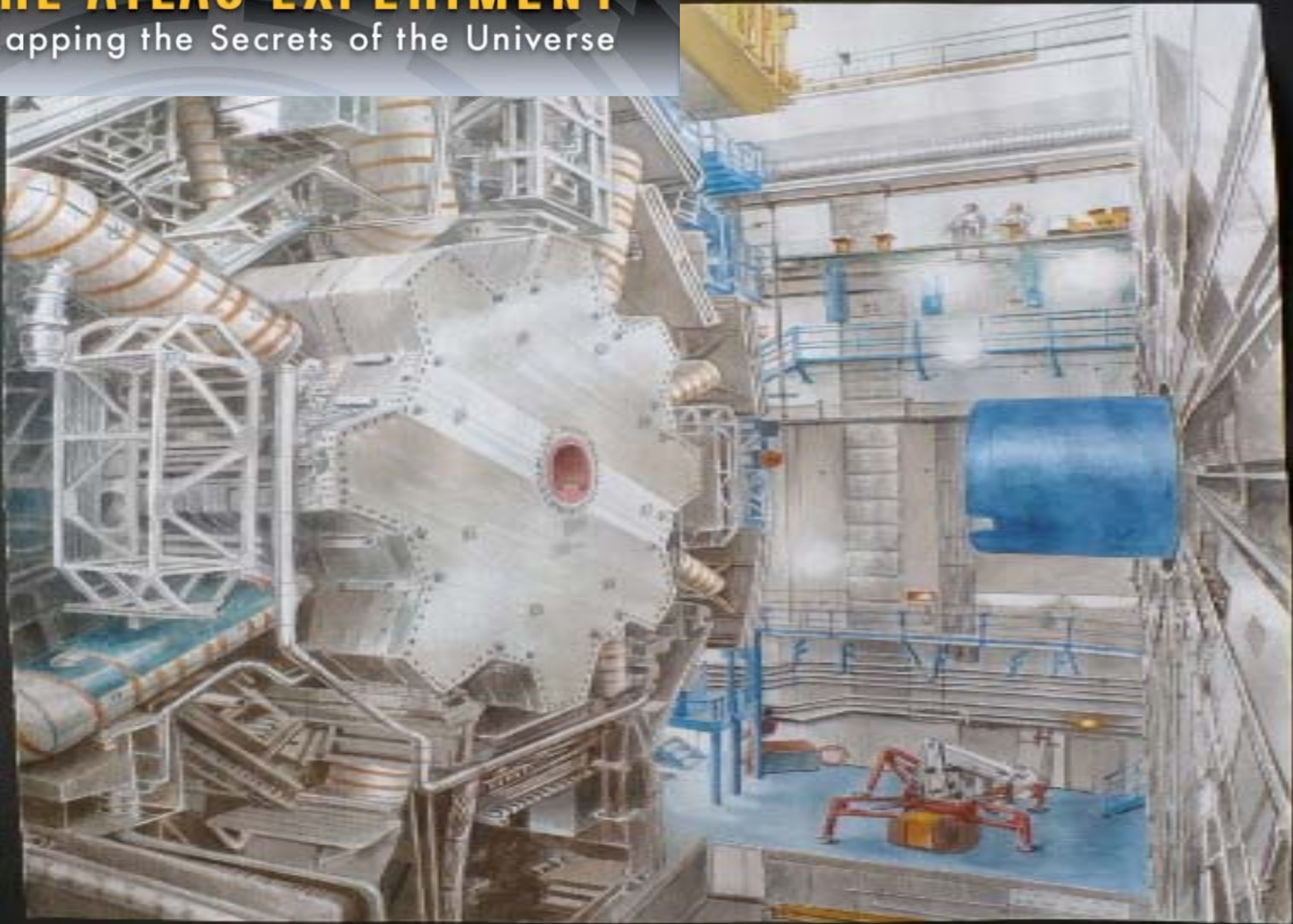
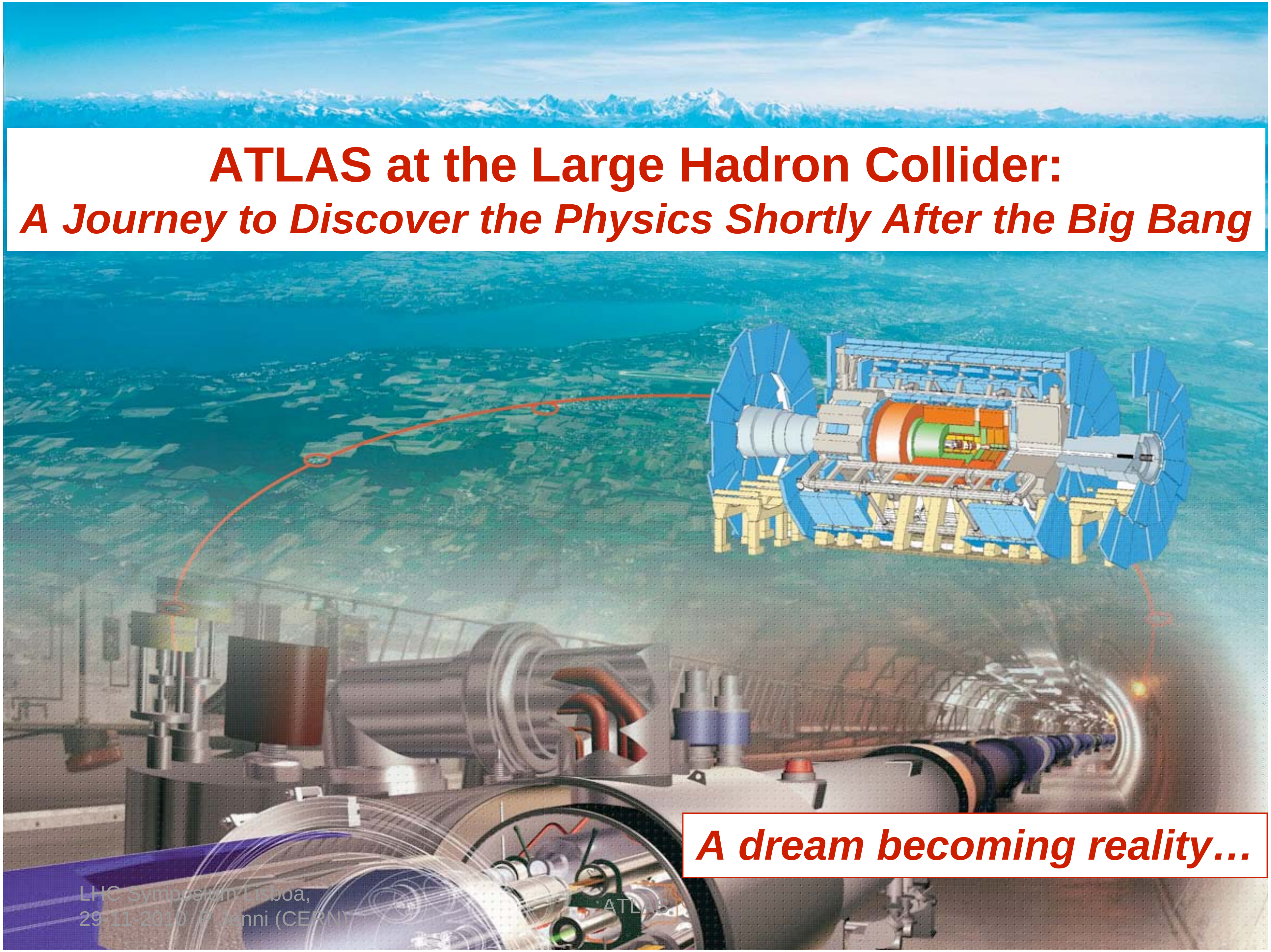
The ATLAS Experiment
Mapping the Secrets of the Universe



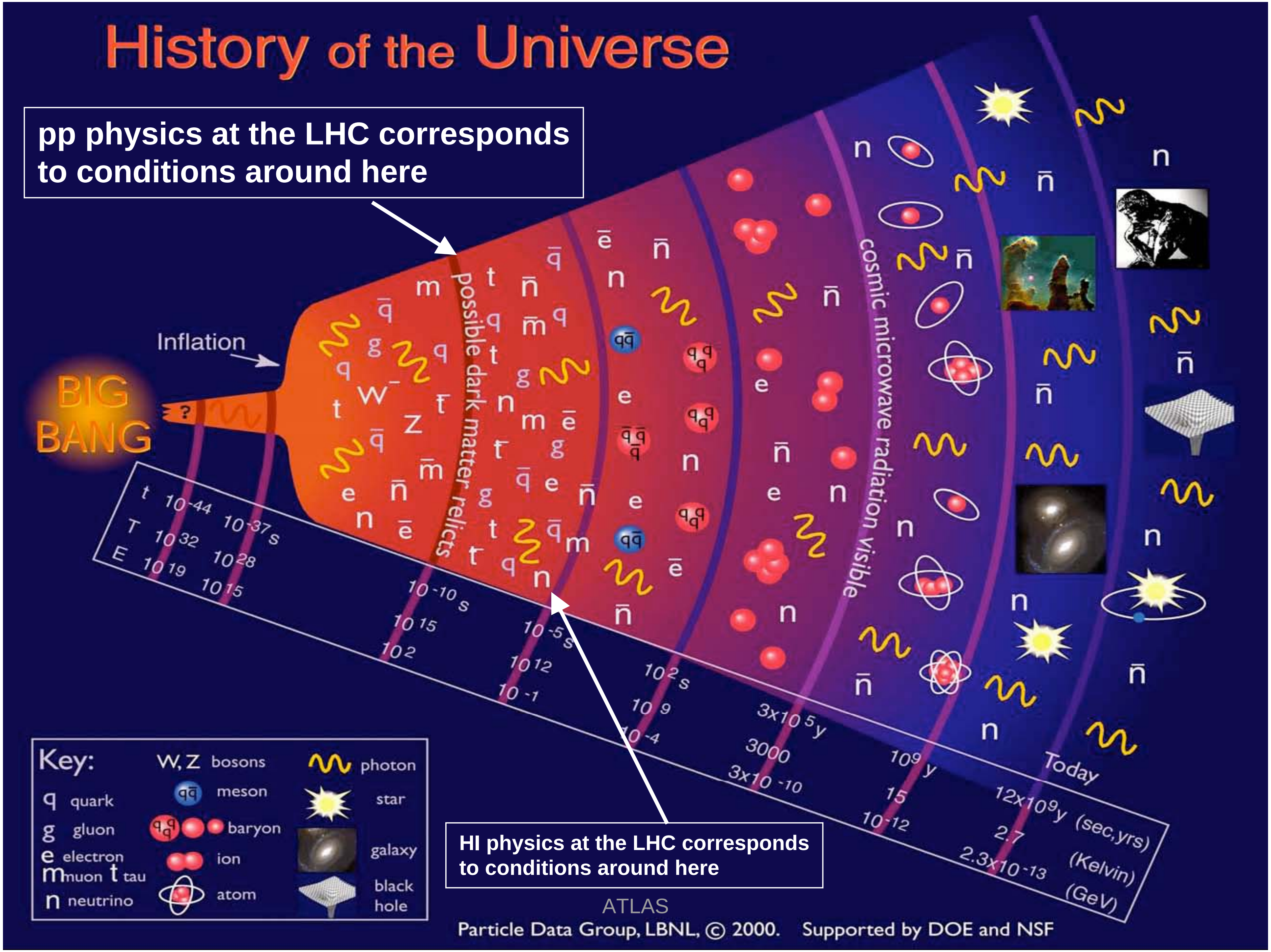
LHC Symposium '*after one year of operation*'
29 November 2010, Lisboa - Portugal

Peter Jenni, CERN

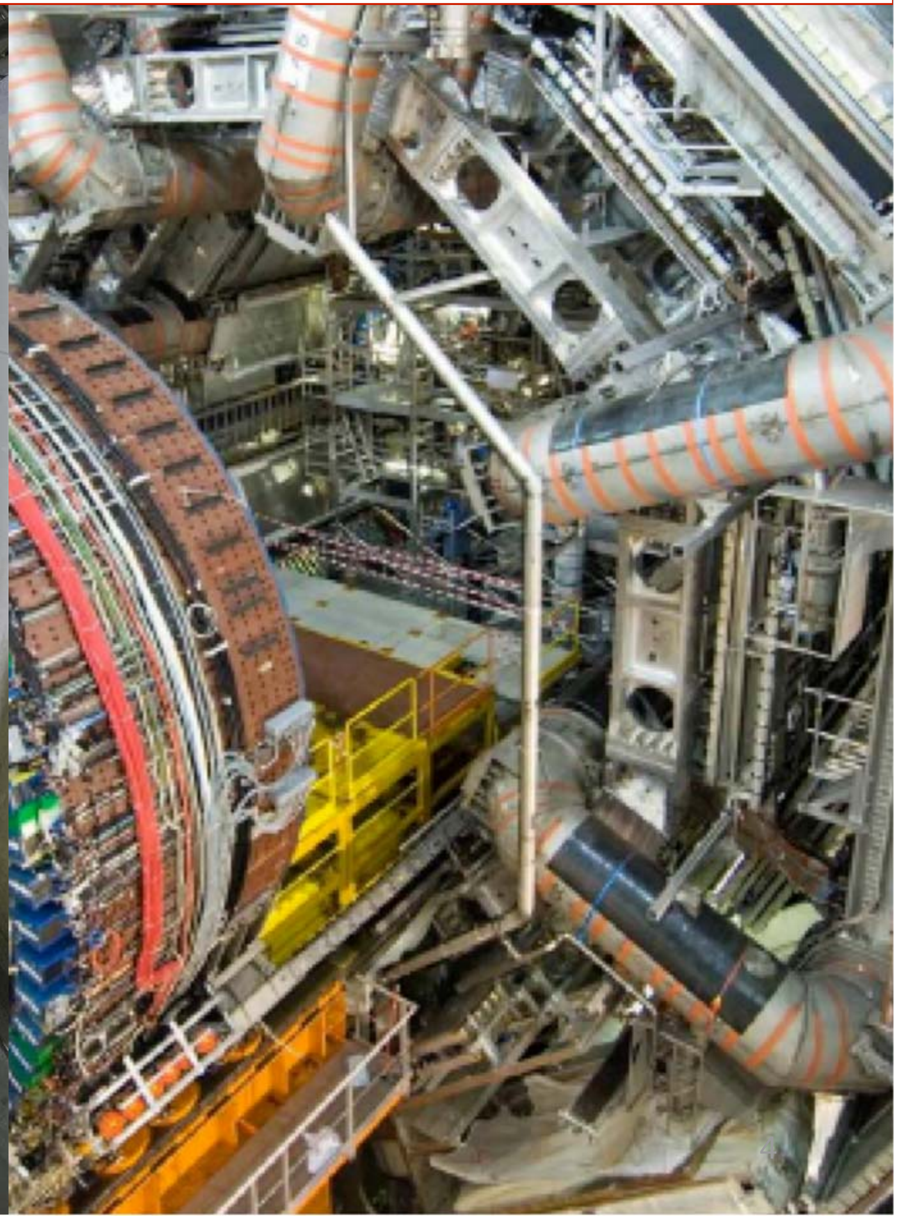
ATLAS at the Large Hadron Collider:
A Journey to Discover the Physics Shortly After the Big Bang



A dream becoming reality…


History of the Universe
pp physics at the LHC corresponds to conditions around here
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
t 10-44 10-37 s 10-10 s 10-5 s 10 2 s 3x10 5 y 10 9 y Today 12x10 9 y (sec,yrs)
T 10 32 10 28 10 15 10 12 10 9 3000 15 2.7 (Kelvin)
E 10 19 10 15 10 2 10 -1 10 -4 3x10 -10 10 -12 2.3x10 -13 (GeV)
Key:
q quark
g gluon
e electron
m muon t tau
n neutrino
W, Z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
HI physics at the LHC corresponds to conditions around here
ATLAS
Particle Data Group, LBNL, © 2000. Supported by DOE and NSF

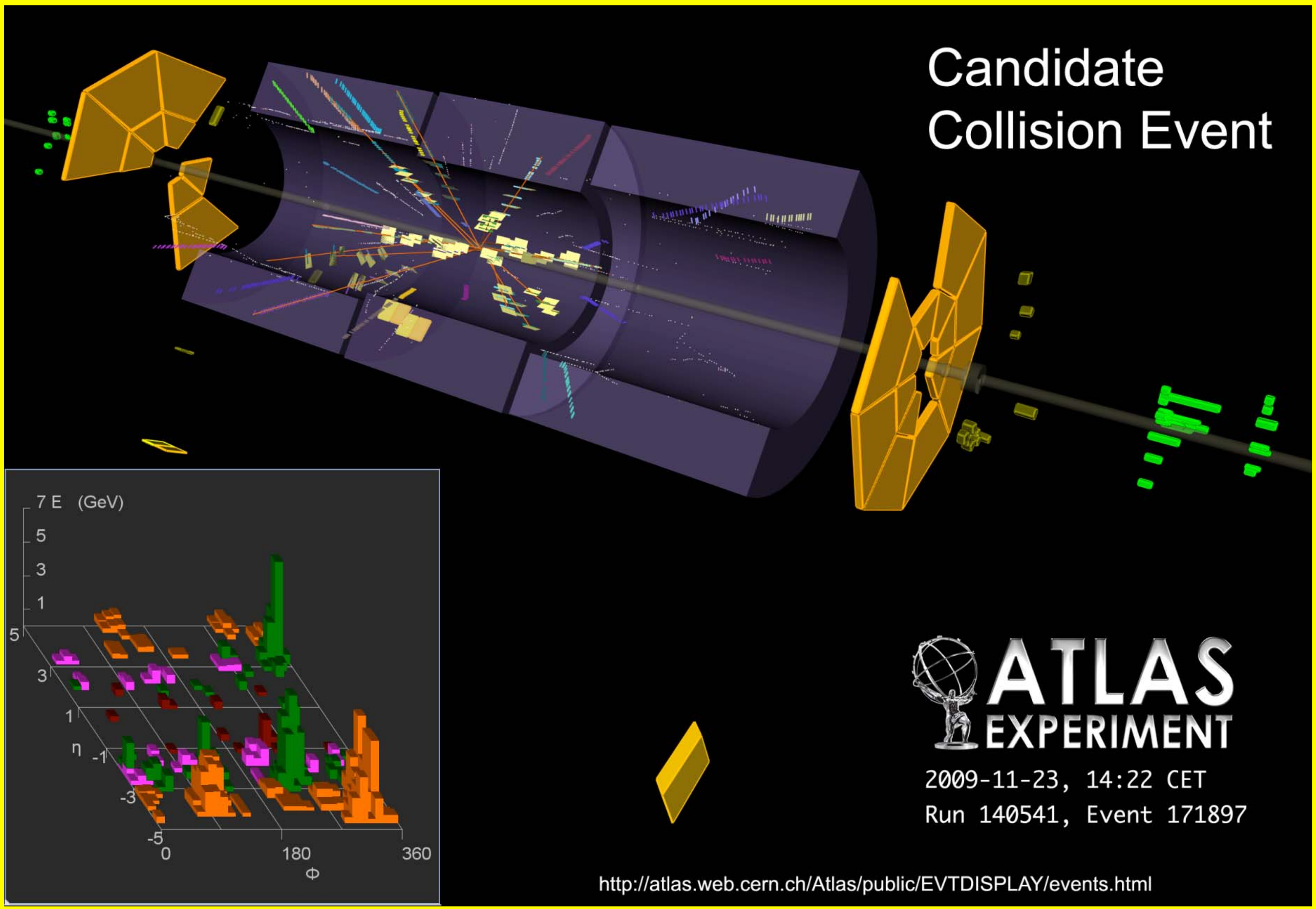
The Large Hadron Collider project has to be seen as a global scientific adventure, combining the accelerator and the experiments



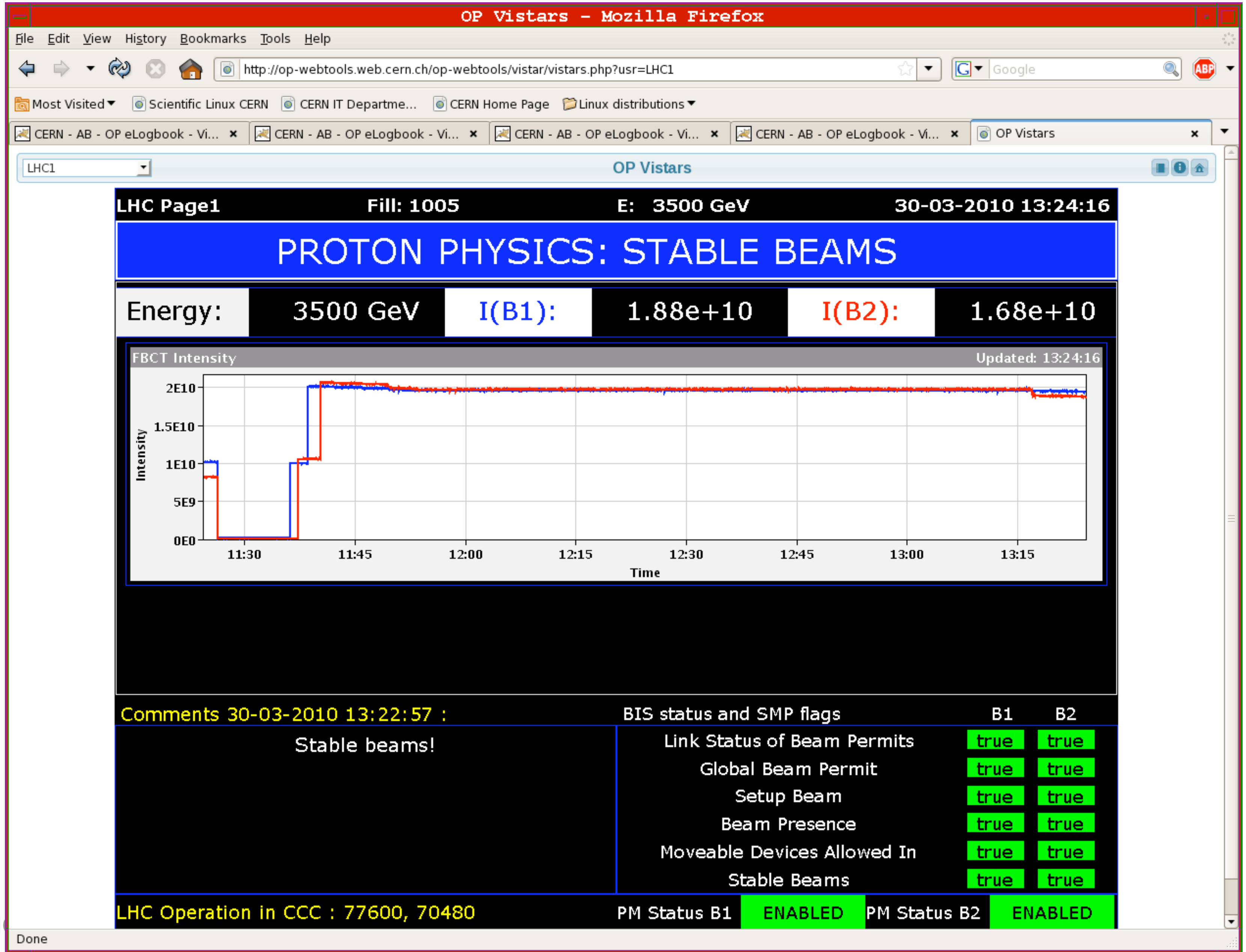
ATLAS

ATLAS Control Room when the first LHC beam collided....

First collisions at the LHC end of November 2009 with beams at the injection energy of 450 GeV



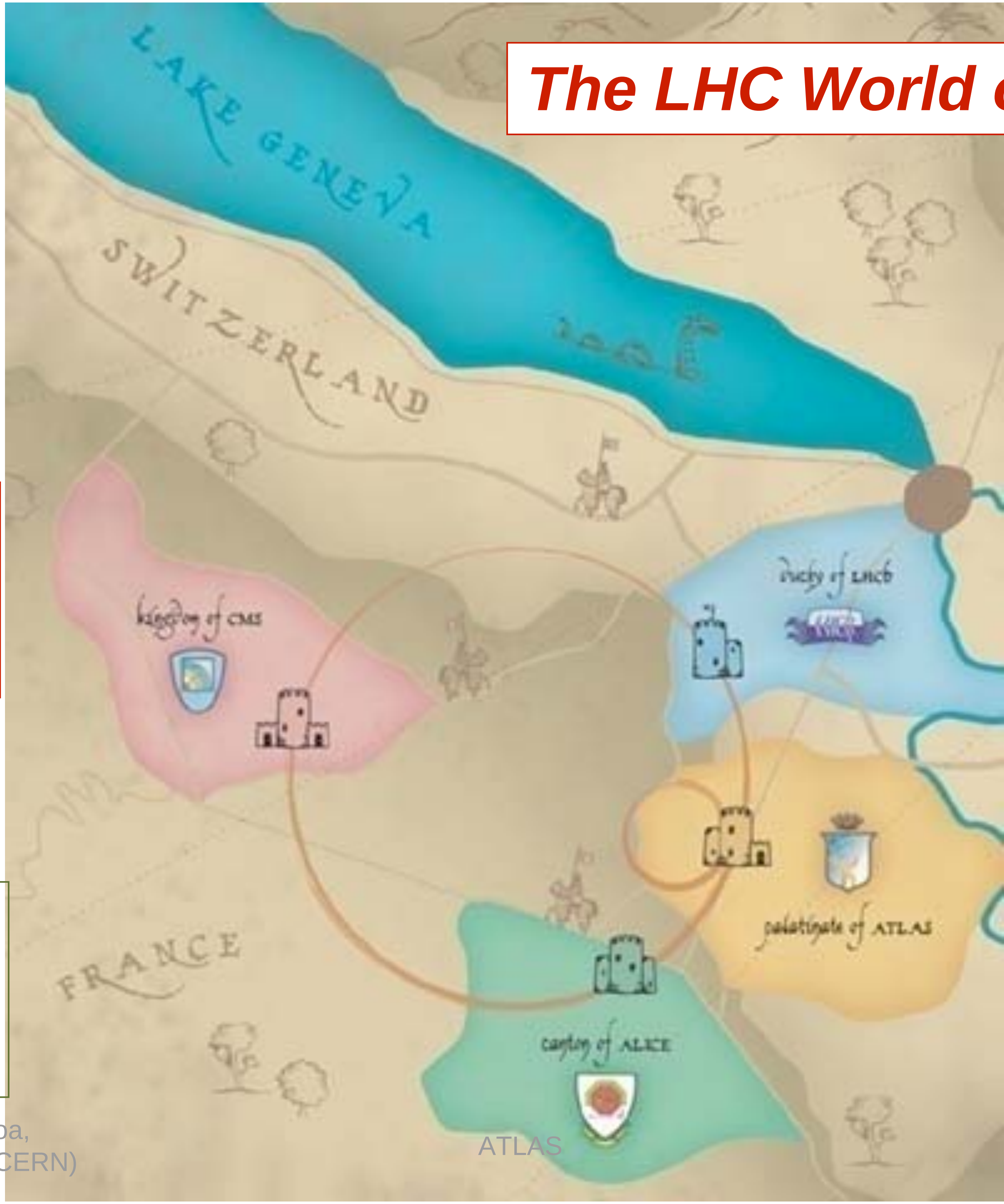
High-energy operation with 3.5 TeV beams started on 30th March 2010




Fill: 1005
E: 3500 GeV
PROTON PHYSICS: STABLE BEAMS
30-03-2010 13:47:40
3500 GeV
I(B1):
1.79e+10
I(B2):
1.64e+10

The LHC World of CERN

Plus smaller local earldoms
LHCf (point-1)
TOTEM (point-5)
Moedal (point-8)



CMS
2900 Physicists
184 Institutions
38 countries
550 MCHF

LHCb
730 Physicists
54 Institutions
15 countries
75 MCHF

ATLAS
3000 Physicists
174 Institutions
38 countries
550 MCHF

ALICE
1000 Physicists
105 Institutions
30 countries
150 MCHF

ATLAS Collaboration

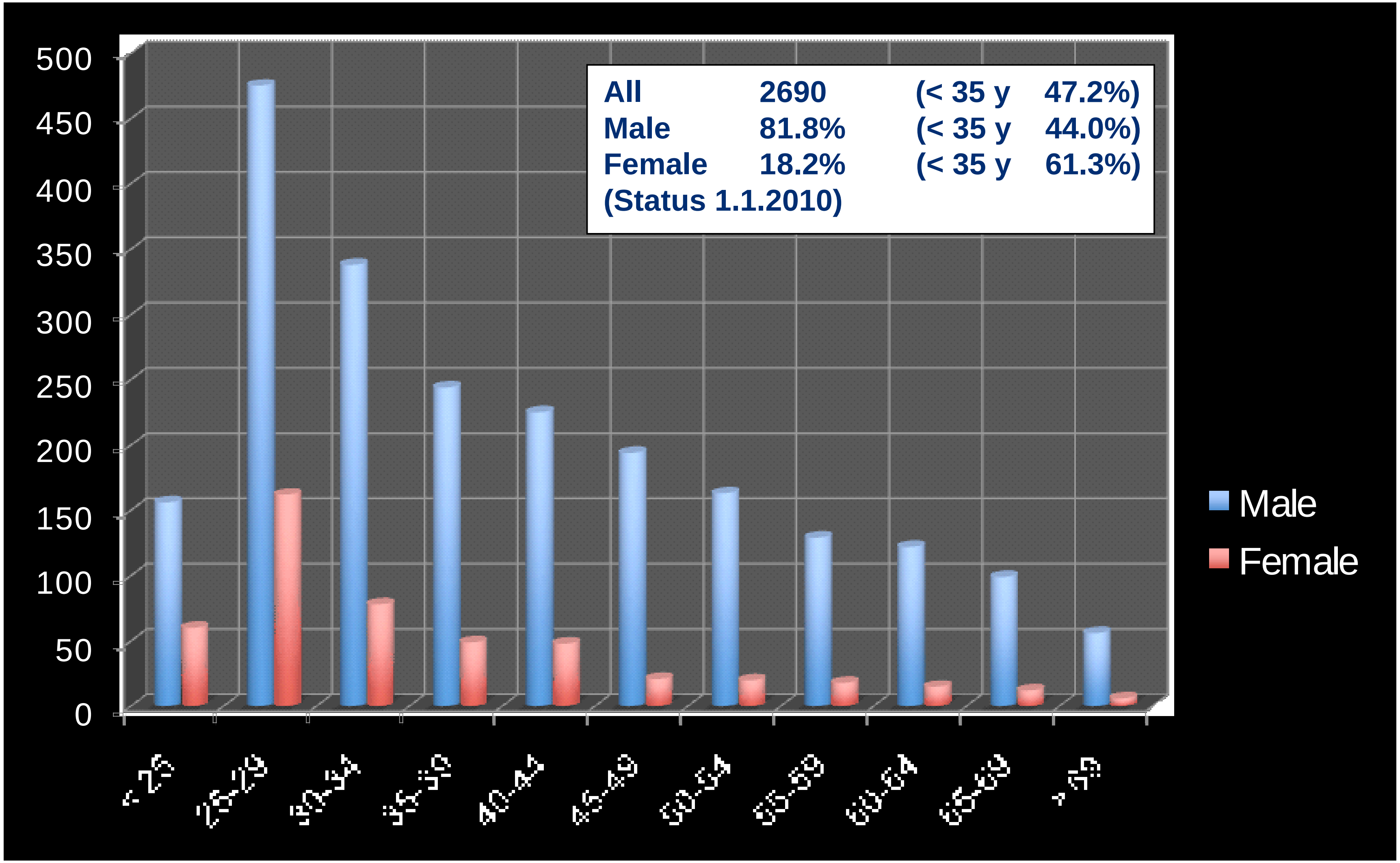
(Status August 2010)

38 Countries
174 Institutions
3000 Scientific participants total
(1000 Students)

A LIP Lisbon team (with several Portuguese universities) was a member of ATLAS since the very first day, and pioneering already before in the calorimeter R&D

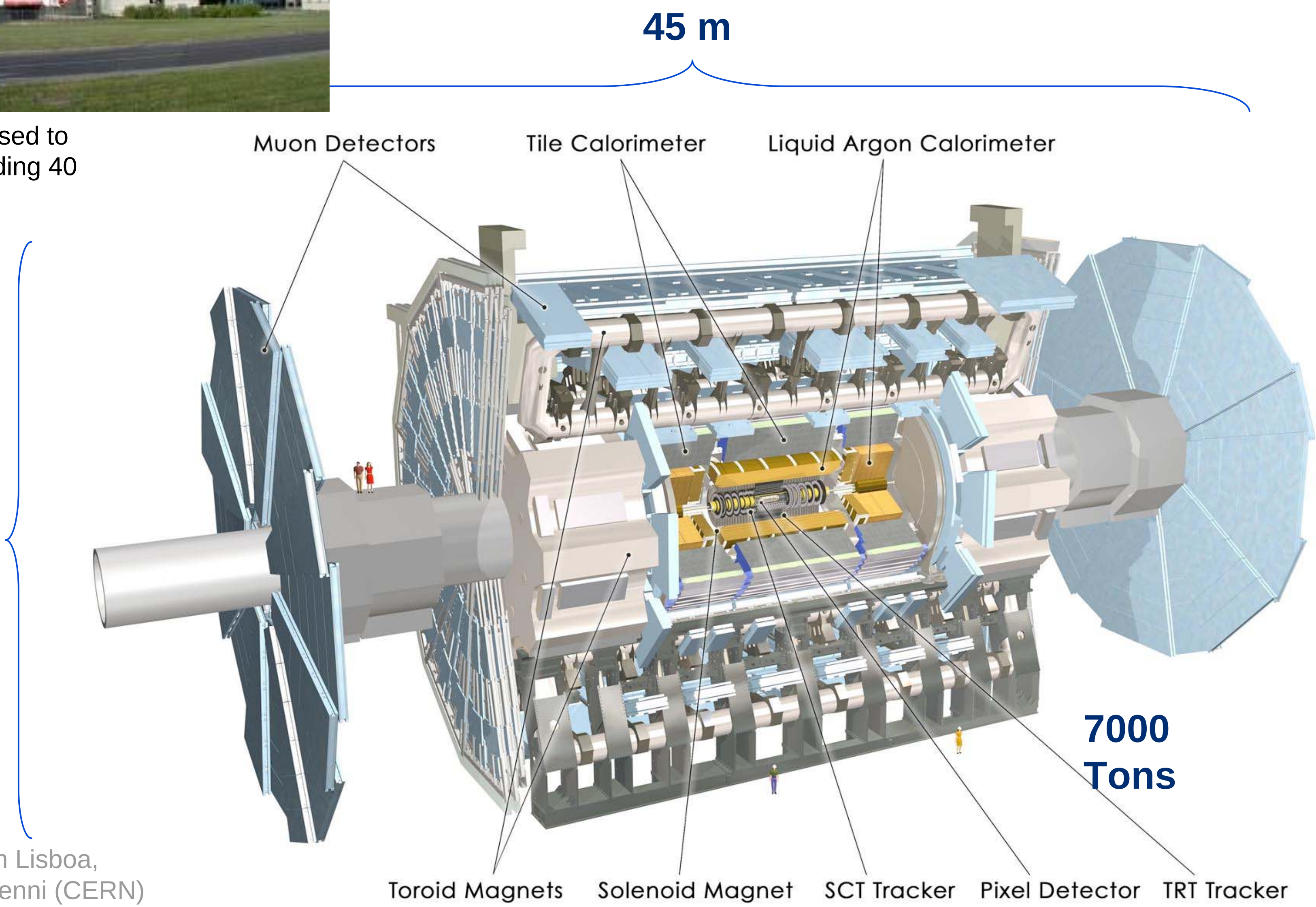
Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, UAN Bogota, Bologna, Bonn, Boston, Brandeis, Brasil Cluster, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, CERN, Chinese Cluster, Chicago, Chile, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, SMU Dallas, UT Dallas, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Edinburgh, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Iowa, UC Irvine, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, **Lisbon LIP**, Liverpool, Ljubljana,
QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, RUPHE Morocco, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, LMU Munich, MPI Munich, Nagasaki IAS, Nagoya, Naples, New Mexico, New York, Nijmegen, Northern Illinois, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, NPI Petersburg, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, South Africa, Stockholm, KTH Stockholm, Stony Brook, Sydney, Sussex, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Tokyo Tech, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, UI Urbana, Valencia, UBC Vancouver, Victoria, Waseda, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan

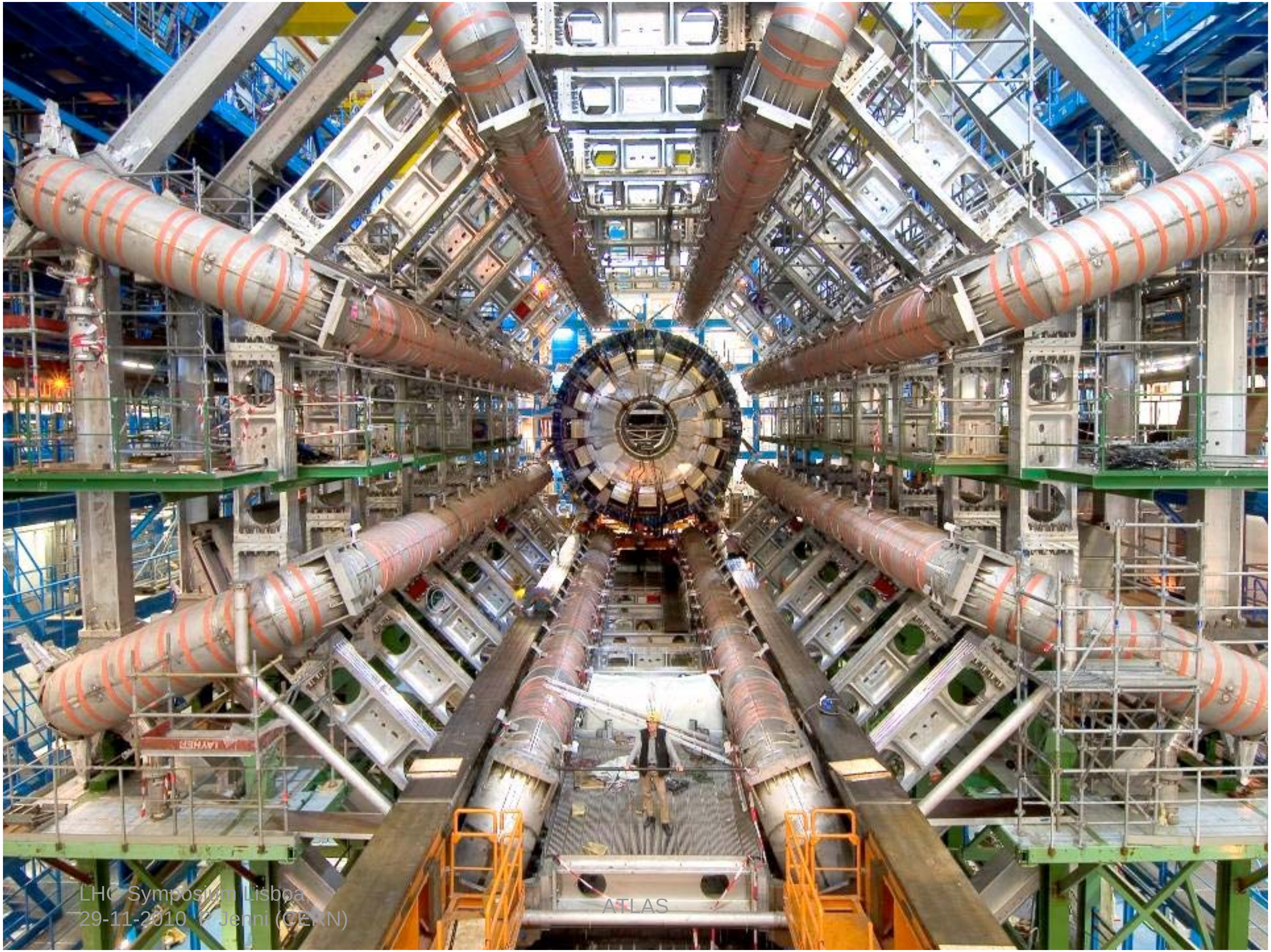
Age distribution of the ATLAS population

