VHE Event Sims

Christian Haack, christian.haack@fau.de

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About me ☺

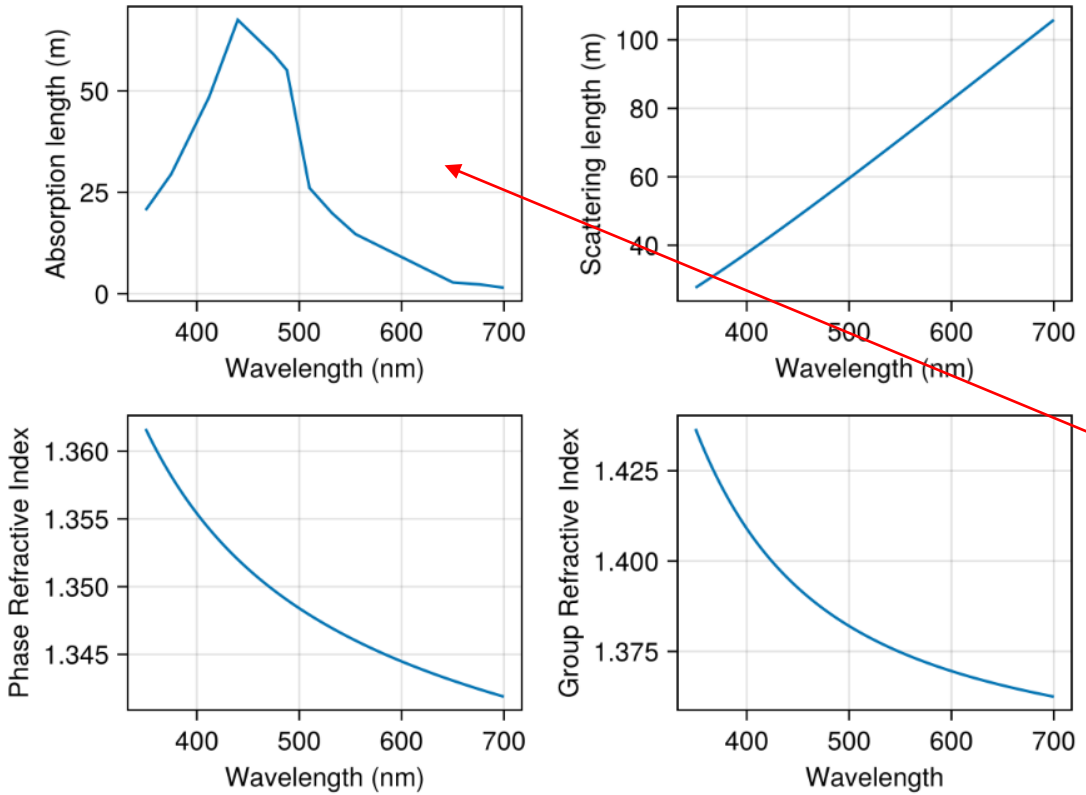
- Postdoc at ECAP (FAU Erlangen Nürnberg)
- Research interests: Data analysis, reconstructions, ML, differentiable analysis pipelines
- Joined KM3NeT earlier this year
- Also member of IceCube for 10+ years, worked on:
  - Diffuse flux measurement
  - Galactic Plane
  - Glashow Resonance
- IceCube Reconstruction WG convener 2021-2023

GPU Photon Propagation Code

- https://github.com/PLEnuM-group/PhotonPropagation.jl
- Forward ray-tracing of individual photons
- Pure julia implementation, CUDA accelerated photon propagation
- Customizable medium properties (absorption length, scattering length, scattering function, refractive index, dispersion), however only completely homogenous media supported
- Customizable emitters / receivers
- Uses IceCube parametrizations for Cherenkov light yields

ARCA Medium Properties

- Implemented:
  https://simulation.pages.km3net.de/input_tables/Simulations_Description.pdf



Scattering function in Henyey-Greenstein with <cos(theta)> = 0.924

Is there a smooth interpolation somewhere?

DOM Acceptance

- Using Tamas‘ LumenManufaktur for angular acceptance & QE
- QE is applied directly at the light source (spectrum biasing)

