Simulations update August 2018

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TUCAN Collaboration Meeting

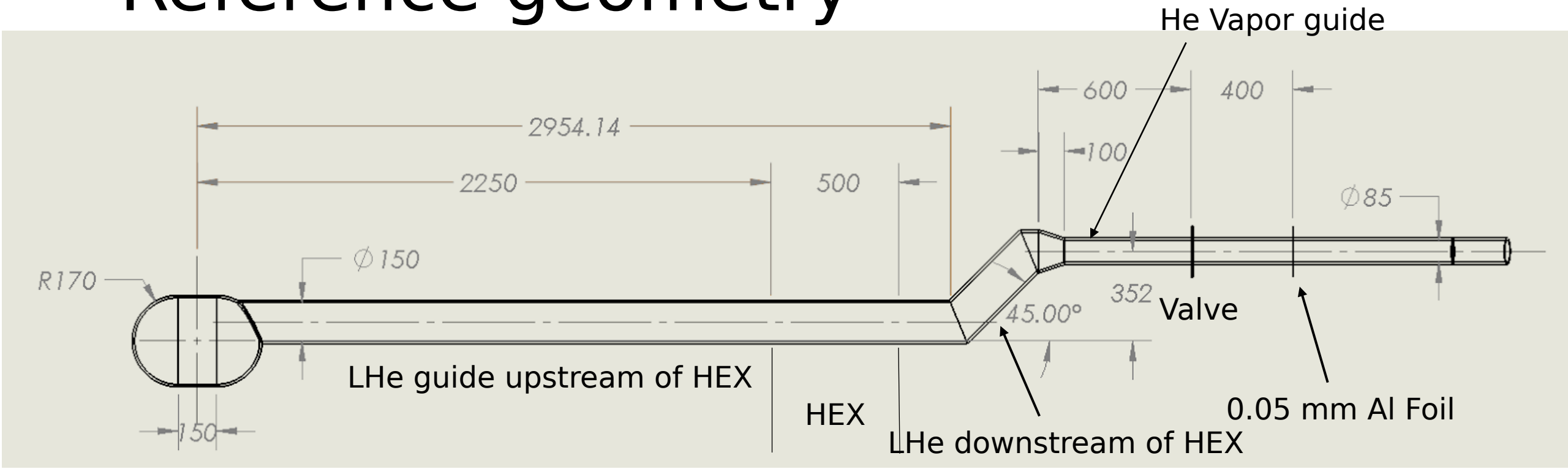
PENTrack parameters

- PENTrack was used for all simulations
- All guide components were assumed to be NiP (iW = 0.113 nev near room temperature and iW + 0.07 in the low temperature areas)
- Lambert diffusion of 3% through out all simulations
- Used Van Sciver estimate Temperature gradient in superfluid helium. The liquid helium fills were broken into ~10 cm segments. This was used to estimate the helium bottle temperature from the HEX temperature.
- Simulated all three operational modes. Showing only results for Steady beam mode.

HEX parameters

- Assumed a Kapitza resistance coefficient of 21.70
- Heat load of 10.5 W
- UCN production: $2.261*10^{6}$ UCN/W
- Fin width of 1mm
- Fin length of 2mm

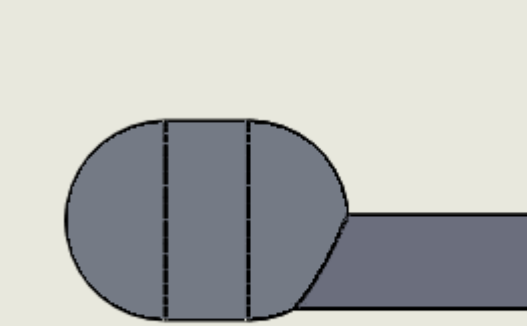
Reference geometry



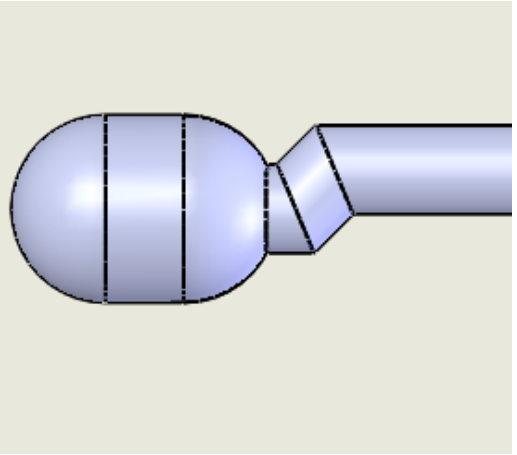
- This was the reference geometry, similar to the geometry used for simulations presented in CDR.

Extraction height

- Looked at 4 different extractions out of the helium bottle
- **High extraction and the double kink had the best efficiency**
- The length of the kink was adjusted to normalize for different starting energies



