Search for new decay modes in neutron-deficient silicon isotopes

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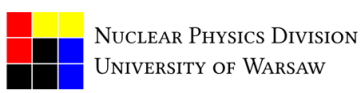
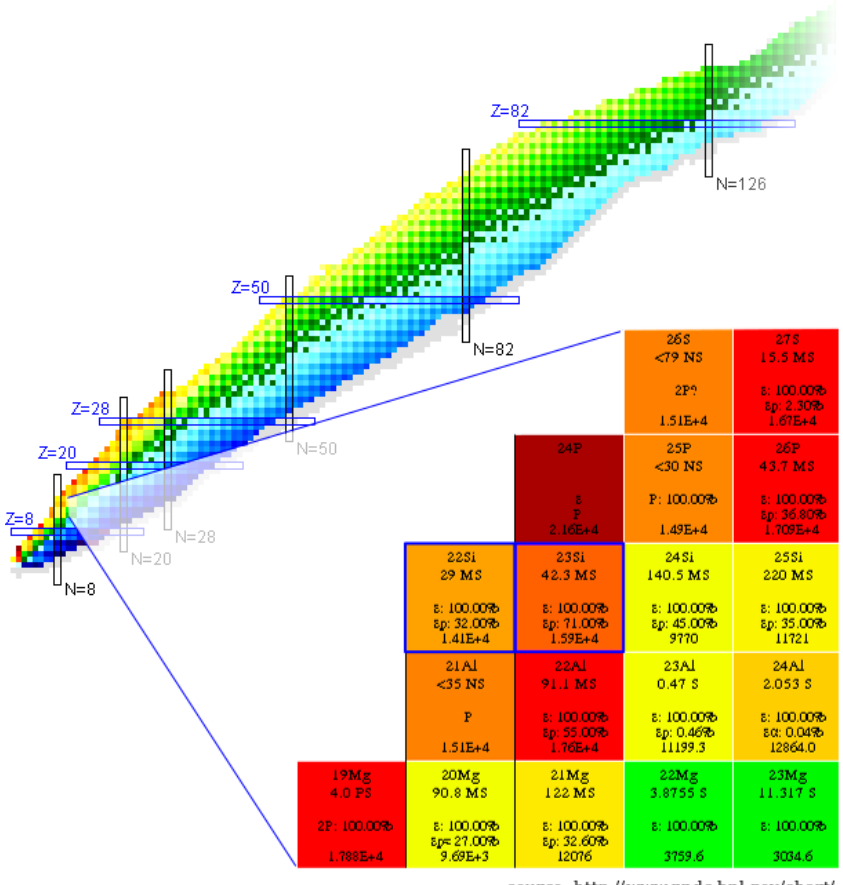


Introduction - radioactivity at the proton drip-line

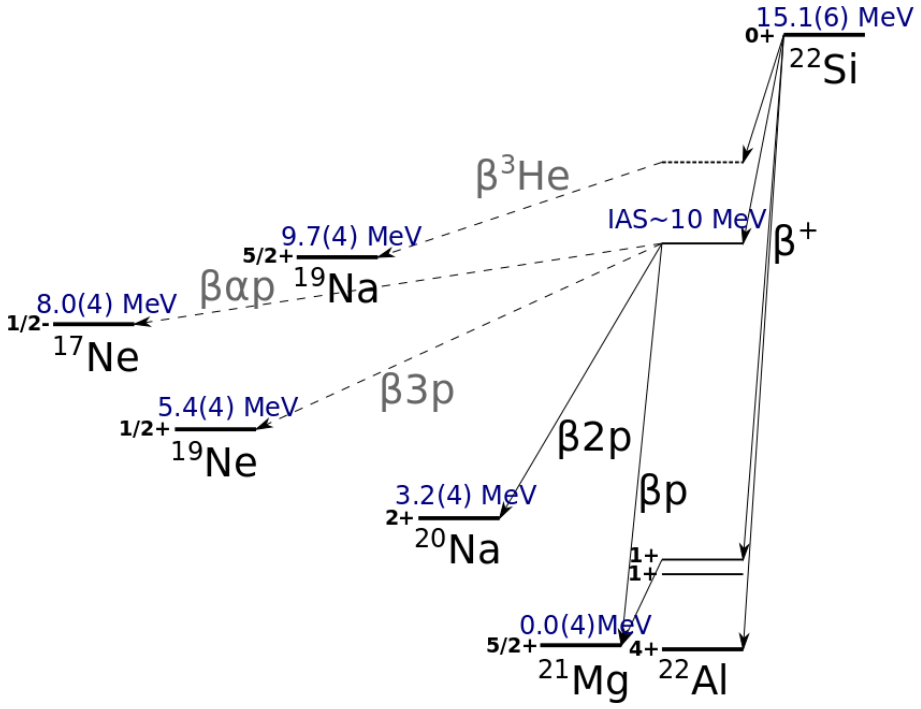
- Large Q_{β^+} value
- Population of highly excited (particle unbound) states
- β-delayed (multi-) particle emission (βx)
- Competition with β-γ decay
- βx spectroscopy crucial for understanding nuclear structure
- ^{22,23}Si – a variety of rare β-delayed decay modes expected



