Gain Calibration of the ALICE TRD using the Decay of ^{83m}Kr by Internal Conversion

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TRDs for the third Millennium - September 14, 2011

BMBF Forschungsschwerpunkt ALICE Experiment 201

ALICE

HELMHOLTZ GEMEINSCHAFT

Outline

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4. Experimental Setup & Data Taking
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   - Correlations between Gain and High Voltage
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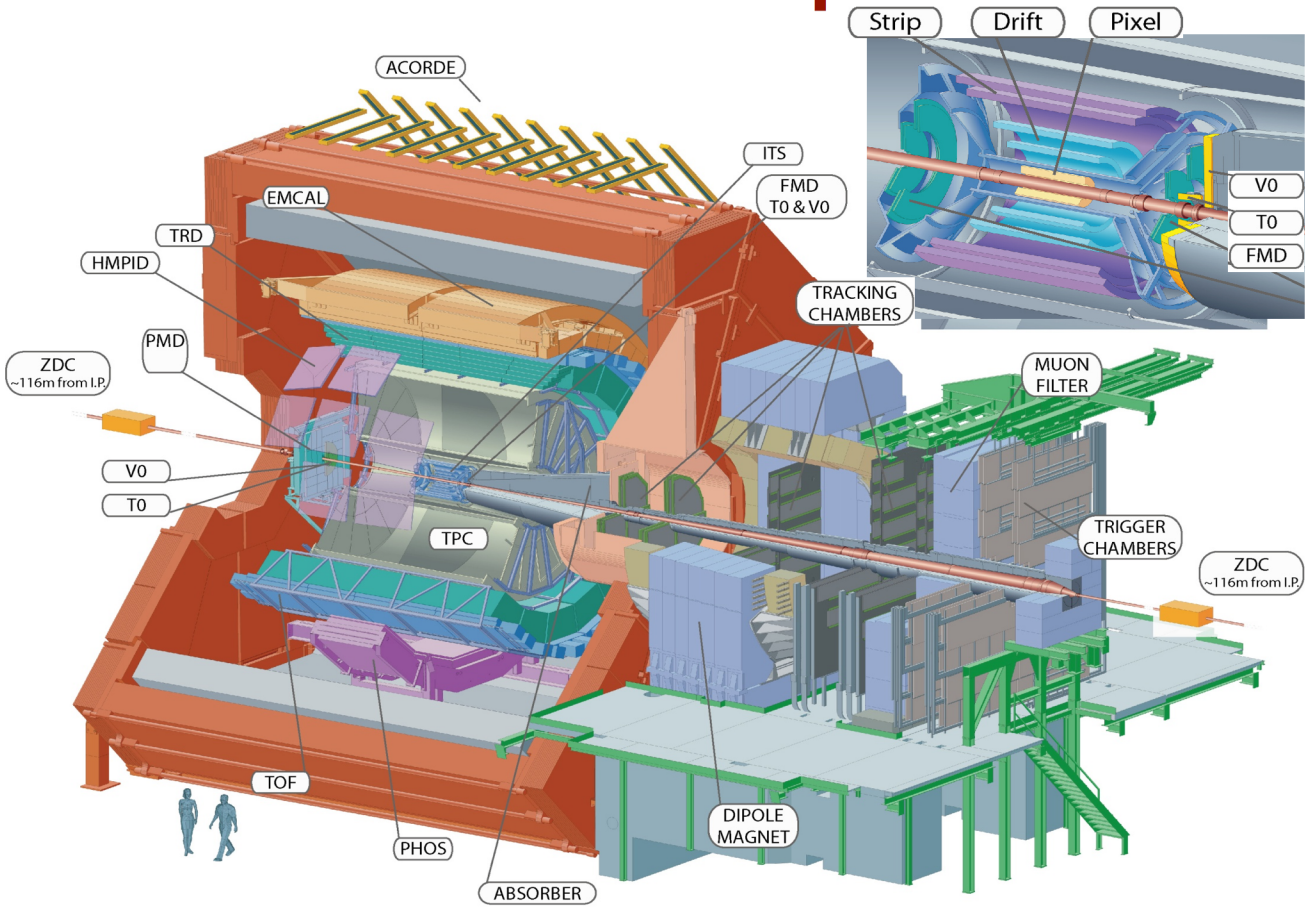
Motivation

- ALICE studies strongly interacting matter at extreme energy densities in high-energy nuclear collisions
- ALICE's transition radiation detector (TRD) provides:
  - Track reconstruction of charged particles
  - e^-/e^+ identification
  - Fast trigger (7 μs; see Jochen Klein's talk)
    → 2 μs drift + online tracking and particle identification
- Particle identification demands gain uniformity of Δ_{Gain}<1% (10% rel. change in Pion suppression)
- Information on particle's mean energy loss essential
  - Gain fluctuations with…
    … Chamber geometry
    … Pad-by-pad variations

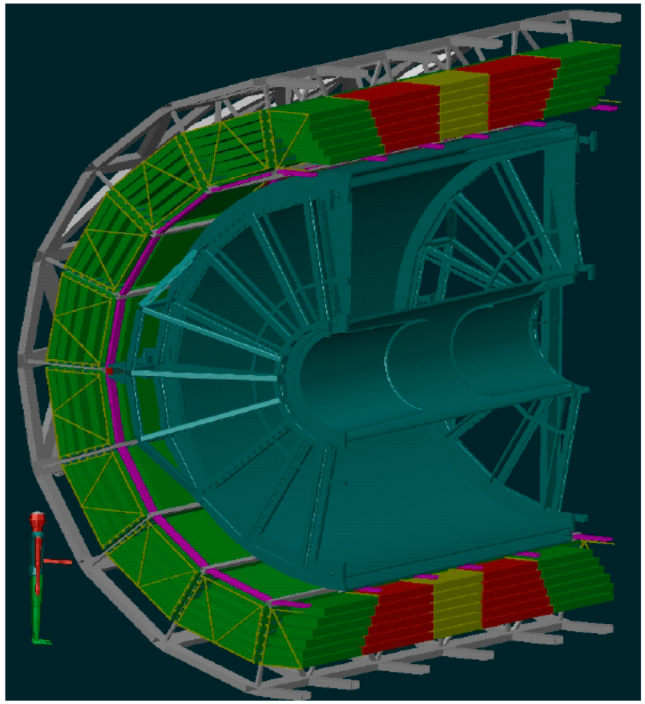
The ALICE Experiment



- 18 subsystems
- 16 x 16 x 26 m
- 10.000 tons

- TPC+ITS+TRD: 645 million pixel
- Readout: 17.5 TB/s
  - PbPb: 1.2 GB/s to tape
  - pp: 100 MB/s to tape

