Research Updates

Petr Stepanov

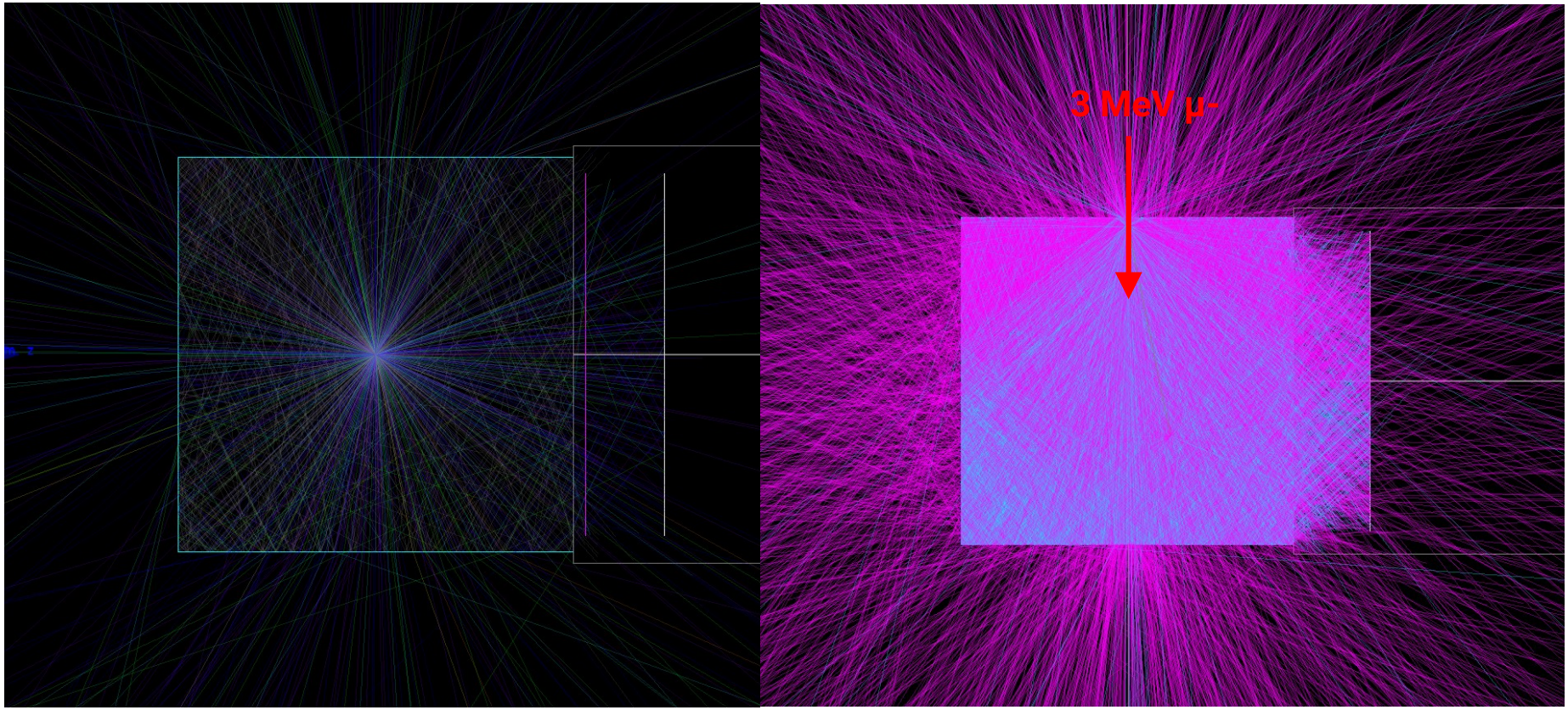
petrs@jlab.org

Apr 1, 2022

Simulation Program for the “Dual Readout”

A program for simulating and visualizing the detector response from interaction of a particle with various glass samples is developed. Source code.