source: http://www.nndc.bnl.gov/chart/

Introduction - ^{22}Si

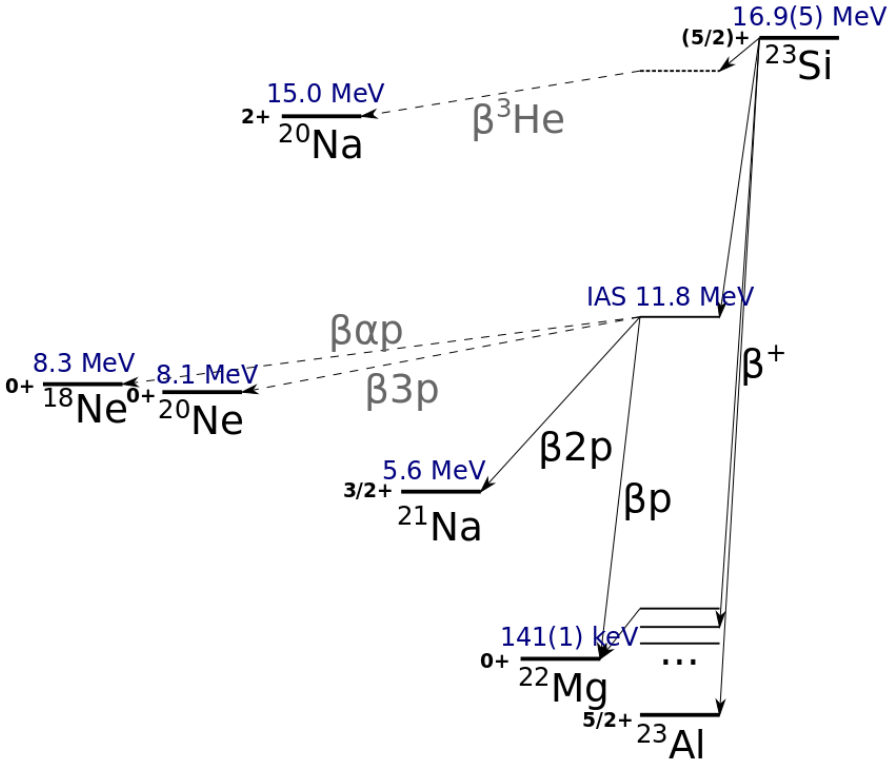
- First observation in 1987, in ^{36}Ar fragmentation reaction.
  First T_z = -3 nucleus observed
- βp identified and energy spectrum measured in 1996
- β2p from IAS reported in 2017:
  - charged-particle group @ 5600(70) keV
  - BR = 0.7(3)% (5 events)



M.G. Saint-Laurent et al., PRL 59, 33, 1987
B. Blank et al., PRC 54, 572, 1996
X.X. Xu et al., PRL B 766, 312-316, 2017