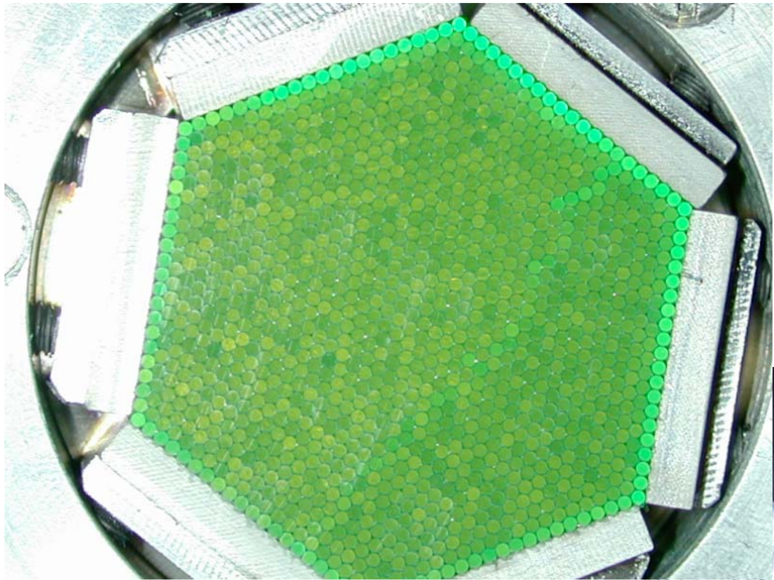


ATLAS Detector

ATLAS superimposed to
the 5 floors of building 40







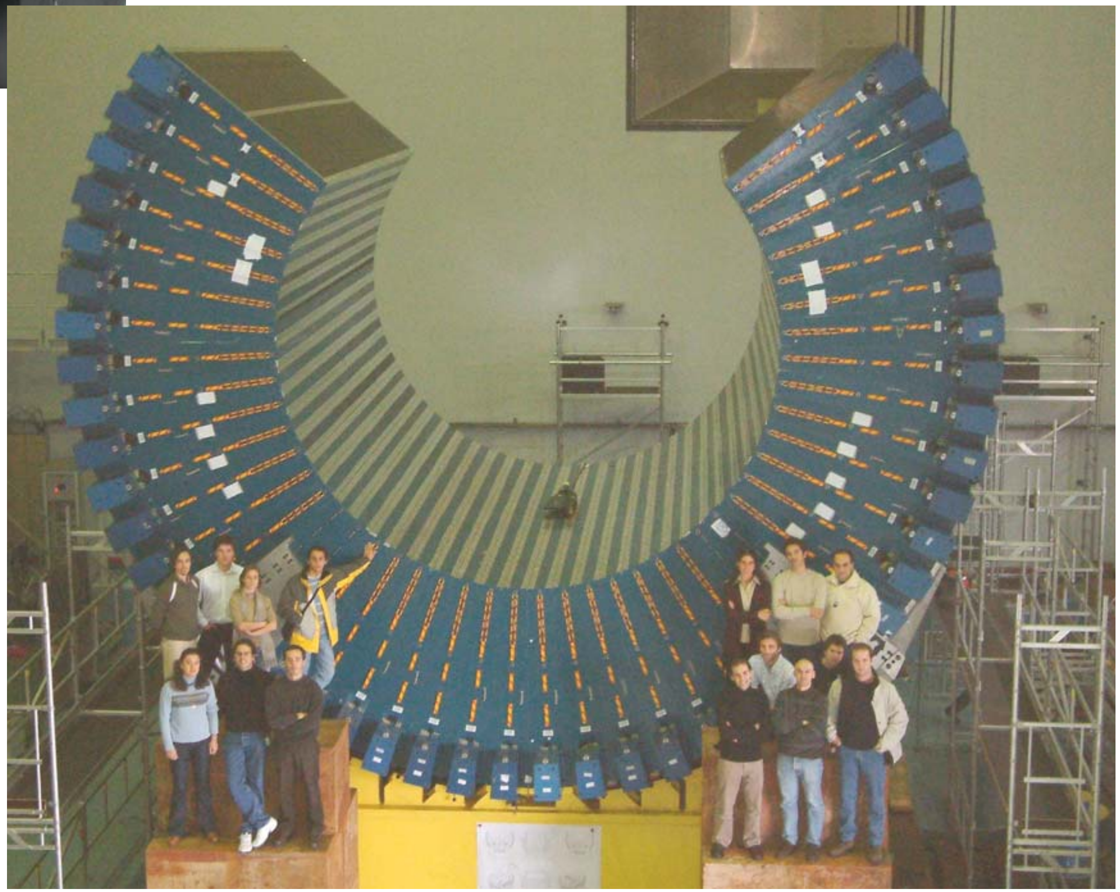
Fibres polished in bundles

We should remember the huge detector construction efforts, for example the crucial contributions of our Portuguese colleagues to the Tile Calorimeter optics…

WLS fibre readout of the Tile Calorimeter

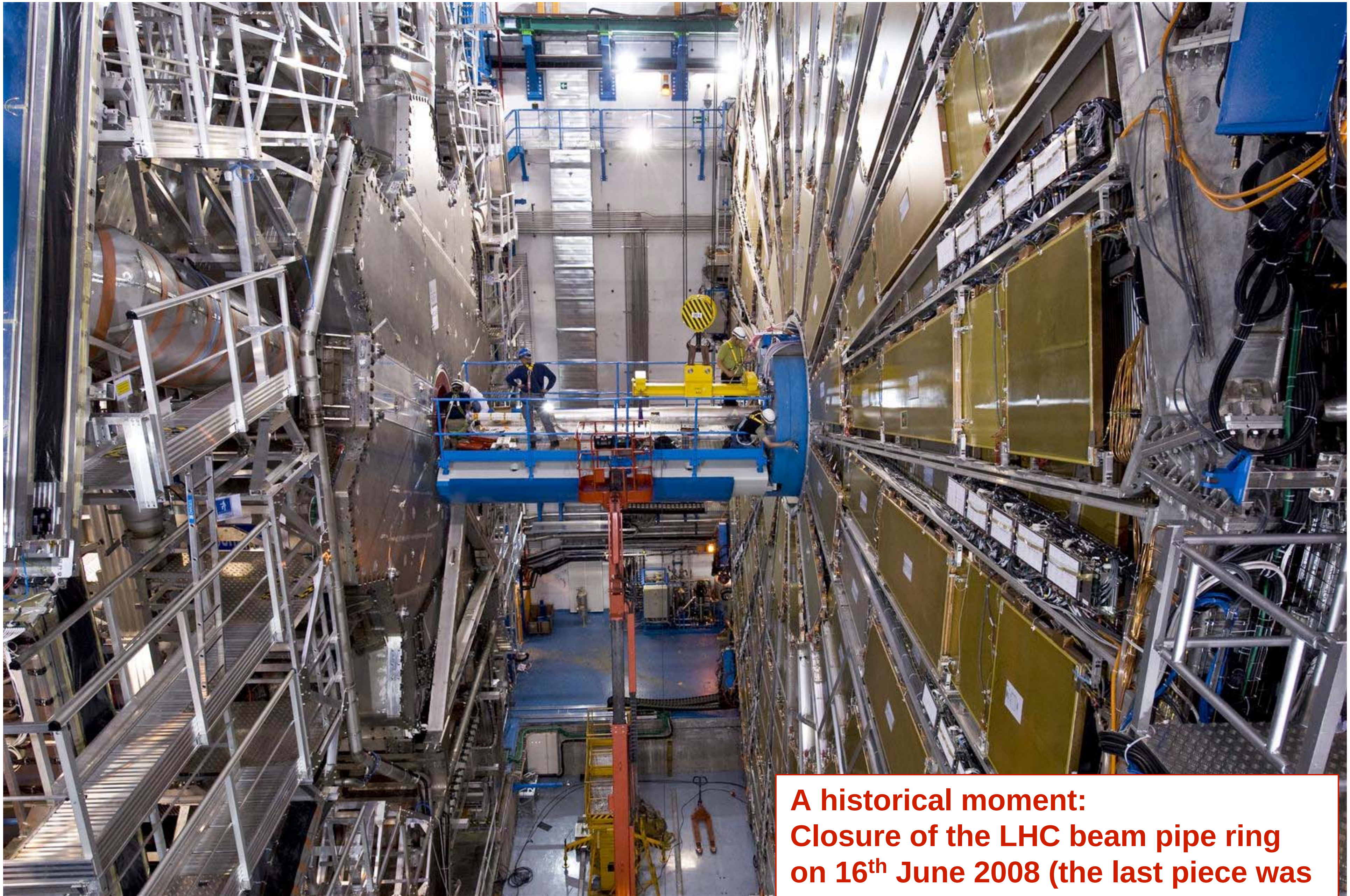
Fibres are inserted in profiles with robot

Ana Maria Henriques Correira, now Tile Calorimeter Project Leader, explains to Minister Pedro Augusto Lynce de Faria, the scintillator tile readout (May 2003)



Many Portuguese trainee engineers participated in ATLAS, here the Tile Calorimeter barrel pre-assembly

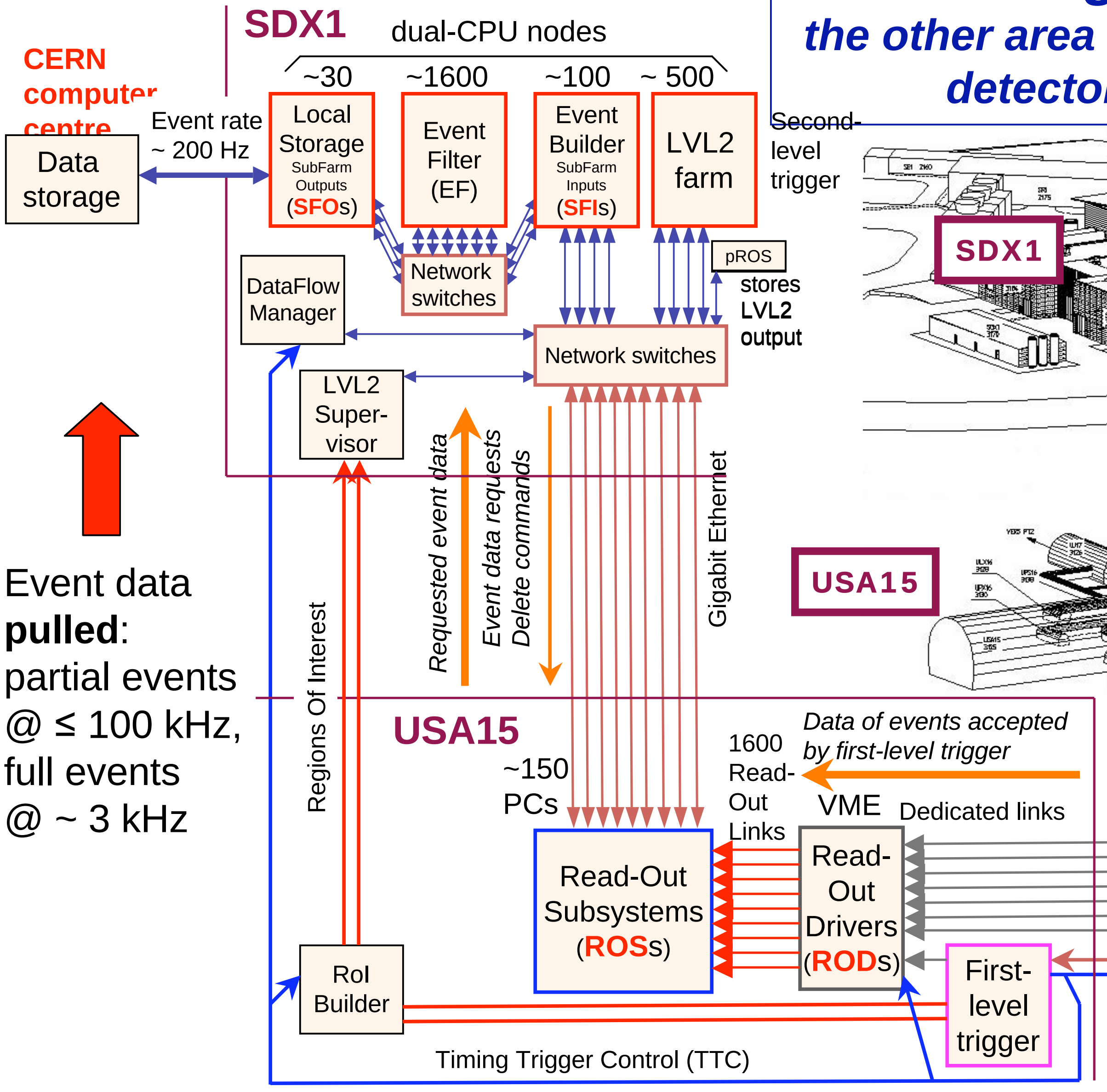
A spectacular transport, and installation of the first Tile Calorimeter modules in the underground cavern (March 2004)

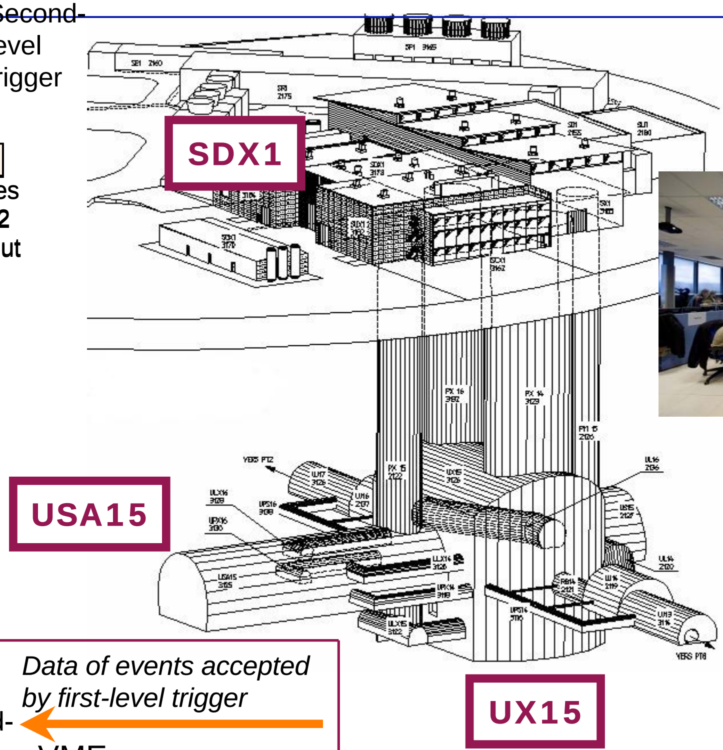


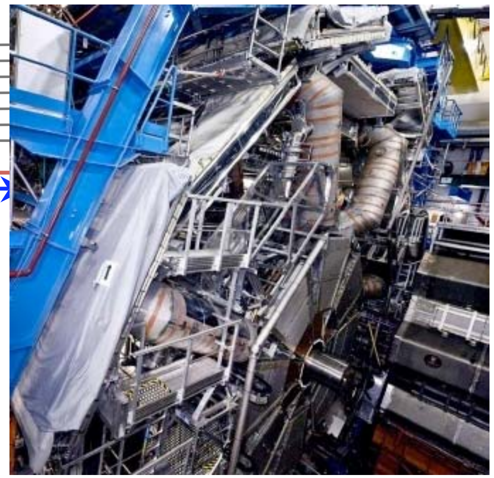
A historical moment:
Closure of the LHC beam pipe ring on 16th June 2008 (the last piece was the one shown here in ATLAS side A)

ATLAS Trigger / DAQ Data Flow

the other area with important Portuguese detector contributions in ATLAS



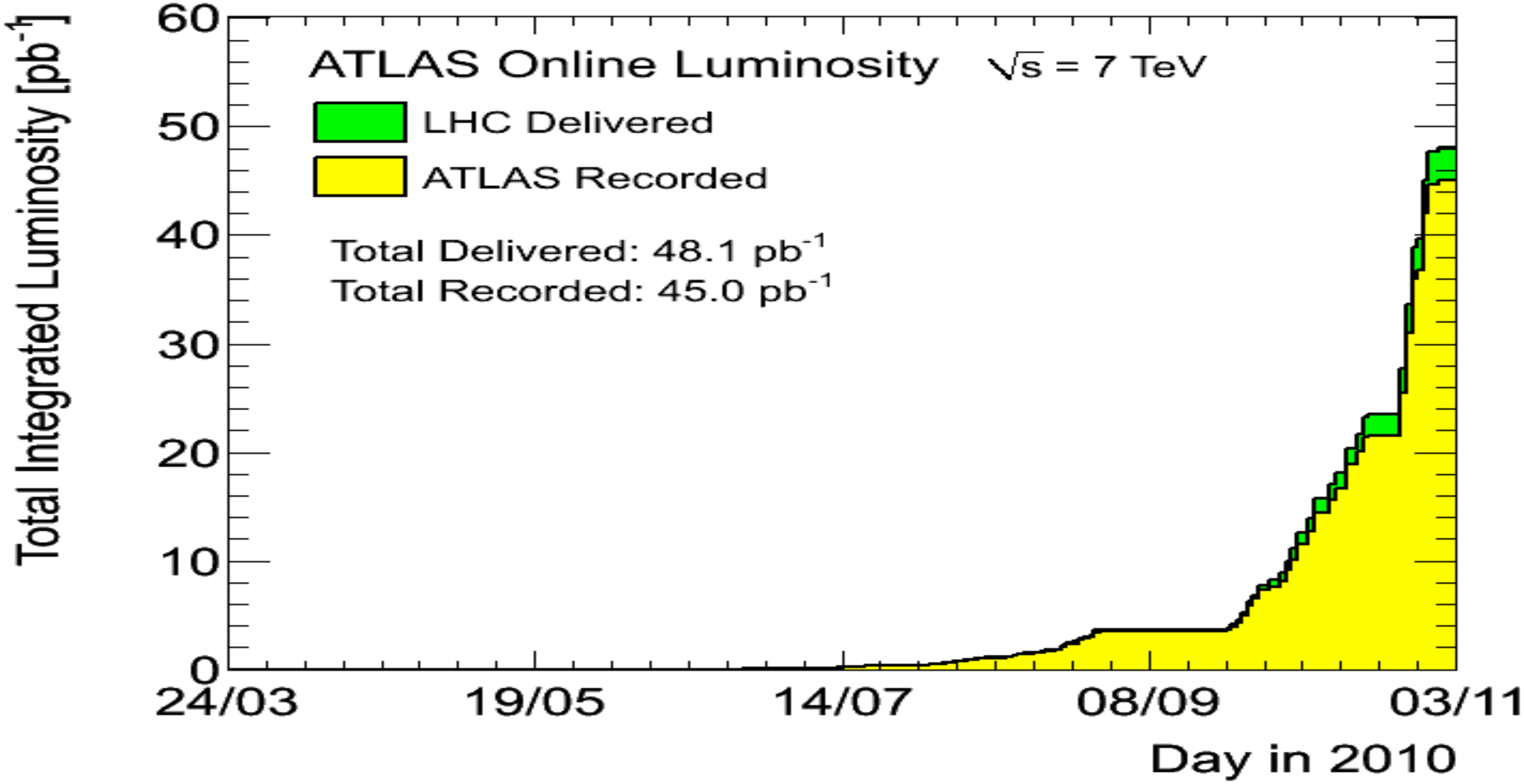




Event data **pulled**:
partial events @ ≤ 100 kHz,
full events @ ~ 3 kHz

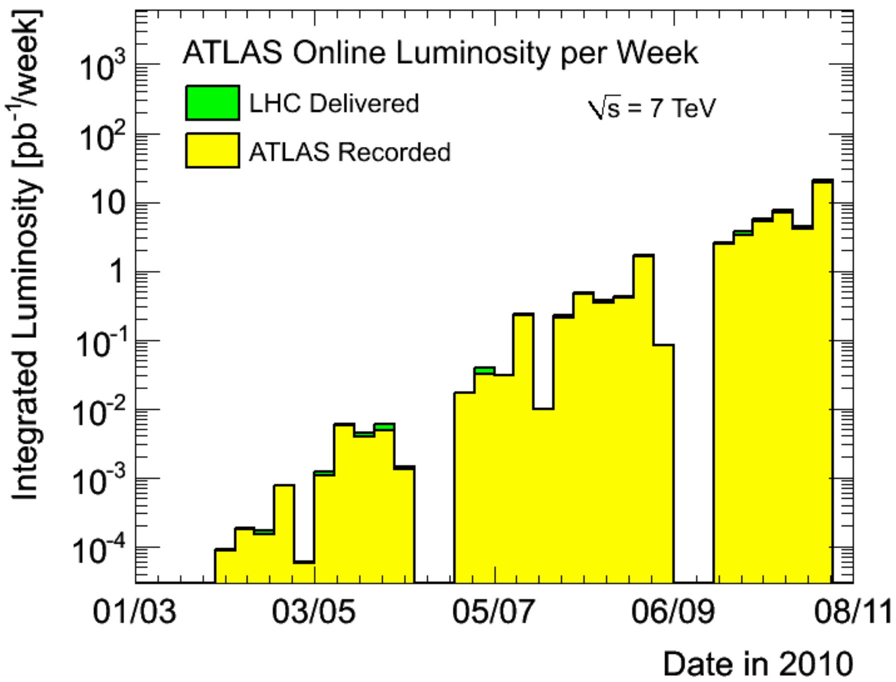
Event data pushed @ ≤ 100 kHz, 1600 fragments of ~ 1 kByte each

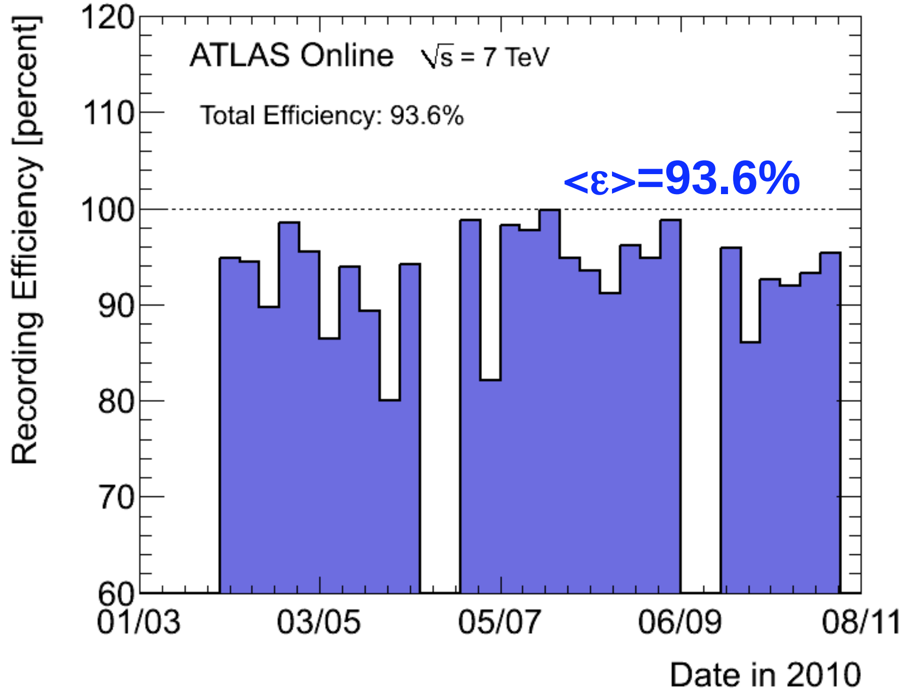
Integrated Luminosities 2010 Run



Note that 24 out of 48 pb^{-1} were delivered in one week of pp running

Data taking efficiency (pp)





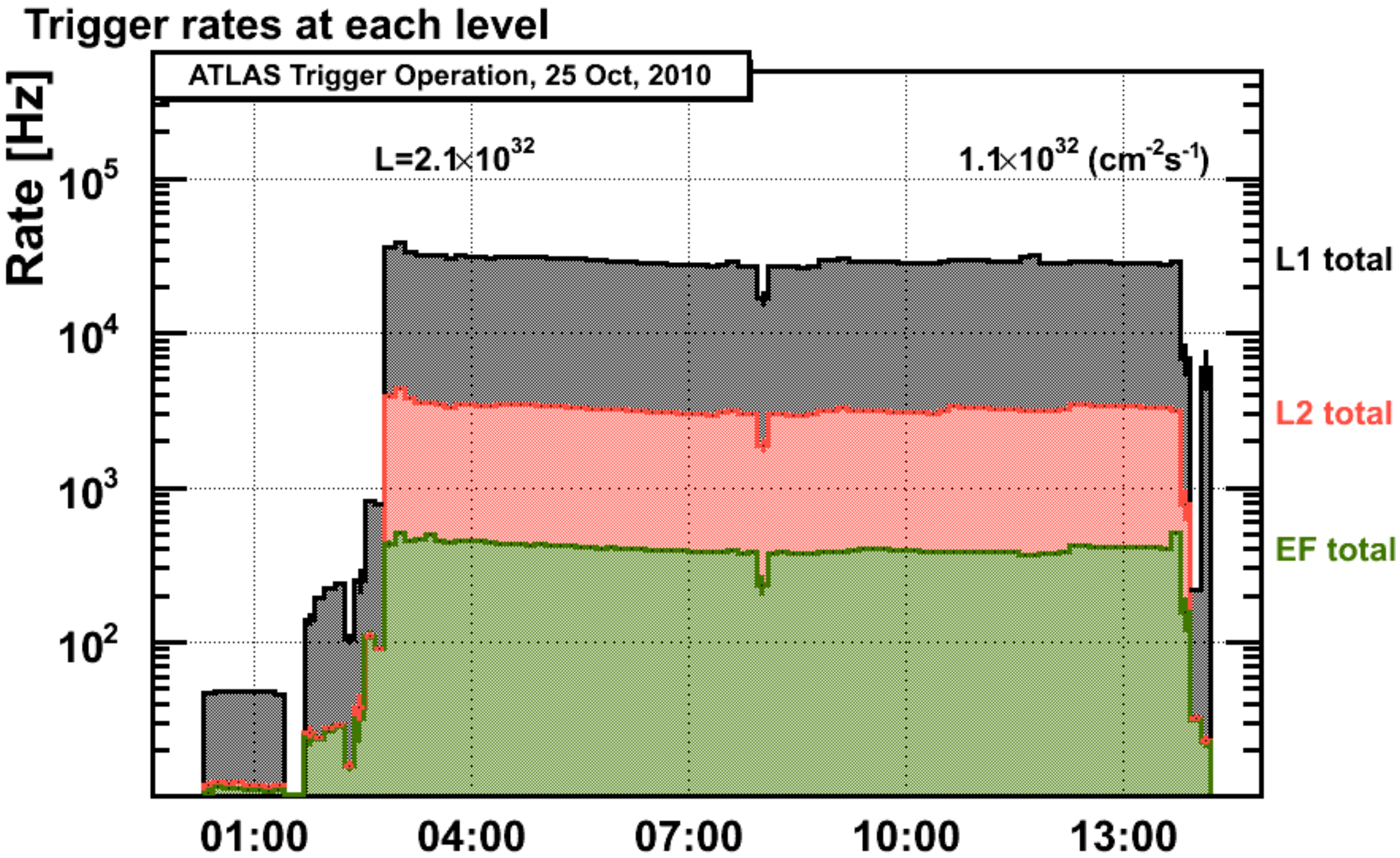
Luminosity weighted data taking efficiency 93.6%, including readout dead time, and 2% due to 'warm start' (HV ramps, and pixel preamps switched on only after stable beams)

Data Quality for physics analyses

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.0	99.9	100	90.5	96.6	97.8	94.3	99.9	99.8	96.2	99.8

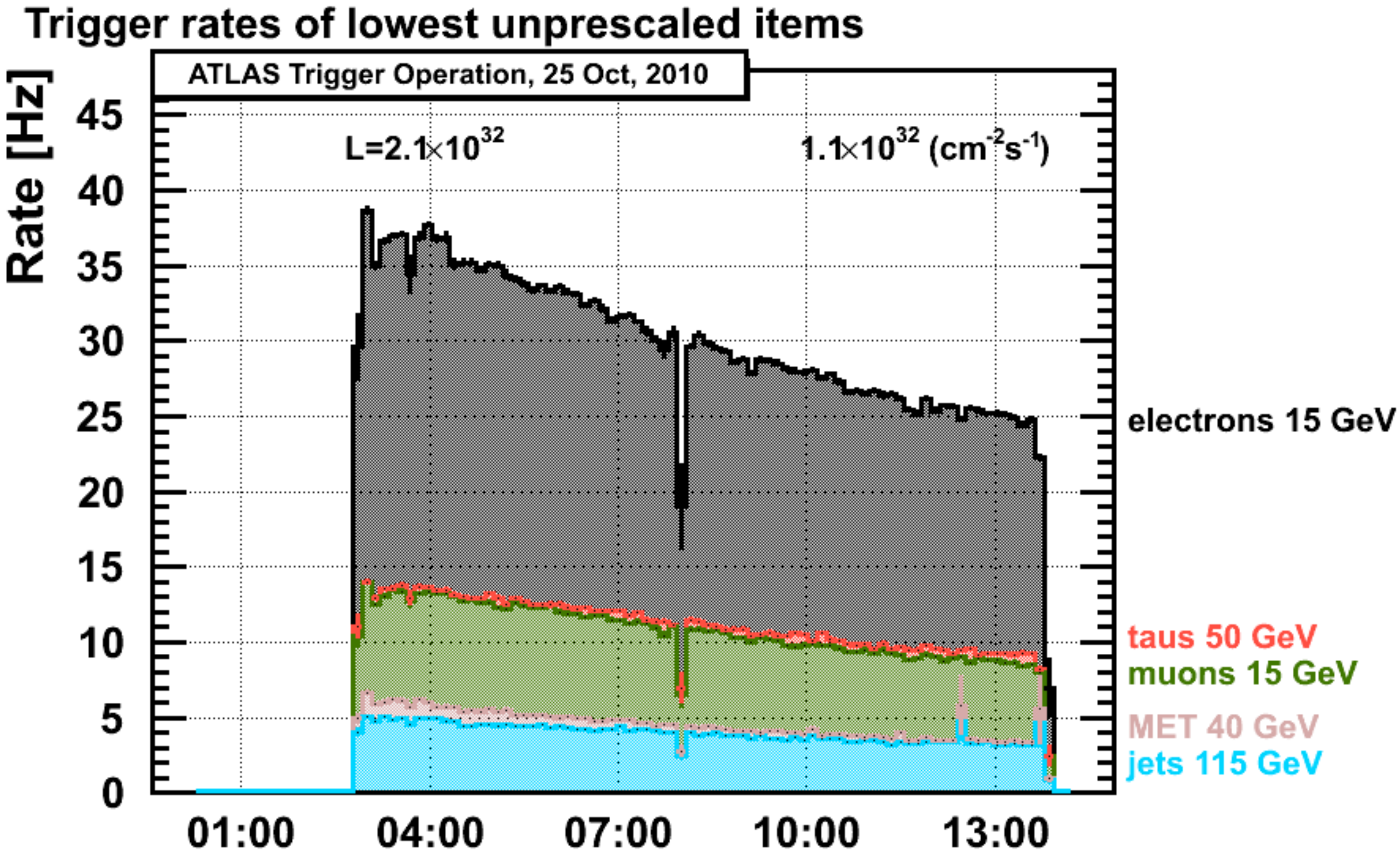
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at √s=7 TeV between March 30th and October 31st (in %). The inefficiencies in the calorimeters will largely be recovered in a future data reprocessing.

Trigger rates in the highest luminosity fill



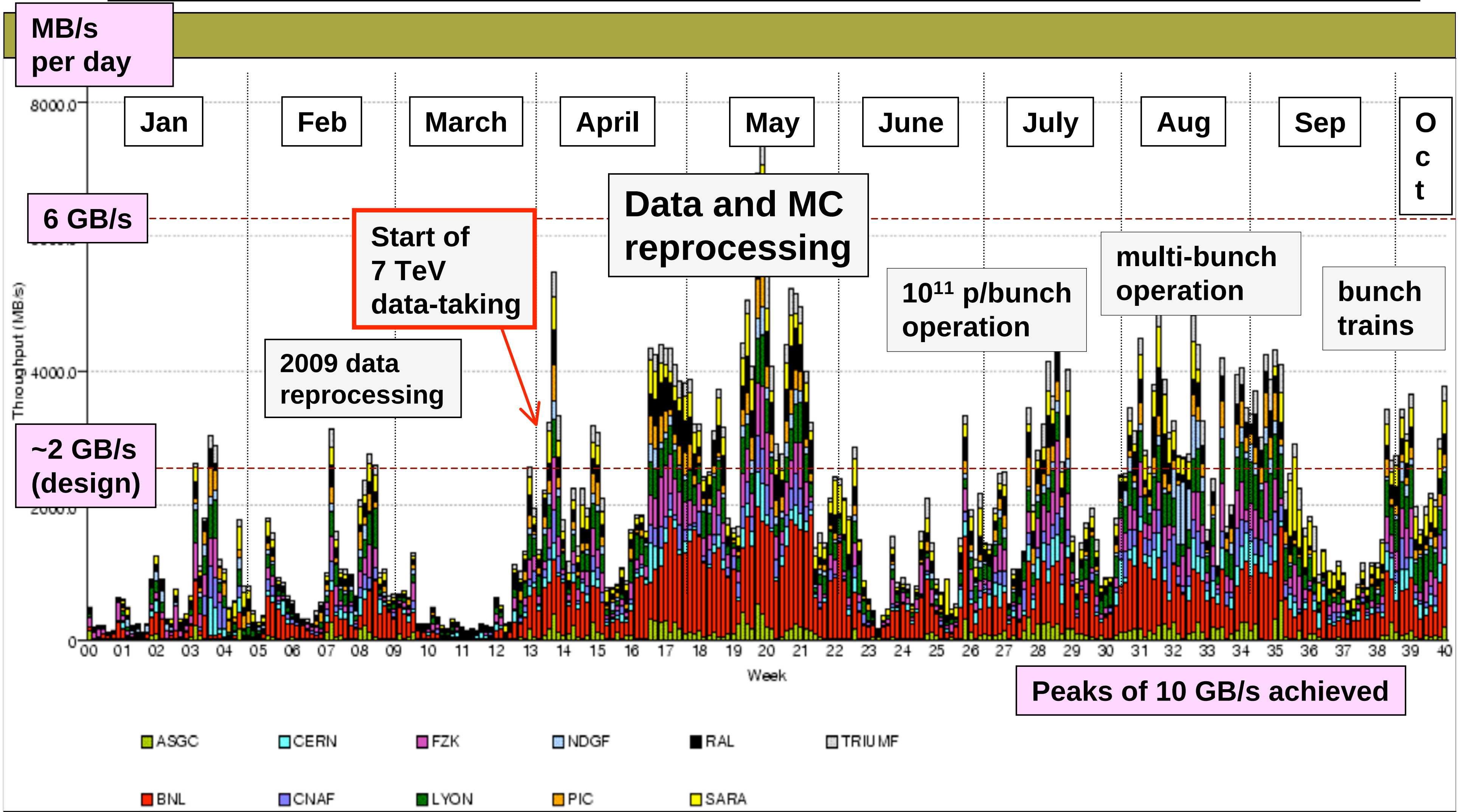
Adjusted prescales to maintain ~400 Hz EventFilter output

Trigger rates by objects in the highest luminosity fill



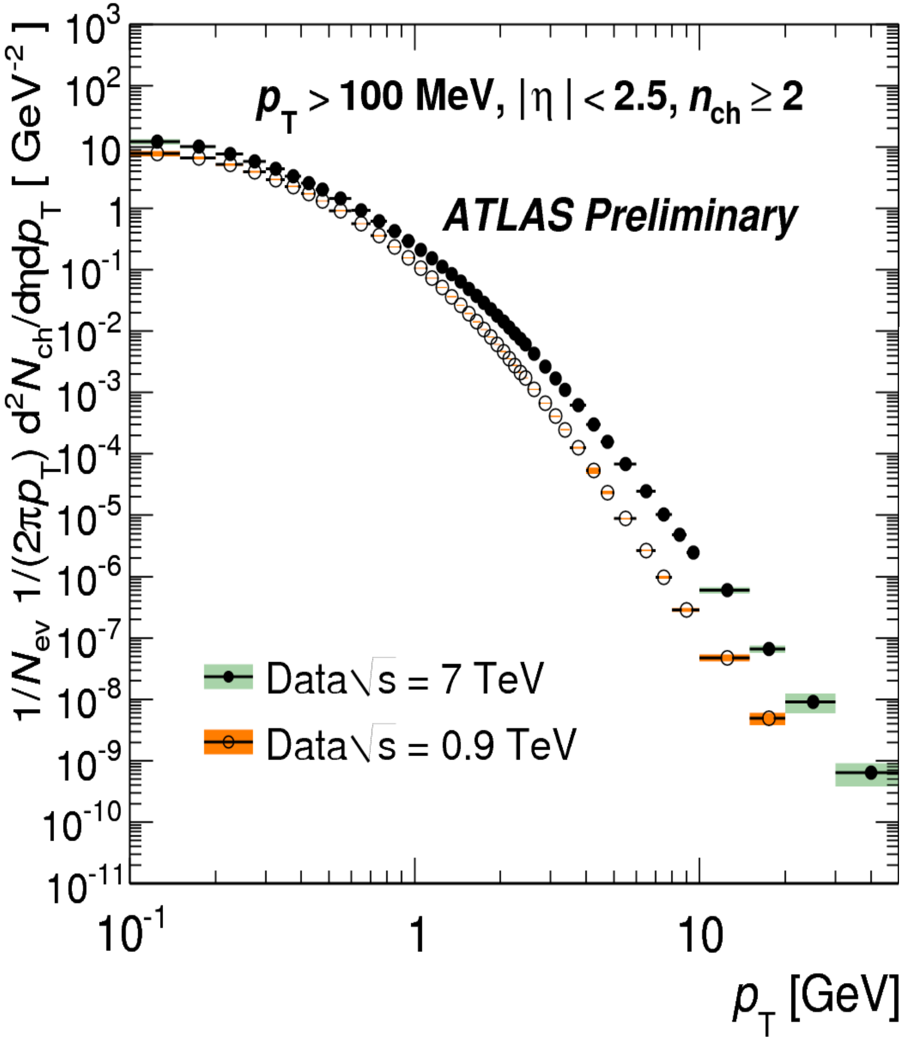
Worldwide data distribution and analysis

