# Hall C LH2 Targets

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Hall A GMp Meeting
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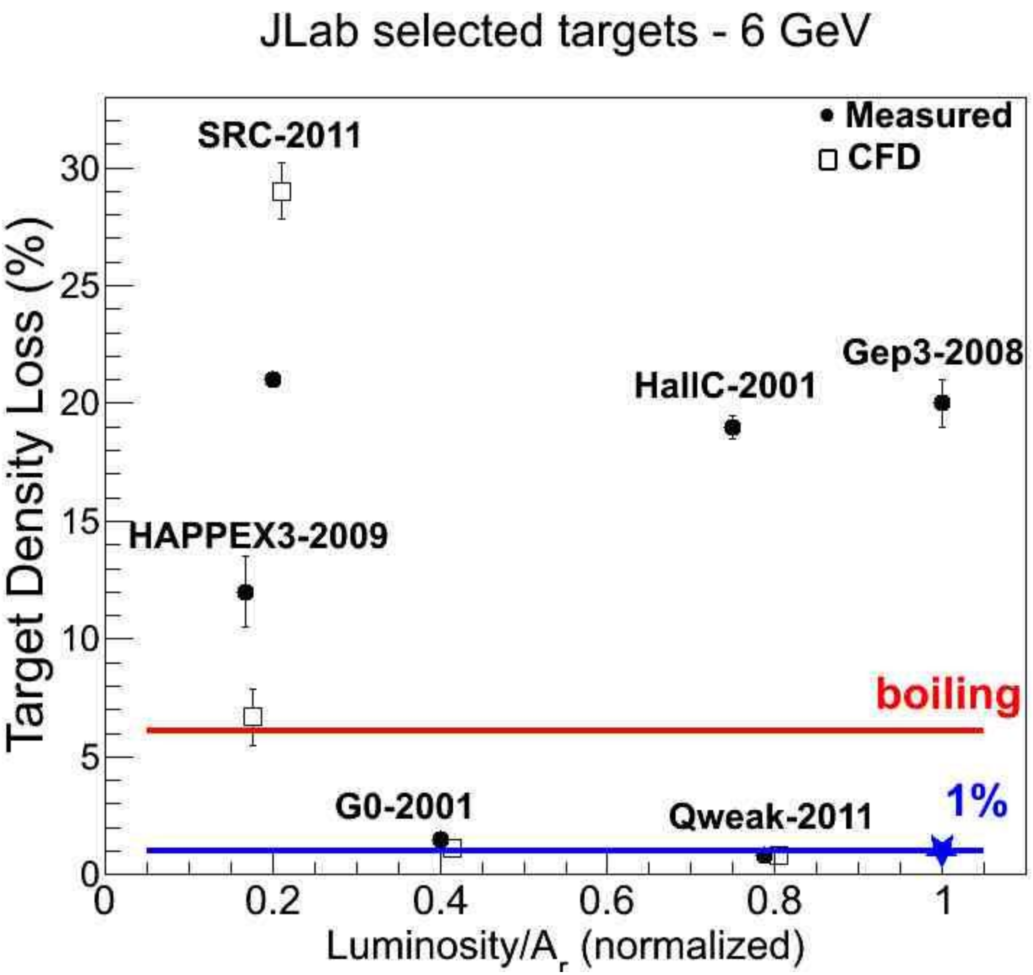
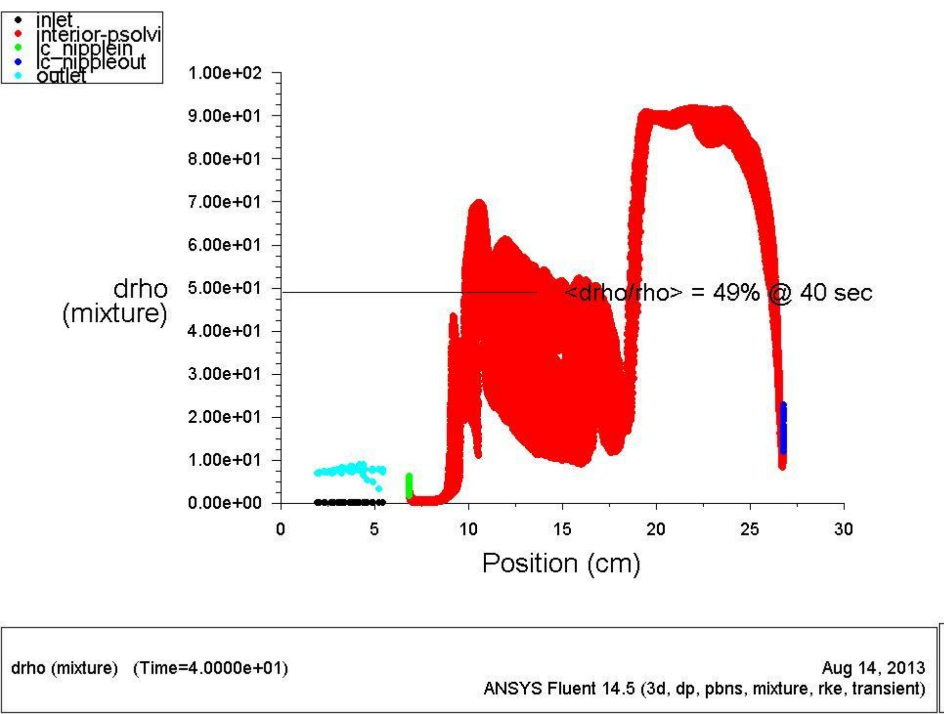
# 6 GeV Targets Performance

