

Status of DArT



darkside
two-phase argon TPC for Dark Matter Direct Detection



I am the coordinator of this activity that involves:

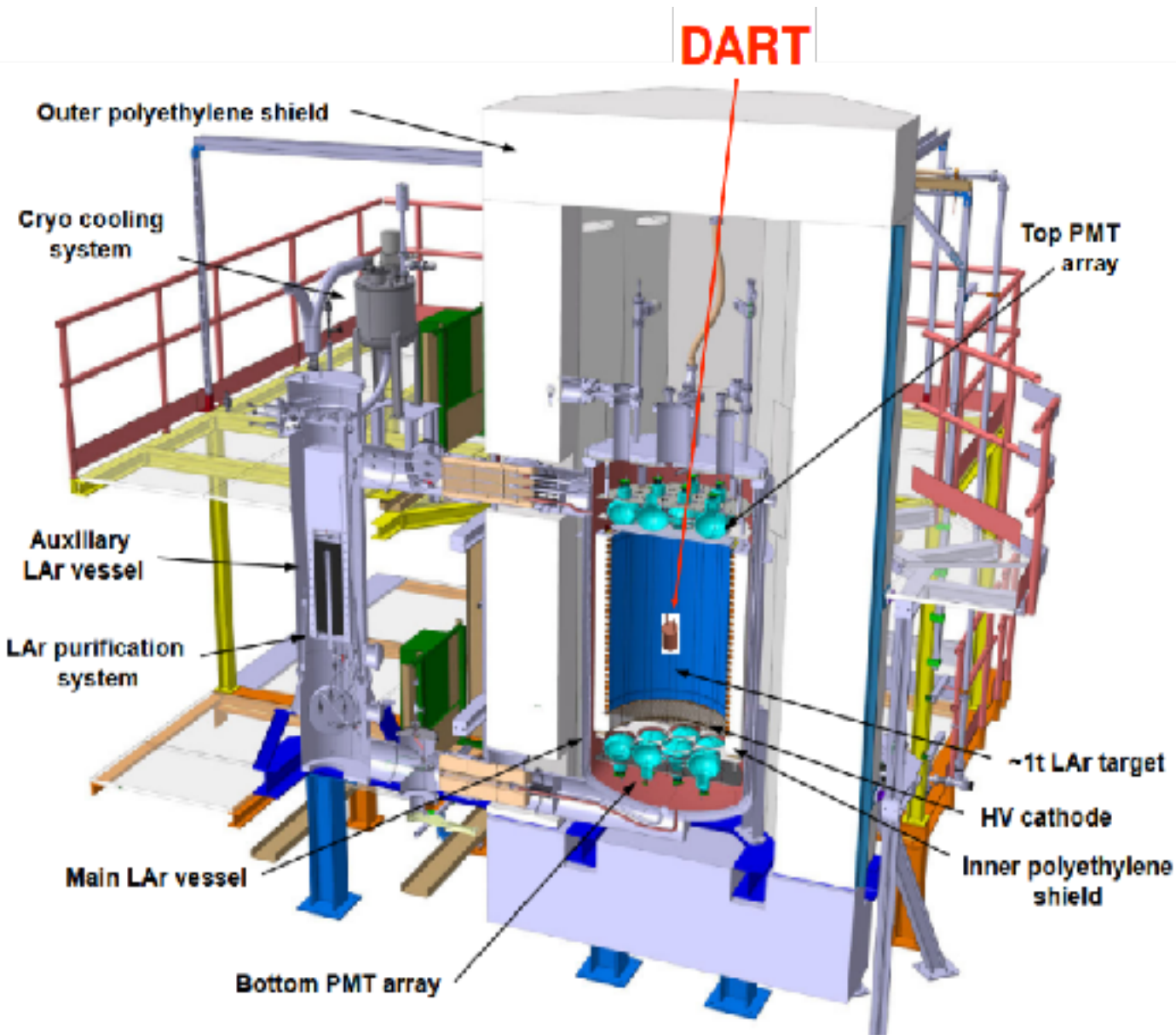
- CIEMAT**
- ETHZ**
- LSC**
- APC**
- LPNHE**
- LNGS**
- TO**
- CA**
- UH**
- possible involvement of Canadian institutions**

**WE ARE STUDYING THE FOLLOWING CONFIGURATION
(the main issue is background rejection, still not satisfactory)**

- Goal: measurement of the UAr activity.
- AAr \rightarrow 1 Bq/kg
UAr (DS-50) \rightarrow 0.73 mBq/kg
- Argon Dark Matter (ArDM), 850 kg LAr TPC. Currently taking data at LSC (Spain).
- DArT, low background detector will be installed inside ArDM.
- ArDM will be used as active veto.



