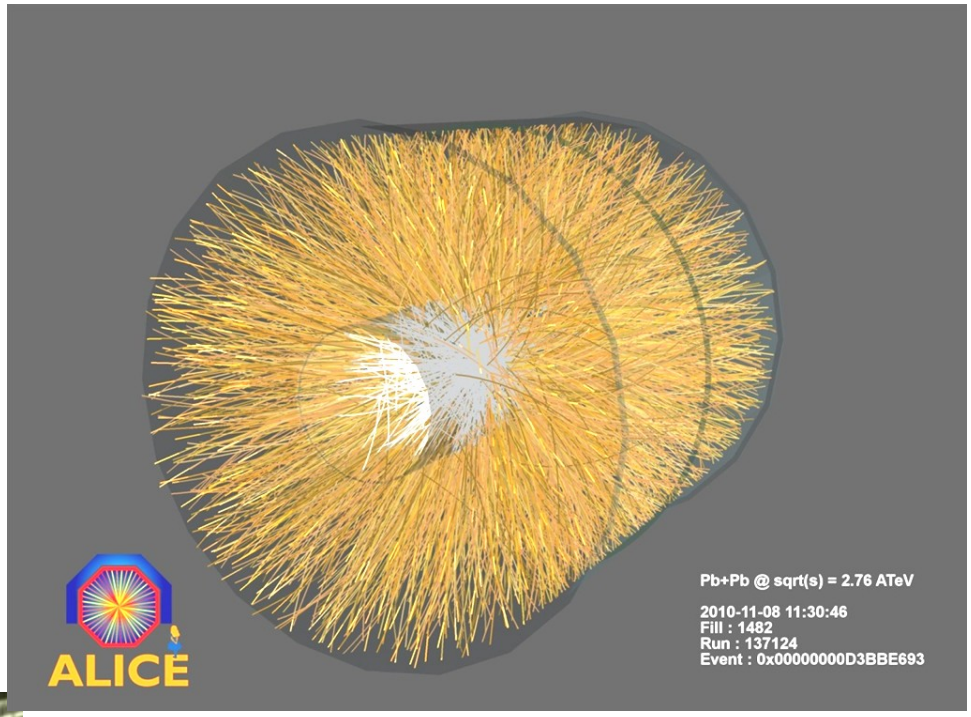
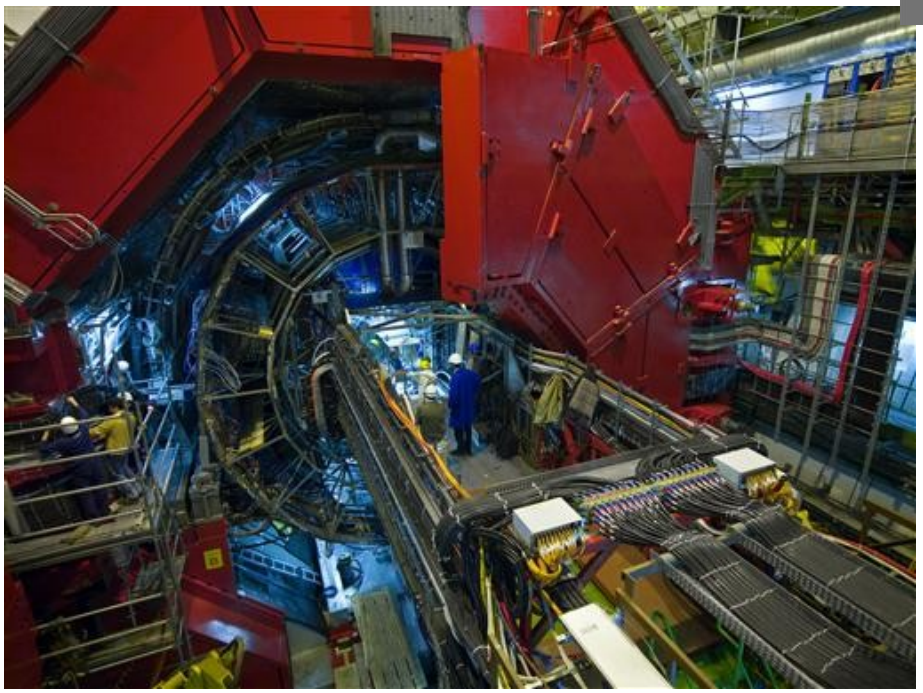
ALICE





The 2010 LHC Experience

Where is Jurgen ... ?

Jurgen Schukraft is off to a conference to tell the world on how beautiful the LHC works.

He transmits his apologies for not being present and congratulates LHC for an incredible achievement.

Note: The reason of Jurgen's absence is not the fact that he got too annoyed about the 2010 heavy Ion schedule discussions.

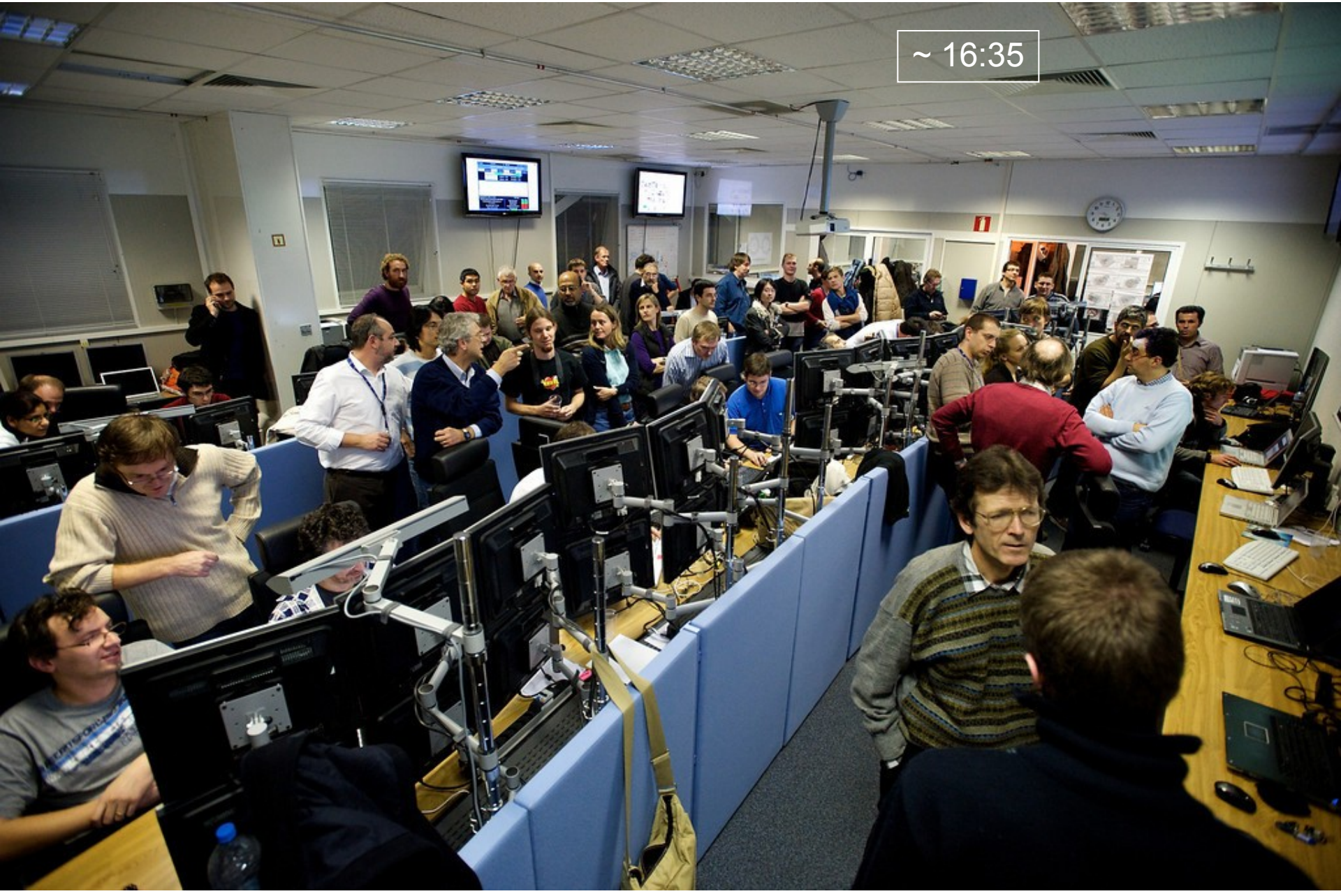
The LHC (and everything else) accelerates ..

..after concentrated preparations..

