

LIDINE 2025

A Compact Optical Liquid Argon Facility at Roma Tre

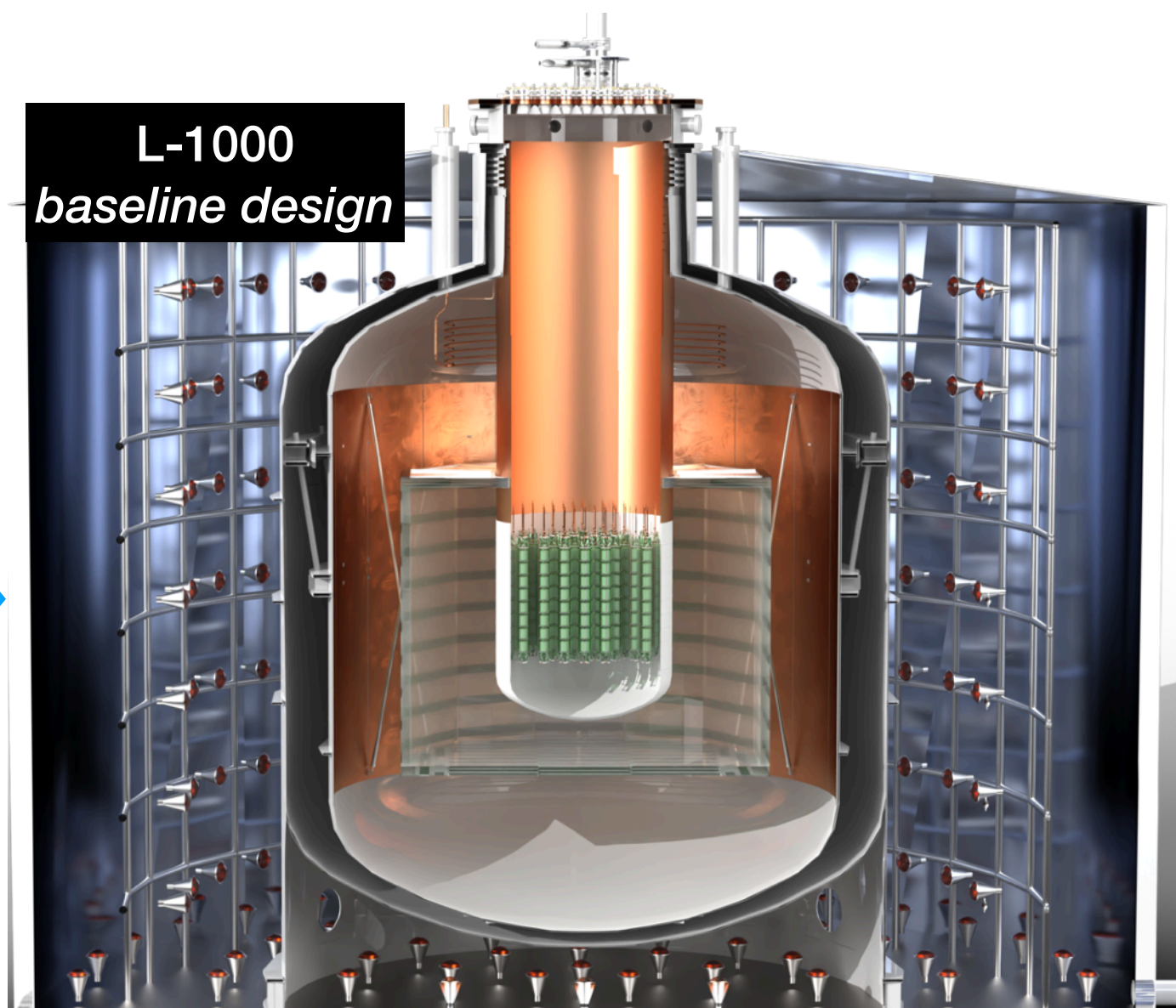
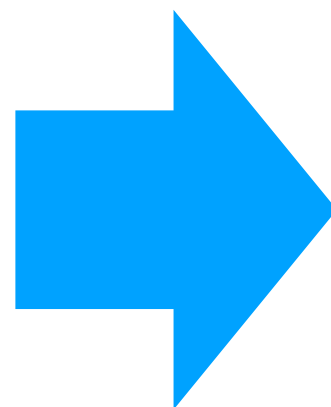
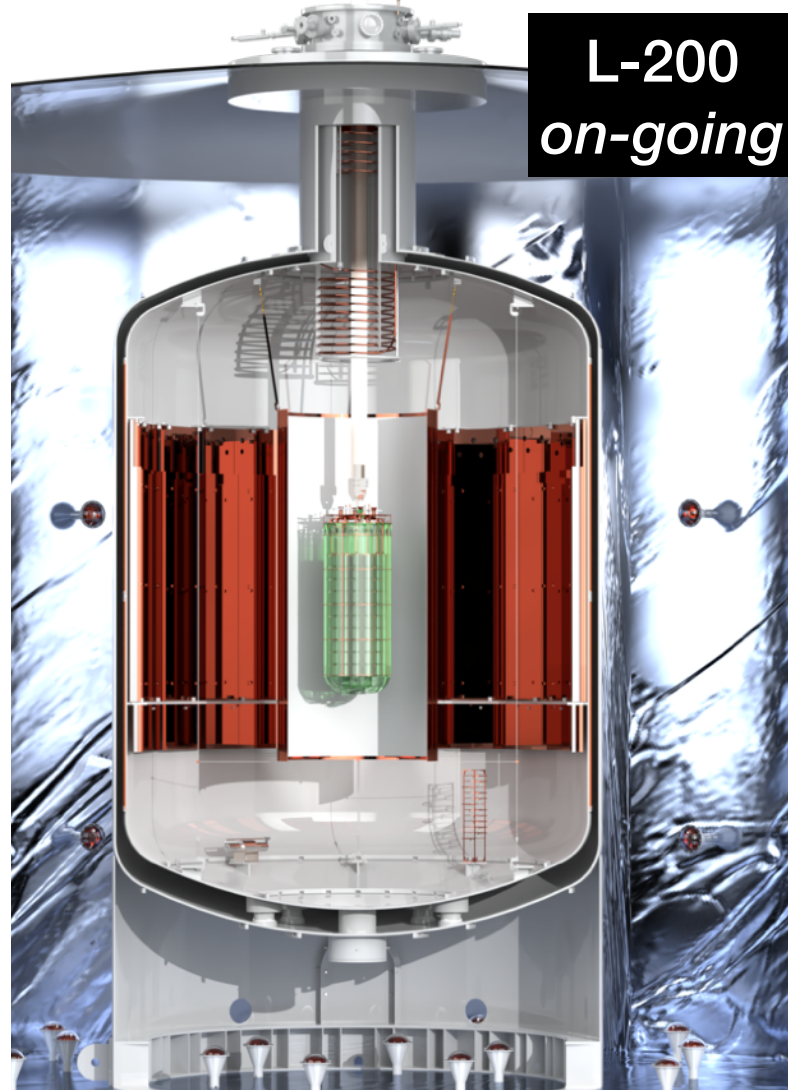
Valerio D'Andrea¹, Giuseppe Salamanna^{1,2},
Hexi SHI (Kaku)^{1,2}, Diego Tagnani^{1,2}

1. Istituto Nazionale di Fisica Nucleare, Sez. RomaTre

2. Università degli Studi Roma Tre

23.10.2025
HongKong

OLAF for LEGEND-1000



- L-200 operating since 2022;
- up to 200 kg Ge;
- **LAr as active shielding**

- L-1000 baseline design ready;
- ~1000 kg Ge;
- **LAr as active shielding**

OLAF

explore/qualify readout solutions for large assembly
improve understanding of LAr as scintillation detector

LEGEND LAr talks:
Lucia Canonica
Luigi Pertoldi
Rosanna Deckert

OLAF

Optical **L**iquid **A**rgon **F**acility

setup at Roma3 featuring:

LAr: Ar 6.0 gas liquefied by LN₂

LAr scinti. photon by SiPM(VUV)

OLAF

Optical Liquid Argon Facility

benchmark/test:

LAr - SiPM - Front End - Trigger - DAQ
readout chain for Legend-1000

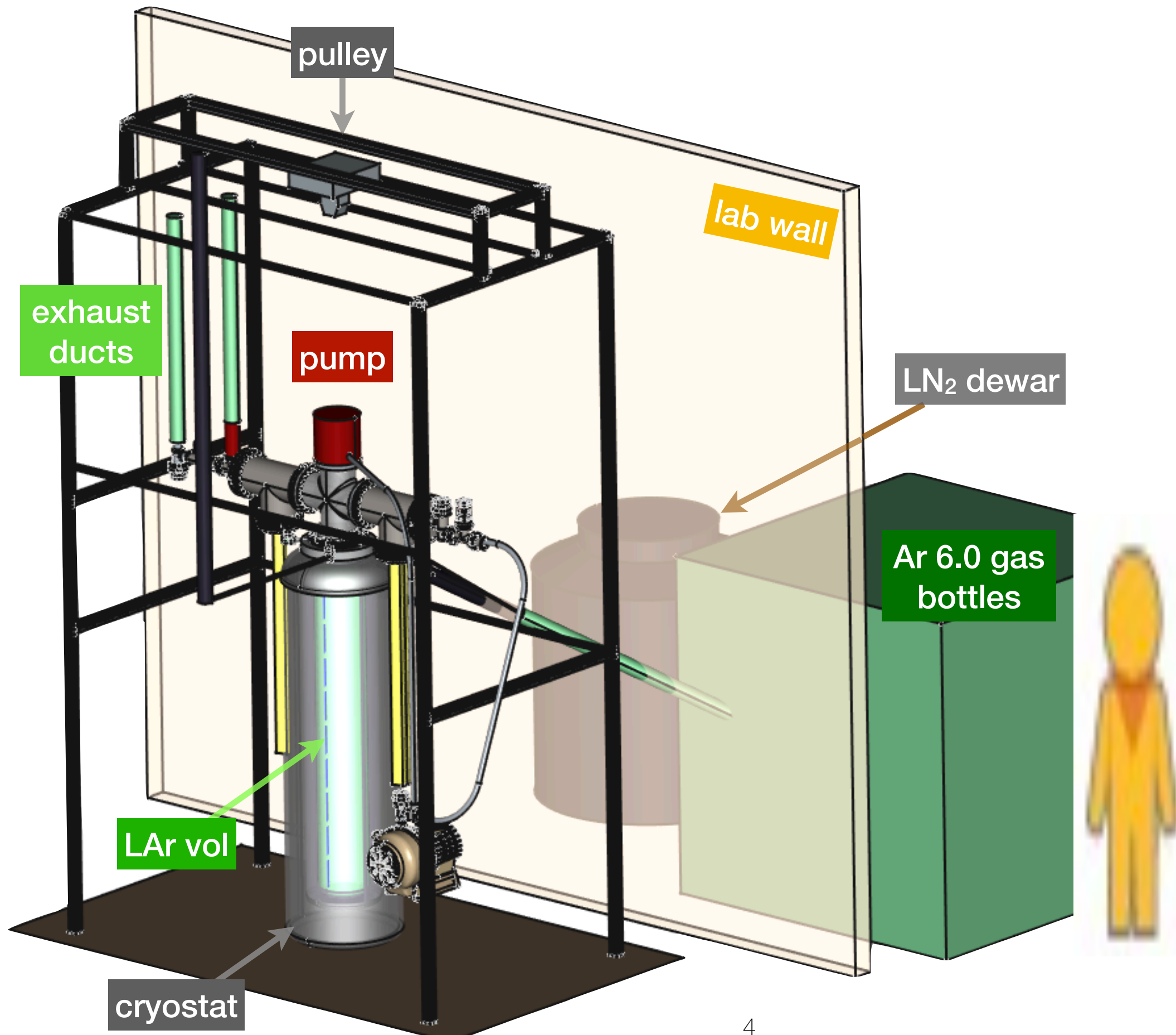
setup at Roma3 featuring:

LAr: Ar 6.0 gas liquefied by LN₂
LAr scinti. photon by SiPM(VUV)

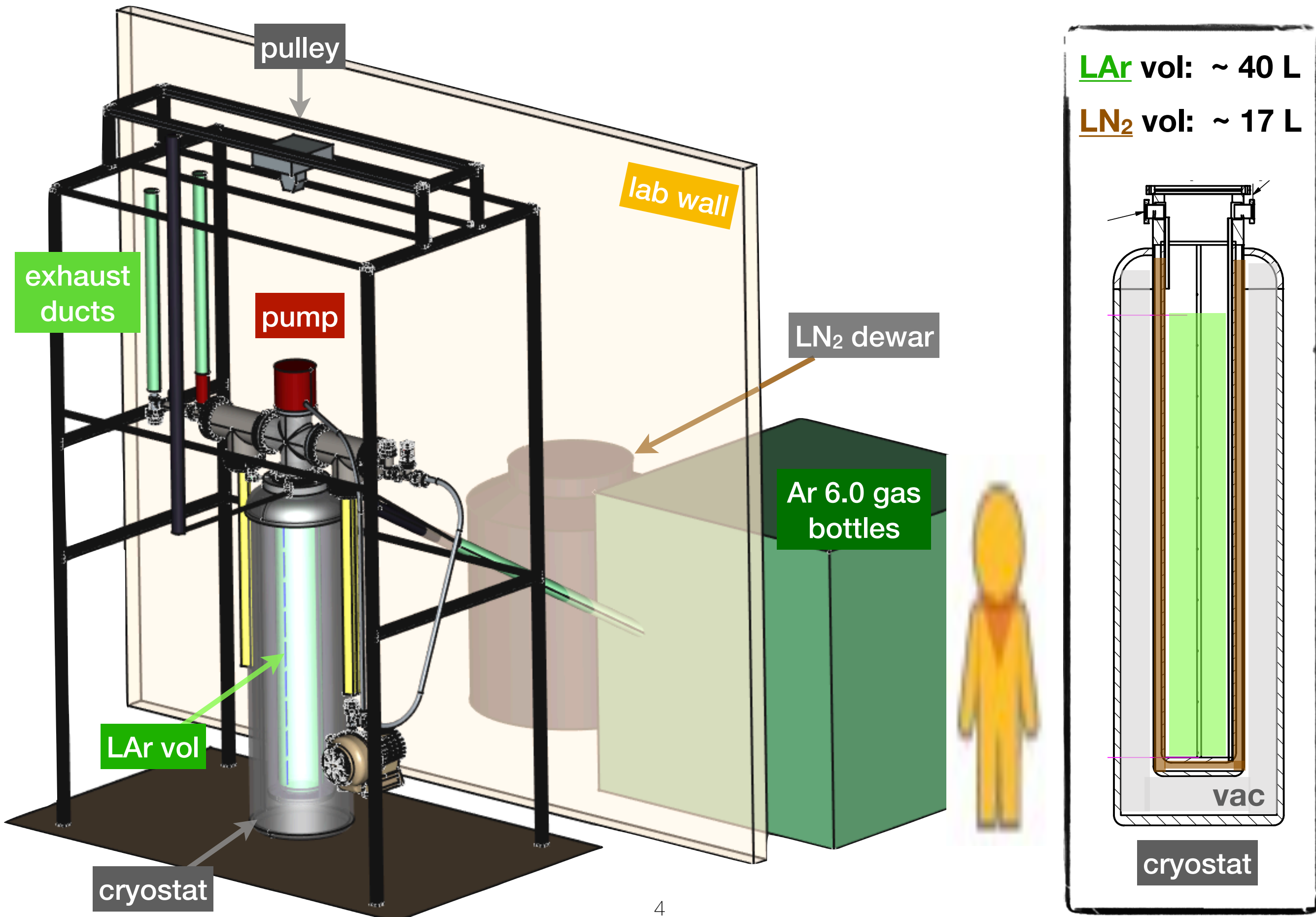
LAr optical properties that can be studied

- scintillation photon yield
- (effective) attenuation length
- time constants
- impurity effect (*wo purification or doping*)
- *reflective surfaces*

