Plans for commissioning of ATLAS physics

Fabiola Gianotti (CERN)

Strategy for Physics commissioning

➊ Before data taking starts:
- Understand and calibrate (part of) detector with test beams, cosmics, …
- Prepare software tools: simulation, reconstruction, calibration/alignment procedures
  In particular : realistic description of detector "as built and as installed"
  (actual placement, mis-calibrations, HV problems, dead channels, etc.)
- Develop (theorists), validate (with Tevatron and HERA data), compare MC generators

➋ After data taking starts:
- Commission/calibrate detector and trigger in situ with physics samples ($Z \to ll$, tt,…)
- Understand SM physics at $\sqrt{s}$ =14 TeV (minimum bias, W, Z, tt, QCD jets, …)
- Validate and tune MC generators
- Measure backgrounds to New Physics (W/Z+jets, tt+jets, QCD multijets, …)

⬇

prepare the road to discovery

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  (actual placement, mis-calibrations, HV problems, dead channels, etc.)
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→

ATLAS combined test-beam
Realistic detector description
Cosmics runs

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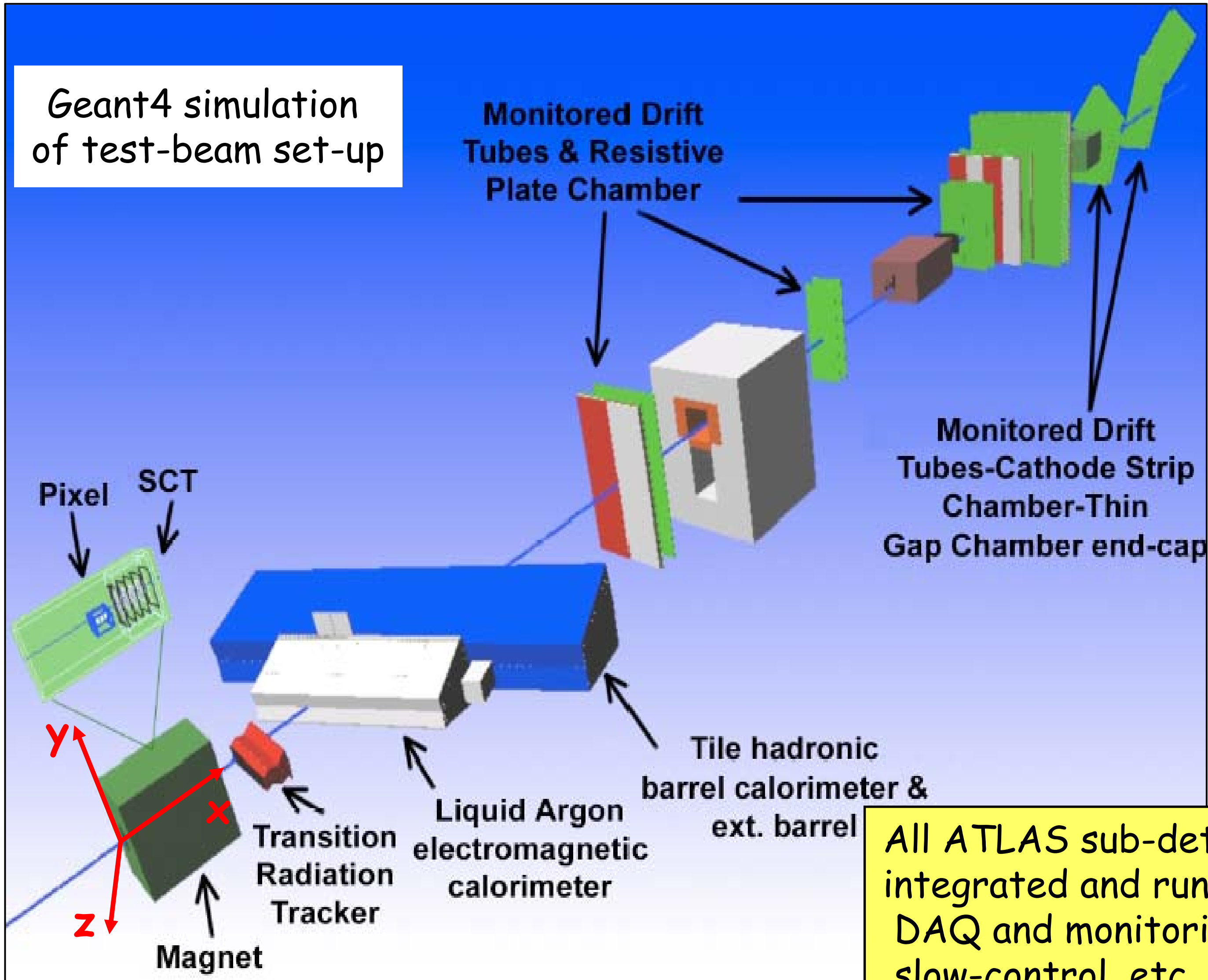
→

Minimum-bias events
W and PDFs
tt events

Here only a few examples
(lot shown already in previous talks)

Towards Physics (1) : the 2004 ATLAS combined test beam

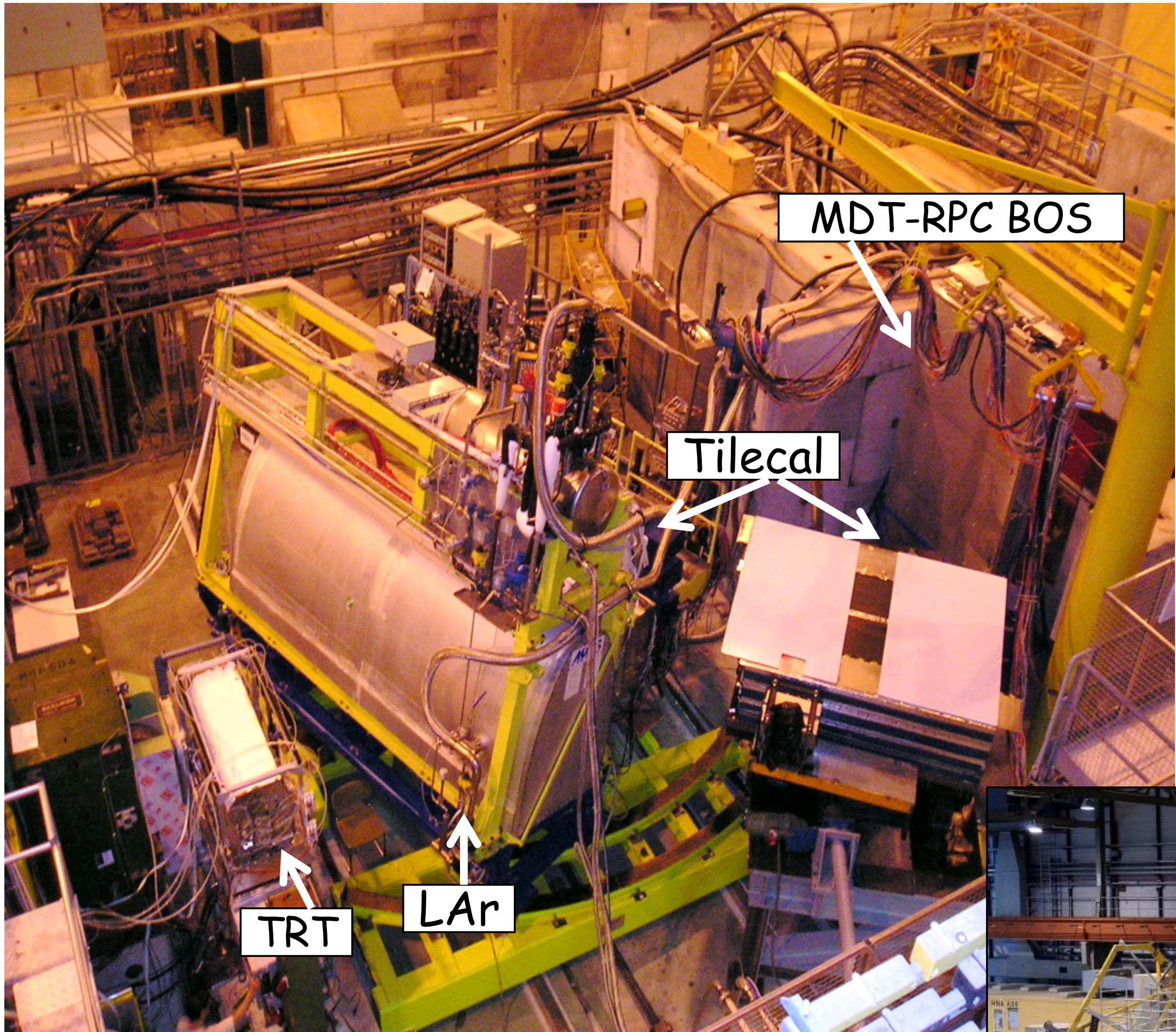
Full "vertical slice" of ATLAS tested on CERN H8 beam line May-November 2004



O(1%) of ATLAS

Production modules in most cases

All ATLAS sub-detectors (and LVL1 trigger) integrated and run together with common DAQ and monitoring, "final" electronics, slow-control, etc. Gained lot of global operation experience during ~ 6 month run.



~ 90 million events collected
~ 4.5 TB of data:

$e^{\pm}$, $\pi^{\pm}$	$1 \rightarrow 250$ GeV
$\mu^{\pm}$, $\pi^{\pm}$, p	up to 350 GeV
γ	20-100 GeV

B-field (ID) = $0 \rightarrow 1.4$ T

Many configurations
(e.g. additional material in ID, 25 ns runs, etc.)

End-cap Muon chambers

Aspects most relevant to Physics "commissioning"

Standard ATLAS software (Athena, G4 simulation, event display, …) used to analyze data

Deployment and refinement of detector-specific and combined (several detectors together) reconstruction with real data

Validation of G4-based simulation in complex environment close to real experiment (several detectors, material, B-field, …)

Exercised alignment and calibration procedures, including use of Condition DB

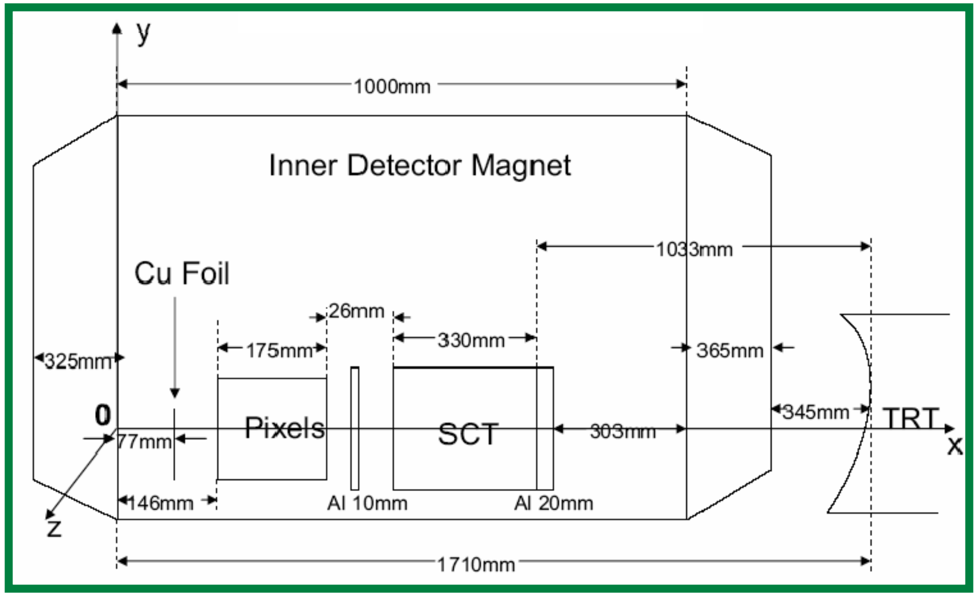
Worked as an experiment and not as a "collection of sub-detectors"

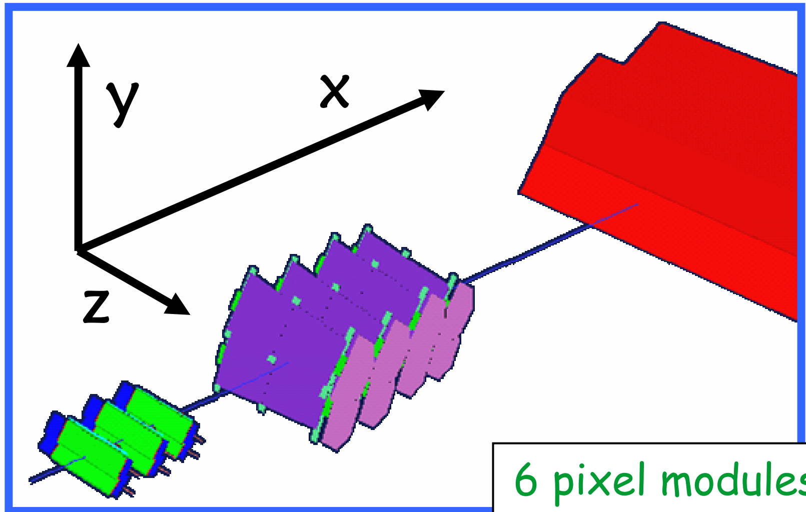
↓

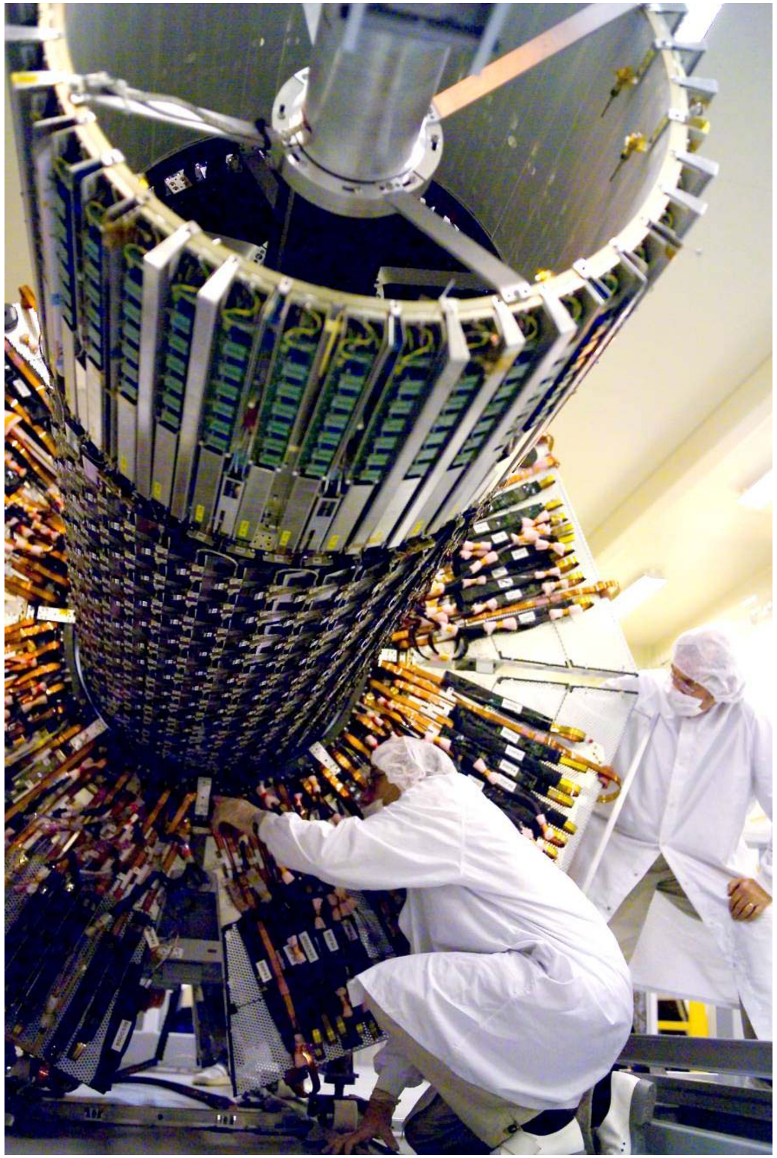
Gained lot of experience with ATLAS offline software, combined detector performance, optimization of tools, ….

Here only a few physics-related examples (all results are PRELIMINARY)

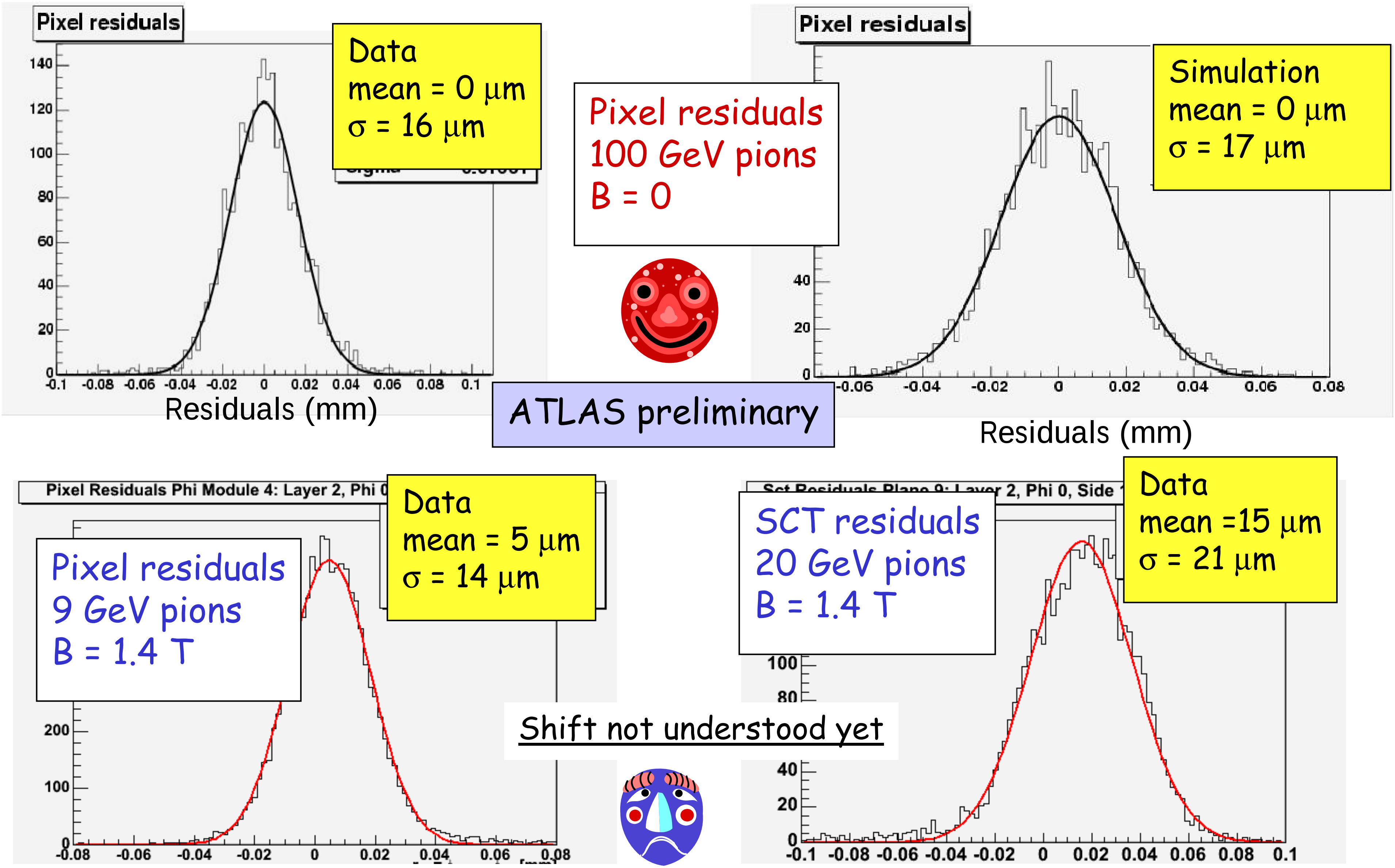
Tracking and alignment in Inner Detector







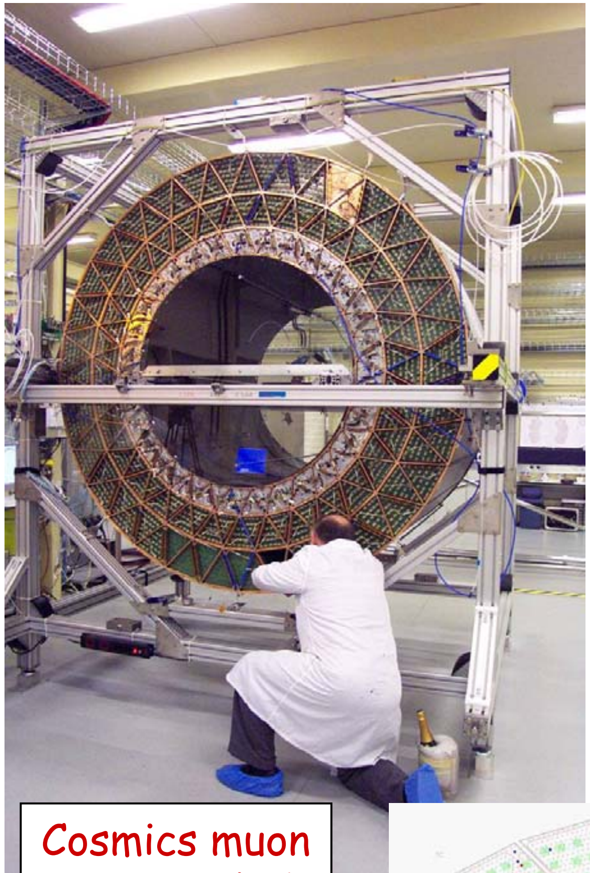
6 pixel modules and 8 SCT modules (inside B=0→1.4 T)
6TRT modules (outside field)



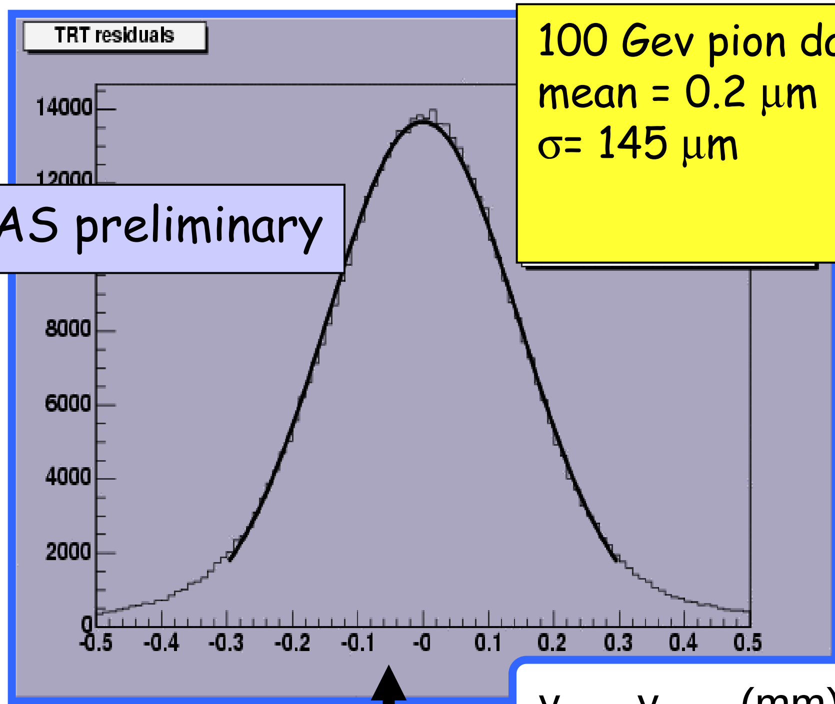
- All corrections (alignment constants, noisy/dead channels) in Condition DB
- Alignment stability (B=0): within 10 μm over ~ 4 days

(ATLAS goal after few months of operation: ~ 10-20 μm; ultimate: 1 μm)

TRT internal alignment and calibration exercised: -- find t_0 values for each straw
-- determine R-t relation for each straw
-- align modules
-- align individual wires



Cosmics muon in assembled barrel TRT



In agreement with expected detector resolution
σ (simulation) $\approx$ 138 μm

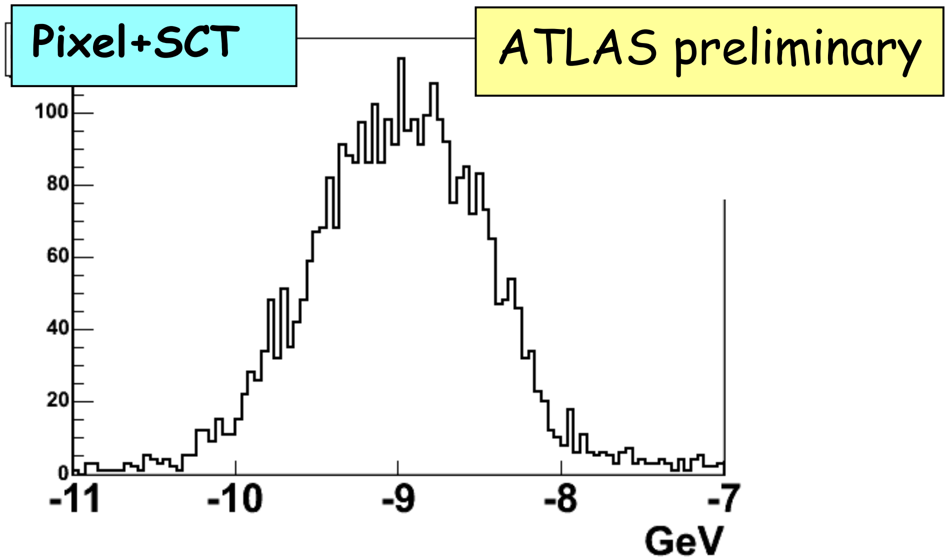
At LHC: new set of calibration/alignment constants every fill using p_T>2 GeV trakcs

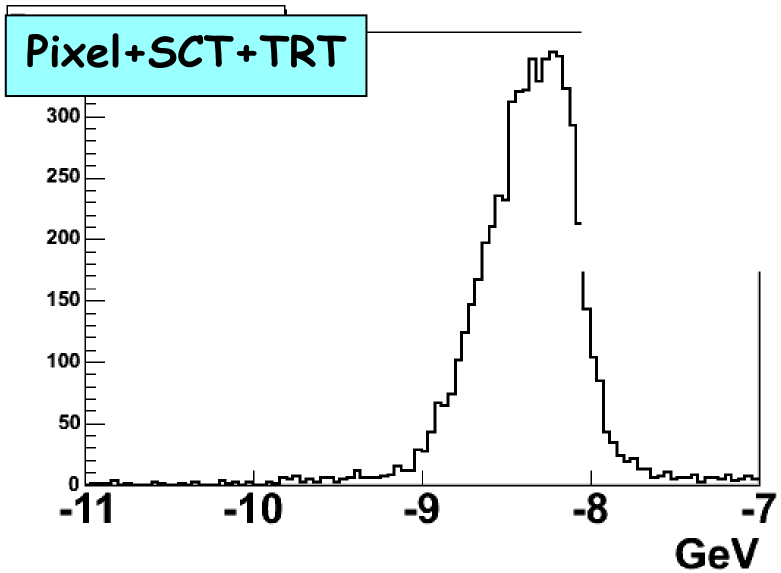
Combined reconstruction: Pixels + SCT + TRT

