Simulation status

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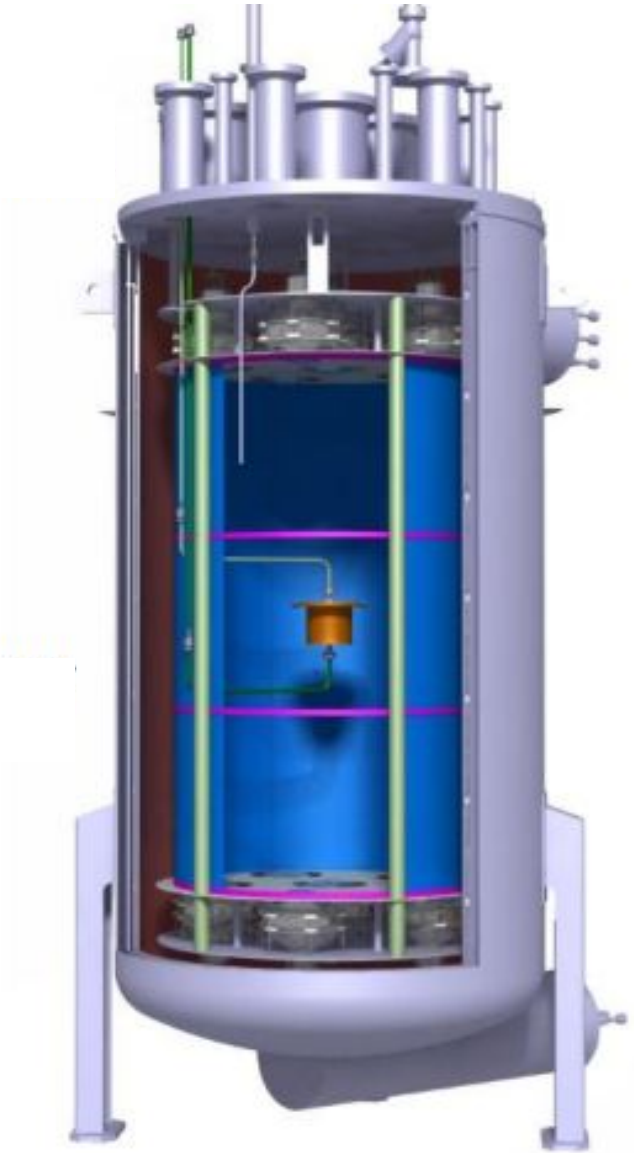
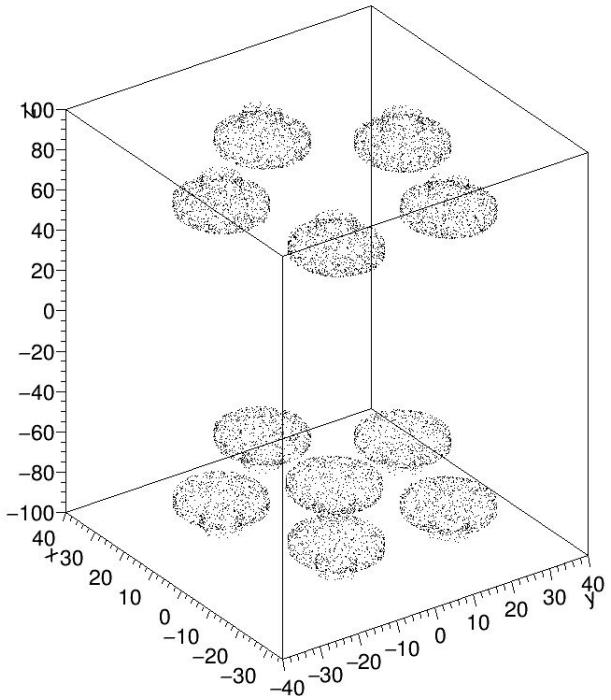
New ArDM SP geometry

1. Borotron and field shaping rings removed.
2. 24 PMTs → 11 PMTs
3. Veto active volume increased (ArDM), 650 kg → 1000 kg
4. New pillars
5. New rings

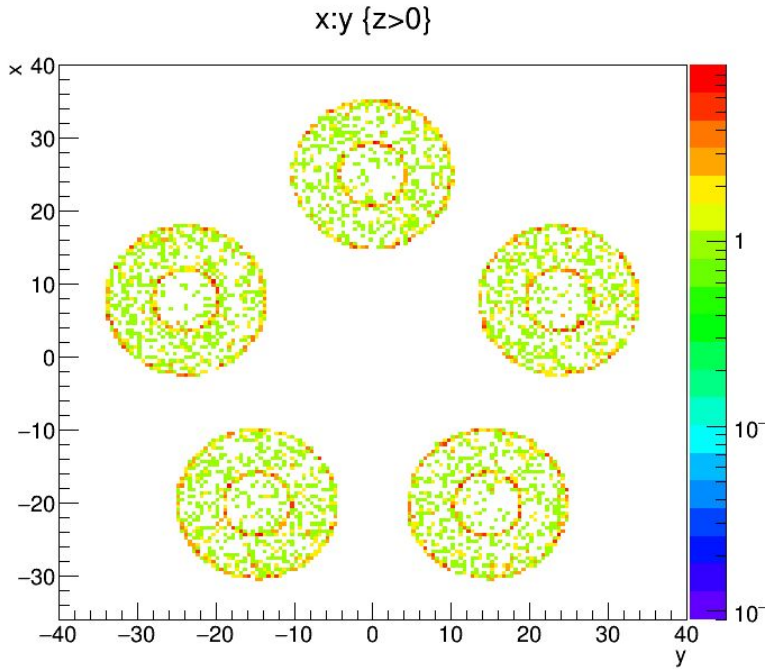


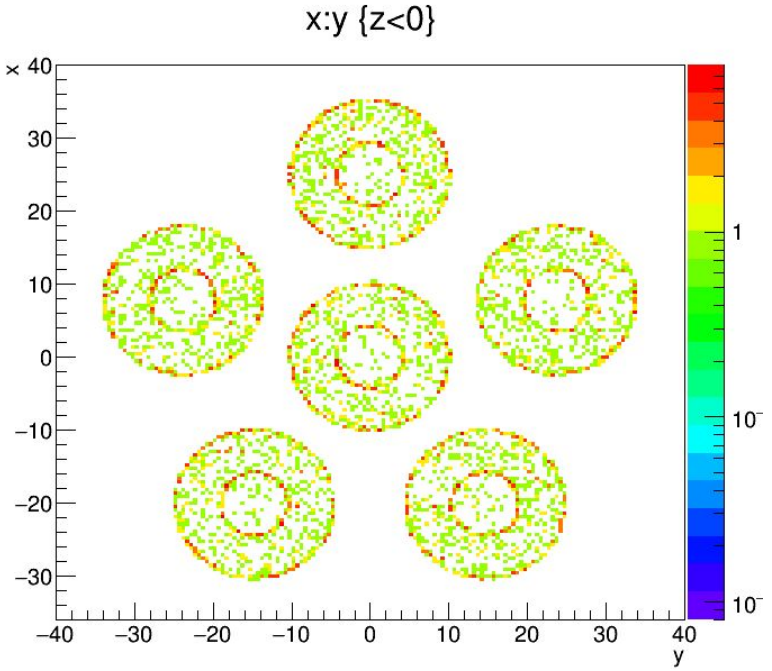
Photomultipliers

- 11 new low background PMTs (5+6)
- Weight: 10.8 kg
- Same radiopurity level as the old ones is assumed.



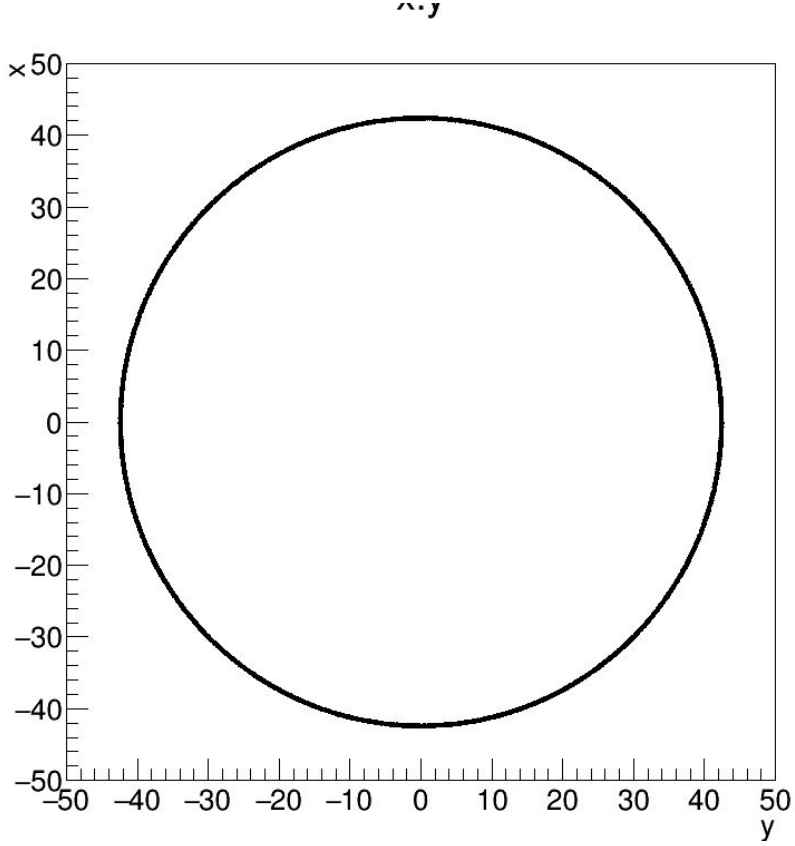
ArDM Collaboration. “The ArDM Liquid Argon Time Projection Chamber at the Canfranc Underground Laboratory: a ton-scale detector for Dark Matter Searches”

