Calorimeters and 3D Maps

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Model Airplane Video (on desktop)

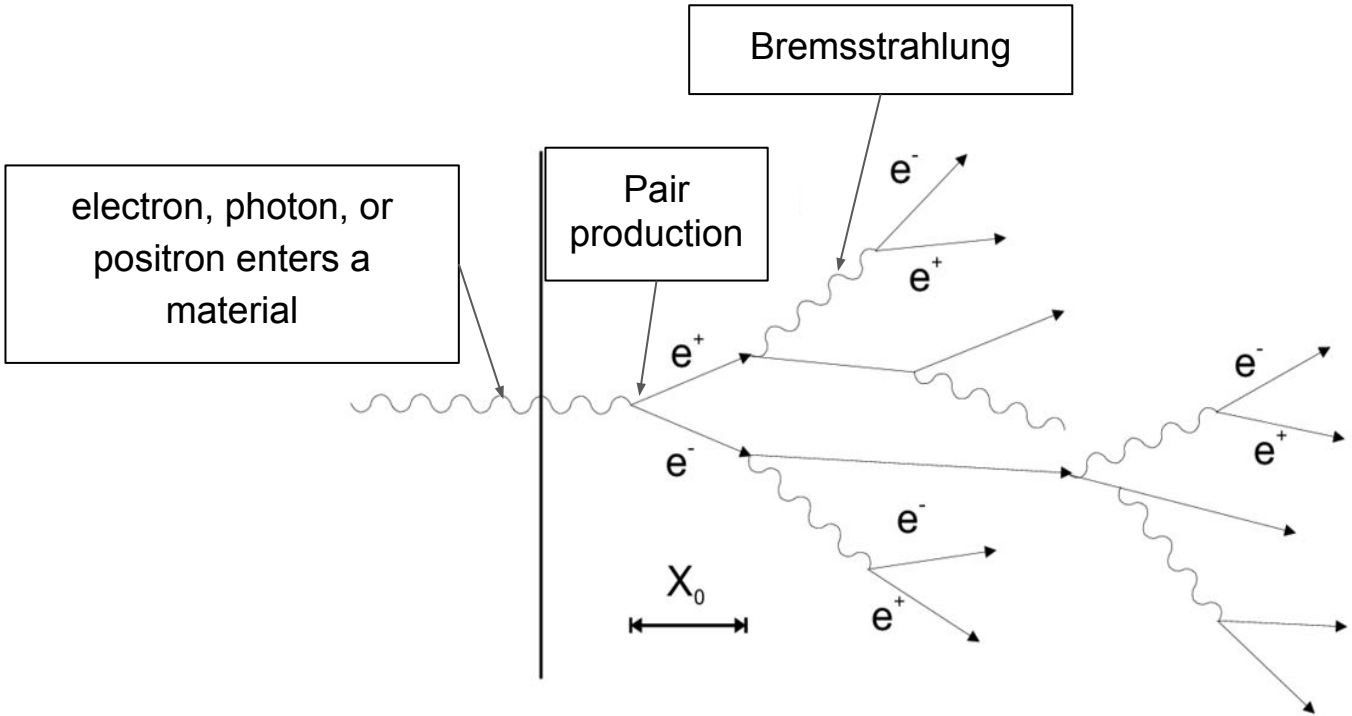
How calorimeters are used in nuclear physics and what techniques are used?

- Calorimeter - a device (placed AFTER a stack of detectors) that measures the energy of particles (particle shower → collection)

Sampling	**Homogenous**
○ One material produces the particle shower; another material measures the deposited energy	○ One material produces the particle shower and measures the deposited energy

What is an electromagnetic shower?

