HRIBF Research Capital Equipment: New Initiatives

HRIBF is the best equipped laboratory in the US and is leading the way in developing experimental techniques for using radioactive ion beams. We view ourselves as the training ground for experimentalists to learn their trade so that when RIA comes on-line, they are ready.

The problems to conducting RIB research

- Low intensity beams
- High background rates
- Isobaric beam contamination

The keys to conducting RIB research

- Coincidences
- Time correlations
- Beam particle counting
- Highly efficient detector systems
- New electronics
- Physical properties of the beam and/or reaction product

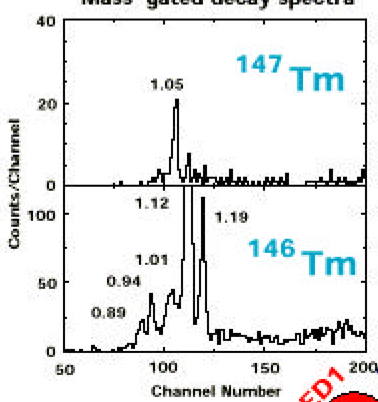
What is required?

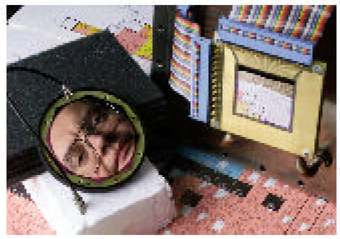
Continued high investment in equipment as new techniques are developed

Recoil Mass Spectrometer Endstation

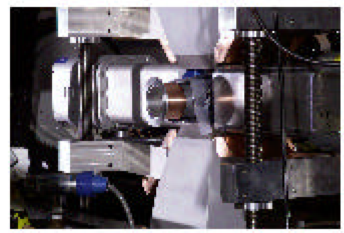
Nuclear structure equipment

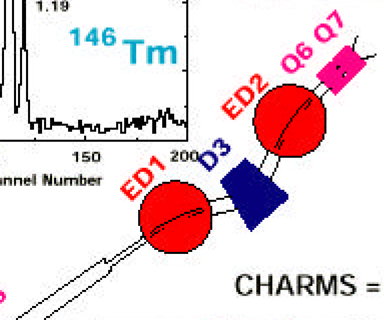
Mass gated decay spectra

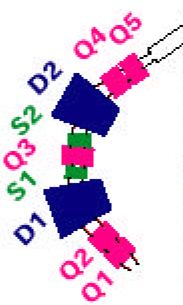




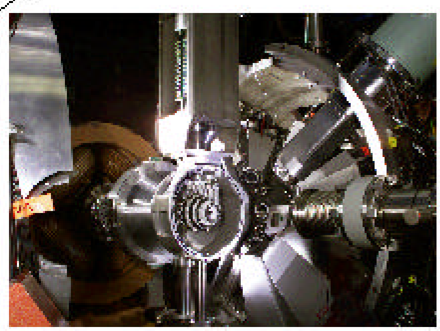
Focal Plane Areas
Silicon Strip
Moving Tape
Clover Ge
Gas Counters







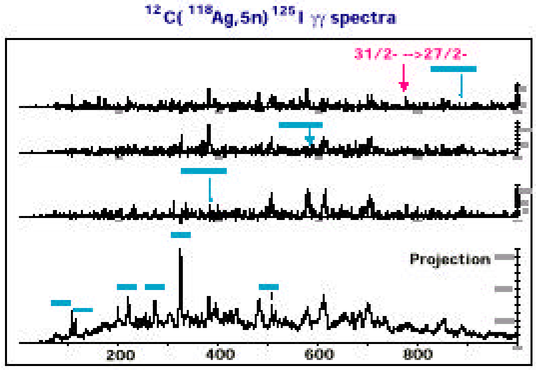
CHARMS = CLARION + HyBall + RMS



CLARION Clover Ge
HyBall - CsI + Silicon
Micro-Channel Plate

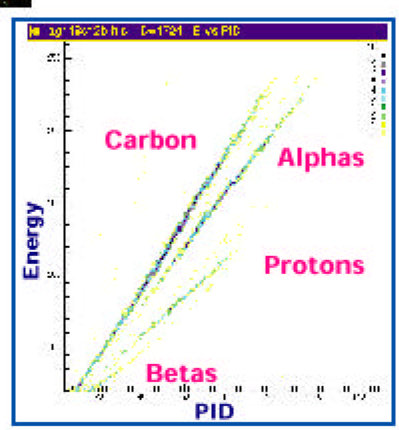
Upgrades:
In progress: Si part of HyBall
300k RMS gas-filled mode
1100k CLARION (5 Clovers)
(double $\gamma\gamma$ efficiency)

