Photon-Based Detector Workshop

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SNOWMASS 2021

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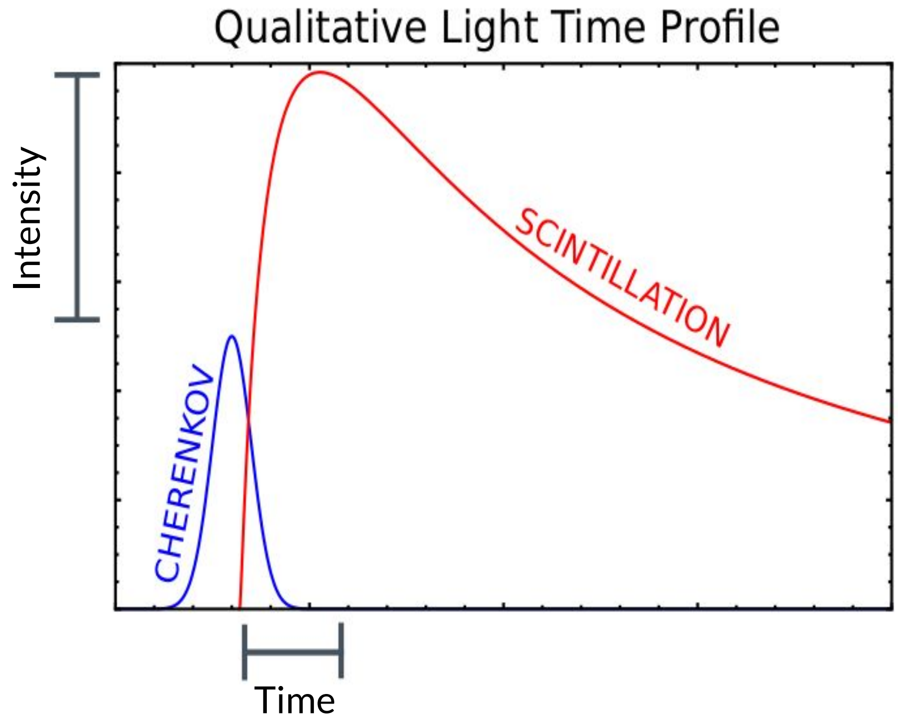
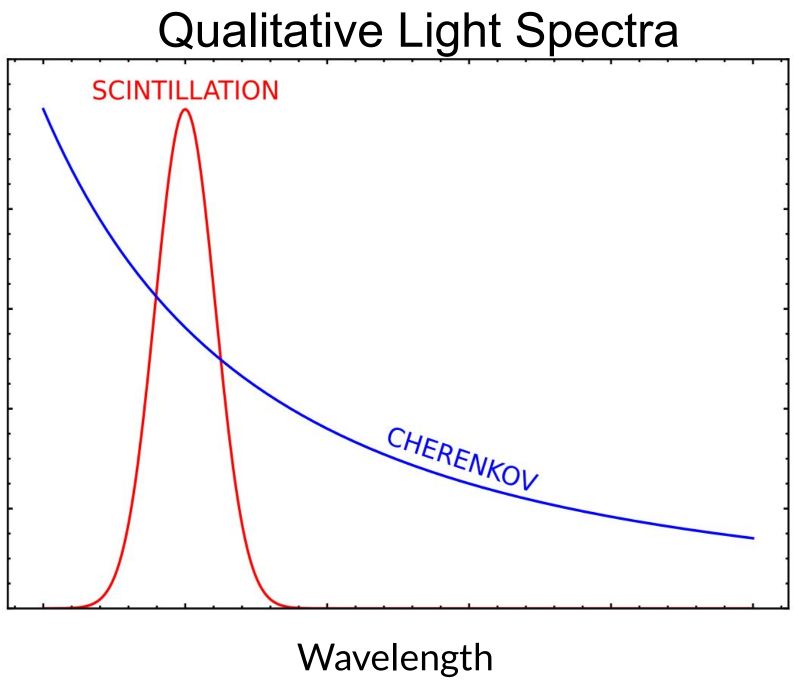
Cherenkov/Scintillation Separation