9 GeV pion (data)

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Momentum reconstruction, 9 GeV pion data, B=1.4 T



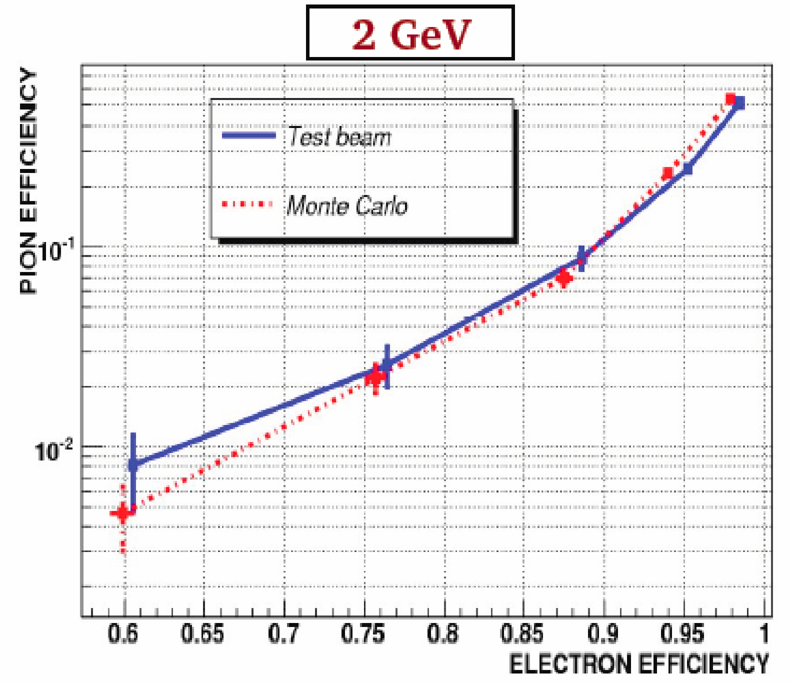


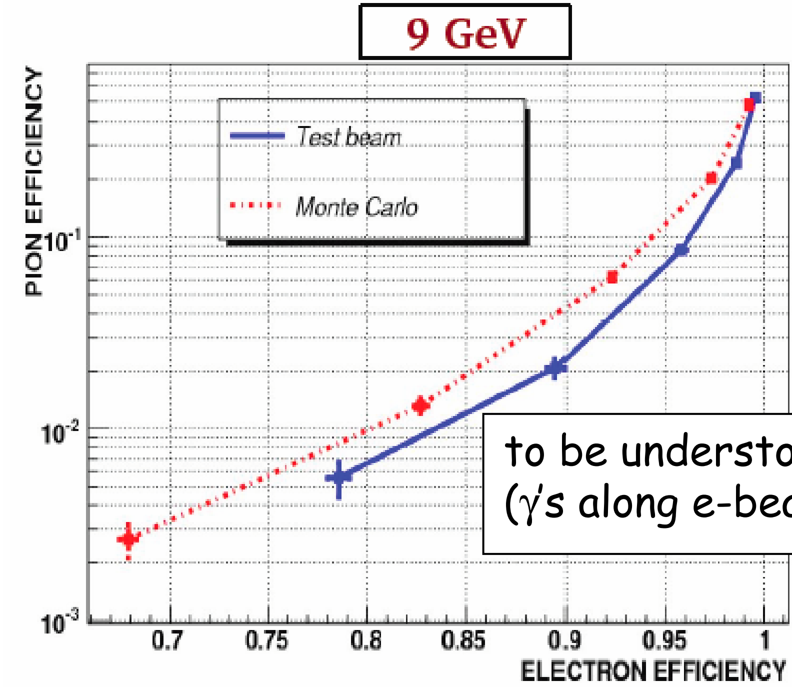
- Including TRT improves resolution by ~ 2 as expected but mean value shifted by 0.5 GeV (need to understand systematics from alignment vs knowledge of B-field)
- Several algorithms for combined reconstruction tested

e/π separation with TRT : comparison data-simulation

ATLAS preliminary

- e/π samples selected with beam-line Cherenkov + ECAL
- curves obtained by cut on fraction of TRT hits

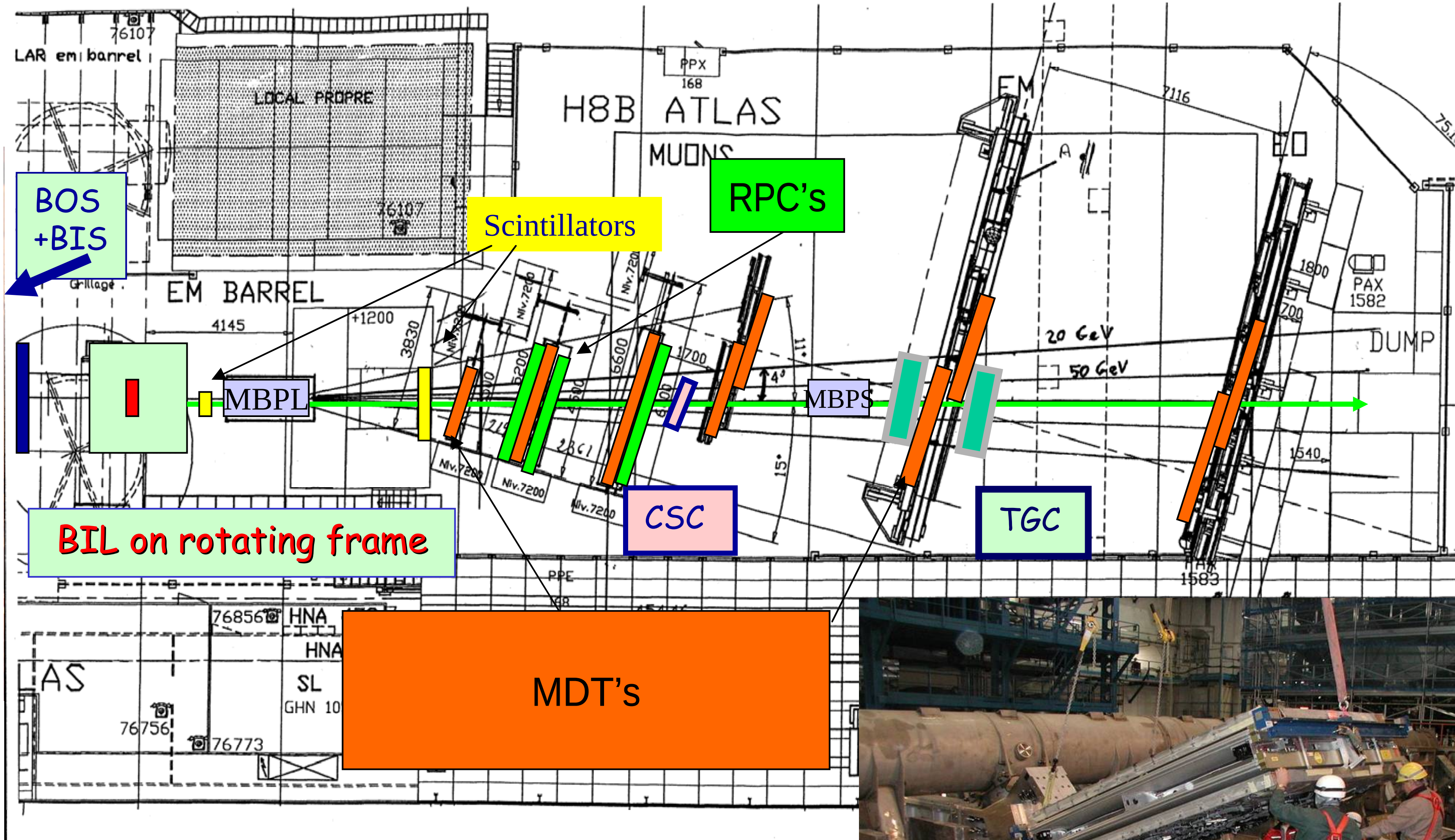




to be understood …
(γ's along e-beam ?)

e/jet (LHC) ≈ 10^{-5} (compared to ≈ 10^{-3} at Tevatron) at p_T~20 GeV
ATLAS: R_j ~ 5×10^4 after calo+ID cuts; TRT provides additional R_j > 10
→ important handle esp. at beginning to extract pure inclusive $e^{\pm}$ sample

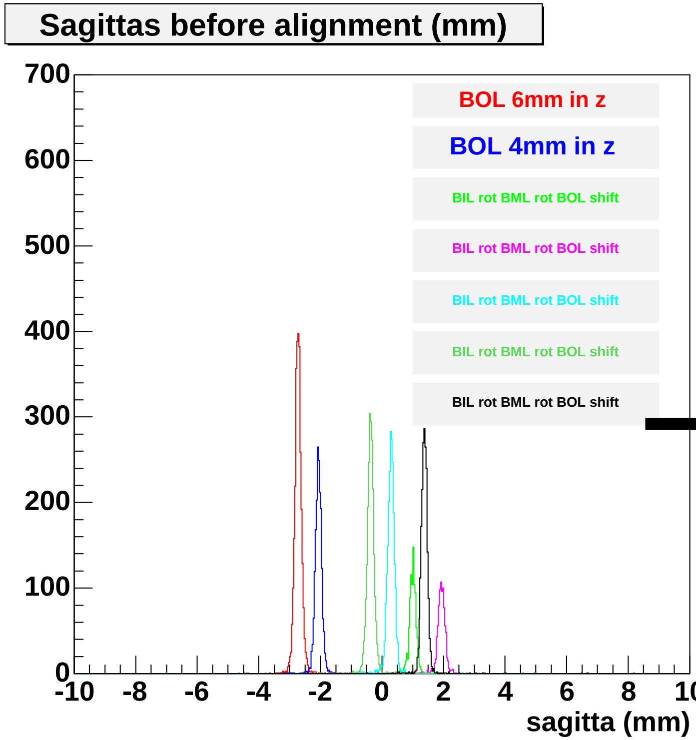
Tracking and alignment in Muon Spectrometer

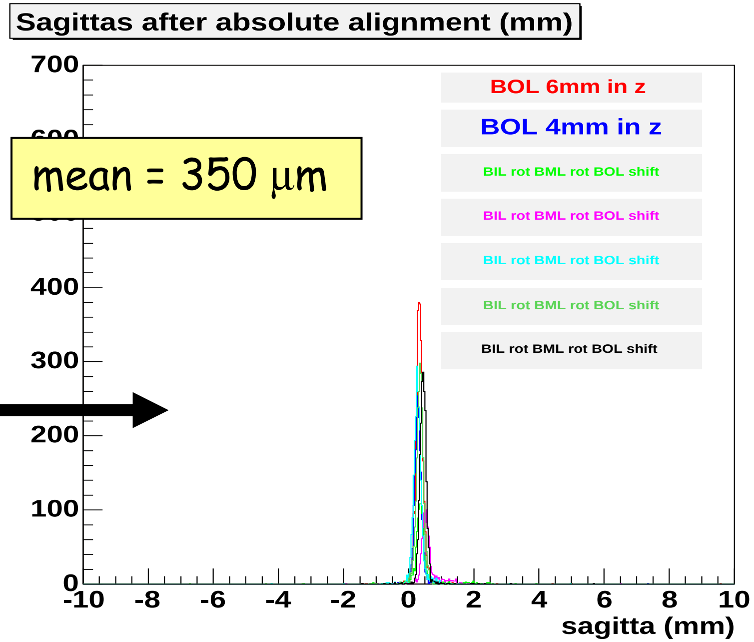


Muon chamber installation in ATLAS pit

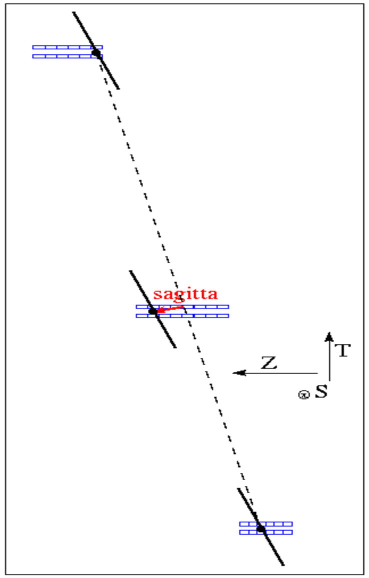
3996 channels out of 4000 working

Test alignment with complex movements (rotations, displacements) of all barrel chambers





ATLAS preliminary

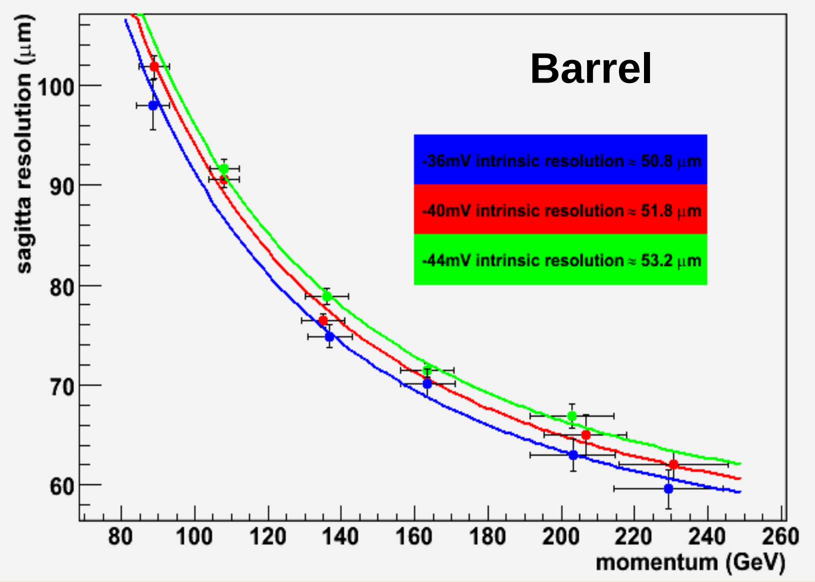


Absolute alignment with optical sensors to 350 μm
(sensor calibration not yet final)
Relative alignment to < 20 μm with optical sensors demonstrated
Alignment with straight tracks to < 10 μm

ATLAS alignment goal at LHC : ~ 20 μm

Sagitta resolution vs momentum

ATLAS preliminary

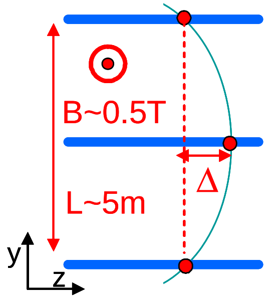


Data fitted with:

$$\sigma_{meas} = \sqrt{K_1^{\,2} + (K_2 / P_{meas})^2}$$

K_1 intrinsic resolution term; K_2 multiple scattering

P_{meas} from beam magnet



E_μ ~ 1 TeV $\Rightarrow$ Δ~500 μm
σ/p ~10% $\Rightarrow$ δΔ~50 μm

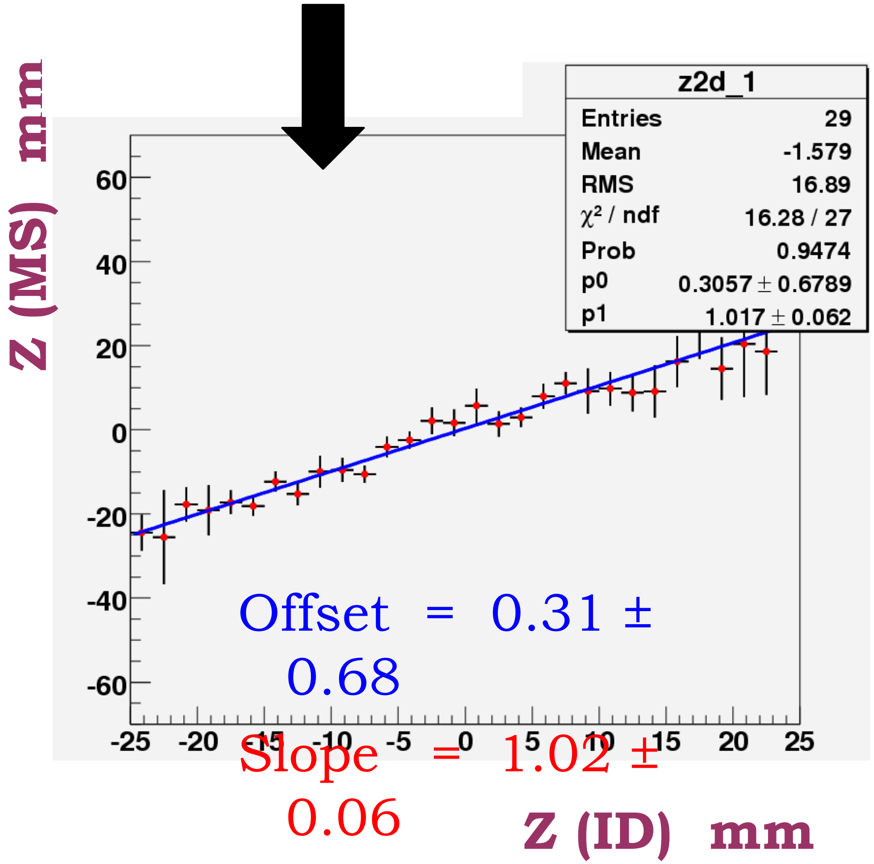
From the fit (36 mV)

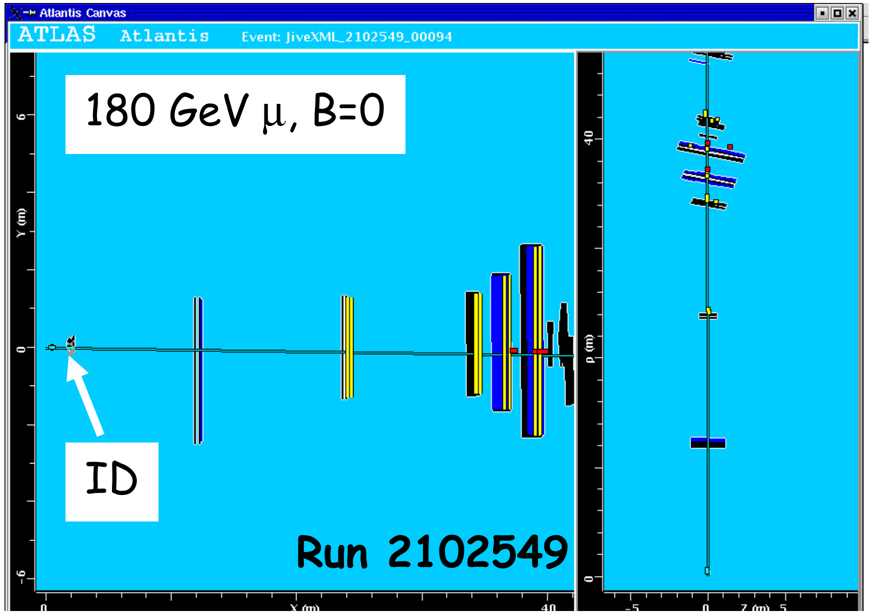
Data	Simulation
K_1 = 51±3 μm	K_1 = 40±3 μm
x/X_0 ~ 0.27±0.04	x/X0 ~ 0.32 ±0.03

50 μm accuracy achieved at high muon momentum (corresponds to σ/p ~ 10% at 1 TeV in ATLAS)

Inner Detector-Muon Spectrometer alignment

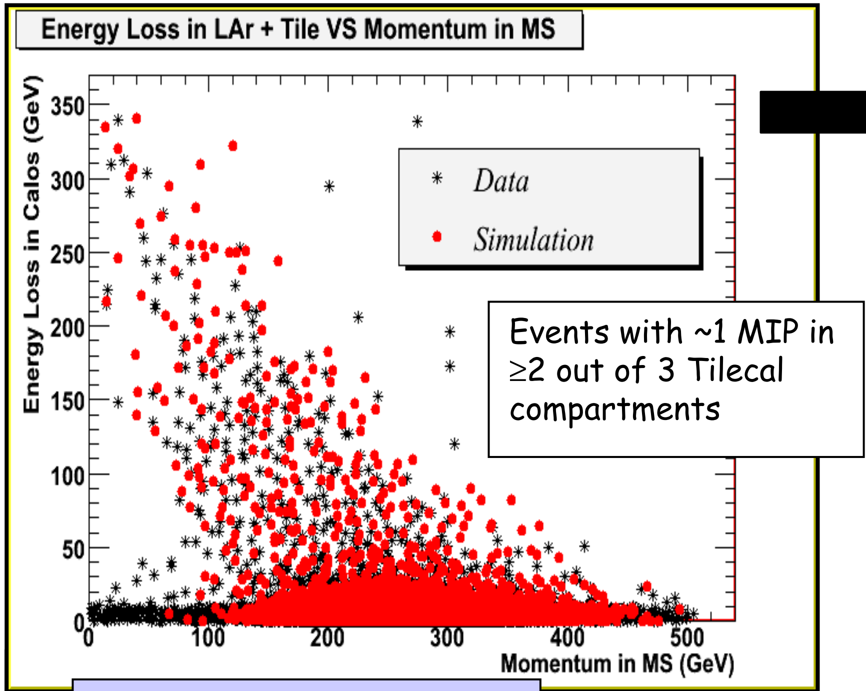
- Extrapolate tracks from MS to ID
- At x=0: offset = 20mm
  rms 44 mm (over 40 m)
- Compare extrapolated MS track with ID track

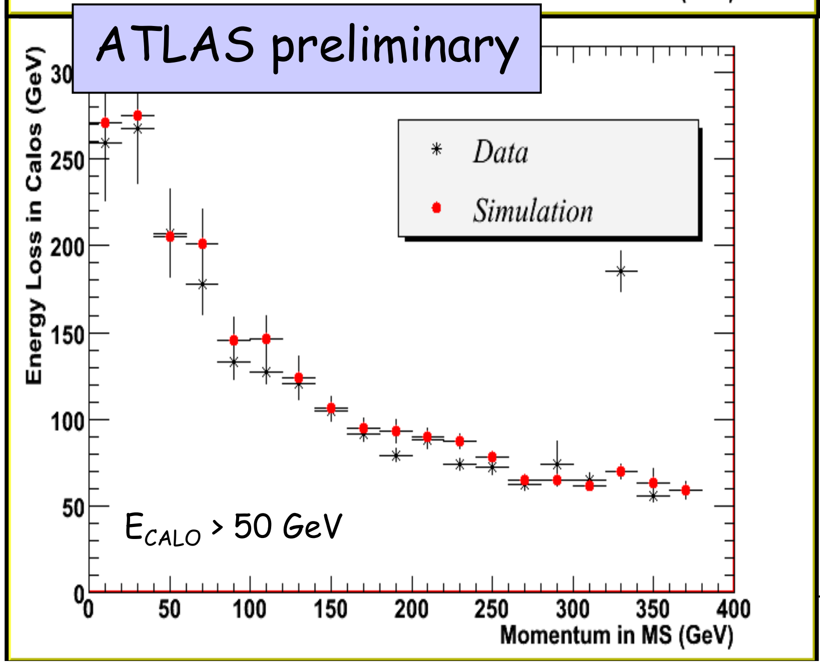




ATLAS preliminary

Muons in calorimeters and Muon Spectrometer: catastrophic E losses





Events with E(Lar+Tile) > 10 GeV:
$3.37 \pm 0.05\%$ data
$3.27 \pm 0.05\%$ MC

Reproducing catastrophic E losses in simulation essential to optimize high-E μ reconstruction and understand efficiency

ATLAS @ LHC: full simulation

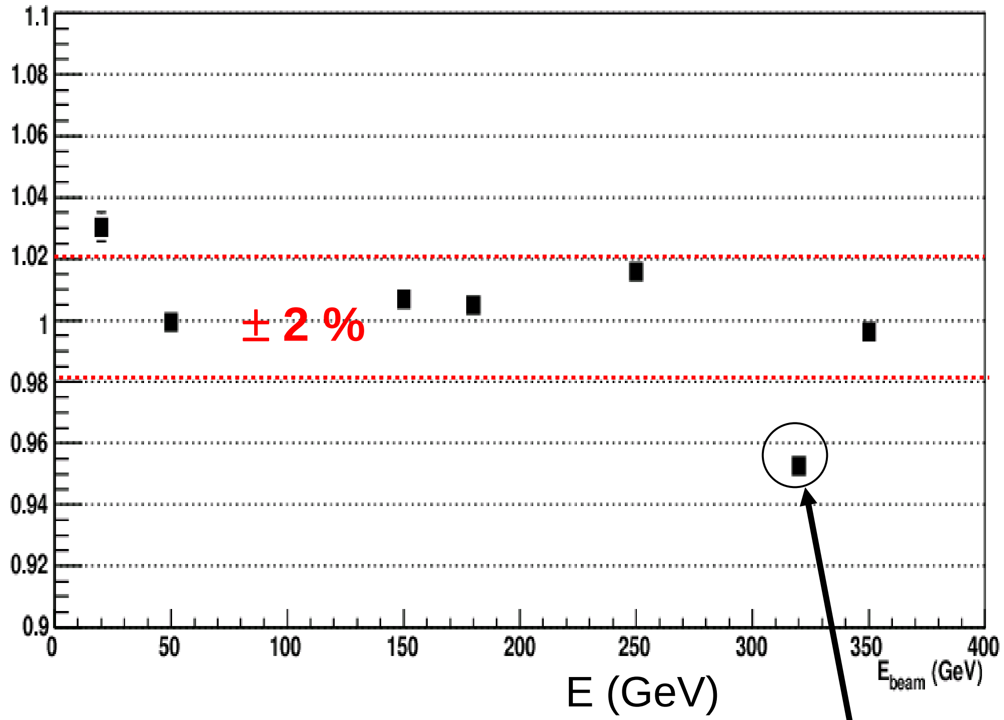
QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

