# Use of the Berkeley Gas-filled Separator to Study Cold Fusion Reactions Leading to the Production of Elements 110, 111, and 107

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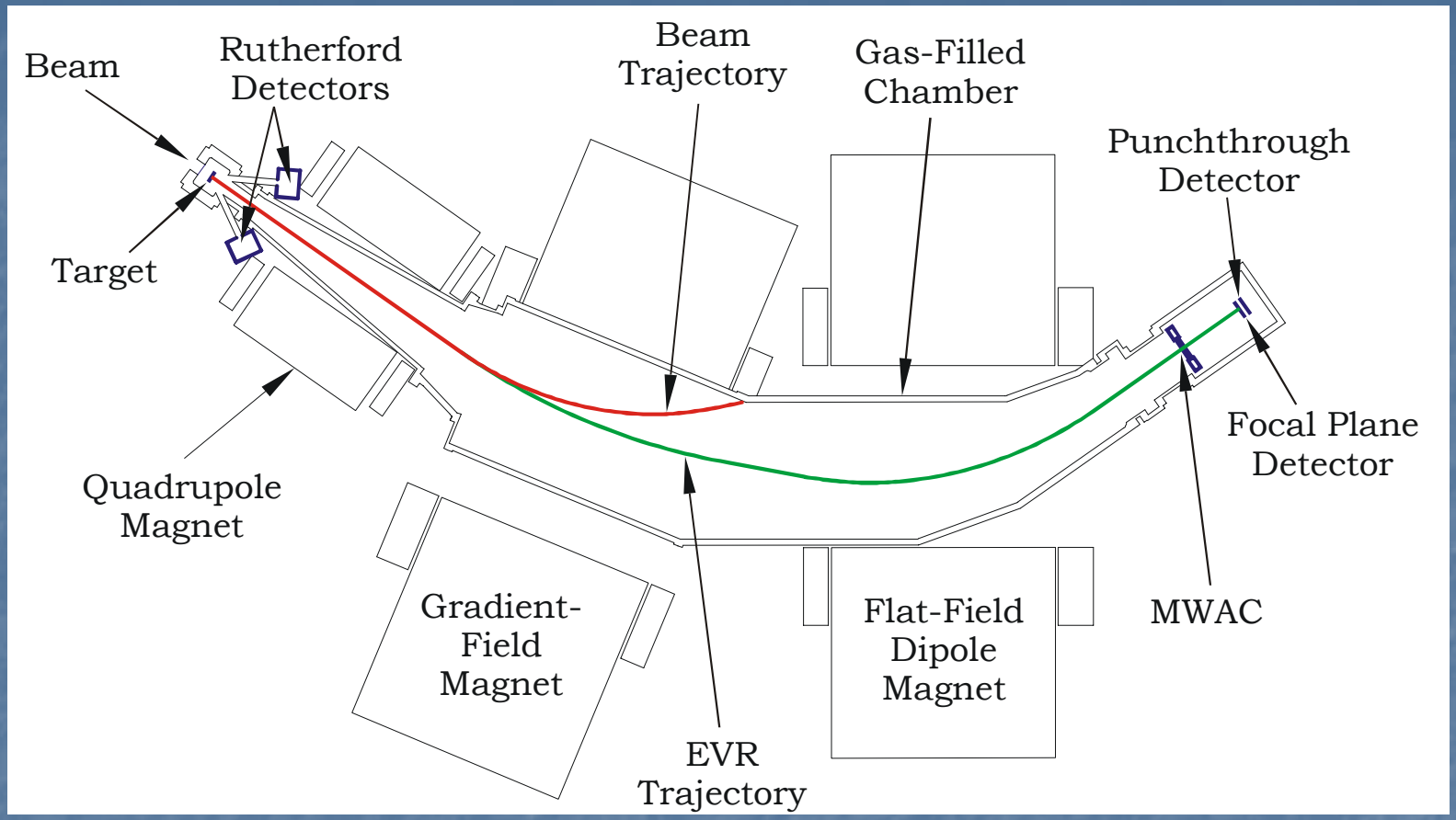
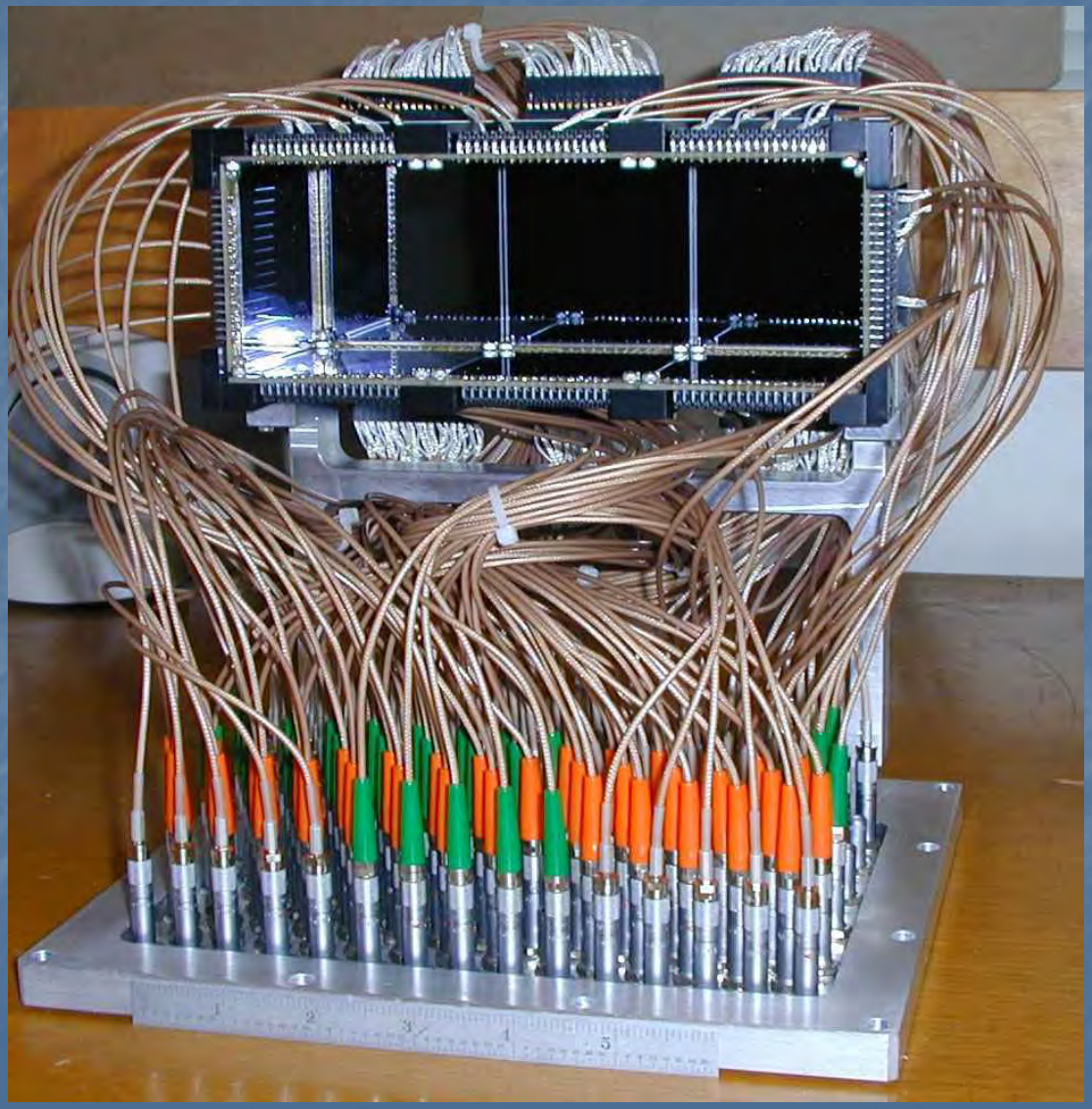
# The BGS