Introduction - ^{23}Si

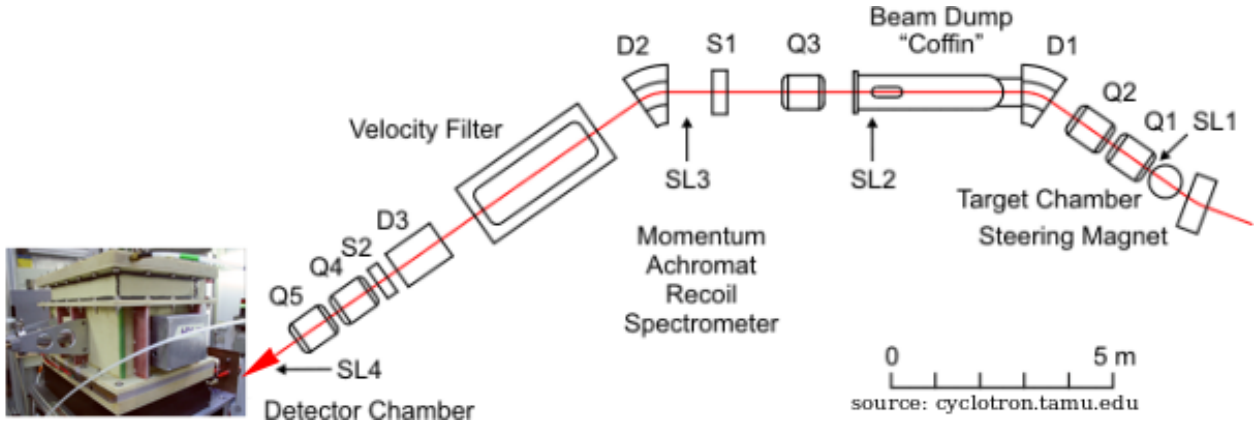
- First identification in 1986, ^{40}Ca fragmentation on Ni target
- Lightest of the T_z = -5/2 series (^{23}Si, ^{27}S, ^{31}Ar ...)
- 10 years later βp (BR = 71%) and β2p (BR = 3.6%) channels observed



M. Langevin et al., Nucl. Phys. A 455, 149, 1986
B. Blank et al., PRC 54, 572, 1996

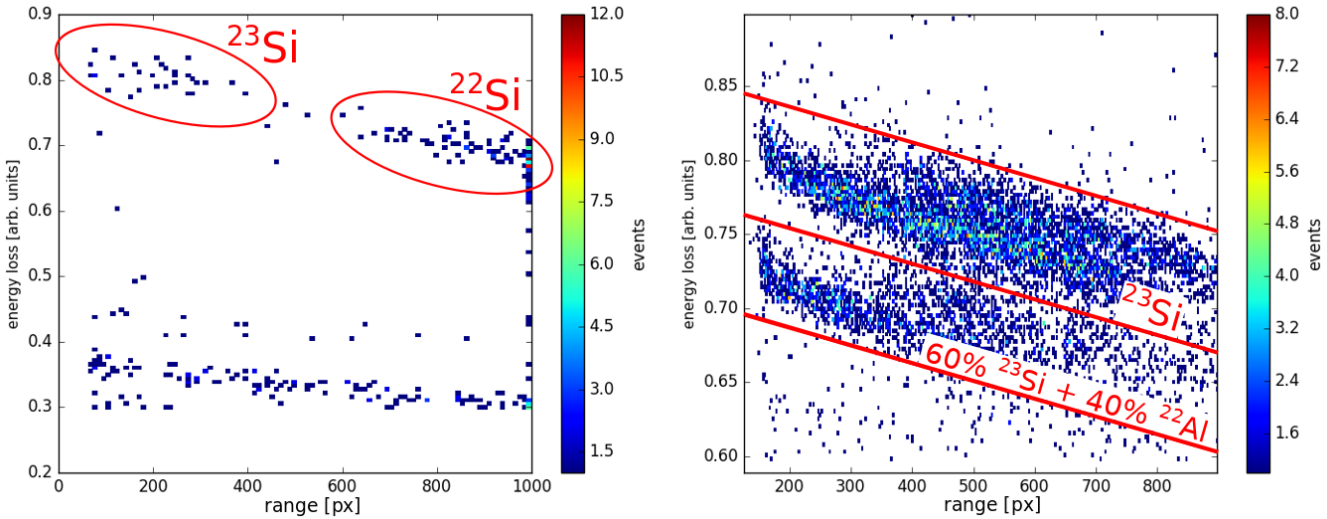
Experimental setup

- March 2017: ^{22,23}Si ions produced @ the Cyclotron Institute, Texas A&M University and separated from other fragments by MARS spectrometer
- Ions implanted into the Warsaw Optical Time Projection Chamber (OTPC)



