Mass measurements with (d,p) transfer reactions

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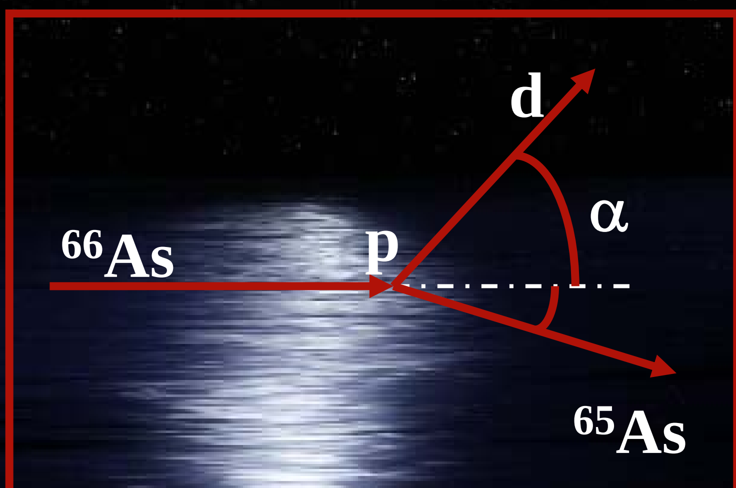
06/10/05

Experimental Program

- Measure the Mass of ^{64}Ge and ^{65}As to calculate the Q-Value of $^{64}Ge(p,\gamma)^{65}As$
- Use (p,d) Transfer Reactions in Inverse Kinematics
  - Produce ^{66}As and ^{65}Ge Beams.
  - CH_2 Target for Protons
- Magnetic Spectrometer to separate reactions products.
- Measure Deuterons from (p,d) in Charged Particle Array
- Measure Reaction Angle with Position Sensitive Beam Tracking Detectors

How Do We Measure These Nuclear Masses?

$$^{66}As + p \rightarrow d + ^{65}As$$



Using Inverse Kinematics:
(p,d)

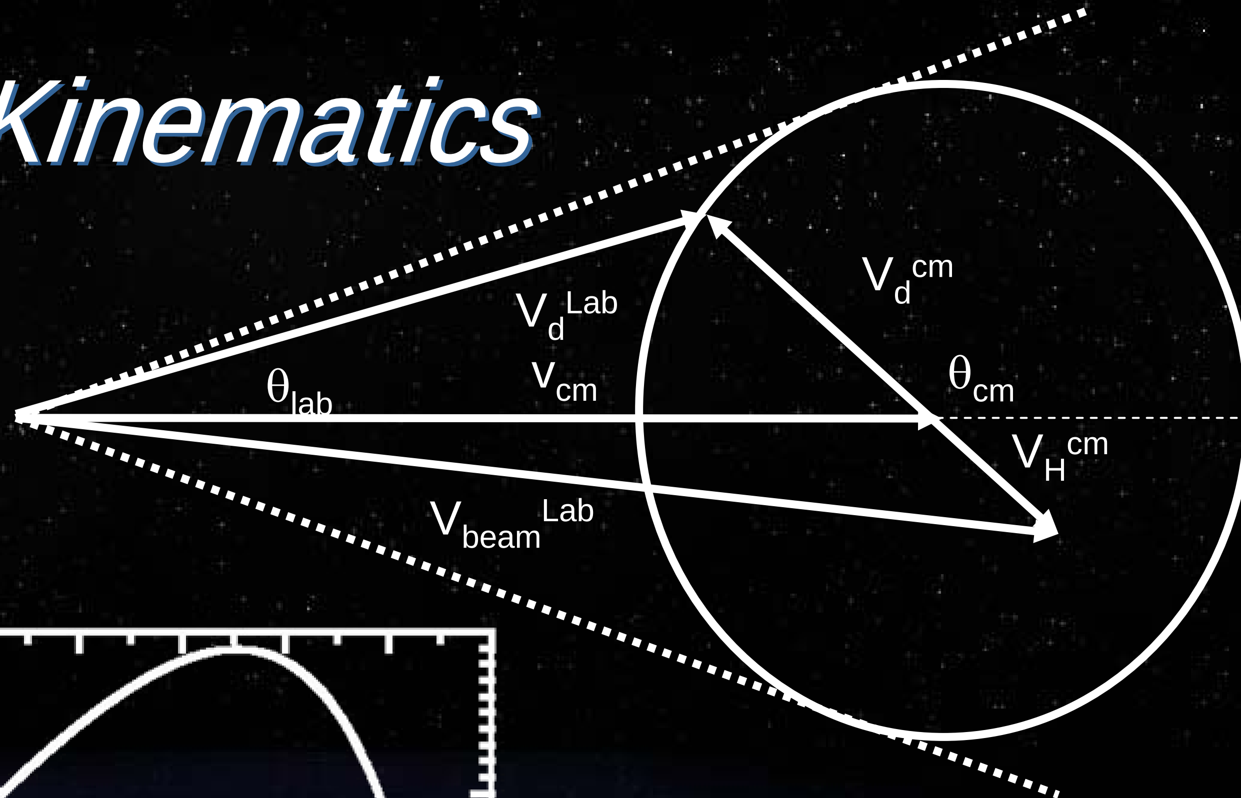
Use Heavy Beam Particle.

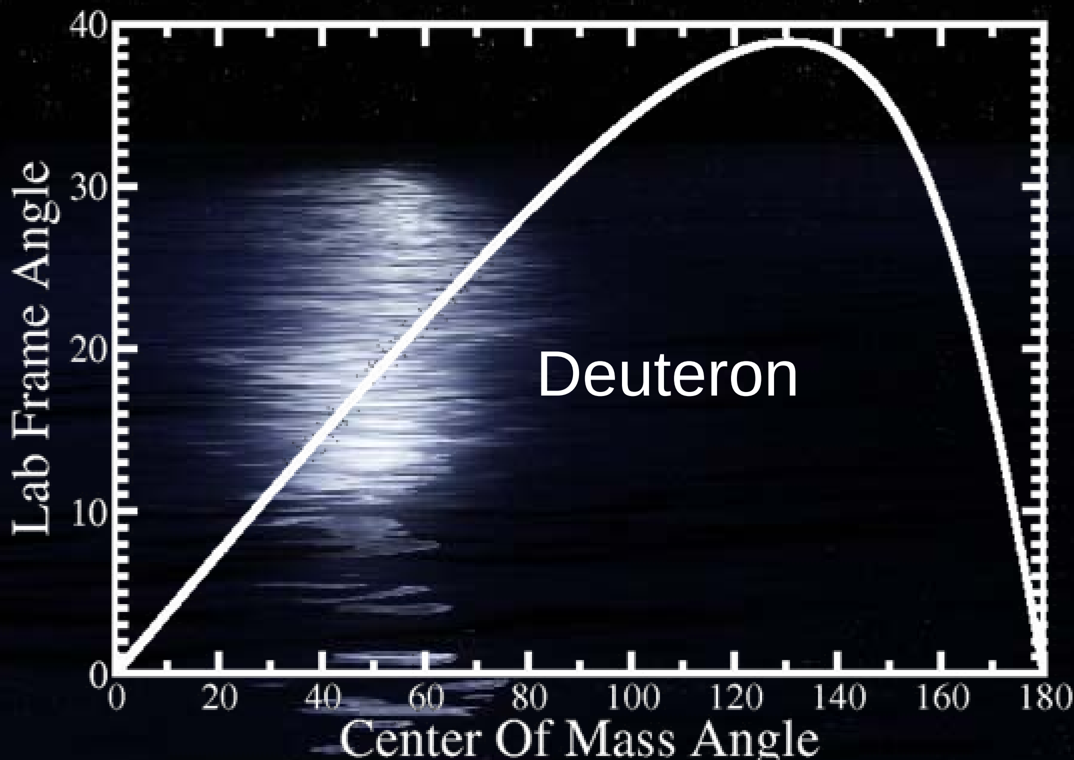
Heavy Fragment Which Has An Unknown Mass

The Proton is in a CH_2 target or a Frozen Hydrogen Target

$$M_{65As}{}^{2} = M_{66As}{}^{2} + M_{p}{}^{2} + M_{d}{}^{2}$$
$$+2\left[E_{66As}M_{p} - E_{d}M_{p} - E_{66As}M_{d} + \sqrt{E_{66As}{}^{2} - M_{66As}{}^{2}}\sqrt{E_{d}{}^{2} - M_{d}{}^{2}}\,Cos(\alpha)\right]$$