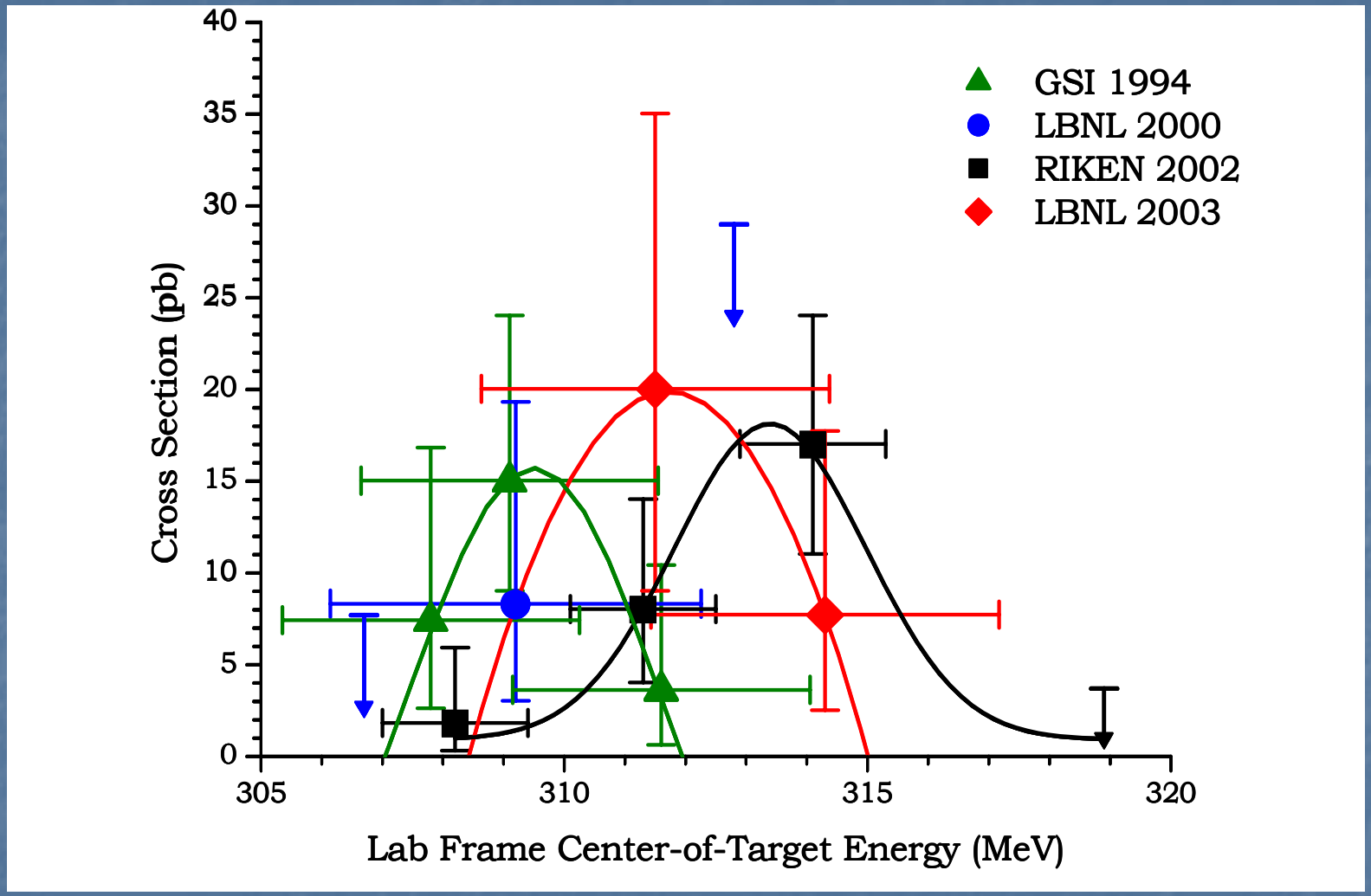

- ☑ Large acceptance cone: 45 msr
- ☑ Large bend angle: 70°
- ☑ High transmission (ex. ~70% Ni + Pb)
- ☒ Large dispersion: 2 cm/(% Bρ)

