

The Greek contribution to ATLAS
The muon project

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UoA

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- E. Katsoufis
- T. Papadopoulou
- E. Fokitis
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- S. Maltezos
- A. Tzamarioudaki
- R. Avramidou
- F. Antoniou
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- E.Mountricha
- M. Papadopoulou
- E. Panagiotopoulou

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- C. Anastopoulos
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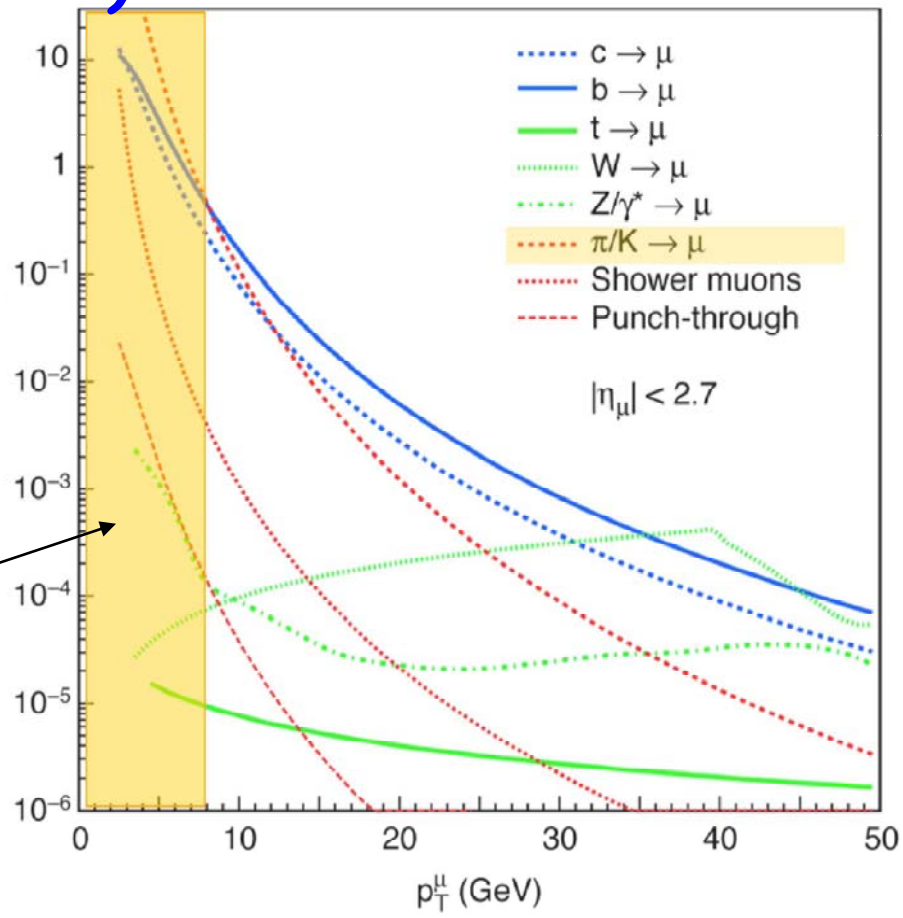
- D. Iliadis
- I. Nomidis
- A. Petridis
- D. Sampsonidis

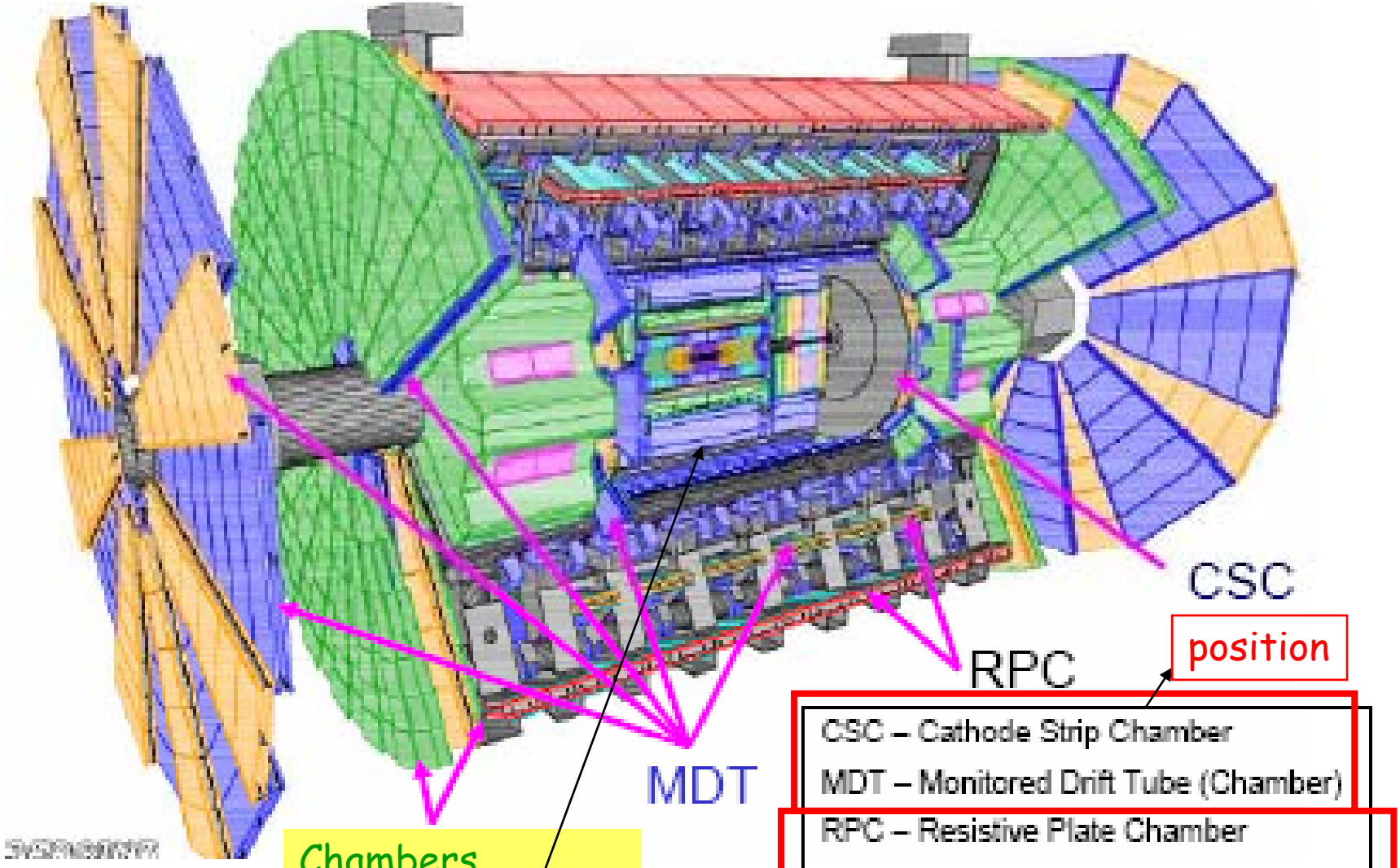
Muons in ATLAS

- **Measure momenta** from ~5 GeV to few TeV
- **Trigger** on muons (+BC)
- Identify muons
- Physics channels:
  - $H \rightarrow ZZ^* \rightarrow \mu\mu\ell\ell,$
  - $A \rightarrow \mu\mu,$
  - $Z' \rightarrow \mu\mu.$

+ others .....



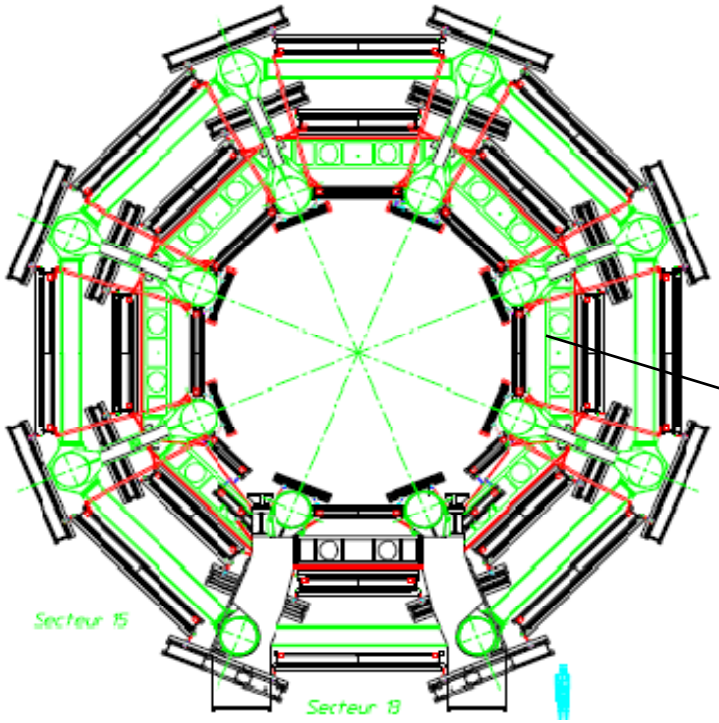
The four different technologies of Muon chambers



Chambers constructed by the three Greek institutions

The Greek Tracking Muon Chambers (BIS)

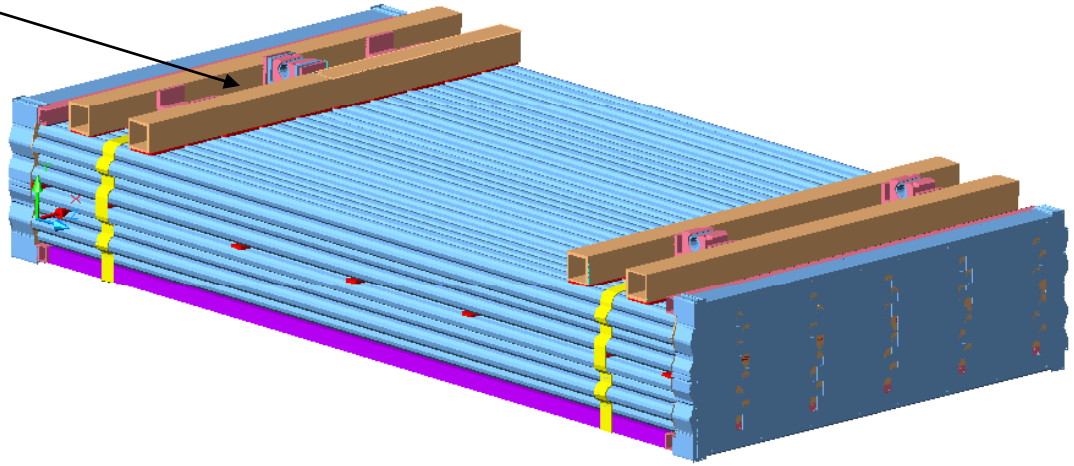
Transverse view of the Muon Spectrometer



The three Greek Laboratories:

- University of Athens (UoA)
  MDT tube assembly
- National Technical University of Athens (NTUA)
  Quality Assurance/Quality Control of MDT tubes
- Aristotle University of Thessaloniki (AUTh)
  MDT chamber assembly and test

Barrel **I**nner **S**mall Chambers



PRECISION CHAMBERS (380,000 MTD tubes)+CSC's

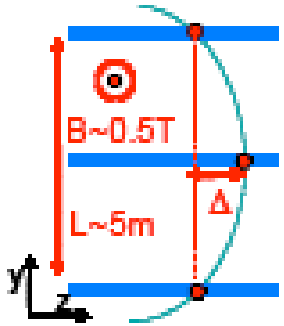
Challenge was the construction accuracy and the constant monitoring

ATLAS Muon Spectrometer:

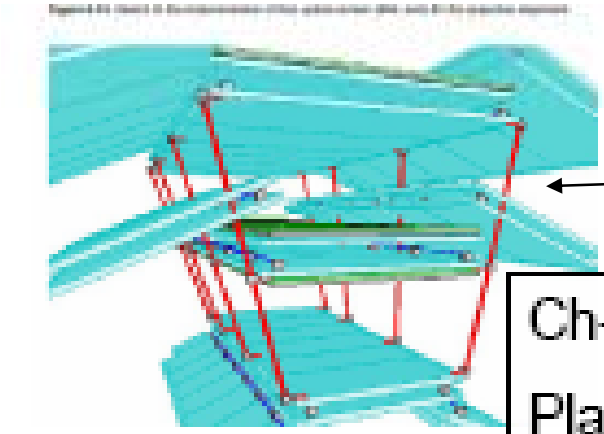
$E_{\mu} \sim 1$ TeV $\Rightarrow \Delta \sim 500$ μm