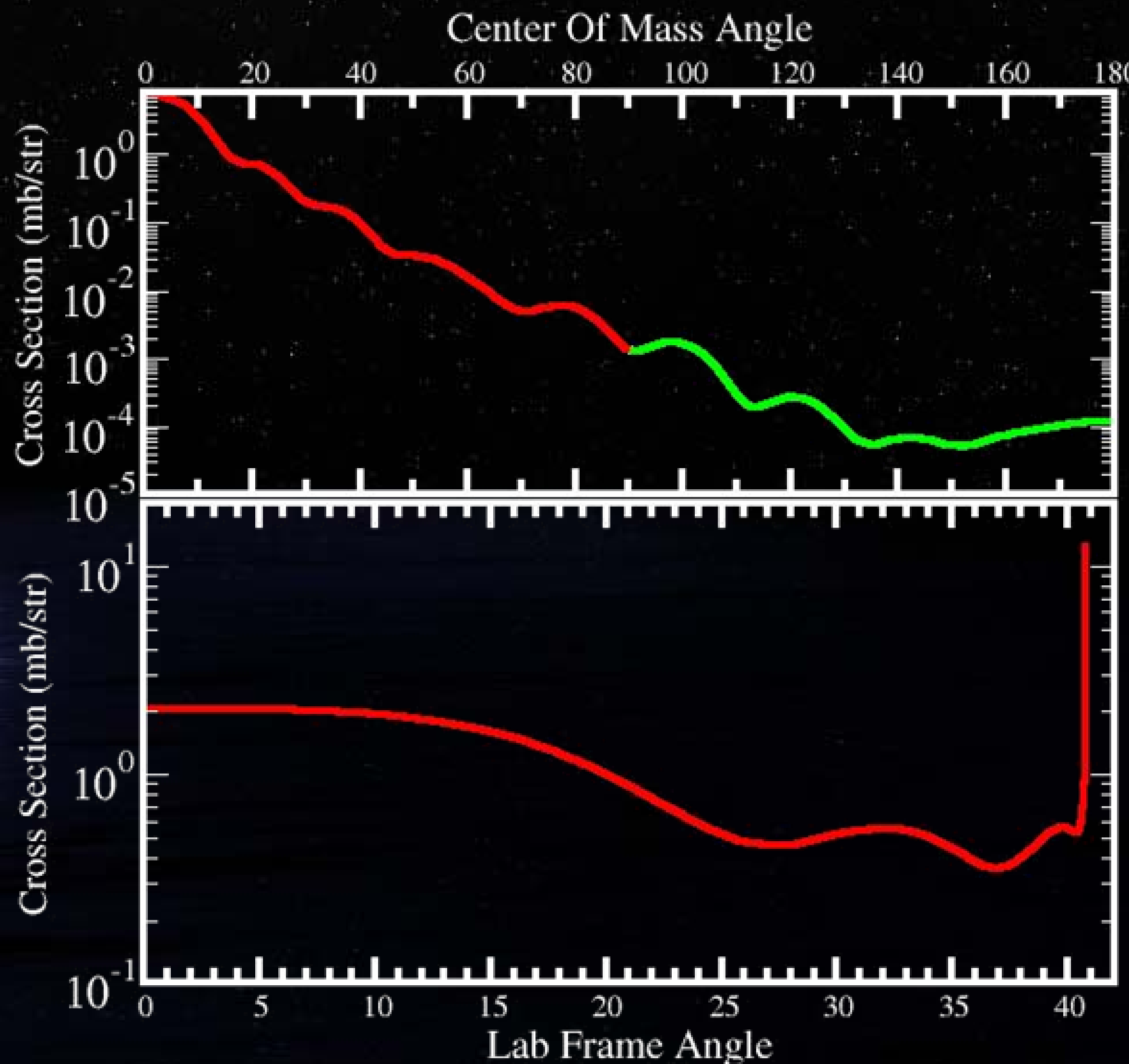
Inverse Kinematics



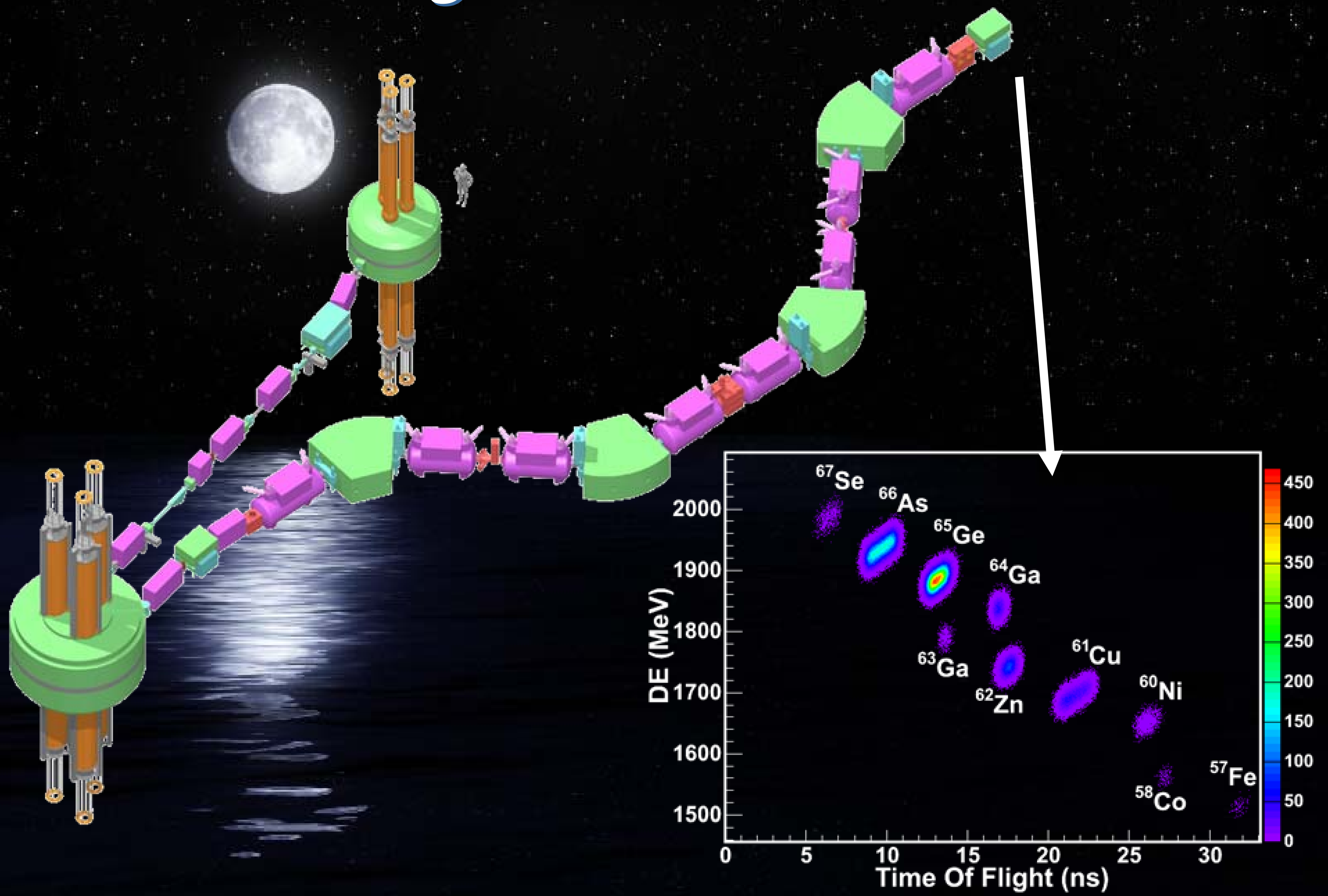


Cross Section in Inverse Kinematics

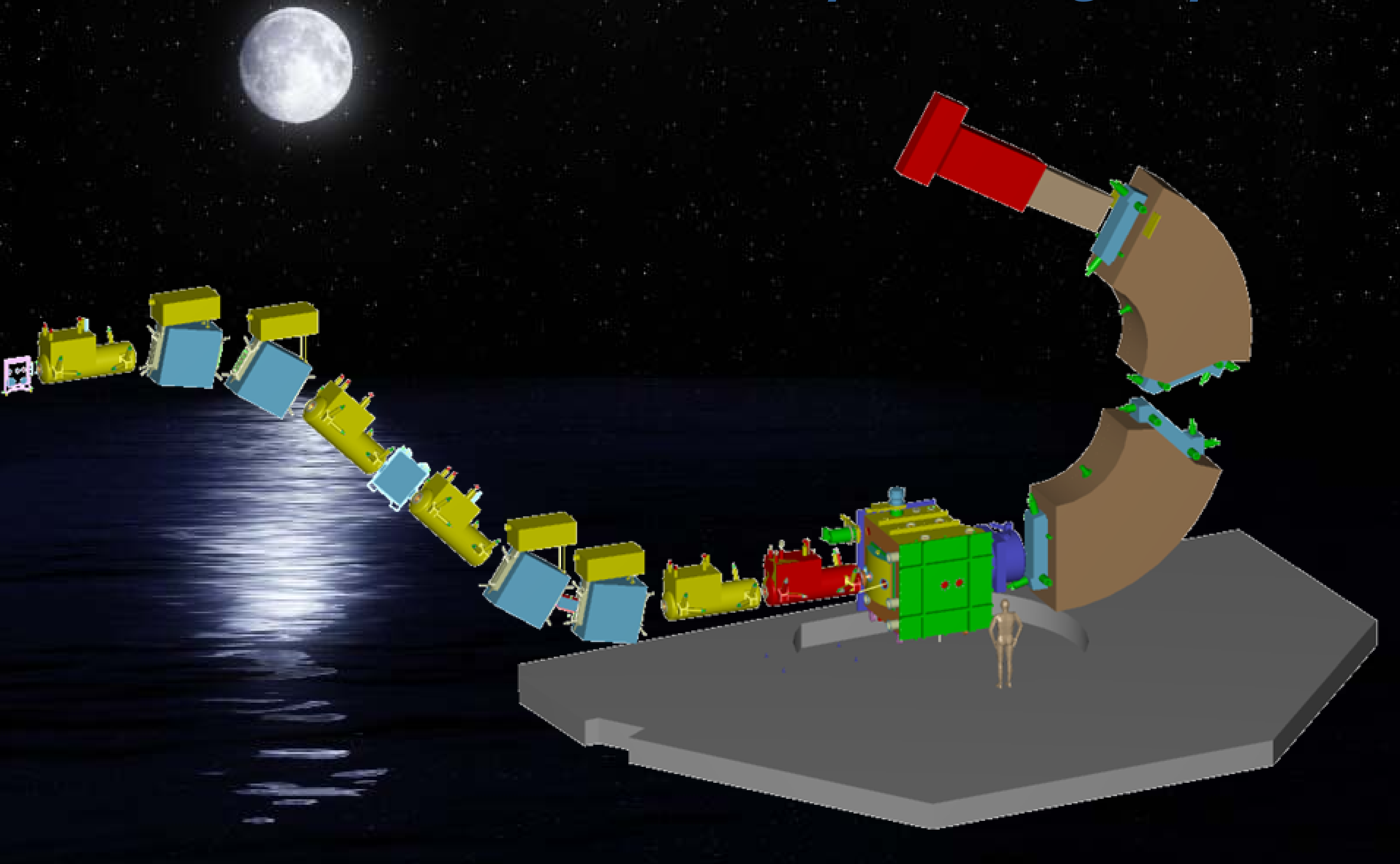
$^{65}Ge(p,d)^{64}Ge$
At 60 MeV/u



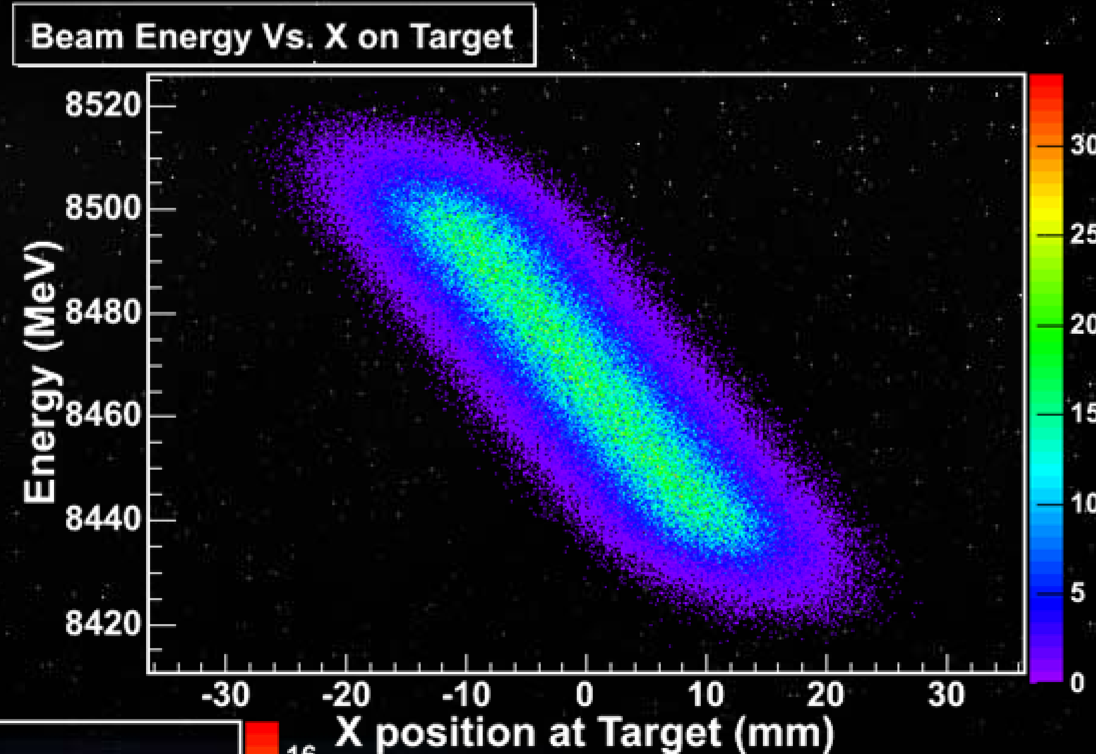
Generating the Radioactive Beam

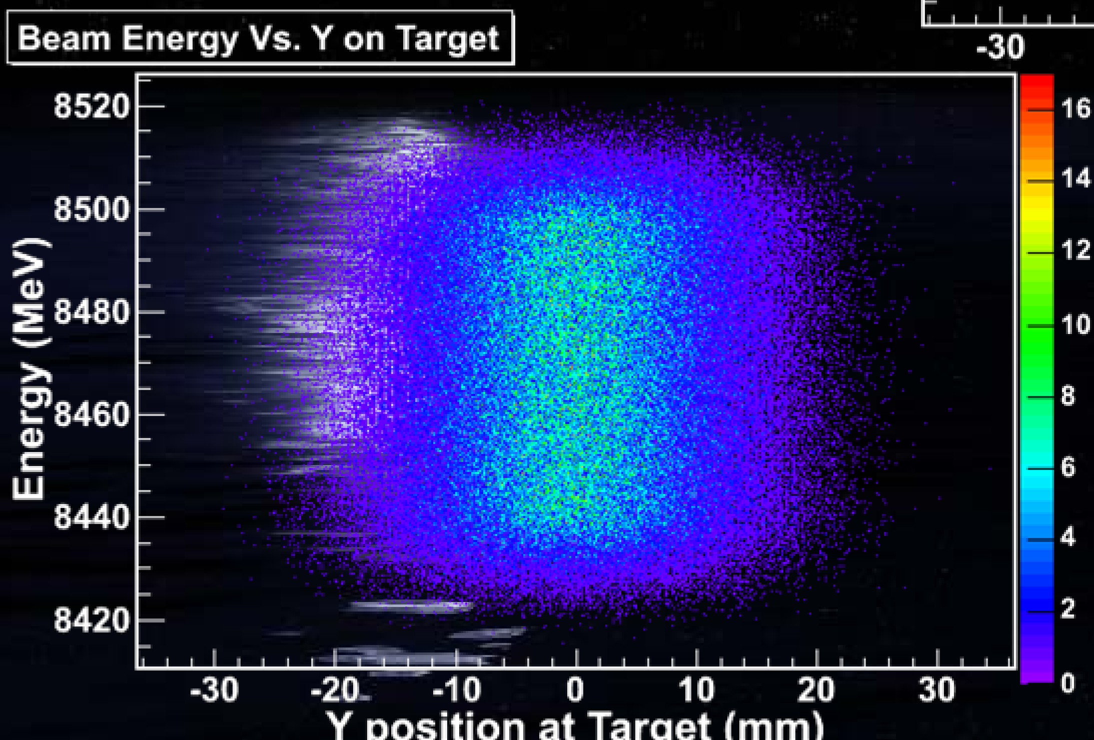


The S800 Spectrograph



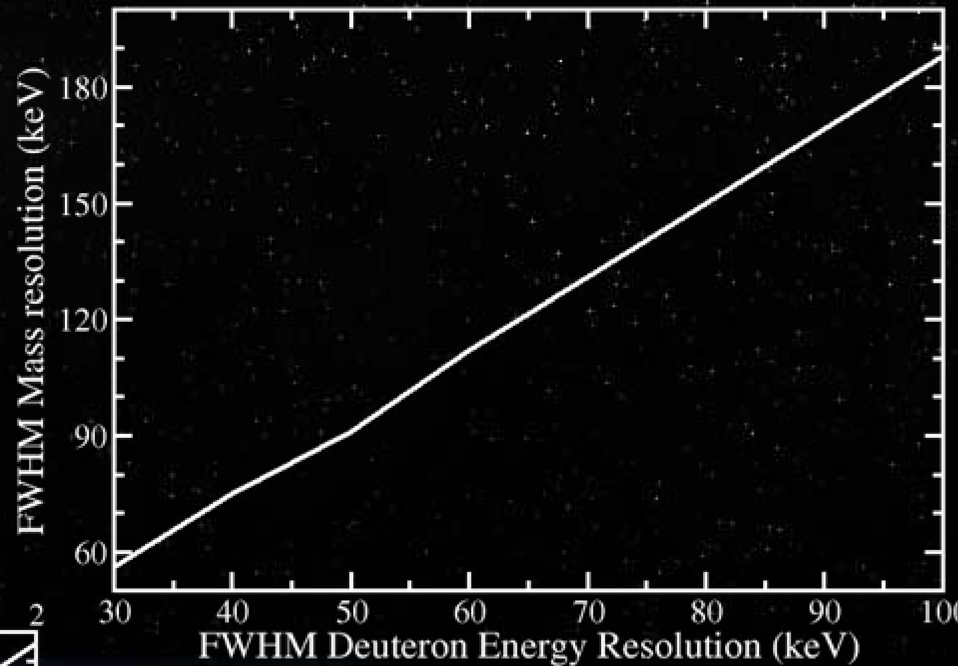
Dispersion Matching

