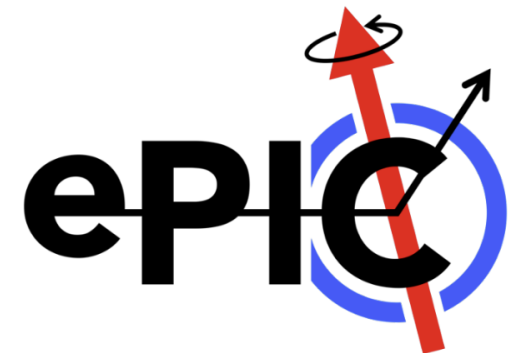


NPE per MeV Measurement Using Kuraray Single-Clad Fiber

Bo Gyeong SEO, Jun Seop SHIN, Shin Hyung KIM

Department of Physics, Kyungpook National University





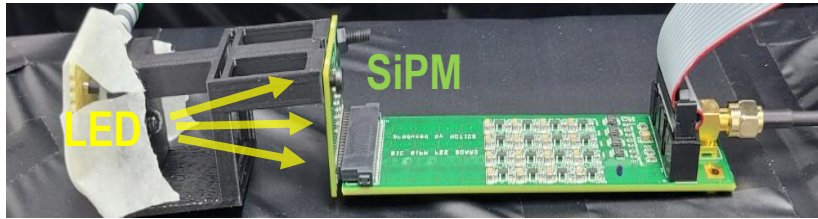
About 5.2 Npe/MeV

- SPE measurement
- Bias voltage setting
- Calorimeter setup
- Electron beam test at

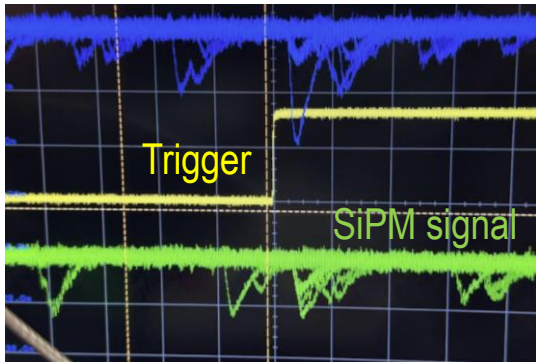
Single Photoelectron (Spe) measurement



Different bias V
per SiPM array

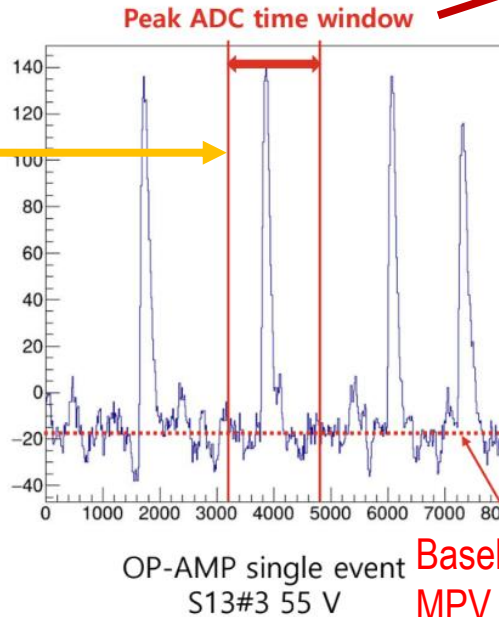


SPE measurement with LED



Signal x21 amplified

DAQ : FADC, 14 bits



Peak ADC

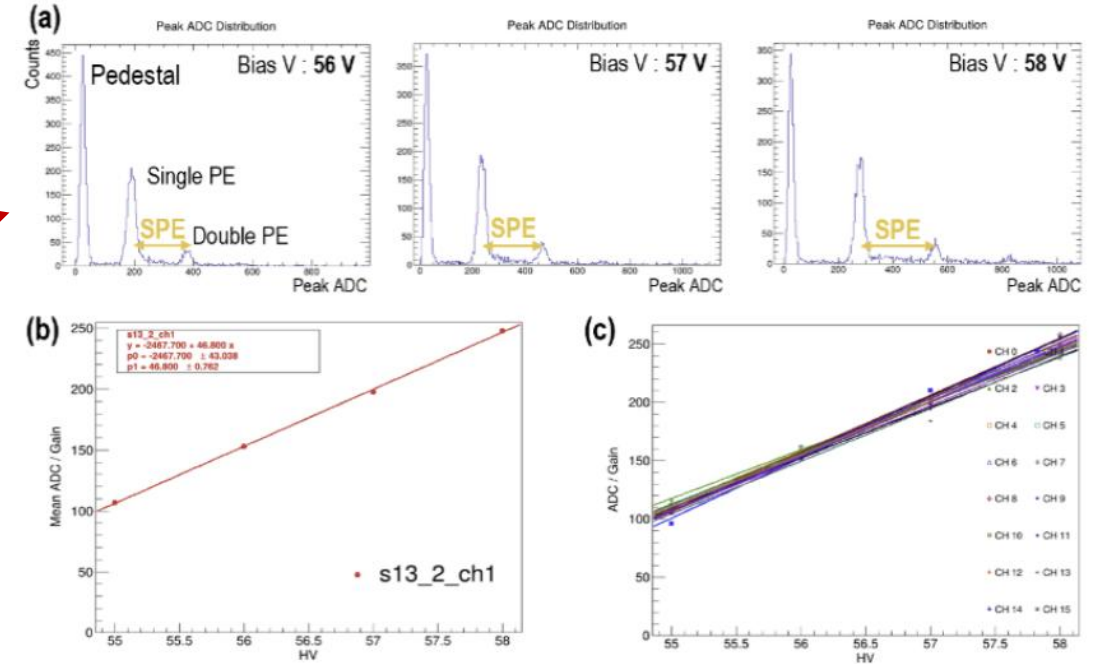
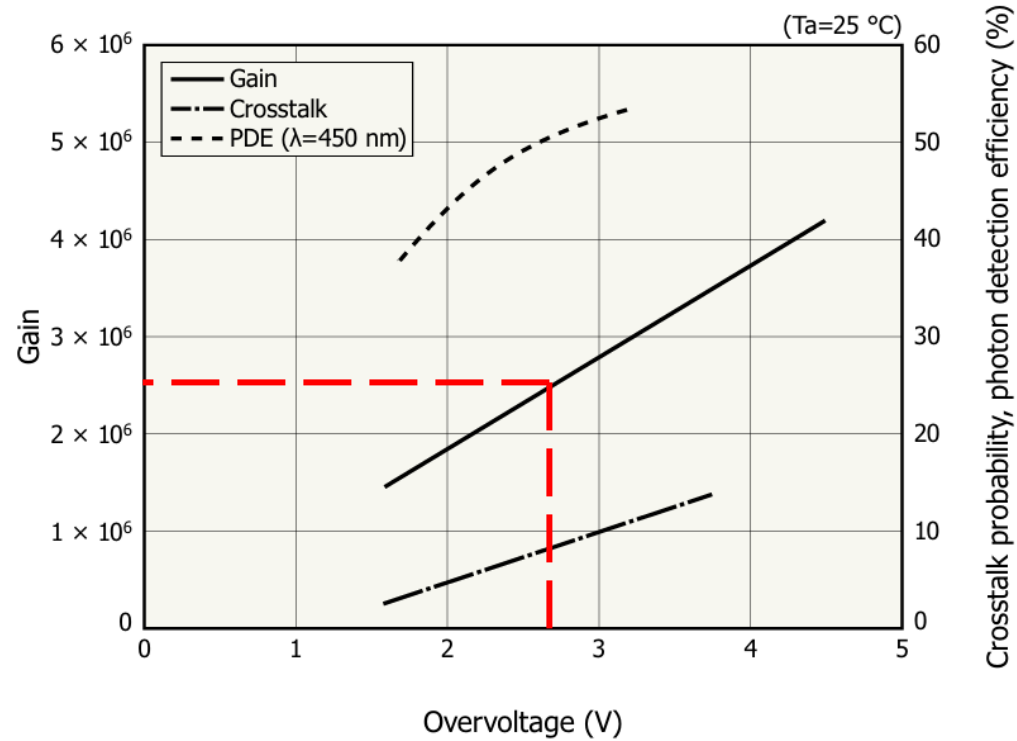


Figure 1: (a) Single photoelectron gain of S13, with increasing bias voltage (b) Linear fitting of single channel. (c) Linear fitting of all 16 channels.