OLAF setup overview



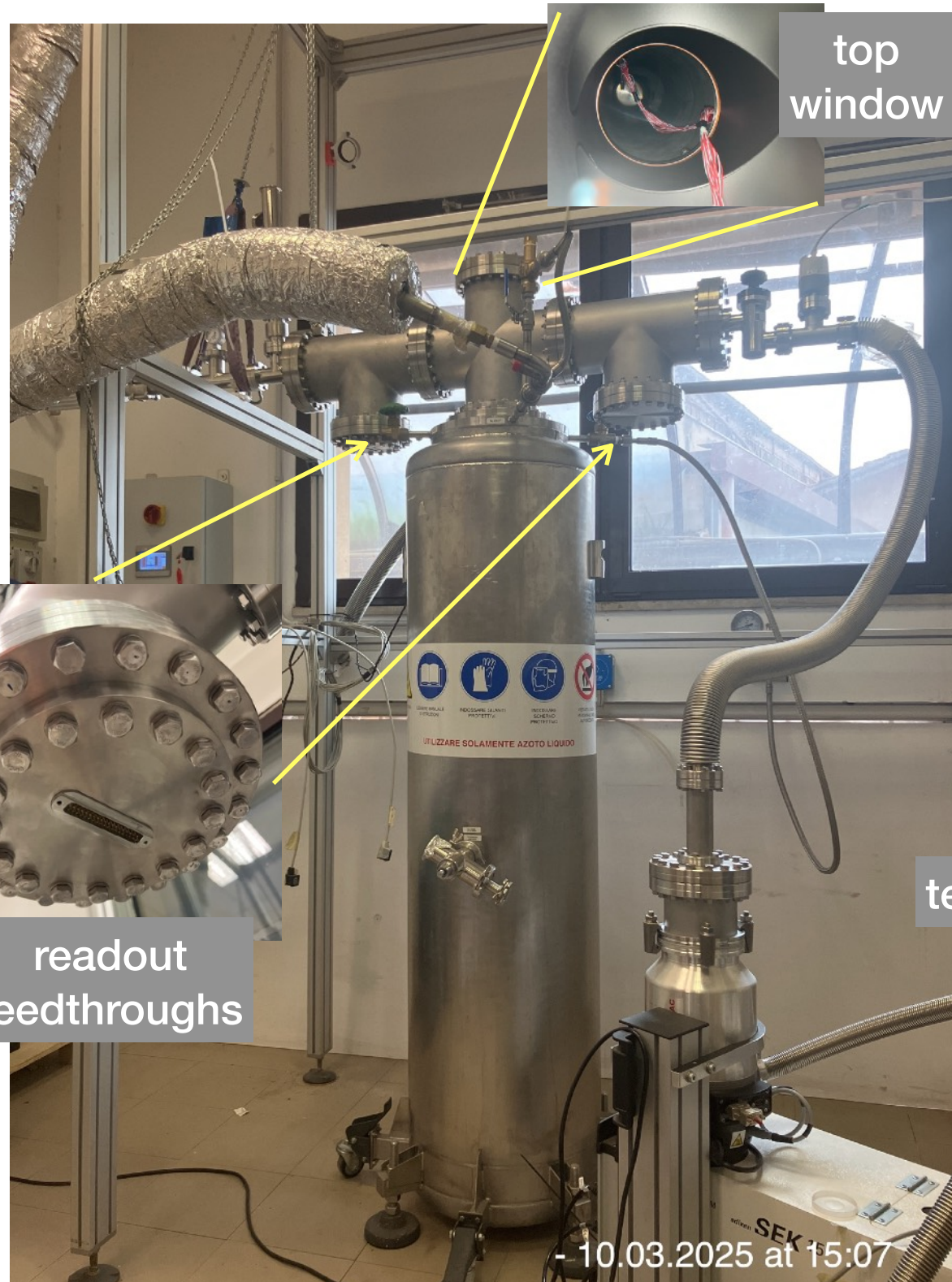
OLAF setup overview



OLAF in preparation at INFN-Roma3

as in 2025

configuration for Ar liquefaction test



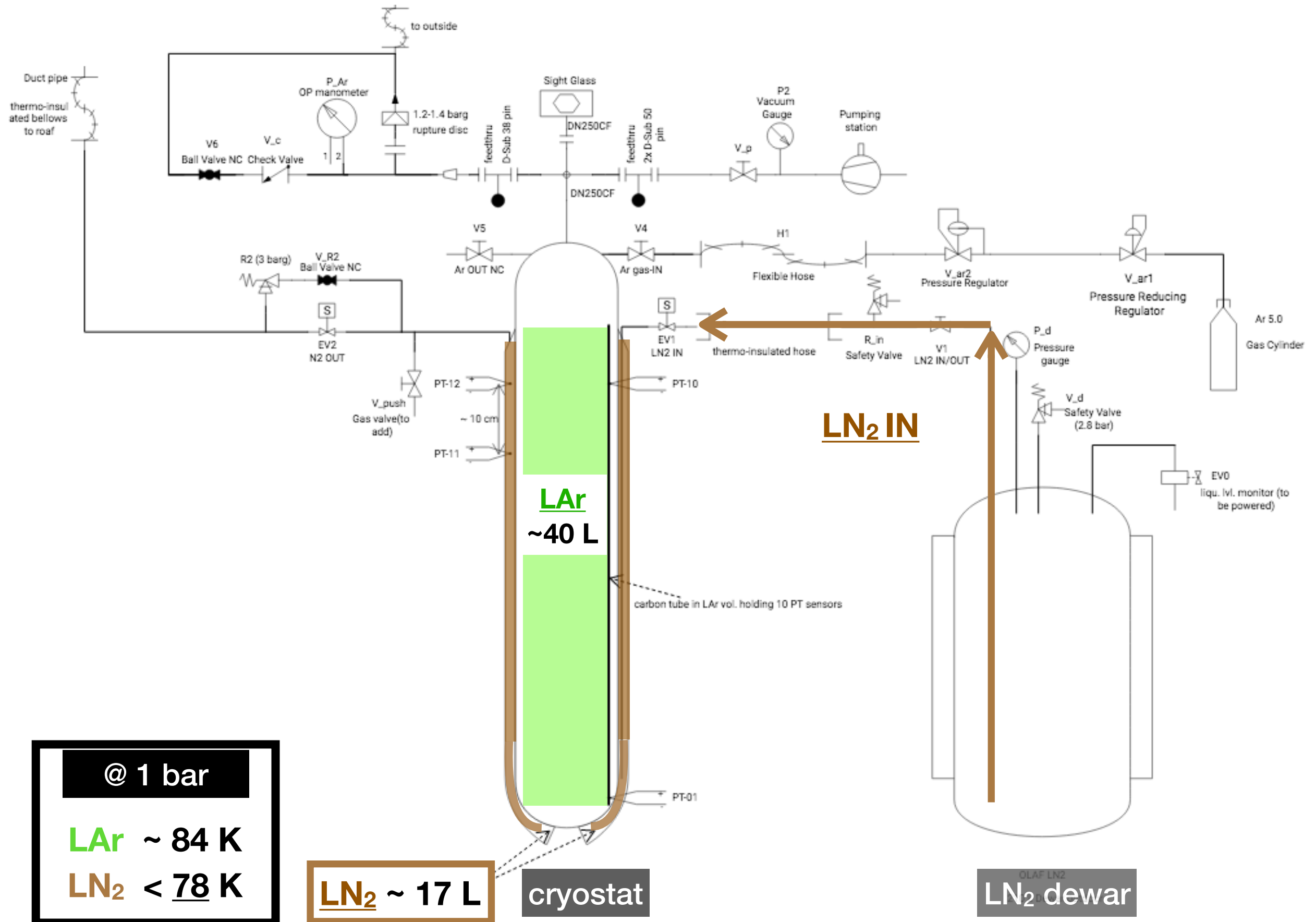
temperature display

vacuum and cryogenic vessels, LN₂ dewar

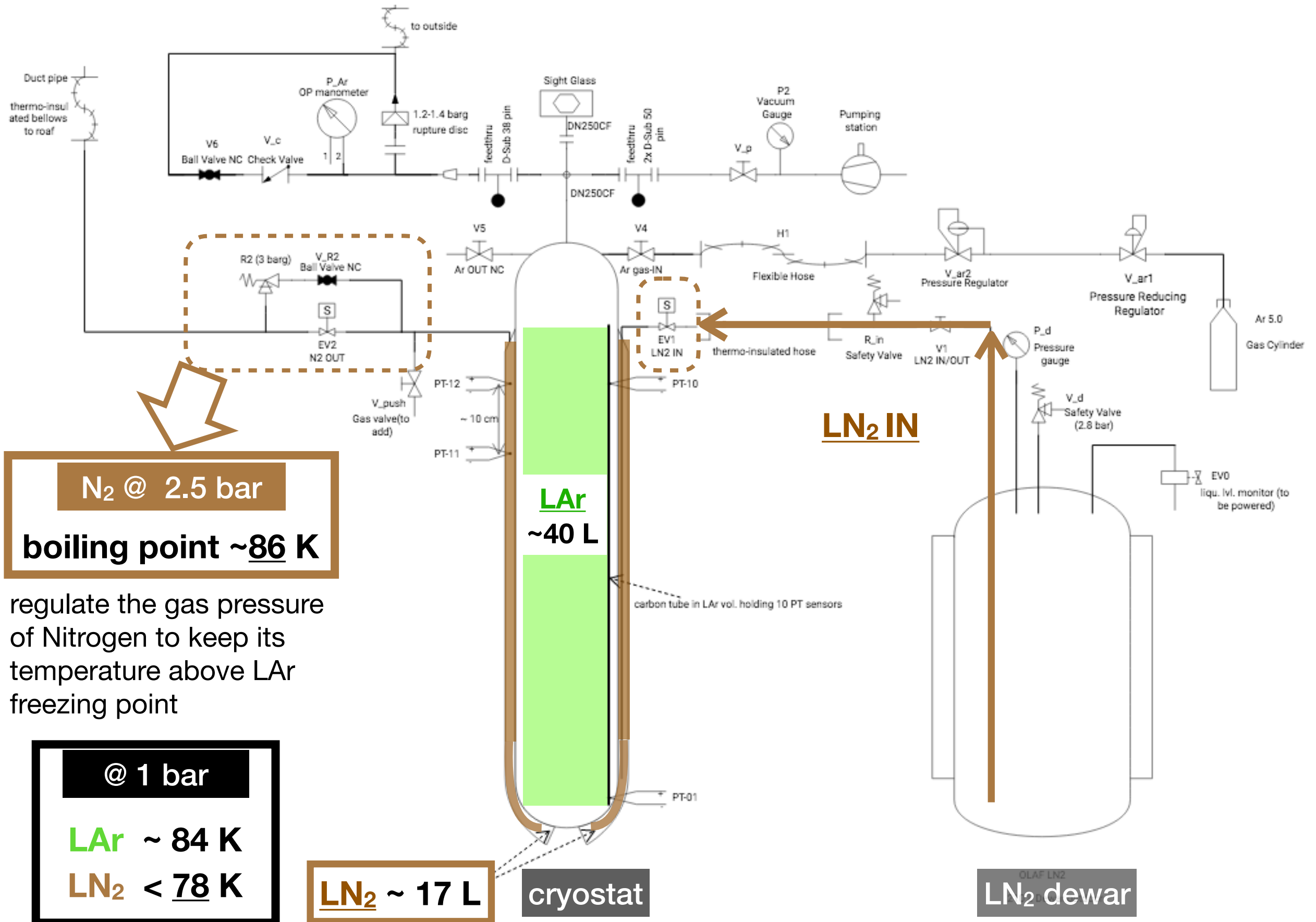


LDetek_LD8000
Trace gas impurity analyser

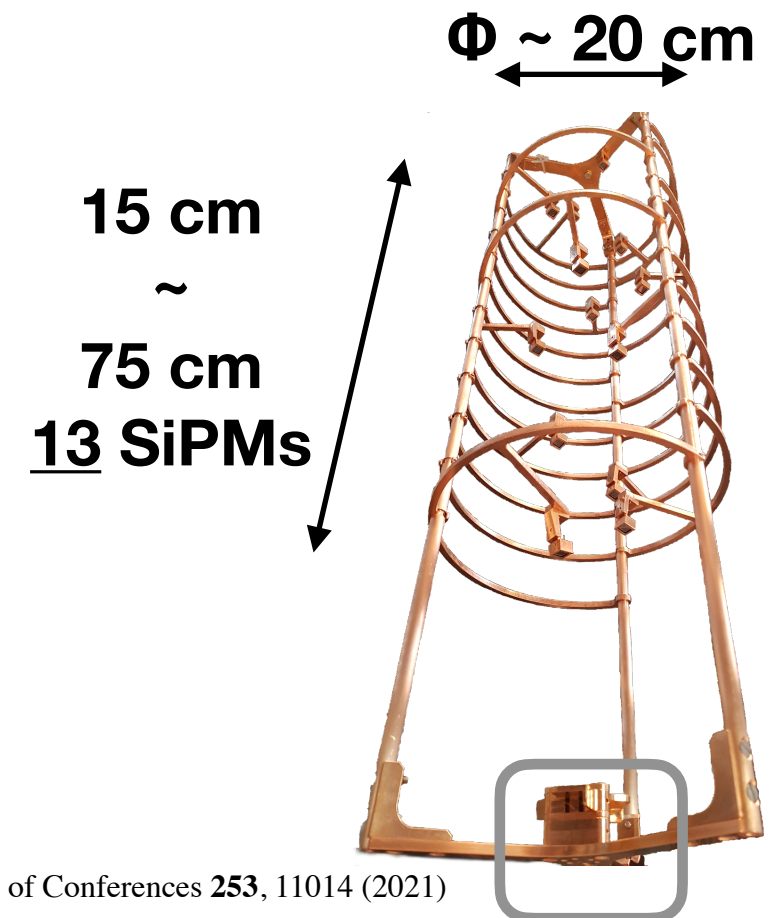
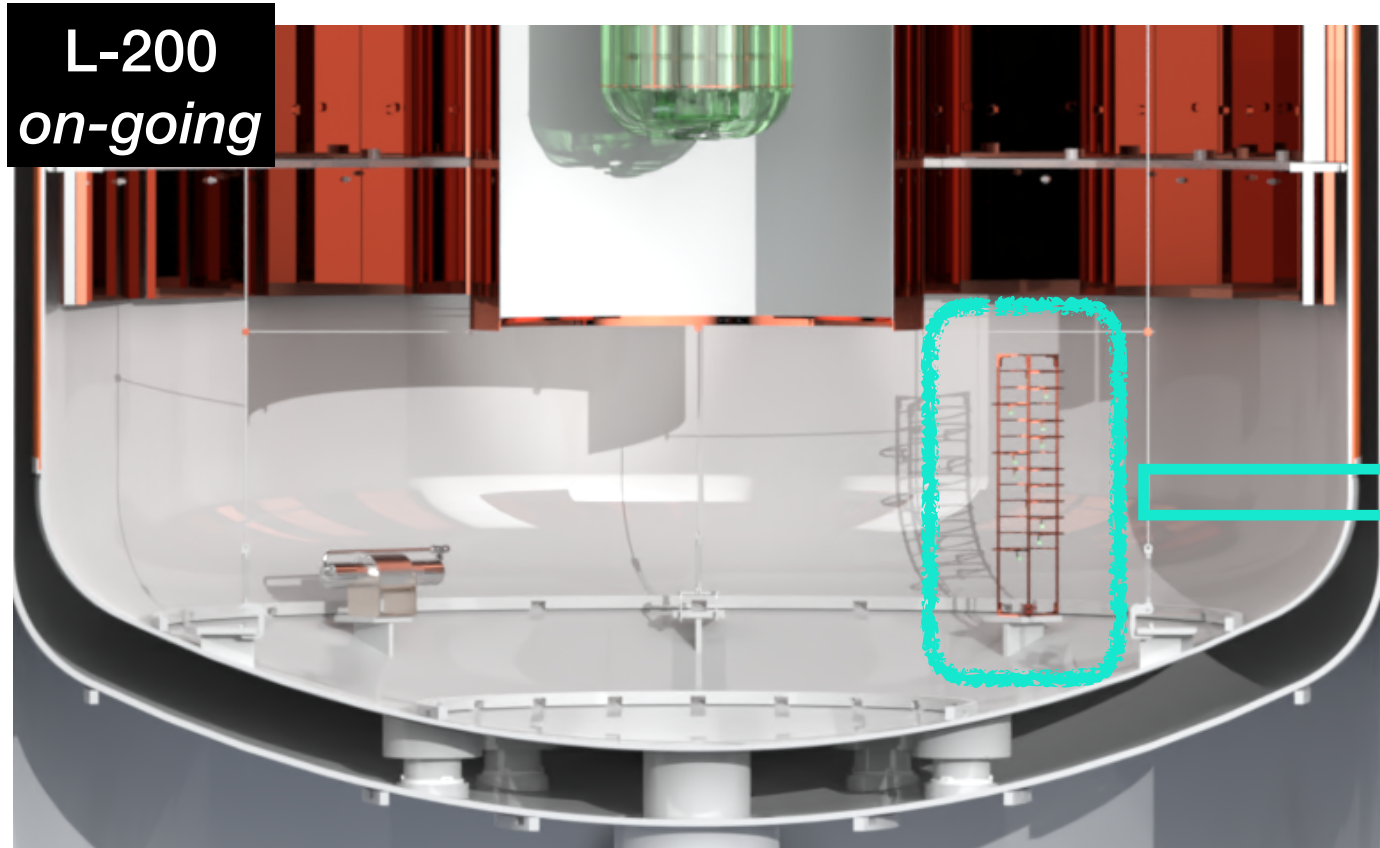
LAr liquefaction with LN₂



