Future developments: Enhanced DArT

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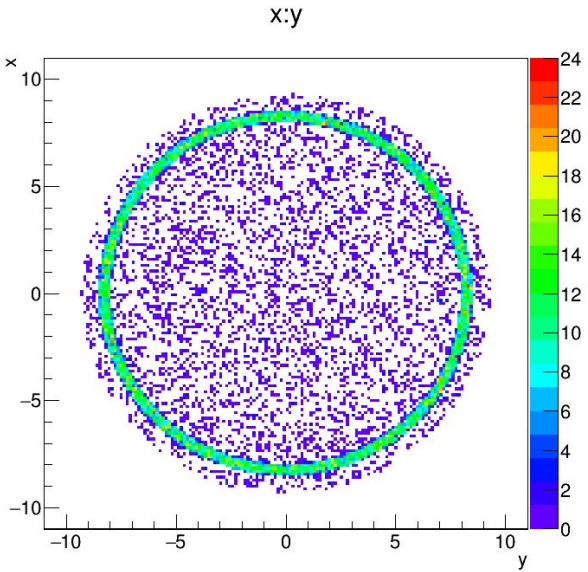
Introduction

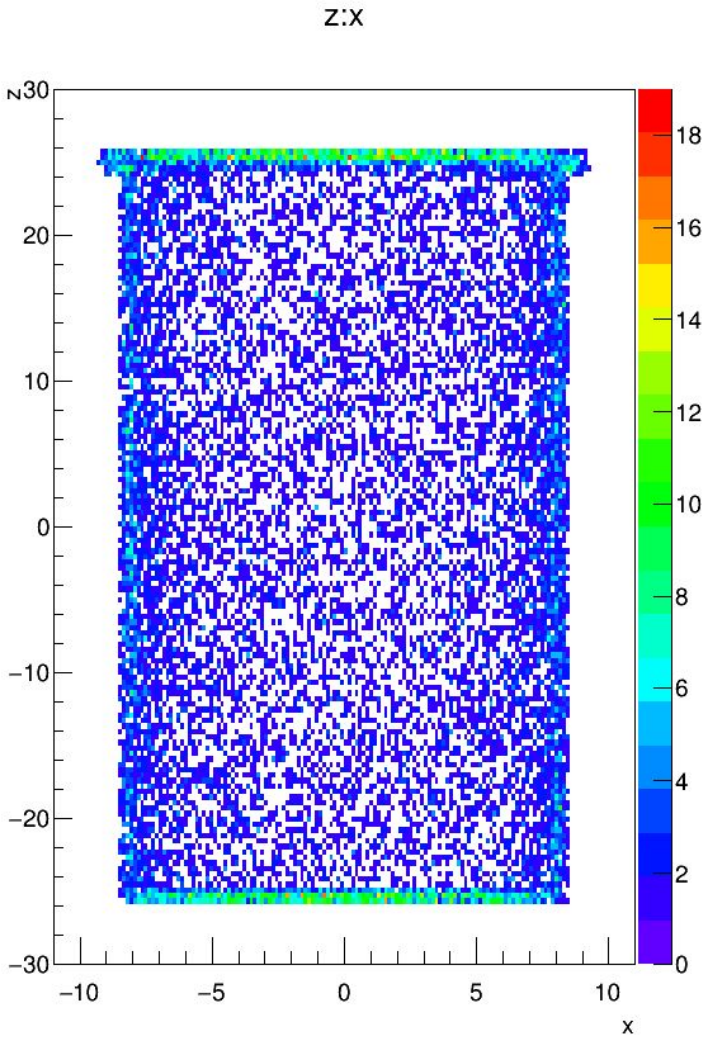
- Update of DArT detector, in order to increase the sensitivity to the DAr (0.073 mBq/kg) (first time presented 10.10.2018).
- ^{39}Ar signal produces a single ionization track in the detector. A time projection chamber will remove multiscattering events reducing background.
- Active volume of 10 L of DAr. Copper vessel of 5 mm thickness on lateral and 8 mm for the top flange (as in DArT).
- Vessel dimensions: Radius: 8 cm Height: 50 cm

EDArT geometry

- EDArT geometry implemented
  (Radius: 8 cm Height: 50 cm)

- SiPM at top and bottom.





Background EDArT

Untagged: E_{ardm} < 10 keV (veto)
ROI: 1 < E_{dart} < 600 keV

Signal: 5200 event/week for UAr in DART-2

Material	Events untagged / week in ROI EDArT	Events untagged / week in ROI DART
DArT Cu	51	8
DArT tile (Arlon)	161	89
ArDM Cryostat	1801	187
ArDM PMT	636	65
External	3380	351
TOTAL	6039	700

https://docs.google.com/spreadsheets/d/1cOng0W7qbLCFLdGSF26In5qKKPeYLq_rt_TTz38uxpg/edit?usp=sharing

Multiscattering (MS) events

Material	Percentage of Multiscattering events[%]	Events untagged / week in ROI EDArT after MS cut
DArT Cu	70	17
DArT tile (Arlon)	50	86
ArDM Cryostat	81	338
ArDM PMT	80	136
External	81	642
Total		1212

Signal/background ratio

Configuration	DArT (only light)	EDArT (only light)	EDArT (light+charge)
Signal UAr[evt/week]	613	6130	6130
Background [evt/week]	700	6039	1212
Ratio (S/B)	0.88	1.02	5.06

How to convert DArT into a TPC?

