

Cosmogenic backgrounds in Darkside with GEANT4

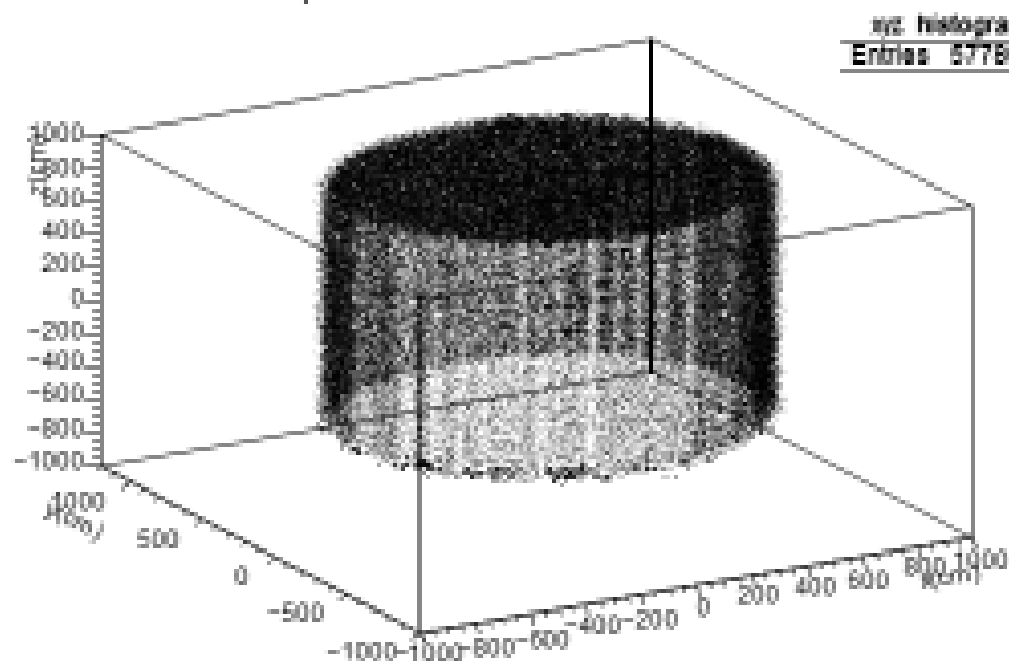
Dmitry Golubkov, Igor Machulin

Simulation of 10^6 muons with E=270 GeV for Borexino scintillator and 20 tonn of Liquid Argon

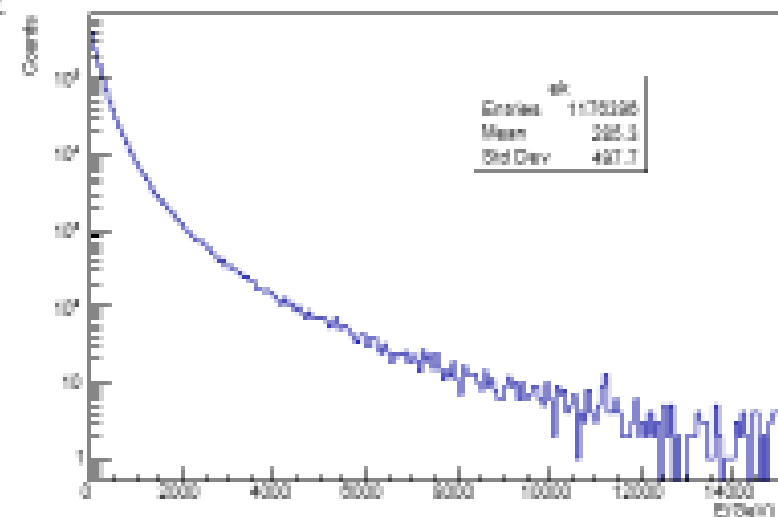
	Borexino results for psevdocumen scintillator	Geant4 Old (HP_Bertini_LEP_QGS)	Geant4 New (QGSP_BERT_HP)	Geant4 New (QGSP_BERT_HP)
Medium	C_9H_{12}	C_9H_{12}	C_9H_{12}	Liquid Argon
Isotopes	Yield [$10^{-7} * (\text{muon} * \text{g}/\text{cm}^2)^{-1}$]			
3H	Not measured	No calculation	195±2	64.4±1.3
6He	38±15	8.9±0.4	6.0±0.3	0.81±0.15
8He ($\beta+n$)	<1.5	0.18±0.05	0.49±0.08	0.03±0.03
8Li	7±7	7.8±0.4	4.36±0.25	0.33±0.09
9Li ($\beta+n$)	2.9±0.3	1.68±0.16	2.8±0.2	0.03±0.03
8B	14±6	1.44±0.15	1.26±0.14	<0.03
12B	56±3	29.7±0.7	23.1±0.6	0.24±0.08
11Be	<7.0	0.45±0.09	0.32±0.06	0.03±0.03
9C	<16	0.99±0.13	0.45±0.08	<0.03
10C	18±5	41.1±0.8	31.1±0.7	0.05±0.04
11C	886±115	415±3	402±3	0.24±0.08
12N	<1.1	2.0±0.2	2.1±0.2	0.03±0.03

