Istituto Nazionale di Fisica Nucleare

SABRE MC simulation updates

Giulia D'Imperio

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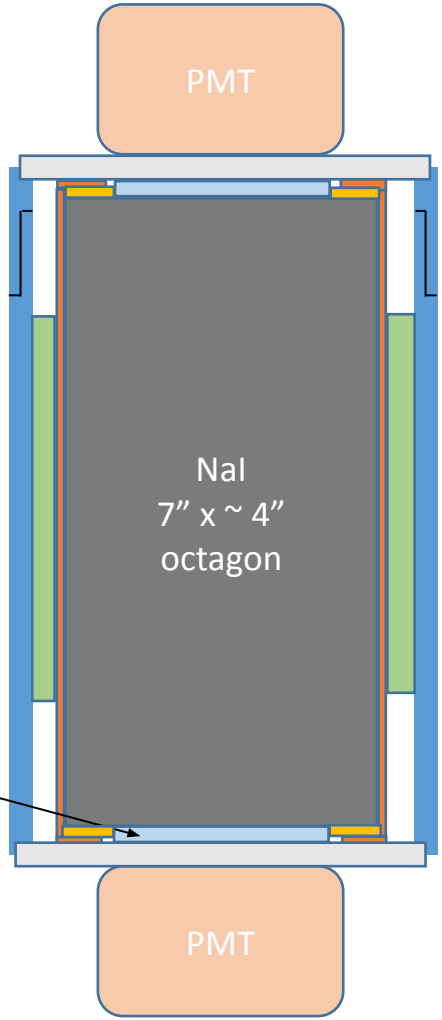
Status Monte Carlo simulations

- Geant4 code in gitlab: https://gitlab.com/SABRE-EXPERIMENT/SABREMC/-/tree/SABRE-North-TDR
    - Still based on Geant 4 v10.5.1 (most recent version is v11.3.3), some low energy models have been updated (photoelectric effect, electron interactions, ...)
- Group/interested people: Giulia, Claudia, Ambra, Krys, Chems, Sana
- We tried recurrent meetings every 2 weeks but not enough material to discuss so we moved to more relaxed schedule
- Started simulations for RMD enclosure

Enclosure “RMD”

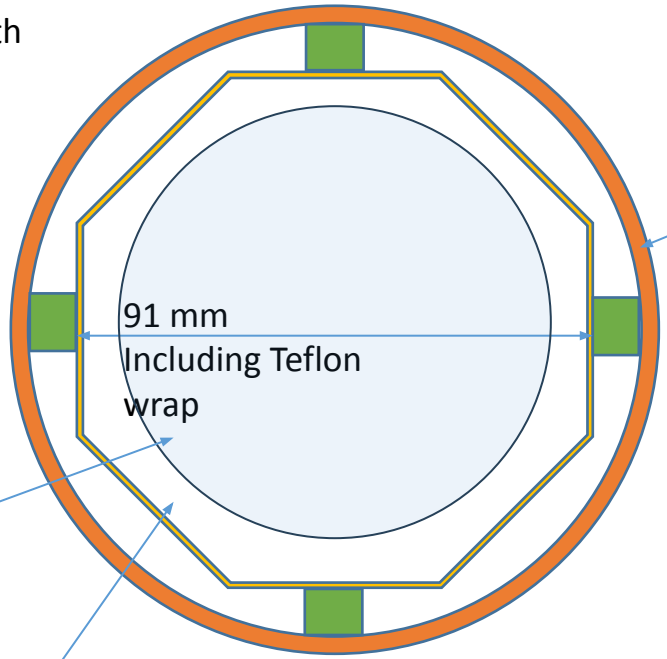


Gel pad sized to match the active area of the PMT

- Reflective Teflon wrap (~ 1 mm)
- Silicone Gel pad optical coupling (2 mm) Eljen EJ-560
- Window (Corning 7980 fused silica)
- Shim (x4) (PTFE)
- Gore DRP ring (1.5 mm)
- Copper enclosure (Thyssenkrupp, OFE copper C10100 H58)

NOT DRAWN TO SCALE!

