STEREO: Quick Review

UT-ORNL n $\rightarrow$ n' Group Meeting
6/22/2023
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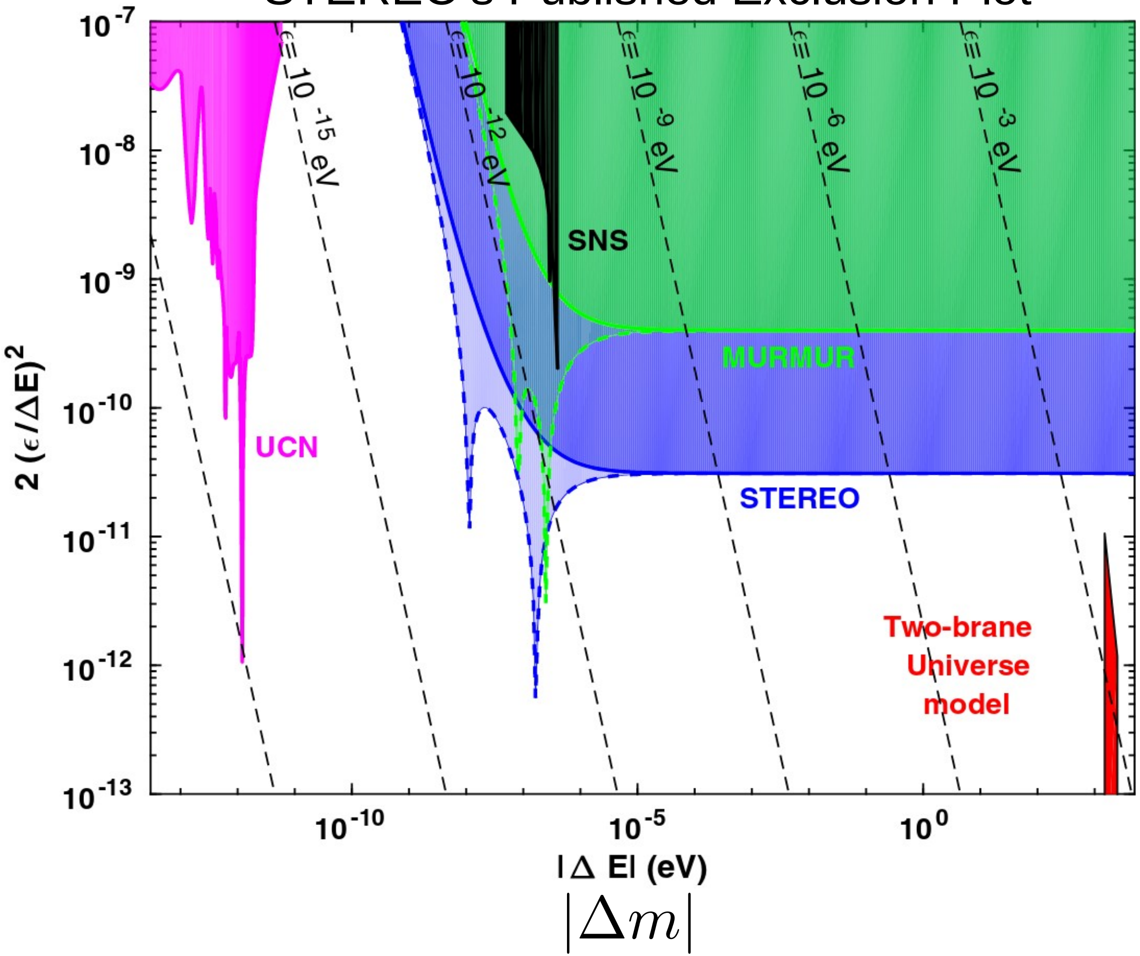
STEREO: The Experiment and Claim

- Repurposed neutrino detector at the RHF of ILL, Grenoble
- Claim limit on $n \rightarrow n'$ of $p_{nn'} \sim 3.1 \times 10^{-11}$

STEREO's Published Exclusion Plot



STEREO's Probability Calculation

STEREO's final calculation depends on:

$$\varepsilon = \Delta m \theta_0 \qquad \Gamma = v\Sigma_{sc}$$

1. computing the prob. per neutron, *p*,

$$p = \frac{2\varepsilon^2}{(\pm\Delta m + V_F)^2 + 4\varepsilon^2 + \hbar^2\Gamma^2/4}$$

2. multiplying by the visible flux, $\Phi_{vis}(\vec{r})$, to give the volumic rate of projections, $S_{hid}(\vec{r})$,

