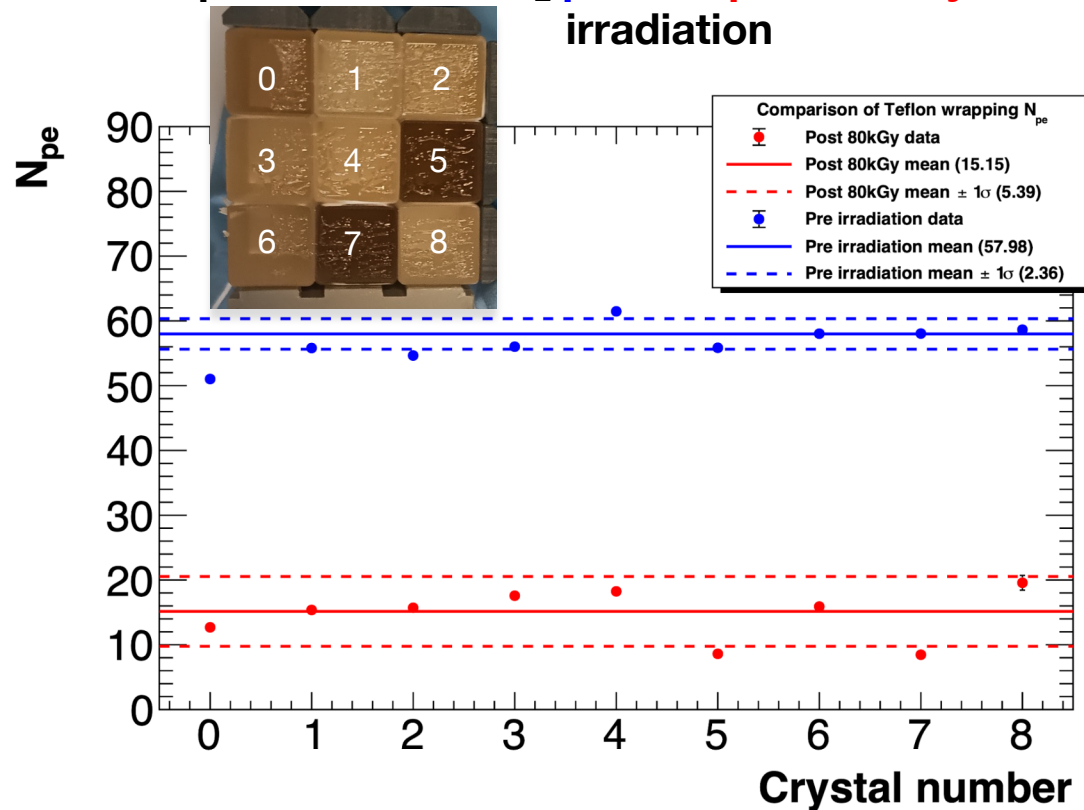


# Beam test @ BTF: crystals

- Two different wrappings tested, Teflon and Mylar
- LY loss evaluated through variation in charge and number of photo-electrons