The ALICE TRD



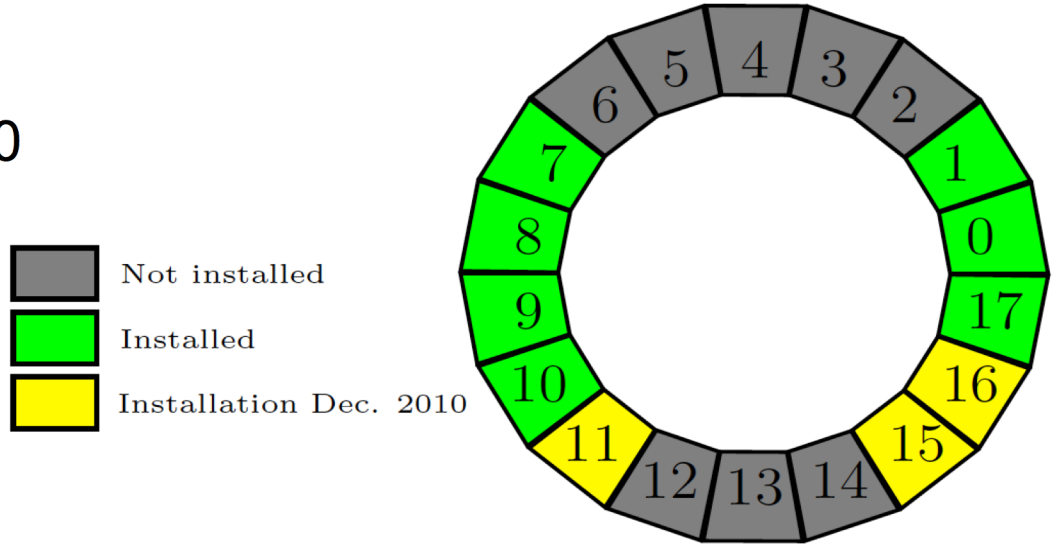
- 18 super modules
- 522 TRD chambers
- 5 stacks along z-axis
- 6 layers covering 2.9 < r < 3.7 m
- -0.9 < η < 0.9 (7 m long)
- 1.15 million readout pads

At present:

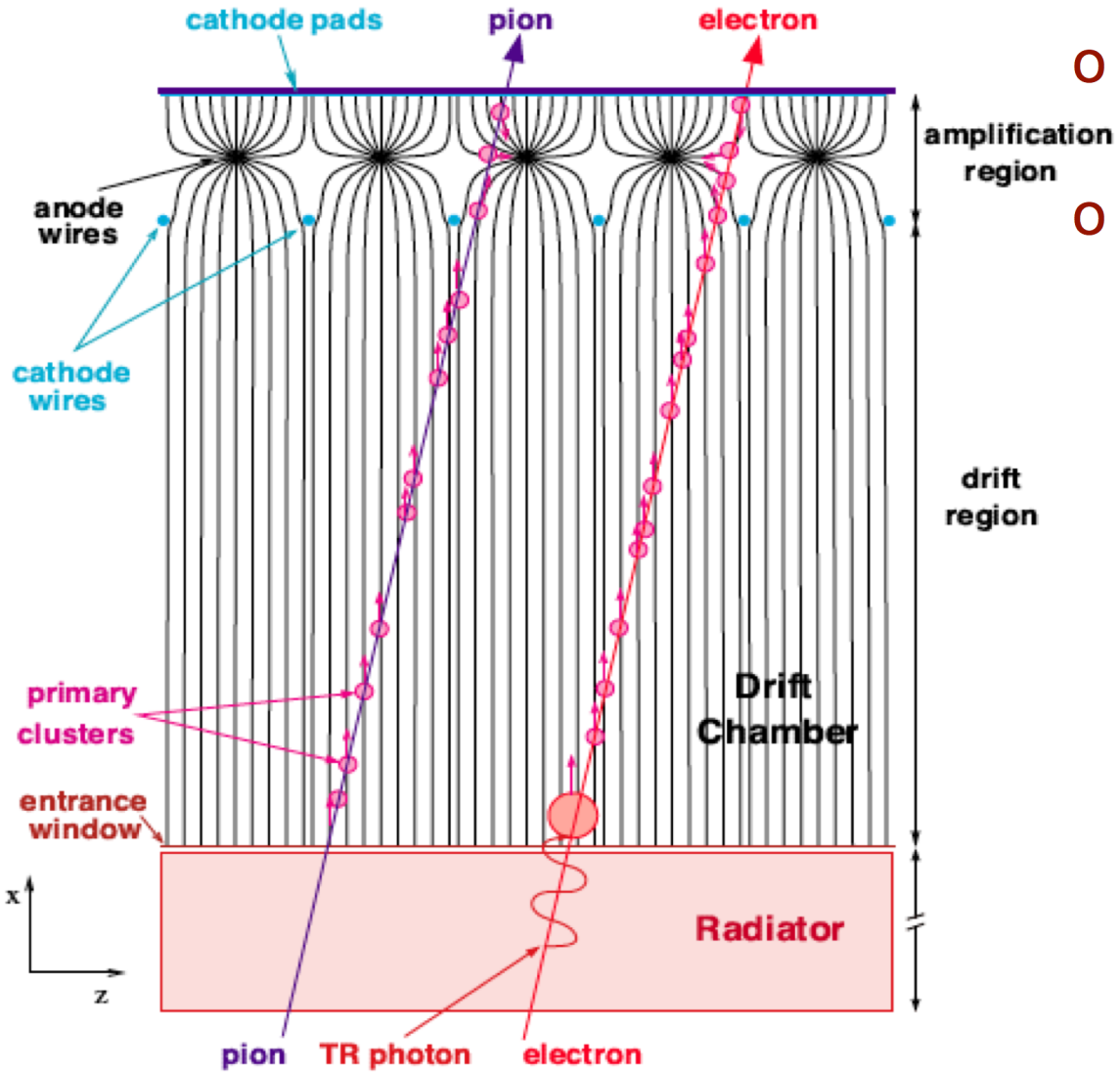
- 7 super modules installed before 2010
- 3 new super modules installed in December 2010

Near Future:

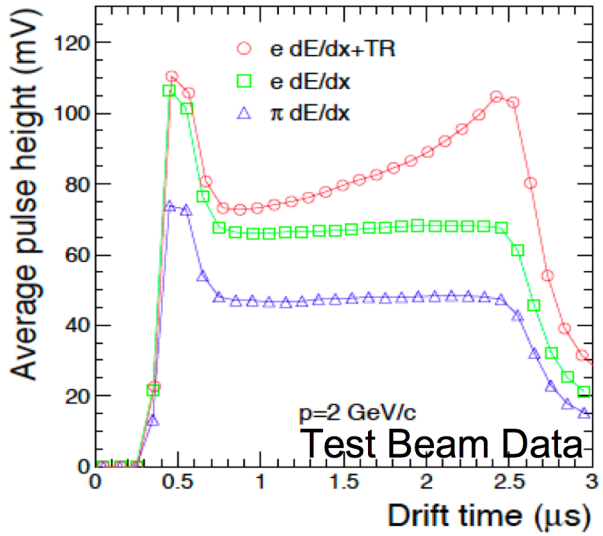
- Installation of 4 super modules during this winter shutdown