# BGS Focal Plane



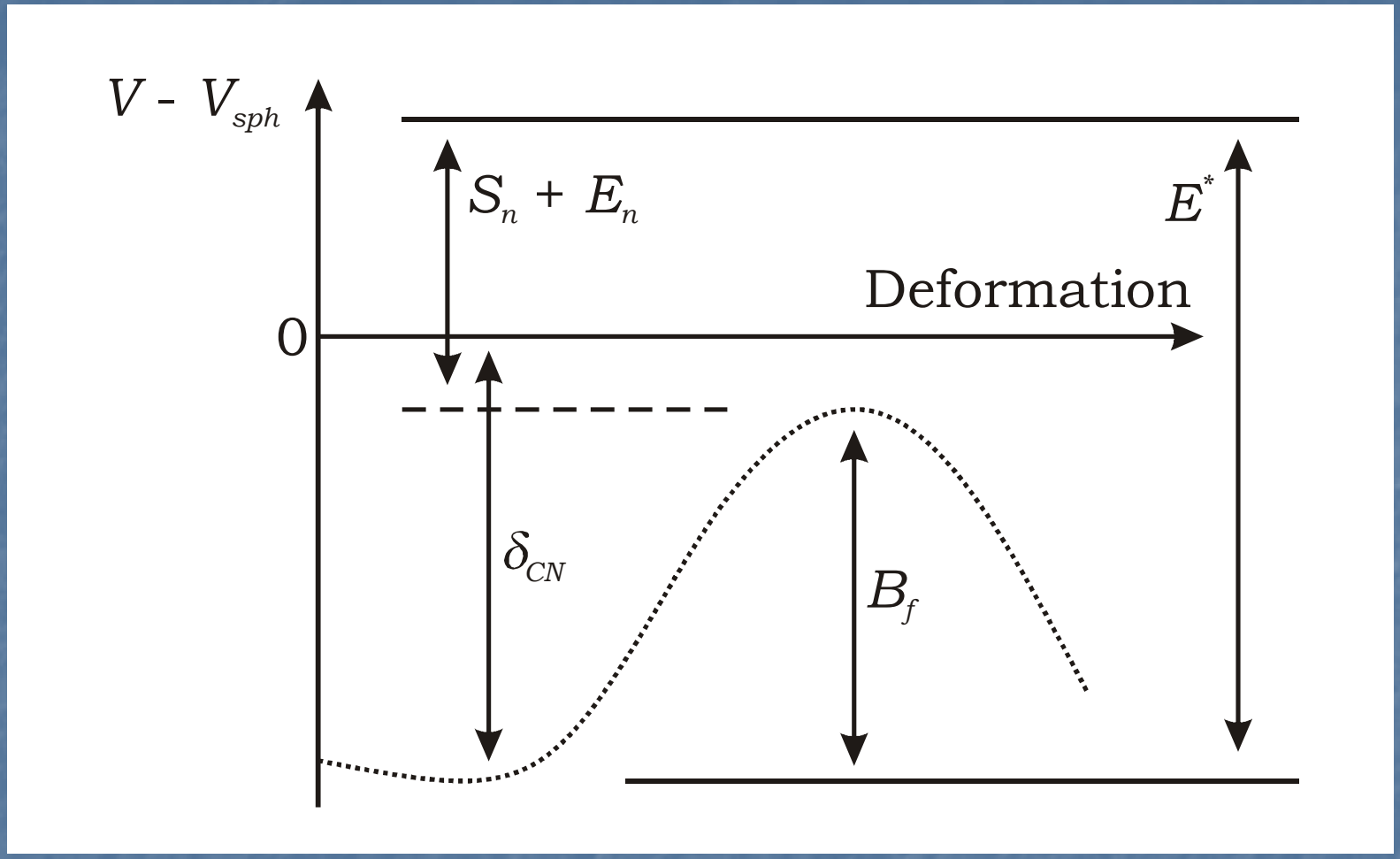
- ☑ 48 Position-Sensitive Si Strips
- ☑ 32 “Upstream” Detectors
- ☑ 12 “Punchthrough” Detectors
- ☑ 18 cm x 6 cm x 6 cm
- ☑ ~80% Geometric Efficiency

