Some first thoughts on DART

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+ ideas and discussions with F.Calaprice, G.Fiorillo, D.Franco, L.Pandola, C. Galbiati, H.Wang…

^{39}Ar content reminder

AAr —> 1Bq/Kg

UAr is 0.7x10^{-3}Bq/Kg —> factor 1400

Aria —> another factor of 10—>14000

Then there is the issue of ^{85}Kr (in DS50 the rate from ^{85}Kr is 3x the ^{39}Ar)

<<Kr in Xe has been reduced by a factor ←1000 per pass by cryogenic distillation [71], which should be even better for Ar. For the DarkSide-20k target, calculations show that the Aria cryogenic distillation column can reduce ^{85}Kr by a similar factor of more than 10^{3} per pass, making this source of contamination in DarkSide-20k negligible.>> (Collaborative Research: DarkSide-20k)

What and where?

The idea is to setup a process control tool that allows to provide a quick feedback on the effectiveness of Argon purification ON-SITE

Staged process:

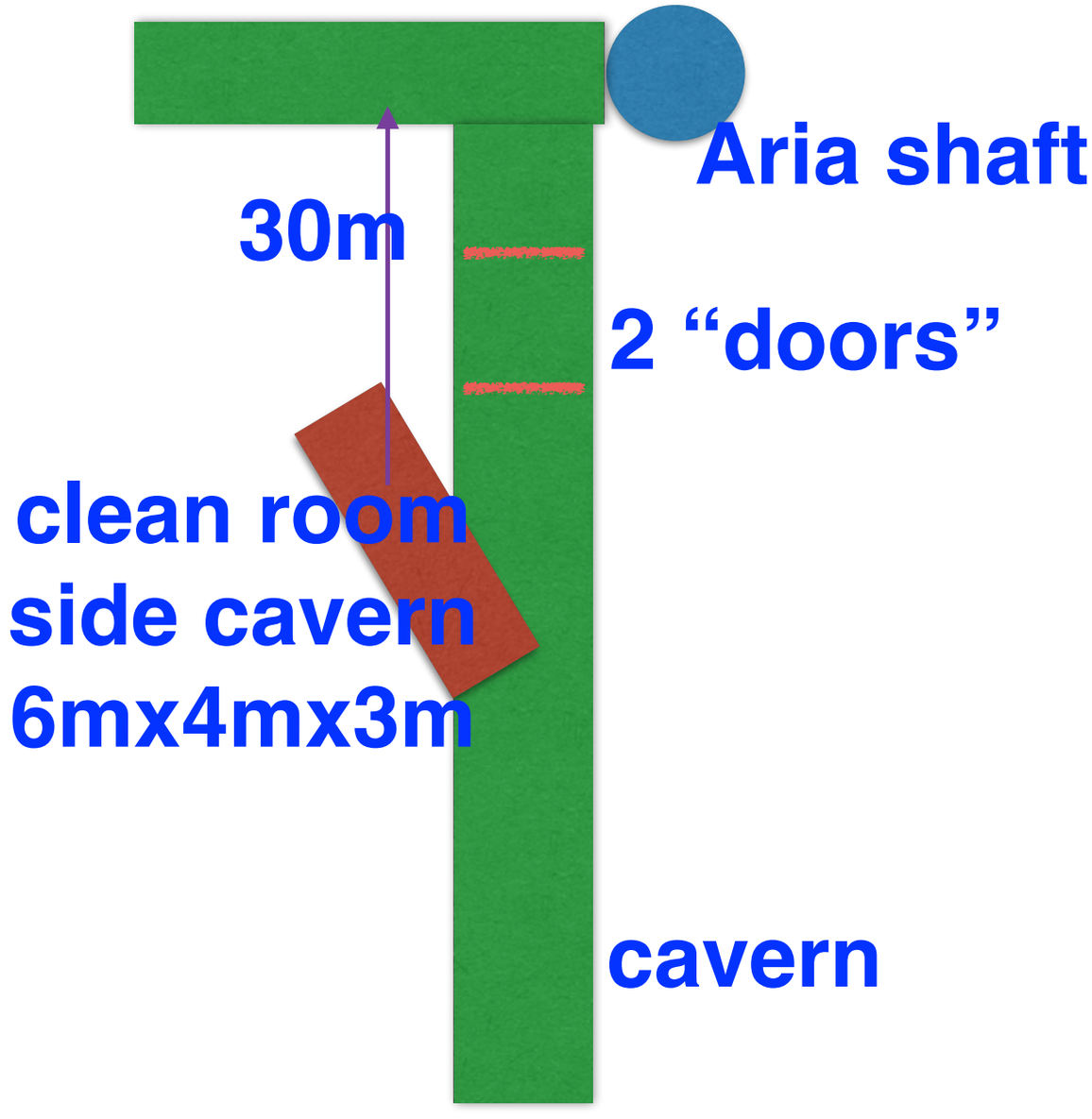
stage 1) Qualify the isotopic reduction from processing of atmospheric argon for the commissioning of Seruci I in 2017. Measurement of a depletion factor 10-100 would be sufficient.

