BIC Fiber Specifications - OPA Review

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Weekly Barrel Imaging Calorimeter (BIC) Meeting, November 14, 2023

Draft Specs for OPA Review (Mid November)

- **Fiber Work**
  - Measurements at Regina; Simulations at ANL.
- **Fiber Specifications** (Contractors to Describe how each specification will be met)
  - Light yield shall exceed 8000 photons/MeV.
  - Diameter mean value and variation shall be 1.00 mm, RMS =<0.02 mm.
  - Attenuation length for blue light > 4m.
  - Batch to batch or lot to lot variation of light yield =<15%.
  - Batch to batch or lot to lot variation of attenuation length =<10%.
  - Delivery method in canes. Length of fibers 4.55 meters +/- 0.01m.

Attenuation Length (Kuraray)

Formulations[1)]

Description	Emission			Decay Time [ns]	Att.Leng.[2)] [m]	Characteristics
	Color	Spectra	Peak[nm]			
SCSF-78	blue	See the following figure	450	2.8	>4.0	Long Att. Length and High Light Yield
SCSF-81	blue		437	2.4	>3.5	Long Attenuation Length
SCSF-3HF(1500)	green		530	7	>4.5	3HF formulation for Radiation Hardness

1) Test fibers are Non-S type, 1 mmϕ.

2) Measured by using bialkali PMT and UV light(254nm).
Quality control is made by another measurement of the transmission loss every batch.

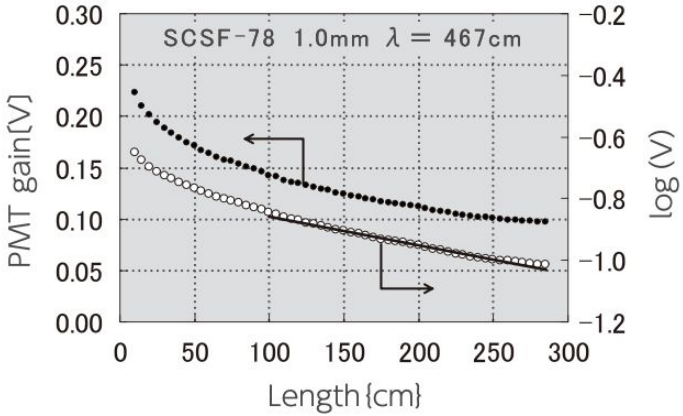
Use 254nm @ Regina

Attenuation Length Measurement (Kuraray)

Attenuation Length Measurement

We routinely measure attenuation length by 3m fiber sample for all production.

The attenuation curve (for example) in the figure is approximated by the one exponential expression $I(x)=I_0\exp(-\frac{x}{\lambda})$ except very near distance. The attenuation length λ is calculated using the data between x=100cm and x=300cm.



- **Single- or two-component specification? ⇒ Consider, and possibly discuss with both Contractors.**

Fiber Type (Kuraray)

Type of Polymer Orientation of PS Core

Standard type (Non-S type)
PS core is almost no oriented polystyrene chain and is optically isotropic and very transparent.
This conventional standard type has good attenuation length, but it shows weakness against clacking caused by bending or handling during assembling.

S type (S)
Core has molecular orientation along drawing direction.
This fiber is mechanically stronger against clacking at the cost of transparency.
The attenuation length of this type is nearly 10% shorter than standard type.

- **We are ordering Non-S type. If in coils, those "bobbins" have a large enough diameter: no issue.**

Fiber Diameter (Kuraray)

Tolerance of Diameter

Cut Fiber (1-5m long) :

$\left|\frac{\Delta D}{\bar{D}}\right| < 2.0\%$ for round fiber

$\left|\frac{\Delta S}{\bar{S}}\right| < 3.0\%$ for square fiber

Endless Spool Fiber :

$\frac{3\sigma}{\bar{D}} < 2.5\%$ (σ: rms, Spool Dia. : 900mm)

Minimum Bending Diameter

We recommend minimum bending diameter as the following table on safety side and long term reliability.

