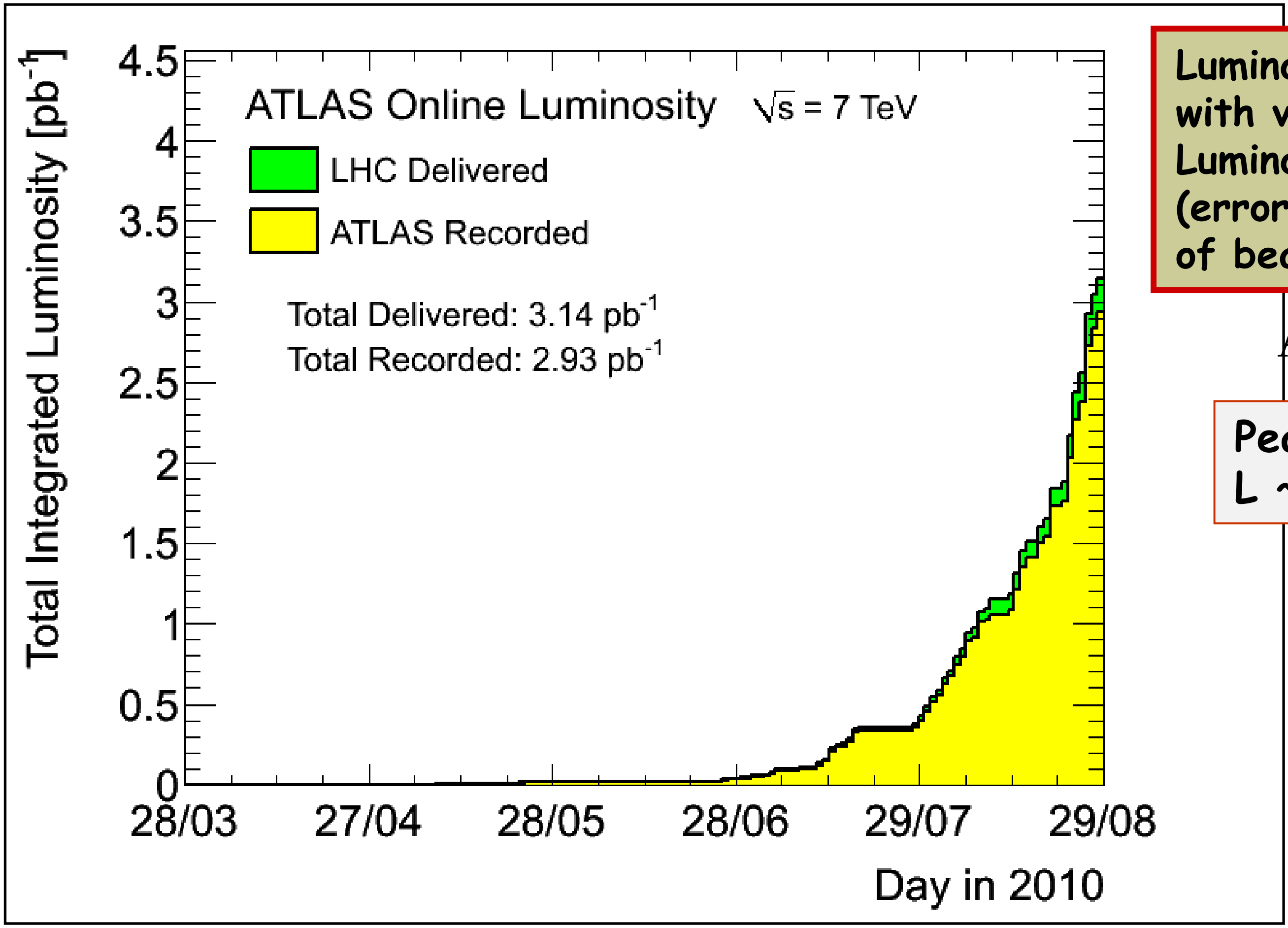




granularity of 1st sampling of calorimeter

$\Delta\eta \sim .003$

Overall data taking efficiency (with full detector on): 95%



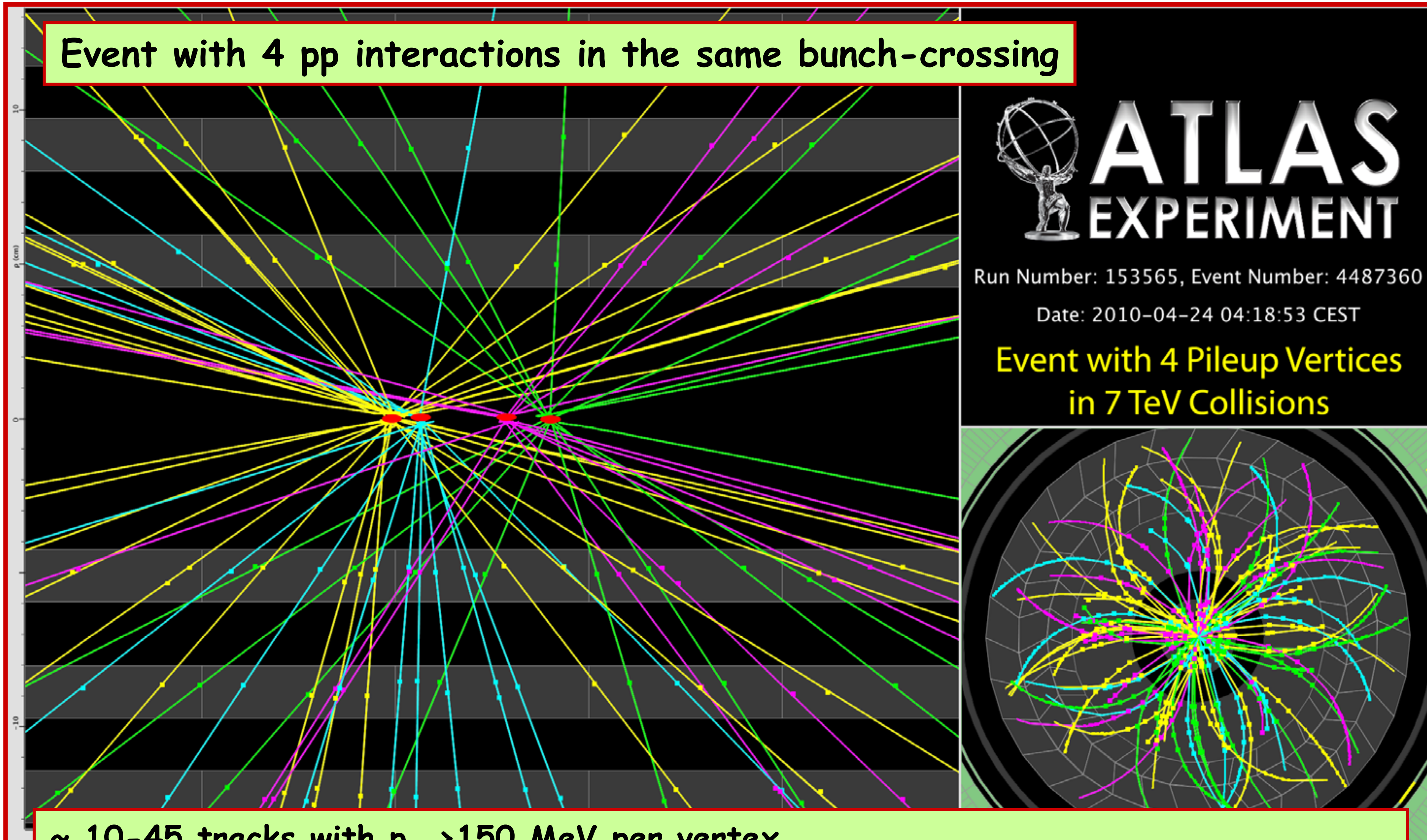
Luminosity detectors calibrated with van der Meer scans. Luminosity known today to 11% (error dominated by knowledge of beam currents)

ATLAS-CONF-2010-060

Peak luminosity in ATLAS
$L \sim 10^{31}\ cm^{-2}\ s^{-1}$

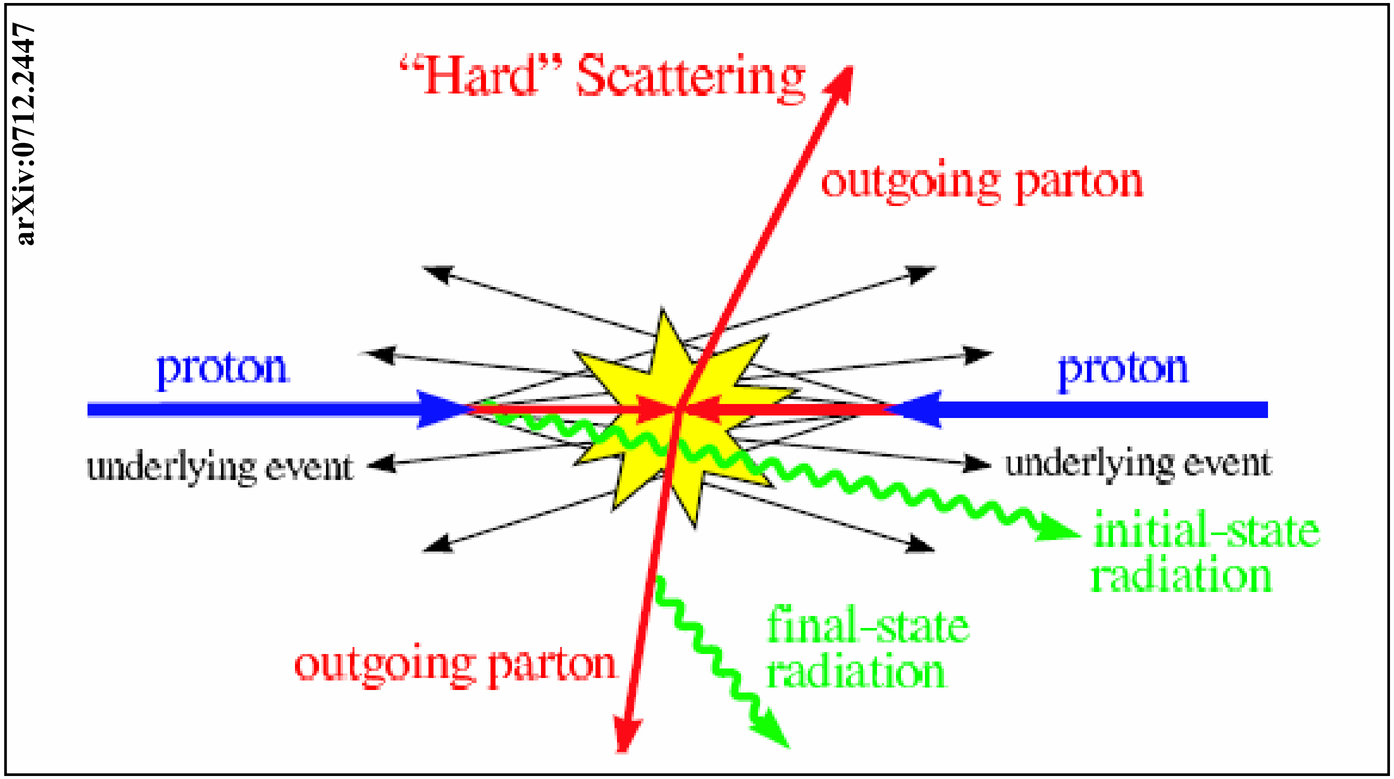
For most of the time an average number of pp interactions per crossing slightly larger than 1
→ half of events have >1 pp interaction per crossing

Event with 4 pp interactions in the same bunch-crossing

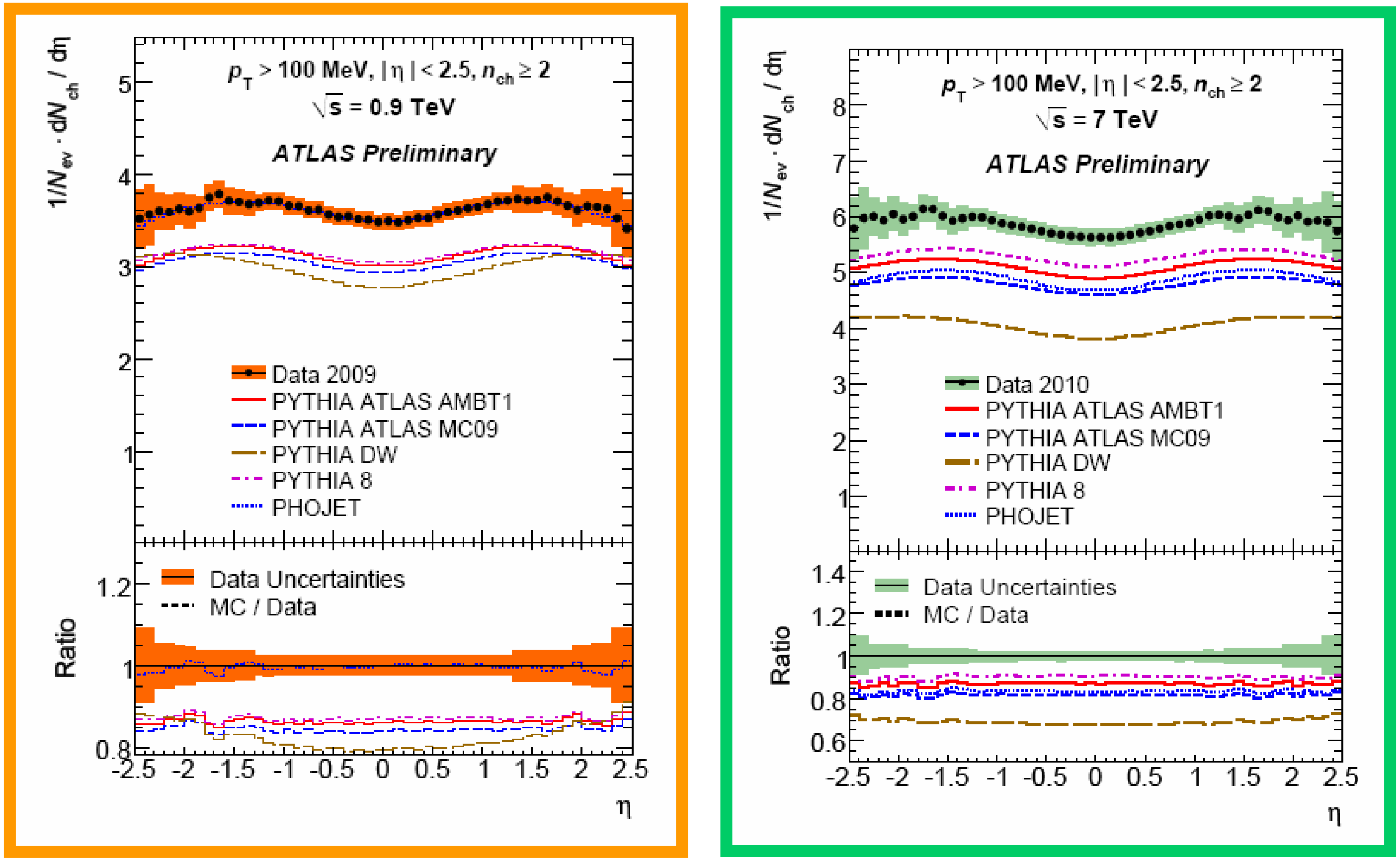


~ 10-45 tracks with p_T >150 MeV per vertex
Vertex z-positions : −3.2, −2.3, 0.5, 1.9 cm (vertex resolution better than ~200 μm)

Soft QCD - Minimum Bias and Underlying event



Non perturbative Physics



ATLAS-CONF-2010-031, 2010-046

No model dependent corrections or extrapolations

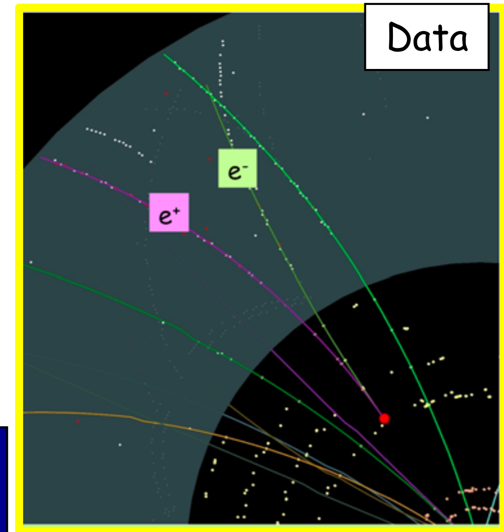
Data corrected back to particle level applying efficiency corrections and various unfoldings (migrations)

Shape described well , but not normalization to MC .

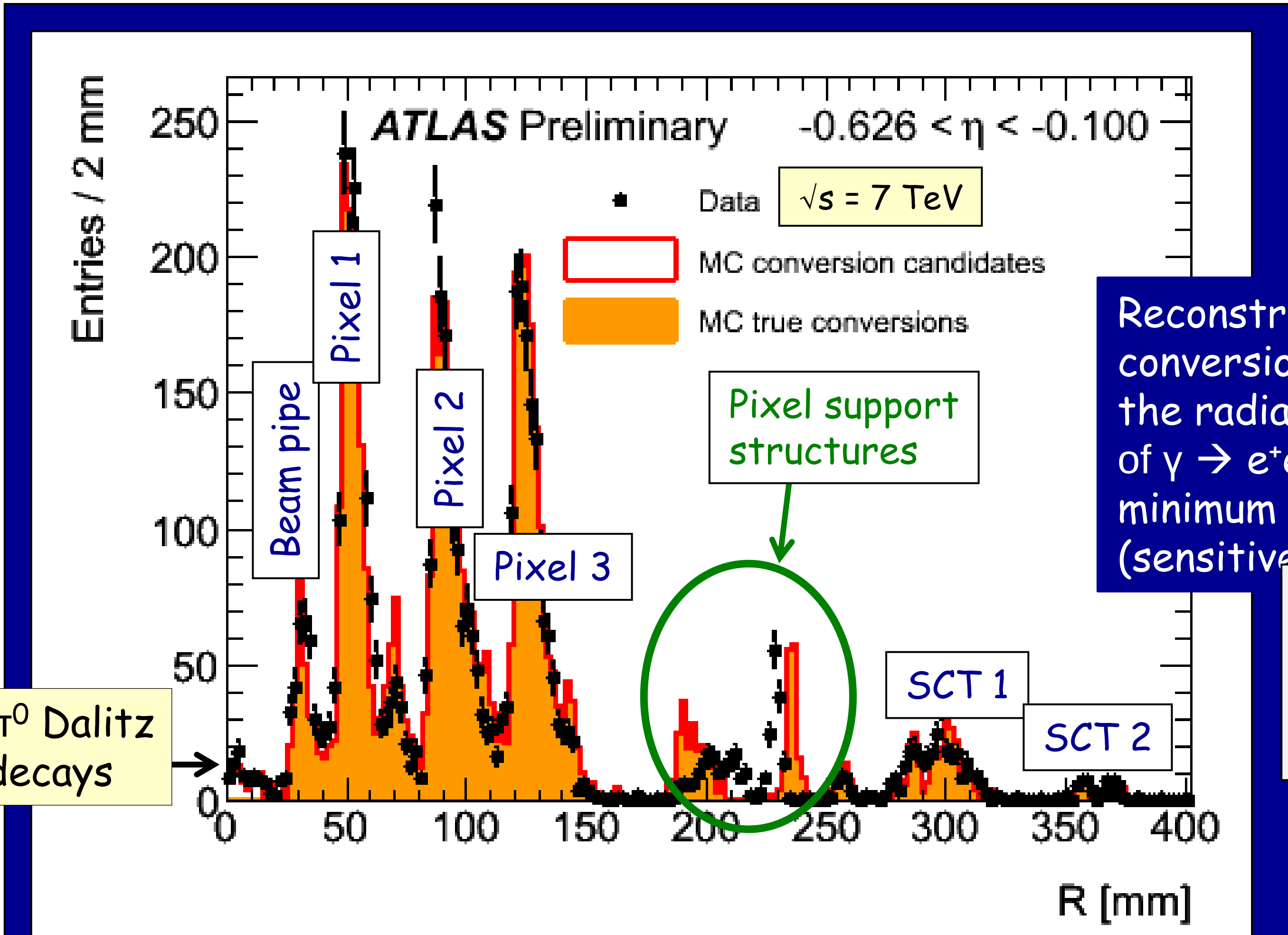
AMBT1 shows significant improvement

Mapping the Inner Detector material with $\gamma \rightarrow e^+e^-$ conversions and hadron interactions

… and using data to find geometry imperfections in the simulation

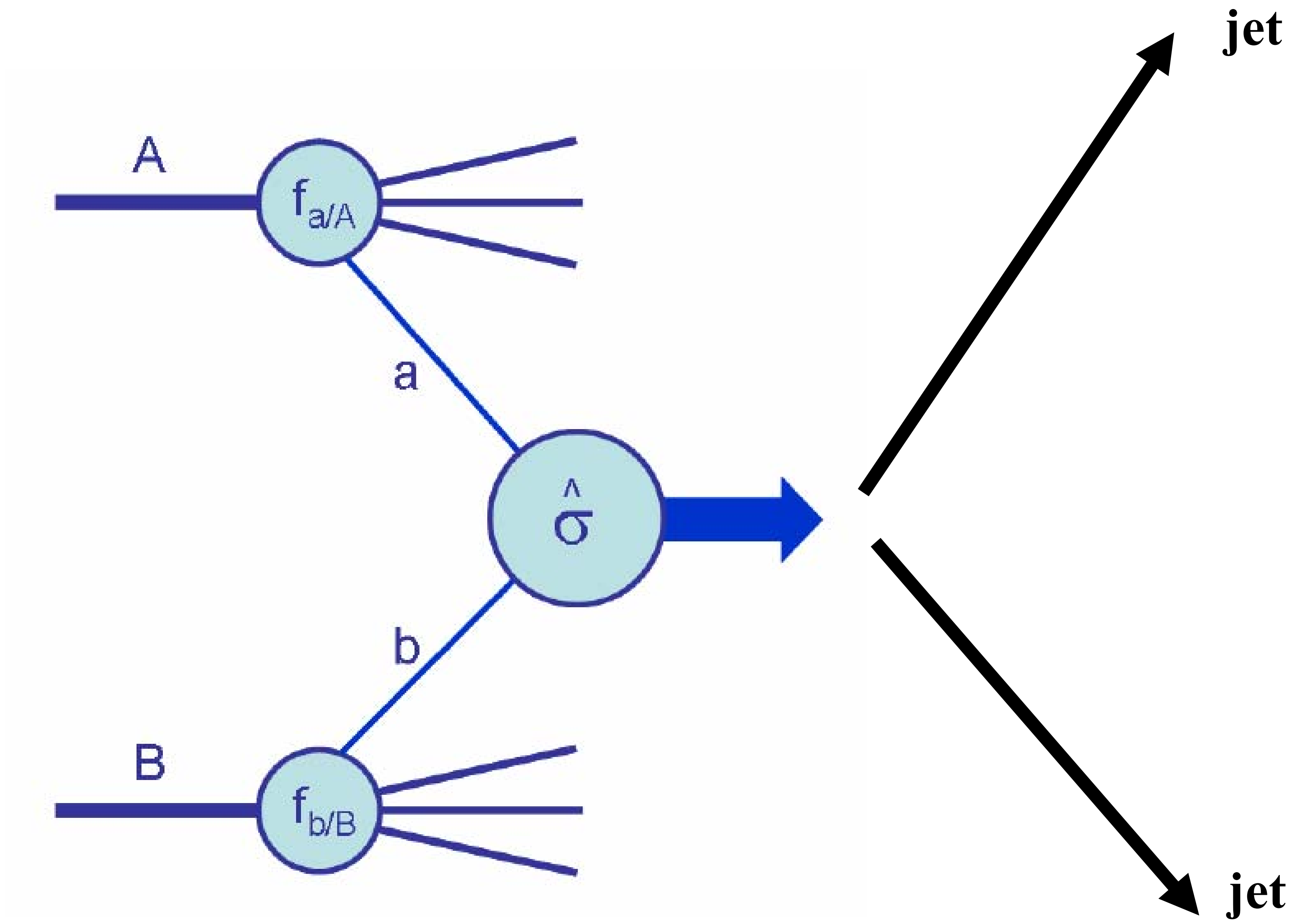


Goal is to know material to better than 5%
(over-constraining with several methods)
Present understanding: at the level of ~ 10%