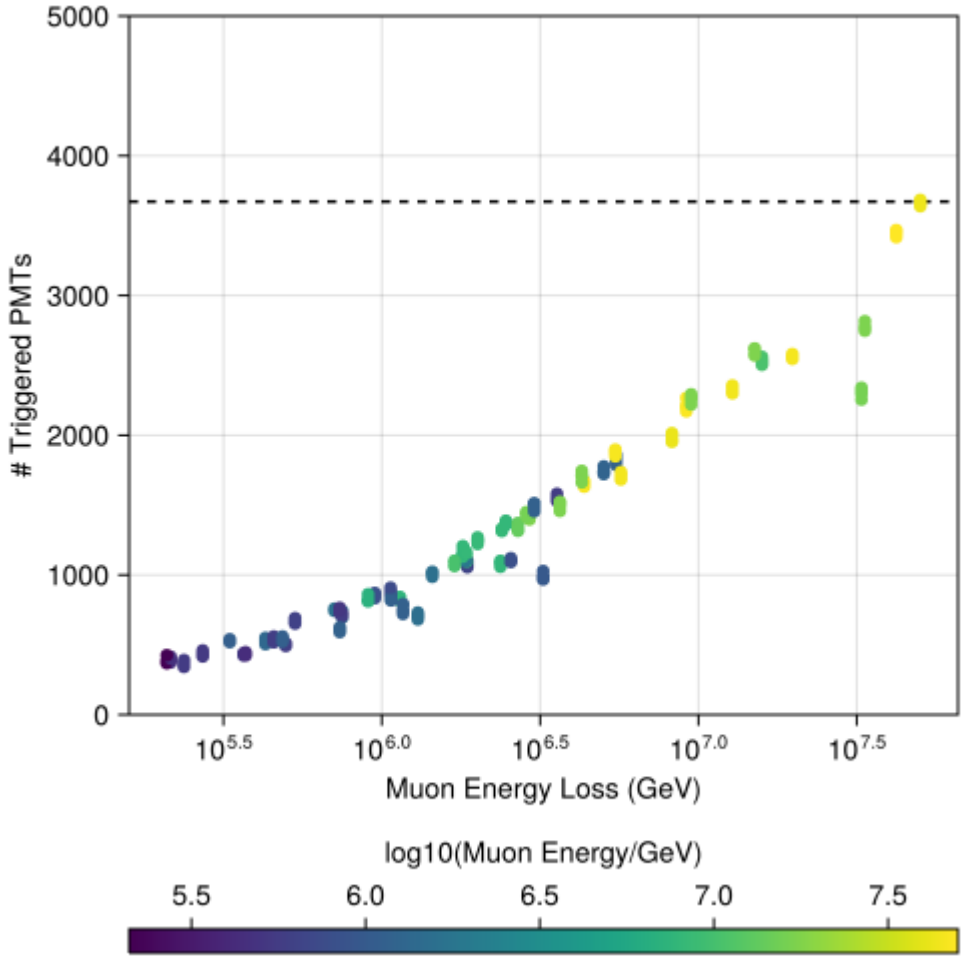
$$\frac{dn}{d\lambda} \rightarrow \frac{dn}{d\lambda} \cdot QE(\lambda)$$

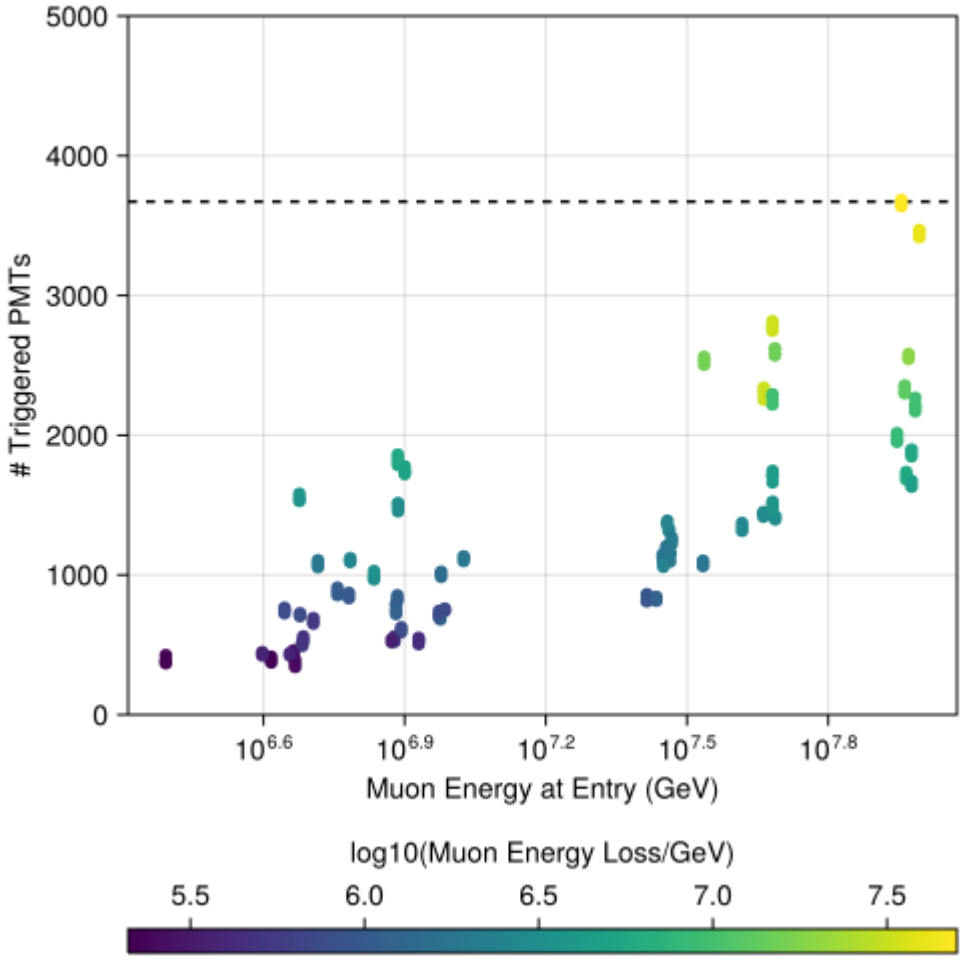
- For each photon that hits a DOM (sphere with 0.2159m radius), the angular acceptance curve is evaluated and converted into an effective area for each PMT. Total acceptance probability is the effective areas sum / (4*pi*r^2)
- If photon is accepted, PMT is randomly samples with weight = pmt angular acceptance

