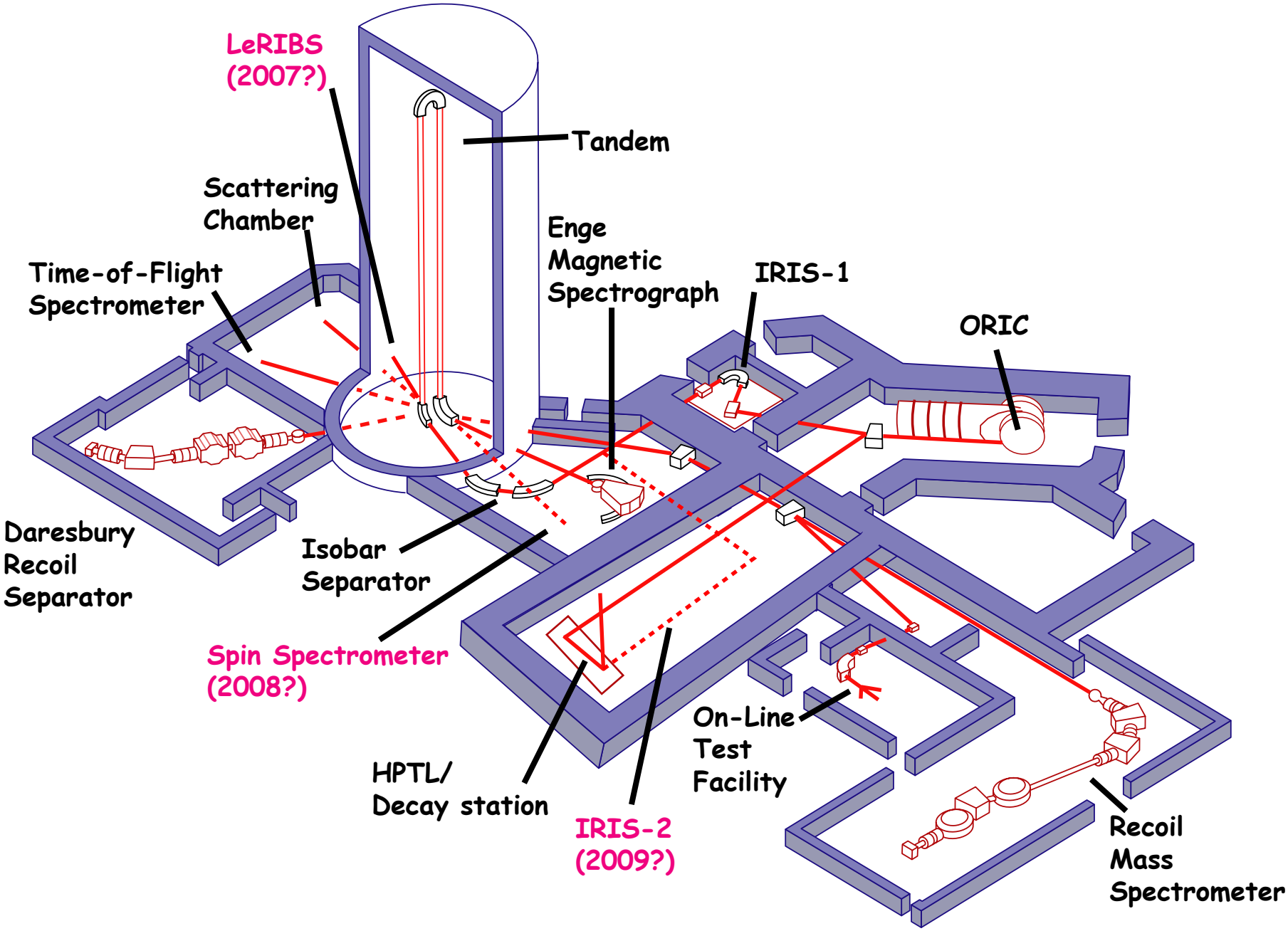
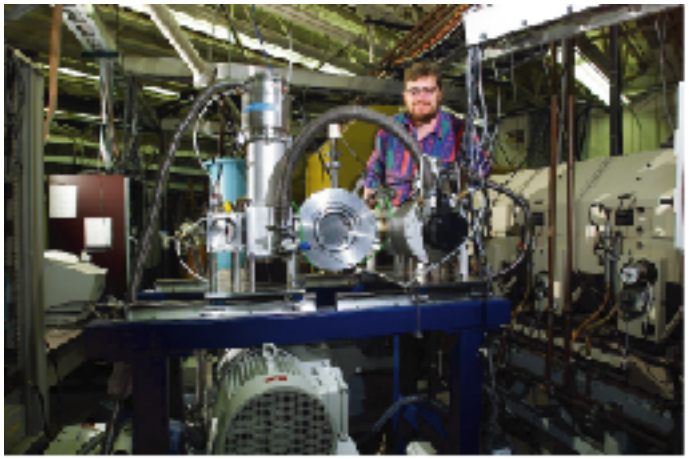
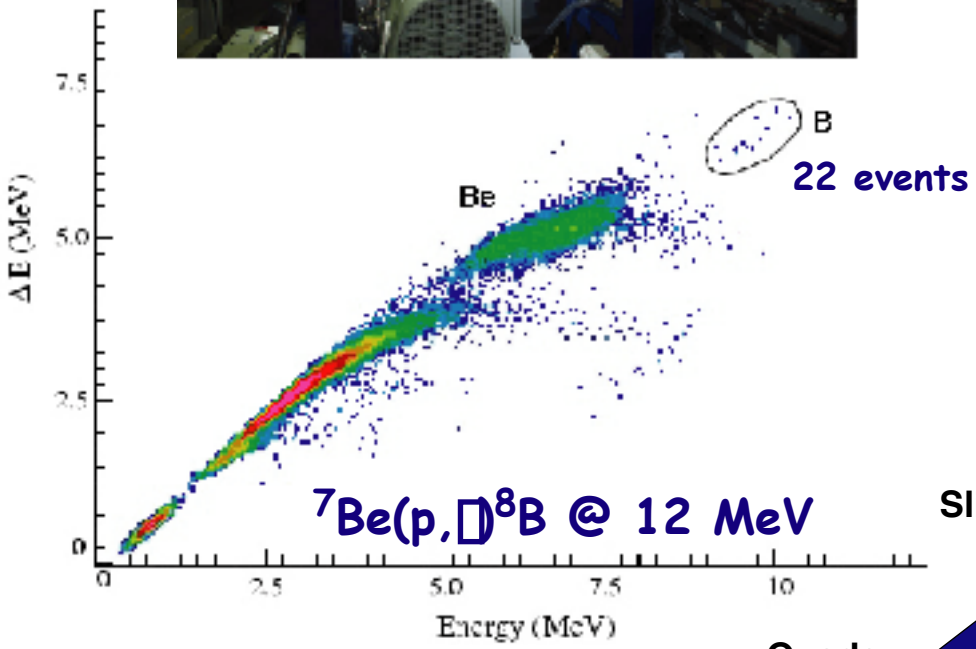
HRIBF Schematic Layout



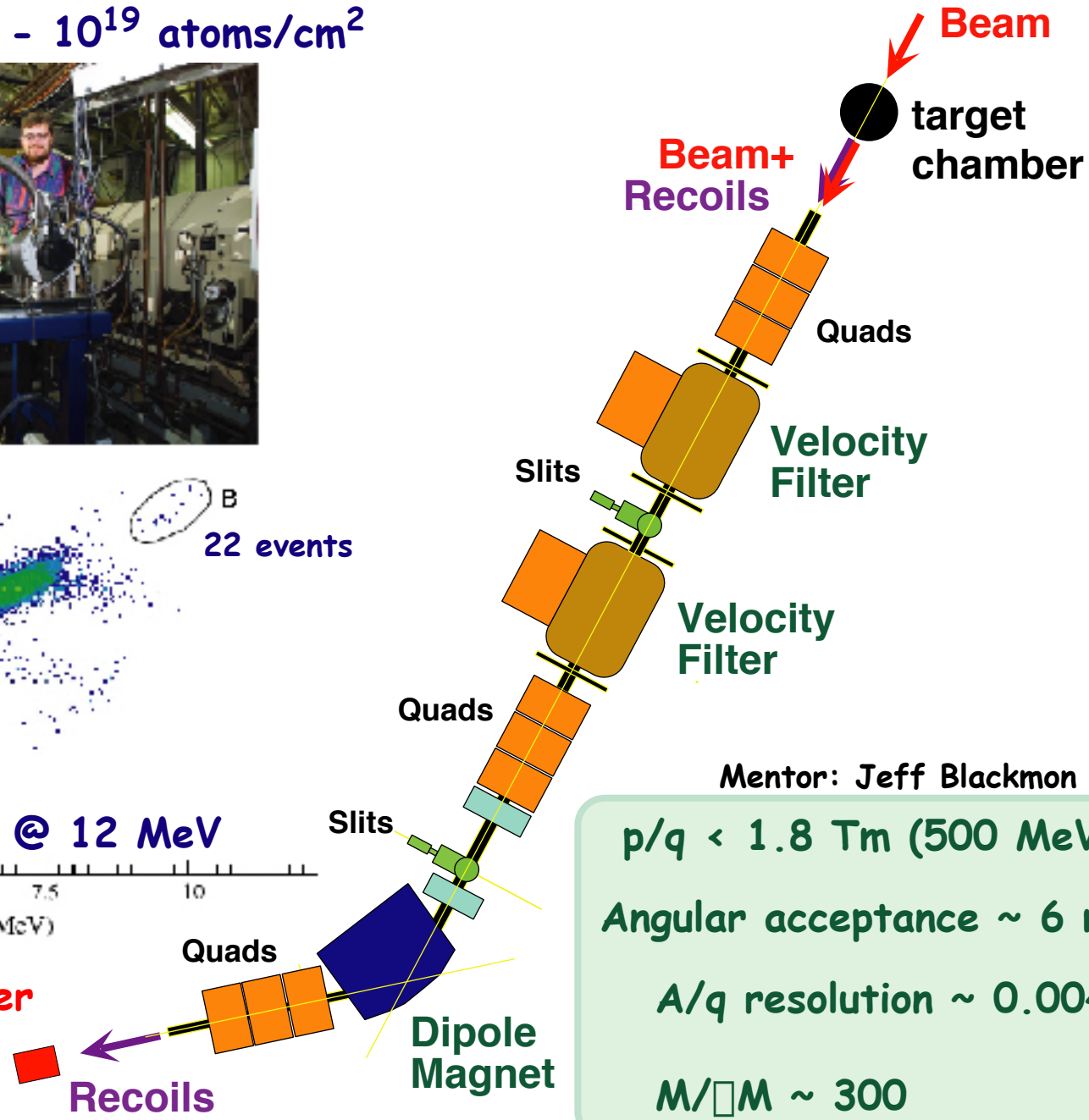
Daresbury Recoil Separator and Windowless Gas Target

Windowless gas cell - 10^{19} atoms/cm^2





^{7}Be(p,□)^{8}B @ 12 MeV



Mentor: Jeff Blackmon

p/q < 1.8 Tm (500 MeV/c)

