Status of CRT Simulation

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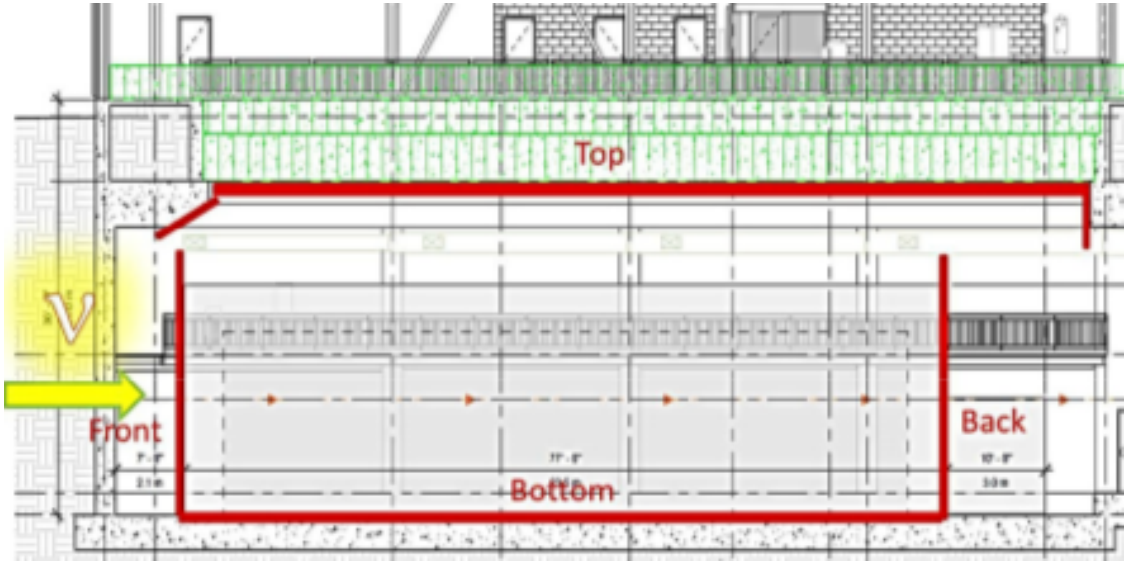
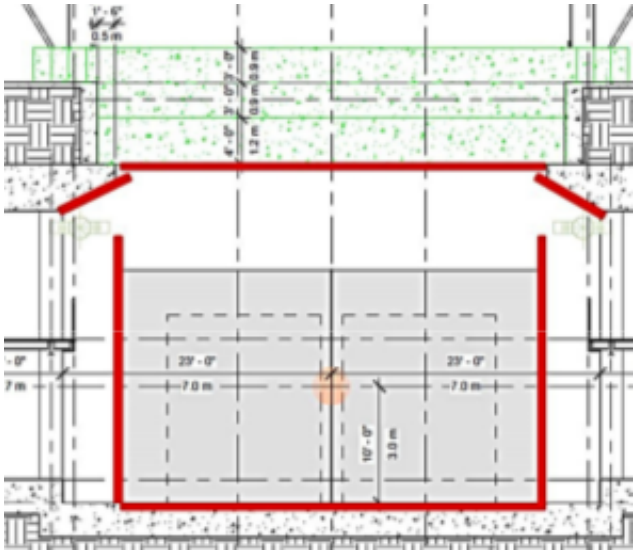
ICARUS Collaboration Meeting
Fermilab, 14 May 2018

Previous Simulation Work

- Cosmic simulation (generation/propagation) performed for SBN proposal via FLUKA
- Initial analysis presented in internal note *Cosmic Ray Tagger*. M. Nessi, U. Kose, P.R. Sala, et al. 20 May 2015
- Planned CRT geometry unknown at the time, CRT approximated as two-layer slabs of plastic scintillator providing 4π coverage

