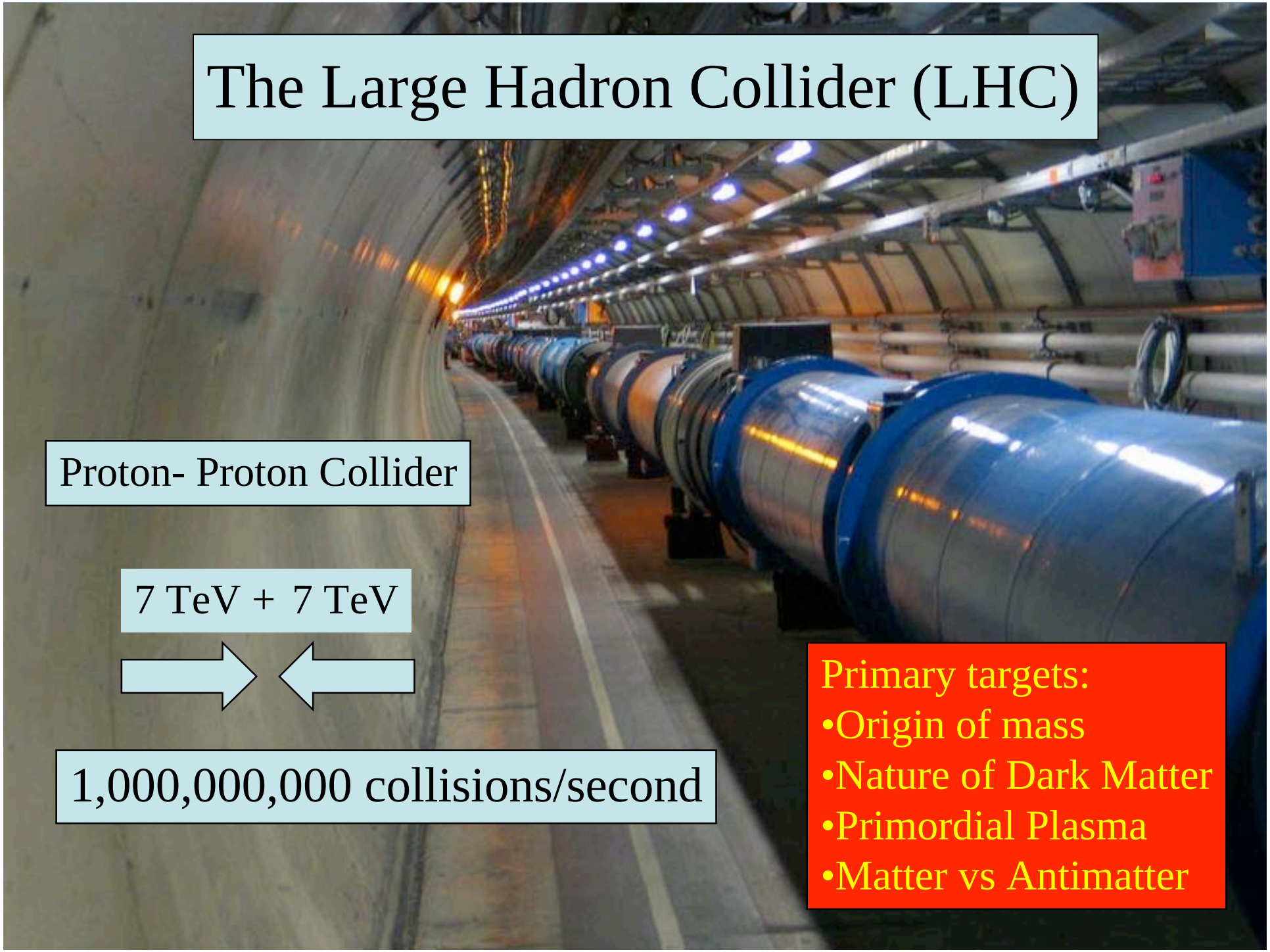
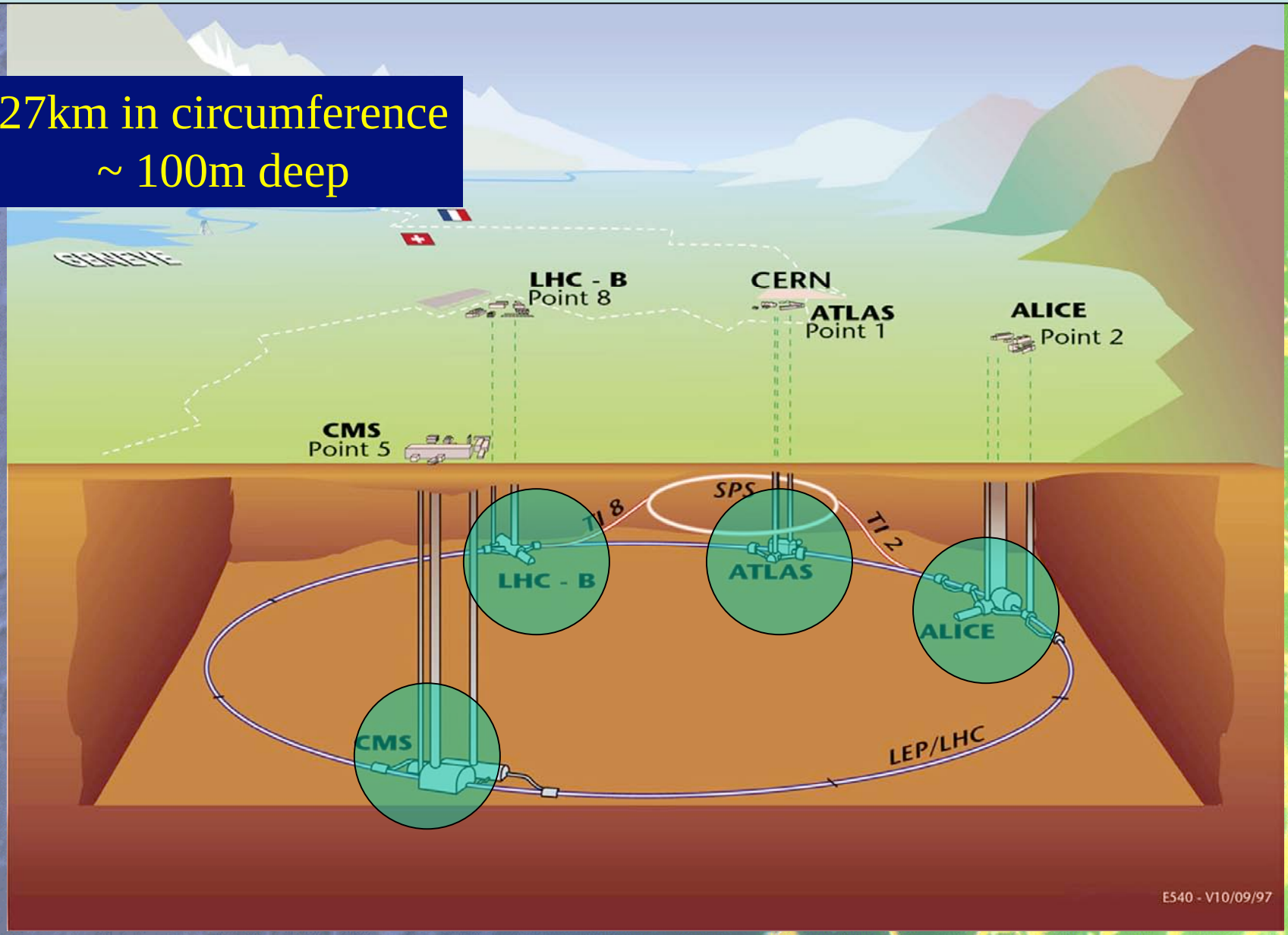

The Start-up of the LHC


The Large Hadron Collider (LHC)
Proton- Proton Collider
7 TeV + 7 TeV
1,000,000,000 collisions/second
Primary targets:
•Origin of mass
•Nature of Dark Matter
•Primordial Plasma
•Matter vs Antimatter

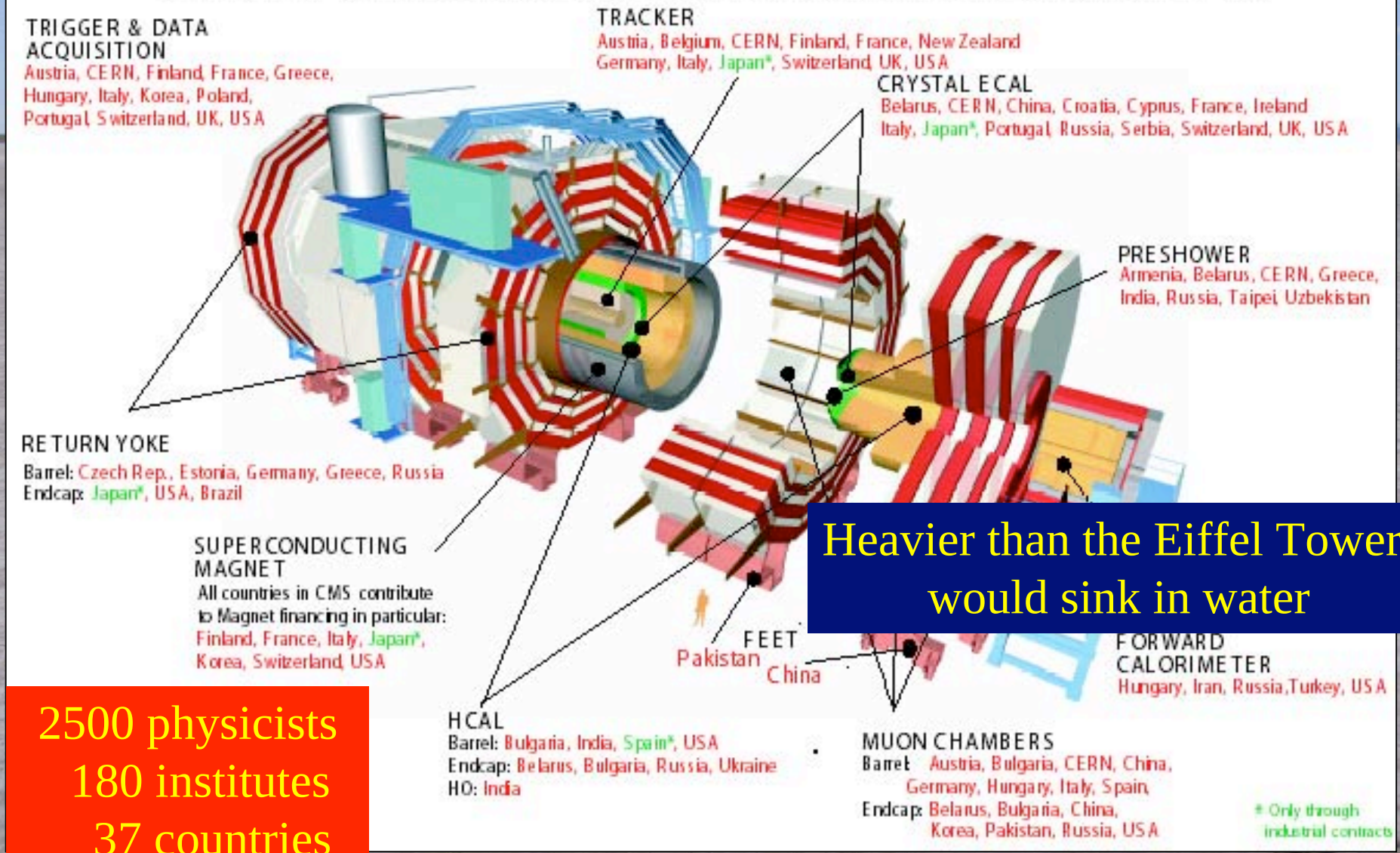
General View of LHC & its Experiments

27km in circumference
~ 100m deep



The CMS detector:

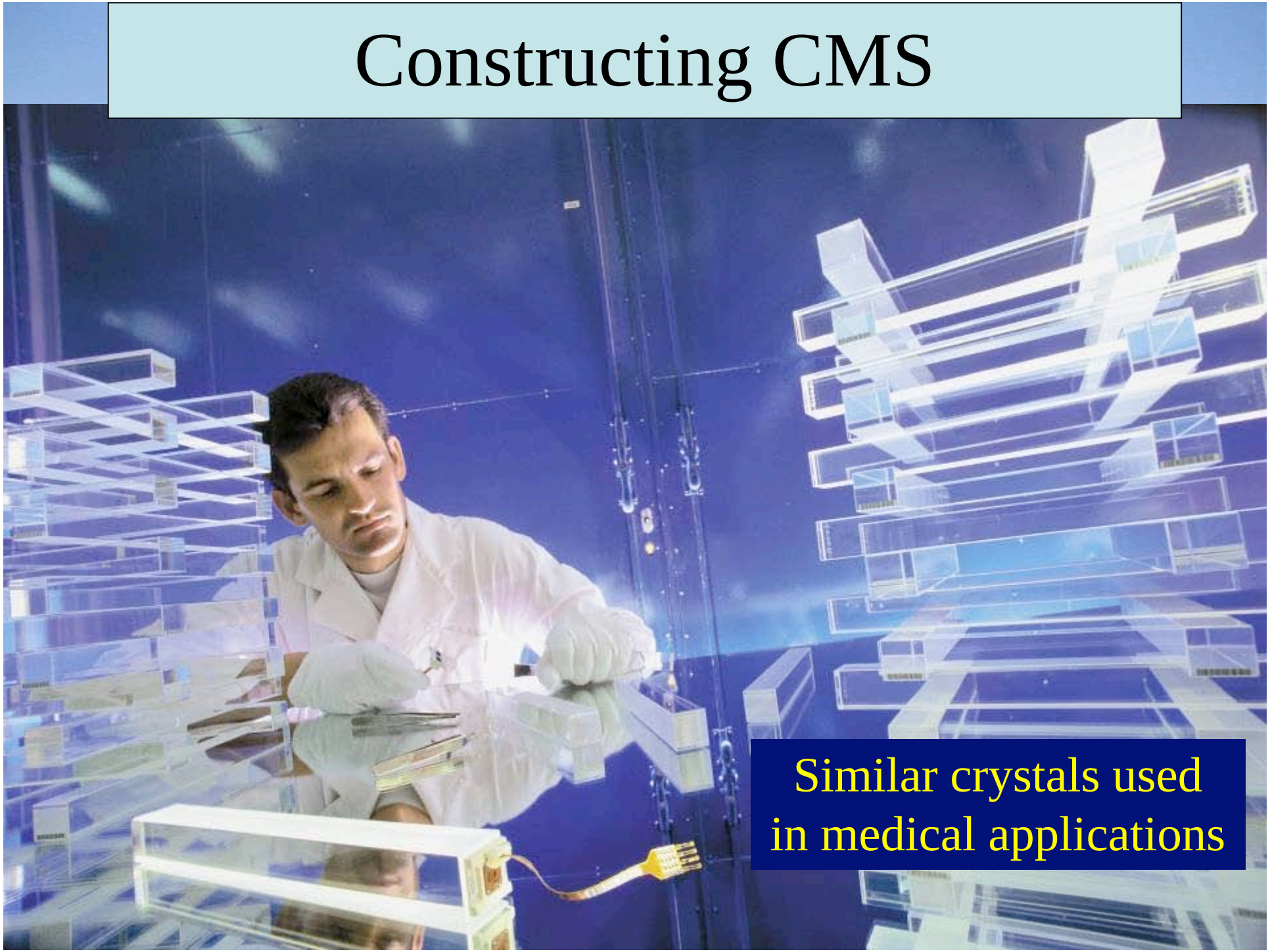
search for Higgs and supersymmetry



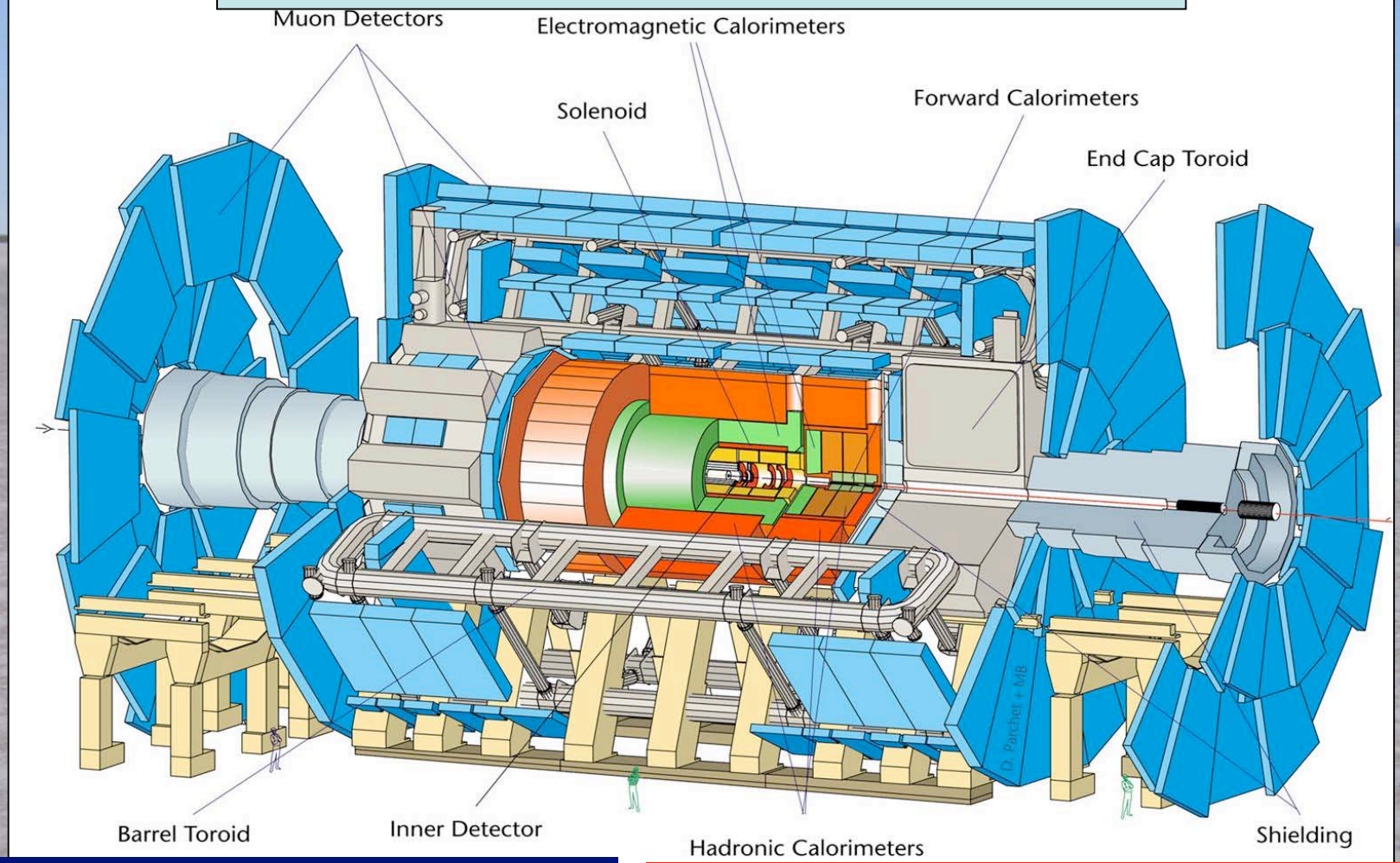
Heavier than the Eiffel Tower: would sink in water

