DUNE Trigger Description and Update

David Last[1] and David Rivera[1]

[1]University of Pennsylvania

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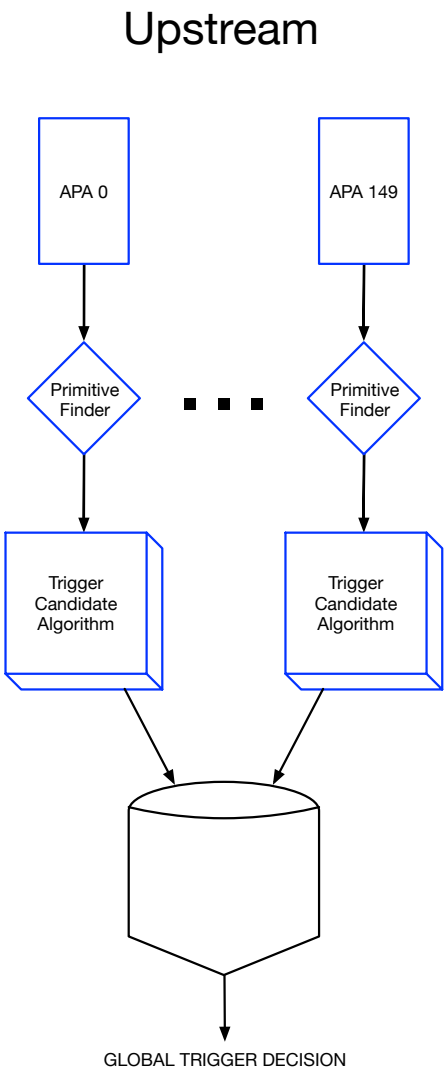
Introduction



Flow Diagram

- DUNE will utilize a Software (SW) Trigger
- Data volume is large
- Detector segmented by 150 APAs
- Primitive and Trigger Candidates will be generated on the fly at the APA level
- focus only on collection wires

Primitive Generation

- **Previous Studies:**
  - RawHit-based finder in reconstruction
  - default noise
- **MCC11 and Onward:**
  - Phil's tools – operate on data or simulation
  - Allows for noise to be added post detector simulation → Reusable
  - Develop custom primitive finding algorithms

```
recob::Hit::Hit  raw::ChannelID_t  channel,
                 raw::TDCtick_t    start_tick,
                 raw::TDCtick_t    end_tick,
                 float             peak_time,
                 float             sigma_peak_time,
                 float             rms,
                 float             peak_amplitude,
                 float             sigma_peak_amplitude,
                 float             summedADC,
                 float             hit_integral,
                 float             hit_sigma_integral,
                 short int         multiplicity,
                 short int         local_index,
                 float             goodness_of_fit,
                 int               dof,
                 geo::View_t       view,
                 geo::SigType_t    signal_type,
                 geo::WireID       wireID
                )
```