- Simulation supports use of different glass parameters (size, composition, density, emission, transmission spectra) as well as different type of detectors (PMTs, MPPCs).
- **Track visualization** supports differentiation of the particles **by the photon energy** and by **creation process type** (Cerenkov, Scintillation).



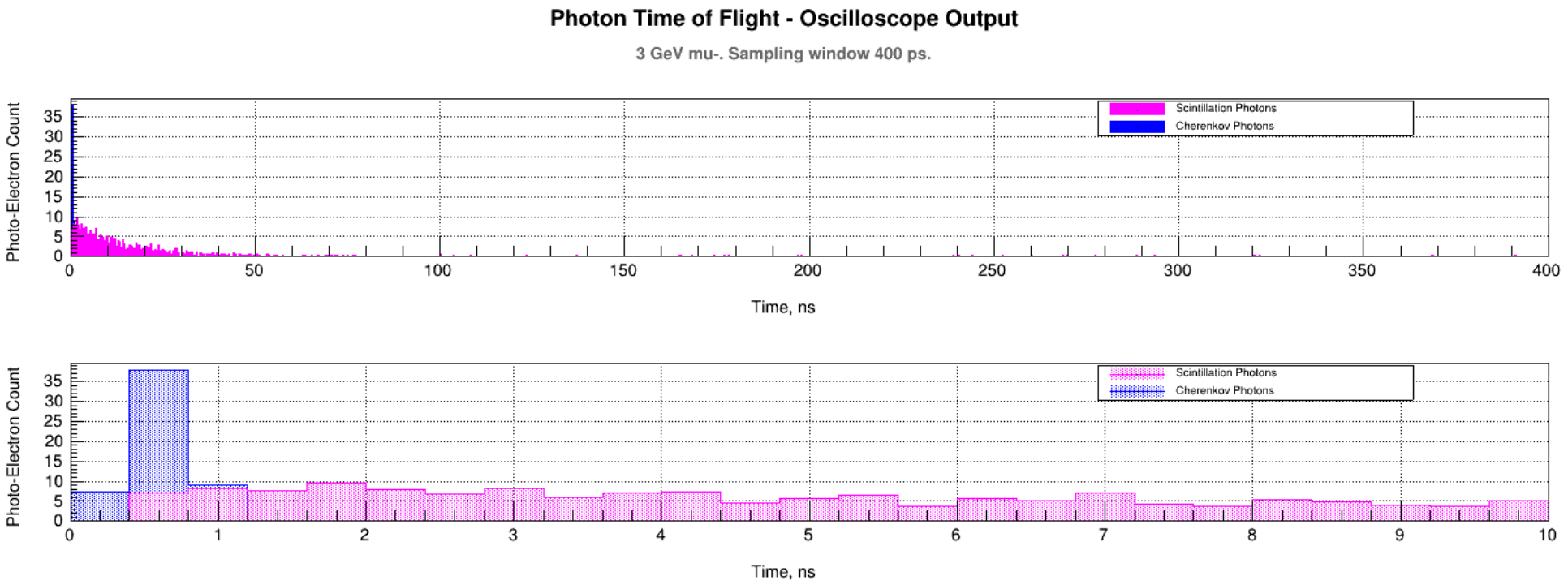
Visualizing the photon travel by the particle energy (left) and by the creator process (right)

Simulating the PMT Response

Simulation can **reconstruct the detector response** from interaction of a particle with the glass sample. Response from Cerenkov- and scintillation-produced light can be observed individually.

9.1

SciGlass
46.4 × 46.5 × 48.6 mm, 4.04 g/cm³, transmission side 1.