$^{12}C(^{118}Ag,5n)^{125}I$ $\gamma\gamma$ spectra

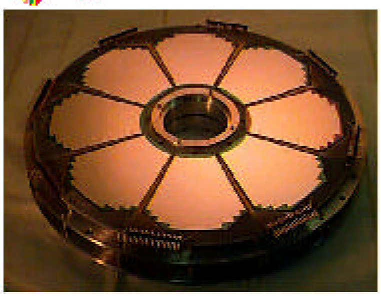


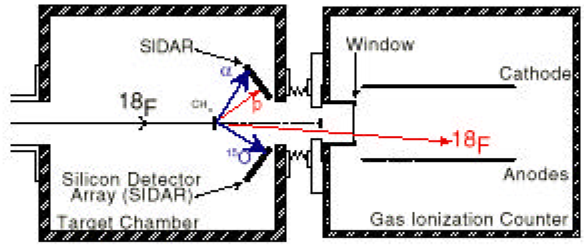
Data taken 6 pm Saturday thru 3 am Monday
Resolution should improve factor of 2

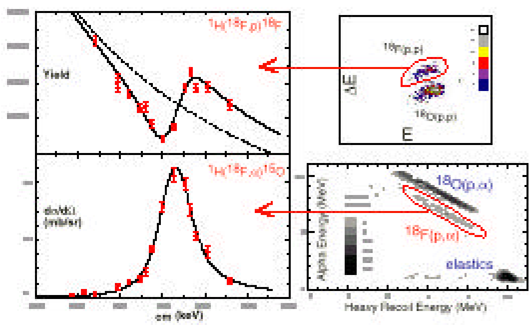
DC Radford, et al.



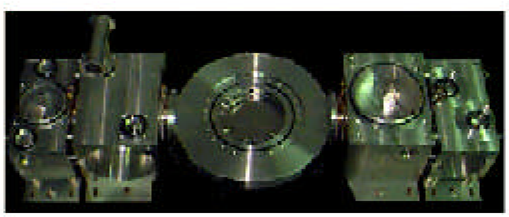
Daresbury Recoil Separator Endstation

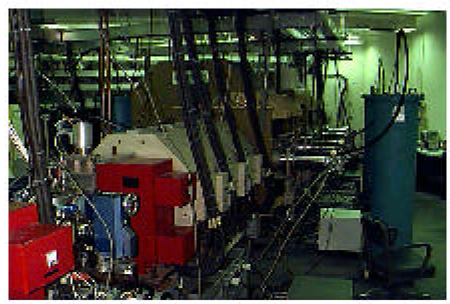






- SIDAR - Silicon Strip Detector
- Separator commissioning ongoing
- Windowless gas cell tests proceeding with He; ~5x10^18 atoms/cm^2
- Ionization chamber
- Micro-channel plate detector

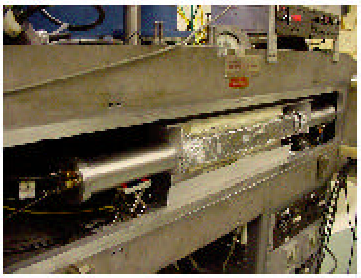


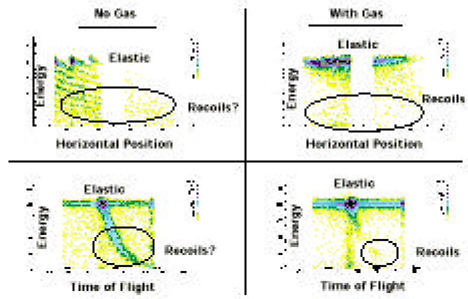


Resonance reactions using ^{17}F and ^{18}F
Transfer reaction such as (d,p)
Equipment must be flexible and efficient to handle low count rates for difficult RIBs and ultimately high count rates as beam intensity improves