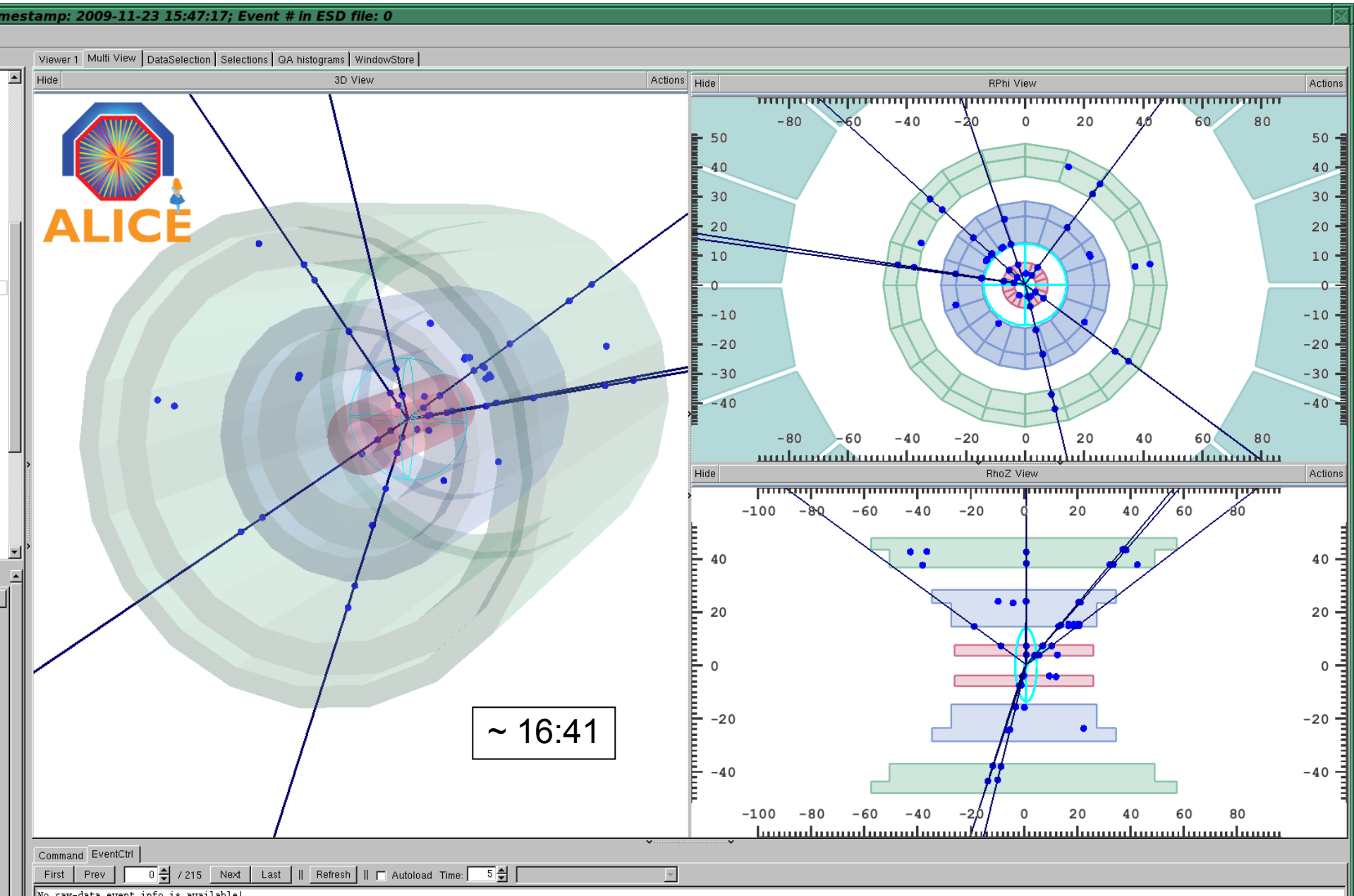
.. and tense anticipation..

Monday, 23rd November 2009, ~15:30
in the ALICE Control Room

some anxious minutes waiting for collisions..



The first ‘event’ pops up in the ACR



Relief and jubilation..

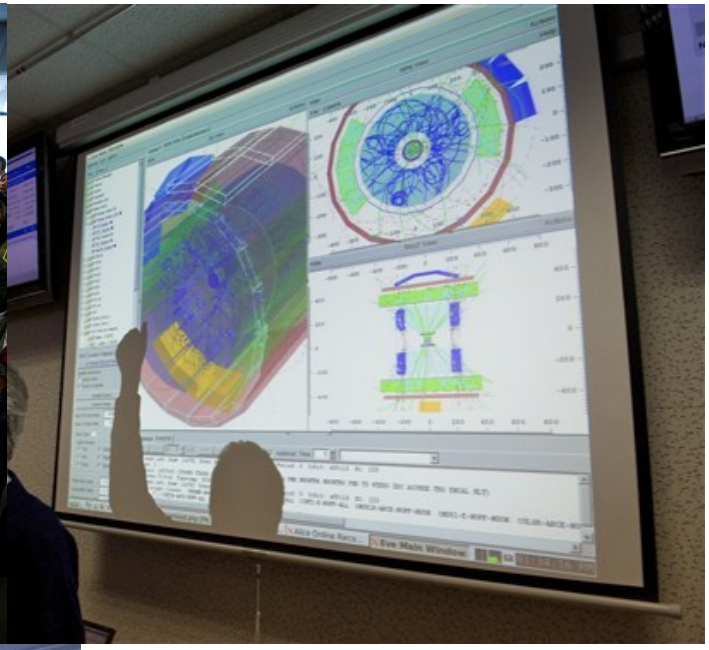
Collisions in ALICE !!

.. and some celebration..

‘First Physics’ in the making

After years of looking at simulated data, there was no holding back:
First physics results examined,
ca 1 hour after data taking finished (284 events !)..

First High Energy Proton Collisions



March 30th 2010

More Drinks …

$\bar{p}/p$ Ratio @ LHC

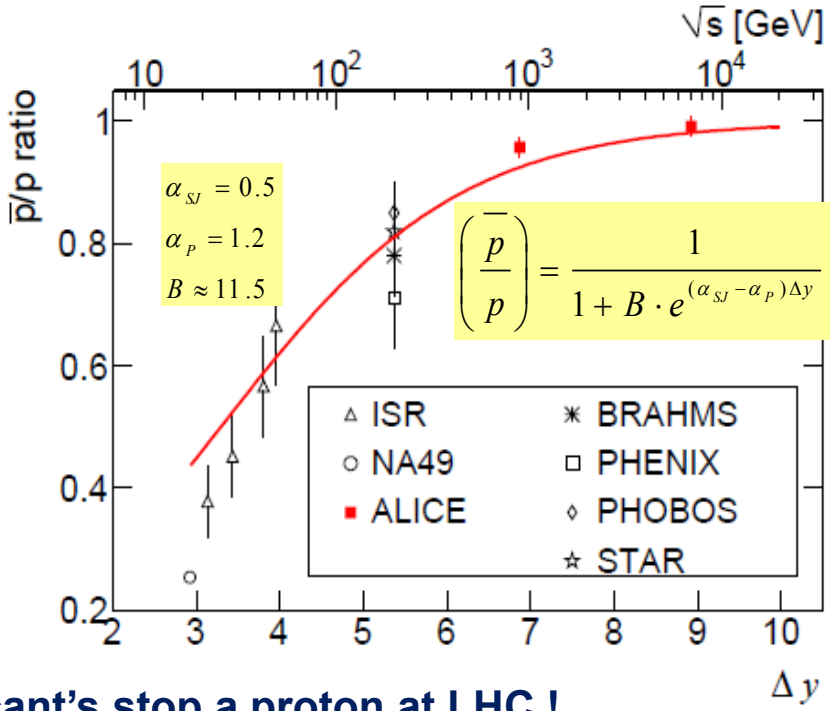
PRL 105, 072002 (2010) PHYSICAL REVIEW LETTERS week ending 13 AUGUST 2010

Midrapidity Antiproton-to-Proton Ratio in pp Collisons at $\sqrt{s} = 0.9$ and 7 TeV Measured by the ALICE Experiment

K. Aamodt *et al.**
(ALICE Collaboration)

(Received 29 June 2010; published 12 August 2010)

