nTMM Probability Calculations: V-Spectrum

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DATE: 10/06/22

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Calculation Basics

- $\varepsilon = 10^{-17}$
- $\kappa = \ 10^{-5}$
- $\delta = 3 * 10^{-11}$ (Fermi potential of air)
- ω is the angular frequency associated with the energy of the magnetic field
- Distance: 1.5 meters
- $P^{\uparrow}(t)$ is the probability of oscillation for a neutron that is spin up.
- Everything inside $\sin[]^2$must be divided by $\hbar$ to be in radians.

$$P^{\uparrow}(t) = \frac{(\varepsilon - 2\kappa\omega)^2}{(\delta - \omega)^2 + (\varepsilon - 2\kappa\omega)^2} \sin[\sqrt{(\delta - \omega)^2 + (\varepsilon - 2\kappa\omega)^2} t]^2$$

Previously

Velocity (fixed): $1000\ \frac{m}{s}$

Distance: 1.5 m

ω: $10^{-11} \leftrightarrow 5 * 10^{-11}$ eV

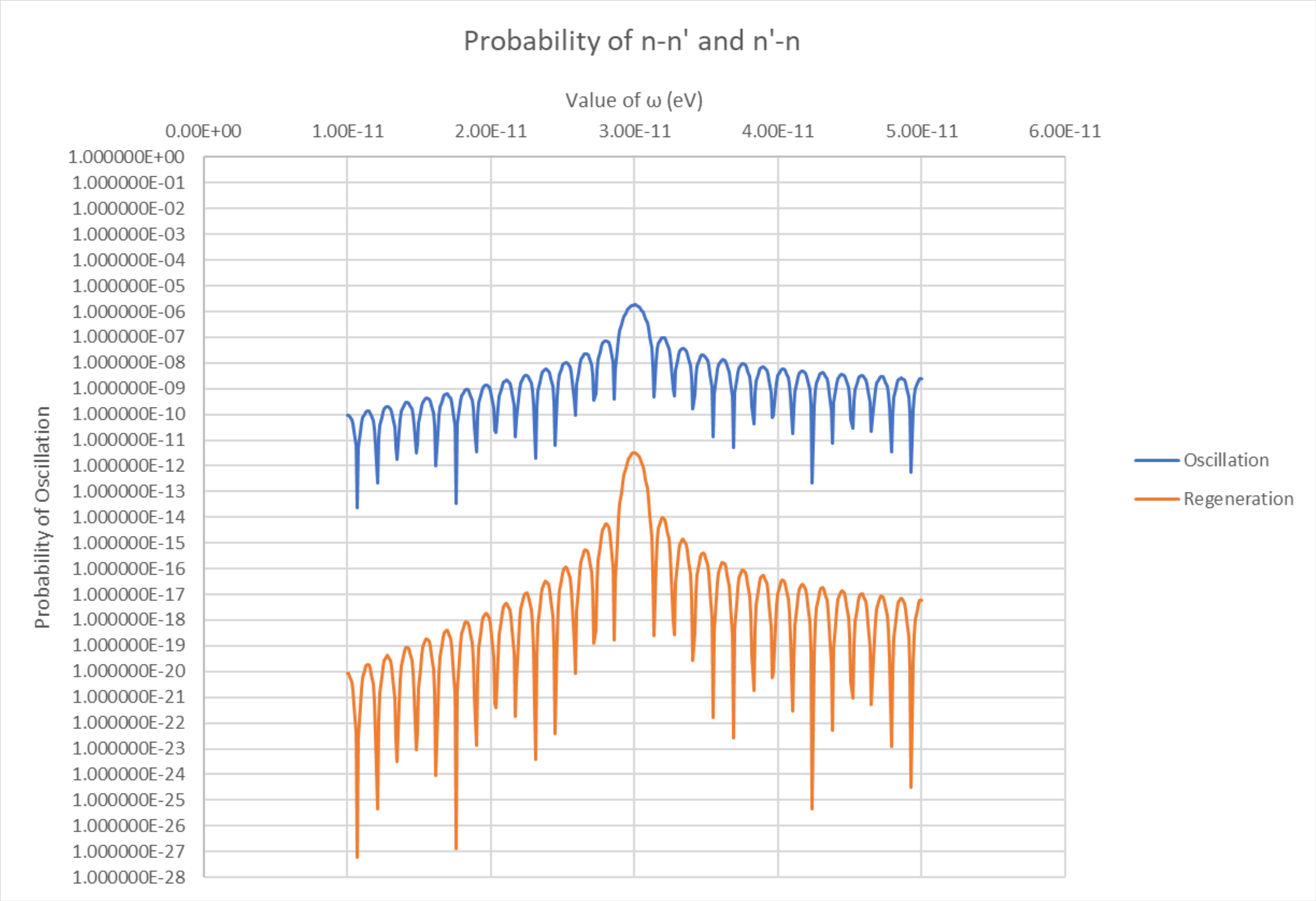
Blue: $n \rightarrow n'$

Orange: $n' \rightarrow n$

In order to see the effect, regeneration must occur.