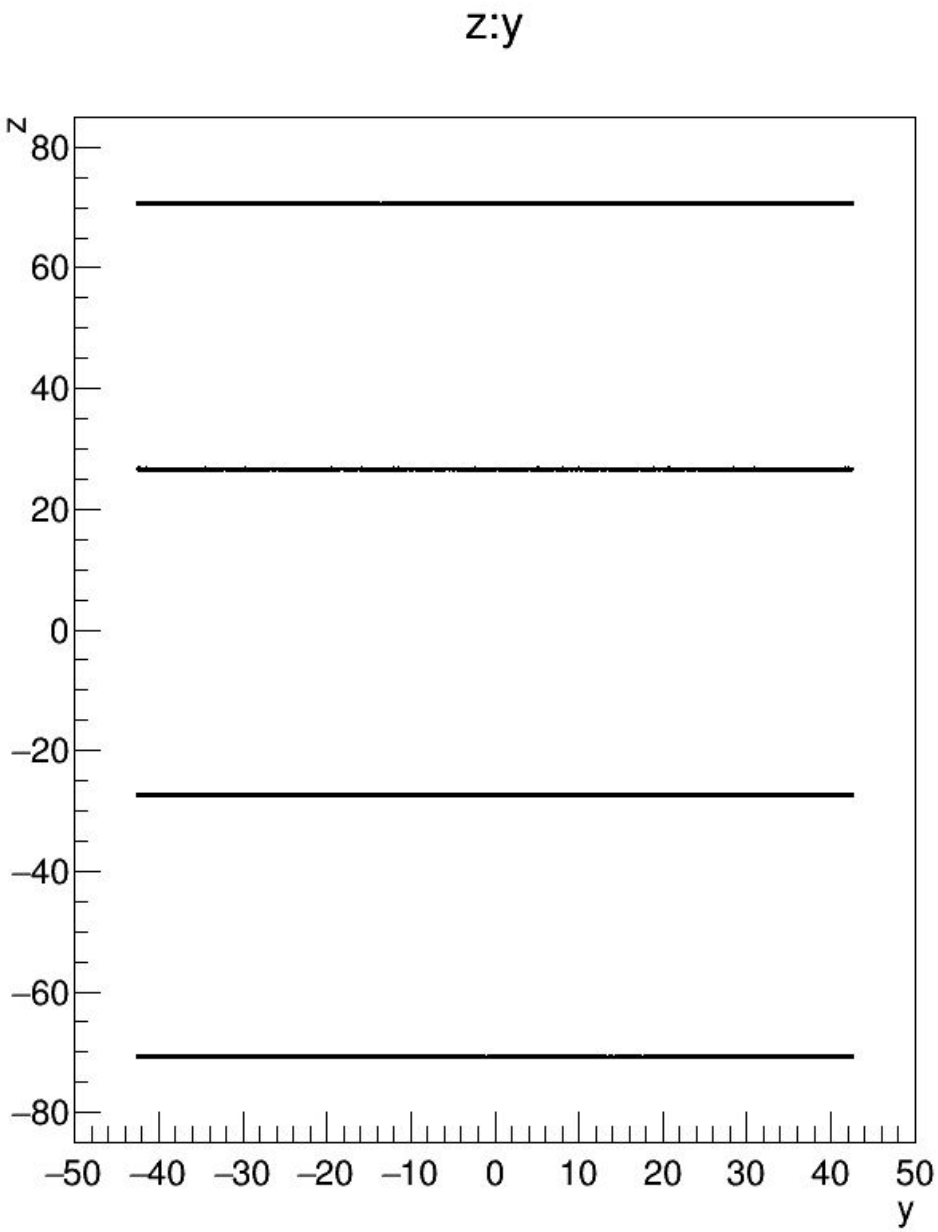




Support rings

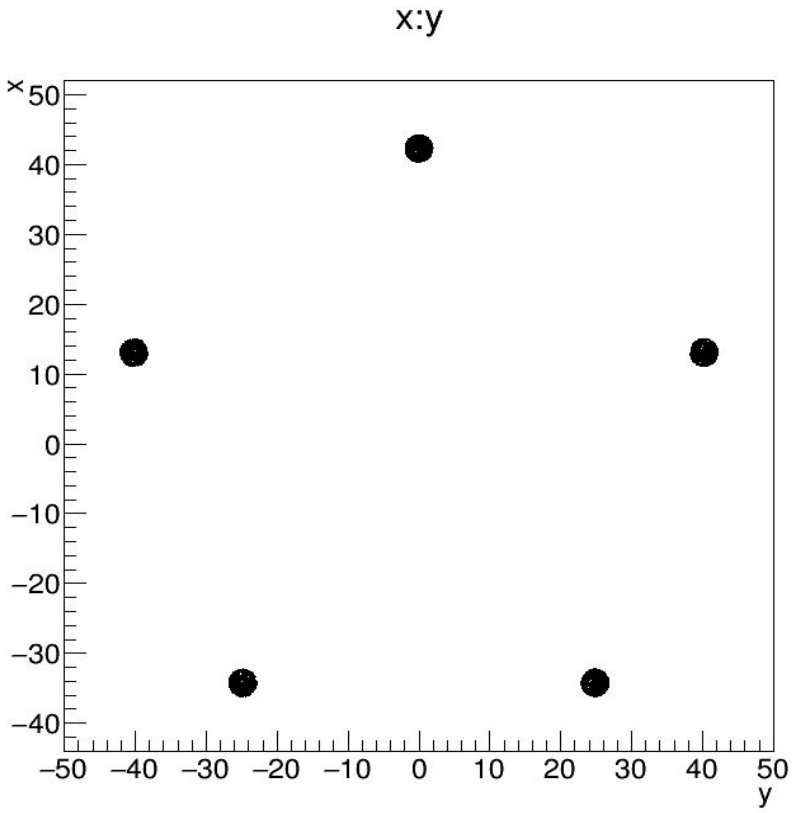
- 4 rings of stainless steel.
  Weight ~ 2 kg

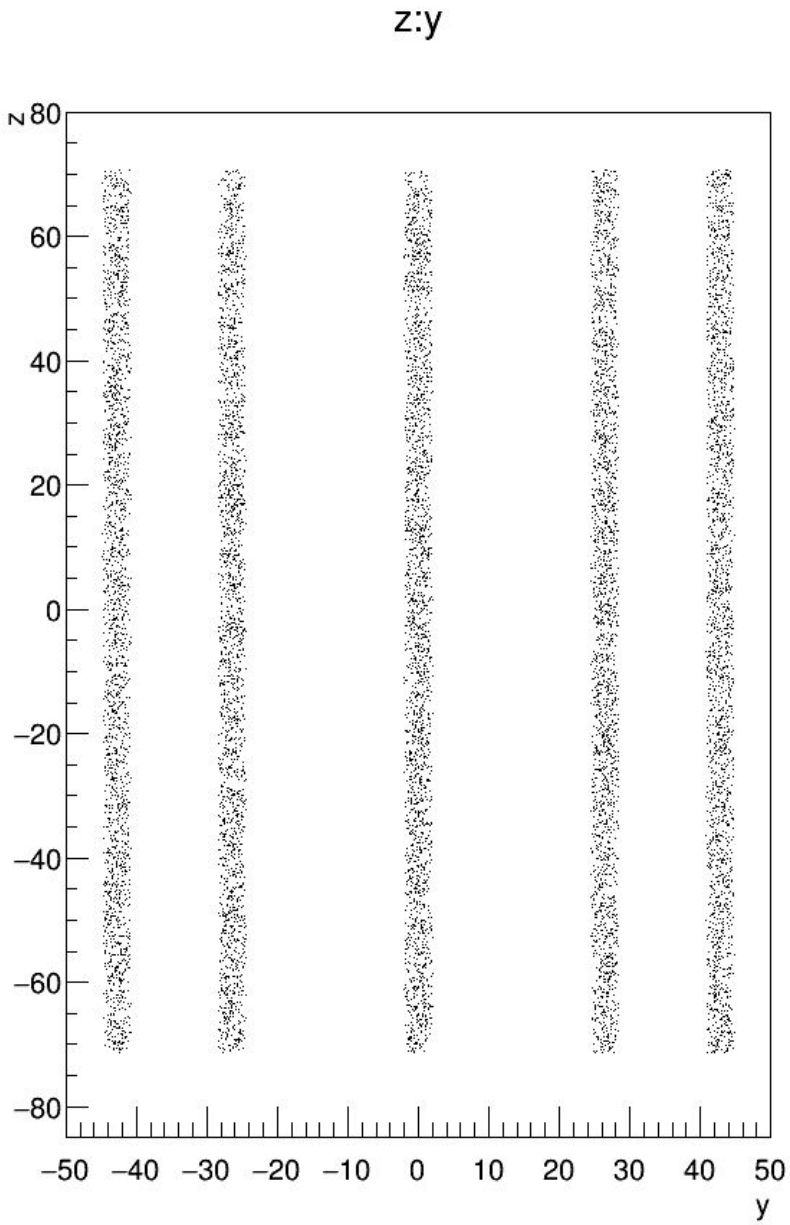




Support pillars

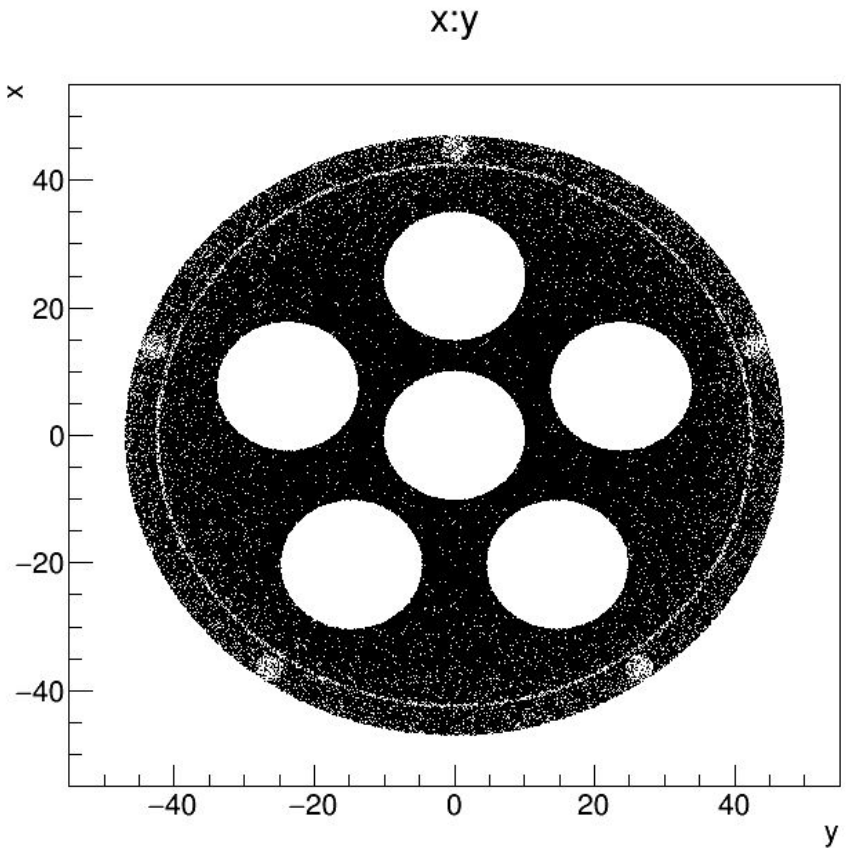
- 5 pillars of copper.
  Weight ~ 16 kg
- 40 mm diameter





PMTs support

- Two planes of 0.5 cm thickness.
- Same radiopurity level as the old ones is assumed.
- Weight ~ 16 kg



ArDM Collaboration. "The ArDM Liquid Argon Time Projection Chamber at the Canfranc Underground Laboratory: a ton-scale detector for Dark Matter Searches"

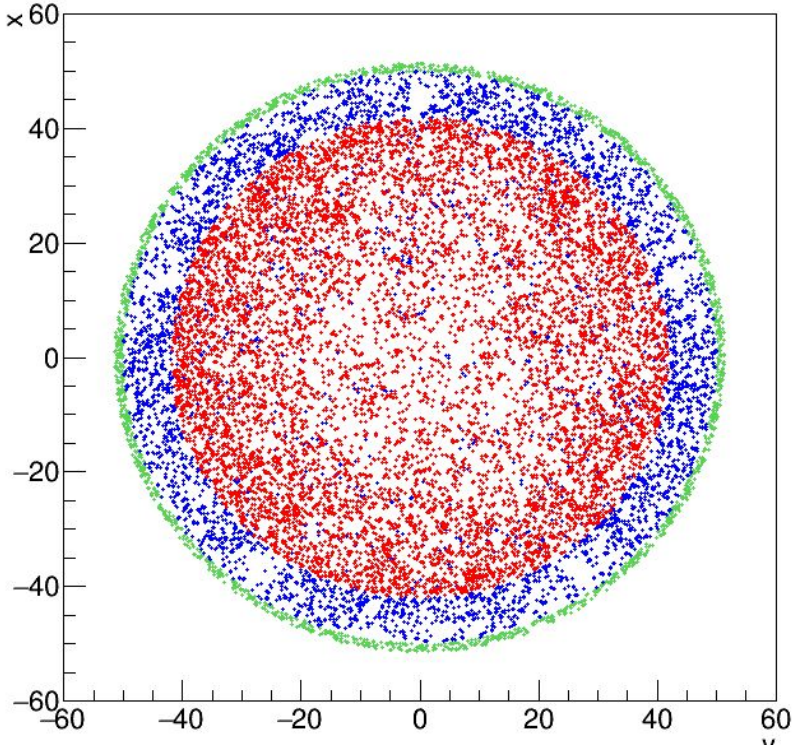
Sample	^{238}U [ppb]	^{235}U [ppb]	^{232}Th [ppb]	^{40}K [ppb]	^{60}Co [kru]
PMT glass	51.7±0.3	0.70±0.02	28.3±0.5	1.7±0.07	<0.2
PMT metal	14.7±0.3	0.71±0.04	18.4±0.7	12±0.4	–
PMT base	746±1	9.0±0.1	2720±10	64±0.7	–
SS struct	0.257±0.002	<0.05	1.57±0.01	<0.04	1.24±0.01
SS clamp	<0.6	1.0±0.3	<3	<0.1	2.0±0.2
SS rod	<2	1.18±0.08	<6	0.18±0.01	0.76±0.02
PE clamp	2.85±0.05	<0.2	23.3±0.6	0.3±0.07	<0.5
PE shield	0.34±0.06	<0.03	2.41±0.03	0.06±0.01	<0.06
HVres	118±1	1.92±0.02	466±1	6.7±0.06	–