Event Resimulation

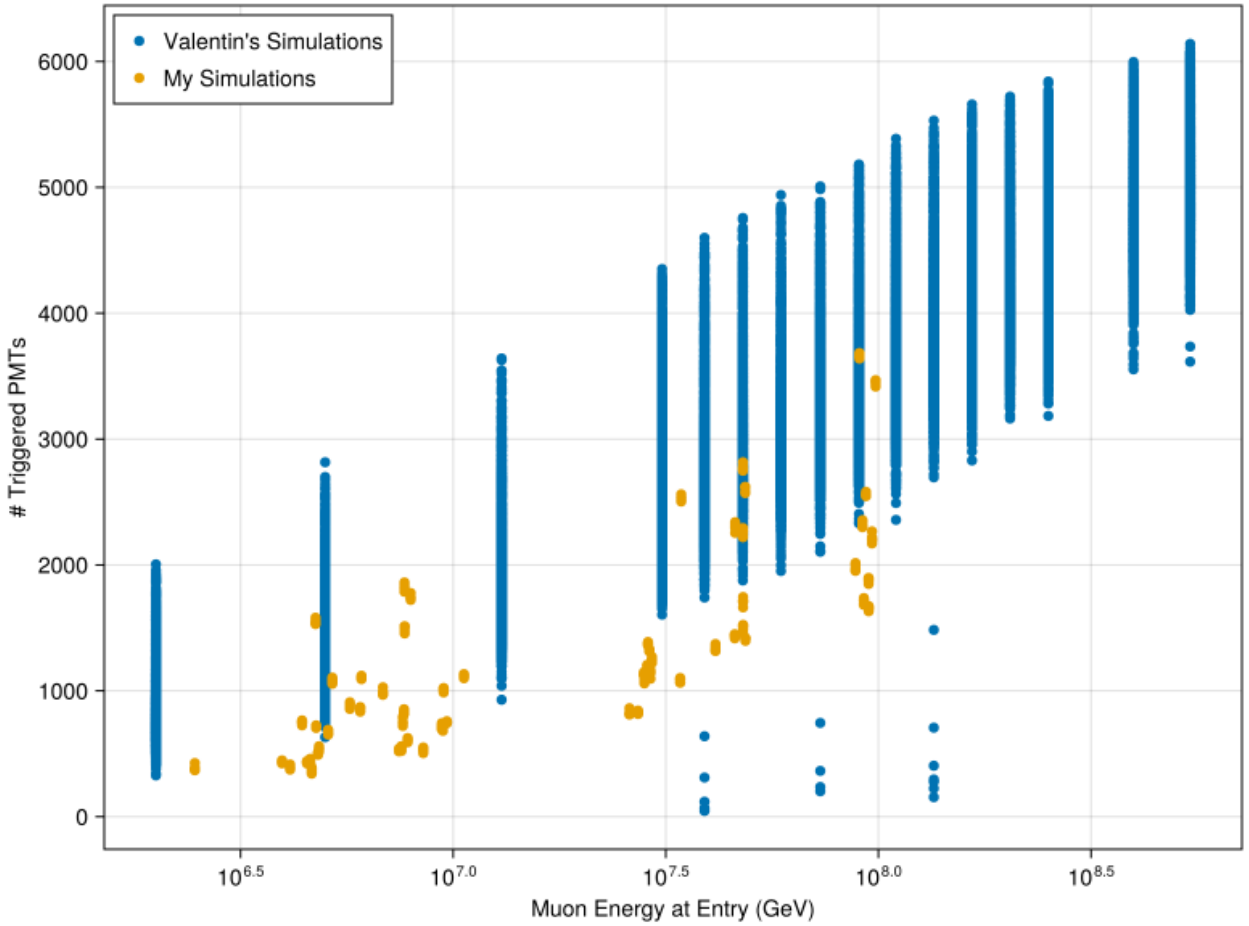
- Using detx file from https://git.km3net.de/vhe-event/data/vhe-event-and-calibration-data
- Using bestfit reco as MCTruth (vertex, direction)
- Shift muon back by 50m from fit vertex
- Simulate muon energy losses with PROPOSAL (losses tracked until 150m behind detector -> will change to 50m in next run)
- Muon energy losses (showers) are Cherenkov light emitters for photon prop
- Scan muon energy and resimulate muon propagation a couple of times for each energy

