TREX-DM & ARIA

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StG-2009: T-REX
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Outlook

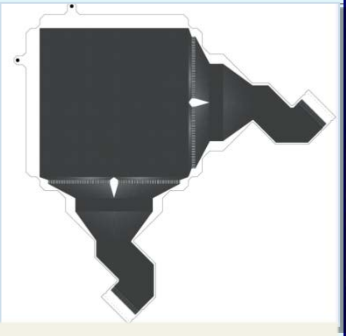
- TREX-DM: A Micromegas TPC for Dark Matter detection
  - Detector description
  - Detector setup and layout at Canfranc
  - Background model
  - Detector performance
  - Experiment sensitivity
- TREX-DM &DART

TREX-DM (TPC for Rare Event eXperiments-Dark Matter)

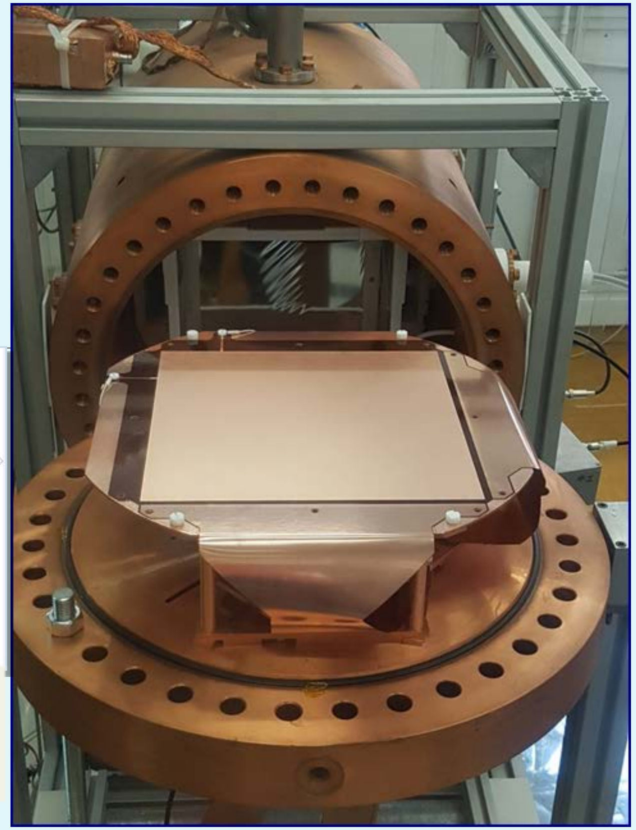
- A Micromegas TPC for Dark Matter detection
  - ~20 l of pressurized gas (flexible target: ~0.3 kg Ar, ~0.16 kg Ne at 10 b)
  - Equipped with novel micromesh gas structures (Micromegas) readouts
  - **Goals:** low energy threshold (< 1 keV) and low background level (~1 (keV kg day)$^{-1}$).
  - NOT focused in directionality → operation at high pressure.

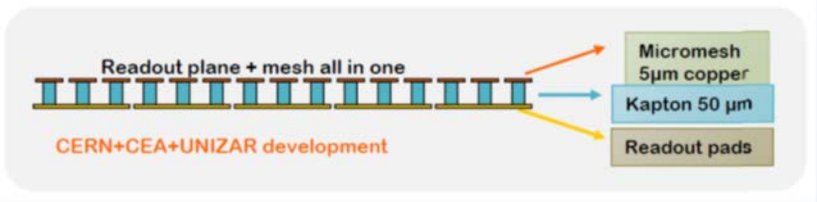
Readout planes:MicroMegaS

- A reliable detector largely used at CAST offering advantages for rare event detection:
  - Topological information: to discriminate backgrounds from expected signal by dark matter
    - few microns track → point-like event
    - Fiducial cuts →electron events from walls
  - Low intrinsic radioactivity: made out of kapton and copper, potentially very clean
  - Scaling-up

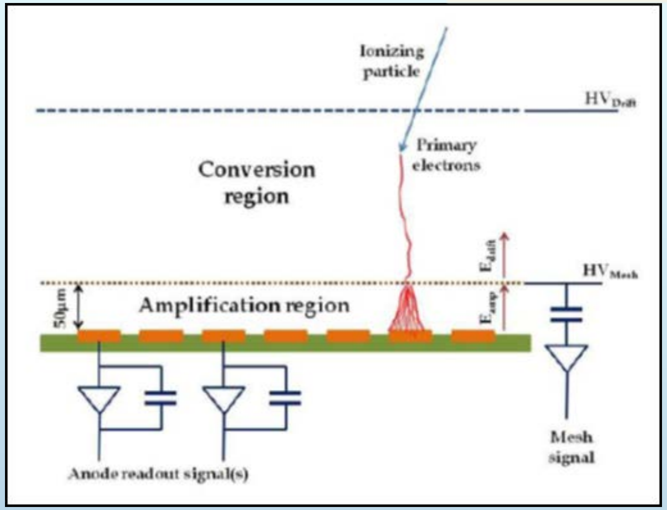


25 x 25 cm^2
TREX-DM fabricated at CERN





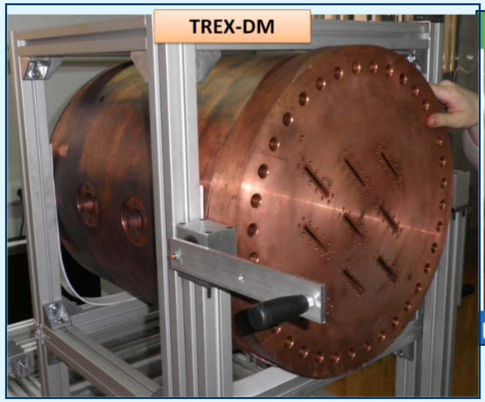
Microbulk technology → more homogeneus and radiopure