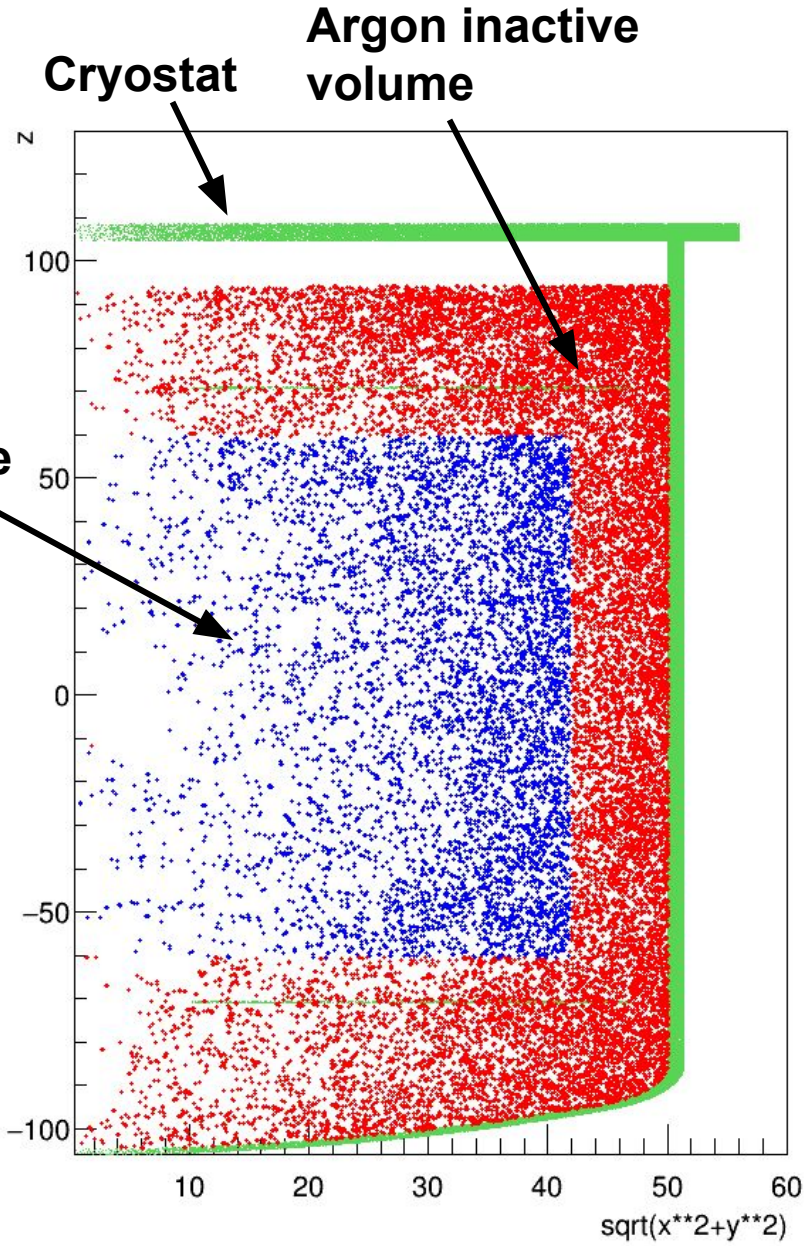
Argon volumes

- Stainless steel cryostat (green) of 14 mm thickness.
- Top flange 40 mm thickness.
- ArDM argon active volume (blue) ~ 900 kg

  Diameter : 84 cm

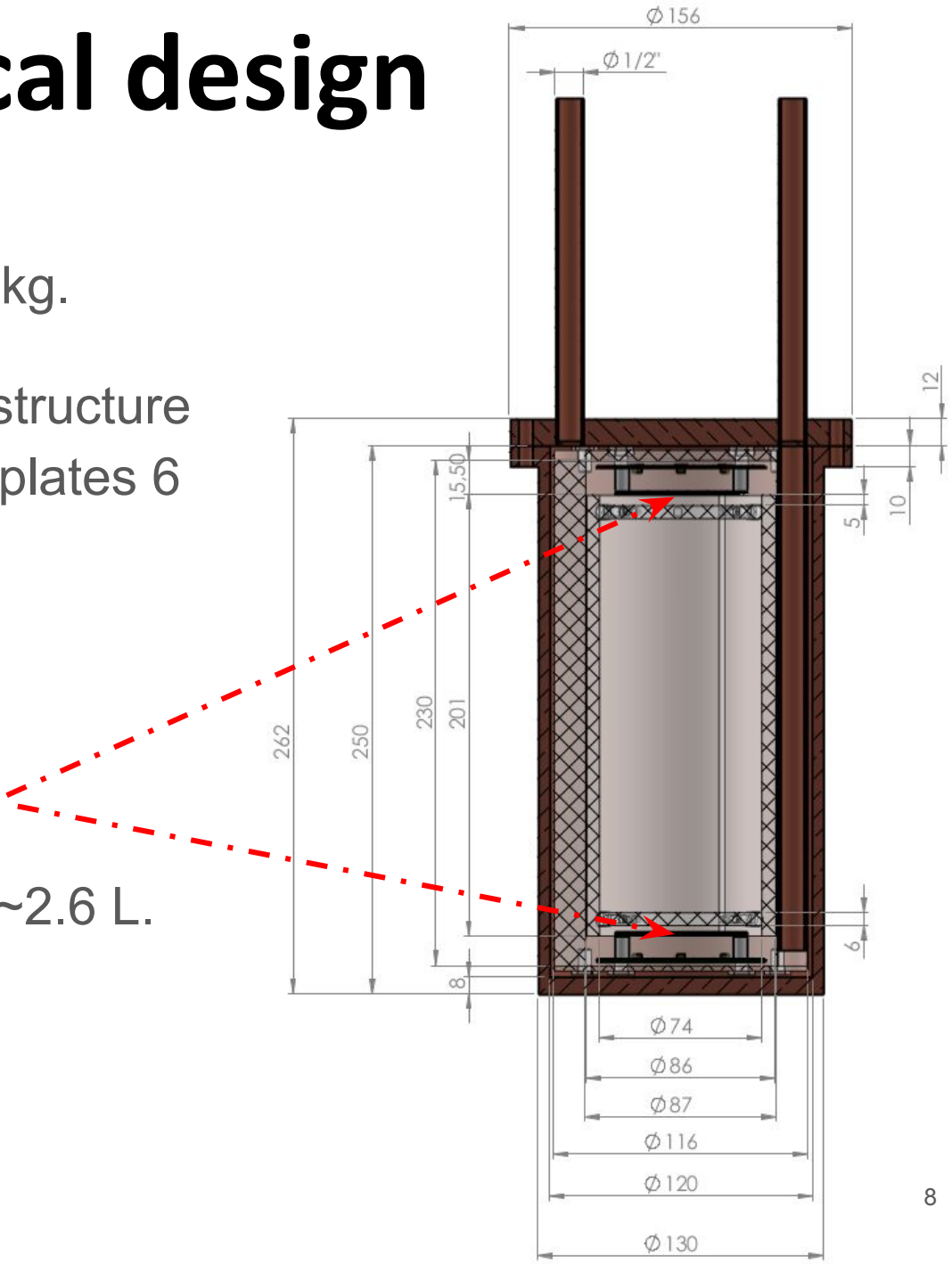
  Height : 120 cm



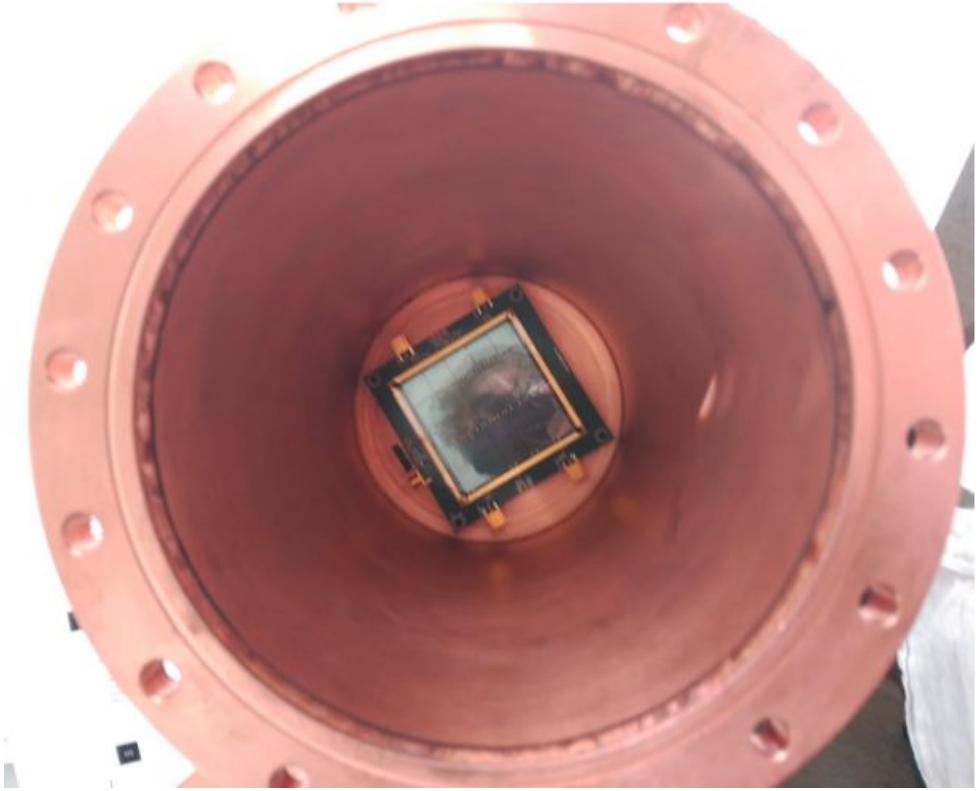


DArT mechanical design

- OFHC copper vessel ~6.9 kg.
- PMMA cylindrical support structure (two halves cylinder + two plates 6 mm thickness) ~1.5 kg.
- Lateral (outer) 3M foil.
- 2 SiPM tiles (top+bottom).
- Maximum internal volume ~2.6 L.
- LAr volume ~0.8 L.