Highest probability is in resonance when ω = $3 * 10^{-11}$ eV

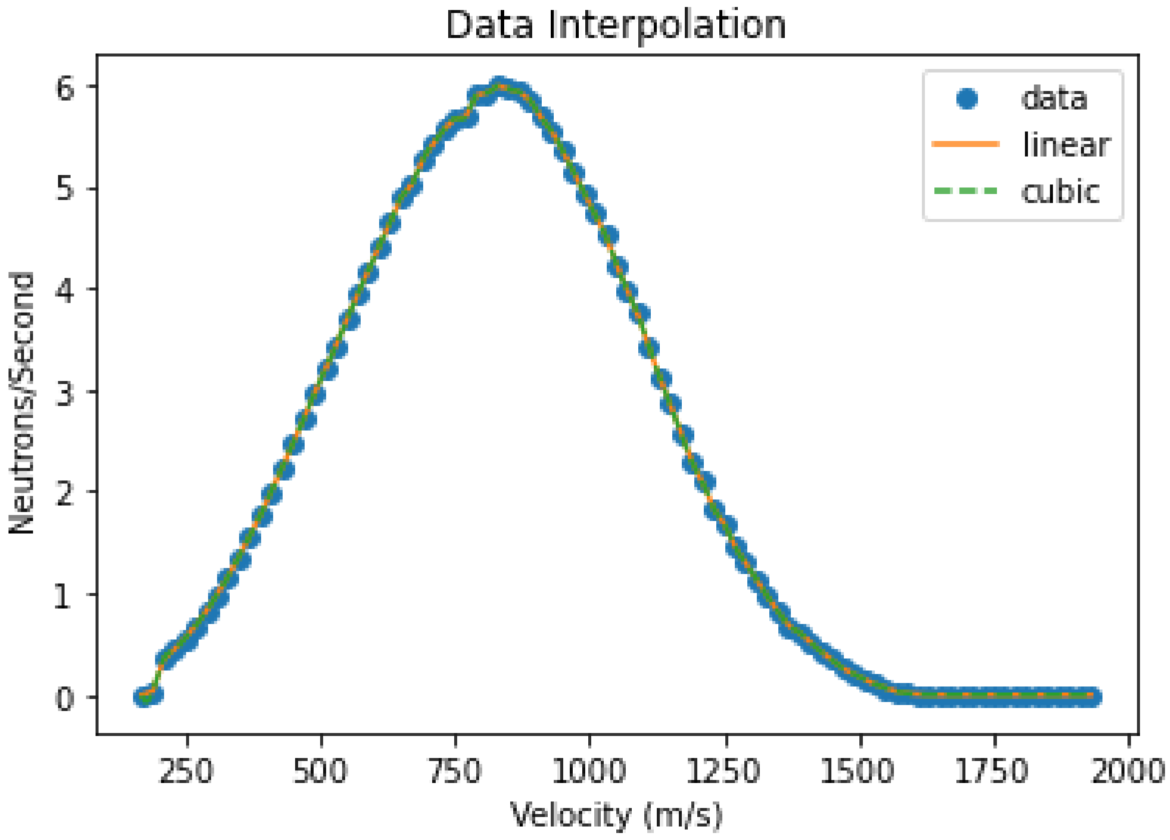
Done in Excel



Interpolation and Monte Carlo

Used data given by Dr. Kamyshkov in an interpolation function in python. Cubic interpolation was used.

