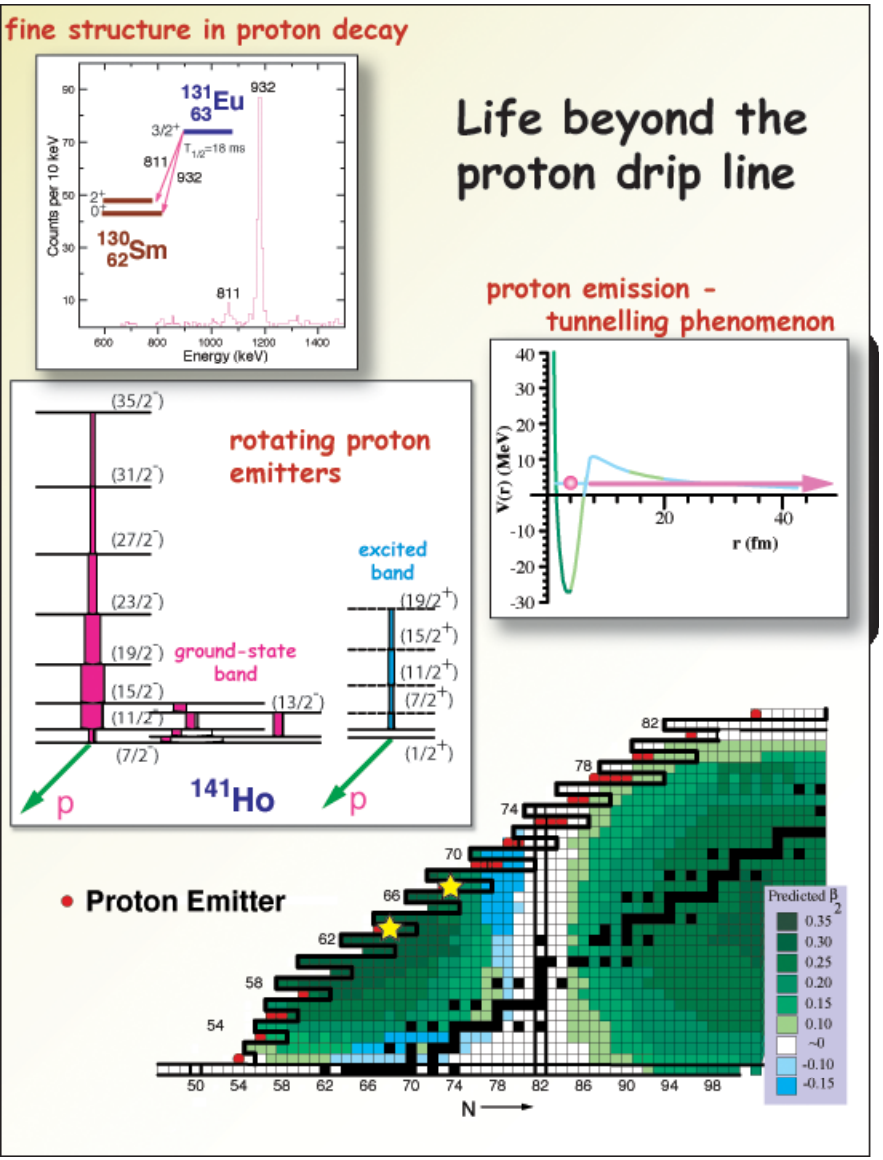
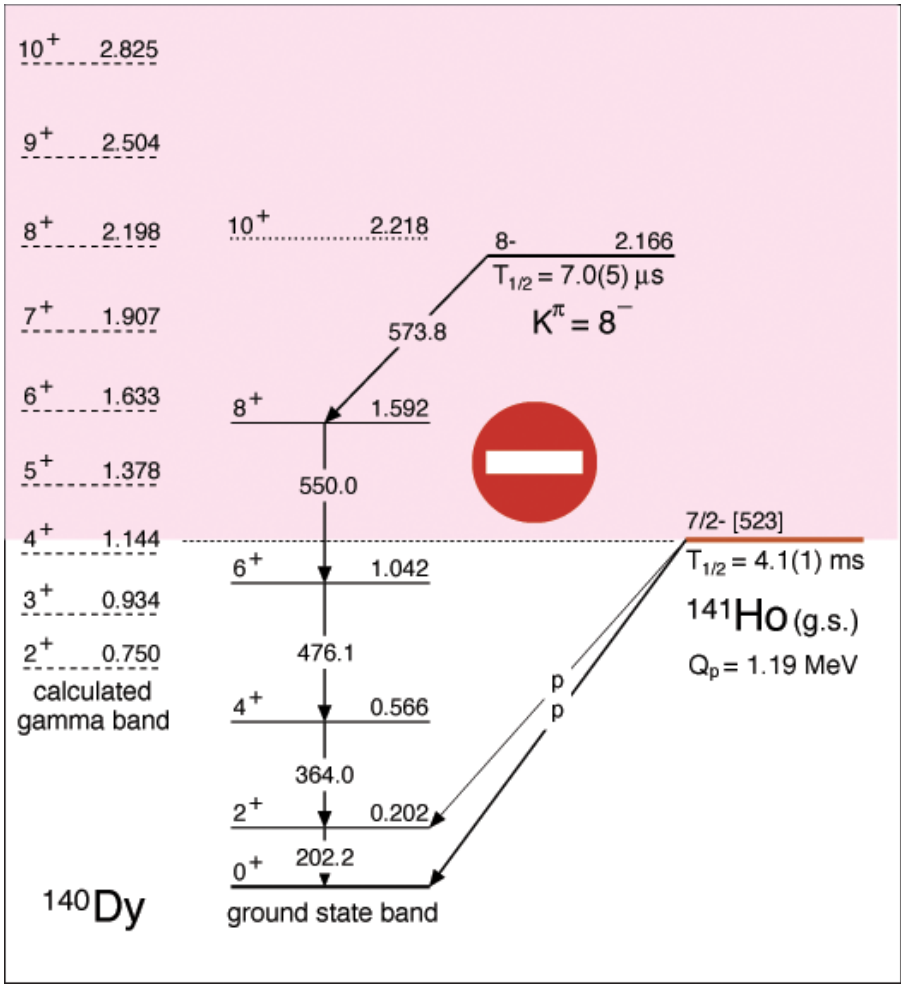
# Spectroscopy of open systems: proton emitters