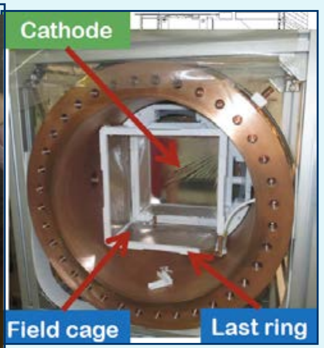


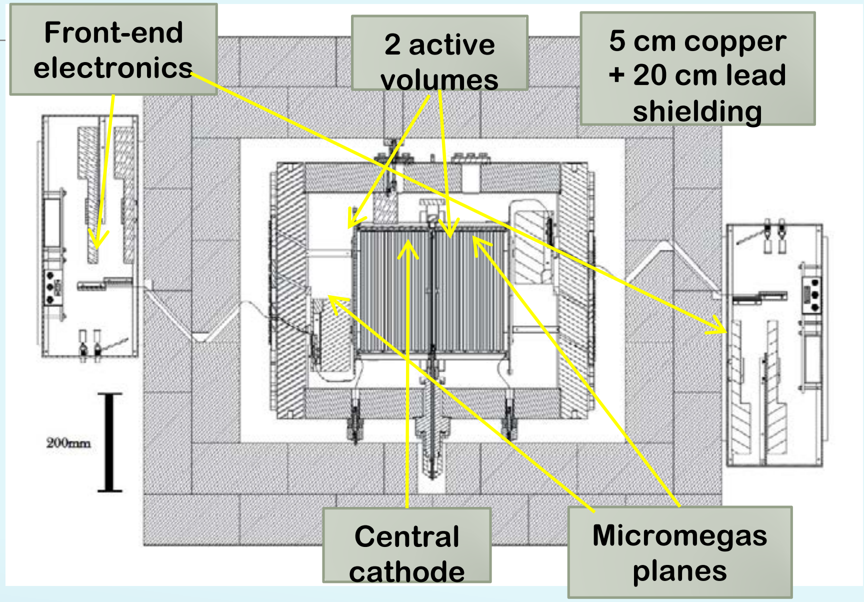
Two planes manufactured at CERN
Flat cables take out signals from strips and connect to the interface cards out of the vessel

Vessel, field cage and shielding

- Field Cage made of Teflon
- Vessel
  - Central body (ETP copper) + two end-caps (OFE copper), to hold up to 12 bar
  - Certification as a pressure equipment has been a previous step to installation at LSC