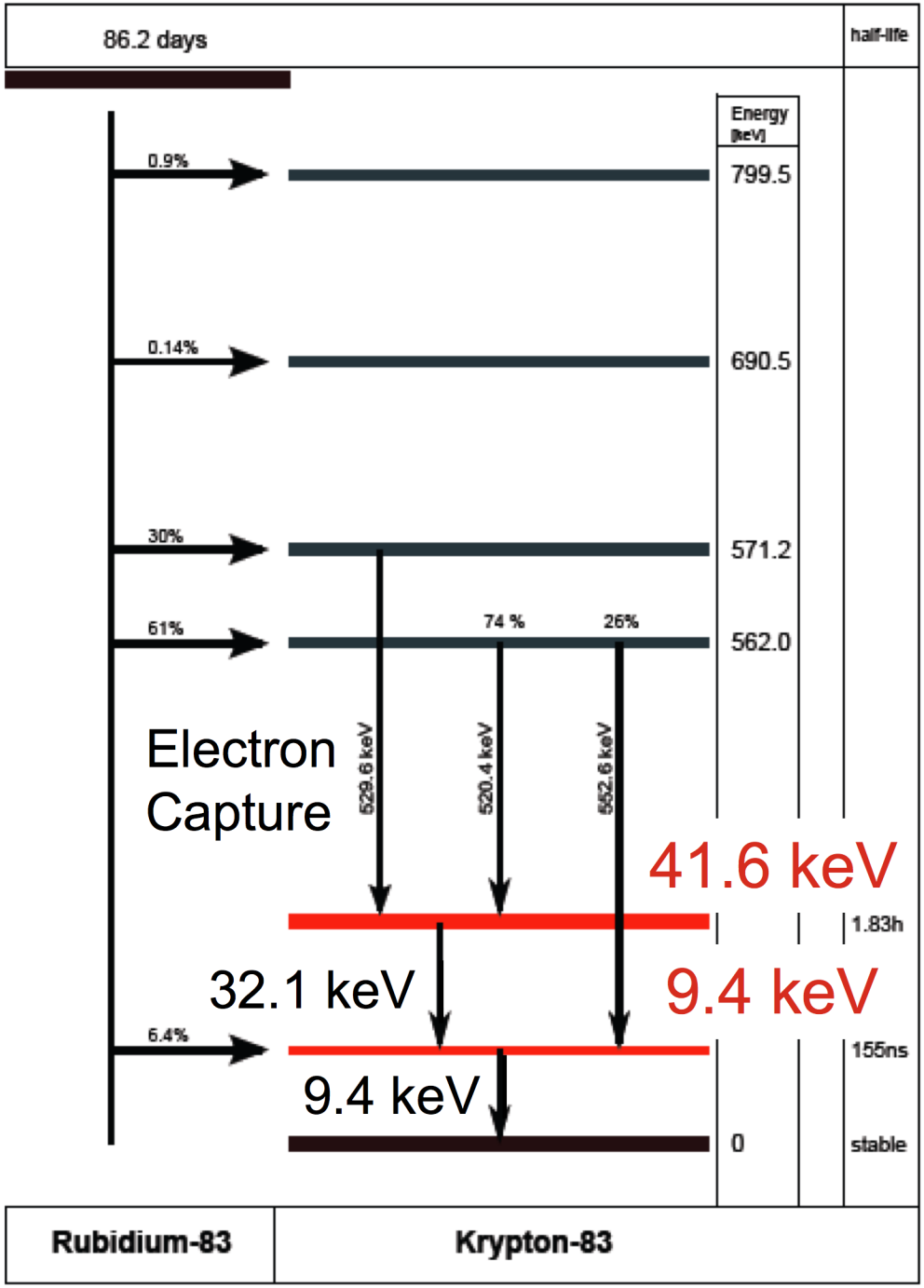
The TRD Chamber



- **Radiator**
  - Rohacell foam + glass fiber
- **Multiwire proportional chamber**
  - Operated at 1530V
  - Gas gain of ~3250
  - Xe-CO_2 [85-15]

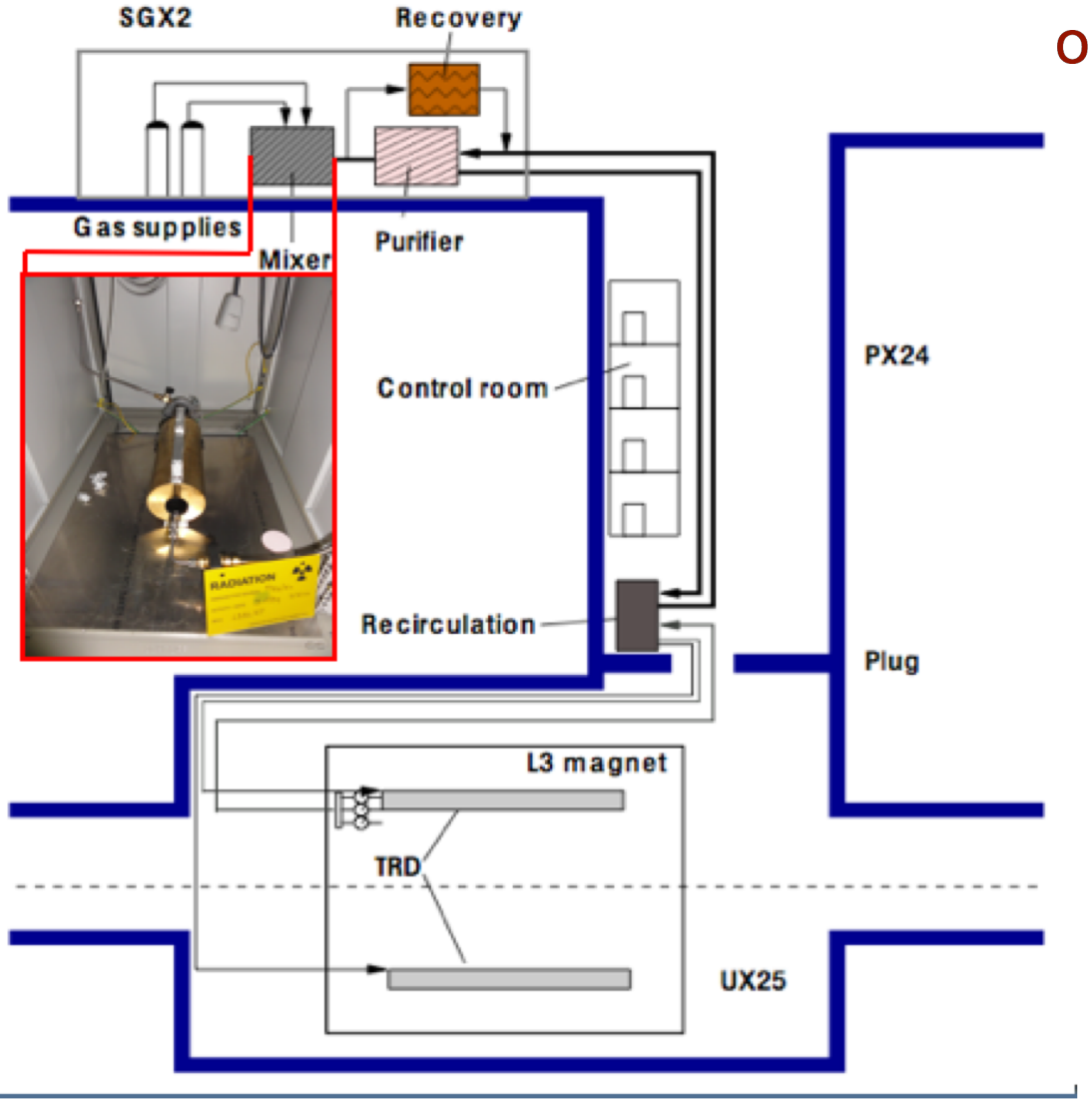


The ^{83m}Kr-Decay for Calibration



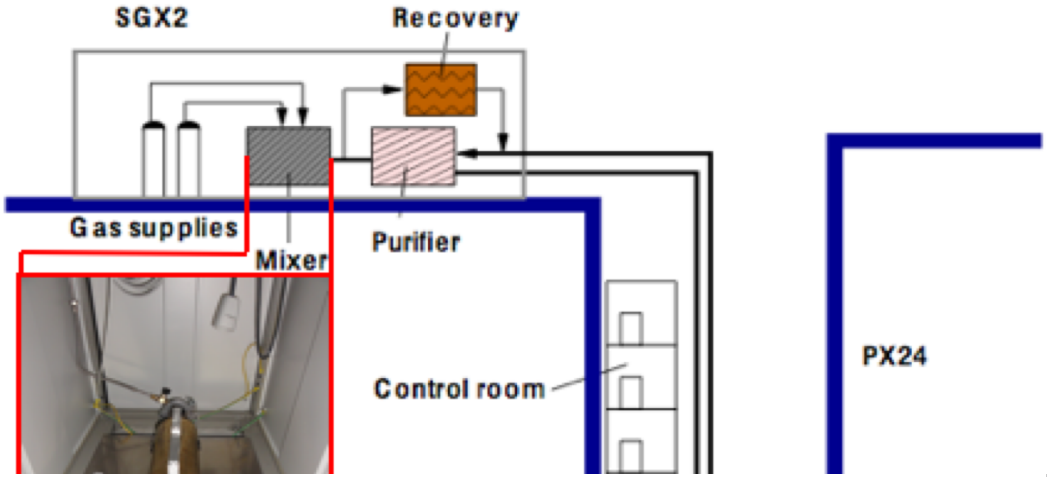
- ^{83m}Kr-Decay by internal conversion ideal candidate
  - $t_{1/2}$=1.83 h
  - Covers same energy range as minimum ionizing particles in Xe-CO_2 [85-15]
- 75.14%: $^{83}{}_{37}$Rb decays via electron capture into ^{83m}Kr
- Most prominent: Cascade decay of 41.56 keV and 9.41 keV levels
- ^{83}Rb-source can be simply (dis-)connected to gas flow
- About 3 half-lives after disconnection: Almost no activity left within active gas volume