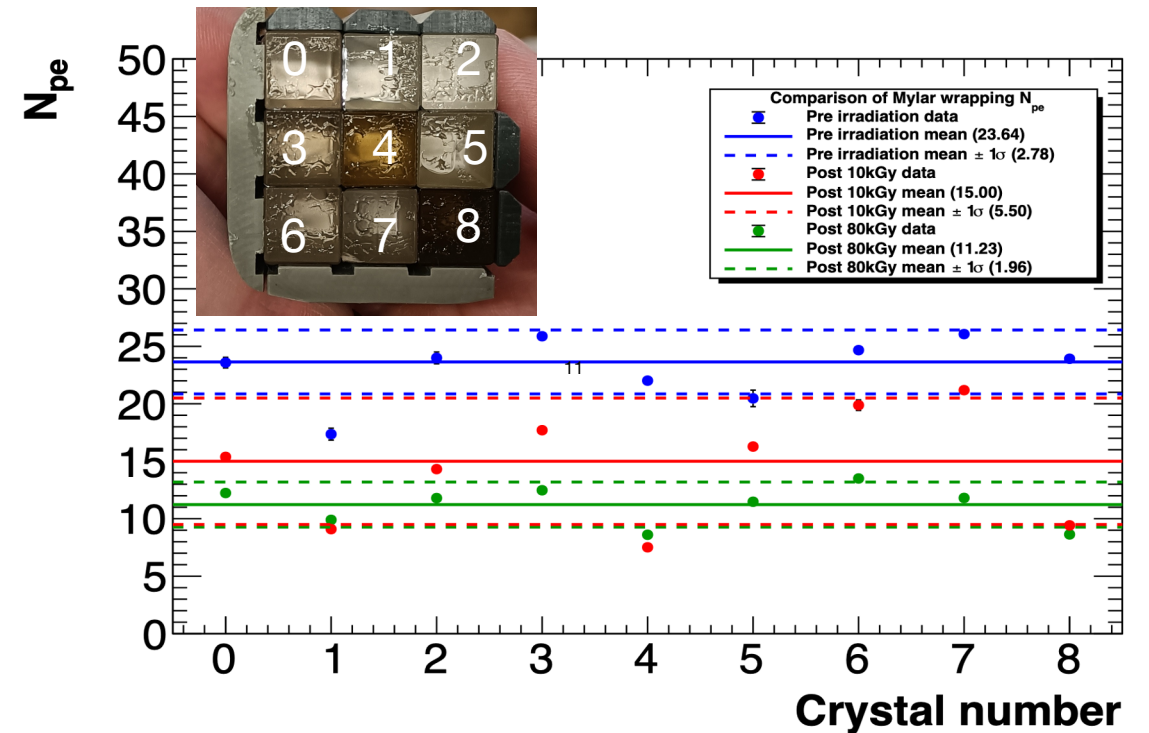
## Teflon wrapping

N<sub>pe</sub> values of PbF<sub>2</sub> pre and post 80 kGy irradiation



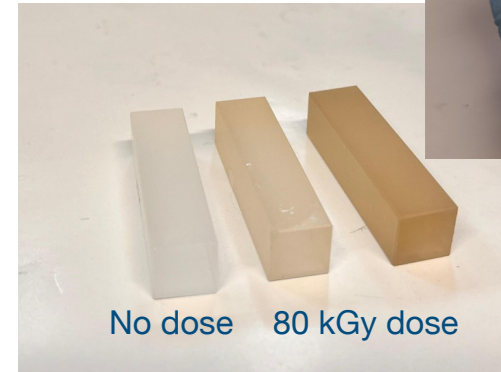
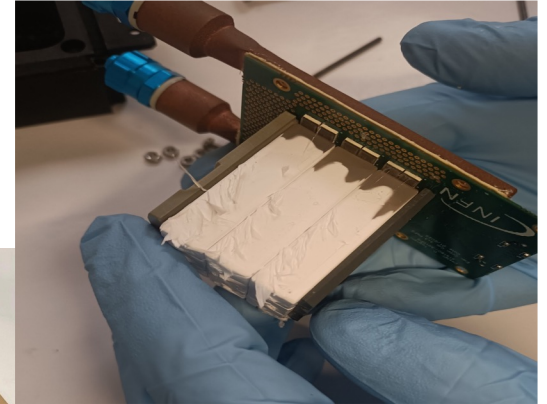
## Mylar wrapping

N<sub>pe</sub> values of PbF<sub>2</sub> pre, after 10 kGy and after 80 kGy irradiation

