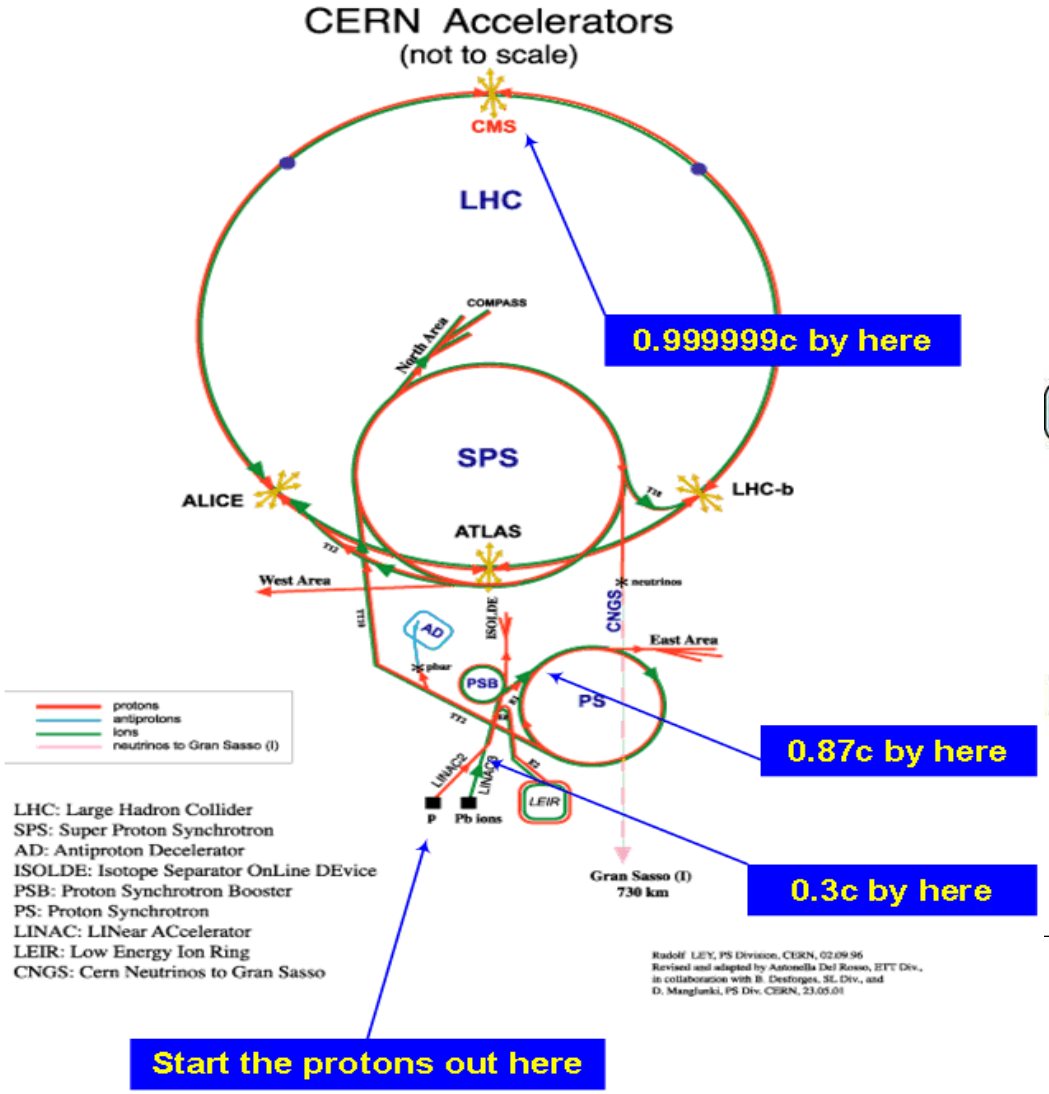
# ALICE@LHC, status, physics prospects, and plans

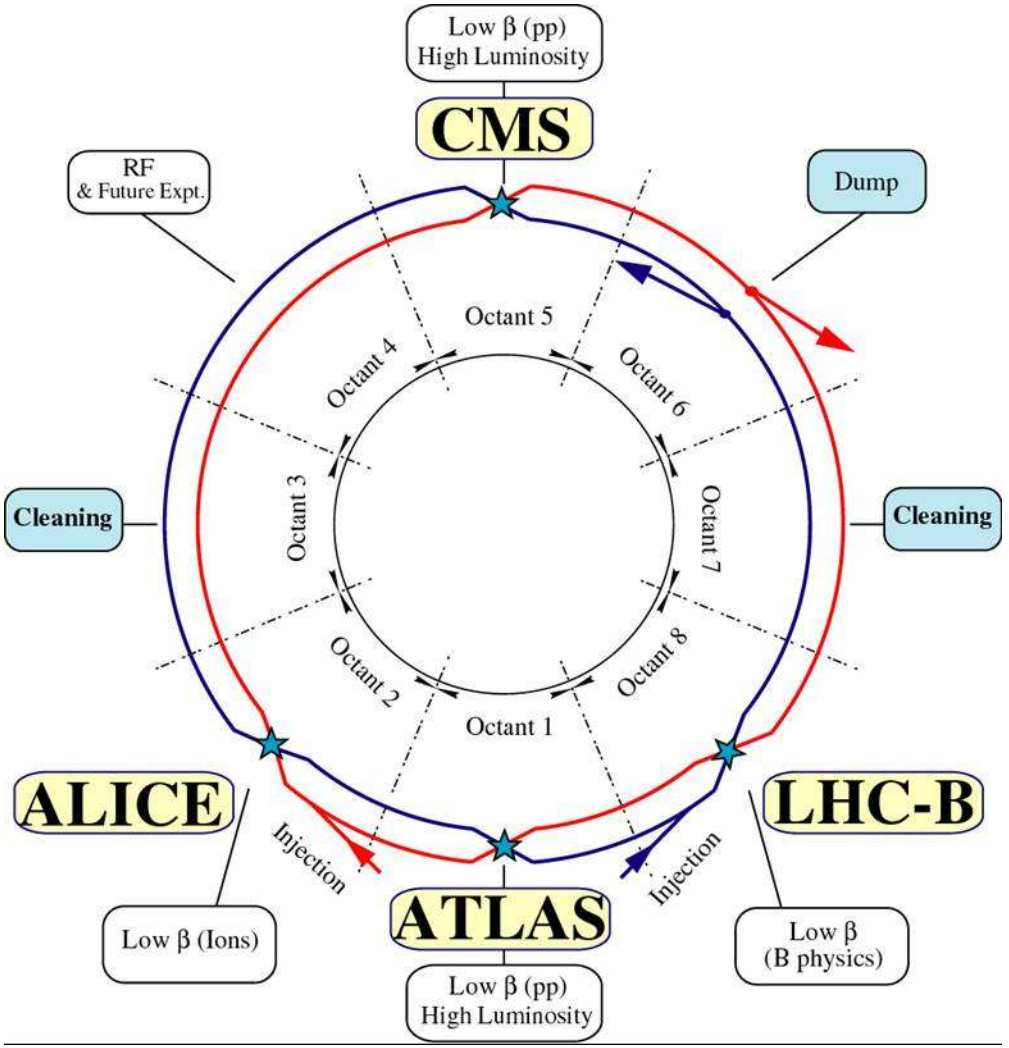
- status LHC
- the ALICE experiment
- results of commissioning
- some remarks about physics
- plans

pbm, Extreme Matter Institute ***EMMI***, GSI
also at TU Darmstadt and FIAS, Frankfurt