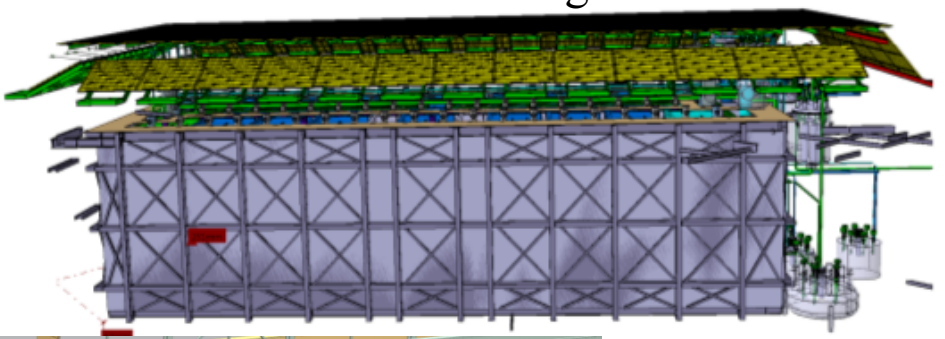


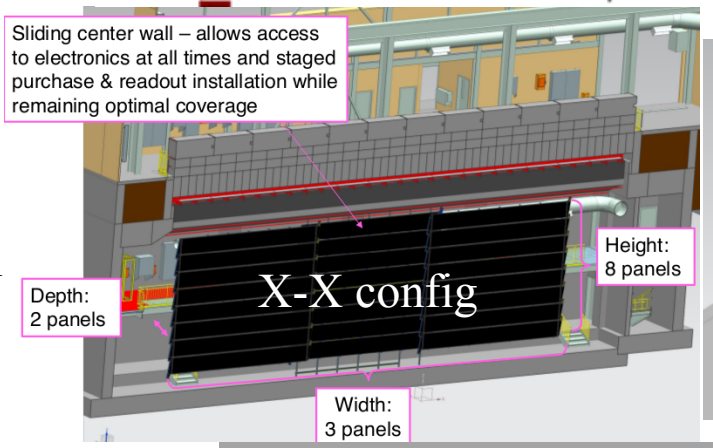


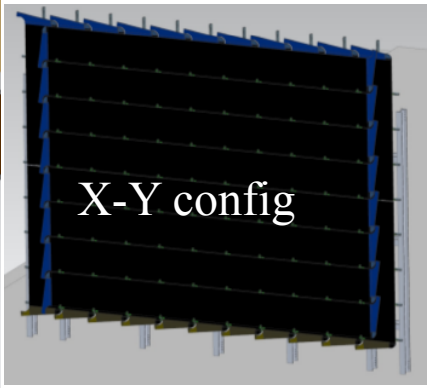
CRT Subsystems

- Three systems based on polystyrene scintillator and WLS fibers
- Collaborative effort between Europe and US
  - CERN & Bologna constructing new modules similar to SBND design
  - Repurposed MINOS FD scintillator modules with a new SiPM based readout by FNAL and CSU, mechanical installation planned for this summer
  - Re-use of Double Chooz veto modules by FNAL in collaboration with UChicago and VT, installed last summer
- Extra complications for DAQ, simulation and analysis

X-Y config







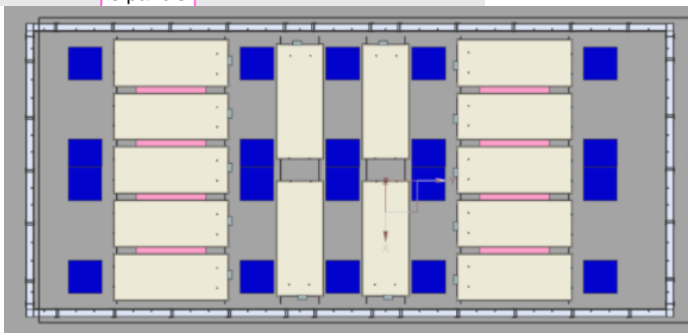
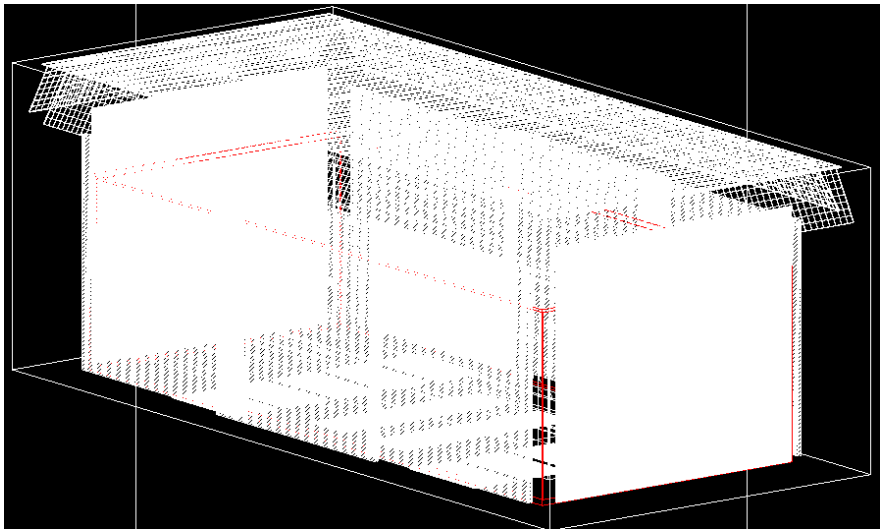


