Measurement of characteristics of lightguide for forward EMcal for ePIC detector

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Introduction

- Design: lightguide (PMMA/acrylic) + SiPM structure
- Purpose: measure

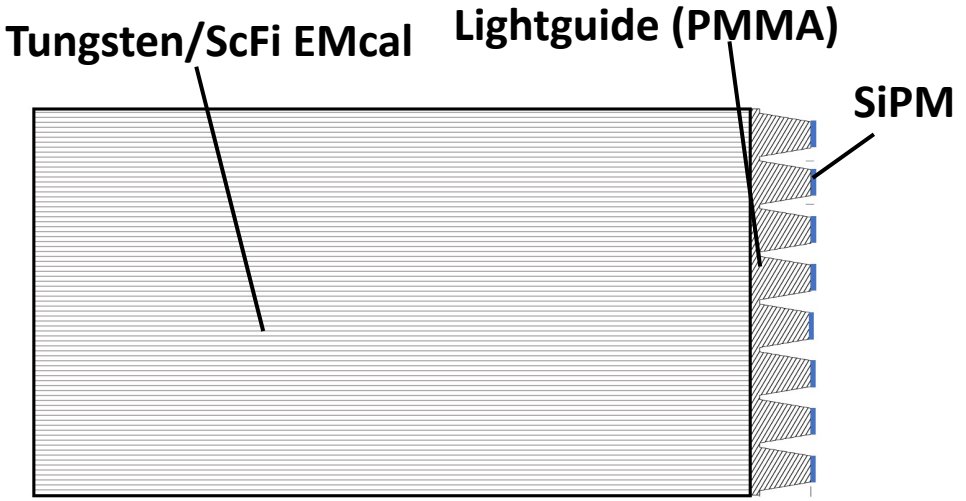
a) efficiency of light collection

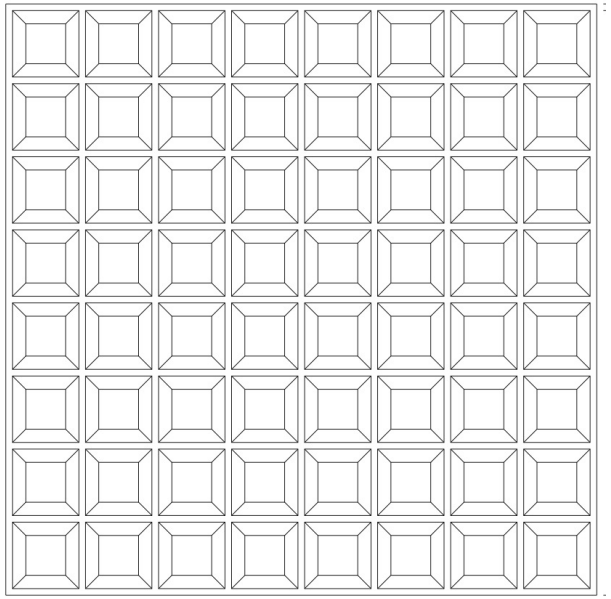
- We want a good Signal/Noise at low level of light once SiPM becomes noisy after exposure to neutrons.
- Earlier prototypes of calorimeter tested at FNAL yield 0.4-0.6 pixel/MeV.
- ePIC should measure energy from 50 MeV.

  It is desired to increase yield to 1.5 pixels/MeV.

