
# ETH to fiber converters and fiber bundle radiation hardness tests at CHARM and IRMA


*BE-BI-PM*

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# Introduction

## Beam profile imaging nowadays: BTV – Vidicon

Advantages:

1. Most Rad Hard so far…
2. No active components inside.

Drawbacks:

1. Limited life.
2. Limited sensitivity (observation instruments).
3. Issues of procurement (no production since > 5years, still ≈100 pieces in stock).

## Beam profile imaging upgrade: imaging fiber system

*Principle*: Transport an image away from a high radiation level area up to the camera located in a 'safer' place.

Advantages: Increased life time.

Procurement of 2x2m and 2x10m long/bunch of 10k fibers.

## Radiation hardness tests on:

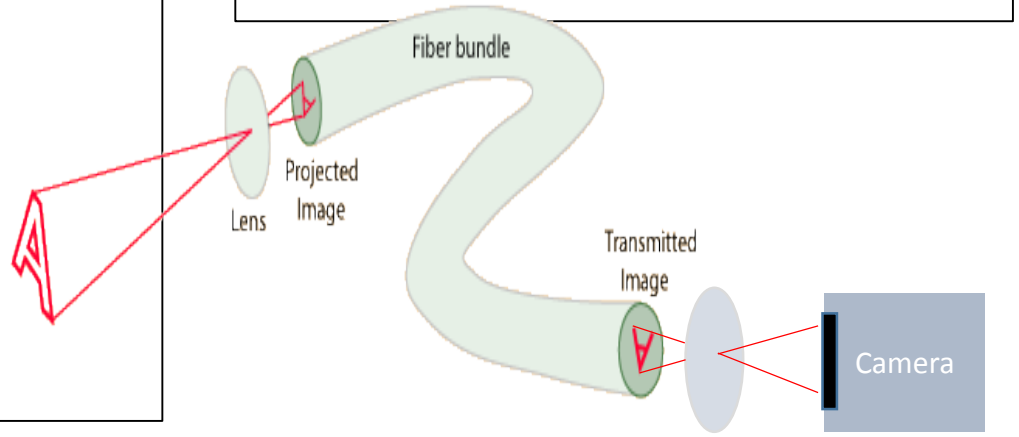
1. Digital cameras @ CHARM

   (RADWG 13th Avril 2017, S. Burger)

2. Eth/fiber converters @ CHARM

3. Fiber bundle @ IRMA

   (RADWG 23rd May 2018, D. Celeste)



# Summary

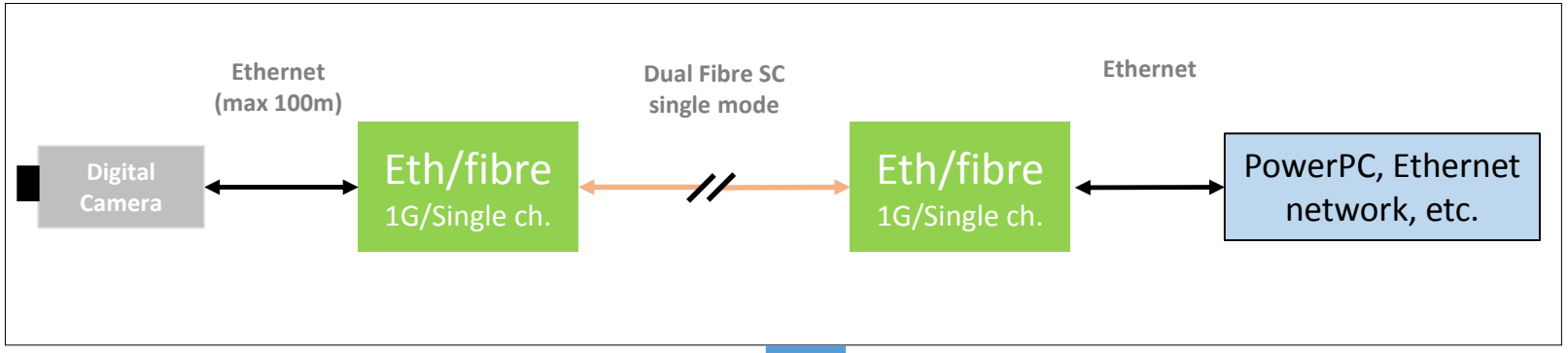
- Introduction
- Tests at CHARM: introduction and setup
- Results  on ethernet to fiber converters RadHard test
- Tests at IRMA introduction and setup
- Results  on fiber bundle RadHard test
- Conclusions

# Tests at CHARM: introduction and setup (1)

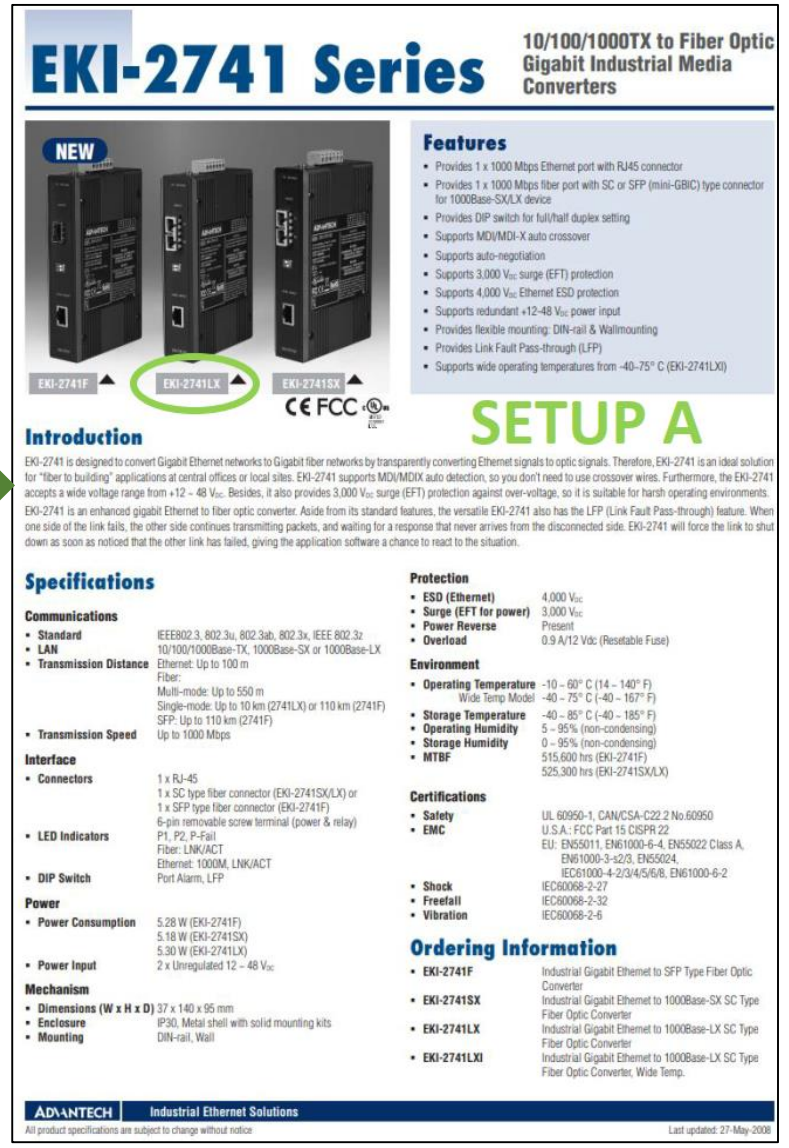
Increase of the use of high performance digital cameras in BI.
Radiation effect issue mitigated with optical line, shielding and RadHard innovation.

