HKS Target Design and Status

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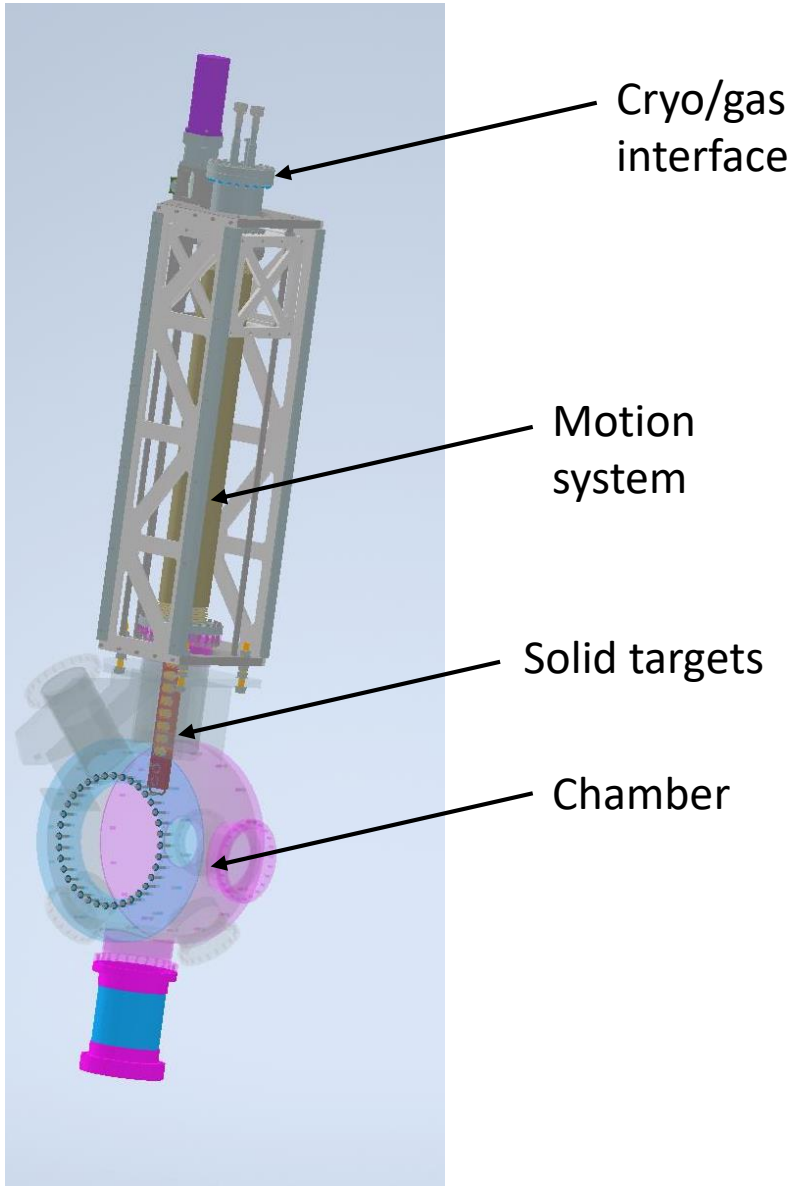
Design Status

- Design is in concept stage and will be for some time
  - Target group does not have resources to develop a comprehensive design at this time.
  - Solid target concept complete
  - Gas targets will still need input from collaboration
- Exploring 2 options
  - System with solid targets only
  - System with both fluid and solid targets (this is more work to install)
- Both systems require cryogenic cooling
  - Pb and Li both need this to meet beam current requirements
  - He and Hydrogen gas cells will need it to reach proposed densities
- A simplistic method for optimization of the cells/solid targets has been developed
- Fluid systems are designed to appropriate Codes and Standards
  - Somewhat limiting

Concept Design

- Base motion system and top end design on PREX/CREX target
  - Plenty of range for all targets needed for
- Custom chamber will be needed
- Long transfer lines will be needed.
  - Base this design on existing design for PREX
- Cooled solid target ladder/heat exchanger
- Cooled cells (not shown)
  - Fed gas from gas panels in Hall C



“Original” Proposal (circa 2022)