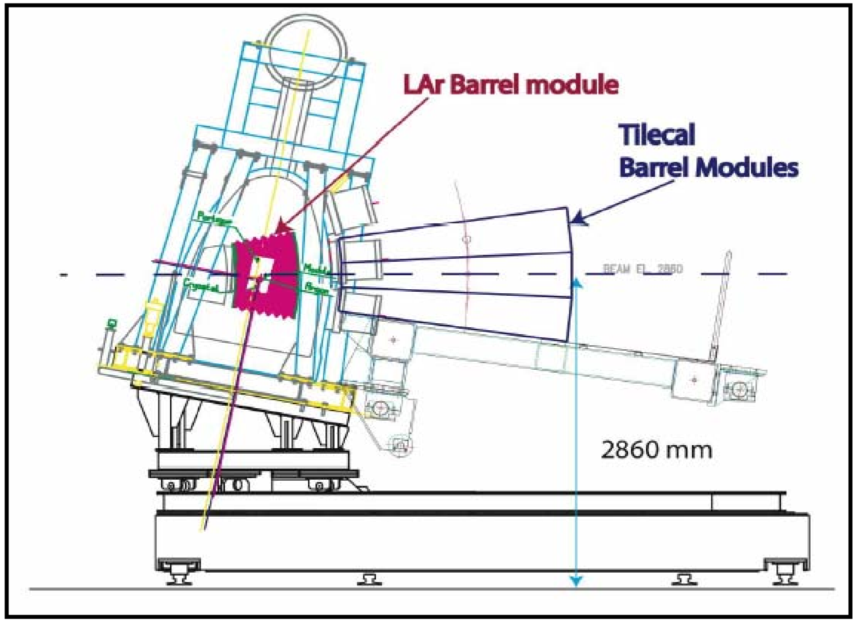
Muon

Combined calorimetry:
data/simulation comparison for pion response in LAR EM + Tilecal

Ratio Data/MC for reconstructed pion energy

ATLAS preliminary

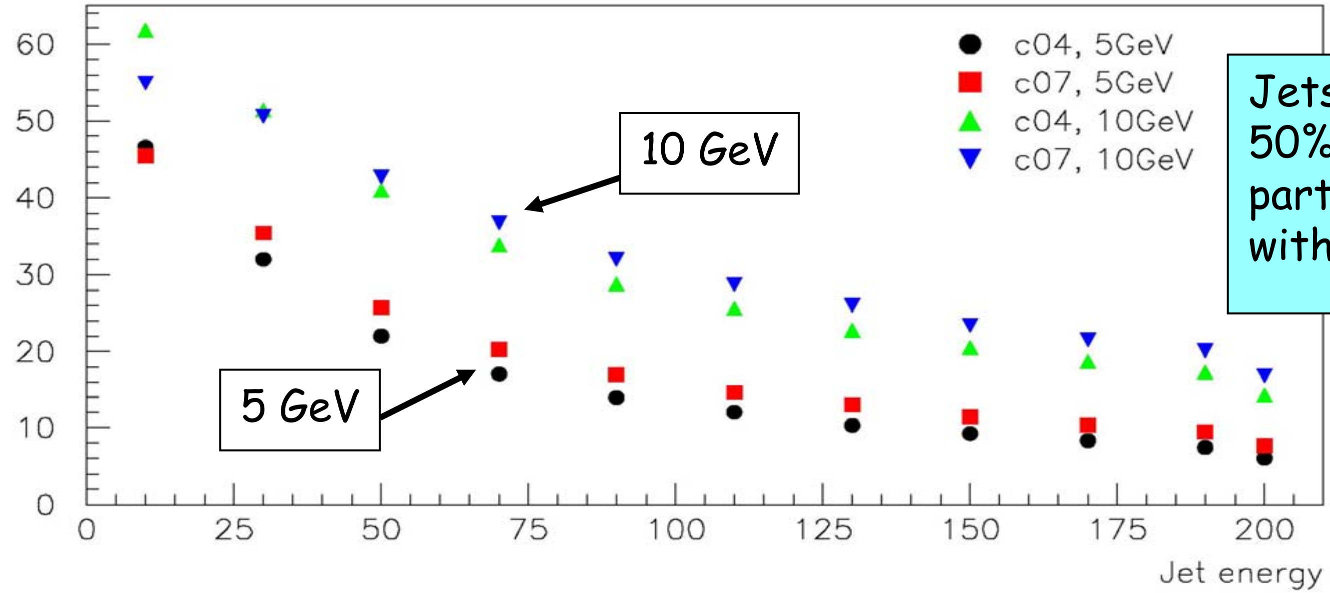




HV problem in Tilecal ?

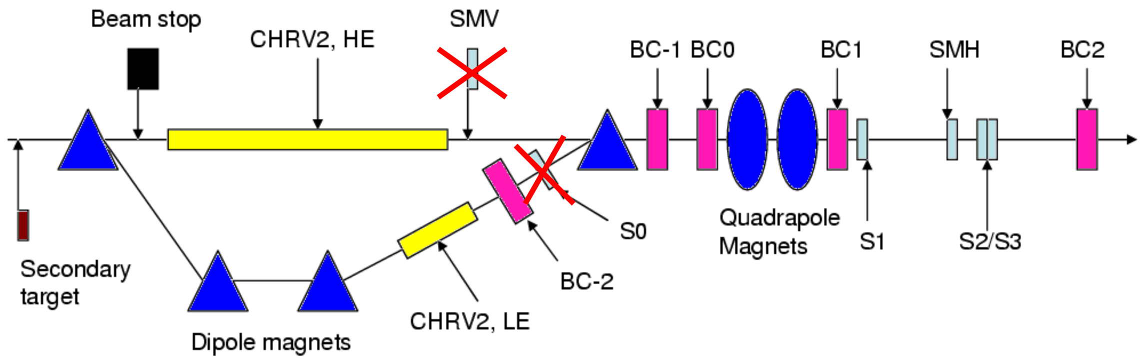
Modelling the detector response to the bulk of QCD jets

E fraction (%) carried by charged particles with E ≤ 5, 10 GeV



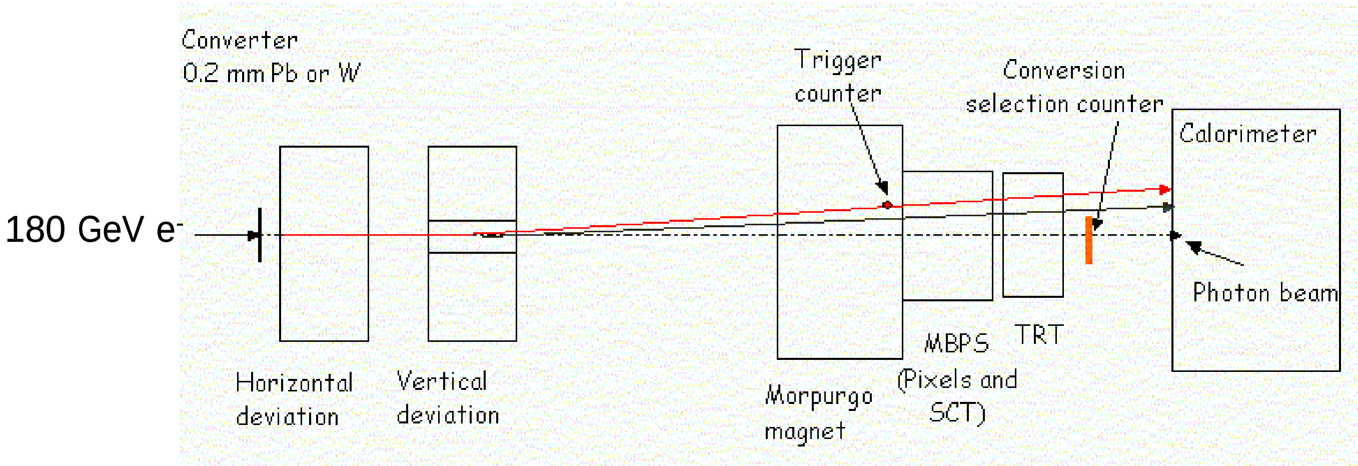
Jets with E = 50 (100) GeV:
50% of E carried by particles (charged + neutral) with E ≤ 5 (10) GeV

π^- with E = 1→ 9 GeV collected with special beam set-up
→ data being analyzed



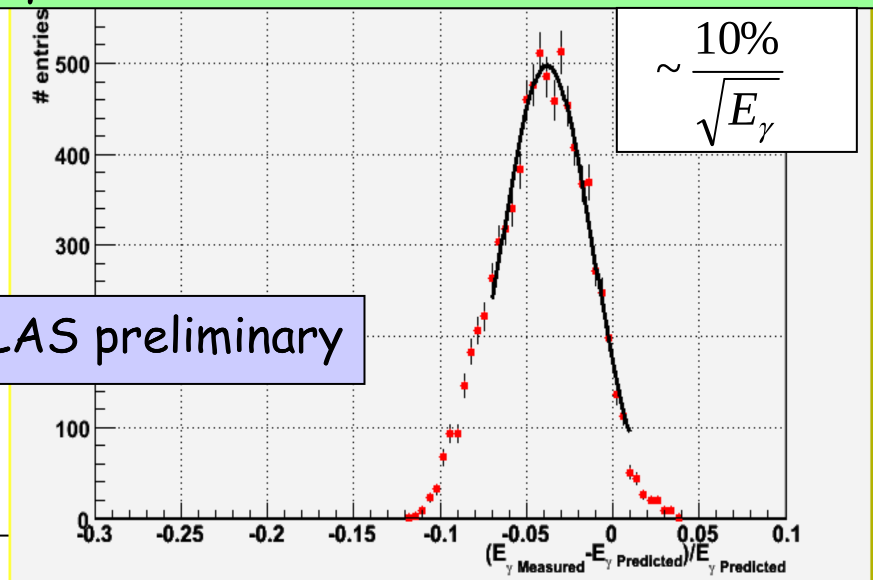
Photon studies

⇒ reconstruction of conversions in ID
γ/π^0 separation in ECAL
validation of simulation

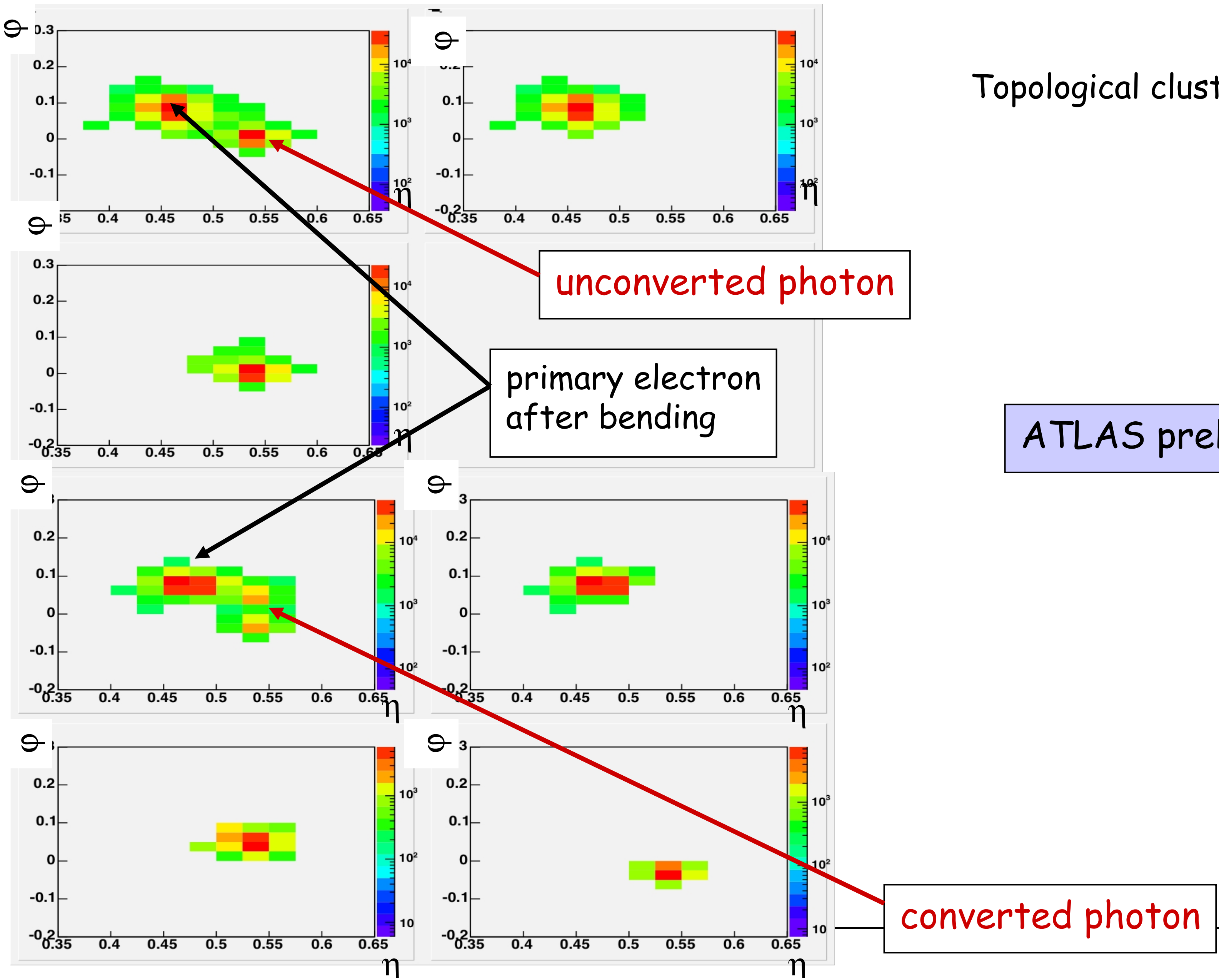


- Primary e- bent away from beam line in both directions
- Trigger counter selects e⁻ angle hence γ energy
  (bulk of γ's have E ~ 60 GeV)
- Conversion e± in Pixels, SCT separated by MBPS magnet

E_γ in ECAL: (measured-predicted)/predicted



Optimization of clustering tools in EM calorimeter with photon data

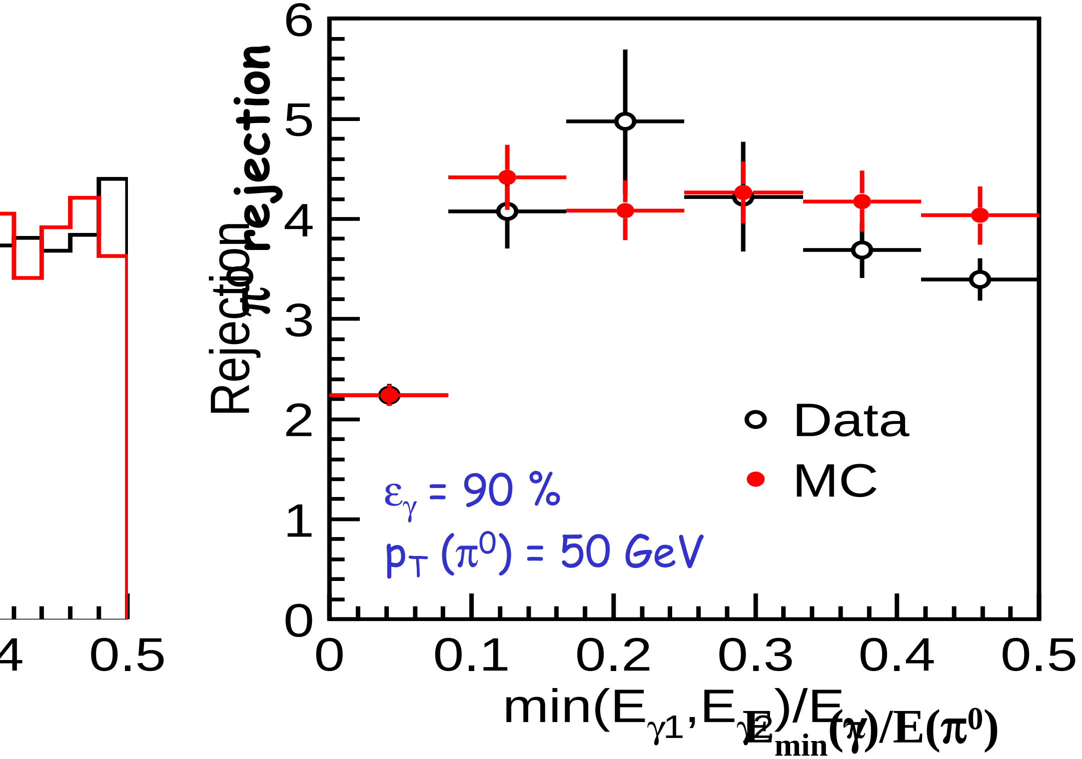


Topological cluster

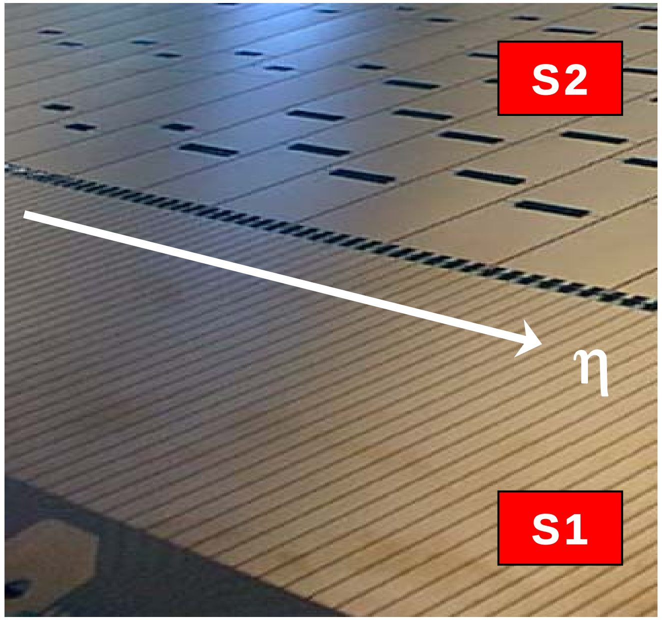
ATLAS preliminary

LHC: $R(\pi^0) \geq 3$ for $\varepsilon(\gamma) \sim 90\%$ needed to reject $\gamma j + jj$ background to $H \to \gamma\gamma$

From a previous test-beam (1999-2000) with standalone LAr "module zero"



Using 4mm η-strips in 1st ECAL compartment



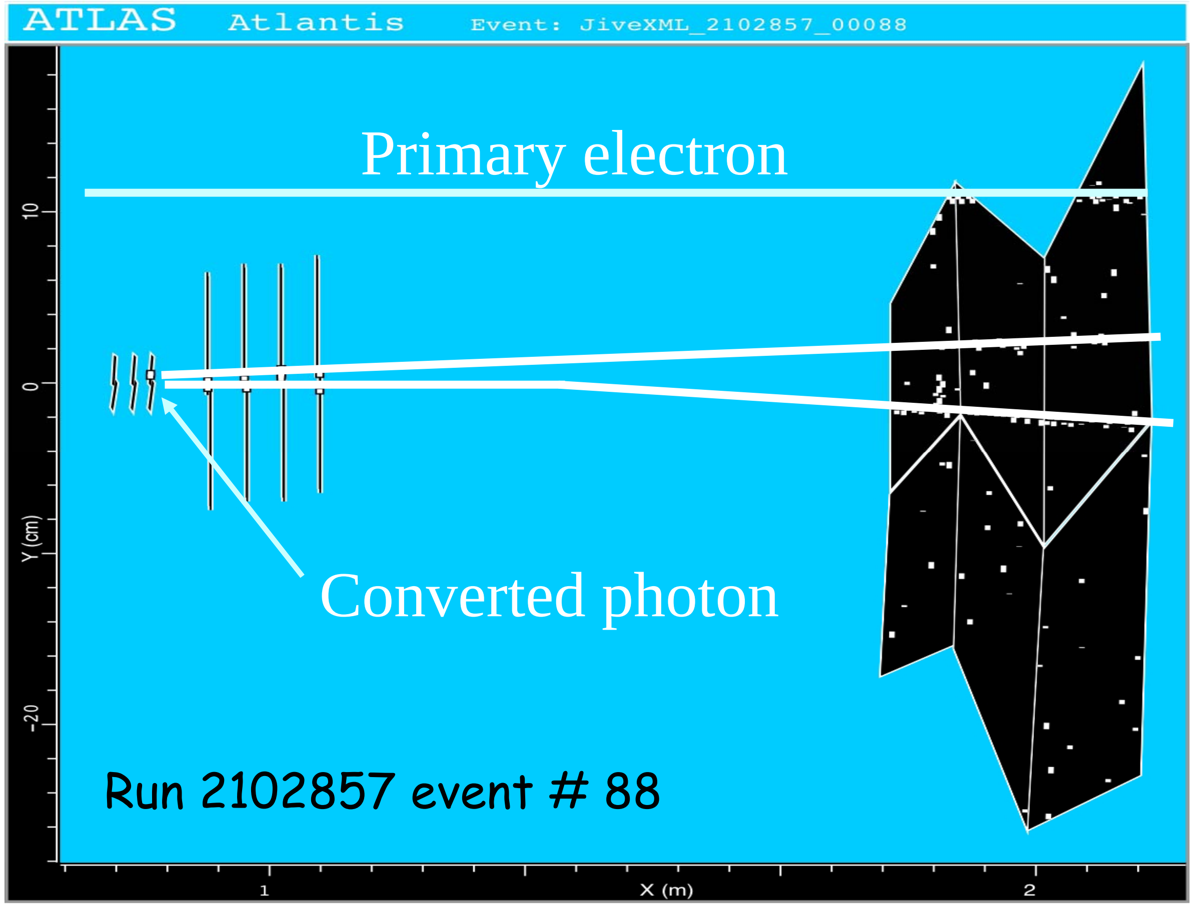
Data: ‹$R(\pi^0)$› = 3.54 ± 0.12

MC: ‹$R(\pi^0)$› = 3.66 ± 0.10

→ repeat these studies in ATLAS-like environment of combined test-beam (upstream detectors, B-field, ..)

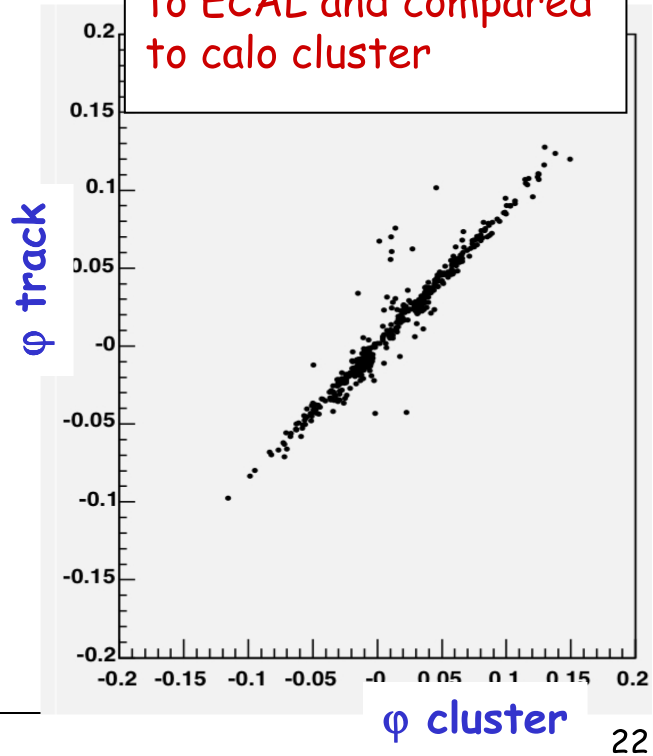
Matching tracks to clusters

ATLAS preliminary



ATLAS @ LHC:
γ-conversion probability is > 30% → important to develop (and validate !) efficient reconstruction tools

ID track extrapolated to ECAL and compared to calo cluster



Work in progress to reconstruct full $\gamma \rightarrow e^+e^-$ in ID

Conclusions on combined test-beam and impact on Physics commissioning

- Preliminary results indicate that the detector performance (individual sub-detectors and combined) in complete ATLAS-like environment is close to expectation

- Many technical and performance aspects related to data quality and validation (noisy channels, electronics stability with time, etc.) and to alignment and calibration procedures exercised and consolidated

- G4-based simulation and (combined) reconstruction validated and improved in a realistic environment, with a variety of particles and detector configurations

- Should be able to understand several detector-related systematic effects
  $\rightarrow$ disentangle from physics-related effects when LHC operation will start

- ATLAS has worked as a coherent experiment, using common infrastructure and tools from on-line data taking up to extraction of "physics results"

- Still a lot of work ahead of us to exploit fully the huge amount of data !

