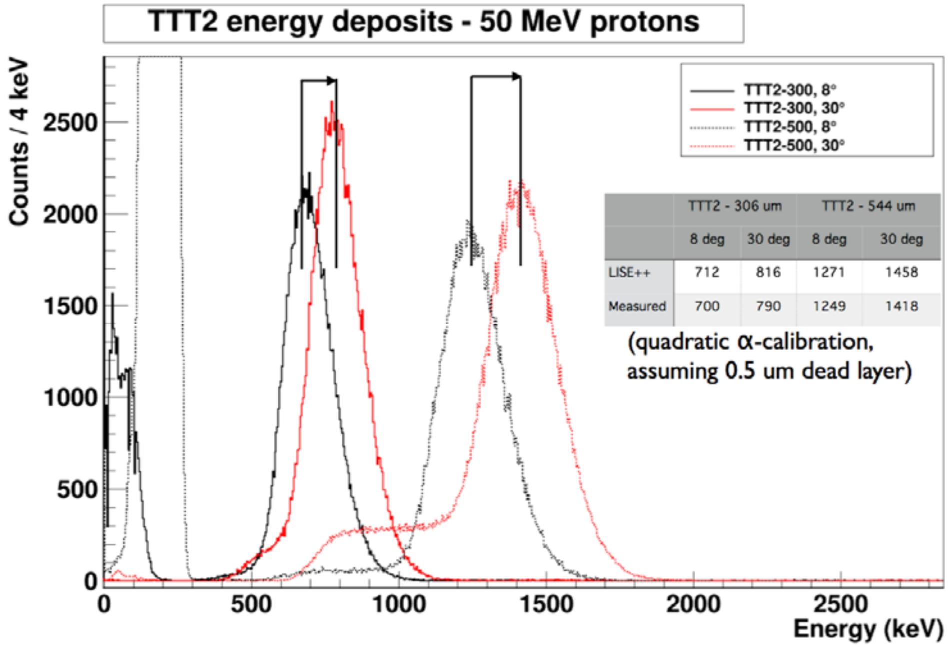
Detector developments for SAMURAI silicon tracker

A. Saastamoinen, M. McCleskey, B. T. Roeder, R. E. Tribble, L. G. Sobotka,[1] and C. Rasco[2]
[1] *Washington University, St. Louis, Missouri*
[2] *Louisiana State University, New Orleans, Louisiana*

We have continued characterizing the detectors and electronics for the SAMURAI Si project. Based on the results of our earlier in-beam tests at HIMAC facility [1], we have acquired new TTT2-500 double-sided silicon strip detectors (DSSSD). The new detectors are 500 µm thick, increasing the effective thickness by ~67% compared to the old 300 µm. To verify the performance of these new TTT2-500 detectors, and to see if increased thickness helps with proton detection, we have measured the responses of both 300 and 500 µm thick versions with 50 MeV protons from K150 cyclotron here at the Cyclotron Institute.

For these tests we used the present revision of the HINP16C chips. Both detectors were calibrated with a 4 species alpha source (^{148}Gd, ^{239}Pu, ^{241}Am, ^{244}Cm). The responses for 50 MeV protons were measured with the detector rotated at 8 degrees (to avoid channeling) and also at 30 degrees rotation to see that the energy deposit changed accordingly with the increased effective thickness. In both cases, behind the TTT2 detector was a 1 cm thick CsI detector with 32 elements coupled to standard NIM electronics to provide an independent trigger for the acquisition. In this experiment we also ran the TABS acquisition system by using the Cyclotron Institute DAQ software (CycApps) for the very first time. This allowed more convenient online monitoring than the NSCL DAQ that we have used previously.