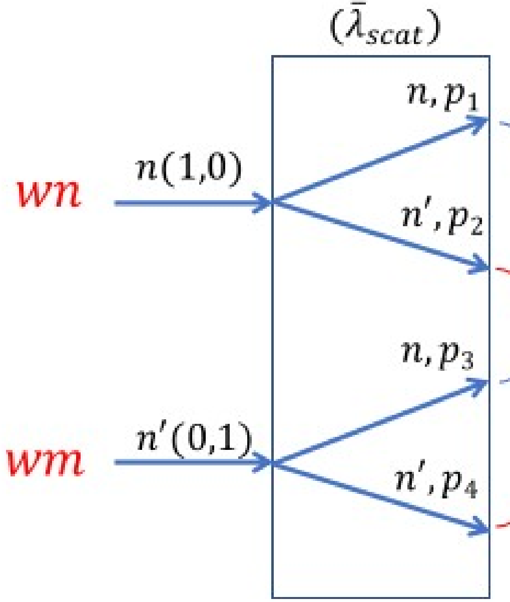
$$S_{hid} = p\frac{\Sigma_S}{2}\Phi_{vis}(\vec{r})$$

3. and then integrating over the reactor volume to get $\Phi_{hid}(\vec{r})$.

$$\Phi_{hid}(\vec{r}_d) = \frac{1}{4\pi}\int_{Reactor}\frac{S_{hid}(\vec{r})}{|\vec{r}-\vec{r}_d|^2}d^3r$$

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. $\begin{pmatrix}n(t)\\n'(t)\end{pmatrix}$.



One layer of material or detector

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

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

wn: prob. of entering as n

wm: prob. of entering as n'

p_1: contribution of n to exit as n
p_2: contribution of n to exit as n'
p_3: contribution of n' to exit as n
p_4: contribution of n' to exit as n'

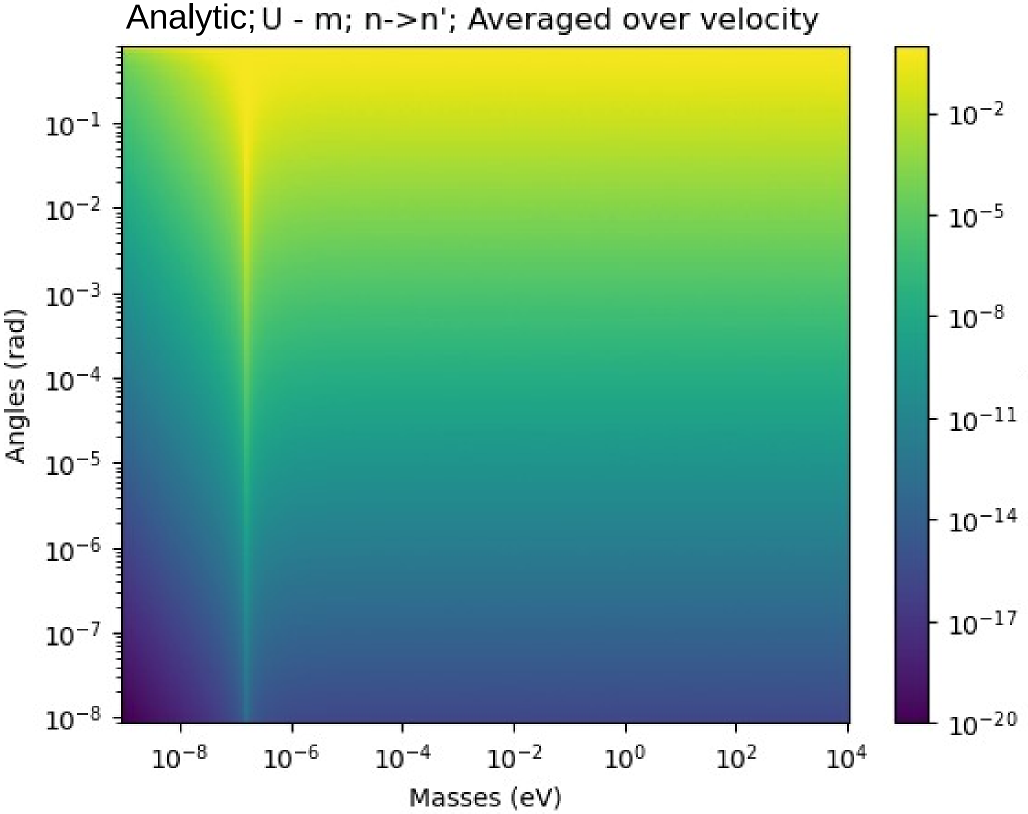
Number of absorbed or "detected" in the layer:

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

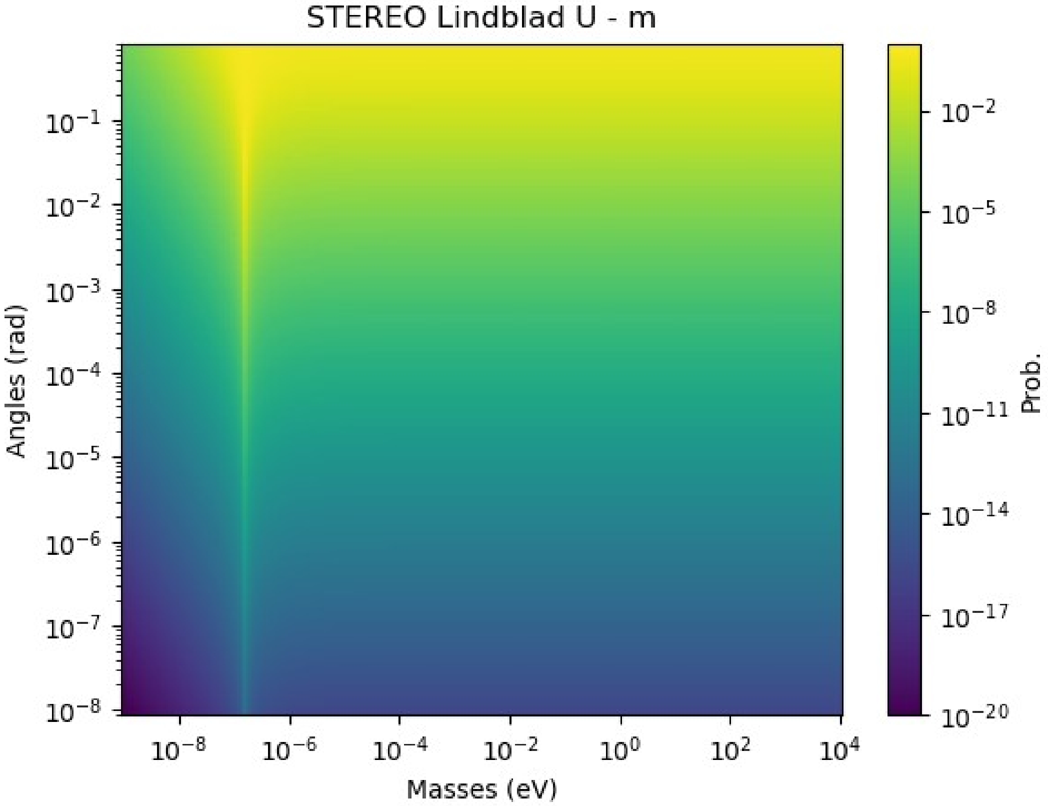
If there is no "mirror absorber"

Comparison in D_2O

Analytic;