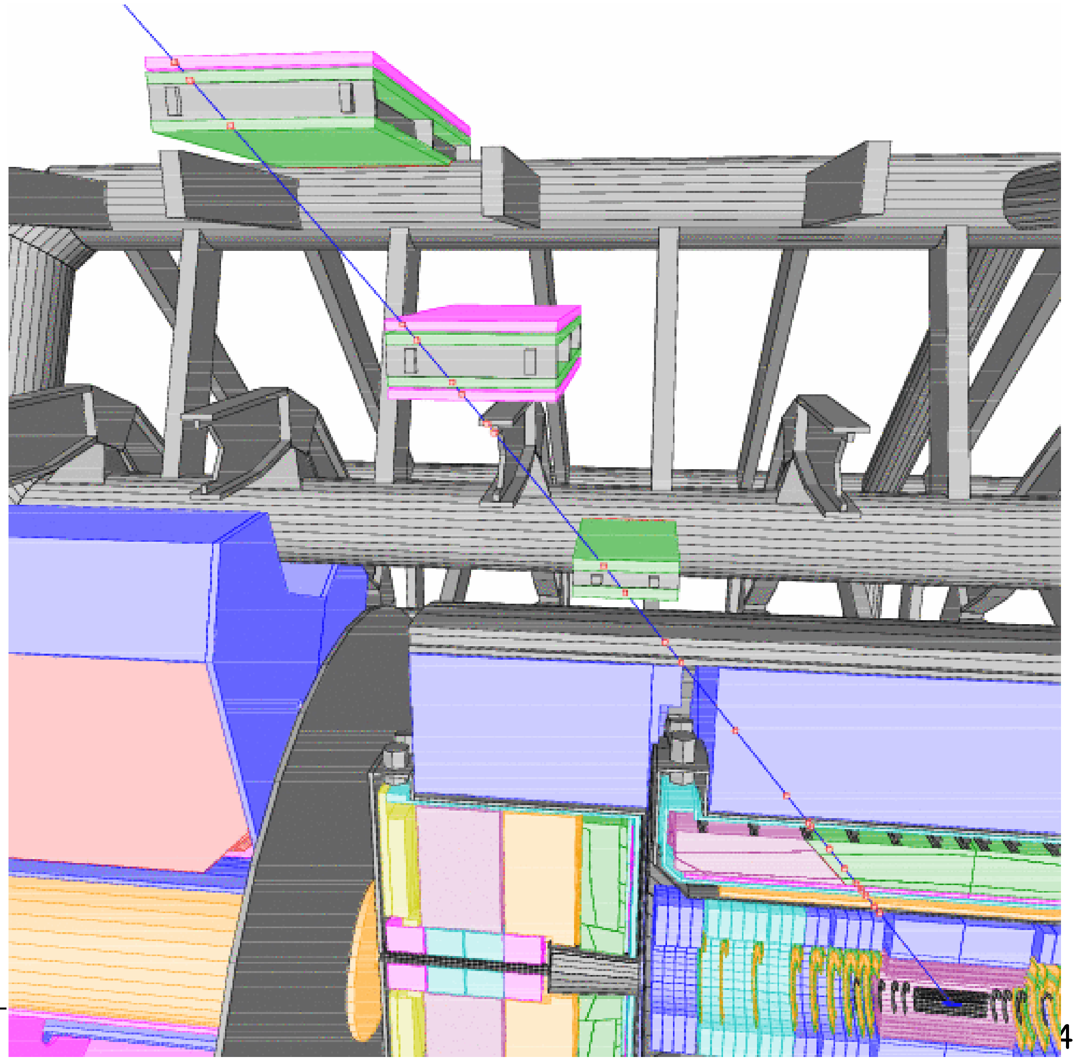
this experience will save a lot of time at LHC/ATLAS start-up

Towards Physics (2): description of the detector "as built and as installed"

ATLAS detector description and simulation very detailed since several years

However: need to inject more realism, in parallel with what is going on in the underground cavern

A very complex issue …



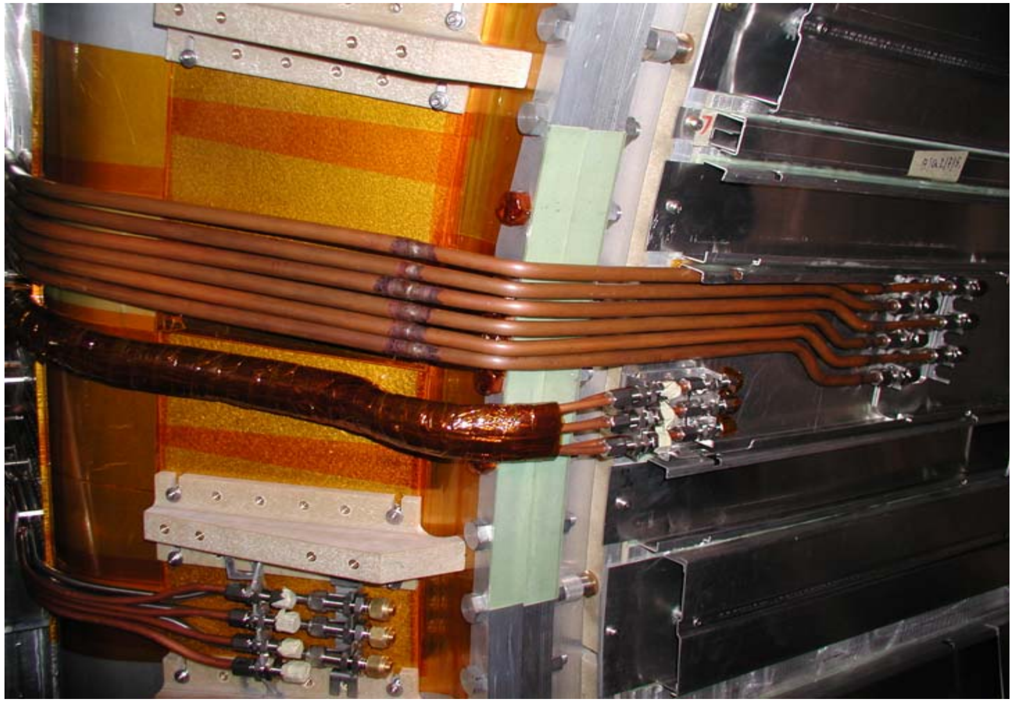
Examples of additional "realism" being included

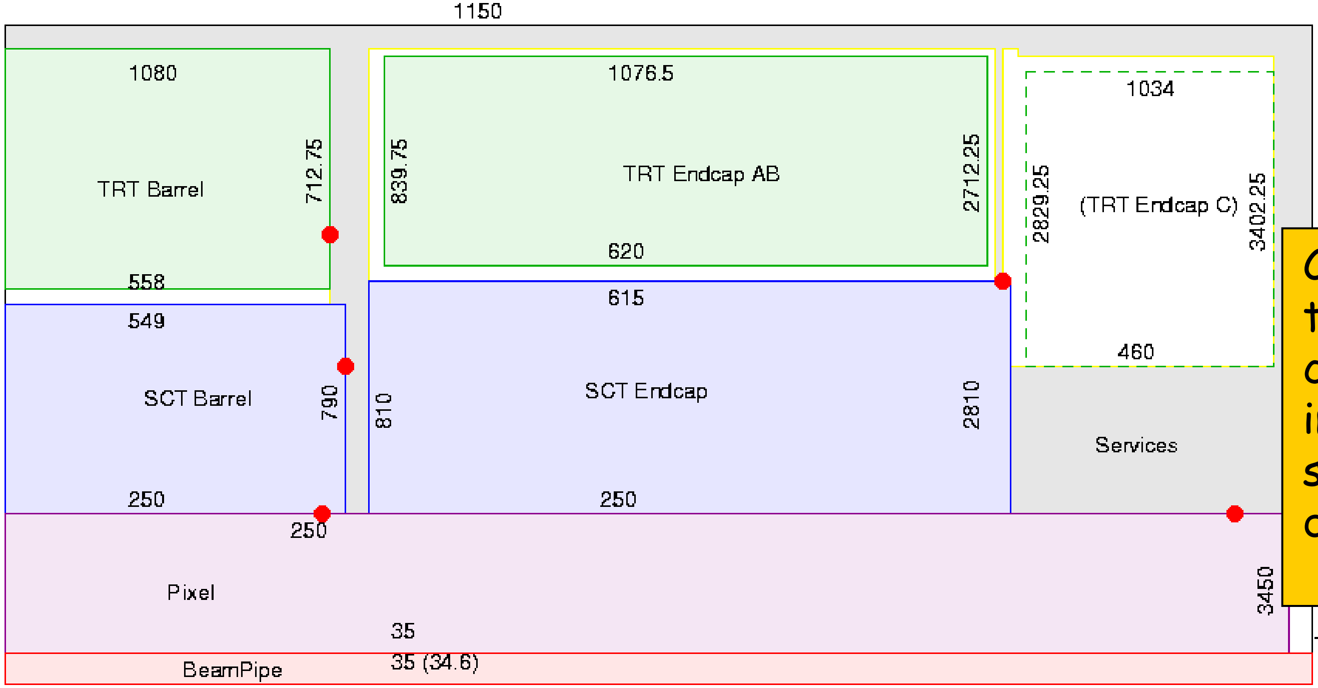
(because of impact on detector performance and physics)

- cables, services from latest engineering drawings, barrel/end-cap cracks from installation
- realistic B-field map taking into account non-symmetric coil placements in the cavern ($\pm$ 5-10 mm from survey)
- include detector "egg-shapes" if relevant (e.g. Tilecal elliptical shape if it has an impact on B-field …)
- displace detector (macro)-pieces to describe their actual position after integration and installation (e.g. ECAL barrel axis 2 mm below solenoid axis inside common cryostat) $\rightarrow$ break symmetries and degeneracy in Detector Description and Simulation
- mis-align detector modules/chambers inside macro-pieces
- include chamber deformations, sagging of wires and calorimeter plates, HV problems, etc. (likely at digitization/reconstruction level)

Technically very challenging for the Software …

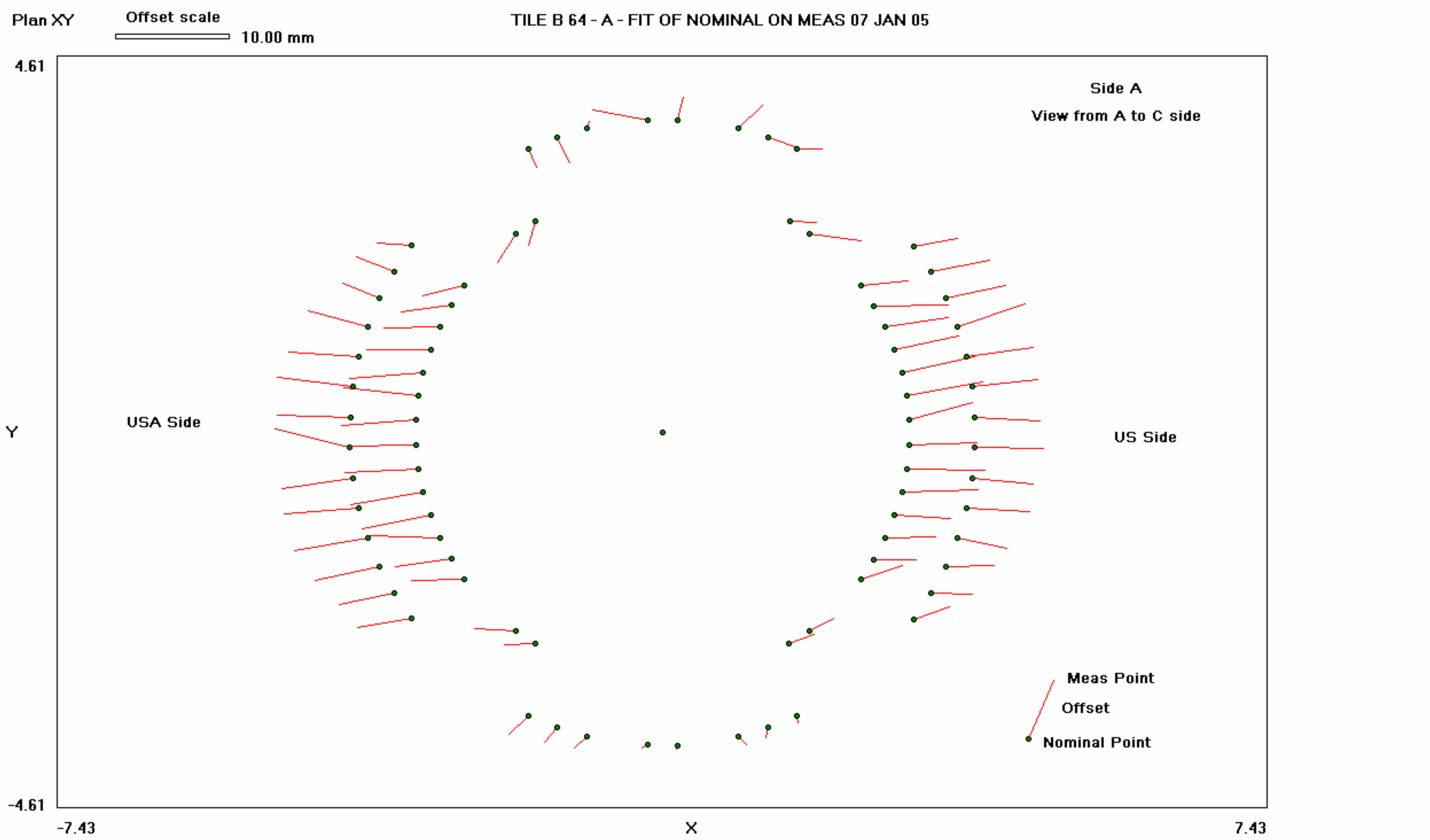
On-going inventory of material in the barrel/end-cap crack (where tracker services are routed) following installation in the pit





Current tracker envelopes touch, but engineering clearances (5-9 mm) will be implemented to allow for small rotations and displacements of components

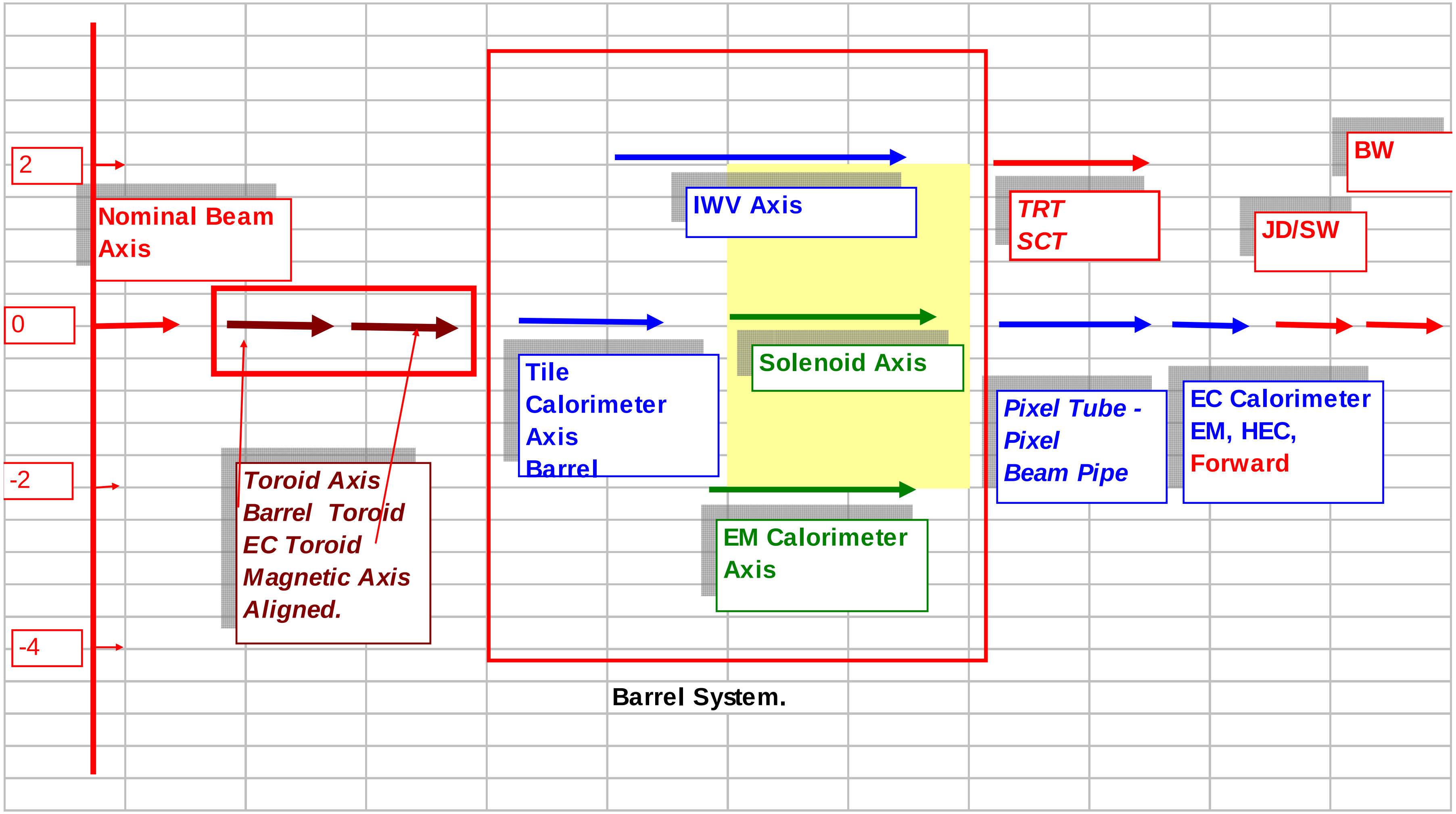
Barrel Tilecal measured deviations from nominal circle ("egg-shape")



Vertical: inside envelope; horizontal: +6 mm from nominal → elliptical shape

Needs to be included if it has impact on B-field

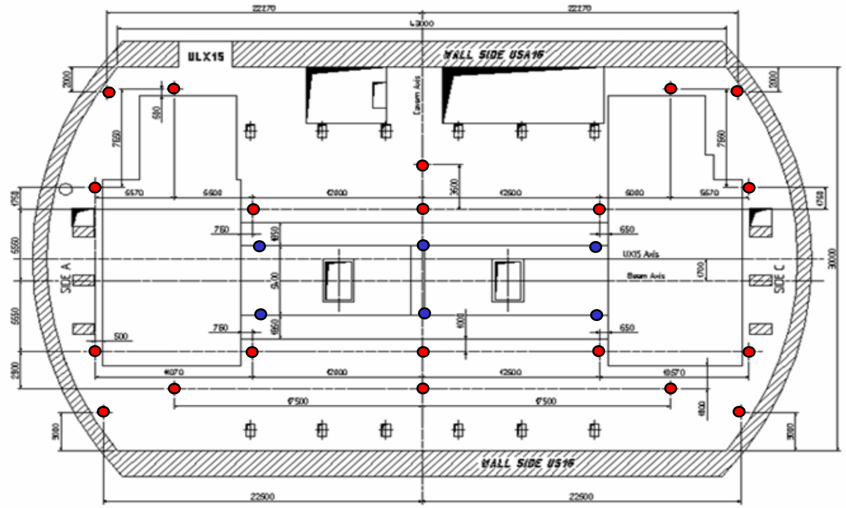
ATLAS detector placement strategy in the cavern

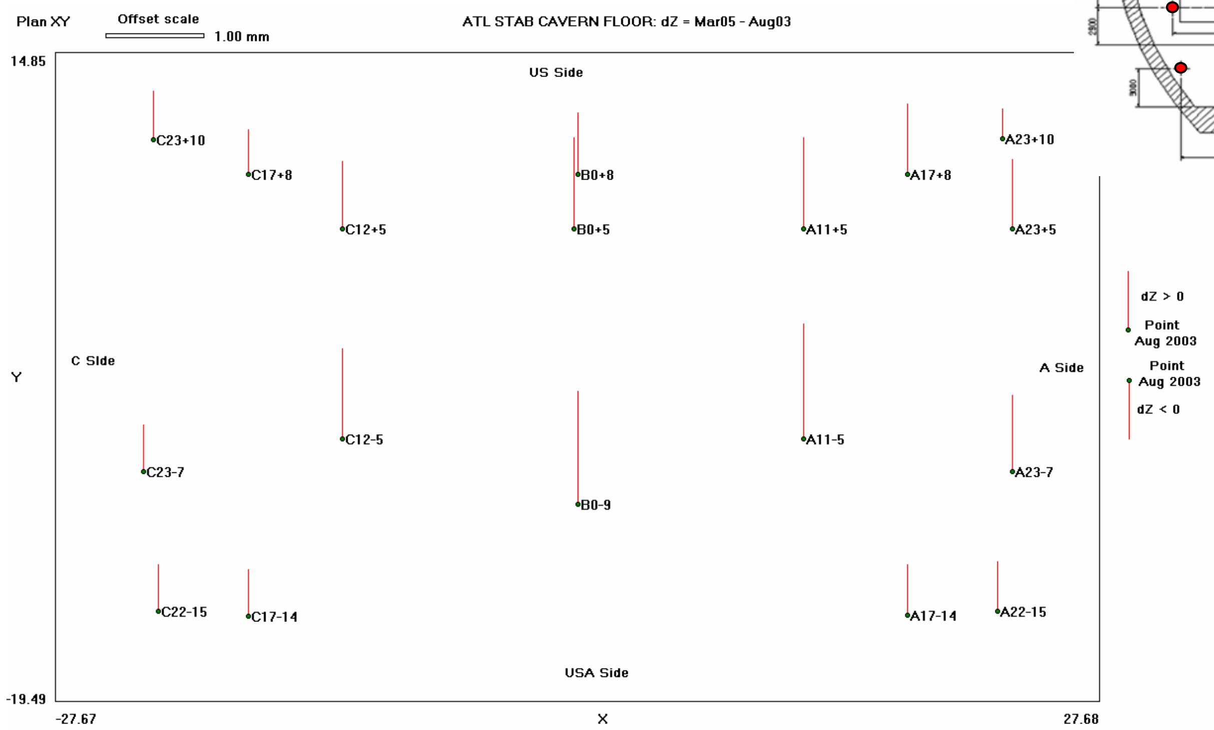


Typical position accuracy of macro-pieces : 1-3 mm

Additional complication: cavern floor moves up by ~1 mm/year
(i.e. up to 15 mm in 20 years !) due to the hydrostatic pressure
→ ATLAS will be positioned such that the "experiment axis"
(e.g. the solenoid axis) will coincide with the nominal beam line in 2010
→ must be taken into account in the software

20 reference points on the cavern floor
Measurements (precision of few μm)
wrt deep reference points in
LHC tunnel at ±350 m from IP





Floor stability relative to nominal beam line from August '03 to March '05
Clear indication of upward movement

Towards Physics (3): in situ pre-collision data

Cosmic runs : start with calorimeters and part of muon chambers in Spring 2006, add progressively more pieces until ATLAS global cosmic run in April 2007
Beam-halo muons and beam-gas events (during machine commissioning with single beams): Spring-Summer 2007 ?

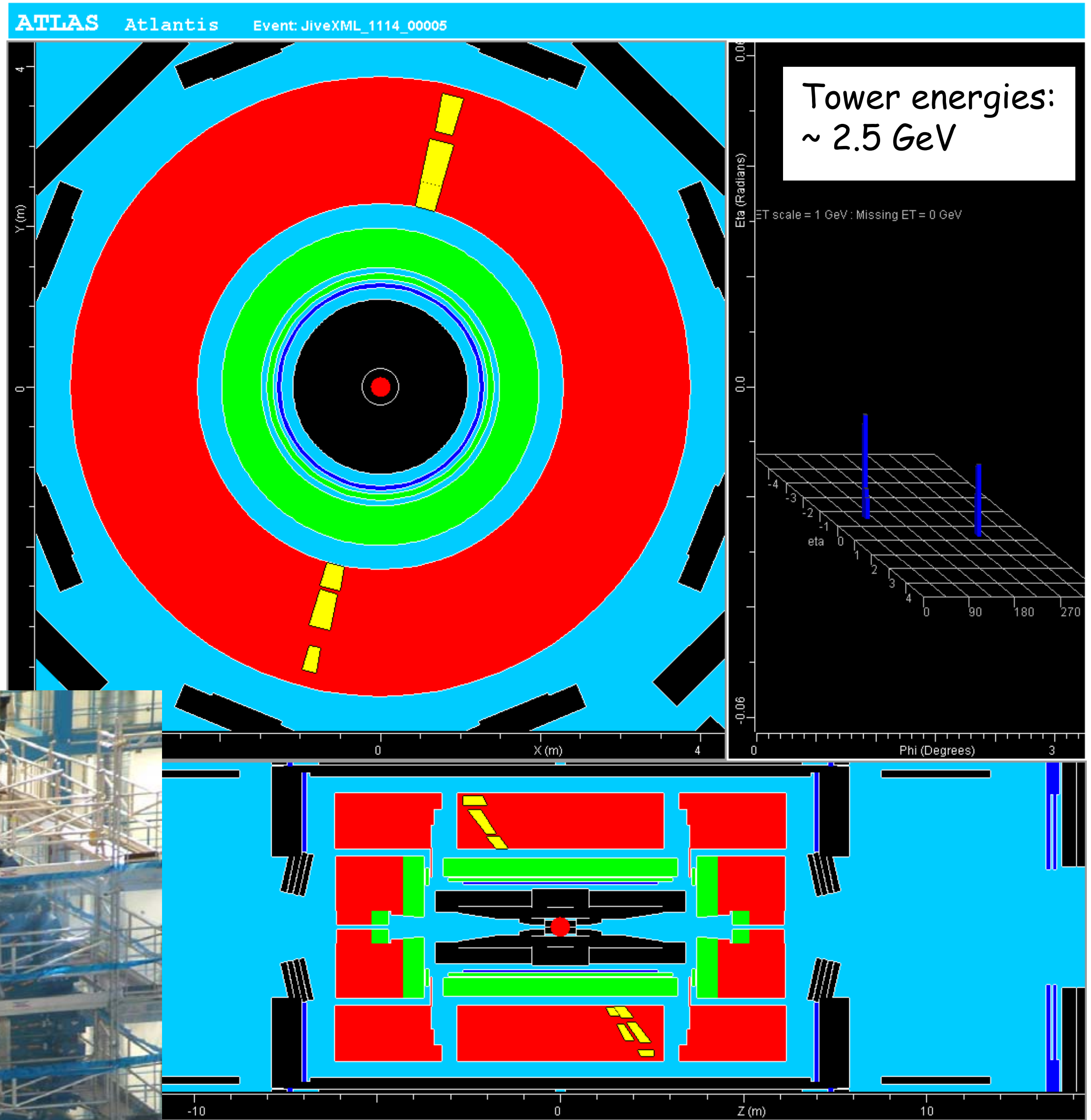
From full ATLAS simulations:
expected statistics for ~ 2 months of data taking (at 30% efficiency):
10^6-10^7 events per type
(cosmics, beam-halo, beam-gas)

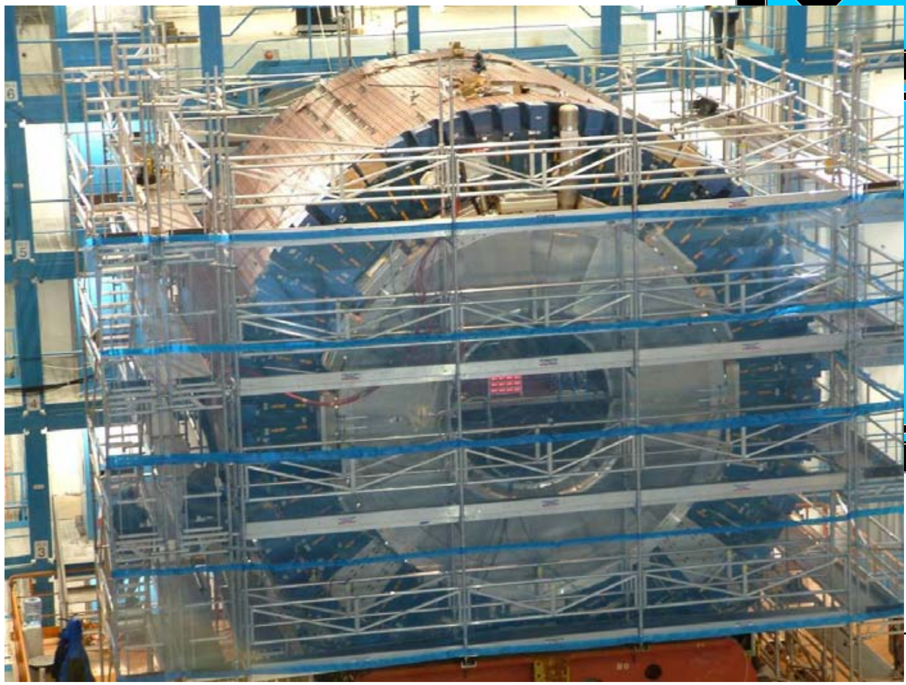
→ enough for initial shake-down,
to catalog problems,
to gain operation experience,
for detector synchronization,
for some calibration/alignment

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

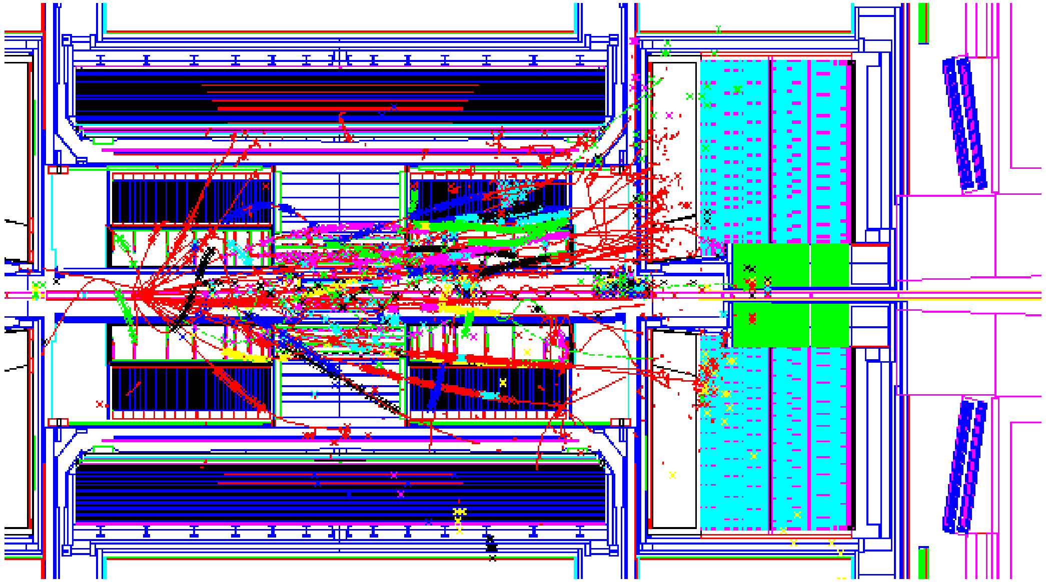
Trigger for cosmics:
Tilecal, RPCs

First cosmic muons observed by ATLAS in the pit on June 20th (recorded by hadron Tilecal calorimeter)





A beam-gas event in ATLAS (full sim.)