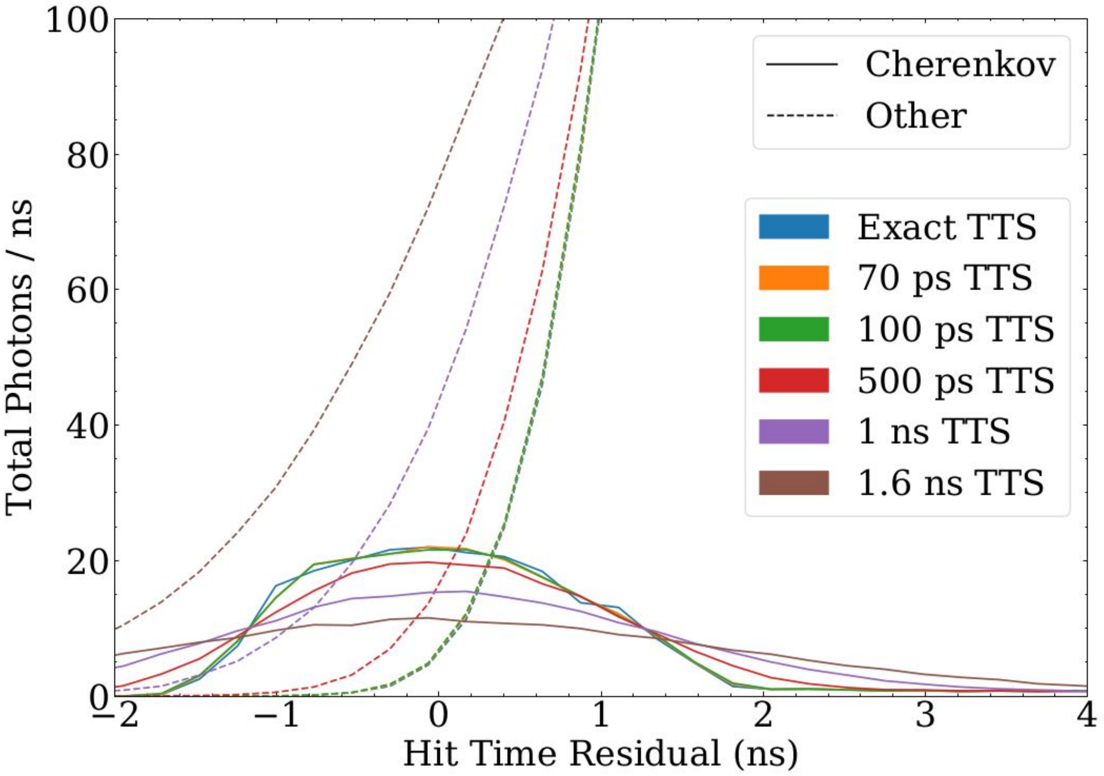
C/S Separation, Conceptually





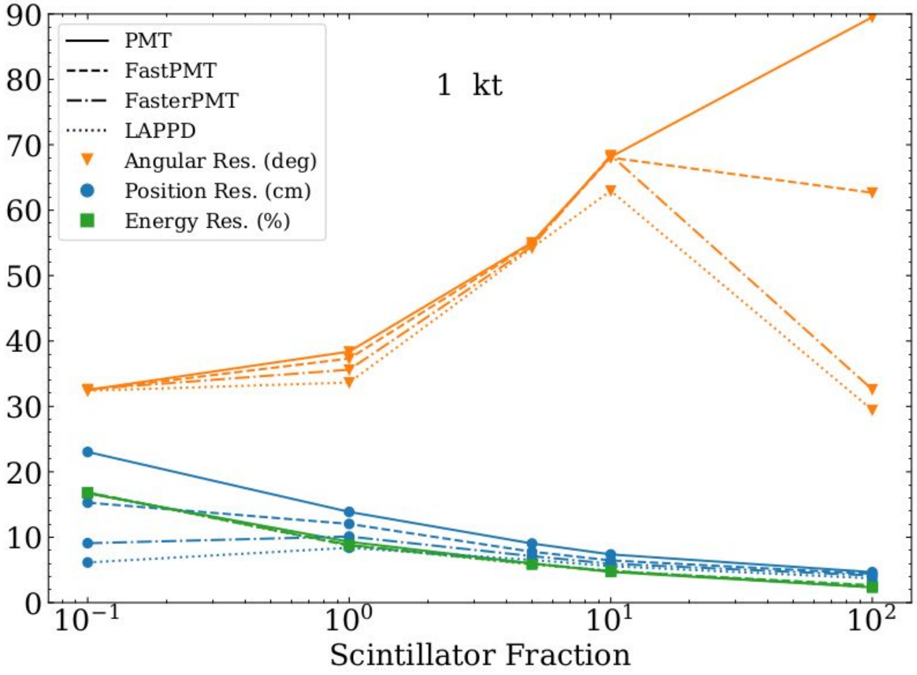
Impact of fast timing on C/S separation

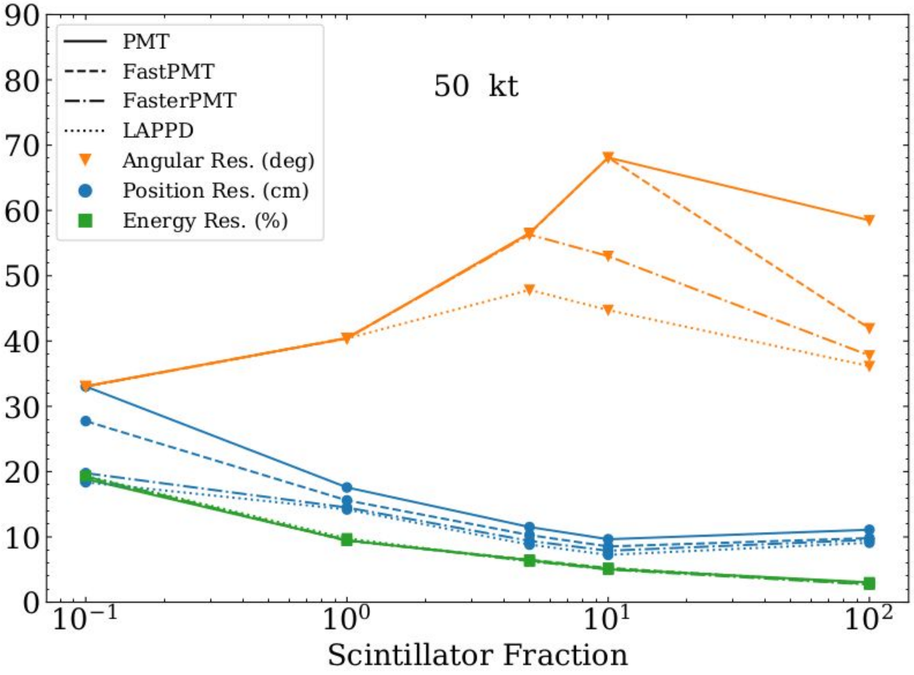
- Simulated hit time residual distributions for Cherenkov and Other (scintllation + remission) photon signals
- Great overlap at standard large area PMT transit time spreads
- Diminishing returns with better than ~500ps transit time spread



Impact of TTS (and WbLS) on vertex reconstruction

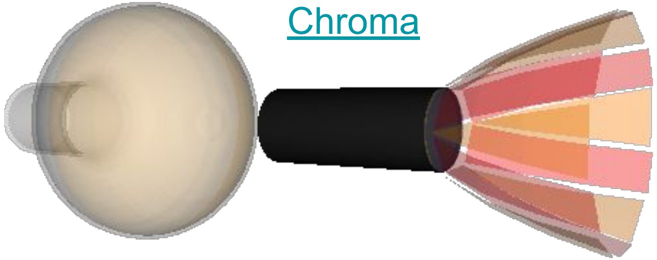
PMT → LAPPD :: 1.6ns, 1.0ns, 500ps, 60ps transit time spread (see arXiv:2007.14999 for more details)