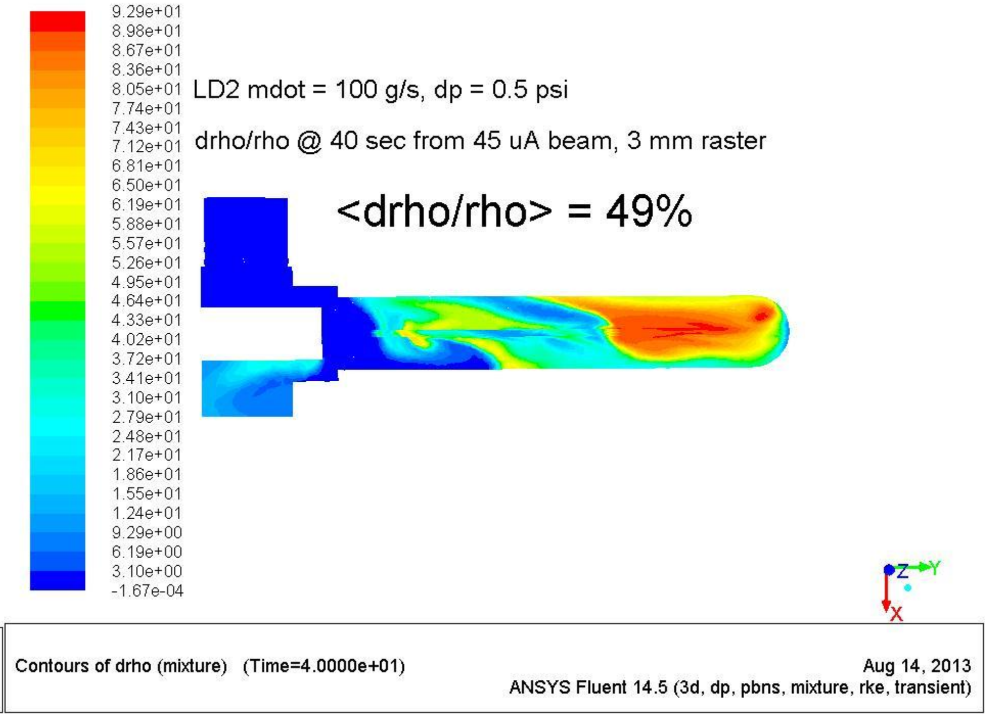
- HAPPEX3 cell was 25 cm long, racetrack design
- All the other cells, except qweak cell, were cylindrical cells
- The only high performance target cells at jlab with lengths > 15 cm were G0 and Qweak! (G0 designed at Caltech, Qweak designed with CFD)
- The goal is to standardize target performance for the 12 GeV program at 1 % density loss over 20 cm with beam of 100 µA, 2 mm raster



# The Hall A SRC-2011 Target

- LD2 up to 45 µA, 4He/3He up to 120 µA (@202 psia!)
- CFD predictions for running LD2 at 30.5 psia, 100 g/s, 0.5 psid over the cell-block only, 45 µA beam, 3 mm raster
- Dangerous vapor-lock bubble over 8 cm in length and 90 % of LD2 density lost