Angular acceptance ~ 6 msr

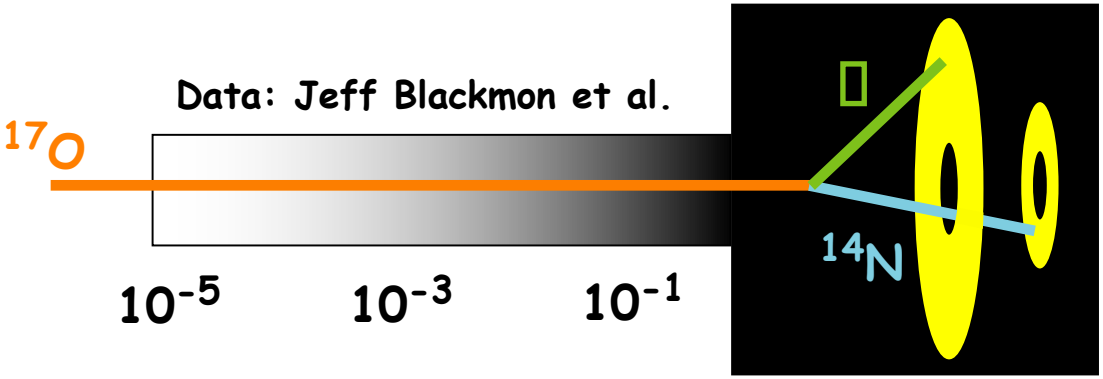
A/q resolution ~ 0.004

M/□M ~ 300

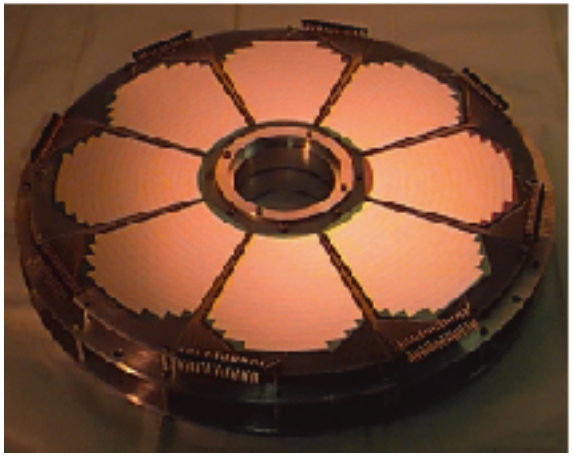
SIDAR in a gas target

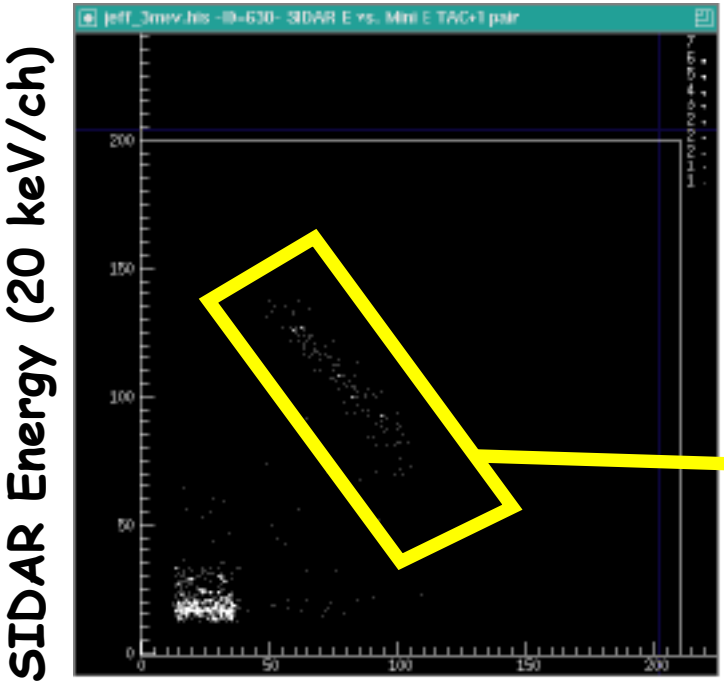
Mentor: Dan Bardayan

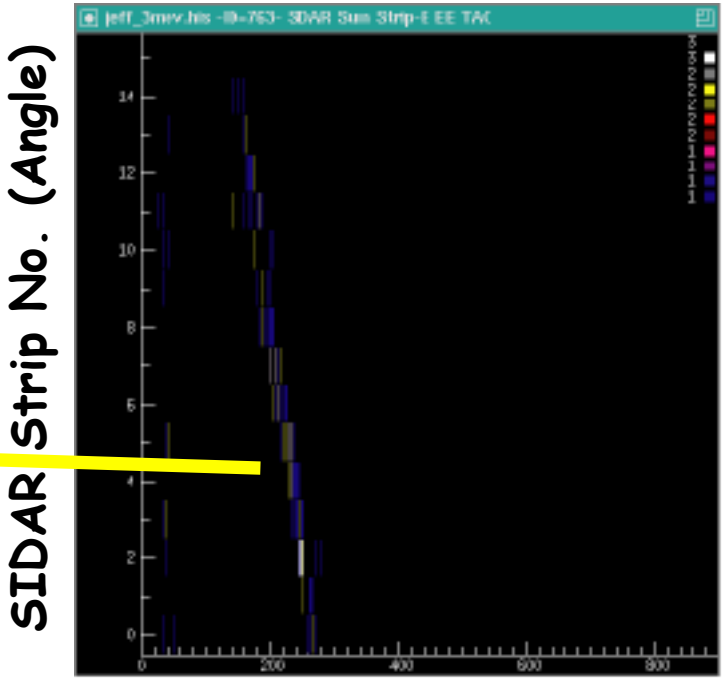
Data: Jeff Blackmon et al.



4 Torr Hydrogen







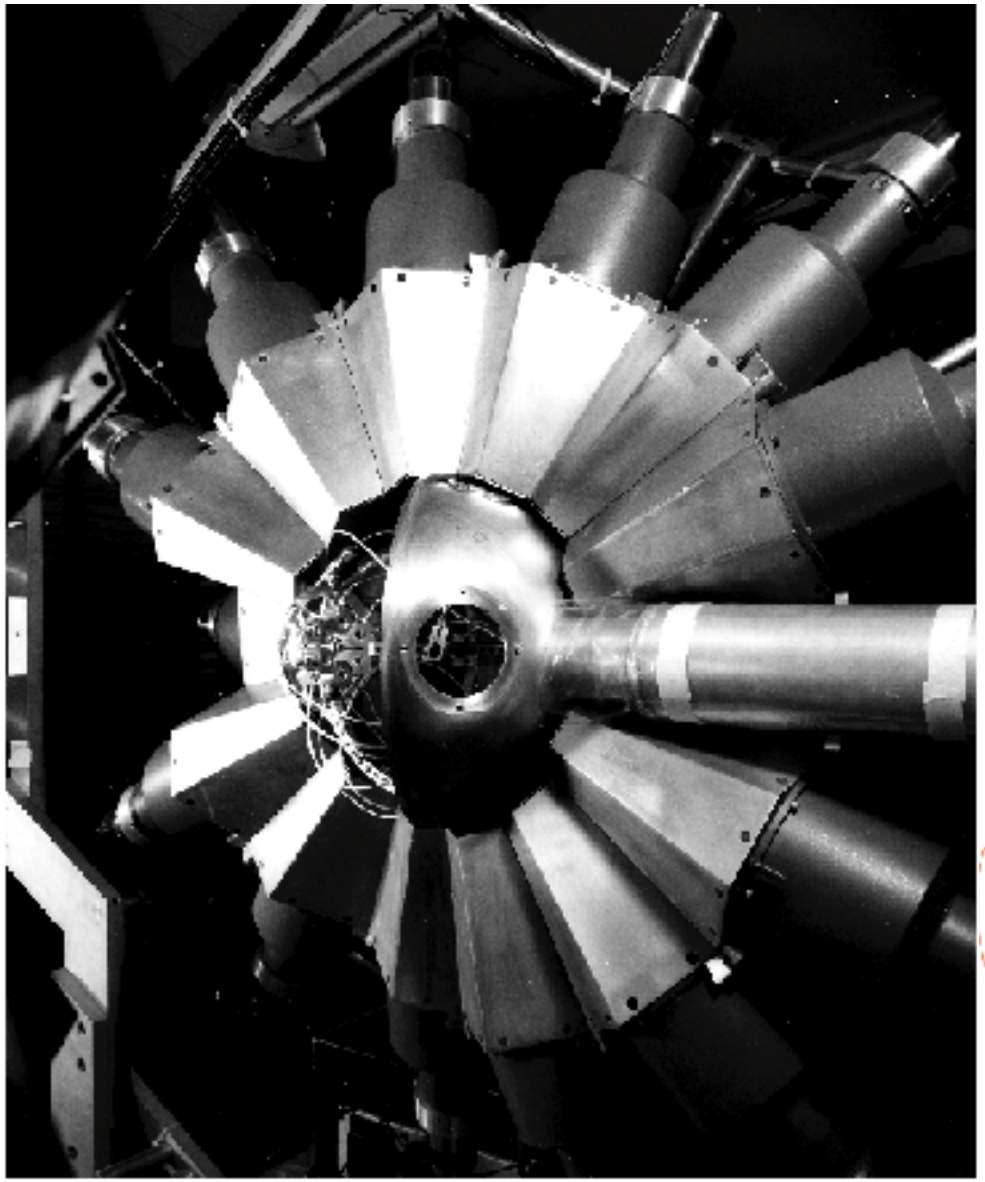
180 keV resonance in $^{17}O(p,\square)^{14}N$ @ 3.3 MeV

$\square$-width ~4 eV (~70 eV in ^{17}O)

