The ePIC Barrel Imaging Calorimeter

ScFi Testing Procedures

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University of Regina

BIC Systems Testing
February 11, 2025

Fiber Specs

3.1 Technical/Performance Characteristics

A. Light yield: the average response to a Sr-90 source shall be greater than 3.5 photoelectrons measured using a bialkali photomultiplier tube 200 cm from the source, and the opposite end blackened (assessed via methods mutually acceptable to the BSA and Contractor). SiPM

B. Diameter mean value and variation shall be 1.00 +/- 0.01 mm, RMS ≤0.02 mm. Calliper

C. Attenuation length for blue light > 4m. Photodiode

D. Batch to batch or lot to lot variation of light yield <15%.

E. Batch to batch or lot to lot variation of attenuation length <10%.

F. Emission spectrum in blue-green light Spectrophotometer

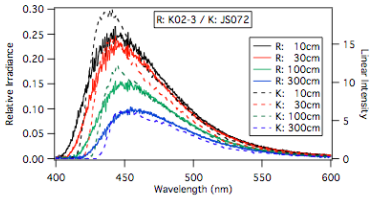
G. Scintillation decay time <3ns

H. Total length 4900 km

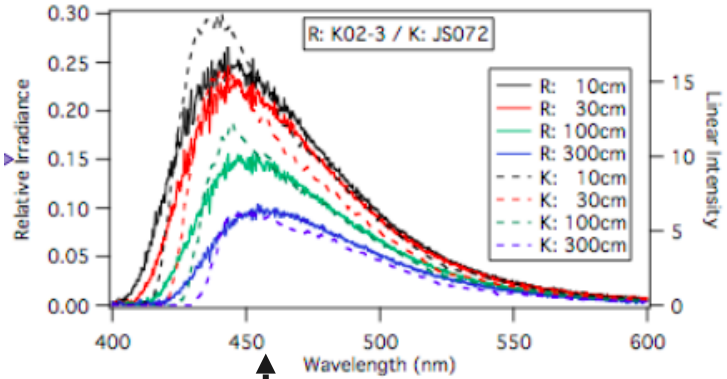
I. Delivery method in canes. Length of fibers 4.55 meters +/- 0.01m. Tape measure

Fiber Tests @ UofR

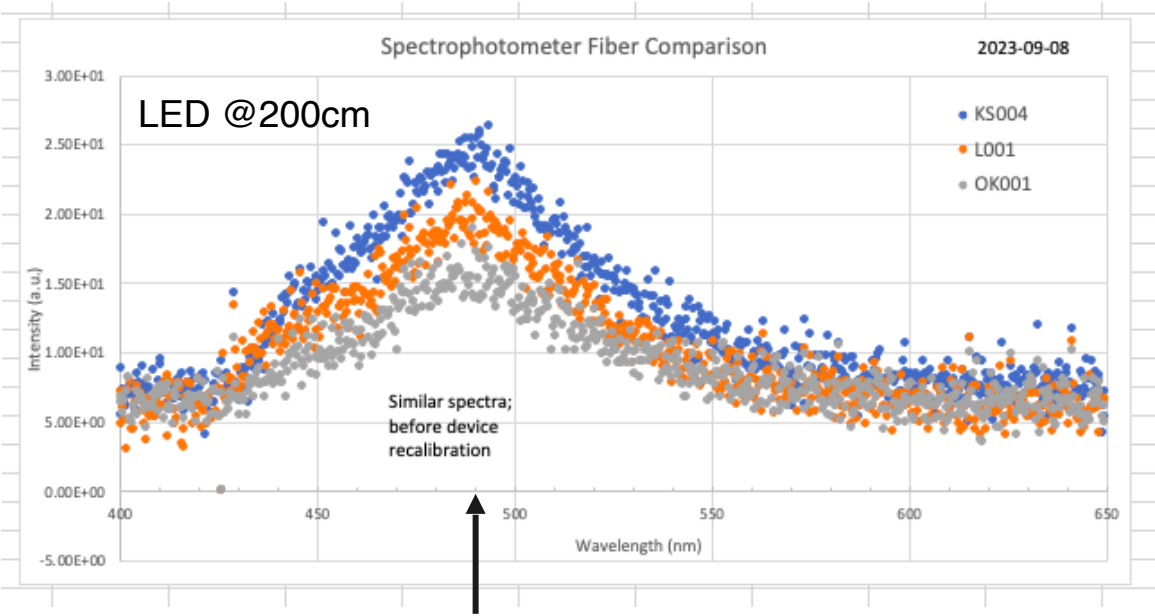
- **Test Stations** (resurrected BCAL equipment; 2023 and 2024)
  - **Spectrophotometer station**:
    - ageing; qualitative; recalibration
  - **Photodiode station**:
    - 3 setup upgrades since July 2023. results stable.
    - Measured 12-300 cm (and some to 410 cm)
    - **1-** & 2-exp **fits: selection on long-attenuation**
  - **Npe station**: photopeaks; recent upgrade.
- Bottom line:
  - Attenuation length: Kuraray D and S, Luxium S ≳ 4m
  - Light output: NKD > NKS > L (photodiode & Npe differences)