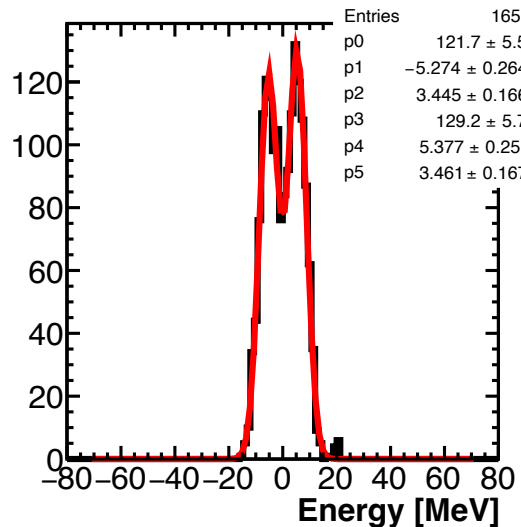


# Beam test @ BTF: considerations

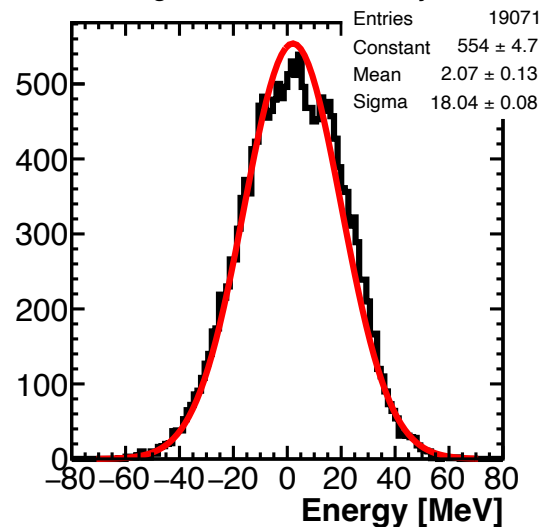
- Considerable variability in the crystals' response to radiation, despite SICCAS claiming the use of high-purity (>99.9%)  $\text{PbF}_2$  powder for crystal growth
- Crystals evident loss of transparency
- Transparency loss was uniform length-wise in the crystals
- Teflon was damaged and brittle
- SiPM pedestal increases significantly with the absorbed dose
- **New test planned to evaluate SiPMs PDE loss and optical grease degradation**



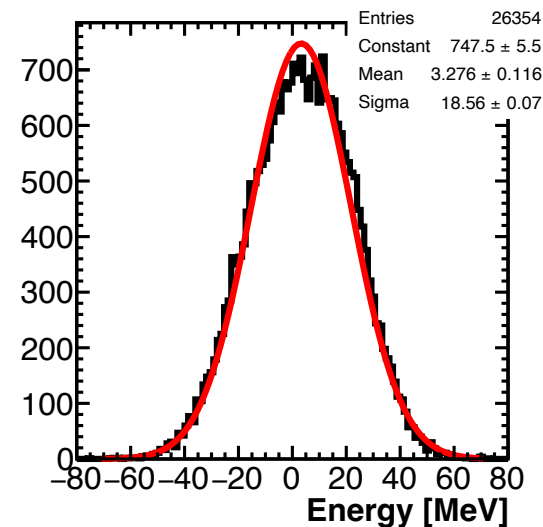
Pedestal charge distribution for no dose



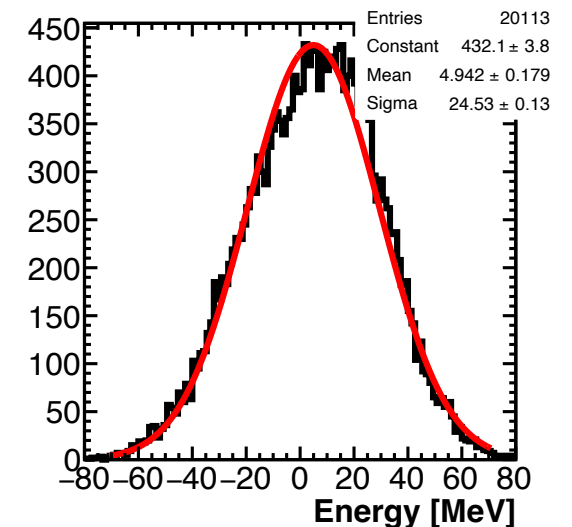
Pedestal charge distribution for 80kGy total dose



Pedestal charge distribution for 90kGy total dose



Pedestal energy distribution for 160kGy total dose



# Summary 2023 - 2024

- **Time resolution:**  $< 40$  ps for single crystals, for  $E_{\text{dep}} > 1$  GeV
- **Radiation resistance:**  $\text{PbF}_2$ (PWO-UF) robust to  $> 35(200)$  Mrad and SiPMs validated up to  $10^{14}$   $n_{1\text{MeV}}/\text{cm}^2$  displacement-damage eq. fluence