2500 physicists
180 institutes
37 countries

Constructing CMS

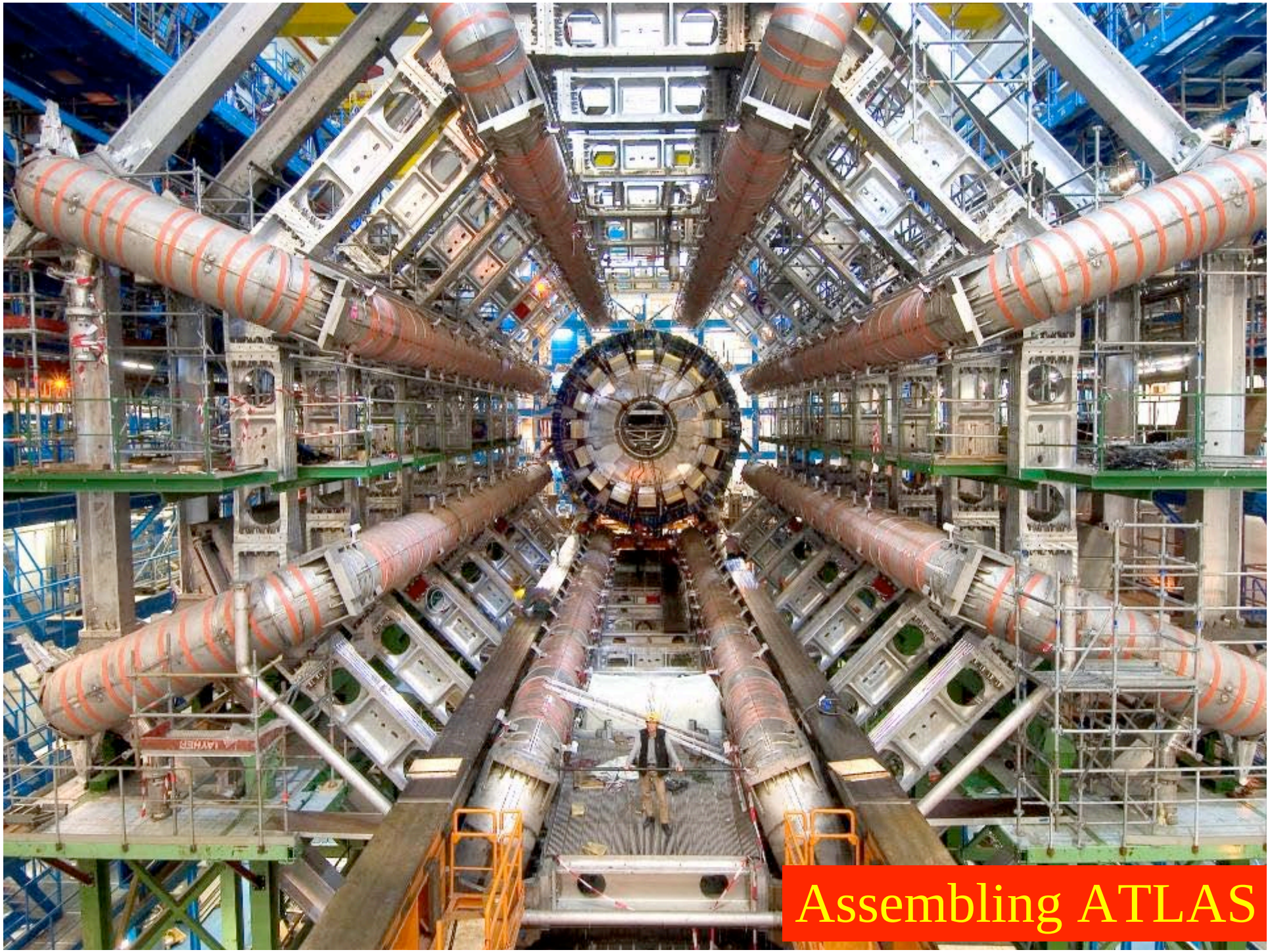


The ATLAS Detector



Diameter	25 m
Total length	46 m
Overall weight	7000 tons

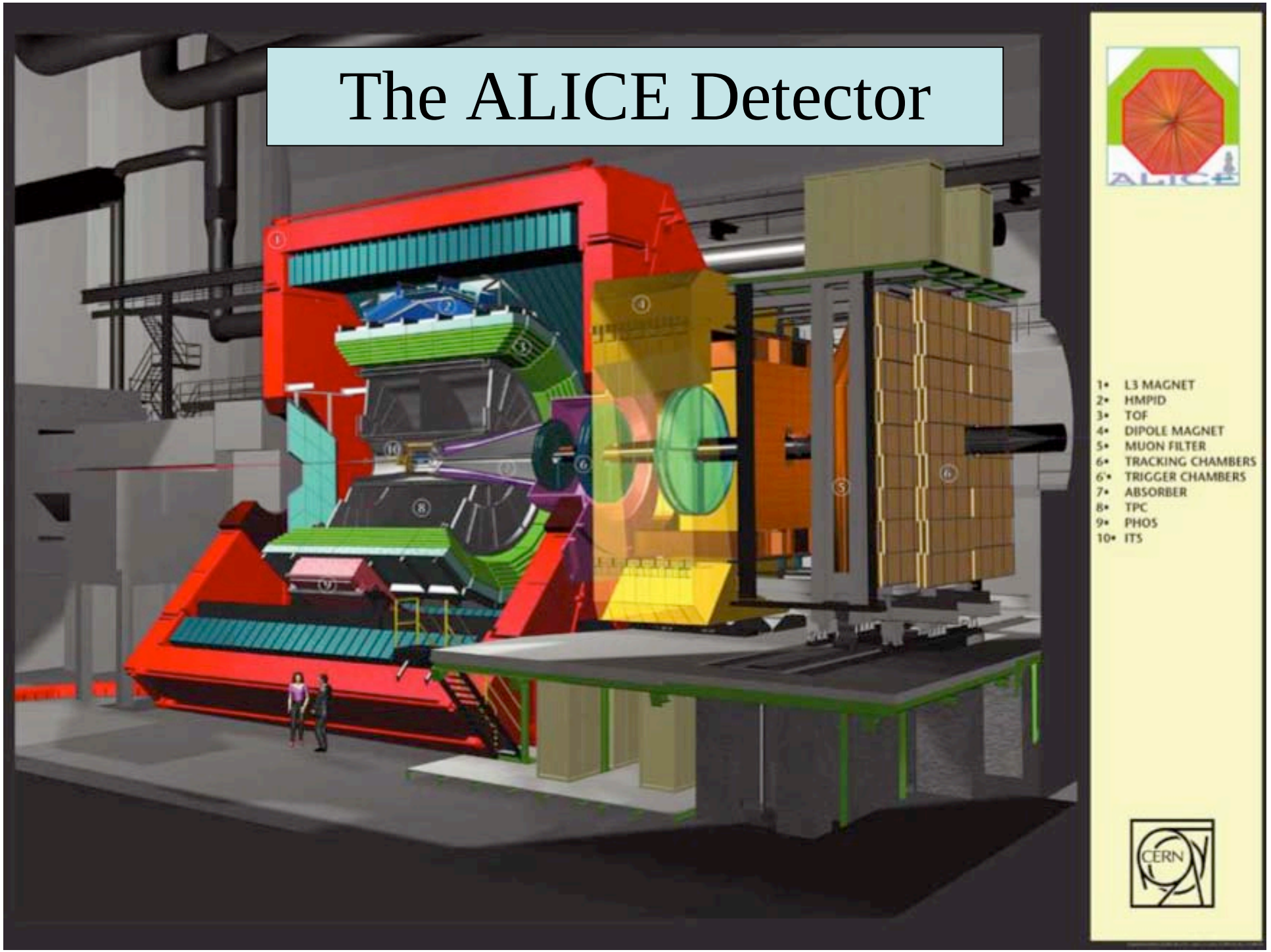
Over 2000 scientists and engineers
Nearly 40 countries
More components than a moon rocket


Assembling ATLAS

Set for Opera “Les Troyens”

performed in Valencia, Spain

The ALICE Detector

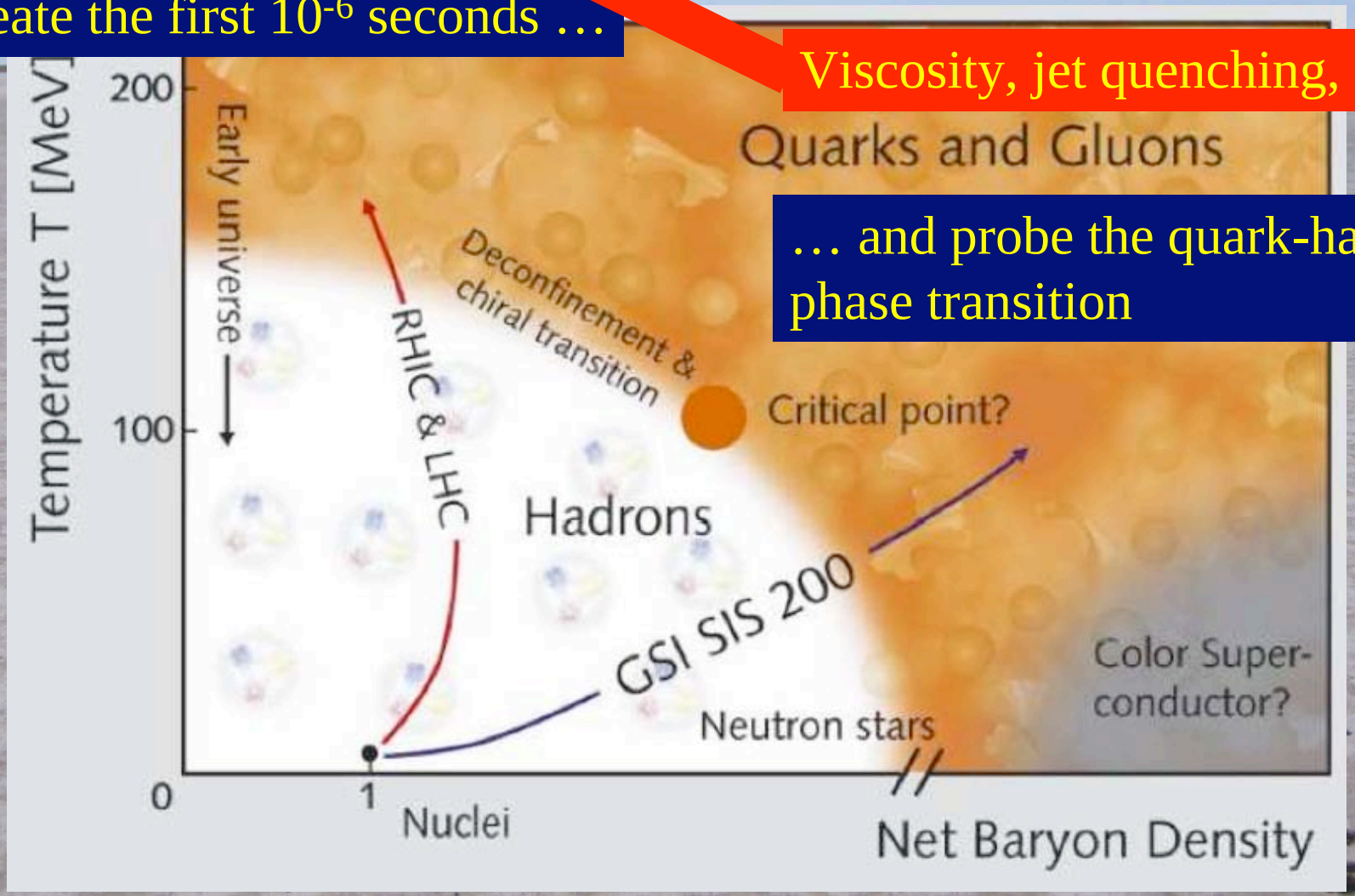


Collide heavy nuclei at high energies to create …

Hot and Dense Hadronic Matter

Recreate the first 10^{-6} seconds …

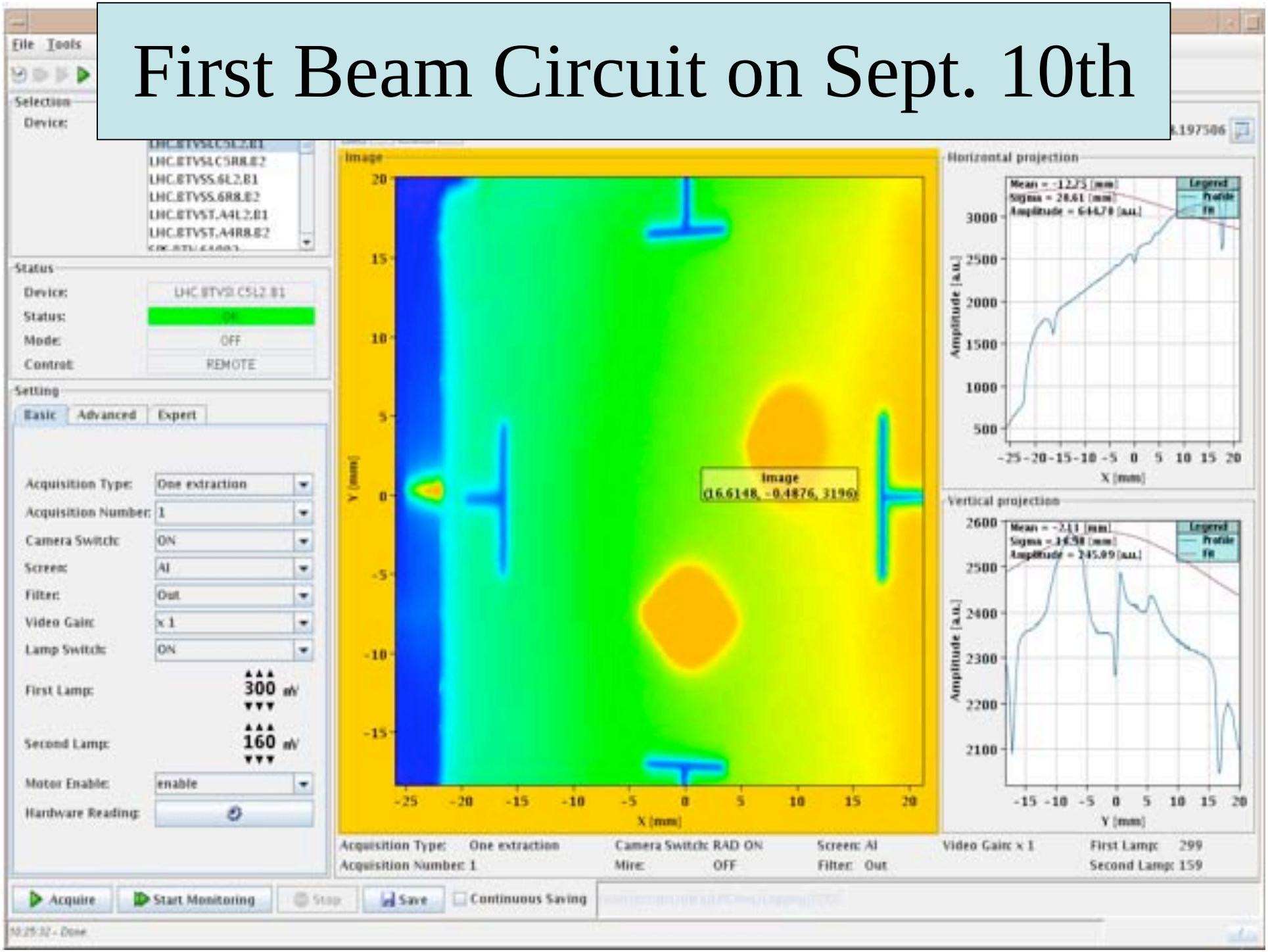
Viscosity, jet quenching, …?



… and probe the quark-hadron phase transition


Google
A billion people watched on TV

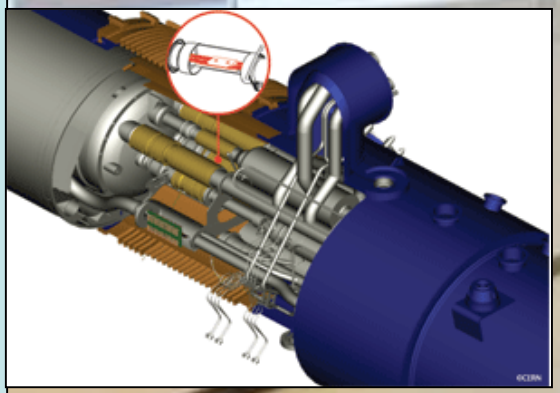
First Beam Circuit on Sept. 10th



The LHC Enters Popular Culture

Yes, it really Works!

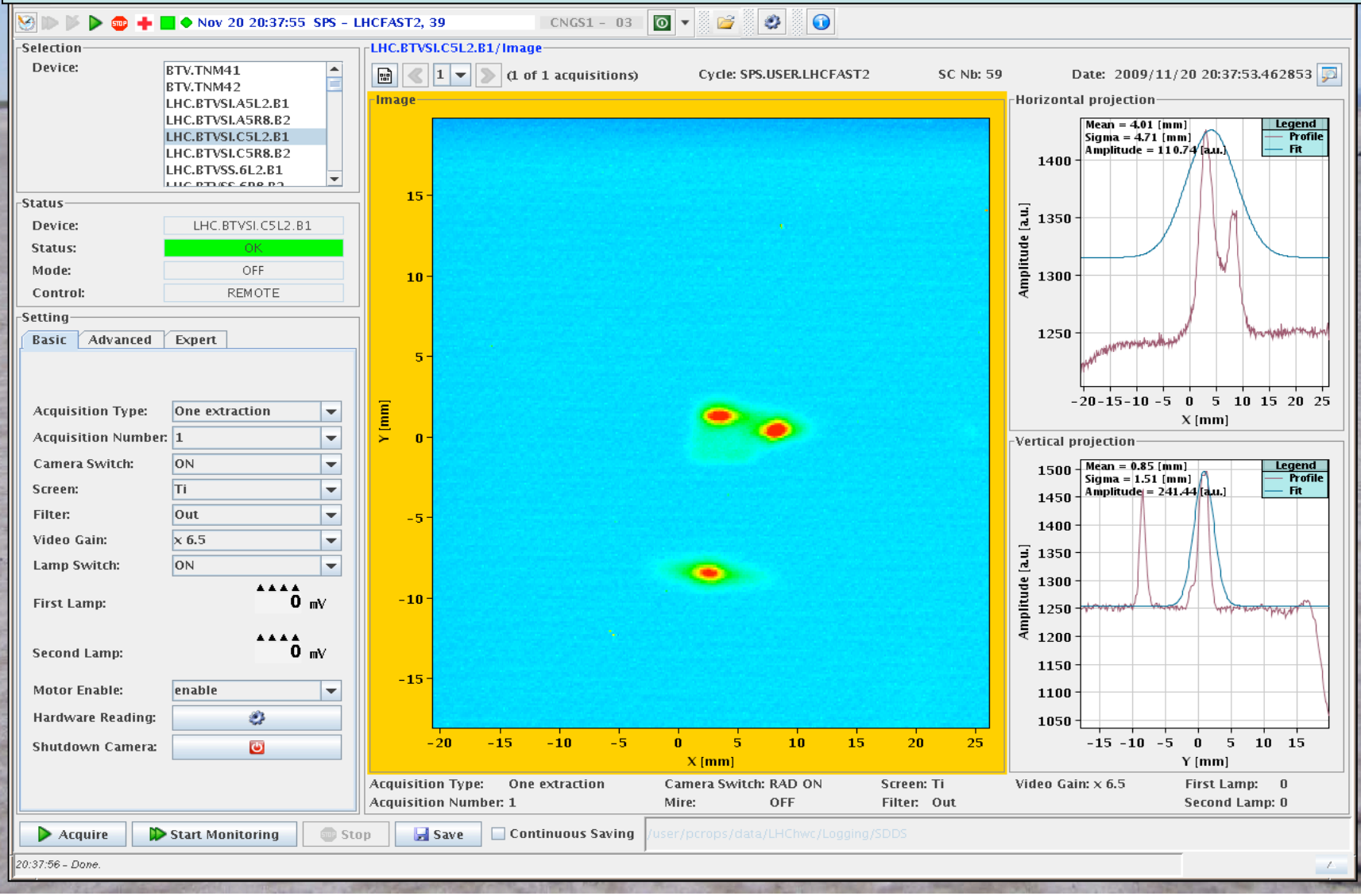
- Until electrical fault in connection between two magnets
- Ohmic heating broke cryostat, vacuum pipe
- Repairs underway
- Restart later in 2009