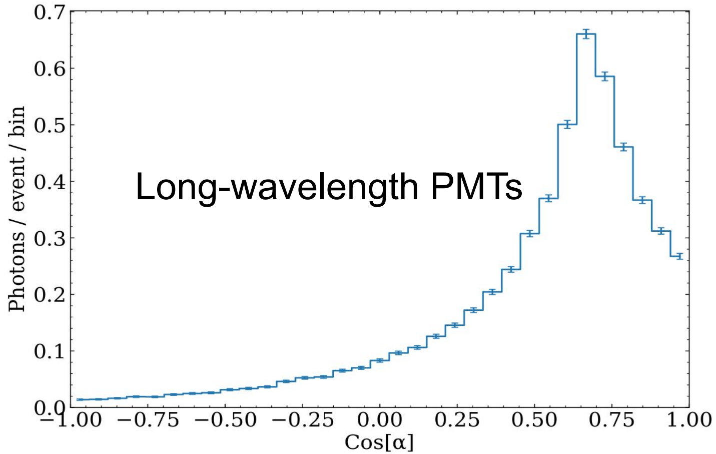


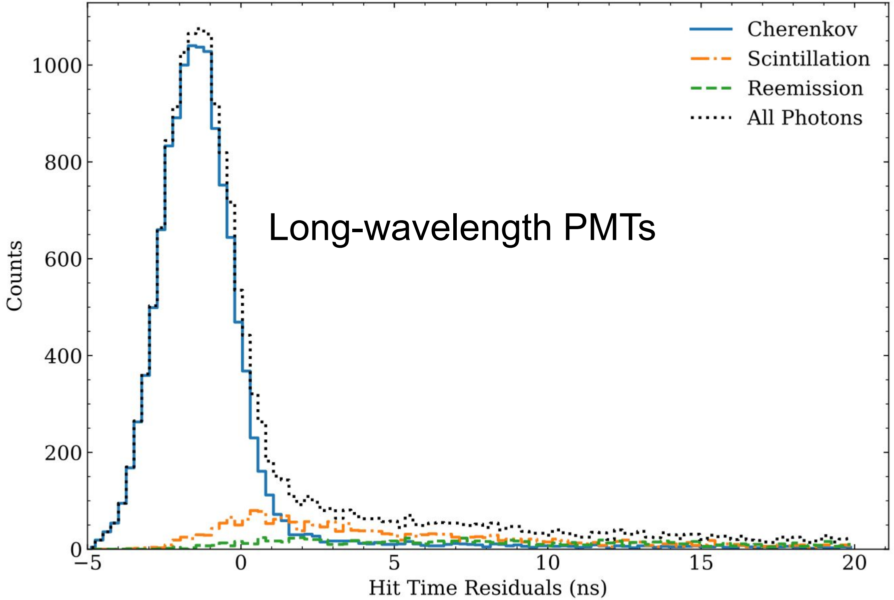


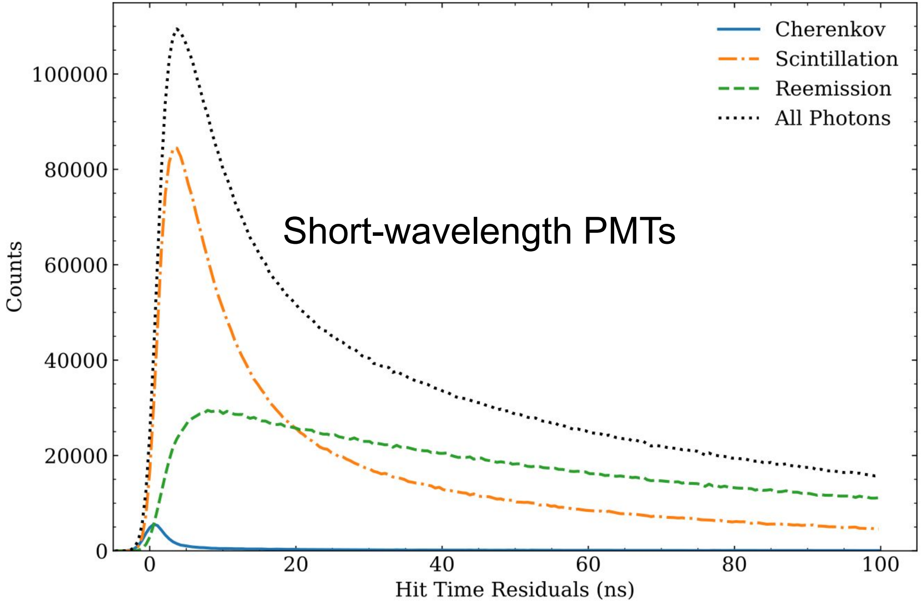
C/S separation with dichroicons

Chroma





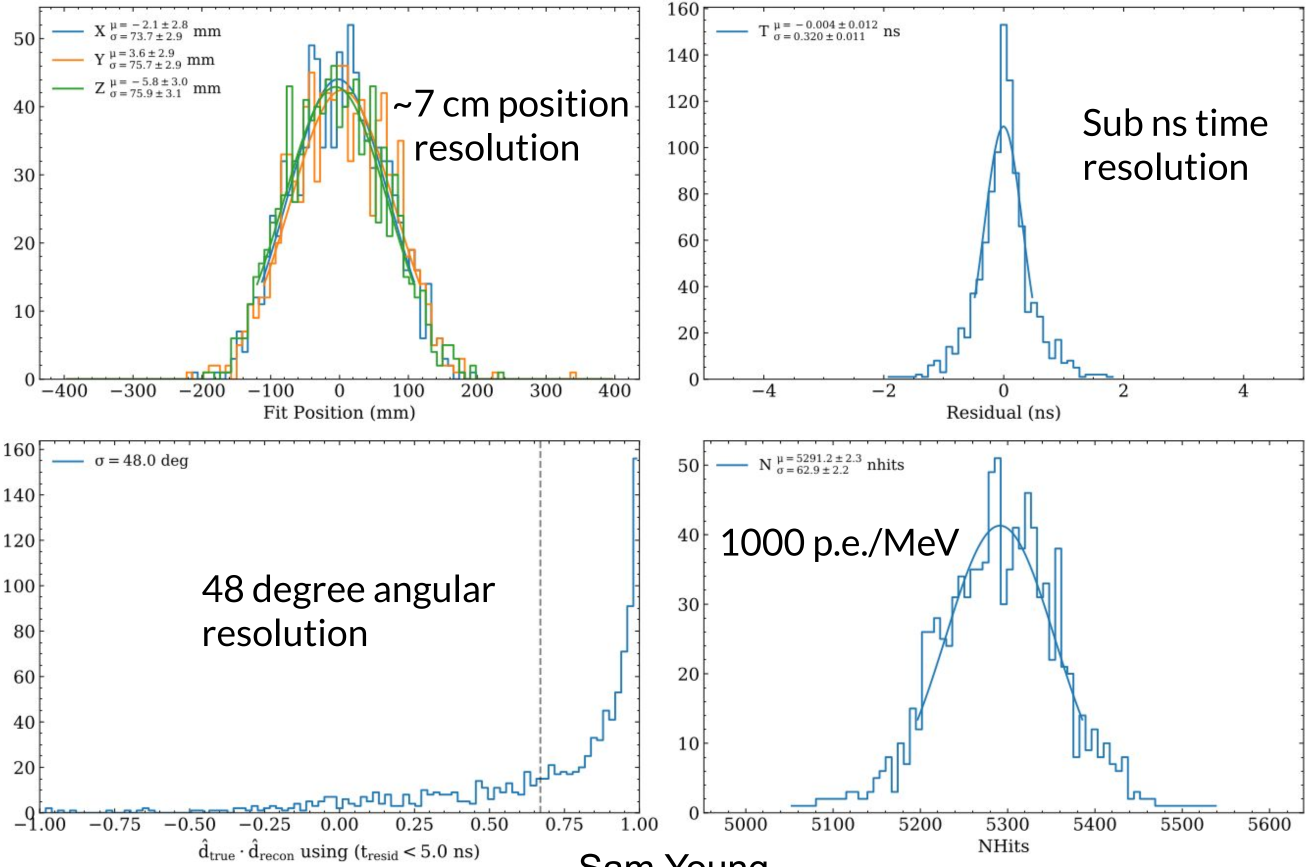