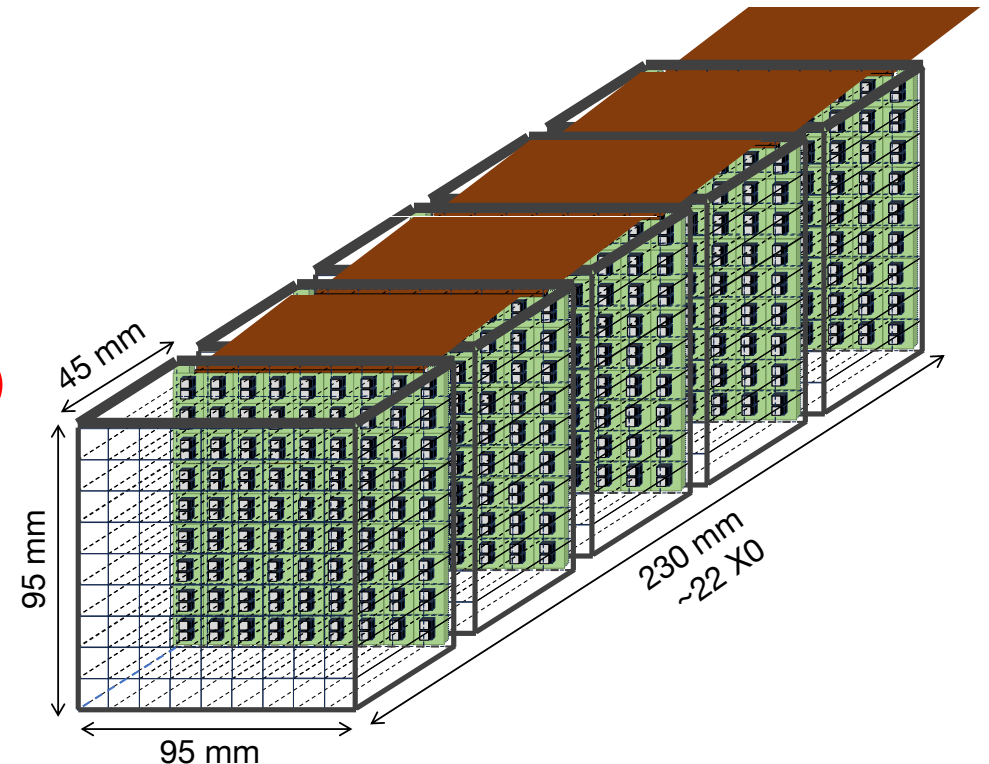
- Use  $\text{PbWO}_4$ -UF or  $\text{LYSO}$  in the first calorimeter layer.
- Conduct new irradiation tests and monitor Cherenkov light variations with a blue laser.
- Simultaneously test crystals with SiPMs and SiPMs alone.

## Next steps (2024 - 2025)

- We submitted and won an Italian grant for the project CALORHINO: *An innovative radiation-hard calorimeter proposal for a future Muon Collider Experiment.*
  - funds assigned for the development of a  $5 \times 5 \times 4$ (layers) Crilin prototype:  $1 M_R - 16.8 X_0$

## DRD6-WP3 from 2025

- Expanding upon the PRIN prototype to a  $9 \times 9 \times 5$ (layers) configuration, with a target of  $2 M_R - 22 X_0$ .



