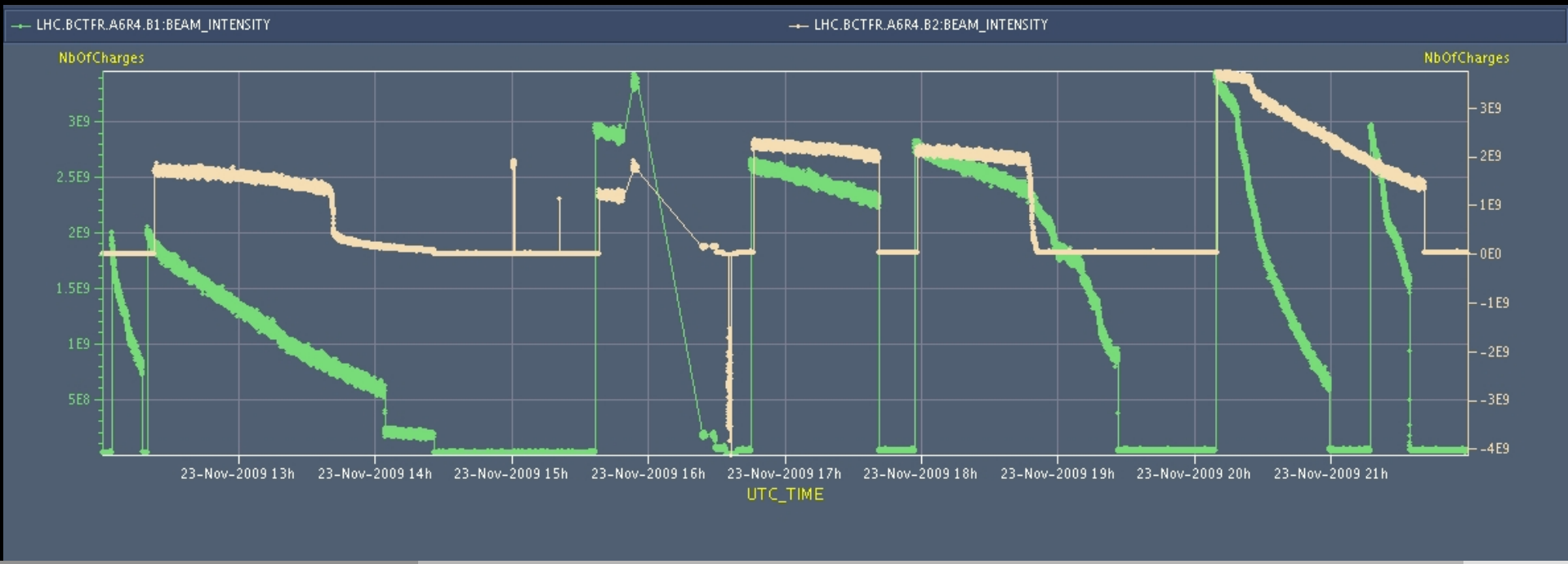
ATLAS

Beams and first collisions

Andreas Hoecker (CERN) **on behalf of the ATLAS Collaboration**

CERN seminar “LHC, week 1”, Nov 26, 2009

Big thanks to the machine team for a spectacular performance, and the excellent communication between ATLAS and CCC



Nov 20 – 23: beam history from ATLAS perspective

Friday, November 20:

~ 20:30h: beam-1 threading → 6 beam splashes to ATLAS

~ 22:30h: beam-2 threading → 7 beam splashes to ATLAS

Saturday, 21 November:

~ 1h: beam-2 splashes to ATLAS → 27 events (side C)

~ 4h: beam-1 splashes to ATLAS → 26 events (side A)

Sunday, 22 November:

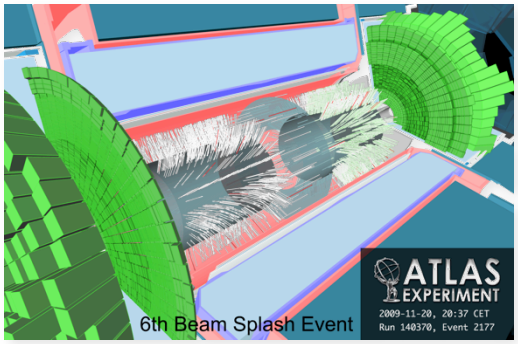
~ 6h: 15 splash events to test beam abort by BCM → successful

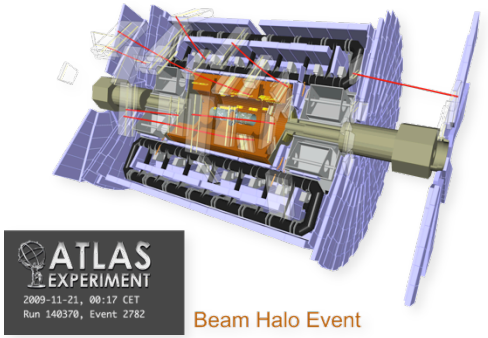
Monday 23 November:

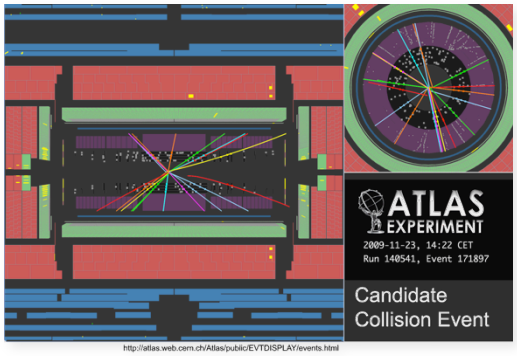
~ 6:30: last series of splashes to ATLAS→ 25 events (side C)

~ 13:30: two beams injected for collisions at IP1 and IP5

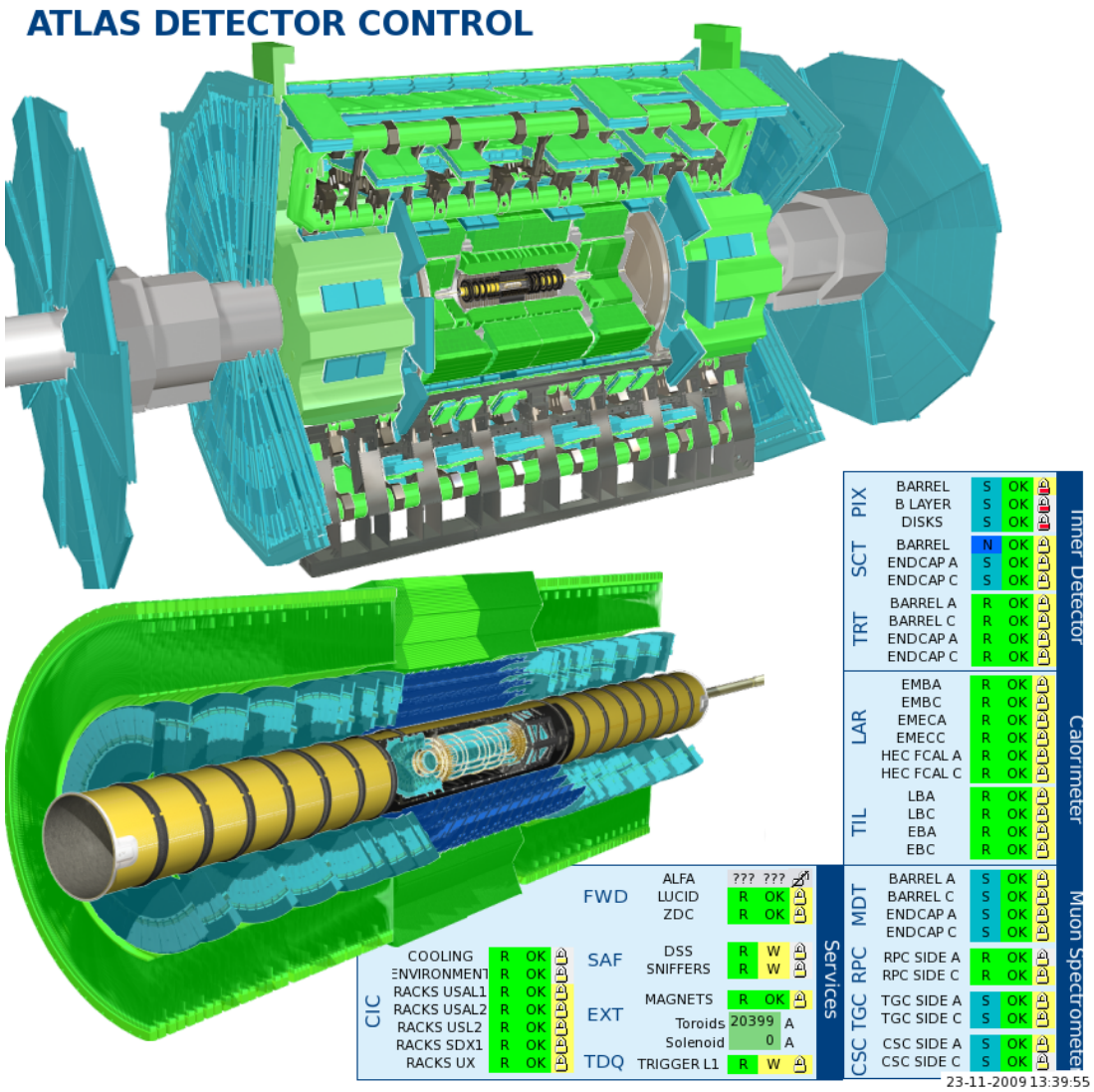
~ 14:22: first ATLAS collision event seen







Detector fully operational



Setup for beam commissioning

- Pixel off
- SCT (standard bias voltage 150 V)
  - Standby V is 20 V → ~50% hit efficiency (increases with incidence angle)
  - Barrel and endcap increased to 50V for short stable beam periods during collisions
  - Barrel voltage sometimes lower than 20V for beam set up (eg. splash events)
- All other systems ON
- **No solenoid field, toroids ON**