Based on the source calibration, the 50 MeV proton energy deposit was observed to be close to the expected value in each case, as seen in Fig 1. The discrepancies are most likely due to the fact that the detector dead layer (Al contact + the implantation layer in Si) is only an estimate based on the Micron



	TTT2 - 306 um		TTT2 - 544 um	
	8 deg	30 deg	8 deg	30 deg
LISE++	712	816	1271	1458
Measured	700	790	1249	1418

(quadratic α-calibration, assuming 0.5 um dead layer)

FIG. 1. Responses of TTT2-300 and 500 type detectors to the 50 MeV proton beam.

Semiconductor Ltd. specifications and for the fact that the lowest calibration energy is at 3.2 MeV, while the proton energy deposits are about 1.5 MeV. It is worth noting that while there is an offset in the energy compared to that expected (from LISE++ calculation), the energy deposit changes as expected when the effective thickness of the detector is increased in both cases.

The system was triggered with the CsI array, but also the triggering from the HINP16C chips was tested as shown in Fig. 2. We found that the electronics noise level was rather low, about 200 keV at worst. However, this may not be quite exact as it is known that the linearity of the present revision of the HINP16C chip is not very good below 0.5 MeV. The WU group will study the linearity in offline tests to provide a better estimate for the observed noise level. Based on this test it is likely that we saw proton responses in the test last year at HIMAC, but that the thresholds were too high in most channels giving poor efficiency. This gives a rather good foundation for testing the next evolution of the HINP chip to be produced later this year.

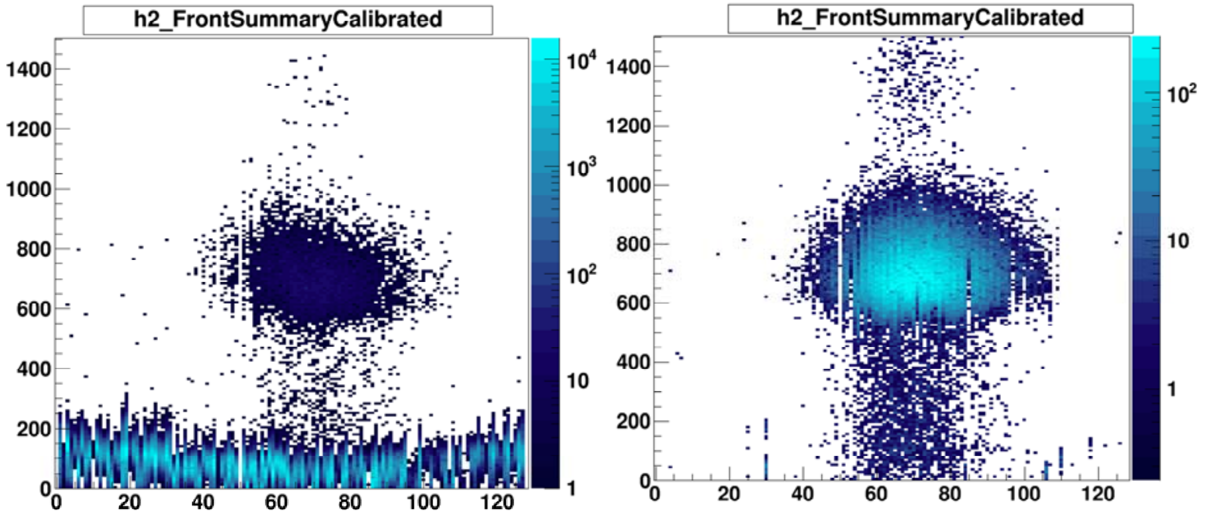


FIG. 2. Effect of triggering thresholds to the detection efficiency by individual strips (x-axis). Energy scale (y-axis) is in keV. Left side: Low thresholds (trigger mostly from noise) TTT/CsI = 12.5k/131k. Right side: Higher thresholds, cutting away noisy channels (trigger rate few Hz w/o beam), TTT/CsI = 21.9k/21.6k. In both cases the DAQ was triggered by the CsI array behind the Si detector and the thresholds of Si were adjusted as described.

[1] A. Saastamoinen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2012-2013), p. IV-55.