Reconstructed conversion point in the radial direction of $\gamma \rightarrow e^+e^-$ from minimum bias events (sensitive to X_0)

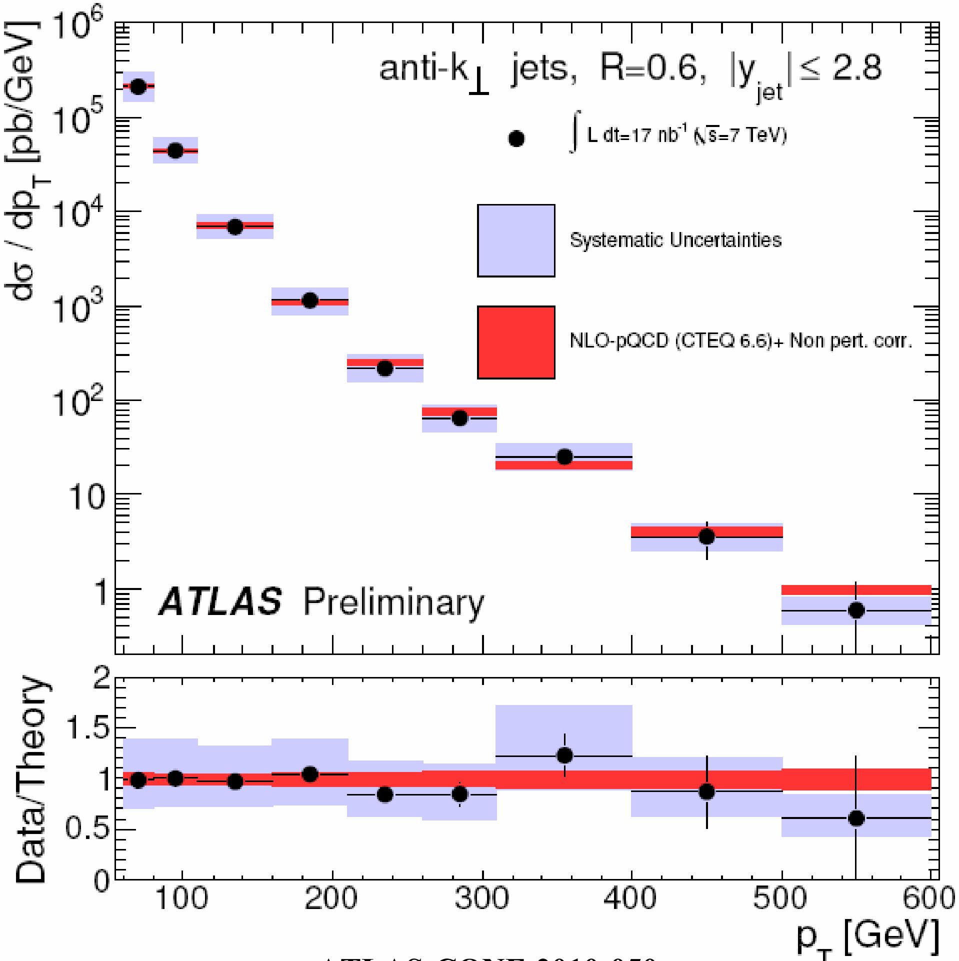
Data show that Pixel supports are displaced in the simulation
→ to be fixed


jet
A
$f_{a/A}$
a
$\hat{\sigma}$
b
B
$f_{b/B}$
jet

Inclusive jet cross-section

$p_T^j > 60$ GeV, $|y^j| < 2.8$

- Measured jets corrected to particle-level using parton-shower MC (Pythia, Herwig): justified by detailed comparison studies and good agreement with data
- Results compared to NLO QCD prediction after corrections for hadronization and underlying event
- Theoretical uncertainty: ~20%
  (up to 40% at large $|y_j|$)
  from variation of PDF, α_s, scale (μ_R, μ_F)
- Experimental uncertainty: ~30-40%
  dominated by Jet E-scale
  (known to ~7%)
  Luminosity (11%) not included



ATLAS-CONF-2010-050

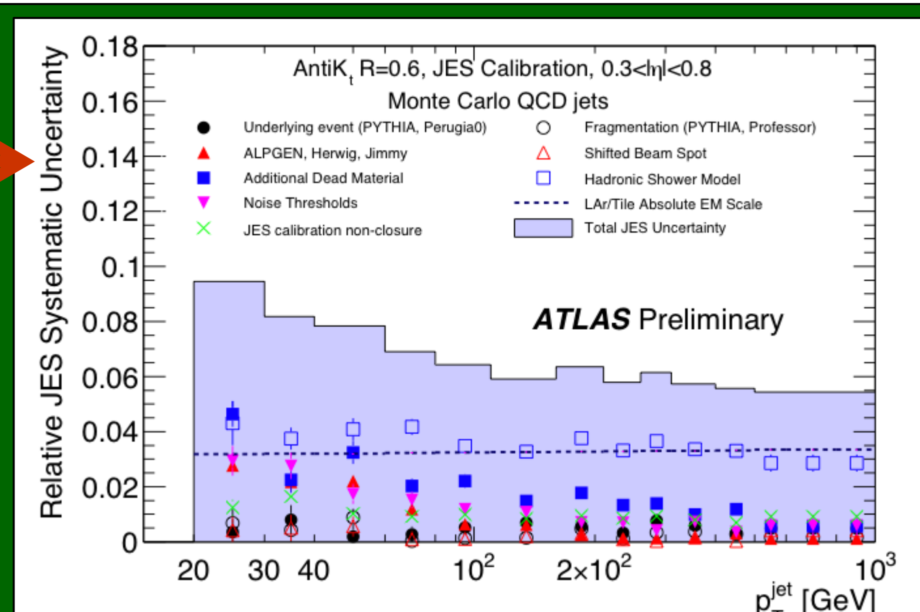
Good agreement data-NLO QCD over 5 orders of magnitude

Jet Energy Scale uncertainty

Dominant uncertainty on jet cross-section measurement

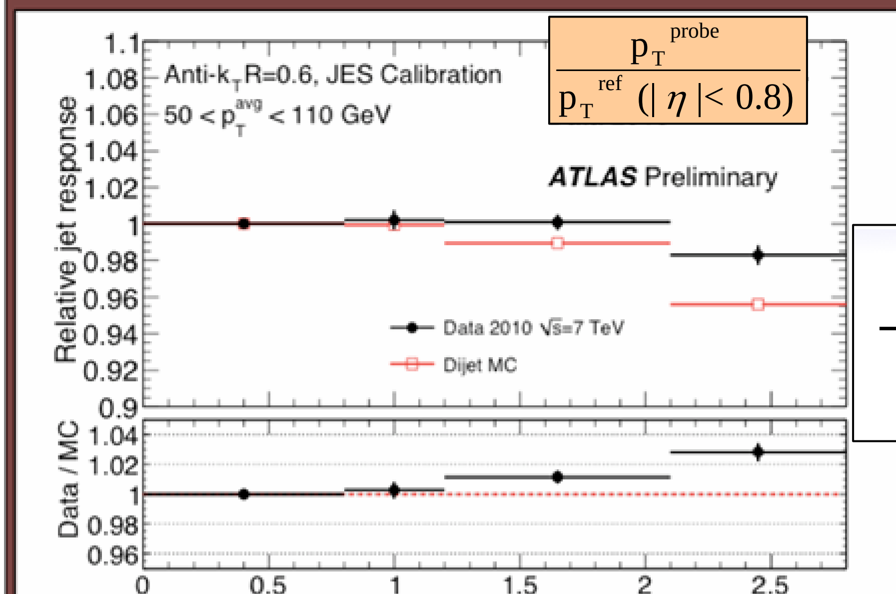
Jet momenta corrected (for calorimeter non-compensation, material, etc.) using η/p_T dependent calibration factors derived from MC (need ~ 1 pb^{-1} for precise in-situ γj balance)

- Builds on detailed foundation work to understand main ingredients by comparing MC/data
- Many sources of systematic uncertainties studied in detail

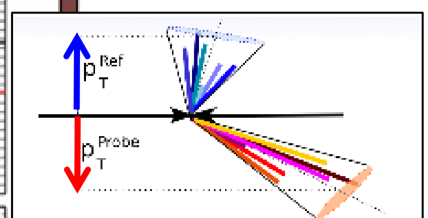


ATLAS-CONF-2010-056

Inter-calibration central-forward checked using jet p_T-balance



ATLAS-CONF-2010-056



Today JES known to : ~ 7%

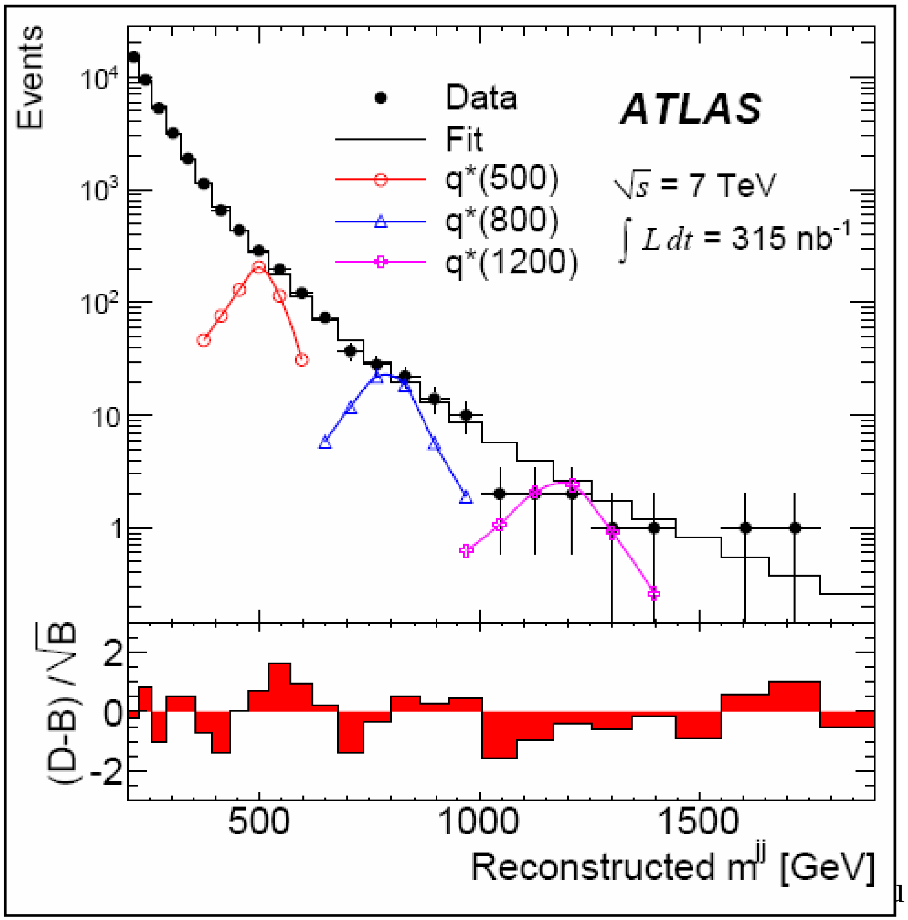
Ultimate goal: ~1%

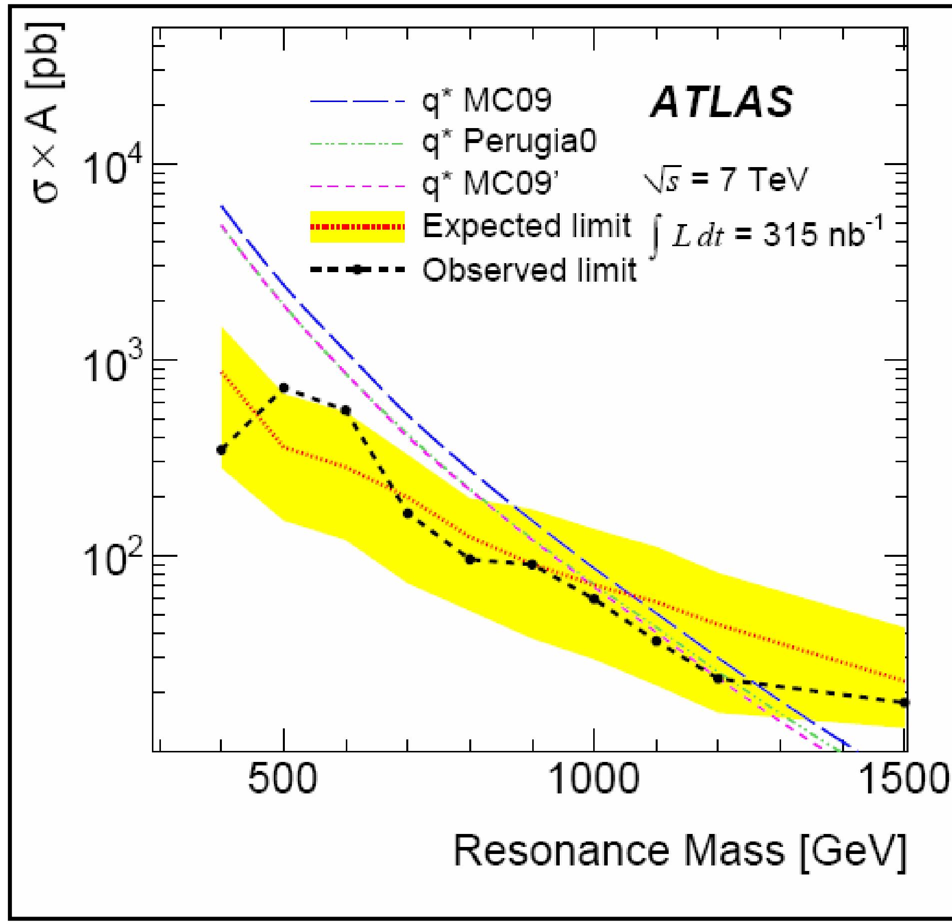
Search for new particles in Two-Jet Final States

limit on q* mass **0.4 < m(q*) <1.26 TeV**

limit better than Tevatron (0.87 TeV)

arXiv:1008.2461

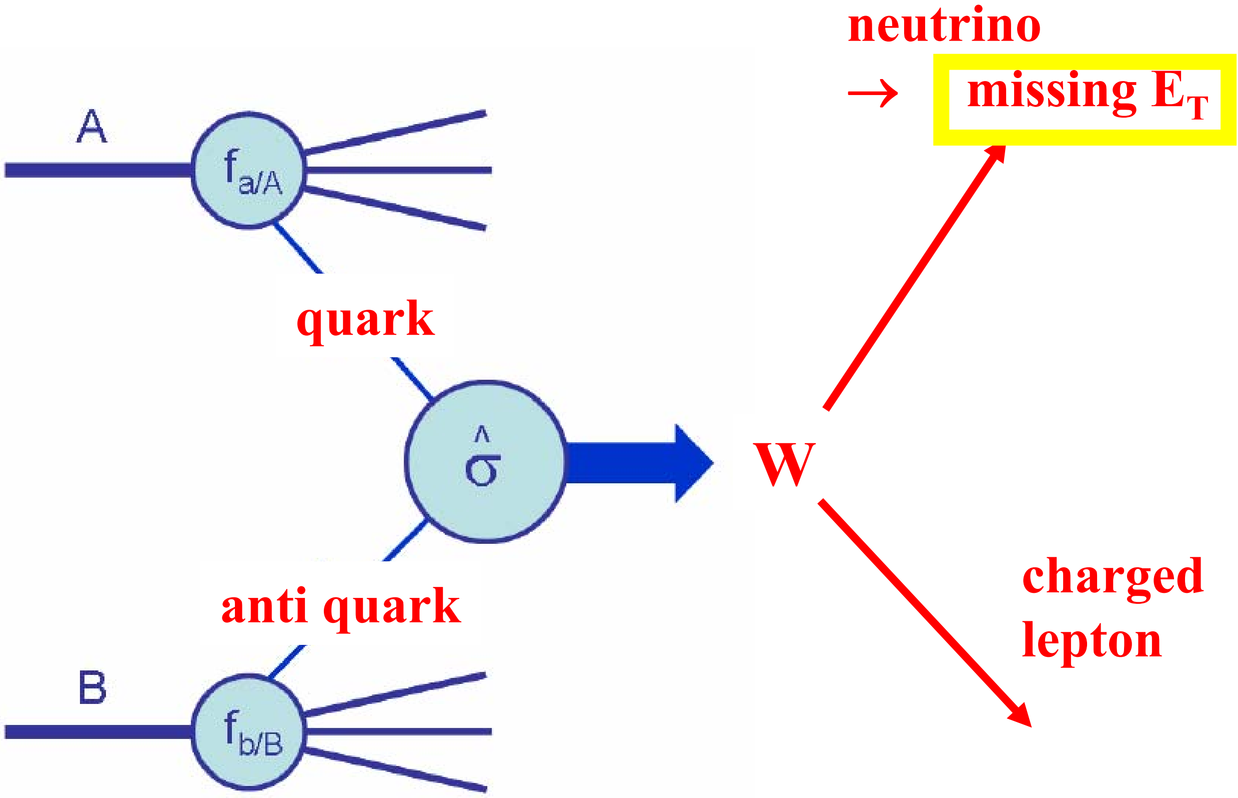




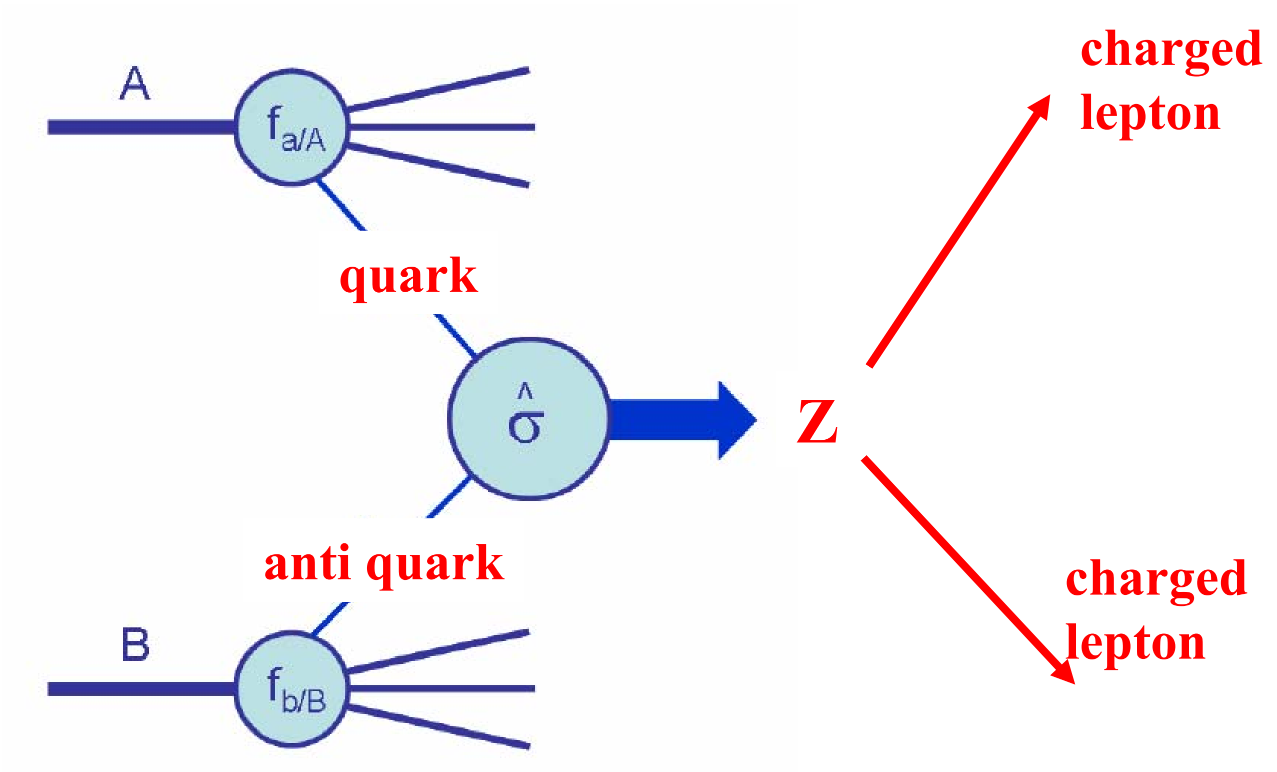
W and Z Physics

- Powerful tool to constain parton distributions
- Will be one of the dominant background of new physics
- Very important for calibration of the detector

I will present first what was shown at ICHEP and then show updates



M(W) ~ 80.4 GeV


A
$f_{a/A}$
quark
$\hat{\sigma}$
Z
charged
lepton
anti quark
B
$f_{b/B}$
charged
lepton