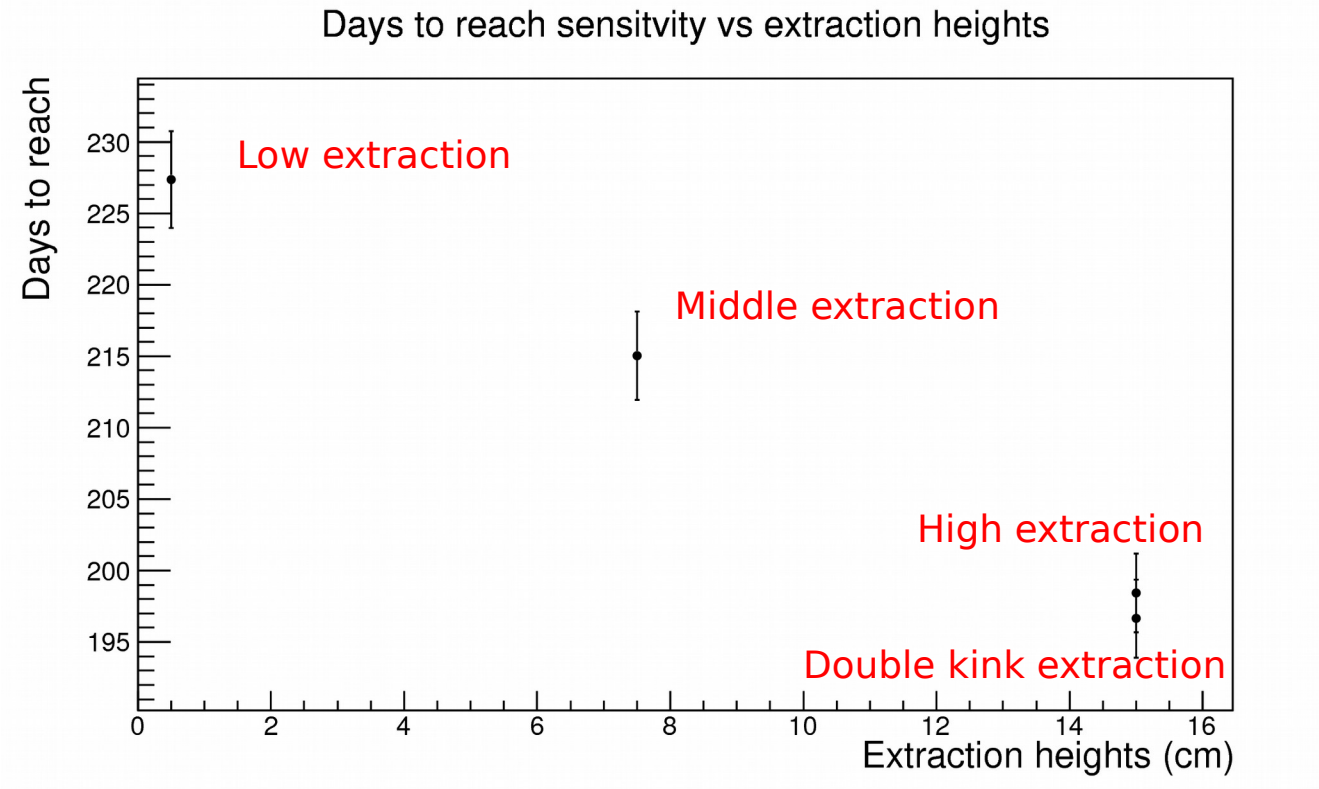
Low extraction



Double kink extraction

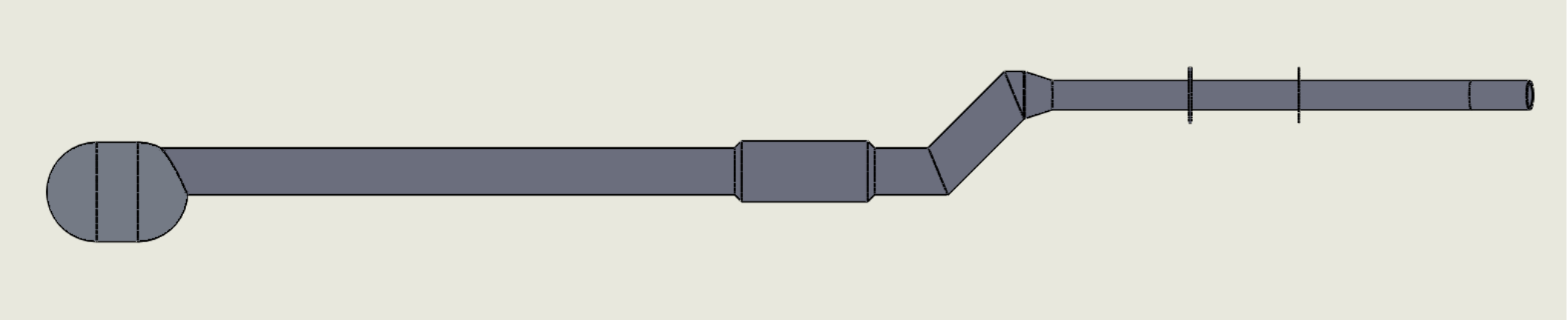
Extraction height

Days to reach sensitivity determined from RP's sensitivity spreadsheet. Input from simulations: transport efficiency of UCN to cell, source storage lifetime, EDM cell fill time.



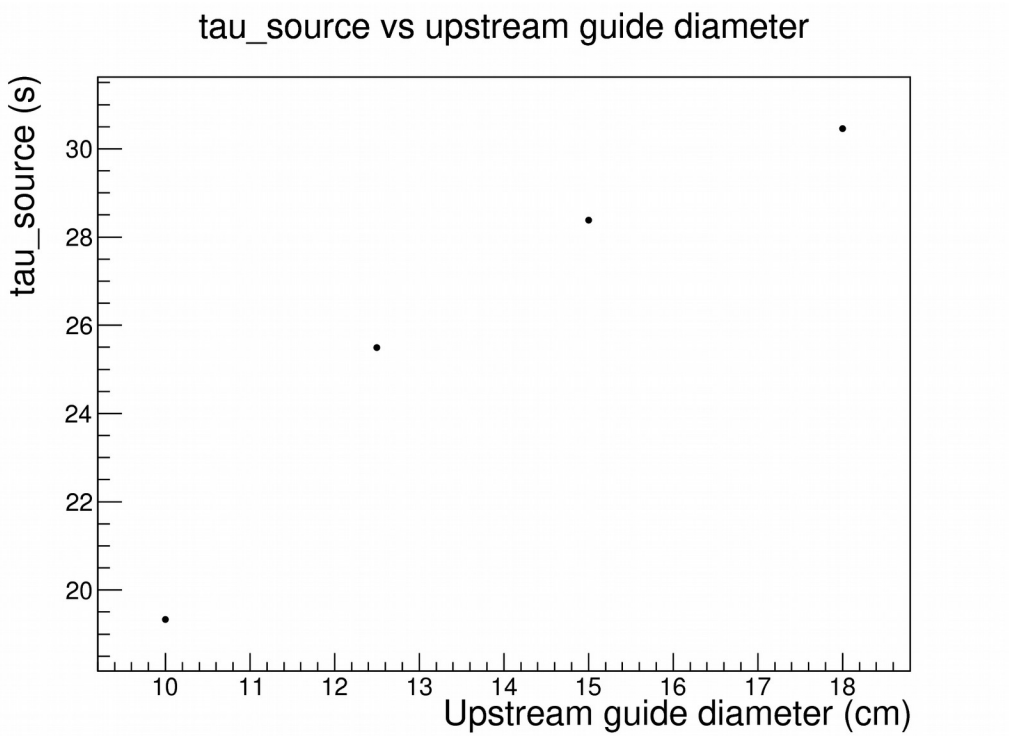
LHe guide

- Simulated different diameters of guide. The HEX diameter was kept at 15 cm. The bottle temperature was affected because of the change in liquid helium volume. HEX temperature varied with changing geometries.