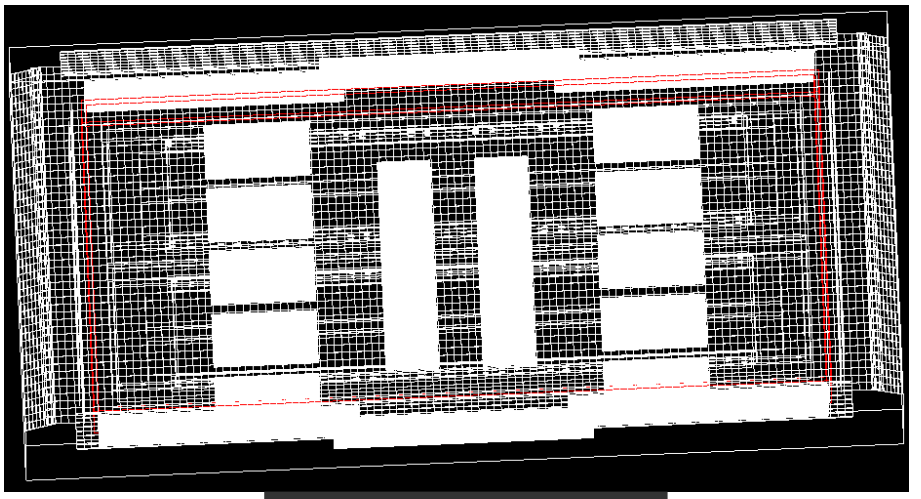
*Photo credit: Justin Tilman

X-X config

Geometry

- Note actual system does not provide 4π coverage!
  - Some gaps in sloped top and sides may be covered with spare side modules (not considered here)
  - Sparse coverage on bottom due to installation constraints
- CRT, cryostats, TPCs, overburden, and detector hall described in gdml
- Each CRT module approximated as polystyrene strips contained in an Al box according to known dimensions
- Current CRT description will need to be updated once final module positions are known