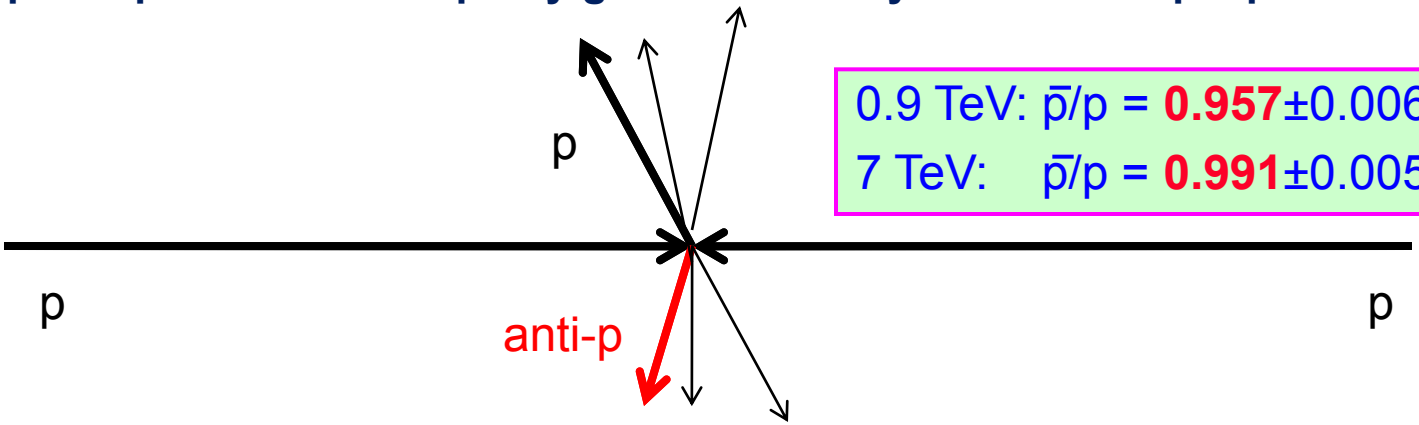
The ratio of the yields of antiprotons to protons in pp collisions has been measured by the ALI experiment at $\sqrt{s} = 0.9$ and 7 TeV during the initial running periods of the Large Hadron Collider. T measurement covers the transverse momentum interval $0.45 < p_t < 1.05$ GeV/c and rapidity $|y| <$ (The ratio is measured to be $R_{|y|<0.5} = 0.957 \pm 0.006(\text{stat}) \pm 0.014(\text{syst})$ at 0.9 TeV and $R_{|y|<0.5}$ $0.991 \pm 0.005(\text{stat}) \pm 0.014(\text{syst})$ at 7 TeV and it is independent of both rapidity and transve momentum. The results are consistent with the conventional model of baryon-number transport and stringent limits on any additional contributions to baryon-number transfer over very large rapic intervals in pp collisions.



Can we stop a proton at LHC ?

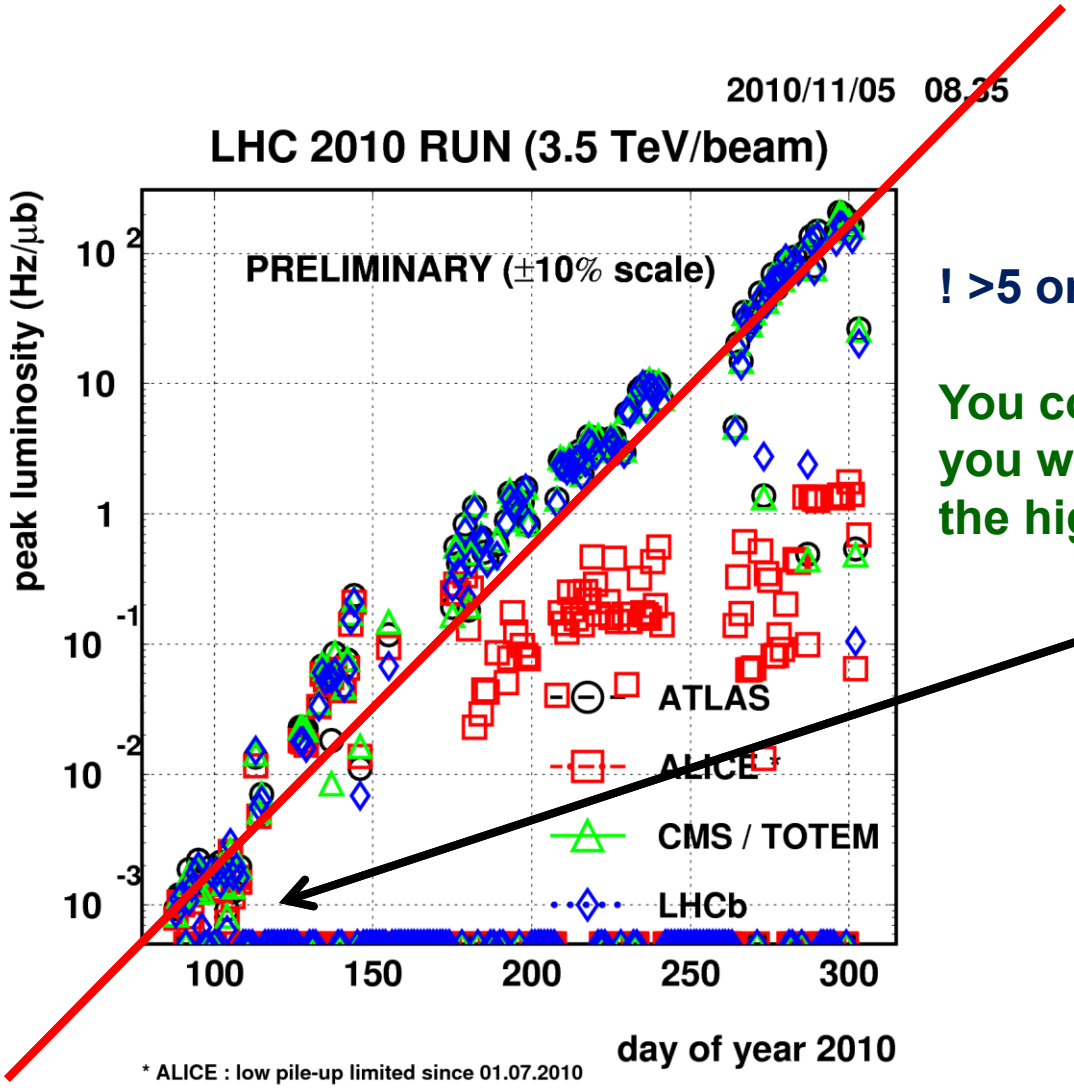
→Where does the conserved Baryon Number reappear ?

p/anti-p ratio at mid rapidity goes to one → you cant's stop a proton at LHC !



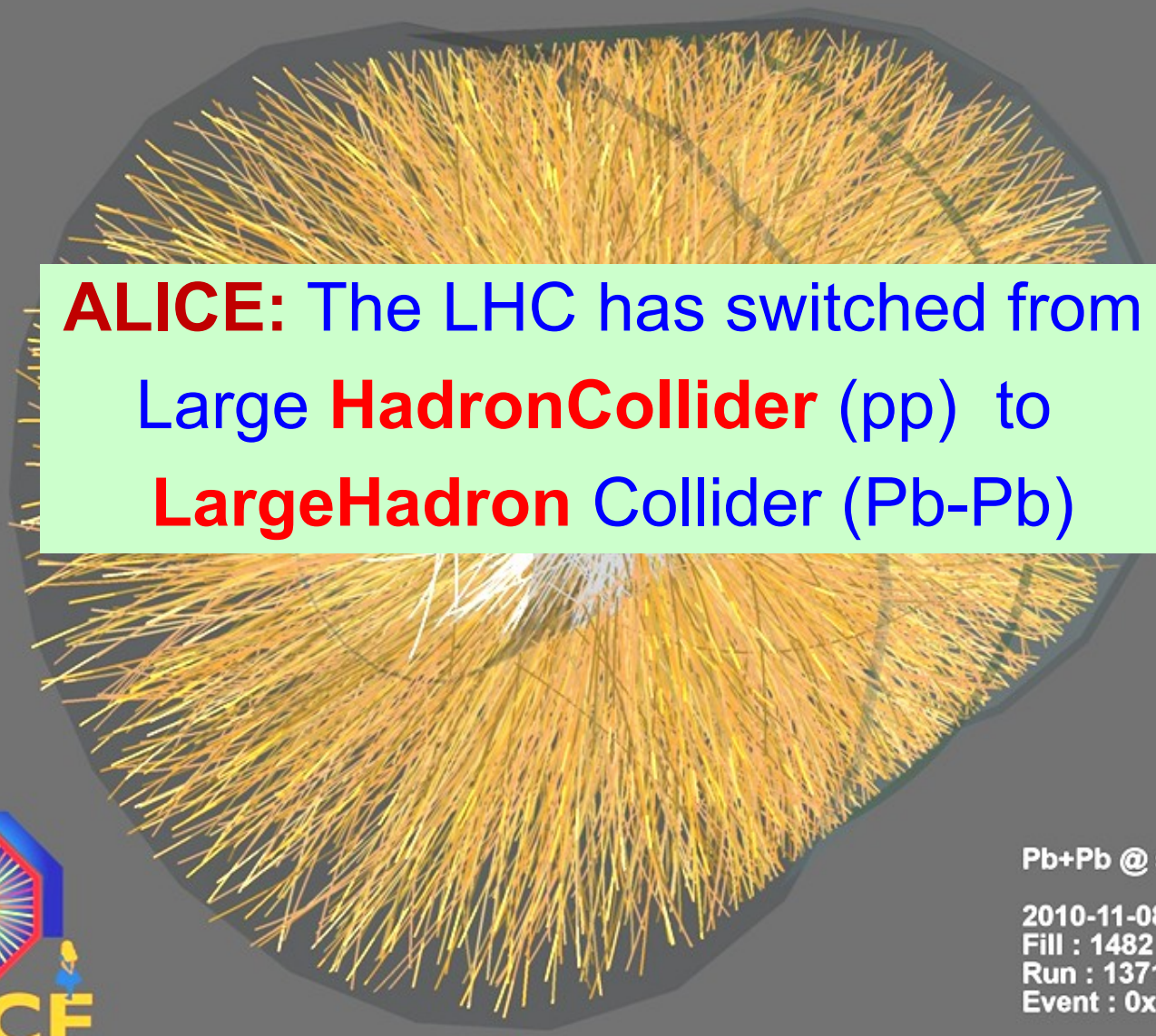
0.9 TeV: $\bar{p}/p$ = **0.957**±0.006(stat) ±0.014(syst)
7 TeV: $\bar{p}/p$ = **0.991**±0.005(stat) ±0.014(syst)

LHC p-p Peak Luminosity Evolution



! >5 orders of magnitude in 200 days !

