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FRIB Decay Station Working Group Summary

FRIB equipment workshop 2010

R. Grzywacz, UT

S. Liddick, NSCL

Darek Seweryniak, ANL

Volker Werner, WNSL

et al.

Decay studies of exotic nuclei at FRIB

- Sensitive decay spectroscopy will be one of the primary discovery probes at FRIB.
  - Emerging and disappearing magic gaps
  - Rapid changes in deformation
  - Limits of stability
  - Half lives and branching ratios for astrophysics
  - Fundamental symmetries
- An efficient, state-of-the-art detection station(s) equipped with instruments capable of characterizing various forms of radiation such as gamma rays, conversion electrons, beta particles, protons, alpha particles and neutrons will be required

FRIB Decay Station Working Group

- FRIB Decay Station Working Group was formed to promote and facilitate the design and construction of experimental apparatus to study radioactive decays of exotic decays which will take full advantage of the new and exciting opportunities provided by FRIB.
- ~30 scientists registered so far
- Website http://groups.nscl.msu.edu/fribdecaystation
- A follow-up workshop is planned this year to discuss technical issues and ways to transition from several small collaborations into a coherent effort aimed to build the world's best decay station.

Session program

- “Implantation and charged-particle decay array” D. Seweryniak, ANL
- “The CERDA Ge array” S. Liddick, NSCL
- “Decay spectroscopy with GRETINA” C.J. Lister, ANL
- “Total Absorption Spectrometer” K. Rykaczewski, ORNL
- “The Picosecond Timing Array” F.G. Kondev, ANL
- “Neutron detectors for decay spectroscopy" G. Lorusso, NSCL
- “Electron detectors and transport systems for decay spectroscopy” E. Zganjar, LSU
- “Precision decay studies with traps” J. Clark, ANL
- “Non-conventional detector techniques“ R. Grzywacz, UT

Decay station components

- Implantation-Decay Array
- Ge array
- Total Absorption Spectrometer
- Neutron detectors
- Electron detectors
- Transport systems
- Ion Traps

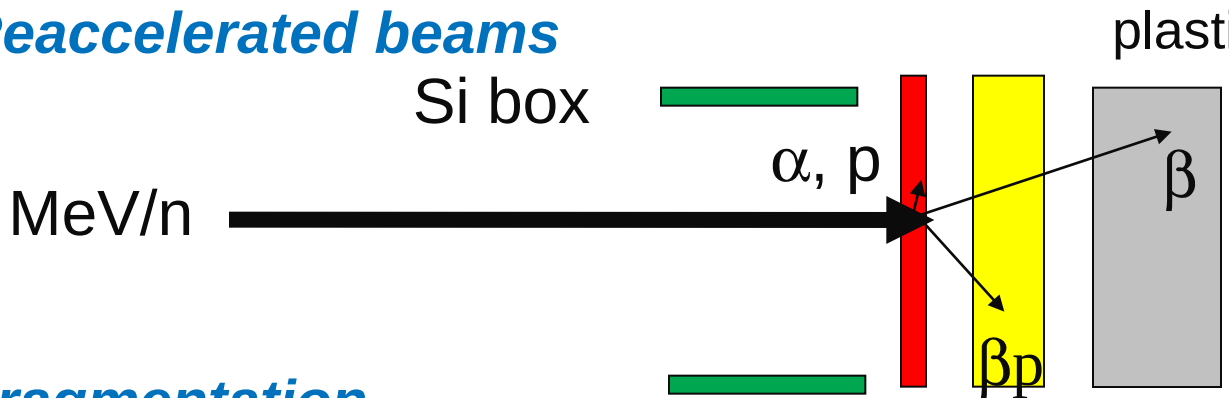
Decay station locations

- Fragmentation separator
- Low-energy radioactive beams
  - Gas cell
  - ISOL
- Ion traps and atomic traps
- Separators for reactions with reaccelerated beams