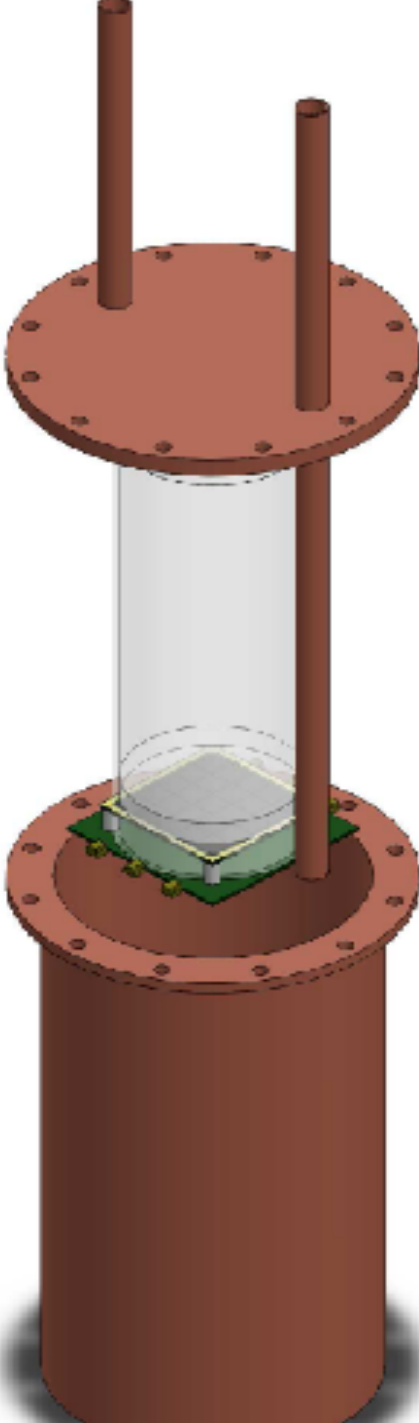
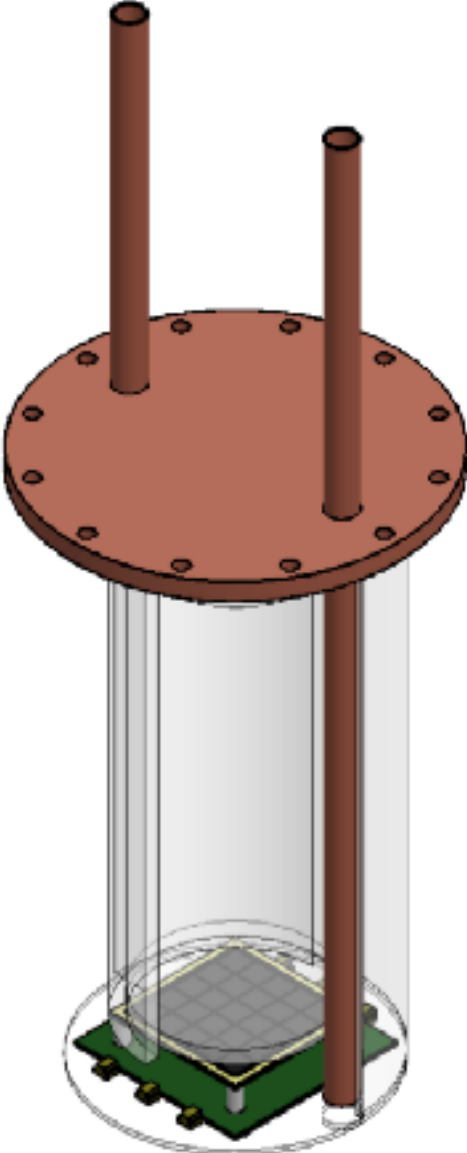
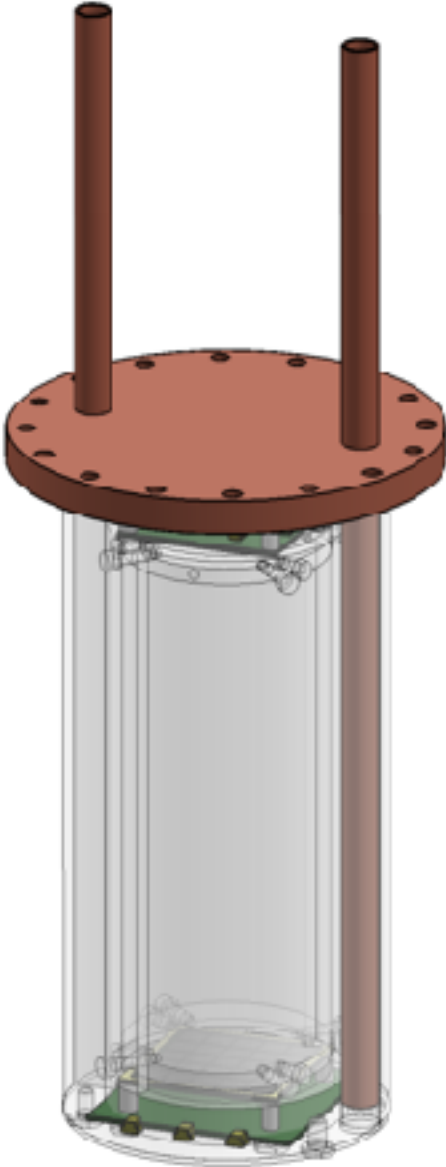
Experimental set-up using the ArDM facility



Insertion of active small chamber in ArDM. Use ArDM as veto(single phase).

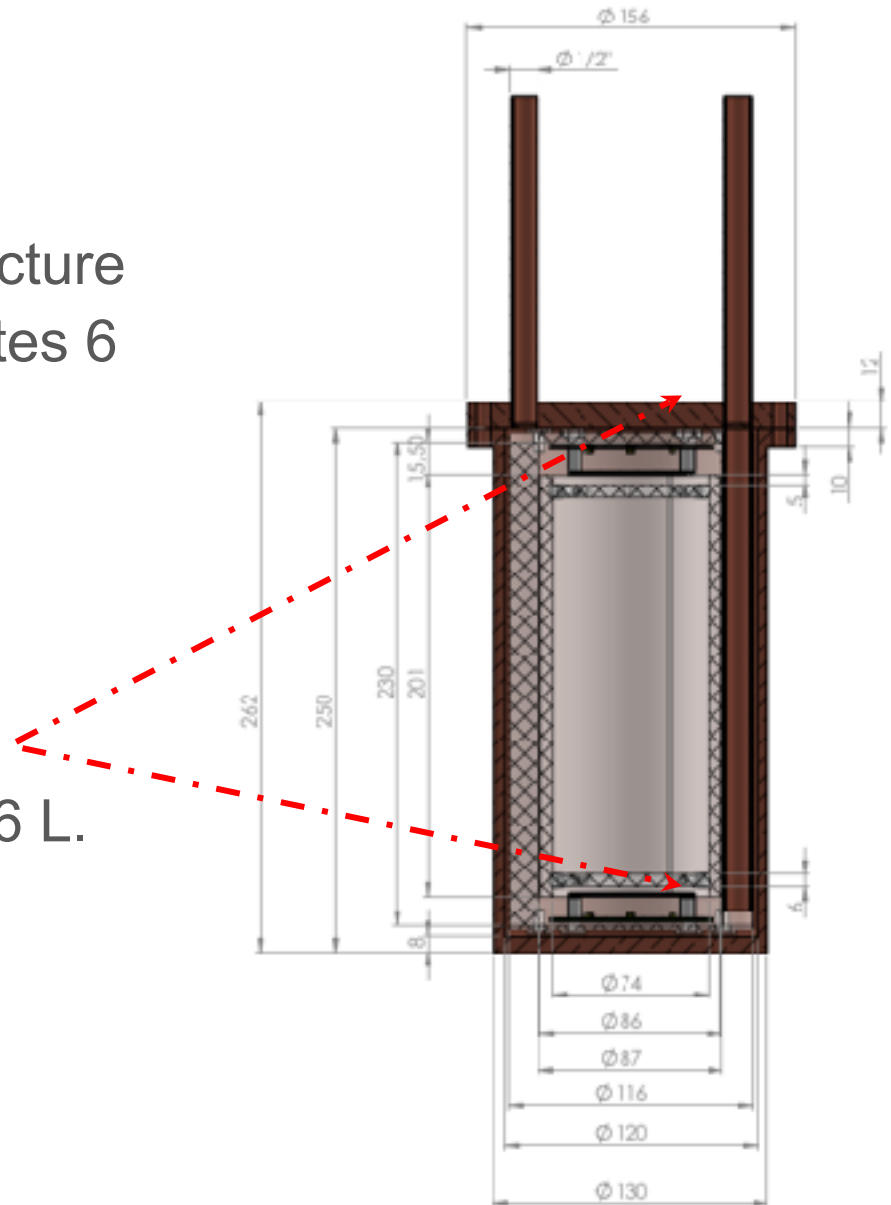
Dissipated power and condensation heat to be absorbed by ArDM cryogenic system.

