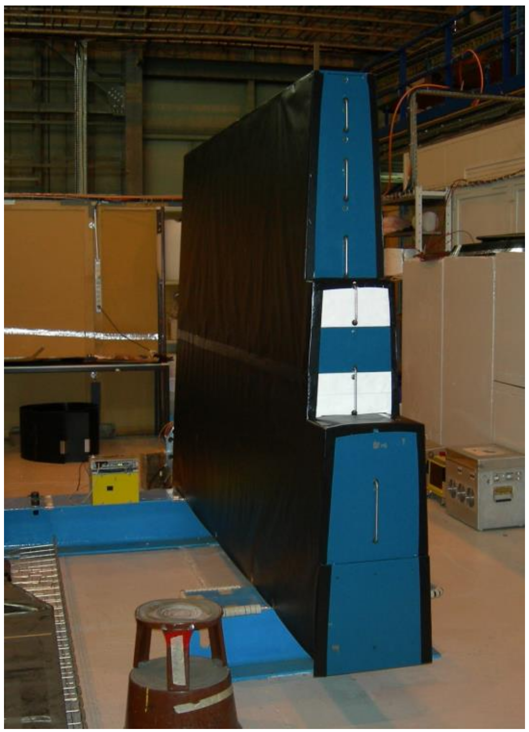
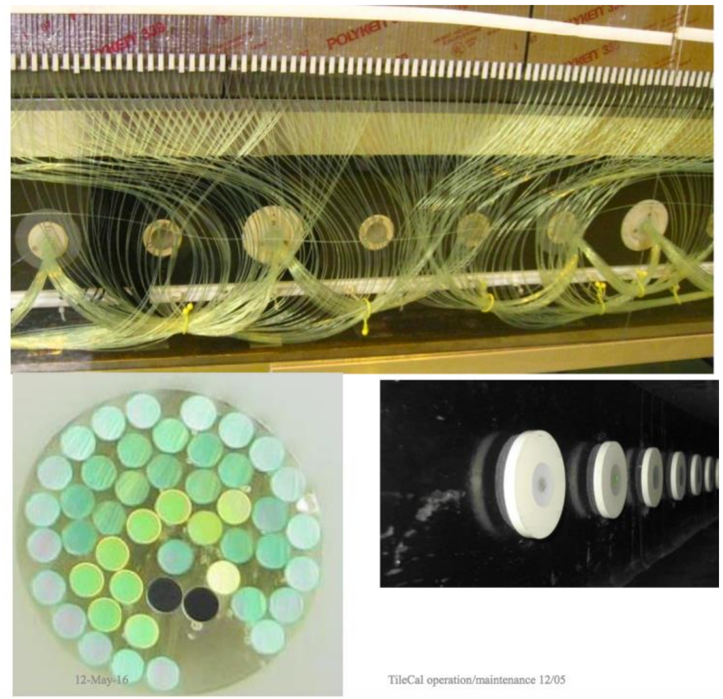
Increasing the Spatial Resolution of the Tile Calorimeter

