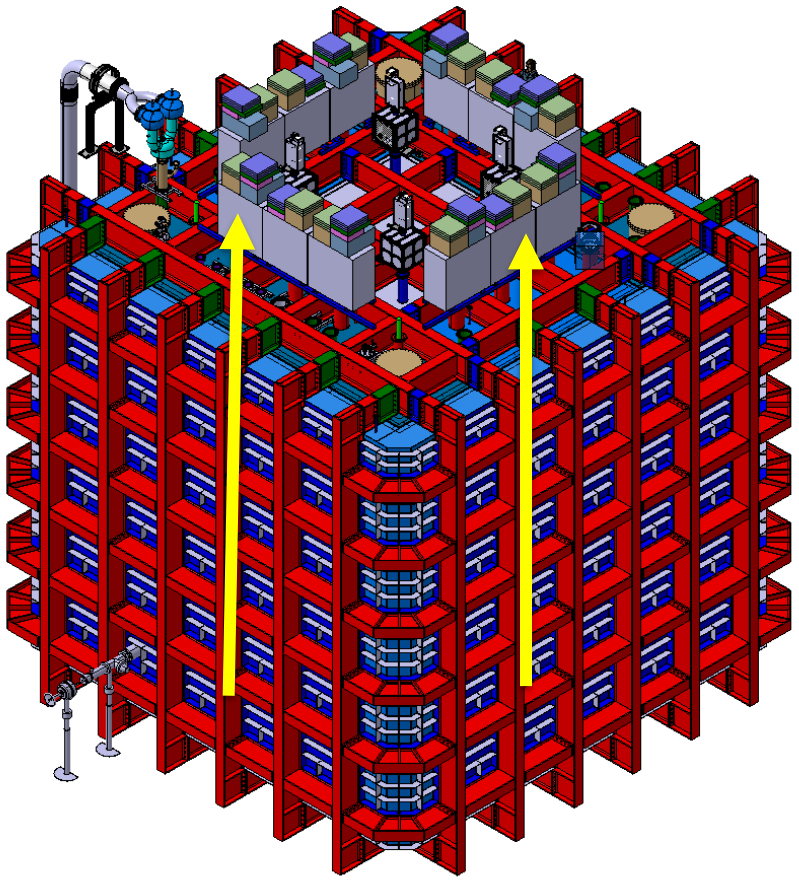
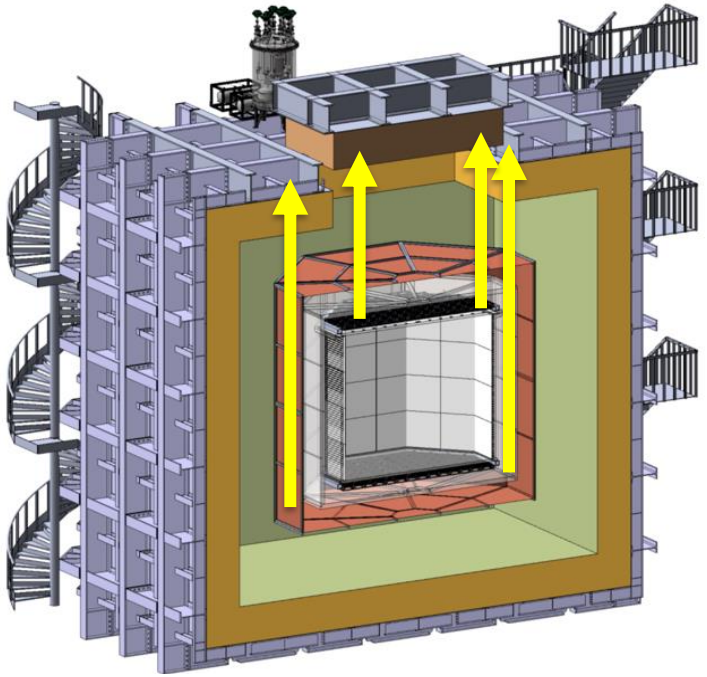
DarkSide Opto-Link

rignanes@bo.infn.it

Opto-link: analog signal extraction from the detectors (TPC-VETO) to the chimneys.