Photon Detection Developments

Vertex reconstruction with dichroicons in pure scintillator

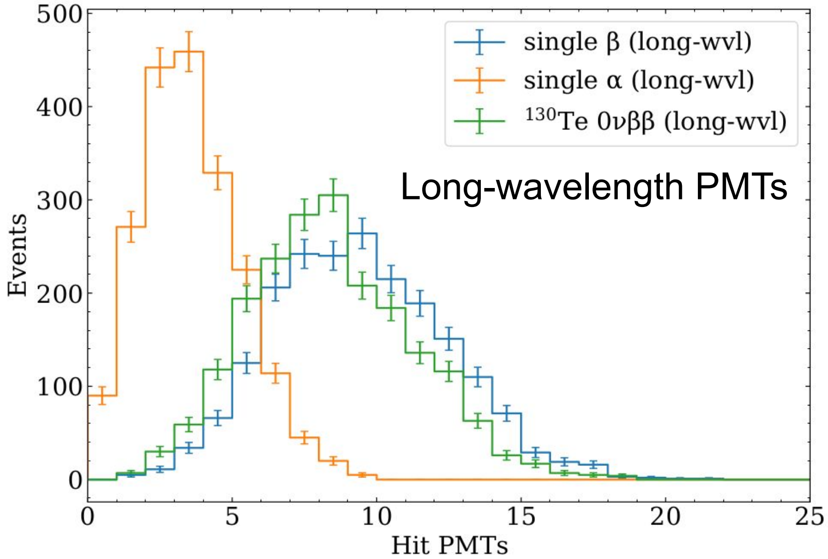
- Chroma simulation of 50 kt detector with dichroicons and LAB+PPO target material