# $^{64}Ni + {}^{208}Pb \rightarrow {}^{271}Ds + n$



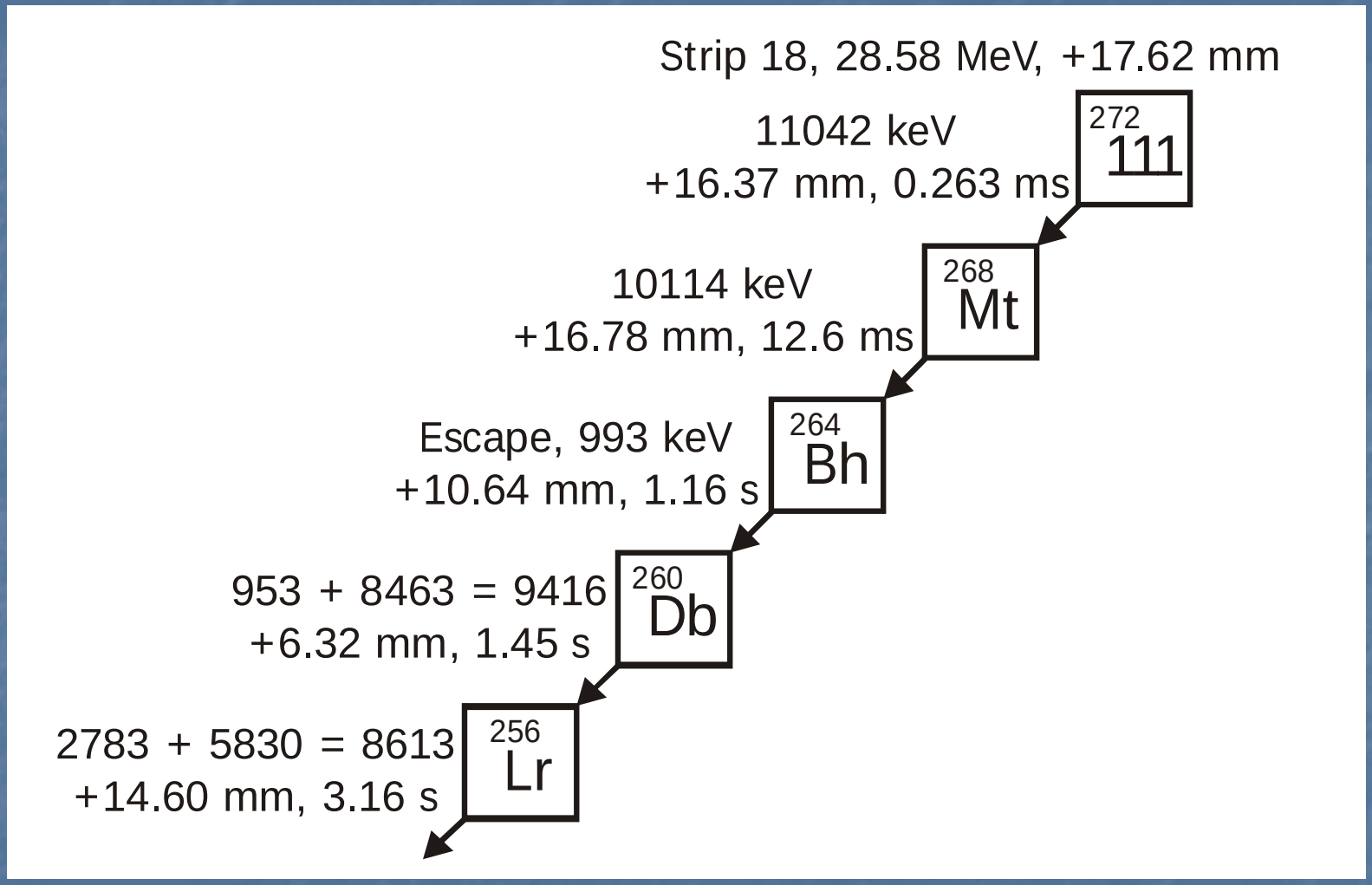

Trendlines are intended to guide the eye only.

# Swiatecki *et al*. Cold Fusion Theory



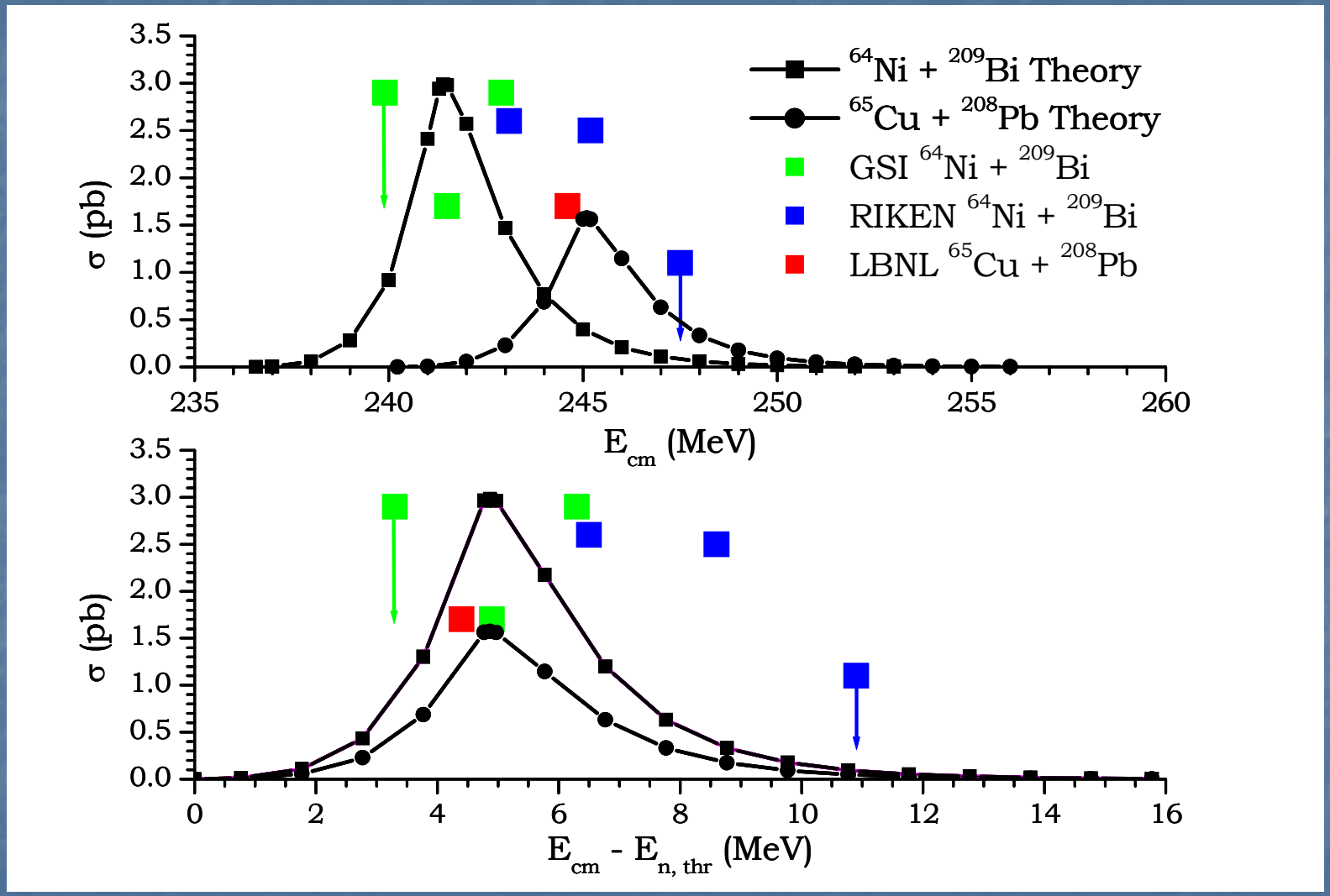

Optimum beam energy produces a 1n product with its excitation energy at the fission barrier (second-chance fission is forbidden).

