Measurement of protons for correlation functions using the newly upgraded FAUSTUPS

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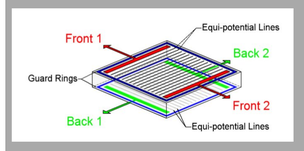
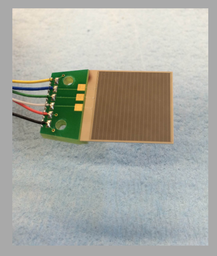
Abstract

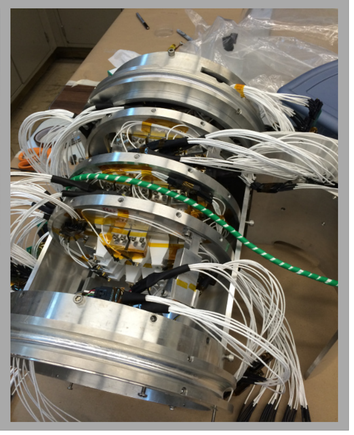
Proton-proton (pp) correlation functions have been predicted to be sensitive to the density-dependence of the asymmetry energy in the nuclear equation of state. We have upgraded the FAUST with position-sensitive delta-E silicon detectors, to measure correlation functions with high resolution. We developed a methodology for accurate position calibration. Light charged particles produced in the reactions of ^{40}Ar+^{70}Zn,^{58}Fe and ^{40}Ca+^{58}Ni at 40 MeV/nucleon have been measured in the resultant Forward Array Using Silicon Technology with Upgraded Position Sensitivity (FAUSTUPS). These systems were chosen to allow the asymmetry to vary while holding either the Z or the A constant. The resolution achieved in this campaign and progress on the calibration is demonstrated.

FAUSTUPS: Forward Array Using Silicon Technology with Upgraded Position Sensitivity

- Uses existing CsI(Tl)/PD E detectors [1]
- Dual-Axis Dual-Lateral (DADL) detectors improve angular resolution [2]
  - 4 signals per silicon
- ASIC HINP Chips & new cabling/biasing scheme to accommodate additional signals [3]
- Signal split across surface requires higher-gain preamps (~110mV/MeV), to pick up higher energy LCPs [4]
- Position Resolution < 200 um
- Energy Resolution < 2 %



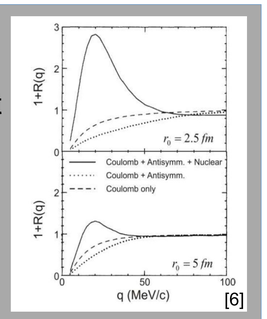




[1] F. Gimeno-Nogues, *et al.*, *NIM A*, **399**, 94 (1997).
[2] S. N. Soisson, *et al.*, *NIM A*, **613**, 240 (2010).
[3] G. Engel, *et al.*, *NIM A*, **652**, 462 (2011).
[4] R. Todd, RIS-Corp., 5905 Weisbrook Lane, Suite 102, Knoxville, TN 37909 (2013).

Literature: Proton-Proton Correlation Functions

- Interferometry, patterns in relative proton momenta, due to the interactions between any 2 protons in the same event
- Correlation Functions sensitive to the asymmetry energy
- Direct interaction between the 2 protons in the reaction
- Good Angular Resolution Important



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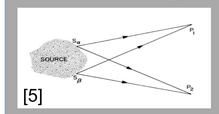
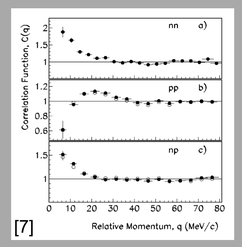


[5]

$$\vec{q}_{Rel} = \left|\frac{1}{2}\vec{p}_1 - \vec{p}_2\right|$$

$$C(\vec{q}_{Rel}) = N\frac{Y_c(q_{Rel})}{Y_{nc}(q_{Rel})}$$



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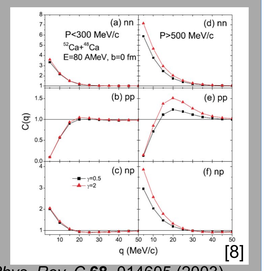
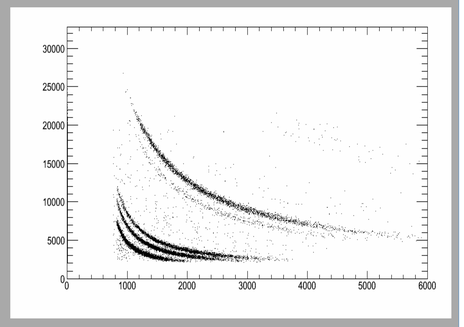