DArT mechanical design

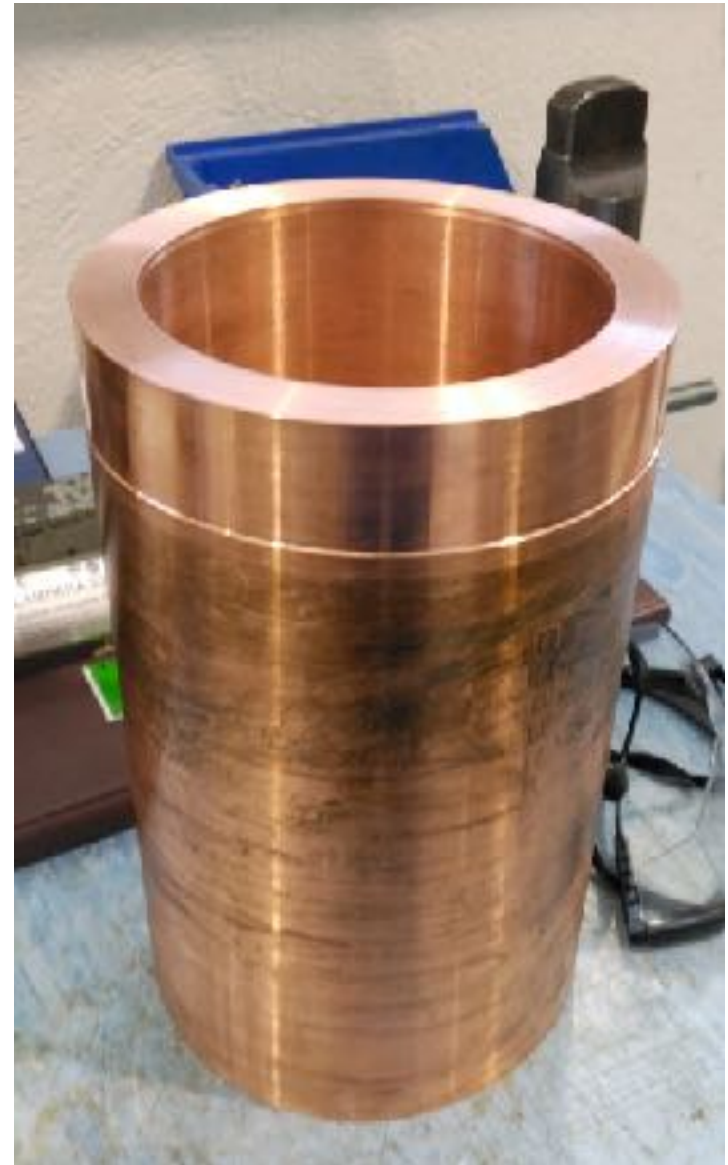
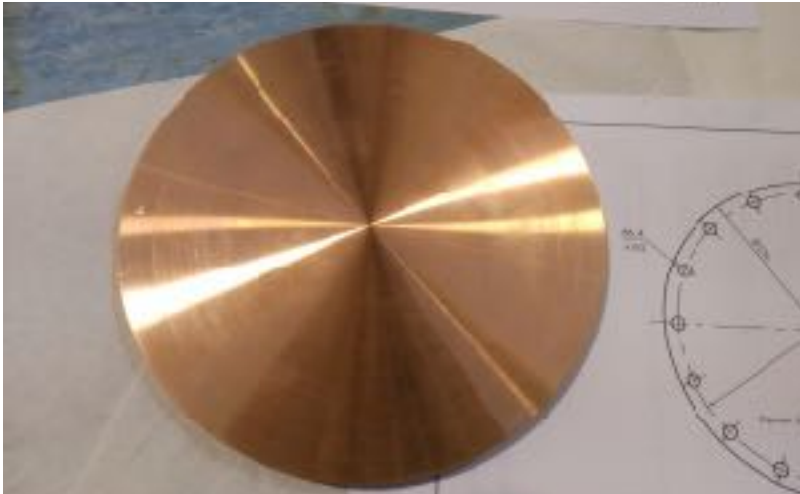


DArT mechanical design

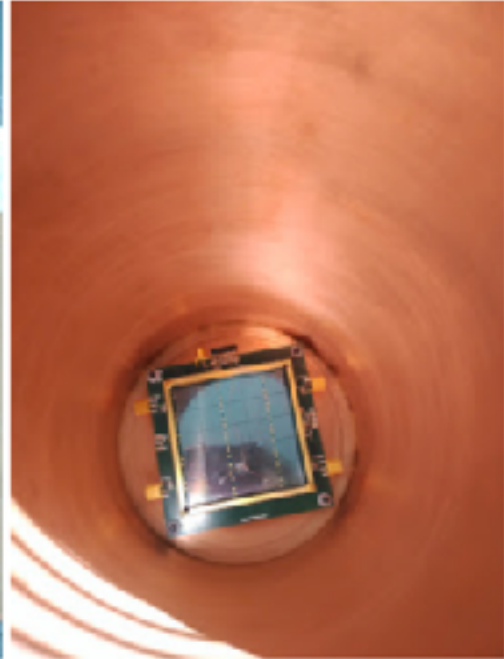
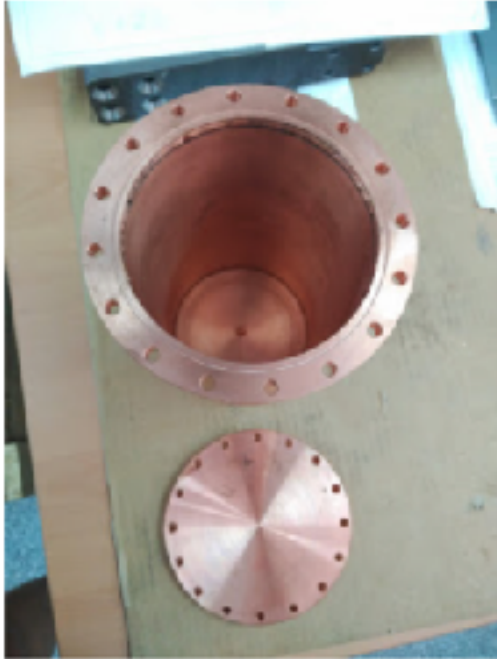
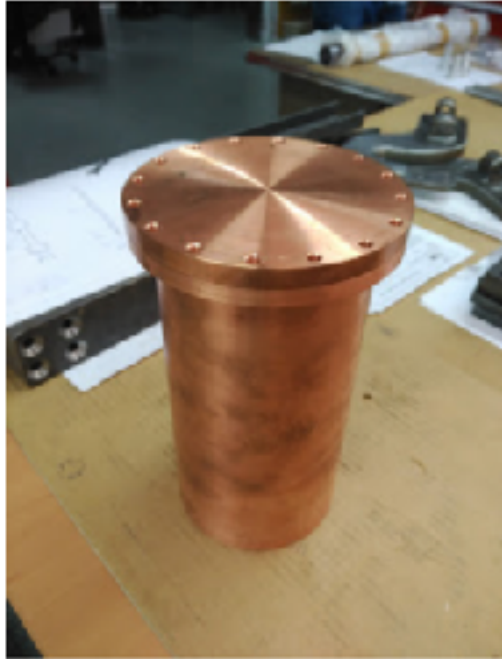
- OFHC copper vessel ~6.9 kg.
- PMMA cylindrical support structure (two halves cylinder + two plates 6 mm thickness) ~200 g.
- Lateral (outer) 3M foil.
- 2 SiPM tiles (top+bottom).
- Maximum internal volume ~2.6 L.
- LAr volume ~0.8 L.