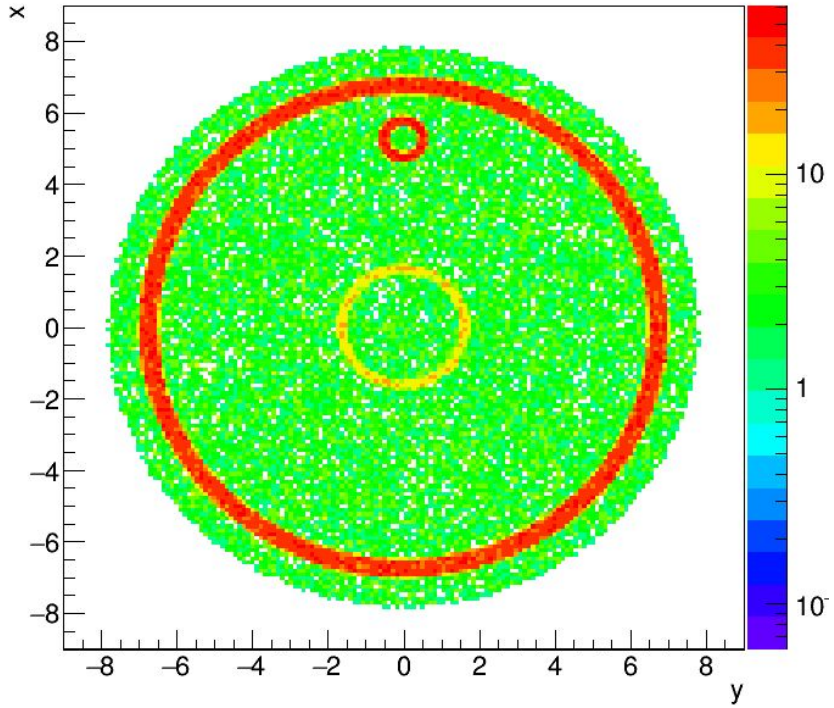


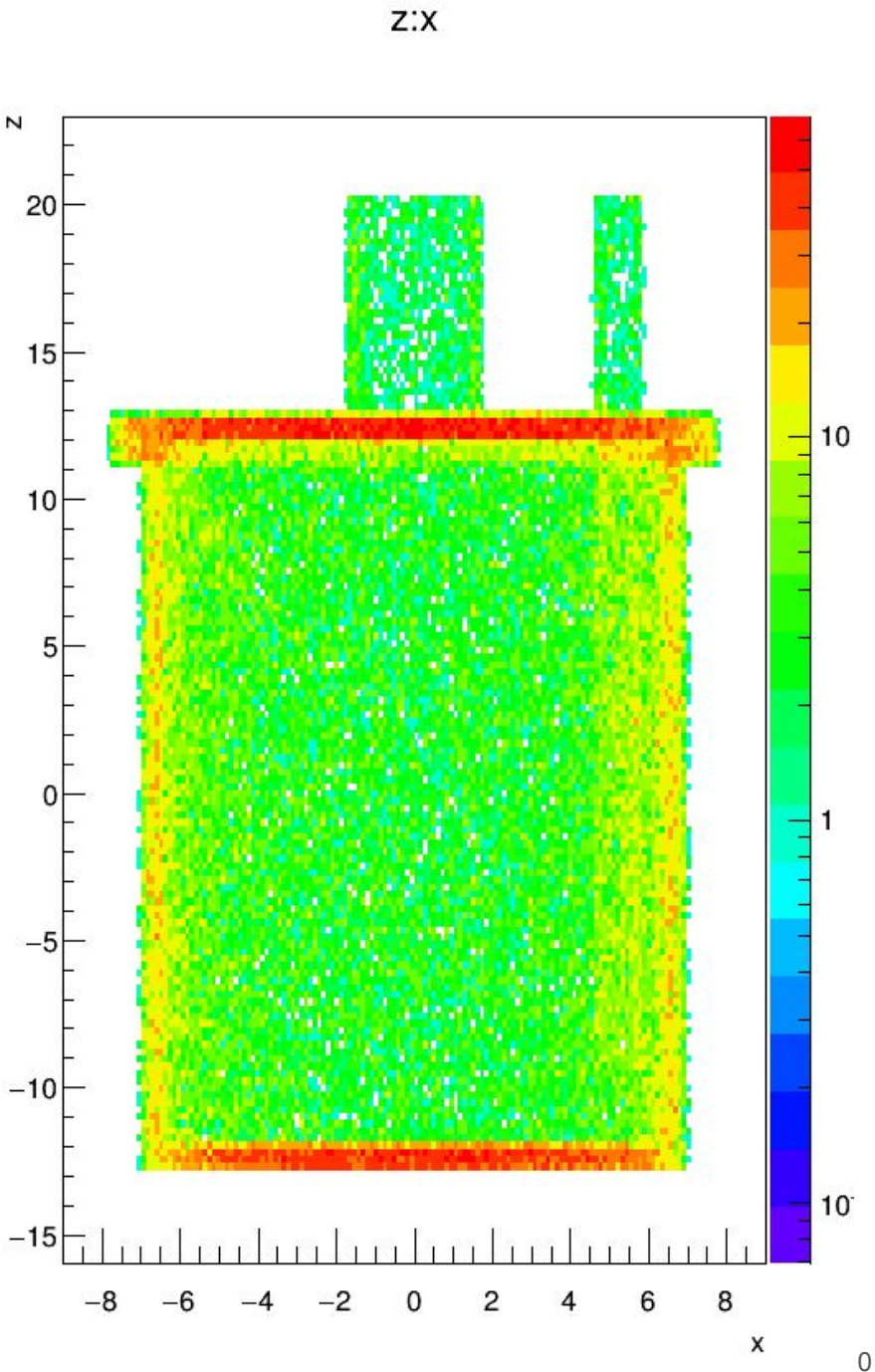
DArT Vessel



Copper vessel

- Two pipes (cables + argon)
- Wall thickness: 5 mm Flange: 16 mm
- Weight ~ 7 kg OFHC copper

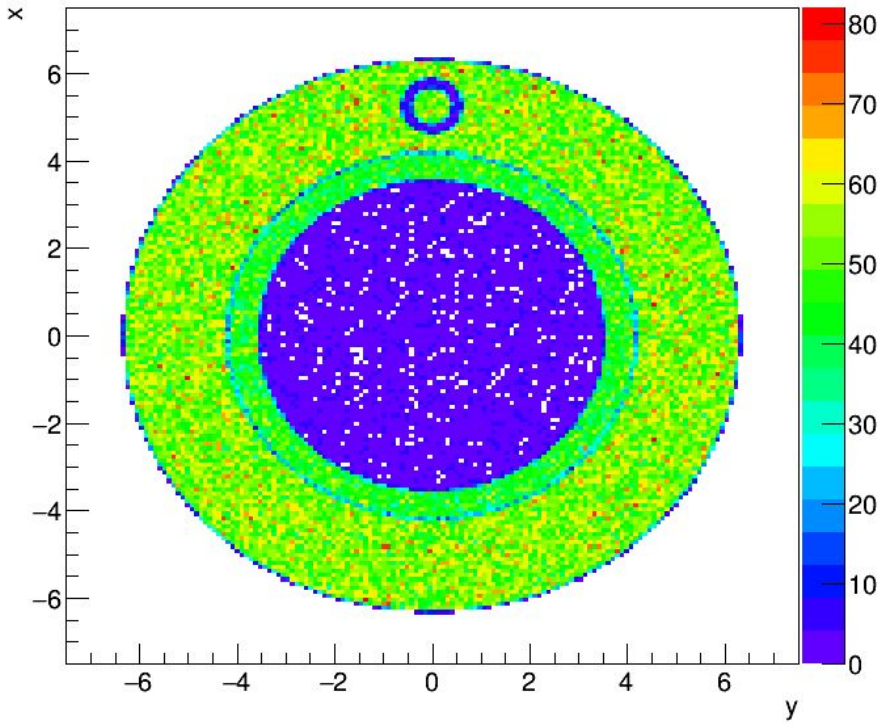




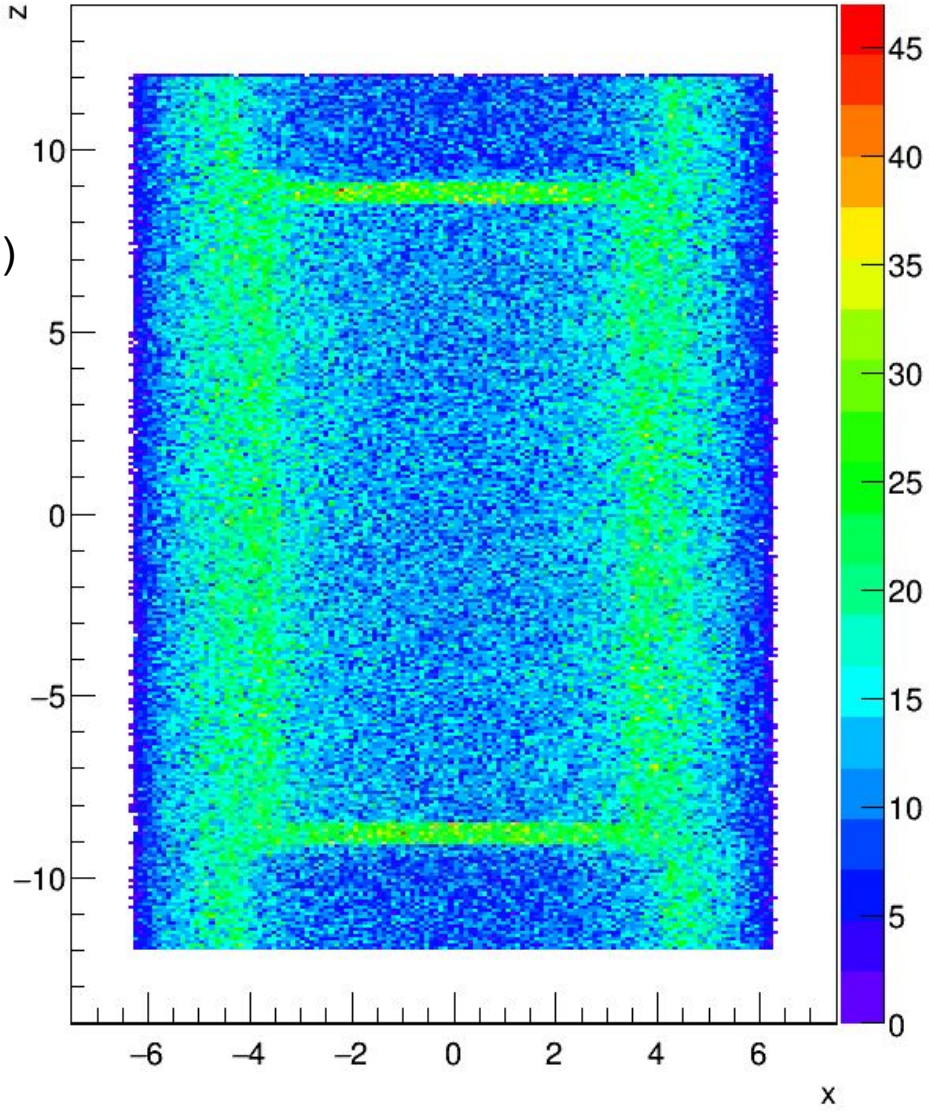
Acrylic support

- TPB+ 6 mm acrylic + reflector + acrylic filler
- Two acrylic disks with TPB (top + bottom). Distance between disks 170 mm (182 before)
- Weight ~ 1.8 kg