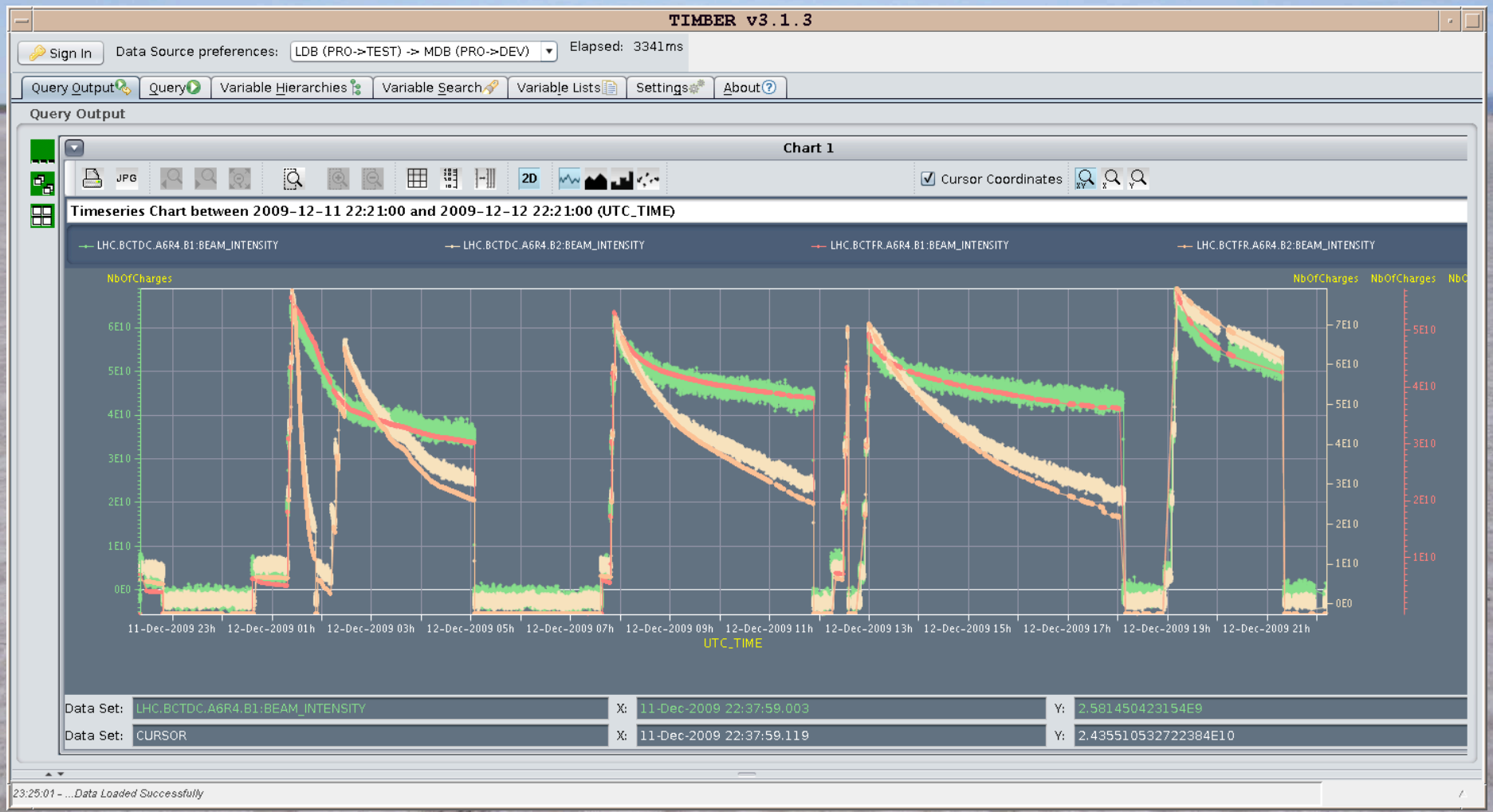
LHC Accelerator Progress in 2009

Nov 20	1	Each beam circulating. Key beam instrumentation working.
Nov 23	4	First collisions at 450 GeV. First ramp (reached 560 GeV).
Nov 26	7	Magnetic cycling established (reproducibility).
Nov 27	8	Energy matching.
Nov 29	10	Ramp to 1.18 TeV.
Nov 30	11	Experiment solenoids on.
Dec 04	15	Aperture measurement campaign finished. LHCb and ALICE dipoles on.
Dec 05	16	Machine protection (Injection, Beam dump, Collimators) ready for safe operation with pilots.
Dec 06	17	First collisions with STABLE BEAMS, 4 on 4 pilots at 450 GeV, rates around 1Hz.
Dec 08	19	Ramp colliding bunches to 1.18 TeV
Dec 11	22	Collisions with STABLE BEAMS, 4 on 4 at 450 GeV, > 10^{10} per bunch, rates around 10Hz.
Dec 13	24	Ramp 2 bunches per beam to 1.18 TeV. Collisions for 90mins.
Dec 14	25	Collisions with STABLE BEAMS, 16 on 16 at 450 GeV, > 10^{10} per bunch, rates around 50Hz.
Dec 16	27	Ramp 4 on 4 to 1.18 TeV. Squeeze to 7 m.

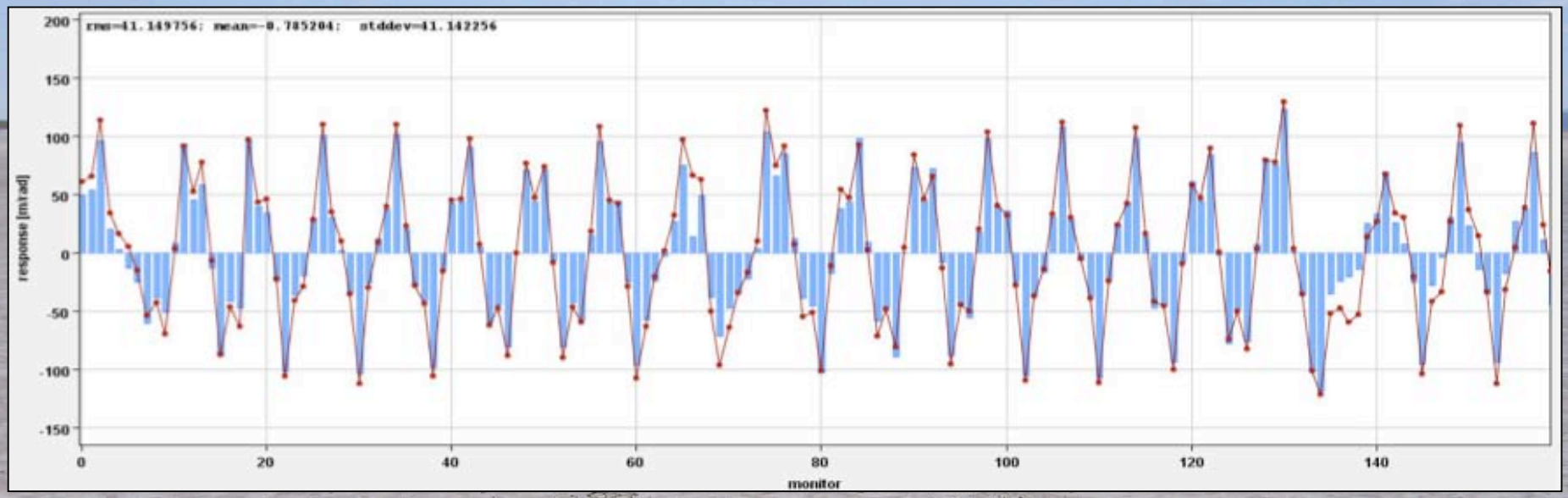
First 2009 Beam Circuits: Friday Nov. 20th @ 8.15pm



Colliding Beams @ 900 GeV

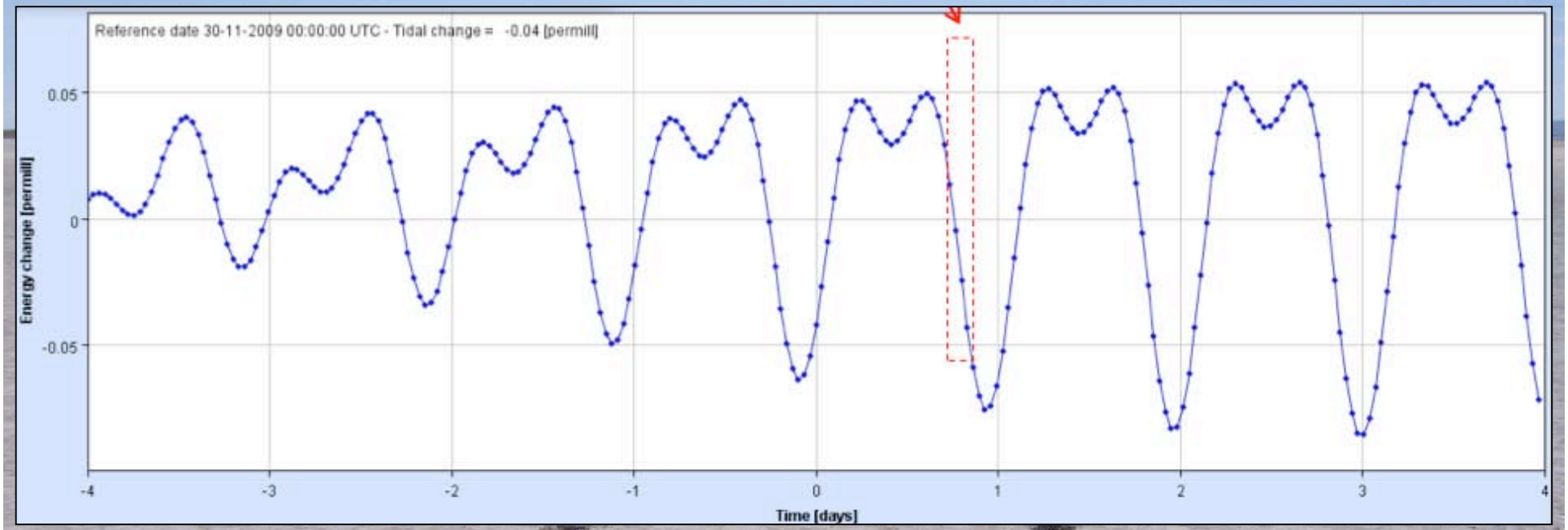


Measurements of the Beam Orbit



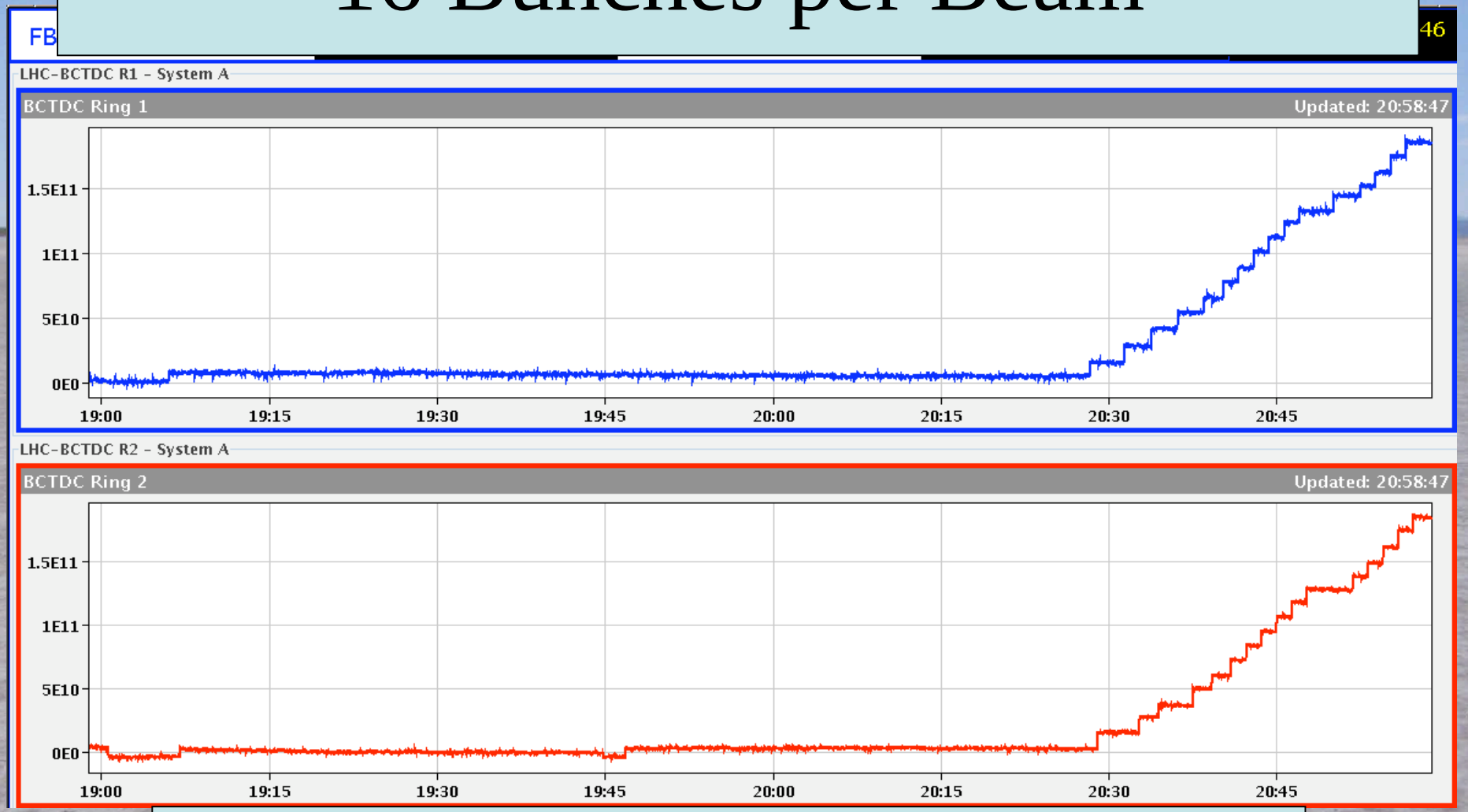
- Excellent agreement between measurements and model of the LHC accelerator
- The LHC is very well measured & understood

Effect of Tides on Beam Energy



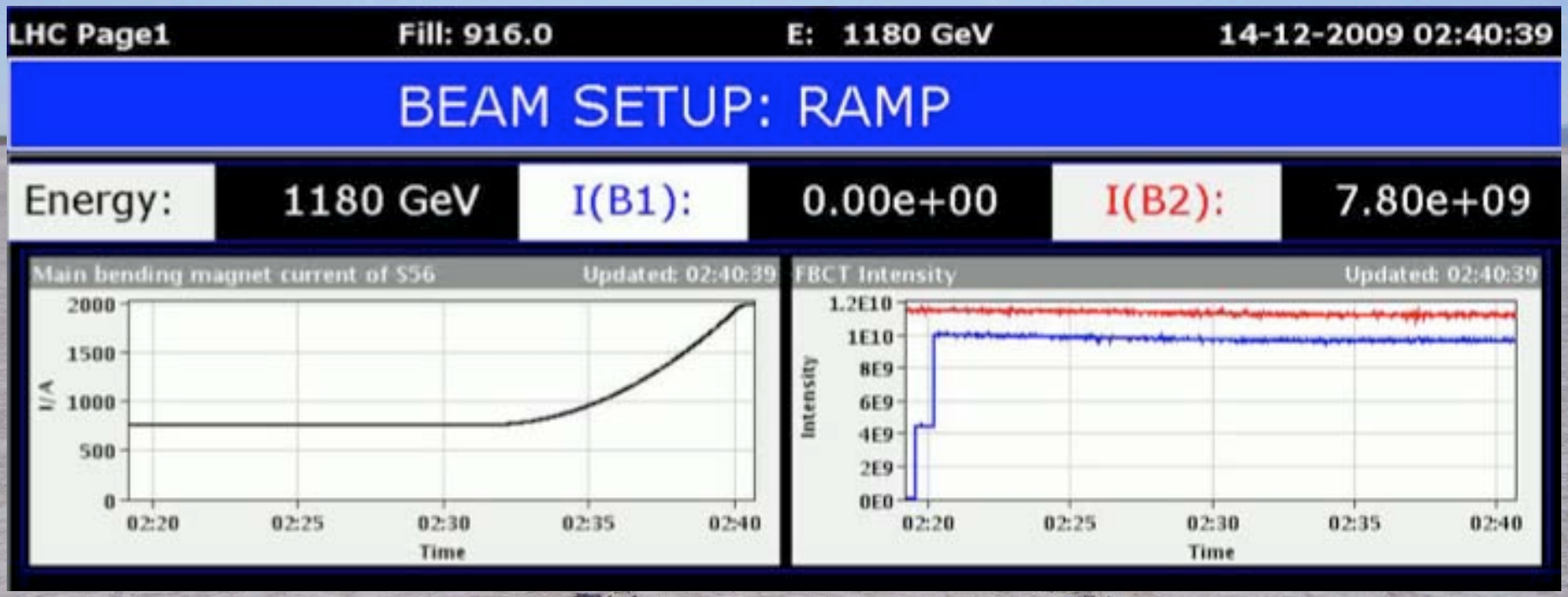
- Tides change the circumference of the LHC
- For fixed RF frequency, proton energy changes
- Effect seen at LEP, important for value of m_Z

16 Bunches per Beam



- Eventual aim > 2500 bunches per beam
- Each with ~ 100 greater intensity

Accelerating 2 Beams to 1.18 TeV

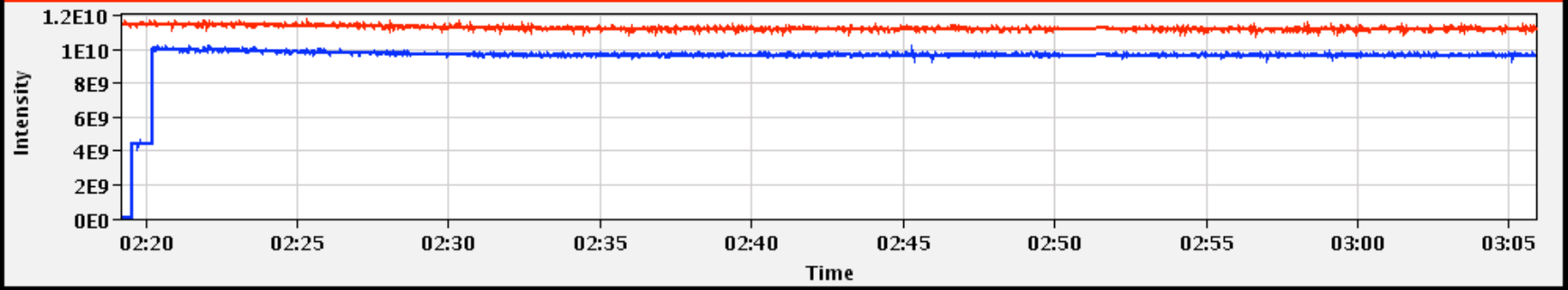


- Smooth increase of magnet current to 2000 Amps
- Few protons lost during the acceleration

Colliding Beams @ 2.36 TeV

Energy:	1180 GeV	I(B1):	0.00e+00	I(B2):	8.49e+09

FBCT Intensity — An exception occured when starting monitoring parameter [LHC.BCTFR.A6R4.B1/Acquisition]



Comments 14-12-2009 04:06:42 :