M(Z) ~ 91.2 GeV

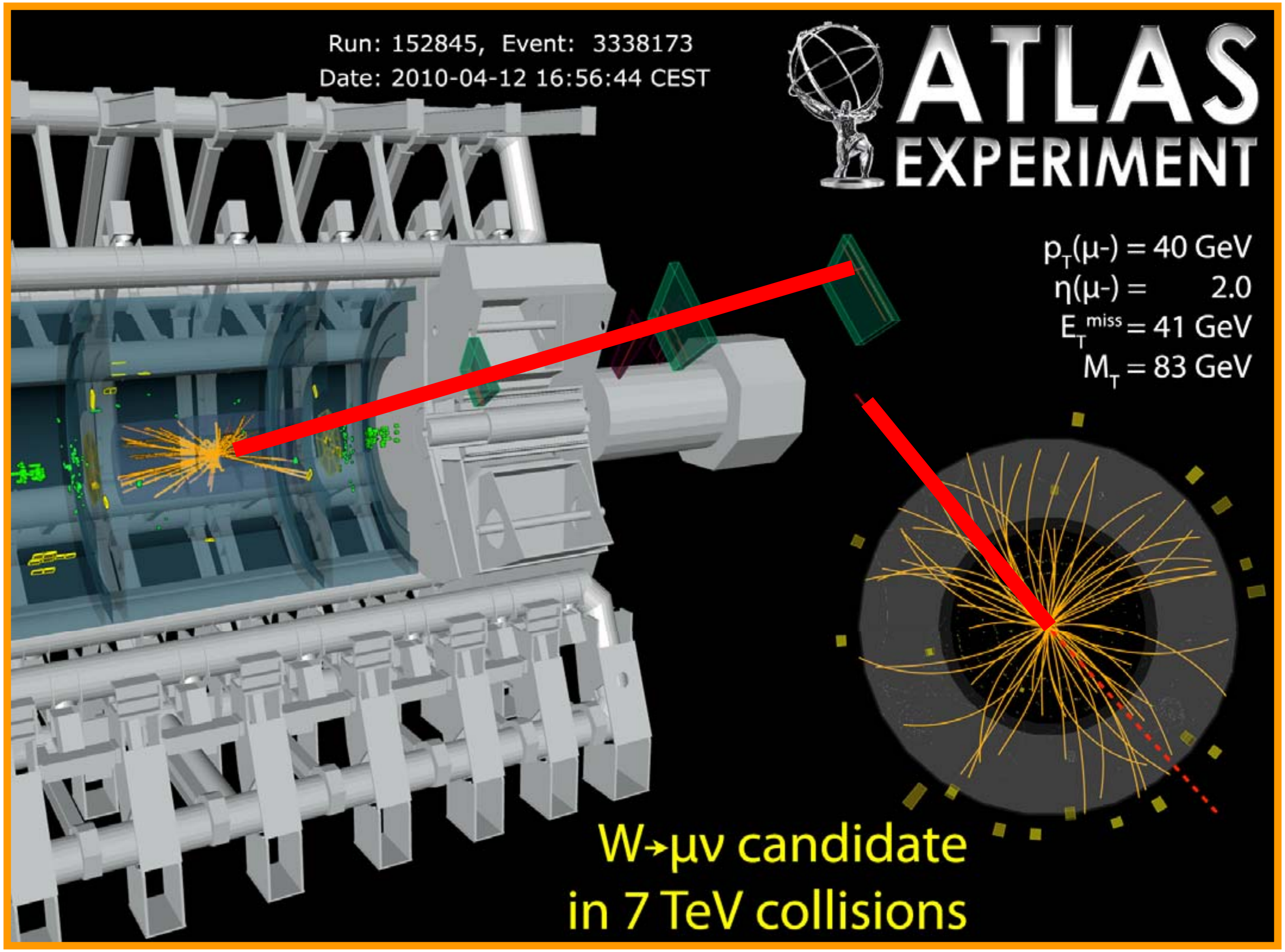
Muon:

3 Pixel, 8 SCT, 17 TRT, 14 MDT hits

Z~0.1 mm from vertex

ID-MS matching within 1 GeV

E_T^{miss} (calorimeter only) ~ 3 GeV



$W \rightarrow e\nu$, $\mu\nu$ measurements

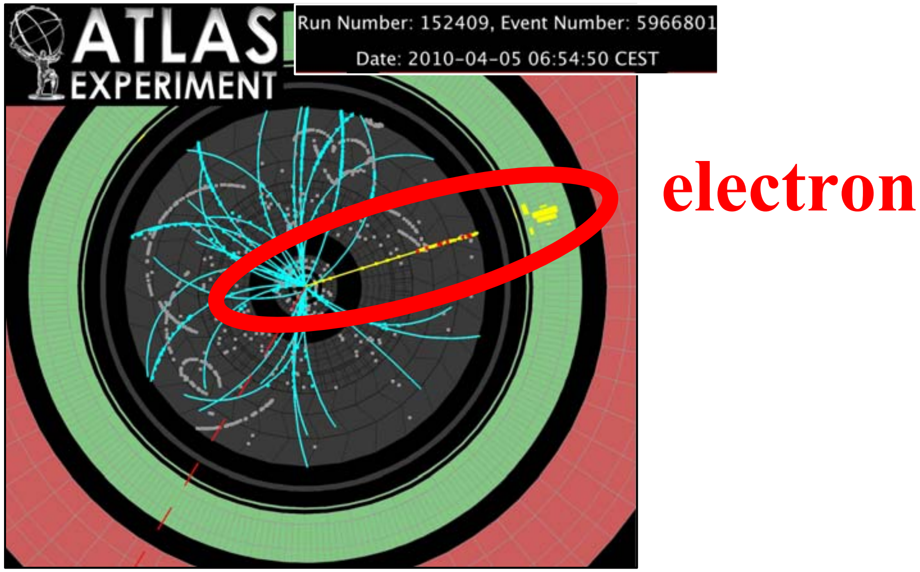
$\sigma^{NNLO}(W \rightarrow l\nu)$ = 10.46 nb per family

Main selections : $W \rightarrow e\nu$
- ❑ $E_T(e) > 20$ GeV, $|\eta|<2.47$
- ❑ tight electron identification criteria
- ❑ $E_T^{miss} > 25$ GeV
- ❑ transverse mass $m_T > 40$ GeV

Acceptance x efficiency : ~ 30%
Main background: QCD jets
Expected S/B: ~ 20

Main selections : $W \rightarrow \mu\nu$
- ❑ $p_T(\mu) > 20$ GeV, $|\eta|<2.4$
- ❑ $|\Delta p_T$ (ID-MS)$| < 15$ GeV
- ❑ isolated; $|Z_\mu - Z_{vtx}|<1$ cm
- ❑ $E_T^{miss} > 25$ GeV
- ❑ transverse mass $m_T > 40$ GeV

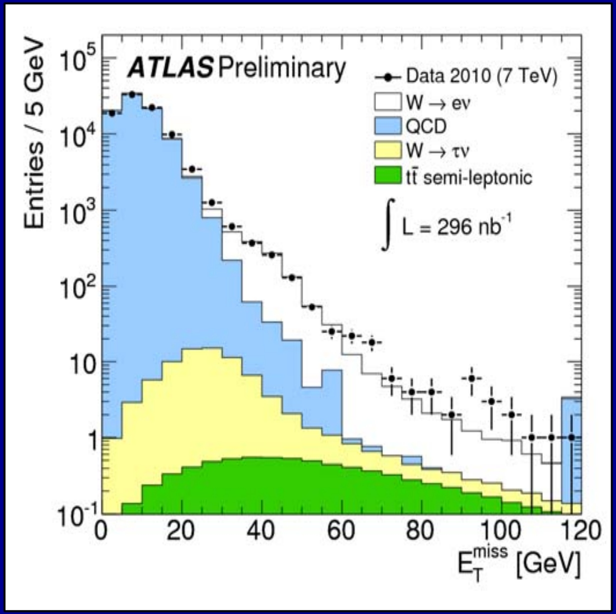
Acceptance x efficiency: ~ 40%
Main background: $Z \rightarrow \mu\mu$ and QCD
Expected S/B ~ 20

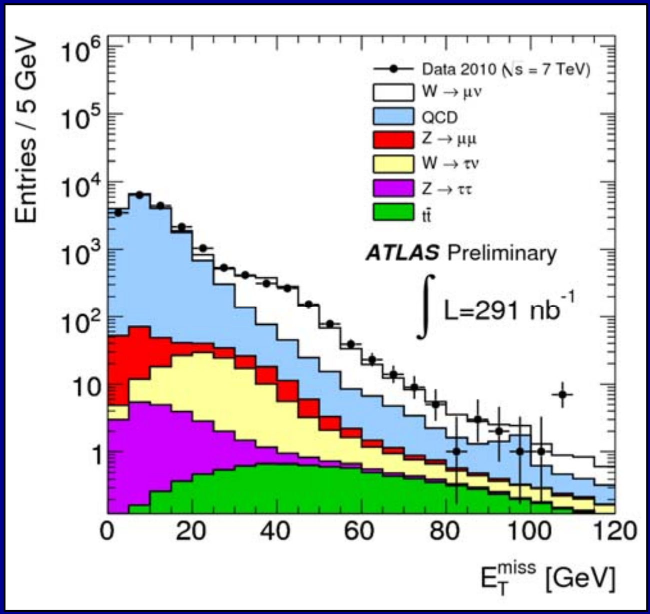


QCD background estimation: several methods used, mostly data-driven: based on control-samples in background-enhanced regions (low E_T^{miss}, non-isolated leptons, …).
Main uncertainties from low-statistics of data control samples and MC model (Pythia)

After pre-selection:

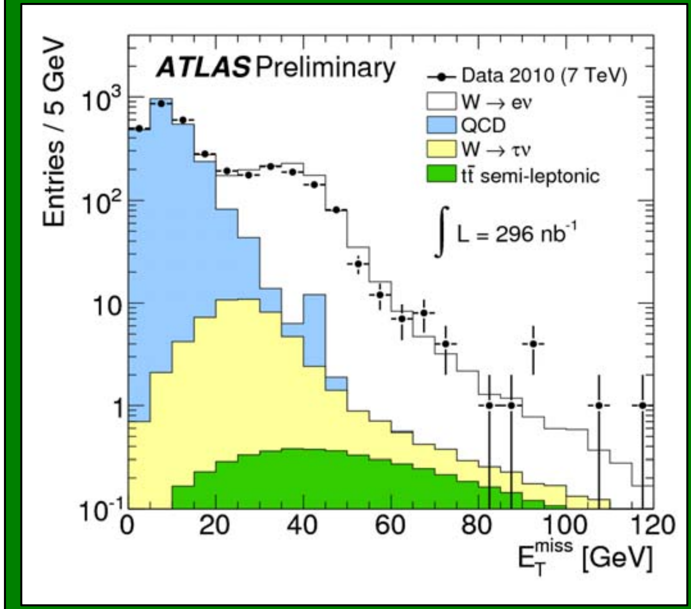
- $W \rightarrow e\nu$:
  loose $e^{\pm}$, E_T > 20 GeV
- $W \rightarrow \mu\nu$:
  $p_T(\mu)$> 15 GeV
  $|\Delta p_T(\text{ID-MS})|$ < 15 GeV
  $|Z_\mu - Z_{vtx}|$<1 cm

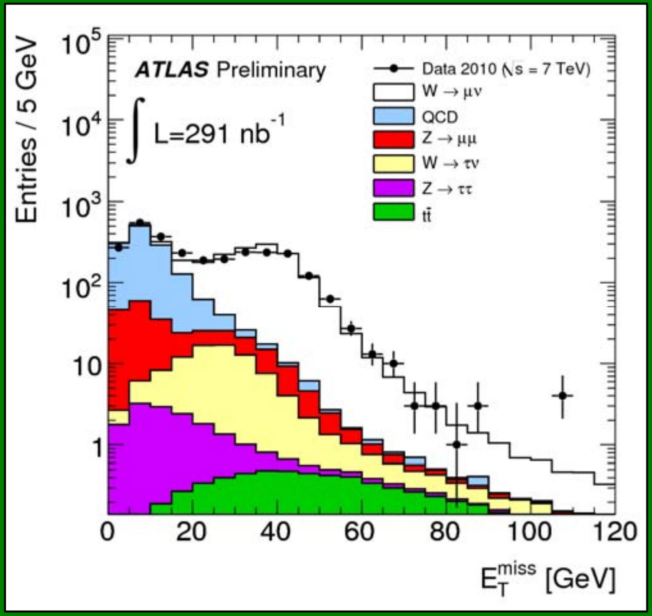




MC normalised to data

After all cuts but E_T^{miss} and m_T

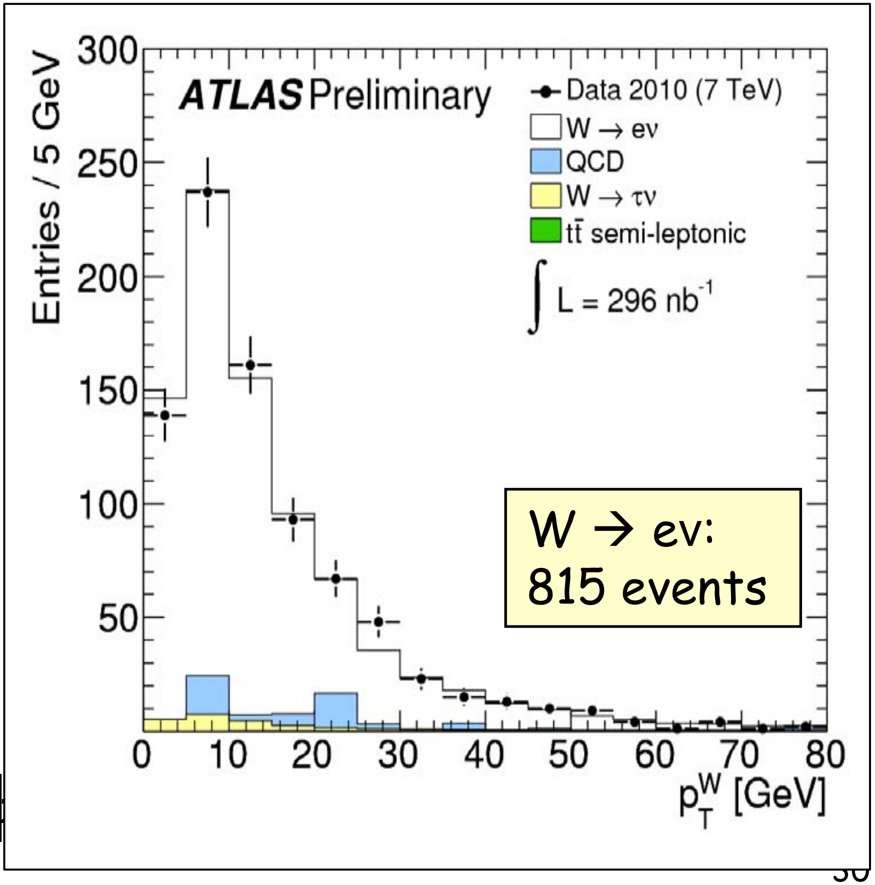




Work to determine systematic uncertainties (ET^{miss}, …) in the presence of pile-up ongoing
→W cross-section measurements presented here are based on first 17 nb-1 (recorded at lower instantaneous luminosity)

After all selections

Observed in data
W→ eν (296 nb^{-1}): 815 events
W→ μν (291 nb^{-1}): 1111 events



MC normalised to data

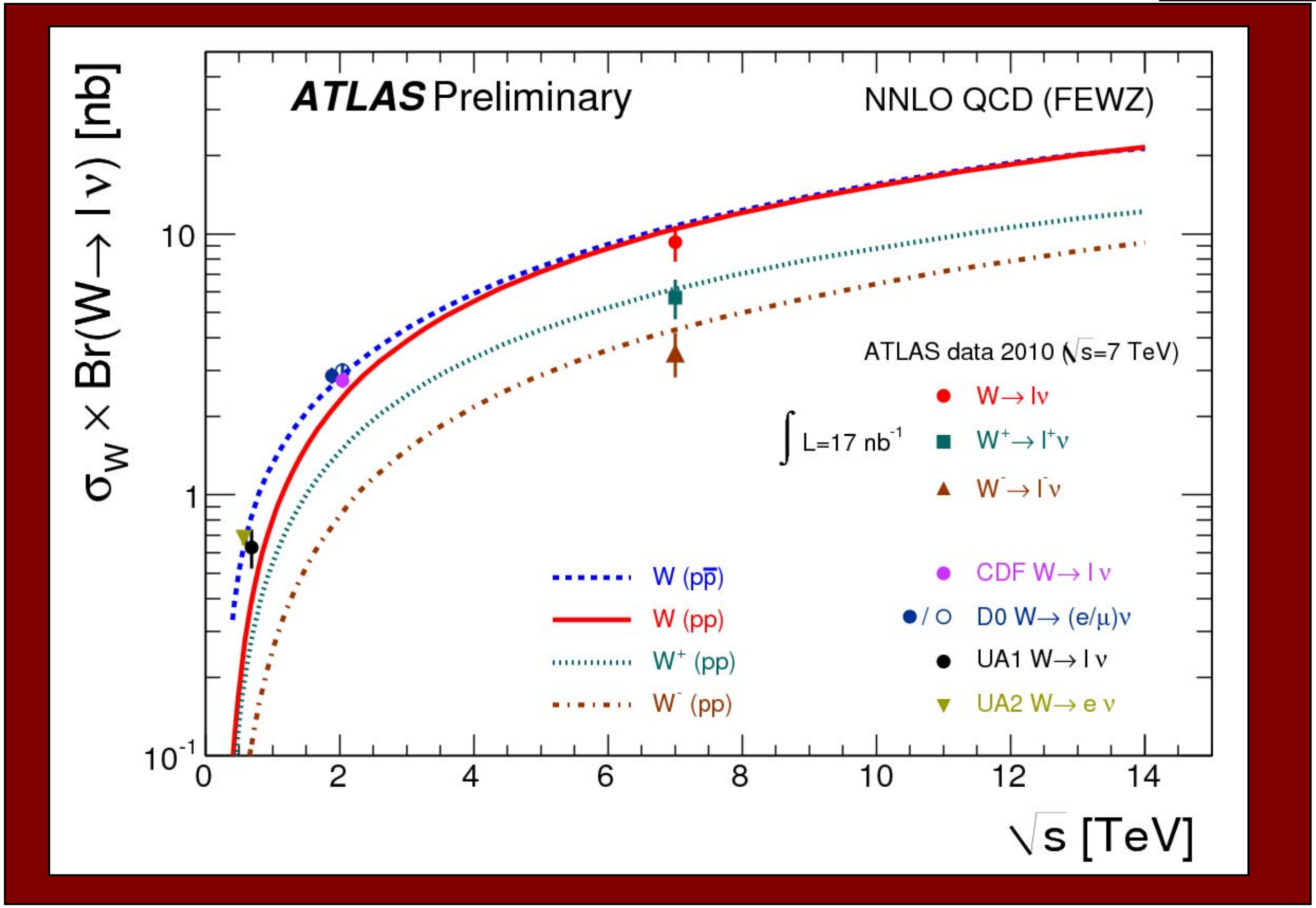
W cross-section and asymmetry measurements

118 events:
47 W→ eν
72 W→ μν

σ (W → lν) = 9.3 ± 0.9 (stat) ± 0.6 (syst) ± 1.0 (lumi) nb

σ (W → eν) = 8.5 ± 1.3 (stat) ± 0.7 (syst) ± 0.9 (lumi) nb
σ (W → μν) = 10.3 ± 1.3 (stat) ± 0.8 (syst) ± 1.1 (lumi) nb

Dominant experimental uncertainties:
e: identification efficiency
μ: trigger and reconstruction efficiency



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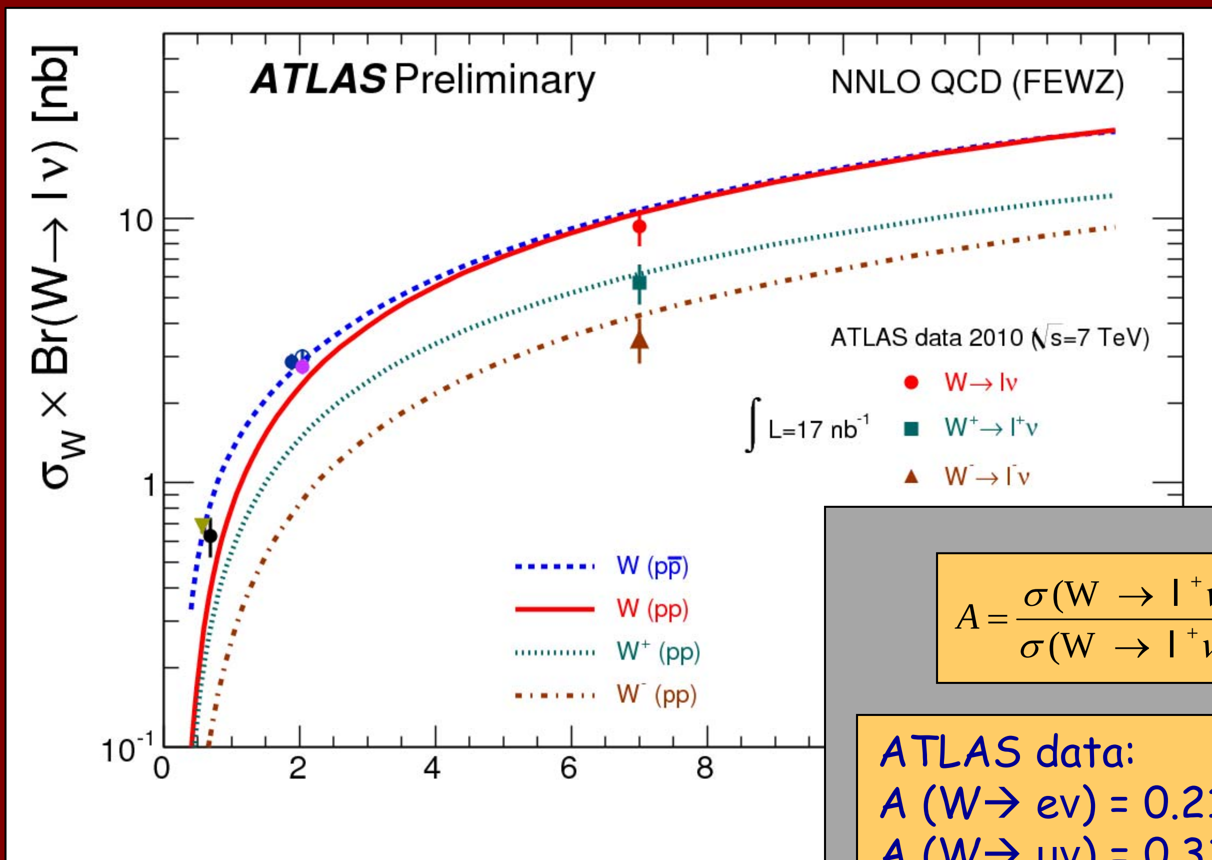


$$A = \frac{\sigma(W \to l^+\nu) - \sigma(W \to l^-\nu)}{\sigma(W \to l^+\nu) + \sigma(W \to l^-\nu)} \neq 0$$

ATLAS data:
A (W→ eν) = 0.21 ± 0.18 (stat) ± 0.01 (syst)
A (W→ μν) = 0.33 ± 0.12 (stat) ± 0.01 (syst)
NNLO theory prediction: A=0.2