Total throughput of ATLAS data through the Grid: 1st January → early October



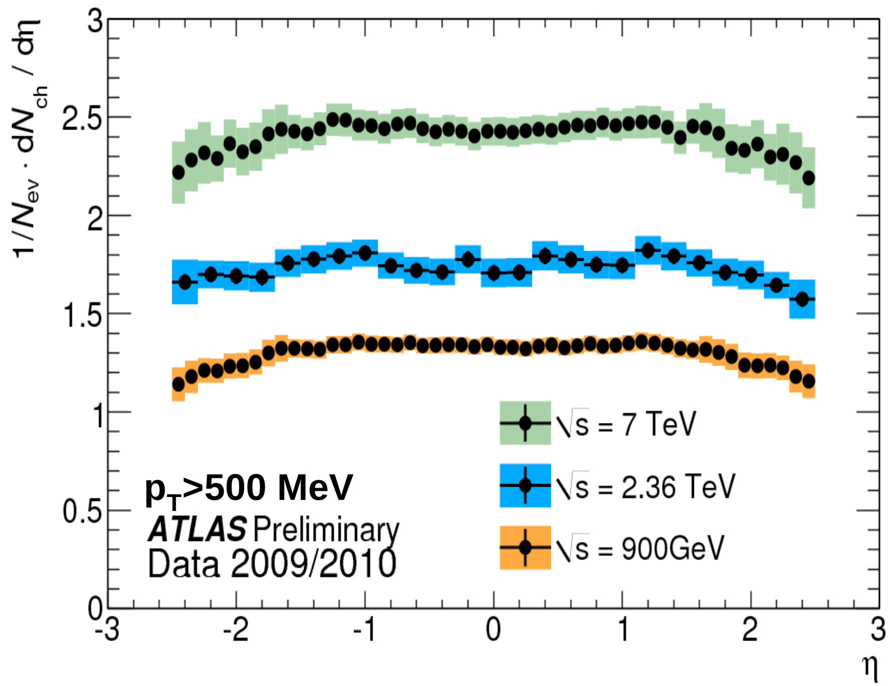
More than 1000 users

Basic 'minimum bias' measurements with pp



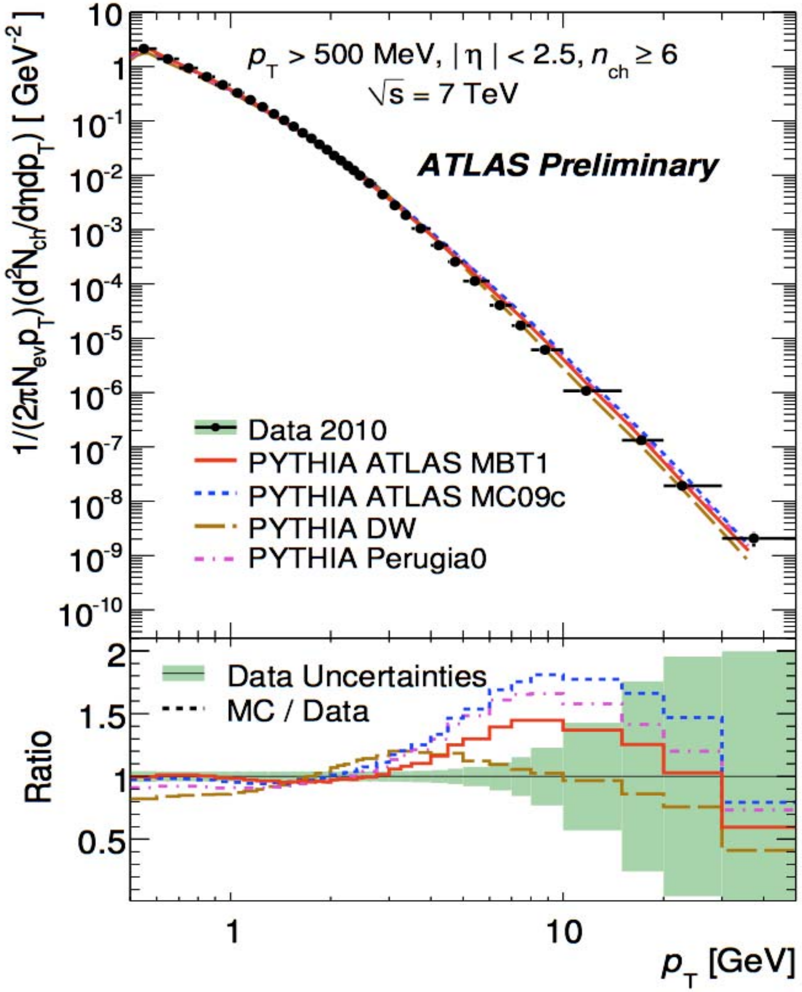
Number of charged particles as a function of p_T and η

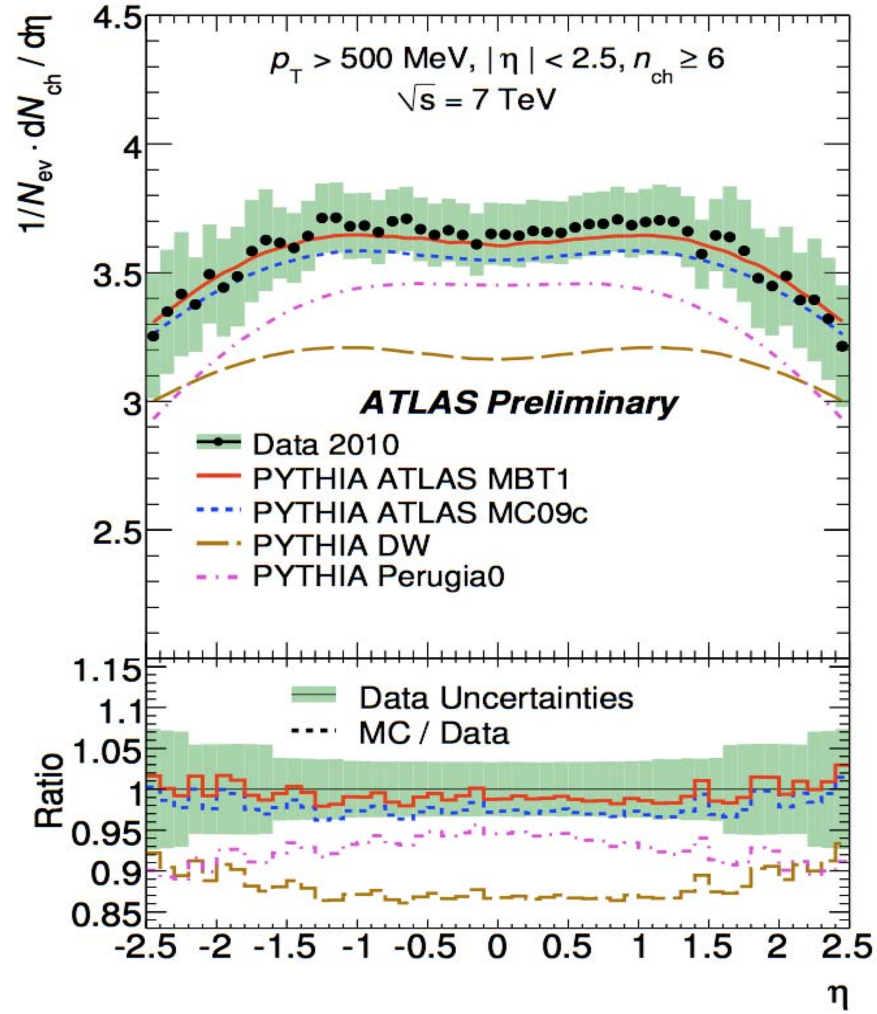
Plus studies of underlying event, new MC tune…



Data with minimal model dependence can be used for detailed MC tuning

Used for the tune
- ATLAS UE data at 0.9 and 7 TeV
- ATLAS charged particle densitites at 0.9 and 7 TeV
- CDF Run I underlying event analysis (leading jet)
- CDF Run I underlying event "Min-Max" analysis
- D0 Run II dijet angular correlations
- CDF Run II Min bias
- CDF Run I Z pT

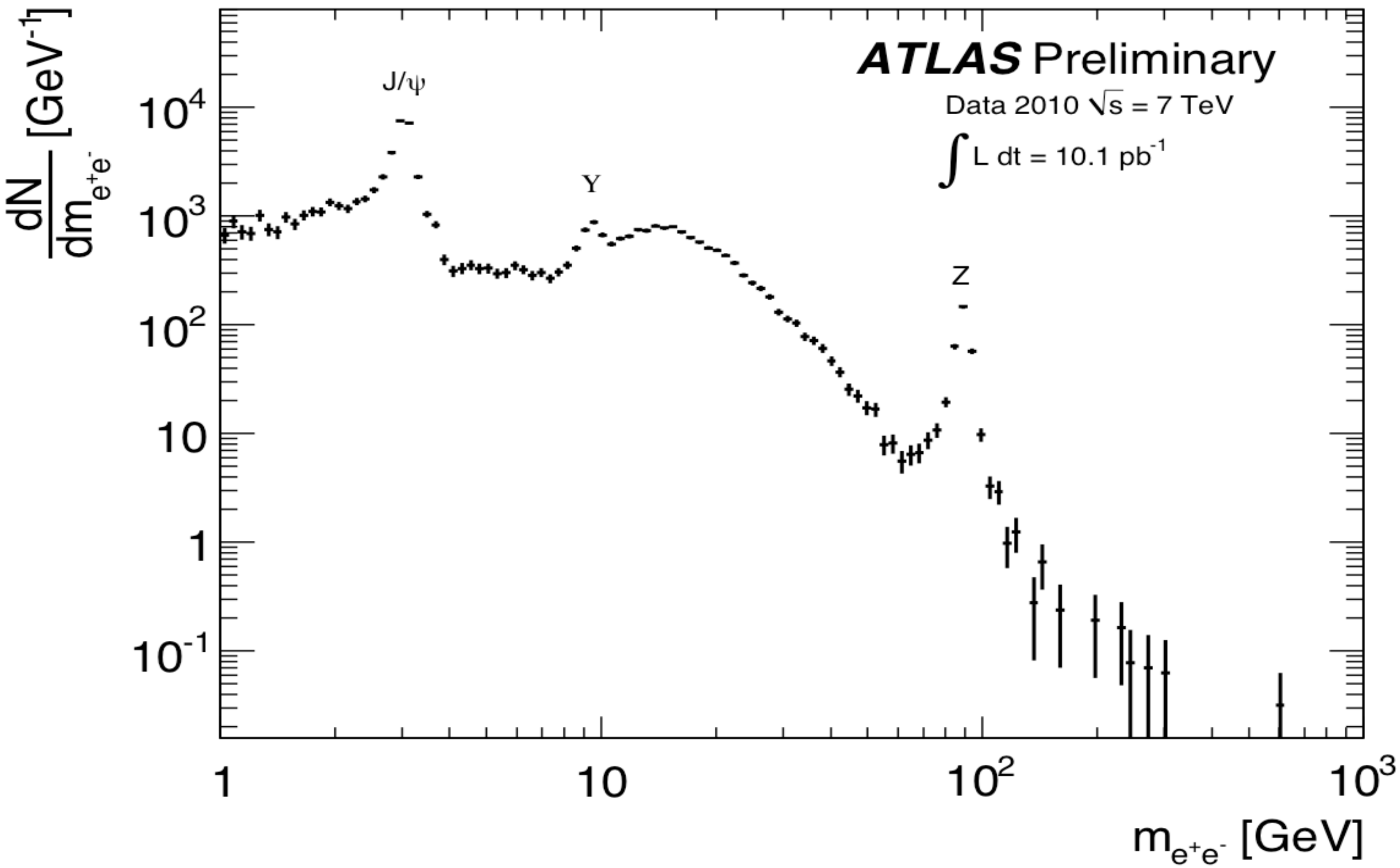




Di-electron invariant mass

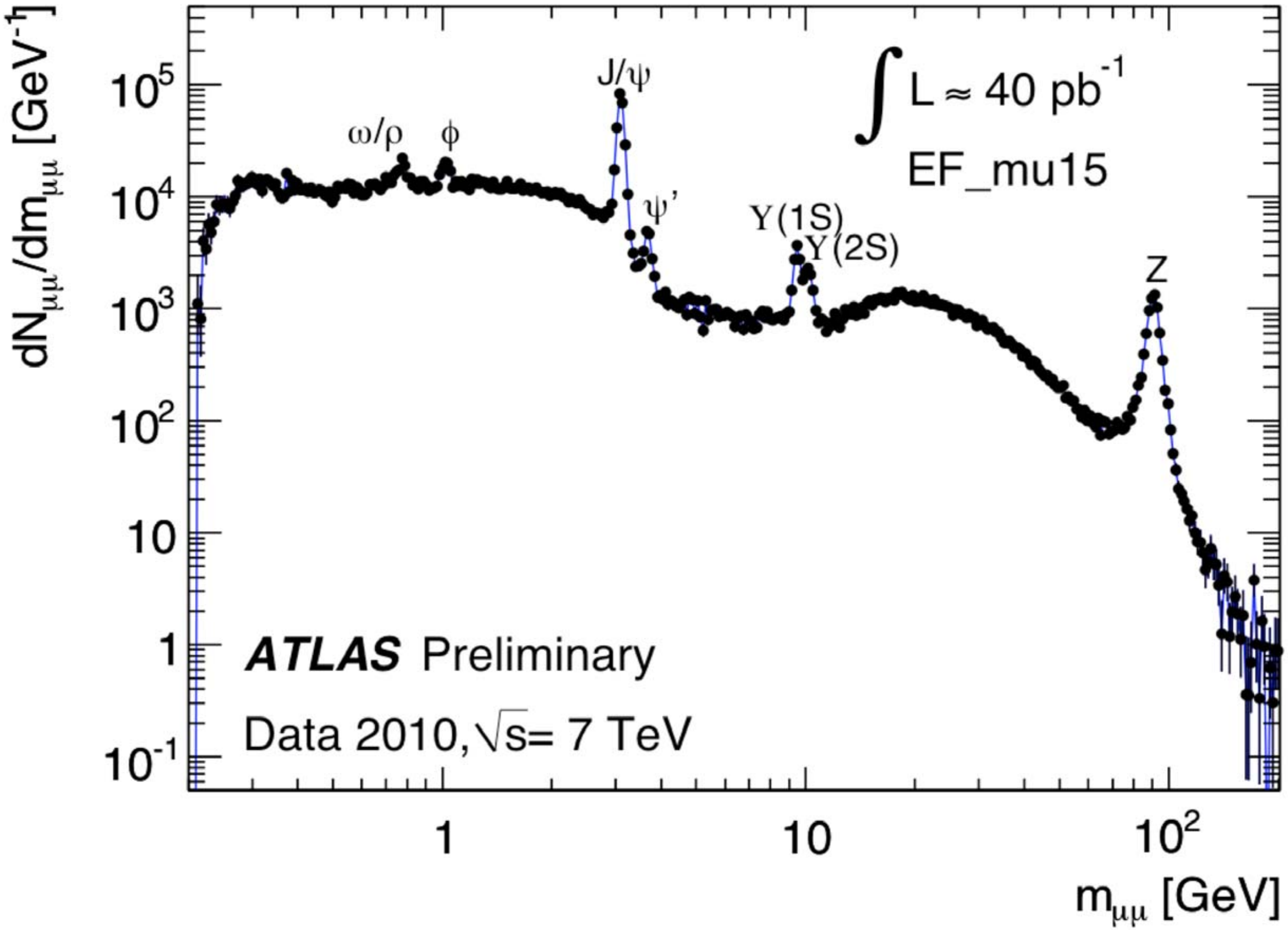
Data with 5 GeV E_T di-electron trigger (prescaled in later data)

(Trigger selection produces shoulder around 15 GeV)



Di-muon invariant mass

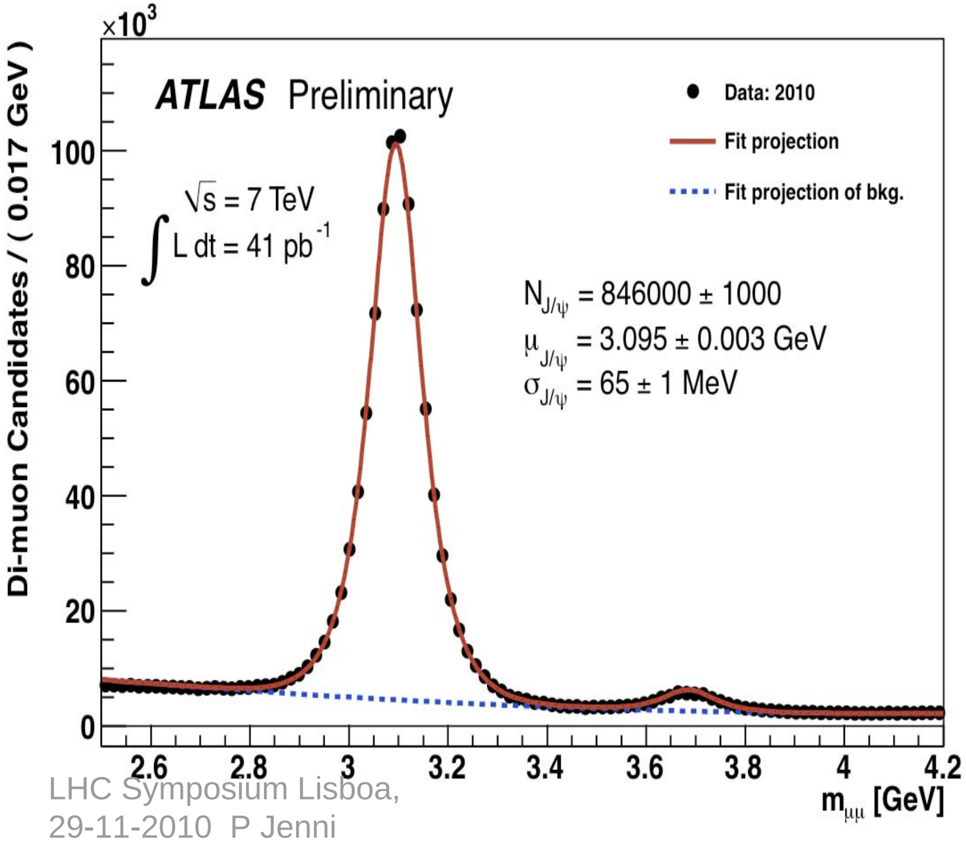
Leading muon, p_T>15 GeV, second muon, p_T>2.5 GeV

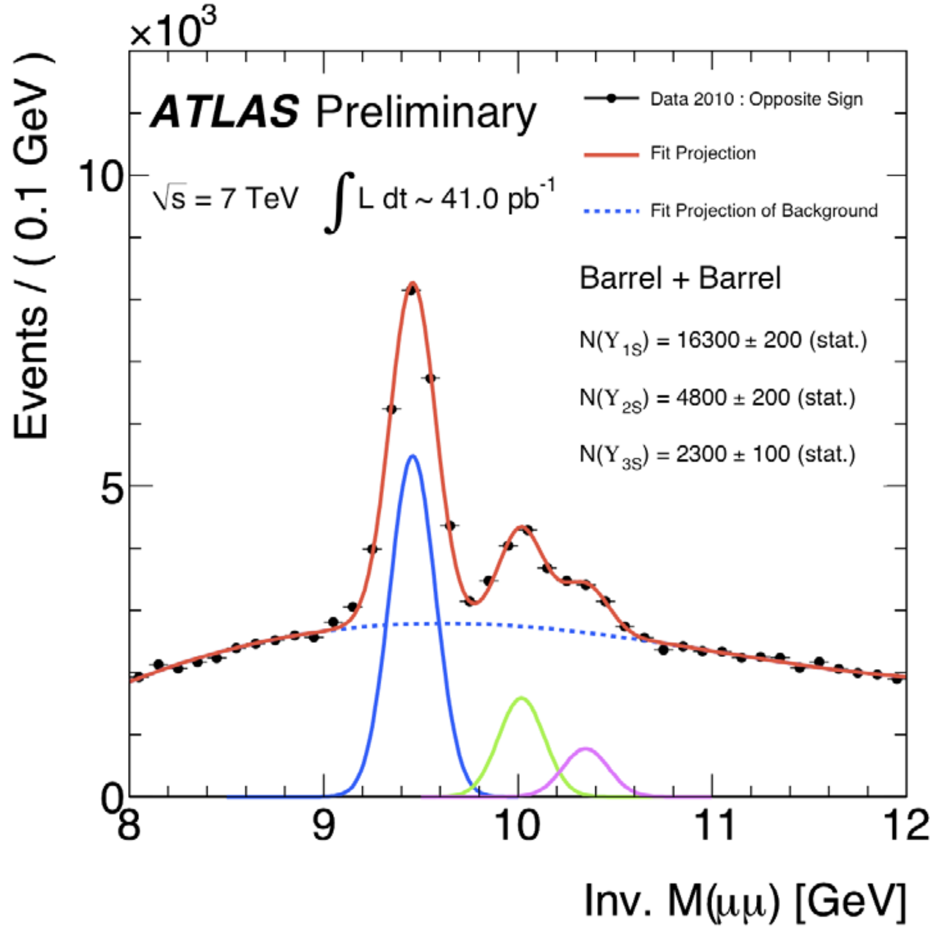


J/Ψ,Ψ(2S) and ϒ→μμ

Use a selection of looser triggers (Oppositely charged muons with $p_T(\mu_1,\mu_2)$>(2.5,4) GeV)

For J/Ψ & Ψ(2S) fit tracks to a common vertex and recalculate mass





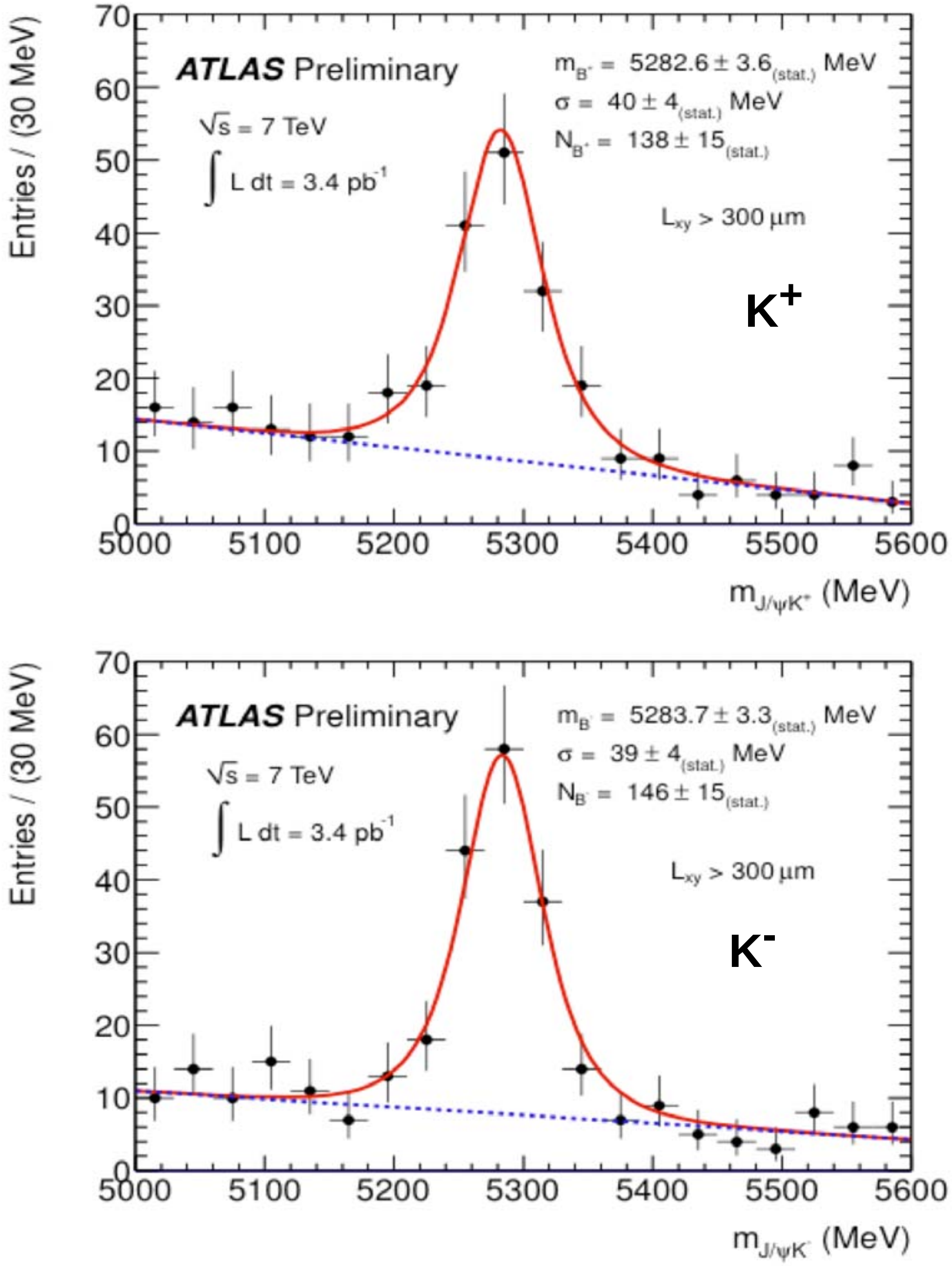
About 60k ϒ(1S,2S,3S) candidates over full acceptance

$B \rightarrow J/\Psi(\mu\mu)K$

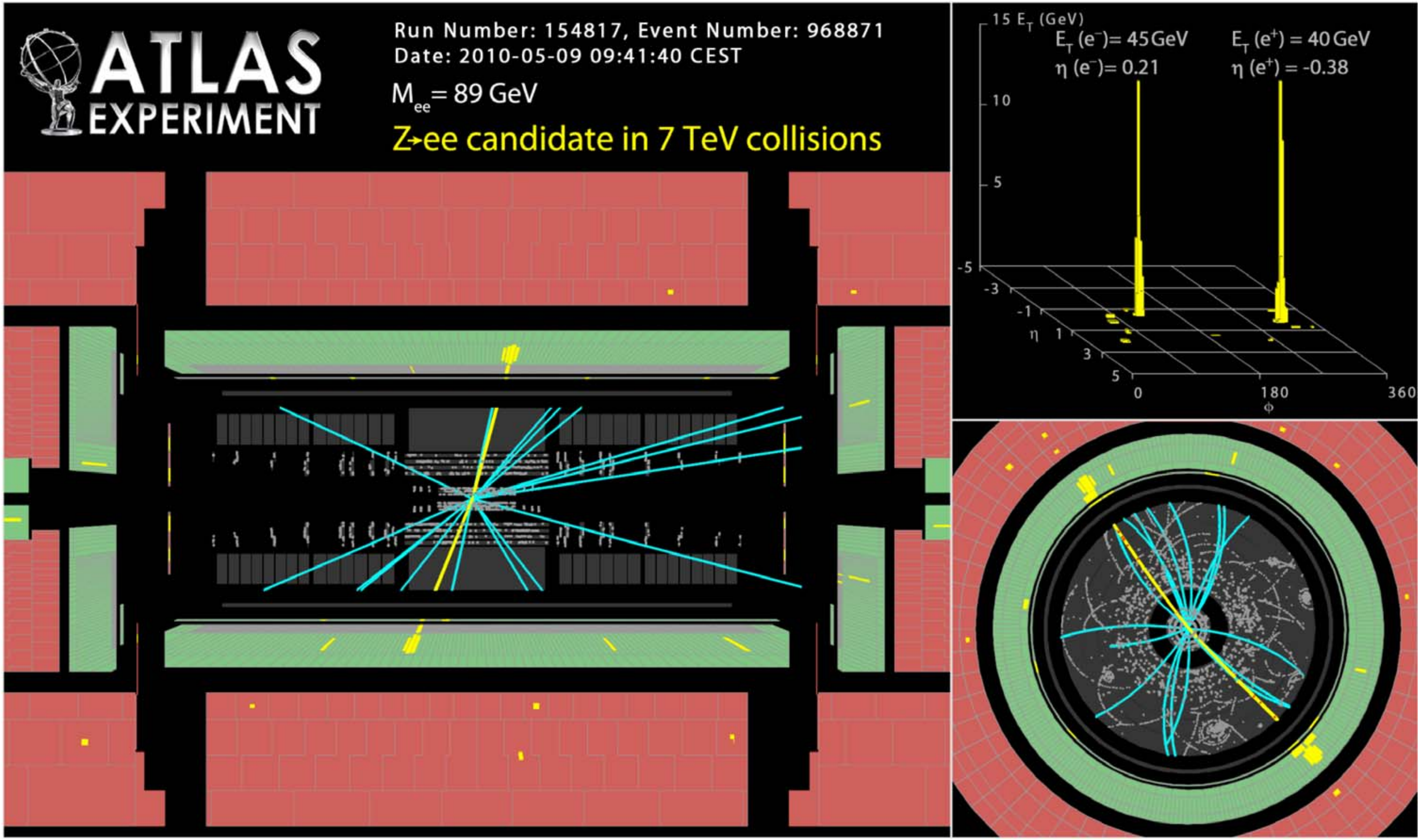
Signal for $B^{\pm} \rightarrow J/\Psi(\mu\mu)K^{\pm}$ require transverse decay length >300μm

Unbinned likelihood fit to signal (with event-by-event mass uncertainty) and linear background

Combining K^{+} and K^{-}
283±22 signal events,
fitted mass 5283±2.5 MeV



Intermediate Vector Bosons W and Z



How the LHC came to be …

(see a nice article by Chris Llewellyn-Smith in Nature 448, p281)

Some early key dates

1977 **The community talked about the LEP project, and it was already mentioned that a new tunnel could also house a hadron collider in the far future**

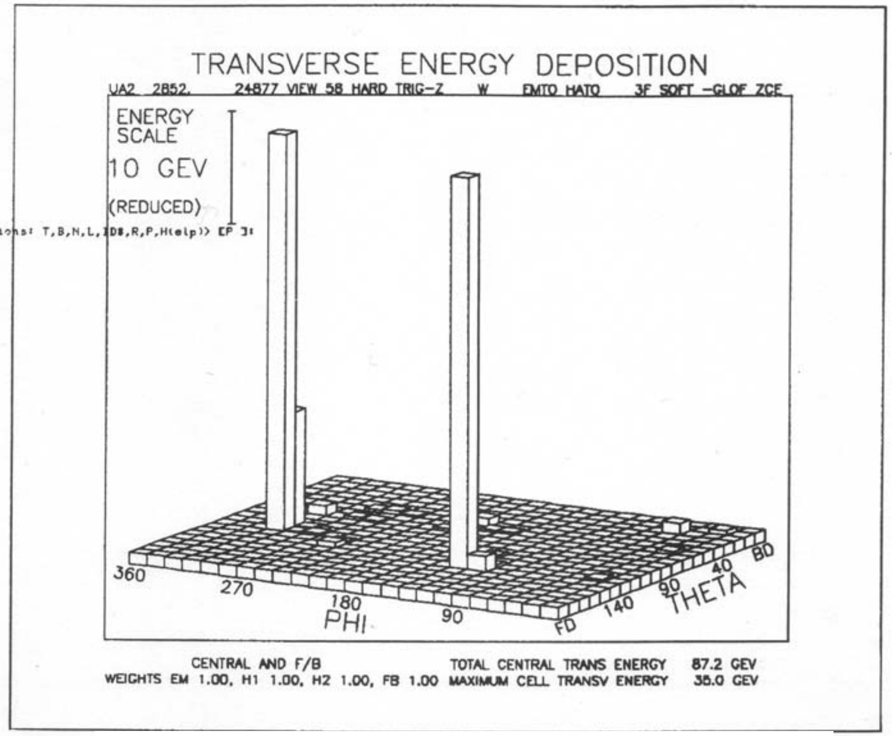
1981 **LEP was approved with a large and long (27 km) tunnel**

1983 **The early 1980s were crucial:**

The real belief that a 'dirty' hadron collider can actually do great discovery physics came from UA1 and UA2 with their W and Z boson discoveries at CERN

This also triggered a famous quote from a 1983 New York Times editorial:

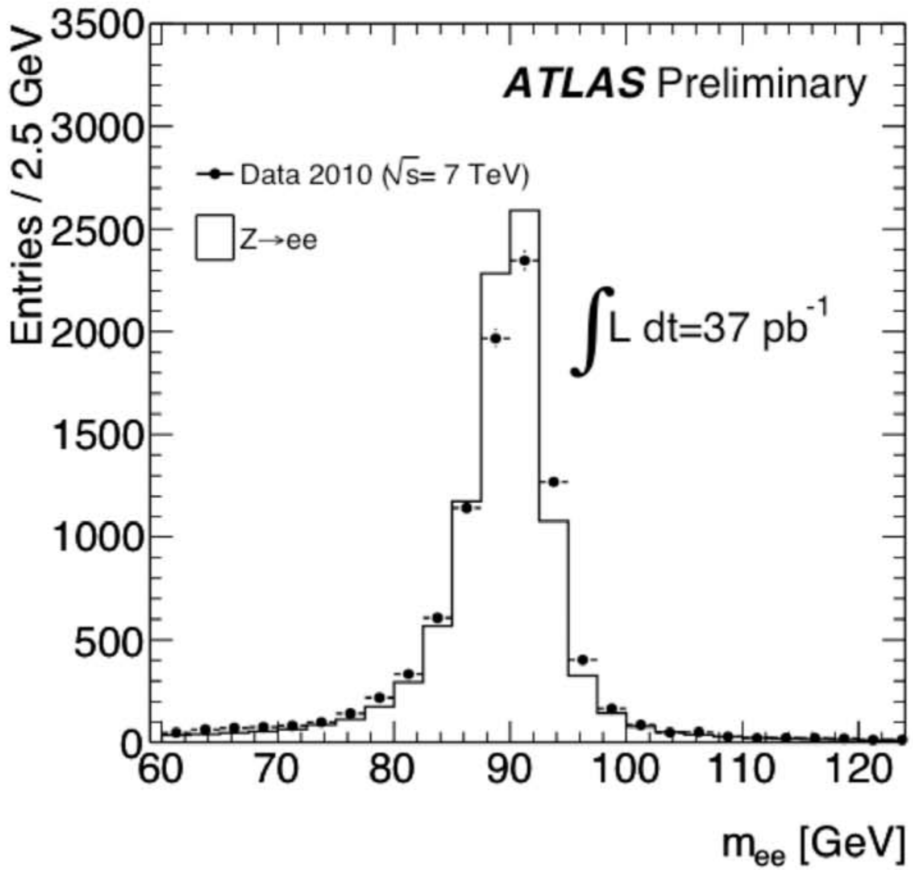
'Europe: 3 - US Not Even Z-Zero'

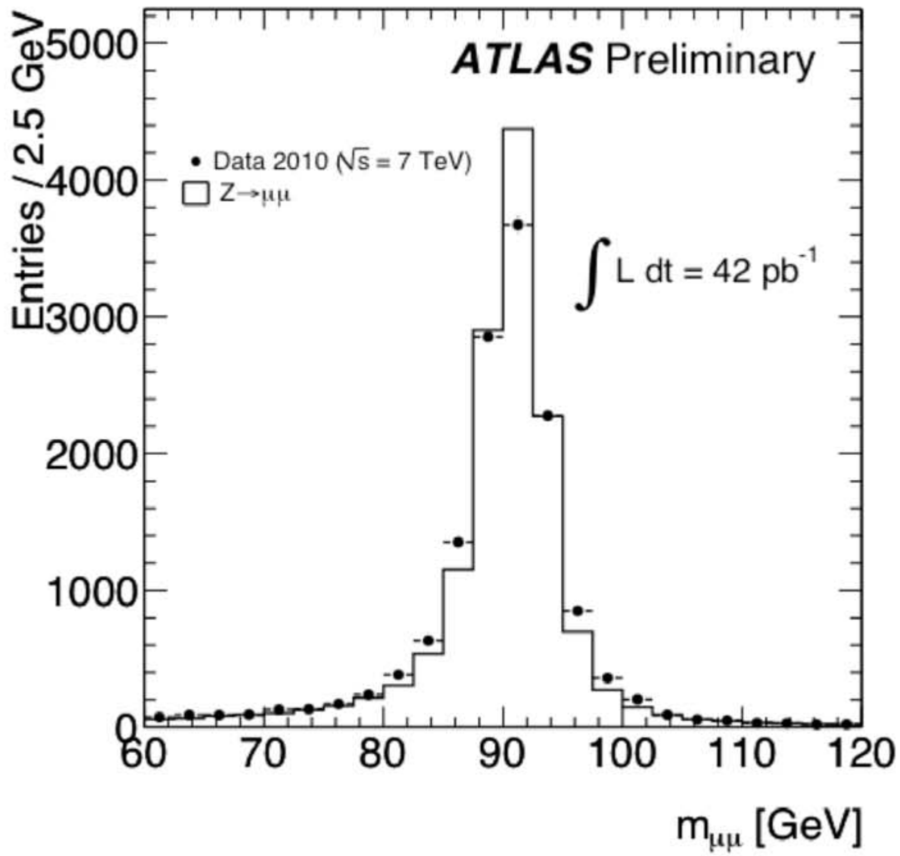


A very early Z → ee online display from one of the detectors (UA2)

Z mass peaks

- Invariant mass of Z candidates with first pass processing
- MC normalised to data
- 9k electron and 14k muon pair events