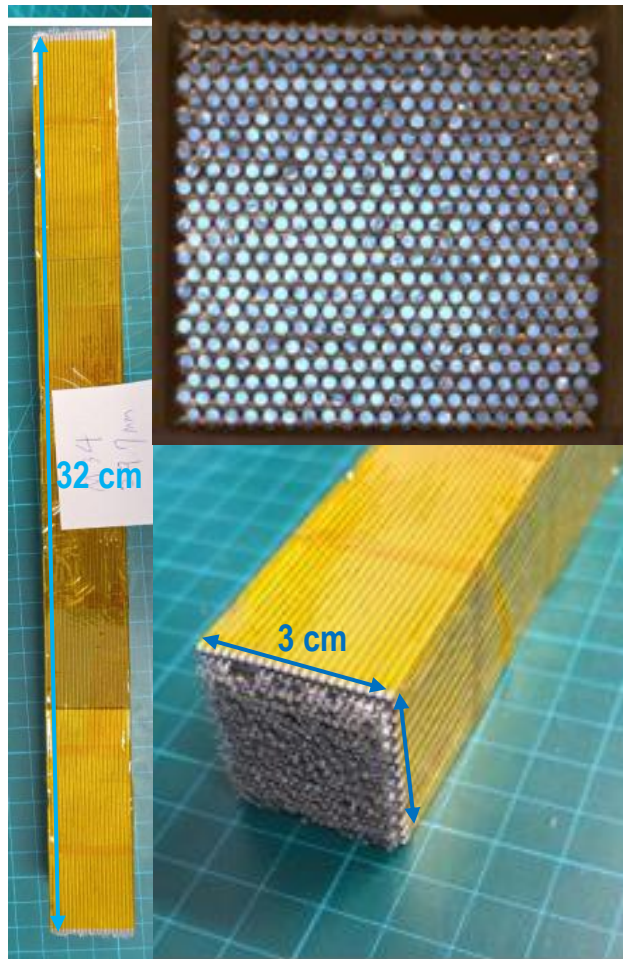


Hamamatsu recommended : 40.7 V

CH	S13 1 (V)	S13 2 (V)	S14 1 (V)	S14 2 (V)
1	55.22	54.70	40.93	40.94
2	55.37	54.72	41.11	40.96
3	55.02	54.54	40.98	40.86
4	55.20	54.75	41.00	40.97
5	55.15	54.53	40.97	40.89
6	55.18	54.55	40.95	40.76
7	55.19	54.70	40.91	40.98
8	55.22	54.65	40.96	40.93
9	55.20	54.78	40.88	40.80
10	55.20	54.79	40.90	40.75
11	55.08	54.76	40.93	40.84
12	55.25	54.60	40.87	40.84
13	55.20	54.69	40.88	40.81
14	55.28	54.59	40.88	40.77
15	55.20	54.63	40.73	40.72
16	55.20	54.48	40.87	40.80

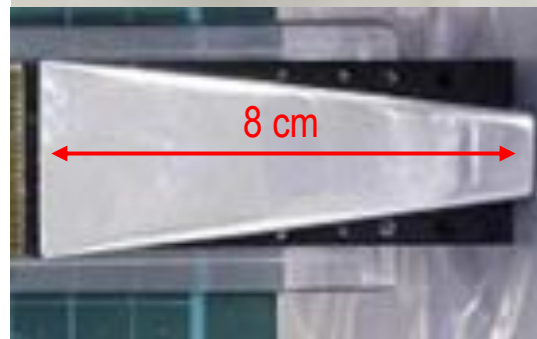
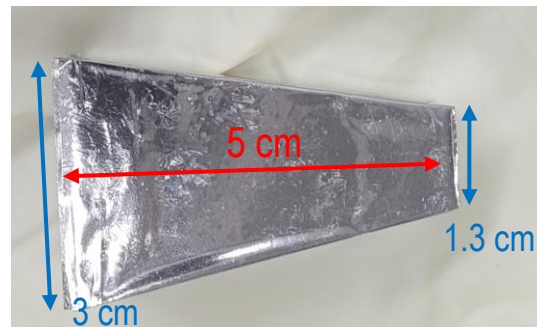
Table 1: Bias voltage per SiPM channels. Each voltage were chosen for same gain per channel.

Measures $V_{\text{breakdown}}$: 38 – 38.5



1. Calorimeter

Pb plates & Scintillating fibers
No glue, wrapped with Kapton tape



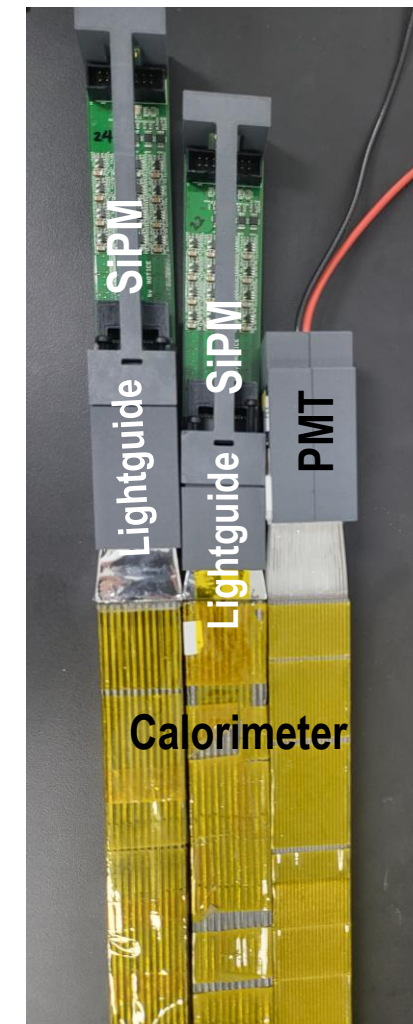
2. Lightguide

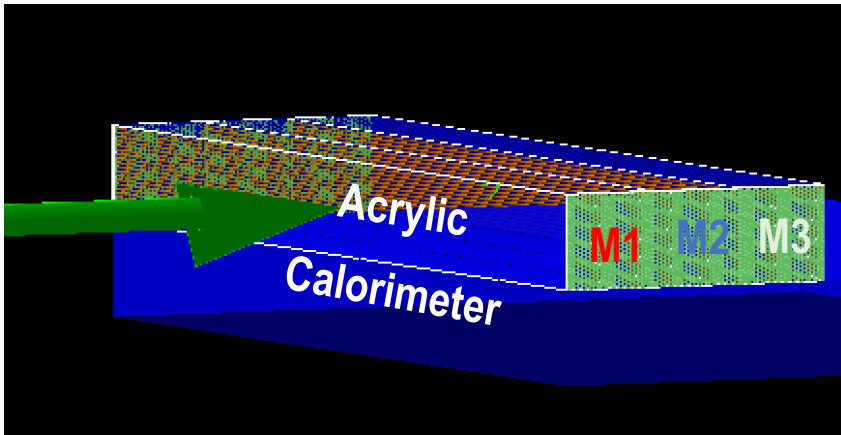
Square, acrylic lightguides wrapped with Al Mylar (5, 8 cm)
Bundled fiber for PMT



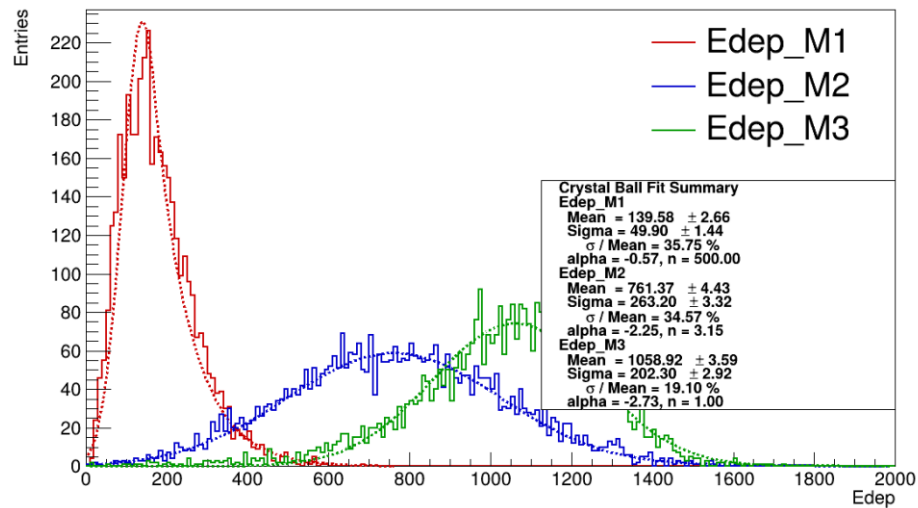
3. Photon sensor (Hamamatsu)