Distance to its control front end.
The Gigabit Ethernet allows up to 100m connections.
Not enough in the case of the SPS BTV dump future camera based (BTV) system.

Ethernet to Optical Fiber converter




As SPS machine…test in CHARM facility



EKI-2741 Series

10/100/1000TX to Fiber Optic Gigabit Industrial Media Converters

NEW

EKI-2741F EKI-2741LX EKI-2741SX

Features

- Provides 1 x 1000 Mbps Ethernet port with RJ45 connector
- Provides 1 x 1000 Mbps fiber port with SC or SFP (mini-GBIC) type connector for 1000Base-SX/LX device
- Provides DIP switch for full/half duplex setting
- Supports MDI/MDI-X auto crossover
- Supports auto-negotiation
- Supports 3,000 $V_{DC}$ surge (EFT) protection
- Supports 4,000 $V_{DC}$ Ethernet ESD protection
- Supports redundant +12-48 $V_{DC}$ power input
- Provides flexible mounting: DIN-rail & Wallmounting
- Provides Link Fault Pass-through (LFP)
- Supports wide operating temperatures from -40-75° C (EKI-2741LXI)

SETUP A

Introduction

EKI-2741 is designed to convert Gigabit Ethernet networks to Gigabit fiber networks by transparently converting Ethernet signals to optic signals. Therefore, EKI-2741 is an ideal solution for "fiber to building" applications at central offices or local sites. EKI-2741 supports MDI/MDIX auto detection, so you don't need to use crossover wires. Furthermore, the EKI-2741 accepts a wide voltage range from +12 ~ 48 $V_{DC}$. Besides, it also provides 3,000 $V_{DC}$ surge (EFT) protection against over-voltage, so it is suitable for harsh operating environments.

EKI-2741 is an enhanced gigabit Ethernet to fiber optic converter. Aside from its standard features, the versatile EKI-2741 also has the LFP (Link Fault Pass-through) feature. When one side of the link fails, the other side continues transmitting packets, and waiting for a response that never arrives from the disconnected side. EKI-2741 will force the link to shut down as soon as noticed that the other link has failed, giving the application software a chance to react to the situation.

Specifications

Communications

| | |
|---|---|
| Standard | IEEE802.3, 802.3u, 802.3ab, 802.3x, IEEE 802.3z |
| LAN | 10/100/1000Base-TX, 1000Base-SX or 1000Base-LX |
| Transmission Distance | Ethernet: Up to 100 m<br>Fiber:<br>Multi-mode: Up to 550 m<br>Single-mode: Up to 10 km (2741LX) or 110 km (2741F)<br>SFP: Up to 110 km (2741F) |
| Transmission Speed | Up to 1000 Mbps |

Interface

| | |
|---|---|
| Connectors | 1 x RJ-45<br>1 x SC type fiber connector (EKI-2741SX/LX) or<br>1 x SFP type fiber connector (EKI-2741F)<br>6-pin removable screw terminal (power & relay) |
| LED Indicators | P1, P2, P-Fail<br>Fiber: LNK/ACT<br>Ethernet: 1000M, LNK/ACT |
| DIP Switch | Port Alarm, LFP |

Power

| | |
|---|---|
| Power Consumption | 5.28 W (EKI-2741F)<br>5.18 W (EKI-2741SX)<br>5.30 W (EKI-2741LX) |
| Power Input | 2 x Unregulated 12 ~ 48 $V_{DC}$ |

Mechanism

| | |
|---|---|
| Dimensions (W x H x D) | 37 x 140 x 95 mm |
| Enclosure | IP30, Metal shell with solid mounting kits |
| Mounting | DIN-rail, Wall |

Protection

| | |
|---|---|
| ESD (Ethernet) | 4,000 $V_{DC}$ |
| Surge (EFT for power) | 3,000 $V_{DC}$ |
| Power Reverse | Present |
| Overload | 0.9 A/12 Vdc (Resetable Fuse) |

Environment

| | |
|---|---|
| Operating Temperature | -10 ~ 60° C (14 ~ 140° F) |
| Wide Temp Model | -40 ~ 75° C (-40 ~ 167° F) |
| Storage Temperature | -40 ~ 85° C (-40 ~ 185° F) |
| Operating Humidity | 5 ~ 95% (non-condensing) |
| Storage Humidity | 0 ~ 95% (non-condensing) |
| MTBF | 515,600 hrs (EKI-2741F)<br>525,300 hrs (EKI-2741SX/LX) |

Certifications

| | |
|---|---|
| Safety | UL 60950-1, CAN/CSA-C22.2 No.60950 |
| EMC | U.S.A.: FCC Part 15 CISPR 22<br>EU: EN55011, EN61000-6-4, EN55022 Class A, EN61000-3-s2/3, EN55024, IEC61000-4-2/3/4/5/6/8, EN61000-6-2 |
| Shock | IEC60068-2-27 |
| Freefall | IEC60068-2-32 |
| Vibration | IEC60068-2-6 |

Ordering Information

| | |
|---|---|
| EKI-2741F | Industrial Gigabit Ethernet to SFP Type Fiber Optic Converter |
| EKI-2741SX | Industrial Gigabit Ethernet to 1000Base-SX SC Type Fiber Optic Converter |
| EKI-2741LX | Industrial Gigabit Ethernet to 1000Base-LX SC Type Fiber Optic Converter |
| EKI-2741LXI | Industrial Gigabit Ethernet to 1000Base-LX SC Type Fiber Optic Converter, Wide Temp. |