$\downarrow$

- $\sigma/p \sim 10\% \Rightarrow \delta\Delta \sim 50$ μm
- alignment accuracy to ~20 μm



The sagitta story



Barrel alignment

Ch-to-Ch ~ 40 μm

Placement ~ 5 mm

A bit of History:

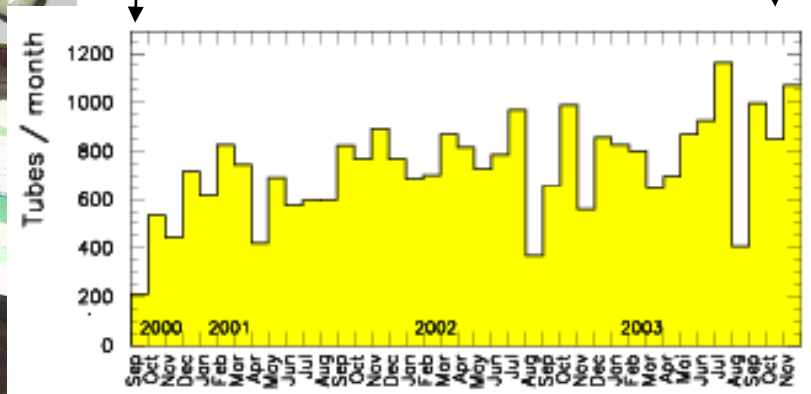
Started wiring the first tubes in **UoA** in 1998 (module 0)

All Greek sites passed the Site Review May 1999

Started series production in Sept 1999

Finished wiring (30,000 tubes) in Nov. 2003

(4 YEARS)

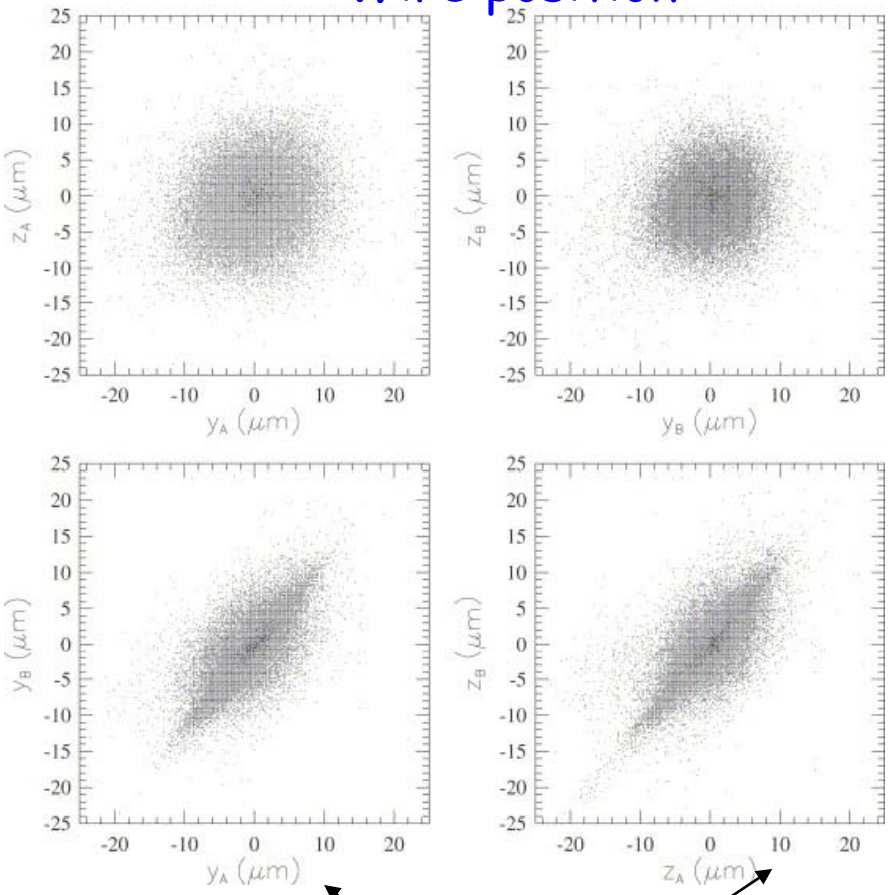


The tube wiring table at UoA (start 1998)

1999-April 2004 continuous QC/QC of wired tubes at **NTUA**

- Gas leak rate
- Wire tension check
- Wire position
- Leak current of tubes

Wire position

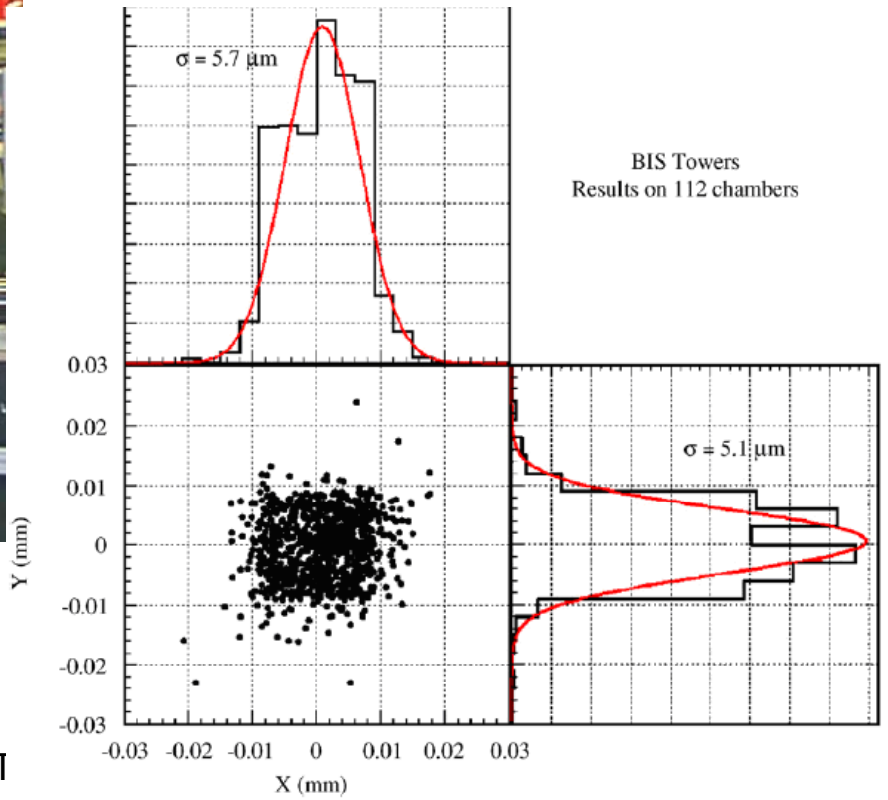


Scale is μm

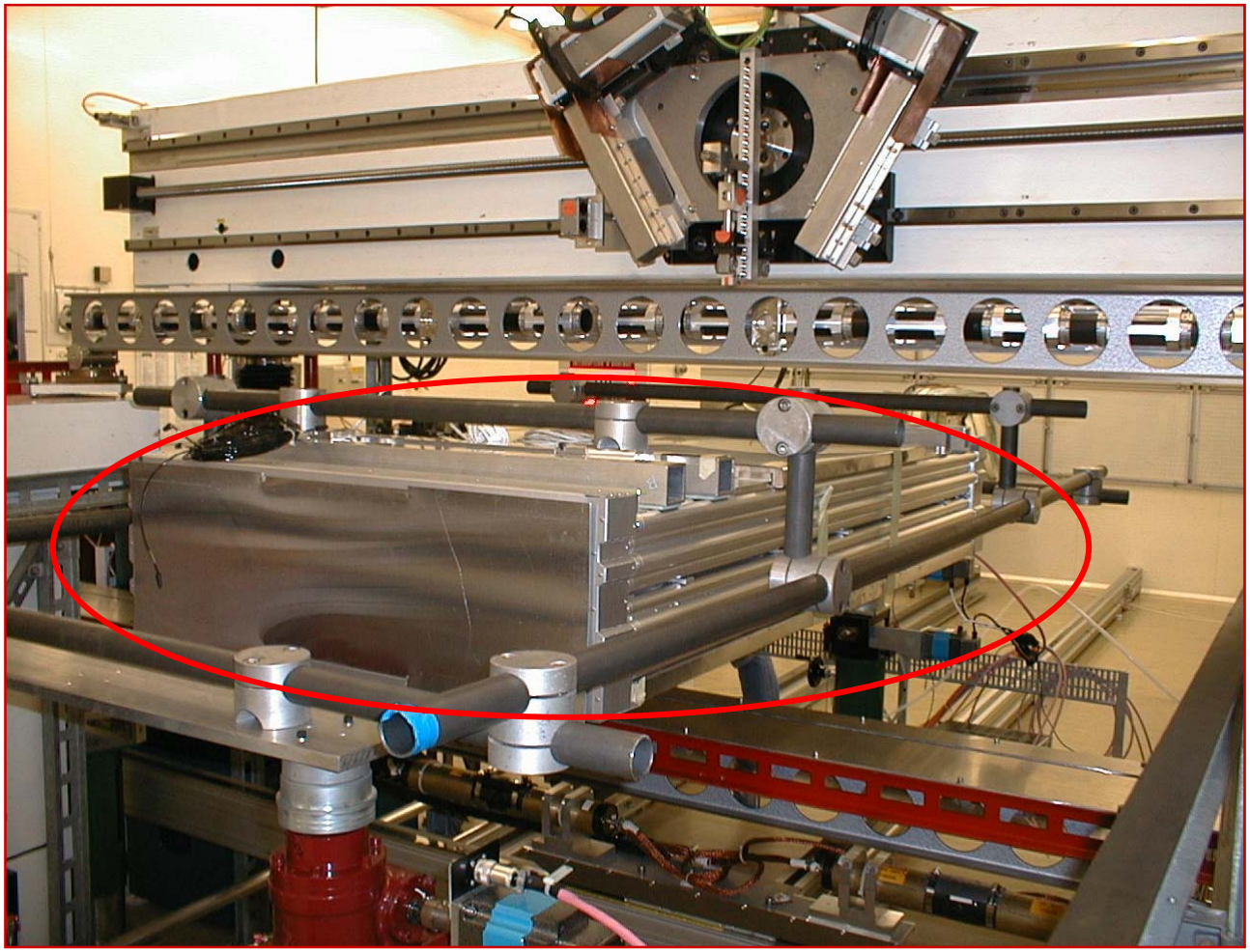
End 1999-May2004 : Chamber construction at the **AUTh** in Temperature and Humidity controlled Clean Room (56 m2) precision granite table (112+2 chambers)