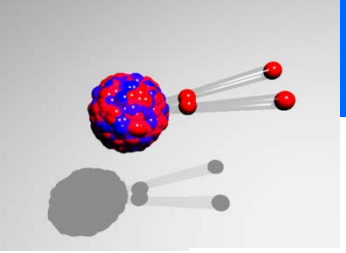



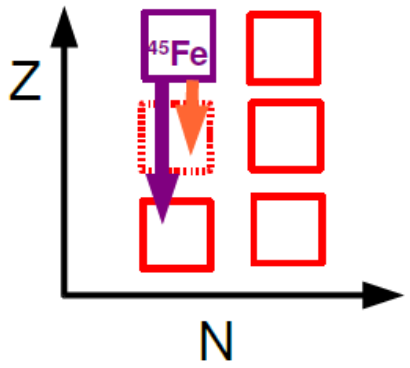

**Non-adiabatic theory:**

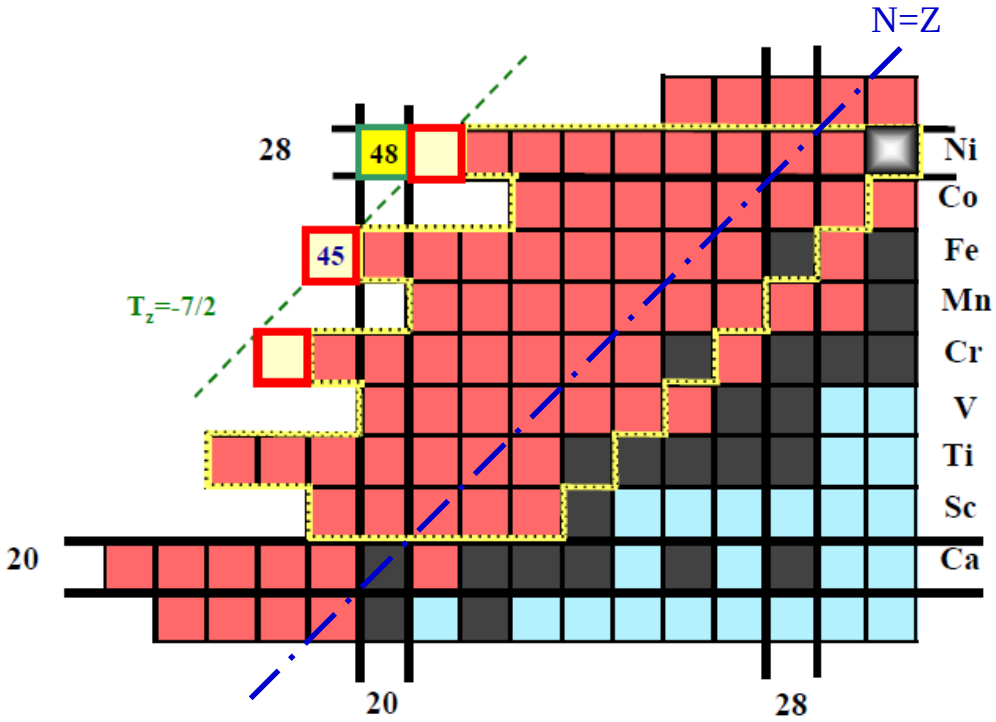
B.Barmore et al., Phys.Rev. C62, 054315 (2000)