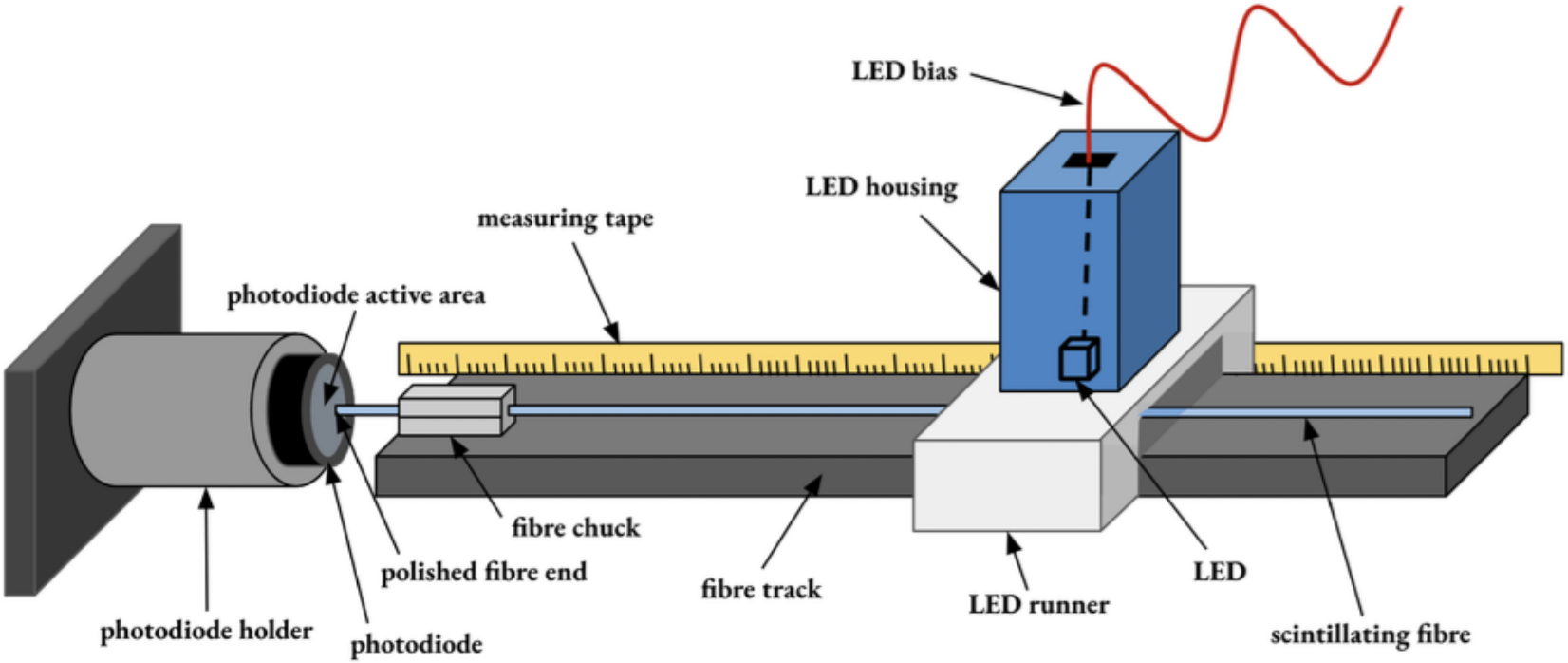
Fiber wavelength spectrum



LED @200cm

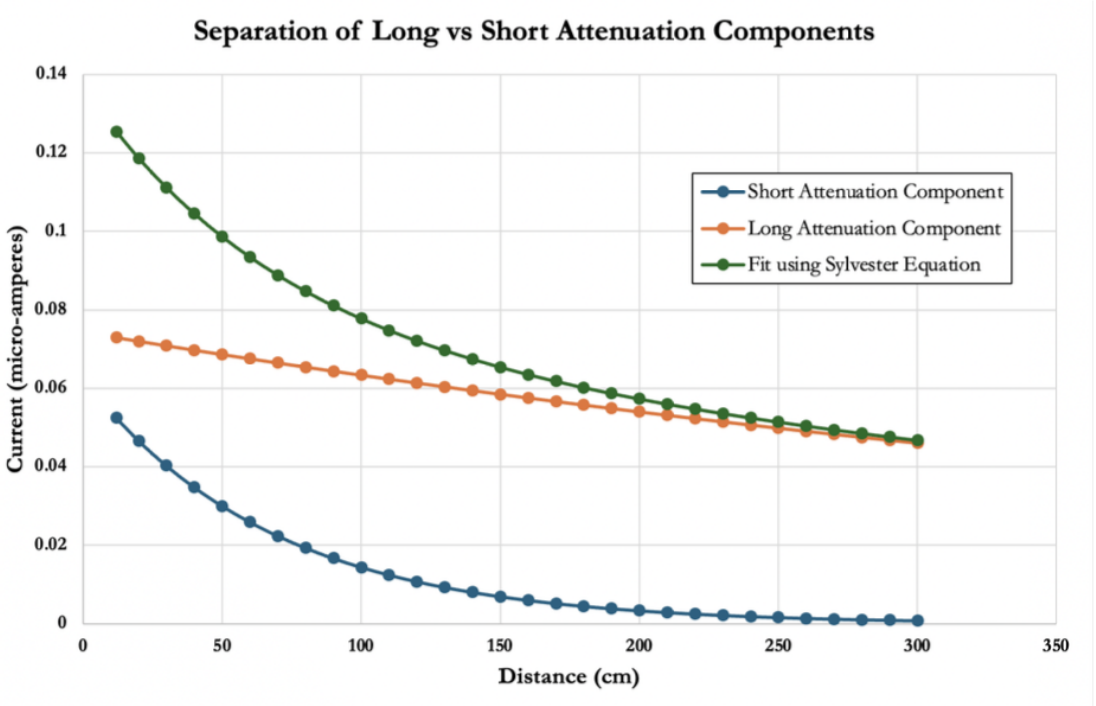


Photodiode Station



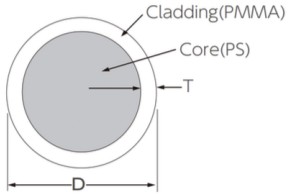
Measurements in complete darkness

Fiber Light Componets

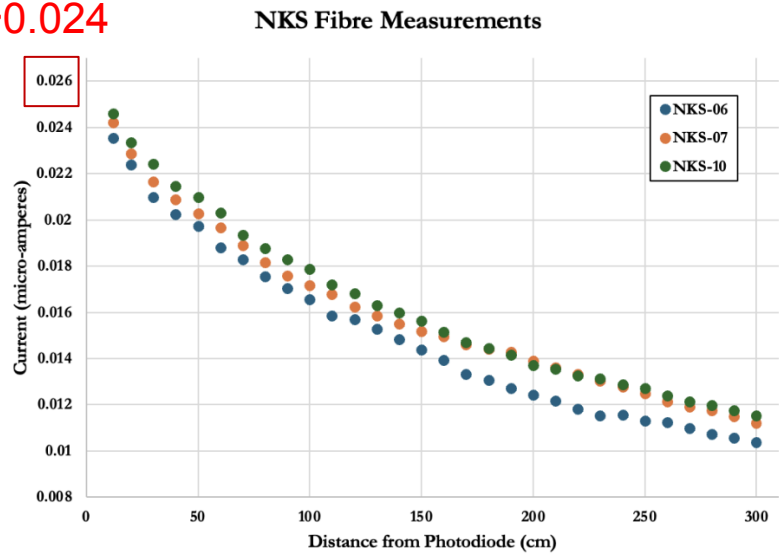


