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# MUSIC - Past, Presence, and Future of a detector concept

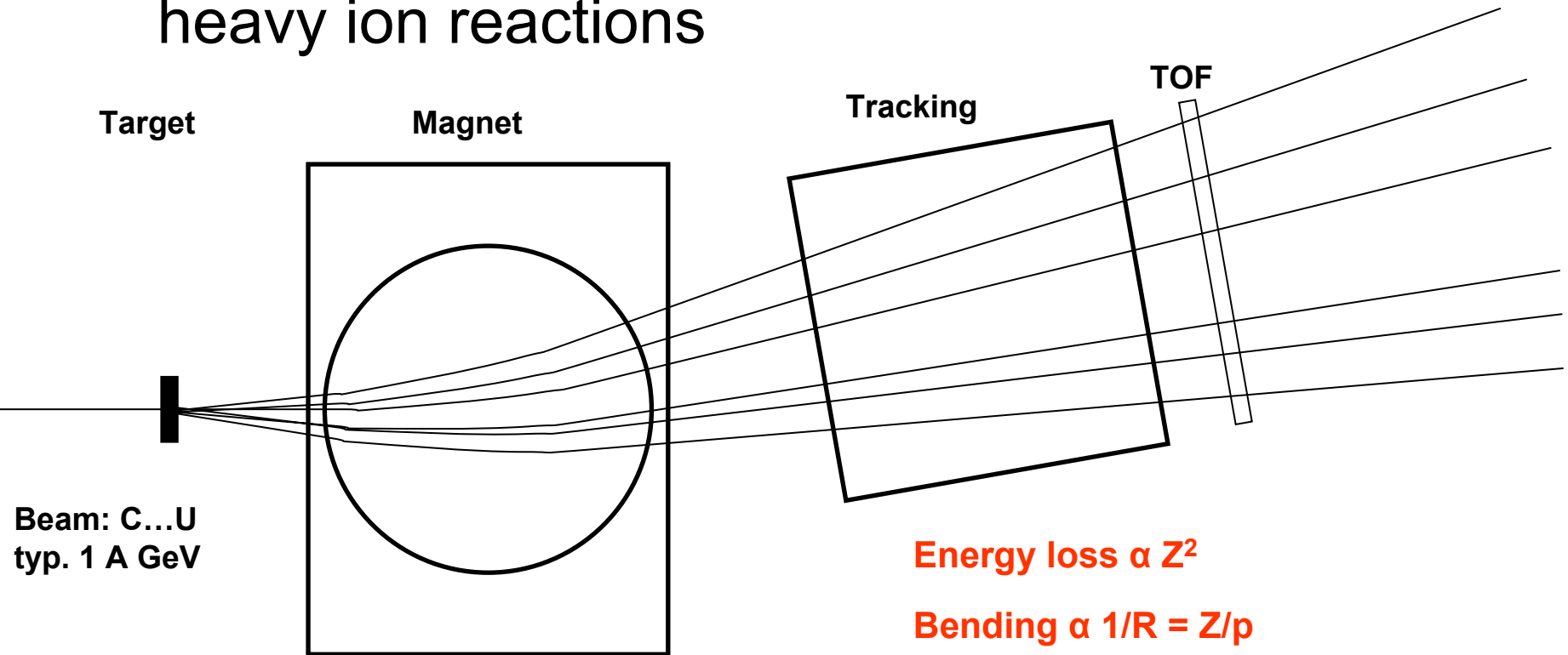
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Walter F.J. Müller, GSI

Bormio 2004

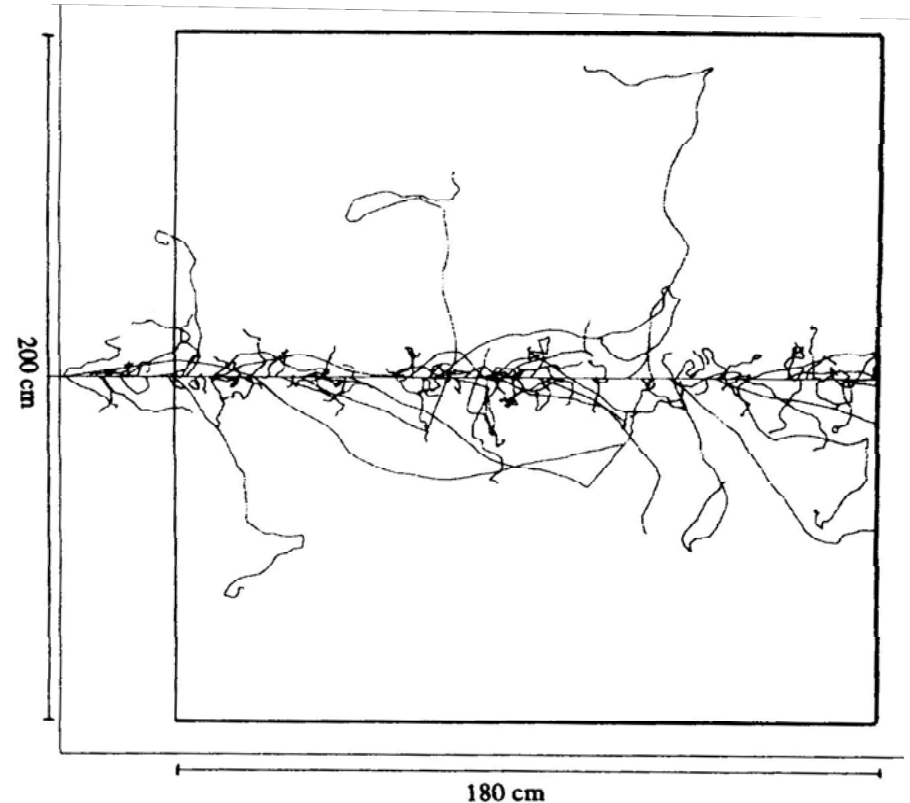
# Multiple Sampling Ionization Chamber

- A tracking chamber with good charge resolution
- Used for projectile-like fragments in relativistic heavy ion reactions



# Energy Loss vs. Energy Deposition I

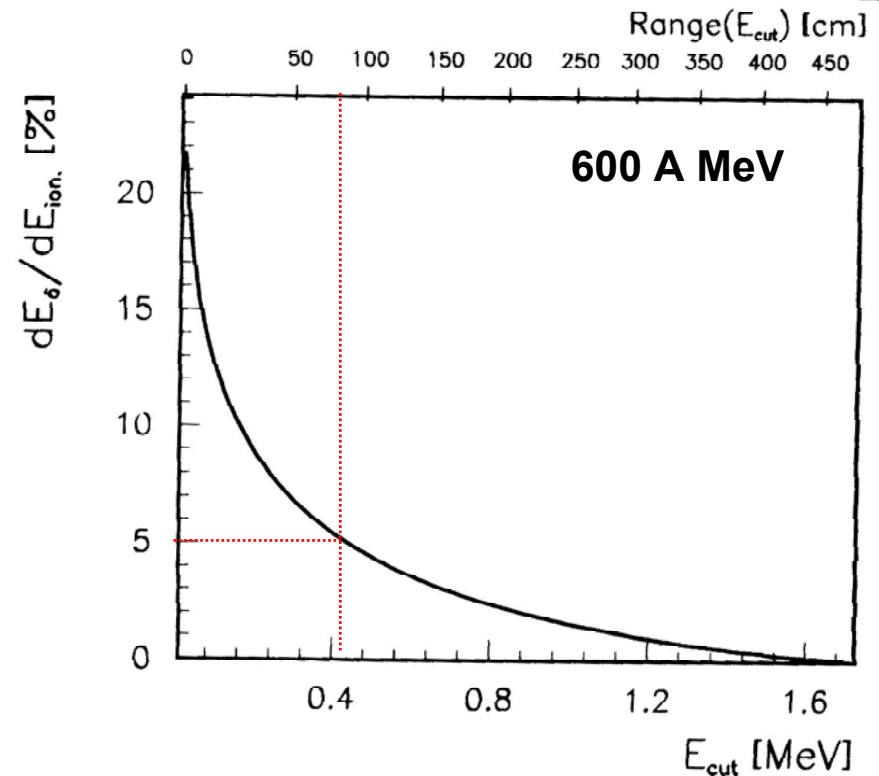
- Energy loss is by Rutherford scattering on electrons
- Low impact parameter collisions give high energy electrons (Delta rays)
- Energy is transported away from ion track and deposited far away from the track