A.T. Kruppa and WN, Phys. Rev. C69, 054311 (2004)

# 2-proton radioactivity of $^{45}$Fe






*1-proton emission:*

$^{45}_{26}Fe_{19} \rightarrow {}^{44}_{25}Mn_{19}$

-120 keV < $S_p$ < 70 keV

$t_{1/2}$ > 100s

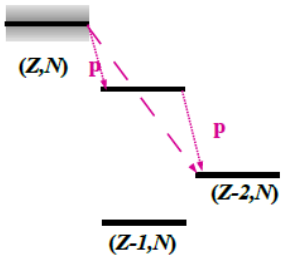
*2-proton emission:*

$^{45}_{26}Fe_{19} \rightarrow {}^{43}_{24}Cr_{19}$

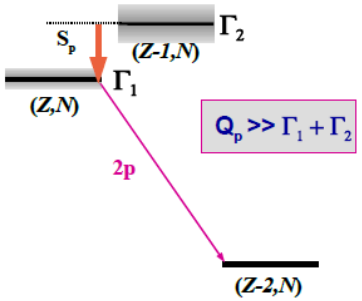
-1000 keV < $S_{2p}$ < -1300 keV

$t_{1/2}$~$10^{-6}$s – 1s

sequential

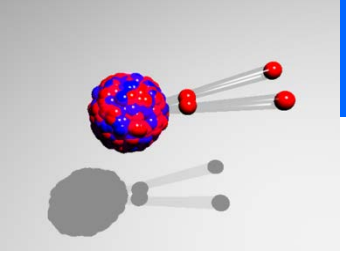



simultanious




proposed by V.I. Goldansky; Nucl.Phys. 19 (1960), 482 Nucl.Phys. 27 (1961), 648

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

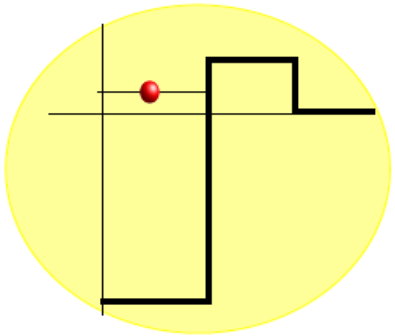


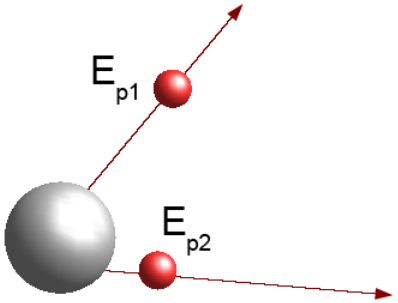
# 2-proton radioactivity of $^{45}$Fe

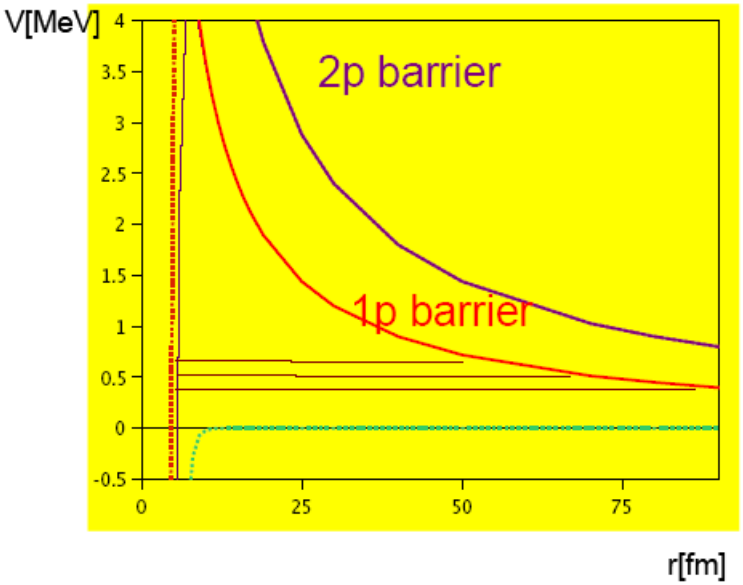
*Tunneling through a potential barrier:*

$$\lambda = S \cdot \omega \cdot P$$

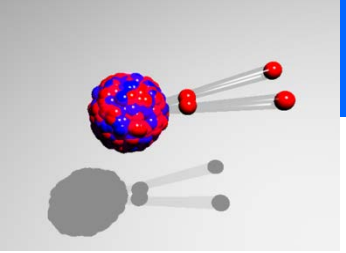
- S spectroscopic factor for 2-proton creation
- ω frequency, with which both protons hit the barrier
- P is the penetrability, the probability for a tunneling process



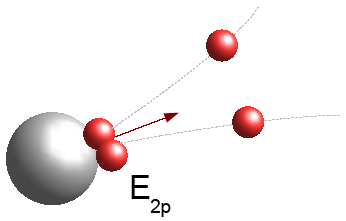


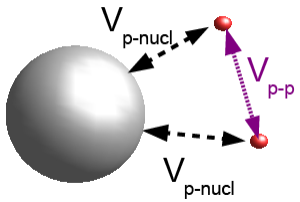



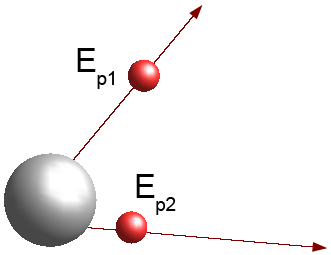

proposed by V.I. Goldansky; Nucl.Phys. 19 (1960), 482 Nucl.Phys. 27 (1961), 648 discovered by M.Pfützner et al., EPJA 14 (2002) 279