$$I(x) = I_0(\alpha e^{-x/\lambda_1} + (1-\alpha)e^{-x/\lambda_2})$$

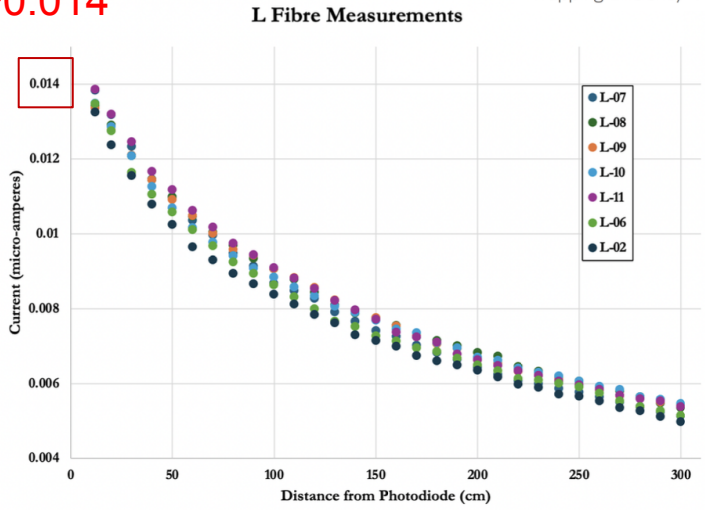
Fiber Scans: Single-Clad



~0.024



~0.014



BIC measurements 2024

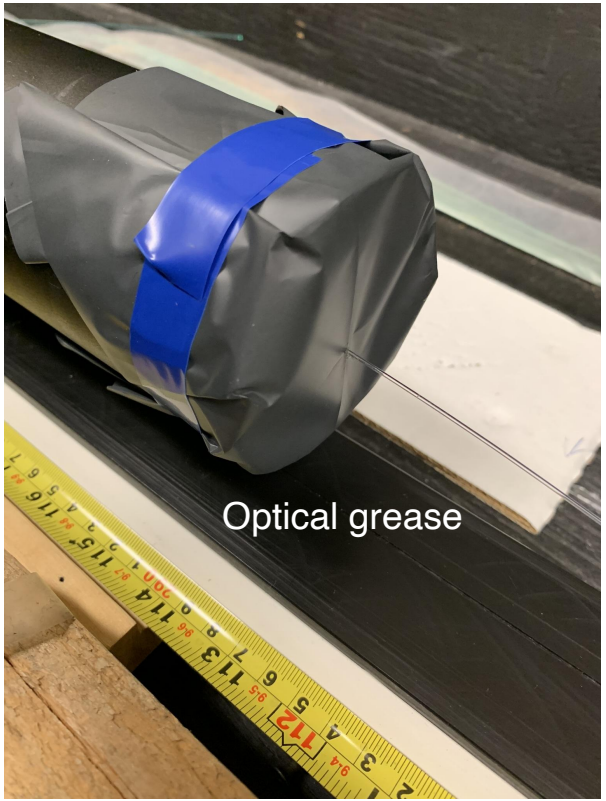
(LED issue)

BIC measurements 2024

(LED fixed)