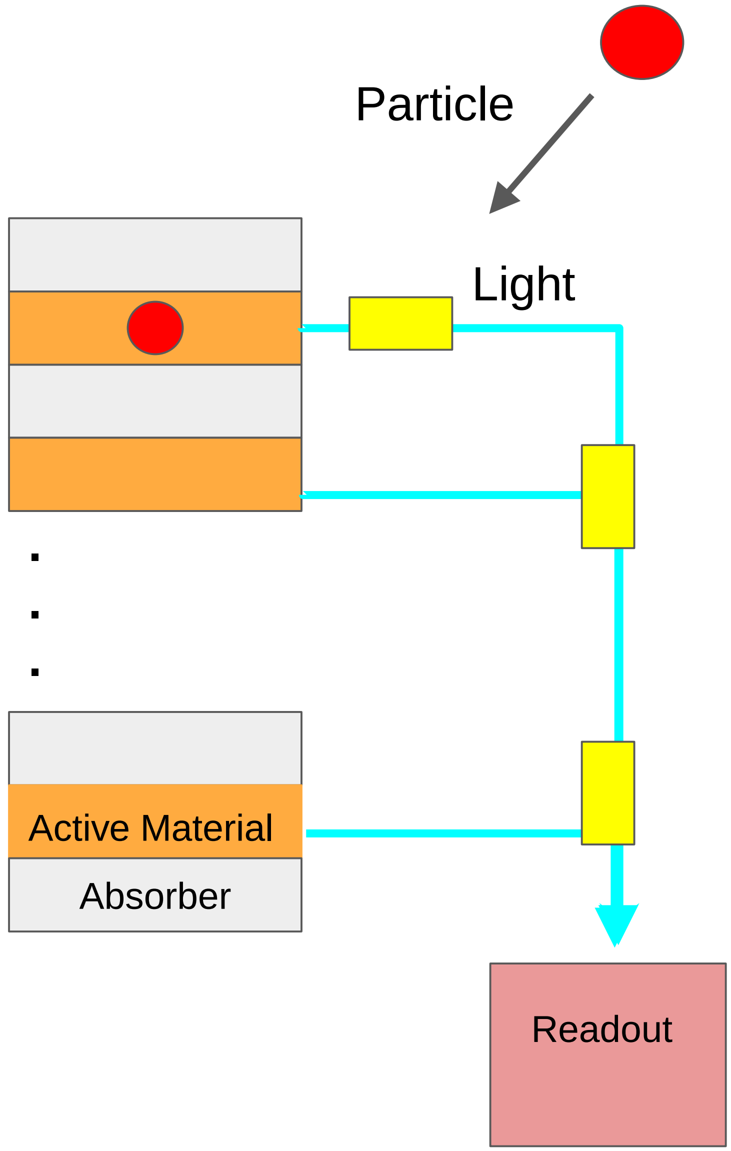




By Anthony Bisulco

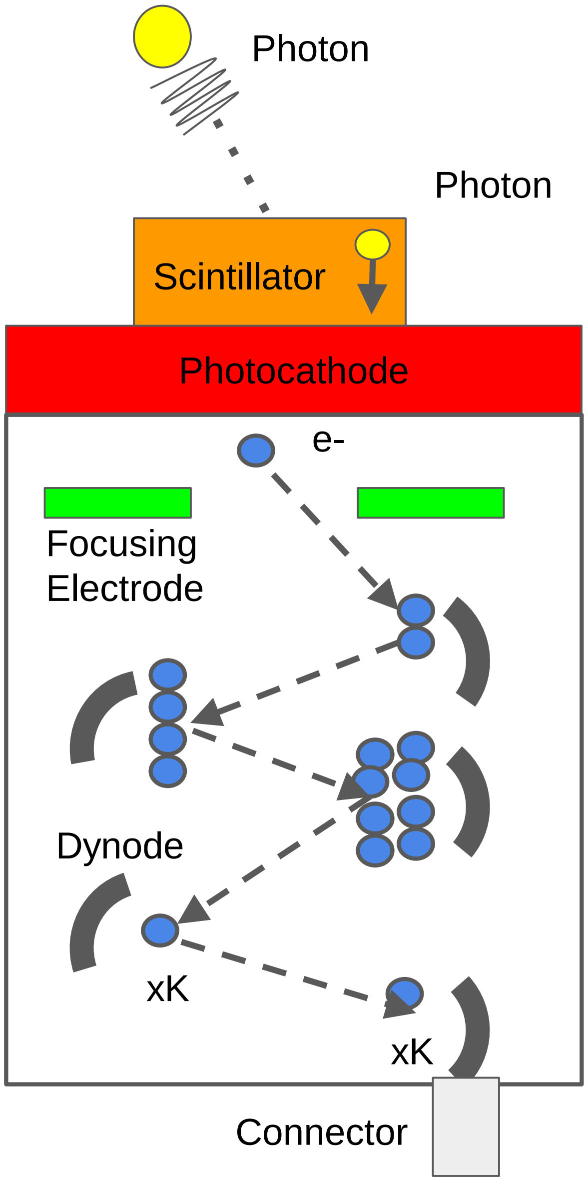
Tile Calorimeter Overview

- Tile calorimeter is a device used to measure the energy of particles
- A particle deposits energy in the **active material**(Scintillator) and **absorber**(Steel) of the calorimeter
- A **scintillator** is a material that exhibits the ability to luminesce when struck by a particle
- The tile calorimeter reads this light off using a fiber optic system