- particles that interact primarily through the electromagnetic force

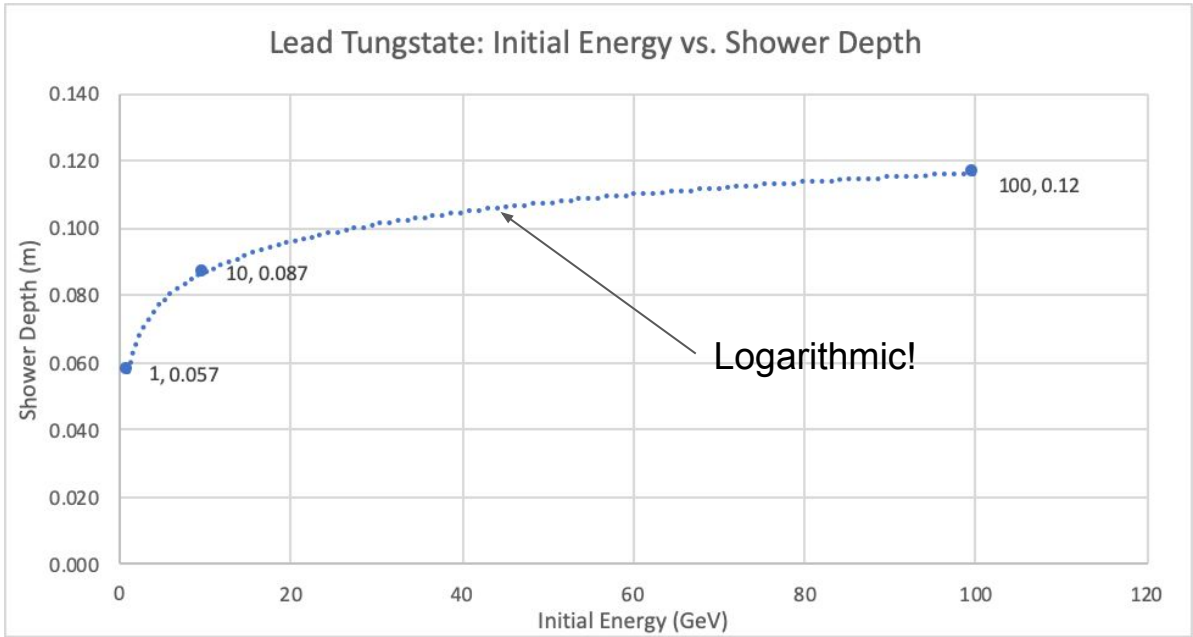


Source: Quality control and preparation of the PWO crystals for the electromagnetic calorimeter of CMS

What is the radiation length? How thick would the calorimeter have to be if you wanted to detect photons of energy 1 GeV, 10 GeV, and 100 GeV, and used PbWO4 crystals?

- Radiation length - Property of how far a shower can travel in a material
  - mean distance over which a high-energy electron loses all but 1/e of its energy by bremsstrahlung

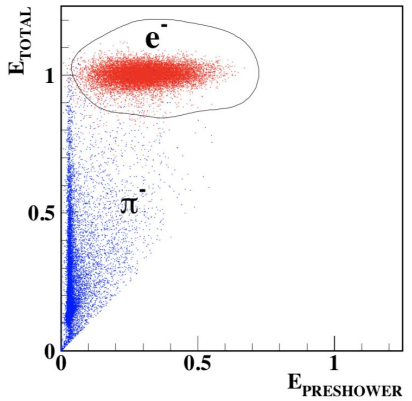
$$X = X_0 \frac{\ln(E_0 / E_c)}{\ln 2}$$



Would you need a different type of calorimeter to detect protons?