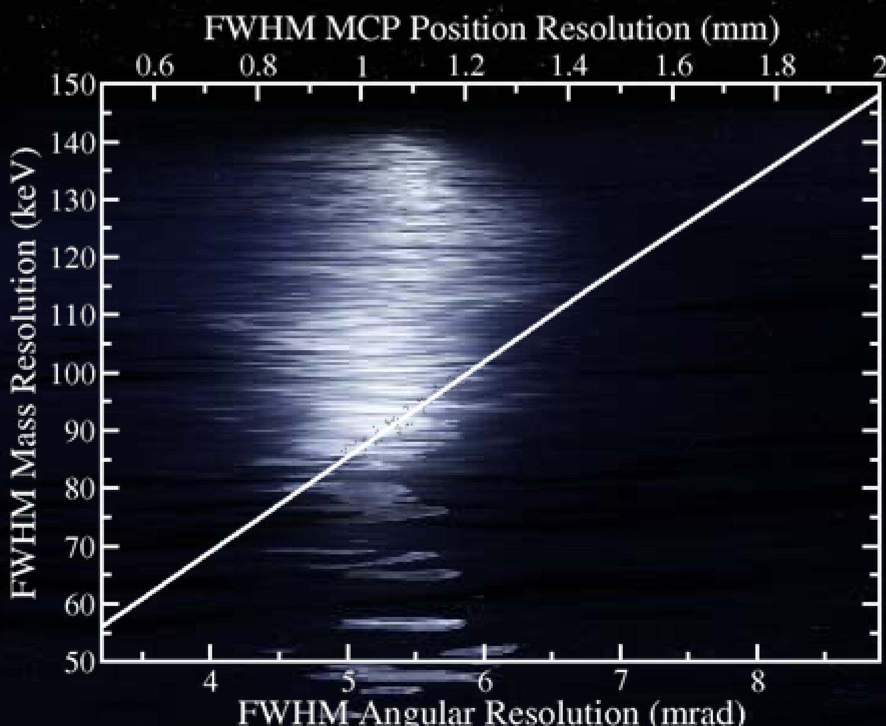




Only 3 keV/mm Effect From Beam Energy using Dispersion Matching in S800

Resolution Effects





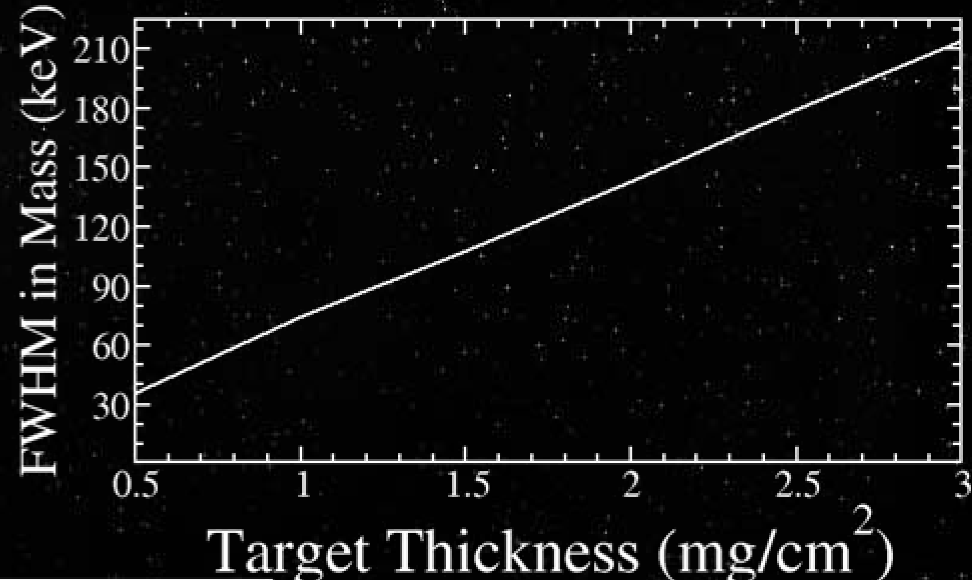
<u>Slope of these lines</u>

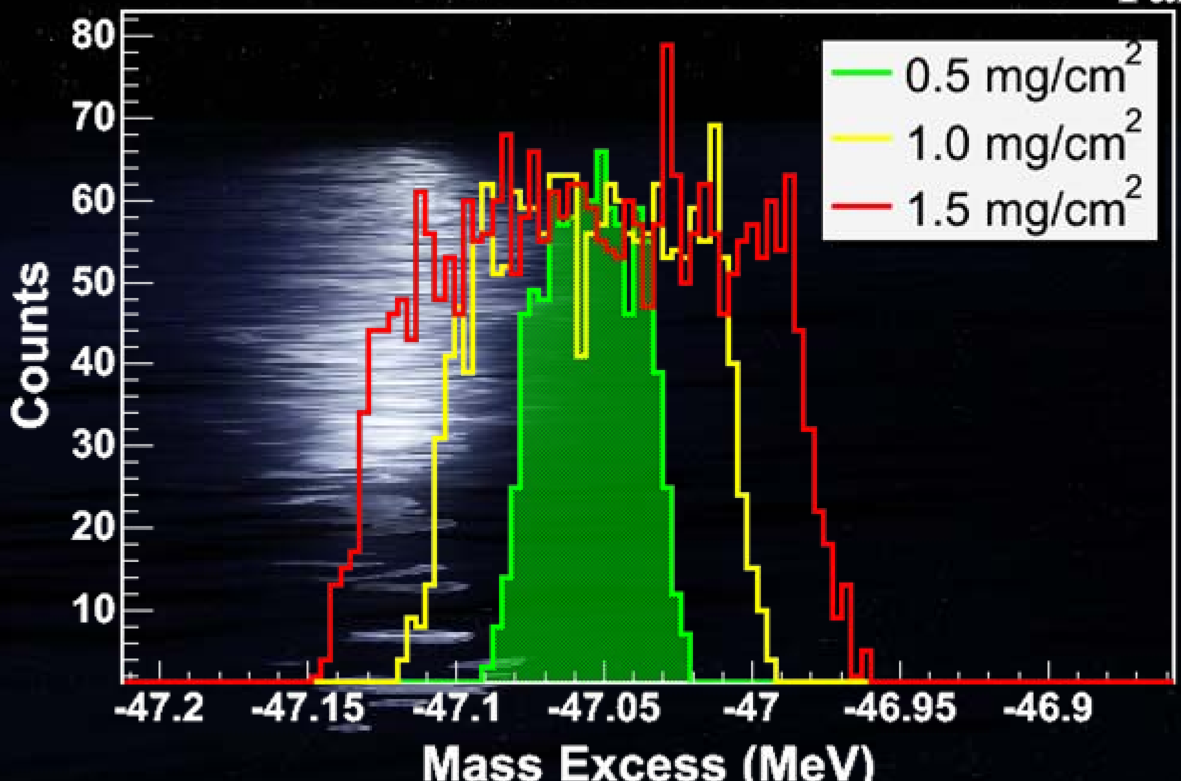
1.8 keV_{mass}/keV_{deu}

61 keV/mm or

16 keV/mrad

Target Effect

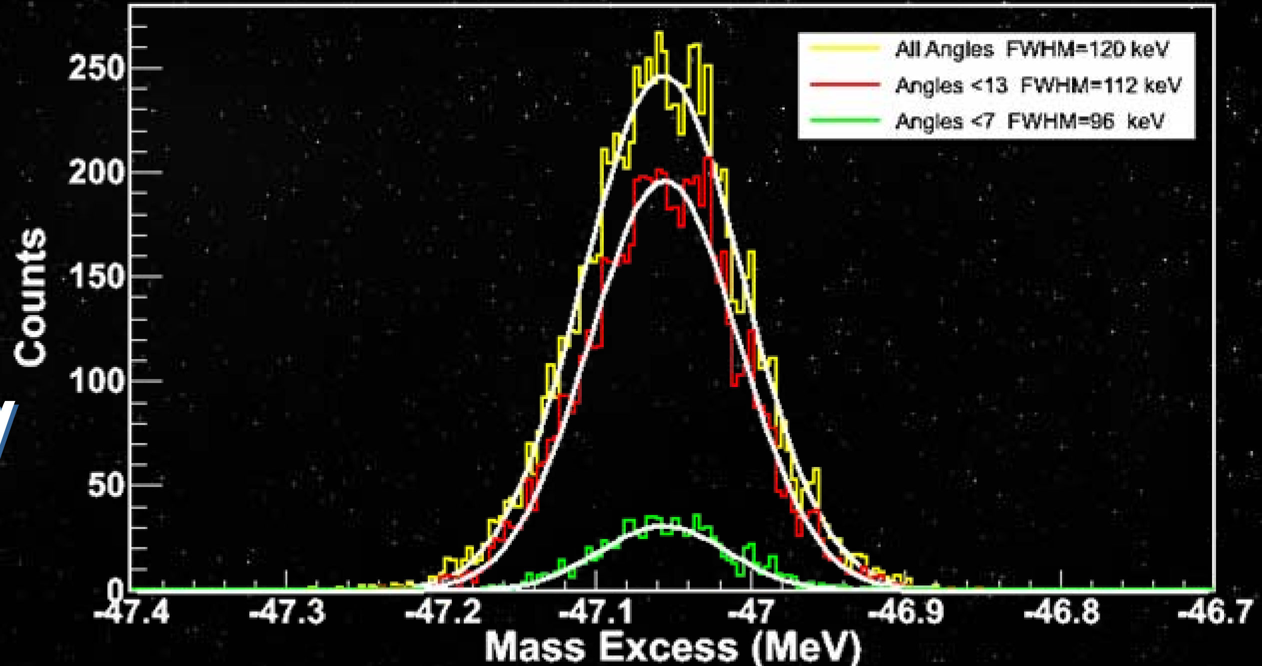


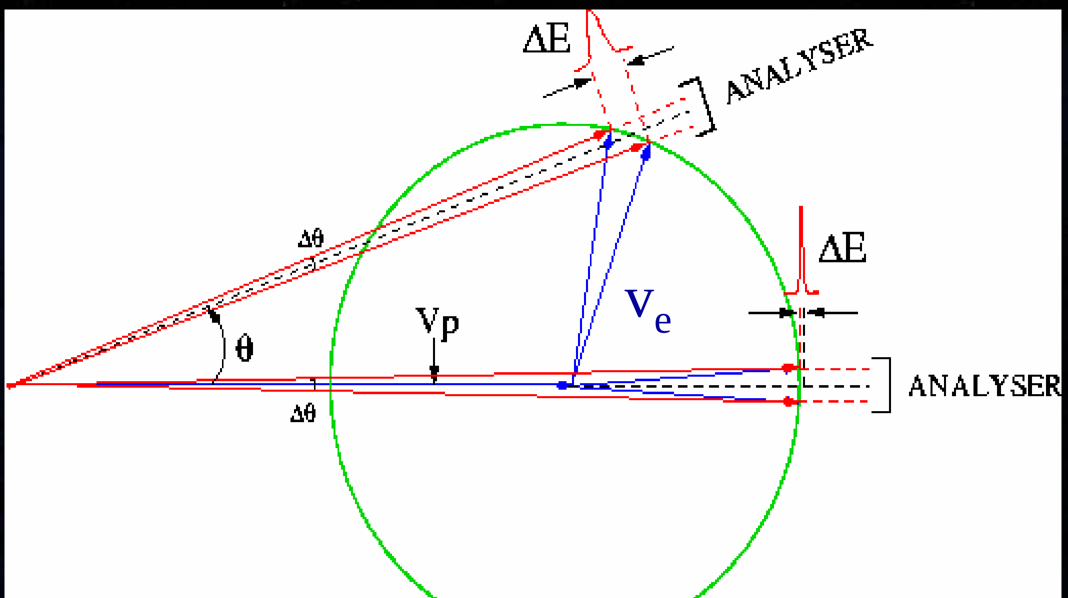


Slope

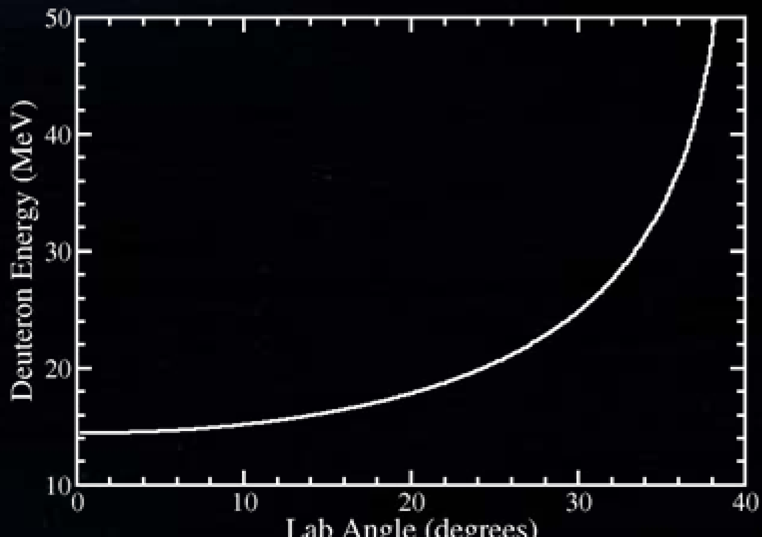