CSC running in separate DAQ partition for rate tests

1st Beam Splash from Beam-2

Beam-splash events

Avalanche of scattered particles from beam-on-collimator hits

Detectors fully lit, typically

- 300,000 SCT hits
- 350,000 TRT hits (~all passing high-threshold)
- 3000 TeV calo energy sum
- 490,000 MDT hits
- 320,000 RPC hits
- 65,000 TGC hits

2009-11-20, 23:32 CET
Run 140370, Event 2666

We were very excited…

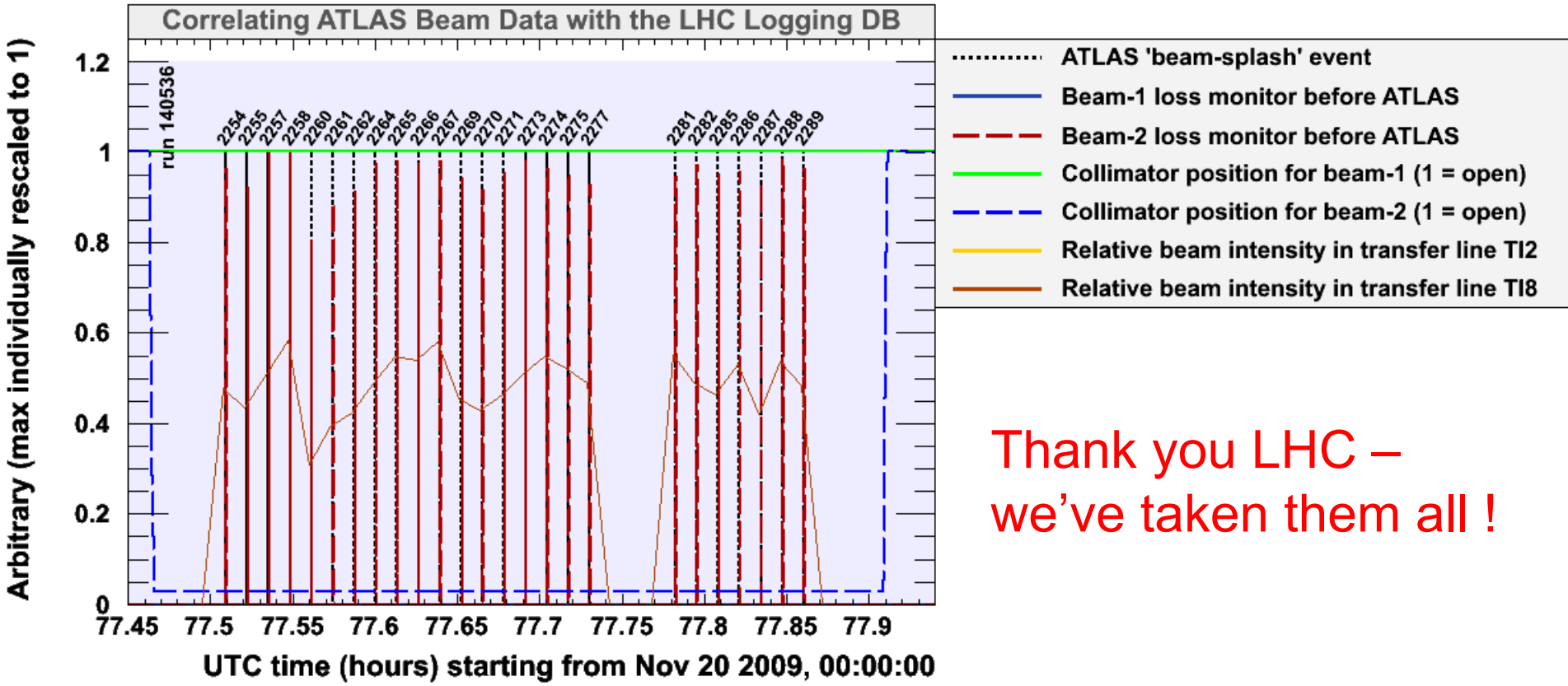
But some stayed cool and concentrated …

Proudly presents …

Indeed … why do it again ?

Timing and beam-abort tests!

- Triggering on splashes: ATLAS received and triggered on 106 splashes

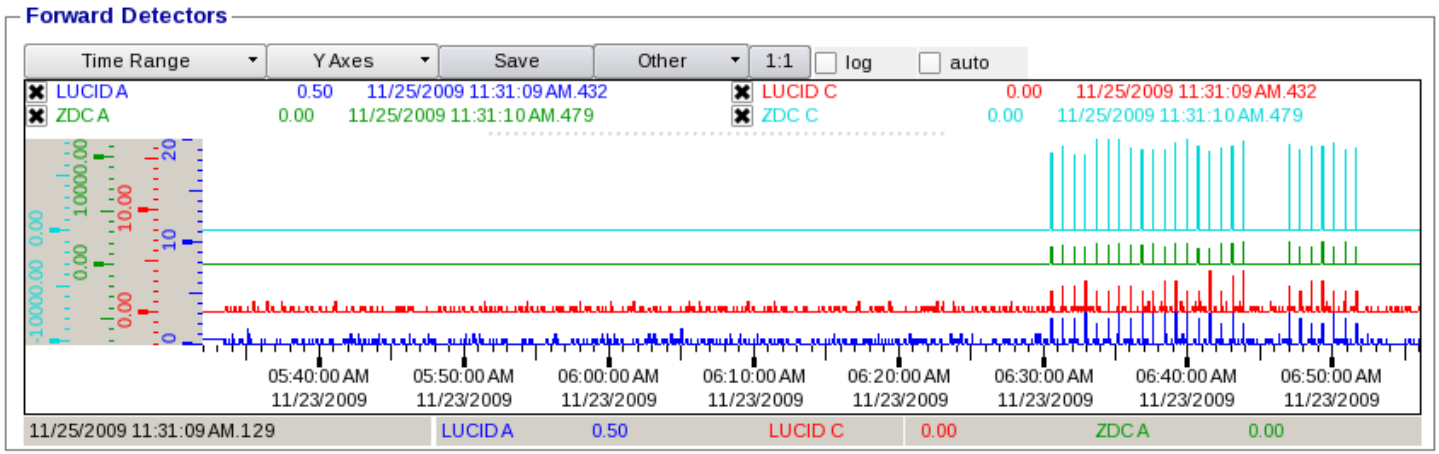


Thank you LHC –
we've taken them all !

Indeed … why do it again ?

Timing and beam-abort tests!

Beam splash events also measured by ATLAS very forward detectors (LUCID z = ±17 m and ZDC z = ±140 m)



ZDC C

ZDC A

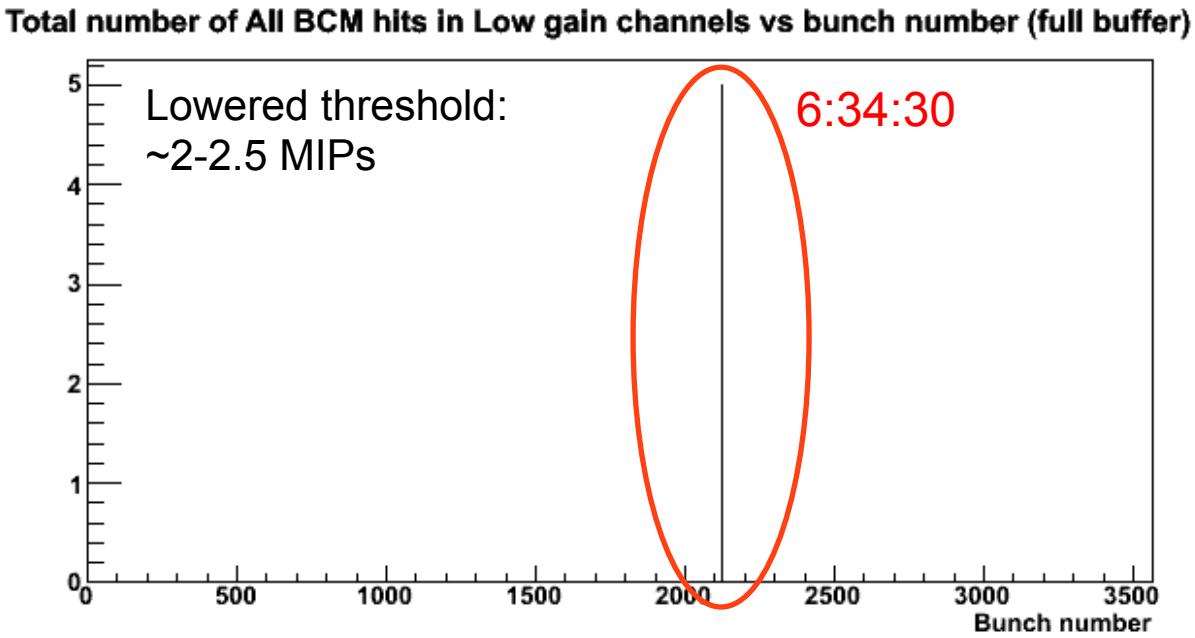
LUCID A

LUCID C

Indeed … why do it again ?

Timing and beam-abort tests!