LAr liquefaction with LN₂



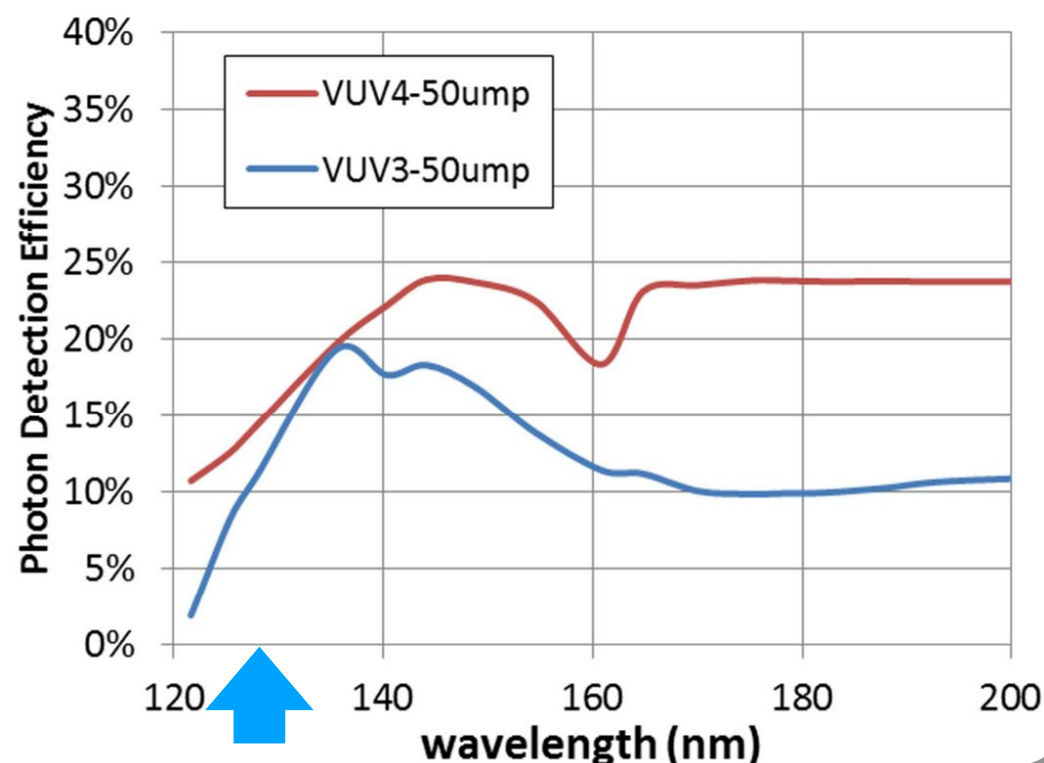
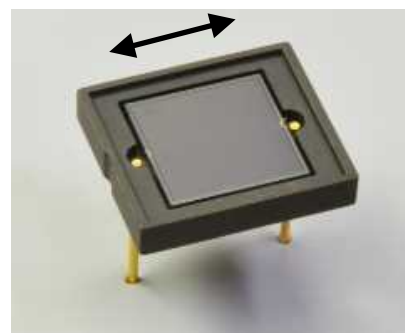
Source and detector configuration - LLAMA case



EPJ Web of Conferences **253**, 11014 (2021)

Hamamatsu **VUV4** type MPPC SiPM

6 mm



Light source and trigger

Am-241

triple coincidence of 3 SiPMs near source

LED (green)

external pulser for power supply

OLAF: SiPM and light source mounting structures

tentative
design

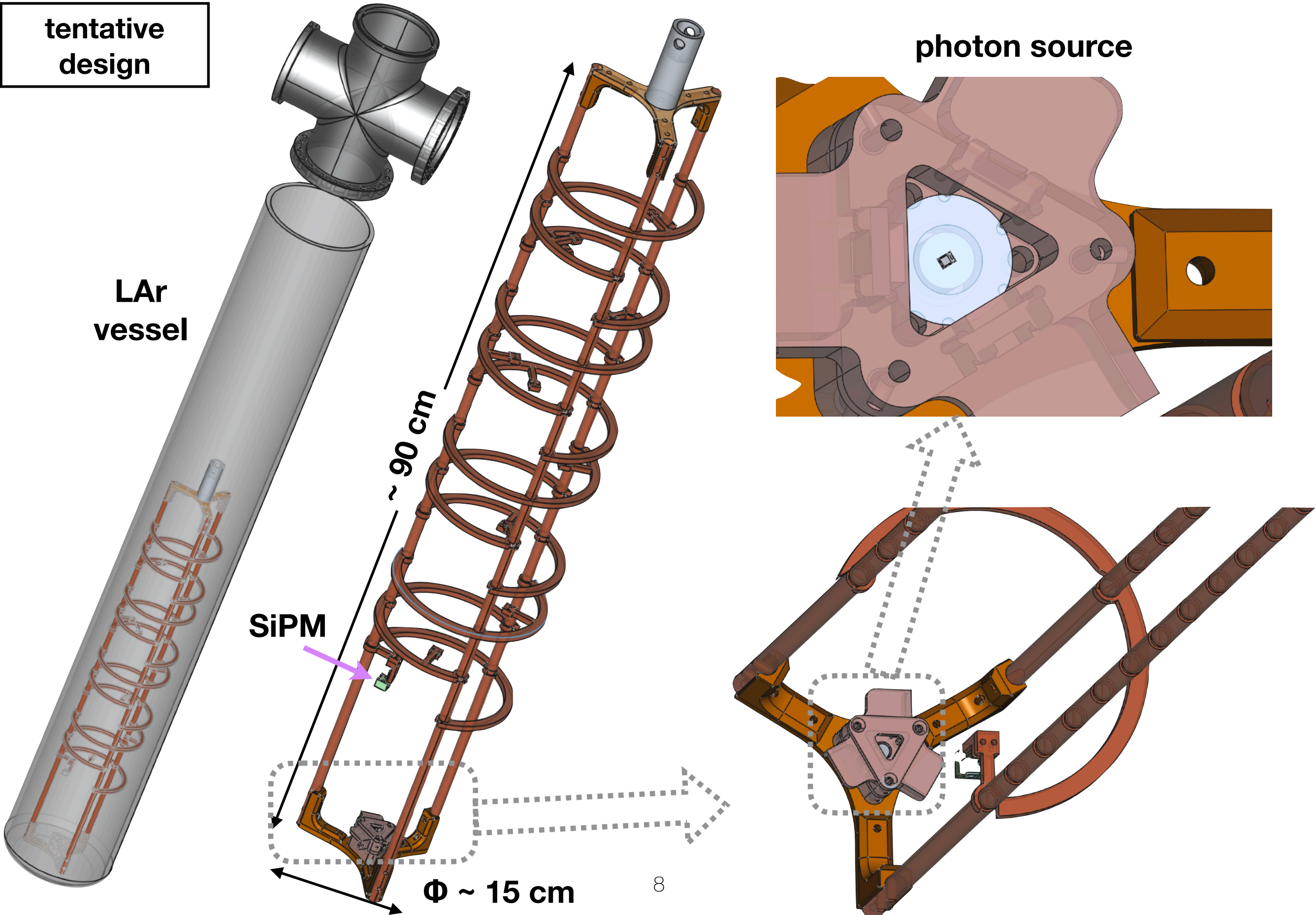
LAr
vessel

SiPM

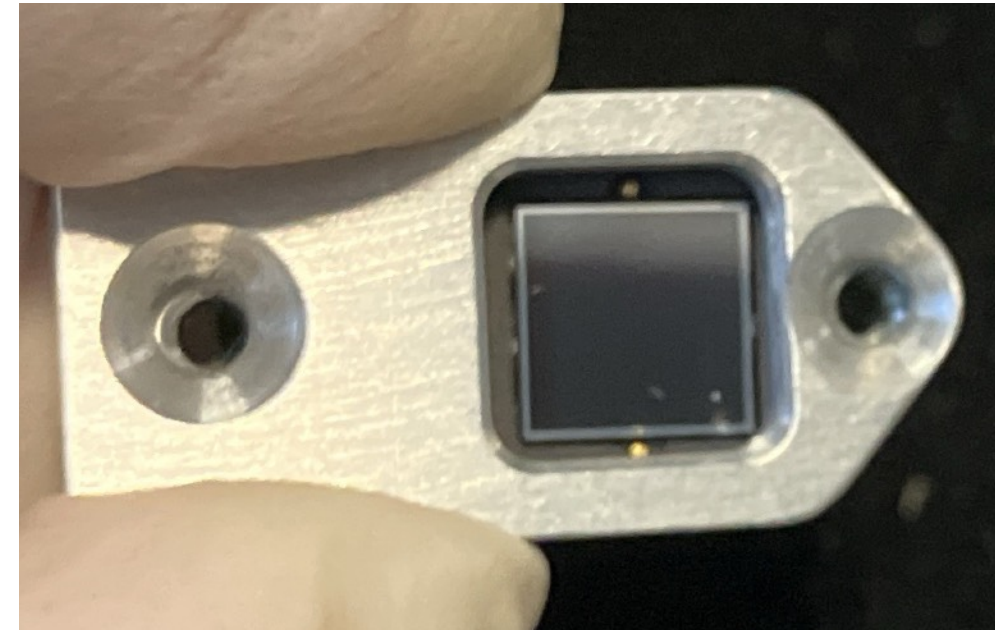
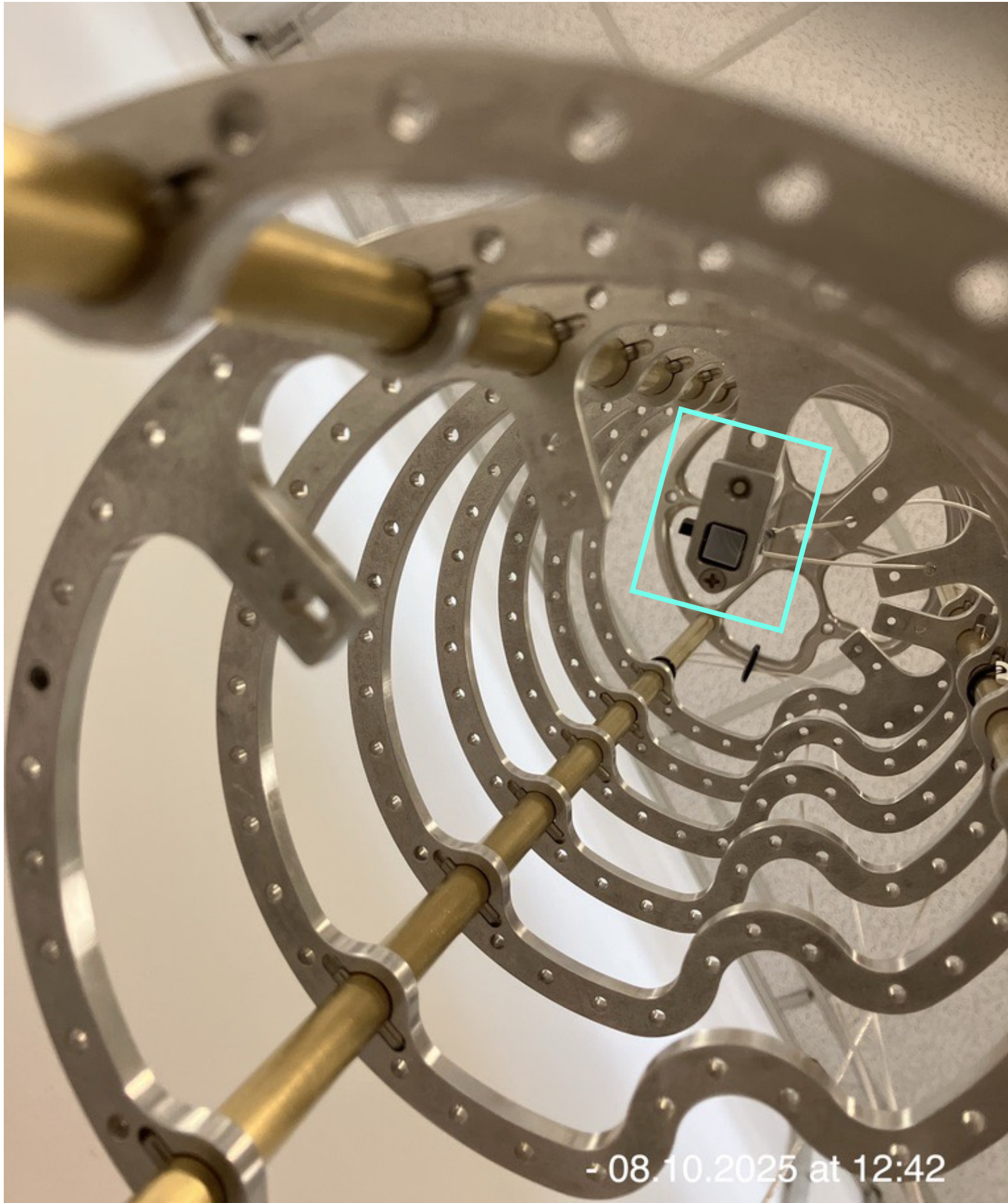
~ 90 cm

$\Phi \sim 15$ cm

photon source



OLAF: SiPM and light source mounting structures



- 08.10.2025 at 12:42

OLAF Am-241 source housing and trigger

✓ Am-241 gamma source at Roma3:

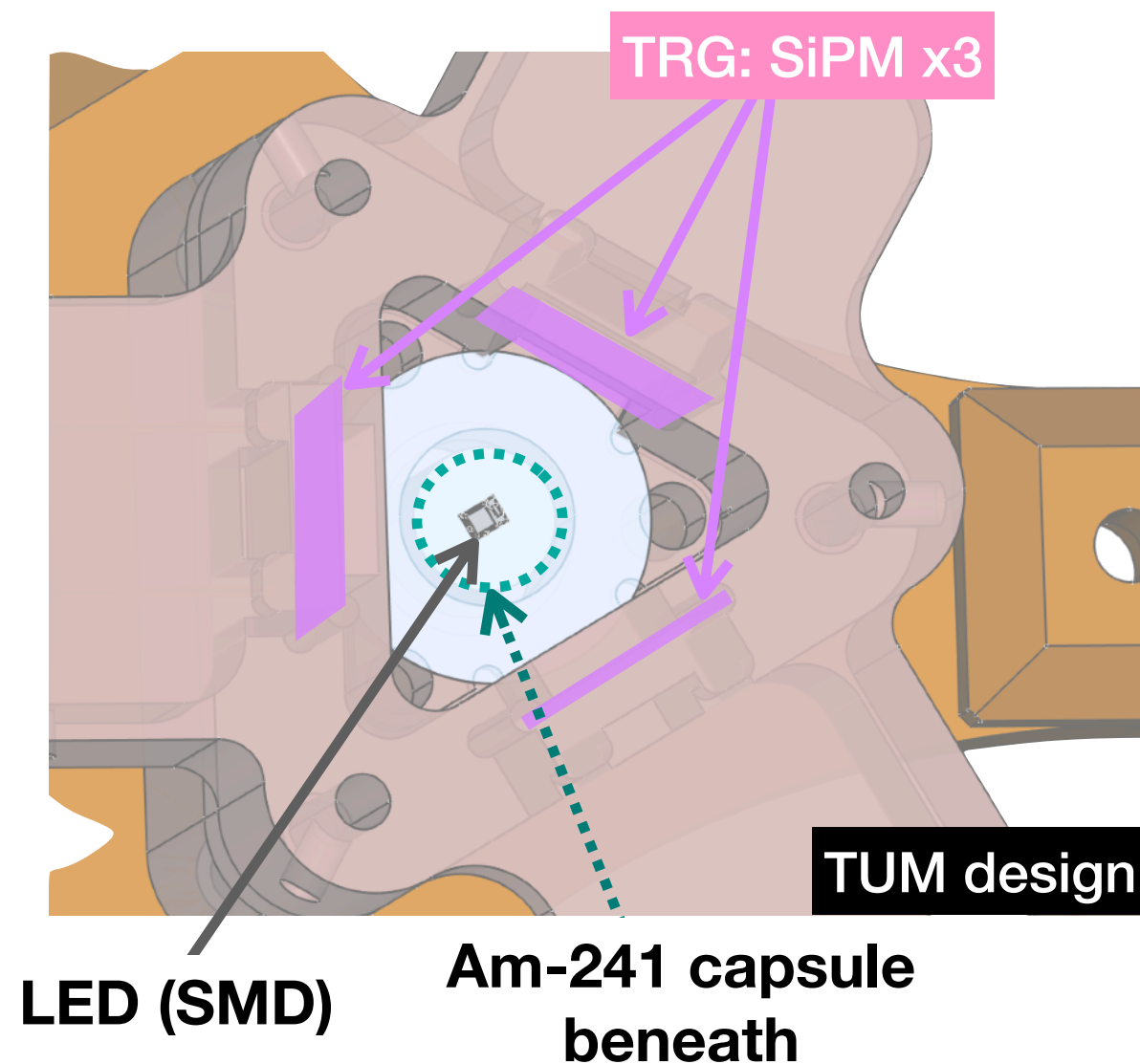
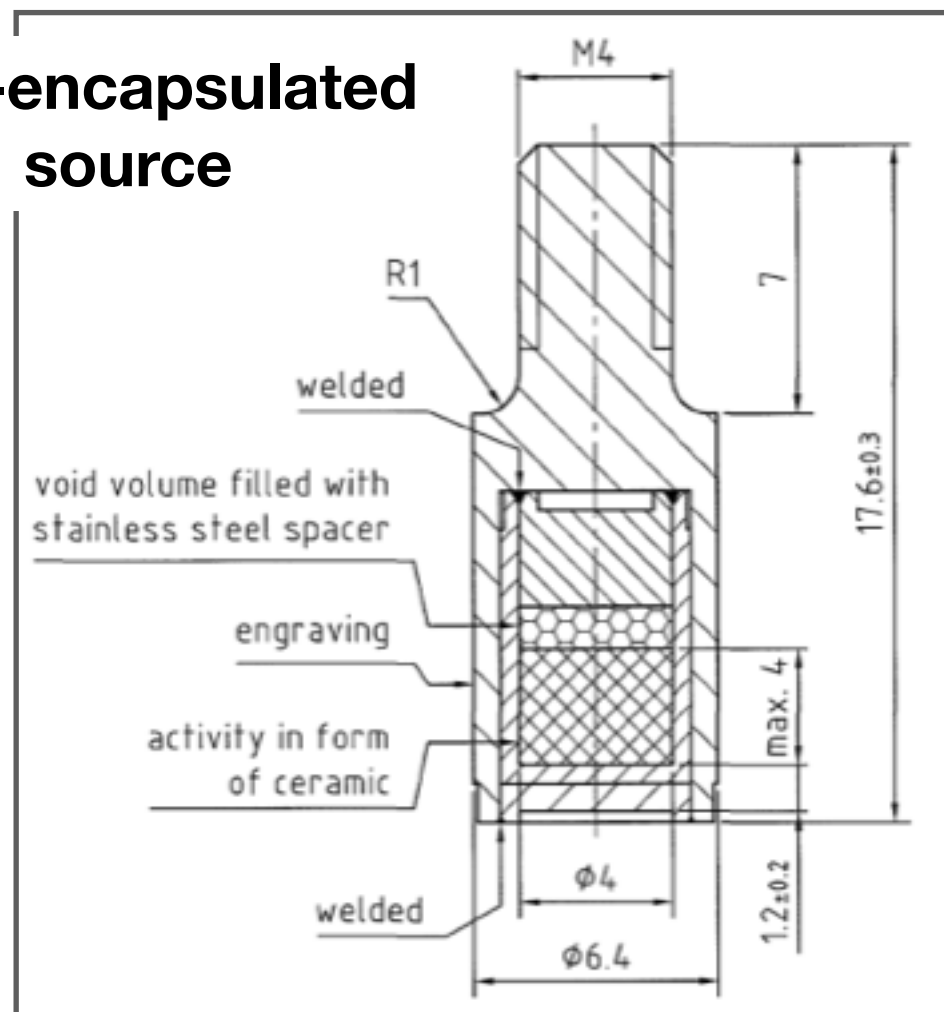
Commercially sealed capsule

Gamma: mainly 60 keV

Activity: 200 kBq

Activity tolerance: $\pm 30\%$

**Fully-encapsulated
source**



OLAF Am-241 source housing and trigger

✓ Am-241 gamma source at Roma3:

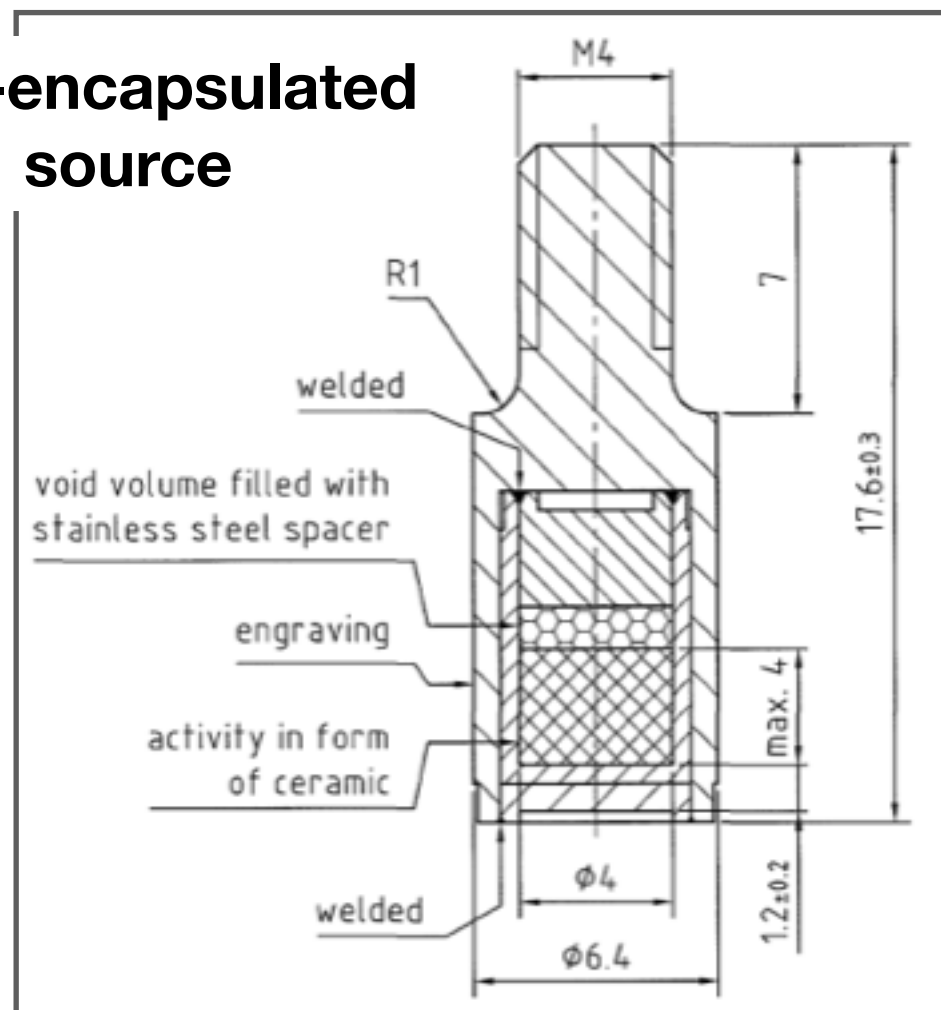
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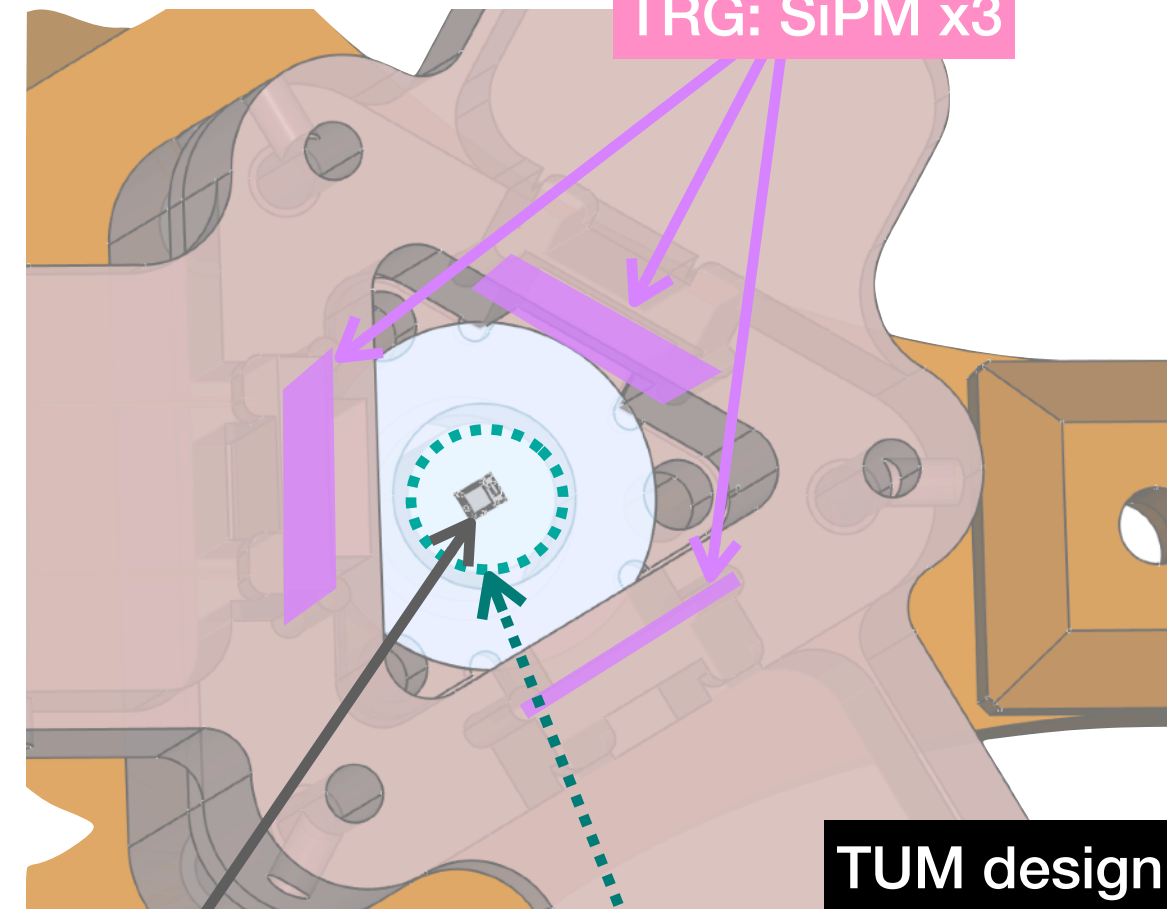
Activity: 200 kBq

Activity tolerance: $\pm 30\%$

**Fully-encapsulated
source**



TRG: SiPM x3



LED (SMD)

Am-241 capsule
beneath

LED source

- single photon calibration
- timing calibration
- basic functionality validation

SiPM TRG: in sync with LED power modulator

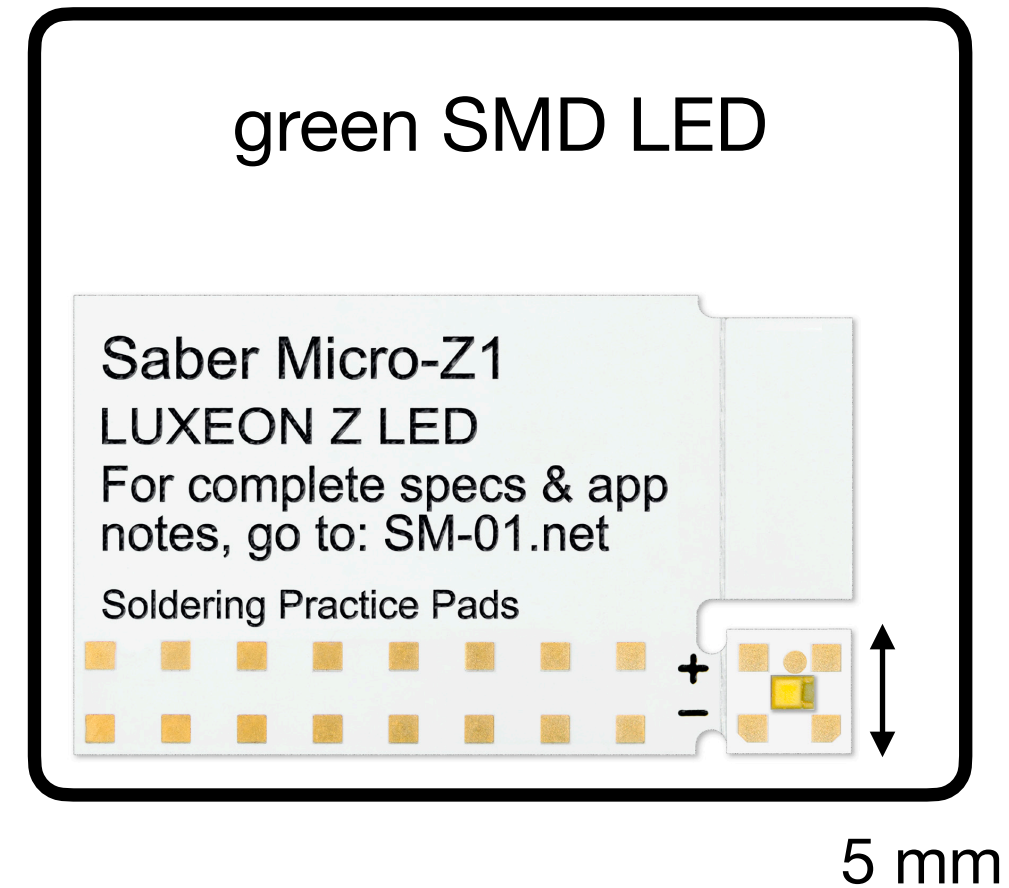
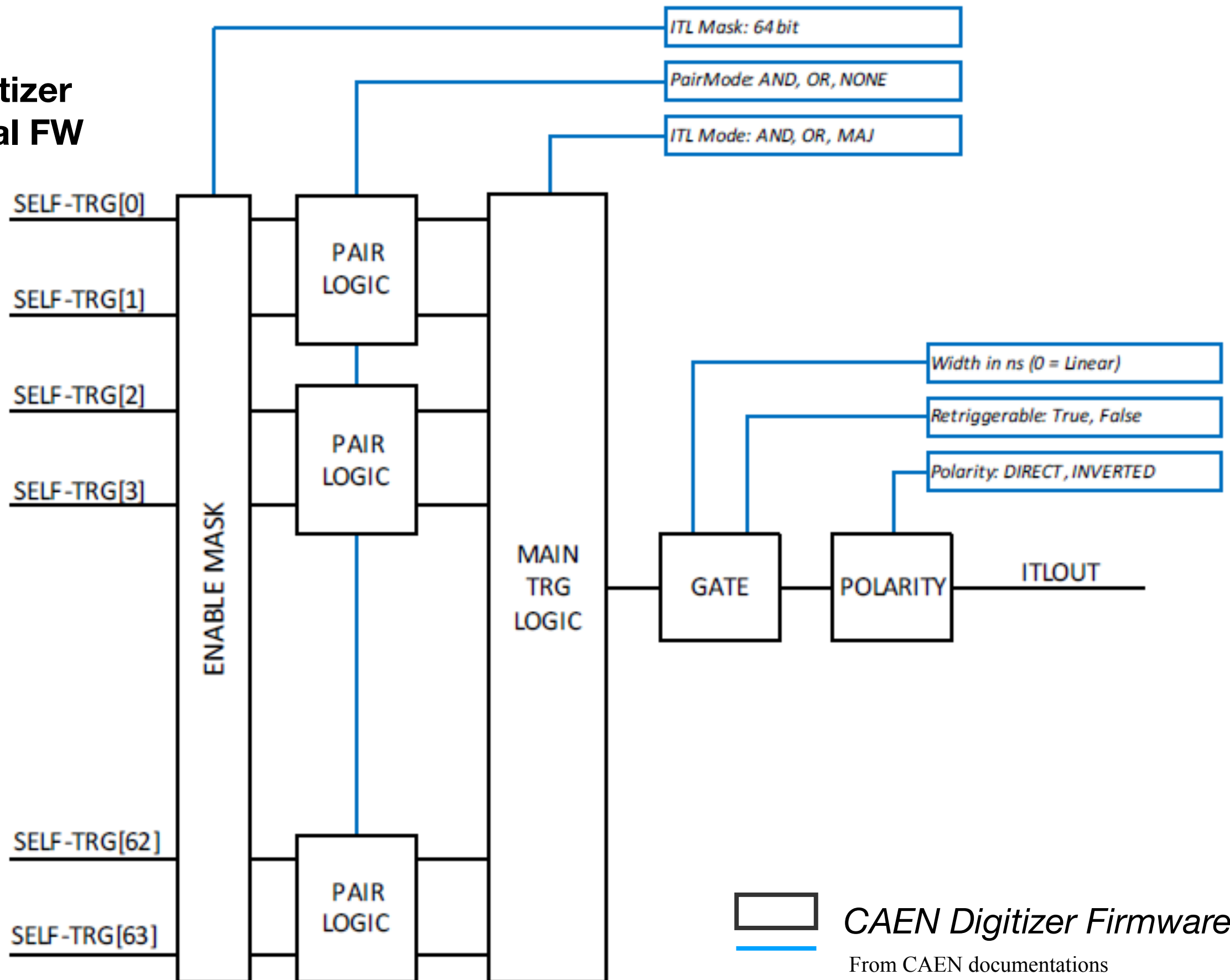


Table 1a. Product performance of LUXEON Z Color Line at 500mA, $T_j=25^\circ\text{C}$.