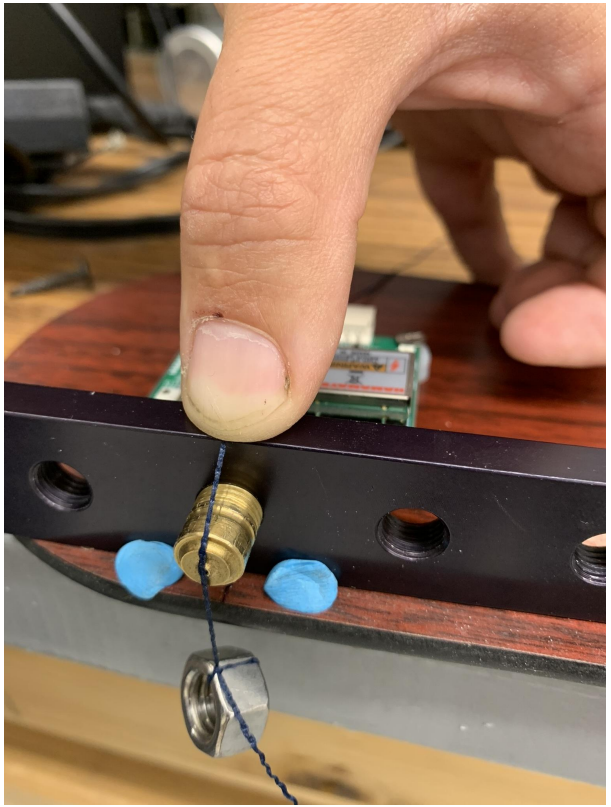
Npe Station - Setup PMT

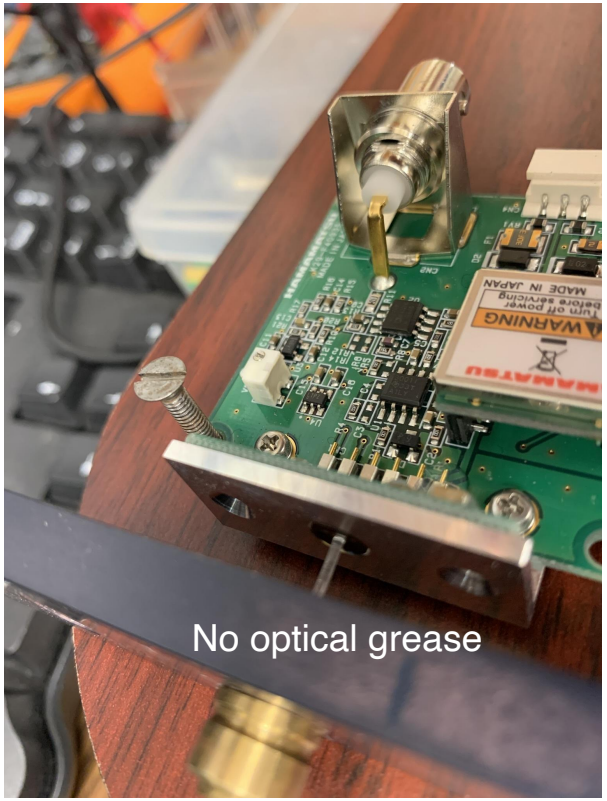
- puck board and runner
- Stronger ^{90}Sr
- Ambient light control
- Coincidence with PMT



Npe Station - Setup PMT

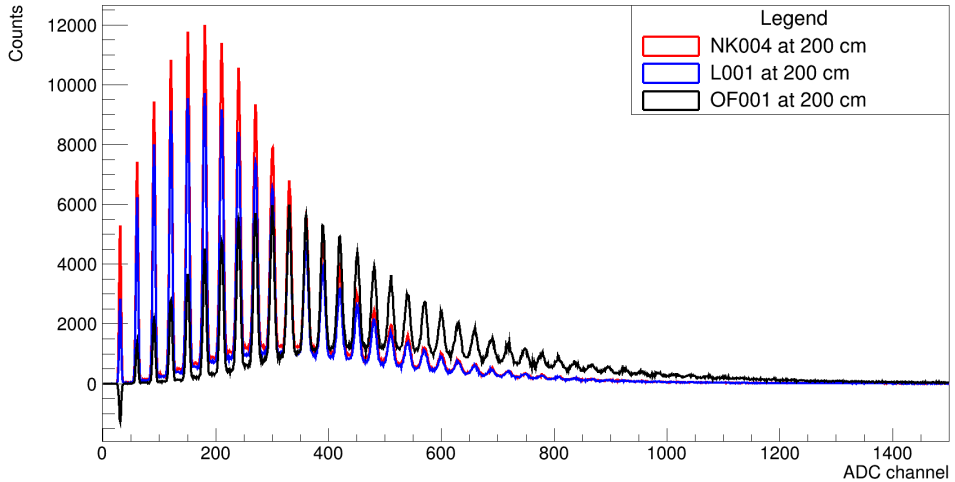
- Hamamatsu Module: high resolution, low noise, temp control
- Alignment
- Reproducible coupling





Npe spectra

- **NKS, L and OKD** fibers measured; **coincidences**
- Noise-subtracted comparison at 5 distances (100, 140, 200, 240, 280 cm)
- Analysis scripts: multi-peak finding and light calibration



OKD > NKS > L

ScFi Testing Procedures

Summary

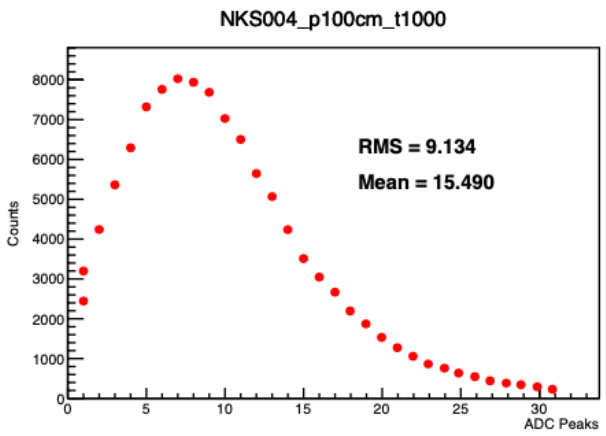
- Lots of experience at Regina.
- **All stations ready!**
- Personnel available for rapid testing.

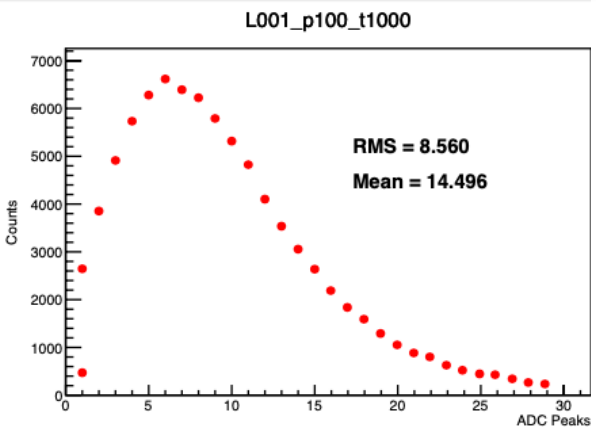
BACKUP Slides

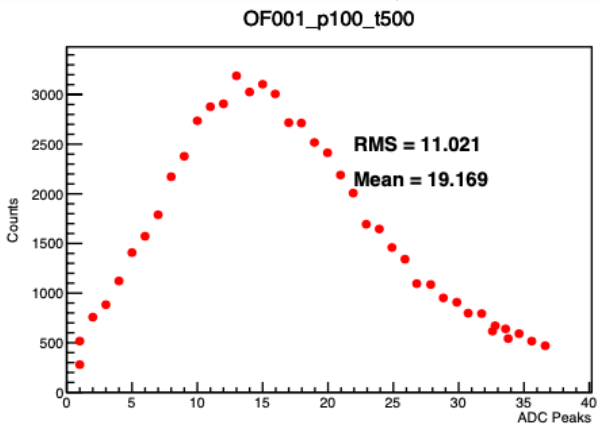
Npe - Comparisons - 90Sr at 100 cm

No grease!