x:y

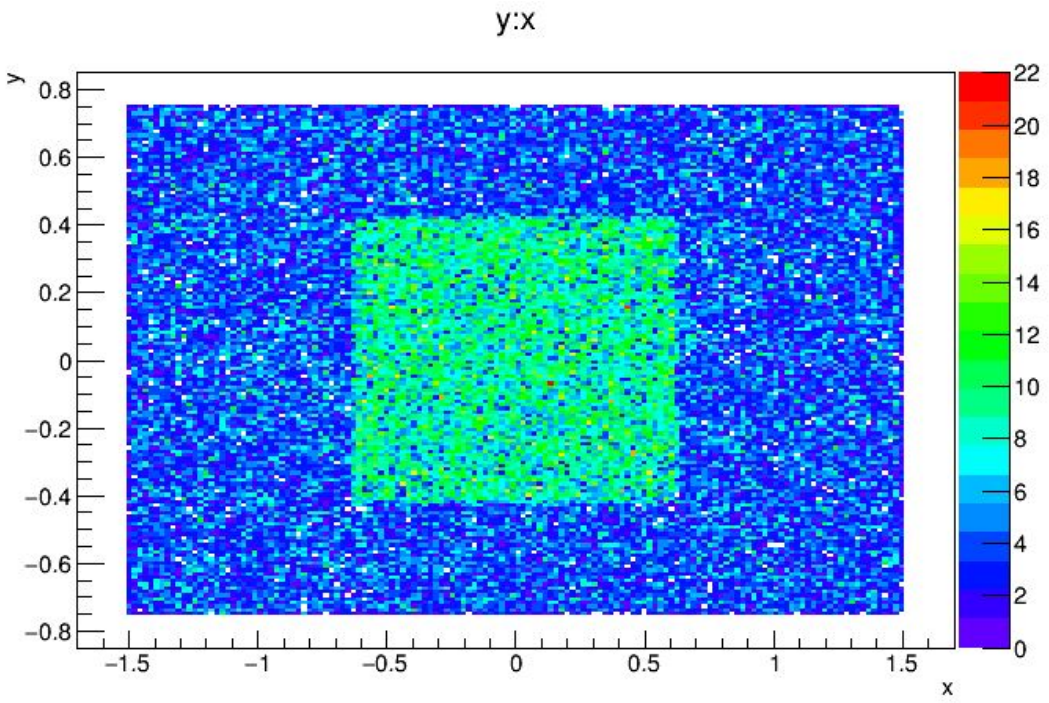


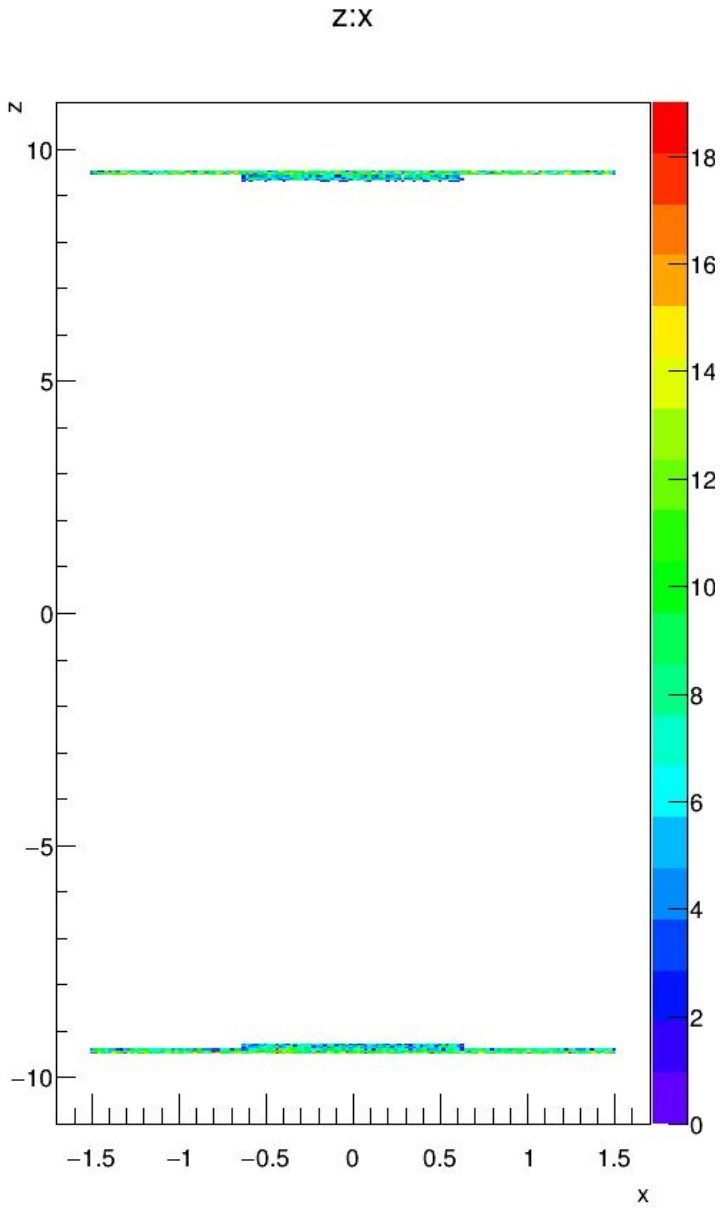
z:x



New SiPM (tile+FEB integrated)

- 1.5 x 3 cm of tile + FEB (top + bottom)
- 1 SiPM of 8.4 x 12.5 mm
- 1 g of Arlon per tile





Material Background Events/week

Signal: 420 event/week

Material	Events / week in ROI	Events untagged / week in ROI
DArT Cu	36.2	8.1
DArT tile (Arlon)	28.9	16.5
DArT Acrylic	5.3	2.7
ArDM Cryostat	3070	181
ArDM pillars	0.4	0.2
ArDM PMT support	14.1	0.1
ArDM rings	14	0.3
ArDM PMT	892.8	42.6
Lead Belt	150.5	16.2
TOTAL	4207	272

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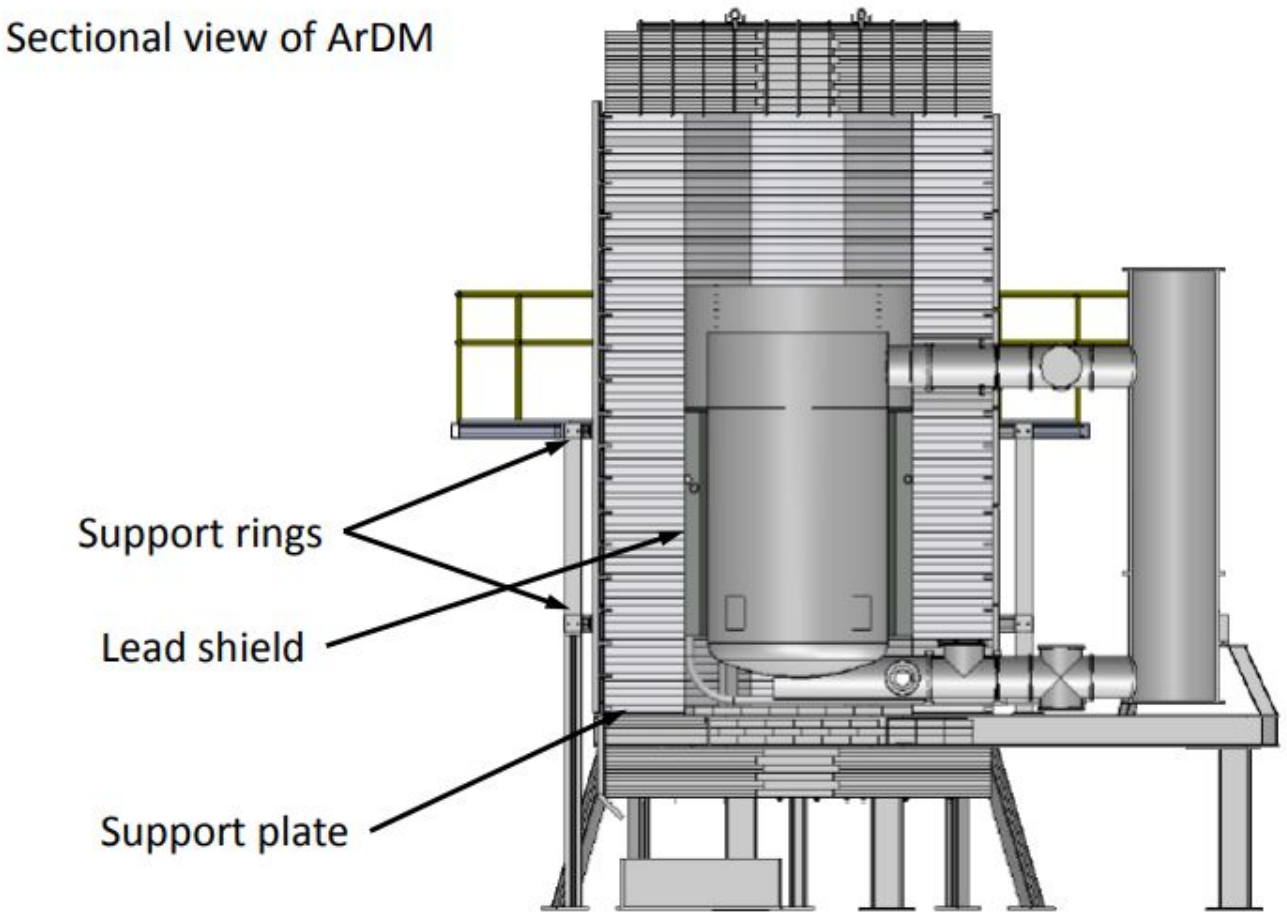
All background summarize in:

https://docs.google.com/spreadsheets/d/1dlieyL8ZC-GV0VWXHKam-_xc5uX-wqfxI4HAfm-blx0/edit?usp=sharing

Lead belt for external background

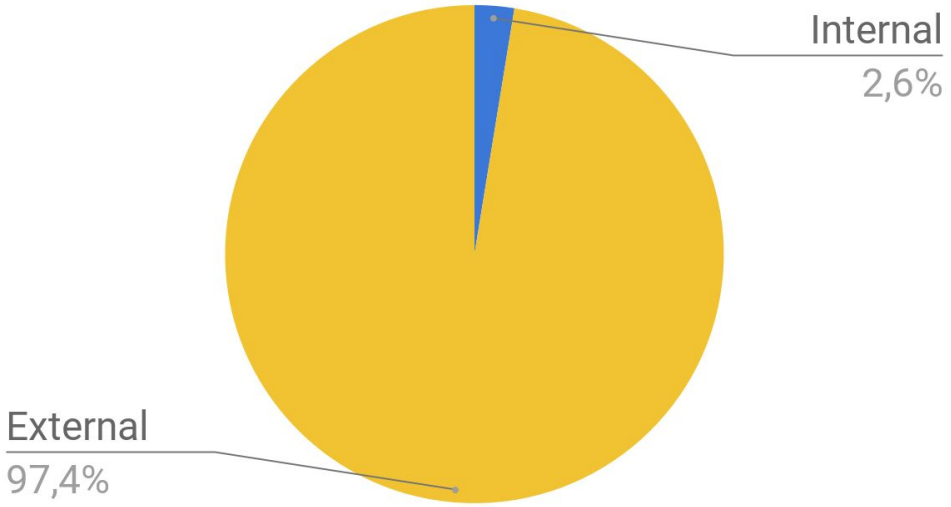


Reduction factor ~25 with 140 x 10 cm (height x width) of lead.

The weight will increase 6 Tons.