Status of Materials

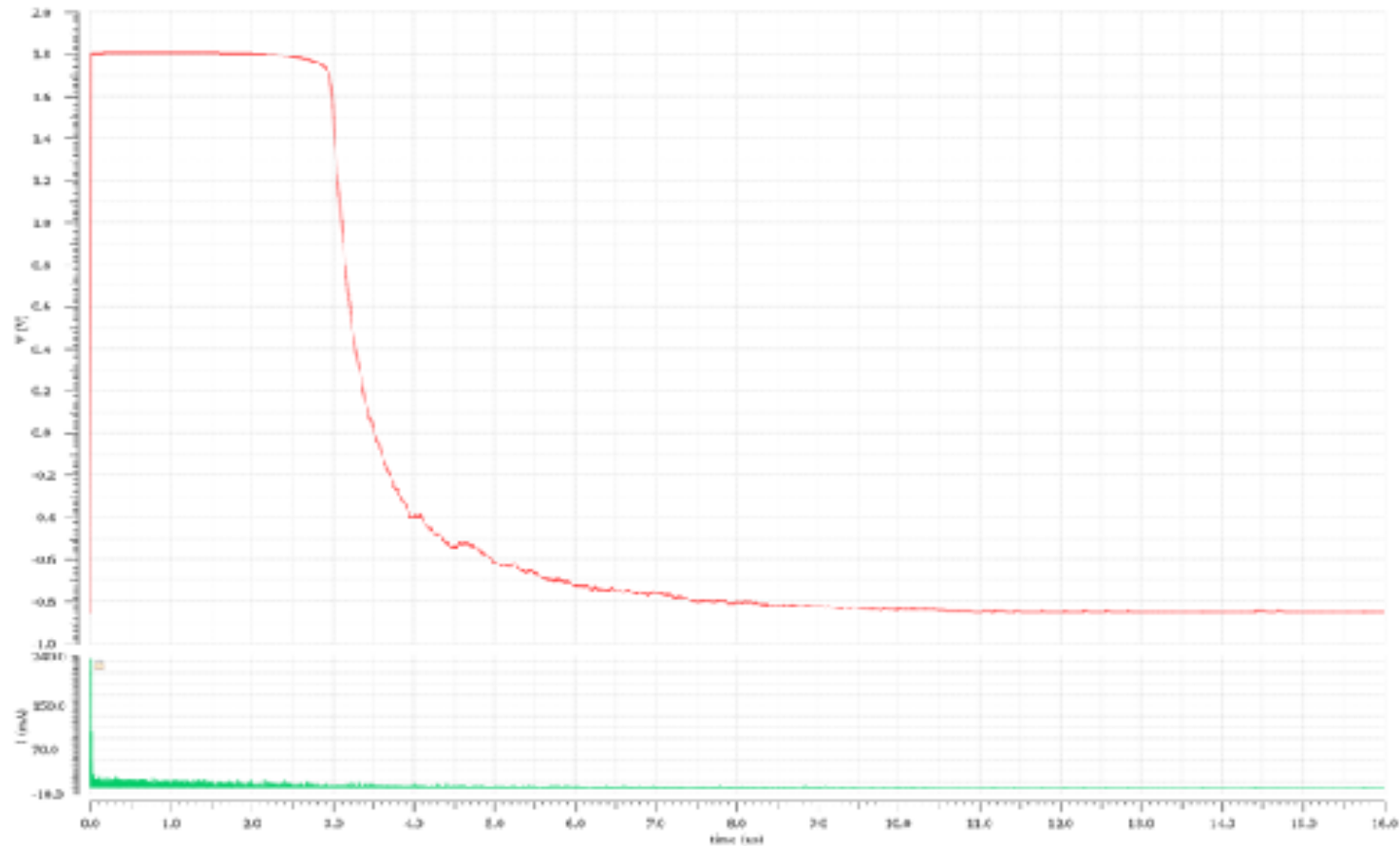


- OFHC copper vessel already machining at CIEMAT. Electropolishing in discussion.



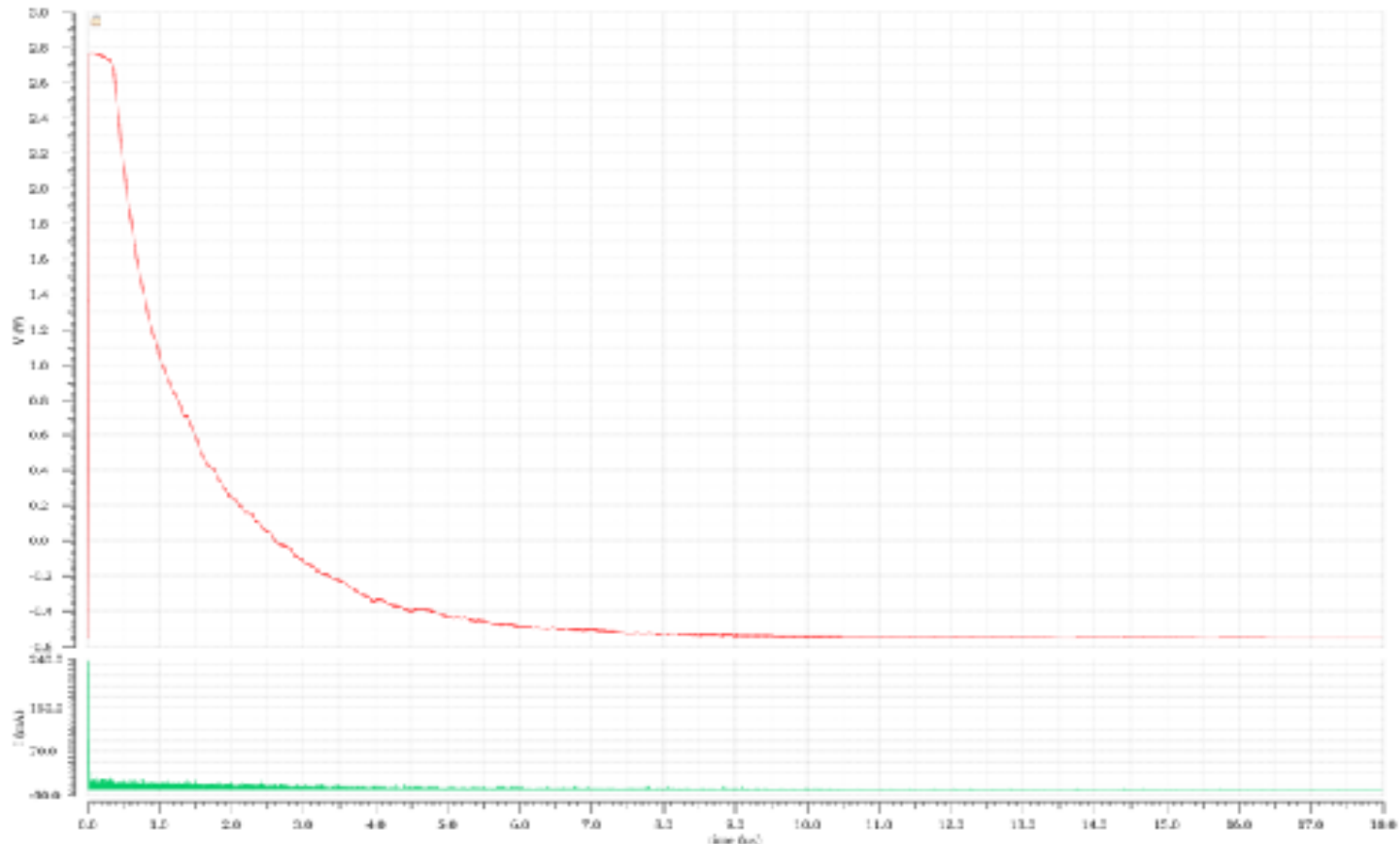
simulation of the electronic signals

- The dynamic range has been studied by the Torino group for an energy deposition of 2 MeV close to the SiPM-tile. PDE of 40 % is considered.
- Simulation with SPAD at room temperature for a tile of 6cm². Feedback resistor of the TIA stage 4K Ω . The signal is saturated in the first μ s.