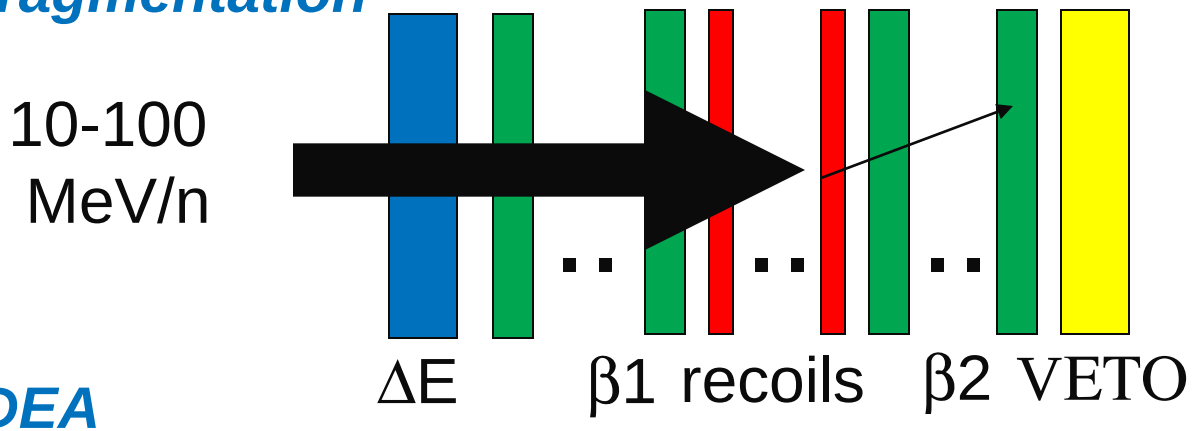
The system will be modular and portable so it can be deployed at different beam lines with customized configuration.