Sum energy => Q-value

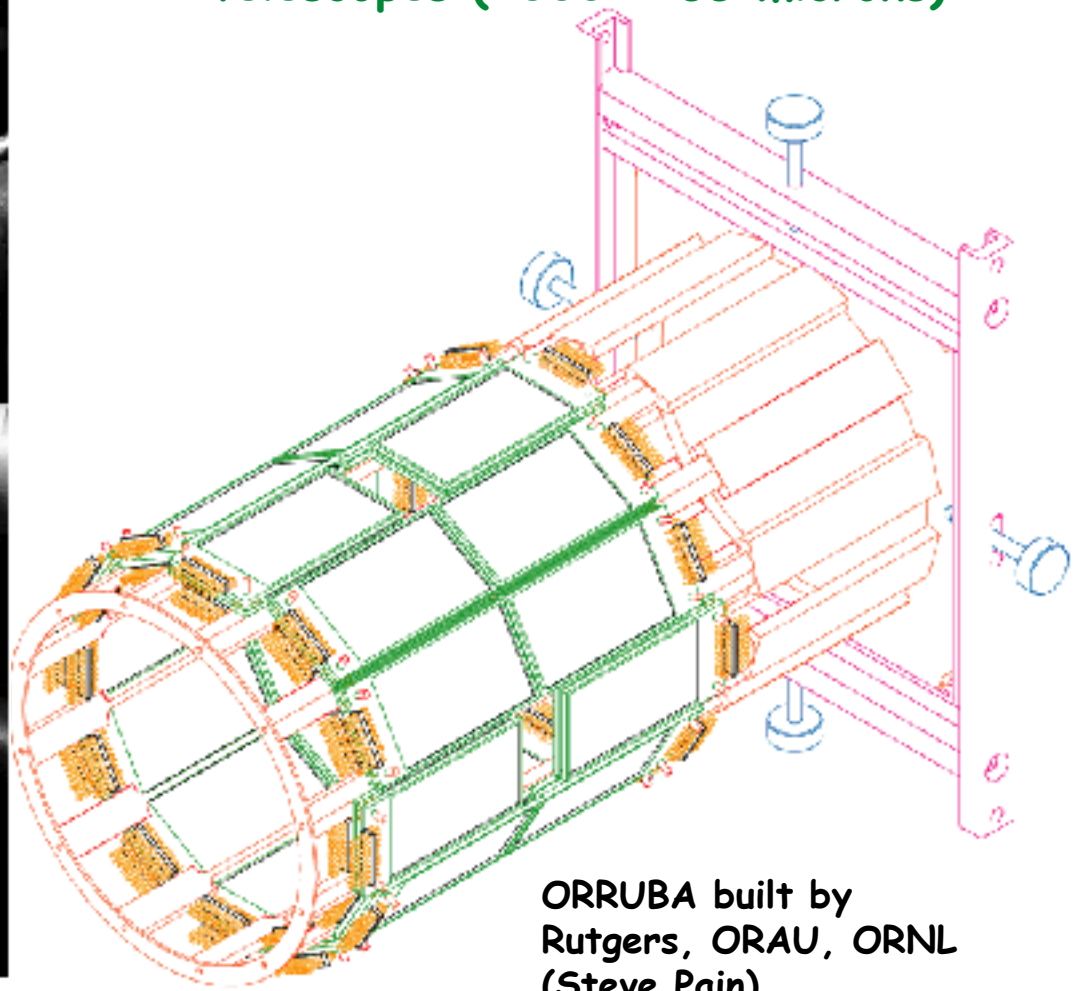
Spin Spectrometer and ORRUBA

72 NaI detectors, aux. detectors



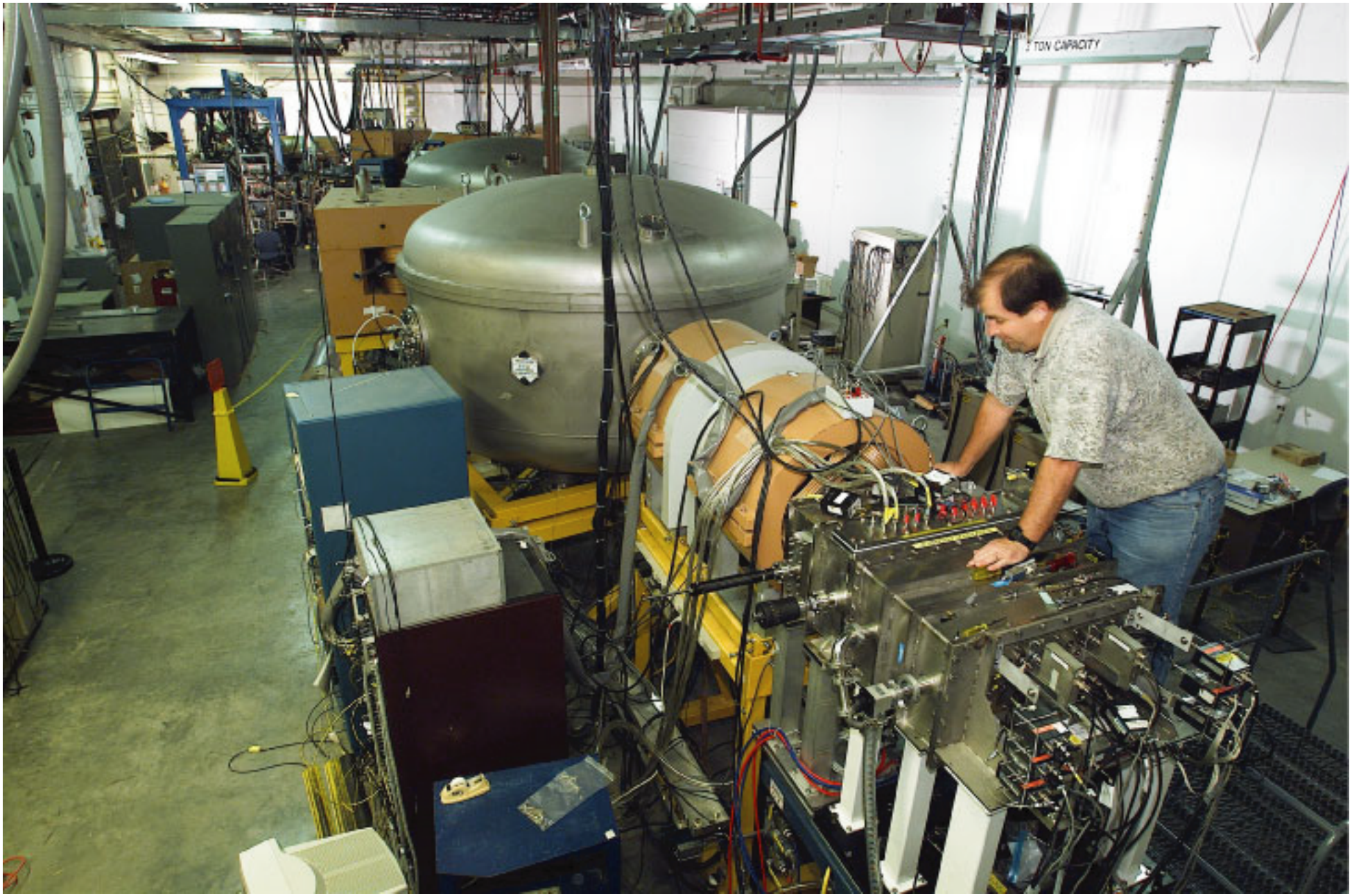
Future (d,p) tools
New beamline discussed

2 rings centered about 90°
- 12 telescopes (1000 + 140 microns)
- 12 telescopes (1000 + 65 microns)

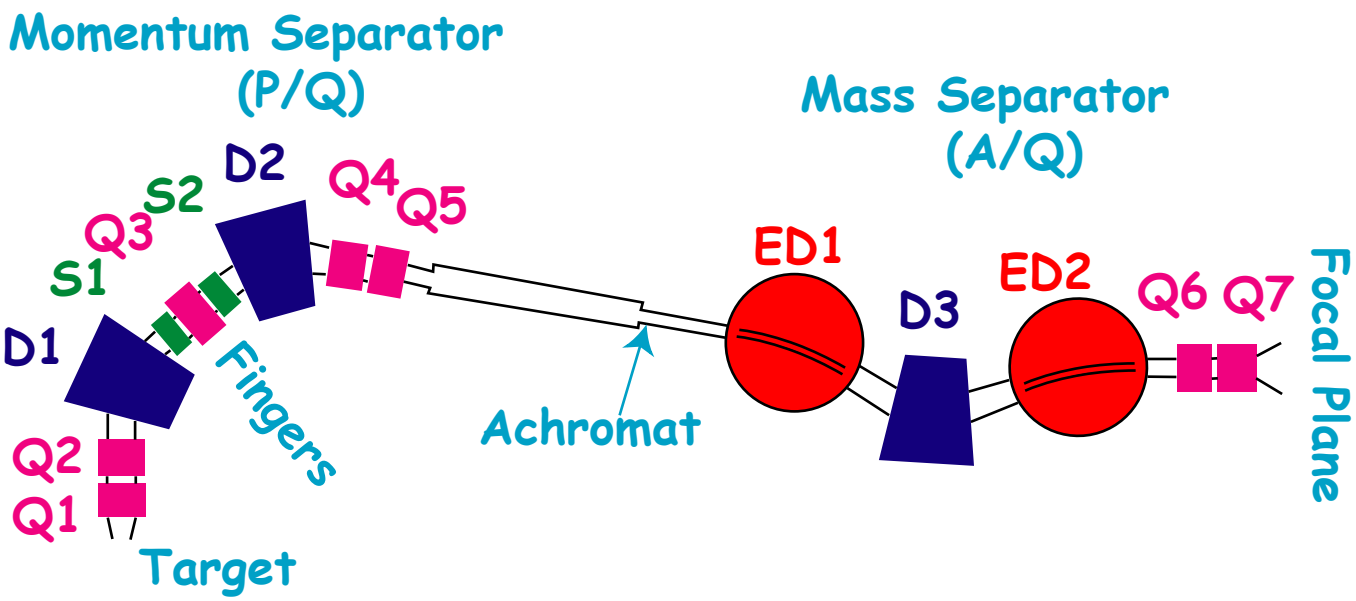


ORRUBA built by
Rutgers, ORAU, ORNL
(Steve Pain)

Recoil Mass Spectrometer



Recoil Mass Spectrometer



Mentors:
Carl Gross
Kris Rykaczewski
David Radford
Alfredo Galindo-Uribarri
Chang-Hong Yu

Performance Numbers

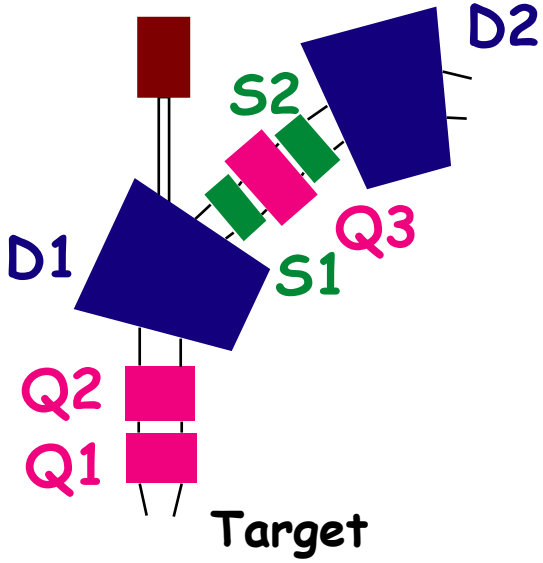
Energy acceptance +/-10%
A/Q acceptance +/-4.9%
Mass resolution (M/ΔM) ~400
Efficiency: Reaction dependent
(typically around 5%)
Length - 25 m
Time-of-flight - 1.5-3 us
Gross et al., NIM 450A, 12 (2000)

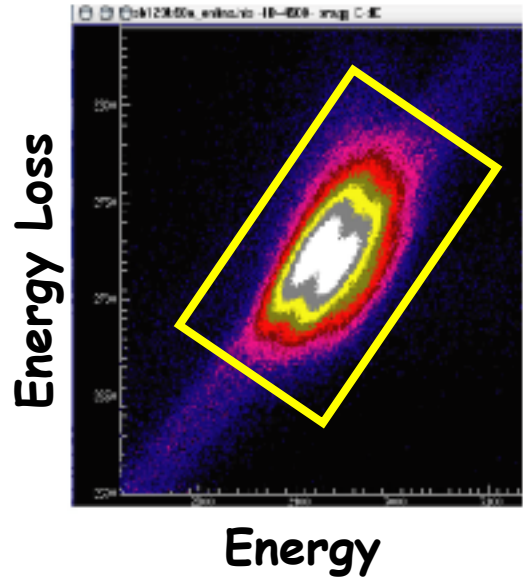
Detectors

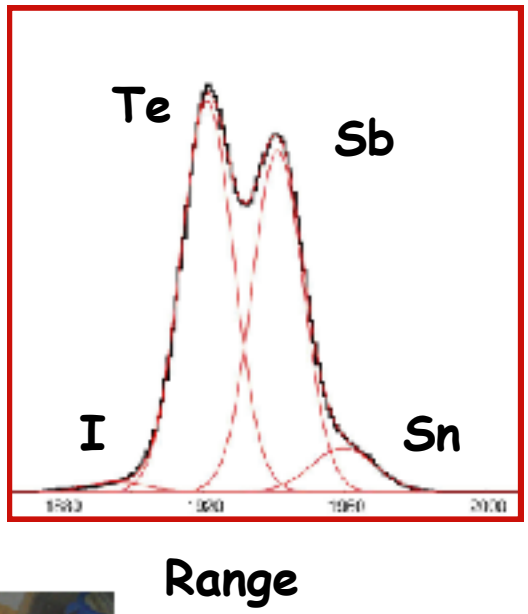
Clarion - 11 Clover Ge (2.2% eff)
HyBall - 95-element CsI
Neutron array - 19-element NE-213
Forward array - Si E-ΔE (~7º-~30º)
MCPs and PSAC @ focal plane
Double-sided Si strip detectors
Moving Tape Collector
CARDS - Ge detectors @ focal plane
Beta & electron (BESCA) detectors