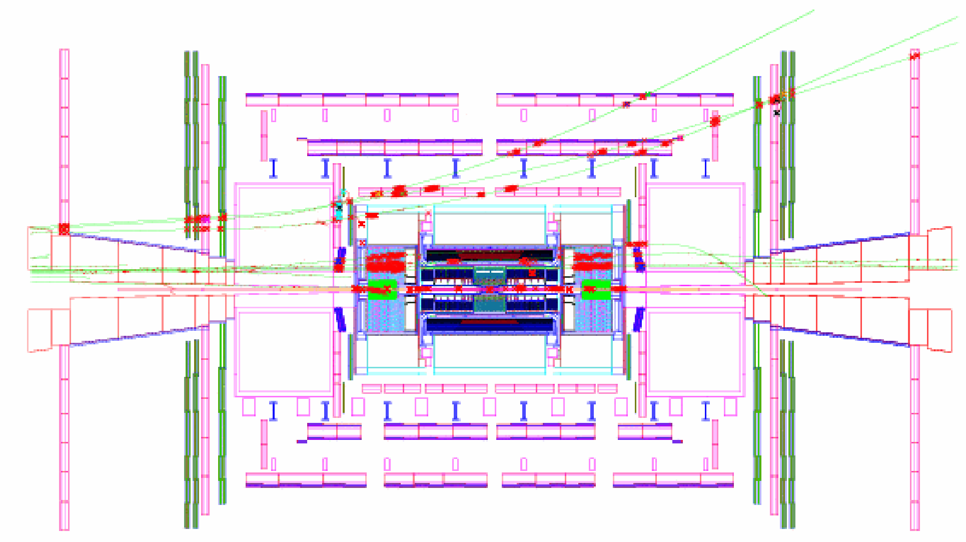


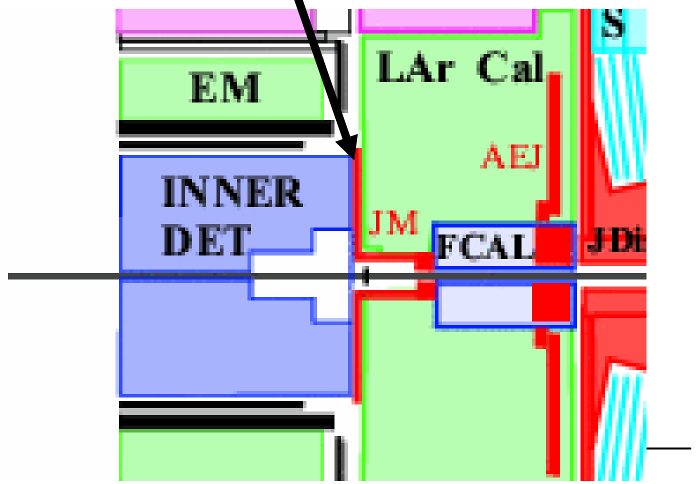
Trigger ?

Scintillator counters inside ID cavity, in front of end-cap cryostats (replacing part of moderator), covering R=15→ 90 cm

Provide trigger on beam-halo at low R (TGC at large R), beam-gas, and minimum bias for initial LHC operation

Beam-halo muons in ATLAS (full sim.)



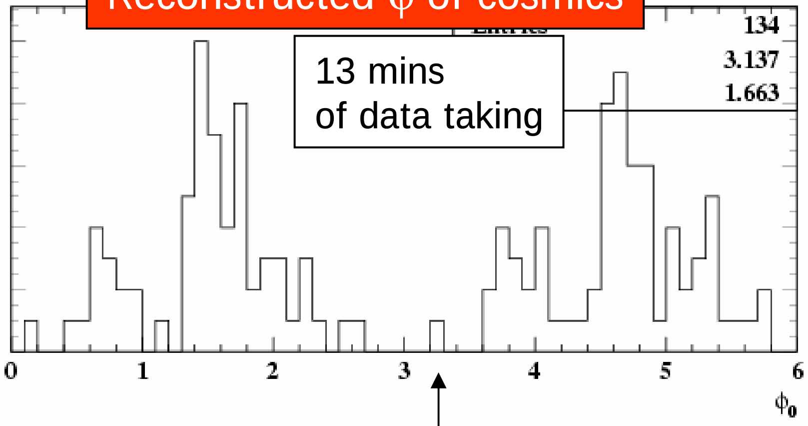


Commissioning ID with cosmics and beam gas (some ideas ...)

Cosmics : O (1Hz) tracks in Pixels+SCT+TRT

- useful statistics for debugging readout, maps of dead modules, etc.
- check relative position Pixels/SCT/TRT and of ID wrt ECAL and Muon Spectrometer
- first alignment: may achieve statistical precision of ~10 μm in parts of Pixels/SCT, 50 μm in TRT
- first calibration of t_0 and R-t relation in straws

Reconstructed φ of cosmics



standard ATLAS patt. rec.
(no optimisation for cosmics ...)

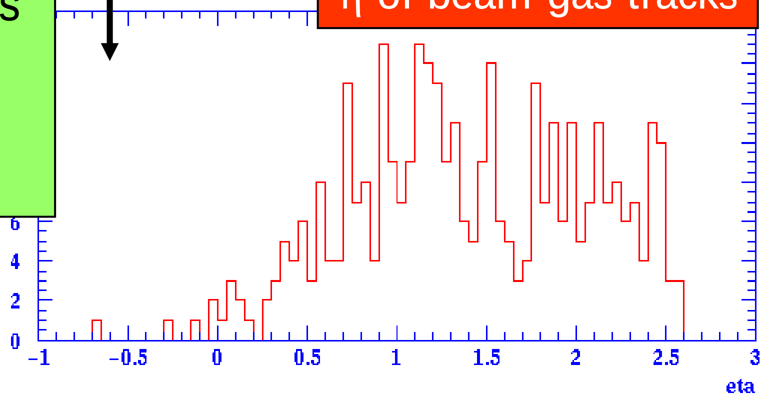
Beam-gas :

- ~ 25 Hz of reconstructed tracks with p_T > 1 GeV and |z|<20 cm

→ >10^7 tracks (similar to LHC events) in 2 months

- enough statistics for alignment in "relaxed" environment → exceed initial survey precision of ~100 μm

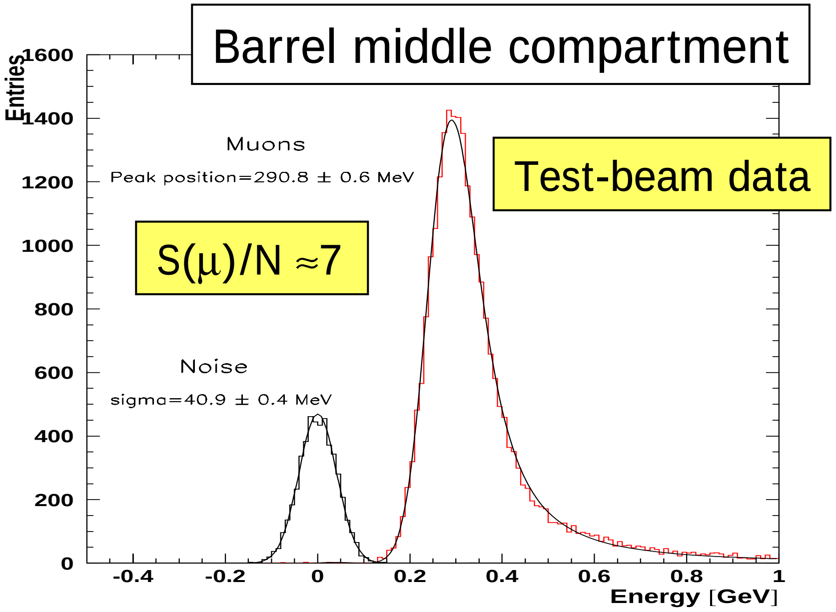
η of beam-gas tracks

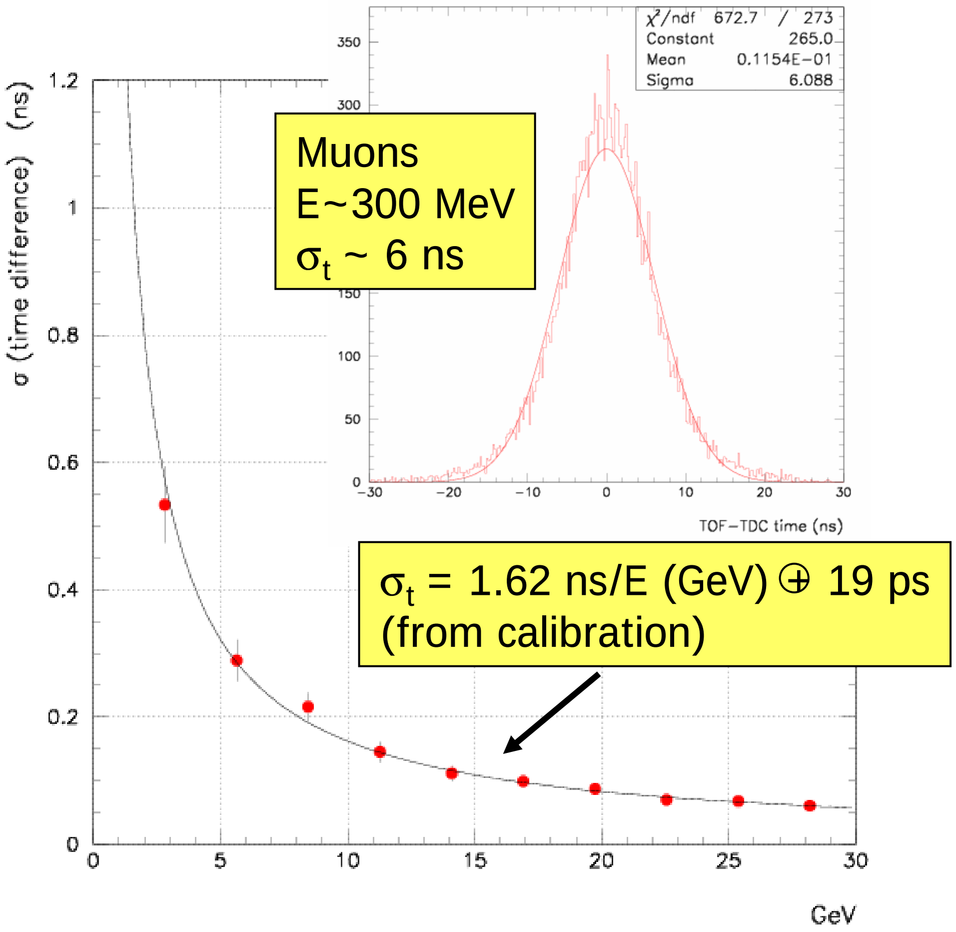


Commissioning ECAL with cosmics (first studies ...)

- check calorimeter timing to < 1 ns → input to optimal filtering in electronics
- check calorimeter position in η / φ wrt other sub-detectors to < 1 mm
- check response uniformity vs η: ≈ 0.5% precision could be achieved

Test-beam data





Towards Physics (4): the first pp data

Starting in Summer 2007 ...

Knowledge of detector on day 1 ?

Examples based on experience with test-beam and on simulation studies

	Expected performance day 1	Physics samples to improve (examples)
ECAL uniformity e/γ scale	~ 1% ~2 %	Minimum-bias, $Z \to ee$ $Z \to ee$
HCAL uniformity Jet scale	3 % < 10%	Single pions, QCD jets $Z (\to ll)$ +1j, $W \to jj$ in tt events
Tracking alignment	10-200 μm in Rϕ Pixels/SCT ?	Generic tracks, isolated μ , $Z \to \mu\mu$

Combined test-beam, realistic simulations, cosmics and pre-collision data will help to:

- determine detector "operation" parameters: timing, voltages, relative position, initial calibration and alignment, etc.
- classify and disentangle some systematic effects: material, B-field, intrinsic performance, ...

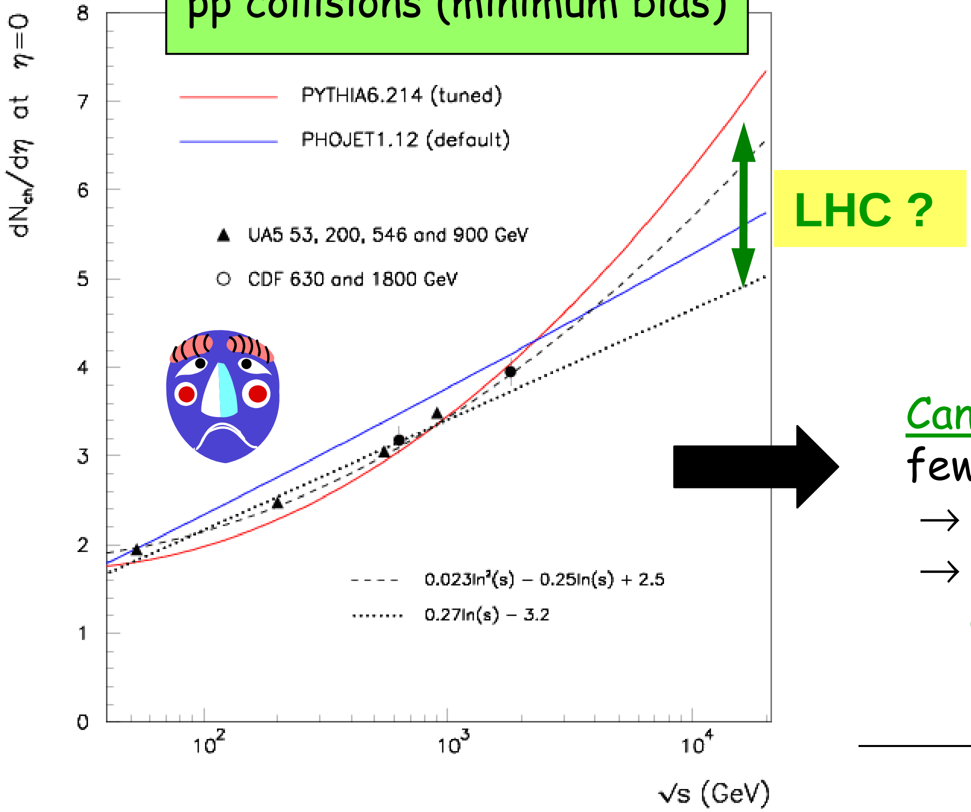
$\Rightarrow$ gain time and experience before commissioning with pp data starts

Knowledge of SM physics on day 1 ?

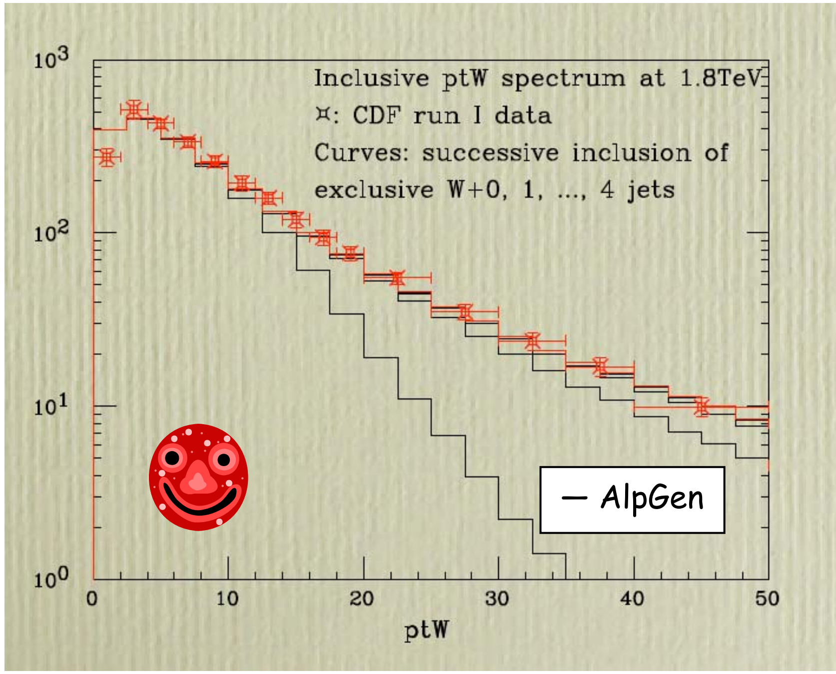
W, Z cross-sections: to 3-4%
(NNLO calculation → dominated by PDF)

tt cross-section to ~7% (NLO+PDF)

$\langle N_{ch} \rangle$ at $\eta = 0$ for generic pp collisions (minimum bias)

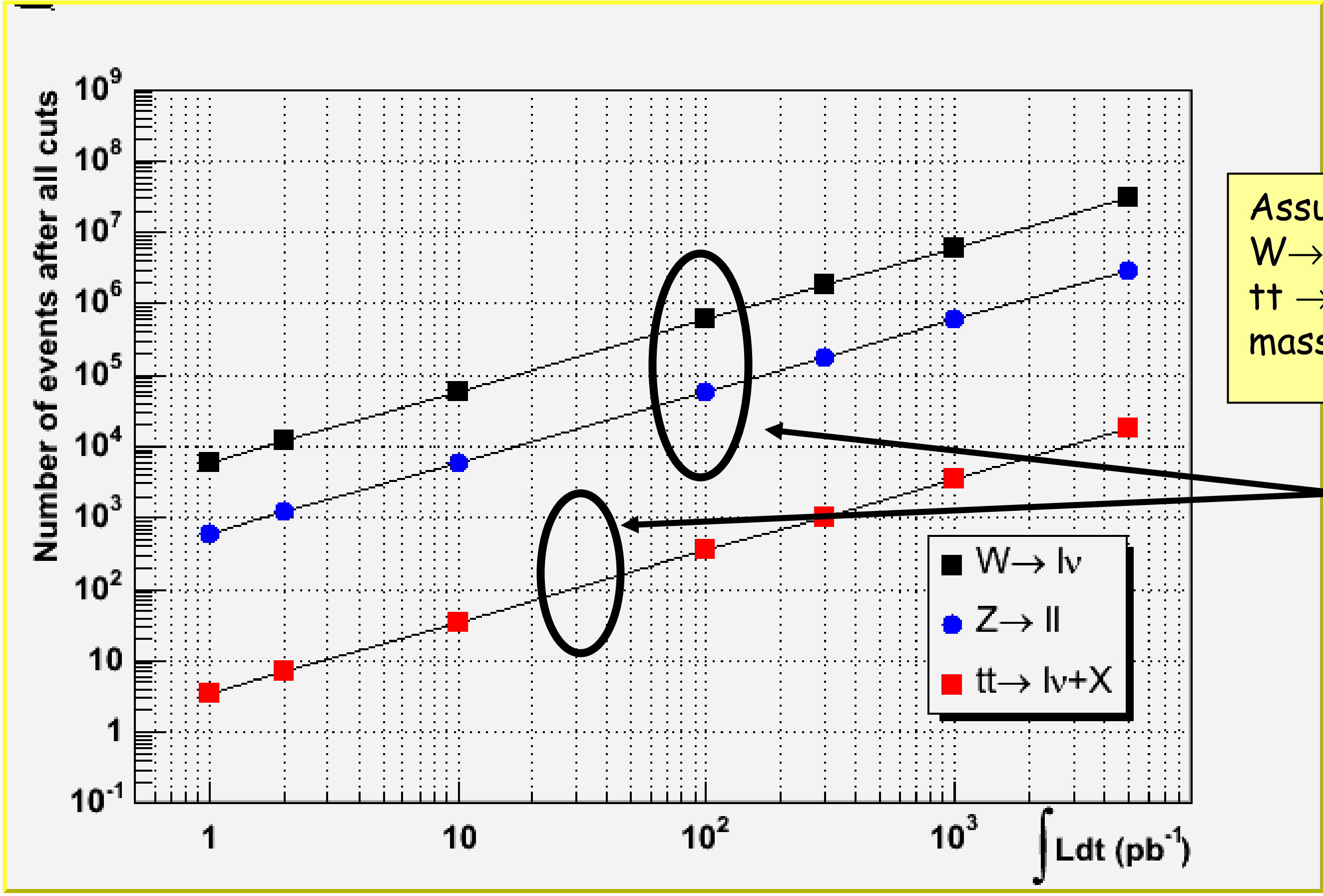


Lot of progress with NLO matrix element MC interfaced to parton shower MC (MC@ NLO, AlpGen,..)



Candidate to very early measurement:
few 10^4 events enough to get $dN_{ch}/d\eta$, dN_{ch}/dp_T
→ tuning of MC models
→ understand basics of pp collisions, occupancy, pile-up, …

How many events in ATLAS at the beginning ?