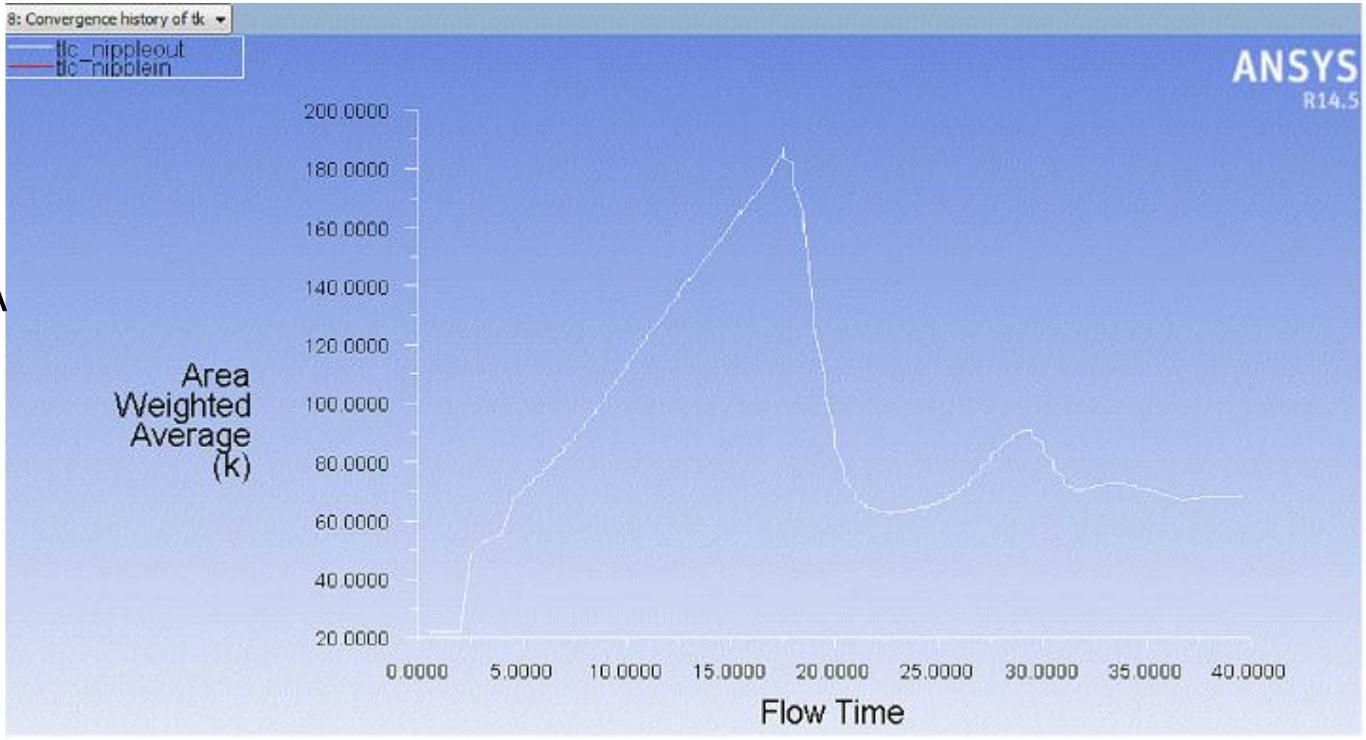



# SRC-2011 Al Windows Heating

- Target cells made of Al, cell diameter 3.114 cm, 20 cm long, it ran 210 psia with 3He/4He and 30.5 psia with LD2
- Beam nipples assumed 0.1016 mm beam-in and 0.127 mm (0.005") beam-out
- Plot shows the average temperature of the beam-out Al nipple (3x3 $mm^2$) versus time, beam being ramped from 0 to 45 µA in ~ 20 sec

## CFD predictions for this cell design:

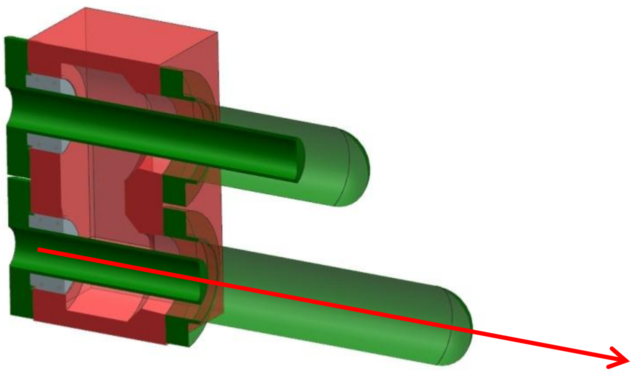
- <T> reaches **200 K** at 45 µA, $T_{max}$ ~ **250 K!!!**
- Runaway T for Al7075 ~ **433 K**
- Beam-out nipple likely to fail at I>70 µA with this ramp rate or lower I for faster ramps
- There is also a pressure spike associated with beam ramping



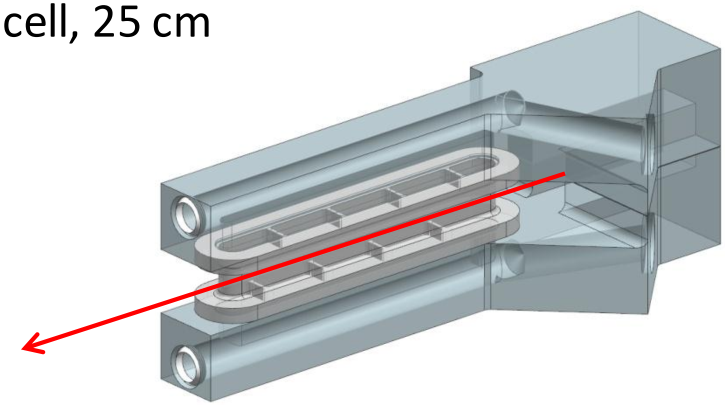
# CFD simulations of 6 GeV Target Cells

- Two geometries considered: 25 cm racetrack cell (HAPPEXIII) and machined double-cells, 15 cm + 4 cm