SiPM (S13 & S14)
PMT





1x3 simulation

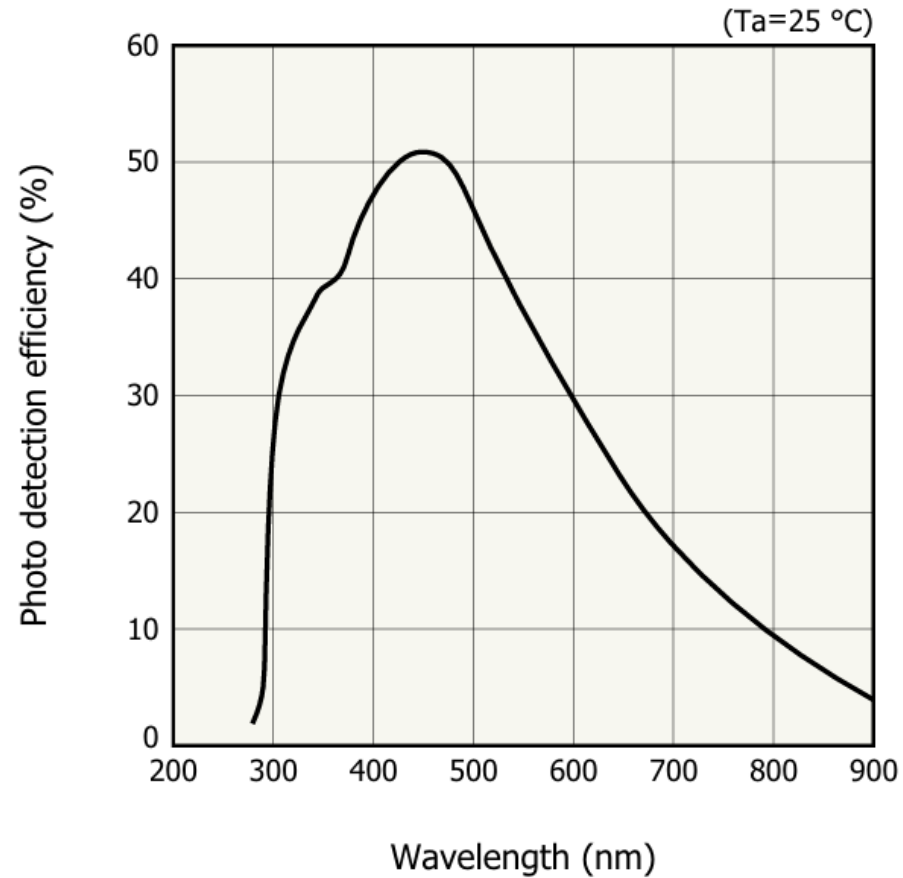


Edep at 5 GeV/c

Geant4 simulation

Energy deposition

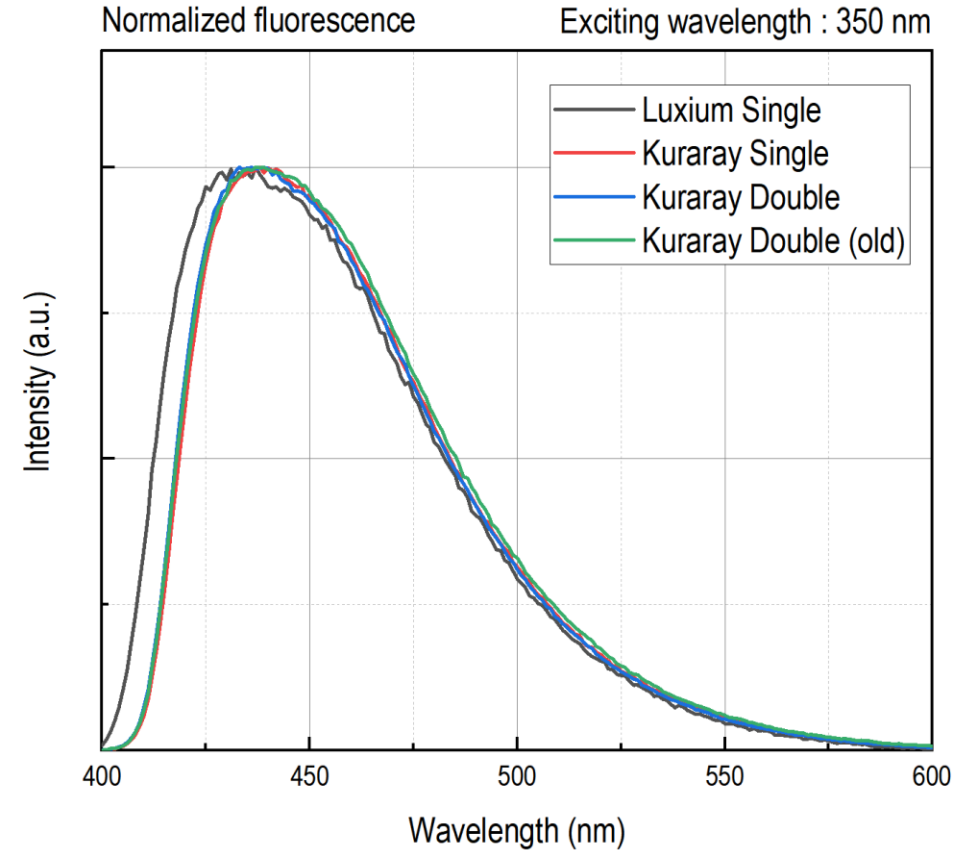
- 3 calorimeter modules were not enough for full energy deposition of beam particle (e^- , $0.5 \sim 5 \text{ GeV}/c$)
- Energy deposited within each module was obtained
- Crystal ball fitted, mean value is plotted



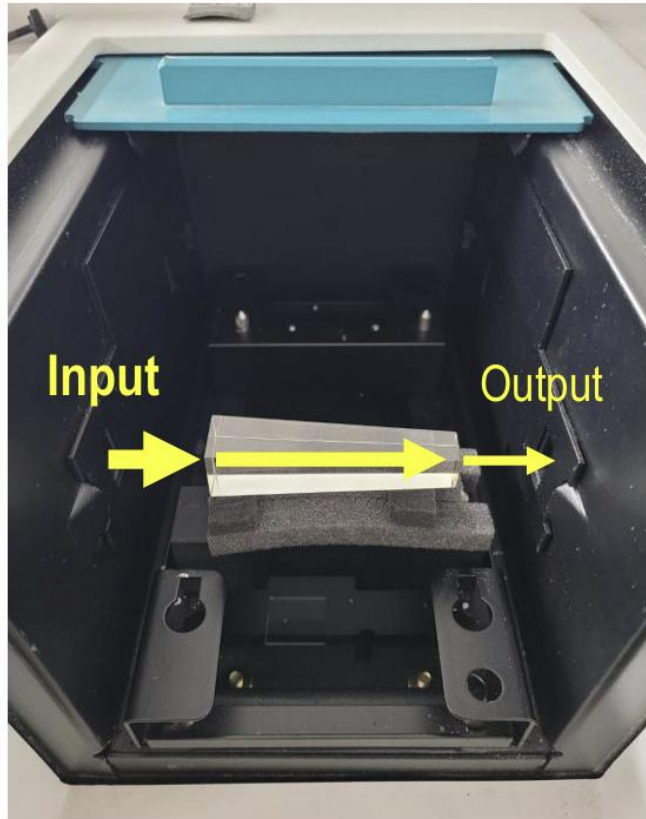
KAPDB0429EA

Photon detection efficiency does not include crosstalk and afterpulses.

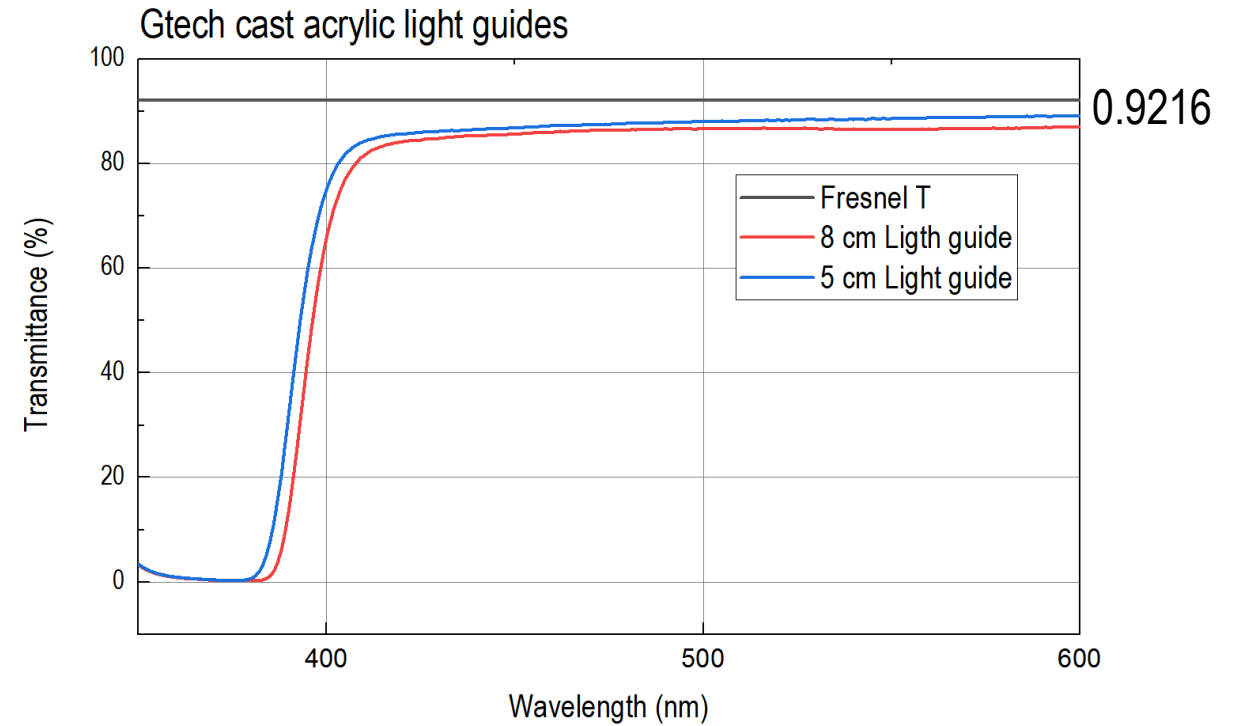
S14160-3050HS-05, Hamamatsu
Photo detection efficiency