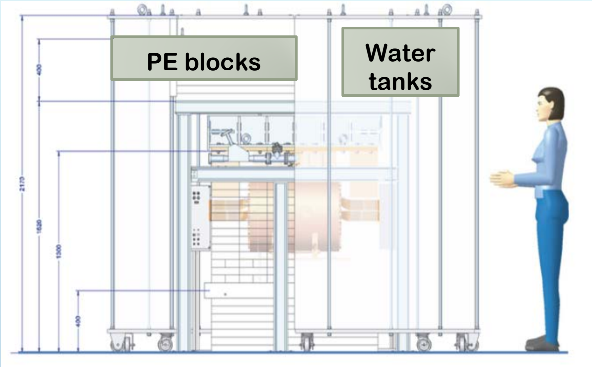




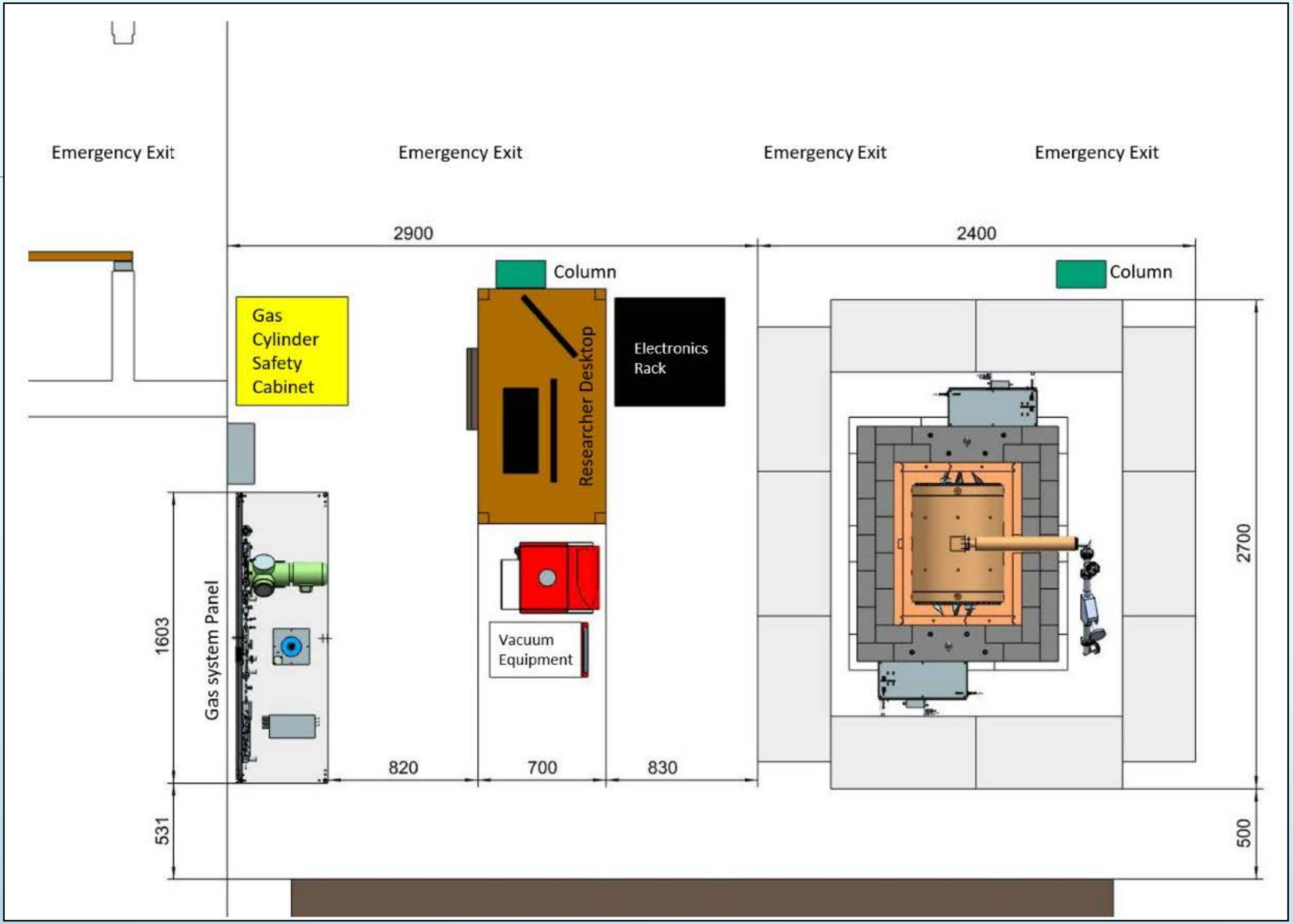


- Lead:
  - 700 bricks + 550 bricks
- Copper:
  - 5-cm-thick copper plates
- Polyethylene:
- Water Tanks

- DAQ outside the shielding
- Rn-free atmosphere inside shielding

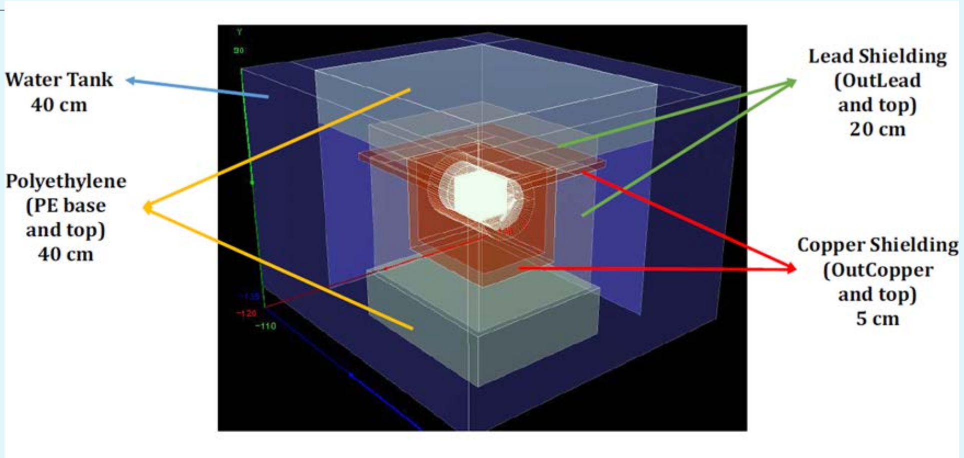


Experimental layout

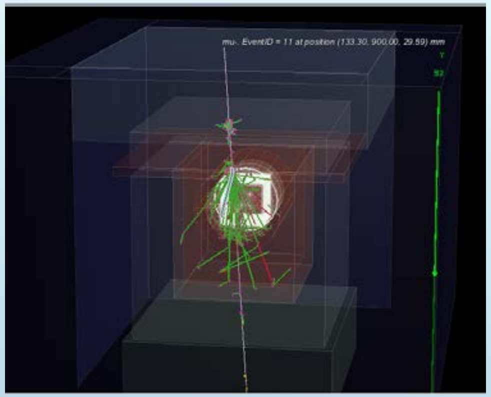


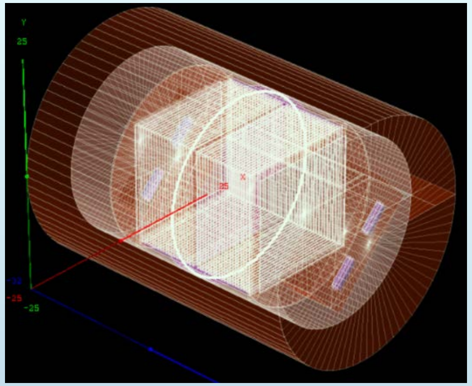
Background model: simulation

- Based on Geant4 (Physics processes) + REST code
  - electron generation in gas
  - diffusion effects during drift
  - charge amplification at Micromegas
  - signals at mesh and strips