You could have done much better if you would have not only worked on the high side …



ALICE: The LHC has switched from Large **HadronCollider** (pp) to **LargeHadron** Collider (Pb-Pb)

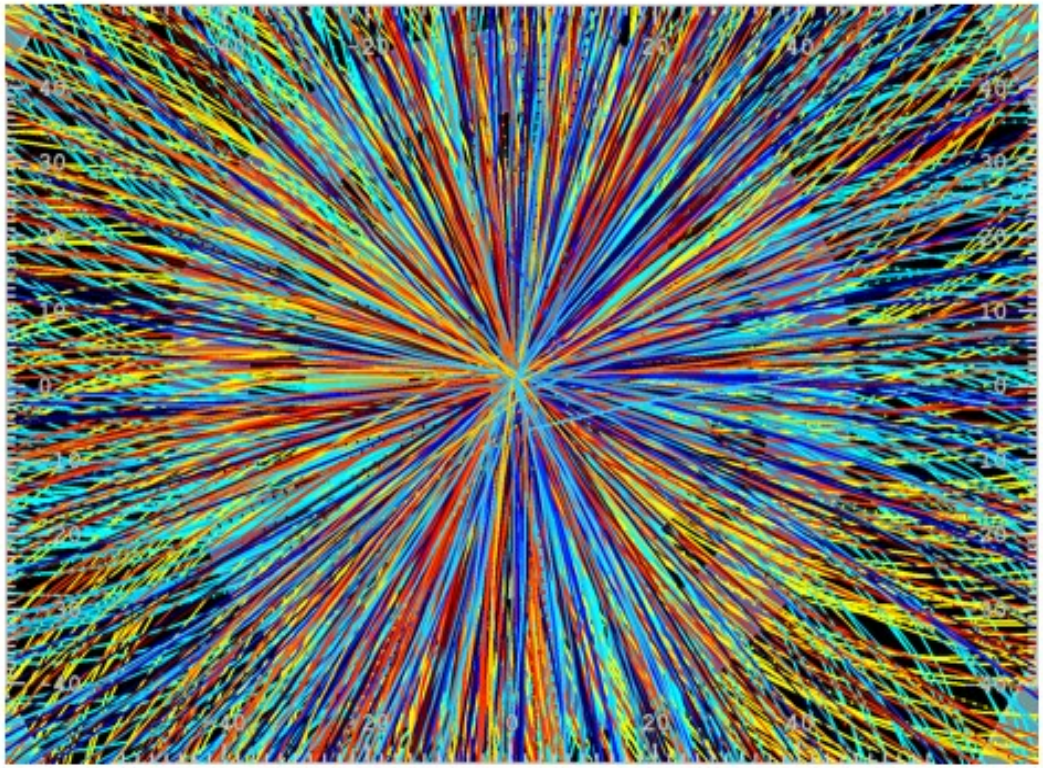
ALICE

Pb+Pb @ sqrt(s) = 2.76 ATeV

2010-11-08 11:30:46
Fill : 1482
Run : 137124
Event : 0x00000000D3BBE693

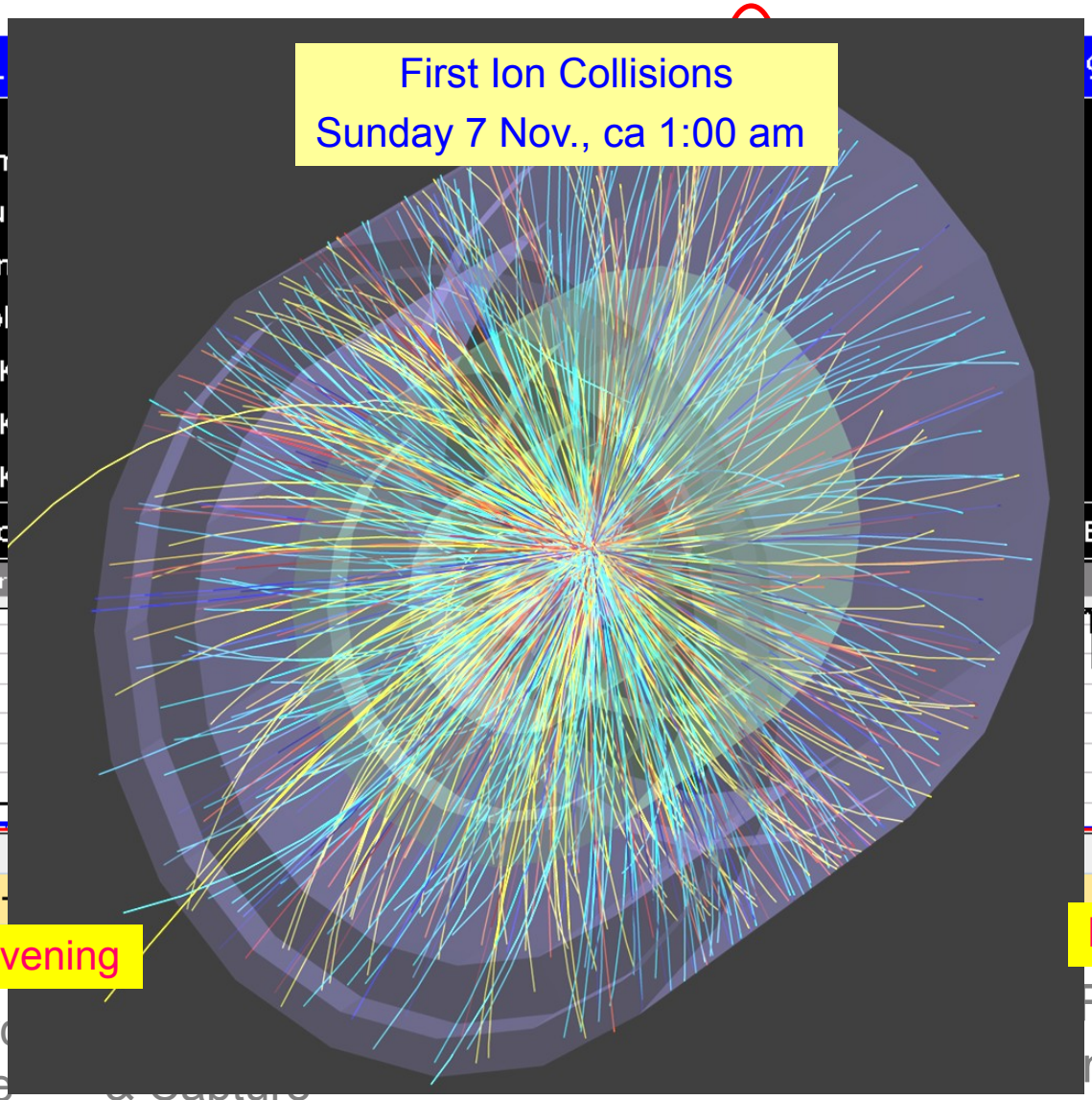
Heavy Metal in the Large Hadron Collider: this time for real

Here are some pictures of what happens - for real, not simulation - when lead ions with 287 TeV of energy each collide head on.