Expts: can go back to LHC clocks

QUIET BEAMS until 6h00

filling schema: bucket 1 and 17851 in B1

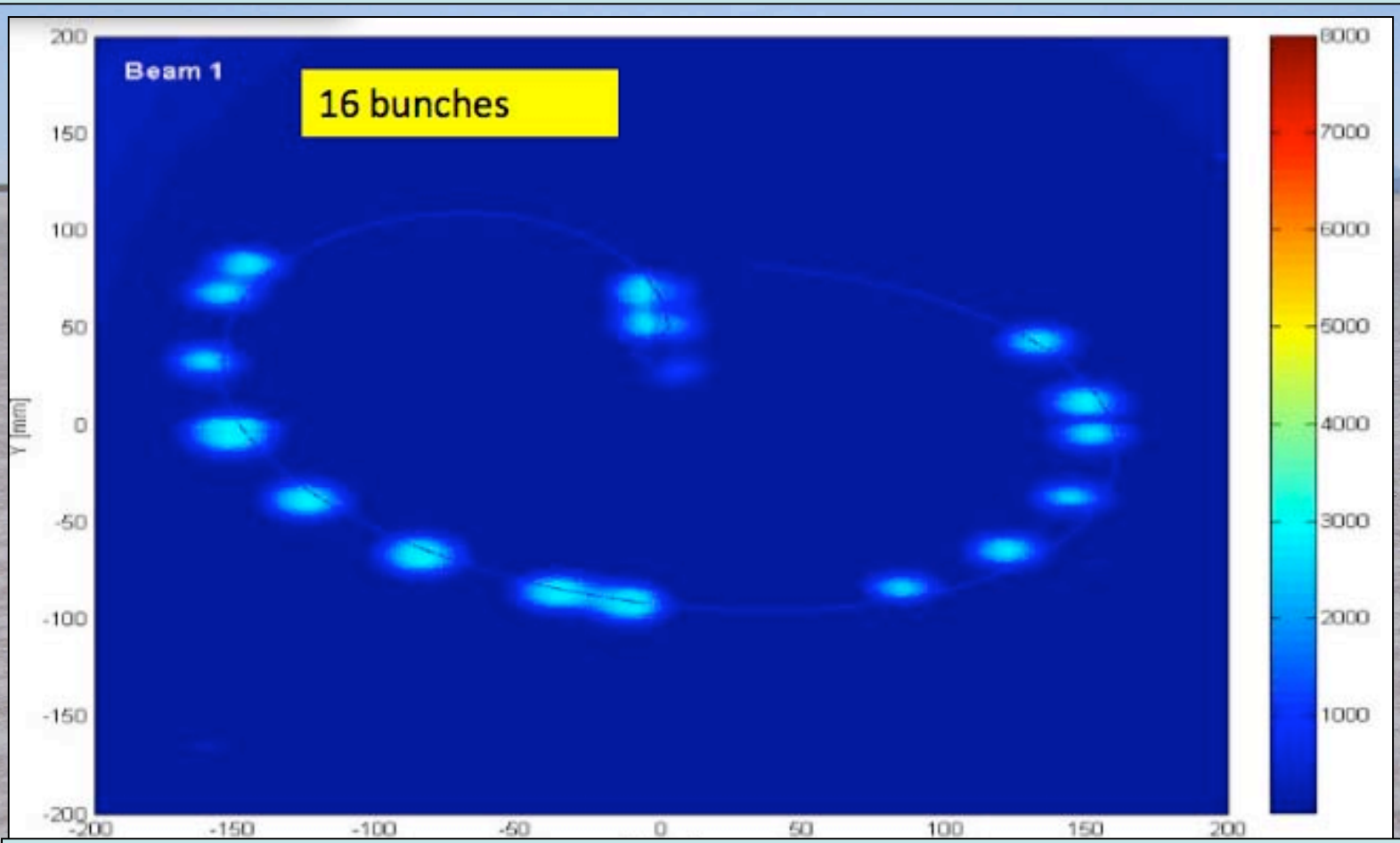
filling schema: bucket 1 and 8911 in B2

LHC Operation in CCC : 77600, 70480

SMP Flags	B1	B2
Channel Link Status A-B B-A	false	false
Global Beam Permit	true	true
Setup Beam	true	true
Beam Presence	true	true
Moveable Devices Allowed In	false	false
Stable Beams	false	false