$Z \rightarrow ee, \mu\mu$ measurements

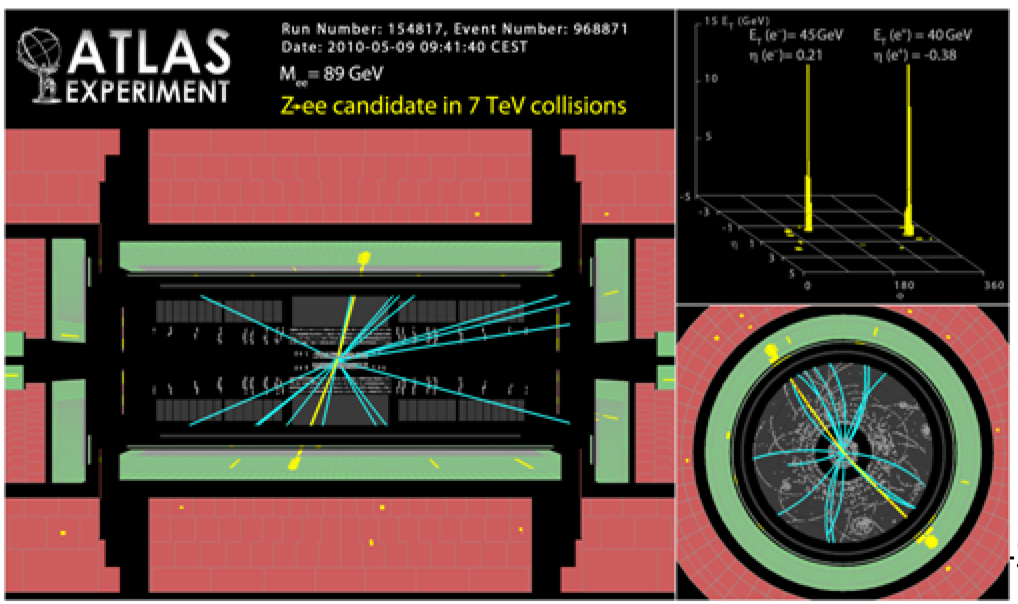
$\sigma^{NNLO}(\gamma^*/Z \rightarrow ll) \sim 0.99$ nb per family for $M(ll) > 60$ GeV

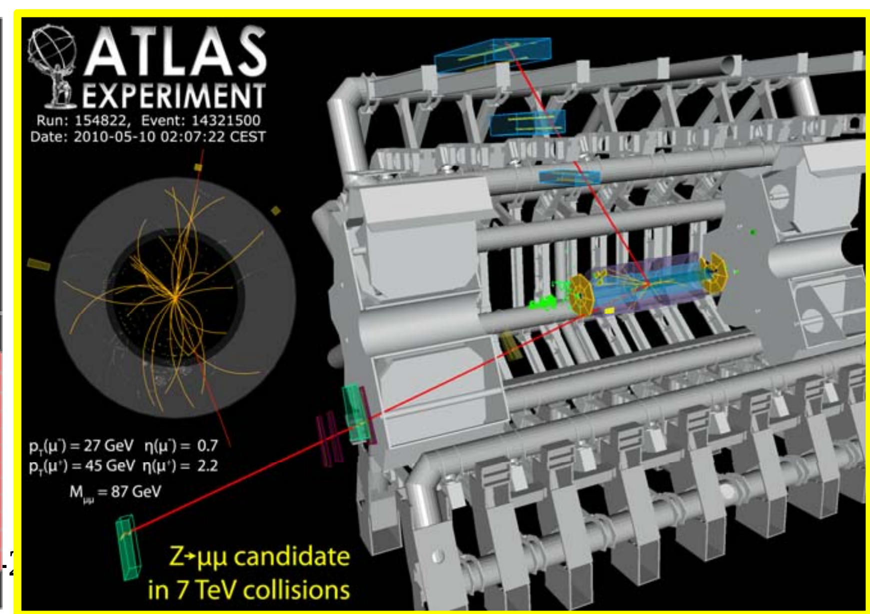
Main selections : $Z \rightarrow ee$
- 2 opposite-sign electrons
- $E_T > 20$ GeV, $|\eta|<2.47$
- medium electron identification criteria
- $66 < M(e^+e^-) < 116$ GeV

Acceptance x efficiency : ~ 30%
Main background: QCD jets
Expected S/B ~ 100

Main selections : $Z \rightarrow \mu\mu$
- 2 opposite-sign muons
- $p_T > 20$ GeV, $|\eta|<2.4$
- $|\Delta p_T$ (ID-MS)$| < 15$ GeV
- isolated; $|Z_\mu - Z_{vtx}|<1$ cm
- $66 < M(\mu^+\mu^-) < 116$ GeV

Acceptance x efficiency: ~ 40%
Main background: $t\bar{t}$, $Z \rightarrow \tau\tau$
Expected S/B > 100

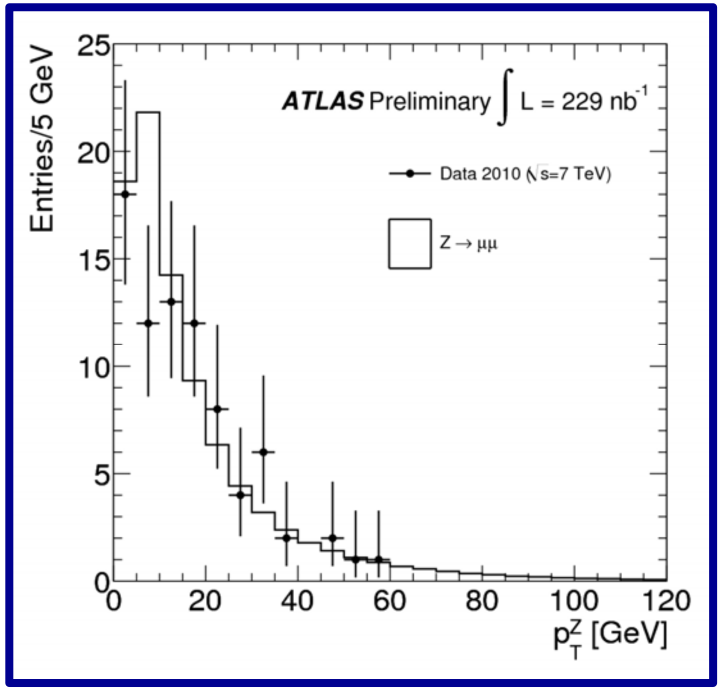


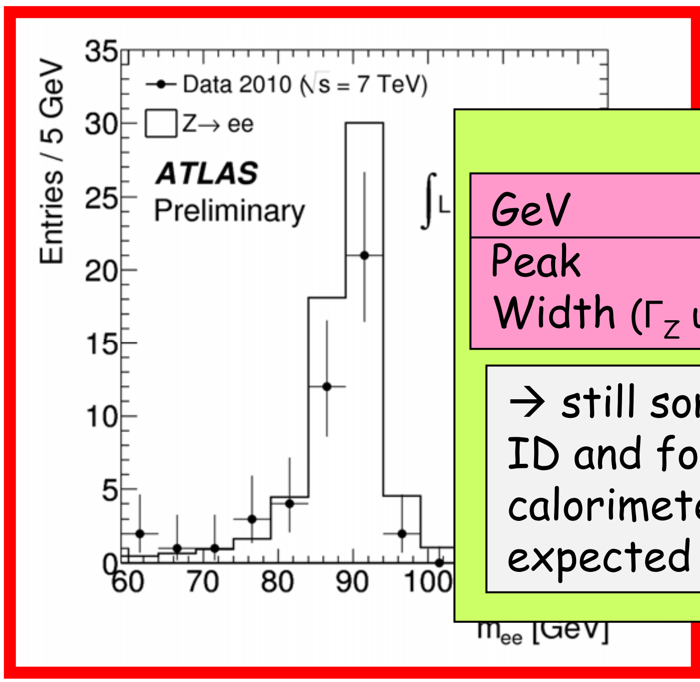


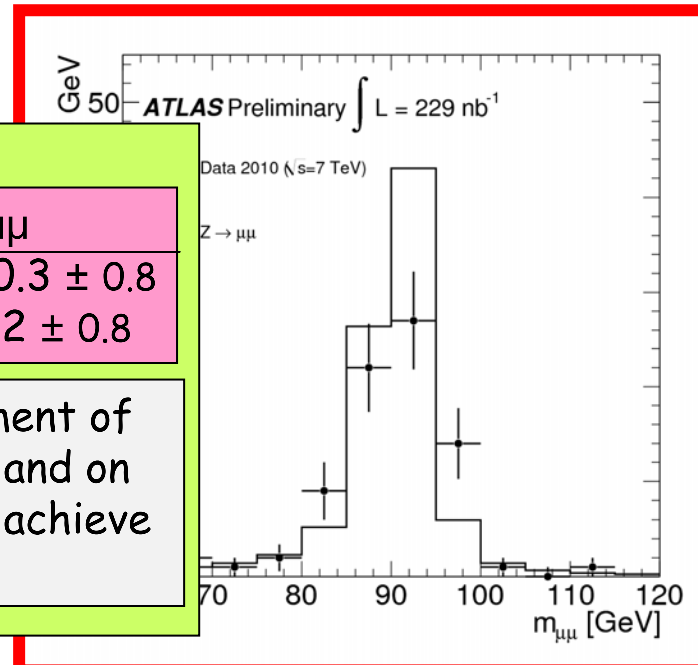
After all selections, observed in data

$Z \rightarrow ee$ (219 nb^{-1}): 46 events

$Z \rightarrow \mu\mu$ (229 nb^{-1}): 79 events







GeV	ee	μμ
Peak	88.7± 0.8	90.3 ± 0.8
Width (Γ_Z unfolded)	3.6 ± 0.8	4.2 ± 0.8

→ still some work to do on alignment of ID and forward muon chambers, and on calorimeter inter-calibration, to achieve expected resolution

Z cross-section measurement

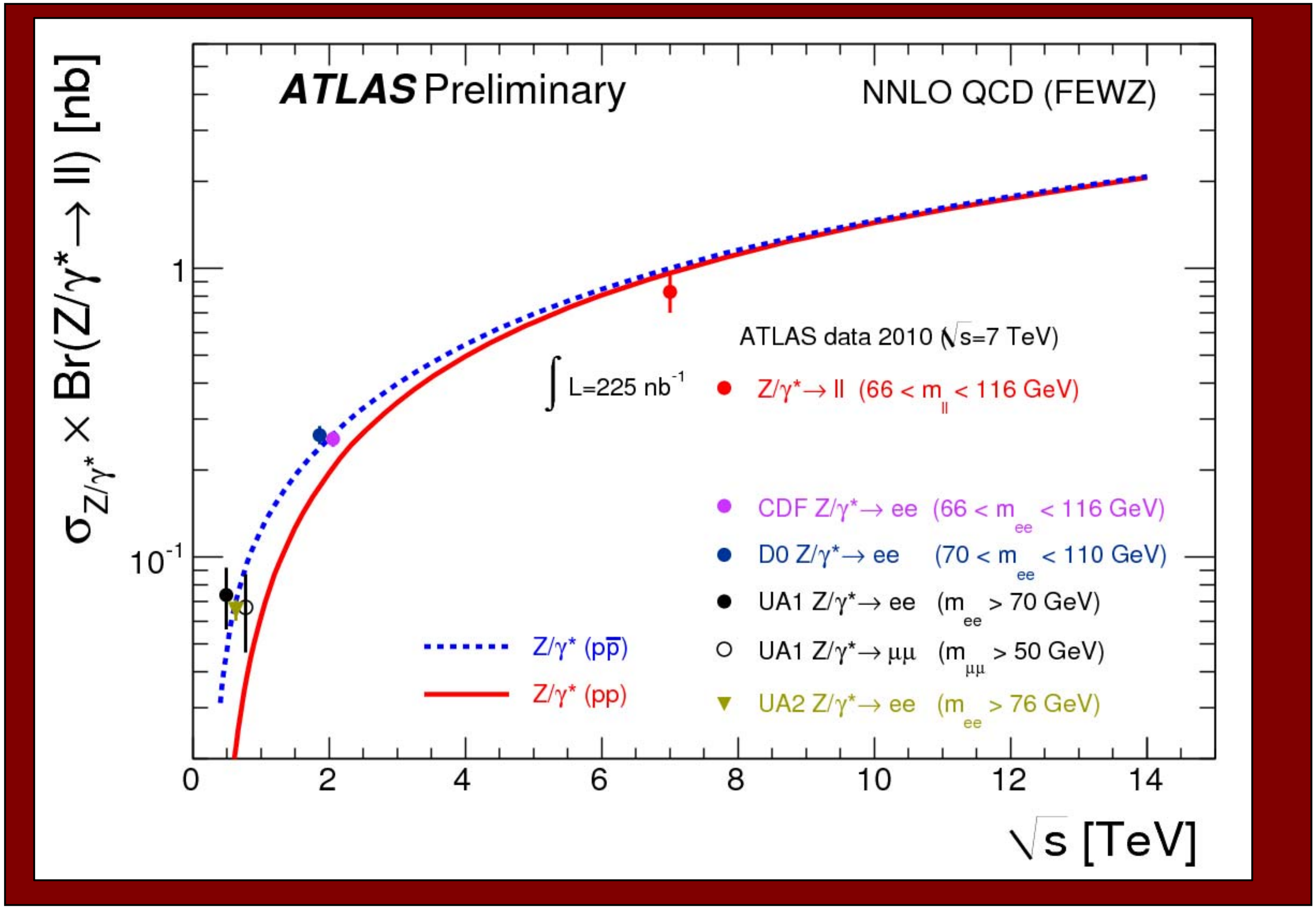
~225 nb^{-1}

$\sigma(Z \to ll) = 0.83 \pm 0.07\,(stat) \pm 0.06\,(syst) \pm 0.09\,(lumi)$ nb

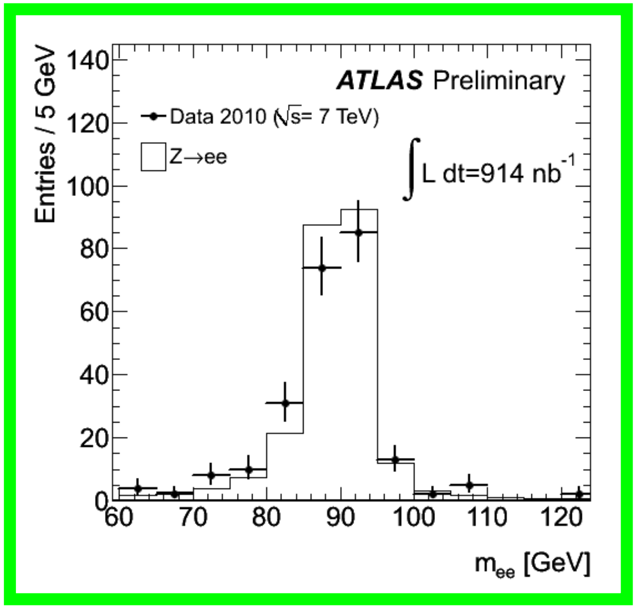
$\sigma(Z \to ee) = 0.72 \pm 0.11\,(stat) \pm 0.10\,(syst) \pm 0.08\,(lumi)$ nb
$\sigma(Z \to \mu\mu) = 0.89 \pm 0.10\,(stat) \pm 0.07\,(syst) \pm 0.10\,(lumi)$ nb

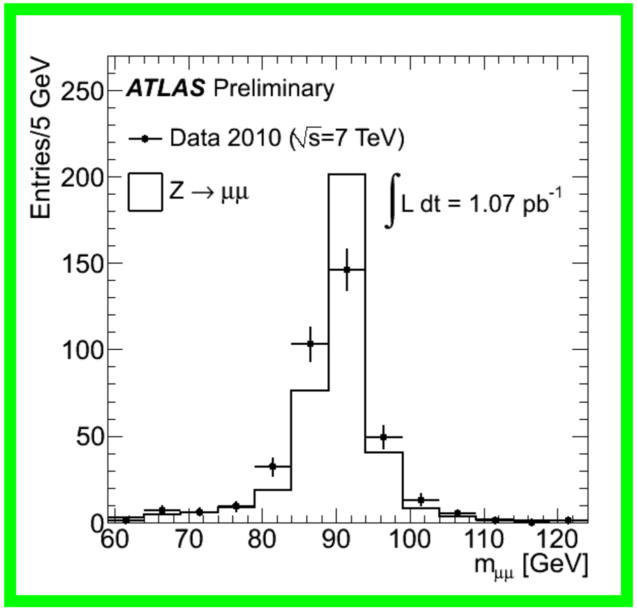
125 events:
46 Z→ ee
79 Z→ μμ

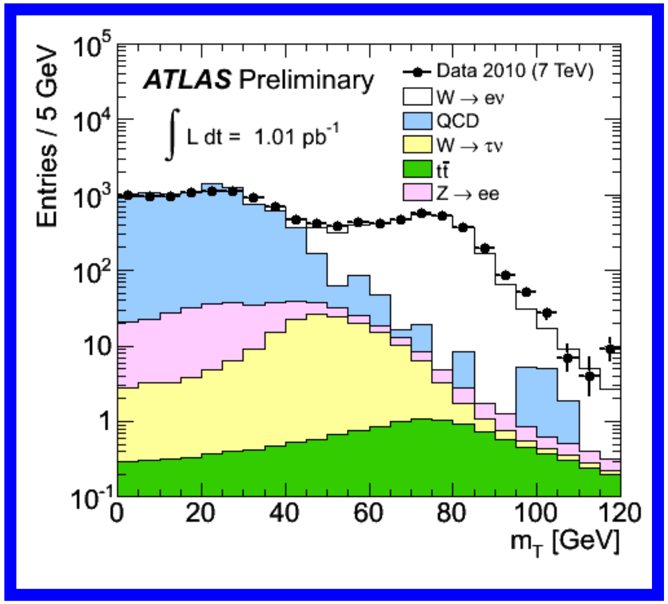
Dominant experimental uncertainty: lepton reconstruction and identification

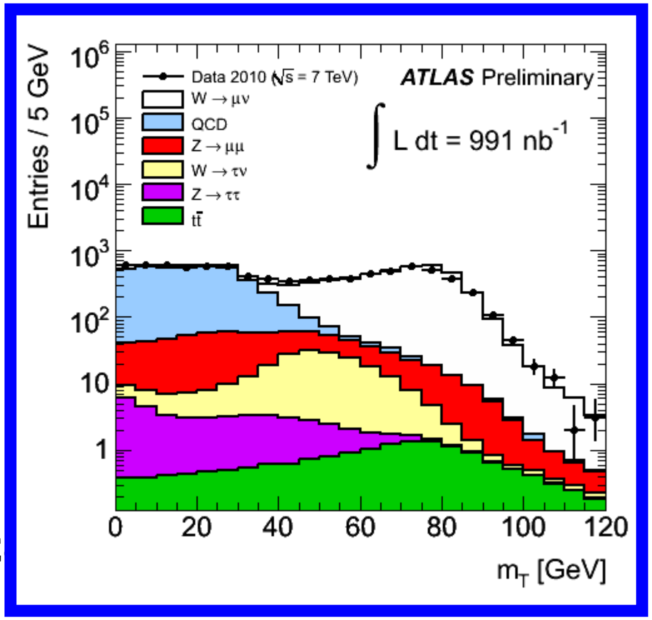


What's new on W,Z since ICHEP ? : more statistics



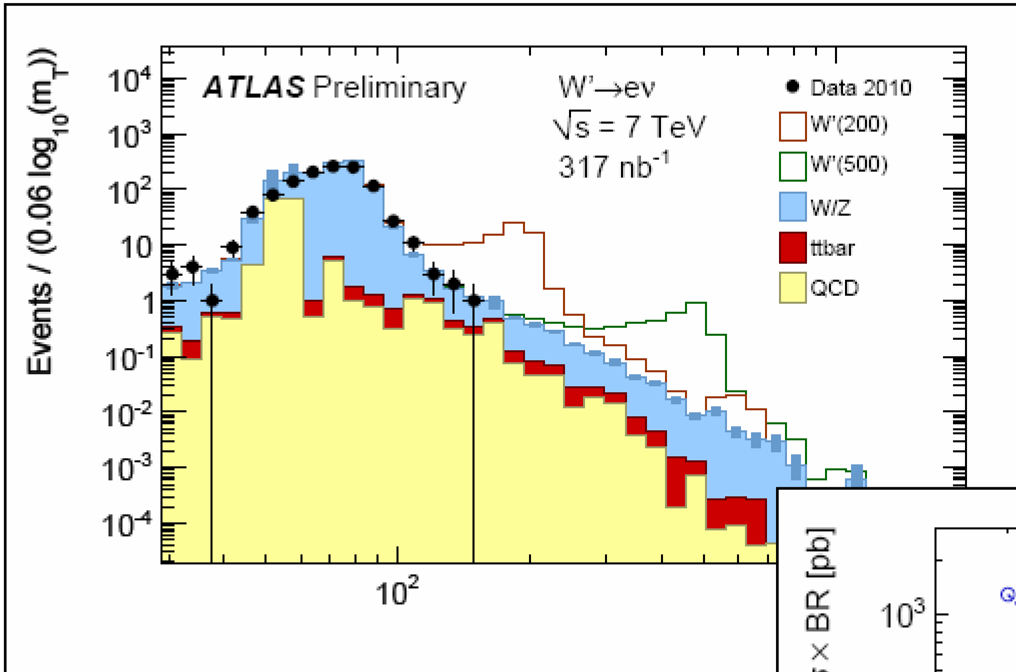


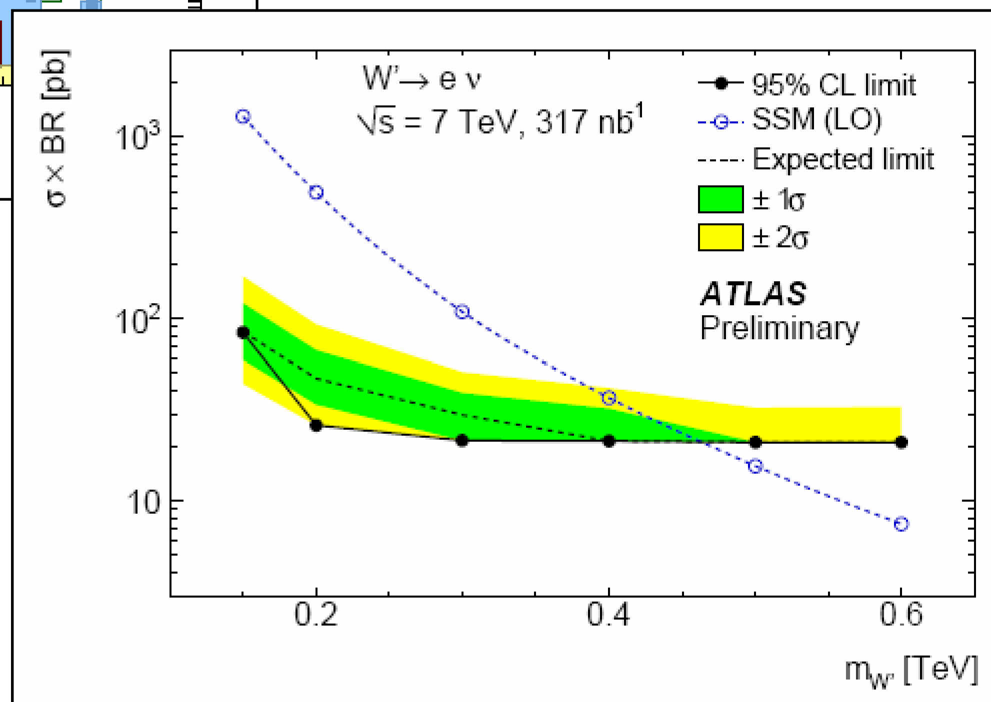




New analysis : search for W' (Sequential Standard Model)