Option A: DArT as a dual-phase detector.

No additional signal detection system needed.

Possible to reduce the energy threshold.

Dynamic range of SiPMs problematic.

It could be non-trivial to produce a stable gas pocket.

Three high voltage connections inside EDArT.

How to convert DArT into a TPC?

Option B: DArT as a single phase TPC

It is not necessary to produce the gas pocket. Simple design.

Only one additional high voltage in DArT.

Dynamic range of SiPMs not problematic.

Not possible to reduce the energy threshold. Light yield will decrease by ~40% at least.

Additional system to detect the charge signal.

How to convert DArT into a TPC?

Option C: Produce electroluminiscence signal in liquid argon

Simple design. No additional signal detection system needed or gas pocket.

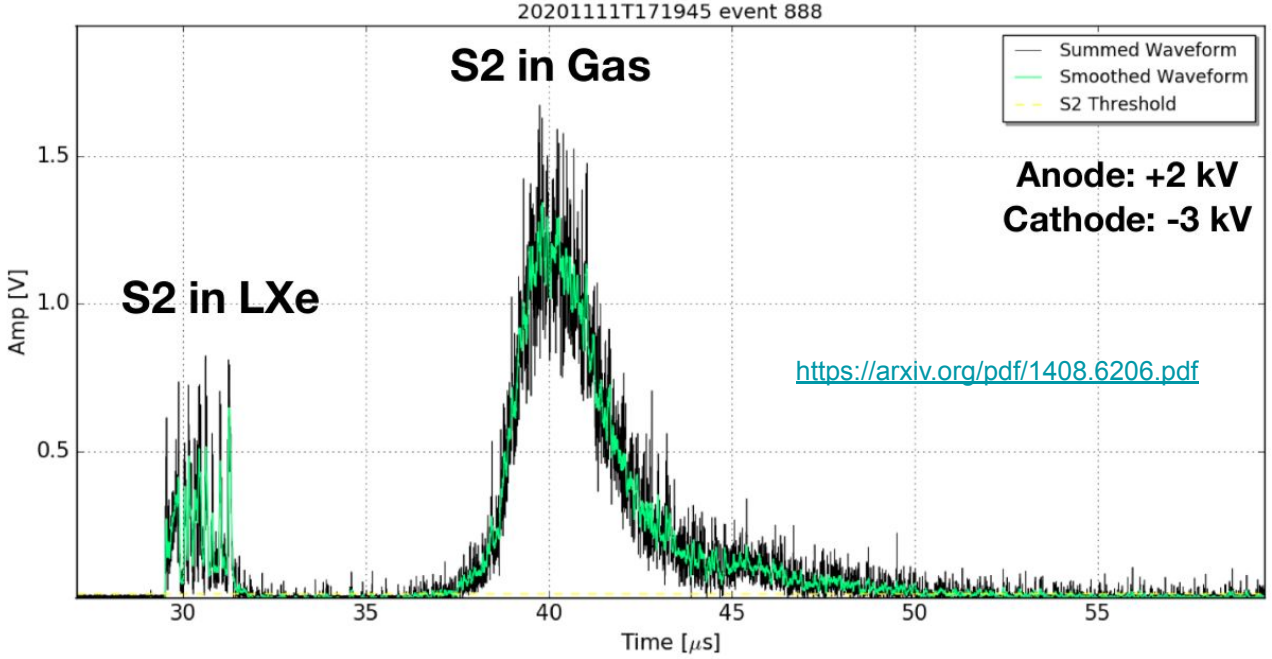
Possible to reduce energy threshold.

Dynamic range of SiPMs could be problematic (but effect smaller).

Some R&D will be necessary.

S2 in liquid phase

Liquid: Field 412 kV/cm → 209 ph/e-
Dual-phase: few kV/cm → 454 ph/e-



Also possibility of using THGEM at 2 kV(https://arxiv.org/pdf/1310.4074.pdf).

How to convert DArT into a TPC?

Option D: DArT “à la” DEAP: covered full inner surface with SiPMs.

No additional signal detection system needed or gas pocket.

Possible to reduce energy threshold through light yield increasing.

Dynamic range of SiPMs fine. No reflector needed, only direct light.

Necessary to include WLS in front of each SiPM. Or direct TPB evaporation?

How efficient is the 3D position reconstruction in a small detector?

Lot of SiPMs, cables, channels… It has to be justified.

Summary

- Using DArT as a time projection chamber could significantly increase the signal to background ratio.

- These numbers are based in simulation studies from 2018. The simulations have been updated since then and it will be good to evaluate the impact.

- There are different possibilities to convert DArT in a TPC. However, detailed studies are needed for each one of these options before construction (e.g. integration in ArDM).