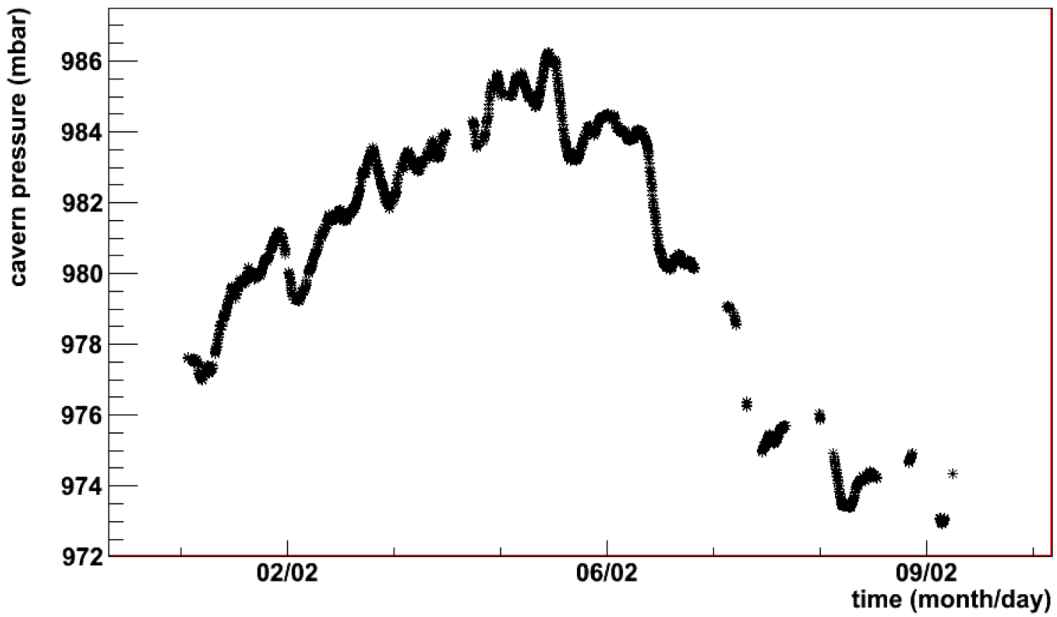
Experimental Setup & Data Taking



- Data taking between Feb. 2 and 10, 2011
  - 134 runs ≈ 2.3×10^8 Kr decays with HV=+1530V (Gain≈3250)
  - 13 runs with HV=+1490V (Gain≈2260)
  - 6 runs with HV=+1450V (Gain≈1570)

Experimental Setup & Data Taking





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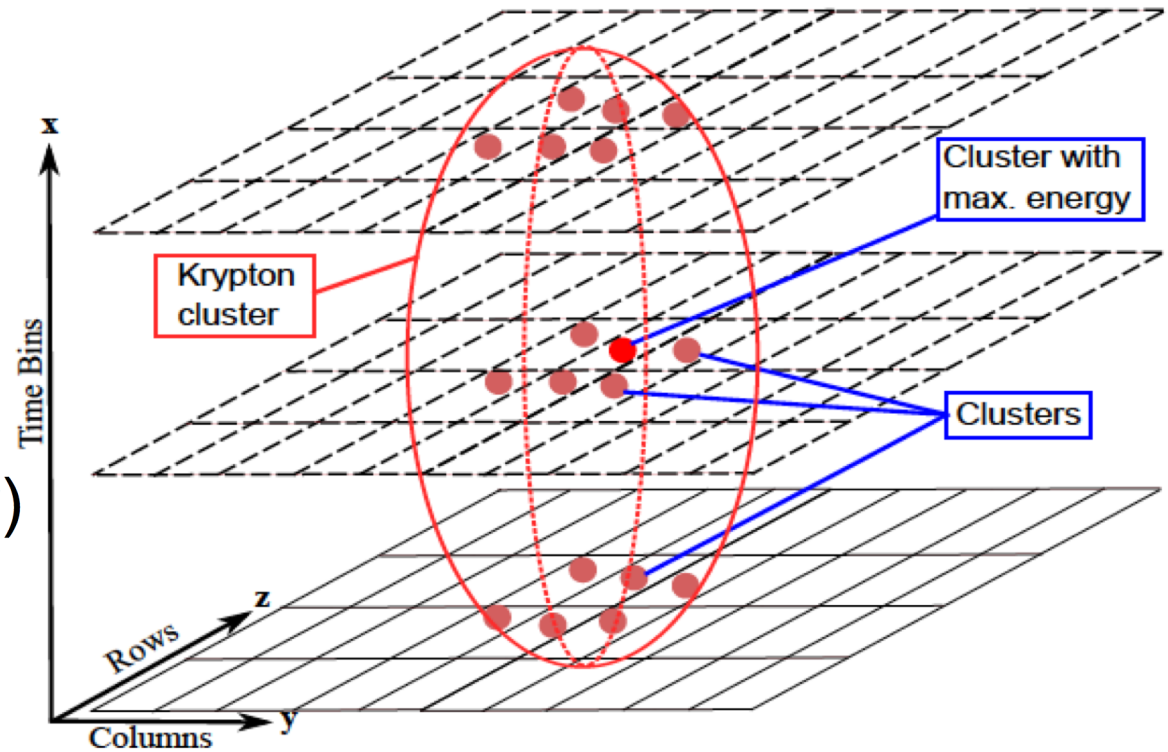
- Monitor:
  - Gas flow (statistics)
  - Change of atmospheric pressure (gain)
  - HV stability (gain)
  - Gas composition (gain)