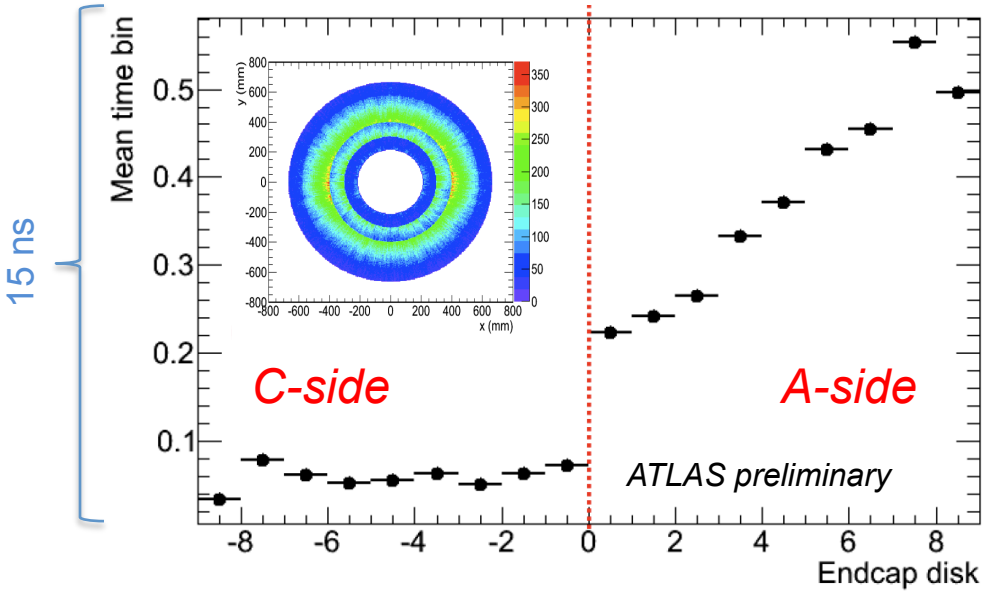
Beam abort test using dedicated diamond Beam Condition Monitors was successfully conducted on Sun, 22 Nov at 6:34, and no fake abort!



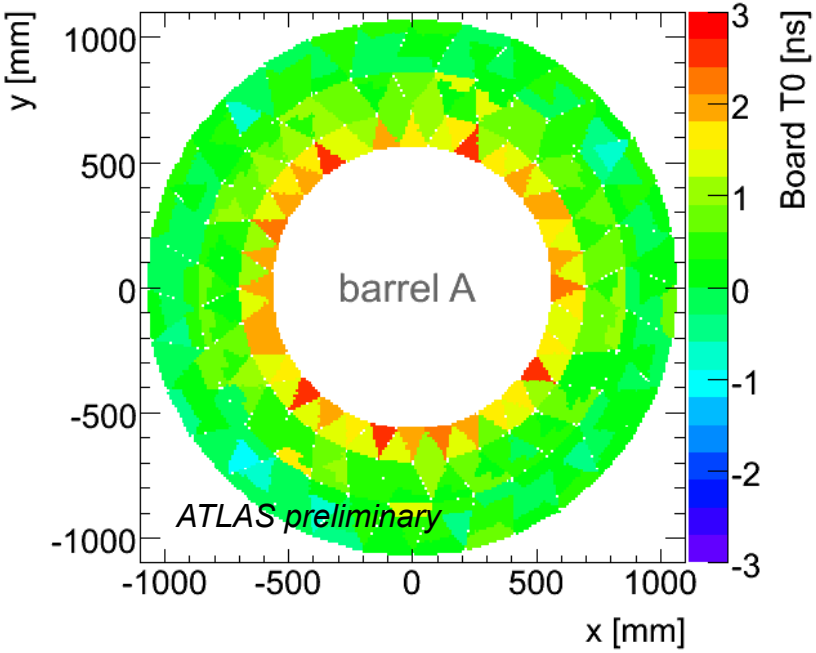
Timing studies with beam-splash events (Inner Detector)

- Inner tracking systems:
  - SCT already well timed-in from cosmics and known cable lengths (better than 2 ns)
  - TRT boards timed-in to better than 2 ns

Beam-1 arriving from A-side: timing as collisions for C-side, but wrong for A-side



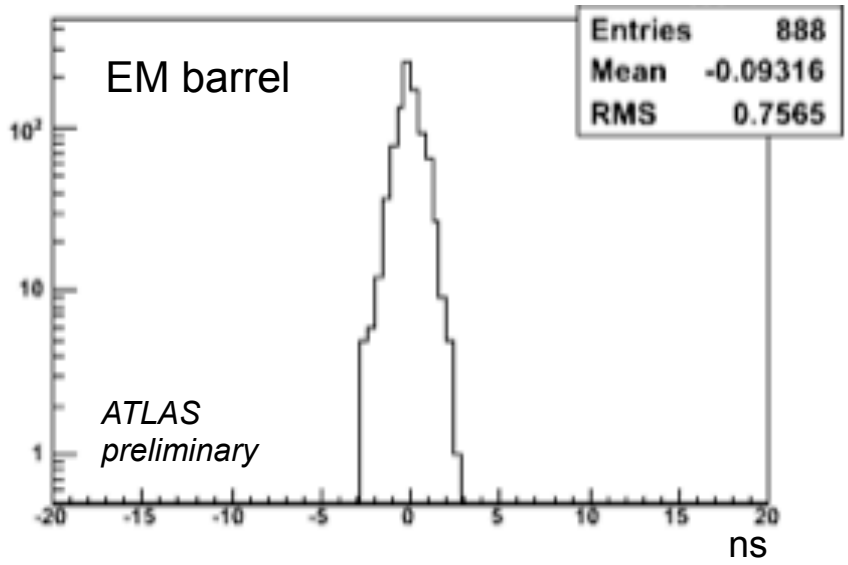
TRT Barrel: plot made with collision timing
→ sensitive to ToF effect on Inner Boards !



Timing studies with beam-splash events (Calorimeter & Muons)

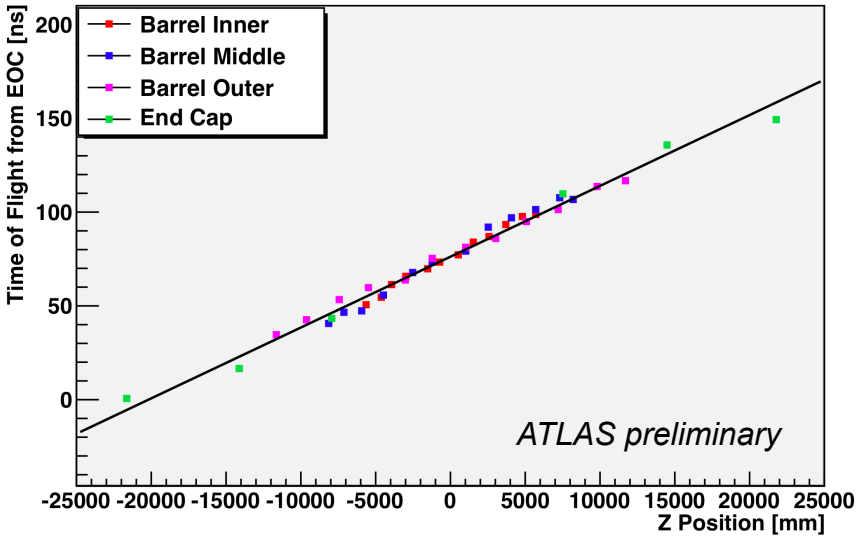
LAr Timing:

After 2008 beam-splash data taking and analysis of many millions of cosmics events, timing good within a few ns



MDT Timing:

Synchronize all chambers at a given *z* using the synchronous front of splash particles and the very large particle flux



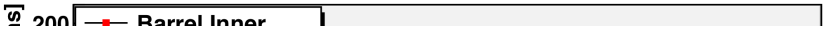
Timing studies with beam-splash events (Calorimeter & Muons)

LAr Timing:

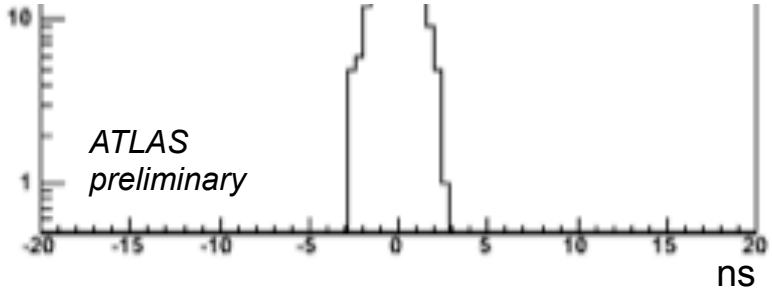
After 2008 beam-splash data taking and analysis of many millions of cosmics events, timing good within a few ns

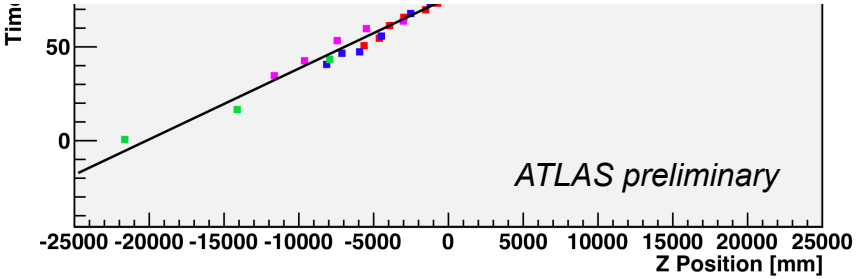
MDT Timing:

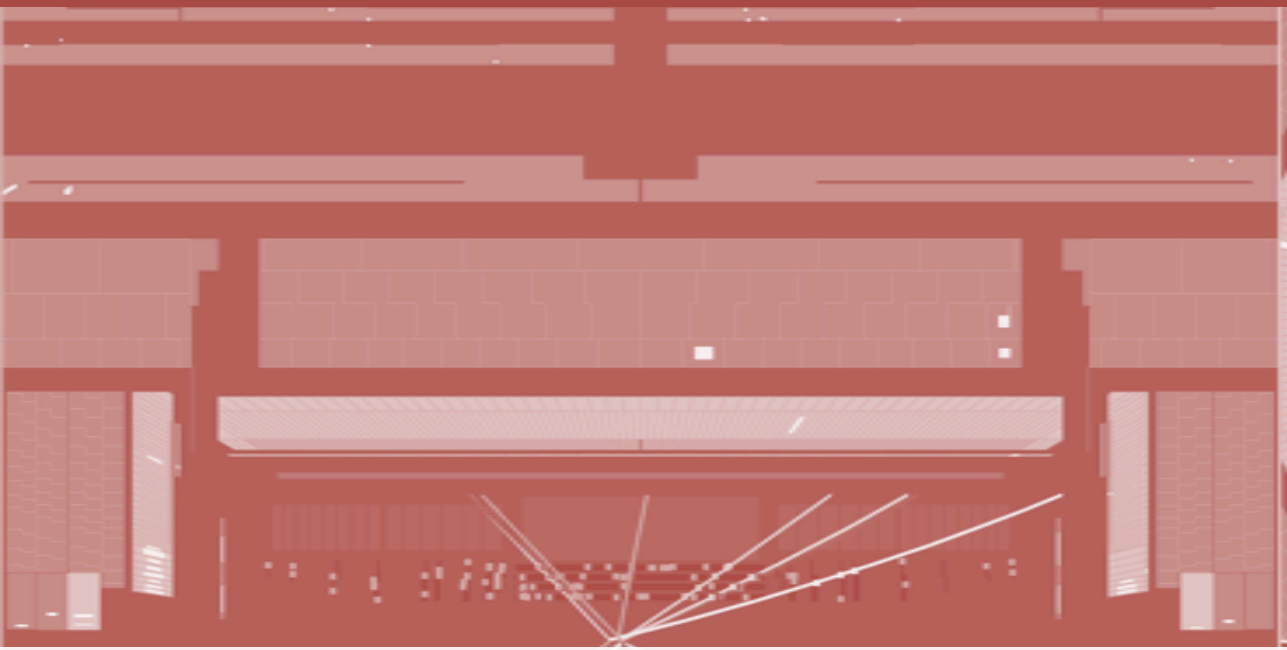
Synchronize all chambers at a given *z* using the synchronous front of splash particles and the very large particle flux



ATLAS now well timed in for collisions

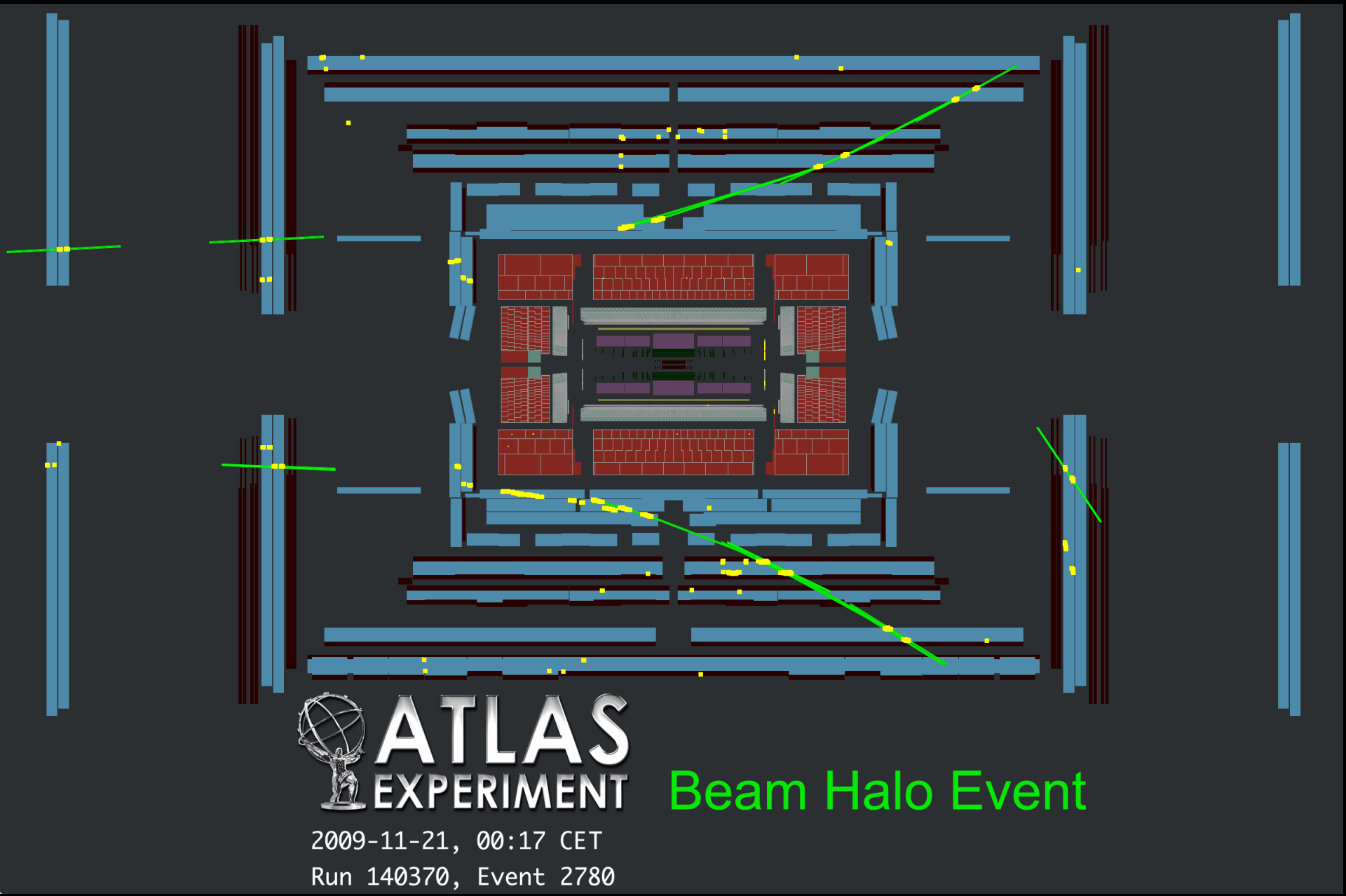




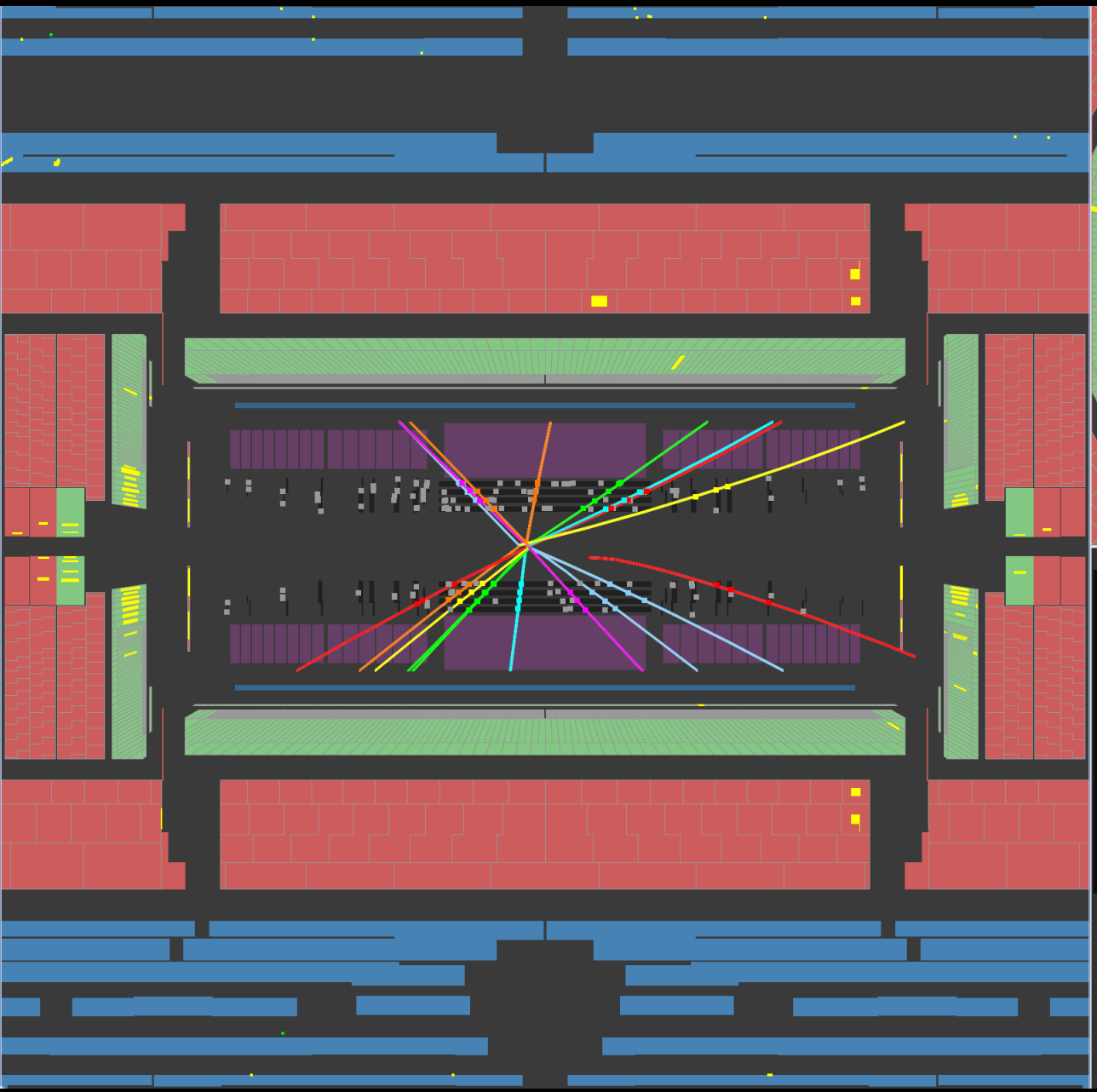


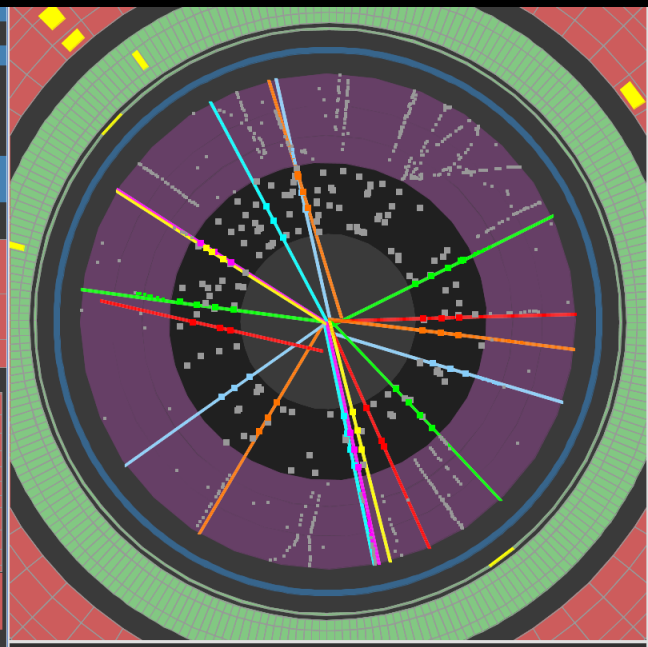
Single beam, two beams,
two synchronised beams,
colliding beams, ***collisions*** ?

