ORNL N → N’ Group Update

On STEREO Calculations

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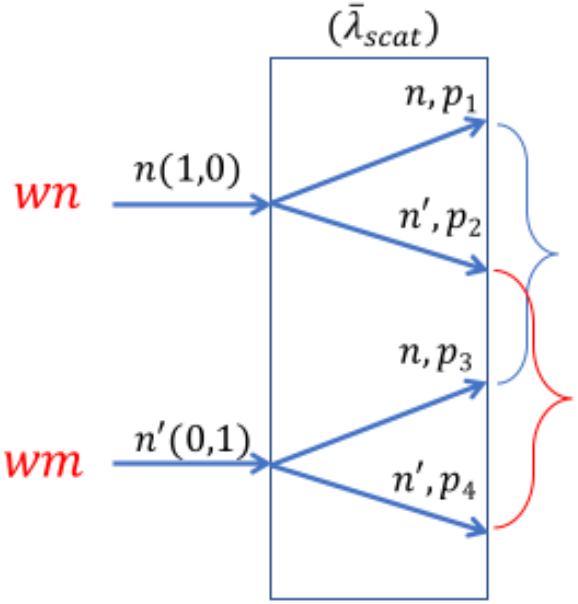
Method of Calculation

In the fast calculation method using Berezhiani's formulas (4)-(12) from the paper https://arxiv.org/abs/2111.01791 the wave functions solution of Schrodinger equation is used instead of density matrix. This solution always starts with initial $\begin{pmatrix}1\\0\end{pmatrix}$ or $\begin{pmatrix}0\\1\end{pmatrix}$ for $\begin{pmatrix}n(0)\\n'(0)\end{pmatrix}$, which allows to construct final density matrix from the solutions of S.E. $\begin{pmatrix}n(t)\\n'(t)\end{pmatrix}$.



$$n: \quad wn_{new} = wn \cdot p_1 + wm \cdot p_3$$

$$n': \quad wm_{new} = wn \cdot p_2 + wm \cdot p_4$$

Number of absorbed or "detected" in the layer:

$$\Delta = (wn + wm) - (wn_{new} + wm_{new})$$

If there is no "mirror absorber"

Method of Calculation

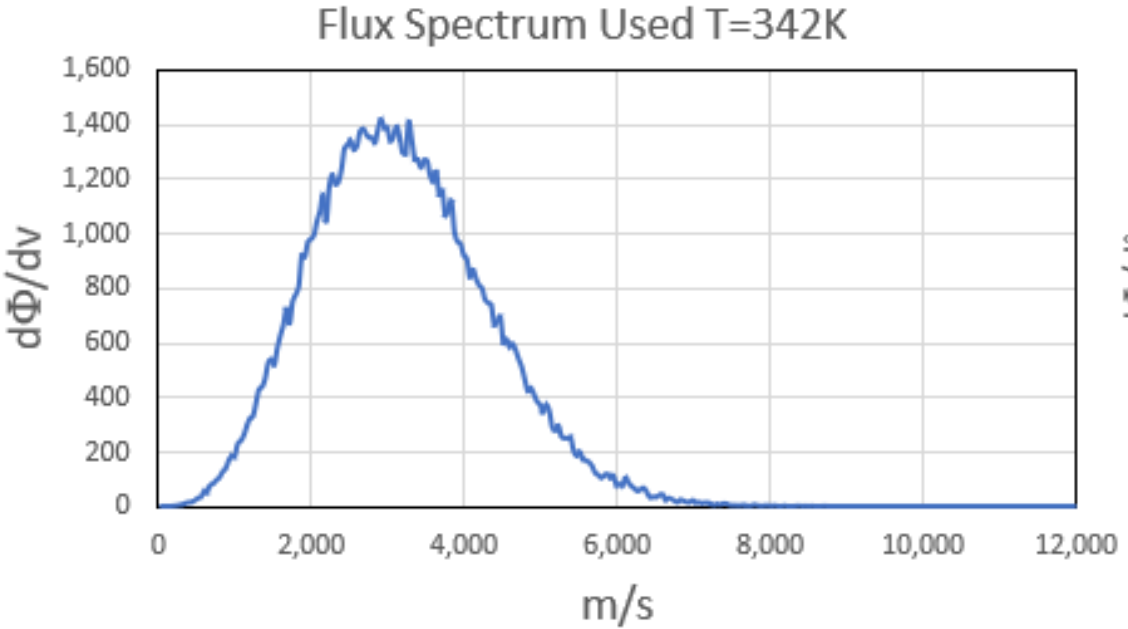
Given a material layer of thickness *L*, an important question of the number of elastic scatterings at length *L* arises.

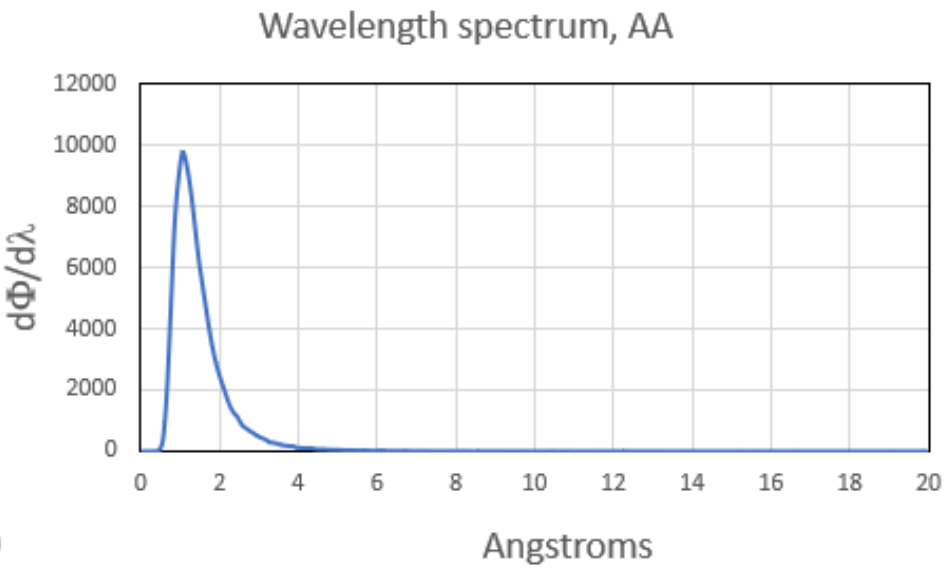
The elastic scattering length is calculated from the number density of nuclei and known elastic scattering cross sections:

$$\lambda_{sc} = \frac{1}{\sum n_i \sigma_i^{sc}}$$

The total number of elastic scatterings with a layer of thickness *L* was determined by a diffusion Monte-Carlo process where the absorption cross sections of the materials were set to 0.

