Development of a purity monitor based on an α-source

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Principles of the purity monitor operation

α-Source

E-field

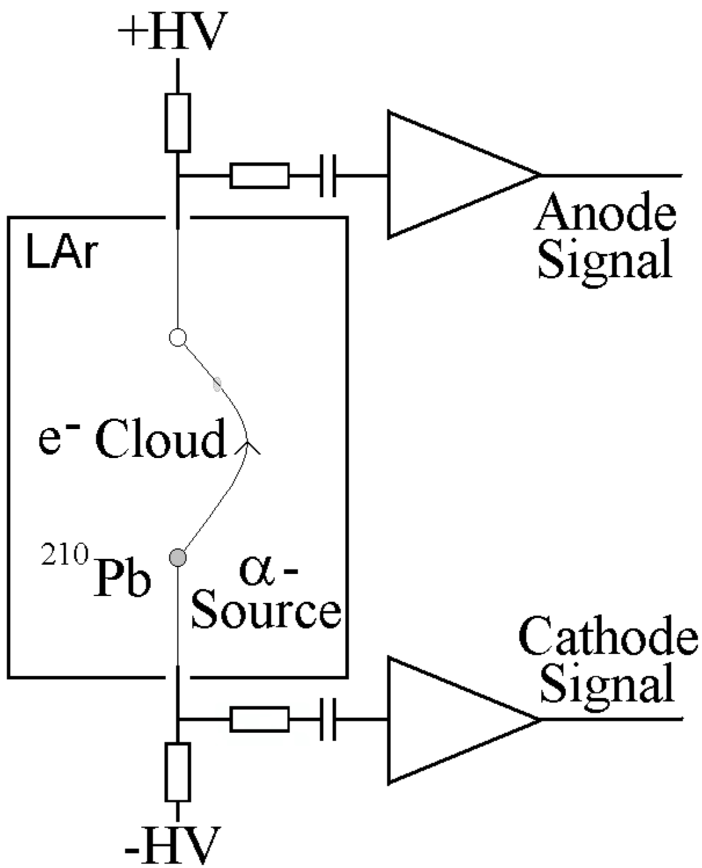
Mechanical design

Measuring setup

Results

Conclusions

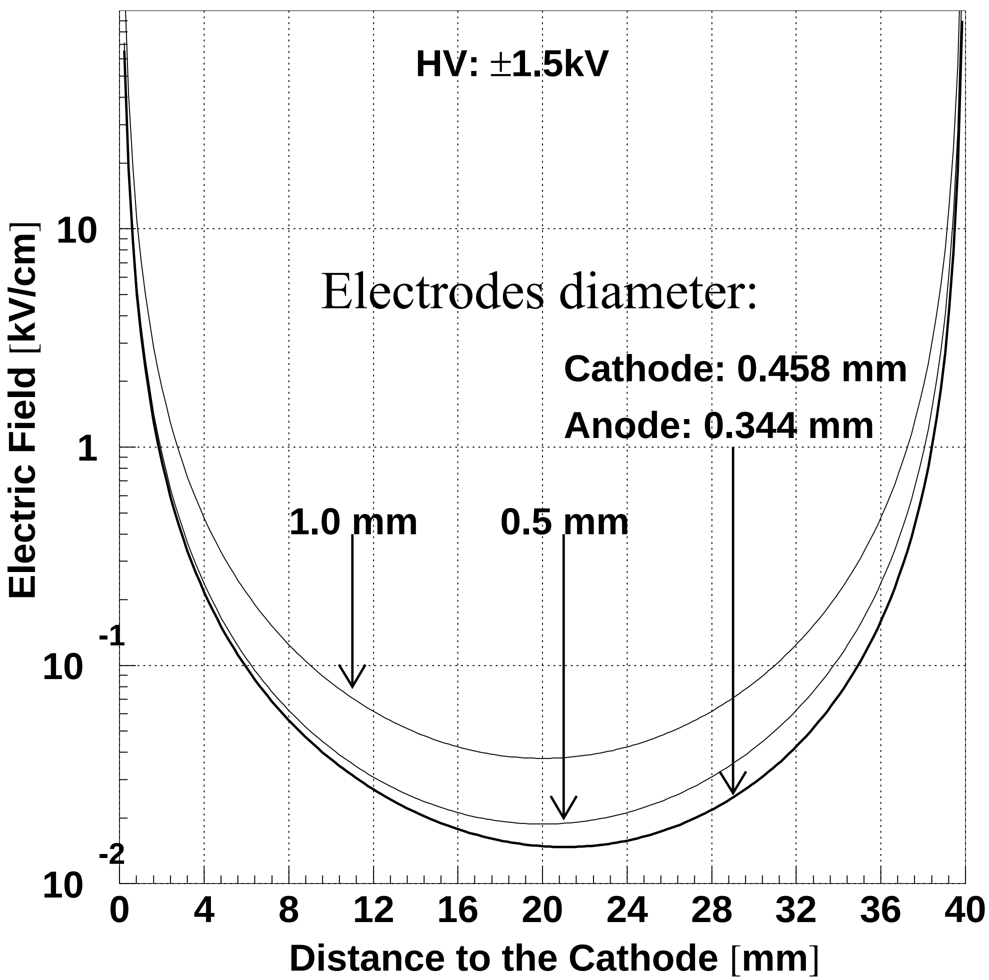
Schematic of the purity monitor



Important features:

- Spherical electrodes with a diameter of about 0.5 mm (dipole field).
- High field at the cathode surface suppresses the recombination.
- Range of 5.3 MeV α-particles in LAr: $\cong$ 50 μm.
- Fast drift velocity near surface induces short ($\cong$ 1 μs) current pulse.
- Small drift velocity in the central region allows to measure long drift times.
- Drift time variation due to different drift paths along the dipole field lines.