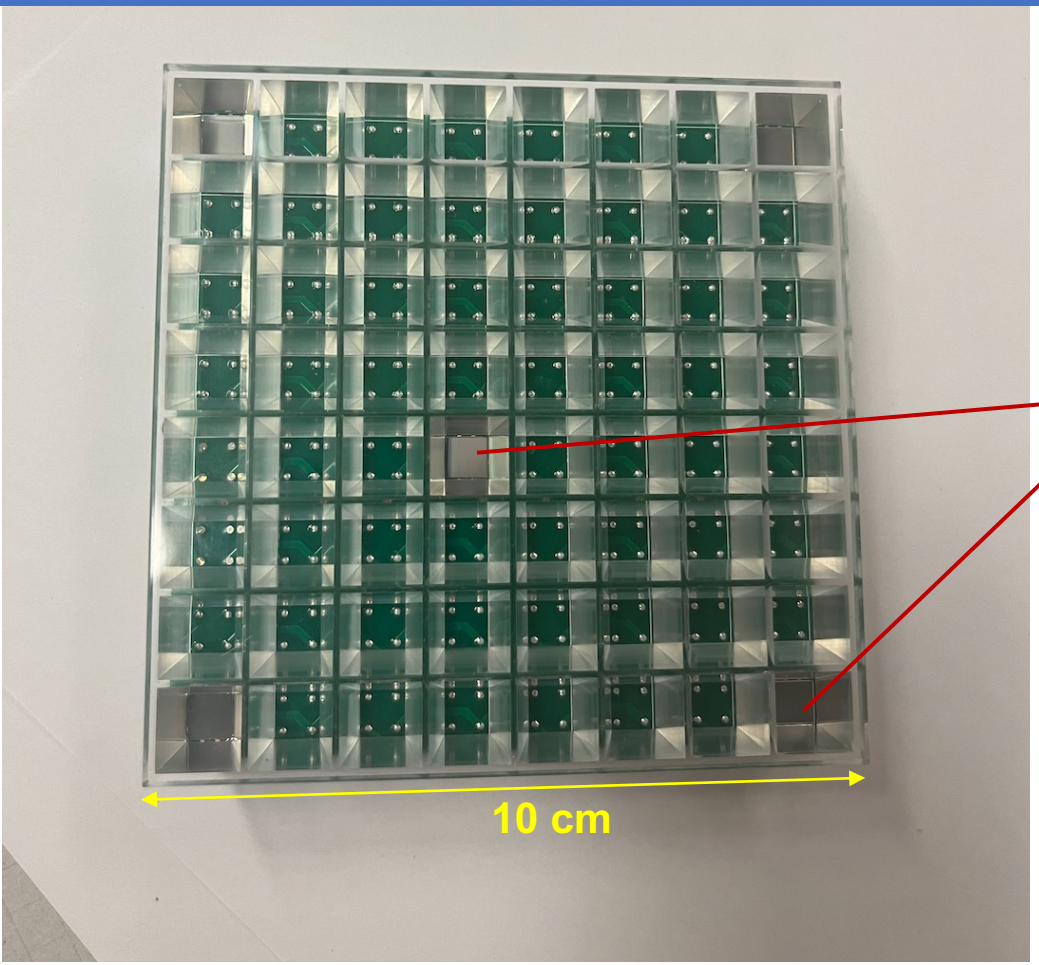
b) uniformity of light collection

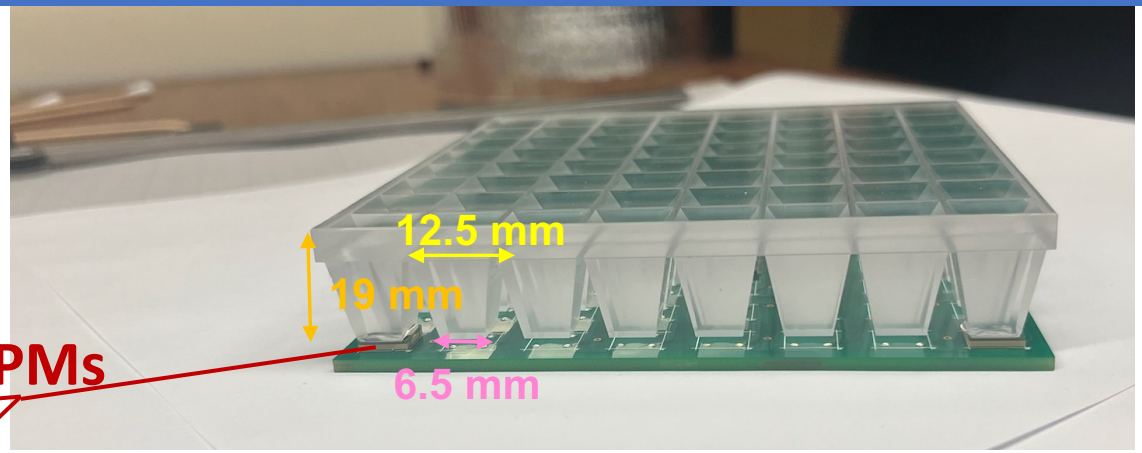
- At high energy (~100 GeV), resolution is dominated by constant term.
- Constant resolution depends on non-uniformities in the calorimeter (including non-uniformity of light collection).





Prototype of lightguide for ePIC Forward EMCal





SiPMs

- A single lightguide per W/ScFi installation block. It has 64 pyramids to collect light from 10 x10 cm^2 area of block to 64 6 x 6 mm^2 SiPMs.
- Thickness of lightguide is 19 mm, reduction area is 12.5 x 12.5 mm^2 to 6.5 x 6.5 mm^2.
- Optical coupling between SiPMs and lightguide is Sylgard 3145 RTV.
- Non-uniformity: light incident to the edges of pyramids has lower efficiency.
- Not enough calibrated SiPMs for now.

Results: Efficiency

- Efficiency was measured with HPK 6x6 mm^2 SiPM. Light source is 1mm diameter plastic optical fiber, 35 cm away from SiPM. 2% light is lost in 19 mm Acrylic (PMMA) and Sylgard coupling.

- Two versions of lightguide were tested. One straight after machining, another with additional polishing after machining.