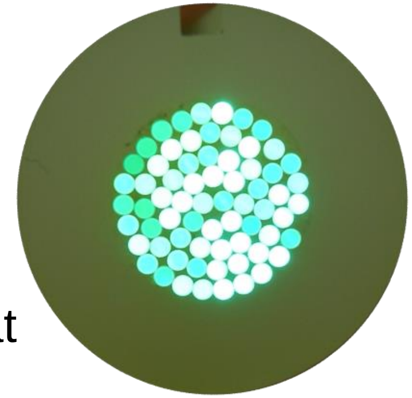
Read Out Electronics

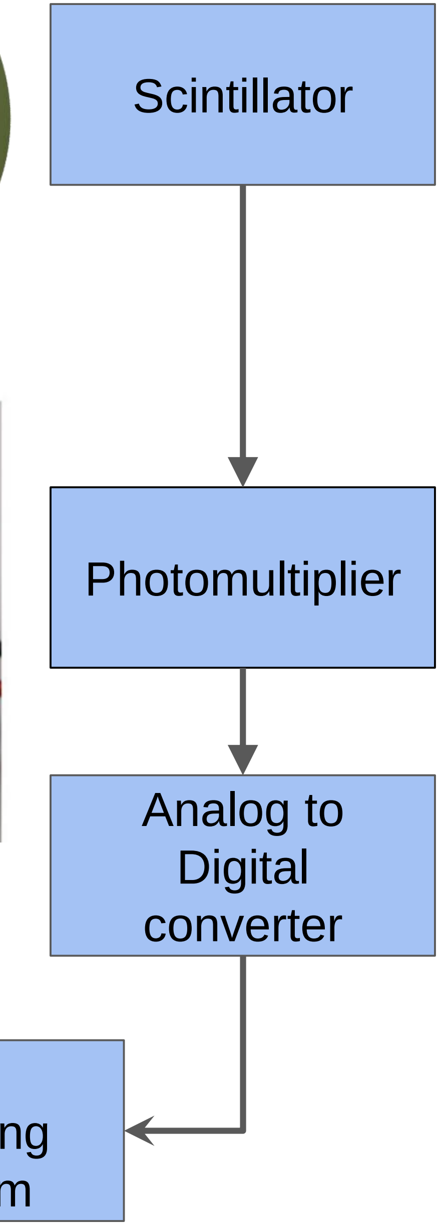
- Light signal from the **scintillator** is read out using a photomultiplier tube
- Photomultiplier tube converts the light signal to a corresponding current, process:
    - **Photon** from fiber hits another scintillator
    - Via the photoelectric effect **electrons** are stripped from metal (**Photocathode**)
    - These electrons are **focused** for the trajectory of a **dynode**(charged plate)
    - Dynode then focus for another dynode until reach end of chain where current is produced



Past Setup

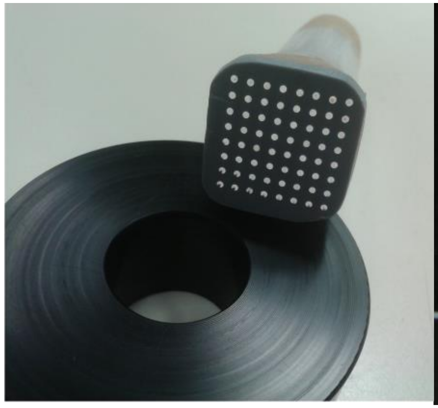
- Photomultiplier tube would read out a bunch of fibers all at once
- This grouping of fiber bundles reduces the calorimeters spatial resolution since not all are read individually
- Also, current electronics are not optimized to store and sample individual fibers
- Hence, the goal is to further implement hardware and software methods to increase system's resolution