Type	2mmΦ Fiber	1mmΦ Fiber	0.5mmΦ Fiber
S type	200mm	100mm	50mm
Non-S type	400mm	200mm	100mm

- **Need clarification from Kuraray, which may impact decision to "force" the delivery to be canes.**

Summary

- Specs are mostly good as we have in the latest SOW. This includes single-exp attenlen >4.0m (between 100-300 cm).
- Should we update the diameter spec to include numbers for spool and cane or force only canes?
- Specify method for attenuation length extraction: we need decide/clarify whether we ask for single-component with the Kuraray method, or something more complex (short and long).
- Figure of Merit (Scoring) on specs? [AB answer: no; consensus decision]

Backup Slides

Sept 22, 2023

Sasha's Single- vs Double-Clad fibers

1. It may affect e/pi separation for eID and photon measurements (down to 100 MeV), and ToF measurements (e.g. to define z from the time difference between two sides) - and we need to develop our conclusion on all of these.

2. Our simulation has to have realistic light attenuation implemented (from Zisis's measurements; one exponent model is definitely not enough), and thresholds (equivalent 5-10 MeV per readout channel looks reasonable?).

3. As we discussed we don't expect any significant effect on resolution due to increased light yield (with double clad), because it is defined mainly by sampling fluctuations; however the fact that the energy is distributed among many channels (segmented in both transverse and longitudinal directions) with their own noise and threshold, may eventually affect the resolution, particularly for lower energy photons.

4. The light yield per channel along with thresholds may effect ToF measurements (and therefore z measurements), particularly at sector ends, when signal on the far side will be significantly attenuated.

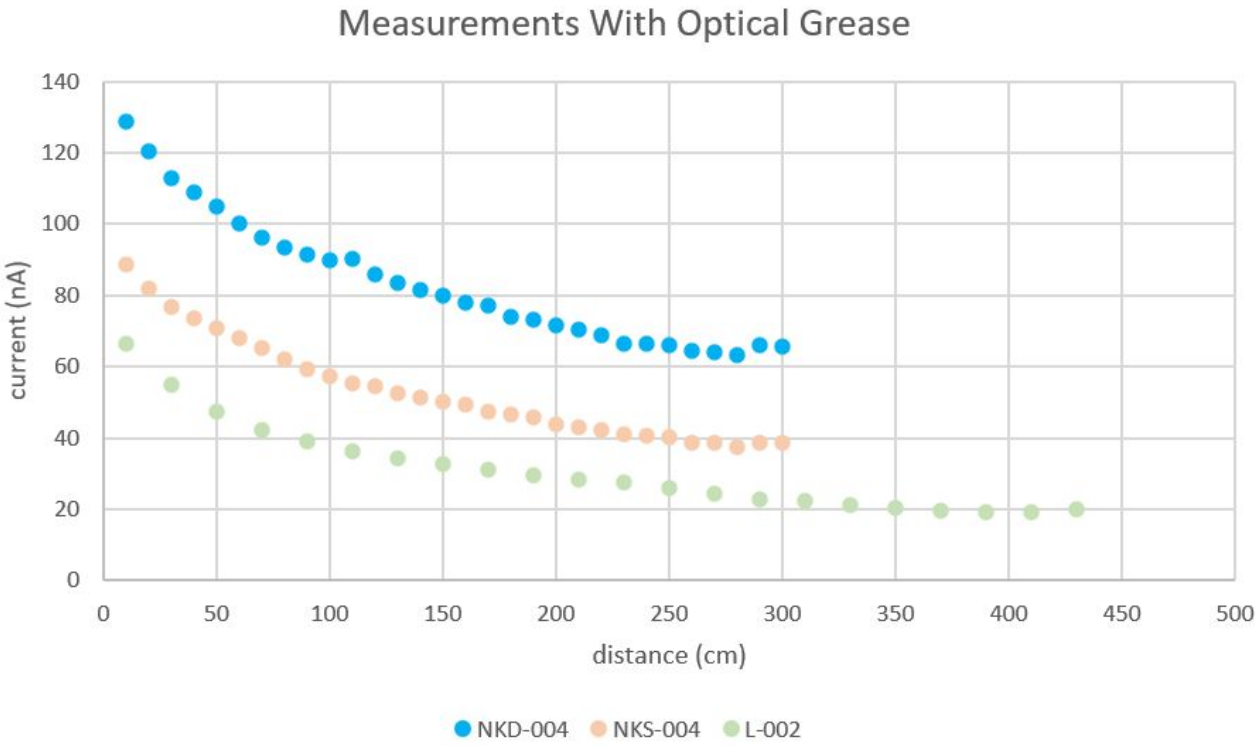
5. Elke insists that on the negative rapidity end, we have to be capable to measure electrons as well as possible (important kinematical region with intermediate Q2), and having double clad fibers in imaging layers, where basically the whole shower will be confined in imaging layers in far end - it could be beneficial for us. Let's quantify it too.