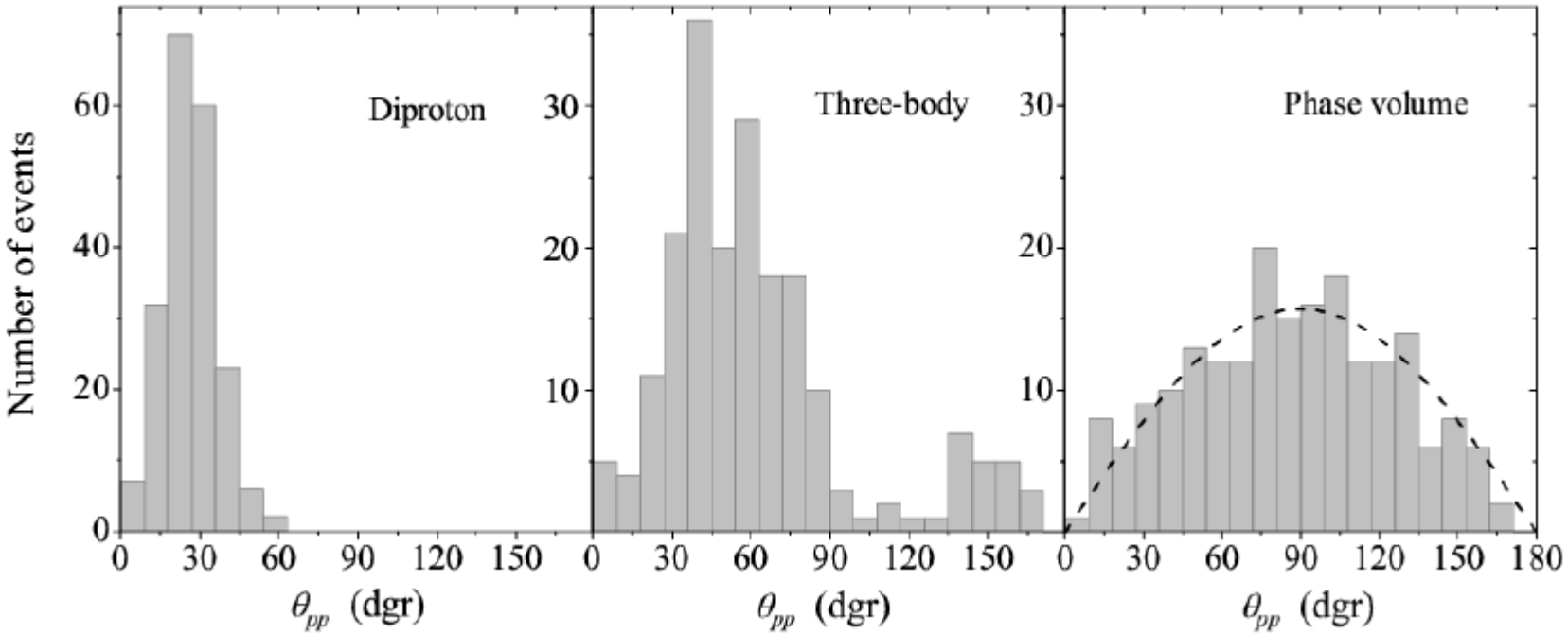


# 2-proton radioactivity of $^{45}$Fe



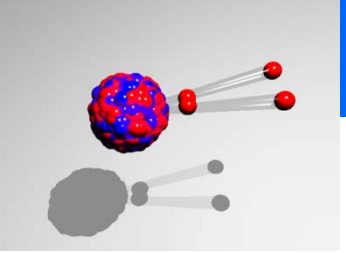



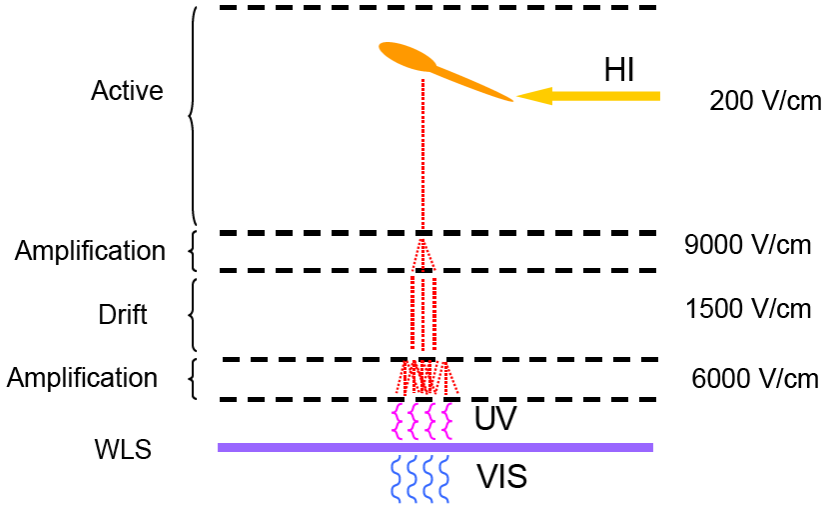



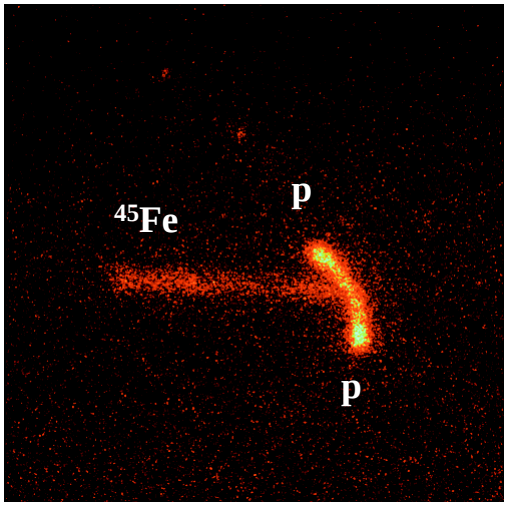

Monte Carlo simulation (200 events) of the opening angles between both protons for the $^{45}$Fe decay