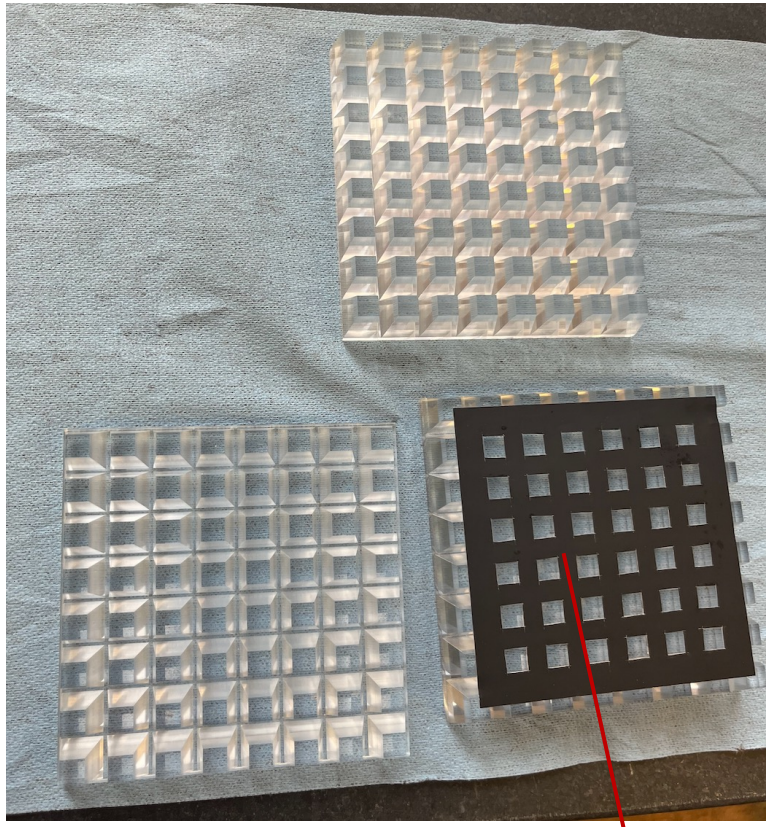
Type of Light Guide	Lightguide Efficiency	Transmittance (Acrylic +Sylgard)	Geometrical Efficiency (6 mm / 6.5 mm)^2	Total Light Collection Efficiency
Machined	84%	98%	85.2%	70%
Machined + Polished	95%			80%

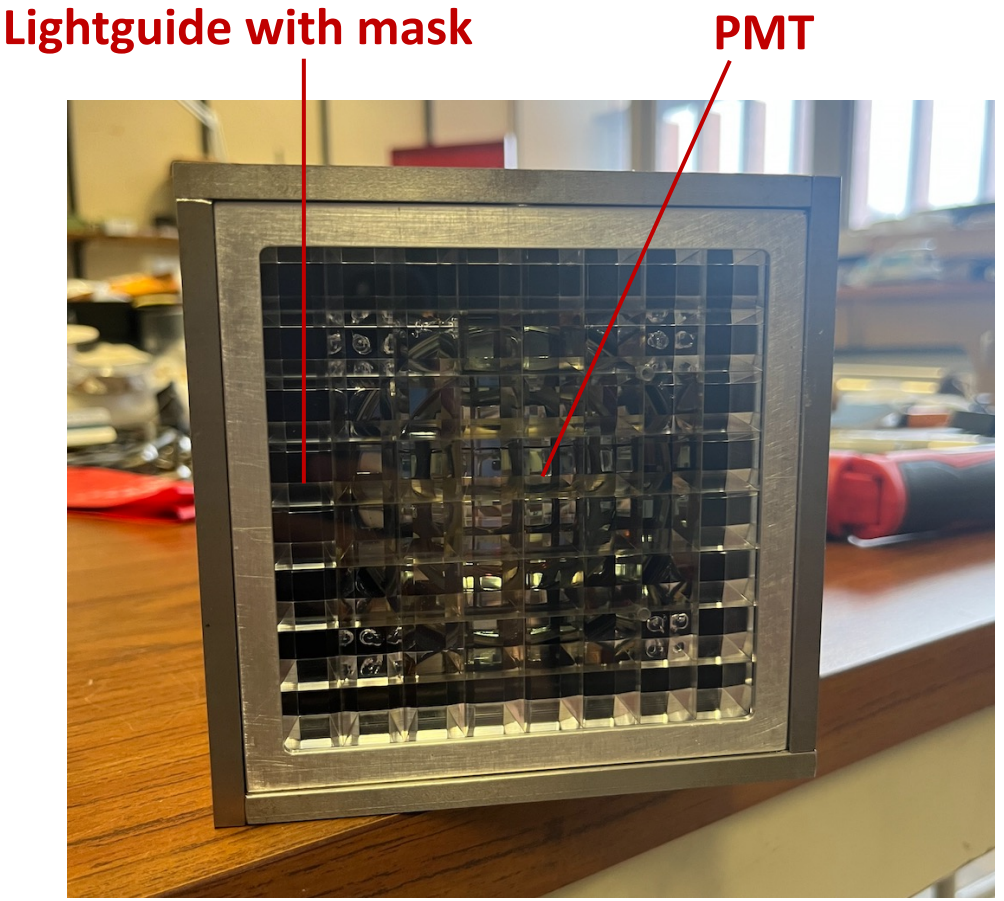
- FNAL test run measures light yield ~ 400 pixels/GeV with efficiency at ~ 21%.

