Cryo-Target/^{3}He Thermal Analysis

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Hall A - SBS meeting

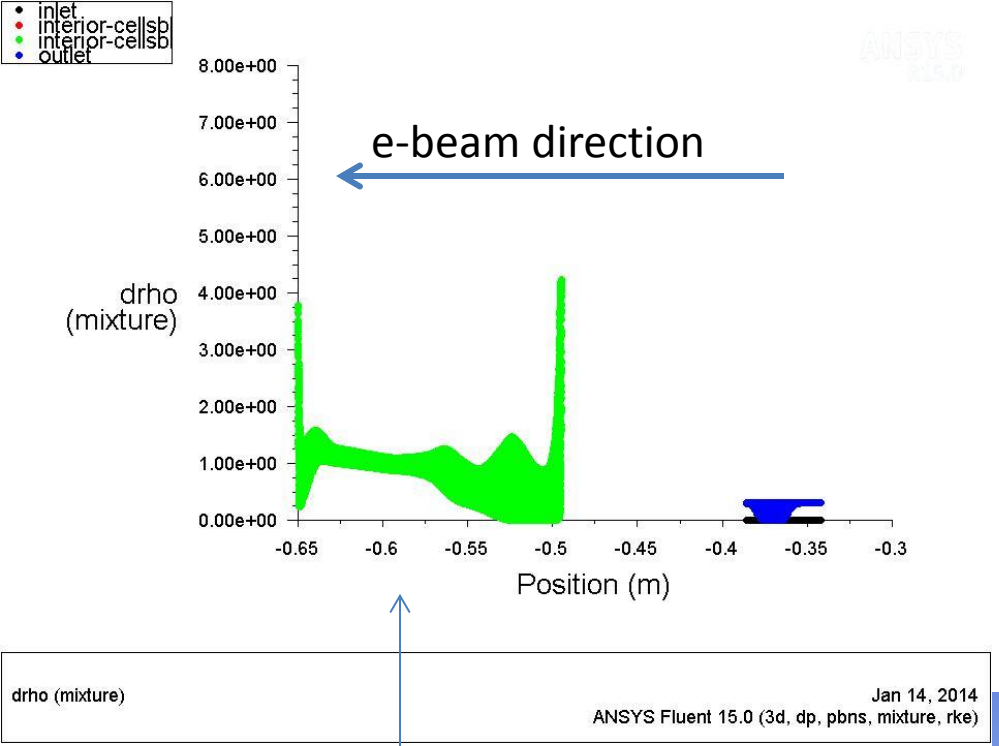
22 Jul 2016

Cryogenic Targets for SBS

- 10 cm target cells for Gmn should be standard
- The 40 cm target cell for Gep(5) would be a challenge
- 2 designs considered for Gep(5) (for now), which were presented at the SBS meeting July 2014 :
  - A g0 (or SAMPLE) type cell, cylindrical with internal flow diverter (+/- 90° acceptance)
  - A qweak-type cell, conical, without internal flow diverter (acceptance limited by cone opening (+/- 14° in qweak)
  - Jlab target group needs 3 years from start of design to delivery

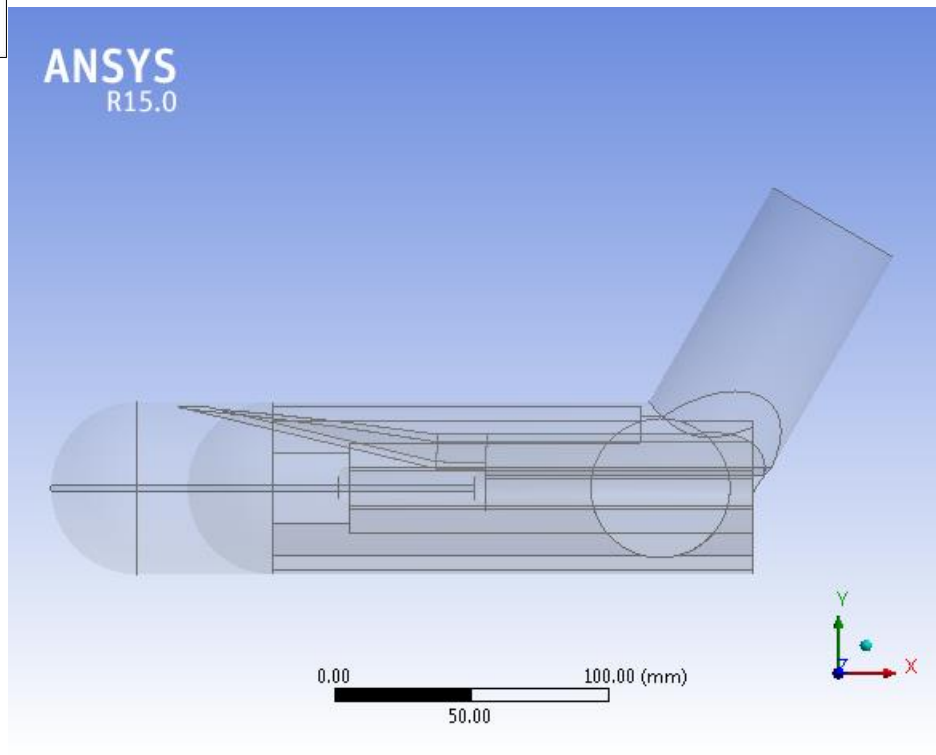
Gmp target boiling studies – spring 2016