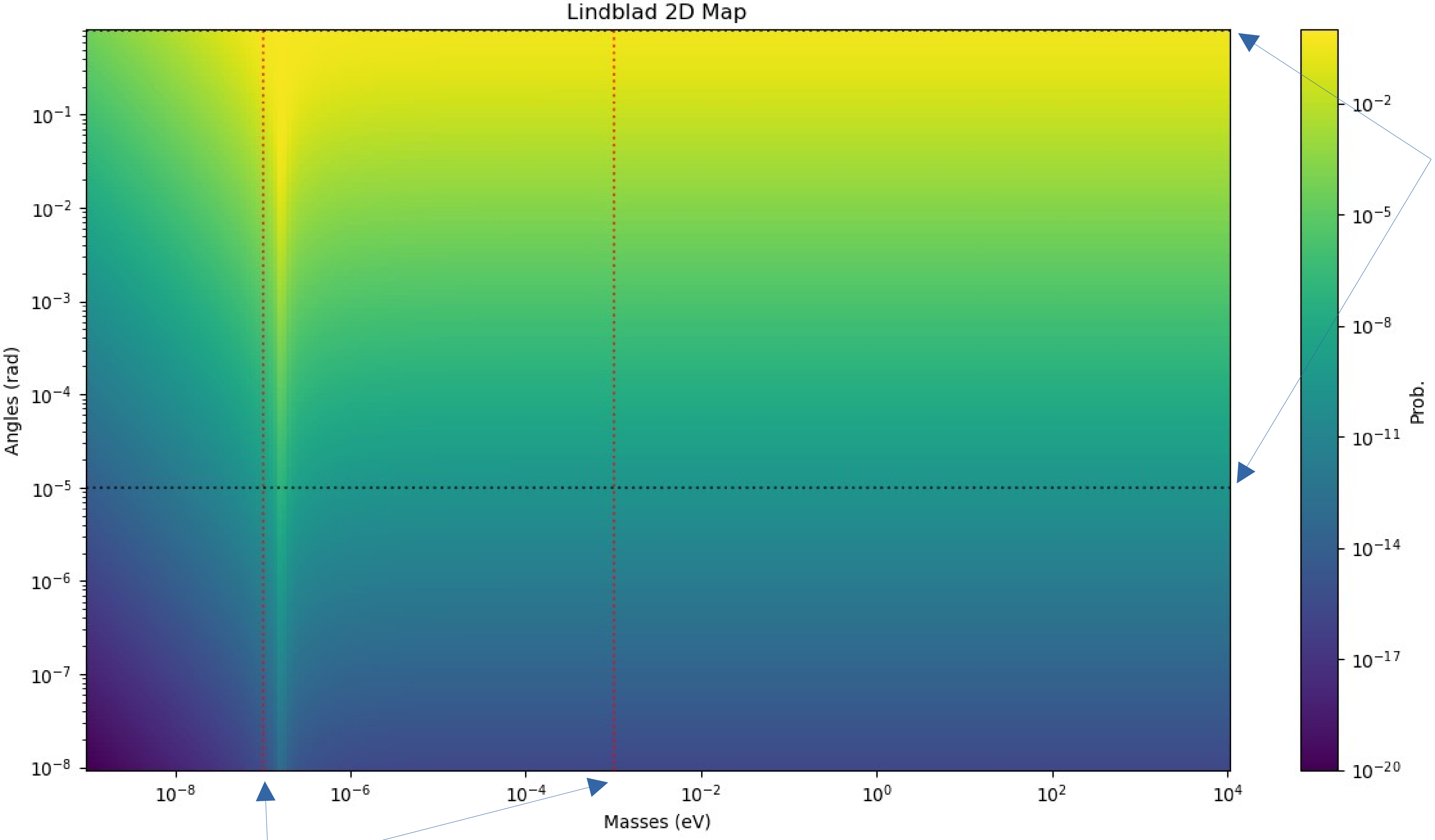


Averaged over 1000 velocities



Any difference between these two is not very obvious at this level