**Simulation Ar 600 A MeV in P10 gas**

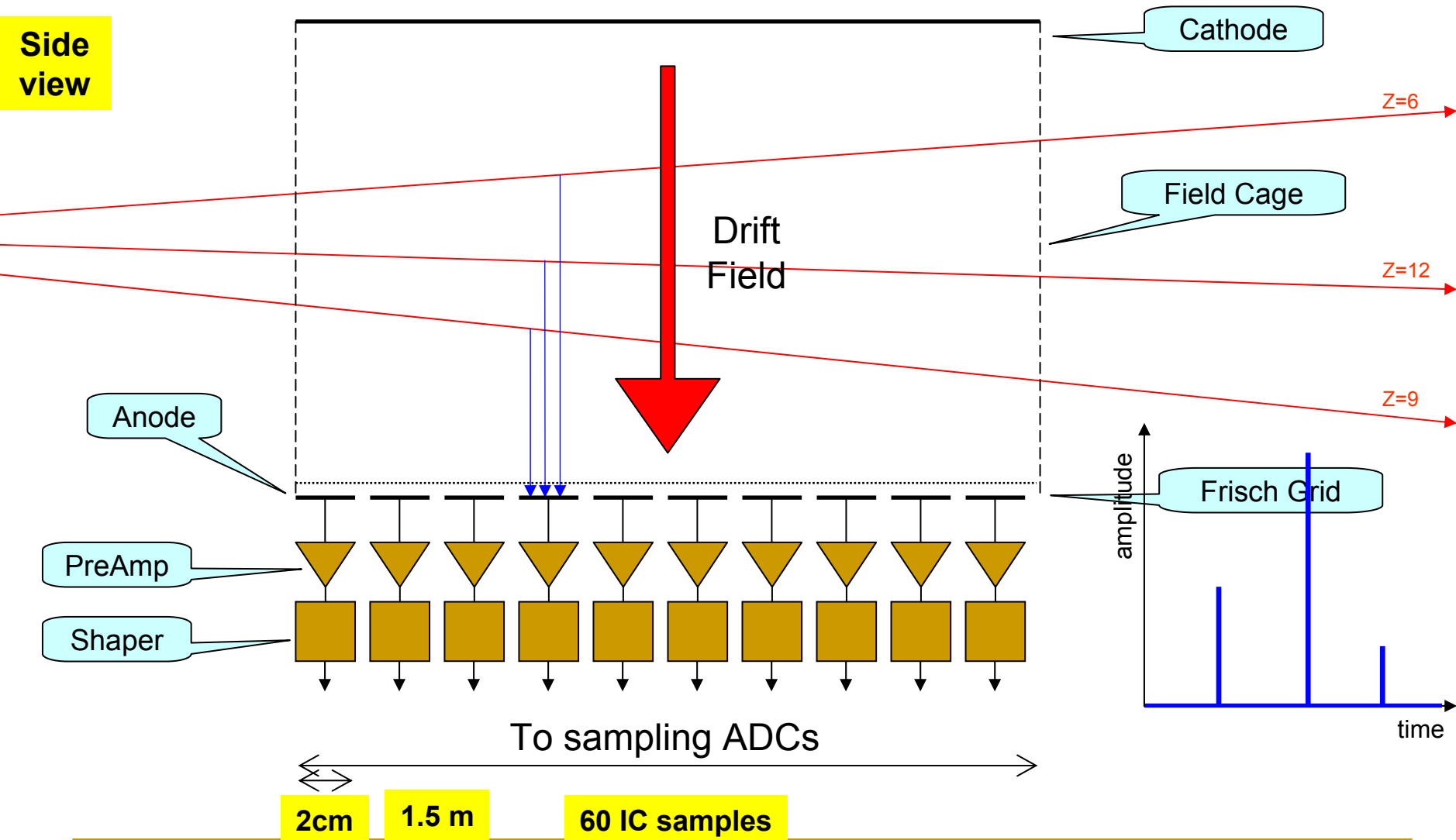
# Energy Loss vs. Energy Deposition II

- For  $Z=1$ : Landau tail
  - Use truncated mean
- For  $Z>6$  energy deposition distribution roughly gaussian
- Width depends on effective Delta cut-off energy
  - segment anodes
  - short shaping times
  - MUSIC



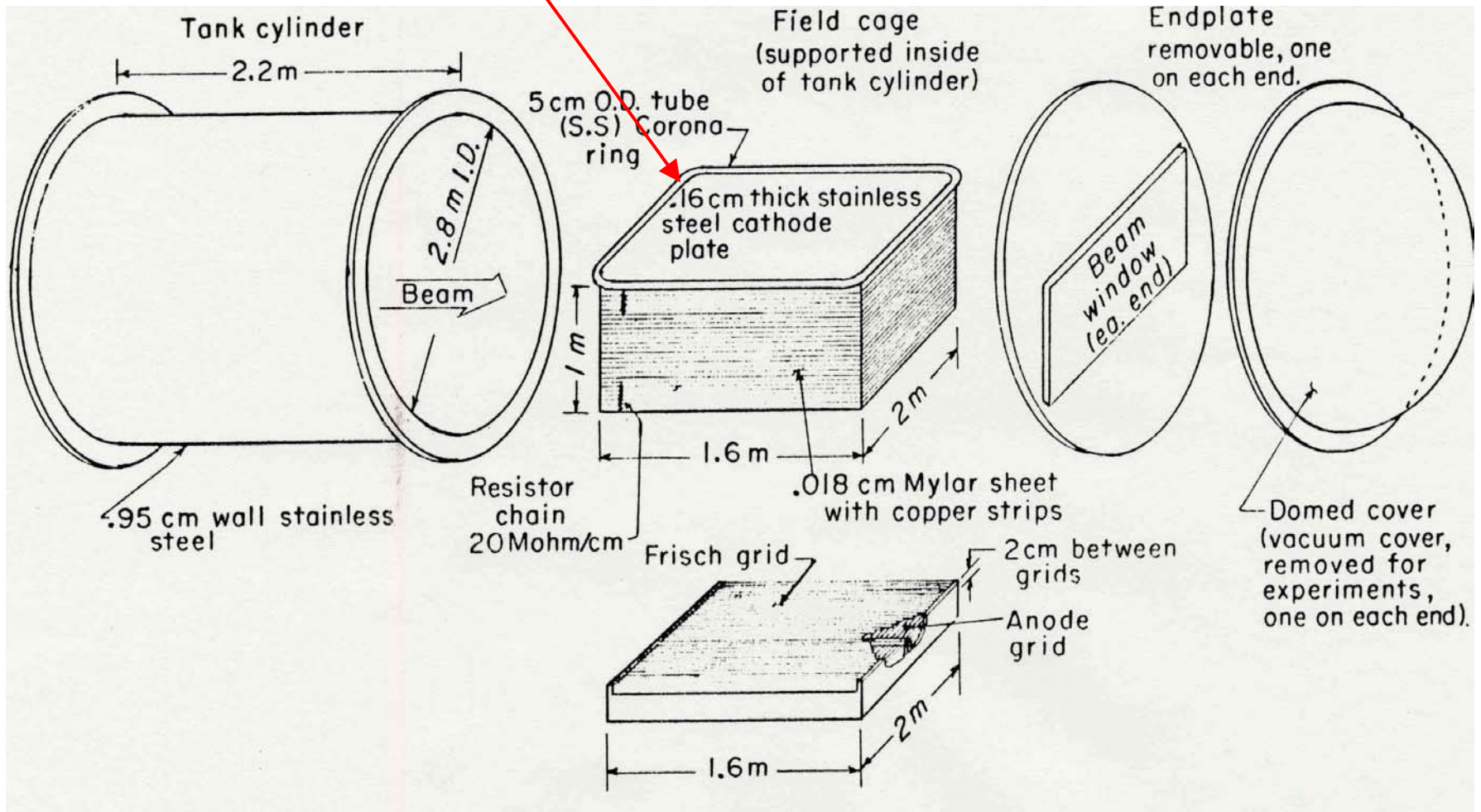
Fraction of total energy in  
Delta rays with  $E > E_{cut}$

