

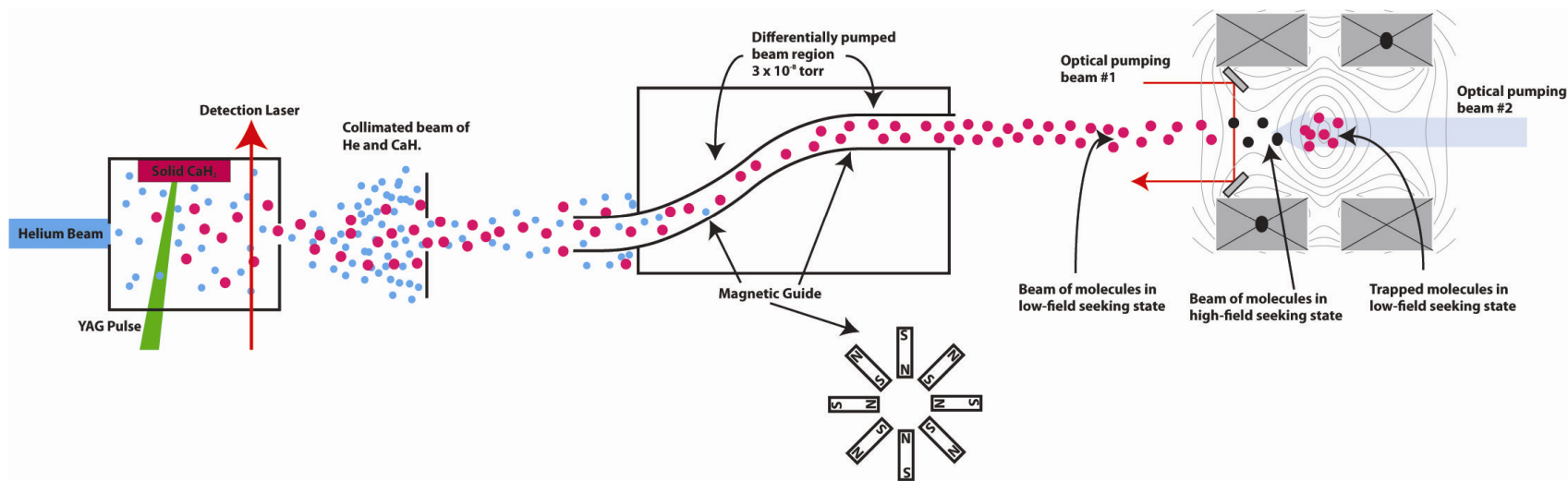
DESIGNING MAGNETIC GUIDE FOR CALCIUM MONOHYDRATE

CaH Team:

M. J. Wright, H.-I. Lu, J. Rasmussen, J. Doyle

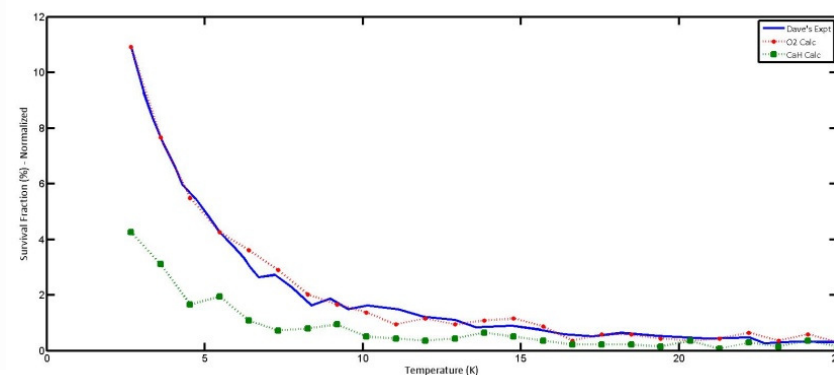
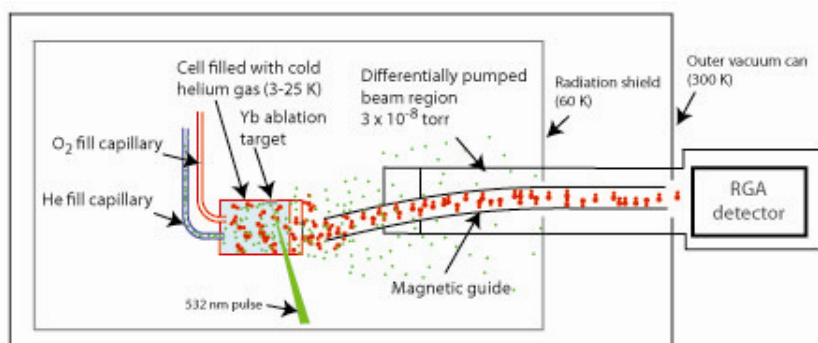
Why Design a Magnetic Guide for CaH?