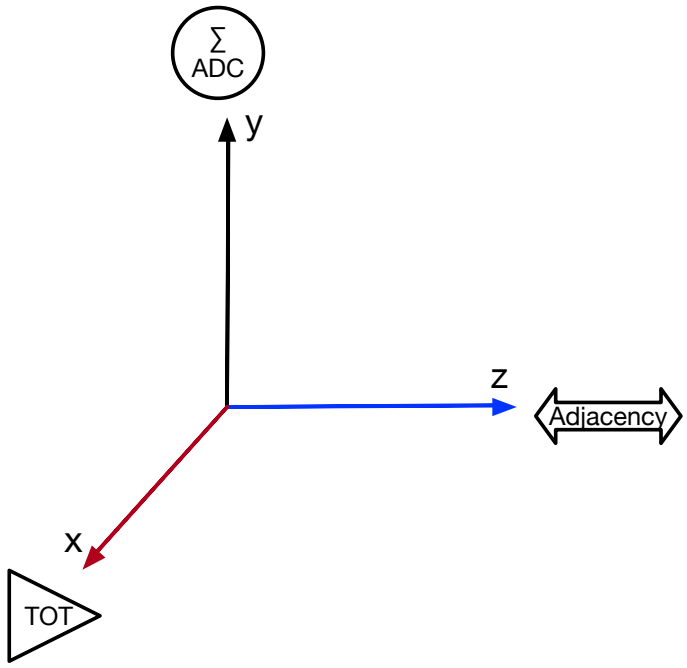
Parameters

channel	ID of the readout channel the hit was extracted from
start_tick	initial tdc tick for hit
end_tick	final tdc tick for hit
peak_time	tdc for the peak charge deposition
sigma_peak_time	uncertainty for tdc of the peak
rms	RMS of the hit shape
peak_amplitude	the estimated amplitude of the hit at its peak
sigma_peak_amplitude	the uncertainty on the estimated amplitude of the hit at its peak
summedADC	the sum of calibrated ADC counts of the hit
hit_integral	the integral under the calibrated signal waveform of the hit
hit_sigma_integral	uncertainty on the integral under the calibrated signal waveform of the hit
multiplicity	how many hits could this one be shared with
local_index	index of this hit among the Multiplicity() hits in the signal window
goodness_of_fit	how well do we believe we know this hit?
dof	number of degrees of freedom in the determination of hit shape
view	view for the plane of the hit
signal_type	signal type for the plane of the hit
wireID	WireID for the hit (Cryostat TPC Plane Wire)

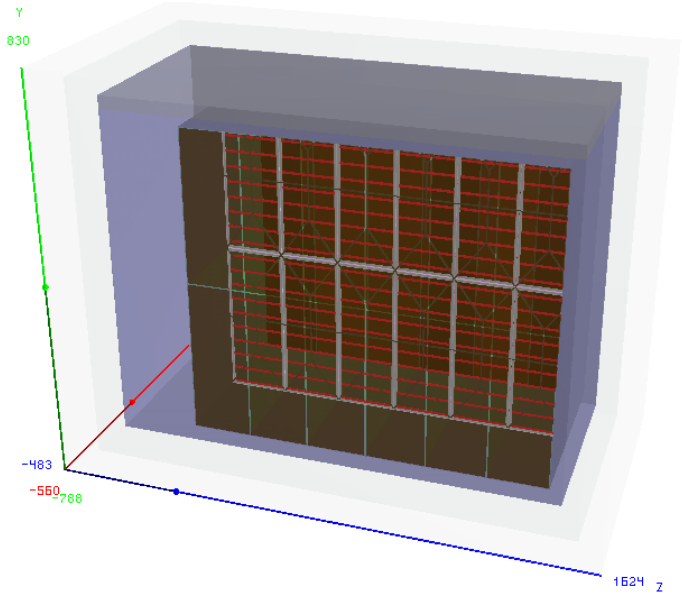
recob::Hit

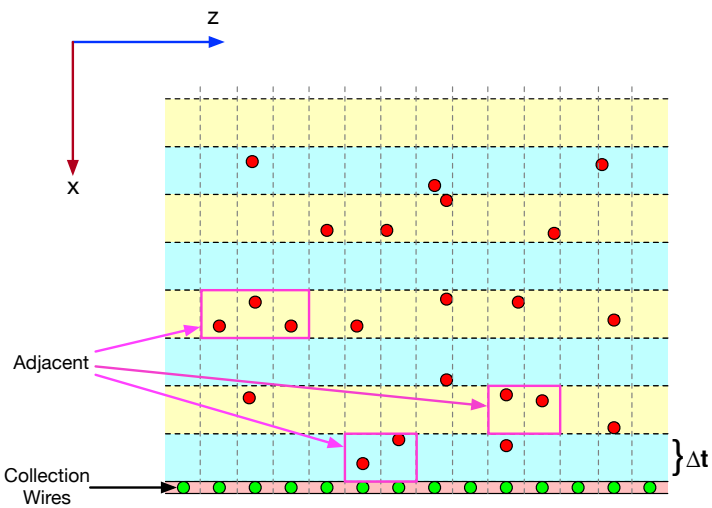
Definitions and Conventions

- **Time Over Threshold (TOT)** – Maximum number of ticks that a single hit is over threshold in a candidate window (end_tick - start_tick) .
- **TPC ADC (TADC)** – Sum of all ADC values above threshold for all hits in a TPC. The larger number between the two TPCs across an APA is chosen as the characteristic variable for the APA (ΣsummedADC).
- **Wire ADC (WADC)** – The maximum summedADC of a single hit in a window
- **Adjacency** – Maximum adjacent wire hit multiplicity in a candidate window (see next slide)