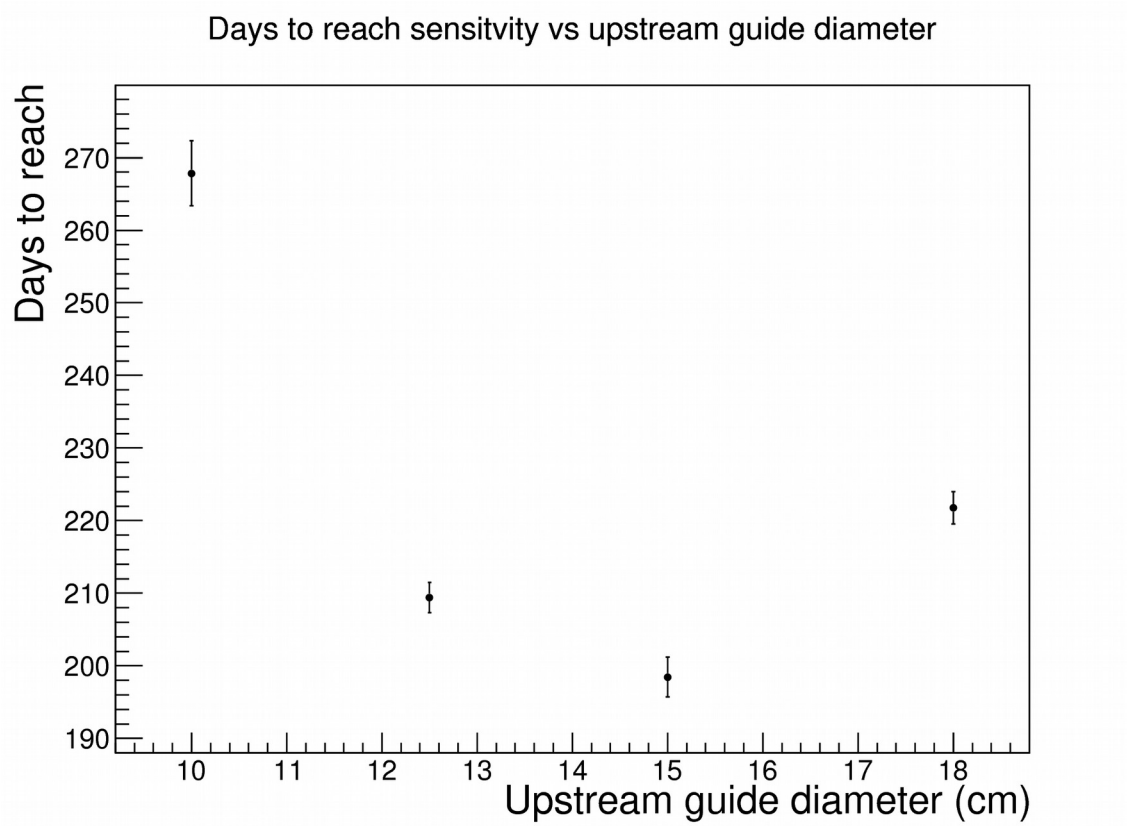


- The guide diameter was kept constant on both sides of the HEX up the top funnel of the kink, where it narrows down to a 8.5 cm diameter.

LHe guide

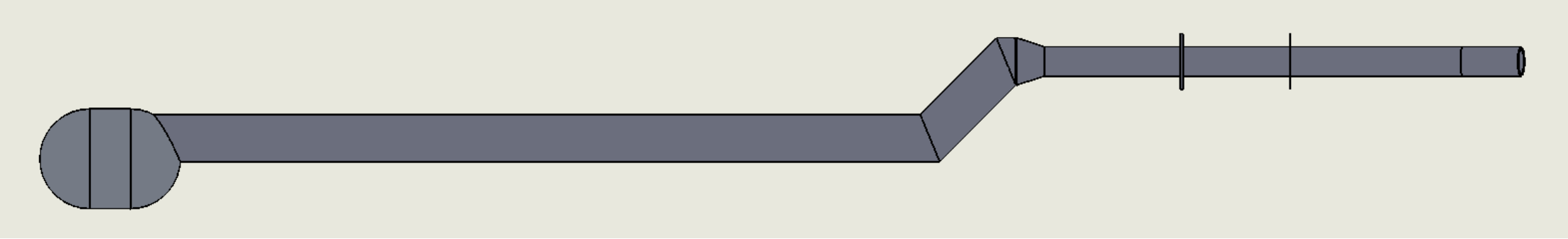


LHe guide diameter (cm)	He-II bottle temperature (K)
10.0	1.28
12.5	1.20
15.0	1.17
18.0	1.15

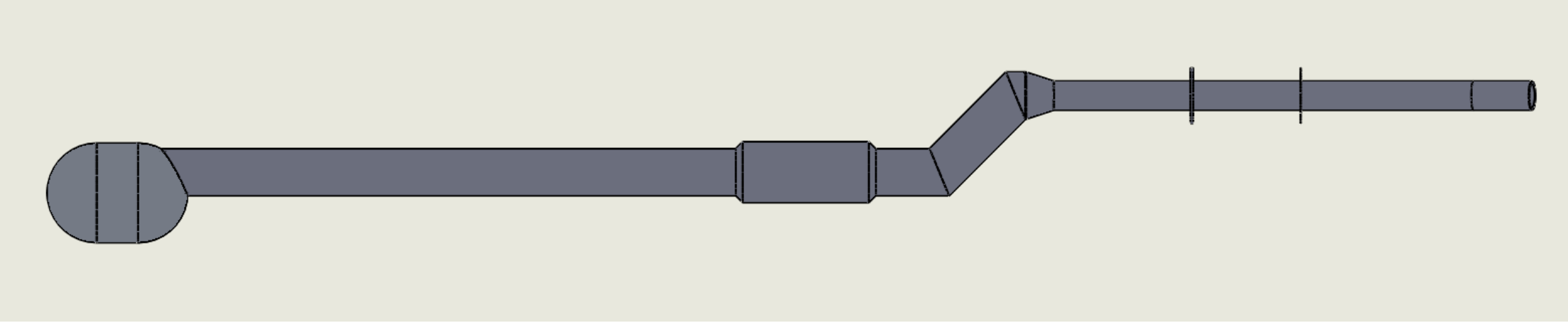


The 15.0 cm guide is clearly favored.