71 keV/mg/cm^2

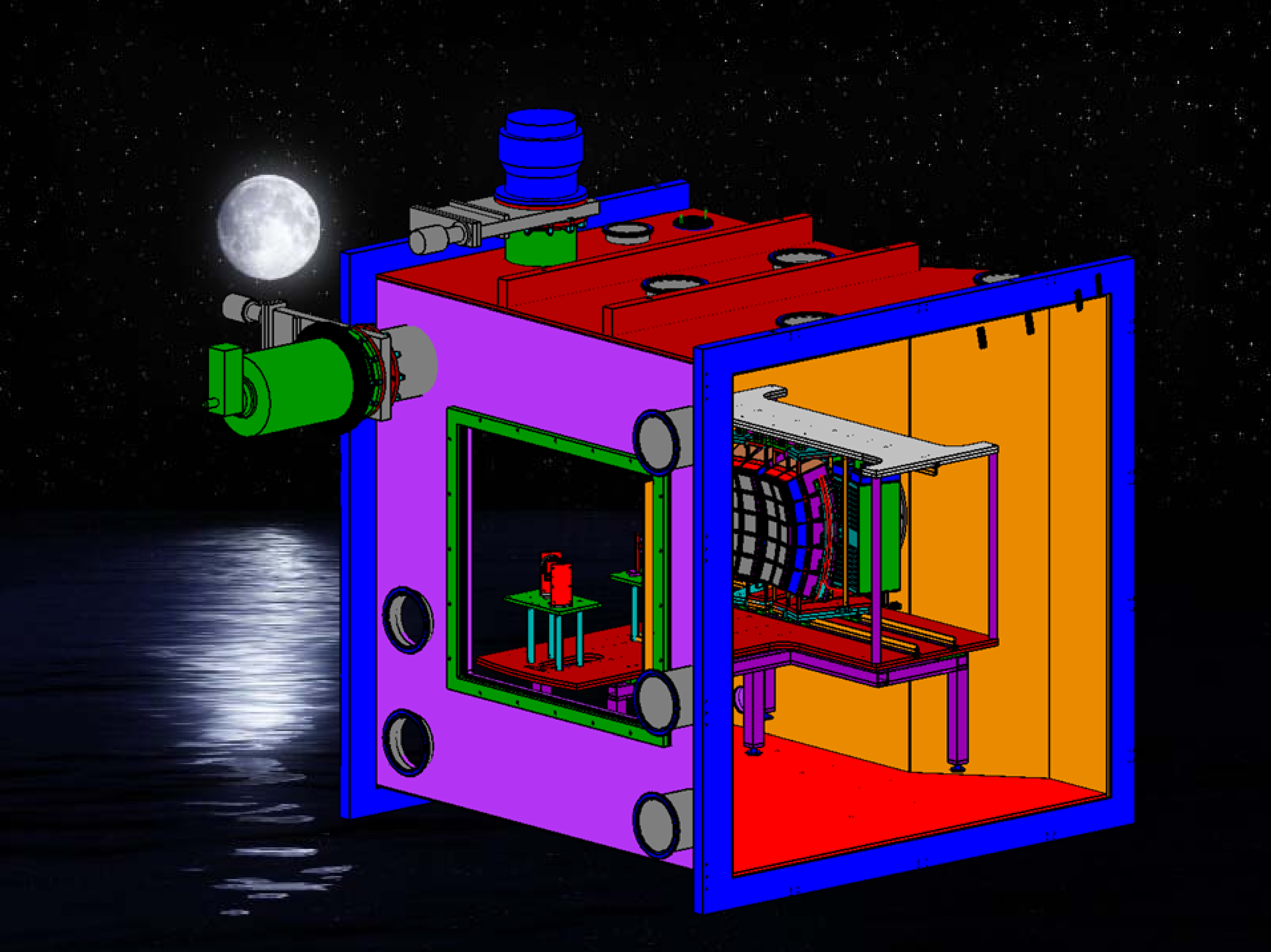
Kinematic Broadening

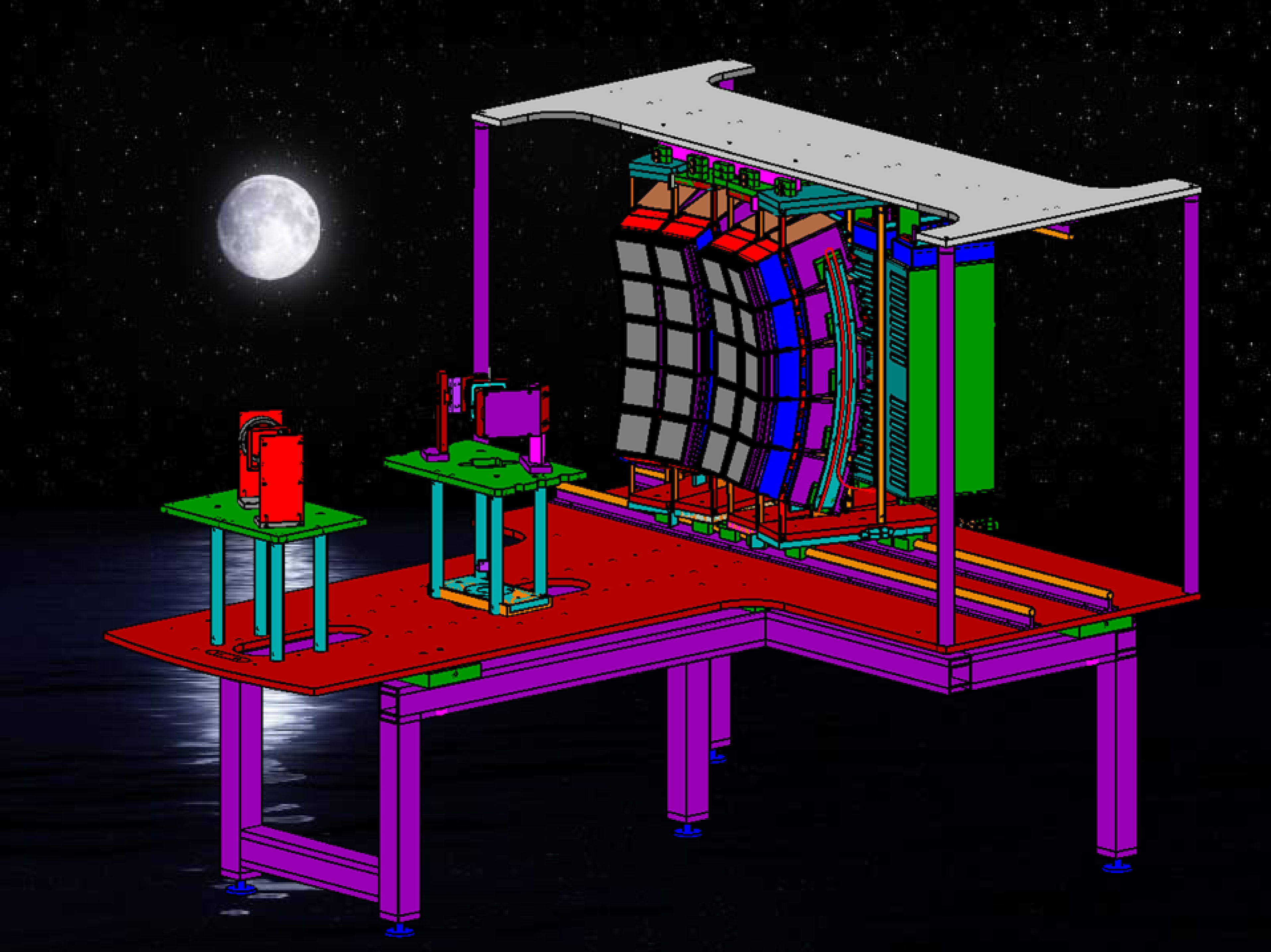




http://www.phys.ksu.edu/~benis/

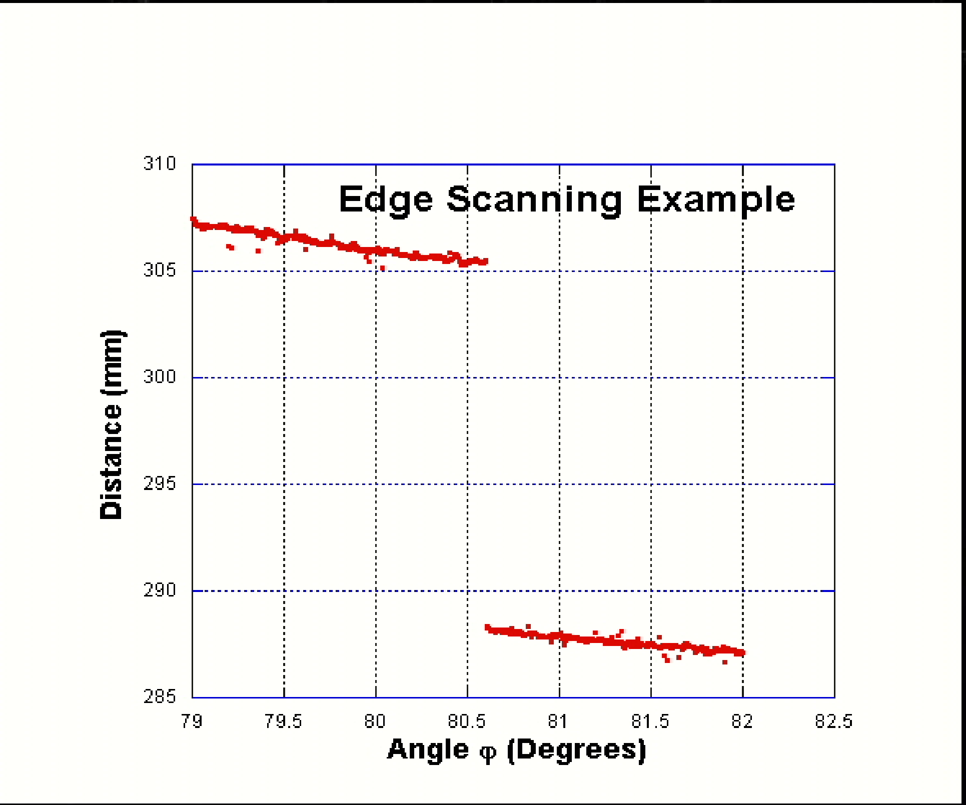






Laser Based Alignment System

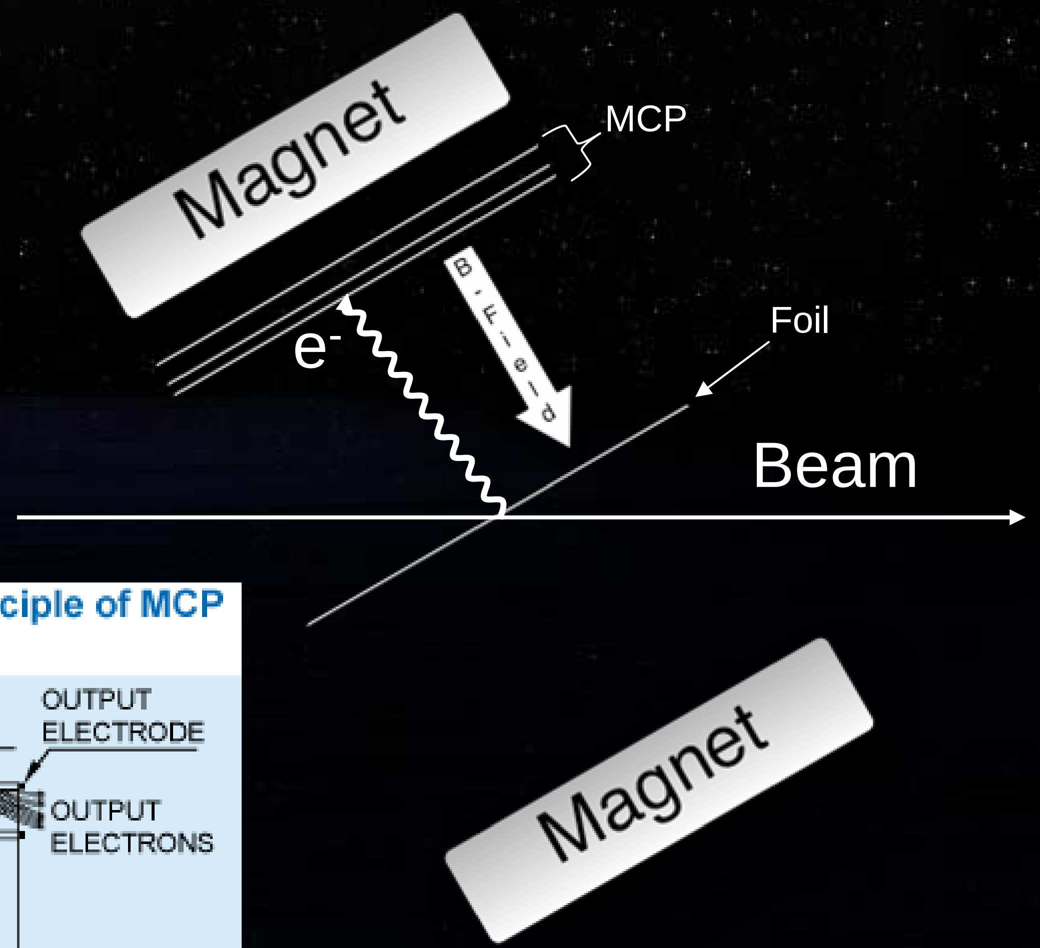
- Designed for precision measurement of detector positions relative to target.
- Adaptable to various configurations and other devices.
- Computer controlled.