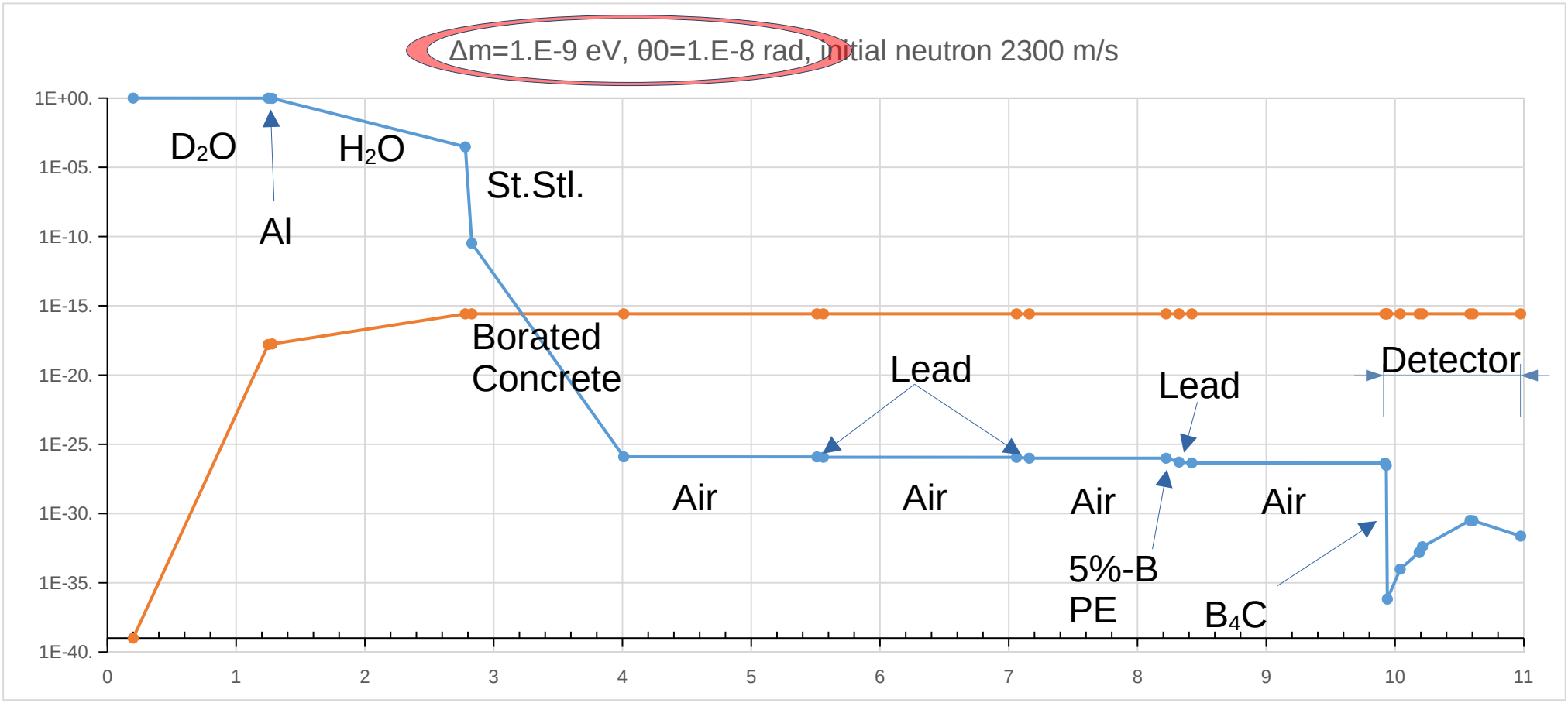
YK Velocity Spectrum

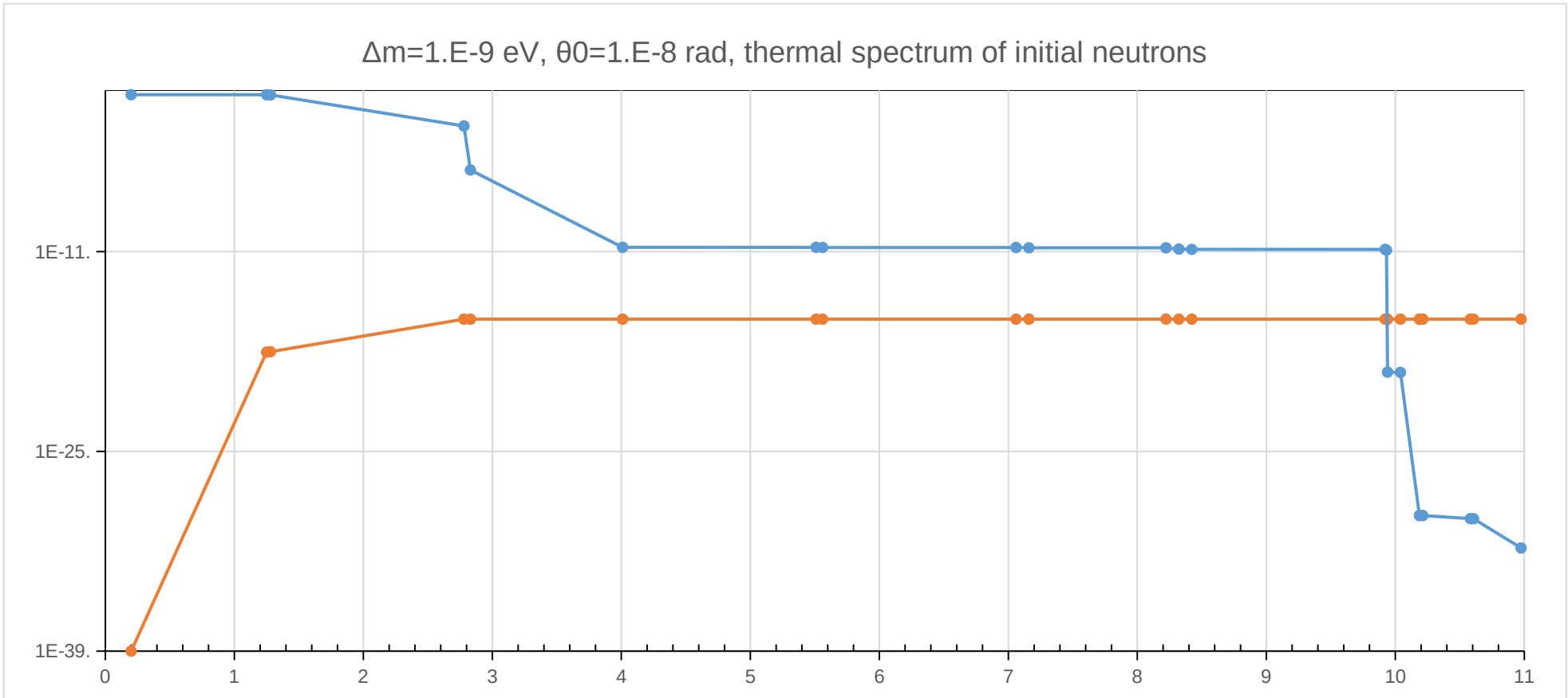




- Velocity spectrum shows expected Maxwell-Boltzmann flux distribution
