N. Di Marco - 05/09/2024

Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DEL GRAN SASSO

Attività LNGS

LNGS

GRUPPO:

Ricercatori: 10 (6.6 FTE)
Tecnologi: 7 (2 FTE)

- + 1 AdR INFN stranieri (in servizio da Settembre 2024)
- + 1 selezione per RTT in corso
- + 1 PhD student

Attività L200:

- Screening dei materiali
- Analysis tasks
  - Quality cuts
  - Online monitoring sw development
  - Pulse Shape Discrimination
- Roles:
  - Co-chairing SB

Attività L1000:

- Water Tank → L3 (C.Vignoli), budget O(1000)k€
- Ancillary equipment → L3 (C. Vignoli), budget O(800)k€
- Installation and Commissioning → L3 + Manager Installation and Commissioning (C. Vignoli)
- HV of Ge detectors
- Outer LAr veto → L3 (N. Di Marco), budget O(2800)k€
- Analysis, simulation, BSM search
- Screening dei materiali

Water tank

- Gara e realizzazione nel 2025
- Installazione a Gennaio 2026

Dr. Ing. Pierluigi D'ANGELO - Via Orientale, 55 ☎0871 930384 – 66030 Arielli (CH) e-mail: pierluigidangelo.ing@gmail.com

ISTITUTO NAZIONALE DI FISICA NUCLEARE

LABORATORI NAZIONALI DEL GRAN SASSO

ESPERIMENTO "LEGEND 1000"

SERBATOIO IN ACCIAIO INOX AISI 304L

DN 12000 mm – Hfasc.=9000 mm – Capacità nom. 1078 m³

CIG: B1055F510A

PROGETTO DI FATTIBILITA' TECNICO-ECONOMICA

QUADRO ECONOMICO

(art. 5 dell'Allegato I.7 del D.lgs. 36/2023)

UBICAZIONE: LABORATORI SOTTERRANEI DEL GRAN SASSO DEI LNGS

COMMITTENTE: LABORATORI NAZIONALI DEL GRAN SASSO - (L'AQUILA)

IMPRESA:

COMMESSA N.: 24047

DISEGNO N.: DWG-24047 rev. 0

DOCUMENTO N.: QE-24047

D'Angelo Pierluigi
Ordine degli Ingegneri della Provincia di Chieti
Ingegnere
11.07.2024 08:46:27 GMT+00:00

REV	DATA	EMESSO IL PROGETTISTA	VALIDATO RUP INFN - LNGS	VERIFICATO
01	05/07/2024	Ing. PIERLUIGI D'ANGELO	Ing. UMBERTO DI SABATINO	

Dr. Ing. Pierluigi D'ANGELO - Via Orientale, 55 ☎0871 930384 – 66030 Arielli (CH) e-mail: pierluigidangelo.ing@gmail.com

QUADRO ECONOMICO (*art. 5 dell'Allegato I.7 del D.lgs. 36/2023*)

Lavori per la realizzazione, all'interno della sala C dei laboratori sotterranei, di un serbatoio in acciaio INOX AISI304L per acqua demineralizzata - LEGEND1000

				IMPORTI DA P.F.T.E.	
A. SOMME A BASE D'APPALTO			A. IMPORTO A BASE DI GARA	%	€
	A.1		Importo dei lavori a corpo		€ 641.435,56
		A1.1	di cui oneri per la manodopera	17,82%	€ 114.335,00
			Totale importo lavori		€ 641.435,56
	A.2		Oneri per la sicurezza non soggetti a ribasso		€ 63.375,71
			Totale importo dei lavori (A.1 + A2)		€ 704.811,27
			Totale importo soggetto a ribasso		€ 641.435,56
B. SOMME A DISPOSIZIONE DELL'AMMINISTRAZIONE			B. SOMME A DISPOSIZIONE DELL'AMMINISTRAZIONE	%	€
	B.1		Spese tecniche		
		B.1.1	Spese tecniche (incarichi esterni) per PFTE/Progetto Esecutivo e Coordinamento della Sicurezza in fase di Progettazione - comprensivo di CNPAIA (4%)		€ 20.800,00
		B1.2	Spese tecniche (incarichi esterni) per Coordinamento della Sicurezza in fase di Esecuzione - comprensivo di CNPAIA (4%)	(*)	€ 4.000,00
		B1.3	Spese tecniche (incarichi esterni) per Collaudo Statico - comprensivo di CNPAIA (4%)	(*)	€ 4.500,00
		B1.4	Incentivo per le funzioni tecniche svolte dai dipendenti pubblici per le attività di programmazione della spesa per investimenti, per la verifica preventiva dei progetti di predisposizione e di controllo delle procedure di bando e di esecuzione dei contratti pubblici, di responsabile unico del procedimento, di direzione dei lavori, ecc. (art. 45 del D.lgs. n. 36/2023) = massimo il 2,00% dell'importo dei Lavori a base d'appalto	2%	€ 14.096,23
			Totale spese tecniche		€ 43.396,23
	B.2		Altre somme a disposizione dell'Amministrazione		
		B.2.1	Imprevisti e arrotondamenti (max 10% dell'importo lavori a base di gara)	10%	€ 70.481,13
		B.2.2	Spese per pubblicità e contributo ANAC	(*)	€ 3.500,00
		B.2.3	Spese per prove di laboratorio, accertamenti e verifiche tecniche obbligatorie o specificatamente previste nel capitolato speciale d'appalto (art. 116 comma 11 del D.lgs. 36/2023)	(*)	€ 3.000,00
		B.2.4	Polizze rischi professionali per le funzioni tecniche svolte dai dipendenti dell'amministrazione (art. 2, comma 4 del D.lgs. 36/2023)	(*)	€ 2.500,00
			Totale altre somme a disposizione		€ 79.481,13
	B.3		I.V.A.		
		B.3.1	I.V.A. su Lavori	22%	€ 141.115,82
		B.3.2	I.V.A. su sicurezza	22%	€ 13.942,66
		B.3.3	I.V.A. su Somme a disposizione dell'Amministrazione	22%	€ 23.931,85
			Totale I.V.A.		€ 178.990,33
			Totale somme a disposizione dell'Amministrazione		€ 301.867,68
			TOTALE COSTO INTERVENTO (A+B)		€ 1.006.678,96

NOTA (*): gli importi (*) sono stati inseriti forfettariamente ai soli fini della completezza formale del quadro economico e saranno [illegible] in sede di progetto esecutivo

Arielli (CH), li 05/07/2024 Il tecnico progettista: (*Dr. Ing. Pierluigi D'Angelo*)

D'Angelo Pierluigi
Ordine degli Ingegneri della Provincia di Chieti
Ingegnere
11.07.2024 08:46:27 GMT+00:00

Ge detector HV

O(400) canali

Parameters	Specifications
Number of HV channels	$\geq$ 340-360
HV output range	0 to $\geq$ 5 kV
Maximum current output	$\geq$ 10 μ A
Voltage set precision	$\leq$ 1 V
Voltage ripple	$\leq$ 10 mV
Voltage monitor resolution	$\leq$ 0.1 V
Current monitor resolution	$\leq$ 50 pA
Minimum ramping speed	$\leq$ 5 V/s

CAEN/ISEG vendors fulfill above requirements
Minimization of intrinsic electronic noise needed

Attività 2024-2025: acquire and test a CAEN system --> chassis equipped with A1632HP and A1560HDPE boards and measure their electronic noise. Develop custom filter-box prototypes.

Richieste:

- Sonda per oscilloscopio Teledyne LeCroy AP033
- Materiale di consumo vario per fare filter box e power supply nuovi per ridurre rumore

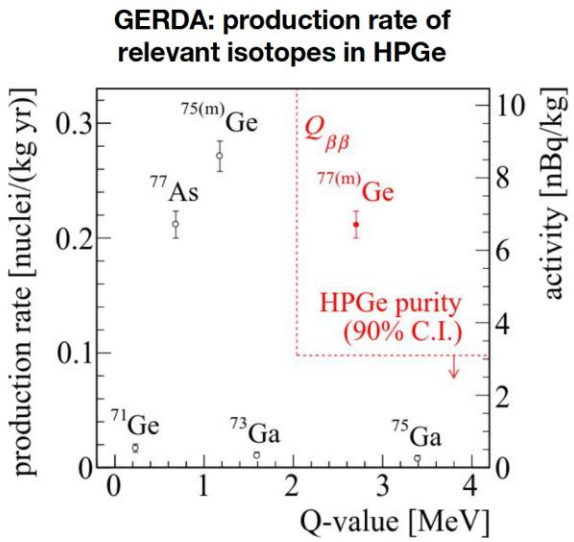
Outer LAr veto

Muons can cause a hadronic shower in the cryostat with a high multiplicity of neutrons.

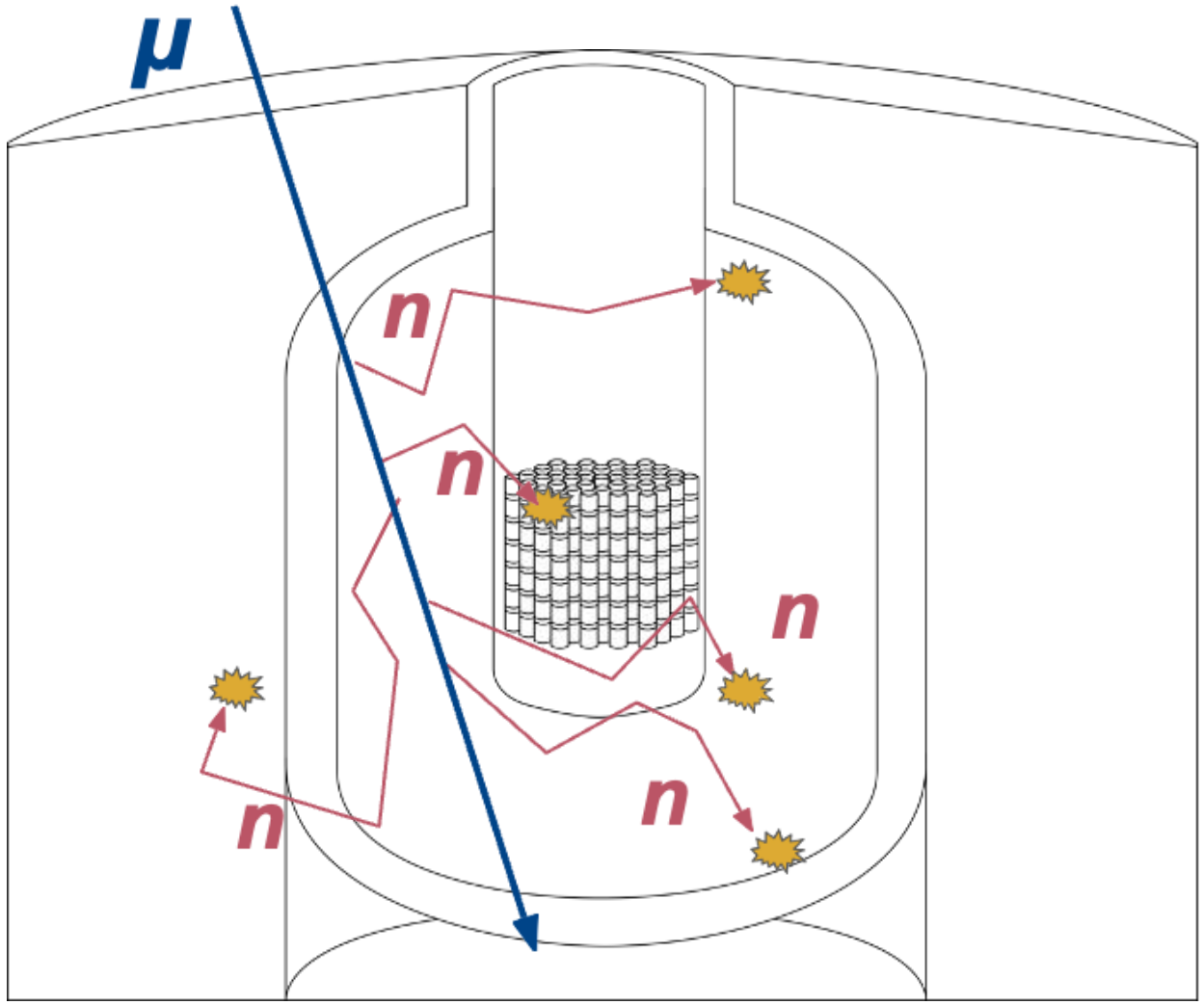
Neutrons can be captured in the HPGe and produce long-lived isotopes.

Such cosmogenic isotopes are relevant if $Q_{\beta} > Q_{\beta\beta}$ and are produced frequently enough.

The only relevant one is 77(m)Ge

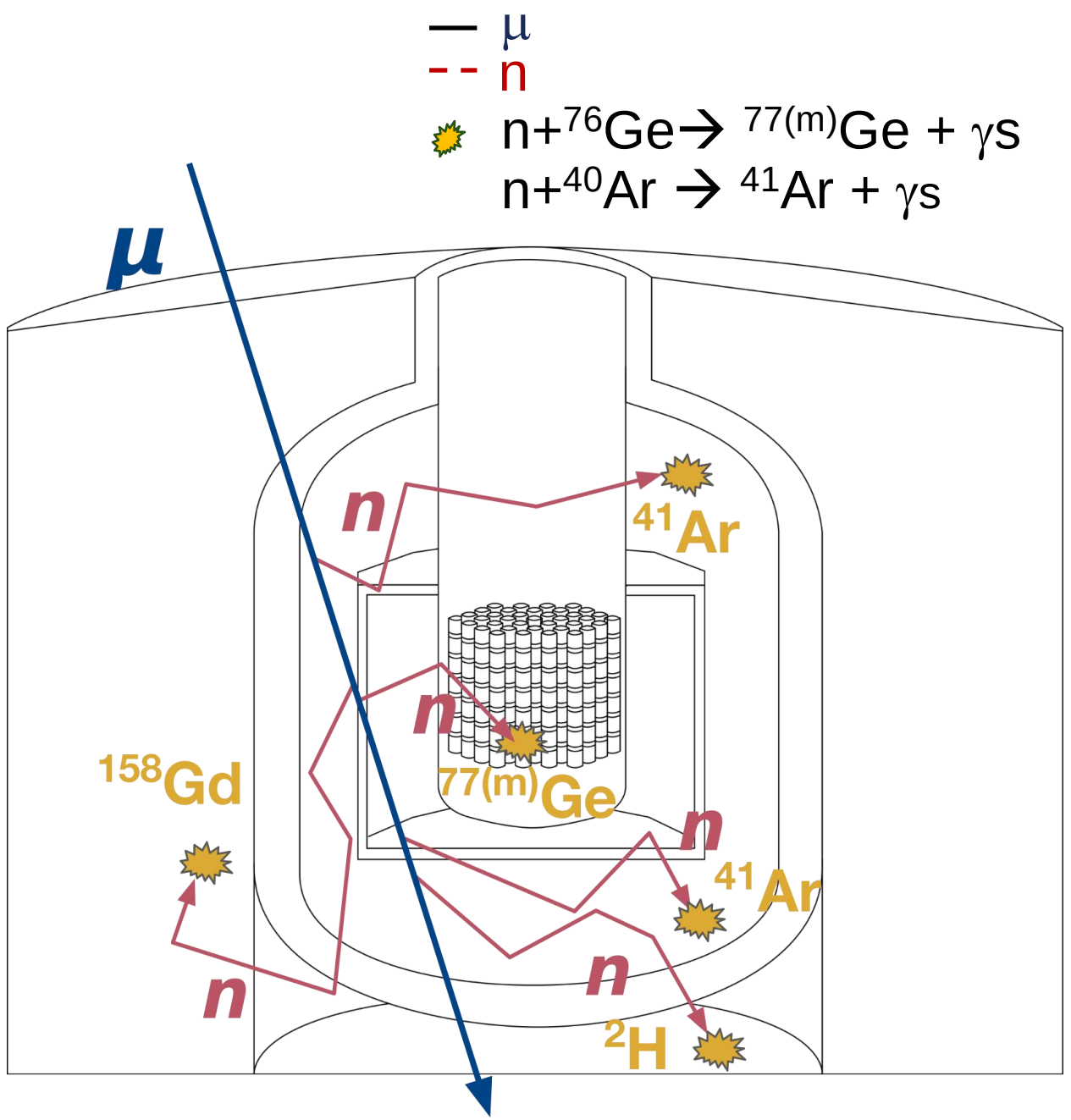


~ 2×10^{-5} counts/(keVkgyr)



Outer LAr veto

Tag ^{77}Ge and ^{77m}Ge cosmogenic isotopes by detecting ***siblings neutrons***, i.e. neutrons captured on nuclei other than ^{76}Ge.

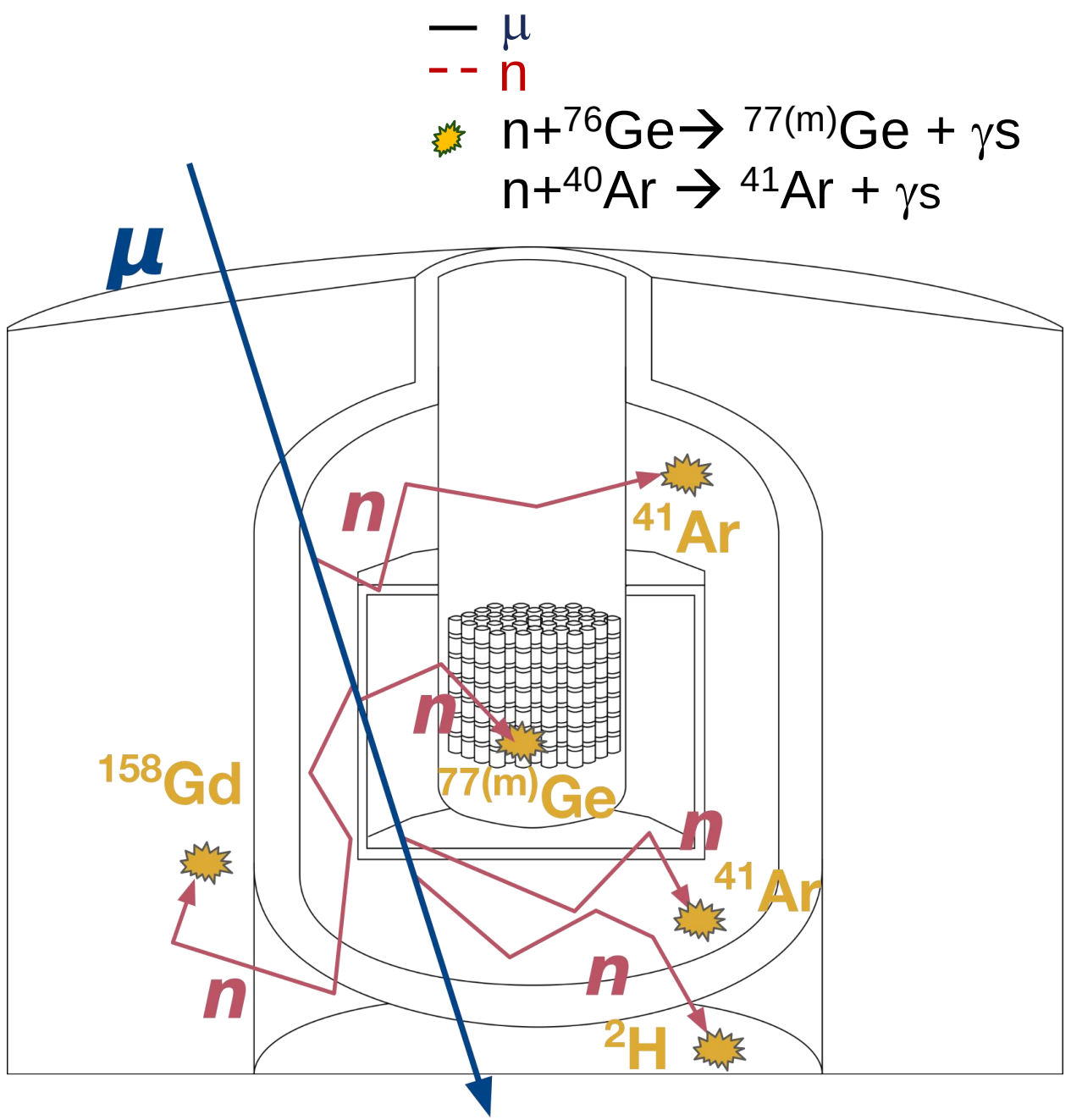


Outer LAr veto

Tag ^{77}Ge and ^{77m}Ge cosmogenic isotopes by detecting ***siblings neutrons***, i.e. neutrons captured on nuclei other than ^{76}Ge.

