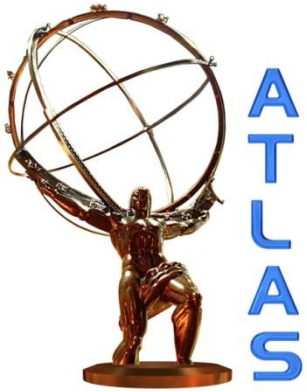
ATLAS



Neckarzimmern, 18.2.2010

Rainer Stamen
Kirchhoff-Institut für Physik
Universität Heidelberg

Content

- ATLAS: Physics and Detector
- The Level 1 Calorimeter Trigger
- Commissioning examples
- ATLAS Performance and First Physics

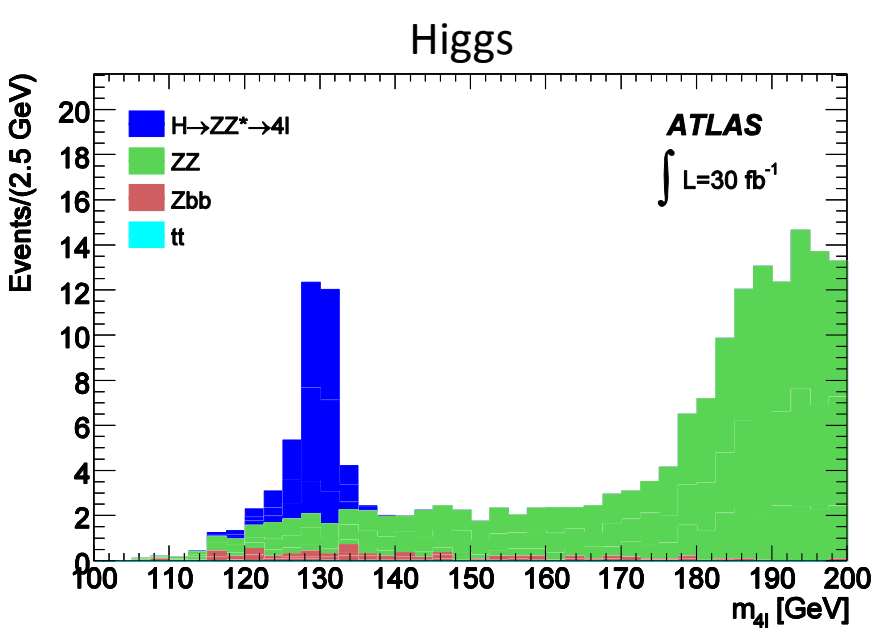
ATLAS
Physics and Detector

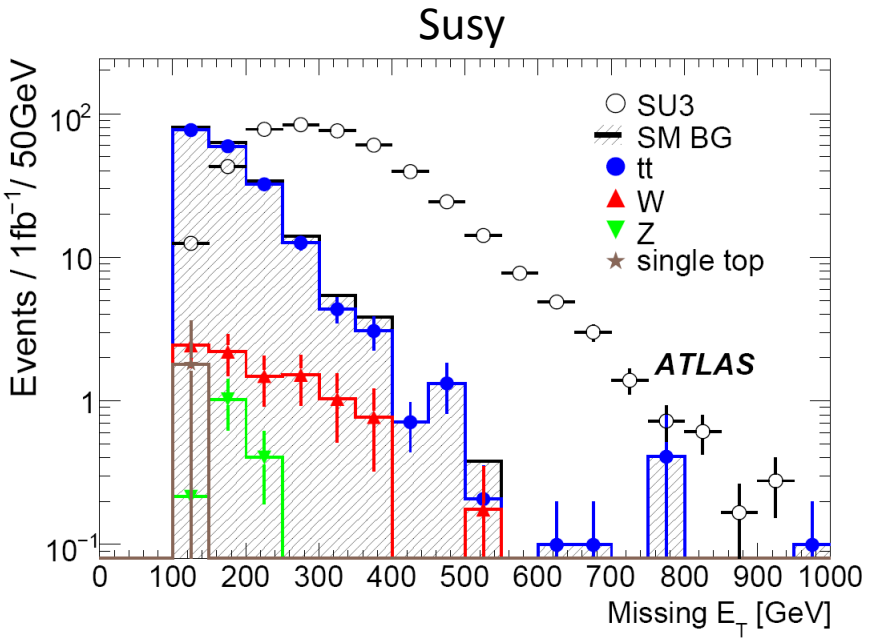
What and What Not?

- Stress Tests of the Standard Model
- **Search for new Physics**
  - Precision Measurements (W mass...)
  - Some B-physics
  - Some Heavy Ion Physics

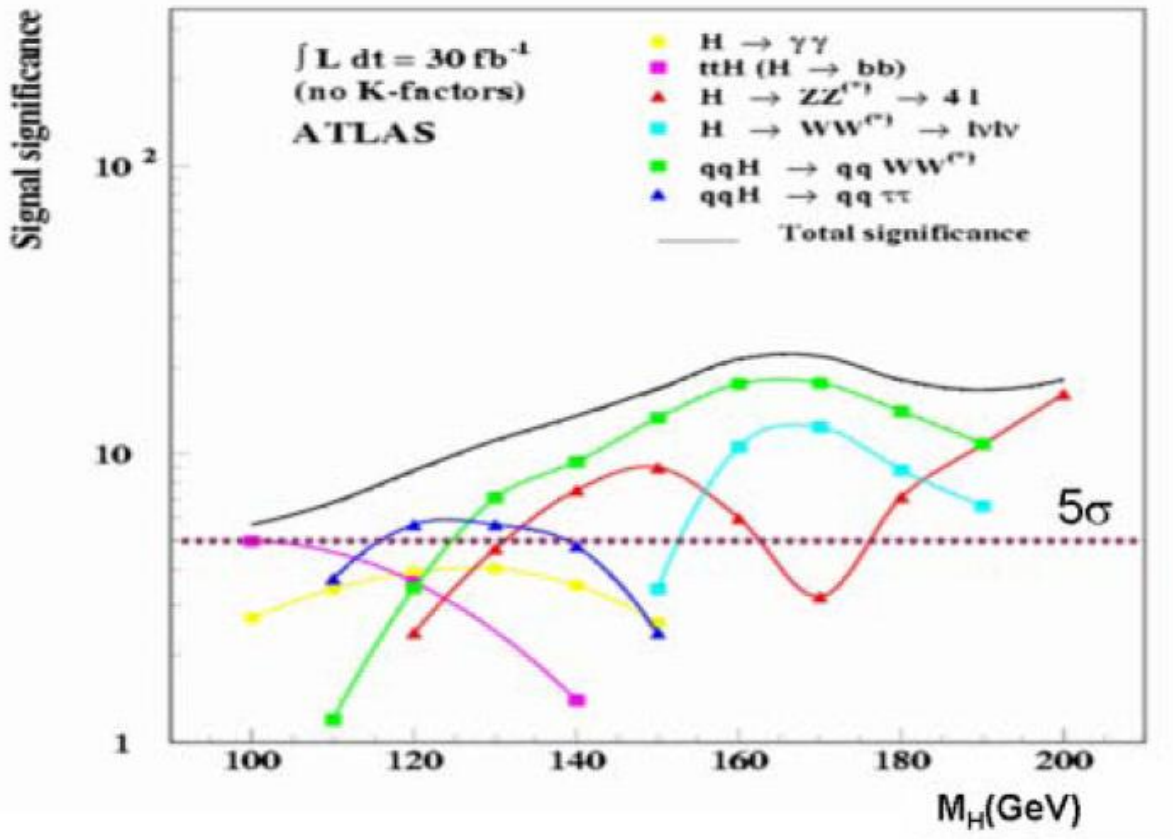
Search for New Physics

- Higgs
- Supersymmetry
- Extra Dimensions (Micro Black Holes,...)
- Compositness, ...





Physics Objects



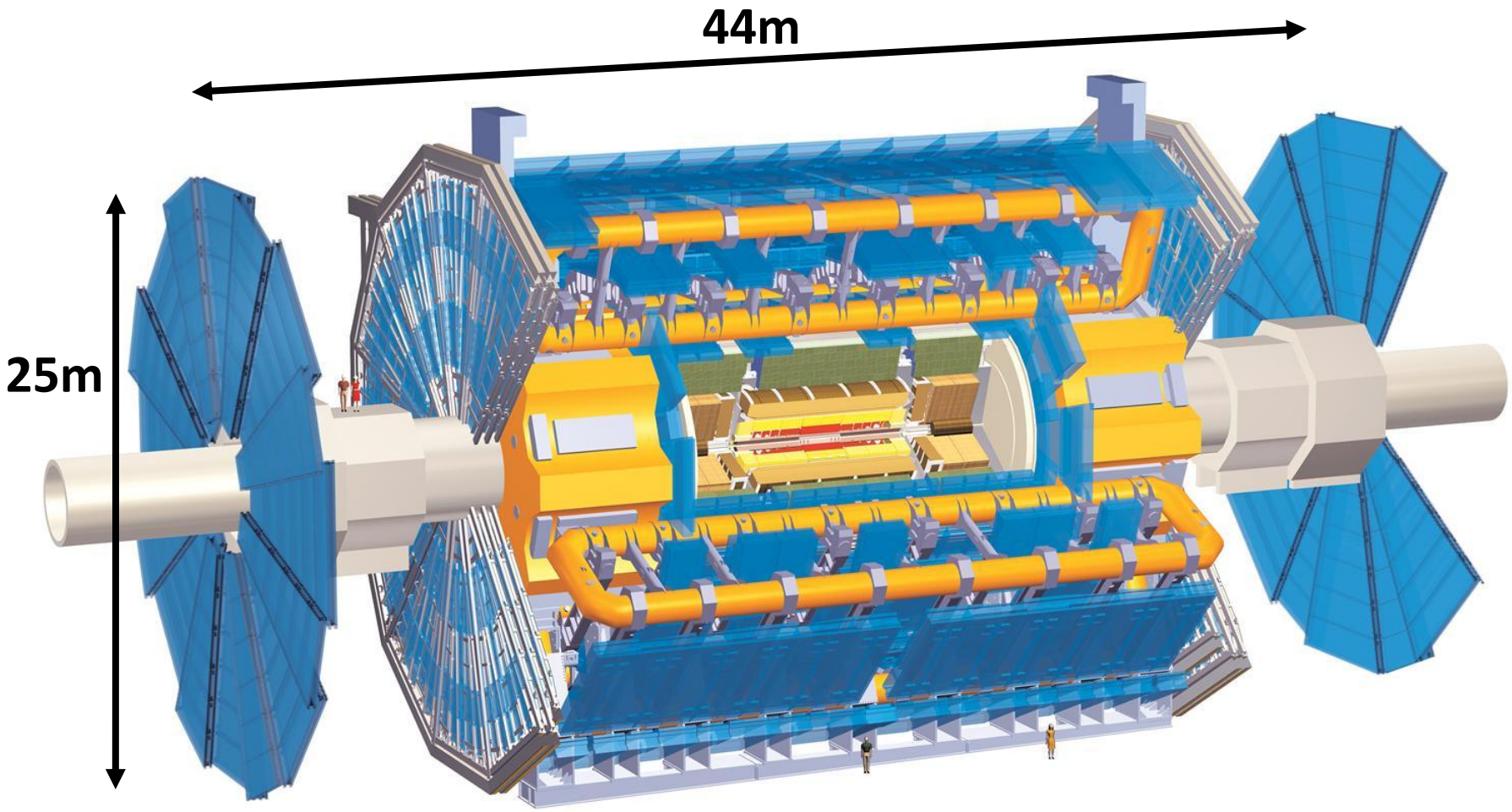
Objects needed for event selection

-> also needed for Trigger:

- Electrons
- Photons
- Muons
- Jets
- b-Jets
  (vertex or lepton tagged)
- forward jets
- Taus
- Missing Transverse Energy

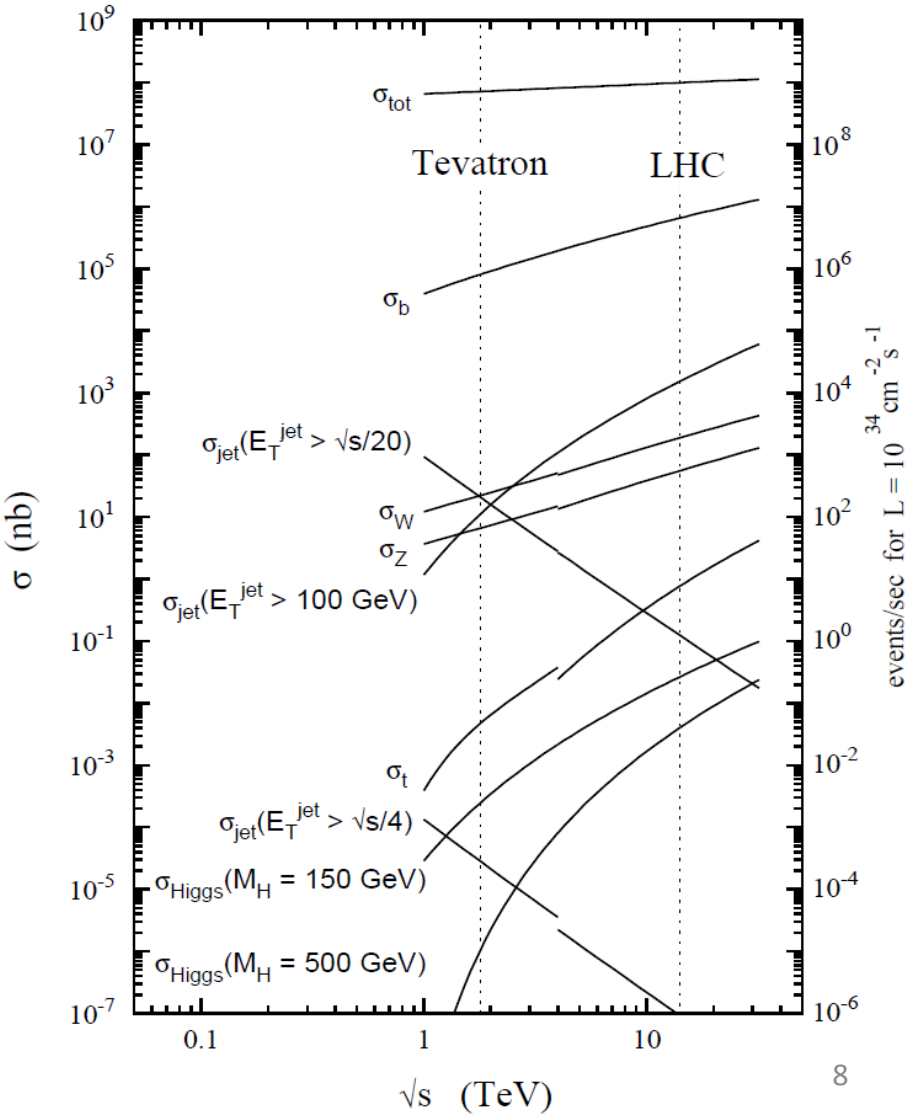
Various physics objects needed, high P_T (> 20 GeV), 4π

The ATLAS Experiment



LHC vs. Tevatron

(why we need high lumi and high energy)

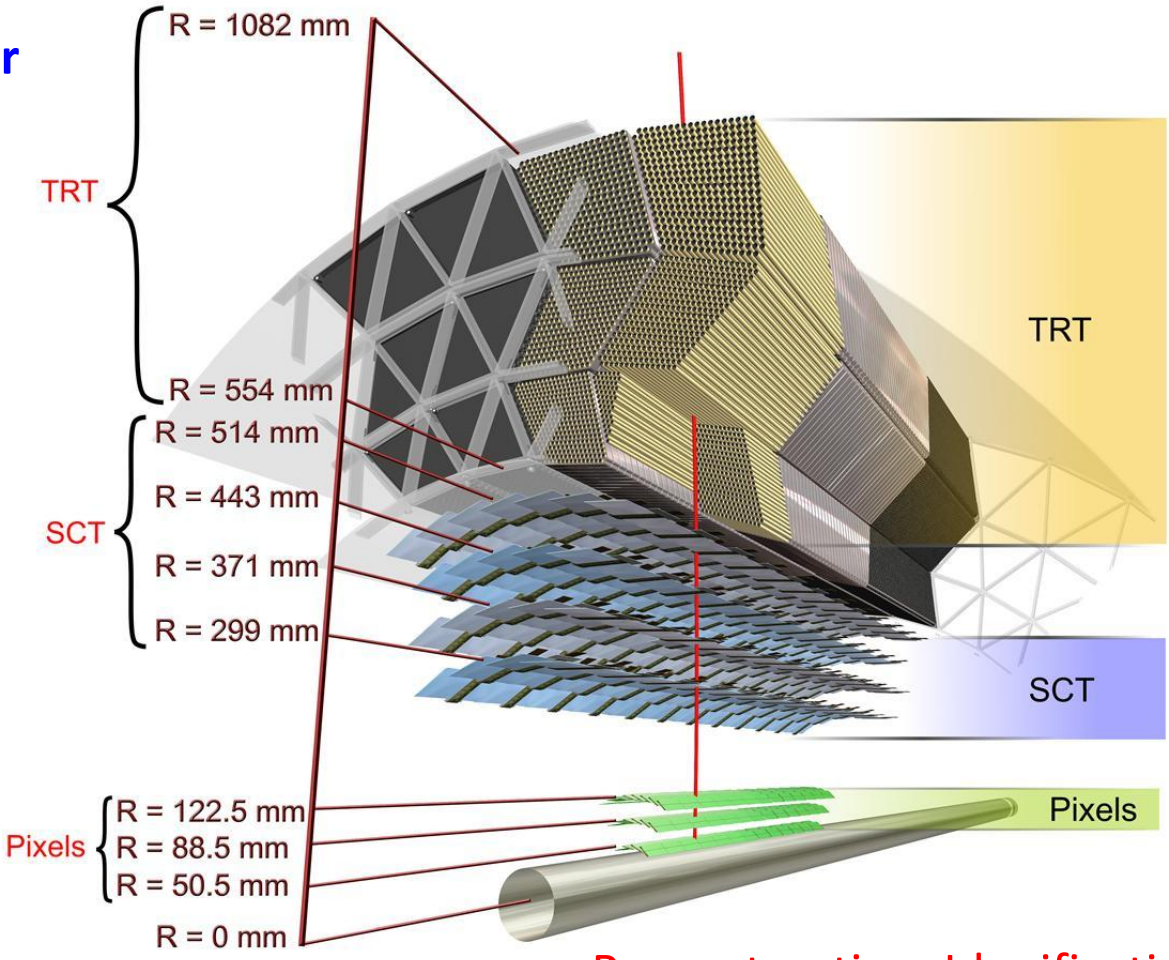


The Inner Detector

Transition Radiation Tracker
- 4mm Straw Tubes
- 350 000 Channels

Silicon Strip Detector
- 80 μm x 62 mm
- 6.2 million channels

Silicon Pixel detector
- 50 x 400 μm
- 80 million channels



Resolution

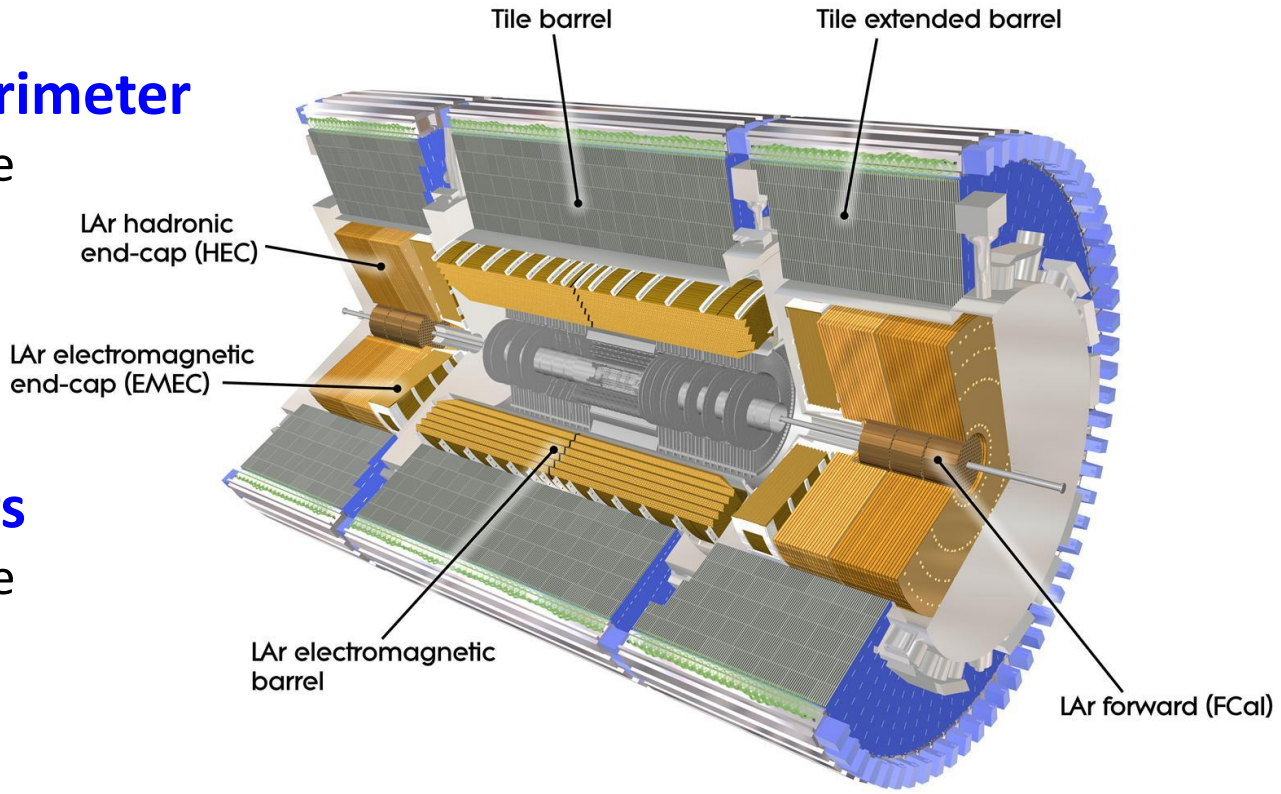
- Momentum: $\sigma/p_T \approx 5 \cdot 10^{-4}\, p_T \oplus 0.001$
- Impact Param.: $\sigma(d0) \approx 15\ \mu m$ @ 20 GeV

Reconstruction, Idenification, Momentum measurement of charged particles

The Calorimeters

Electromagnetic Calorimeter

- Liquid Argon Technologie
- 120 000 Channels



Hadronic Calorimeters

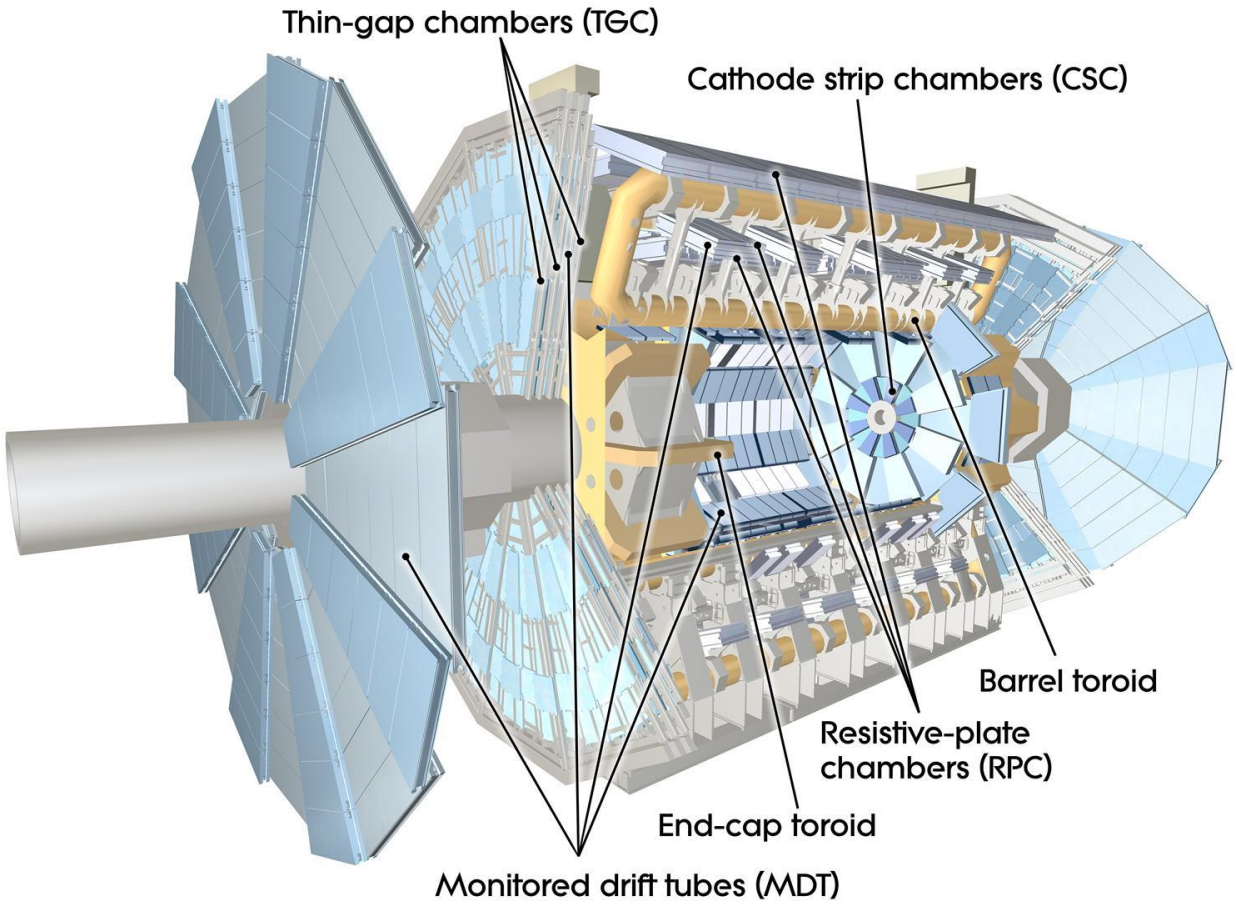
- Liquid Argon Technologie
  - 70 000 Channels
- Tile Calorimeter
  - 10 000 Channels

Energy measurement
electrons, photons
und hadrons

Resolution

- EM: $\sigma(E)/E = 10\%/\sqrt{E} \oplus 0.7\ \%$
- Had. (jets): $\sigma(E)/E = 50\%/\sqrt{E} \oplus 3\ \%$

The Muonsystem



Precision chambers

- Drift Tubes
- 360 000 Channels

Trigger chambers

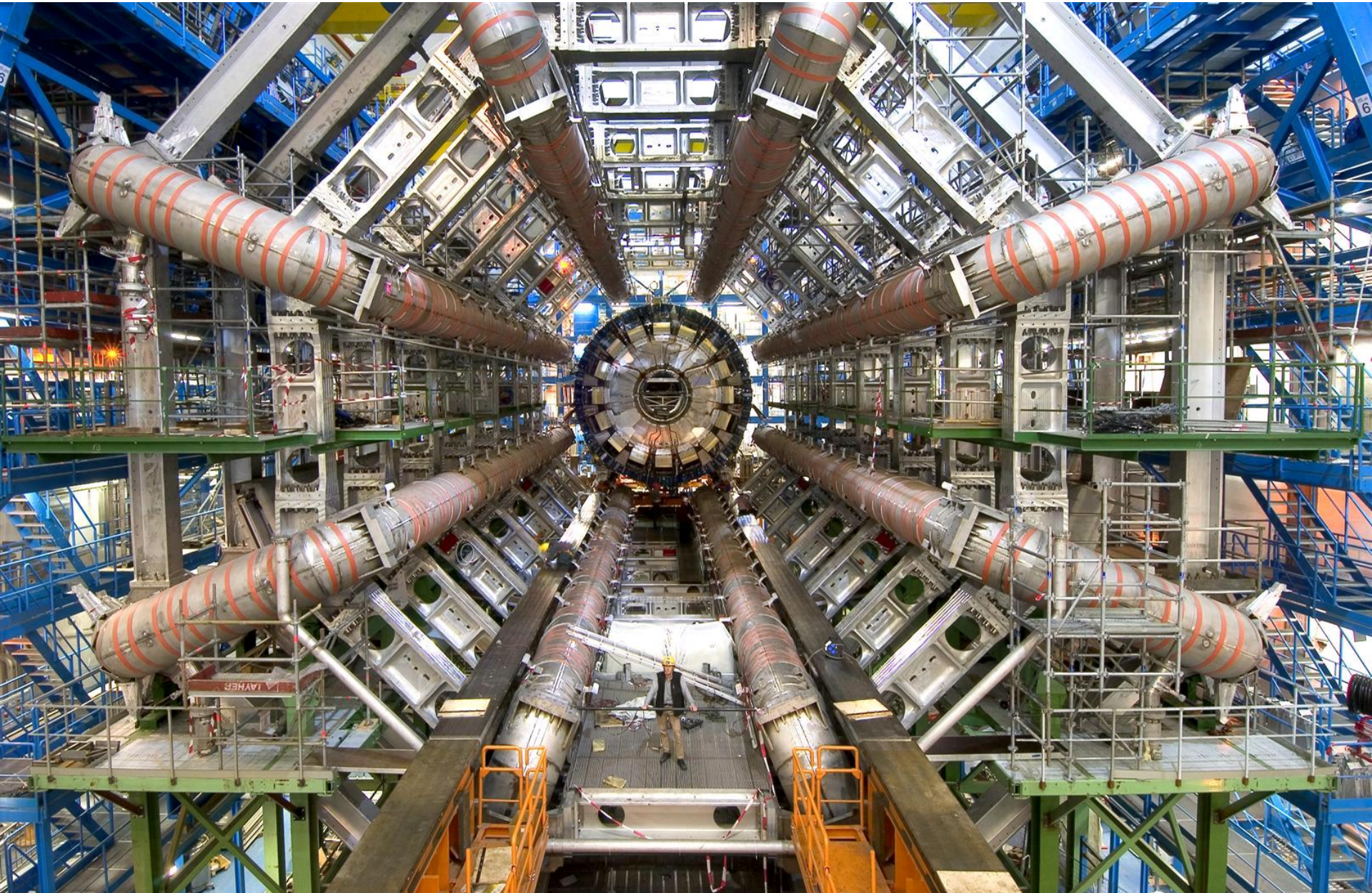
- Resistive Plate chambers
- Thin Gap chambers
- 680 000 Kanäle