# MUSIC I: Measure Charge (LBL 1984)



# MUSIC I: Not a 'piccolo pezzo'

1/16 inch

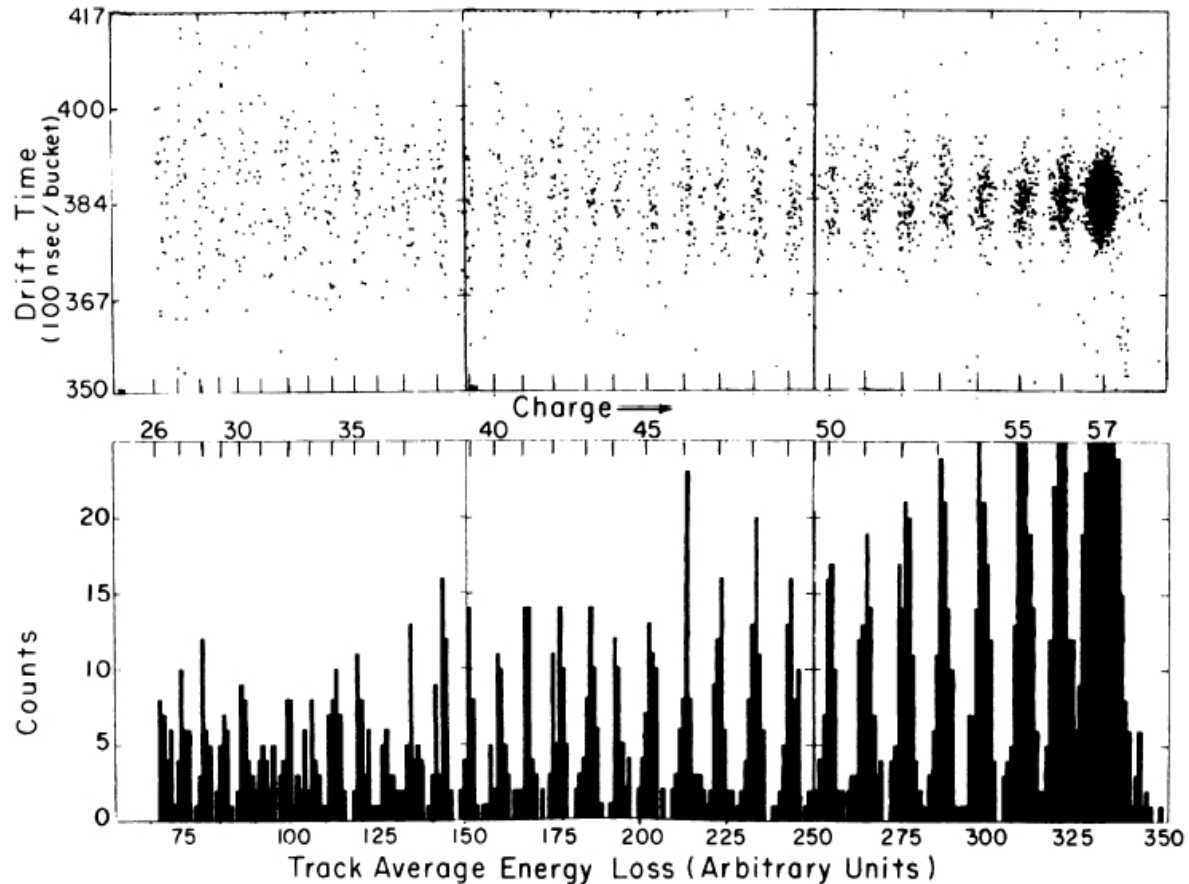


# MUSIC I Performance

VOLUME 60, NUMBER 17

PHYSICAL REVIEW LETTERS

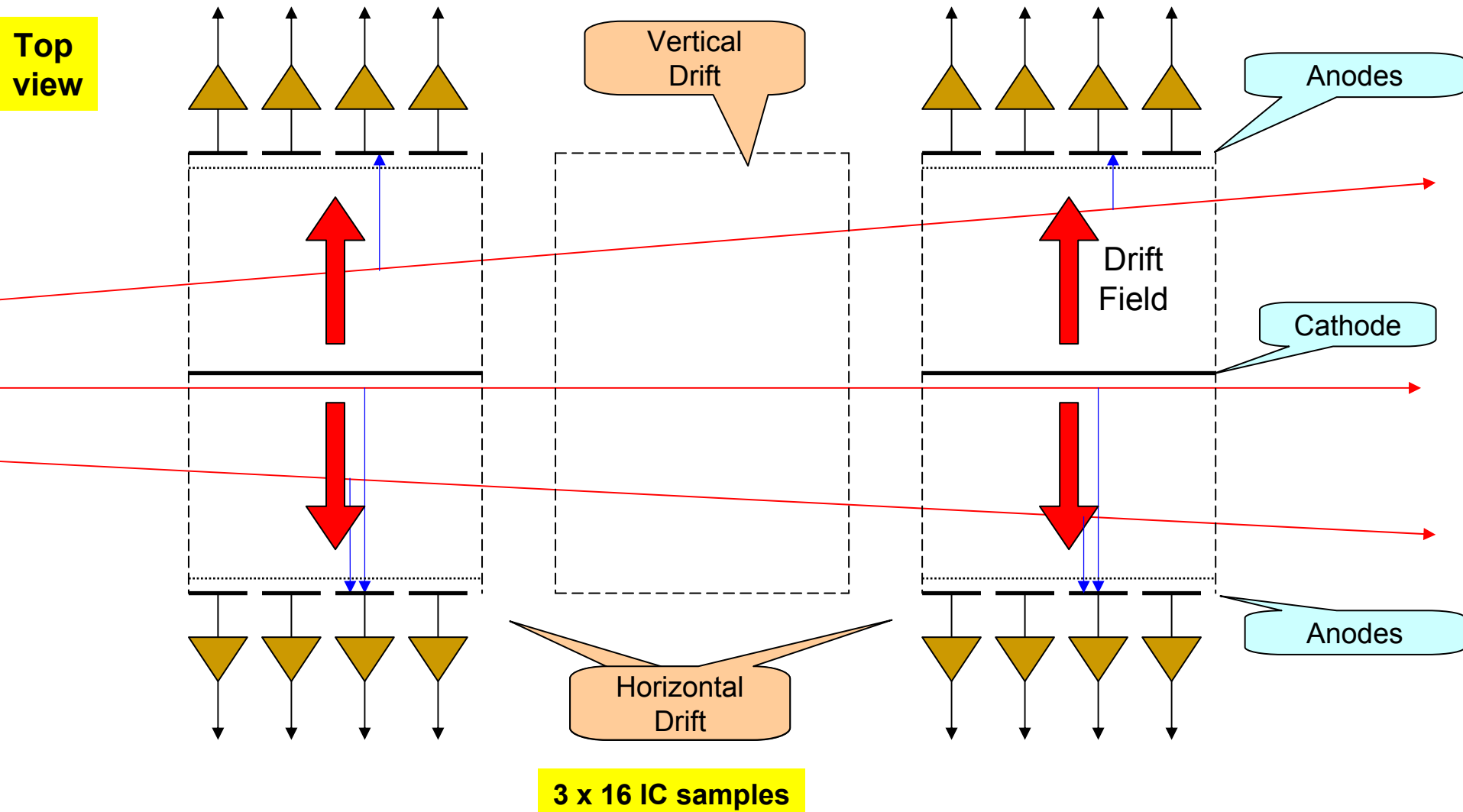
25 APRIL 1988



$\Delta Z = 0.3$  (FWHM)