Hex diameters



Standard, 15 cm diameter HEX



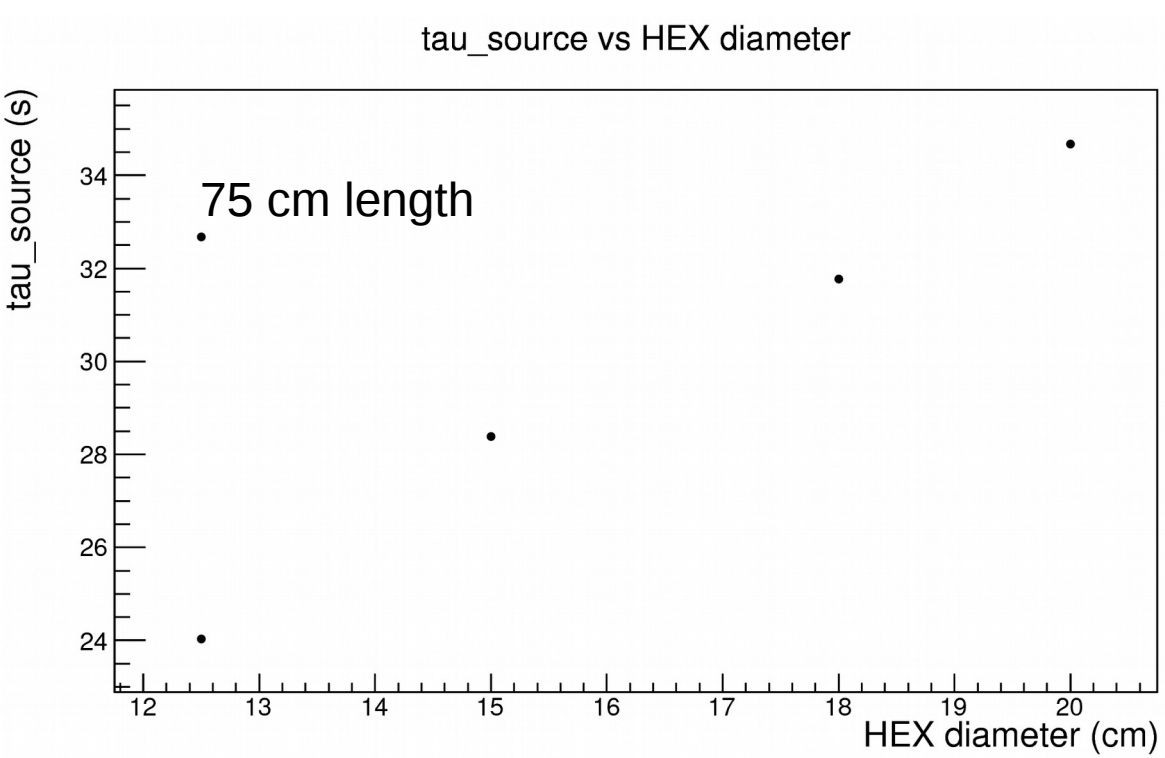
18 cm diameter HEX

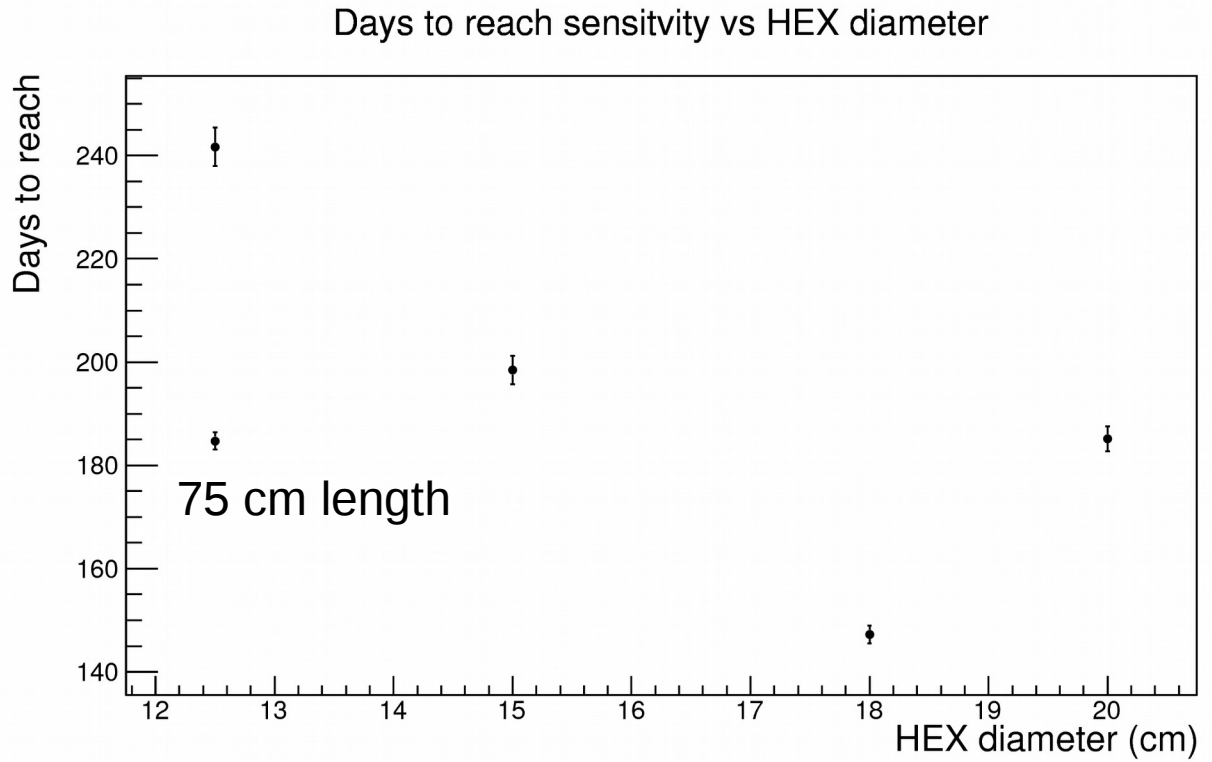
HEX diameters

- Using a 15 cm tube, the HEX diameter was varied.

HEX diameter (cm)	HEX to Bottle temperature (K)	HEX length (cm)	He3 Volume (L)
12.5	1.19 : 1.21	50	313.45
15	1.14 : 1.17	50	364.98
18	1.10 : 1.14	50	426.8
20	1.07 : 1.13	50	468.02
12.5	1.09 : 1.14	75	456.17

Hex diameters



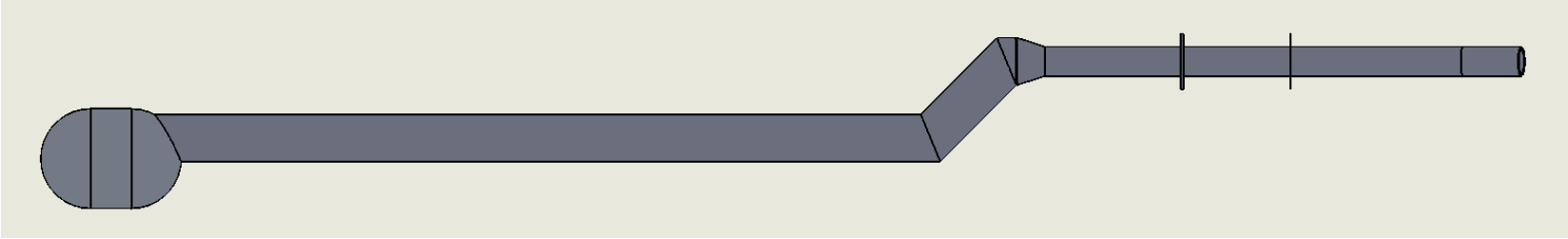


For a 50cm length HEX, a 18cm diameter was the best .