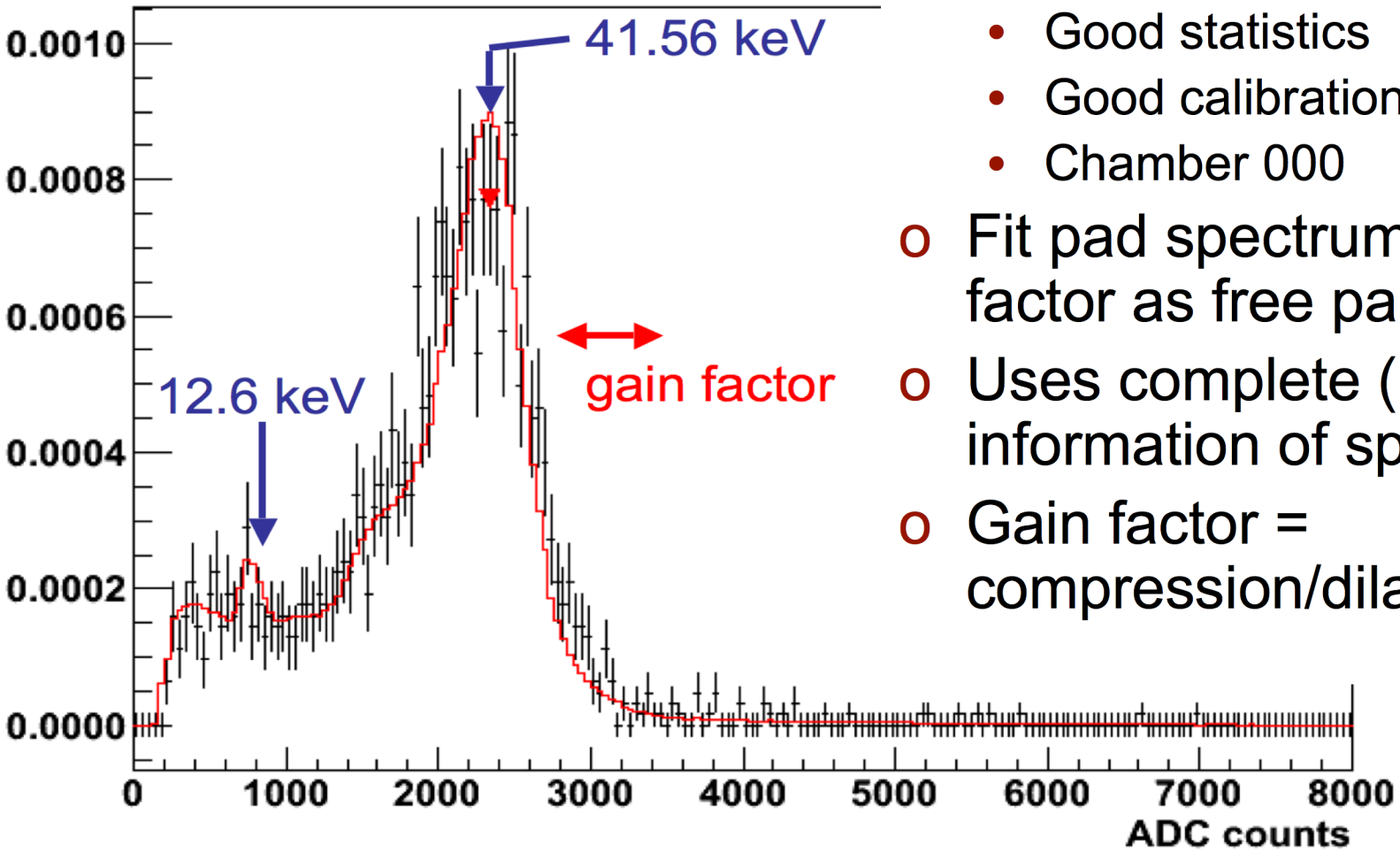
The Kr Cluster Finder

- Tune analysis to Kr decay properties
  - Advanced cluster finder applied after tracking reconstruction

- e^- stopped in Xe-CO_2 within <1 cm (≈1-2 pads)
- Search within 20 time bins (2μs)
- Assign found clusters to single pad (with max. energy)

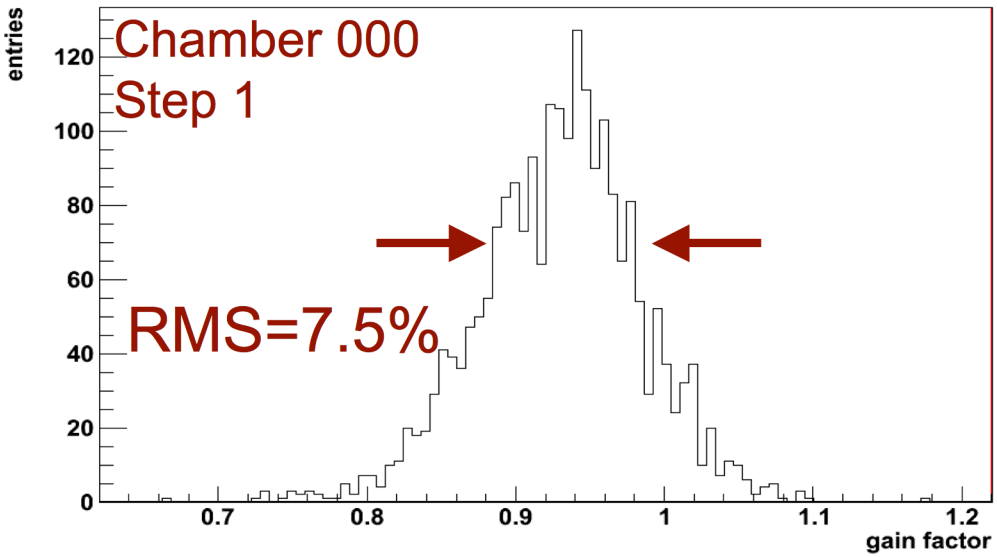


Fitting the Data



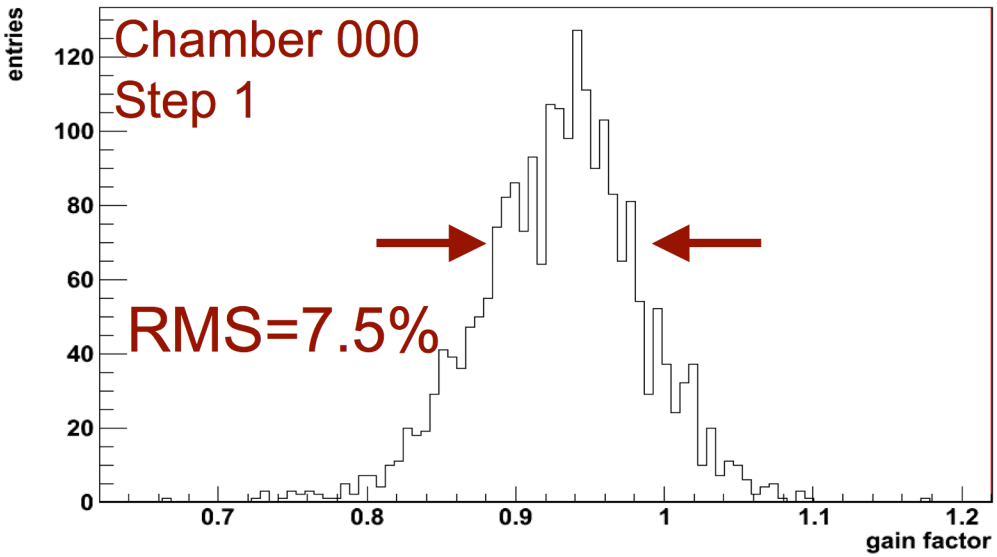
- Pick reference spectrum
  - Good statistics
  - Good calibration
  - Chamber 000
- Fit pad spectrum with gain factor as free parameter
- Uses complete (!) information of spectrum
- Gain factor = compression/dilation