5 min running

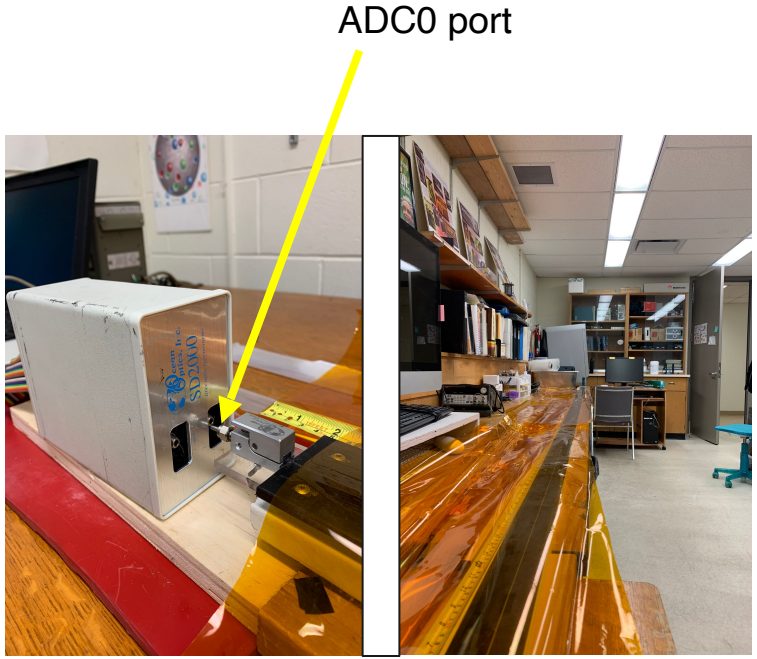






Spectrophotometer Set-up

- Fiber laid in groove of polyurethane tray (puckboard).
- Fed into **ADC0** of Ocean Optics SD2000[1] spectrophotometer; clip for stability.
- SD2000 connected to ADC (Ocean Optics ADC1000-USB Serial[1]), then connected to DAQ laptop via USB.
- Measurements in darkness; double layer of UV-absorbing film covering fibers.



Spectrophotometer with fiber inserted (left); view down the tray holding the fibers (right)

[1]Ocean Insights, Orlando, FL, USA (www.oceaninsight.com)

Long Atten Len: fits 100-300cm

Attenuation Curve Coefficients from Single Exponential Fit - 370nm LED with 3.3V Current Limit					
Fibre Type	**Fibre #**	**Relative Error (%)**	I_0	λ	χ^2/NDF
Luxium	02	1.1	0.0105 ± 0.0001	396 ± 7	19.86 / 17
	06	1.3	0.0107 ± 0.0001	411 ± 9	20.28 / 17
	07	1.5	0.0112 ± 0.0001	372 ± 9	15.18 / 17
	08	1.1	0.0114 ± 0.0001	393 ± 7	19.59 / 17
	09	1.4	0.0117 ± 0.0001	369 ± 8	17.99 / 17
	10	1.0	0.01113 ± 0.00009	408 ± 7	16.01 / 17
	11	1.5	0.0116 ± 0.0001	369 ± 9	20.77 / 17
NKS	06	2.1	0.0207 ± 0.0004	411 ± 15	14.61 / 17
	07	0.7	0.0208 ± 0.0001	486 ± 7	15.69 / 17
	10	1.3	0.0217 ± 0.0002	459 ± 12	16.53 / 17
NKD	06	0.9	0.0292 ± 0.0002	513 ± 10	15.1 / 17
	07	1.2	0.0254 ± 0.0003	509 ± 13	21.04 / 17
	10	1.7	0.0262 ± 0.0004	557 ± 22	16.9 / 17

All types have long atten > 4m

Short & Long Atten Len: fits 100-300cm

Attenuation Curve Coefficients from Double Exponential Fit - 370nm LED with 3.3V Current Limit							
Fibre Type	**Fibre #**	**Relative Error (%)**	I_0	α	λ_1	λ_2	χ^2/NDF
Luxium	02	0.6	0.0147 ± 0.0001	0.321 ± 0.006	40 ± 2	434 ± 8	27.57 / 26
	06	0.9	0.0148 ± 0.0001	0.33 ± 0.12	47 ± 4	467 ± 18	28.03 / 26
	07	0.7	0.0151 ± 0.0001	0.37 ± 0.02	59 ± 4	476 ± 22	23.07 / 26
	08	0.6	0.0146 ± 0.0001	0.28 ± 0.01	52 ± 4	447 ± 12	29.27 / 26
	09	0.8	0.0141 ± 0.0001	0.35 ± 0.05	81 ± 12	542 ± 69	28.76 / 26
	10	0.6	0.0149 ± 0.0001	0.301 ± 0.007	42 ± 2	458 ± 10	25.59 / 26
	11	0.7	0.0148 ± 0.0001	0.42 ± 0.04	80 ± 7	597 ± 67	28.96 / 26
NKS	06	2.1	0.0244 ± 0.0003	0.40 ± 0.02	100 ± 18	742 ± 59	8.095 / 26
	07	0.8	0.0260 ± 0.0003	0.214 ± 0.009	40 ± 4	506 ± 13	23.22 / 26
	10	0.6	0.0256 ± 0.0001	0.34 ± 0.03	94 ± 8	734 ± 71	27.72 / 26
NKD	06	0.9	0.03386 ± 0.0003	0.21 ± 0.02	62 ± 10	624 ± 42	21.67 / 26
	07	2.7	0.037 ± 0.001	0.42 ± 0.04	53 ± 10	775 ± 161	30.35 / 26
	10	1.2	0.0301 ± 0.0003	0.28 ± 0.02	98 ± 5	833 ± 53	20.04 / 26