Resolution

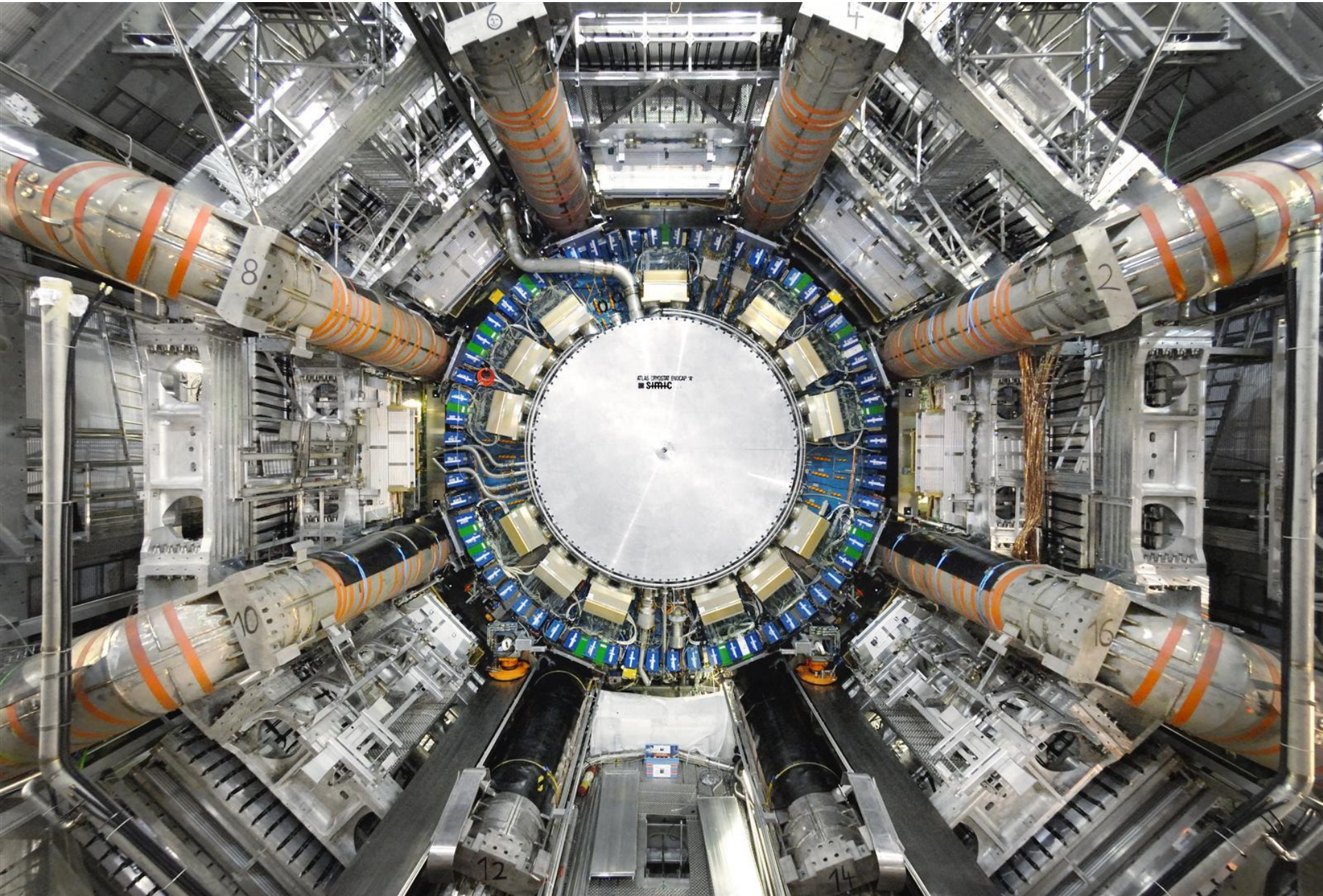
- $\Delta p_T/p_T < 10\%$ at 1 TeV

Identification and momentum measurement of Muons

ATLAS: „Rohbau“ 2005



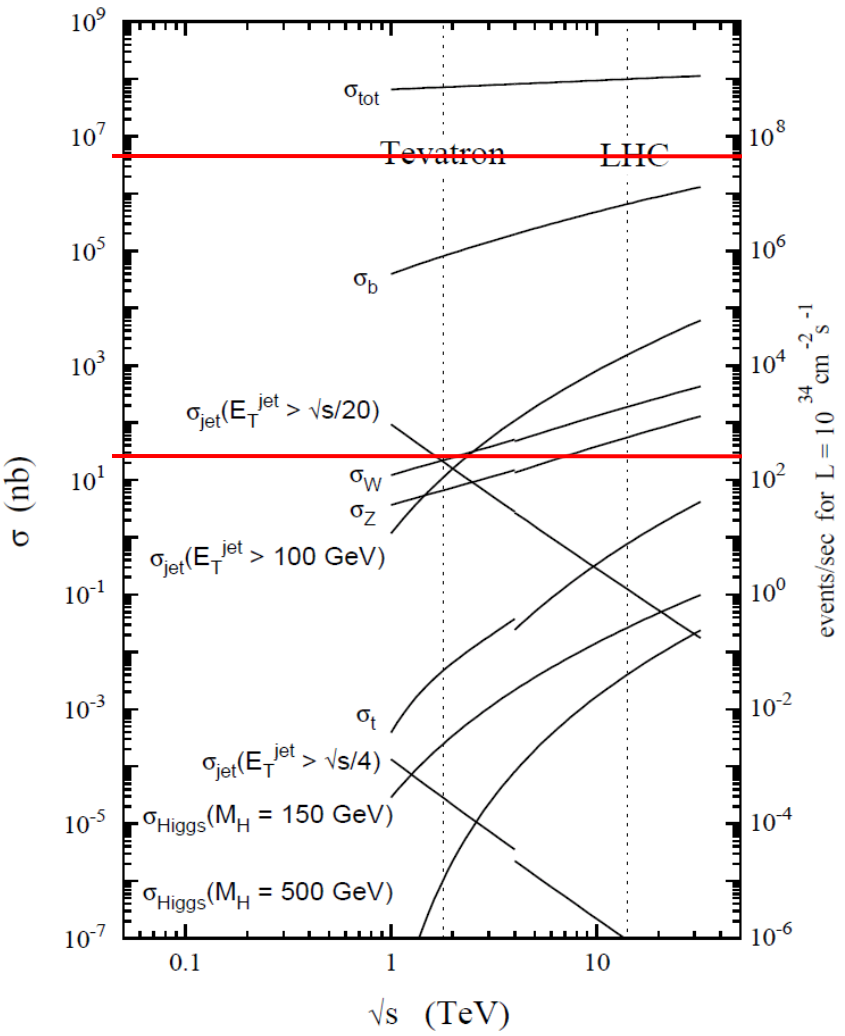
ATLAS: 2008

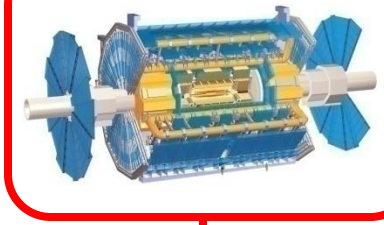



UX15 Jura Tue Feb 16 21:03:22 2010
ATLAS now

The Triggersystem

Luminosity: $L_{inst} = 10^{34}\ cm^{-1}s^{-1}$





LHC und ATLAS
Collisions Rate 40 MHz
23 inel. Interact. Per BX

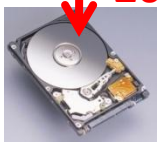
40 MHz

1. Trigger Level
Dedicated Elektronics
Calorimeter und Muonsyst.

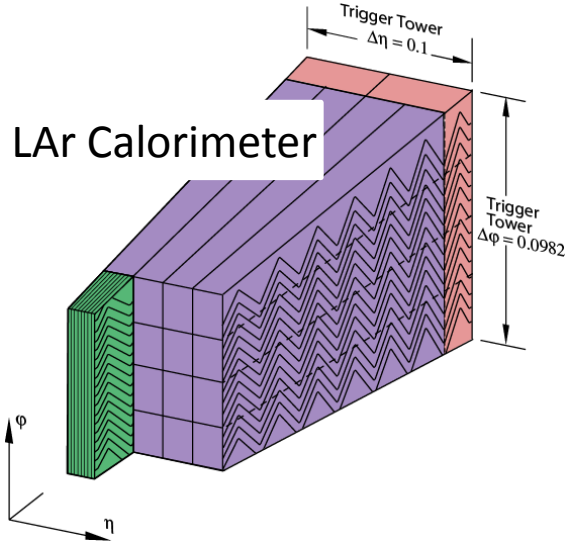
75 kHz

2. and 3. Level
PC Farms
Highspeed network

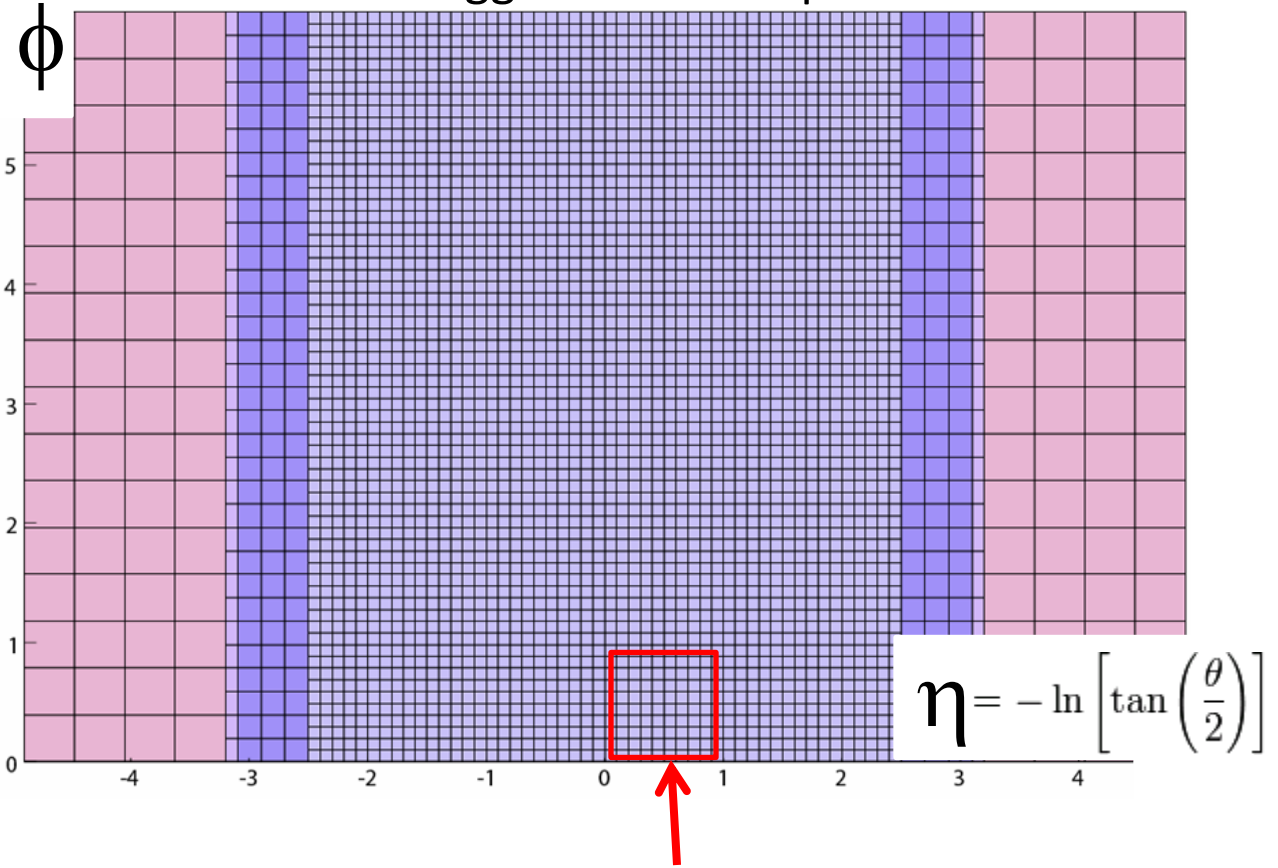
200 Hz



Level 1 Calorimeter Trigger



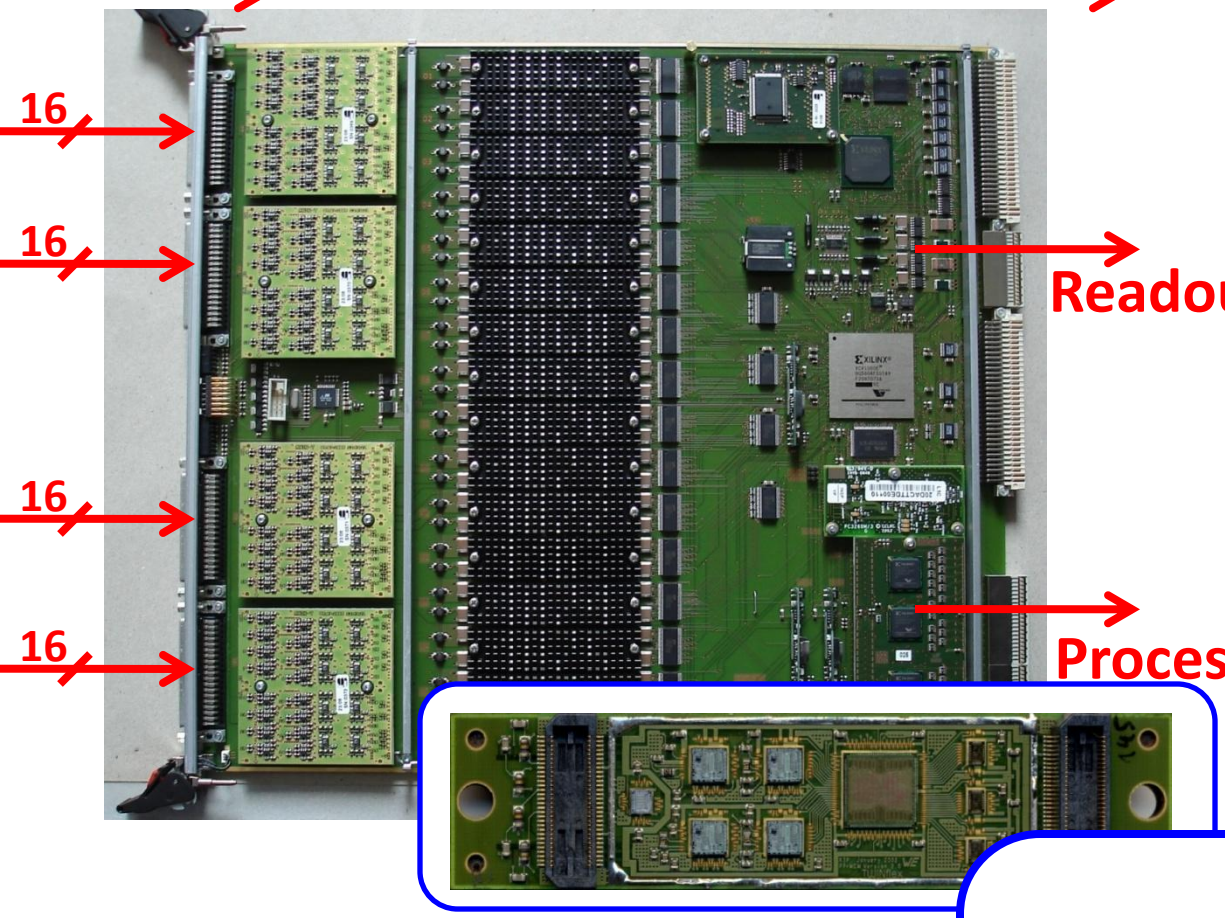
trigger towers map



Reduced Granularity
- Trigger Tower
- sum up to 60 cells
- still finer granularity than e.g. CDF

sliding window
(search for local energy deposits)

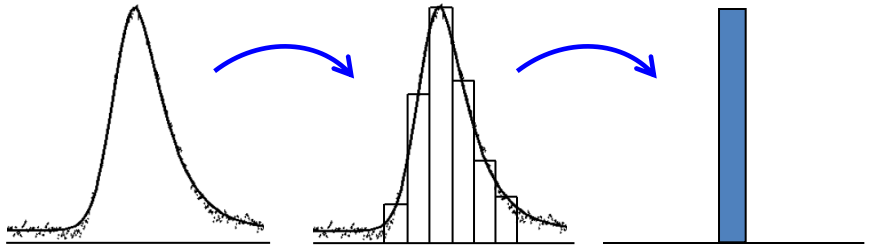
PreProcessor
(KIP Heidelberg)



- 160 Elektronic boards
- 4000 Daughter Modules
- Mixed Design
  (analog/digital)
- ASIC (KIP/HD)

Funktionality

- Digitisation
- Noise filter (digital)
- Energy determination
- Determination of BX



The Level 1 Calorimeter Trigger

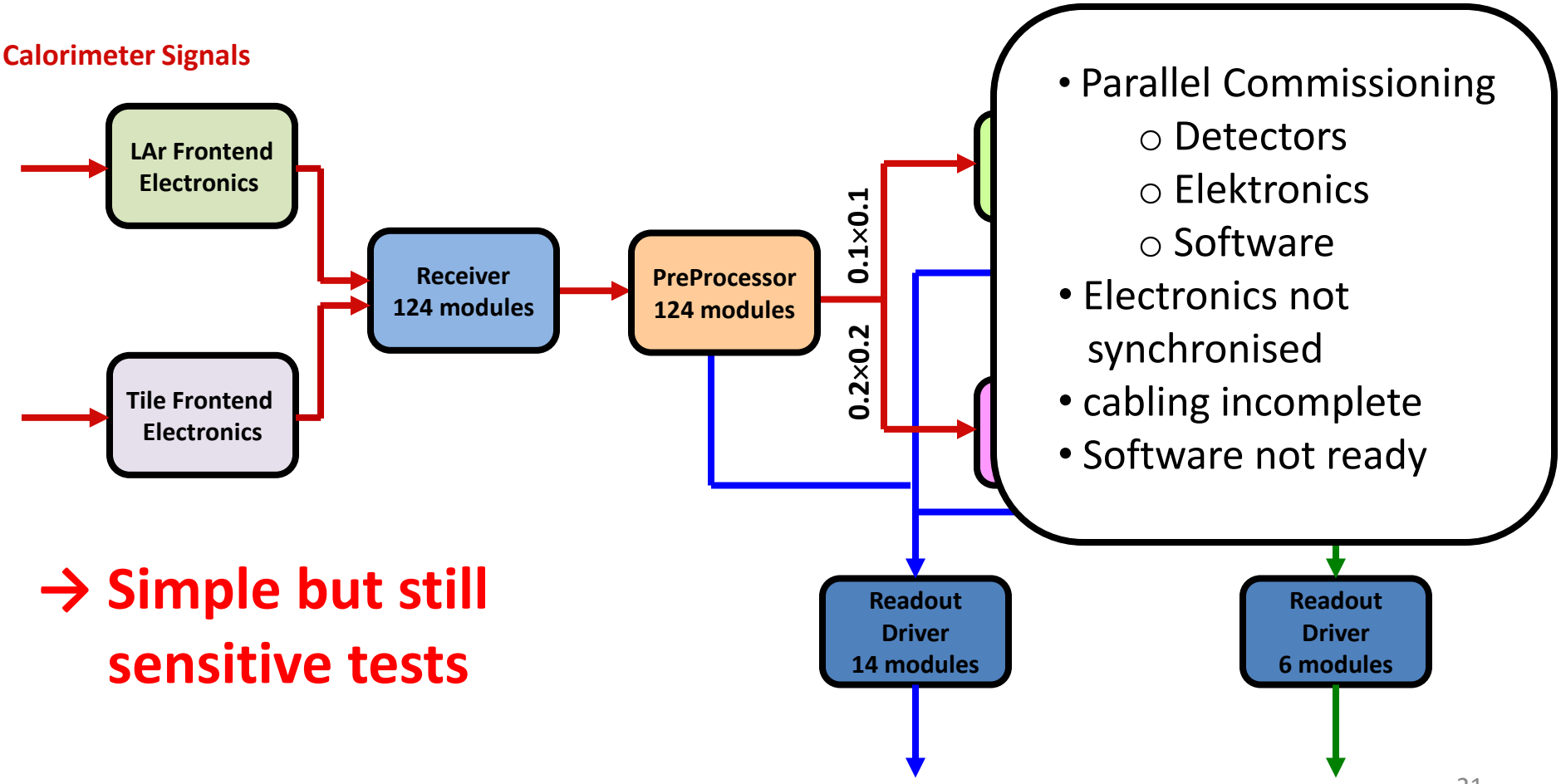
- Data reduction: 60TB/s -> 150GB/s
- 450 Elektronic Boards (160 from Heidelberg)
- 10 different Board Types
- Collaboration of 50 Physicists

Commissioning
(selected topics)

„Commissioning is a nonlinear and messy process“

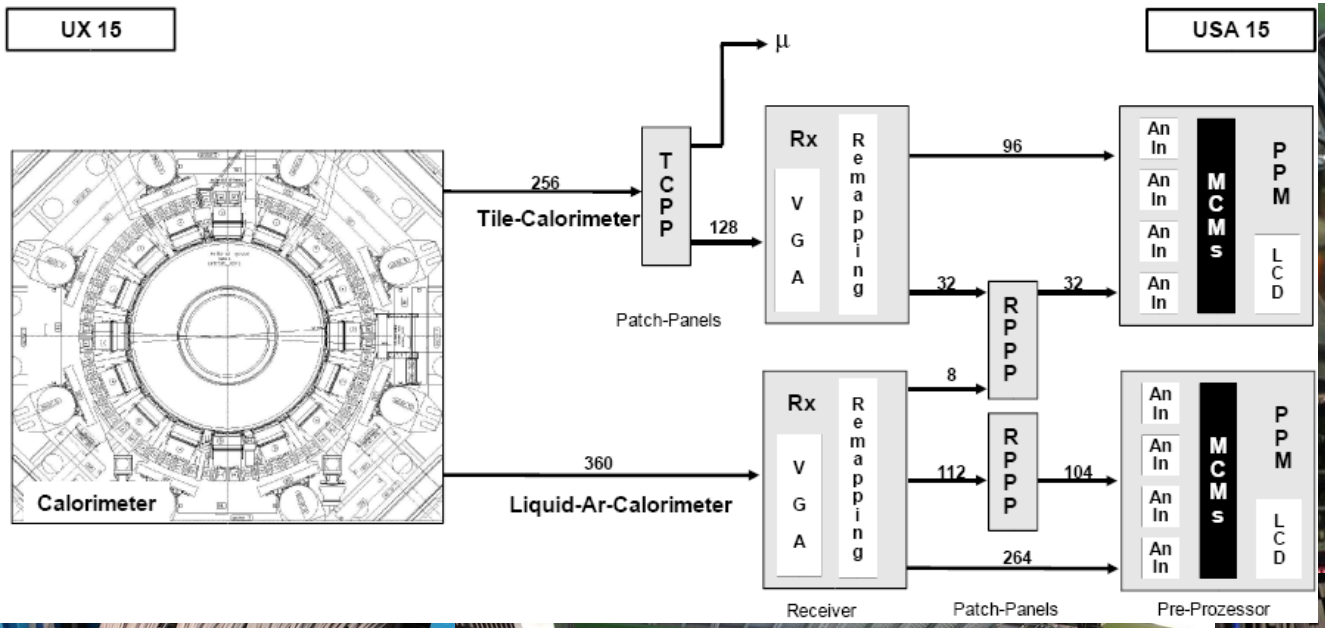
(K. Einsweiler, ATLAS)

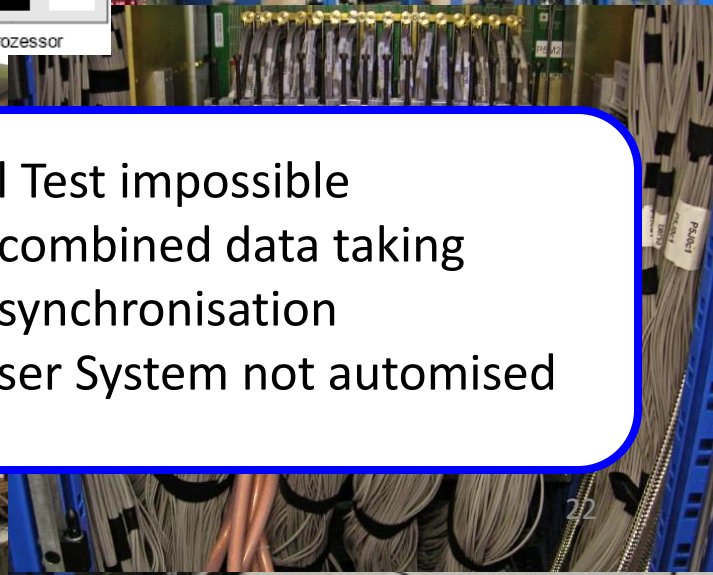
Challange of Commissioning



→ **Simple but still sensitive tests**

Cabling (2007)



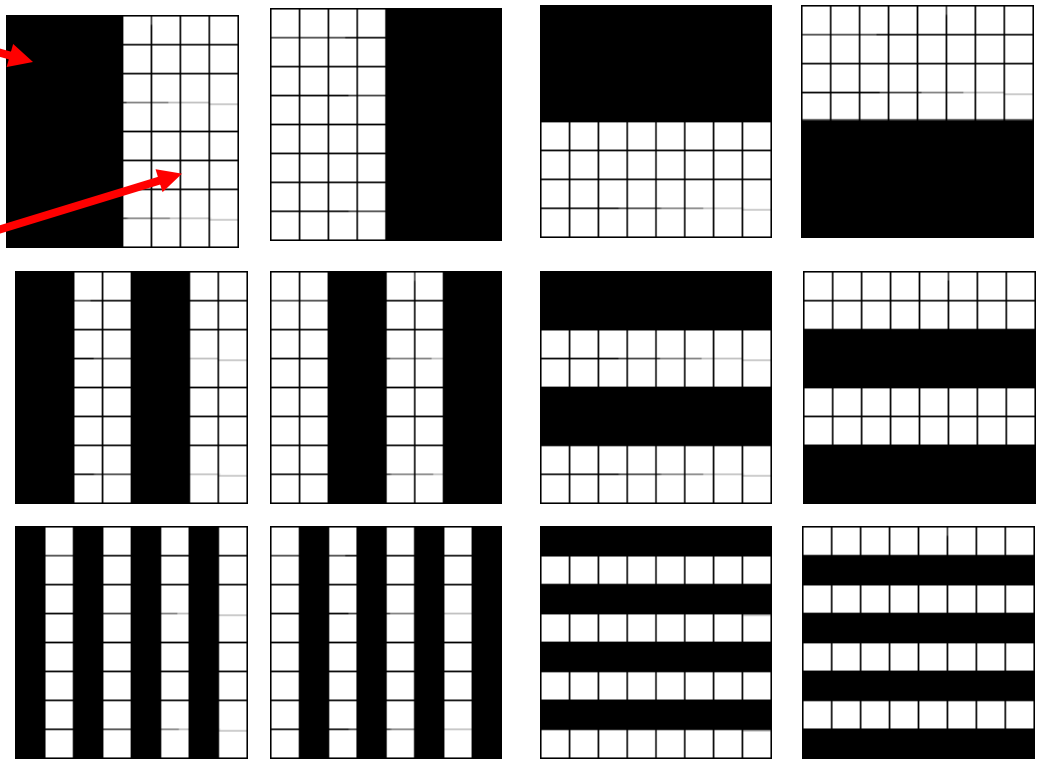


Serial Test impossible
- no combined data taking
- no synchronisation
- Pulser System not automised

Method (F. Föhlisch, PhD 08)

Pulsed channels

Not pulsed channels

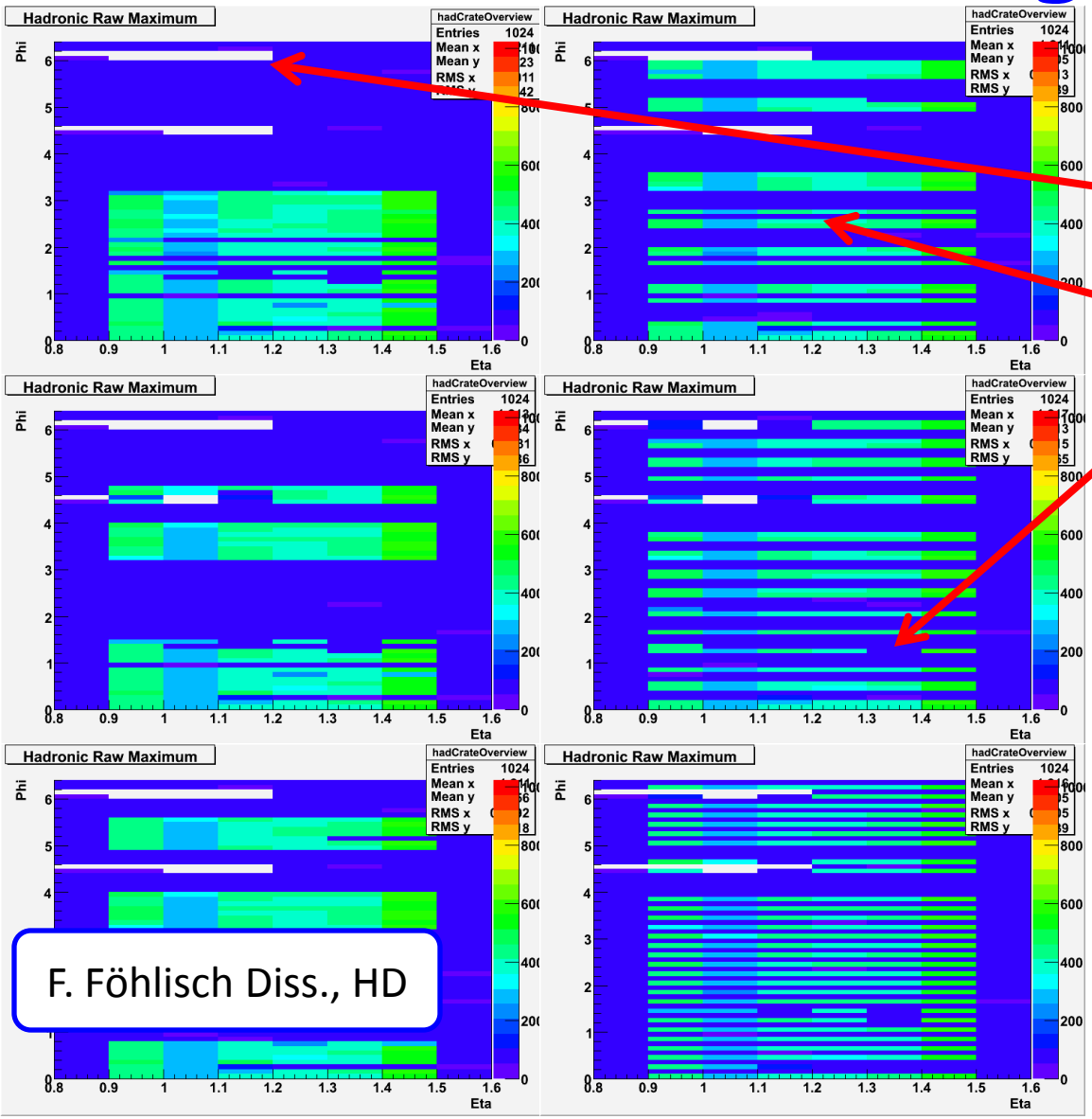


Idea:

- Pulse patterns
- unambigious error detection
- simplified pulsing and data taking
- simple analysis