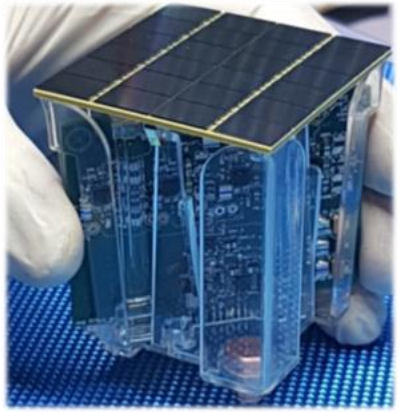




Cryogenic

Radiopure

Photo Detection Module (**PDM**)
5x5cm^2



Front End Boards (**FEB**)
Low noise cryo FE

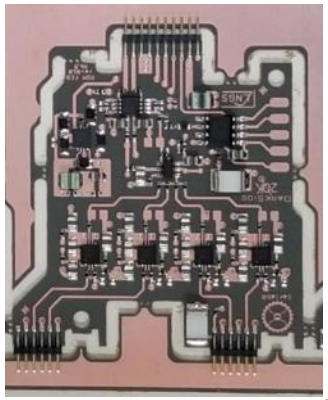
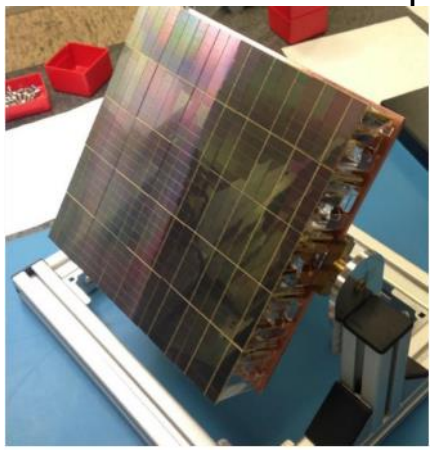
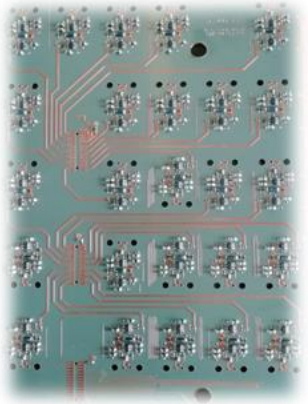
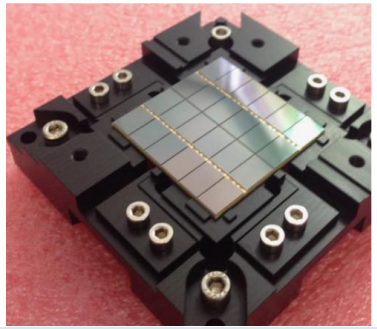