# $^{272}$111 Decay Chain



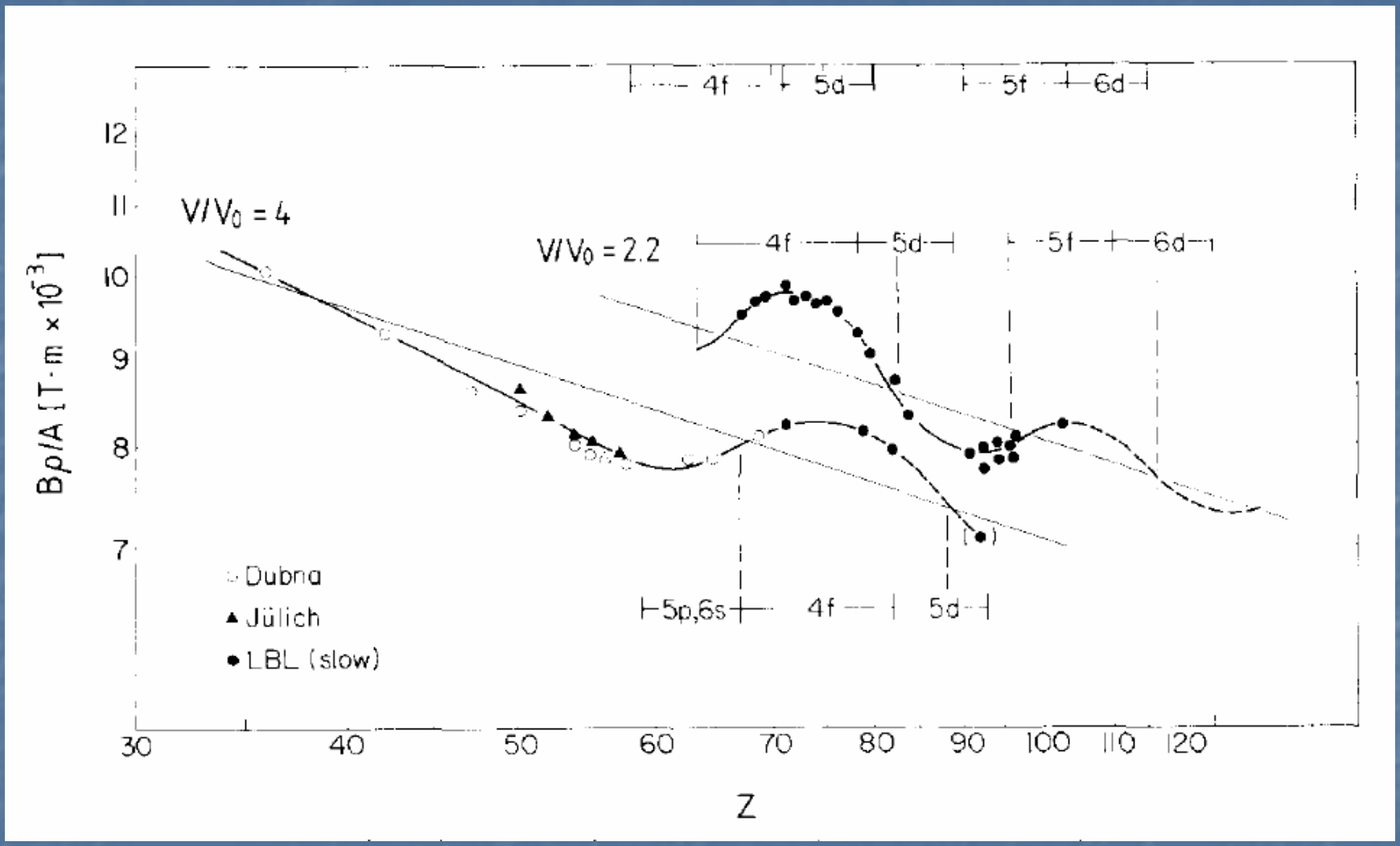

$^{65}Cu + {}^{208}Pb \rightarrow {}^{272}111 + n$: $\sigma(321.1\ MeV) = 1.7^{+3.9}_{-1.4}$ pb