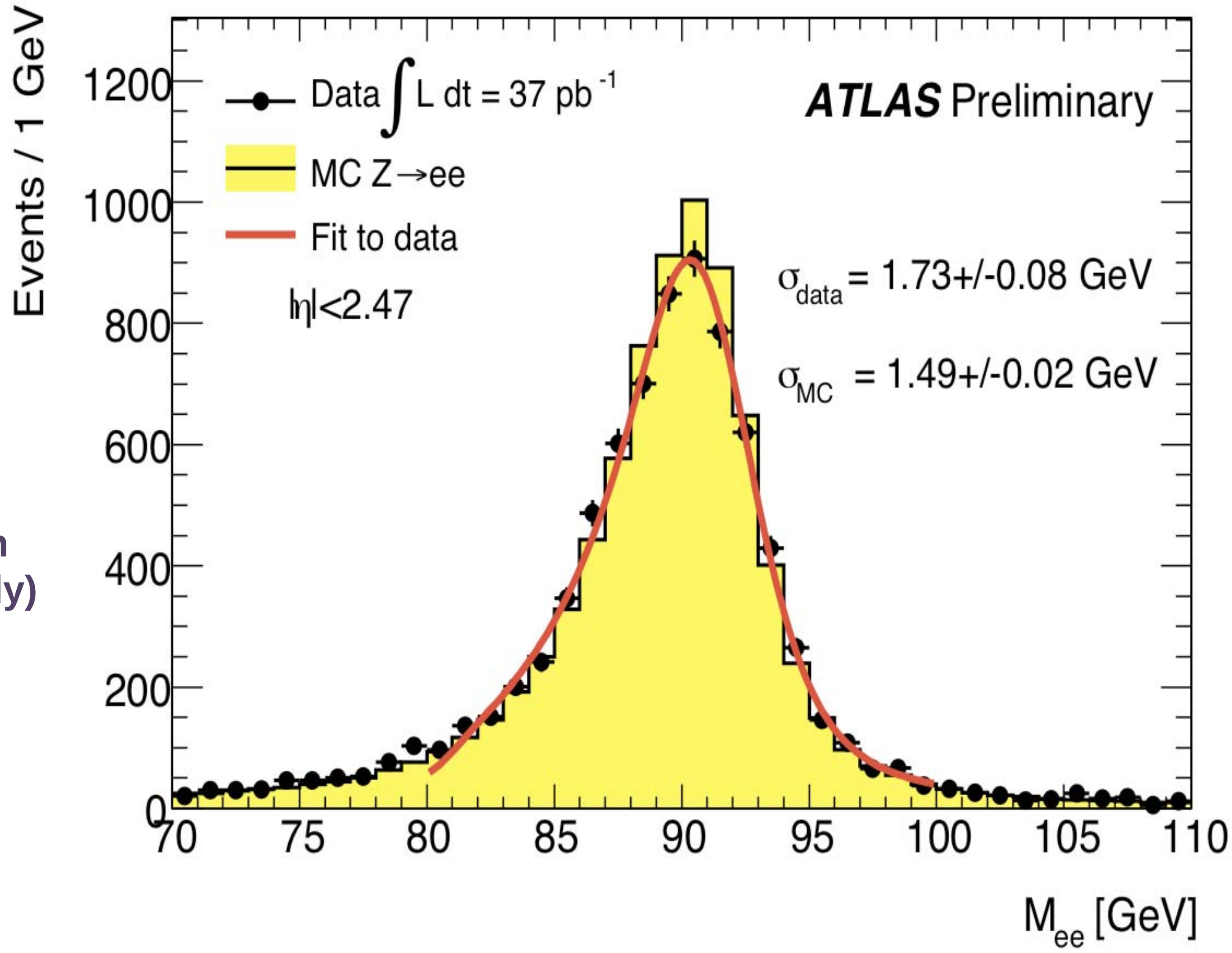




Z → ee invariant mass

Used to calibrate the EM scale with constrained fit to the Z lineshape in 28 calorimeter regions: Typical corrections 2%, consistent with precision of cryostat temperature measurement in test beam (this calibration is being applied in the reprocessing)

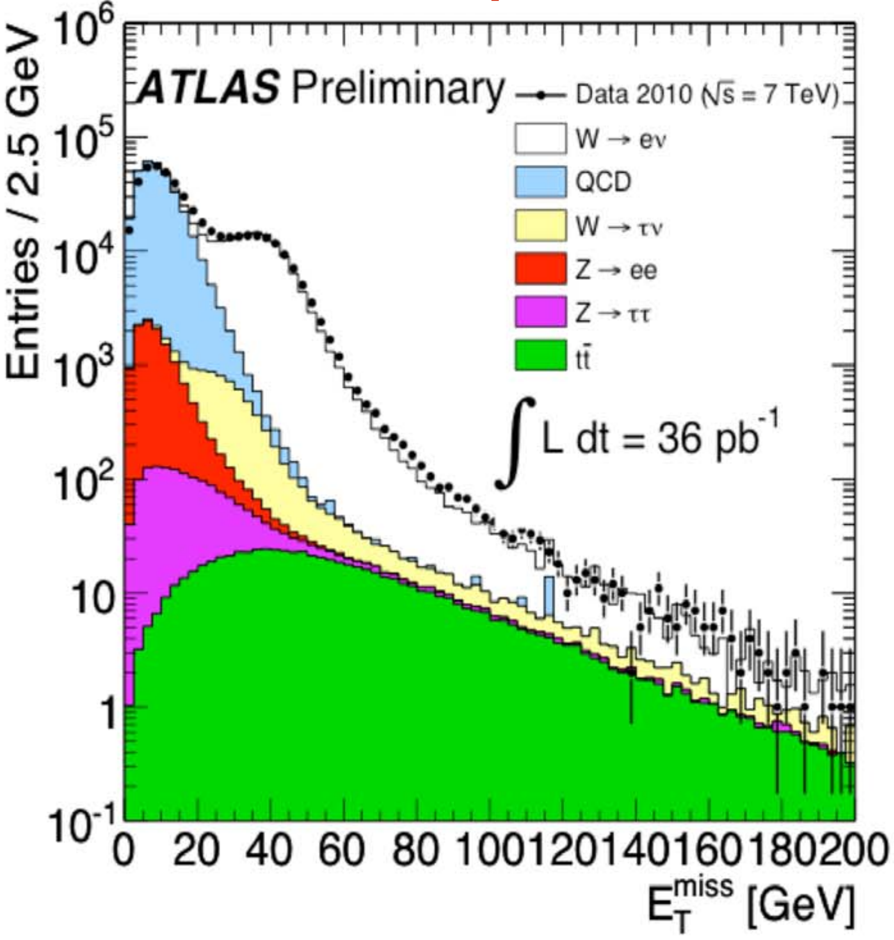
Fit to a Breit-Wigner convolved with a ‘crystal ball’ function (statistical errors only)



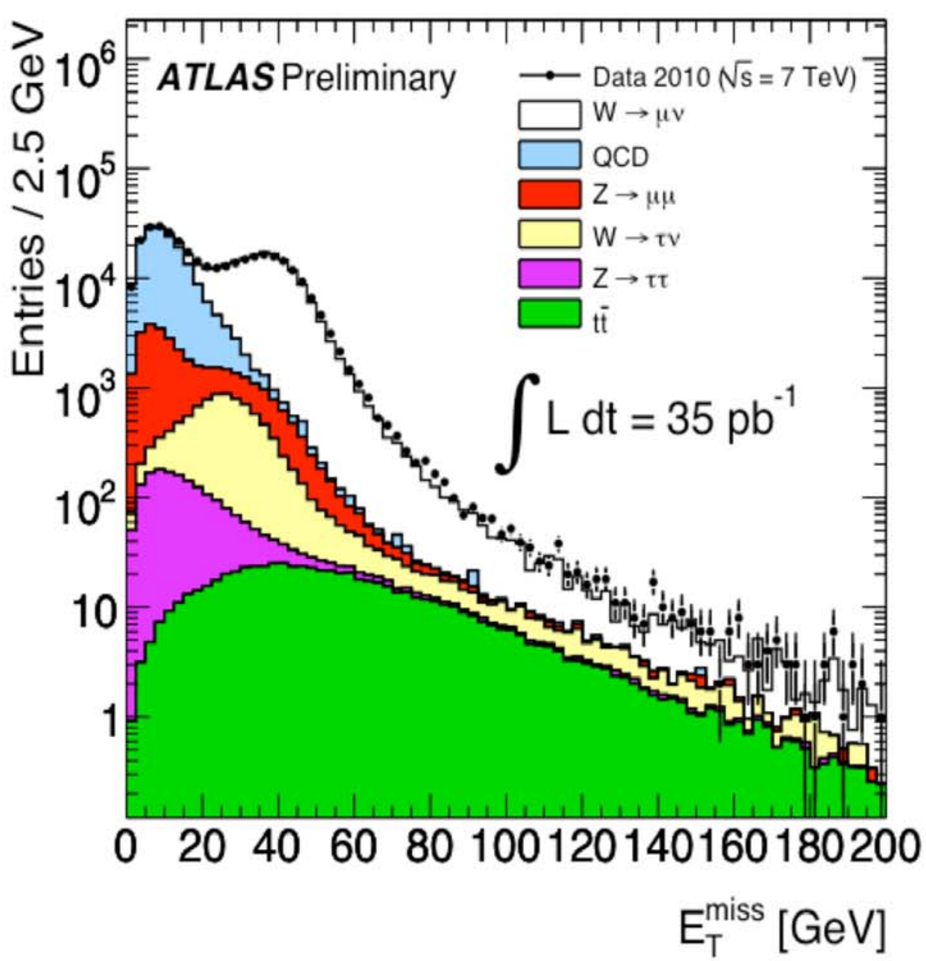
ATLAS

Missing transverse energy

e - sample



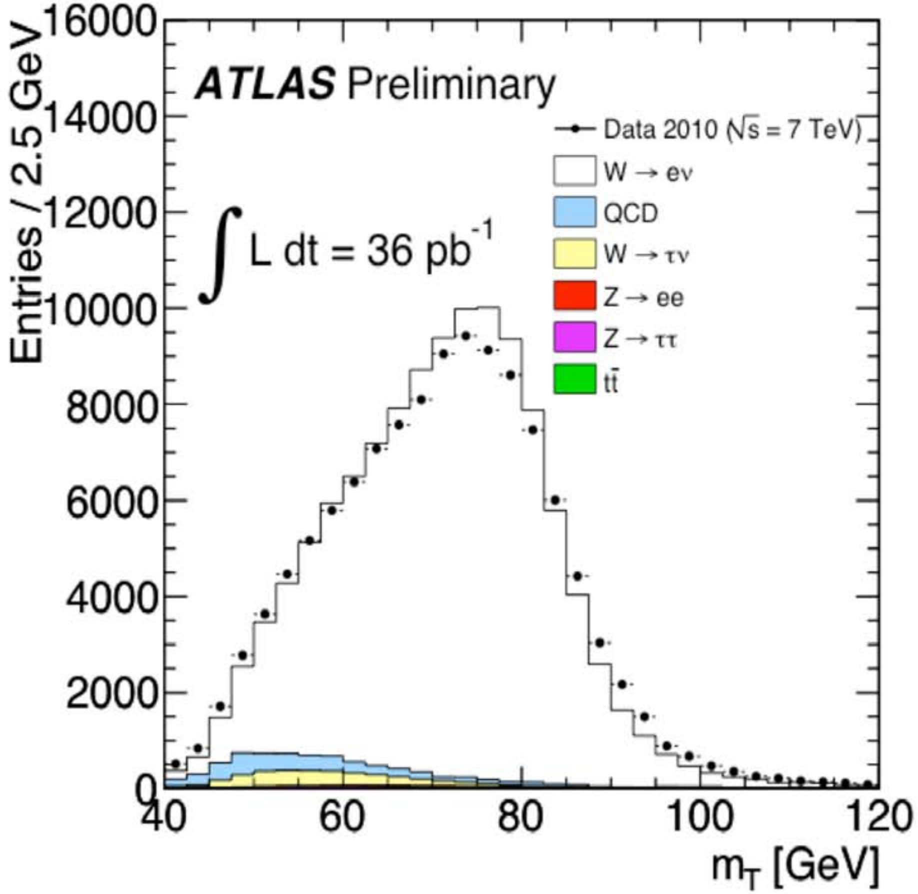
μ - sample

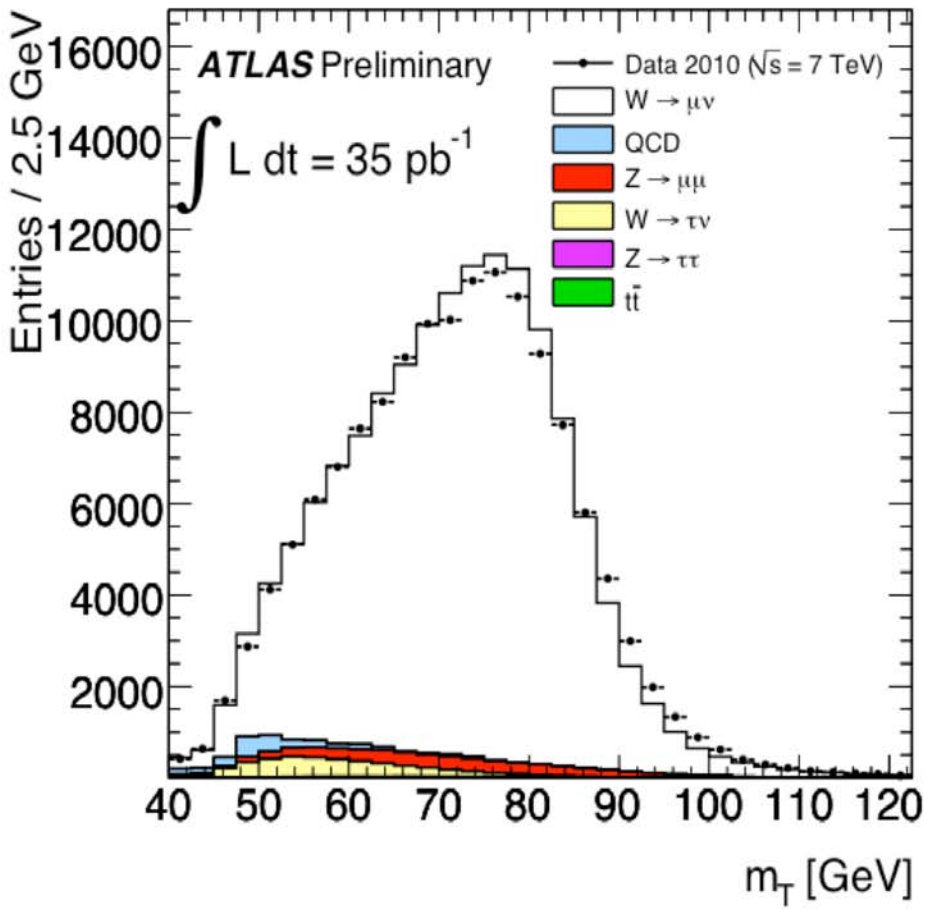


W transverse mass

- e or μ with p_T>20 GeV, E_T^{miss}>25 GeV
- MC normalised to data
- 119k electron and 135k muon candidates

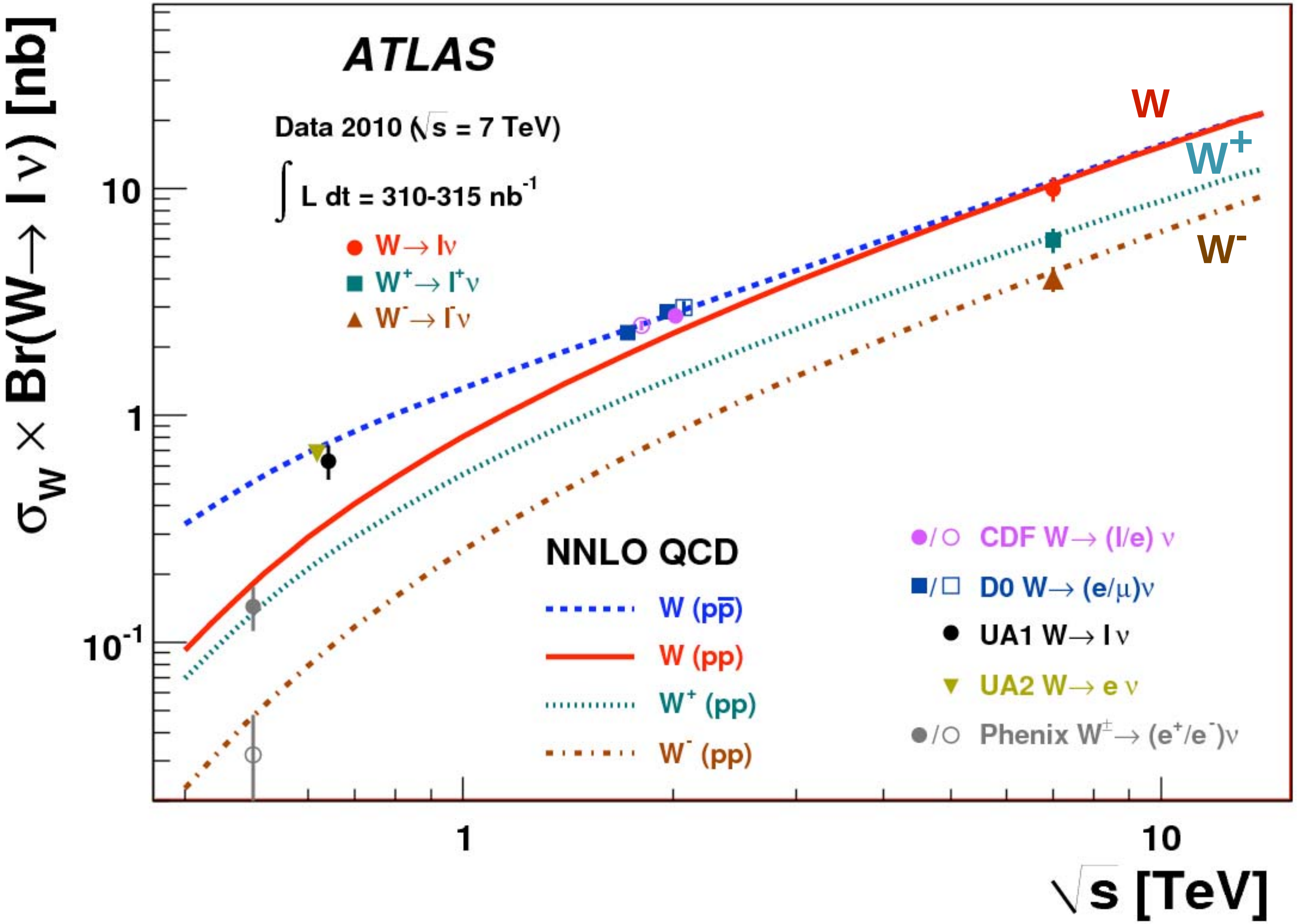
$$m_T = \sqrt{2 p_T^{\ell} p_T^{\nu} (1 - \cos(\phi^{\ell} - \phi^{\nu}))}$$





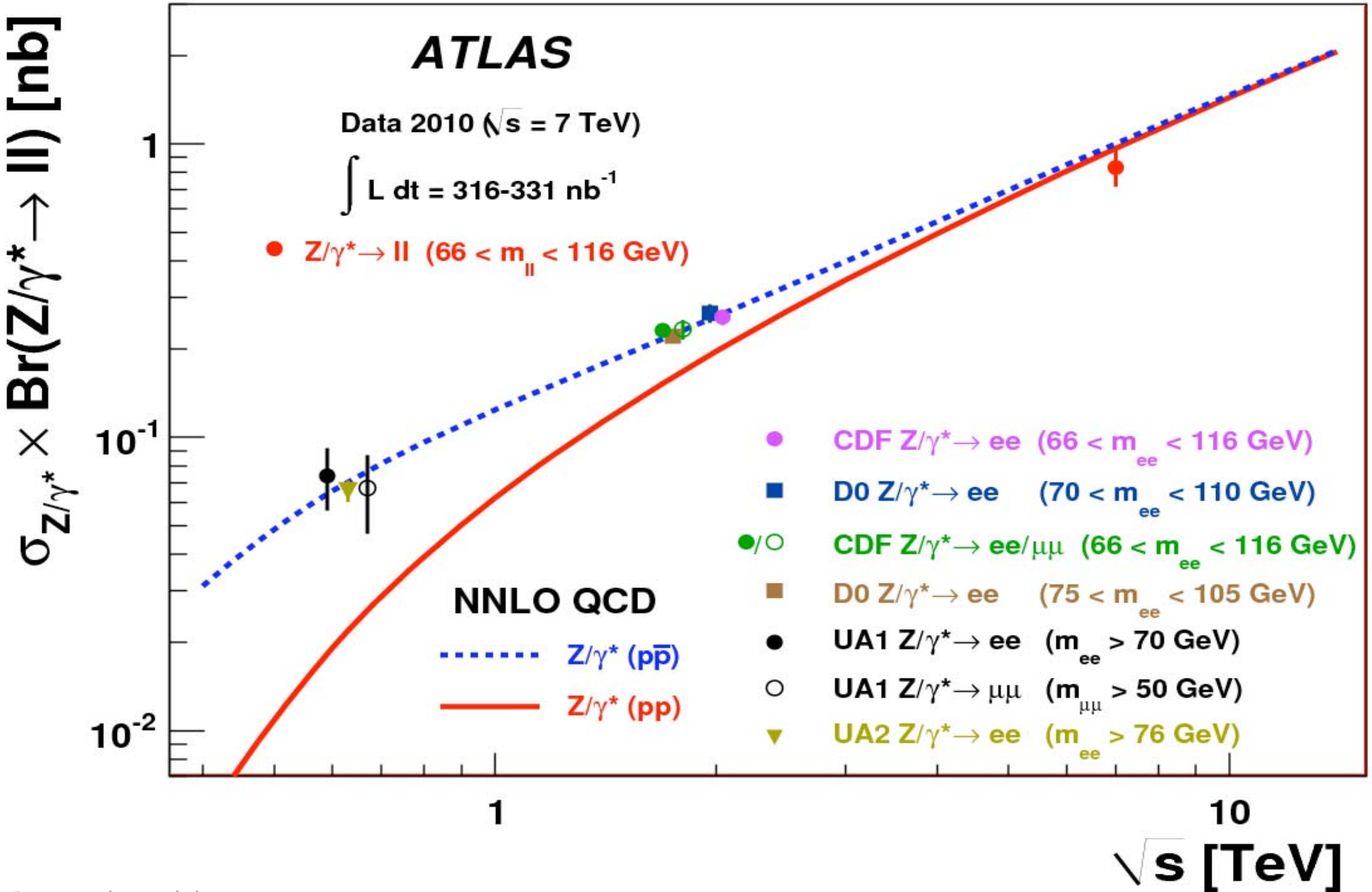
W cross section with e and μ

$$\sigma_W^{tot} \cdot BR(W \to \ell\nu) = 9.96 \pm 0.23(stat) \pm 0.50(syst) \pm 1.10(lumi)\ nb$$



Z cross section with e and μ

$$\sigma^{tot}_{Z/\gamma^*} \cdot BR(Z/\gamma^* \to \ell\ell) = 0.82 \pm 0.06(stat) \pm 0.05(syst) \pm 0.09(lumi)\ nb$$
$$(66 < m_{\ell\ell} < 116\ GeV)$$



$W \rightarrow \tau\nu$ observation

Initial observation of $W \rightarrow \tau\nu$ based on only 550 nb^{-1}

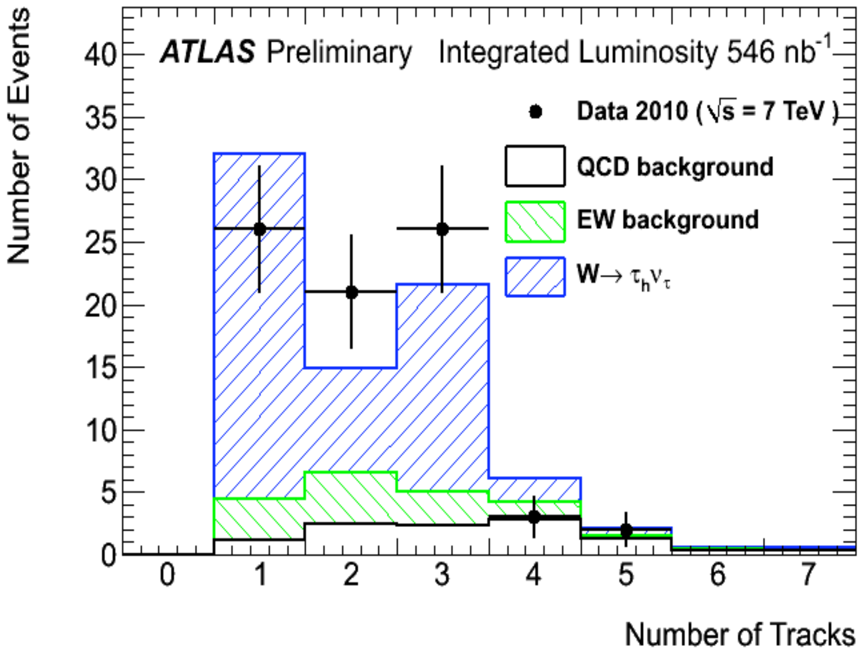
78 events with hadronic τ decay candidates

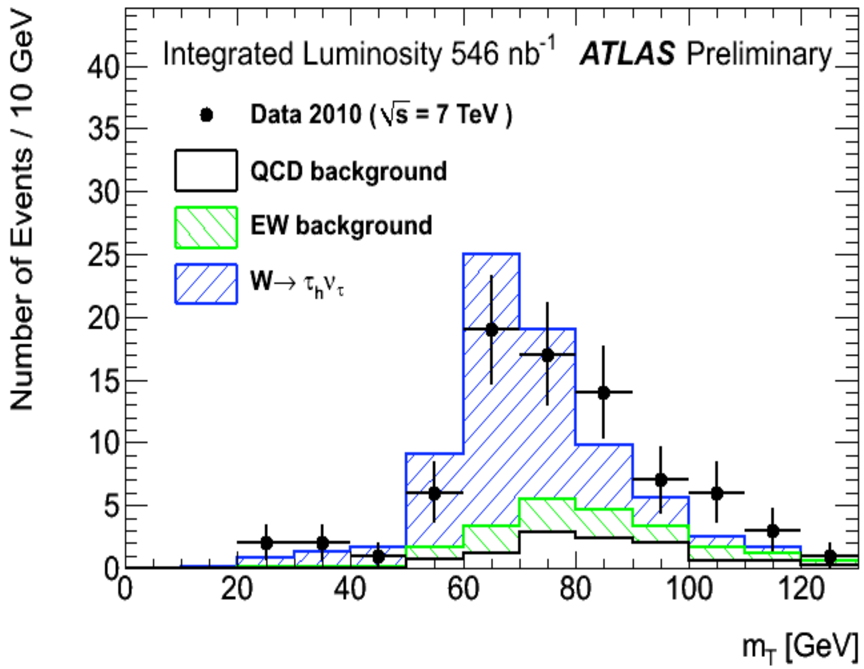
Backgrounds:

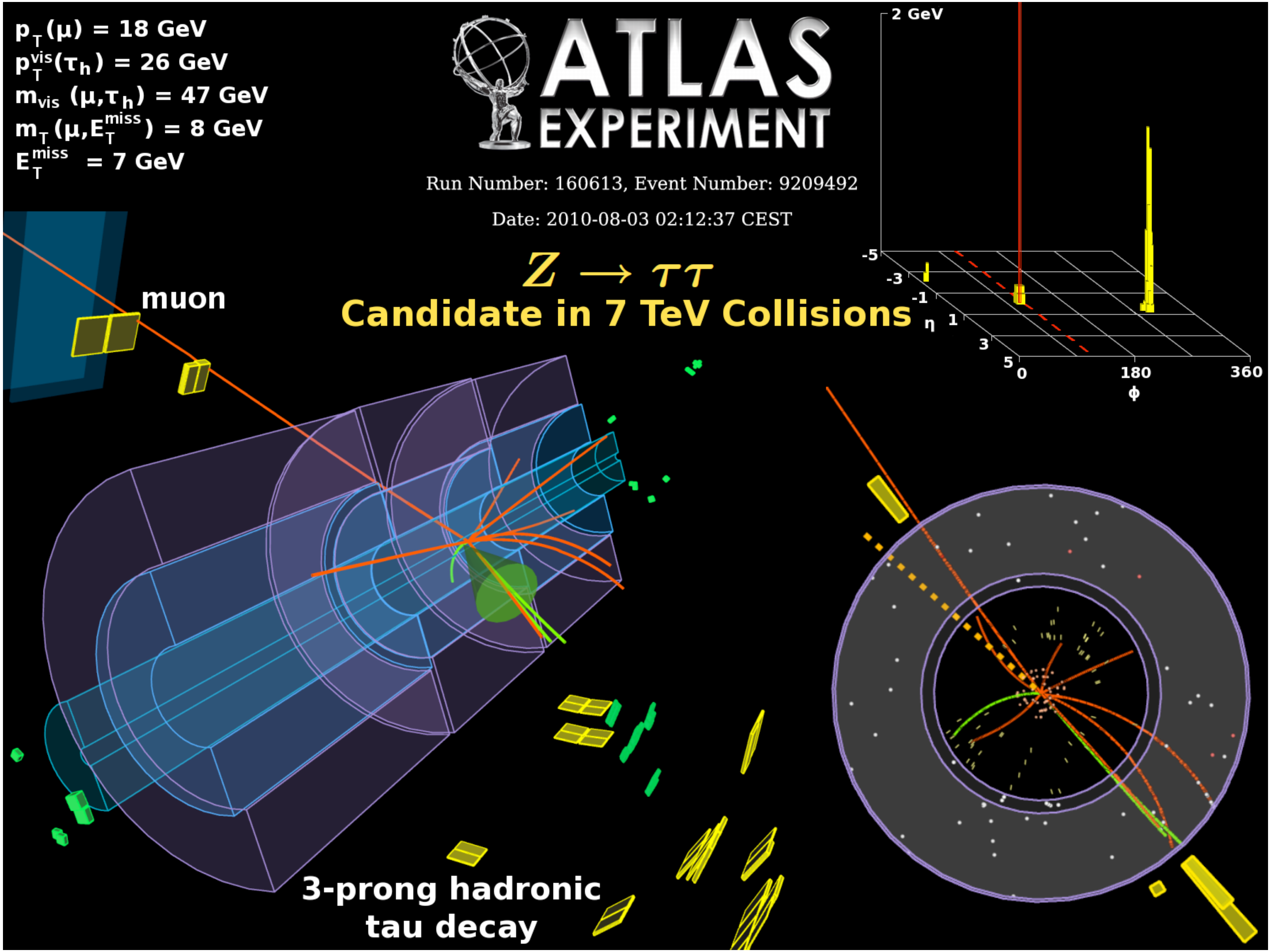
11.1±2.3±3.2 from QCD

11.8±0.4±3.7 from other W/Z decays

Event properties consistent with expectation



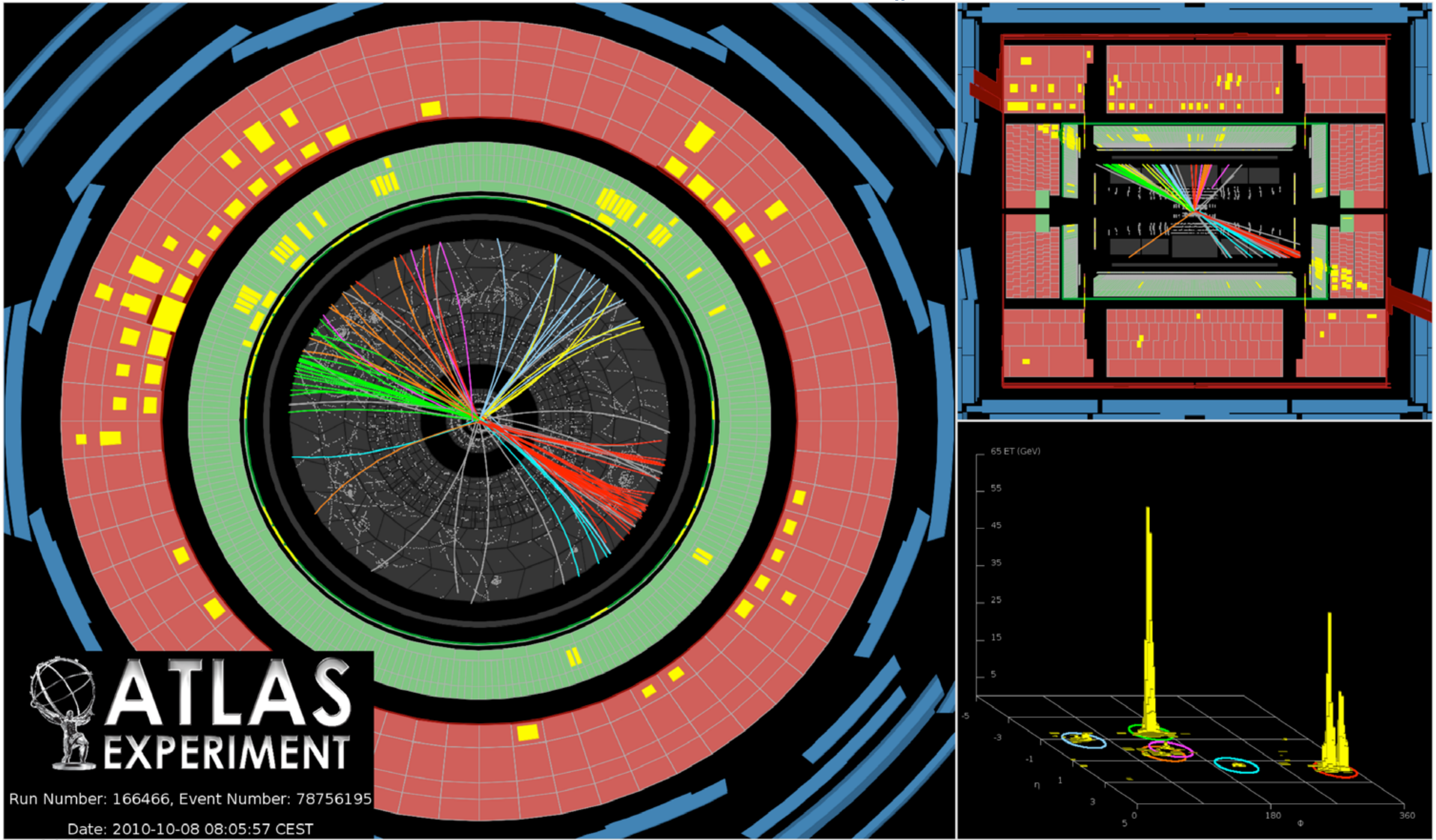




$p_T(\mu)$ = 18 GeV
$p_T^{vis}(\tau_h)$ = 26 GeV
$m_{vis}(\mu,\tau_h)$ = 47 GeV
$m_T(\mu,E_T^{miss})$ = 8 GeV
E_T^{miss} = 7 GeV
ATLAS EXPERIMENT
Run Number: 160613, Event Number: 9209492
Date: 2010-08-03 02:12:37 CEST
$Z \rightarrow \tau\tau$
Candidate in 7 TeV Collisions
muon
3-prong hadronic tau decay
2 GeV
η
ϕ
-5
-3
-1
1
3
5
0
180
360

Jets

Highest di-jet mass event with p_T jet1 = 670 GeV, p_T jet2 = 610 GeV, m_{jj}=3.7 TeV

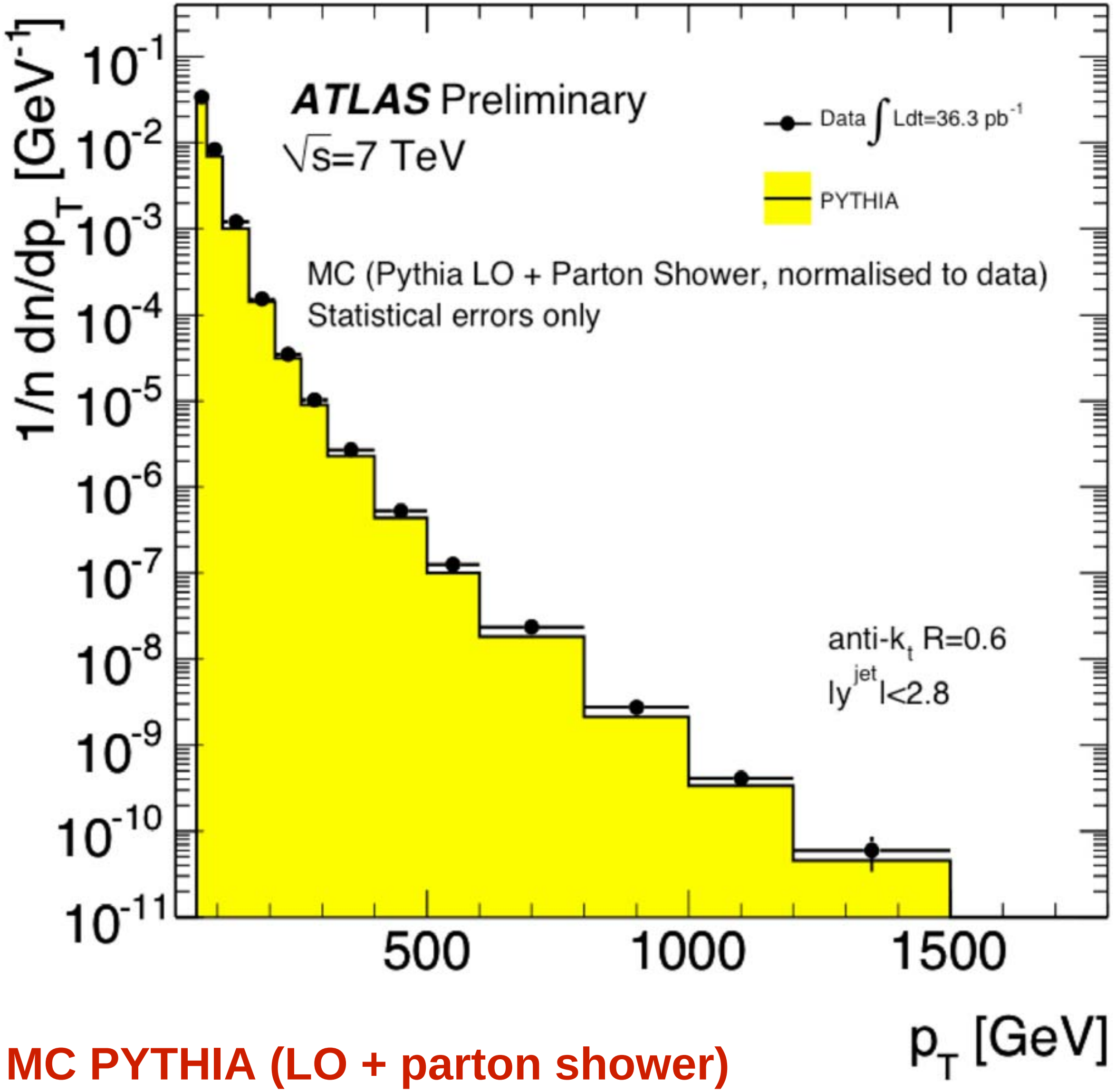


Inclusive jets

Combine a range of triggers to cover the full p_T spectrum

In all cases, jets corrected to hadronic scale (JES uncertainty 7%)