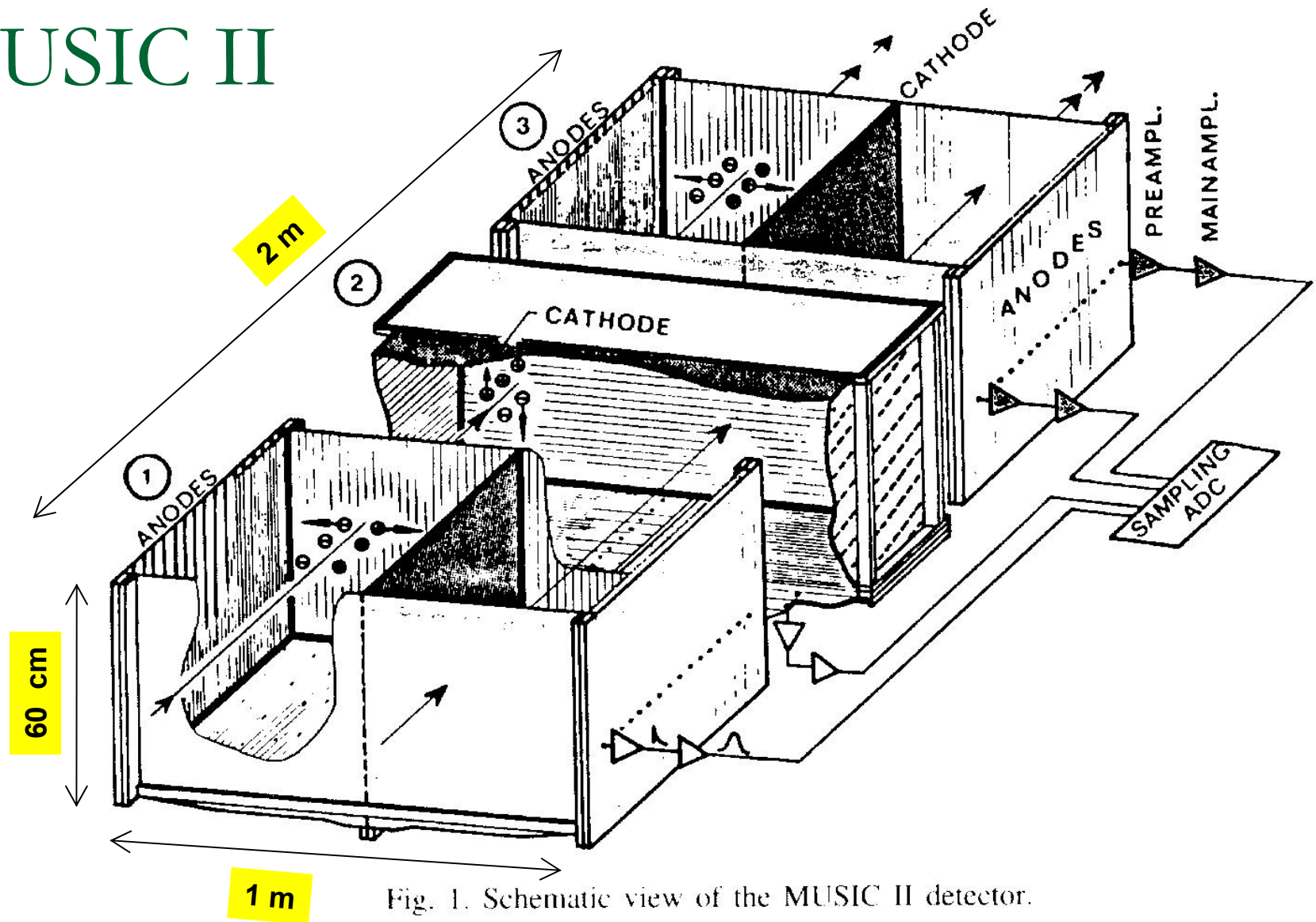
FIG. 1. Top: Drift time vs track average energy loss and charge of fragments from  $^{139}\text{La}$  (1.2 GeV/nucleon) + C. Bottom: Projected spectrum.

# MUSIC II: 3d Tracking (GSI/LBL 1987)



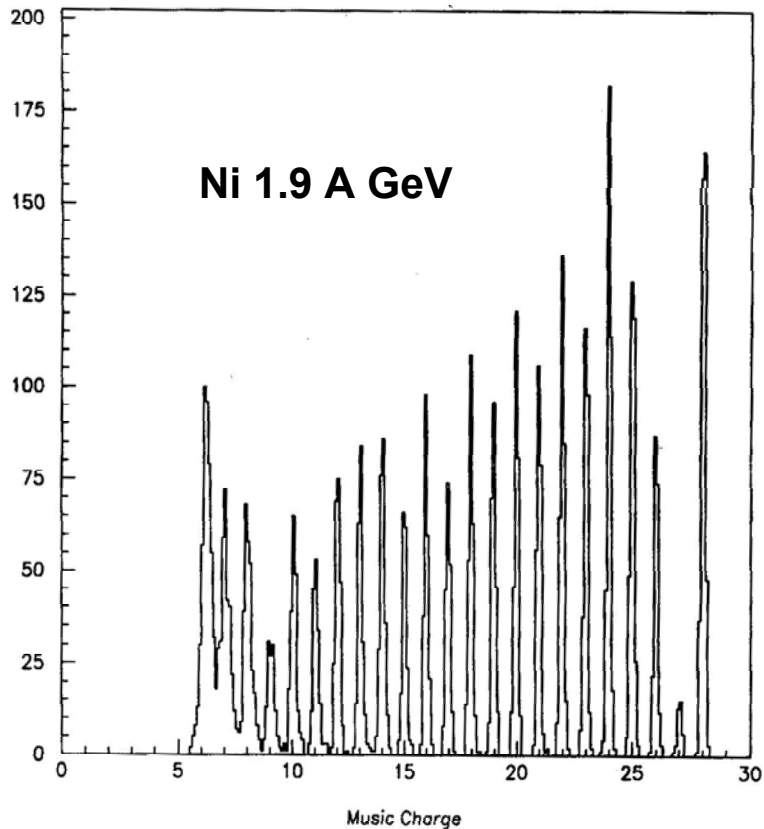


# MUSIC II



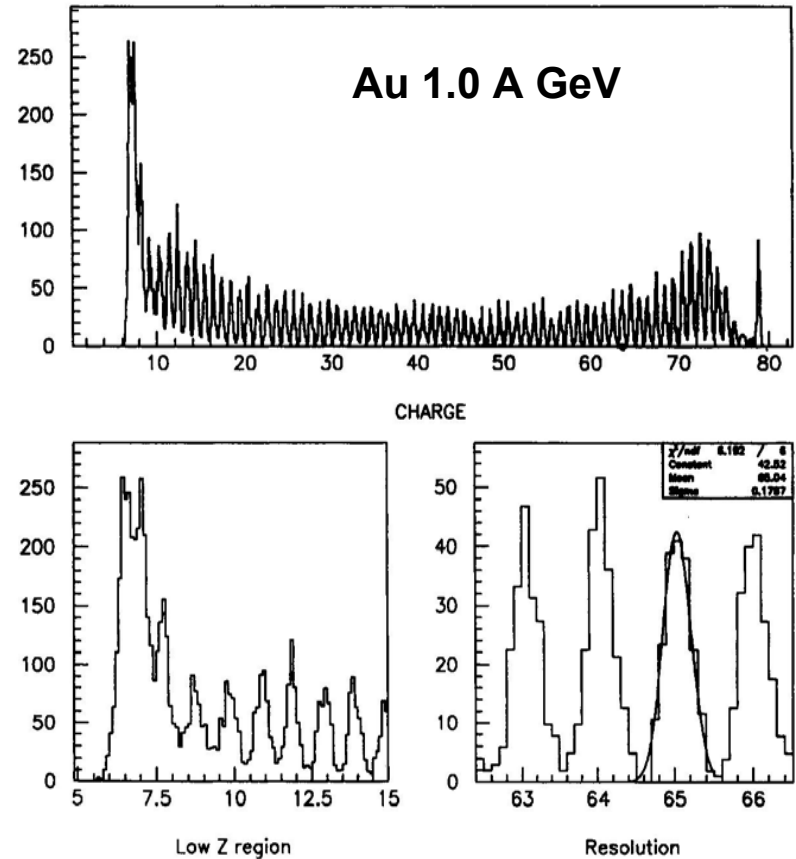
# MUSIC II Performance

G. Bauer et al. / Nucl. Instr. and Meth. in Phys. Res. A 386 (1997) 249–253



$\Delta Z = 0.24$  (FWHM)

G. Bauer et al. / Nucl. Instr. and Meth. in Phys. Res. A 386 (1997) 249–253



$\Delta Z = 0.4$  (FWHM)