The granite assembly table in AUTh

Class 50000 Temperature ±0.5^{0}C Humidity ±5%



Checks: The Chambers were sampled tested with the X-Ray Tomography at CERN

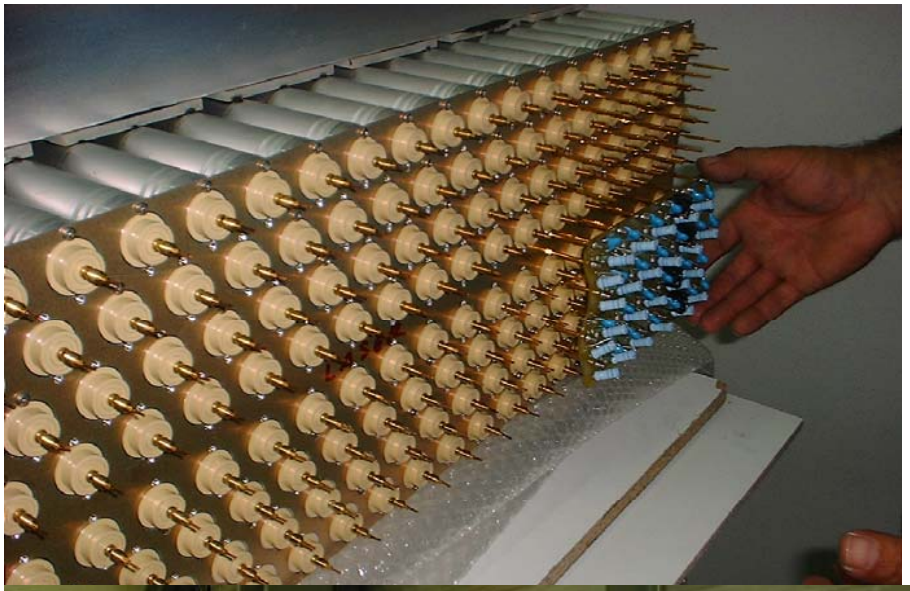


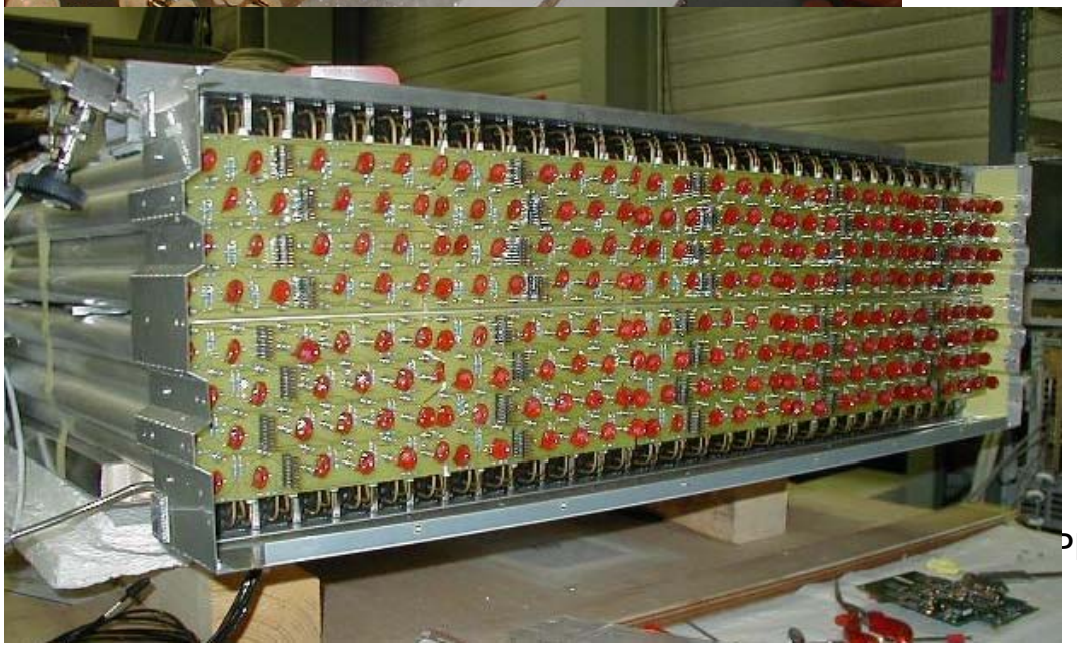
The results met the ATLAS specifications !!!

April-01 **11.7 ÷ 13.9 μm**
July-00 **11.0 ÷ 16.2 μm**

Jan2005-Jan 2006 tests of chambers for gas leaks, noise and with **cosmic rays**

Feb 2004-Jan 2006 chambers equipped with services (FE electronics, gas manifolds, Faraday cages etc)





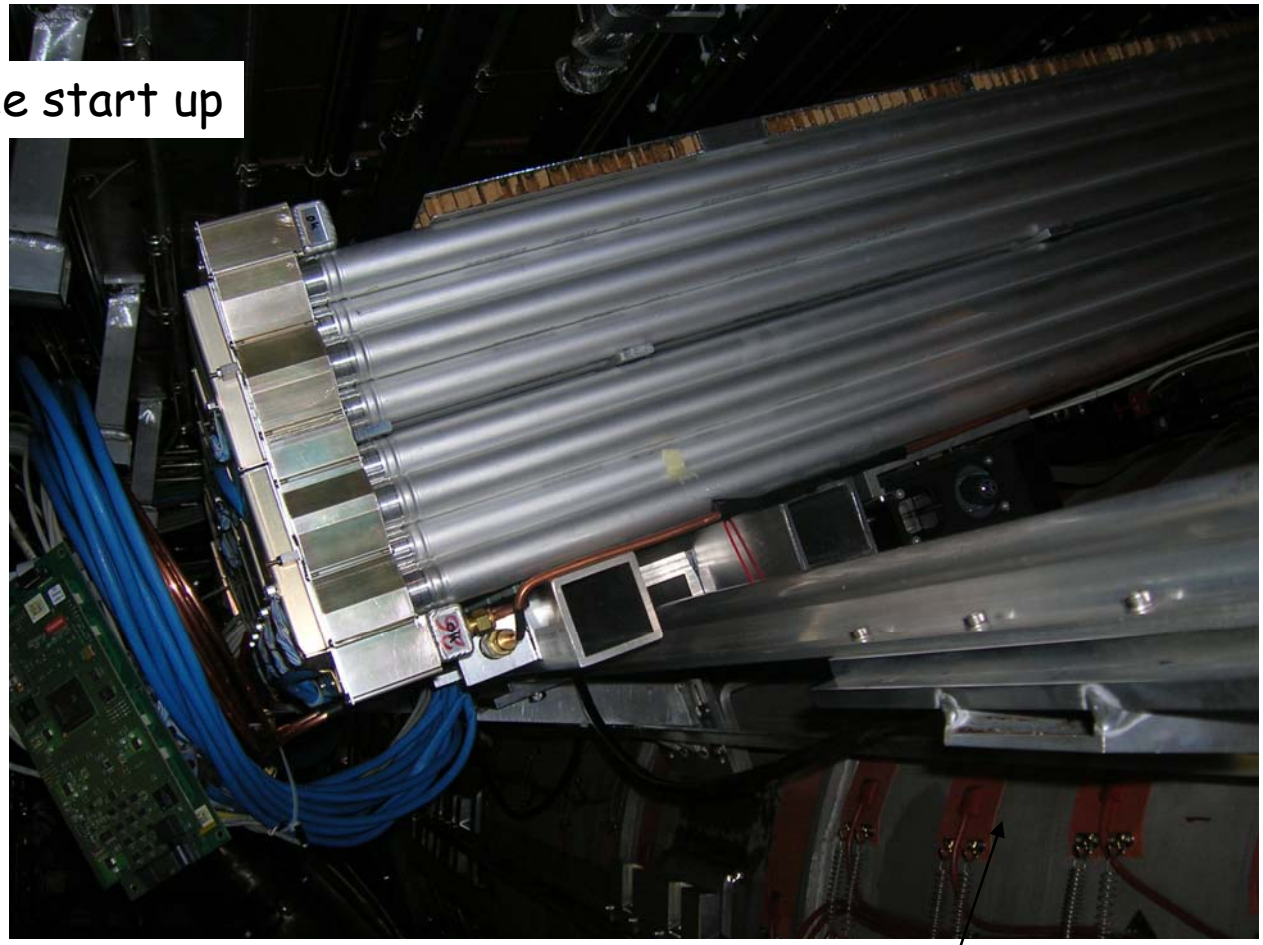
Jun 2006-Dec 2006 the BIS chambers installed in ATLAS pit

Already 7 years since start up

The finished product!!

In general:

All muon chambers installed in the ATLAS Pit
Very few bad channels
Few chambers with problem (gas leak, overpressure accident,...)
BUT no acceptance hole

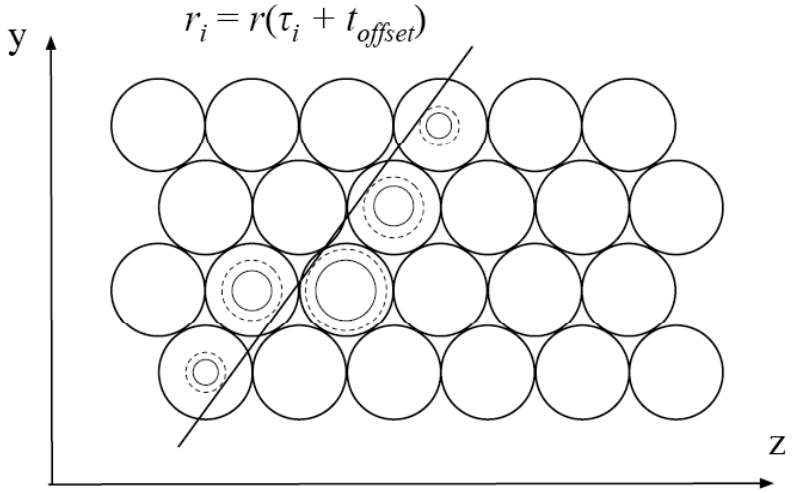


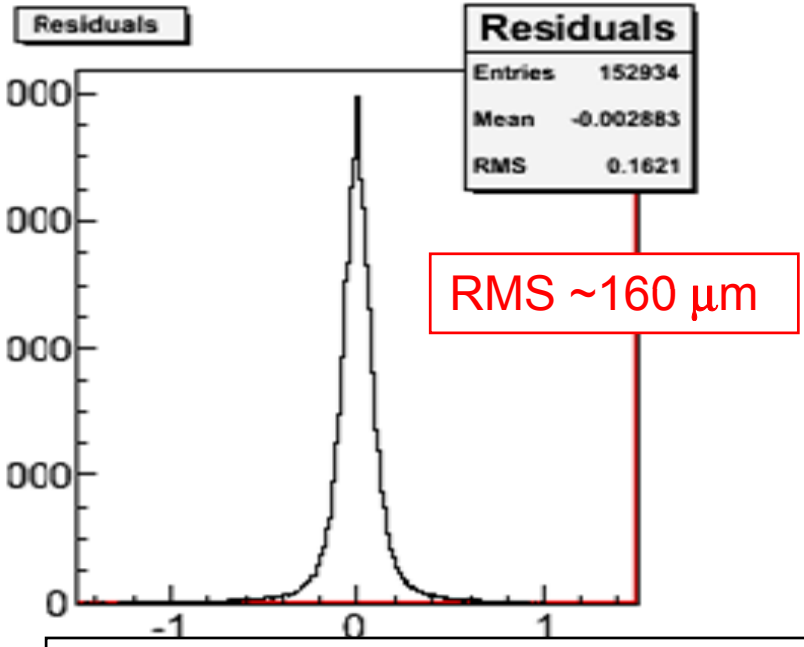
One of the barrel coils

Pre Data-Taking

- **"Milestone weeks" (Mx):**
  Combined runs using cosmic muons
  and integrated calibration systems
  Learn about detector response, timing, alignment …
  M1 (December 06) ⇨ M8 (July 08)