Candidate
Collision Event


ATLAS
EXPERIMENT
Beam Halo Event
2009-11-21, 00:17 CET
Run 140370, Event 2780

We were lucky – shortly after colliding beams were announced, at 14:22 an interesting event appeared on our screens





ATLAS EXPERIMENT

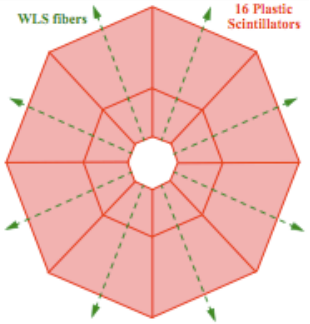
2009-11-23, 14:22 CET

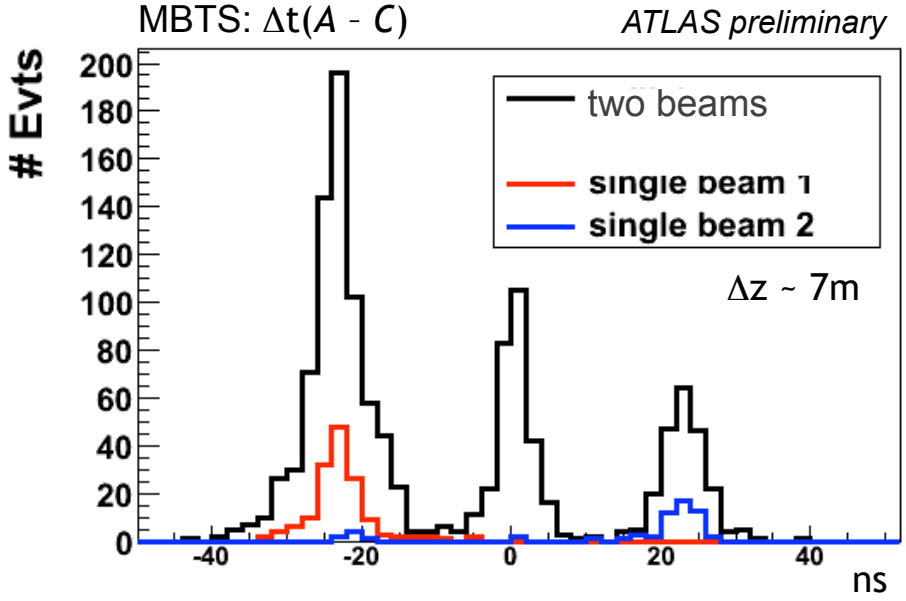
Run 140541, Event 171897

Candidate Collision Event

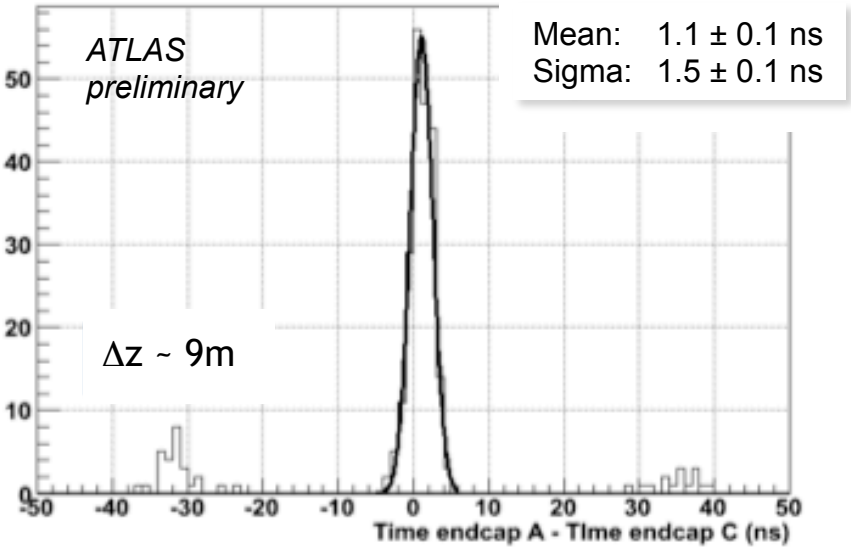
Two beams in the machine, how to detect a collision event?

- Trigger synchronized with beam pickup signals (suppresses cosmics)
- Separation of beam-related backgrounds and collisions via timing measurements on *A* and *C* sides of ATLAS (ToF)
  - Use minimum bias scintillators (MBTS) in forward regions (use also multiplicity)
  - Use precise Liquid-argon endcap calorimeter timing





LAr calorimeter:
Δt(*A* - *C*)

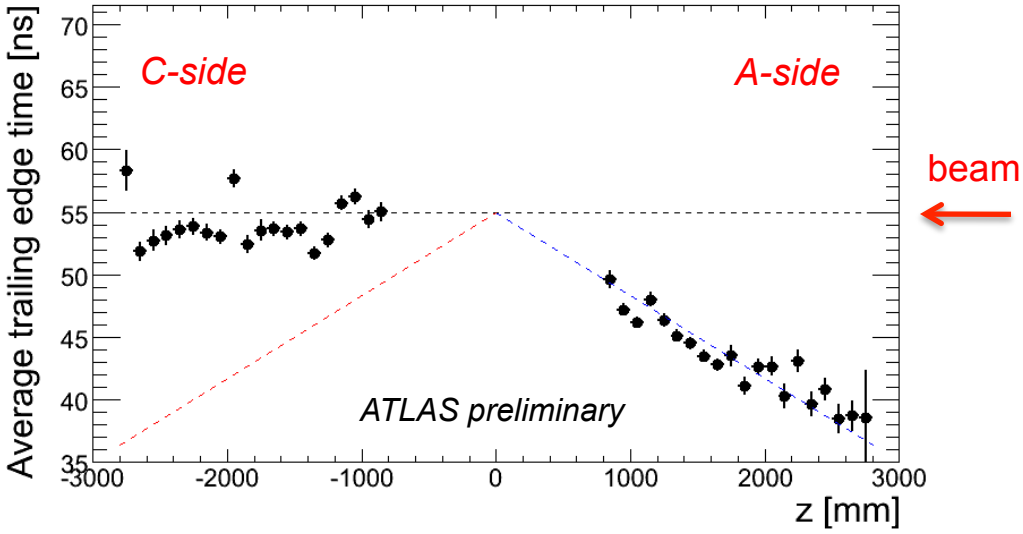


Two beams in the machine, how to detect a collision event?

- Can also use TRT timing

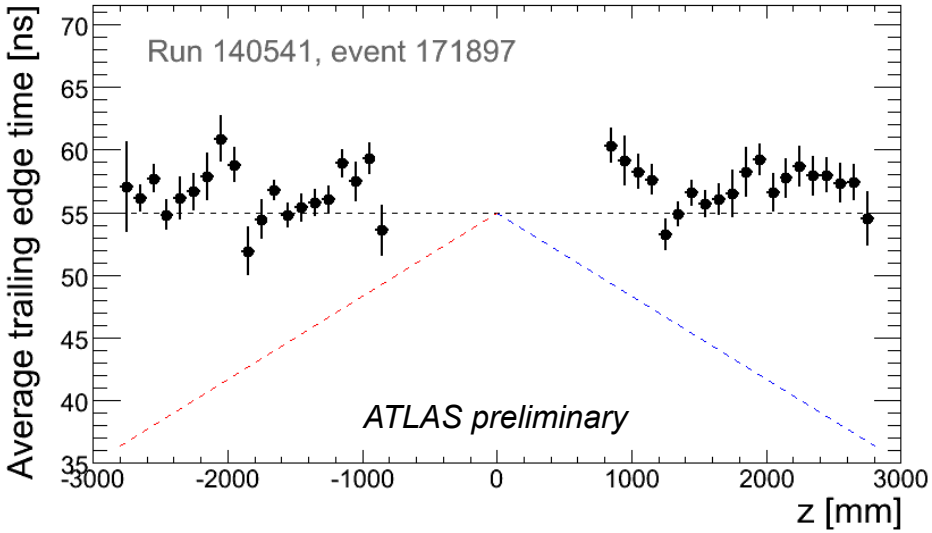
A beam-related background event coming from beam-1 (A-side)