- Reconstructing 5 MeV center generated electrons
- Can optimize dischroicon design to improve results

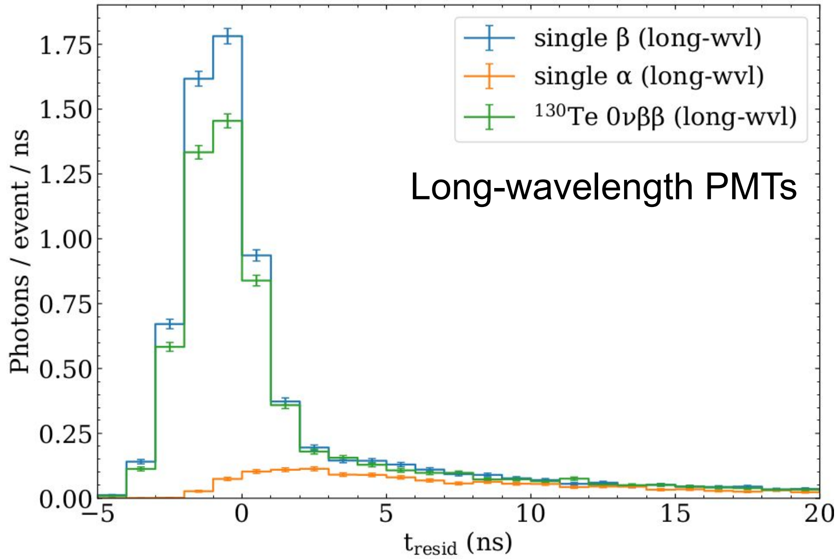


Sam Young

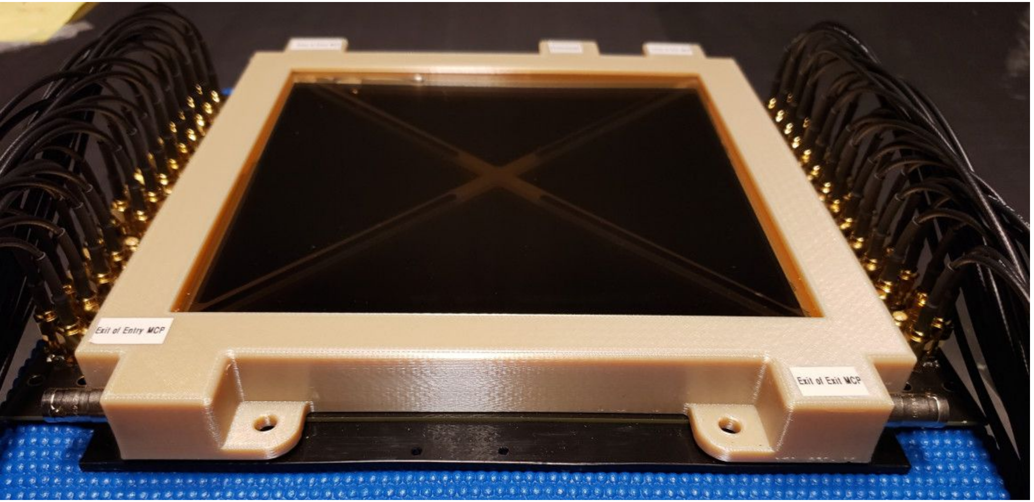
Particle ID with dichroicons in pure scintillator