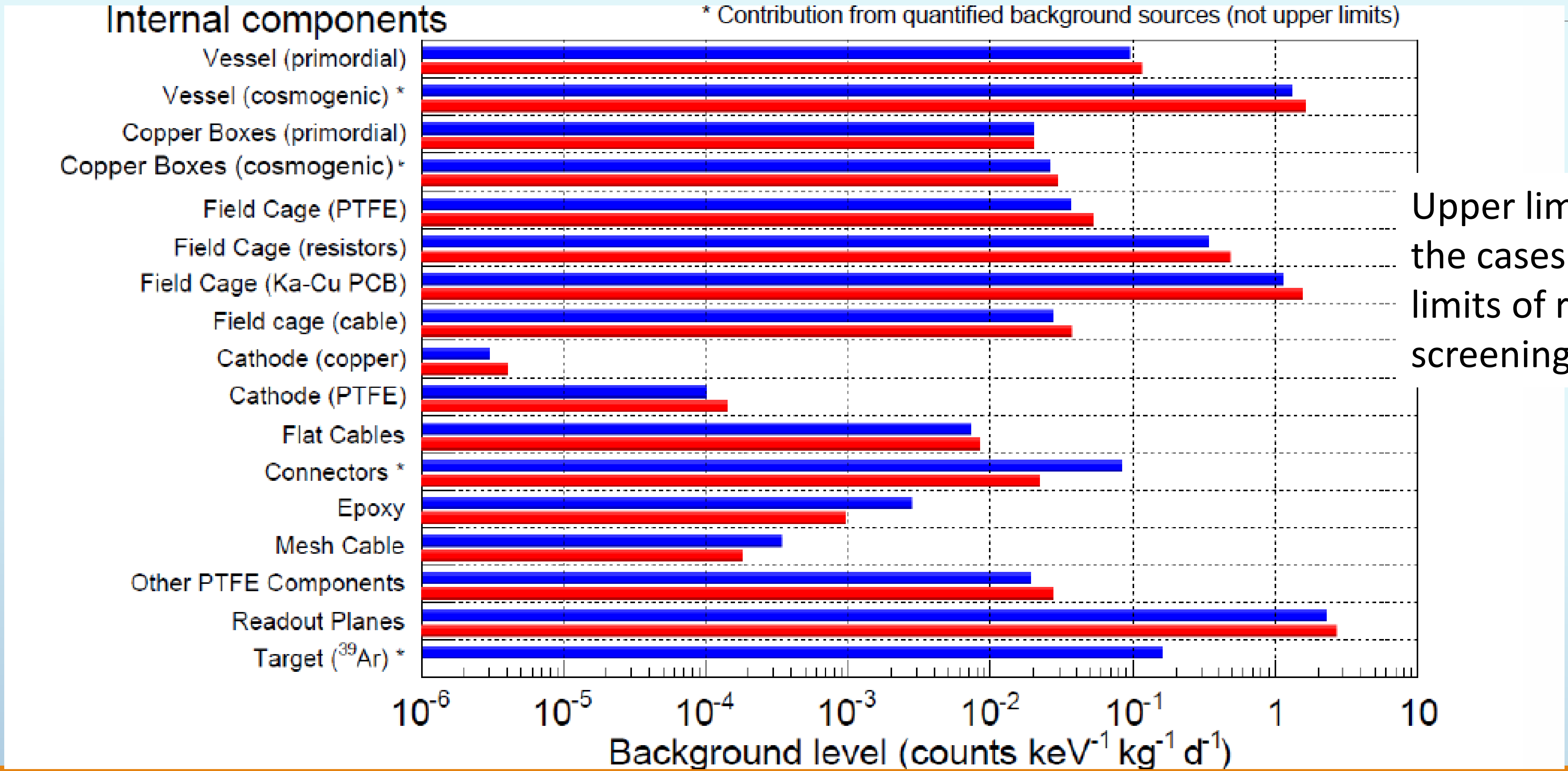


- Analysis to discriminate point-like events from complex topologies
- Detailed geometry including shielding implemented
- For Ar+1%iC_4H_{10} and Ne+2%iC_4H_{10} mixtures at 10 b
- Successful validation against experimental data



