

Joint Cosmic Ray Mitigation Task Force & ICARUS Cosmic Ray Tagger

Bob Wilson

SBN Program Director's Review
Detectors Breakout Session II
15 December 2015



Overview

- SBN Joint Cosmic Ray Mitigation Task Force
 - Being established
 - Proposed co-conveners:
 - Roxanne Guenette (SBND/MicroBooNE), Bob Wilson (ICARUS)
 - Building on substantial joint effort for the three-detector proposal submitted to Fermilab PAC early this year
 - First meeting of the (proto-)Task Force last Friday
 - RG, BW, Sowjanya Gollapini (MicroBooNE), Paola Sala (CERN), Umut Kose (CERN)
 - Joint technical meeting on Cosmic Ray Tagger designs yesterday.
- ICARUS Cosmic Ray Tagger
 - SBND presentation to follow (Igor Kreslo)

Task Force on Cosmic Ray Mitigation for SBN Detectors

(the following is extracted from the draft charge)

- Mitigation of cosmic ray backgrounds is needed for all three of the SBN detectors particularly to address showers that mimic the low energy electron signal from electron neutrino interactions.
- A Cosmic Ray Background taskforce is being created to more clearly define the requirements and implementation of the overburden and cosmic ray tagger systems for the SBN detectors.

Task Force on Cosmic Ray Mitigation for SBN Detectors

The general need for these mitigations has been identified but the necessary funding to build the desired systems is not fully in place:

1. The SBND tagger is being designed and constructed by the Bern group
2. Partial funding (1.2 MCHF) for the ICARUS-T600 tagger is included in approved WA104; this is not sufficient to construct the full desired system and is a potential area for scope from the DOE or another funding agency
3. The Bern group has proposed to construct the MicroBooNE tagger, however the current funding may not be sufficient to cover both SBND and MicroBooNE. Design of the mounting system is not currently funded.
4. Designs of overburden for each detector are being developed. The current funding plan includes overburden for SBND and ICARUS in FY2018. Funding has not yet been identified for MicroBooNE

Task Force on Cosmic Ray Mitigation for SBN Detectors

The following questions should be considered in the context of the ν_e appearance signal channel

Overburden Questions

- What is the necessary thickness of overburden (1m, 2m, 3m) for each of the detectors? What is the impact on primary particles? What is the impact on secondary particles?
- Are the most up to date building geometries (including feasible overburden configurations) being used?

Cosmic Ray Tagger (CRT) Questions (just a subset shown here...):

- Is a two-layer system providing a hit coincidence required or can a single layer system provide the necessary cosmic rejection?

Task Force on Cosmic Ray Mitigation for SBN Detectors

Cosmic Ray Tagger (CRT) Questions (contd.):

- What is the **loss of neutrino signal efficiency from neutrino “auto-veto” interactions inside the LAr creating signals in the cosmic tagger detectors?** What is the difference in the efficiency loss between a single layer system and a two-layer system?
- What is the impact of **radiogenic sources** (e.g. from concrete of building or overburden) on the neutrino signal efficiency?
- What is the impact on cosmics detection efficiency and/or neutrino signal loss from: **Partial or full layer coverage under the TPC**
- What **additional rejection** does the cosmic ray tagger system provide for each of the detectors relative to relying on overburden and the internal light collection systems alone?

Task Force on Cosmic Ray Mitigation for SBN Detectors

Cosmic Ray Tagger (CRT) Questions (contd.):

- Identify areas where a common technical solution can be used for SBND, MicroBooNE and ICARUS-T600, ...
- The CRT systems will need to be installed in a staged fashion due to resource limitations and interference with installation and commissioning of other components. What are the best strategies for this staging based on possible funding and installation scenarios?