E-field on the axis



E-field at the cathode surface:

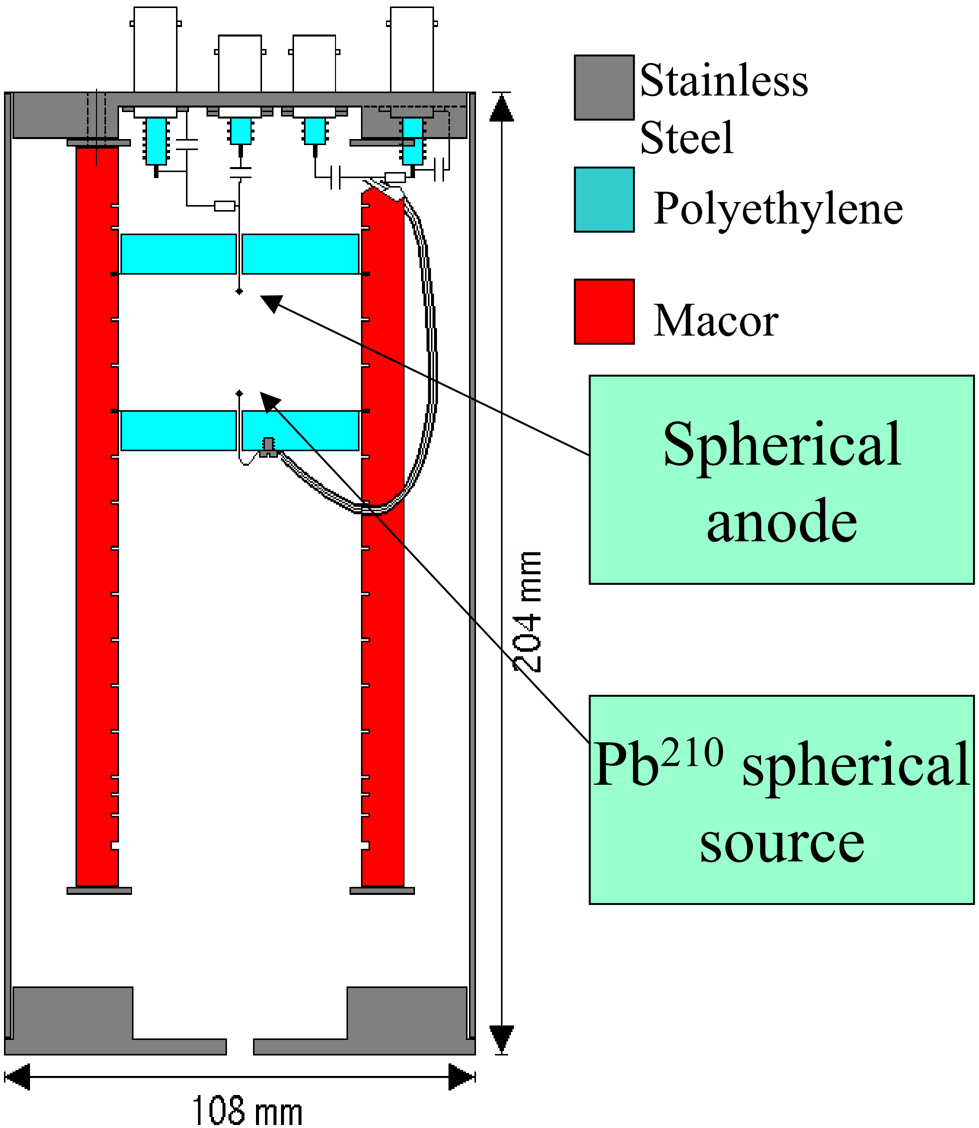
$$\frac{V_0}{R_{Cathode}}$$

$R_{Cathode} = 0.229$ mm

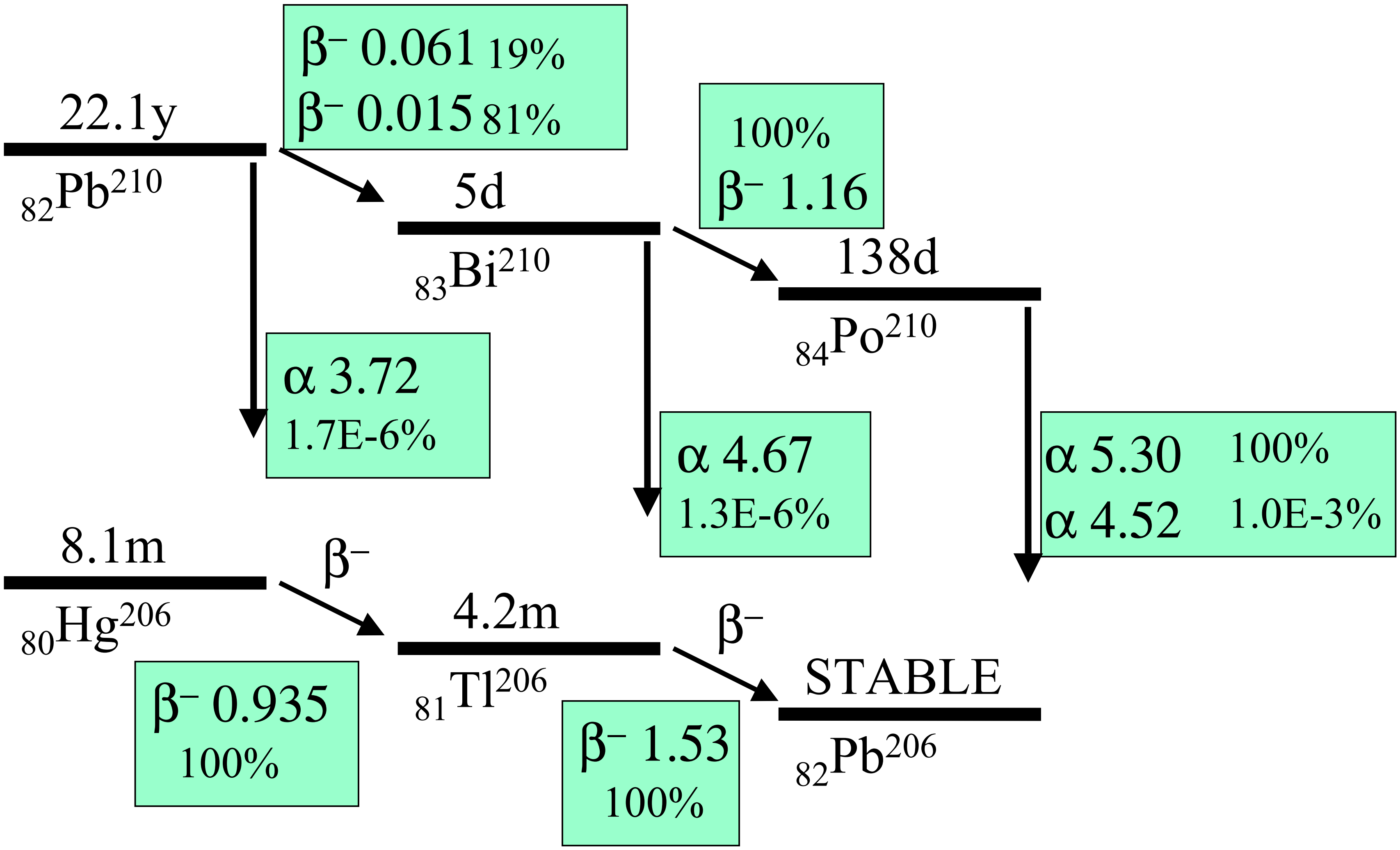