From this interpolation a function was created which would be used for velocity calculation.

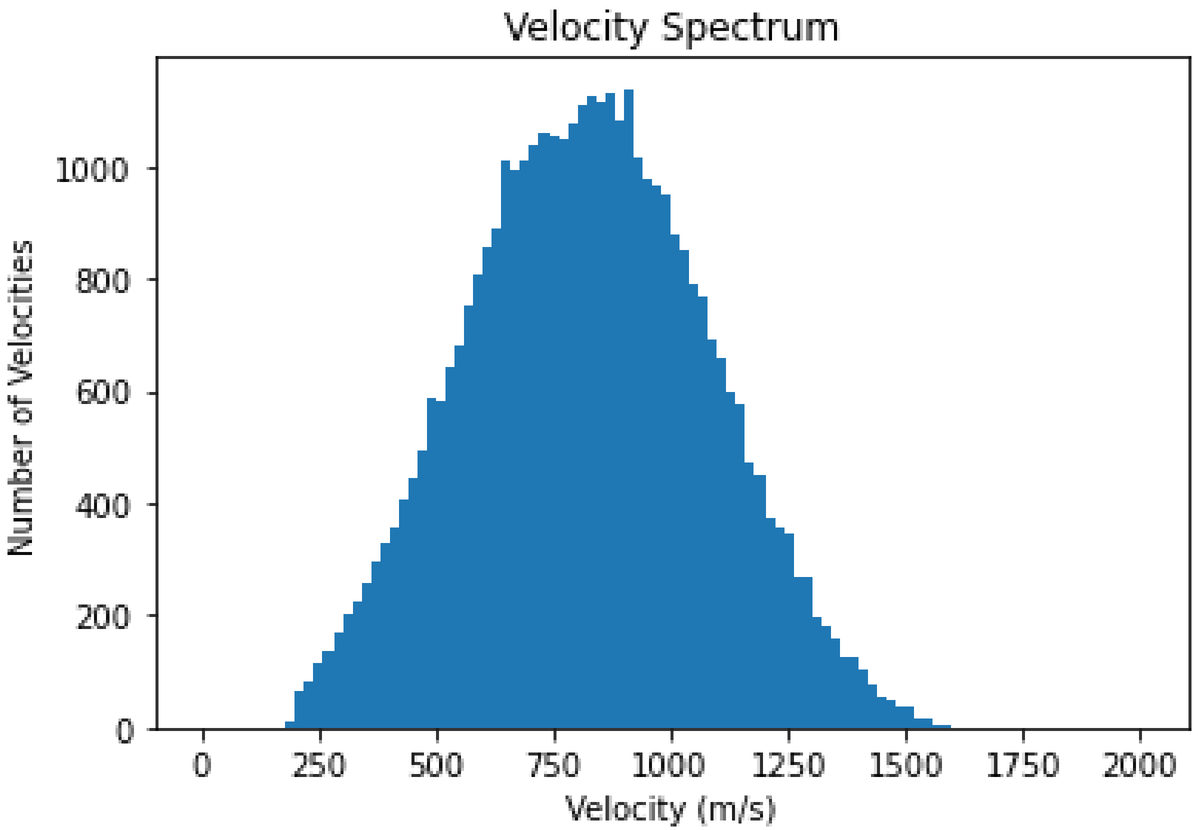


V-Spectrum

Here there are approximately 100,000 random velocities. These velocities were generated from the interpolated data using a Von-Neumann random number generation method.