Measure t0 and (r,t) relation

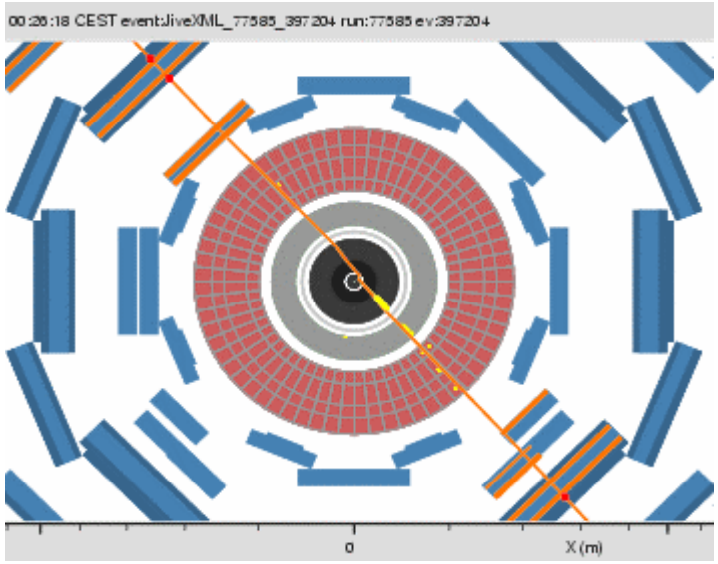


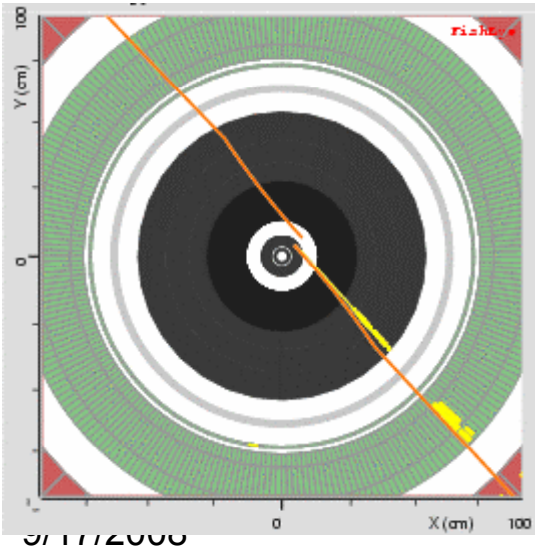


RMS ~160 μm

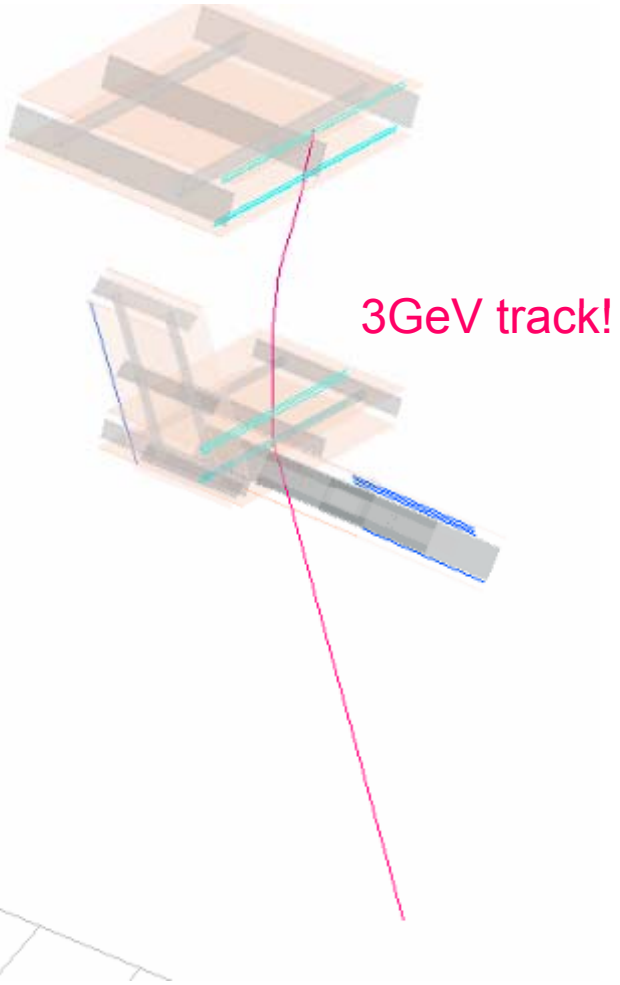
To reach 40 μm will need large samples of tracks B field ON and OFF

Commissioning with Cosmics





Short run with B toroidal on @20.5kA



ϕ(TRT+SCT)-θ(MDT)

μ~ -0.9 ± 0.2 mrad

σ~ 9.3 ± 0.3 mrad

Recent research activities of the groups

- Commissioning of the MDT's → all groups
- Commissioning of the CSC's → UoA, NTUA
- DCS and HV/LV, Bfield control for MTD's → NTUA
- Muon Data Quality Assessment software development → AUTh
- Cosmic ray runs for the detector commissioning → AUTh, NTUA
- Development of microMegas for SLHC → all groups

- Physics studies → all groups

Physics studies

- ATLAS since more than year has started the so called **CSC** exercise (Computing System Commissioning) which is now finished and the "book" will be published soon
- Purpose :train for data, learn to work in common analysis..

There were groups on SM, Higgs, Exotics, B-physics, top, SUSY and detector performance

The Greek ATLAS institutions are heavily involved in most physics groups, studying mainly decays with muon final states

➢ ***Involvement ranges from SM to Exotics!!***

List of CSC notes (physics studies just finished)

UoA

Higgs->4l
H/A ->2μ
Z'->μμ
W'->μν
Muon energy loss in calorimeters
Muon reconstruction performance

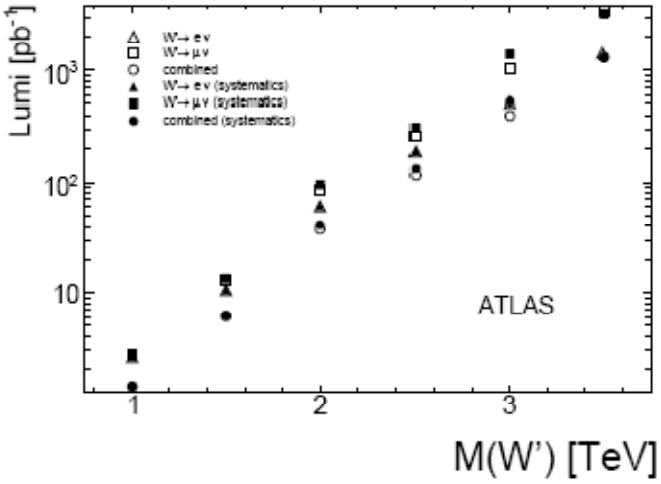
NTUA

Heavy quarkonia
Lepto-Quark searches
Quark compositeness

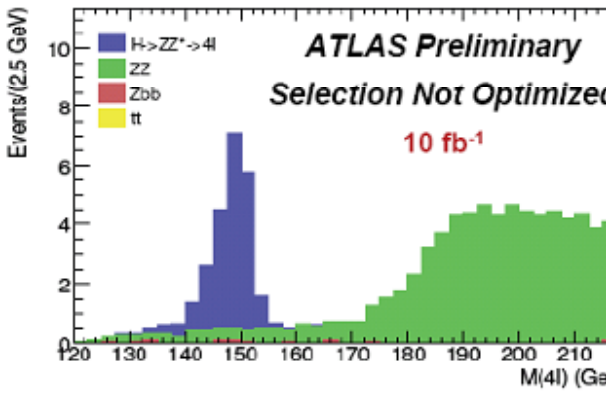
AUTh

SM dibosons
B cross section measurements
($B^+ \rightarrow J/\Psi\ K^+$)
Lepton reconstruction performance

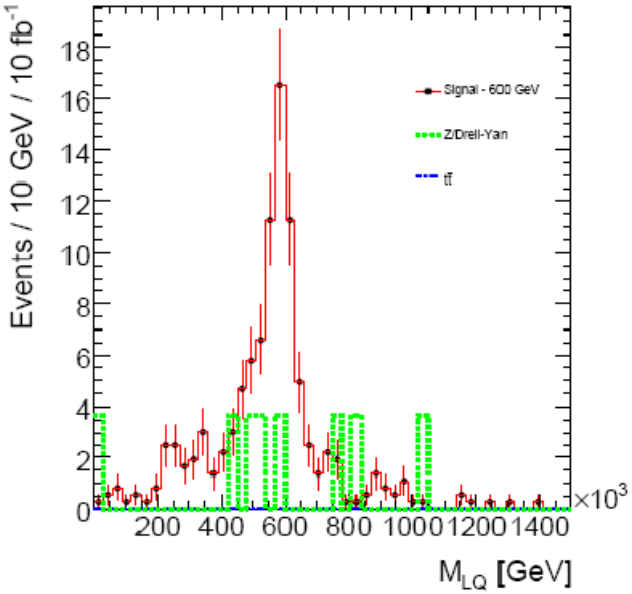
Discovery potential
W'-> μν @ 1 TeV



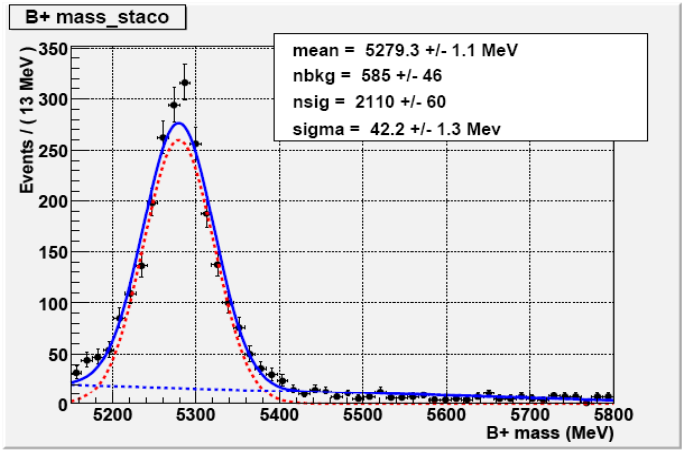
Z→4l discovery



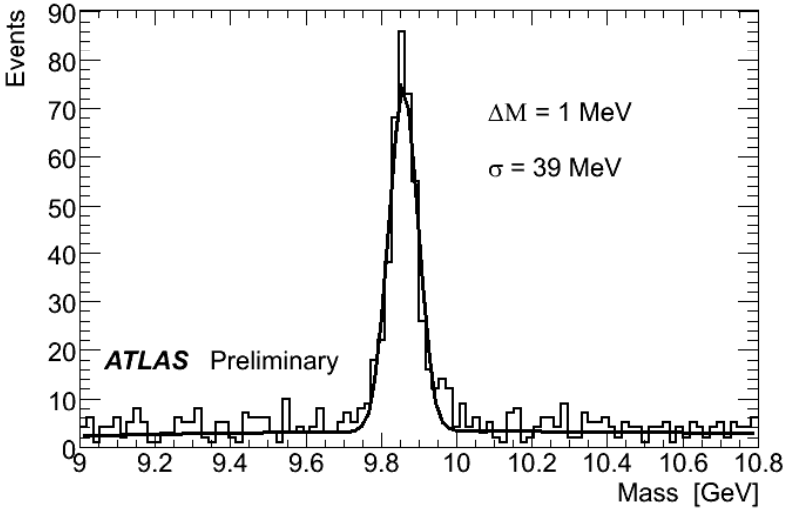
LQ Searches



B+→J/Ψ K+ measurements



The χ_b invariant mass



Conclusions

The Greek Muon construction project was very successfully (<1% failure rate) and timely accomplished thanks to a fruitful collaboration of all 3 involved institutes

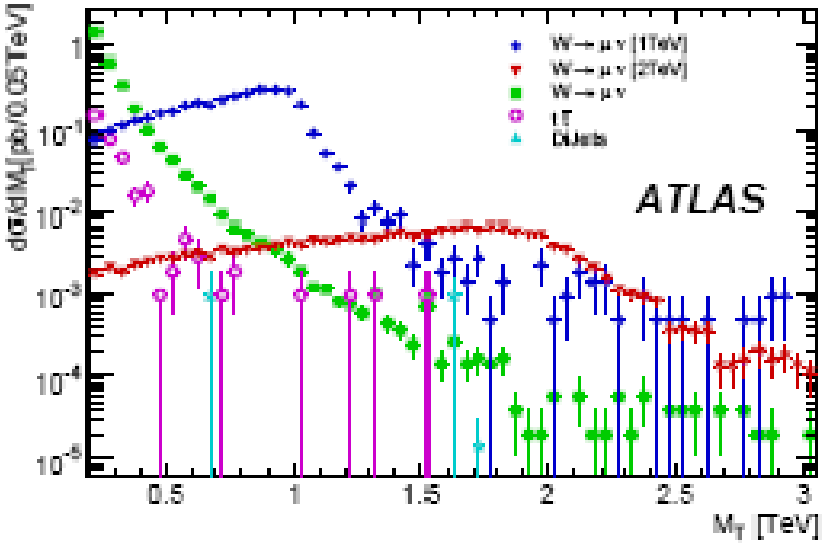
Data will be soon (are) in hand

- We have to understand them
- Calibrate the detector, mass scale

If the above is done : then we can look for the Higgs, SUSY, the unexpected …

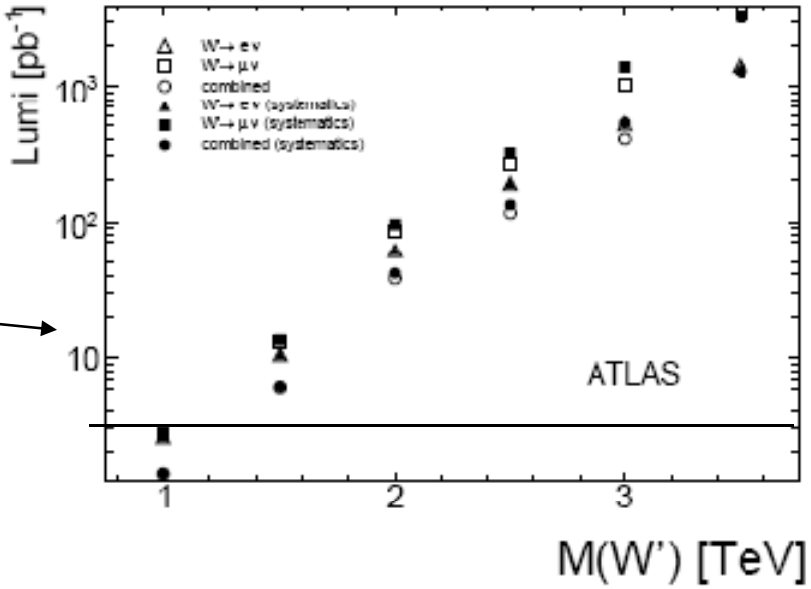
Back-up slides

ATLAS NOTE
Search for Non-Standard Model Lepton+MET Signals with the ATLAS Detector
D.Fassouliotis,C.K, K.Nikolopoulos, UoA N.Vranjes(Belgrade)