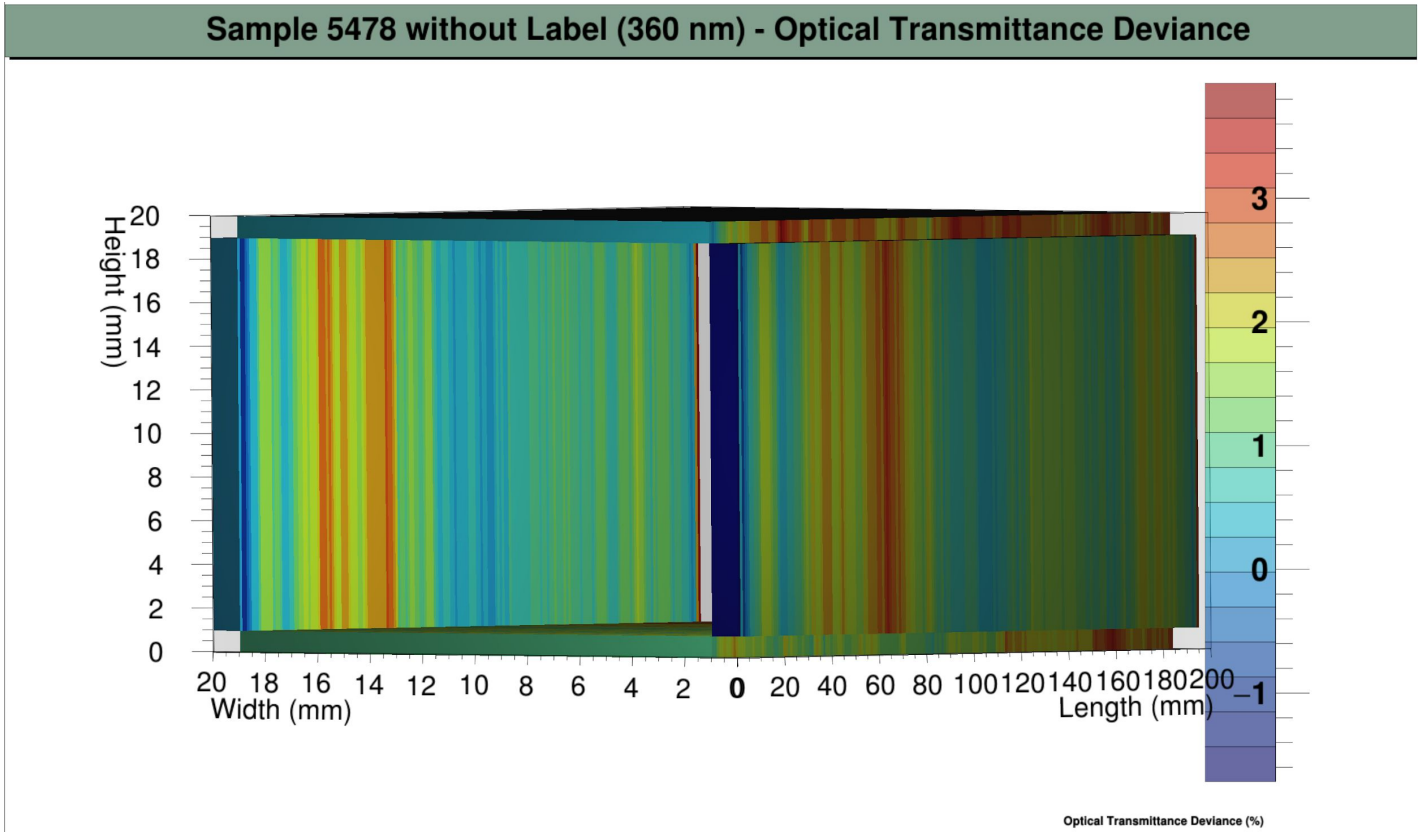
- It depends
  - Most charged hadrons go <u>through</u> the calorimeter.
    - HOWEVER, in JLab Hall C, charged hadrons can be detected by choosing the magnetic field and trigger configuration
    - Also, some charged hadrons interact with its front surface

Source: Monte Carlo Simulations of the JLab Hall C Calorimeters
Part I, HMS Calorimeter



