Ternary fission fragment yield analysis in ^{124}Sn+^{112,124}Sn at 26*A* MeV

J. Gauthier, M. Barbui, X. Cao, K. Hagel, J.B. Natowitz, R. Wada, and S. Wuenschel

An analysis of the data set coming from 26*A* MeV ^{124}Sn on ^{112}Sn and ^{124}Sn targets acquired by the NIMROD heavy ion detector [1] is underway. These data are being used to perform studies of the reaction products and thus the emission sources [2] in order to better characterize the charge and the isotopic yields of the fragments emitted in ternary fission processes [3] at high temperature and excitation energy. A better understanding of this phenomenon should help to improve the characterization of the reaction dynamics [4].

The initial analysis focuses on global features of the reaction. The data set is composed of 33 runs combining 26,000,000 events. The linearization [5] of those data is now completed [6] and the particle identifications have been generated for every detector. Fig. 1 shows the isotopic fractional yields from detected hydrogen to oxygen fragments for both ^{112}Sn and ^{124}Sn targets. As one should expect, the more neutron rich system tends to produce more neutron rich isotopes. The yields are also in very good agreement with previous measurements shown in reference [2].

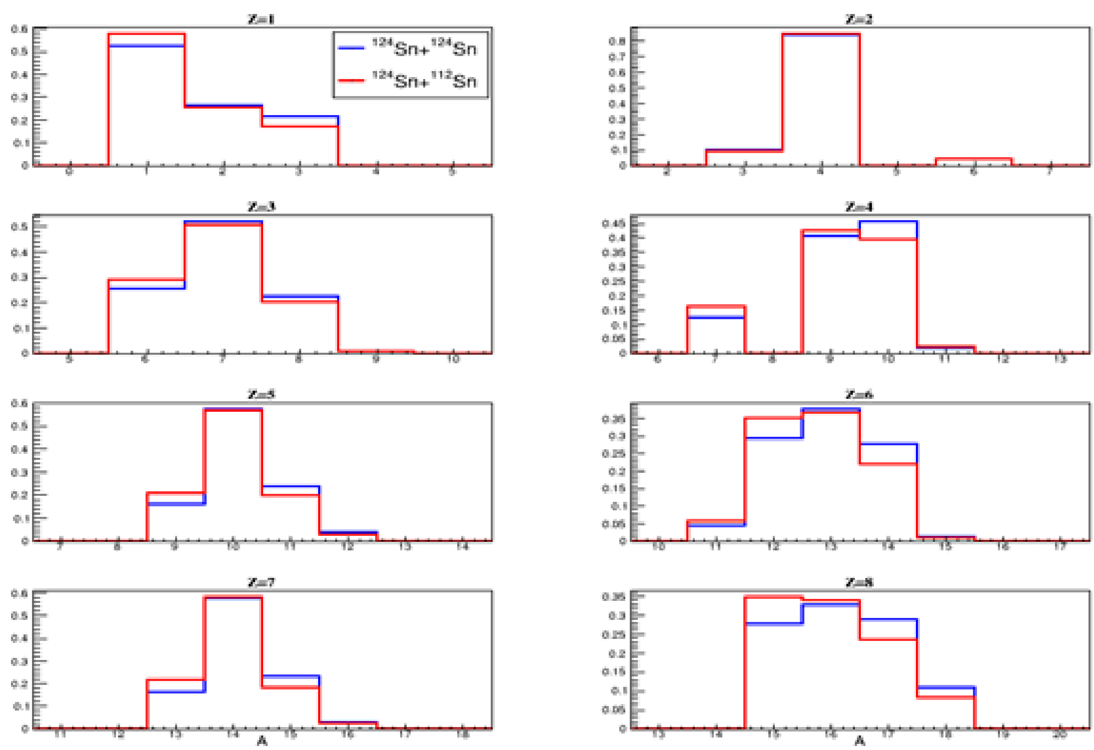

FIG. 1. Isotopic fractional yields up to Z=8 for ^{112}Sn and ^{124}Sn targets.