Jet p_T > 60GeV
Highest p_T jet 1.3 TeV

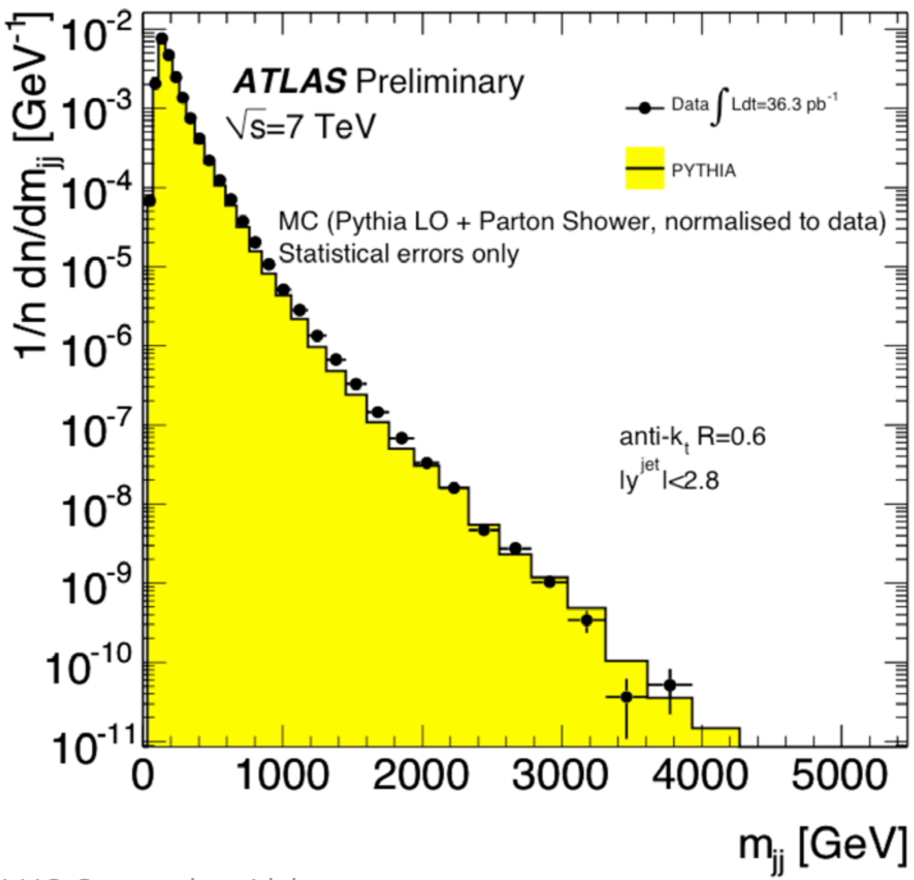


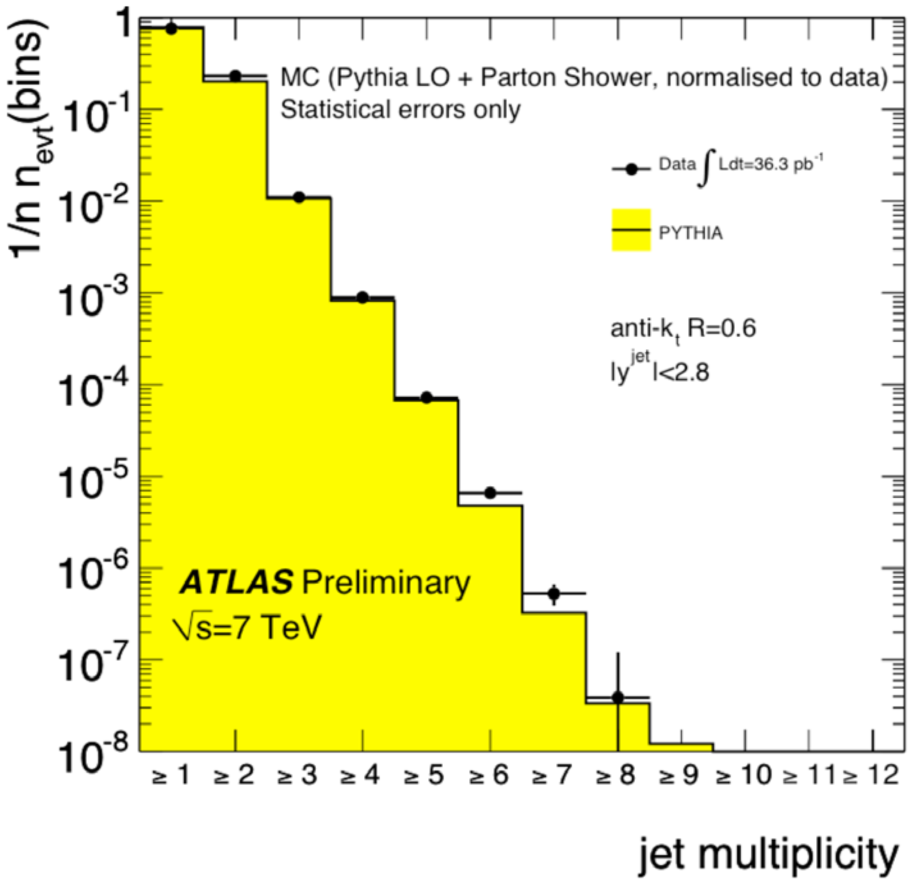
Shape comparison with MC PYTHIA (LO + parton shower)

Di-jets and multi-jets

- Leading jet p_T > 60 GeV,
- Subleading p_T > 30 GeV
- Highest di-jet mass 3.7 TeV

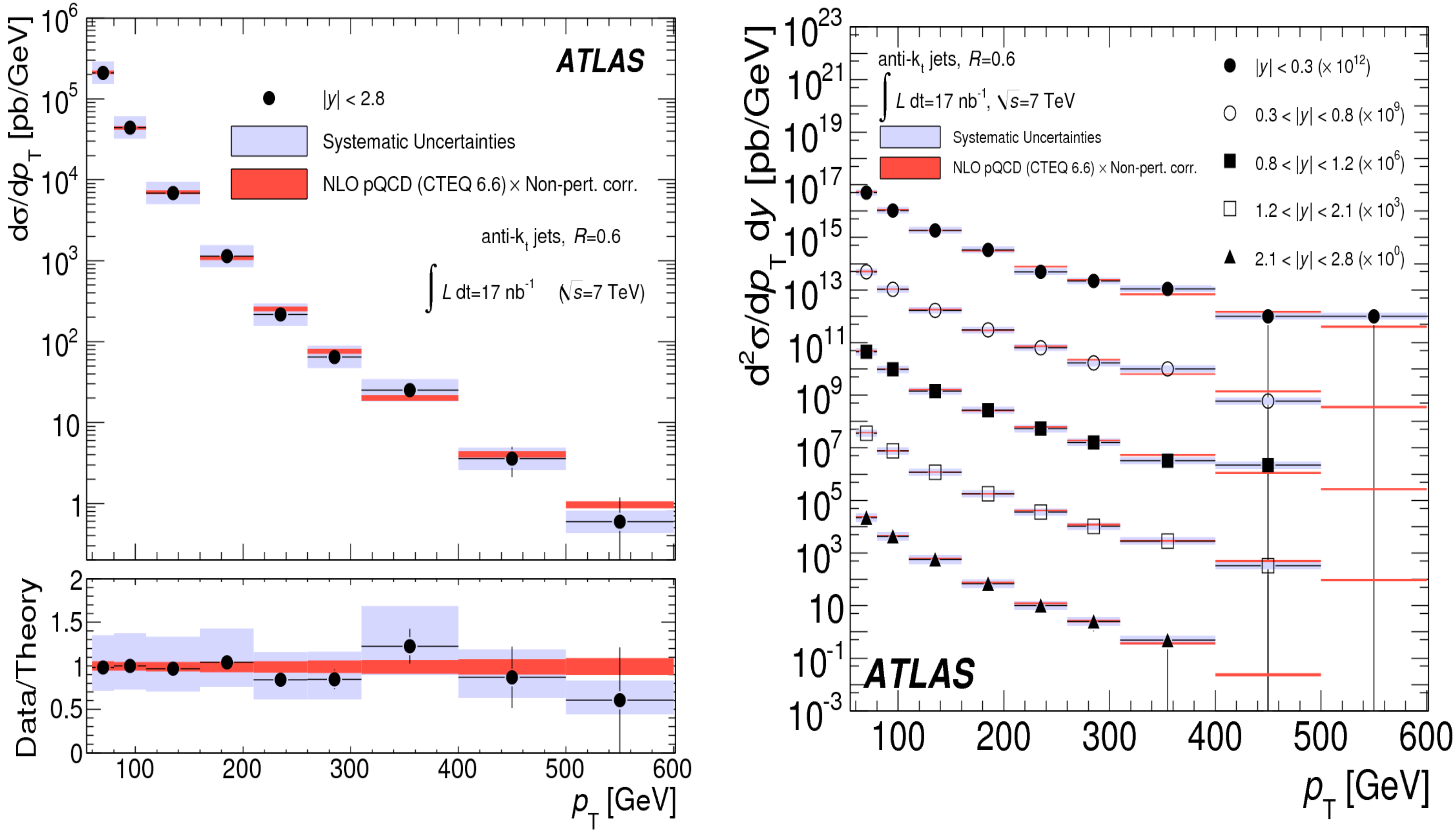
- Count jets with p_T > 60 GeV
- One event with 8 jets





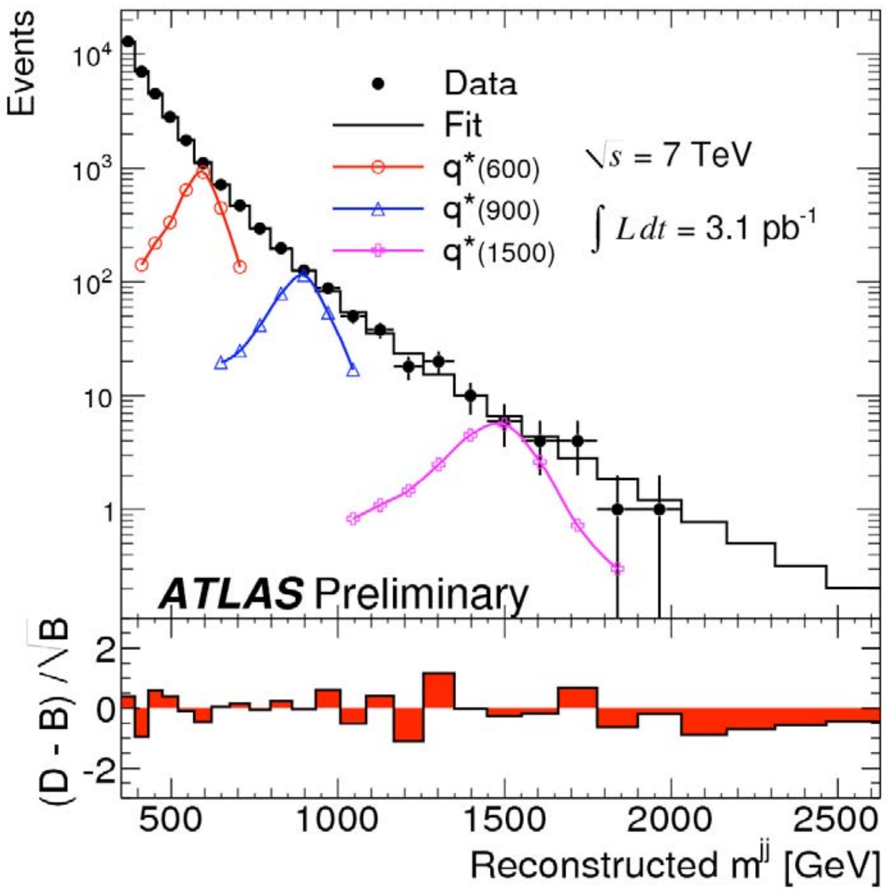
Inclusive jet cross sections

Uncertainty dominated by Jet Energy Scale (at present ~7%)

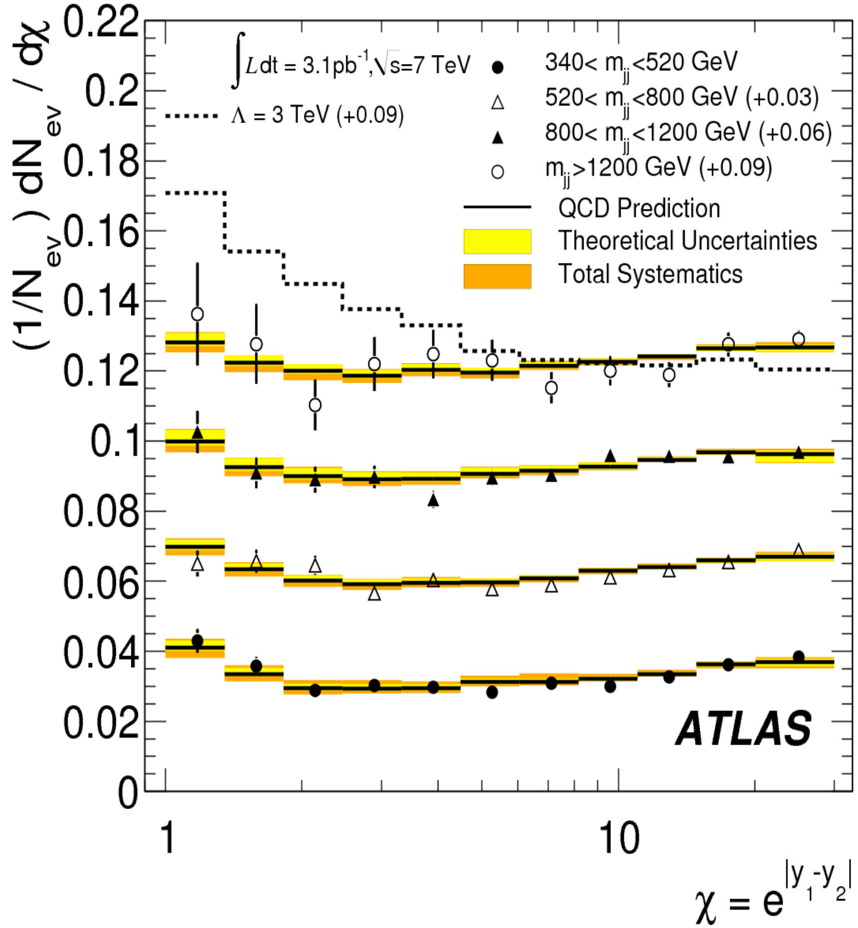


Di-jet mass & angular distributions: search for deviations from QCD

Excited Quarks
0.50 < m(q*) < 1.53 TeV (95% CL)



Quark Contact Interactions with scale Λ < 3.4 TeV excluded (95% CL)

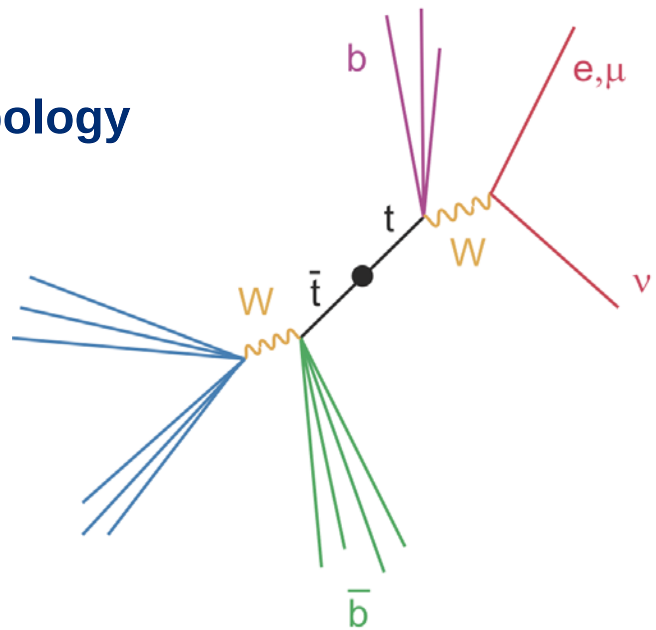


Similar results have been published by CMS

Measurement of the top cross section

- **Complete set of ingredients to investigate production of ttbar, which is the next step in verifying the SM at the LHC:**
  - **e, μ, E_T^{miss}, jets, b-tag**

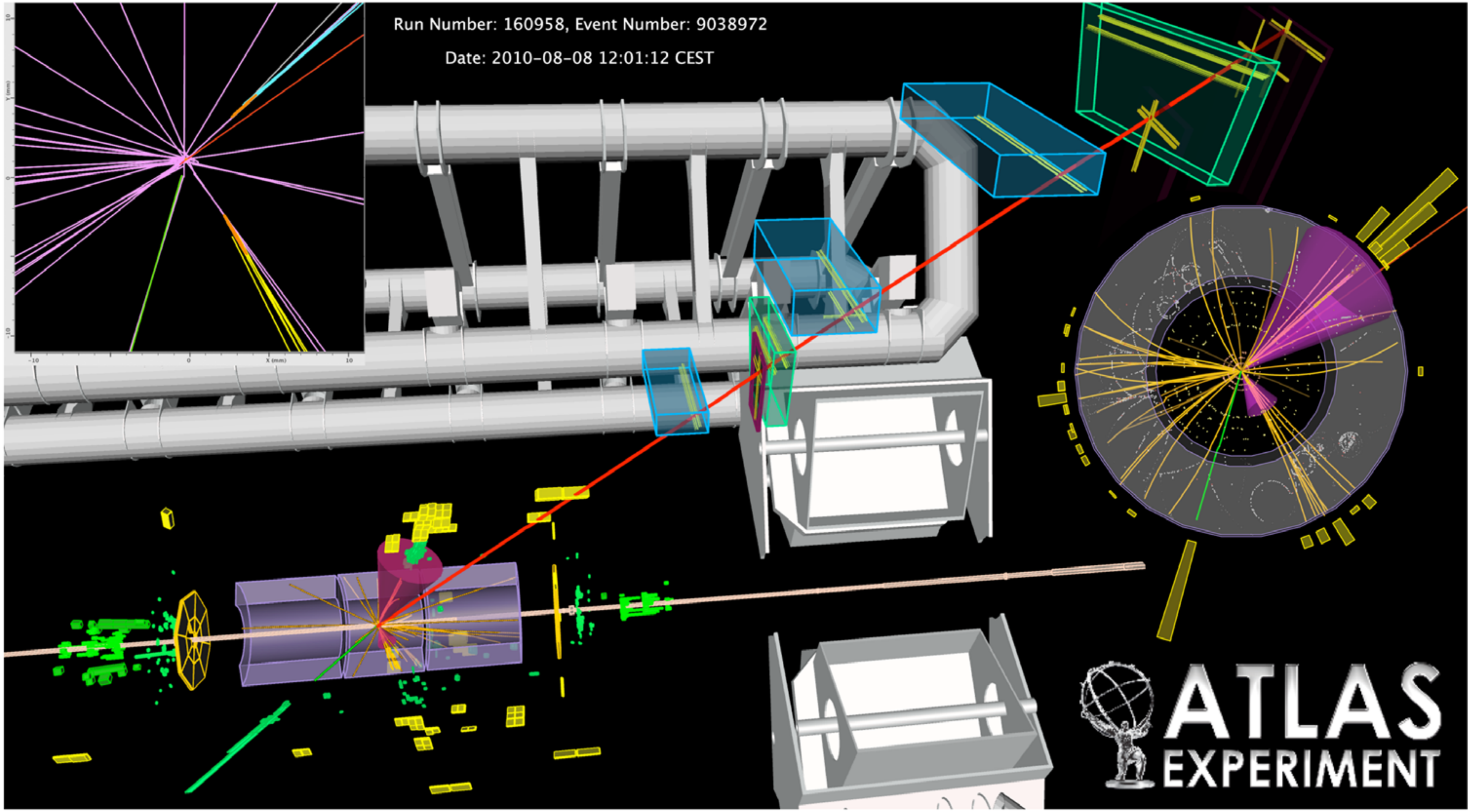
- **Assume all tops decay to Wb: event topology then depends on the two W decays**



- **Of interest for this analysis:**
  - **one lepton (e or μ), E_T^{miss}, jjbb (37.9%)**
  - **di-lepton (ee, μμ or eμ), E_T^{miss}, bb (6.46%)**

- **Data-driven methods to control QCD and W+jets backgrounds**

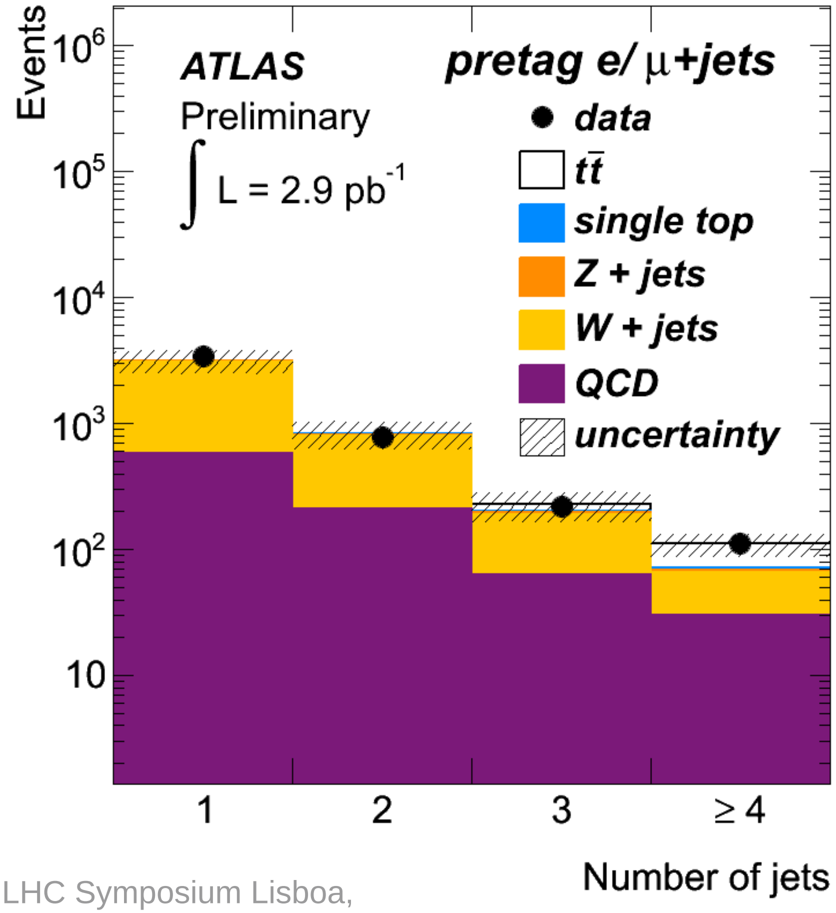
- **Counting experiment, with simultaneous likelihood fit to all channels to derive the combined cross section**

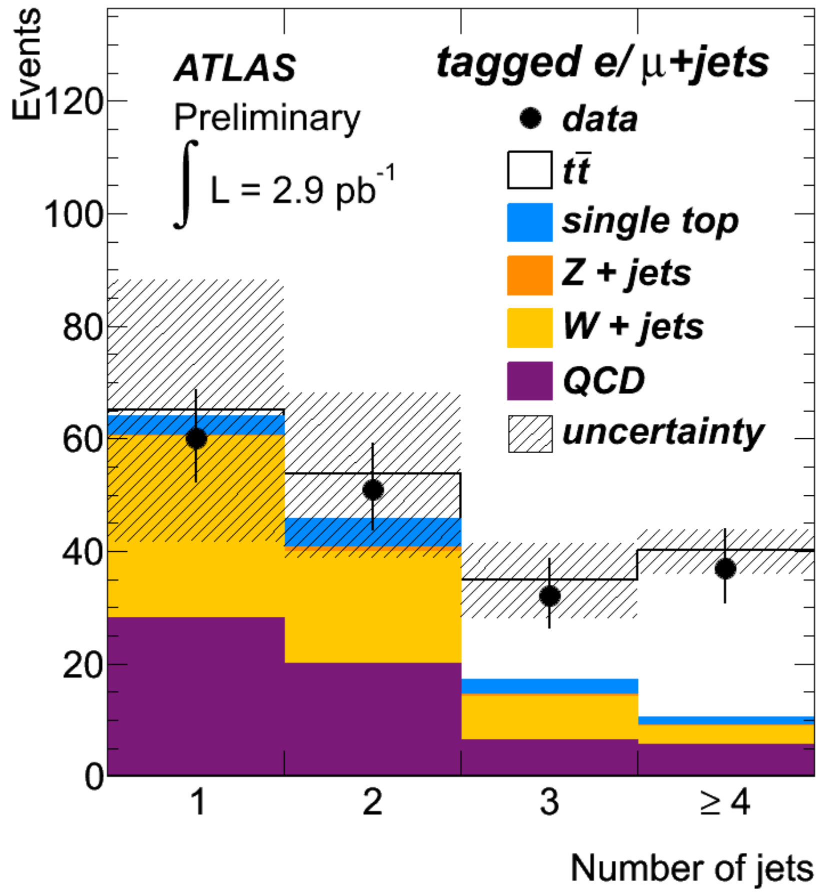


eμ + 2 b-jets tt-candidate event

Single lepton channel

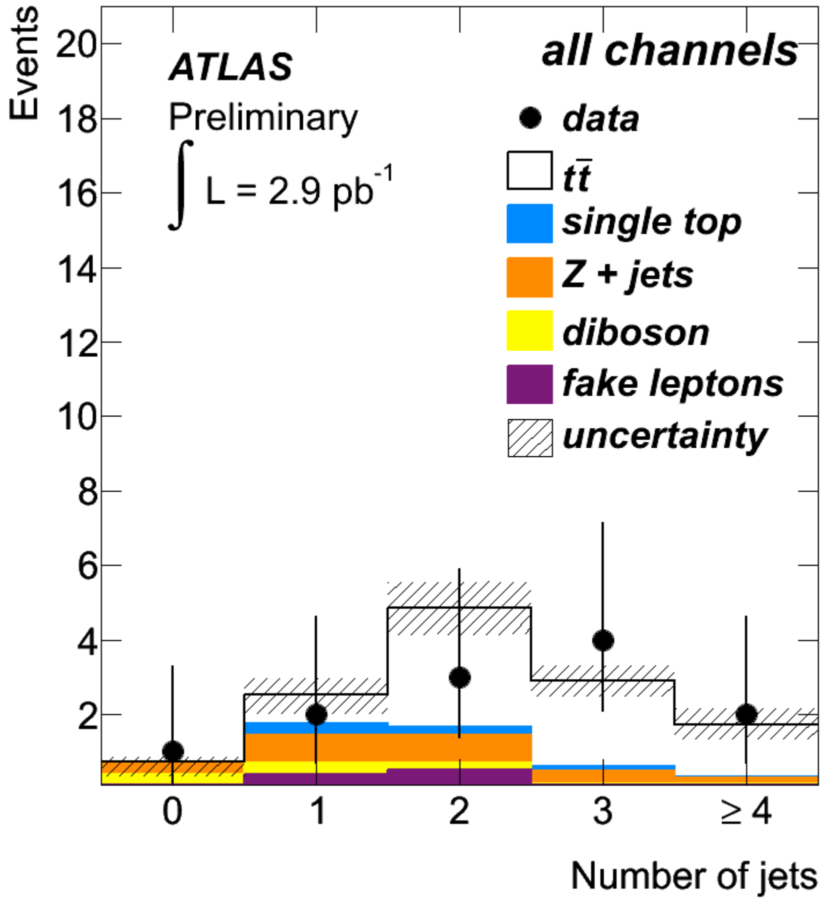
- 1 e or μ with $p_T > 20$ GeV, $E_t^{miss} > 20$ GeV, $E_T^{miss}+m_T(W) > 60$ GeV
- N_{jets} with $p_T > 25$ GeV, with no b-tag requirement or at least one b-tag
- Signal defined to have 4 or more jets, and at least 1 b-tag

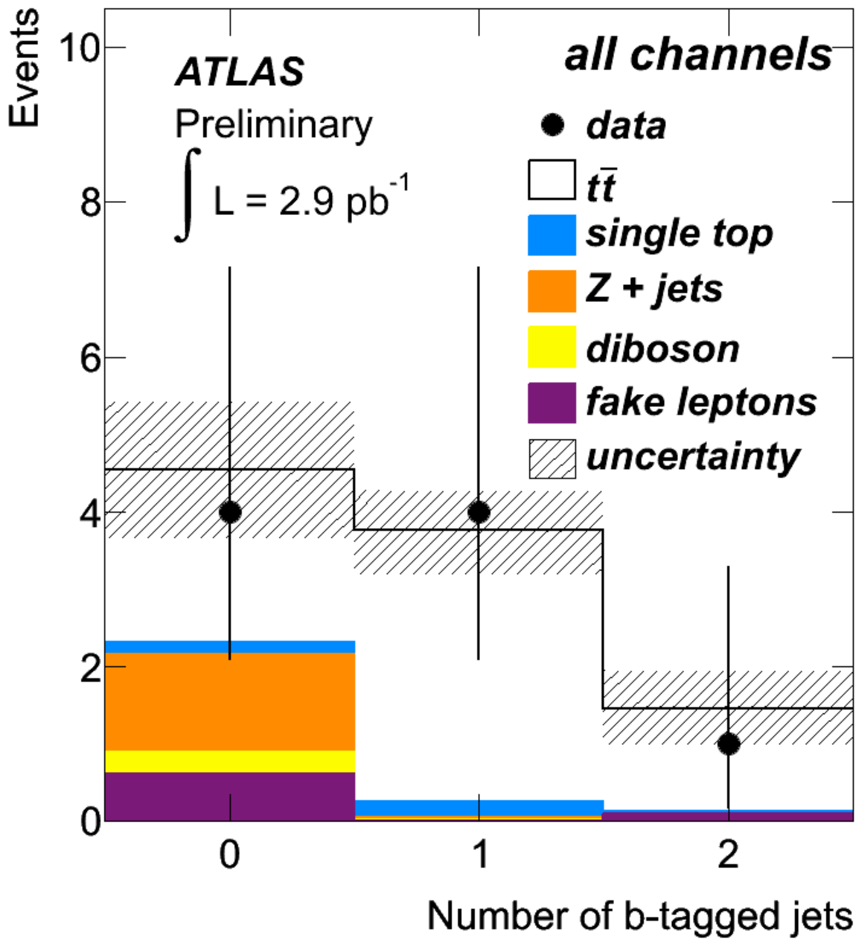




Di-lepton events

- Count events with two or more jets: 2 ee, 3 μμ, 4 eμ
- b-tag is not used in the analysis, but is a cross-check

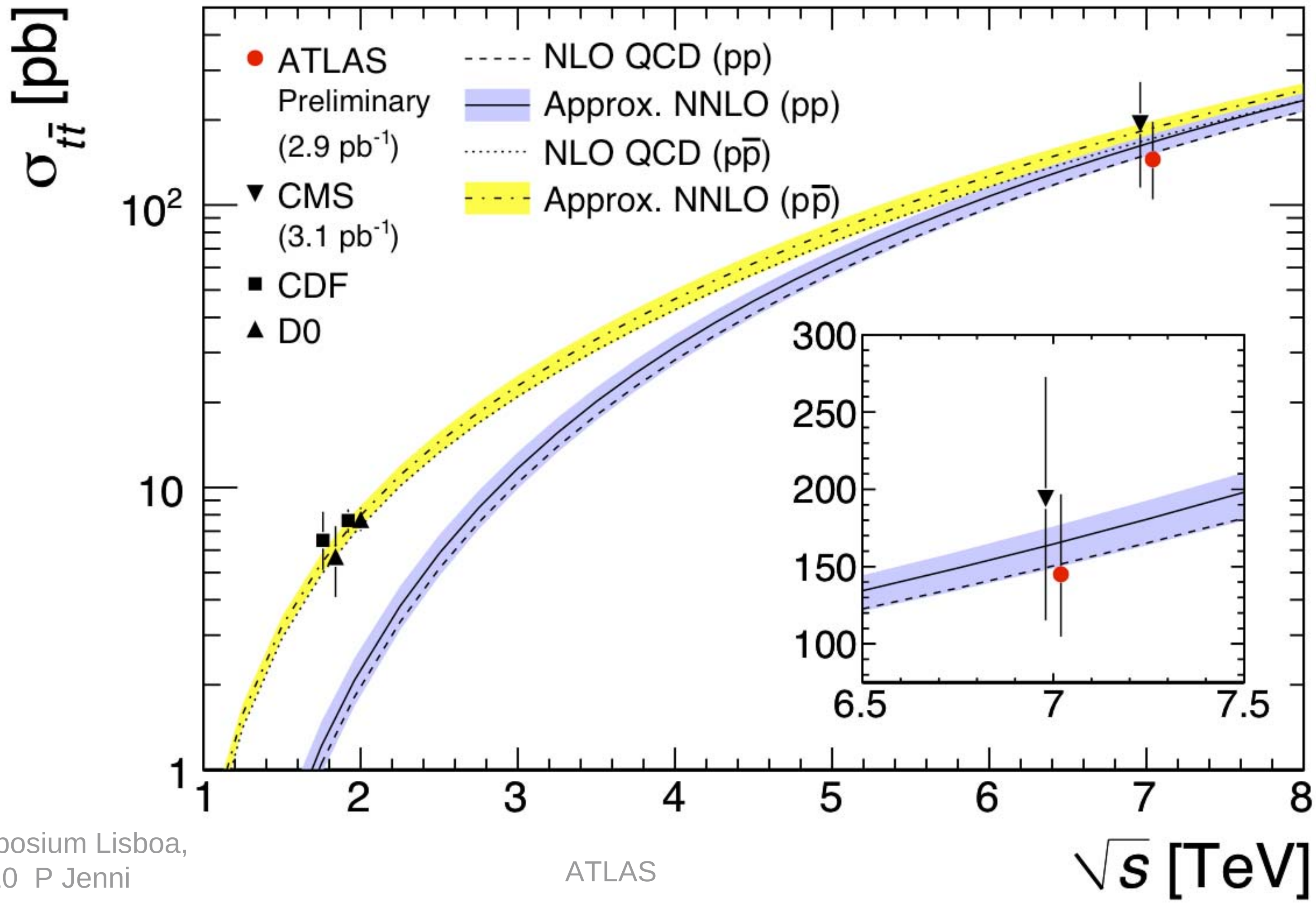


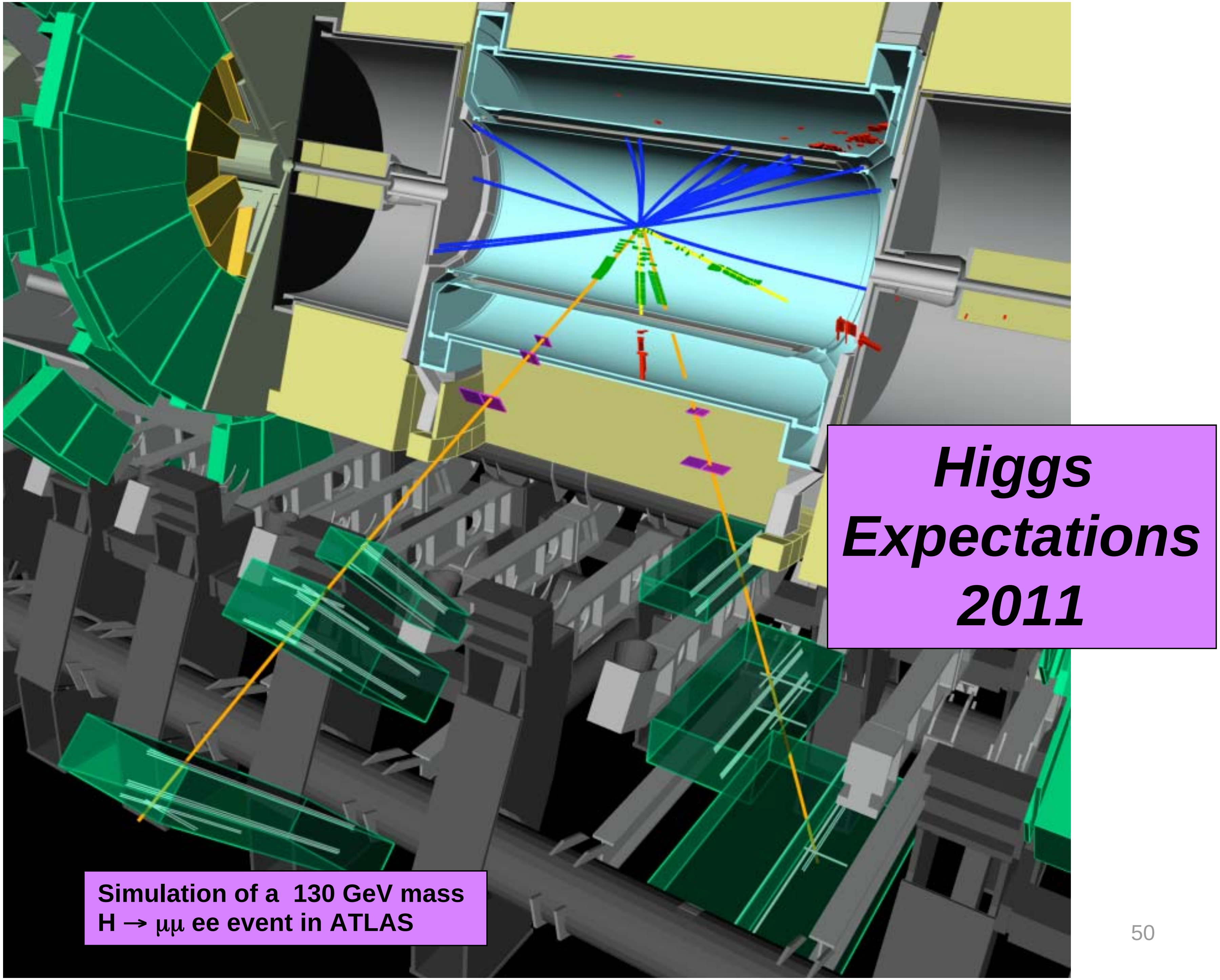


Top production cross section

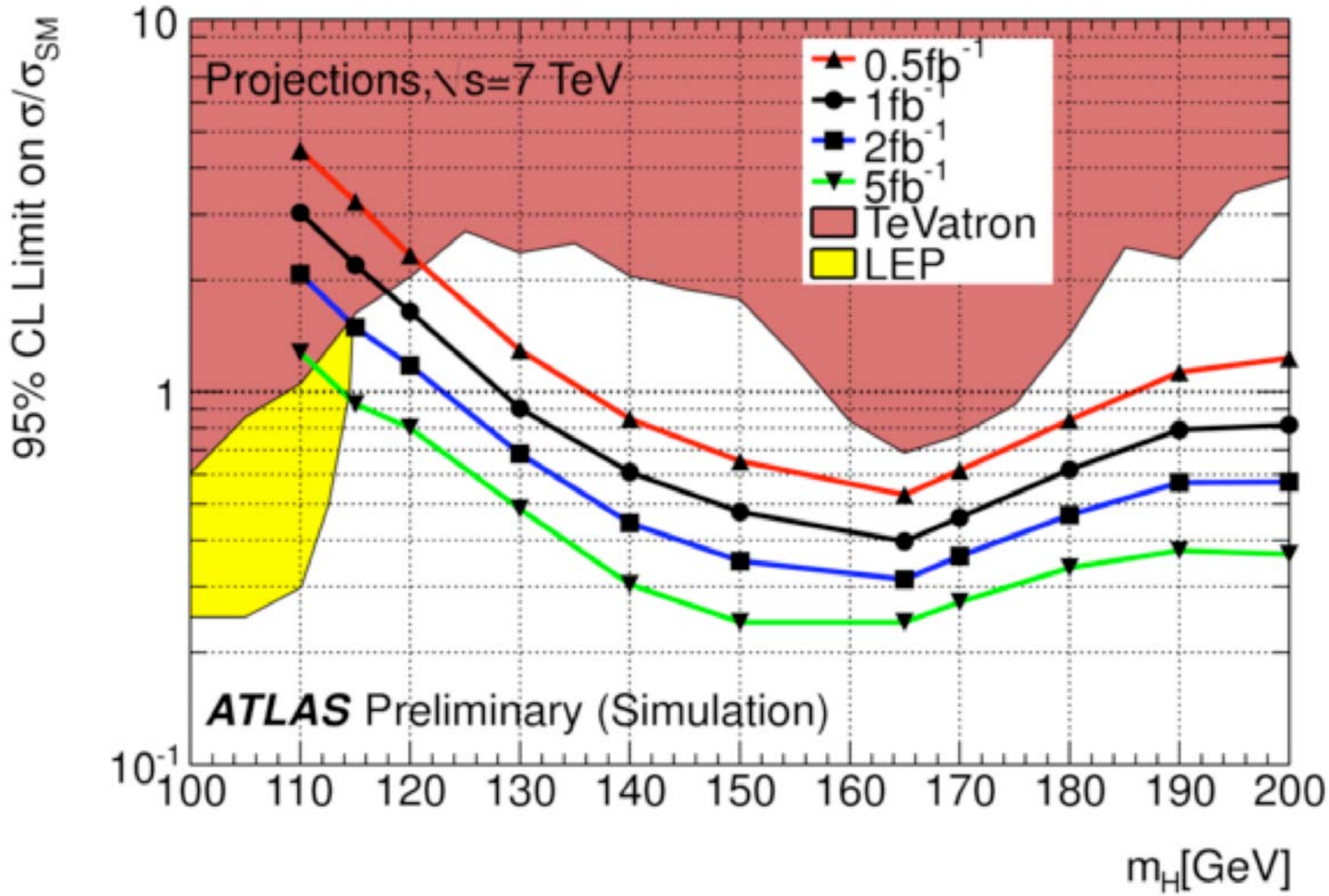
Combining all channels: $\sigma_{t\bar{t}} = 145 \pm 31^{+42}_{-27}\ \mathrm{pb}$