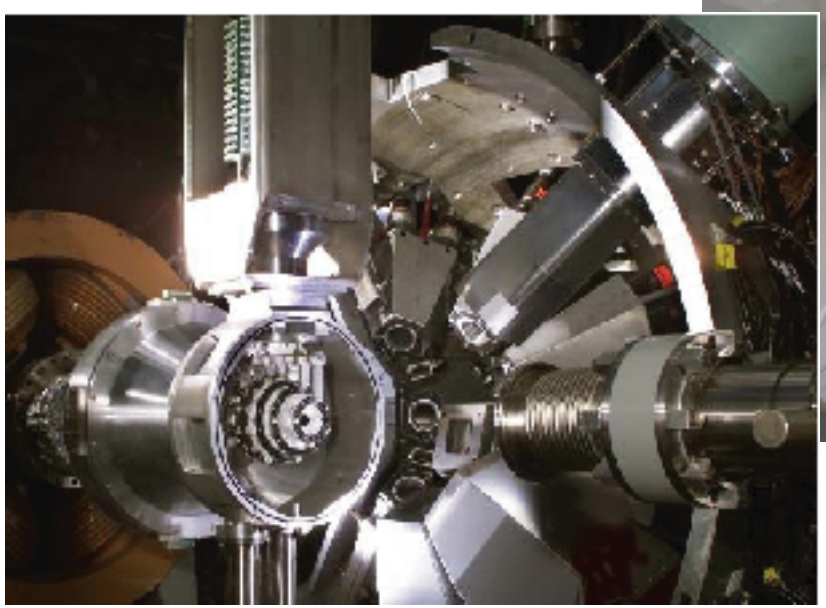
Coulomb excitation and light-ion transfer experiments

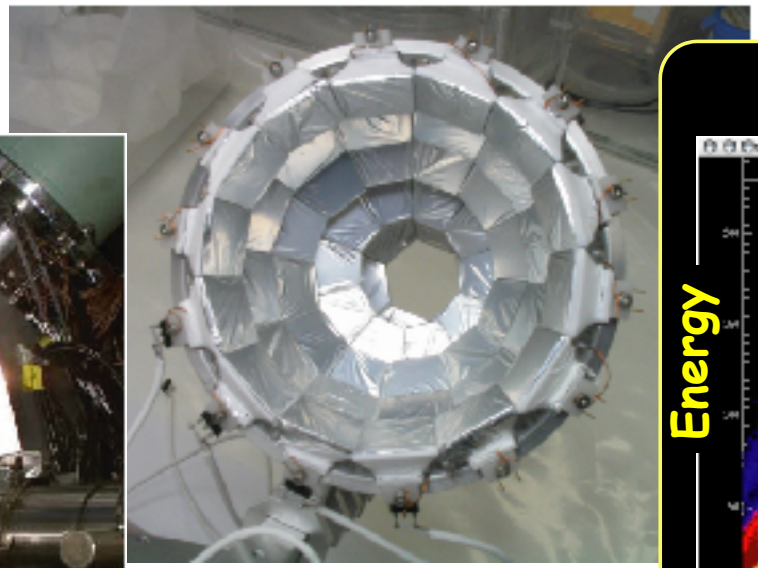
Sampling Bragg Detector (RMS Off)

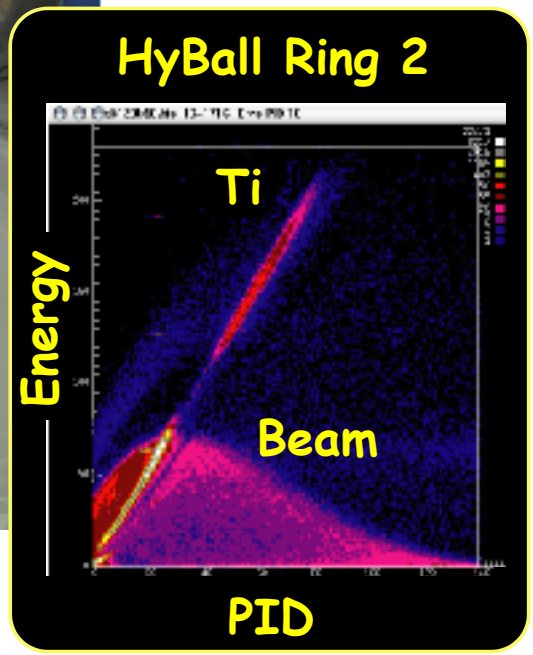












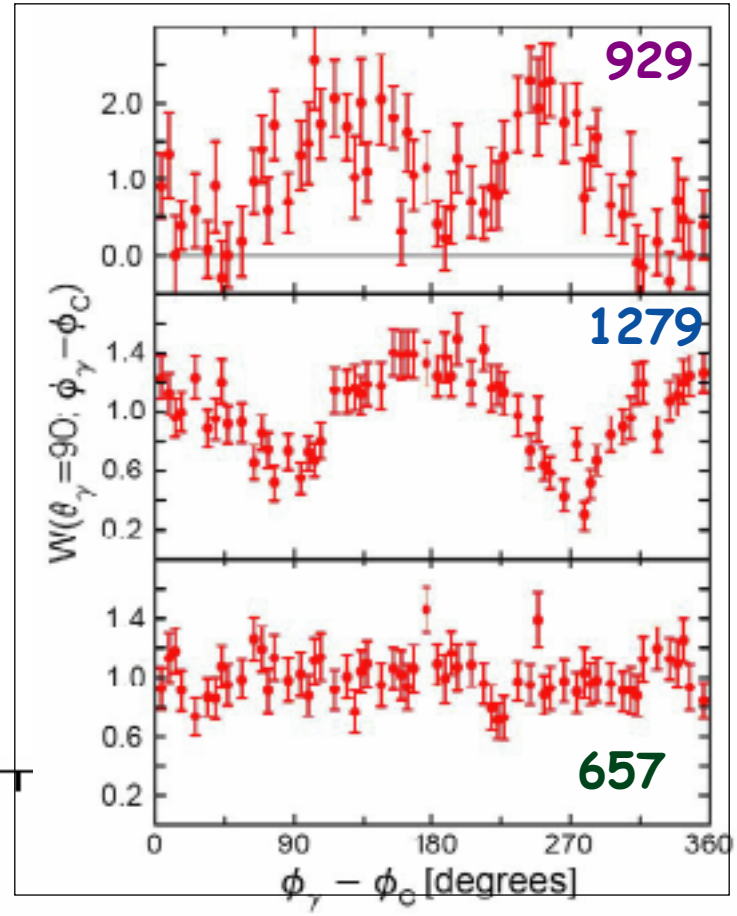
Particle-gamma angular correlations in $^{13}C(^{134}Te,^{135}Te)^{12}C$

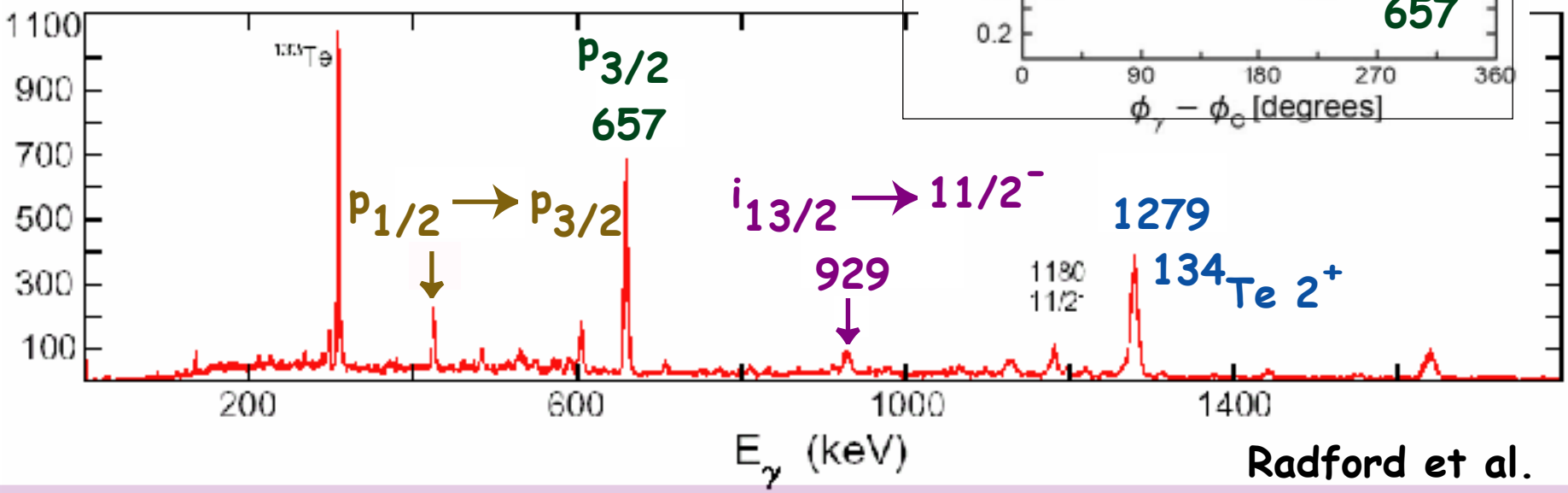
Transfer reaction imparts alignment
- detected target particle defines axis
- W(θ,φ) can reveal transition multipolarity

Coulex of 2+ state of beam
- small but measurable alignment
- 1279 keV is stretched E2

Transfer to p3/2 state
- little alignment from reaction
- 657 keV should be nearly isotropic

Transfer of l=7 to i13/2 state
- decays to known 11/2- state
- 929 keV is a stretched dipole



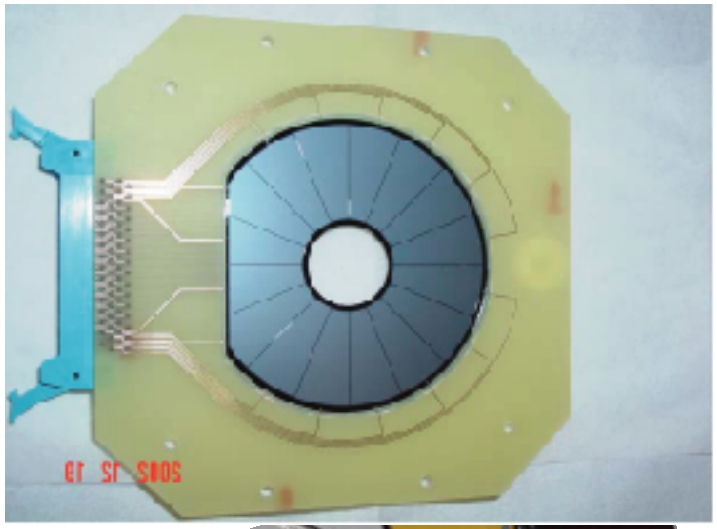


Radford et al.

