Discovery of the Two-Proton Decay of ^{45}Fe

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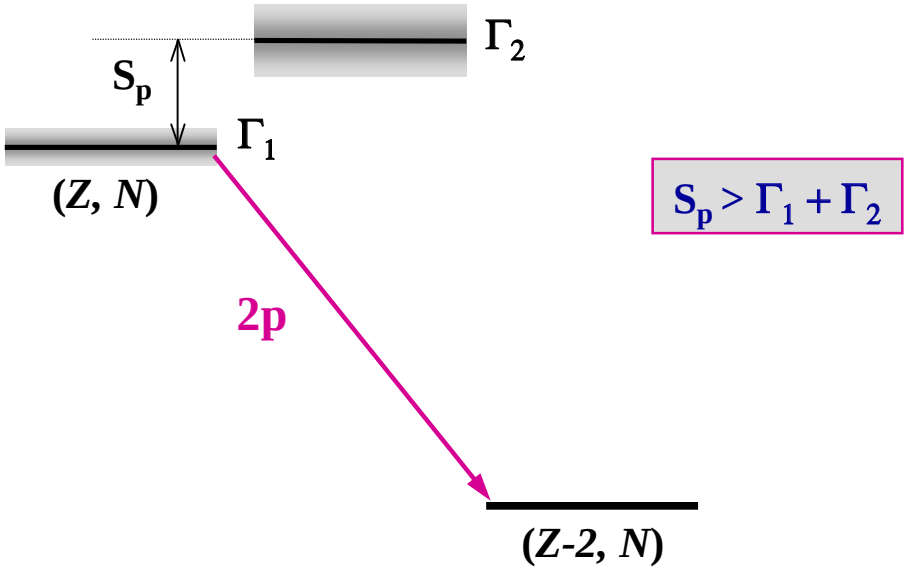
Two proton radioactivity