The Si-Si super telescope energy calibration using the punch through energy points and SRIM stopping power calculations [7] is also completed. Using the HIPSE (Heavy Ion Phase Space Exploration) event generator [8], we can compare the energy and velocity distributions as we can see in Fig. 2. The addition of the degrader foil introduces a much higher threshold than what we see in the experimental data. It has to be noticed that the upper Z cut in the experimental data is induced by detector gain saturation and not by a detection threshold.

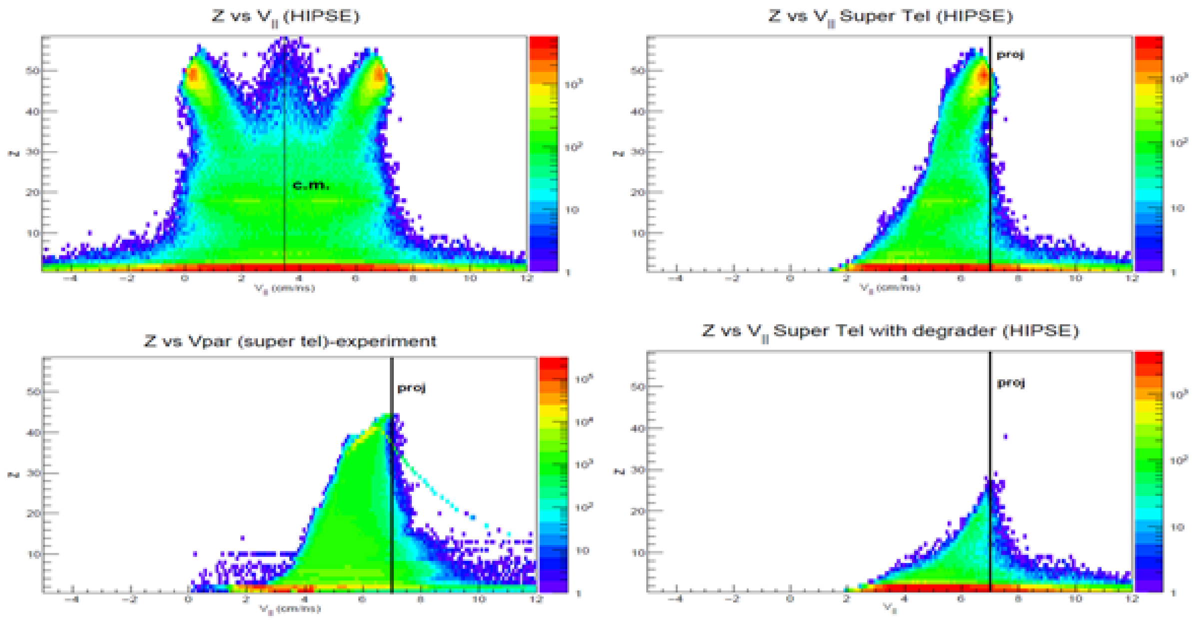

FIG. 2. HIPSE and experimental charge vs. parallel velocity comparison. Up-left: HIPSE not filtered. Up-right: HIPSE filtered.

Most of the experimental energy distributions match those of the HIPSE calculation very well especially for high Z fragments. Fig. 3 shows a sample of these energy comparisons for Z=17 to 23 in ring #3. Moreover, we have seen that experimental Z ratios and angular distributions are also in generally good agreement with the HIPSE generated data set.