This spectrum of velocities will be used in calculating the probability of n-n' oscillation. Higher velocity means lower time of flight, while a lower velocity means lower time of flight.

The number of generated velocities can be changed to any value, but higher values lead to more accurate (and broad) measurements.

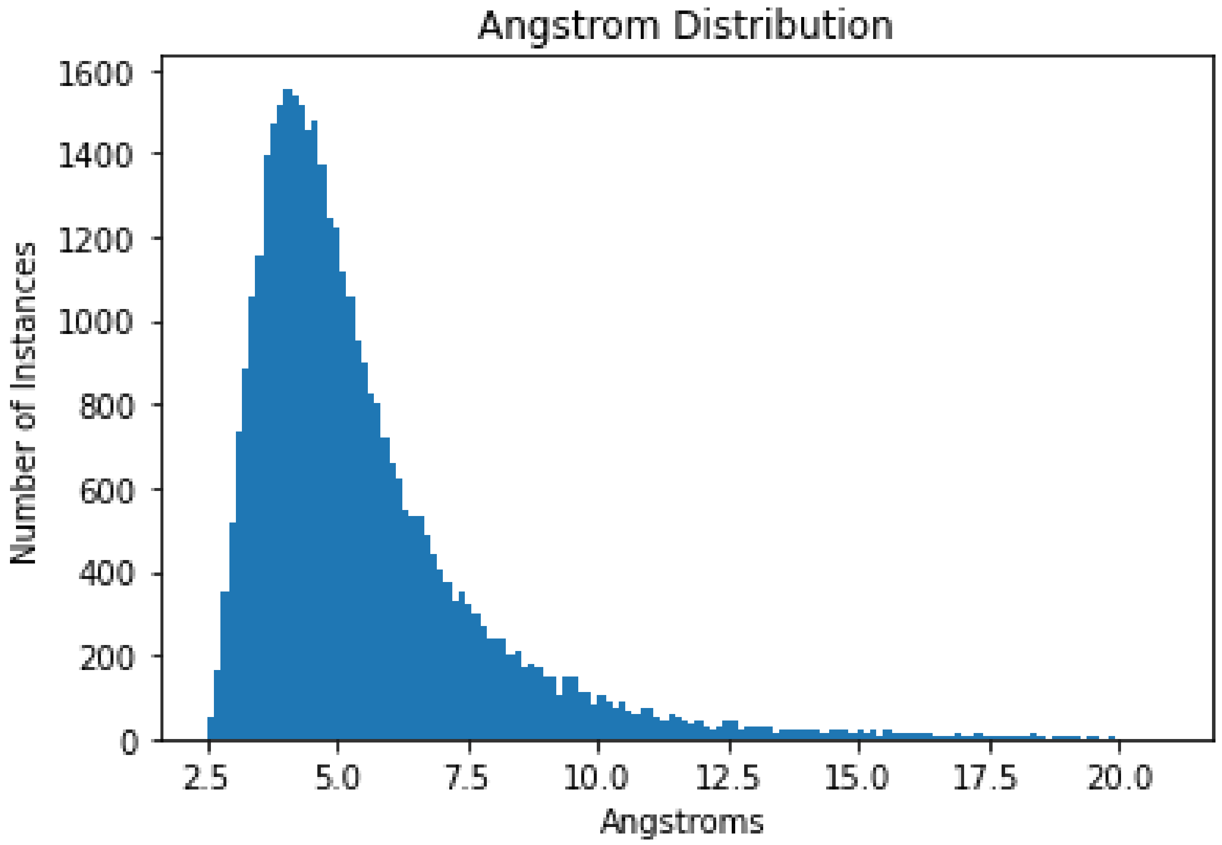


Å-Distribution

Using the function $\lambda(\text{Å}) = \frac{4000}{v}$ for every random velocity, we get this plot