Scaling this for ePIC gives about 1600 pixels/GeV light yield for forward EMCal.

- This will be verified in another test run at FNAL.

PMT + lightguide for uniformity test

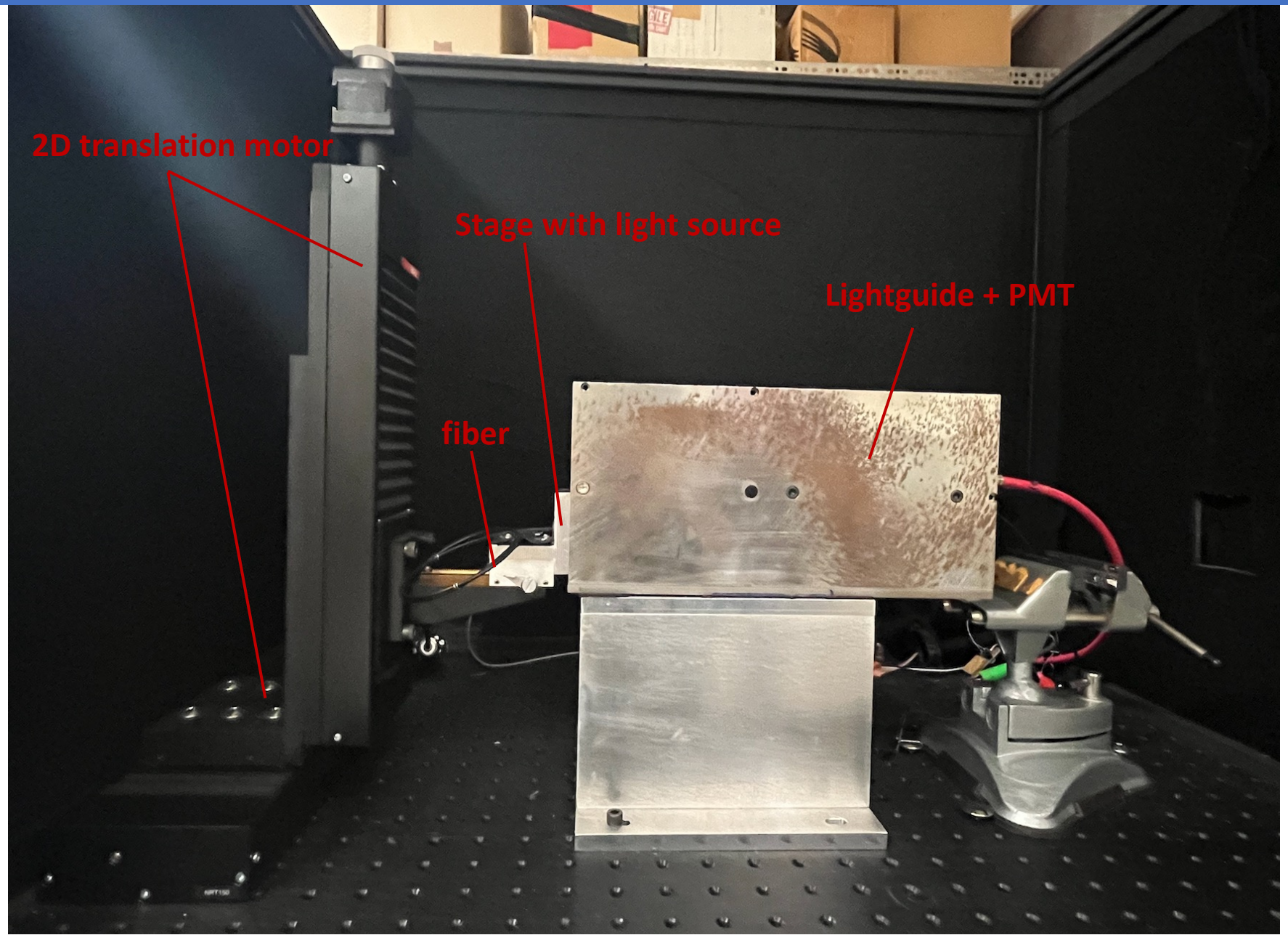




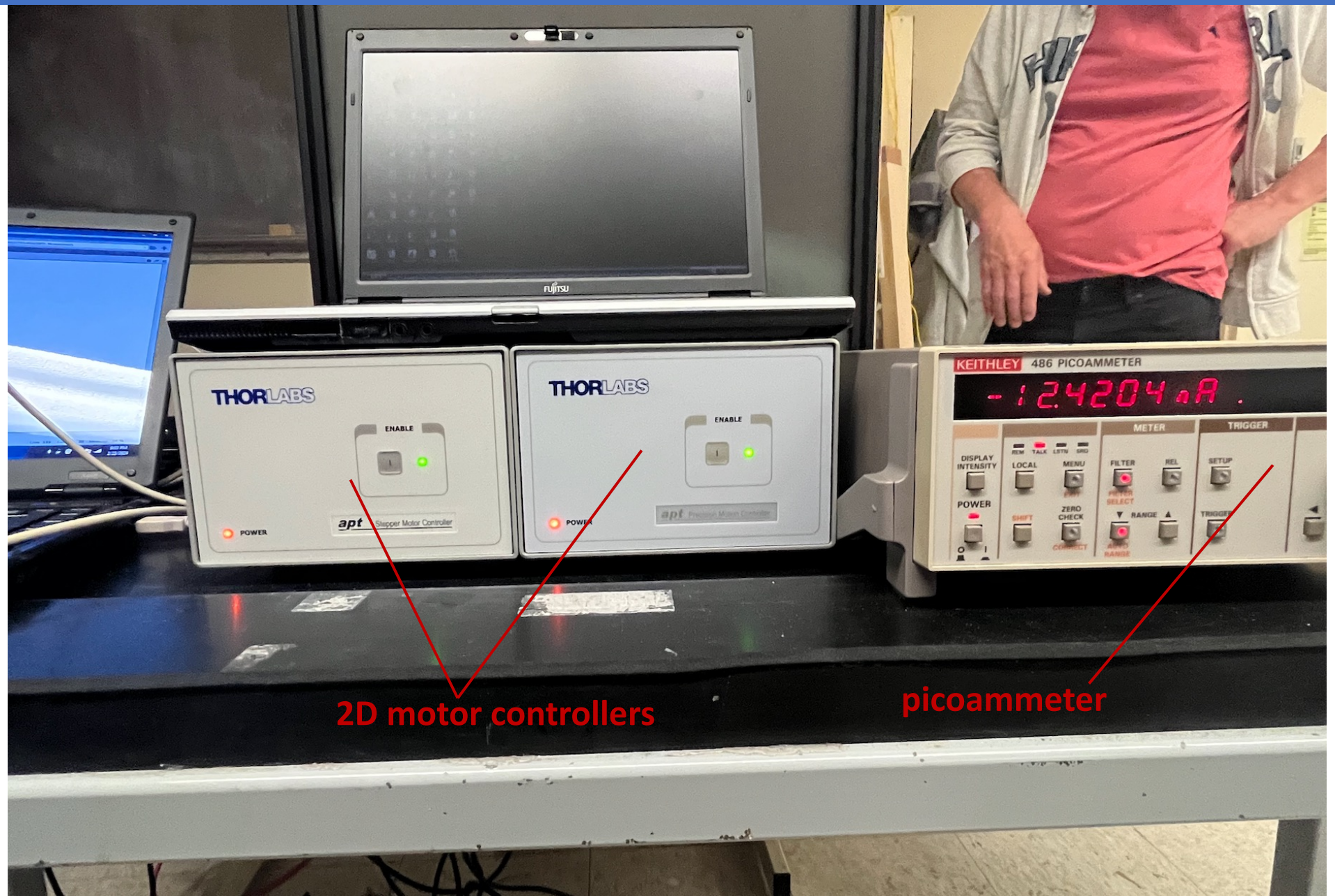
- **PMT + Masked lightguide to mimic the SiPM detection**

  Incident light that hits the edge (black masked area) won't be detected by PMT. Similar to SiPM detection.
- **Lightguide and PMT are glued to ensure optical contact.**