-> Simple method which is 100% sensitive

Cabling

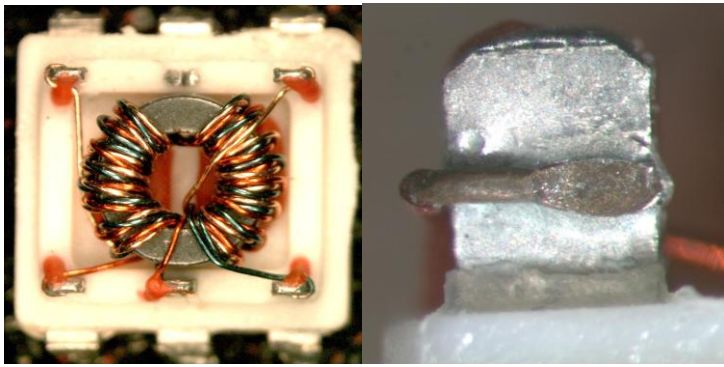


F. Föhlisch Diss., HD

Firmware Errors

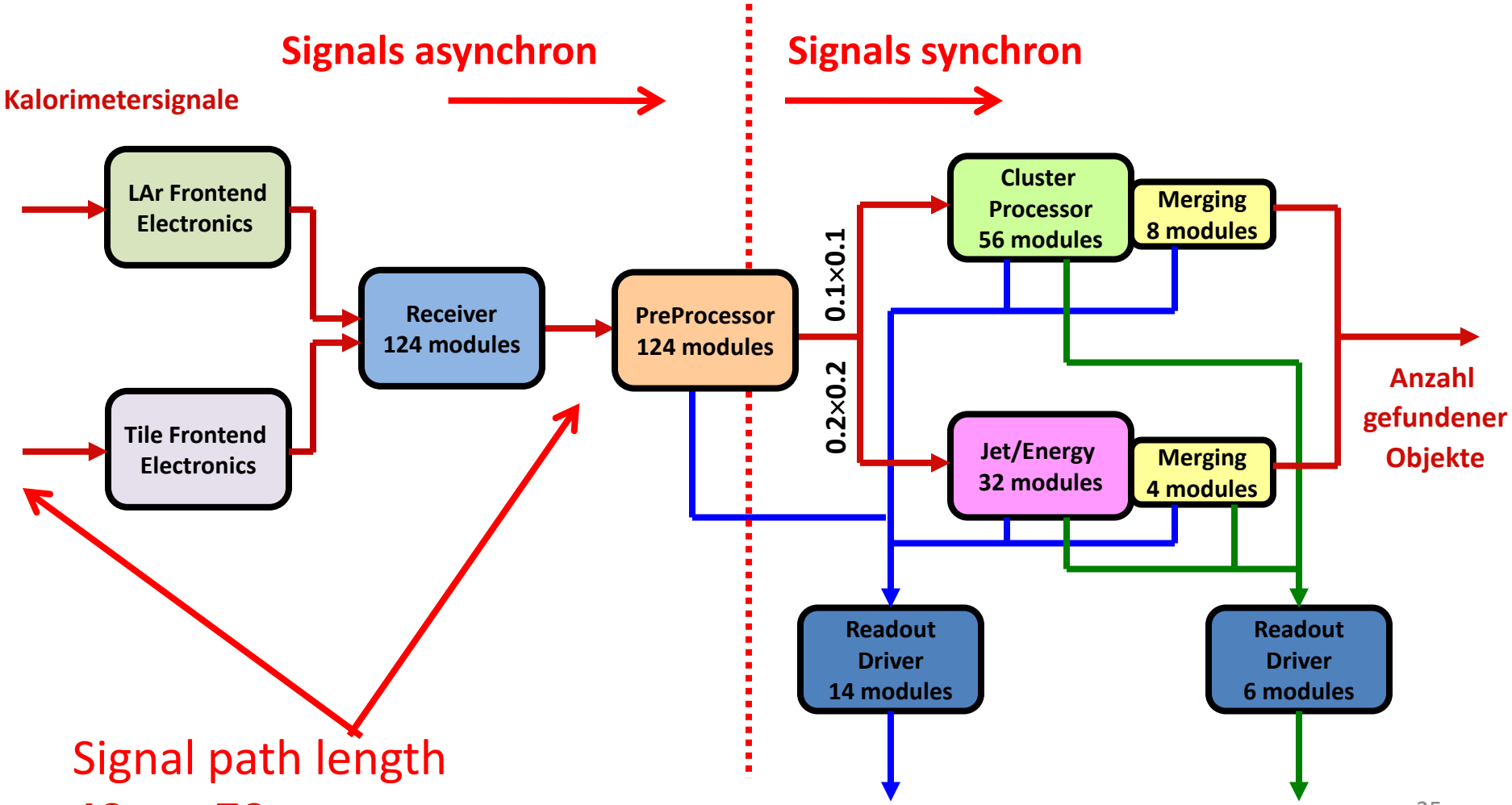
Pulser System Error

Broken Transformer



→ Exchange of all 15000 Trafo‘s

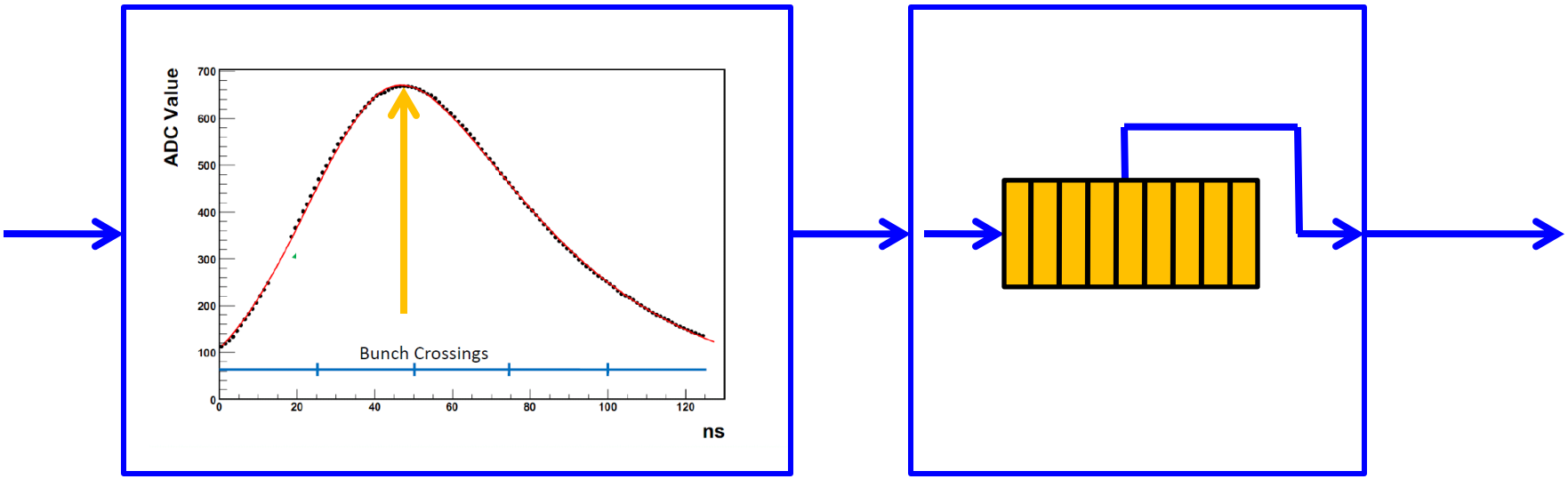
Synchronisation



Synchronisation

Precision Synchronisation
(N x 1ns)

Coarse Synchronisierung
(N x 25ns)



Digitisation Phase

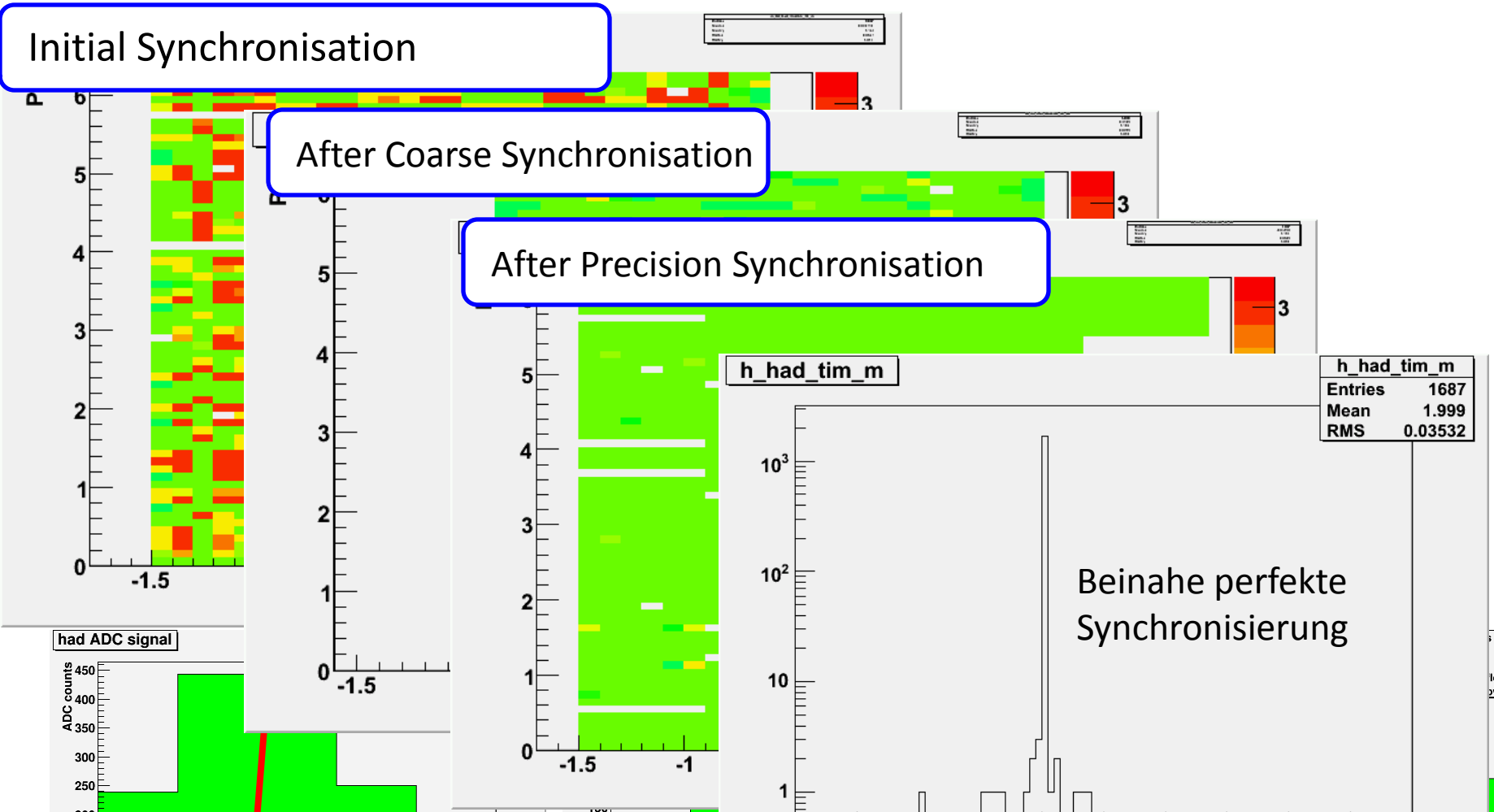
Shift Register

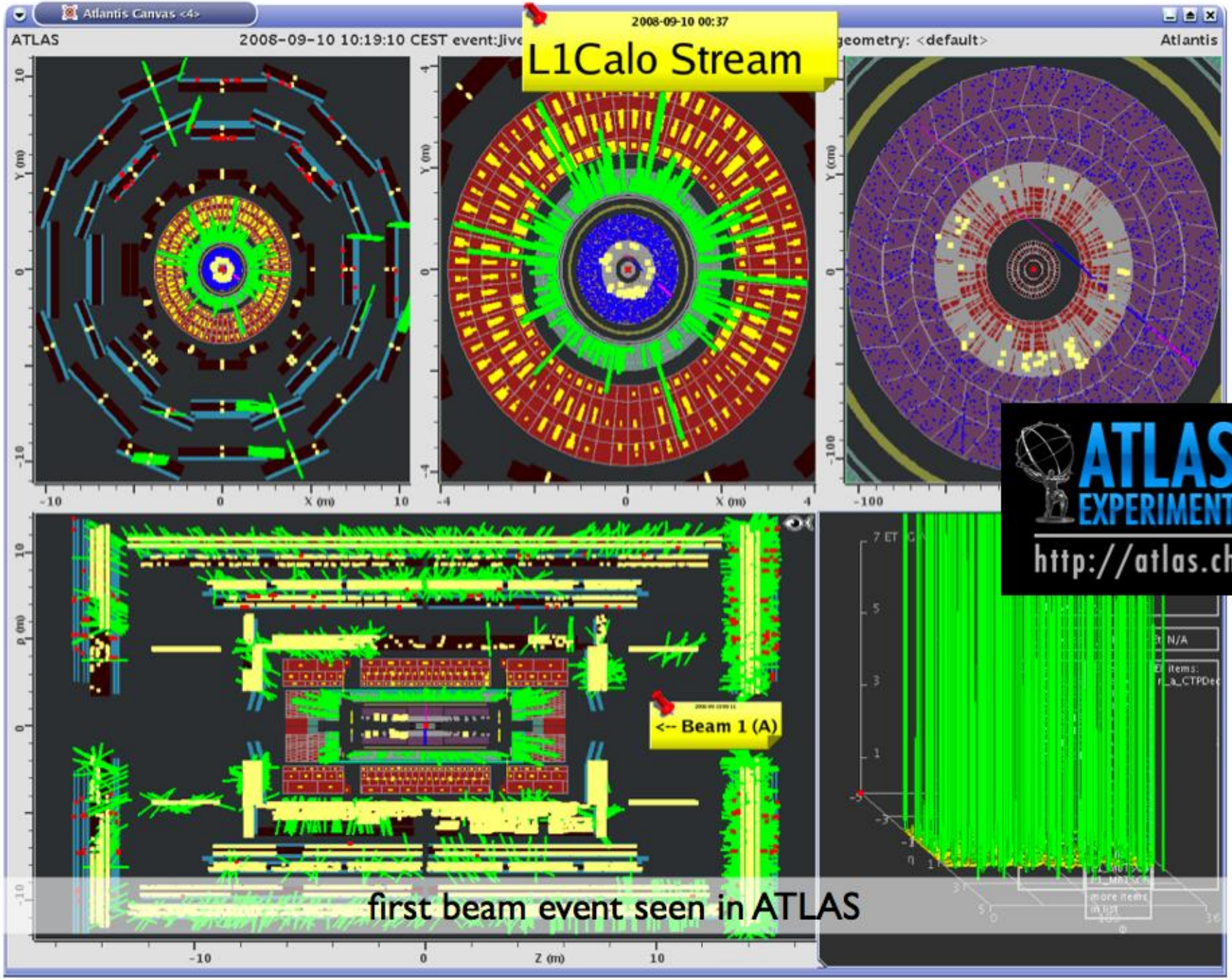
Synchronisation with Pulsers

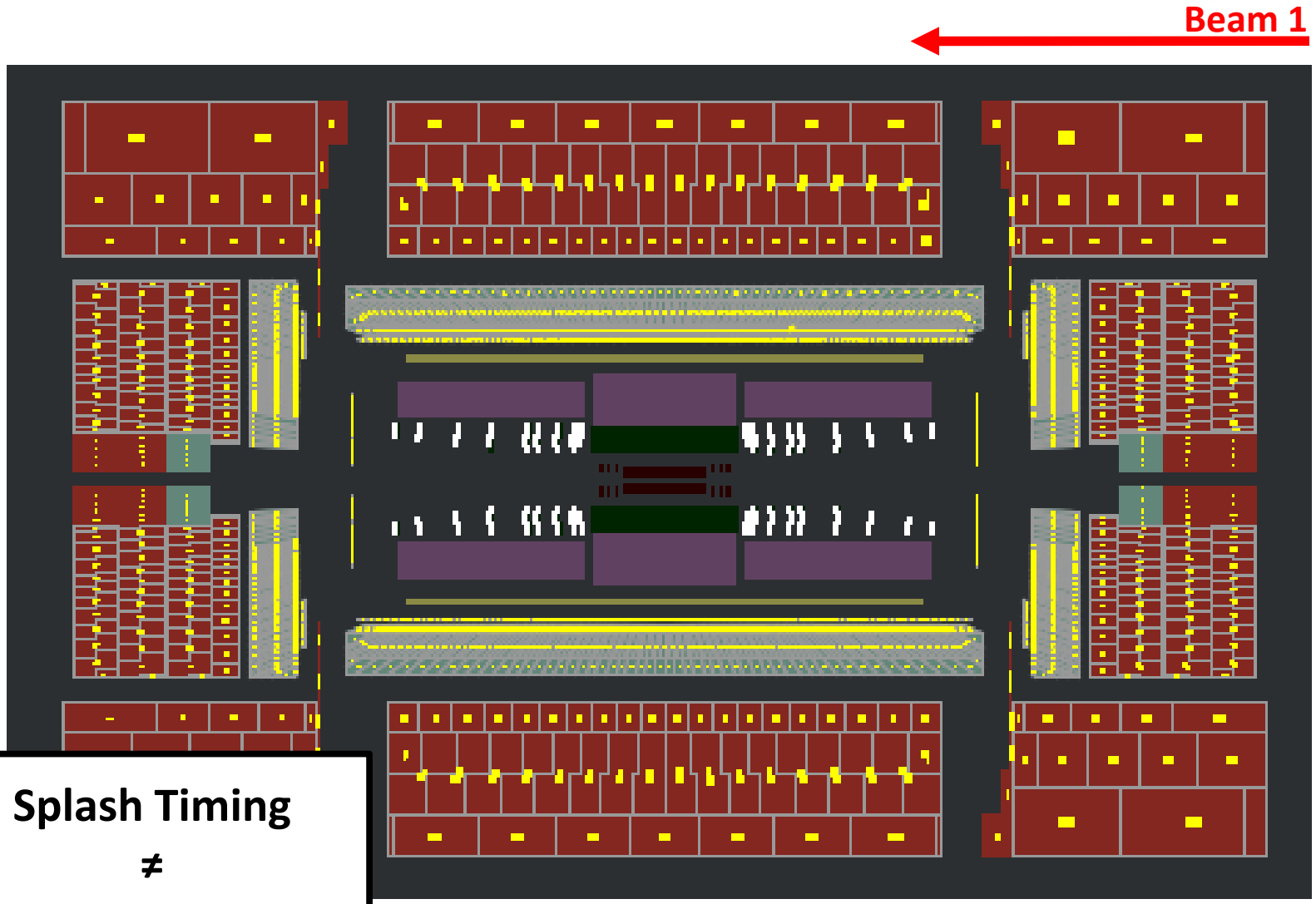
Initial Synchronisation

After Coarse Synchronisation

After Precision Synchronisation



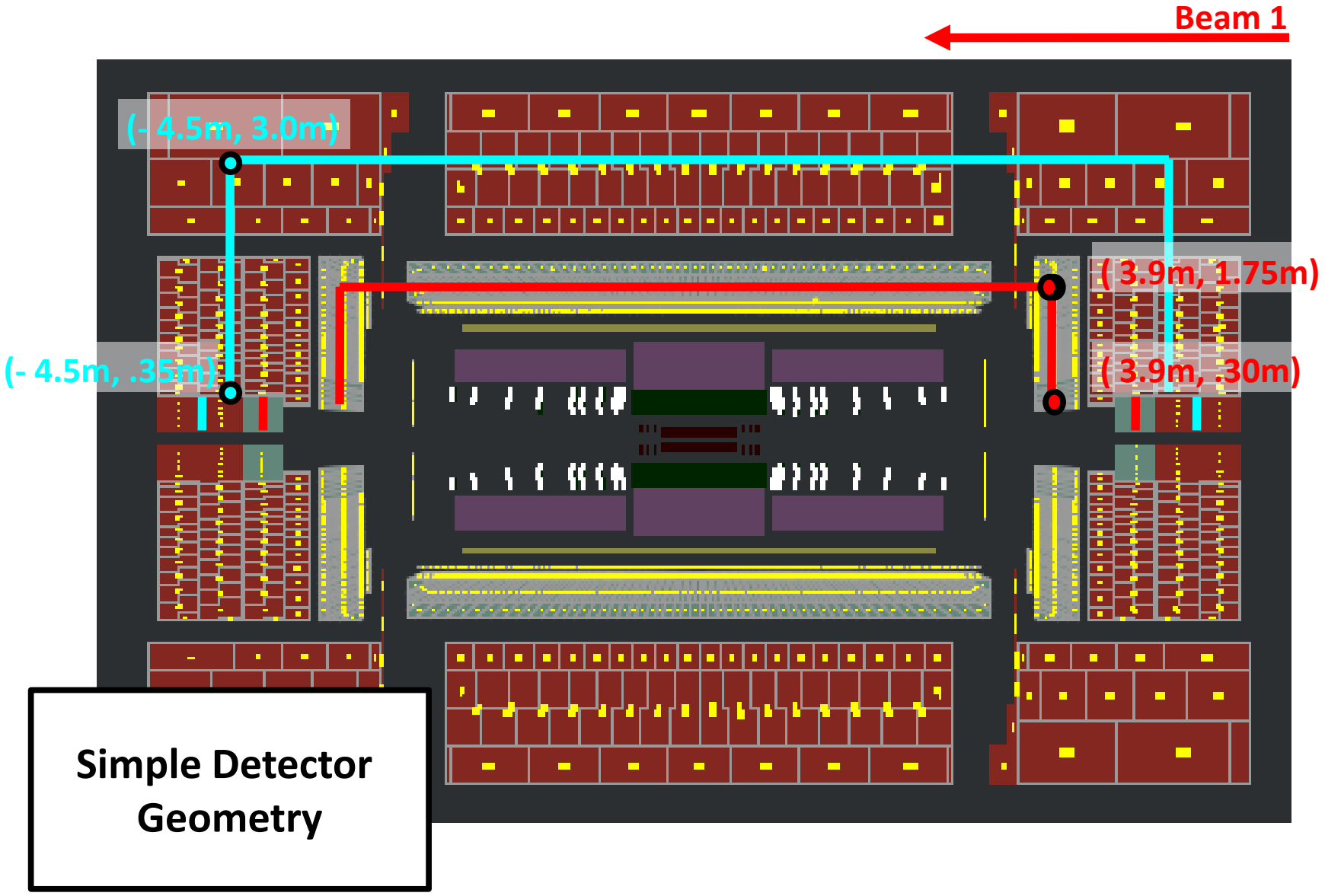

Atlantis Canvas <4>
ATLAS
2008-09-10 10:19:10 CEST event:Jive
geometry: <default>
Atlantis
2008-09-10 00:37
L1Calo Stream
ATLAS EXPERIMENT
http://atlas.ch
<-- Beam 1 (A)
first beam event seen in ATLAS

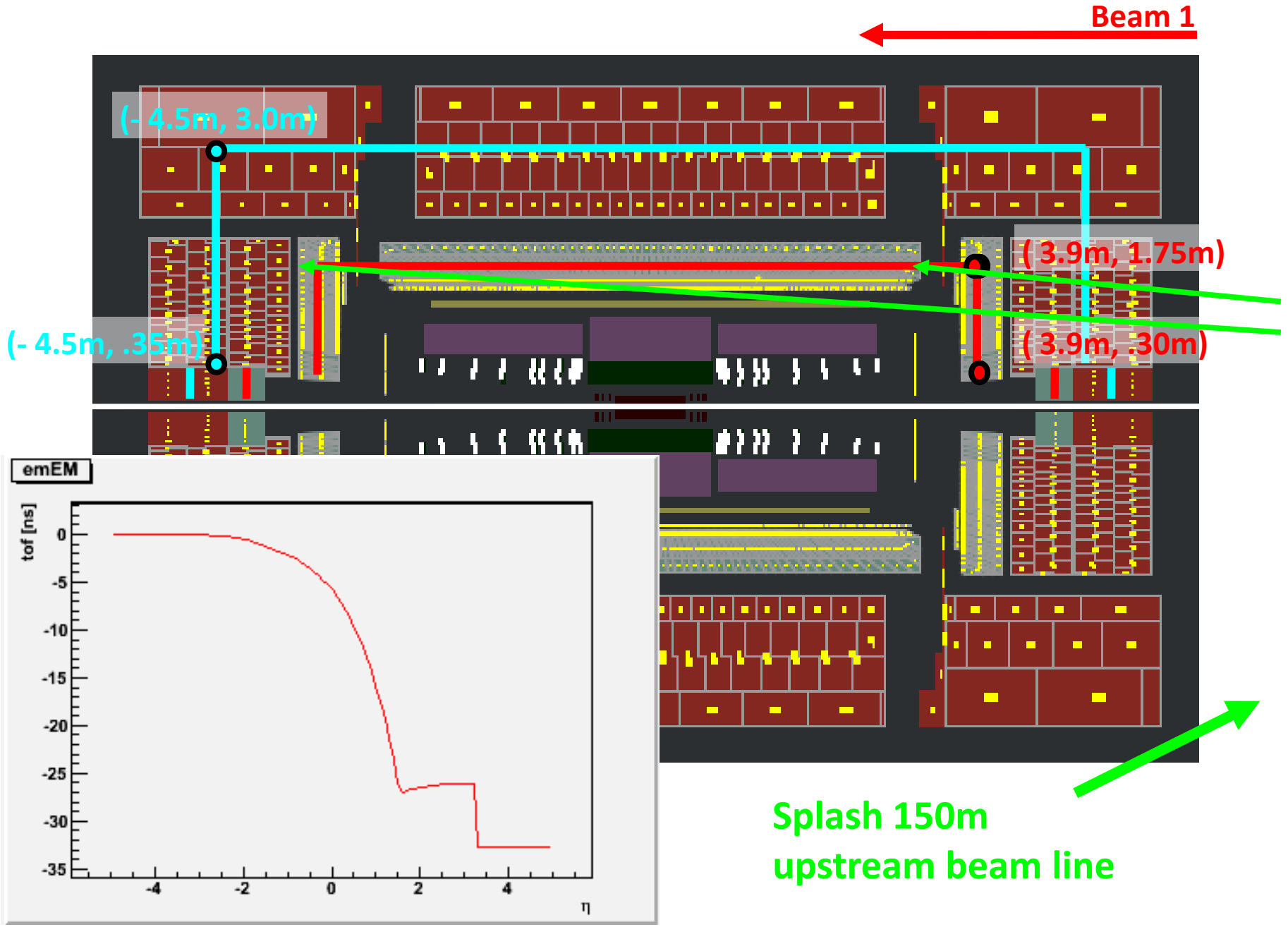


Splash Timing

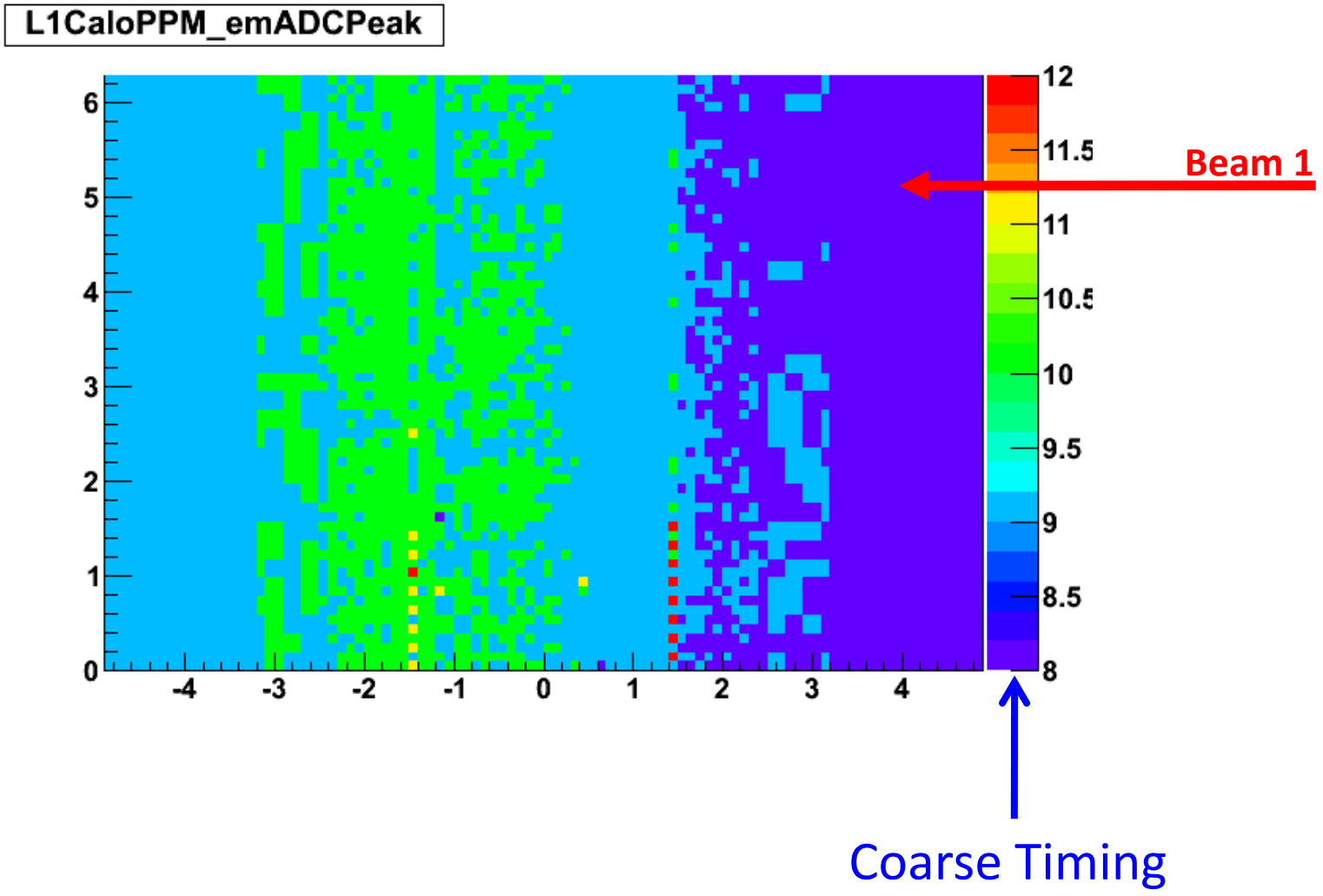
≠

Physics timing

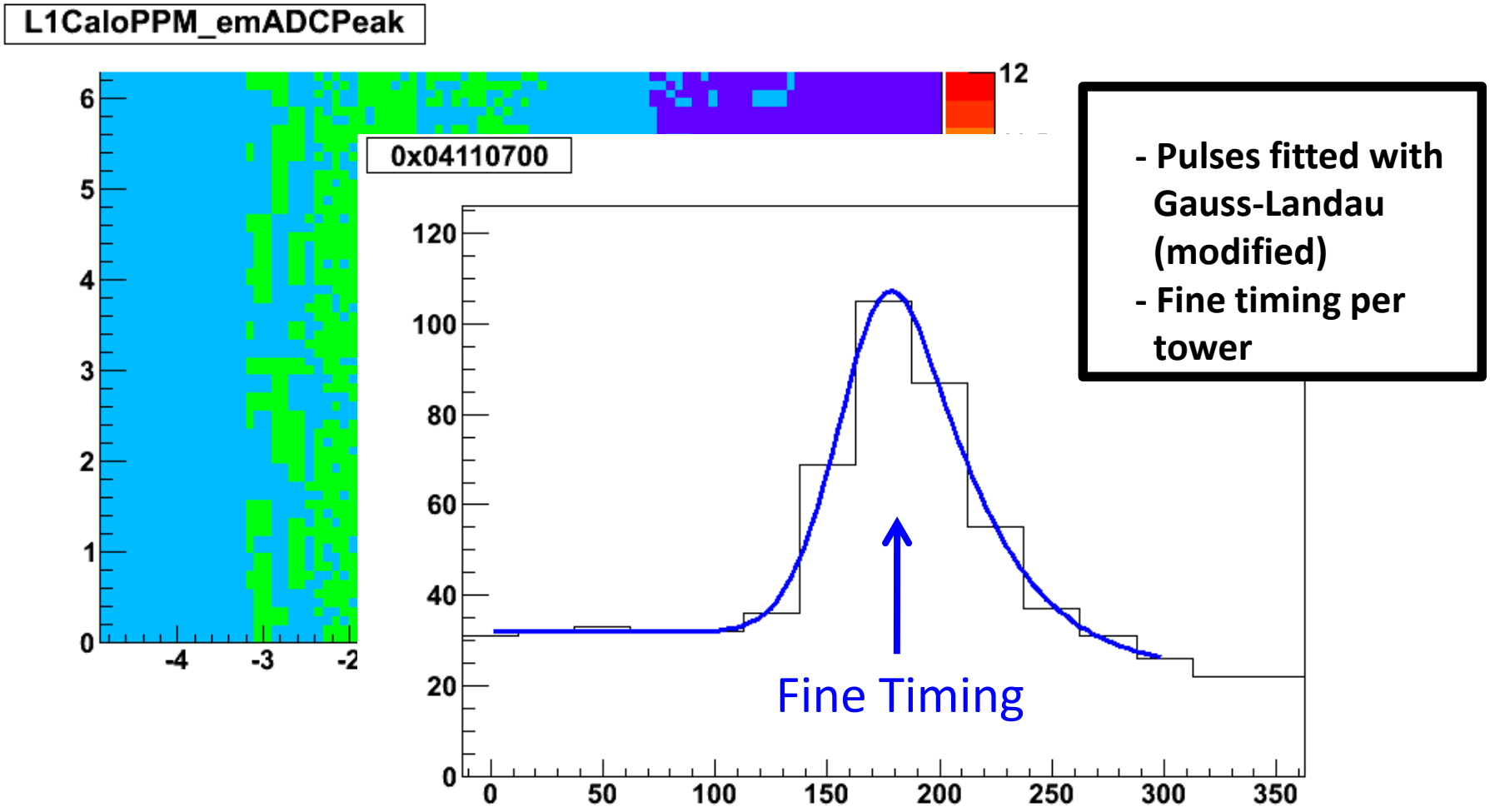

Beam 1
(- 4.5m, 3.0m)
(3.9m, 1.75m)
(- 4.5m, .35m)
(3.9m, .30m)
Simple Detector Geometry


Beam 1
(- 4.5m, 3.0m)
(- 4.5m, .35m)
(3.9m, 1.75m)
(3.9m, .30m)
emEM
tof [ns]
0
-5
-10
-15
-20
-25
-30
-35
-4
-2
0
2
4
η
Splash 150m
upstream beam line