$1\text{Å} = 10^{-10}\ m$

From this, we see that with higher velocities there is a large contraction in length compared to slower velocities

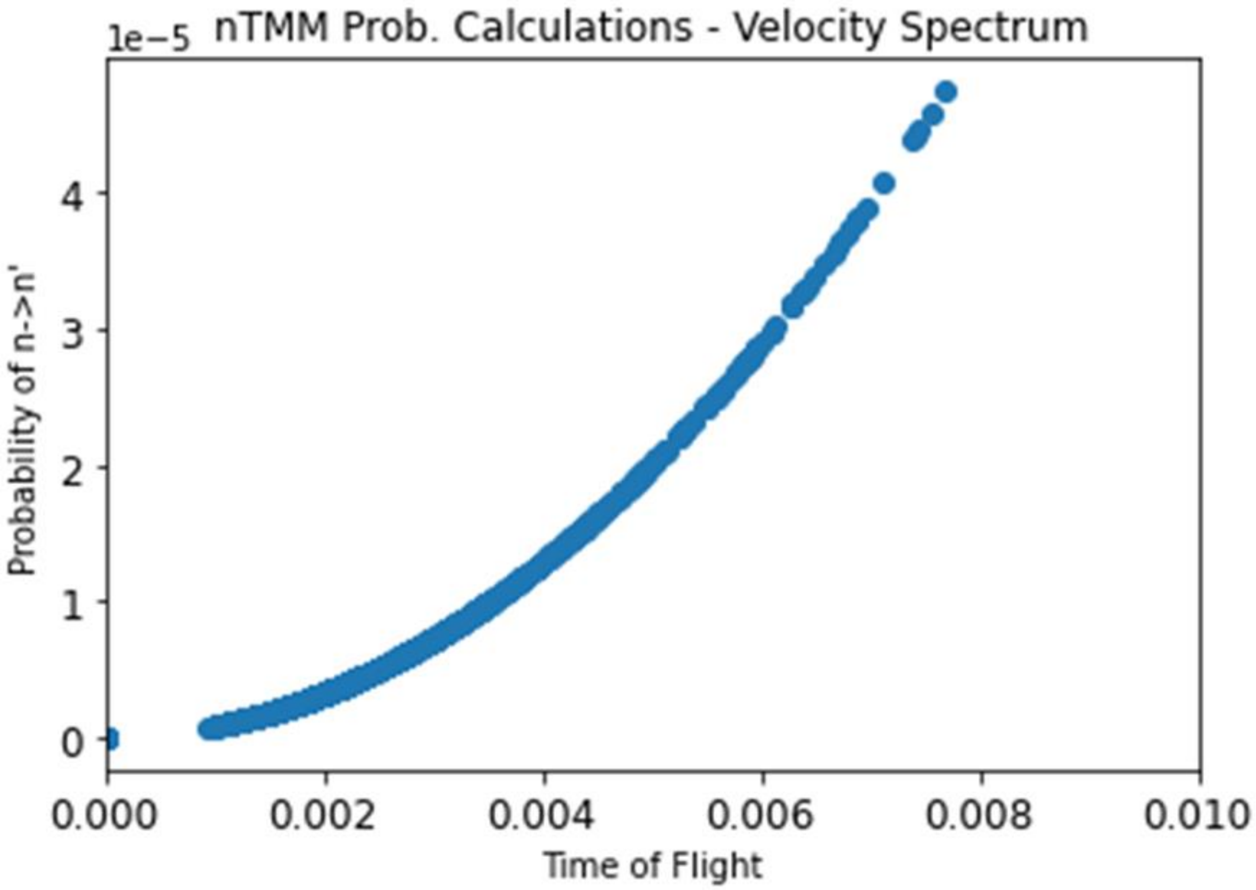


Calculation Basics

- ω is variable and calculated from μB
- B ranges from 9 to 11 G (magnetic field)
- $\mu = 6 * 10^{-12}\ \frac{eV}{G}$ (magnetic moment of neutron)
- $\omega = \frac{\mu B}{2}$
- $\omega_{Resonance} = \frac{(6*10^{-12})*10}{2} = 3 * 10^{-11}$