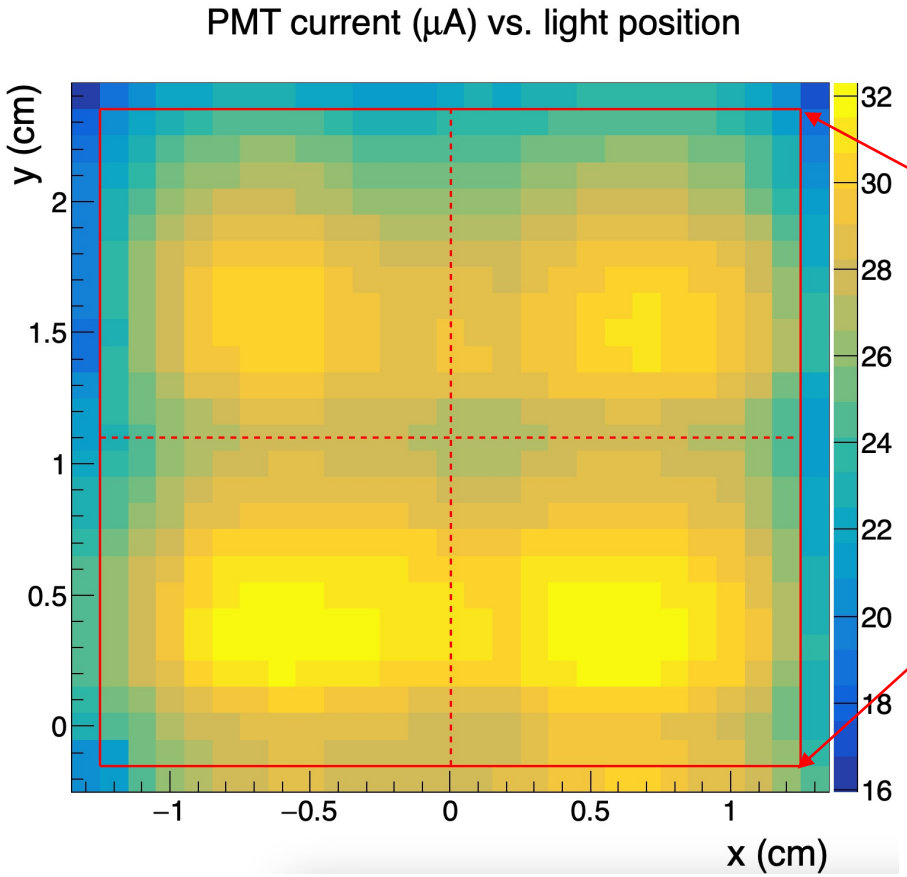
2D scan setup for uniformity test

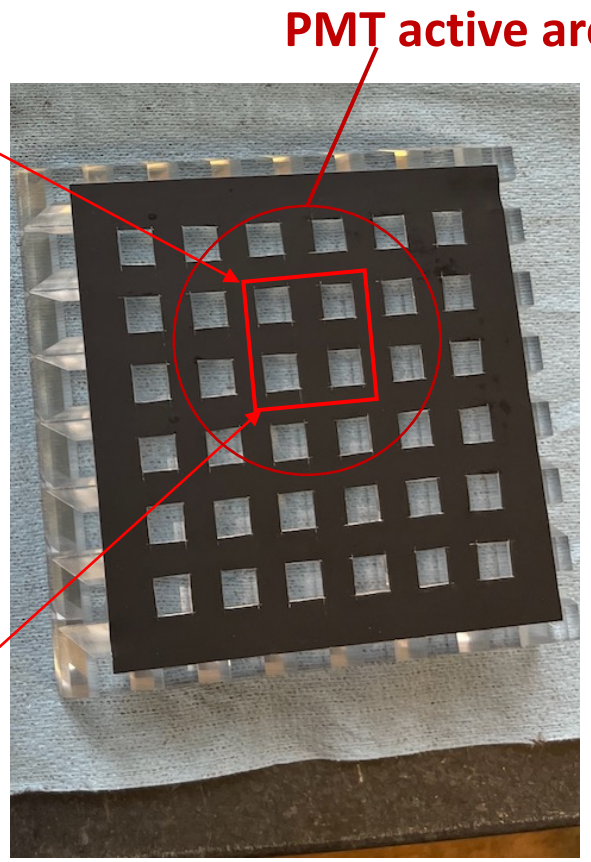


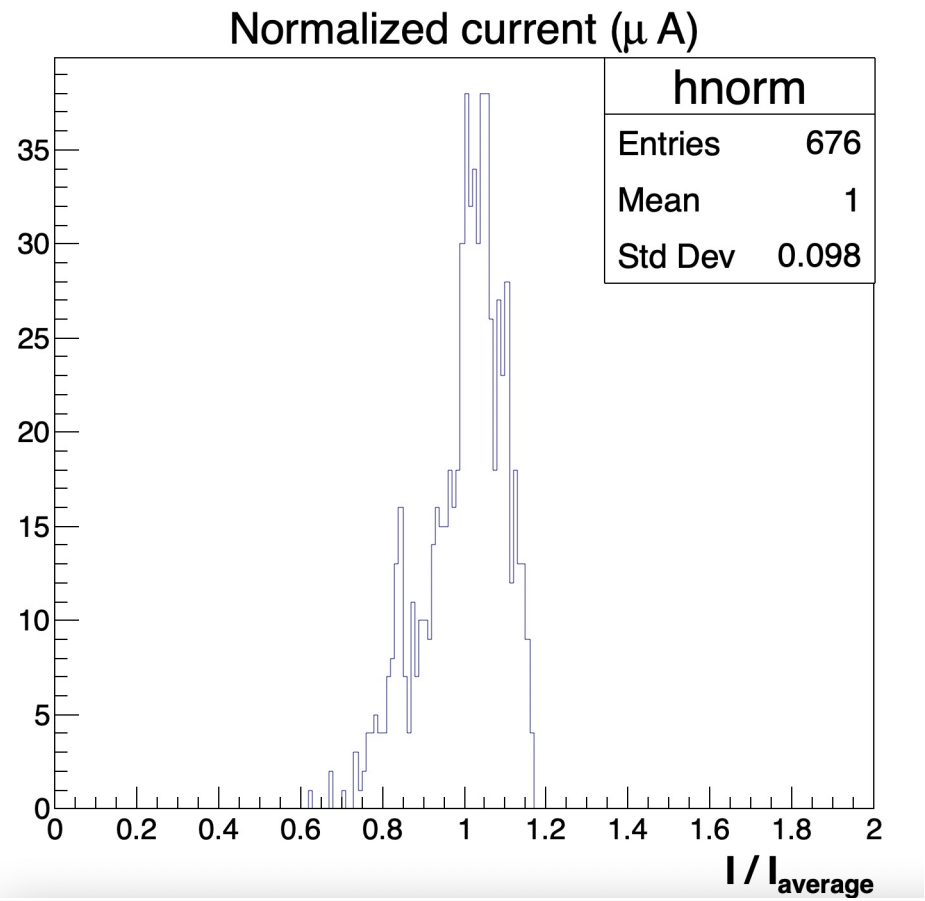
2D scan setup for uniformity test



Results: Uniformity

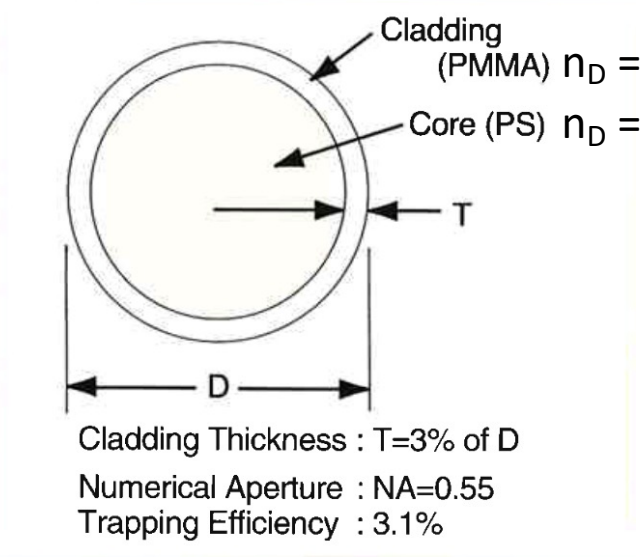


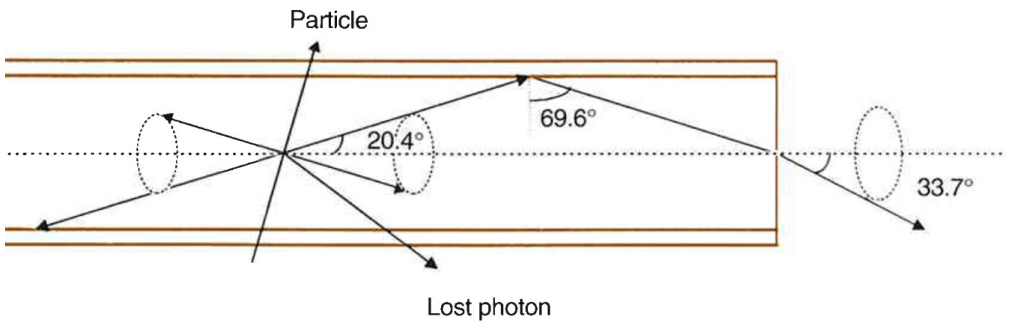