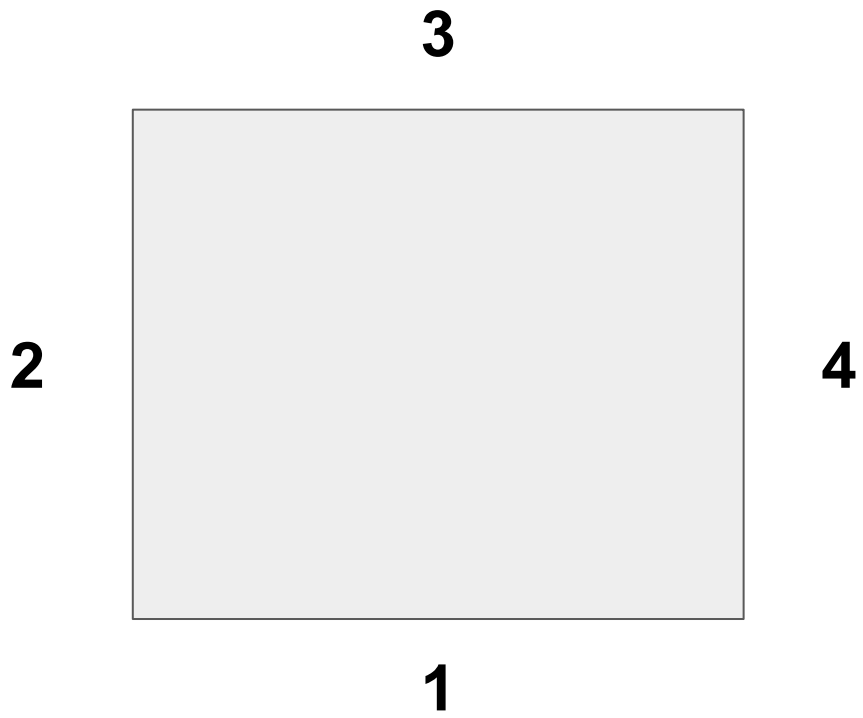
  - Some calorimeters like CERN's ECAL can detect charged hadrons