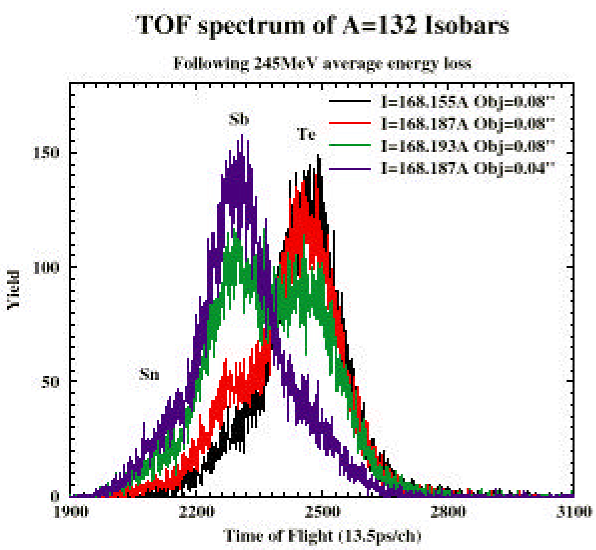
Gas targets coupled with the separator, BaF_2 detectors and intense RIBs will ultimately enable (p,γ) reactions

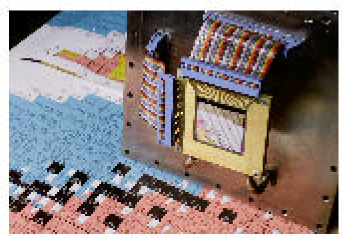
Enge Spectrometer Endstation





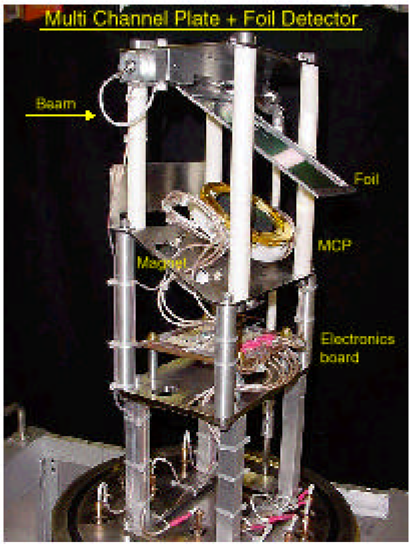
Operates in vacuum or gas-filled modes
Cramped chamber allows only small set-ups
Microchannel plate timing and beam counting
Time-of-Flight beam contaminant detectors
Silicon detectors
New chamber and beam line for more complex setups

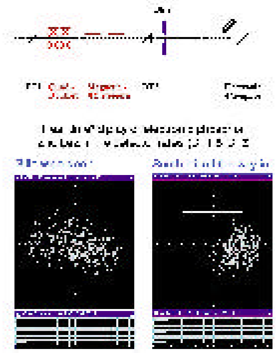




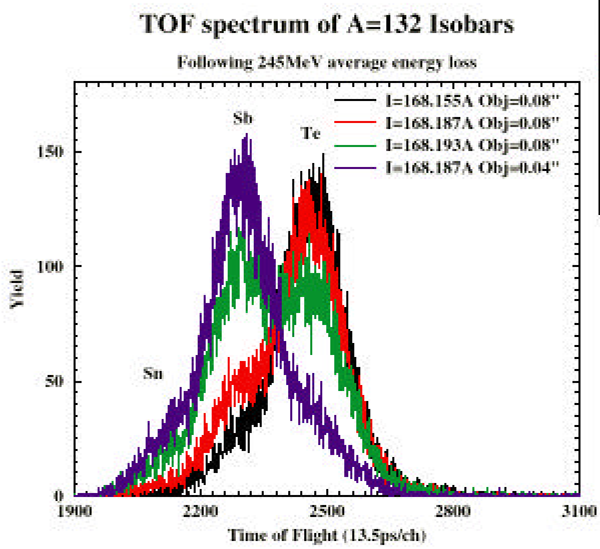
Resonance reactions
Transfer reactions
Break-up
Sub-barrier fusion
Accelerator Mass Spectrometry
ORNL seed money: 100k