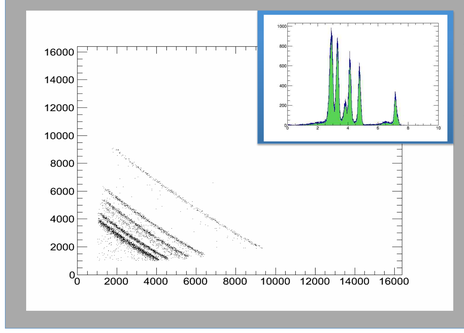
[8]

[5] D.H. Boal, *et al.*, *Rev. of Mod. Phys.*, **62**, 553 (1990).
[6] G. Verde *et al.*, *Eur. phys. j. a* **30,** 81 (2006).
[7] R. Ghetti, *et al.*, *Nuclear Physics A* **674,** 277 (2000).
[8] L. W. Chen *et al.*, *Phys. Rev. C* **68**, 014605 (2003).
S. Koonin, *Phys. Lett. B*, **70**, 43 (1977).
S. Pratt and M. B. Tsang, *Phys. Rev. C* **36**, 2390 (1987).

Experimental Details

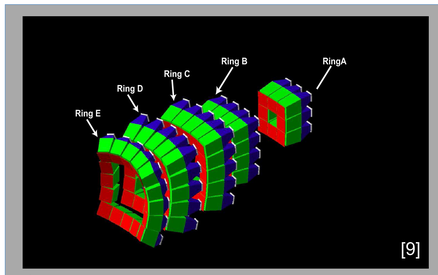
- 40A MeV ^{40}Ar+^{70}Zn,^{58}Fe and ^{40}Ca+^{58}Ni
- Clear p,d,t delineation in dE-E Plots
- Require all 4 signals
- For 3-Signal events on a detector, can recreate expected 4th signal
- Front1+Front2 = Back1 + Back2





- Array shows good Si energy resolution
- Calibration Beams
  - Energy (p+alpha @ 10 A MeV)
  - Position (See Upper Right)

Position Calibration Method



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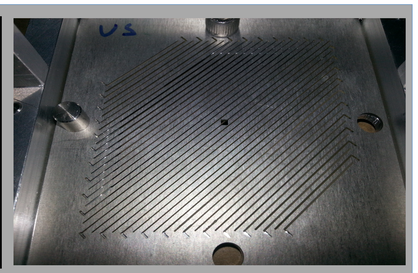
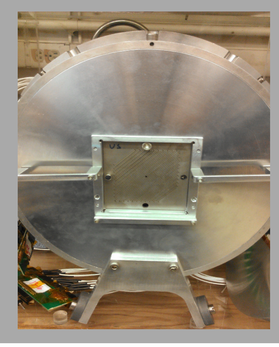
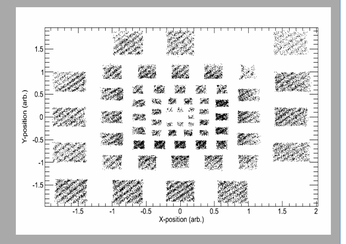


- Need a measure of relative detector position for acceptable angular resolution
- 0.040” tungsten mask machined by wire EDM
  - Center hole for beam
  - Stripes
    - (0.010”)
    - Each stripe angled to hit detector behind
- Positioned on Front Plate of FAUST
- Collimated Au Target, elastically scattered 15 MeV/nucleon alphas (rings A & B)
- Collimated Th Source (rings C-E)
- Align stripes

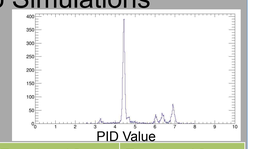




[9] P. Cammarata, *et al.*, *NIMA,* **792,** 61-66 (2015).

Current Status

- ☑ FAUSTUPS Hardware
- ☑ FAUSTUPS Electronics
- ☑ All Data Collected (November 2014-March 2015)
- ☑ Calibration Data Collected
- ☑ Si Energy Calibration Completed
- ➢ CsI Energy Calibration
- ➢ Particle Identification
- ❑ Position Calibration
- ❑ Extract Correlation Functions
- ❑ Compare to Simulations



System	# Events	Events w/ 2 or more protons	Events w/ 3 or more protons
^{40}Ar+^{58}Fe	31M	254k	16k
^{40}Ar+^{70}Zn	44M	542k	28k
^{40}Ca+^{58}Ni	84M	1.3M	172k
TOTAL	161M	2.1M	216k

Acknowledgments

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