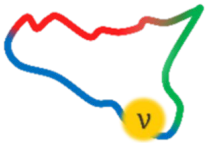
UNIVERSITÀ DI PAVIA

CUPID

INFN
Istituto Nazionale di Fisica Nucleare

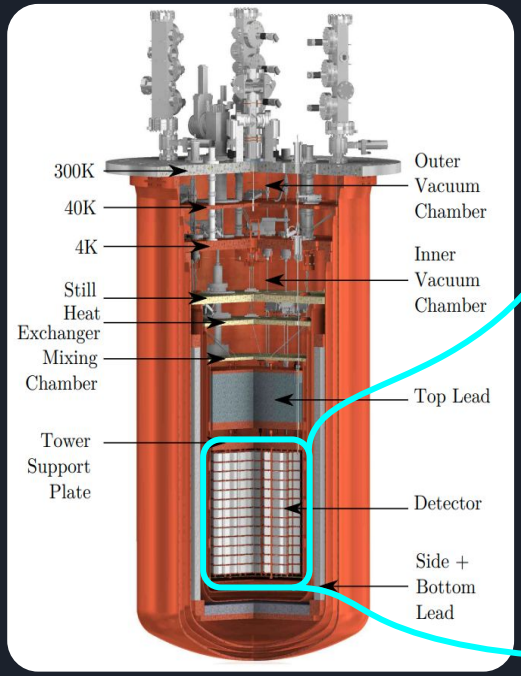
Optical Injection System feasibility study for CUPID

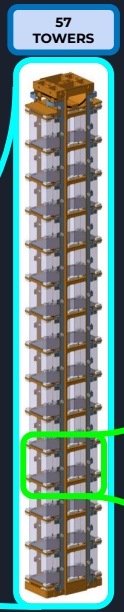
MANENTI Nicola
on behalf of the Pavia group

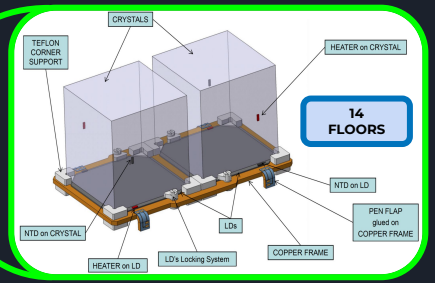


MAYORANA School
Modica - 23.06.2025

The CUPID experiment

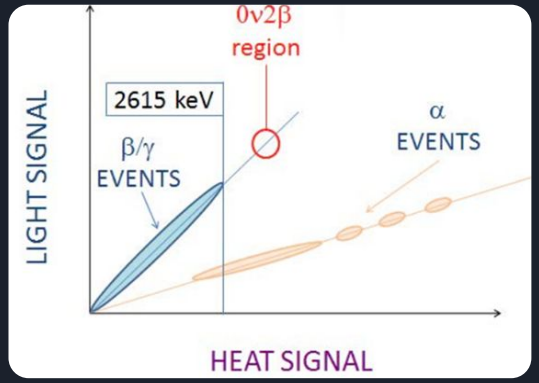






CUORE **U**pgraded with **P**article **ID**entification searches for the $0\nu\beta\beta$ decay of ^{100}Mo ($Q_{\beta\beta}$ = 3034 keV)

- Underground experiment (LNGS, Italy)
- Cryogenic bolometers
- Double readout approach (Light Yield Discrimination)



The CUPID experiment

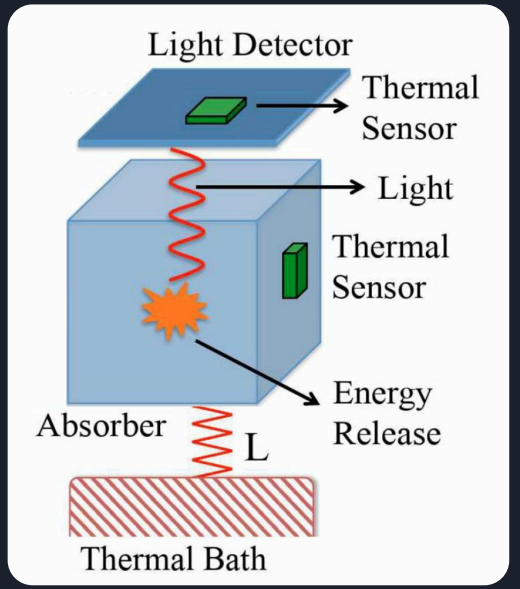
Double Readout

Heat Channel

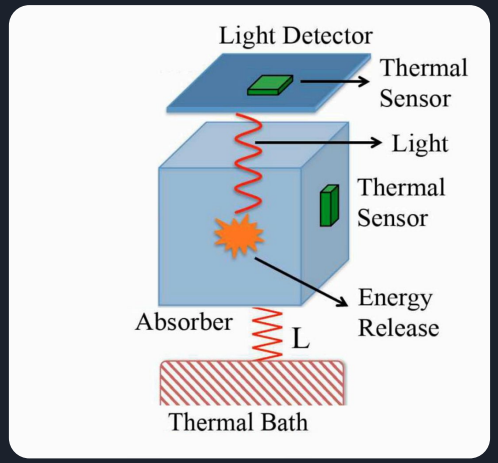
- Li_2MoO_4 Scintillating Crystals
- Ge-NTD thermistors