Resonance Across V-Spectrum (1)

- Velocity Min: 170 $\frac{m}{s}$
- Velocity Max: 1930 $\frac{m}{s}$
- ~10,000 random velocities from this range were used for calculation
- Time of flight is in seconds (s)
- Distance: 1.5 m
- ω: $3 * 10^{-11}$ eV
- Longer time of flight means higher probability of oscillation; colder neutrons with lower velocities are better (but rare)
- Fast neutrons hit the detector before having the chance to oscillate
- Done in python (graphing was most difficult part)



Resonance Across V-Spectrum (2)

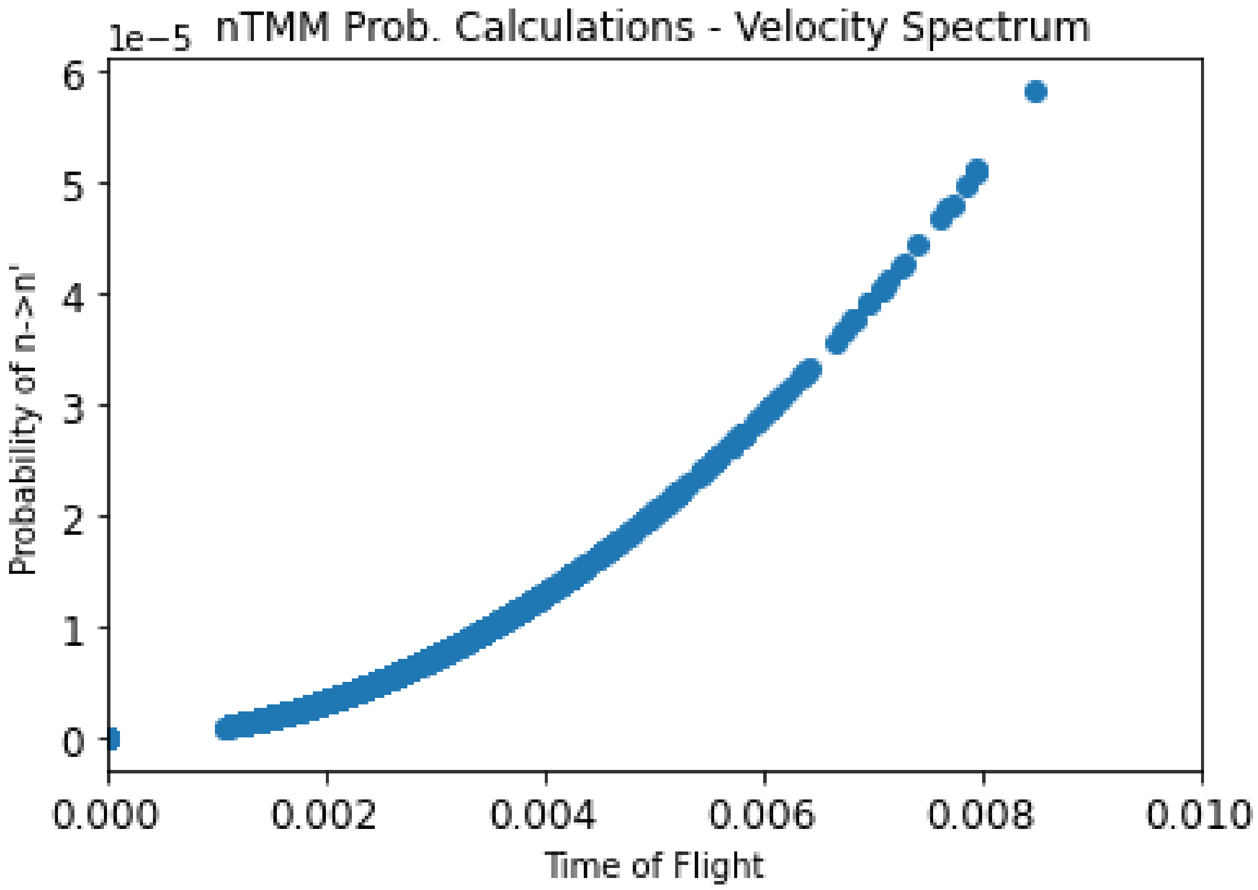
Velocity Min: 170 $\frac{m}{s}$

Velocity Max: 1930 $\frac{m}{s}$

Distance: 1.7 m

ω: $3 * 10^{-11}$ eV

Longer distance means overall more flight time—this results in higher probabilities