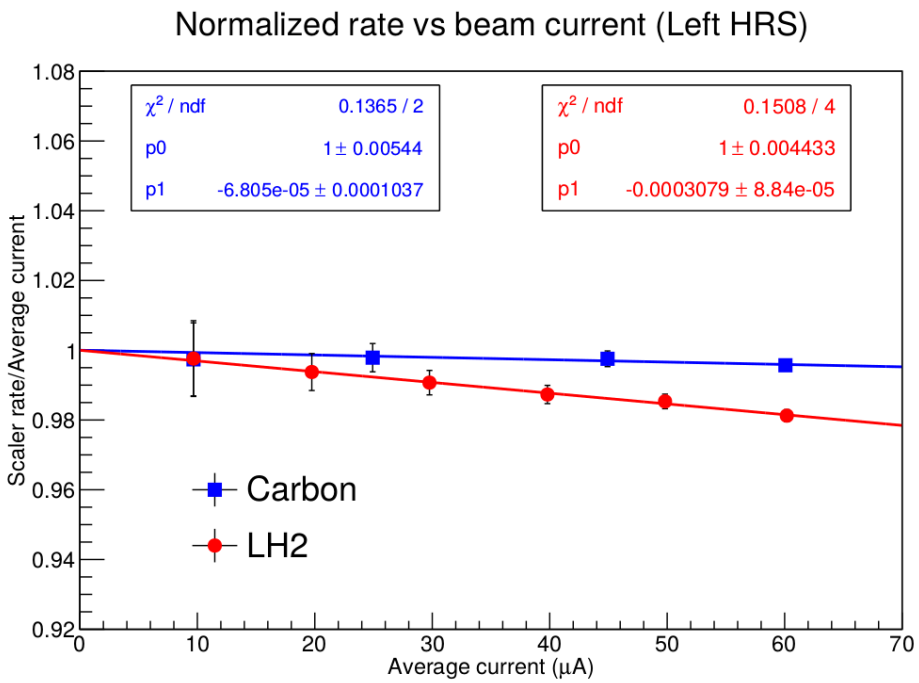
- Beam current scan data taken on 15 cm long LH2 and carbon targets up to about 50 μA, beam energy 8 GeV
- Independent study done with left and right HRSs: LRHS@43° and RHRS@48°, spectrometer central momentum 0.85 GeV/c
- Two analysis methods used:
  - Electron yield/beam charge vs. beam current (poor statistics)
  - Raw scaler counts/beam charge vs. beam current (better statistics)
- Data analyzed by Longwo Ou (MIT) and Thir Gautam (HU)