Machined cells, 4 cm and 15 cm

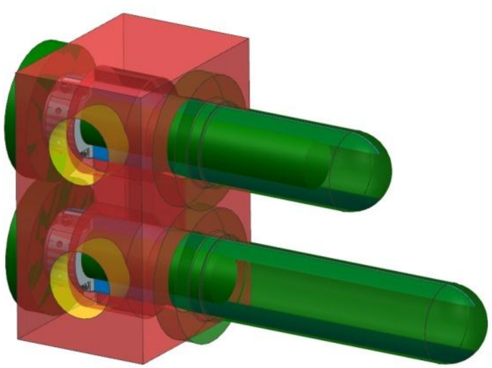


Racetrack cell, 25 cm

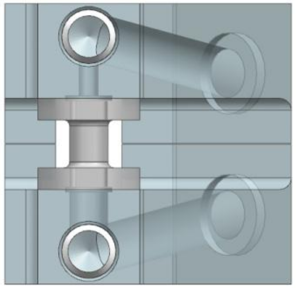


Beam direction

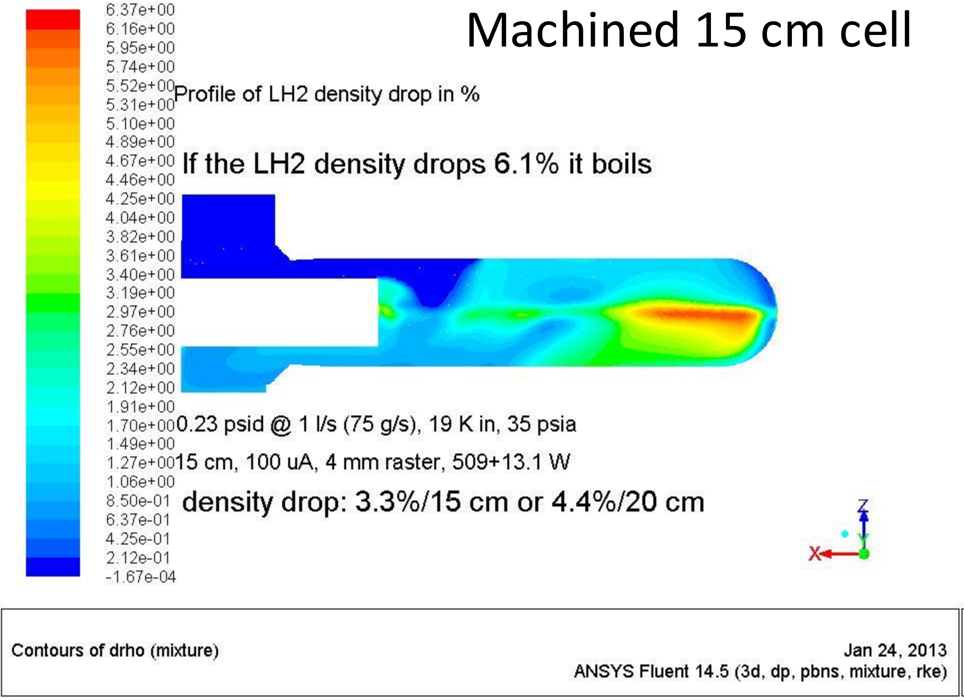
Cell-block volume 0.5 liters

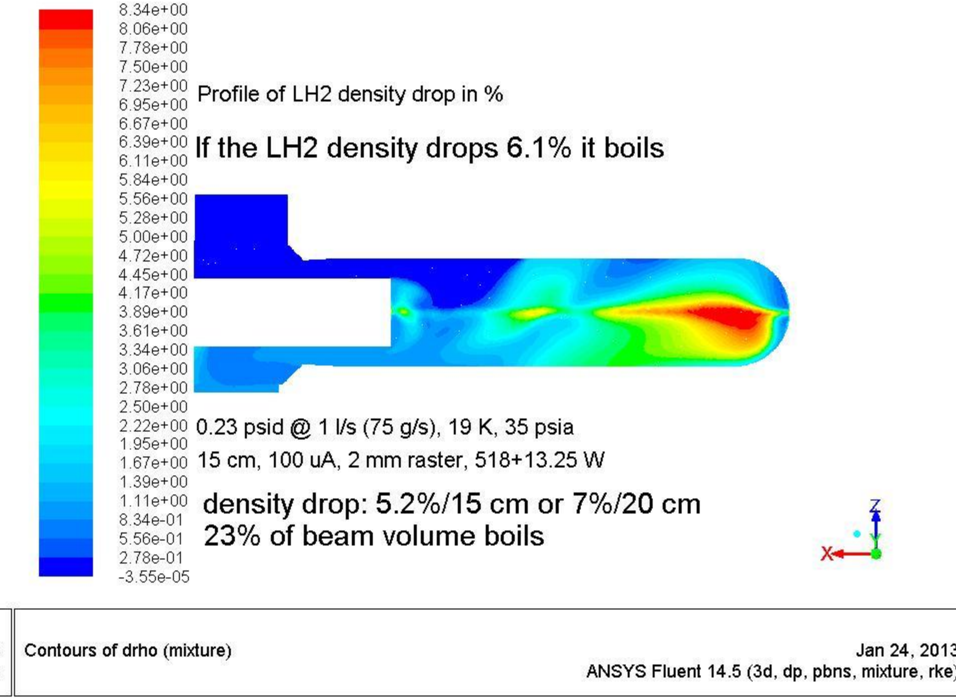