External background

Background without lead belt

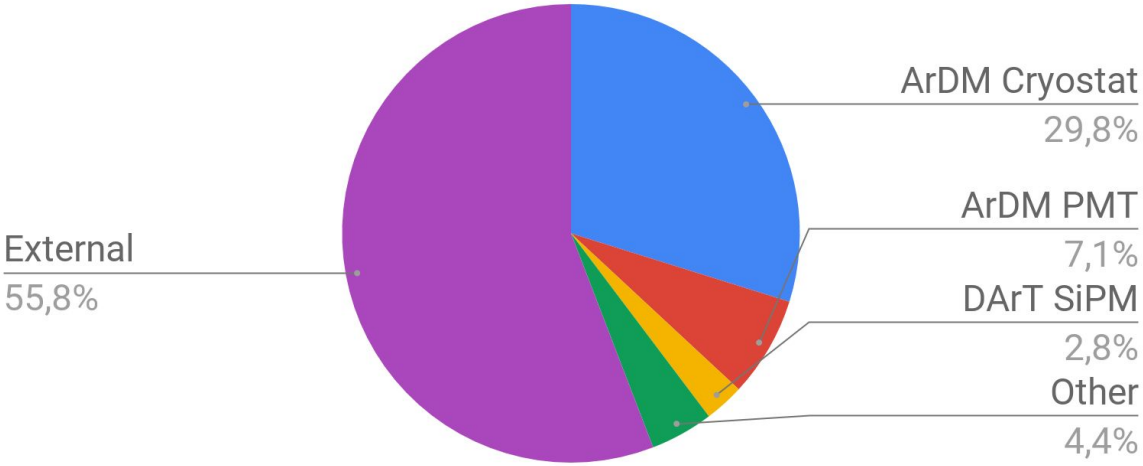


Signal : 420 evt/week

Background : 9979

S/B → 0.05

Background with lead belt 140 x 10 cm



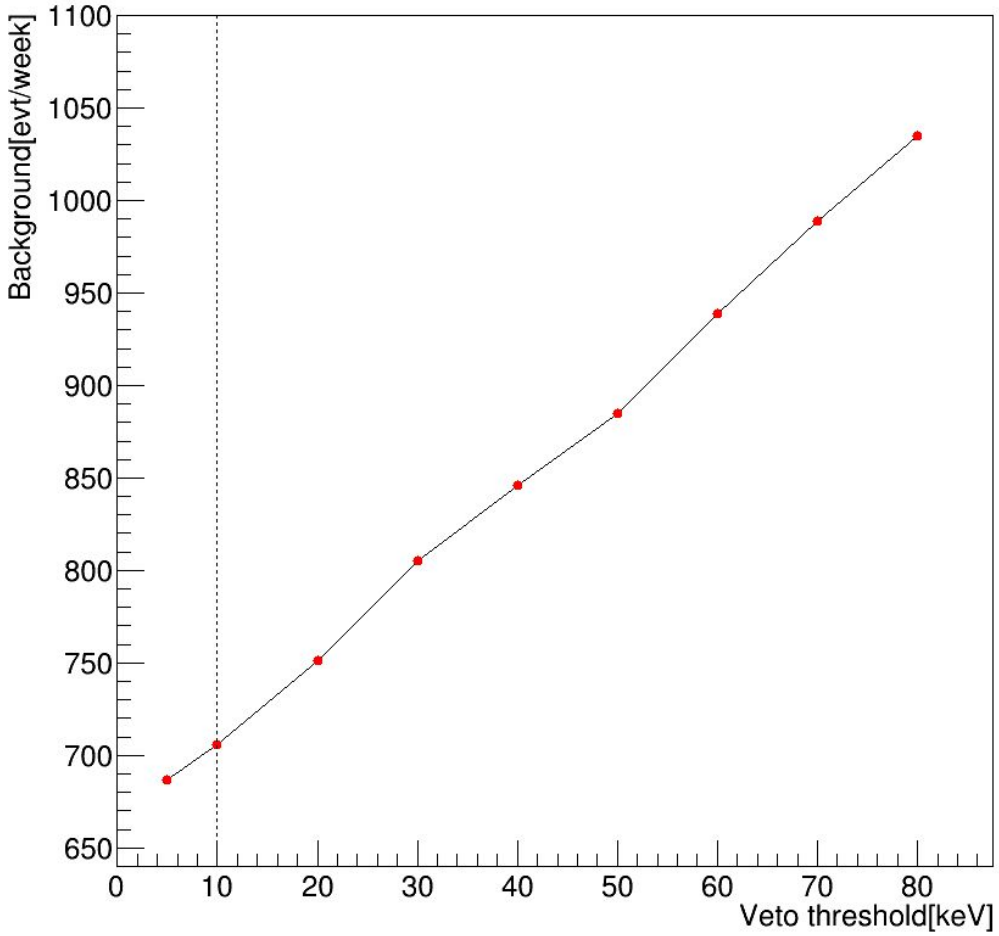
Signal : 420 evt/week

Background : 611

S/B → 0.7

ArDM Veto Threshold

- Number of background events as function of the veto threshold.
- Single phase ArDM geometry configuration.
- The background scales linear. Small variations are expected with a higher threshold.

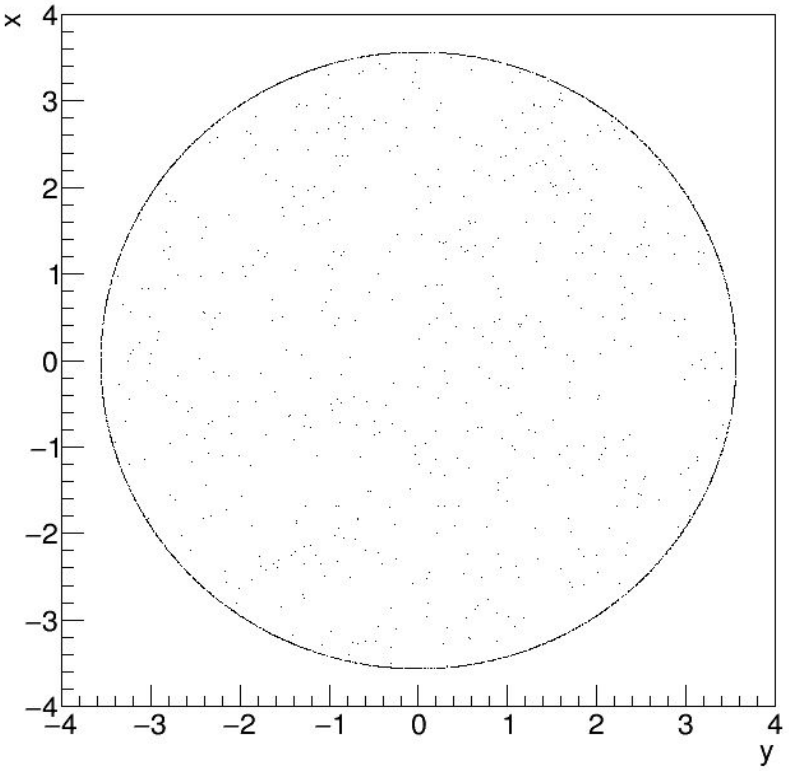


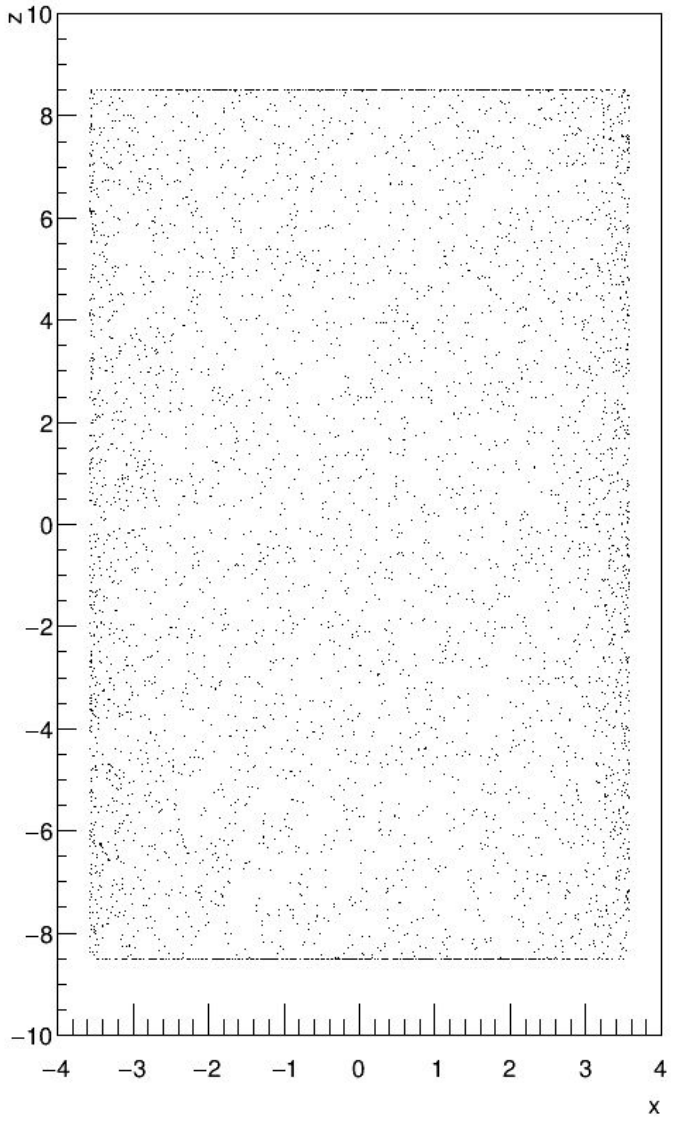
Surface contamination

- Inner acrylic surface 514 cm^2.
- Acrylic contamination in DEAP-3600 → 0.22 mBq/m^2

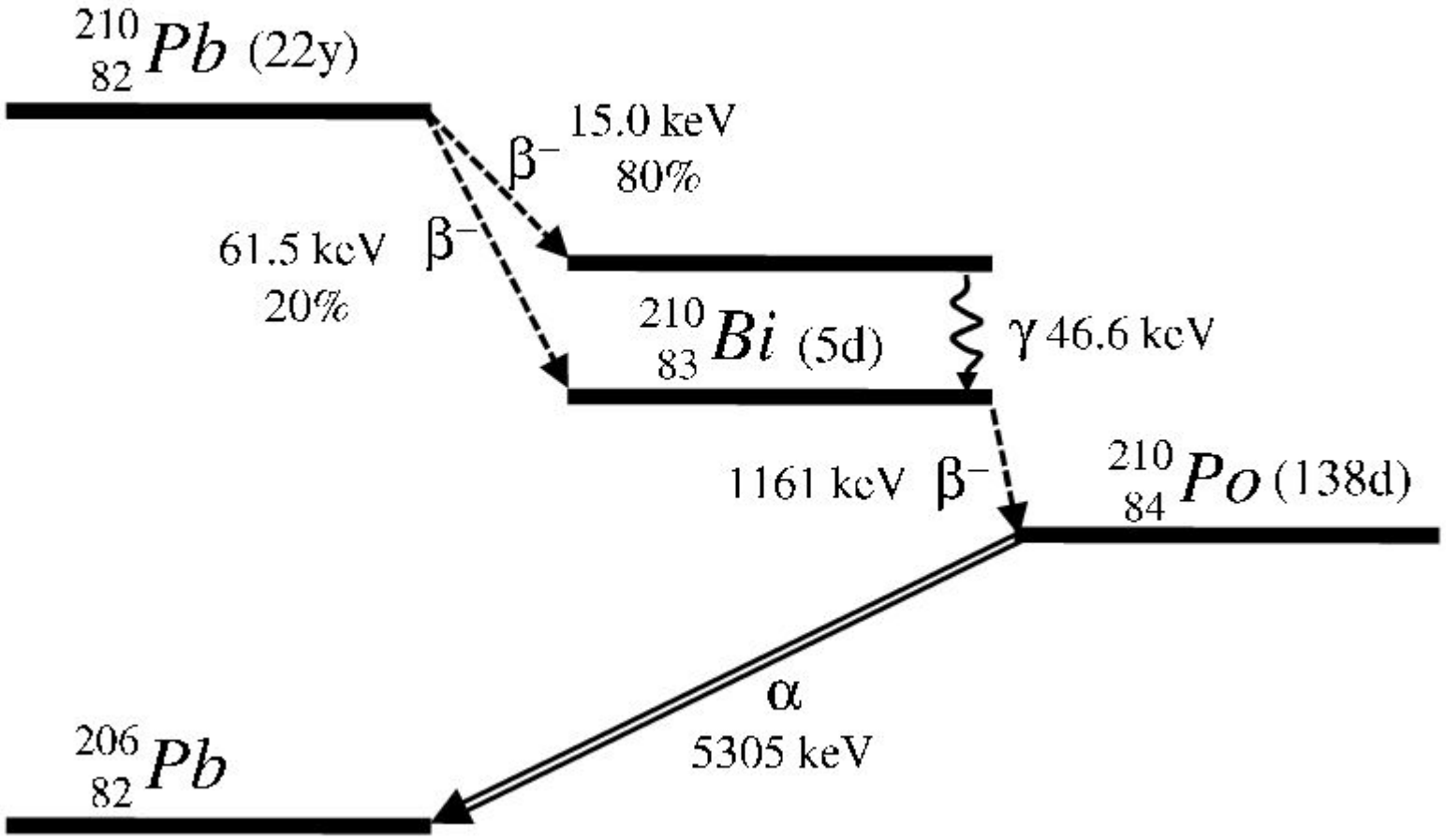
From: **^{210}Bi surface contamination in DART, Andrea Pocar**

- A generator has been developed in order to generate events in the inner acrylic surface of DArT.