Photo Detection Unit
External optical driver

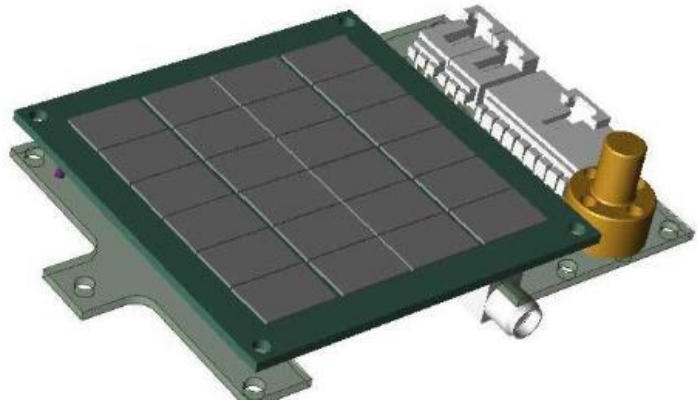




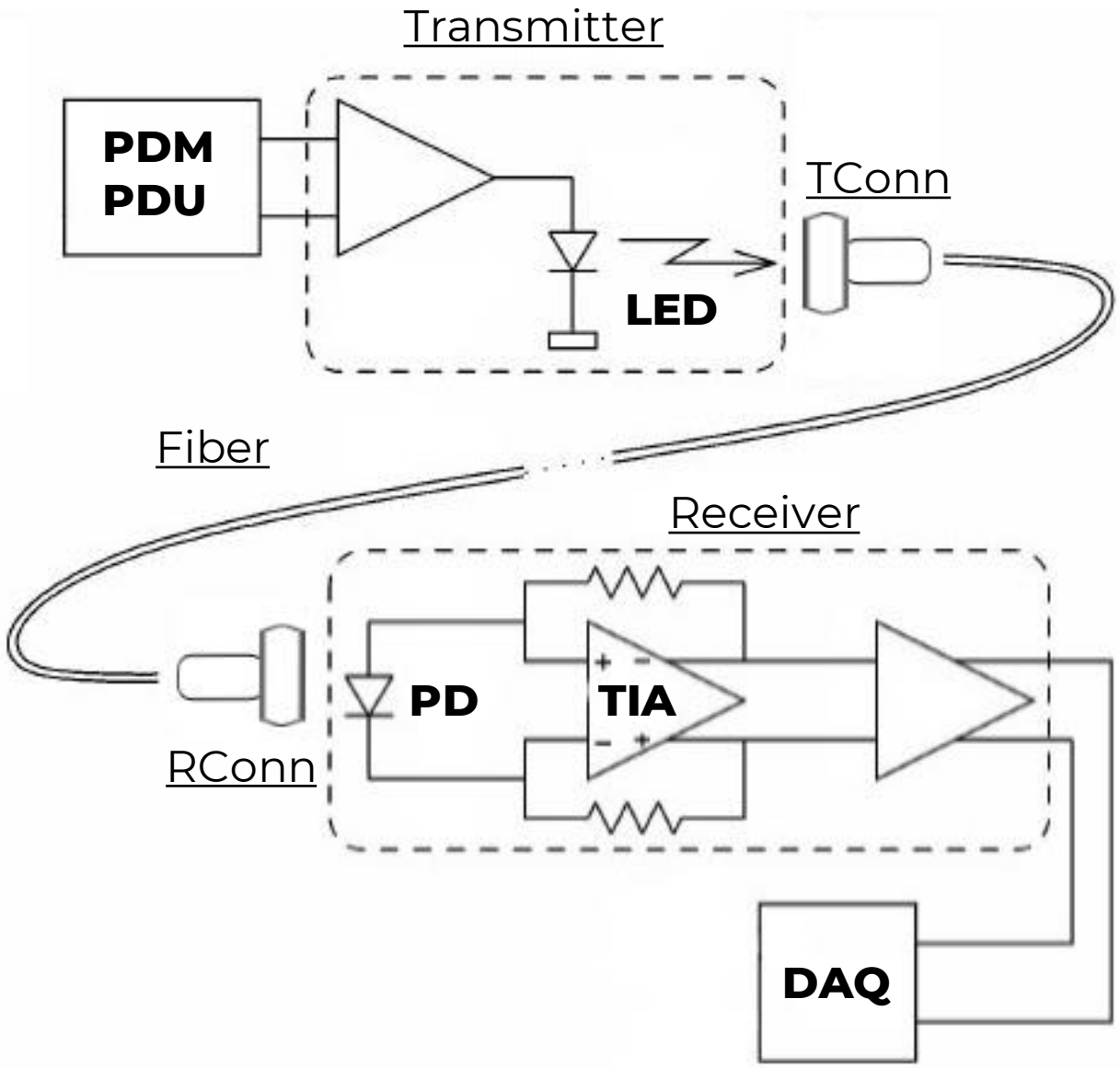
NUV-HD-Cryo **SiPMs** (FBK-LF)
8x12 mm^2



VETO Photo Detection Module (**PDM**)
embedded optical driver



Detector	Nb. of PDU/VDU	Nb. of PDM
DS-20k TPC	344	8280
DS-20k VETO	212	3000



Transmitter

Tconn

Fiber

Rcon

Receiver

Requirements:

- rt(10-90) < 8 ns
- BW>50 MHz
- SNR > 10 (considering 1PE=20mV)
- Dynamic Range: 100PE=2.0V output

Transmitter

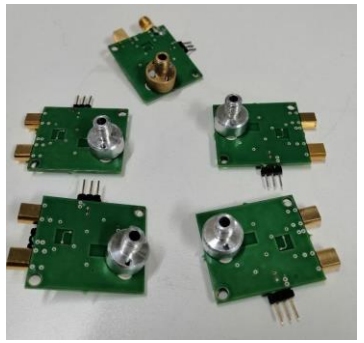
The first part of the chain is the transmitter board. Such board, attached to the PDU **converts** each PDM **signal** into a **light pulse**.

The circuit is a simple **LED driver**. The **InGaAs** LED produces a light pulse with a wavelength of 1300 nm. Such wavelength was chosen because **non detectable** by our SiPMs.

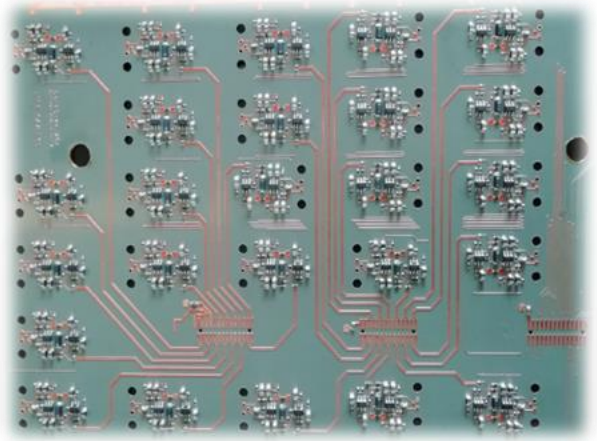
Issue: LED light output is **not linear** with the input current! (≈10% linearity deviation in [1] and [2])

However, one can find in literature[3] some test on the LED light output linearity in cryogenic environments.