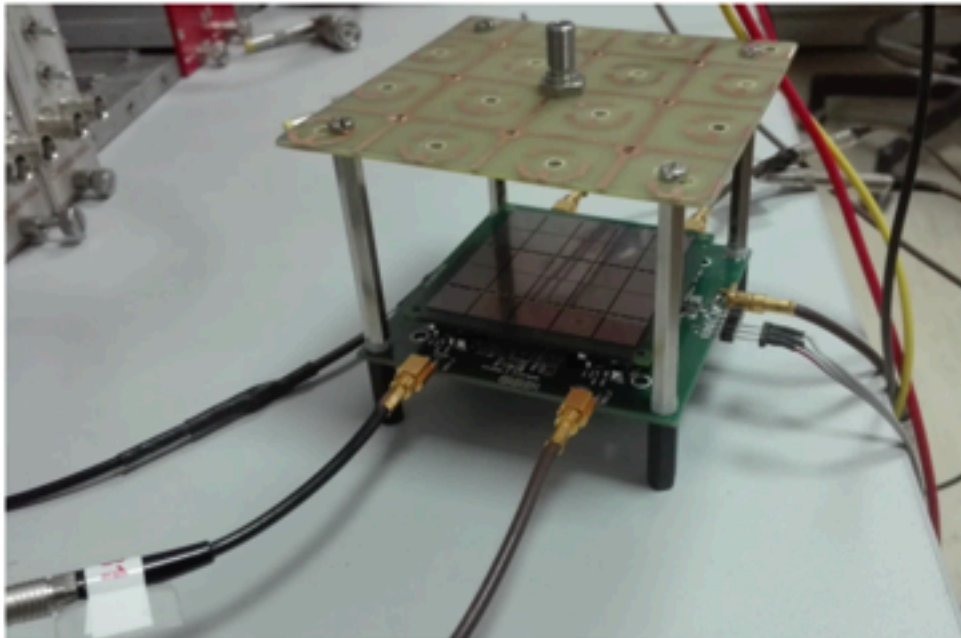
Simulation of the electronic signals

- Feedback resistor smaller ($2\text{K}\Omega$) in order to reduce the saturation in the output signal.
- Capacitance of 5 pF added in parallel to the feedback resistance to reduce bandwidth. Bias voltage of 7V instead of 5V .



Experimental set-up

- SiPM tile 5x5cm² from LNGS.
- Cryogenic dewar.
- Light pulse generator
- ADC
- Oscilloscope

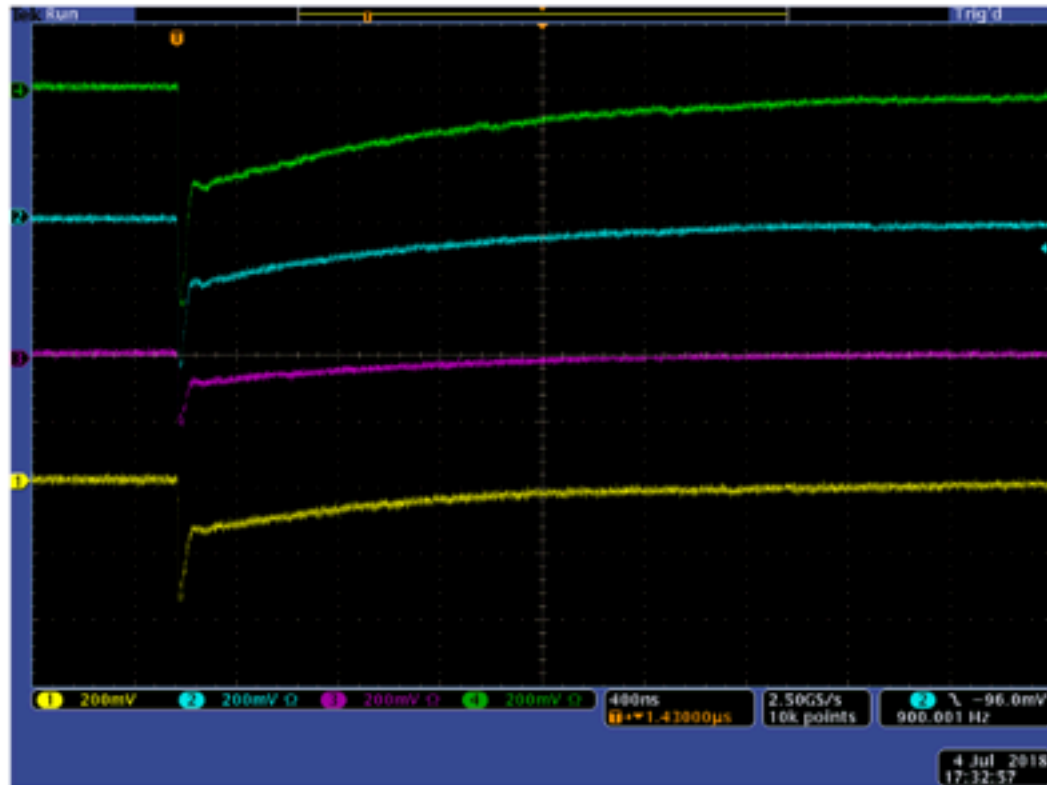


Test at cryogenic conditions

- SiPM power supply:
54.2 V
- Operational power supply:
2.5, -2.5 V
- Light pulse:
900 Hz,
100 ns (bandwidth)
6 V
- Test with liquid nitrogen.