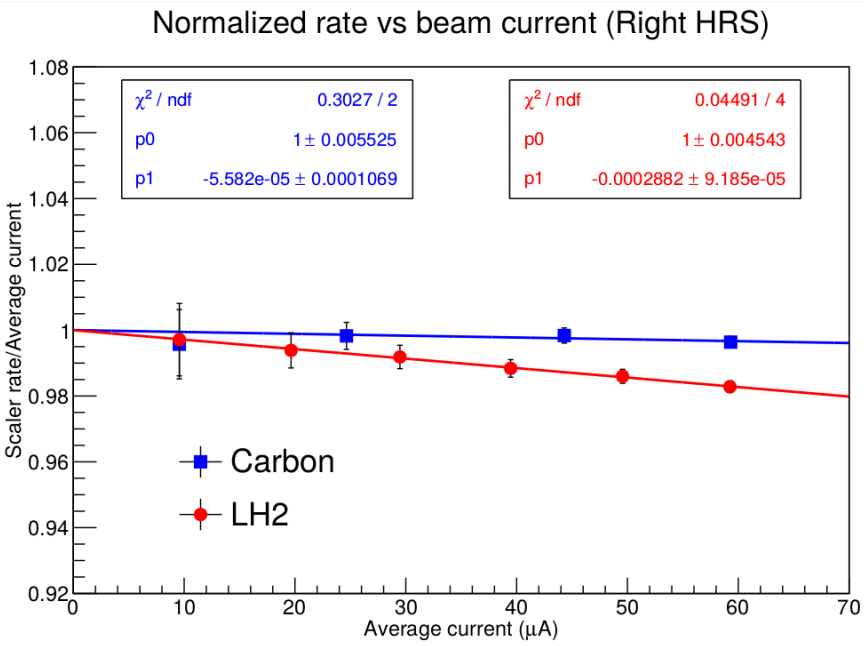


CFDFAC estimate of LH2 density loss (%) distribution along the beam line in the beam volume. The vertical spread is the distribution in the beam raster area at that z-location. The beam raster is assumed 2x2 mm^2

1. 15 cm long LH2 target cell designed by CFDFAC, cylinder with 6.28 cm diameter with an internal flow diverter (acceptance +/- 74 mrad).
2. Gmp used a single cell/loop, but one loop could accommodate 2 cells
3. It could be used by Gmn, either as 15 cm or 10 cm long





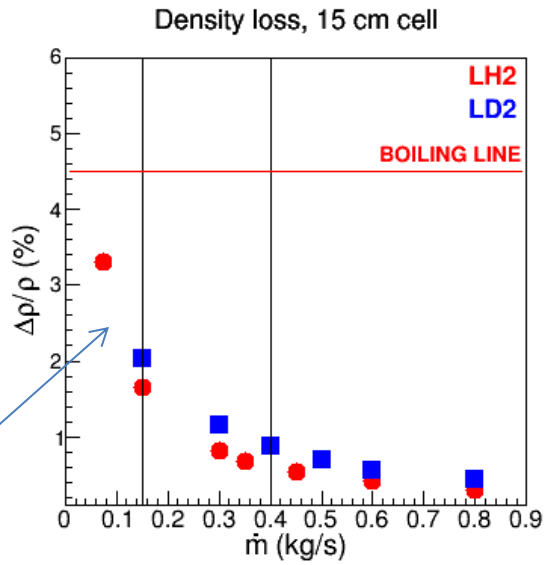


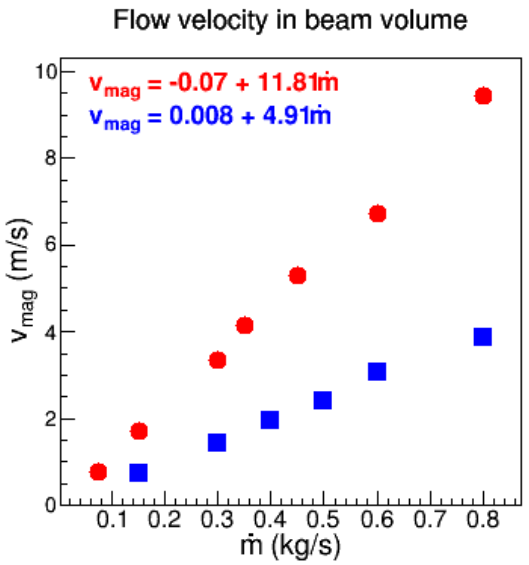
LHRS: carbon (-0.7+/-1)%/100 μA
LH2 (-3.1+/-0.9)%/100 μA

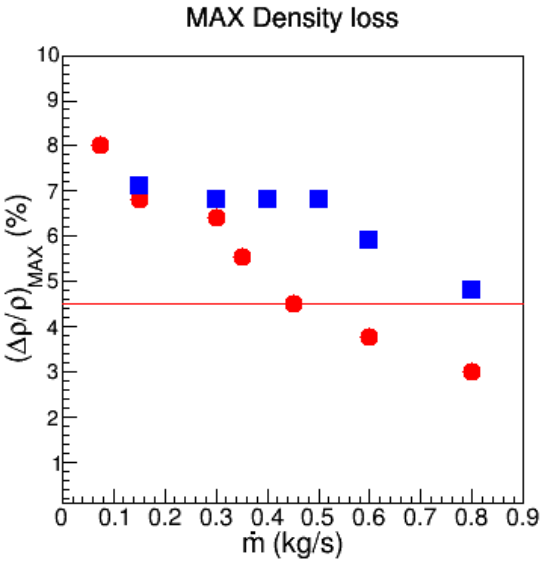
RHRS: carbon (-0.6+/-1.1)%/100 μA
LH2 (-2.9+/-0.9)%/100 μA