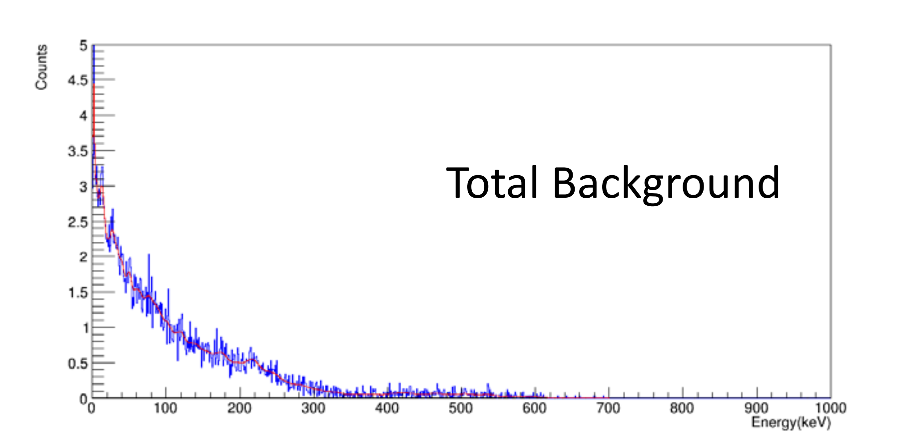


Internal background budget

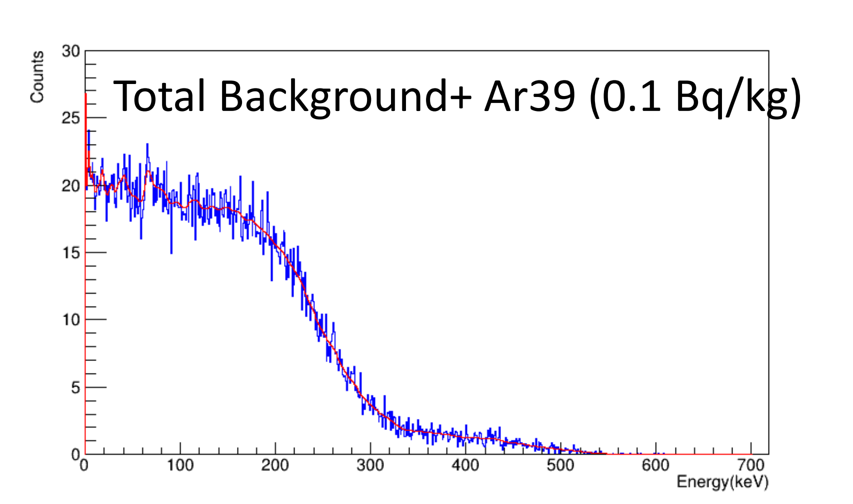


Upper limits in most of the cases due to upper limits of radioactive screening

Contributions



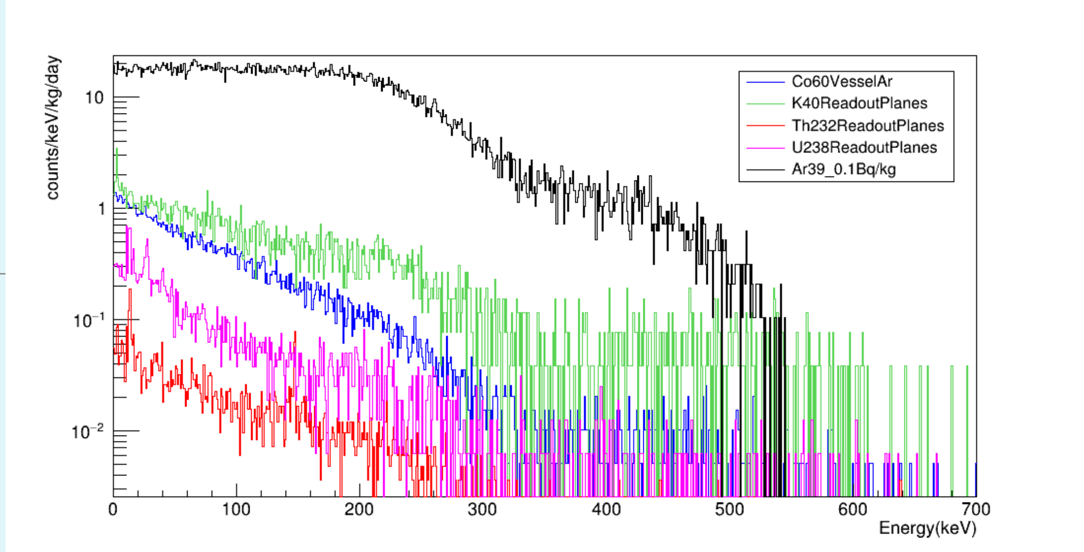
Total Background

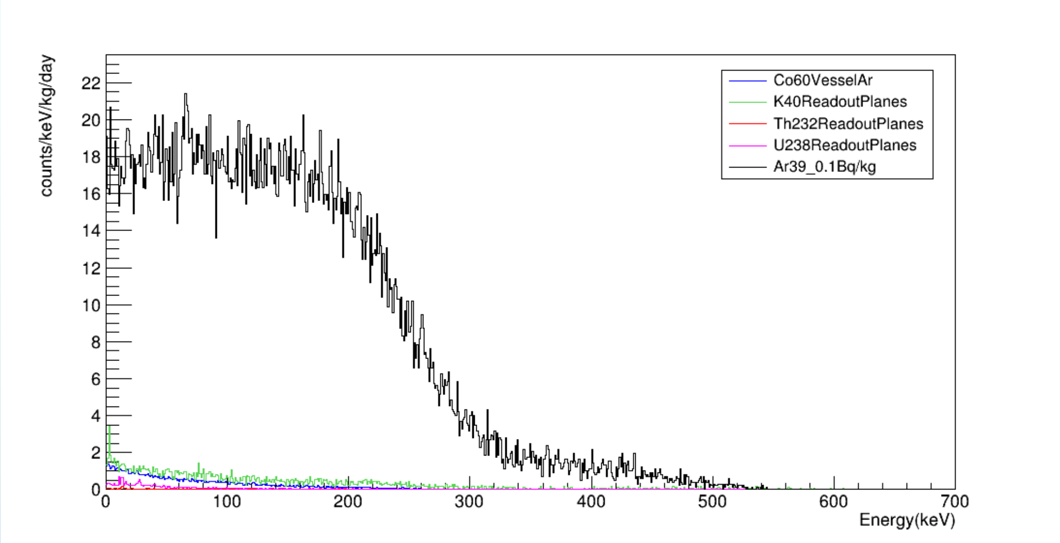


Total Background+ Ar39 (0.1 Bq/kg)