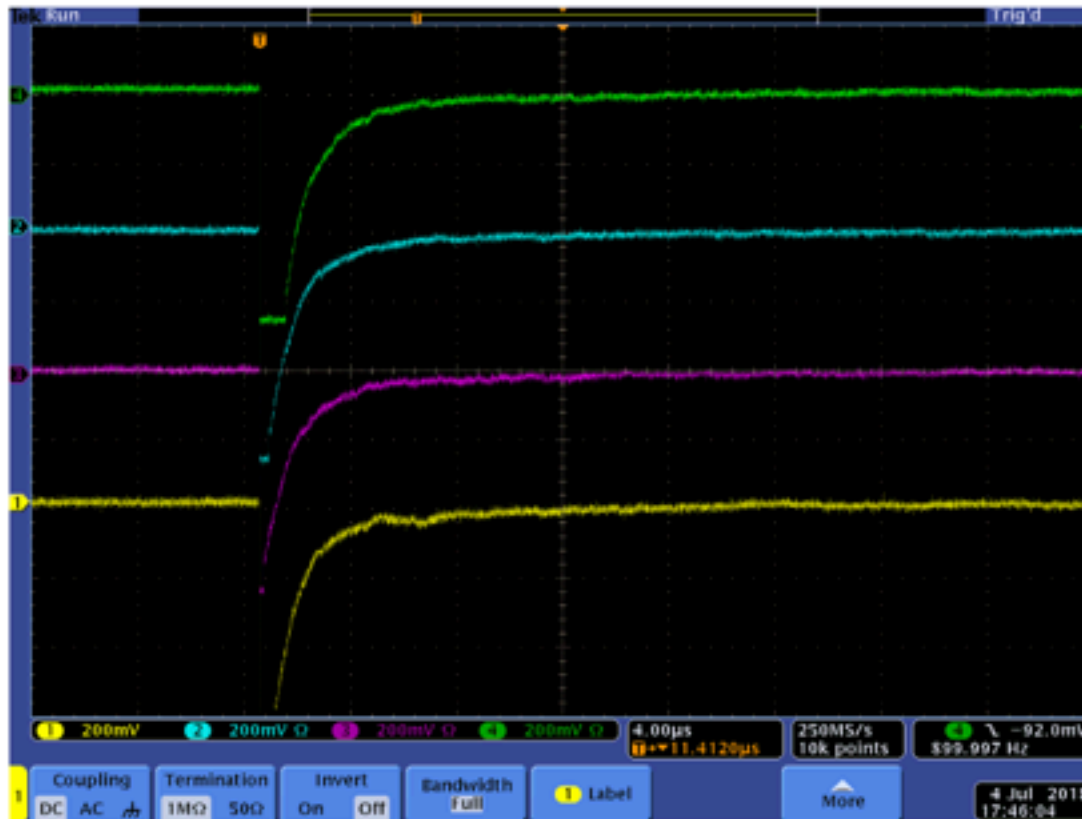


Signal pulse



- Signal from light pulse for the 4 channels.
- Different gains are observed for each channel.
- The shape is strange → slope decrease too slowly. **Is this normal??**

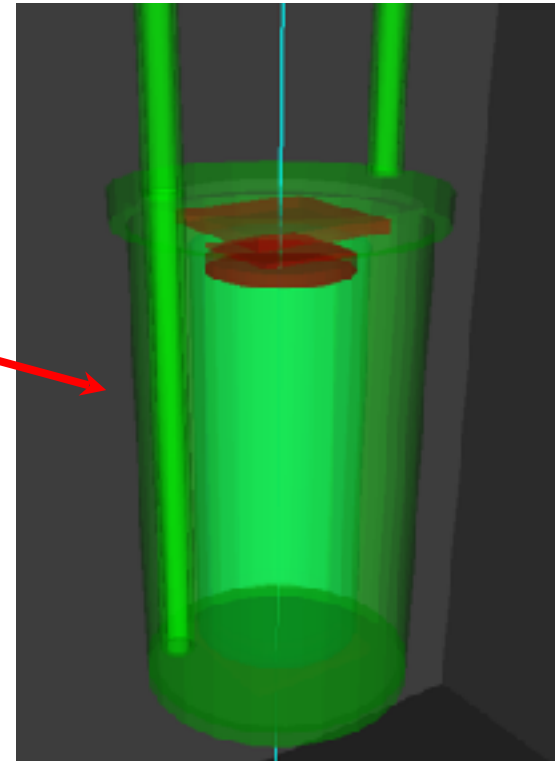
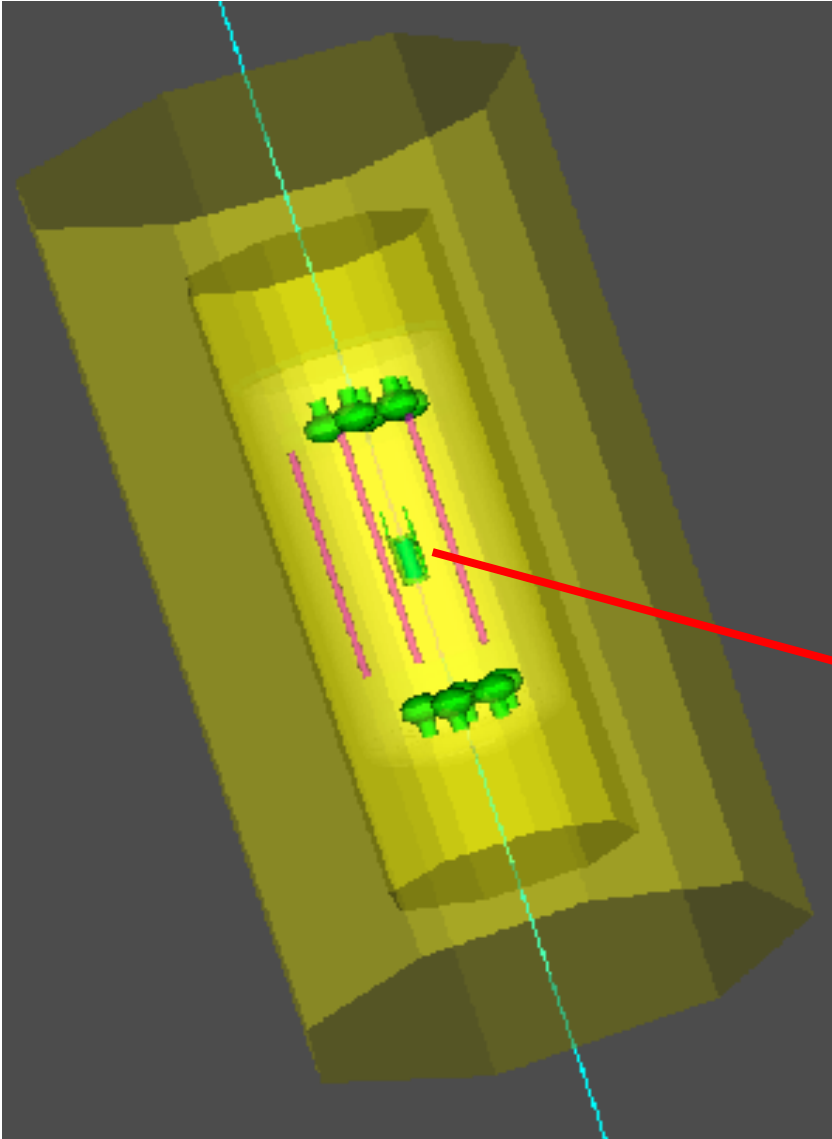
Saturation level



- The saturation appears with signals between 600-700 mV.
- These values are equivalent to 40 PE.