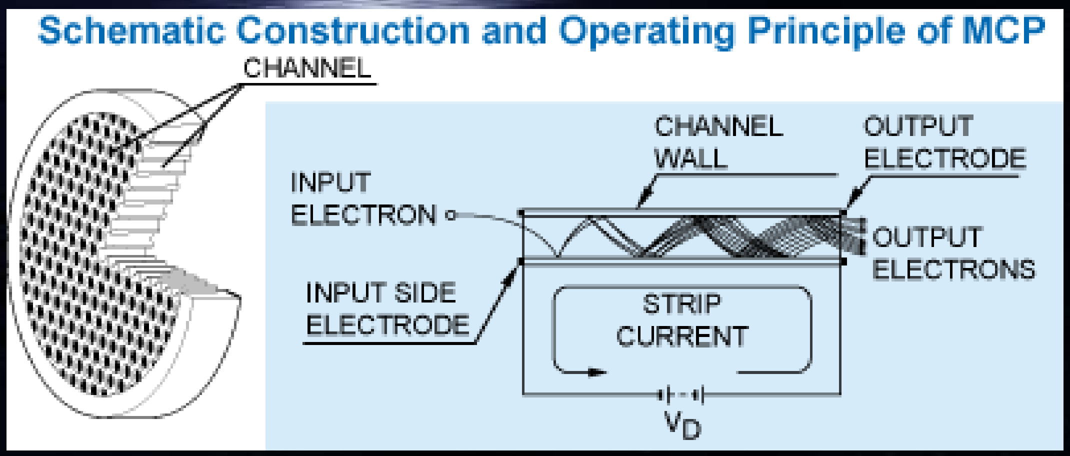


•Resolution:

- ±0.005° for angular stages.
- 100 microns for distance.

Beam Tracking Using Micro Channel Plate Detectors





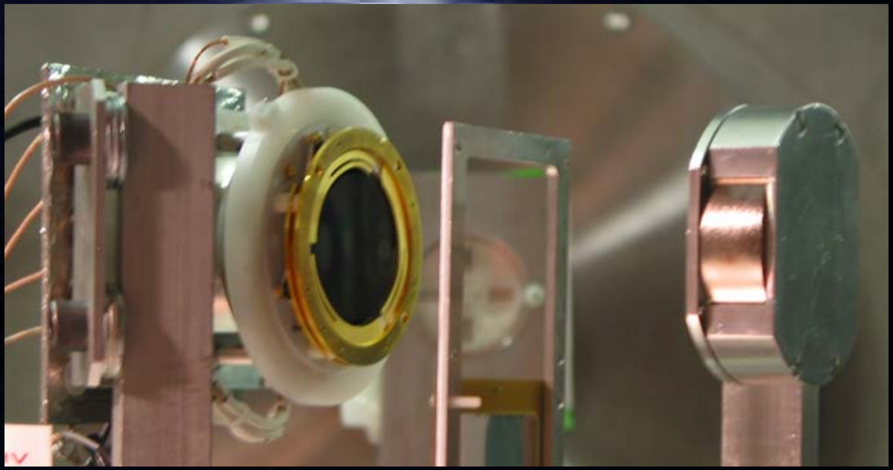
Resolution of MCP Tracking System

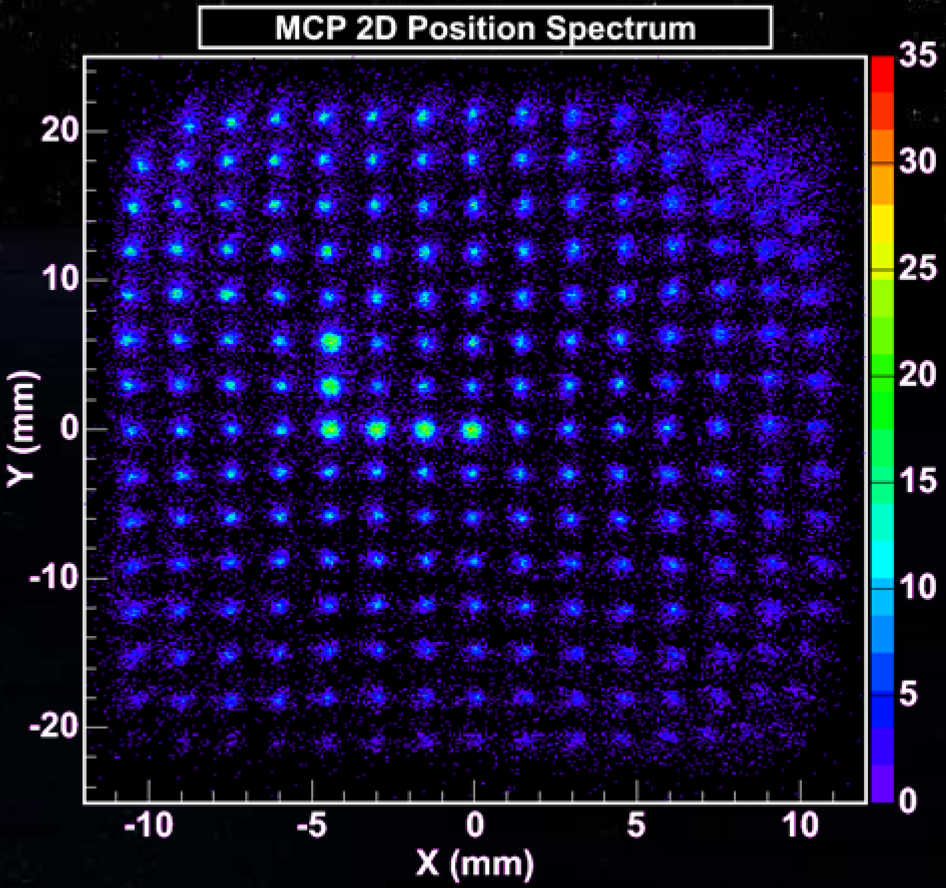
Position: X ~0.35 mm FWHM - Y~0.74 mm FWHM

Time: ~ 600 ps FWHM

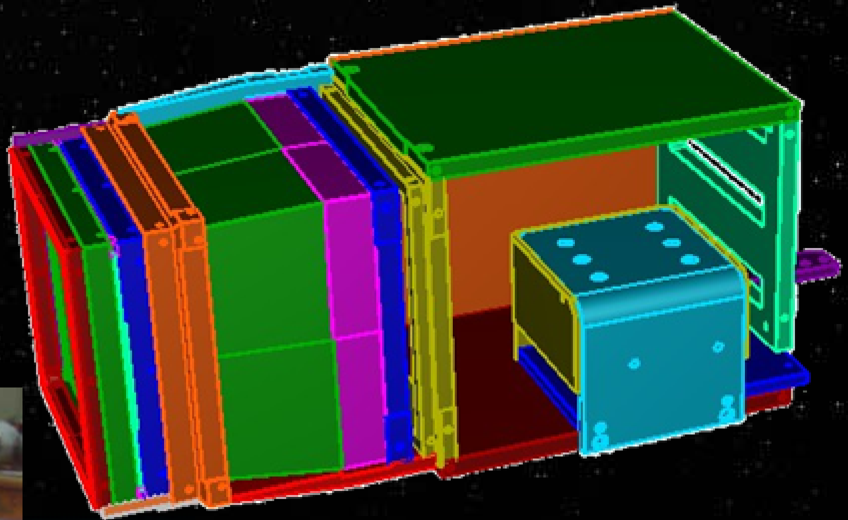
Beam Rates up to 1 MHz

Efficiency ~ 90 % at 1 MHz

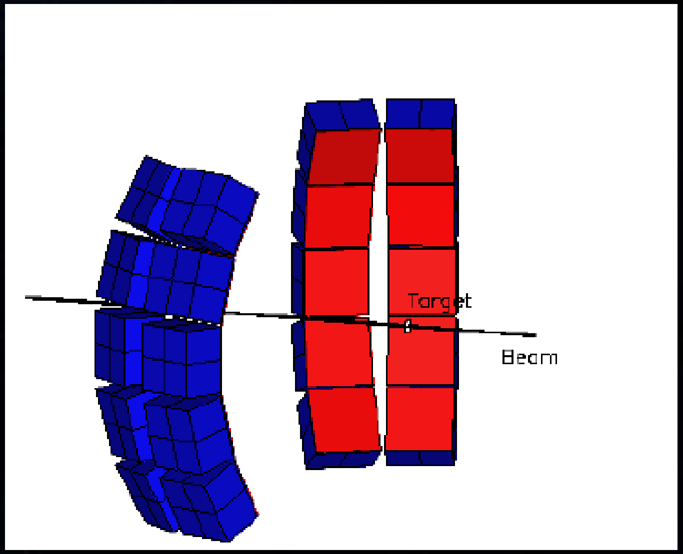




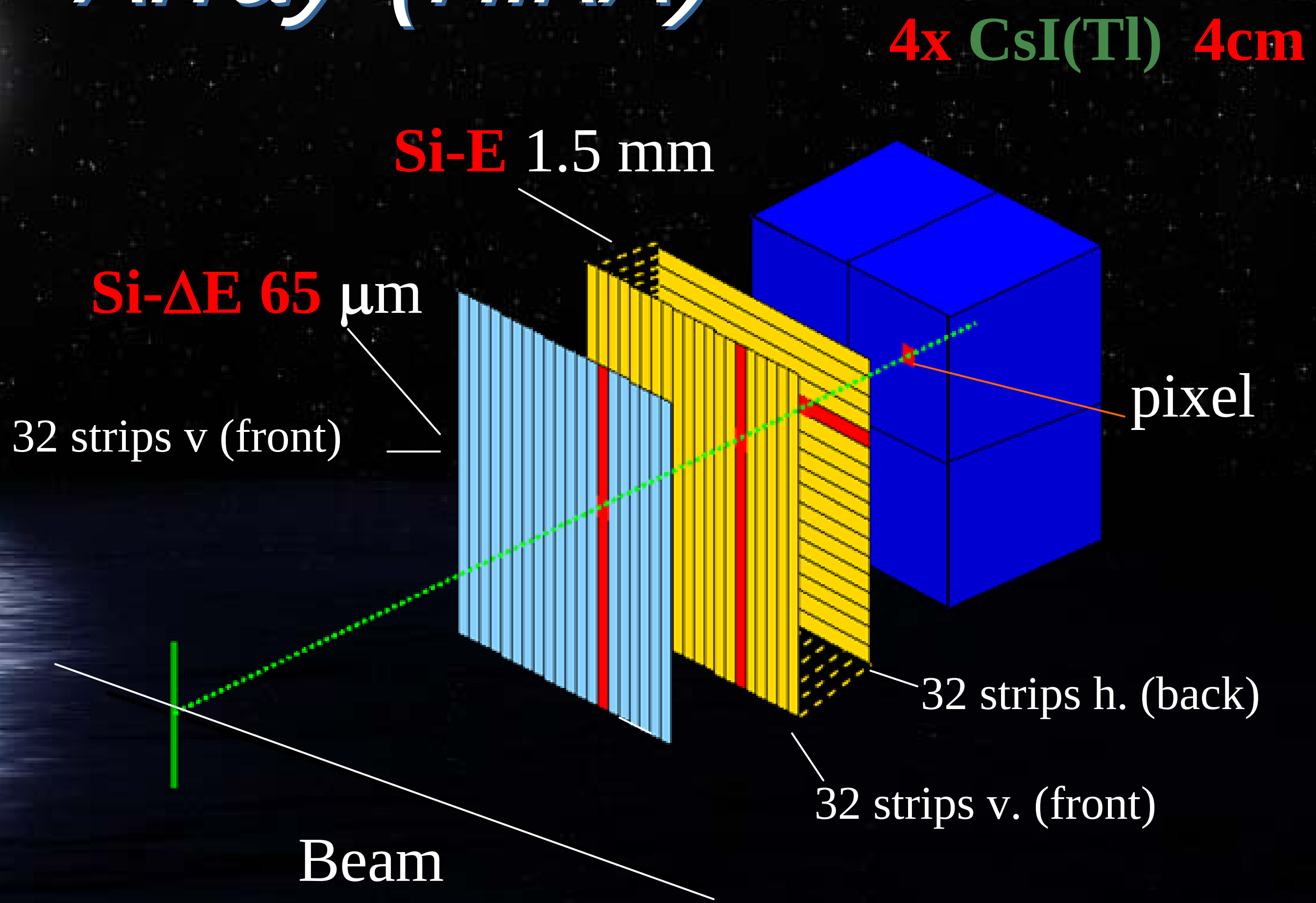
The High Resolution Array (HiRA)