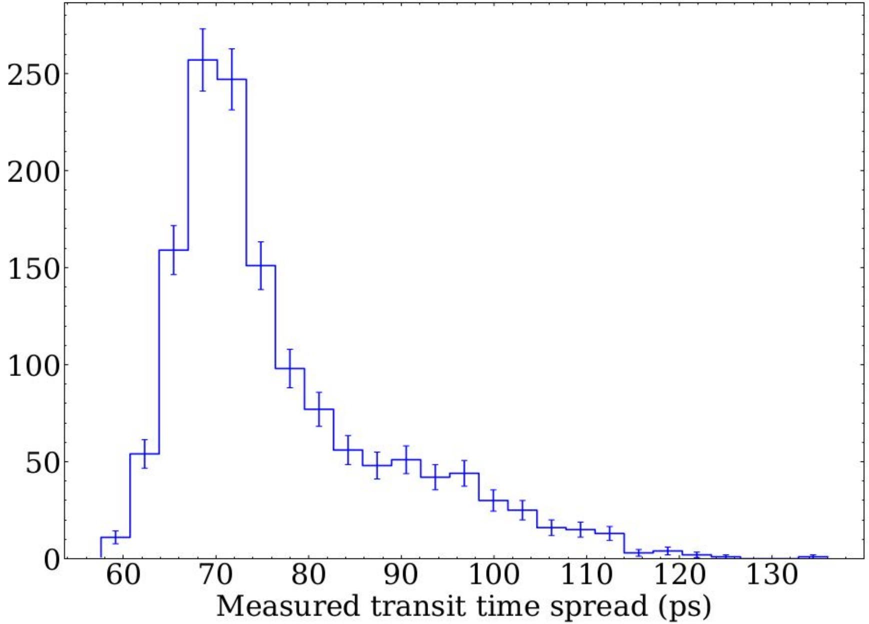
- Simulated single β, single α, and 0νββ, all with the same visible energy
- Looking at long wavelength PMT hits below
  - β and α clearly different (optimize design to reduce scintillation leakage)
  - β and 0νββ slightly different