Simulation with G4DS

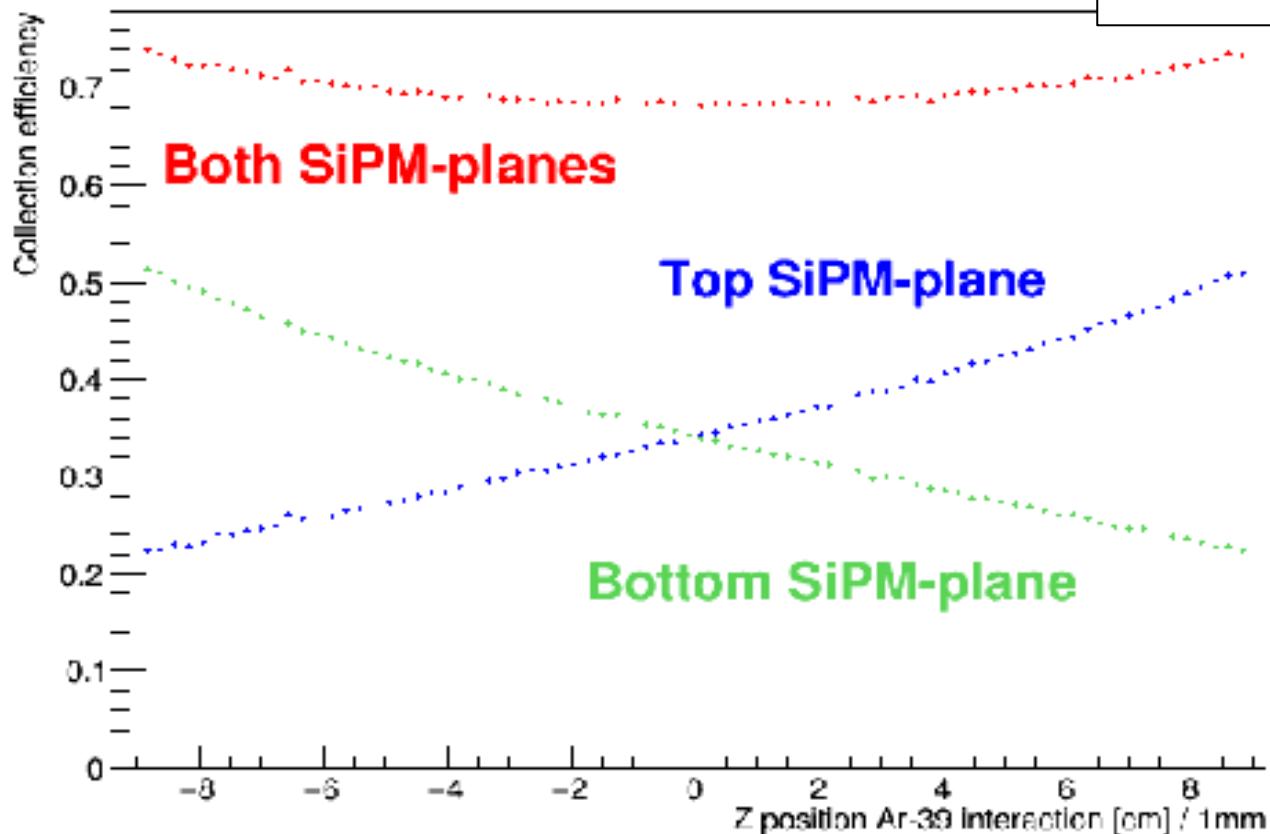
- Cu vessel with 2 pipes on top simulated.
- Acrylic, TPB, SiPM and reflector implemented.



Optical simulation: Collection efficiency

- ^{39}Ar : 10^4 events in the UAr active volume.
- Collection efficiency is higher for events close to the SiPM-plane. Overall efficiency is rather flat.
- Assuming PDE 0.35 \rightarrow LY 12 PE/keV

Collection efficiency $\sim 70\%$.



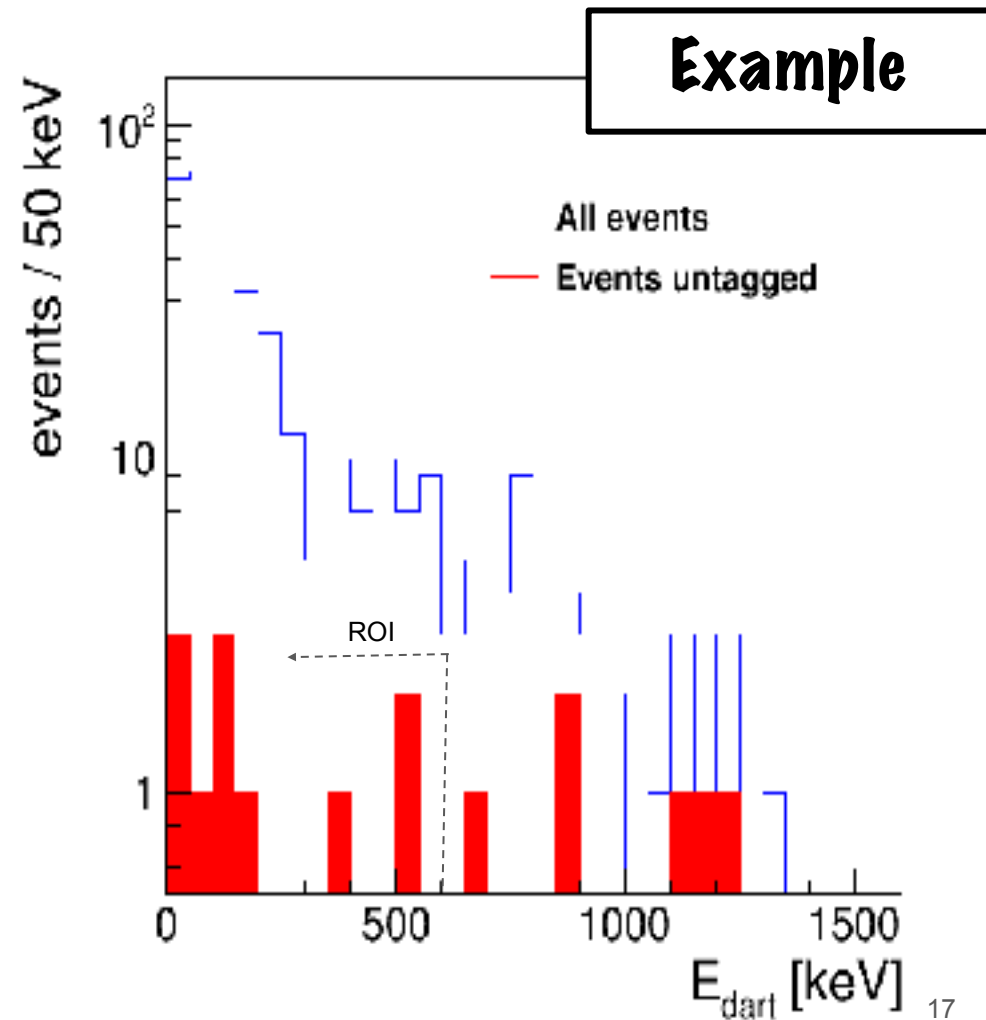
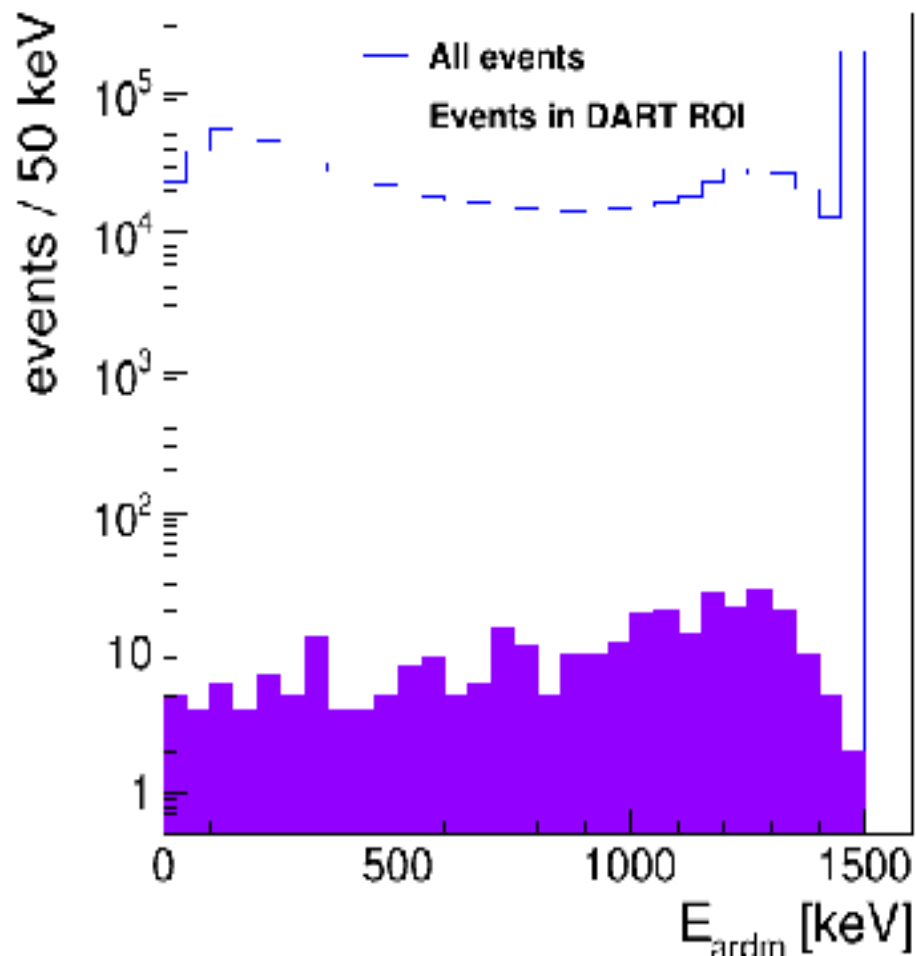
Analysis of background in DArT