ISHIP GSI, November 2008

# The CERN Accelerators and LHC Experiments

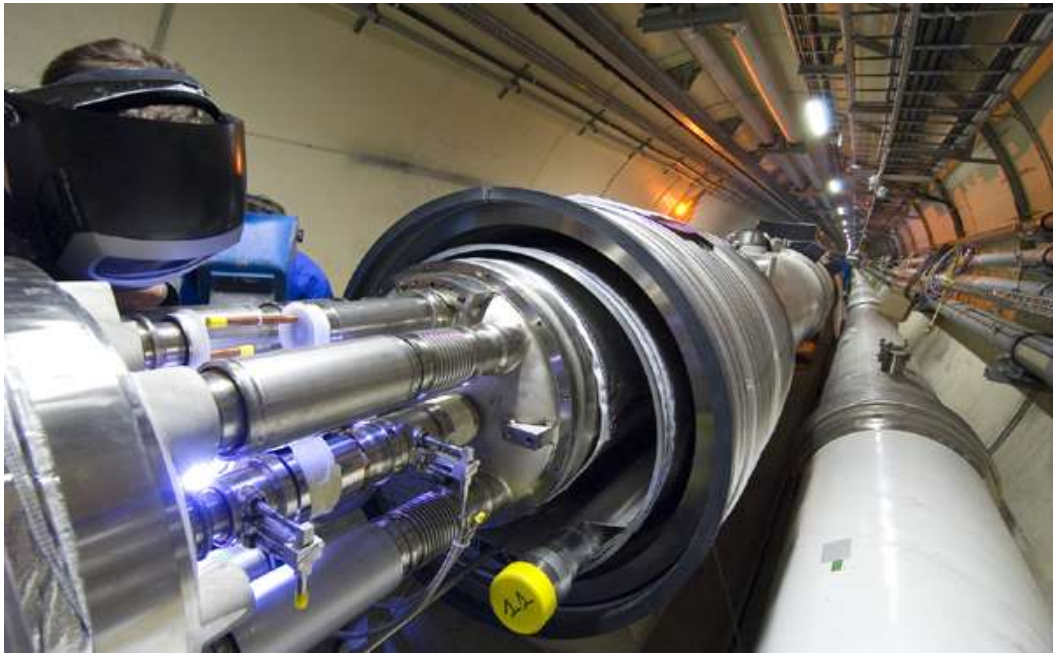


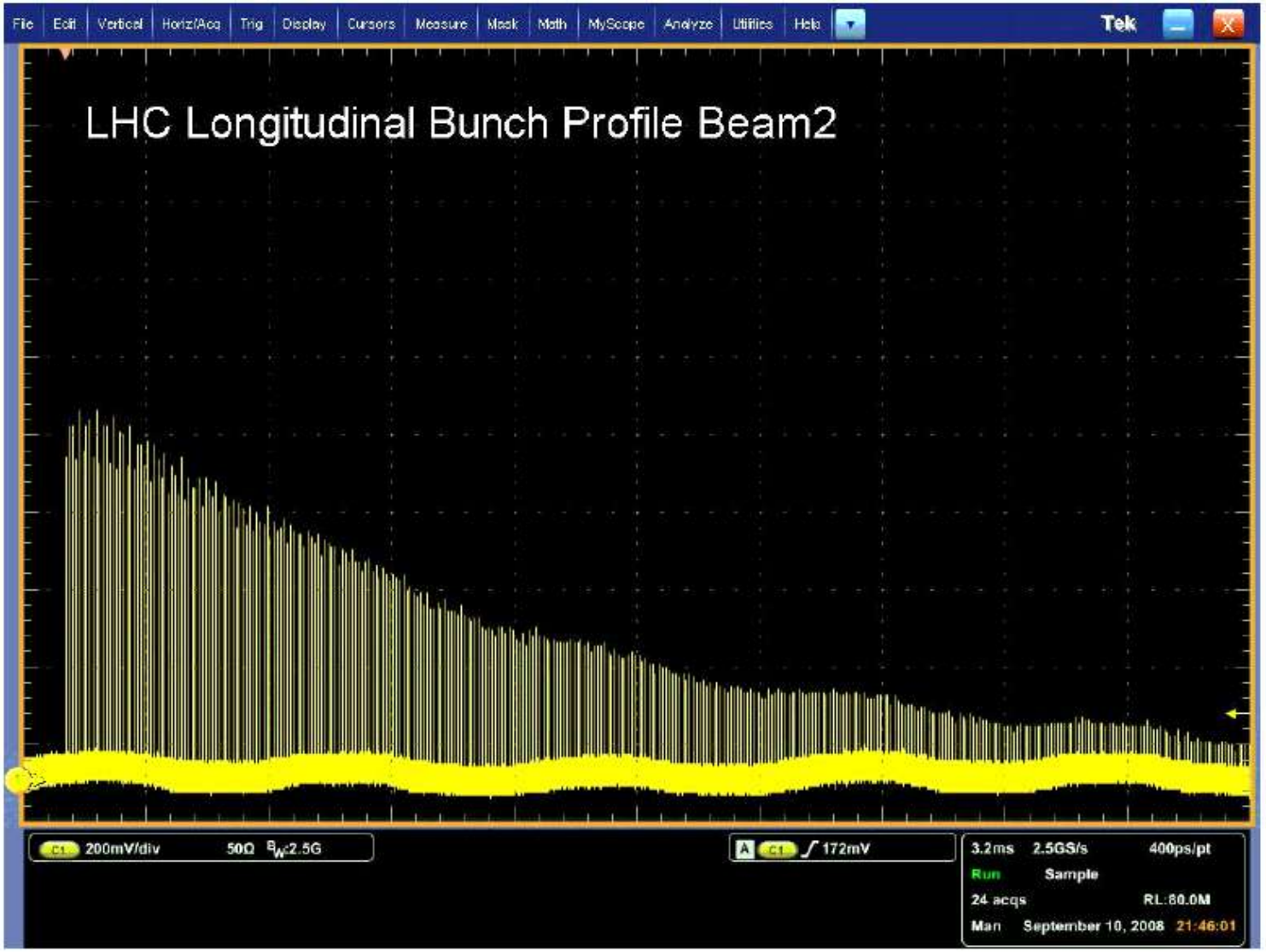
# LHC – Tunnel and Magnets

the tunnel in 2008

joining two magnets by welding



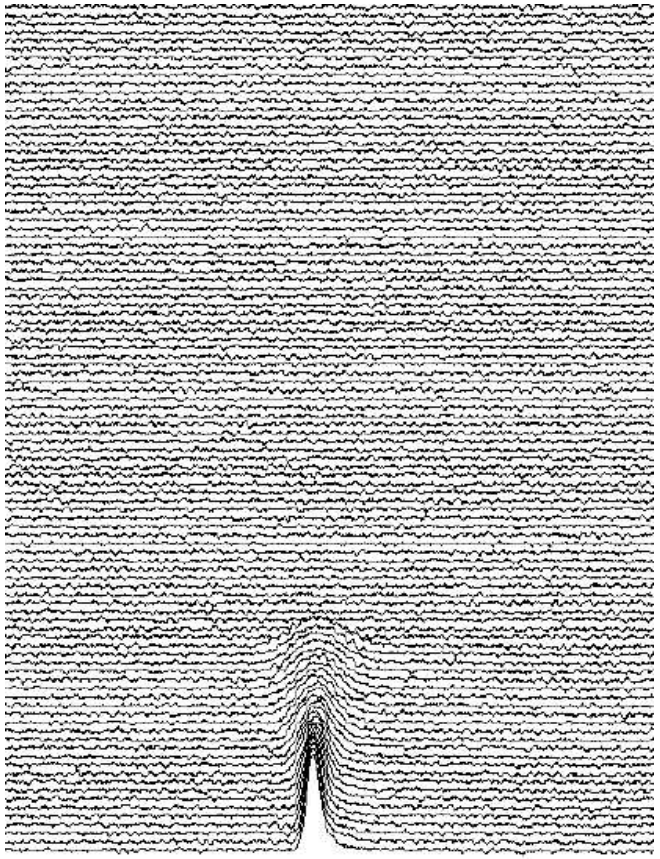
# First beam in Ring 2



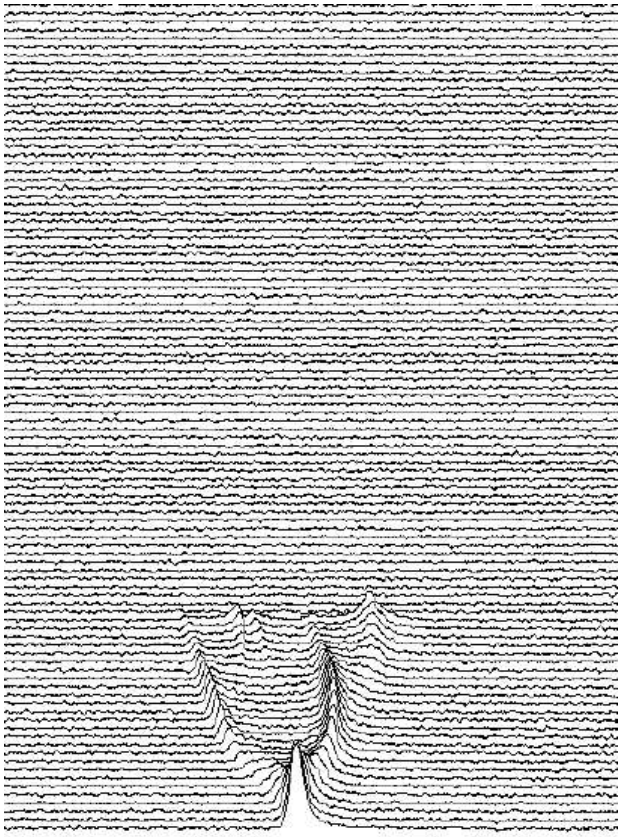

injection energy 450 GeV, few hundred turns, no RF capture

# Capturing the LHC beam with the RF System

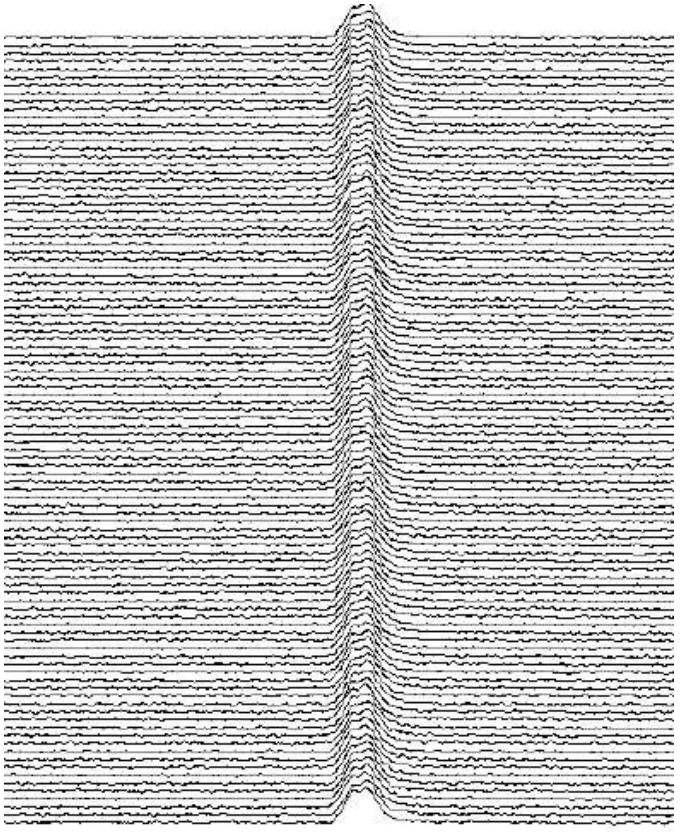
no capture, few turns



capture, wrong phase



capture, correct phase



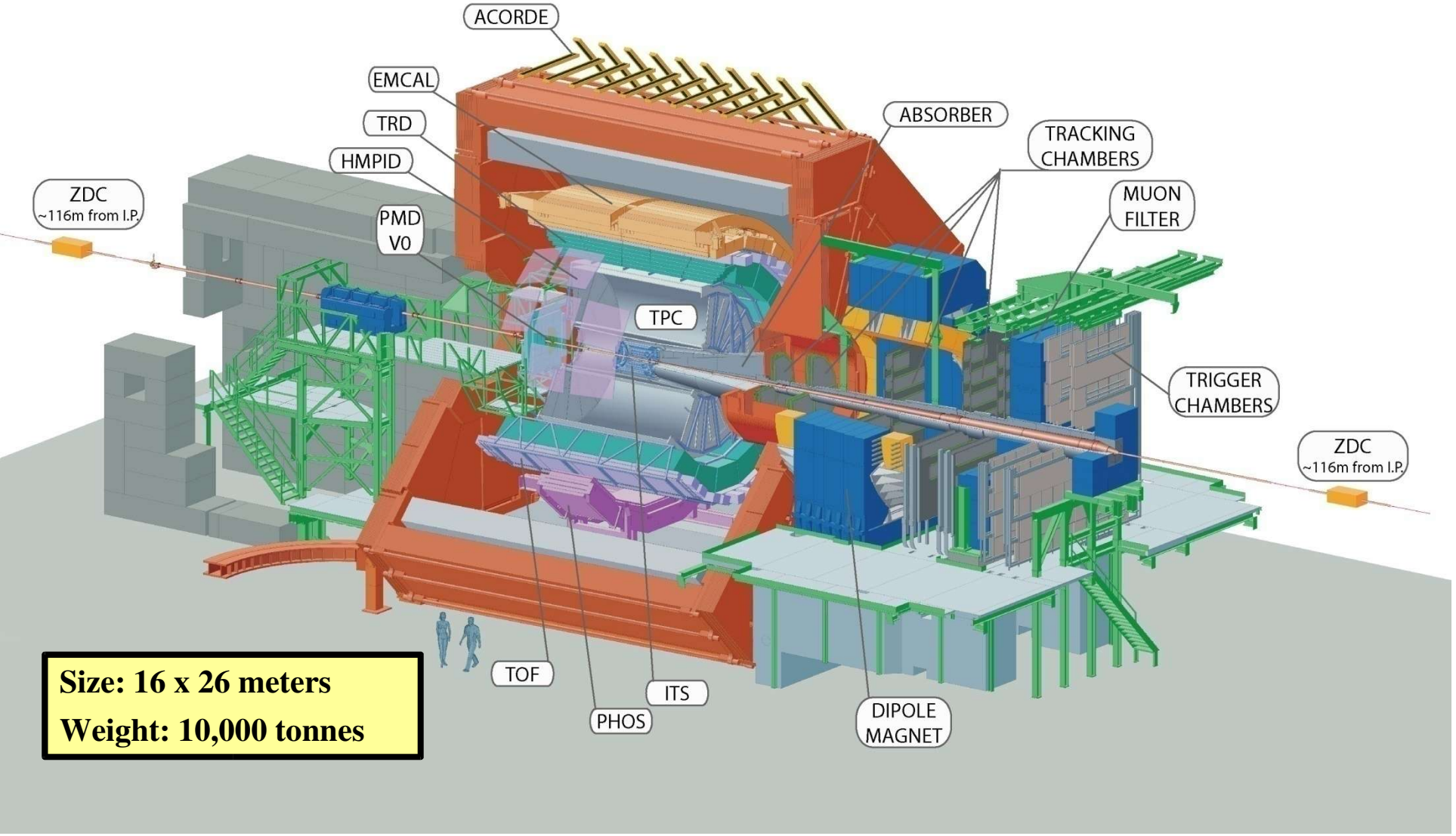
# LHC Beam Commissioning

both rings commissioned with beams
RF capture like in textbooks
interlocks and beam dumps exercised
next planned steps: collisions at 900 GeV
and 10 TeV

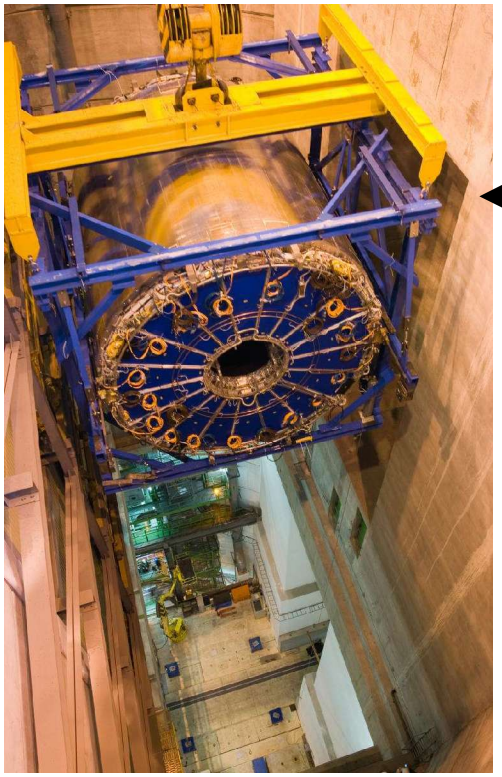
but

early winter shut-down because of
accident in sector 3-4
restart summer 2009

# ALICE: A Large Ion Collider Experiment at CERN-LHC

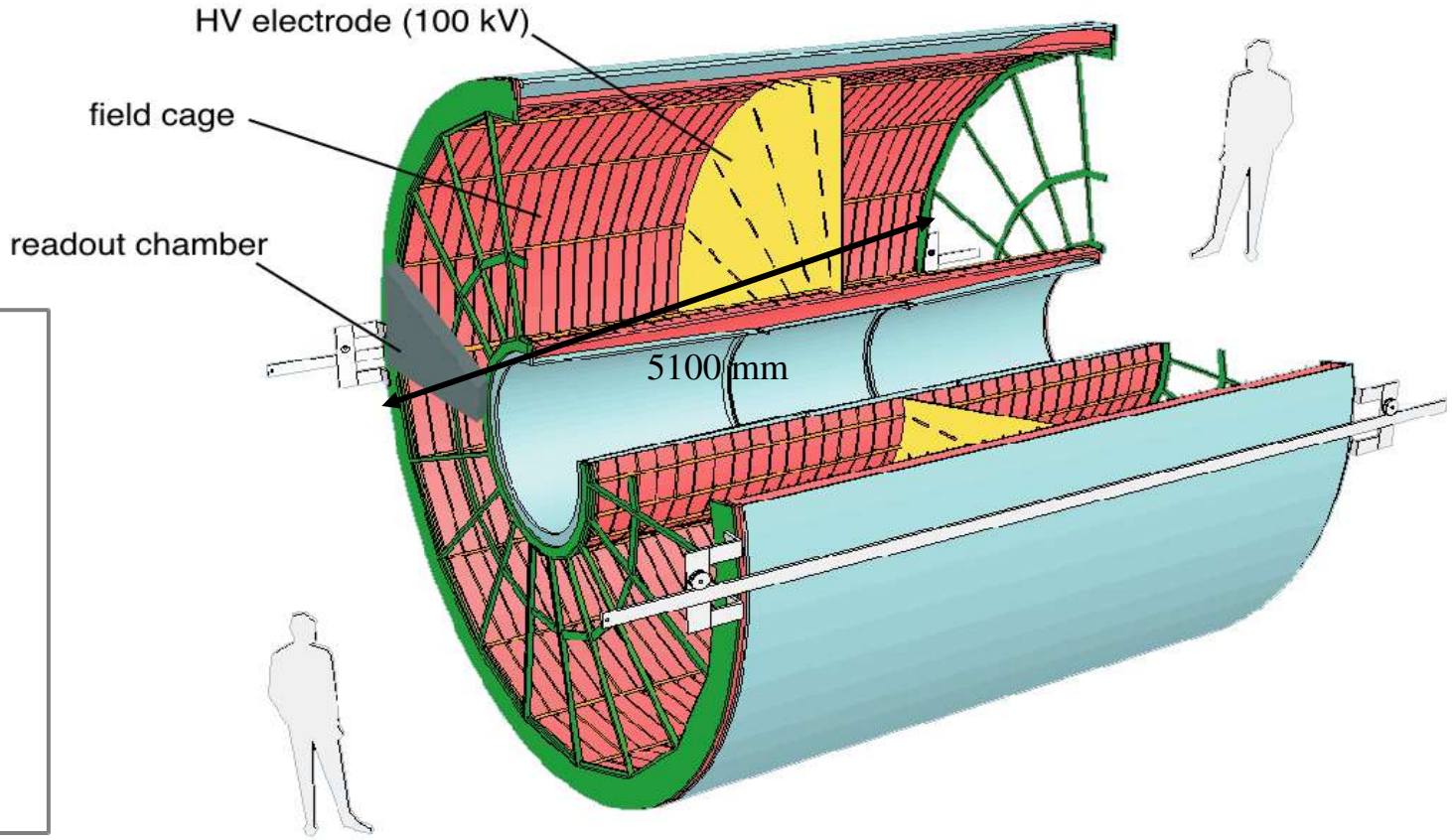


# The ALICE Experiment



## Time Projection Chamber (TPC)

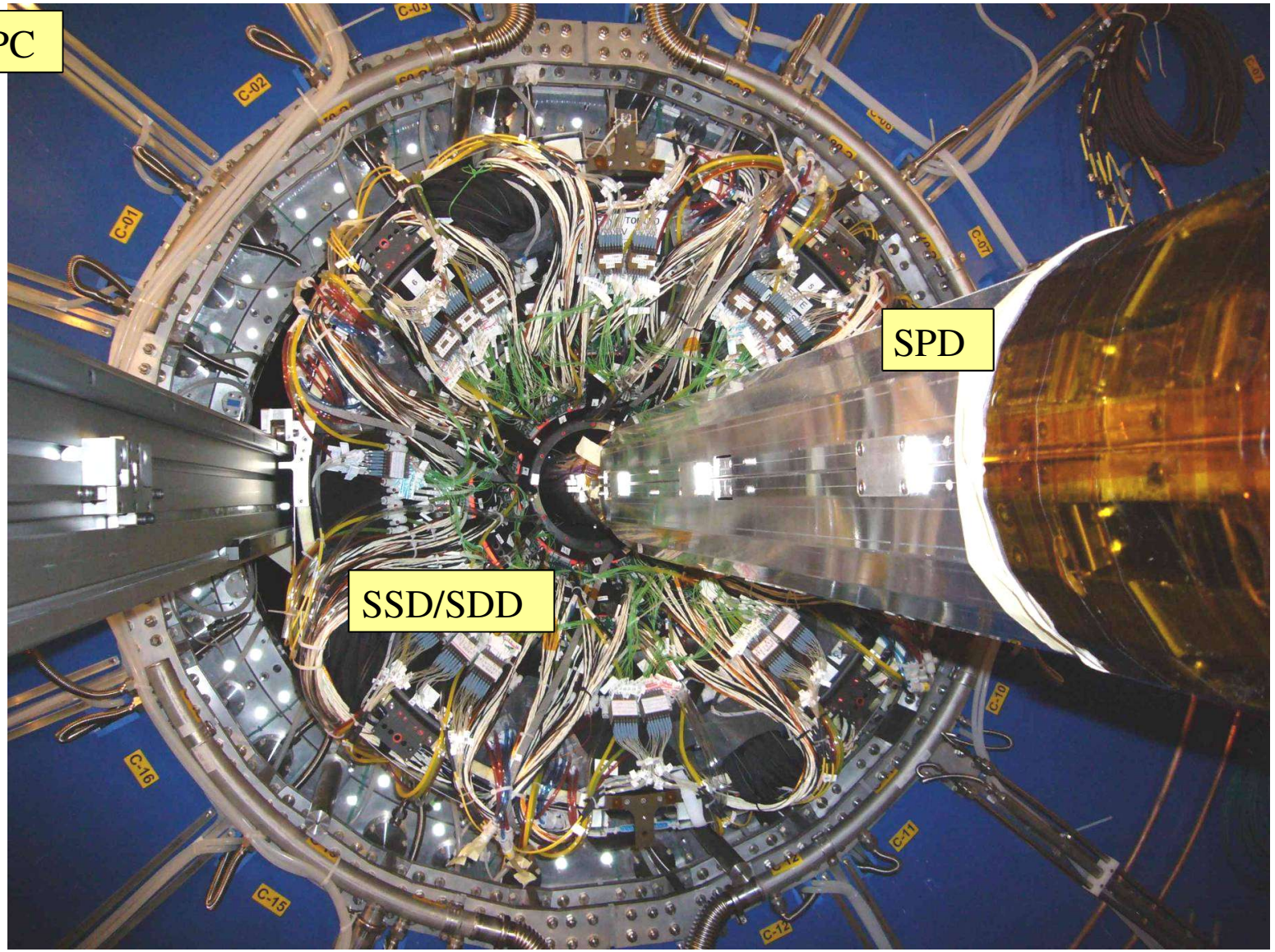
TPC on its way into the ALICE cave




### Largest TPC ever built

Radius: 845 - 2466 mm
Drift length: 2 x 2500 mm
Drift time: 92 μs
Drift gas Ne-$CO_2$-$N_2$
Gas volume: 95 $m^3$
557568 readout pads
Material: ($\eta$=0) 3% $X_0$

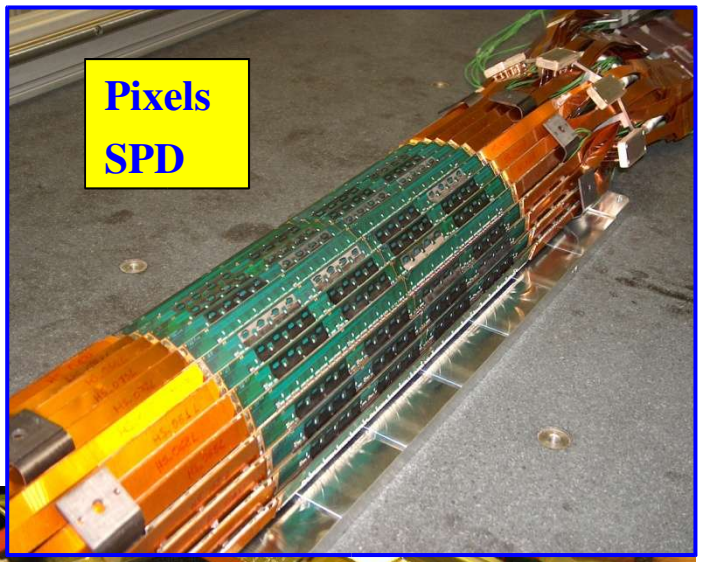
# Insertion of the Inner Tracking Detector into the TPC