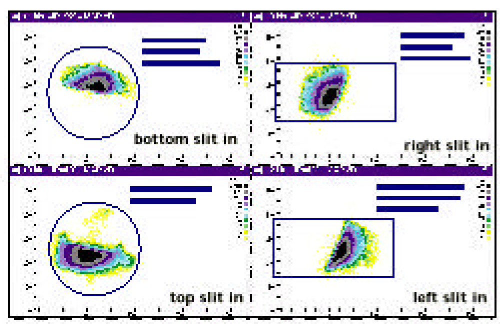
Beam diagnostic, focal plane, and time-of-flight detectors based on microchannel-plates and thin foils





High count rates (>10^6 Hz)
Position sensitive (large area)
Sub-mm position resolution
Sub-ns timing resolution
Low energy-loss transmission
Image compression/enlargement





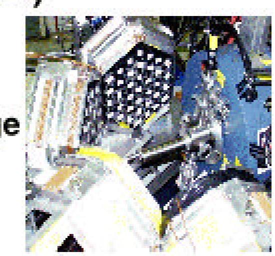
HRIBF/RIA Applications
Identification of beam contaminants
Large focal planes
Beam delivery
Background reduction

HRIBF

ORNL-MSU-TAMU BaF2 Array
Intermediate energy photon spectroscopy

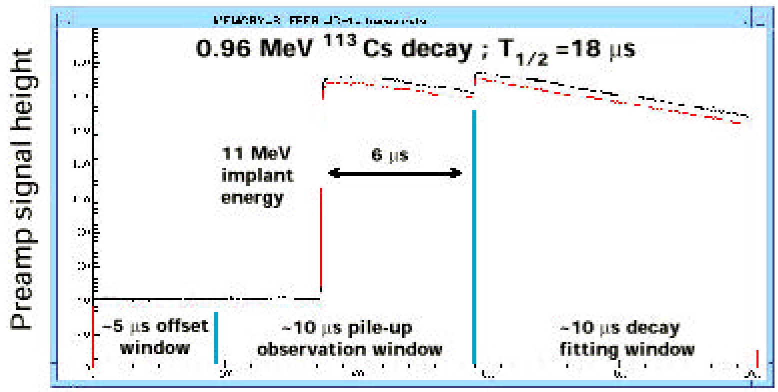
- **Major tool for structure and reaction studies**
  - **Versatile detector**

    - Efficient for 5 MeV$<E_\gamma<$200MeV
    - Fast timing, n-γ identification
    - Flexible geometry
  - **Applications**
    - Cold giant resonances in targets and unstable projectiles
    - Hot giant dipole resonance in fusion-evaporation and fusion-fission
    - Capture-gamma and others
- **Upgrades and refurbishment**
  - Replace 10 yr. old PMT's (60 for $135K)
  - Replace aging high voltage ($43K)
  - Upgrade electronics ($300K)

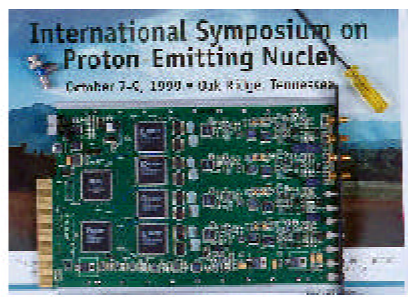


    - Individual thresholds and gates
    - Dual-gain to improve dynamic range
  - Path to future upgrades and expansion

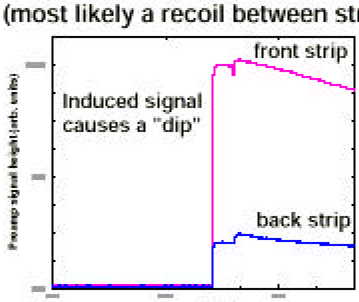
Pulse analysis via digital signal processing (DSP)
detector + signal + processor



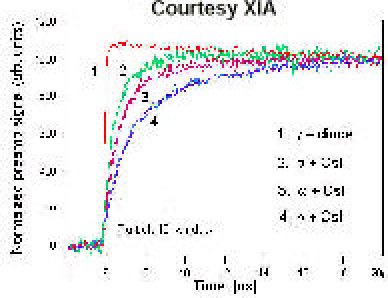
- Large dynamic range
- Low energy threshold
- Compact, versatile, portable
- Fast (25 ns digitization)
- Pulse-shape analysis
- Individual event analysis
- Detector independent



Individual event analysis possible
(most likely a recoil between strips)