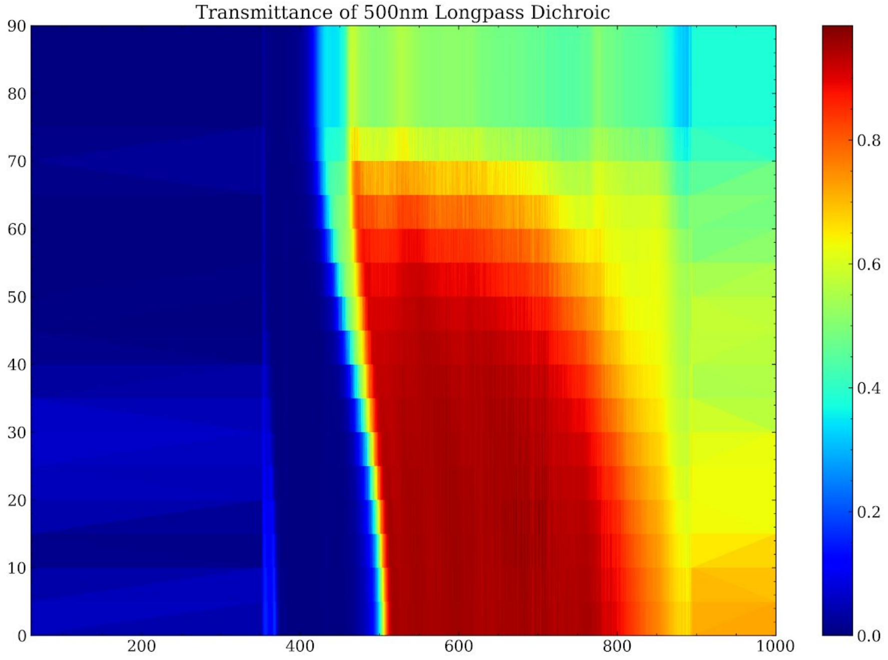


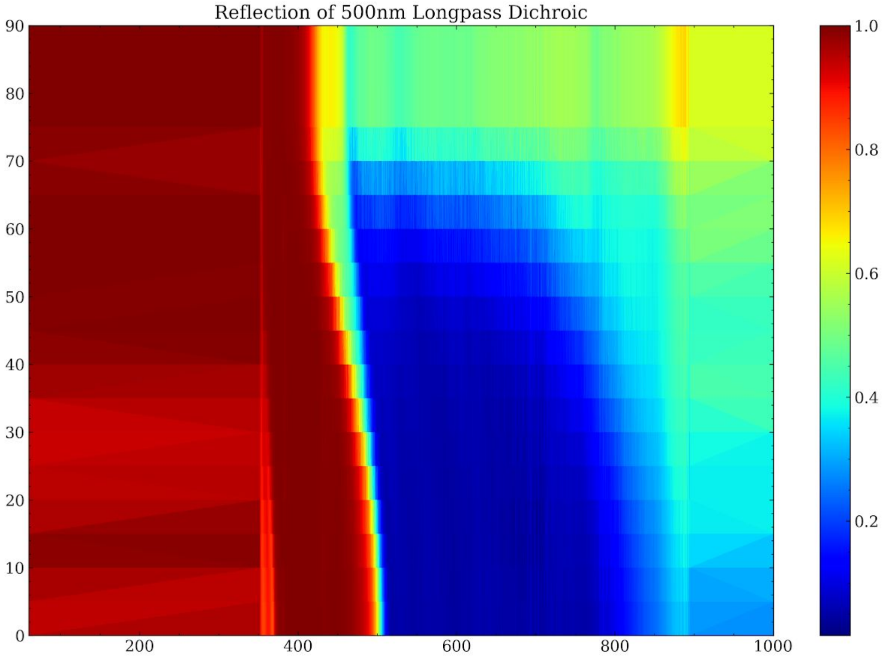
Fast timing with LAPPDs (tile #22 in 2019)





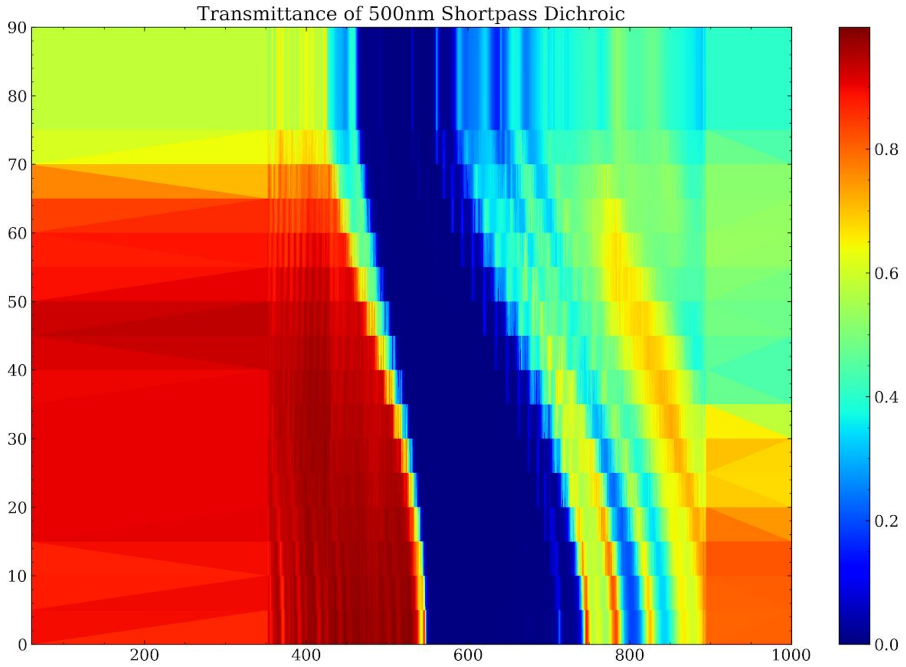
Longpass dichroic filters evaluated for dichroicon