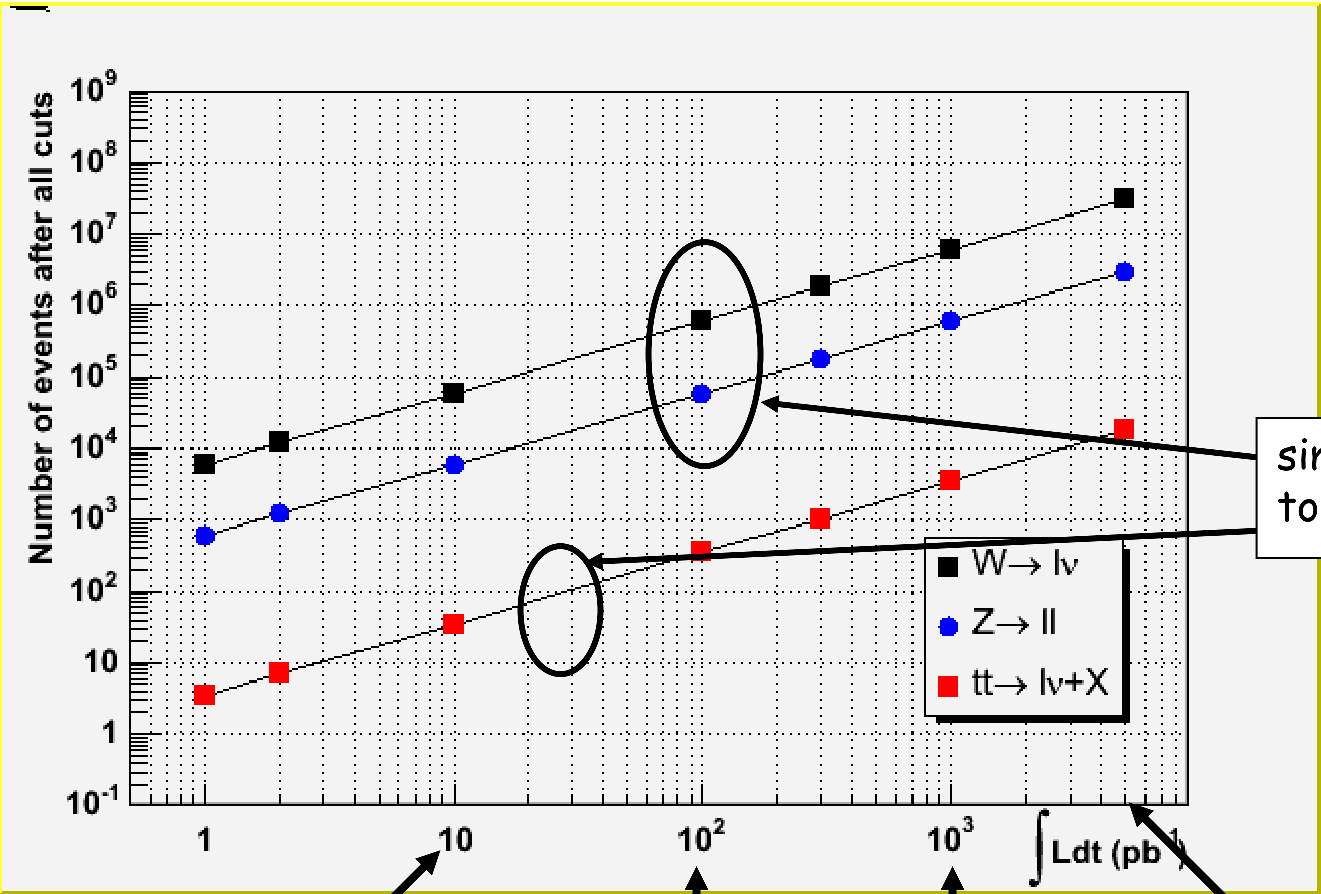


l ≡ e or μ

Assumed selection efficiency:
W→ lν, Z→ ll : 20%
tt → lν+X : 1.5% (no b-tag, inside mass bin)

similar statistics to CDF, D0 today

How many events in ATLAS at the beginning ? **And when ?**



similar statistics to CDF, D0 today

10 $pb^{-1} \equiv$ 1 month at 10^{30} + < 2 weeks at 10^{31}, ε=50%

100 $pb^{-1} \equiv$ few days at 10^{32}, ε=50%

1 $fb^{-1} \equiv$ 6 month at 10^{32}, ε=50%

5 $fb^{-1} \equiv$ 3 month at 10^{32} + 3 month at 10^{33}, ε=50%

→ **end 2007 ?**

→ **end 2008 ?**

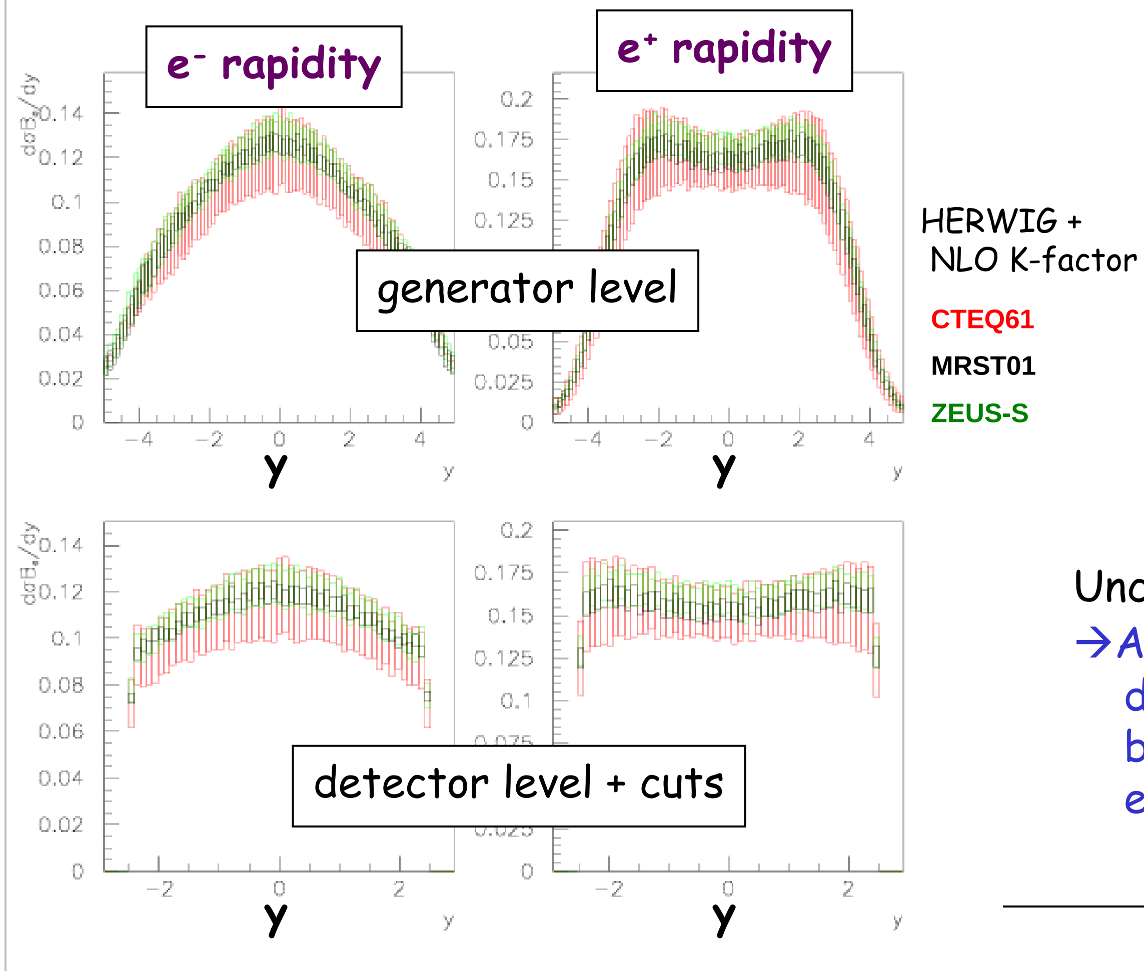
Constraining PDF with early ATLAS data using $W \to l\nu$ angular distributions

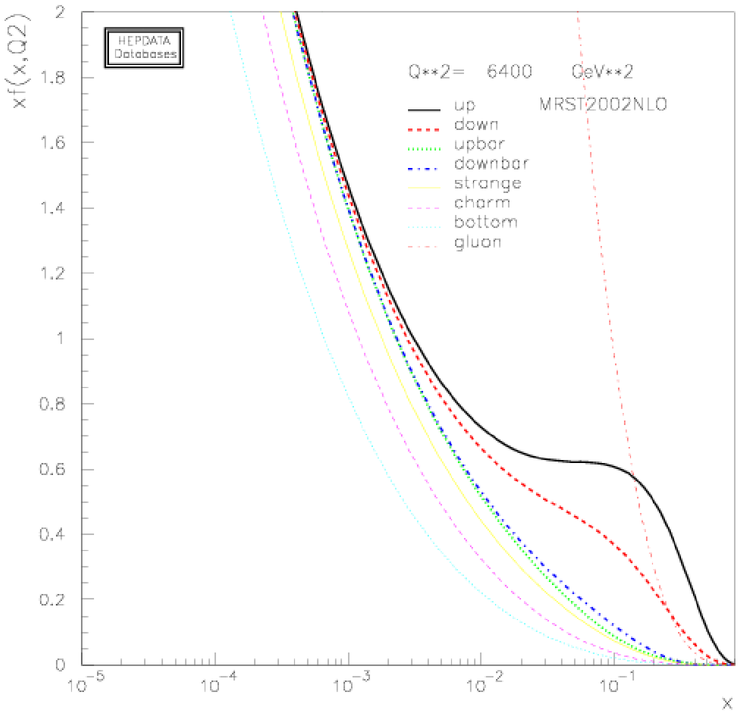
$$x_{1,2} = \frac{M}{\sqrt{s}} \exp(\pm y)$$

$\Rightarrow$ W production over $|y|<2.5$ at LHC involves $10^{-4} < x_{1,2} < 0.1$

$\Rightarrow$ region dominated by $g \to qq$

Tricoli et al., ATL-PHYS-CONF-2005-008



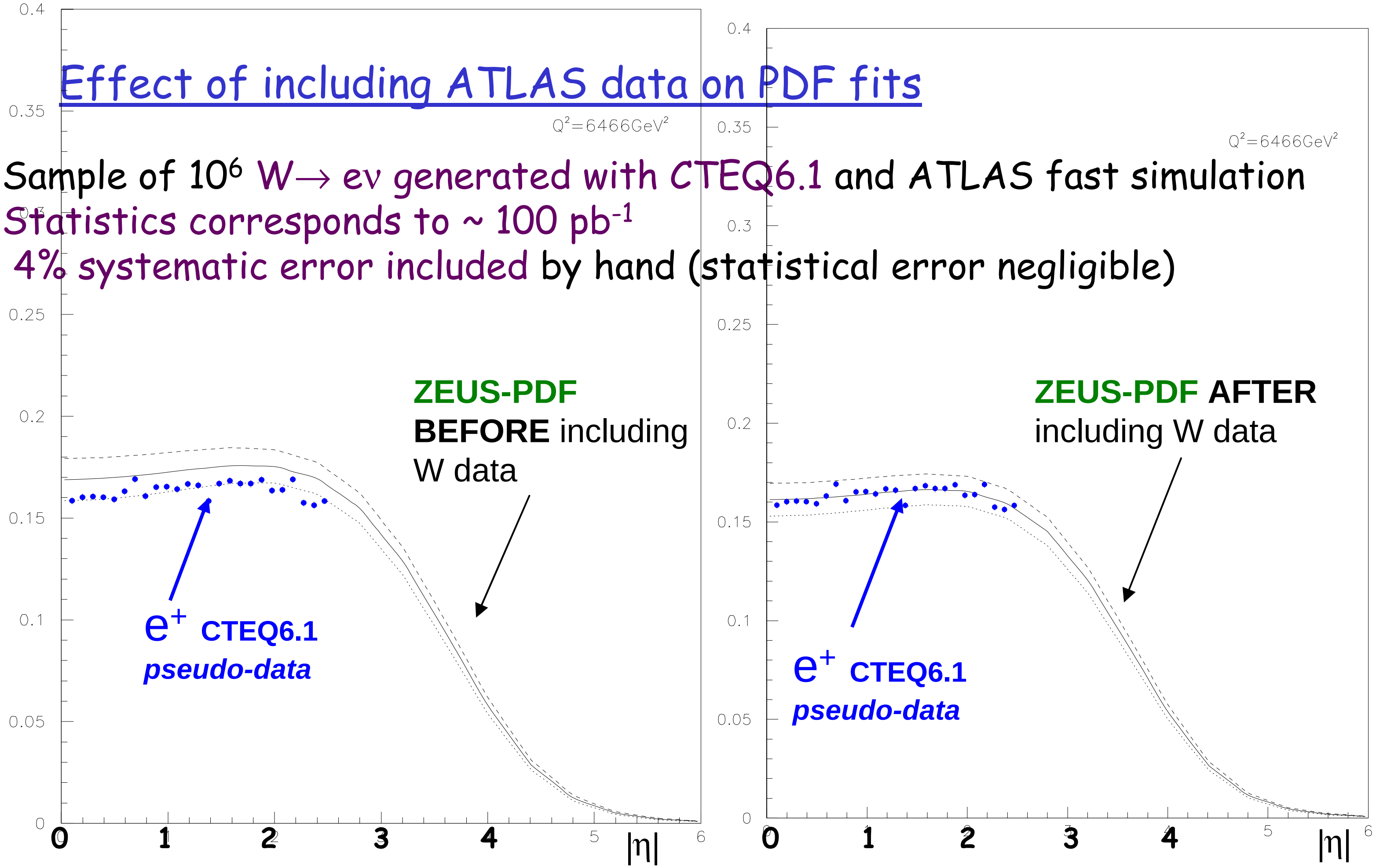


Uncertainties on present PDF: 4-8%

→ATLAS measurements of $e^{\pm}$ angular distributions provide discrimination between different PDF if experimental precision ~ 3-5%

Effect of including ATLAS data on PDF fits

Sample of 10^6 $W \to e\nu$ generated with CTEQ6.1 and ATLAS fast simulation
Statistics corresponds to ~ 100 pb^{-1}
4% systematic error included by hand (statistical error negligible)



Tricoli et al.

Central value of ZEUS-PDF prediction shifts and uncertainties is reduced
Error on low-x gluon shape parameter λ ($xg(x) \sim x^{-\lambda}$) reduced by 35%

Systematics (e.g. $e^{\pm}$ acceptance vs η) can be controlled to few percent with $Z \to ee$
(~ 30000 events for 100 pb^{-1})

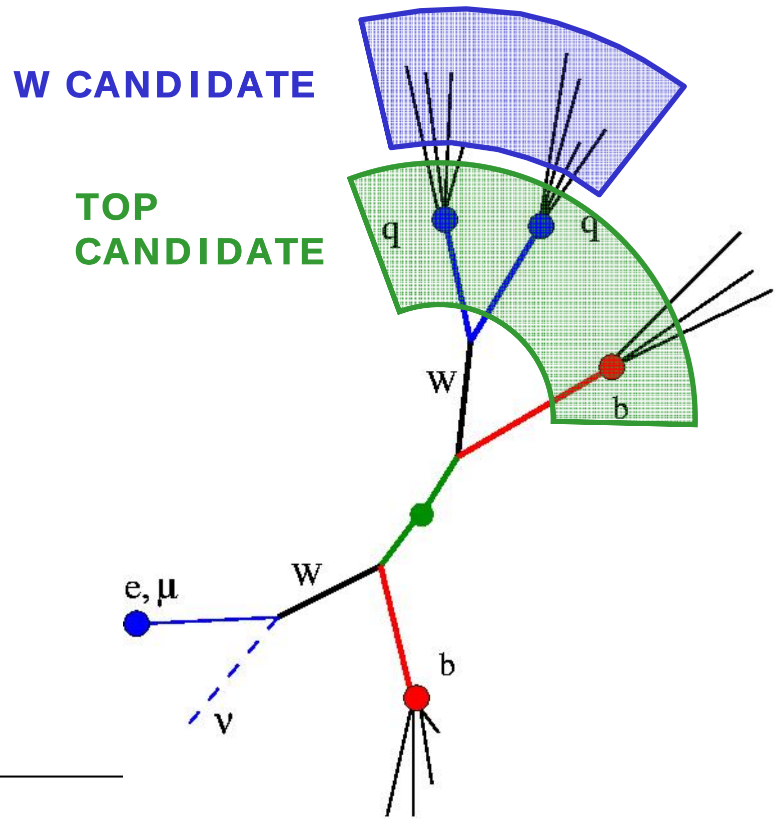
Commissioning ATLAS detector and physics with top events

Can we observe an early top signal with limited detector performance ?
Can we use such a signal to understand detector and physics ?

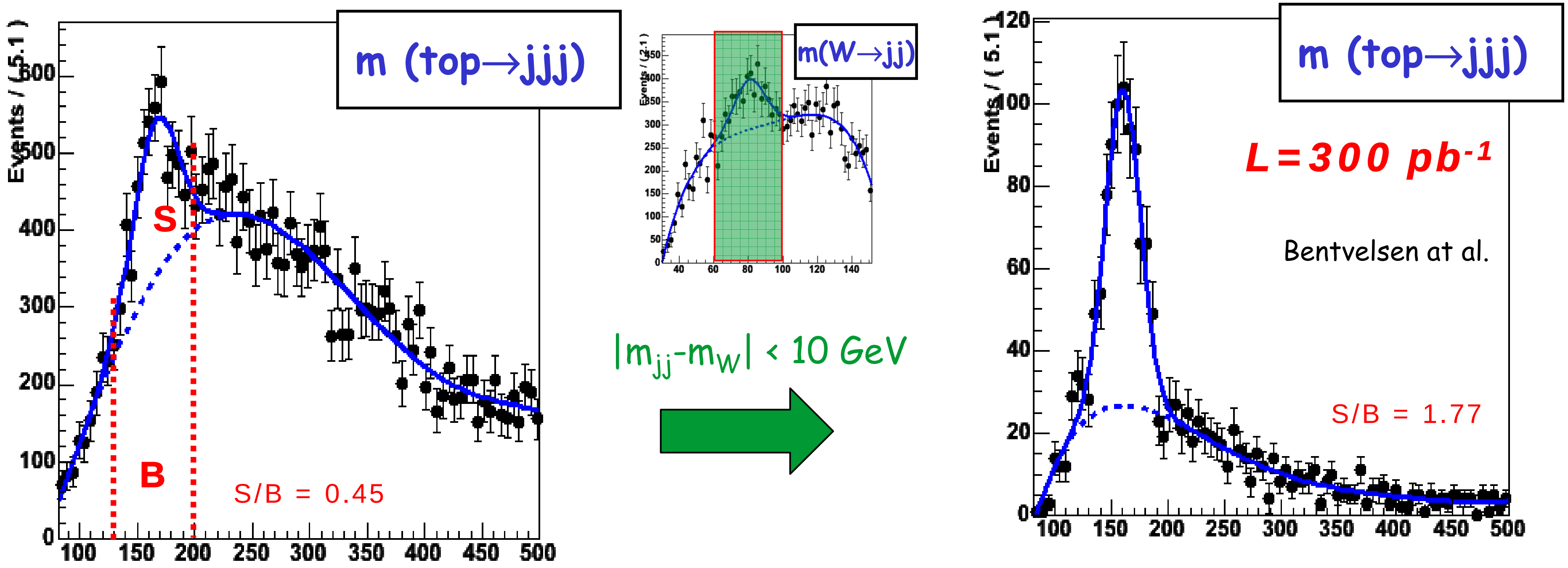
YES !

σ_{tt} (LHC) ≈ 250 pb for gold-plated semi-leptonic channel

- use simple and robust selection cuts:
  p_T (l) > 20 GeV
  E_T^{miss} > 20 GeV
  only 4 jets with p_T > 40 GeV
  } $\varepsilon \sim 5\%$
- no b-tagging required (early days …)
- m (top → jjj) from invariant mass of 3 jets giving highest top p_T
- m (W→jj) from 2 jets with highest momentum in jjj CM frame



Total efficiency, including m_{jjj} inside m_{top} mass bin : ~ 1.5% (preliminary and conservative …)



S : MC @ NLO
B : AlpGen x 2 to account for W+3,5 partons (pessimistic)

Expect ~ 100 events inside mass peak for 30 pb^{-1}
→ top signal observable in early days with no b-tagging and simple analysis

W+jets background can be understood with MC+data (Z+jets)

tt is excellent sample to:

- -- commission b-tagging, set jet E-scale using W → jj peak and W-mass contraint
- -- understand detector performance and reconstruction tools for many physics objects (e, μ, jets, b-jets, missing E_T, ..)
- -- understand / tune MC generators using e.g. p_T spectra

Conclusions

Understanding (complex) ATLAS and CMS detectors in (complex) LHC environment will require a lot of time and a lot of data

Experience with pre-collision data (combined test-beam, runs with cosmics) is crucial to accelerate this phase (in a more relaxed environment …) :

- understand many aspects of detector performance in "realistic" environment disentangle some of the systematic effects
- fix some problems, set calibration and alignment beyond initial calibration/survey
- exercise procedures for data validation, calibration and alignment
- exercise and optimize software tools

Physics commissioning with first collision data ($1 \rightarrow 100$ pb^{-1} ?) :

- understand detector performance in situ ⇔ physics (the two are correlated !)
- measure particle multiplicity in minimum bias (a few hours of data taking …)
- measure QCD jets ($>10^3$ events with E_T (j) > 1 TeV with 100 pb^{-1}) and their underlying event
- measure W, Z cross-sections : to 15% with <10 pb^{-1} and 10% with 100 pb^{-1} ?
- observe a top signal with ~ 30 pb^{-1}
- measure tt cross-section to 20% and m(top) to 7-10 GeV with 100 pb^{-1} ?
- improve knowledge of PDF (low-x gluons !) with W/Z: with O(100) pb^{-1} ?
- first tuning of MC (minimum bias, underlying event, tt, W/Z+jets, QCD jets,…)

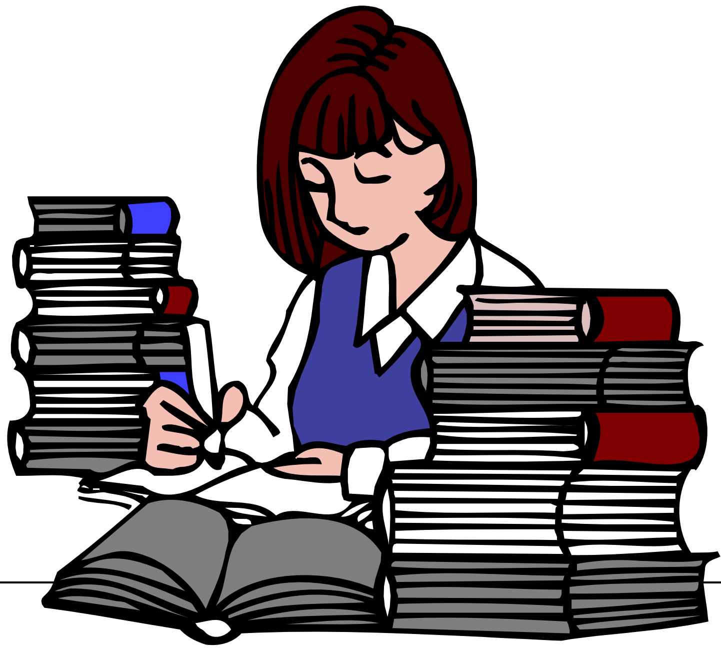
The first physics paper(s) with 10-100 pb^{-1} ?

Measurements of particle multiplicities and energy flow in pp collisions at $\sqrt{s}$ = 14 TeV

Measurements of the W and Z production cross-sections in pp collisions at $\sqrt{s}$ = 14 TeV

Measurement of the tt production cross-section in pp collisions at $\sqrt{s}$ = 14 TeV

…. …..



Back-up slides

LHC start-up scenario

Stage 1
Initial commissioning
43x43 to 156x156, $N=3\times10^{10}$
Zero to partial squeeze

$L=3\times10^{28} - 2\times10^{31}$

Stage 2
75 ns operation
936x936, $N=3\text{-}4\times10^{10}$
partial squeeze

$L=10^{32} - 4\times10^{32}$

Stage 3
25 ns operation
2808x2808, $N=3\text{-}5\times10^{10}$
partial to near full squeeze

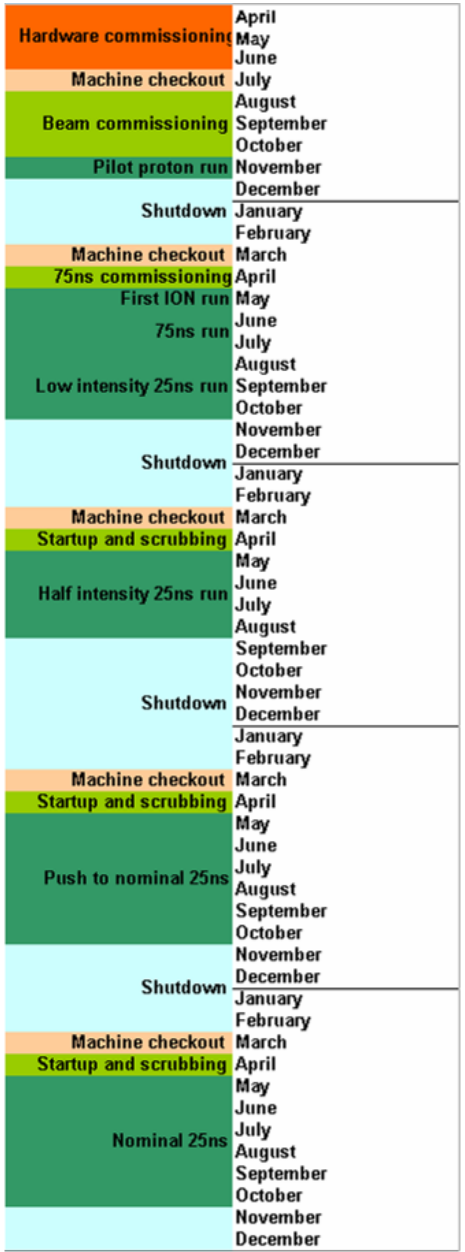
$L=7\times10^{32} - 2\times10^{33}$

Stage 4
25 ns operation
Push to nominal per bunch
partial to full squeeze

$L=10^{34}$

“ Difficult to speculate further on what the performance might be in the first year. As always, CERN accelerators departments will do their best !”

Lyn Evans, LHC Project Leader



LHC Kinematic regime

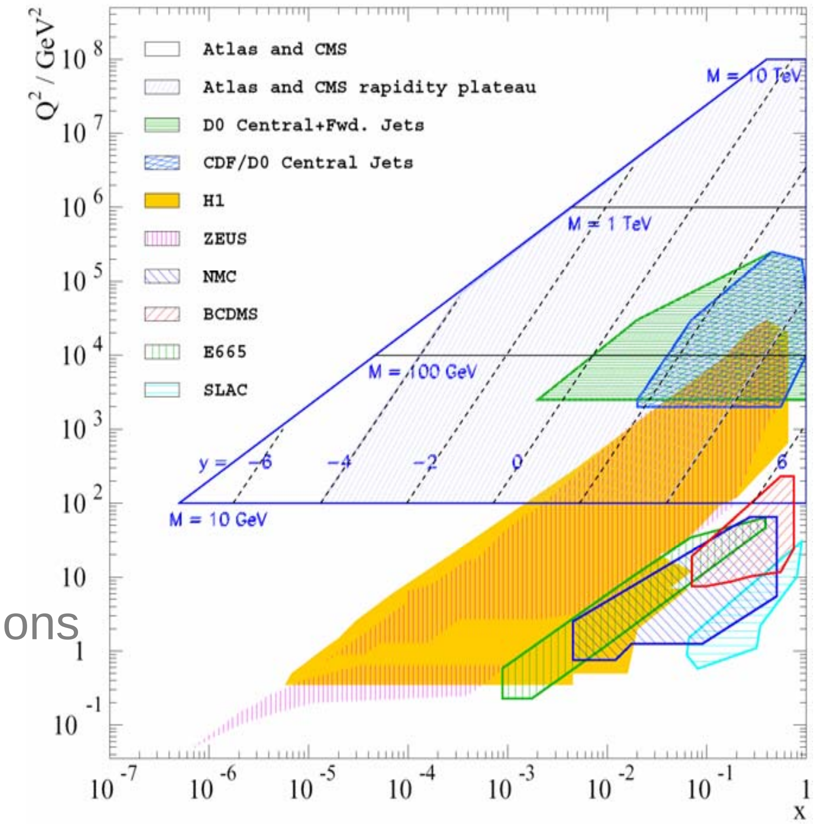
Kinematic regime for LHC much broader than currently explored

➡ Test of QCD:

- Test DGLAP evolution at small x:
  - Is NLO DGLAP evolution sufficient at so small x ?
  - Are higher orders $\sim \alpha_s^n \log^m x$ important?
- Improve information of high x gluon distribution

At TeV scale New Physics cross section predictions are dominated by **high-x gluon** uncertainty
(not sufficiently well constrained by PDF fits)

At the EW scale theoretical predictions for LHC are dominated by **low-x gluon** uncertainty
(i.e. W and Z masses) => see later slides



$$x_{1,2} = \frac{M}{\sqrt{s}} \exp(\pm y) \qquad Q = M \qquad y = \frac{1}{2}\ln\left(\frac{E+p_z}{E-p_z}\right)$$

How can we constrain PDF's at LHC?