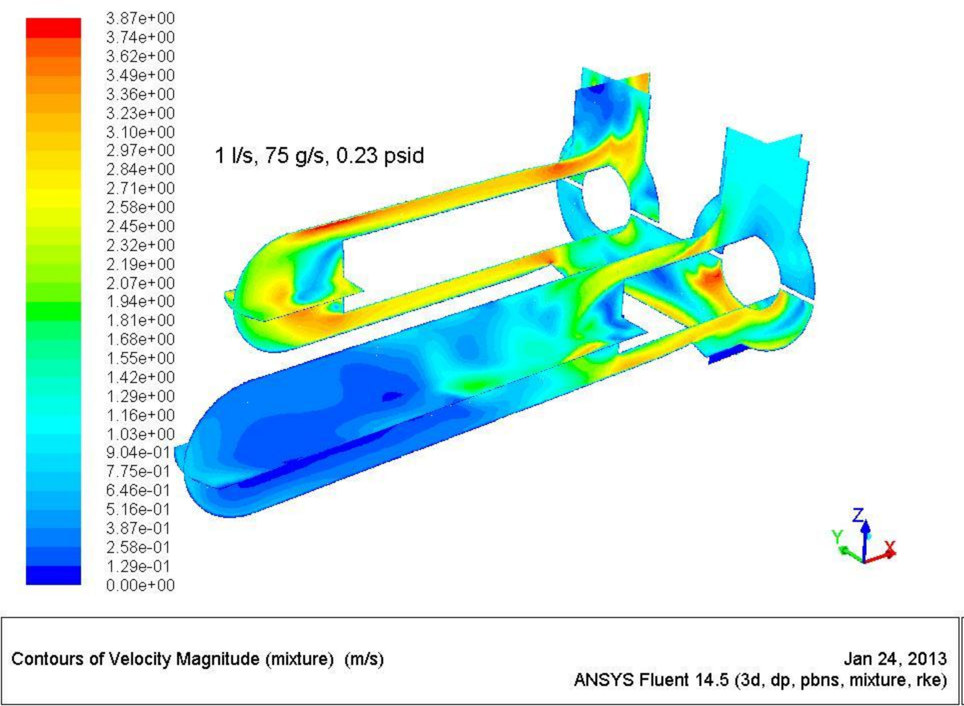
Cell-block volume 1 liter

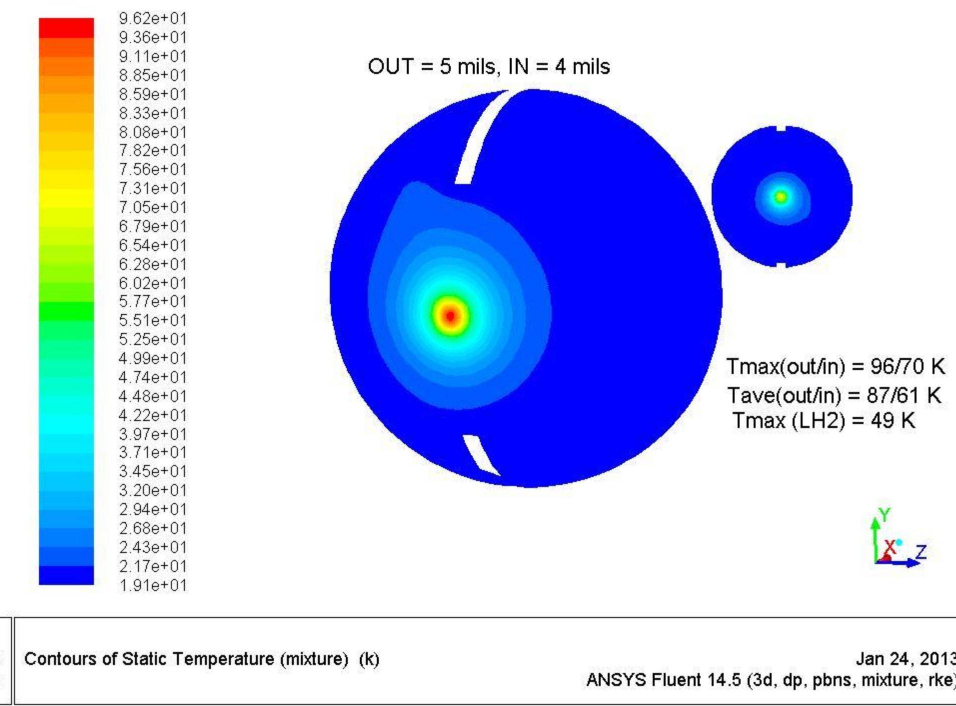


# Machined 15 cm cell

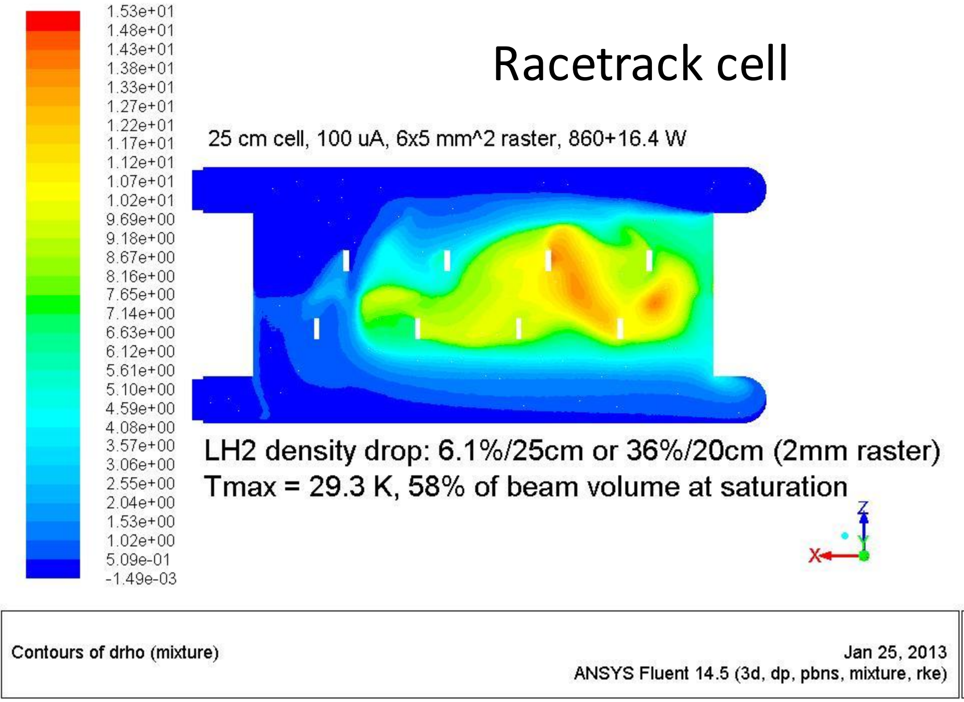


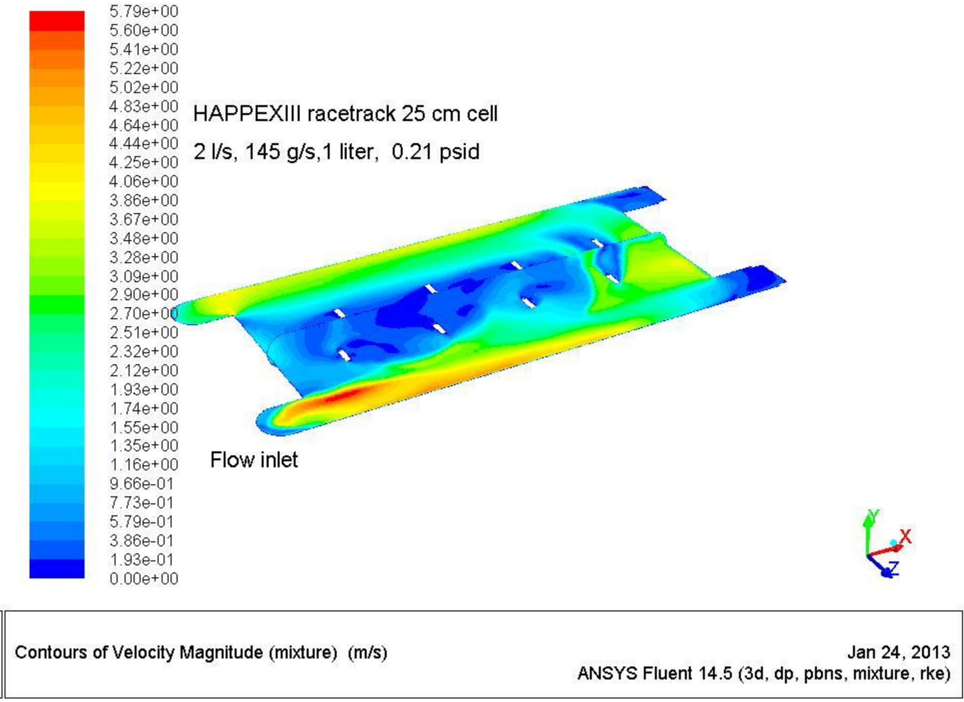



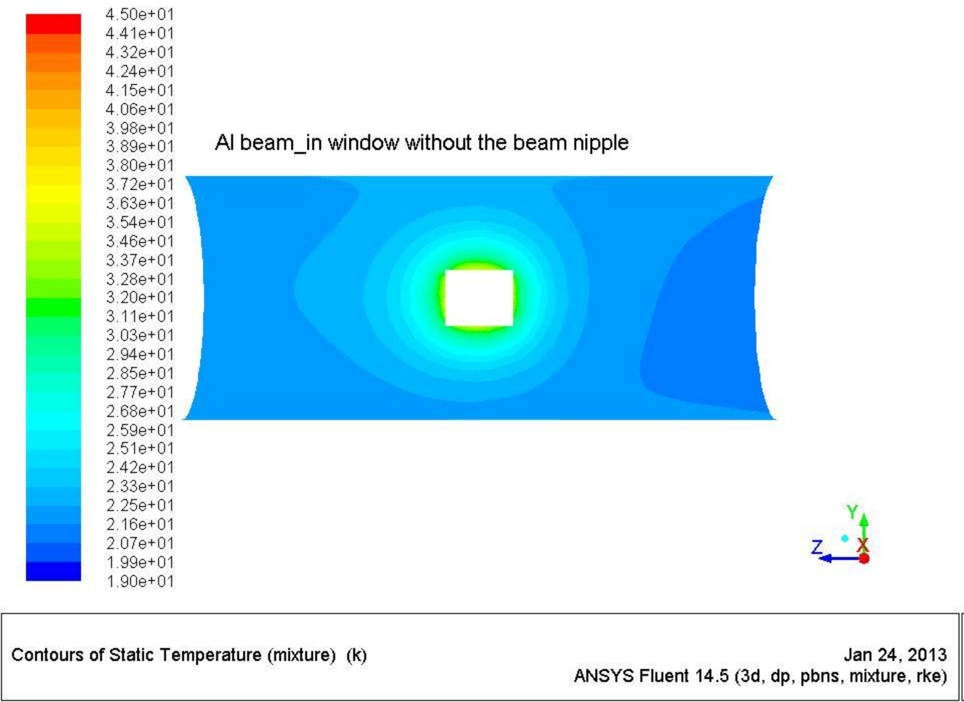