We kind of proven this in our tests (next page)



Single channel prototypes

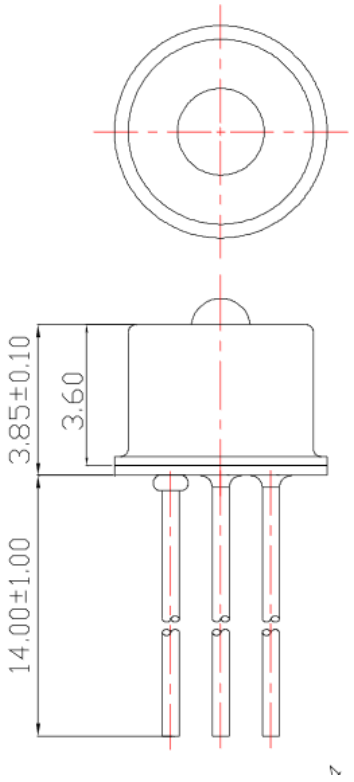


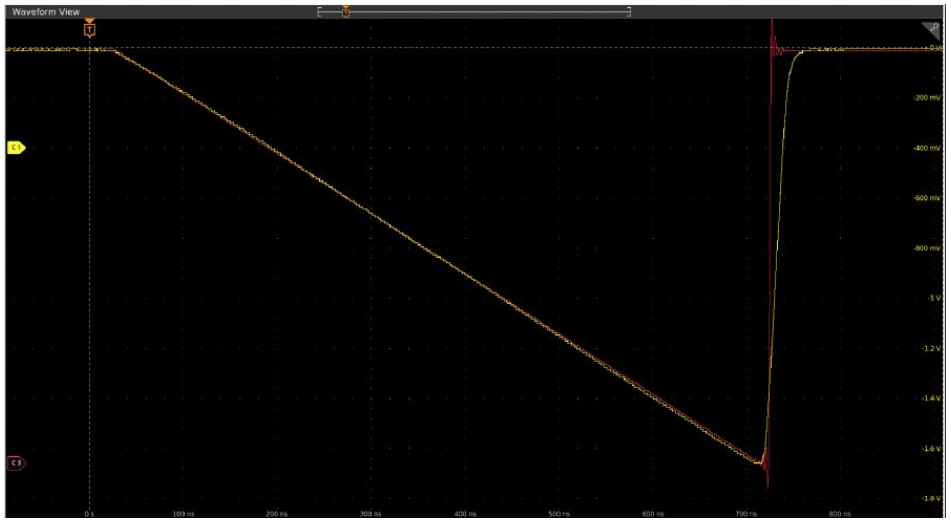
25 channels prototype.
Made with piralux flexible PCB

1. R.J.White, H.J. Rose, and S.M. Bradbury. **A temperature-stable optical link for the transmission of fast analogue signals**. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 595(2):332 – 338, 2008.
2. Joachim Rose, Isobel Bond, Albrecht Karle, Eckart Lorenz, Si Tran, and PeterWeißbach. **Fast analog signal transmission for an air cherenkov photomultiplier camera using optical fibers**. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 442(1):113 – 116, 2000.
3. D. V. Camin and V. Grassi. **Cryogenic behavior of optoelectronic devices for the transmission of analog signals via fiber optics**. IEEE Transactions on Nuclear Science, 53(6):3929– 3933, 2006