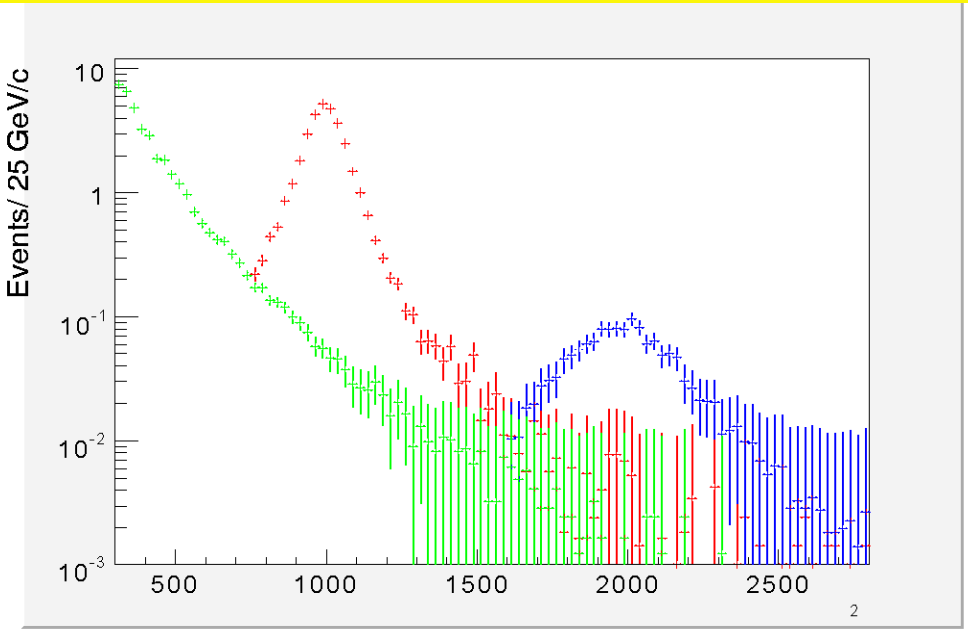


W'-> μν @ 1 TeV
x-section* BR~ 3fb

5σ discovery with ~3pb^{-1}

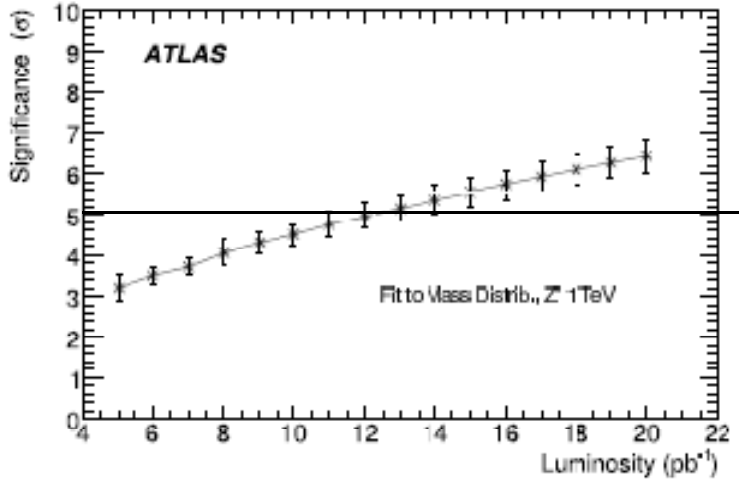


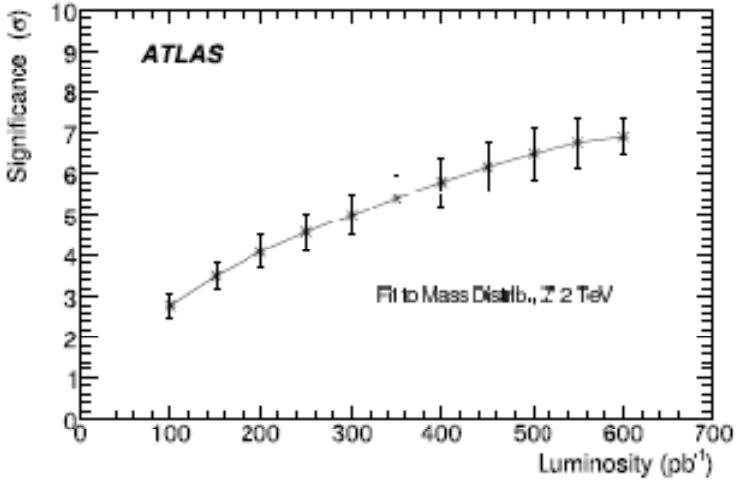
ATLAS NOTE
Dilepton Resonances at High Masses
A.Antonaki, D.Fassouliotis,C.K, K.Nikolopoulos UoA



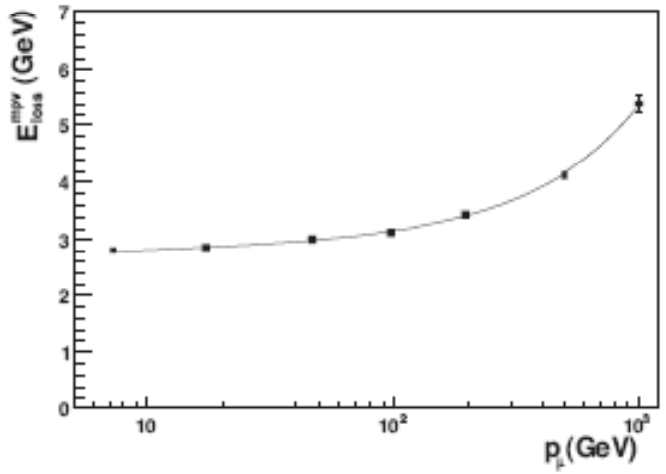
Z'-> μμ @ 1 TeV
x-section* BR~ 0.5fb

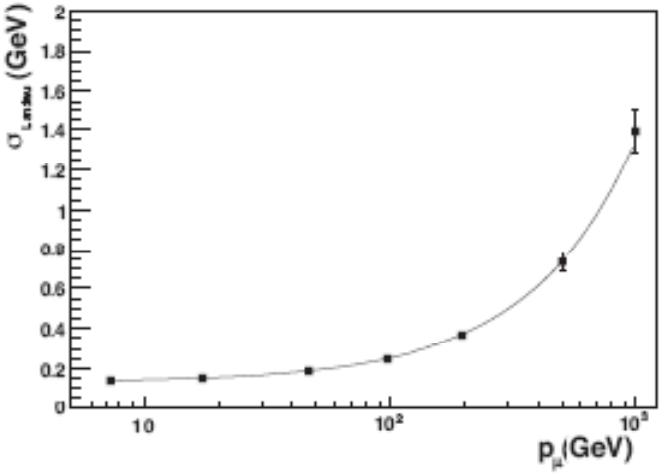
5σ discovery with ~15pb^{-1}



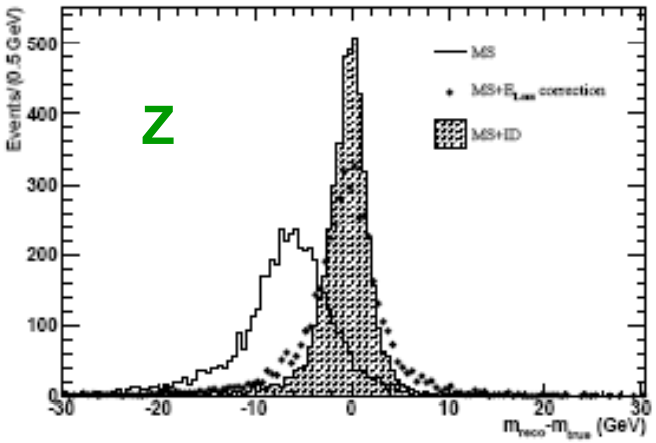


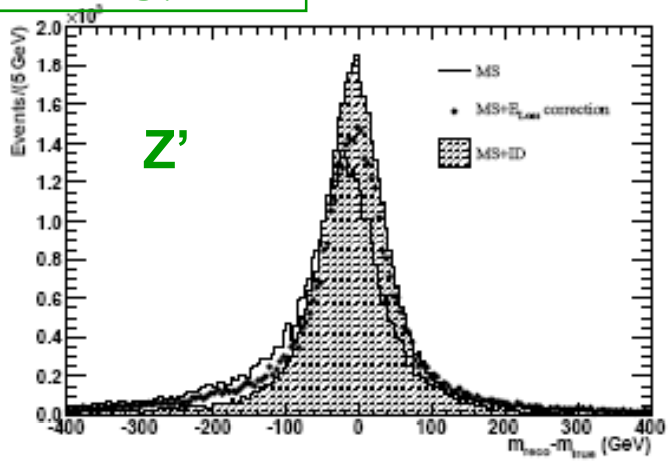
ATLAS NOTE
Muons In the ATLAS Calorimeters:Energy Loss Corrections and Muon Tagging
D.Fassouliotis,C.K, K.Nikolopoulos UoA