Untagged: $E_{\text{ardm}} < 10 \text{ keV}$ (veto)

ROI: $0 < E_{\text{dart}} < 600 \text{ keV}$

Cryostat ^{40}K : events in **ArDM 909200**, events in **DART ROI 324**, **Untagged 11**

$2 \cdot 10^7$ evts \rightarrow 3 weeks



Material Radioimpurities

Material		²³⁸ U-chain [mBq/kg]			²³² Th-chain [mBq/kg]	⁴⁰ K [mBq/kg]	⁶⁰ Co [mBq/kg]
ArDM Cryo		3.42			6.37	10.36	11.21
ArDM PMTs	base	9277			11036	16588	0
	metal	183			75	3110	0
	glass	643			115	441	1.81
DArT Cu		0.012			0.004	0.06	0.04
DArT Arlon		Top	Middle	Bottom	70	1300	
		3.8	53	137			

Material background Events/week

Signal UAr: 618 event/week

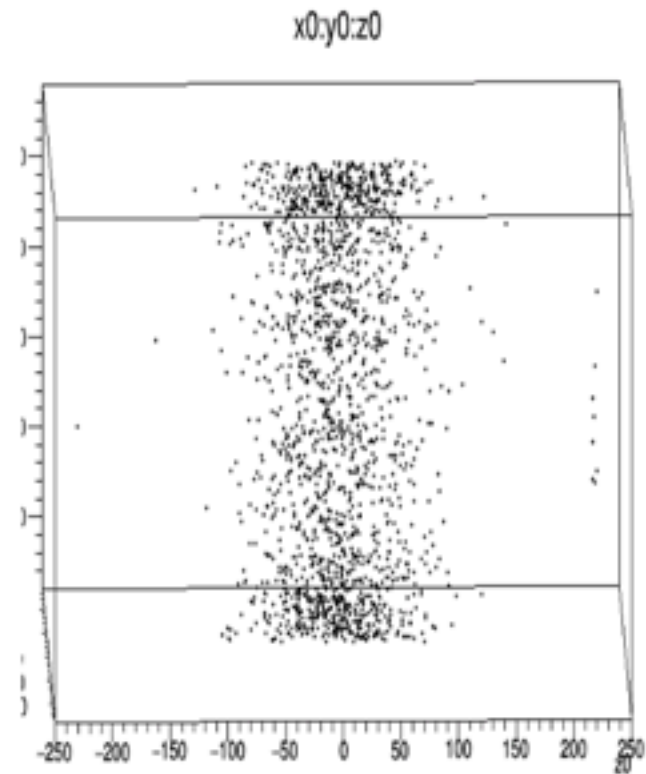
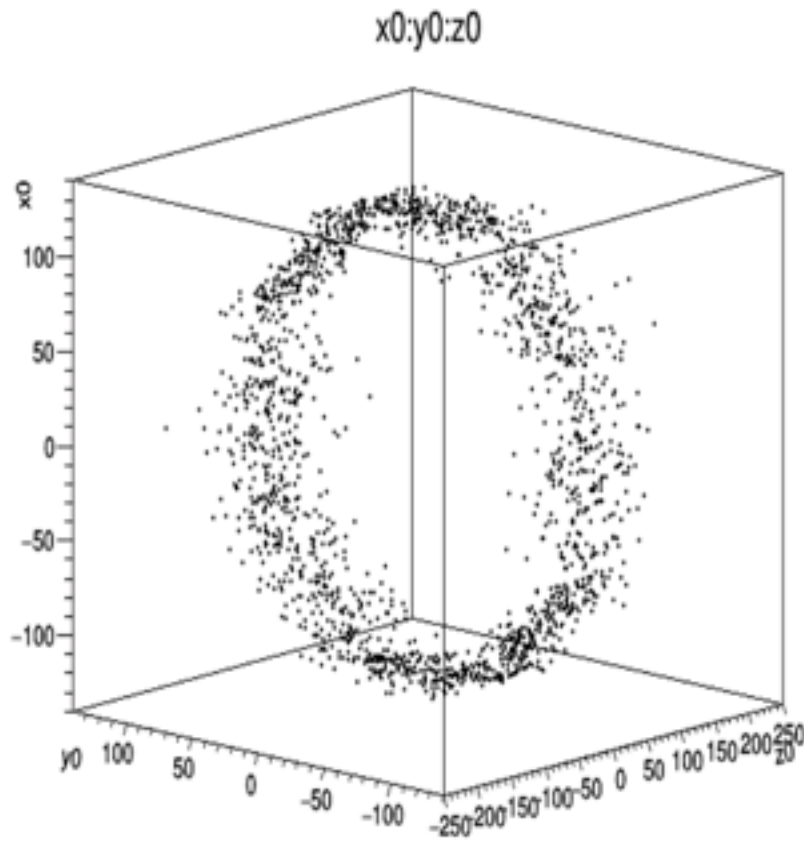
Material	Events / week in ROI	Events untagged / week in ROI
DArT Cu	36	8
DArT Arlon	909	483
ArDM Cryostat	2947	101
ArDM PMT	2953	55
TOTAL	6845	647

now working on external
background

there is a new geometry
implementation of the ArDM
detector is the simulation
ongoing; should leave room
for 15cm Lead belt—>
suppress external background

Interaction vertex origin

- ^{40}K produced without lead belt around polyethylene. Initial particle: γ 1460 keV
- Events untagged with energy > 0 in DArT (< 10 keV in veto).



External Background events/week

- External background fluxes in $\gamma/\text{cm}^2 \text{ s}$: ^{238}U 0.72, ^{232}Th 0.13 and ^{40}K 0.05 [1].
- Numbers significantly higher than previous studies. New geometry and more statistics.

Radionuclide	Events / week in ROI	Events untagged / week in ROI
^{238}U -chain	140943	9456
^{232}Th -chain	74261	4674
^{40}K	42068	2809
TOTAL	257272	16939

[1] ArDM Collaboration, “Backgrounds and pulse shape discrimination in the ArDM liquid argon TPC” arXiv:1712.01932 (2017)