# Crilin Module Prototype

## 9x9 crystals/layer – 5 layers

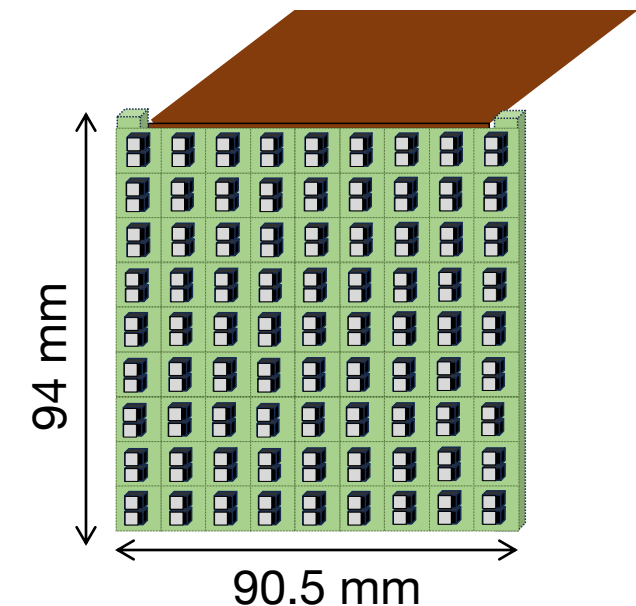
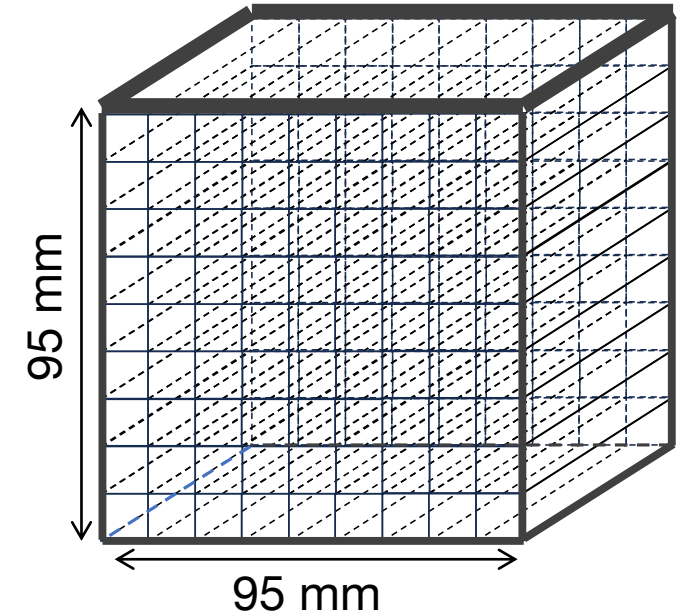
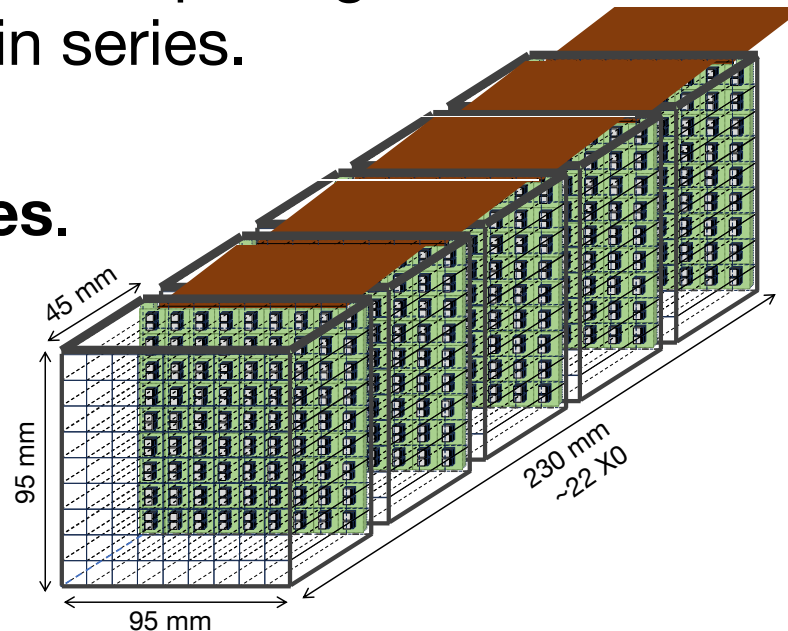
### 1. Aluminum matrix to hold the crystals:

1. 50-100  $\mu\text{m}$  thickness between crystals
2. Thicker ( $\sim 2\text{mm}$ ) in the external envelope with microchannels for cooling

### 2. Kapton strip for polarization and output signal:

1. Handles polarization and output signals for each channel of two SiPMs in series.

### 3. Connectors at the back of the 5 assembled modules.



PRIN - Abbiamo fondi per:

- Riempire gli 81x5 cristalli e 81x2x5 SiPM
- Elettronica per 100 canali 5x5 cristalli per layer

ELETTRONICA (soluzione PRIN)

1. Mezzanine per fornire Vbias ai SiPM (un bias ogni 9 SiPM), amplificazione veloce a  $\sim 1$ m dal calorimetro
2. Abbiamo bisogno di una risoluzione temporale  $<50$  ps e di una risoluzione sulla carica  $<1\%$
3. Ogni mezzanina contiene 3 moduli da 9 canali  $\rightarrow$  tot. 27 canali a mezzanine  $\rightarrow$  tot. 4 mezzanine  **$\sim 15$ keur**
4. 2 board di flash adc CAEN v2745 (4 Vpp – 125 Ms/s) + un canale fast ogni 9 per timing con flash adc CAEN v1742 (2 Vpp – 5 Gs/s)  **$\sim 35$ keur**

# Preventivi 2025

- Adattare un asic esistente per fare timing con ToT + ADC lento per la carica. Con un asic si potrebbero leggere i ~400 canali del prototipo senza sovraccarico di flash adc.
  - Proposta di uno studio di fattibilità dell'applicazione di un asic ed eventuale realizzazione della board di interfaccia.
  - 10-15k su Torino e 5k su LNF.
- Test ad Enea Casaccia di cristalli + SiPM e SiPM soli per scorporare le dipendenze del danno da radiazione. Test in presa dati diretta al crescere della dose con laser blu.
- Poche spese non coperte dal PRIN necessarie per la realizzazione e test della matrice.

cognome	nome	contratto	profilo	aff	perc
<b>Cantone</b>	Claudio	Dipendente	Tecnologo	5	20%
<b>Cemmi</b>	Alessia	Associato	Scientifica Dipendenti altri enti	1	25%
<b>Ciccarella</b>	Vittoria		Borsista	1	100%
<b>Colao</b>	Francesco	Associato	Scientifica Dipendenti altri enti	1	20%
<b>Di Sarcina</b>	Ilaria	Associato	Scientifica Dipendenti altri enti	1	25%
<b>Gianotti</b>	Paola	Dipendente	Dirigente di Ricerca	1	20%
<b>Happacher</b>	Fabio	Dipendente	Primo Ricercatore	1	10%
<b>Li Voti</b>	Roberto	Associato	Professori Università	1	30%
<b>Sarra</b>	Ivano	Dipendente	Tecnologo	1	40%
<b>Scifo</b>	Jessica	Associato	Scientifica Dipendenti altri enti	1	25%
<b>Soleti</b>	Stefano Roberto	Associato	Scientifica Enti stranieri	1	50%
<b>Verna</b>	Adriano	Associato	Scientifica Dipendenti altri enti	1	25%

RICHIESTE 2025		keuro	SJ
Consumi	Test irraggiamento con laser blu cristallo+SiPM e SiPM da solo a Casaccia fino a 80kGy	3.5	
	Scheda interfaccia mezzanine con board con asic TOPHIR2	5	
	Cavi interfaccia tra connettori sul kapton e mezzanine (x125 canali)	3	
Inventariabile	Modulo caen A5818 controllo digitizer		4.5
Missioni	Metabolismo 3.9 FTE	20	
	Test beam CRILIN al CERN ed attività correlate di integrazione		10
	Conferenze e riunioni in preparazione prossima Strategy	5	

DRD6 Tak3  
350 chs to acquire with respect  
PRIN expectation of 100 chs

RICHIESTE DRD Crilin		keuro
Consumi	Mezzanine boards	40
Inventariabile	Moduli CAEN V2745 64ch x 4board	80

**Institute 1 : INFN-LNF, Frascati (Italy)**

**Institute 2 : INFN-Padova, Padova (Italy)**

**Institute 3 : INFN-Torino, Torino (Italy)**

**Institute 4 : INFN-Trieste, Trieste (Italy)**

**Institute 5 : HZDR, Dresden (Germany)**

**Institute 6 : DIPIC, San Sebastián (Spain)**