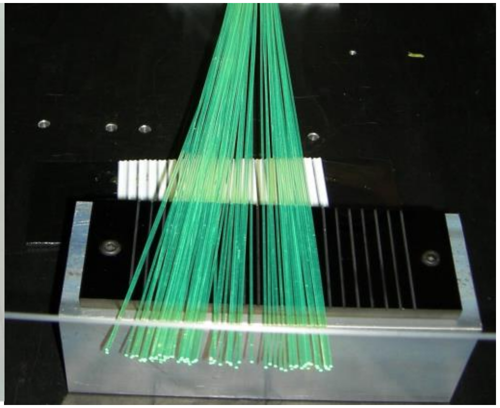


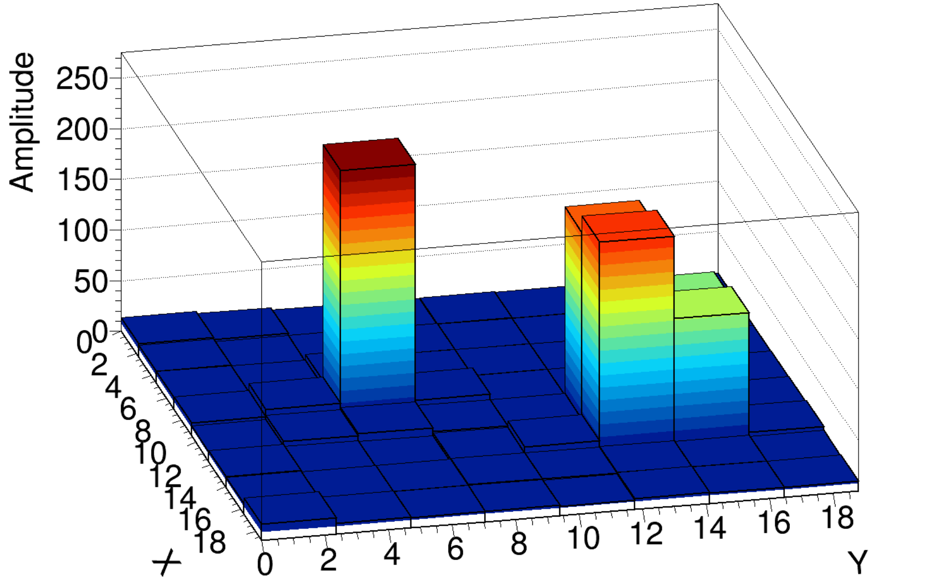


Current Prototype System

- Photomultiplier prototype system has an 8x8 pixel array
- Test setup: two fibers coupled to two different pixels are pulsed via an LED
- Note:coupling between fiber and photomultiplier has 5x loss
- Measurements highlight this reduces signal to noise ratio
- Data has been processed with pedestal(noise) removal
- Results highlight that crosstalk amongst pixels in the same region
- This crosstalk needs to be eliminated to increase sensor's spatial resolution