6. If we decide to use double clad fibers for thin (imaging) layers, it is not necessary to use it for all five layers; moreover I see not so much meaningful to provide high light yield in the last imaging layers, as they locate at show max and provide highest light yield anyway. So if it is meaningful at all, only first couple of layers may give some effect.

SciFi Vendor Communications (week Oct 2)

- Kuraray:
  - Double-clad fibers use fluorinated polymers - longer procurement lead time (raw materials).
  - “Roll habit” (lift-up/elastic memory): no way to eliminate it. They are offering us sample shipment in larger-diameter bobbins (stock SCSF-78M, 1mmφ, single, Non-S type).
- Luxium:
  - LLP timetable?
  - They ask for our test result details. Their tests show attenuation length > 400 cm.
- Other:
  - Figure-of-merit calculation for single vs double? (shower, MIP, etc).
  - Figure-of-merit calculation for vendor? (dimensions, performance, price, delivery).
  - Single alone, or single-double order and LLP: timetable? notify vendors asap.

With Optical Grease

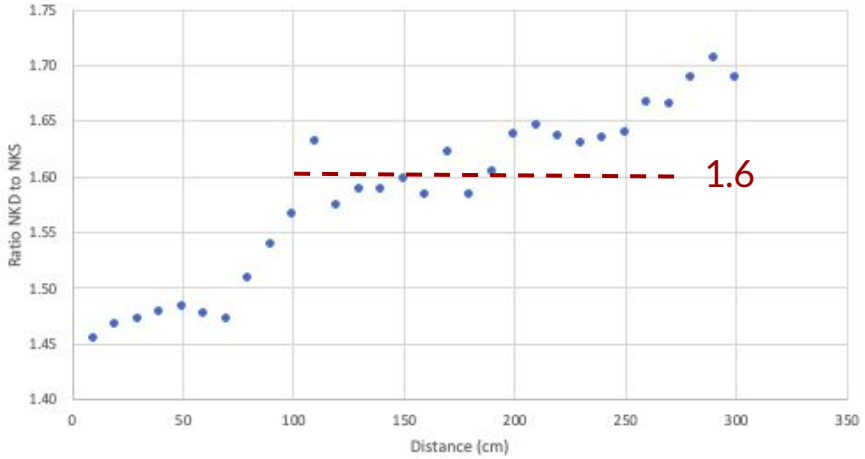


Attenuation Length Comparison (100-300cm)

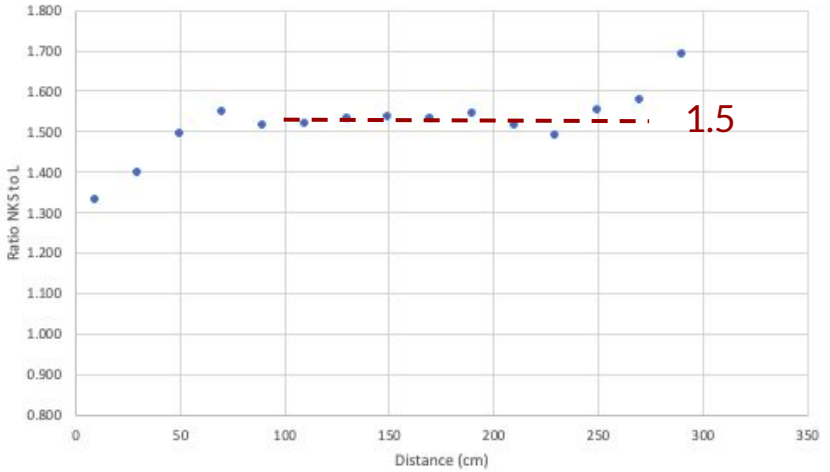
NKS-00i	λ (cm)	L-00i	λ (cm)	NKD-00i	λ (cm)
001	431±17	001	412±17	001	620±41
002	480±22	002	386±13	002	528±24
003	486±16	003	377±8	003	505±21
004	441±46	004	406±8	004	544±17
005	460±13	005	439±8		
001G	432±27	001G	425±8	001G	641±67
002G	532±42	002G	407±9	002G	529±41
004G	449±17	004G	567±66	004G	531±29

Photodiode Station - Current Ratio (Light Output)