Procedure





Reminder : All studies utilize 1x2x6 Far Detector sub-geometry

Skim Stage:

- extracts information from the recob::Hit objects

Trigger Stage:

- takes outputs from the Skim stage and
- Sorts hits into APAs and TPCs
- Divides drift into 50 μs windows
- Loops through hits within the window and calculates the aforementioned quantities

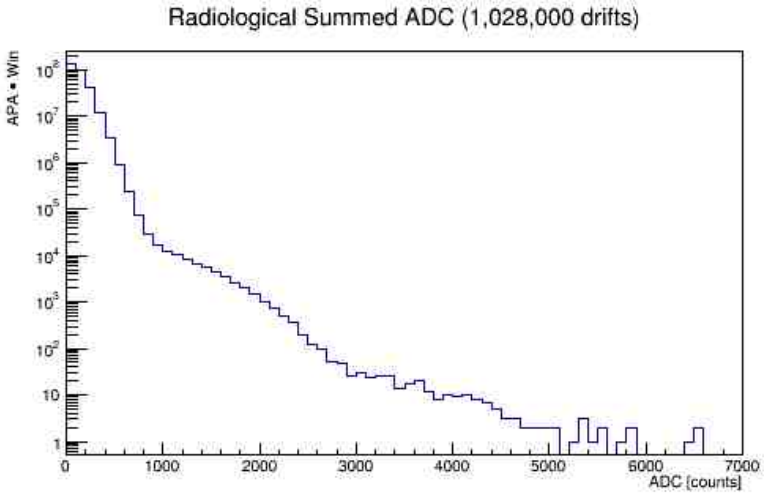
Selection Criteria

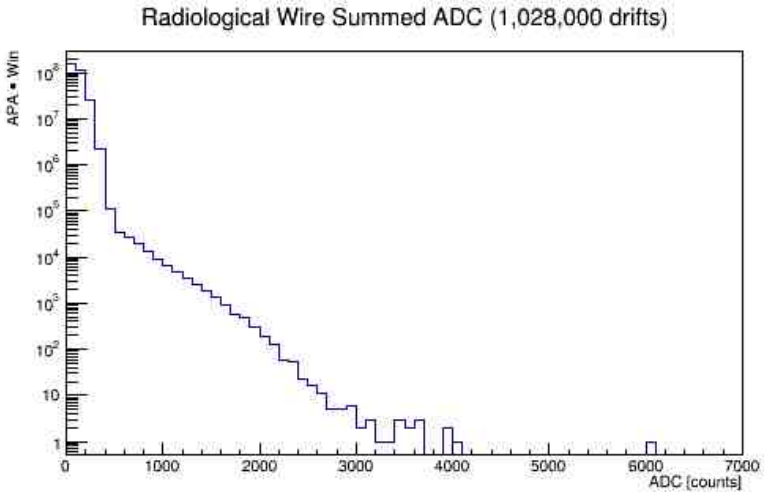
Event selected if the window with the highest TPC Summed ADC (TADC) meets **any** of the following conditions:

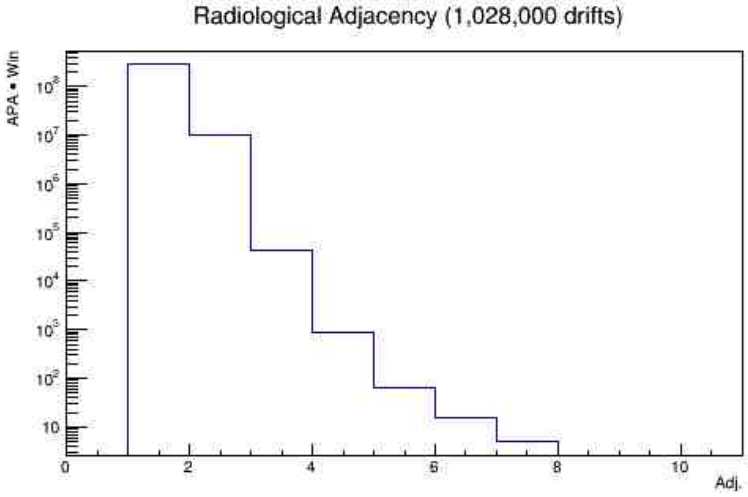
- TADC greater than or equal to 7000 counts
- WADC greater than or equal to 6500 counts
- Adj greater than or equal to 8 wires
- TOT greater than or equal to 45 ticks

