Designing the νSTORM detector

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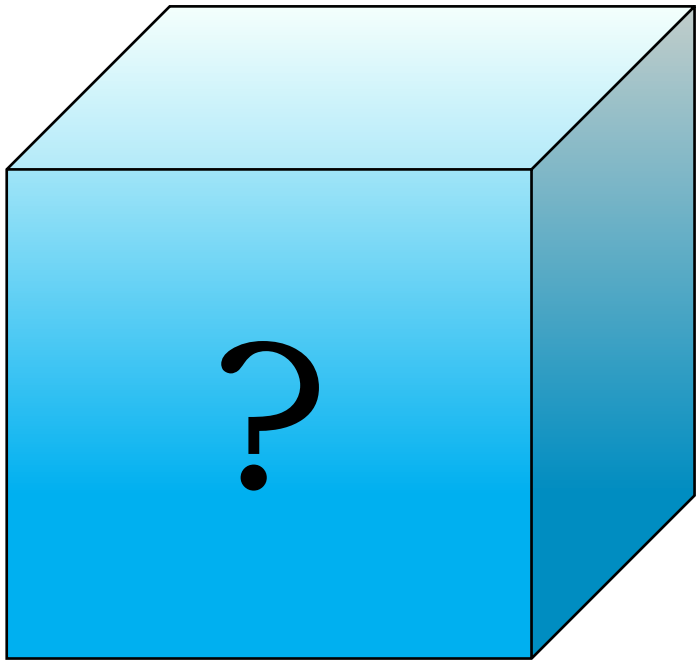
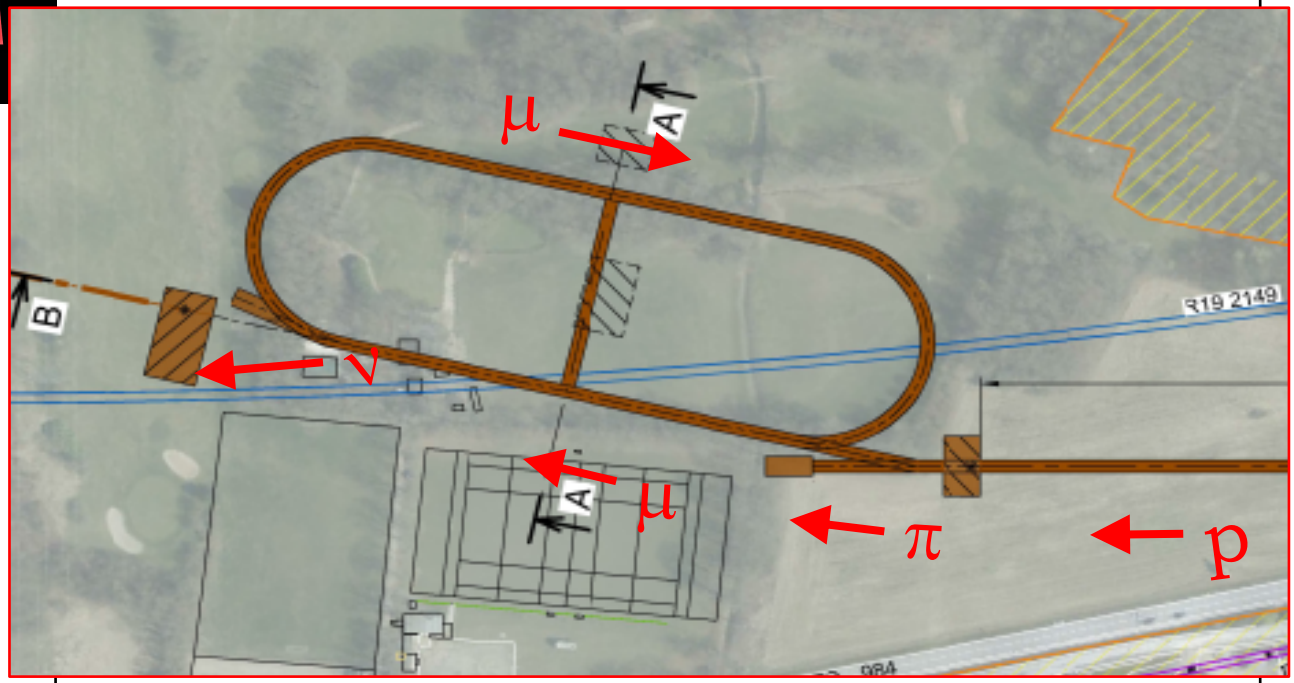
Process



- Identify the crucial channels
- Simulate the channels with a realistic ν flux – including ν backgrounds
- Determine the detector requirements for a ”meaningful measurement”
- Build a model detector with the required mass and resolution
- … reconstruction software etc.