A lead-lead collision as seen by the ALICE detector. (credit ALICE/CERN)

Ion Commissioning at Incredible Speed



Thursday evening

B1 Inj., Circ
& Capture

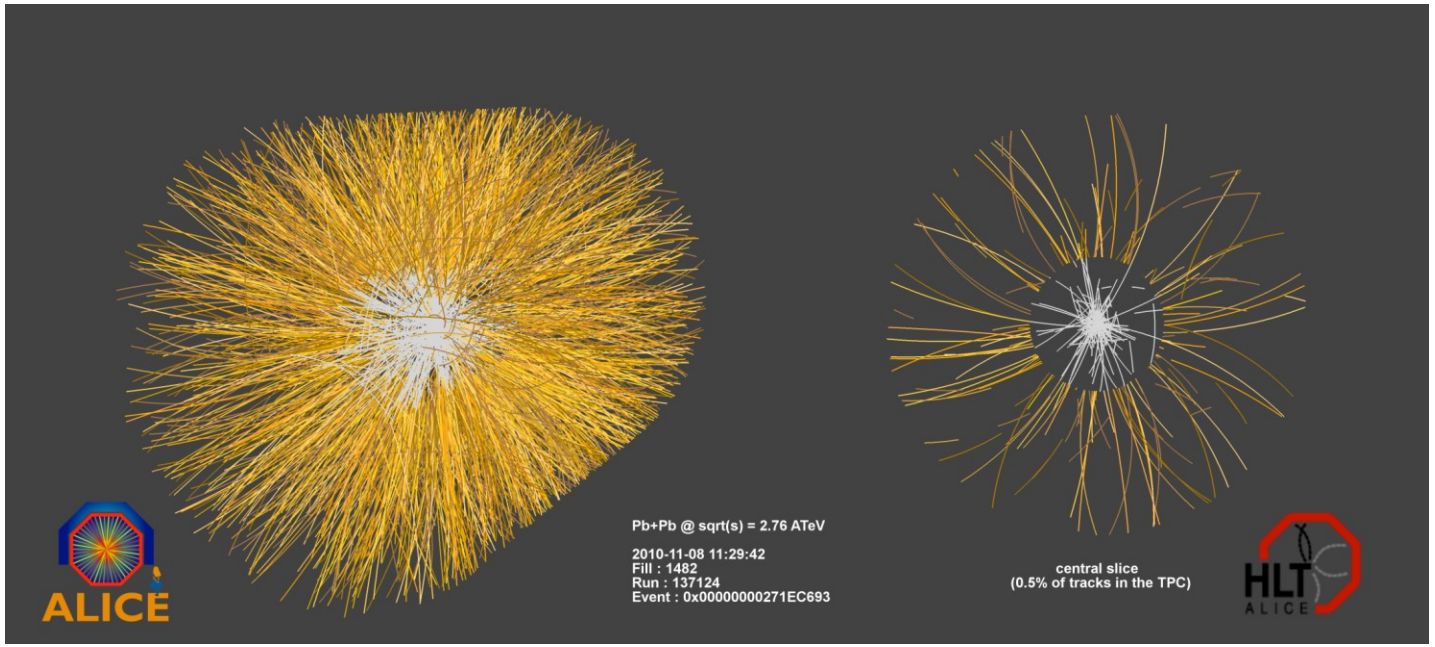
Collimation Checks

Friday evening

First Ramp
mation Checks
Squeeze

! Pb Pb Collisions !

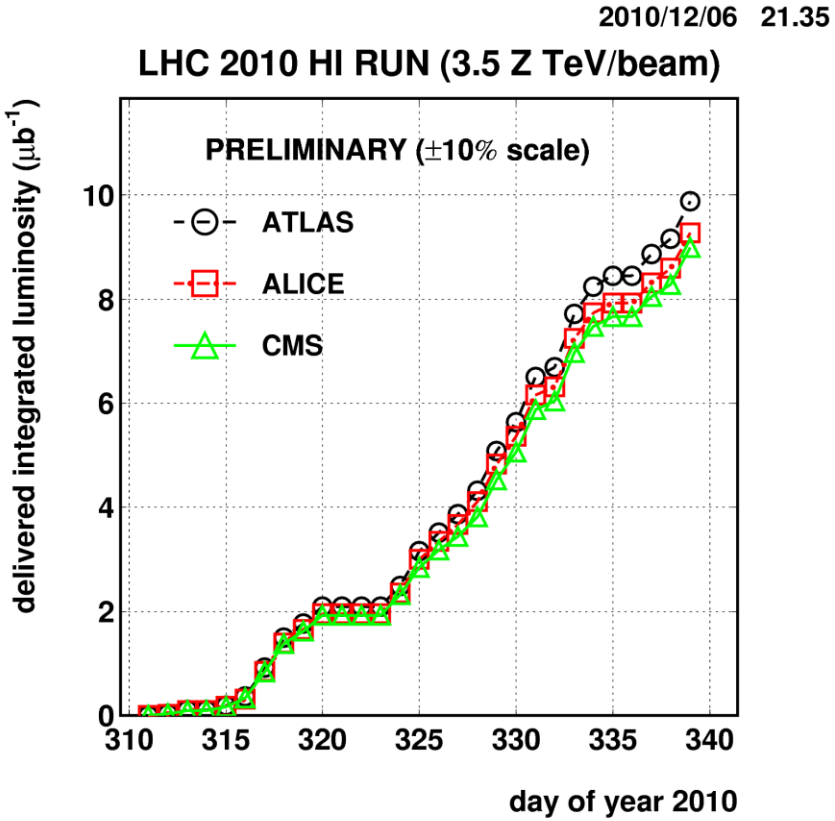
Mon. Nov 8th Fill 1482 – stable beam –
! All detectors running smoothly !



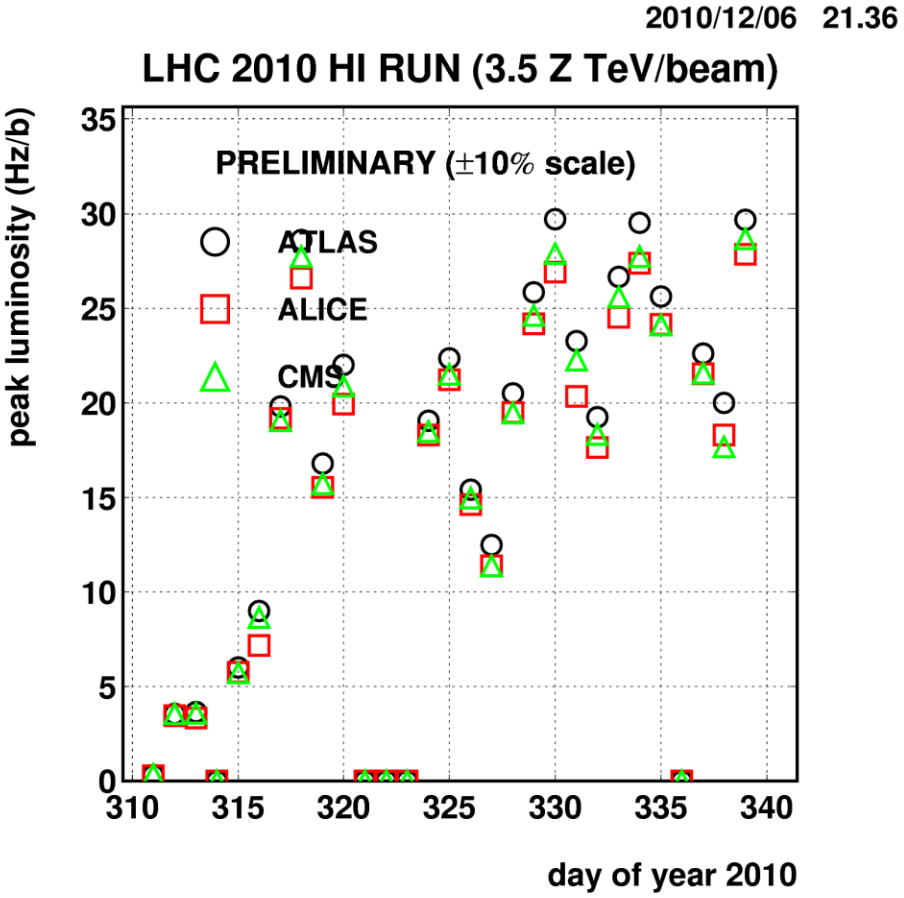
From an e-mail exchange in concerning the ALICE collaboration week:

… we advance the ALICE drink from Thu. Nov. 11th to Wed. Nov. 10 because we might already expect heavy Ion collisions on Thursday …

Pb-Pb Integrated Luminosity



LHC had to stop on Monday Dec 6th because otherwise it would have missed the 2010 goal of 1-10 ub^{-1} !



Very intense Days of Data Analysis

Elliptic flow of charged particles in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

We report the first measurement of charged particle elliptic flow in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ALICE detector at the CERN Large Hadron Collider. The measurement is performed in the central pseudorapidity region ($|\eta| < 0.8$) and transverse momentum range $0.2 < p_t < 5.0$ GeV/c. The
method, averaged over transverse
(syst) in the 40–50% centrality cla
near $p_t = 3$ GeV/c. C
increases by about 30%
are in agreement with

Charged-particle multiplicity density at mid-rapidity in central Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

The first measurement of the charged-particle multiplicity density at mid-rapidity in Pb–Pb collisions at a centre-of-mass energy per nucleon pair $\sqrt{s_{NN}} = 2.76$ TeV is presented. For an event sample corresponding to the most central 5% of the hadronic cross section the pseudo-rapidity density of primary charged particles at mid-rapidity is 1584 ± 4 (*stat.*) ± 76 (*sys.*), which corresponds
ir. This represents an increase of about a factor 1.9
rgies, and about a factor 2.2 to central Au–Au colli-
rovides the first experimental constraint for models

Suppression of Charged Particle Production at Large Transverse Momentum in Central Pb–Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV

The ALICE Collaboration*

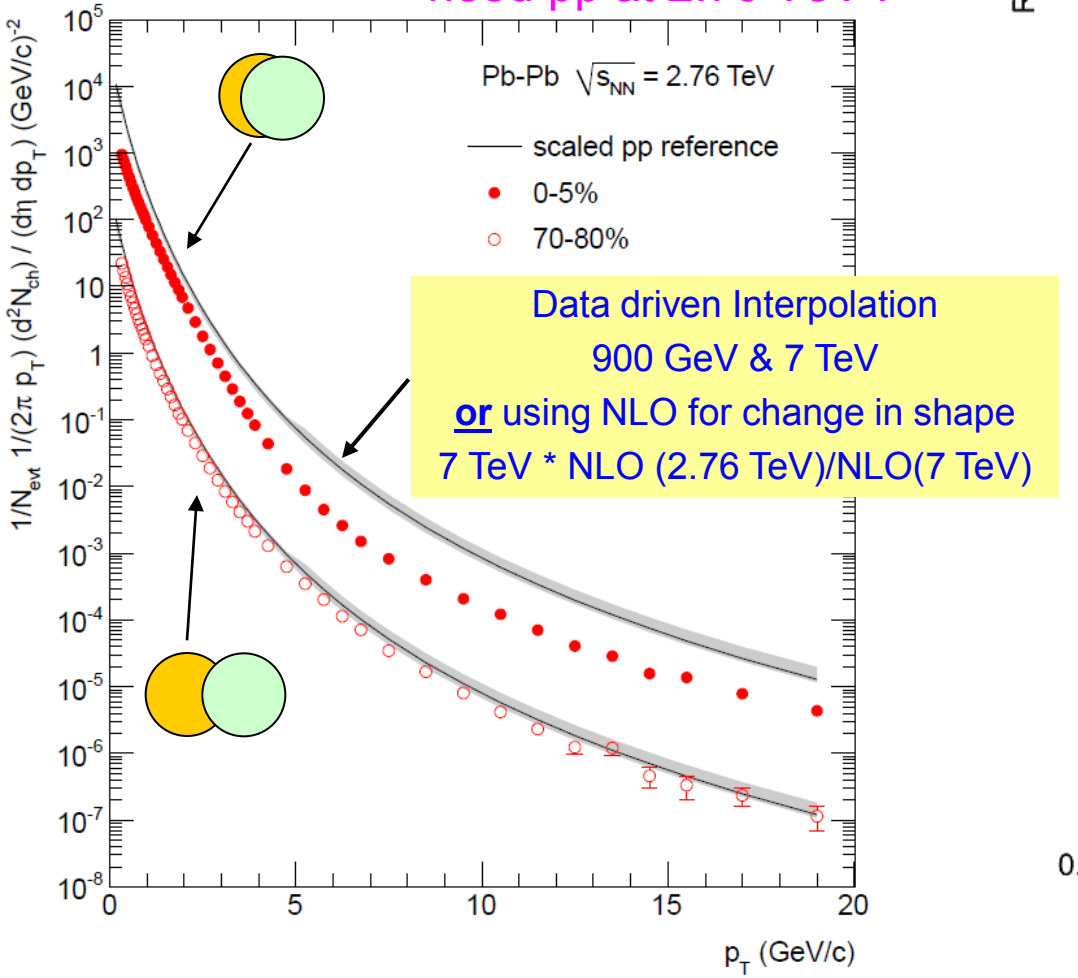
Abstract

Inclusive transverse momentum spectra of primary charged particles in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV have been measured by the ALICE Collaboration at the LHC. The data are presented for central and peripheral collisions, corresponding to 0–5% and 70–80% of the hadronic Pb–Pb cross section. The measured charged particle spectra in $|\eta| < 0.8$ and $0.3 < p_T < 20$ GeV/c are compared to the expectation in pp collisions at the same $\sqrt{s_{NN}}$, scaled by the number of underlying nucleon–nucleon collisions. The comparison is expressed in terms of the nuclear modification factor R_{AA}. The result indicates only weak medium effects ($R_{AA} \approx 0.7$) in peripheral collisions. In central collisions, R_{AA} reaches a minimum of about 0.14 at $p_T = 6$–7 GeV/c and increases significantly at larger p_T. The measured suppression of high–p_T particles is stronger than that observed at lower collision energies, indicating that a very dense medium is formed in central Pb–Pb collisions at the LHC.

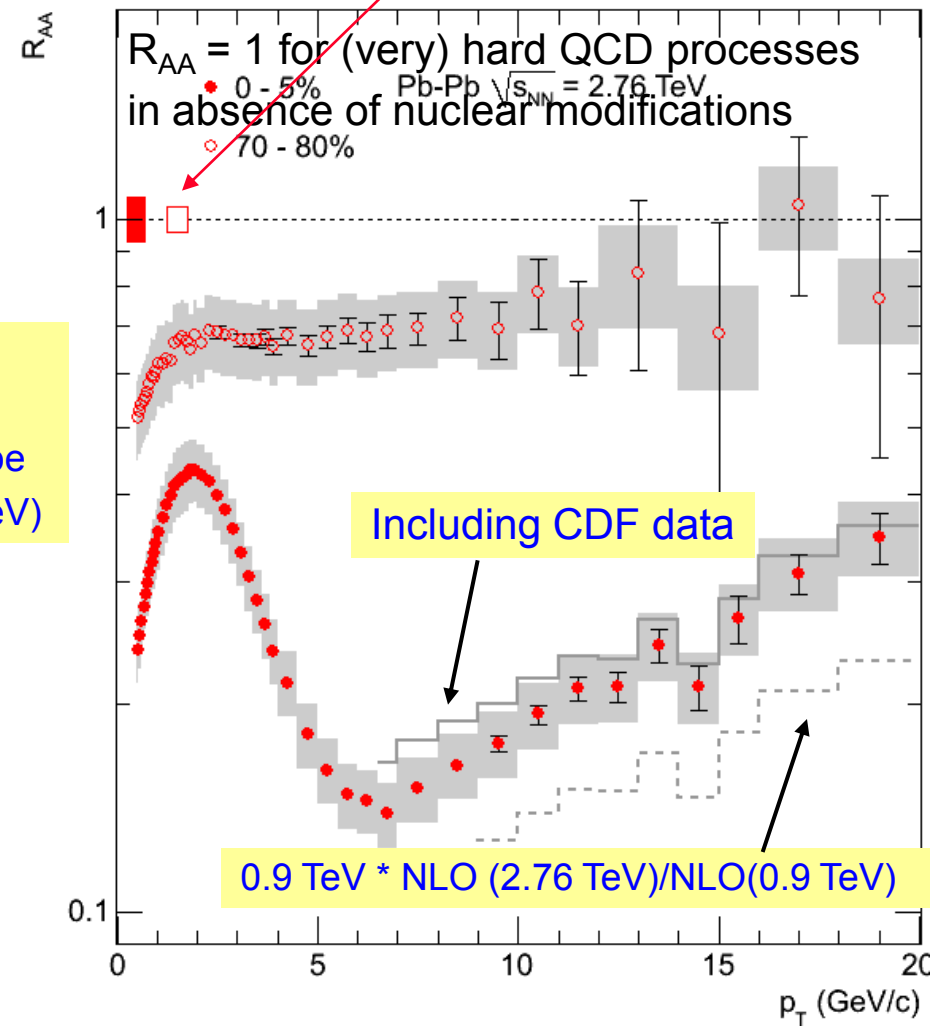
‘Jet Quenching’ as seen by p_t spectra

- Suppression of high p_t particles (~ leading jet fragments)
  - ⇨ Minimum R_{AA} ~ 1.5 – 2 x smaller than at RHIC
  - ⇨ Rising with p_t ! (ambiguous at RHIC !)
  - ⇨ accuracy limited by pp reference
    => need pp at 2.76 TeV !

$$R_{AA}(p_T) = \frac{(1/N_{evt}^{AA})\, d^2N_{ch}^{AA}/d\eta dp_T}{\langle N_{coll}\rangle\, (1/N_{evt}^{pp})\, d^2N_{ch}^{pp}/d\eta dp_T}$$



Data driven Interpolation
900 GeV & 7 TeV
or using NLO for change in shape
7 TeV * NLO (2.76 TeV)/NLO(7 TeV)