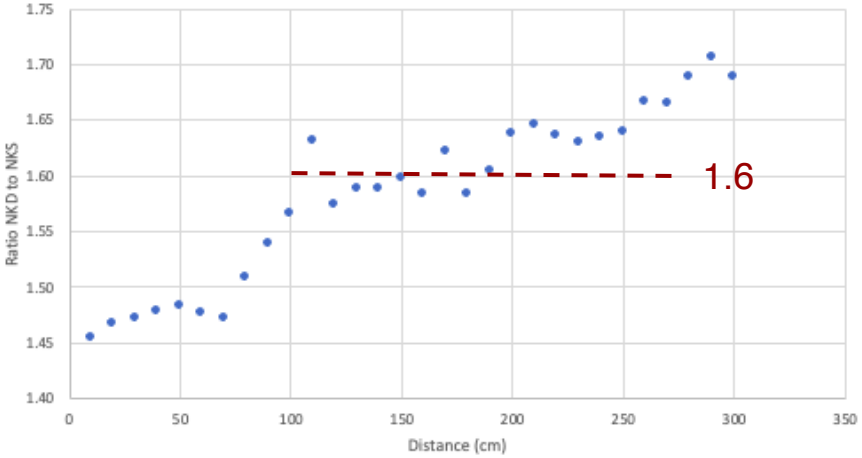
BCAL had ~50cm and ~500 cm for PHT fibers

Attenuation Length Comparison (100-300cm) 2023

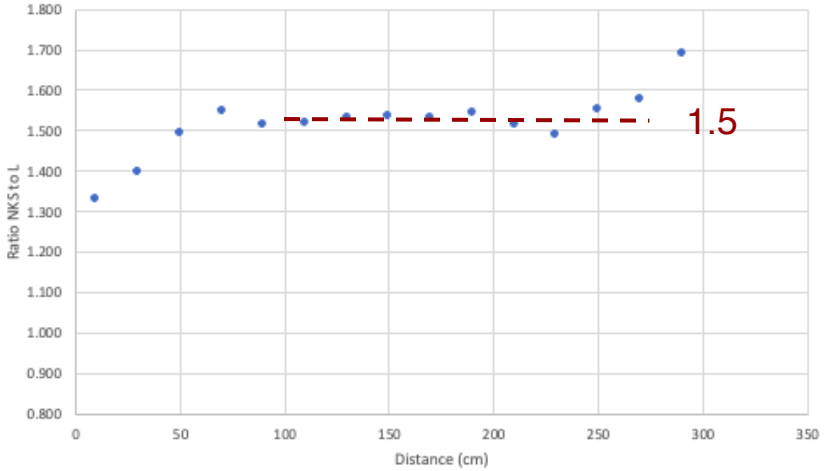
NKS-00i	λ (cm)	L-00i	λ (cm)	NKD-00i	λ (cm)
001	431±17	001	412±17	001	620±41
002	480±22	002	386±13	002	528±24
003	486±16	003	377±8	003	505±21
004	441±46	004	406±8	004	544±17
005	460±13	005	439±8		
001G	432±27	001G	425±8	001G	641±67
002G	532±42	002G	407±9	002G	529±41
004G	449±17	004G	567±66	004G	531±29