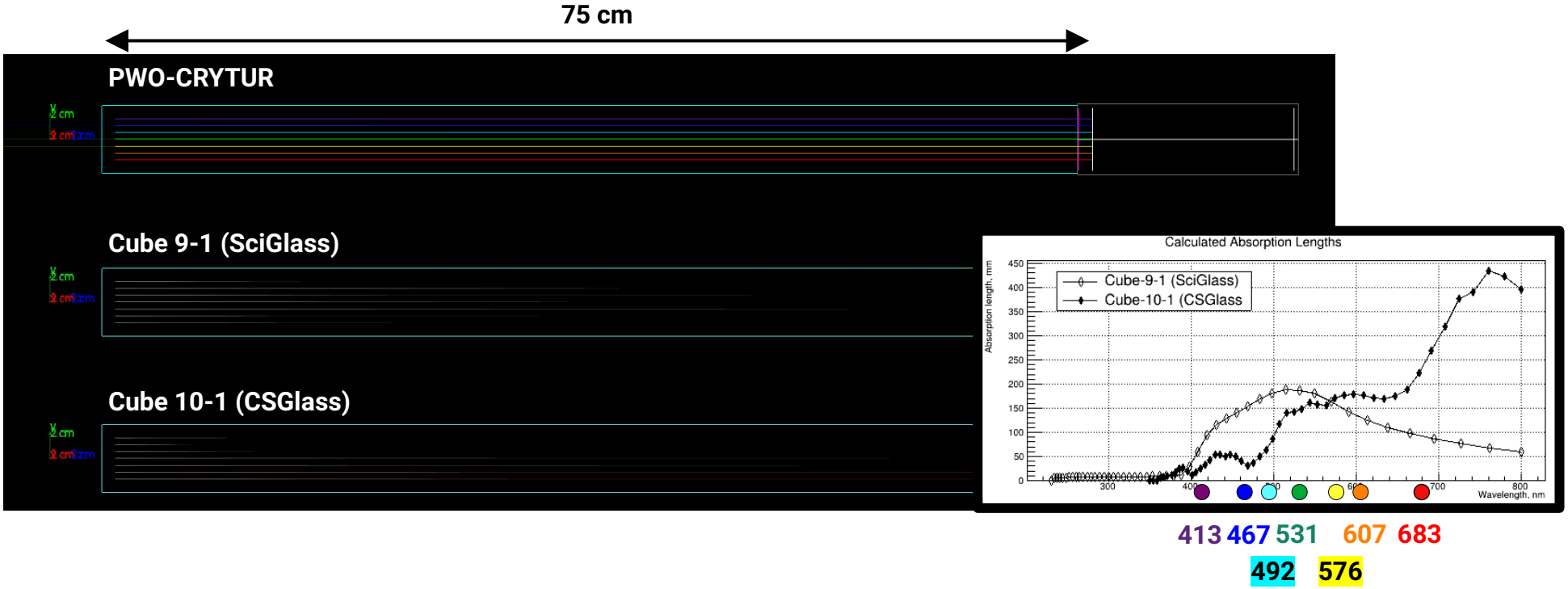


Simulated PMT response from interaction of a 3 GeV mu- with SciGlass Cube9 sample.

Simulation of the Photon Travel Distances

5k events of **7 optical photons** of a different wavelengths (violet to red) **simultaneously emitted** through various scintillation materials: PWO-CRYTUR, Cube 9-1 (SciGlass) and Cube 10-1 (CSGlass). Length of the crystal is set to 75 cm. Opacity of each photon track is set to 2%.

This way we **visualize the travel distance and validate** the **calculated absorption length** .



Validating the absorption length effect (ABSLENGTH) in Geant4

Observation: travel distances of the photons correspond to the absorption spectra.