$V_0 = 1 – 3.5$ kV

$E(R) = 44 – 153$ kV/cm

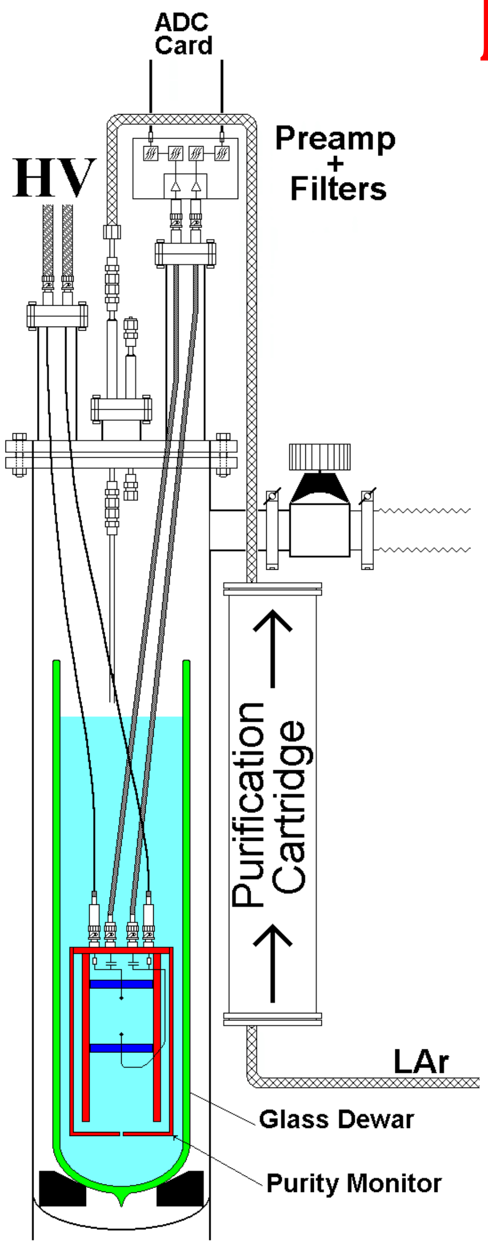
Purity monitor mechanics



Decay scheme of the ^{210}Pb
α-Source



Measuring setup