The goal of the guide is to separate He from CaH.



Already Developed Guide Technology

- Developed by Dave for O₂. *Bright, guided molecular beam with hydrodynamic enhancement.* J. Chem. Phys., **126**, 154307 (2007).
- Guide is only about 1/2 as good for CaH as O₂.



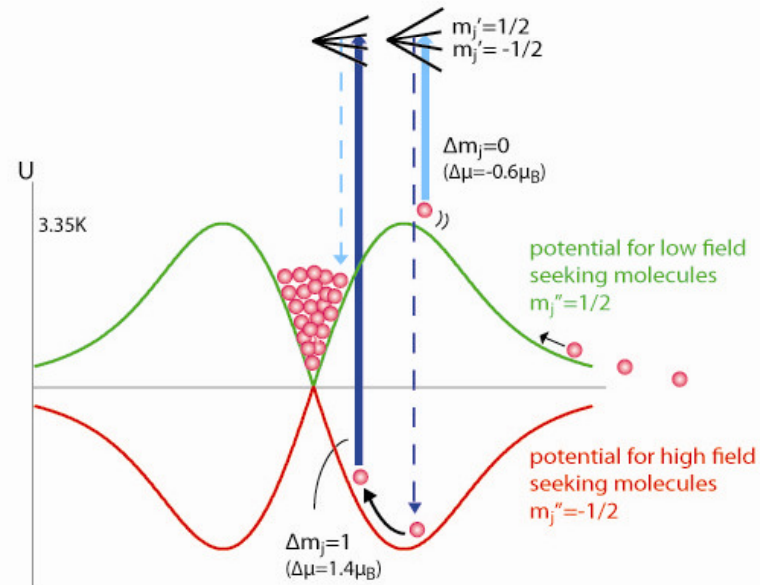
Guide Considerations



- Evaluating different options for the Guide
- Molecule losses in the guide can be a limited factor in future experiments or even the success of the entire experiment
- Key Considerations:
 - ▣ Angle of Curvature
 - ▣ Depth of Guide

What Makes a Good Guide?

- He density is reduced ($n_{He} \leq n_{CaH}$)
- Molecule survival $>5\%$ of initial particles with a velocity distribution that is suitable for trap loading ($\sim 5K < v_z < \sim 7K$).



Simulation

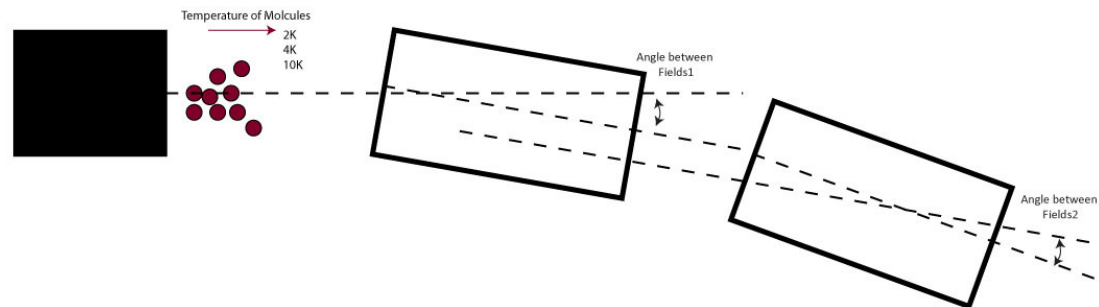
- Monte Carlo.
- Single molecule in Magnetic Field $F = -\nabla(\vec{\mu}_B \cdot \vec{B})$
- Magnetic fields are calculated in Radiana (Mathematica) and then use in Matlab
- Field blocks are reused where appropriate.
Molecule transformation each time it enters a new field block (translation, rotation)
- Molecule is lost when the distance to the center of the guide is larger than the guide itself.