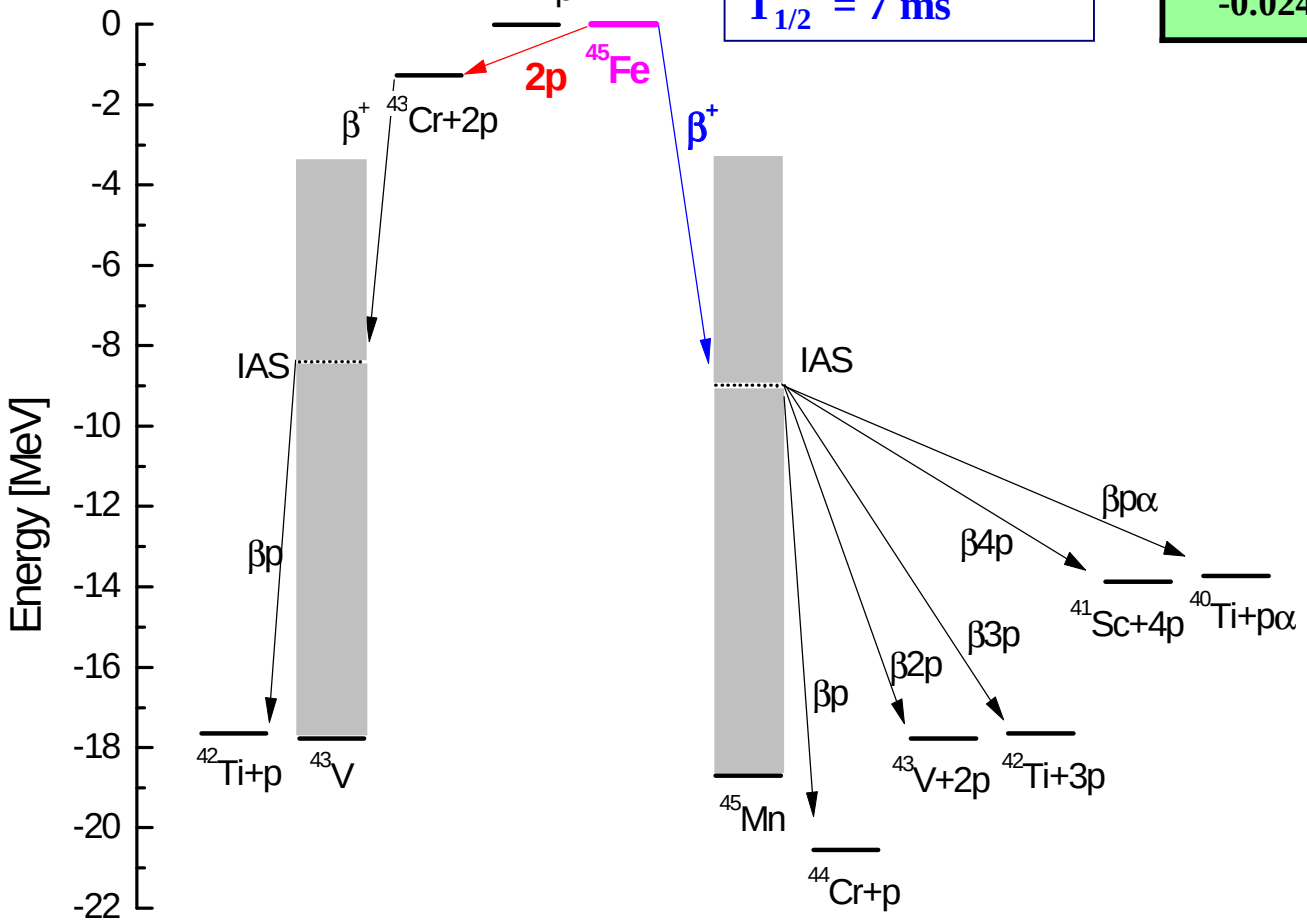


$S_p > \Gamma_1 + \Gamma_2$

Best candidates :

^{19}Mg, ^{45}Fe, ^{48}Ni, ^{54}Zn

Predicted decay scheme of ^{45}Fe



Q_{EC} = 18.7 MeV
$T_{1/2}$ = 7 ms

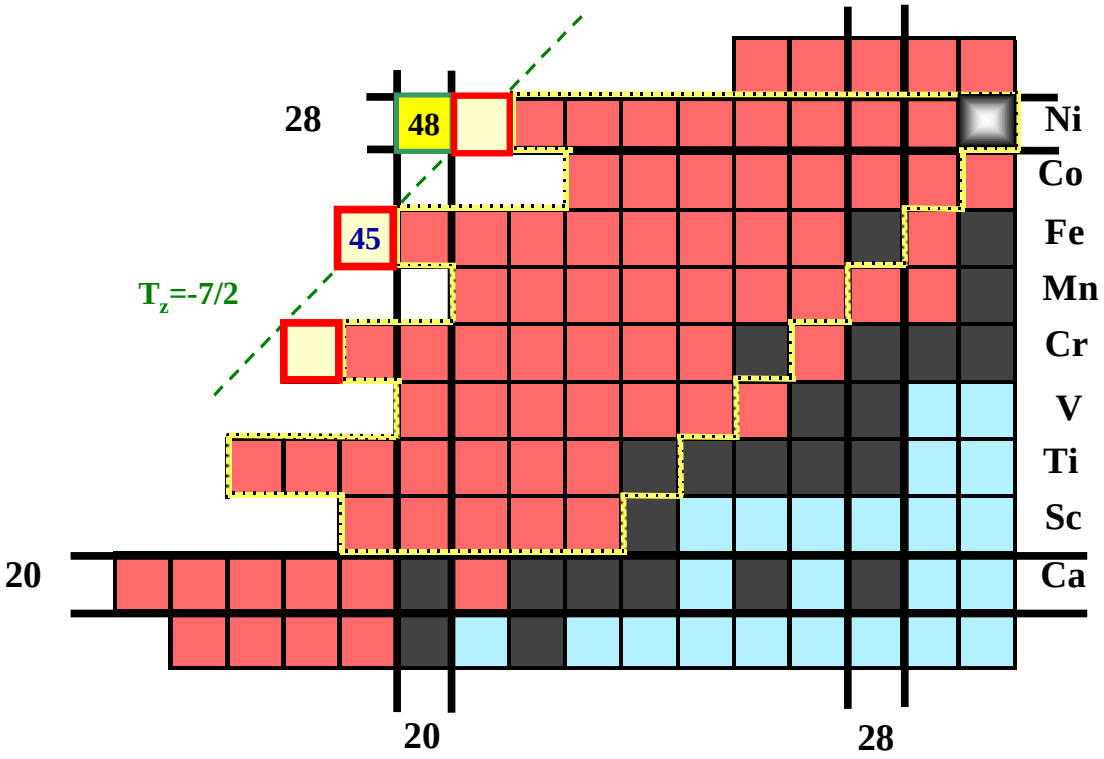
Q_{1p} [MeV]	Q_{2p} [MeV]	$T_{1/2}$ [μs]
-0.024	1.15 ±0.09	2 - 300

