**Using the K-150 cyclotron to measure proton reaction cross sections on separated isotopes**

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This Using the rejuvenated K-150 cyclotron, a new program was started measuring $\sigma_{rxn}$(p) for stable but rare isotopes. These cross sections are accurate reporters of the integrated strength of the imaginary component of the optical model ($J_W$) and the isotopically resolved data is far from complete, see the Table I and [1].

An apparatus was constructed at WU modeled after the one used by Carlson [2], see Fig. 1. It consists of two very thin "passing detectors", several annular ring beam "veto" detectors, a central "plug" detector at zero degrees, and an energy analyzing detector at forward angles. The beam is defined by scoring on the "passing" and missing the "veto" detectors. To first order, the unreacted beam (this includes most of the elastic) hits the center "plug" (detector 5 in Fig. 1). The reacted beam events are defined as those which score on the passing detector (detectors 1 and 2 in Fig. 1), miss the veto detectors (detectors 3 and 4), do not hit the center plug (detector 5) or score with less than the elastic energy in the final energy analyzing detector (detector 6, in Fig. 1). These experiments require very little, but a low divergence, beam and thick (~ 45 mg/cm2) and uniform separated isotope targets.

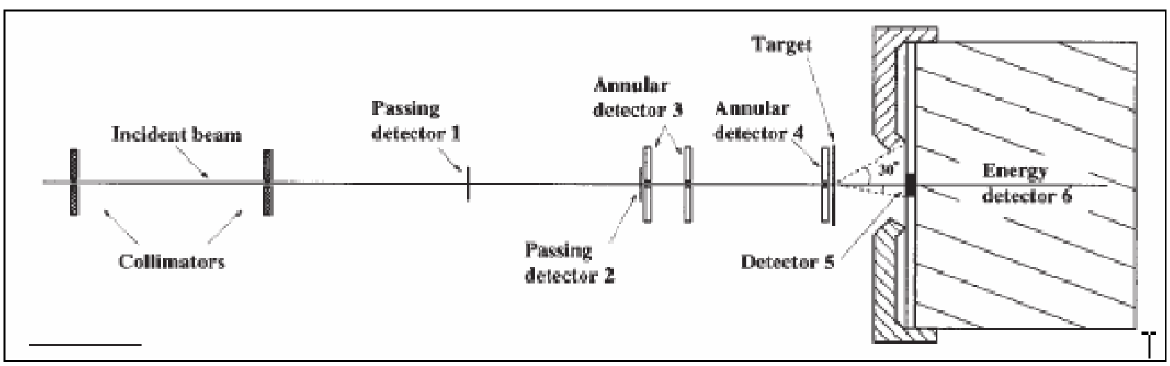


**FIG. 1.** The logical elements of $\square_{xn}$(p) apparatus.

In March of 2011 there was a test run, the first run using the revitalized 88" cyclotron, using a natural Ni target. In this test, the K-150 supplied a 30 MeV proton beam, all of the detectors functioned but a cross section was extracted that was 35% above the literature value. A second test run, with improved collimation (beam definition) and detector alignment capabilities is required before physics generating experiments can be undertaken. Ultimately we intend to supply data from 20-60 MeV, in 10 MeV steps (with uncertainties of less than 5%) for the cases listed in Table I without high precision entries.

**Table I.** Status of $\sigma_{rxn}(p)$ for isotope isotone chains.

| Z=28 (%) | $E_p$(MeV) | N=28 (%) | $E_p$(MeV) |
|---|---|---|---|
| $^{58}$Ni (68.3) | Good data set | $^{48}$Ca (0.187) | 23.,25.3,30.3,35.1, 39.9,45.3,48.,700 |
| $^{60}$Ni (26.1) | Good data set | $^{50}$Ti (5.4) | 60.8* |
| $^{62}$Ni (3.59) | 14.5, 40.0*, 60.8* | $^{52}$Cr (83.8) | 60.8* |
| $^{64}$Ni (0.91) | 40.0*, 60.8* | $^{54}$Fe (5.9) | Complete data set |
| | | | |
| **Z=40 (%)** | **$E_p$(MeV)** | **N=40 (%)** | **$E_p$(MeV)** |
| $^{90}$Zr (51.45) | 14.5, 30.0, 40.0 49.5, 60.8 | $^{70}$Zn (0.6) | nothing |
| $^{92}$Zr (17.15) | 14.5 | $^{72}$Ge (27.4) | nothing |
| $^{94}$Zr (17.38) | 14.5 | $^{74}$Se (0.9) | nothing |
| $^{96}$Zr (2.80) | 60.8* | | |
| | | | |
| **Z=50 (%)** | **$E_p$(MeV)** | **N=50** | **$E_p$(MeV)** |
| $^{xxx}$Sn | Excellent data | $^{88}$Sr (82.58) | nothing |
| | | $^{90}$Zr (51.45) | 14.5, 30.0, 40.0 49.5, 60.8 |
| | | $^{92}$Mo (14.84) | nothing |
| | | | |

* Large statistical errors (~> 10%)


[1] R.F. Carlson, At. Data and Nucl. Data Tables **63**, 93 (1996).

[2] R.F. Carlson, et al. Phys. Rev. C **53**, 2919 (1996).