rignanes@bo.infn.it

LUXNET
1310nm 155Mbps
LED TO46-can
EI6C-806x-x Series

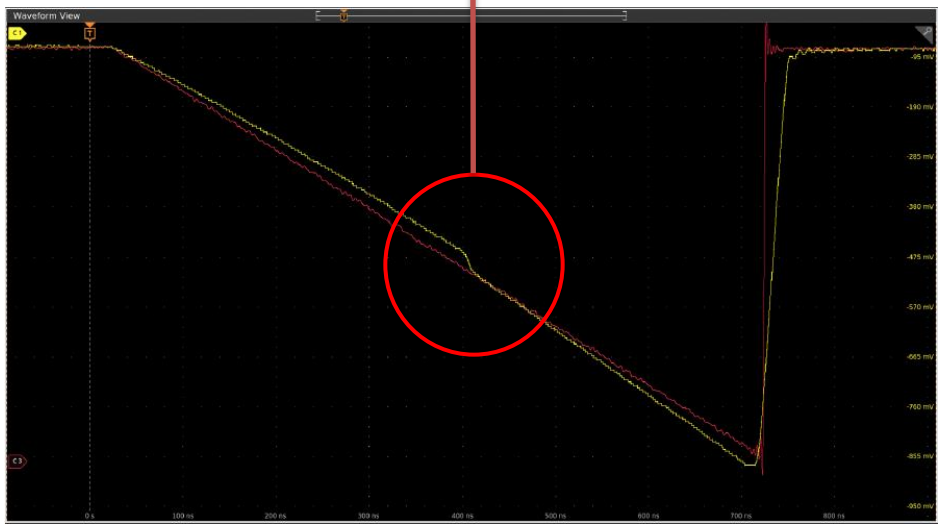




Red: input
Vin: 0-2V
Dt=700ns
Rt=2ns

Yellow: output
Vout:0-1.7V
Dt=700ns
Rt=10ns

Linearity defects

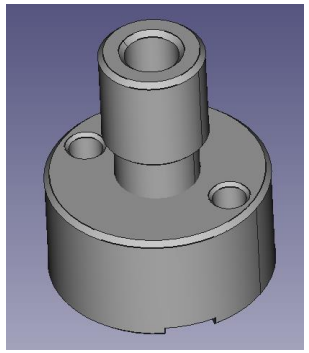


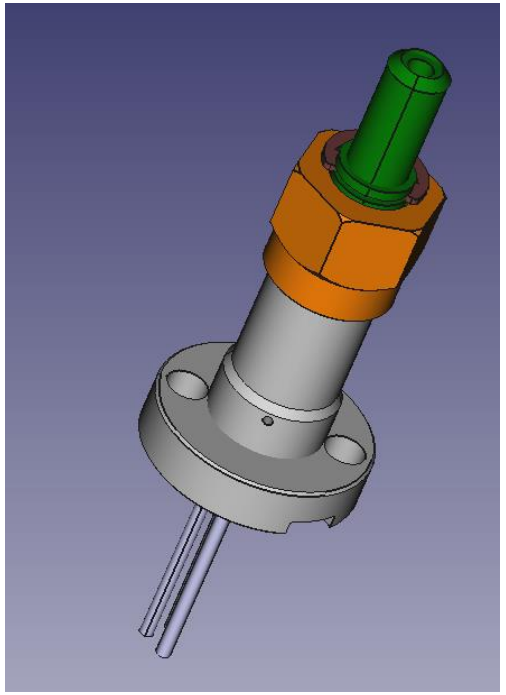
We are investigating if the defect can be identified with a room temperature test (IV, CV...)
In the meantime, new supplier are being contacted.

TConn

This connector is in charge the mating between the LED and the **SMA** connector of the optical fiber. It must be designed for the best **optical coupling**, be **radiopure** and **cryo-compatible**.