stage 2) Fully qualify the argon for DarkSide-20k from the end of 2018. Measurement of a depletion factor 10^5 is required.

Location

350m underground

dust



Possible approach

Stage 1) use PNNL detector —>factor 20

Stage 1.5) use Princeton detector —>factor 100-200

Stage 2) a new detector

The group of INFN Cagliari is keen to coordinate the effort and work in particular on stage 1.5) and 2); but we absolutely need to build a collaboration though around these items!

PNNL

Low-background copper proportional tubes that have a sensitivity of a factor 20 depletion.

The advantage of this scheme is that it works with a few grams of argon

Princeton detector

A Study of the Residual ^{39}Ar Content in Argon from Underground Sources

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Operated both on the surface and underground (KURF, Virginia) at 1450mwe: veto not used underground

(in Seruci we are at 700mwe —> cosmic suppression factor 30 wrt to surface)

The device

0.5Kg of LAr

standard Lead

standard Copper

low background PMT

standard=not low background

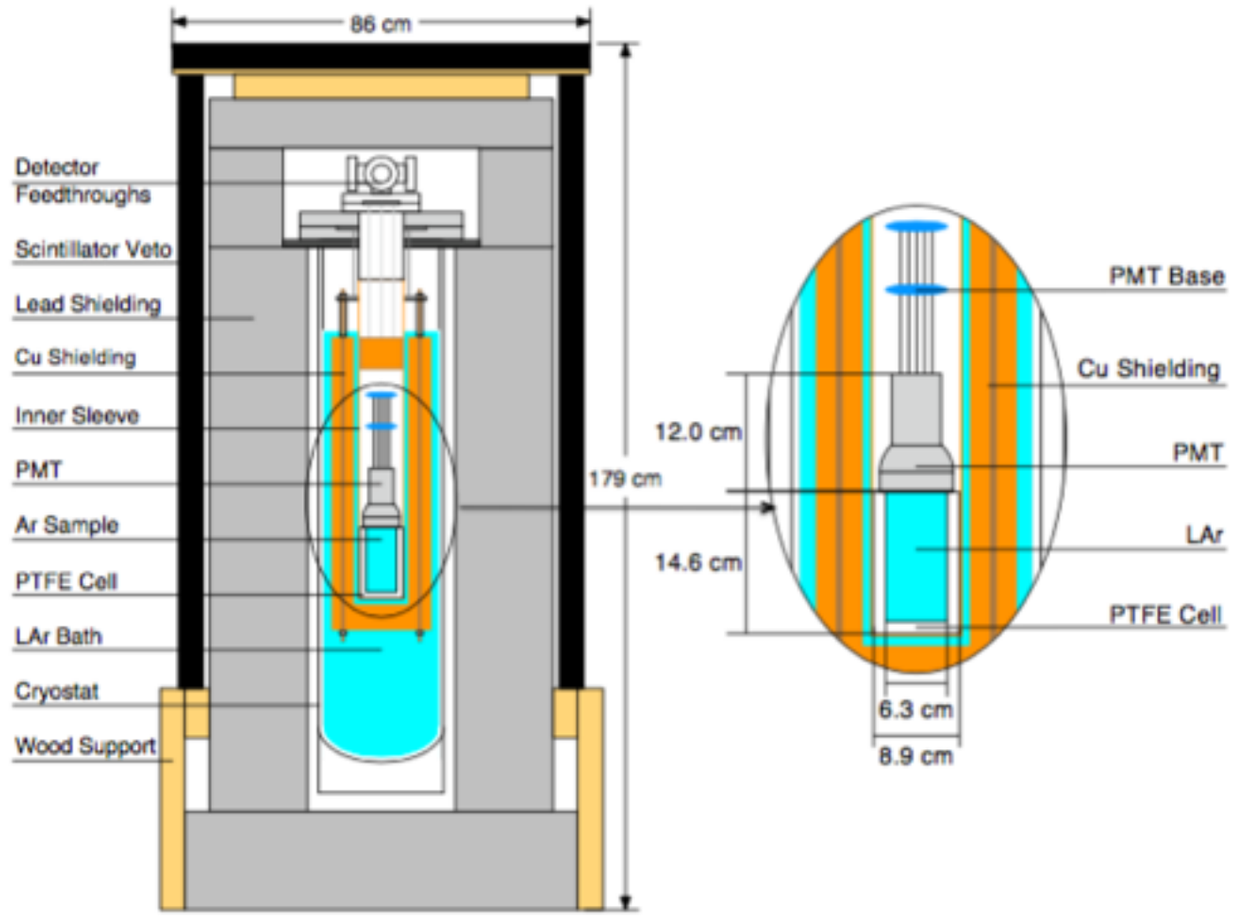


Figure 2: A schematic diagram of the low background detector.

Signal

	Rate/mBq, (300, 400) keV
Natural Ar (NAr)	108.78 ± 0.39
Underground Ar (UAr)	1.87 ± 0.06
Estimated Background	1.54 ± 0.22
^{85}Kr Background	< 1.83
NAr, Background Subtracted	107.2 ± 1.9
UAr, Background Subtracted	0.32 ± 0.23