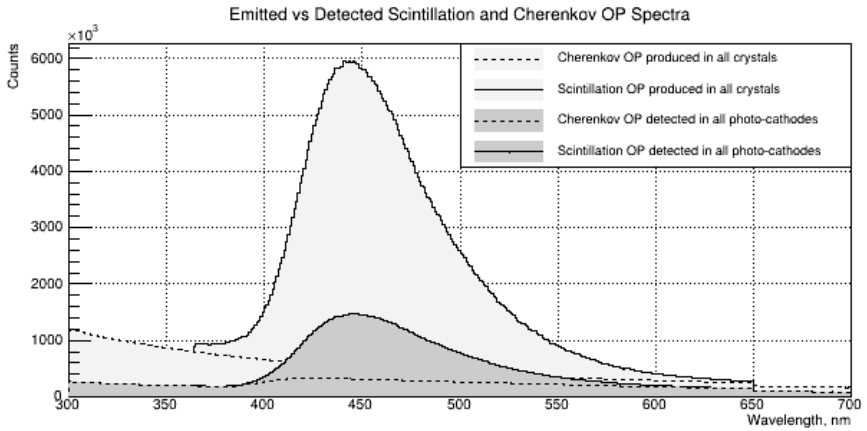
Conclusion: better transmittance in the “blue” Cerenkov region is desired.

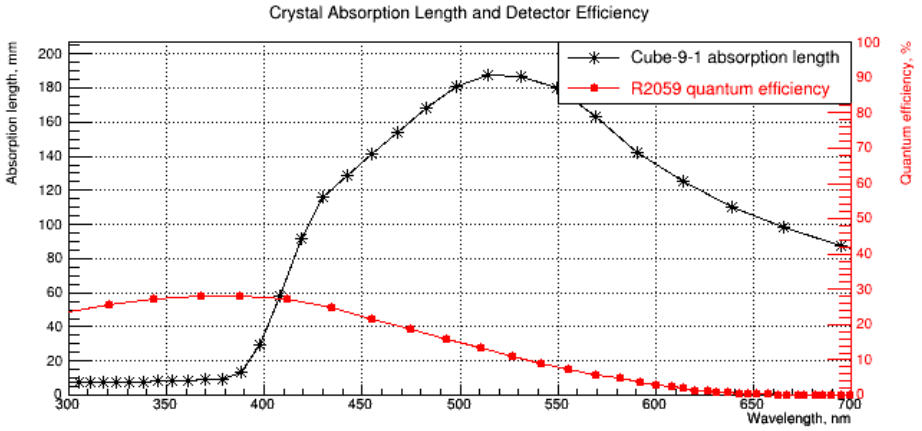
SciGlass (Cube9) Results

Final detector response depends on following processes: **emission, transportation, detector quantum efficiency**.

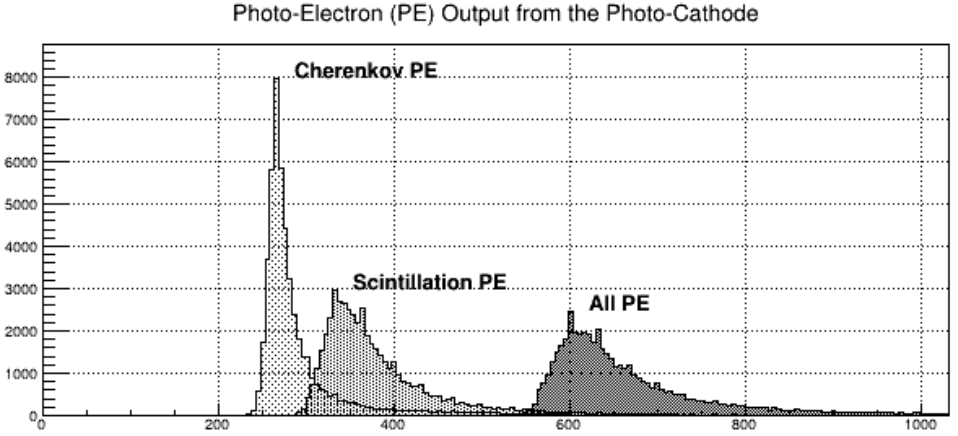
9.1 *SciGlass*
46.4 × 46.5 × 48.6 mm, 4.04 g/cm³, transmission side 1.