Task Force on Cosmic Ray Mitigation for SBN Detectors

Cosmic Ray Tagger (CRT) Questions (contd.):

- Identify areas where a common technical solution can be used for SBND, MicroBooNE and ICARUS-T600, ...
- The CRT systems will need to be installed in a staged fashion due to resource limitations and interference with installation and commissioning of other components. What are the best strategies for this staging based on possible funding and installation scenarios?

A preliminary report from the task force should be provided by January 31, 2016

ICARUS-T600 Cosmic Ray Tagger Concept

Technology/Configuration

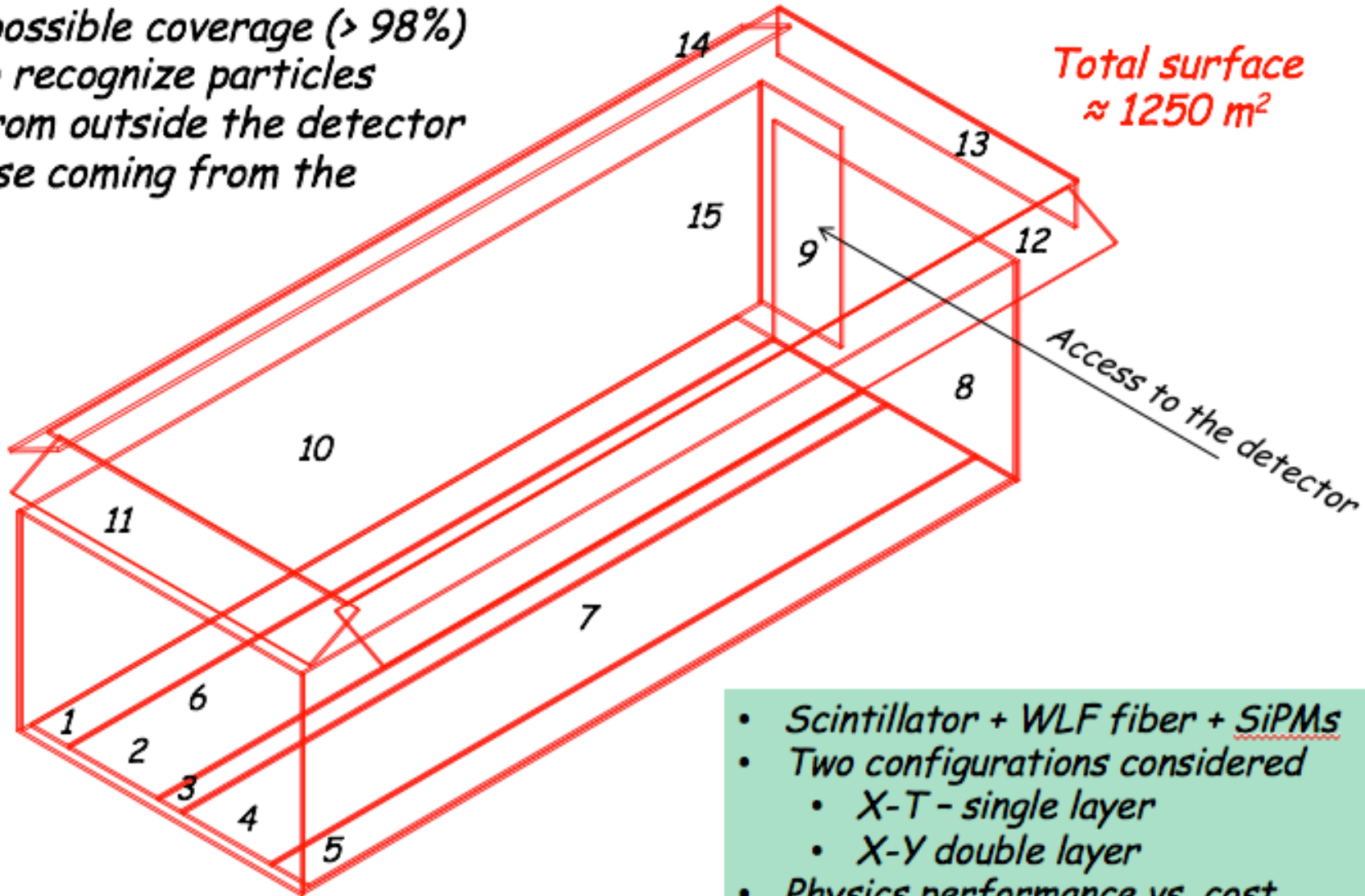
- Based on past experience and solution adopted by SBND select **Scintillator + Wavelength-Shifting (WLS) fiber + Silicon PMs**
- Joint effort of (new) ICARUS US groups & CERN w/ help from Bern group
- Natural configuration choice – follow SBND two-layer (X-Y) solution - see following talk (I. Kreslo)
- **Cost consideration: SBND CRT ~400 m² vs. T600 CRT ~1200 m²**
- Investigate potentially cheaper options: single layer X-T, where time measurement at each end gives 2nd dimension
- X-T used in T2K ND280 muon system, meets SBN requirements
 - Only ~90 cm long, need to verify for longer counters
 - Data from 200 cm WAGASCI prototypes by INR group
 - Signal 3-4 p.e. at furthest point is uncomfortably low