Several materials and design are studied

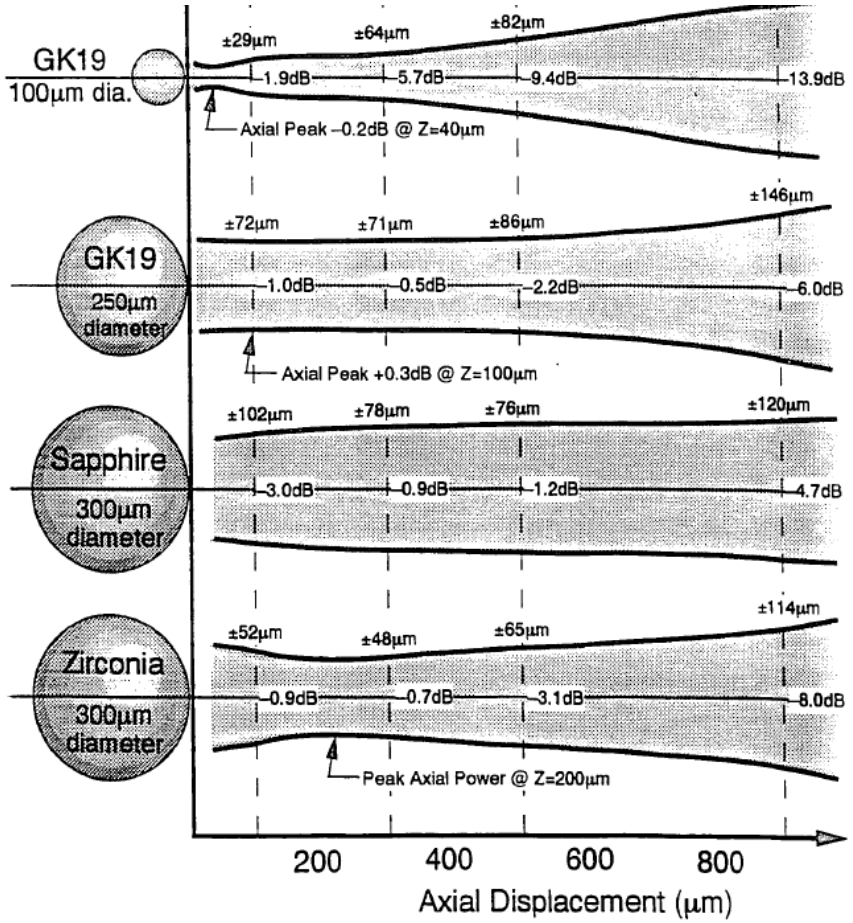


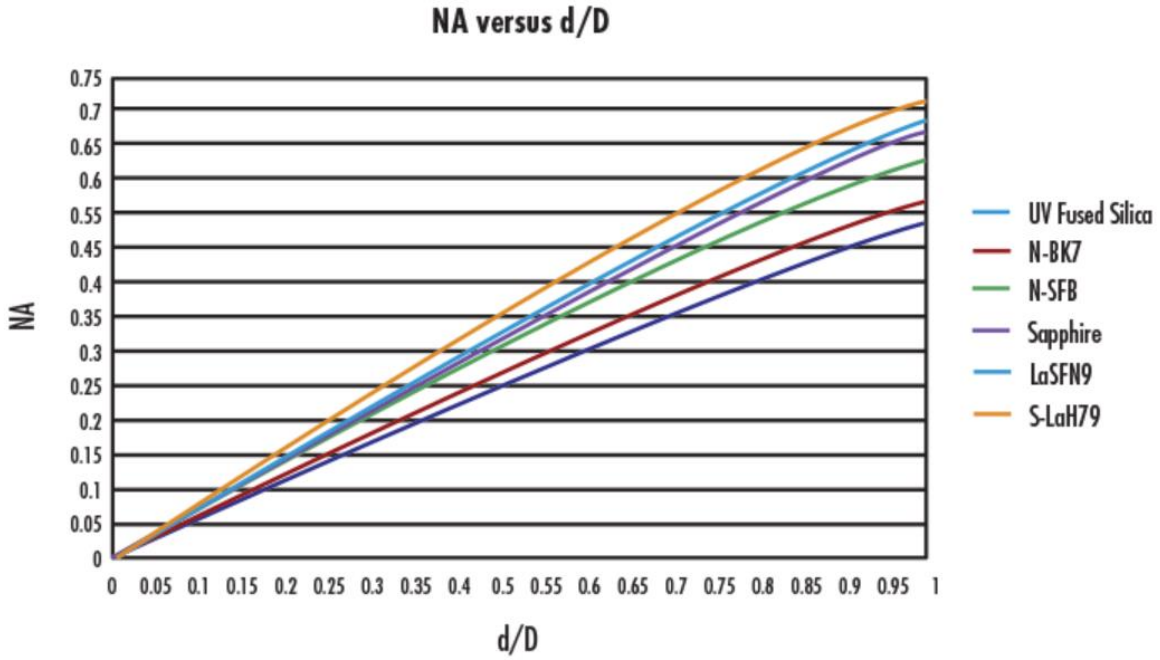


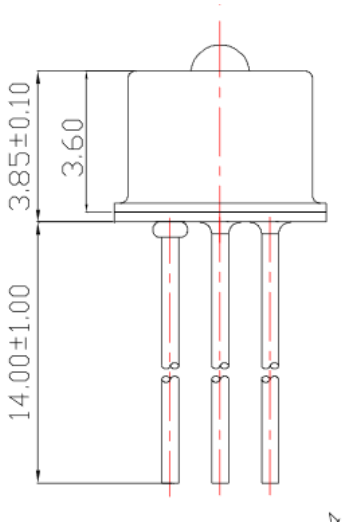
In order to have a reliable and fully functional design, we must study the **LED** component **beam profile** and infer its shape in liquid Argon[a].

[a] The refractive index of Argon is known up to 644 nm only where its value is 1.22. It seems quite stable though. https://refractiveindex.info/?shelf=main&book=Ar&page=Grace-liquid-90K

We are going to build on **optical bench** to study the **LED** component beam profile.







One of the most used glass for the ball lenses mounted on LEDs is **borosilicate** (N-BK7). This is a problem in DS for the high neutron yield.

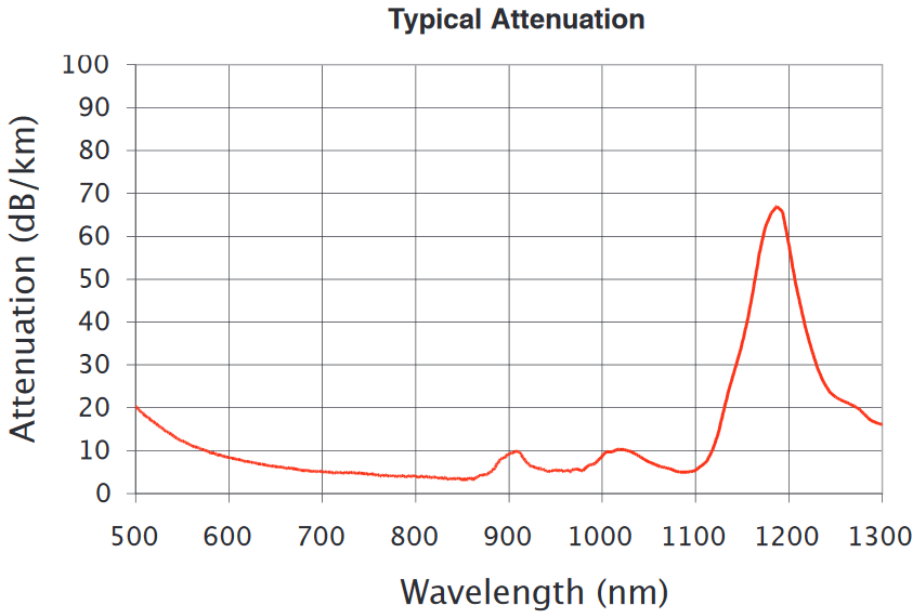
Fused silica is the most promising candidate.