# Inner Silicon Tracker

**Inner Tracking System**
**~ 10 m² Si detectors, 6 layers**
**Pixels, Drift, double sided Strips**

**Strips**
**SSD**



**Pixels**
**SPD**

**Drift**
**SDD**

# The ALICE Experiment

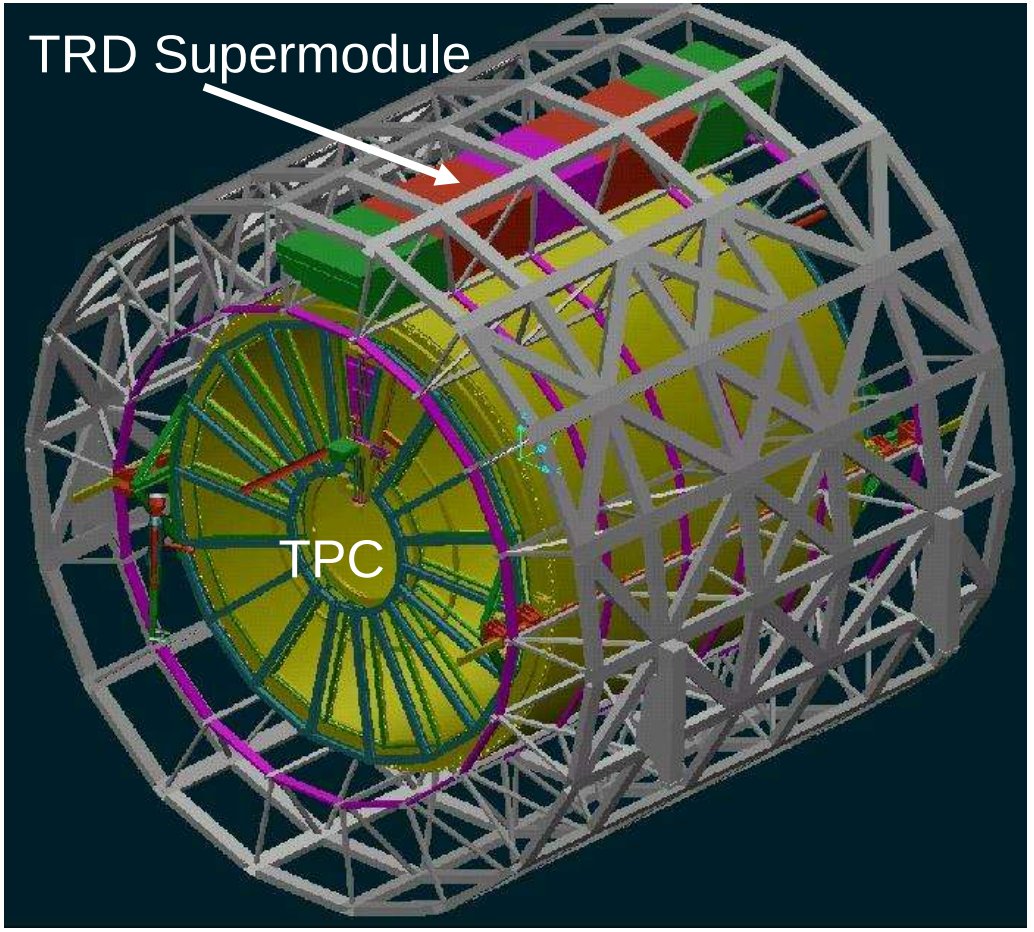
## Transition Radiation Detector (TRD)

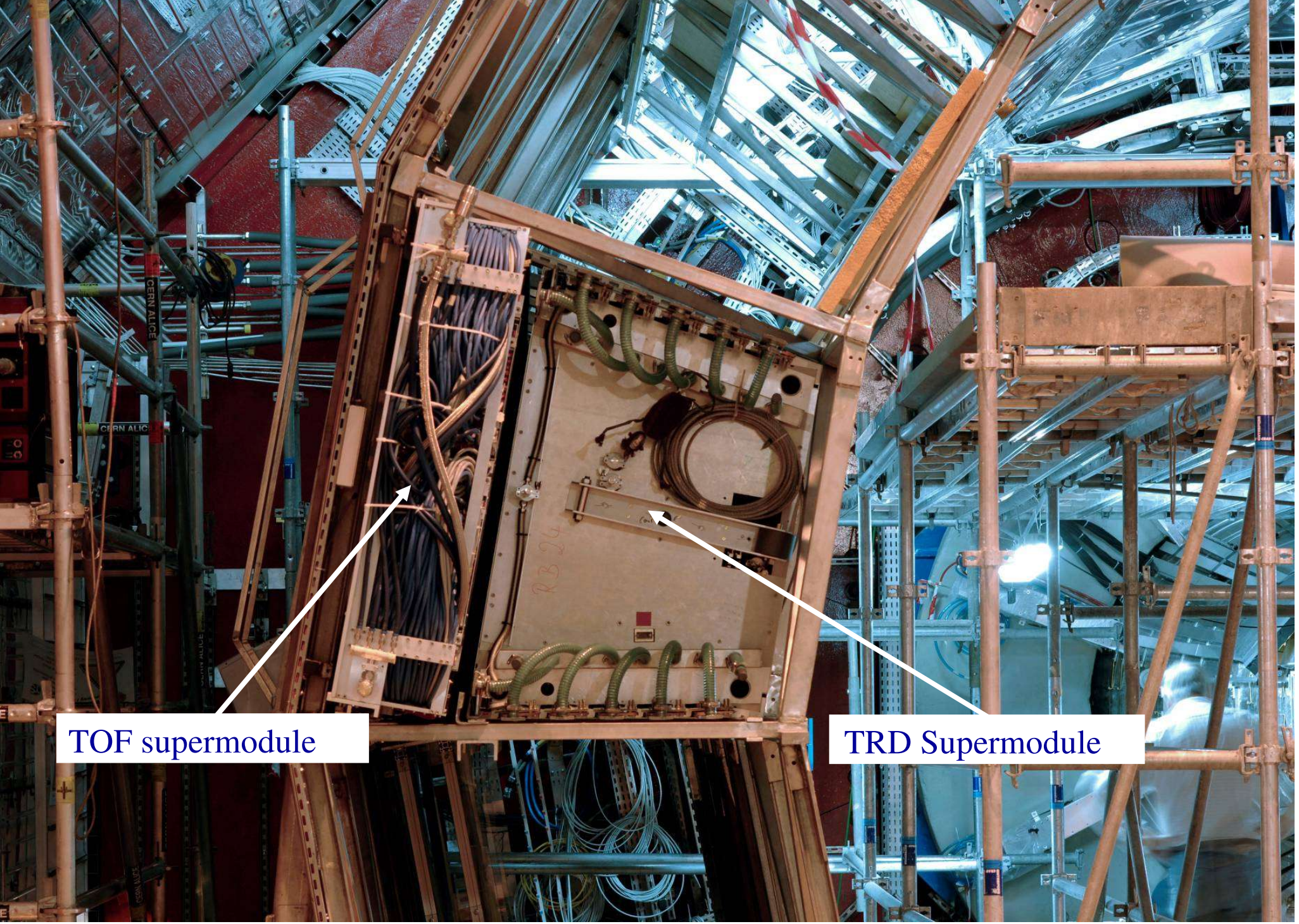
Purpose:

- Electron-ID & trigger
- Quarkonia $\rightarrow e^+e^-$
  Heavy flavour

Some numbers:

- 540 chambers
- Total area: 736 $m^2$
  (3 tennis courts)
- Gas volume: 27.2 $m^3$
- Resolution
  ($r\varphi$) 400 $\mu m$
- Number of read out
  channels: $1.2 \times 10^6$




TOF supermodule
TRD Supermodule

# ALICE TPC --- commissioning

- taking the detector into operation
- calibration – 560000 channels
- temperature stability -- how to reach 0.1K
- determination of resolution for particle identification (dE/dx)
- determination of momentum resolution
- determination of and correction for non-linearities (ExB, ...)

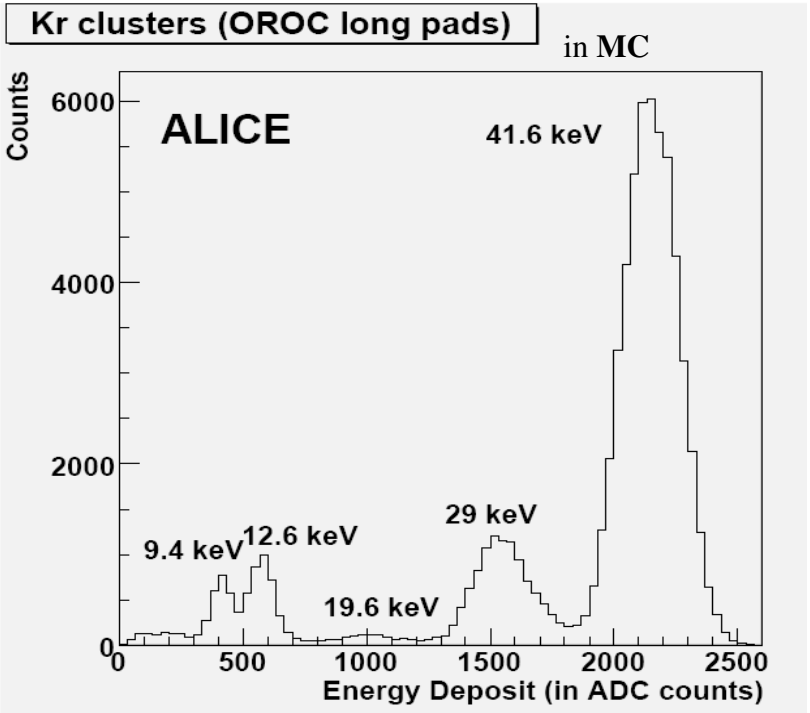
# TPC gain calibration using radioactive $^{87}$Kr

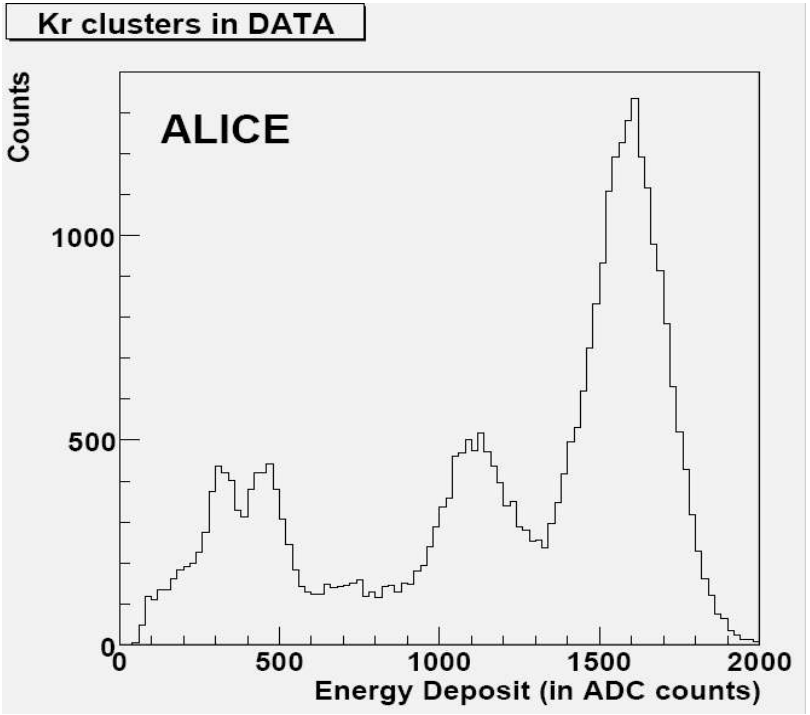
- inject radioactive Kr into TPC via gas system
- source intensity about 5 MBq
- run TPC with random triggers
  and collect a few x$10^6$ events

**absolute gain calibration of all 560000 channels**

# Method

- Exploited at ALEPH, DELPHI and NA49
- Rb → Kr* → Kr  - characteristic spectrum
- Multiple pad row clusters - special cluster finder