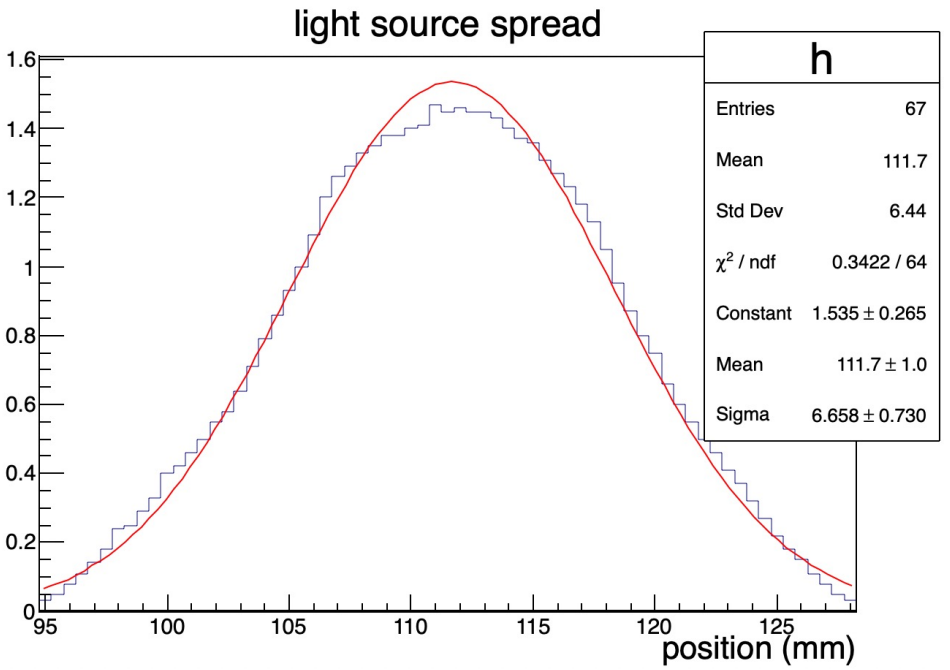
- **Light source is close to lightguide, so it is regarded as point-like without transverse dispersion.**
- **Grid structure is observed.**
- **PMT efficiency drops at the bottom region. Limited active area (diameter ~65 mm). So we focus on top 4 grids in the test.**