Double strategy.:

1. The use of a ***passive layer of a hydrogen-rich material*** to reduce the energy of fast neutrons produced by the interaction of cosmic muons with the experimental setup. This energy reduction enhances the fraction of neutrons captured in materials other than Ge.



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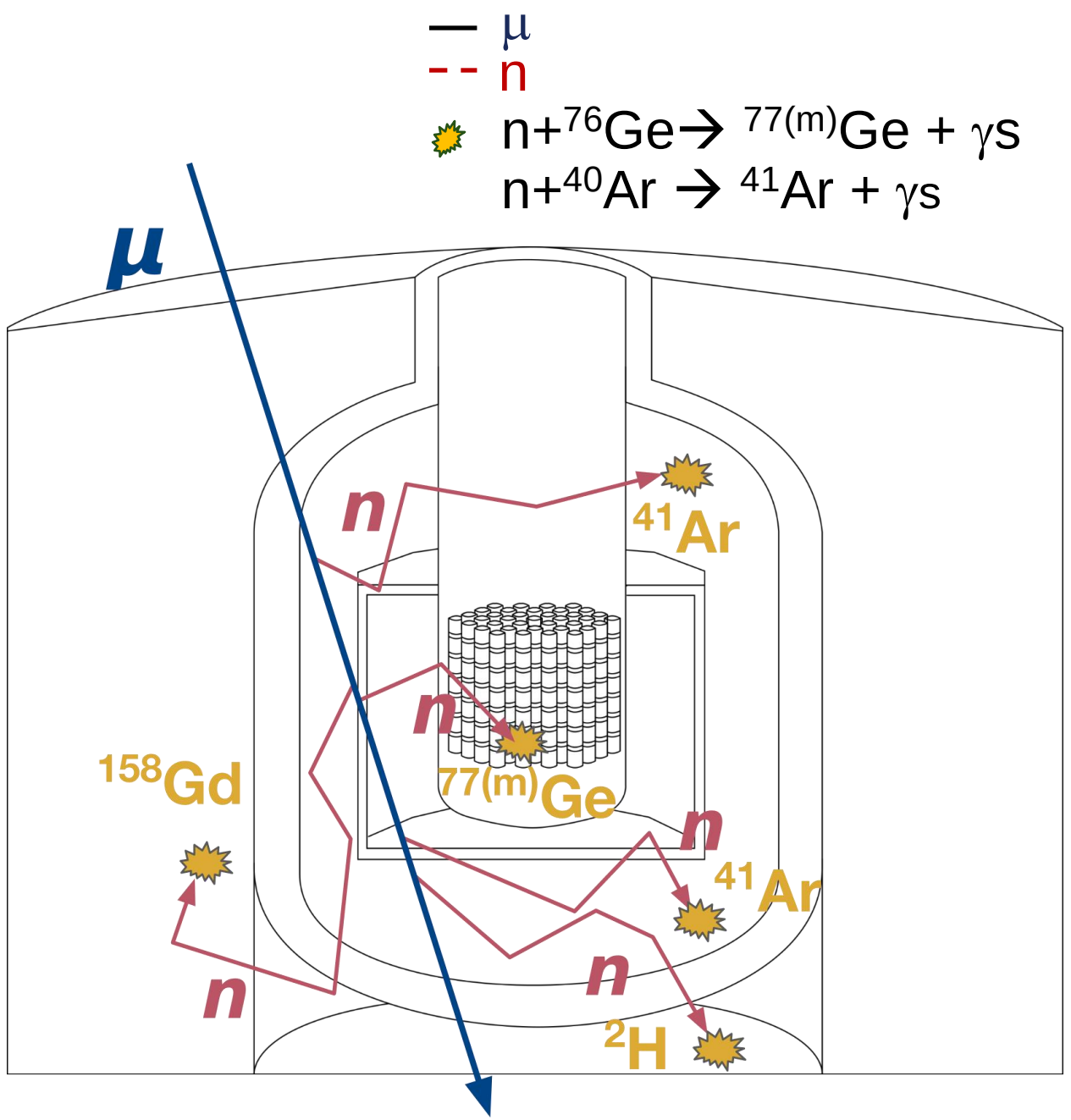
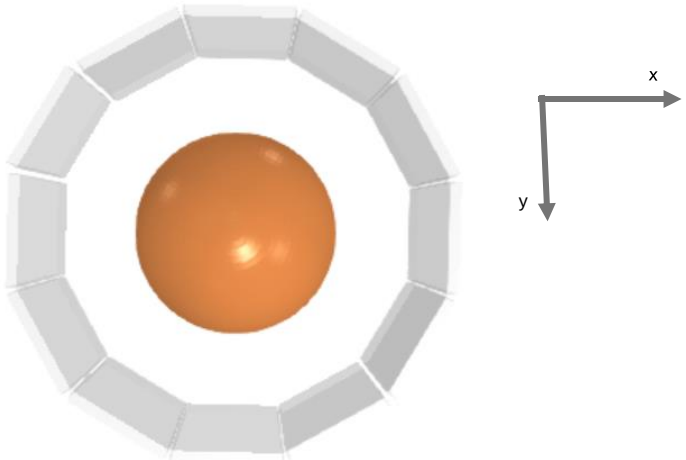
Double strategy.:

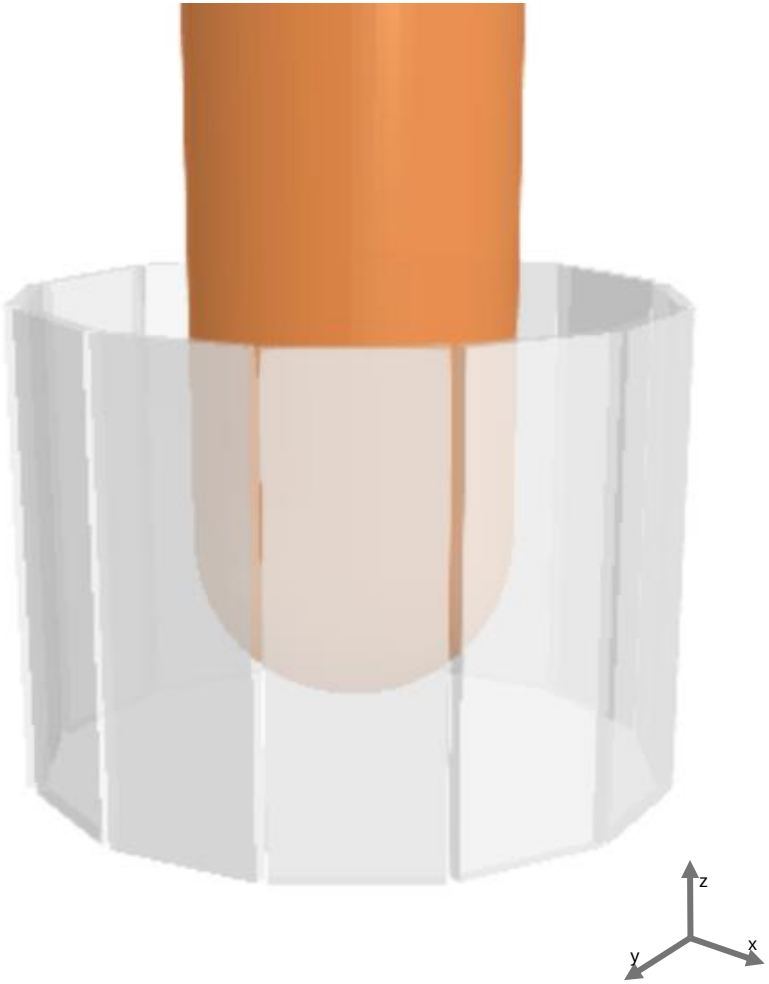
1. The use of a ***passive layer of a hydrogen-rich material*** to reduce the energy of fast neutrons produced by the interaction of cosmic muons with the experimental setup. This energy reduction enhances the fraction of neutrons captured in materials other than Ge.

2. The detection of such captures, through a dedicated ***LAr instrumentation***, introduces the possibility of applying and improving the ***delayed coincidence methods***.



Outer LAr veto – n moderator



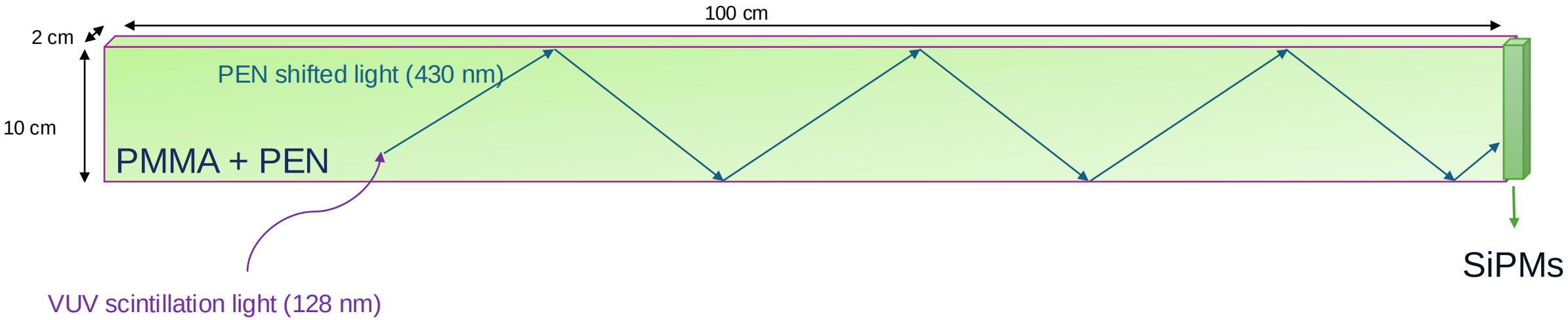


Polymethyl methacrylate (PMMA) ensures the best compromise between moderation performance and radiogenic background level.

- Dodecagonal prism sitting in the atmospheric LAr volume at 2 m from the center of the Ge strings
- 12 panels, 300 x 100 x 10 cm^3 each
- Segmented top and bottom lids

Outer LAr veto – LAr read-out

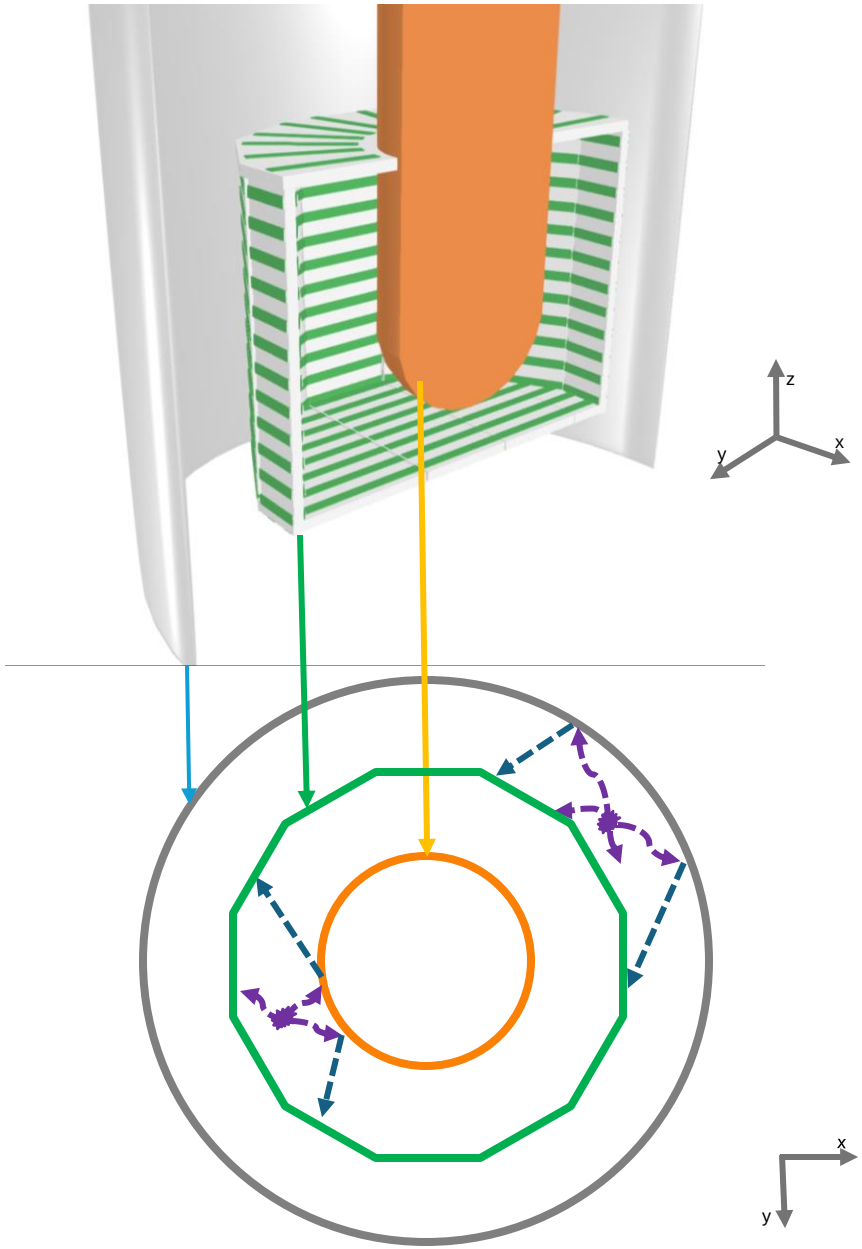
- Read-out instrumentation (reference design):
  - 100×10×2 cm^3 ***light guides*** made of PMMA and wrapped with a thin foil of PEN or TPB acting as a wavelength shifter for the 128 nm Ar light (or 175 nm of Xe-doped LAr).
  - The readout is performed at one (or both) end(s) of the guide with 12, 6 × 6 mm^2 ***SiPMs***.



Outer LAr veto – LAr read-out

(reference design)

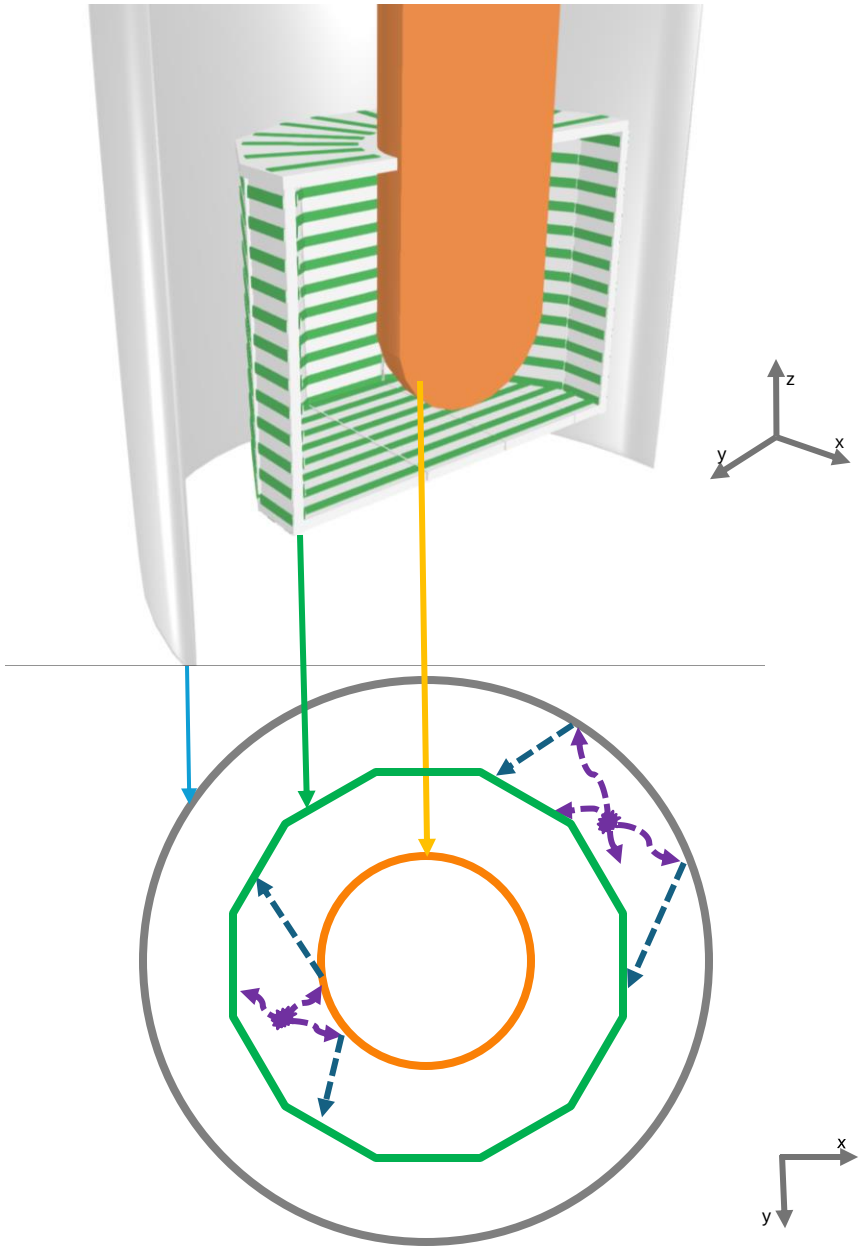
- 12 horizontal light guides on each side of the moderator panel: 288 SiPMs/panel.
- Each side of the top and bottom lids is equipped with 24 and 45 light guides, respectively.