- Cutoff at > 12 km/s
  - Negligible count disproportionaly affects statistics

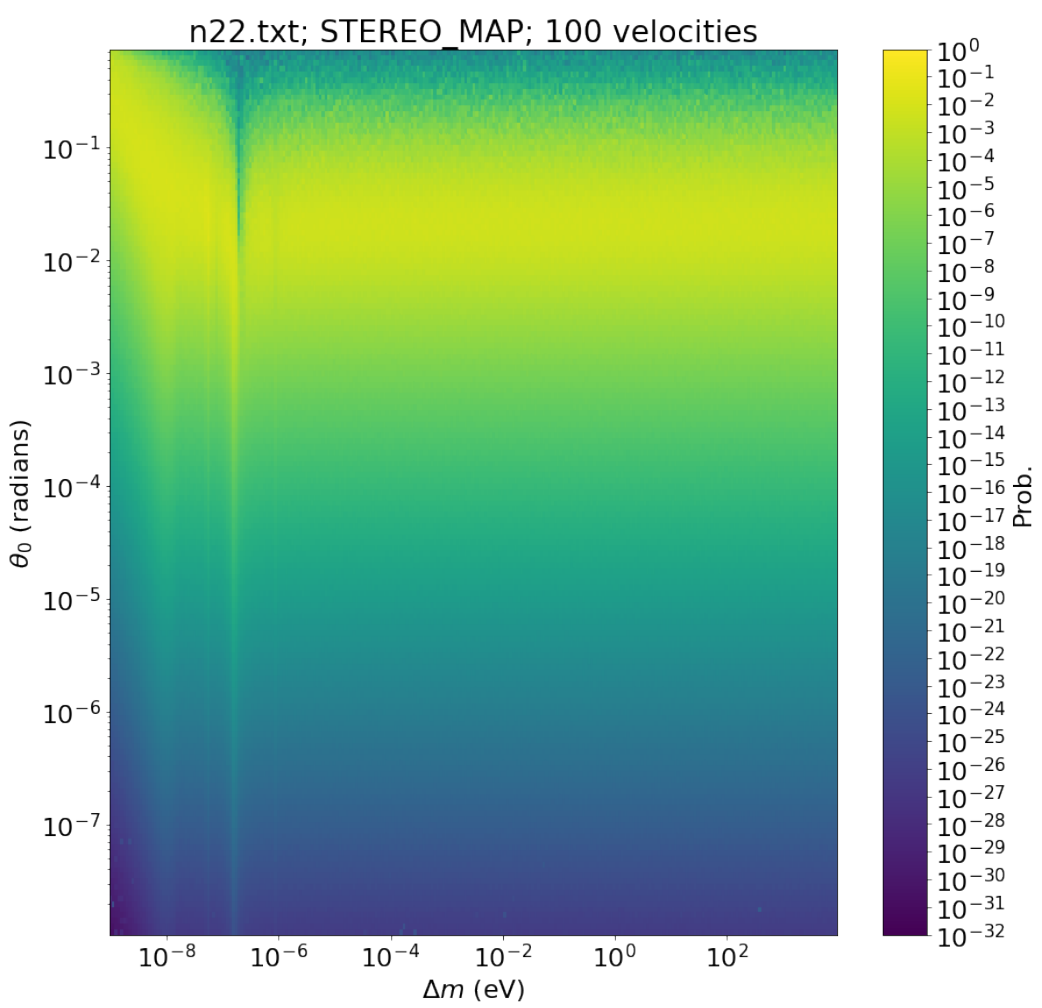
Probabilities of Different Materials Along Radial Direction