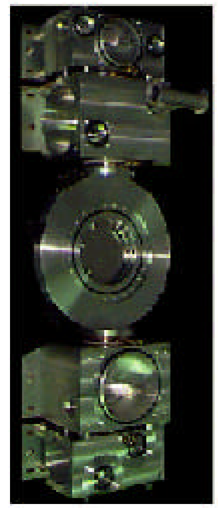


CsI pulse analysis
Courtesy XIA



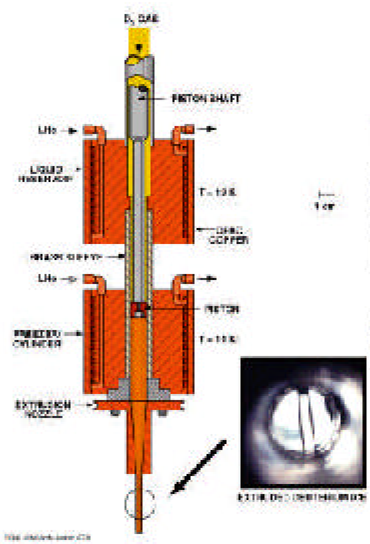
HRIBF/RIA Applications
Silicon, Ge, CsI, NE-213, and ultimately BaF_2
Software optimized for each detector system
Faster digitization steps
Huge data transfer rates
DOE funding removes vendor redirection a la LeCroy

Advanced Gas Targets



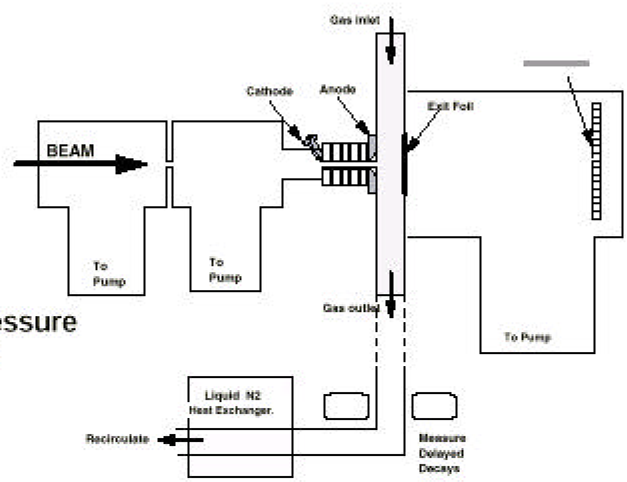
Gas Jet Targets

Windowless gas target cell available at end of 2001
(~1x10^19 H_2 atoms/cm^2)
Conversion of windowless gas target cell to gas jet target
(>1x10^18 H_2 atoms/cm^2)
More localized target (jet) compatible with Si detectors in target chamber;
3He(RIB,d), astrophysics type reactions, etc.
Expected costs: ~500k



Hydrogen Ice Targets

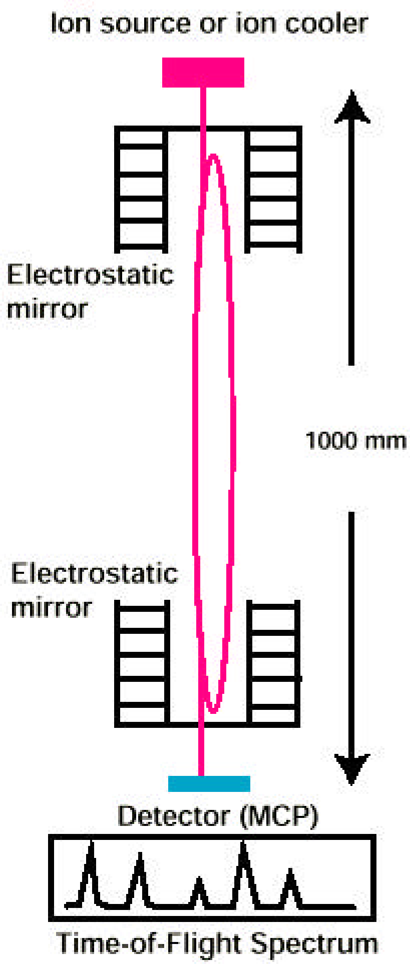
Fusion energy technique for plasma loading
New nozzle for thin ribbons (0.3mm x 10 mm)
Research needed on uniformity & evaporation
(present estimates is 10% loss in 5 minutes)
ORNL seed money project: 100k
Expected costs: ~300k for cyrogenic infrastucture