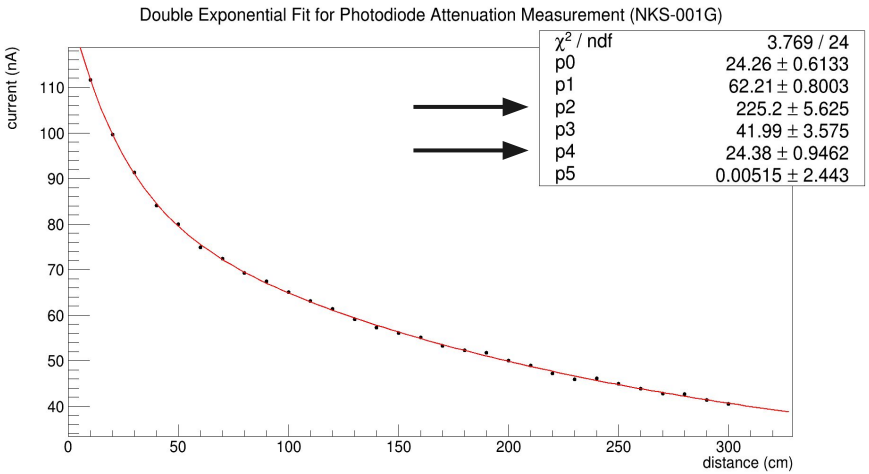
NKD/NKS

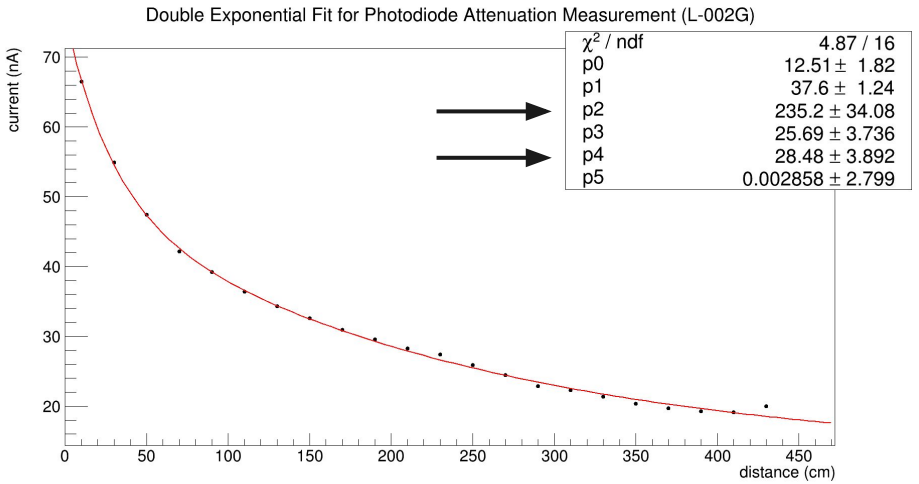


NKS/L



Photodiode Station - double exponential fits

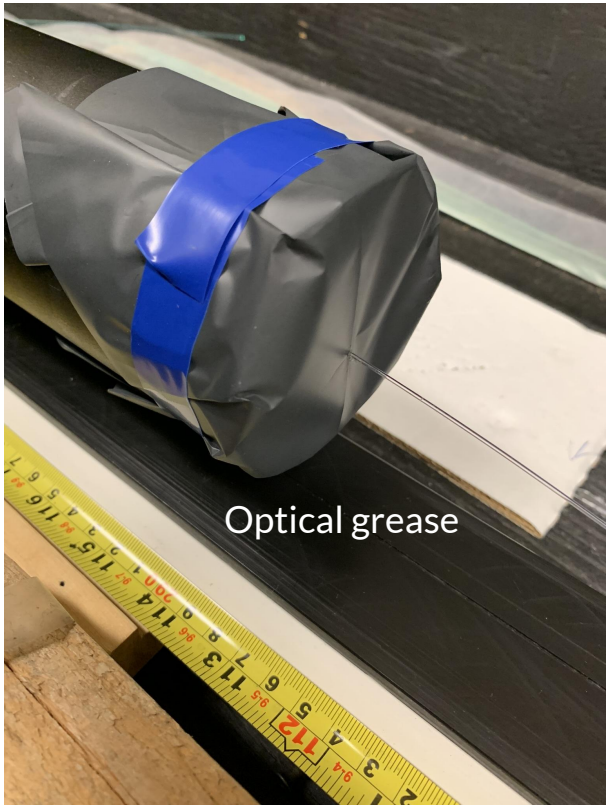




Do not agree with GlueX; more work needed.

Npe Station - Setup PMT

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



Npe Station - Setup SiPM

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