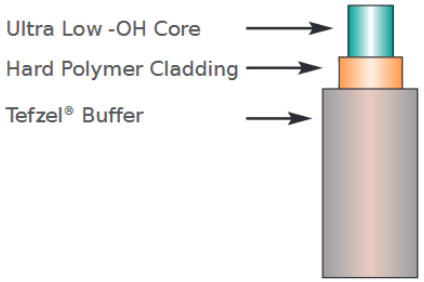
Fiber

The fiber is the key component of the transmission. It must be radiopure and suitable for cryogenic operations

Polymicro multi-mode step index 200/230/500 optical fiber
Low-OH Fused Silica Core: 200 ± 4µm
Hard Polymer Clad: 230 +0/-10µm
Acrylate Buffer OD: 500 ± 50µm· Numerical Aperture: **0.37** ± 0.02

22% less in LAr





Connectors:
- S/S SMA905
- LC

- No fluorine doped cladding
- Acrylate buffer should be suitable for cryogenic operations. Polyimide is an option.
- We are going to test the light output and the long-term stability of the fiber in a LN bath

We have to evaluate the microbend[b] induced by the coating shrinking.
If unacceptable, dual coated fibers can be used.
Most of the microbend should come from the connector ferrule.

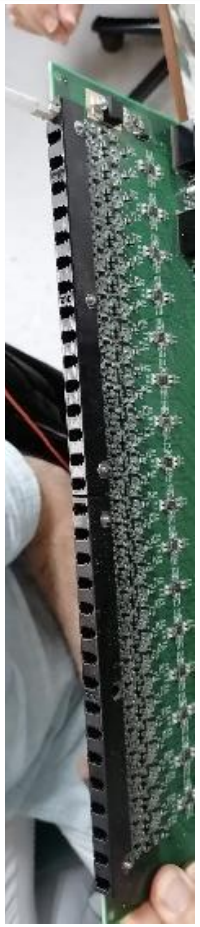
http://www.literature.molex.com/SQLImages/kelmscott/Molex/PDF_Images/987650-8939.PDF)

[b] Microbend produces optical losses and induces a higher occupation of higher-modes (more light travels close to the cladding, if not in the cladding)

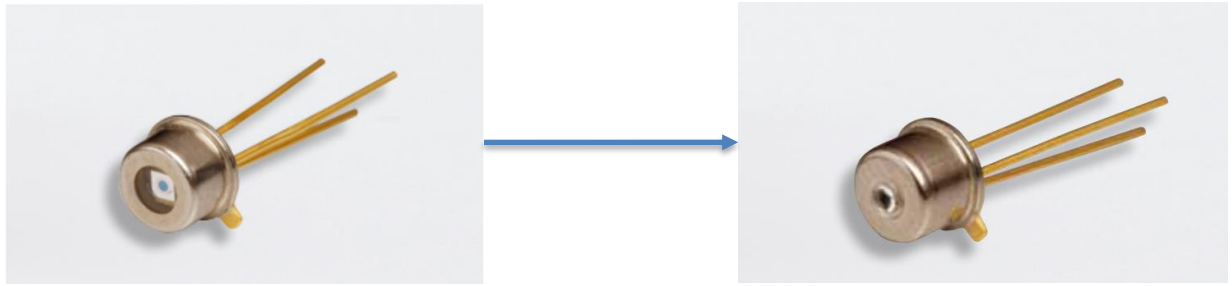
Receiver

The **receiver** converts the **light** carried by the fibers in an **electric differential** signal towards the **DAQ**. It is hosted inside the **chimney**, inside the cryostat. It will work in **gaseous Argon** at **room temperature**.

An **InGaAs photo-diode** attached to a **TIA** circuit.
The dimension of the active area drives the speed of the system. Smaller area devices guarantee higher speed at cost of output power.
Particular attention must be put in the beam profile exiting the fiber and impacting the **PD**. In case of overfilling, the signal results much slower due to poor collection at the boundary of the active area[4].