Implantation-decay stations

Reaccelerated beams

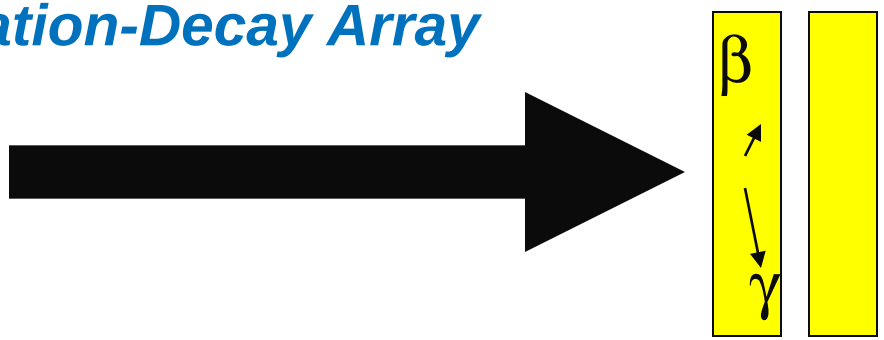


Fragmentation



- Efficient
- High granularity
- Digital electronics
- Compact

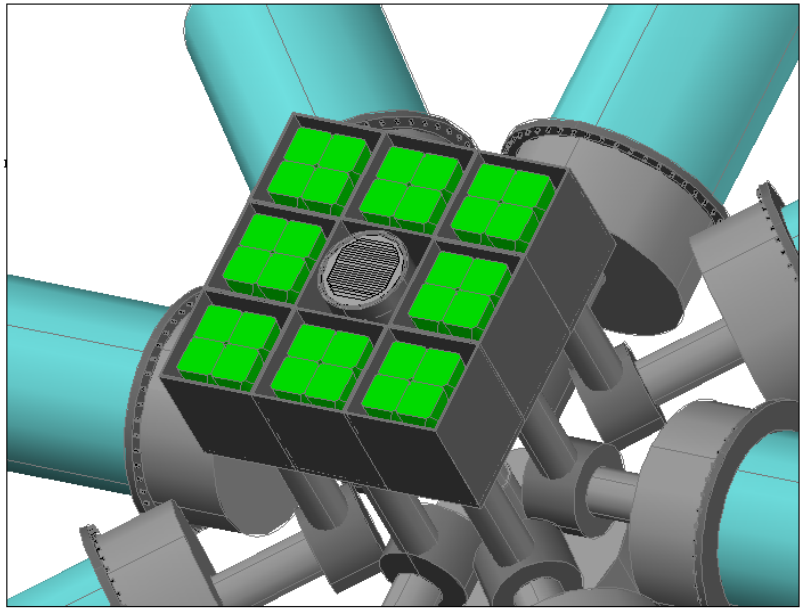
IDEA
Ge Implantation-Decay Array



- Low implantation rate

Dedicated Ge array for decay studies

- CERDA – proposal exists
  - Planar Ge DSSD for implantation (IDEA)
  - 16 Ge clovers
  - scintillators
- Existing Ge with scintillators
  - GRETINA
  - Exisiting Ge clovers
- GRIFFIN – dedicated Ge clover array with Compton suppressors for TRIUMF



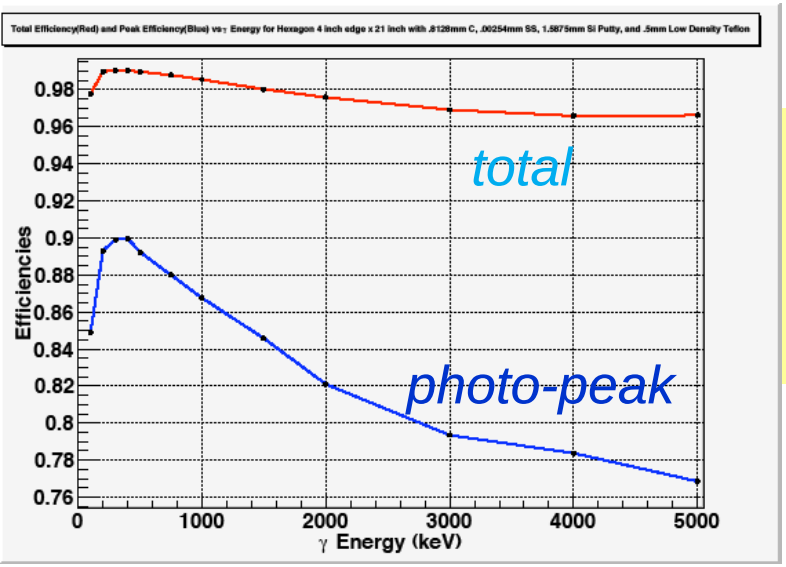
CERDA+IDEA

Decay Studies of Fission Products with a new Modular Total Absorption Spectrometer (MTAS)

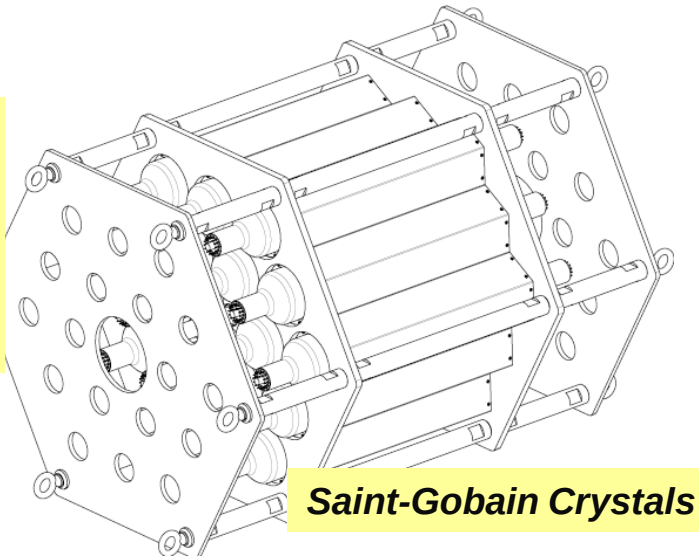
K.Rykaczewski (ORNL), R.Grzywacz (UTK/ORNL), M.Karny (Warsaw), B. Rasco (Seattle) et al