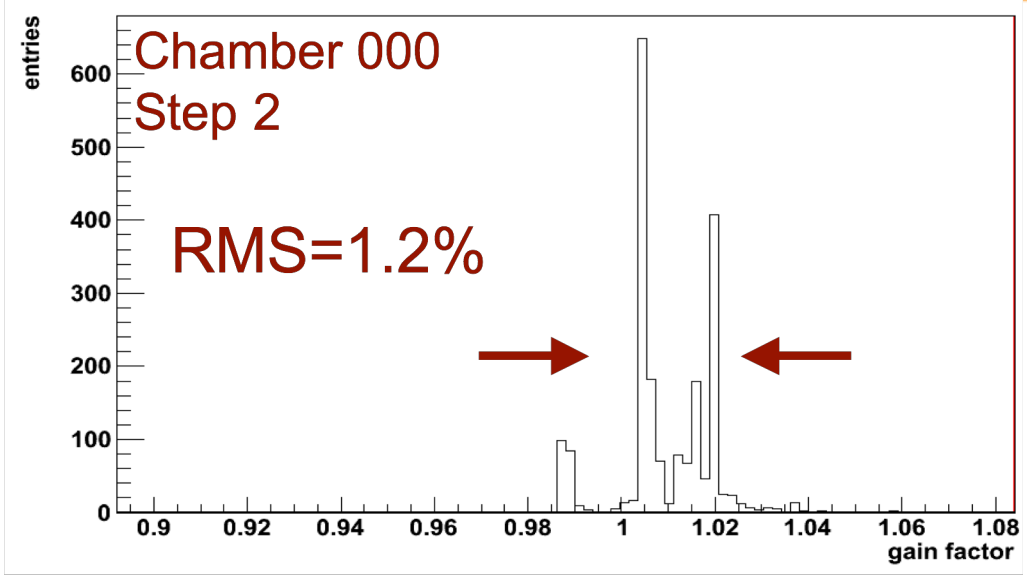
Gain Factor Distribution



- Analyze all pad gain factors for a chamber
- Correct for broken pads, edge effects and bad fits
  - Only accept 0.5 < gain factor < 1.5
  - All others set to default (not shown here)
- Normalize all pad gain factors to corresponding chamber mean

Gain Factor Distribution

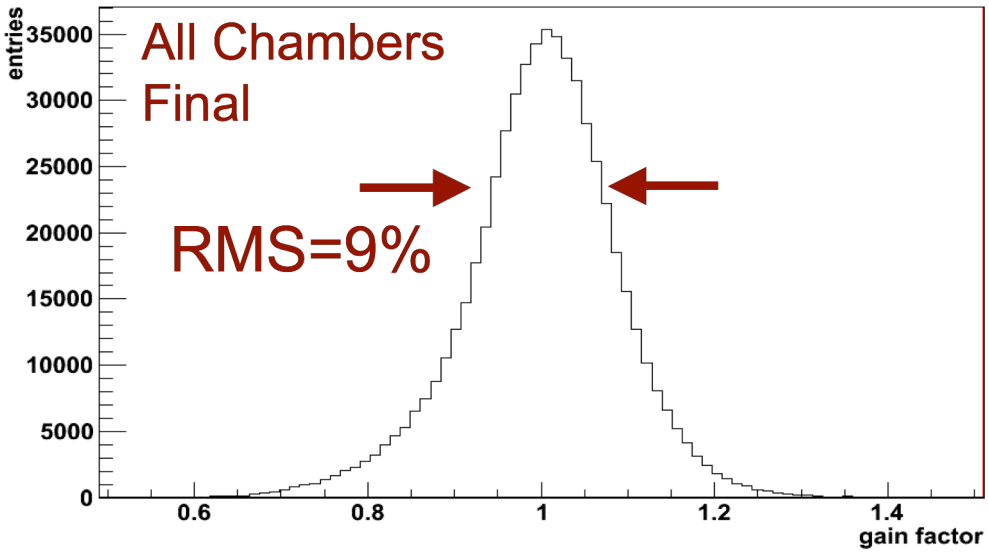


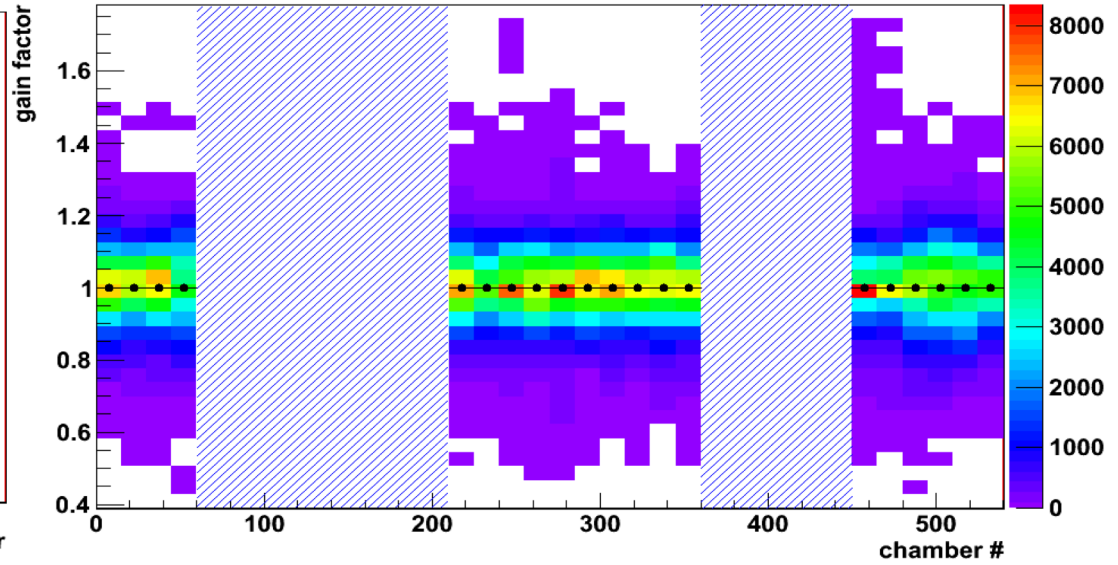


- Feed gain factors into database and redo analysis
- Gain factors converge against optimal value
  - Gain factor distribution is significantly narrower
  - Analysis improves gradually

→ Iterative Process (converges after 2nd step)