Outer LAr veto – LAr read-out

(reference design)

- 12 horizontal light guides on each side of the moderator panel: 288 SiPMs/panel.
- Each side of the top and bottom lids is equipped with 24 and 45 light guides, respectively.
- The total number of SiPMs is 5112. Assuming groupings of 6 (12) SiPMs, this translates into 852 (426) readout channels



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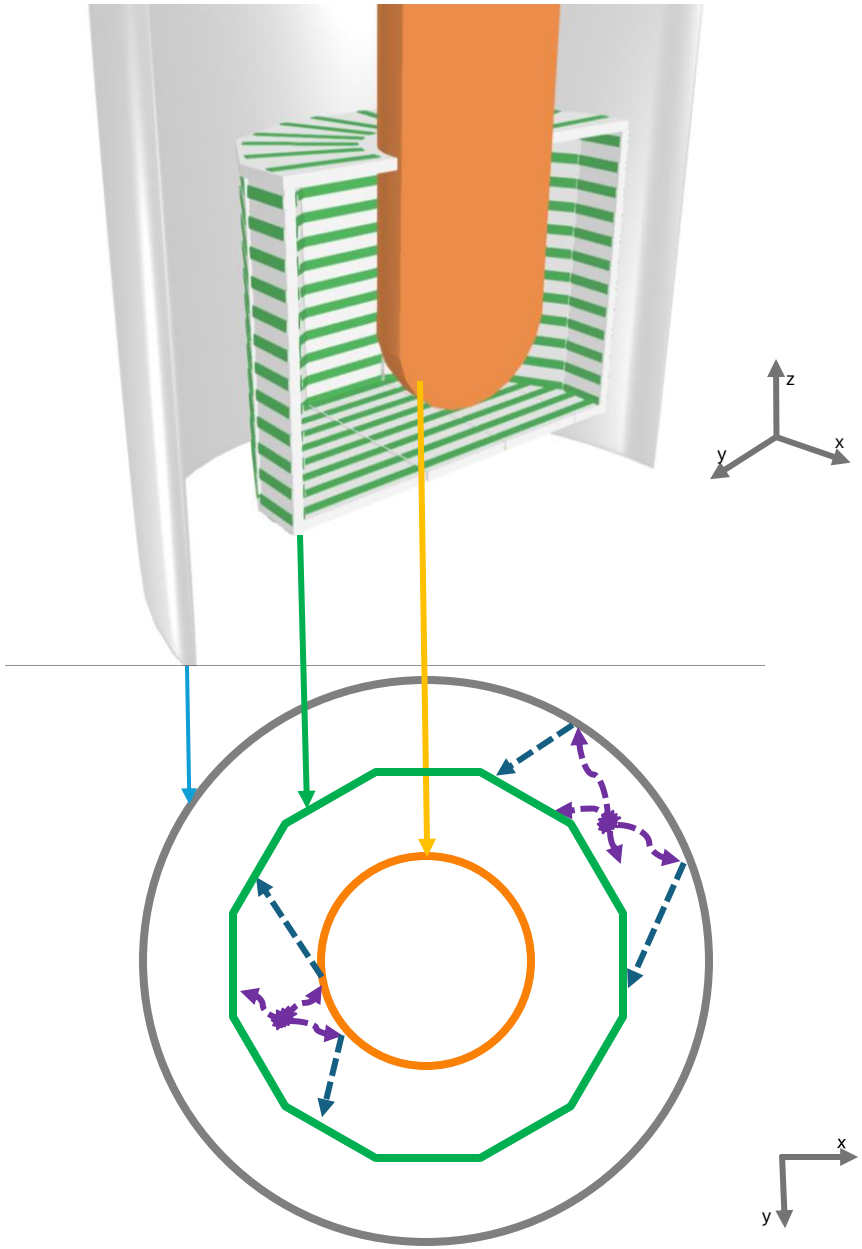
- To assure a high light collection efficiency, the cryostat surfaces facing LAr, as well as the external reentrant tube wall, will be lined with a ***wavelength-shifting reflective foil***.



Outer LAr – Activities

Neutron moderators:

- Screening — LNGS
- Tests (radon emanation, crioresilience, mechanics, mod. power) — PD + RM3 + LNGS
- Support structure — **PD**
- Production
- Cleaning
- Handling
- Mounting

} PD + RM3 + LNGS

Light Guides:

- Screening — **LNGS**
- Simulation — PD + RM3 + LNGS + MiB
- Test — PD + LNGS + MiB
- Production — MiB
- TPB evaporation /PEN lamination — NA/MiB + LNGS
- Cleaning
- Assembly
- Quality test
- Mounting

} PD + RM3 + LNGS + MiB

SiPM:

- Screening — LNGS
- Design + Down-selection
- Quality test (characterization)

} **RM3** + PD + NA(?)+LNF(?)+MIB

- Procurement
- Assembly — MiB

Cables: LNGS

- Screening

- Cables — **MiB**
- Feed-through — RM3

Test stands

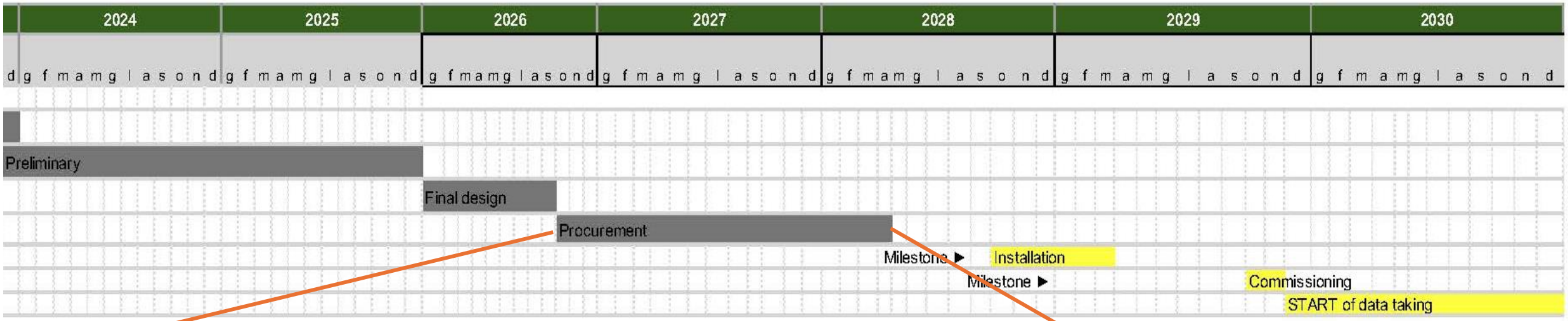
- Design
- Construction
- Commissioning
- Tests

} - **LEGENDArYno** — PD + **LNGS** + MiB
- **LEGENDARy** — PD + RM3 + **LNGS**

Reflector + WLS: under development@Zurich

Xe-doping system: under development@TUM — NA

Time plan (preliminary)



Neutron moderator

- Production (Clax/Donchamp/Reynolds)
- Transportation to above-ground clean-room (CR2-NOA@LNGS)
- Surface cleaning

Light guides

- Production (Glass2Power, Plastidite)
- Transportation to above-ground clean-room (CR2-NOA@LNGS)
- Surface cleaning
- PEN wrapping/TPB evaporation

SiPM

- Production (FBK)
- SiPM assembly NOA@LNGS
- Characterization OLAF@Roma3

Light read-out system

- SiPM installation on the light guides NOA@LNGS
- Test of the full read-out chain in the LEGENDArY facility @LNGS

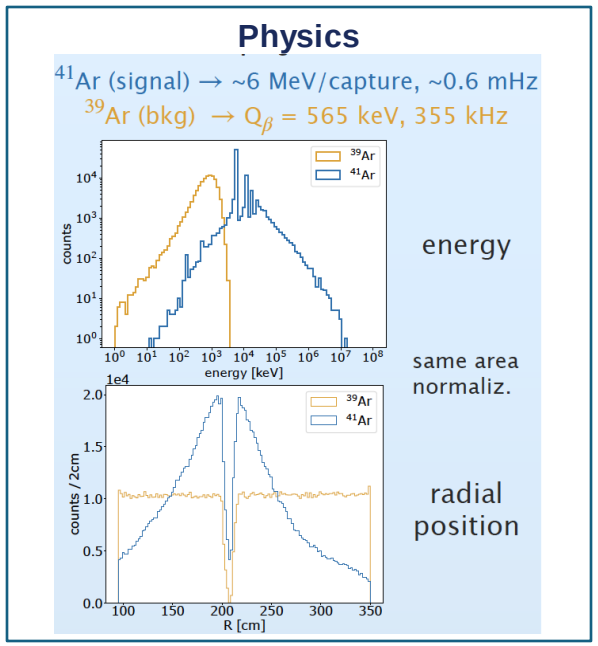
Outer LAr instrumentation

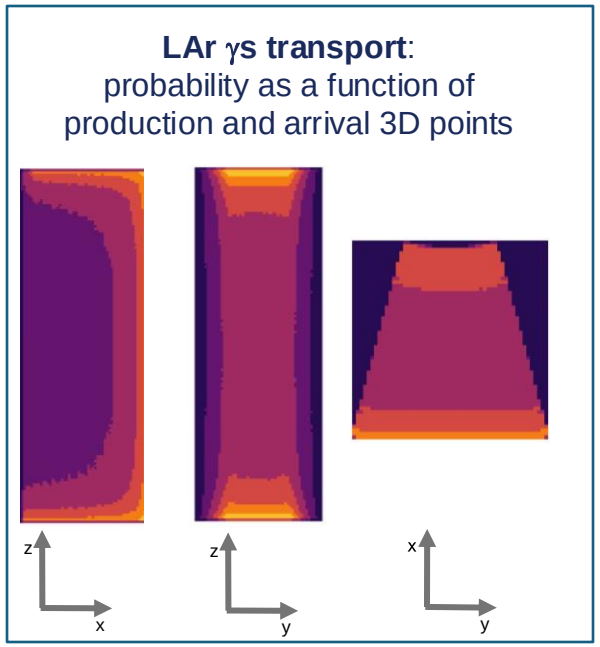
- Light readout system installation on moderator panels
- Sealing, transportation in UG, installation
- Installation of reflector + WLS on cryostat wall + RT
- Installation of Xe-doping system

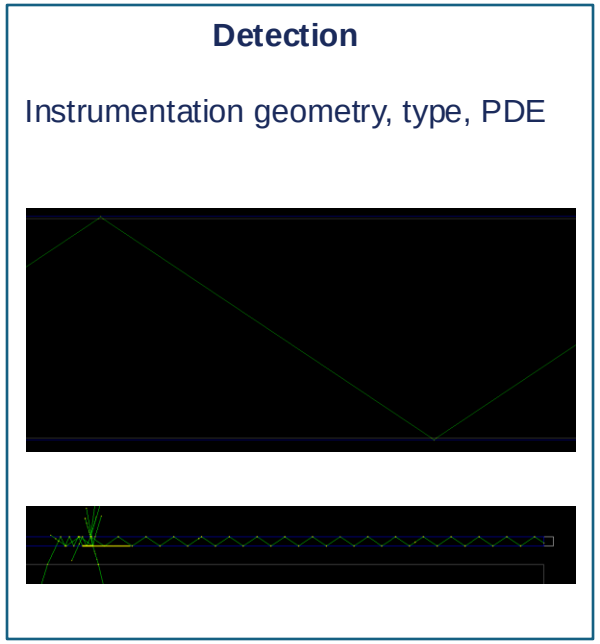
Outer LAr Simulation

1. Simulation

i. 77(m)Ge production rate vs cryostat and moderator geometry (reevaluation on new design requirements)
ii. Radiogenic bkg budget (reevaluation on new design requirements). Include radiogenics from instrumentation, reflectors + WLS, support structure etc…
iii. Veto efficiency evaluation, trigger condition accounting for different bkg contribution (39Ar, 42K, Th/U)
iv. Determination of the target photon detection efficiency of the instrumentation
v. Compare reference vs alternative design







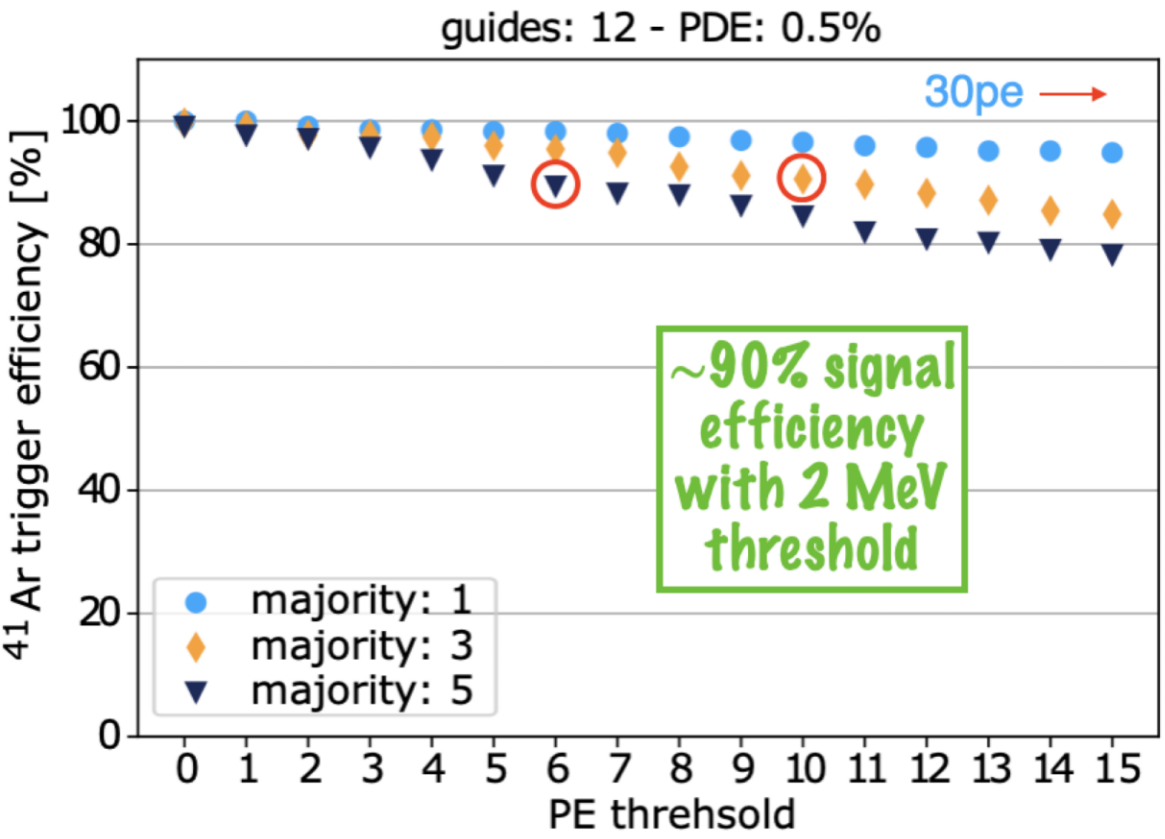
Simulation framework (almost) completed: modular sw to compare baseline vs alternative design, different instrumentation geometries and PDEs.

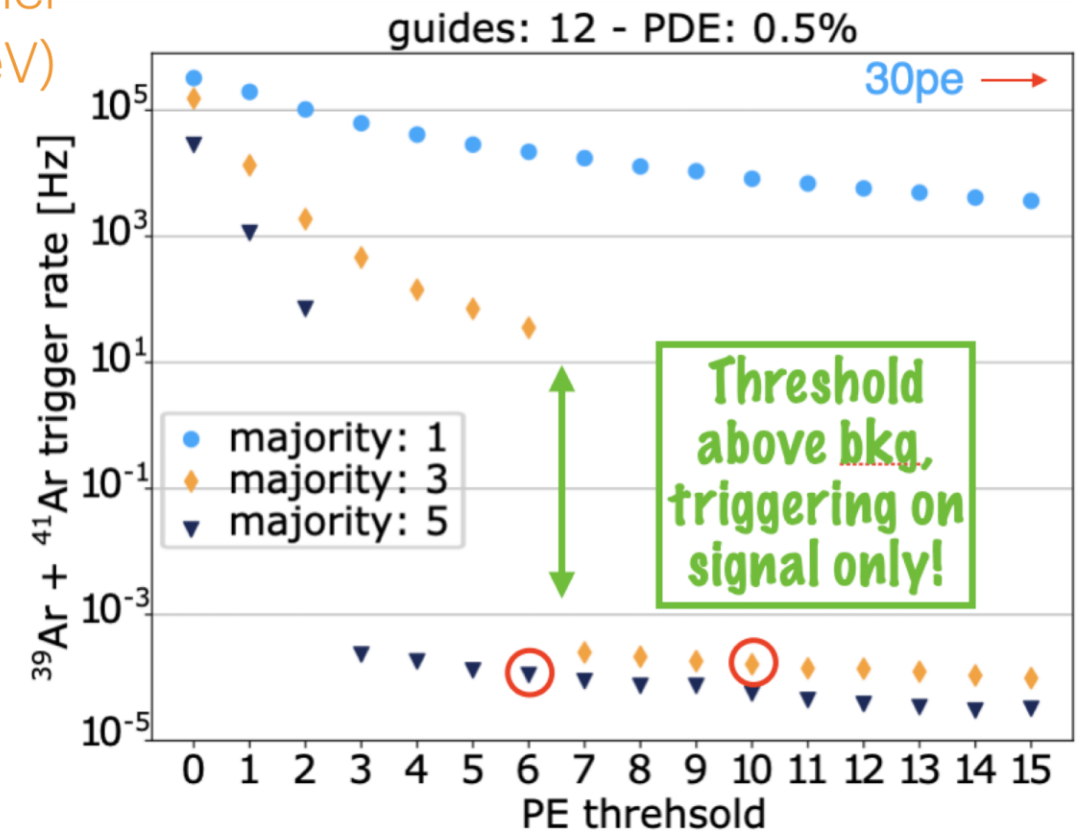
Outer LAr veto -simulation

LY is now actually slightly higher (~20 PE/MeV)