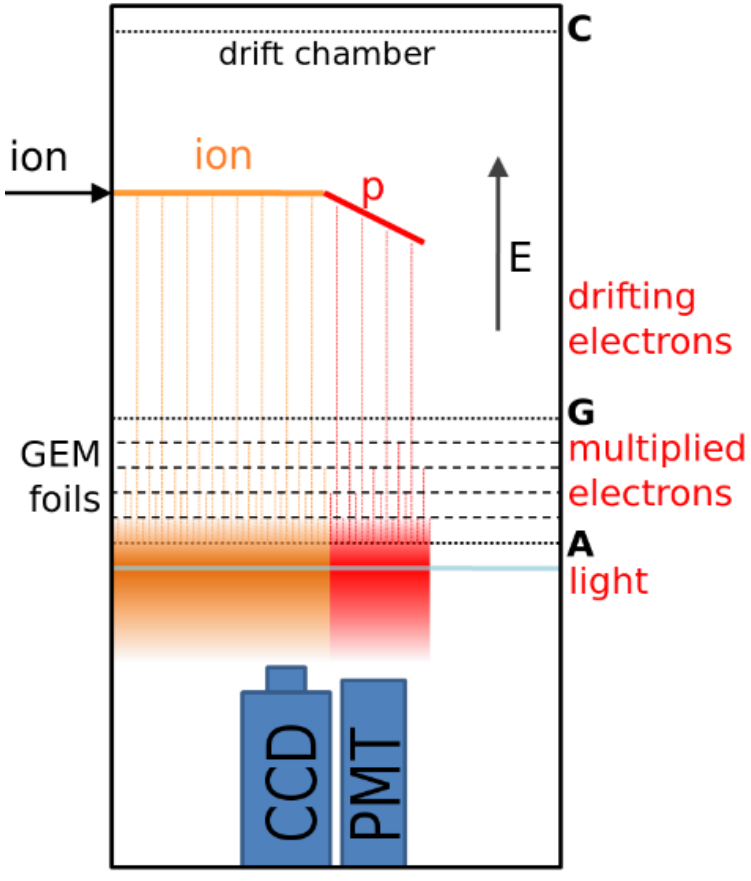
Identification

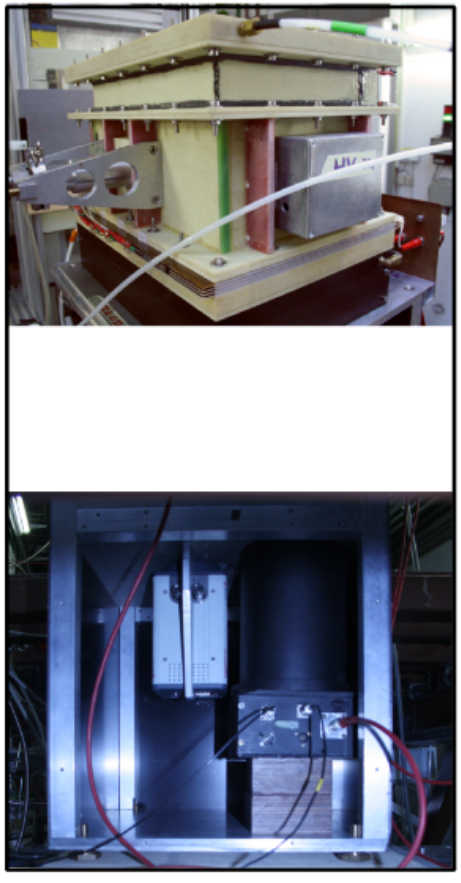
- Clean beam with minimal amount of contaminants
- Ions identified on basis of:
  - range in OTPC gas (69% He + 29% Ar + 2% CF_4)
  - energy loss in Si detector



- Around 60 **well implanted** ^{22}Si ions
- Above 6k **well implanted** ^{23}Si ions
- $T_{1/2}$ values of ion groups compatible with literature