Light Channel

- Ge-Wafer
- Ge-NTD thermistors
- Neganov Trofimov Luke (NTL) Amplification



The CUPID experiment



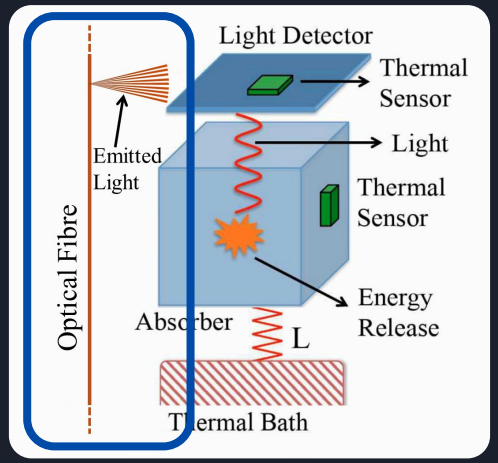
CHALLENGES

- Pile-up efficiency monitoring
- LD periodic regeneration
- LD stabilisation

\+

? LD calibration with photon statistics

The CUPID experiment



OUTSIDE THE CRYOSTAT

- **light source**
- **optical fibre with feedthrough**
- **emitting fibre**

TO BOLOMETERS

Several challenges, one solution

Optical Injection System (OIS)

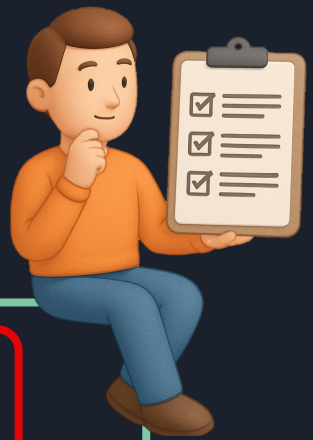
A system capable to inject light pulses of a given wavelength to be absorbed by a group of LDs.

Optical Injection System

What is the ideal setup ?

Which light source to use ?

How to control it ?



Requirements

- ➤ Multichannel
- ➤ Negligible impact on cryogenics
- ➤ Contribution to the background budget as small as possible
- ➤ Wavelength
- ➤ Stable pulses
- ➤ Pulse width
- ➤ DAQ interface

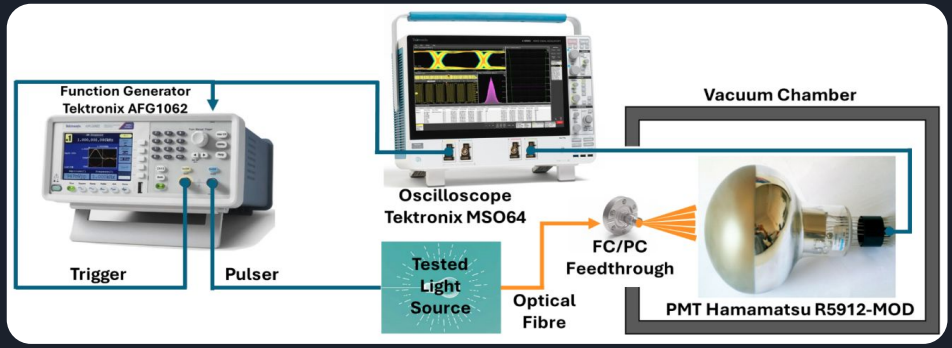
NOW
Feasibility Test in Pavia

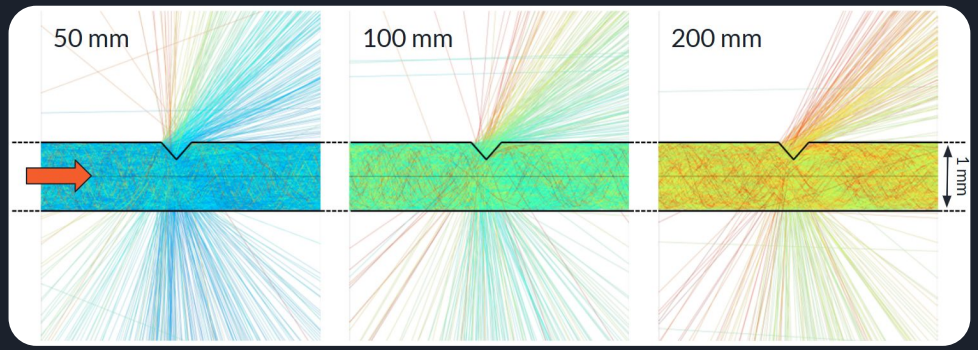
NEXT
Validation Test at LNGS

OIS - Pavia

Measures with a simple system ...