Other Values Across V-Spectrum

~10,000 random velocities

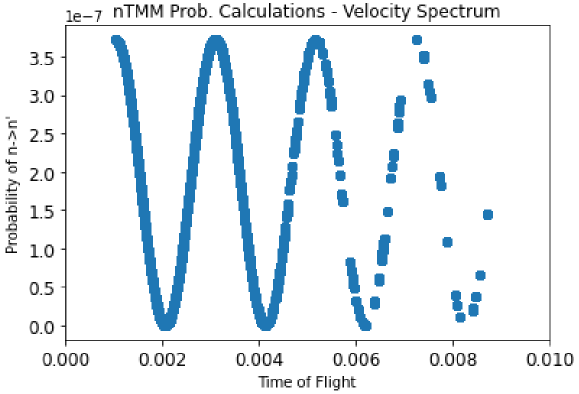
ω: $3.1 * 10^{-11}$ eV (top)

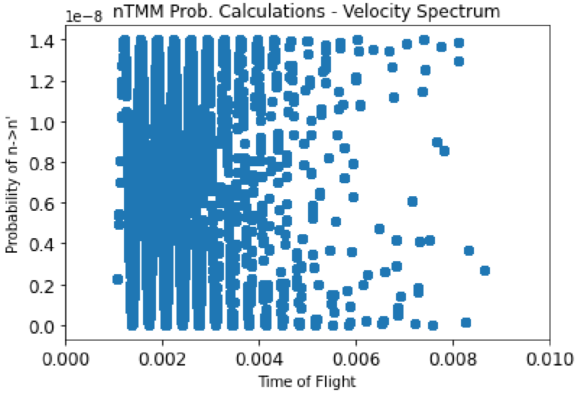
ω: $3.6 * 10^{-11}$ eV (middle)

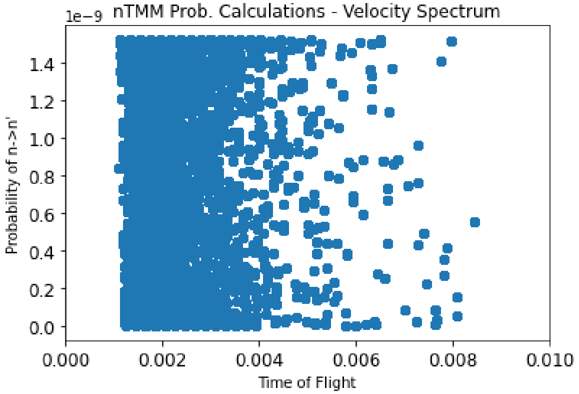
ω: $2 * 10^{-11}$ eV (bottom)

Significantly lower probability compared to resonance

Similar sinusoidal pattern for all values of ω within the calculated range, with “frequency” increasing with values further from resonance







Future

- Calculate the total probability of seeing the effect with regeneration included
- Take other factors into account such as the optimal gas for least scattering and best Fermi potential
- Take into account magnetic field in all directions