# $^{272}$111 Excitation Functions



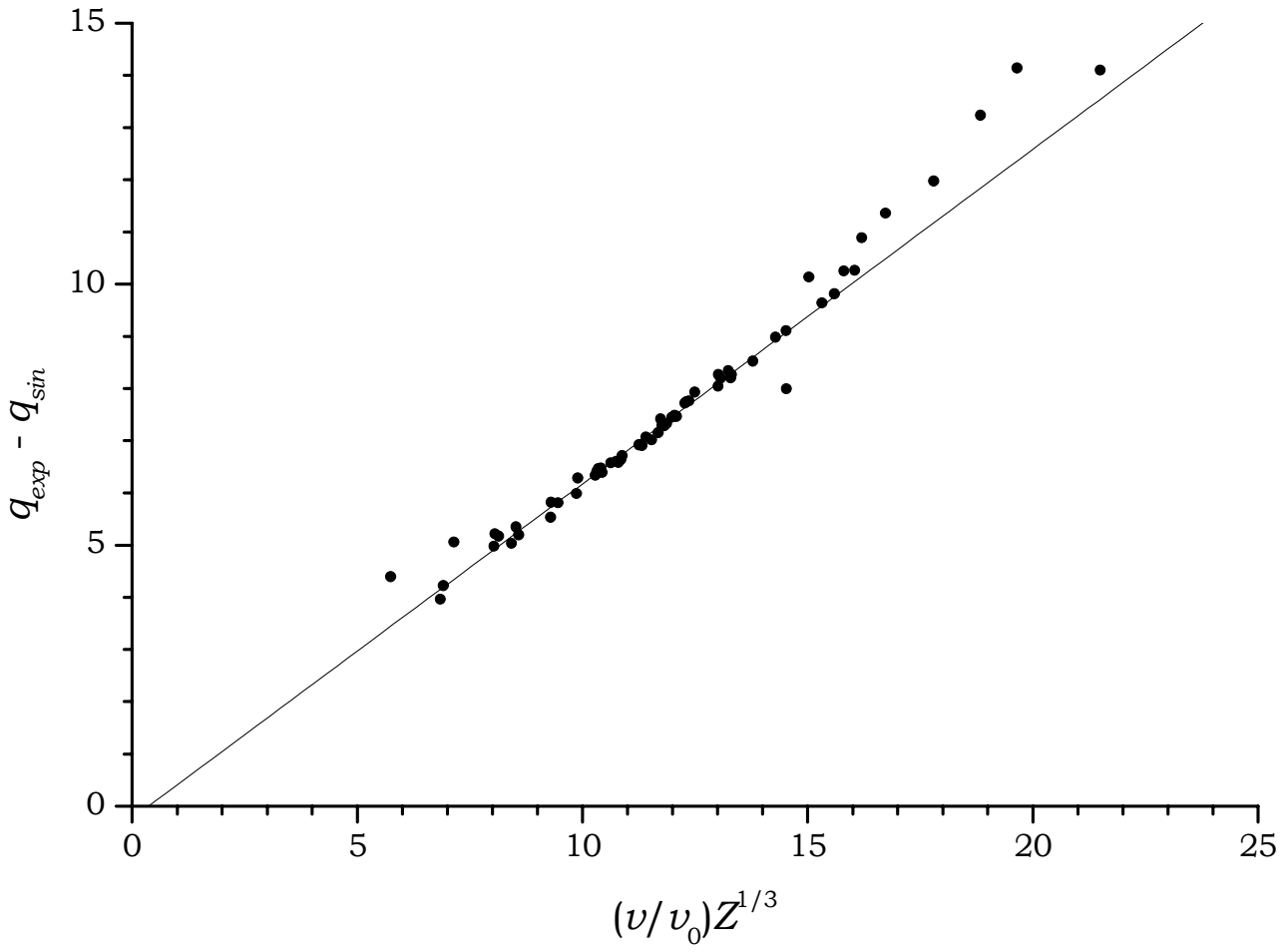

(Theory assumes an infinitely thin target).