Fiber Scans: Comparisons 2023

NKD/NKS



NKS/L

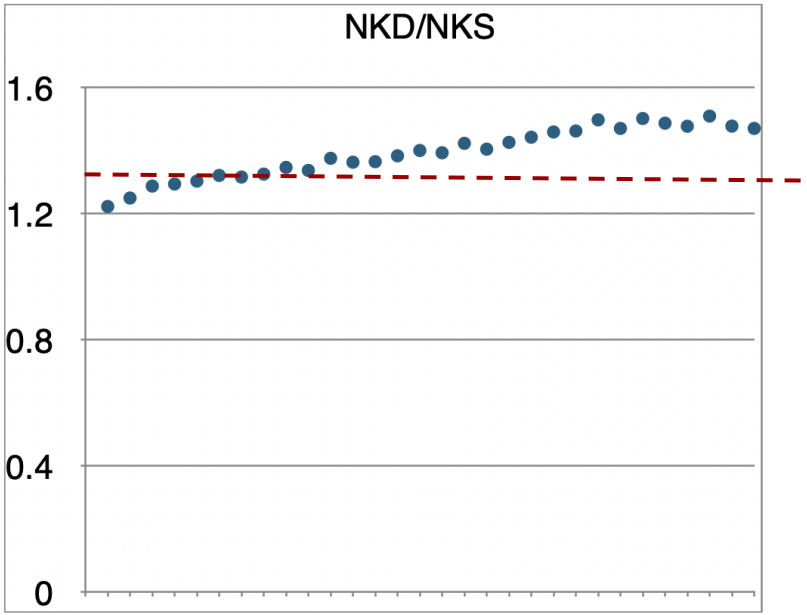


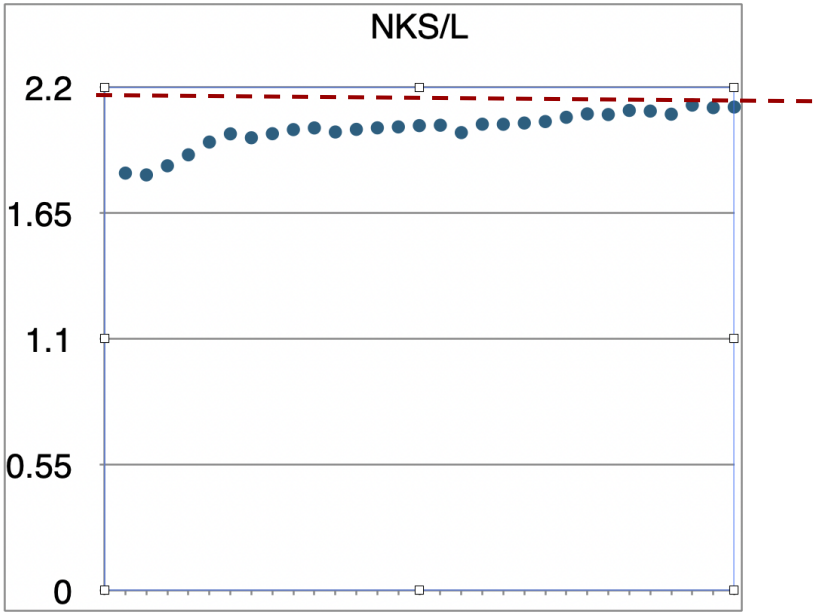
Kuraray brochure: D is 50% > S

NKS > L by ~50%

(Oleg Tsai saw 20%)