Actual octagon
dimensions:
89 mm side to side
181 mm end to end length



Copper tube
ID = 108 mm
OD = 114
mm

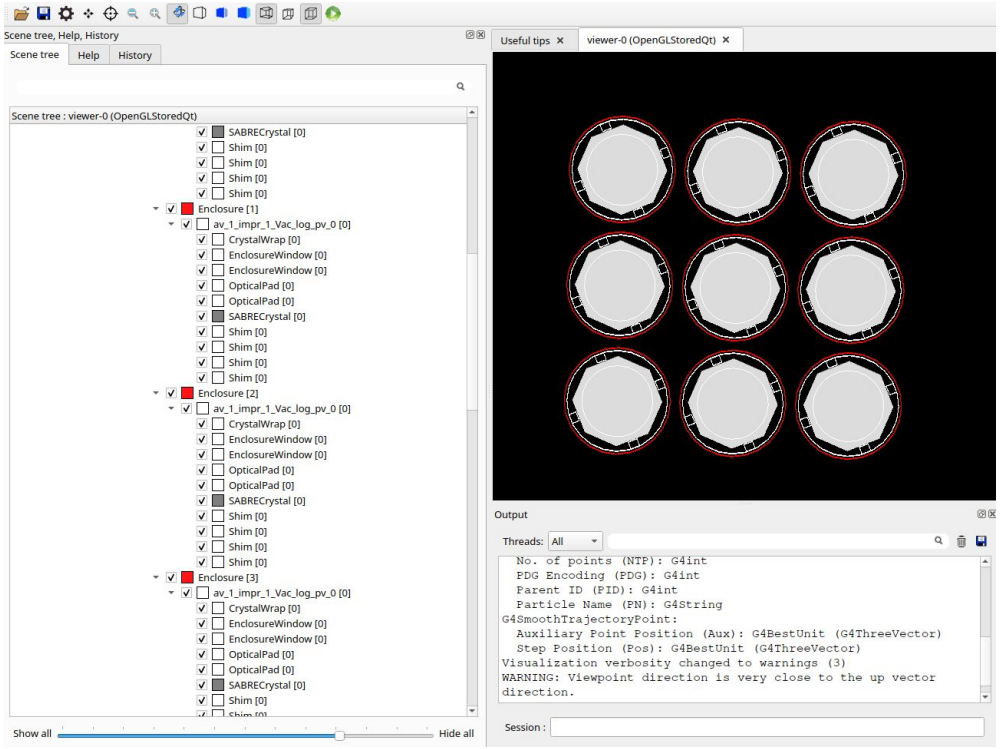
Shim (PTFE) 8 x 10 x 100 mm

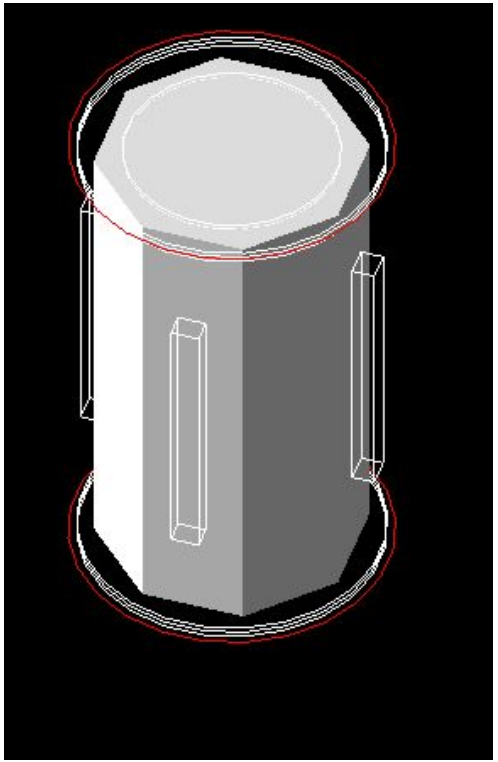
3” dia gel
pad

Gore DRP annulus
3” dia hole inside
Octagon periphery

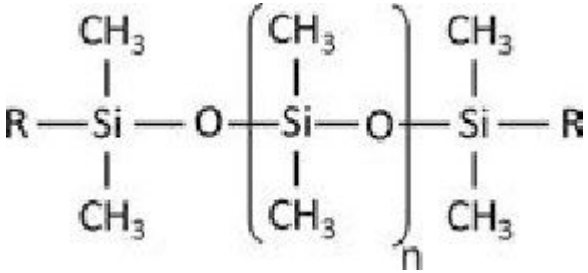
Enclosure “RMD” in Geant4

Code updated in https://gitlab.com/SABRE-EXPERIMENT/SABREMC/-/tree/SABRE-North-TDR





New materials definition



- Optical pad ➜ Silicone rubber:
  - chemical structure from: https://www.researchgate.net/publication/322902333_Mechanical_Thermal_and_Morphological_Behavior_of_Silicone_Rubber_during_Accelerated_Aging
  - density 1.03 g/cm3 from https://eljentechnology.com/products/accessories/ej-560

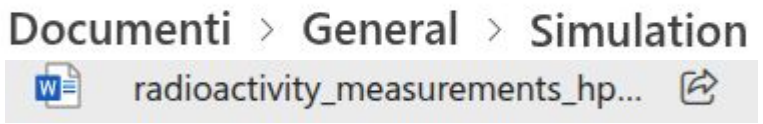
- Gore DRP annulus ➜ a type of Teflon

Materials used for the enclosure

- Copper
- Teflon shims
- Teflon wrapping
- Optical pad
- Quartz
- Gore DRP (a type of teflon)