ATLAS-CONF-2010-089

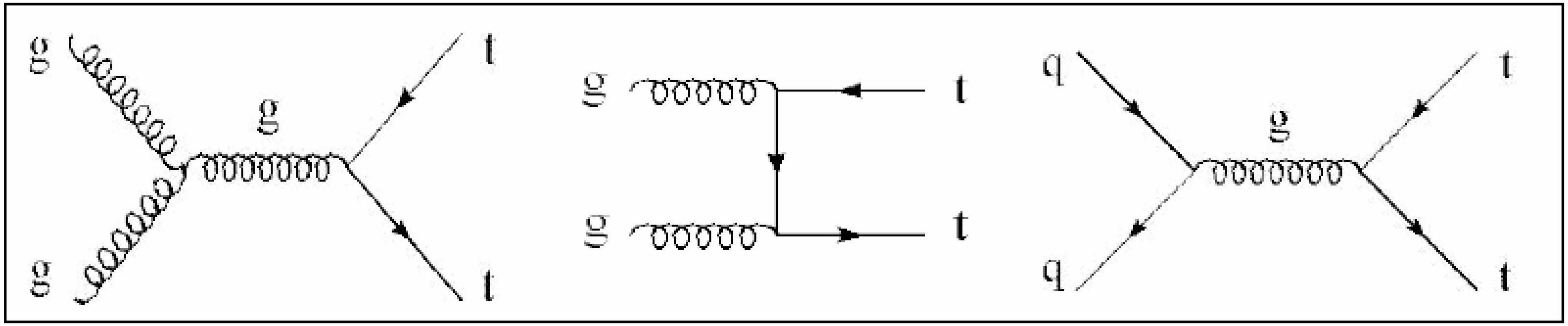


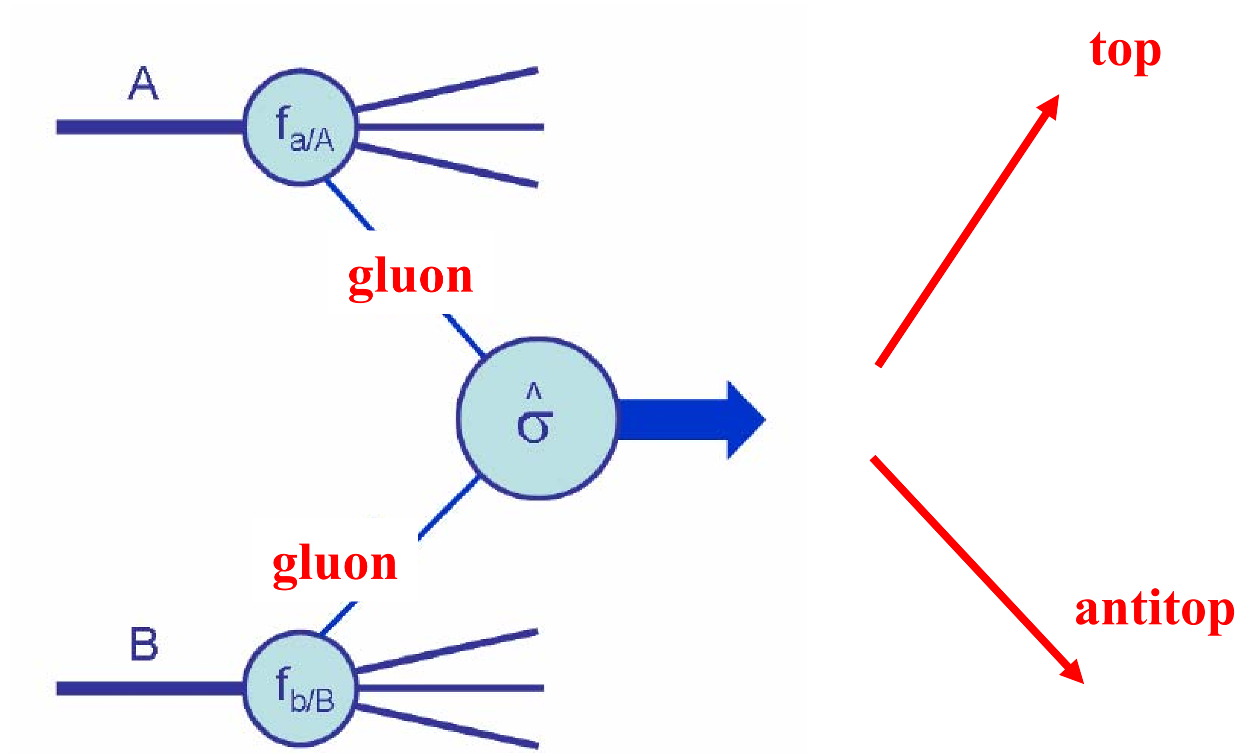


Exclude W' with masses smaller than 465 GeV

soon (with ~ 10 pb^{-1}) we will be able to make limits similar to Tevatron *(~ 1 TeV)*

Leading order diagrams





M(top) ~ 173 GeV

Top-quark candidates

$\sigma(t\bar{t}) \cong 160$ pb $\sqrt{s} = 7$ TeV

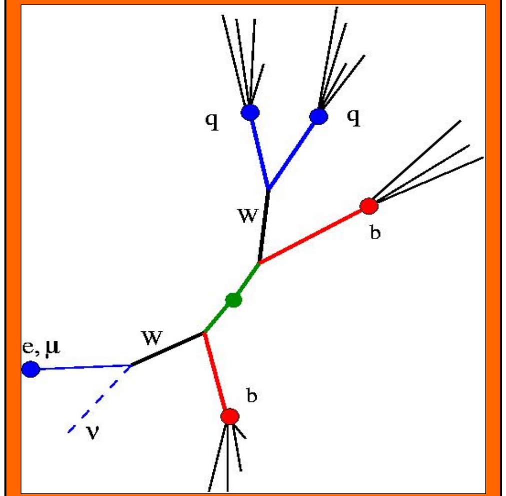
About 300 nb-1 analysed

lepton + jets channel
tt → bW bW → blν bjj
σ ~ 70 pb

1 isolated lepton p_T > 20 GeV
E_T^{miss} > 20 GeV
≥ 4 jets p_T > 20 GeV
≥ 1 b jet

Acceptance x efficiency ~ 30%

Expect ~ 5 signal events



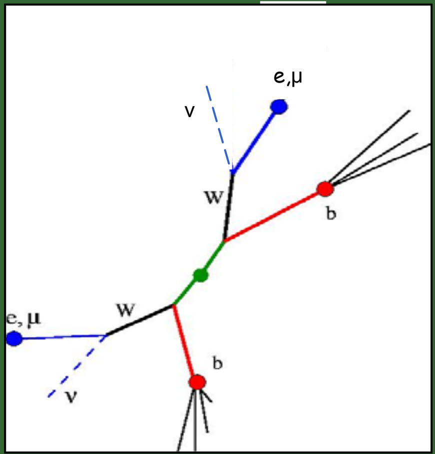
ATLAS-CONF-2010-063

2-lepton channel
tt → bW bW → blν blν
σ ~ 10 pb

2 opposite-sign leptons: ee, eμ, μμ
both leptons p_T > 20 GeV
≥ 2 jets p_T > 20 GeV
ee: E_T^{miss} > 40 GeV $|M(ee)-M_Z|$> 5 GeV
μμ: E_T^{miss} > 30 GeV $|M(\mu\mu)-M_Z|$> 10 GeV
eμ: $H_T = \Sigma E_T$ (leptons, jets) > 150 GeV

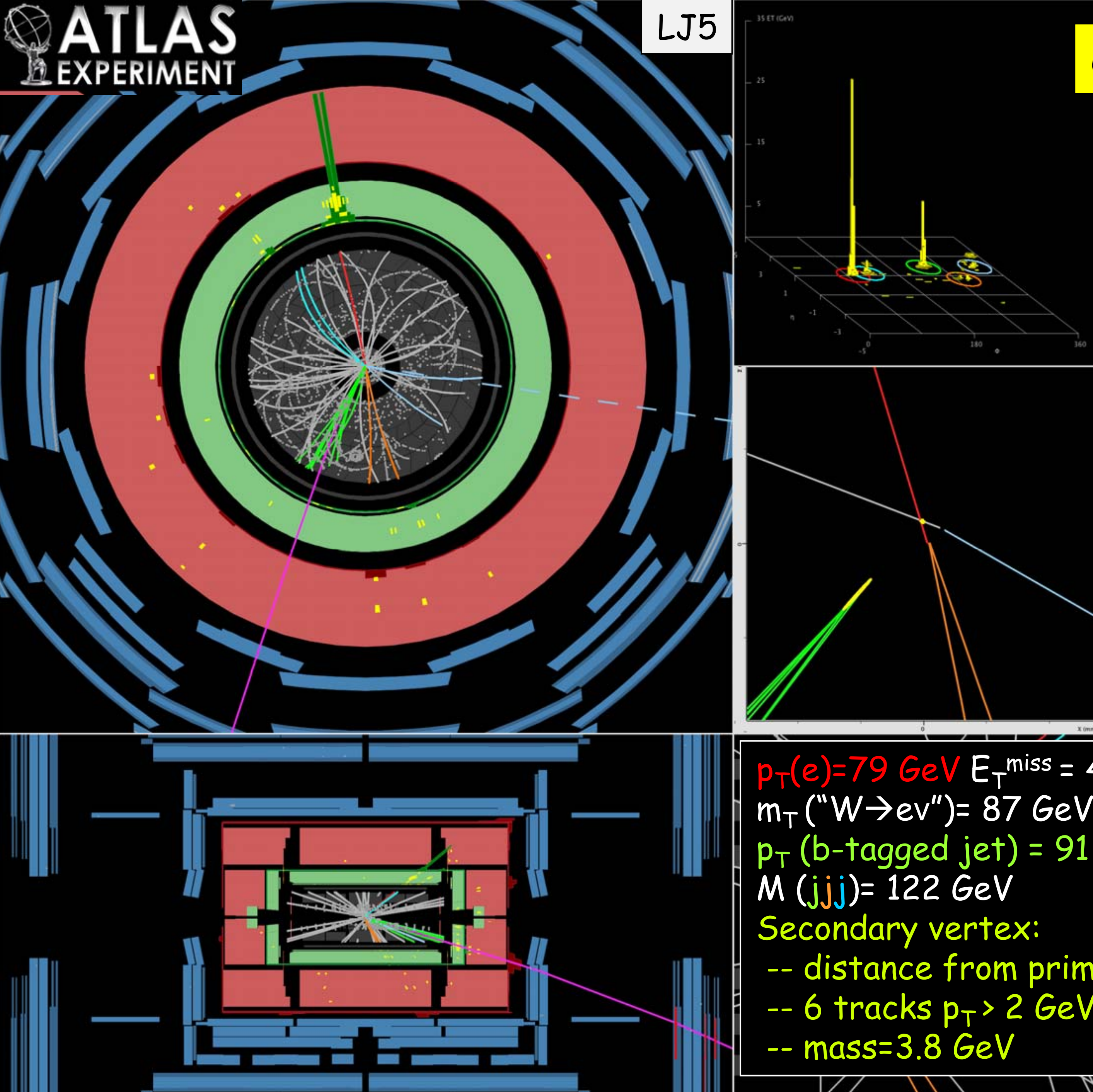
Acceptance x efficiency ~ 25%

Expect ~ 0.7 signal events



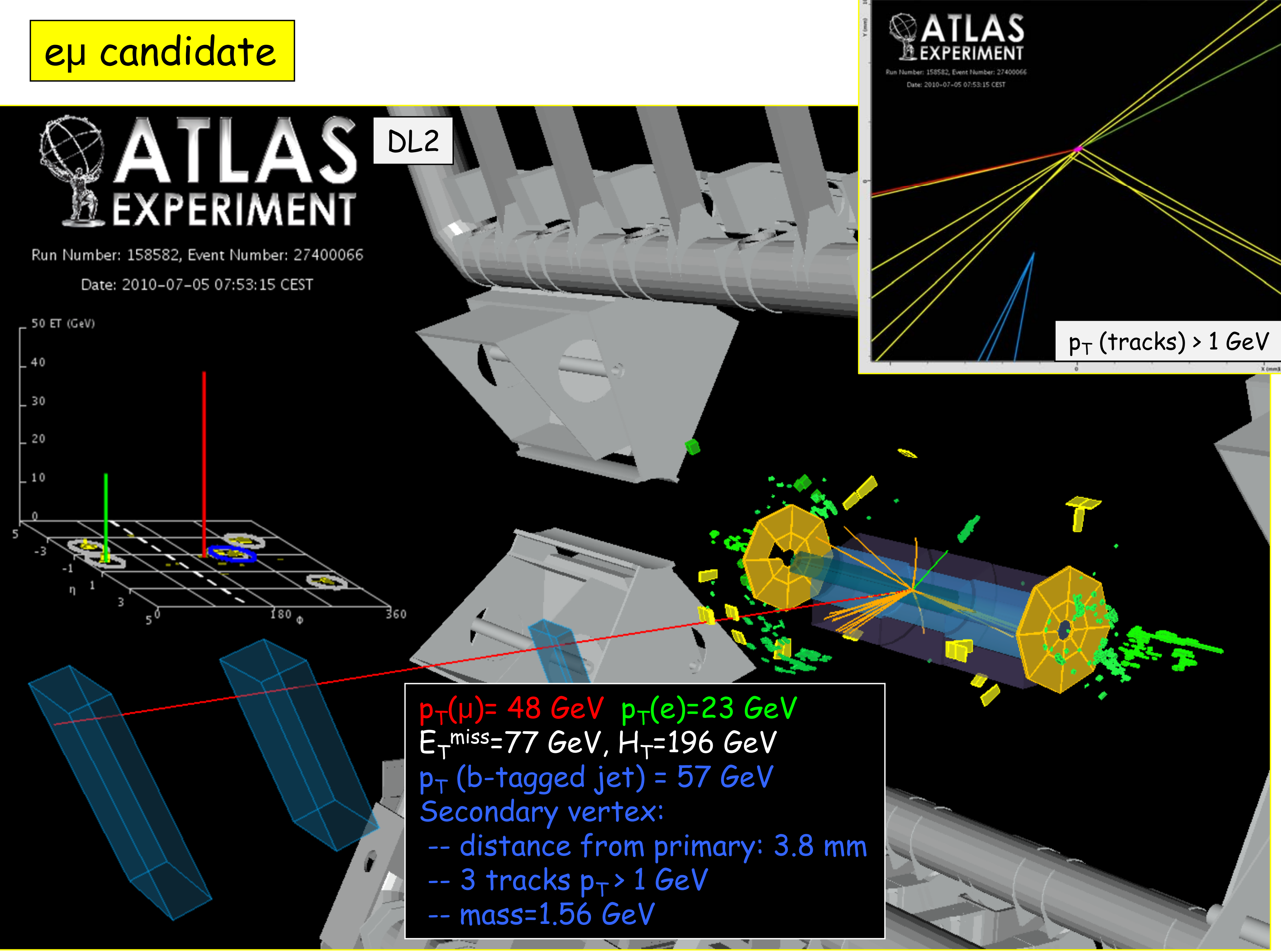
ATLAS-CONF-2010-042

e+jets candidate



$p_T(e)$=79 GeV E_T^{miss} = 43 GeV
m_T ("$W \rightarrow e\nu$")= 87 GeV
p_T (b-tagged jet) = 91 GeV
M (jjj)= 122 GeV
Secondary vertex:
-- distance from primary: 5 mm
-- 6 tracks p_T > 2 GeV
-- mass=3.8 GeV

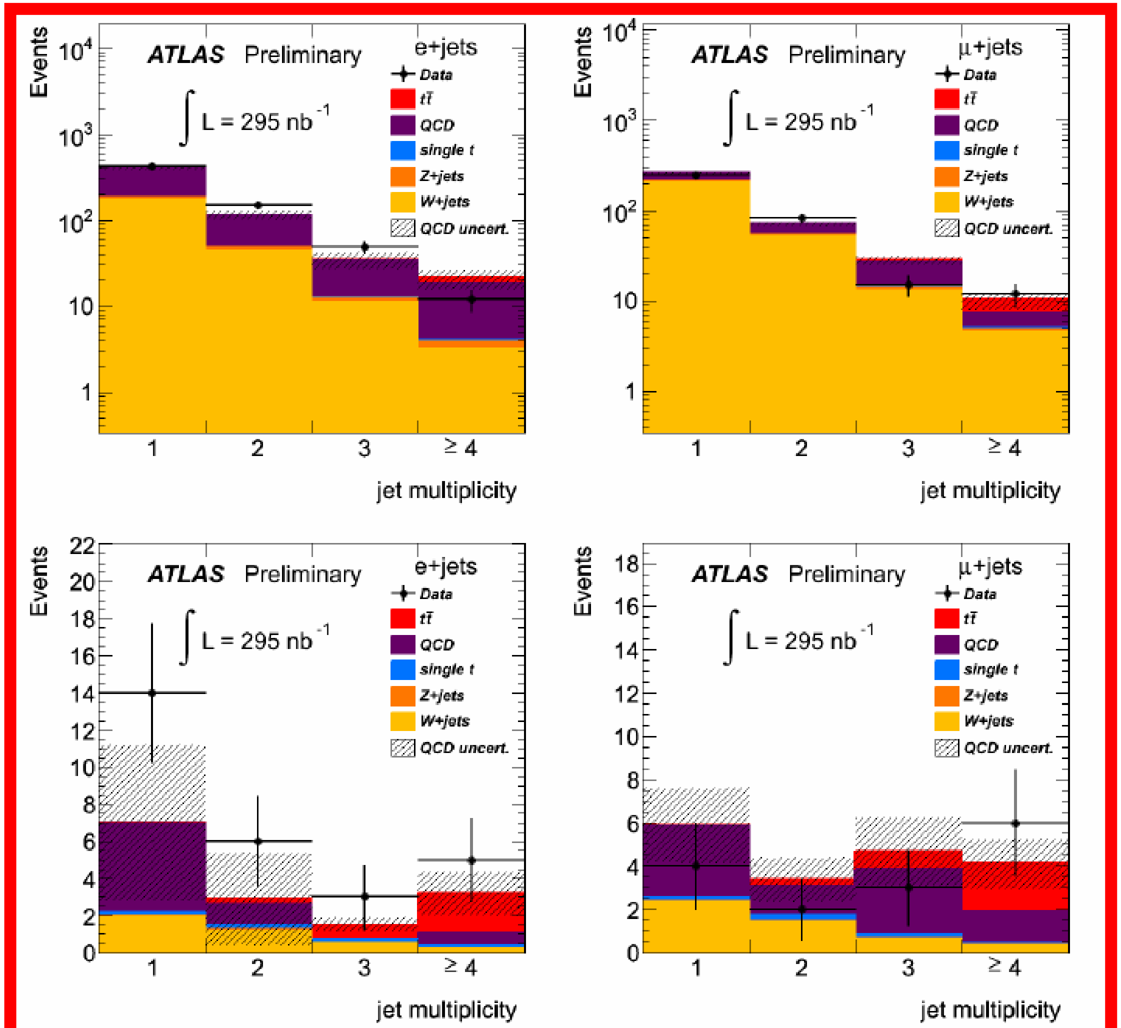
eμ candidate



$p_T(\mu)$= 48 GeV $p_T(e)$=23 GeV
E_T^{miss}=77 GeV, H_T=196 GeV
p_T (b-tagged jet) = 57 GeV
Secondary vertex:
-- distance from primary: 3.8 mm
-- 3 tracks p_T > 1 GeV
-- mass=1.56 GeV

2 e-mu candidates

11 l-jet candidates with ≥ 4 jets and 1 jet b-tagged



b tagging

candidates

Conclusions and prospects on top

All ingredients needed for top physics are available:
leptons, jets, missing ETreconstruction/identification and b-tagging tools are in an advanced commissioning stage. Data/MC is in overall good agreement

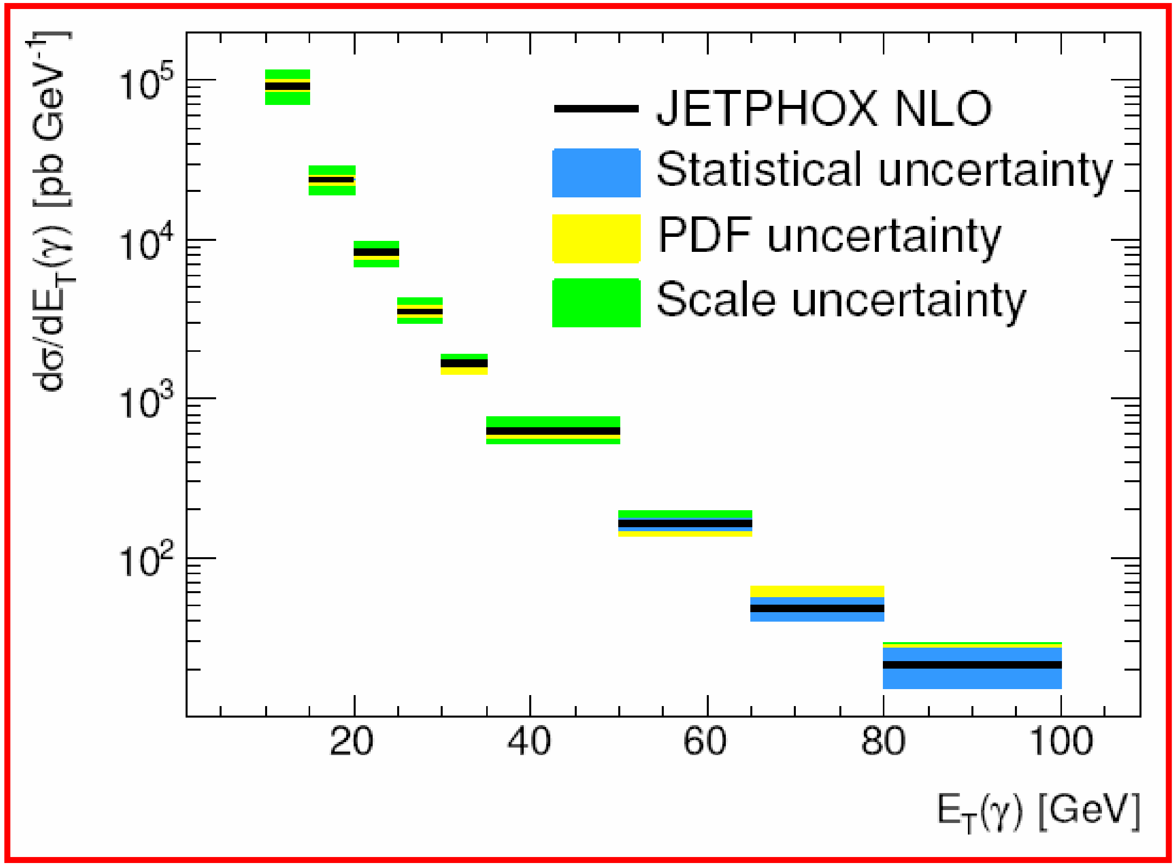
First top candidates have been recorded and more are to come
We were/are ready to catch and analyze them

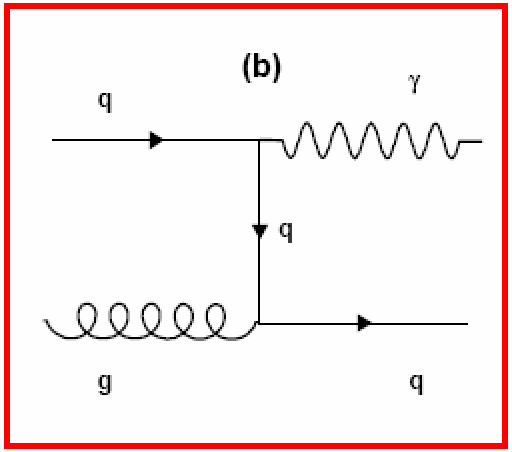
Background determination/studies are ongoing:
QCD data-driven background estimate start to be exercised
Data driven W+jetscontribution requires some more stats
Procedure/analyses are ready and being tested