→ timing is “wrong” for A-side

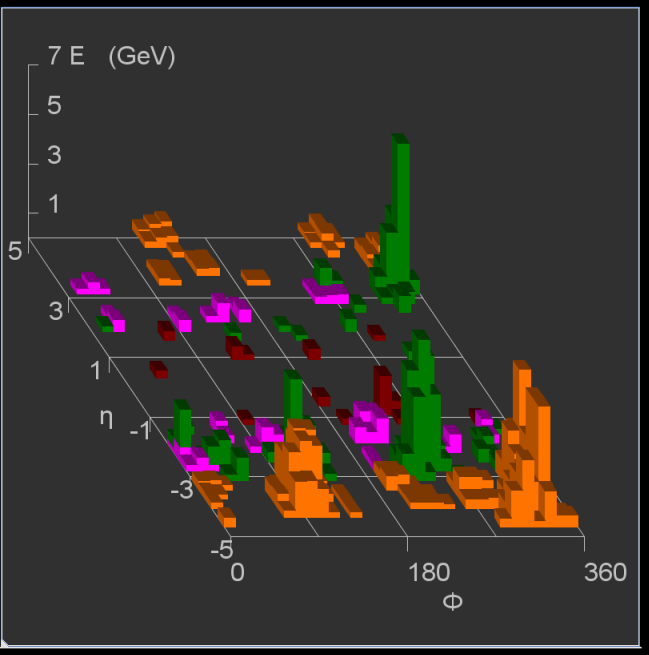


A collision event

→ timing is collision-like on both sides



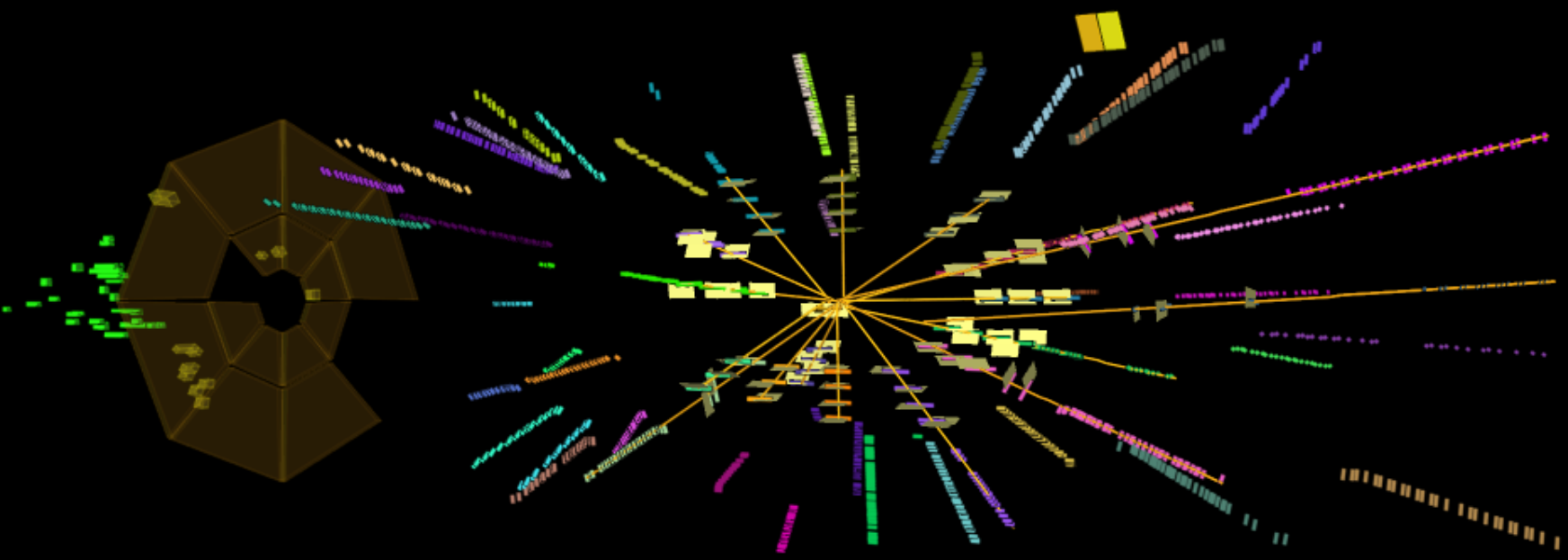
Candidate Collision Event



ATLAS EXPERIMENT

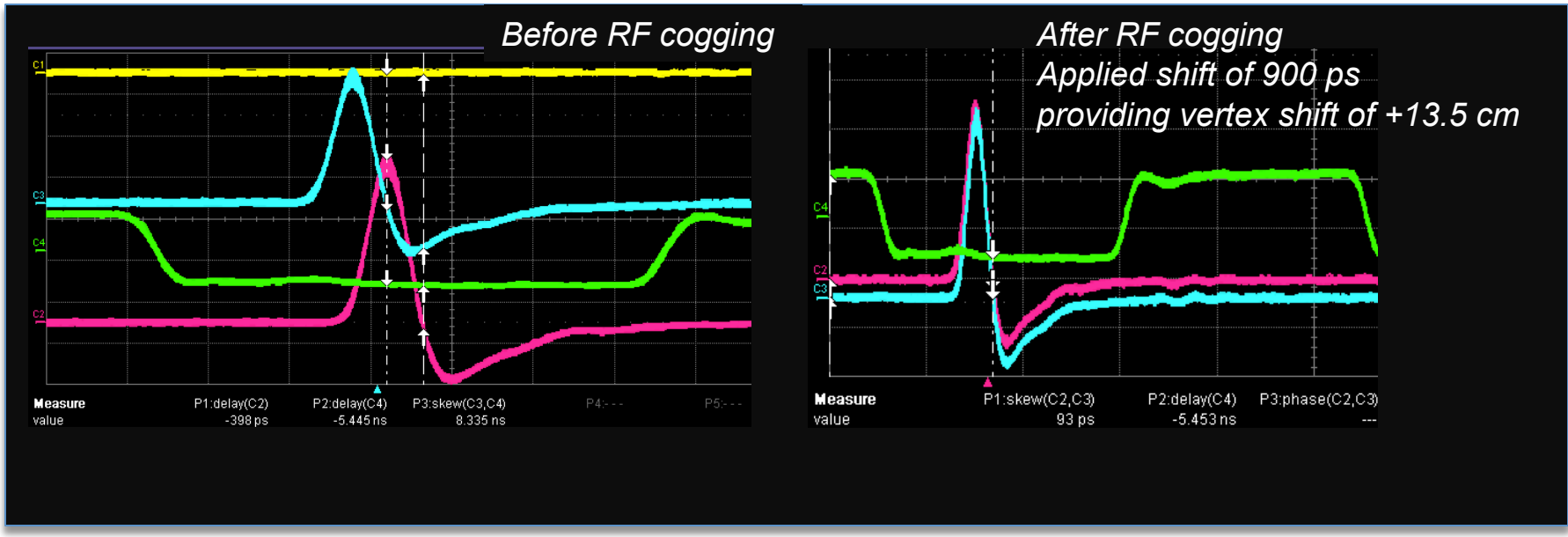
2009-11-23, 14:22 CET
Run 140541, Event 171897

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



Can we prove that our background separation works?

- The ATLAS beam pickups showed a phase inconsistency of 900 ps causing the primary vertex to be shifted by −13.5 cm in *z*
- Based on this information, at around 14:50, the LHC operators performed an RF cogging to correct the *z* positioning of the beam spot at IP1

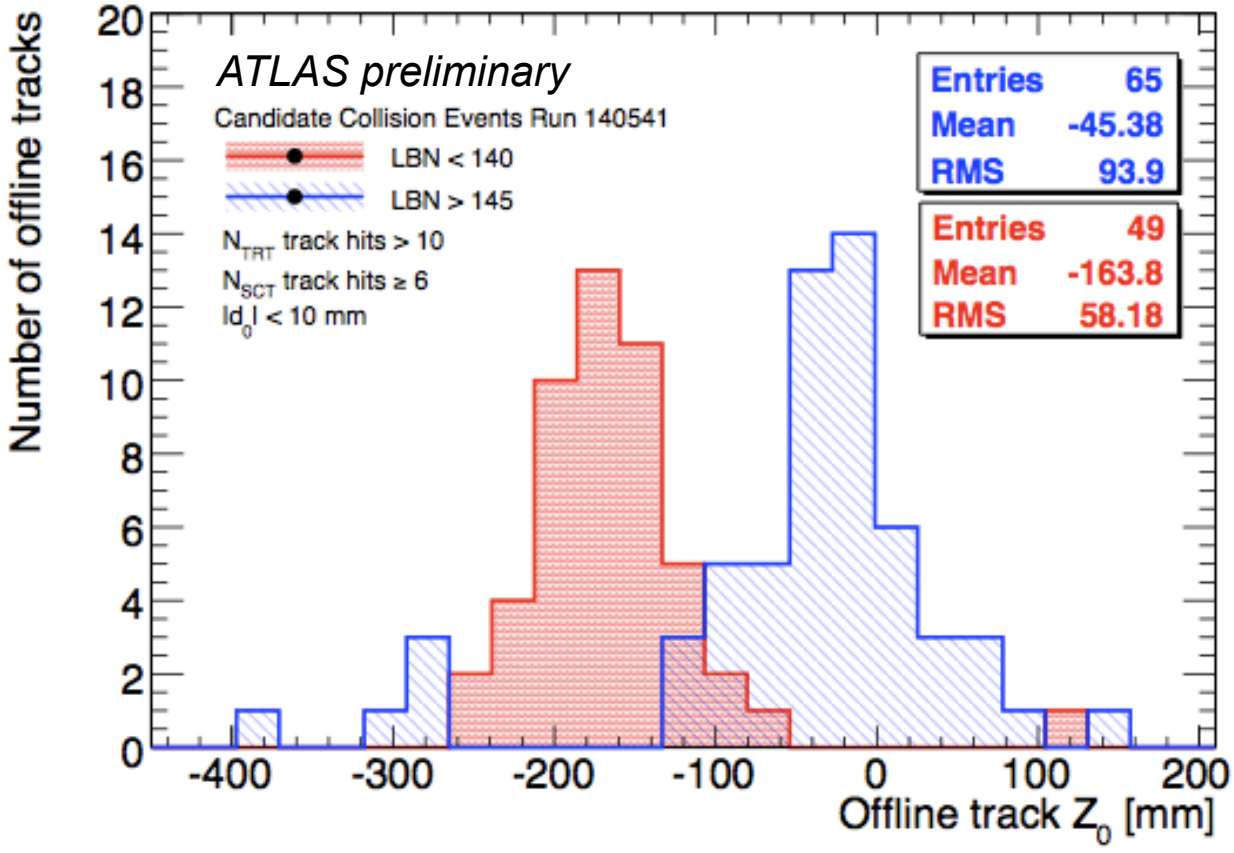


Beam pickup scope shots, beam 1 & 2

Bunches stable within 20 ps (RMS) !

