# Ultra-Low background Alpha particle spectrometer

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## Outline

- Basic assumptions for the large-surface alpha scaler
- Monte Carlo simulations of the detector
- Construction details
- Initial perfomance of the spectrometer
- Concusions and plans

### Design assumptions

#### MultiWire Proportional Chamber with a Guard Detector

- Low background materials used for construction:
  - Electropolished/etched Stainless Steel
  - Electropolished Copper
  - PTFE and Indium (+ rubber) Sealings
  - Ultra-High-Purity Nitrogen Gas used as a Counting Gas (Generated by a dedicated purifier based on charcoal trap).
- Overall chamber dimensions (LxWxH) ~ 50x50x40 [cm]

- Distance from Sample to Anode Plane (adjustable) approx. 4x to 6x α-particle range in gaseous N<sub>2</sub> (~15-24[cm])
  - $\alpha$ -particle energy ca. 4-6 MeV
  - Ionisation energy in gaseous  $N_2$  36.3 eV per pair (e<sup>-</sup>/ion)
- Sample Tray [LxW]: 45x28 [cm]
- Max sample dimensions [LxW]: 30x20 [cm]
- Aquisition
  - 16-channel 250 MHz Fast Flash ADC card for signal shape analysis and rising edge time measurment "Struck SIS3316"
    - Rising edge time measurment for distinguish alpha particle from sample and anode or walls
      - slow signal for  $\alpha$ -particle emanating from sample,
      - fast signal for  $\alpha\mbox{-particle}$  emanating from anode wire or side walls
  - For Testing Purposes Multi-Channel Pulse Height Analyzer and Multi-Channel Scaler "*Tukan 8k*" used
- Slight Over-pressure gaseous kept in chamber for minimising air flow into the detector
- Background << background of semiconductor a spectrometers

#### General view (first draft)



### Sketch of MultiWire plane



### Simulations

- Monte Carlo simulations were performed to detmine optimal parameters of the specrtometer: distance between the sample tray and anode plane, distance between anode wires, distance between anode and guard wires
- MC simulations include radioactive decays (random emmissions of alphas), charge generation, tracking and collection (G4 + GARFIELD)



#### Track, clusters and drift lines



Plotted at 15.52.01 on 29/04/1-Distance from alpha source to MultiWire <sup>§</sup>plane, dy = 8.5cm  $V_{anode} = 1000 V,$   $V_{screen} = 0 V,$   $V_{guard} = 1000 V$ 





Distance from alpha source to MultiWire plane, dy = 15cm



### Simulation: different shapes of signals



• 001

- 010
- 100
- etc.-

Various directions of alpha particle

xyz

- 001 means that alpha particle travel in z direction (parallel to wire)
- 010 means that alpha particle travel in y direction (exactly vertical and instantaneous)



### **Chamber top view**





### HV and signal feedthroughs



### Anode wire frame (stesalit)



### Top cover with anode wire frame



### Printed Circuit Board (to mount 20μm and 50μm Gold Plated Tungsten Wire)



### Top cover with MultiWire Plane

- variable distance from sample to MultiWire Plane
- ortogonal Wire Plane
- segmented Wire Plane



## Chamber with MW-Plane (left) and sample tray (right)



#### Guard electrode Ground Anode Ground Guard electrode

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## Electronics for signal conditioning and aquisition



### Signals from preamplifiers



### Determination of the operational HV



### **Active Guard Mechanism**



### Guard test





Alpha source (<sup>241</sup>Am) position on the sample tray

### Guard test





Alpha source (<sup>241</sup>Am) position on the sample tray

## Comparision of spactra from anode and guards in different colimated alpha-particle source positions



•Alpha-particle source at position No.9:

electrons travel to guard electrodes (V=2500V) and anodes (V=1200V)
 Alpha-particle source at position No.0:
 electrons travel only to anodes (V=1200V); Signal on guard electrodes (V=2500V) is very small (noise?)

### Background



- In selected region anode counts 83 events per 14 hours ca.6 α/h
- at this moment not calculated total active detector area (approx. 16,000 cm<sup>2</sup>)
   ca. 0.000375 α/cm<sup>2</sup>/h
  - In this area guards counts 3289 events
    235 α/h
    total events during 14 hours is 36985
    2642 α/h

### Some problems with electronics

Overdrive



## Ultra-high-purity gaseous nitrogen generator (Radon Trap)

- Liquid Nitrogen
   Dewar volume ~ 60 L
- Radon <sup>222</sup>Rn trap filled with activated carbon
- Activity <sup>222</sup>Rn (~0.5µBq/m<sup>3</sup>)
- Pressure in MWPC ca. 1.05 atm.



### Gas flow regulation (constant flow)

Purging after opening the tray: 20 lpm (for ~1 h) Normal operations: 5 lpm



### Conclusions and plans

- The spectrometer has been constructed basing on MC simulations
- Preliminary tests show that the performance of the detector meets the expectations
- Still to be done:
  - carefull background determination (long-term test)
  - determination of the eficiency for large-area surface source (source available, A<sub>s</sub> = 0.6 mBq – thanks to prof. Mietelski)
  - determination of the Minimum Detectable Activity
  - measurement of tests steel/copper/teflon samples