Light Yield ~15 PE/MeV

2 MeV threshold

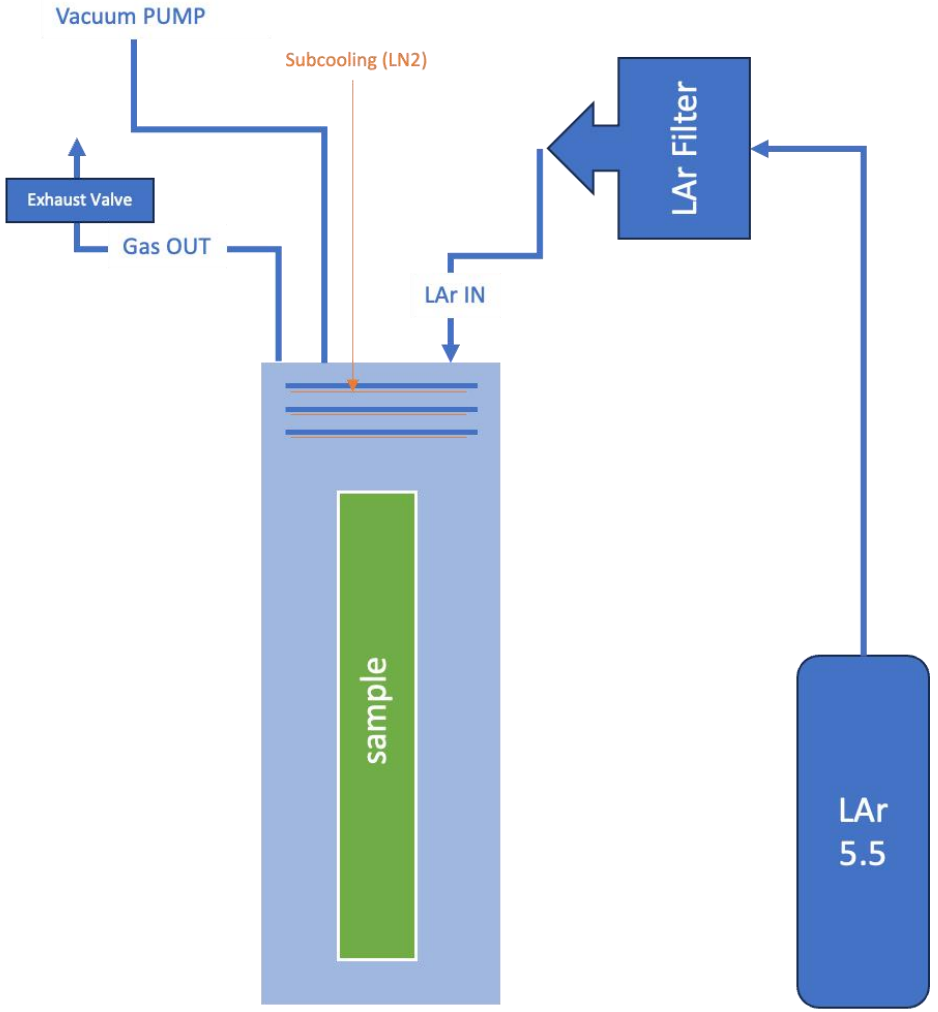




LEGENDArYno – test stand

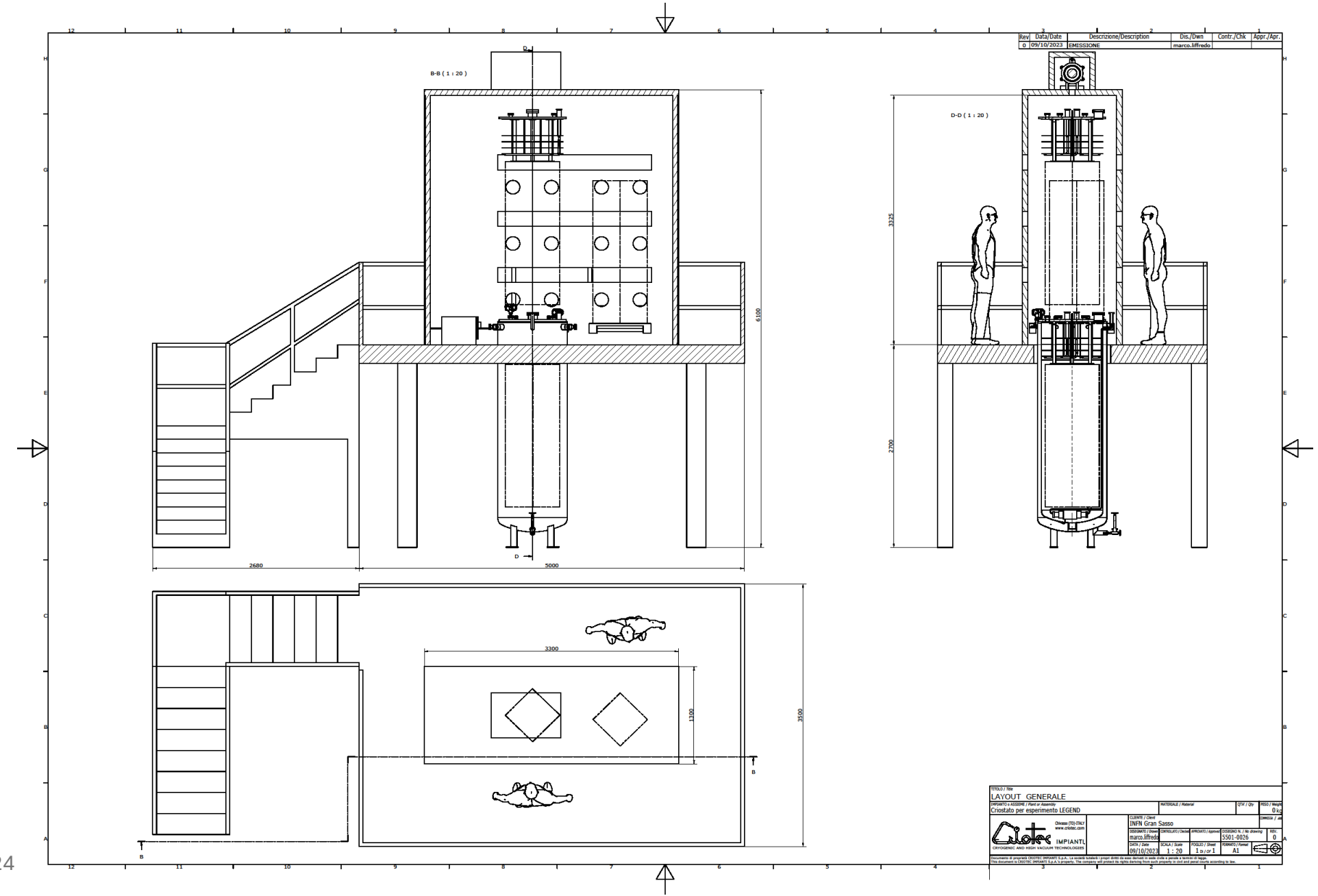
Richieste 2025

1. Crane sollevamento flangia
2. Pompa da vuoto (primaria + turbo)
3. Digitizer
4. Consumi LAr, GAr, LN2

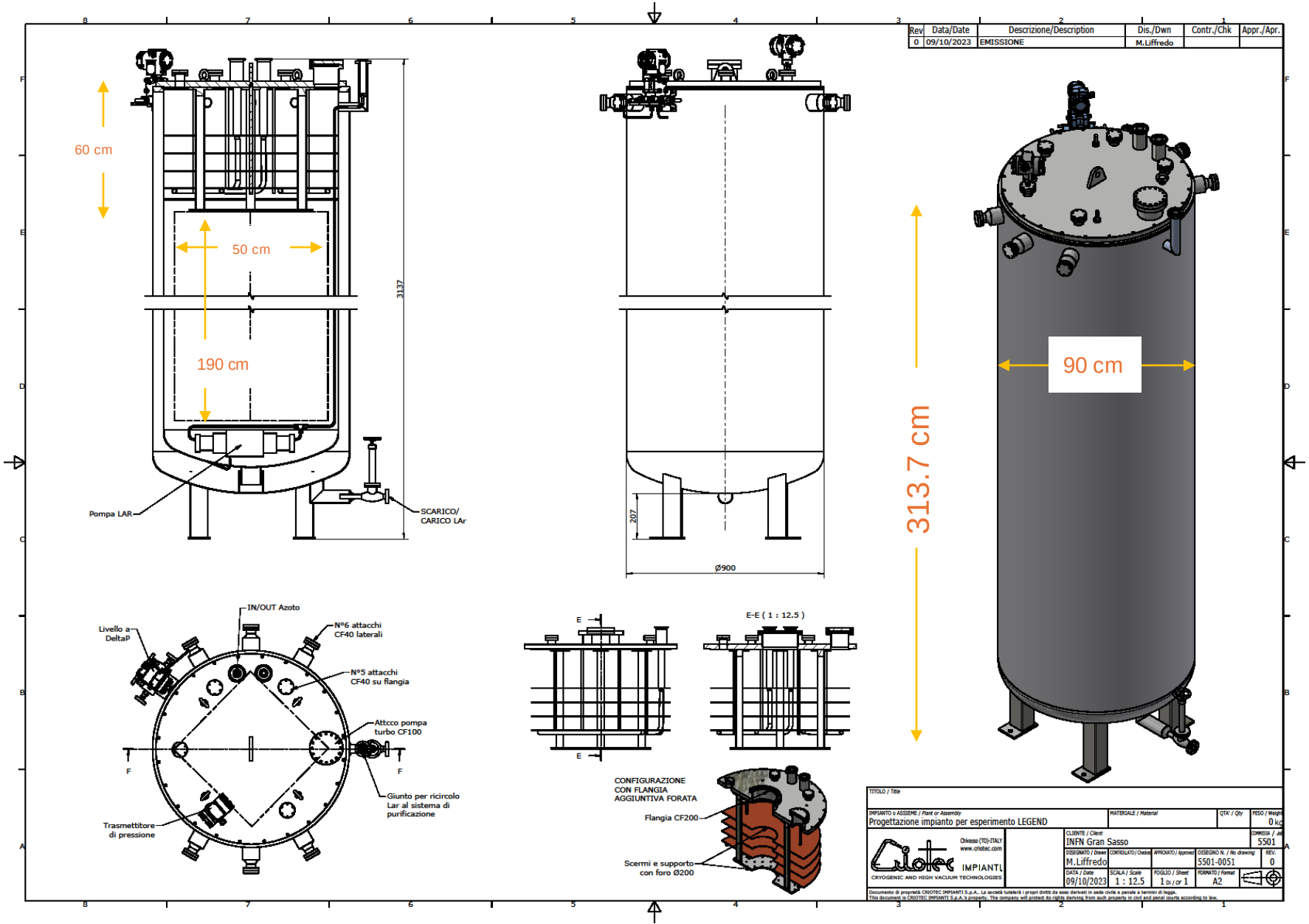


LEGENDArY – mass test stand

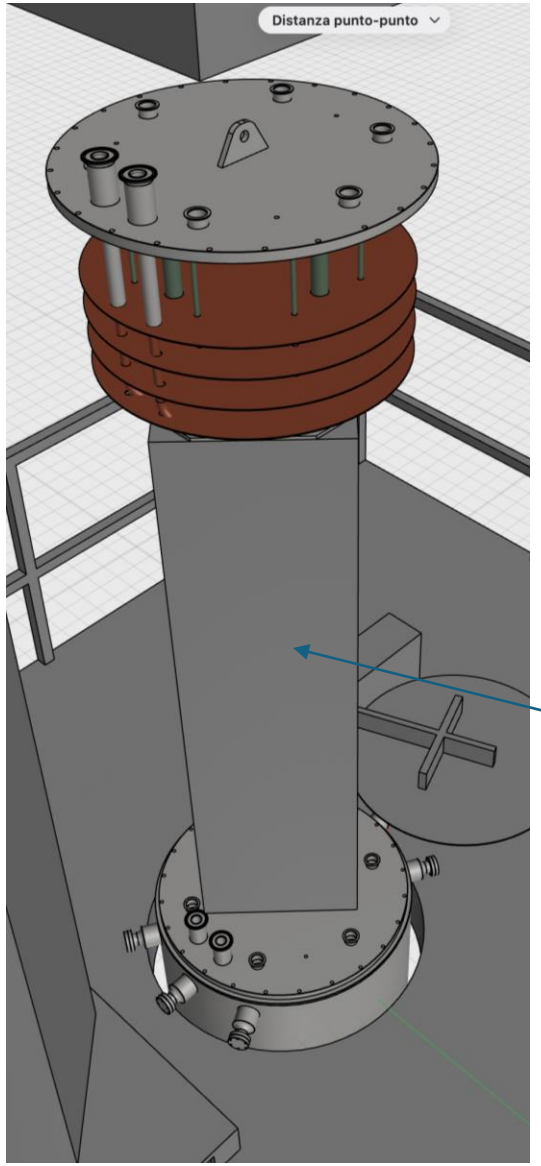
LEGENDArY

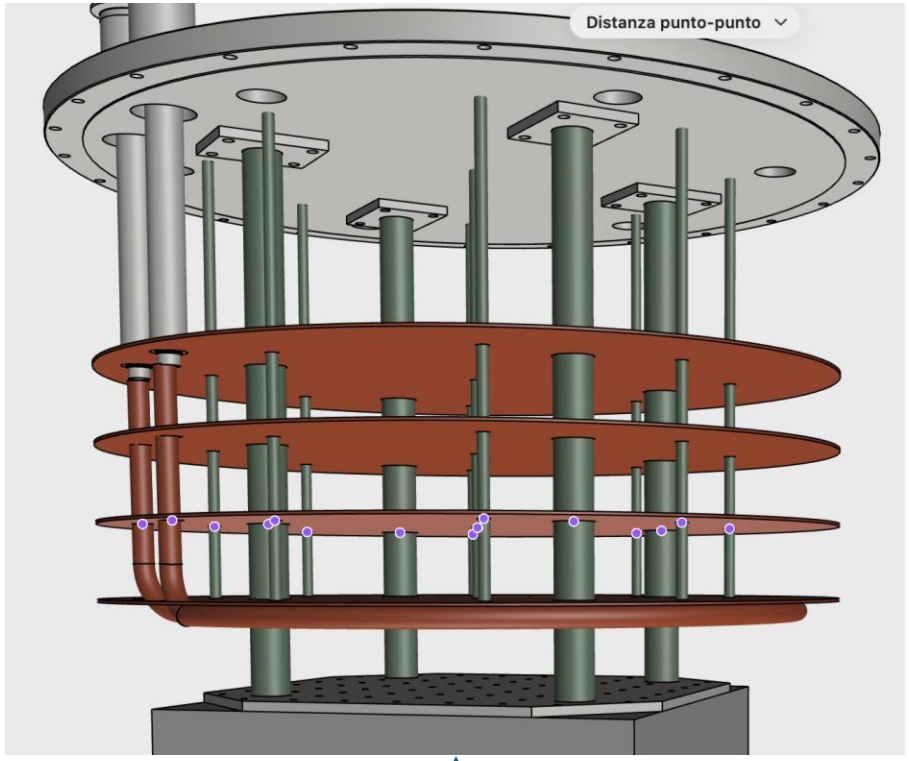

B-B (1 : 20)
D-D (1 : 20)
6100
2680
5000
3325
2700
3300
1300
3500
Rev Data/Date Descrizione/Description Dis./Dwn Contr./Chk Appr./Apr.
0 09/10/2023 EMISSIONE marco.liffredo
LAYOUT GENERALE
Criostato per esperimento LEGEND
INFN Gran Sasso
5501-0026
09/10/2023
1 : 20
A1

LEGENDArY

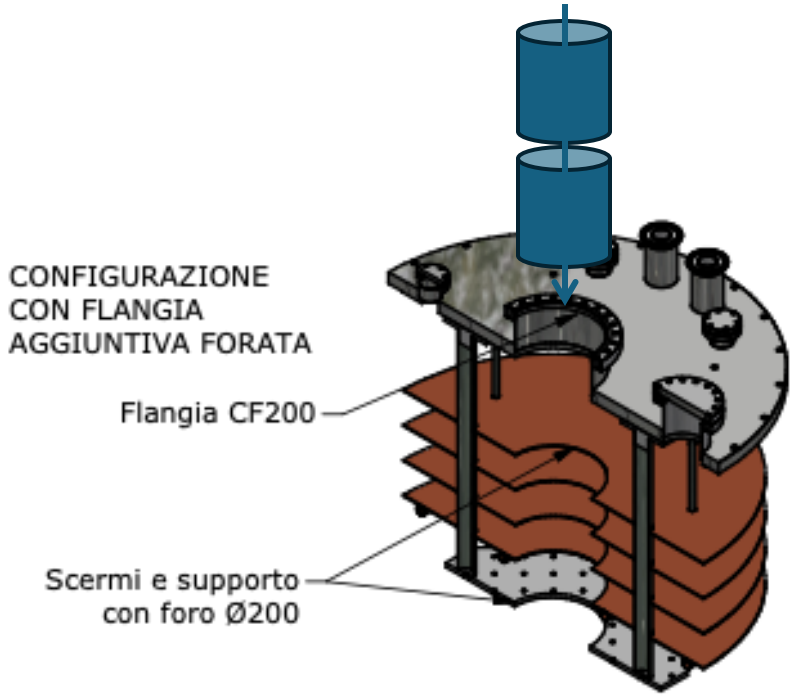

60 cm
50 cm
190 cm
3137
Pompa LAR
SCARICO/
CARICO LAr
207
Ø900
313.7 cm
90 cm
IN/OUT Azoto
Livello a
DeltaP
N°6 attacchi
CF40 laterali
N°5 attacchi
CF40 su flangia
Attcco pompa
turbo CF100
Giunto per ricircolo
Lar al sistema di
purificazione
Trasmettitore
di pressione
E-E (1 : 12.5)
CONFIGURAZIONE
CON FLANGIA
AGGIUNTIVA FORATA
Flangia CF200
Scermi e supporto
con foro Ø200
Rev
Data/Date
Descrizione/Description
Dis./Dwn
Contr./Chk
Appr./Apr.
0
09/10/2023
EMISSIONE
M.Liffredo
TITOLO / Title
Progettazione impianto per esperimento LEGEND
INFN Gran Sasso
5501
M.Liffredo
5501-0051
09/10/2023
1 : 12.5
A2
CRYOGENIC AND HIGH VACUUM TECHNOLOGIES

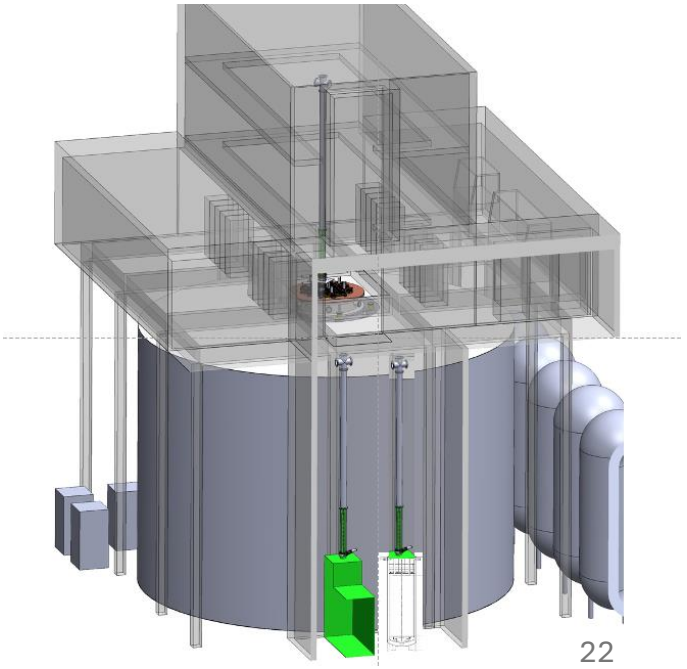
LEGENDArY





Max sample dimension → 190 cm x 50 cm x 50 cm





LEGENDArY

[above ground @HdM] Hp1

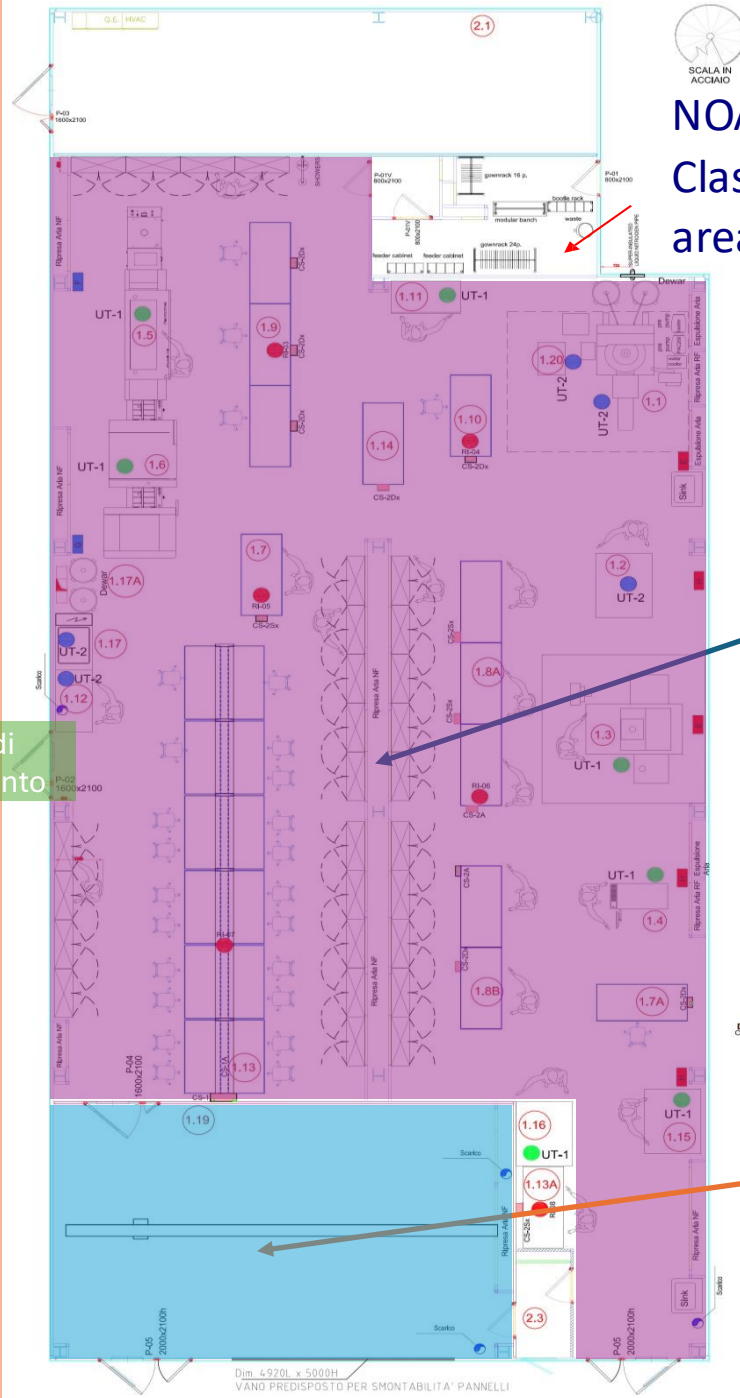
N_2 LN_2 LAr GAr

40 m2
H =6,5-7m

Tunnel di collegamento

HdM

Building beam



NOA:
Class ISO 6
area -> 420 m^2

CR3: 3.0 m high, 353 m^2 (SiPM packaging, test and integration)