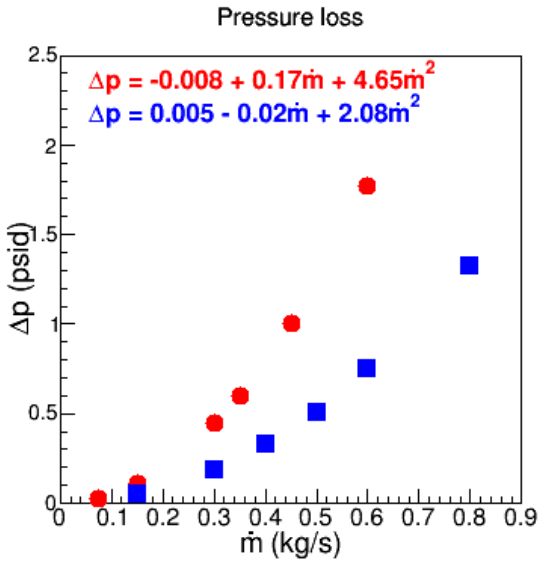
- Corrected for carbon yield drop, the measured LH2 density loss is **(-2.3+/0.9)%/100 μA** with a nominal beam raster of 2.5x3 mm^2 (in MCC units) or less than 2.5x2.5 mm^2 at the target
- CFDFAC predicted a LH2 density loss of **(-1.86+/-0.4% / 100 μA)** beam current with a 100% efficient LH2 pump (which it is not) for the 15 cm target cell

- CFDFAC predictions for the 15 cm long target cell (LH2 and LD2)
- Depending on the LH2 pump efficiency the density loss for LH2 could be anywhere between 1.8% and 3.2% over 100 μA