# From LBL to GSI





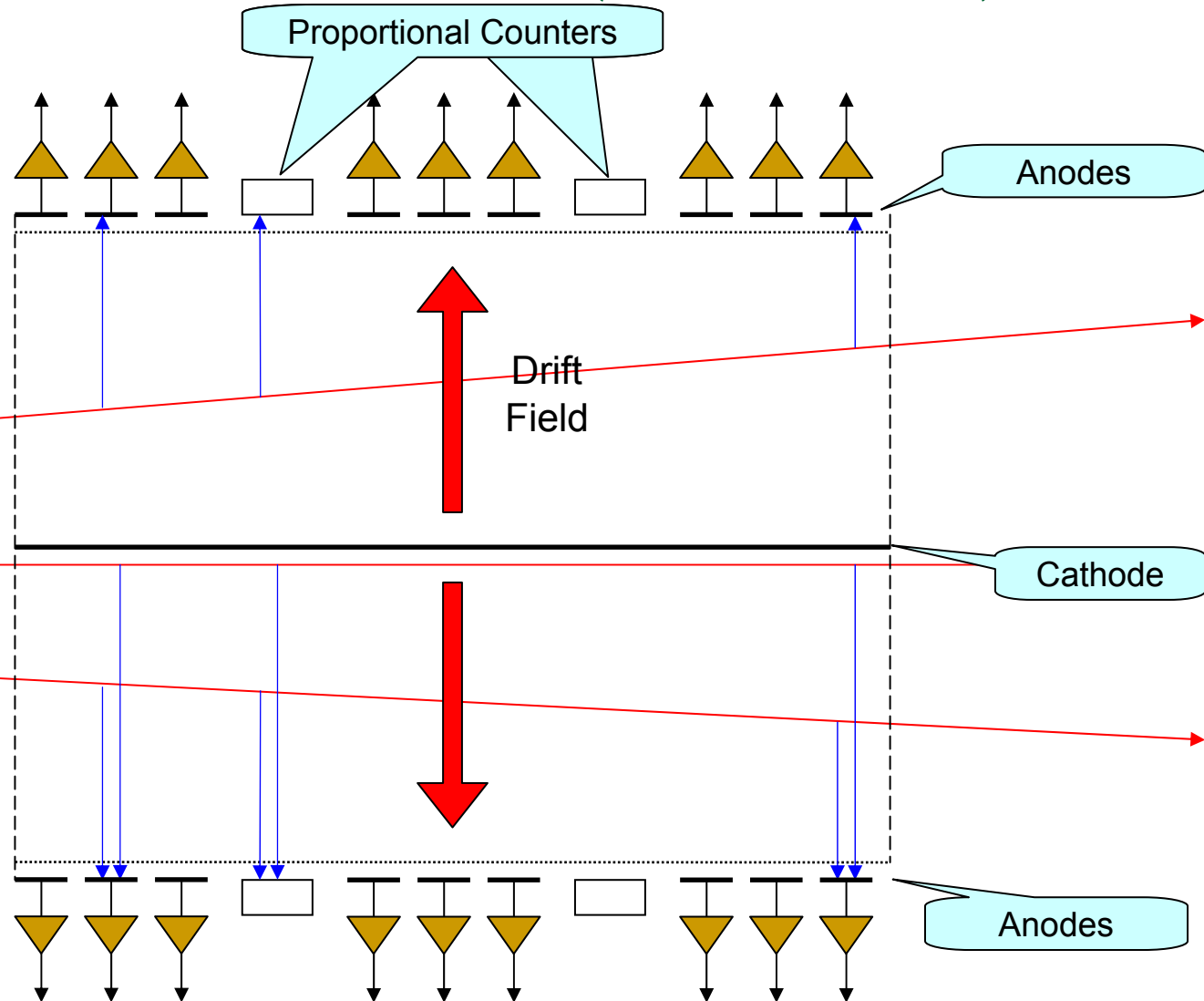




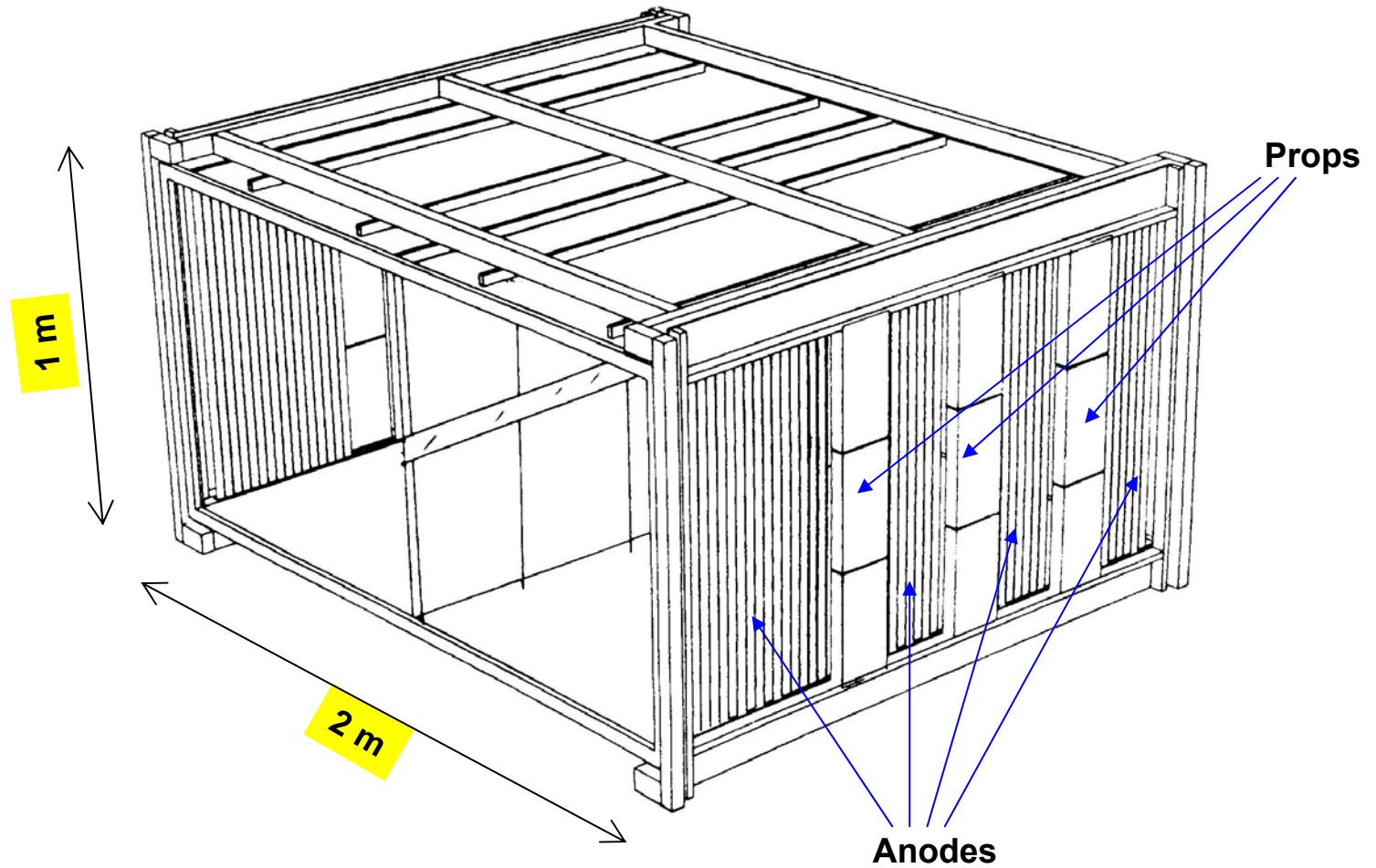




# MUSIC III: Detect $Z \geq 2$ (GSI 1993)

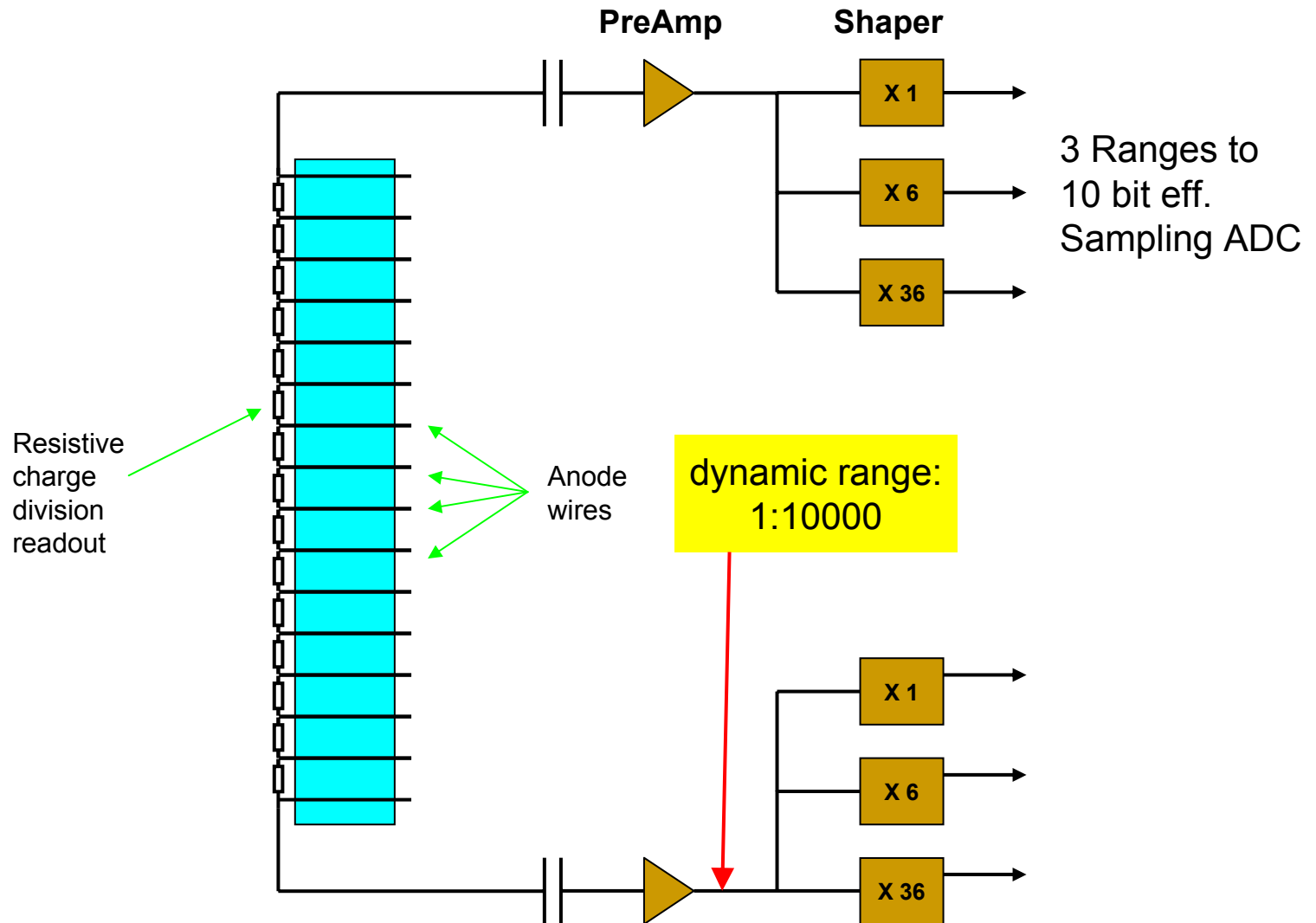


# MUSIC III Geometry

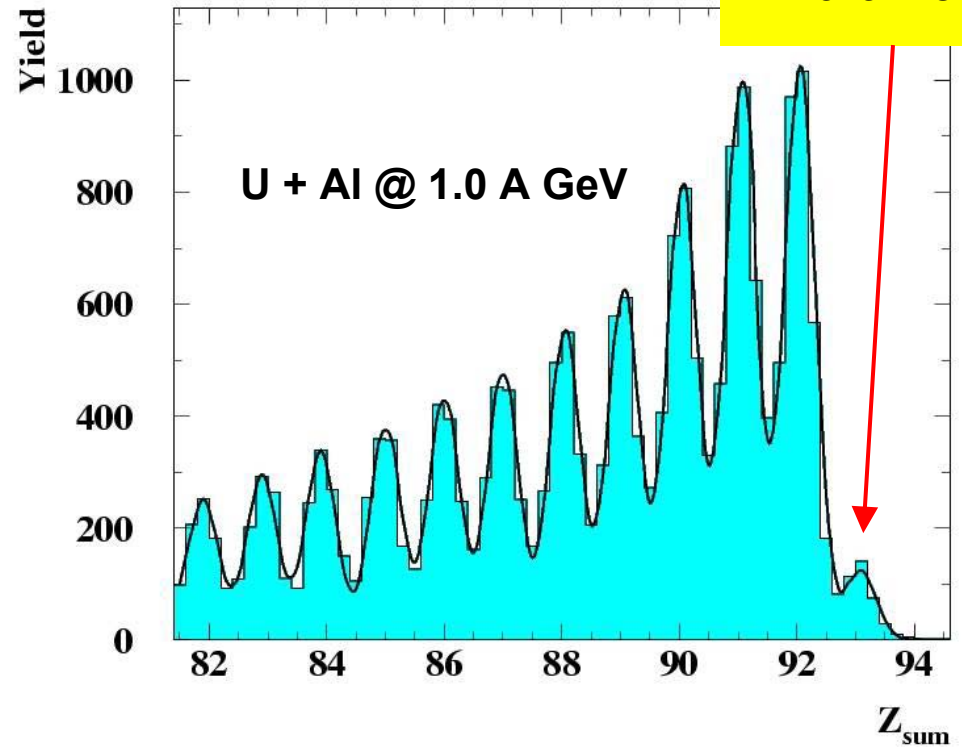
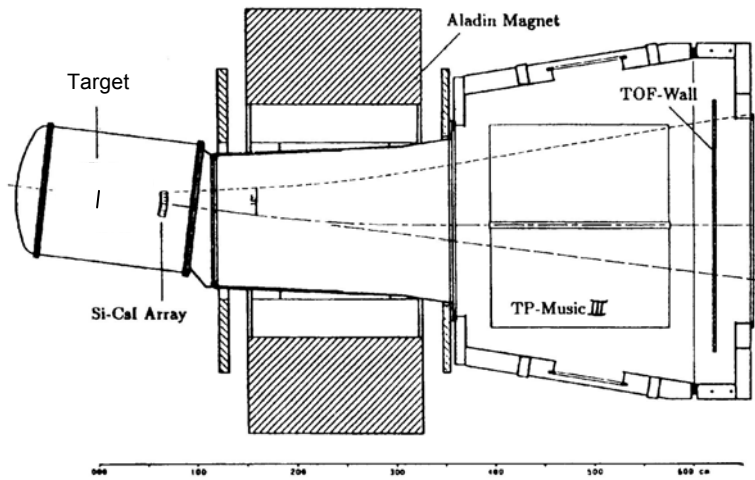