2009-2012, fully funded in its HRIBF version by ARRA grant (1.6 M$)

A **Modular Total Absorption Spectrometer (MTAS)** will be constructed from multiple NaI(Tl) scintillator segments, and applied to the **decay studies with pure beams of neutron-rich nuclei produced in the ^{238}U fission at the HRIBF.** The total absorption gamma spectra measured with MTAS will be used to derive a **true β-feeding pattern and resulting β-strength function**. The studies important for the verification and development of **the microscopic description of neutron-rich matter** will be performed as well as **applied studies of decay heat released by radioactive nuclei produced in nuclear fuels at power reactors.**



MTAS photo-peak γ-efficiency
90% at 0.3 MeV
77% at 5 MeV
B. Rasco (Seattle)

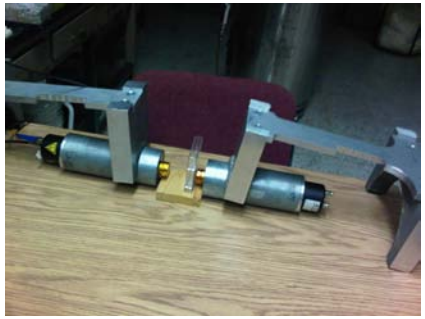


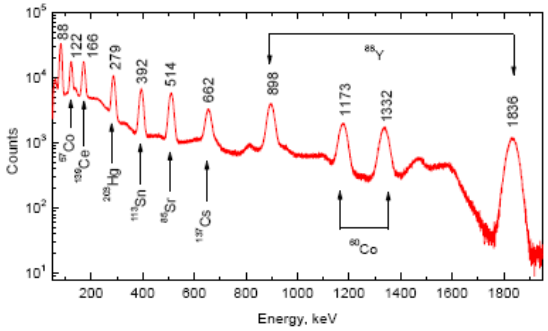
Saint-Gobain Crystals

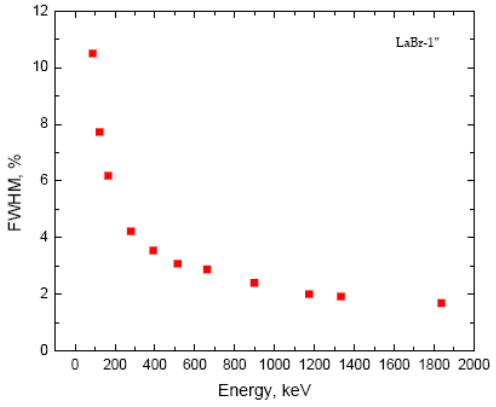
MTAS, with its hexagonal modular structure (~7" face-to-face), allows us to modify the central section according to the NSCL/FRIB needs. MTAS is a very efficient, segmented detector with ***a large discovery potential for rare decays of proton-rich and neutron-rich nuclei***

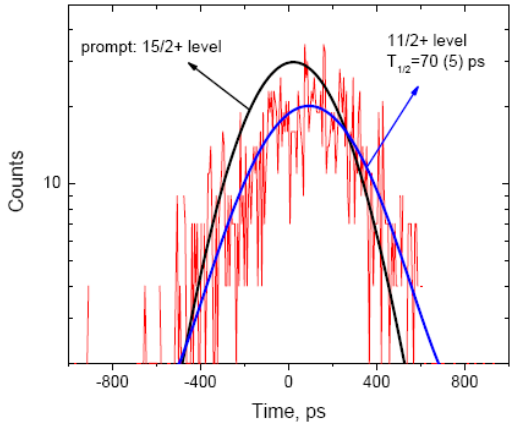
NSCL/FRIB adaptation cost (rough estimate) ***~ 100 to 200 k$***