$T_{1/2}$ for the 2p emission from the ground state:

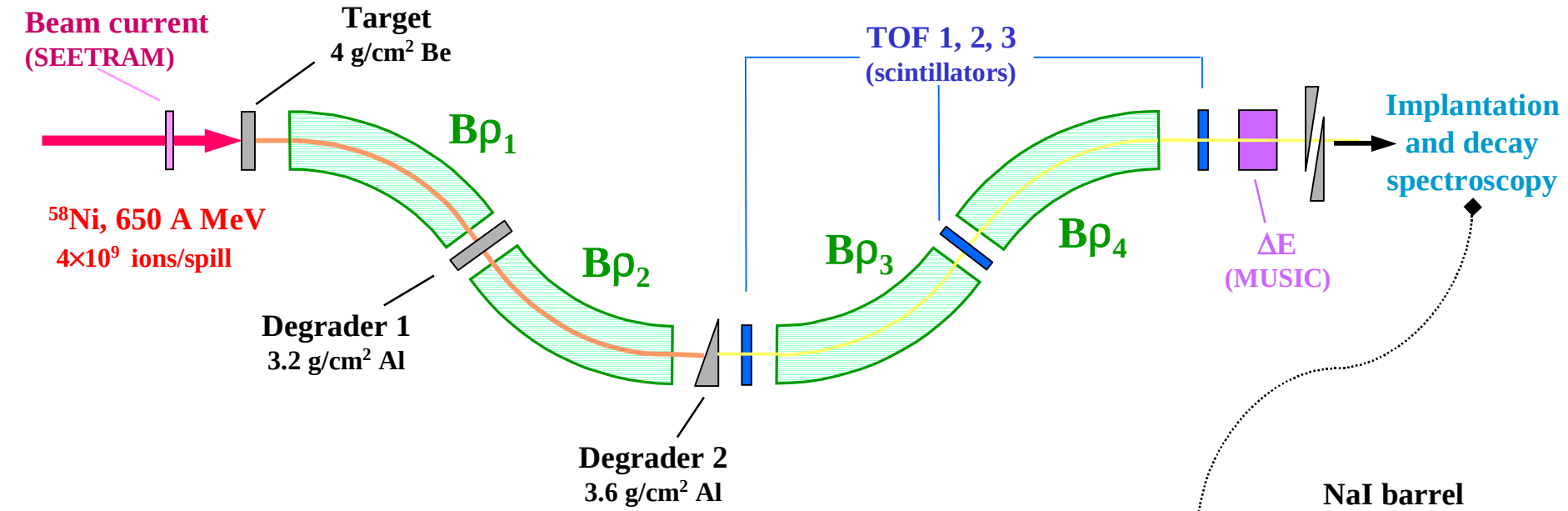
- diproton, L=0
- $\theta^2 = 1$

History of ^{45}Fe studies

- **GSI, 1996 – first observation of ^{45}Fe (3 atoms !), ^{49}Ni and ^{42}Cr**
- **GANIL, 1999 – discovery of ^{48}Ni, 53 atoms of ^{45}Fe, $T_{1/2}$ = 6 (+17–3) ms**
- **GANIL, July 2000 – next attempt of spectroscopy of ^{48}Ni, ^{45}Fe, …**
- **GSI, July 2001 – new approach to ^{45}Fe studies**