Optical Time Projection Chamber

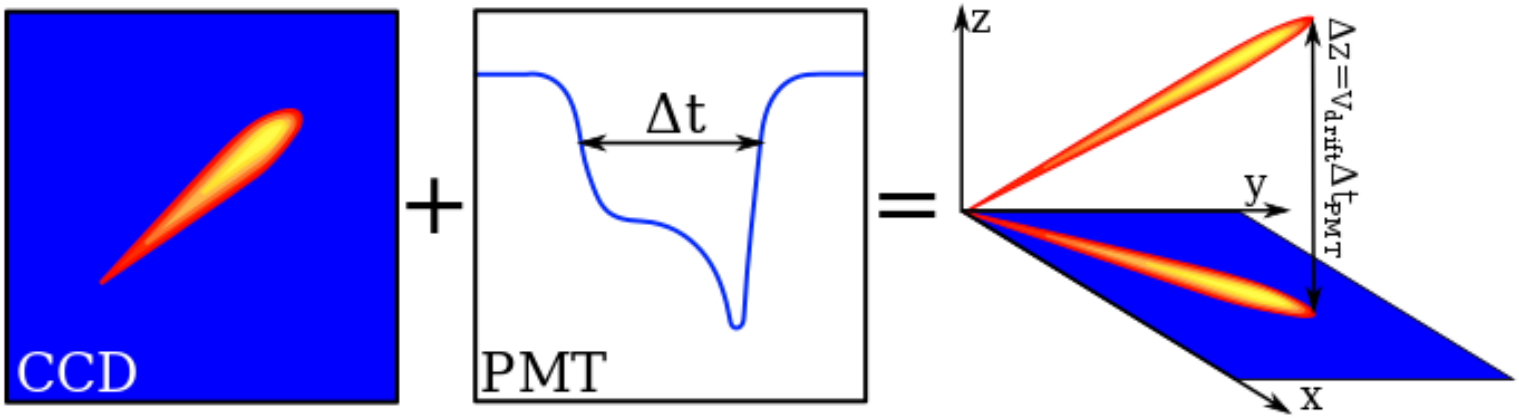




OTPC - details: A.A. C. et al., Eur. Phys. J. A 52, 89, 2016

See also poster by N. Sokołowska

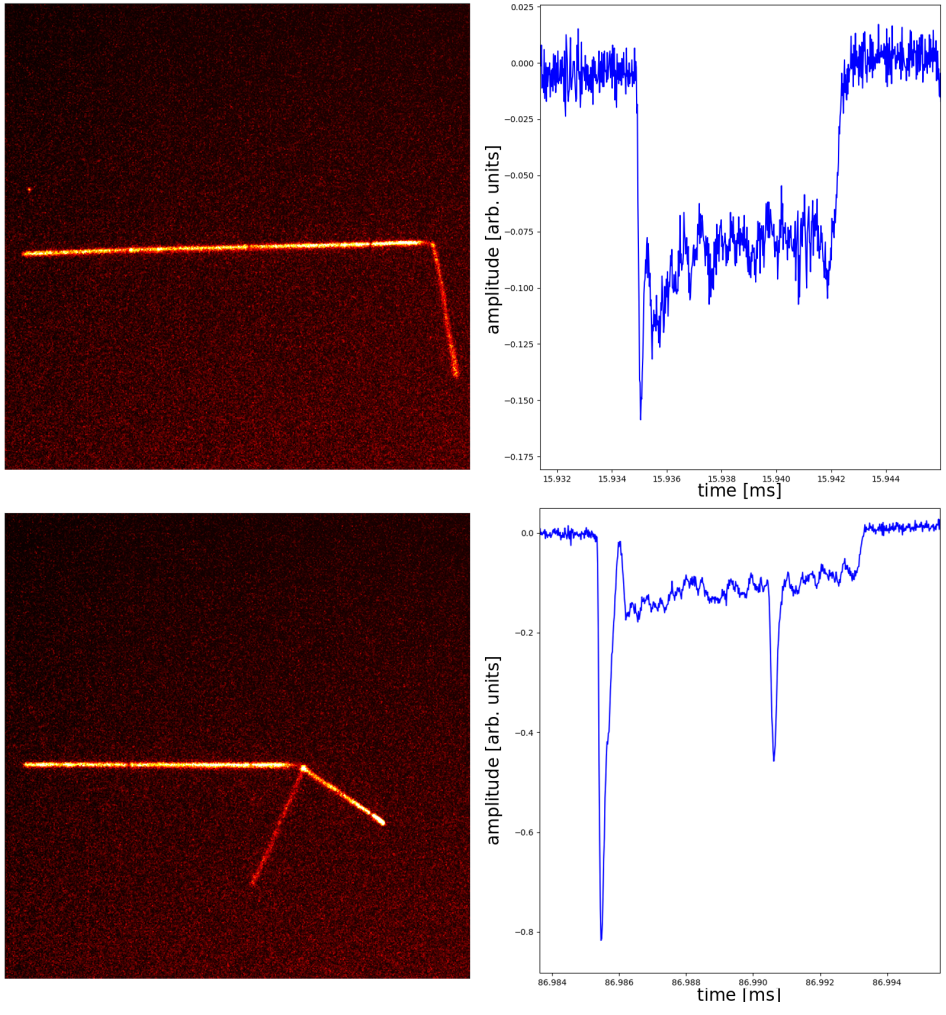