Slices for Better Comparison

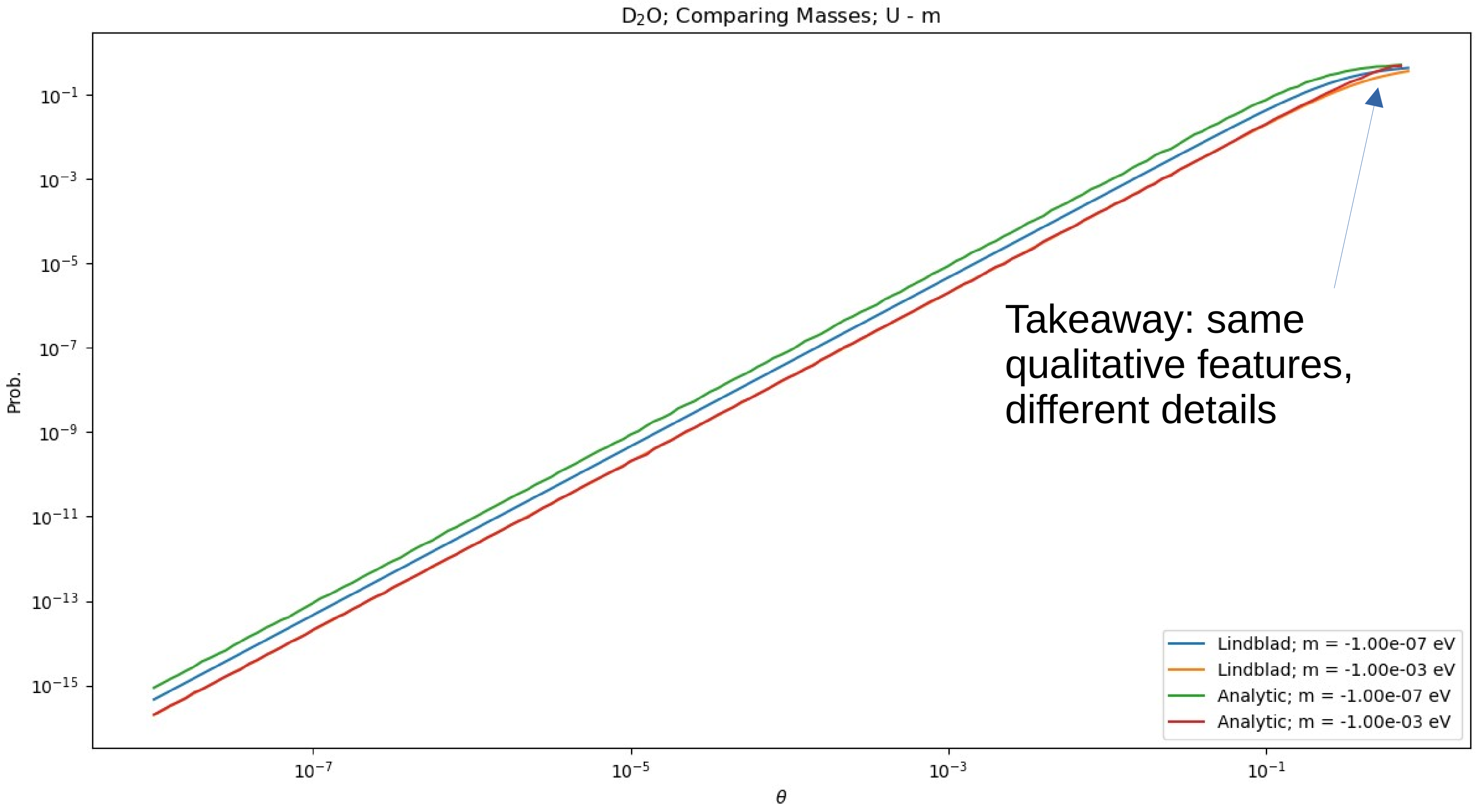


tan(45 deg) and 10^{-5} compared

Varying "gamma" term in STEREO's "p" was also investigated.