- Solid targets
  - Some basic solid targets (these targets are relatively easy)
    - C, Al, B4C etc.
  - More Challenging (these targets require special handling/cooling)
    - Lead, Ca40,48, Li6, Pb etc.
- Gas Cells
  - H2, He3 and He4
  - Tuna can with vertical axis perpendicular to the beam
  - Diameter is 20 cm
  - Total Al thickness 162 mg/cm^2
  - Gas pressures low

Optimization of the Cells

- Assumptions for improvement
  - Thinner cells walls
  - Higher fluid densities
  - Smaller diameter
- Plan to use actively filled cells
  - This is contrast to the tritium target were the cells were filled with a static pressure
  - Two gas isotopes can be used concurrently
  - One gas species at a time (e.g., H2 and D2 **OR** He3 and He4)
- Requires gas handling system
  - This might need to be in a second phase as schedule permits

Status of Cell Optimization

- Cell geometry
  - 7.5 cm tuna can
  - Wall thickness depends on fluid pressure
  - Height of thin section is 2 cm
  - Mechanical knife edge sealing system
  - No welding on cell or cell block
- Fluids: 2 basic options which can be refined a bit if needed
  - Option 1: Fluid pressure 60 psia – wall thickness 0.13 mm
  - Option 2: Fluid pressure: 130 psia – wall thickness 0.25 mm
  - Operate He targets at 5.6K
  - Operate Hydrogen targets at 35K
- This improves the ratio of fluid to target cell wall as well as overall thickness
- Smaller cell form factor will be easier to design around for the motion and chamber systems.
- Still need input from the collaboration on this “final” design.

Comparison

Three concepts are compared

Seems like the best option

Fluid	2022 Cell 2022		Option 1) P=60 psia		Option 2) P=130 psia		Fluid only	Fluid only
	ρt fluid	Fluid to wall	ρt fluid	Fluid to wall	ρt fluid	Fluid to wall	#1 to 2022	#2 to 2022
	g/cm^2		g/cm^2		g/cm^2			
H2	54	0.33	24	0.35	61	0.45	1.13	1.13
D2	-	-	50	0.73	133	0.99	-	-
He3	165	1.02	322	4.7	566	4.2	1.95	3.4
He4	228	1.41	803	11.8	998	7.4	2.75	7.4

Need input from the collaboration on final choice.

Thermal Loads

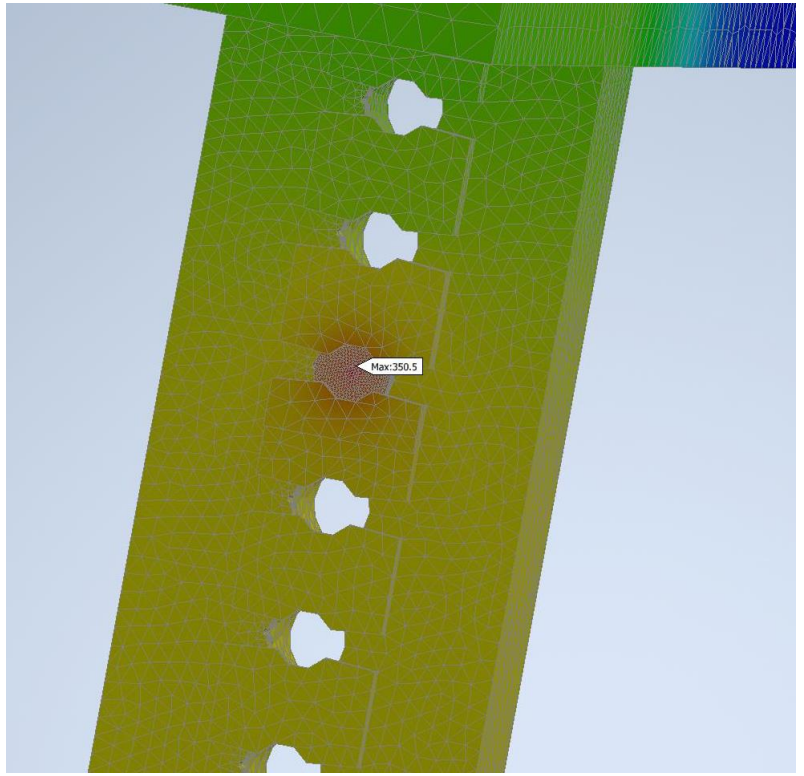
Thermal loads are modest but we will still need cryogens for cooling.