Optical Time Projection Chamber



Reconstruction of the 3D tracks in the OTPC detector:

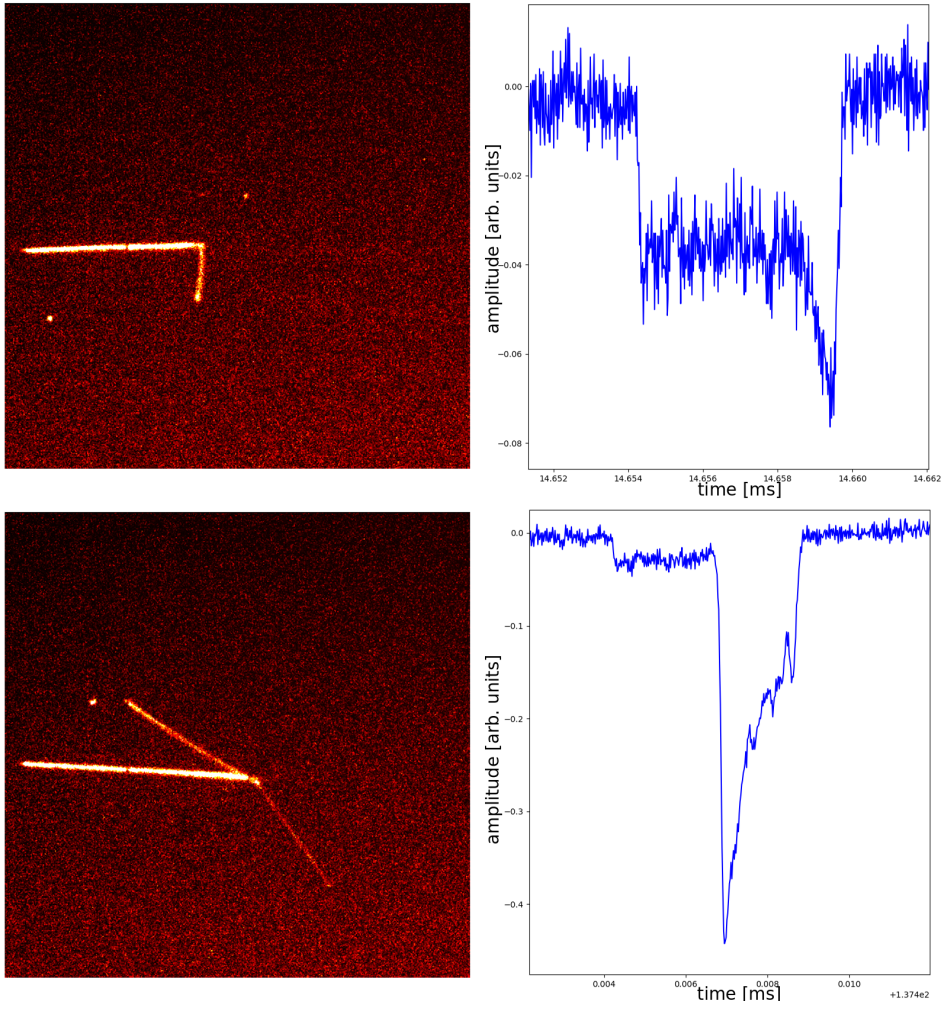
- CCD camera picture = xy-plane
- PMT = signal in time
- Known drift velocity → z-coordinate
- Range in gas → energy!