ADVANTECH Industrial Ethernet Solutions

All product specifications are subject to change without notice

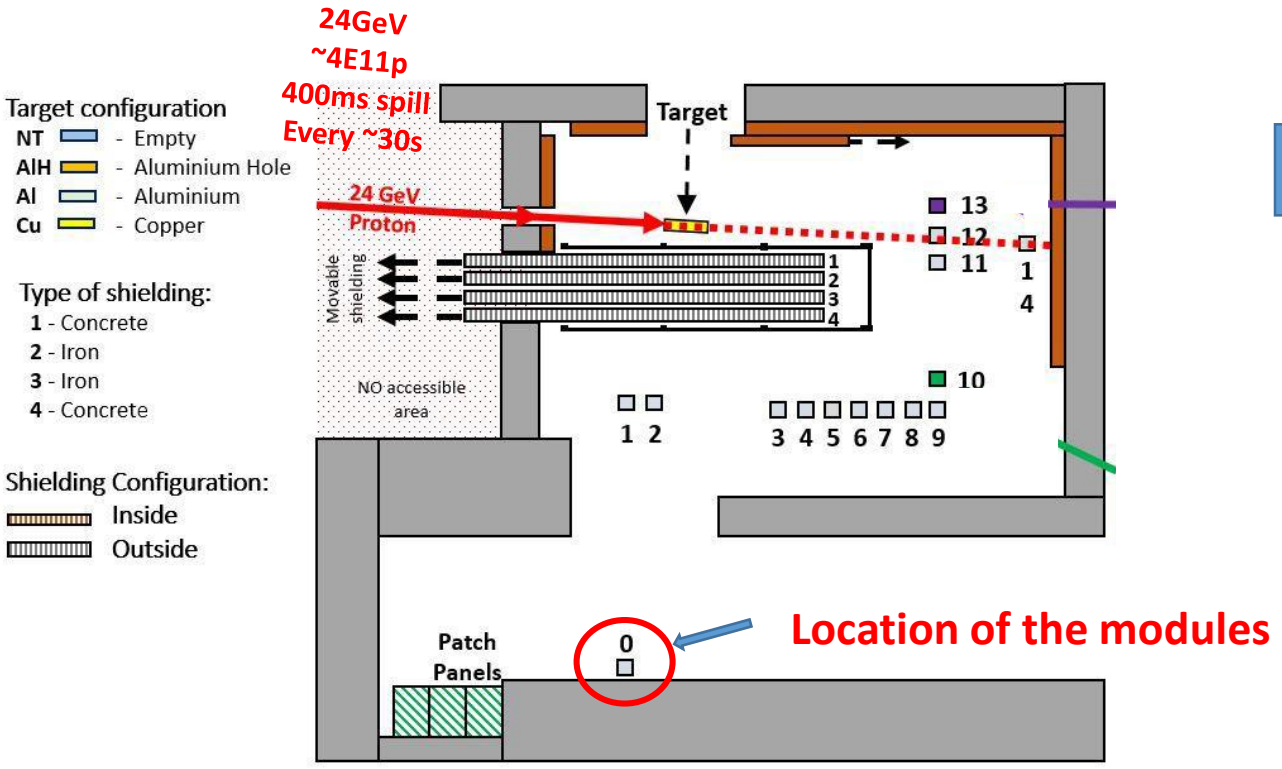
Last updated: 27-May-2008

# Tests at CHARM: introduction and setup (2)

Request:

- To reach approximately 50 Gy TID
- RUN1: from 08/08/2018 to 14/08/2018
- RUN2: from 16/08/2018 to 21/08/2018

**Configuration: CuOOOO**

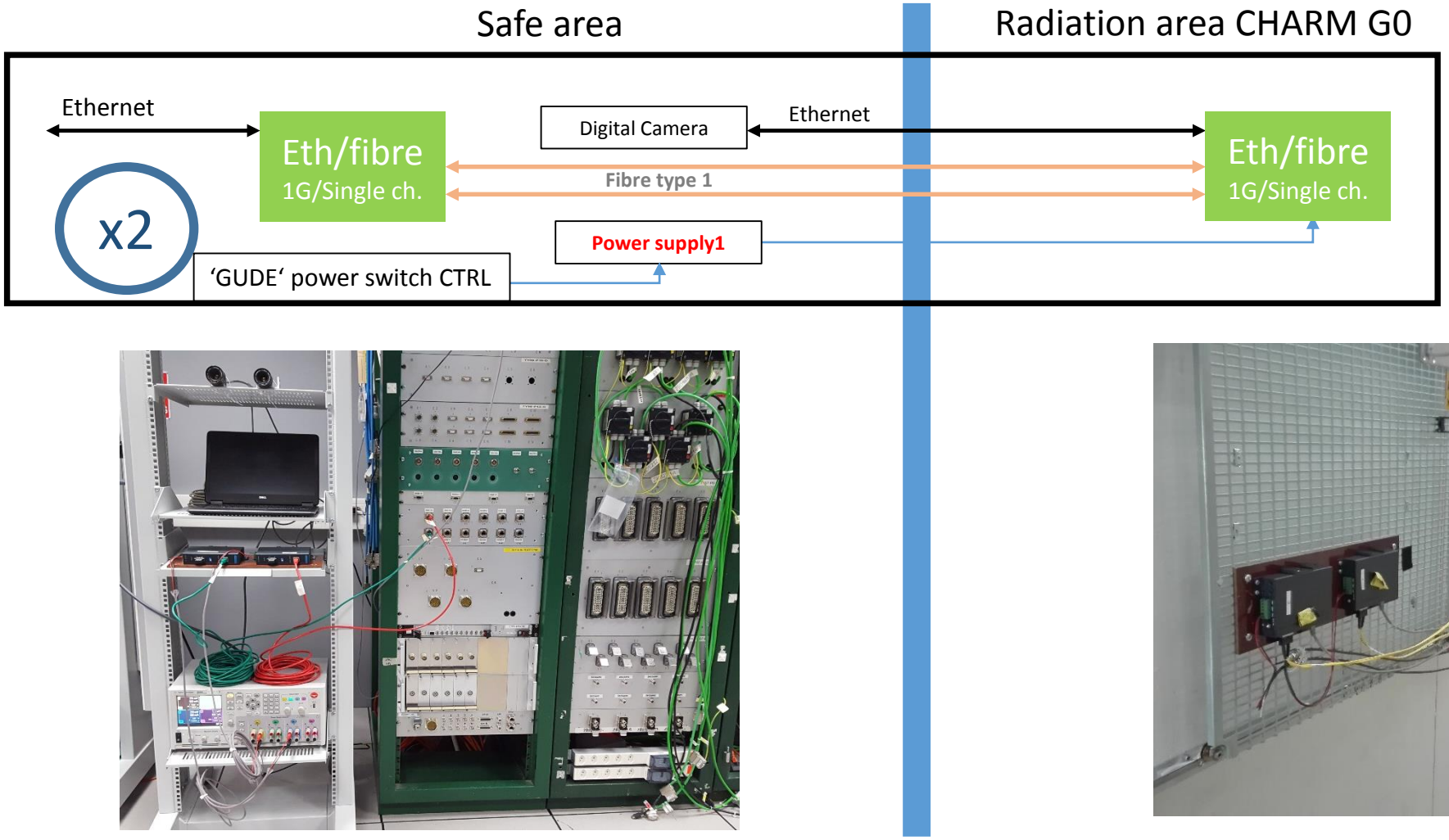



**Monitoring tool by CHARM**

- Extract dose/HEH/1MeV eq. fluence

# CHARM installation

## Layout for Ethernet/Fibre module irradiation test @ CHARM




*Summary of cables and fibres needed*

| Function | Desc. | Connector | Qty |
|---|---|---|---|
| Ethernet | | RJ-45 | 10 |
| Power Supply1 | +12V | 2 wires or coax | 2 |
| Fibre type1 | SC Single Mode | SC type fiber connector (EKI-2741SX/LX) | 2x2 |



# CHARM results (1)

Test procedure:

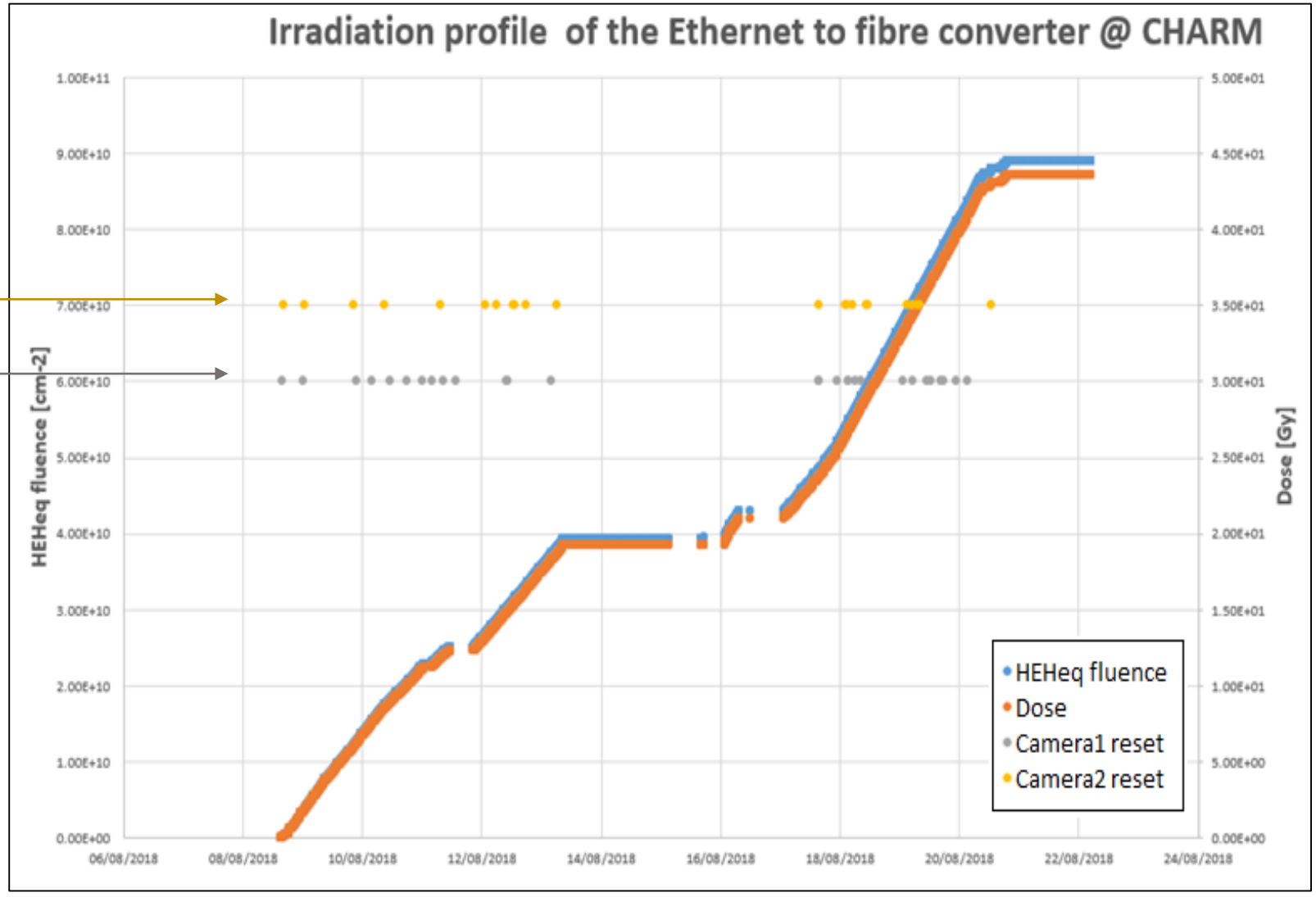
- Image acquisitions every minute
- Power cycles at each connection loss

Module2: 22 failures

Module1: 28 failures

Analysis:

- Logging cameras
- Logging GUDE power switch
- Checking connection failures



# CHARM results (2)

- Average impact on modules per spill:

| Parameter | Value |
|---|---|
| POT [#] | 4.64973 E+11 |
| Dose [Gy] | 6.71596 E-04 |
| 1 MeV Neutron eq. Fluence [$cm^{-2}$] | 1.629182257 E+07 |
| HEH eq. Fluence [$cm^{-2}$] | 1.372112079 E+06 |

**SETUP STILL WORKING AT THE END OF THE TWO RUNS**

- Results module power cycles:

| | *Module 1* | *Module 2* |
|---|---|---|
| *Reset number* | *28* | *22* |
| *HEHeq* | *8.91E+10* | *8.91E+10* |
| *$\sigma SEE$ [cm2]* | *3.14E-10* | *2.47E-10* |
| *Φfailure [cm-2]* | *3.18E+09* | *4.05E+09* |
| | | |
| *Φfailure Basler camera [cm-2]* | 1.5 E+09 | |

**OK!**

# Tests at IRMA: introduction and setup

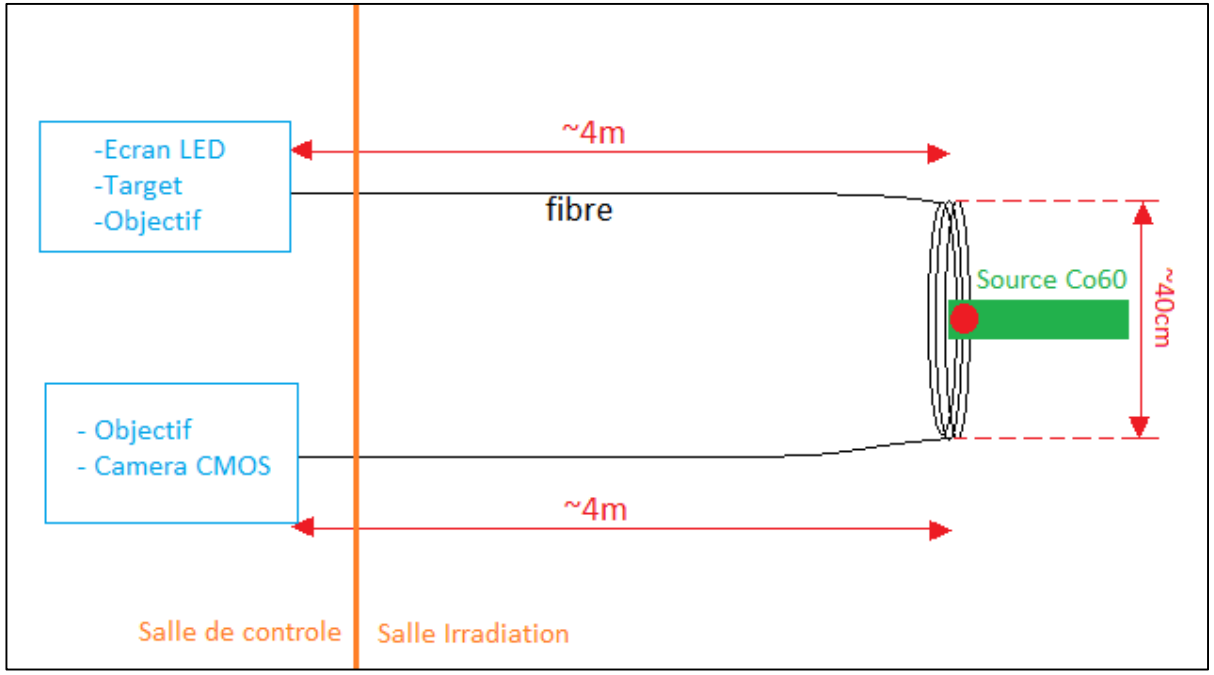
Simulating 10 years of operation of fiber bundle
Choice of gamma radiation
On-line results to monitor behaviour