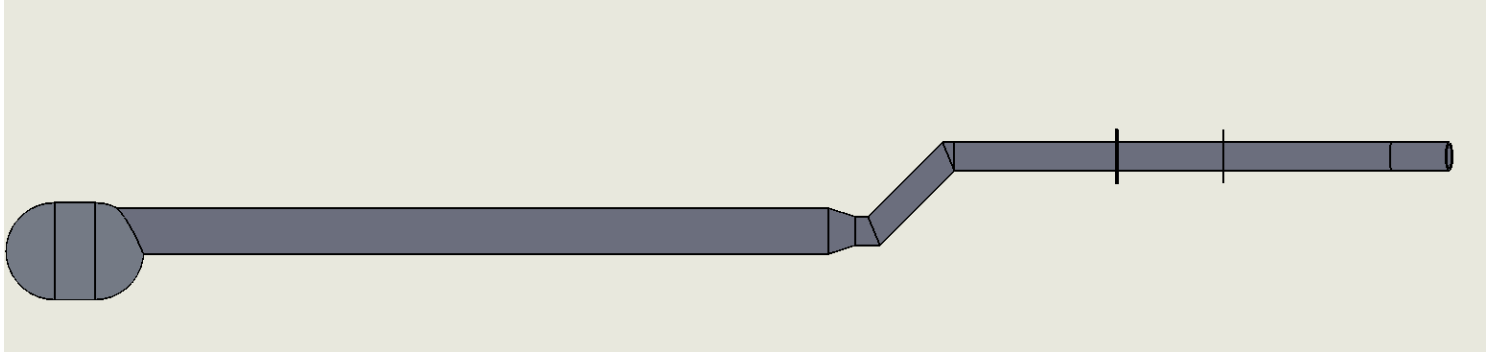
These results match RP's parameter studies for KG = 21.7. In the same studies a KG = 40 gave a HEX diameter of 15cm.

Funnel

- There needs to be a funnel to go from a 15cm diameter guide to a 10 or 8.5cm diameter guide around the kink.