- **Physics Motivation – fast lifetimes (ps-ns region)**
  - ✓ transition probabilities - elucidate the composition of the wave functions
  - ✓ for deformed nuclei - quantify the size of deformation
- **Fast-timing capabilities - a valuable addition to the FRIB decay station**
  - ✓ $LaBr_3(Ce)$ scintillator array in conjunction with Ge hi-res detectors - a perfect marriage
- **$LaBr_3(Ce)$ scintillator detectors**
  - ✓ offer a combination of good efficiency, energy & time resolution
  - ✓ 1″x1″ cost 5KEuro now, BUT in 10 years … what about other materials, e.g. $LaCl_3(Ce)$ and CeBr3, others?



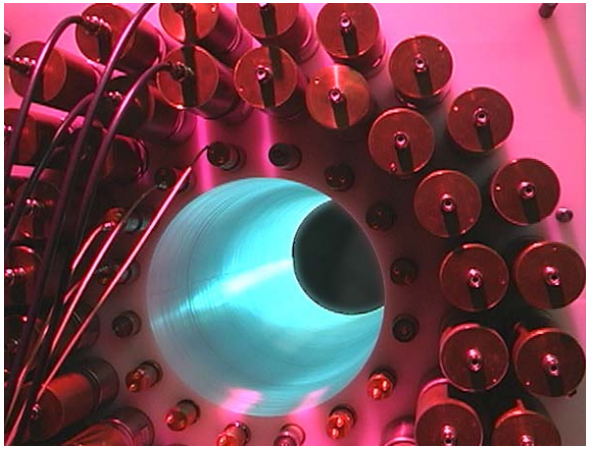