Results - ^{22}Si



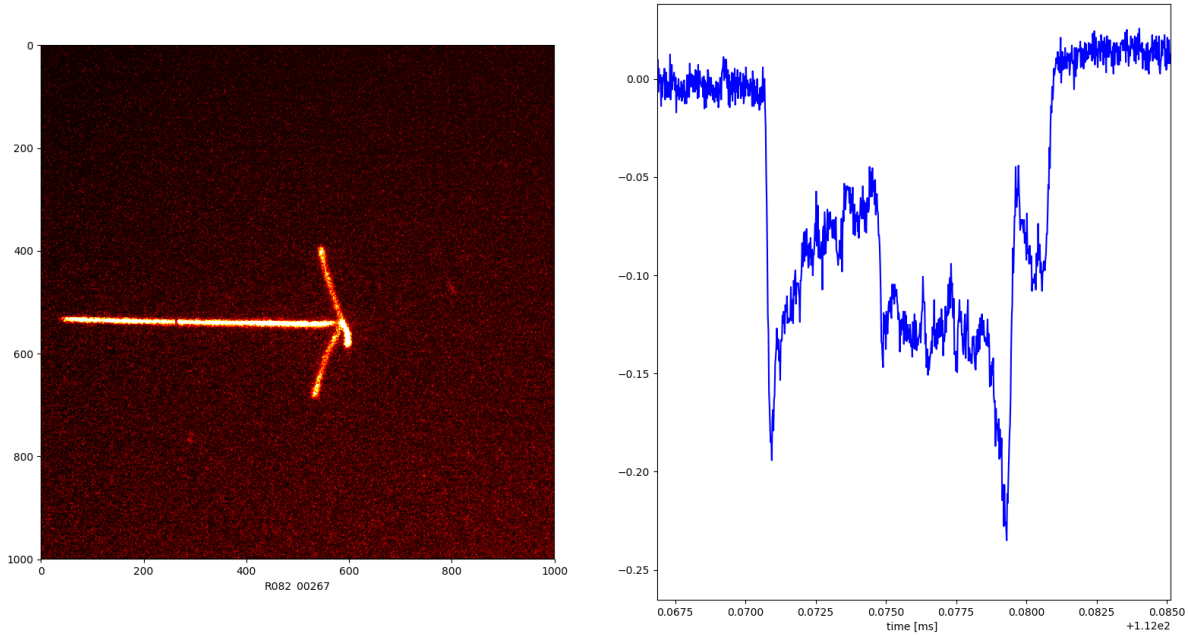
- Around 60 correctly implanted triggering ^{22}Si ions
- Much more of them stopped at the end of the chamber
- BR(β1p)≈100% (vs 30% in lit.)
- β2p emission observed (2 events)

Results - ^{23}Si



- Above 6k well implanted ^{23}Si ions in the "pure" group
- Branching ratios:
  - BR(β1p) = 82.2(1.2)%
  - BR(β2p) = 7.4(3)%

Results - ^{23}Si - β3p emission

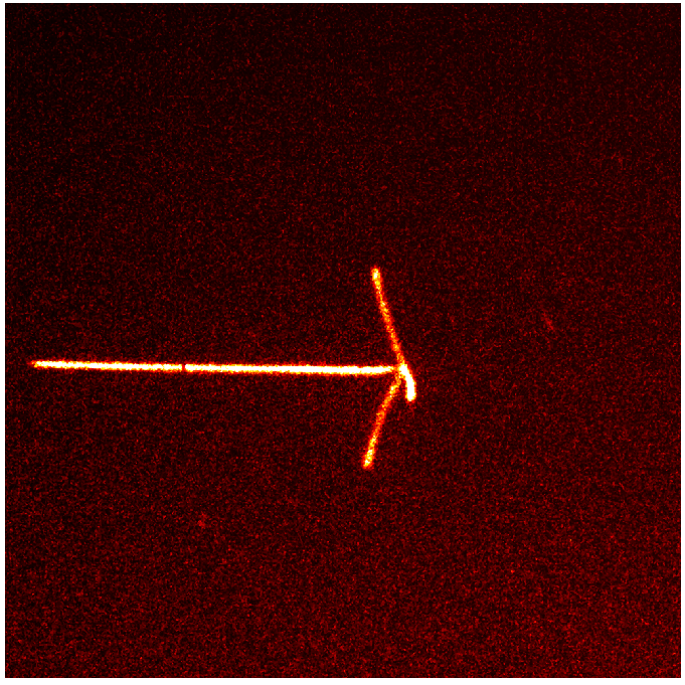


- First observation of β3p decay of ^{23}Si
- BR(β3p) = 0.05(3)%
- 4th β3p emitter identified by OTPC group