Each pixel is about 2.35 mm x 2.35 mm

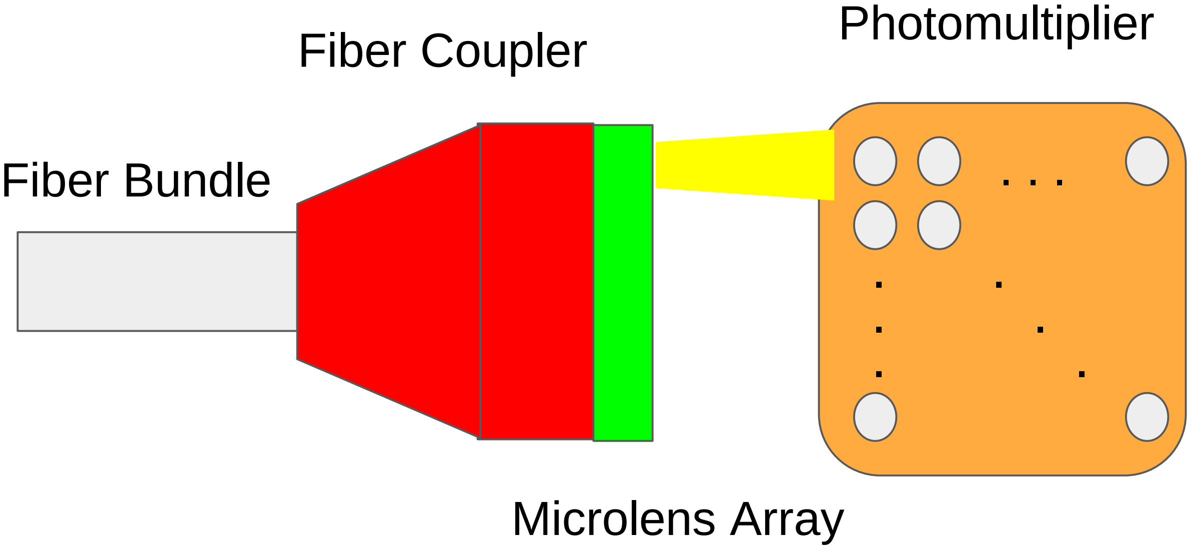
Images and Data Courtesy of Tigran Mkrtchyan

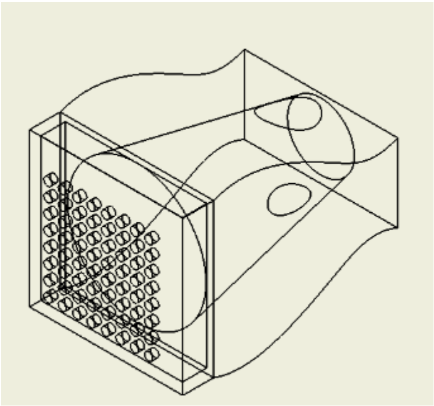
Future Prototype System

- Developing **3D printed parts** using Solidworks for fiber bundle to array coupler

- Developing **microlens array** to evenly distribute sensor signal over localized region

- Developing new analog to digital converter for signal readout





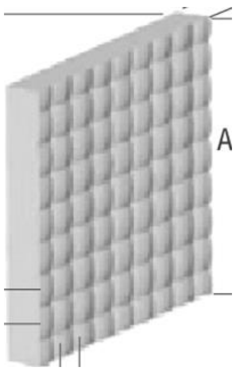
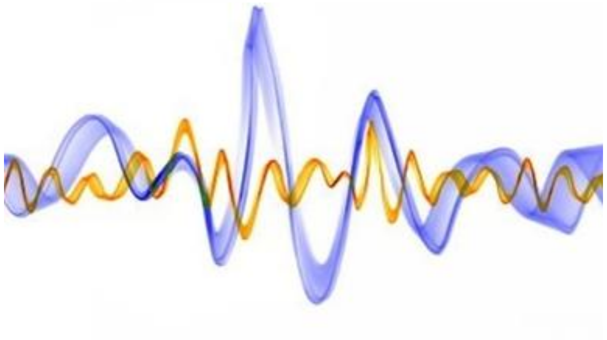


Photo Courtesy: https://www.newport.com/mam/celum/celum_assets/square_microlens_600w.gif?1

Conclusion and Future Tasks

- Develop 3D printed parts for fiber and photomultiplier tube coupling
- Test pixel sensitivity with new stable fixture for fiber to photomultiplier
- Implement signal processing algorithms to optimize signal to noise ratio
- Perform standard operating procedure for calibration using a radioactive source



ROOT
Data Analysis Framework

Photo Courtesy:
https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwi_zfn9n7LPAhUFbxQKHXCFAN0QjRwIBw&url=http%3A%2F%2Fwww.pcmag.com%2Farticle2%2F0%2C2817%2C2470038%2C00.asp&psig=AFQjCNFXNIYSGEBoum4TzjhusvBdXkNQCw&ust=1475158552098010, https://media.licdn.com/mpr/mpr/AAEAAQAAAAAAAAQpAAAAJGNmNDlhNGUwLTk4YTgtNDQzMS1iMjY4LWQyNzgzZjdlNzdkOA.jpg

Travel