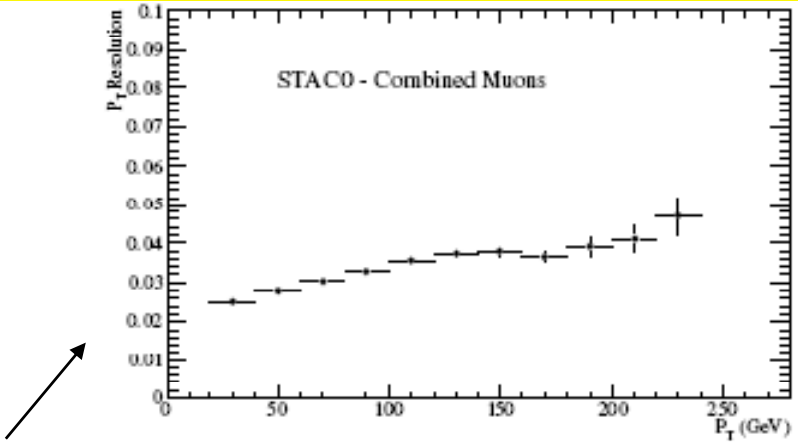
Parametrization of energy loss

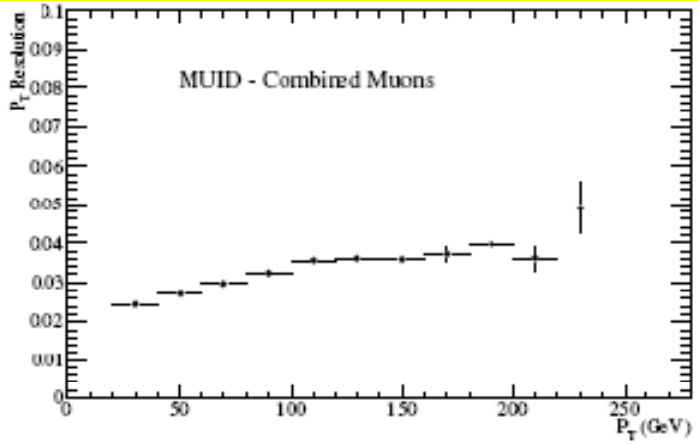




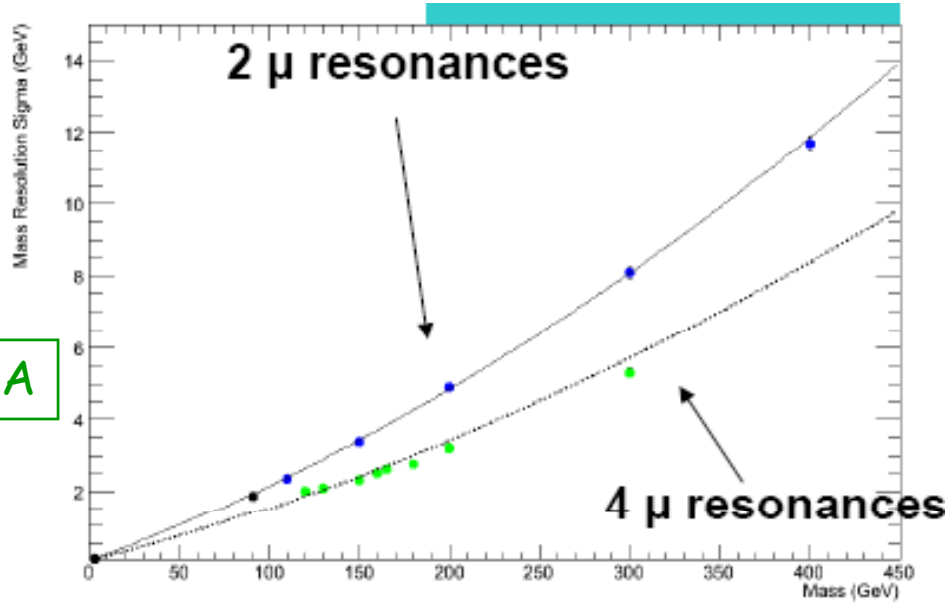
Improvement of resonance reconstruction

ATLAS NOTE
Muon Reconstruction and Identification Performance in ATLAS: Studies with Simulated Monte Carlo Samples
D.Fassouliotis,C.K, K.Nikolopoulos UoA





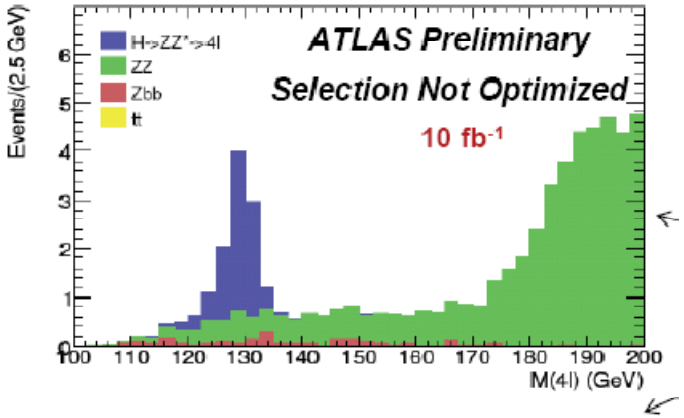
Comparison of two muon reconstruction algorithms for the Higgs samples

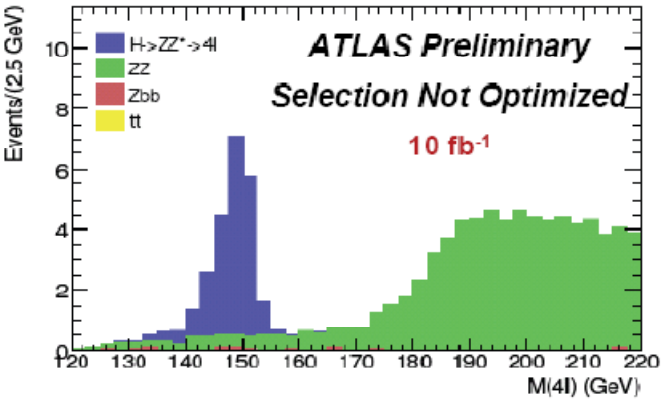


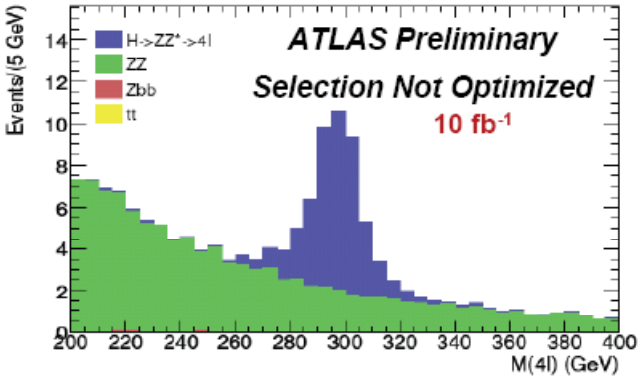
Linearity check for J/ψ, Z, H, H/A

ATLAS NOTE
Search for the Standard Model Higgs → ZZ(*) → 4leptons with the ATLAS Detector
D.Fassouliotis,C.K, K.Nikolopoulos UoA+ AUTh in "technical analysis"

- Studies on cut optimization
- Studies on calorimeter and track isolation
- Studies on alignment
- Reconstruction of signal+background

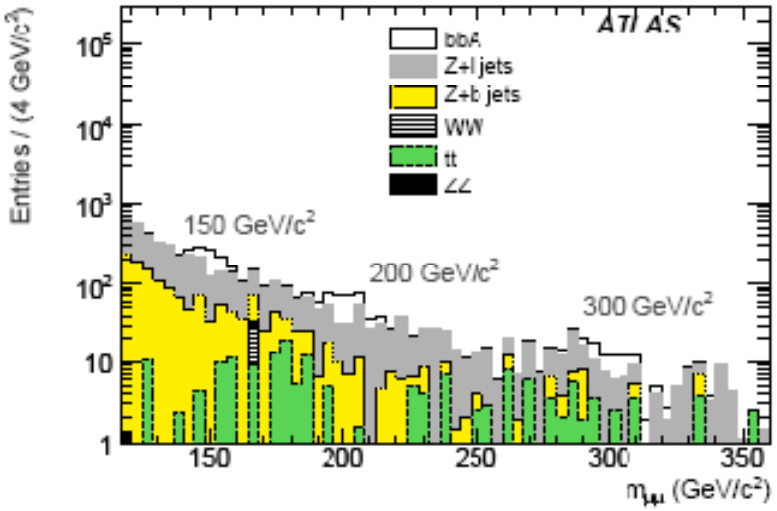






ATLAS NOTE
Search for the neutral MSSM Higgs bosons in the decay channel *A*/*H*/*h*→μ+μ−
D.Fassouliotis,C.K, M.Milosavljevic(Belgrade), K.Nikolopoulos UoA

- D.Fassouliotis is the editor of this note
- Studies initiated by our group 2006 (MUON-PUB)



ATLAS NOTE

Diboson physics studies with the ATLAS detector

C. Anastopoulos, K. Bachas, I. Christidi*, C. Petridou, D. Sampsonidis AUTh

In collaboration with N. Kerschen) +ZZ->4l muon and electronrformance studies

Preselection cuts on leptons

Require at least 2 pairs of either flavor (τ's not included),
opposite charge leptons (3 event topologies: 4μ, 4e, 2μ2e)

Cuts on pairs:

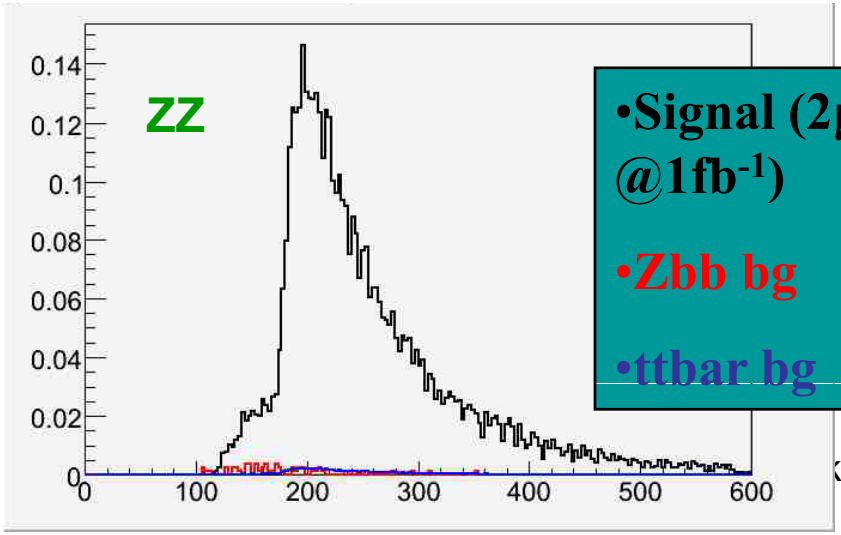
at least one lepton in each pair must have pt > 20 GeV/c

all leptons must be "isolated" (no significant energy, possibly coming from jets should be detected around them)

Invariant mass requirement:

ZZ: both pairs between 70 and 110 GeV/c2

ZZ*: one pair between 70 and 110 GeV/c2 and the other above 20 GeV/c2

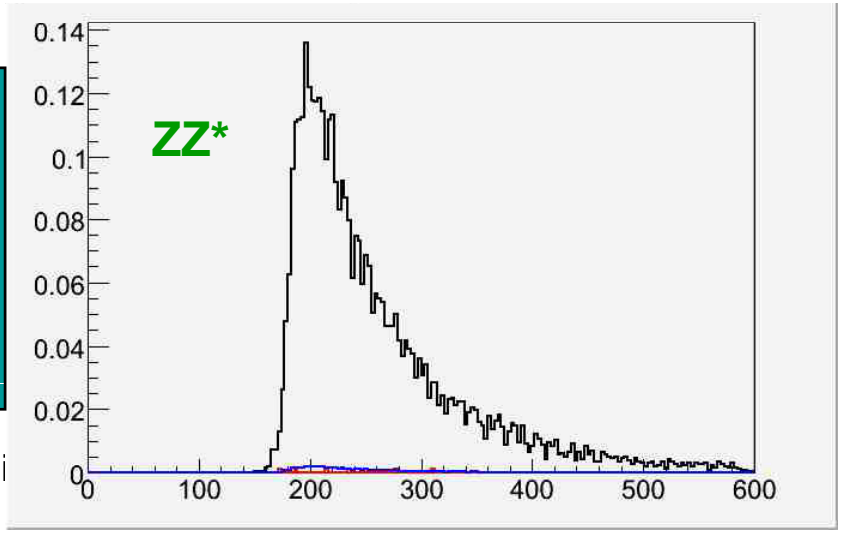


•Signal (2μ2e @1fb^{-1})

•Zbb bg

•ttbar bg

koumeli



ATLAS NOTE

"B Production Cross Section Measurements

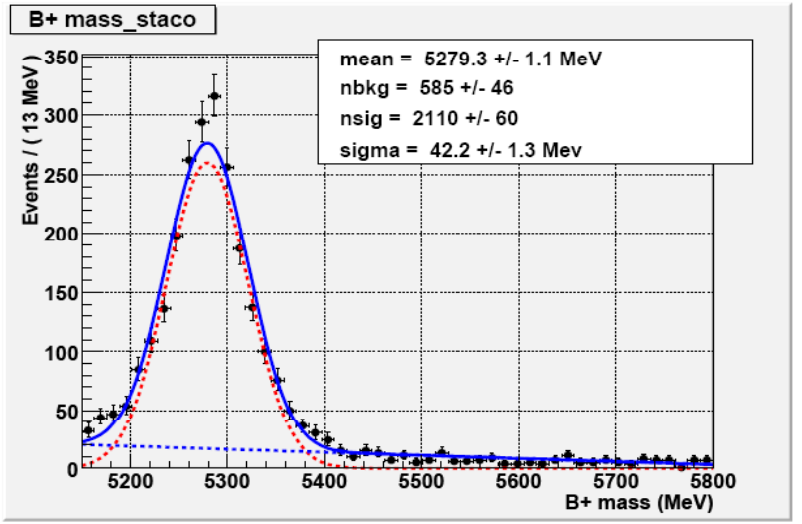
C. Anastopoulos, C. Petridou AUTh

J/Ψ selection:
Muon pairs with pt(μ1) ≥ 3.0 GeV and pt(μ2) ≥ 6.0 GeV
The muon pairs are fitted to a common vertex
Invariant mass inside a 120 GeV window around mJ/ψ