PM Status B1	ENABLED	PM Status B2	ENABLED

Dumping the Beam

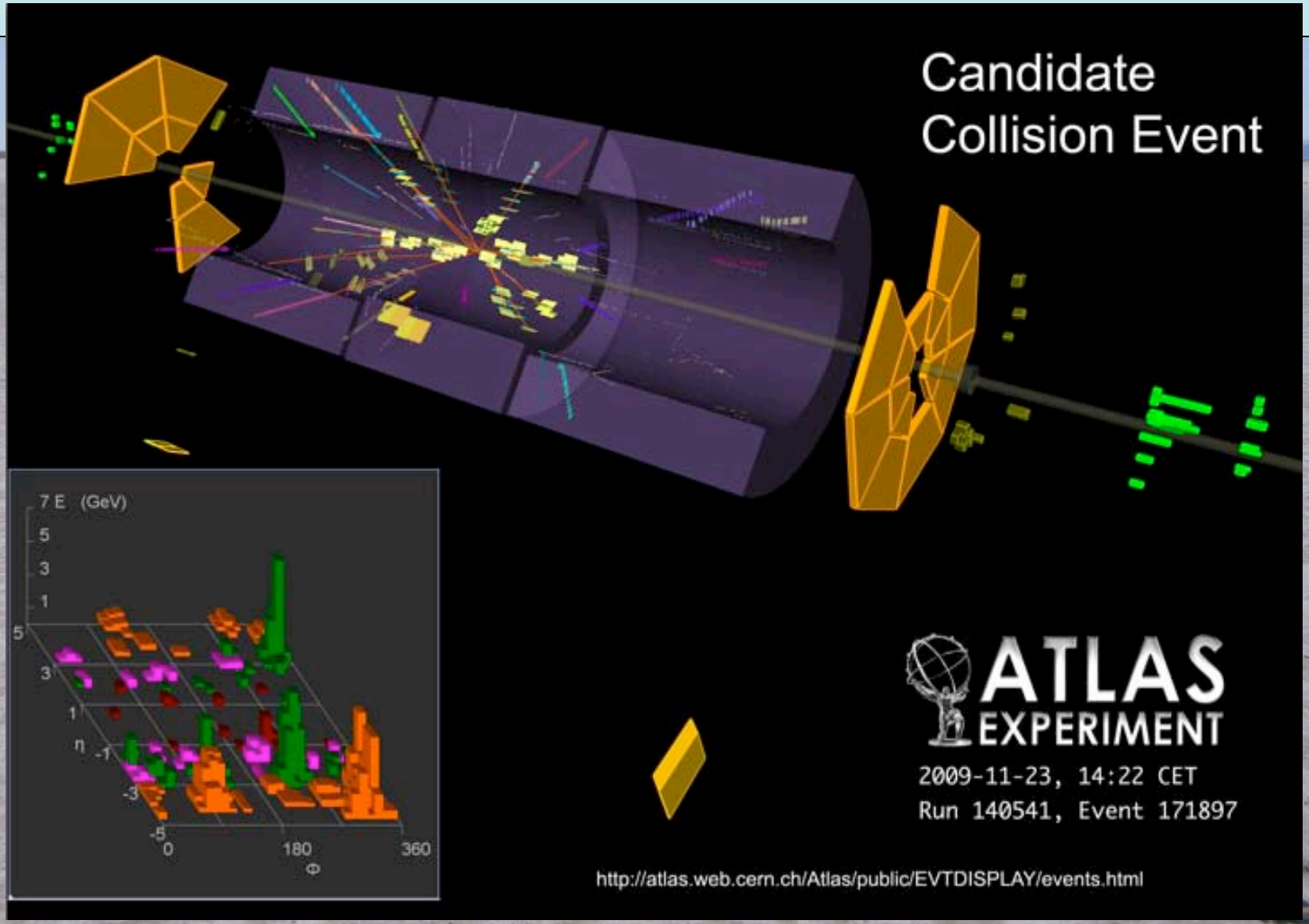


- Beam is ‘smeared’ across the beam dump, so as to spread out deposit of energy

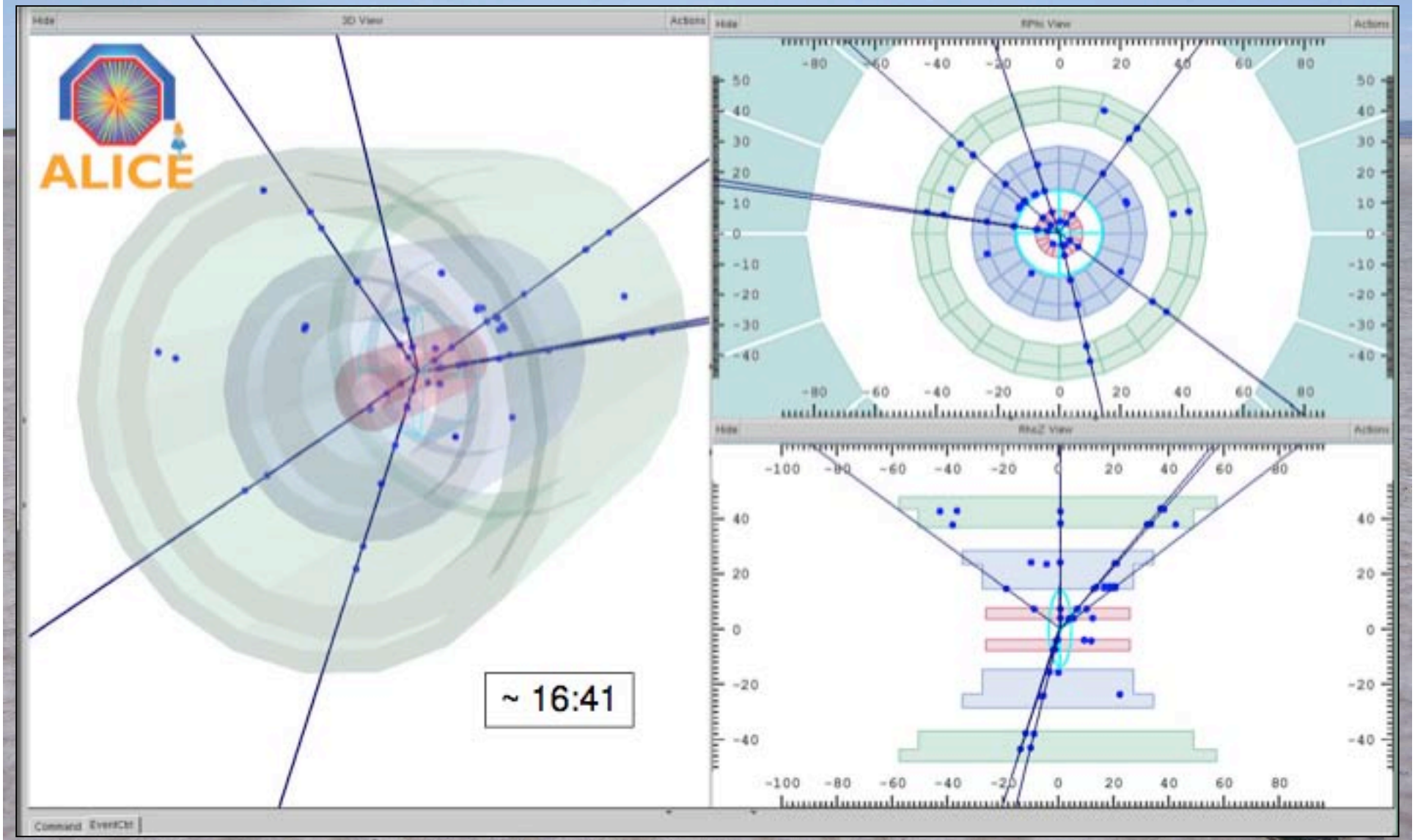
Tense Anticipation …

… and Jubilation

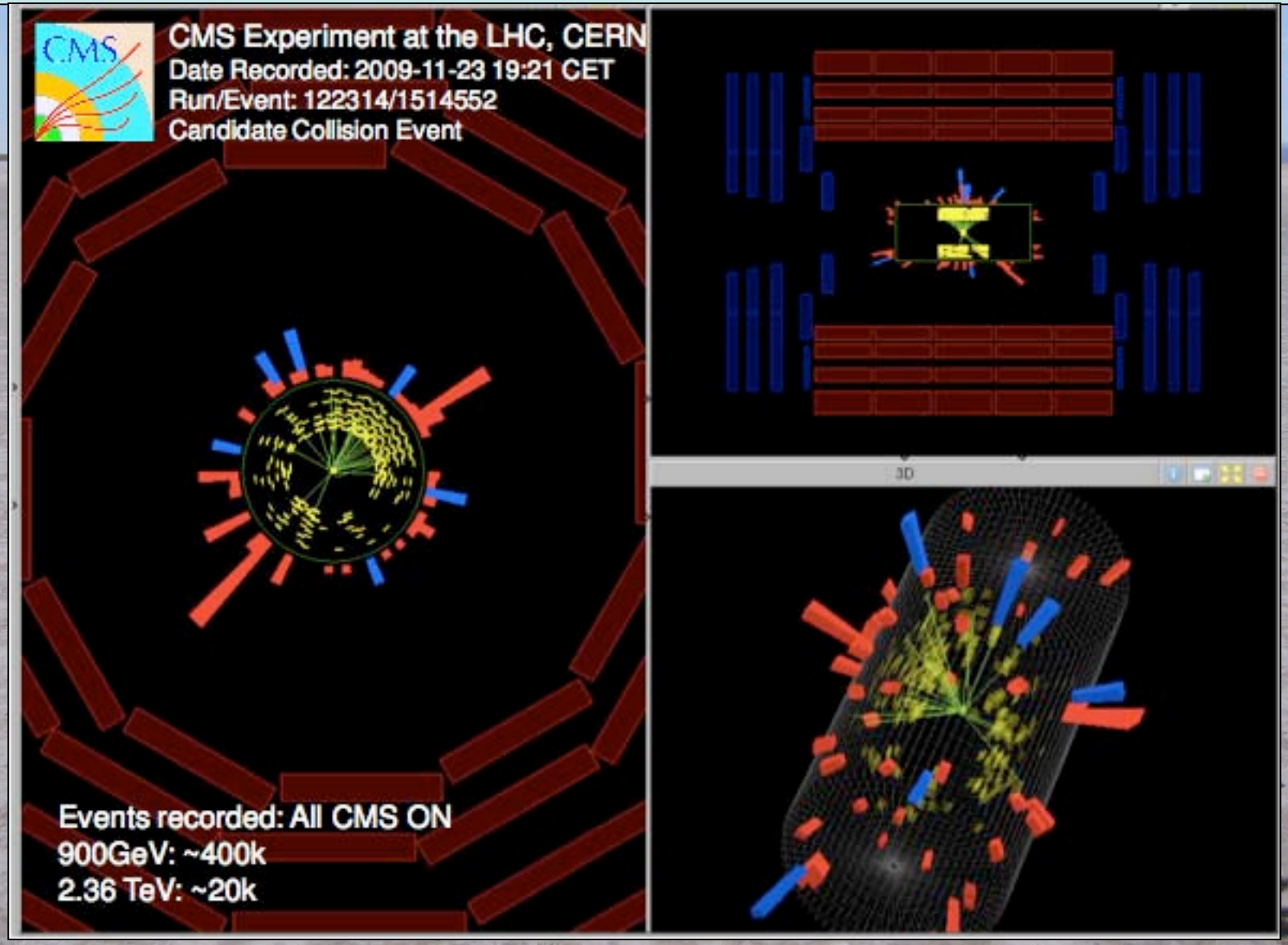
First LHC Collision in ATLAS



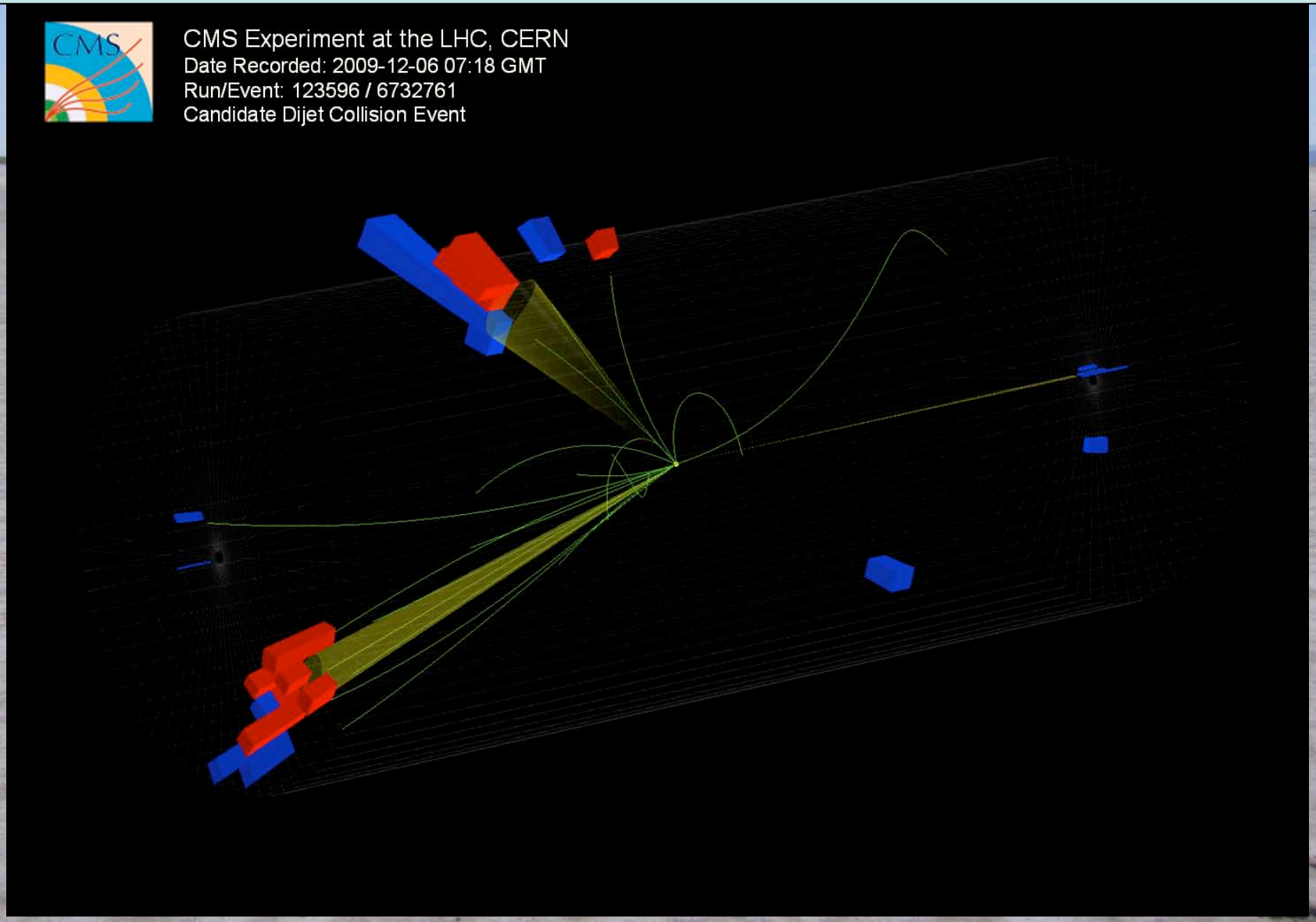
First Collision in ALICE Detector



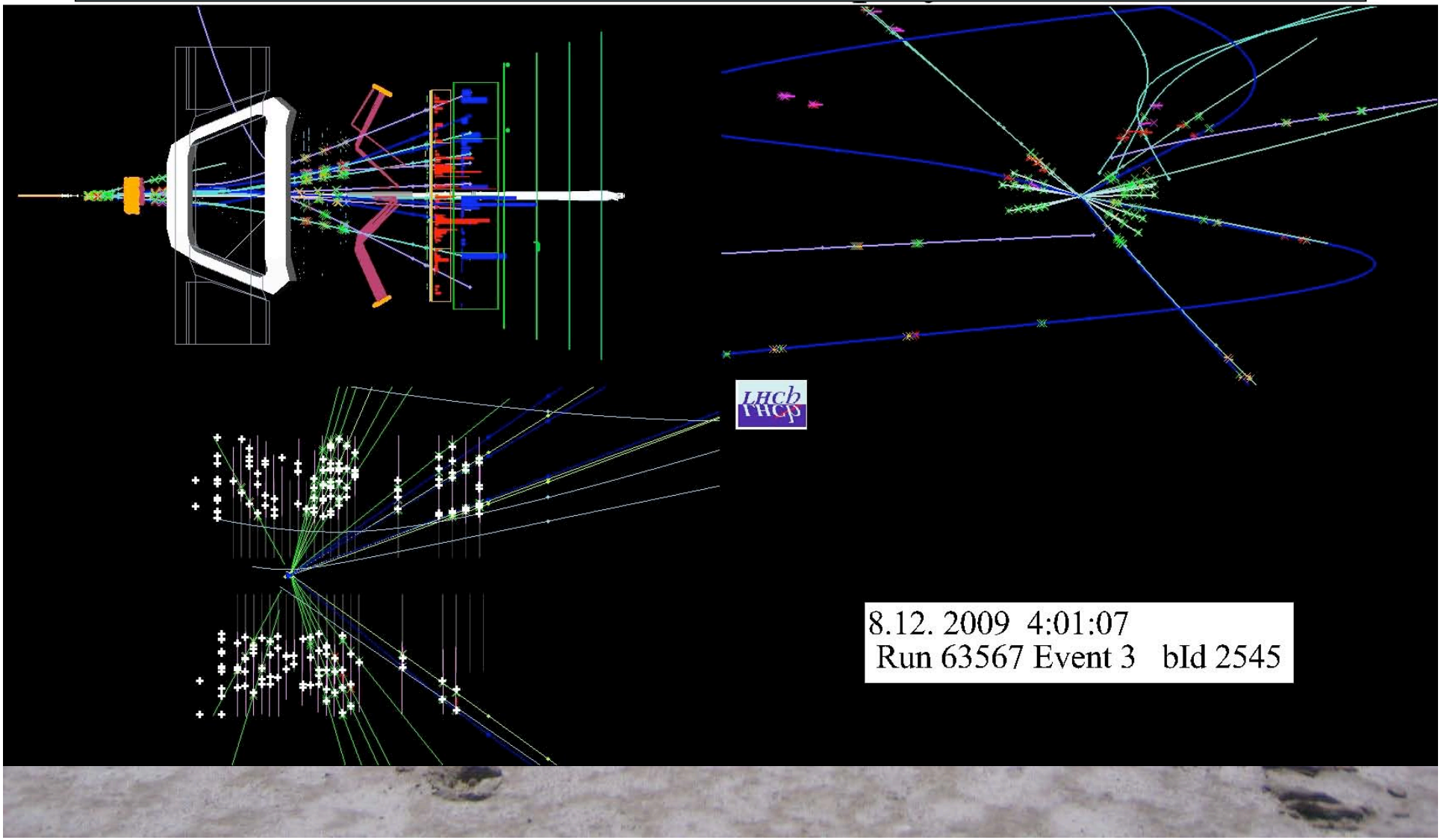
First Collisions in CMS Detector



Two-Jet Event in CMS

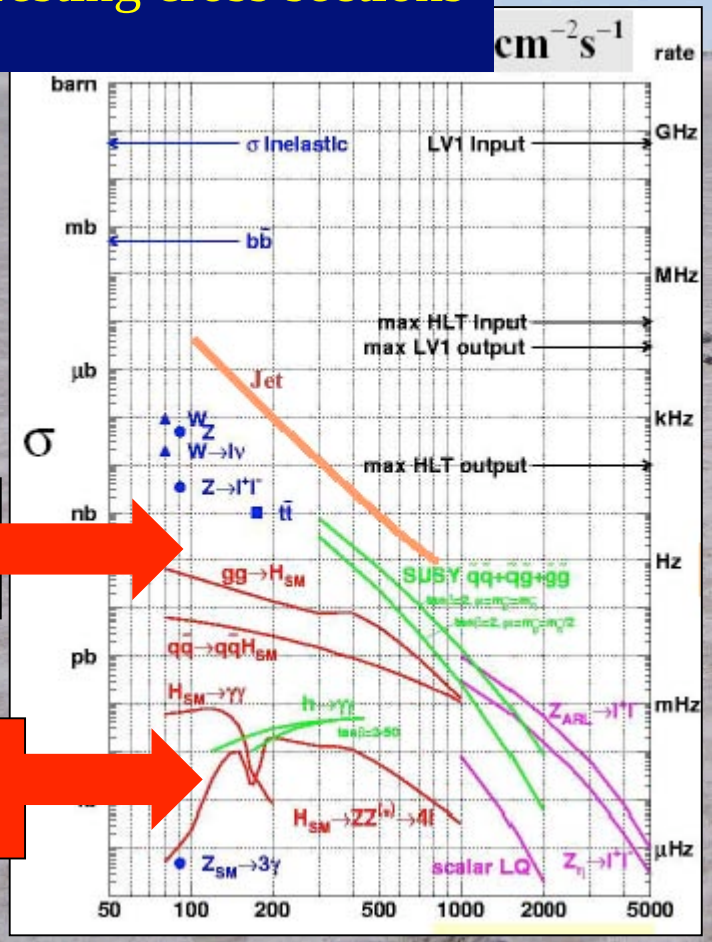


Collision in LHCb



The LHC Physics Haystack(s)

Interesting cross sections



Susy

Higgs

- Cross sections for heavy particles
  ~ 1 /(1 TeV)^2
- Most have small couplings ~ α^2
- Compare with total cross section
  ~ 1/(100 MeV)^2
- Fraction ~ 1/1,000,000,000,000
- Need ~ 1,000 events for signal
- Compare needle
  ~ 1/100,000,000 m^3
- Haystack ~ 100 m^3
- Must look in ~ 100,000 haystacks

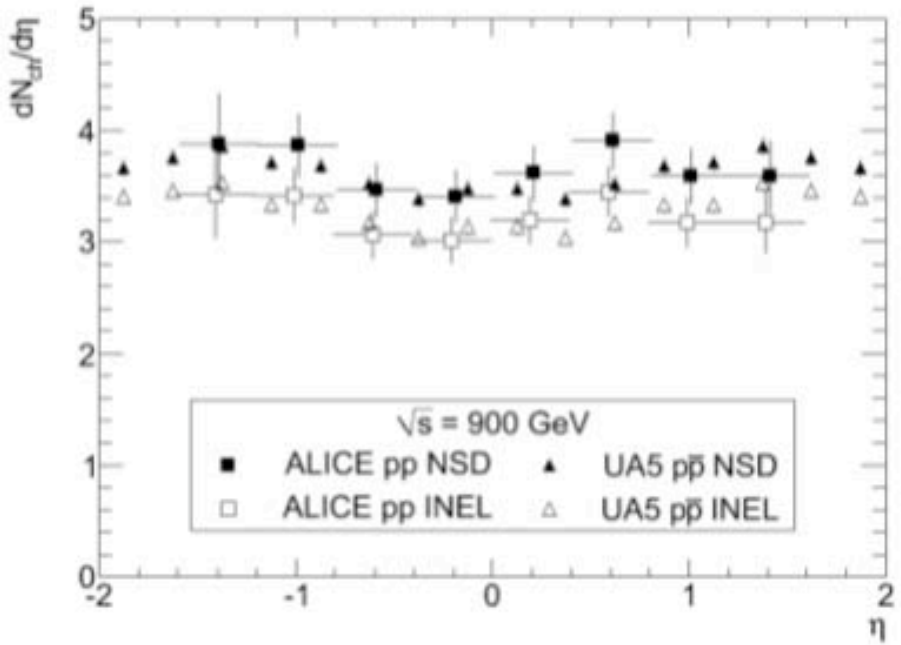
First LHC Physics Paper from ALICE

First proton–proton collisions at the LHC as observed with the ALICE detector: measurement of the charged particle pseudorapidity density at $\sqrt{s} = 900$ GeV

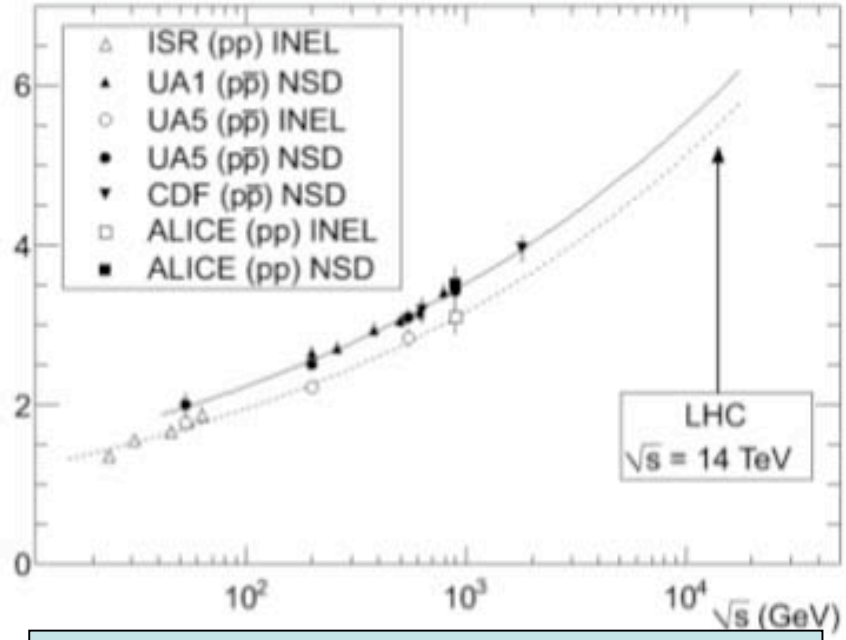
Based on 300 events from 23/11

ALICE collaboration

Experiment Model	ALICE pp	UA5 $p\bar{p}$ [3]	QGSM [26]	PYTHIA [17] (109) [18]	PYTHIA [17] (306) [27]	PYTHIA [17] (320) [28]	PHOJET [8]
INEL	$3.10 \pm 0.13 \pm 0.22$	3.09 ± 0.05	2.98	2.33	2.99	2.46	3.14
NSD	$3.51 \pm 0.15 \pm 0.25$	3.43 ± 0.05	3.47	2.83	3.68	3.02	3.61



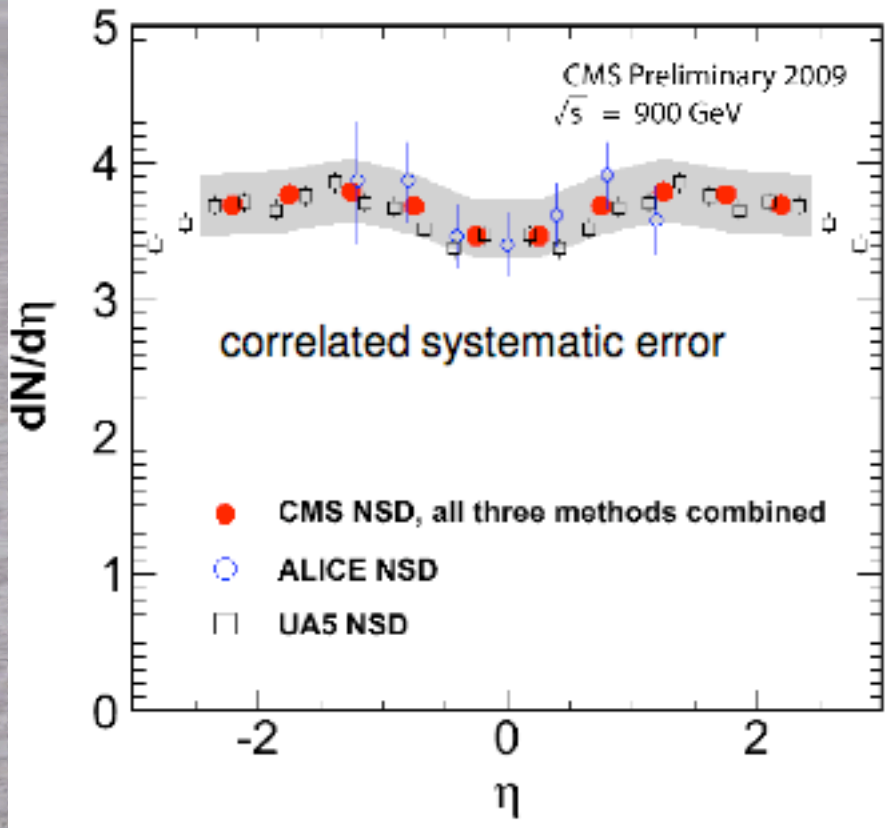
Angular distribution of produced particles



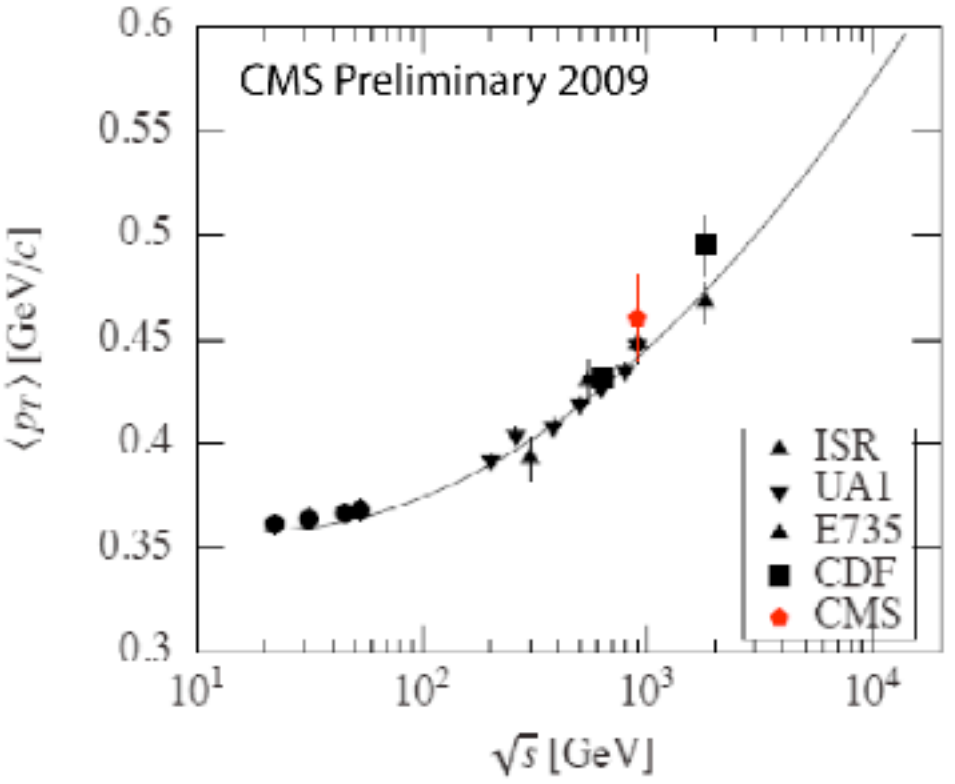
Total number of produced particles

Particle Production seen by CMS

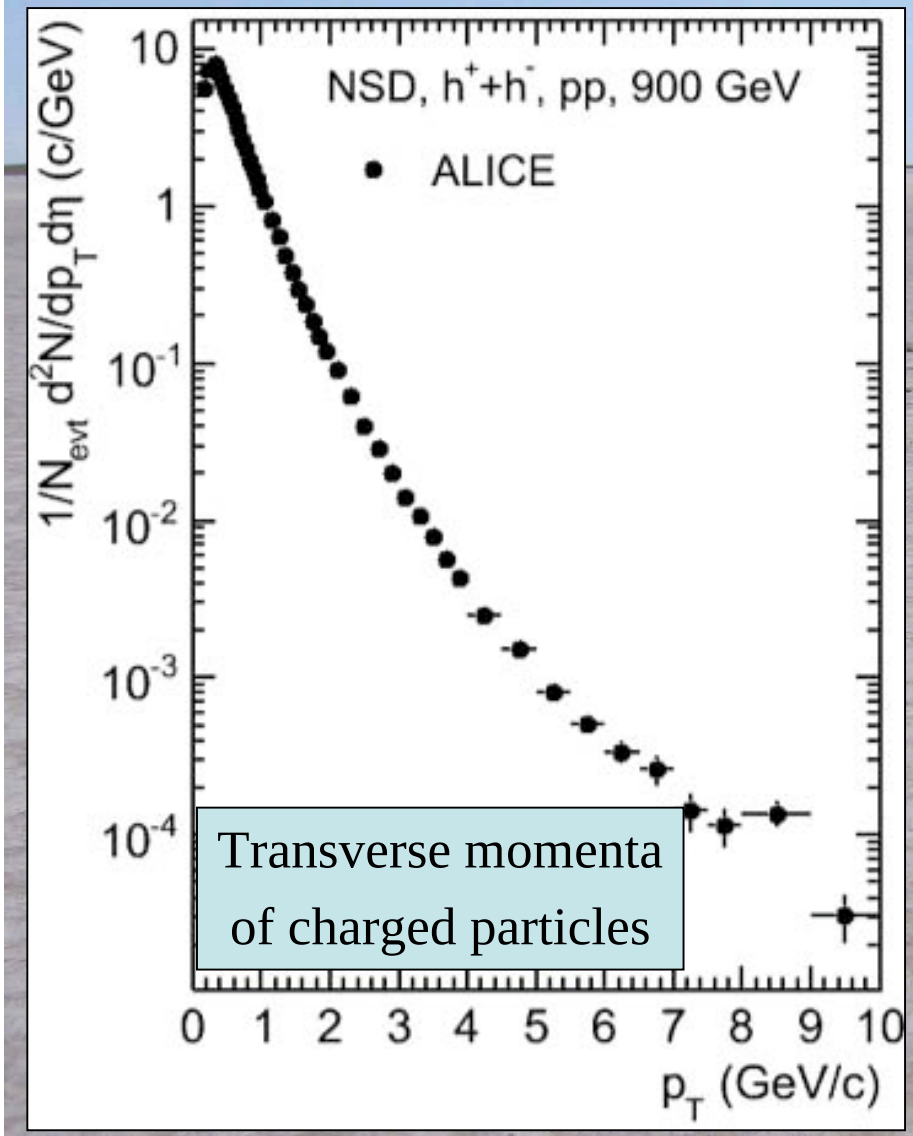
Angular distribution of charged particles