# The “SASSY Plot”




A. Ghiorso *et al*., NIM A269, 192 (1988).

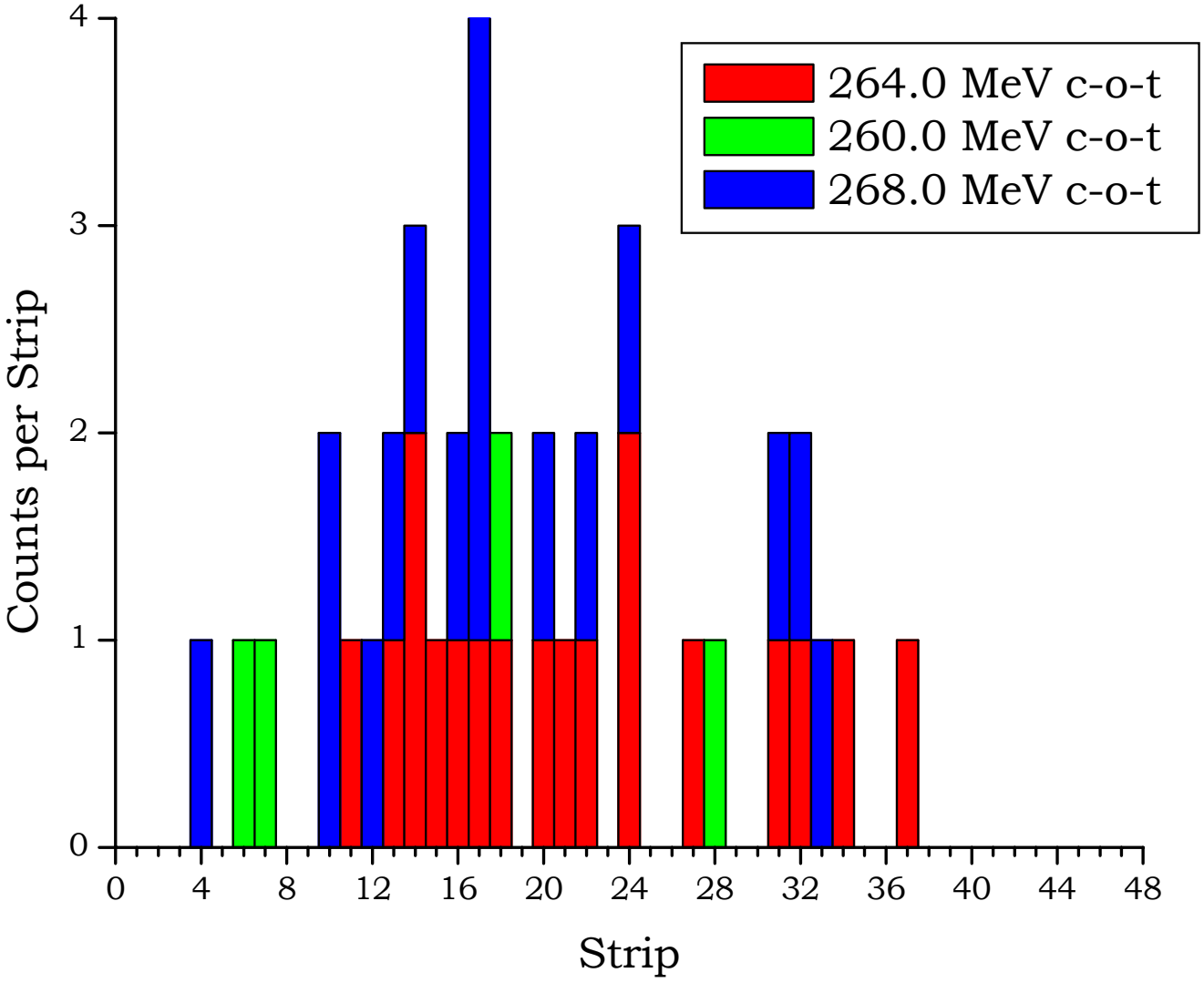
# Charge States in Helium



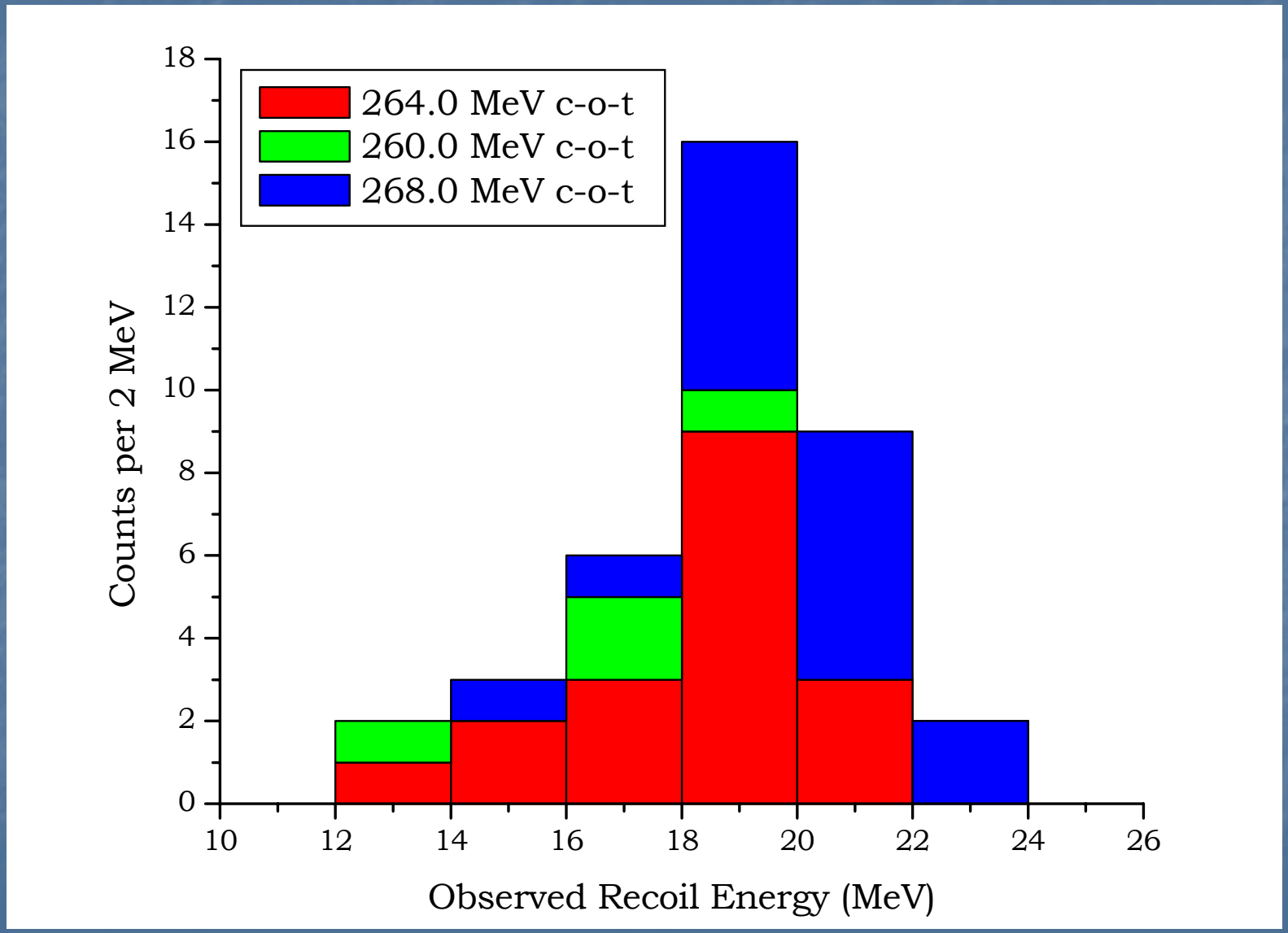

$$q_{calc} = mx + b + \sin\left[\frac{2\pi}{32}\left[Z - (mx + b) - d\right]\right]$$

$x = (v/v_0)Z^{1/3}$, m = 0.641, b = -0.235, c = 0.517, d = 74.647

# $^{55}Mn + {}^{208}Pb \rightarrow {}^{262(m)}Bh + n$
# Events per Strip



# $^{262(m)}$Bh Observed Recoil Energy



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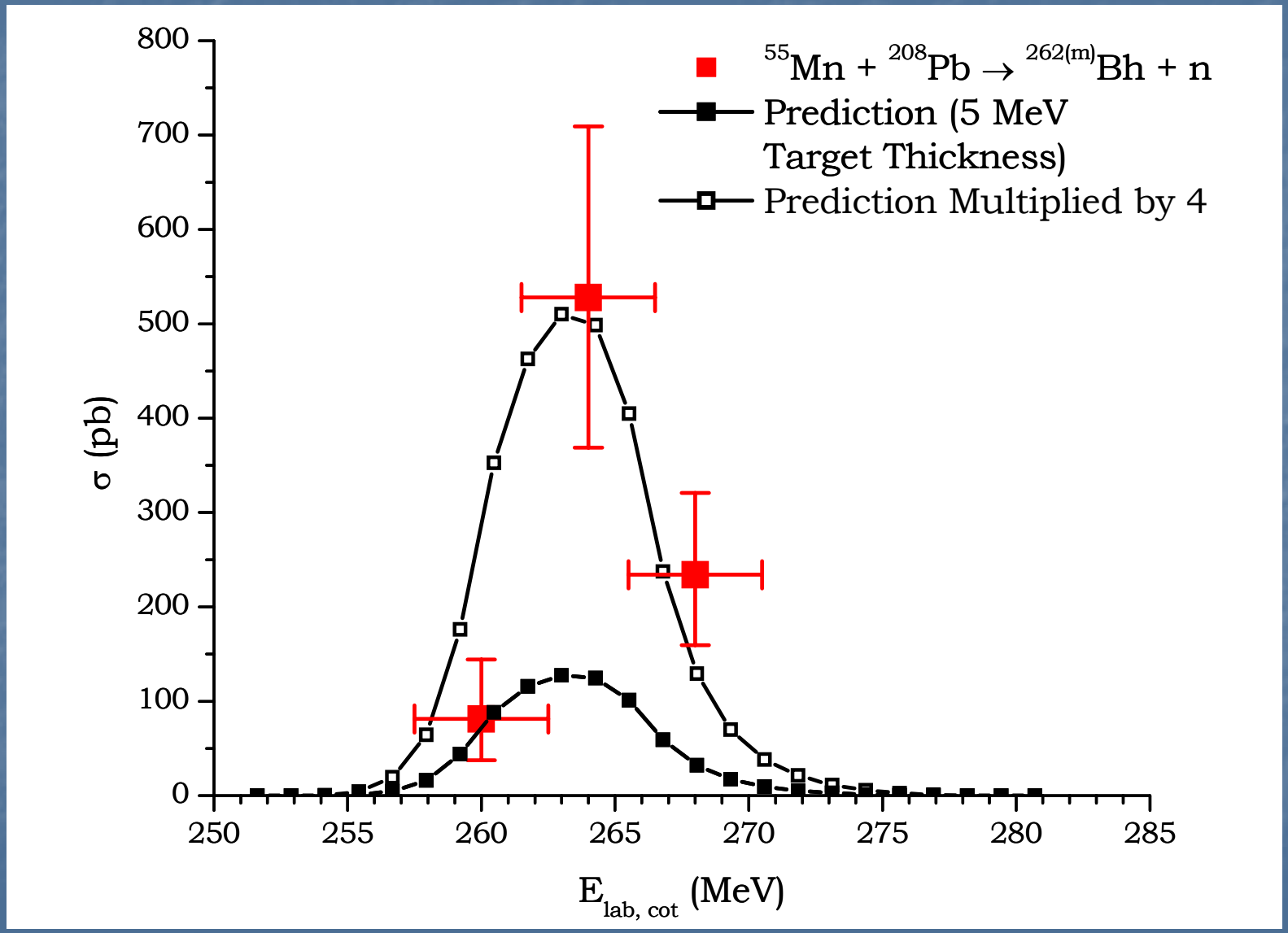