# MUSIC III Proportional Counters



# MUSIC III: The tracker for ALADiN

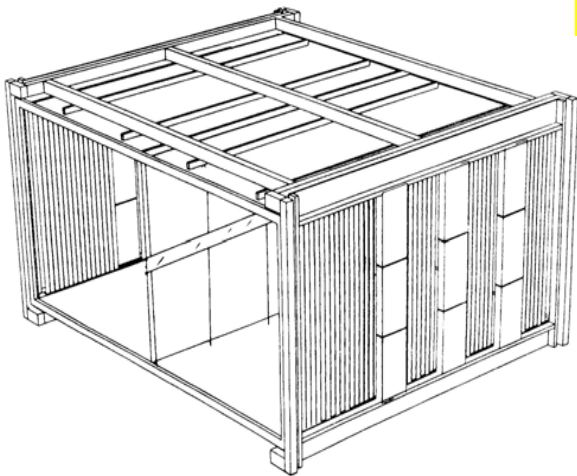


$\Delta Z = 0.6$  (FWHM) for sum charge  
of two fission fragments

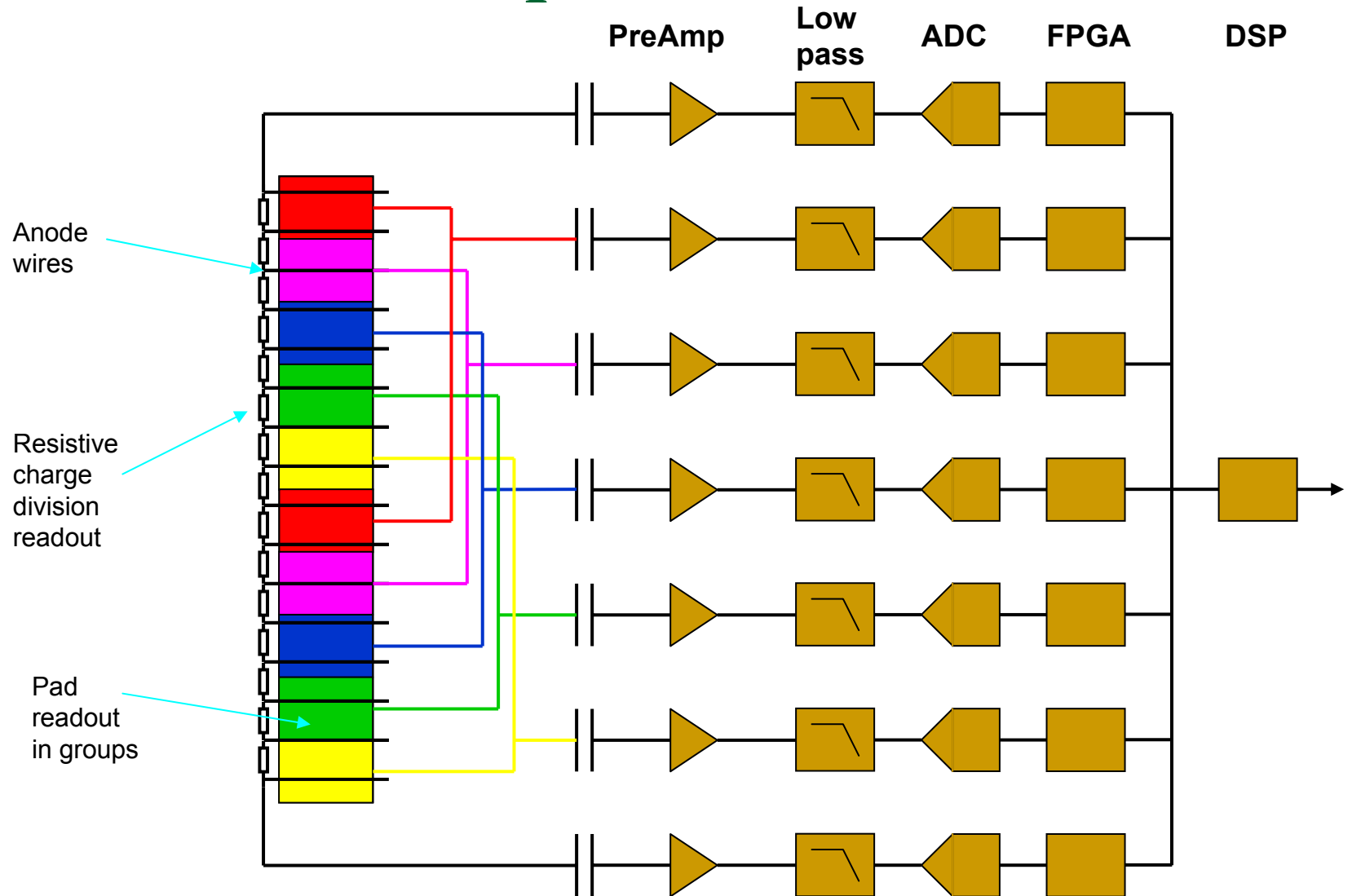
# MUSIC IV: The Conclusion (GSI 2003)