PDF scenario at LHC start up (2007) might be different

•In most of the relevant x regions accessible at LHC
HERA data are most important source of information in PDF determinations
(low-x sea and gluon PDFs)

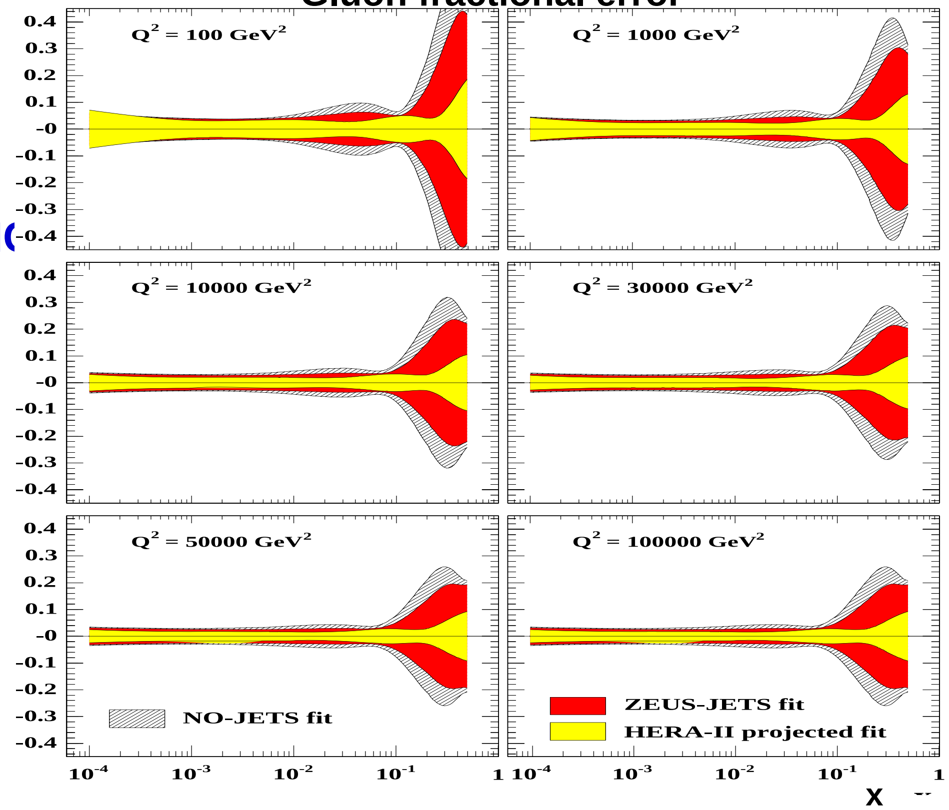
•HERA now in second stage of operation (HERA-II)
- substantial increase in luminosity
- possibilities for new measurements

HERA-II projection **shows significant improvement to high-x PDF uncertainties**

⇒ relevant for high-scale physics at the LHC

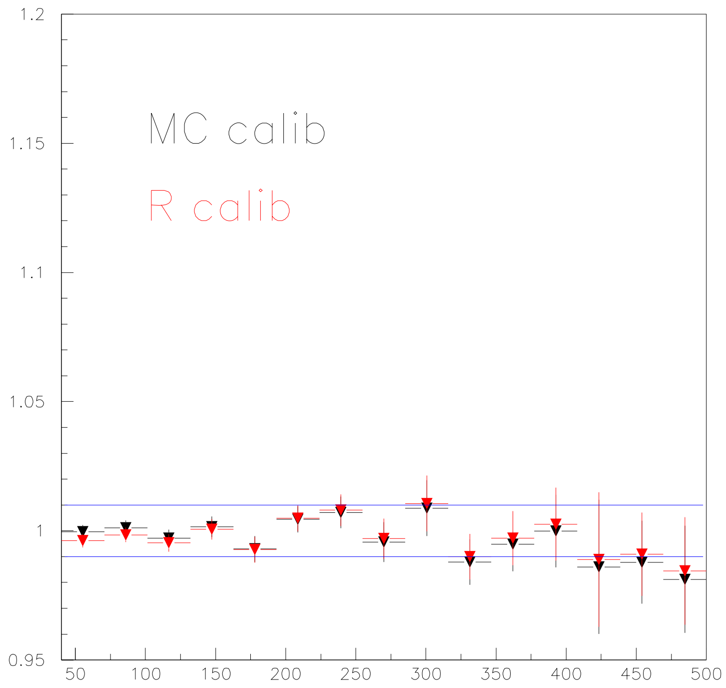
→ where we expect new physics !!

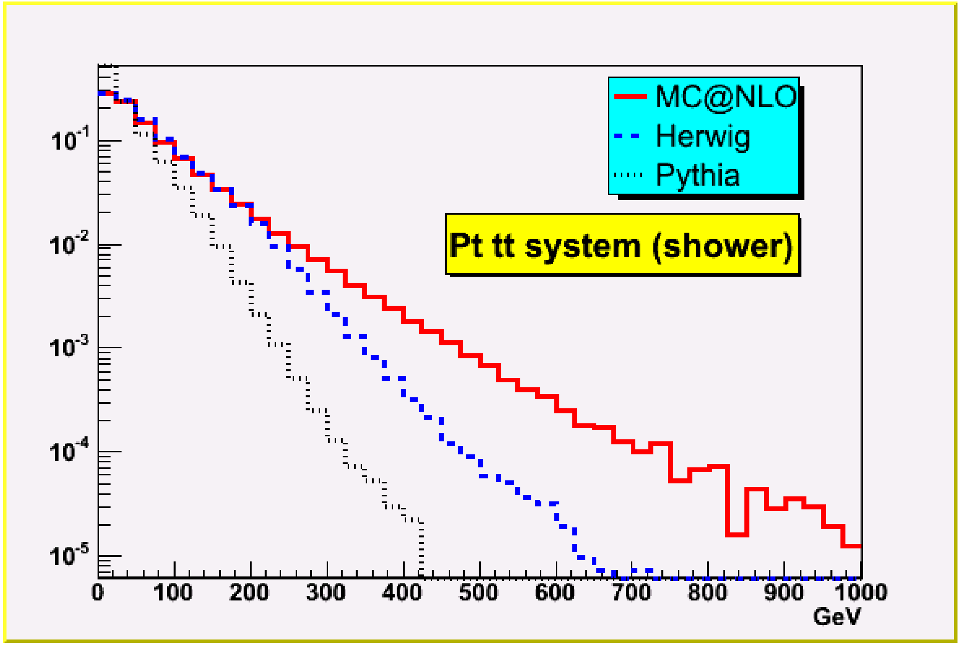
Gluon fractional error

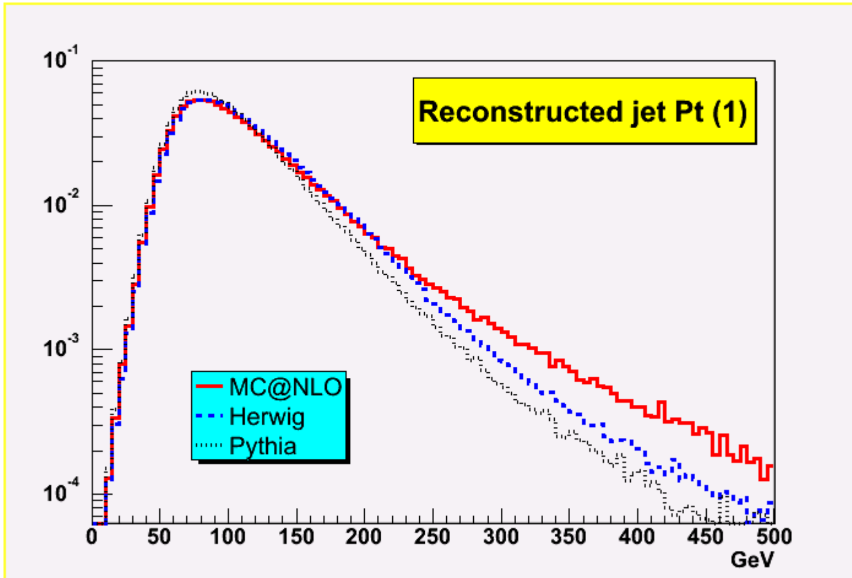


- significant improvement to <u>valence-quark</u> uncertainties over <u>all-x</u>
- significant improvement to <u>sea and gluon</u> uncertainties at <u>mid-to-high-x</u>
- little visible improvement to <u>sea and gluon</u> uncertainties at <u>low-x</u>

Use the W mass constraint to set the JES.
Rescale jet E and angles to parton energy $\alpha = E_{parton} / E_{jet}$

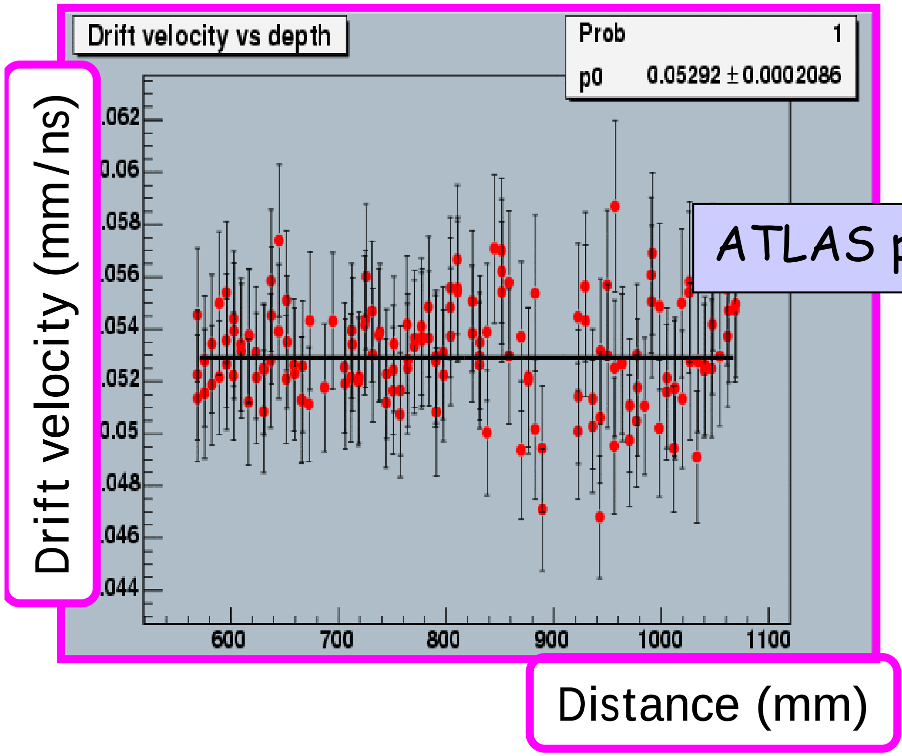


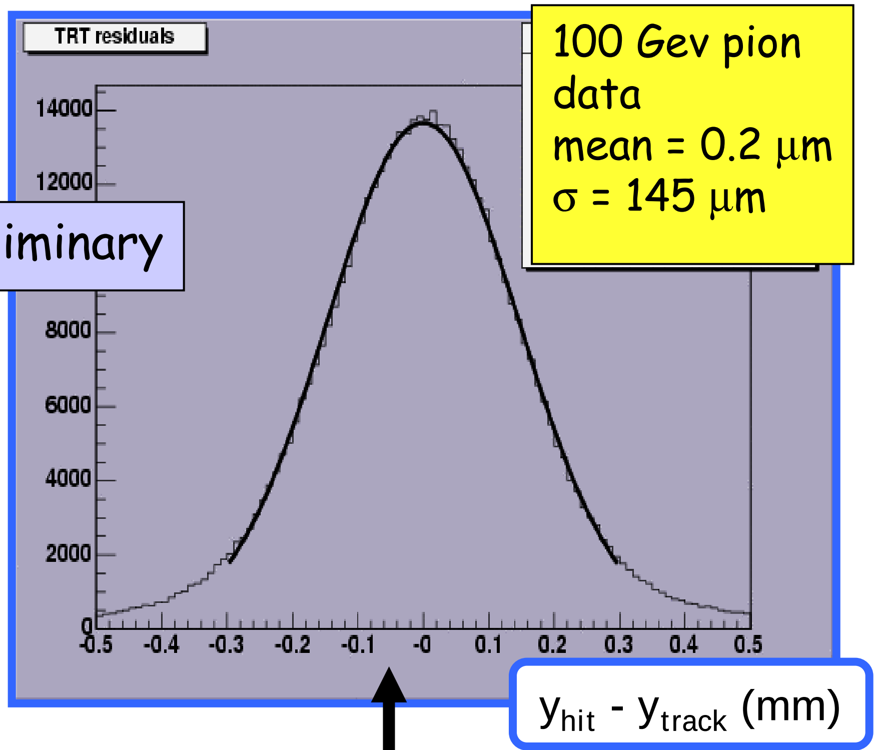




TRT internal alignment and calibration exercised:

-- find T_0 values for each straw
-- determine R-t relation for each straw
-- align modules
-- align individual wires





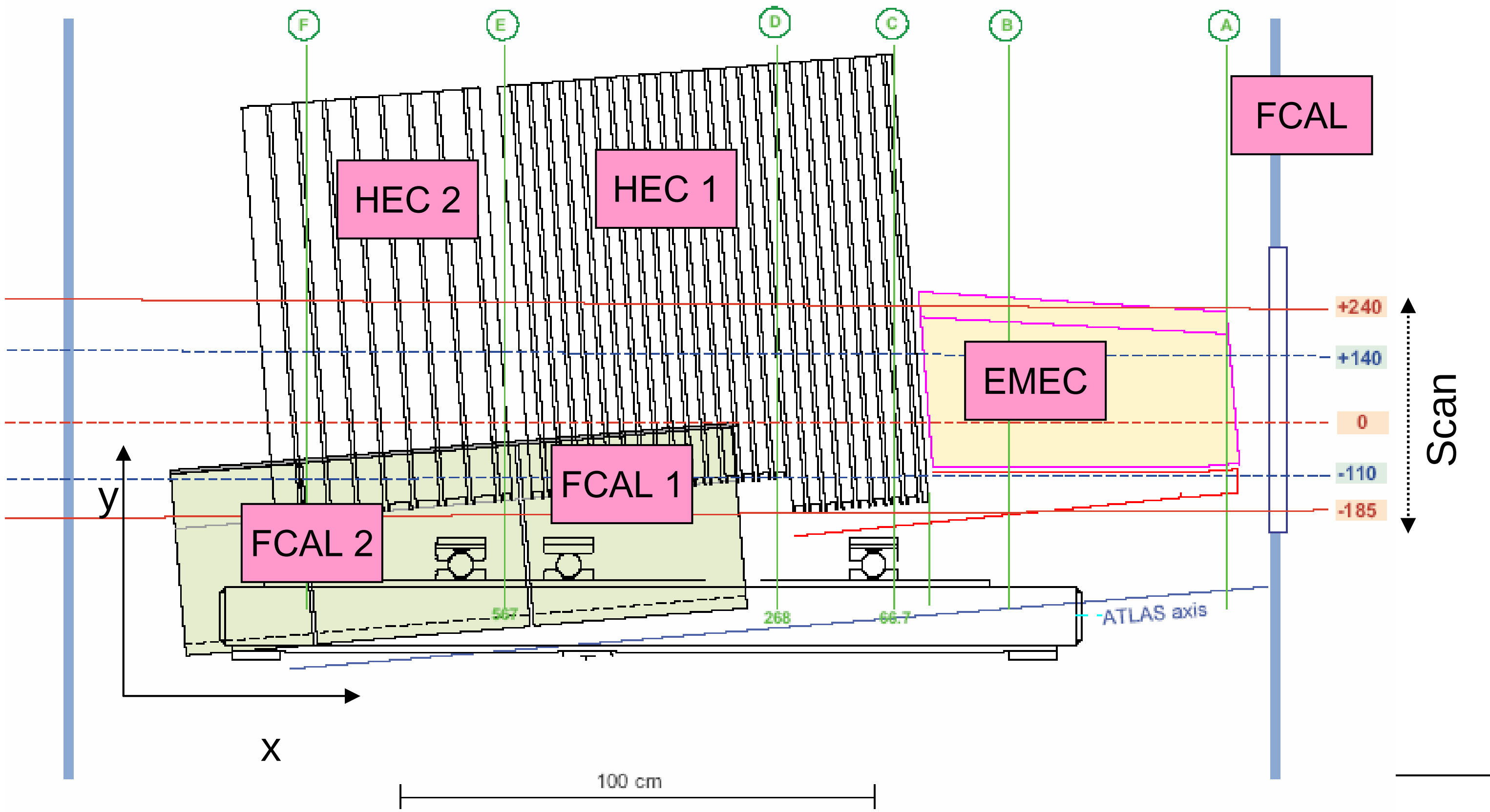
In agreement with expected detector resolution
σ (simulation) ≈ 138 μm

ATLAS @ LHC: new set of calibration/alignment constants every fill using p_T>2 GeV trakcs

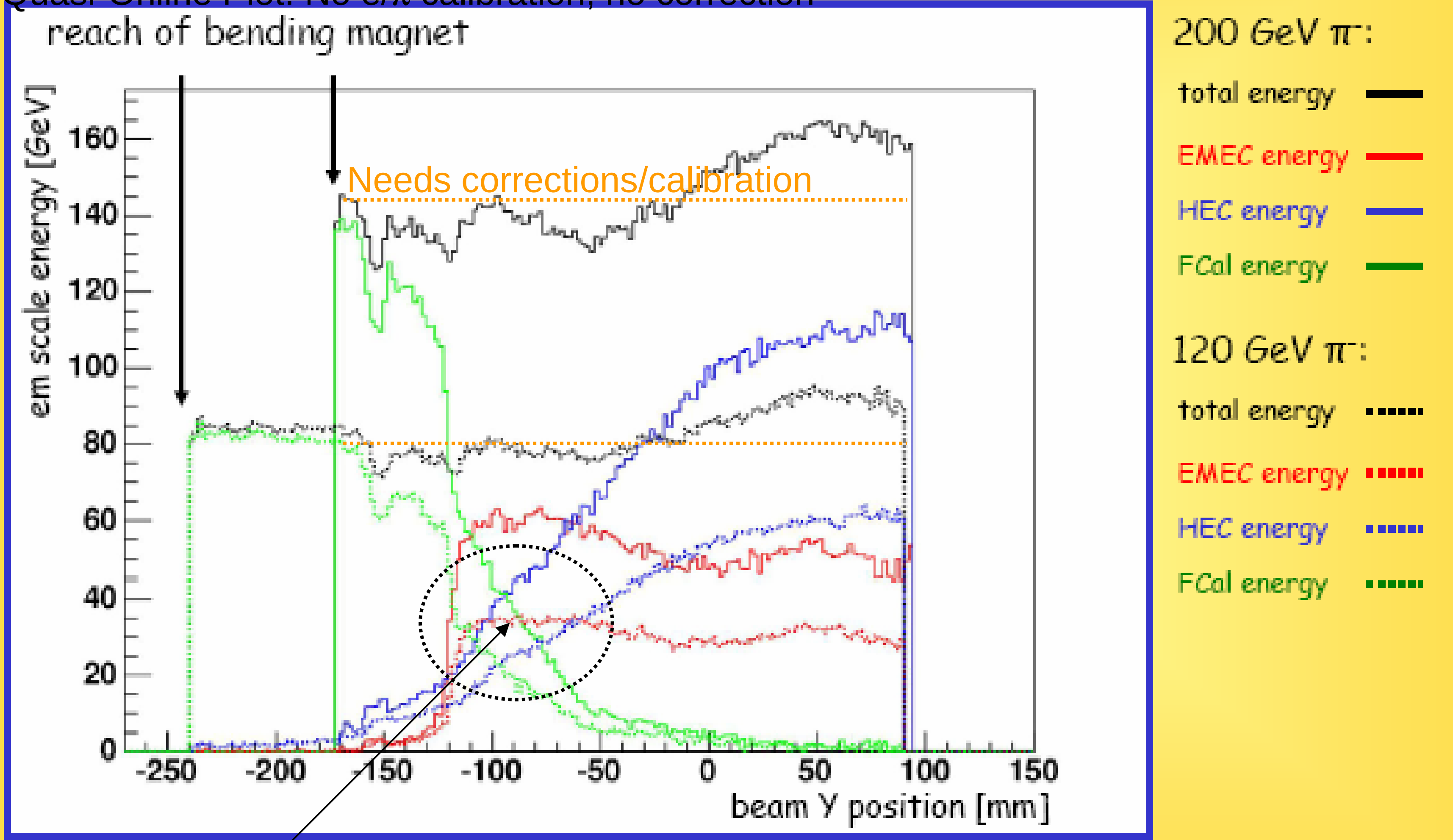
EMEC/HEC/FCAL 2004: H6 Set-up

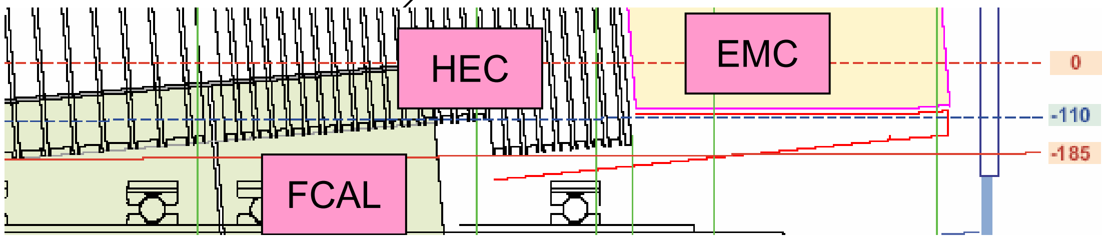
Goals:

- study transition region at η =3.2
- intercalibrate subdetectors: 3 technologies/communities !
- study dead material energy losses, cracks etc.
- study tails in energy resolution
- validate GEANT 4
- study hadronic energy weighting schemes



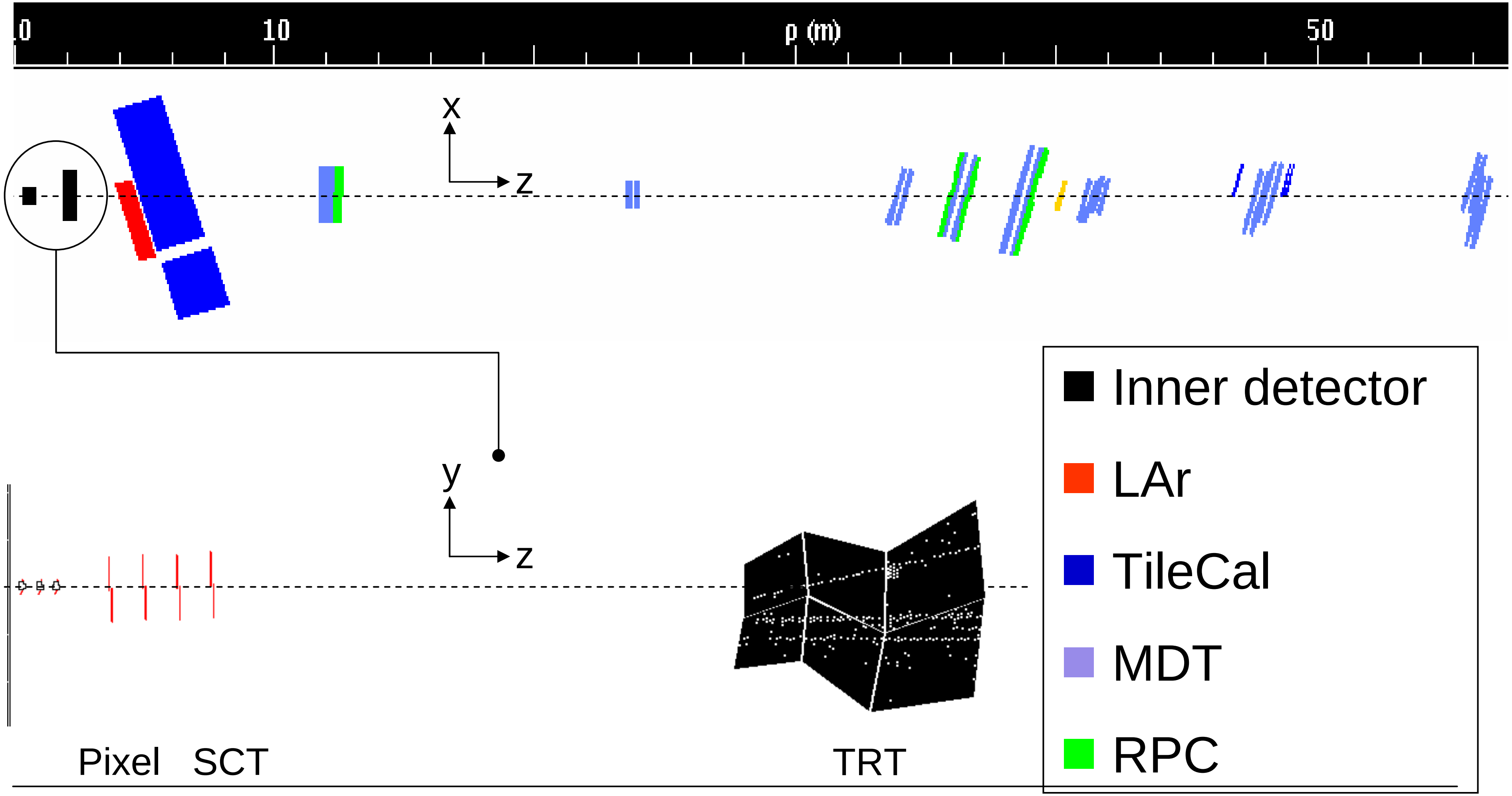
Quasi-Online Plot: No e/π calibration, no correction



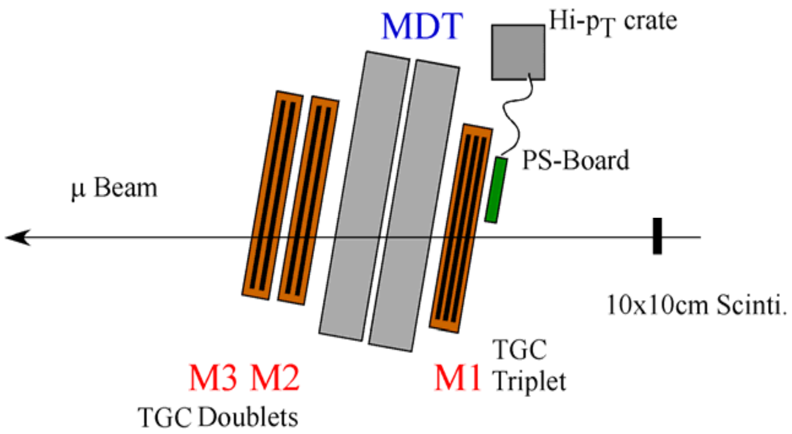


Study relative energy sharing and intercalibration of calorimeters

The 2004 H8 ATLAS barrel slice



TGC: LVL1 trigger efficiency



7 layers of TGC in 3 stations

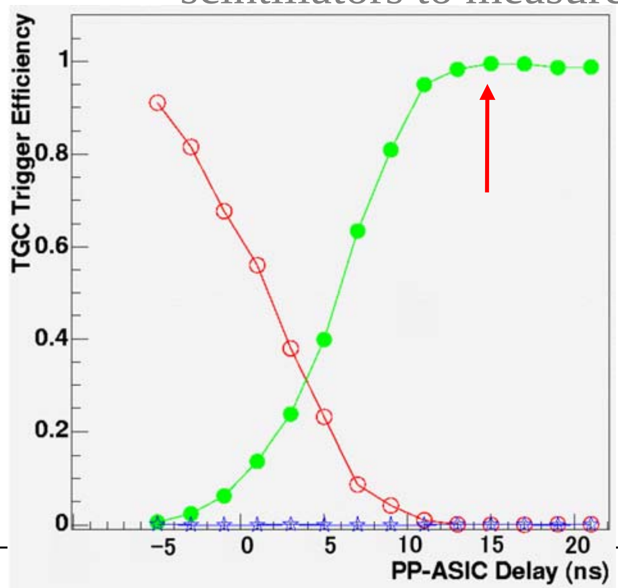
Full chain of trigger/readout electronics for a part of "forward region"