... for both requirements and applications.

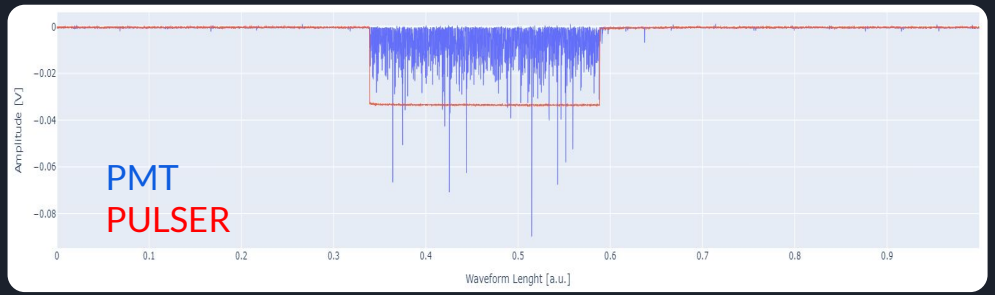




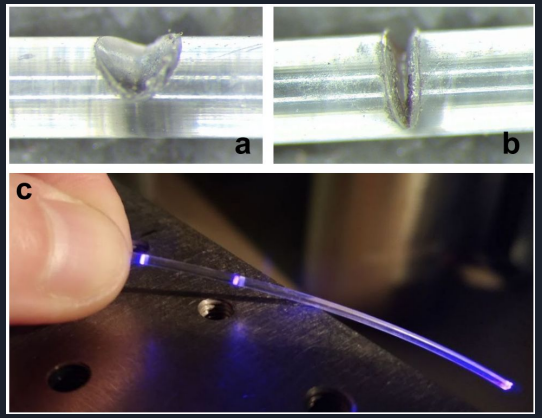
Simulations with COMSOL Multiphysics ...

... for the requirements.

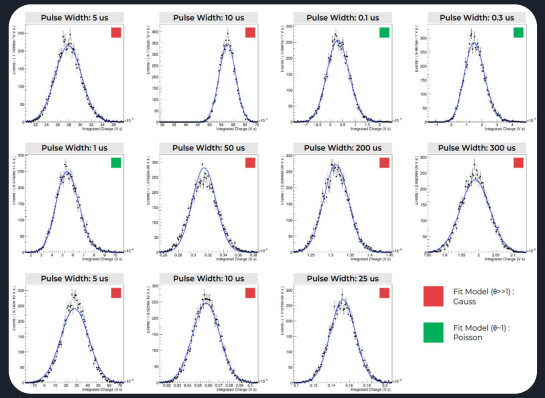
OIS - Pavia



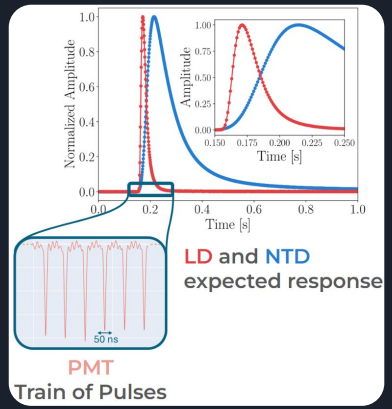
Required Power



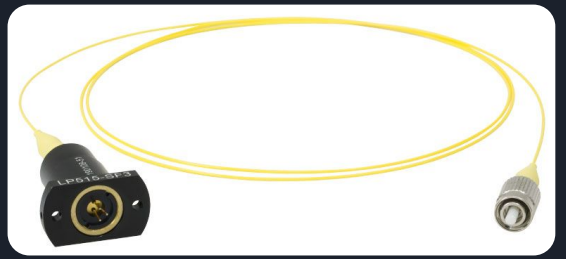
Photon statistics



Pulse Generation



Light Source



Thank you for your time

Photon-statistics

Source emitting photons of fixed energy (ϵ)

The N-photons collected by my detector follow a Poisson distribution

From my measurable quantity $\mathcal{X}$, I can evaluate the calibration parameter (g)

➤ absolute energy calibration achieved !

By simply fitting $V_{\mathcal{X}}$ vs. $\mu_{\mathcal{X}}$ it is not possible to resolve the two terms in $V_{\mathcal{X}}$ linear to N

➤ we are overestimating g

ALTERNATIVE combined fit of the distributions

$$\mu_x = \epsilon\, g N$$

$$V_x = V_0 + (\epsilon g)^2 N + V_{1ph} N$$

Noise

Poisson

Single Photon Response ($\propto g$)