↓

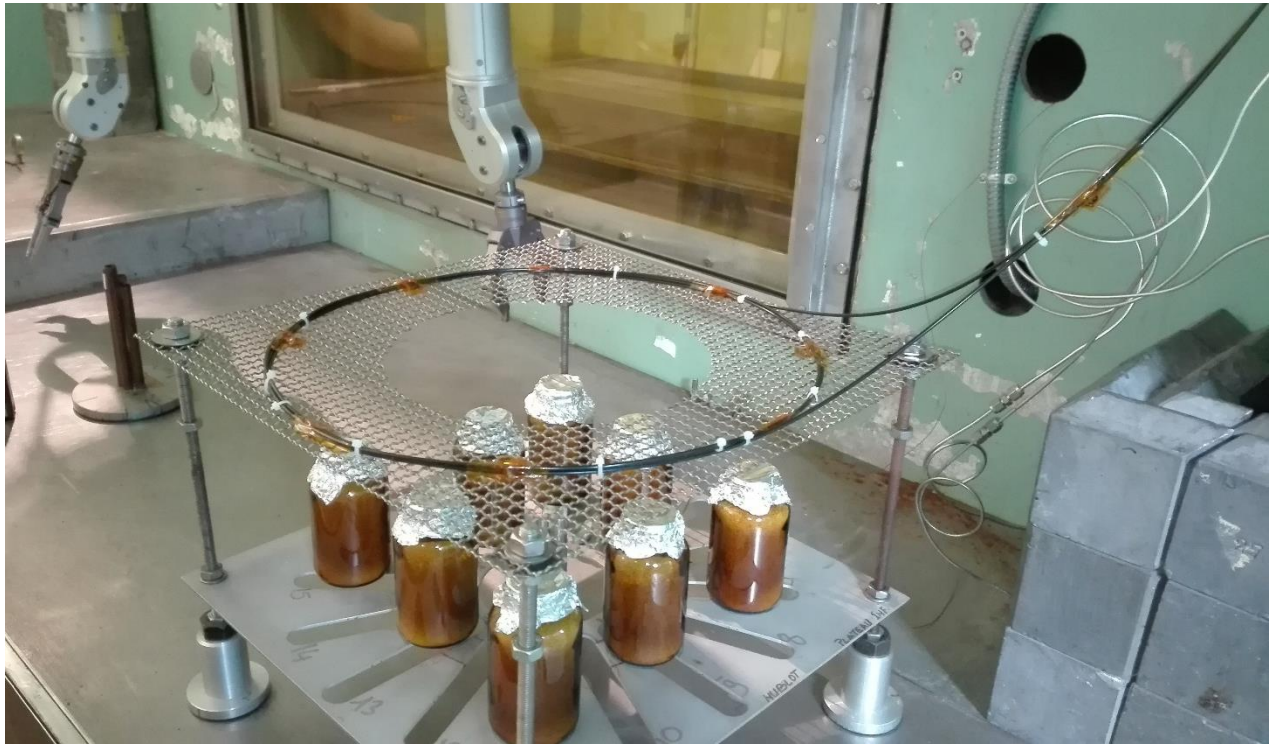
Isotropic $^{60}$Co source facility
Dose rate to reach at least 500 kGy total dose
Reasonable measurement time (days/month)
Reasonable cost

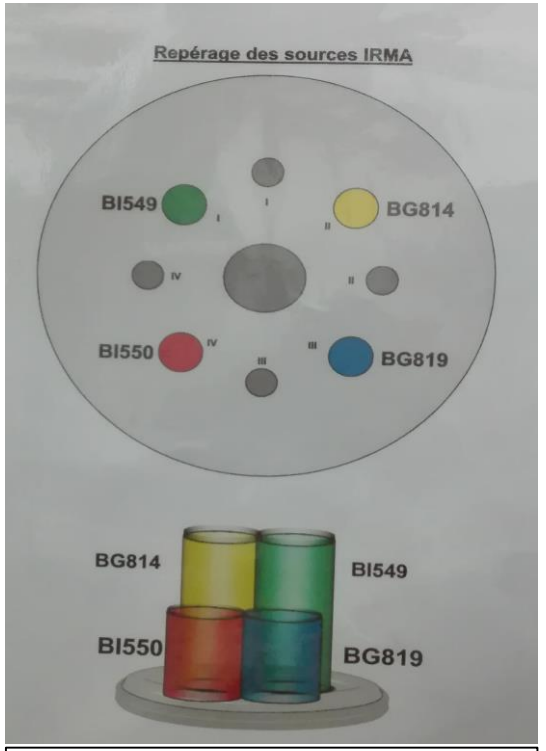
↓

IRMA facility at CEA Saclay



# IRMA introduction and setup (2)

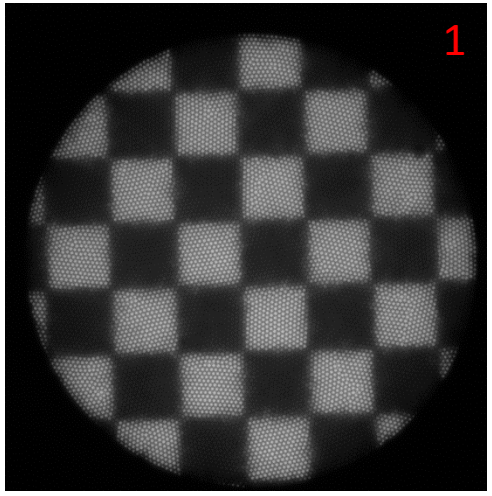


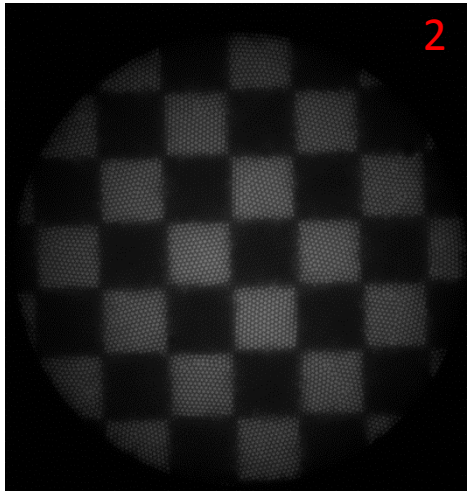


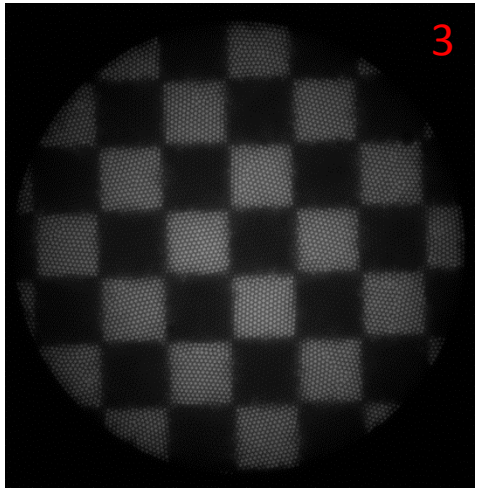

| Date/Time | Integrated Dose [Gy] |
|---|---|
| Start acquisition: 10/09/2018 14:41:03 | 0 |
| Start irradiation: 10/09/2018 15:14:05 | 0 |
| Stop irradiation: 18/09/2018 15:14:31 | 694.076 E+03 |
| Stop Acquisition: 19/09/2018 14:36:25 | 694.076 E+03 |