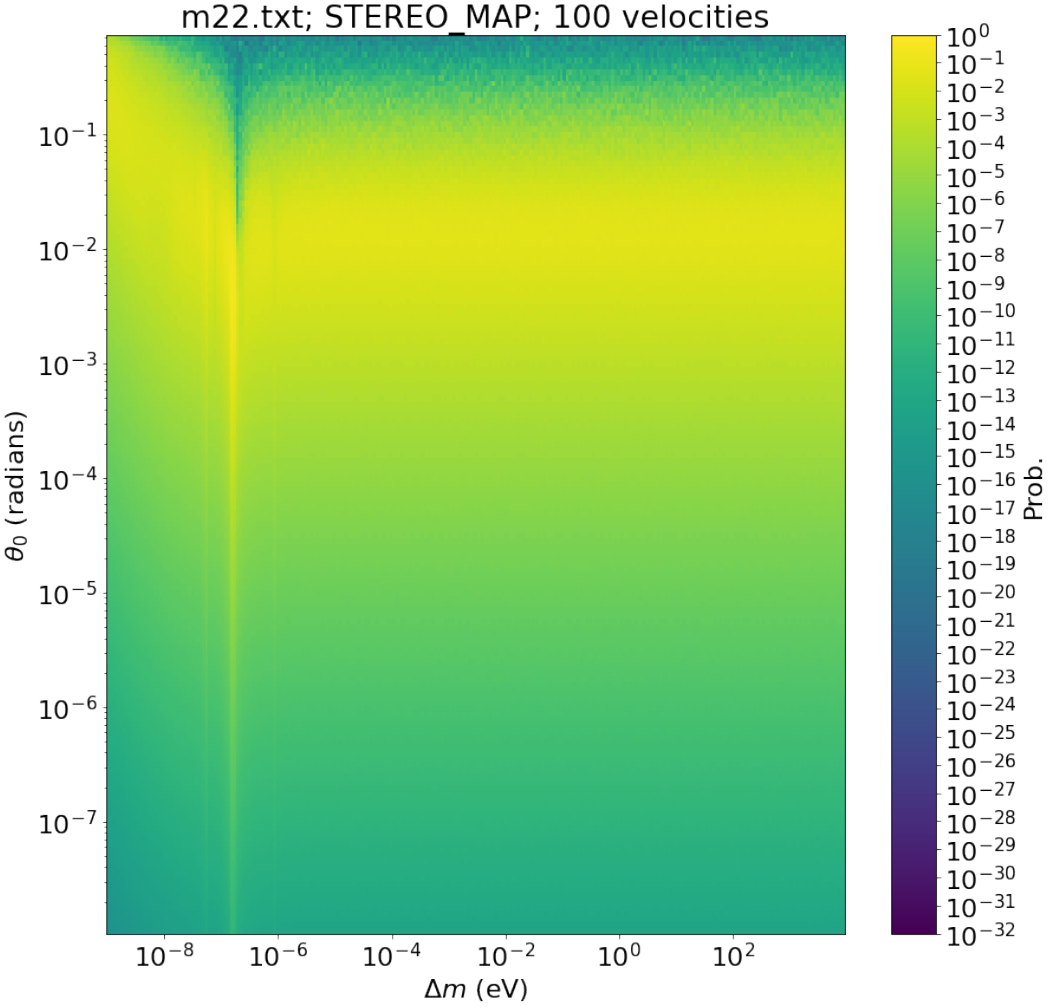




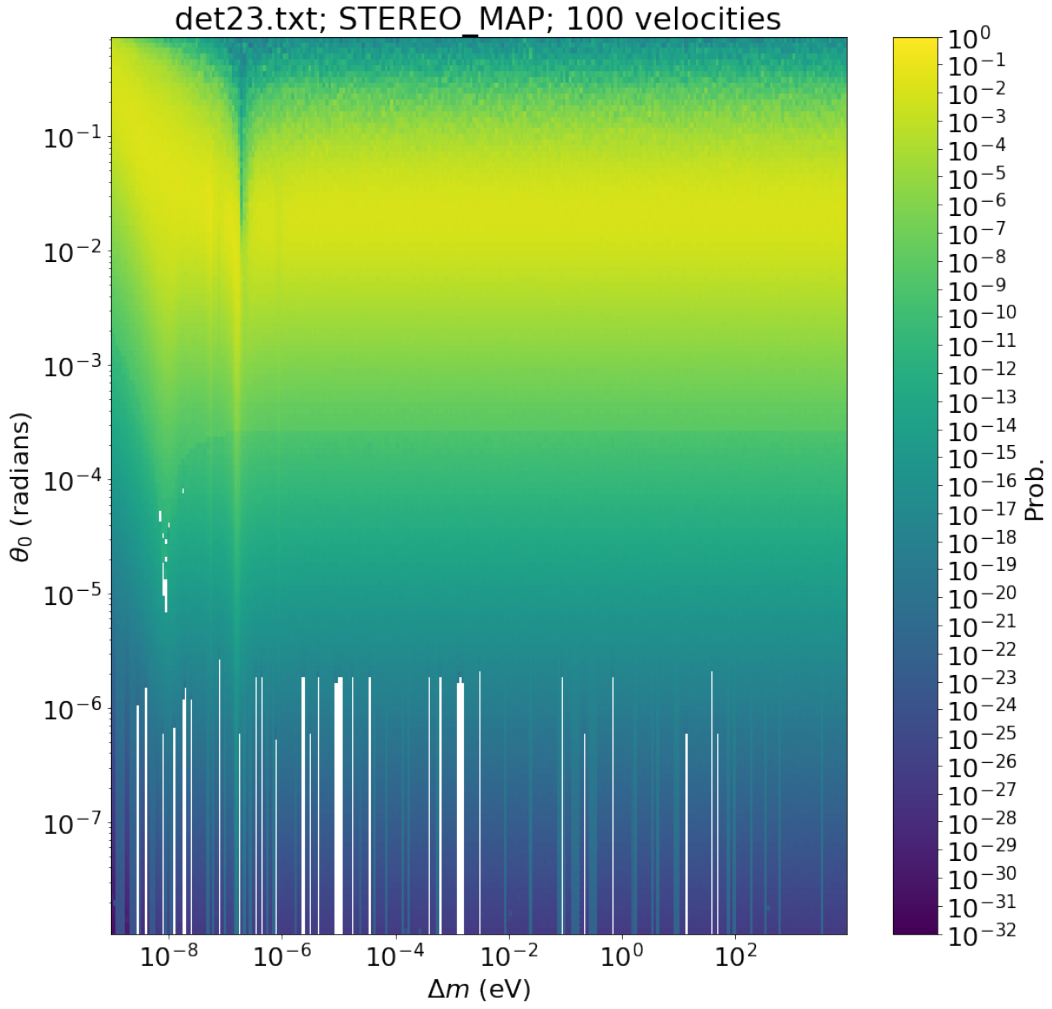
Averaged over 10,000 velocities