- 20 Independent Telescopes

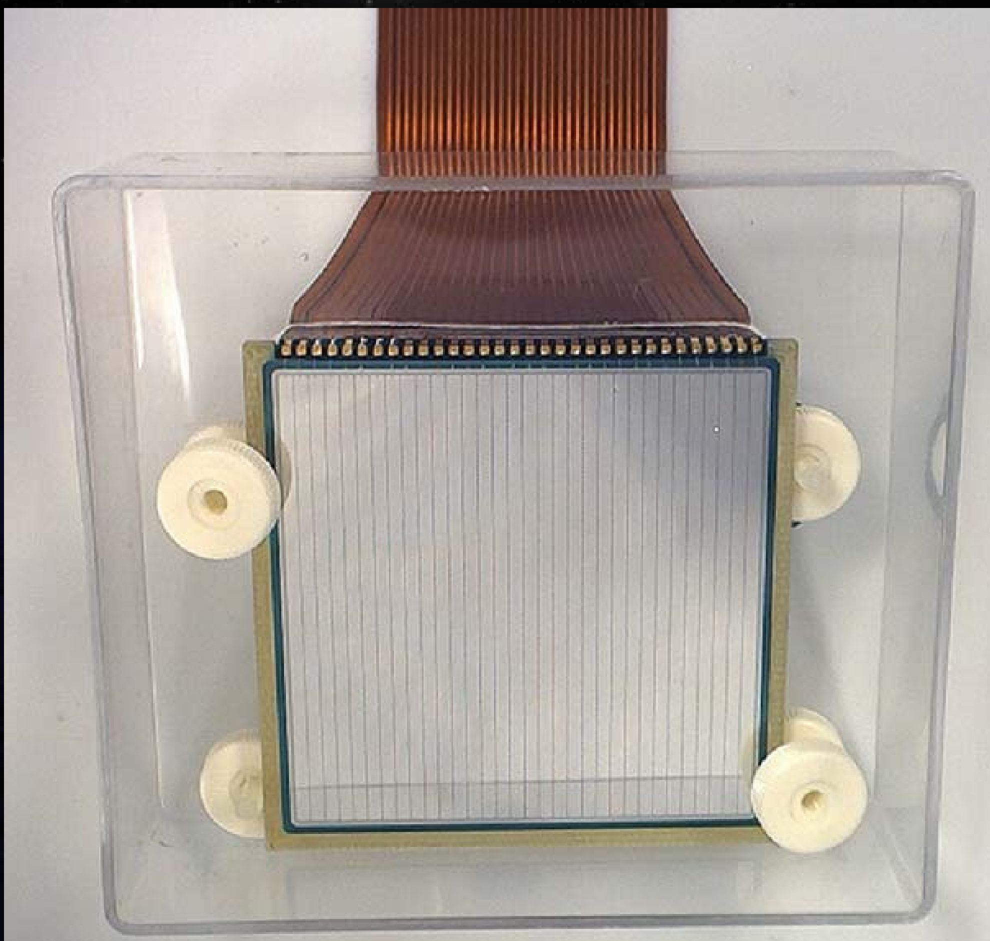


The High Resolution Array (HiRA)



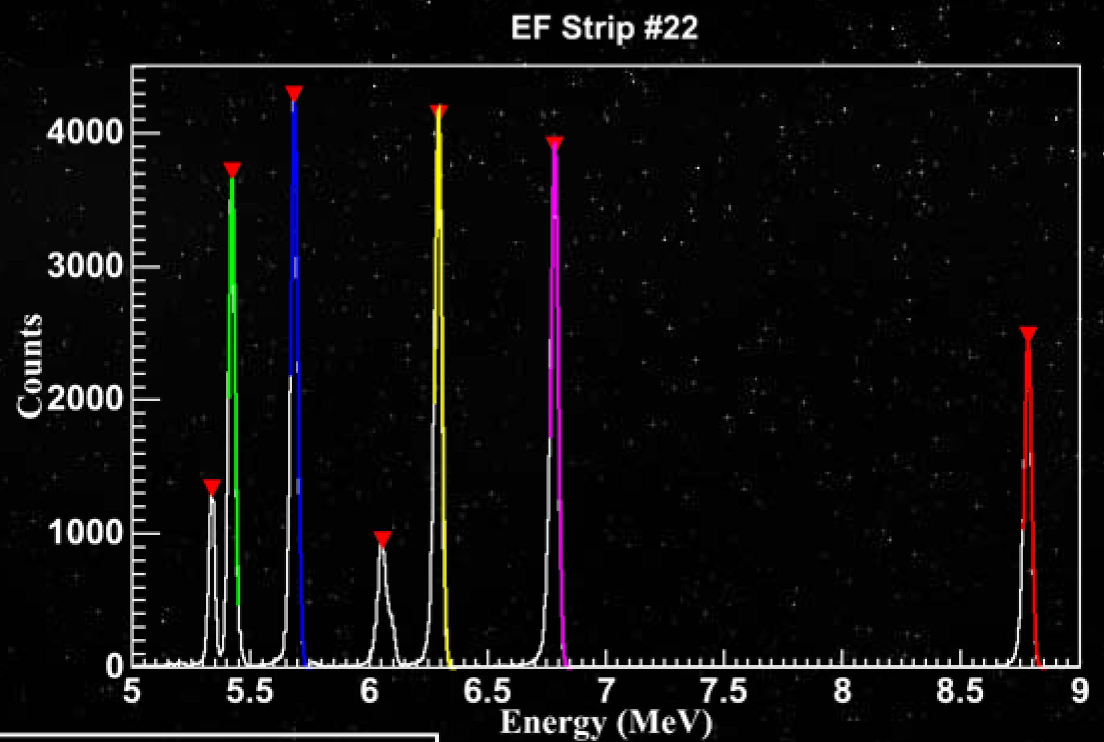
Silicon Detectors

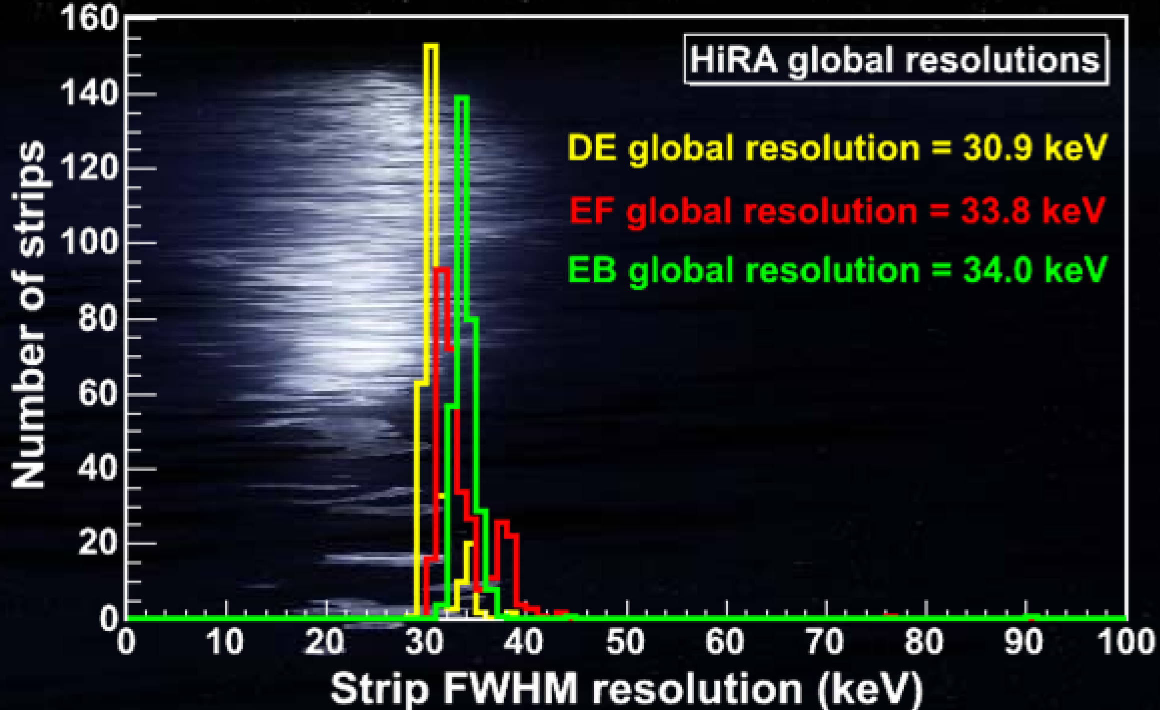
- **62.3 x 62.3 mm^2 Active Area**
- **Pitch 1.95 mm**
- **1024 Pixels per telescope**



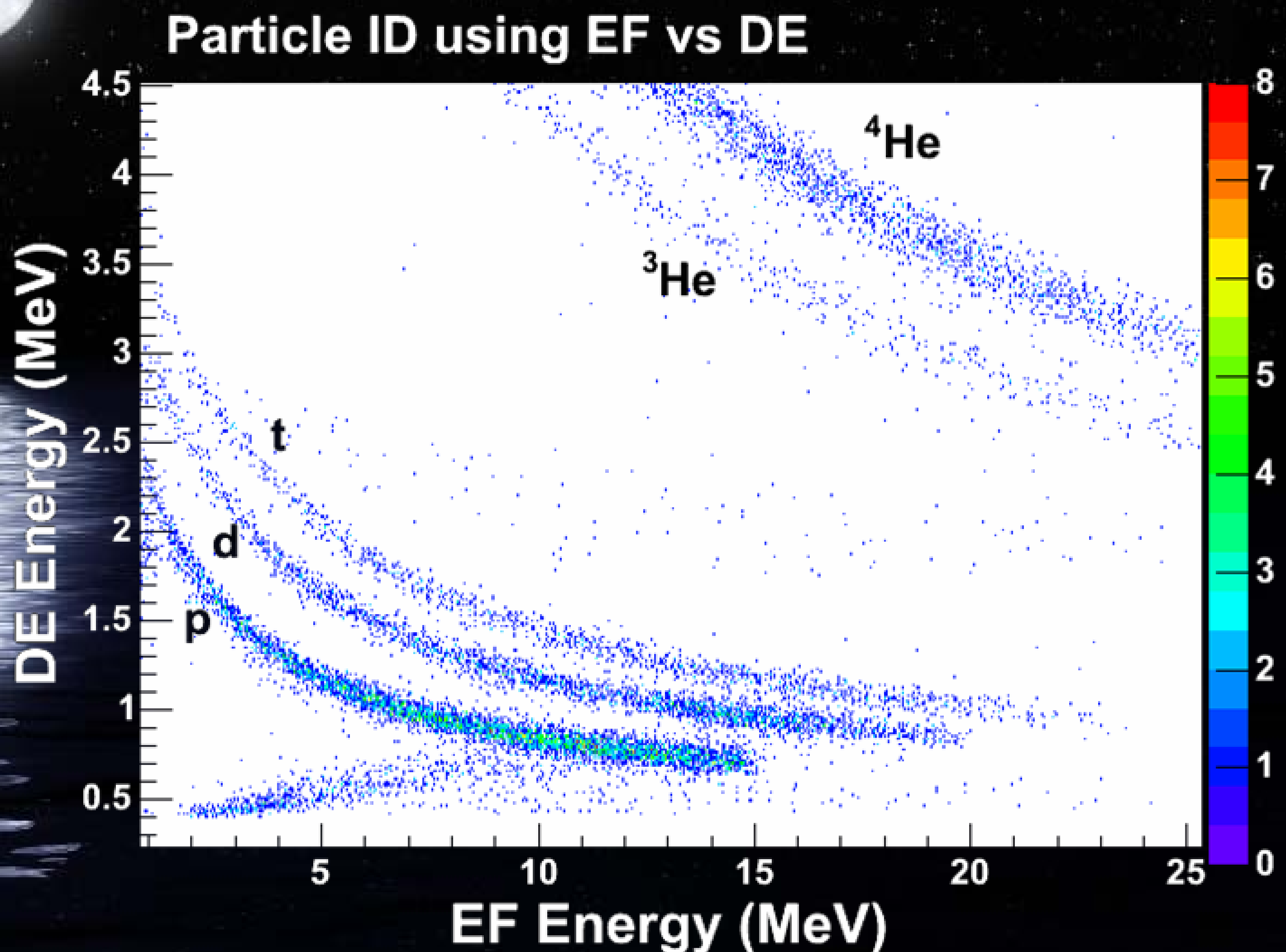
- Bulk material is n type
- Interstrip on junction side is 25 μm
- Interstrip on ohmic side is 40 μm
  - P+ implant for better interstrip isolation
- Depletion voltage for 1.5 mm detector < 500 V
- 10 guard ring structure on periphery (2mm dead area region)

Silicon Energy Resolution





Particle Identification



Electronic Readout

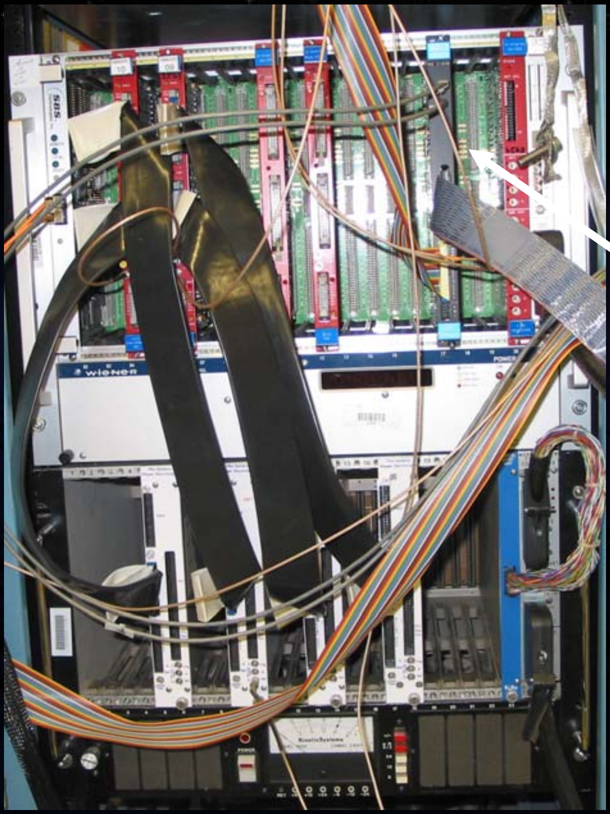
developed at Washington University (St. Louis)

With 2000 channels to readout, cost of "traditional" readout is prohibitive.