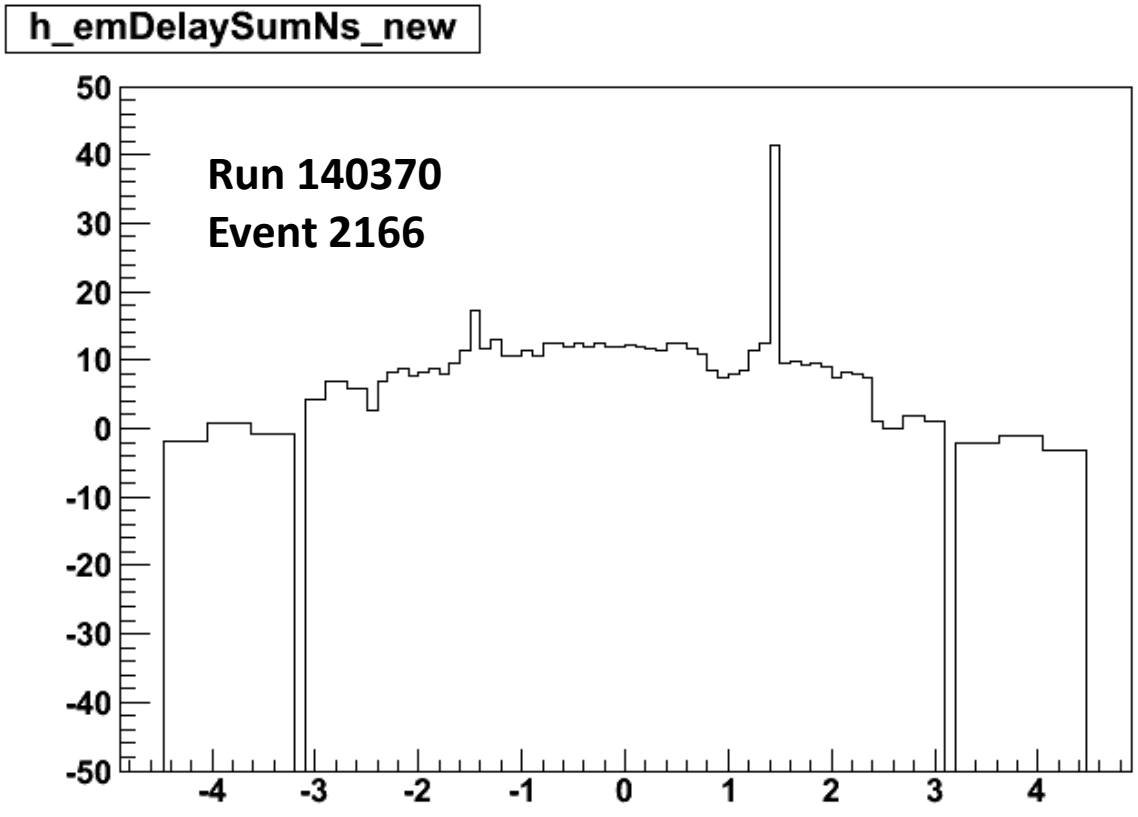
Determination of Timing



Determination of Timing



Determination of Timing



Result 10 min. after data copy to Castor

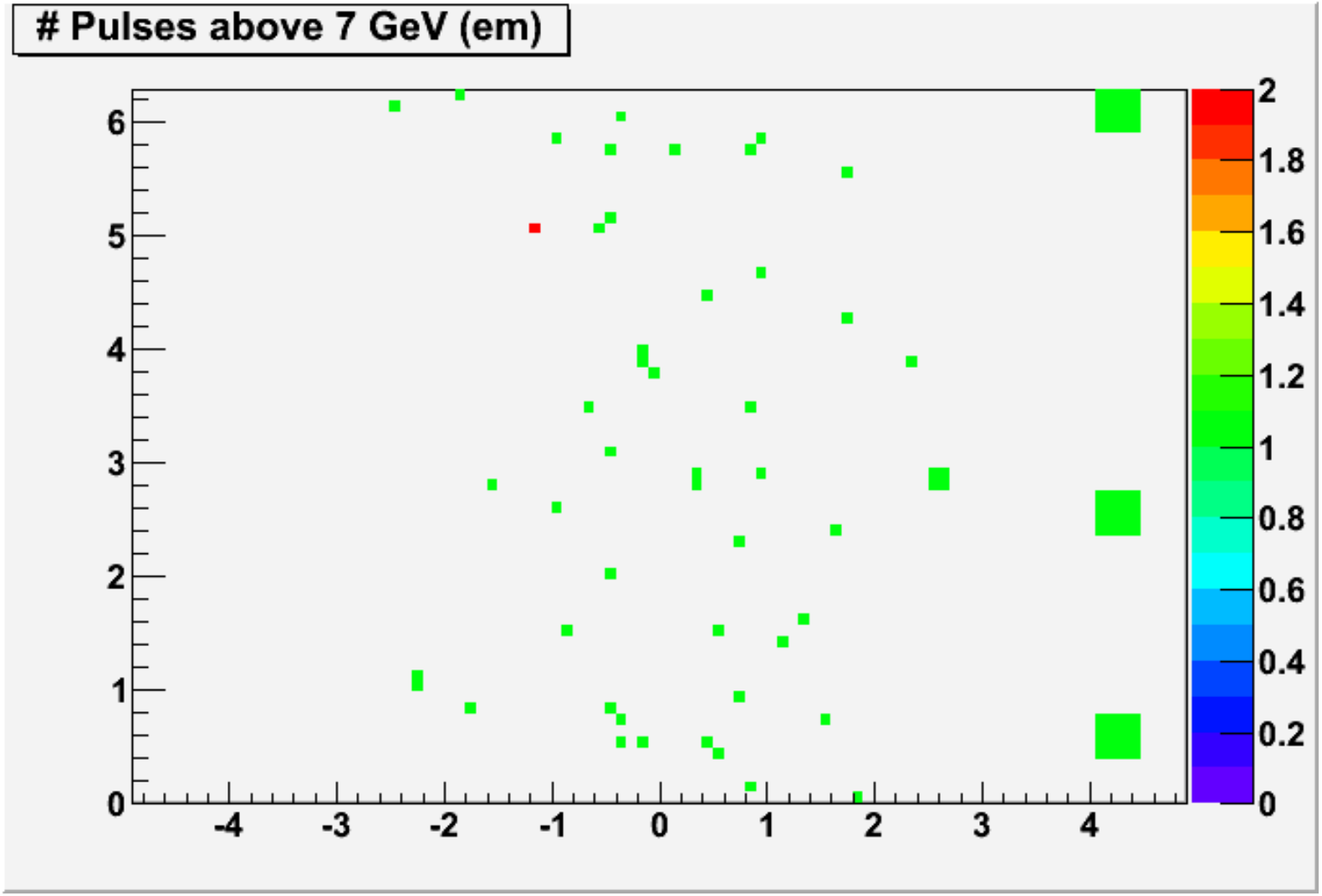
F. Müller
M. Henke
V. Scharf
V. Lang

EM basically *flat* (good within 1BC)

LAr did a very Good job!

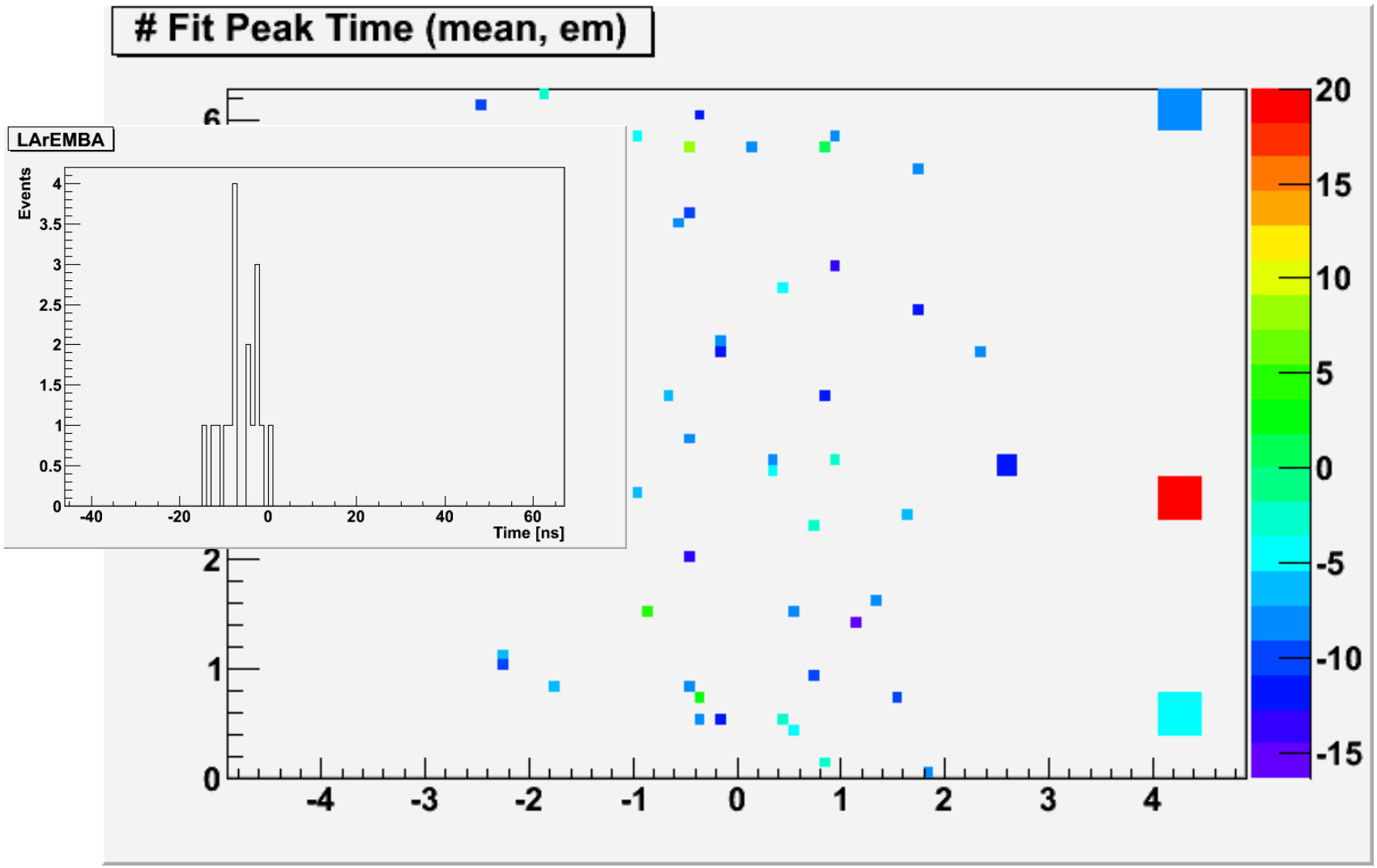
Only small corrections to predetermined timing neccessary

Timing with beam



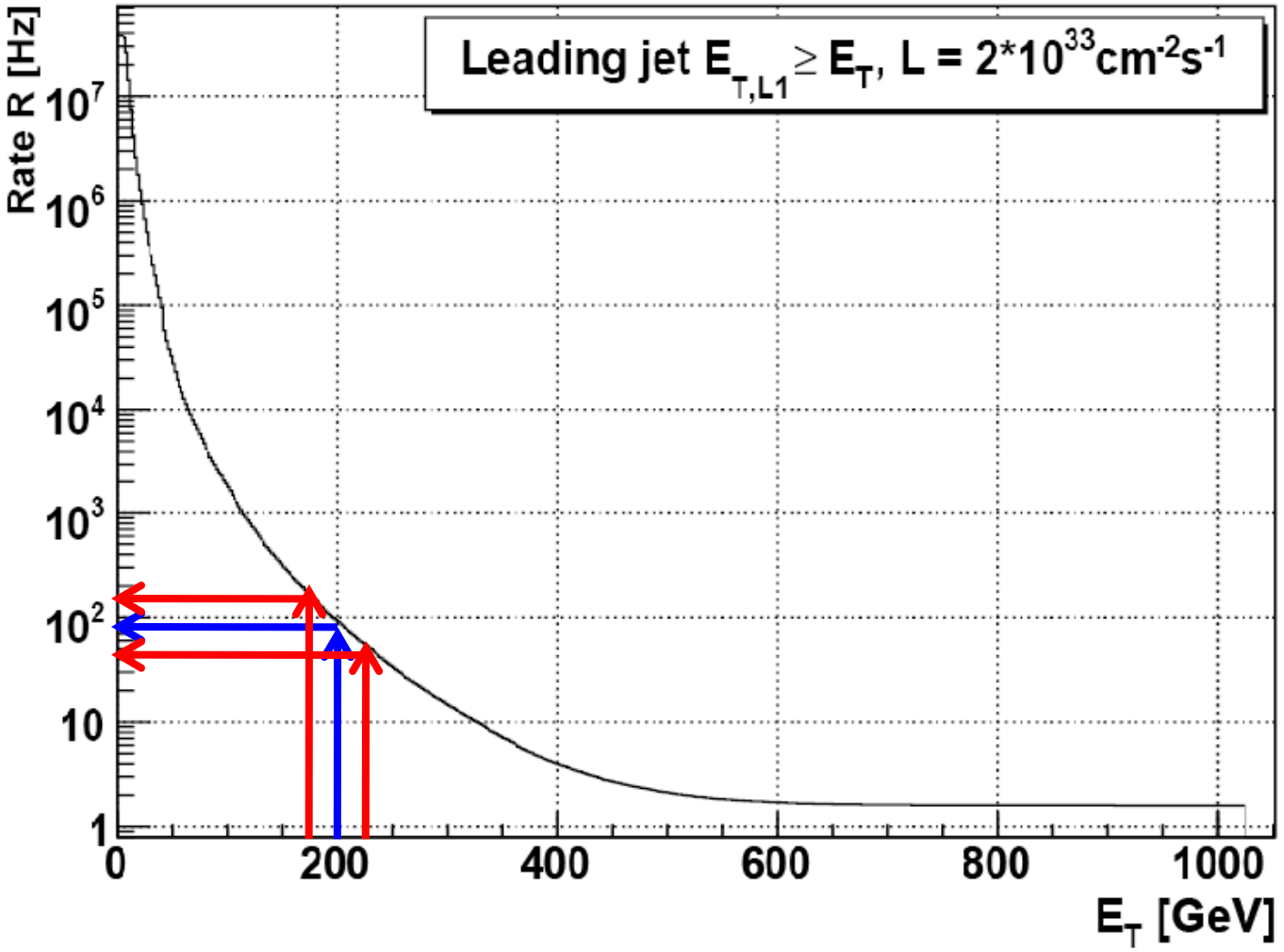
Only very little data available with significant energy in Calorimeter

Timing with beam



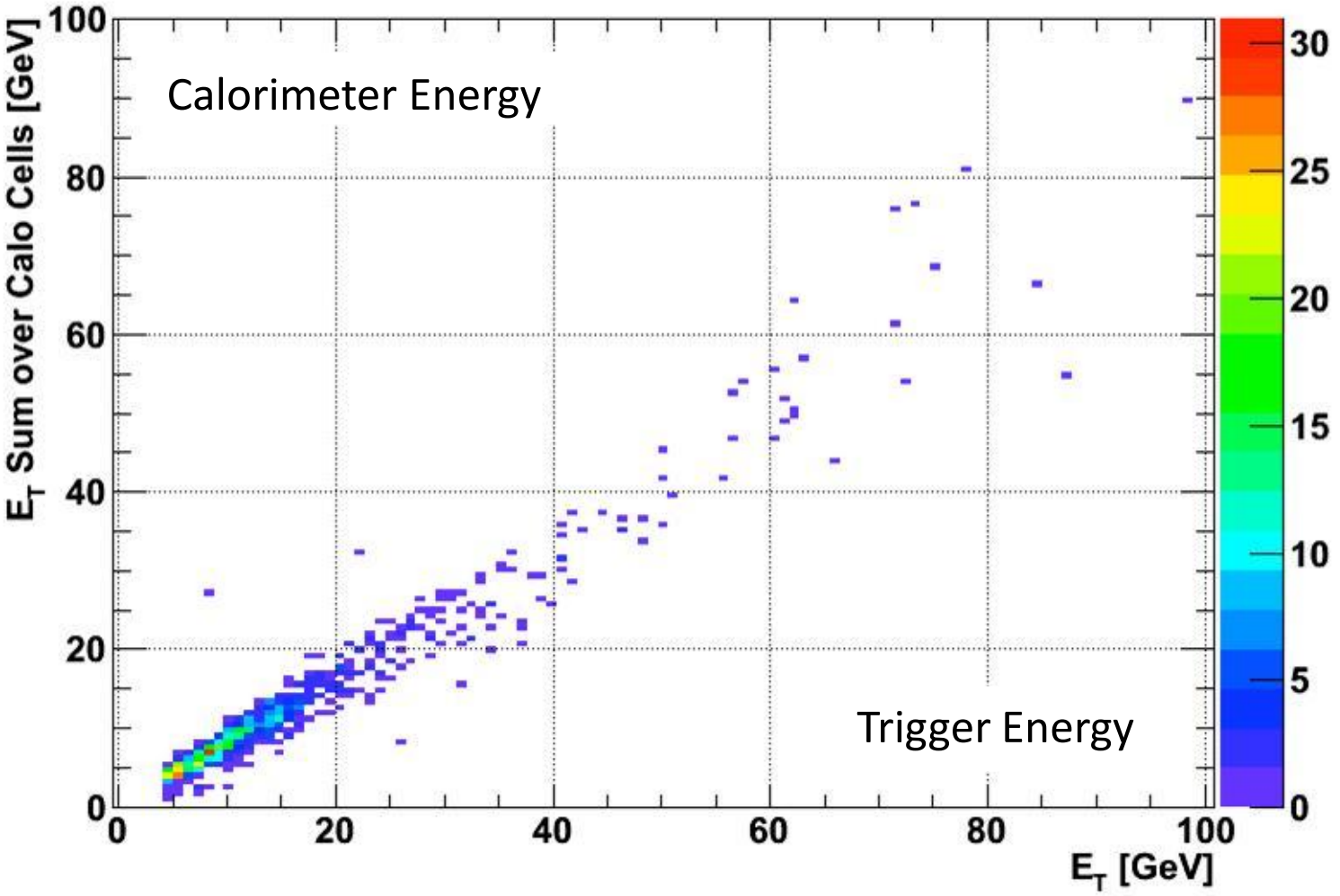
Timing not so bad: all channels within +- 0.5 BC

The Calorimeter Trigger: Rates



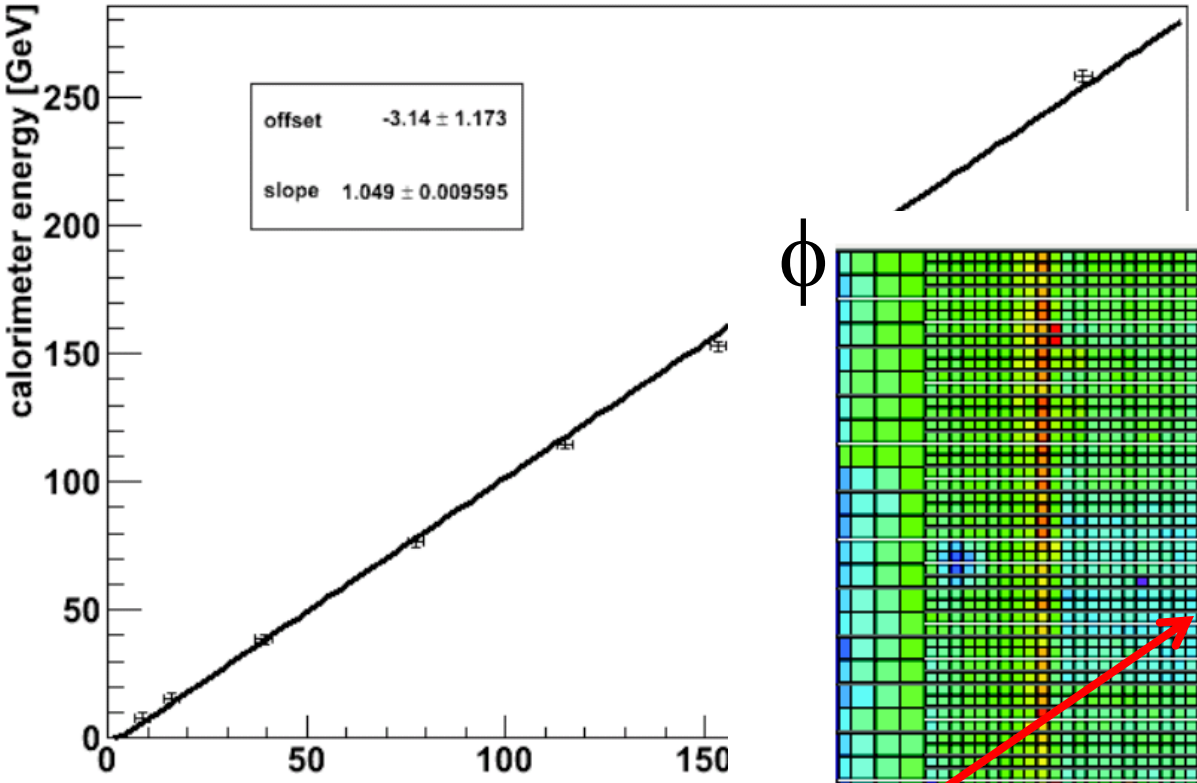
Energy calibration influences strongly the rates

Energy Response in Cosmics

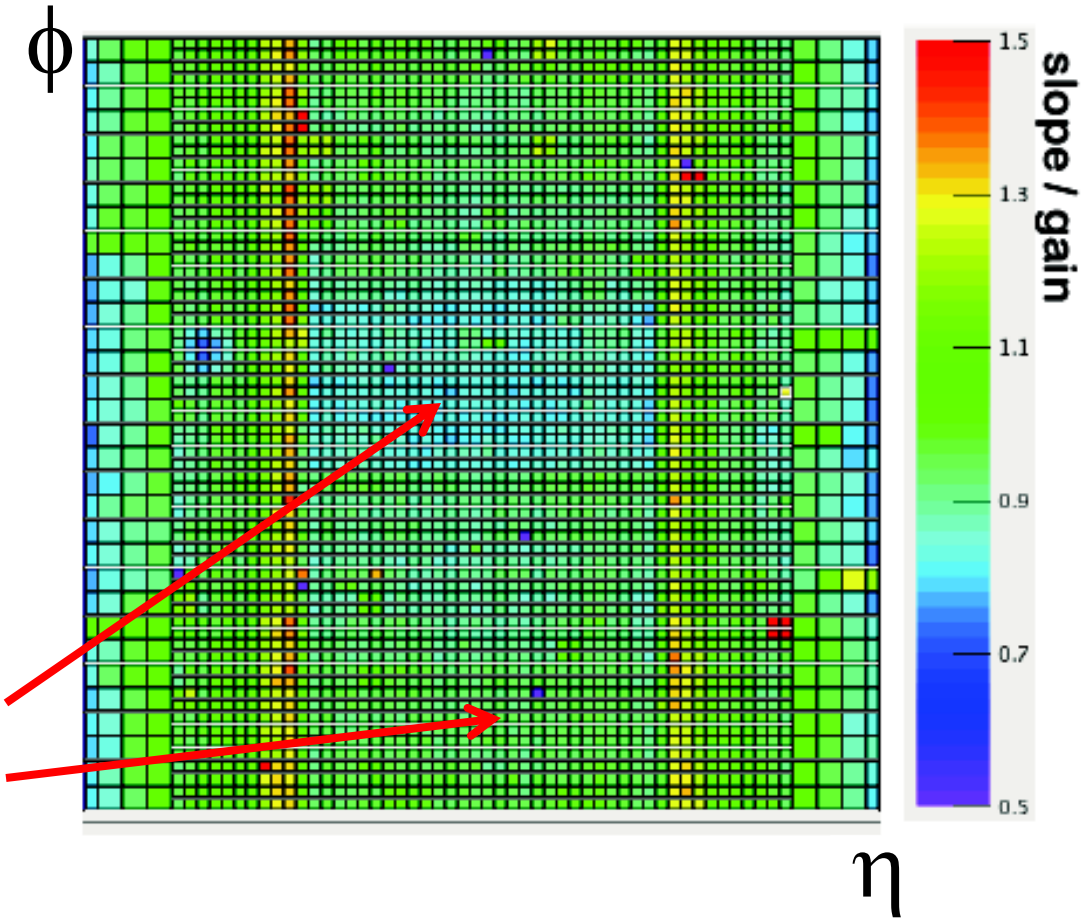


Not bad but not good either

Energy calibration



- Pulser system injects charge into electronics



Calibration Constants as expected:

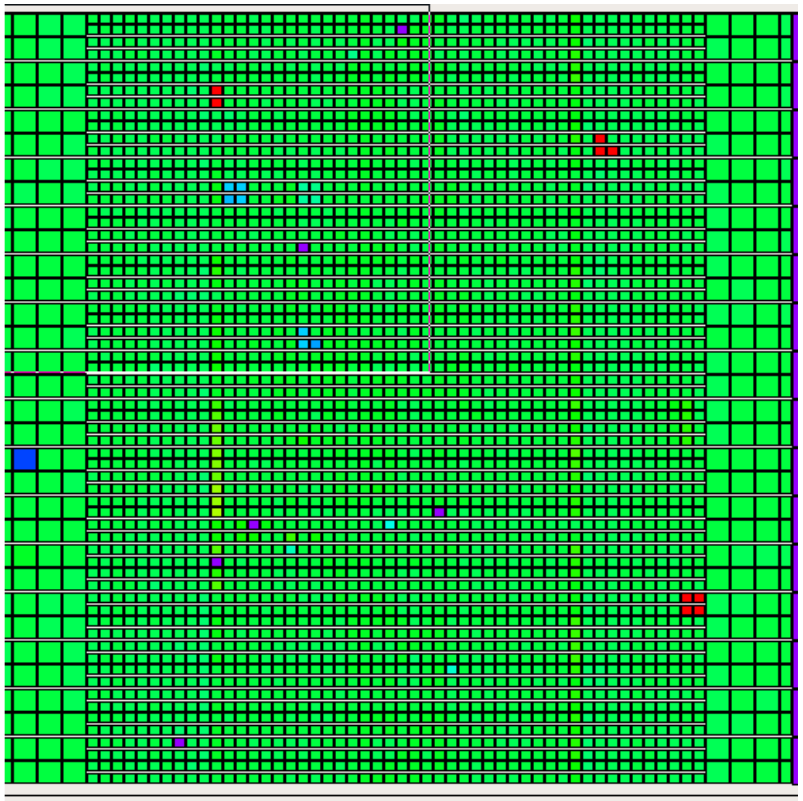
Short Cables

Long Cables

Energy calibration

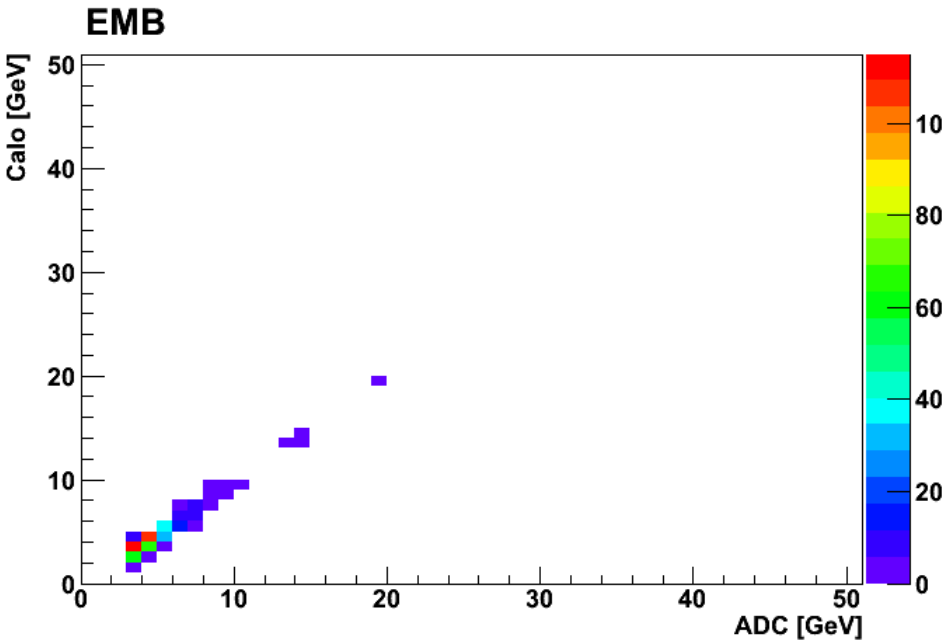
Redo calibration after application of constants

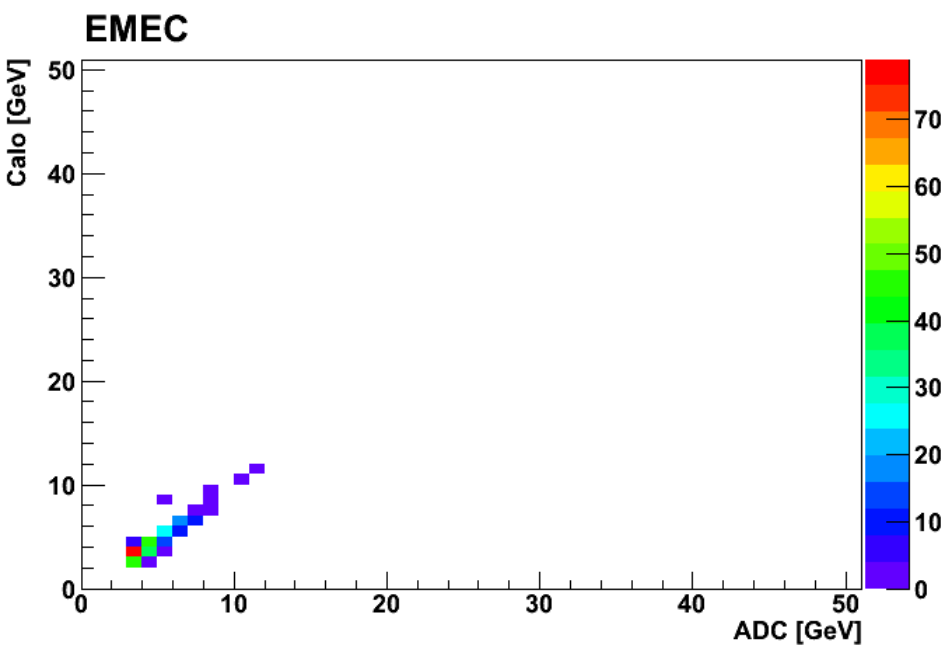
- Flat Trigger response
- Ony 0.5% of channels with problems (mostly recoverable)



Energy calibration (with beam)