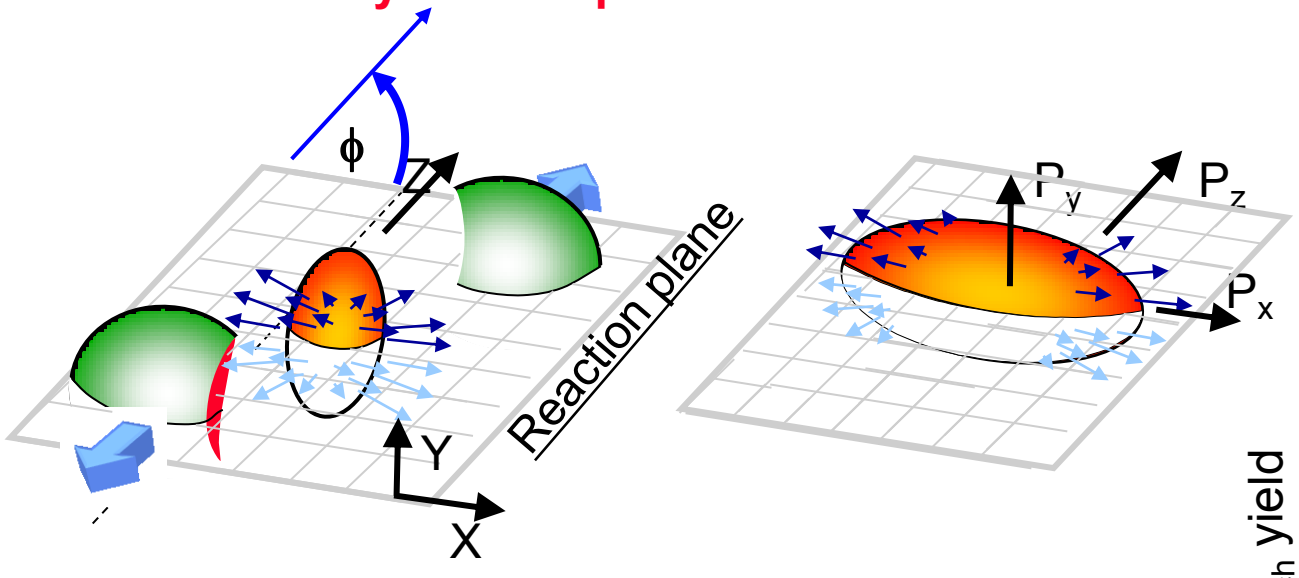


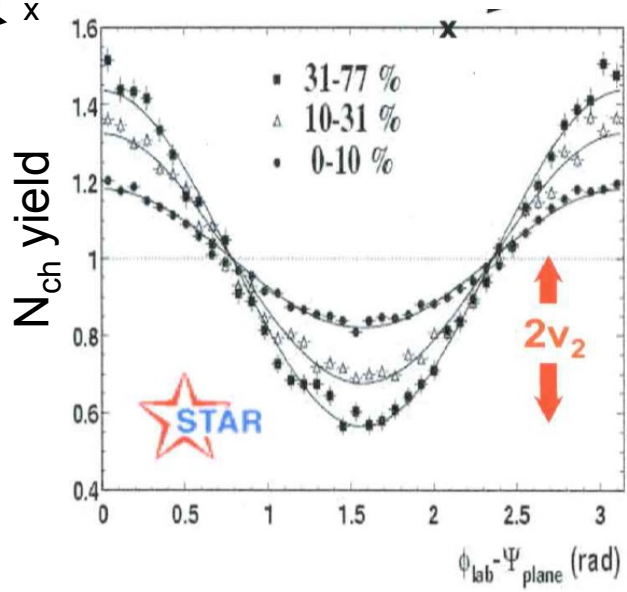
2) Testing the HI 'Standard Model'

- Elliptic Flow: one of the most anticipated answers from LHC

⇨ **experimental observation:** particles are distributed with azimuthally anisotropic around the scattering plane

⇨ **Are we sure Hydro interpretation is correct ?**



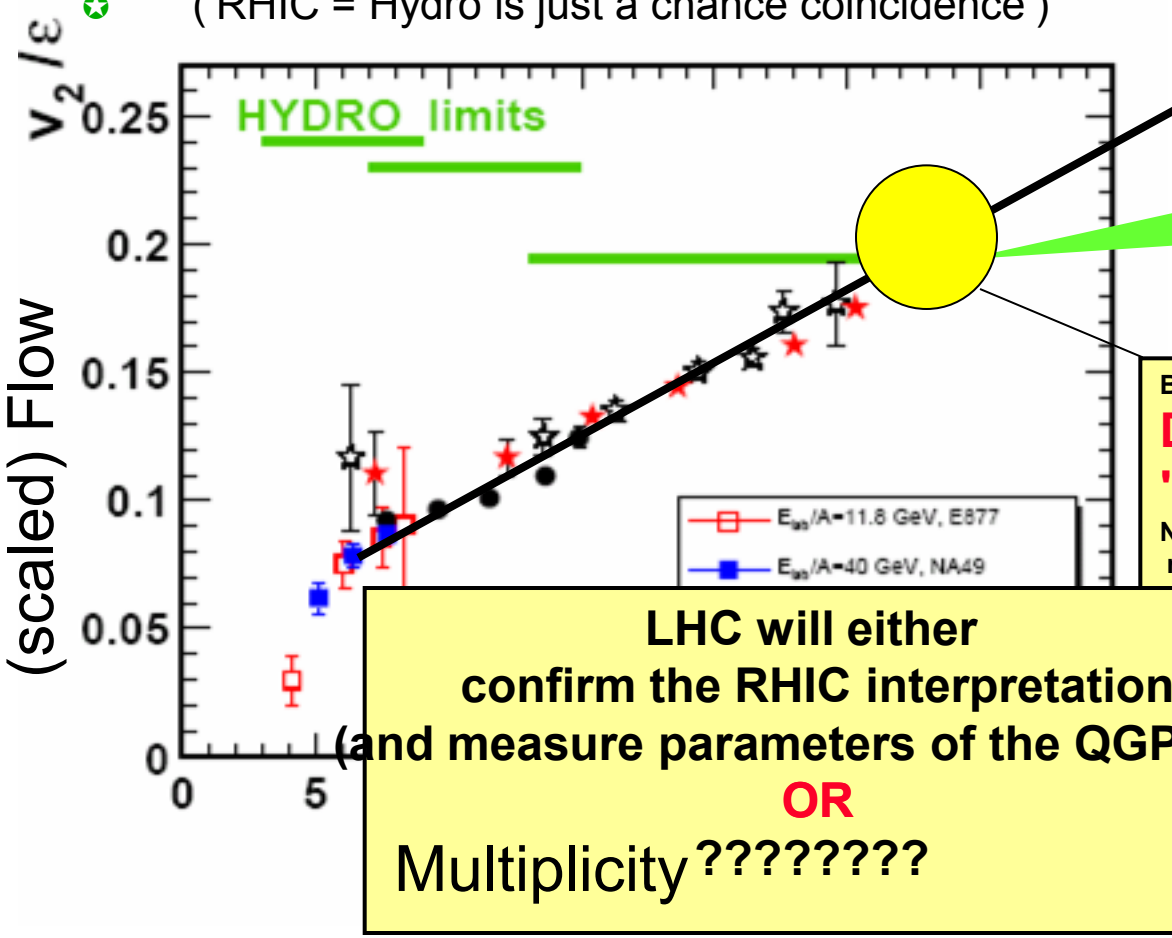


Elliptic Flow v_2 as interpreted by **Hydrodynamics**
Pressure gradient converts
spatial anisotropy → momentum anisotropy
→ particle yield anisotropy

Testing the HI 'Standard Model'

- Hydro seems to work very well for first time at RHIC
  - ⇨ LHC prediction: modest rise (Depending on EoS, viscosity, speed of sound, $dN_{ch}/d\eta$, ..)
    - ('better than ideal is impossible')
  - ⇨ experimental trend & scaling predicts large increase of flow
    - ('RHIC = Hydro is just a chance coincidence')

LHC ?



BNL Press release, April 18, 2005:

Data = ideal Hydro

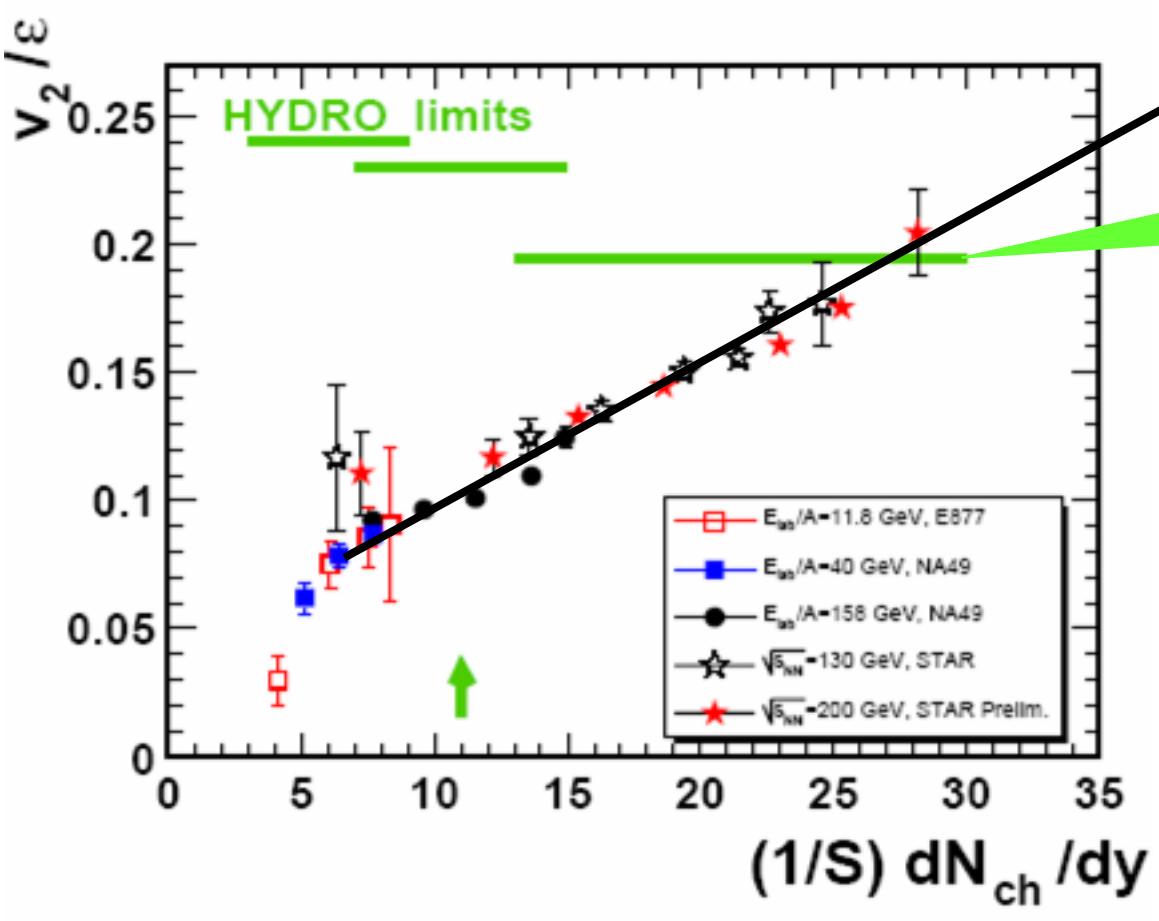
"Perfect" Liquid

New state of matter more remarkable than predicted – raising many new questions

LHC will either
confirm the RHIC interpretation
(and measure parameters of the QGP EoS)
OR
Multiplicity ????????

Testing the HI 'Standard Model'

- Hydro passed the first test !
  - ⇨ many more tests of Hydro and the HI-SM to come….

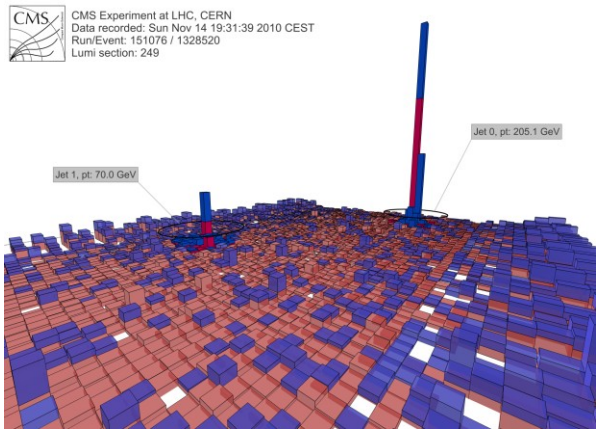


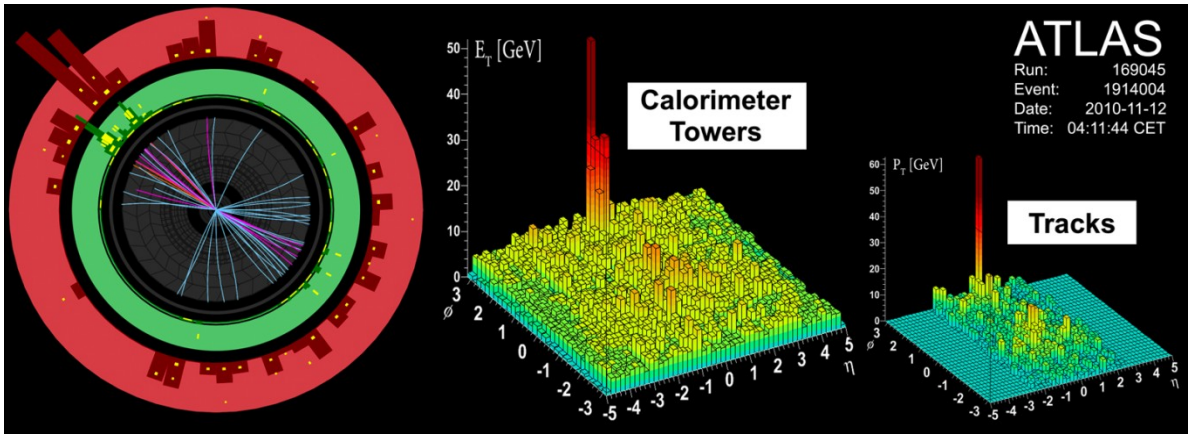
LHC !

CERN Press release, November 26, 2010:

'confirms that the much hotter plasma produced at the LHC behaves as a very low viscosity liquid (a perfect fluid)..'

Pb-Pb ALICE, CMS





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

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

Using the ATLAS detector, observations have been made of a centrality-dependent dijet asymmetry in the collisions of lead ions at the Large Hadron Collider. In a sample of lead-lead events with a per-nucleon center of mass energy of 2.76 TeV, selected with a minimum bias trigger, jets are reconstructed in fine-grained, longitudinally-segmented electromagnetic and hadronic calorimeters. The underlying event is measured and subtracted event-by-event, giving estimates of jet transverse energy above the ambient background. The transverse energies of dijets in opposite hemispheres is observed to become systematically more unbalanced with increasing event centrality leading to a large number of events which contain highly asymmetric dijets. This is the first observation of an enhancement of events with such large dijet asymmetries, not observed in proton-proton collisions, which may point to an interpretation in terms of strong jet energy loss in a hot, dense medium.

ALICE is of course very happy about the excitement that the Heavy Ion program has also generated within the other experiments.

The competitive and complementary views on the Heavy Ion Collisions have and will certainly boost this field of research at LHC !

End of Run Parties

The ALICE run coordinator discussing more efficient ways of enforcing discipline in the control room …

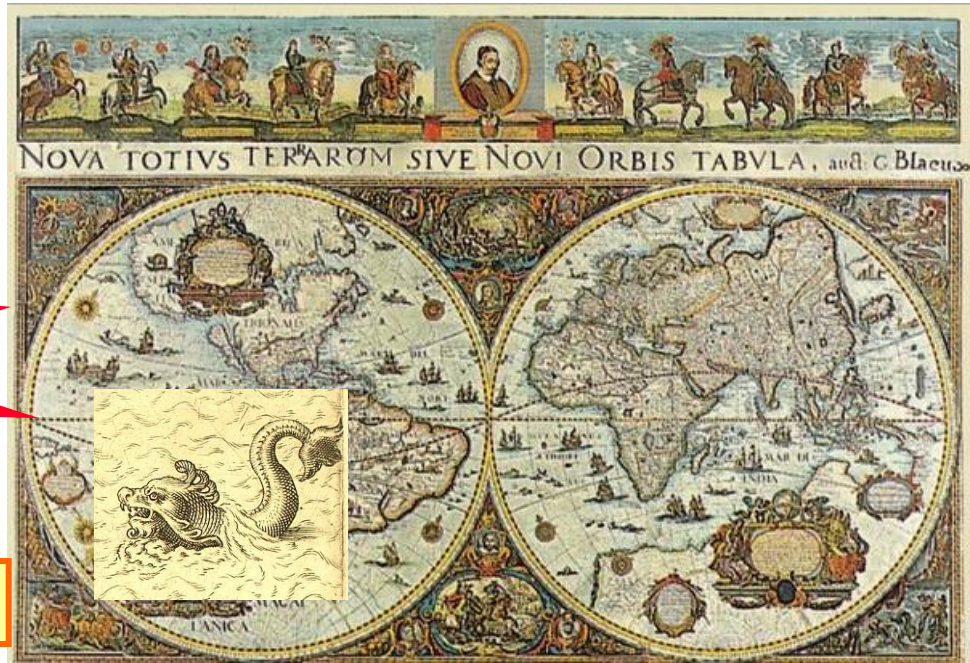
Jurgen's Summary

- LHC is a fantastic 'Big Bang' machine
  - ⇨ even for LHC standards, speed and quality of ion run is outstanding
  - ⇨ unprecedented powerful and complementary set of detectors
  - ⇨ physics looks to be even more interesting than anticipated

While waiting for Mr. Higgs and Ms. Susy,
there is plenty of exciting physics (and fun)
exploring QCD in a new domain,
where the strong interaction is really strong !

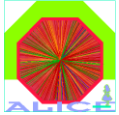
- Looking forward to the 'terra incognita' of HI at LHC

Big THANKS to the **CERN crew**
from ion source all the way to LHC



Hic sunt Leones !

Acknowledgements



ALICE (thanks) congratulates the Accelerator Team for an incredible performance during 2010, surpassing all possible expectations.

Commissioning a machine while having all eyes of the particle physics community following every step did certainly not make the task easier.

The Heavy Ion performance and speed of commissioning, starting from the source, LEIR, etc. up to LHC was mindblowing.

We hope very much that the accelerator team feels like being part of the physics exploitation of the machine.

We do sincerely thank the LHC operations team for supporting the sometimes difficult ALICE running requirements. This made it possible for us to take full advantage of the proton period for physics exploitation and reference running for the Heavy Ion physics.

Congratulations, thank you & looking forward for exciting years ahead !