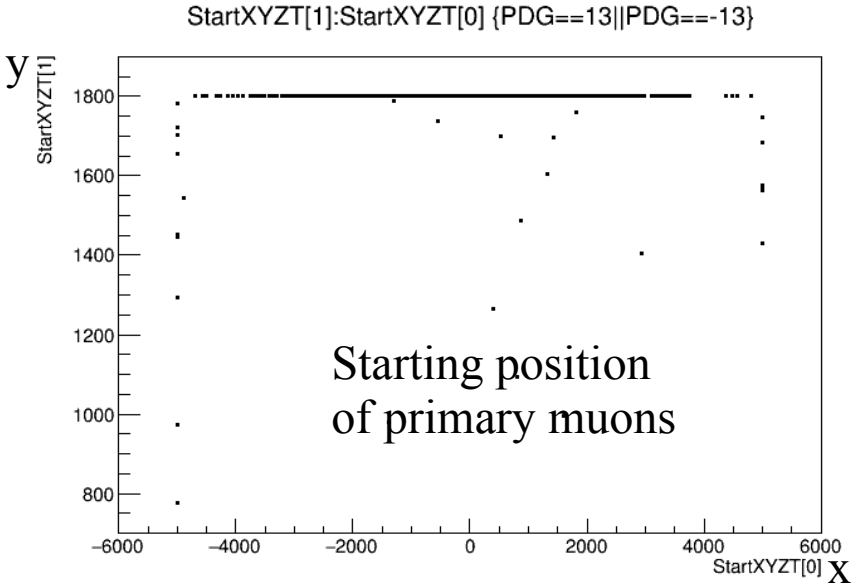


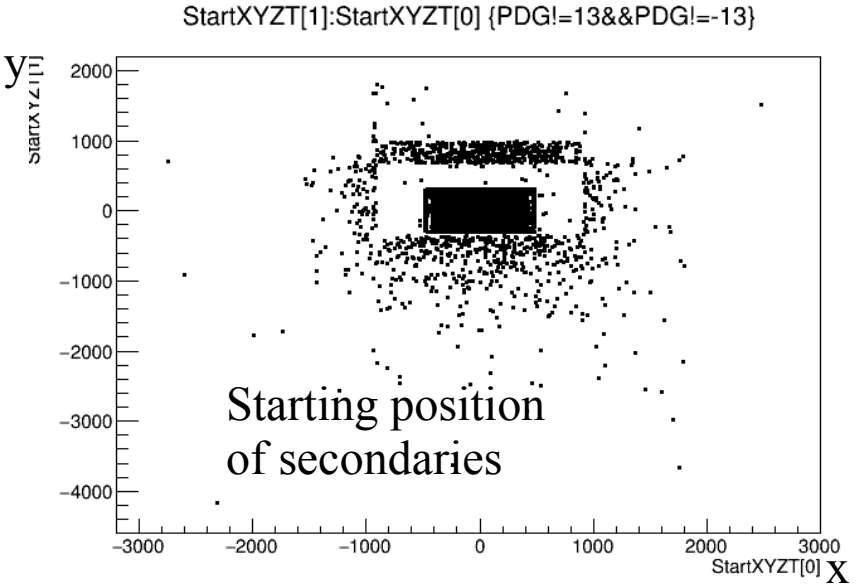


Outer cryostat
CRT strips

Cosmic Simulation with CORSIKA

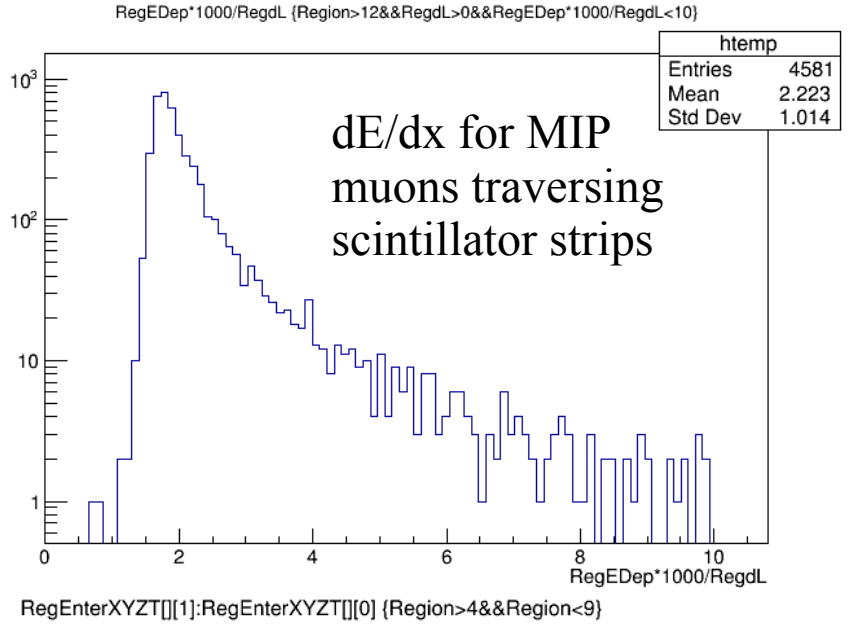
- 3m-thick concrete overburden
- Same flux files used in current uBooNE and SBND simulations
- Buffer box (distance beyond cryostat): [-500.0, 500.0,-300.0,300.0,-600.0,600.0] cm
- Sample time: 3.3ms ~ 3 drift times
- CMC model used
- Elevation of primary surface w.r.t. cryostat center: 18m
- For first studies, using filter after generation stage to select only primary muons entering cryostat