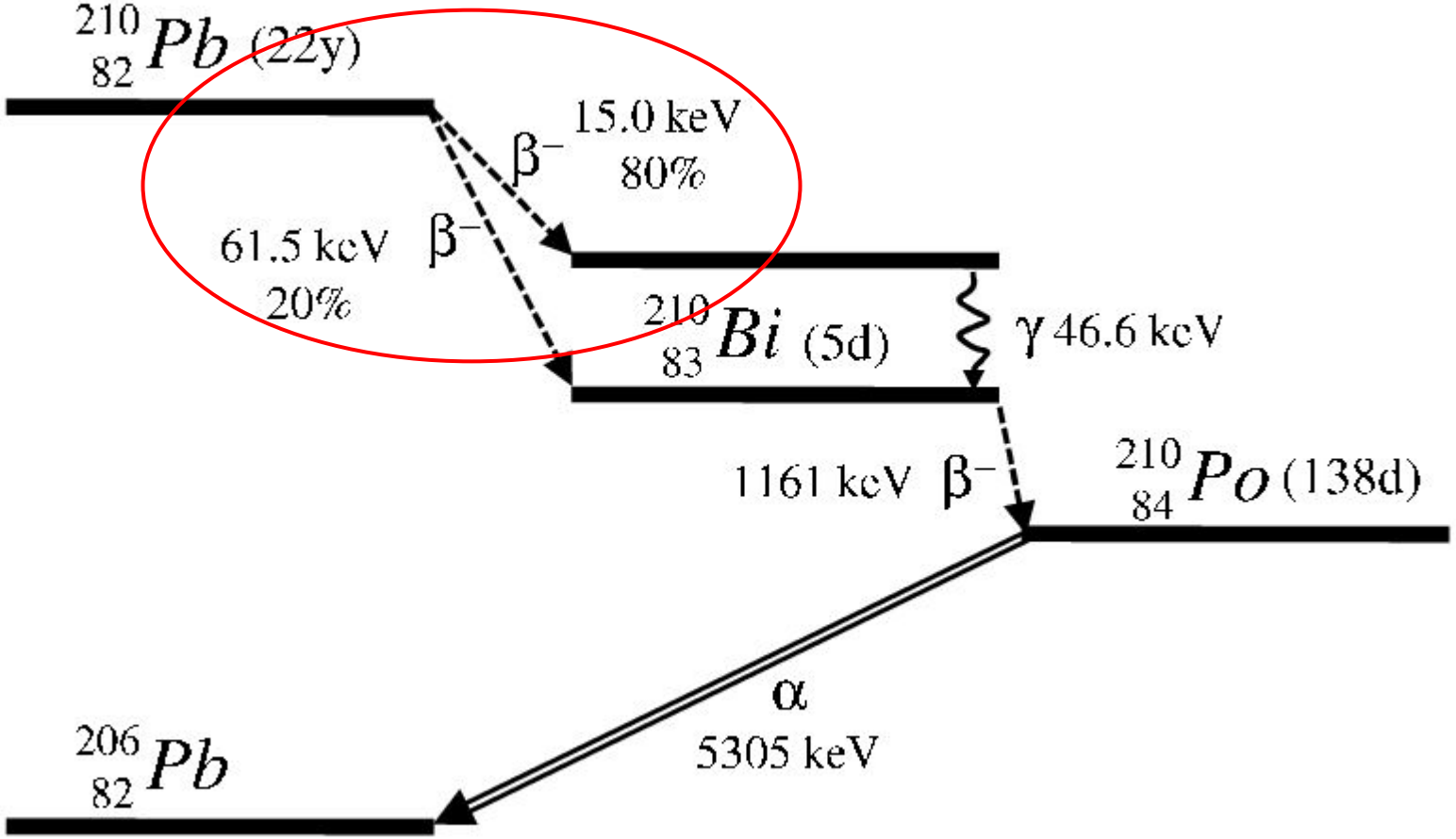


^{210}Pb decay

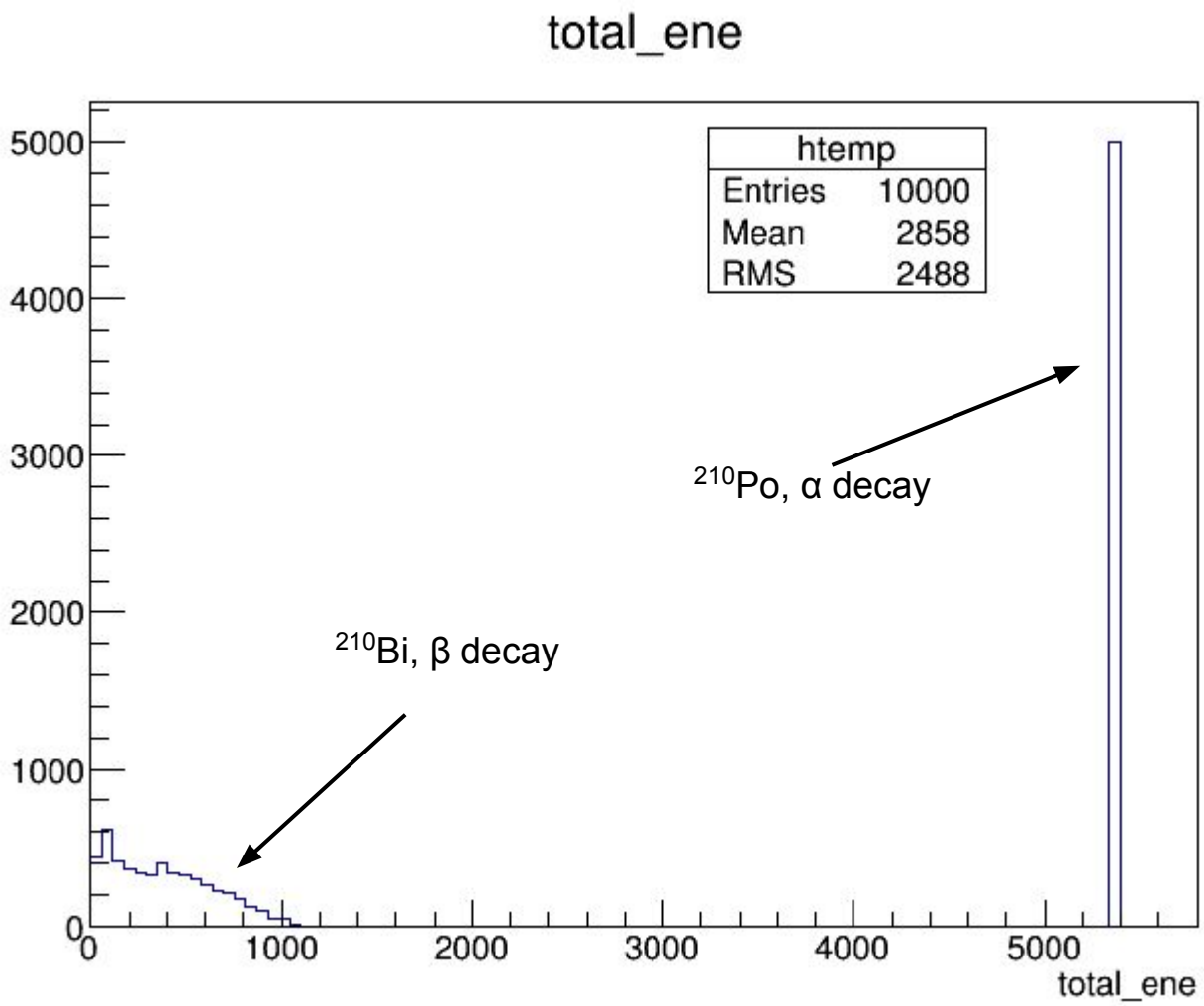

210 82 Pb (22y)
15.0 keV
80%
β−
61.5 keV
20%
β−
210 83 Bi (5d)
γ 46.6 keV
1161 keV
β−
210 84 Po (138d)
α
5305 keV
206 82 Pb

^{210}Pb decay

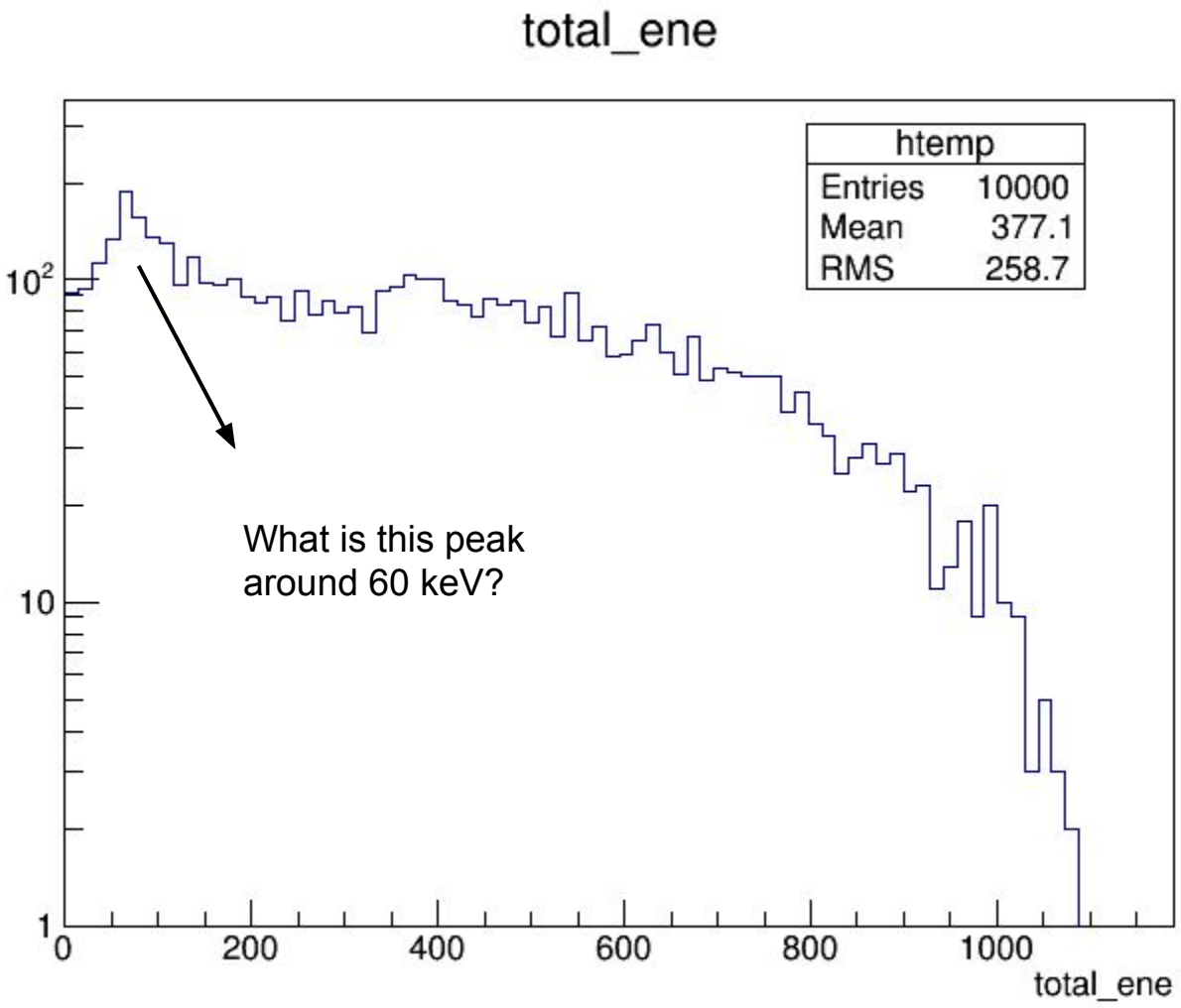
< 60 keV → low energy
(we can reject these events)



^{210}Bi energy spectrum generated



^{210}Bi energy spectrum generated



Energy in DArT

- Assuming the values from "**^{210}Bi surface contamination in DART, Andrea Pocar",** we expect 7 evt/week from ^{210}Bi and ^{210}Po.