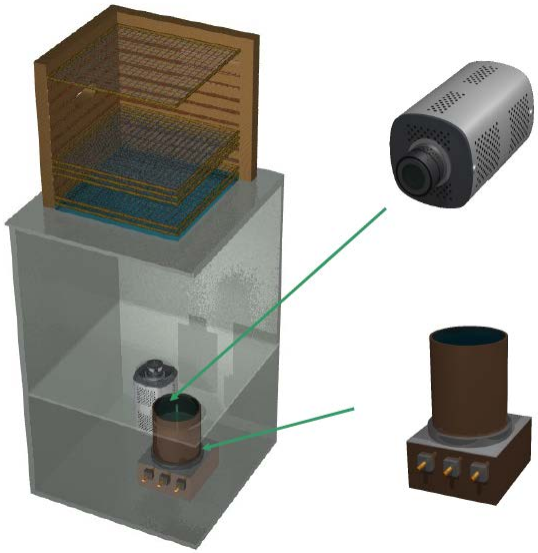
L. Grigorenko et al. Phys. Rev. Lett. 85 (2000), 22, Nucl.Phys. A714 (2003), 425

# Optical time projection chamber





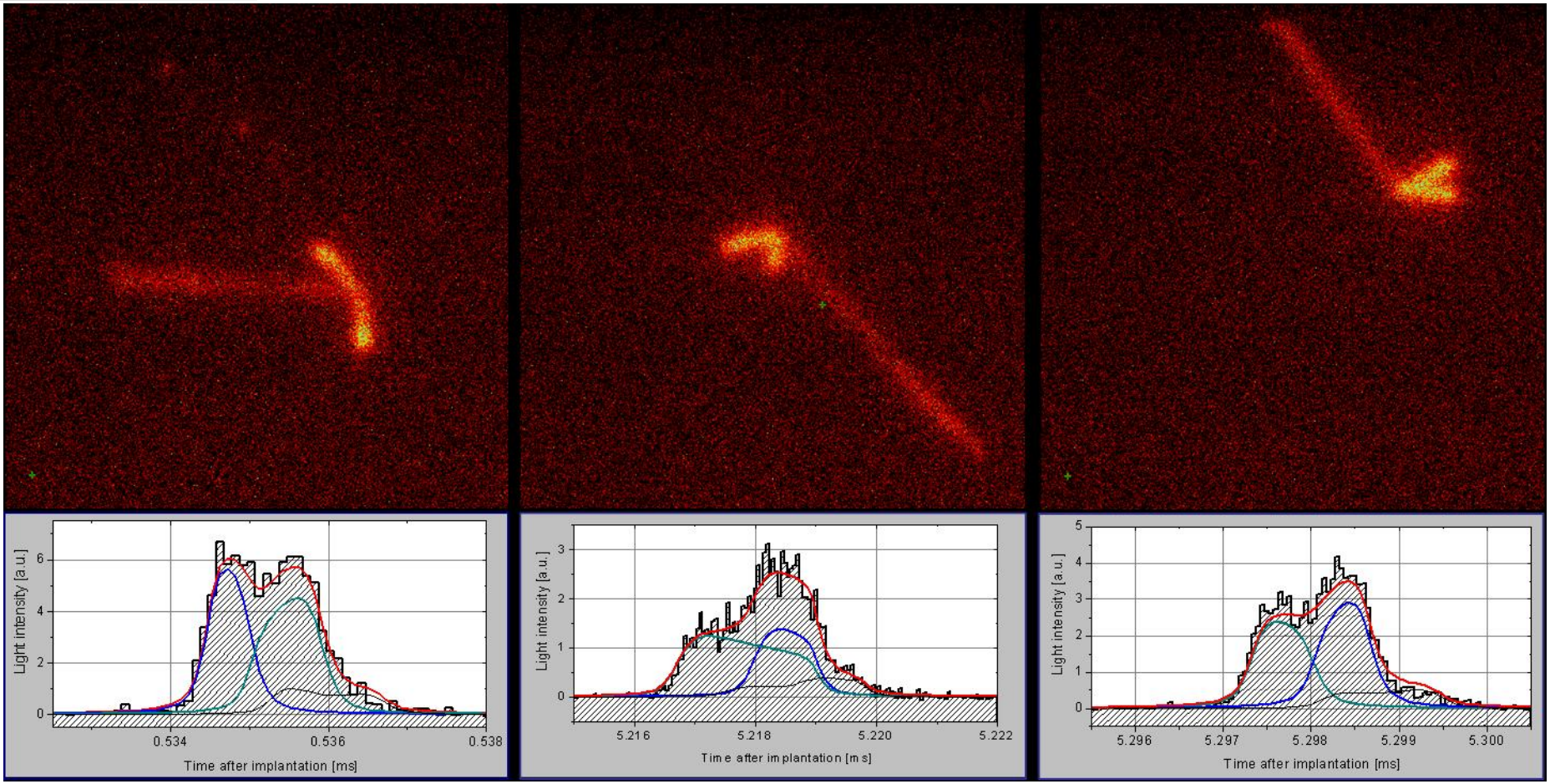



CCD Camera
- 1000x1000 pix
- 12-bits
- image amplification (x2000)