COLOR	DOMINANT ^[1] or PEAK WAVELENGTH ^[2] (nm)		LUMINOUS FLUX ^[1] (lm) or RADIOMETRIC POWER ^[3] (mW)		PART NUMBER
	MINIMUM	MAXIMUM	MINIMUM	TYPICAL	
Deep Red	650	670	250	350	LXZ1-PA01
Red	620	645	40	52	LXZ1-PD01
Red-Orange	610	620	56	65	LXZ1-PH01
Green	520	540	80	118	LXZ1-PM01
Cyan	490	510	48	82	LXZ1-PE01
Blue	460	480	24	38	LXZ1-PB01
Royal Blue	440	460	500	575	LXZ1-PR01

Trigger logic with V2740 digitizer Firmware

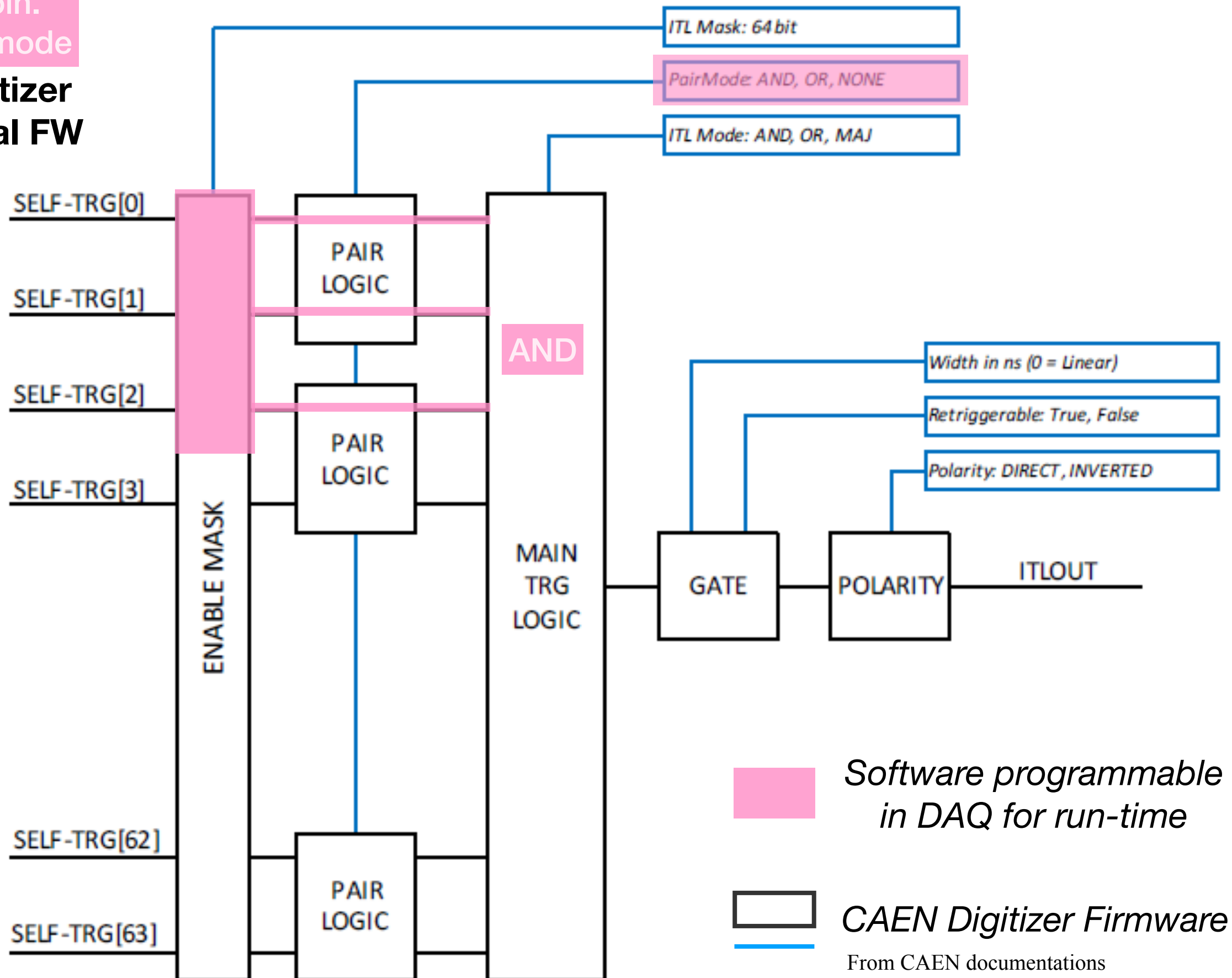
**CAEN digitizer
Commercial FW**



Trigger logic with V2740 digitizer Firmware

Tripple coin.
for source mode

**CAEN digitizer
Commercial FW**



SiPM readout: Front-End, trigger, and DAQ

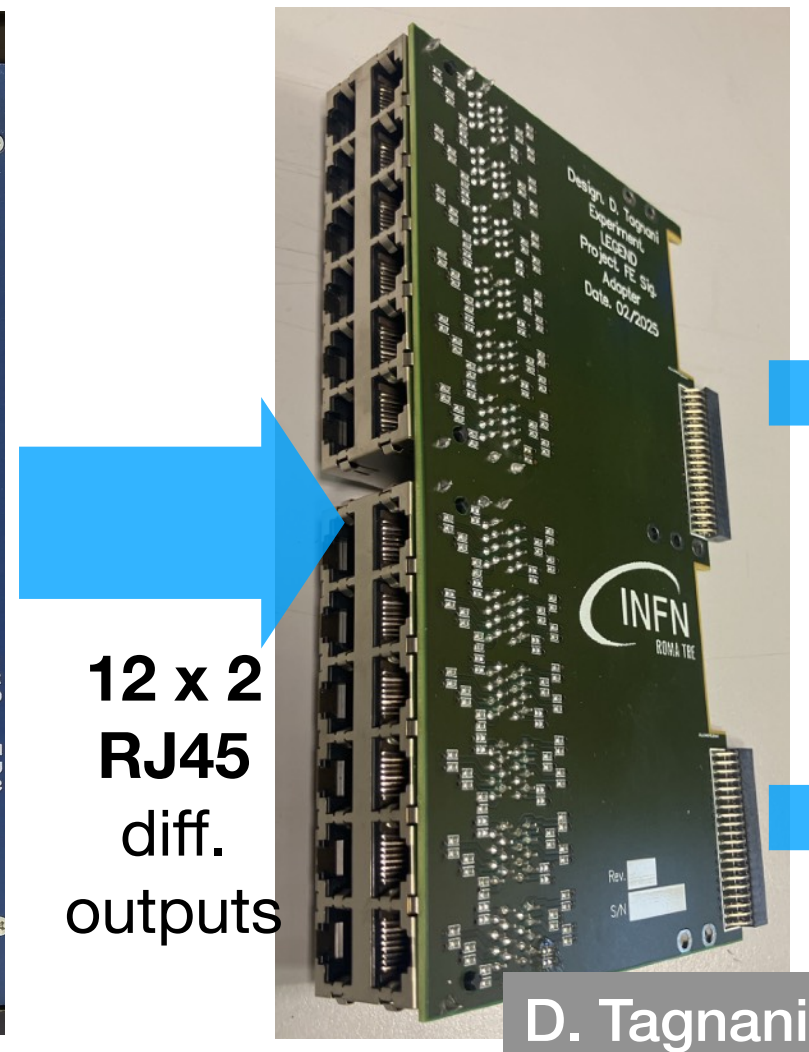
2023 JINST 18 P09007



**LEGEND-200 FE boards x 2
& controller board**

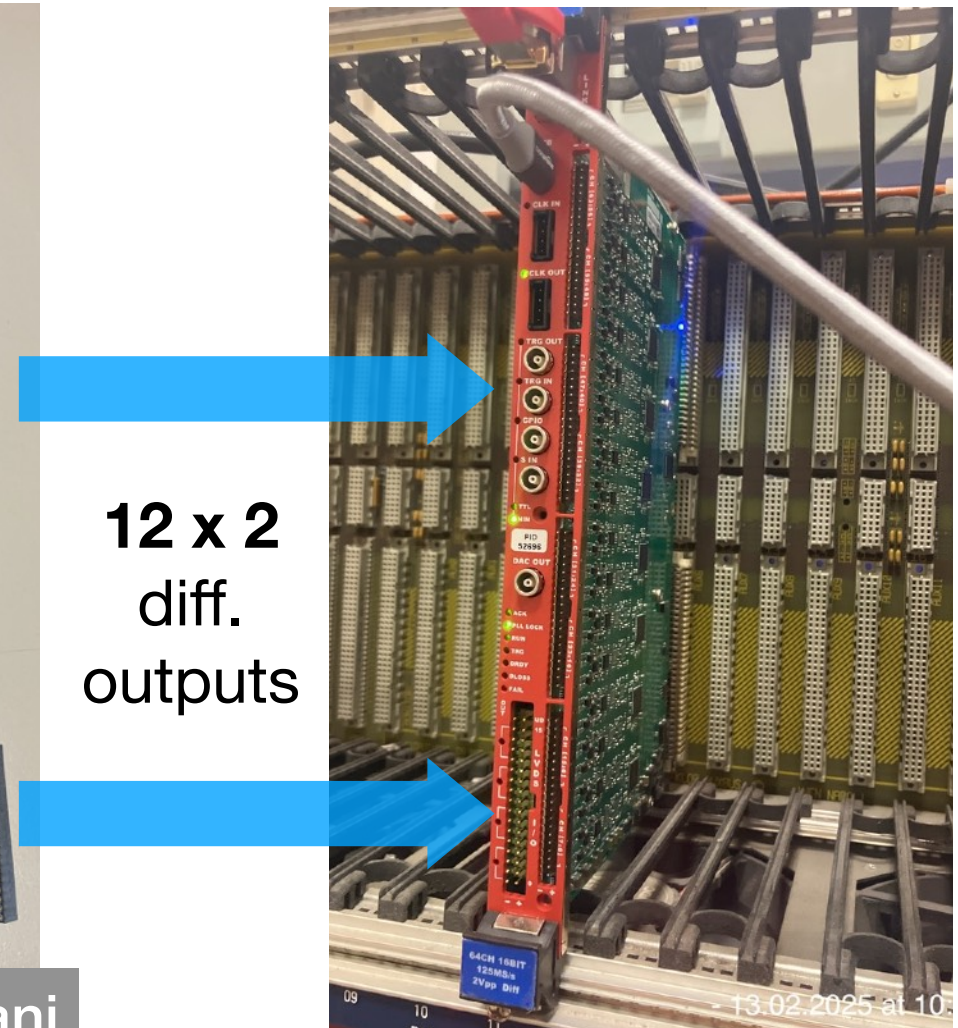
up to 24 SiPM channels

- connection to SiPM
 - controller interface
- in preparation
—> validation to follow



D. Tagnani
FE output adaptor

**12 x 2
RJ45
diff.
outputs**



CAEN V2740 digitizer

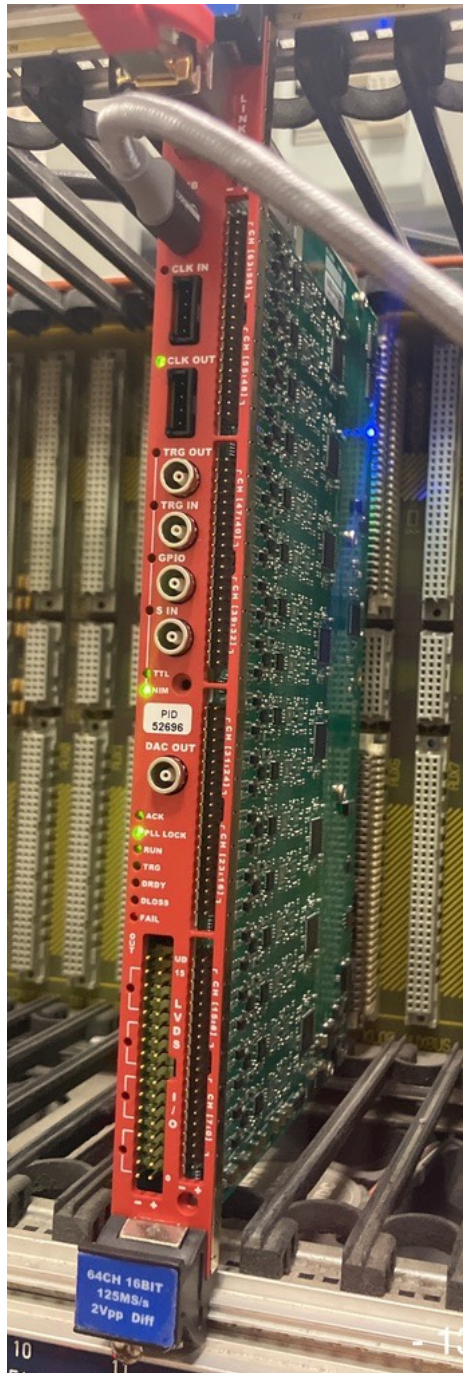
**12 x 2
diff.
outputs**

FPGA FW for TRG logic
MIDAS based DAQ

DAQ implementation and first FW test

CAEN Dig V2740
FELib
OEM FW for PSD

MIDAS package of TRIUMF
Linux, C++ library;
Online Data Base (ODB) for control and logging;
GUI control from browser



64 CH
8 ns/S

localhost:8080/?cmd=custom&page=vx2740 settings

OlafDigV2740 Alarms: None 30 May 2025, 17:32:36 UTC+2

Status
Transition
ODB
OldODB
Messages
Chat
Elog
Alarms
Programs
Buffers
History
OldHistory
MSCB
Sequencer
Event Dump
Config
Help
vx2740 settings

This page allows you to configure the settings for the VX2740 "single-board" frontends. If you want to use the "group" frontends, start a group frontend then refresh this page to see an updated interface.

Midas does not support 64-bit values in the ODB, so some channel masks are split into two - one for channels 0-31 and one for channels 32-63.

The VX2740 has two internal self-triggers for comparing waveforms to threshold values; these are referred to as A and B; you can enable neither, either, both, or require a coincidence of both.