Fiber Scans: Comparisons 2024

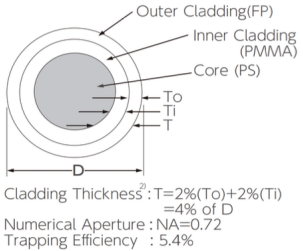


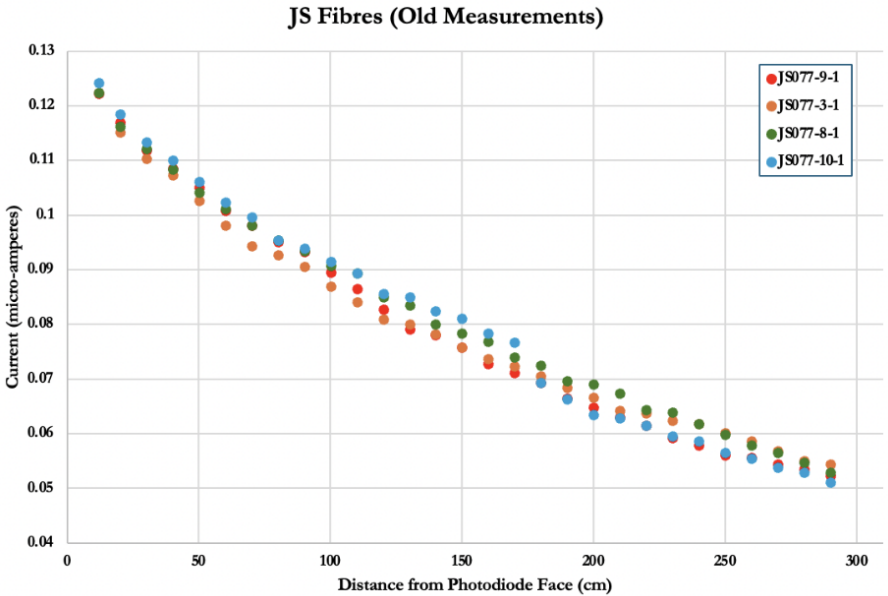


Kuraray brochure: D is 50% > S

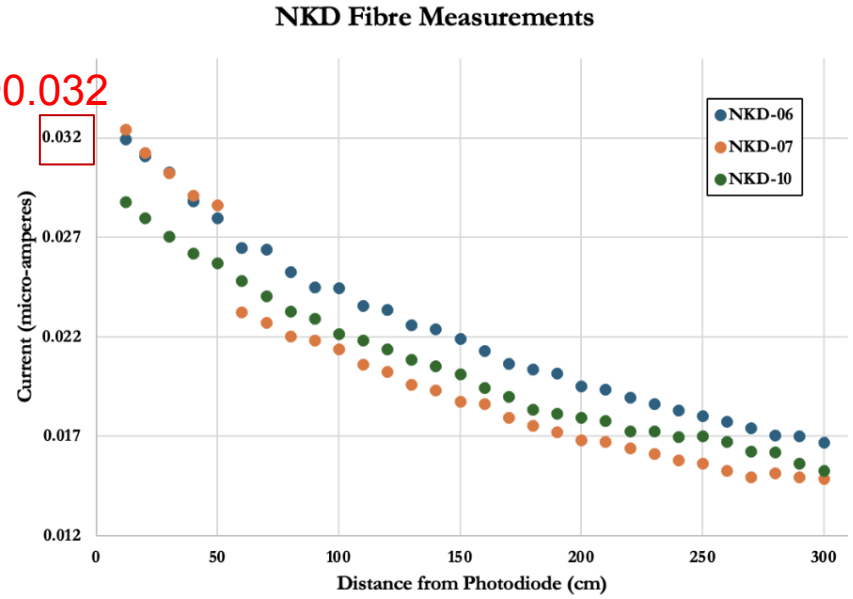
NKS > L by ≳50%

Fiber Scans: Double-Clad





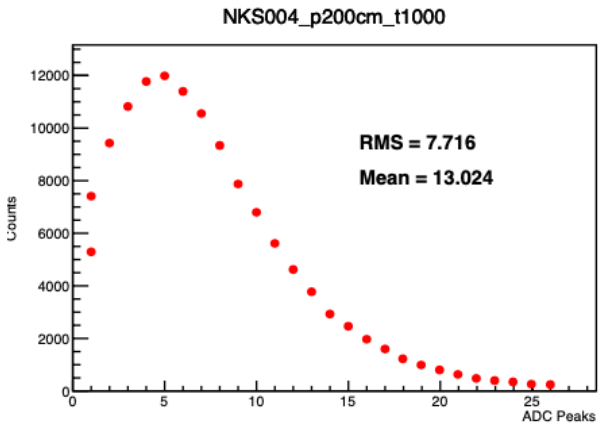
BCAL measurements 2011

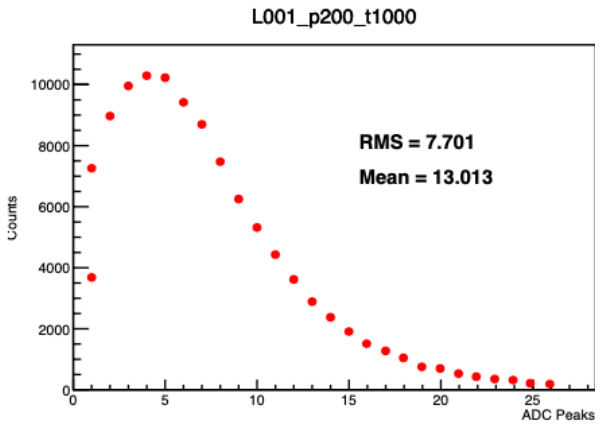


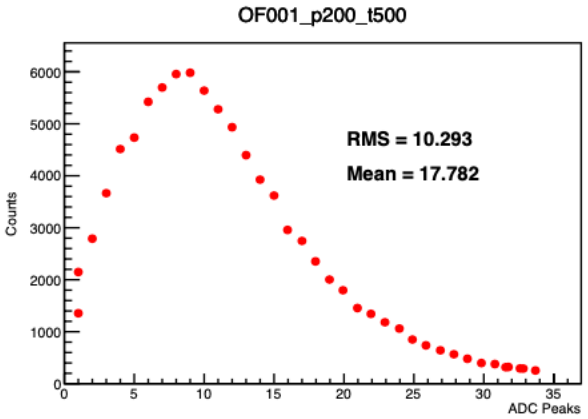
BIC measurements 2024

(LED issue)

Npe - Comparisons - 90Sr at 200 cm





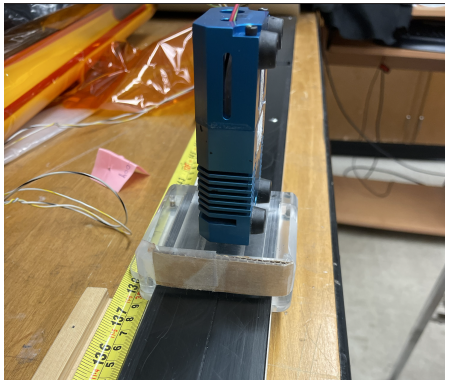


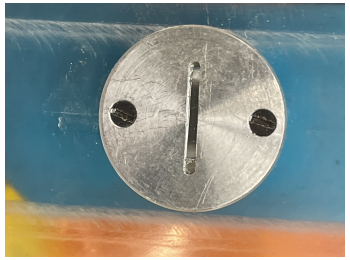
No grease!

NKS/L = 0.3%, NKD/NKS = 27%

BACKUP Slides

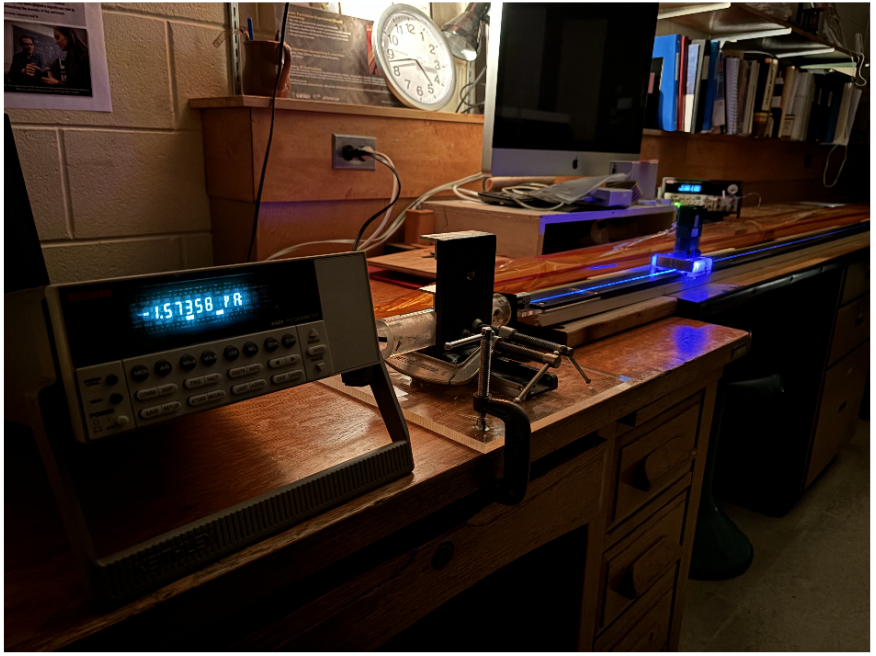
Photodiode Station

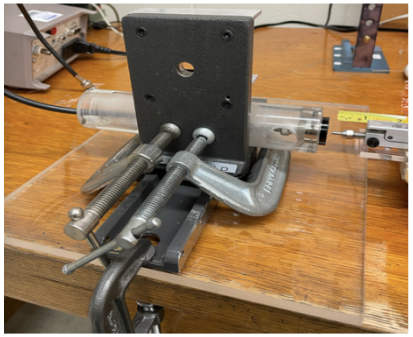




Light slit

LED housing





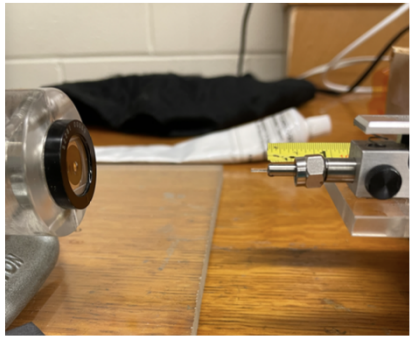


Fig. 5. Photodiode is levelled and secured to the table using clamps.