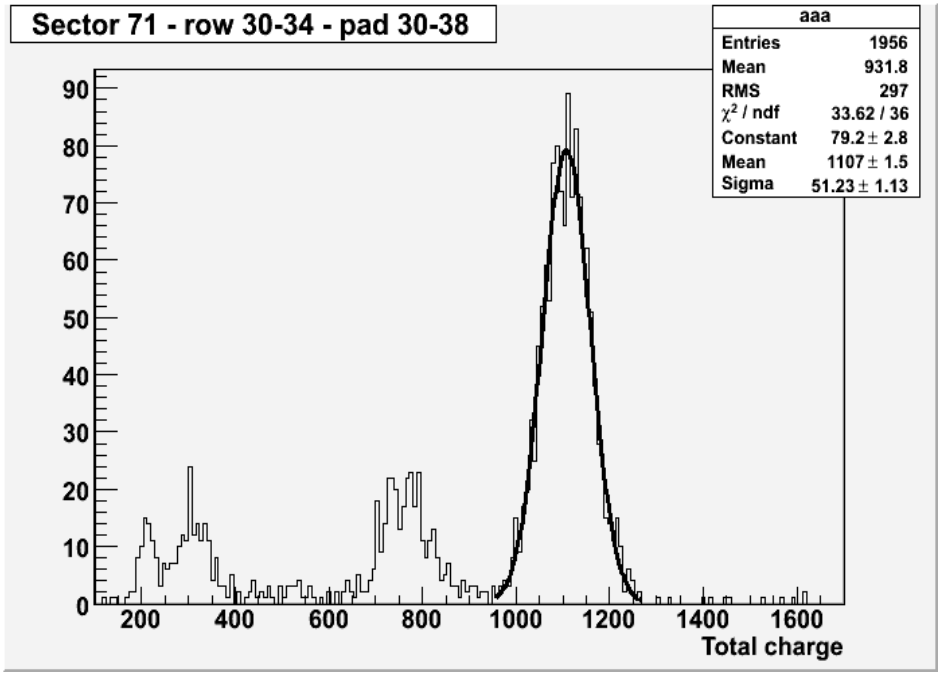


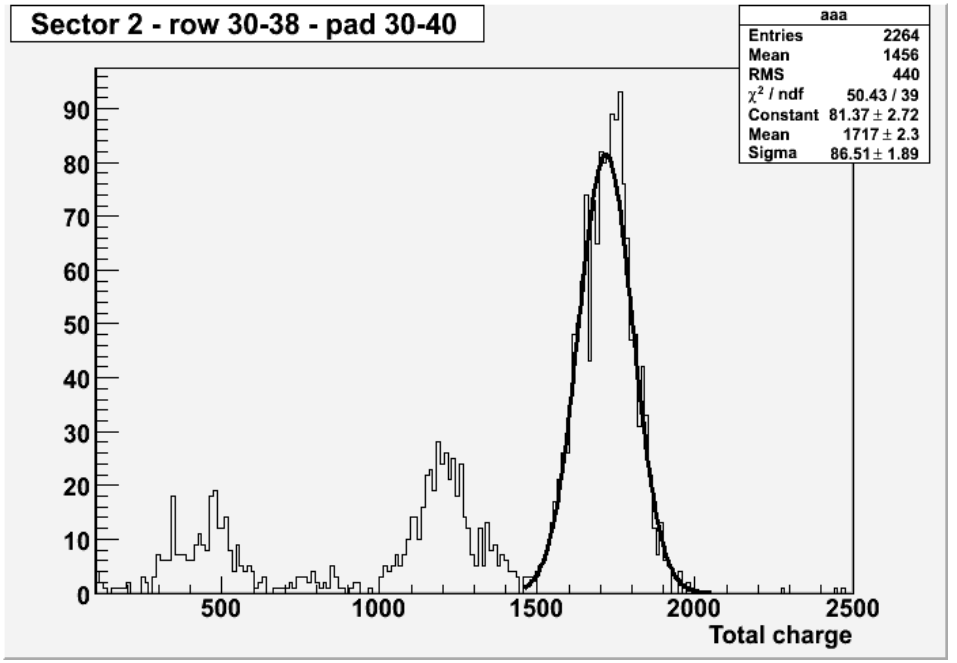




simulation

data

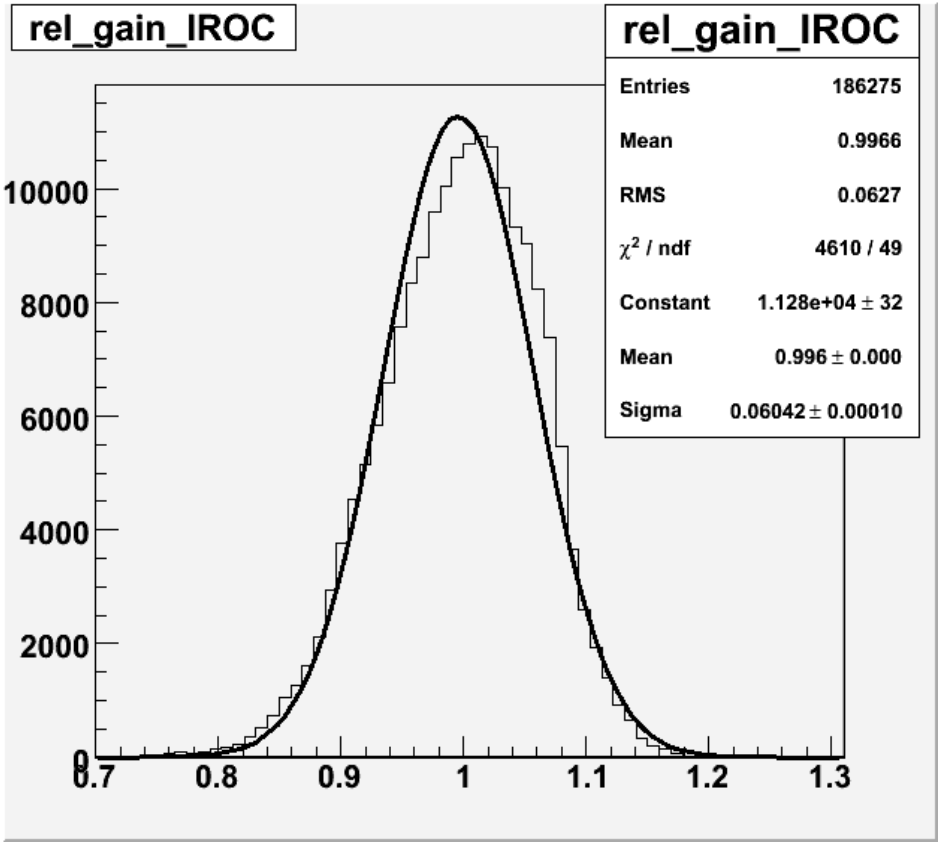
# Example Krypton spectra

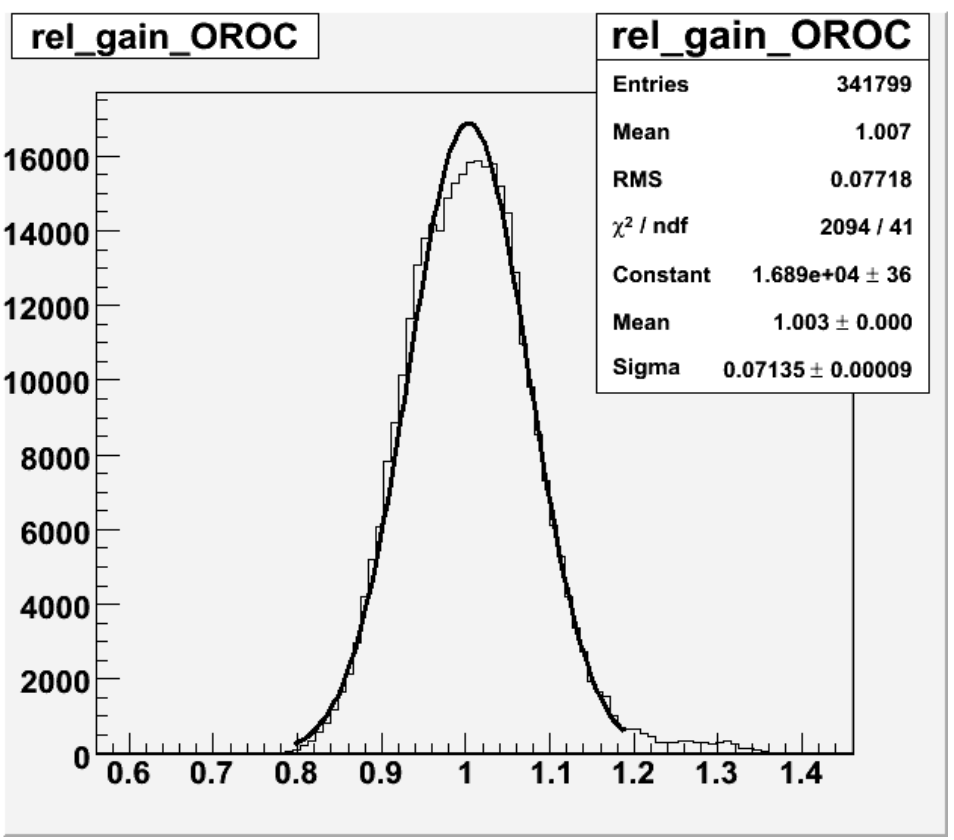



- Relative resolution at main peak
  - 4.6% OROC
  - 5.0% IROC

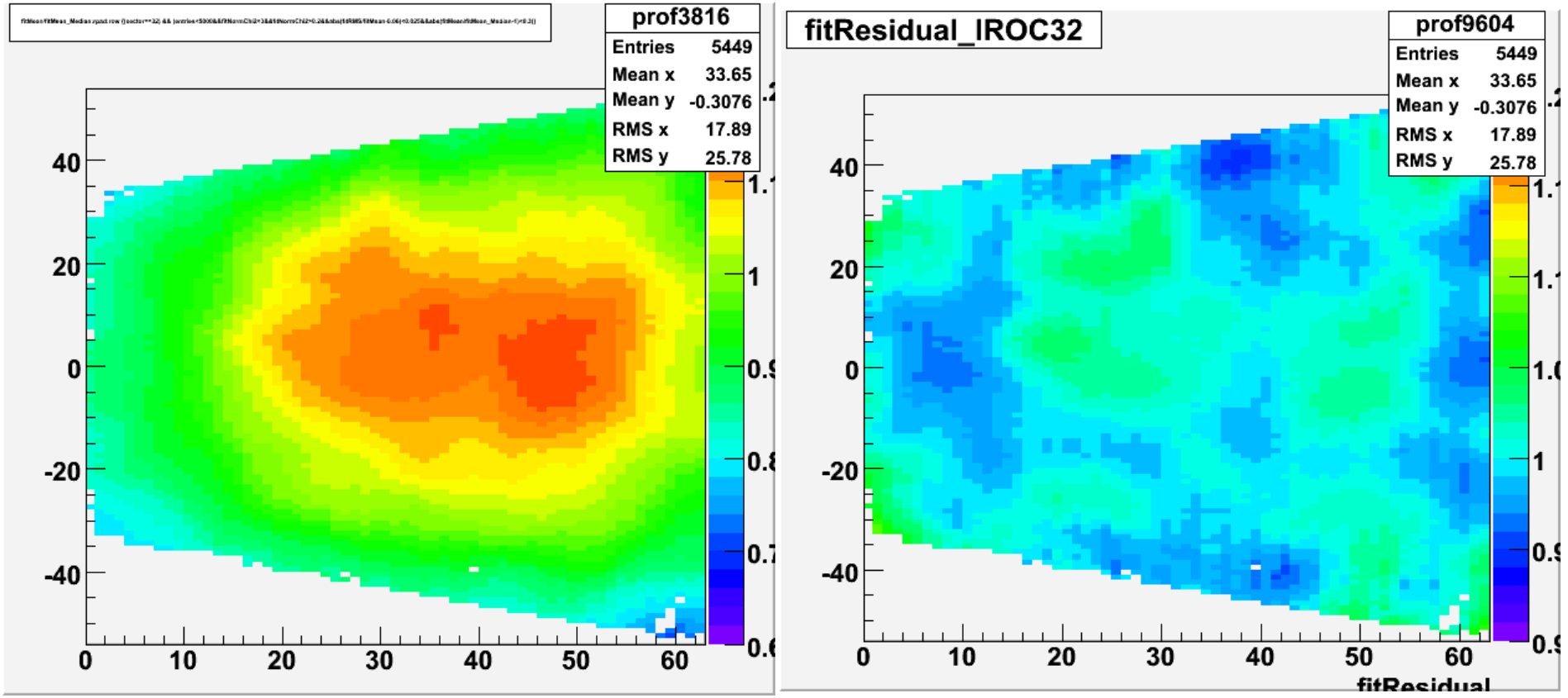
# Relative gain variation




- Relative gain variation  within specifications

# Gain fit -IROC 32

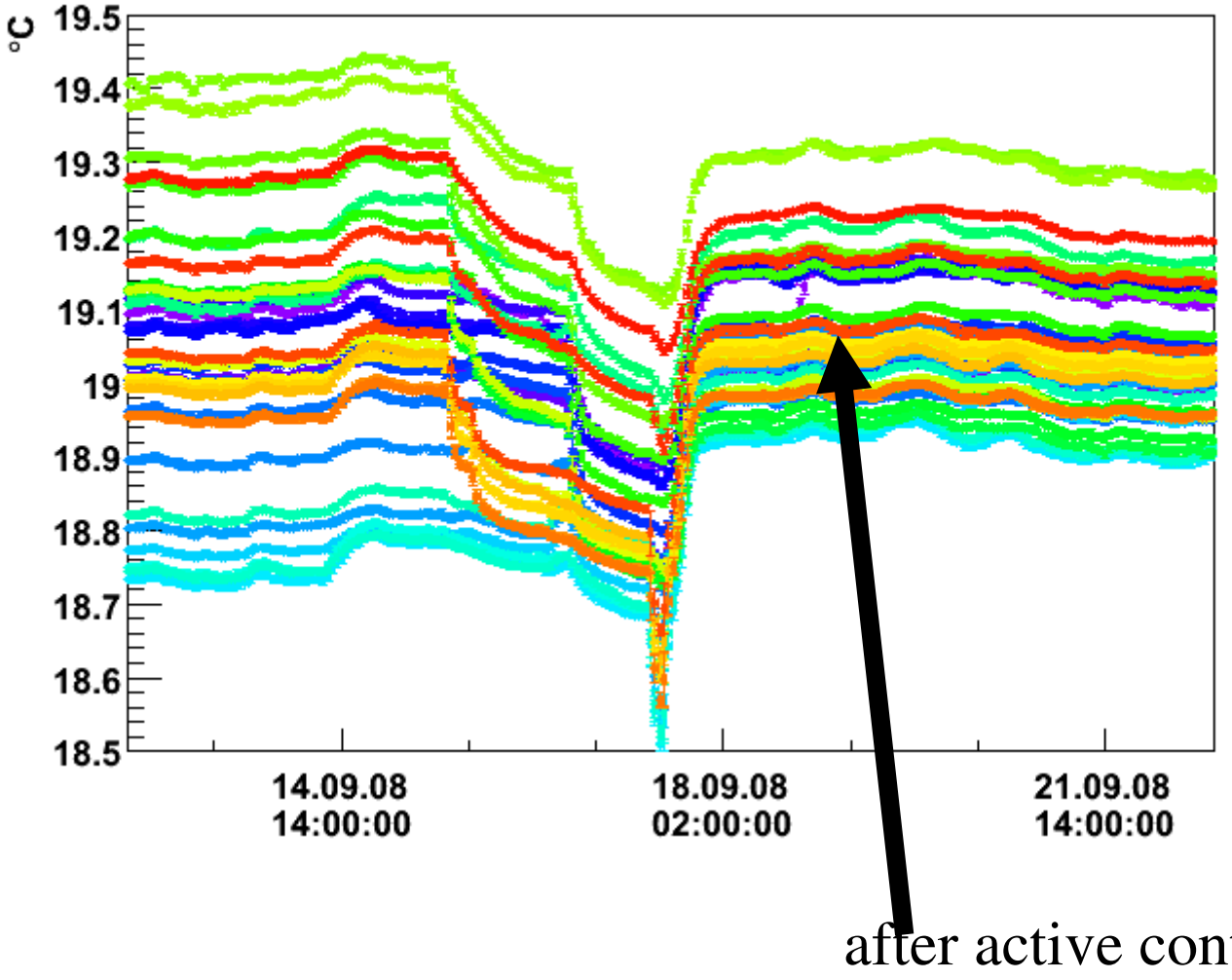



- Relative gain variation within chamber < 4%
  - Left side - raw data
  - Right side – residuals to parabolic fit, better than TDR specs