Problems



Protons on target produce π

Some π captured & transferred to ring

π in the ring decay and produce μ

Some μ captured and circle the ring

μ decay - some ν interact in detector

Stage 1

nuSIM:

- Produce μ's with a parameterized distribution in energy, position and angle at the start of the nuSTORM production straight.
- Choose their decay point in the ring according to an exponential lifetime.
- Calculate their decay products according to the μ decay kinematics.
- Track the resulting decay products to a detector plane – (currently set at 50m downstream from the end of the production straight and 5m by 5m centred on the axis of production straight)
- Use GENIE to generate events

Stage 1a

nuSIM:

- Produce π's with a parameterized distribution in energy, position and angle at the start of the nuSTORM production straight.
- Choose their decay point in the production straight exponential lifetime.
- Calculate their decay products according to the π decay kinematics.
- Use machine studies of the nuSTORM ring to select μ's that will be captured

arXiv:1806.02172v2 [physics.acc-ph]

- Feed into stage 1 simulation

(Use results to normalise the muon distributions)

nuSim architecture

Designed so that we can generate parameterised distributions **or** improve accuracy by using flux datasets from other code.

π Production	***Fluka/Mars***
π capture & transfer	***BDSim/G4Beamline***
π decay produces μ	nuSim
μ Orbit	***BDSim/G4Beamline***
ν Production	nuSim
ν Interaction	**GENIE/Geant4**

Current Status

Pion production: from NuMI data

Pion distribution from target nuSTORM performance. Detailed modelling being done

Muon production distribution from **nuSIM**

Muon ring capture from “Racetrack FFAG muon decay ring for nuSTORM with triplet focussing” arXiv:1806.02172v2 [physics.acc-ph]

Neutrino production distribution and propagation to the detector plane from **nuSIM**

Next steps

π	Production	Fluka/(Mars)
	working to have Version 1.0 by end 2021	
π	capture & transfer	BDSim/G4Beamline
	1st iteration nearing completion	
π	decay produces μ	nuSIM
	complete	
μ	Orbit	BDSim/G4Beamline
	In progress	
ν	Production	nuSIM
	complete	
ν	Interaction	GENIE/Geant4
	Preliminary distributions	

Flux files

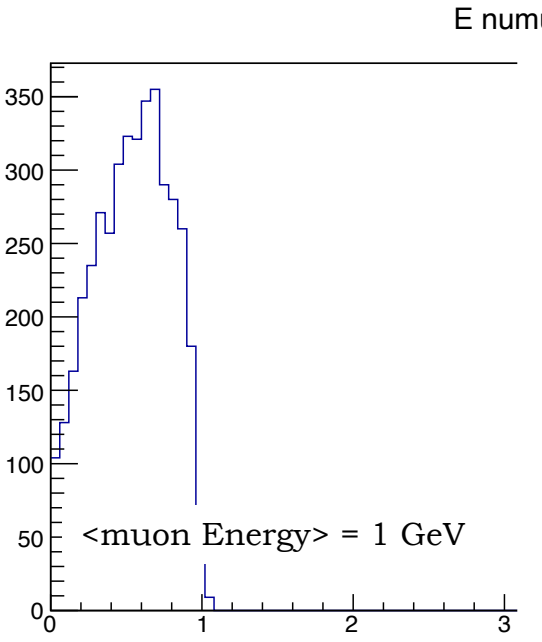
Total efficiency from protons on target to reaching the detector is around 0.03%
Dependant on the energy of the circulating muon beam)