- 2116 left energy in DArT. All from the β decay (5000 evt generated).

- ROI >0 keV && <600 keV

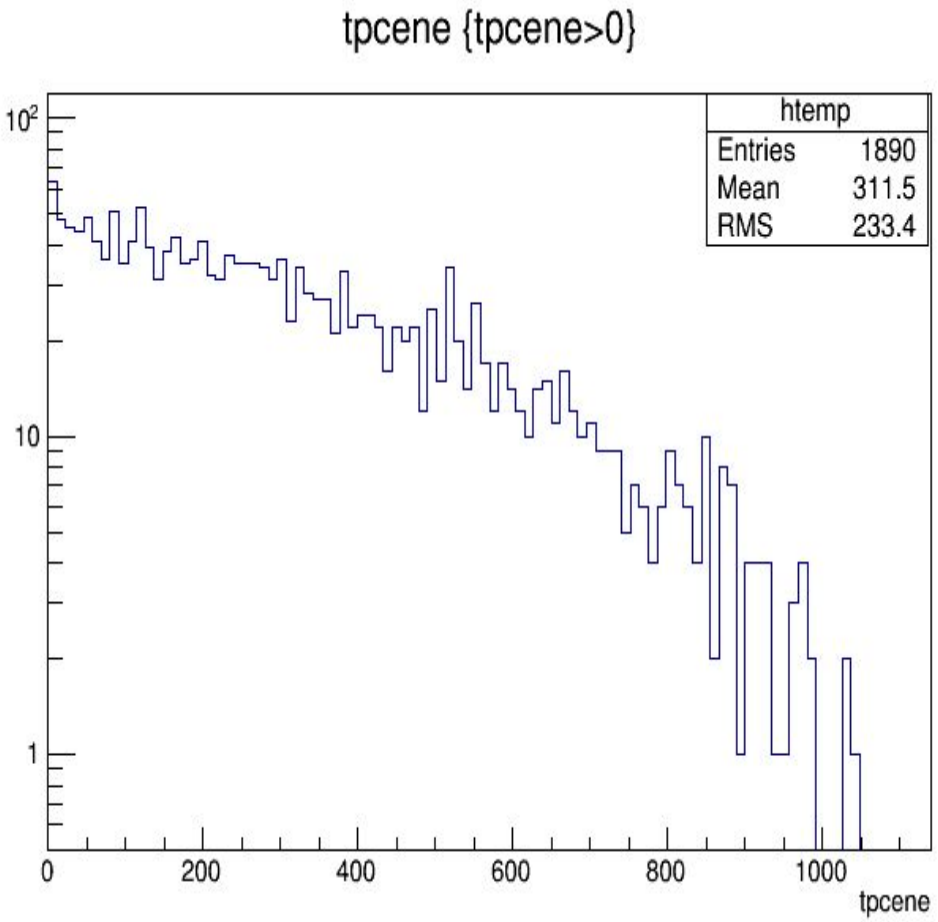
1854 evt → 37 % of evts generated

- ROI > 80 keV && < 600 keV

1459 evt → 29 % of evts generated

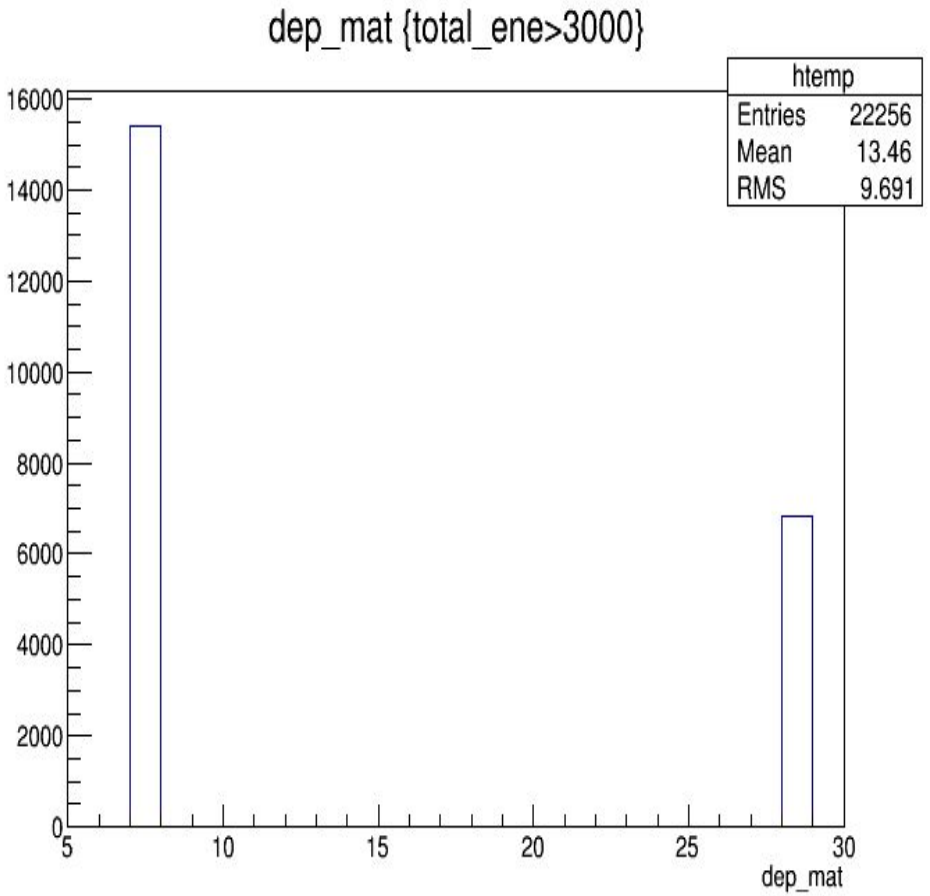
- We are going to have ~ 2 evt/week of surface background contamination in DArT.

- However, we have to consider the possibility of light emission from the interaction of TPB and α particles.



Energy in DArT

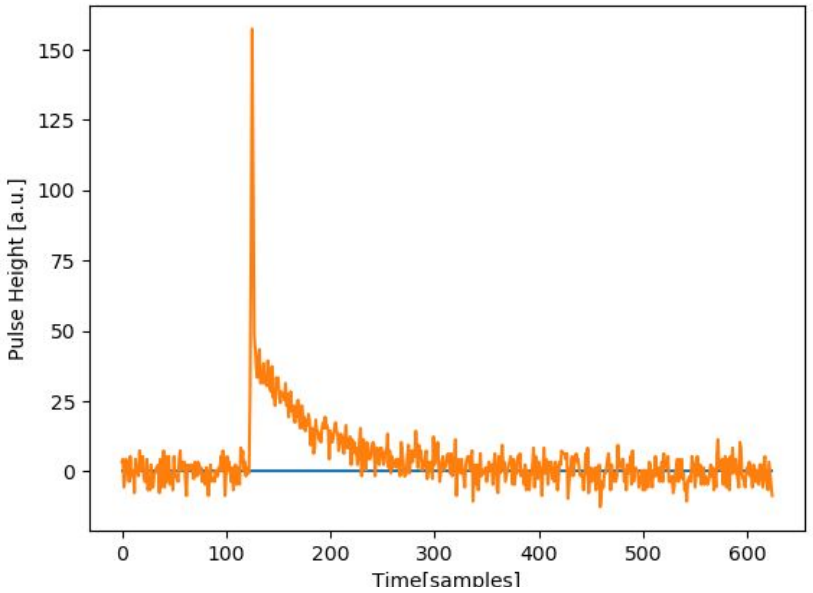
- Energy cut in order to select only α events.
- Some events reach the TPB layer. It could produce light.
- It is necessary to include some direction cut (only with direction to the center).

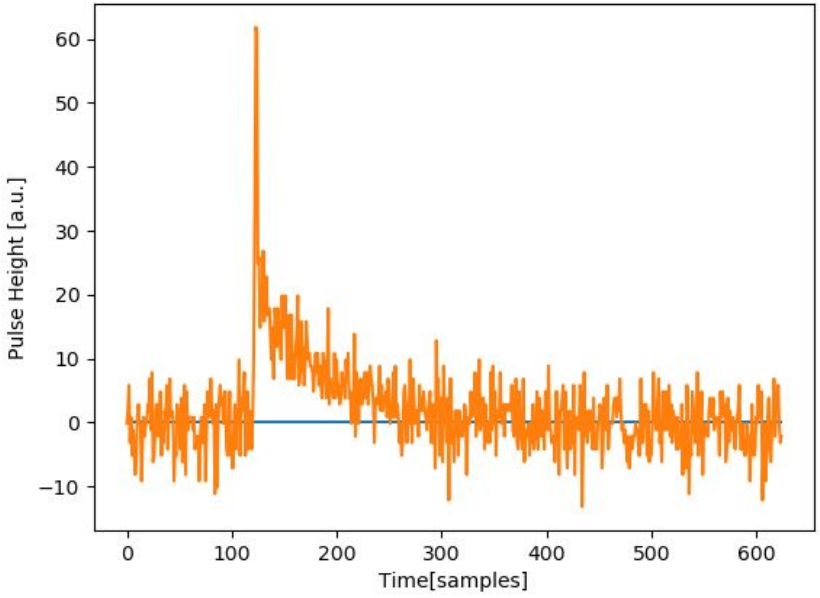


Signal simulation

- ^{39}Ar events simulated with 1 SiPM.
- Example of signal generated with Alessandro + Valerio code.
- We need to find the parameters for DArT redout.

```
[ds20k]
n_channels = 2

[daq]
eff = 0.9
jitter = 20e-9
gate = 5e-6
pre = 1e-6
sampling = 125e6
snr = 25
baseline = 80
bits = 12

[sipm]
spread = 0.08
dcr = 200
ap-tau = 3e-6
# these are probablities and not mean values
ap = 0.15
dict = 0.2
phct = 0

[arma]
gain = 80
tau = 540e-9
sigma = 8e-9
scale = 0.25

[reco]
baseline_from = -1e-6
baseline_to = -20e-9
t0_cumfrac = 0.20
fprompt_from = -1e-6
fprompt_to = 90e-9
# for the moment, integration is performed over the full gate
```





Next steps

- Update of background level vs veto threshold. Light simulation in ArDM ? (Maybe too time consuming)
- Large production of material and external background in order to increase the statistics (weights for external near of 1).
- Full surface background study. Stability of PSD with energy.
- Full optical simulation with ^{39}Ar events (around 20000). Update of lookup table.
- Integration of signal simulation. Energy resolution with signal simulation.
- Updated of sensitivity studies. ARIA, URANIA, DS-50, ^{83}Kr ….