Simulation Results

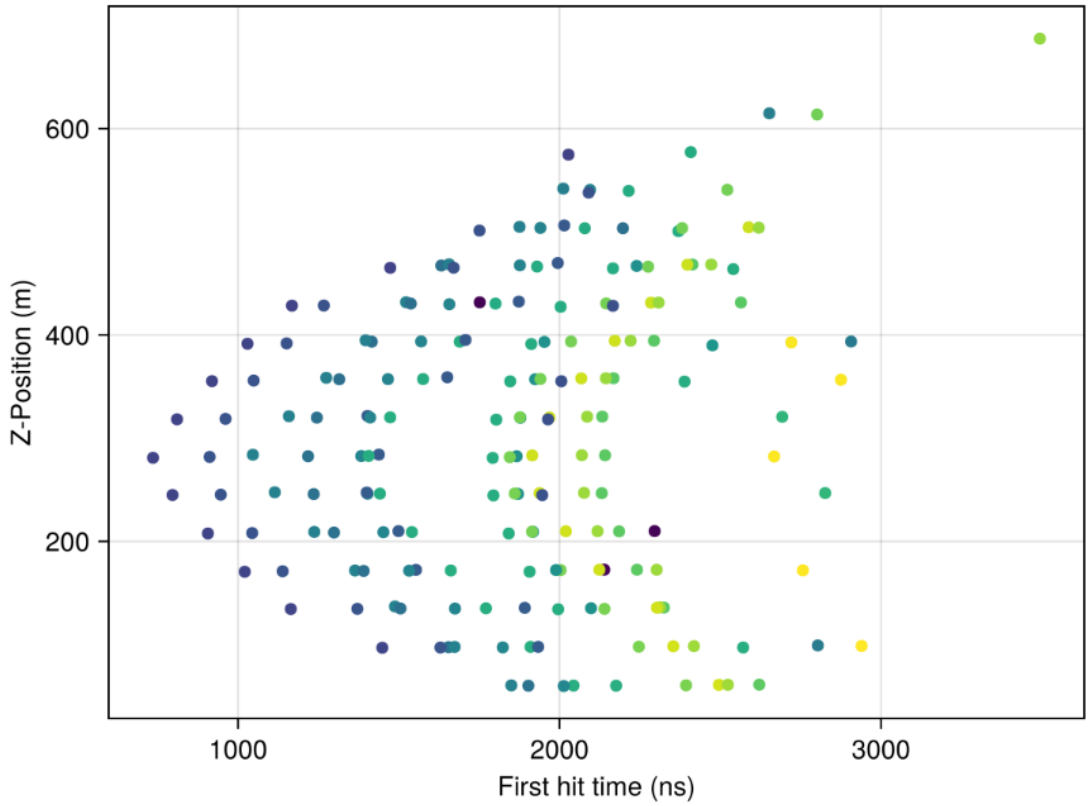




Comparison to JSirene



Z vs T (Sanity Check)



Next Steps

- Validate implementation of module acceptance
  -> Is there a way to run the standard KM3sim acceptance code for a list of photon impact positions / directions?
- Compare light-yield parametrisations
  -> Is there a way to plot the parametrisations used in Jsirene
- Question: Are muon energy losses always simulated as EM showers in JSirene?

Backup

Processing Script

```
DETECTOR=$1
DETECTOR_ONLINE=$2
INFILE=$3
OUTFILE=$4
DAQFILE=$5
PMTFILE=$6
QE_FACTOR=$7

export TRIGGEREFFICIENCY_TRIGGERED_EVENTS_ONLY="-O 1"

export TRIGGEREFFICIENCY_FACTOR=$(python3 -c "print(1/$QE_FACTOR)")

export TRIGGEREFFICIENCY_DISABLE_TURBOT="Y"

JTriggerEfficiencyRunByRun.sh $DETECTOR $DETECTOR_ONLINE $INFILE $OUTFILE
$DAQFILE $PMTFILE

JARCAMuonReconstruction.sh $DETECTOR $OUTFILE ${OUTFILE%.*}.%.root $PMTFILE
```