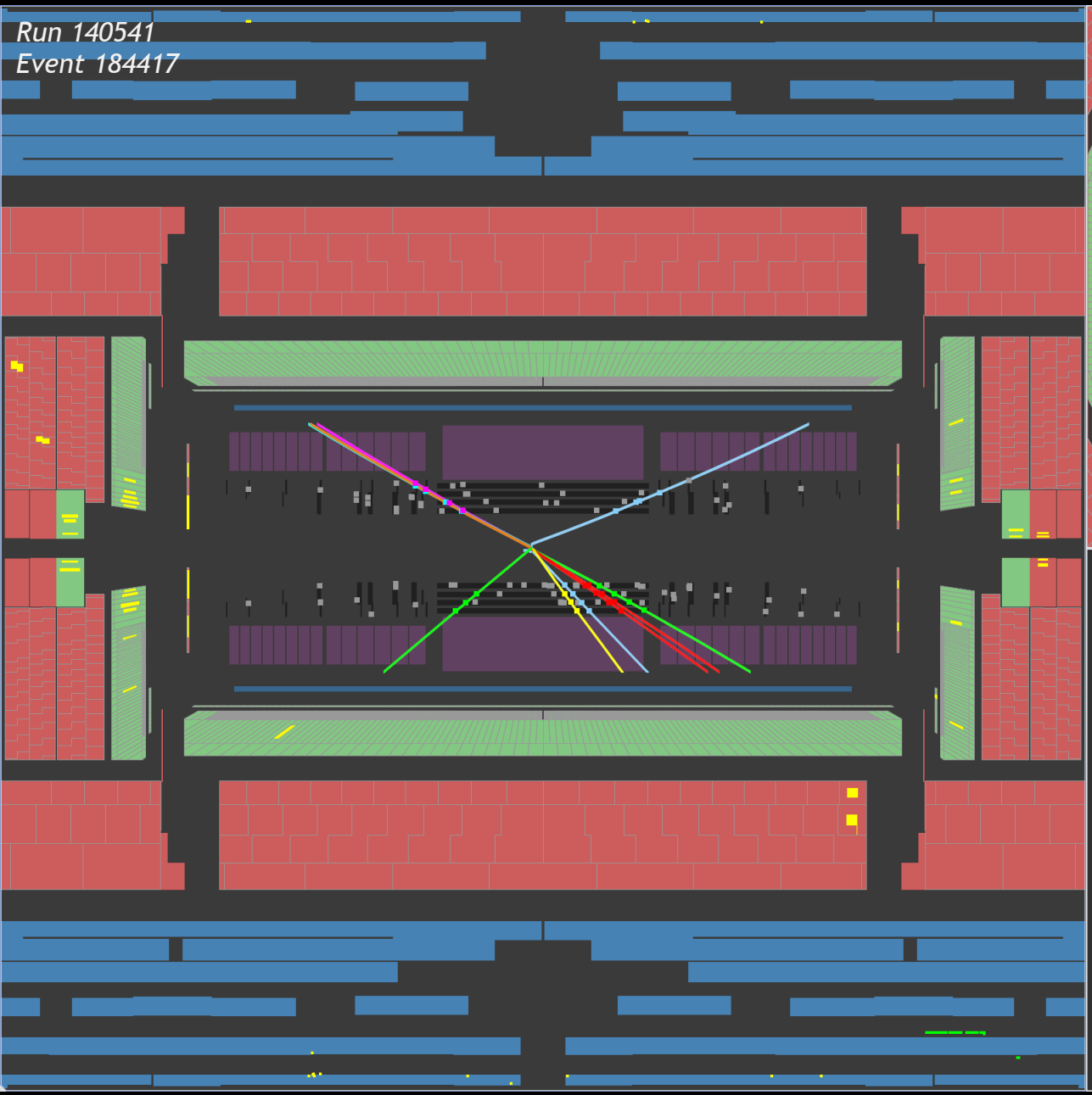
Can we prove that our background separation works?

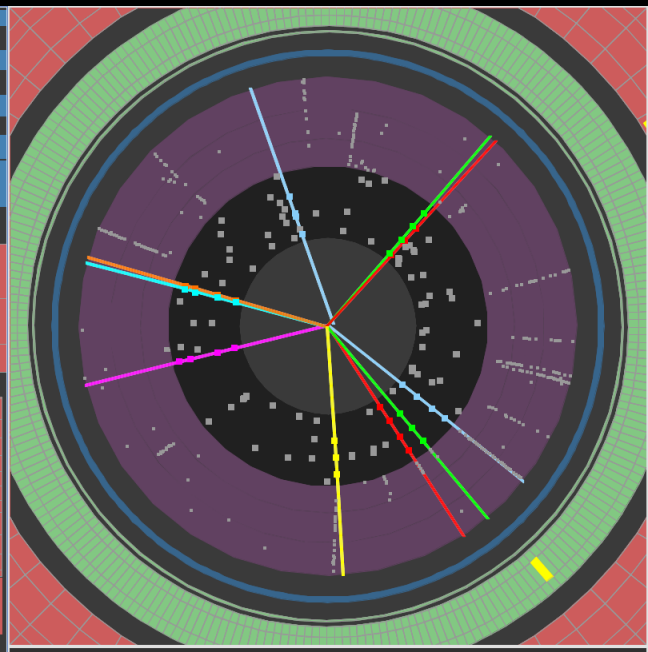
- ATLAS has taken data before and after the RF cogging
- Must observe shift in z_0 of tracks if indeed we select collision events!



Track z_0 distribution of collision candidate events taken **before** and **after** RF cogging