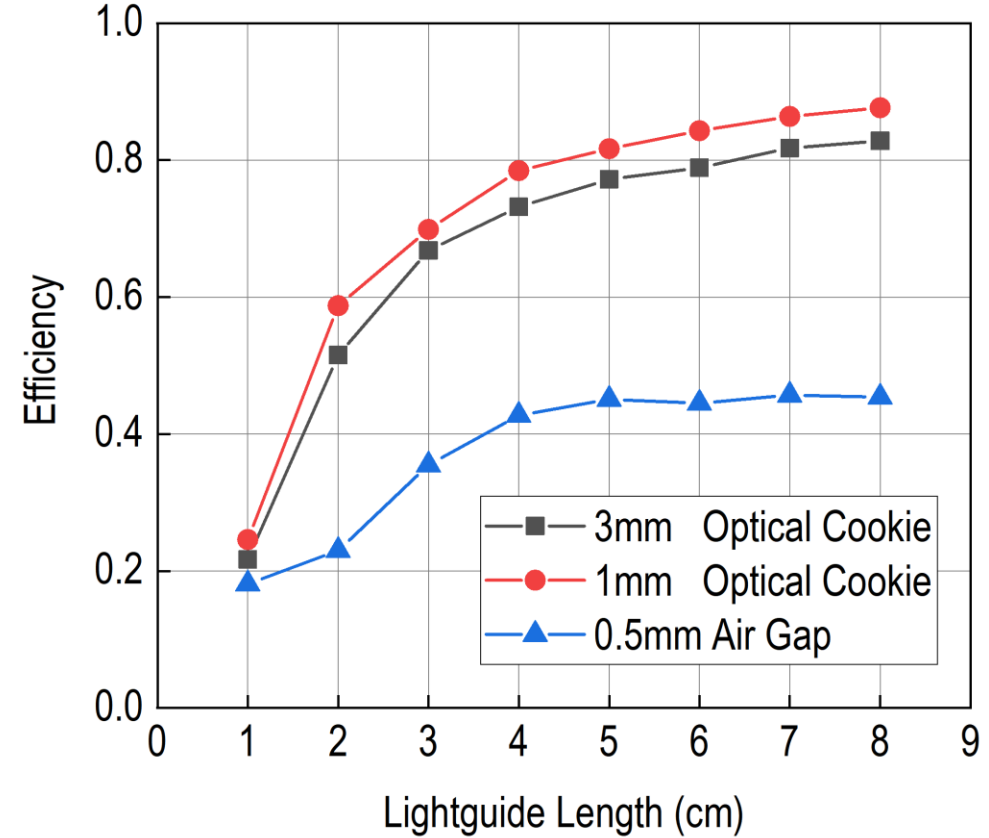
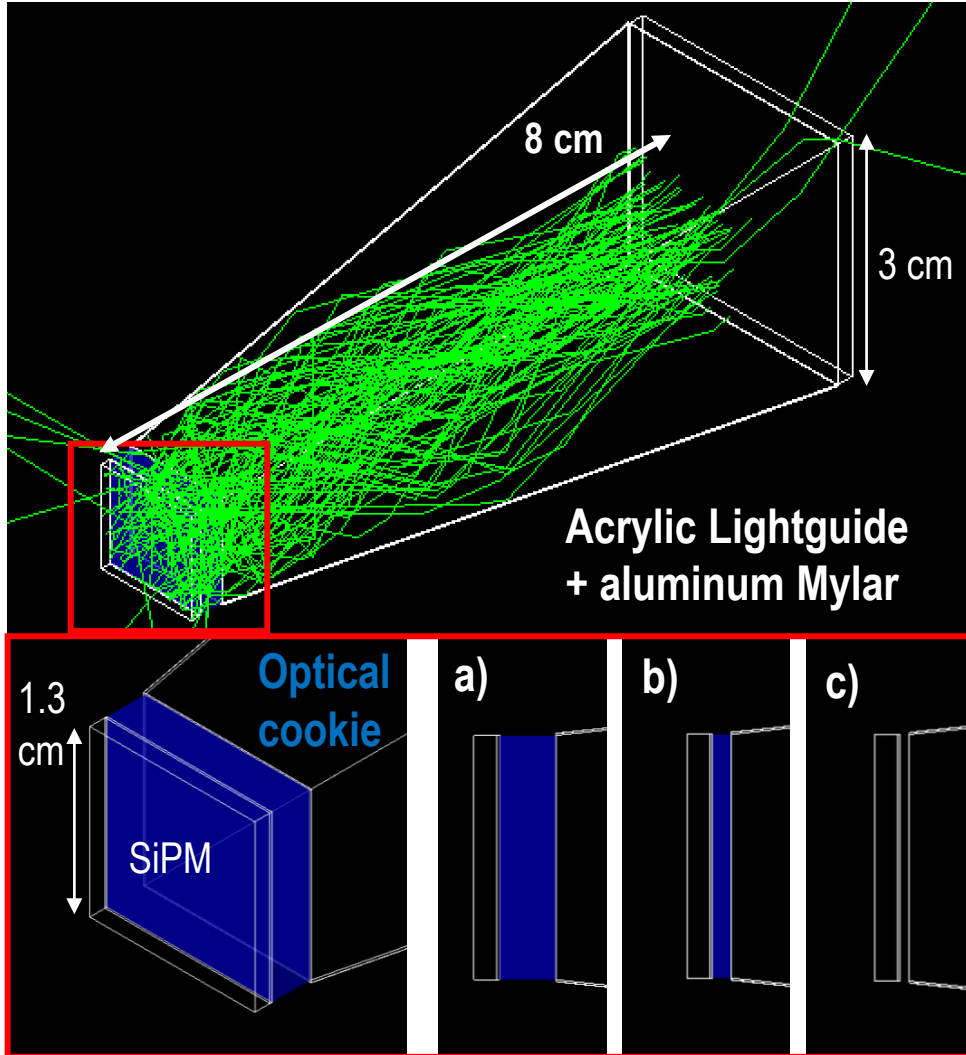
Fluorescence spectra of scintillating fibers



Transmittance measurement (KNU)
UV/Vis spectrophotometer (Cary 100)
Output / Input



Efficiency : Transmission efficiency with Lightguide Length (Geant4)