CR2 : 5.8, 68 m^2 (large volume detector assembly)

40 m2
H =6,5-7m

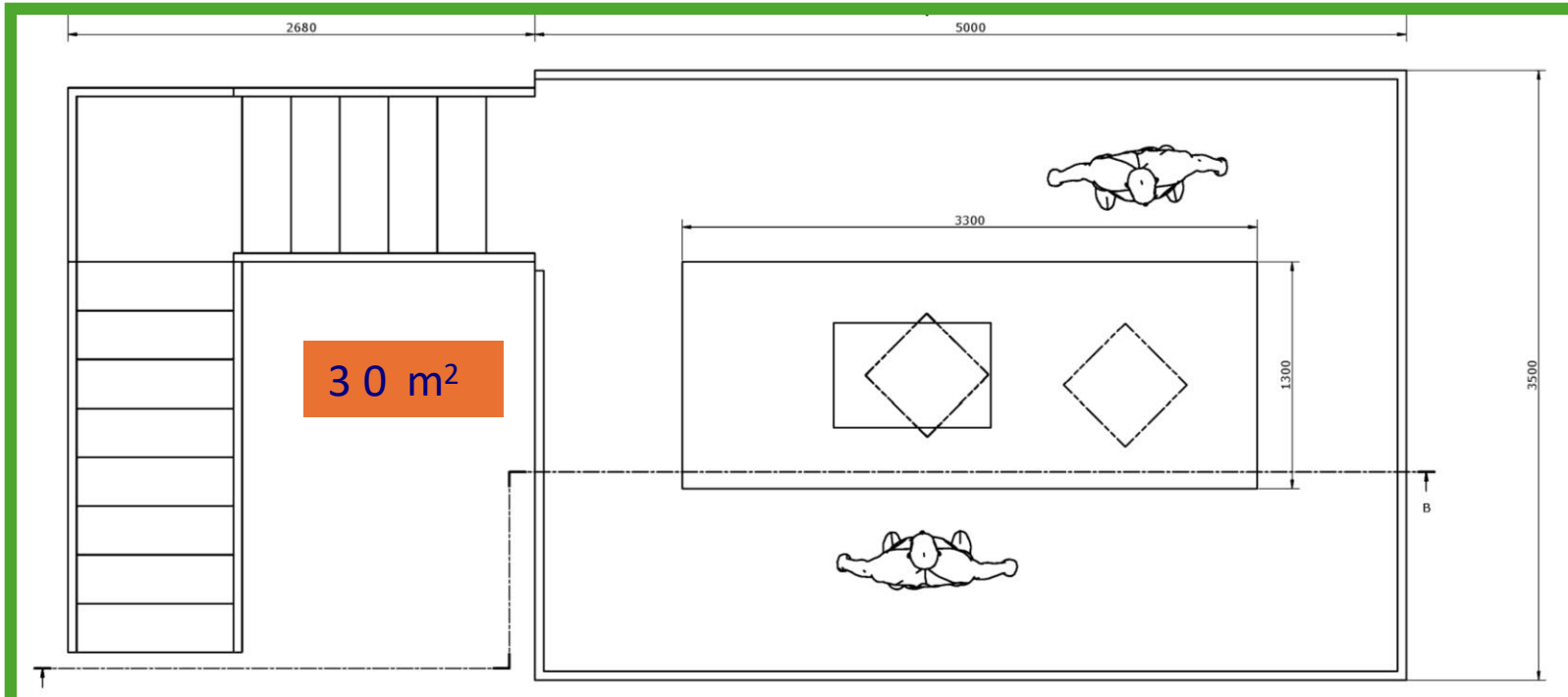
Class ISO 6
area -> 40 m^2

N_2

LN_2

LAr

GAr



30 m^2

rack

table

Tunnel di collegamento

4 m

7.7 m

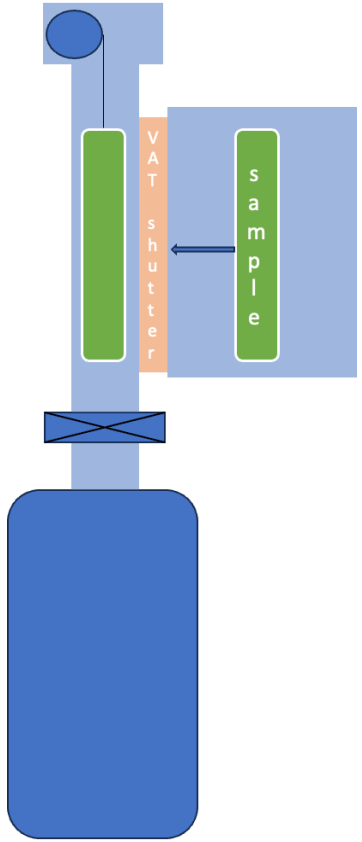
10 m

LEGENDArY

[above ground @HdM] Hp2

Richieste 2025

1. Criostato
2. Glove box + crane
3. Piattaforma
4. Clean room (SJ a luce verde su uso CR2)
5. Sistema di purificazione LAr, sistema di subcooling e linee di trasferimento
6. Progettazione del sistema di evaporazione di TPB della facility LEGENDaRY
7. Pompa da vuoto e pompa criogenica per purification system LEGENDaRY



HdM

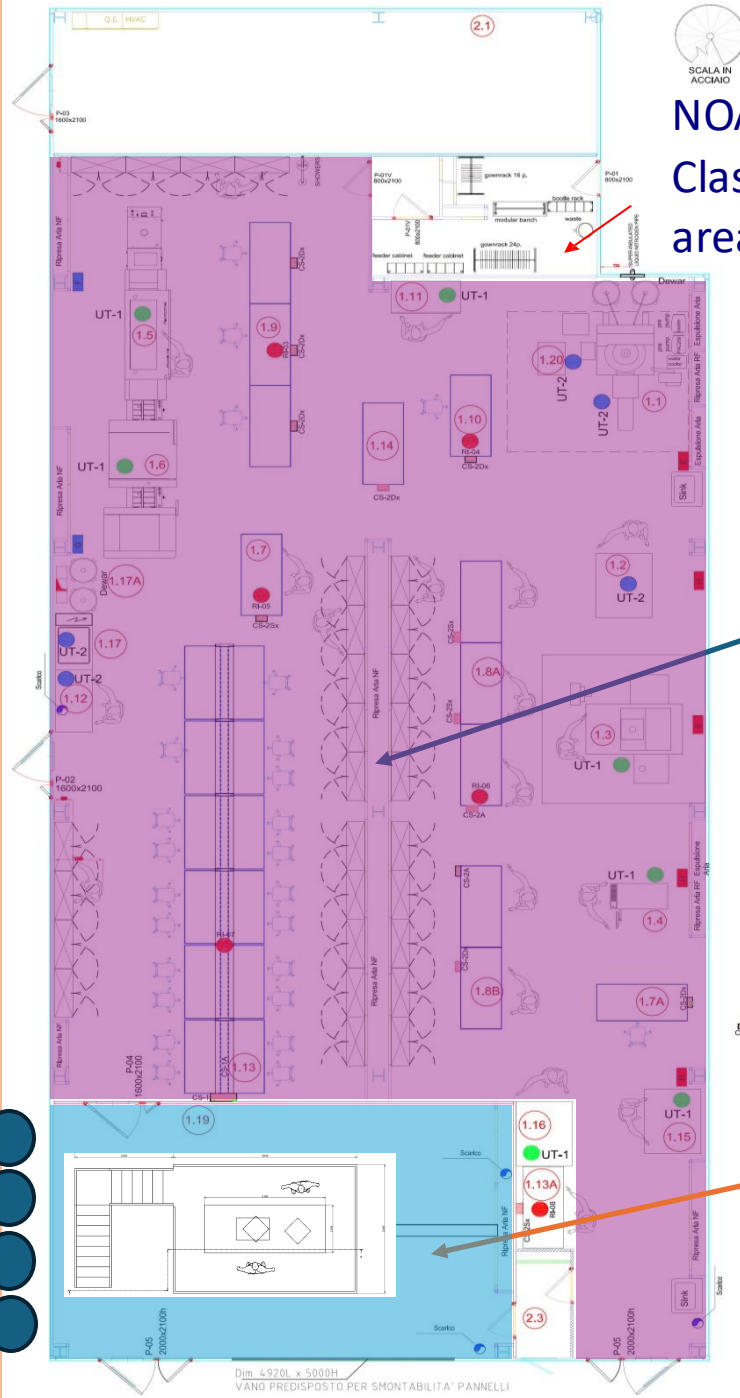
Building beam

GAr

LAr

LN_2

N_2



NOA:
Class ISO 6
area -> 420 m^2

CR3: 3.0 m high, 353 m^2 (SiPM packaging, test and integration)

CR2 : 5.8, 68 m^2 (large volume detector assembly)

LEGENDArY - preventivi

OFFERTA 24100 - CRIOTEC

- **Prezzo budget criostato: 150.000 € IVA esclusa**
- **Prezzo budget glove box + sistema movimentazione: 100.000 € IVA esclusa**

ITECO ENGINEERING

www.itecoeng.com

Glove boxes – Isolators – Containment & Radioprotection equipment

ITECO S.R.L. VIA EMILIA PONENTE N. 1140/A 48014 CASTEL BOLOGNESE (RA) ITALY TEL. (++39) 0546 55525 iteco@itecoeng.com
PARTITA IVA / CF 01031360397 EUROPEAN VAT ID. CODE IT 01031360397 R.E.A. RA 115740 R.IMPRESE RA 11938 **e-Invoicing** M5UXCR1
PEC: iteco@pecitecoeng.com CAPITALE SOCIALE € 119.000,00.- DATE OF ESTABLISHMENT 23.04.1987 CAGE CODE NO. AP717

Spett.le

Castelbolognese, venerdì 9 agosto 2024

Natalia Di Marco, PhD
Associate Professor - Physics Division
Gran Sasso Science Institute
Viale Francesco Crispi, 7 - 67100 - L'Aquila
http://www.gssi.it

OFFERTA N. 24-606-A (Budget)

13670 bozza	Glove Box progetto 13670 adatta a manipolazione campioni da introdurre in gate-valve di accesso a criostato - layout preliminare (bozza) 13670 La struttura è realizzata smontabile	Euro 99.000,00.-
	IMBALLO-TRASPORTO-INSTALLAZIONE-COLLAUDI CON NS PERSONALE TECNICO SPECIALIZZATO	Euro 6.000,00.-

MONTAGGIO

Il montaggio sarà effettuato da personale Icet impianti, con la collaborazione di ditte subappaltatrici specializzate in alcune attività, durante le ore diurne dei giorni feriali. Saranno utilizzate attrezzature adeguate e mezzi di sollevamento appropriati.

QUOTAZIONE

A corpo: **300.000,00 €** **(TRECENTOMILA/00)**

DRD2

- Produzione campioni PMMA-Gd in collaborazione con ditte Clax e Reynolds (DRD2 4.1.3)