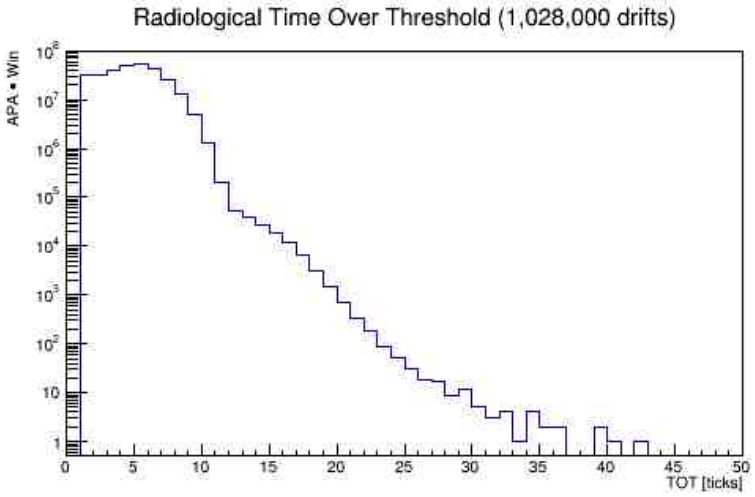
These are the "Keep All" Thresholds in this basis

Radiological Distributions

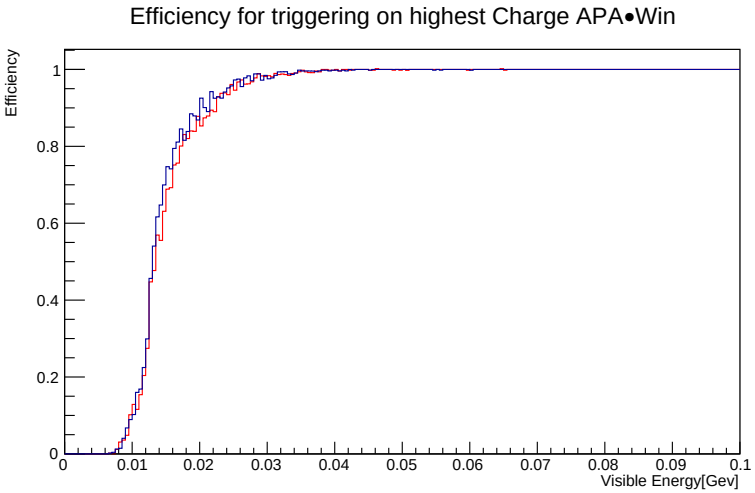








Electron sample



Red:fasthit, Blue:Primitive method

- "oldnoise" model – exponential noise model developed by D. Adams → ∼ 2.5 ADC counts RMS
- Threshold of 18 ADC → 1/2 MIP
- 10k, 1-100 MeV electrons produced at the center of a single TPC with randomized direction
- Visible Energy – energy depositions from ionizations in the active volume of the detector.
  - Sum over sim::IDE objects which are generated in the geant stage

Studies

Datasets:

- Radiologicals :
  - Radiological samples we generated with standard rates (see next slide)
  - MCC11 (currently being processed) $\sim$ 2M drifts with 5x rates for all radiologicals currently simulated in larsoft
- Beam : MCC11 (soon)
- Atmospherics : MCC11 (soon)
- Repeat MIP studies with μs and γs
  - Place particles such that they exit the detector geometry after depositing varying amounts of visible energy E_{vis}
  - Utilize these samples to obtain the E_{vis} "tresholds" which give us 50% efficiency.

Radiological rates

Default Simulated Backgrounds

Background	Source/Nuclide	Content (Bq/cc)
CPA	^{40}K	2.72E-3
^{39}Ar	^{39}Ar	1.41E-3
^{85}Kr	^{85}Kr	1.60E-4
APA	^{60}Co	8.20E-5
^{222}Rn	^{222}Rn	5.58E-5
Neutron	Concrete	3.04E-5
^{210}Po	^{222}Rn	5.00E-6
^{42}Ar	^{42}Ar	1.28E-07

- For the MCC11 sample, a 5th slab of concrete was added increasing the effective (1x) neutron content from 3.04 to 3.8 Bq/cc