A.A. C. et al., Progress in Research (01.04.2017-31.03.2018) Cyclotron Institute, Texas A&M University, College Station, TX, USA, p. IV-67 (2018)

Summary

- ^{22,23}Si studied @ TAMU
- Decays observed with OTPC
- βp and β2p from ^{22}Si
- βp and β2p from ^{23}Si
- β3p emission from ^{23}Si identified for the first time!
- To do: Bragg curve fitting → proper particle energy spectra for observed decay channels
- **Stay tuned!**



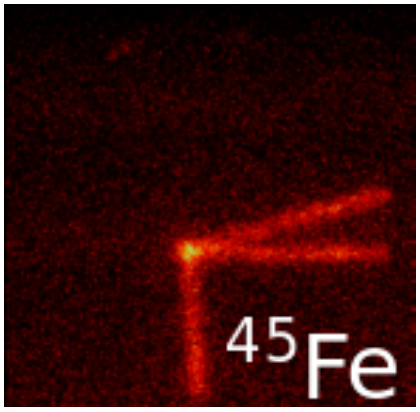
Many thanks to:

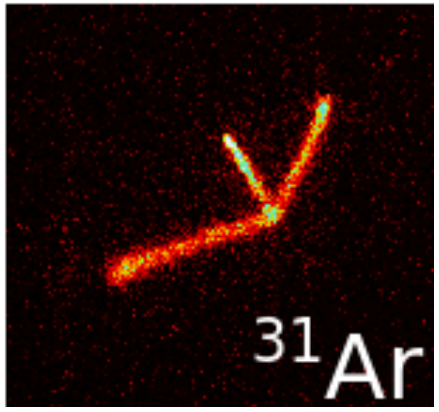
C. Mazzocchi [1], W. Dominik [1], A. Fijałkowska [1,2], J. Hooker [3], C. Hunf [3], Z. Janas [1], Ł. Janiak [1], H. Jayatissa [3], G. Kamiński [4], Y. Koshchiy [3], M. Pfützner [1], M. Pomorski [1], B. Roeder [3], G. Rogachev [3], A. Saastamoinen [3], N. Sokołowska [1], S. Sharma [1]

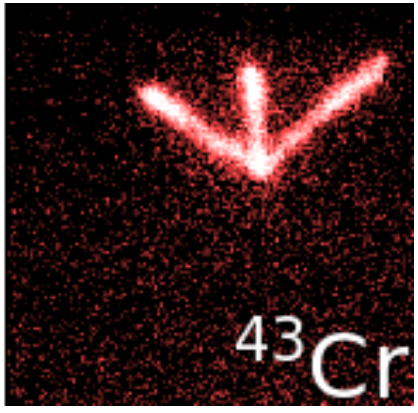
[1] *Faculty of Physics, University of Warsaw, Poland*
[2] *Department of Physics and Astronomy, Rutgers University, New Jersey, USA*
[3] *Texas A&M University, College Station, TX, USA*
[4] *Joint Institute for Nuclear Research, Dubna, Russia*

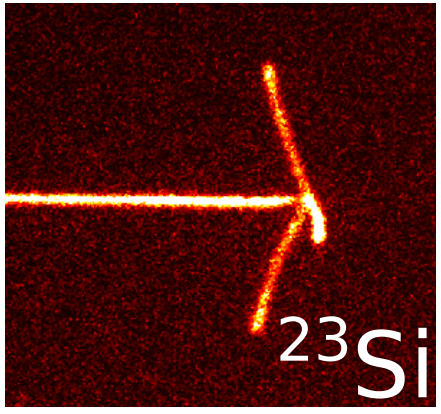
...and thank you for your attention!

β3p gallery and other nice pictures









K. Miernik et al., PRL 99 (2007) 192501
M. Pomorski et al., Phys. Rev. 83 (2011) 014306
A.A. L. et al., Phys. Rev. C 91, 064309 (2015)