Fragment Separator (FRS) at GSI



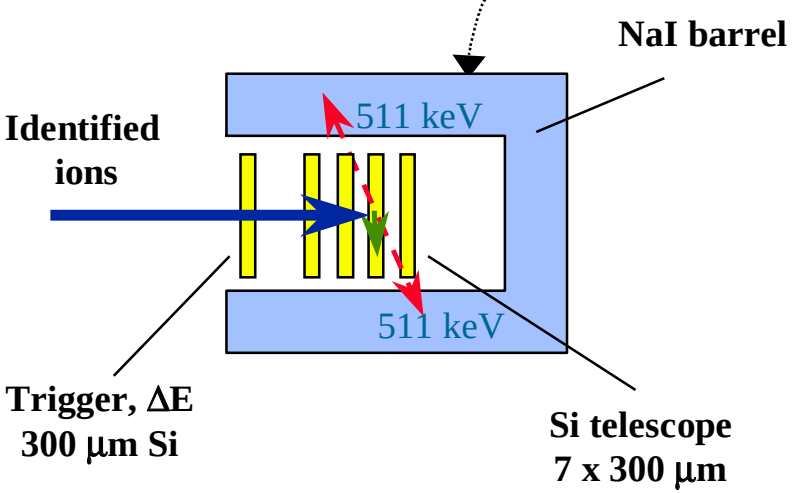
IN-FLIGHT IDENTIFICATION

$B\rho_{3,4} \Rightarrow p/Z$

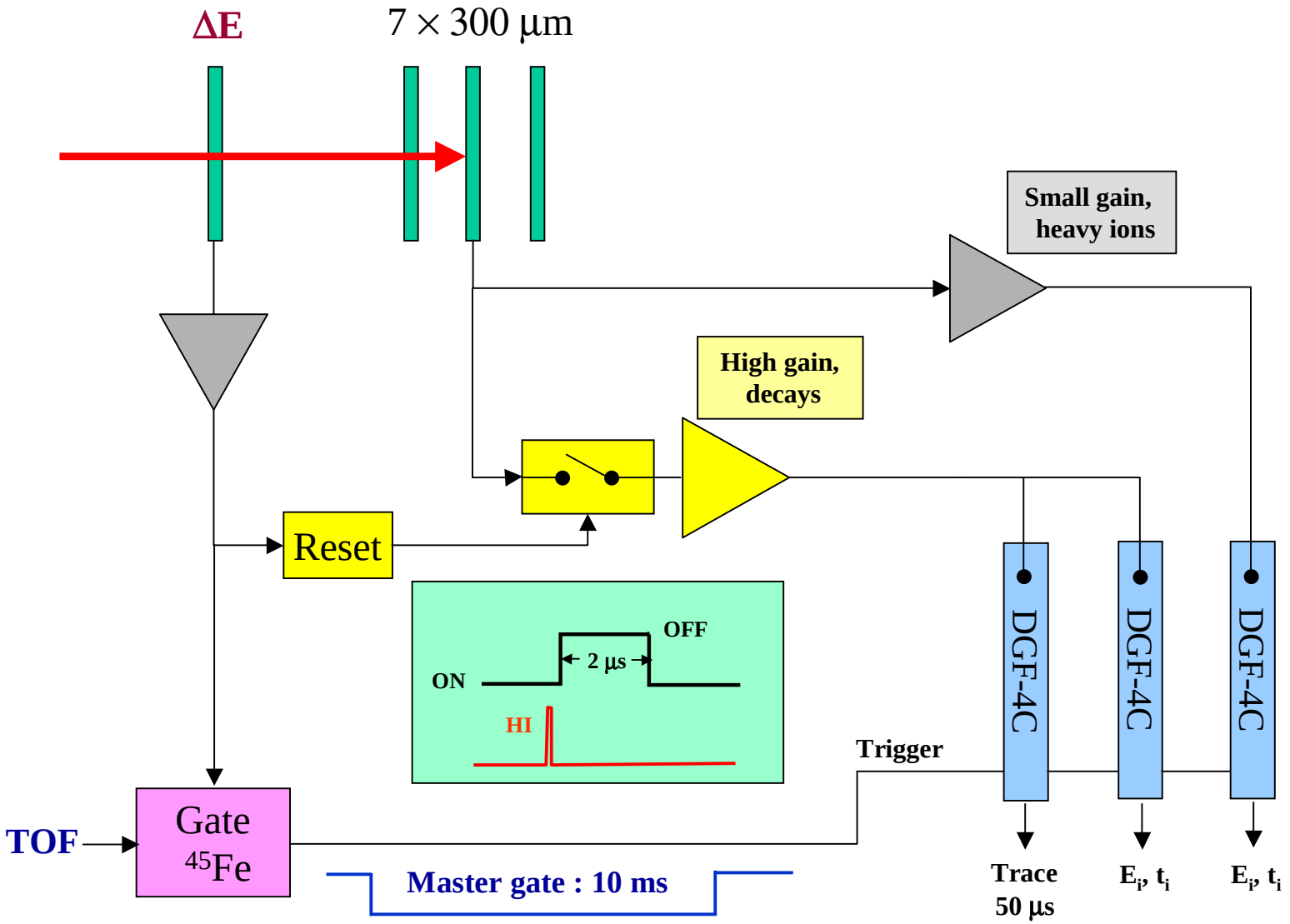
TOF 1,2,3 $\Rightarrow v$

$\Big\} \Rightarrow A/Z$

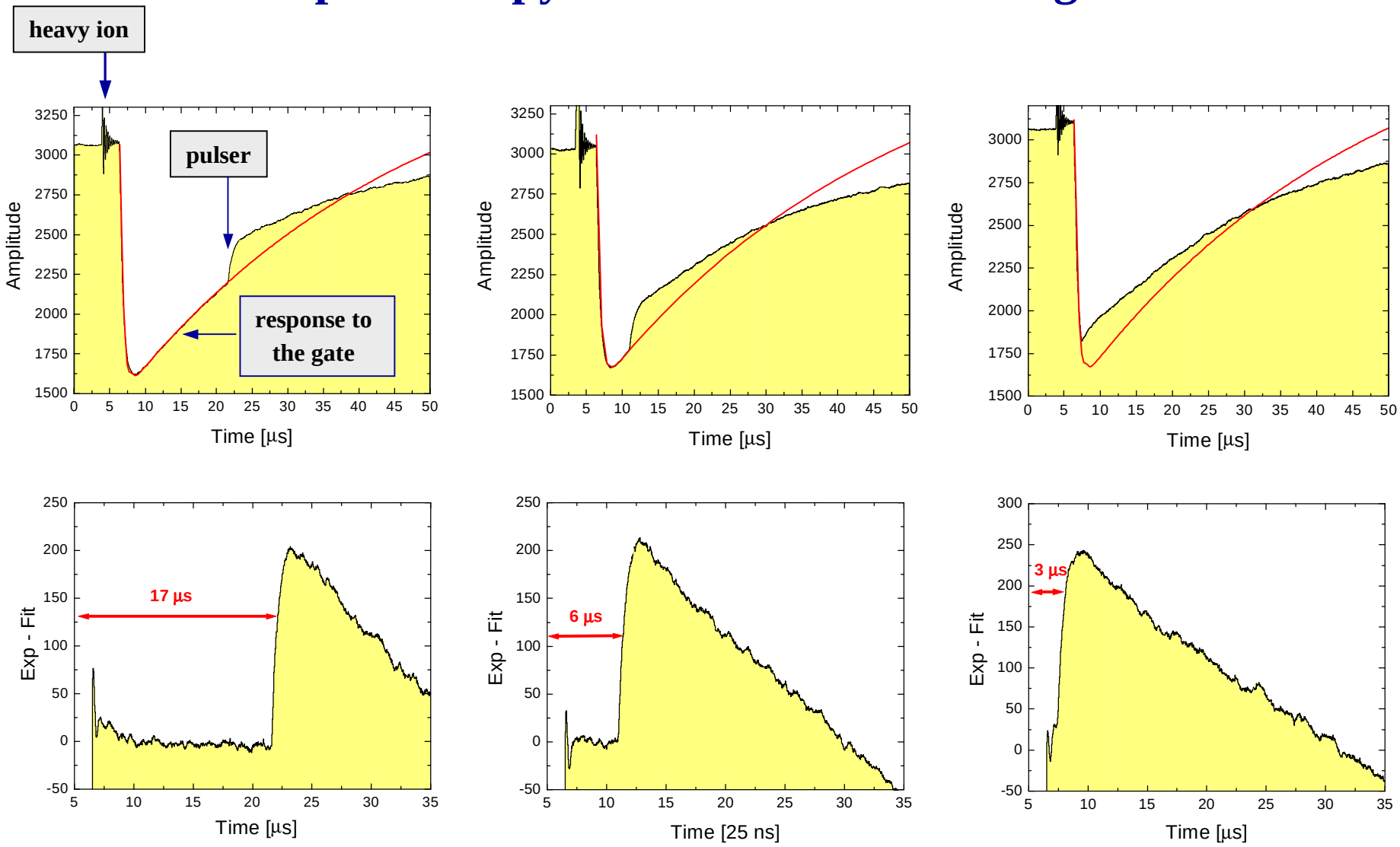
$\Delta E \Rightarrow Z$