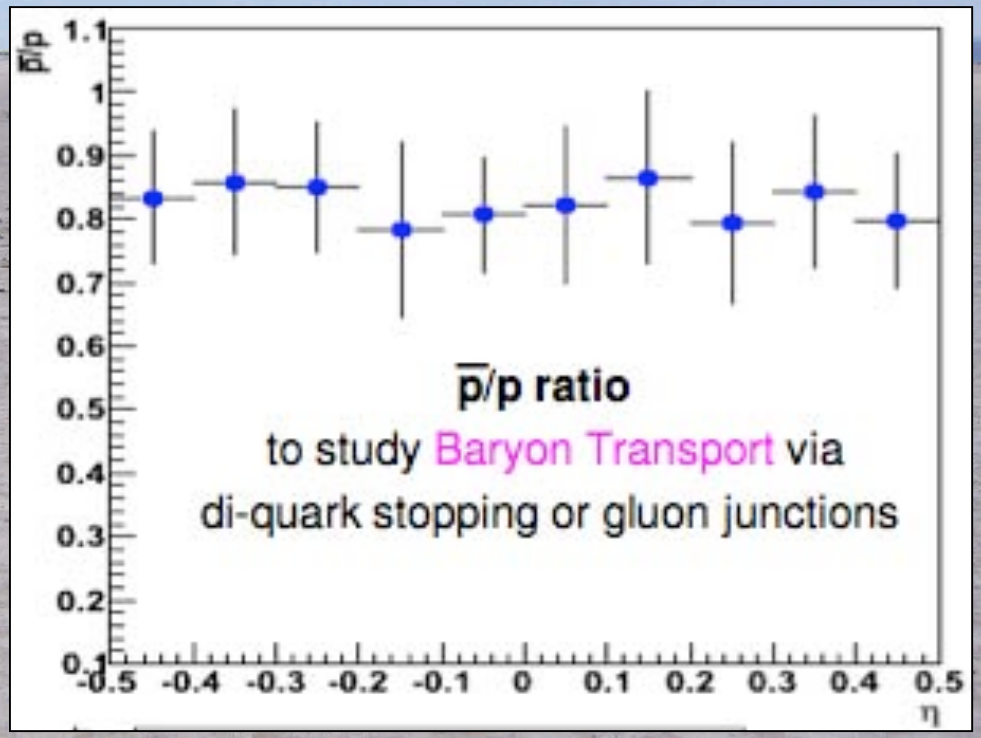
Angular transverse momentum



Particle Spectra & Production Ratio



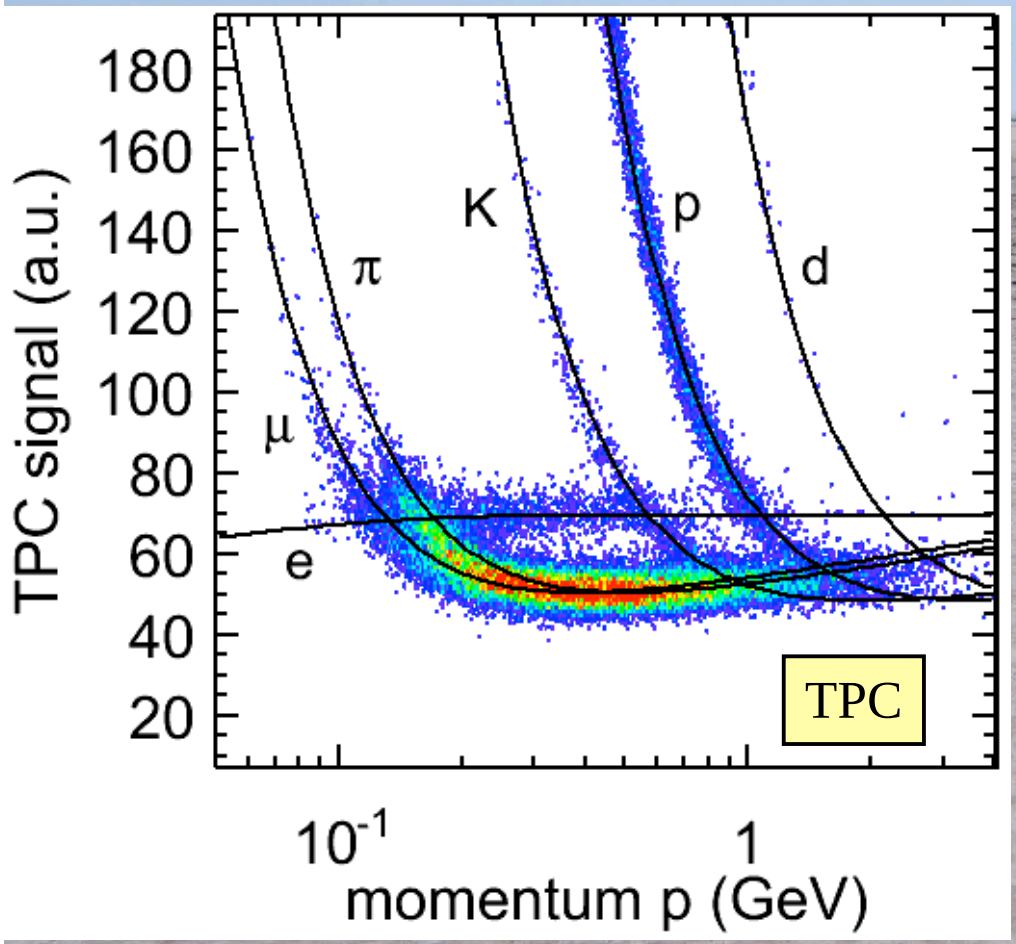
Transverse momenta of charged particles

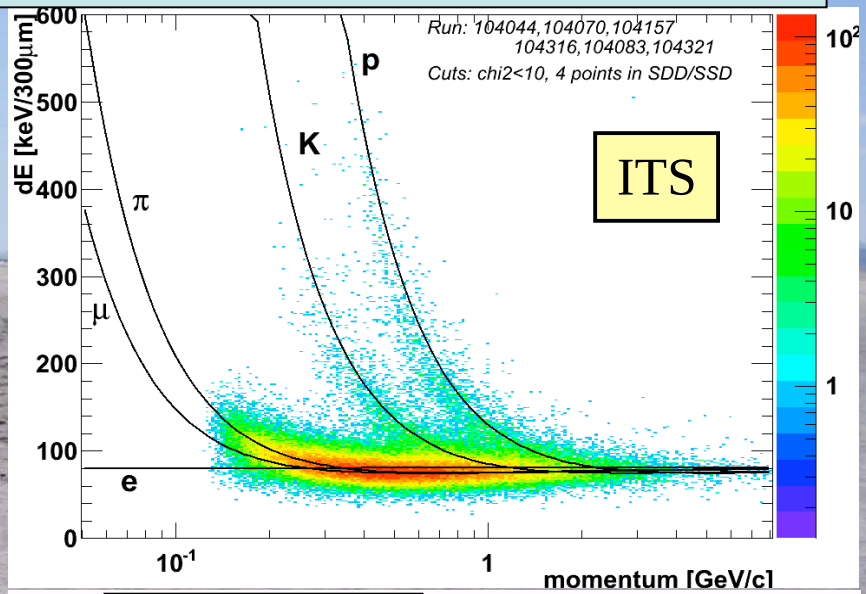


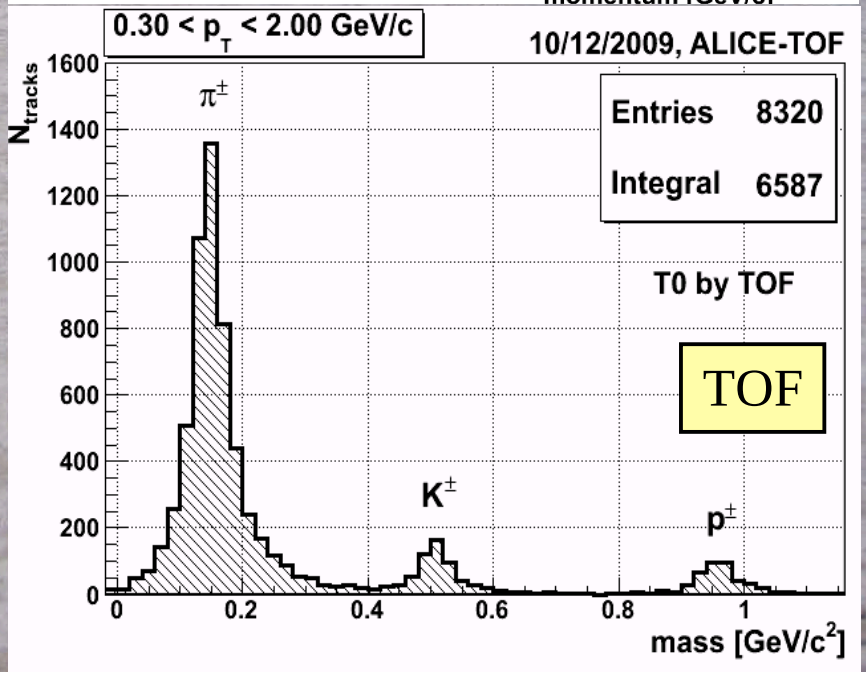
p̄/p ratio
to study Baryon Transport via
di-quark stopping or gluon junctions