Target Matl Material	Wall thick (mm)	Rho of wall (g/cm^3)	Length (cm)	Imax (microA)	Nom Thick (gm/cm^2)	Density (g/cm^3)	Actual Thick (mm)	Q in wall (W)	Q in tgt (W)
H2	0.25	67.5	7.5	20	0.061	0.008	75	4.9	5.5
D2	0.25	67.5	7.5	20	0.133	0.018	75	4.9	6
He3	0.25	67.5	7.5	20	0.566	0.0755	75	4.9	32
He4	0.25	67.5	7.5	20	0.998	0.133	75	4.9	41
CH2				2	0.5	0.88	5.6		1.3
Li6				50	0.1	0.53	2		10
B4C(11)				50	0.1	2.52	0.5		8.5
C				50	0.1	1.8	0.5		8.5
Al				50	0.1	2.7	0.38		9
Ca40				50	0.15	1.5	0.5		15
Ca48				50	0.15	1.8	0.5		12.5
PB208				25	0.114	11.38	0.1		5

100 mg
is thinnest

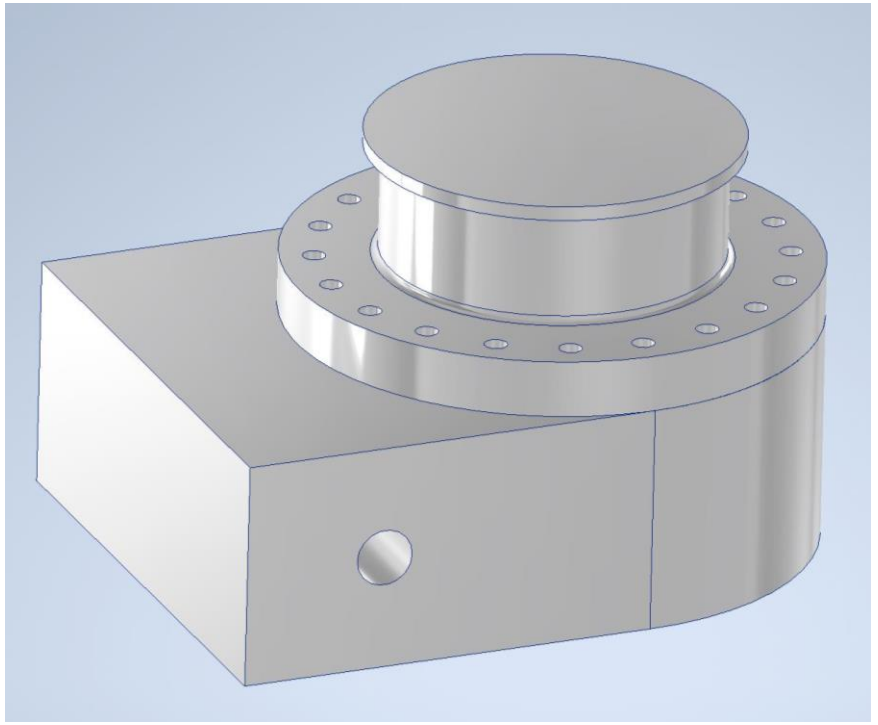
Analysis of Hall C Ca Solid Target

- 80 microA
- Heat sink 30K
- 2x2 mm raster
- Max temp 350K
  - Similar for Li
- This will not be any problem for HKS
- Lead should work with a similar design.



Concept Cell/Block Design

- Cell and block fabricated from ASTM B209 7075 aluminum
- All metallic seals no welding
- Cell is machined and measured to high accuracy.
  - 20% deviation on thin wall cell
  - 10% deviation on thicker wall cell
- Expect ~10% density reduction at full current
- Out of plane acceptance is larger than +/- 4 deg
- Fairly easy to fabricate
  - We have similar models with smaller radius

