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Decreasing the measurement time of the neutron electric dipole moment experiment at TRIUMF

Overview

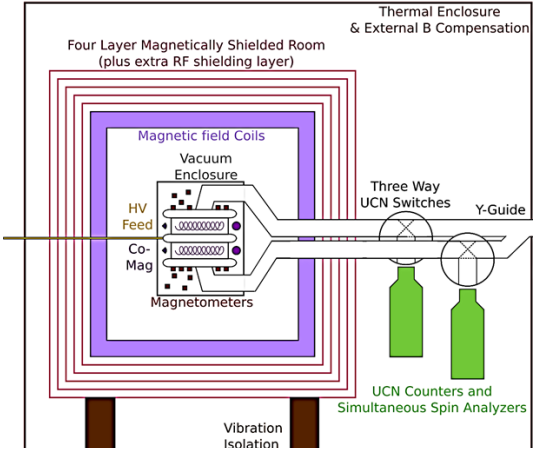
In this talk I will briefly explain

- The figure of merit used to analyze simulations and how it was improved
- How varying operational timing affects the energy distribution of UCN
- How the timings are optimized to increase sensitivity

Sensitivity formula

For Ramsey's method, the statistical sensitivity is given by:

$$\sigma(d_n) \approx \frac{\hbar}{2\alpha T_{\mathrm{Ramsey}} E \sqrt{N_{\mathrm{det}}}}$$



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- where α is the polarization of surviving neutrons, T_{Ramsey} is the free precession time, E is the strength of electric field, and N_{det} is the number of UCN detected
- To improve the precision of the experiment is we must either:
  increase the number of neutrons detected,
  increase their polarization (α),
  increase their storage lifetime in the EDM cells,
  or increase the strength of the electric field.

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- This will help us remain competitive with other experiments around the world
- Systematic studies will add additional days/years to obtain a final result

Days-to-reach metric

The sensitivity formula was adopted to analyze simulations by minimizing the total measurement time for the experiment: the figure of merit used was the days-to-reach metric. The steps to calculate are:

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The days-to-reach was optimized using a differential evolution algorithm (stochastic optimization)

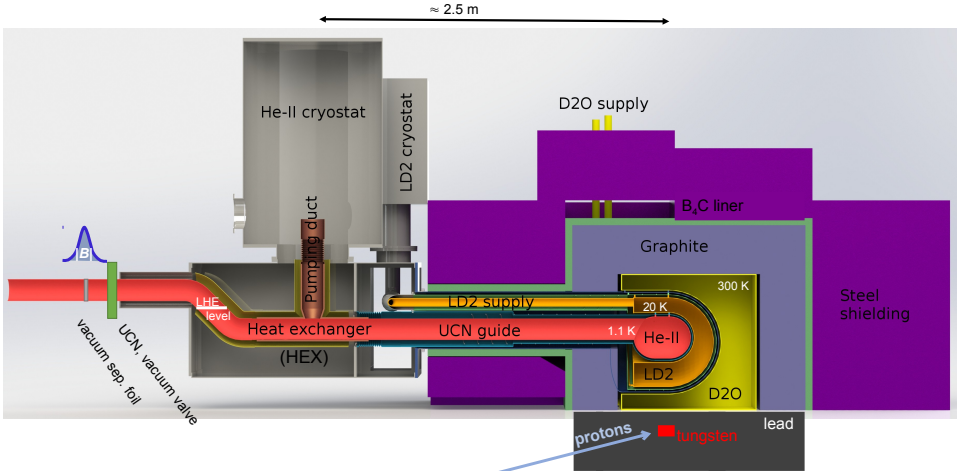
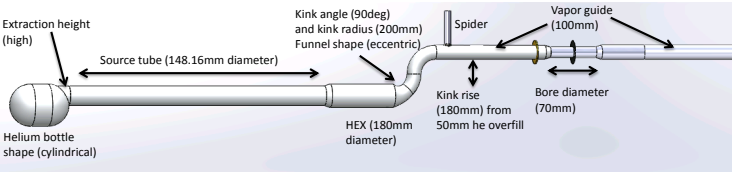
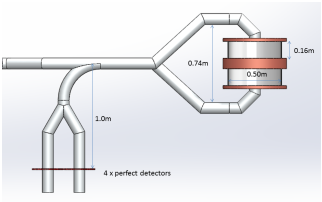


Figure: New TUCAN source concept

Simulation model





- Models were made with Solidworks and simulated using PENTrack.
- A new model was created for each geometry change, simulated and analyzed.