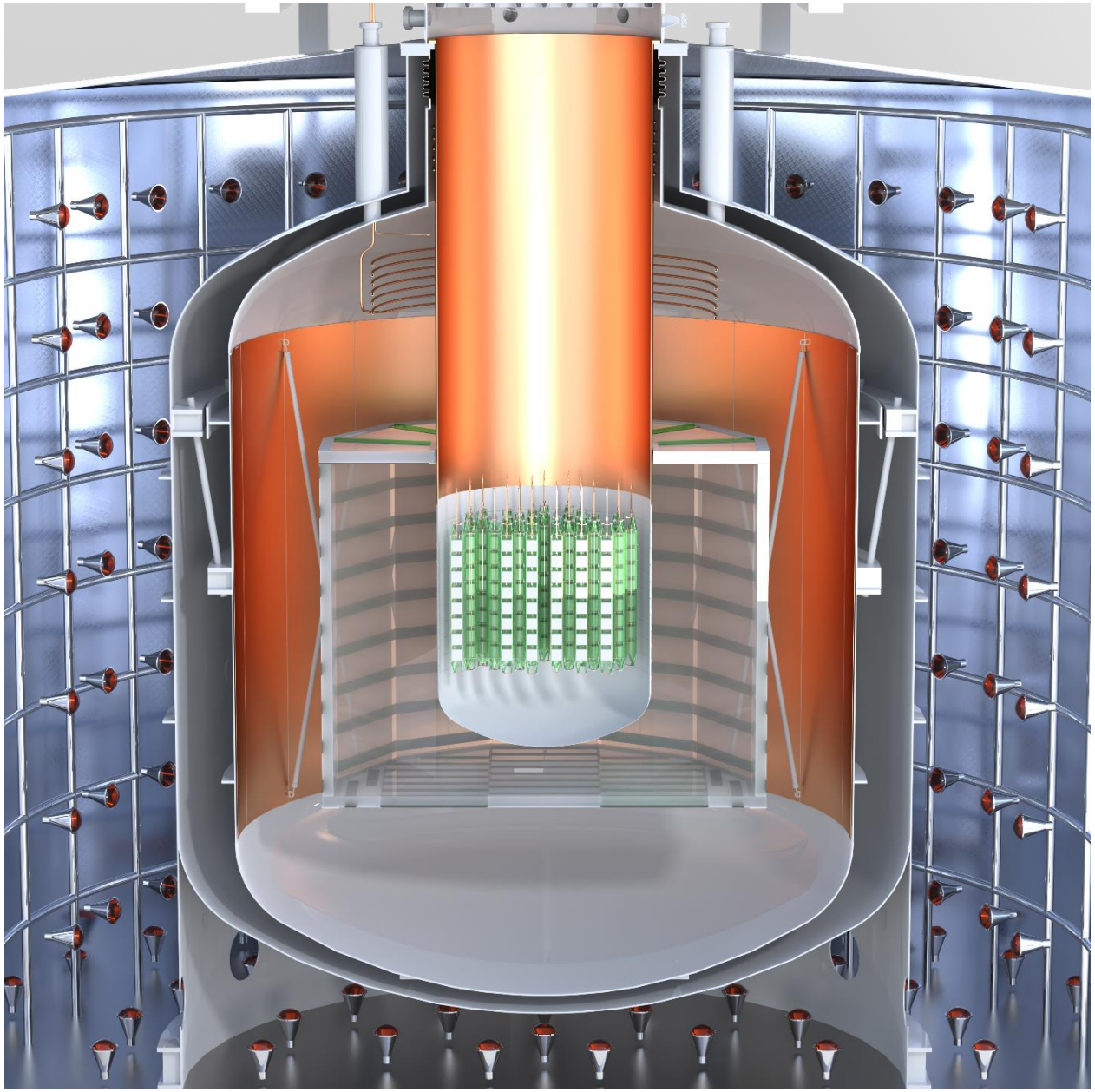
BACKUP

Outer LAr veto

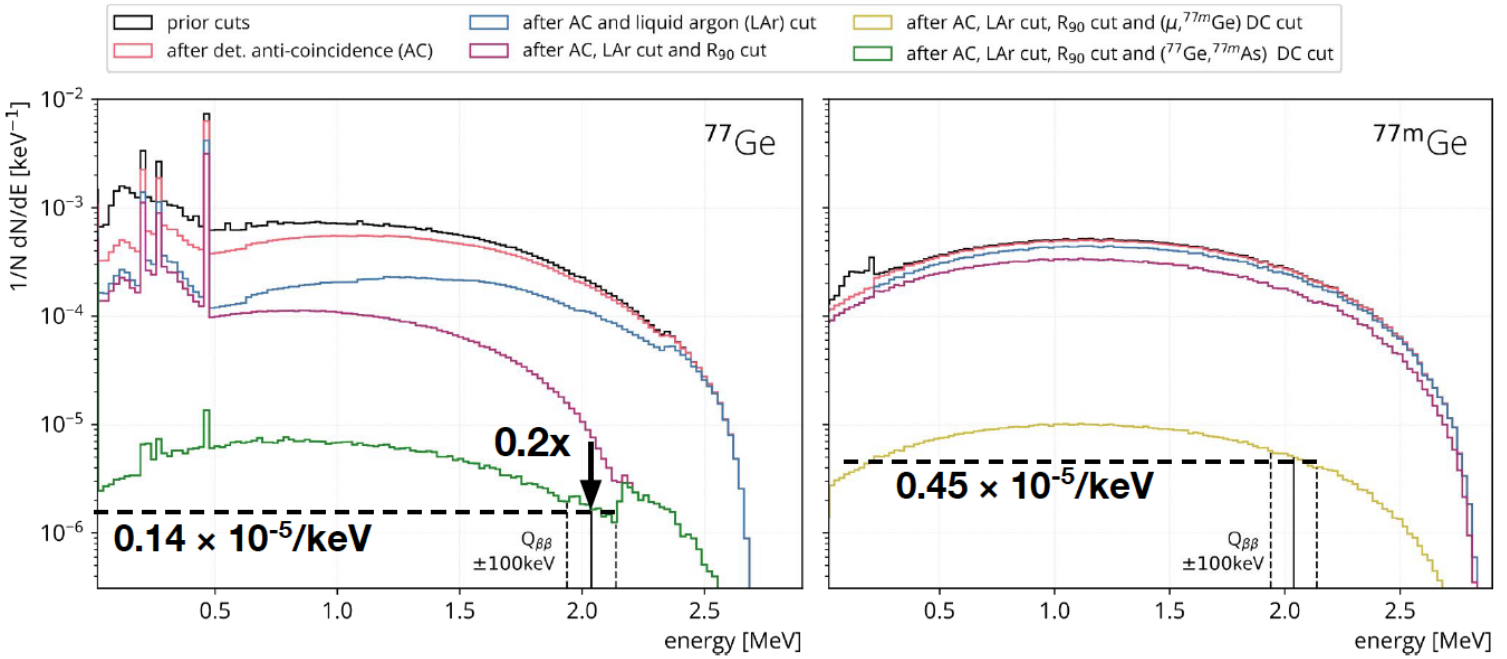
Neutron moderator panels

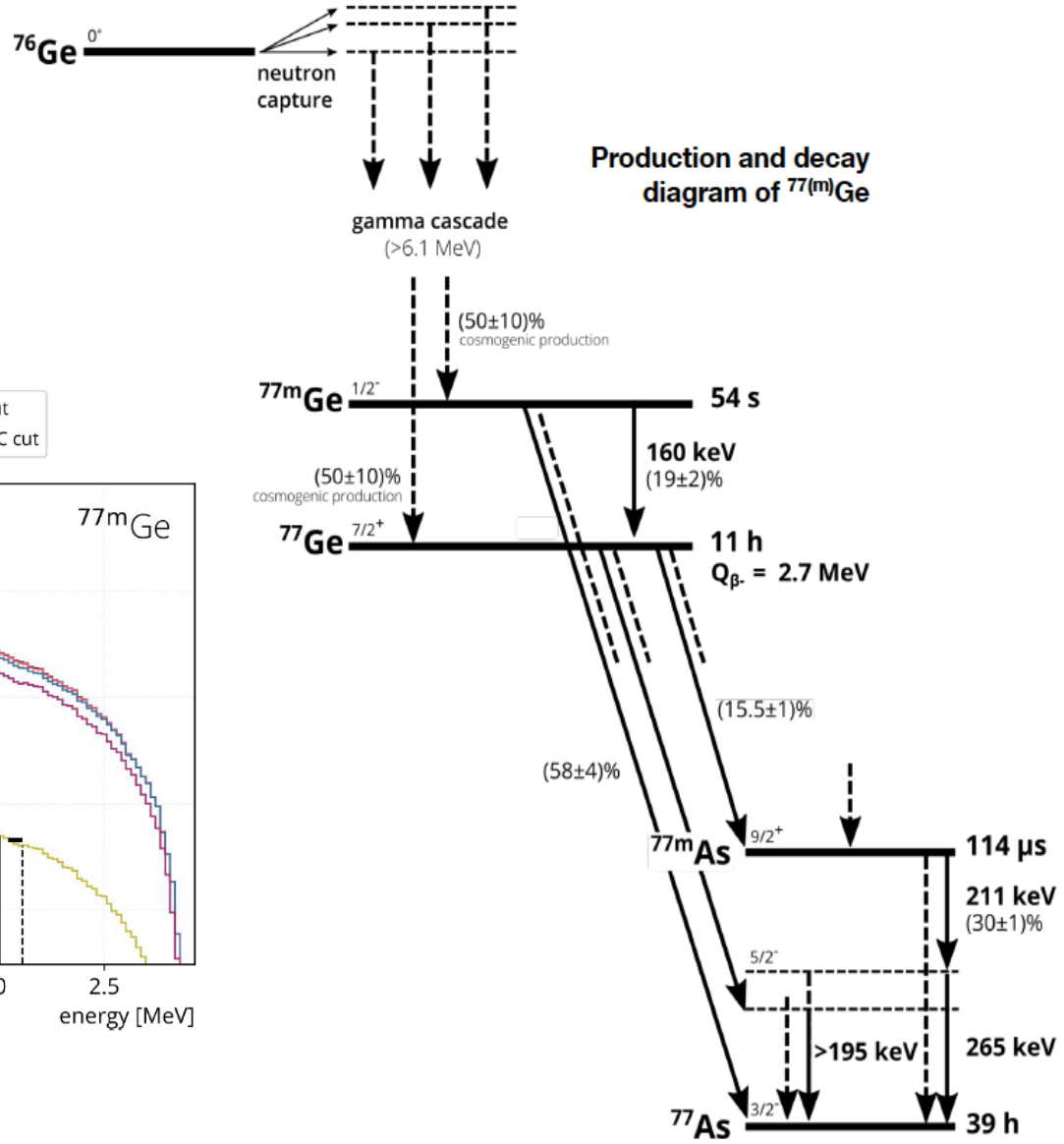
+

LAr scintillation read-out system



Outer LAr veto



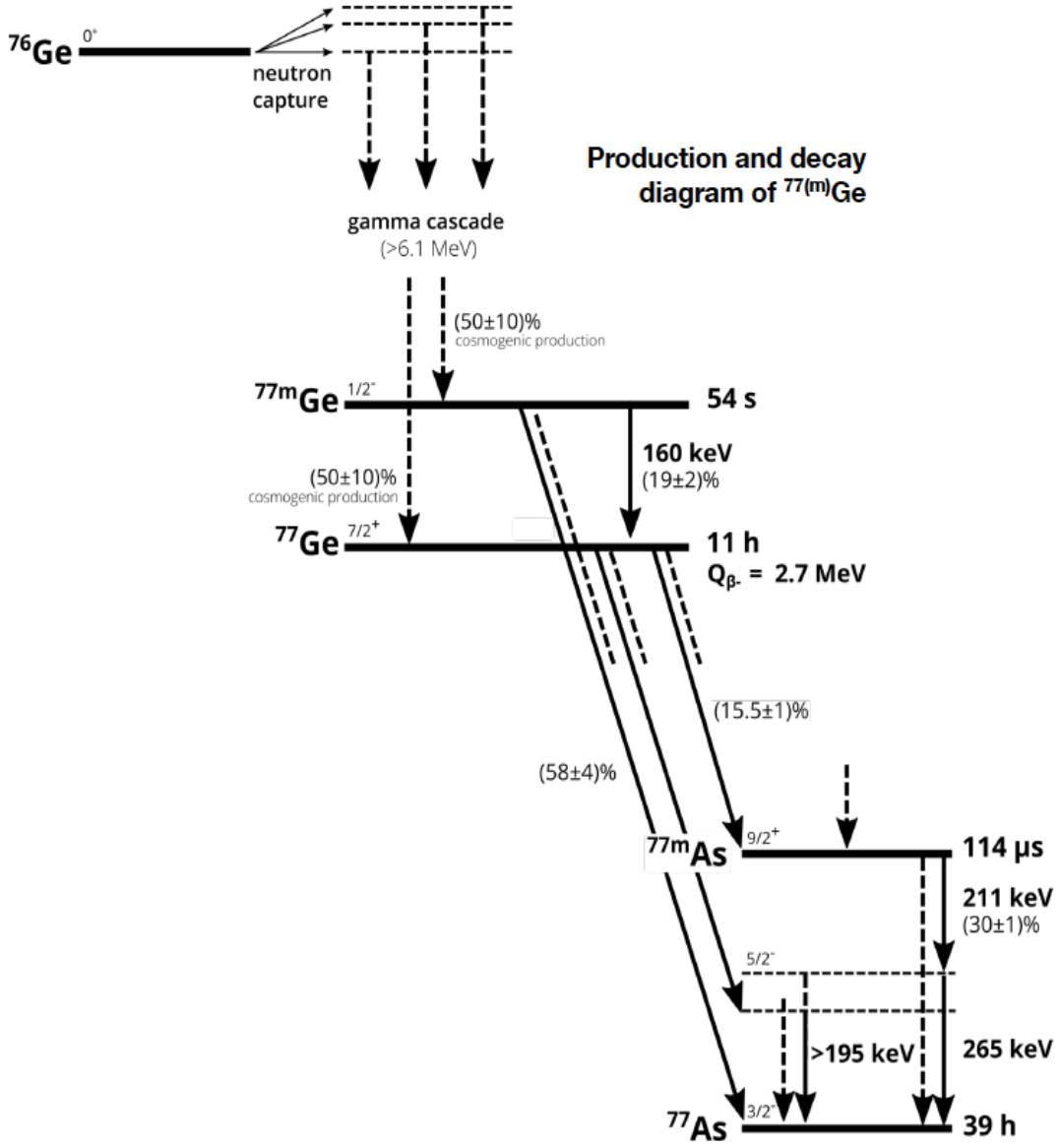


Outer LAr veto

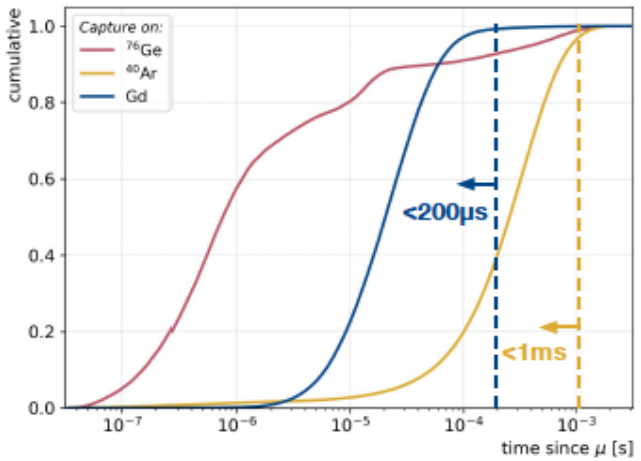
Counts at $Q_{\beta\beta}$ per decay

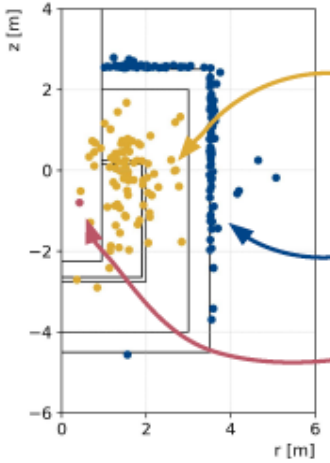
counts @ $Q_{\beta\beta}$ [10^{-5}/keV]	c_{Ge77}	c_{Ge77m}	$\varepsilon_{surv}^{0\nu\beta\beta}$
prior cuts	19.4	24.1	100%
after det. anti-coincidence	16.9	23.5	
… and LAr veto	9.90	21.2	
… and PSD	0.74	15.1	~90%
… and (μ,^{77m}Ge) DC cut	0.74	0.45	~87%
… and (^{77}Ge,^{77m}As) DC cut	**0.14**	**0.45**	~87%

$$BI_{delayed} = 3.8\,^{+2.7}_{-2.6} \times 10^{-7}\ \text{cts/keV/kg/yr}$$



2. Indirect: sibling neutrons in the LAr or water/Gd





	median multiplicity of captures per capture on ^{76}Ge:
n-Capture on ^{40}Ar (>6.1 MeV)	28 (ALAr) + 4 (ULAr)
n-Capture on H/Gd (>7.9 MeV)	21
n-Capture on ^{76}Ge	

For each n-Capture on ^{76}Ge, there are significantly more n-Capture on Ar or H/Gd. However, no position information reconstructable.

LAr tagging condition:

All HPGe detectors are **tagged** when **>10 MeV are deposited in the ULAr** or **>100 MeV in the ALAr <1 ms** after the muon.

Goal: $\varepsilon(\mathrm{LAr})_{surv}^{Ge77m} \lesssim 40\%$ with minimal reduction in $\varepsilon_{surv}^{0\nu\beta\beta}$

→ *Look at* ***"Outer/ATLAr Instrumentation"*** *by* ***Natalia Di Marco***

Water Cherenkov tagging condition (*Neutron Tagger*):

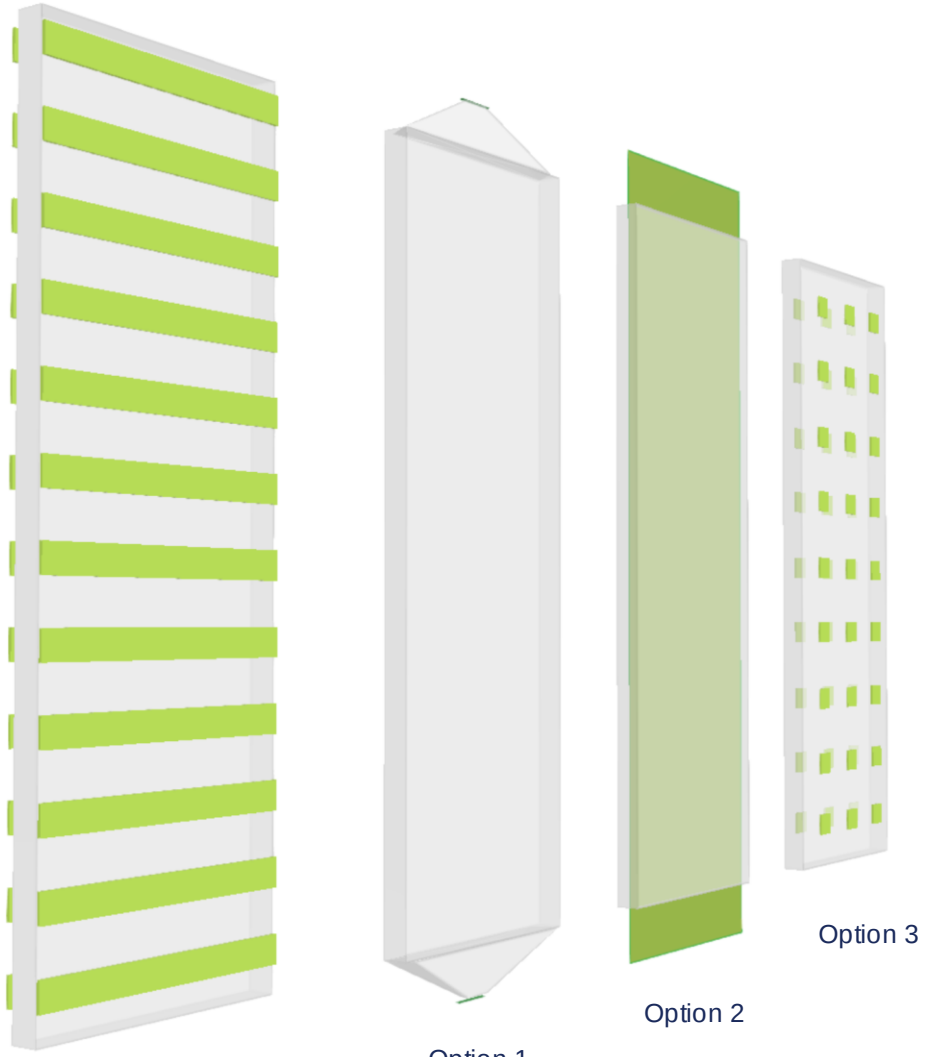
All HPGe detectors are **tagged** when **>50 n-Capture events** occur in the water tank **<200 µs** after the muon.

Goal: $\varepsilon(\mathrm{WC})_{surv}^{Ge77m} \lesssim 60\%$ with minimal reduction in $\varepsilon_{surv}^{0\nu\beta\beta}$

→ *Look at* ***"Water tank instrumentation"*** *by* ***Josef Jochum***

Note: goals defined by reduction of $\varepsilon_{surv}^{0\nu\beta\beta}$ from 90% to 89%.

Read-out instrumentation (alternative designs):



Reference design

Option 1

Option 2

Option 3

Option 1:

Each 100×300×10 cm^3 PMMA panel is wrapped by a thin foil of PEN (or TPB) acting as a wavelength shifter for the 128 nm Ar light (or 175 nm of Xe-doped LAr).

The readout is performed at both ends by a ***matrix of SiPMs*** coupled to the panel by means of an *adiabatic guide*, which reduces the guide-sensor surface ratio.

Option 2:

Sheets of wavelength-shifting fibers are inserted at the center of the PMMA panel

The fiber sheets considered are the Saint Gobain BCF-12, with blue peak emission wavelength (435 nm) and improved transmission for use in longer fibers.

The panel is lined with PEN (or TPB) and the doping of the PMMA with a scintillator could be considered.

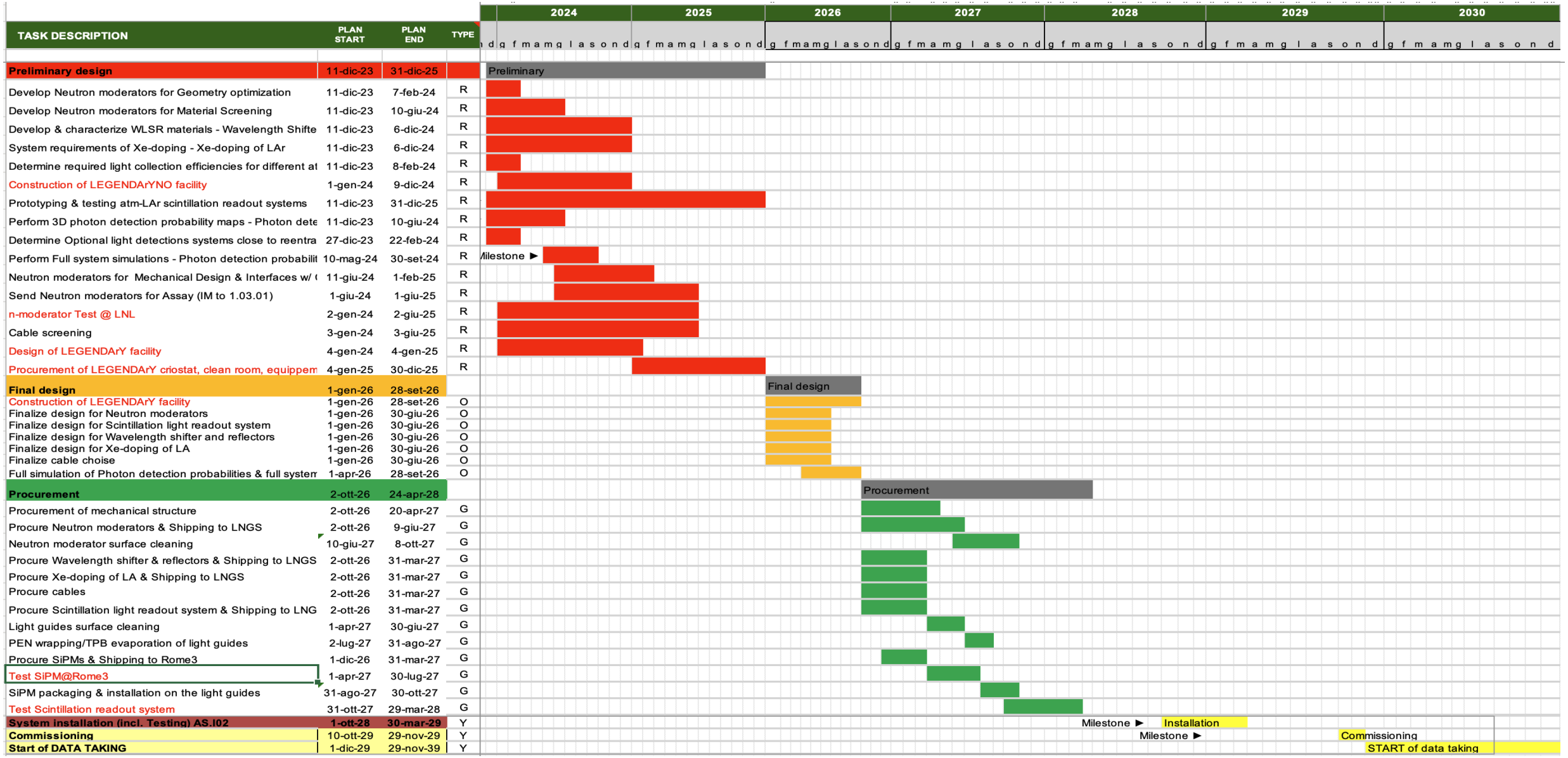
The readout is performed at both ends by SiPMs

Option 3:

Both moderator panel surfaces are instrumented with ***SiPM matrices***, covered with PEN

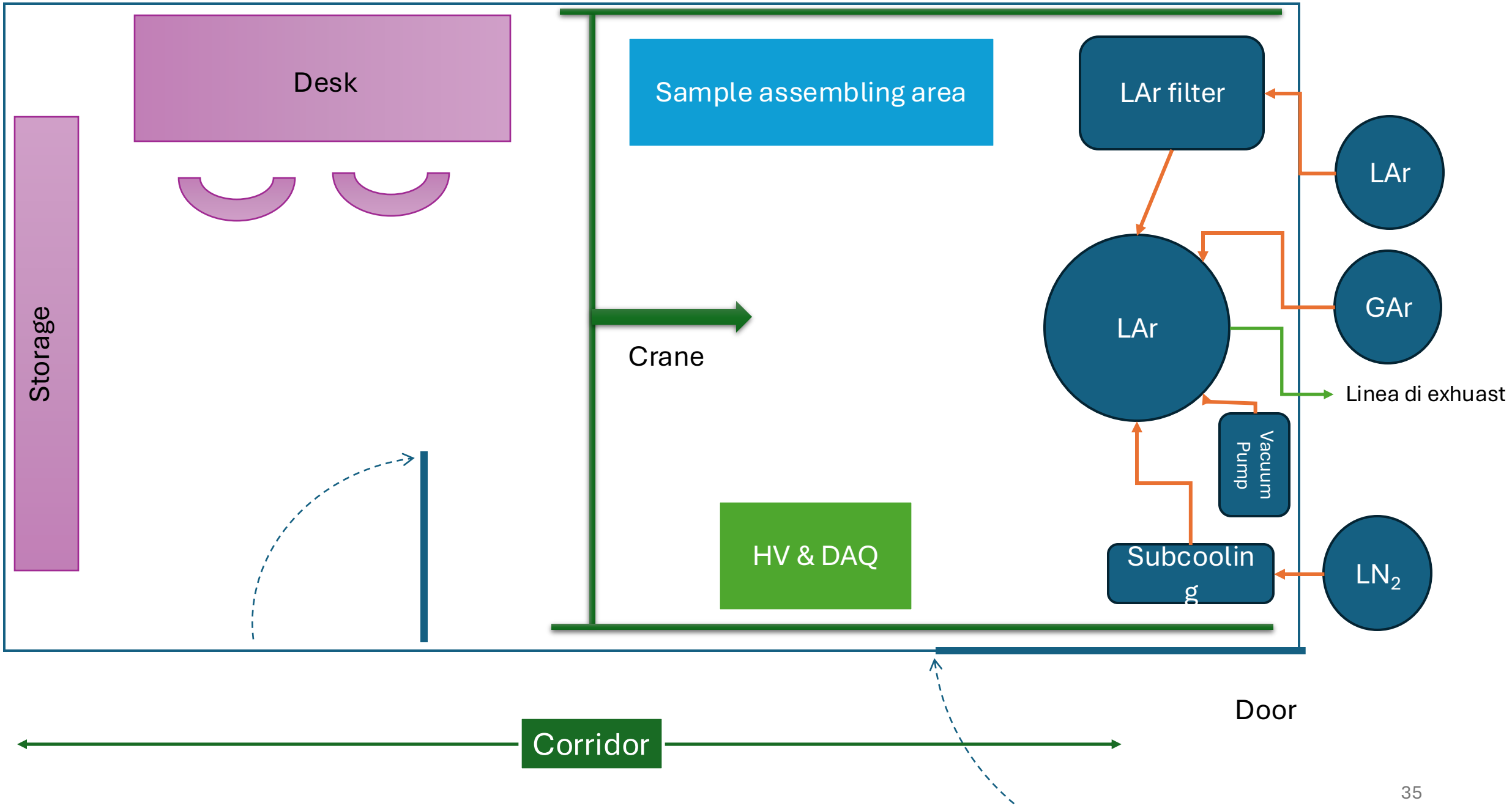
The panel is lined with a reflective thin film (Tetratex) coated with PEN or TPB.