# Temperature control of TPC

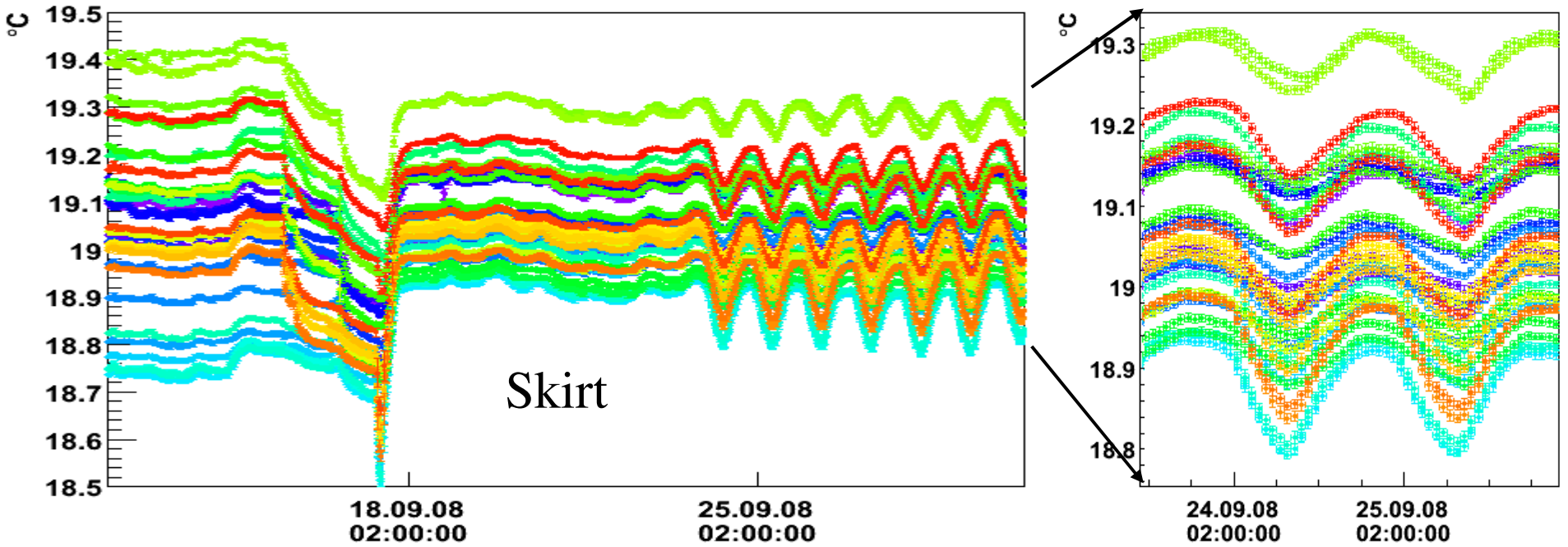
## Skirt temperatures

T measurements around the perimeter of the TPC, from top to bottom




variance about 0.1K

can be further improved by cooling adjustements and corrections

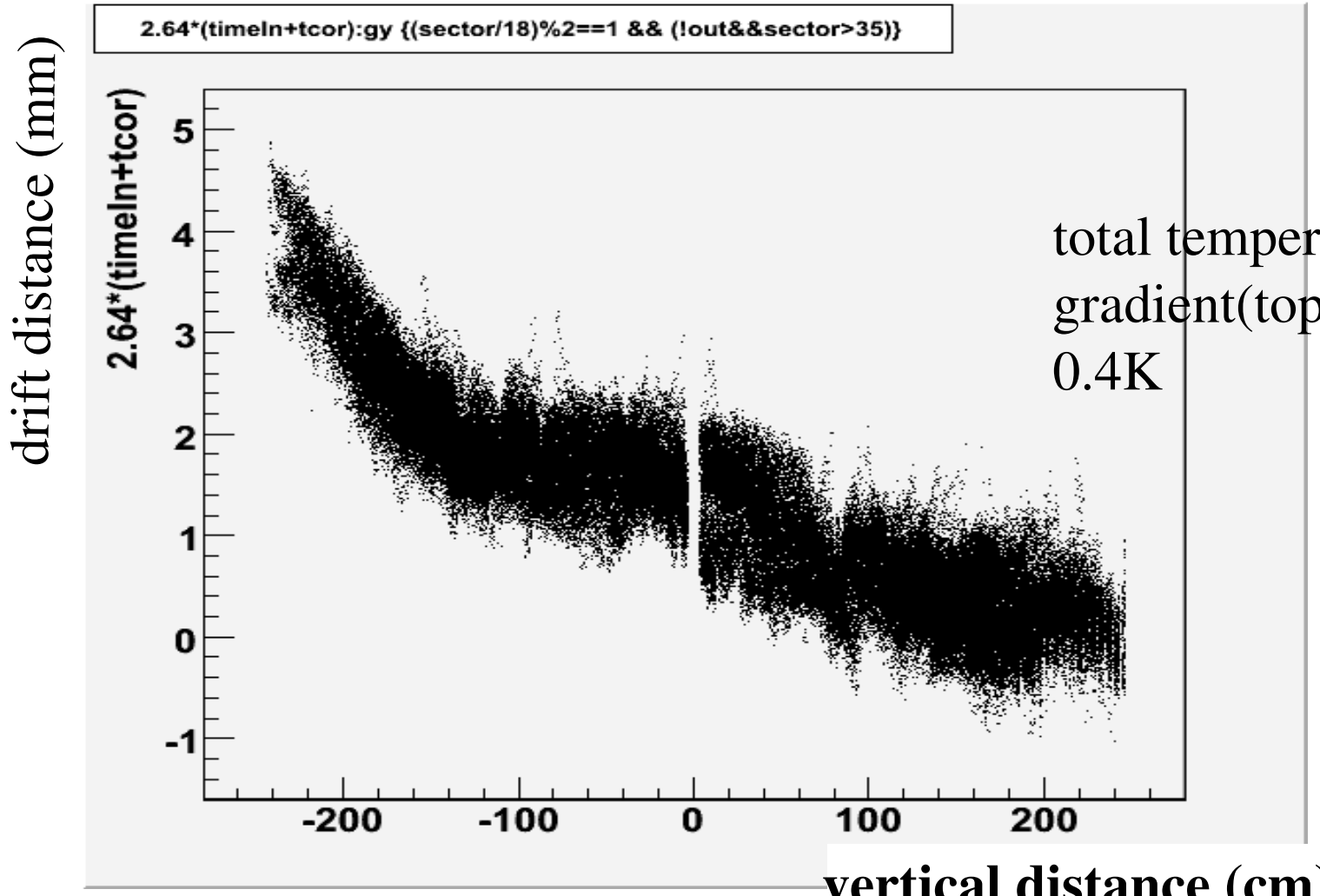



important to control overall heat sources in ALICE

oscillations:
TOF and TRD turned off periodically

Temperature stabilization by active cooling of ROC's

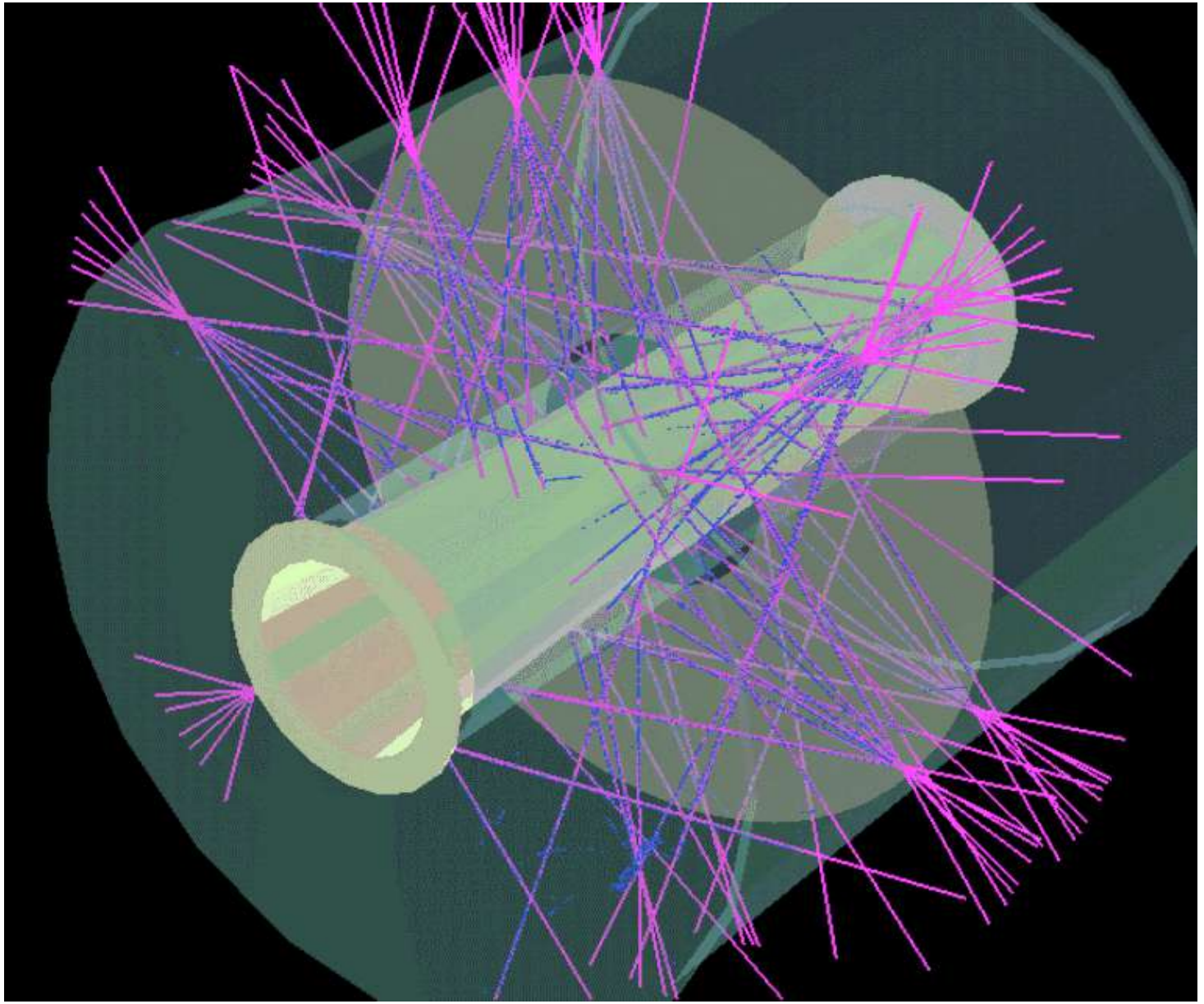
# Calibration of vertical temperature gradient



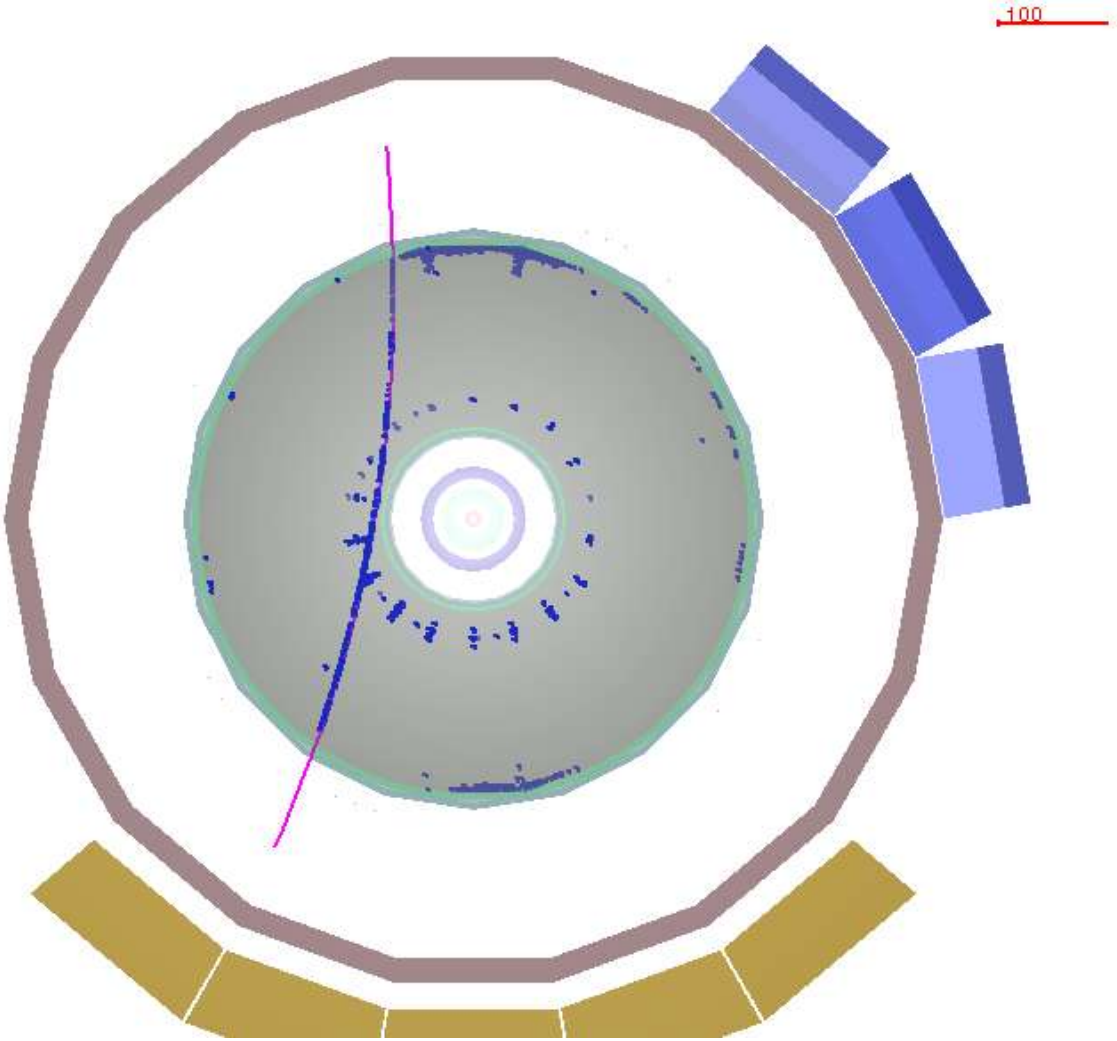

total temperature gradient(top-bottom) 0.4K

dependence of 'drift distance' for laser signal reflected from central electrode, correction accuray: 0.3 mm, corrected variance < 0.05K