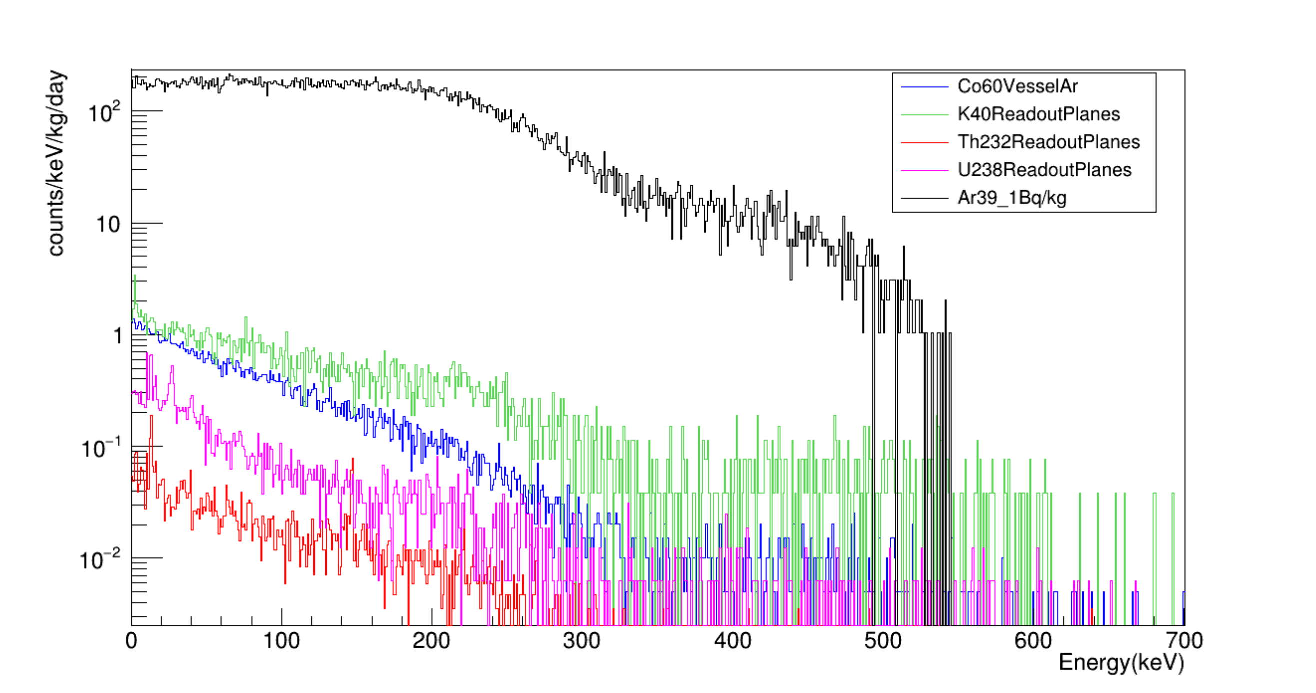
Event selection

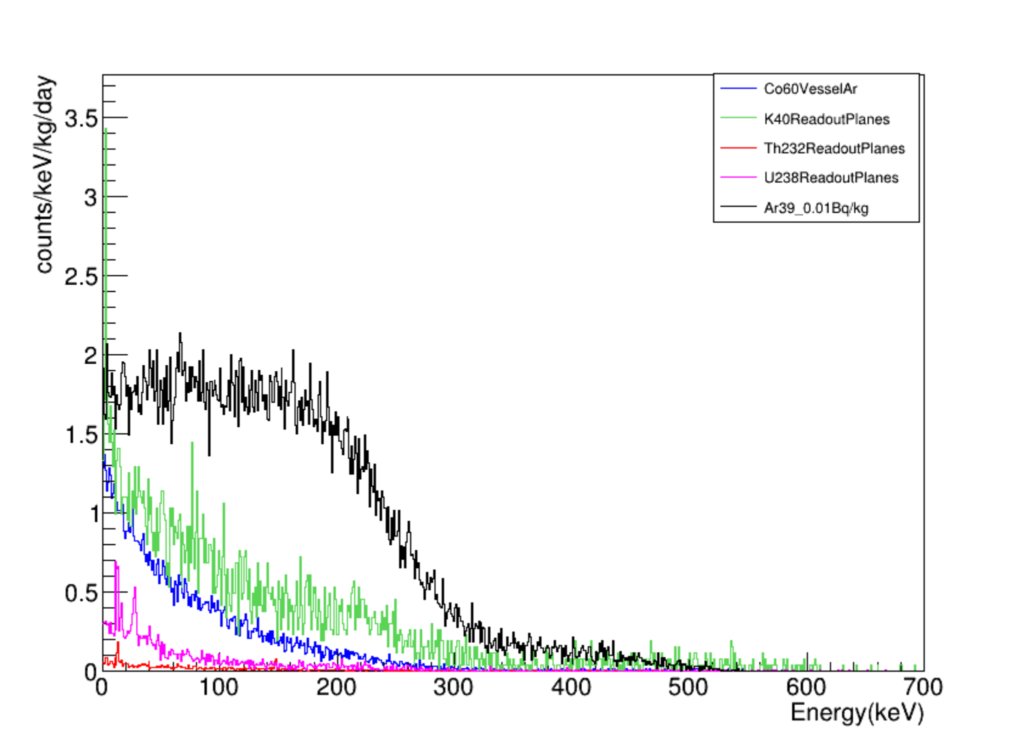
- 1 cluster
- 2cm XY fiducial cut





Other Ar 39 levels





Contributions

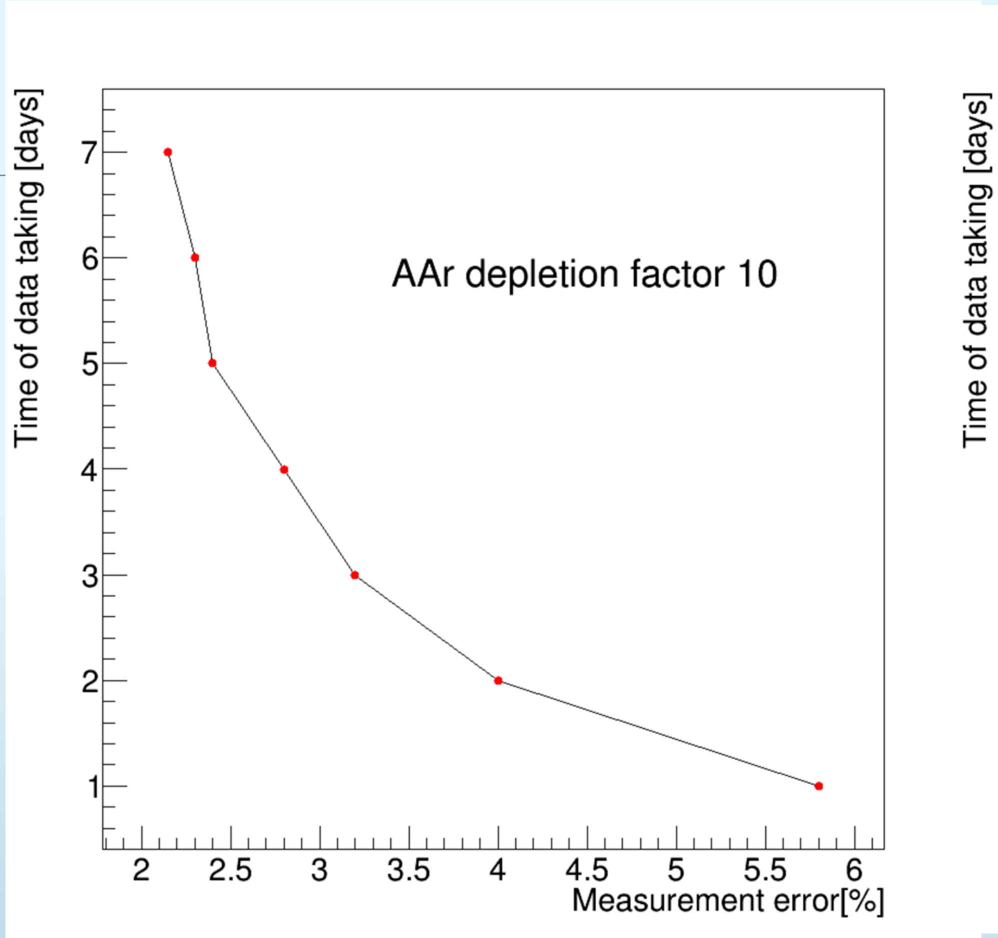
Event selection

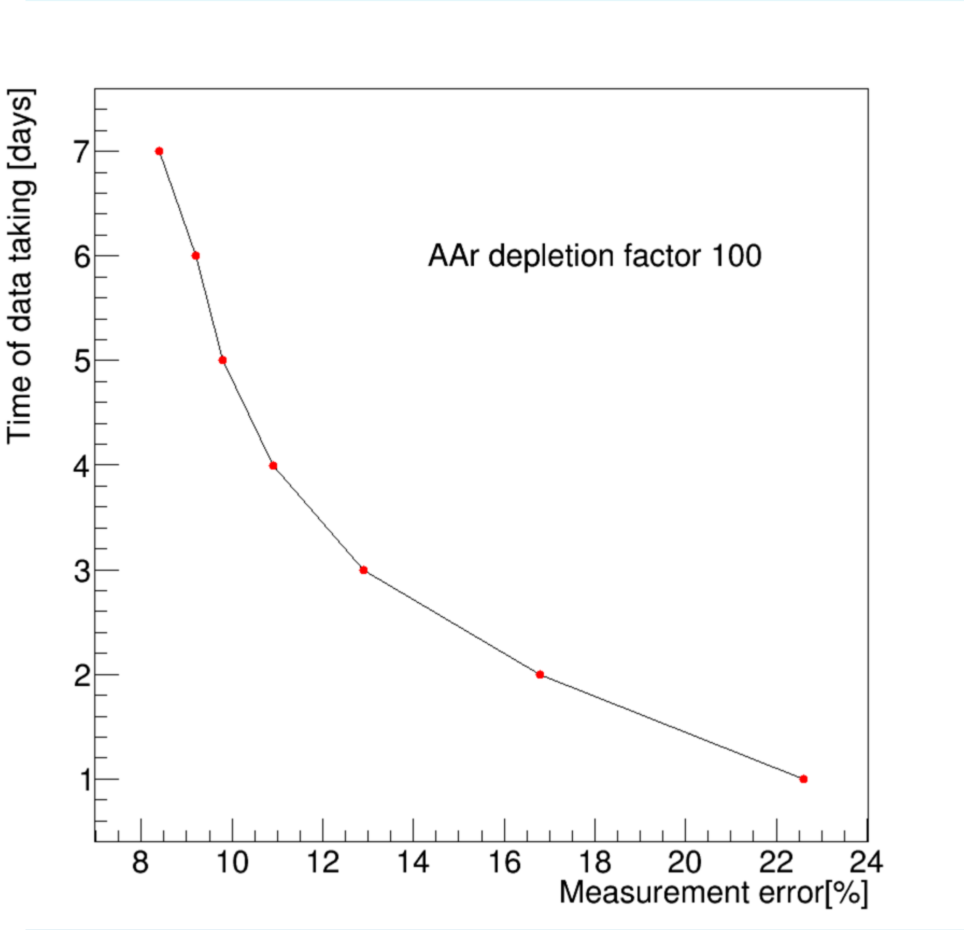
- 0-700 keV
- 1 cluster
- 2cm XY fiducial cut

Source	Mass/ Surface	Contamination	Cts/keV/ kg/day	Cts/day
Co60 (Vessel)	613 kg	2.4E-4 Bq/kg	0.14	25
K40 (Readout)	0.12 m2	3.4E-2 Bq/m2	0.27	47
Th232 (Readout)	0.12 m2	1.4E-4 Bq/m2	0.01	2
U238 (Readout)	0.12 m2	4.5E-4 Bq/m2	0.04	7
Total			0.46	81