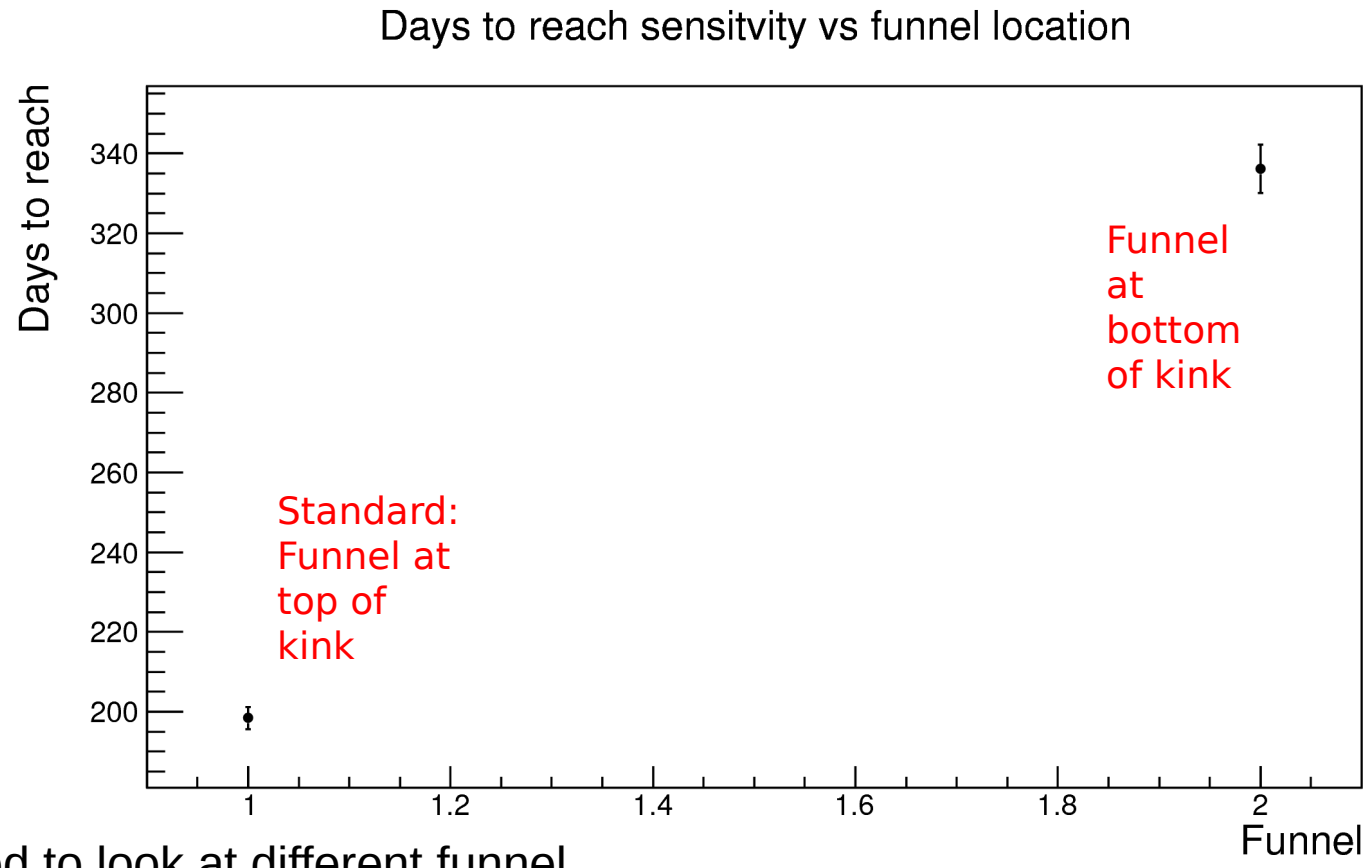
Standard



Shallow funnel at bottom

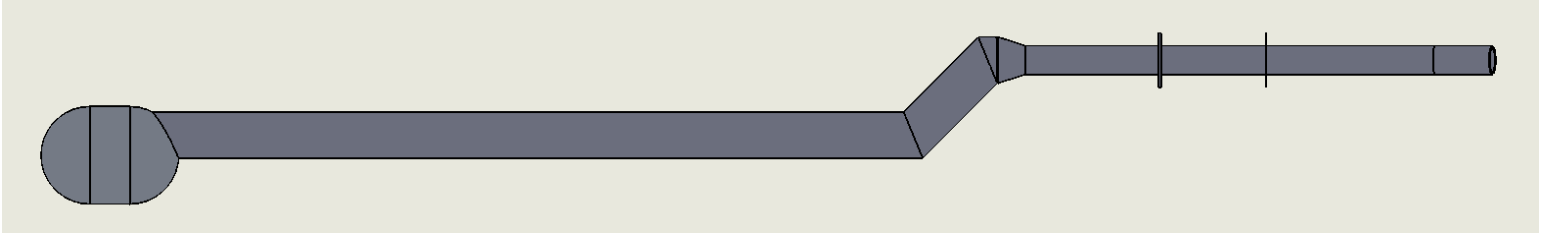
Funnel

The standard funnel at the top of the kink is favored for UCN transport and to maximize total UCN in EDM cells

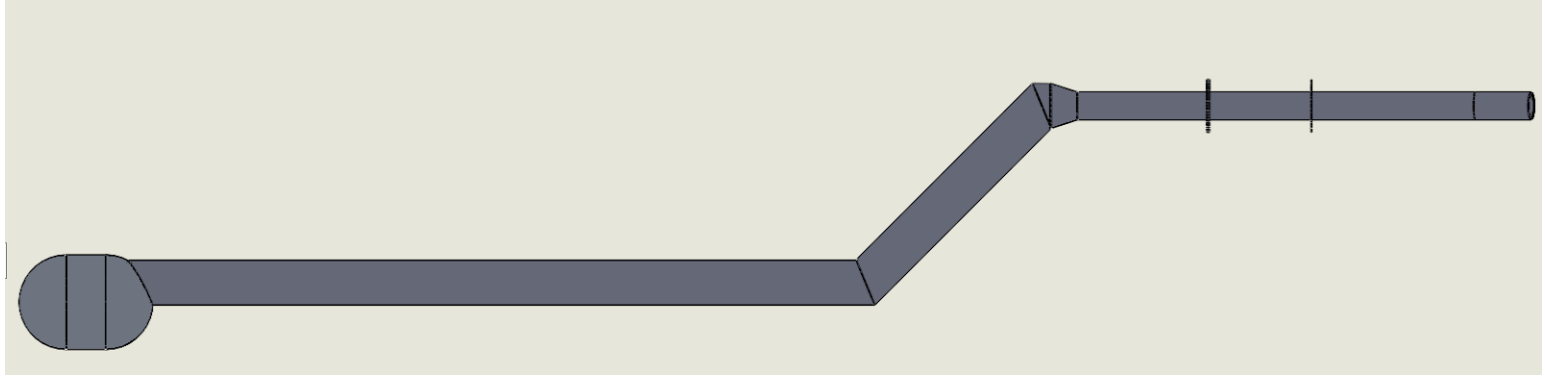


The standard funnel is favored. Need to look at different funnel shapes. There was not a large difference in source storage lifetime (~1.0 s)