Angle of Curvature

- Angle of curvature important in a smooth guide.
 - Consider this back of the envelope calculation:

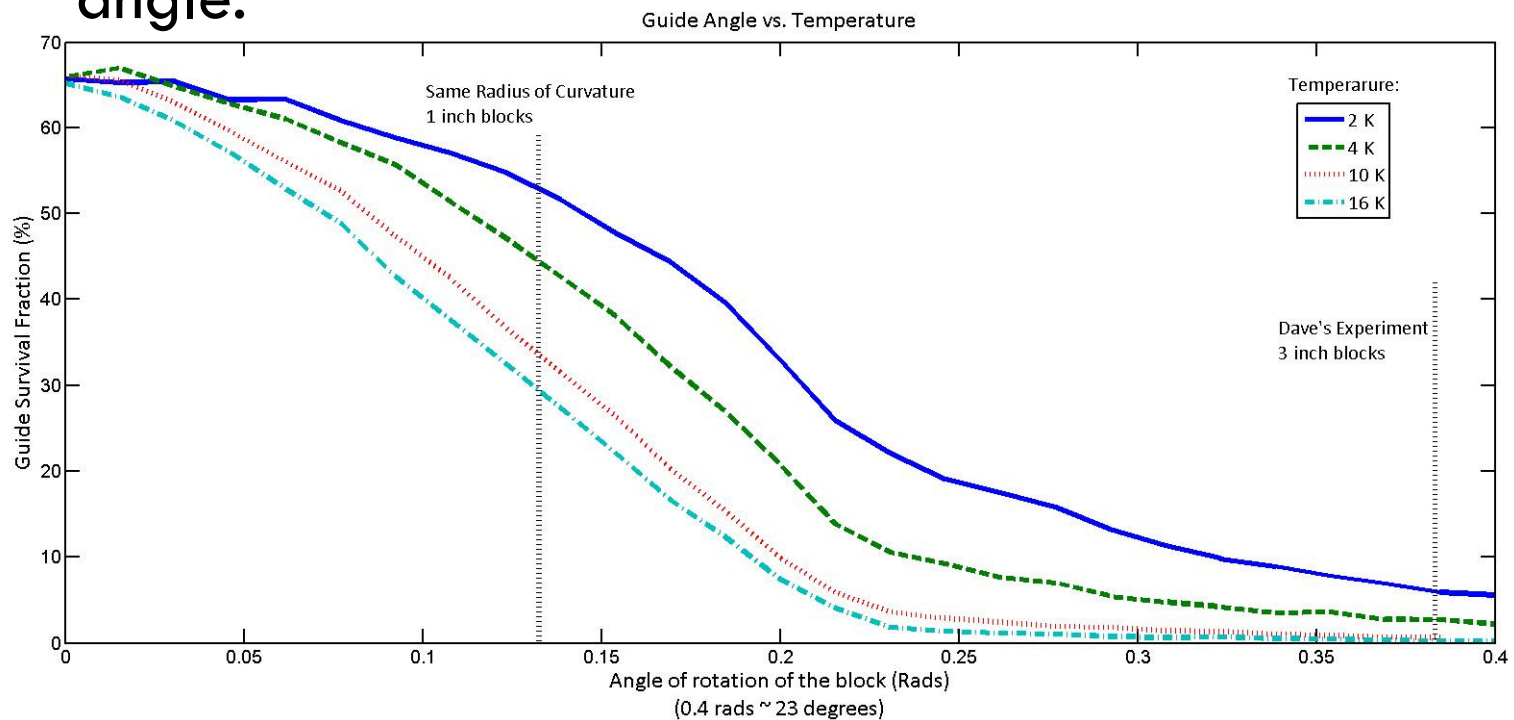
$$\frac{mv^2}{R} = \nabla(\vec{\mu}_B \cdot \vec{B}) \rightarrow v(R = 20) \approx 60m/s$$