Significance of 4.8 σ w.r.t. background only hypothesis




Higgs Expectations 2011
Simulation of a 130 GeV mass
H → μμ ee event in ATLAS

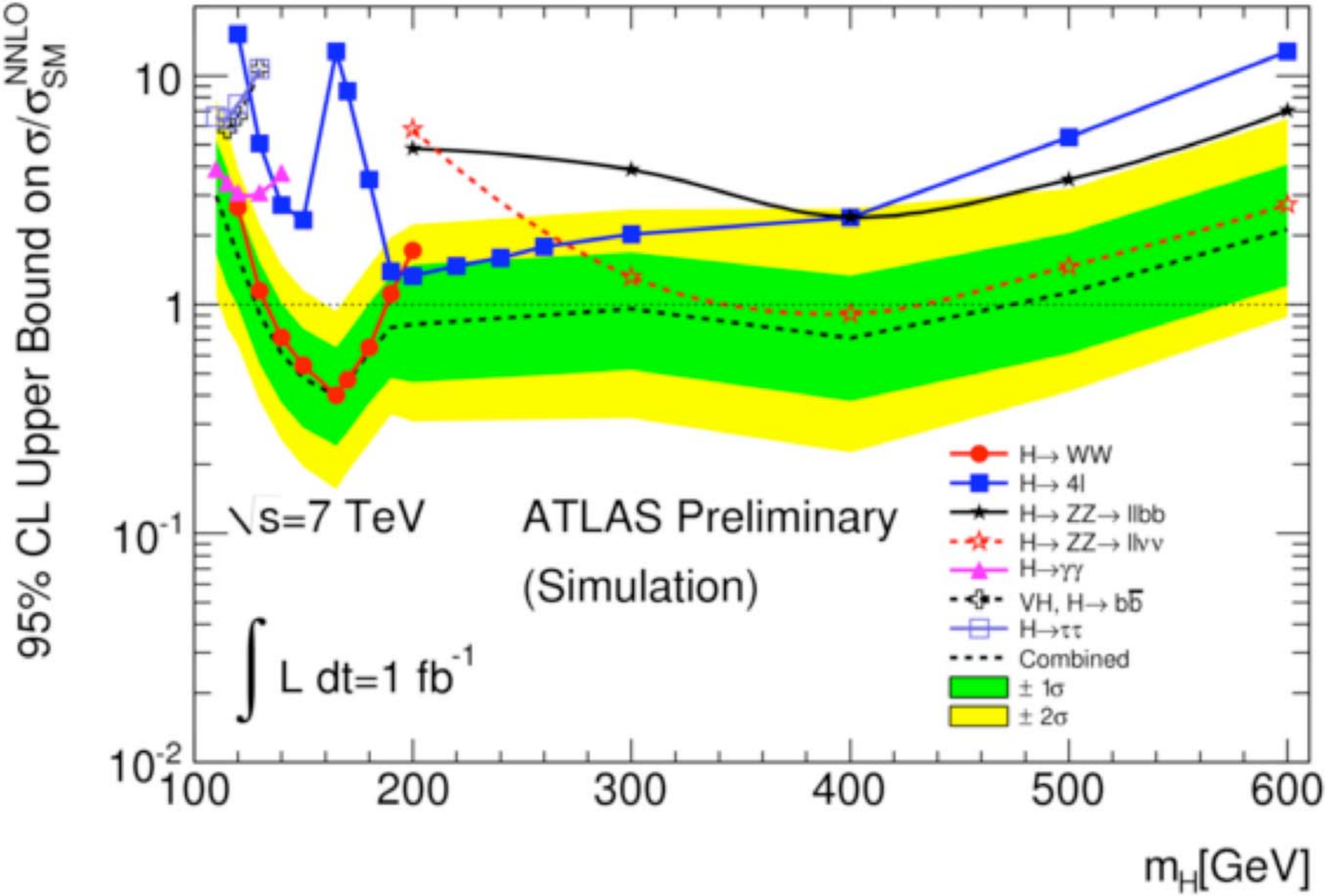
More integrated luminosity



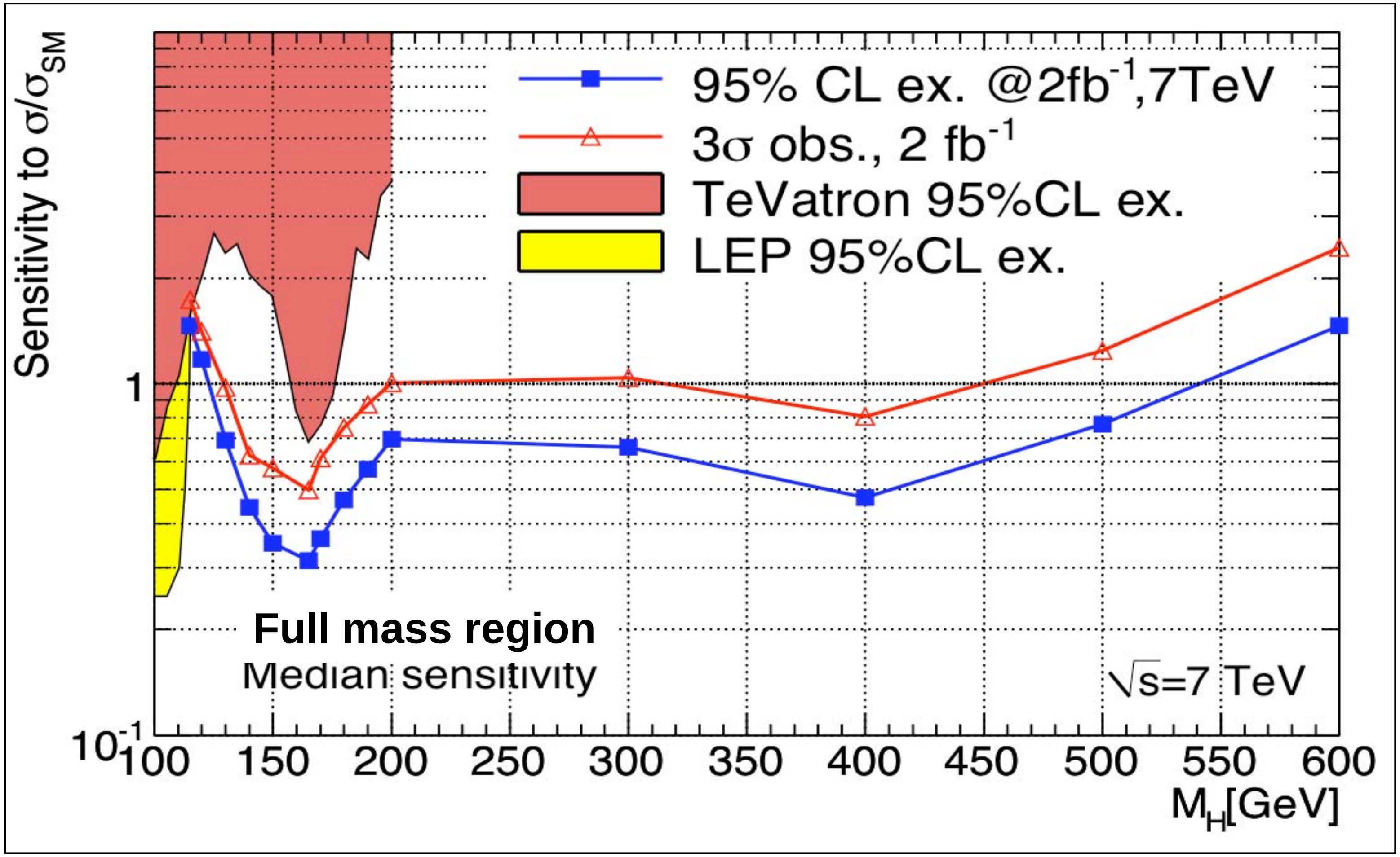
5 fb^{-1} enough to close gap with LEP at 7 TeV

Expected 3σ observation from 123 to 550 GeV

7 TeV, 1 fb^{-1}



95% CL Upper Bound on σ/σ$_{SM}^{NNLO}$
10
1
10^{-1}
10^{-2}
100
200
300
400
500
600
m$_H$[GeV]
√s=7 TeV
ATLAS Preliminary
(Simulation)
∫ L dt=1 fb^{-1}
H→ WW
H→ 4l
H→ ZZ→ llbb
H→ ZZ→ llνν
H→γγ
VH, H→ bb̄
H→ττ
Combined
± 1σ
± 2σ



LHC is complementary to Tevatron: more powerful at high masses, weaker at low masses

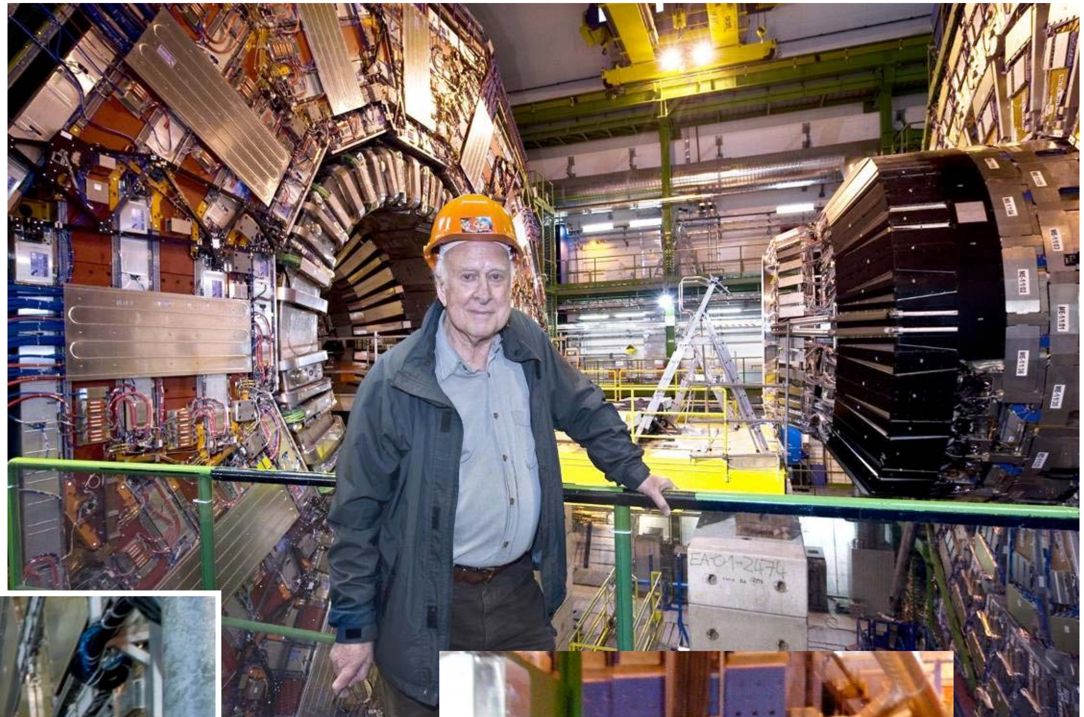
- ❑ **With 1 fb^{-1} per experiment and combining ATLAS+CMS:**
  - **-- could exclude 123 < m_H < 540 GeV at 95% C.L.**
  - **-- 3σ evidence over 130 < m_H < 450 GeV**

→ extend sensitivity to higher masses than Tevatron

→ cover m_H~ 135 GeV where Tevatron is weakest

- ❑ **Expected analysis improvements might allow exclusion down to m_H~ 115 GeV (otherwise would need 2.5 fb^{-1} per experiment) → hard to compete with Tevatron in 2011**

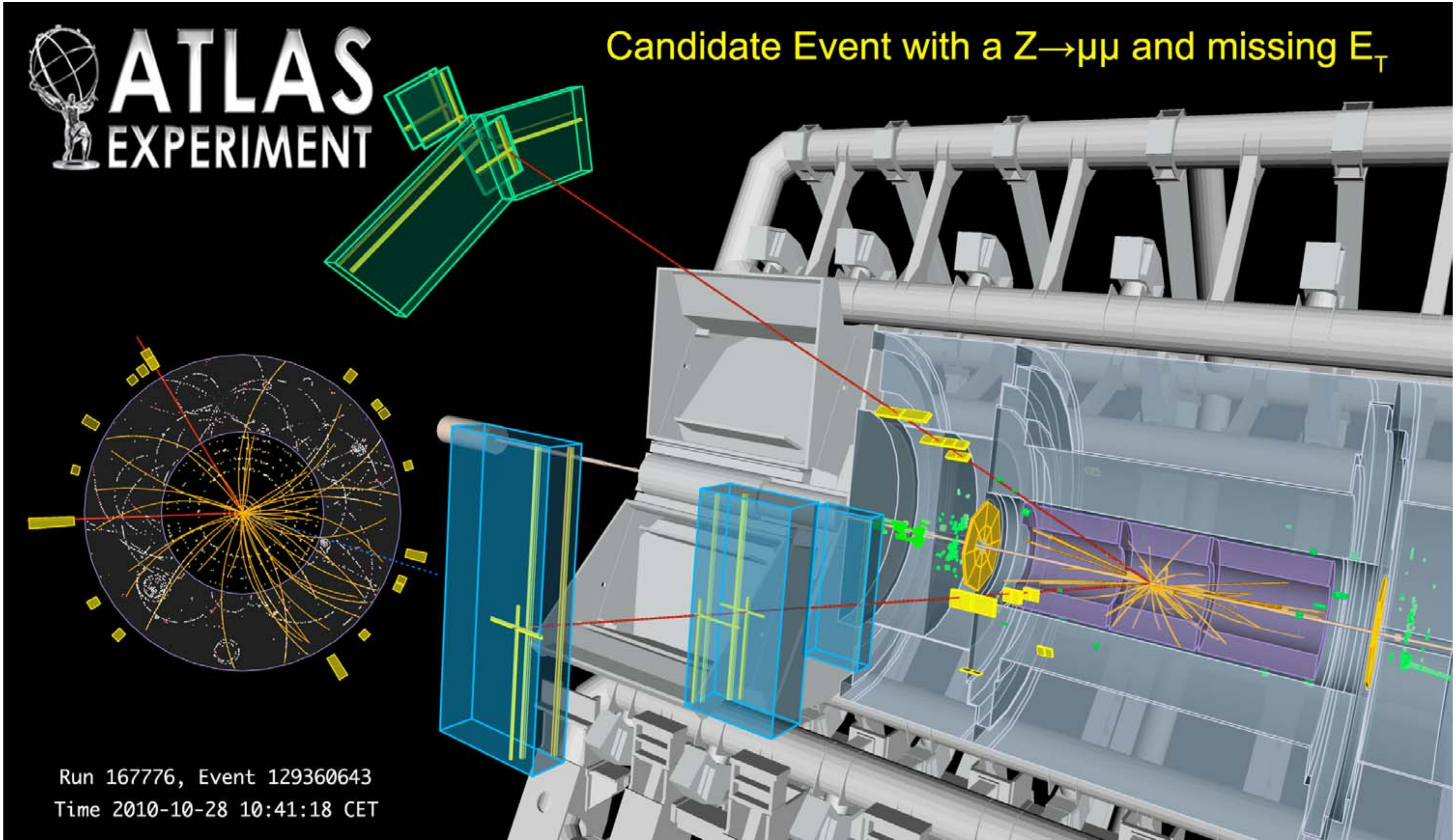
The first "Higgs" events observed jointly in CMS and ATLAS … (April 2008)

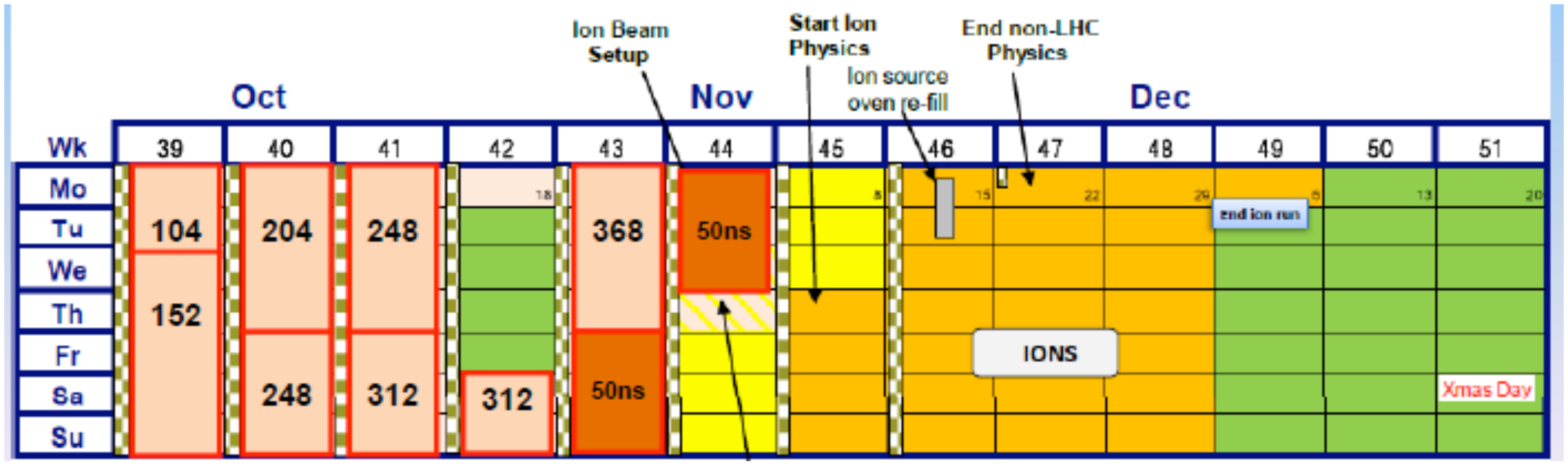


somewhat later, even in AL

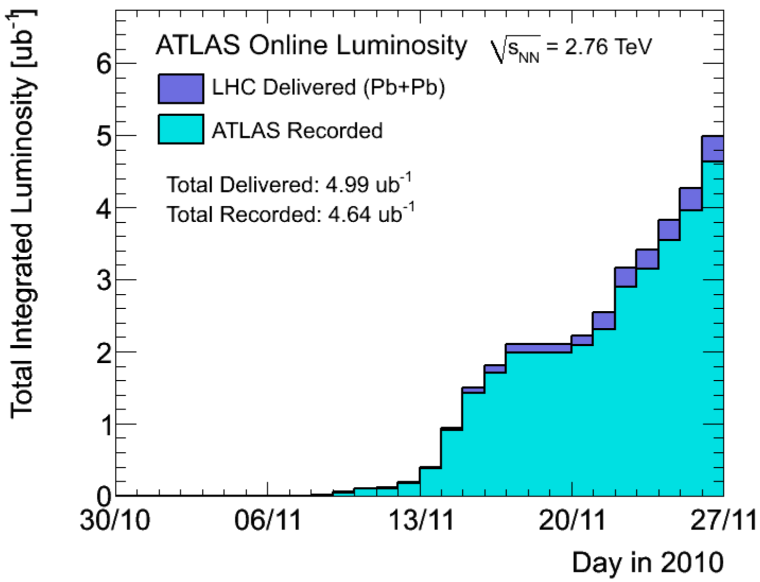
Candidate for ZZ→μμνν

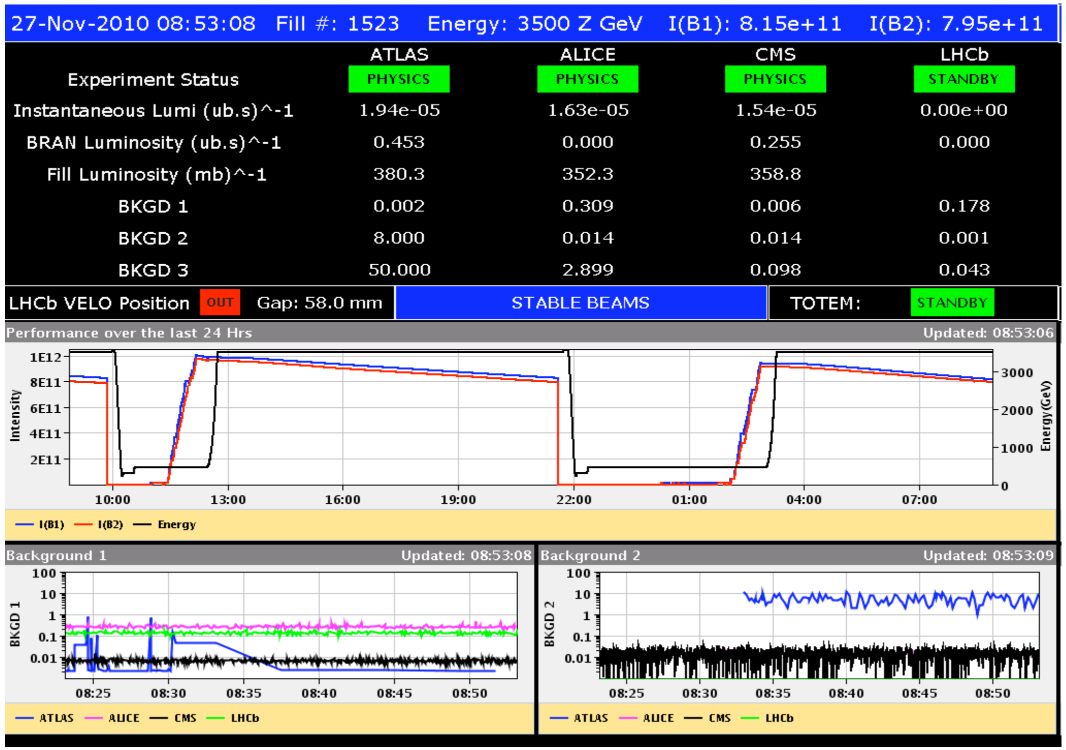
$m_{\mu\mu}$ = 94 GeV, E_T^{miss} = 161 GeV

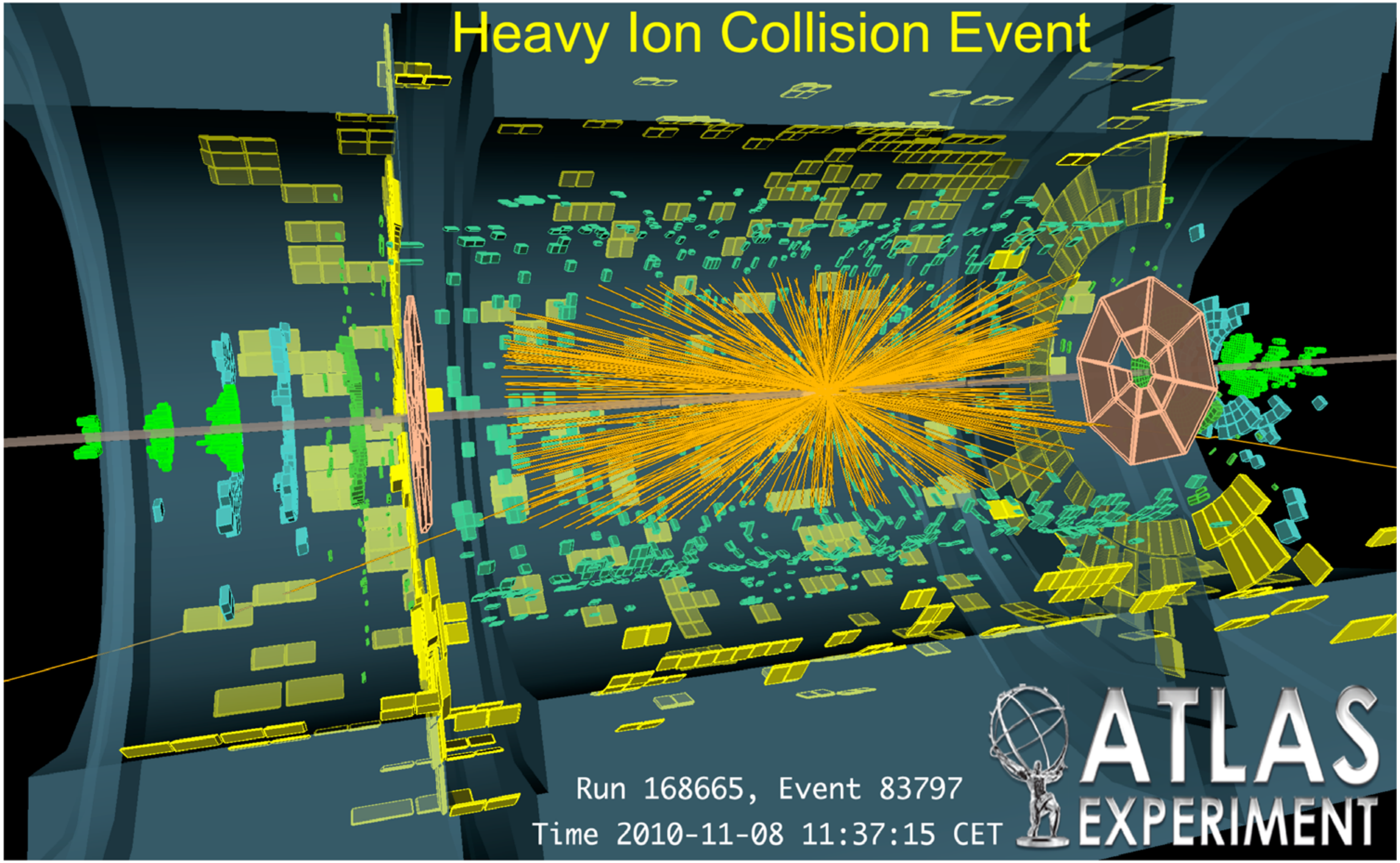




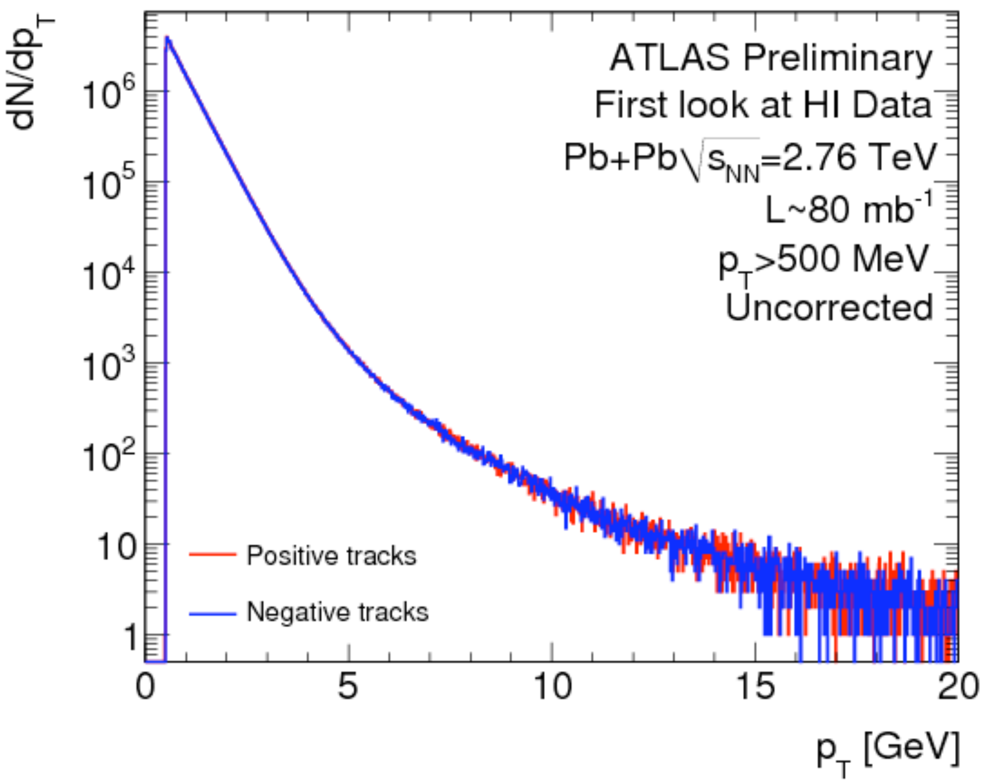
Heavy Ion running

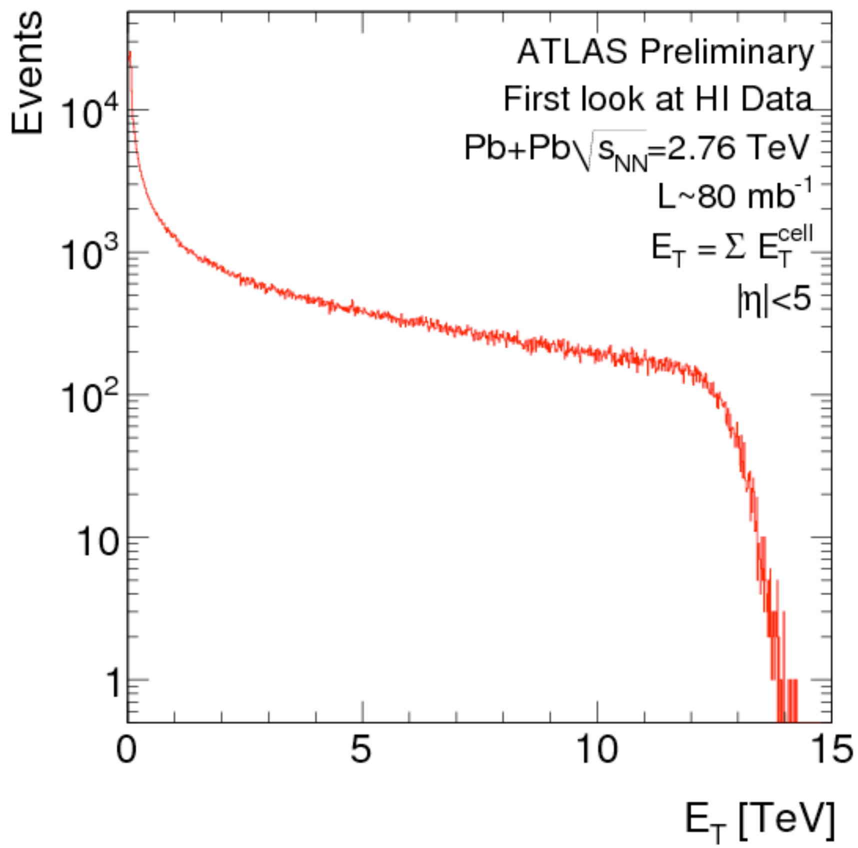





Heavy Ion Collision Event
Run 168665, Event 83797
Time 2010-11-08 11:37:15 CET
ATLAS
EXPERIMENT

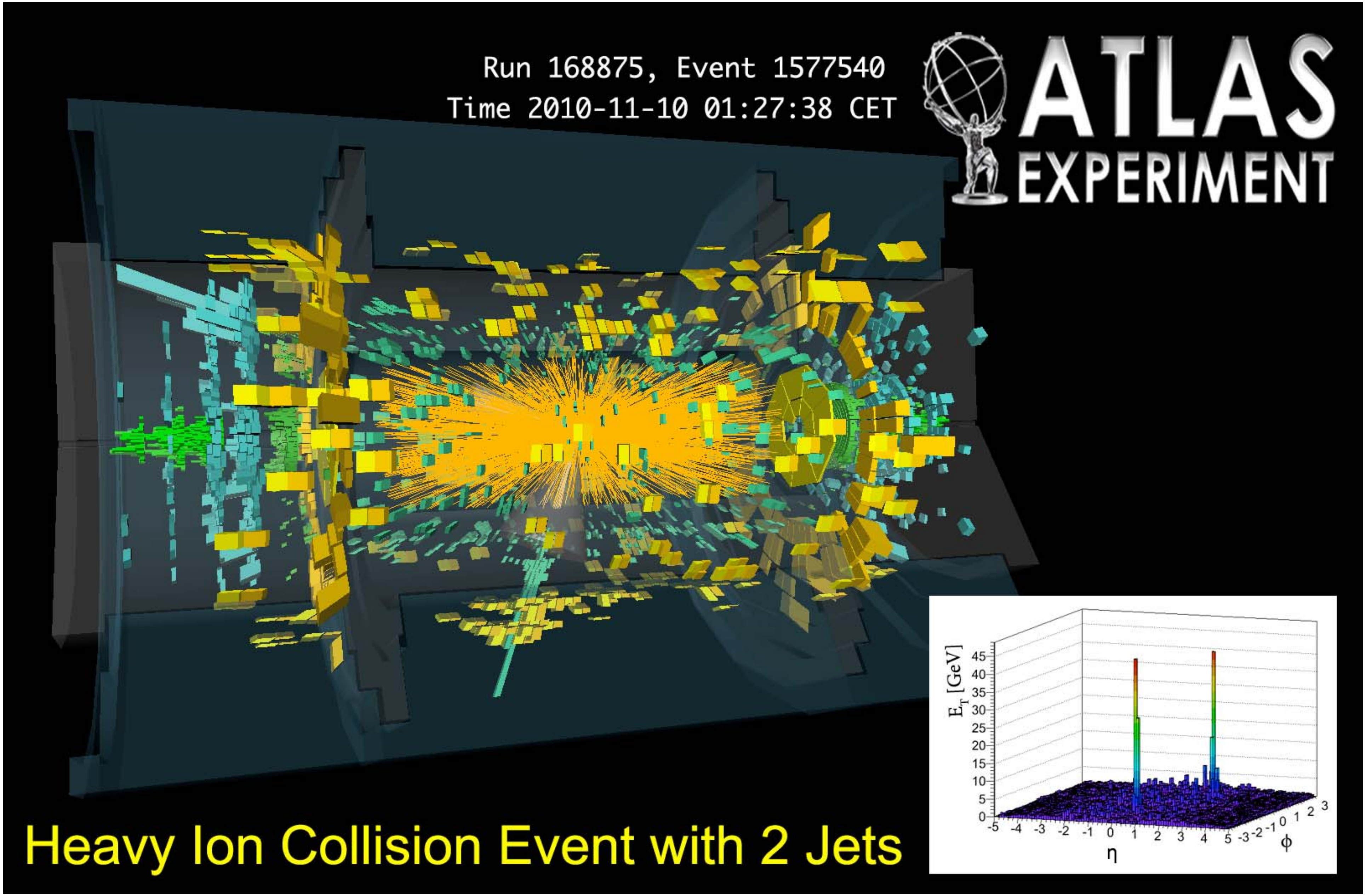
Some sample distributions as a 'first look'





Pb-Pb event with jets

Uncorrected p_T of each jet ~160 GeV



Observation of a Centrality-Dependent Dijet Asymmetry in Lead-Lead Collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS Detector at the LHC

G. Aad *et al.* (The ATLAS Collaboration)*

(accepted by PRL on 25th Nov 2010)

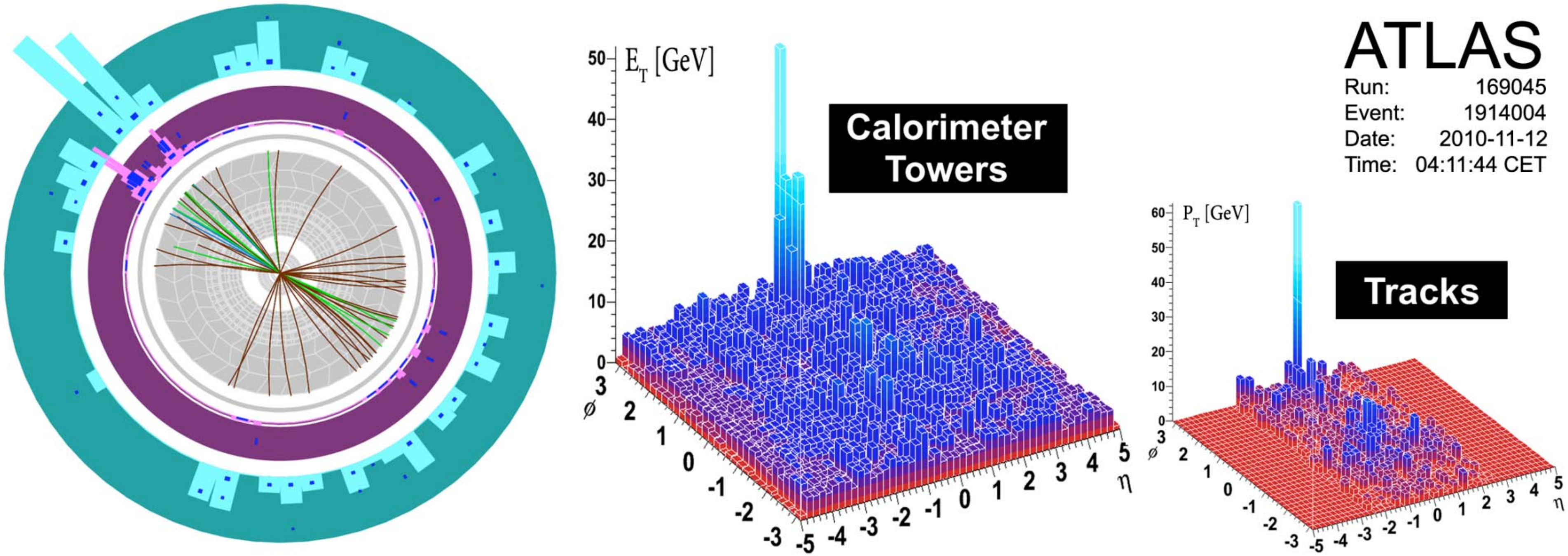


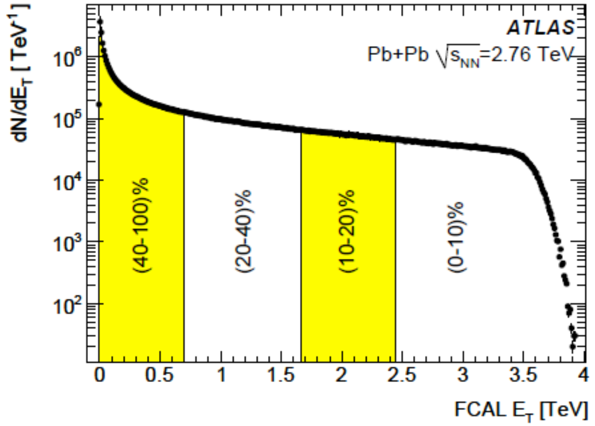
FIG. 1: Event display of a highly asymmetric dijet event, with one jet with $E_T > 100$ GeV and no evident recoiling jet, and with high energy calorimeter cell deposits distributed over a wide azimuthal region. By selecting tracks with $p_T > 2.6$ GeV and applying cell thresholds in the calorimeters ($E_T > 700$ MeV in the electromagnetic calorimeter, and $E > 1$ GeV in the hadronic calorimeter) the recoil can be seen dispersed widely over azimuth.