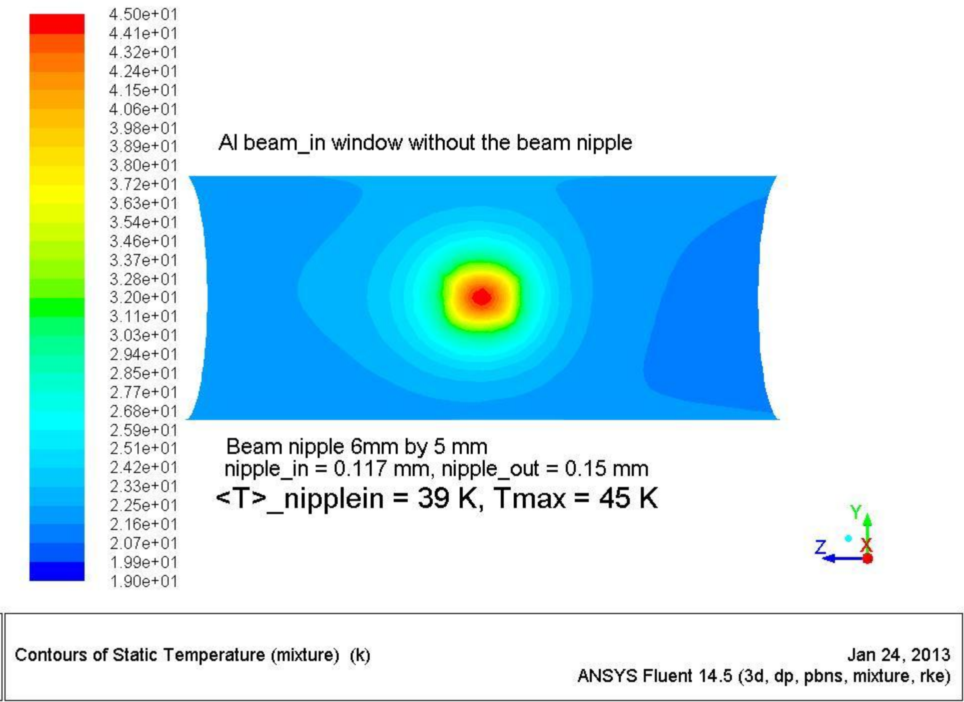



# Racetrack cell



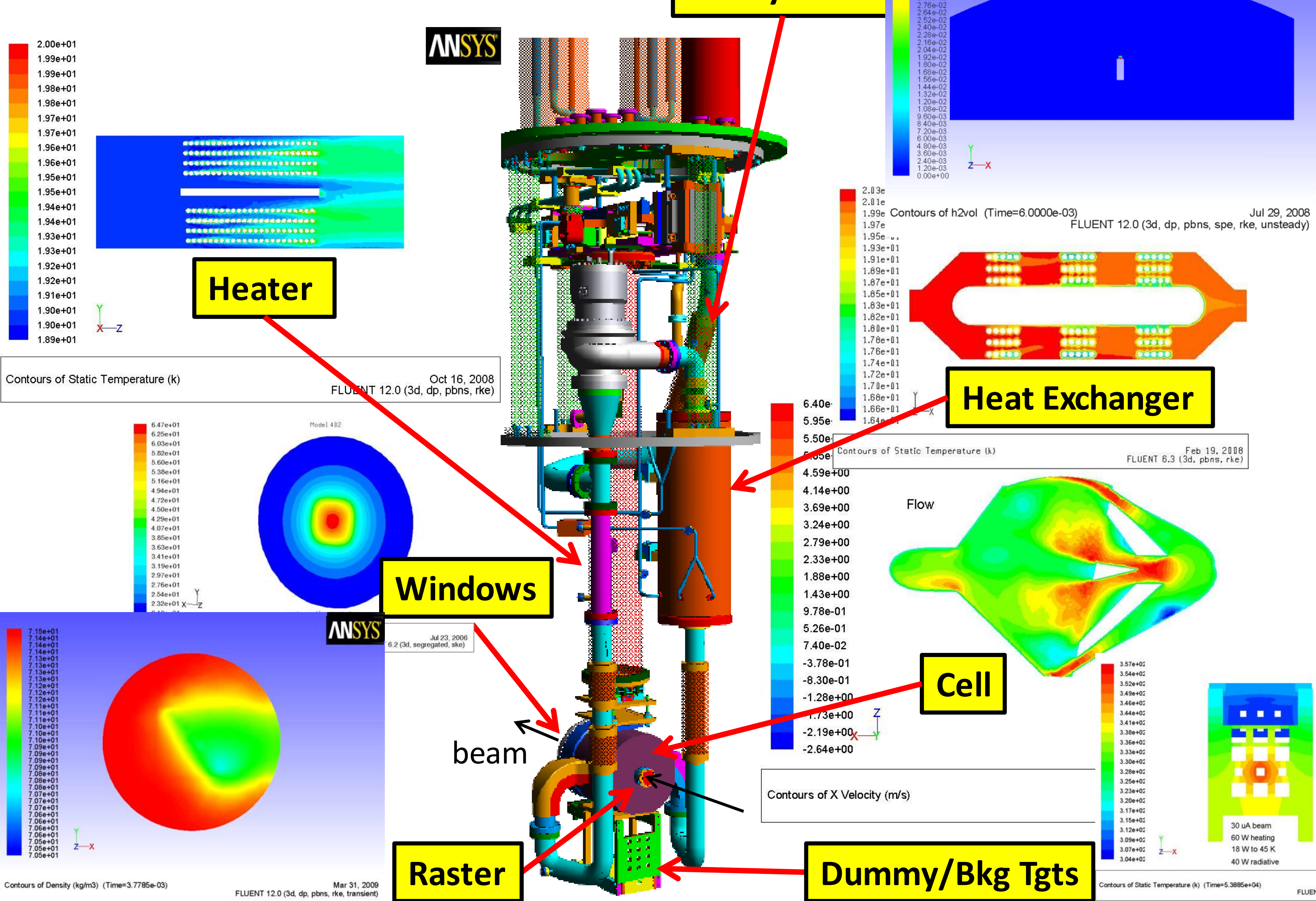



A SEARCH FOR NEW PHYSICS Qweak

# Design by CFD



# The Qweak Target Experience

• LH2 density fluctuations studied versus beam