Plasma Targets

Several atmospheres gas pressure
Thick target resonance work
100k for Helium
200k for Hydrogen
2 FTE minimum

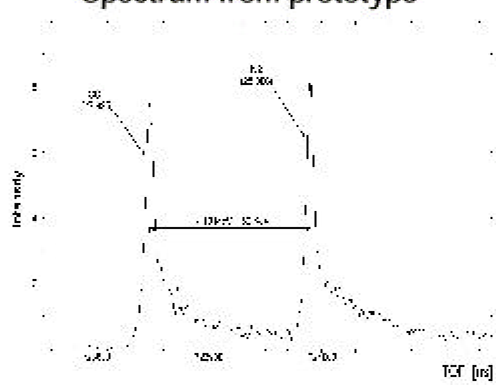
Multipass, high precision mass analyzer



"Table top" portable mass analyzer
Prototype built in Giessen, Germany
Optimized for short-lived nuclei
Precision of 1 ppm after a flight time of ~ 1 ms
Requires:
- Precision power supplies
- Beam cooler (gas-filled)
- Reaccelerator
- Ion buncher (start of ToF)

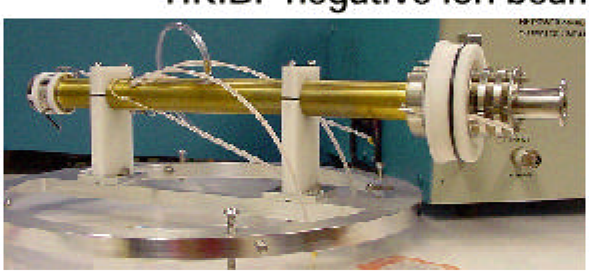
Seed money: 87k
Total cost: 600k

Spectrum from prototype

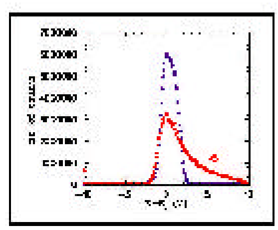


HRIBF negative ion beam cooler

Beam in

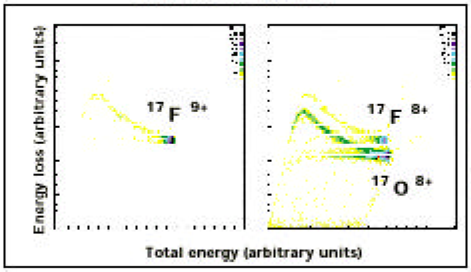


Beam out



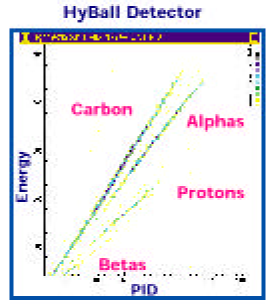
Universal Z Identification?

Ionization chamber



Recoil product detection
Velocity dependent
Low spectrometer efficiency
Low counting rates (<15 kHz)
Coincidences help to extend range to Z~50

HyBall Detector

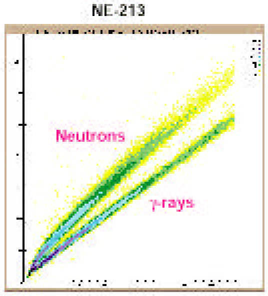


Evaporated charged particle detection
Requires 4π detection
High multiplicities on proton-rich side
Slow detectors (CsI) for stable beam experiments
Potential high backgrounds for RIB experiments
Expensive if silicon detectors are used in 4π

Other method: Decay correlations or Recoil Decay Tagging (RDT)
- dependent on identifiable decay, correlation time, coincidence efficiency

Additional solutions: Neutron and X-ray detection

NE-213



Evaporated neutron detection (NE-213)
Forward focussing requires near 0 degree detection
Detection efficiency ~40%
Proton-rich nuclei have low neutron multiplicities
High background from γ rays
Estimated cost: 250k

Thin foils of similar Z as recoils
to enhance X-ray production

Large coverage area necessary; room temperature; high counting rates
HgI crystals, avalanche Si detectors are possible solutions; are there others?