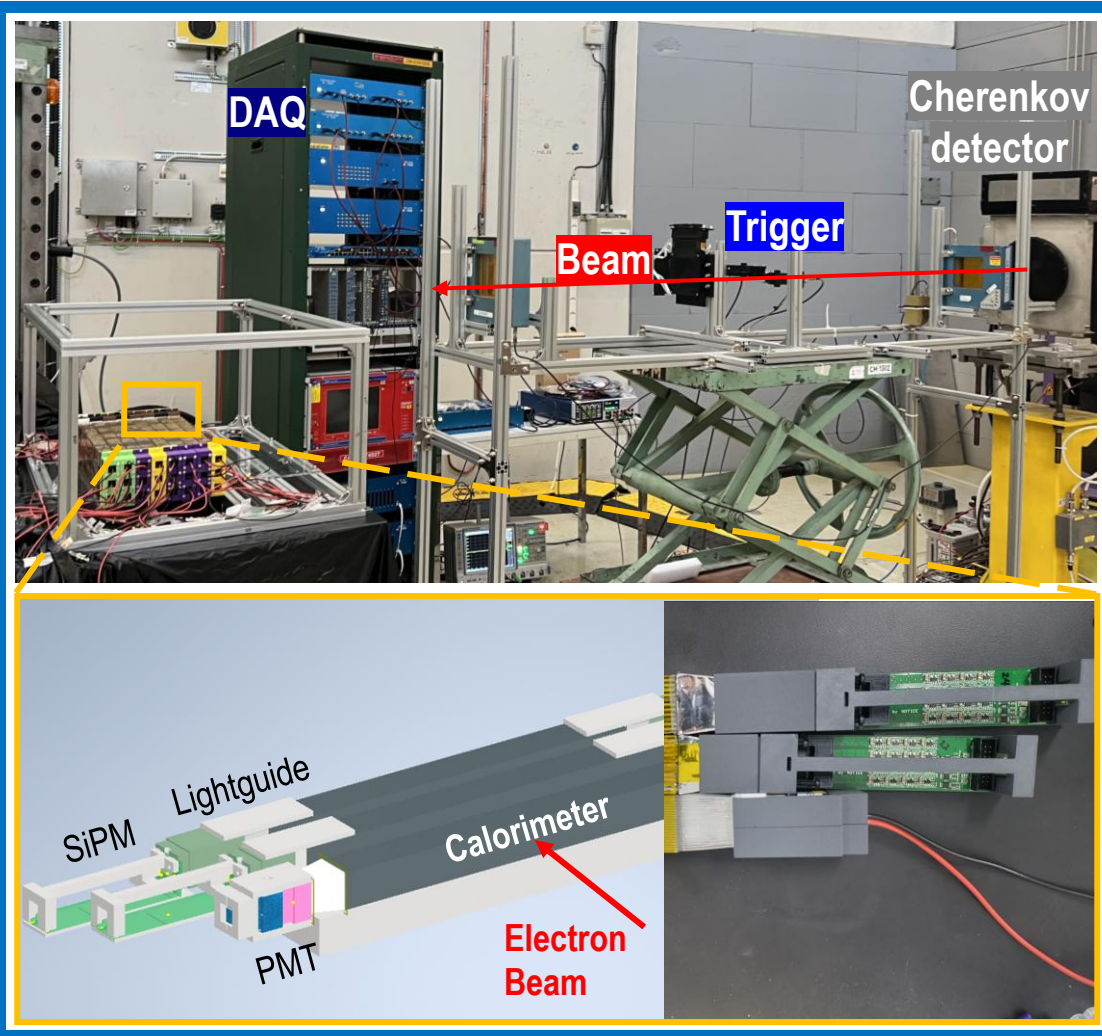
Efficiency = Collected photon / Thrown photon
Sublinear efficiency near ~ 5 cm
Optical cookie needed

1. Different Lightguide (LG) length
2. (a) 3 mm and (b) 1 mm Optical cookie, (c) 0.5 mm air gap



Linearity : electron beam

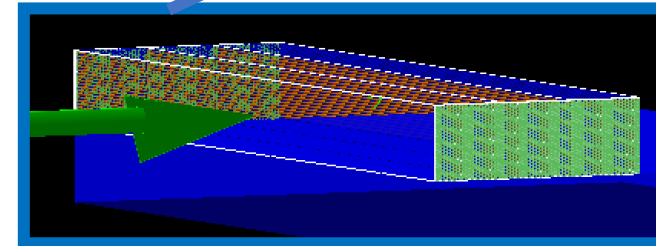
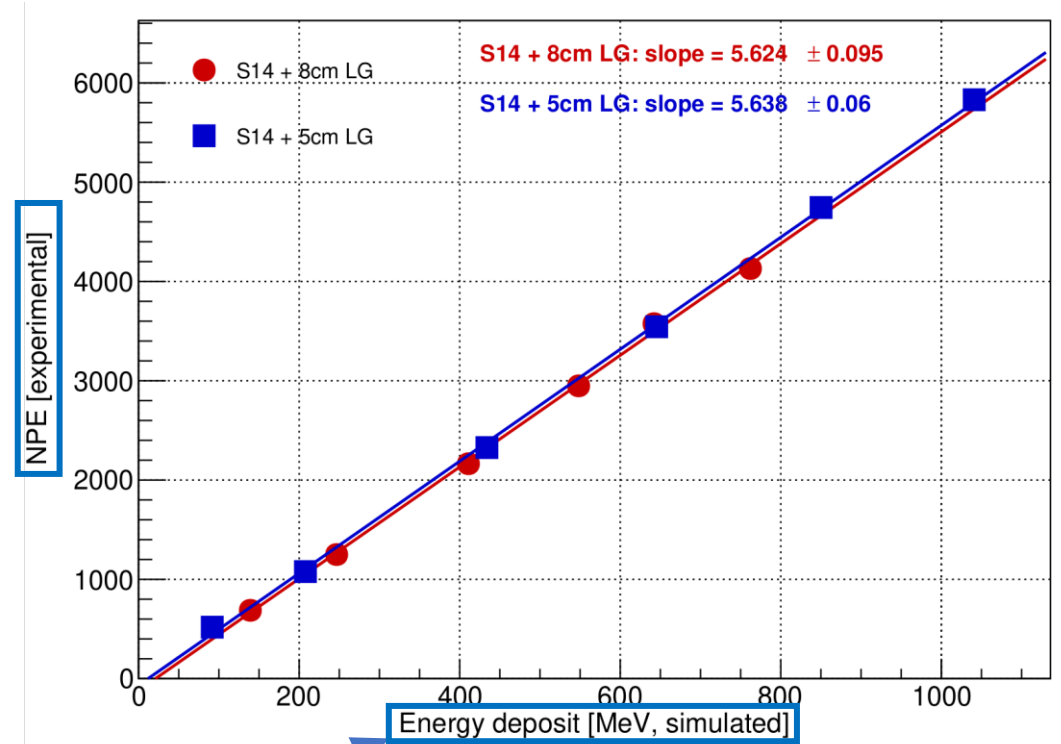
2025 CERN PS T-10 beam line



3 Calorimeter modules with different readouts

S14, S13 + 5cm, 8cm Lightguide

PMT + bundling (reference)



Geant4 simulation

Energy deposition per calorimeter

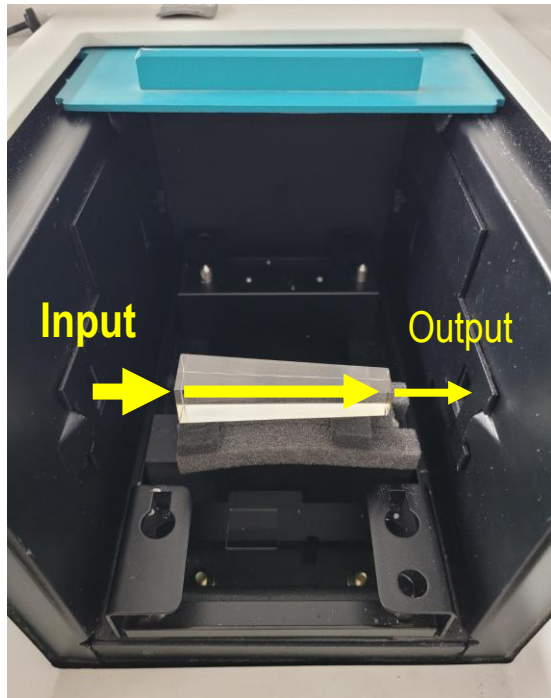
Energy : 0.5 ~ 5 GeV

Great linearity checked with electron beam

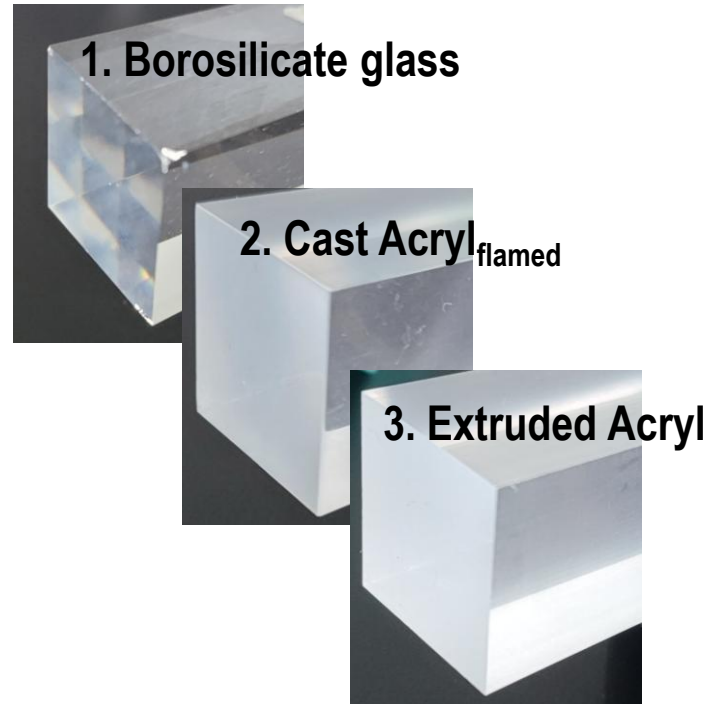
(3 cm x 3 cm Lightguides)



Material : Transmittance measurement (UV/Vis)

