Response to the Coordinate Detector Review Report

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March 22, 2014

This document is a response to the technical review of the proposed Super Bigbite Spectrometer (SBS) Coordinate Detector (CDet) which was held on February 25, 2014. We would like to thank the panel for the thorough review of the CDet project and for the valuable input and recommendations on the proposed design of the detector.

The primary charge to the review panel was to evaluate the performance parameters of the CDet as listed in Table 1 of the *CDet Design Report*. These parameters are the best that we thought will be possible to achieve in the proposed scintillator-based design of the detector. But the Table in the *Design Report* should have been amended with the parameters which are needed by the experiment and the review asked to comment on both sets. The Table below lists both sets of these parameters.

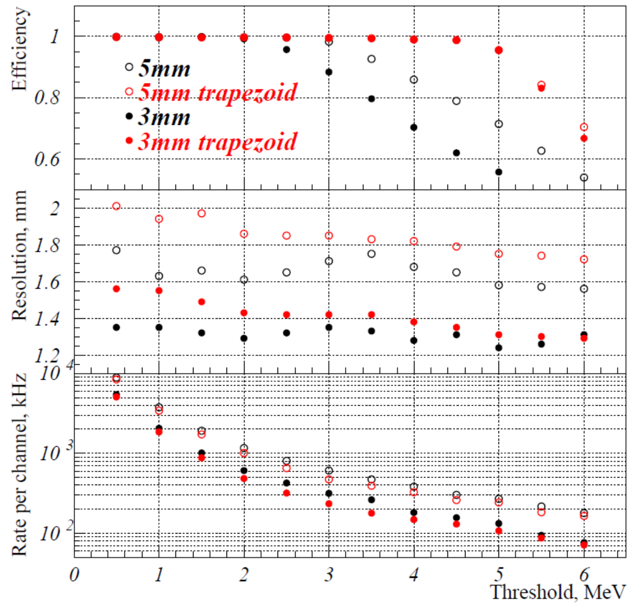
Performance parameter	Best expected	Needed
Coordinate resolution, per plane	1.8 mm	3.0 mm
CDet coordinate resolution	1.3 mm	3.0 mm
Time resolution	0.8 ns	10 ns
Efficiency per plane	99%	95%
Background rates per bar	0.4 MHz	2.0 MHz
Electronic dead time (50 ns per pulse)	2%	10%

Construction/Design Concerns

In view of the significant discussions that took place during the review and the issues that were raised regarding the scintillator bar fabrication plans, we have decided to have the scintillators made **without the $Ti0_2$** coating intended for improving the internal light collection. This will avoid the loss of efficiency due to the thickness and non-uniformity of the TiO_2 coating. Instead, the scintillators will be wrapped in ¼ mil thick aluminized Mylar for light collection efficiency.

The extruded scintillator will be made in a **rectangular shape** and the top and bottom faces will be machined to make the thickness uniform to within 100 μm over its length (Eljen Technology is providing a cost estimate for the machining process). While stacking the plates, the pointing of the scintillator to the target will be measured continuously and adjusted by applying proper shimming using tape.

In the GEANT MC comparison between the trapezoidal and the rectangular shapes of the bar, we presented the two extremes. As shown in the figure below from the GEANT simulation report, at a



threshold of 4 MeV, the rectangular bars **without rotation/tilt** have an efficiency of 0.85, a background rate that is about 20% higher and the coordinate resolution is about the same.   While the performance of the rectangular bars with no rotation is unacceptable, with shimming to orient the rectangular bars the performance will become much closer to that of the ideal trapezoid. We agree that more MC works needs to be done to confirm the precision that will be needed for guidance in the assembly criterion.

Light-yield Concerns

We agree that the light yield estimates in the *Design Report* may be too large, up to a factor of 2. However, even if we have 50 photoelectrons, statistically this number is high enough and will not change the signal distribution shown in the *Design Report*.

The timing resolution of 0.8 ns for the CDet is a goal. In the original GEM-based design only 10 ns timing resolution was required. Even if we cannot achieve 0.8 ns, if the photo-statistics is lower, the improvement of the timing resolution over the original requirement will be significant.

Pixel Gain Non-Uniformity

We have gone through the data on the 602 maPMTs to find the 162 units needed for the experiment. The number of PMTs which had a given gain variation for 14 or more pixels are tabulated below.

Variation in gain	Number of tubes
0.95 to 1.05	0
0.90 to 1.10	7
0.85 to 1.15	63
0.80 to 1.20	125
0.75 to 1.25	189
0.70 to 1.30	269
0.65 to 1.35	346
0.60 to 1.40	415
0.55 to 1.45	469
0.50 to 1.50	520

We see from this Table that 189 PMTs have variation in gain of ±25% or better, while we need 168 PMTs for the detector. We would use the best maPMTs in the first layer of the detector. Given the variation in gain, the optimum choice for efficiency would be to raise the threshold from 3.5 MeV to 4.0 MeV, since the efficiency is still high at 98% and the rates are low enough so that the average dead time is ~2.4%. In the first layer all PMTs with a variation of ±20% would be used, so the effective lowest threshold would be 2.7 MeV which gives a rate of about 0.5 MHz. For the second layer of the detector, PMTs with a gain variation of ±25% would be used, so the effective lowest threshold would be 2.4 MeV, which gives a rate of about 0.7 MHz.

Threshold/Rate Concerns

During the review the question arose: "*What would happen if the background rates are 2 or 4 times higher than estimated?*" Our quick response to this question at that time was to reduce the beam current. After more thought, it would be better to increase the thickness of the plastic absorber in front of the scintillator. Experience in Hall A during the RCS experiment shows that increasing the plastic absorber thickness by 5 cm reduces the background rate by a factor of 3. The increase in the thickness from 15 cm to 20 cm would worsen the position resolution only slightly. A prudent approach to the design would be to assume a thicker absorber initially and then if the measured rates are as expected, to reduce the thickness at the start of the experiment.

Summary and Recommendations

1. Response in "Construction/Design Concerns" section.
2. Presently, we are building a prototype to test mechanical and light tightness properties of the design. Making a fully functioning prototype would be a significant cost since a new die and scintillator would have to be made.
3. Response in "Pixel Gain Non-Uniformity" section.