Kink Height

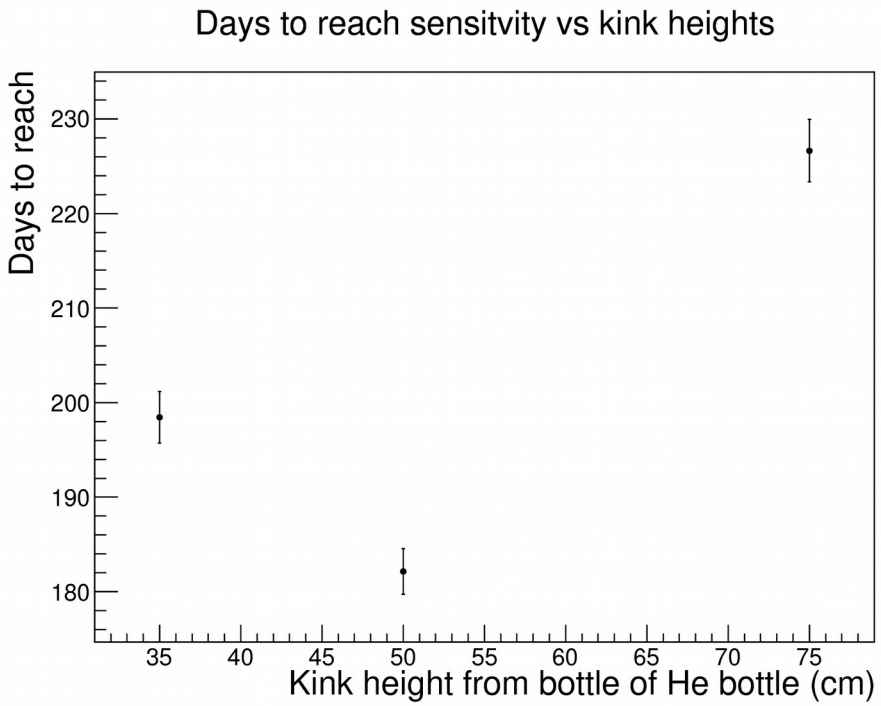


Standard: 37.2 cm above bottom of bottle

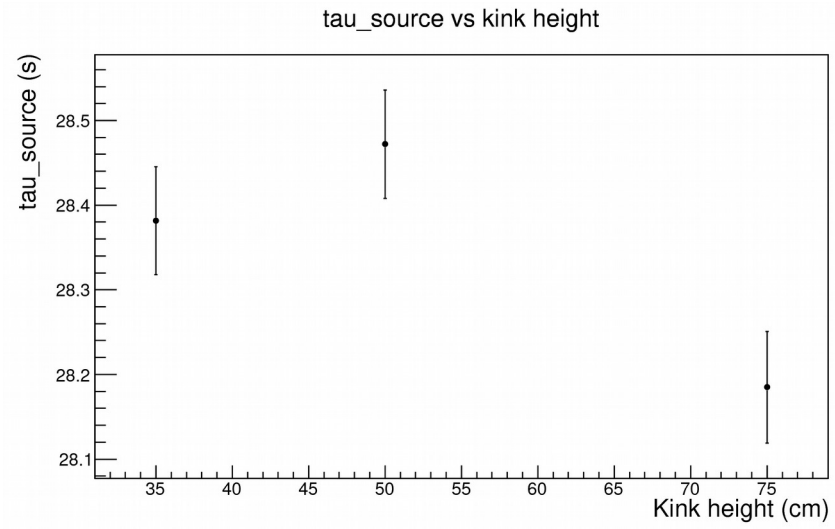


75 cm above bottom of bottle

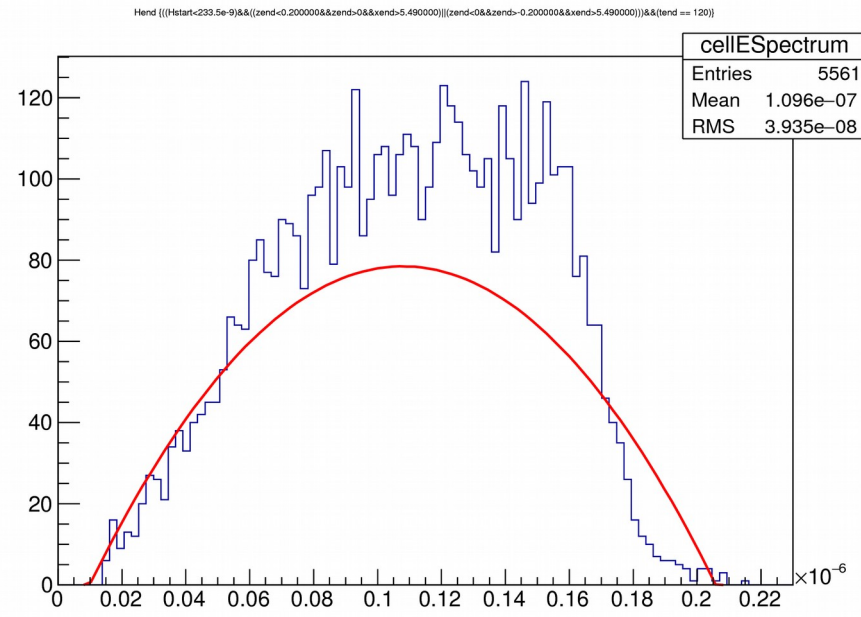
Kink Height



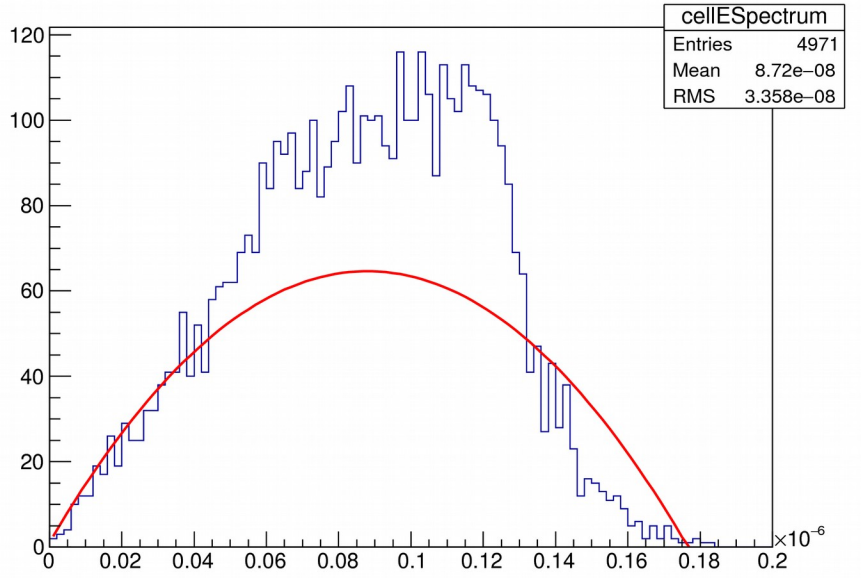
75 cm kink height has the best extraction efficiency. The energy spectrum in the cells at the end of filling time is different.



Standard



75 cm kink height

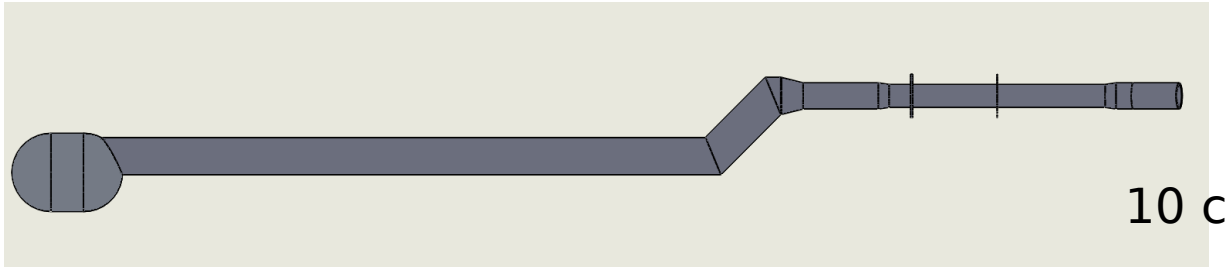


Kink height

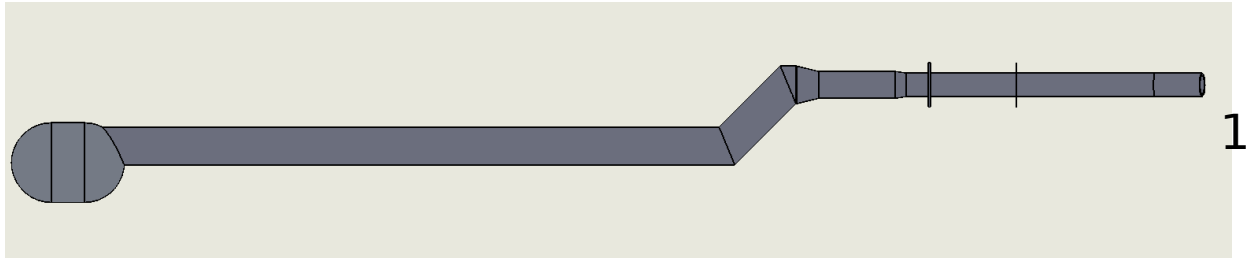
- This tells us how many UCN in the EDM cell at the end of fill time. We need to maximize total UCN that survive a Ramsey cycle.
- **FUTURE WORK:** determine EDM cell storage lifetime vs. UCN energy
- Then determine a duration for Ramsey cycle and EDM cell emptying time
- Finally, determine which kink height results in the highest total number of UCN reaching the detectors