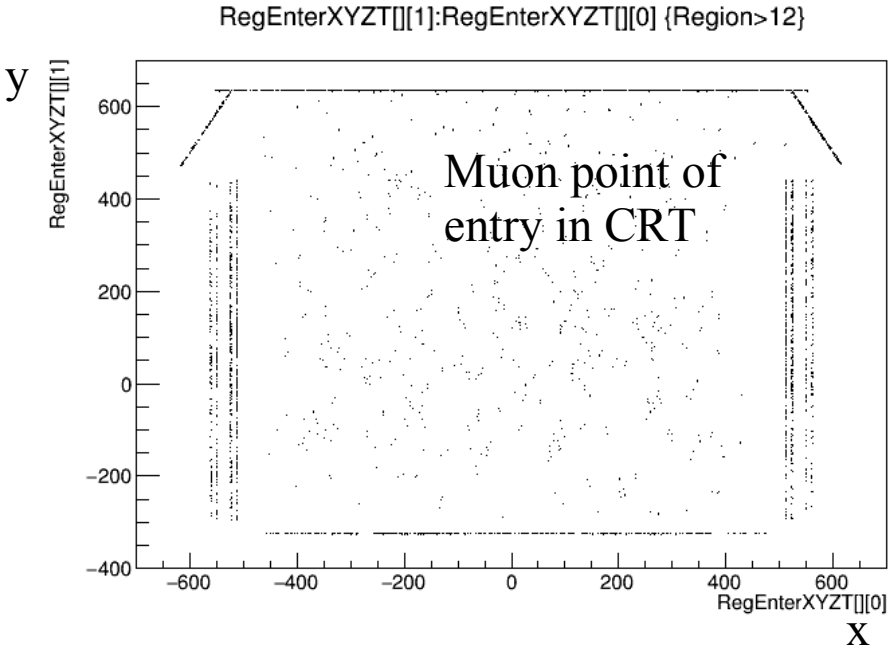


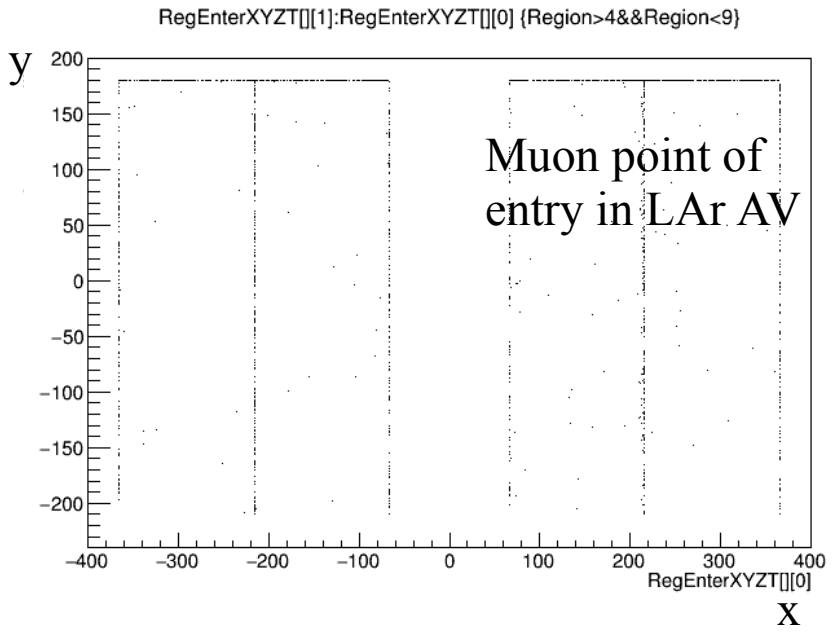


Geant4 Stage Validation (in Progress)

- Use particle gun and cosmics for sanity checks
- Reproduce previous studies based on older simulation
  - Rates of cosmic muons in CRT, TPC
  - Rates of cosmic γ's in different timing, topology groups outlined in SBN proposal
  - CRT efficiencies







Comparison to Previous Results

LAr Volume	Mu Rate (kHz)
All	24.1
Inactive only	8.7
Active	15.5

Previous result:
11 kHz in fiducial volume
35 kHz in CRT

CRT Geometric Efficiency		
# CRT Strips	IV Only (%)	AV (%)
> 0	99.2	99.5
> 1	98.2	98.6
> 2	44.7	42.1
> 3	34.9	34.8
Vector	34.9	34.5

Previous result:
99.9% hit at least one module
78% give vector (4π coverage)
15% give vector (no bottom)

Muon Crossing AV w/ or w/o gamma		
CRT Region	Fraction (%)	Prev. Result (%)
Top	65.0	66
Back	1.7	1
Front	2.3	3
Left	9.4	8
Right	10.0	8
Sloping Lateral	8.8	12
Sloping Front	1.9	2
Sloping Back	0.8	0.4
Bottom	0.2	0

Observe good agreement between previous and current results!

Near-Term Goals

- Finish simulation validation through G4 stage
- Reproduce and extend previous studies on cosmogenic γ's
- Study possible trigger configurations of interest for acquiring background and calibration samples, useful for DAQ group
- Implement detector response for each CRT subsystem
- Develop CRT reconstruction tools for cosmic muon removal

Longer-Term Goals

- Develop CRT-PMT-TPC event matching tools
- Investigate use of CRT in tagging “dirt” events, impact on backgrounds
- Validate CRT response with real CRT data once installed, commissioned
- Work with Tom Brooks from SBND to keep CRT related code as detector agnostic as practically possible
- Determine form of CRT data product (to be used with simulated and real data)