Will be interesting observable in heavy-ion collisions

Towards Heavy Flavours in ALICE

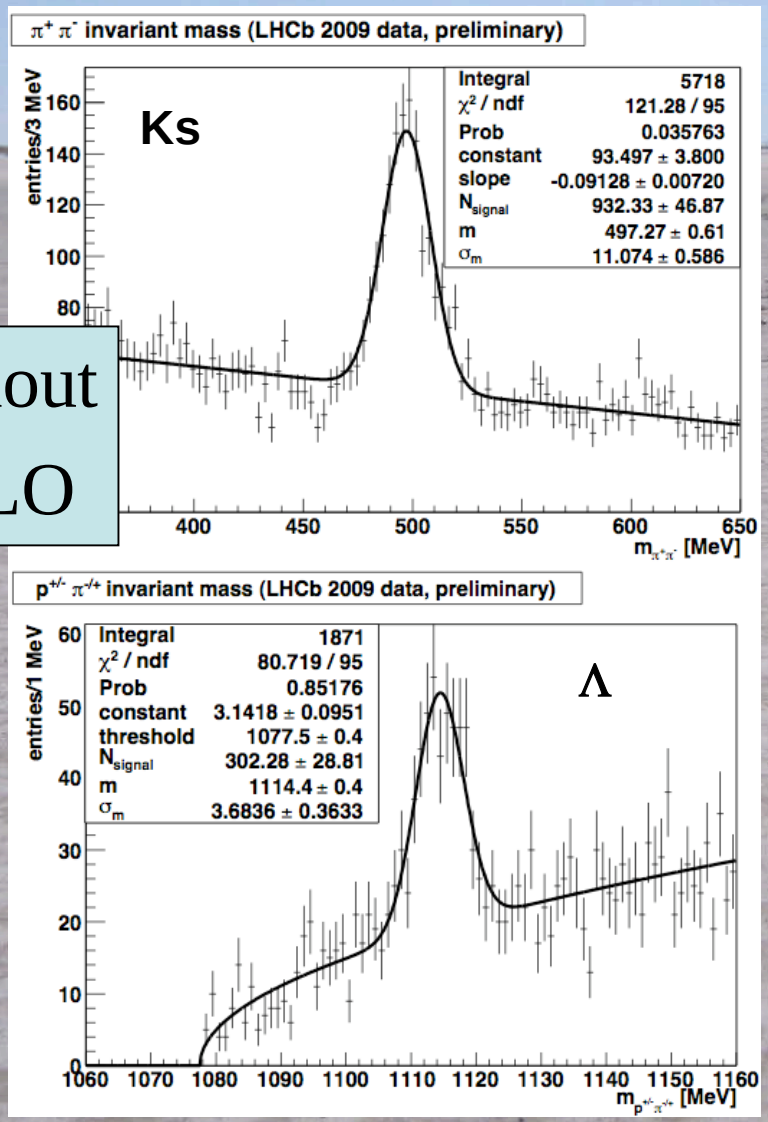




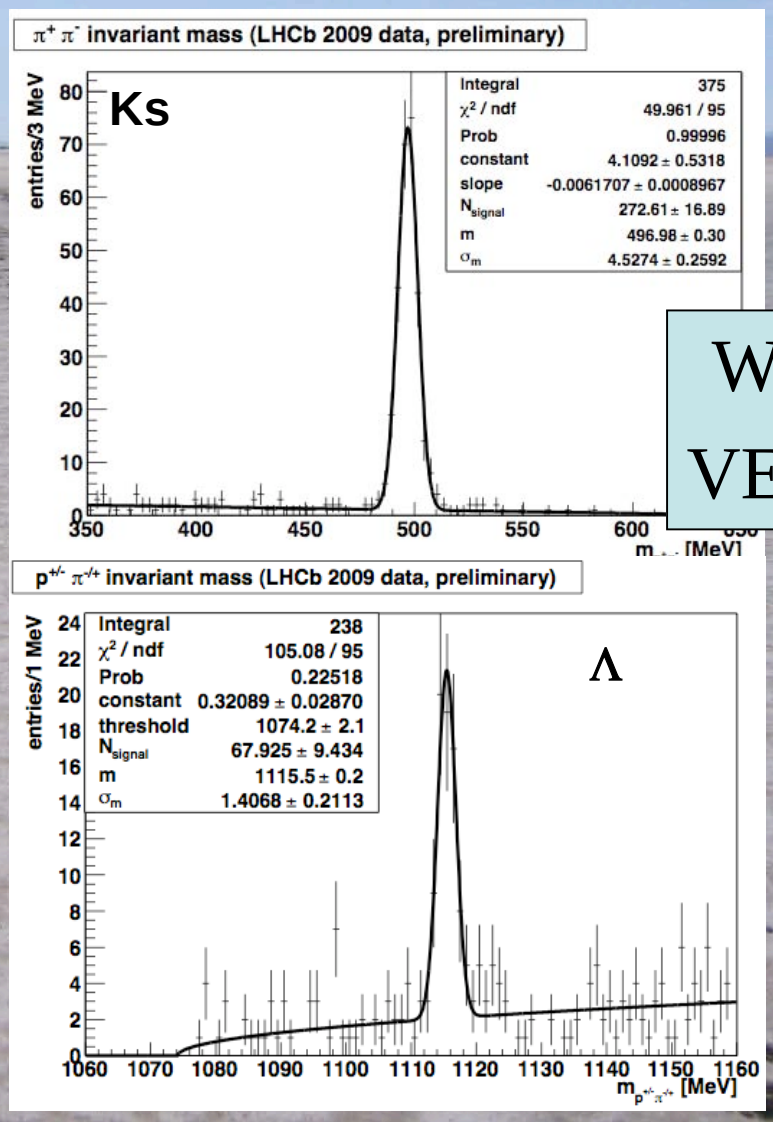


Towards Heavy Flavours in LHCb

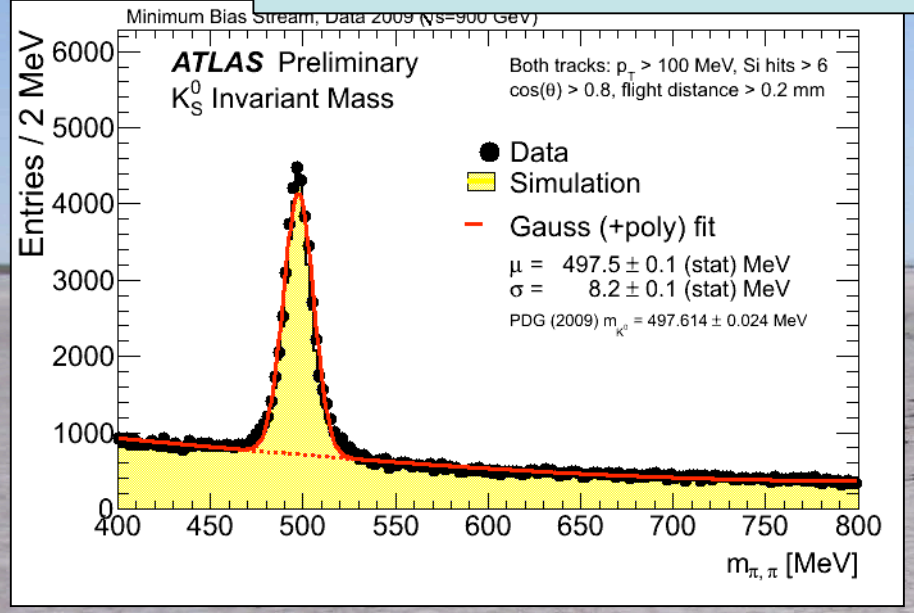
Without VELO

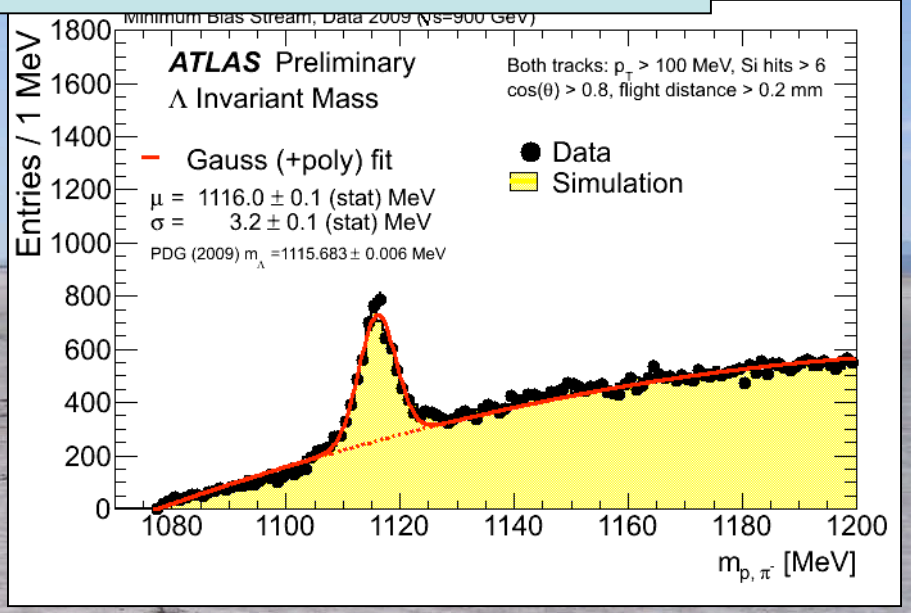


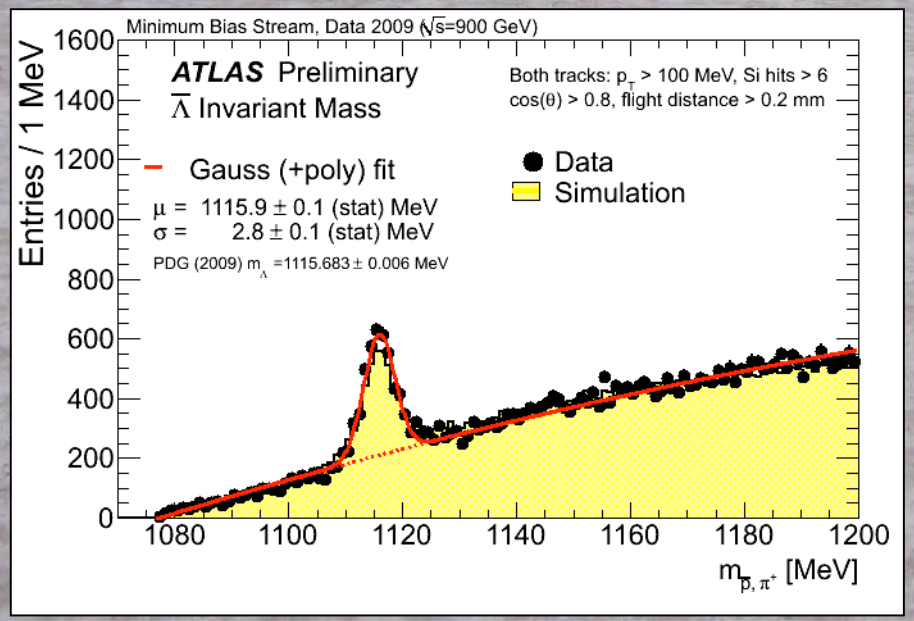
With VELO

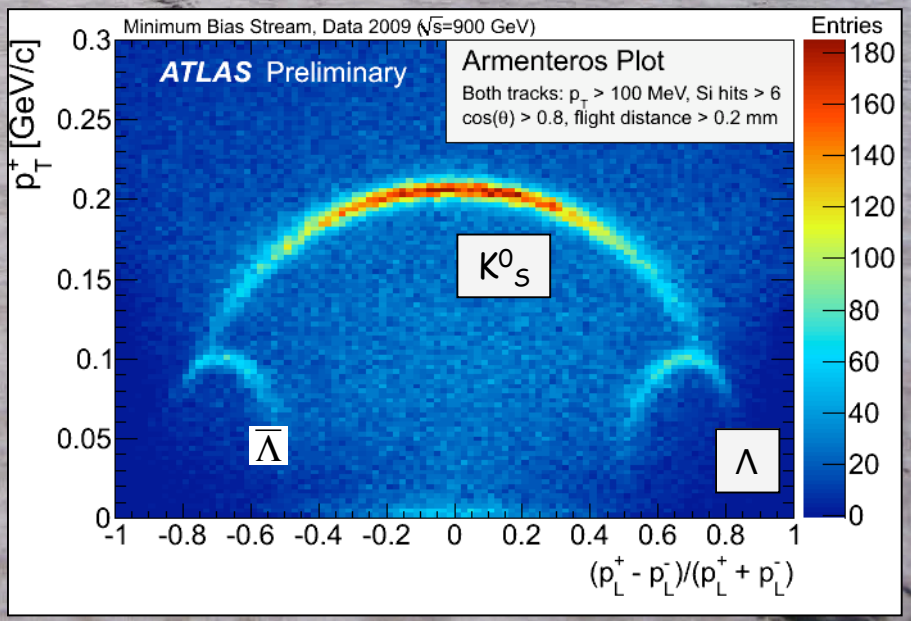


Finding Particles in ATLAS

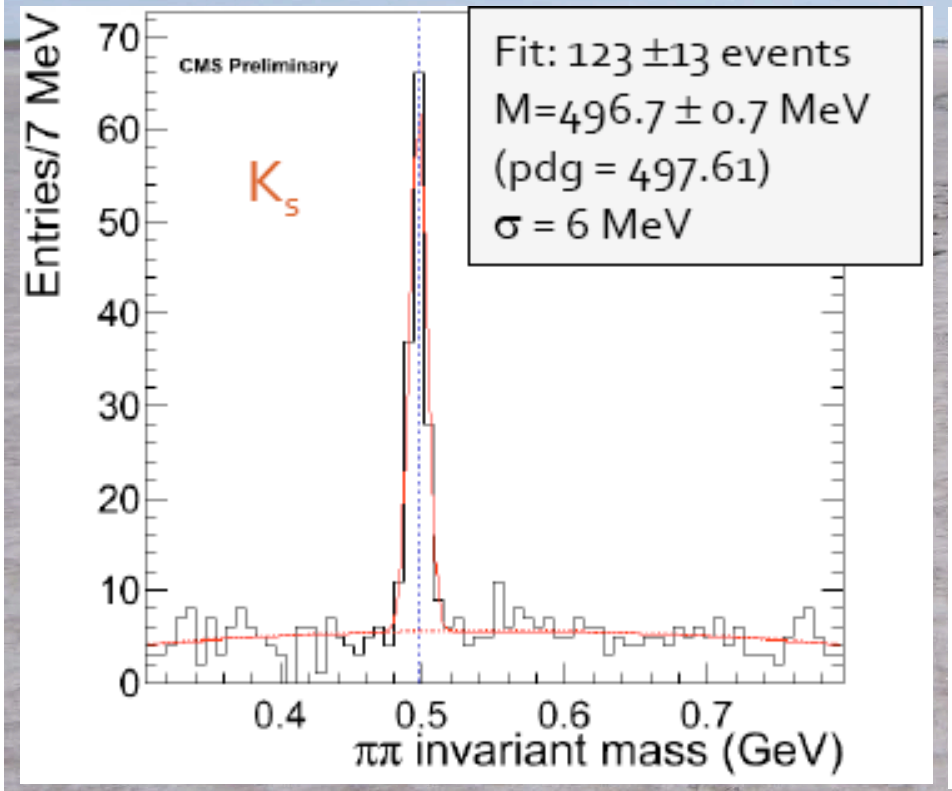


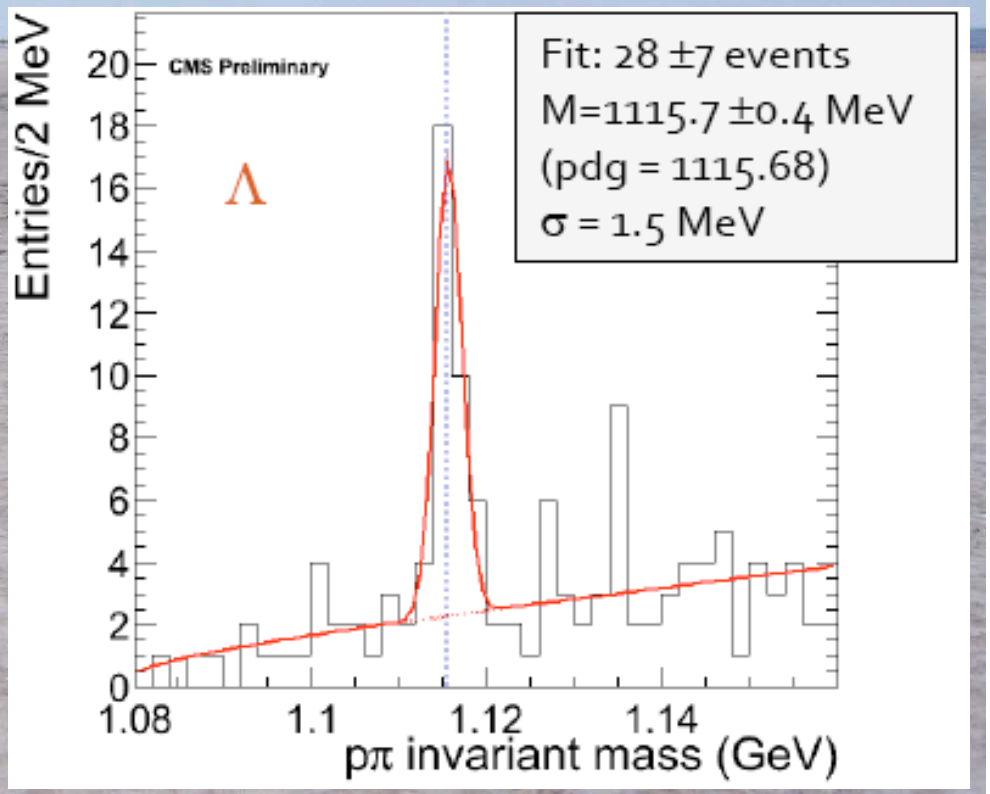




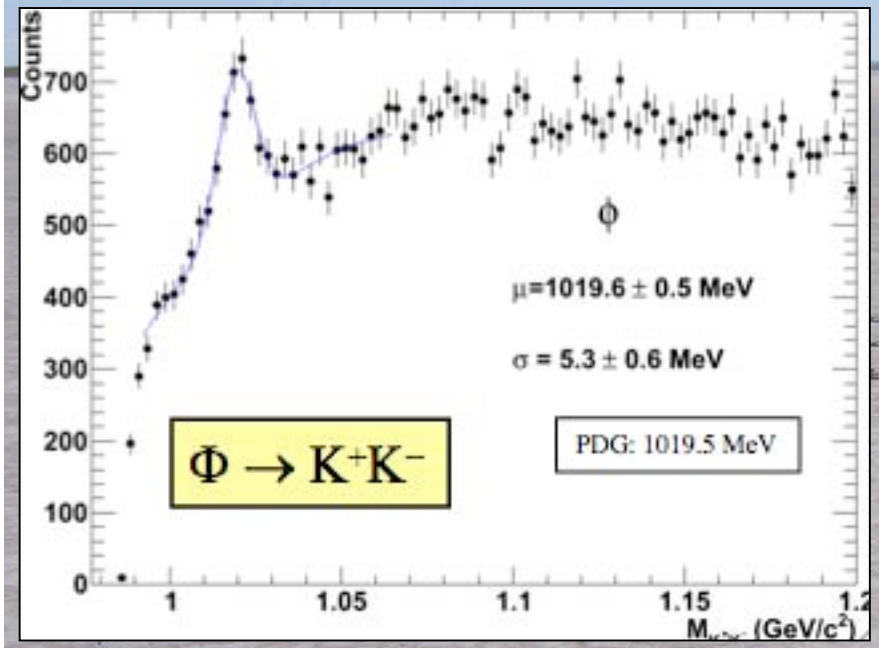


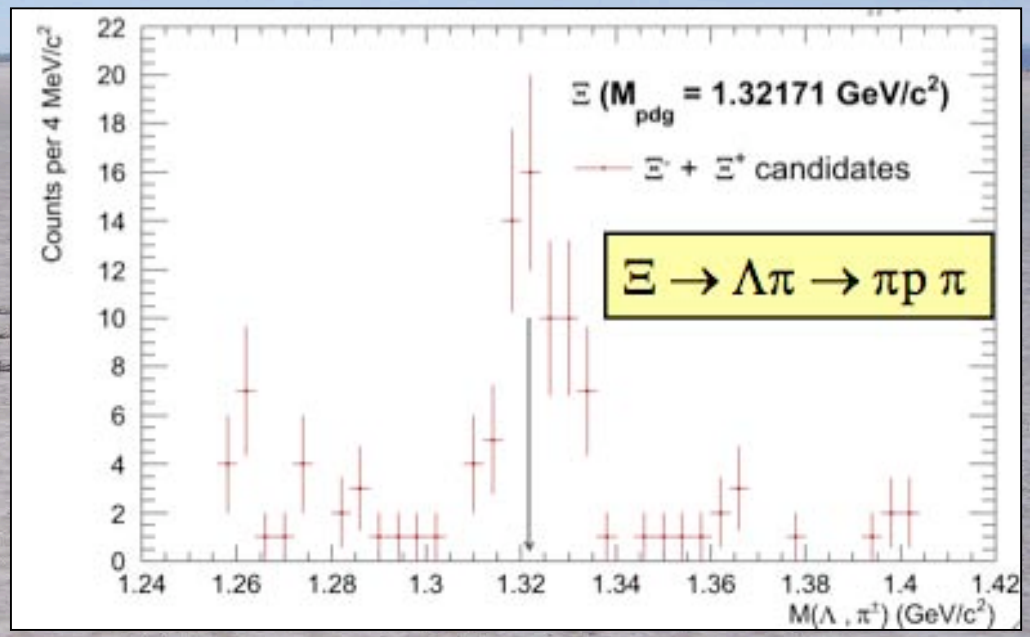
Towards Heavy Flavours in CMS



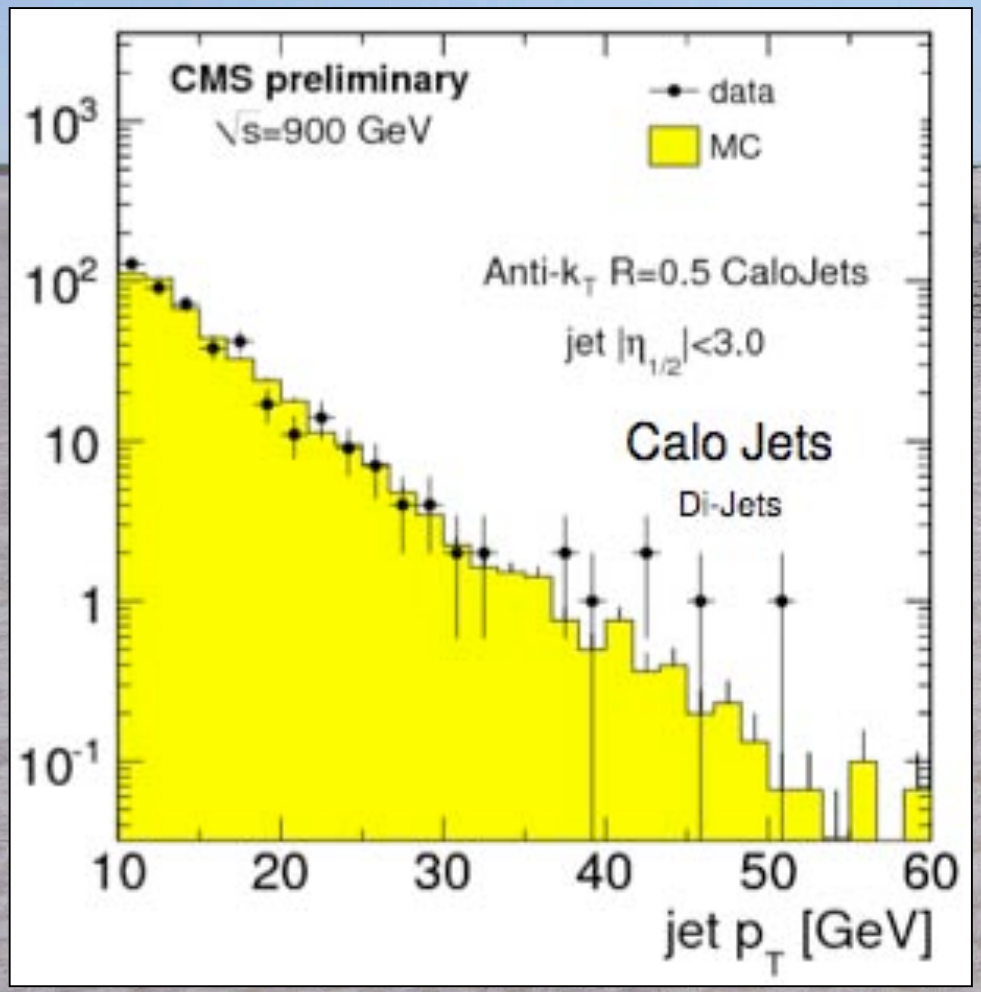


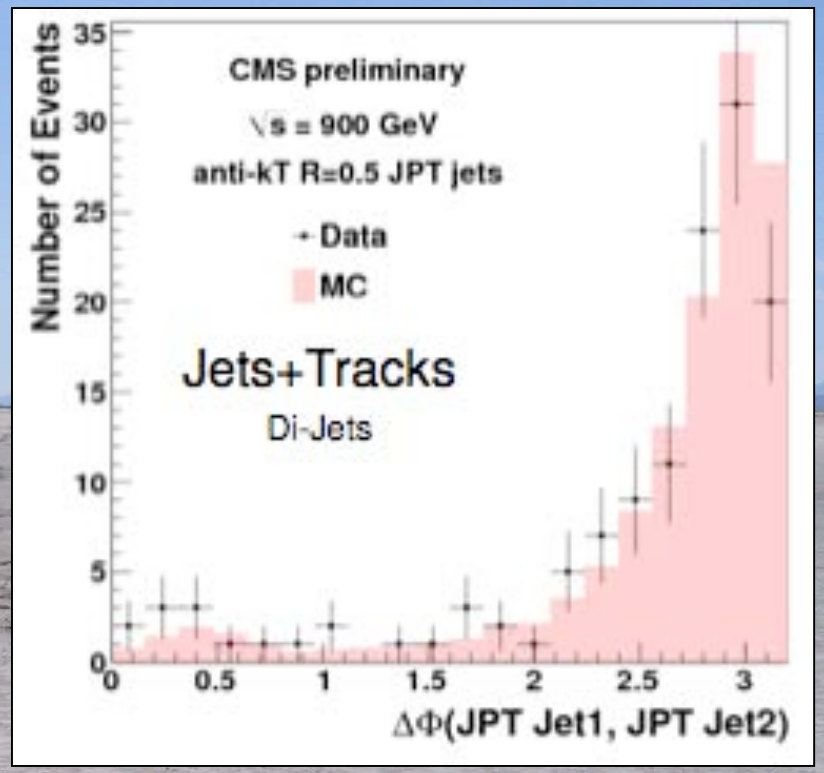
Rediscovering more Known Particles

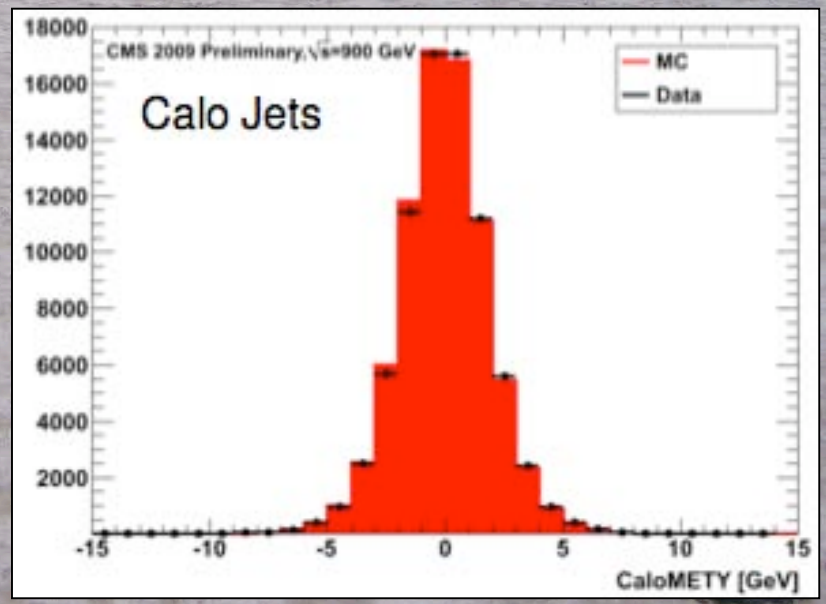




Jets in CMS

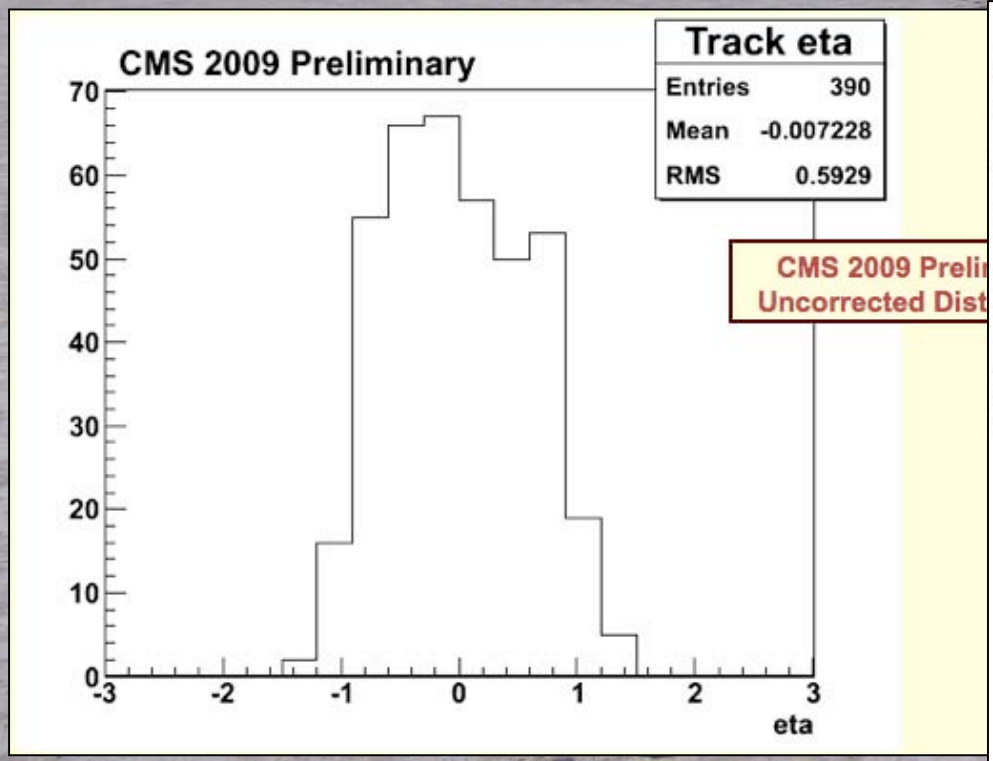

CMS preliminary
√s=900 GeV
data
MC
Anti-k$_T$ R=0.5 CaloJets
jet |η$_{1/2}$|<3.0
Calo Jets
Di-Jets
jet p$_T$ [GeV]


CMS preliminary
√s = 900 GeV
anti-kT R=0.5 JPT jets
Data
MC
Jets+Tracks
Di-Jets
Number of Events
ΔΦ(JPT Jet1, JPT Jet2)

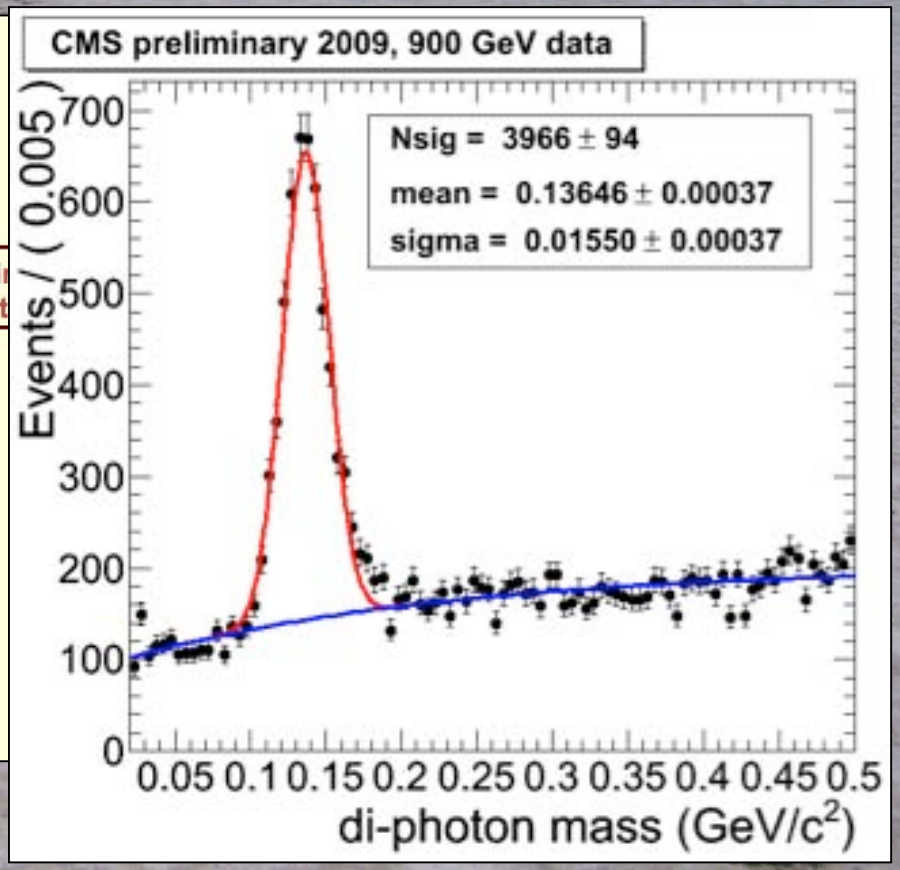

CMS 2009 Preliminary,√s=900 GeV
MC
Data
Calo Jets
CaloMETY [GeV]

No Higgs yet!