Cube-9-1 46x46x48 mm. 3 GeV mu-. 50000 events.





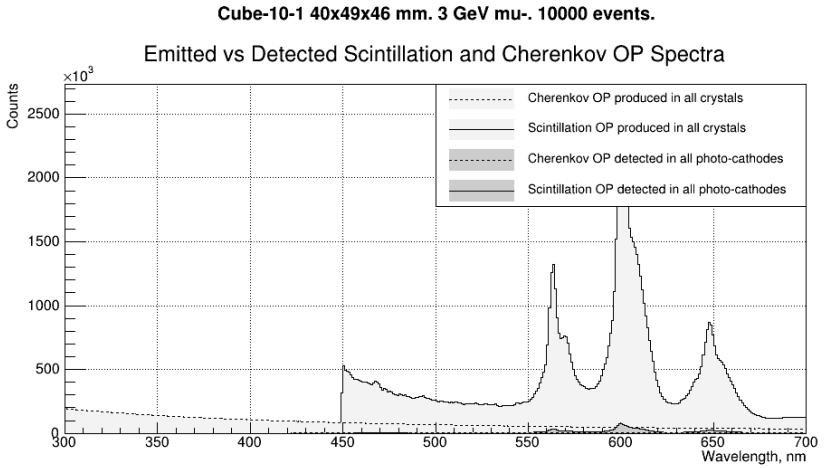
Cube-9-1 46x46x48 mm. 3 GeV mu-. 50000 events.

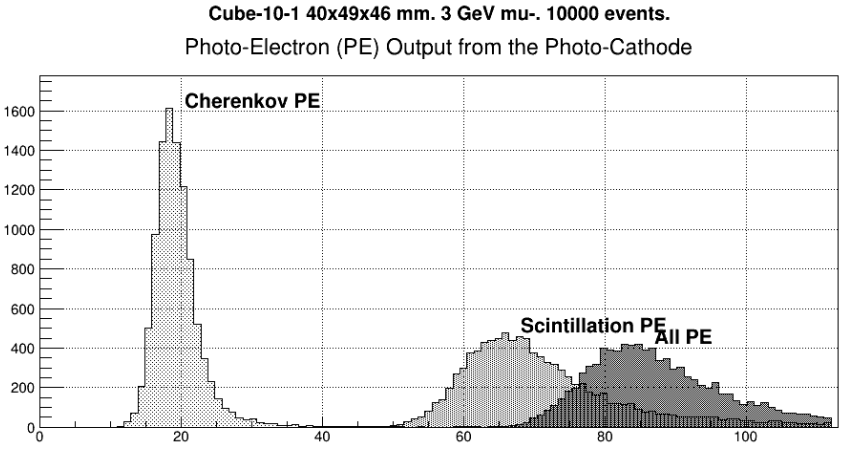


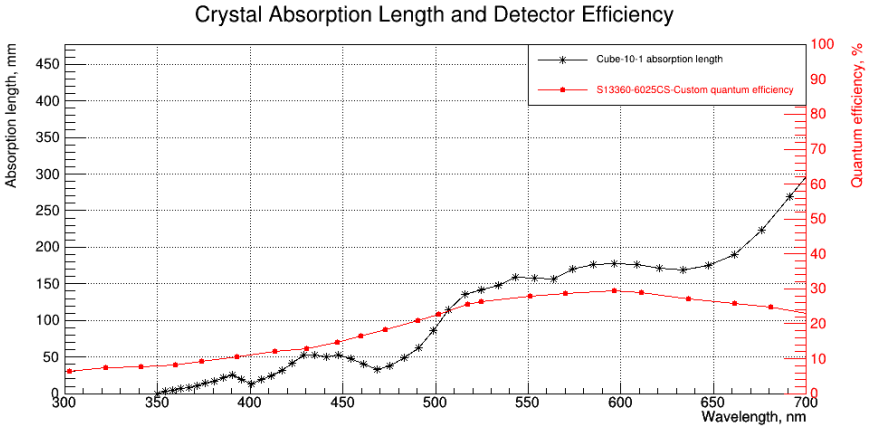
CSGlass (Cube10) Results

Final detector response depends on following processes: **emission, transportation, detector quantum efficiency**.