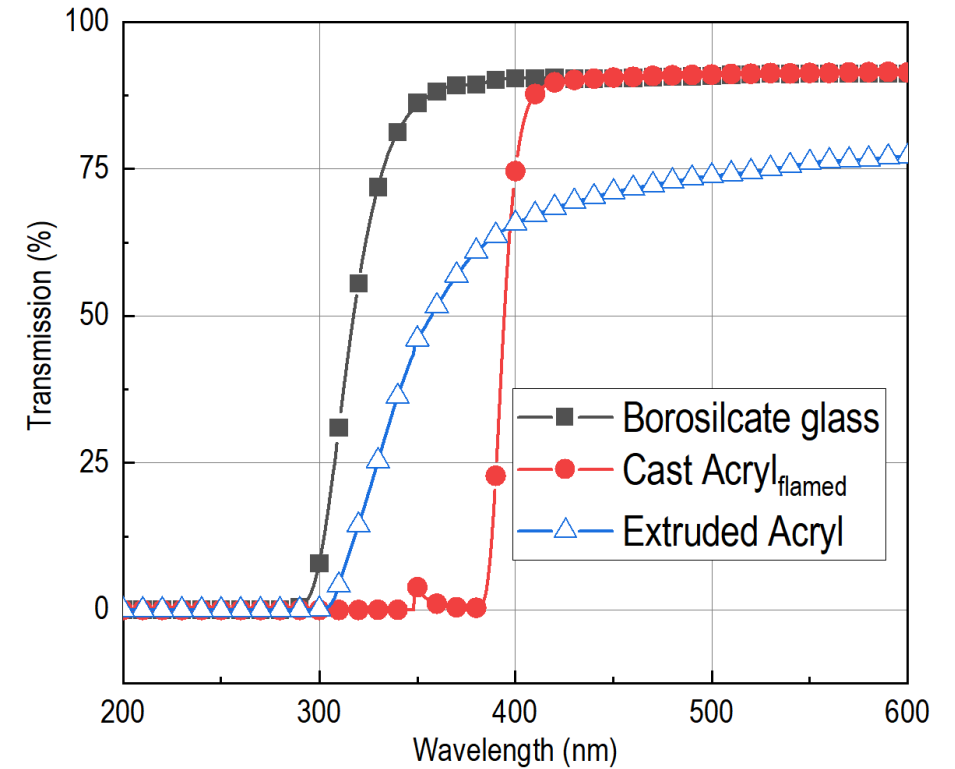


Transmittance measurement (KNU)
UV/Vis spectrophotometer (Cary 100)
Output / Input



Lightguide materials

1. Borosilicate glass
2. Cast Acryl_{flamed}
3. Extruded Acryl

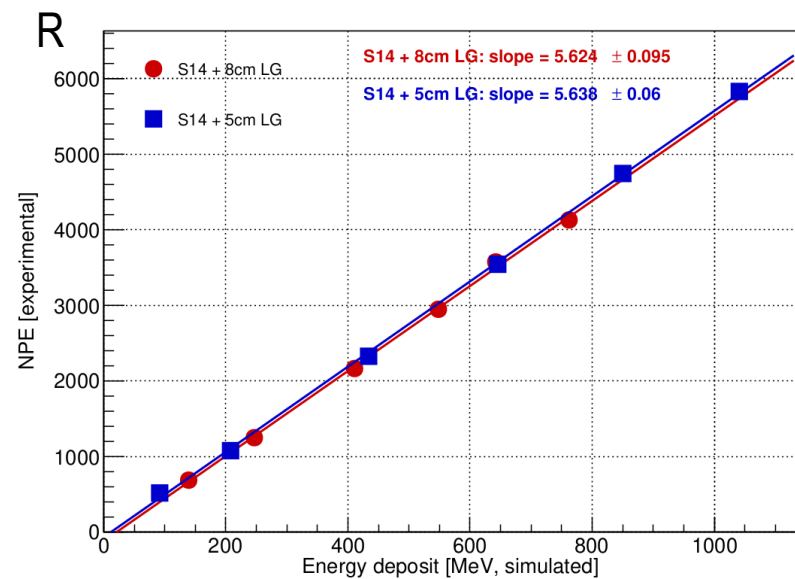


Borosilicate glass : heavy and expensive
Scintillating fiber emission spectrum : 400 – 600 nm

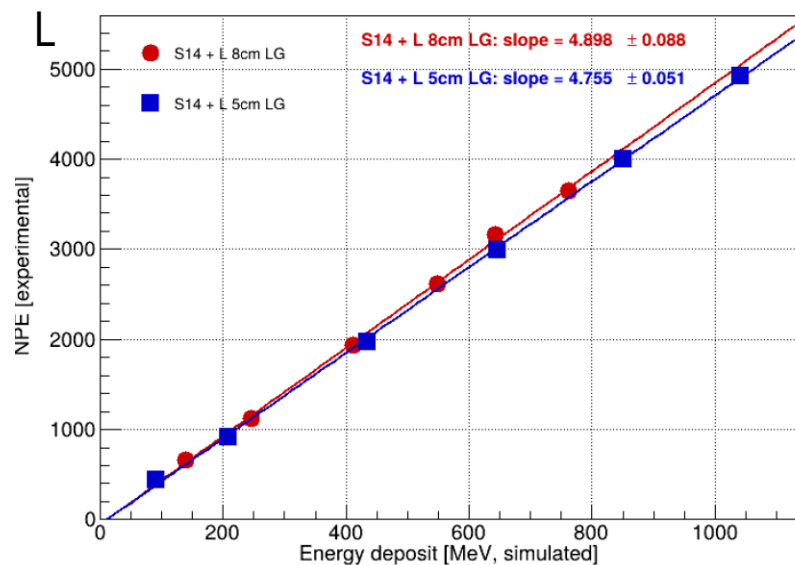
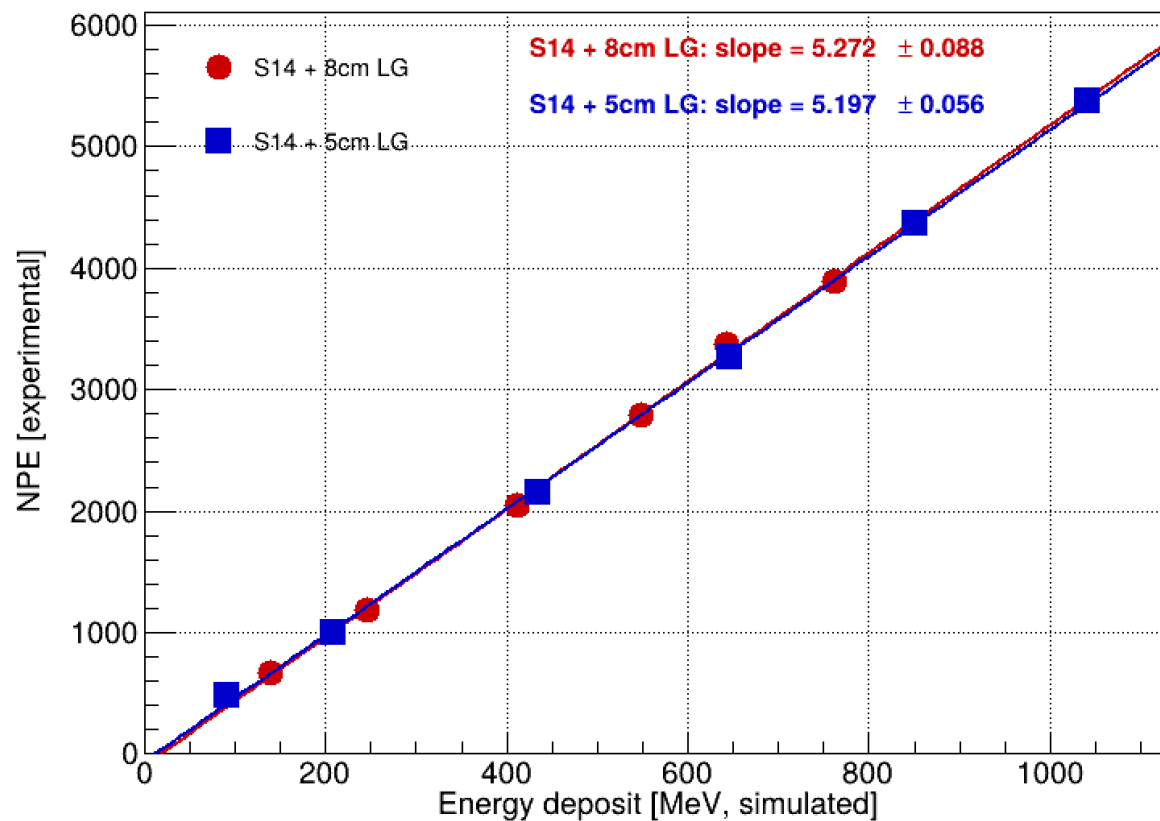
→ **Cast acryl_{flamed}**