Technology/Configuration

- Based on past experience and solution adopted by SBND chose **Scintillator + Wavelength-Shifting (WLS) fiber + Silicon PMs**
- Joint effort of (new) ICARUS US groups & CERN w/ help from Bern group
- Natural configuration choice – follow SBND two-layer (X-Y) solution - see following talk (I. Kreslo)
- **Cost consideration: SBND CRT ~400 m² vs. T600 CRT ~1200 m²**
- Investigate potentially cheaper options: single layer X-T, where time measurement at each end gives 2nd dimension
- X-T used in T2K ND280 muon system, meets SBN requirements
 - Only ~90 cm long, need to verify for longer counters
 - Data from 200 cm WAGASCI prototypes by INR group
 - Signal 3-4 p.e. at furthest point is uncomfortably low
- Pursue efforts for higher light yield; investigate additional SiPM candidate
- Develop conceptual design for mounting scheme and cost – focus on X-T but consider also X-Y
- Simulation of impact of 1 vs. 2 layer CRT on physics is underway

Cosmic Rays Tagger – Conceptual design

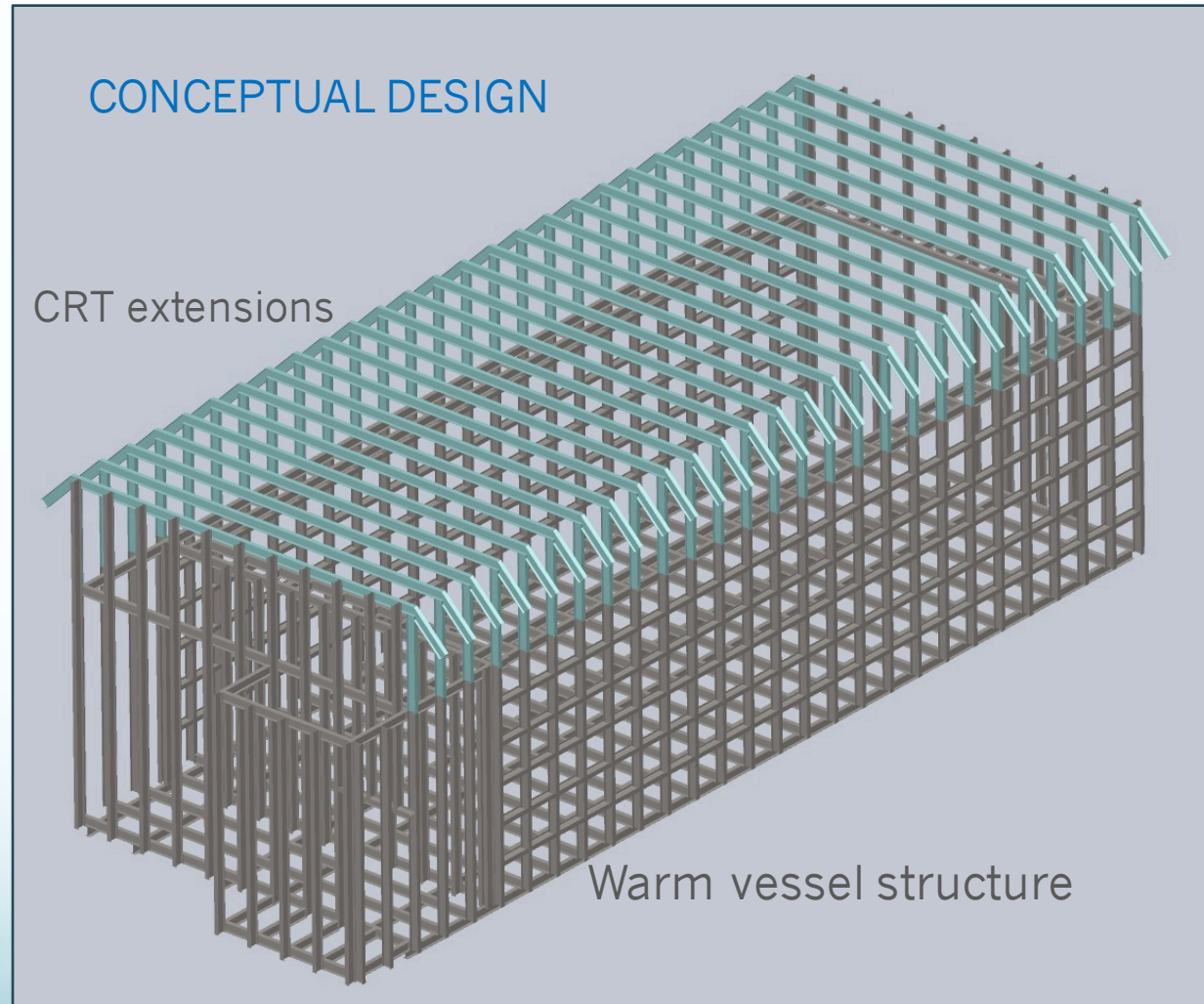
*Largest possible coverage (> 98%)
Timing to recognize particles
coming from outside the detector
from those coming from the
inside.*