Table 3: A summary of the background subtraction analysis. The entire upper limit ^{85}Kr rate is taken as an uncertainty in the background subtracted NAr rate. To convert these rates into activities per unit mass, an argon active mass of 0.56 ± 0.03 kg can be used.

In 0.5Kg rate due to NAr —>200mBq/Kg in [300,400KeV] (1/5th of the total rate); 0.1count/sec

UAr (with 0.7mBq/Kg) —> 0.7×10^{-4} count/s in [300,400KeV]; 0.25counts/h

^{85}Kr in UAr (2mBq/Kg) —> 2×10^{-4} count/s in [300,400KeV]; 0.7counts/h

Now: for 10Kg detector —>

UAr : 5 counts/h ^{85}Kr in UAr : 14counts/h

With DAr: 0.5counts/h in [300,400KeV] —> could be 2 or 3x if we increase window; say 1count /h

Backgrounds

This experiment was limited in sensitivity by the background: U.L. to 10x the actual value!

Source	^{252}Cf	PMT	Base	Copper
Rate (mBq)	0.82 ± 0.16	0.29 ± 0.08	0.07 ± 0.02	0.36 ± 0.11

Table 2: The expected background rate in 300 - 400 keV from different sources.

in principle they

can all go down

with careful design and

material choice

Decay Chain	Measurement Point	PMT (mBq)	Base (mBq)	Cu (mBq/kg)
^{232}Th	^{228}Ra	6 ± 1	41 ± 2.8	-
	^{228}Th	6 ± 1	45 ± 4.7	-
^{238}U	^{234}Th	190 ± 40	25 ± 3.7	-
	^{234m}Pa	80 ± 40	< 149	-
	^{226}Ra	18 ± 1.2	32 ± 1.9	-
^{235}U	^{235}U	8 ± 2	1.4 ± 0.4	-
^{40}K	^{40}K	79 ± 10	65 ± 9.3	-
^{60}Co	^{60}Co	8.8 ± 0.8	< 1.2	2.1 ± 0.19
^{57}Co	^{57}Co	-	-	1.8 ± 0.4
^{58}Co	^{58}Co	-	-	1.7 ± 0.09
^{56}Co	^{56}Co	-	-	0.2 ± 0.03