S14 Npe

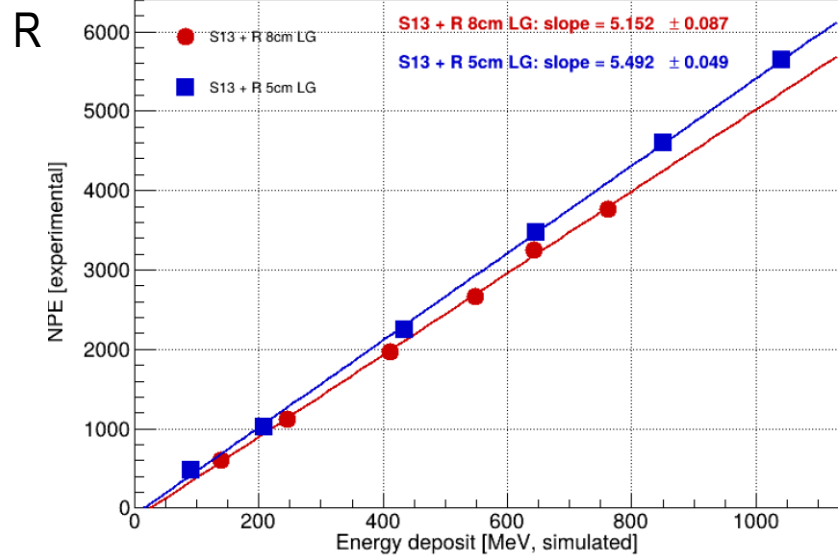


$(L+R)/2$

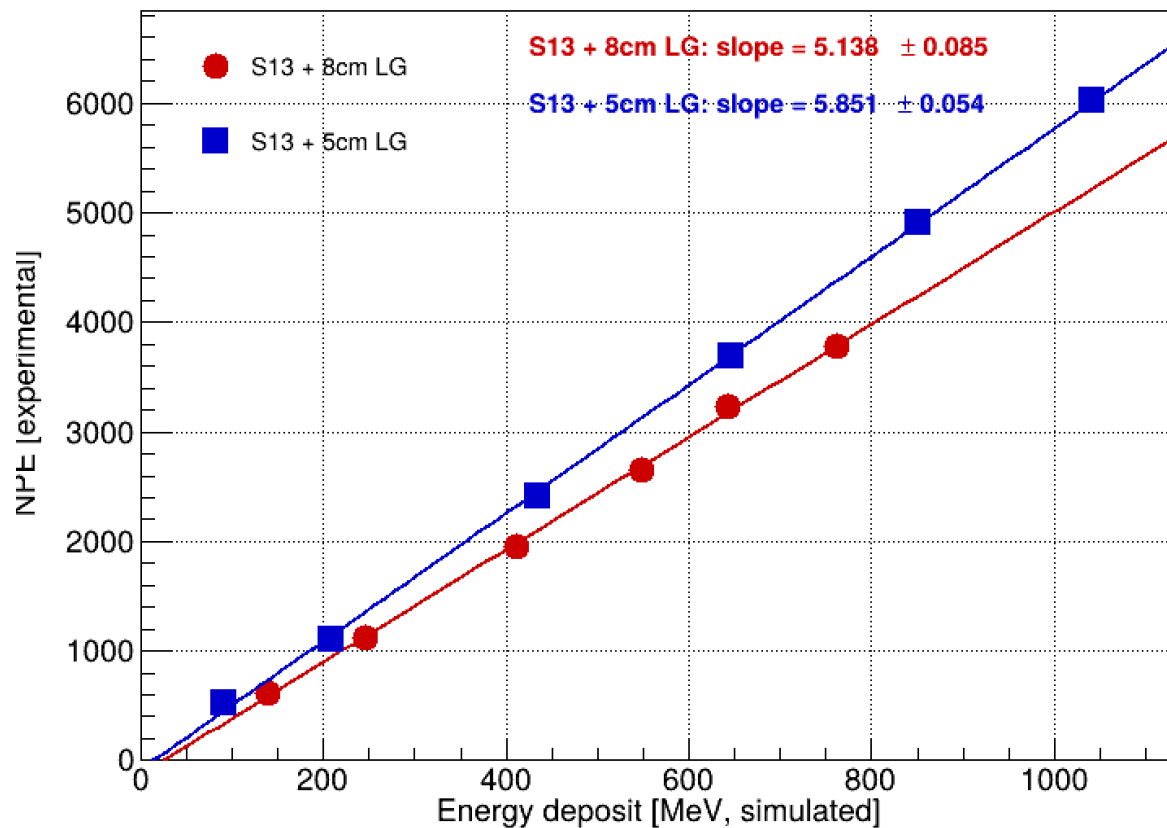
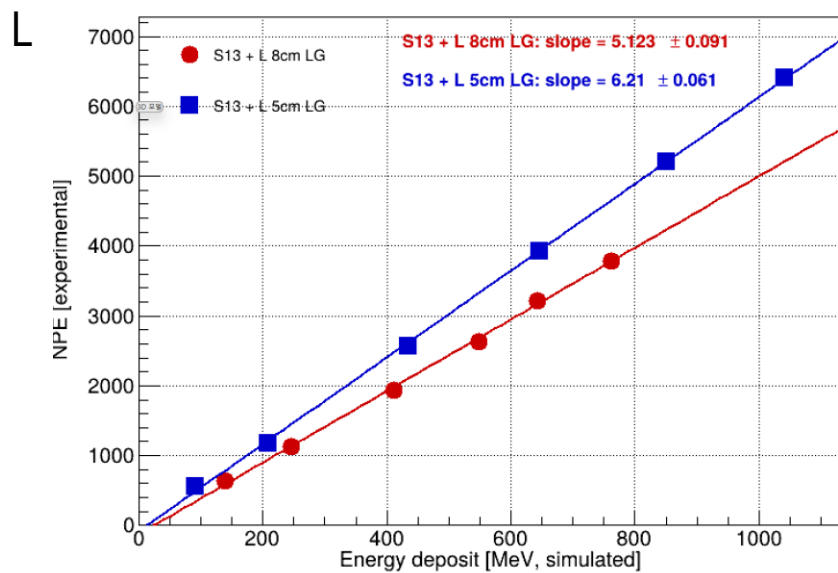




S13 Npe



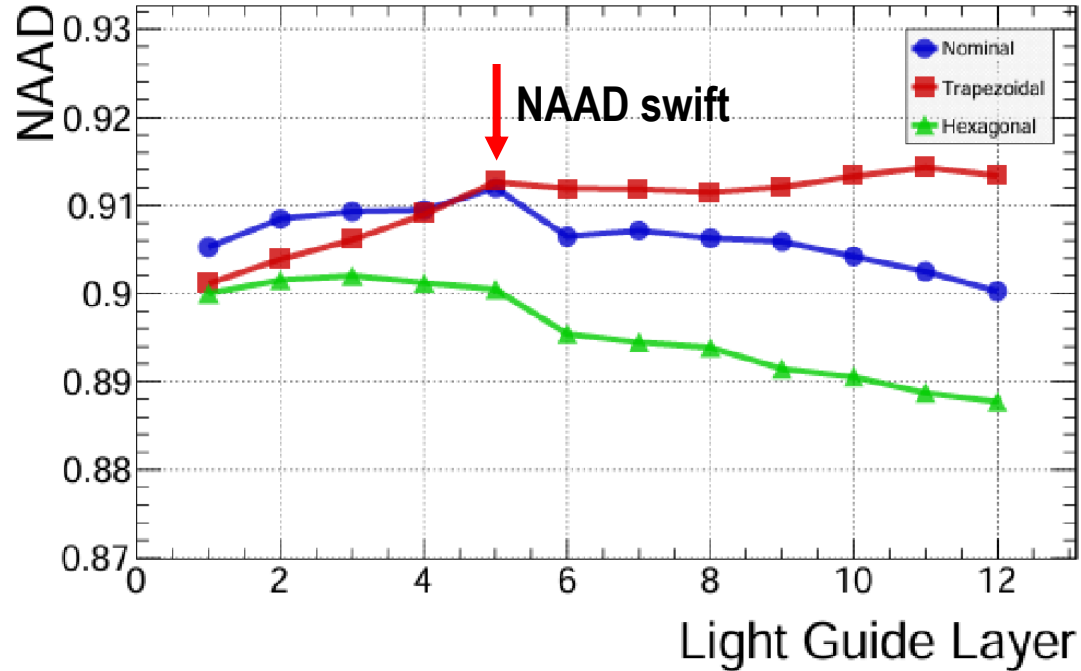
$(L+R)/2$





Lightguide simulation (by Tegan)