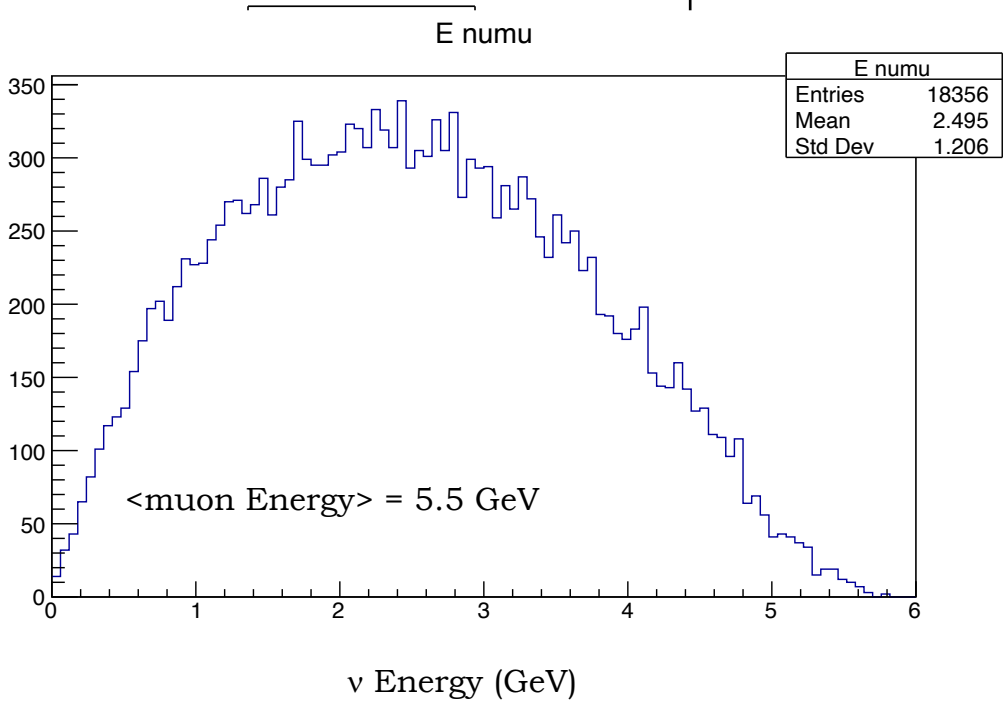
The result of all this is a set of flux files, which correspond the the position, angle and energy of the neutrinos which hit the front face of a “detector plane.”

Work has started on using those files to generate neutrino interactions using GENIE and looking at final state kinematic distributions to determine detector parameters.

ν "rates"

With the baseline detector the neutrino fluxes as a function of Energy

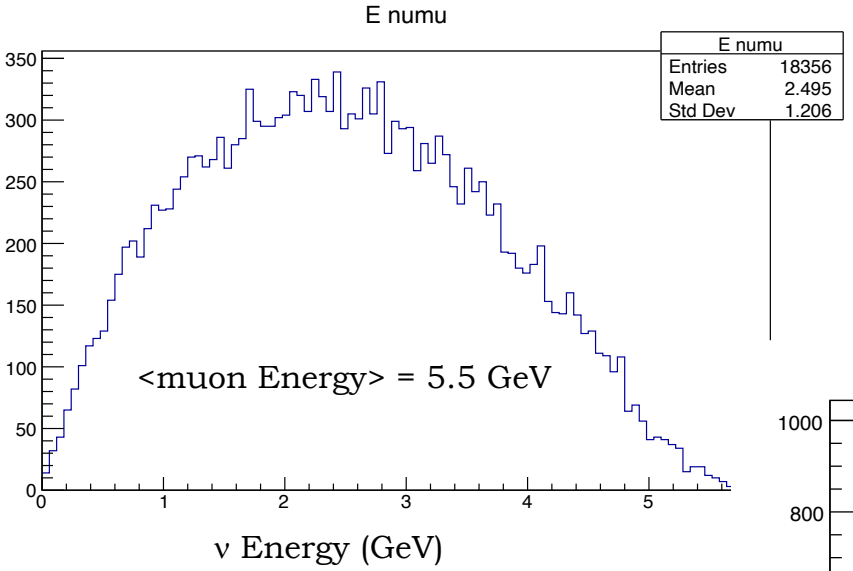




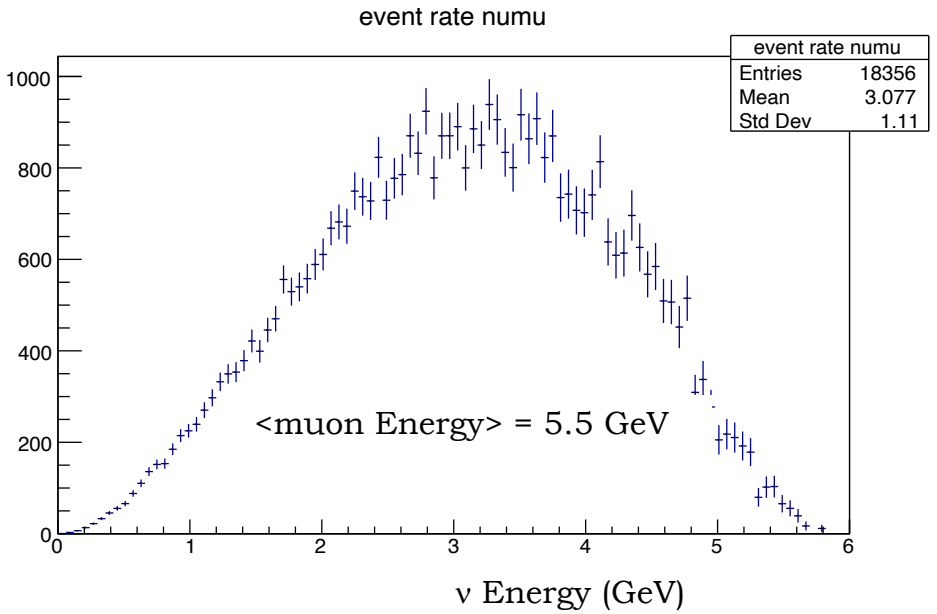
The two plots assume the same number of circulating muons.
Higher Energy give more muons per proton
What is the best way to get 0.5 GeV ν's?