Current work: UCN guide diameter after kink

- Need to optimize guide geometry after kink, including a 8.5 cm diameter, 1m long region around the foil for the warm bore.
- Standard geometry is a straight 8.5 cm diameter guide



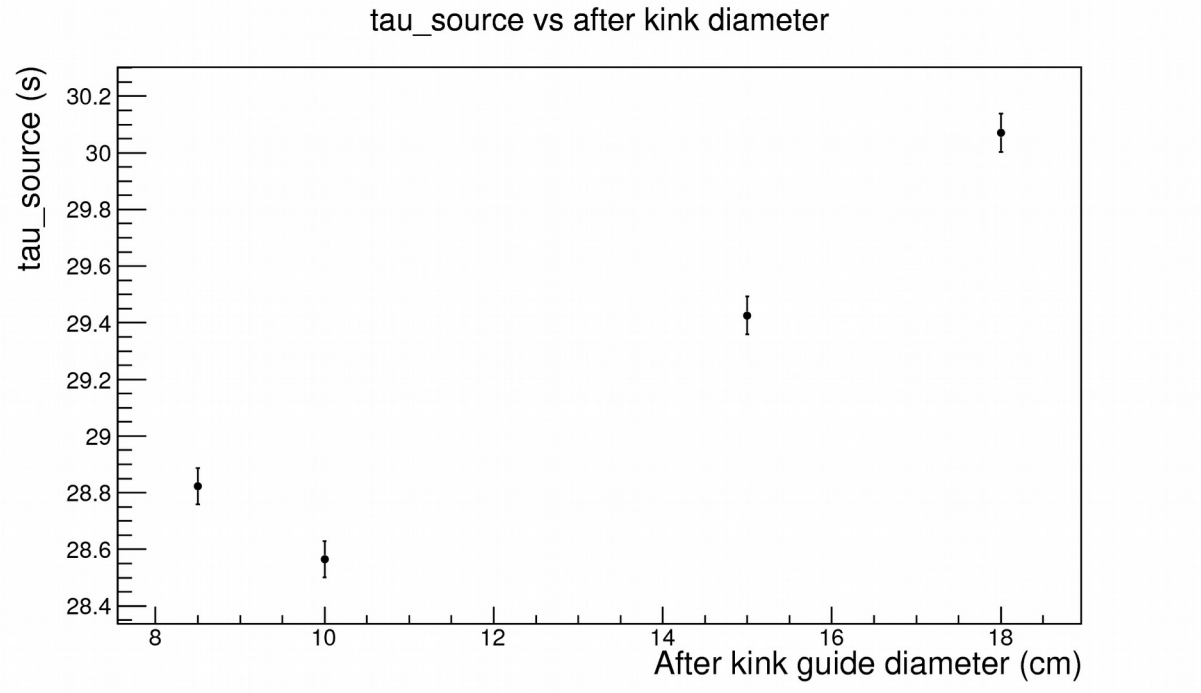
10 cm after kink, warm bore region, back out to 10

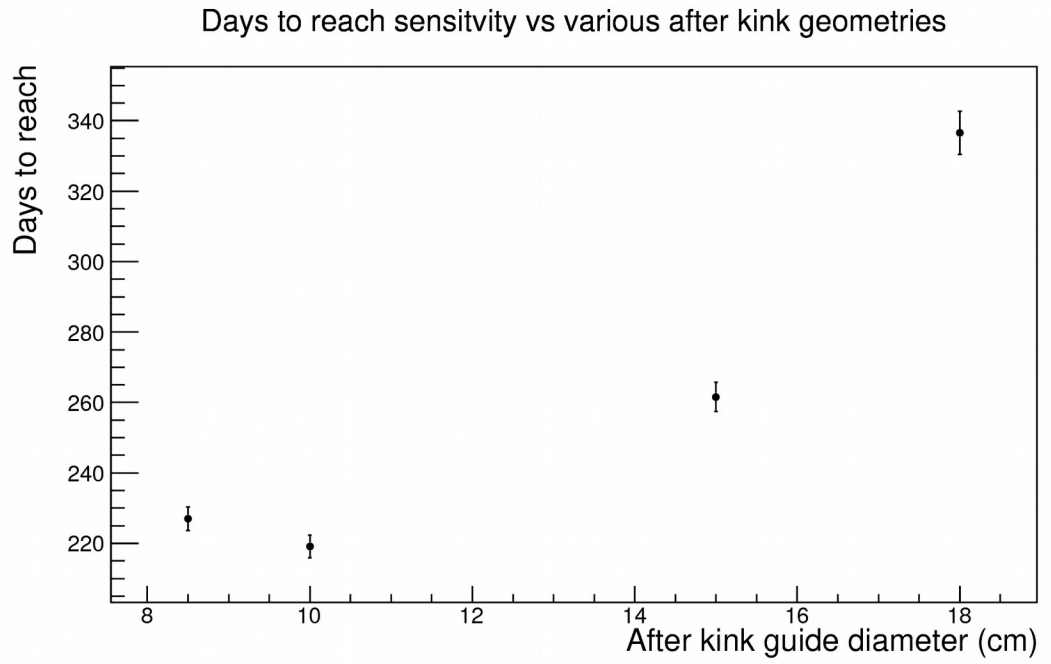


10 cm after kink, 8.5 cm after warm bore region

Straight pipe geometries

These simulations had a 0.1 mm foil.





For straight pipe geometries, a 10cm diameter guide is favored.
Still need to study shrinking the pipe down, and the effect of the B-field coil on different diameters.

Foil simulations

- All simulations done with 0.05 mm thick Al foil and with a B-field
- Running without a B-Field approximately doubled the number of days to reach sensitivity.
- **FUTURE WORK:** PENTrack is limited to the thickness of foils we can simulate. Want to look at PE and Ti foils, which are much thinner. First, need to calculate the scatter cross-section vs thickness for both materials

Simulation results

Study	Status	Result	Why
Extraction height from bottle	**Complete**	High extraction or double kink is best	Best days to reach
LHe guide diameter	**Complete**	15 cm	Best days to reach
HEX diameter	**Complete**	18 cm	Best days to reach for 50 cm length
Funnel location	**Complete, can explore different shapes**	Standard funnel	Best days to reach
Kink height	In progress	Need to run more geometries	
After kink diameter	In progress	-	
He vapor guide around SCM	In progress	-	
Foils	In progress	-	
EDM cell guide diameter	Not yet started	-	