Observed shift: +12 cm

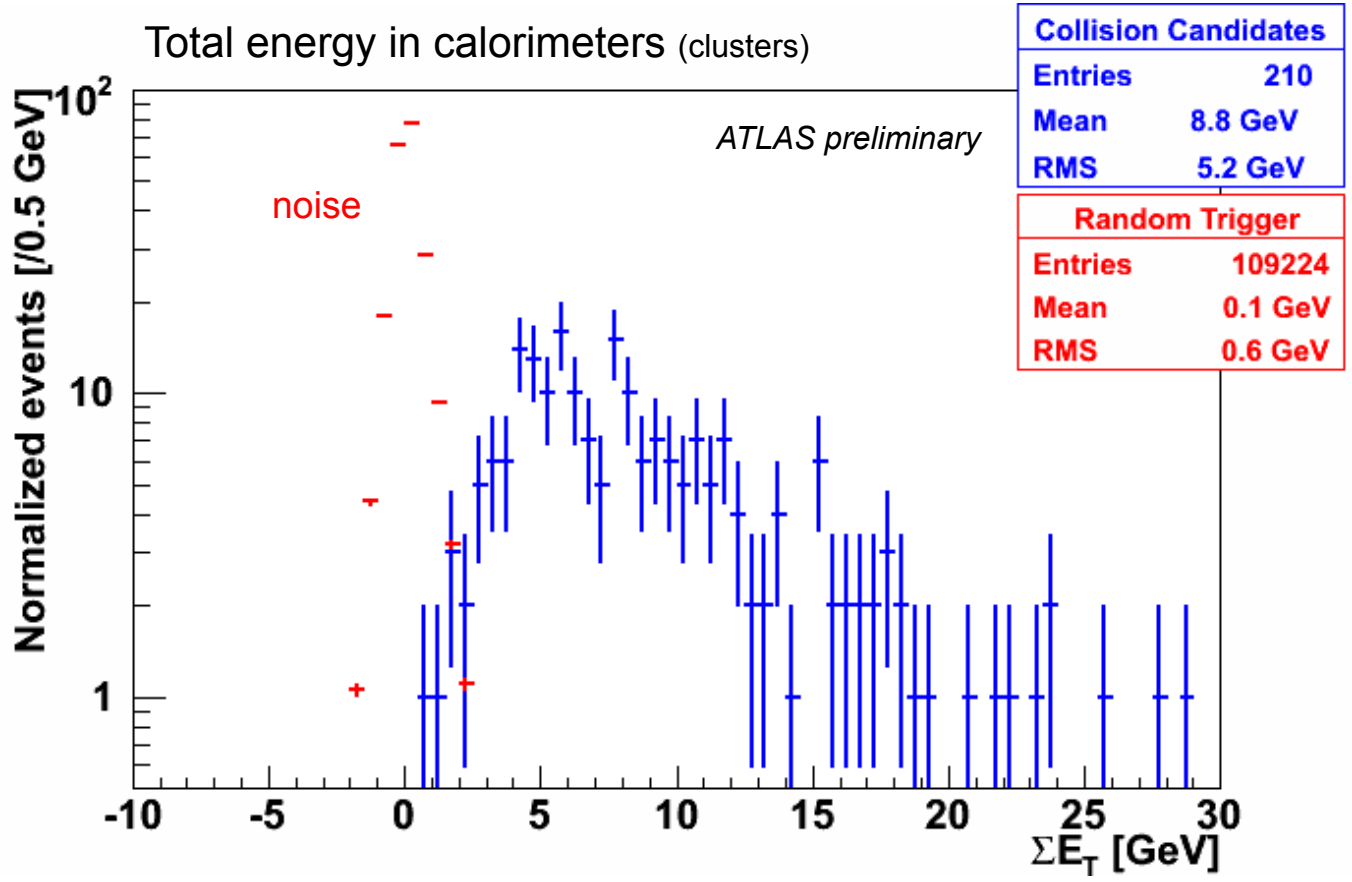




Looking at properties of collision events

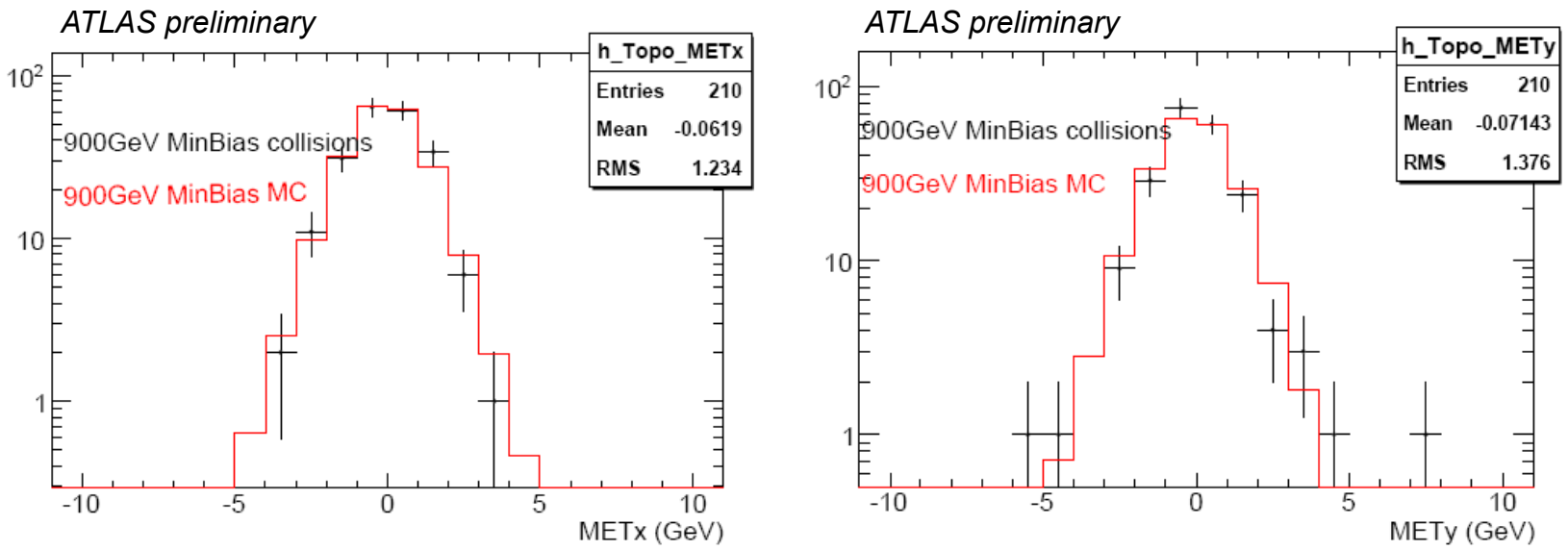
Properties of collision events

- Sum of calorimeter transverse energy compared to random events



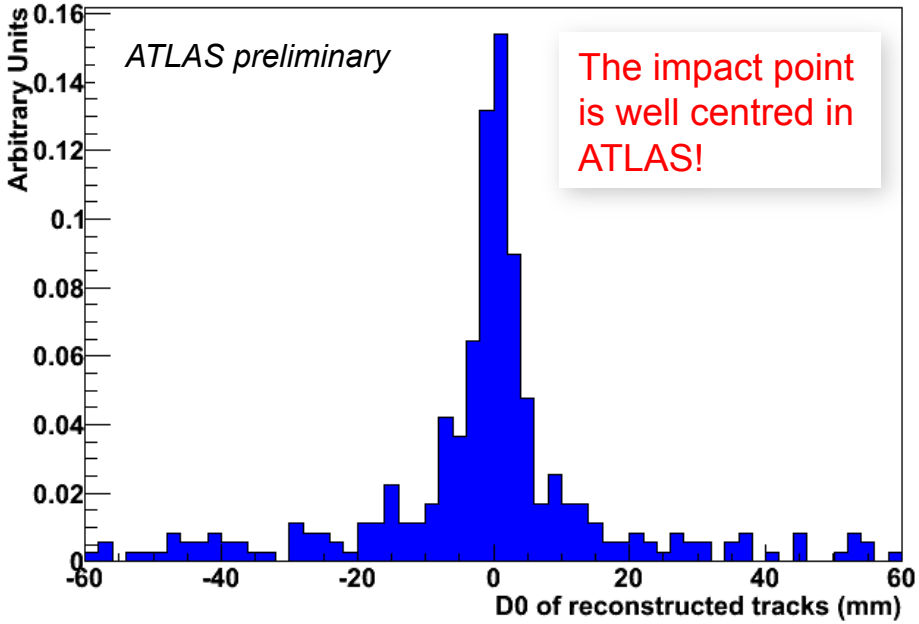
Properties of collision events

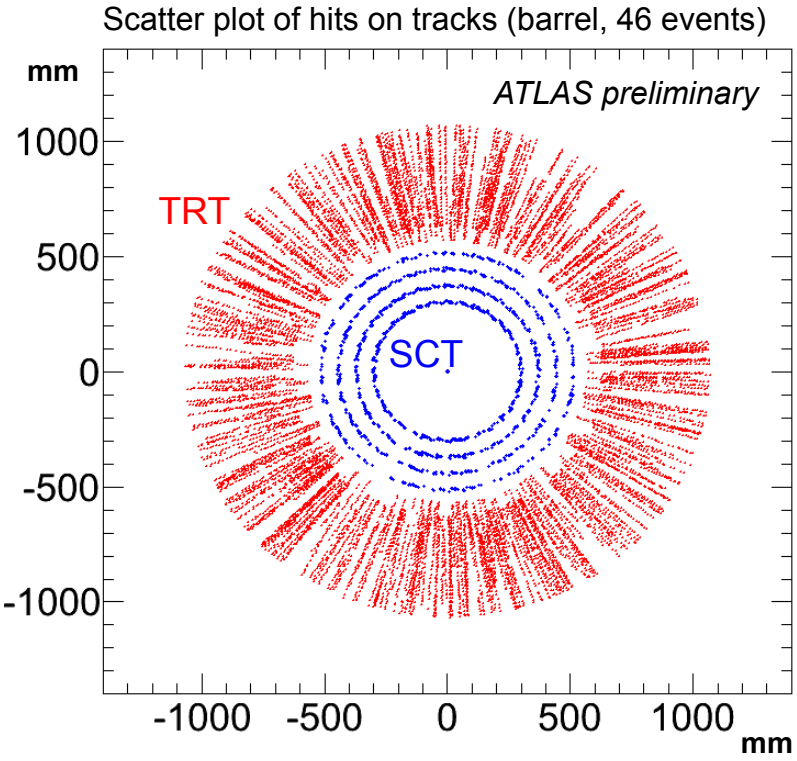
- Missing transverse energy components compared to 900 GeV minimum bias Monte Carlo (solenoid field ON)



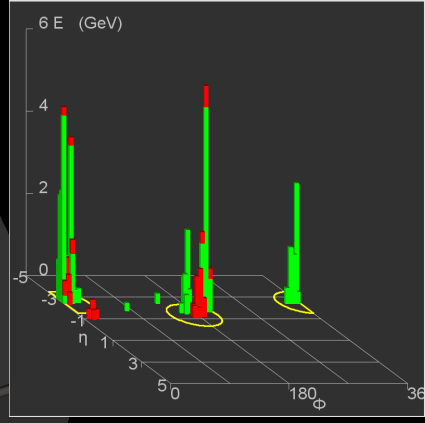
Tracking (challenging w/o Pixel, limited SCT and solenoid field off!)

- Without solenoid field no separation of tracks by momenta
- Fit impact parameter in a “silver-plated” sample with SCT >= 20 V and number of SCT hits >= 6 (46 events)





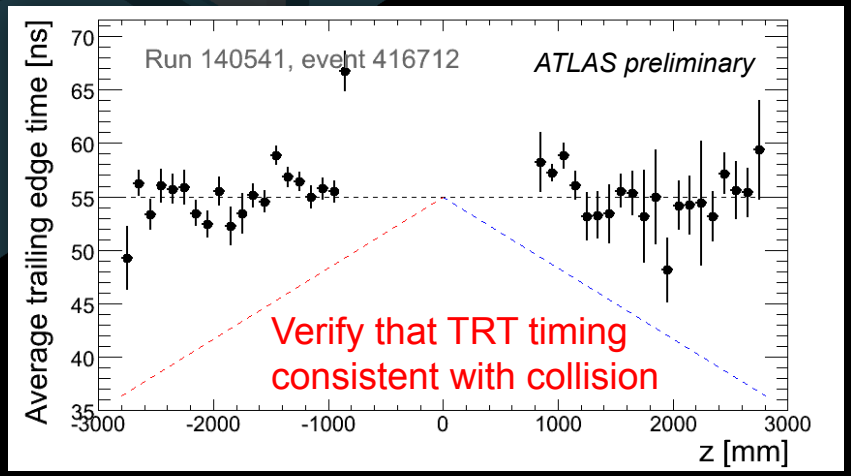
A di-jet candidate



Run 140541
Event 416712

Two jets back-to-back in ϕ, both with (uncalibrated) E_T ~ 10 GeV,
η of −1.3 and −2.5,
~ no missing E_T

Triggered by MBTS A/B in time, several hits
Also triggered by L1Calo EM3



How much luminosity did we collect? Naïve estimate

- With a tight calorimeter-based timing selection, cross-checked by the MBTS and TRT ToF measurements, we have identified 197 golden collision candidates from run 140541 of Nov 23
- We separate this sample into 2 parts (afternoon=A, evening=B) of different beam conditions
- From Monte Carlo (solenoid field on) we find that the selection efficiency, including trigger, for inelastic and diffractive minimum bias events is about 70%
- Using as total minimum bias cross section of 58 mb (40 mb inelastic, 12/6 mb SD/DD):

Sample	Number of events	DAQ duration	Average rate	Average inst. luminosity	Integrated luminosity
A	61	54 mins	0.03 Hz	0.5×10^{24} cm^{-2} s^{-1}	1.5 mb^{-1}
B	136	46 mins	0.07 Hz	1.2×10^{24} cm^{-2} s^{-1}	3.4 mb^{-1}

Cross checks:
- Assuming that ε=0% for SD and DD → increases luminosity by 10%
- change inelastic cross section to 34 mb → increases luminosity by 15%

Final words …

ATLAS welcomes the beams – experiment and collaboration are ready for physics!

What I did not mention: the data acquisition system, prompt reconstruction and the worldwide data distribution worked smoothly with collision and the huge beam splash events.

First collisions at 900 GeV have been recorded, and were a phase transition for ATLAS.

We are looking forward to lots more data, with the solenoid field on.

Again, thanks to the LHC team for a spectacular restart !

… and a final toast !