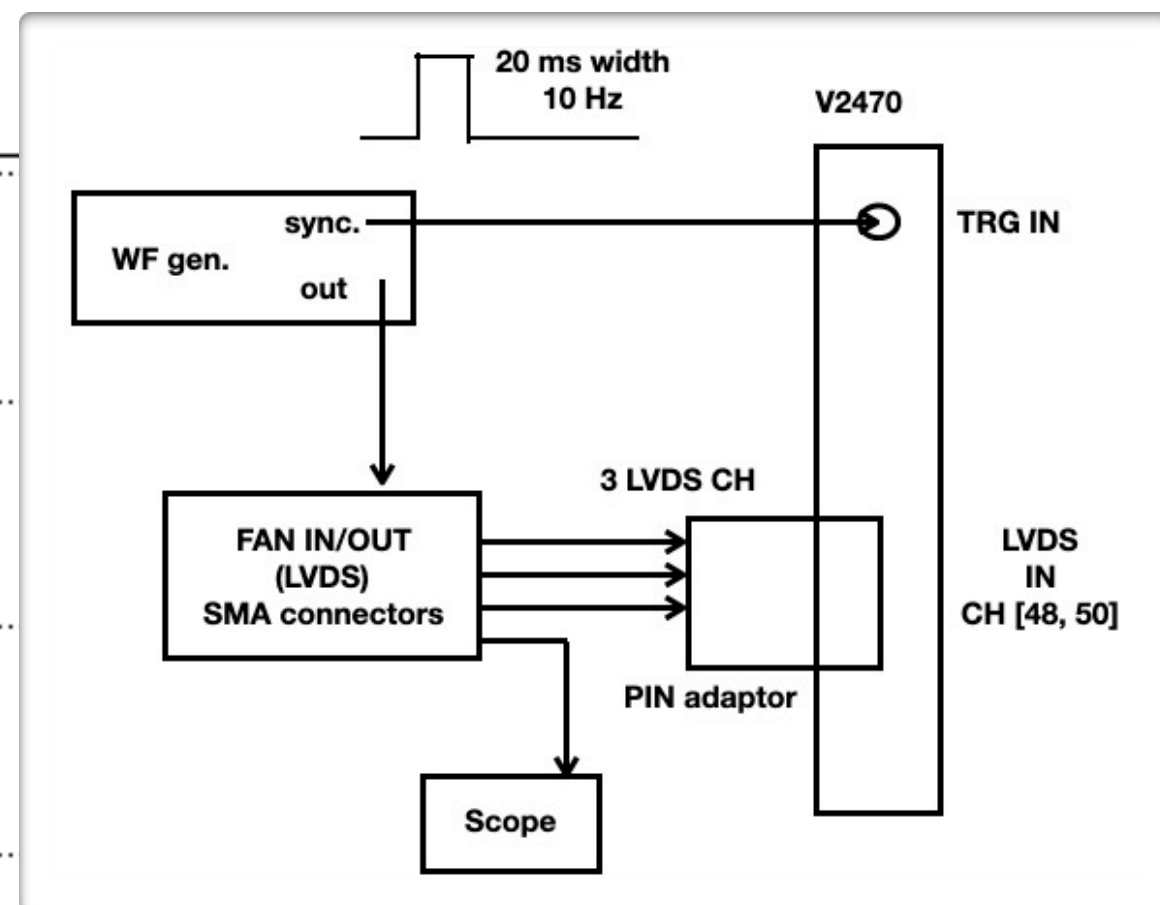
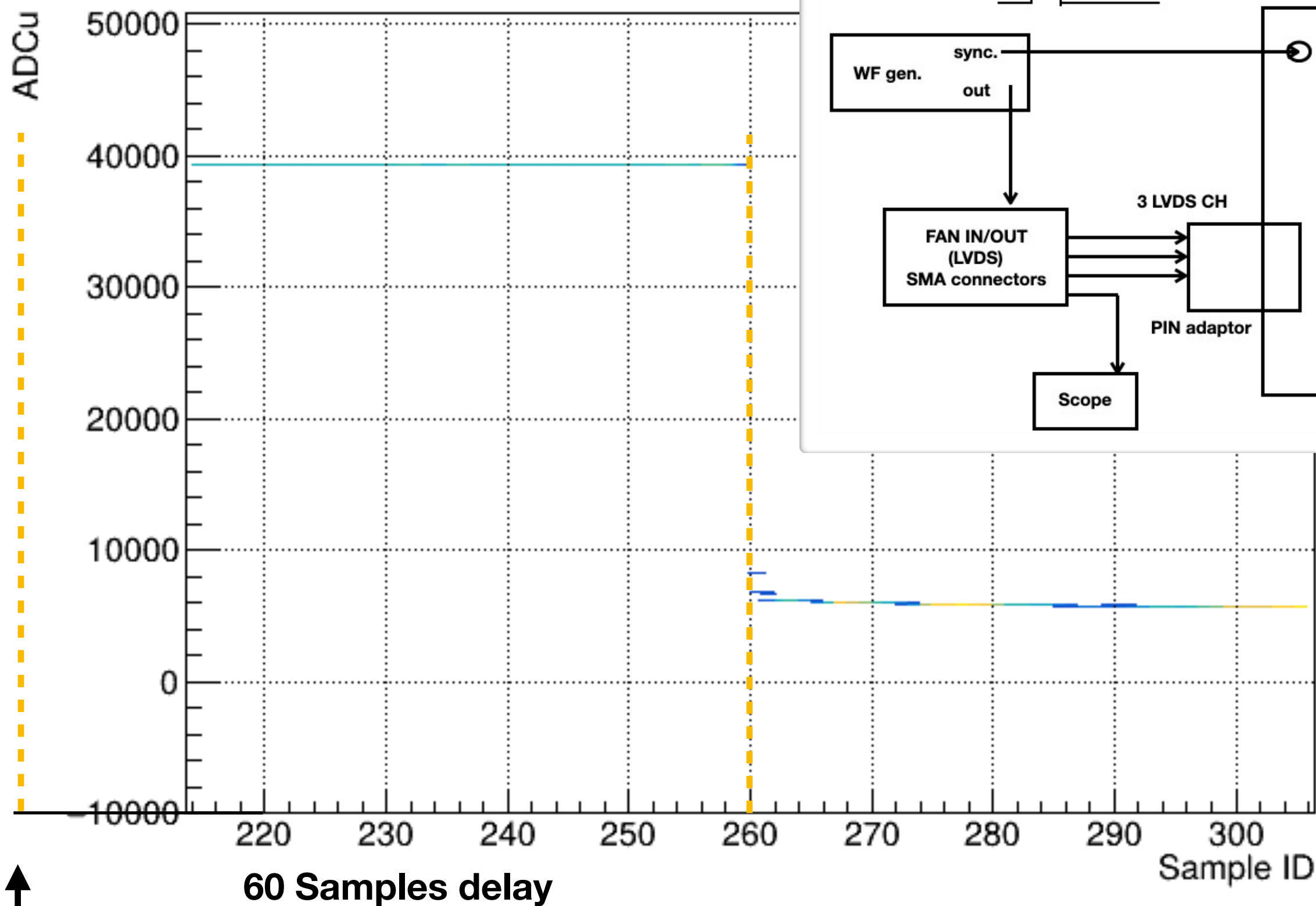
Jump to:

Per-board settings	
Parameter	001
Debug data	☐
Debug settings	☐
Debug ring buffers	☐
Hostname (restart on change)	caendgtz-usb-52696
Enable	☒
Read data	☒
Scope mode (restart on change)	☒
Use NIM IO	☒
Start acq on midas run start	☒
Start acq on encoded CLKIN	☐

TRG logic and run-time settings of digitizer —> set from GUI

DAQ basic validation: timing structure

single digitizer ch. accumulated wave form



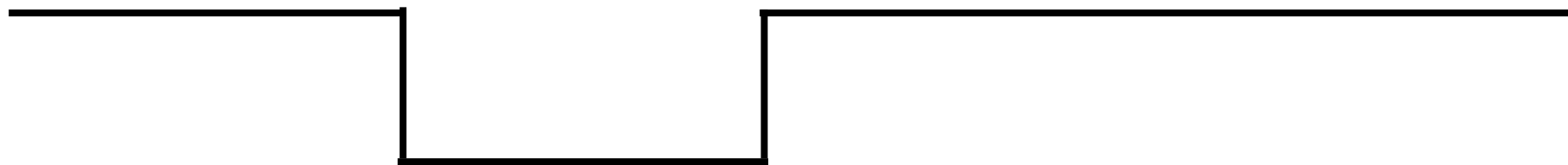
EXT TRG

DAQ basic validation: QDC gate Short-Long

CAEN DPP-PSD FW

for online PSD application

Test pulse

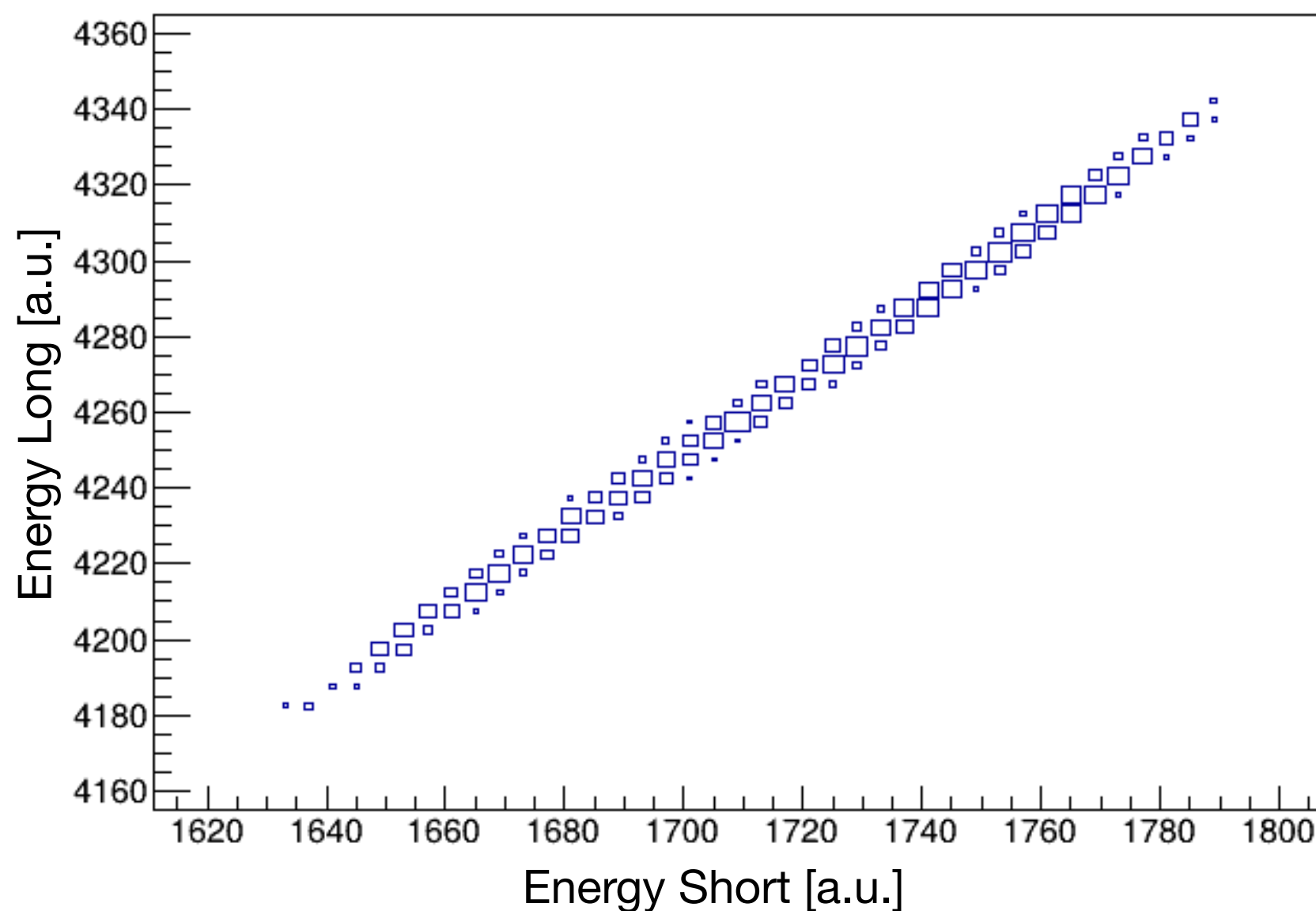


WF integration gates
(QDC gate)