Photomultiplier 5”

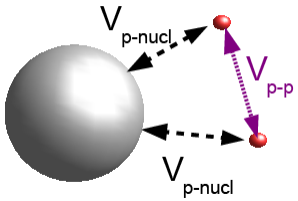
G. Charpak et al., NIM A269 (1988), 142

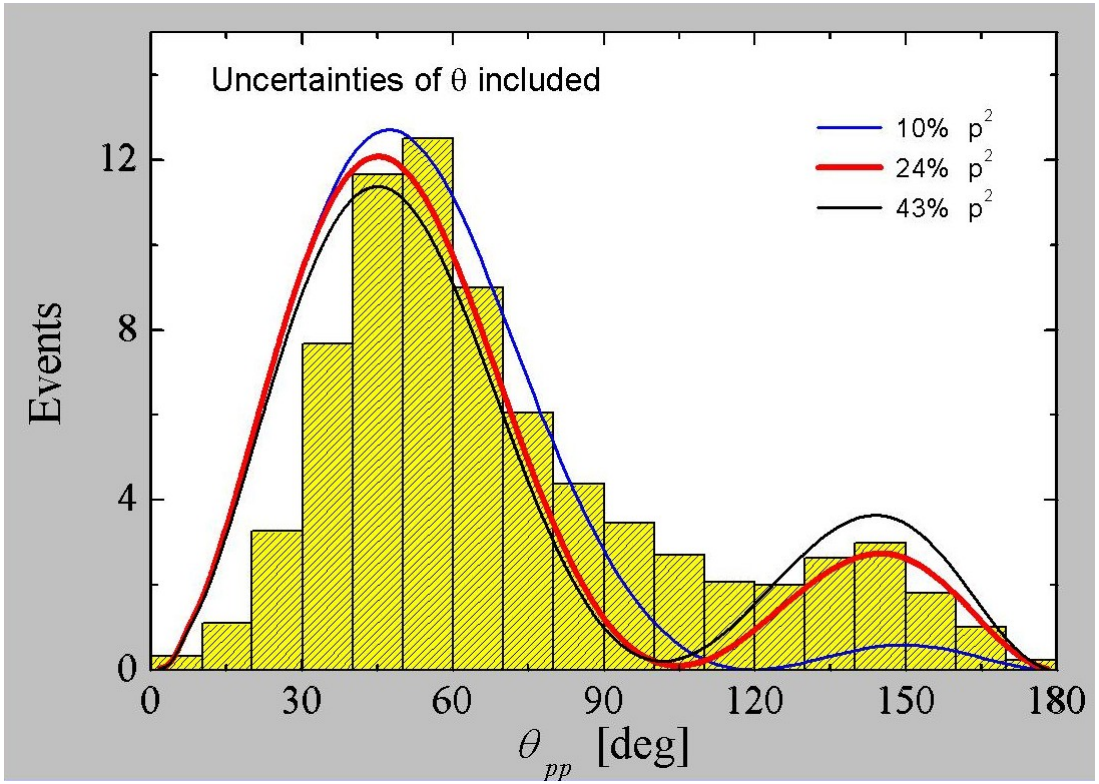
# Optical time projection chamber

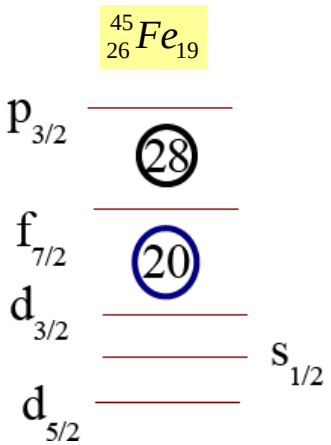



K. Miernik et al., Phys.Rev.Lett. 99 (2007) 192501