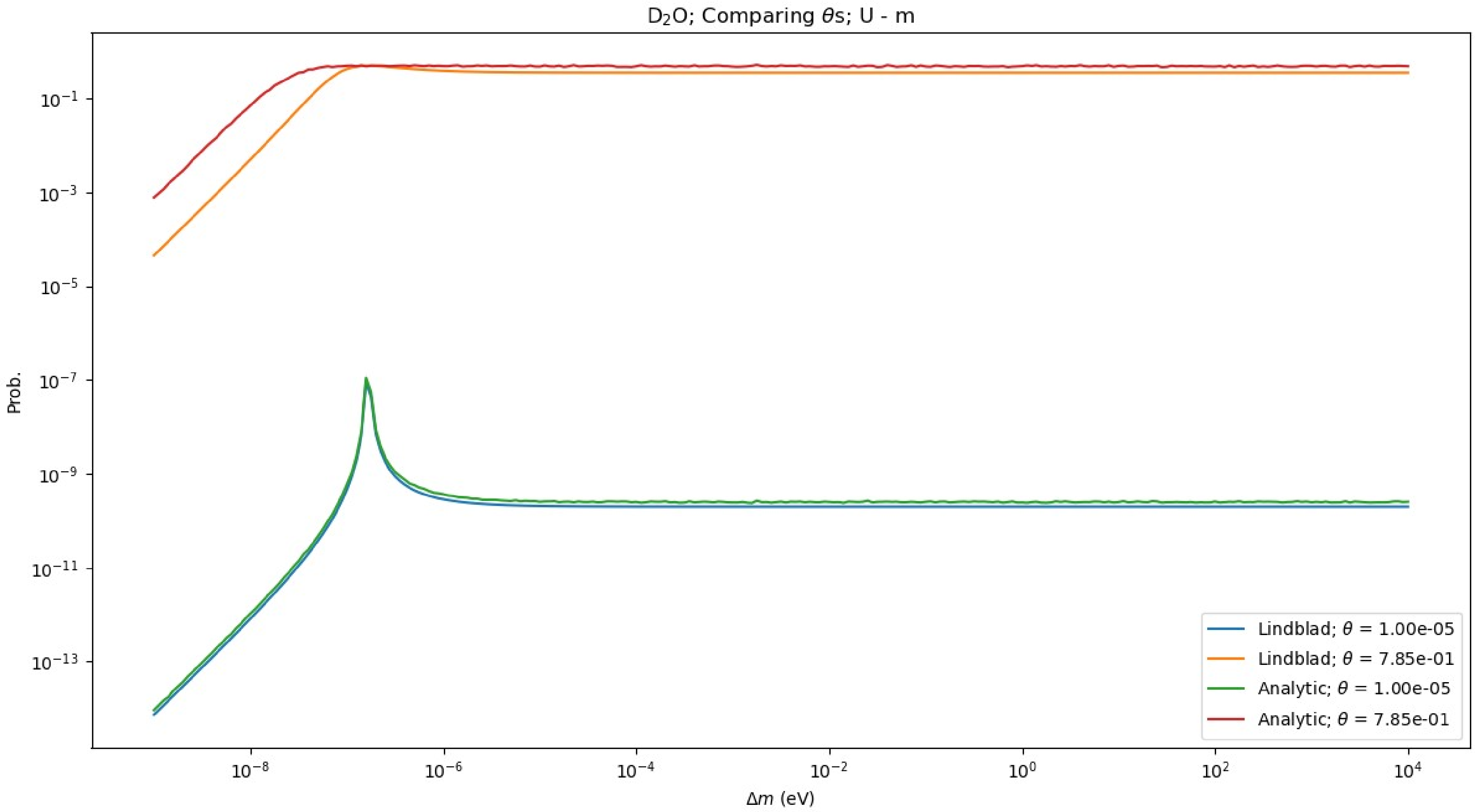
10^{-7}, 10^{-3} eV compared

Comparing masses

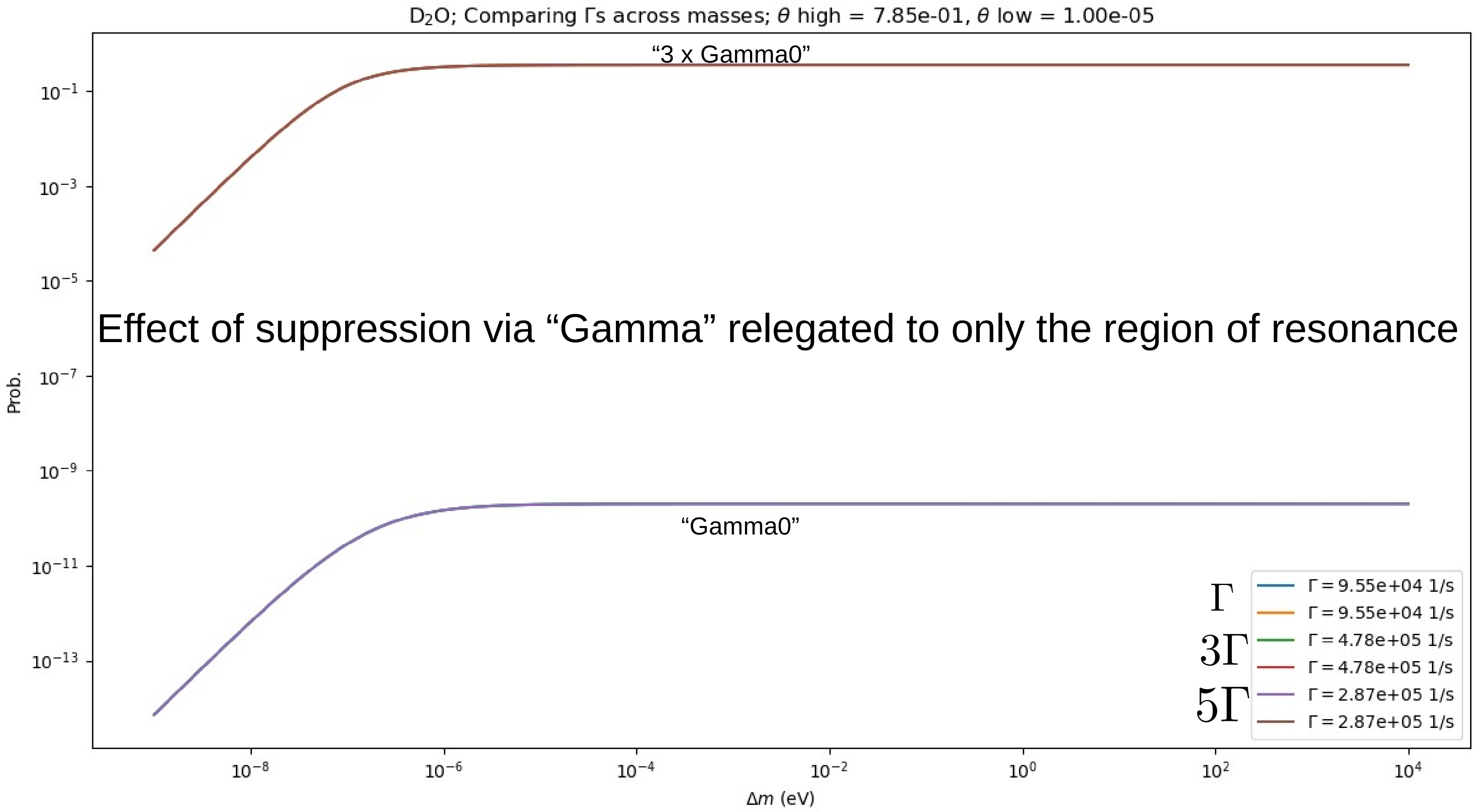


Takeaway: same qualitative features, different details

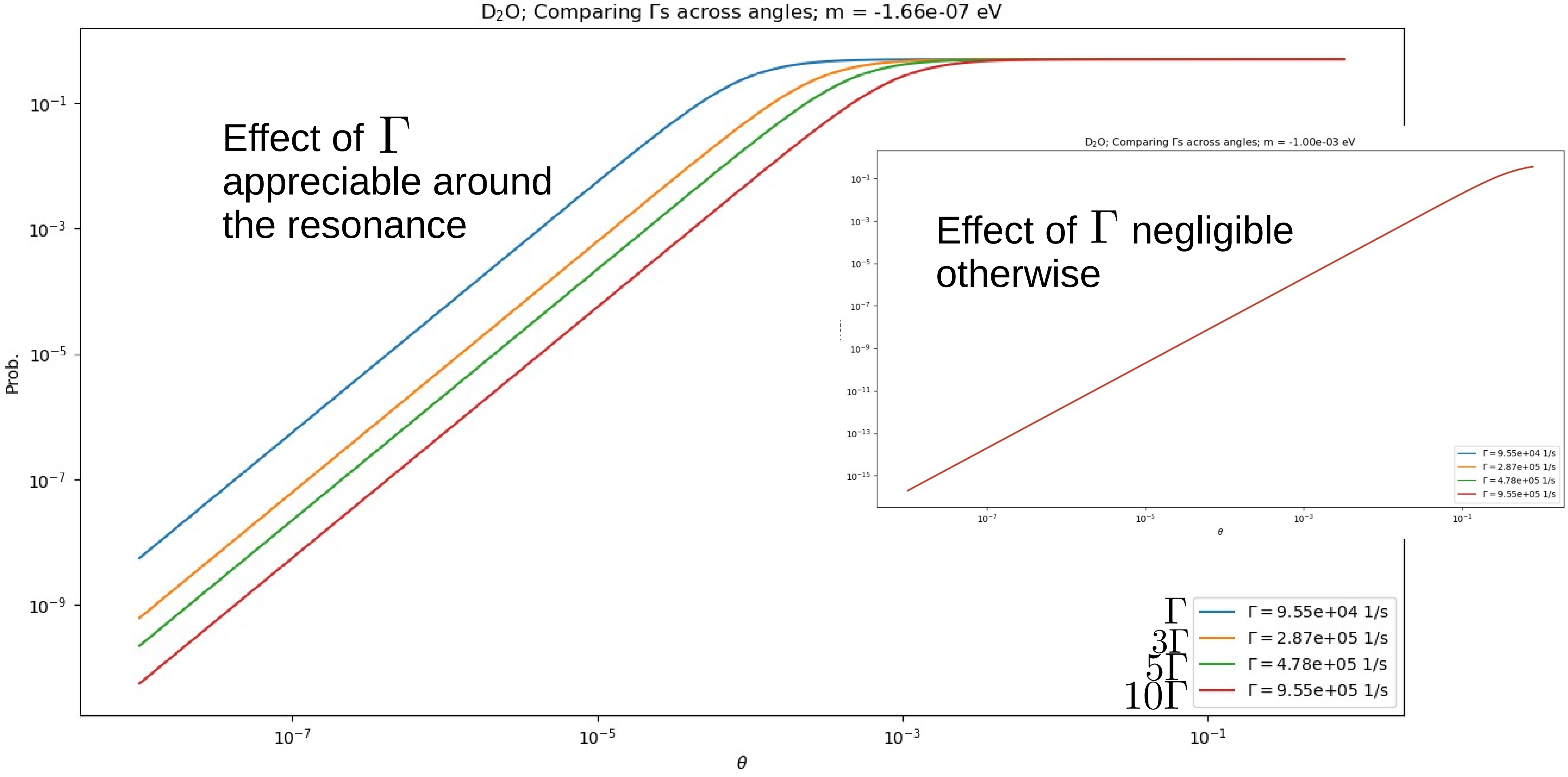
Comparing angles



Γ across masses



Γ across angles

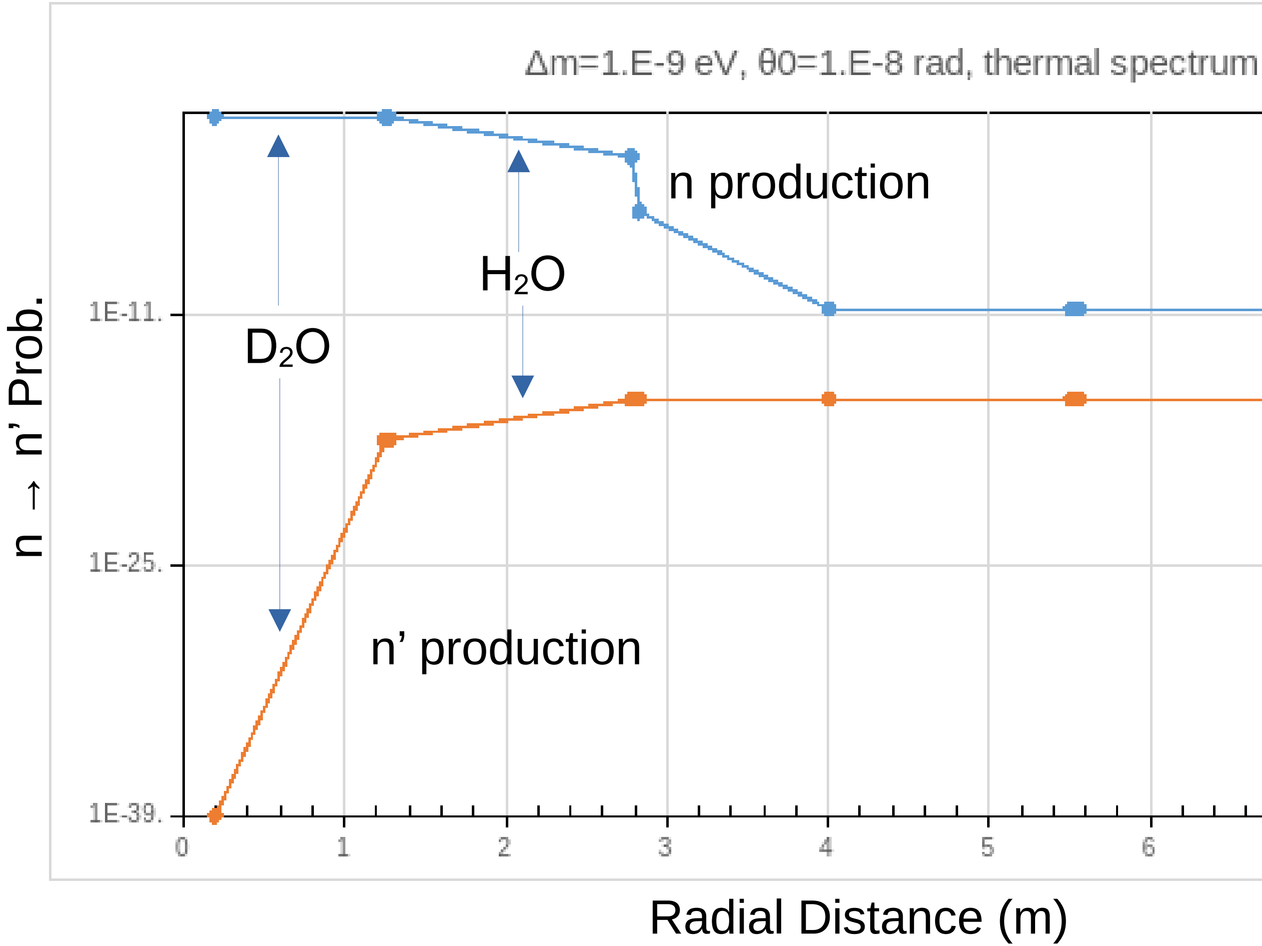


Effect of Γ appreciable around the resonance

Effect of Γ negligible otherwise

Next Step: Computing $\Phi_h(\vec{r}_d)$ and comparing total numbers

- Code is currently being debugged for calculating values of n and n' flux as well as total n and n' from D_2O
- H_2O will also be computed
  - STEREO neglects effects of H_2O, our prior investigations suggest H_2O's contribution is non-negligible.



End

Flux Numbers - PRELIMINARY

```
 === STEREO HEAVY WATER ===
 m =    1.0000000000000001E-009
 a =    1.0000000000000000E-008
 p =    7.3461885378738747E-021

 Check that the results of the `compute_integral`
 function are reasonable.

Phi_h(Rd)              =      7.2031E+08
Total 4pi emit of mn   =      9.6029E+15
Probability per init n =      3.6934E-03
rate of mirror neutrons=      4.6547E-07

 === ANALYTIC HEAVY WATER ===
 m =    1.0000000000000001E-009
 a =    1.0000000000000000E-008
 p =    7.4193829999999996E-021

 Check that the results of the `compute_integral`
 function are reasonable.

Phi_h(Rd)              =      7.8480E+08
Total 4pi emit of mn   =      1.0463E+16
Probability per init n =      4.0241E-03
rate of mirror neutrons=      5.1220E-07
```