Radioactivity measurements (HPGe) -Teflon

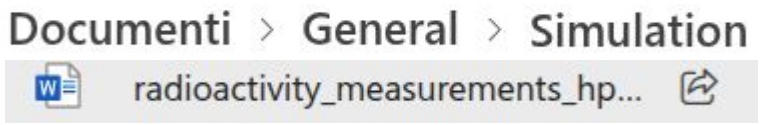
File in our Teams space:




```
sample:           Teflon, Sabre
weight:           0.21244 kg
live time:  1699295 s
detector:   GeMPI3

radionuclide concentrations:
Th-232:
Ra-228:           < 0.87 mBq/kg           <==>   < 2.1 E-10
g/g
Th-228:           < 0.30 mBq/kg           <==>   < 7.3 E-11
g/g

U-238:
Ra-226      < 0.52 mBq/kg           <==>  < 4.2 E-11 g/g
Th-234      < 9.1 mBq/kg      <==>  < 7.4 E-10 g/g
Pa-234m           < 27 mBq/kg       <==>  < 2.2 E-9 g/g

U-235:      < 0.45 mBq/kg           <==>  < 7.8 E-10 g/g

K-40:       < 9.2 mBq/kg      <==>  < 3.0 E-7 g/g

Cs-137:           < 0.18 mBq/kg
```

Radioactivity measurements (HPGe) - copper

File in our Teams space:



sample: two copper blocks KARL SCHREIBER,
each (200 x 100 x 50) mm, SABRE
weight: 18.3278 kg
live time: 2316780 s
detector: GeMPI2

radionuclide concentrations:

Th-232:
Ra-228: < 0.099 mBq/kg <==> < 2.43 E-11 g/g
Th-228: < 0.17 mBq/kg <==> < 4.14 E-11 g/g

U-238:
Ra-226 < 0.10 mBq/kg <==> < 8.2 E-12 g/g
Th-234 < 19 mBq/kg <==> < 1.6 E-9 g/g
Pa-234m < 3.7 mBq/kg <==> < 3.0 E-10 g/g

U-235: < 0.21 mBq/kg <==> < 3.8 E-10 g/g

K-40: < 0.68 mBq/kg <==> < 2.2 E-8 g/g

Cs-137: < 0.11 mBq/kg

Co-60: < 0.031 mBq/kg @ start of measurement: 03-FEB-2022

Co-57: < 0.26 mBq/kg @ start of measurement: 03-FEB-2022

Co-58: (0.35 +- 0.06) mBq/kg @ start of measurement: 03-FEB-2022

Co-56: (0.065 +- 0.002) mBq/kg @ start of measurement: 03-FEB-2022

Mn-54: < 0.045 mBq/kg @ start of measurement: 03-FEB-2022

Be-7: < 0.36 mBq/kg @ start of measurement: 03-FEB-2022

Radioactivity measurements (ICP-MS) - copper

File in our Teams space:

	Etching 2	Etching 3
	[pg * g^{-1}]	[pg * g^{-1}]
Th	9 ± 3	7 ± 2
U	5 ± 2	2 ± 1

Tab.2 Contamination and activity in copper sample, the concentration values refer to solid sample; the uncertainity is about 30% of given values, recovery uncertainity is about 10%

Th: (7 +/- 2) 10^{-12} g/g <==> (28 +/- 4) 10^{-3} mBq/kg
U: (2 +/- 1) 10^{-12} g/g <==> (25 +/- 12) 10^{-3} mBq/kg

about 10-100 lower than HPGe limits

Results for copper

- Path of geant4 outputs on linux.lngs.infn.it

  `/nfs/sabre3/giulia/SABREMC-DATA/pbs_outputs/CopperEnclosureRMD/`

- File in our Teams space: Documenti > General > Simulation  simulations_list.xlsx

Radioactive chains/other	Isotopes	background [cpd/kg/keV] in [1,6] keV	1 year background [cpd/kg/keV] in [1,6] keV
	K40	3.95E-04	
	Cs137	5.54E-04	
	Th232	1.26E-03	
	U238	1.59E-03	
	U235	2.25E-03	
cosmogenics	Co56	3.83E-04	7.58E-05
	Co57	3.41E-04	2.16E-04
	Co58	1.79E-03	3.09E-04
	Co60	1.51E-04	1.41E-04
	Mn54	1.82E-04	1.22E-04
	Be7	1.89E-04	1.79E-05
TOT cosmo		**3.04E-03**	**8.82E-04**
TOT		**9.09E-03**	**6.93E-03**

PoP enclosure ~10^{-2} cpd/kg/keV

Communications, shared material

- Slack channel for chat/quick communication https://join.slack.com/t/sabre-north/shared_invite/zt-2y8yhdqxx-x5LV2MoDHAhHlXzmvJrxkQ

- Mailing lists:
  - for all members: sabre-north@lngs.infn.it
  - simulations working group: sabre-north-mc@lngs.infn.it

- Teams for sharing materials: https://teams.microsoft.com/l/team/19%3aQ4t-496fRD7axygZ9At1Gj6GAkod9EUYm2p8orXLo_c1%40thread.tacv2/conversations?groupId=c7aa97d4-1a33-483c-a7cb-16160b3819ac&tenantId=2e10e44d-c7b9-43e3-b020-1292482e504a