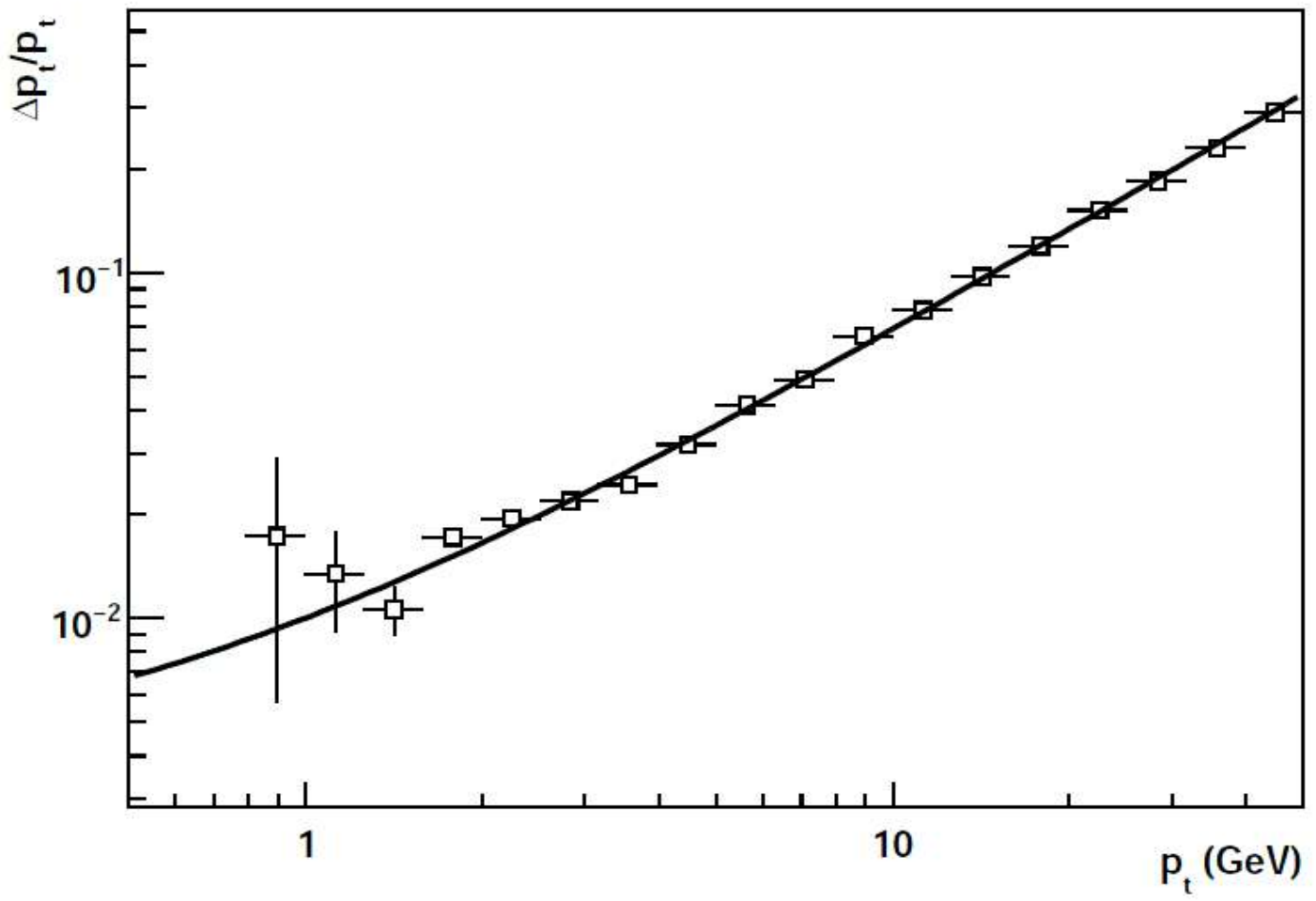
# a view of the 168 laser rays



# a muon track with B = 0.5 T



# momentum resolution from cosmic ray data



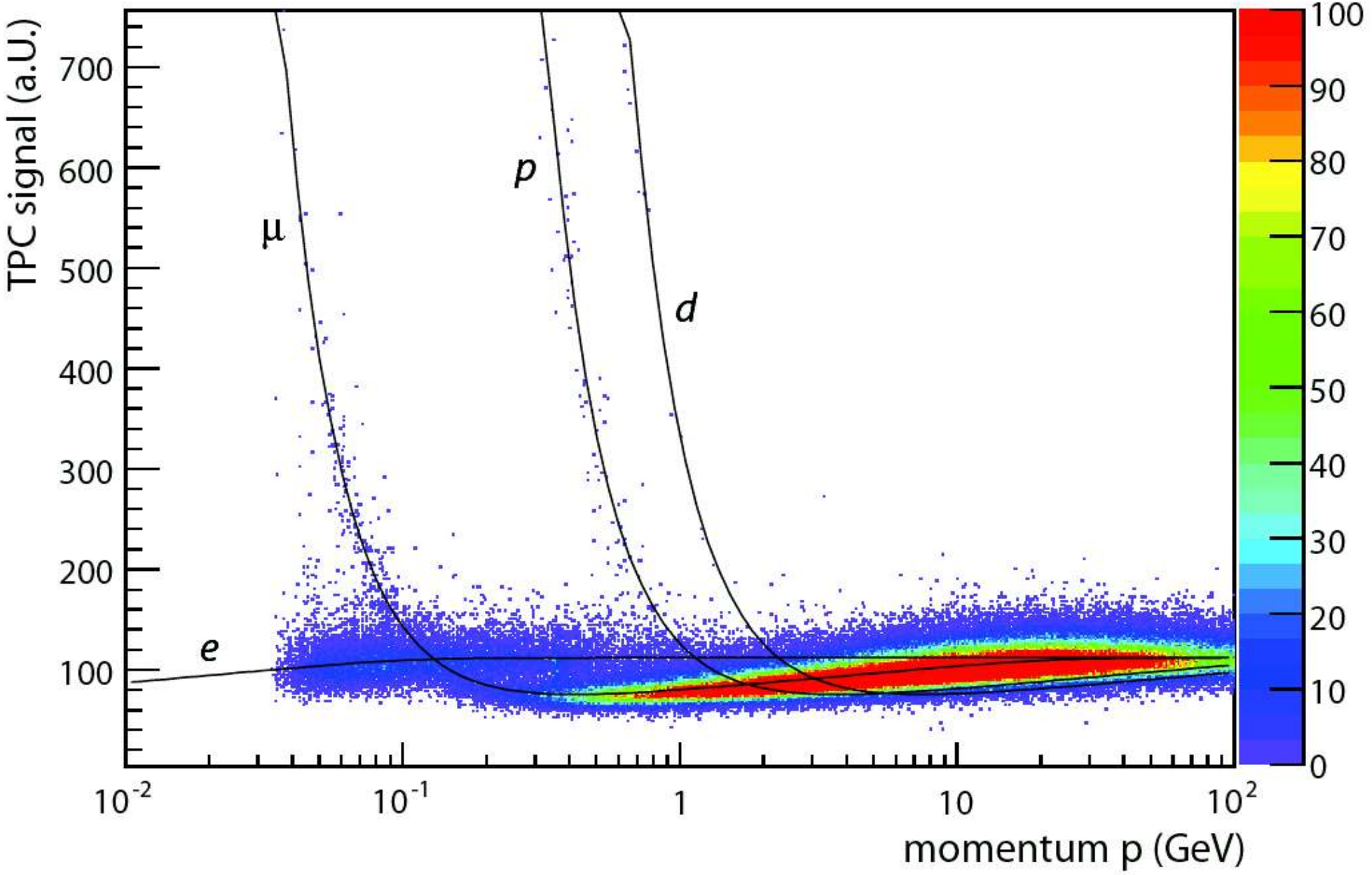

no correction yet for mis-alignment and temperature variations

dp/p = 2% at 2 GeV, 6 % at 10 GeV

**a first look at the dE/dx resolution  better than 5.5%**

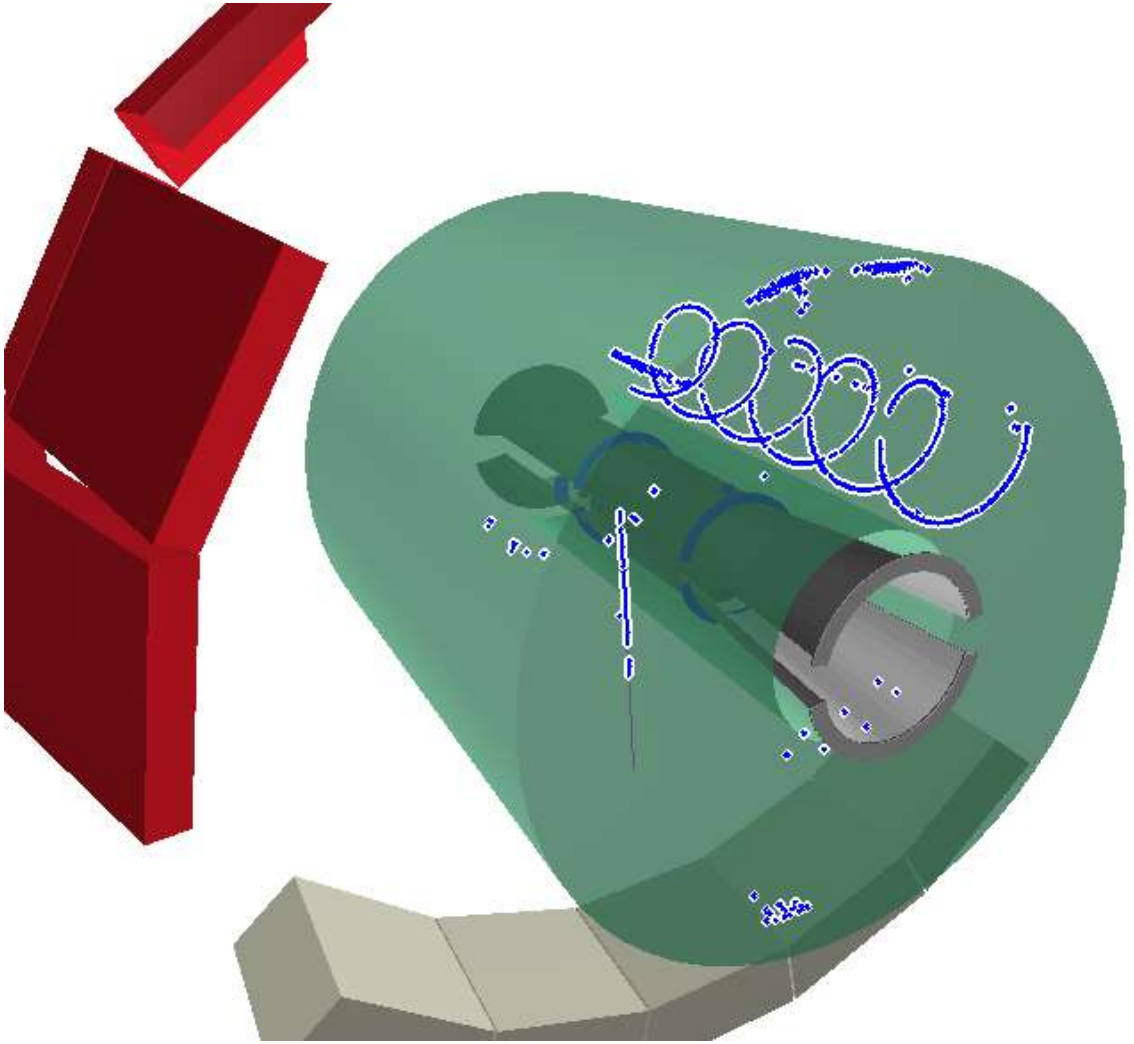
**close to theoretical limit**

'snow' due to pile-up of cosmic ray interactions, will be corrected

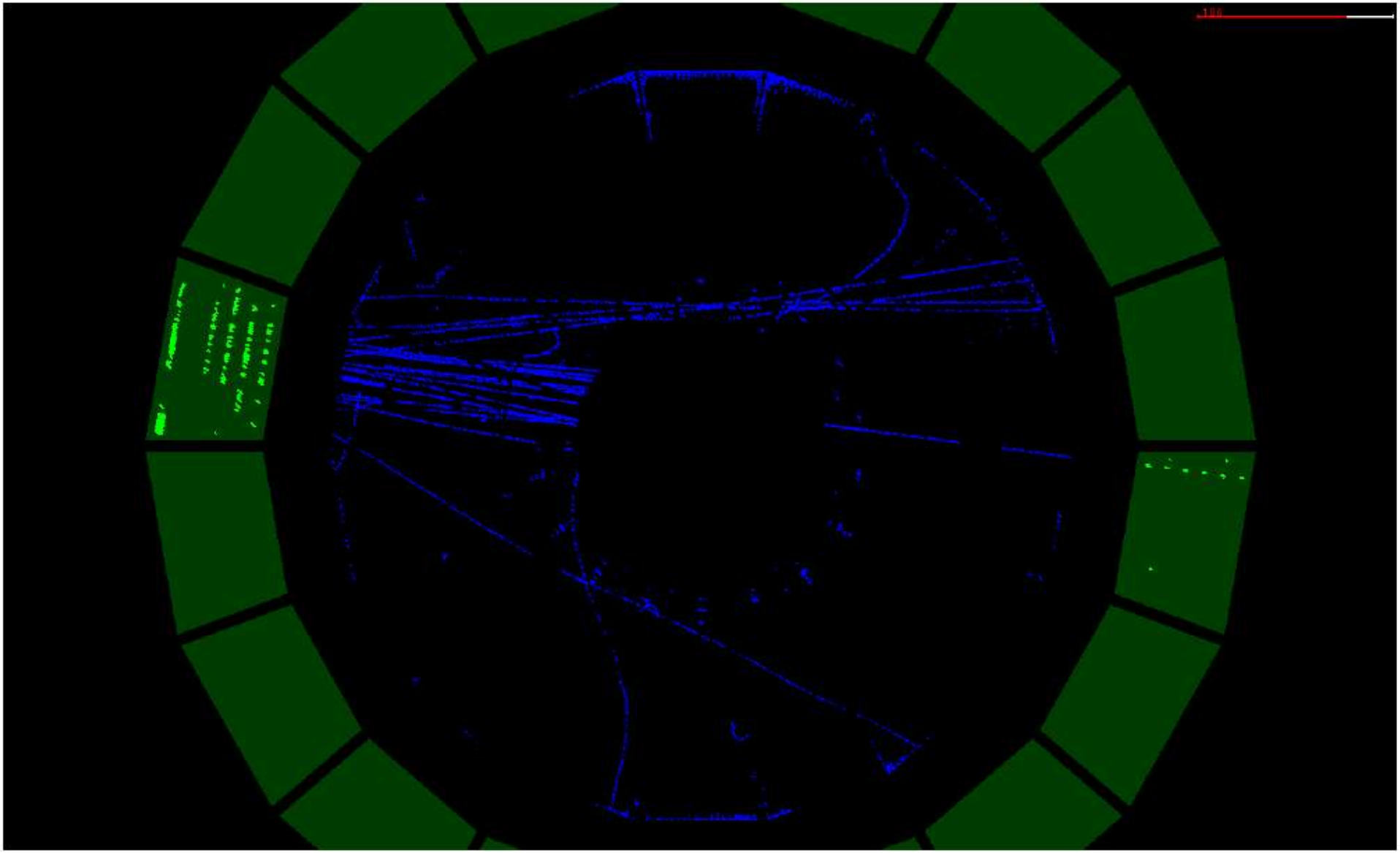


# A sample of cosmic ray events

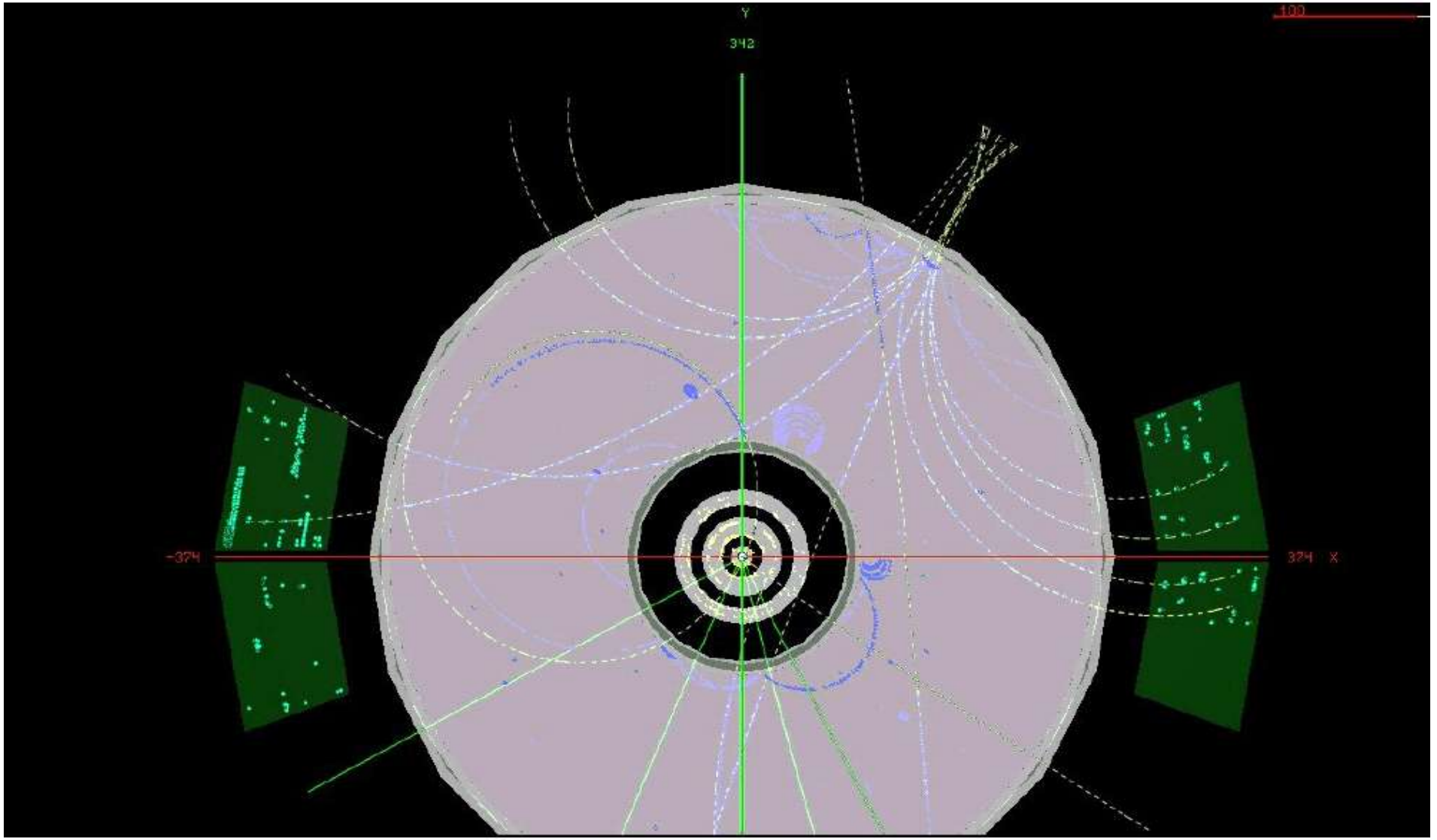
# a spiraling electron

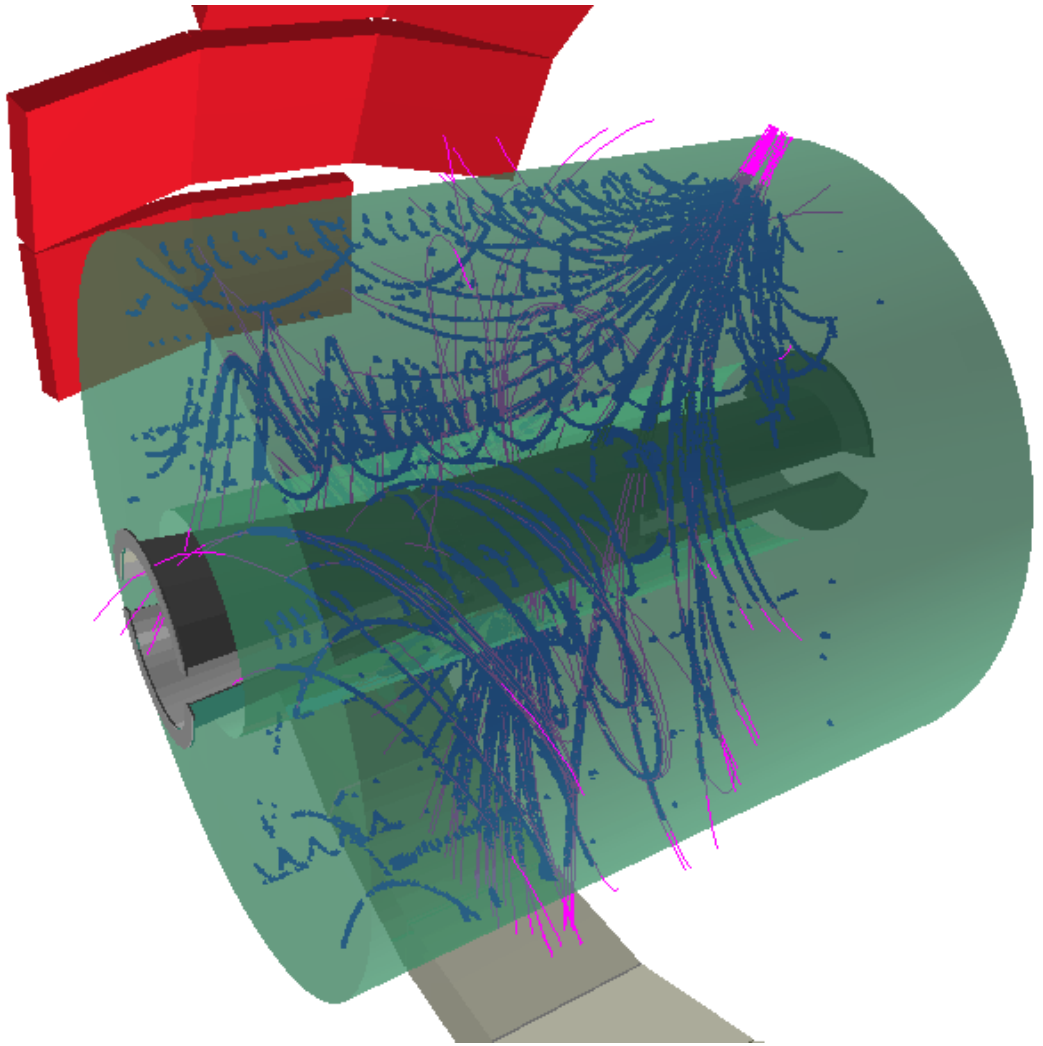


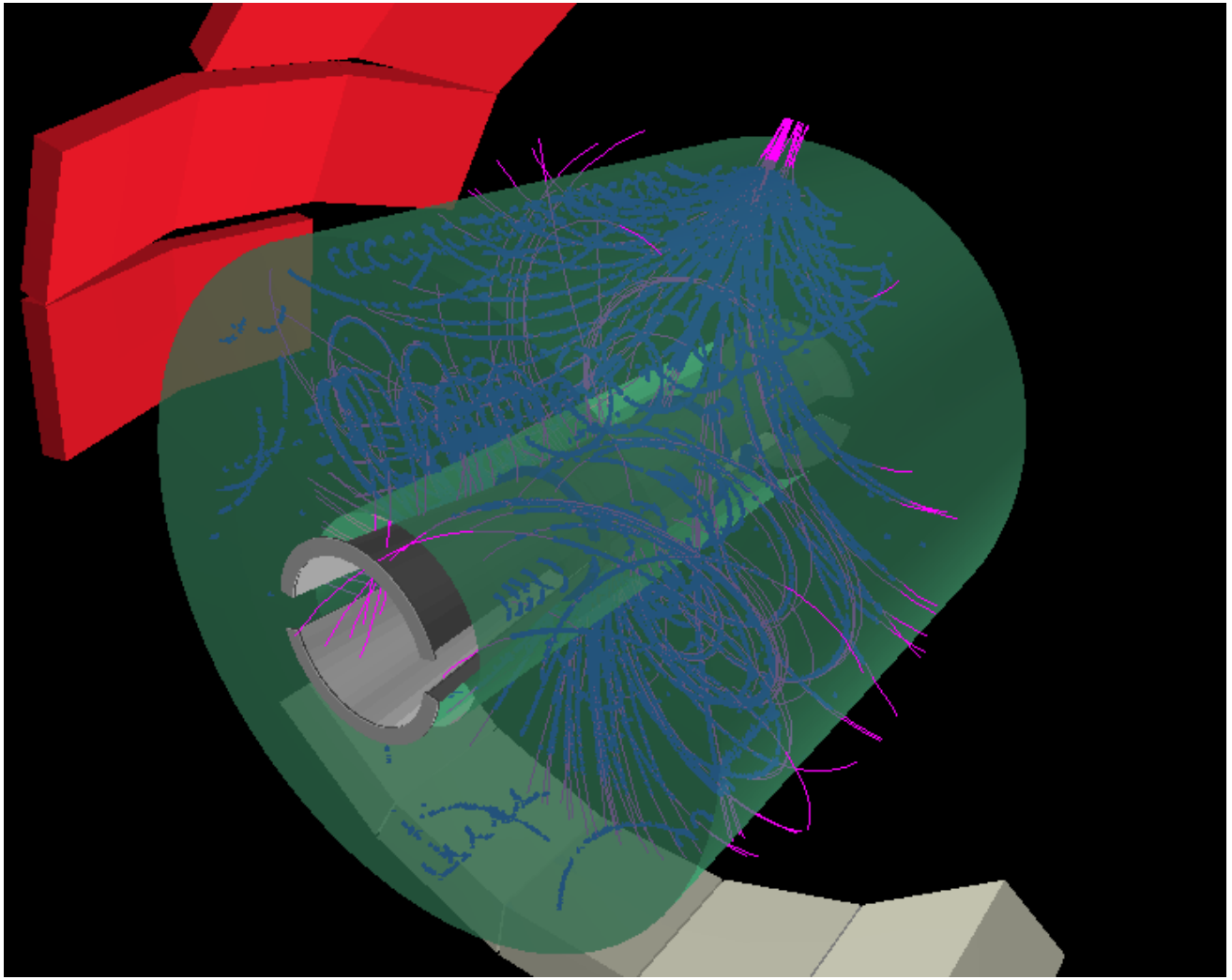
# cosmic ray induced shower, coincidene TRD and TPC