Benchmark tests of the Triggering Algorithm

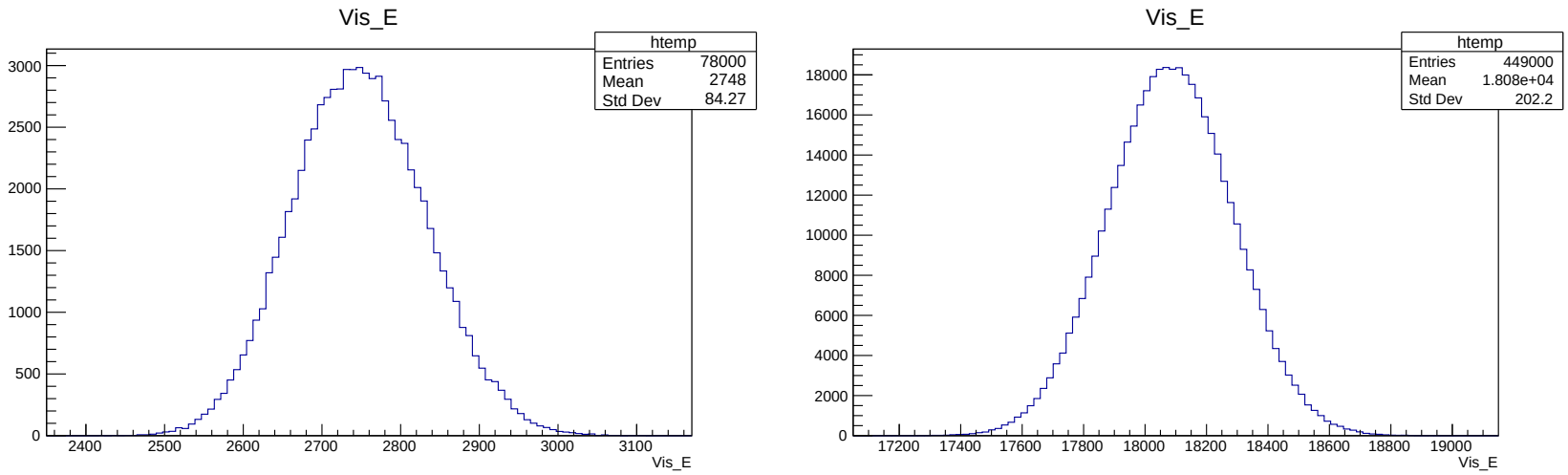
- 150 APAs – 300 "TPCs"
- 200 of which, have full, 3.6m drifts → 100 full-APA equivalents

Adjacency Algorithm Peformance

Sample	APA Data Time	DUNE Module Time	Processing Time
Beam	25483.2s	254.83s	592.97s
Atmospherics	2689.8s	26.90s	16.26s
Radiologicals	231.0s	2.31s	15.35s

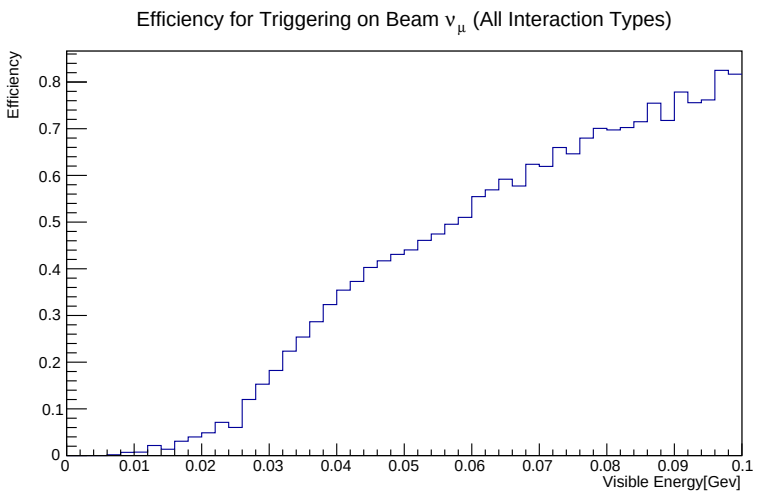
- The Processing Time is the total time spent in the Trigger Candidate Algorithm stage for a single threaded process going through all of the data