OSI LDI InGaAs-PD



500um flat-window

300um ball-lens

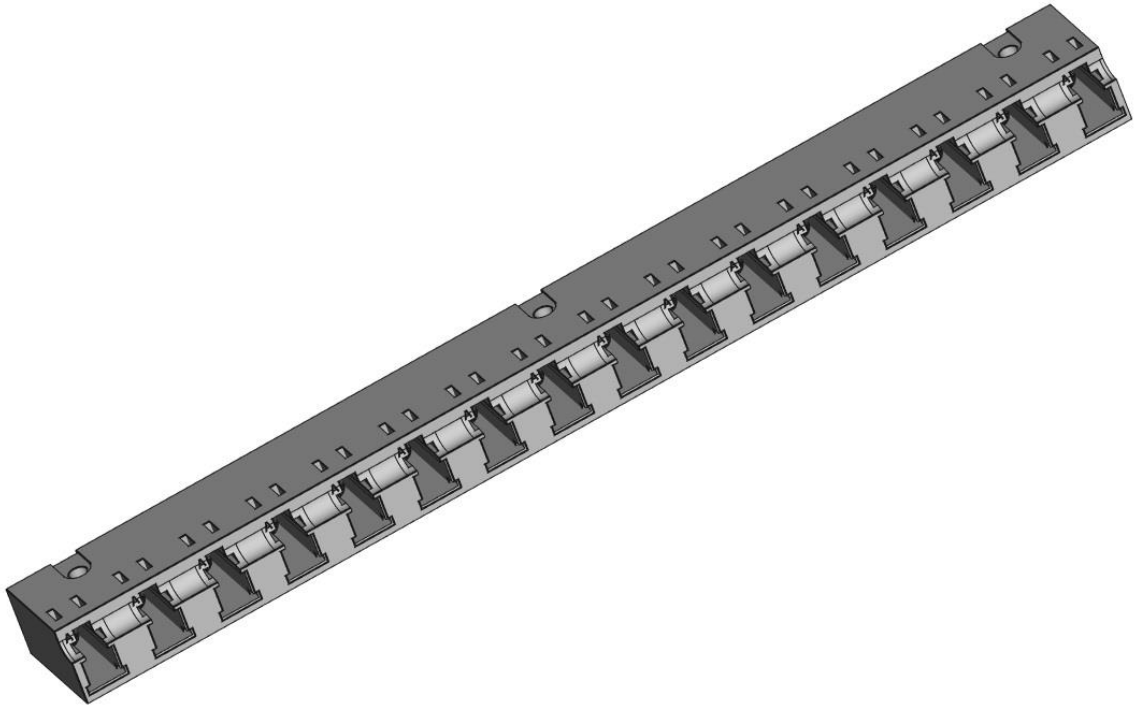
https://sphereoptics.de/wp-content/uploads/2017/08/OSI_InGaAs-Photodiodes.pdf

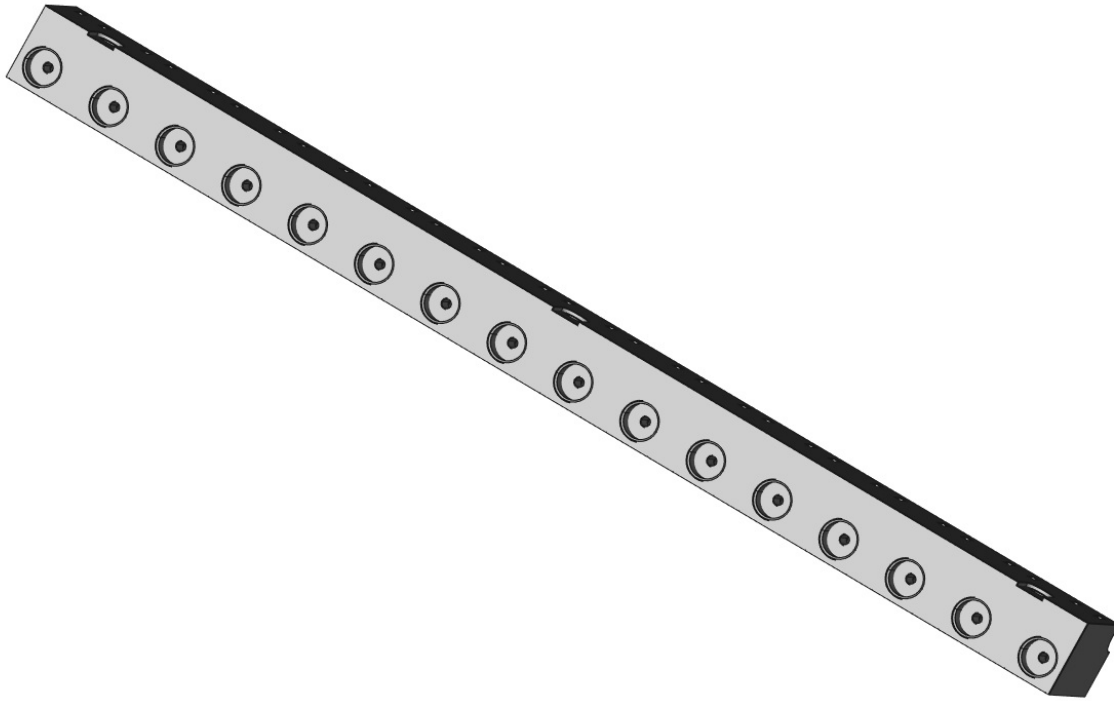
[4] P Corredera et al. **Anomalous non-linear behaviour of InGaAs photodiodes with overfilled illumination.** IOP Publishing S150-S153 1 40 2003


UCLA
71 inch
Alternate Cable Paths
Note: Filters and 220 V distribution would be located in the back.
Sub Floor
C.Kendziora 18 June 2020

Rconn

The receiver connector is way less complicate. In order to increase the density, we plan to use 3D printed LC receptacles.





Some example of “futuristic” designs