Gain Factor Distribution





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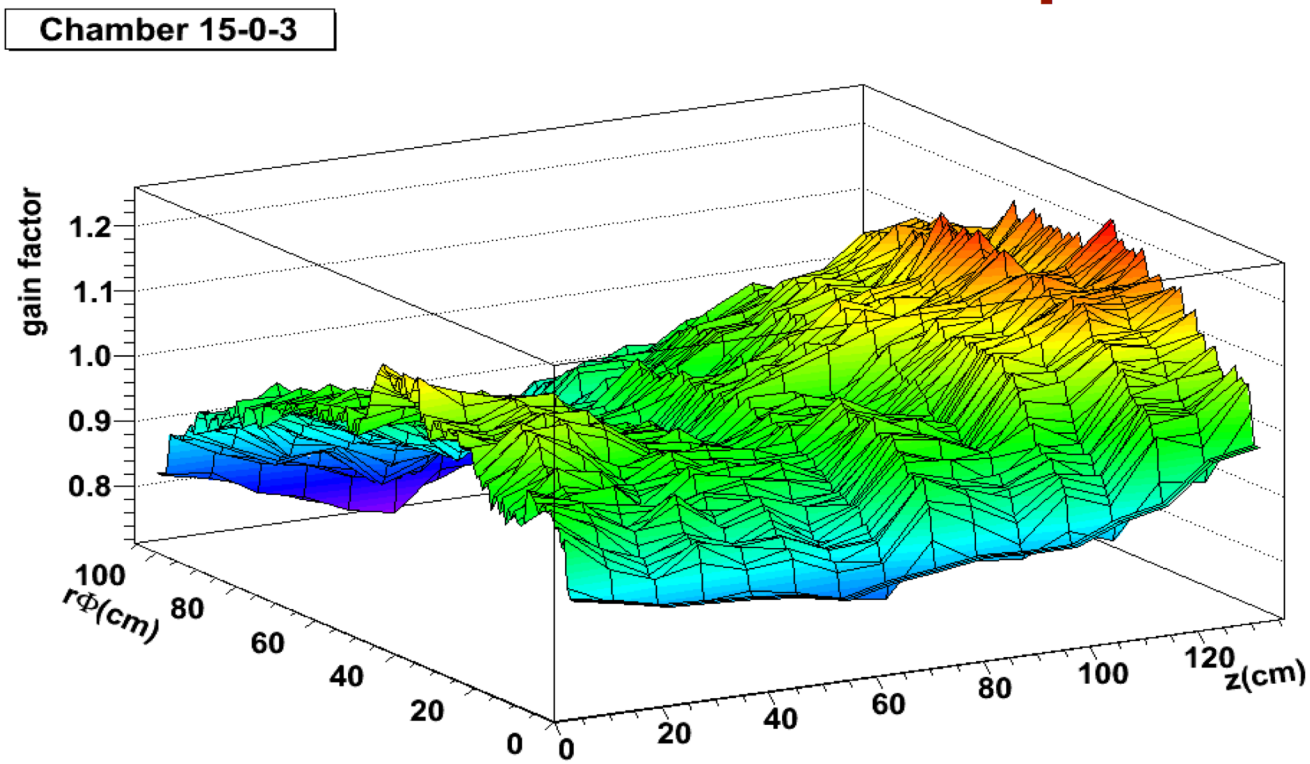
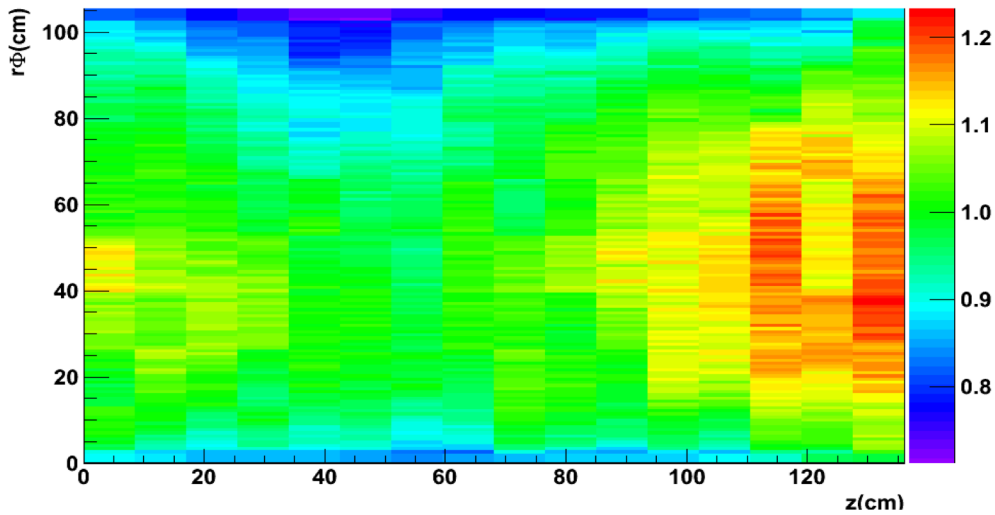
Gain Factor Map



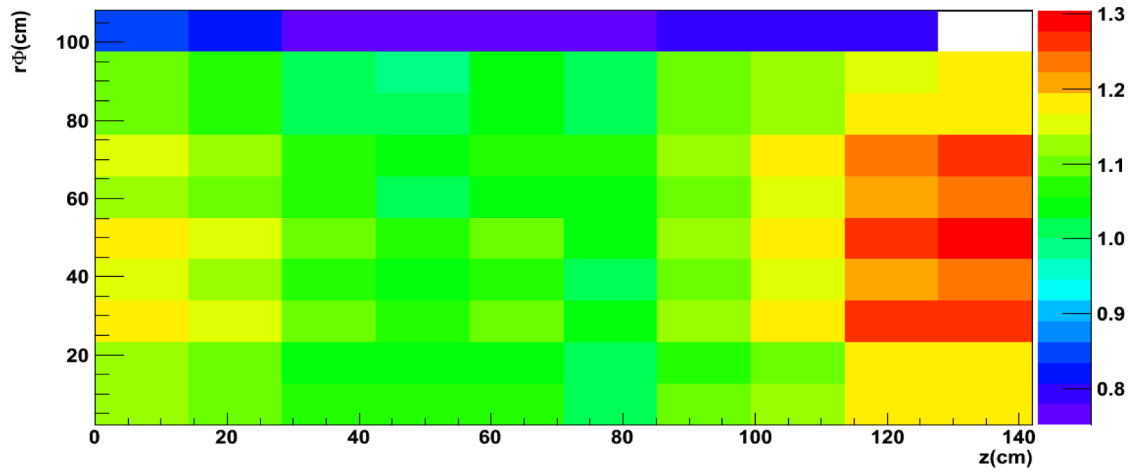
- Geometrical distortions (i.e. outward bending because of overpressure) on pad-by-pad resolution clearly visible
- Various shapes observed, mostly dependent on chamber type (size & position)

Gain Factor Map Comparison

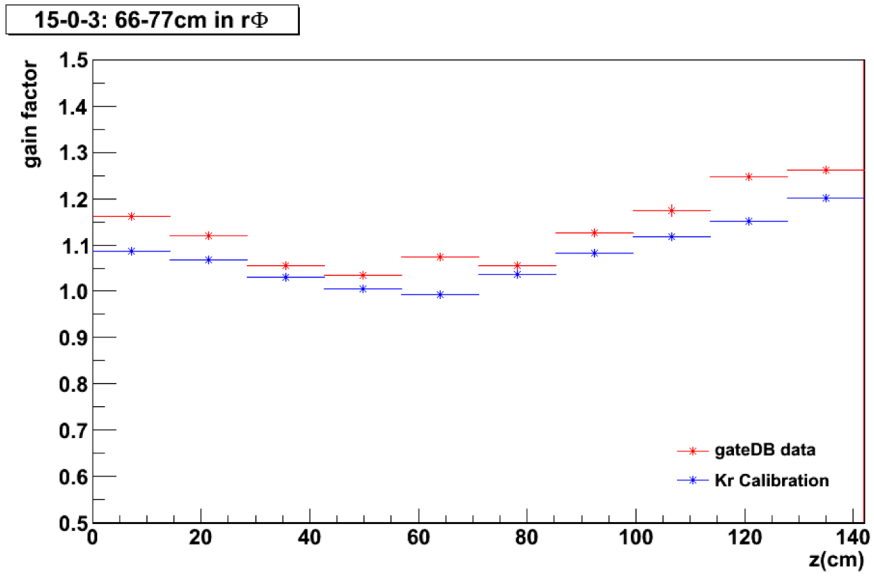
Kr Calibration: Chamber 15-0-3



Standard TRD Chamber Testing: Chamber 15-0-3



- Compare to TRD chamber testing during construction
  - Scan 10x10 mesh with radioactive source
  - Measure anode current
- Mostly good agreement with available data



Energy Resolution Measurement

- Gaussian fit on main decay peak → Relative energy resolution:
  $\Delta E_{res} = Sigma_{Gauss}/Mean_{Gauss}$
- ΔE_{res} dependent on pad position within chamber
- Compares well to TRD design energy resolution of ΔE_{res} <10%