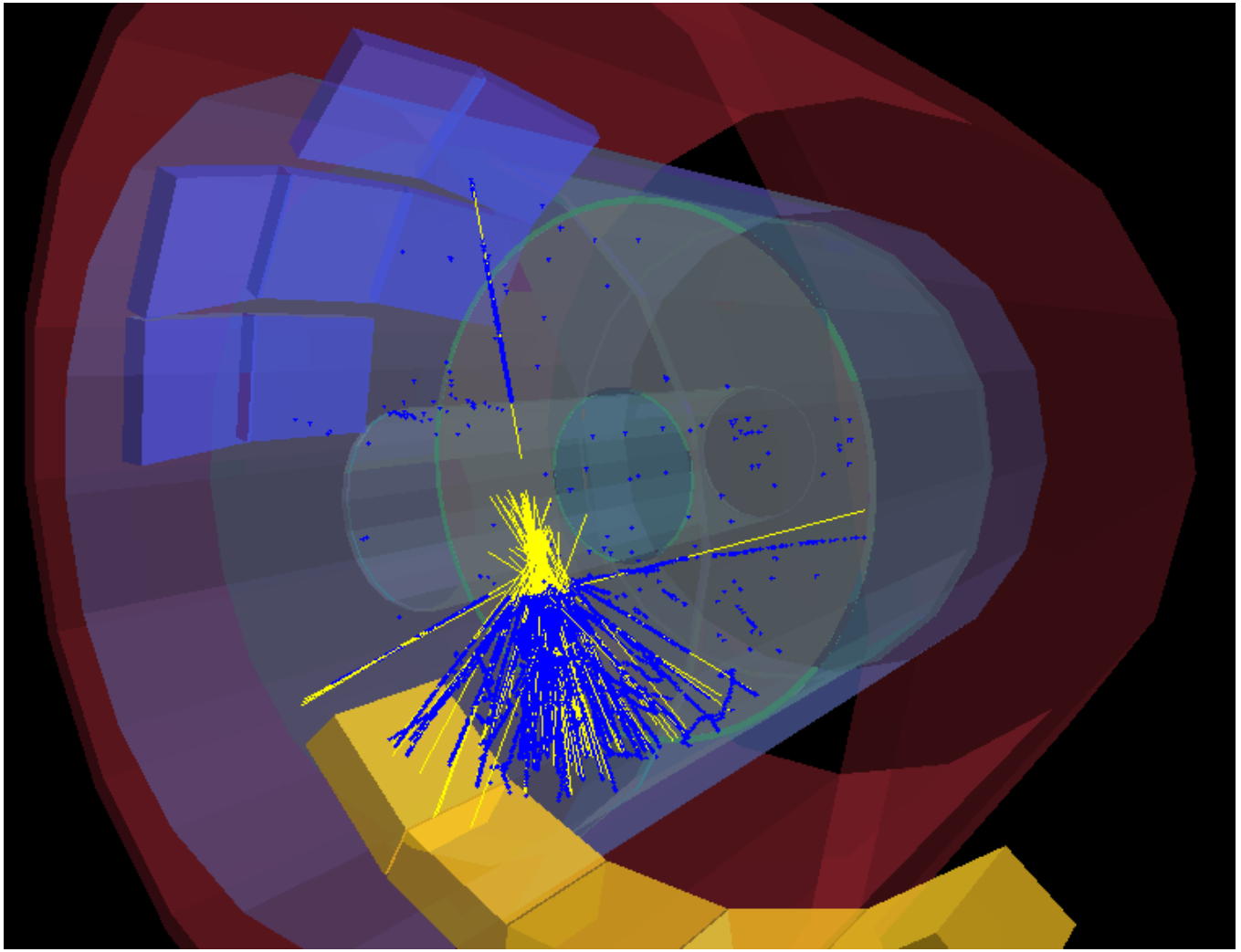
# Cosmic ray event with magnetic field on





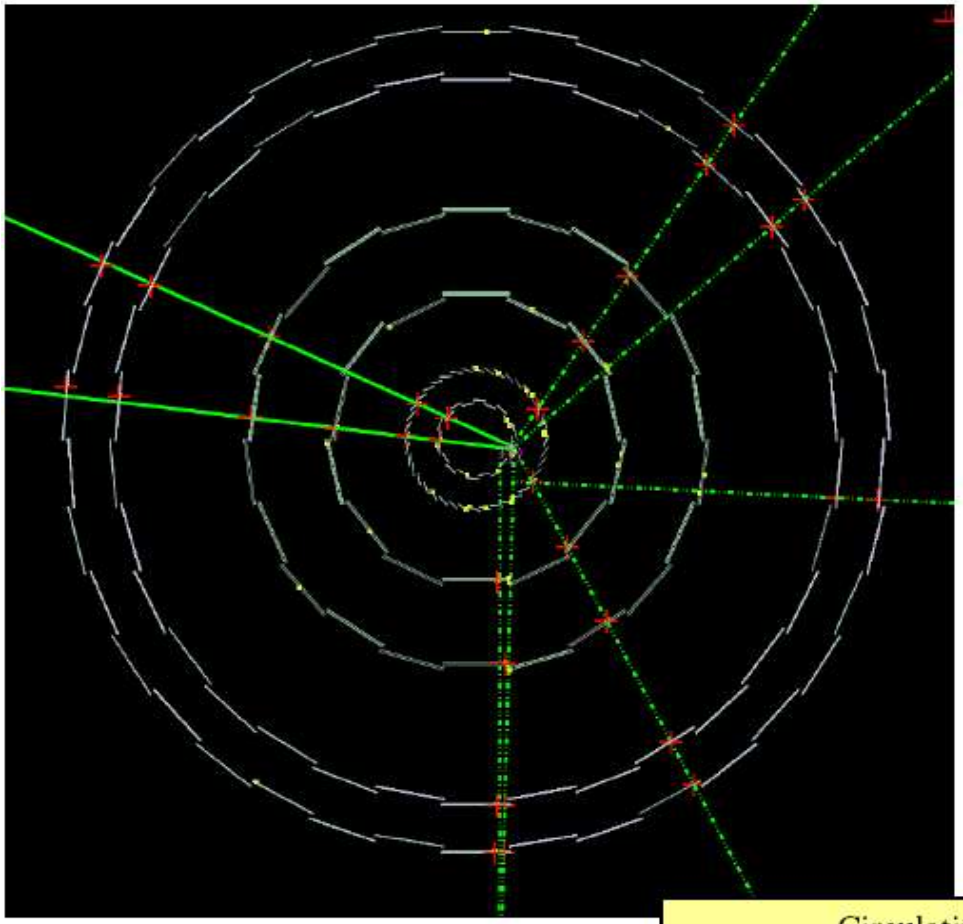


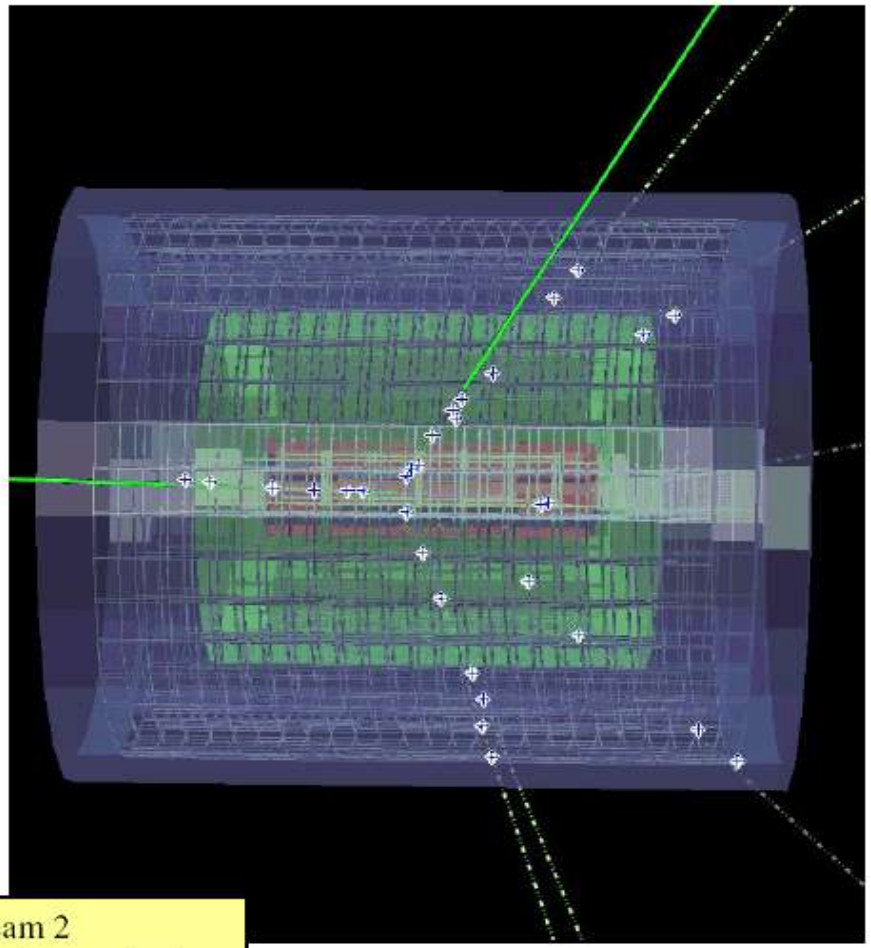
# TPC fully operational and ready to take data



a large cosmic shower in the muon absorber fully tracked

# First interactions on Sept 12





Circulating beam 2
stray particle causing an interaction in the ITS

# Some remarks concerning ALICE physics

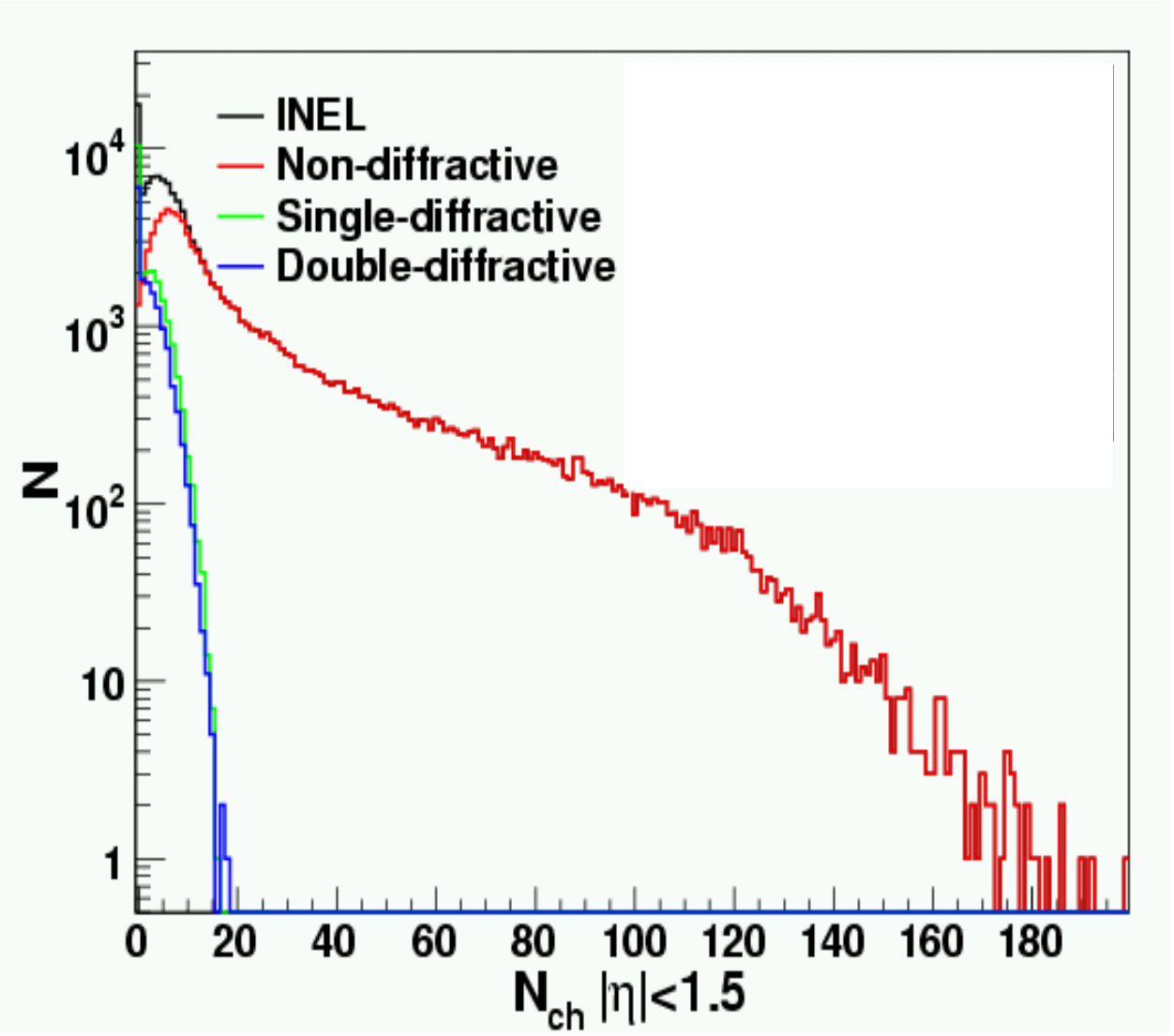
at 30 times increased cm energy
compared to RHIC
the LHC is
the ultimate machine for hard probes
and high multiplicities

# characterizing QGP matter at LHC

equation of state
number of degrees of freedom
transport coefficients (viscosity etc)
velocity of sound
parton energy loss and opacity
susceptibilities
deconfinement