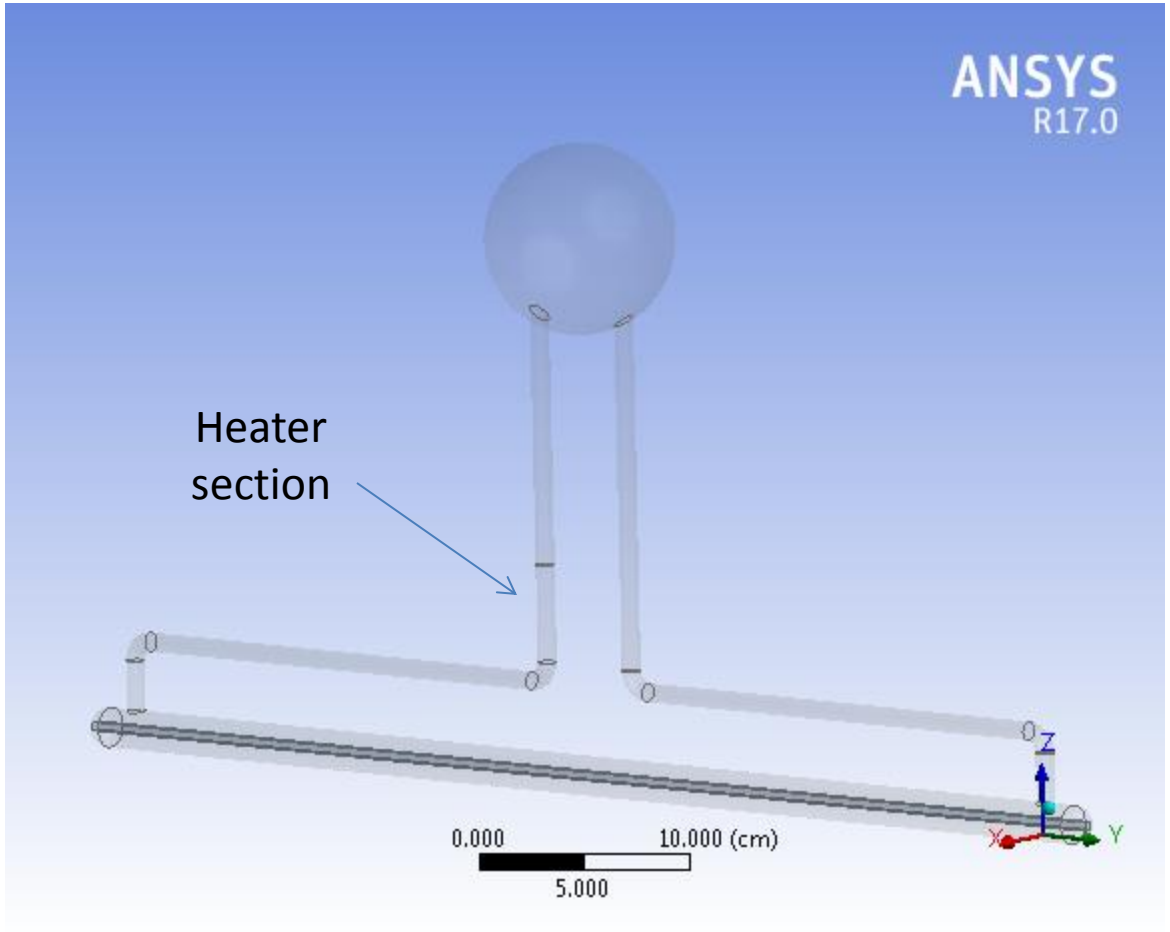




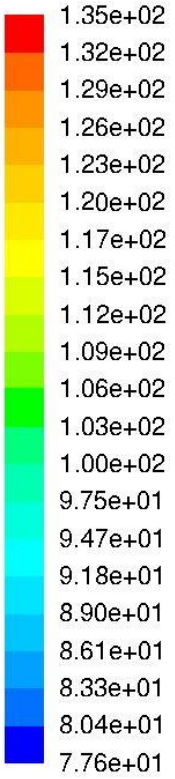


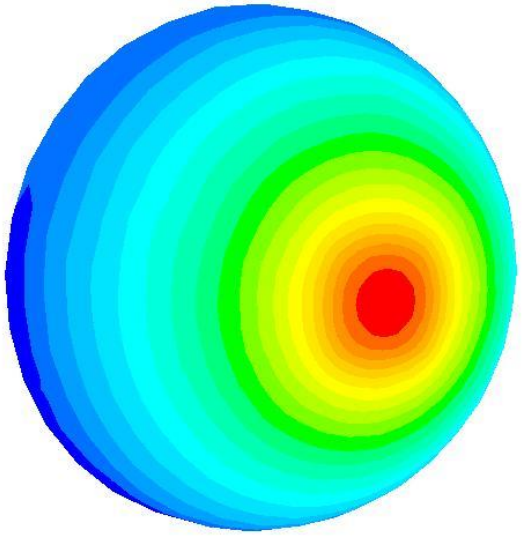
UVA ^{3}He Target Cell, CFDFAC Flow/Thermal Analysis

- 60 cm long glass cell with metal (Cu) end-caps, 2 cm diameter with 3 liter polarizing cell
- 40 atm 3He with the in-beam cell kept at 77 K, the polarizing cell at 240 °C and the heater at 90 °C
- 4x4 mm^2 beam raster at 30 μA
- Glass walls taken to be 1.327 mm thick, Cu beam nipples 0.254 mm
- Conditions proposed in a recent LOI for a PVDIS measurement



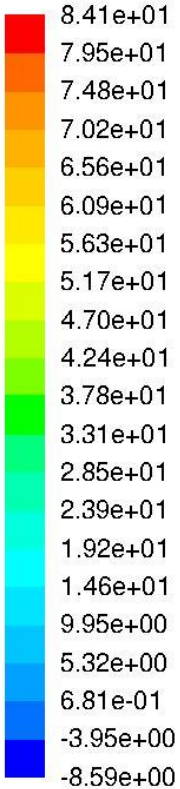
Preliminary results at 9 sec from turning the beam ON