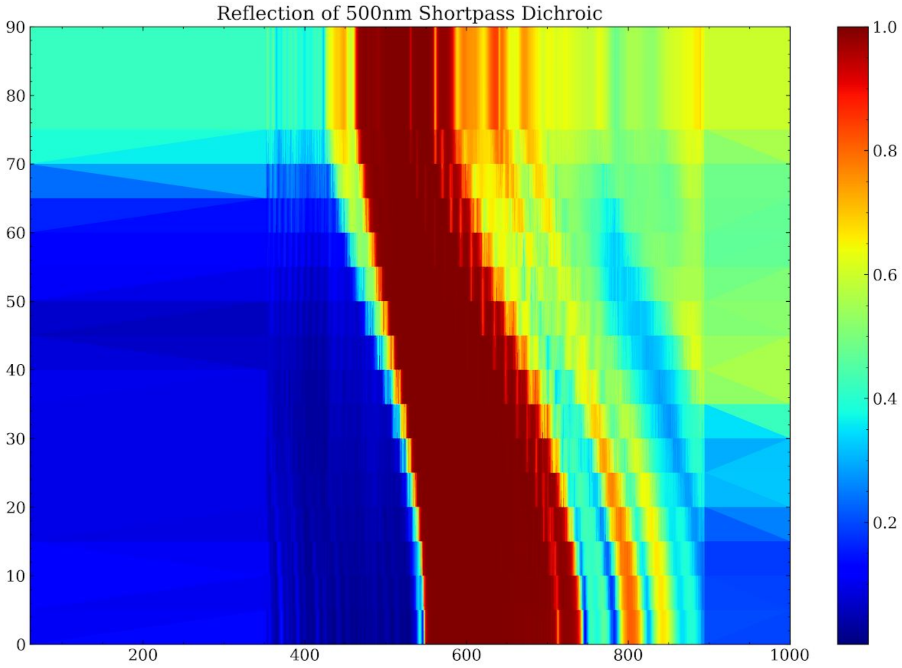




Meng Luo

Shortpass dichroic filters evaluated for dichroicon



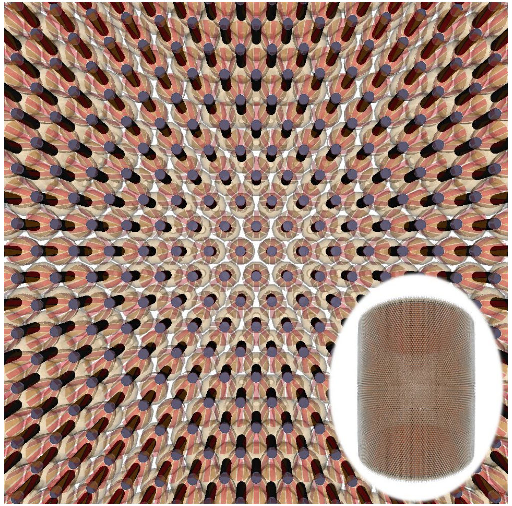


Meng Luo

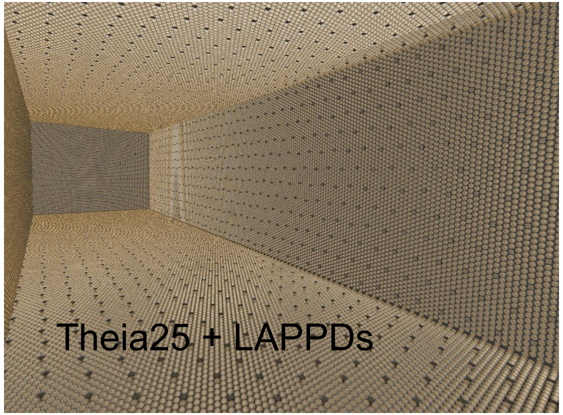
Simulation and Analysis

Simulating with Chroma

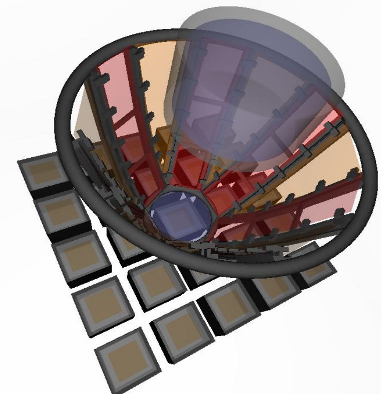
- GPU accelerated optical simulation
  - Up to 200x faster than CPU simulation
- Written in Python (+CUDA)
  - Easy to use, quick to build on
- Can run standalone with Geant4
  - Full end-to-end simulation
- Can interface with RAT-PAC (etc)
  - As a dedicated optical simulation



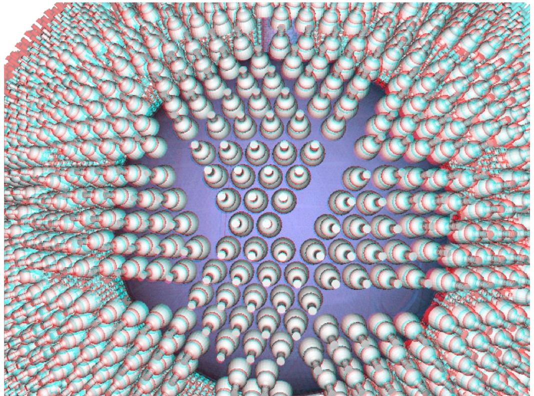
50 kt dichroicon detector



CHESS + Dichroicon



SNO / SNO+



Data analysis with Python

- Data analysis with Python is an industry standard approach
  - Used outside of (high energy) physics → develop marketable skills
  - Easy access to machine learning (Keras, Tensorflow) and big data libraries
- An excellent alternative to data analysis with ROOT
  - Matplotlib, NumPy, and SciPy replace all of ROOTs functionality
  - Uproot and awkwardarray can import ROOT datastructures without ROOT
  - Jupyter provides a nice frontend (even ROOT uses it…)
  - Anaconda packages all of this, trivial to deploy on compute clusters
- “But isn’t Python slow?”
  - Use the (highly optimized, native compiled) libraries like NumPy, SciPy!
  - Minimal overhead from Python code, and much faster development in Python