- Dose Rate = 3.6kGy/h
- Irradiation Time = 8 d
- Relaxation time = 1 d
- Acq. Image delay = 15’
- Temperature = 24-27 °C

# IRMA results

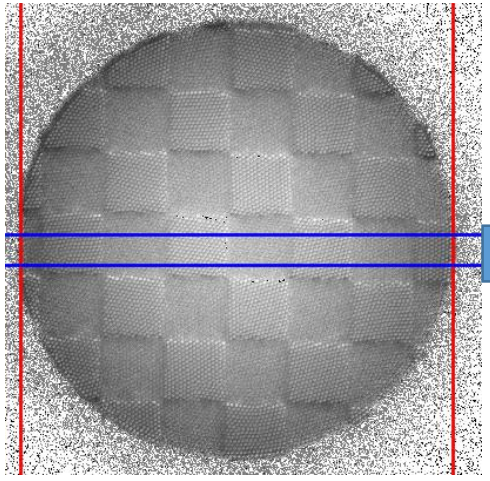


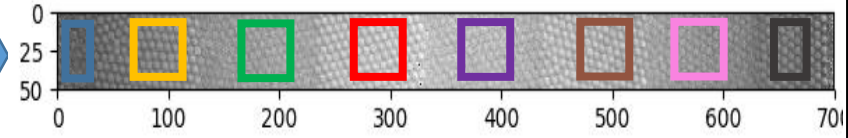



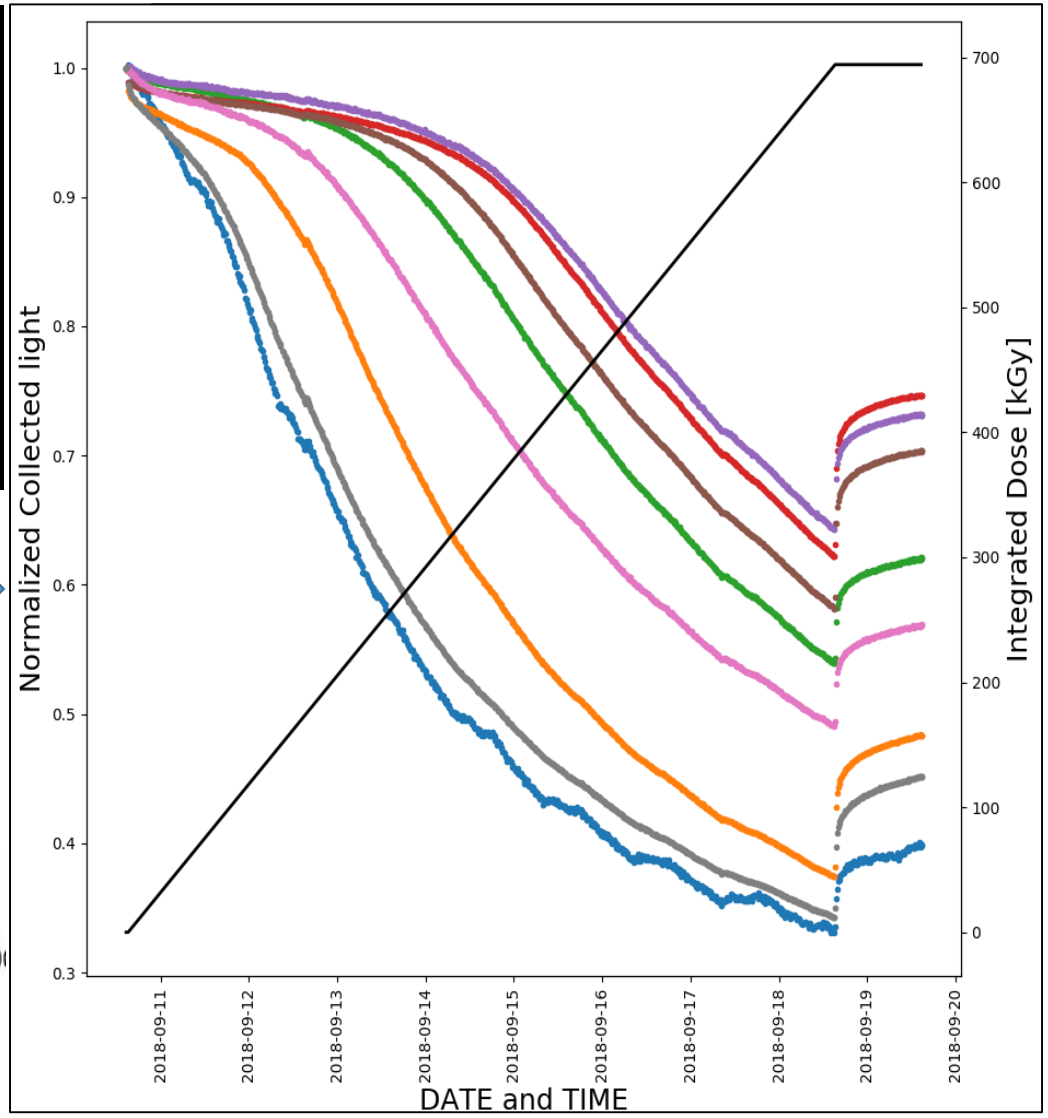




Before Irradiation (0 Gy) After Irradiation (700 kGy) After relaxation (700 kGy)