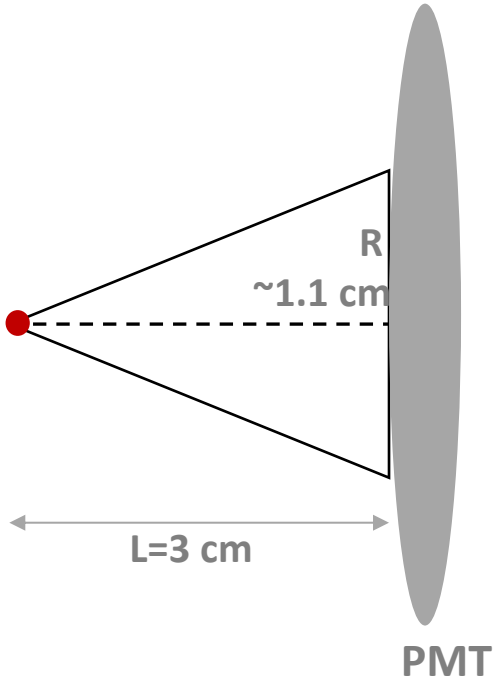
Future: Angular dispersion of light source





- **SCSF-78 single cladding fibers**
- **The light source's fiber has same indexs of refraction with fiber in EM Tower.**





- **When light source is 3 cm away from PMT, 90% light is contained within R ~ 1.1 cm.**
- **Moliere radius R_m = 2.3 cm.**
- **Future measurements: Prior going to FNAL, we can do measurements of uniformity of light collection with light source mimicking EM shower. Tune L to spread light to mimic R_m.**

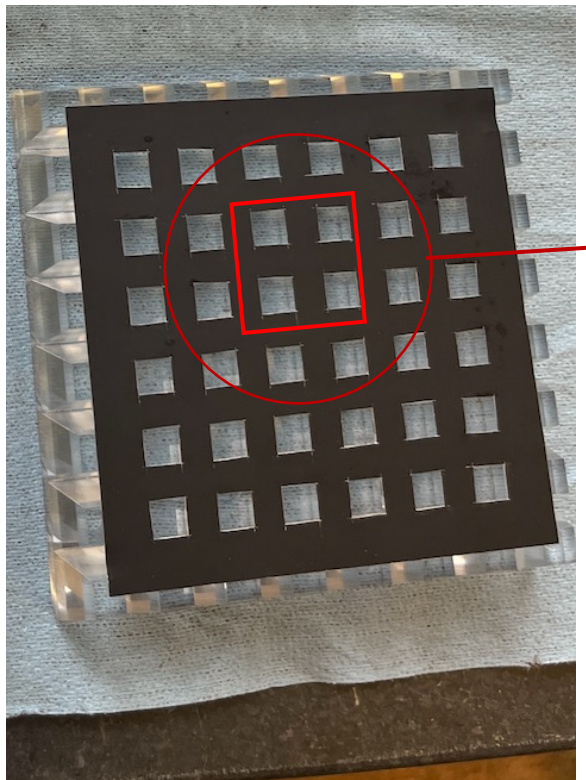
Future: Improve uniformity of PMT

- What was observed:

a) A fast falloff in signal due to limited (65 mm diameter) active area of PMT.

b) It seems photocathode uniformity and efficiency of PMT depend on HV settings.

- For future measurements, setup will be improved with adding lightguide mixer between lightguide for ePIC and PMT.



Conclusions & Outlook

Conclusions

- Light collection efficiency is ~80% with polished lightguide. ePIC expects ~1600 pixels/GeV light yield.
- Non-uniformity of lightguide's grid structure is observed with point light source. Test design needs improvement to fix PMT's efficiency drop.

Outlook

- We will measure uniformity of light collection with light source mimicking EM shower.
- We will apply light guide mixer to eliminate the position-dependent efficiency of PMT.
- In Geant simulation of EM Cal, lightguide will be considered.
- Beam test of this prototype will happen in May at Fermilab.