Again: correlation of calorimeter and Trigger energies





Very good agreement on small statistics sample

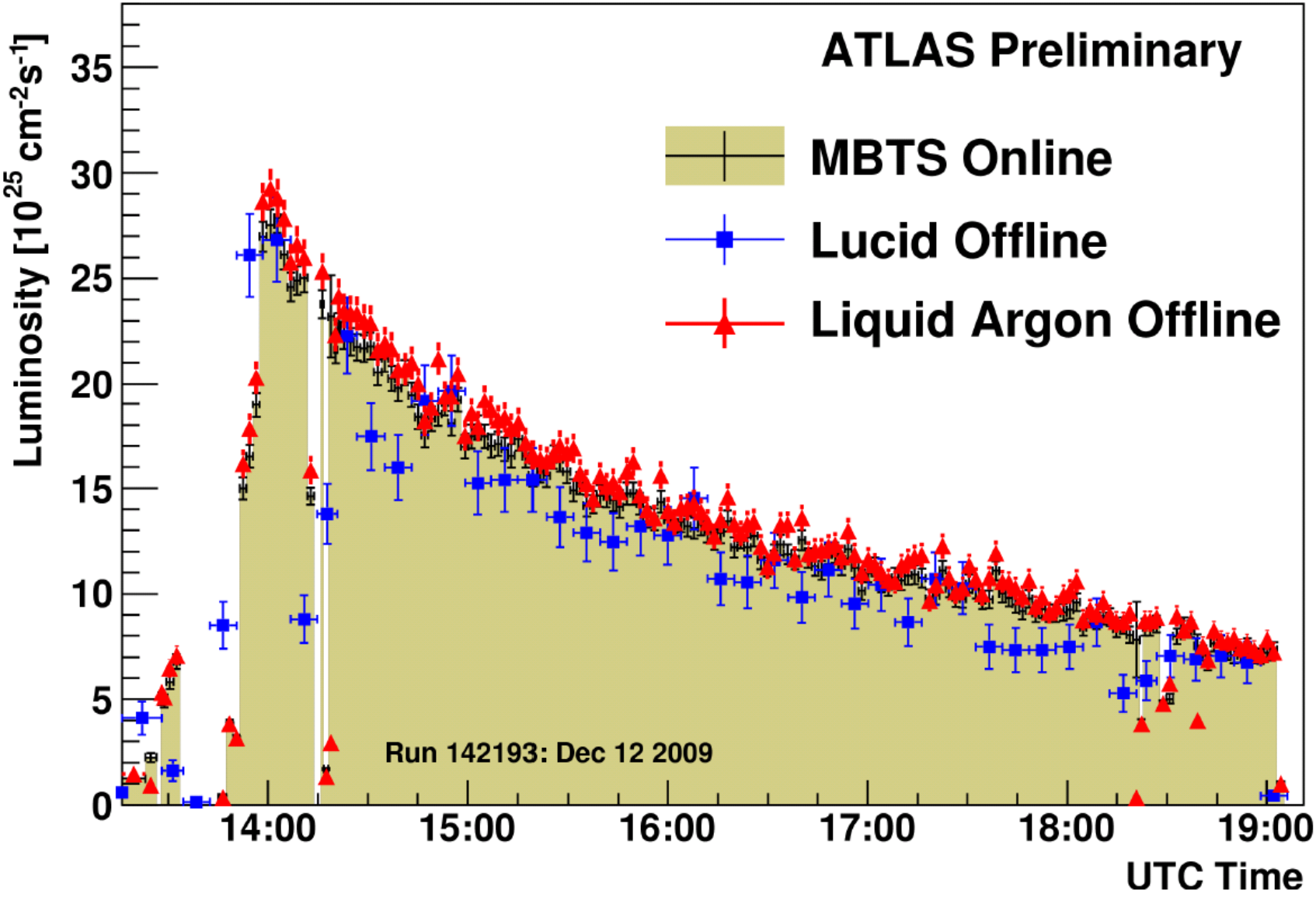
„Grau iss alle Theorie Watt zählt is auffm Platz“

Adi Preißler (1921-2003)
Deutscher Meister 1956,1957

Performance and First Physics with ATLAS

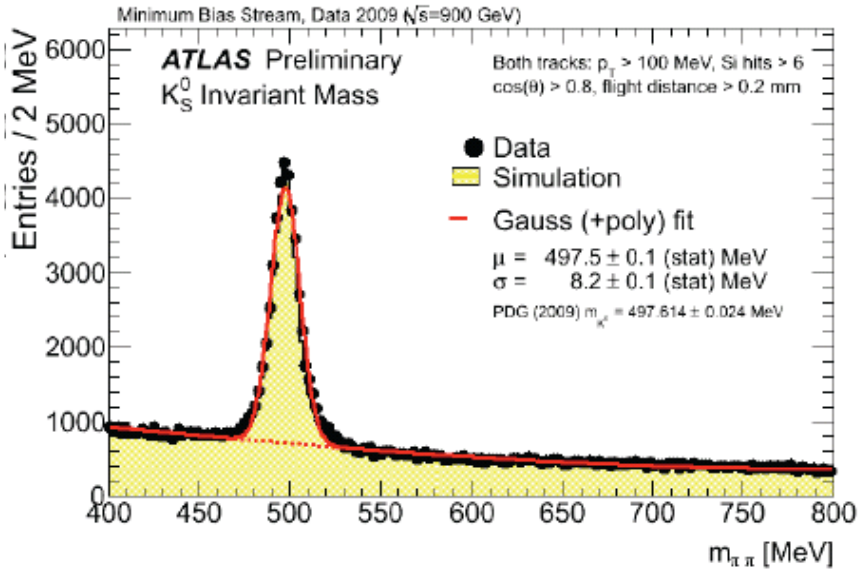
(presented yesterday at the LHCC, comparison with CMS results)

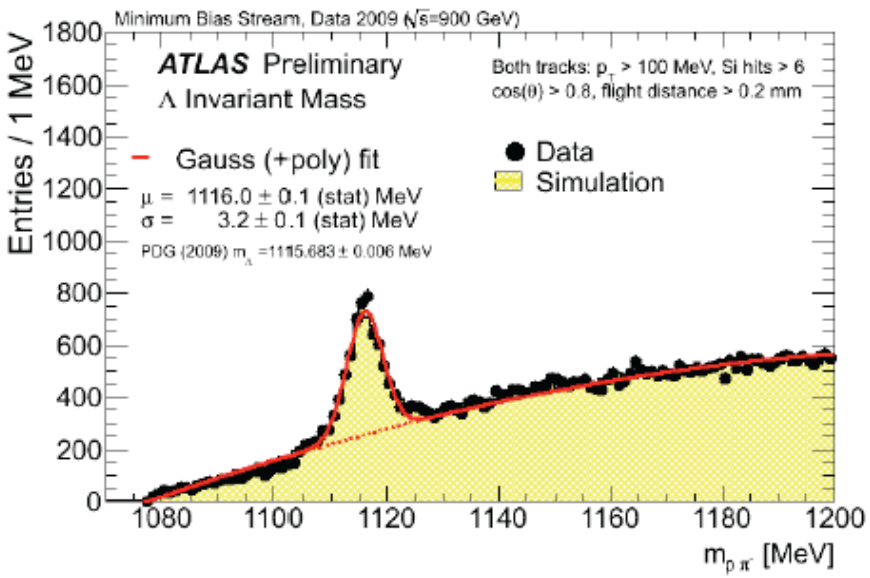
Luminosity Measurement



Tracking Performance (Resonances)

- Select good tracks
- Reconstruct Resonances (invariant mass)

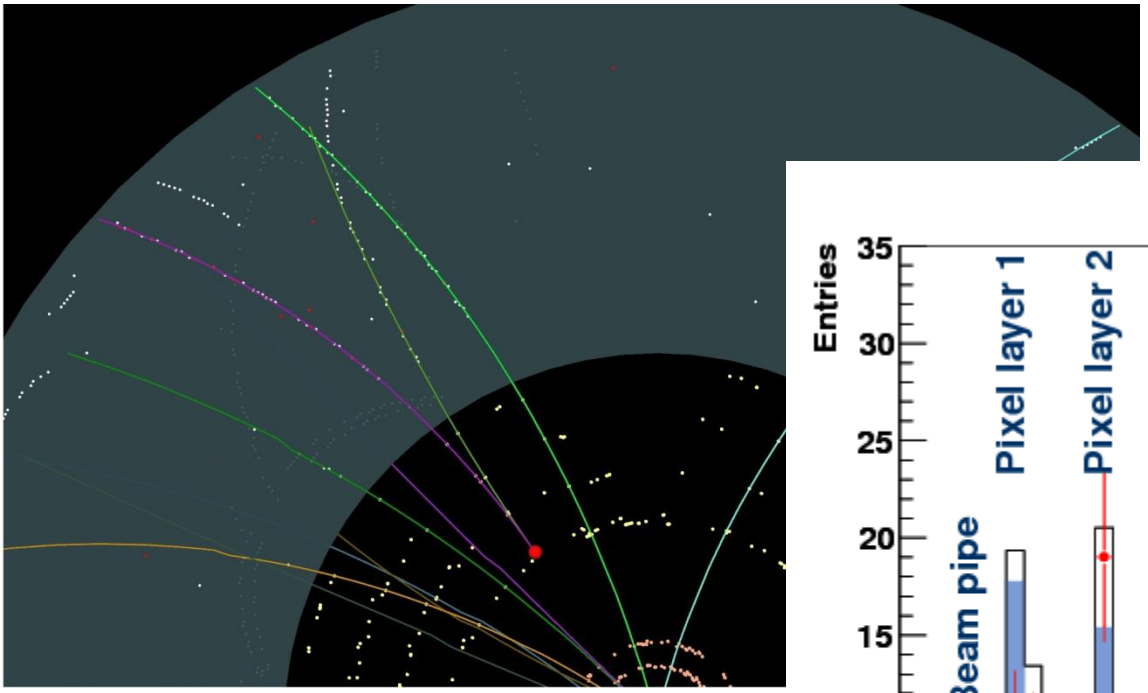




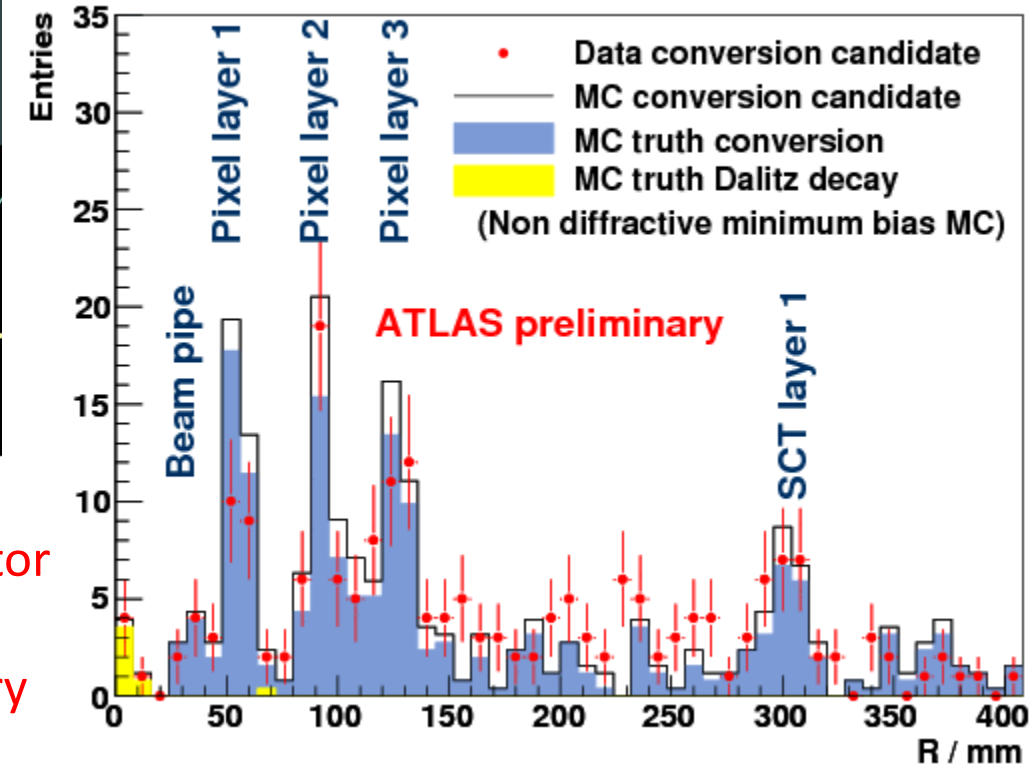
Tracker already well understood

Tracking Performance (Material)

Reconstruct Photon Conversions γ X -> ee

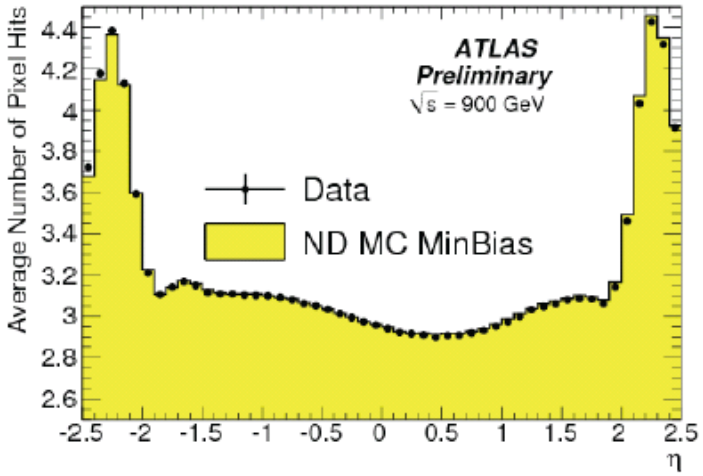


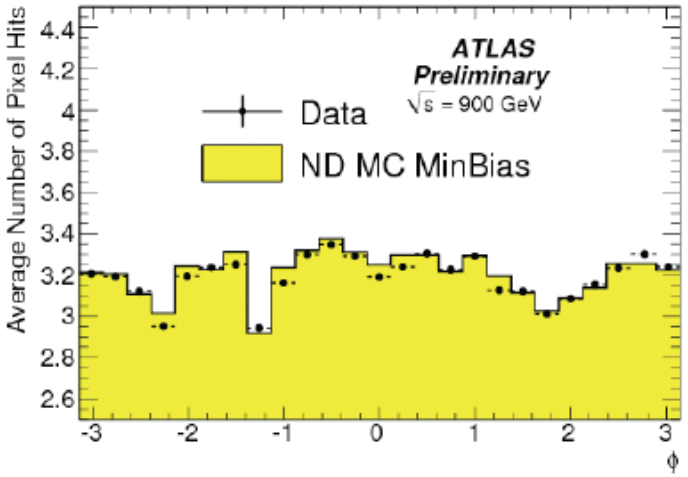
Goal: material mapping



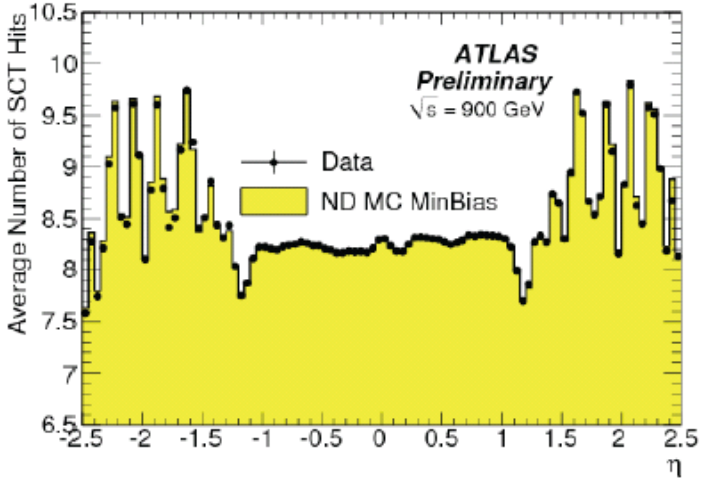
Material distribution of the detector already well understood (~10%)
Only small addition was neccessary (found by checking tracking eff.)

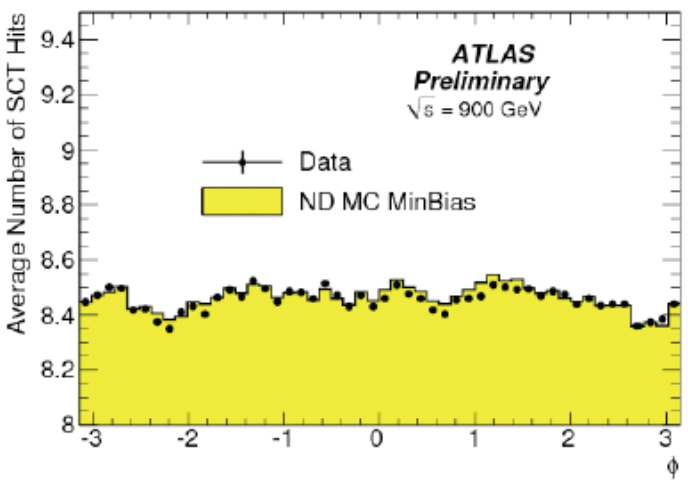
Tracking Performance (hits per track)





Number of pixel hits on track versus η / ϕ

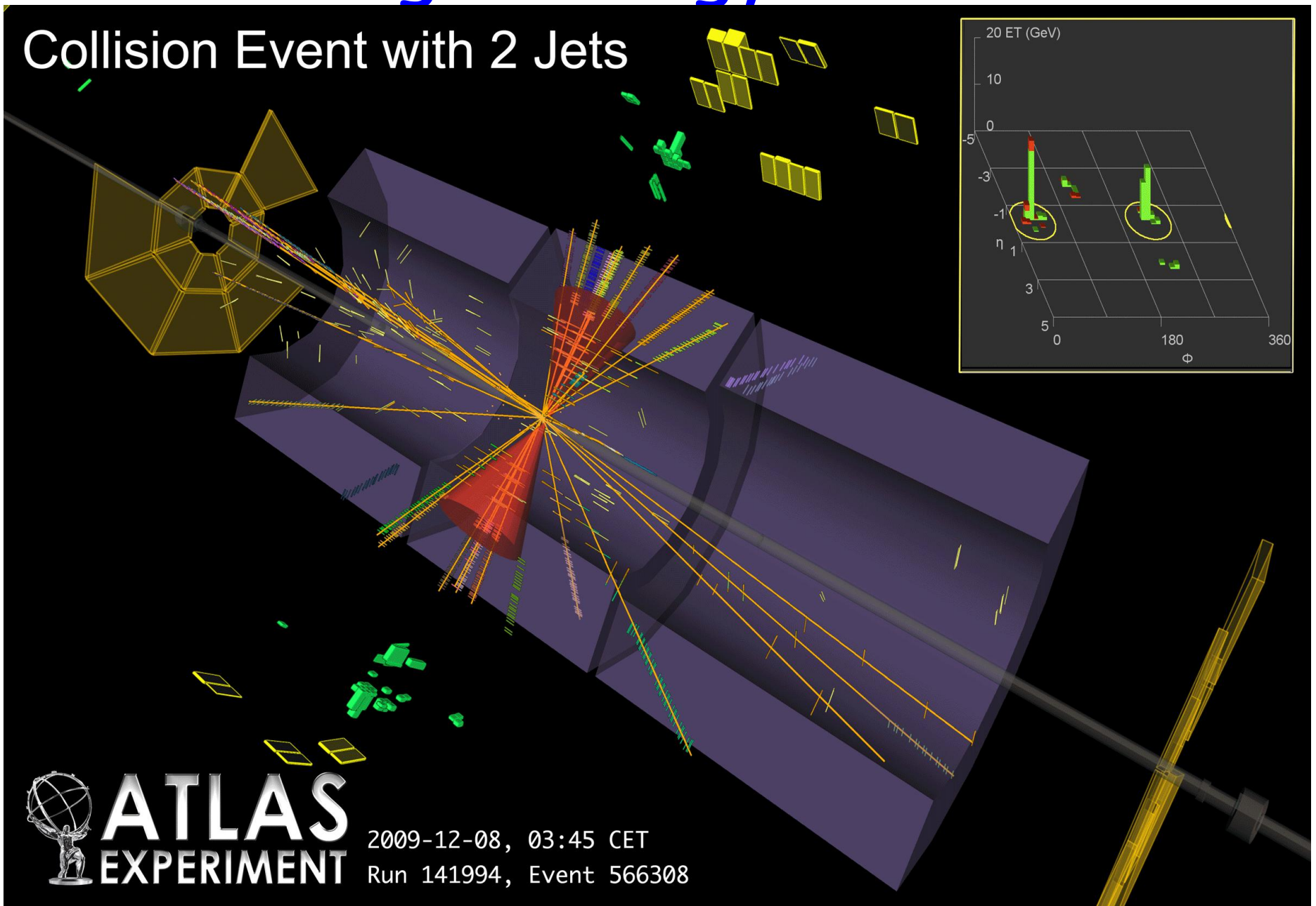




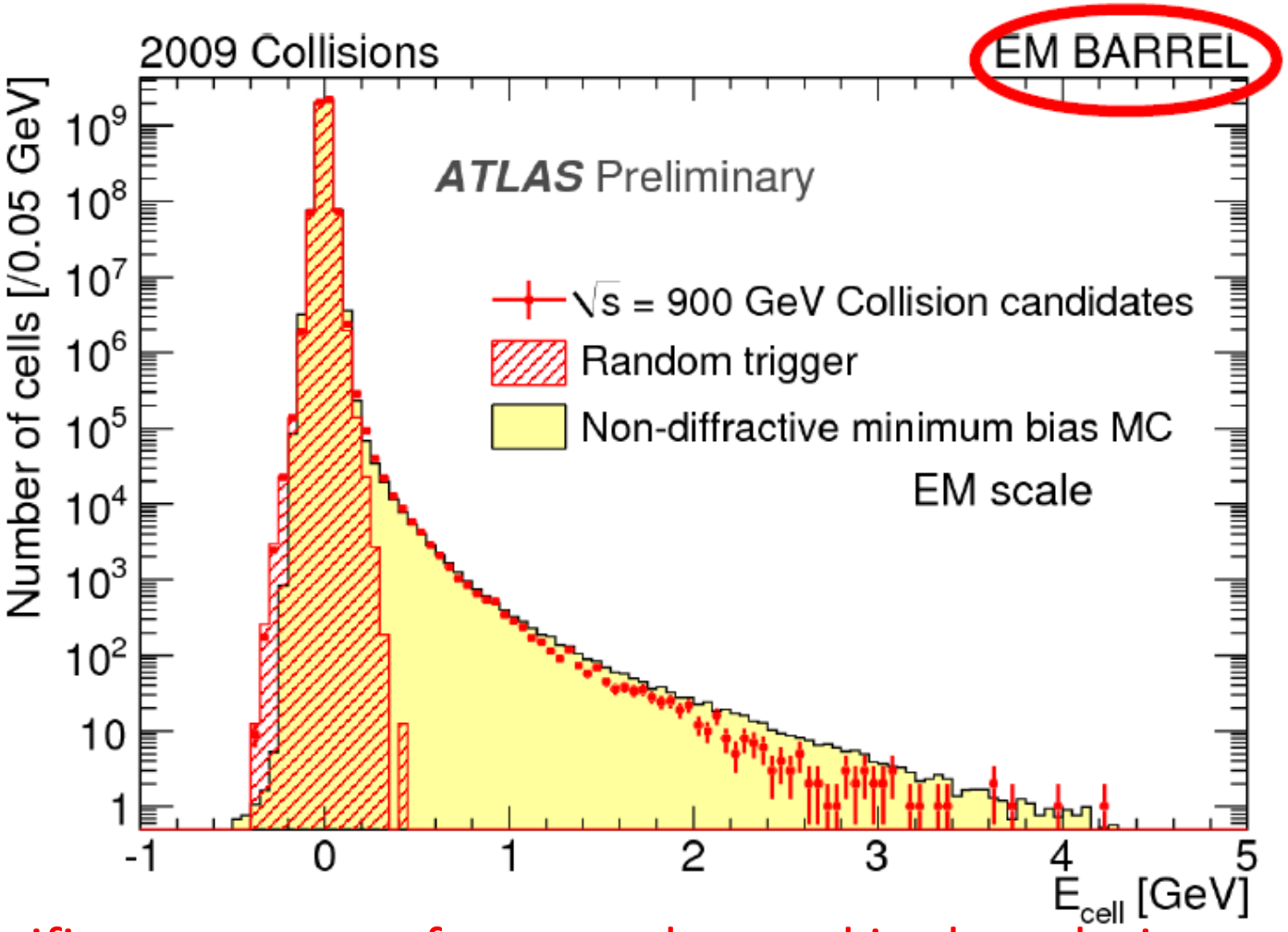
Number of SCT hits on track versus η / ϕ

Detector Response well understood / well modelled in MC

„High Energy“ Jets

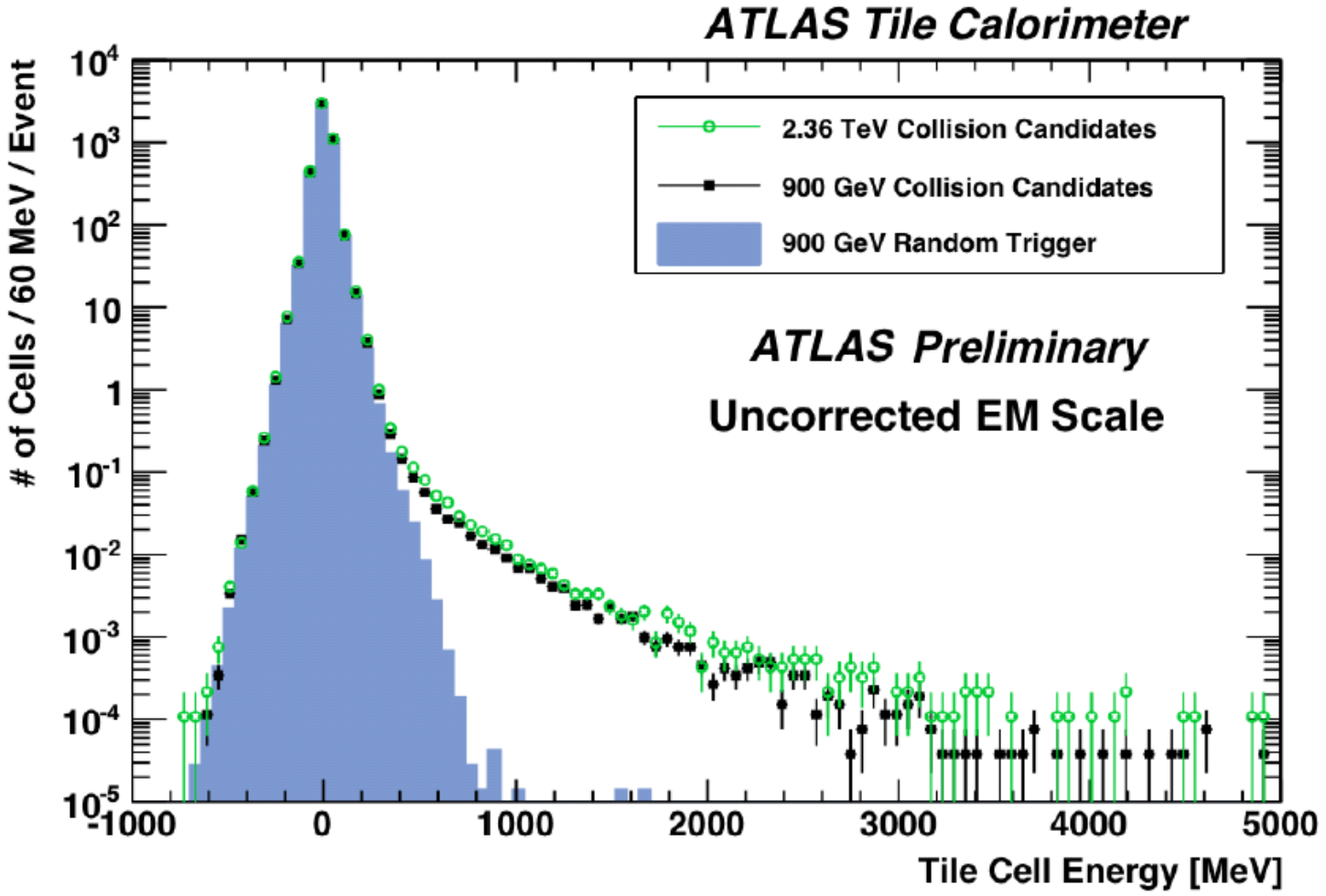


Calorimeter Energy Depositions



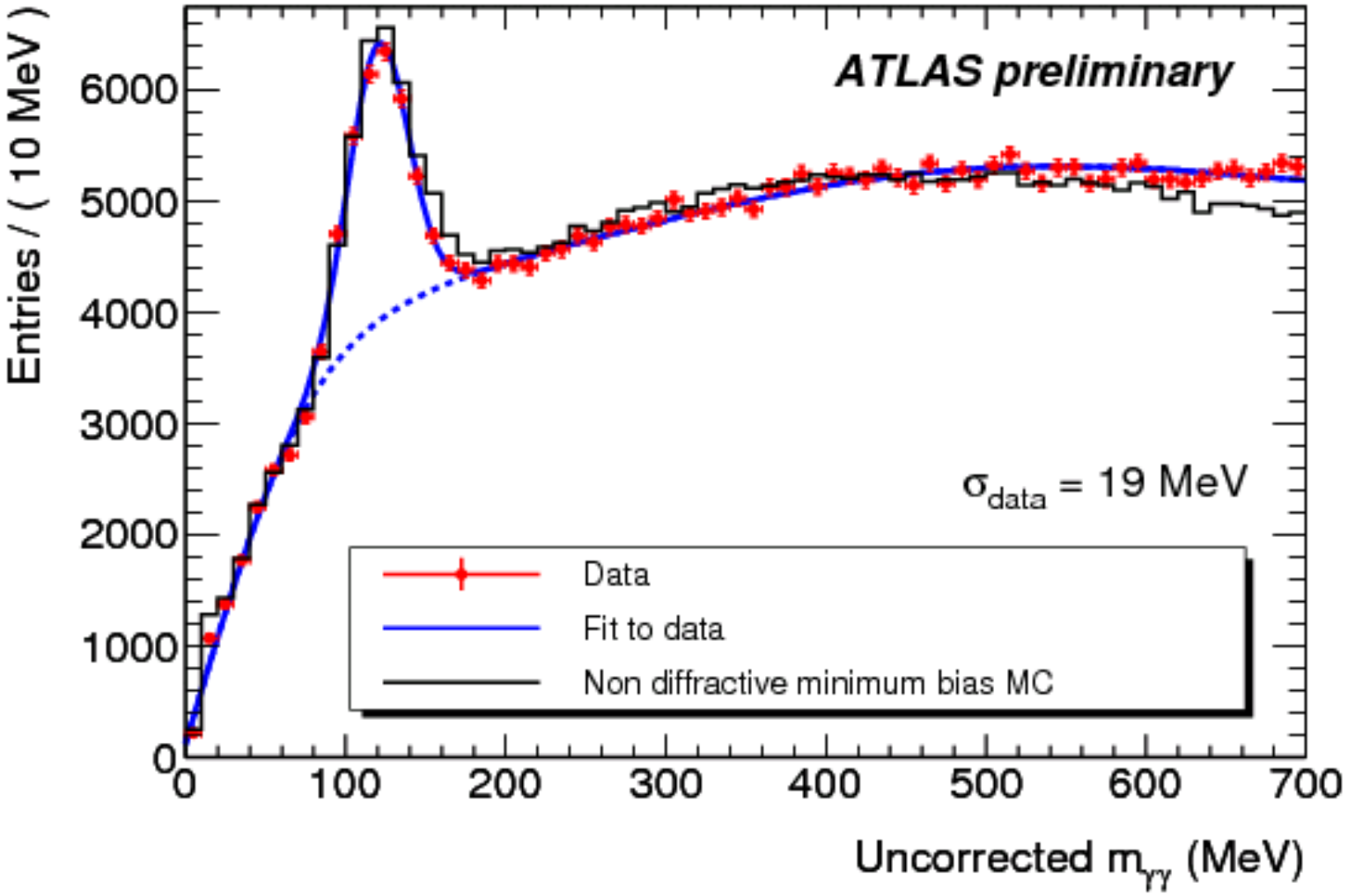
Significant amount of energy observed in the calorimeter (not consistent with noise, in agreement with MC)

Calorimeter Energy Depositions

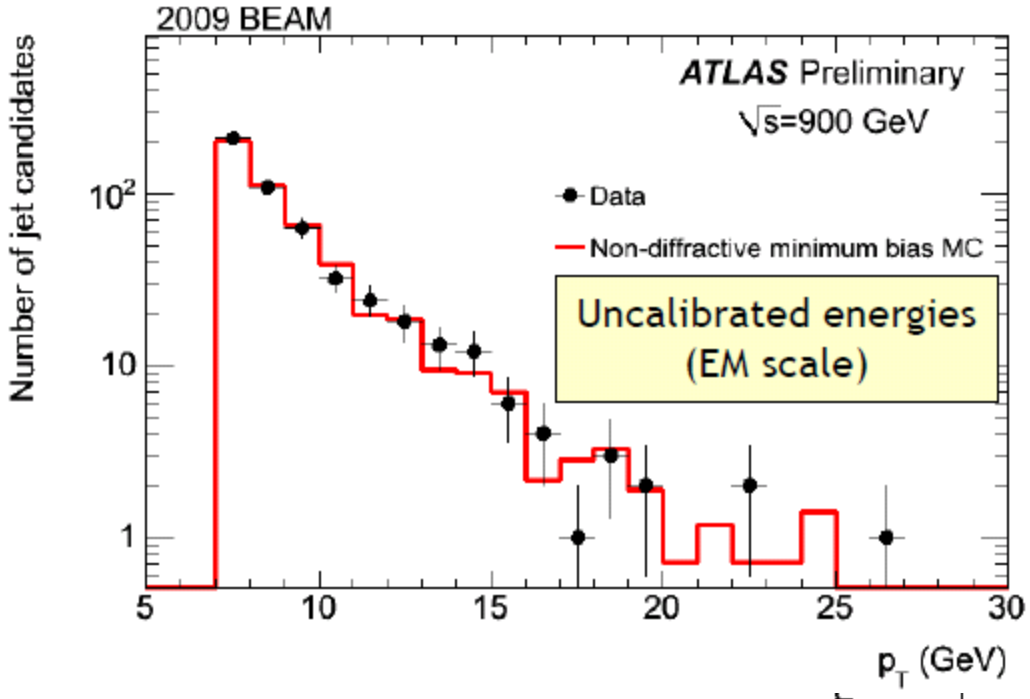


Significant amount of energy observed in the calorimeter (not consistent with noise)