Si telescope electronics



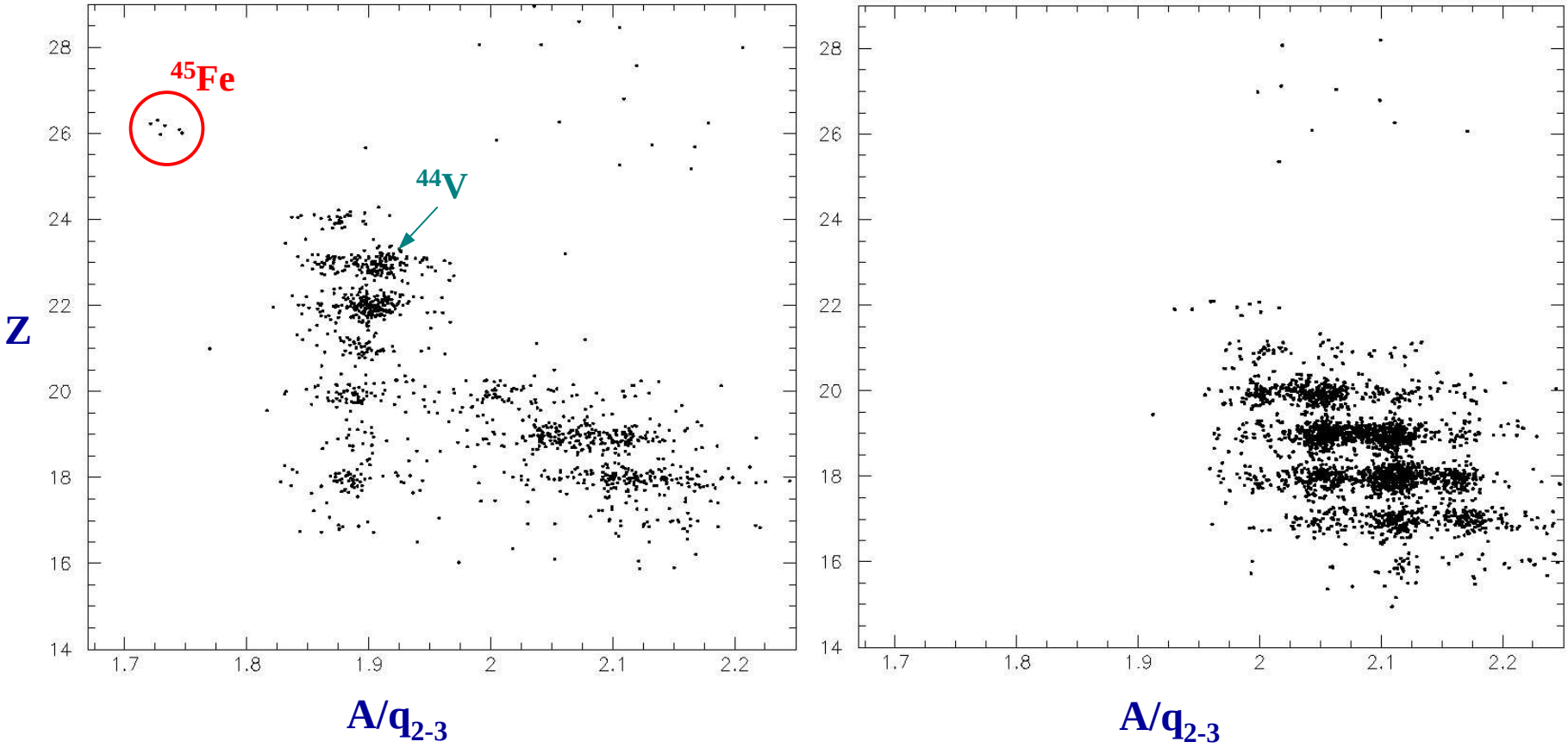
Spectroscopy in the microsecond range



^{45}Fe identification

Ions, which triggered DGF system:
2115 events in 8117 min. (5.6 d)

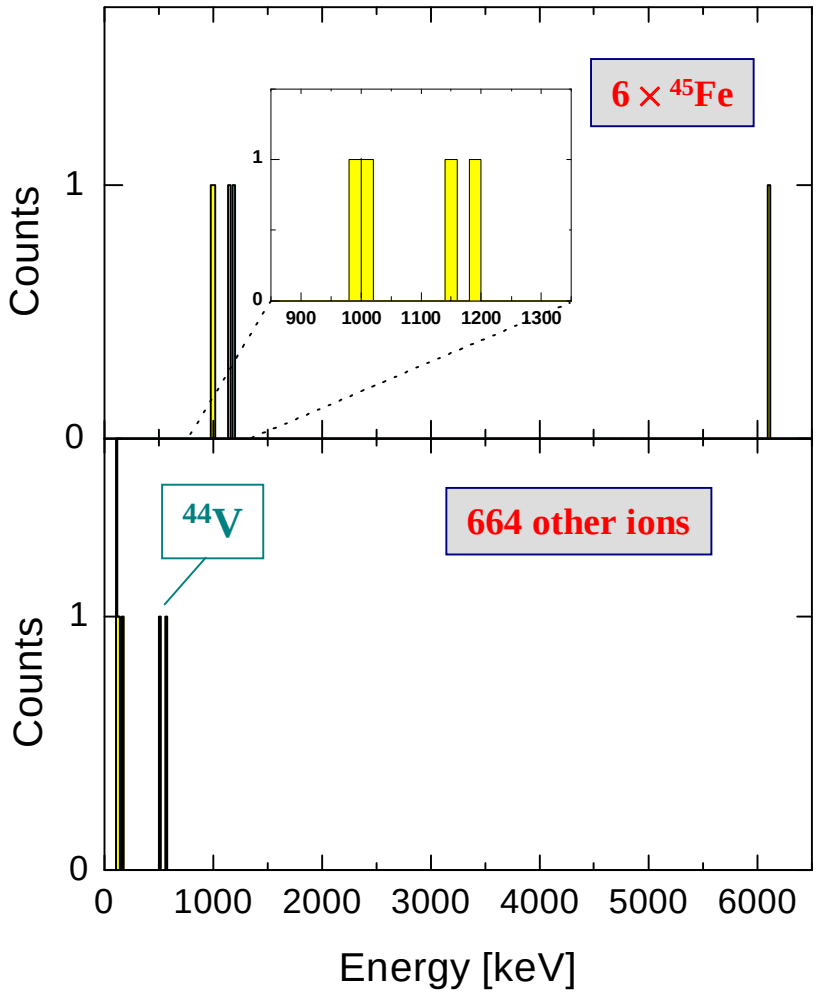
Ions registered in the Si telescope during 10 ms after each trigger
3970 ions in 21 s (2115 × 10 ms)



Radioactivity in the millisecond range

Correlation conditions:

- **implantation and decay in the same detector**
- **correlation time 10 ms**



Evidence for **2p** radioactivity of **^{45}Fe**

- **4** decay events correlated with ^{45}Fe implantation

  E_{2p} = **1.1(1) MeV**

  $T_{1/2} = 3.4^{+3.4}_{-1.1}$ **ms**

- **No** coincident γ – rays
- E_{2p} and $T_{1/2}$ compatible with predictions

Outlook

- Other candidates to measure : **^{48}Ni**, **^{54}Zn**
- Energy and angular correlation of two protons

M. Pfützner et al., EPJA **14**, 279 (2002)