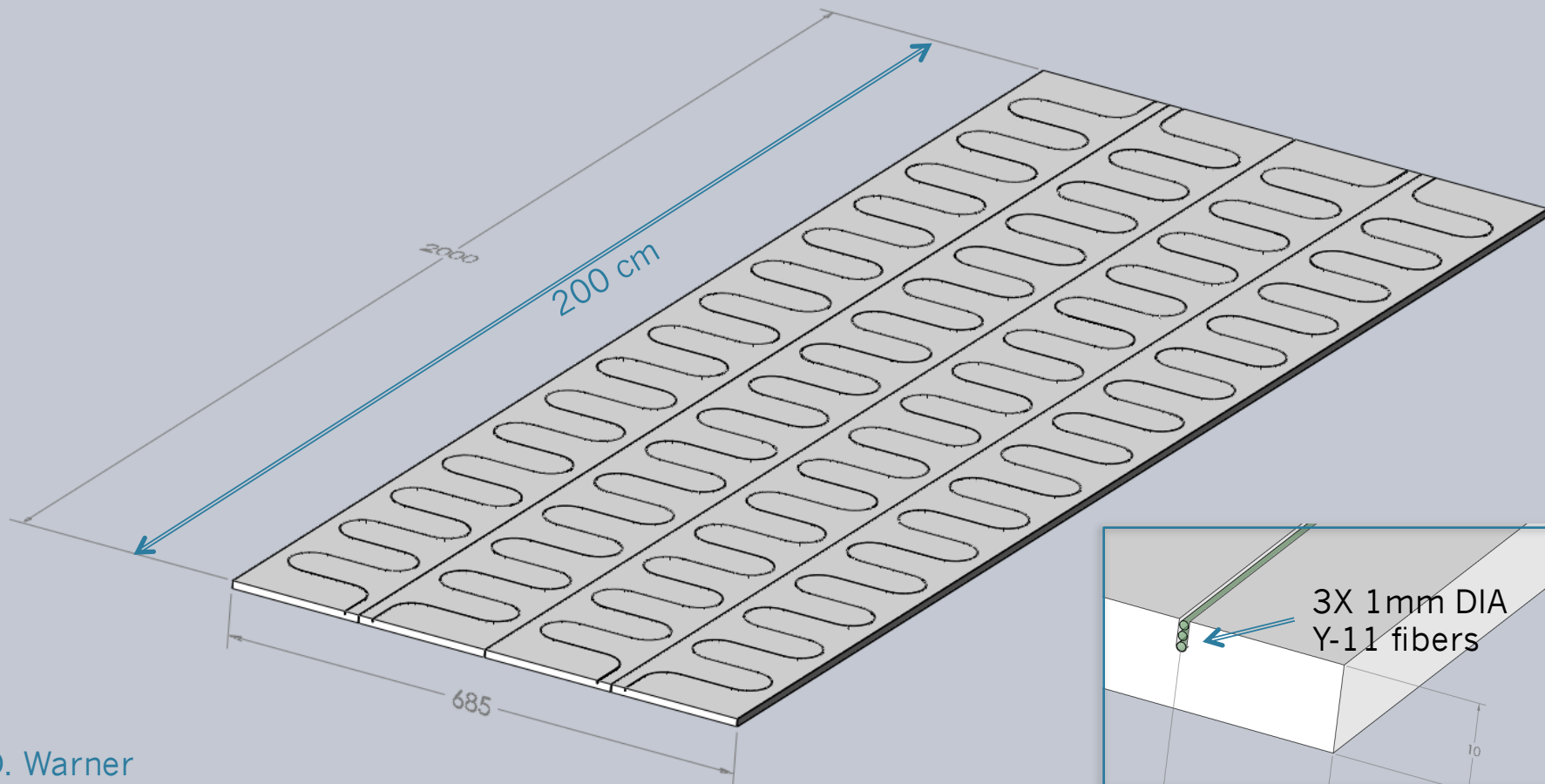
- *Scintillator + WLF fiber + SiPMs*
- *Two configurations considered*
 - *X-T - single layer*
 - *X-Y double layer*
- *Physics performance vs. cost*
- *More details in breakout session*

Modifications to Warm Vessel to Facilitate CRT Mounting

- Beams (teal) added to support upper modules
- Side and end beams extended to enclose upper services
- Steel roof added to support top modules – *could mount on concrete ceiling*
- Side/Top modules clip to flanges of warm cryostat beams
- Modules below the warm vessel slide in tracks to allow for installation after cryostat is installed