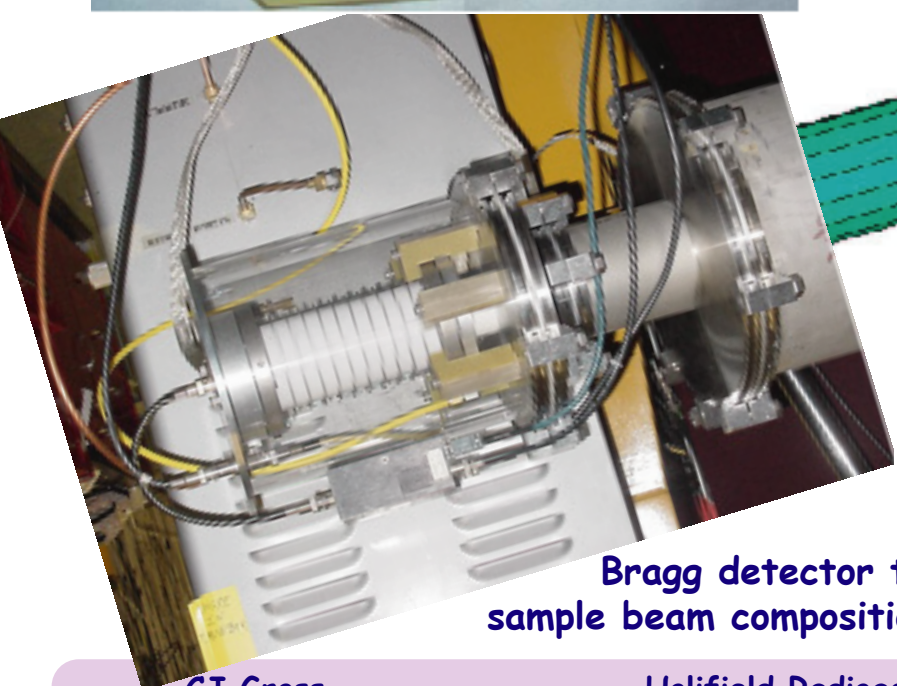
ORNL-TAMU-MSU Barium Fluoride Array

High energy γ-ray detection
hexagonal detectors 20 cm long and 6.5 cm wide
seven 19-packs, four 37-packs or a 145 detector wall

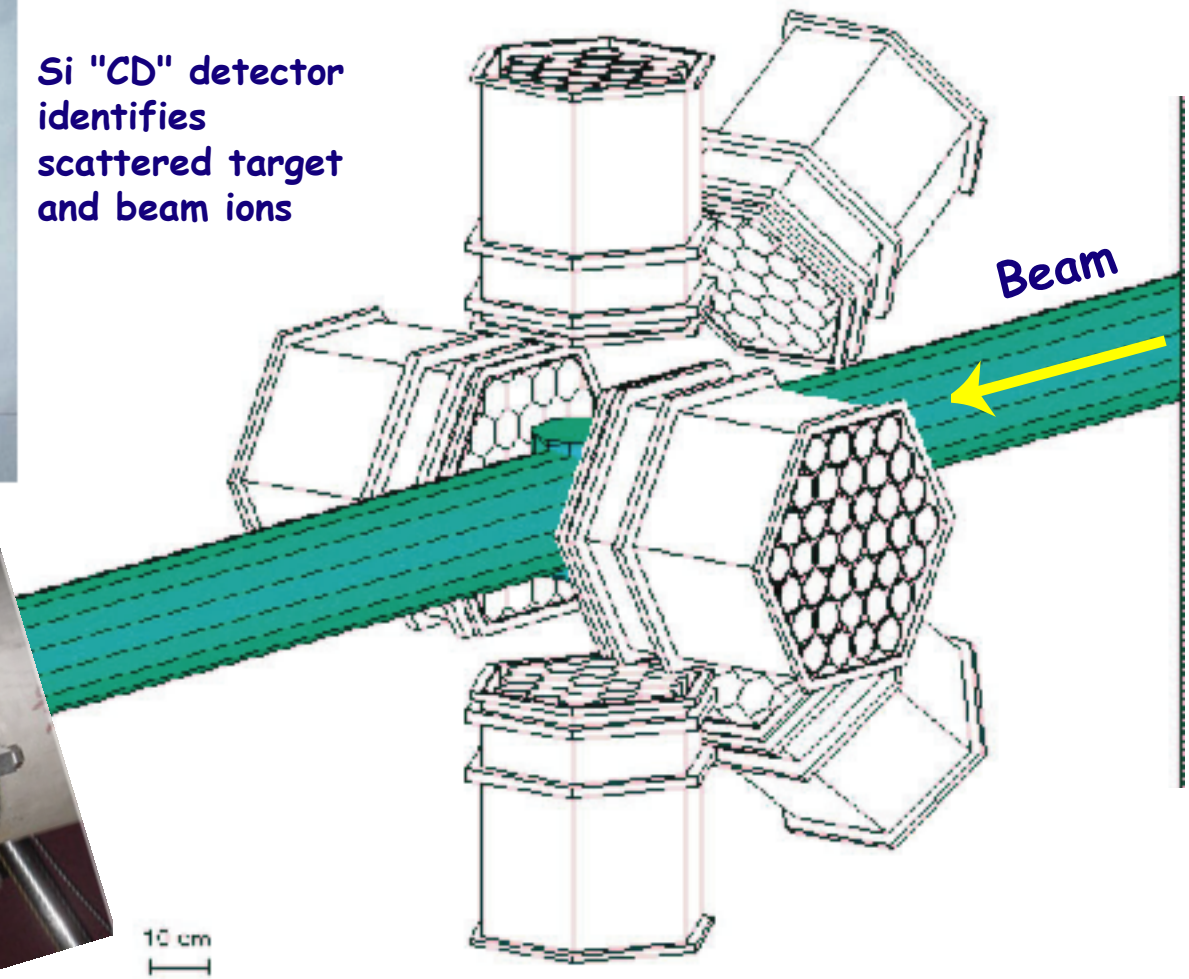
Mentor: Robert Varner
Array available through collaborating institutions



Si "CD" detector identifies scattered target and beam ions



Bragg detector to sample beam composition

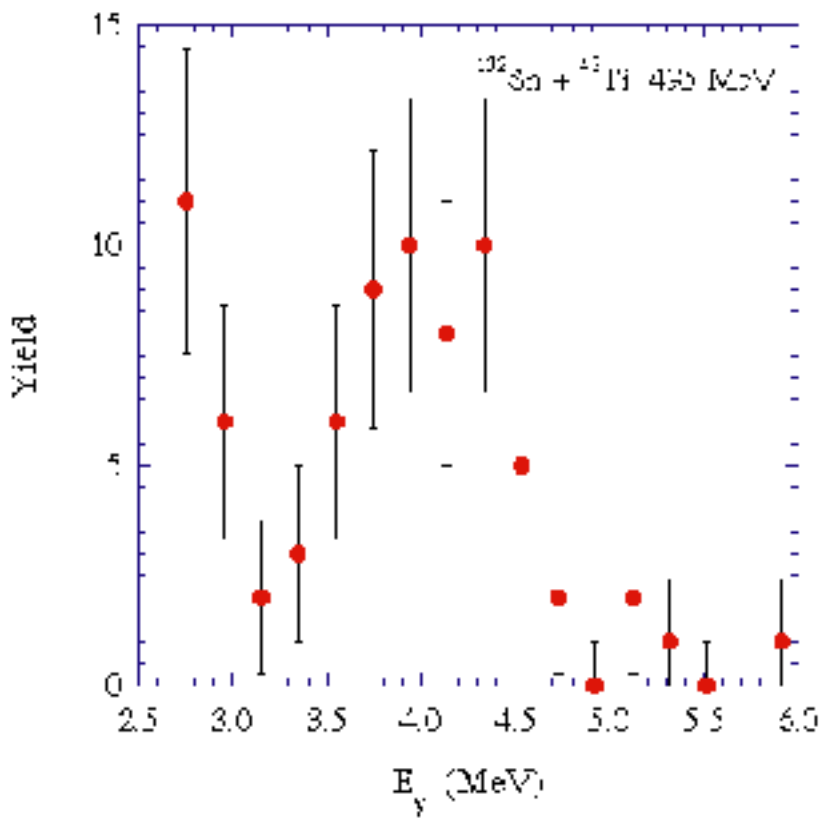


Setup for ^{132,134}Sn Coulex on "scattering chamber" BL-23

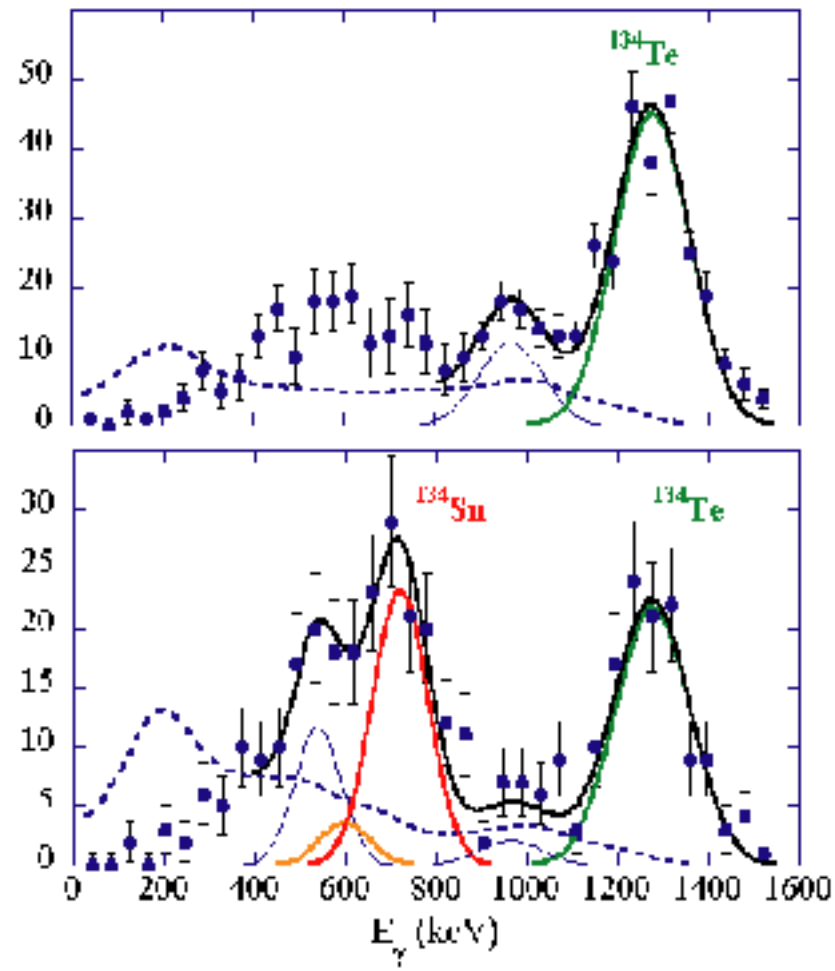
Barium fluoride and Coulex of n-rich Sn beams