Larger data samples are required to quantify background to a level that can support a conclusive top quark observation in ATLAS…
…a new top-quark physics era is just around the corner

Study of photons

- *useful 'per se' QCD ….*
- *very important later for Higgs searches ($H\to\gamma\gamma$)*



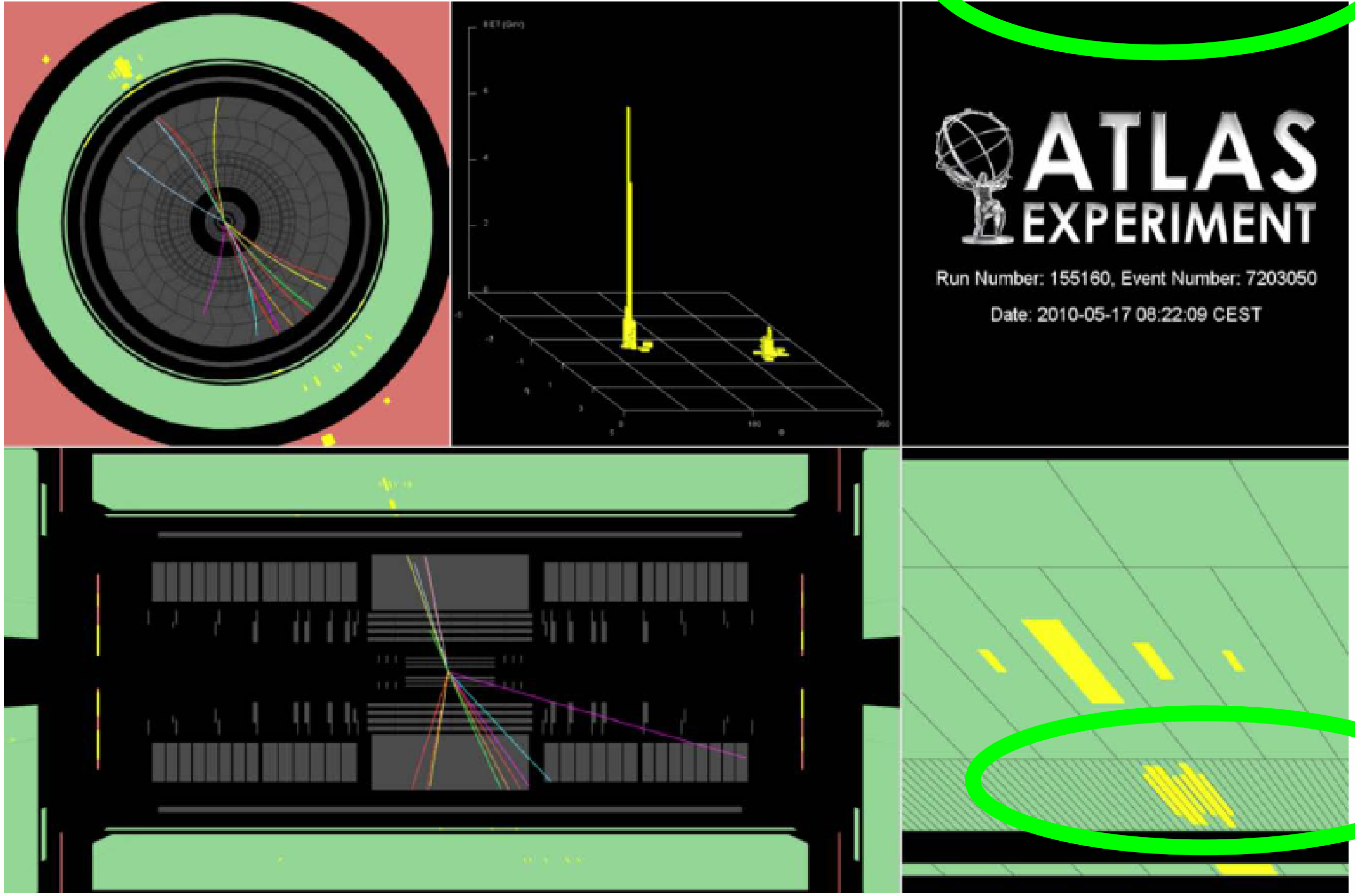


ATLAS-CONF-2010-077

Photon identification with shower shapes

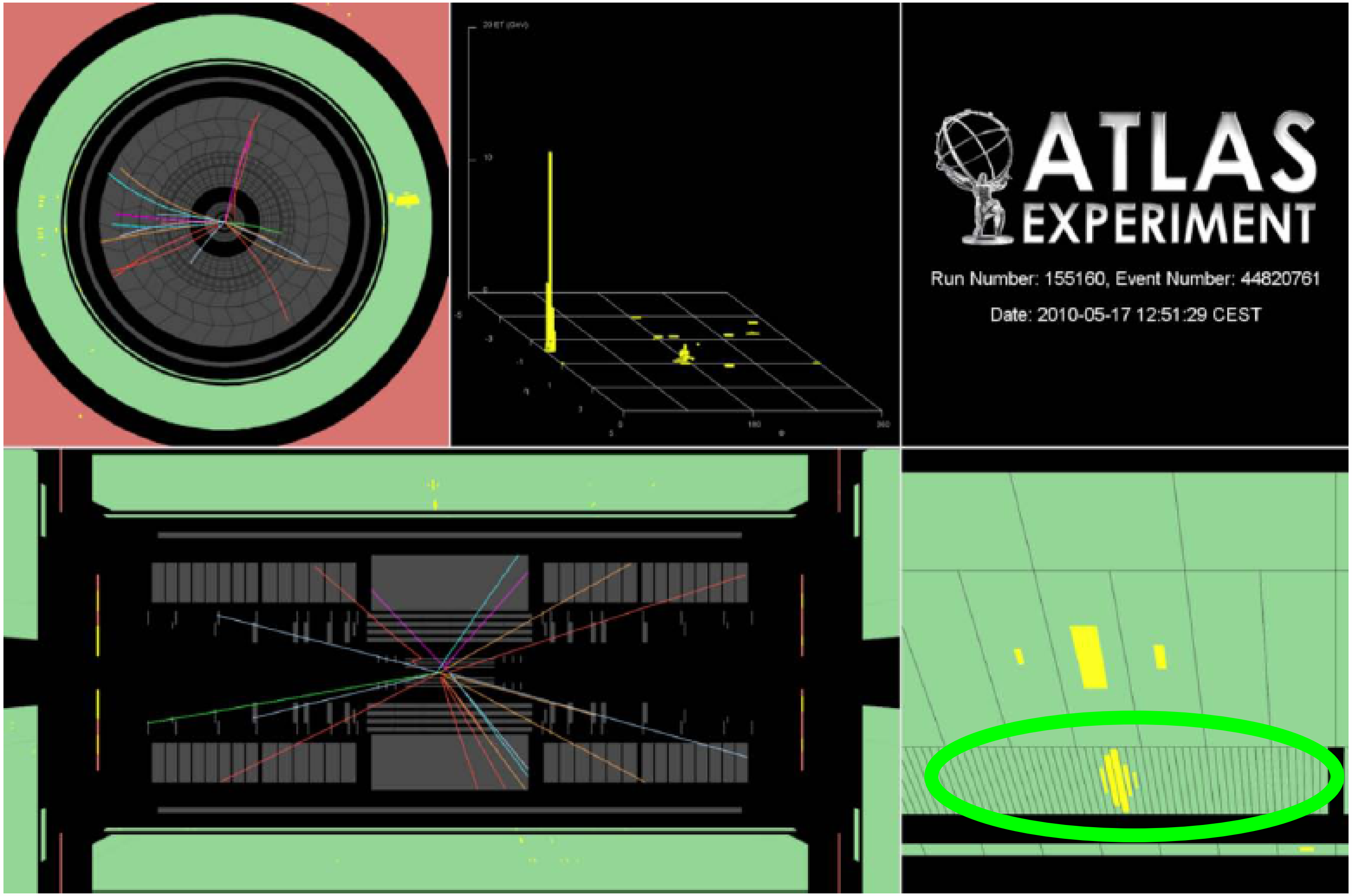
reminder: opening angle between the two photons of a π^0 of** p_T =40 GeV **is > 0.007 to be compared with size of strip calo 1^{st} sampling ~0.003

π⁰ candidate passing "loose", failing "tight" selection



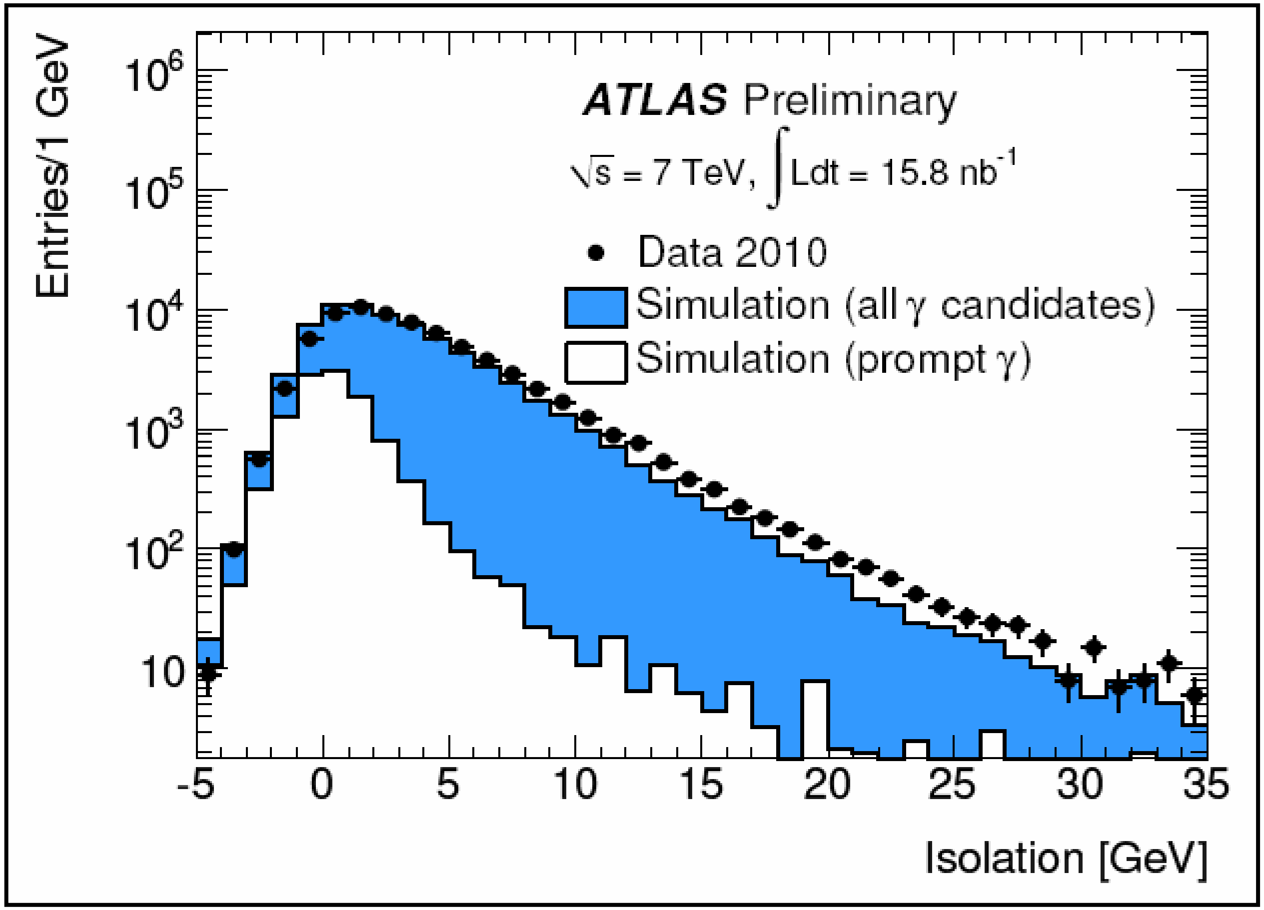
tight selection uses mainly calo 1st sampling

Photon candidate passing "tight" selection

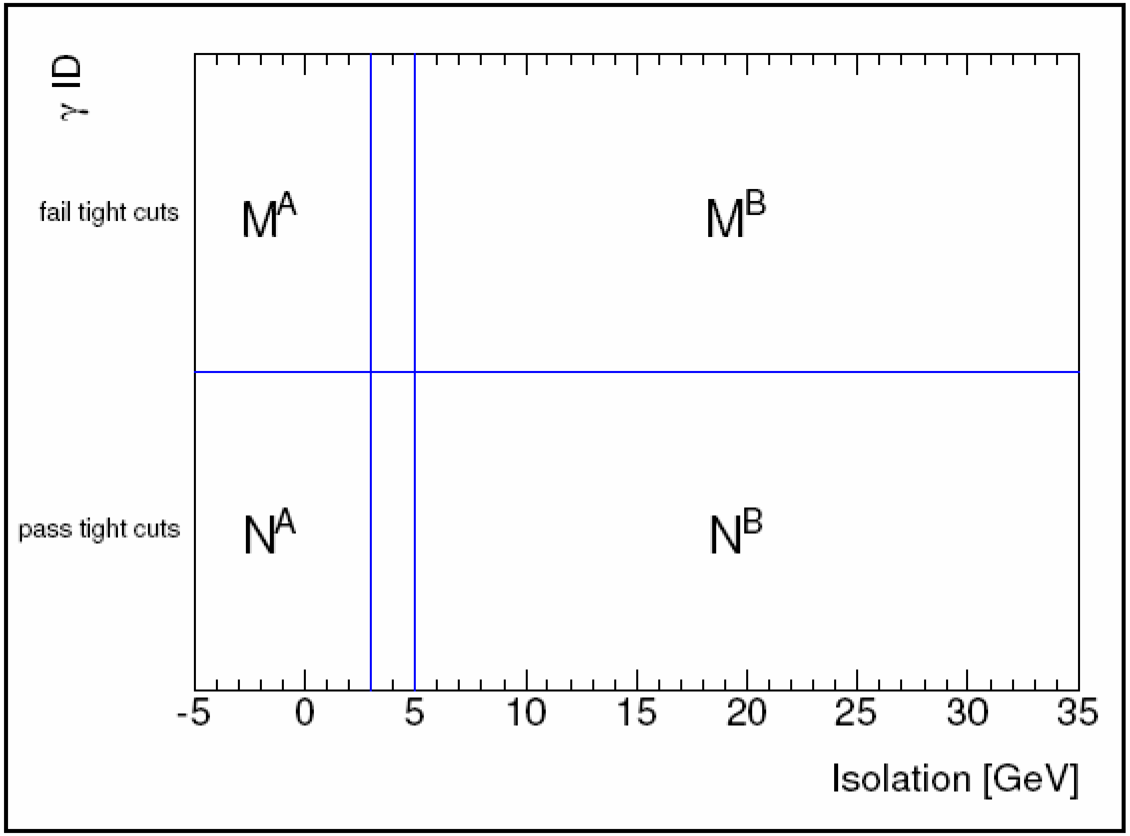


Nice shape in first sampling of EM calormeter

Important discrimination variable is isolation variable



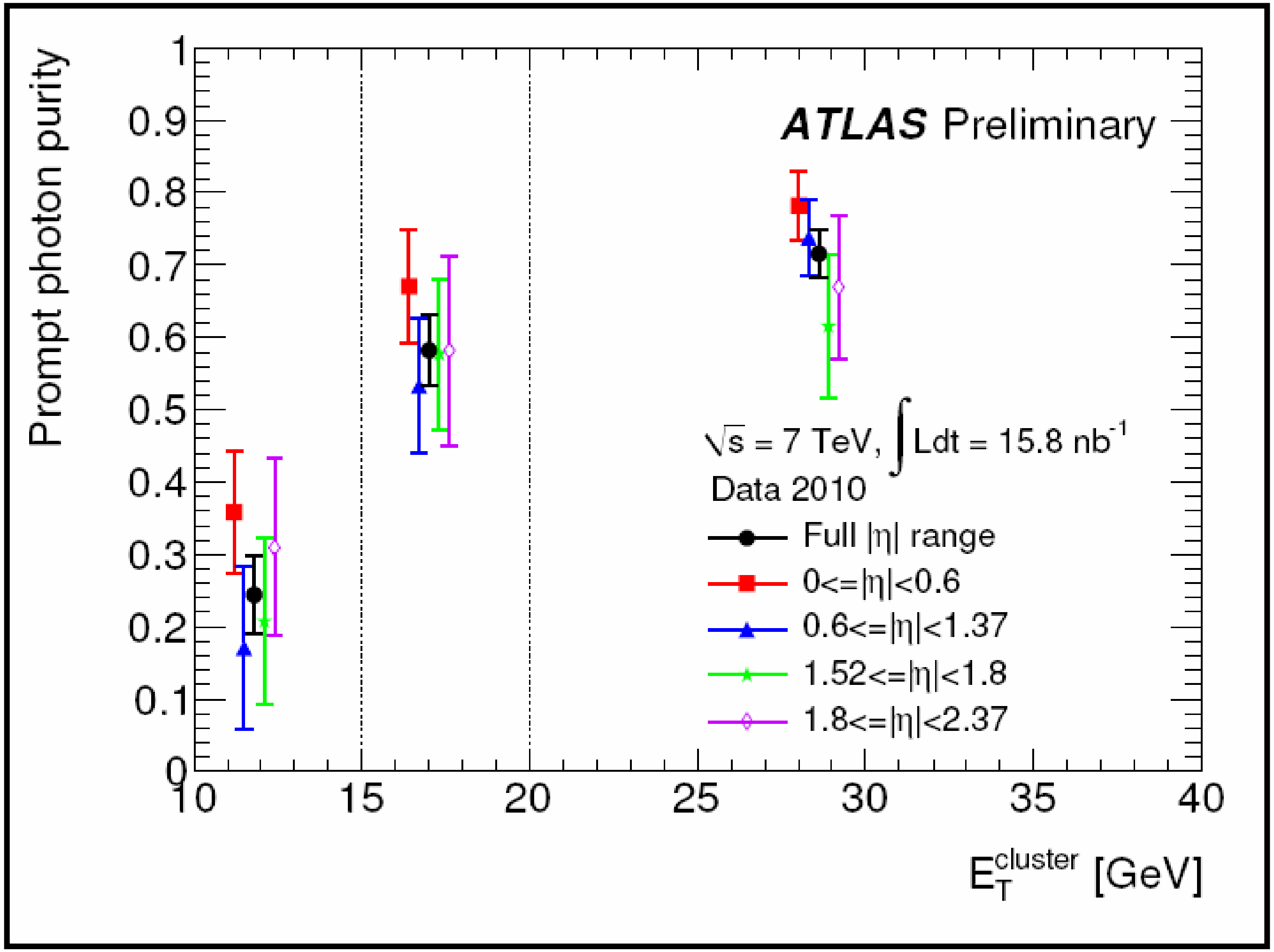
Signal and purity extraction



$$N^A_{\rm sig} = N^A - N^B \frac{M^A}{M^B}$$

$$P = 1 - \frac{N^B}{N^A}\frac{M^A}{M^B}$$

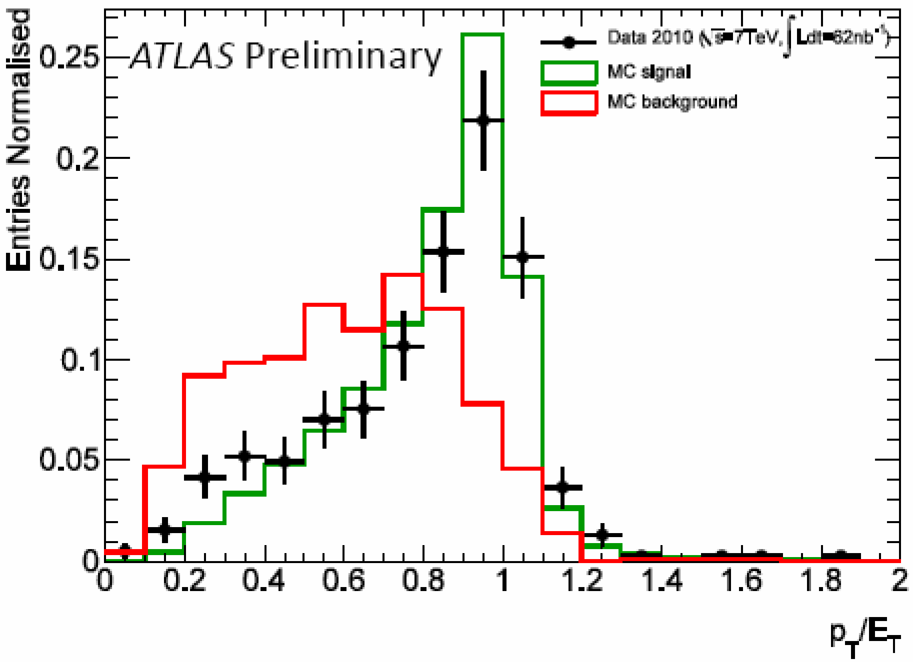
approximate formula



ATLAS Preliminary
Prompt photon purity
$E_T^{cluster}$ [GeV]
$\sqrt{s}$ = 7 TeV, $\int$Ldt = 15.8 nb^{-1}
Data 2010
Full |η| range
0<=|η|<0.6
0.6<=|η|<1.37
1.52<=|η|<1.8
1.8<=|η|<2.37
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
10
15
20
25
30
35
40

Performance of photon conversion reconstruction

- Photon conversions with two reconstructed tracks
- p_T(photon) ≥ 20 GeV/c
- Isolation < 3 GeV



nice evidence for photons

Data/MC comparison

- Data and MC are normalized to unity.

Conclusions and prospects on photons :

From 15.8 nb-1 of 7 TeV *pp* collisions collected with the ATLAS detector, **we successfully extracted prompt photon signals statistically significant in ET > 15 GeV**.

In ET > 20 GeV, a prompt photon yield was measured to be 618 ± 72 with a purity of 72 ± 7 %.

A measurement of the prompt photon production cross section will be performed in the next step.