3D Map Finished

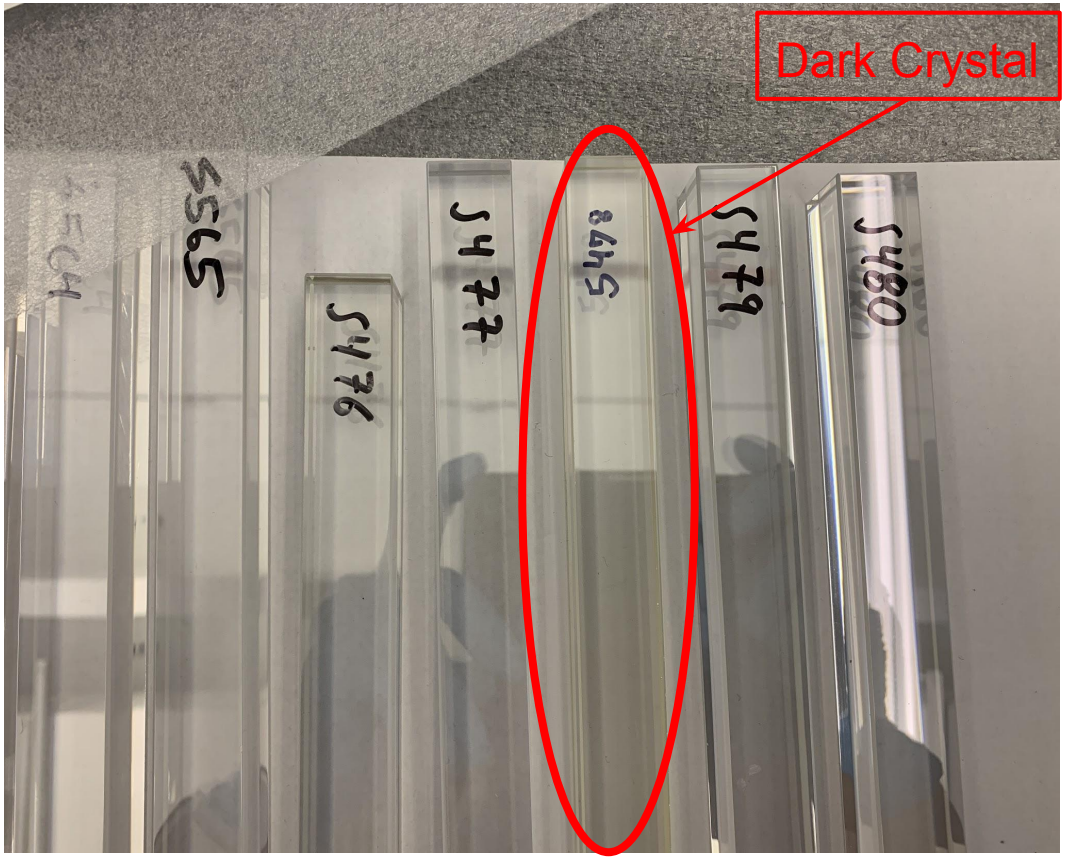


3D Map Crystal Position

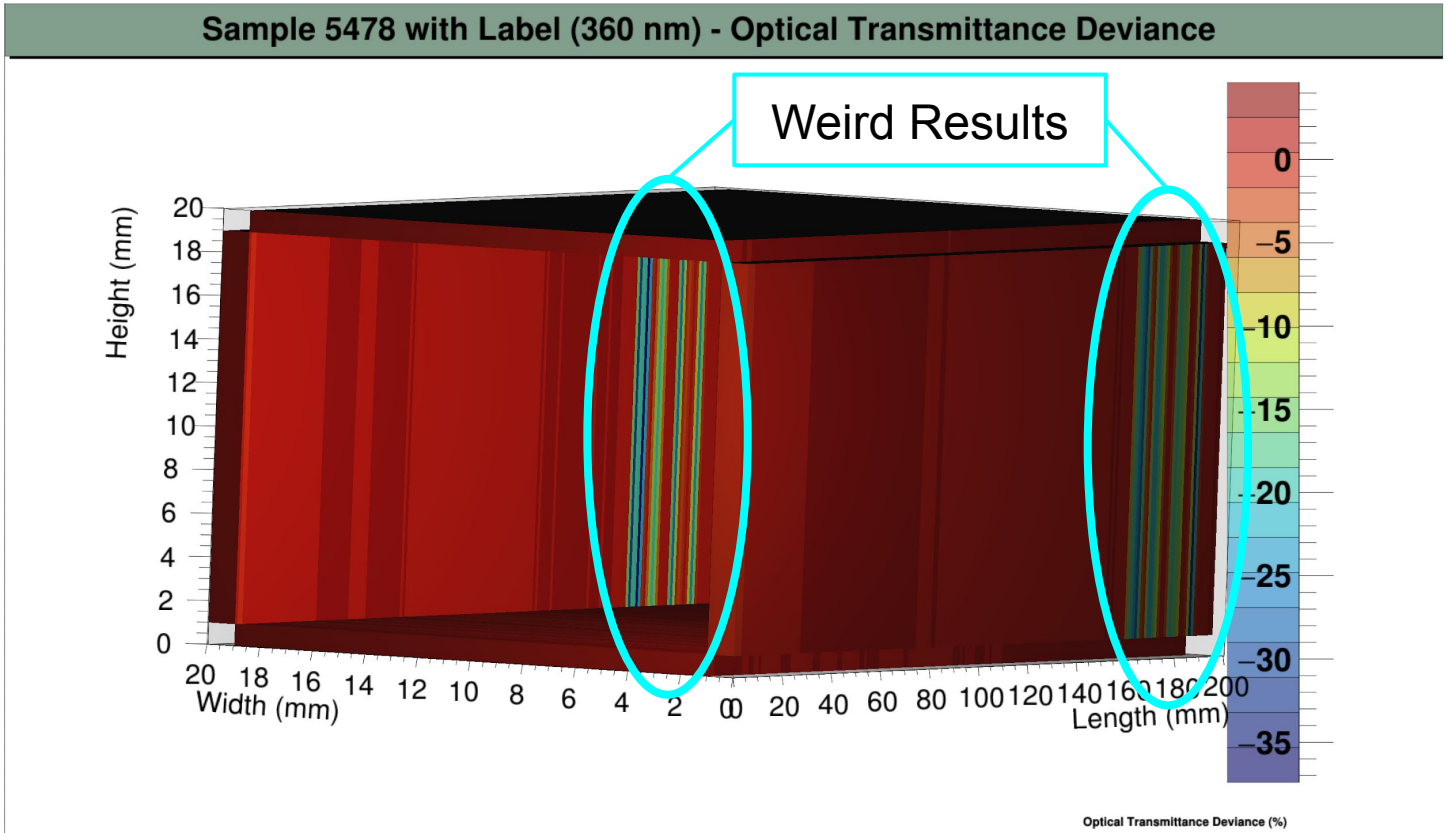
Crystal Cross-Section (Label Down and Back)