Data: Jim Beene/Robert Varner

Gated by 1 particle in Si detector
^{48}Ti target
~40% efficiency
1.3x10^{5} ions/sec (96% pure)
~2 week experiment

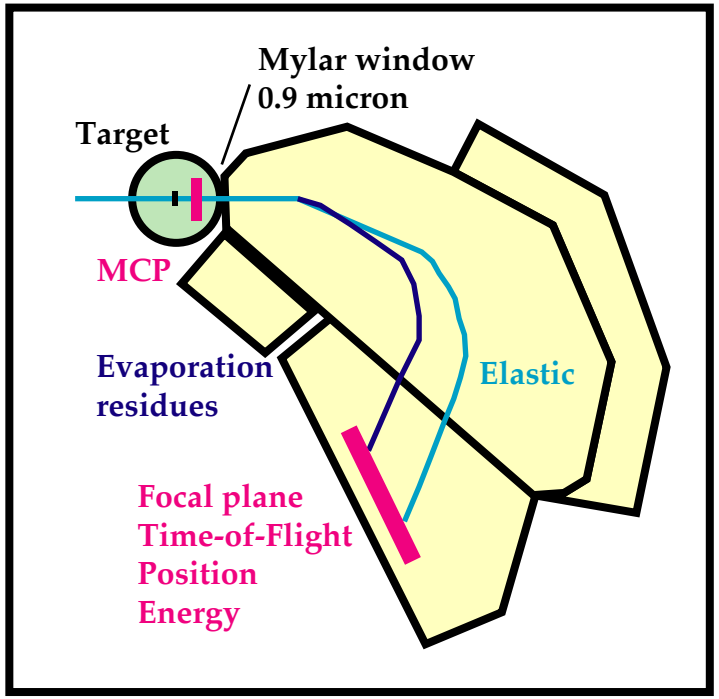


^{90}Zr target
10^{4} ions/sec (33% ^{134}Sn)
~4 day experiment

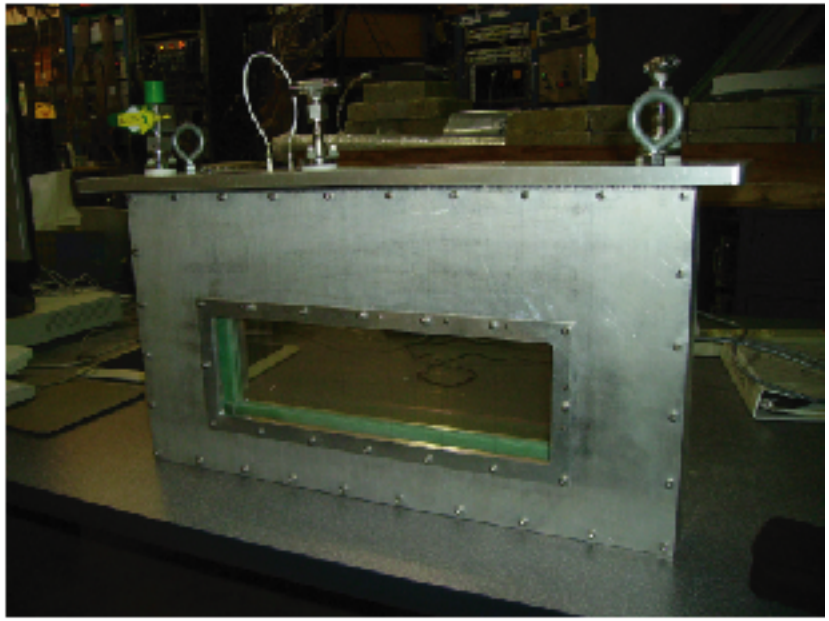


Enge Magnetic Spectrograph - Gas Mode

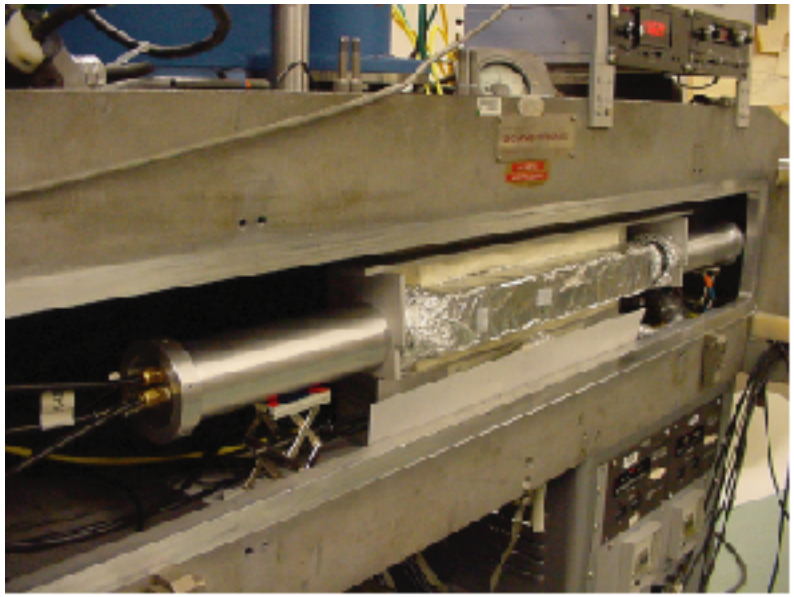
Mentor: Felix Liang



Avalanche Counter (36 cm x 10 cm)



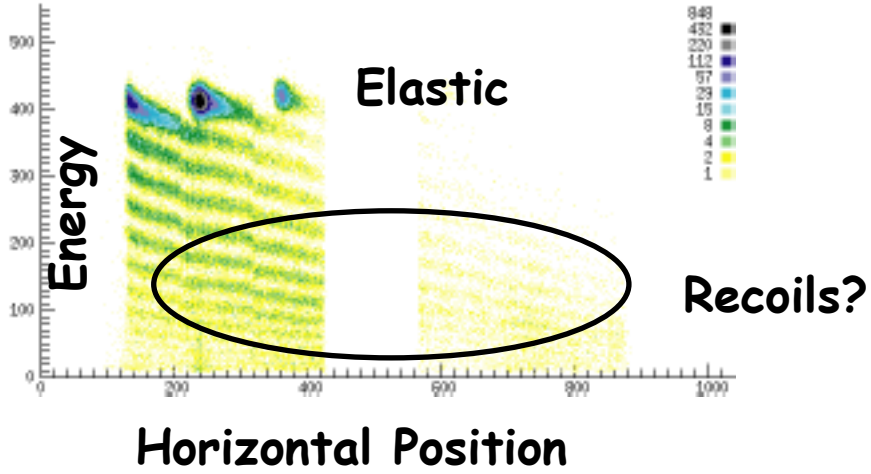
Plastic E detector (2 PMT)



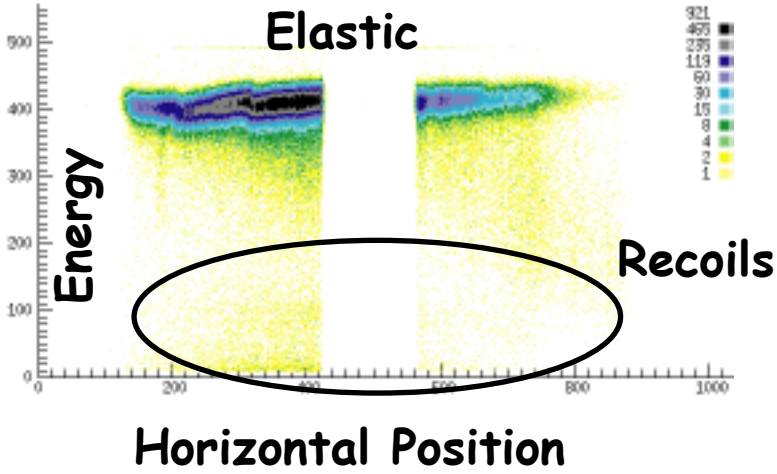
Enge Magnetic Spectrograph

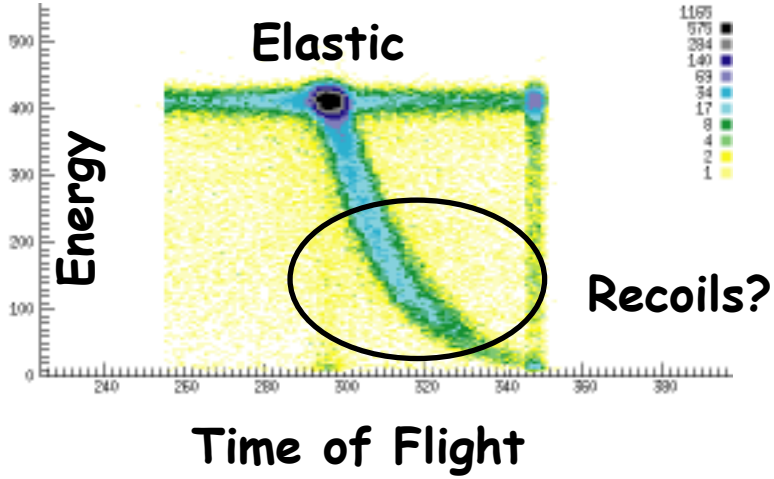
250 MeV ^{70}Ge + ^{27}Al, ~2° off beam axis