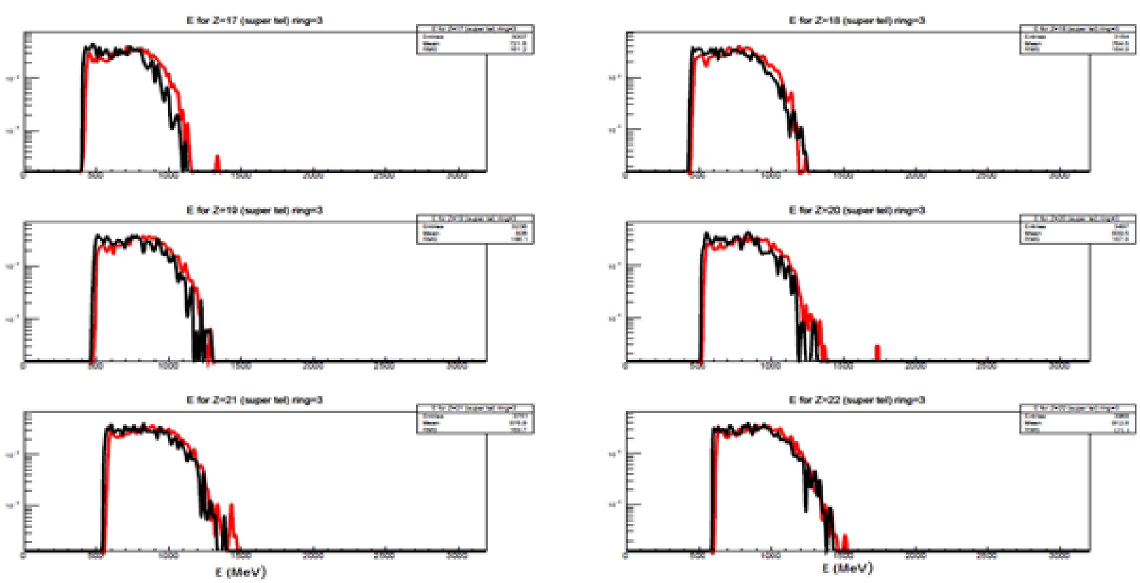

FIG. 3. Energy spectra for 16<Z<23 in Si-Si-CsI(Tl) super telescopes (ring 3). The black line represents experimental calibrated energy, and the red line is for HIPSE filtered data.

In order to select only peripheral and mid-peripheral collisions, which is mandatory for this analysis, we used HIPSE to test some variables sensitive to the impact parameter [9]. As one can see in Fig. 4, a selection on the highest charge detected fragment (Z_{max}) combined to a parallel velocity cut on this fragment efficiently remove most of the central events while minimizing fluctuations that would occur with the use of other variables that require complete event detection (such as multiplicity, total transverse energy, flow angle, etc.).

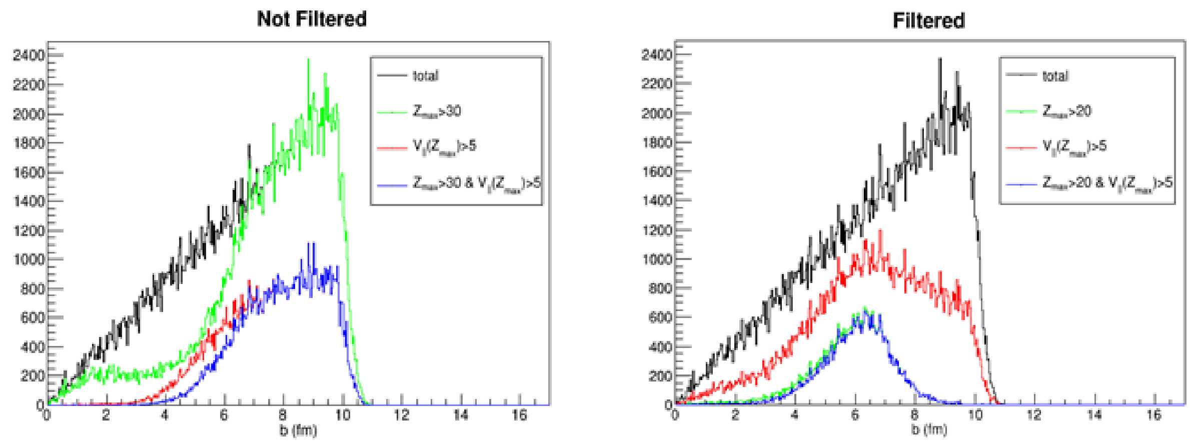

FIG. 4. Effect of Z_{max} and $V_{||}(Z_{max})$ selection on the impact parameter (HIPSE data).