Crystal 5478

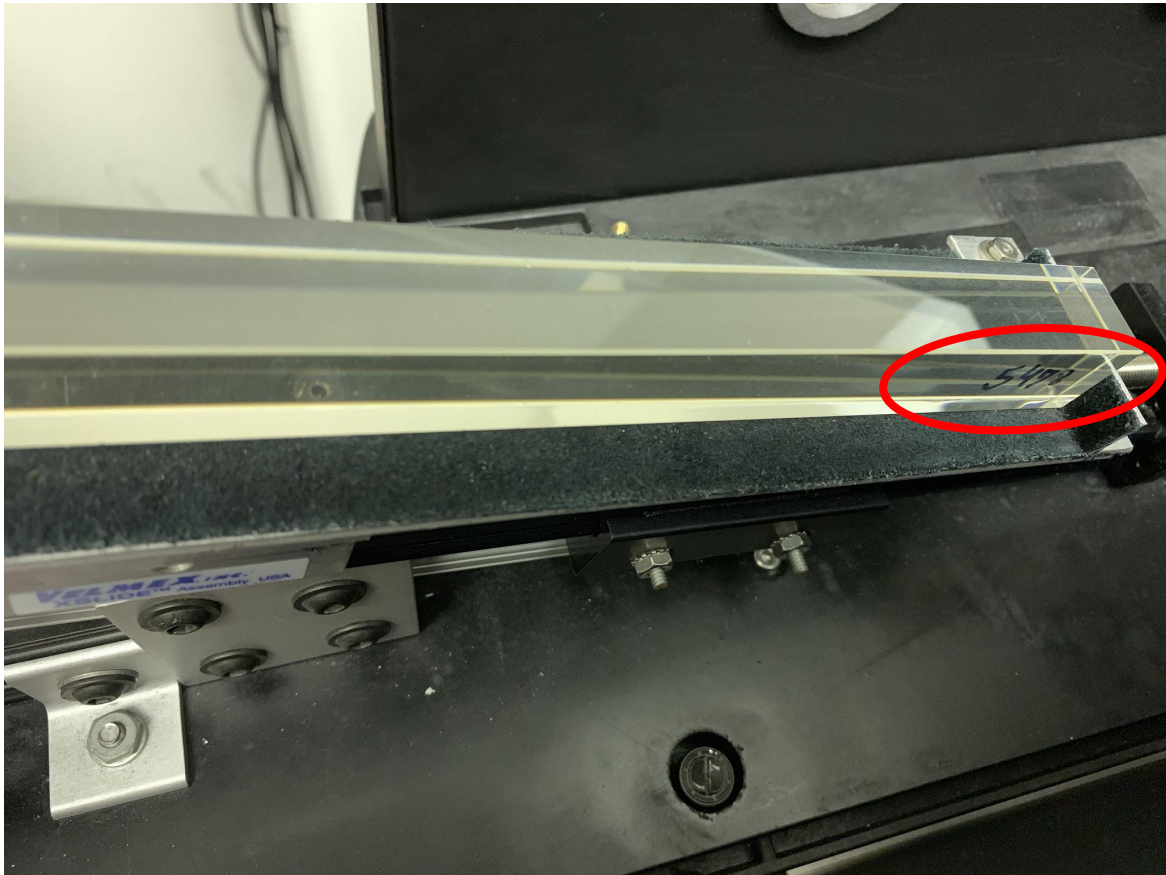


3D Map - Crystal 5478 (w/ label)