50 mm cookie S13-BIC NAAD vs. Layer

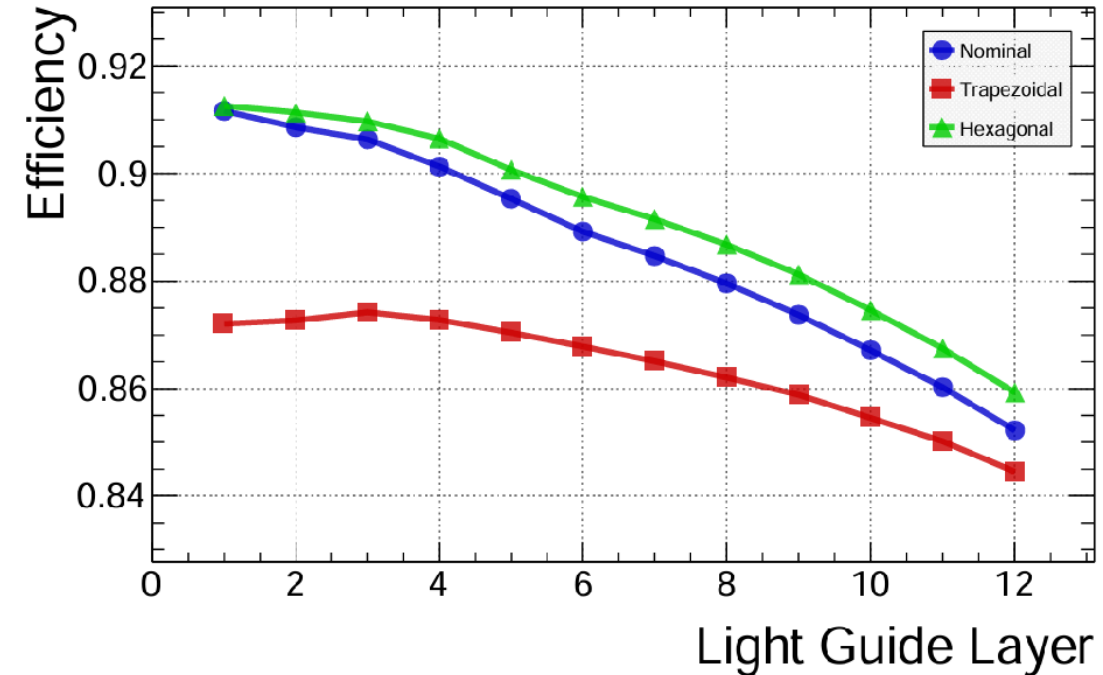


NAAD vs layer number for 50 mm BIC lightguides of Various shapes with a 1 mm optical cookie

Nominal ~ Trape > Hex

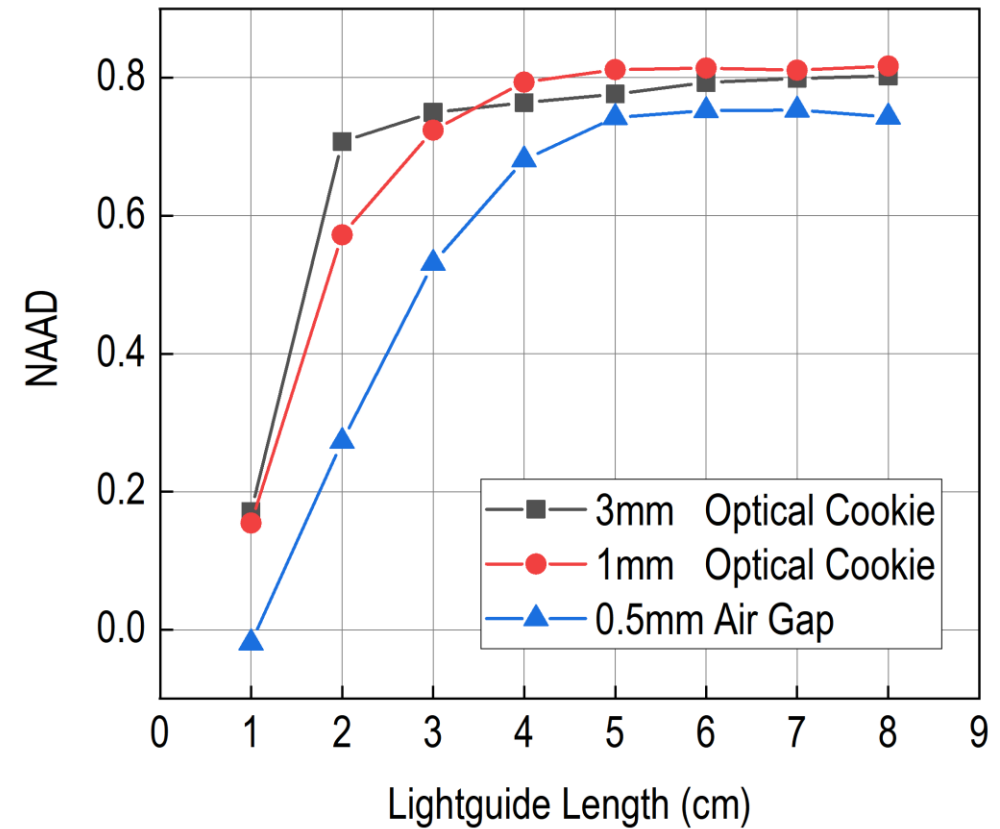
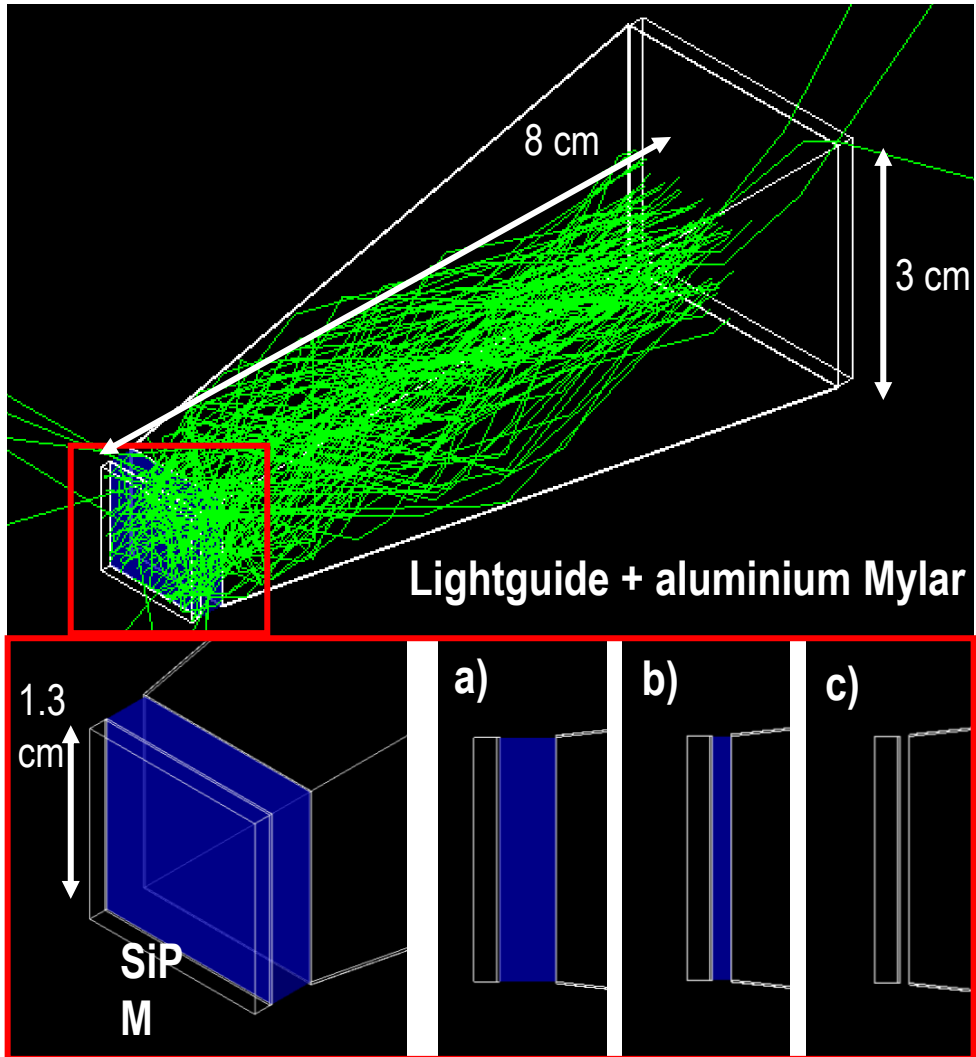
Photon emission all area

50 mm cookie S13-BIC Efficiency vs. Layer



Efficiency vs layer number for 50 mm BIC lightguides of Various shapes with a 1 mm optical cookie

Hex > Nominal > Trape



NAAD

1 mm > 3 mm when 4 – 8 cm

1. Different Lightguide (LG) length
2. (a) 3 mm and (b) 1 mm Optical cookie, (c) 0.5 mm air gap



Pb	Fiber	Air
Pb	Fiber	Air
43	38	19