10.1 *CSGlass*
40.87 × 49.8 × 46.28 mm, 4.46 g/cm³, transmission side 1.







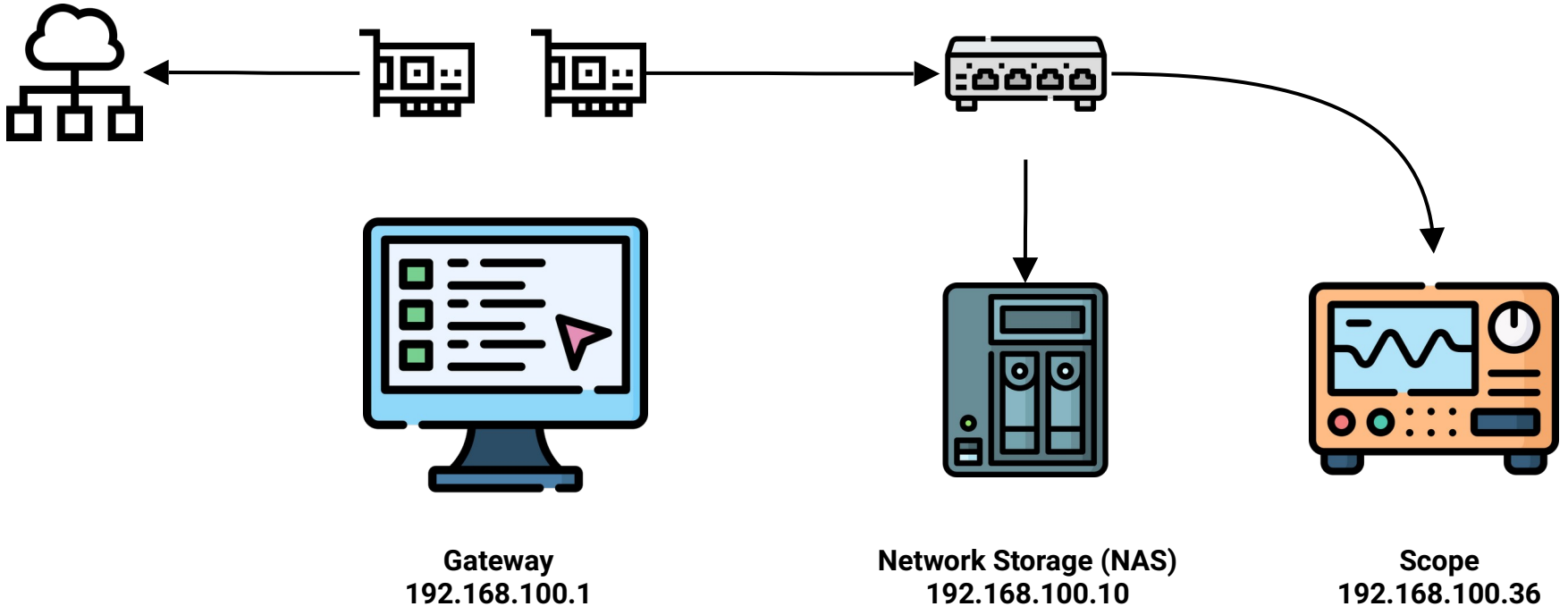
Conclusion: contributions from Cerenkov- and scintillation- produced photons provide different number of photo-electrons (different signal amplitudes).

Better transmittance in “blue” region is desired.

Data Acquisition Setup in JLab

Prototype waveform **data acquisition setup is built and tested** in the JLab NPS clean room.