Physics studies using high pT photons with the ATLAS detector are promising

3 - short term prospects

Decided Scenario 2010-2011

Following the technical discussions in Chamonix (Jan 2010) the CERN management and the LHC experiments decided

- Run at 3.5 TeV/beam up to a integrated luminosity of around $1fb^{-1}$.
- Then consolidate the whole machine for 7TeV/beam (during a shutdown in 2012)
- From 2013 onwards LHC will be capable of maximum energies and luminosities

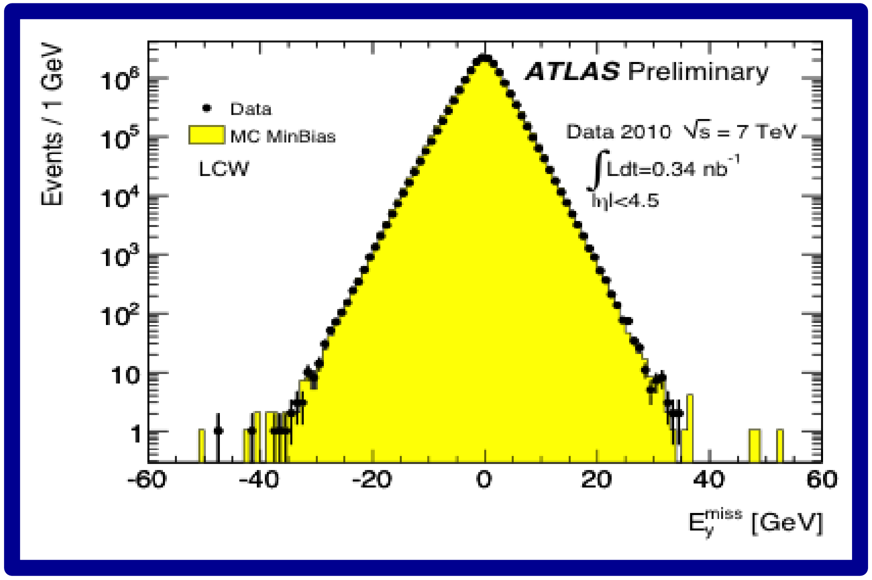
Still possible to achieve

We need to be in this stage asap in order to find low mass Higgs (see discussion of long term prospects)

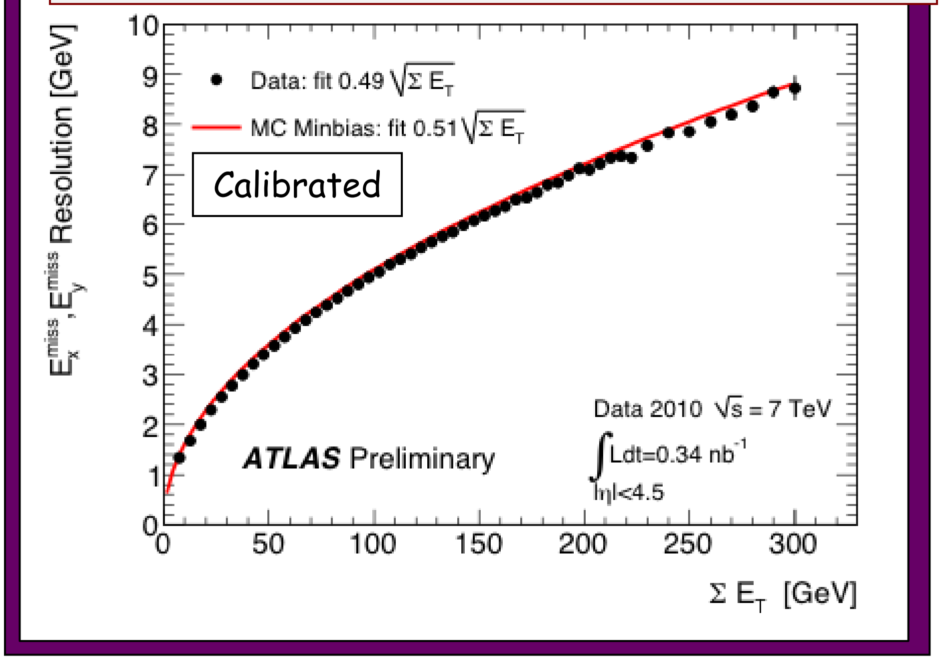
Small reminder on missing transverse energy in the calorimeters

Sensitive to calorimeter performance (noise, coherent noise, dead cells, mis-calibrations, cracks, etc.), and cosmics and beam-related backgrounds

Calibrated E_T^{miss} from minimum-bias events
ATLAS-CONF-2010-057



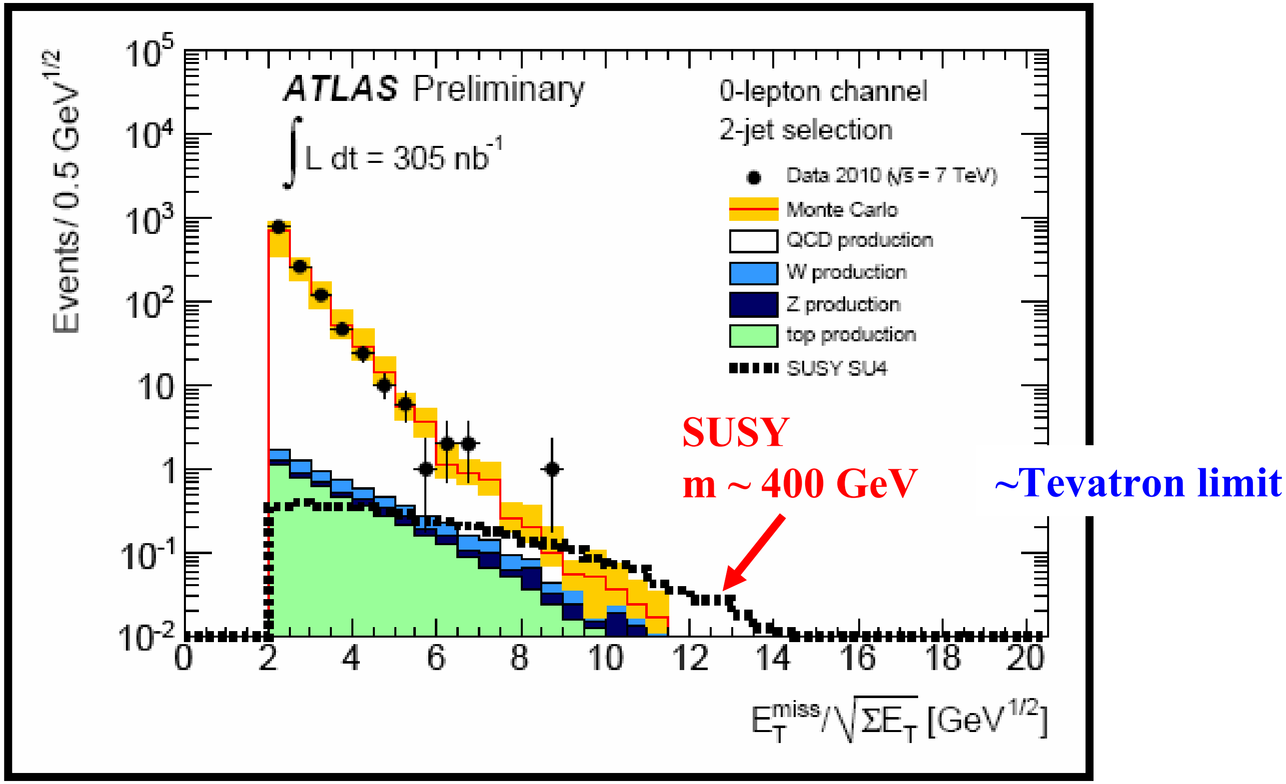
Measured over ~ full calorimeter coverage (360⁰ in φ, |η| < 4.5, ~ 200k cells)



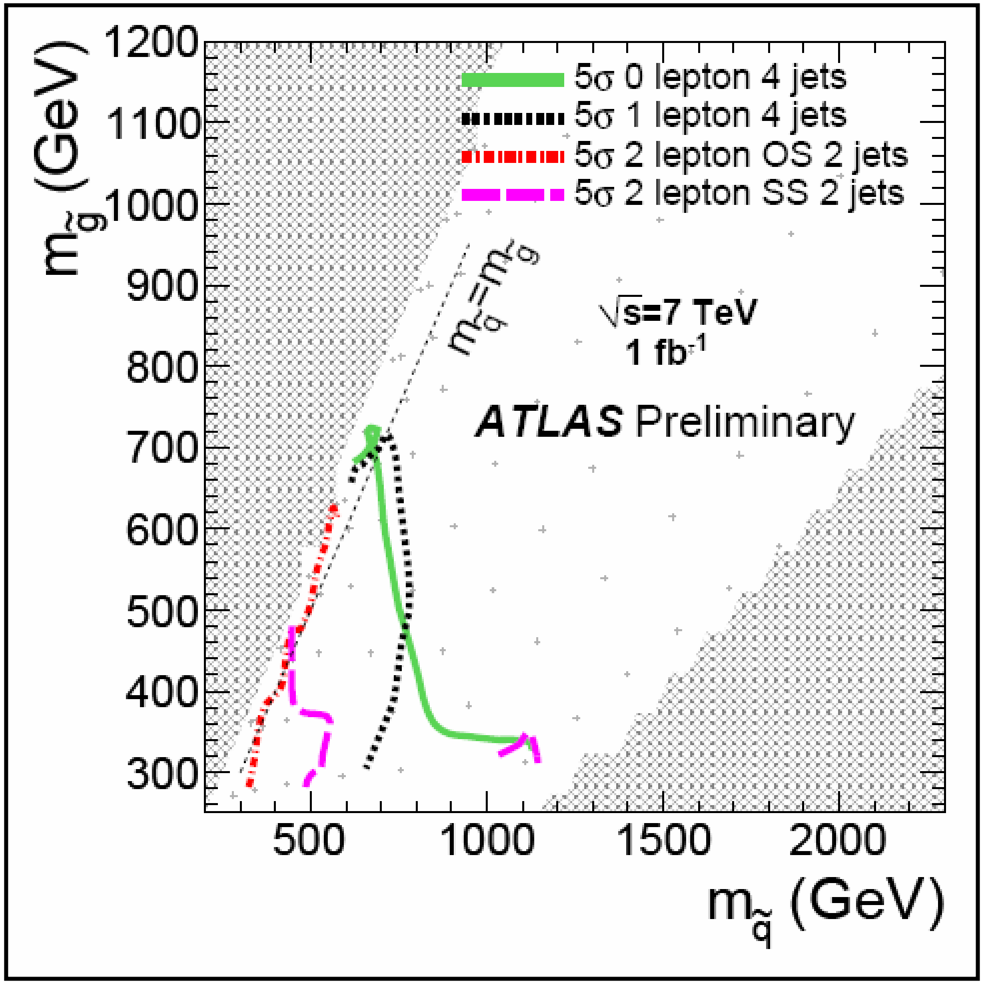
SUSY searches
inspired by analysis on data : jets and missing transverse energy (neutralinos)

ATLAS-CONF-2010-079

E_T^{miss} spectrum from SUSY searches:
events with ≥ 3 high-pT jets,
pT (j1,j3) > 70,30 GeV

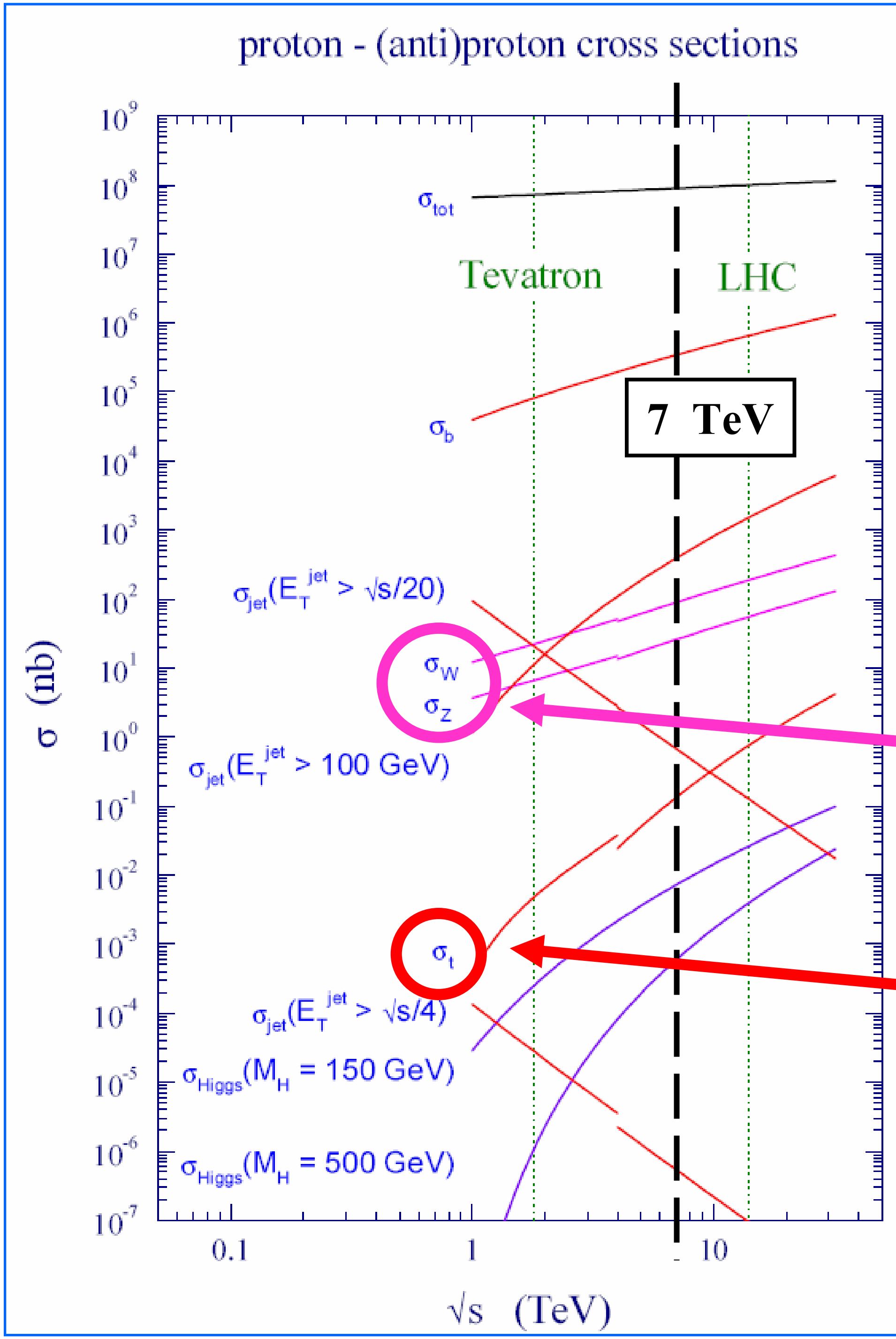


close to a (competitive) limit



ATl-PHYS-PUB-2010-010

With $\vartheta(5)$ pb^{-1} ATLAS can have a better limit than the Tevatron and with $\vartheta(50)$ pb^{-1} we may hope to make a discovery beyond the current Tevatron limits



Campbell et al. Rept.Prog.Phys.**70**:89,2007

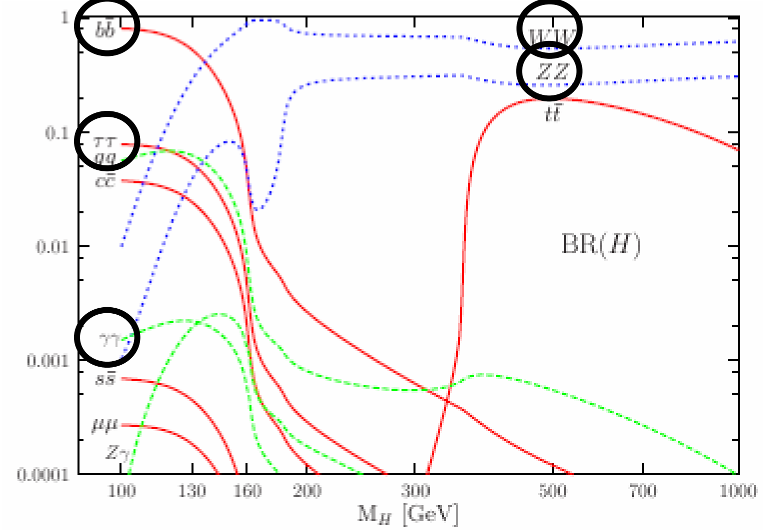
With 1 fb-1 a LHC Experiment should have (at the end of 2011)

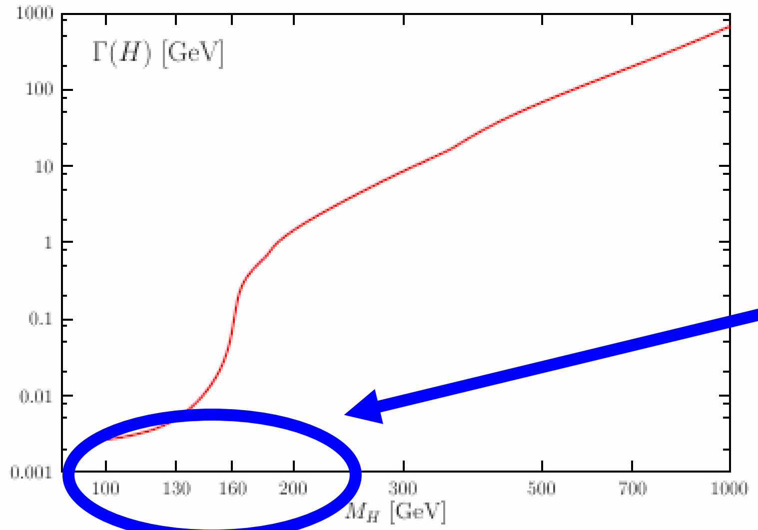
half the number of W and Z than a Tevatron experiment

twice the number of top

SM Higgs physics in 2011   ?

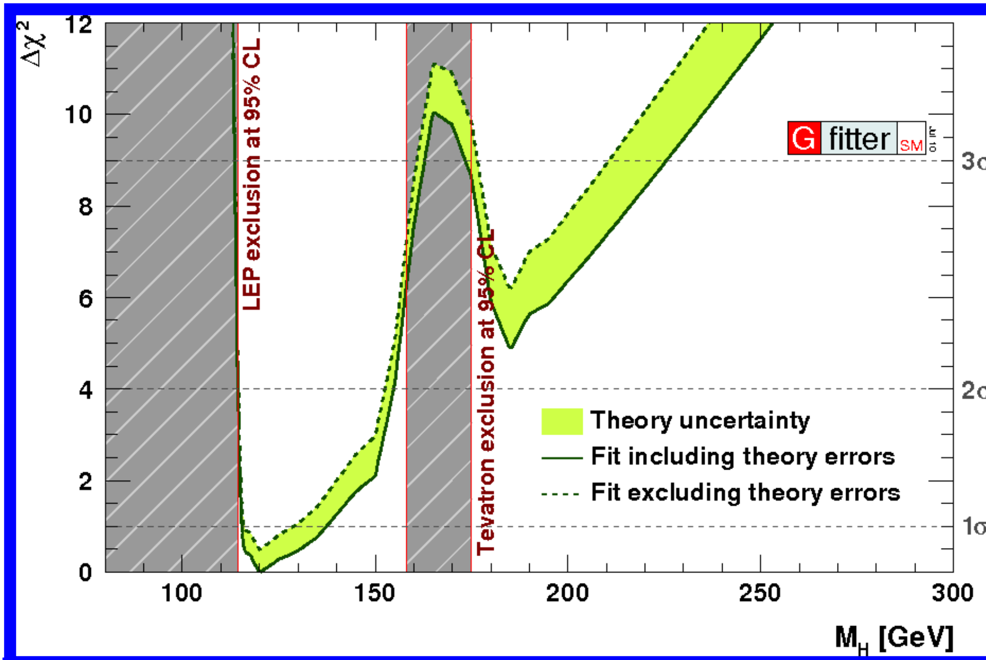
A.Djouadi Phys.Rept.457:1-216





Width smaller than 'leptonic/γ resolution'

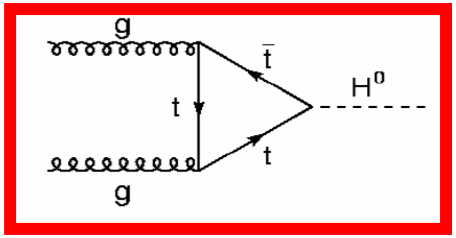
http://project-gfitter.web.cern.ch/project-gfitter/