ν interaction "rates"

Number of interactions per incident ν varies with ν energy.



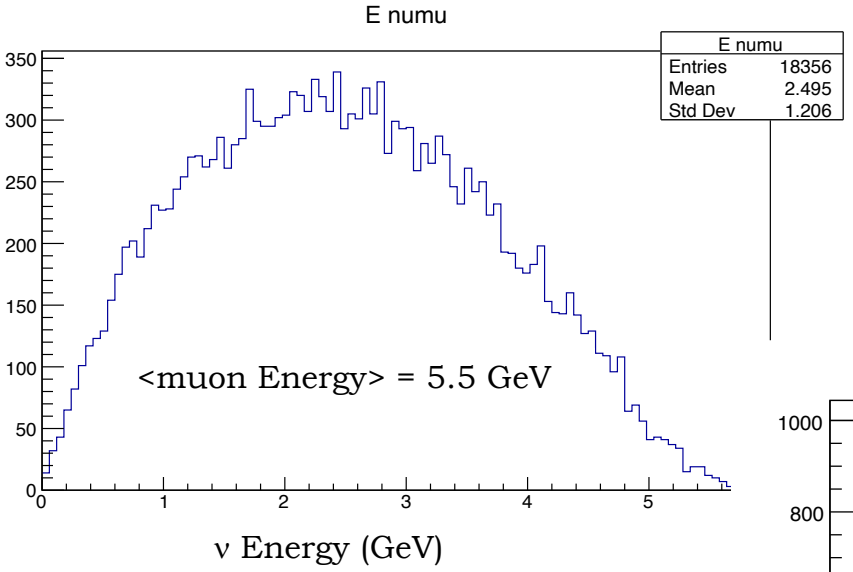
Distribution of ν energies



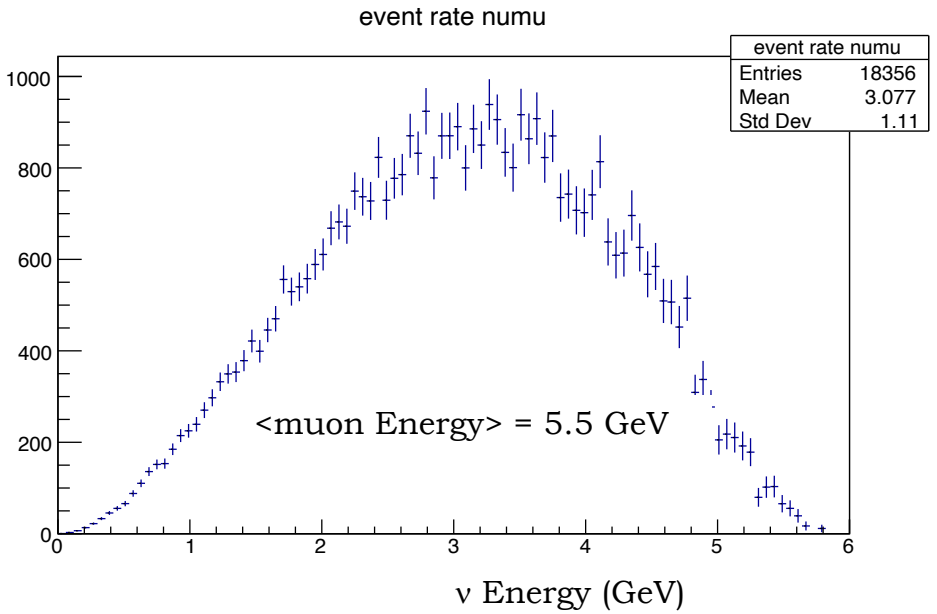
Relative event rate : weighting flux with ν energy

ν interaction "rates"

Number of interactions per incident ν varies with ν energy.



Distribution of ν energies



Relative event rate : weighting flux with ν energy

Programme

Get a firm number for neutrinos against protons on target

Detector resolution requirements for a single channel
Associated detector mass and composition

Incremental improvements to accelerator modelling.

GEANT4 detector model