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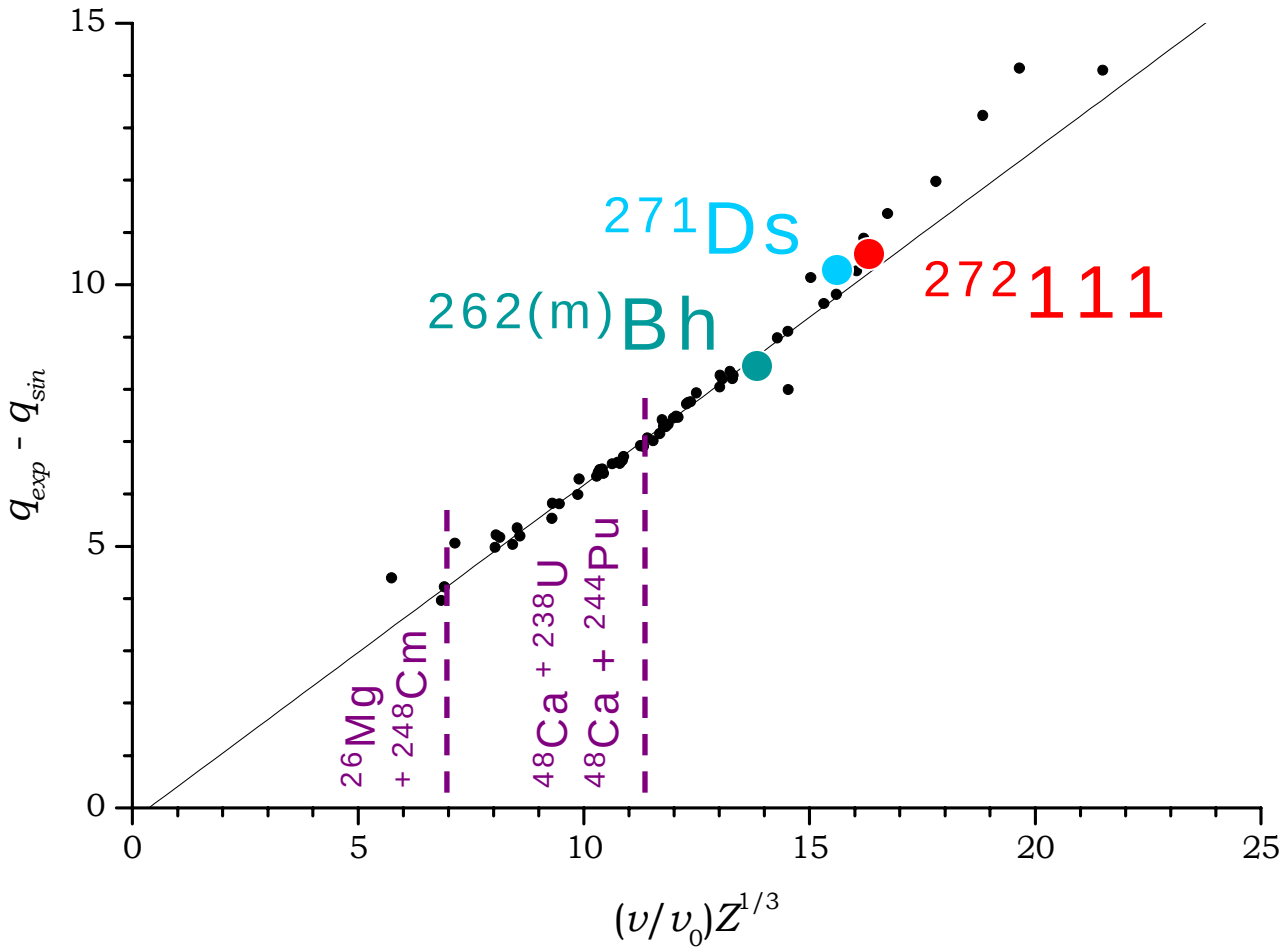


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# Conclusions

- Measured an excitation function for $^{64}Ni + {}^{208}Pb \rightarrow {}^{271}Ds + n$.
- Measured the $^{65}Cu + {}^{208}Pb \rightarrow {}^{272}111 + n$ cross section for the first time.
- Measured an excitation function for $^{55}Mn + {}^{208}Pb \rightarrow {}^{262(m)}Bh + n$.
- The BGS is a well-characterized separator for transactinide research.
- We know how to get what we want from our cyclotron.

# Future Work

- Reactions
  - $^{54}Cr + {}^{209}Bi \rightarrow {}^{262(m)}Bh + n$ at lower beam energy
  - $^{55}Mn + {}^{208}Pb \rightarrow {}^{262(m)}Bh + n$ at higher beam energy
  - $^{59}Co + {}^{208}Pb \rightarrow {}^{266}Mt + n$
  - $^{59}Co + {}^{209}Bi \rightarrow {}^{267}Ds + n$
- Alpha-gamma coincidences with $^{55}Mn + {}^{208}Pb \rightarrow {}^{262(m)}Bh + n$?
- BGS: Actinide target system
- VENUS Superconducting ion source