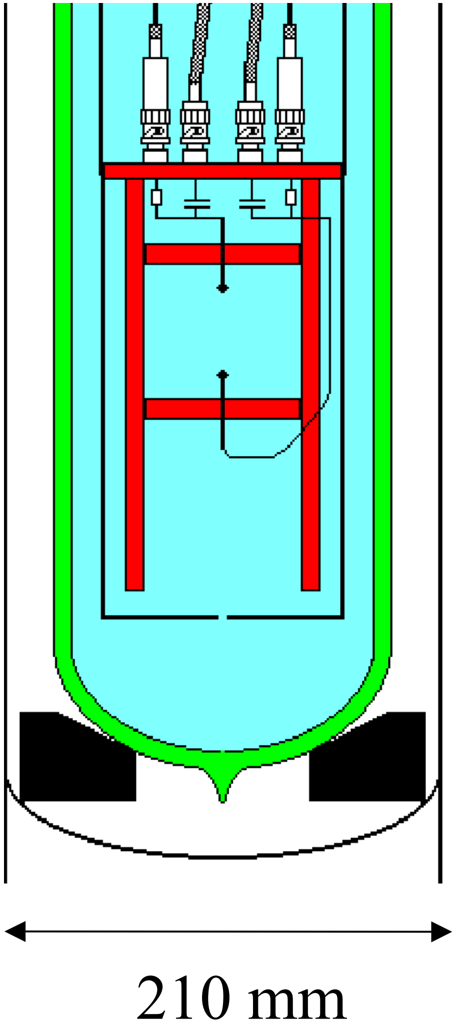
Purification:

CuO_2

BTS (Fluka No. 18820)

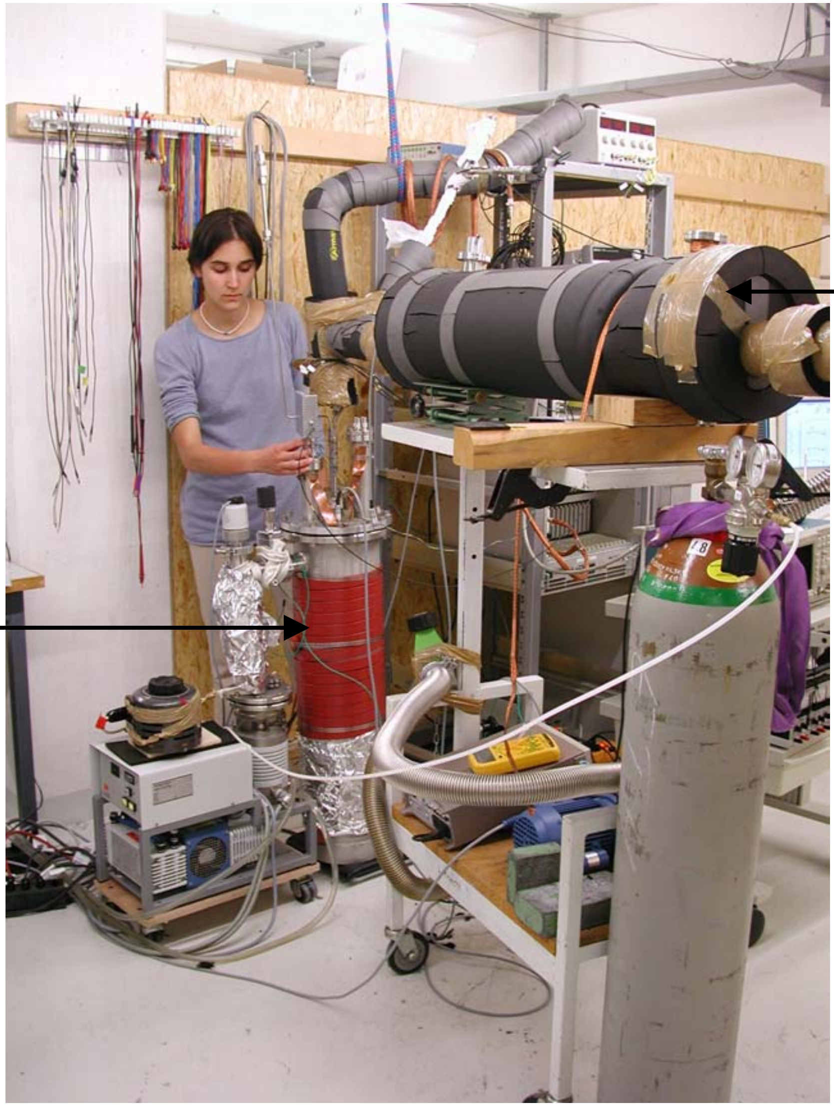
Regenerated with H_2

No recirculation!