Calorimeter Response (Pions)

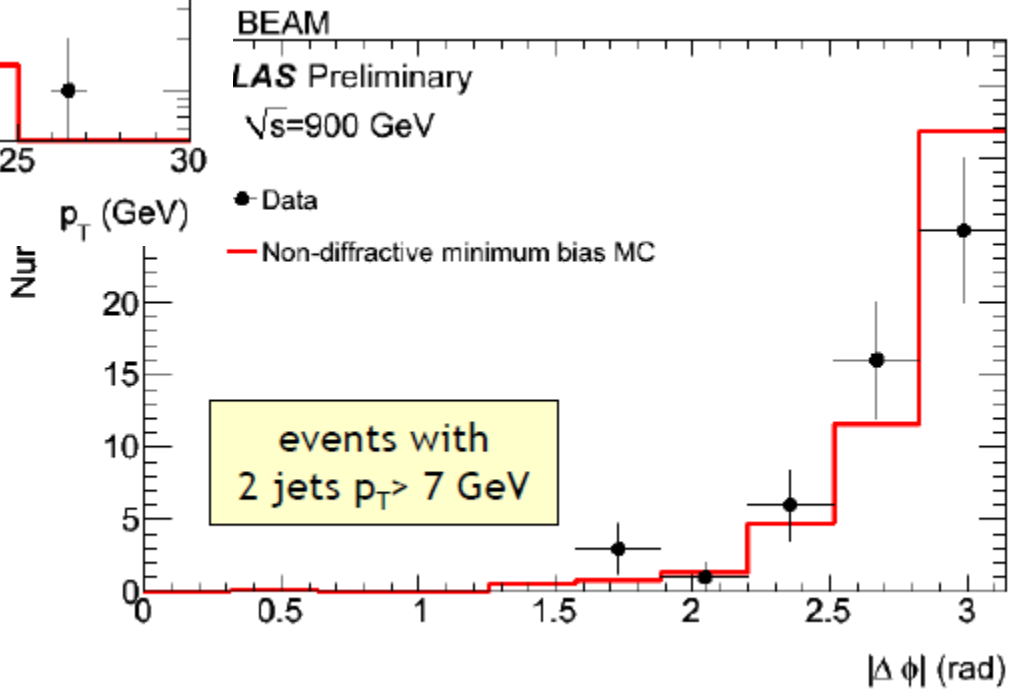


Jet Spectra



Jet P_T spectra

Azimuthal decorralation

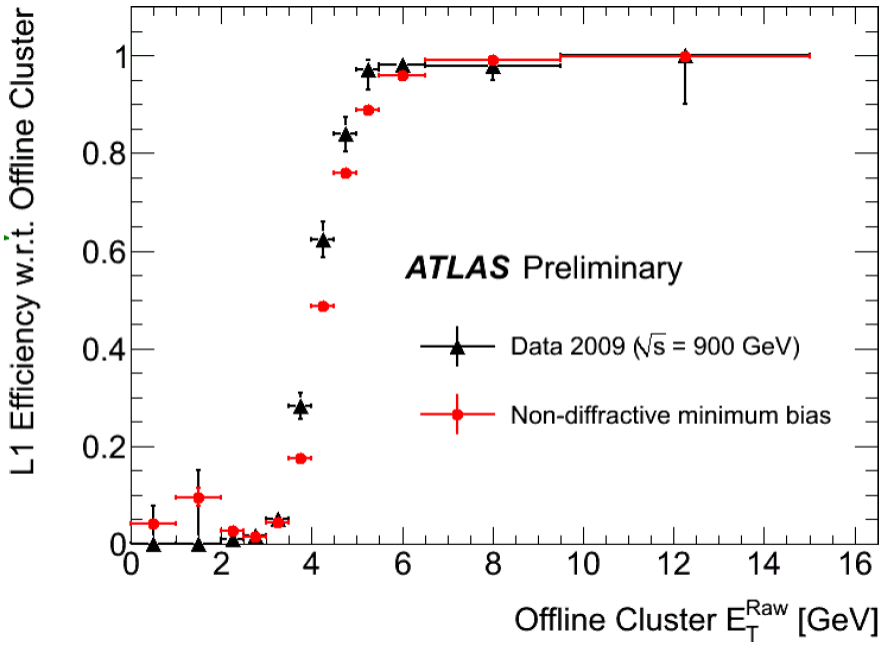


- Jet Spectra well described by min bias MC (shape)
- We have tons of plots which look inmore detail

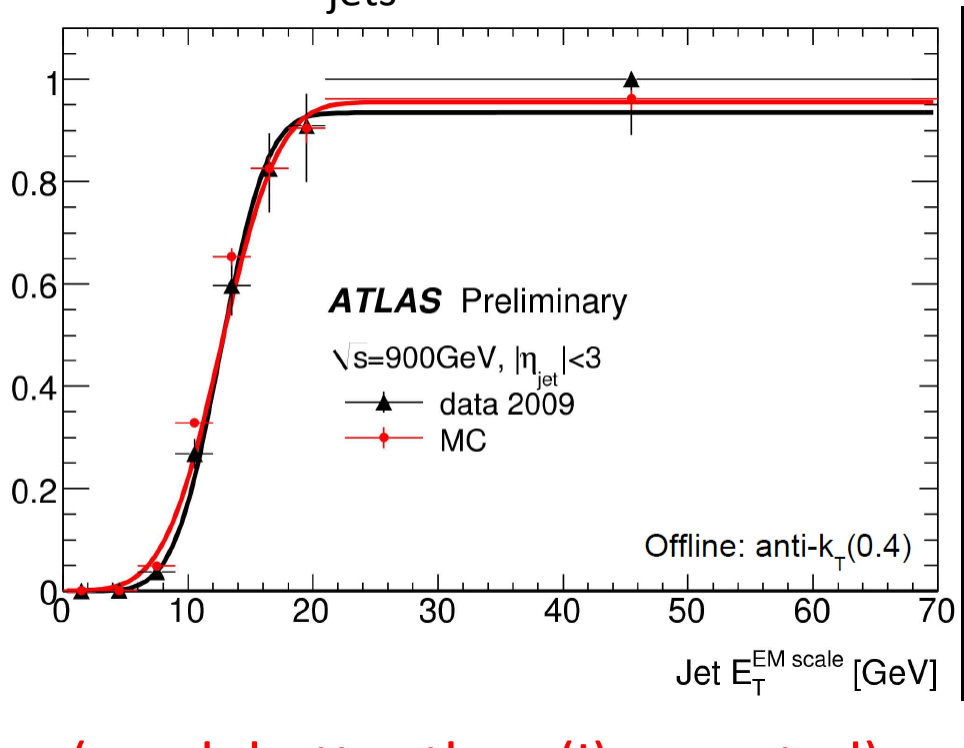
Trigger

All results have been achieved using a special minimum bias Trigger (Scintillators at the endcaps of the experiment)

electrons

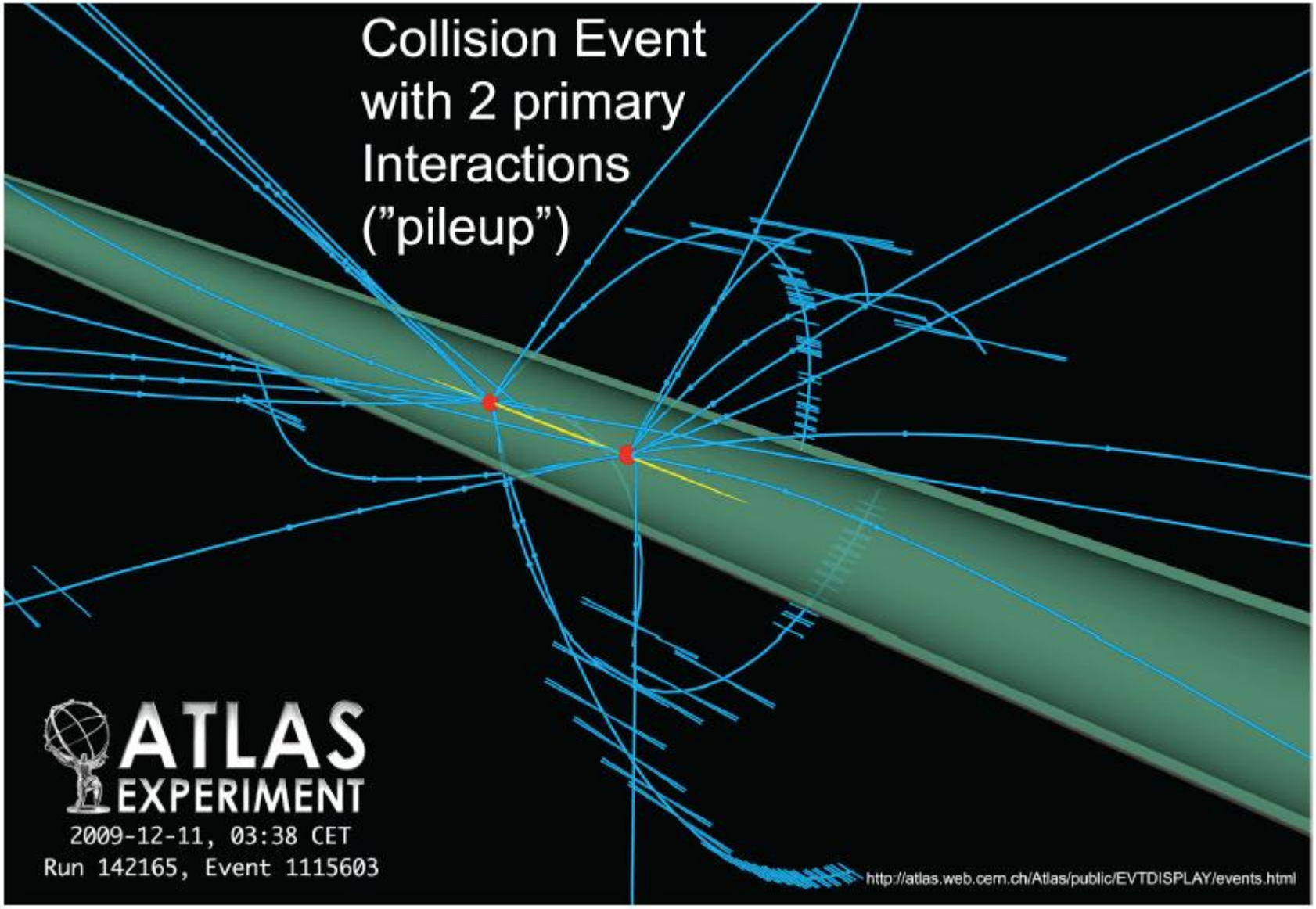


jets

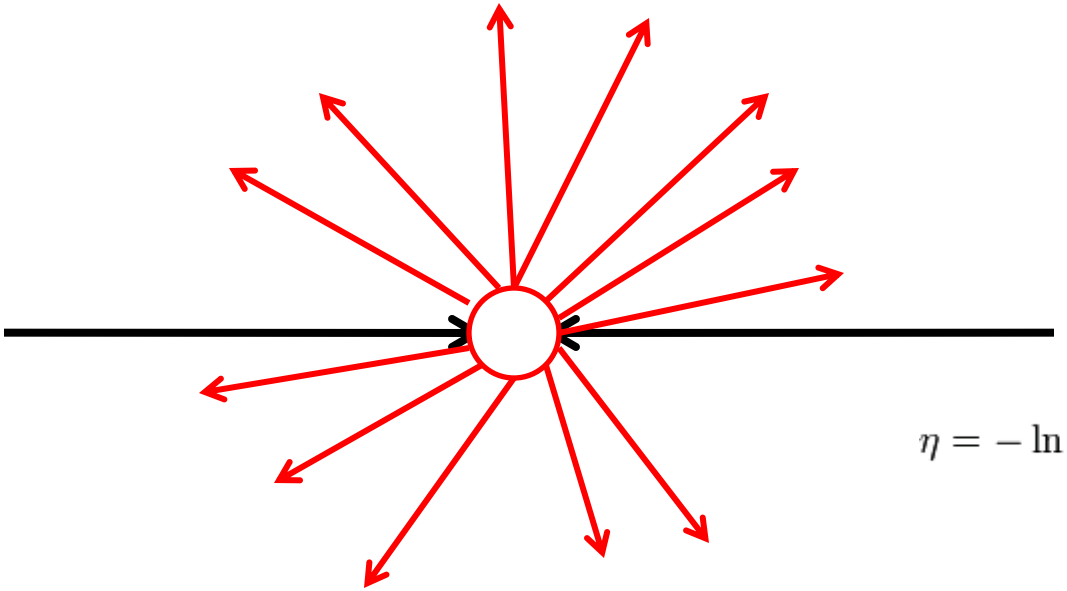


Very good performance already now (much better than (I) expected)

Pile Up (already now)



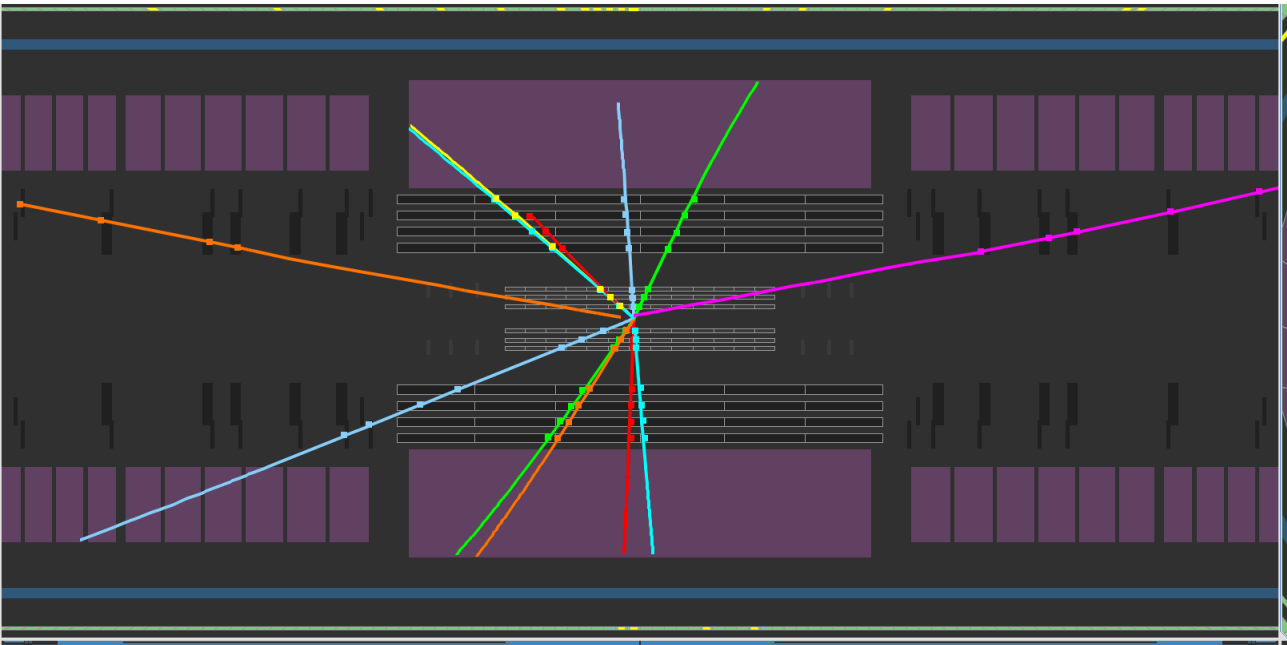
First Measurement

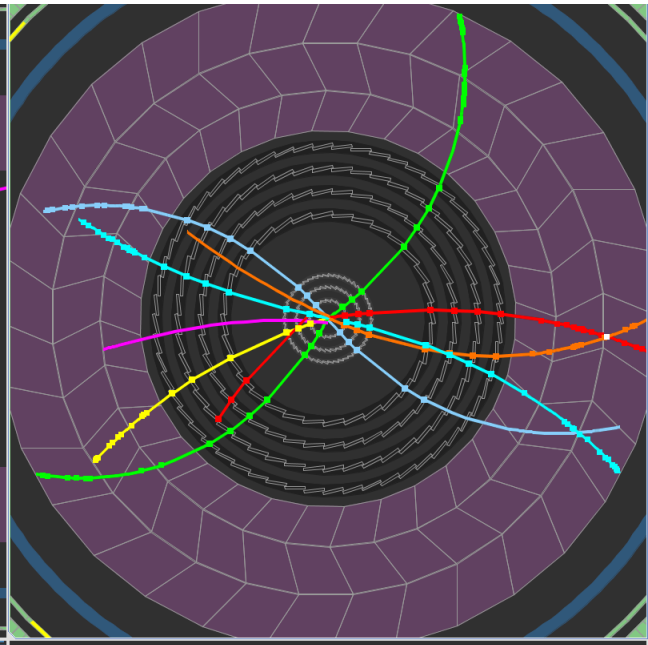


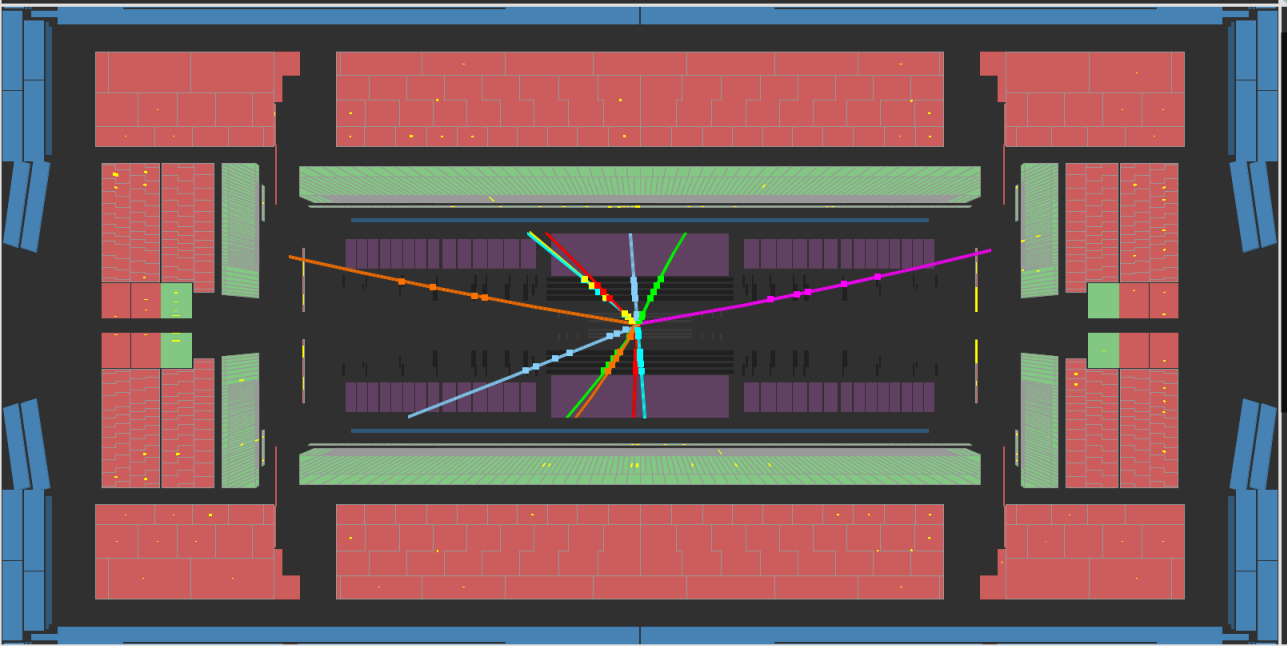
$$\eta = -\ln\left[\tan\left(\frac{\theta}{2}\right)\right],$$

Observables: - spectra of charged particles $\frac{1}{N_{evt}}\frac{\Delta N_{ch}}{\Delta\eta}$

- p_T spectra $\frac{1}{2\pi N_{evt} p_T}\frac{\Delta^2 N_{ch}}{\Delta\eta\Delta p_T}$