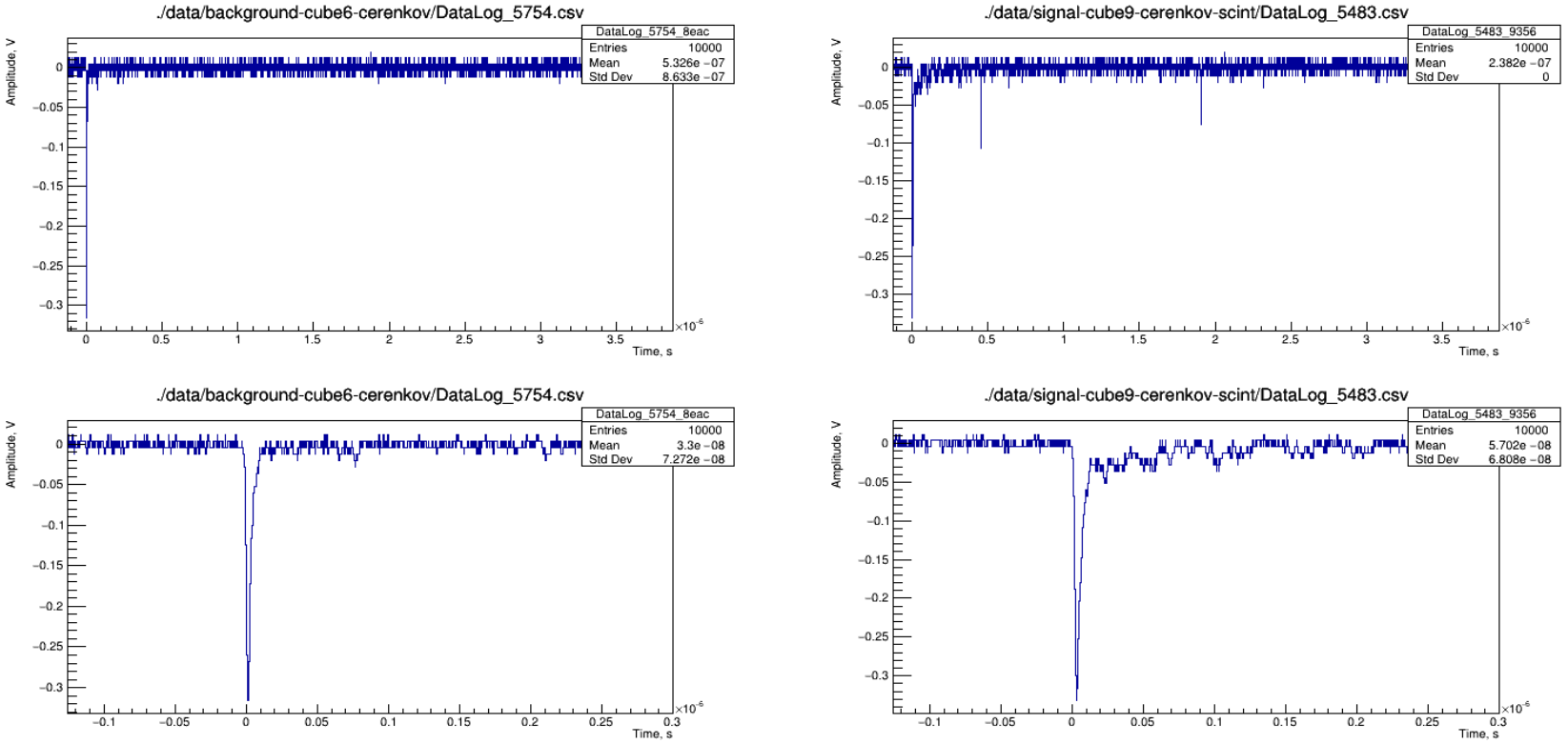
- Computer, oscilloscope and network storage are communicating within a local area network.
- Open-source acquisition software based on National Instruments (NI) Visa library is developed to continuously acquire waveforms from the oscilloscope upon external trigger.