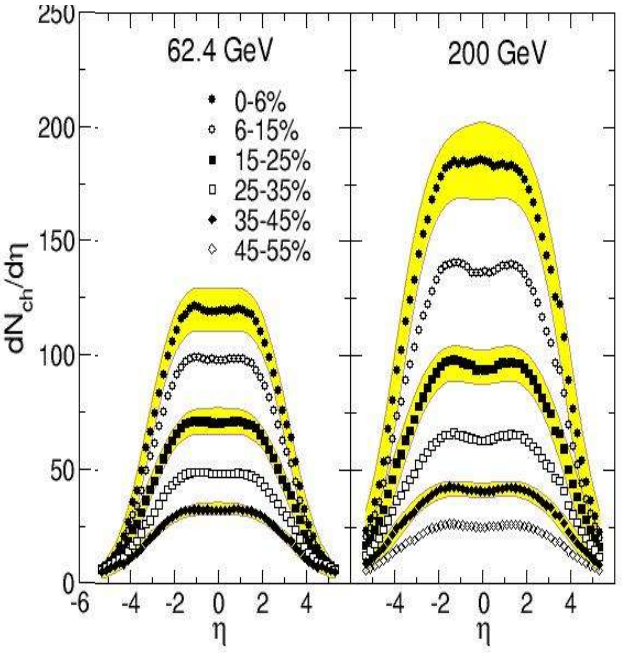
but, foremost, look for the unexpected

# multiplicity distribution of pp collisions at LHC energy

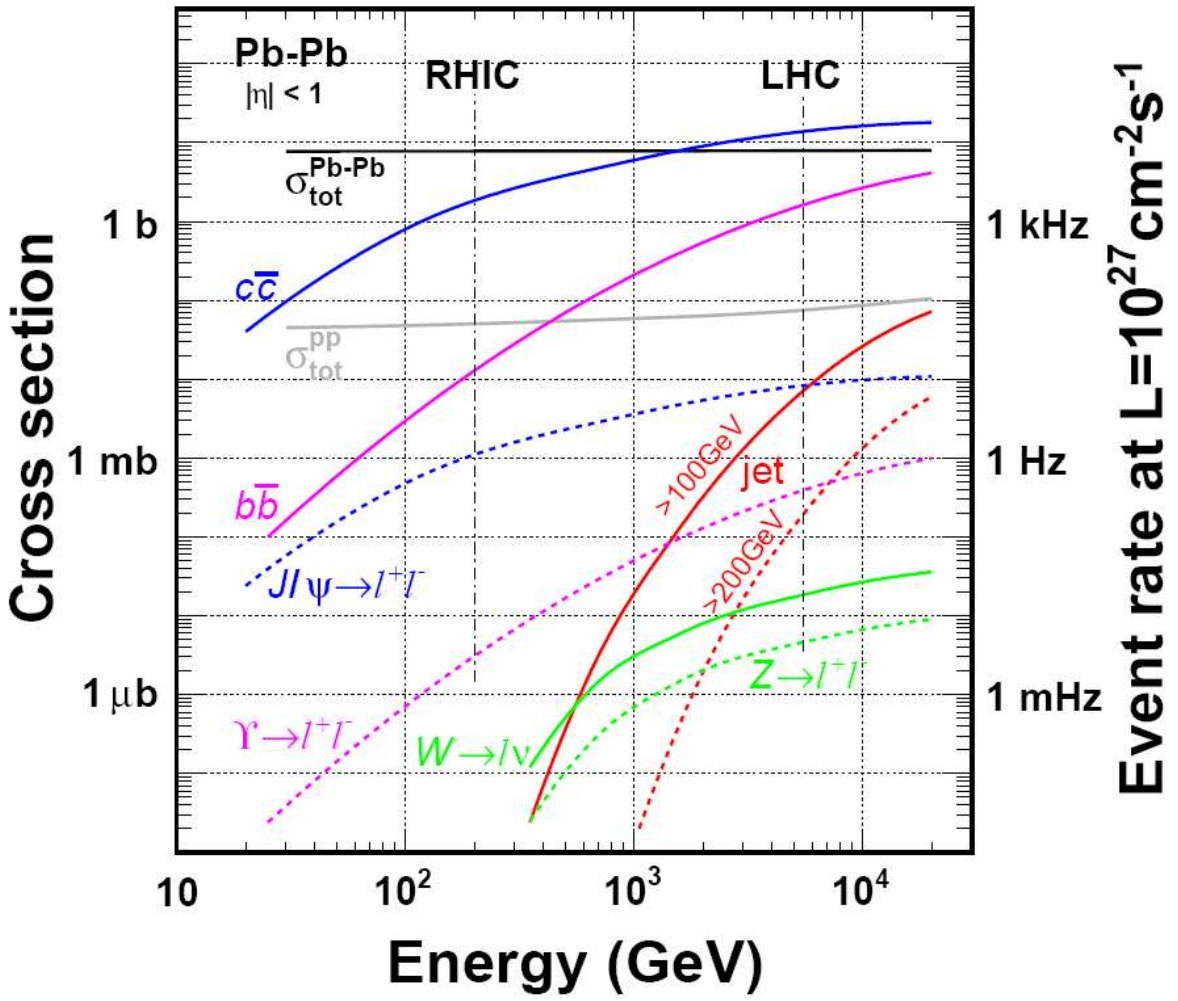



high multiplicity
pp at LHC
is similar to

Cu-Cu at RHIC



# LHC: Cross-sections and Rates

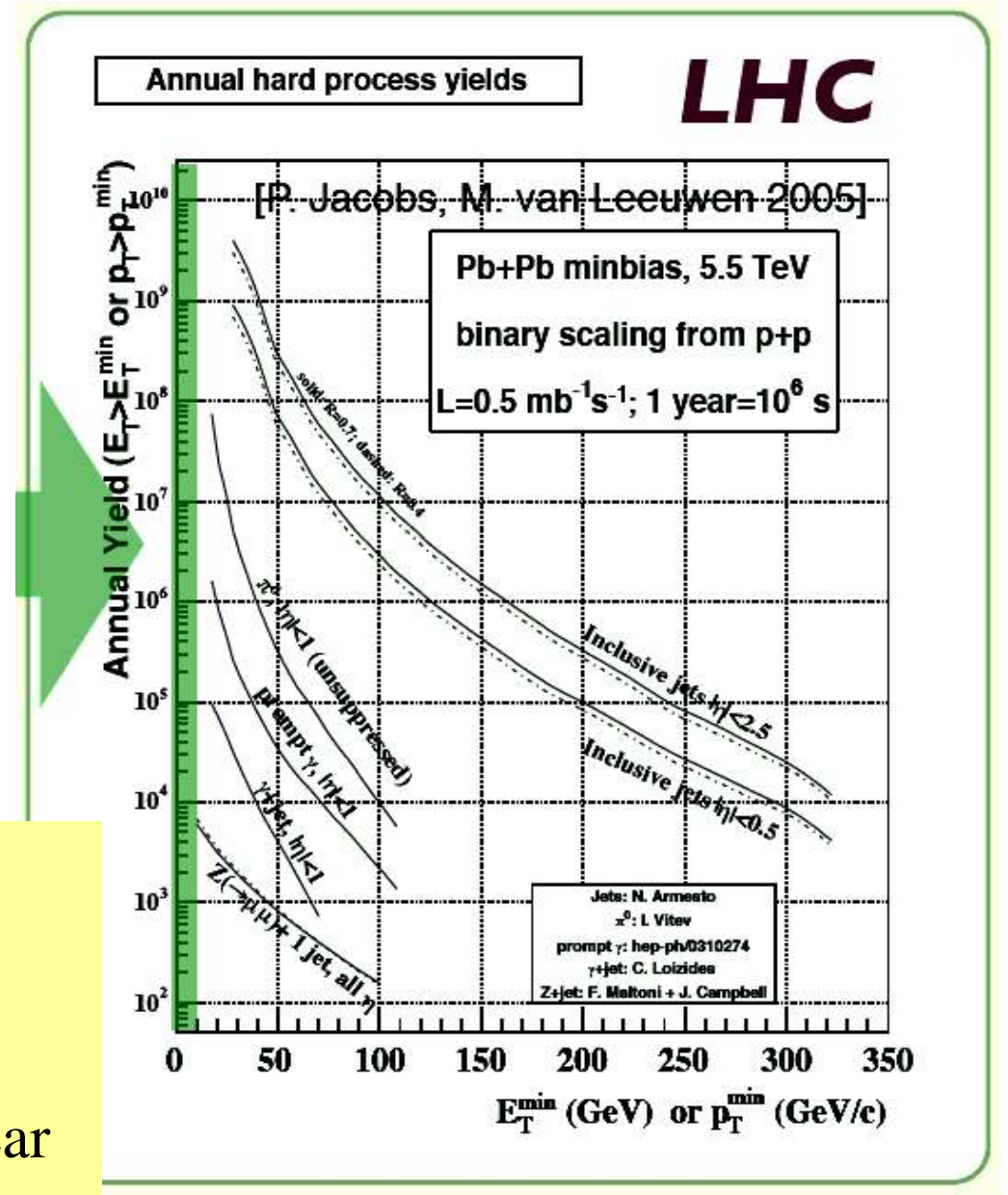



Cross-sections of interesting probes expected to increase by factors of

- ~ 10 ( cc ) to
- ~ $10^2$ ( bb ) to
- ~ > $10^5$ (very high $p_T$ jets)

# the ultimate hard probes machine

covered
at RHIC




> $10^4$ jets with
$E_T$ > 150 GeV
in one ALICE year

# a new era for heavy quark production studies

up to 100 charm quarks in one Pb-Pb collision

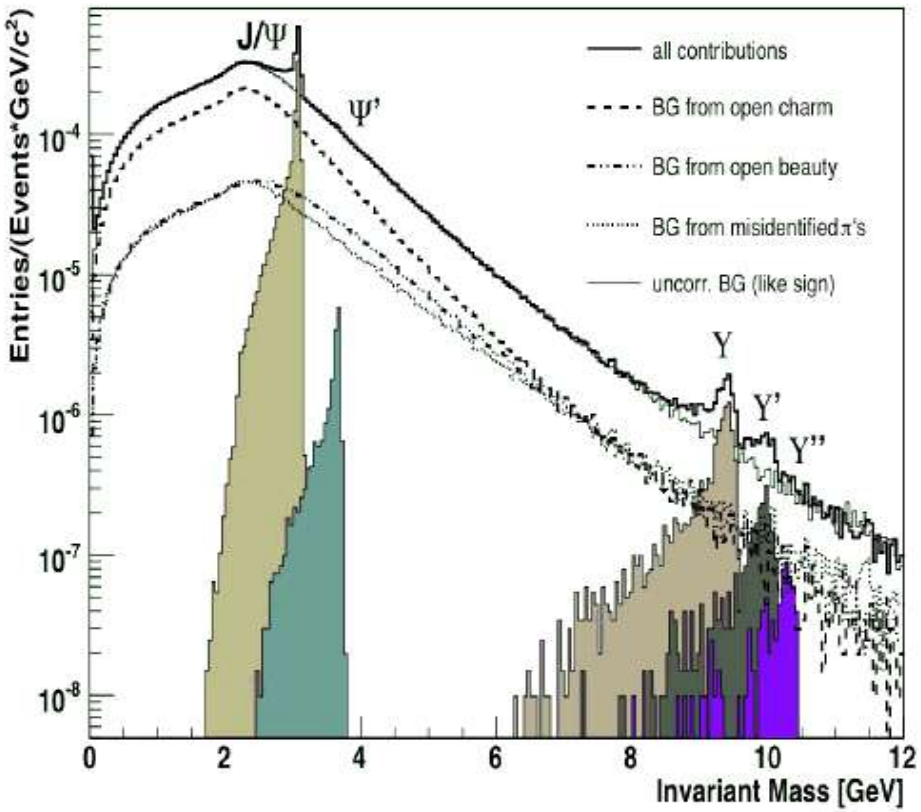
studies of c- and b-quark tagged jets

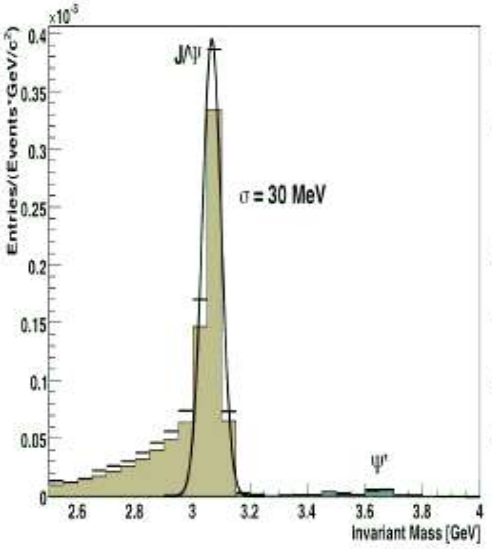
energy loss of heavy quarks

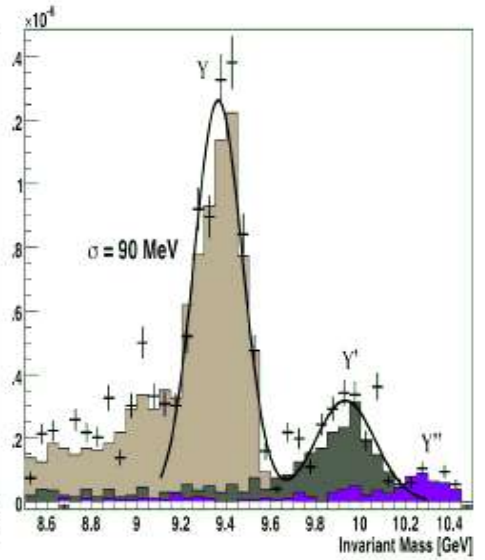
charmonium and bottomonium studies

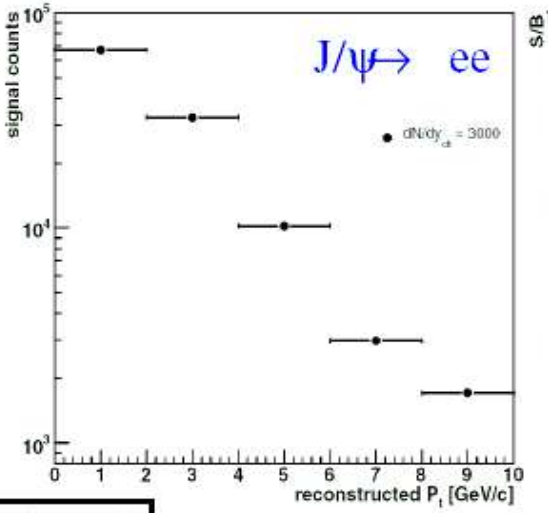
# charmonium measurement in ALICE

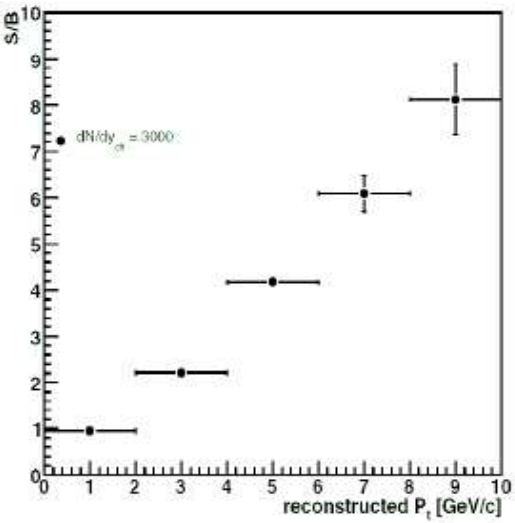
electron identification with TPC and TRD




Simulation: W. Sommer (Frankfurt) $2 \cdot 10^8$ central PbPb coll.

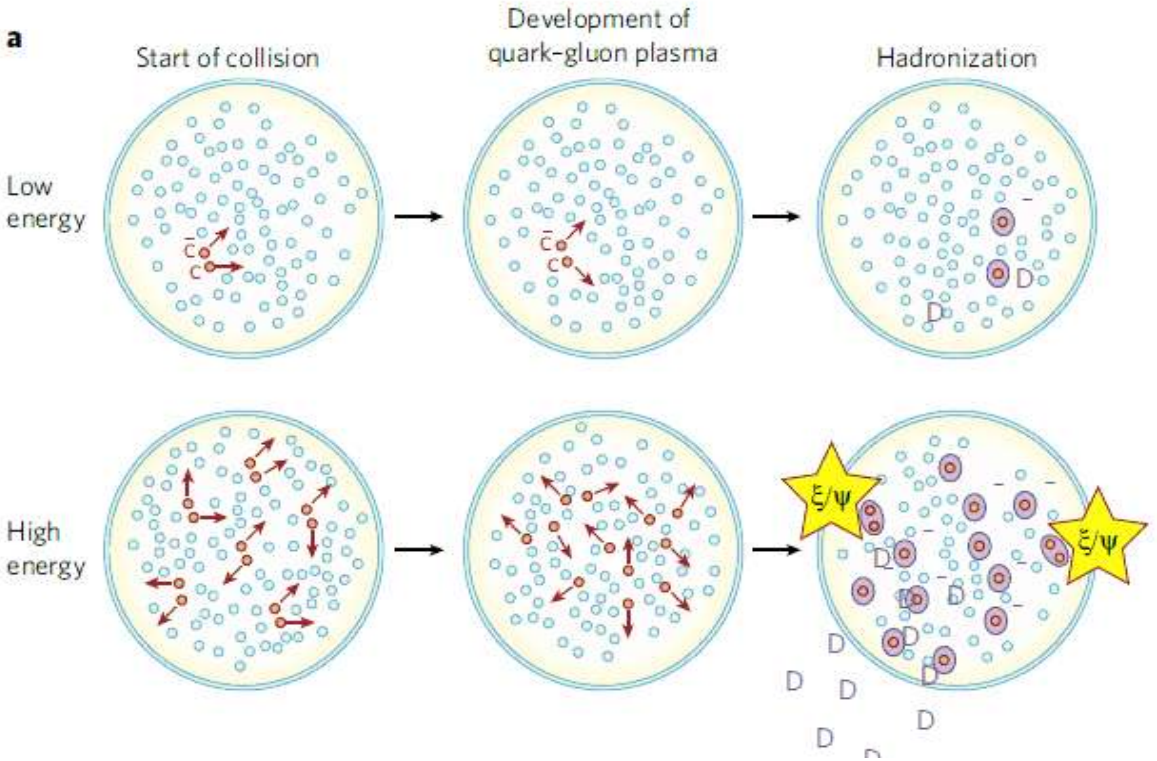
# Quarkonium as a probe for deconfinement at the LHC

at hadronization of QGP
J/ψ can form again
from deconfined quarks,
in particular if number of
ccbar pairs is large

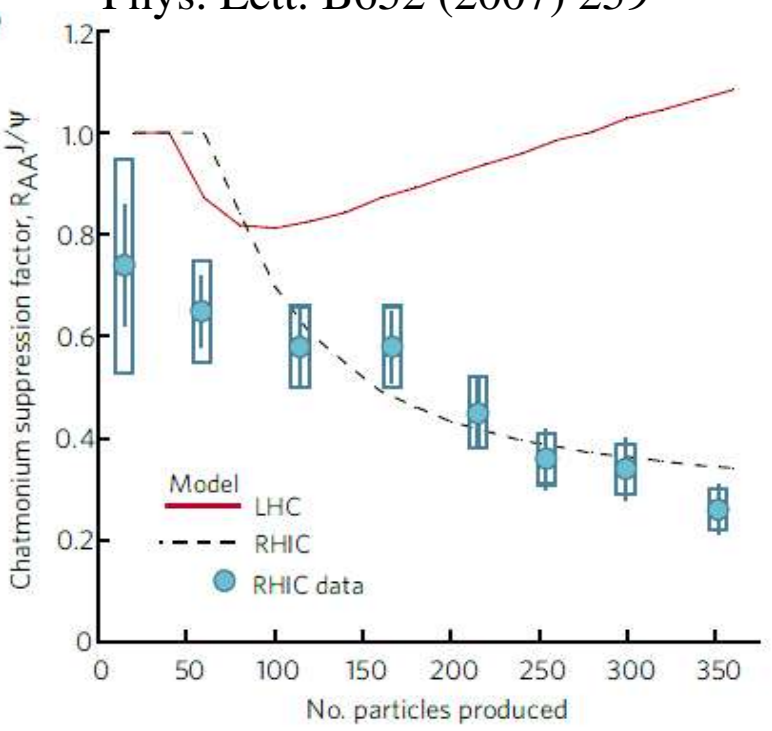
$N_{J/\psi} \propto N_{c\bar{c}}^{2}$

(P. Braun-Munzinger and
J.Stachel, PLB490 (2000) 196)

charmonium enhancement as fingerprint of deconfinement at LHC energy




Andronic et al.,
Phys. Lett. B652 (2007) 259



after nearly ten years of construction,
ALICE is ready for beam

both Hans Gutbrod and Reinhard Stock made important contributions in the initial phase of the experiment

next six months: calibration,consolidation and completion of detectors, including TRD, HLT and ALICE Tier2 at GSI

**we look forward to exciting times**