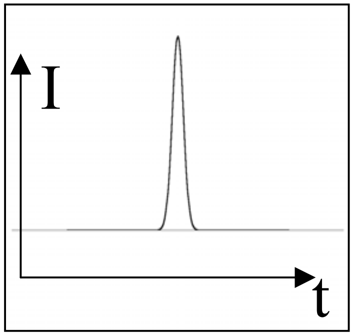
Measuring setup II

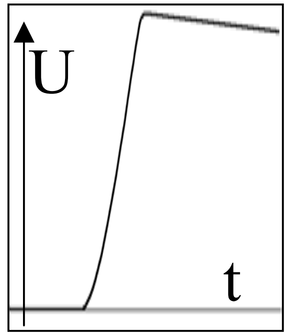
Vacuum chamber for purity monitor

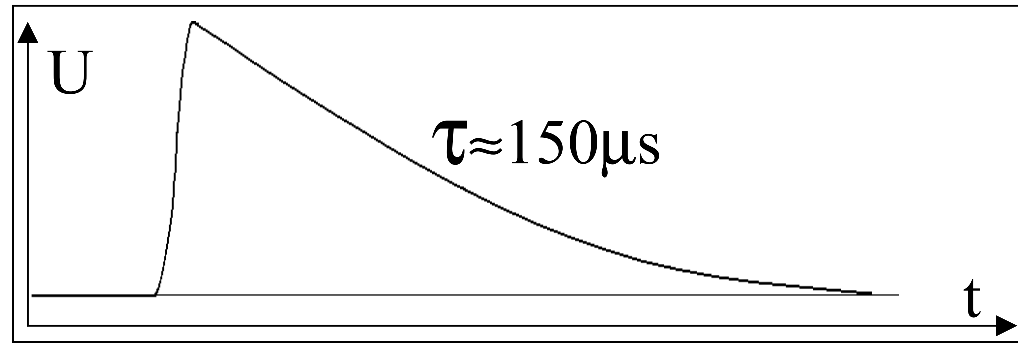


Purification cartridge in a LN_2 bath

Scheme of Electronics and DAQ







Charge to Voltage Preamp

Amplifier with broad band-pass filter

PCI Computer Card

Preamp developed for ICARUS

→Sensitivity of 0.95 mV/10ke$^-$

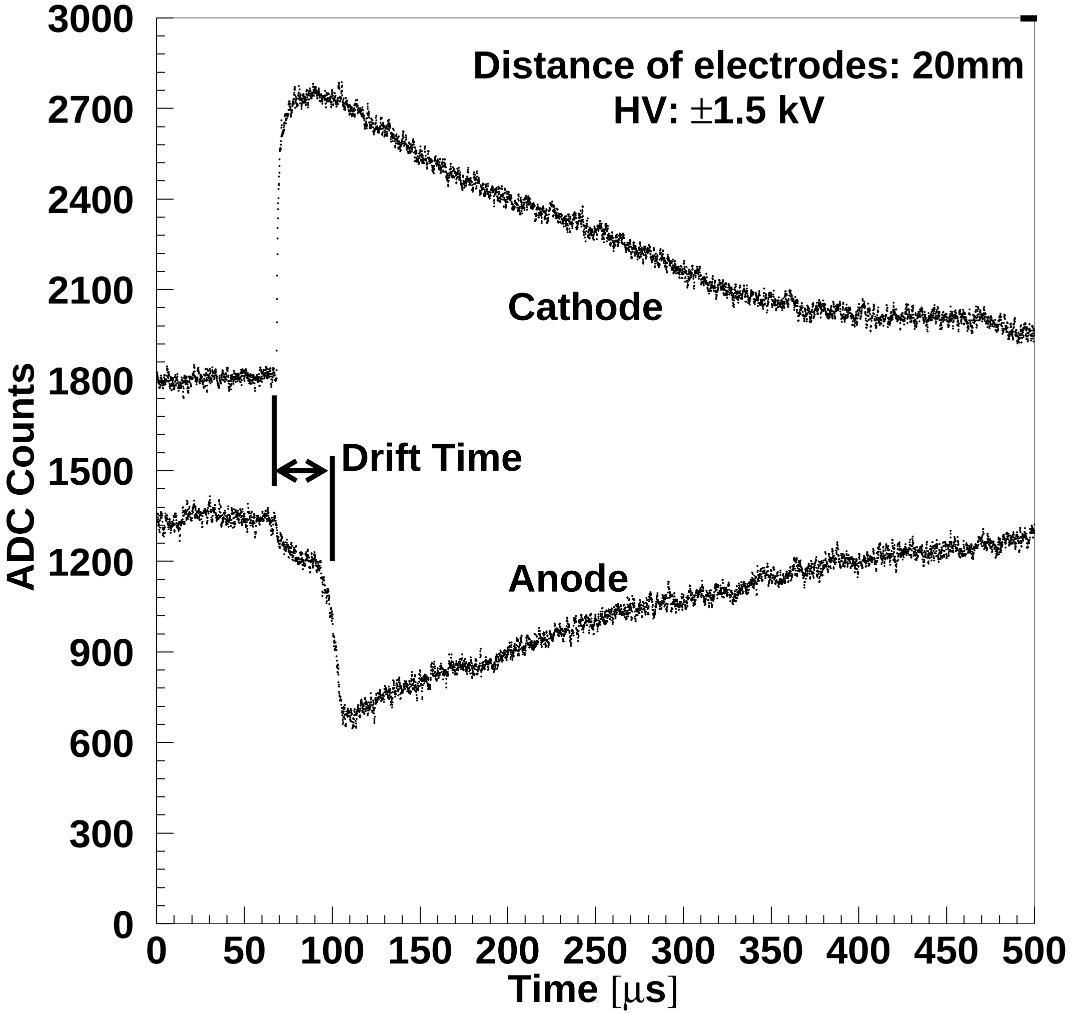
Band-pass cuts

@100 Hz→ low *f*-noise

@5MHz → Nyquist

10Ms/s 12bit ADC

Pulse shapes from an α-particle



Cathode:

Large current induced (fast rise) when α is emitted.