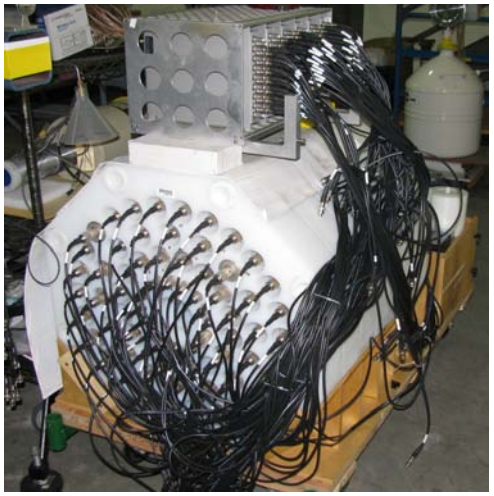


Neutron detectors

Proportional counters

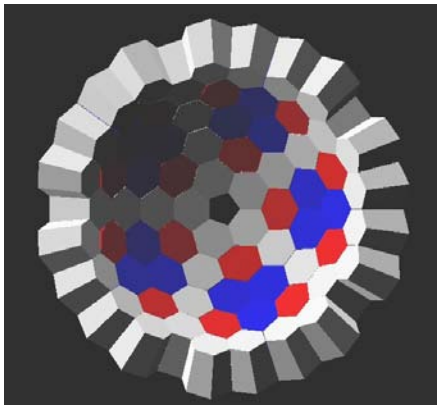


NERO - NSCL

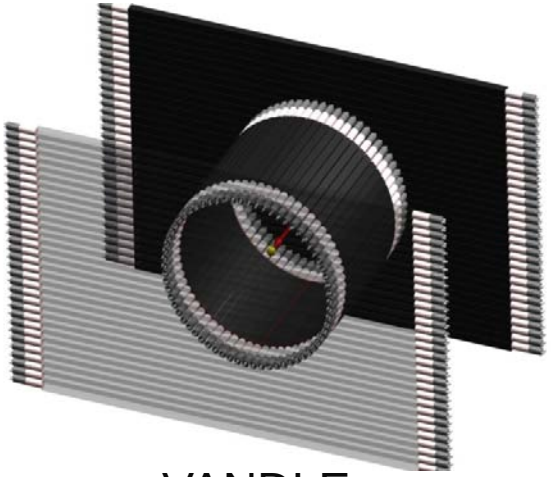


3HEn - HRIBF

Plastic TOF detectors



DESCANT

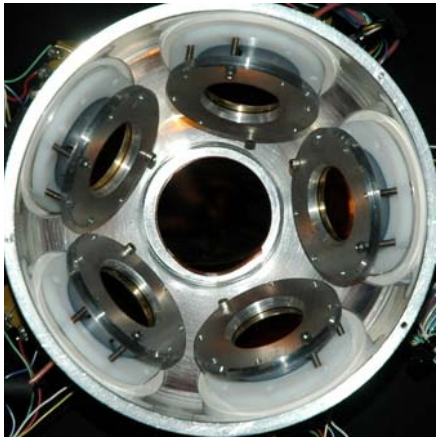


VANDLE

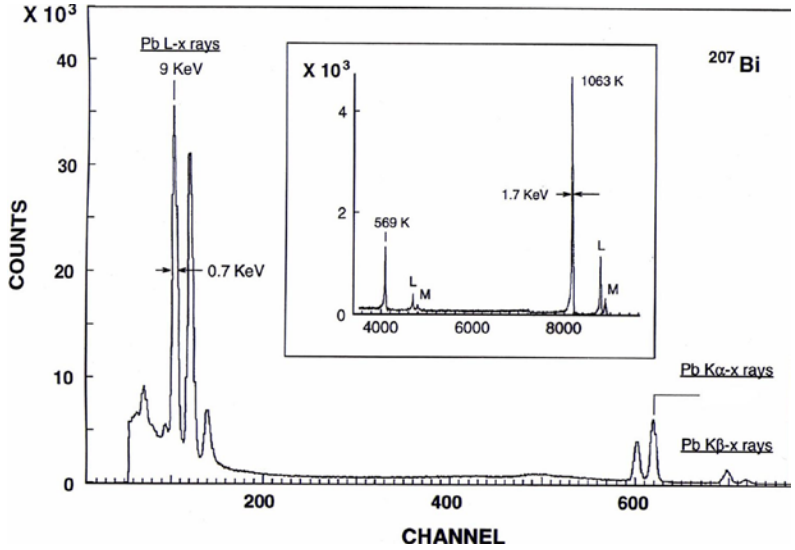
LENDA - NSCL

Fast and Reliable Tape Transport system

High-resolution electron conversion spectroscopy



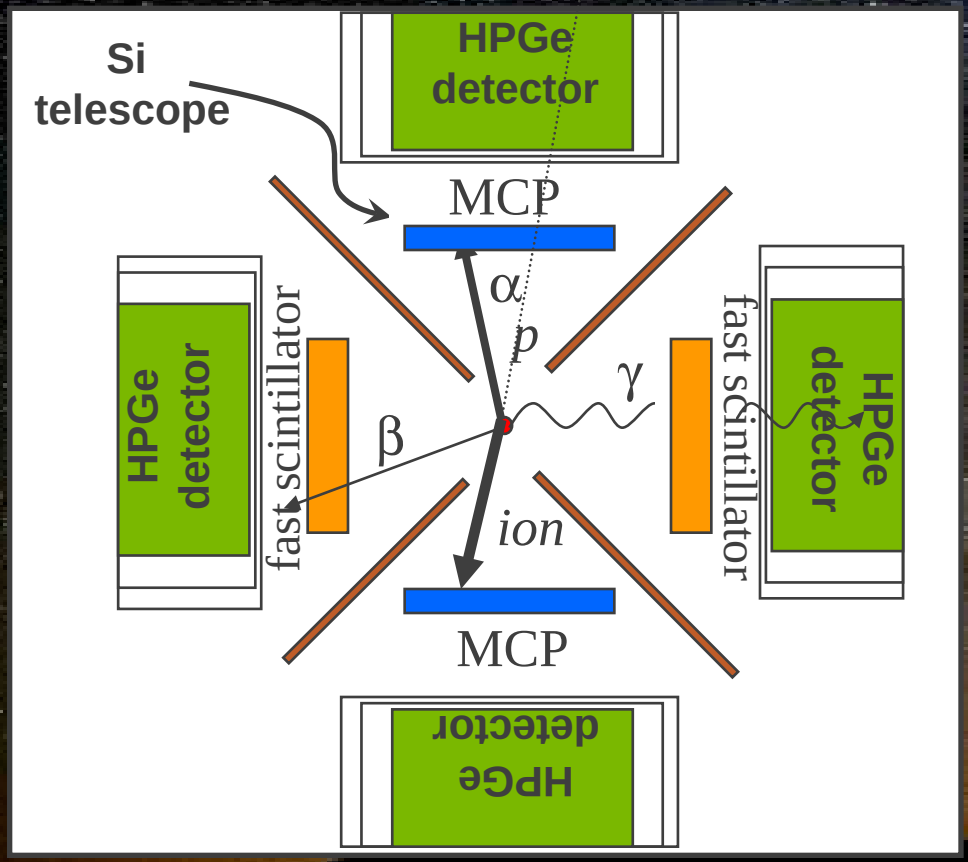
Si(Li) at PACES



In-trap decay spectroscopy

gas-filled Paul trap in open geometry

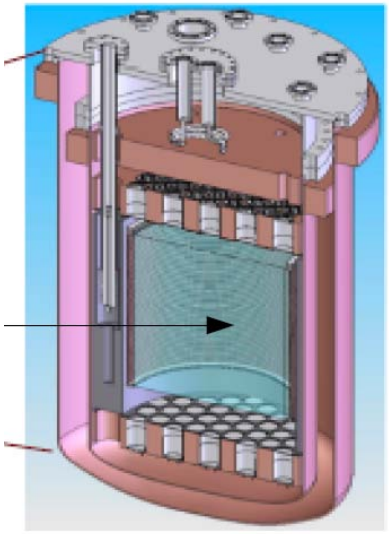
Measure any correlation between emitted particles:



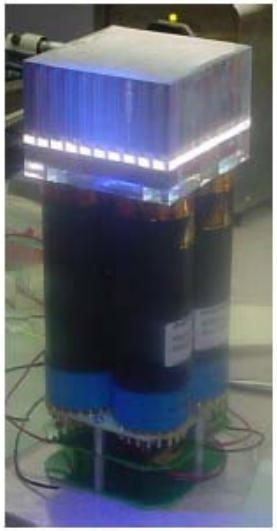
- β particles
- conversion electrons
- γ-rays
- alpha particles
- protons
- β-delayed neutrons
- recoil ions

Novel Techniques

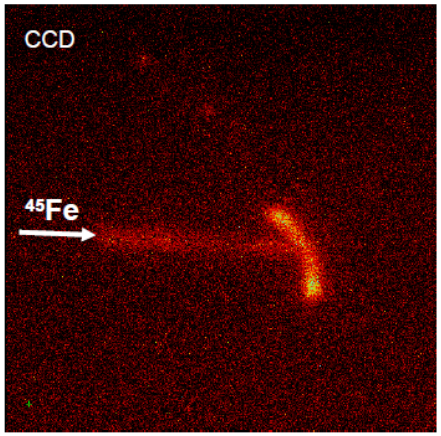
Multiple Ge arrays in a single dewar



Liquid Xe scintillator



Position sensitive scintillator



Optical Time Projection Chamber

If you plan decay studies at FRIB we need your input to identify opportunities, challenges and priorities in the years leading up to FRIB to assure that the best possible detection system is constructed and ready for experiments on day one.

BECOME A MEMBER OF THE DECAY STATION GROUP!

Thank you!