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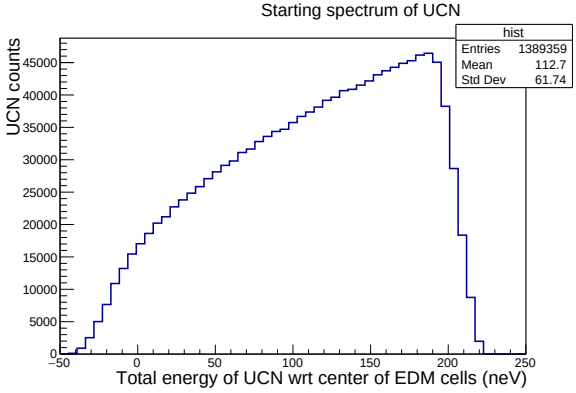
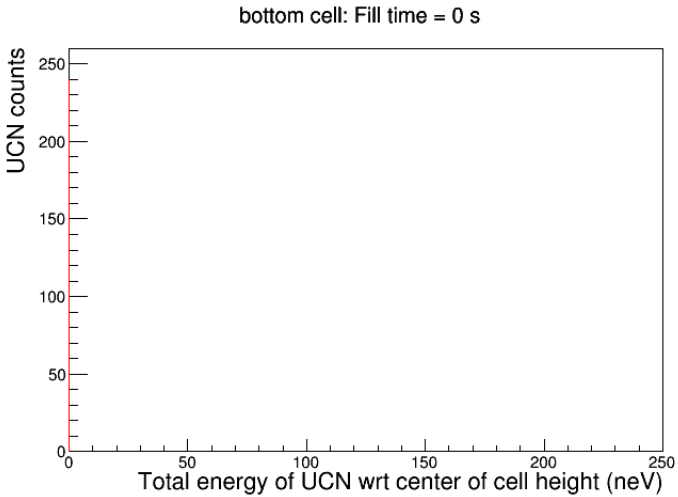
- Main result: the energy spectrum of UCN of the entire experiment and operational timings must be optimized as a whole
- t_{fill} and t_{empty} almost doubled from before, t_{Ramsey} also got longer, this is because of the storage lifetime of UCN

Energy spectrum



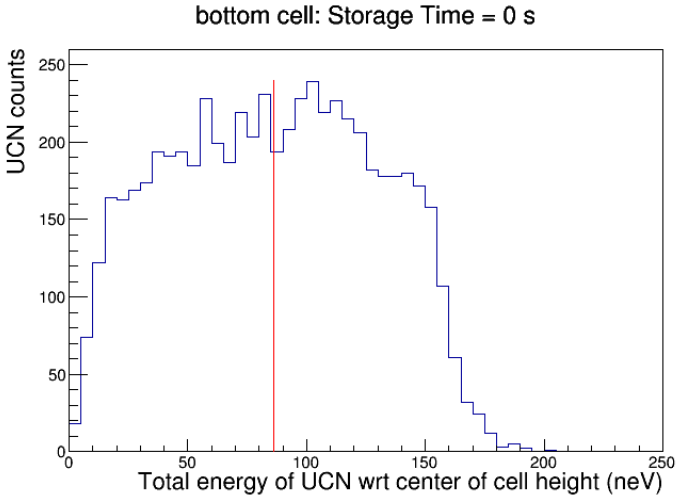
- Starting simulated-spectrum of UCN in production volume
- Assumed to be a $\sqrt{E}$ spectrum.

Filling of bottom EDM cell



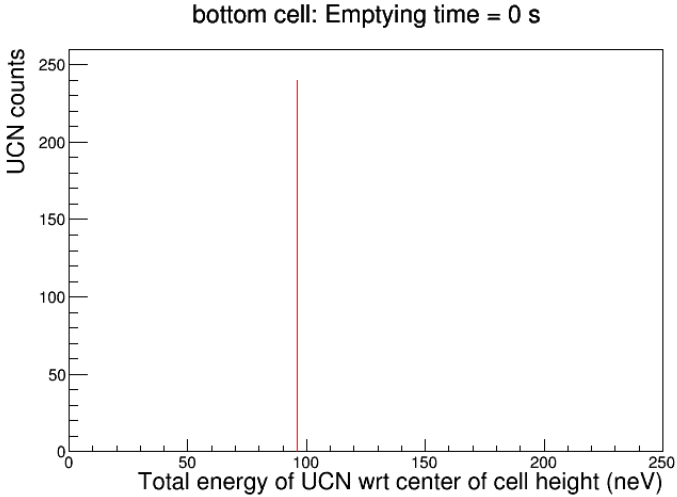
Energy spectrum of UCN that fill the EDM cells. Red line indicates mean energy.

Storage in bottom EDM cell



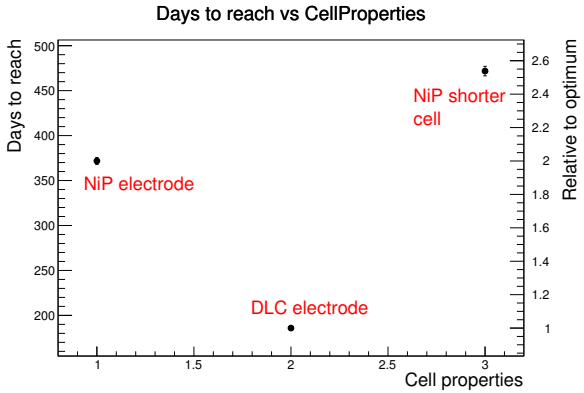
Evolution of energy spectrum during storage. Red line indicates mean energy in the cell. Counts are normalized to filling spectrum.

Emptying to detectors



Energy spectrum of UCN detected. Red line indicates mean energy.
Counts are normalized to filling spectrum.

Cell properties



Simulation	Beam on (s)	Ramsey (s)	Emptying (s)	Cycle t (s)	Days
NiP electrode	135	137	74	346	372 ± 4
DLC electrode	132	169	82	384	186 ± 2
NiP short cell	126	135	76	338	472 ± 5

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- Thank you!

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