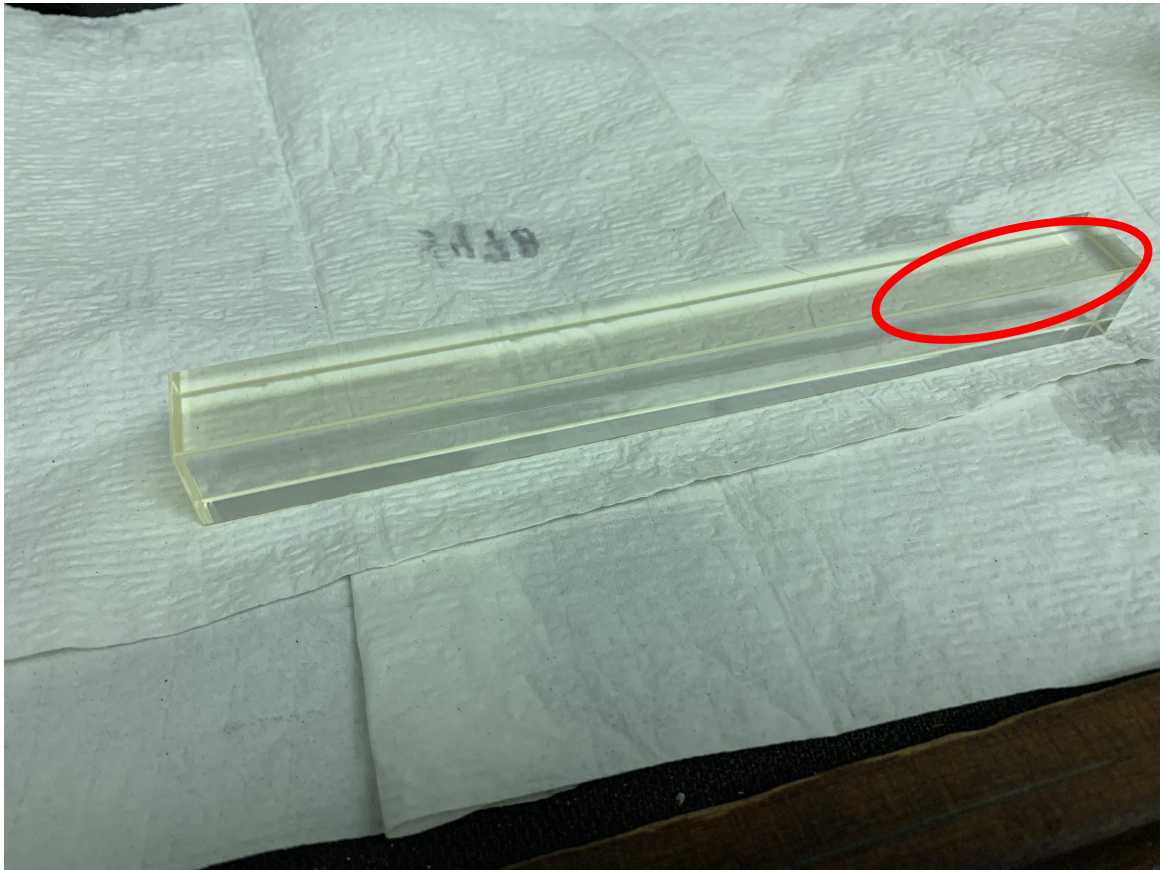
Picture - Crystal 5478 (w/ label)