NORMALIZATION





# Conclusions

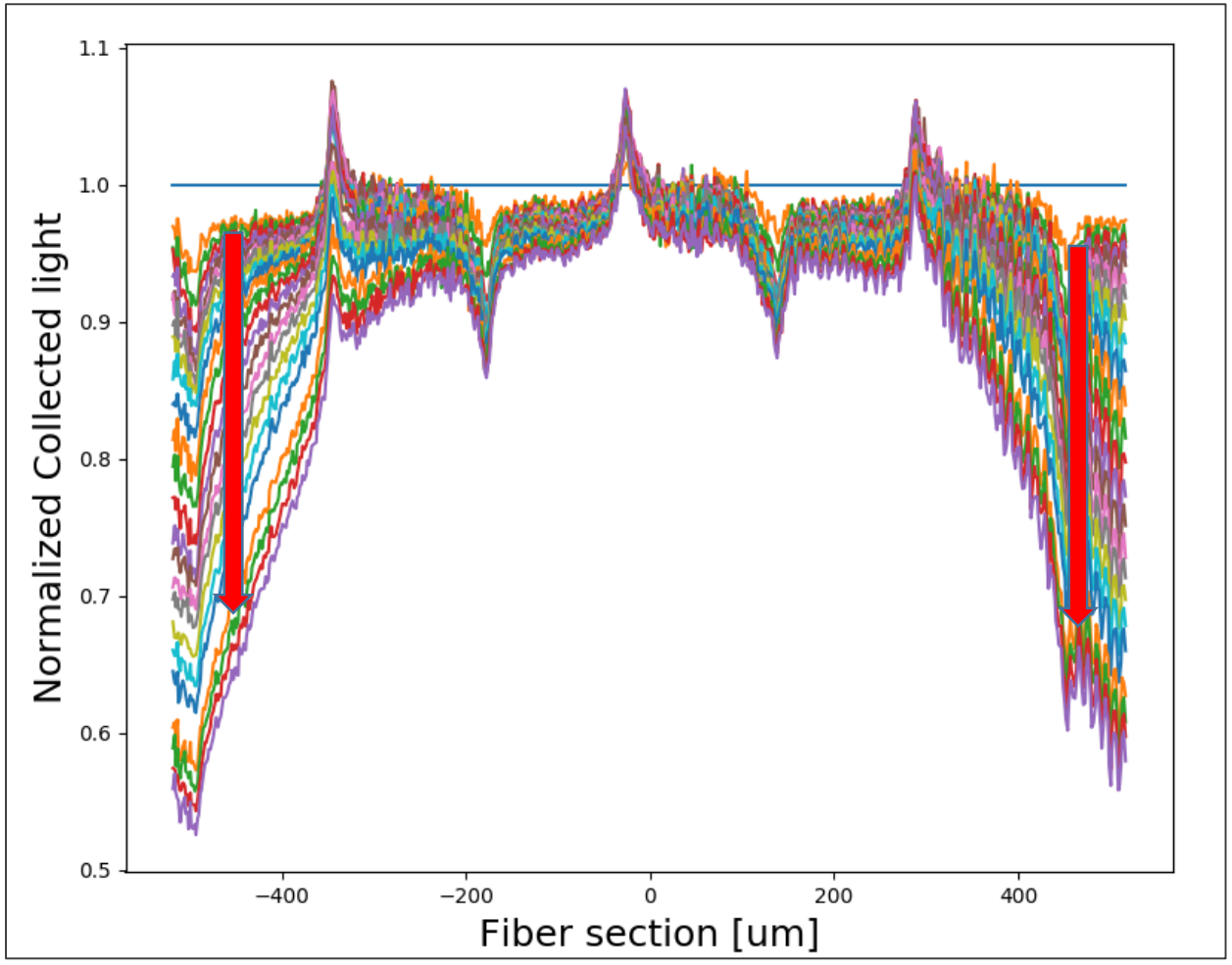
Ethernet to fiber radiation hardness test:

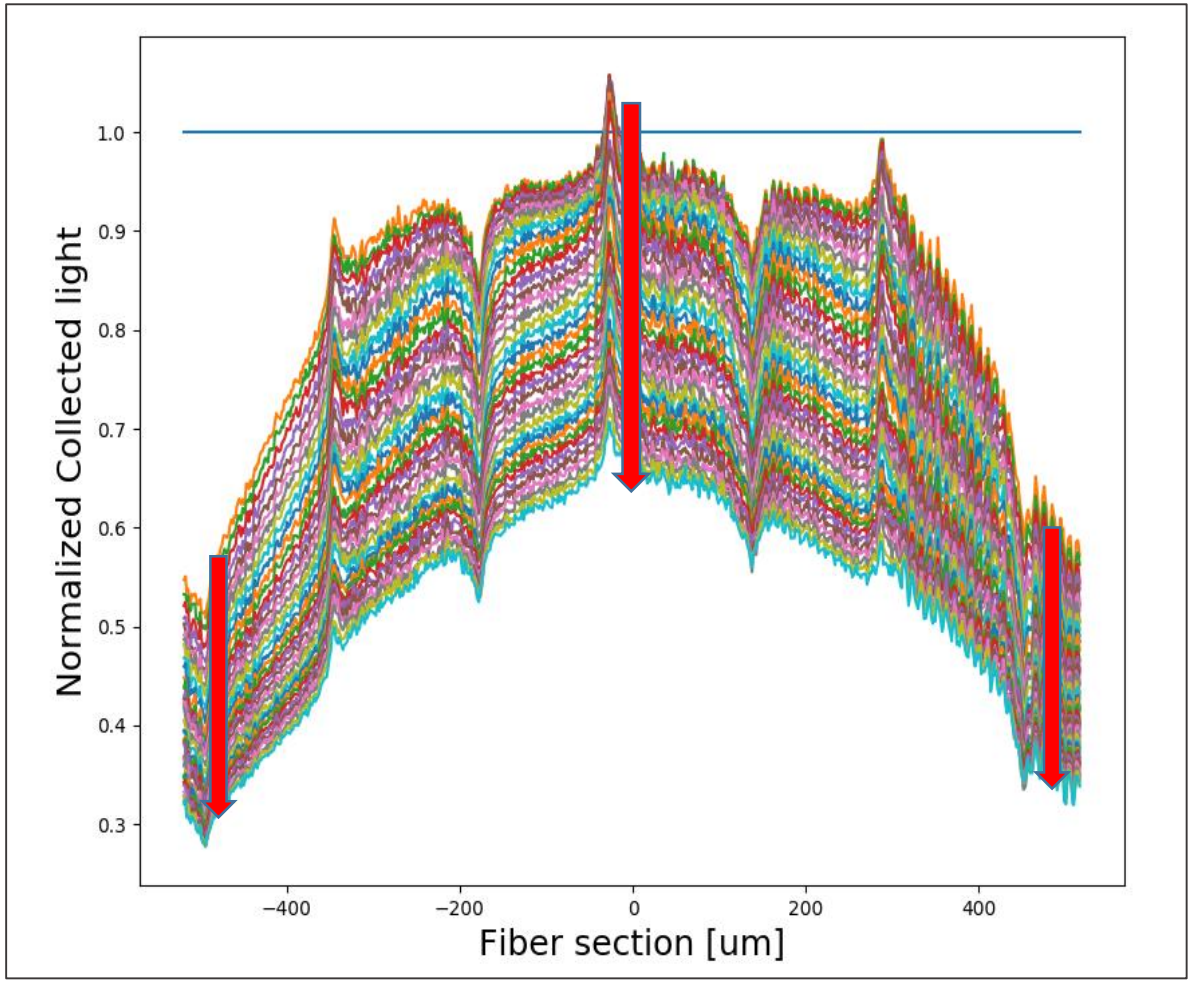
- Single events can stop camera acquisitions
- Power cycles reset correctly the system
- System keeps working up to 45 Gy TID
- Shielding for ETH to fiber converters foreseen
- Failure cross section lower than cameras -> Non limiting factor

Fiber bundle radiation hardness test:

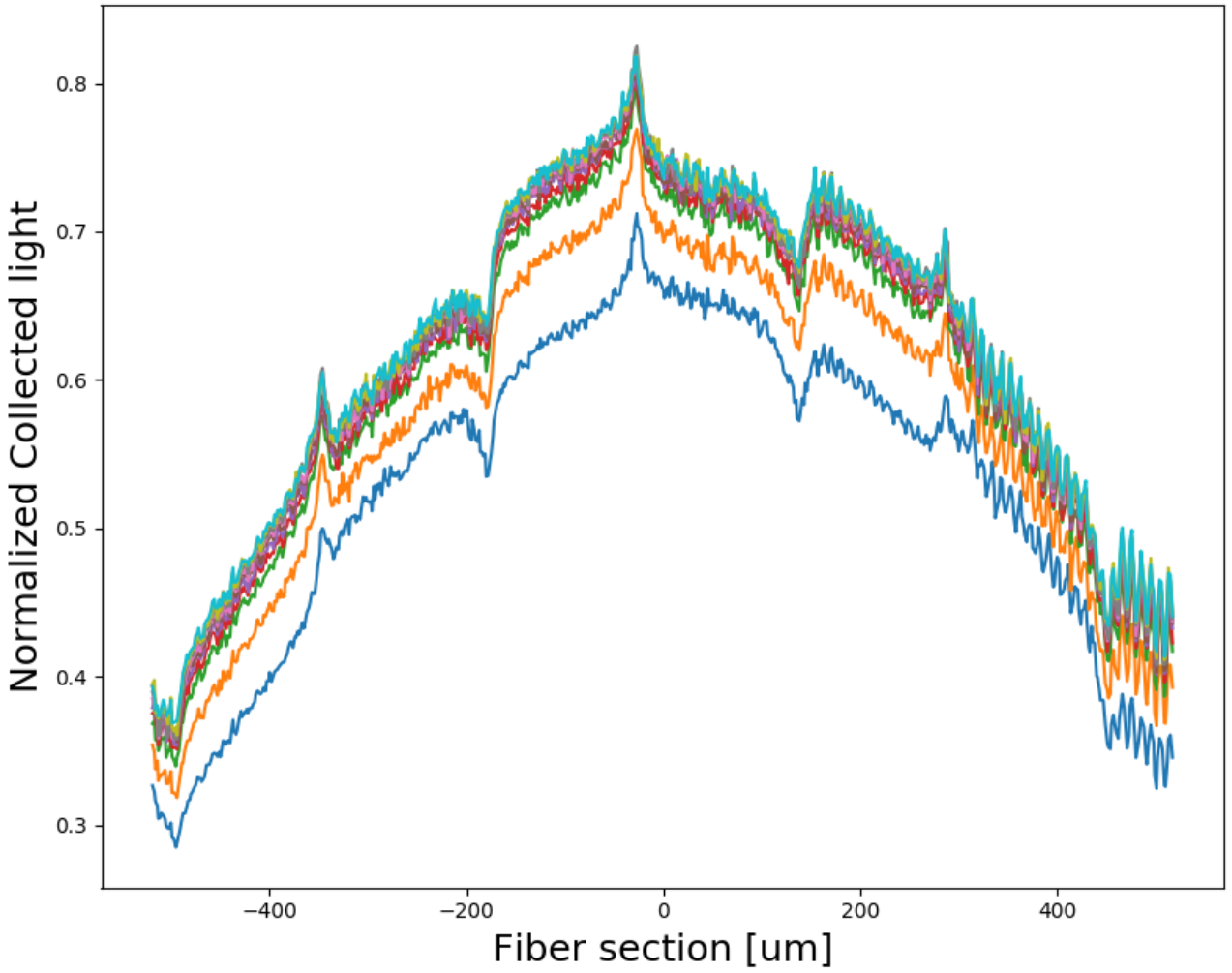
- 700 kGy TID reached in 8 days
- Integrated light loss around 50%
- Non-uniform light loss -> to be investigated
- Temperature effects
- Still able to reconstruct a qualitative image

# IRMA results (2)

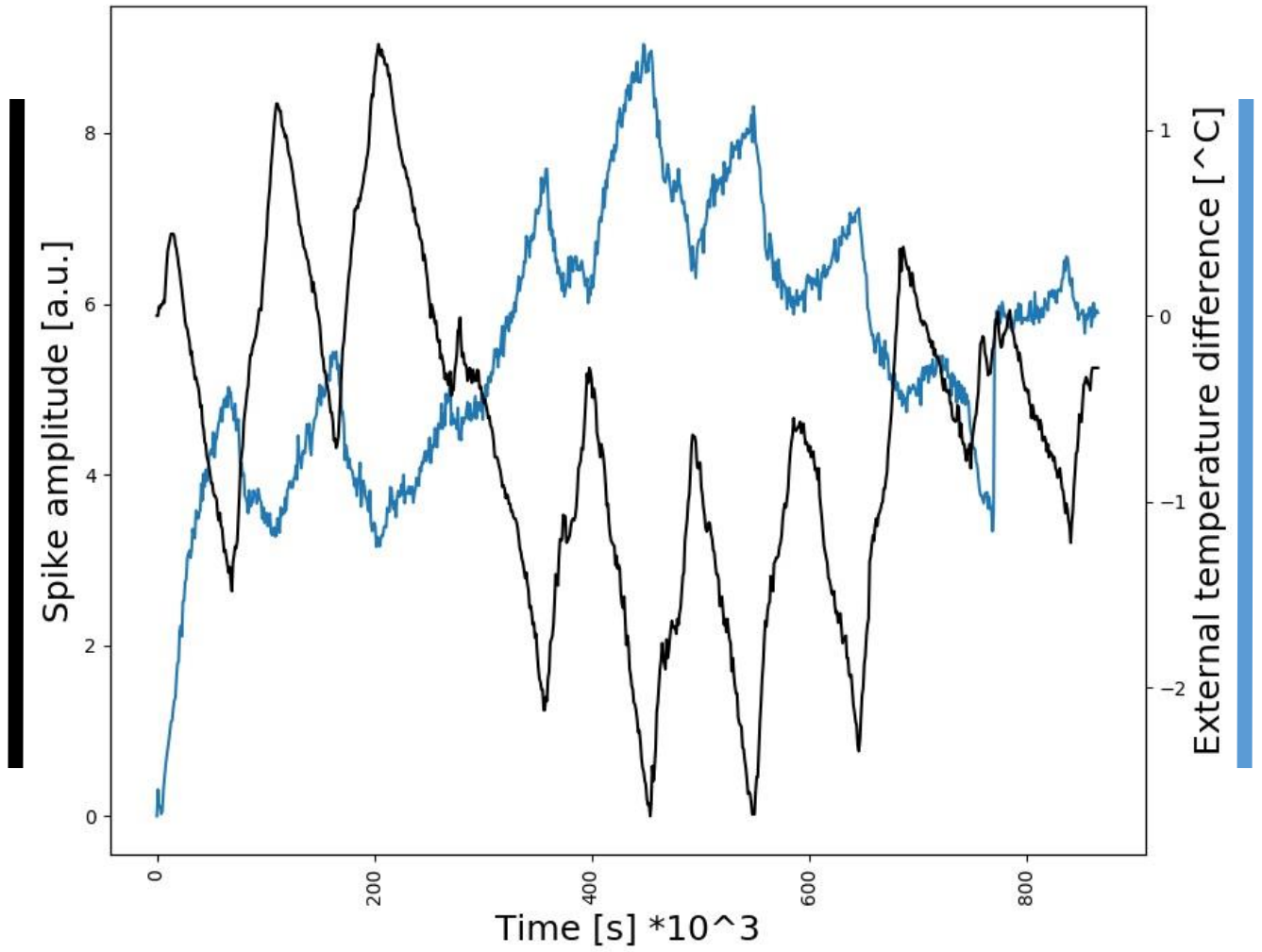


# Relaxation time profiles



# Spikes vs Temperature



# Temperature corrected profiles