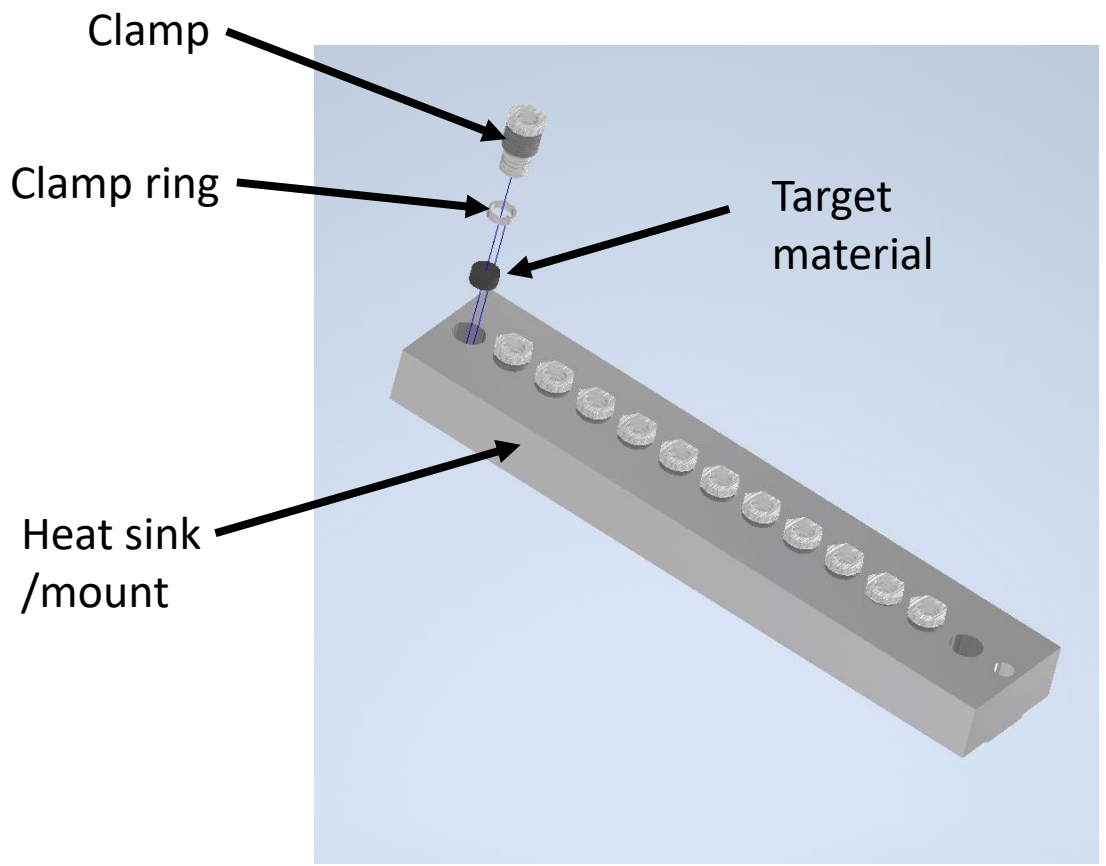


Solid Targets

- Lead and calcium will present challenges
  - Lead will need to be cryogenically cooled with good thermal conductivity
    - Realistic thickness will need to be at least 0.1 mm
  - Ca and Li targets will need special handling
    - Ca48 stock at Jefferson Lab is highly compromised
    - Recommend purchasing new Ca48 foil ($50K to $100K)
- Other solid targets are relatively simple to work with
  - Proposed thickness are OK
  - Multi-foil: reduce to +/- 5 cm to closer match cell length
- Design path:
  - Combine latest Hall C solid target ladder with PREX/CREX motion system and T2 target style heat sink.

Solid Target Ladder

- Solid target design concept
- All components are aluminum 7075
- Target material is clamped into the frame with sufficient force to ensure good Kc
  - Threaded clamp screws into heat sink
  - Nuclear grade anti-seize is used to enhance Kc and prevent galling
  - Clamp ring prevents spinning of the target foil
- Proven to work will all targets except lead
  - Preliminary calcs show design is acceptable for lead as well



Summary

- A completely new cryogenic target will be required to be located ~11 m downstream from the nominal pivot.
  - Current gas handling panels should be sufficient for HKS target
  - New electrical installations will be required
  - New gas lines will be needed
- The cryogenic distribution system will require some new transfer lines in excess of 40 ft.
- We will need to work with Hall engineers/designers to layout target services and design the scattering chamber.
- At the moment the target group does not have the resources to complete a final design or substantially develop the concept
  - It is not clear when the resources will be available