current (I), LH2 pump frequency (or flow velocity), beam raster size and helicity frequency (vary one parameter, keep all others constant)

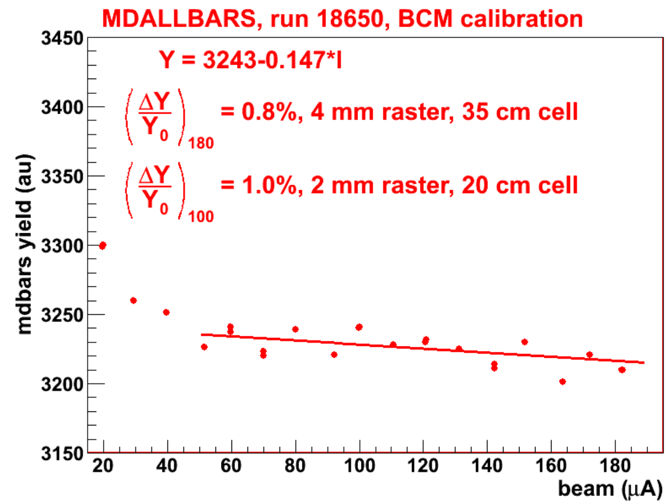
**δρ/ρ of 50 ppm means a 2% increase on pv asymmetry width (the goal was <5%)**