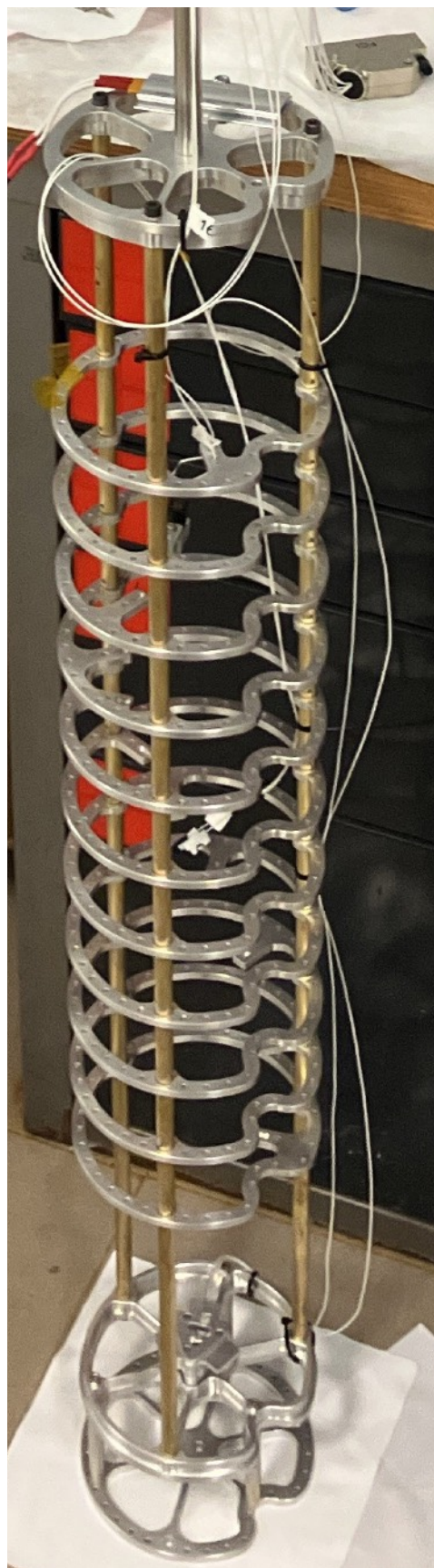
Long: Energy Long

Short: Energy Short

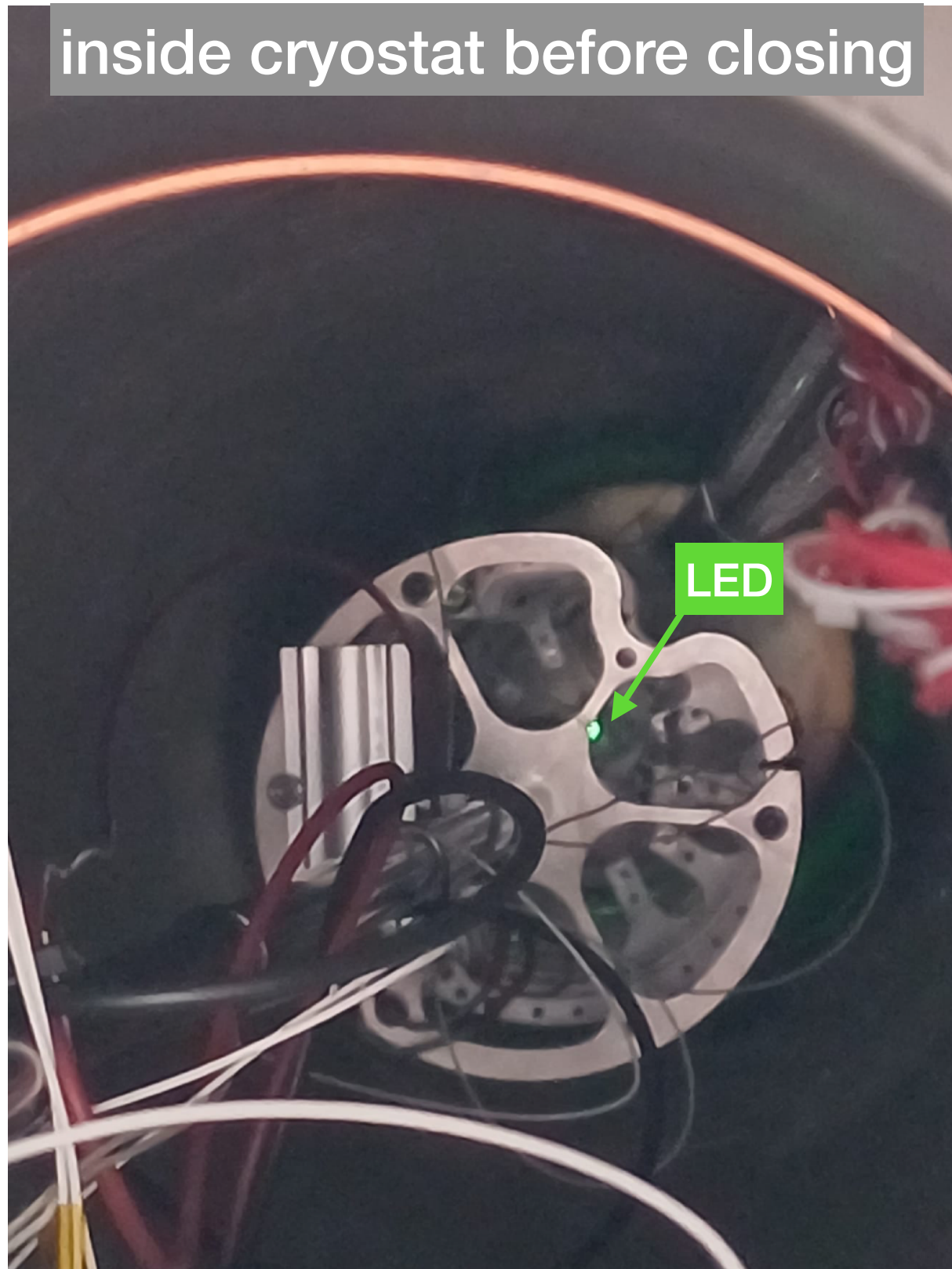


Ongoing prototype under test

assembly

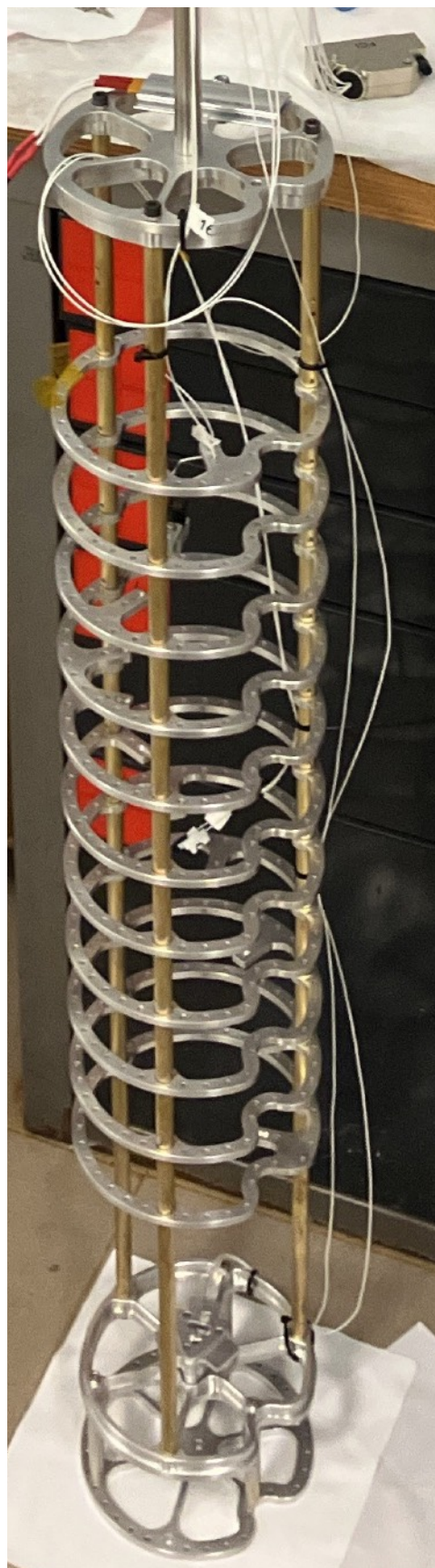


inside cryostat before closing

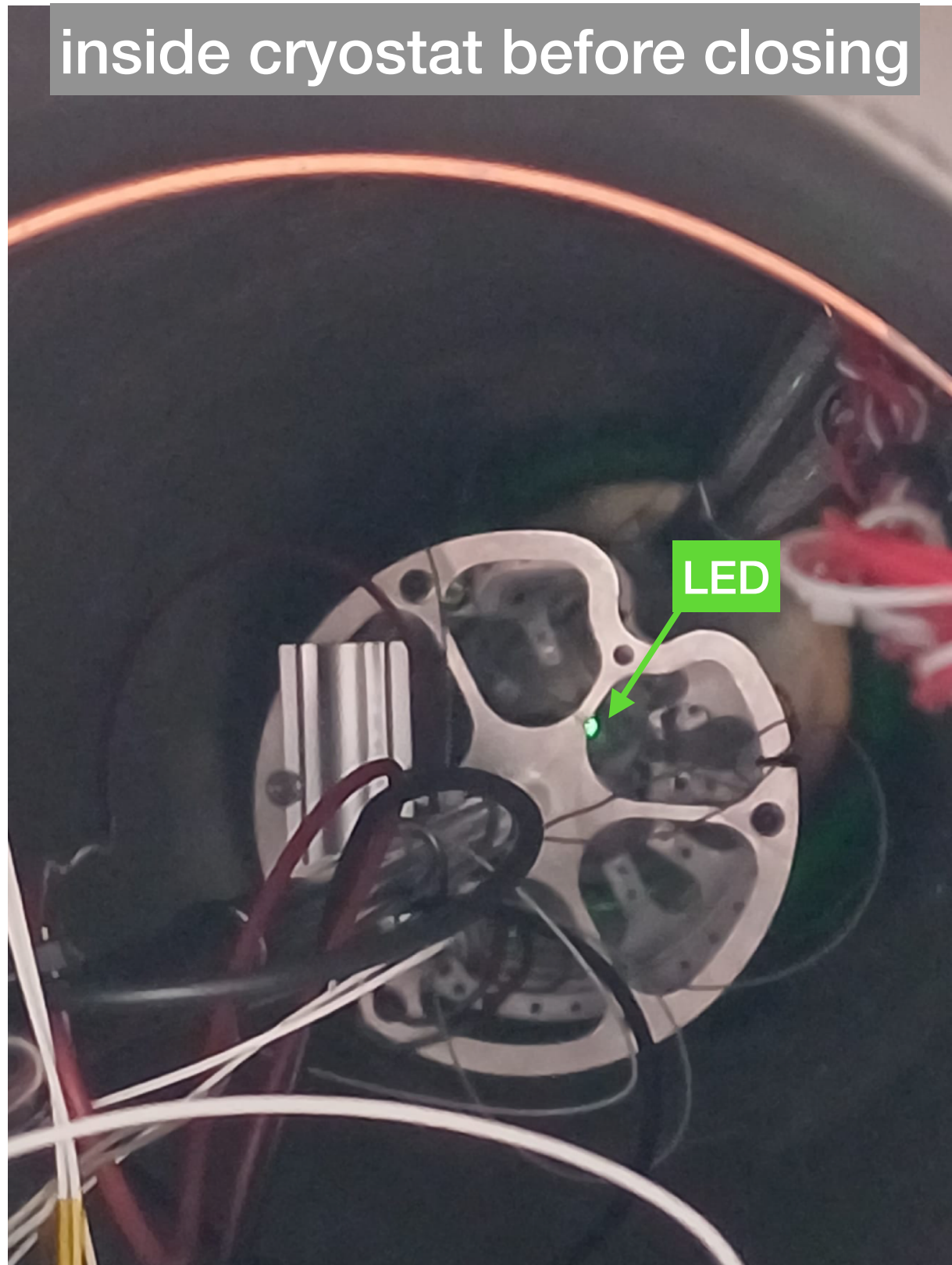


Ongoing prototype under test

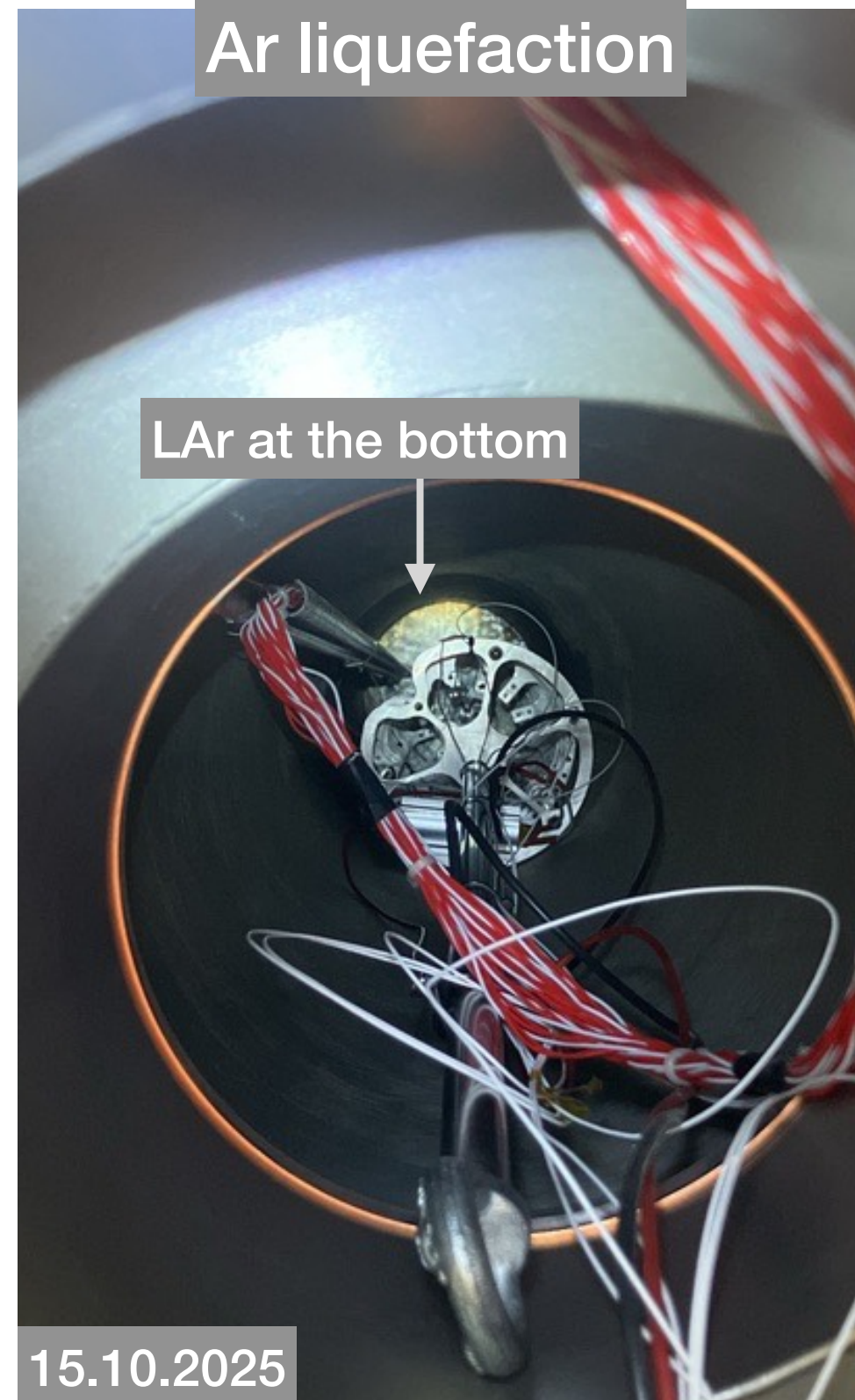
assembly



inside cryostat before closing



Ar liquefaction



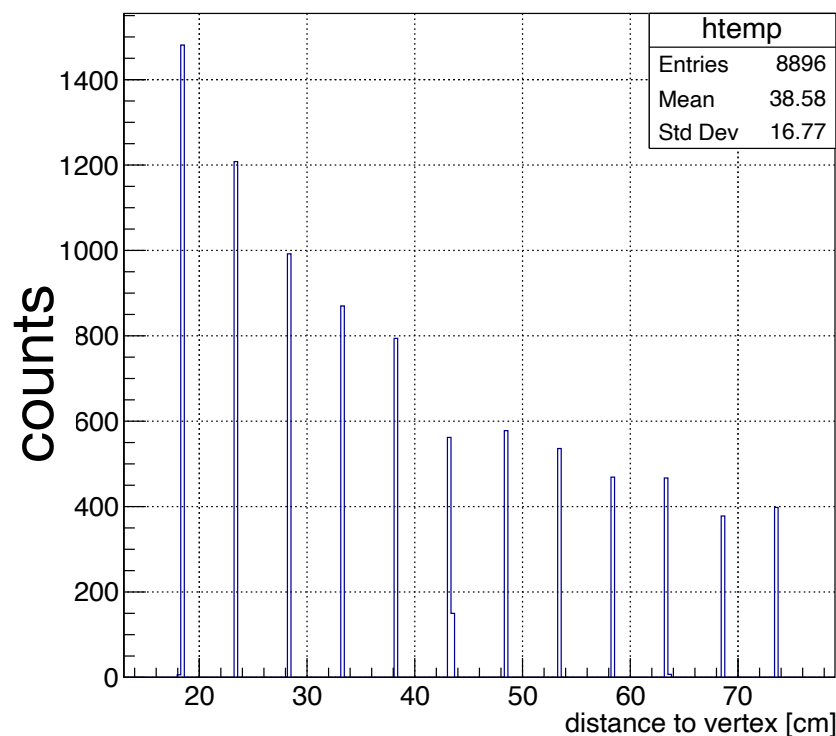
Geant4 simulation preparation

Ground work for G4 MC

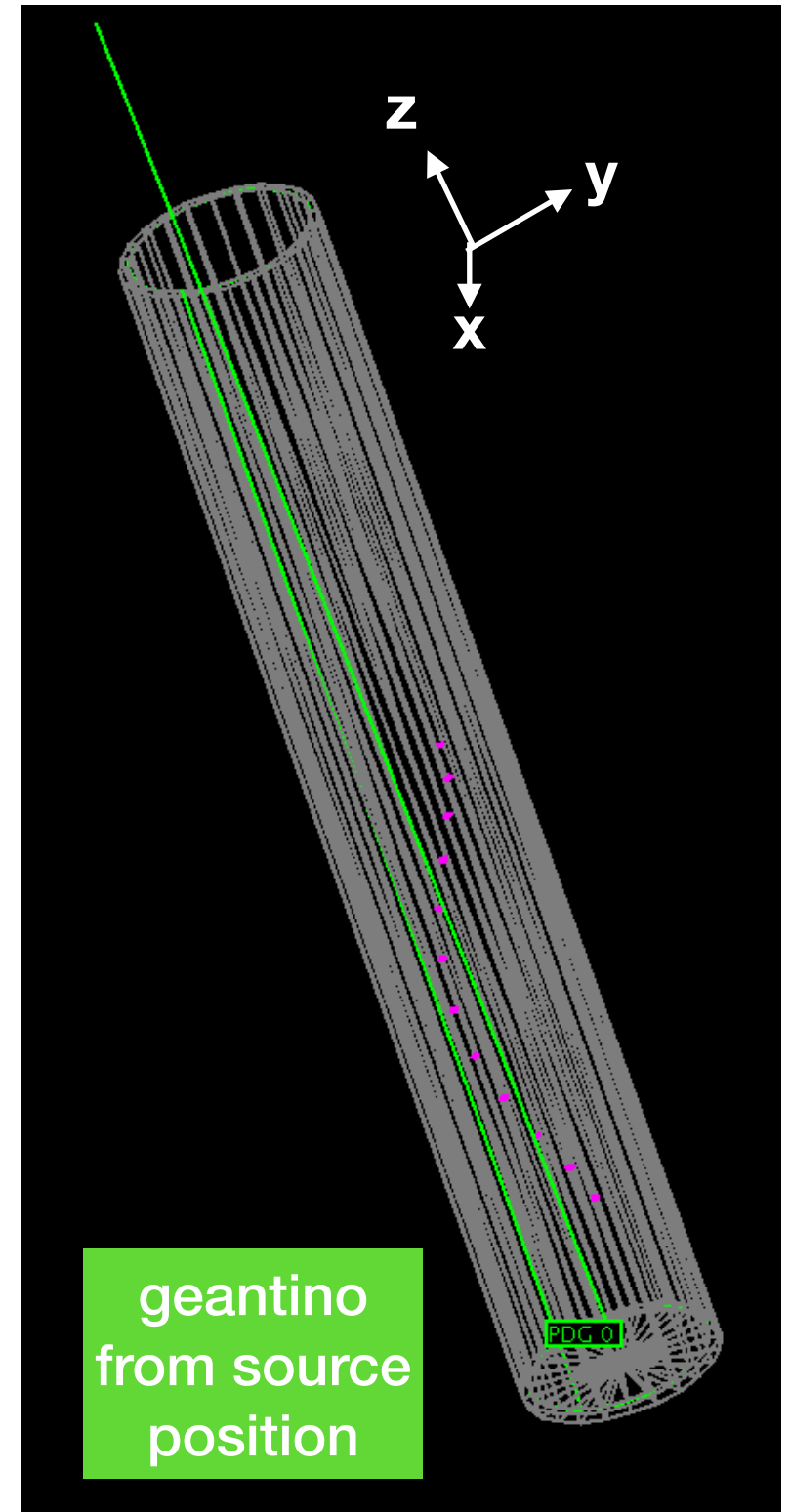
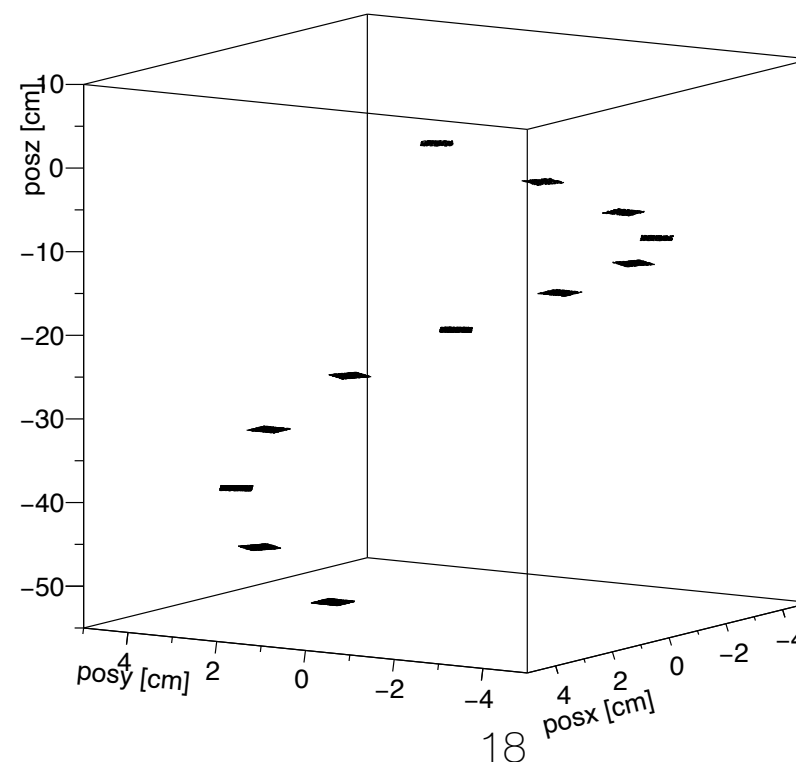
“minimalist” setup implemented:

- LAr vessel, LAr volume
- tentative positions of 12 SiPMs (as Si boxes)
- **geantino** runs for **geometry acceptance**
- Optical Properties & realistic geometry under construction

number of hits @ SiPMs



geantino hits @ SiPM



Summary

Optical Liquid Argon Facility @ Roma Tre

- As an R&D test bench for Legend-1000 LAr detector
- Cryogenic setup constructed
- LAr scintillation direct readout with Hamamatsu VUV4 SiPMs

On-going activities:

- Argon liquefaction procedure establishment
- SiPM frame structure prototype production