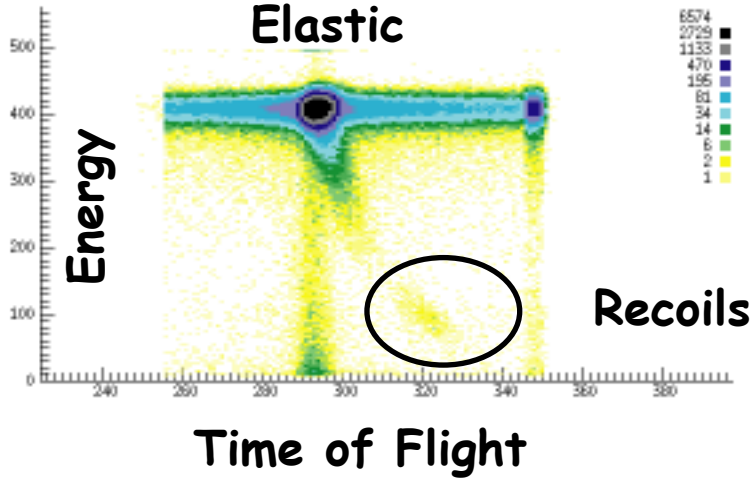
No Gas



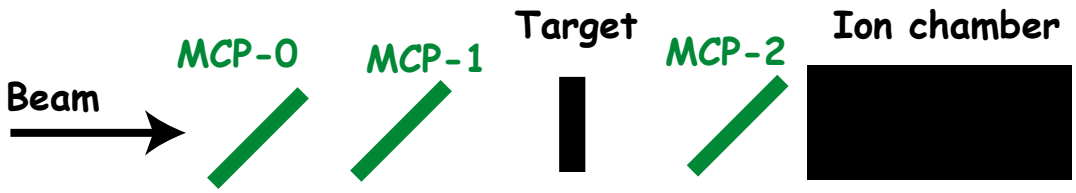
With Gas



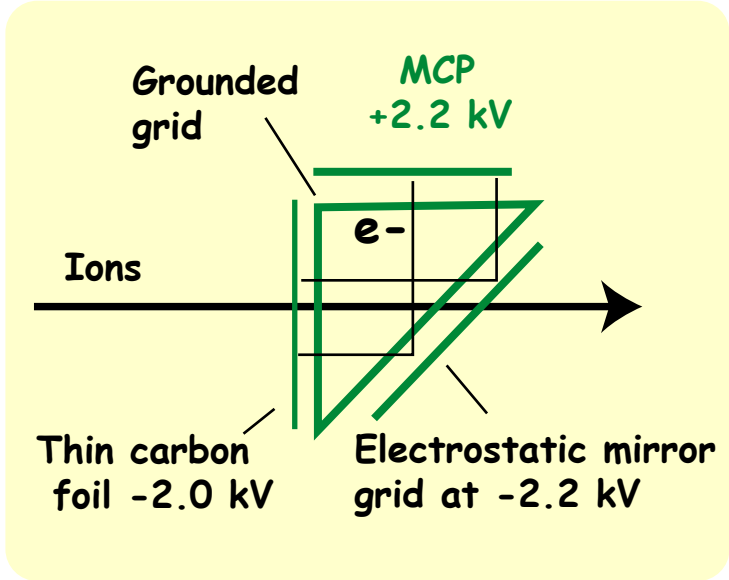


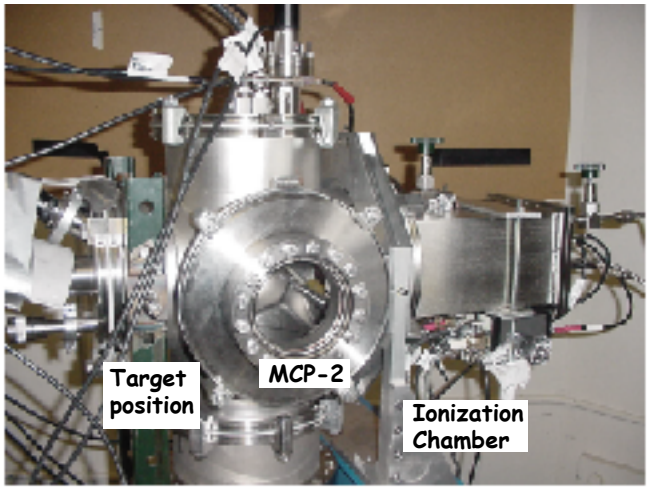


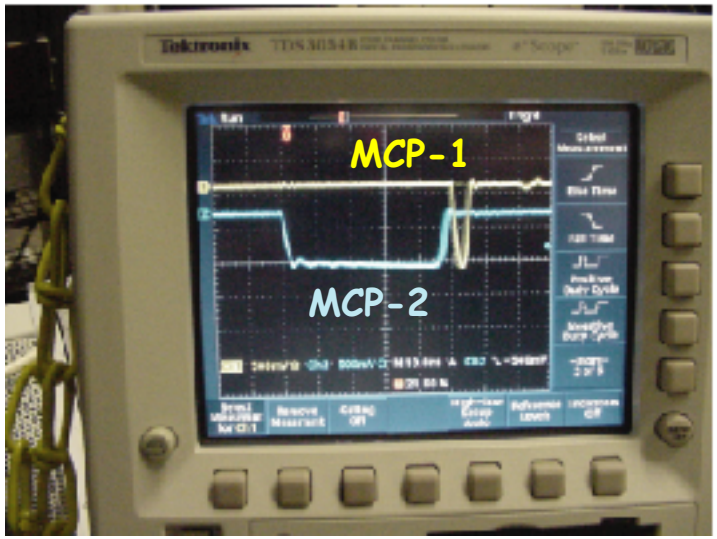
Time-of-flight and MicroChannel Plates

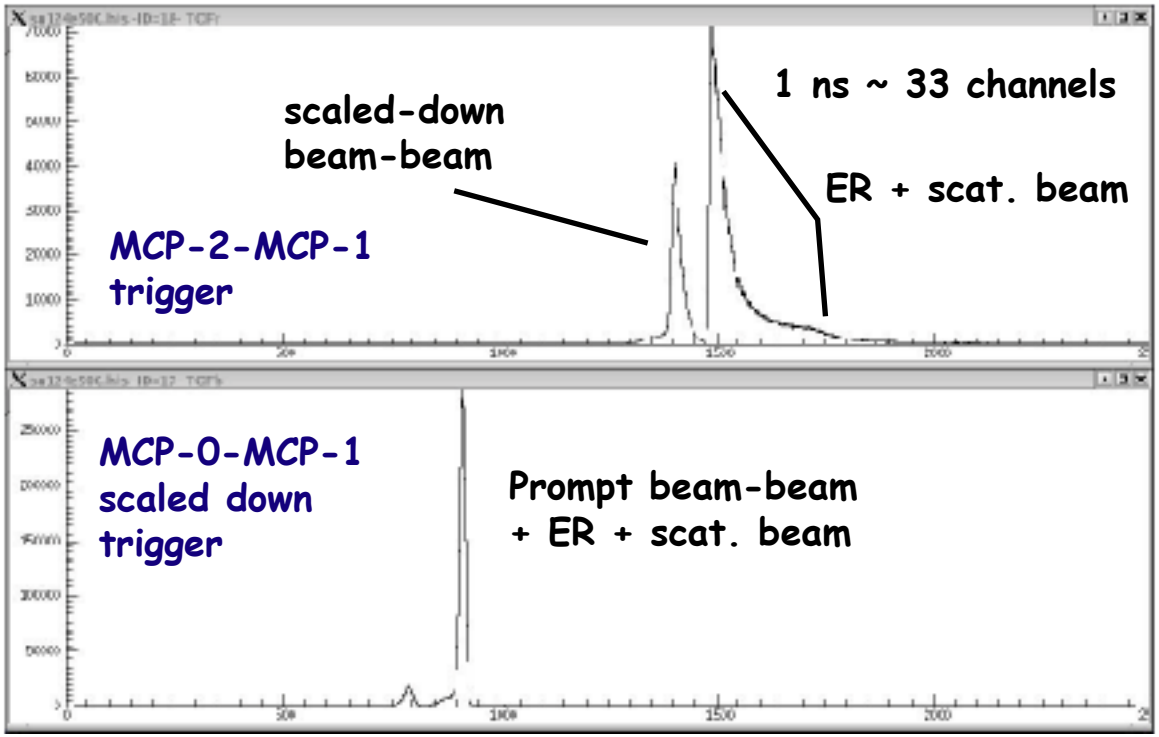


Mentor:Dan Shapira



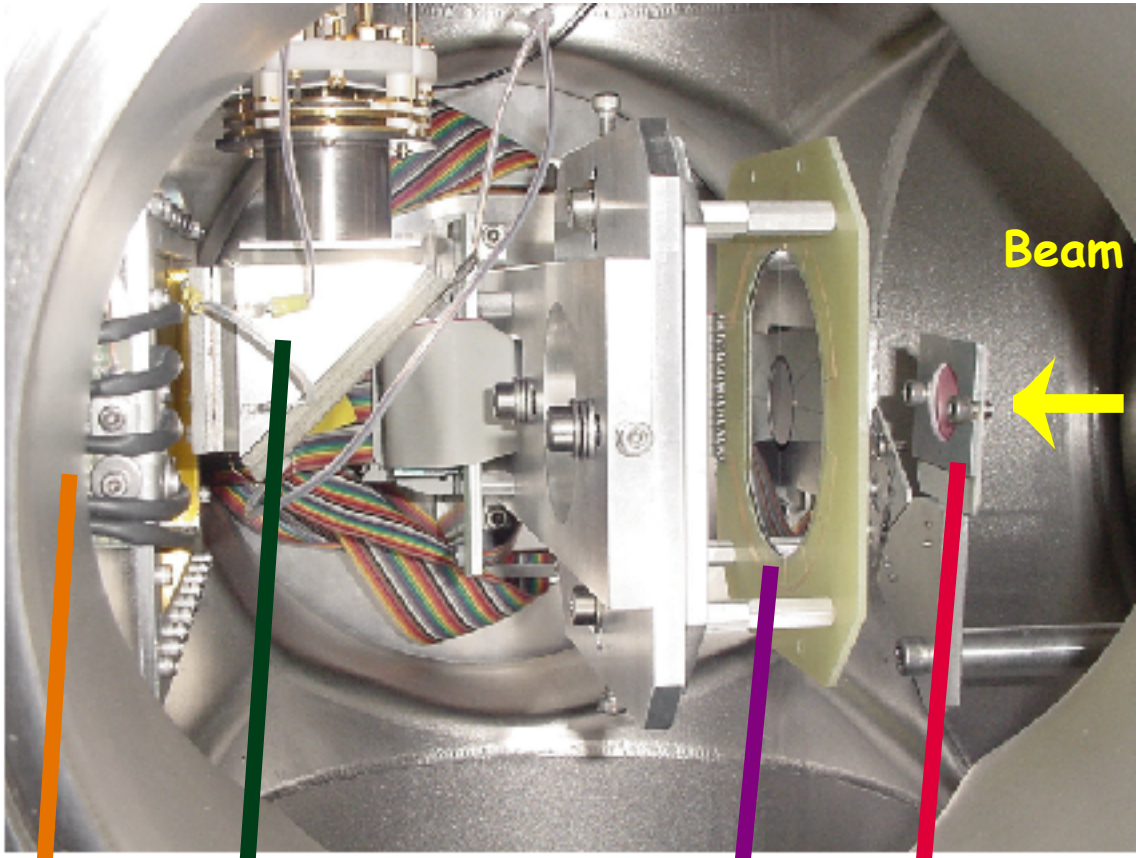






Sub-barrier fusion measurements using time-of-flight

Data: Felix Liang



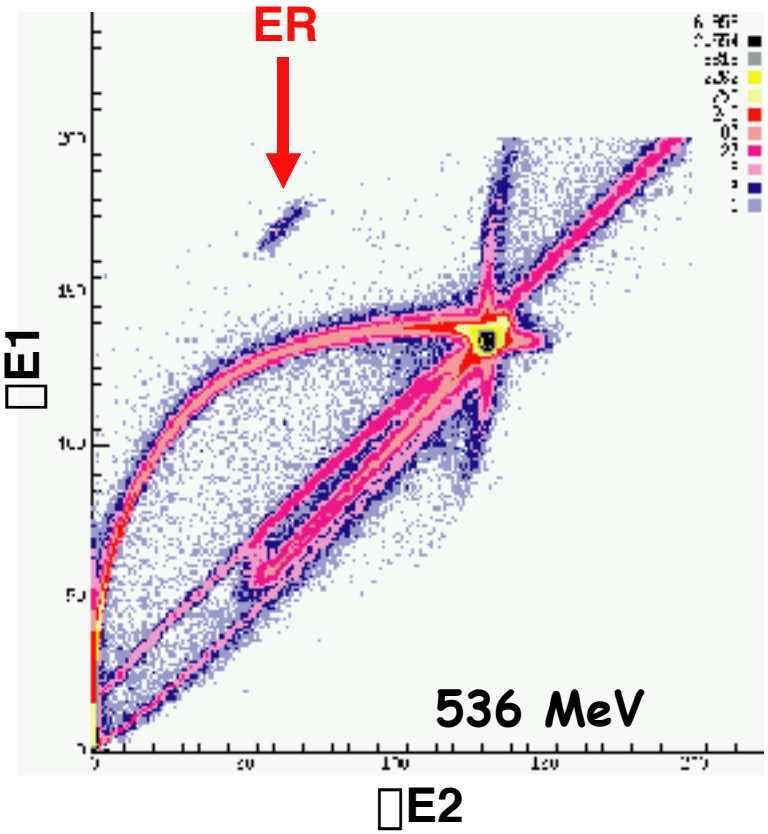
Microchannel Plate & Thin Foil (MCP)