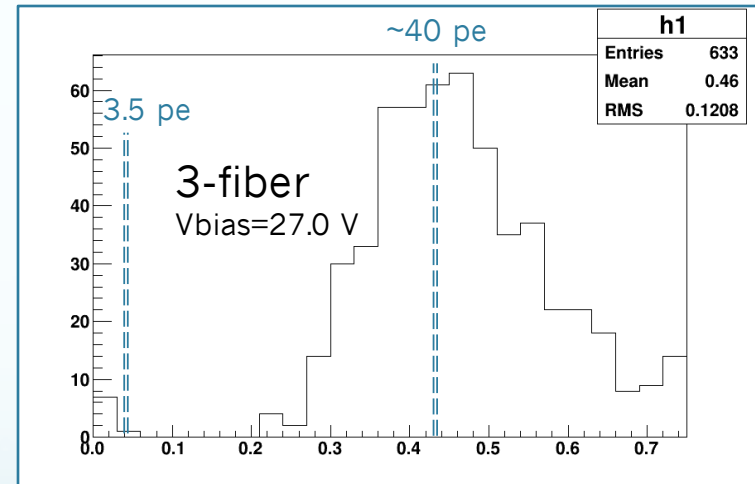
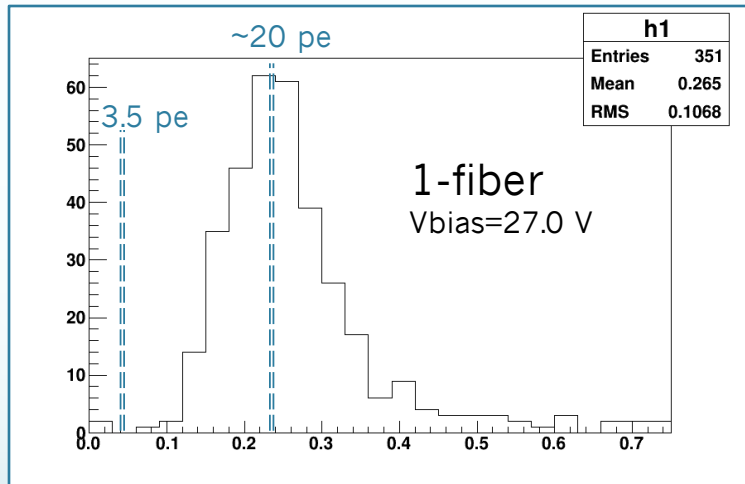
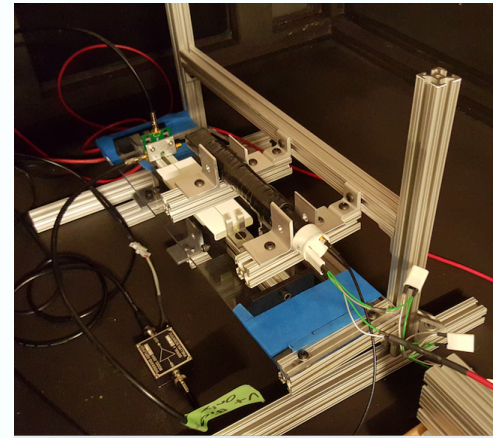
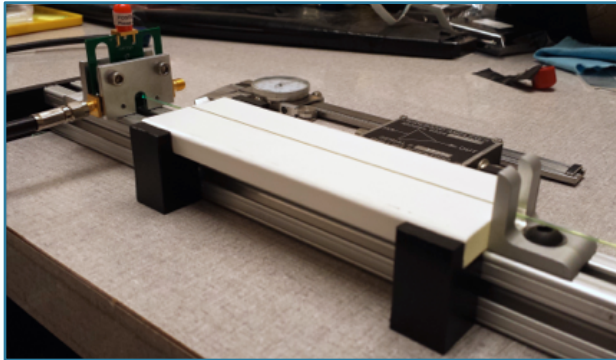
X-T Module Concept