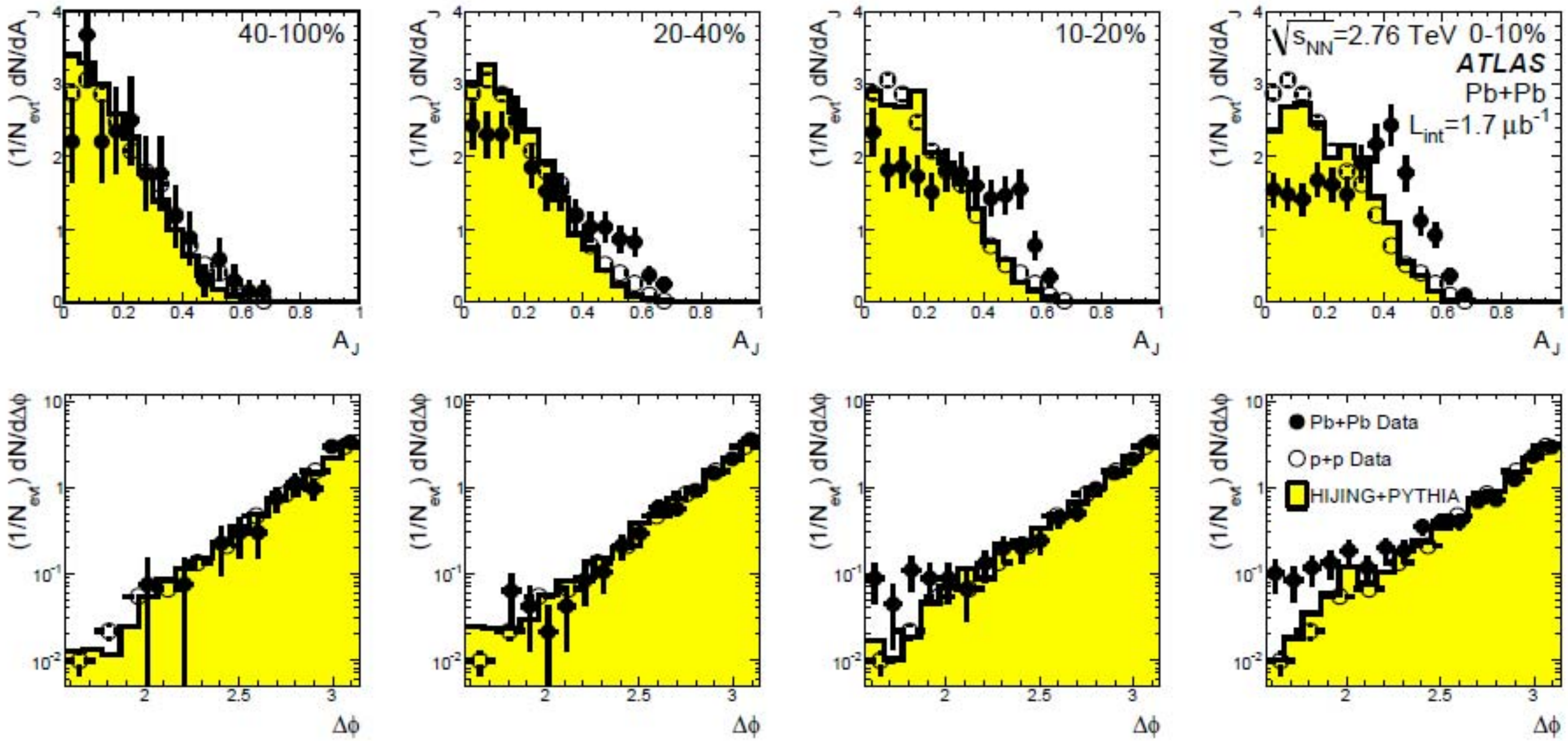
Measured di-jet asymmetry A_J as a function of the centrality

(1.7 μb⁻¹)

$$A_J = \frac{E_{T1} - E_{T2}}{E_{T1} + E_{T2}}, \Delta\phi > \frac{\pi}{2}$$

Centrality bins defined with the ET in FCAL



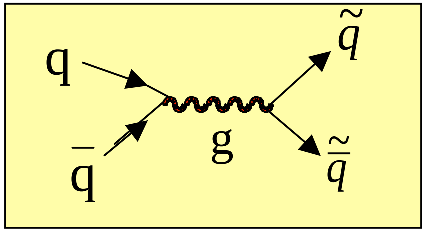


Such an effect could be the first direct indication of 'jet-quenching'

First discoveries at the LHC: Supersymmetry ?

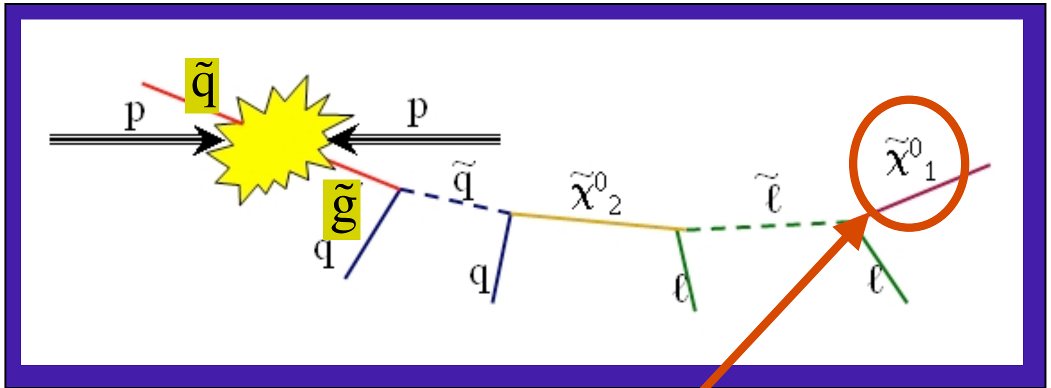
If it is at the TeV mass scale, it should be found "quickly" …. thanks to:

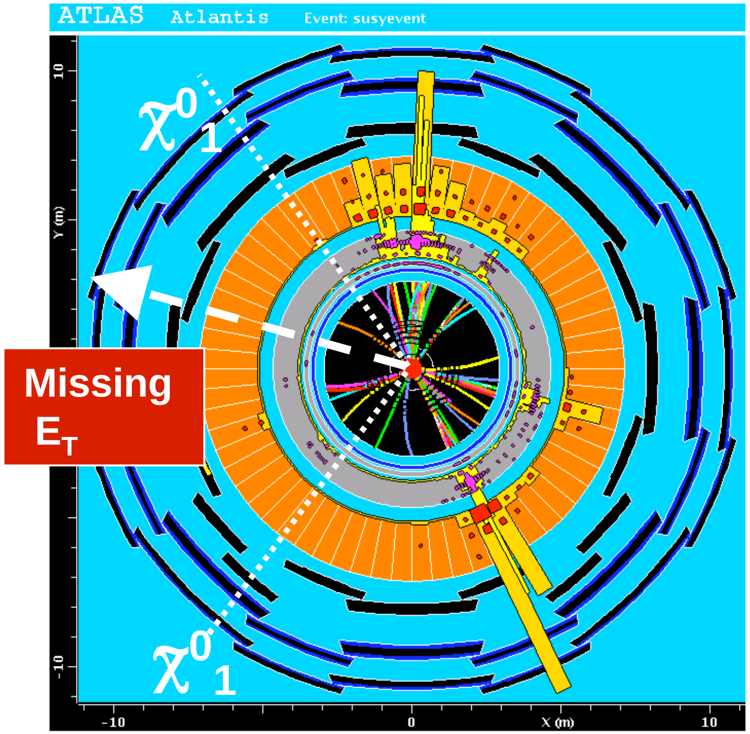
■ **Large production rate for** $\tilde{q}\tilde{q}, \tilde{g}\tilde{q}, \tilde{g}\tilde{g}$ production



For $m(\tilde{q},\tilde{g}) \sim 1$ TeV
expect 1 event/day at $L=10^{31}\ cm^{-2}\ s^{-1}$

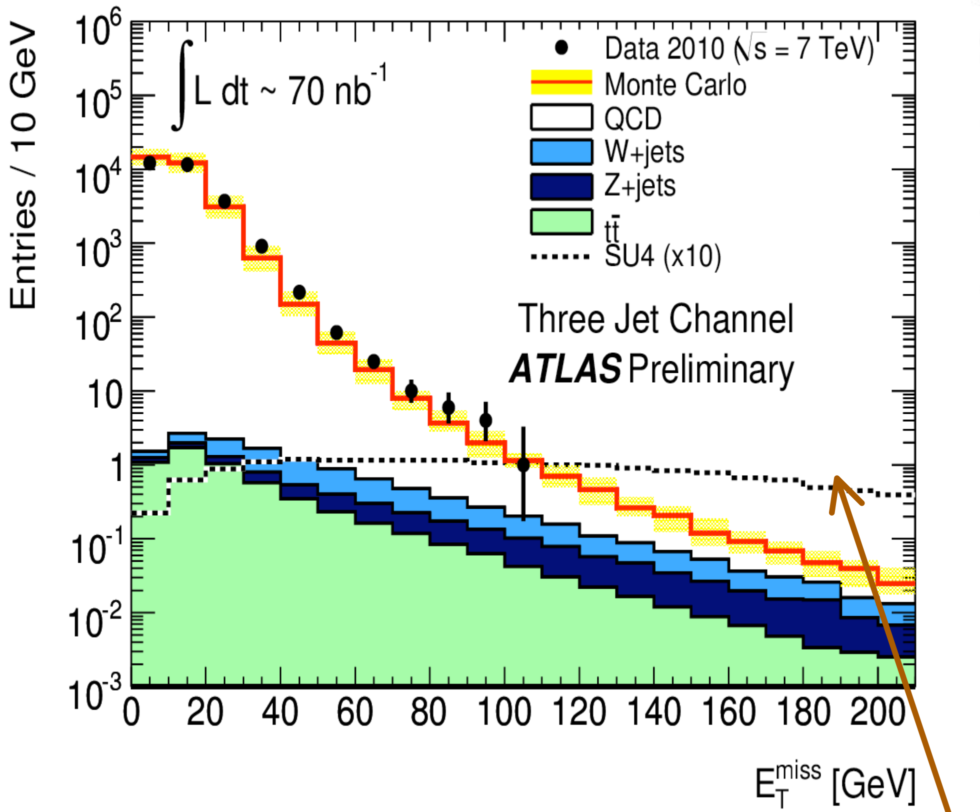
■ **Spectacular final states (many jets, leptons, missing transverse energy)**

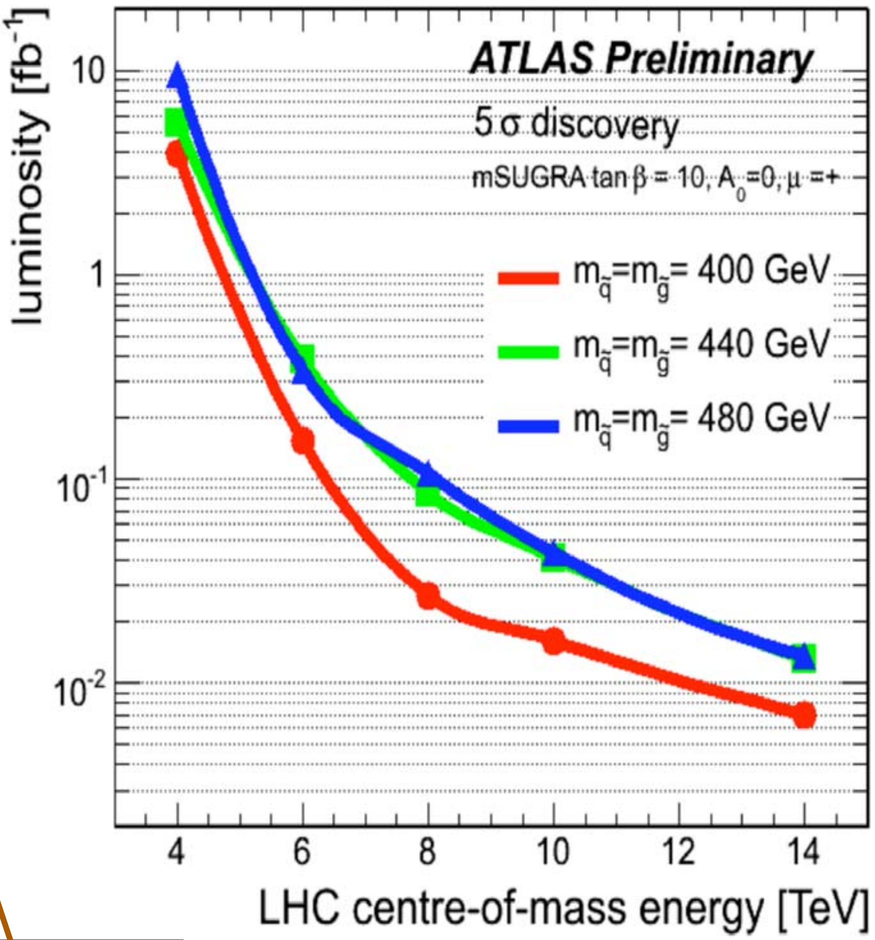




This particle (lightest neutralino) is stable, neutral and weakly interacting → escapes detection (like ν) → apparent missing energy in the final state

The initial LHC running will already match (maybe exceed) by end of 2010 the Tevatron reach





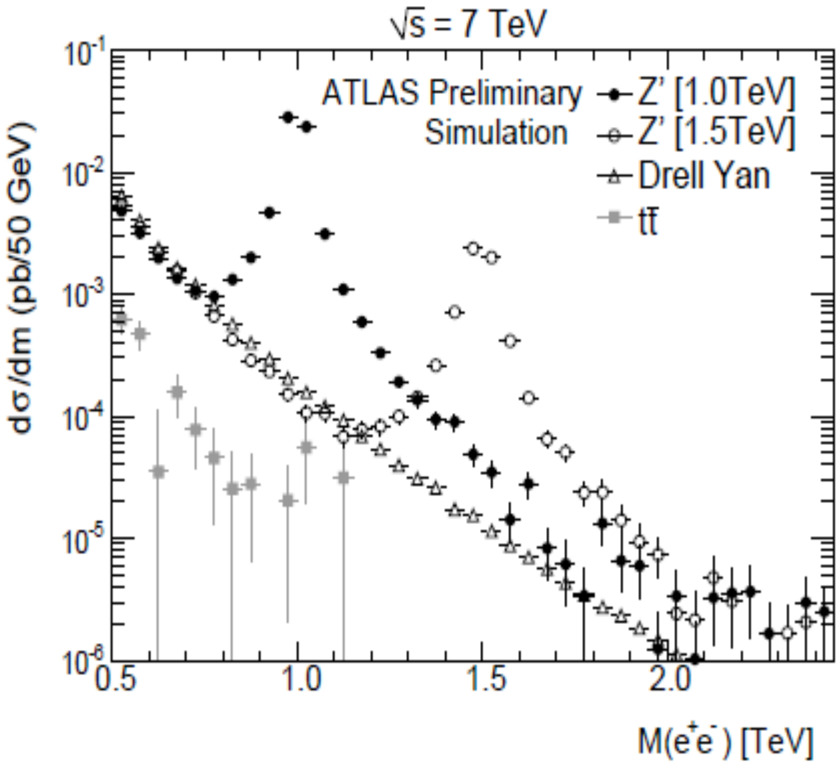
A typical example; note that the missing transverse energy performance enters directly in many SUSY searches, the detectors must be well understood for these measurements

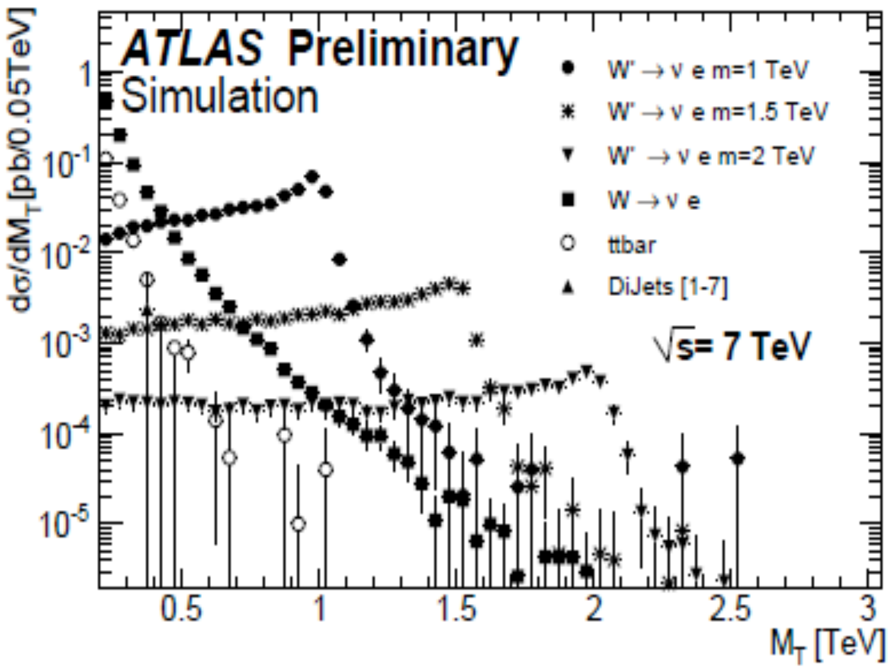
SUSYx10
(m~400 GeV)

An easy case for the LHC: searches for heavy Z' and W'

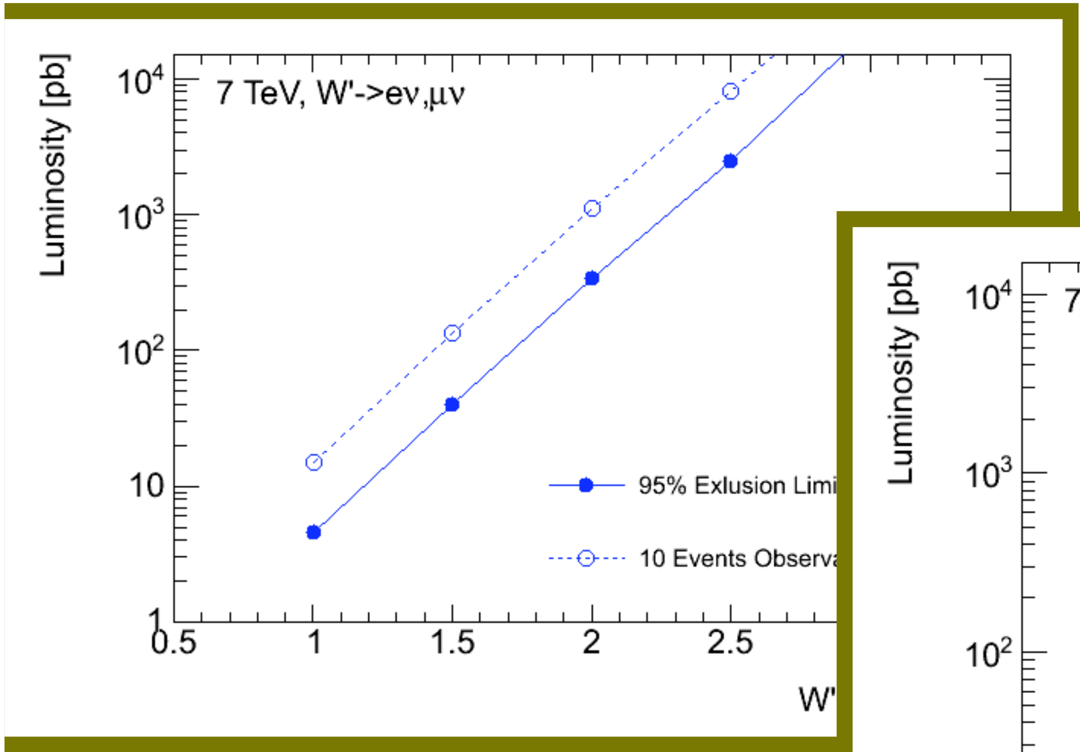
Leptonic decays with electrons or muons would give spectacular signatures

Many different models predict such objects, discoveries of a Z' and W' like particle would be a 'gold mine' for the field, other decay channels could contain yet more new particles!

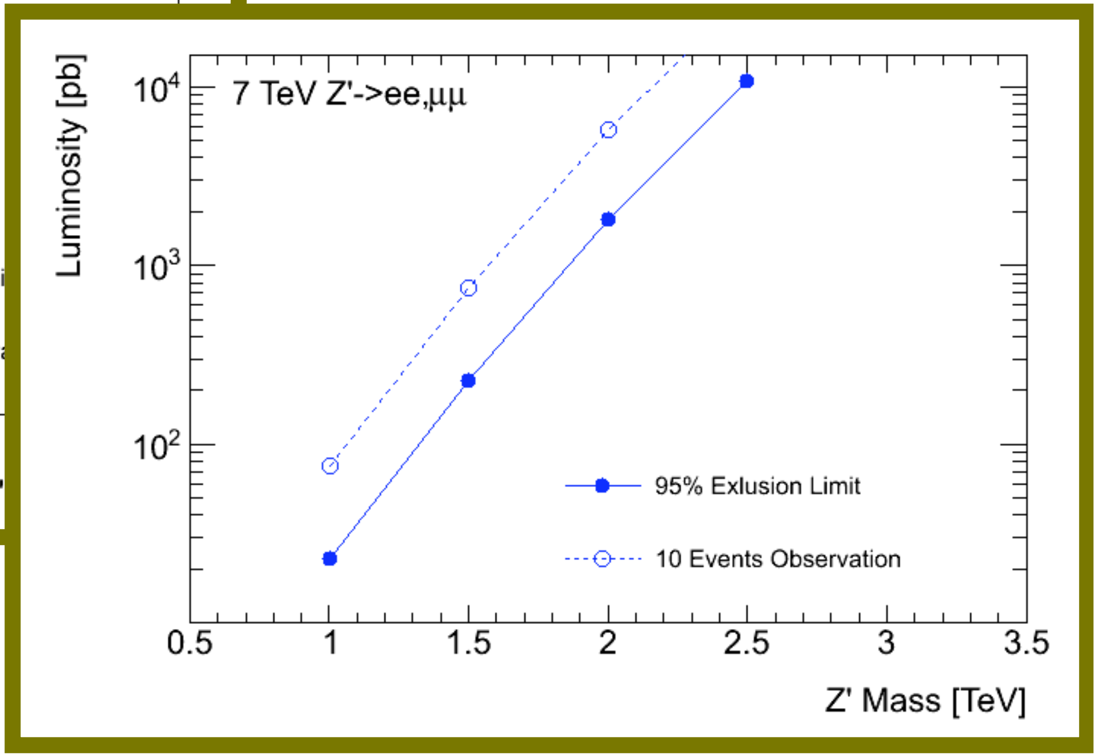




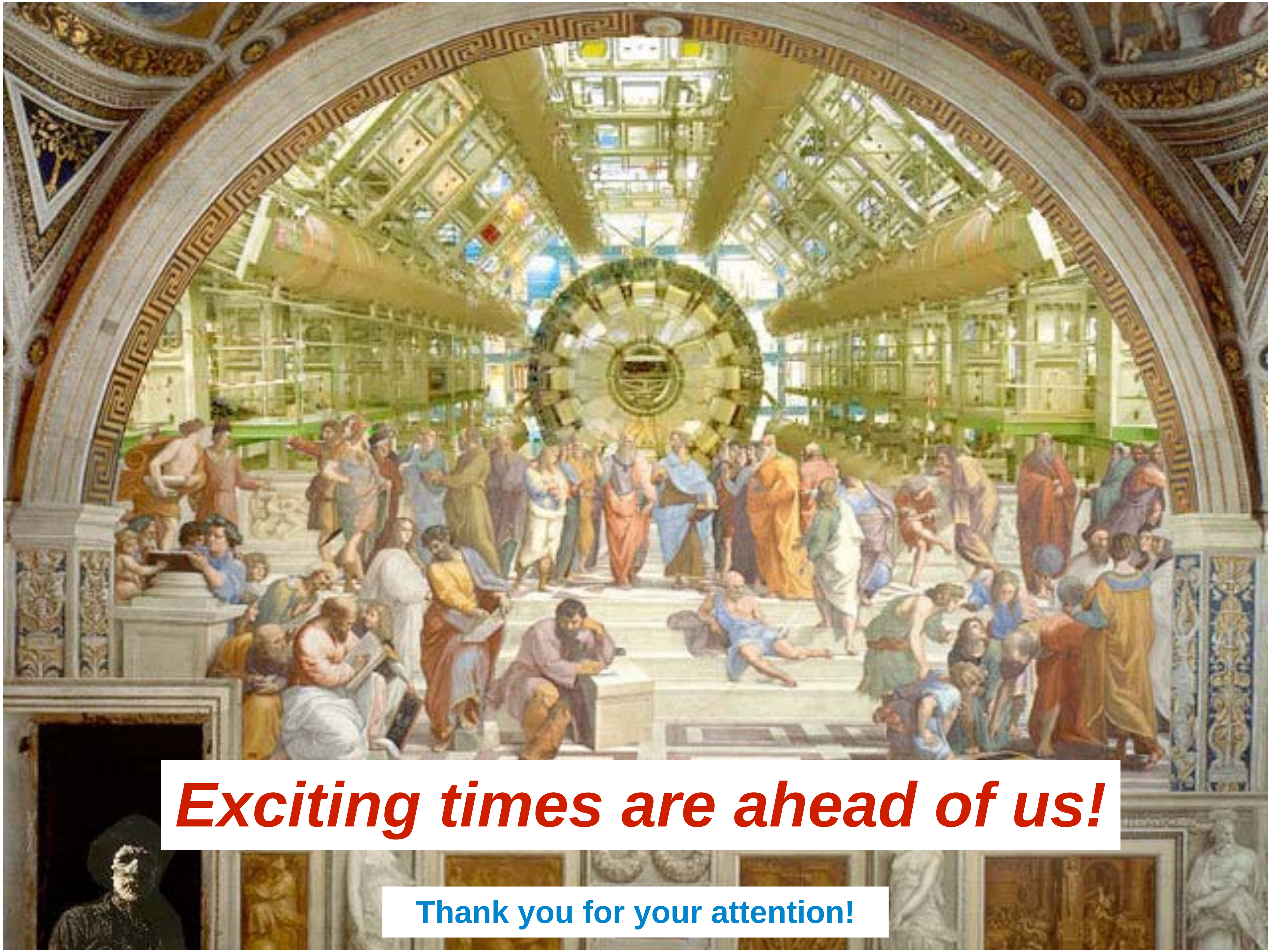
The LHC experiments will have access to the 1 TeV mass range very early on, still this year (2010)



Present Tevatron limits: ~ 1 TeV



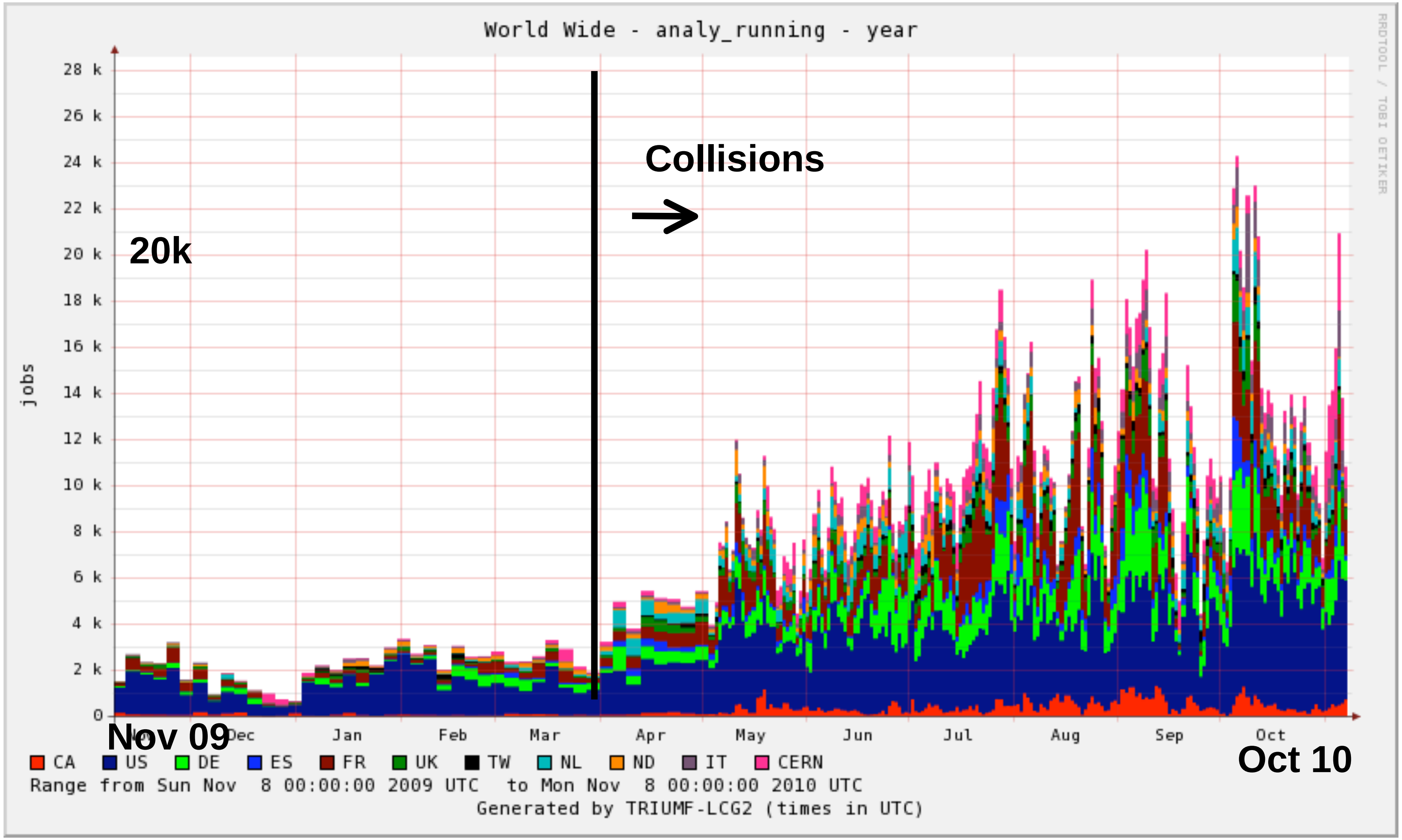
Discovery potential for ATLAS and CMS for the end of 2011, with 1 fb^{-1} at 7 TeV: up to 1.5 TeV for Z' and up to 2 TeV for W'


Exciting times are ahead of us!
Thank you for your attention!