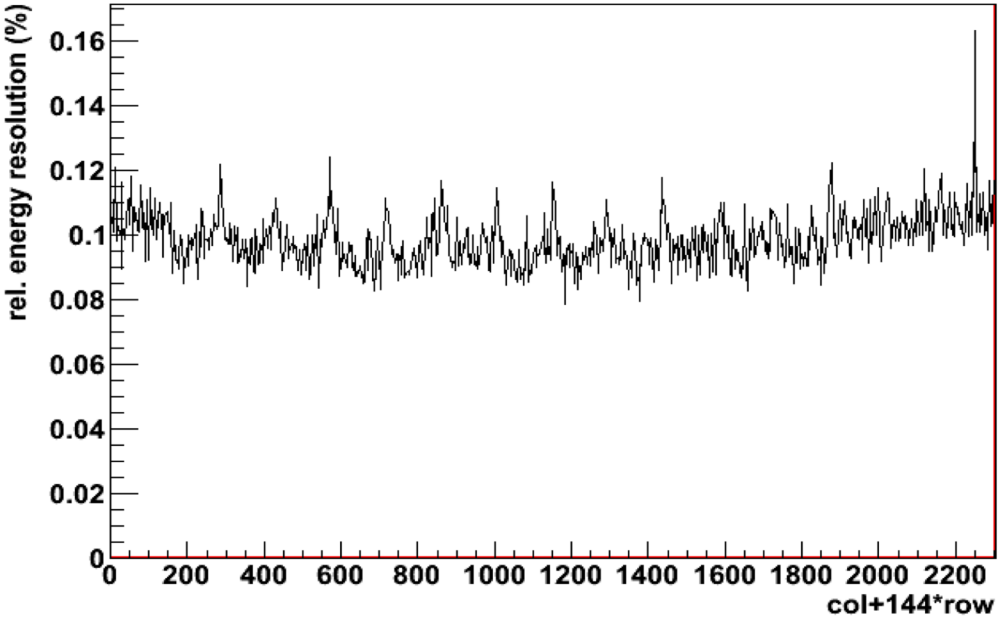


Figure: ΔE_{res} chamber 456

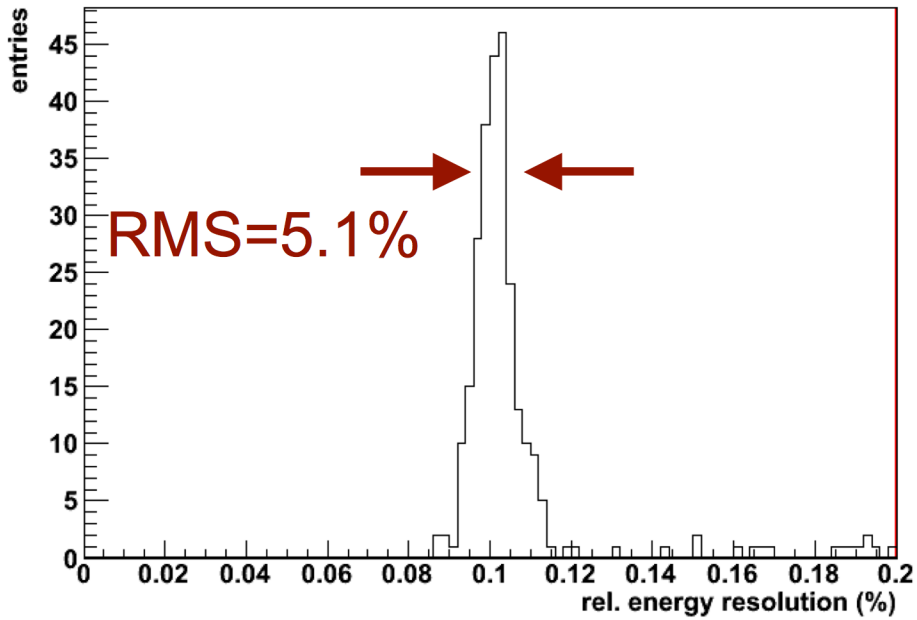
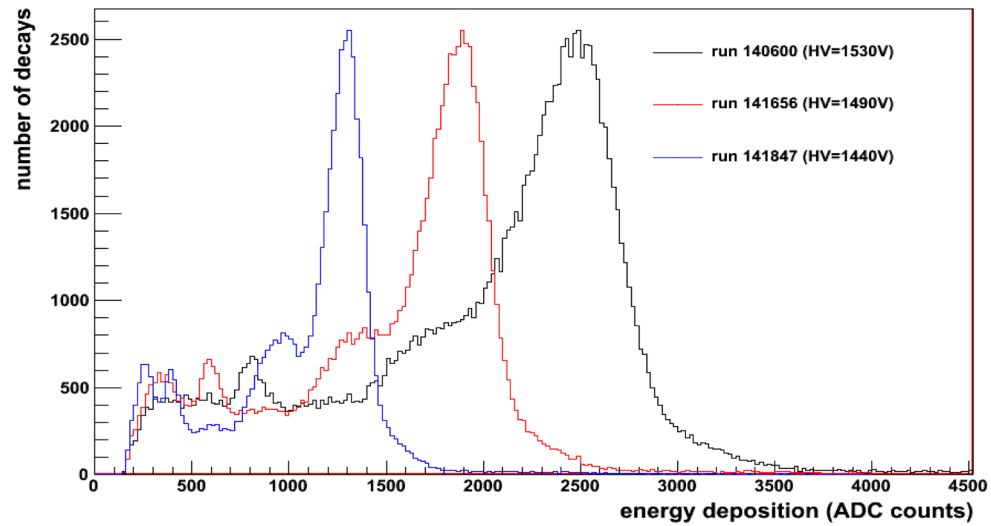
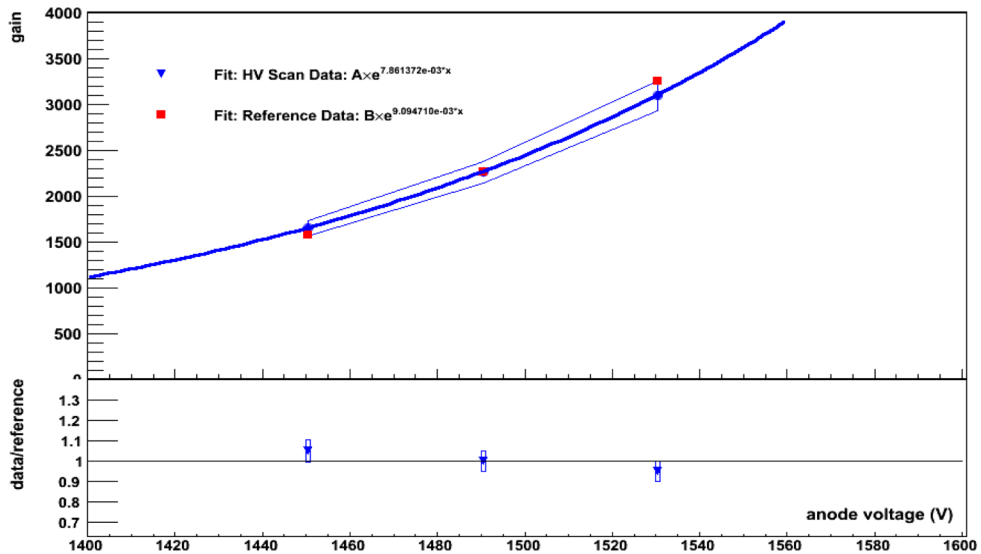


Figure: Mean ΔE_{res} of all chambers

Gain vs. High Voltage

- Study of correlation between high voltage and gain to compensate gain variations
  1) Fit exponential to the three data points at HV_{nom}=1530V, HV_1=1490V & HV_2=1450V
  2) Find mean slope for all chambers and calculate three data points
  3) Scale data to gain simulation for comparison
- Allows online HV adjustment of gain variations due to pressure changes for individual chambers





Summary and Outlook

- Gain calibration with ^{83m}Kr-decay as important tool for particle identification
- Effective fitting procedure developed
  → Uses complete information of spectra!
- Results compare very well to TRD construction testing procedure
- Kr calibration as useful tool to study TRD performance
- Newly acquired gain factors used in:
  - Offline calibration data base
  - Online corrections
- Iterative process to optimal values