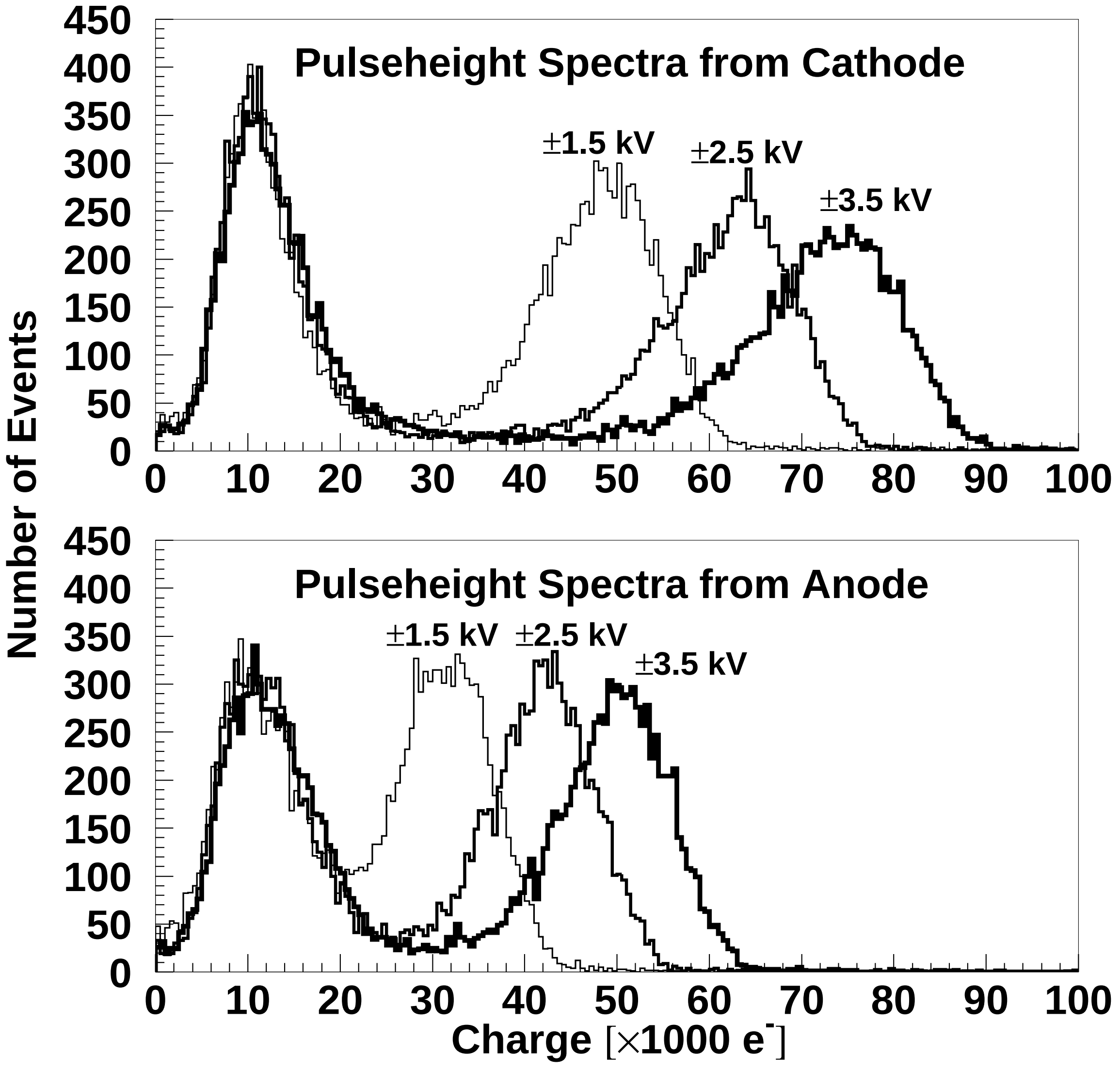
Anode:

•Fast rise (large induced current), when α is emitted from cathode.

•Small induced current when electrons drift through central region.

• Large current induced when electrons arrive at anode.