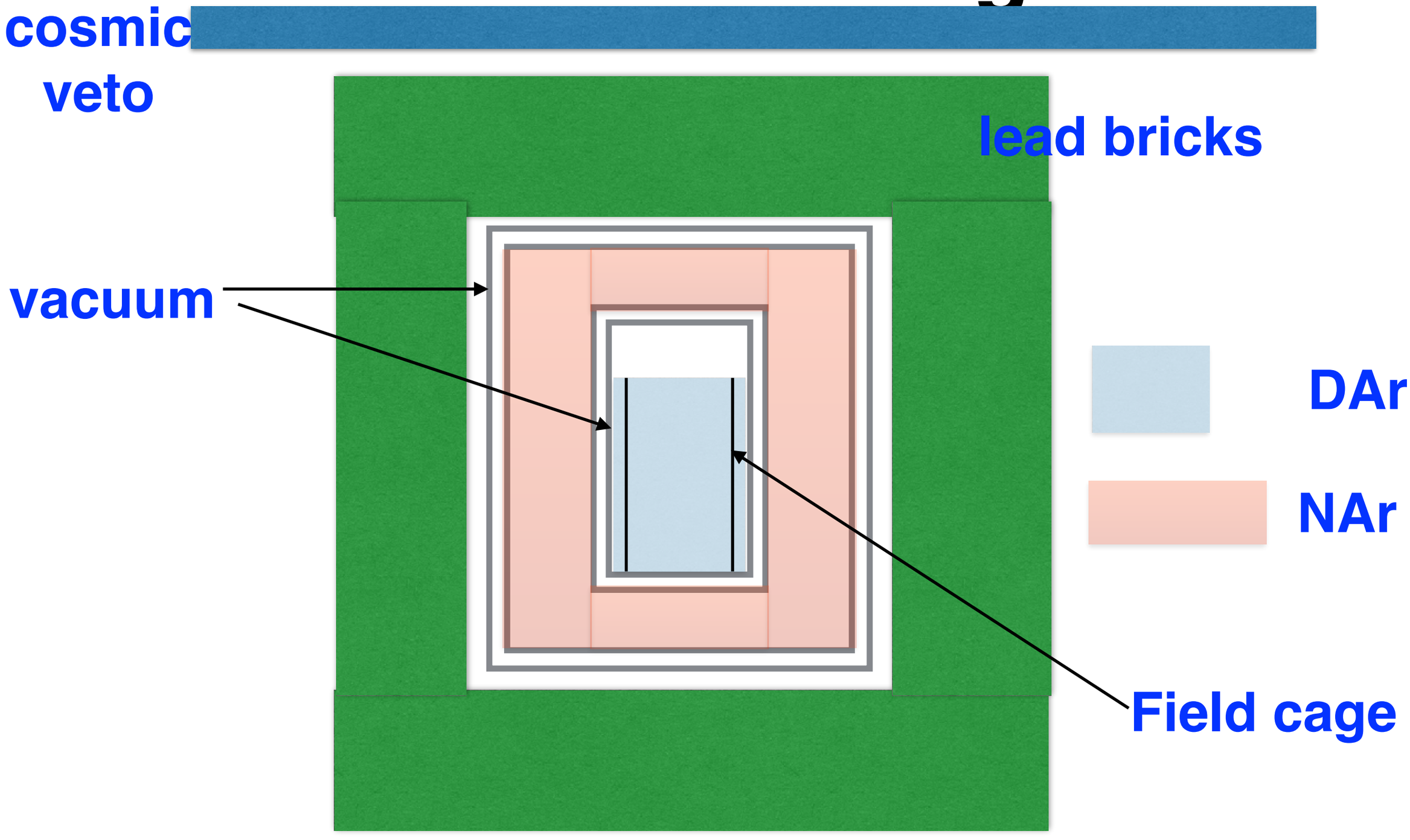
Table 1: The major radioactive isotopes in detector components.

The new detector

Some ideas, need to be tested with simulation of backgrounds

10 l ->cylinder d=20cm h=30cm

Possible design



The new detector

SiPM —> how many? who provides them? who test them?

LAr active shielding with SiPM or passive shielding?

Double phase? field cage? HV?

Cryostat and cryocooler

Monte-Carlo

We will adapt with the help of Davide Franco the DS simulation of backgrounds to see if there is a viable design

Help also offered by Luciano Pandola expert of simulation for WARP

Materials

SiPM and base and cables need checking

Low background copper for shielding

Use Roman Lead for the inside shielding (lead++ for shielding lead - -):is there any left?

For cryostat also consider low background copper. Feasible? Titanium?

We need somebody expert in material selection and procurement and TEST for radiation

LAr from Aria

Dust in the underground cavern should be considerably reduced after refurbishing

Clean room is only for us

How to get LAr from Aria?

Seruci-1 will produce gas argon stored in 200bar bottles

—> we need cryocooler OR LN (this may cause safety issues)

Seruci-2 could yield LAr directly

Calibration

Which sources?

Schedule

Follows Aria

Safety

Cryogenic Argon/Nitrogen underground

Radioactive sources

Who checks it?

Costs