Parallel velocity will also be a useful tool for selecting emission sources and preliminary results show that the values given by the super telescopes are suitable. In Fig. 5, we can see multiplicity distributions and average parallel velocities as a function of the charge for fragments having a parallel velocity either lower or higher than 5 cm/ns and these results are in agreement with a forward projectile-like-fragment source and a mid-rapidity emission.

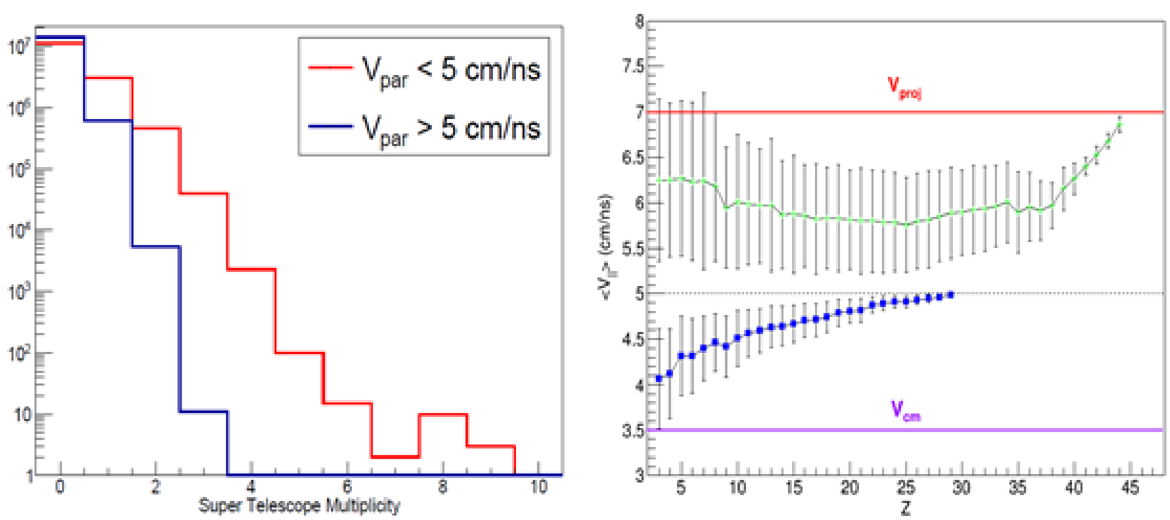

FIG. 5. Left: Multiplicity in the super telescopes for $V_{||} < 5$ (red) and $V_{||} > 5$ cm/ns (blue). Right: average parallel velocity as a function of Z for $V_{||} < 5$ (blue) and $V_{||} > 5$ cm/ns (green).

The next and final steps will be to complete the energy calibrations for the Si-CsI(Tl) telescopes and the light particles in the CsI(Tl) in order to be able to achieve a suitable emission source selection for every fragment of interest and then a good quality yield analysis. Analysis of ternary events will then proceed.

[1] R. Wada *et al.*, Nucl. Phys. News, **24**, 28 (2014).
[2] D.V. Shetty *et al.*, Phys. Rev. C **68**, 054605 (2003).
[3] S. Wuenschel *et al.*, Phys. Rev. C **90**, 011601, (2014).
[4] M.A. Famiano *et al.*, Phys. Rev. Lett. **97**, 052701 (2006).
[5] L.W. May *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2007-2008), p. II-26.
[6] J. Gauthier *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2014-2015), p. II-29.
[7] J.F. Ziegler *et al.*, Nucl. Instrum. Methods Phys. Res. **B268**, 11 (2010).
[8] D. Lacroix *et al.*, Phys. Rev. C **69**, 054604, (2004).
[9] J. Peter *et al*., Nucl. Phys. **A519**, 611 (1990).