- Use 4 Prop Counters
- Use combined charge division plus pad readout
- Use all new electronics

**32 → 24 IC layers**  
**3 → 4 prop layers**

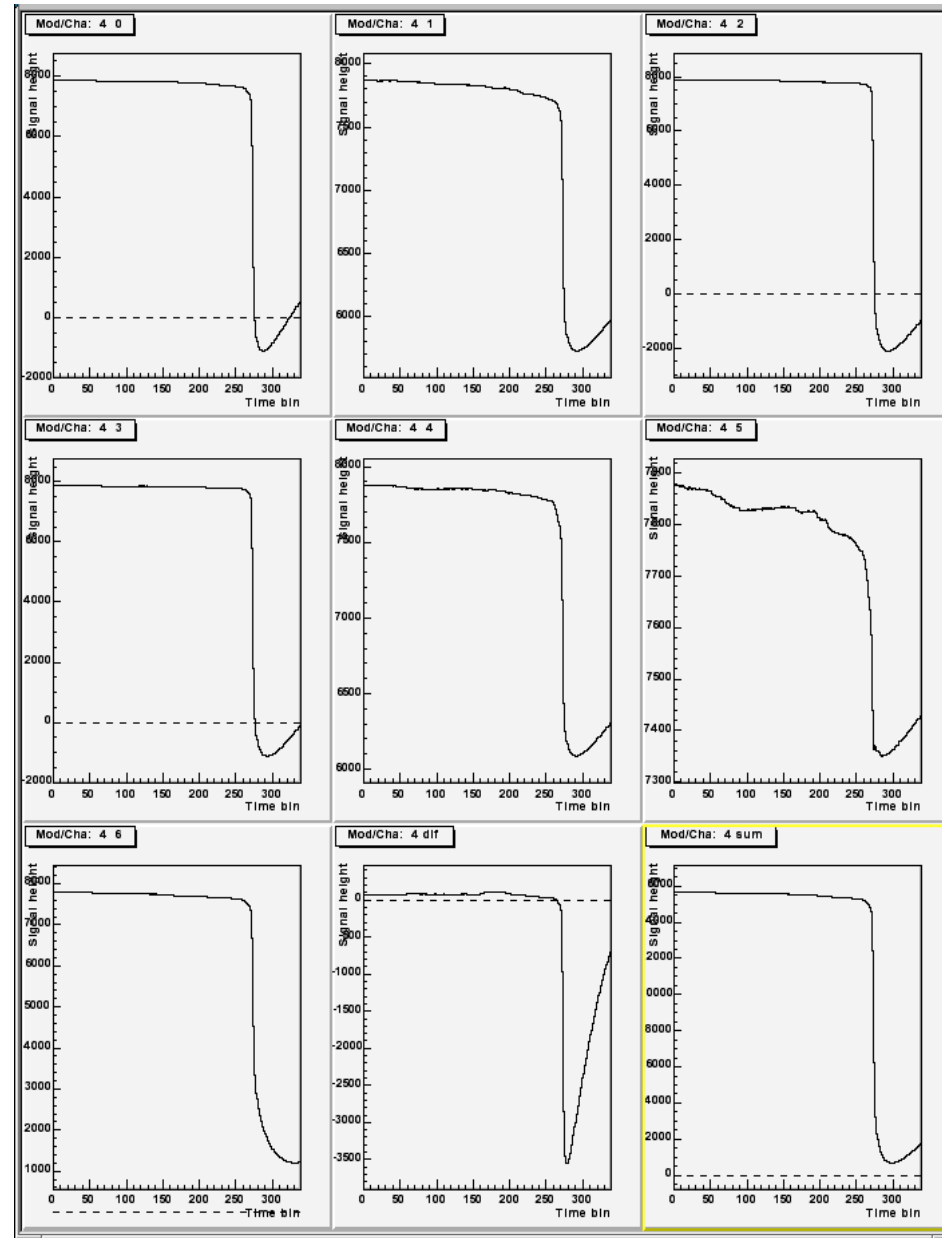


# MUSIC IV Proportional Counters



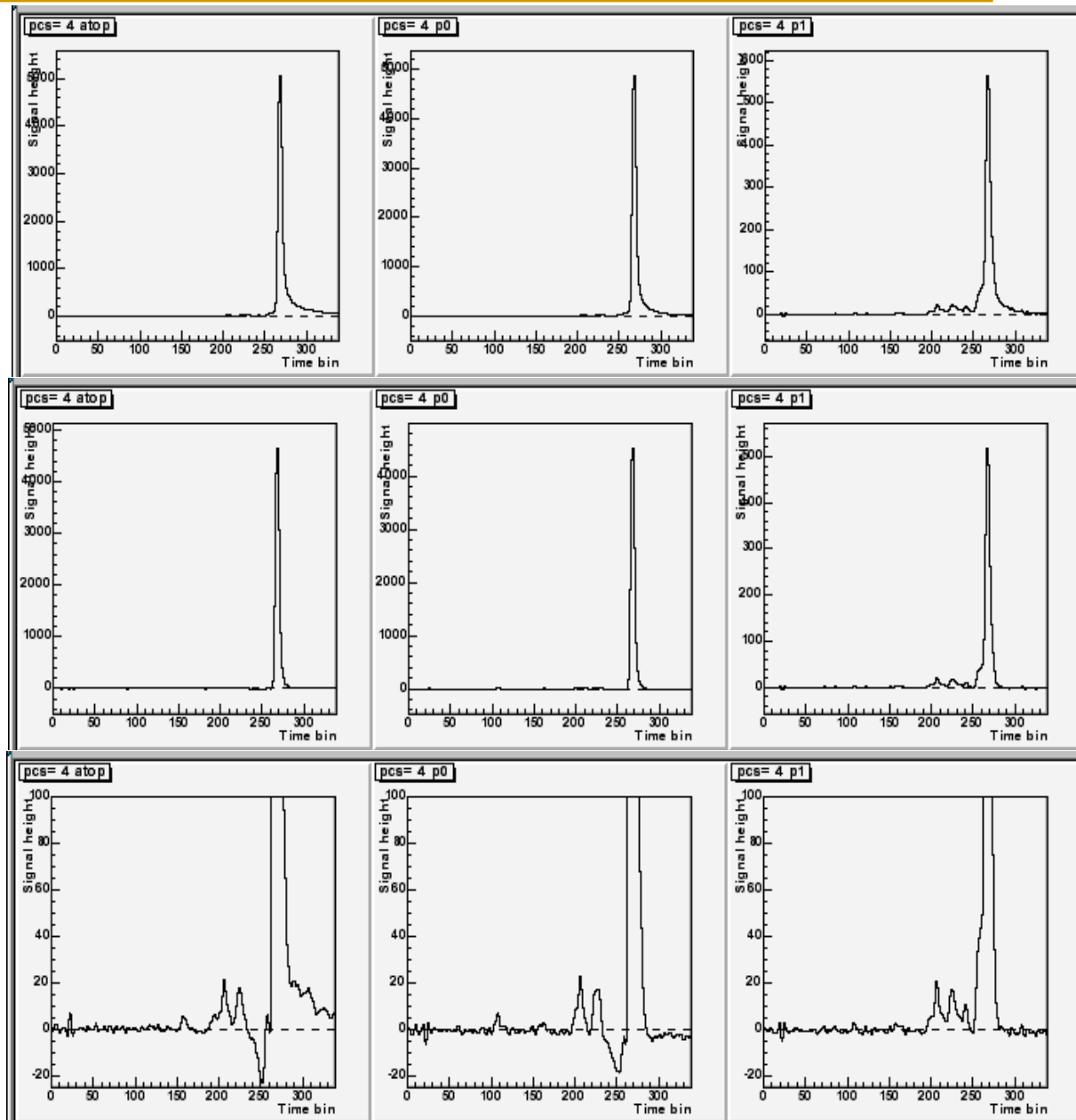
# Direct digitization of PreAmp Signal

- Sampling at 40 MHz
- 1:3 decimation
- 13.3 MHz effective rate
- 14 bit ADC
- Noise typ. 1 LSB (sigma)
- Dynamic range 1:10<sup>4</sup>
- DSP does compressing
- Shaping and hit finding currently done offline