- SiPM readout full chain preparation:
SiPM -> Legend FE boards -> CAEN V2740 digitizer
- FPGA based trigger logics (using digitizer FW)
- DAQ: TRIUMF MIDAS based system

notes

Acknowledgement

On design thanks to the LLAMA team at TUM:

Patrick Krause, Laszlo Papp, Stefan Schönert, and Mario Schwarz

Christoph Vogl (working on SCARF, Xenon doping, and LAr purification)

Possible joint effort with Llama-SCARF

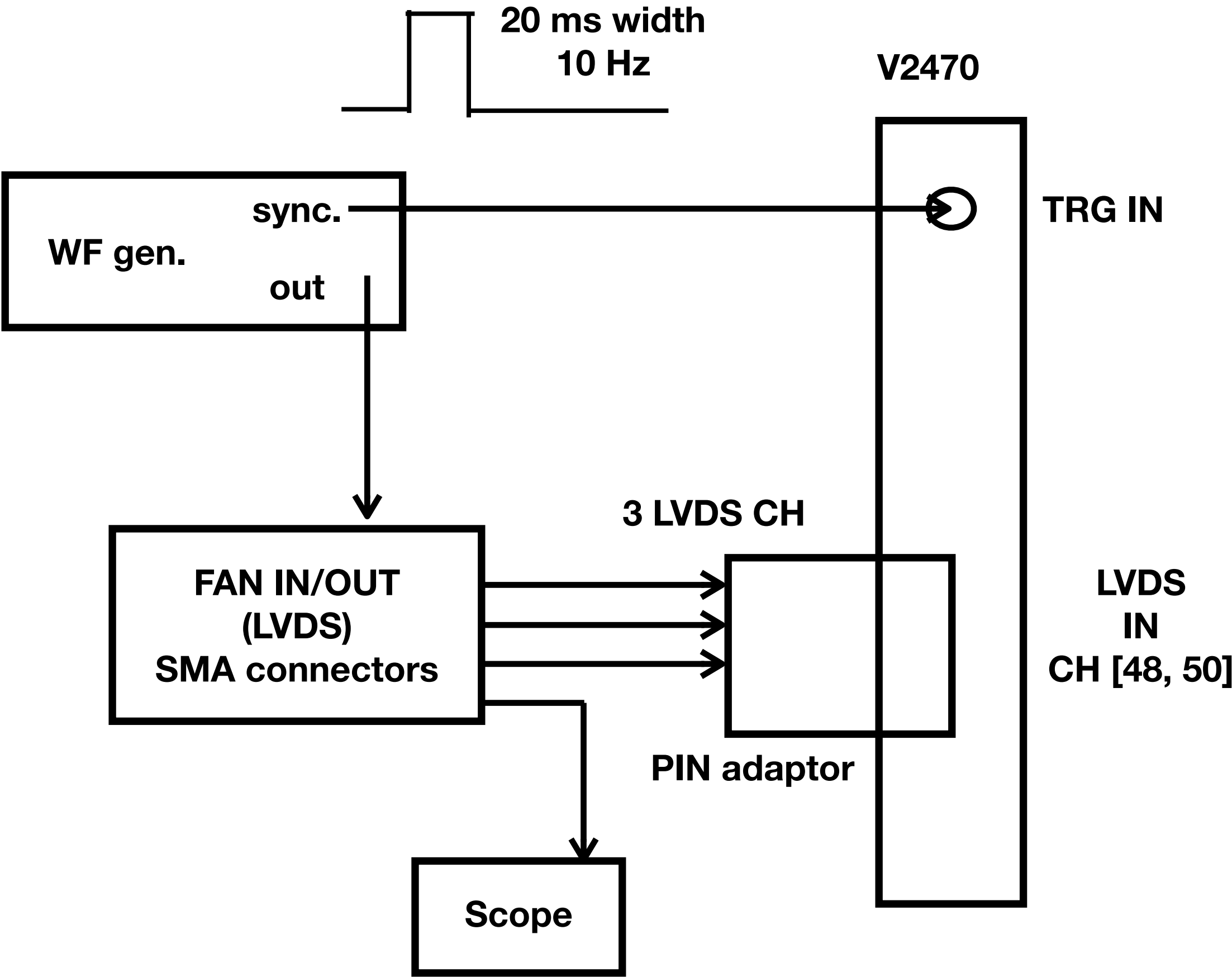
measurement with: reflective surface, doping, impurity ...

**Mechanical workshop team at Roma3:
Gianfranco Paruzza and Co.**

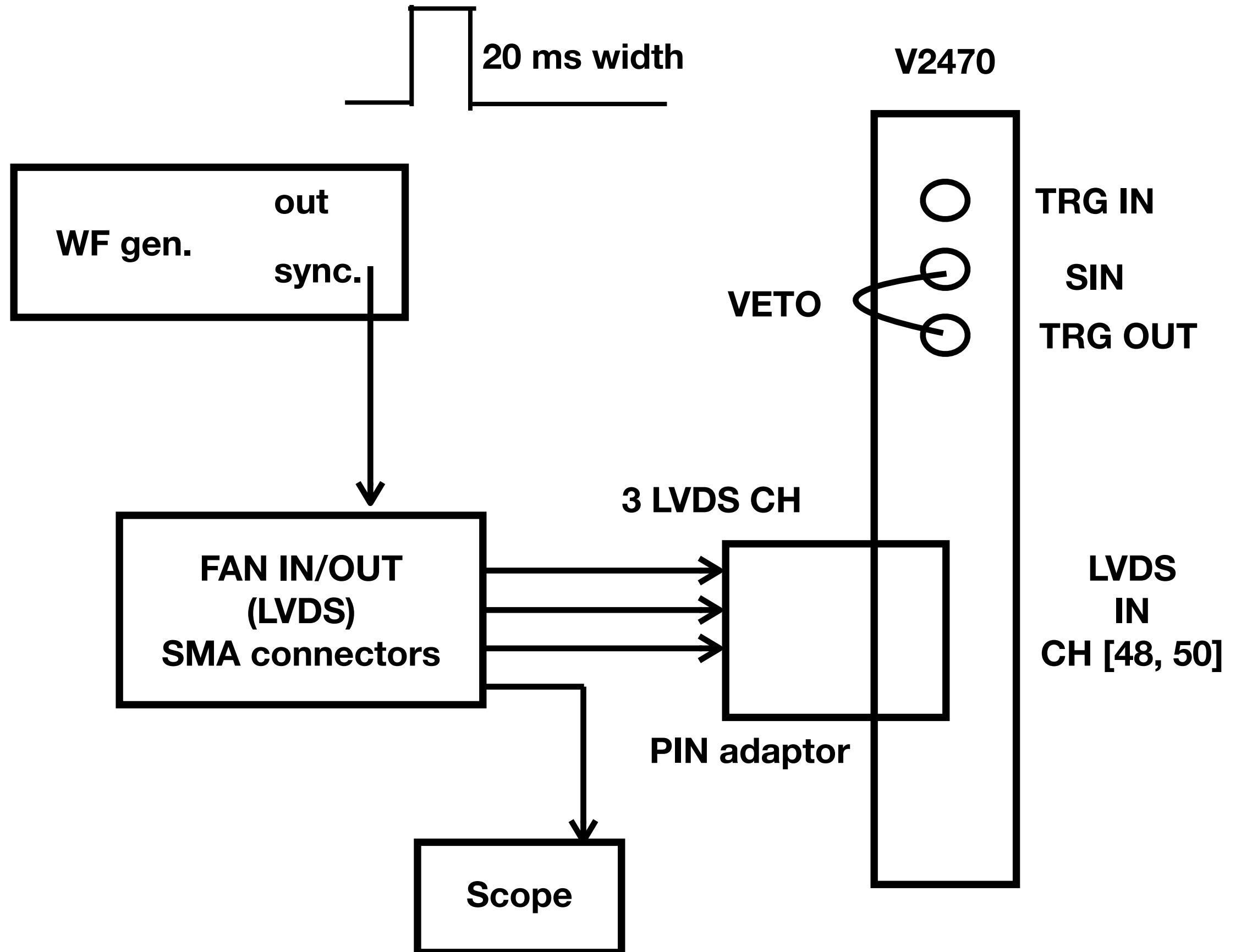
HAMMER team at Roma1 for 3D printing

**Special thanks to:
Krzysztof Szczepaniec @ LNGS**

External TRG readout test



Triple coincidence self-trigger readout test



V2740 DPP-PSD (charge) integration gate length

Internal Test pulse

Test pulse

PreTrigger samples

Test pulse
in
ADC buffer

416 ns (52 samples)

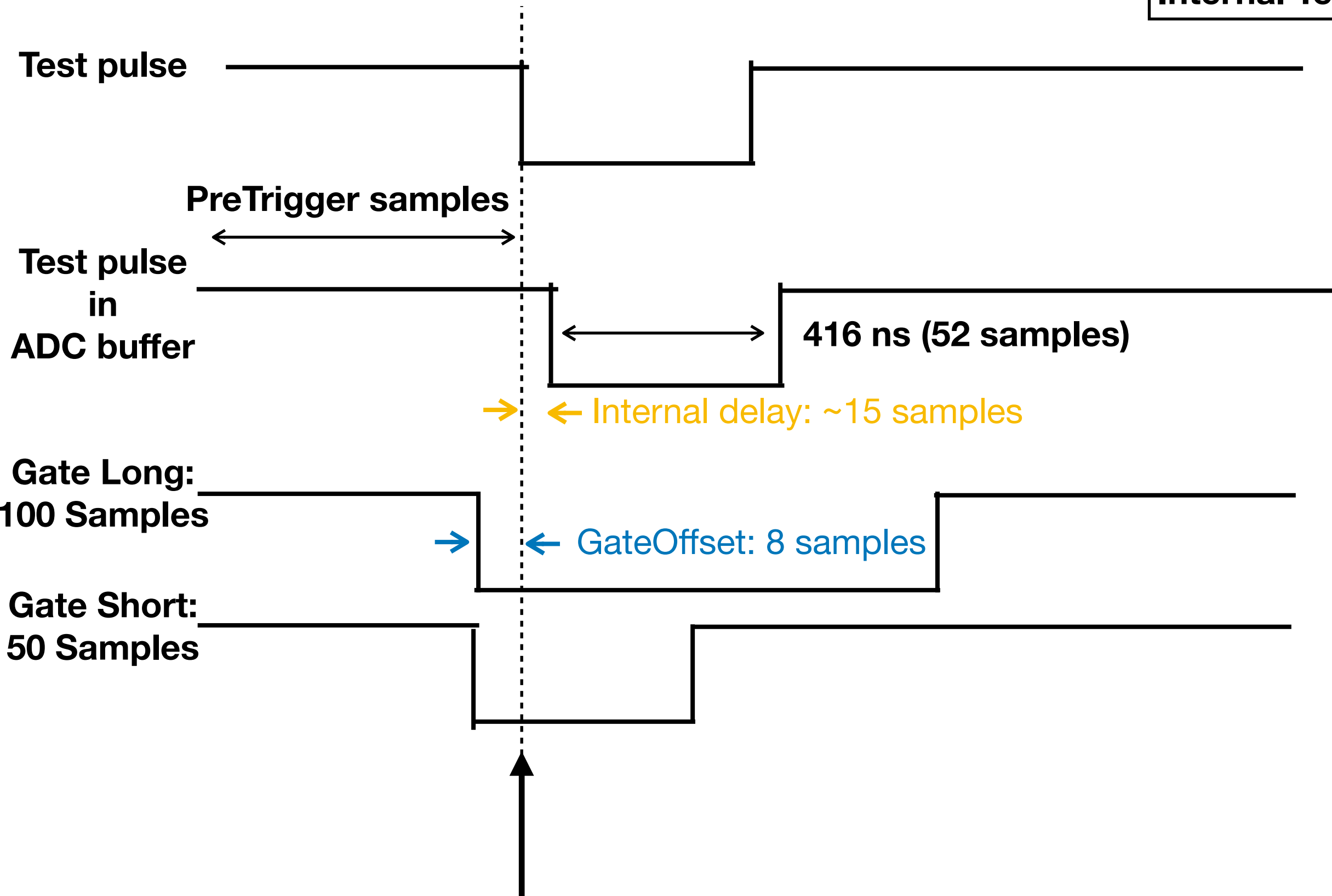
→ Internal delay: ~15 samples

Gate Long:
100 Samples

→ GateOffset: 8 samples

Gate Short:
50 Samples

TRG



G4 geometry preparation

Current environment

MacOS 10.13.6

Geant4.10.2