Time plan (preliminary)

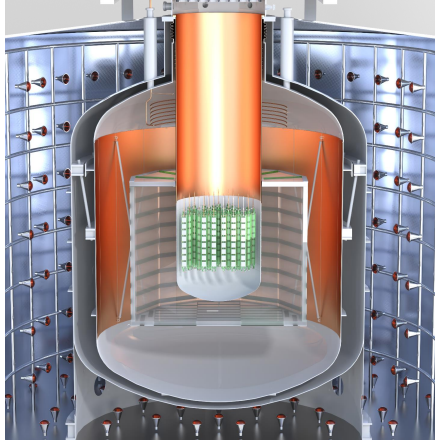


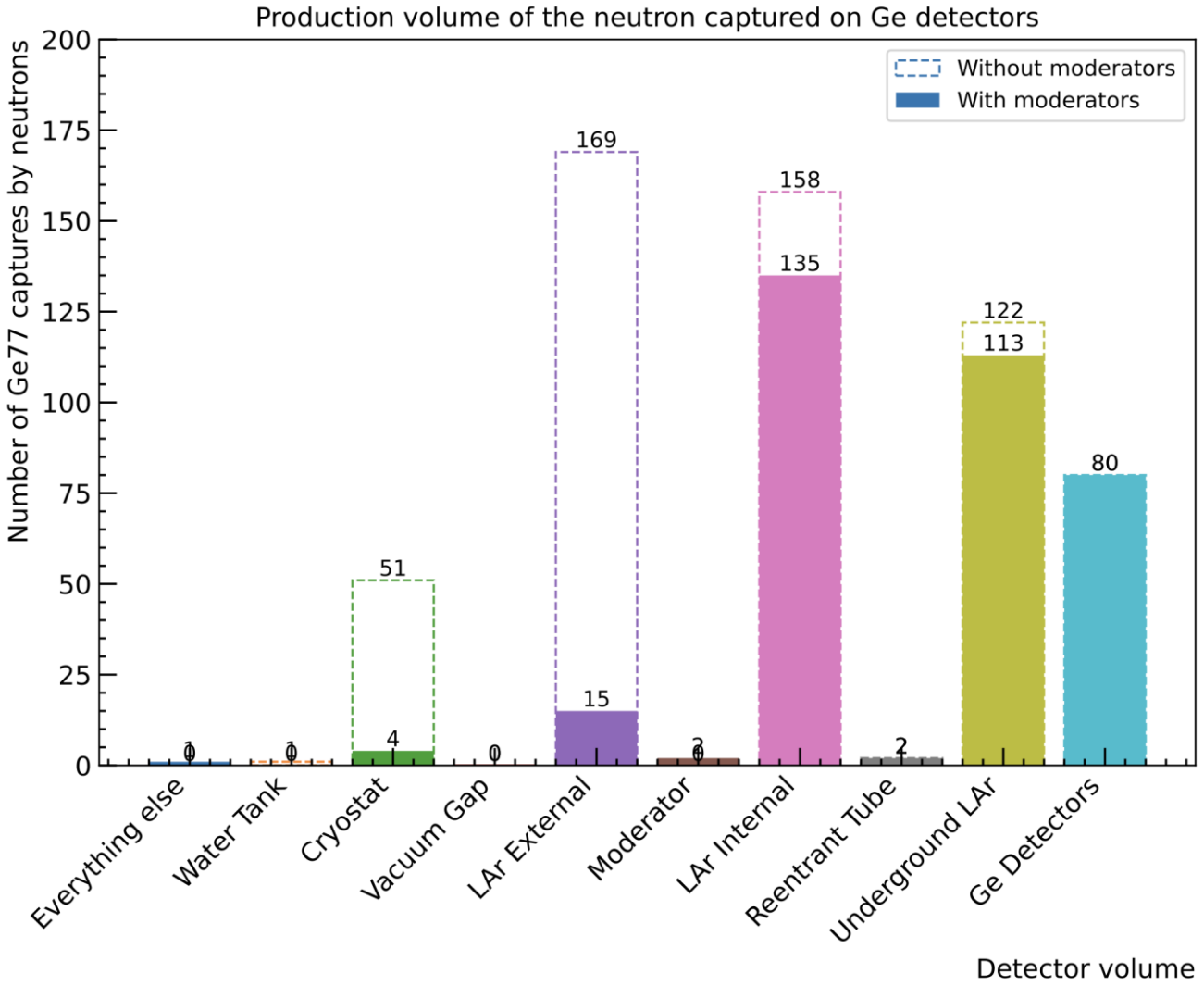
TASK DESCRIPTION	PLAN START	PLAN END	TYPE
Preliminary design	11-dic-23	31-dic-25	
Develop Neutron moderators for Geometry optimization	11-dic-23	7-feb-24	R
Develop Neutron moderators for Material Screening	11-dic-23	10-giu-24	R
Develop & characterize WLSR materials - Wavelength Shifte	11-dic-23	6-dic-24	R
System requirements of Xe-doping - Xe-doping of LAr	11-dic-23	6-dic-24	R
Determine required light collection efficiencies for different at	11-dic-23	8-feb-24	R
Construction of LEGENDArYNO facility	1-gen-24	9-dic-24	R
Prototyping & testing atm-LAr scintillation readout systems	11-dic-23	31-dic-25	R
Perform 3D photon detection probability maps - Photon dete	11-dic-23	10-giu-24	R
Determine Optional light detections systems close to reentra	27-dic-23	22-feb-24	R
Perform Full system simulations - Photon detection probabilit	10-mag-24	30-set-24	R
Neutron moderators for Mechanical Design & Interfaces w/ (	11-giu-24	1-feb-25	R
Send Neutron moderators for Assay (IM to 1.03.01)	1-giu-24	1-giu-25	R
n-moderator Test @ LNL	2-gen-24	2-giu-25	R
Cable screening	3-gen-24	3-giu-25	R
Design of LEGENDArY facility	4-gen-24	4-gen-25	R
Procurement of LEGENDArY criostat, clean room, equippem	4-gen-25	30-dic-25	R
Final design	1-gen-26	28-set-26	
Construction of LEGENDArY facility	1-gen-26	28-set-26	O
Finalize design for Neutron moderators	1-gen-26	30-giu-26	O
Finalize design for Scintillation light readout system	1-gen-26	30-giu-26	O
Finalize design for Wavelength shifter and reflectors	1-gen-26	30-giu-26	O
Finalize design for Xe-doping of LA	1-gen-26	30-giu-26	O
Finalize cable choise	1-gen-26	30-giu-26	O
Full simulation of Photon detection probabilities & full system	1-apr-26	28-set-26	O
Procurement	2-ott-26	24-apr-28	
Procurement of mechanical structure	2-ott-26	20-apr-27	G
Procure Neutron moderators & Shipping to LNGS	2-ott-26	9-giu-27	G
Neutron moderator surface cleaning	10-giu-27	8-ott-27	G
Procure Wavelength shifter & reflectors & Shipping to LNGS	2-ott-26	31-mar-27	G
Procure Xe-doping of LA & Shipping to LNGS	2-ott-26	31-mar-27	G
Procure cables	2-ott-26	31-mar-27	G
Procure Scintillation light readout system & Shipping to LNG	2-ott-26	31-mar-27	G
Light guides surface cleaning	1-apr-27	30-giu-27	G
PEN wrapping/TPB evaporation of light guides	2-lug-27	31-ago-27	G
Procure SiPMs & Shipping to Rome3	1-dic-26	31-mar-27	G
Test SiPM@Rome3	1-apr-27	30-lug-27	G
SiPM packaging & installation on the light guides	31-ago-27	30-ott-27	G
Test Scintillation readout system	31-ott-27	29-mar-28	G
System installation (incl. Testing) AS.I02	1-ott-28	30-mar-29	Y
Commissioning	10-ott-29	29-nov-29	Y
Start of DATA TAKING	1-dic-29	29-nov-39	Y

LEGENDArYno space 4 x 2 m^2 in HdM



Outer LAr veto -simulation





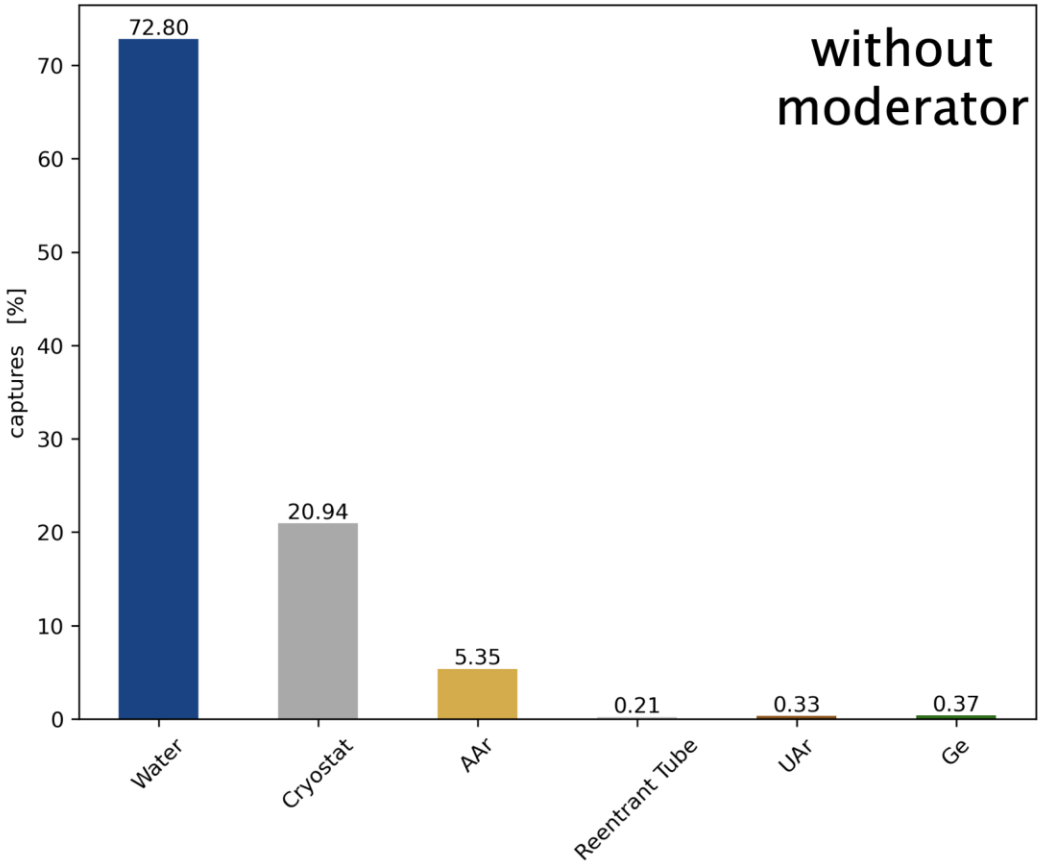
without moderator $N_{tot} = 580$

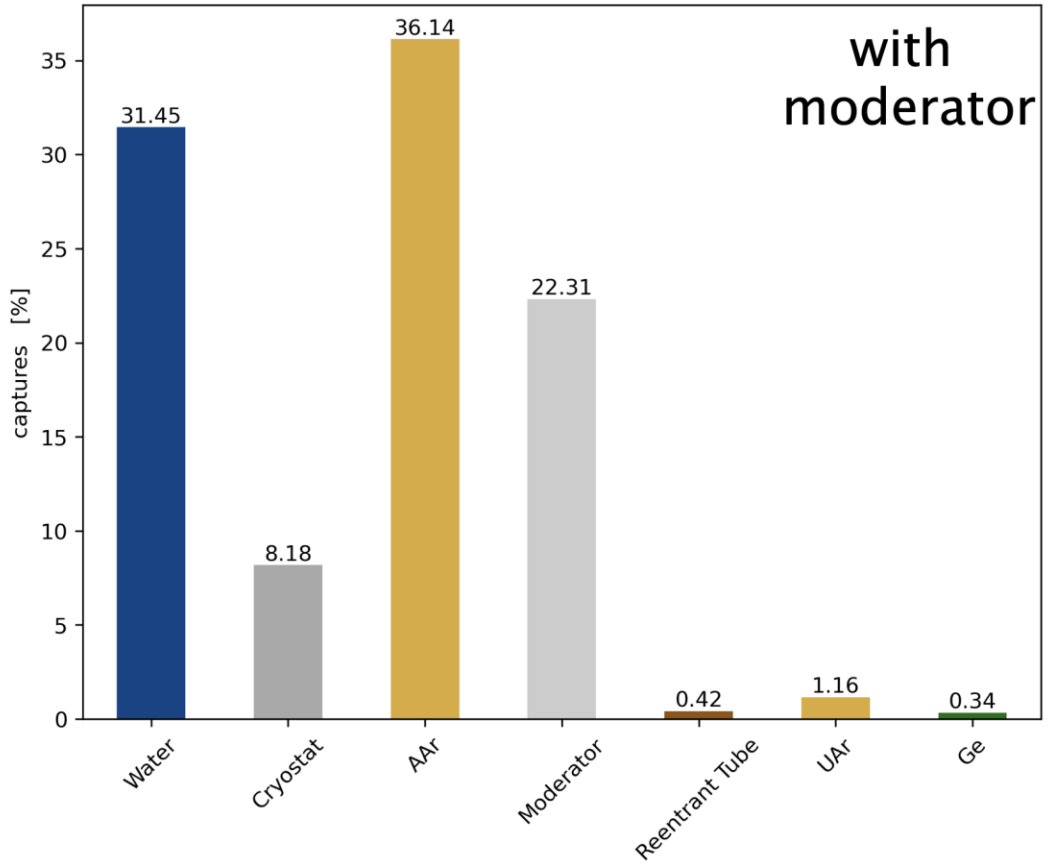
with moderator $N_{tot} = 347$

⇒ x1.7 less $^{77(m)}$Ge

contribution from neutrons produced outside moderator highly suppressed (< 10% produce $^{77(m)}$Ge)

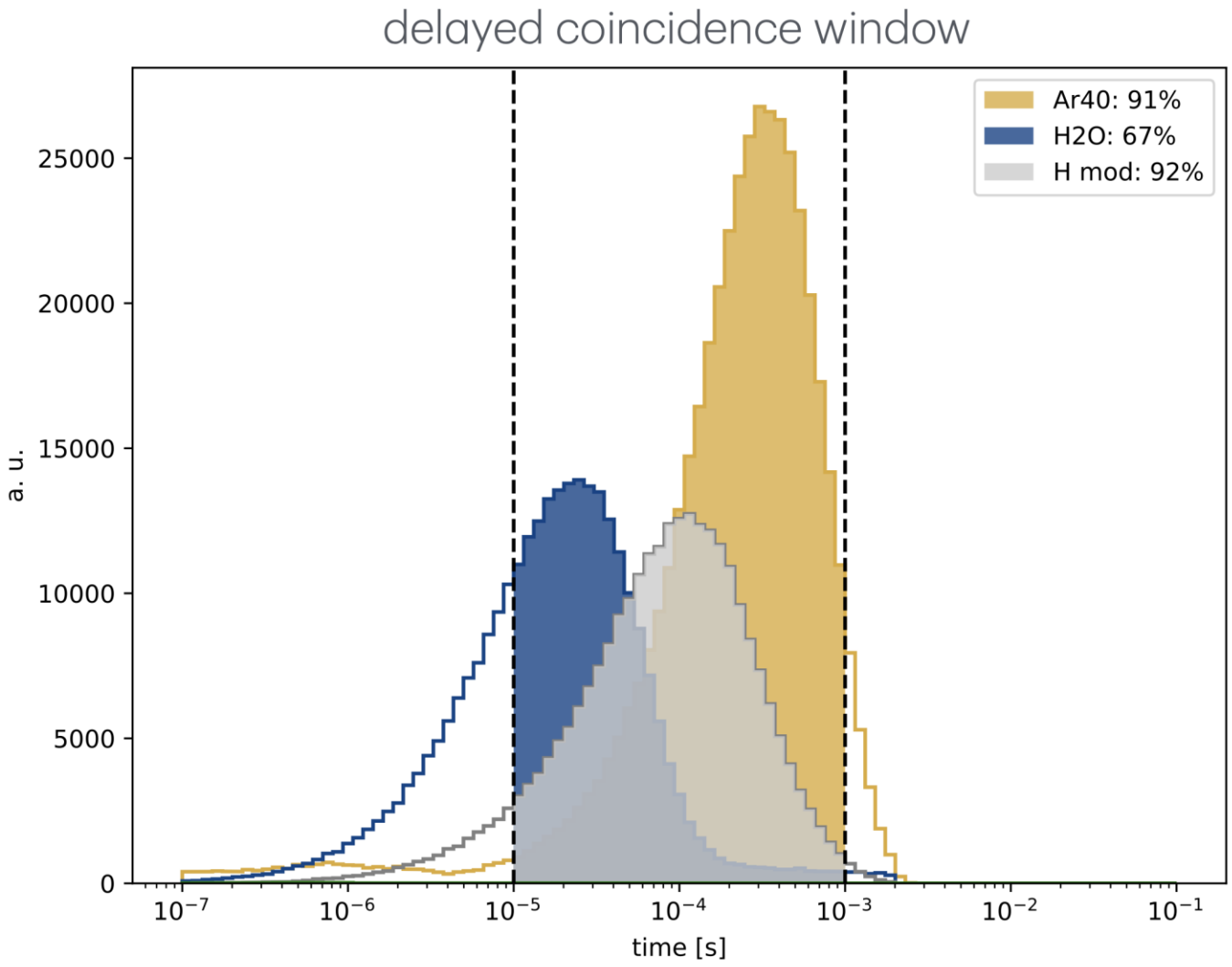
Outer LAr veto -simulation





Neutron moderator effectively slows down neutrons and enhances probability of being captured by Ar!!