Measured pulse height spectra



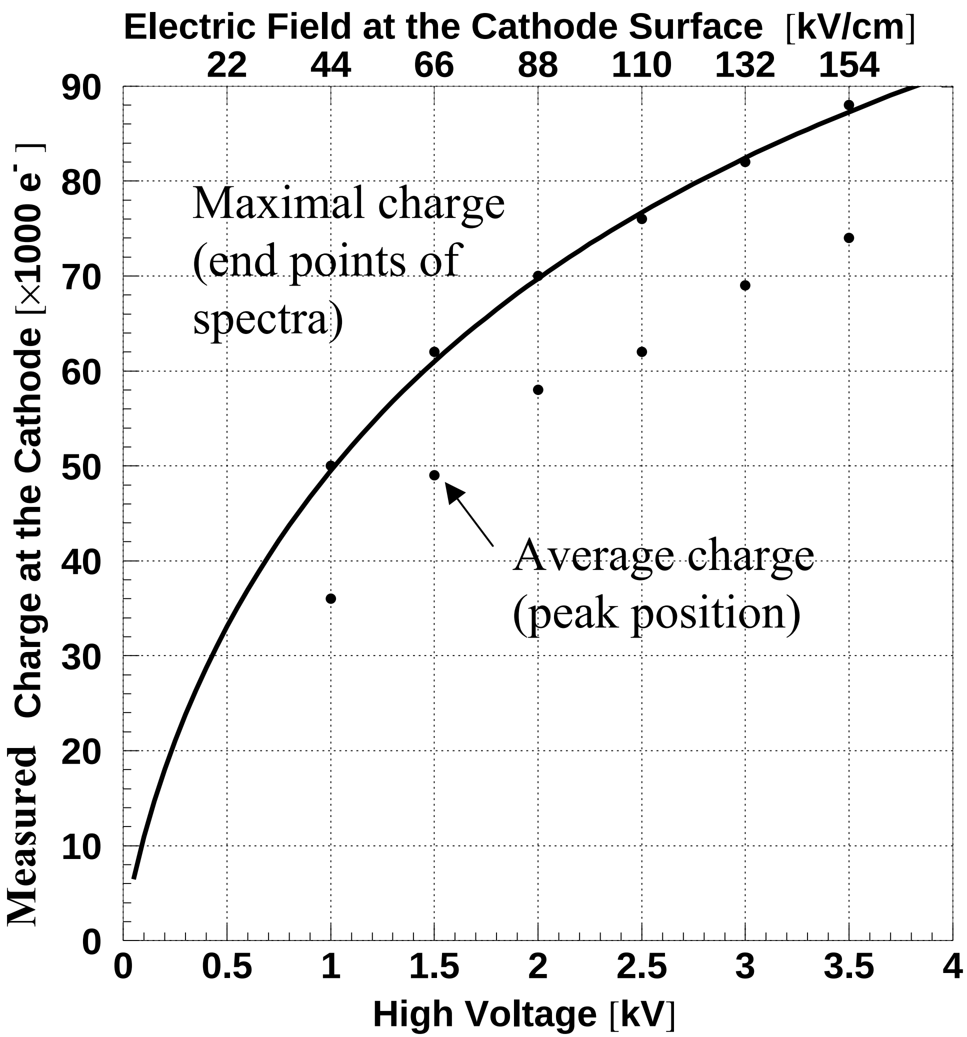
Resolution:

±1 kel. at 62.5 kel.

We used the end points of the cathode spectra.

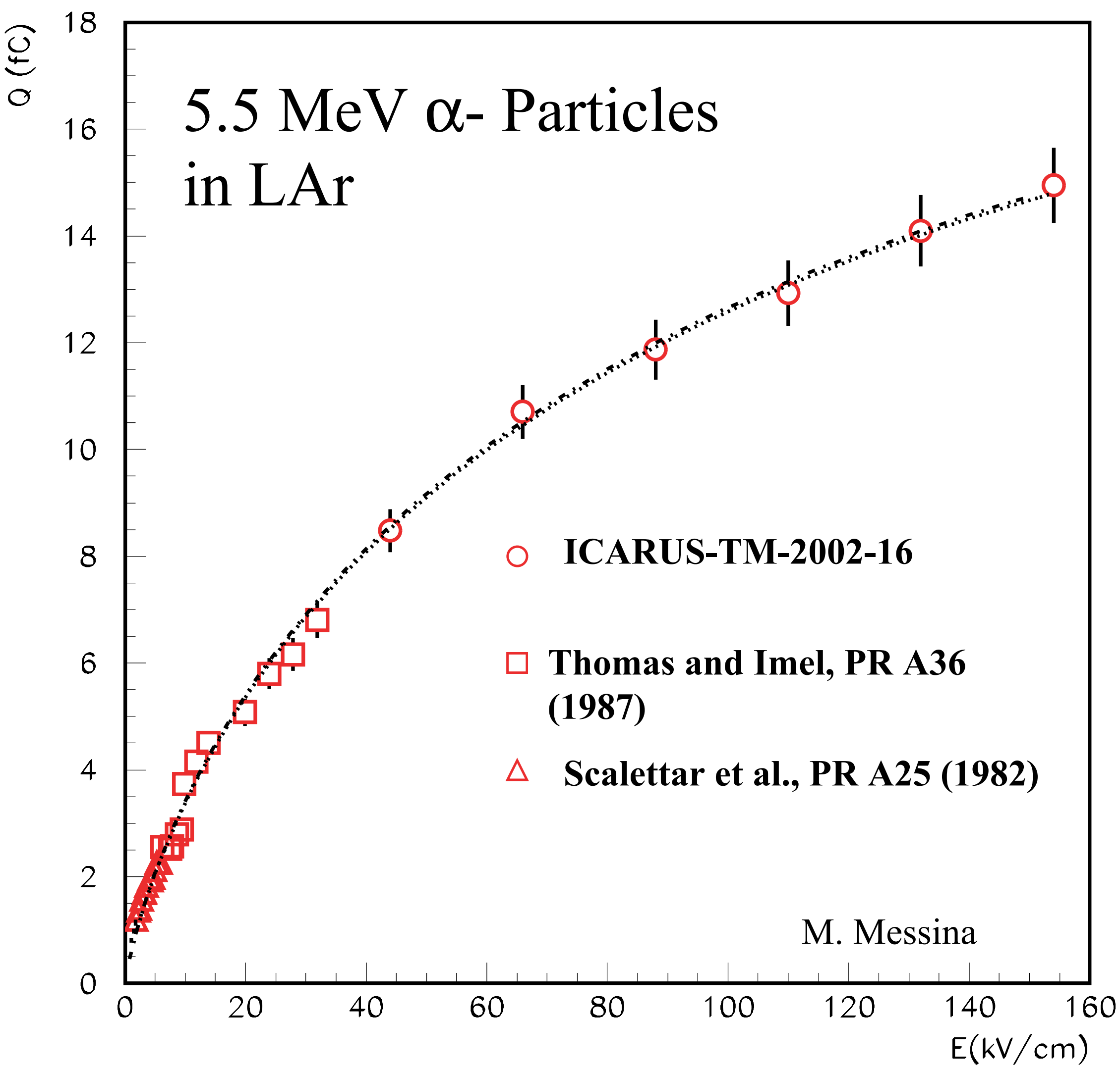
Electrode distance was 20 mm.