- Physical guide made up linear segments
 - Angle between segments critical.



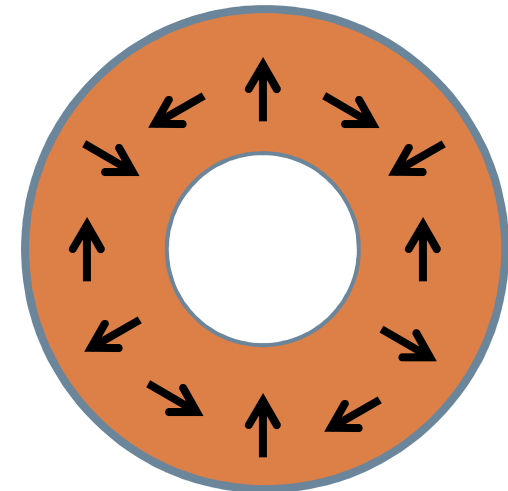
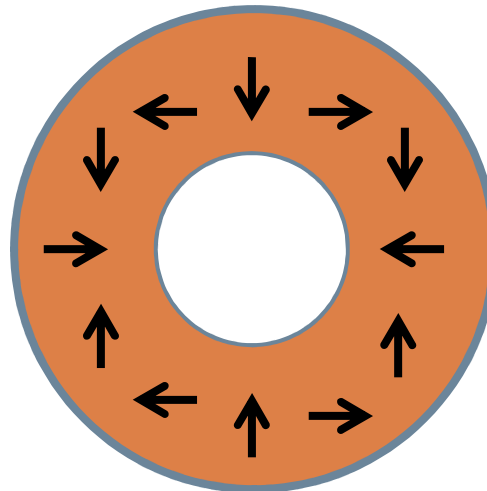
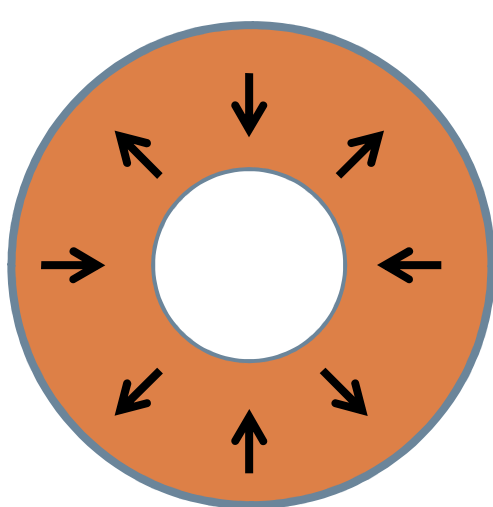
Angle of Curvature

- Non-linear dependence on angle.
 - 3 X 1 inch blocks with a 7 degree angle between them is much better than 1 X 3 inch block with a 21 degree angle.