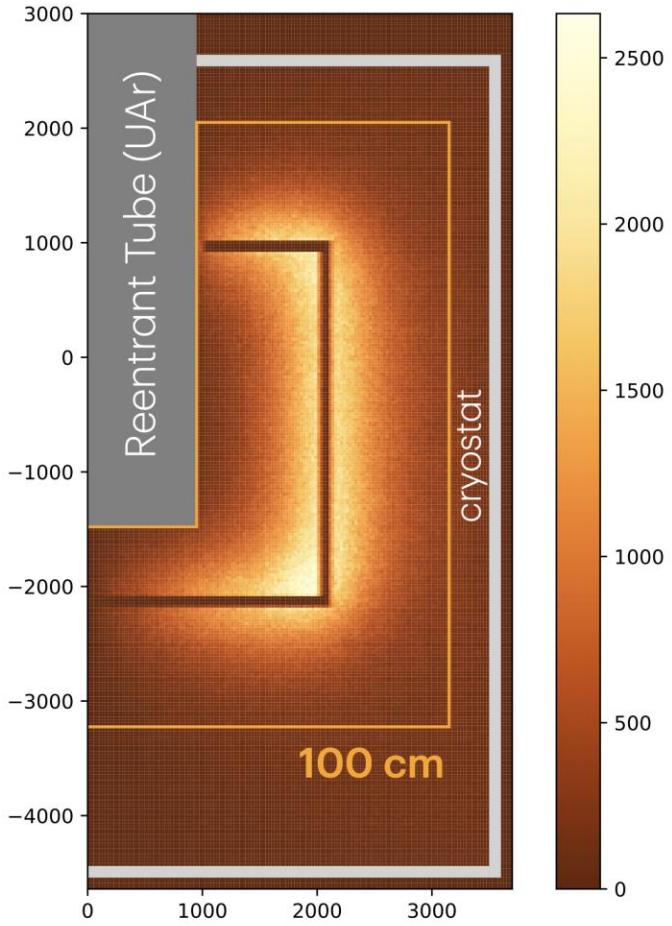
Outer LAr veto -simulation

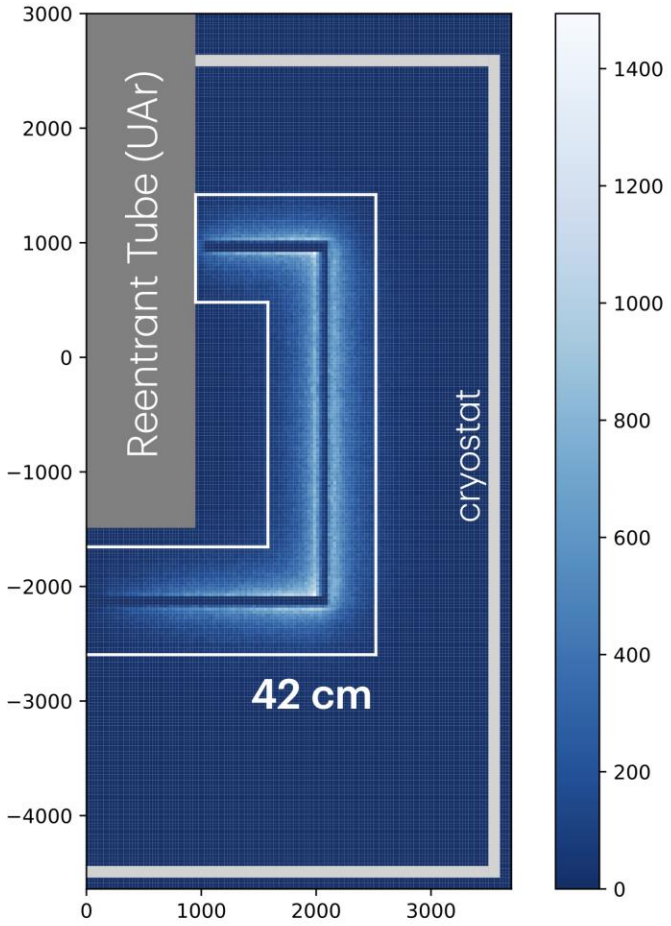


fraction of captures in analysis window

Outer LAr veto -simulation

90% Edep from the moderator - ^{40}Ar vs H



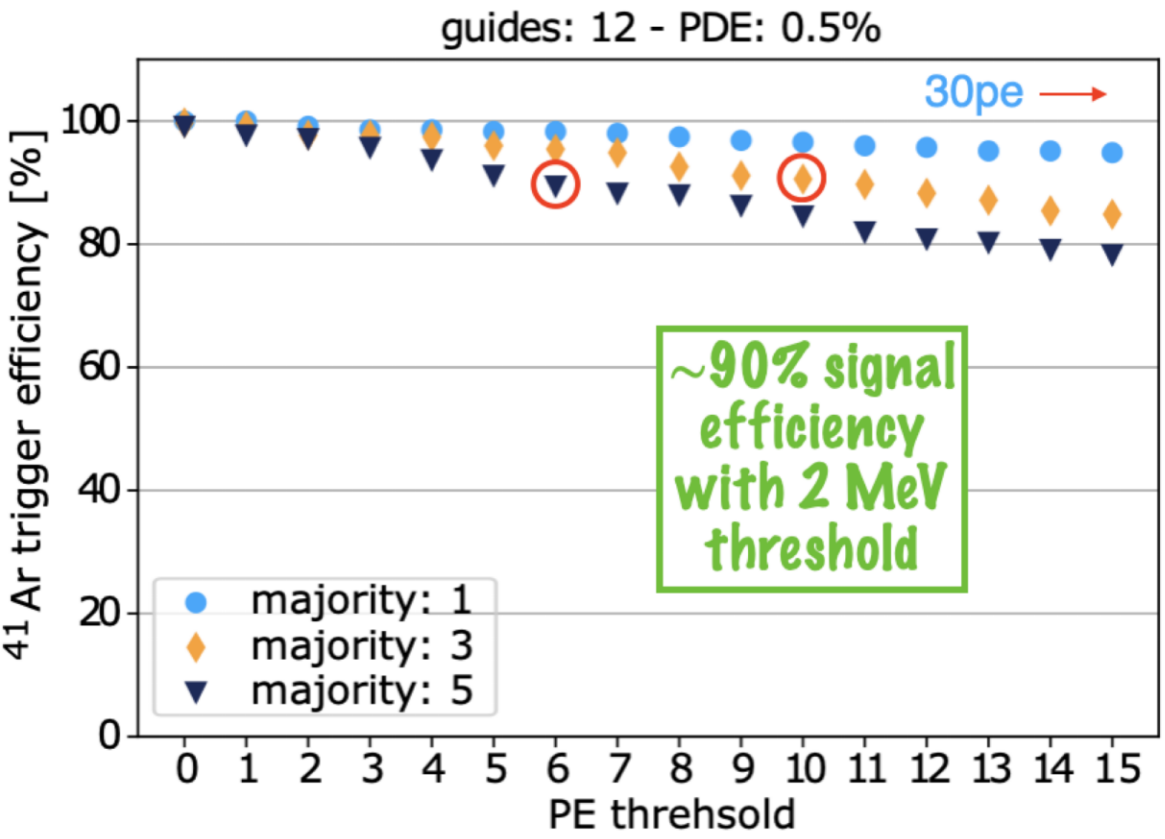


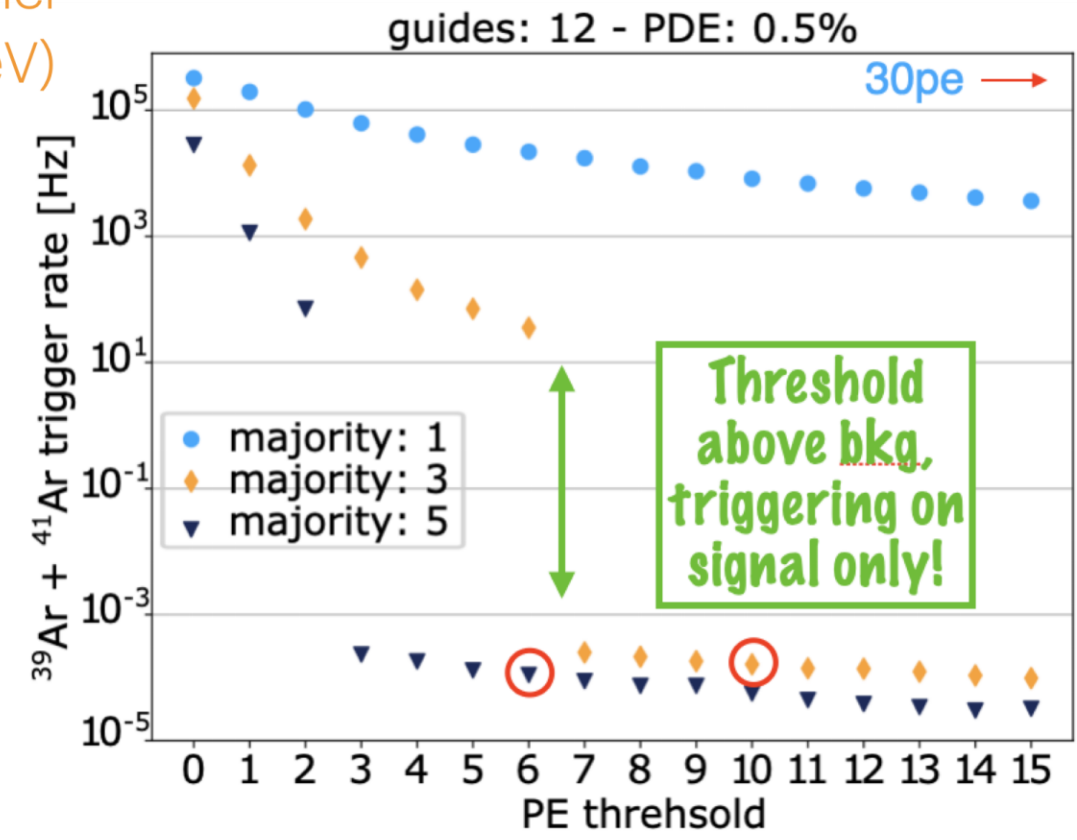
Outer LAr veto -simulation

LY is now actually slightly higher (~20 PE/MeV)

Light Yield ~15 PE/MeV

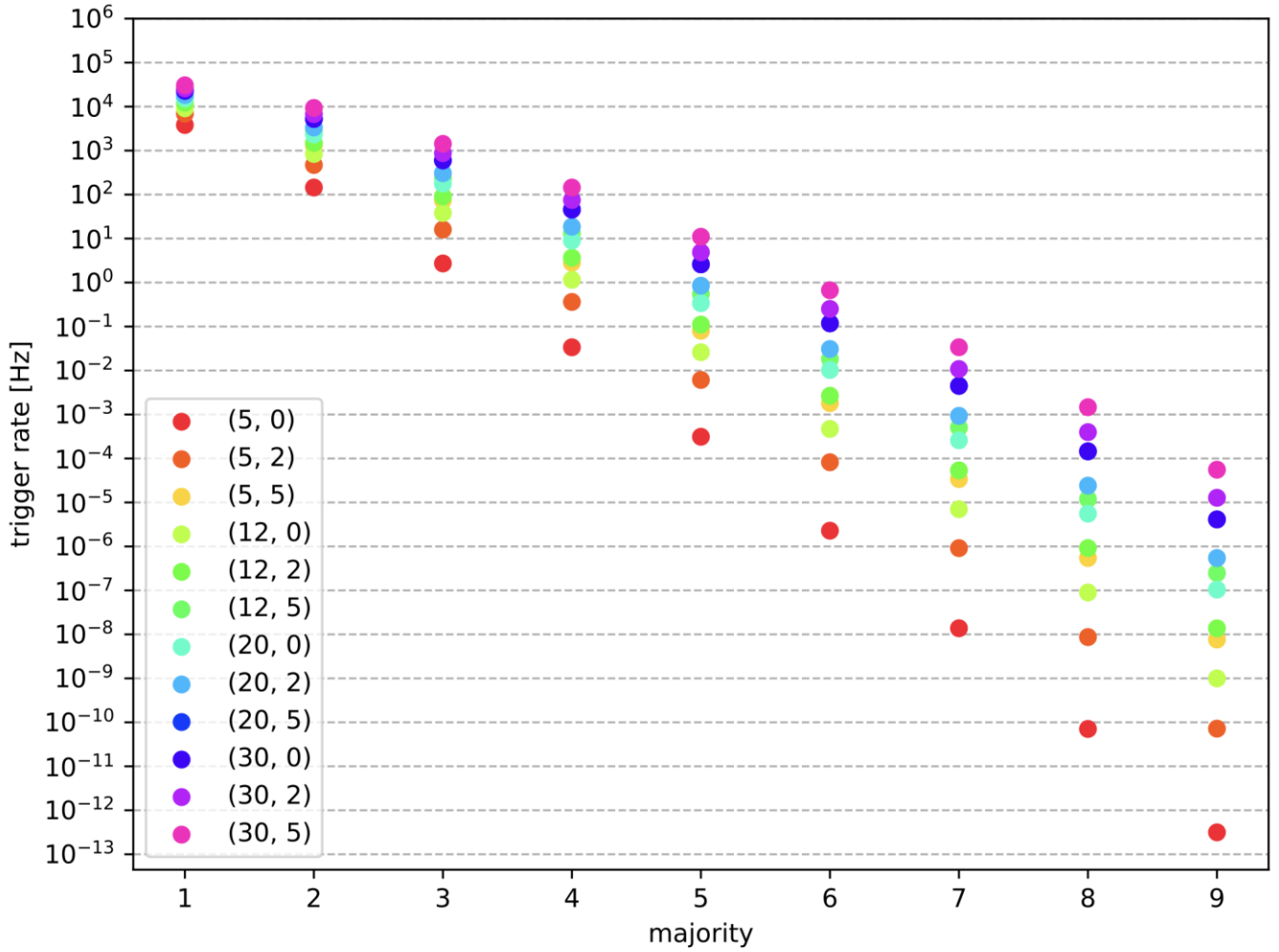
2 MeV threshold





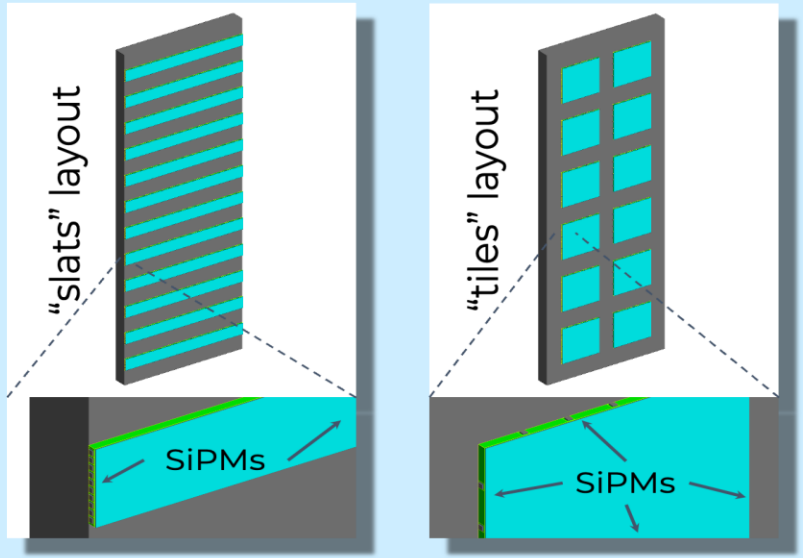
Outer LAr veto -simulation

- NEW (preliminary) Dark Count Rate (DCR)
  - considering DUNE SiPM (from this paper), DCR is ~74 mHz/mm2
  - in our design each channel has 12 SiPM with area 6x6 mm2
  - DCR per channel is 32Hz



If we assume an amplitude of 1 or 2 PE, then it's enough to have a trigger on a single channel higher than that to reduce enormously (or to zero) the trigger rate due to DCR

Note: because of Ar39 at the moment we already are using PE threshold >5 on a single channel



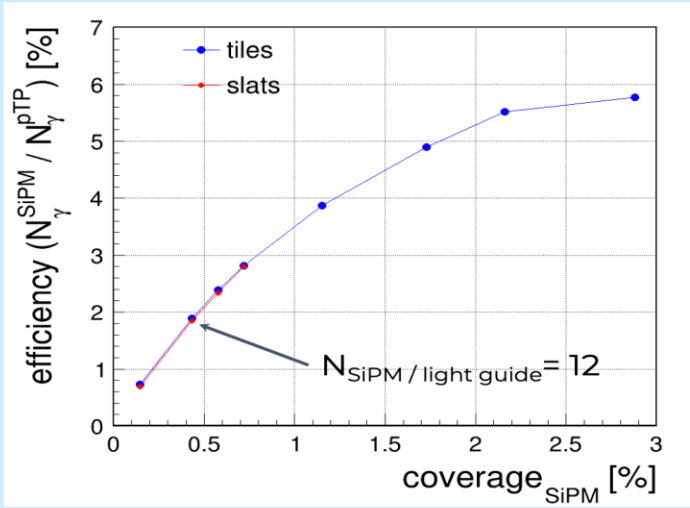
Geant4 simulations for a couple of different geometry layouts:

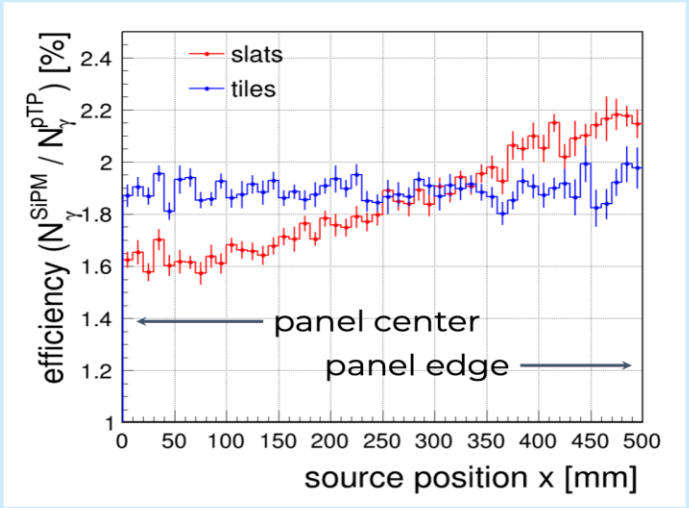
- "slats": 100×10×1 cm^3 elongated light guides
- "tiles": 31×31×1 cm^3 square light guides

Nominal design has 12 SiPM/light guide → **$Coverage_{SiPM}$ = 0.43%**

In both cases, primary WLS (pTP) deposited onto a support PMMA panel, 1 mm away from the light guide

Studying the light guide efficiency (photons hitting the SiPM / photons hitting the pTP):





SiPM PDE not included here

Work in progress

Work in progress:

- optimize neutron moderators
- + water Cherenkov detector / LAr neutron tagger
- Study several read-out configurations (geometry, PDE, coverage etc…)
- learn from L200

- using correlations between observables in multivariate analysis

  (e.g. Likelihood based tagging, ML)
- full simulation of all detector systems including optical photon tracking