	kg	Contamination	Cts/keV/ kg/day	Cts/day
U Ar39	0.300	0.7E-3 Bq/kg	0.05	8.2
Ar39	0.300	0.01 Bq/kg	0.67	117
Ar39	0.300	0.1 Bq/kg	6.7	1170

ARIA argon error with TREX





For depletion factor 10 error < 6 % with 1 day of data taking. Resolution not implemented.

Edgar’s estimates

Larger depletion factor of 100 → error 23 % in 1 day.

Pros and cons of a TREX-DM replica

+ No new design of detector components needed

+ Required sensitivity seems at reach

-Setting of the detector is not straightforward

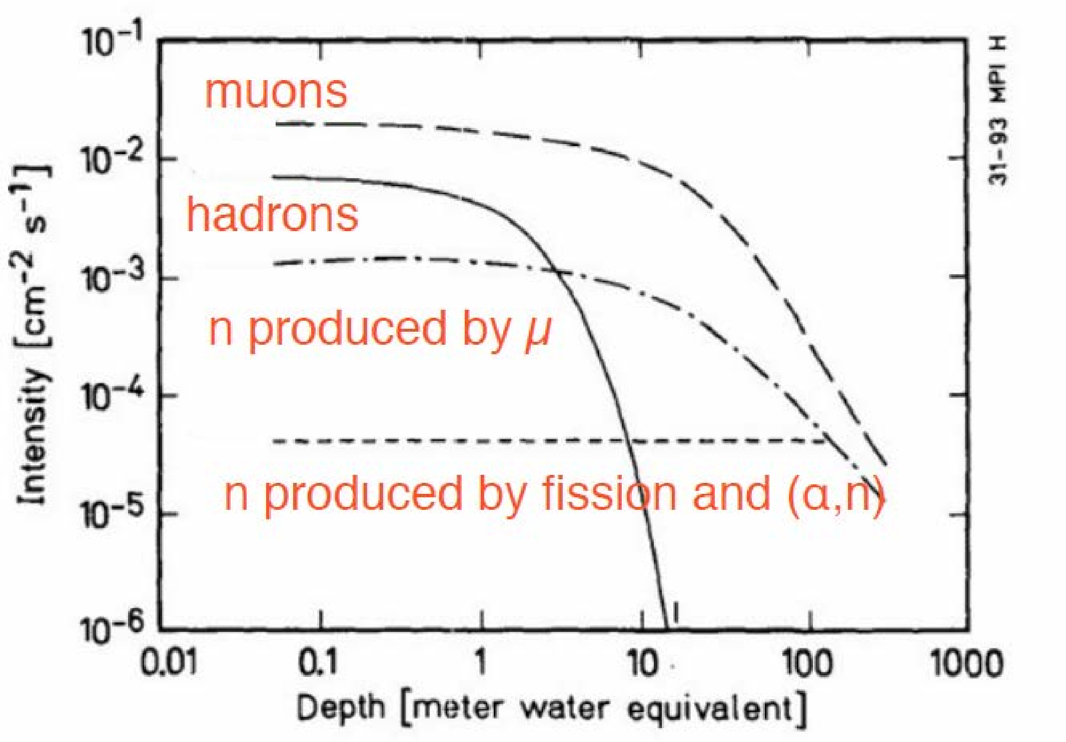
Some questions:

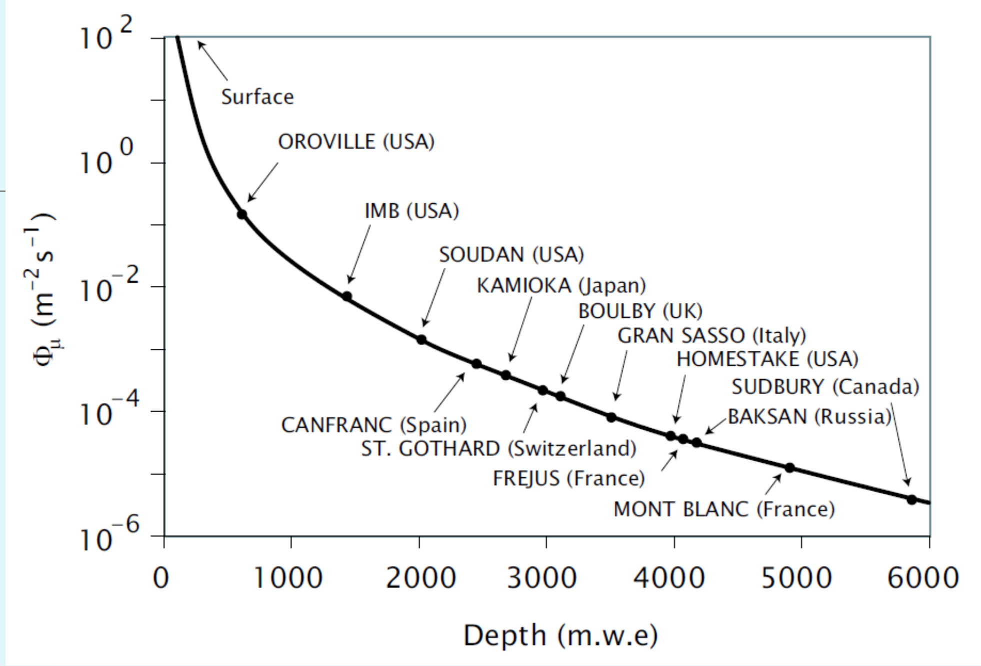
- Which type of operation in Sardinia is expected (short runs, continuous running, …)?
- Which technical resources are available in the Sardinia site?

Contribution from external backgrounds should be reevaluated for new location

Cosmogenic ^{60}Co in Cu shielding	see Section 5.2.1	0.0250±0.0018	0.0288±0.0020
^{222}Rn in air	[39]	0.1495±0.0024	0.0841±0.0013
Surface ^{210}Pb on Cu vessel	see Section 5.3	$<3.5\times10^{-3}$	$<6.2\times10^{-3}$
Surface ^{210}Pb on Cu shielding	see Section 5.3	<0.025	<0.034
Muons (+ muon-induced neutrons)	[63]	0.205±0.021	0.336±0.034
Neutrons at LSC	[65]	$(2.52\pm0.22)\times10^{-2}$	$(7.06\pm0.61)\times10^{-2}$
Neutrons from ^{238}U fission in Pb	see Section 5.6	$(5.82\pm0.39)\times10^{-5}$	$(1.094\pm0.074)\times10^{-4}$
Neutrons from ^{238}U fission in Cu	see Section 5.6	$<2.1\times10^{-6}$	$<4.1\times10^{-6}$
Radiogenic neutrons in Cu, PTFE, steel and polyethylene	Table 4	$<5.6\ 10^{-4}$	$<1.1\ 10^{-3}$

Component to be reevaluated	Comments	Possible tasks
^{222}Rn in air	Assumed 0.63 Bq/m^3 (reduction by 100 of environmetal activity thanks to N_2 gas flux) Measurement of activity in place?	
Environmental gamma	Flux in place?	Simulations to determine minimum shielding
Neutrons	Similar flux than in deeper underground locations expected	Simulations to determine minimum shielding
Muons	Different flux, energy, angular distribution for depth 350 m Order of expected flux (from facilities at similar depth): 0.05 m^{-2} s^{-1}, mean energy 110 GeV	Simulations to quantify rejection power





Muons, neutrons and secondary particles produced in a typical shielding lead

Location	Depth	Muon flux ($m^{-2}\ s^{-1}$)	Reference
Pyhasalmi (Finland)	400 m (980 mwe)	(2.1±0.2) 10^{-2}	NIMA 554 (2005) 286–290 (parametrization flux vs depth)
Daya Bay (China)	324 m (860 mwe)	0.054±0.006	JCAP01(2018)001
Canfranc	850 m (2450 mwe)	4 10^{-3}	J. Phys.: Conf. Ser. 718 (2016) 062025

Cost estimate

Component	Materials	Cost (k€)	Comments
Neutron Shielding	Water, Polyethylene		
Lead Shielding	Lead	~50 (complete shielding made of 1250 bricks, ~50 €/brick)	
Copper Shielding	Copper	~10 (5 cm, ~1 t)	
N2 flux			
Copper vessel		20	
Field cage	Teflon, Kapton PCB Resistors	~1 ~1	
Cathode	Mylar, copper, teflon, HV feedthrough	~1	
Micromegas		2x6	Use of available Bulk Micromegas (on FR4)? Bulk Micromegas cheaper.
Gas system		10	
DAQ	Flat cables, connectors FEC boards, FEMINOS boards, TCM Faraday cages	5 Not comercial	Available Samtec connectors+AFTER-based electronics? Limitations for AGET use fro Saclay?
Slow control			