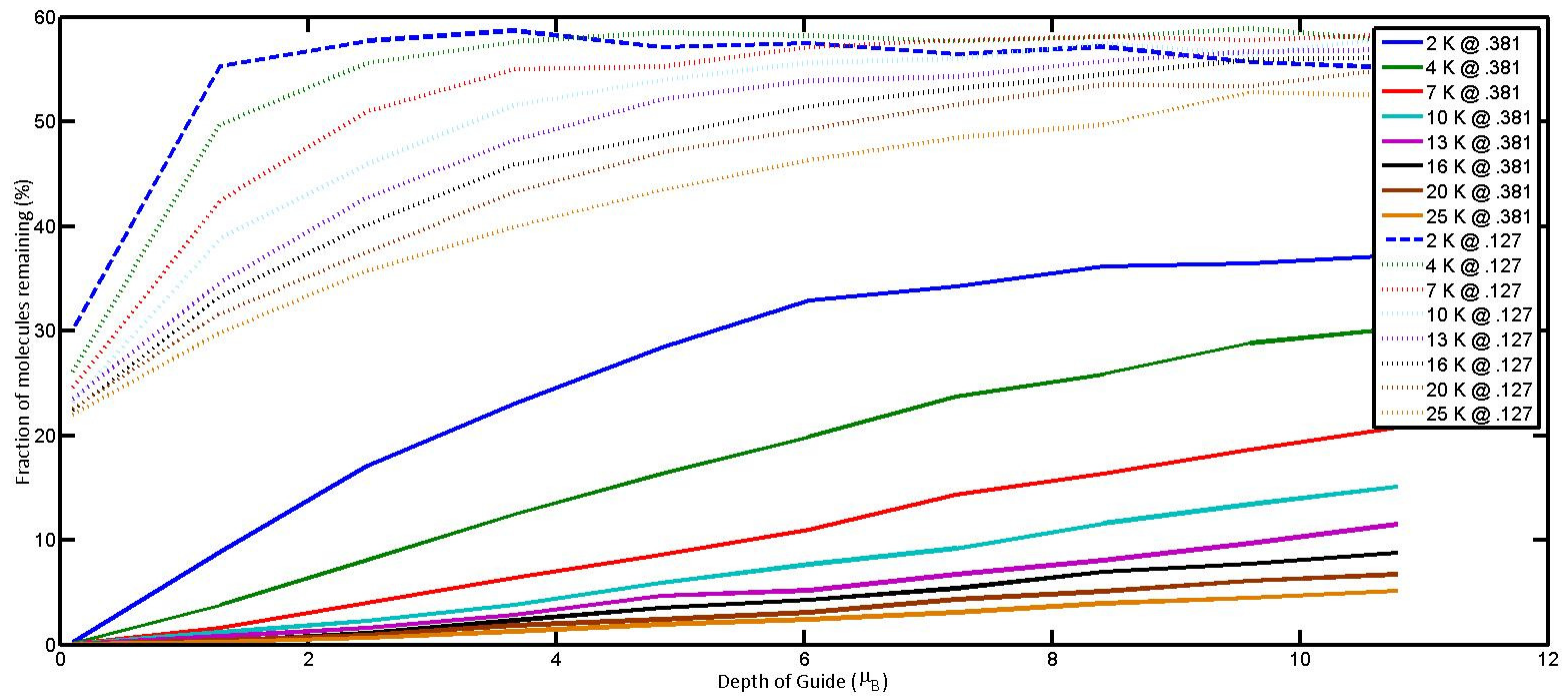
Depth of Guide

- Guide depth must exceed transverse temperature of the beam ($T > 100$ mK). Strong permanent magnets available at ~ 0.5 K.
- Effectiveness of guide is proportional to its depth.
- Number of designs to consider:



$\sim 30\%$ larger Depth

Depth of Guide



Other Considerations



- Optimizing the guide for trappable molecules (i.e., the right velocity).
- Direct comparison of: smaller angle with smaller blocks and larger angle with larger blocks.
- Effect of adding a second field block
- Effect of adding n field blocks
- Effect of the distance between blocks
- Novel methods to collect more molecules in the guide.

Simulation Best Practices



- After any change to the simulation old input files and test cases should work.
 - ▣ All simulation parameters stored in input file (xml). The input file is copied and saved during each run.
 - ▣ Test cases for each function are written using independent Matlab scripts. An excellent way to ensure that your simulation still works after making changes in the future.