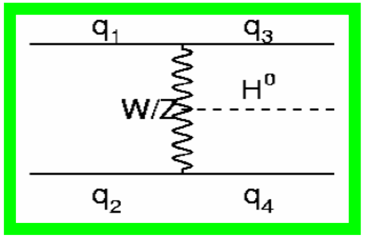
zone favored by data

SM Higgs decay

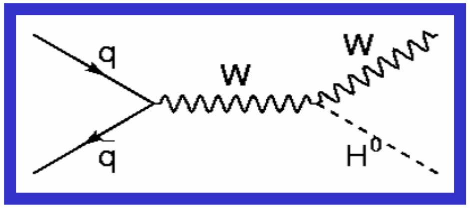
A.Djouadi Phys.Rept.457:1-216



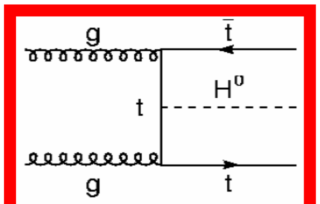
GF **H → WW, ZZ , γγ**



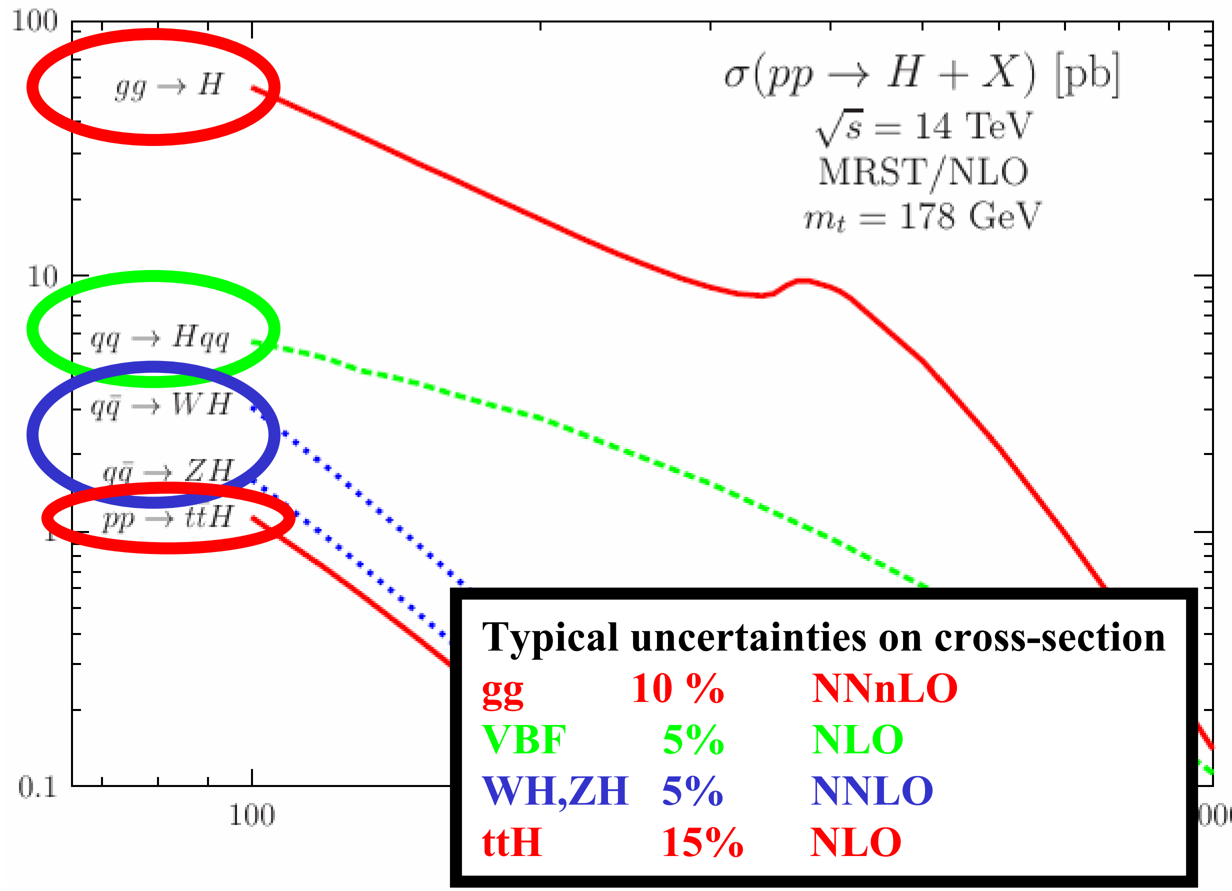
VBF **H → WW , γγ , ττ**



H → WW, γγ



H → WW, γγ, bb

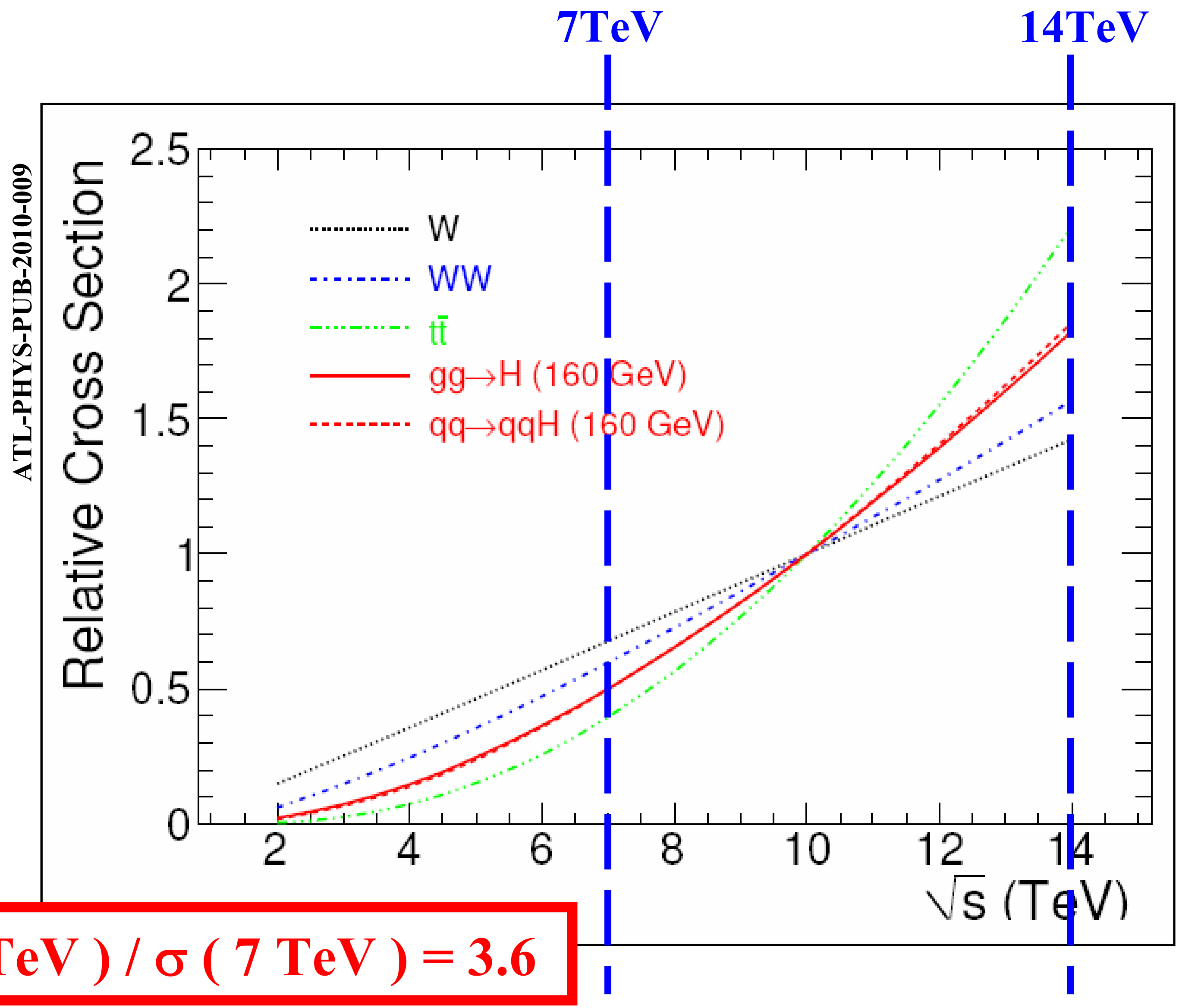


Typical uncertainties on cross-section

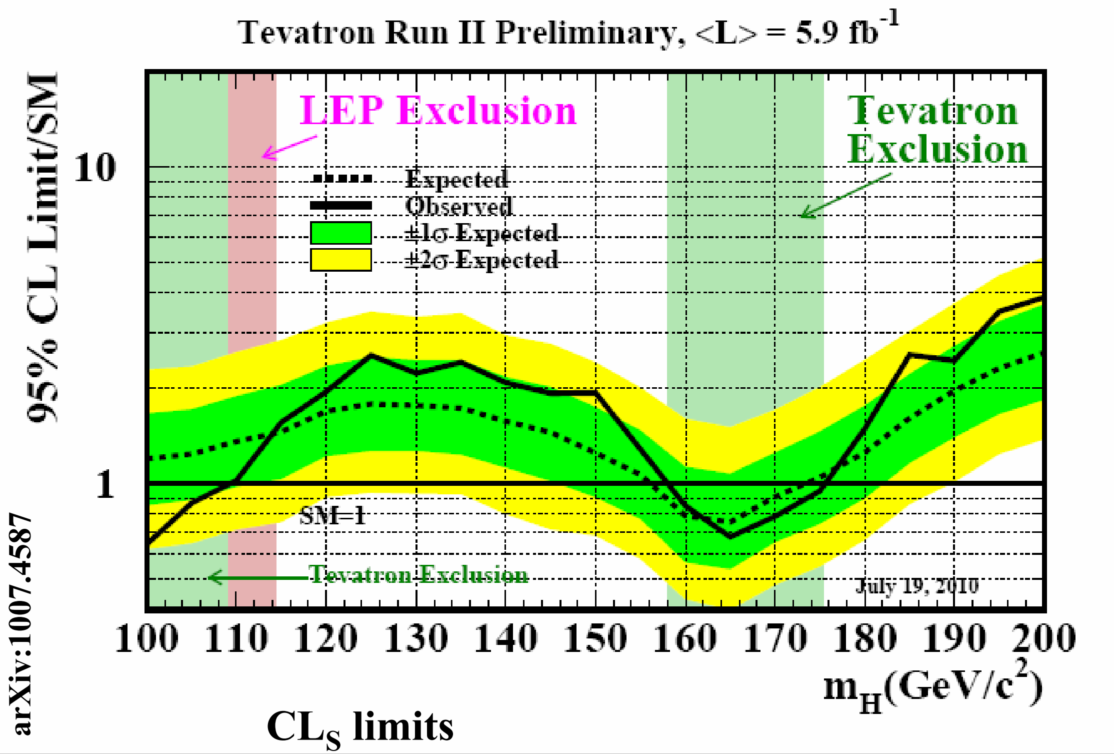
gg	**10 %**	**NNnLO**
VBF	**5%**	**NLO**
WH,ZH	**5%**	**NNLO**
ttH	**15%**	**NLO**

These production cross sections have to be used with the decays **bb , ττ , WW , ZZ , γγ**

Large variation of cross section with √s



σ (14 TeV) / σ (7 TeV) = 3.6



limits comparable to the Tevatron limits at 'high mass' (~160 GeV)

but worse than the Tevatron limits at 'low mass'

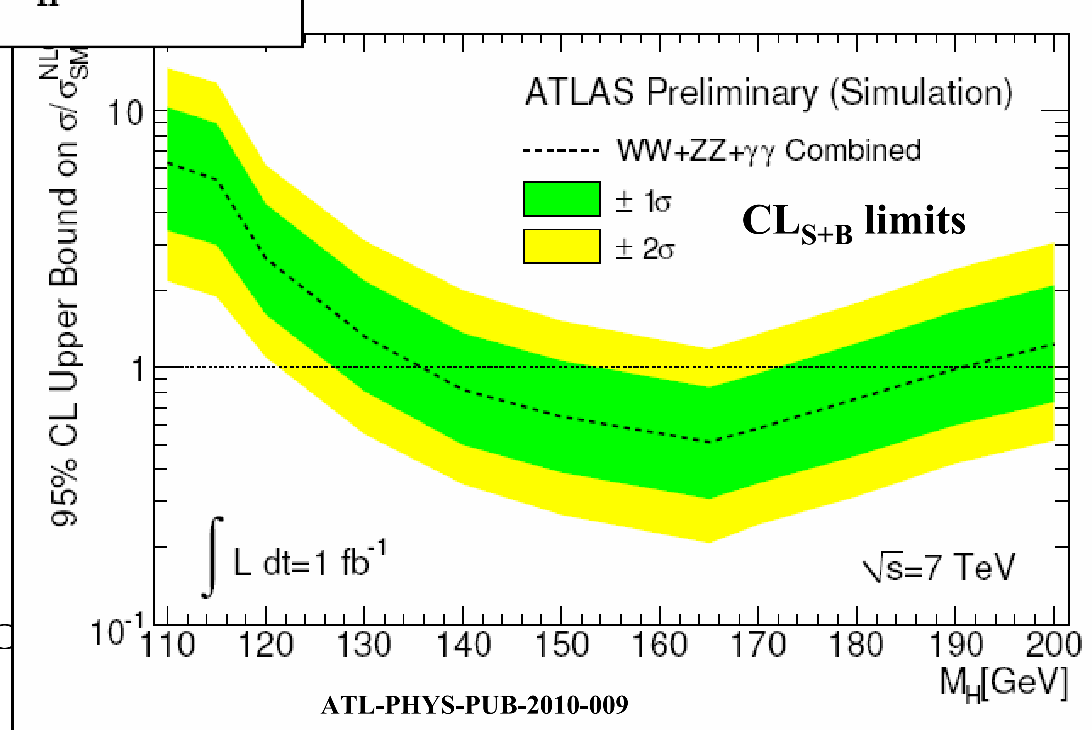
Only H→ WW → llνν

H → ZZ →4l

H → γγ

Will be better with

H → bb , H → ττ



4 - long term prospects

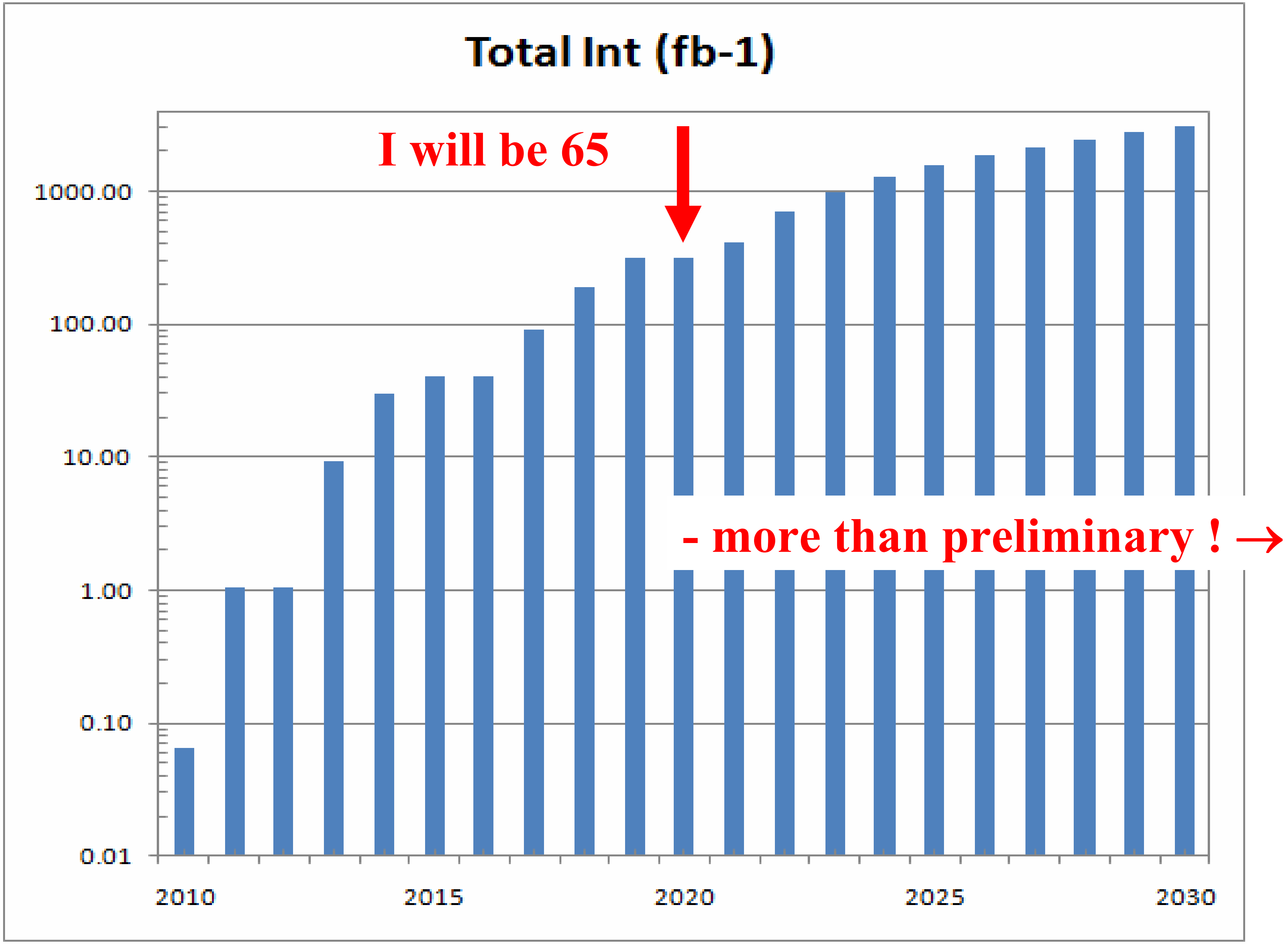
Longer Term Objectives

Integrated luminosity of $\geq$3000fb^{-1} by the end of the LHC life

- requires a peak luminosity of $\geq 5 \times 10^{34}$ cm^{-2}s^{-1} during 2021-2030

- → integrated yearly luminosity of around 250-300fb^{-1}

In addition one has to bear in mind that it is impossible to predict the future (at more than ~ 5 years)

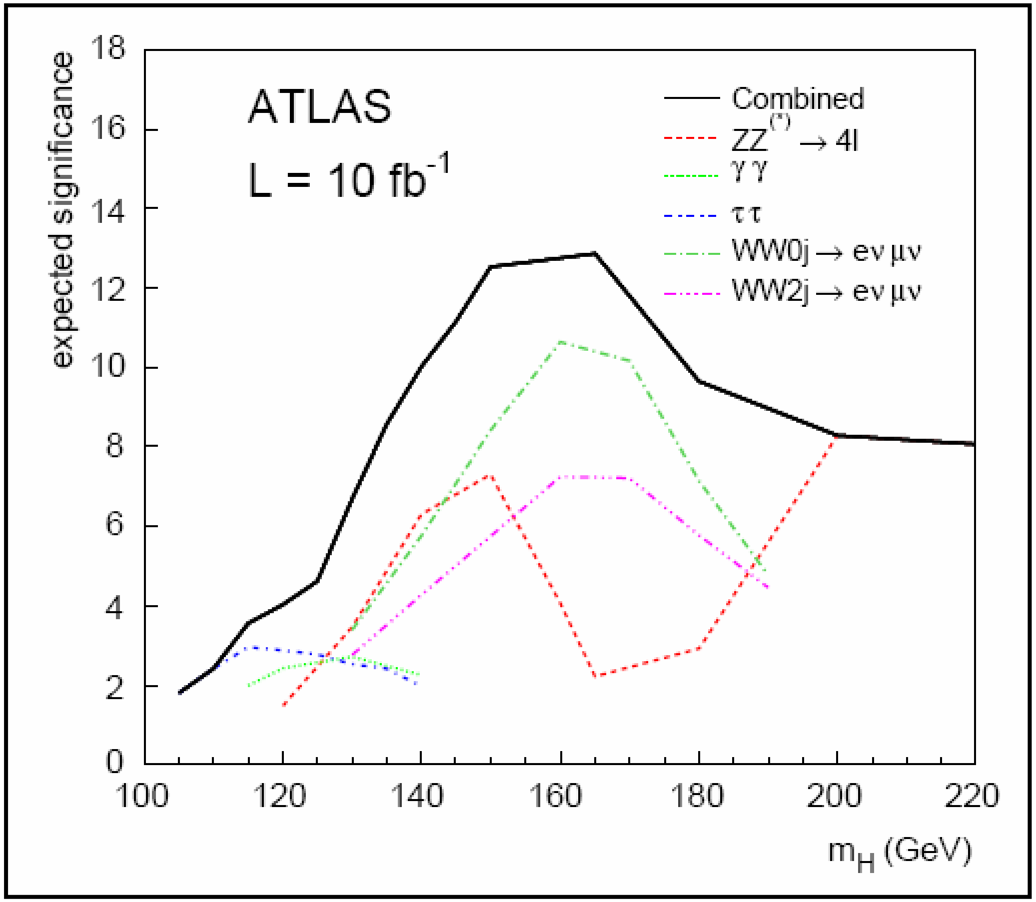

Total Int (fb-1)
I will be 65
- more than preliminary ! →
1000.00
100.00
10.00
1.00
0.10
0.01
2010
2015
2020
2025
2030

Corfu 2014 / *Corfu 2015*

SM Higgs ***will be discovered with 10fb⁻¹ / 30 fb⁻¹***

in almost / all

the whole range



arXiv:0901.0512

Very Long term future : Is it a Standard Model Higgs ?

D.Rainwater hep-ph/0702124

- electric charge [neutral]
- color charge [neutral]
- mass [free parameter]
- spin [0]
- CP [even]
- gauge coupling (g_{WWH}) [$SU(2)_L$ with tensor structure $g^{\mu\nu}$]
- Yukawa couplings [m_f/v]
- spontaneous symmetry breaking potential (self-couplings) [fixed by the mass]

Very (!) difficult pp → HH → WWWW

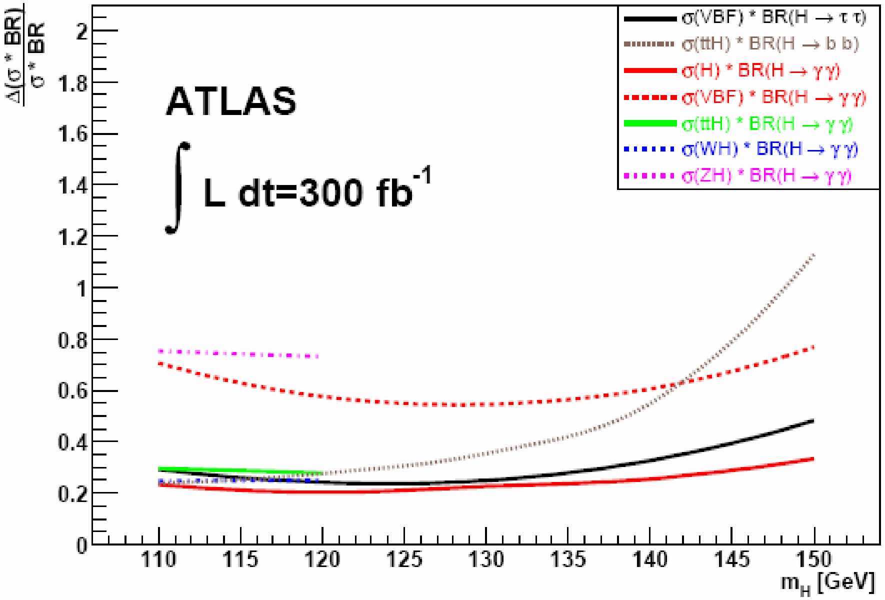
► *limited H mass range at least sLHC luminosities needed*

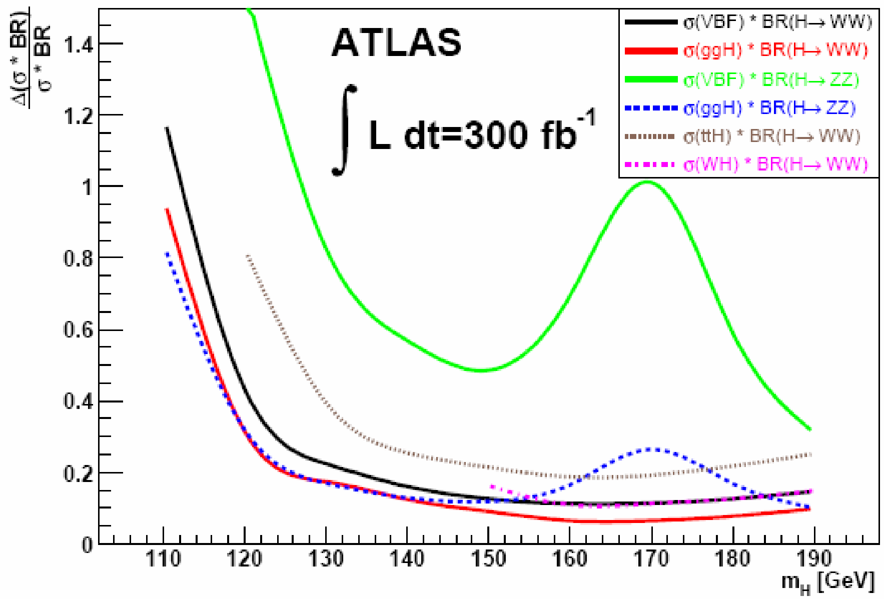
► *analysis (same sign dileptons + 4 jets has to be reassessed in a more realistic way*

Higgs couplings

M.Duhrssen ATL-PHYS-2003-030
M.Duhrssen,S.Heinemeyer,H.Logan,D.Rainwater,G.Weiglein and D.Zeppenfeld Phys Rev D70,113009,2004

based on 'old' expectations , in particular $H \to bb$





Measure σ.BR in different channels with *almost* no assumptions (uncertainties = selection efficiencies , background)

Conclusions

- **Very good start start of the LHC   L = 10^{31} cm^{-2} s^{-1}**

- **First data demonstrate that that the performance of the detector/software … is better than expected .**

- **First physics results : jets , photons, W, Z , top and already   some results the best in the world**

- **The exploitation of the LHC physics has started**
  - **→ good run 2011 to come**
  - **→ runs 2013 …. for Higgs physics**
  - **→ ……**