Background Reduction in TASCA

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During the ^{244}Pu(^{48}Ca,3-4*n*)$^{289\text{-}288}$114 experiment, high background rates in TASCA were observed and attributed to (i) transfer reaction products (TRPs) that have a magnetic rigidity (Bρ) only ~15-30% less than the evaporation residues (EVRs) of interest and decay properties similar to the EVRs and (ii) primary beam passing through pinholes in the target and entering TASCA without charge-exchange or scattering reactions [1]. Both TRPs and primary beam are separated from the evaporation residues (EVRs) of interest in the dipole, but a small fraction are guided back to the focal plane detector by the horizontally focusing quadrupole. This is shown in Fig. 1 for primary beam as compared to EVRs.

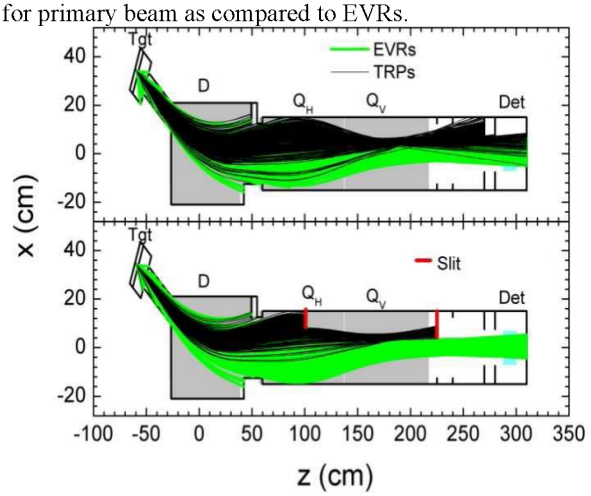

Fig. 1: Primary beam and EVR trajectories in TASCA.

Simulations [2] showed that separation between EVRs and background occurs at the center of the first quadrupole (Q1) and at the exit of TASCA. The use of strategic slits to reduce the acceptance of TASCA in these two areas was expected to result in significantly reduced background without large losses in EVR transmission efficiency as shown in the bottom of Fig. 1. Two solutions (hereafter referred to as M1 and M2) for reducing background in TASCA are:

M1. Introduction of a slit at the center of Q1 reaching from the low Bρ side of TASCA to 8 cm from center. This was expected to result in reductions of 4, 90 and 98% for EVRs, TRPs and primary beam.

M2. M1 plus a slit at the exit of TASCA reaching from the low Bρ side of TASCA to 3.5 cm from center. This was expected to result in reductions of 5, 97 and 99% for EVRs, TRPs and primary beam.

In April 2011, M1 and M2 were tested using the ^{208}Pb(^{40}Ar,x*n*) reaction, chosen to represent 'fast' recoils were the Bρ of the EVRs is approximately 15-30% higher than the Bρ of the TRPs or primary beam. This is similar to what would be expected in reactions such as those currently being investigated to produce elements 119 and 120: ^{249}Bk(^{50}Ti,x*n*) and ^{249}Cf(^{50}Ti,x*n*) and the TASISpec element 115 X-ray Fingerprinting experiment.

The high and low energy spectra during the macropulse and the low energy spectra outside of the macropulse for unmodified TASCA, and TASCA with M1 and M2 are shown in Fig. 2. Background reductions of 77 and 84% for TRPs and primary beam, respectively, were observed with M1. For M2, reductions of 93 and 96 were observed for TRPs and primary beam, respectively, in fair agreement with the simulations. Rates of all events in the macropulse were reduced 65 and 88% for M1 and M2, respectively, while the outside of macropulse event rate for M1 and M2 was reduced by 75 and 89%, respectively. The experimental change in EVR transmission efficiency could not be quantified due to the low ^{208}Pb(^{40}Ar,xn) cross section and interference from TRPs.

Without modification, the rate of events in the focal plane detector during the ^{208}Pb(^{40}Ar,x*n*) reaction was 2900 Hz during the macropulse and 40 Hz outside of the macropulse. With the addition of either M1 or M2, these rates were reduced to <200 Hz inside and <3 Hz outside of the macropulse.

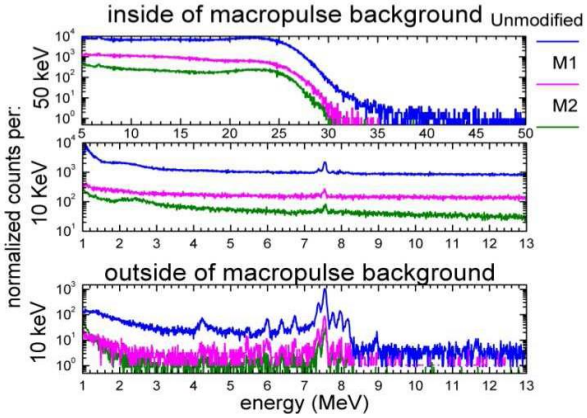

Fig. 2: Total energy spectra for TASCA unmodified and after M1-M2, normalized to the beam integral.

References:

[1] J.M. Gates *et al.*, Phys. Rev. C **83**, 054618 (2011)

[2] K.E. Gregorich *et al.*, Phys. Rev. C **71**, 014605 (2005)