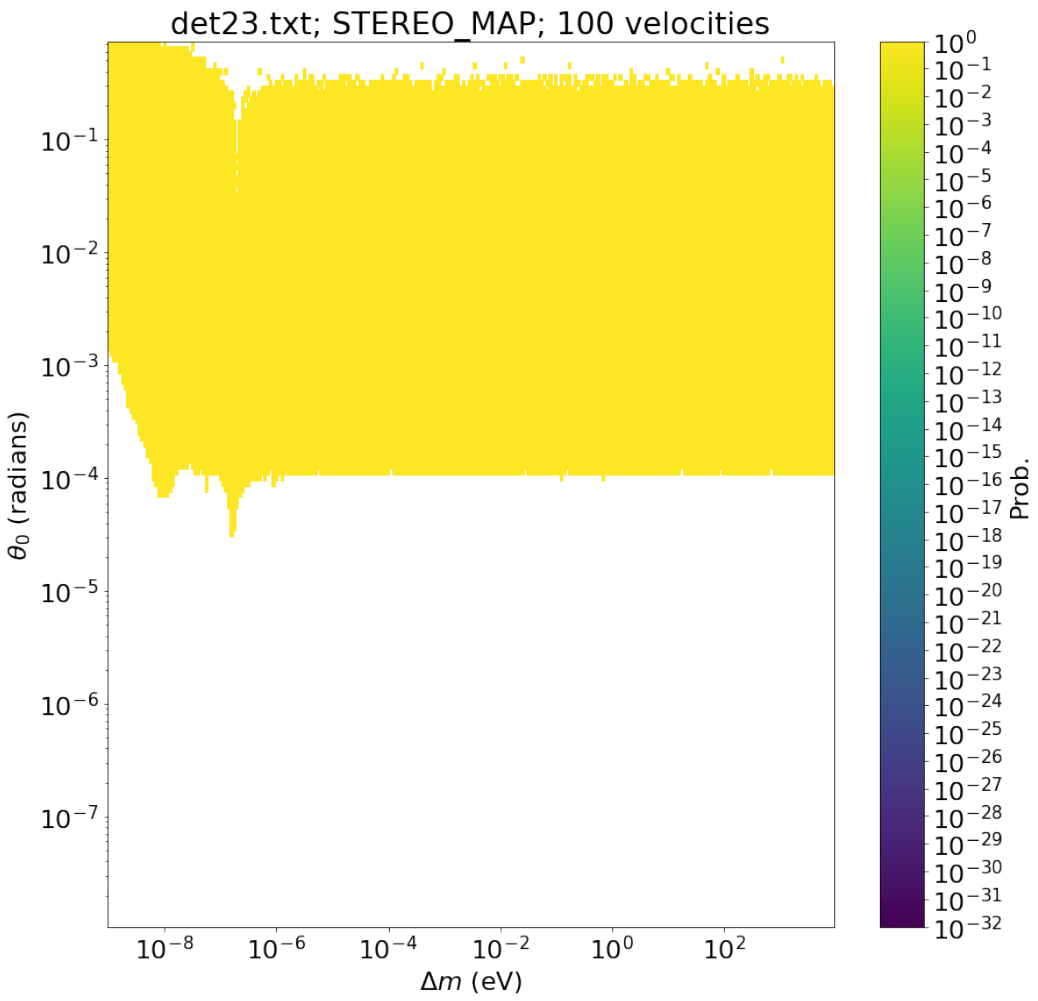
YK Simulation for N and N’ before Detection