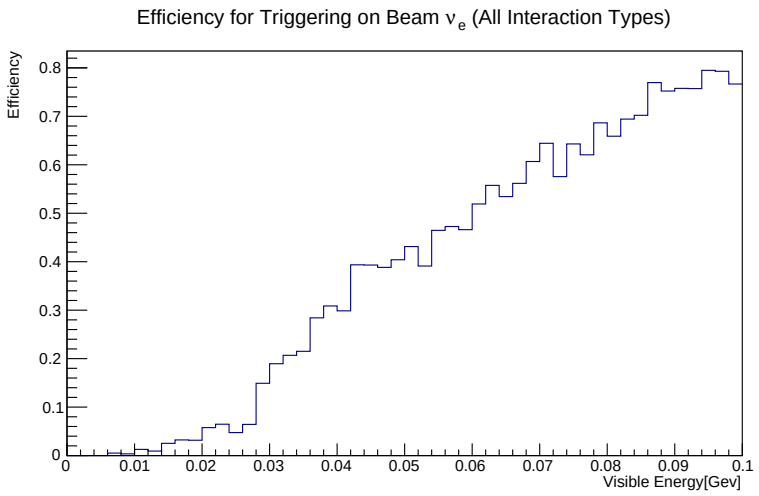
MCC11 Radiological Sub-sample

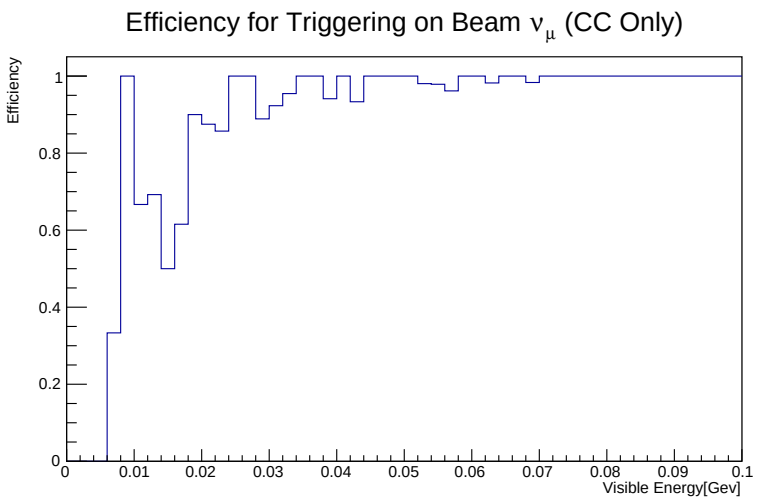


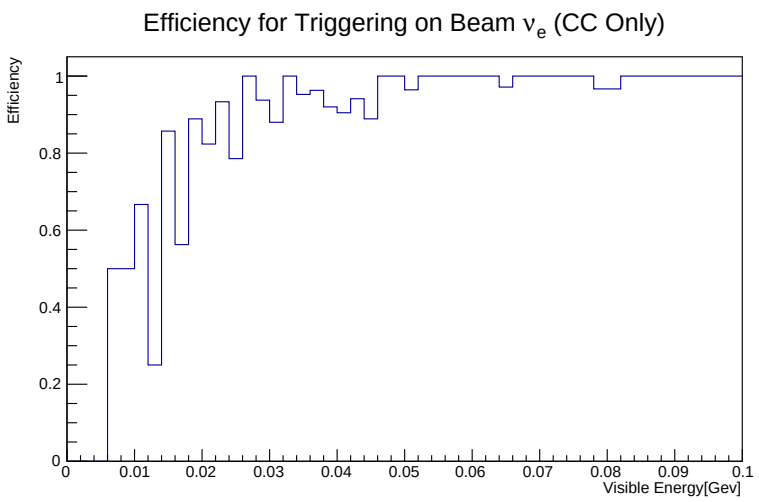
Visible Energy. **Left:** sample with default rates (precedes latest concrete slab positions in 1x2x6 geometry), **Right:** MCC11 sub-sample with 5x rates

MCC10 Beam


Efficiency for Triggering on Beam ν_μ (All Interaction Types)
Efficiency
Visible Energy[Gev]


Efficiency for Triggering on Beam ν_e (All Interaction Types)
Efficiency
Visible Energy[Gev]


Efficiency for Triggering on Beam ν_μ (CC Only)
Efficiency
Visible Energy[Gev]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