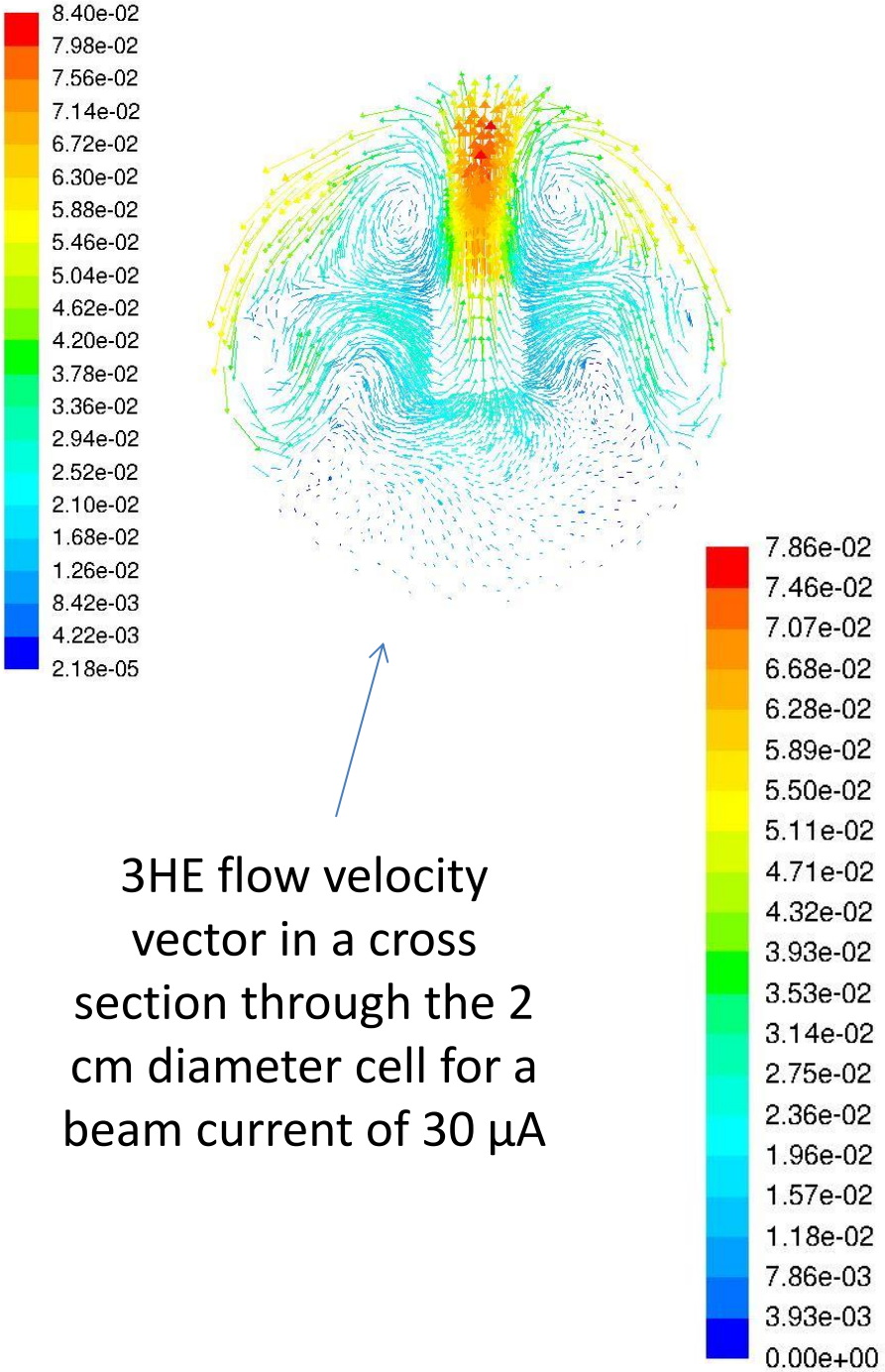
Temperature profile in the beam nipples 4x4 mm^2 and the copper windows, assumed to be 0.254 mm thick

ΔT_{max} = 58 K



3He density loss profile (%) in cross-section through the 60 cm cell at 30 µA beam current, rastered 4x4 mm^2

Estimated total density loss in beam volume 13.4 %@30 µA



3HE flow velocity vector in a cross section through the 2 cm diameter cell for a beam current of 30 µA

3He flow velocity magnitude profiles in cross section through the whole cell

Summary

- Gep(5) 40 cm cell design: two geometries considered for now, qweak-type and g0-type, LH2 in at 25 psia, 20 K, 1 kg/s
- Qweak-type cell CFD predicts less than 1% density loss in beam volume at 75 μA (may have to change the cell geometry to accommodate the acceptance)
- G0-type cell CFD predicts 1.1% density loss @ 75 μA
- Target group needs 3 years to get the Gep(5) target ready for beam
- Gep(5) LH2 target needs more cooling power than ESR(1) can presently deliver on the 15 K supply
- Gmn could use the 15 cm cylindrical cell already designed