D. Warner

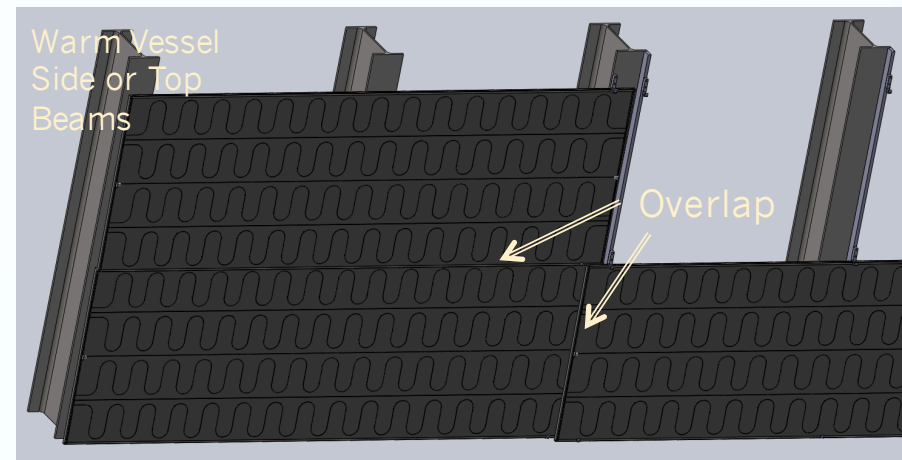
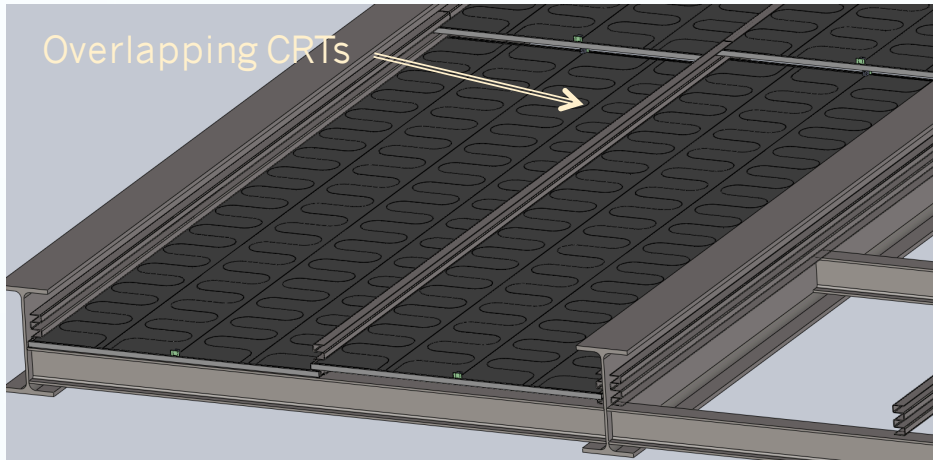
Use time/amplitude from each end to get longitudinal hit position
Based on T2K ND280 & WAGASCI counters
2 m counters w/ single fiber yield ~20 pe near end / 4 pe far end

Multi-Fiber Light Yield



- 1 fiber -> 3 fibers provides factor 2 increase
- Sufficient for high efficiency in > 5 m WLS fiber in 2 m X-T counter

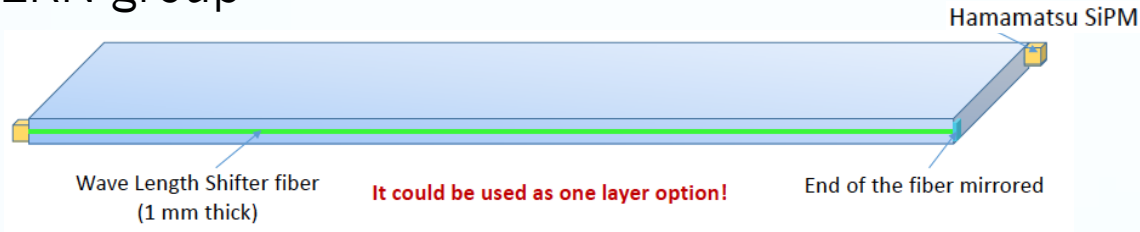
Module Mounting Concepts



- Side and top CRT panels mount to outside of warm vessel structure
 - Panels overlap in both directions -> ~1% dead area
- CRT panels under the warm vessel supported by rails mounted to support beam
 - Panels overlap in both directions
 - ~3% dead area due to support beams and structure
- All panels may be installed after warm vessel installation
- ~900 panels for full coverage 2m X 685mm X-T design