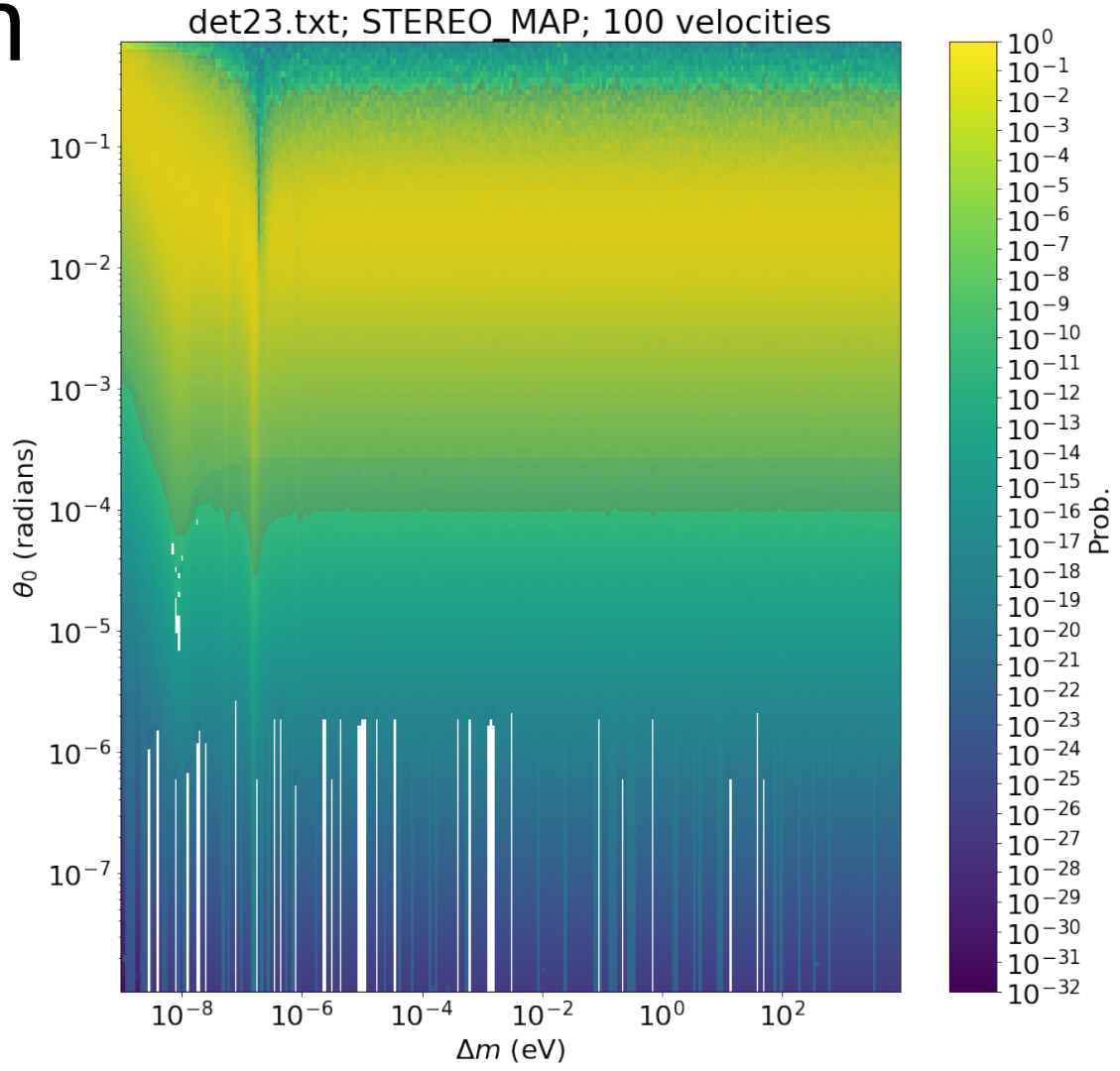
Detection and Exclusion

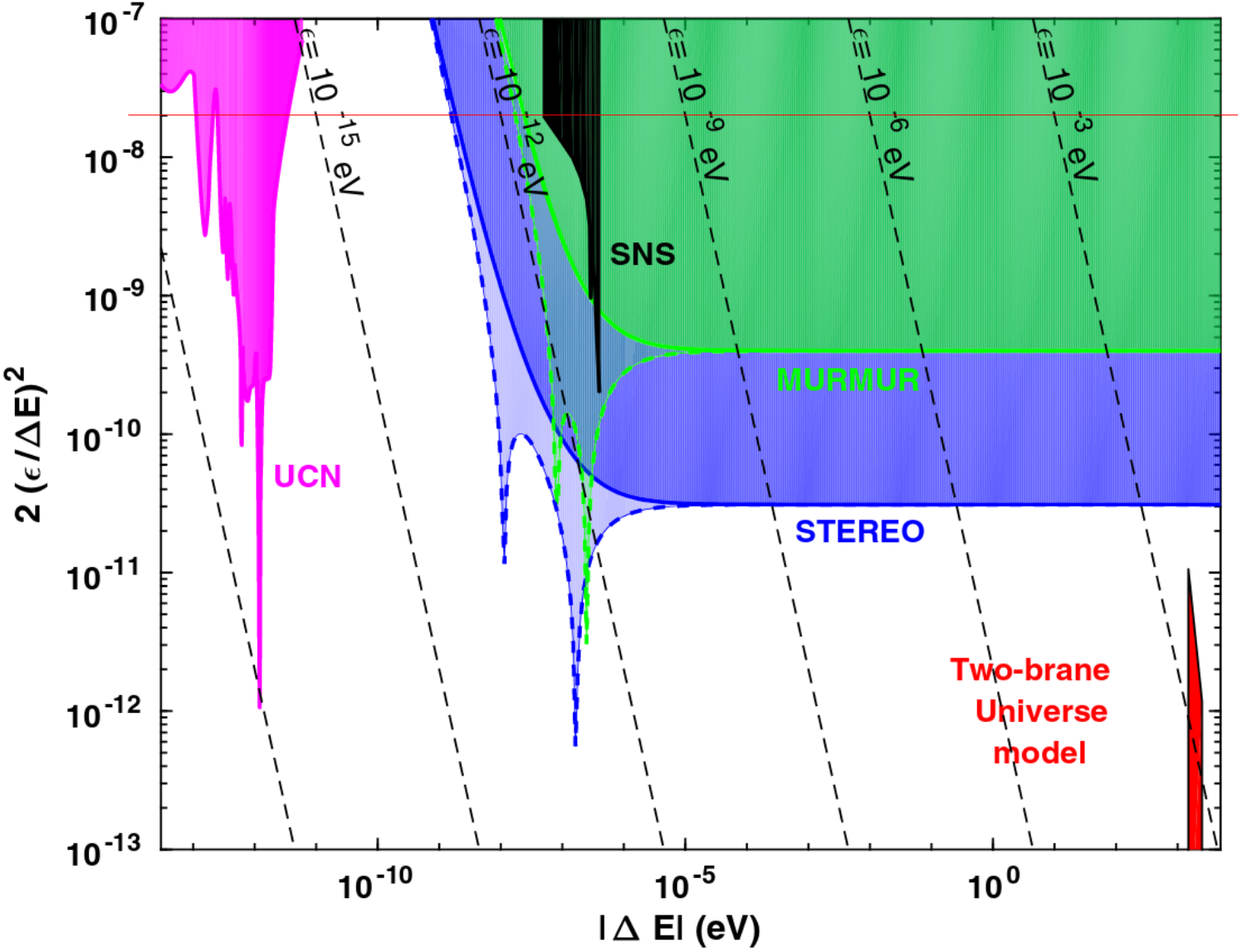




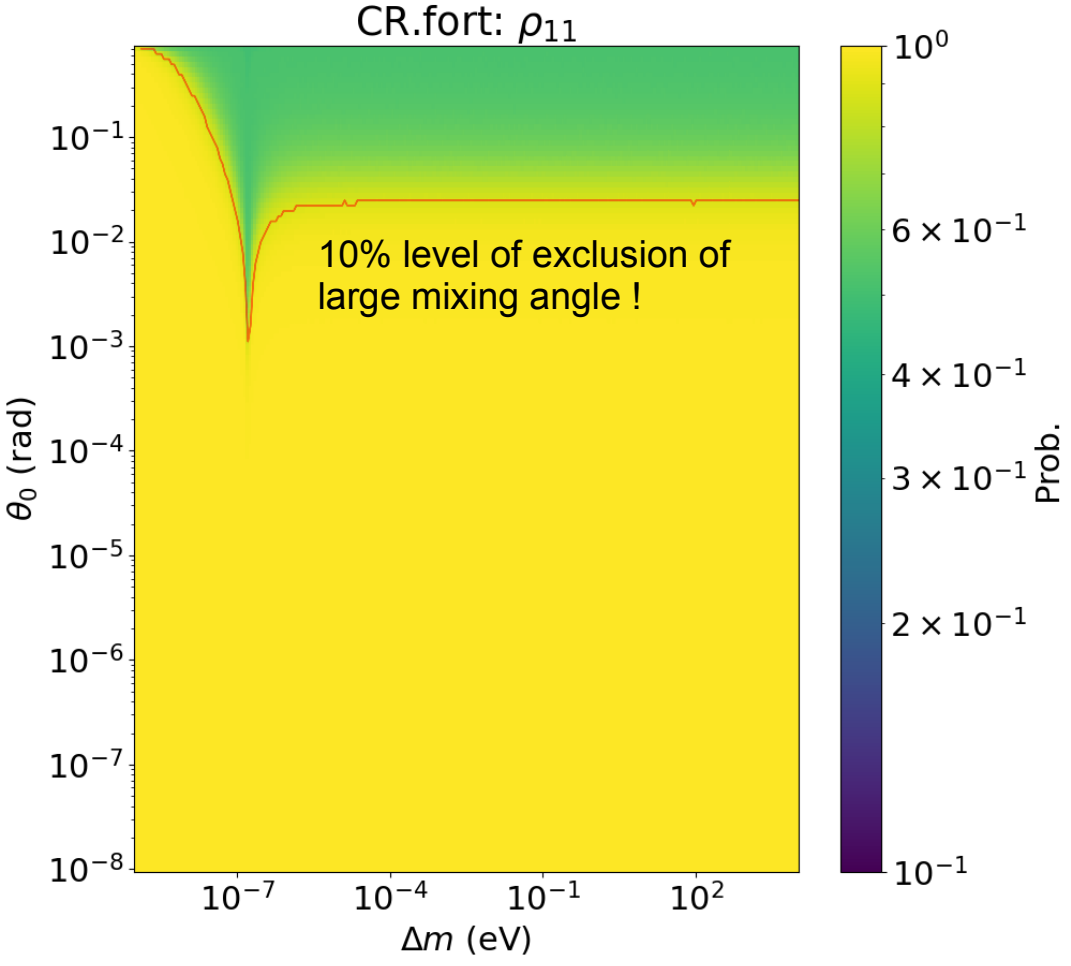
STEREO Exclusion

- Averaged over 10,000 velocities
- Ghostly region corresponds to STEREO's claimed exclusion of p = 3.1e-11
- Excluded $\theta_0 > 10^{-4}$ corresponds to $2*10^{-8}$ in STEREO plot
- Still highly dependent on material analysis being accurate




10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
$2\,(\epsilon/\Delta E)^2$
10^{-10}
10^{-5}
10^{0}
$|\Delta E|$ (eV)
$\epsilon = 10^{-15}$ eV
$\epsilon = 10^{-12}$ eV
$\epsilon = 10^{-9}$ eV
$\epsilon = 10^{-6}$ eV
$\epsilon = 10^{-3}$ eV
SNS
MURMUR
UCN
STEREO
Two-brane
Universe
model