Ion Chamber

Annular Si Strip Detector 48 rings x 16 sectors

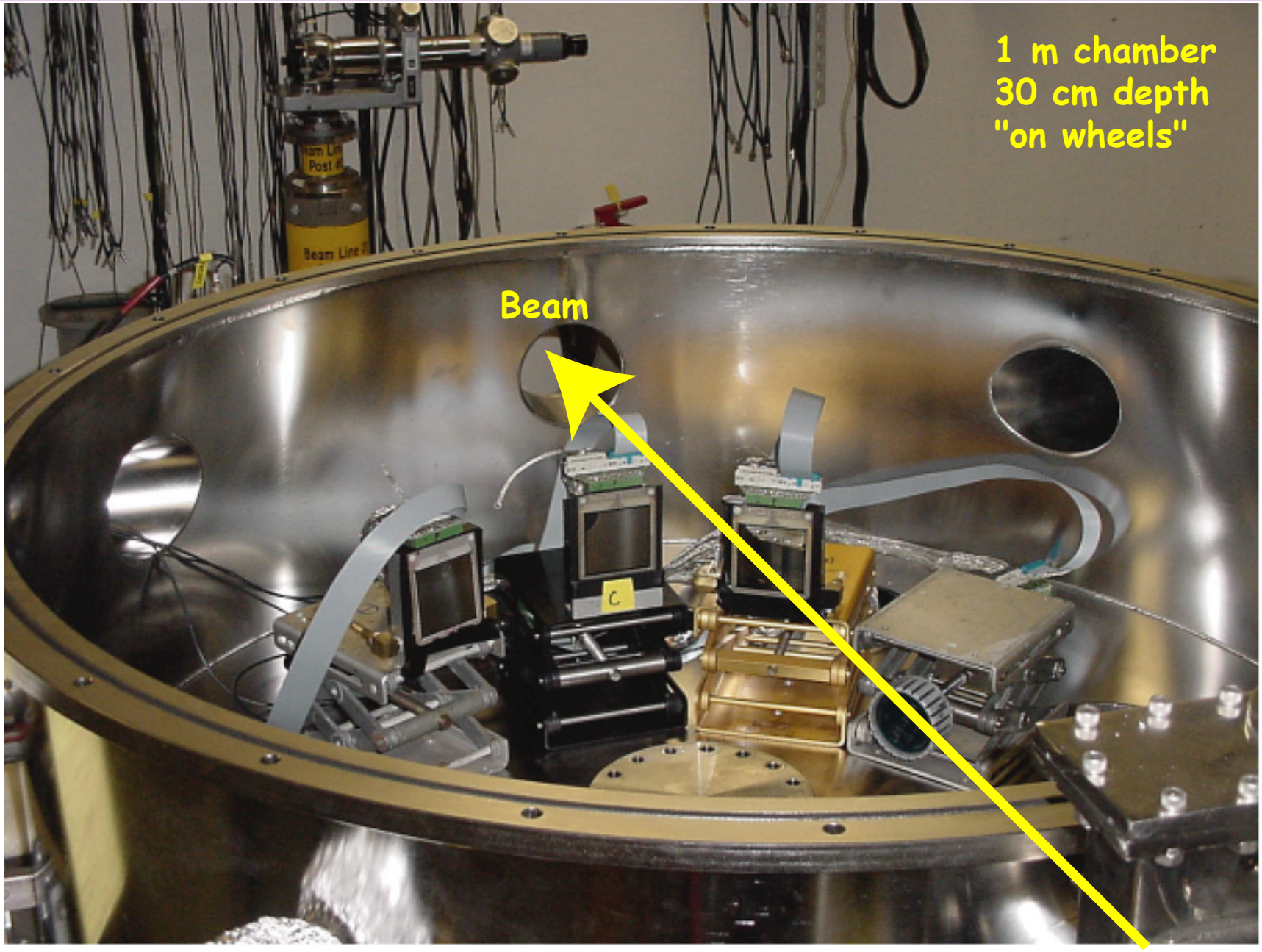
Target & Phosphor

$^{132}Sn + ^{64}Ni$ 530-620 MeV (fission data under analysis)



2 MCPs upstream identify beam

Scattering Chamber



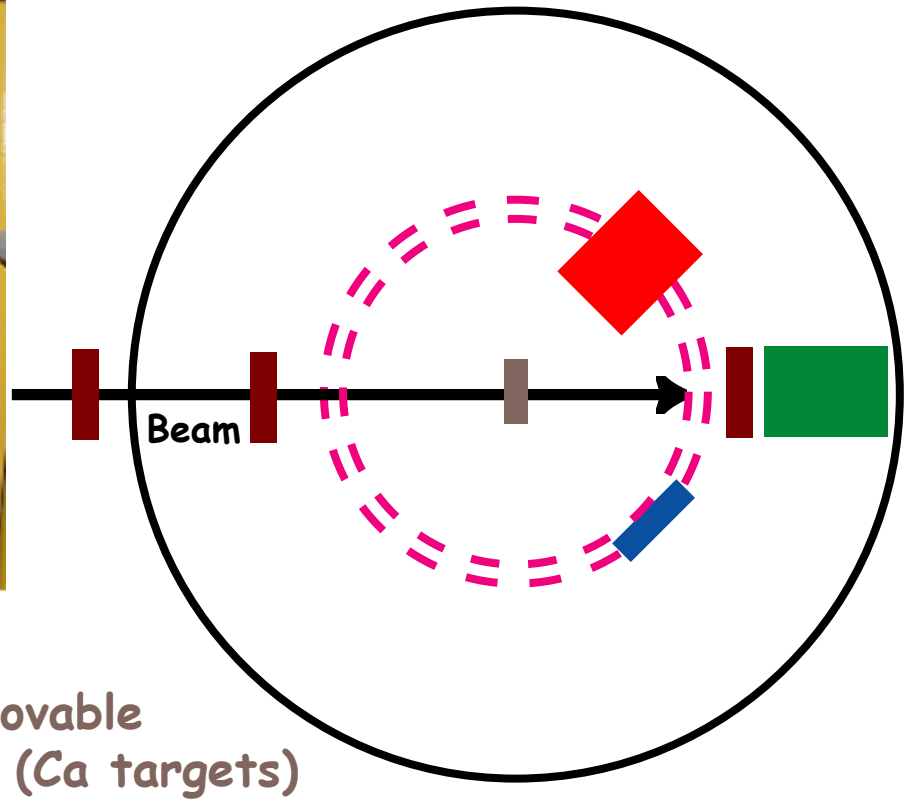
Setting up Walt Loveland's experiment

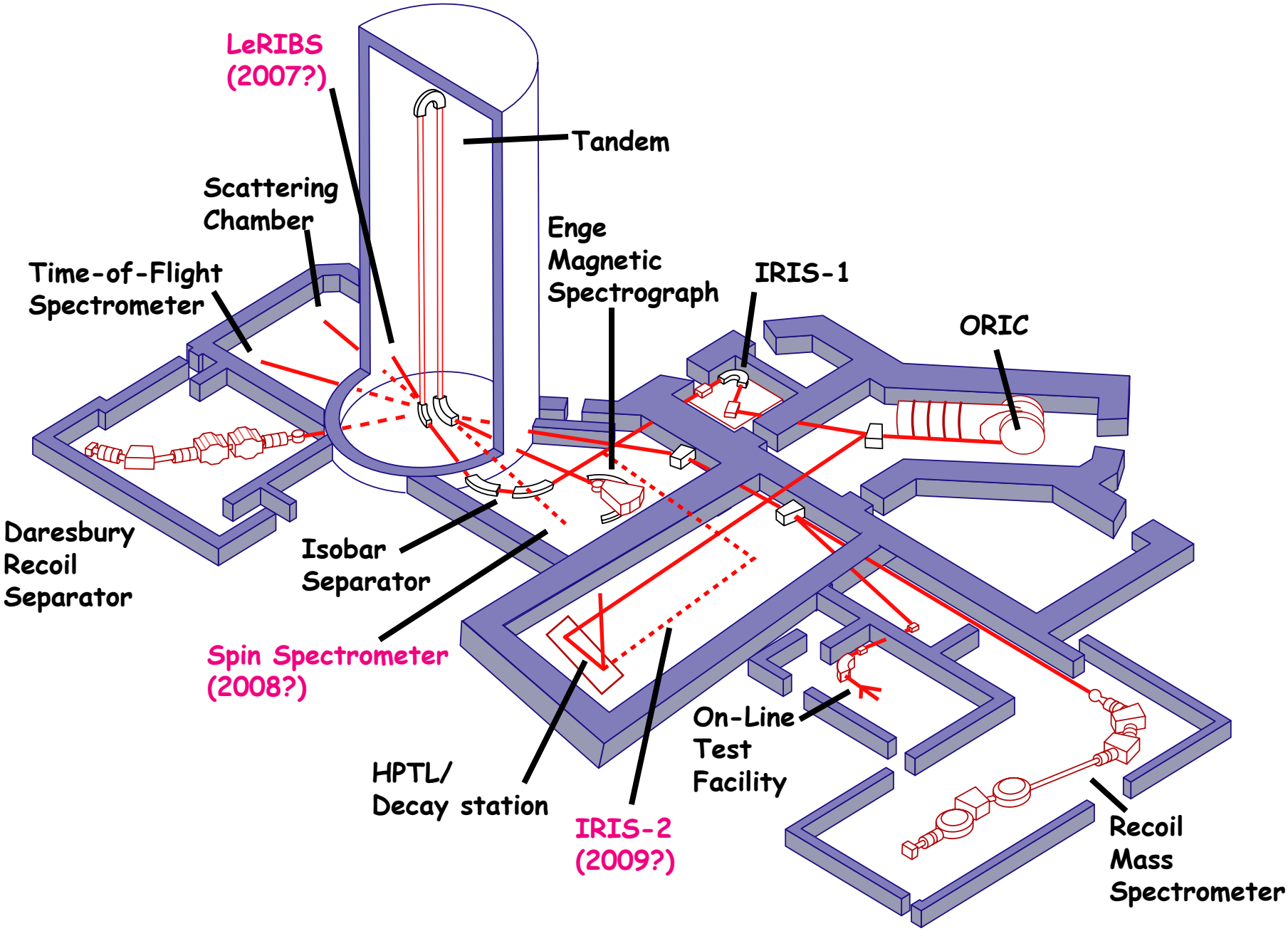
Mentor: Felix Liang

Scattering Chamber

Future improvements include complete fusion detection system evaporation residues and fission

Ion chamber-silicon hybrid
Ionization chamber
Avalanche counters
Microchannel plates
Movable detector rings



Target - removable
under vacuum (Ca targets)

HRIBF Schematic Layout