- Label interferes with transverse transmittance measurement

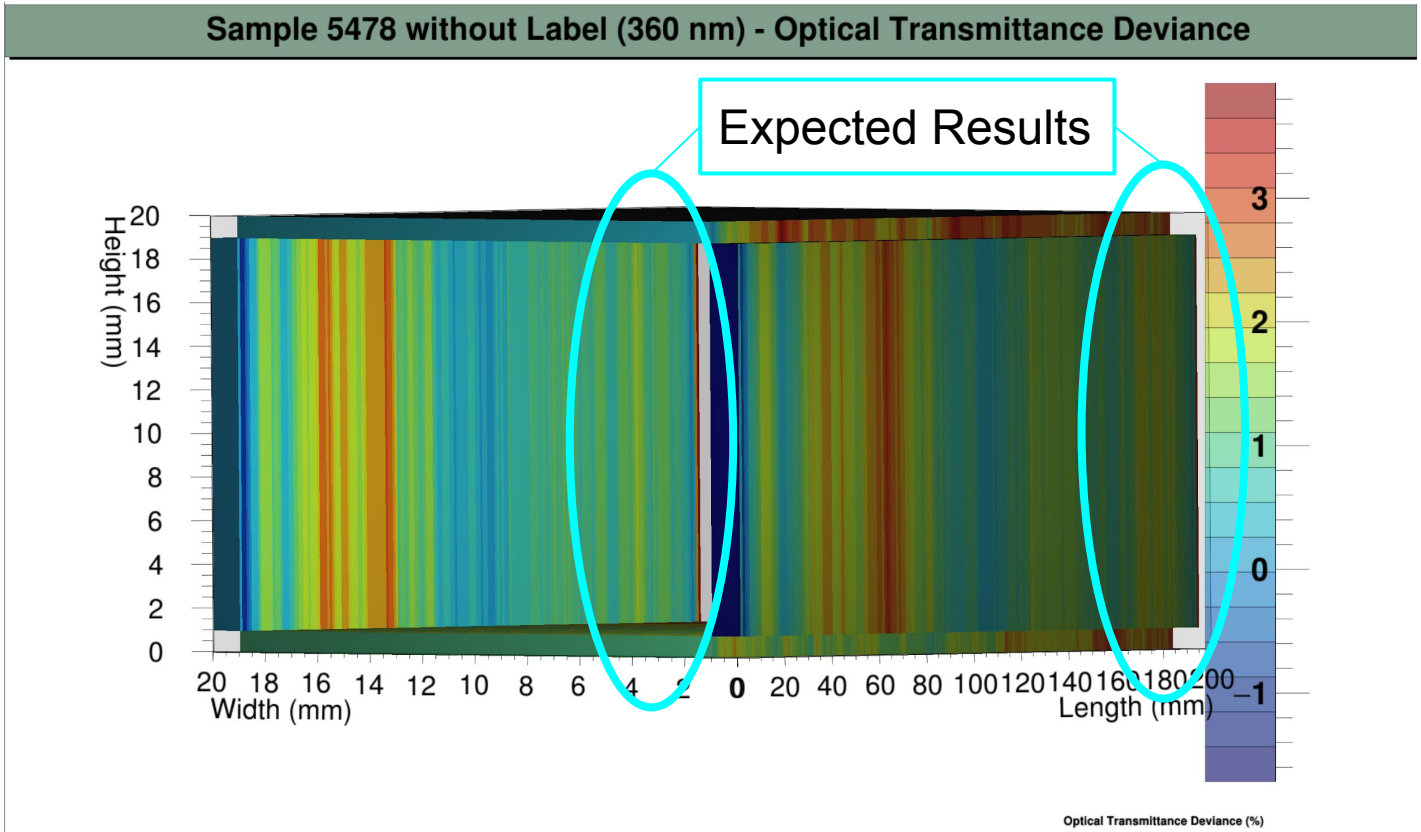


Crystal 5478 (label REMOVED)

- Label (temporarily) erased with alcohol



Crystal 5478 (w/o label)



Sources

CERN - Quality control and preparation of the PWO crystals for the electromagnetic calorimeter of CMS (https://www.roma1.infn.it/cms/talks/fc_1.pdf)

CERN - About the electromagnetic shower lateralprofile in the lead tungstate (https://cds.cern.ch/record/687307/files/note97_037.pdf)

CERN - Introduction to CERN and CMS (https://www.phys.hawaii.edu/ams02/outreachnsf/files/Jamie-Gainer-Masterclass-Presentation-.pdf)

JLab Hall C - The lead-glass electromagnetic calorimeters for the magnetic spectrometers in Hall Cat Jefferson Lab (https://hallcweb.jlab.org/DocDB/0008/000809/001/NIMarticleOverview.pdf)

JLab Hall C - A PbWO4-based Neutral Particle Spectrometer inHall C at 12 GeV JLab (https://iopscience.iop.org/article/10.1088/1742-6596/587/1/012048/pdf)

Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences - The structure of ionization showers in air generated by electrons with 1 MeV energy or less (https://iopscience.iop.org/article/10.1088/0963-0252/23/4/045001)