- The outer cryostat geometry was obtained from CERN group responsible for construction of the ProtoDUNE cryostat at CERN.
- Cosmogenic events(muons and secondaries) with the information (event type, energy, age, position coordinates and direction cosines) stored in a virtual cylinder of 7m radius and 14 m height. (Results from earlier FLUKA simulation through the Gran Sasso Rock.)

spatial distribution of the events



muon energy spectrum

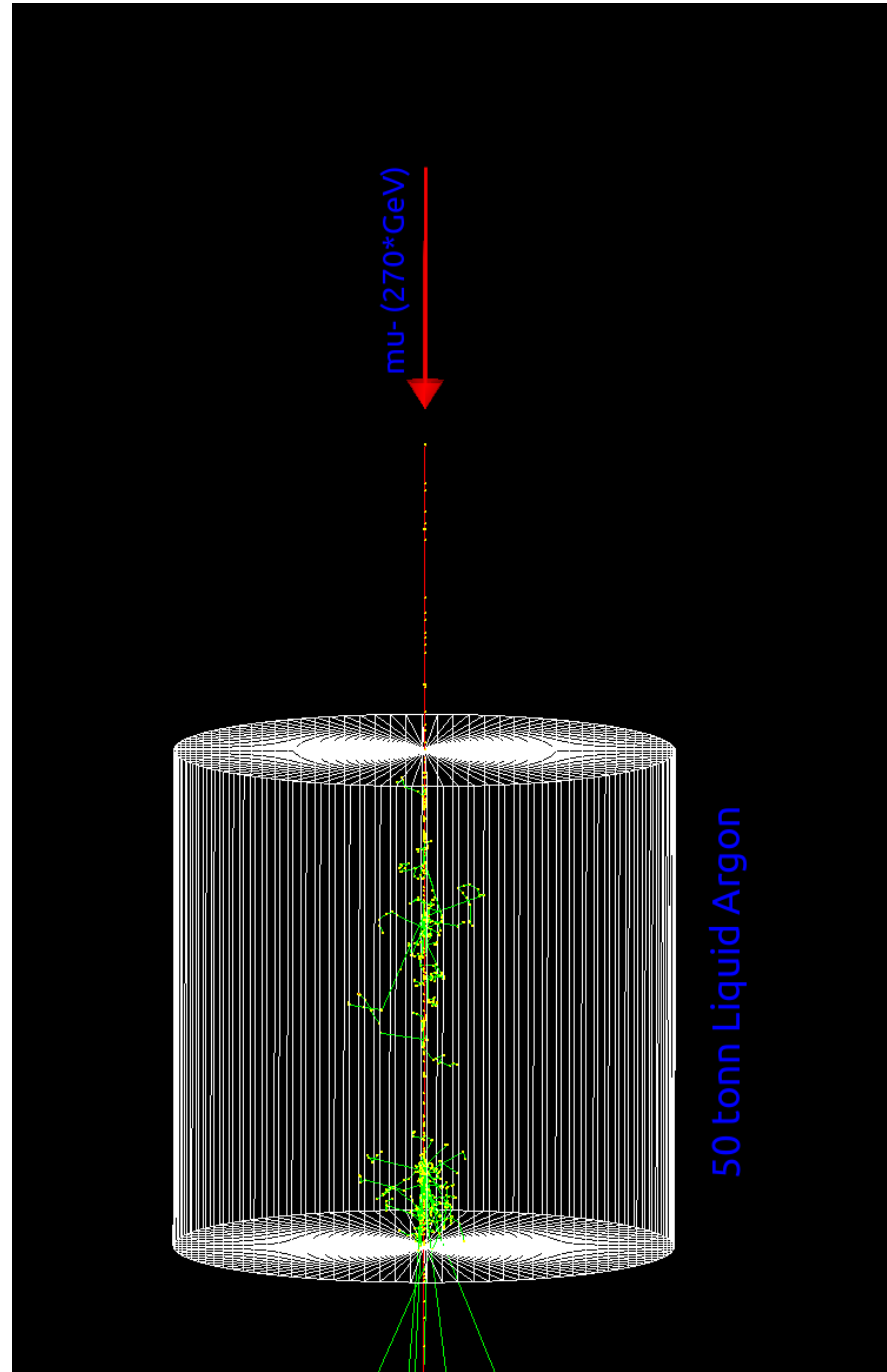


Sample file (C_300), $\sim 8 \times 10^5$ events (5.8×10^6 particles)

10^7 muons at cavern ~ 169 days (normalised with respect to Borexino's muon flux measurements)

Muon event rate at cavern $\sim 3.4 \times 10^{-4} \text{ s}^{-1} \text{ m}^{-2}$

Simulation of muon flux and spectre from Sagar file for 50 tonn of Liquid Argon (beta isotopes)



Simulation of muon flux and spectre from Sagar file for 50 tonn of Liquid Argon (beta isotopes)

	Suzana	Geant4 (QGSP_BERT_HP)	
Isotopes	Yield (per muon)		Yield [$10^{-7} * (\text{muon} * \text{g}/\text{cm}^2)^{-1}$]
41Ar	0.2113	0.0038	75.8 ± 1.1 (no hydrogen moderator)
40Cl	0.0023	0.0014	27.6 ± 0.7
39Cl	0.0159	0.0064	128.9 ± 1.5
39Ar	0.1626	0.0794	1590 ± 5
38Cl	0.0123	0.0061	121.8 ± 1.4