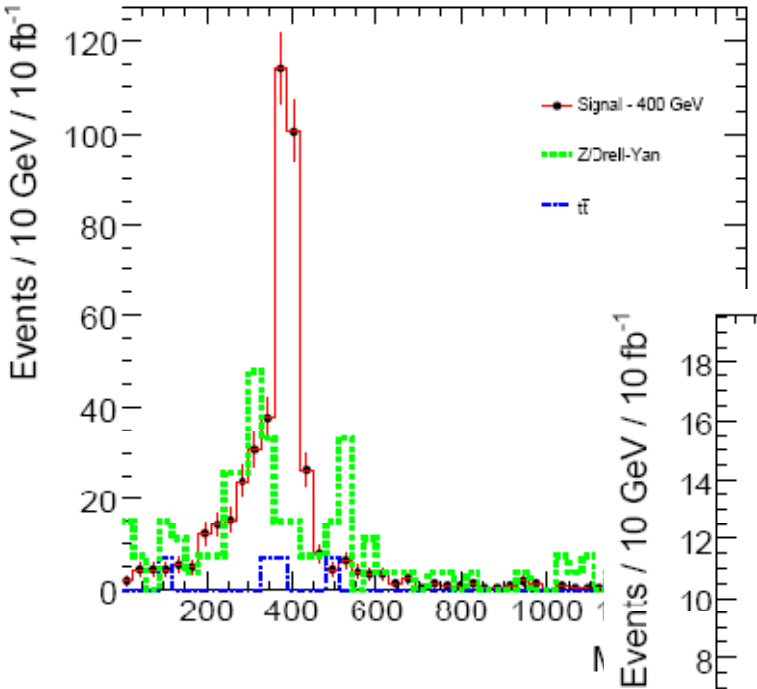
B+ selection:
K+ candidate from tracks with pt ≥ 1.5 GeV and η<2.7
The J/ψ muons and the K+ are fitted to a common vertex
pt(B+) ≥ 6 GeV
Transverse decay length Lxy>0.1 mm
Invariant mass inside a window around m_{B+}

Relative error of 2.2% in the lifetime can be achieved with only 10 pb^{-1} !

B+→J/Ψ K+ measurements

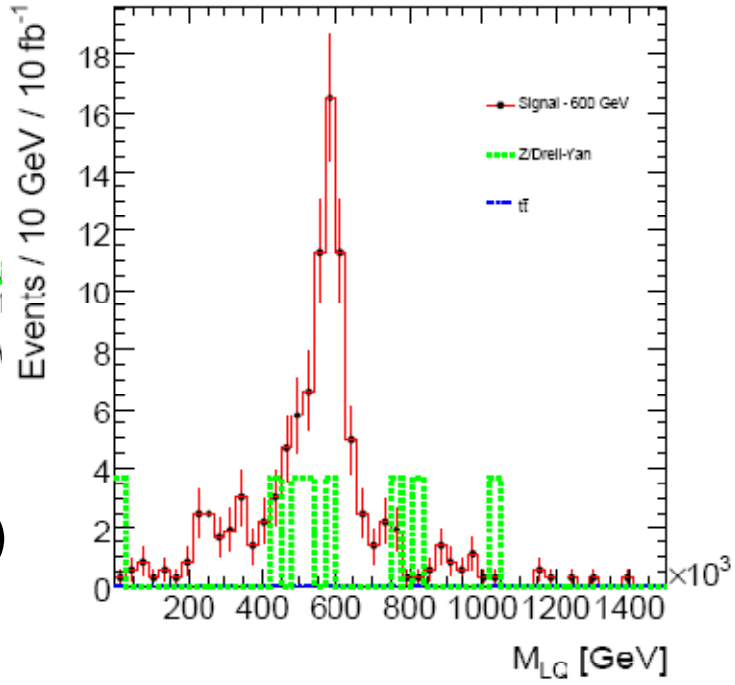


"Early LHC Single LQ searches"
E. Panagiotopoulou ,T. Papadopoulou NTUA



ATLAS

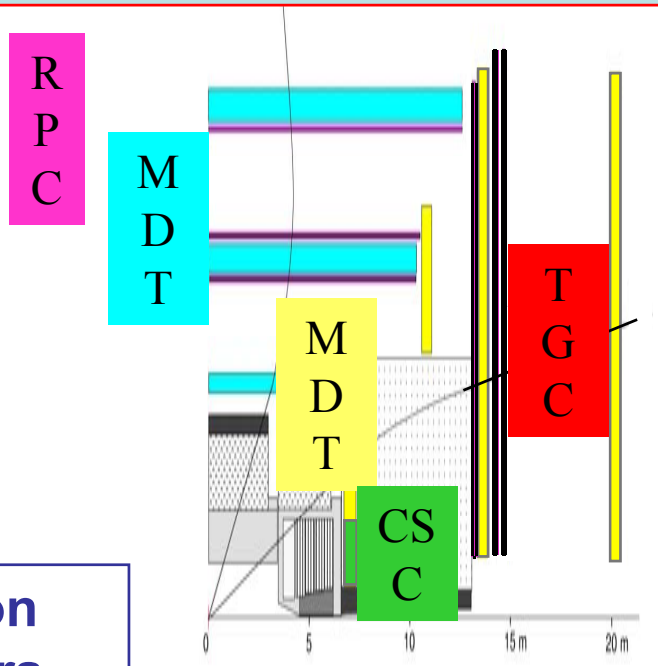
PRELIMINARY RESULTS



- **Invariant mass mu + jet pair**
- **LQ mass at 400 - 600 GeV (full simulation)**
- **plots are normalized to L= 10 fb^{-1}**

	Expected Day 0	Goals for Physics
ECAL uniformity	~ 1% ATLAS ~ 4% CMS	< 1%
Lepton energy scale	0.5—2%	0.1%
HCAL uniformity	2—3%	< 1%
Jet energy scale	<10%	1%
Tracker alignment	20—200 μm in Rϕ	$\mathcal{O}$(10 μm)

ATLAS: Muon Chambers



Precision chambers

Monitored Drift Tubes ($|\eta| < 2$)
with a single wire resolution of 80 μm
1194 chambers, 5500m^2

GREECE constructed 12%

Cathode Strip Chambers ($2 < |\eta| < 2.7$)
at higher particle fluxes
32 chambers, 27 m^2

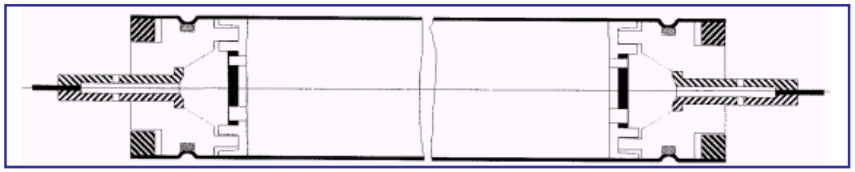
Trigger chambers

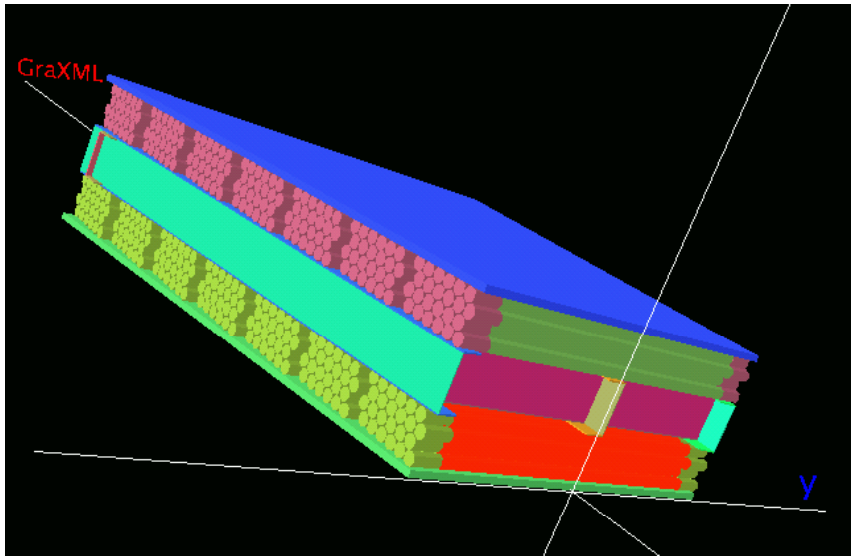
Resistive Plate Chambers ($|\eta| < 1.05$)
with a good time resolution of 1 ns
1136 chambers, 3650 m^2

Thin Gap Chambers ($1.05 < |\eta| < 2.4$)
at higher particle fluxes
1584 chambers, 2900 m^2