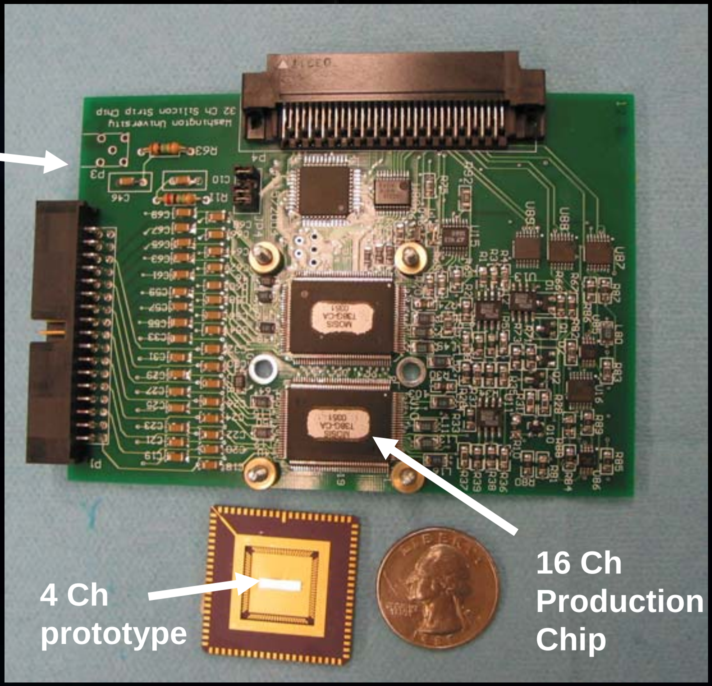
Application **S**pecific **I**ntegrated **C**ircuit

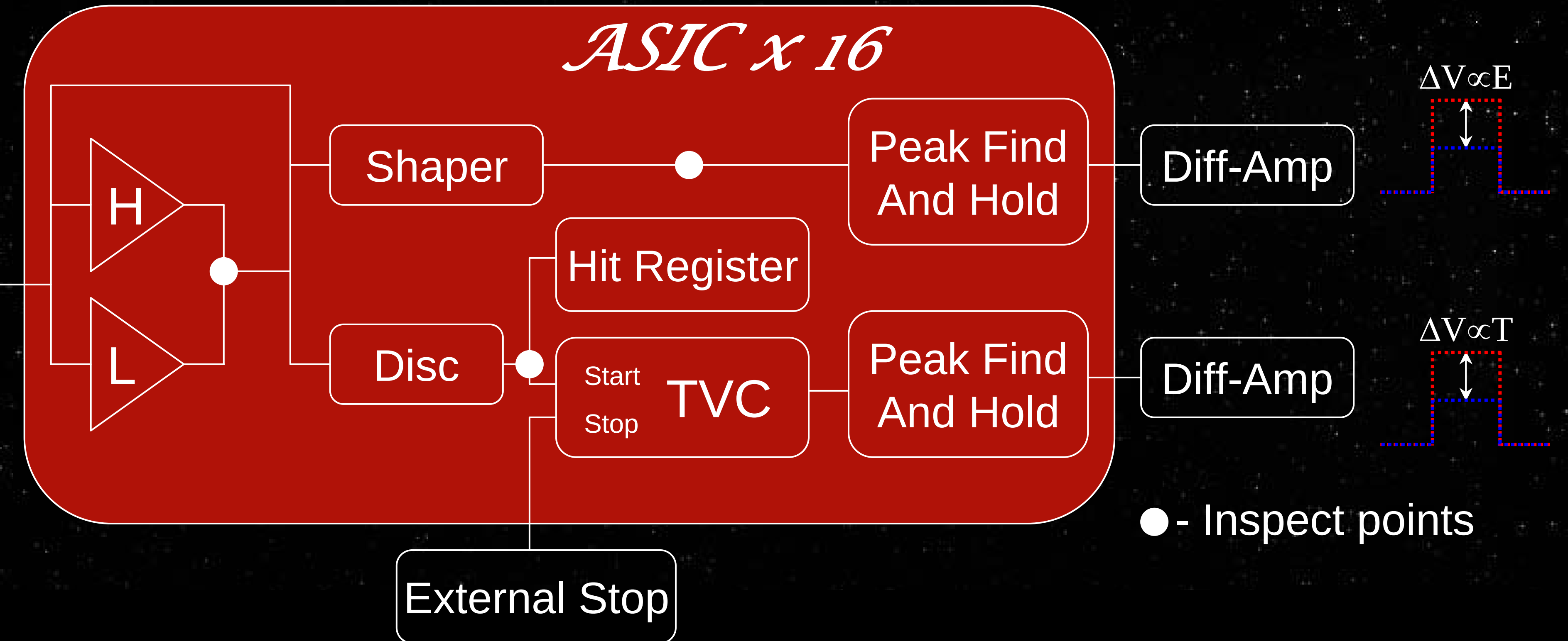
Design Includes:

- **Multiple Preamps**
- **Shapers**
- **Discriminator**
- **Time to amplitude converters**



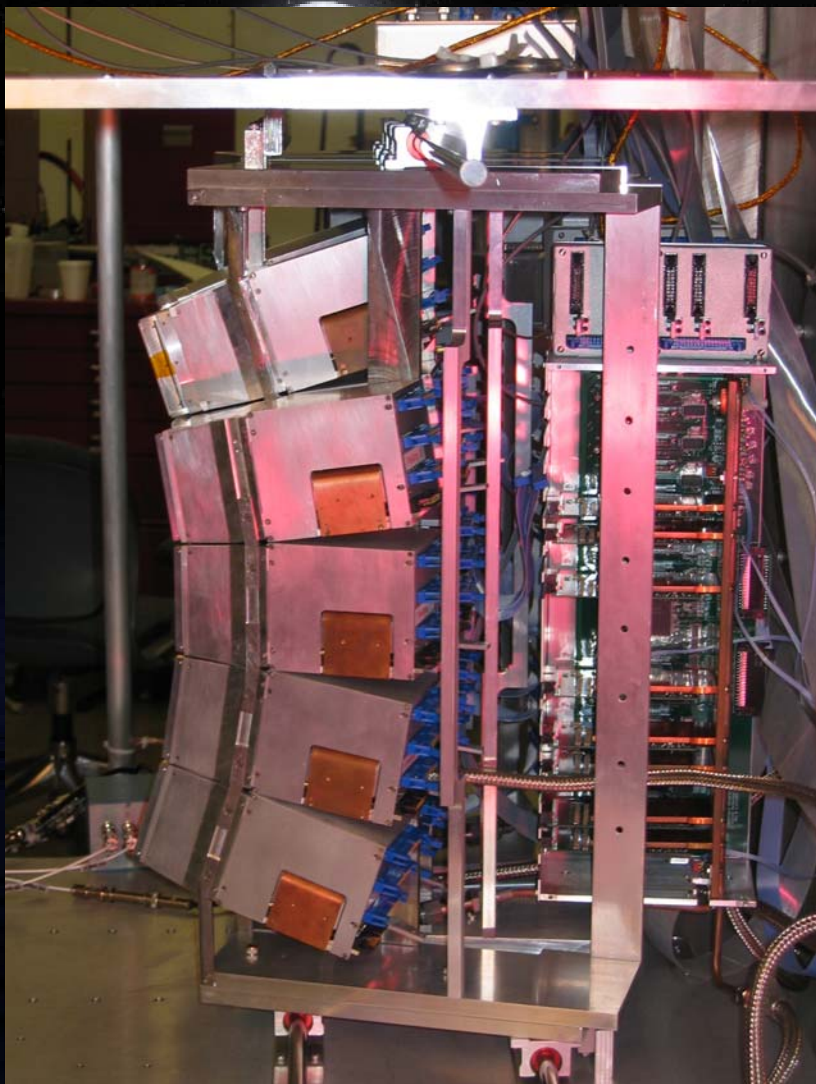
This chip board + one VME module replaces 32 pre-amp's, 32 Shapers, 32 TDCs and 32 ADCs

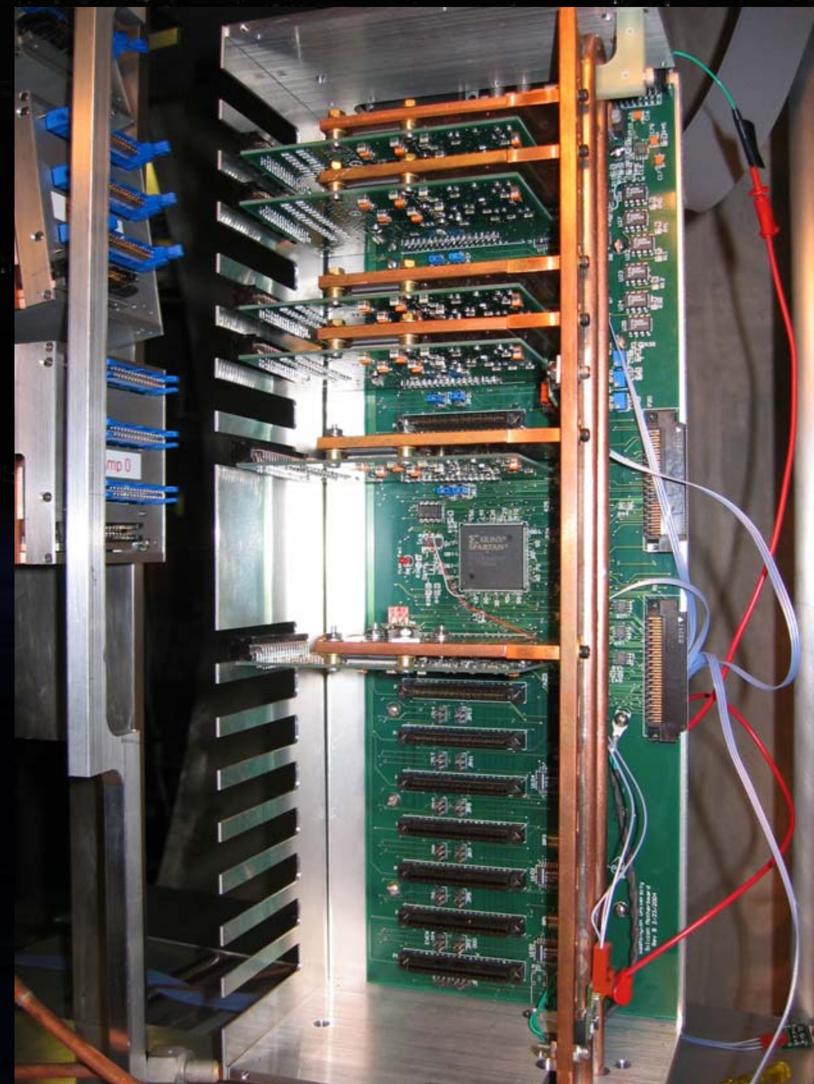




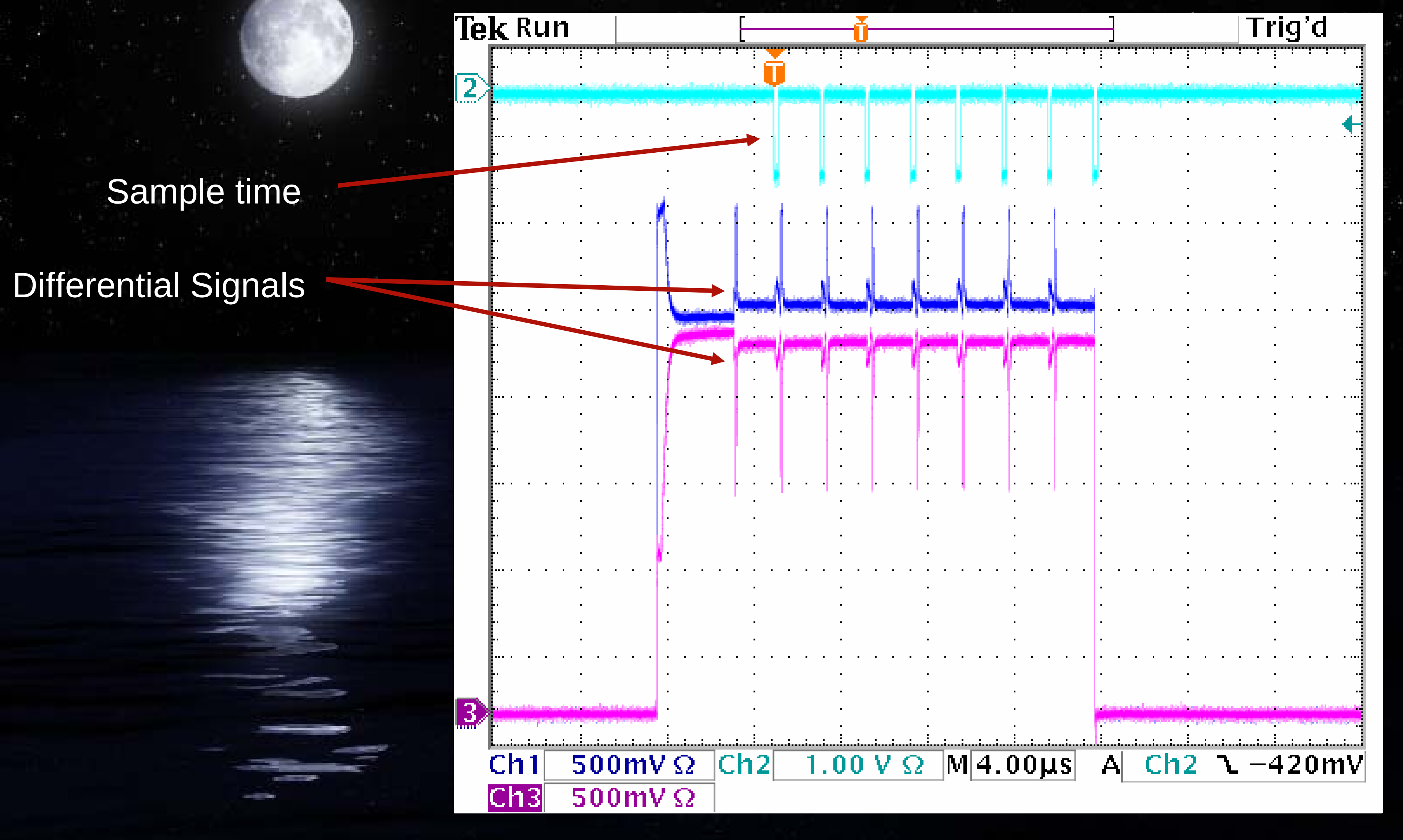
- ✓2 different gain internal Charge Sensitive Amplifiers (CSA)
    - ✓100 MeV & 500 MeV dynamic range
- ✓Bypass internal CSA for use with higher gain external CSA
- ✓Pseudo CFD - Leading edge trigger zero cross discriminator
    - ✓Computer controlled threshold for each strip
    - ✓Positive and negative signals
    - ✓On off for each channel
- ✓TVC 150 ns & 1 μs
- ✓Unity gain Shaper with 1 μs shaping time for both positive and negative signals
- ✓3 computer controlled Inspection points, shown with red dot
- ✓Multiplexed output of E & T signals through differential Amp into LVDS flash ADC.
- ✓Sparse readout based on hit register, or forced readout of all channels
- ✓pulser inputs, even or odd channels