# 2-proton radioactivity of $^{45}$Fe

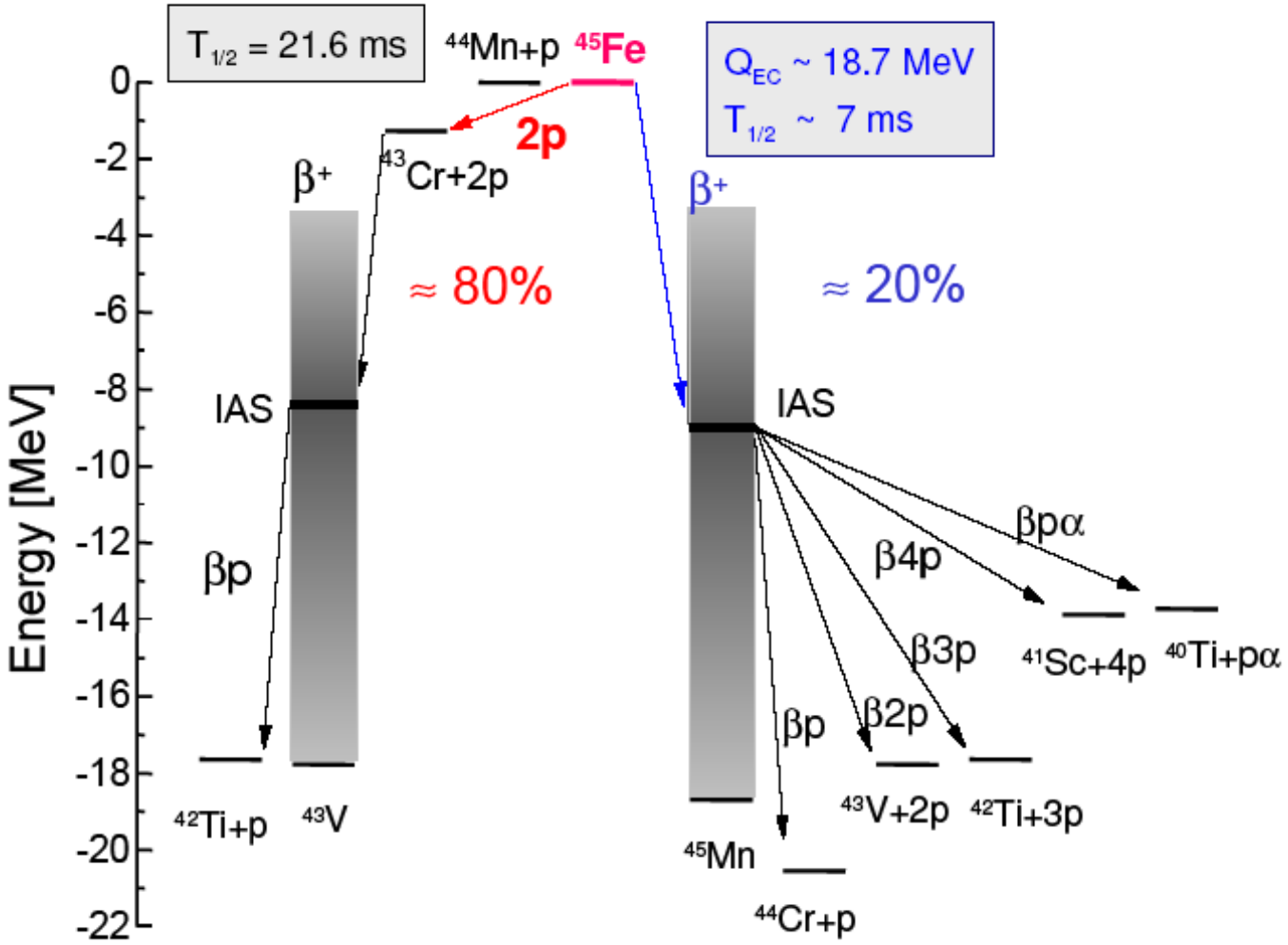



K. Miernik et al., Phys.Rev.Lett. 99 (2007) 192501

# 2-proton radioactivity of $^{45}$Fe




$Q_{2p}$=1.15±0.09 MeV und $T_{1/2}$ consistent with 2p-emission (sensitive between 1μs and 10 ms)

K. Miernik et al., Phys.Rev.Lett. 99 (2007) 192501