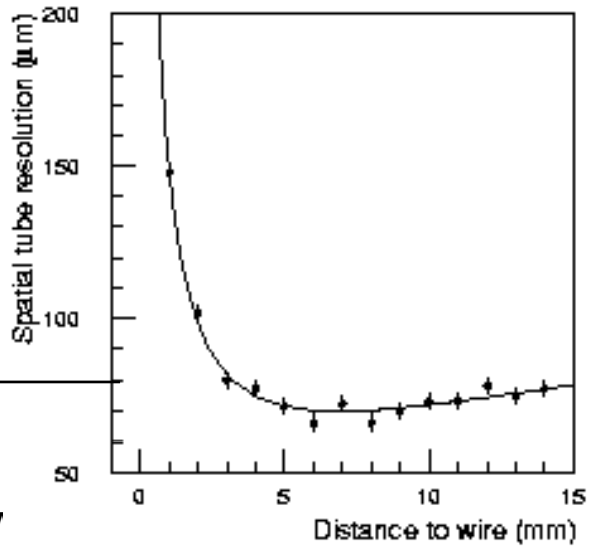
ATLAS: MDT's

Monitored Drift Tubes
width (tube length) : 83-494 cm
length : 90-216 cm

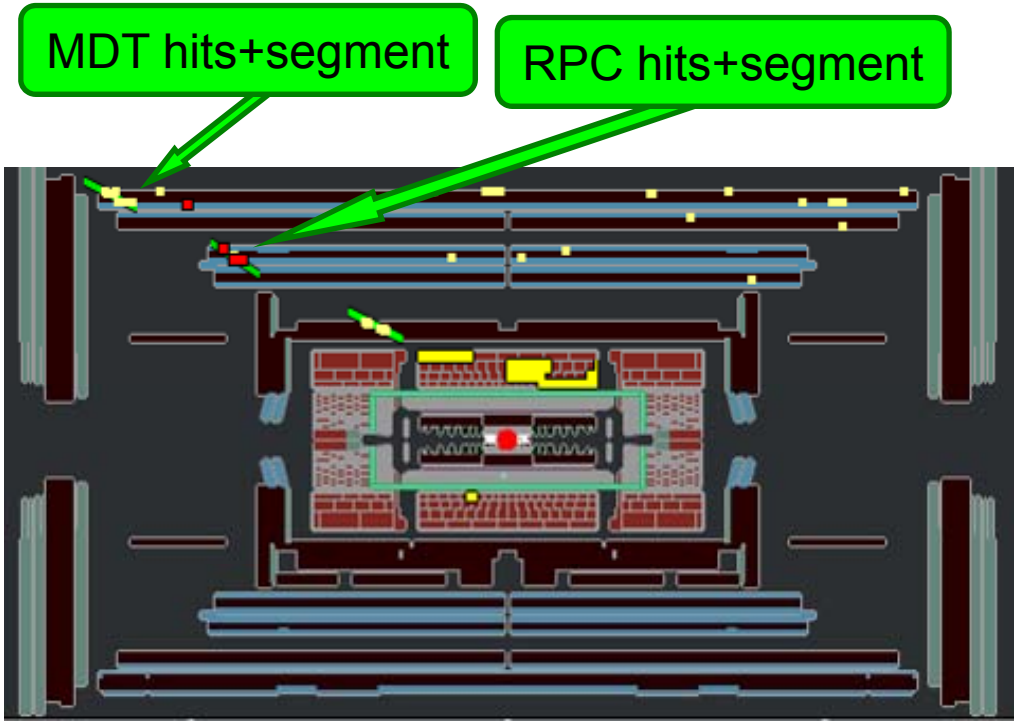


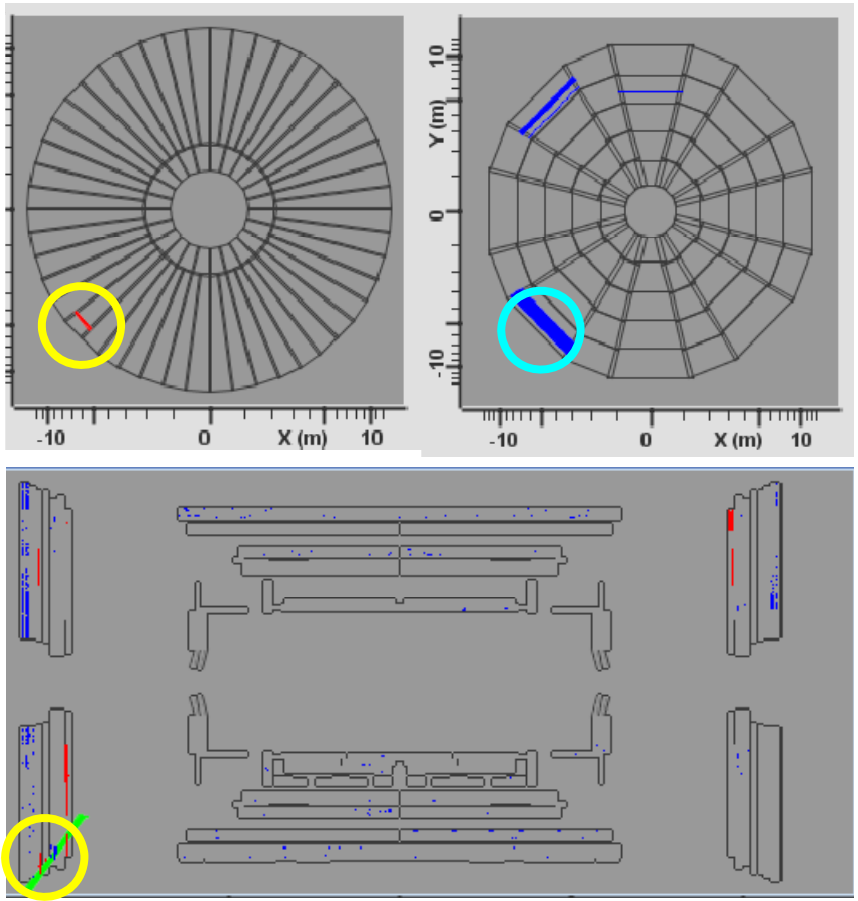


Tube : Al, 30 mm φ, 0.4 mm wall
Wire : 50 μm, W/Re alloy (97/3)
Gas : Ar/CO_2 (93%/7%) at 3 bar
Gas gain : $2x10^4$ at 3080 V
Maximum drift time : ~ 700 ns
Resolution : 80 μm



Event display





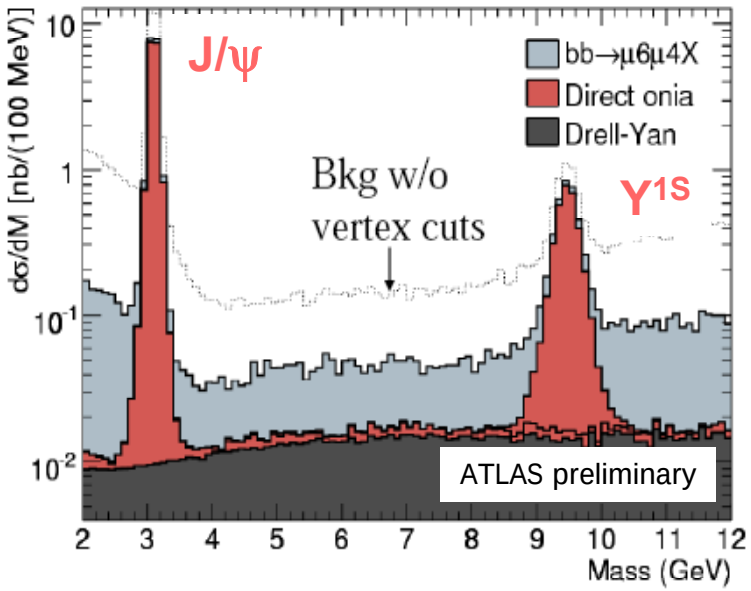
TGC trigger hits

Associated MDT hits

More performance plots in backup and RPC poster by G. Chiodini

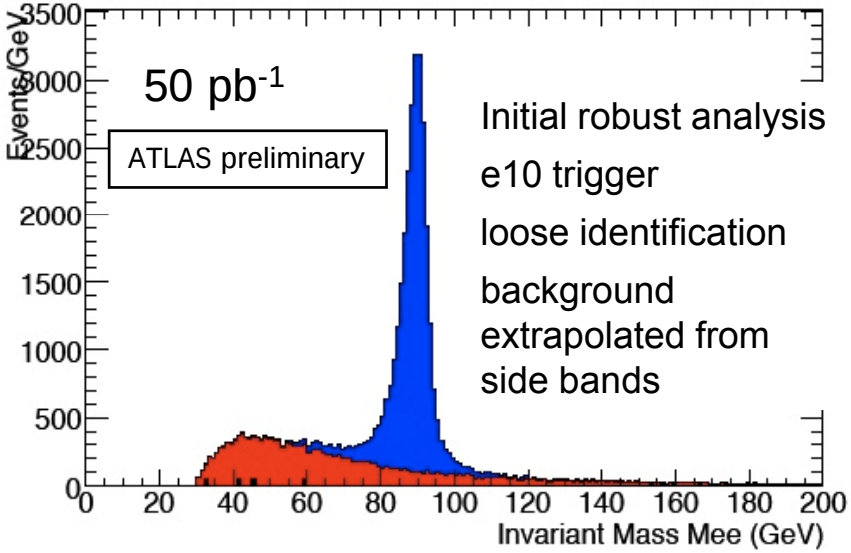
Example of first signals

1 pb^{-1}≡3 days at 10^{31}at 30% efficiency



After all cuts:
~ 5000 (800) J/ψ (Υ) →μμ / day @ L = 10^{31} cm^{-2} s^{-1}
(for 30% machine x detector data taking efficiency)

→ tracker momentum scale, trigger performance, detector efficiency, sanity checks, …



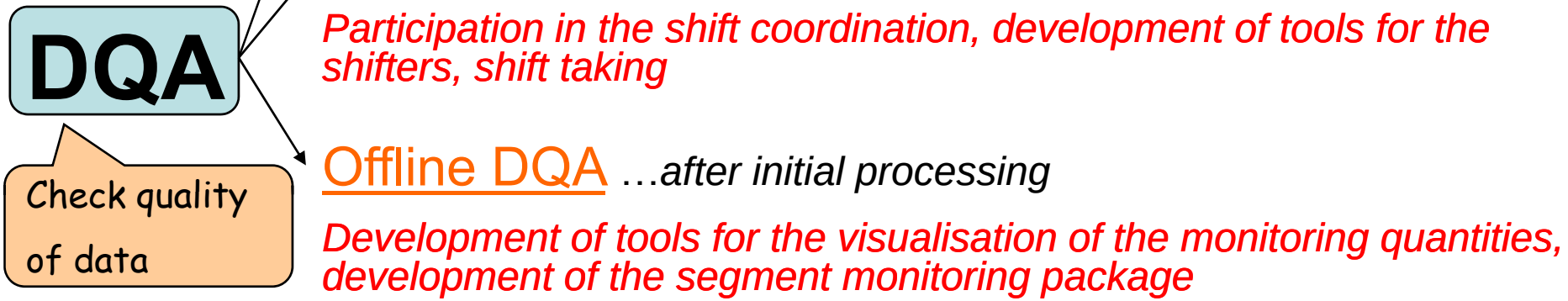
After all cuts:
~ 160 Z → ee / day at L = 10^{31} cm^{-2} s^{-1}

energy/momentum scale of full detector
Muon Spectrometer alignment,
lepton trigger and reconstruction efficiency, …

~25 k events (at 10 TeV reduced by 30%)
quickly dominated by systematic

Offline Muon Data Quality Assessment

I. Nomidis, I. Christidi



- Different levels for **offline** DQA:
  - "Low level", hit related quantities (occupancies, correlations, …)
    → Check readout chain from online to offline
  - "Mid level", reconstructed quantities (track multiplicity, residuals, …)
    → Check reconstruction chain, calibration constants, chamber efficiencies, alignment
  - "High level", physics quantities (cross sections, mass peaks, …)
    → Check calibration constants, long-term stability

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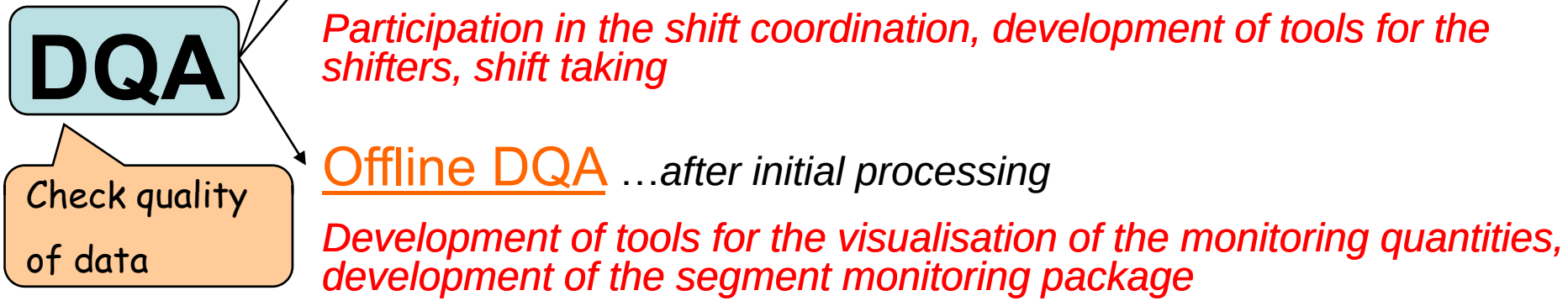

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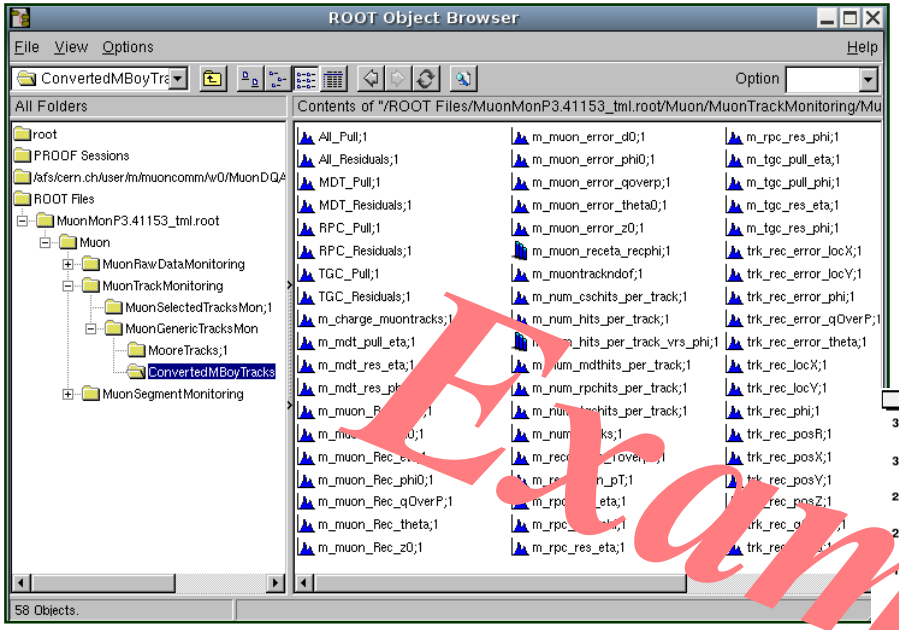
“Mid level” monitoring

- ✓ Monitor track/segment parameters and multiplicities
- ✓ Monitor track/segment finding efficiency, tube/chamber efficiency
- ✓ Monitor hit residuals, to verify alignment and calibration constants



- number of tracks/segments
- number of hits per track/segment
- η vs φ of hits, η, φ, z, d_0 (impact parameter) of track/segment
- χ^2 of track/segment
- residuals of hits