STEREO Does Not Fully Exclude Large Angles



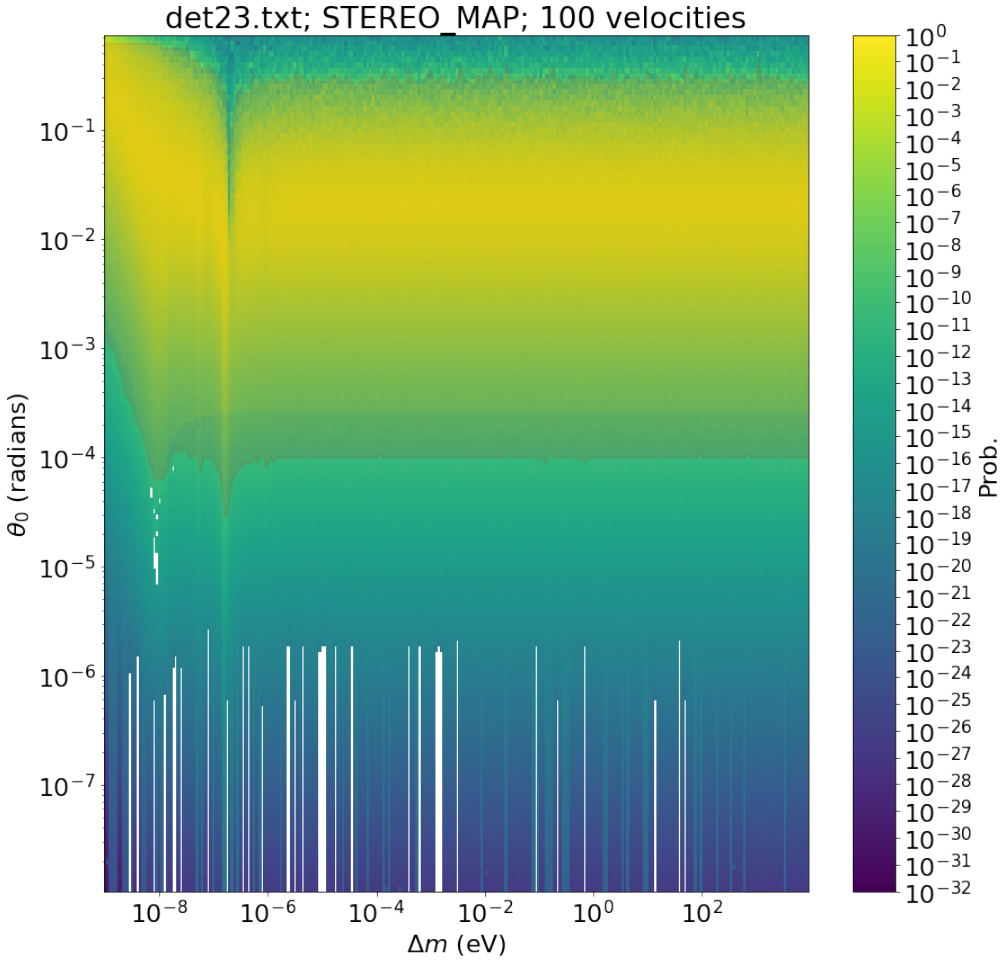
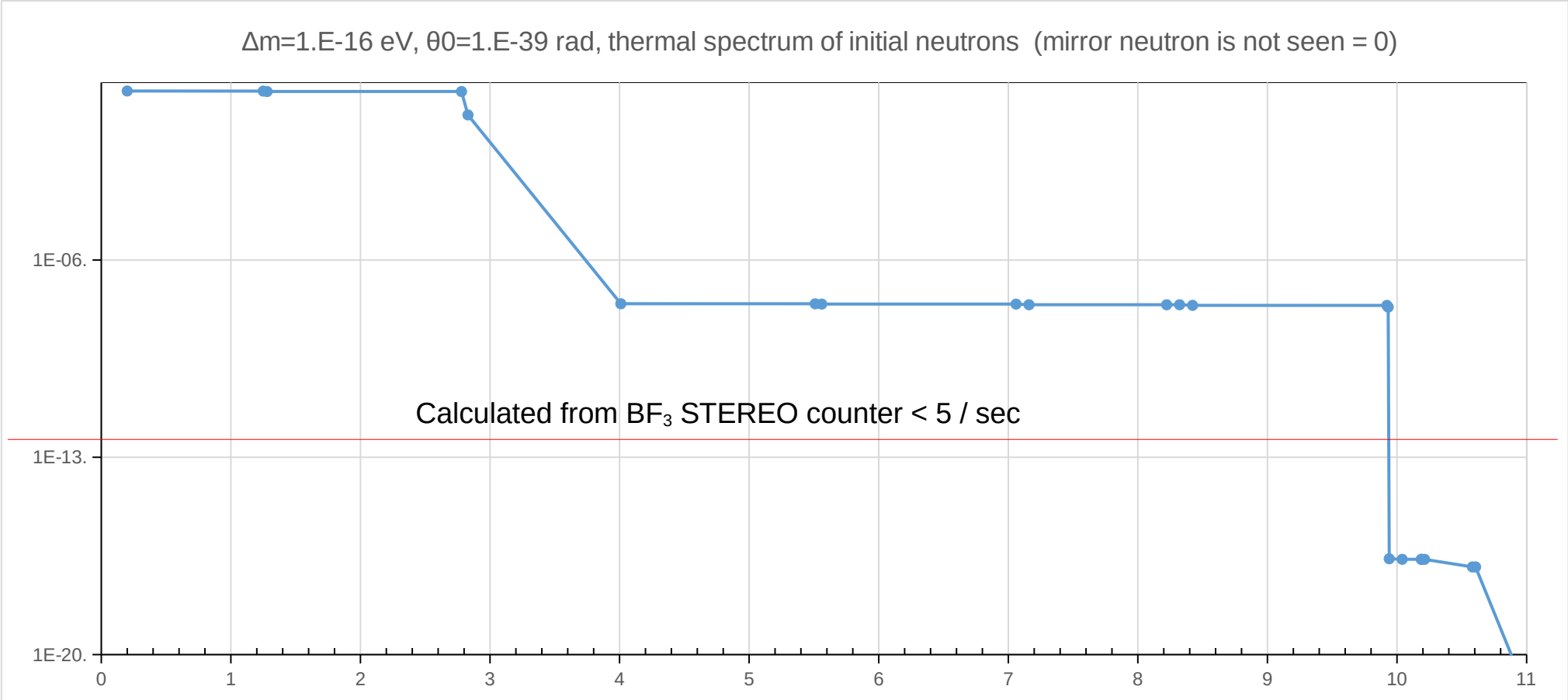


Table of Materials

#	Material	Rmax(m)	Thick(m)	Lelast(m)	Steps	V(eV)	Wabs(eV)
1	Ucore	0.2	0.2	0	0	0.00E+00	0.00E+00
2	D2O	1.25	1.05	0.022	123	1.66E-07	2.96E-15
3	Al27	1.28	0.03	0.11	1	5.41E-08	1.01E-12
4	H2O	2.78	1.5	0.0027	1403	-1.46E-08	1.61E-12
5	SS304	2.83	0.05	0.002219	59	9.14E-07	9.27E-11
6	Concrete	4.01	1.18	0.00288	1045	2.34E-07	8.93E-12
7	Air	5.51	1.5	18.76	1	1.20E-10	5.77E-15
8	Lead	5.56	0.05	0.027	4	8.07E-08	4.08E-13
9	Air	7.06	1.5	18.76	1	1.20E-10	5.77E-15
10	Lead	7.16	0.1	0.027	10	8.07E-08	4.08E-13
11	Air	8.222	1.062	18.81	1	1.20E-10	2.23E-15
12	PE	8.322	0.1	0.0022	115	-8.68E-09	1.94E-12
13	Lead	8.422	0.1	0.027	10	8.07E-08	4.08E-13
14	Air	9.922	1.5	18.81	1	1.20E-10	5.76E-15
15	Fe	9.932	0.01	0.0023	8	2.09E-07	1.57E-11
16	B4C	9.94	0.008	0.014	1	1.99E-07	6.10E-09
17	Lead	10.04	0.1	0.027	10	8.07E-08	4.08E-13
18	B5%PE	10.187	0.147	0.00187	198	-1.12E-08	1.63E-10
19	Mumetal	10.189	0.002	0.044	1	3.46E-08	4.04E-12
20	Acrylic	10.213	0.024	0.004844	13	-1.99E-08	6.02E-13
21	Scint	10.582	0.369	0.001692	557	8.42E-09	1.68E-12
22	Acrylic	10.606	0.024	0.004844	13	-1.99E-08	6.02E-13
23	GdScint	10.975	0.369	0.001682	560	8.50E-09	2.61E-11

Request for Nuclear Engineering Expertise for Review of Materials Table



Can Lawrence predict n fluxes outside the shielded reactor?

This level should give the average over 10,000 velocities as a reference to whether or not our table is accurate or not.

BF3 detector/counter was counting approx. O(640) n/(m2*s) – assuming 1.3” diameter, typical 10” long, area = 78 cm^2