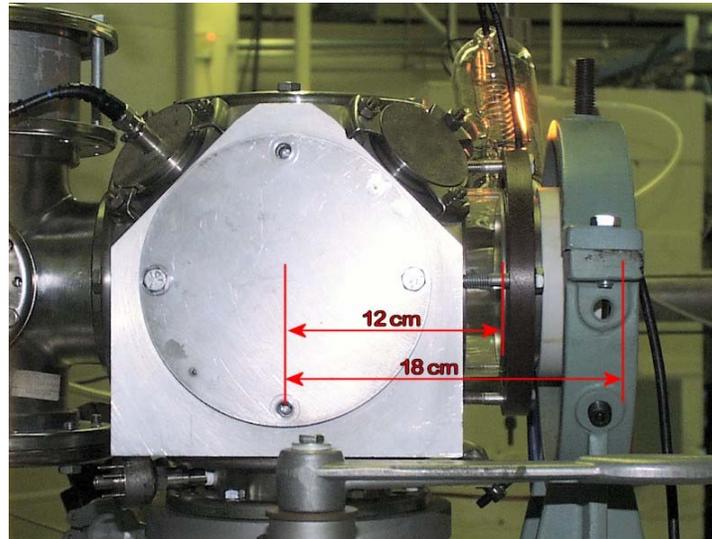


Dosimetry checks for KSU Irradiation system

- Beam flux is measured by directly integrating current measured in a Faraday Cup. This is a well-established technique in nuclear and atomic physics.



- L2 PRR raised serious questions about accuracy of flux based on anomalously low values of α . Most of this problem was due to self-inflicted plotting error.

Dosimetry with Copper foil

- Basic idea: both stable isotopes of Cu can be excited to long-lived Zn isotopes that decay via positron emission or electron capture with accompanying gamma rays back to copper.

$$N(t_1, t_2, t_3) = [\Phi at_1] \sigma(p, n) \frac{N_A \rho f \delta}{A} g \epsilon \frac{(1 - \exp(-t_1/\tau))}{(t_1/\tau)} (\exp(-(t_2 - t_1)/\tau) - \exp(-(t_3 - t_1)/\tau))$$

- Protons on target (what we want) = $[\Phi at_1]$
- Production cross section (biggest external uncertainty) $\sigma(p, n)$
 - 420 mb for Cu-63
 - 720 mb for Cu-65
 - Uncertainty ~ 10-20%
- Target thickness (1.5 mil) $\frac{N_A \rho f \delta}{A}$
 - $f=0.69$ for Cu-63
 - $f=0.31$ for Cu-65

Cu dosimetry, cont'd

- Gamma ray intensity g
 - 8.2% for 669 KeV Zn-63
 - 6.5% for 961 KeV Zn-63
 - 50.8% for 1115 KeV Zn-65
 - 511 KeV from positron not used.

- Detection efficiency ϵ
 - ~1% for Ge detector from KSU Nuclear Engineering.
 - ~15% for NaI(Tl) detector at KSU physics (still underway).

- Production factor

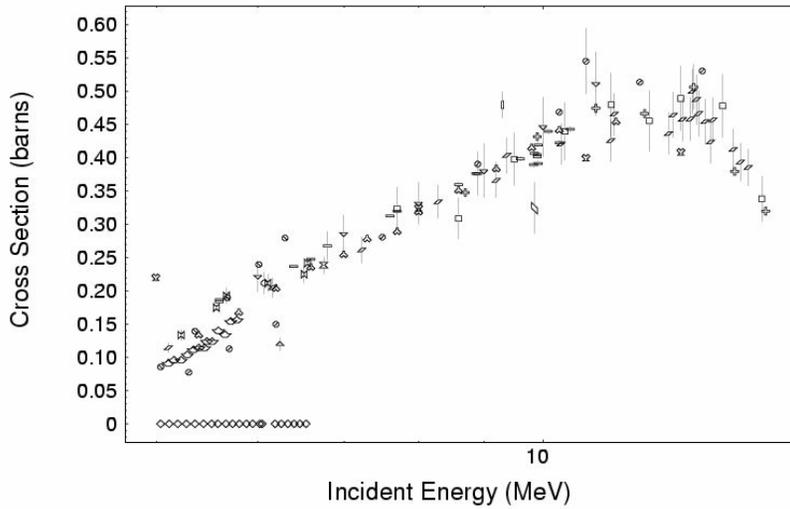
$$\frac{(1 - \exp(-t_1/\tau))}{(t_1/\tau)}$$

- Sampling factor

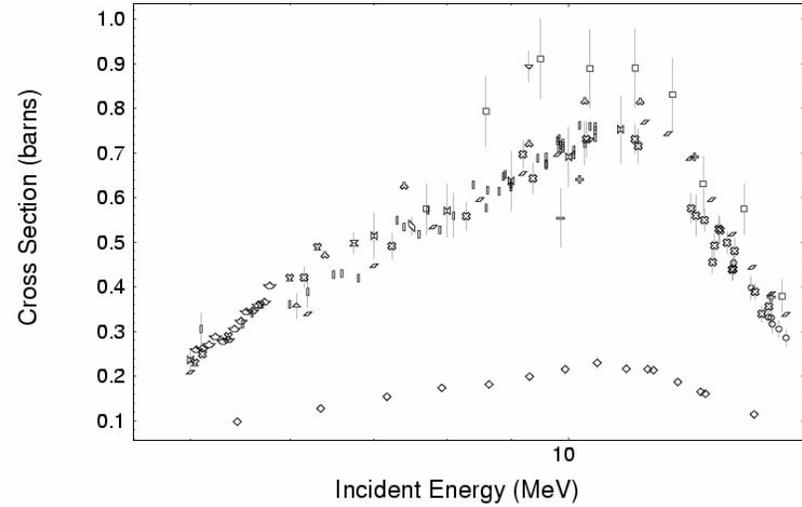
- t_1 =irradiation time
- t_2, t_3 =start, stop of sampling time
- $\tau = 38 \text{ min}/\ln(2)$ for Zn-63
- $\tau = 244 \text{ days}/\ln(2)$ for Zn-65

$$\exp(-(t_2 - t_1)/\tau) - \exp(-(t_3 - t_1)/\tau)$$

Production cross sections



$\text{Cu-63}(p,n)\text{Zn-63}$



$\text{Cu-65}(p,n)\text{Zn-65}$

Spread is probably 10-20%.

Efficiency calibration technique

- Straightforward: use a calibrated source with known gamma lines
 - Cs-137 (662 KeV)
 - Mn-34 (834 KeV)
 - Zn-65 (1115 KeV)
- Source is from NIST, 10/02/00
- Only simple correction for decay need by applied.
- Still finishing cross-check with 3X3 NaI(Tl) counters– “lying around the lab” for awhile, so need re-calibrating.

Exposures

- $1.67\text{E}12/\text{cm}^2$ POT (nominal) on 3/19/03 → same day Zn-63 analysis(Ge).
- $1.67\text{E}13/\text{cm}^2$ POT (nominal) on 3/25/03 → same day Zn-63 analysis(Ge).
- $1.00\text{E}14/\text{cm}^2$ POT (nominal) on 3/25/03 → repeatable Zn-65 analyses(Ge, NaI, FNAL(Capps)).

Preliminary Results

- Activation analysis/direct flux = **0.90 ± 0.15** .
- Further cross-checks and documentation ongoing.