- All on-board ASICs have full functionality
- DAQ including DCS in RCD framework
- 25ns bunched Muons triggered with 10x10 scintillators to measure High-Pt trigger efficiency

25ns bunched Muons triggered with 10x10 scintillators to measure High-Pt trigger efficiency

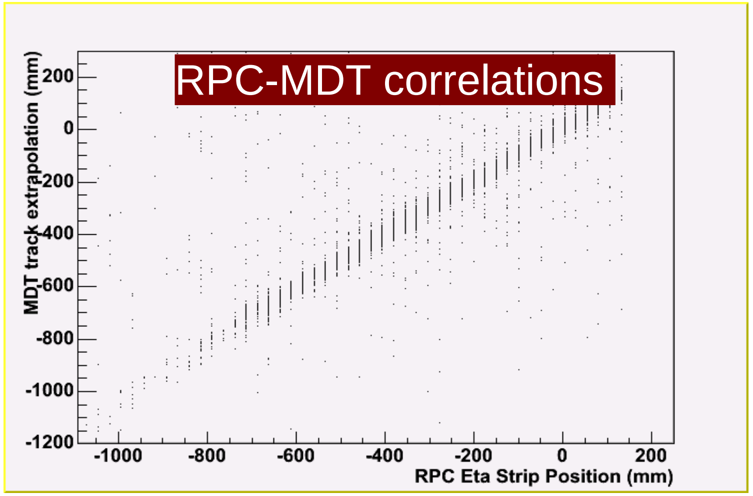
Adjust Delay/Gate Width parameters

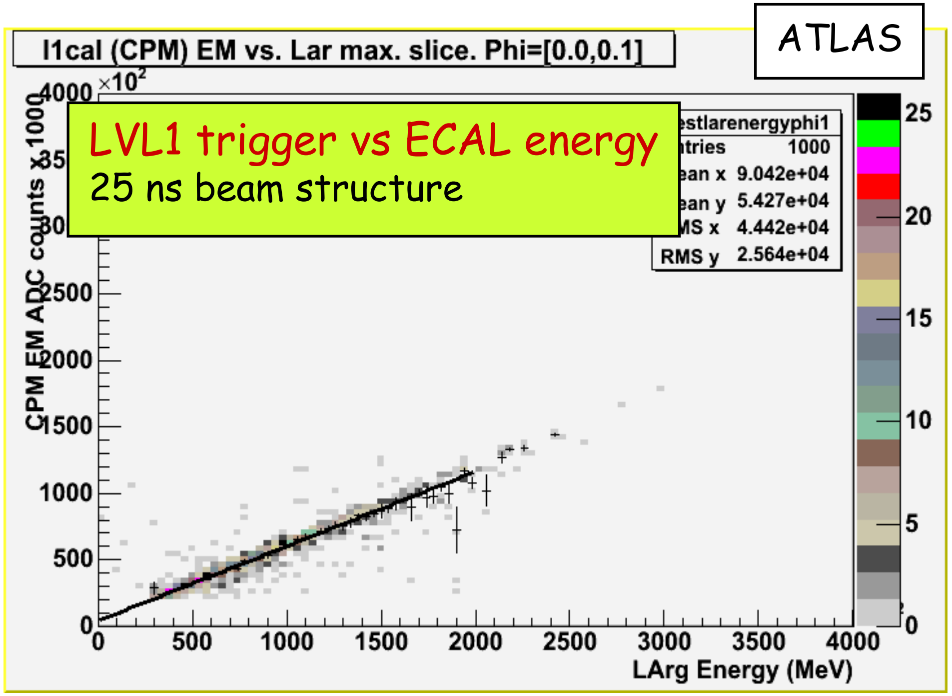
maximize Trigger efficiency and BCID performance



- 98% trigger efficiency
  - ~1% spurious 10x10
  - ~1% tracks out of phase

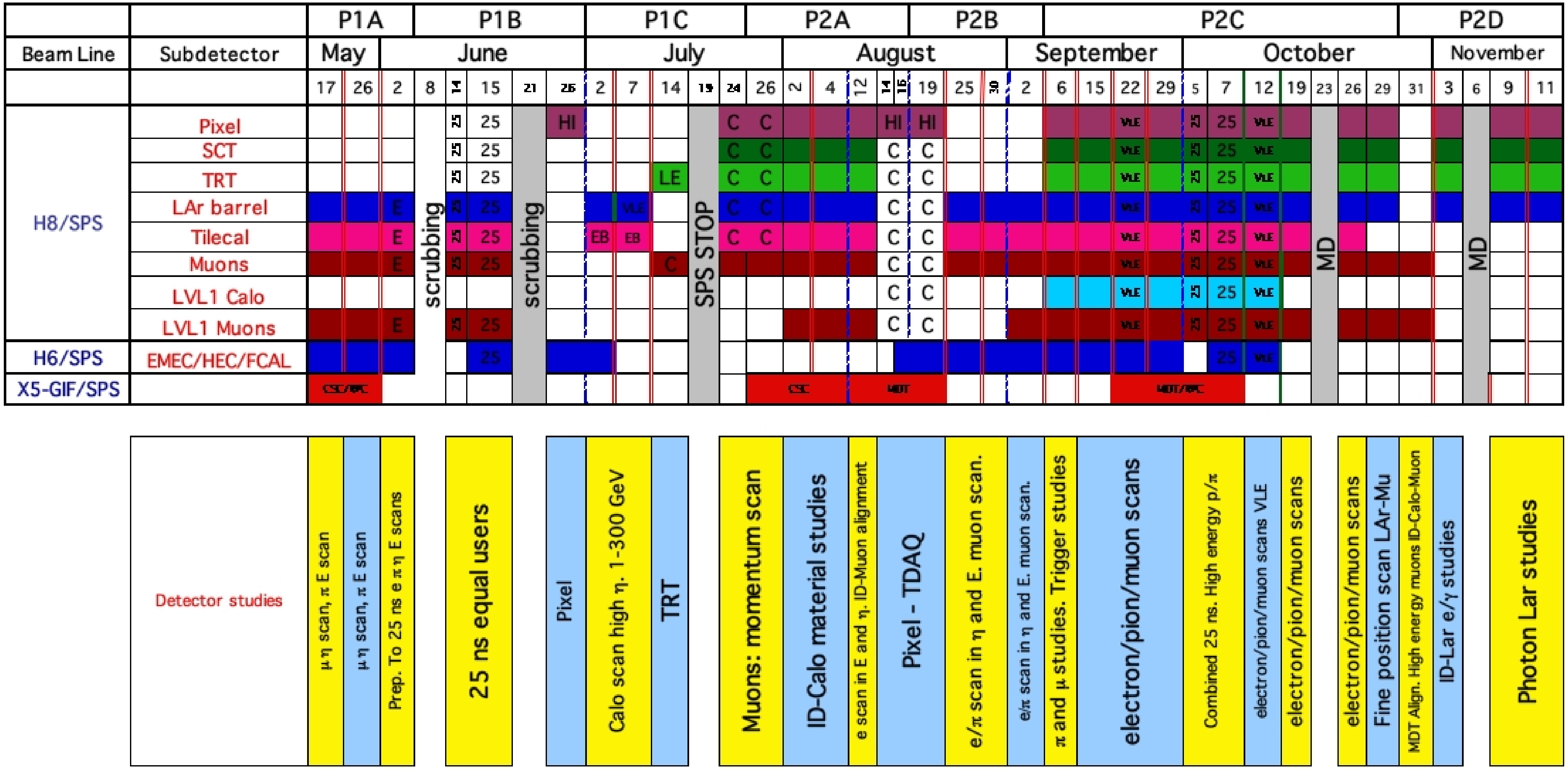
● Triggered Bunch
★ Next Bunch
○ Previous Bunch





- Region-of-Interest trigger information successfully transmitted
- RPC running in self-triggering mode
- RPC+MDT+TGC combined run show good (trigger and readout) synchronization
  - Full integration with all sub-detectors using Muon+Calo Trigger sent by CTP
  - BC identification tested after transmission to CTP First test of Muon Barrel off-detector trigger slice: Trigger Efficiency preliminary measurement = 99.4%

2004 Data taking schedule and samples
steady evolution from sub-systems to combined runs



-- HLT/DAQ deferrals limit available networking and computing for HLT → limit LVL1 output rate

-- <u>Large uncertainties</u> on LVL1 affordable rate vs money (component cost, software performance, etc.)

Selections (examples ...) Real thresholds set for 95% efficiency at these E_T	LVL1 rate (kHz) $L = 1 \times 10^{33}$ no deferrals	LVL1 rate (kHz) $L = 2 \times 10^{33}$ no deferrals	LVL1 rate (kHz) $L = 2 \times 10^{33}$ with deferrals An example for illustration...
MU6,8,20	23	19	0.8
2MU6	---	→ 0.2	→ 0.2
EM20i,25,25	11	12	12
2EM15i,15,15	2	→ 4	→ 4
J180,200,200	0.2	0.2	0.2
3J75,90,90	0.2	0.2	0.2
4J55,65,65	0.2	0.2	0.2
J50+xE50,60,60	0.4	0.4	0.4
TAU20,25,25 +xE30	2	2	2
MU10+EM15i	---	0.1	0.1
Others (pre-scaled, etc.)	5	5	5
Total	~ 44	~ 43	~ 25

LVL1 designed for 75 kHz
→ room for factor ~ 2 safety

Likely max affordable rate,
no room for safety factor

❸ Which data samples ?

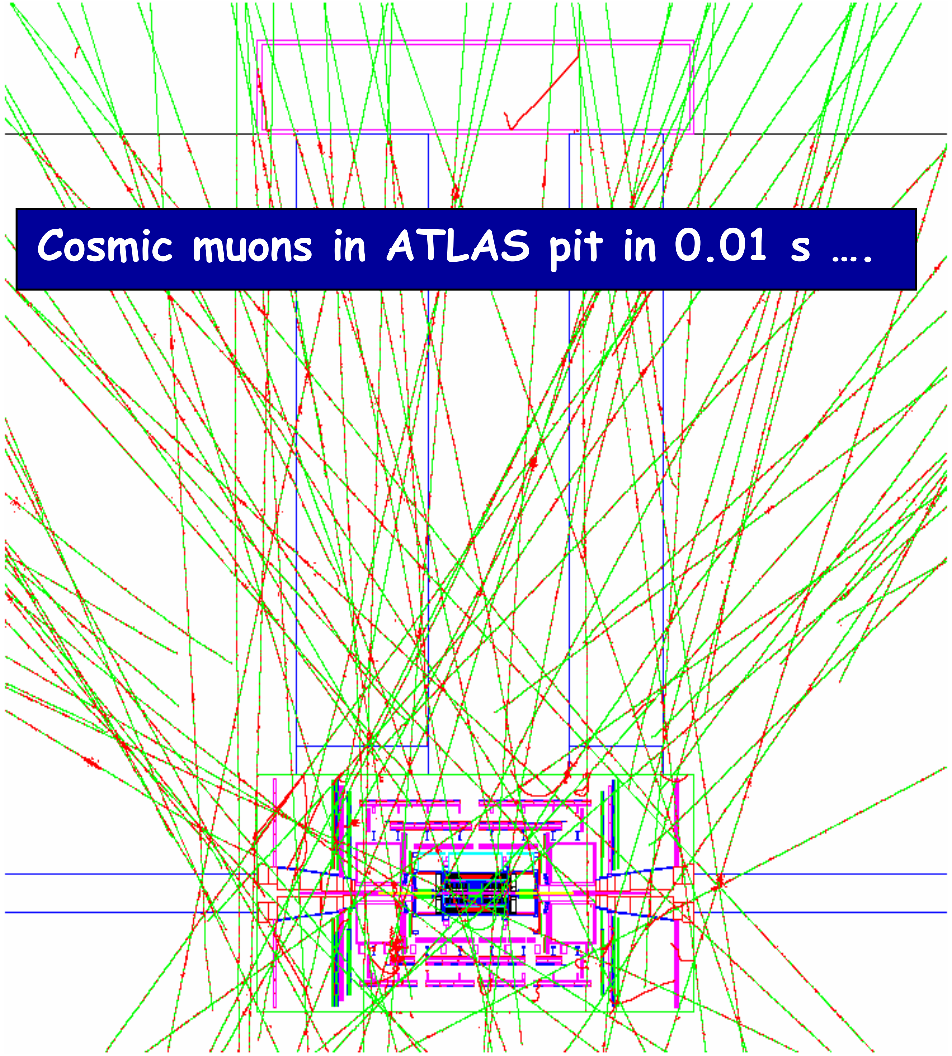
Total trigger rate to storage at 2 x 10^{33} reduced from ~ 540 Hz (HLT/DAQ TP, 2000) to ~ 200 Hz (now)

High-Level-Trigger output

⬇

Selection (examples …)	Rate to storage at 2×10^{33} (Hz)	Physics motivations (example
e25i, 2e15i	~ 40 (55% W/b/c → eX)	Low-mass Higgs (ttH, H→ 4ℓ, qq
μ20i, 2μ10	~ 40 (85% W/b/c → μX)	W, Z, top, New Physics ?
γ60i, 2γ20i	~ 40 (57% prompt γ)	H → γγ, New Physics (e.g. X → γ yy m_X~ 500 GeV
j400, 3j165, 4j110	~ 25	Overlap with Tevatron for new X → jj in danger …
j70 + xE70	~ 20	SUSY : ~ 400 GeV squarks/glui
τ35 + xE45	~ 5	MSSM Higgs, New Physics (3rd family !) ? More difficult
2μ6 (+ m_B)	~ 10	Rare decays B → μμX
Others (pre-scaled, exclusive, …)	~ 20	Only 10% of total !
Total	~ 200	No safety factor included. "Signal" (W, γ, etc.) : ~ 100 H

Best use of spare capacity when L < 2 x 10^{33} being investigated



From full simulation of ATLAS (including cavern, overburden, surface buildings) + measurements with scintillators in the cavern:

Through-going muons	~ 25 Hz
(hits in ID + top and bottom muon chambers)	
Pass by origin	~ 0.5 Hz
(|z| < 60 cm, R < 20 cm, hits in ID)	
Useful for ECAL calibration	~ 0.5 Hz
(|z| < 30 cm, E_{cell} > 100 MeV, ~ 90^0)	

→ ~ 10^6 events in ~ 3 months of data taking

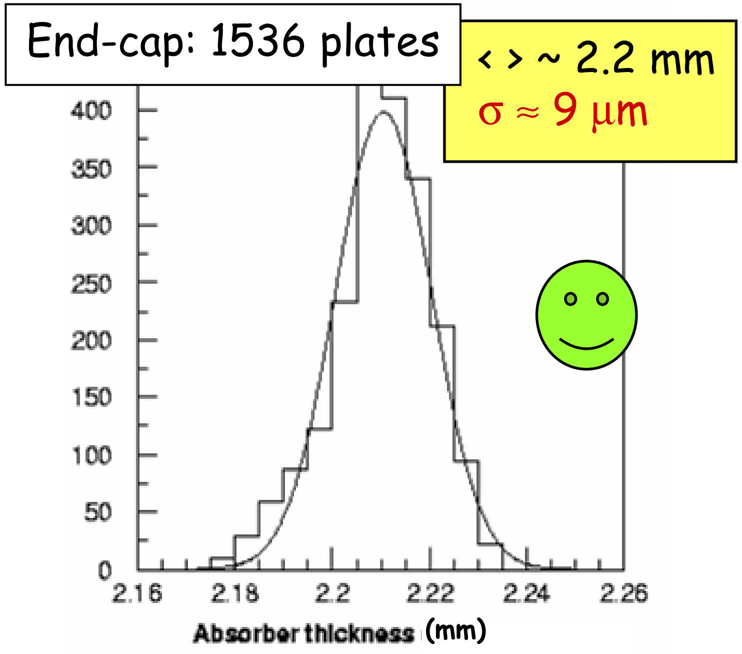
→ enough for initial detector shake-down

(catalog problems, gain operation experience, some alignment/calibration, detector synchronization, …)

❶ Construction quality

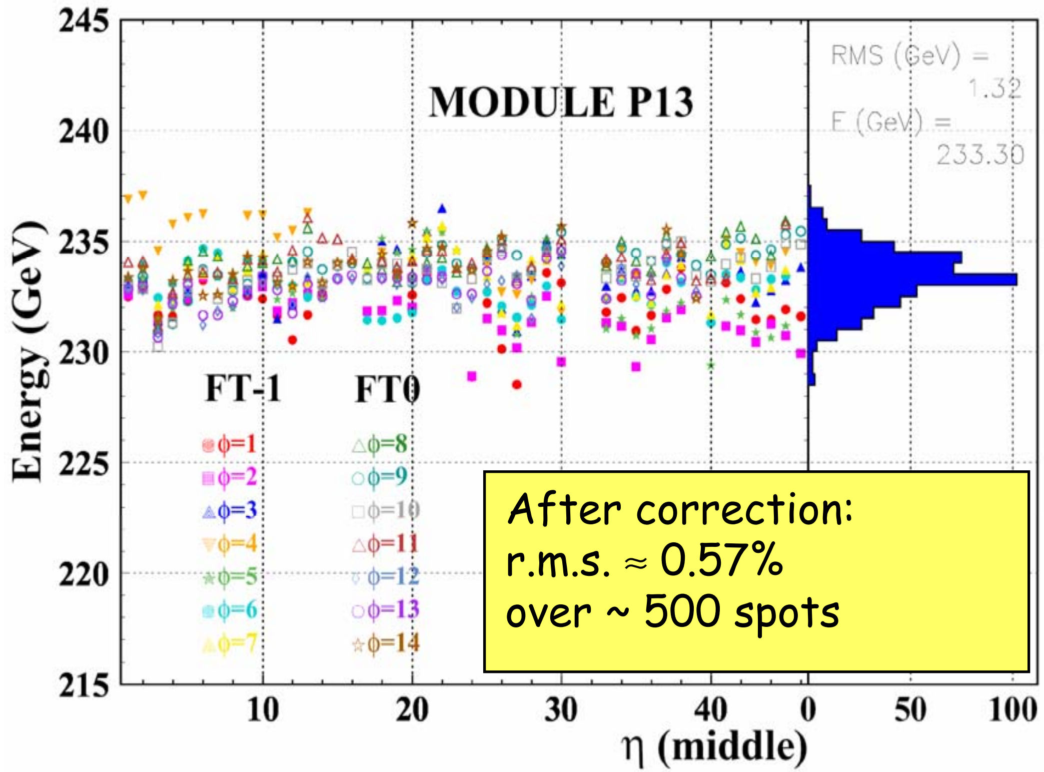
Thickness of Pb plates must be uniform to 0.5% (~10 μm)

End-cap: 1536 plates



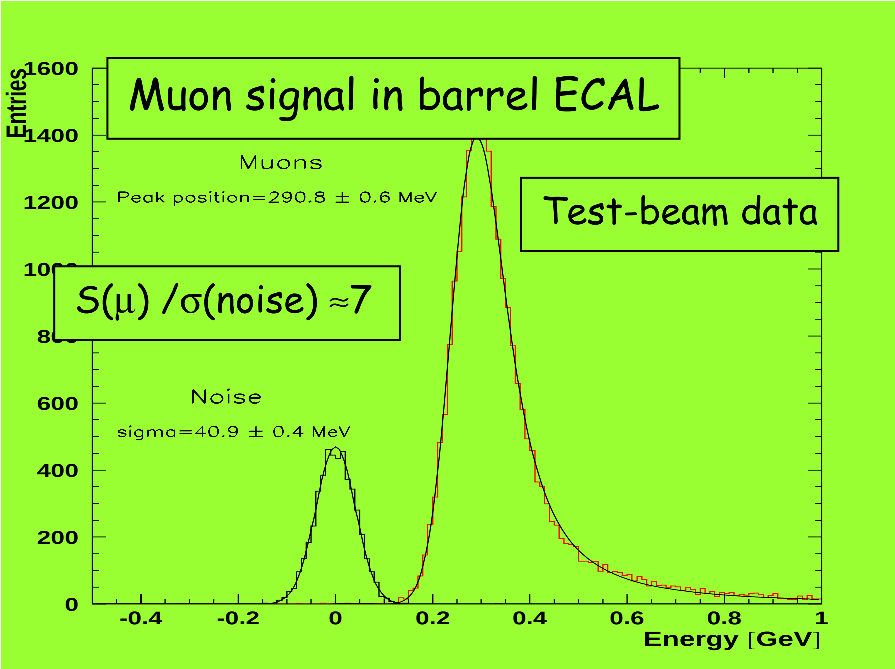
❷ Test-beam measurements

Scan of a barrel module (Δφ×Δη=0.4×1.4) with high-E electrons



❸ Cosmics runs:

Measured cosmic μ rate in ATLAS pit : few Hz
→ ~ 10^6 events in ~ 3 months of cosmics runs beginning 2007
→ enough for initial detector shake-down
→ ECAL : check calibration vs η to 0.5%



❹ First collisions : calibration with $Z \rightarrow ee$ events (rate ≈ 1 Hz at 10^{33})

Use Z-mass constraint to correct long-range non-uniformities
(module-to-module variations, effect of upstream material, etc.)
~ 10^5 $Z \rightarrow ee$ events (few days data taking at 10^{33}) enough to achieve constant term $c \leq 0.7\%$

Nevertheless, let's consider the worst (unrealistic ?) scenario : no corrections applied

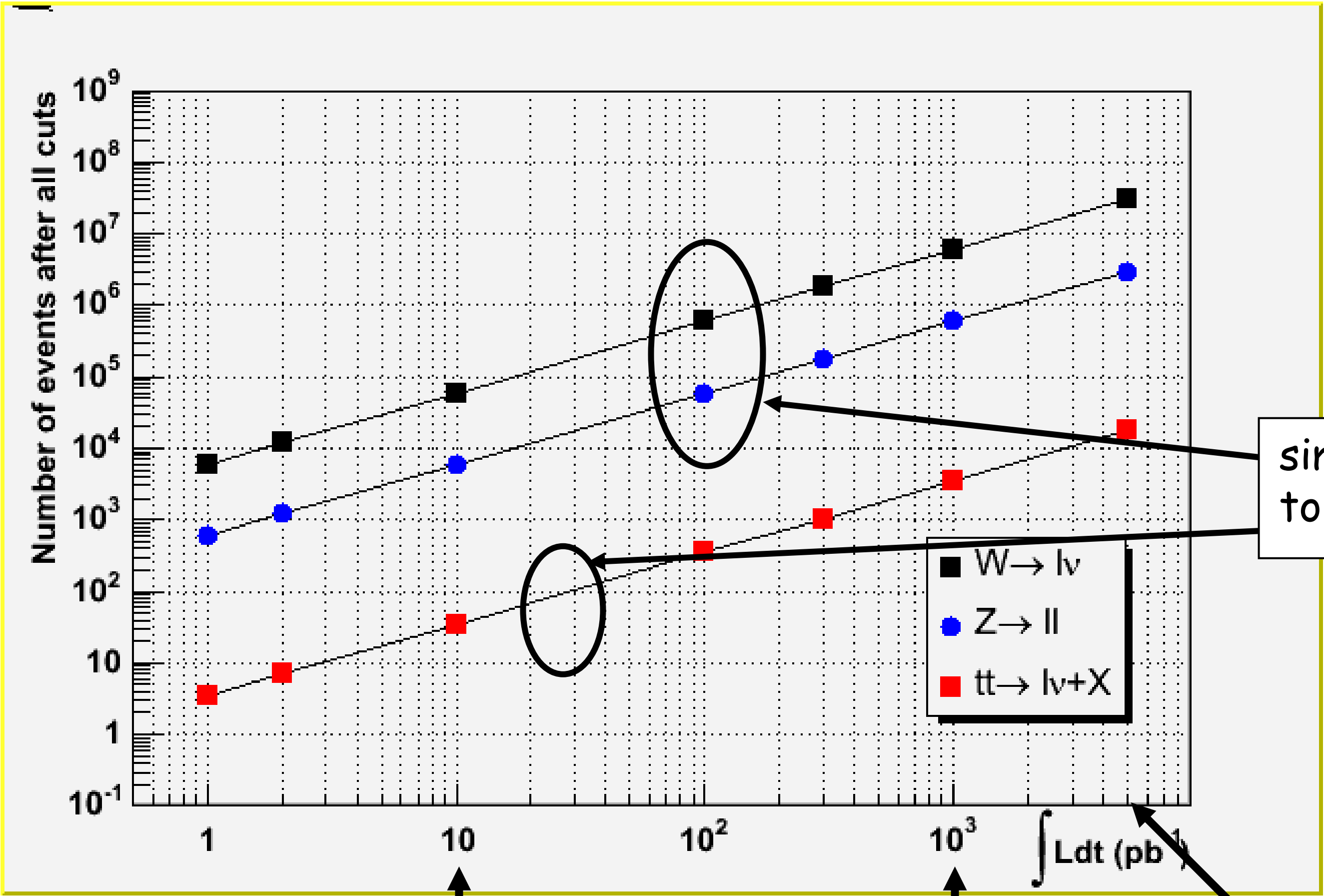
ECAL non-uniformity at construction level, i.e.:
-- no test-beam corrections
-- no calibration with $Z \rightarrow ee$

} → $c \approx 2\%$

↓

$H \rightarrow \gamma\gamma$ significance m_H~ 115 GeV degraded by ~ 25%
→ need 50% more L for discovery

How many events in ATLAS at the beginning ? And when ?



similar statistics to CDF, D0 today

10 pb^{-1} ≡ 1 month at 10^{30} + < 2 weeks at 10^{31}, ε=50%

1 fb^{-1} ≡ 6 month at 10^{32}, ε=50%

5 fb^{-1} ≡ 3 month at 10^{32} + 3 month at 10^{33}, ε=50%

→ end 2007 ?

→ end 2008 ?