37S	0.0016	0.0016	32.6 ± 0.7
37Cl	0.0134	0.0201	400 ± 3
35S	0.0108	0.0047	93.2 ± 1.3
34P	0.0014	0.0005	9.1 ± 0.4
33P	0.0043	0.0014	27.6 ± 0.7
32P	0.0050	0.0017	44.5 ± 0.8
31Si	0.0018	0.0006	12.2 ± 0.5
28Al	0.0019	0.0003	6.7 ± 0.3
10Be	0.0010	0.00002	0.39 ± 0.08
3H	0.0161	0.0035	70.6 ± 1.1

Simulation of muon flux and specter from Sagar file for 50 tonn of Liquid Argon (beta isotopes)

	Suzana	Geant4 (QGSP_BERT_HP)	
Isotopes	Yield (per muon)		Yield [$10^{-7} * (\text{muon} * \text{g}/\text{cm}^2)^{-1}$]
8He	1.59E-5	< 0.8E-6	< 0.02
9Li	1.2E-4	2.5E-6	0.05 ± 0.03
11Li	3.44E-5	< 0.8E-6	< 0.02
11Be	7.99E-5	< 0.8E-6	< 0.02
13B	1.0E-4	< 0.8E-6	< 0.02
17N	7.60E-5	4.2E-6	0.09 ± 0.04
22F	2.2E-6	5.1E-6	0.10 ± 0.04
24F	1.2E-6	1.7E-6	0.03 ± 0.02
27Na	2.6E-8	< 0.8E-6	< 0.02
31Al	1.28E-6	1.1E-5	0.22 ± 0.06
32Al	1.4E-7	1.7E-6	0.03 ± 0.02

Future steps

- Addition of more statistics from Houston initial file (now we have only 169 days muon flux on the cylinder from Sagar)
- Check for physics list in GEANT4
 - a) muon-nuclear interactions – check in physics list
 - b) QGSP_BIC_HP model gives ~ 2 times more isotope yield in comparison with QGSP_BERT_HP (3 times lower in speed).
- Comparison with the FLUKA results
- (we need the FLUKA specialist)