Device connectivity diagram

SciGlass Waveforms: Cube6 vs Cube9

Waveforms from SciGlass samples #6 and #9 are obtained. Visually we observe the difference in shapes of the signals. We are in progress applying the Machine Learning (ML) technique classify signals in two groups.



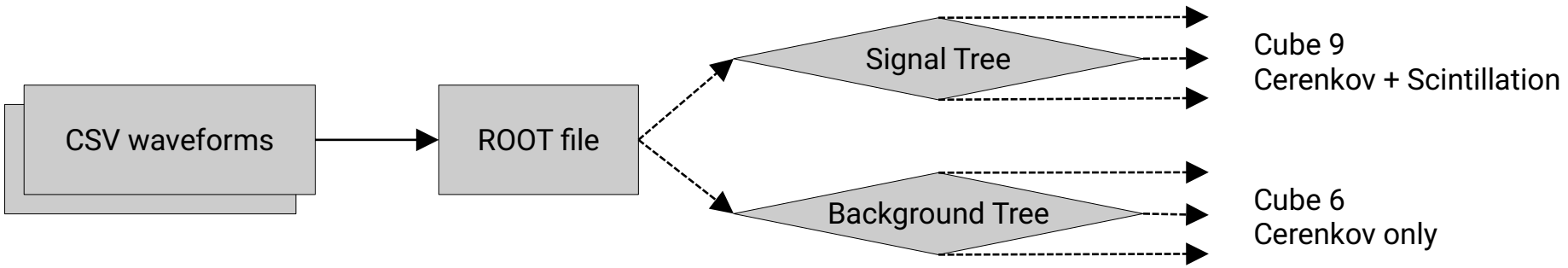
Left: waveform of the Cube6 sample – Cerenkov only.
Right: waveform of the Cube9 sample – Cerenkov and scintillation.

CERN ROOT TMVA

The Toolkit for Multivariate Analysis (TMVA) provides a ROOT-integrated environment for the processing, evaluation, **binary classification** and regression techniques.

1. DATA PREPARATION

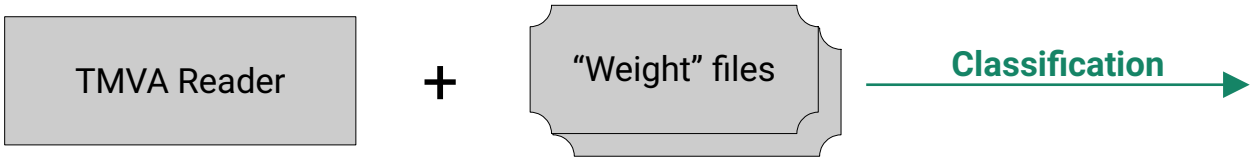
Waveforms as branches. Show example file.



2. TRAINING PHASE

contain all information necessary to recreate the classification method without retraining

3. CLASSIFICATION APPLICATION PHASE



Conclusions

SIMULATION:

- Geant4-based **simulation program is developed**. Program accounts on various glass properties (emission, transmission) and supports multiple detector types (PMTs, MPPCs).
- We can: **visualize photon trajectories**, **reconstruct the detector response** and many more....

DATA ACQUISITION:

- New **data acquisition setup is built** from in counting room.
- Hardware setup: computer, oscilloscope and network attached storage (NAS) are communicating within a local area network.
- Open-source **acquisition script is developed** to continuously acquire waveforms.

EXPERIMENT:

- **Waveforms from Cube6 and Cube9 SciGlass samples are acquired** by means of the new acquisition setup.
- We are in progress **applying Machine Learning** technique **to differentiate** between the shape of the signals from the **Cube6 and Cube9** samples (Cerenkov-only and Cerenkov with scintillation).

MANUFACTURNG:

- **Better transmission** in the “blue” Cerenkov region of the samples **is desired**. Especially tor the beam tests with longer blocks.