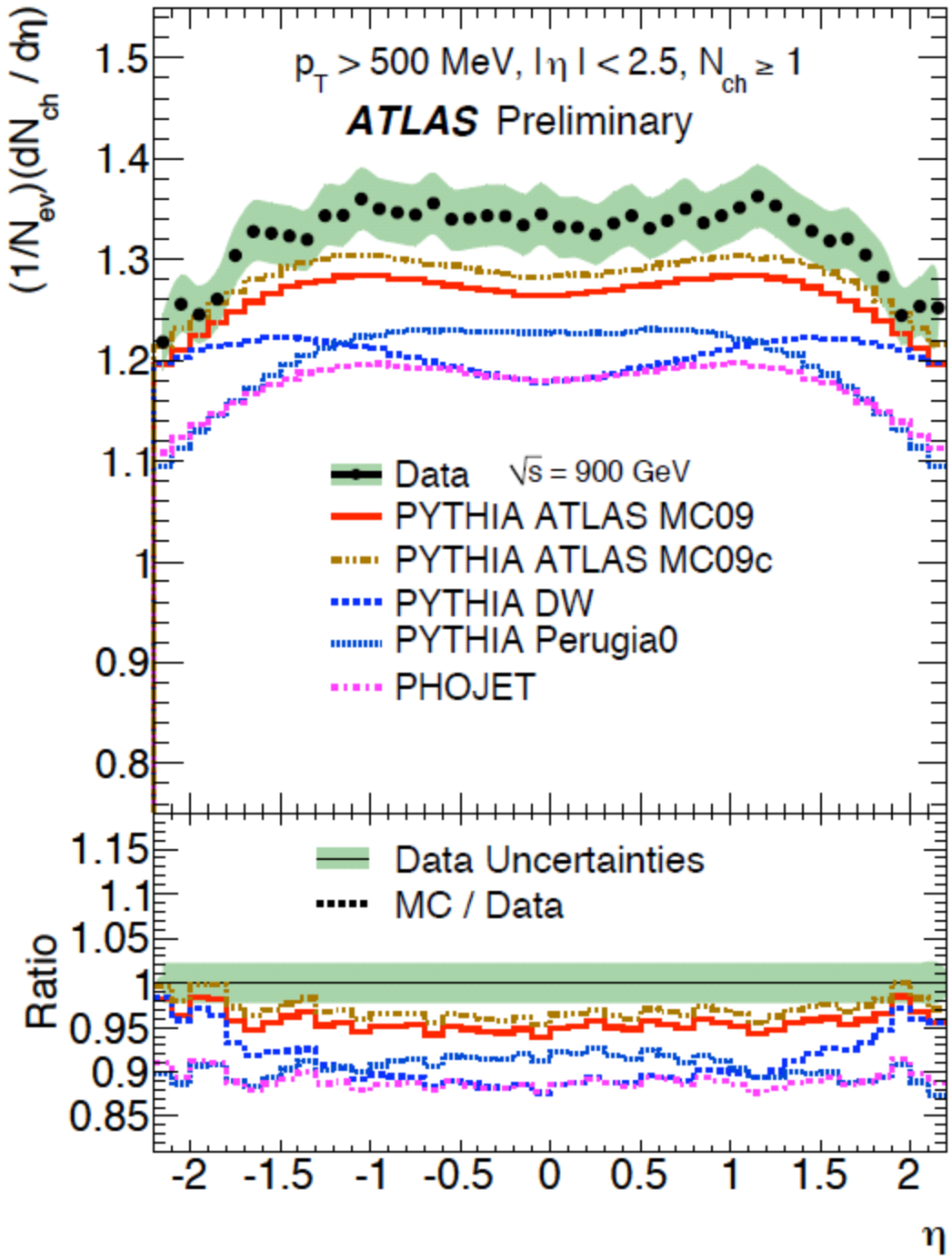
ATLAS EXPERIMENT

2009-12-06, 10:04 CET

Run 141749, Event 406601

Collision Event

http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

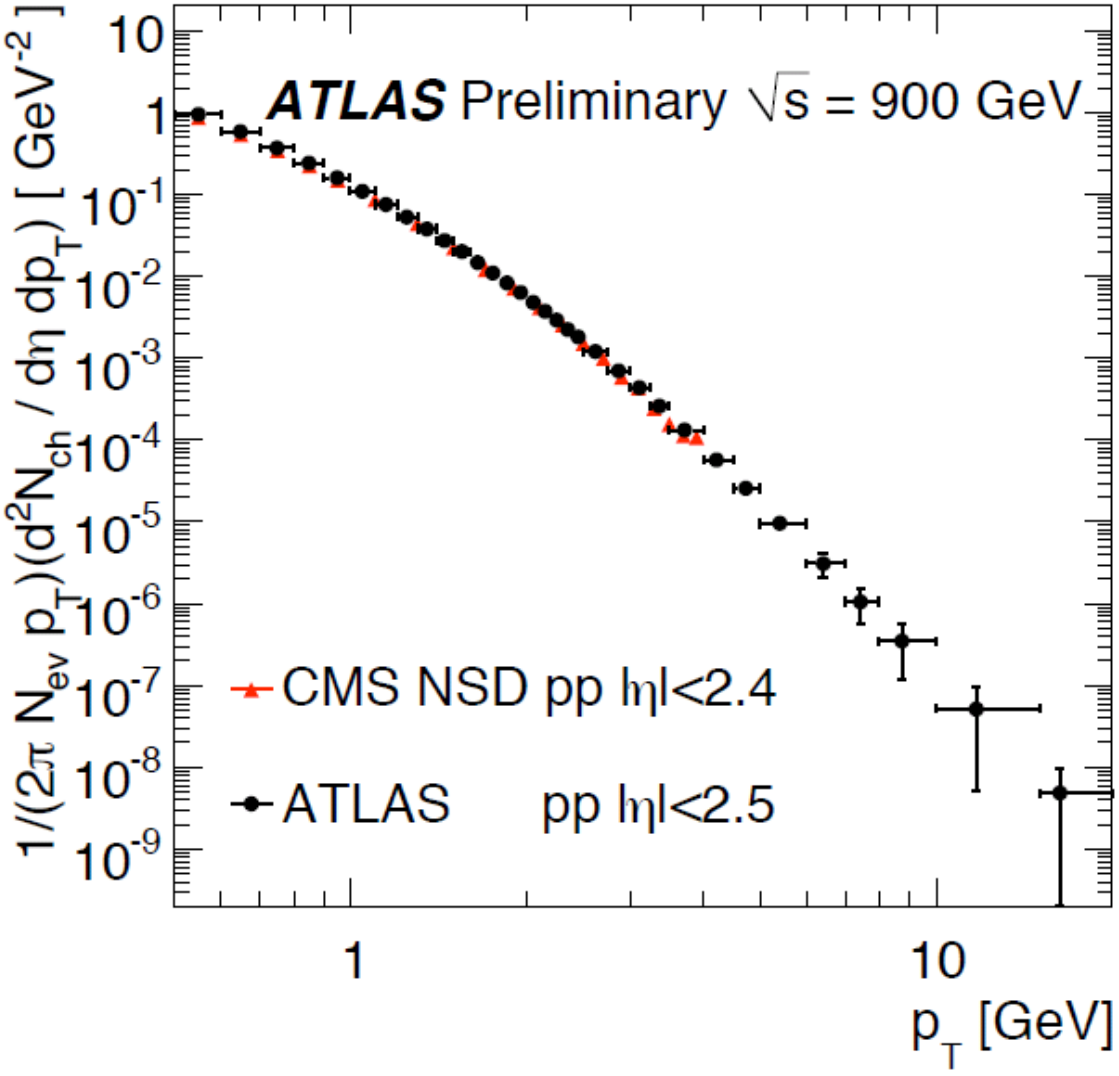


First ATLAS Physics Result

-Particle production flat in η over a large range

-Data higher than MC models

Comparison with CMS

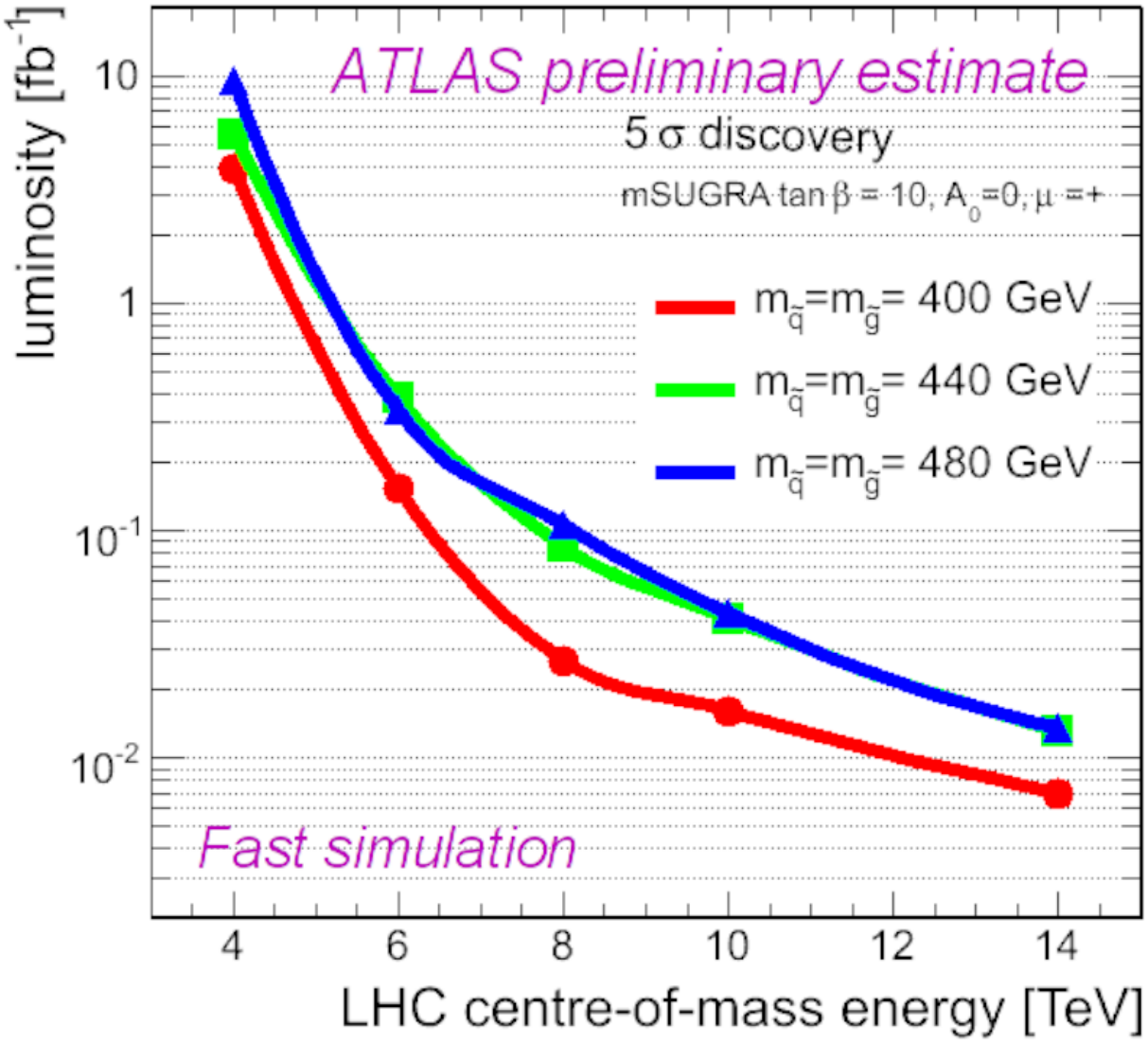


- Good agreement with CMS data

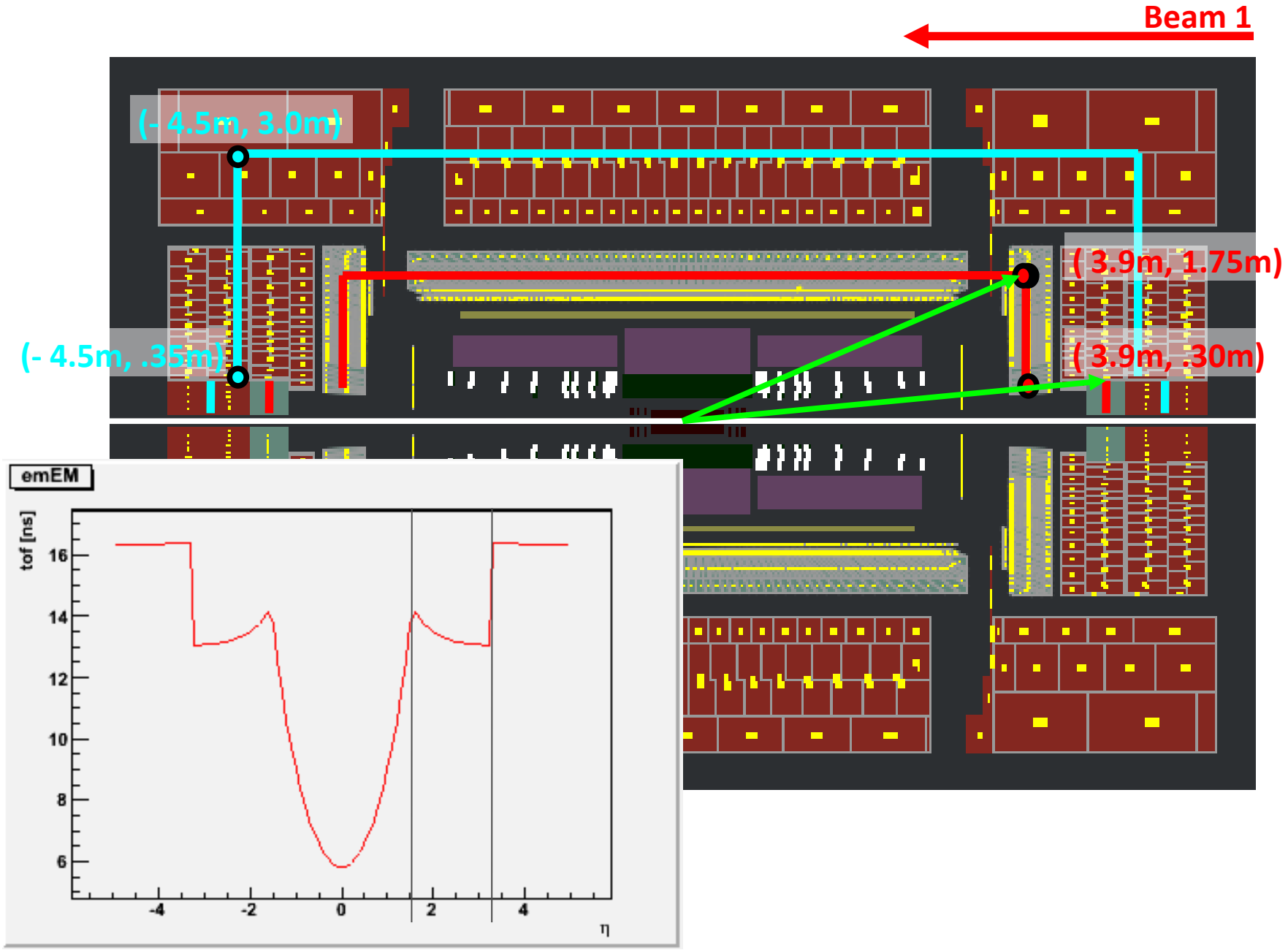
Summary

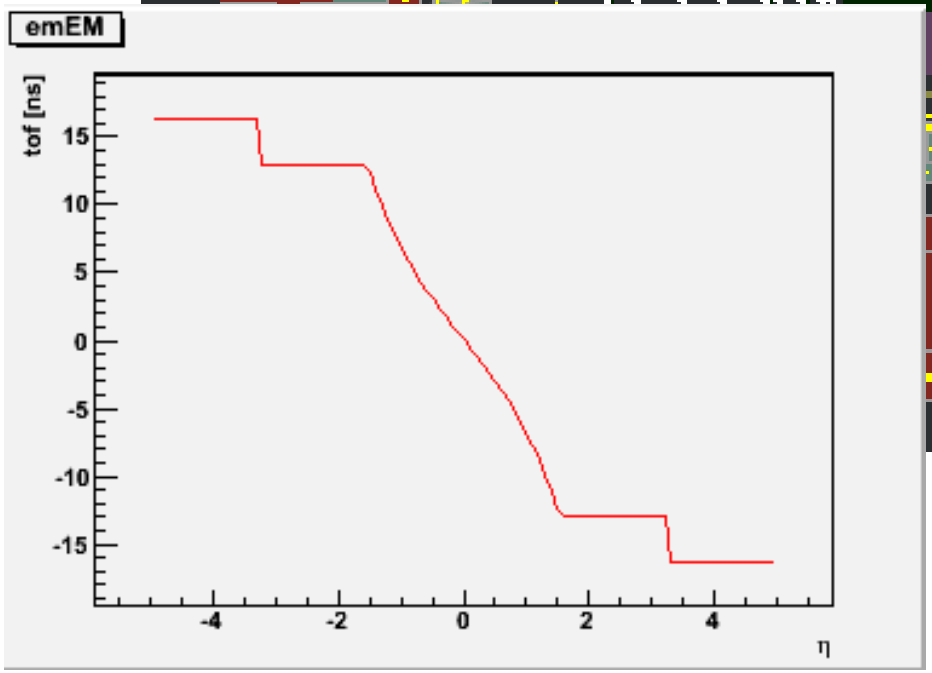
- ATLAS is a complex machinery with the goal/need to be really a multipurpose device
- Commissioning went well
- Detector understanding progresses well
- First Physics result produced on short timescale

Ausblick



Supersymmetrie ist in Reichweite auch bei
- niedriger Energie
- moderater Luminosität


Beam 1
(- 4.5m, 3.0m)
(- 4.5m, .35m)
(3.9m, 1.75m)
(3.9m, .30m)
emEM
tof [ns]
16
14
12
10
8
6
-4
-2
0
2
4
η



Beam 1

(- 4.5m, 3.0m)

(- 4.5m, .35m)

(3.9m, 1.75m)

(3.9m, .30m)

Splash 150m
upstream beam line

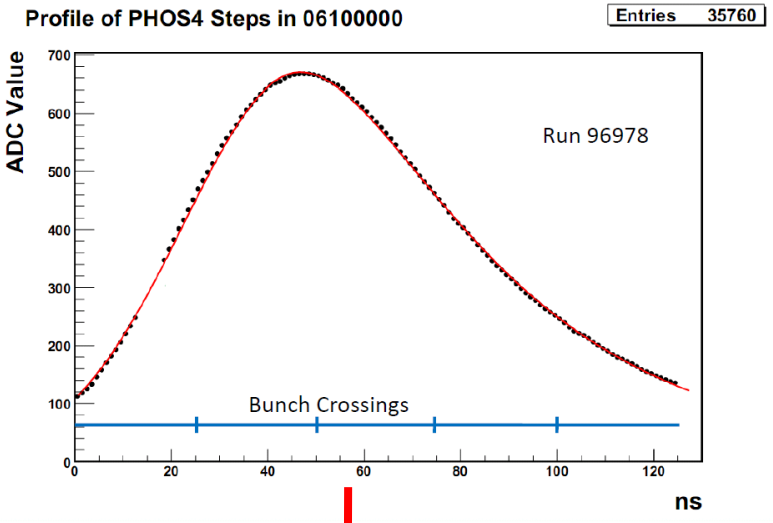
Precision Synchronisation with collisions

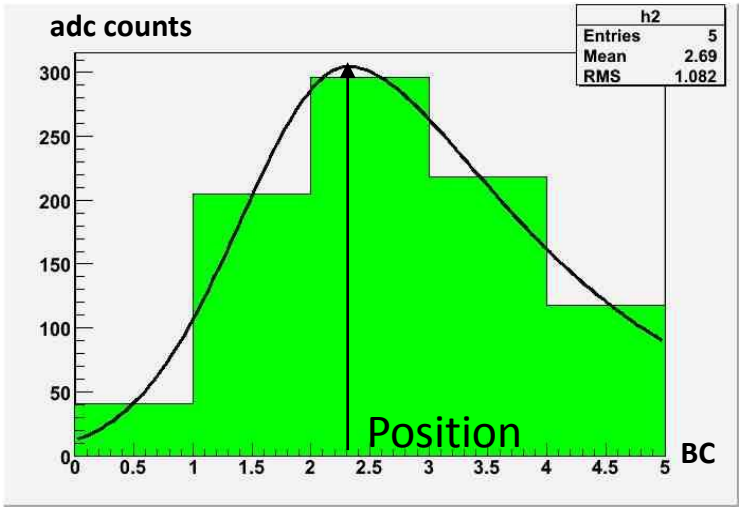
Problem:

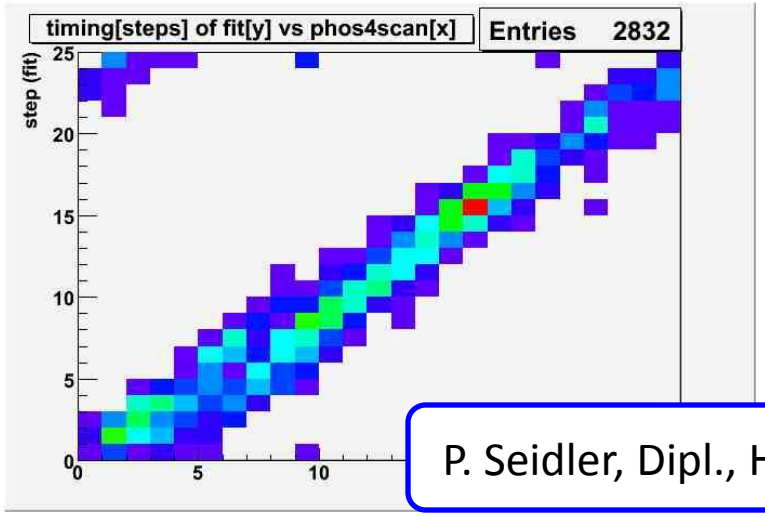
- Synchronisierung für Pulser ist unterschiedlich zur Synchronisierung für Kollisionen (andere Signalwege)

Solution:

- Fit der digitalisierte Signale
- Test der Methode mit Pulsersystem

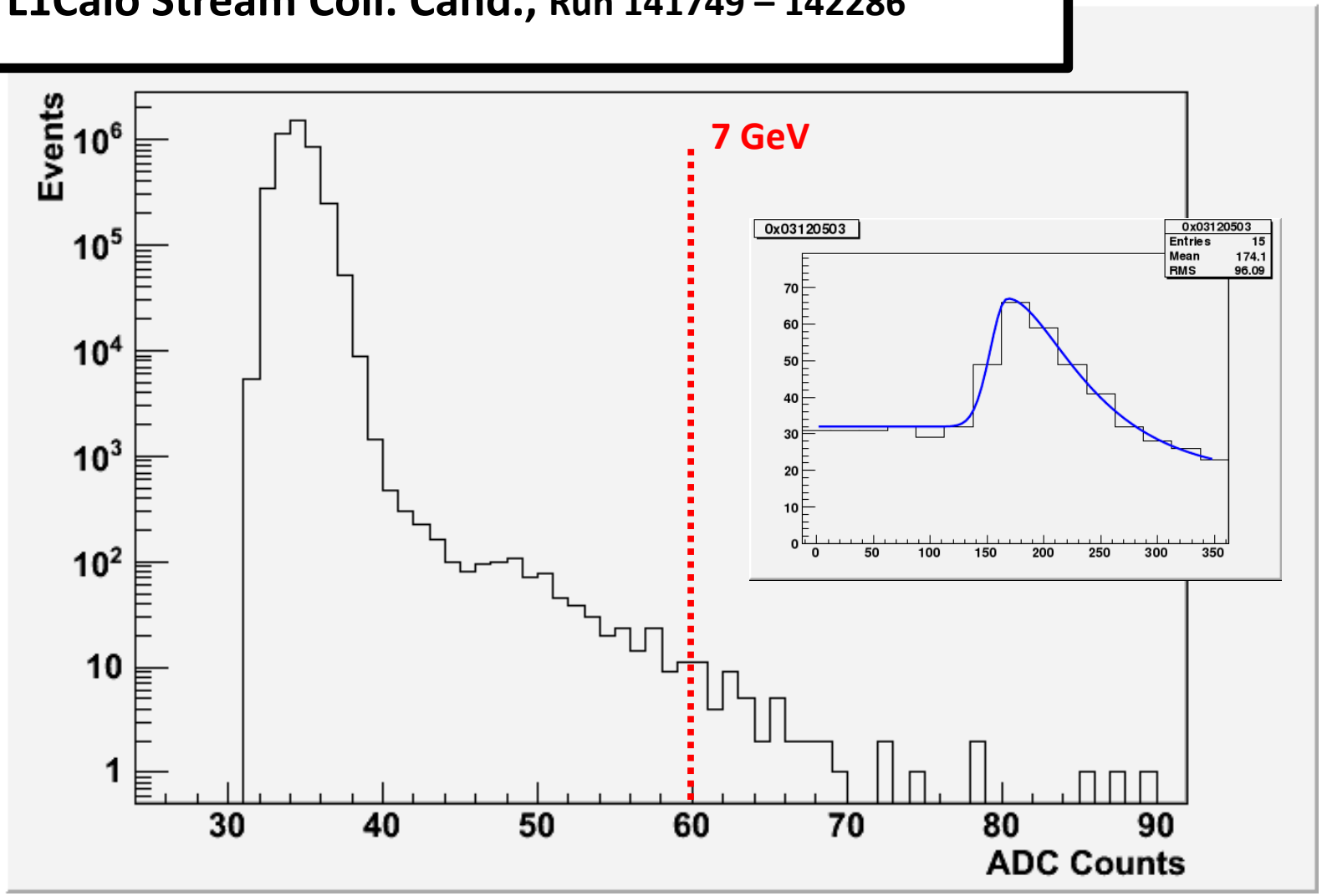




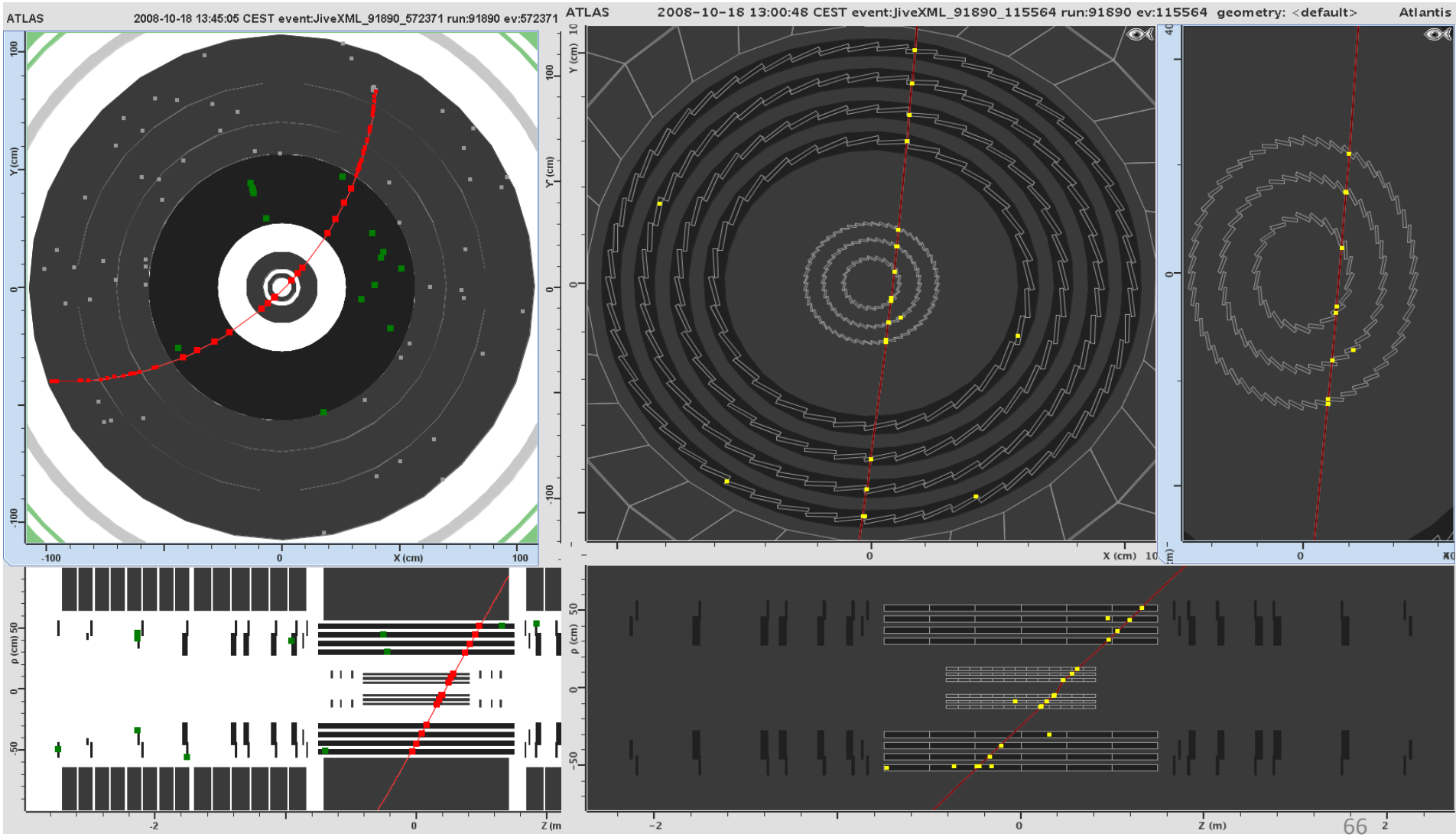


P. Seidler, Dipl., HD

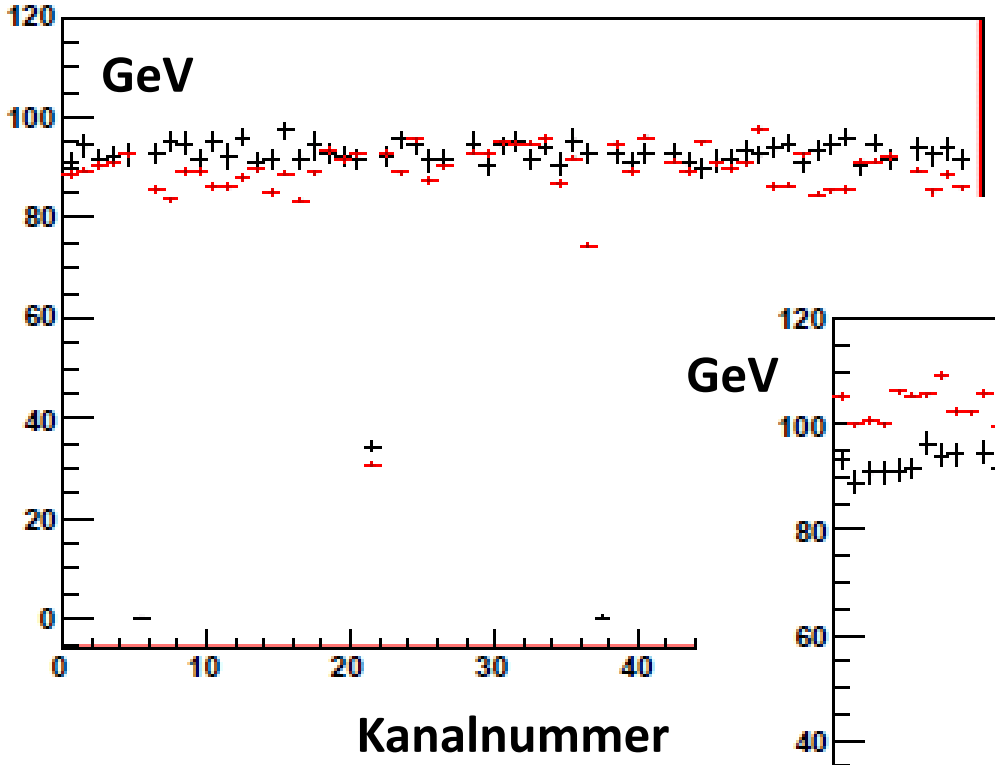
ADCmax spectrum, EM Layer
L1Calo Stream Coll. Cand., Run 141749 – 142286