HiRA Electronics Setup Behind Detectors in Vacuum Chamber

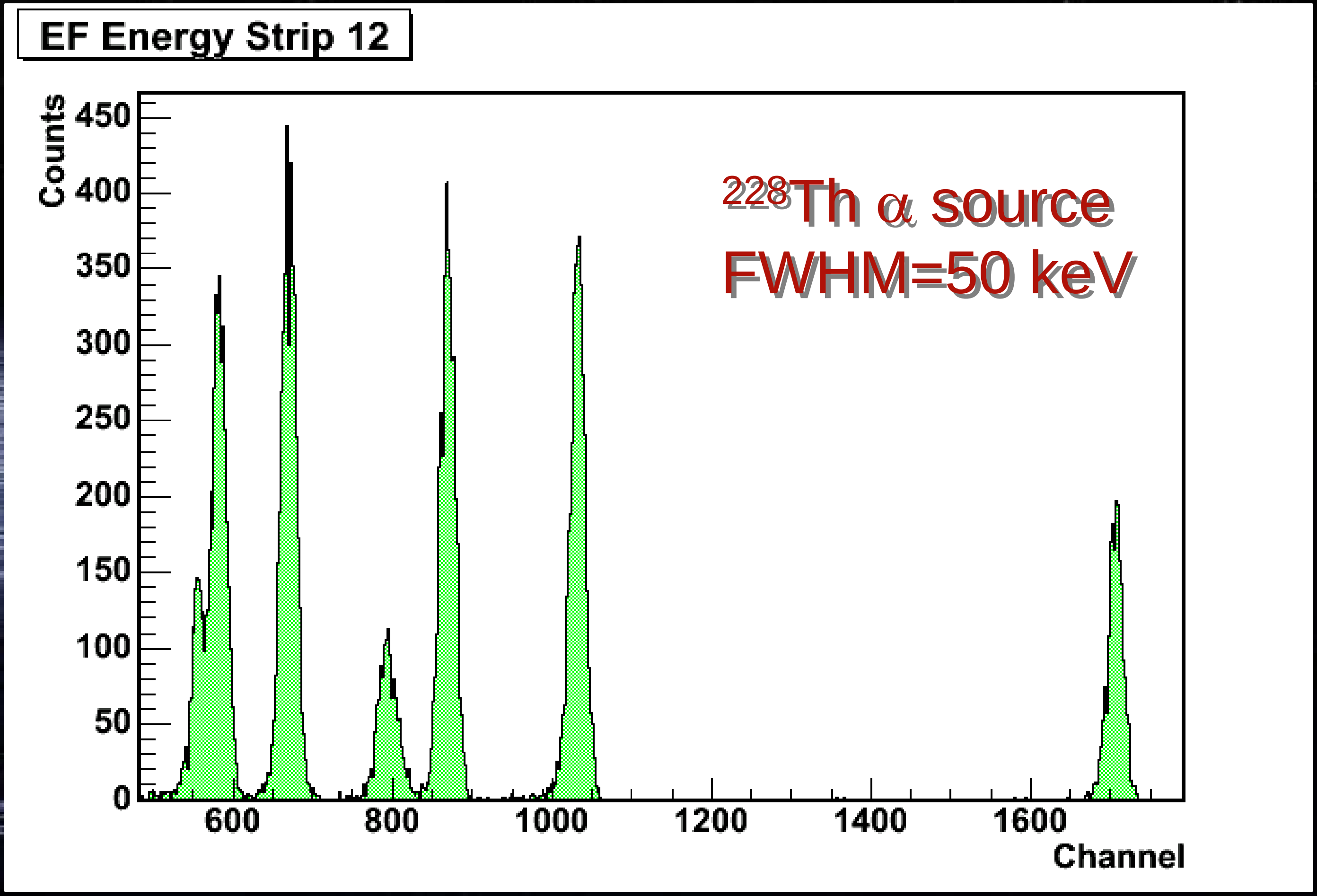




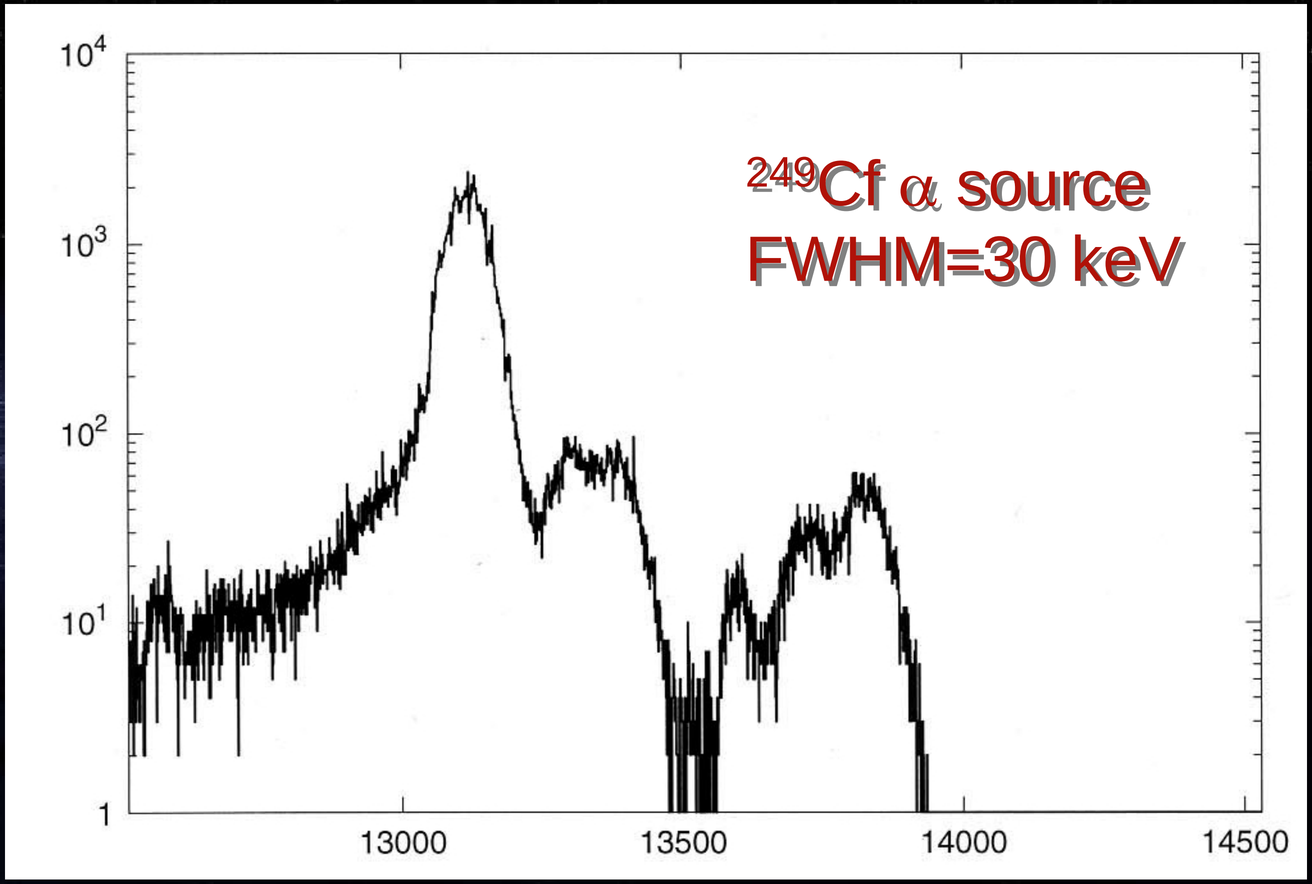
Signal Traces from Differential Amplifier to ADC



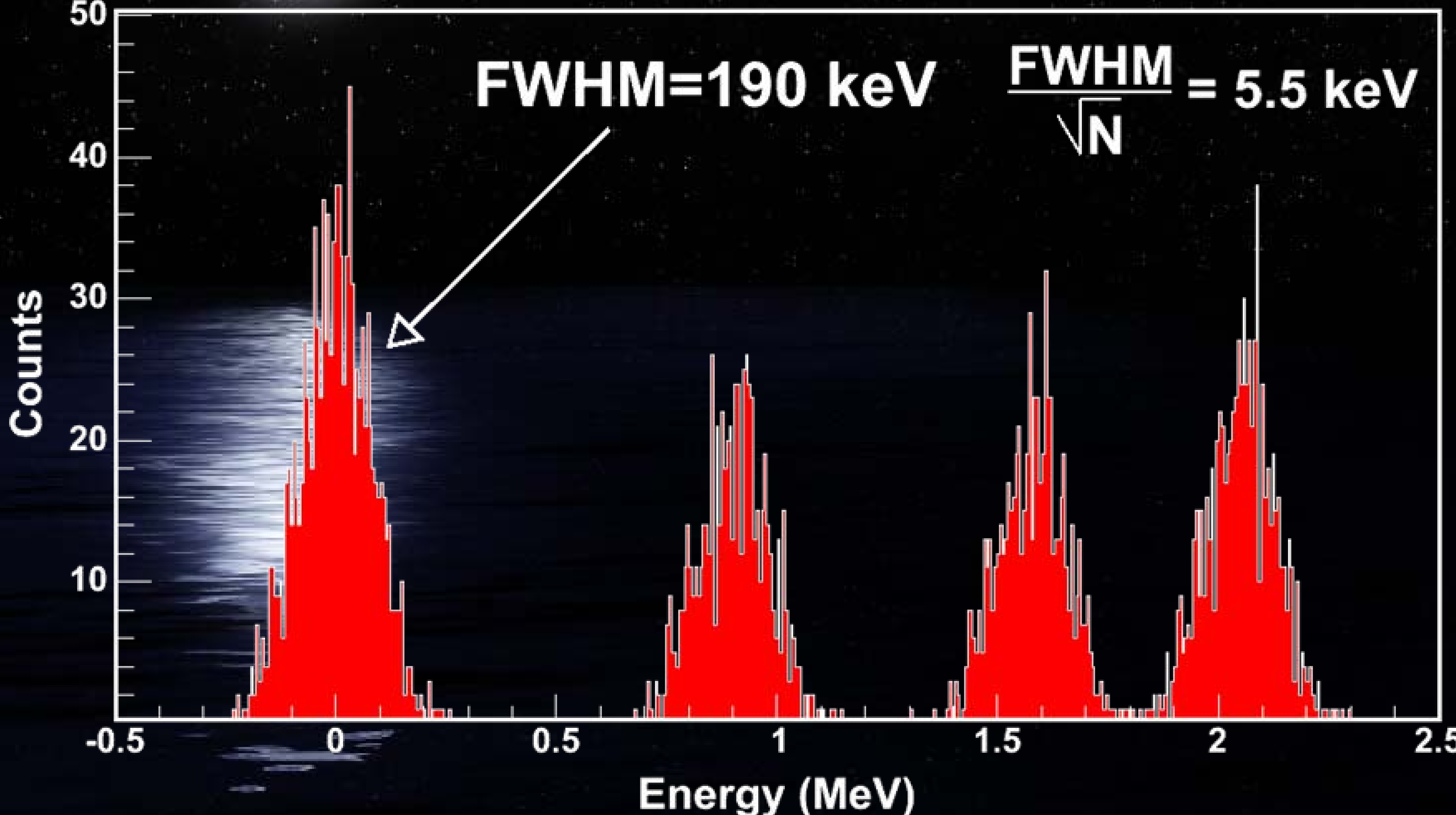
Chip High Gain Pre-Amplifier



External 60 mV/MeV Pre-Amplifier + ASIC Chip



Simulated ^{64}Ge mass spectrum from $^{65}Ge(p,d)^{64}Ge$



Status and Outlook

- Final Test of Entire system July 10th
- Initial Test of (p,d) experiment July 18th
- Measurement of ^{65}As and ^{64}Ge August
- Breakup Measurement of ^{69}Br
- Measurements of ^{72}Kr, ^{73}Rb in the future

Collaborators

MSU / NSCL

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- R.Yanez

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- D.Shapira

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