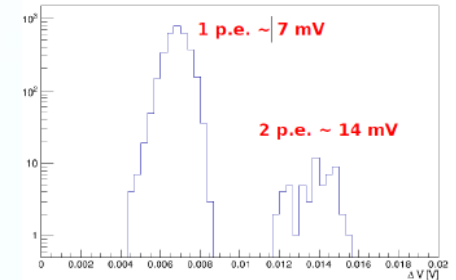
X-Y Concept: Variation on SBND Design

CERN group

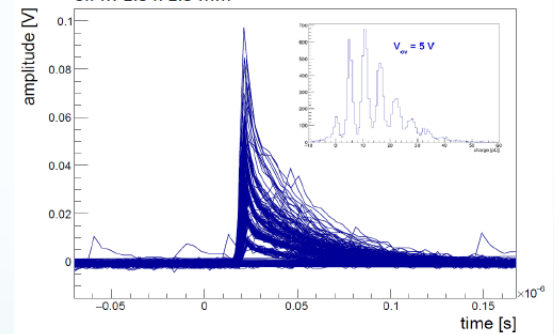


Hamamatsu MPPC

SiPM 1.3 x 1.3 mm²



Peak amplitude distributions



2 x 2 m² single CRT module:

- 20 scintillators (10 in X and 10 in Y)
- 40 Fibers
- 40 SiPM
- Granularity of 20 x 20 cm²



Potential partners in Czech Republic
- 8 scintillator samples with different compositions to improve light yield

Conceptual Design-Level Cost Estimates

- Cost estimates – in progress
 - Completed at conceptual design level for X-T modules
 - Comparison of X-T and X-Y core material and basic assembly costs almost complete
- Materials costs based on quotes/estimates for major components: scintillator extrusions (Fermilab), SiPMs (SensL), WLS fiber (Kuraray), electronics (CAEN using Bern design for SBND)
- Do not yet have full costs for
 - Installation
 - Cables, power supplies, DAQ
 - *Spares, contingency, escalation*

ICARUS-T600 CRT: Funding/Staging

- Funding
 - WA104 agreement provides for 1.2 MCHF towards CRT equipment (fabrication)
 - Preliminary cost estimates confirm that committed funding is insufficient on the order of a factor of 2
 - Funds for engineering/design/development of conceptual design in US provided by Fermilab
 - Discussions with Fermilab (+DOE) for production funding
- Staging options under discussion
 - Fully functional partial coverage e.g. sides and bottom first
 - Fully functional partial “telescope” coverage e.g. single layer above and beneath overburden
 - Full coverage but not instrumented initially

Conclusion

- A Task Force is being formed to advise the Fermilab Short-Baseline Program on the physics impact and cost effectiveness of cosmogenic background mitigation strategies not currently in the program budget
- Overburden is a priority and funding identified in 2018 for SBND and ICARUS-T600; a study is needed to determine optimal thickness; funding is sought for MicroBooNE
- Cosmic ray taggers are requested by all three detectors; SBND has an advanced and funded design; Bern will also provide detectors and electronics for MicroBooNE; funding for CRT mounting and installation for SBND and MicroBooNE has yet to be identified

Conclusion

- A Task Force is being formed to advise the Fermilab Short-Baseline Program on the physics impact and cost effectiveness of cosmogenic background mitigation strategies not currently in the program budget
- Overburden is a priority and funding identified in 2018 for SBND and ICARUS-T600; a study is needed to determine optimal thickness; funding is sought for MicroBooNE
- Cosmic ray taggers are requested by all three detectors; SBND has an advanced and funded design; Bern will also provide detectors and electronics for MicroBooNE; funding for CRT mounting and installation for SBND and MicroBooNE has yet to be identified
- ICARUS-T600 is near completion of a conceptual design with costs for two approaches; the physics impact of the options is being investigated. Down select of the options may be possible on the 6 month timescale