Number of Channels and Operational Fraction of Subsystems

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.3%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	97.1%
LAr EM Calorimeter	170 k	97.9%
Tile calorimeter	9800	96.8%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.5%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.4%

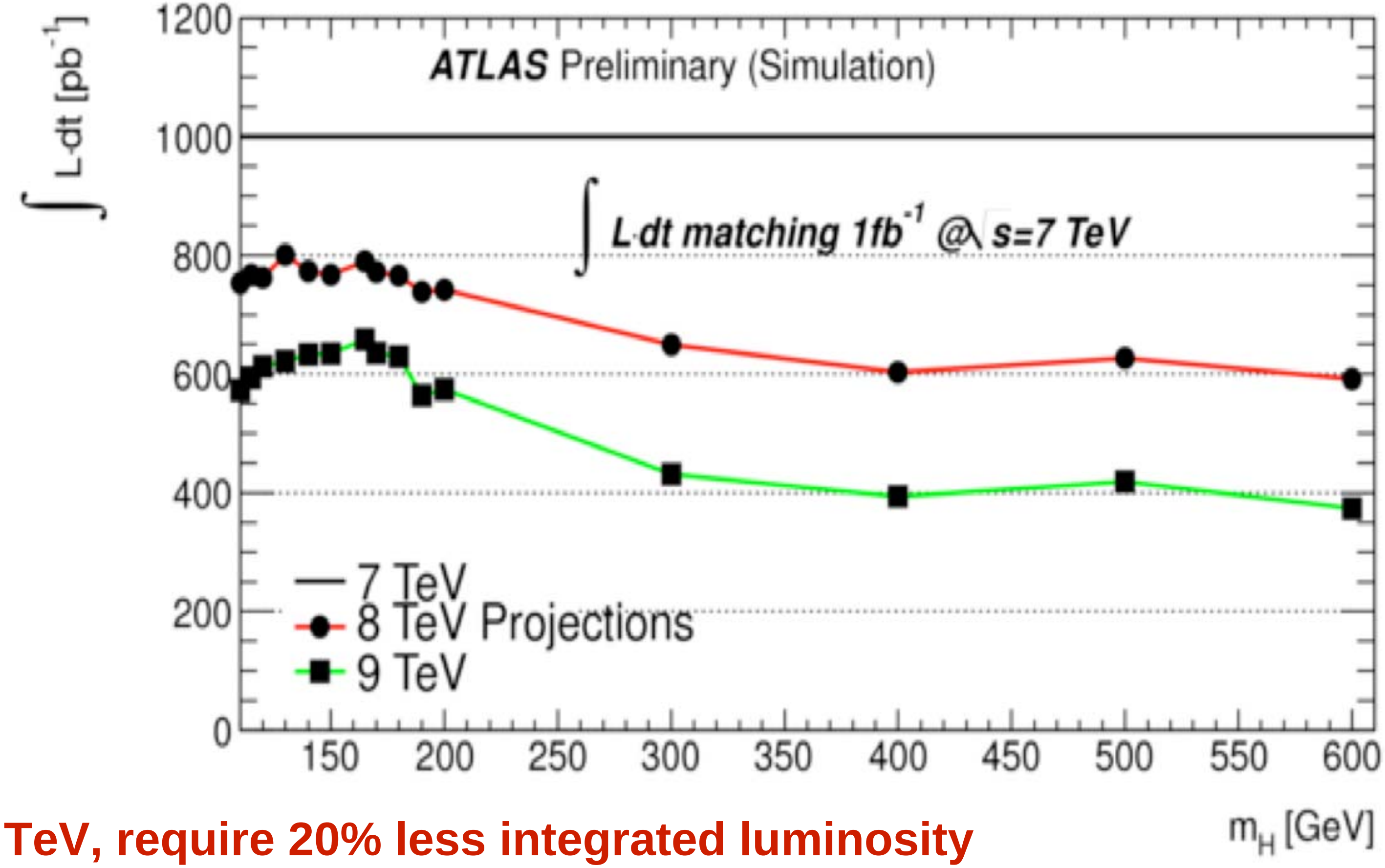
User analysis jobs



More than 1000 users

Higher centre-of-mass energy

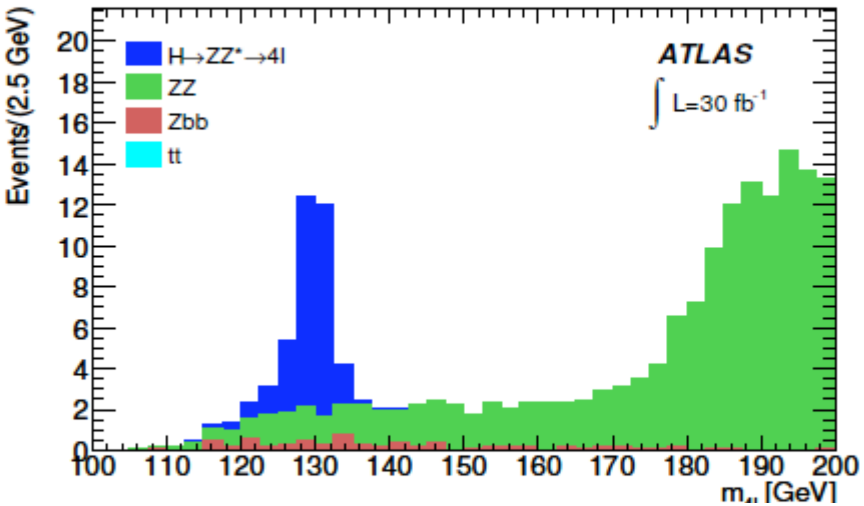
Compare the integrated luminosity at 8 or 9 TeV which gives same median sensitivity as 1 fb^{-1} at 7 TeV

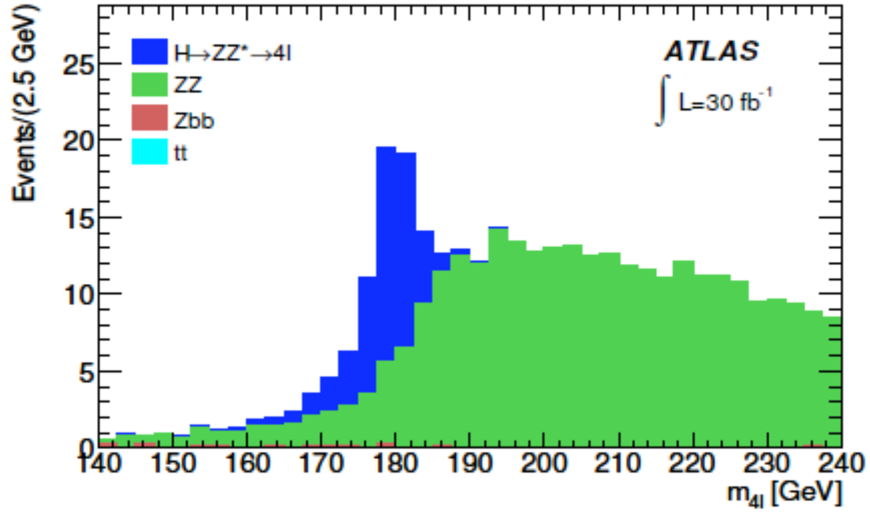


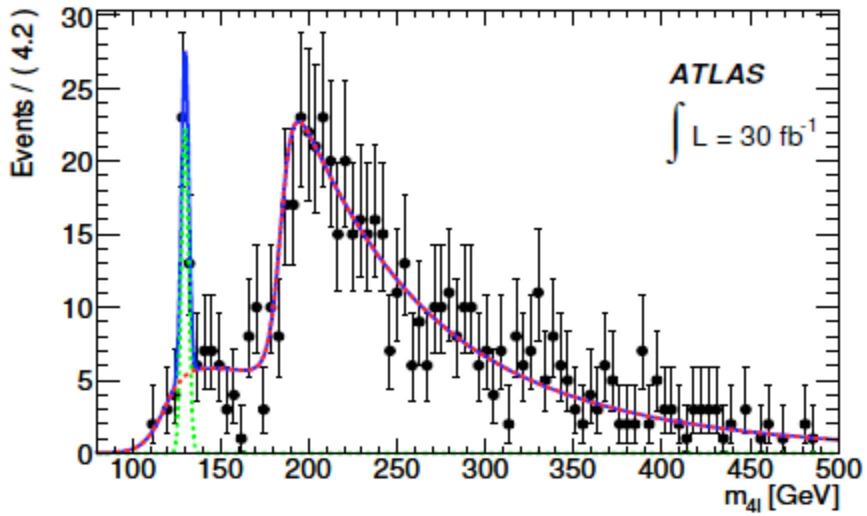
At 8 TeV, require 20% less integrated luminosity

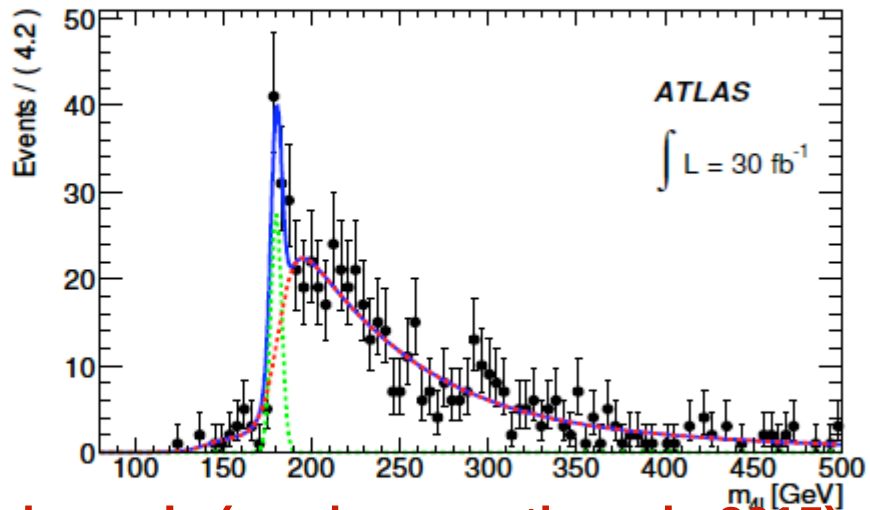
Higgs searches in the years 2014 and after …

14 TeV





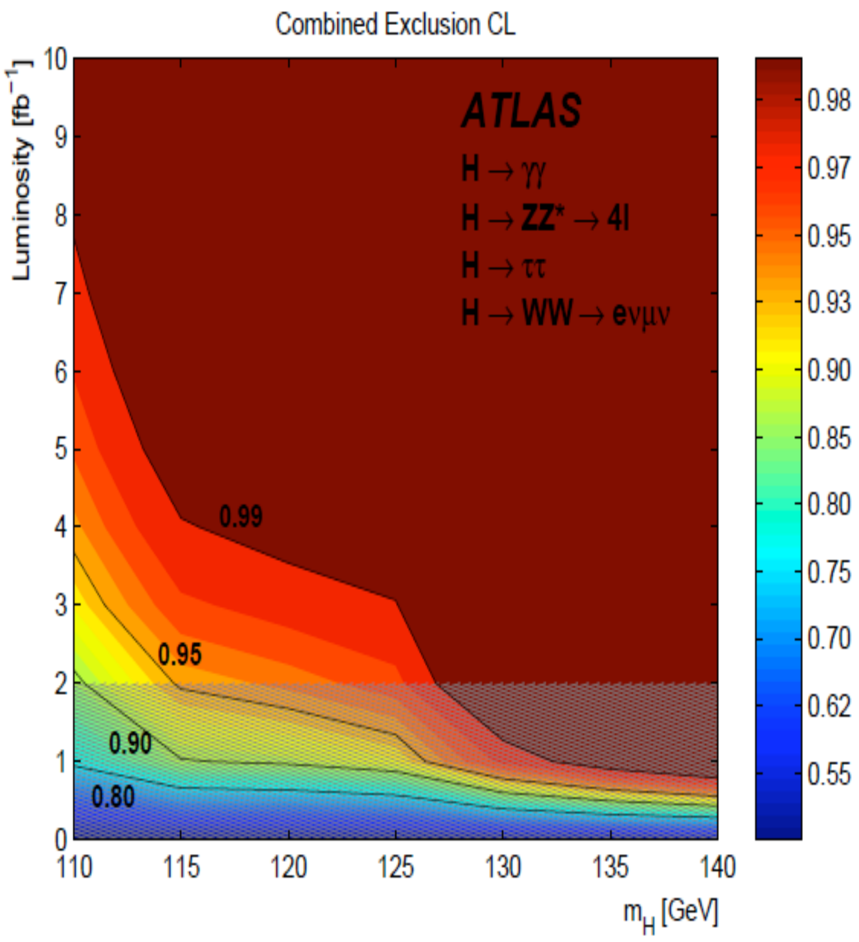




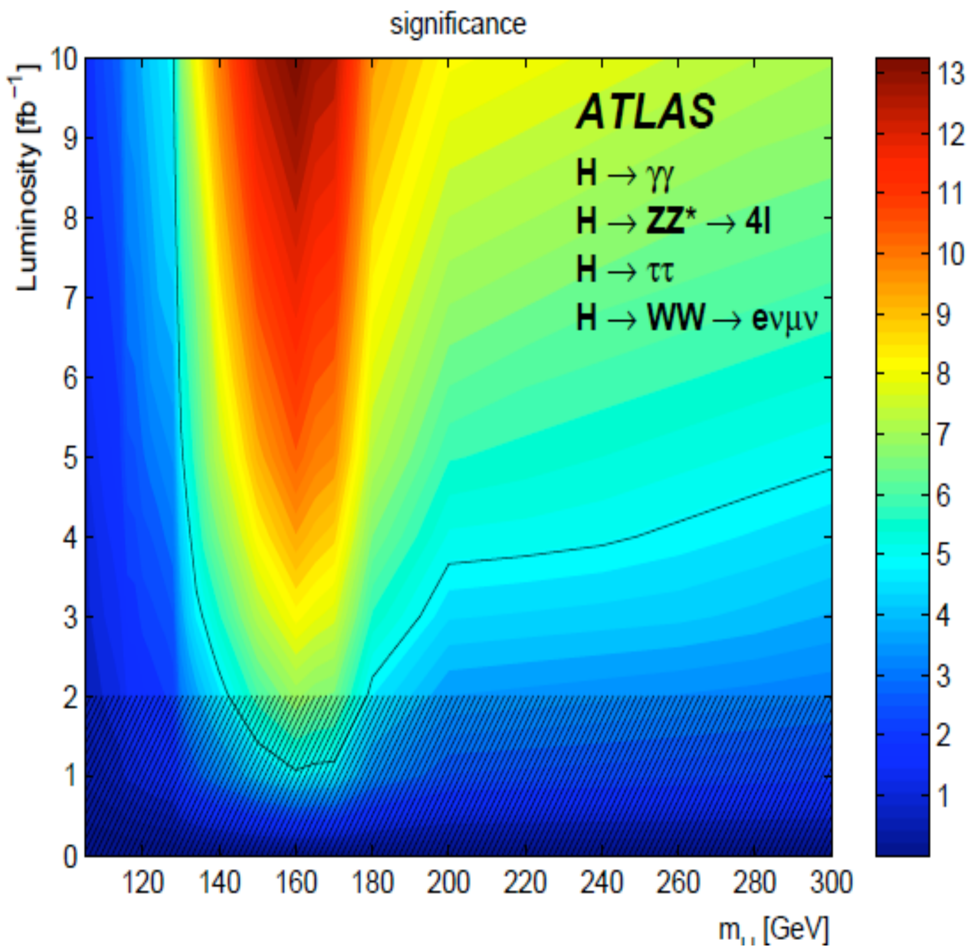
Examples for the 'gold-plated' 4 lepton channels (maybe sometimes in 2015), shown as smooth histogrammes and as a typical experimental distribution

Combining several channels in a single experiment (ATLAS as example, of course CMS very similar)

14 TeV

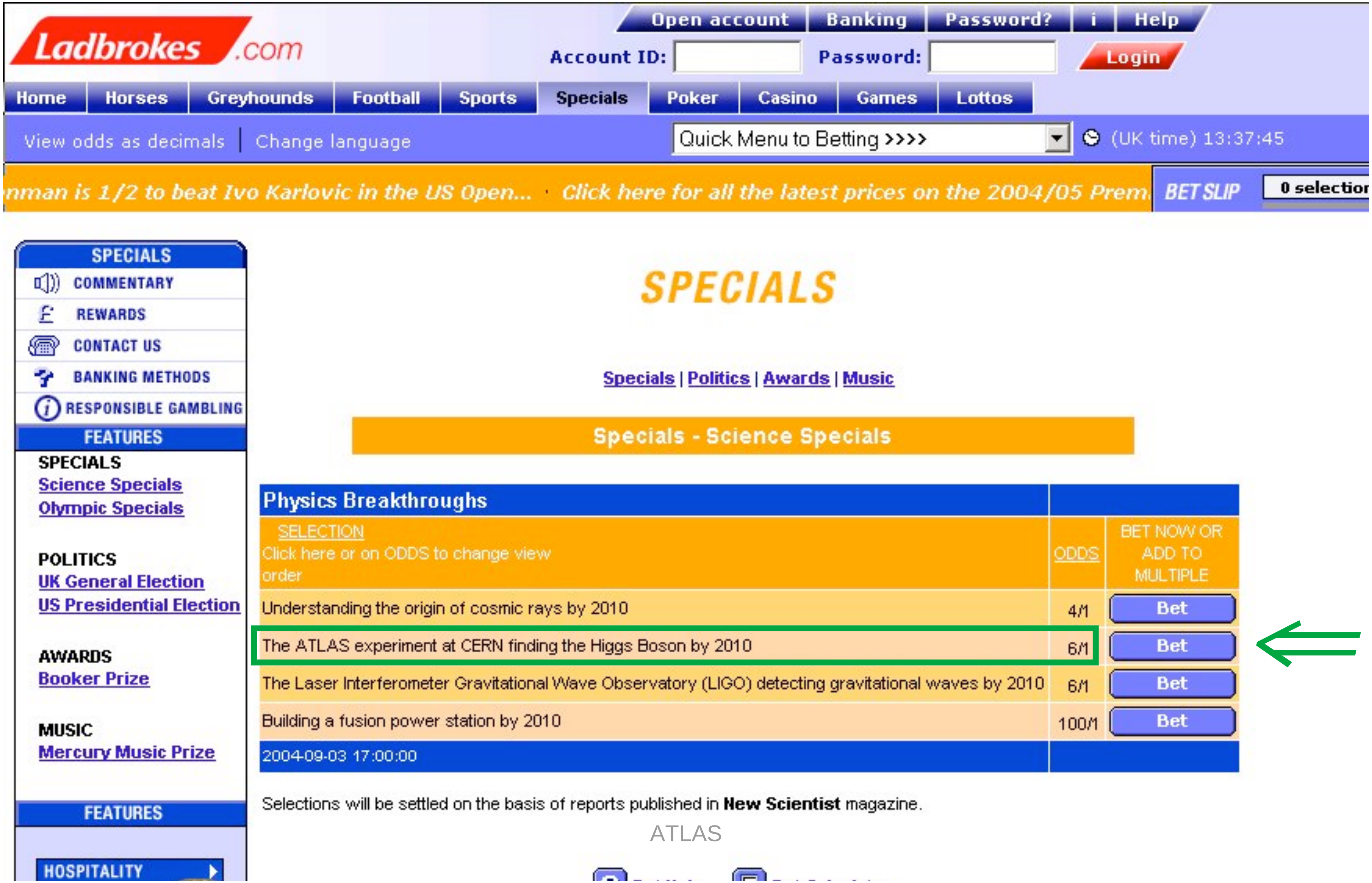


Exclusion confidence levels

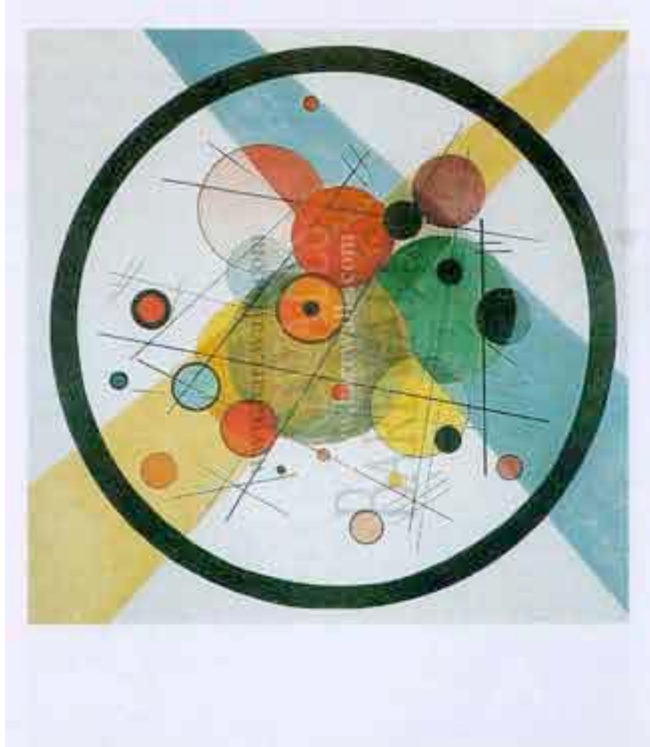


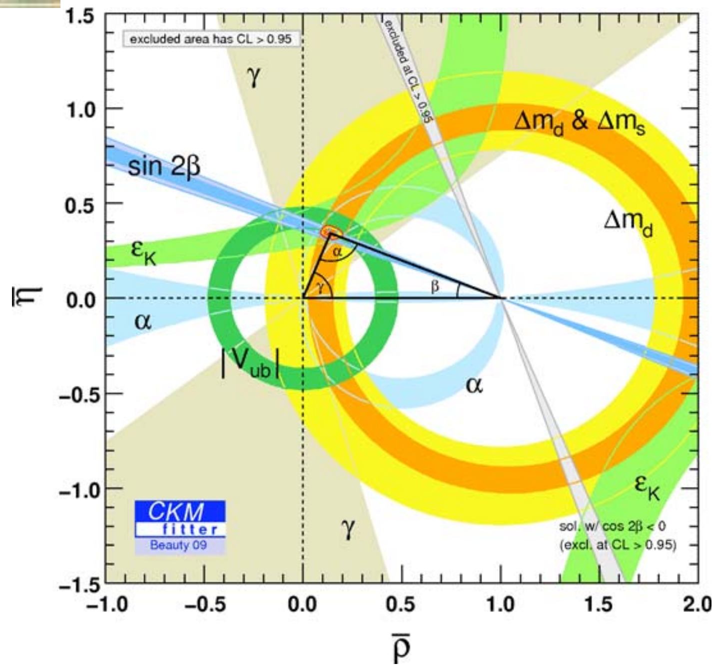
Discovery significance levels in σ

Those of you who have placed Higgs discovery bets in 2004 have unfortunately little chance to recover their money…



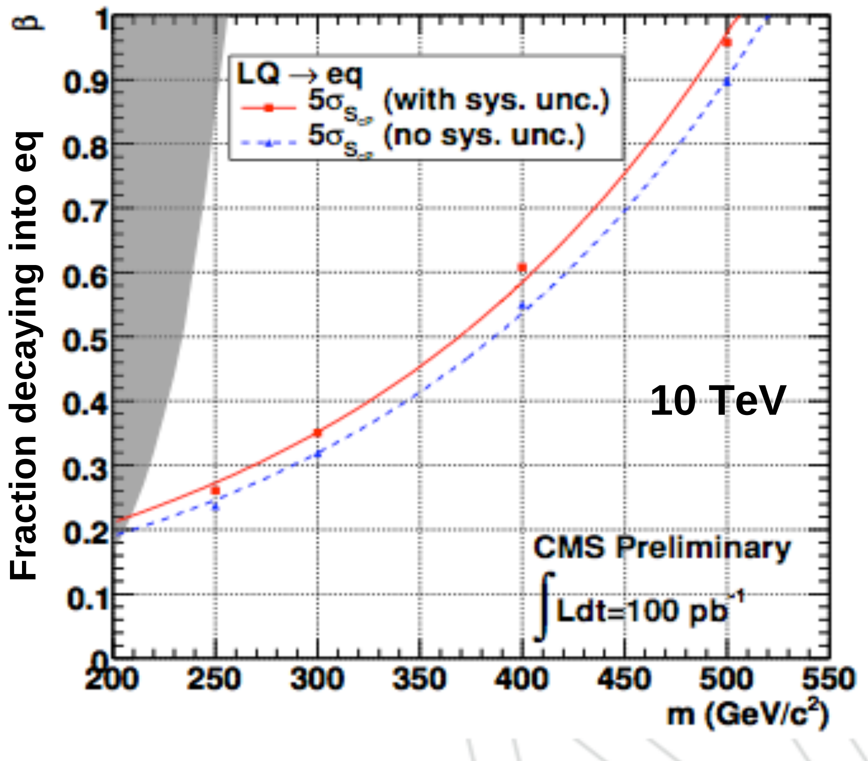
Early hints of news from ‘Beyond the Standard Model’ may come from ‘beautiful’ flavour physics...





Examples of other searches for new (exotic) physics
(and there would be many more not mentioned now!)

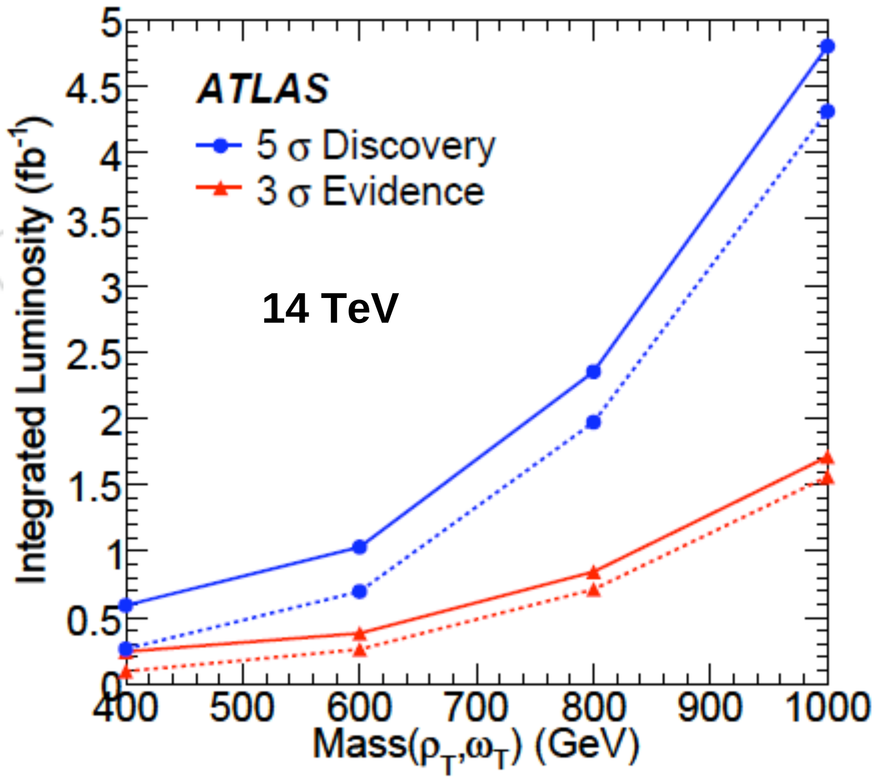
Lepto-quarks



Tevatron limits typically 300 GeV

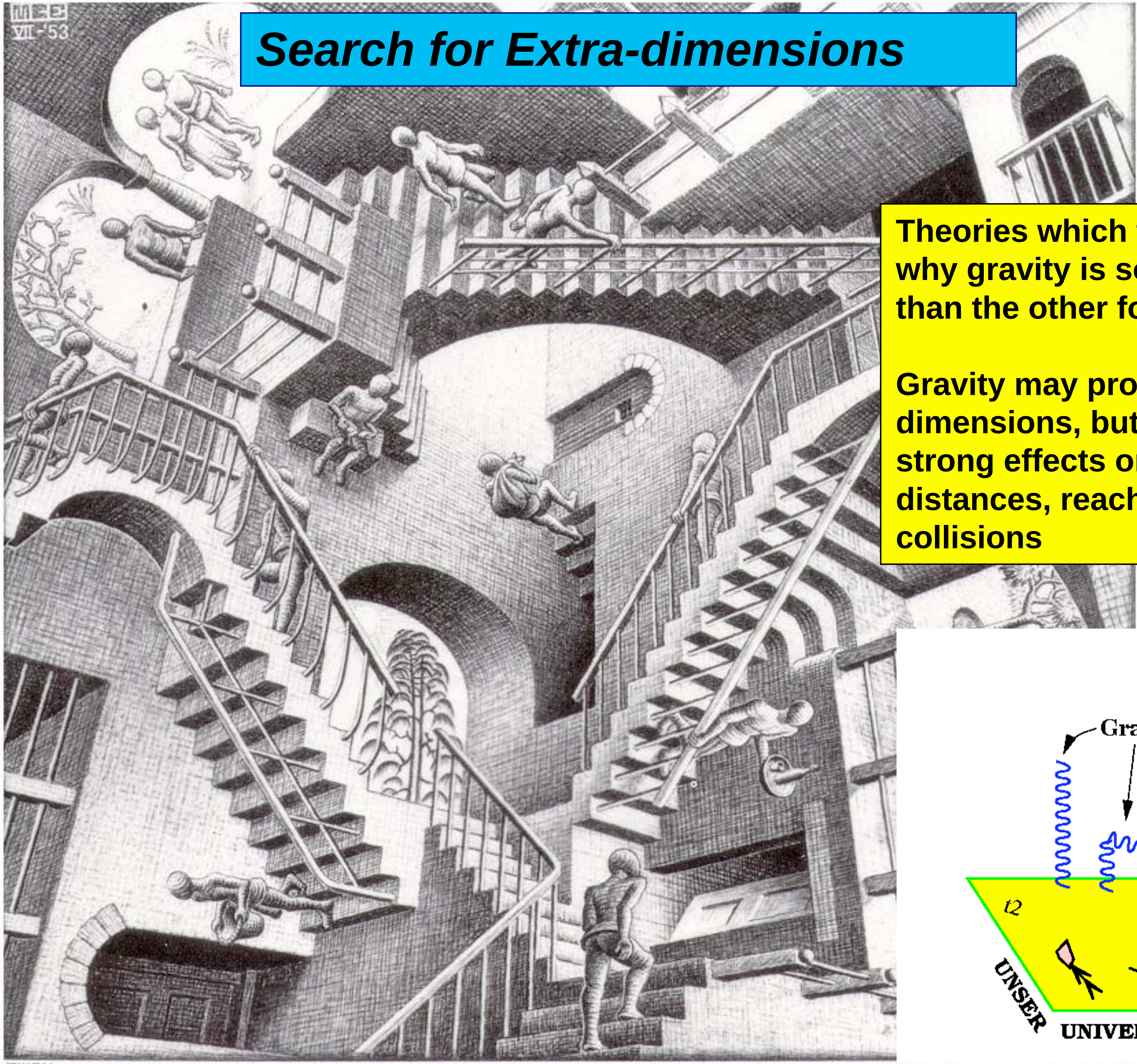
Technicolour resonances

(Models with no Higgs but a new type of force…)



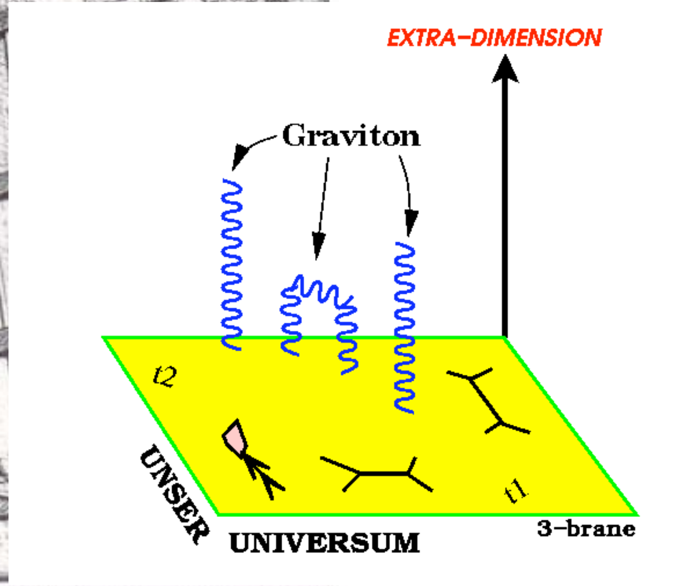
$\rho_T \to \mu^+\mu^-$ and $\omega_T \to \mu^+\mu^-$

Search for Extra-dimensions

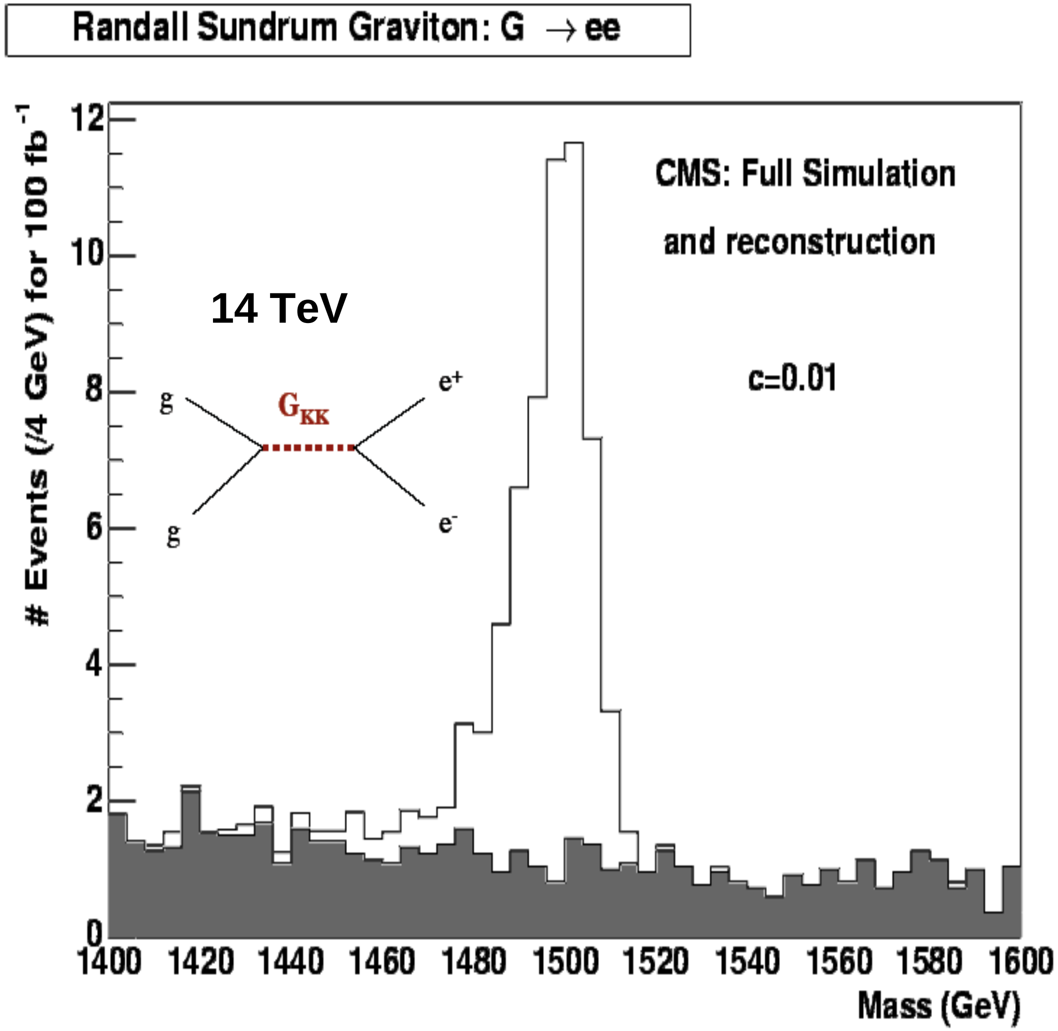


Theories which try to explain why gravity is so much weaker than the other forces

Gravity may propagate in 4+n dimensions, but we could see strong effects only at very small distances, reachable in pp LHC collisions



Warped Extra-dimensions (Randall-Sundrum models): production of narrow Graviton resonances



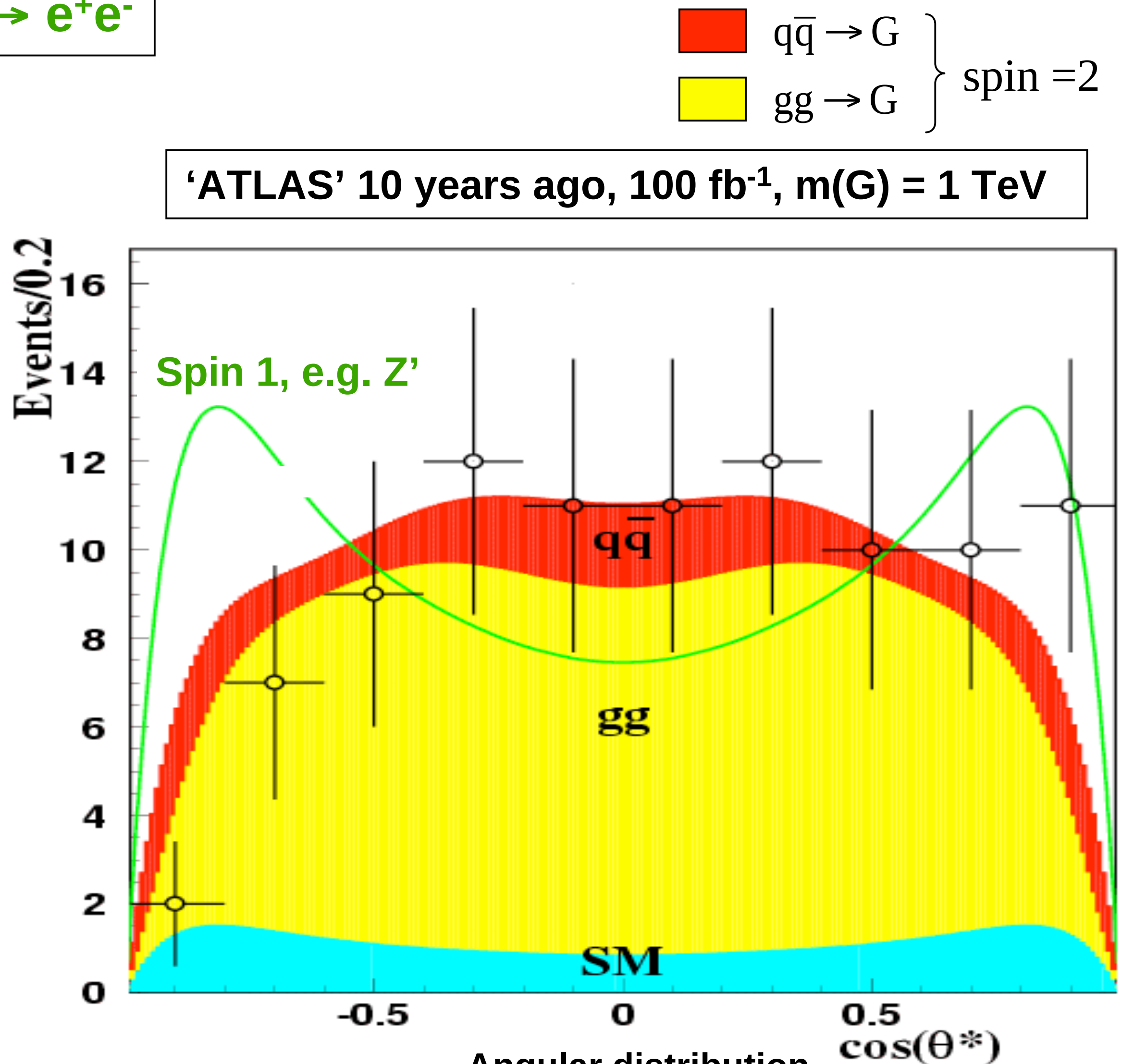
Sundrum
Randall
Gianotti

Signature: a resonance in the di-electron or di-muon final state, as well as di-photons, *a priori* easy for the experiments

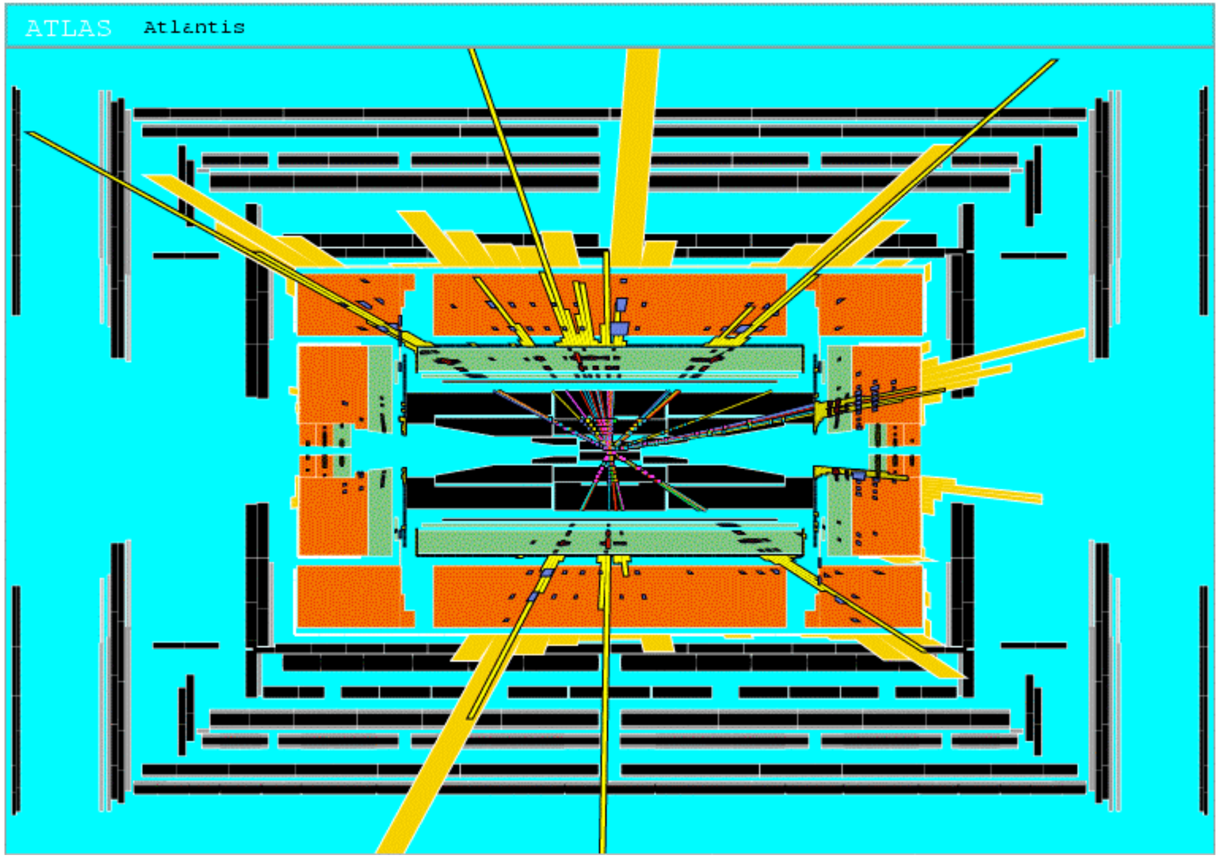
Caveat: new developments suggest that G_{KK} would couple dominantly to top anti-top…

qq, gg → G → e⁺e⁻

Lisa Randall visiting ATLAS



If theories with Extra-dimensions are true, microscopic black holes could be abundantly produced and observed at the LHC



Simulation of a black hole event with M_{BH} ~ 8 TeV in ATLAS

They decay immediately through Stephen Hawking radiation