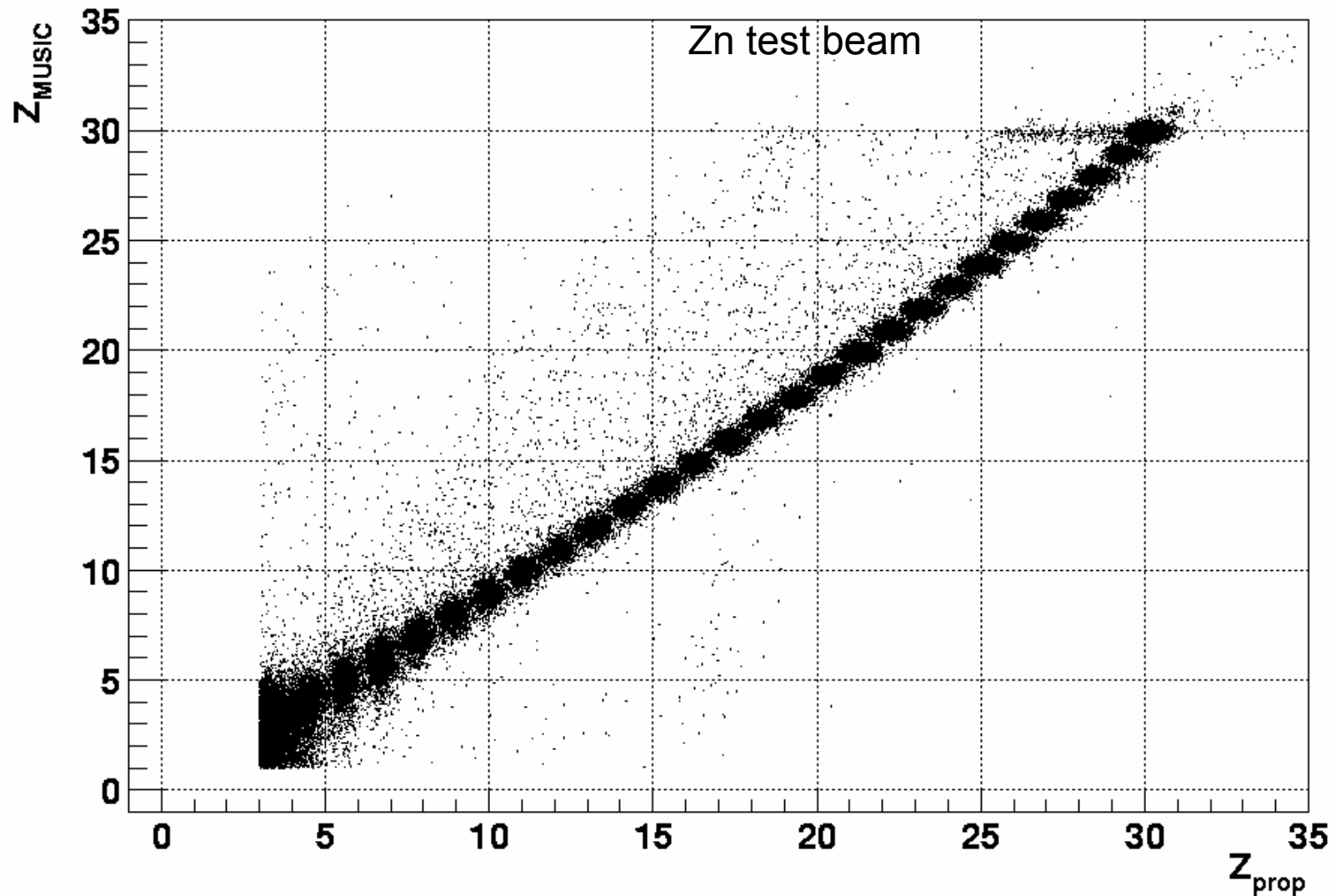


# Digital Filtering

- Shaping
- Tail cancellation
  - Prop  $1/t$  tail
  - Soft Delta-rays (time reverse filter)
- Exchange current cancellation



# MUSIC IV: Performance

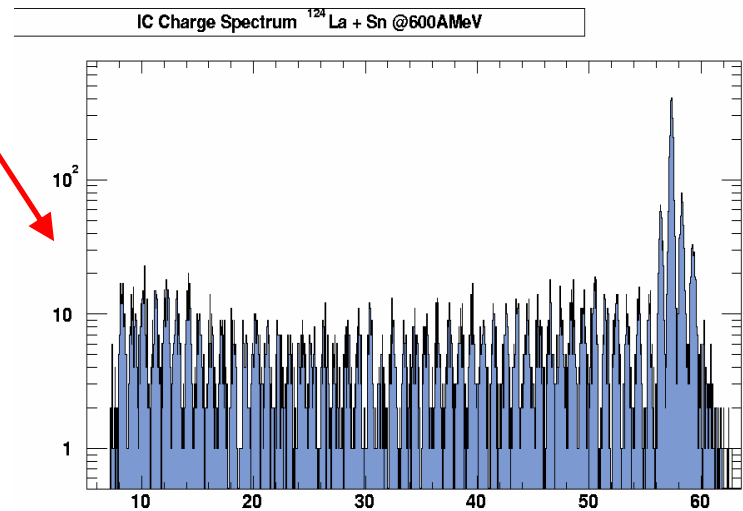
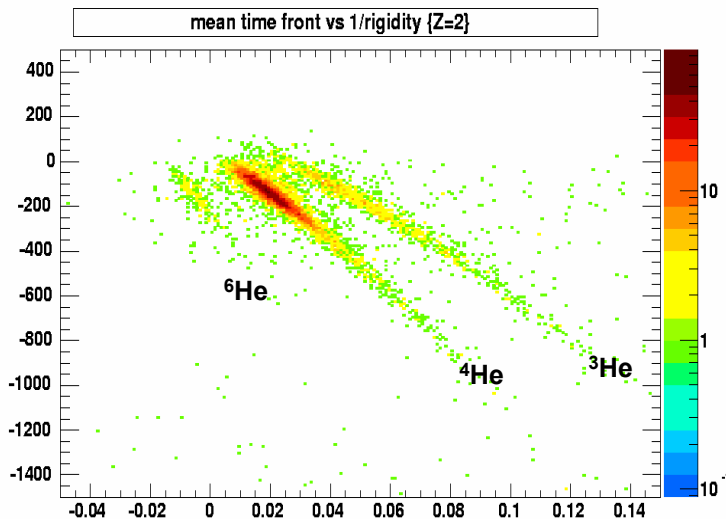
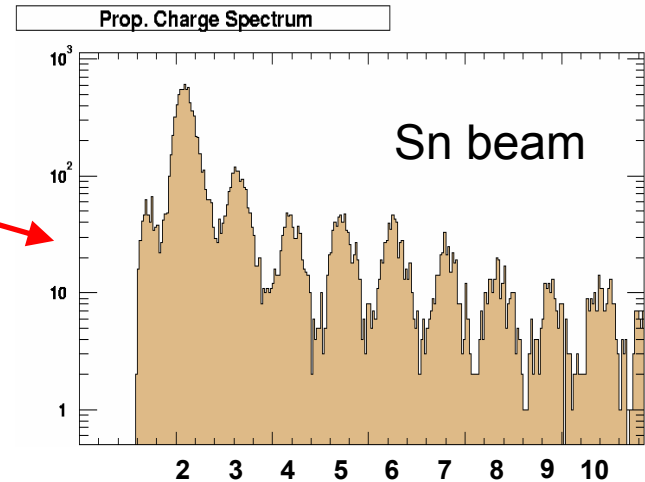


# MUSIC IV: Performance

Prop Charge Resolution

Online Mass Resolution Z=2

Anode Charge Resolution





# Summary

- 20 years of MUSIC
- Focus and Priorities evolved:
  - I: Charge
  - II: 3d tracking
  - III: Cover  $Z \geq 2$
  - IV: Prop Readout / Electronics
- MUSIC's are essential parts in projectile fragmentation setups:
  - MUSIC II at LBL (with HISS/EOS)
  - MUSIC III/IV at GSI (with ALADiN)
  - also at FRS, ....