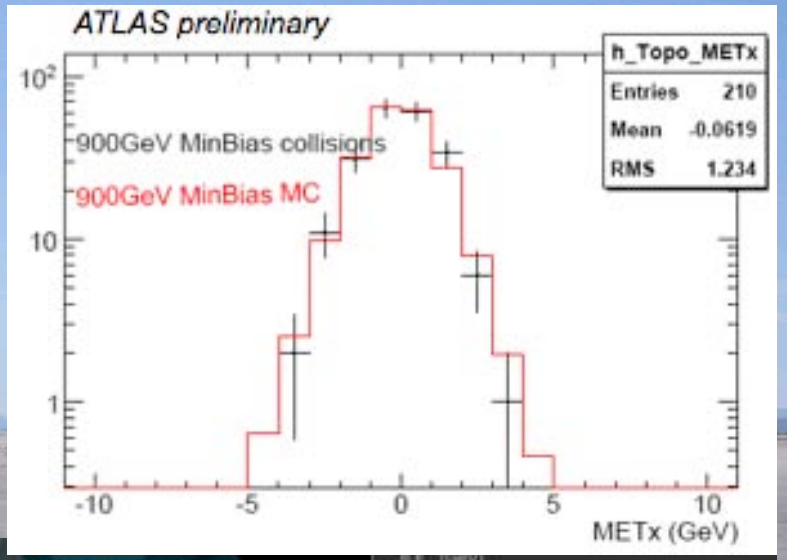
Pseudo-rapidity distribution

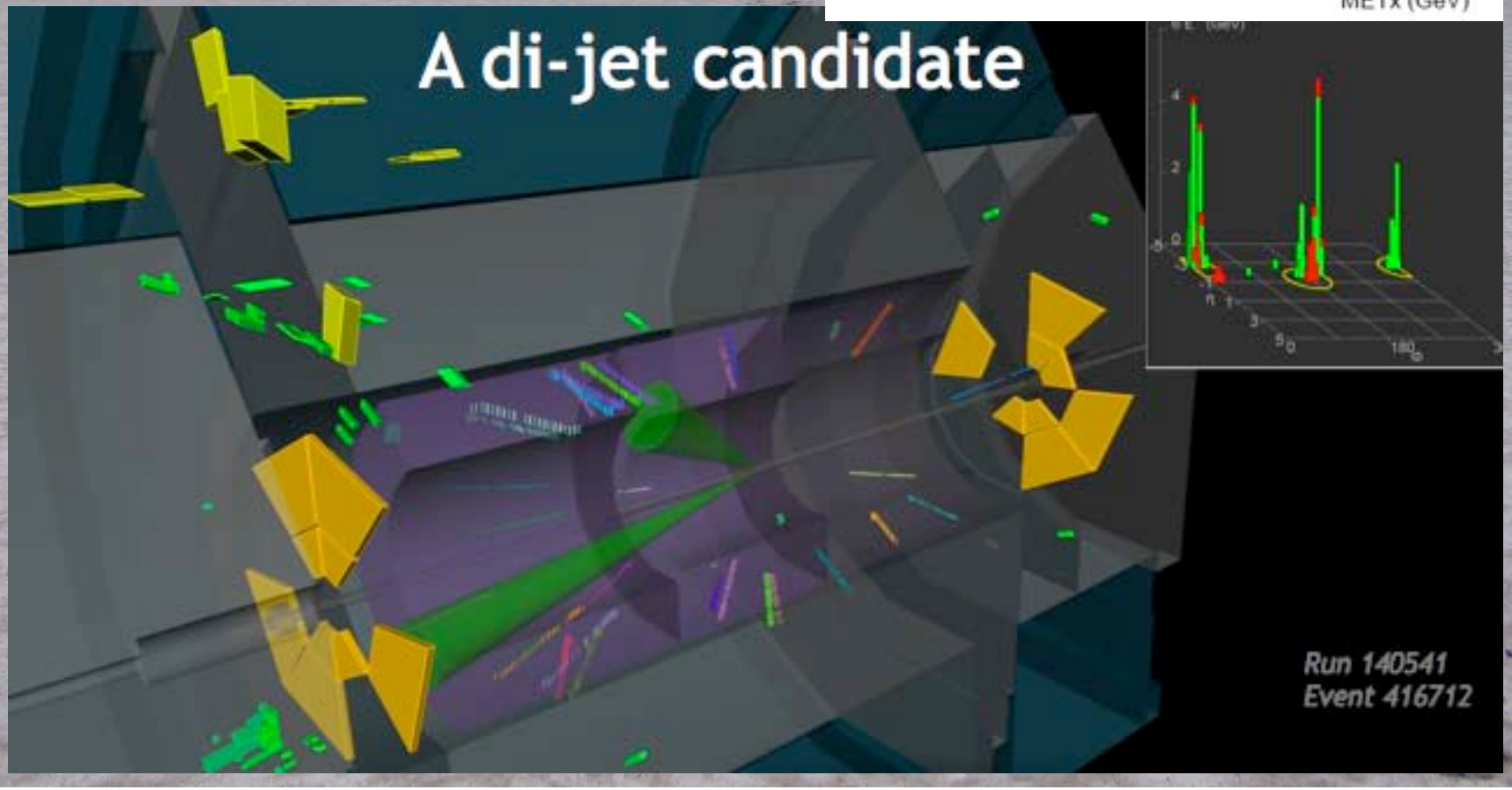


$\gamma\gamma$ invariant mass distribution

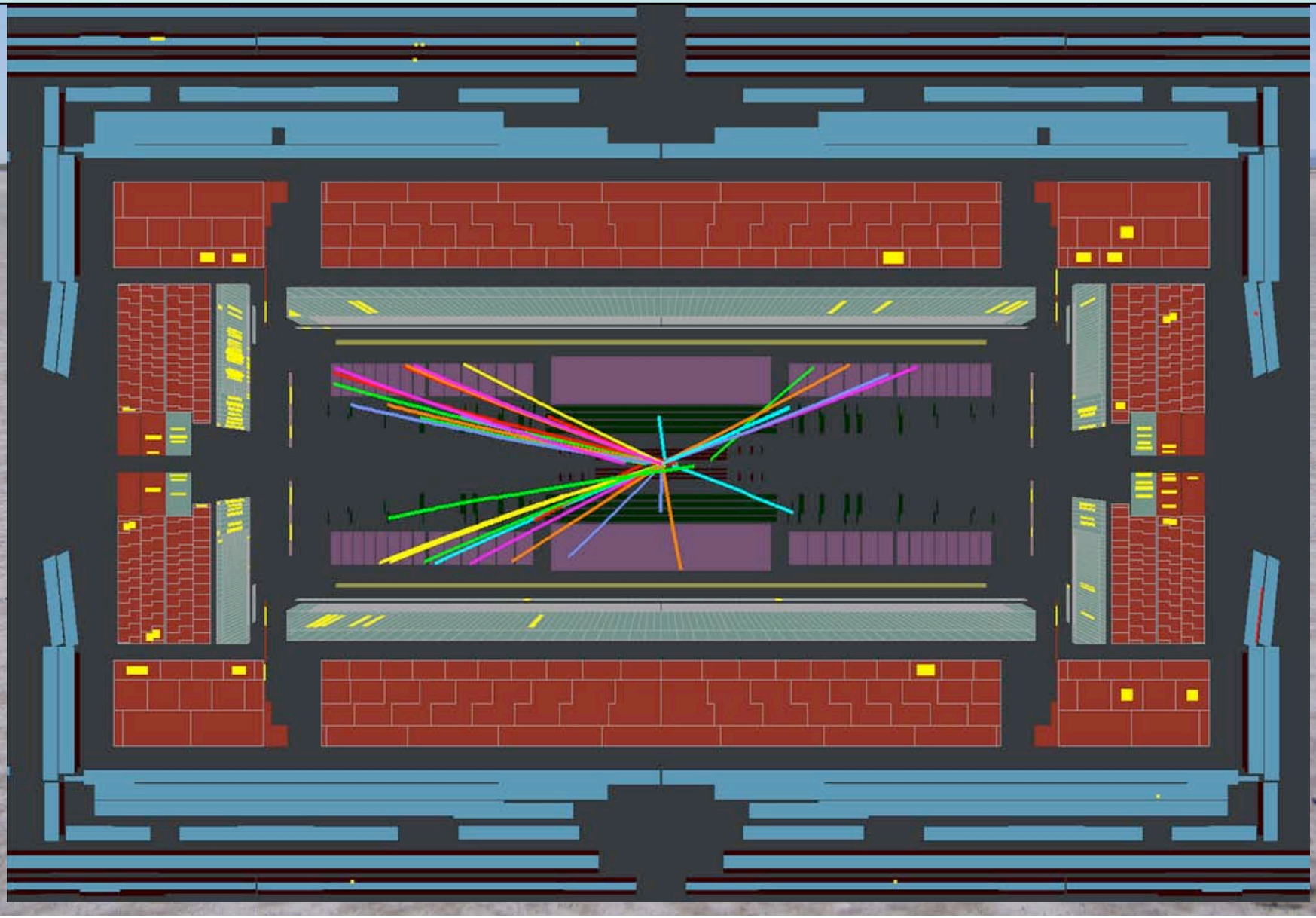


No Supersymmetry yet!



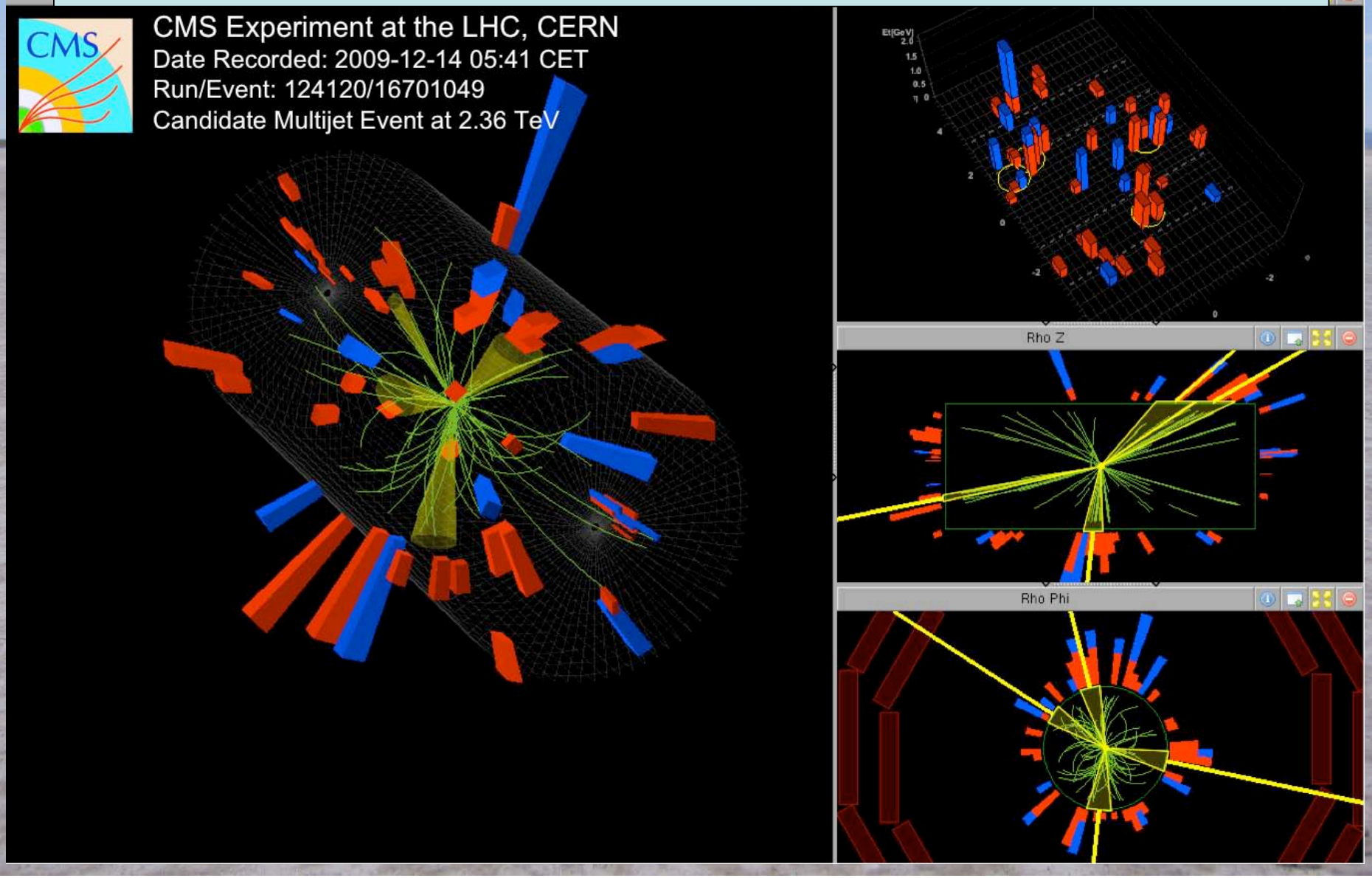


First 2.36 TeV Collision in ATLAS

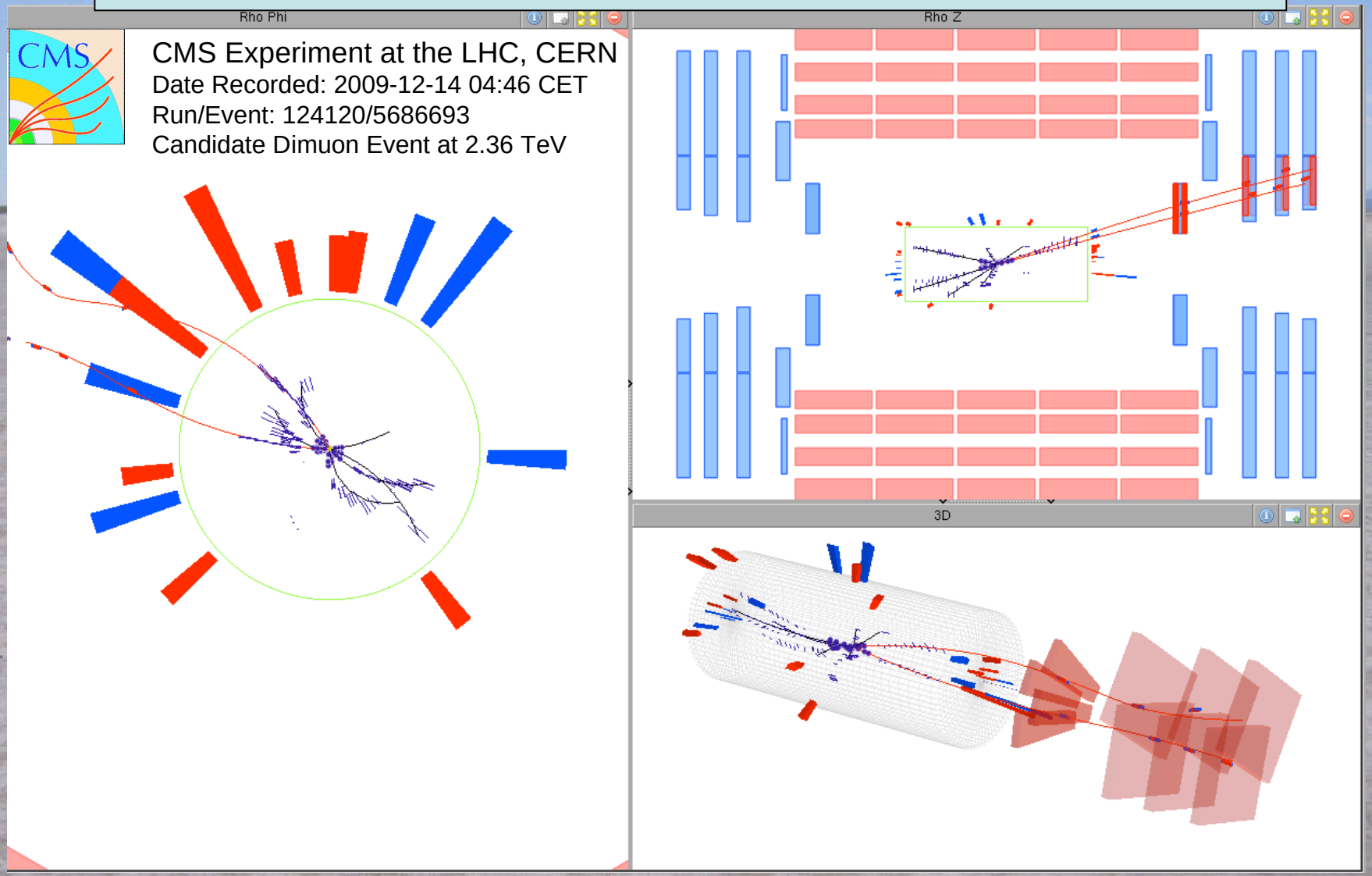


No Black Holes yet!

CMS 4-Jet Event @ 2.36 TeV

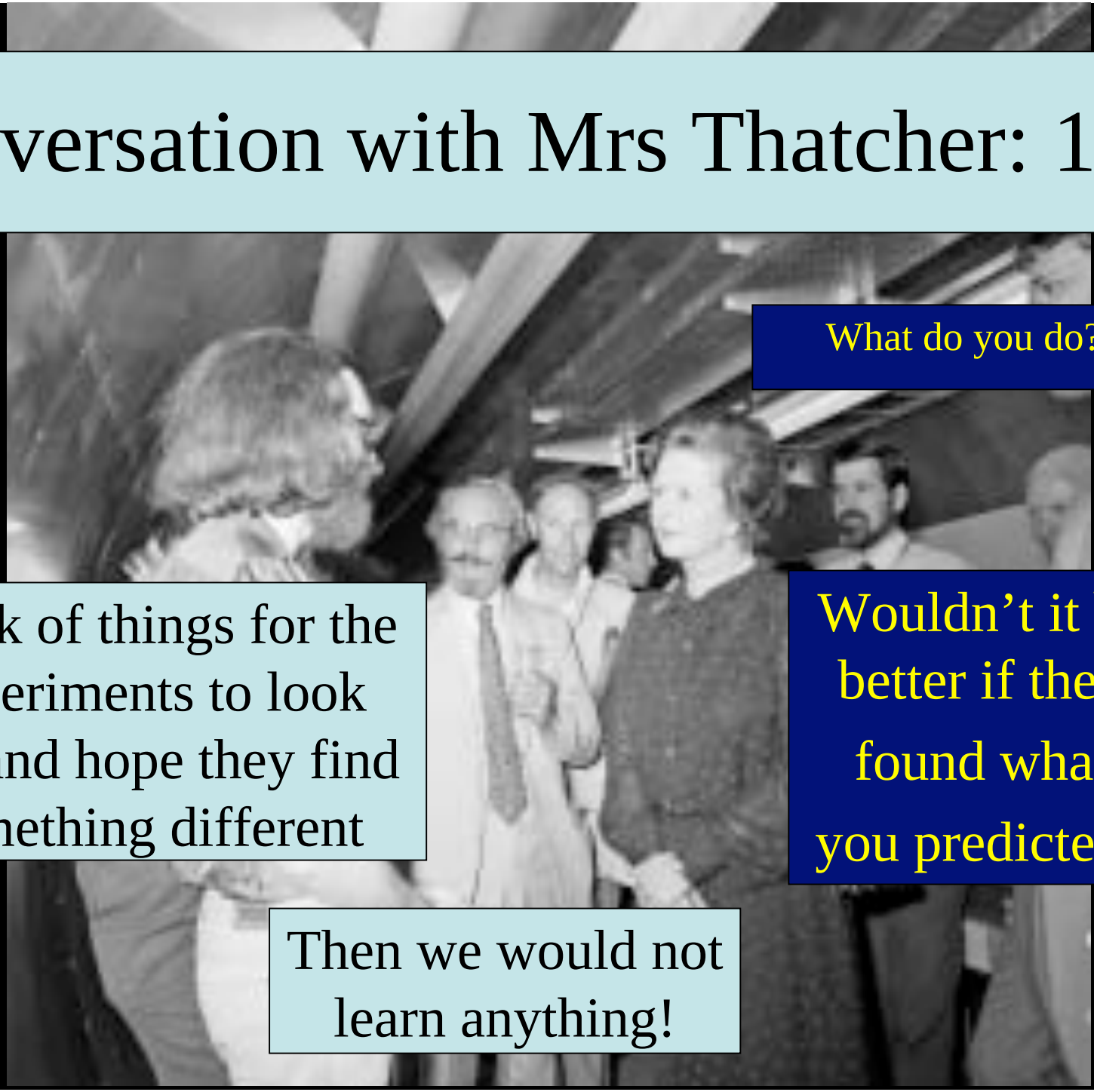


Even Heavier Flavour in CMS?



$p_T(m_1)$ = 3.6 GeV, $p_T(m_2)$ = 2.6 GeV, m(mm)= 3.04 GeV

Conversation with Mrs Thatcher: 1982



What do you do?

Think of things for the experiments to look for, and hope they find something different

Wouldn't it be better if they found what you predicted?

Then we would not learn anything!