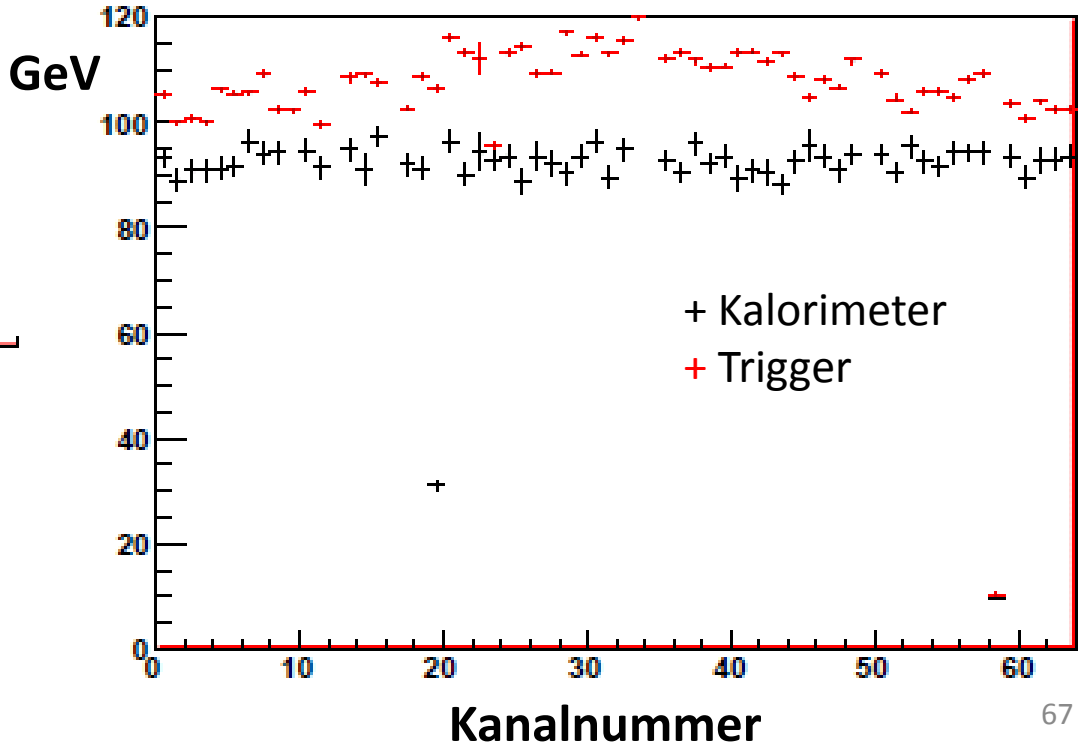
Status Innerer Detektor



Status der Energiekalibration

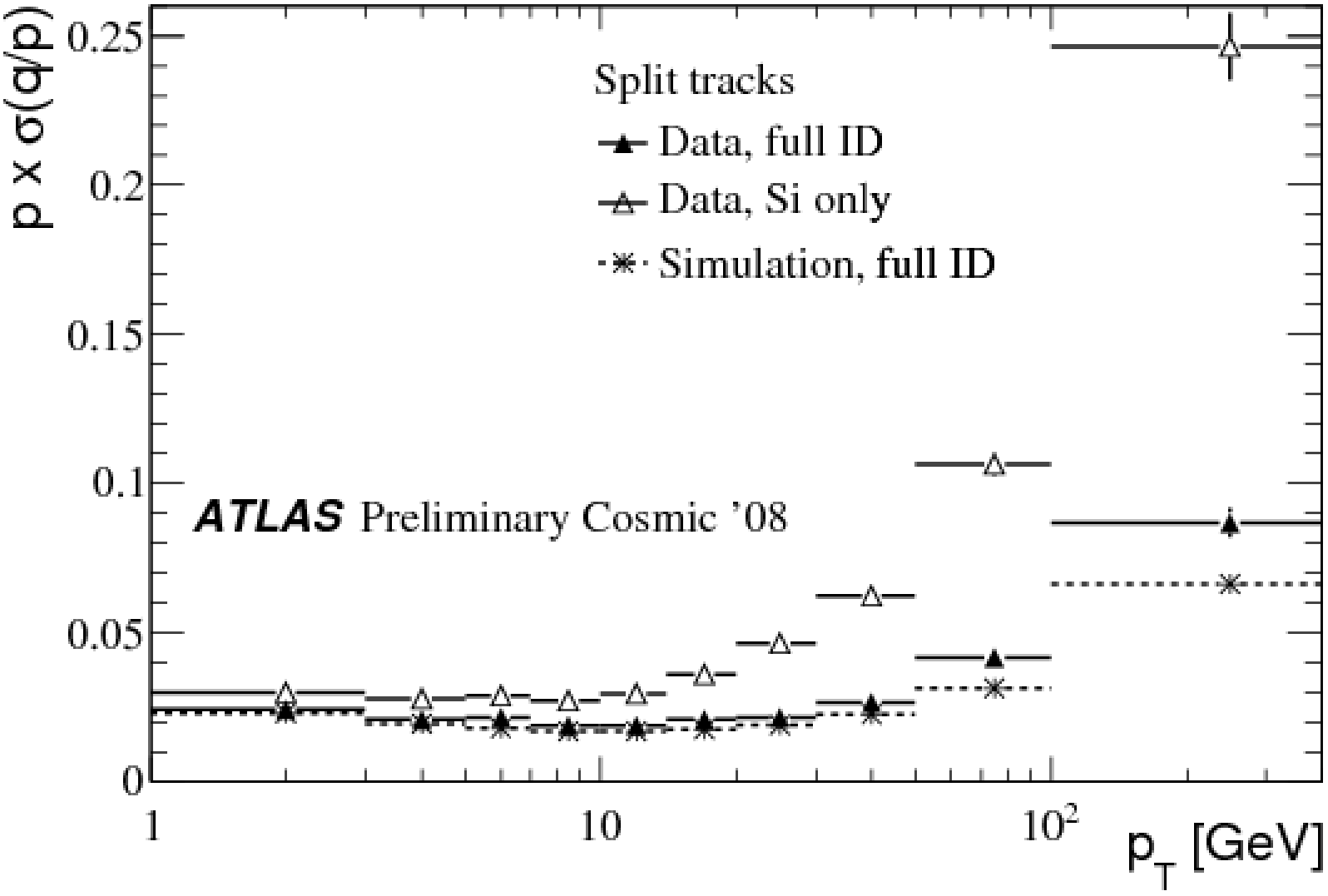


- Pulsersystem
- Kalorimeter an der em-Skala geeicht



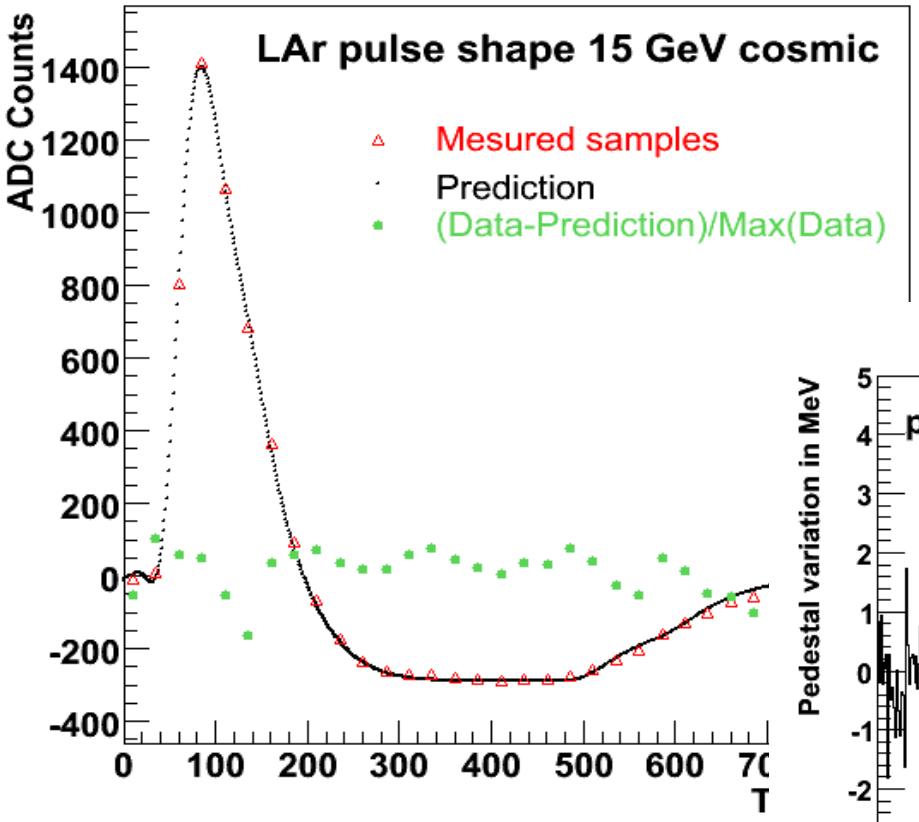
Kalibration um 10-20% notwendig

Status Innerer Detektor

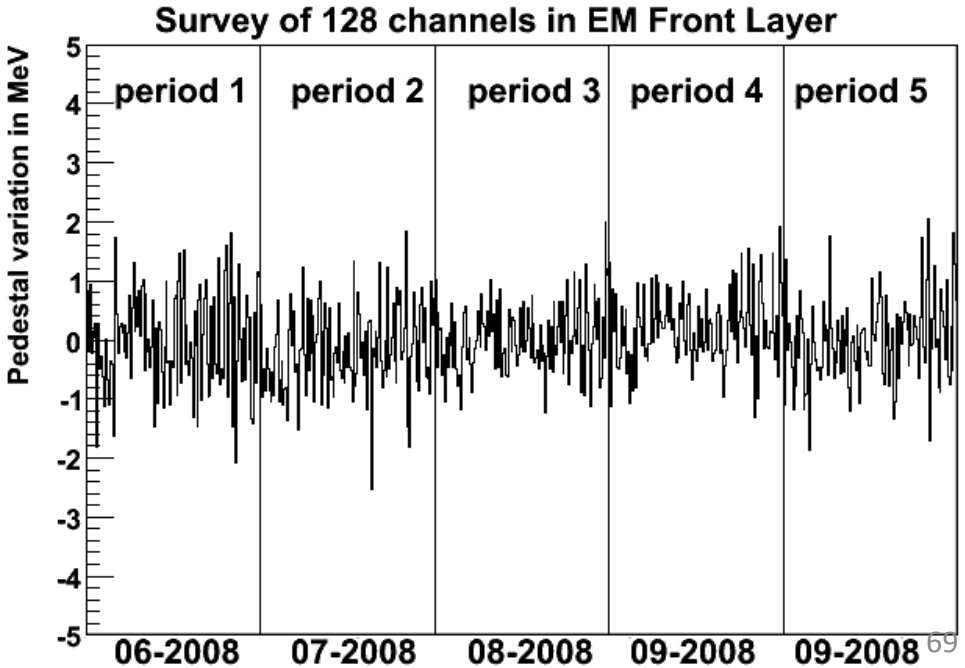


Flüssig-Argon Kalorimeter

Vergleich eines Pulses mit der Vorhersage



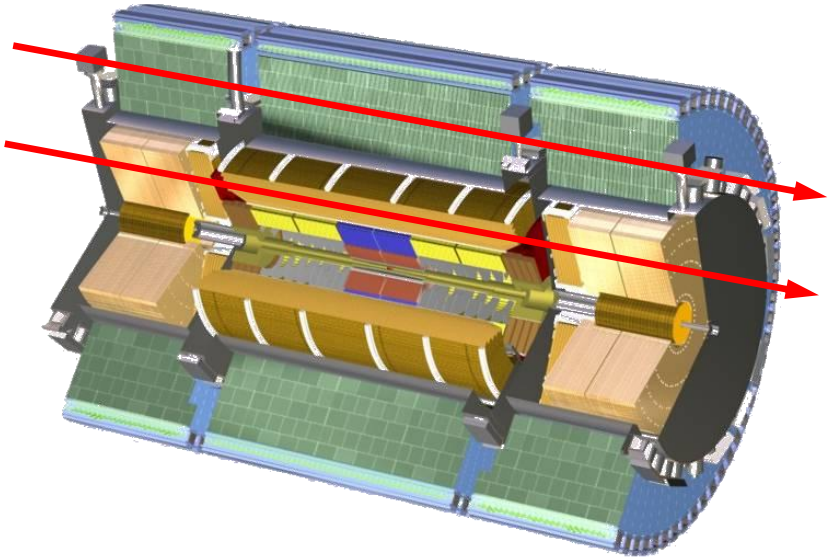
Stabilität des Pedestals

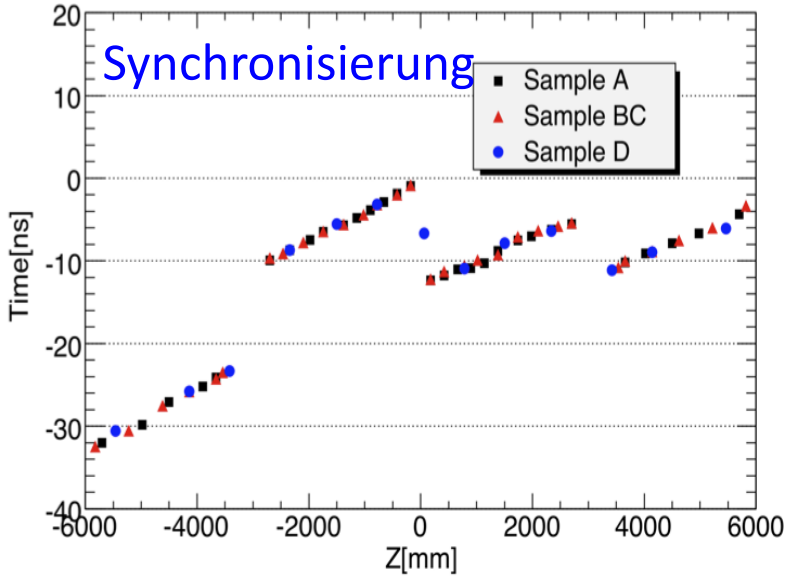


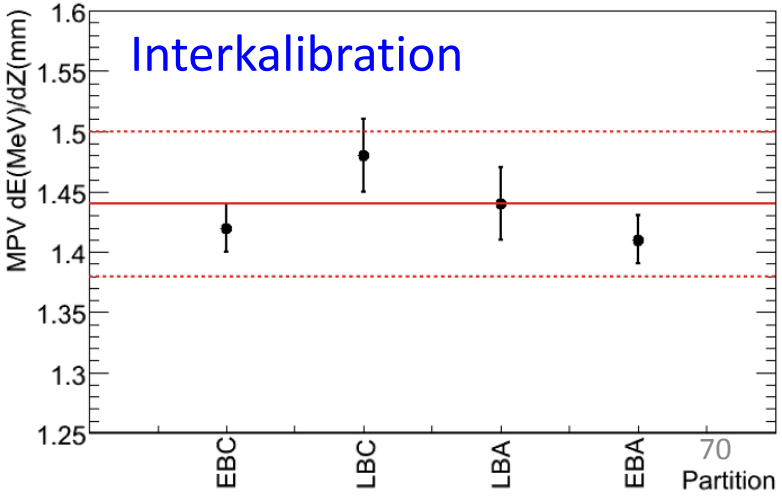
Tile Kalorimeter

Halo Myonen

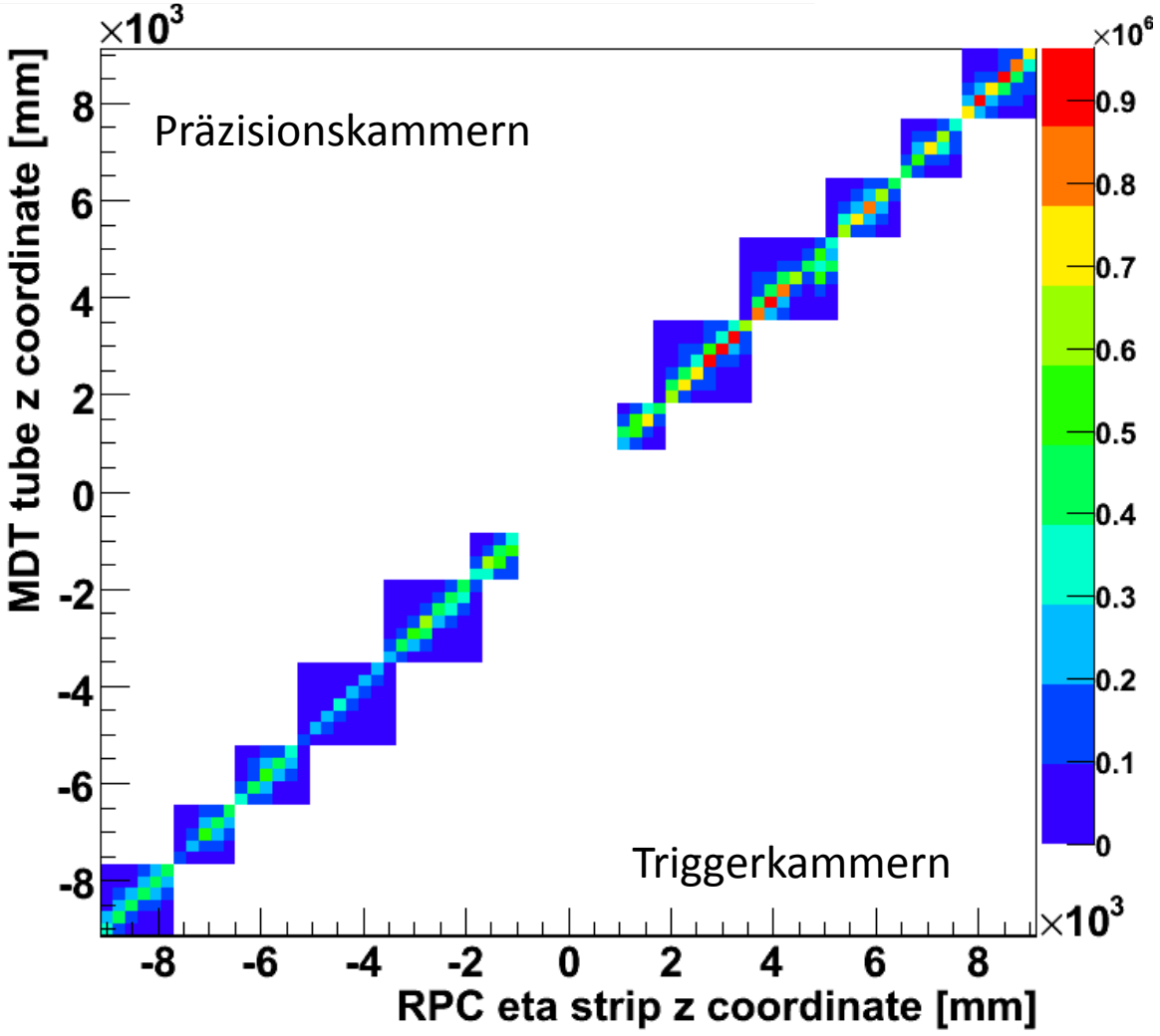
Proton Wechselwirkungen mit
- Restgasatomen im Strahlrohr
- Wand des Strahlrohrs







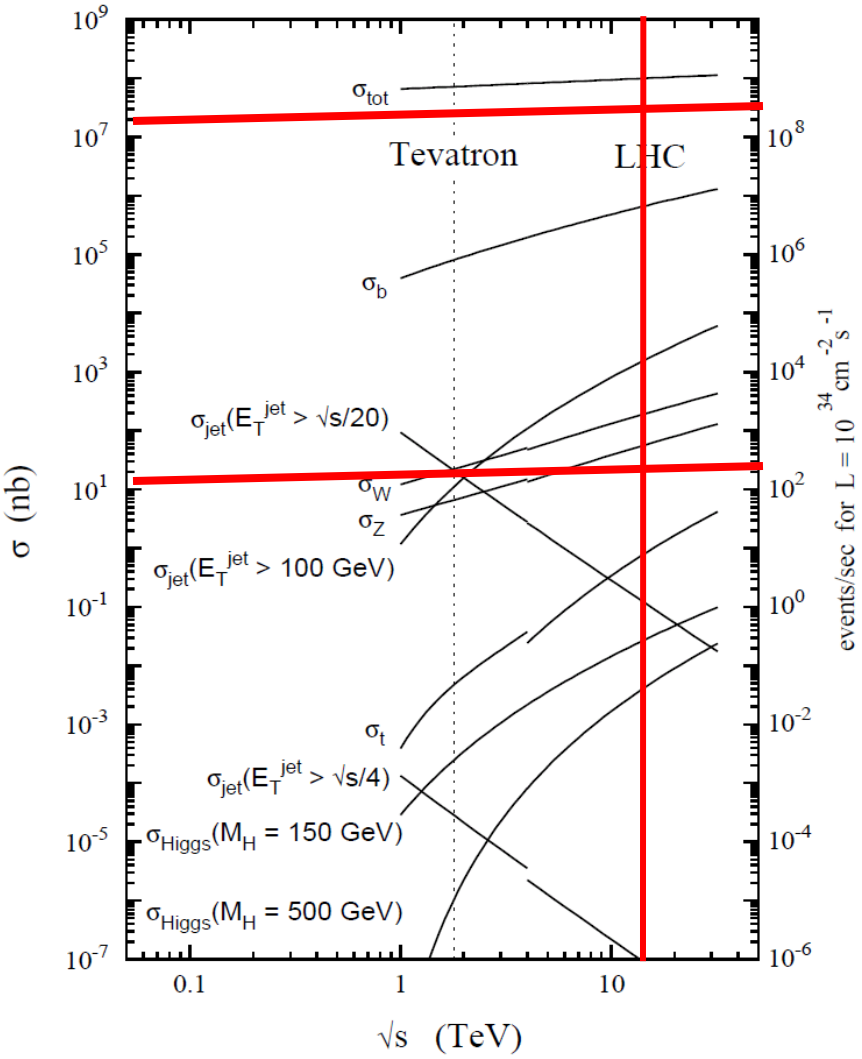
Status Myonsystem

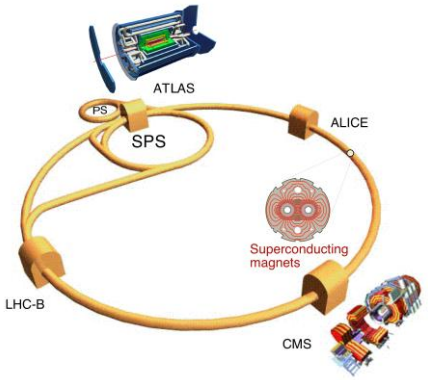


Korrelation rekonstruierter Treffer in den Präzisions- und Triggerkammern

The Trigger Challenge

High luminosity: $L_{inst} = 10^{34}\ cm^{-1}s^{-1}$





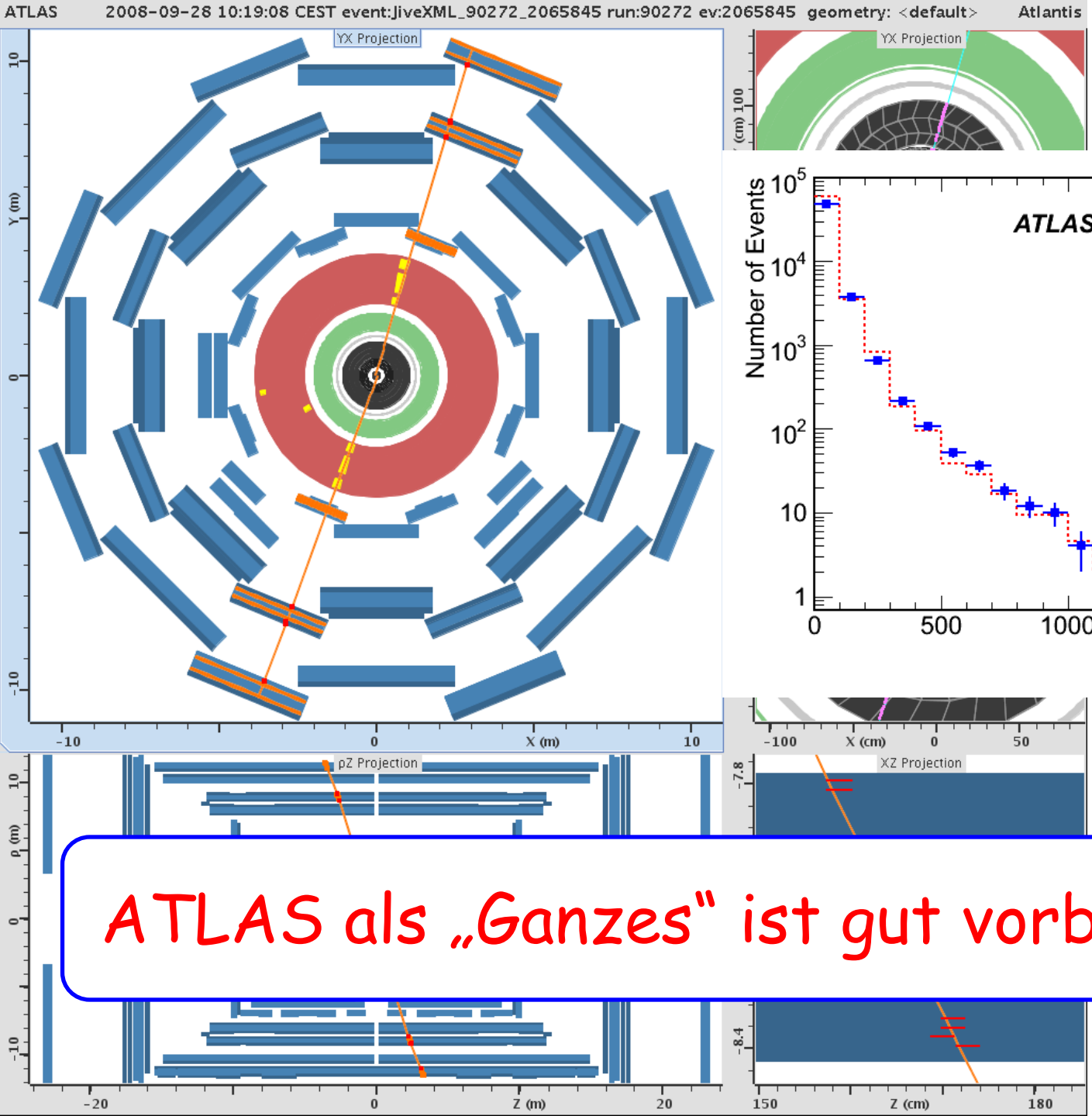
ATLAS
- 10^8 channels

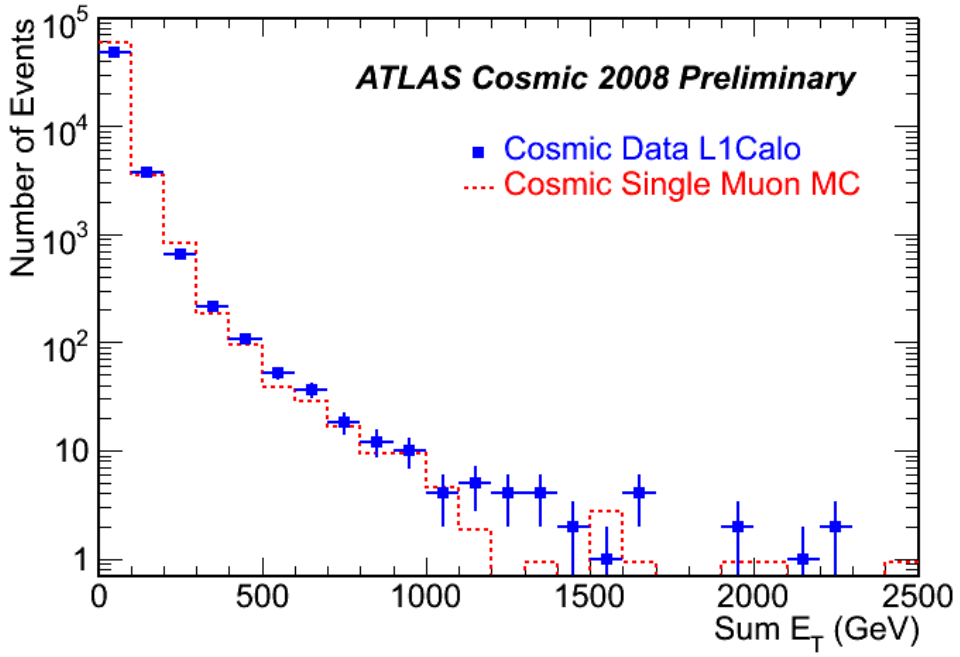
Eventrate
- 40 MHz
  (20 events per BX)

Datarate
- 60TB/s

Reduction: 1/200 000

Data Storage (forseen)
~ 200 Events/s
~ 300 MB/s
(limited by offline ressources)





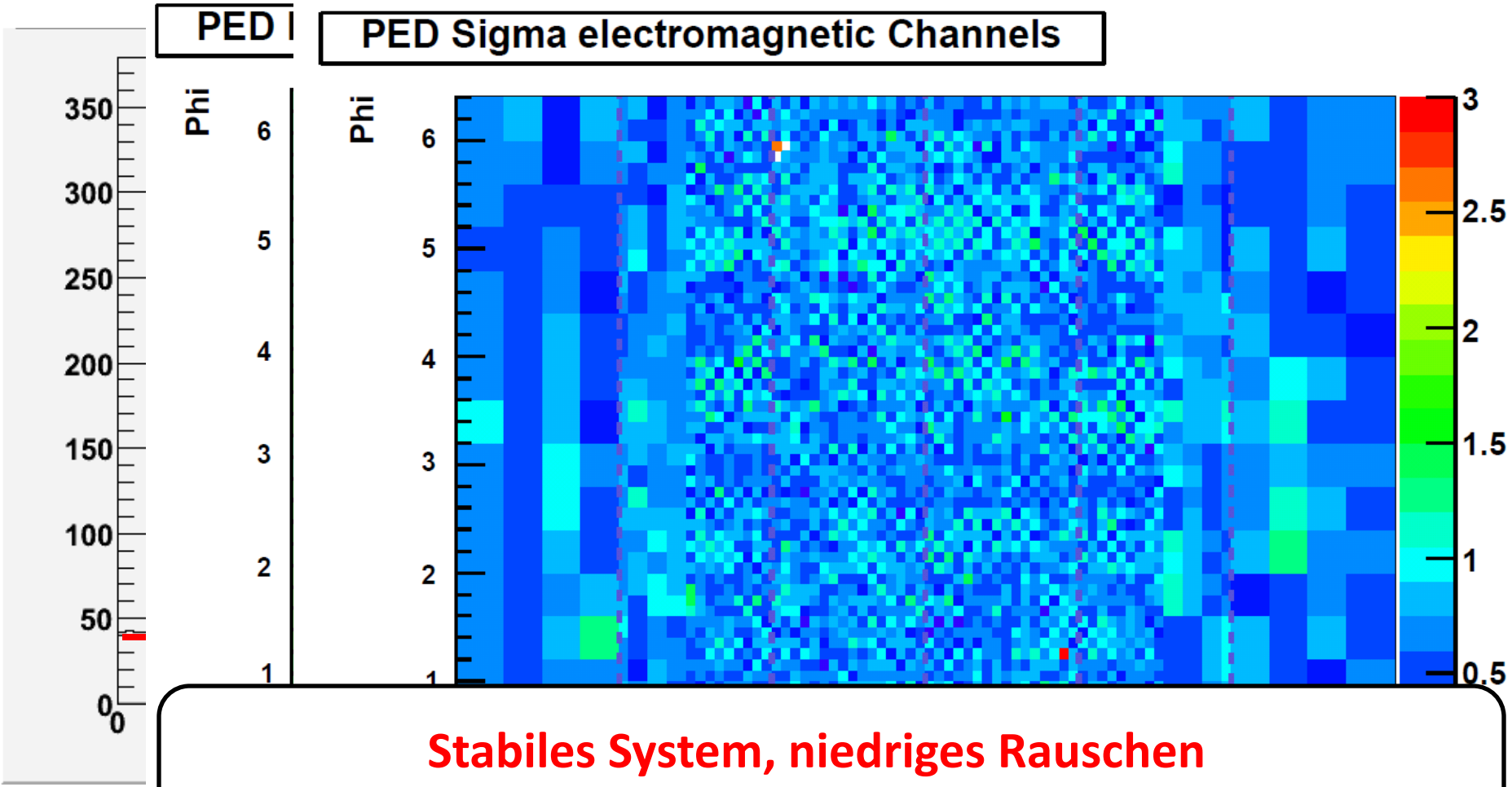
ATLAS als „Ganzes" ist gut vorbereitet

Zusammenfassung

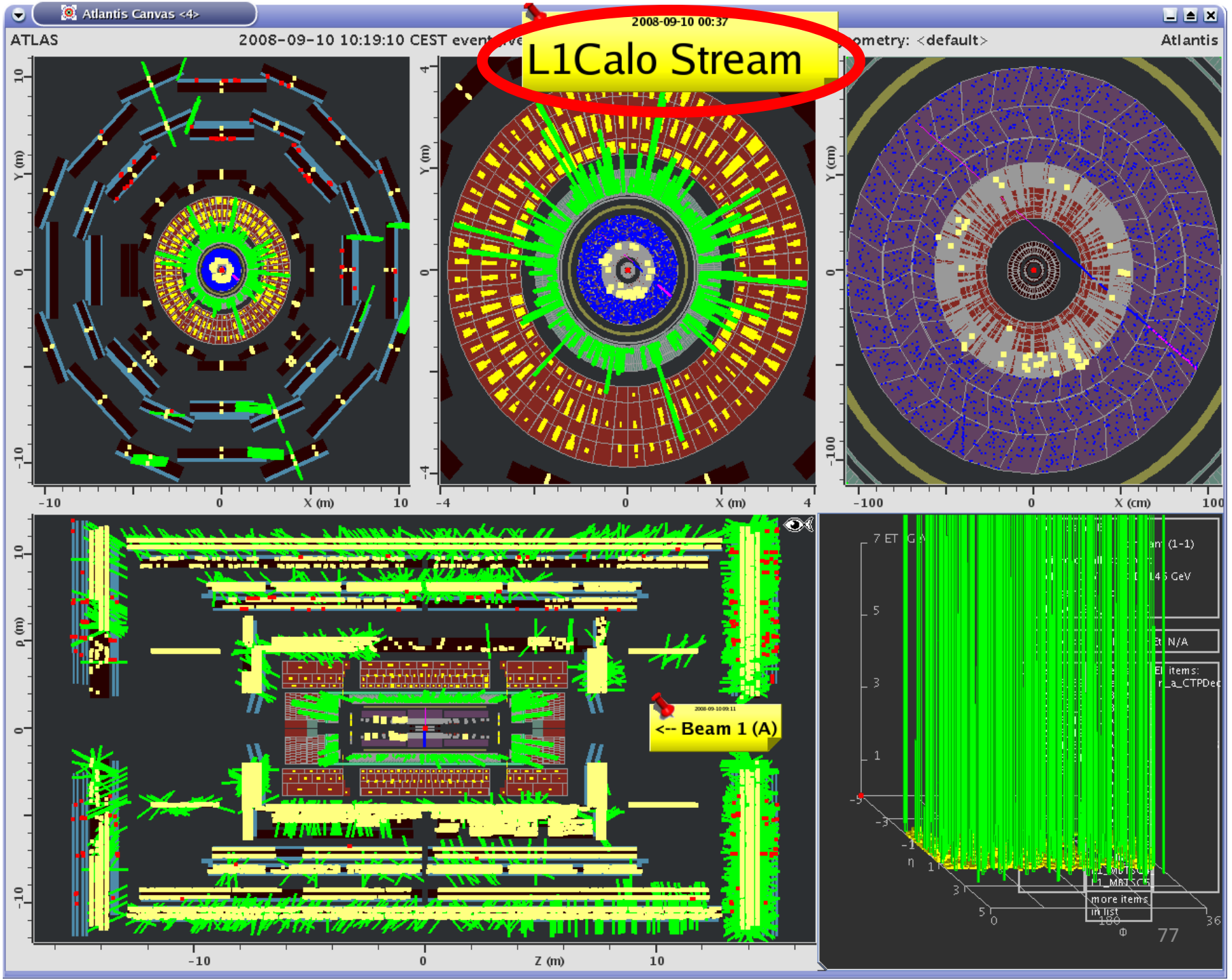
- Uns erwartet in den nächsten Jahren spannende Physik
- Inbetriebnahme sowohl der einzelnen Komponenten als auch von ATLAS als Ganzem ist weit vorangeschritten
- Kollisionen sind notwendig zur endgültigen Inbetriebnahme des Experiments


Wir sind weiter hoch motiviert!!!
10.9.2008

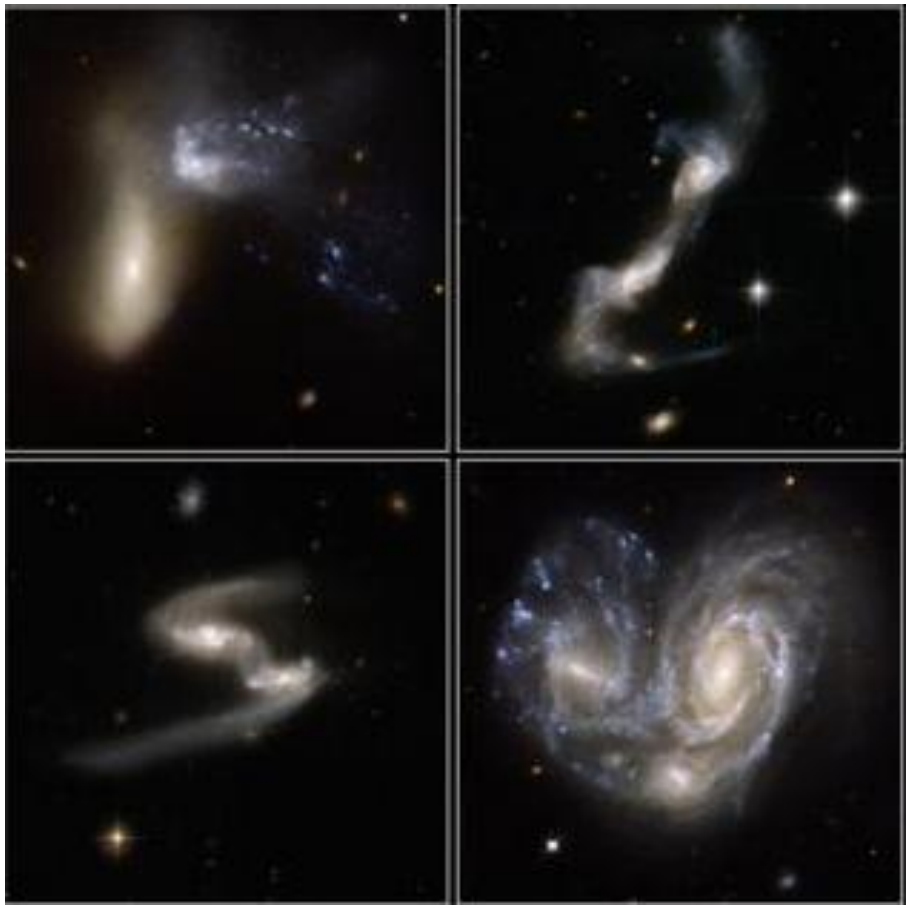
Pedestal und Rauschen



Stabiles System, niedriges Rauschen
(<250MeV PPr , ~ 500 MeV mit Kalorimeter HV an)


Atlantis Canvas <4>
ATLAS
2008-09-10 10:19:10 CEST
2008-09-10 00:37
L1Calo Stream
Atlantis
Y (m)
X (m)
Y (cm)
X (cm)
ρ (m)
Z (m)
<-- Beam 1 (A)
more items
in list
η
Φ

Materie-Antimaterie Asymmetrie



Kollidierende Galaxien (Hubble)
- keine Anzeichen für Materie-Antimaterie Annihilation

→ Universum ist Materie dominiert

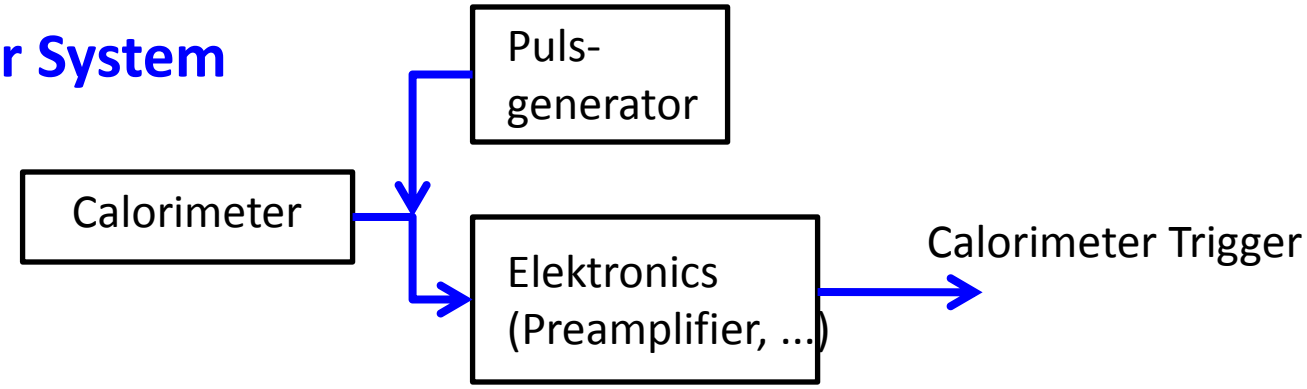
Standardmodell (CP-Verletzung) erklärt die Beobachtung nicht

-> neue Quelle der CP Verletzung wird benötigt

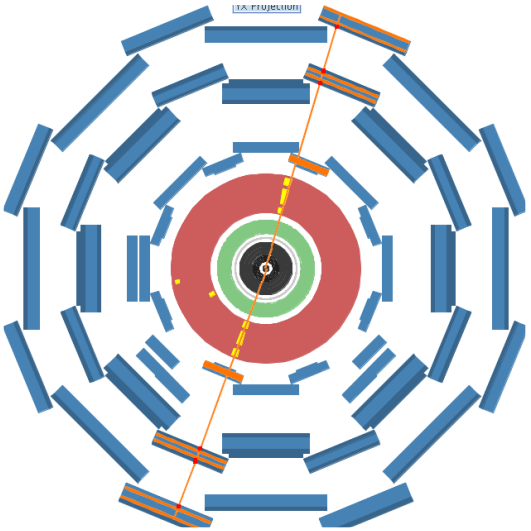
SUSY Entdeckung 201x

Signal Sources before collisions

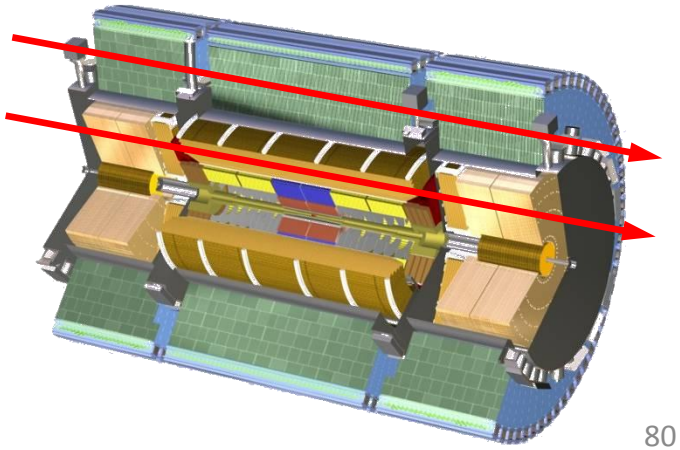
Pulser System



Cosmic Myons



Halo Myons



VIP Besuch

Der Innere Detektor

Übergangsstrahlungs-Spurdetektor
- 73 Lagen (zentral)
- 160 Lagen (Endkappe)
- 4 mm Strohalm Detektoren
- 350 000 Kanäle

Silizium Streifen Detektor:
- 4 Lagen doppelseitig (zentral)
- 9 Lagen doppelseitig (Endkappe)
- 80 μm x 62 mm
- 6.2 Millionen Kanäle
- 60 m^2

Silizium Pixel Detektor:
- 3 Lagen
- 50 x 400 μm
- 80 Millionen Kanäle
- 1.8 m^2