Recombination



Curve:
Box model fit
with two parameters

Box Model Fit



Thomas and Imel,
PR A36 (1987) 614

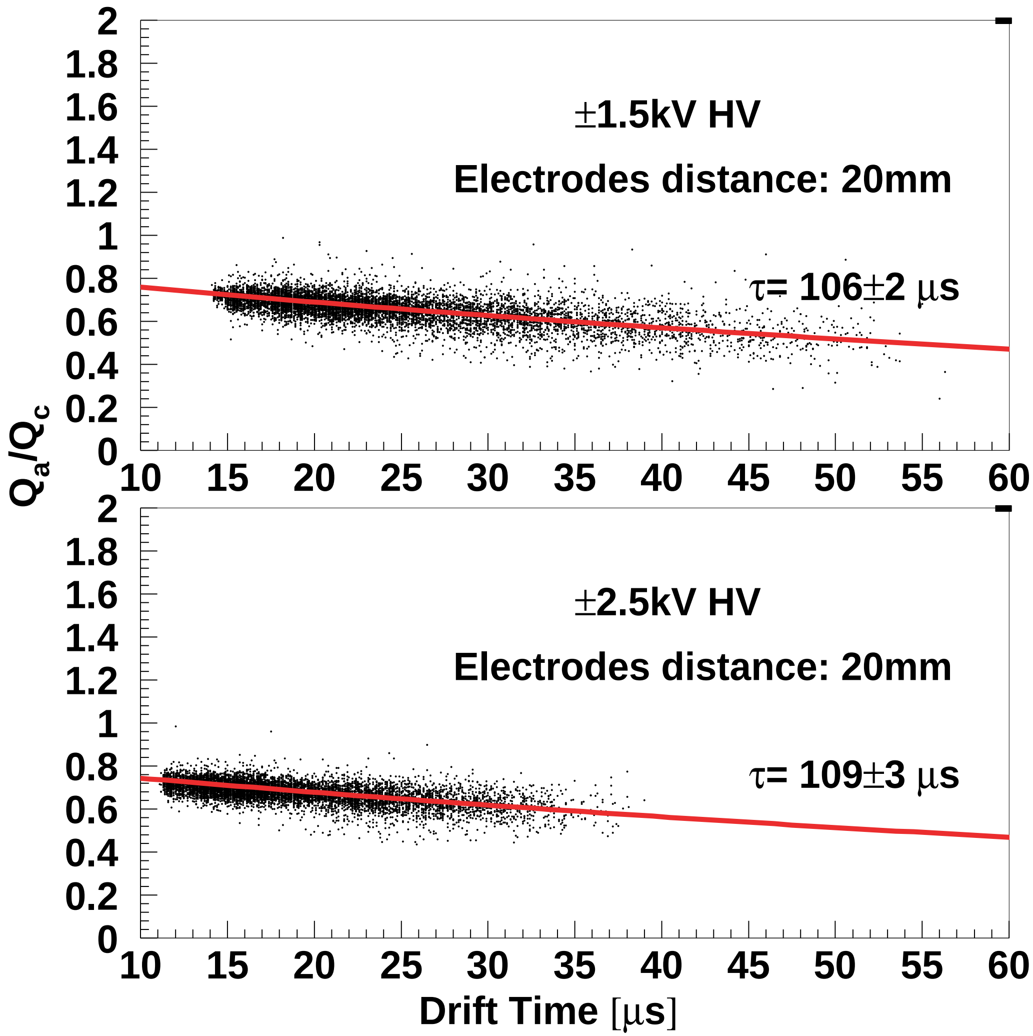
$$\frac{Q(E)}{Q_0} = \frac{E}{C}\ln\left(1+\frac{C}{E}\right)$$

Fit: Q_0 = 24 fC,

C = 220 kV/cm

(⇒ Energy for an electron-ion pair: 37 eV.)

Measured electron life time



Exponential fit:

$$\frac{Q_A}{Q_C} = e^{-\frac{t_{drift}}{\tau}}$$

(Statistical errors for τ only)

Conclusions

• We have developed a purity monitor based on an α-source and a dipole drift field to avoid the strong quenching of the ionization charge from the α-particles.

• Filling the LAr through a purification cartridge, electron lifetimes of about 100 μs were measured (no recirculation).

•We have measured (for the first time) the recombination of the ionization charge from α-particles in LAr at very high electric fields of 40 – 150 kV/cm.

• More details can be found in ICARUS-TM/2002-16