• Run I:

- Δρ/ρ(150 μA) < 1% density reduction
- from beam current scan δρ/ρ = **46 ppm** @ 170 μA, 4x4 mm$^2$, 28.5 Hz
- from LH2 pump scan δρ/ρ = **42 ppm** @ 170 μA, 4x4 mm$^2$, 28.5 Hz
- from beam raster scan δρ/ρ = **46 ppm** @ 182 μA, 4x4 mm$^2$, 28.5 Hz
- helicity frequency from 480 Hz to 960 Hz, δρ/ρ dropped from **68 ppm** to **46 ppm** @ 170 μA

•Run II:

- unclean data (C100 tests done at the same time, trippy, noisy beam), δρ/ρ = **51±5** ppm @ 180 μA, 4x4 mm$^2$, 30 Hz
- sub-cooling @19 K, **δρ/ρ = 36 ppm** @ 180 μA, 4x4 mm$^2$, 30 Hz



# Target Design Principles

## 6 GeV lessons on the standard JLab LH2 target performance

- Cells geometries were not optimized for performance
- LH2 pump flow limits performance

## 12 GeV Design principles: performance and safety

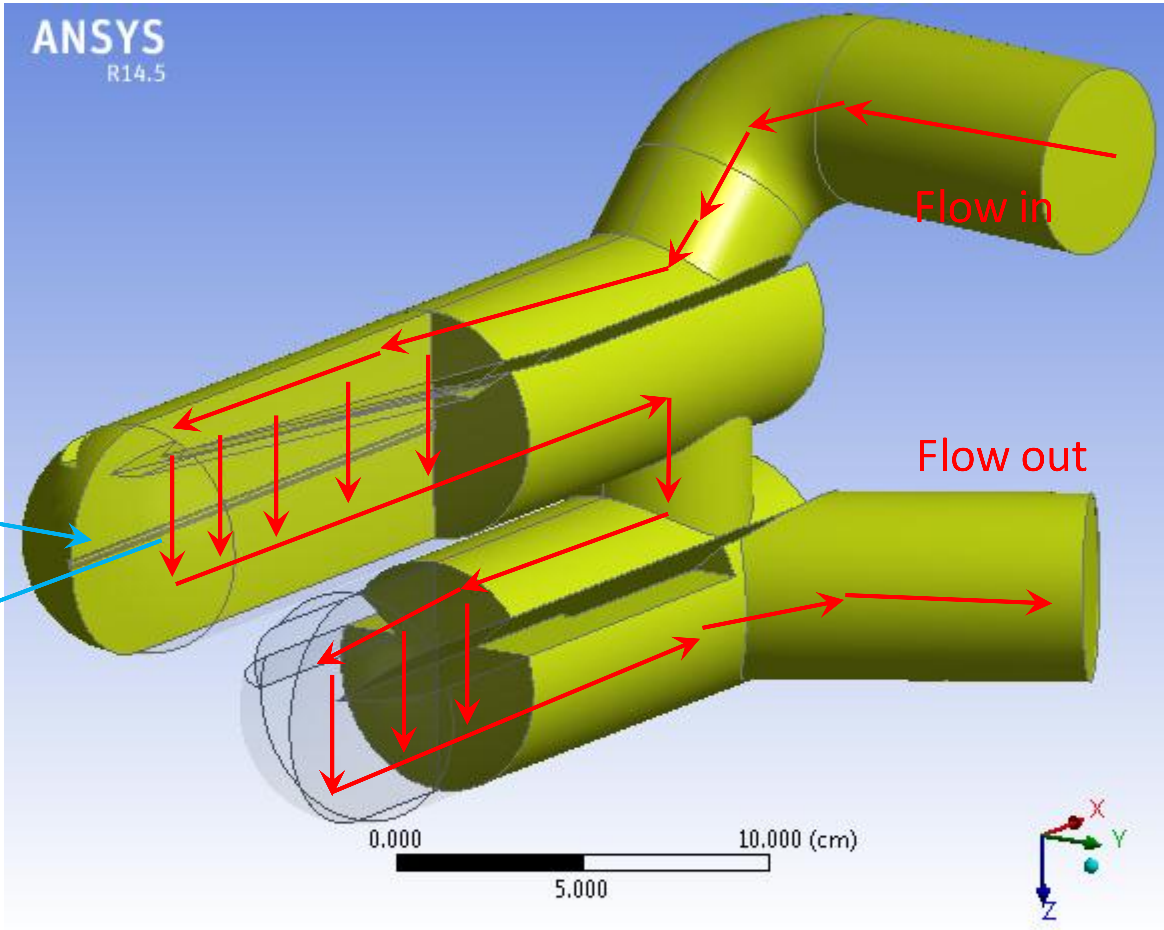
- Performance: limit density reduction **$\Delta\rho/\rho < 1\%$** for cells of 20 cm long, beam currents up to 100 μA, rastered on a square of side 2 mm on the target cell
- Safety (principle: avoid H2 release in the Hall)
- The new target will have 2 high performance loops, each with 2 cells
- A 3$^{rd}$ loop could be installed on demand, single cell, low performance
- **How**: using computational fluid dynamics (CFD)

# Flow Space in the 2 Cell-Block

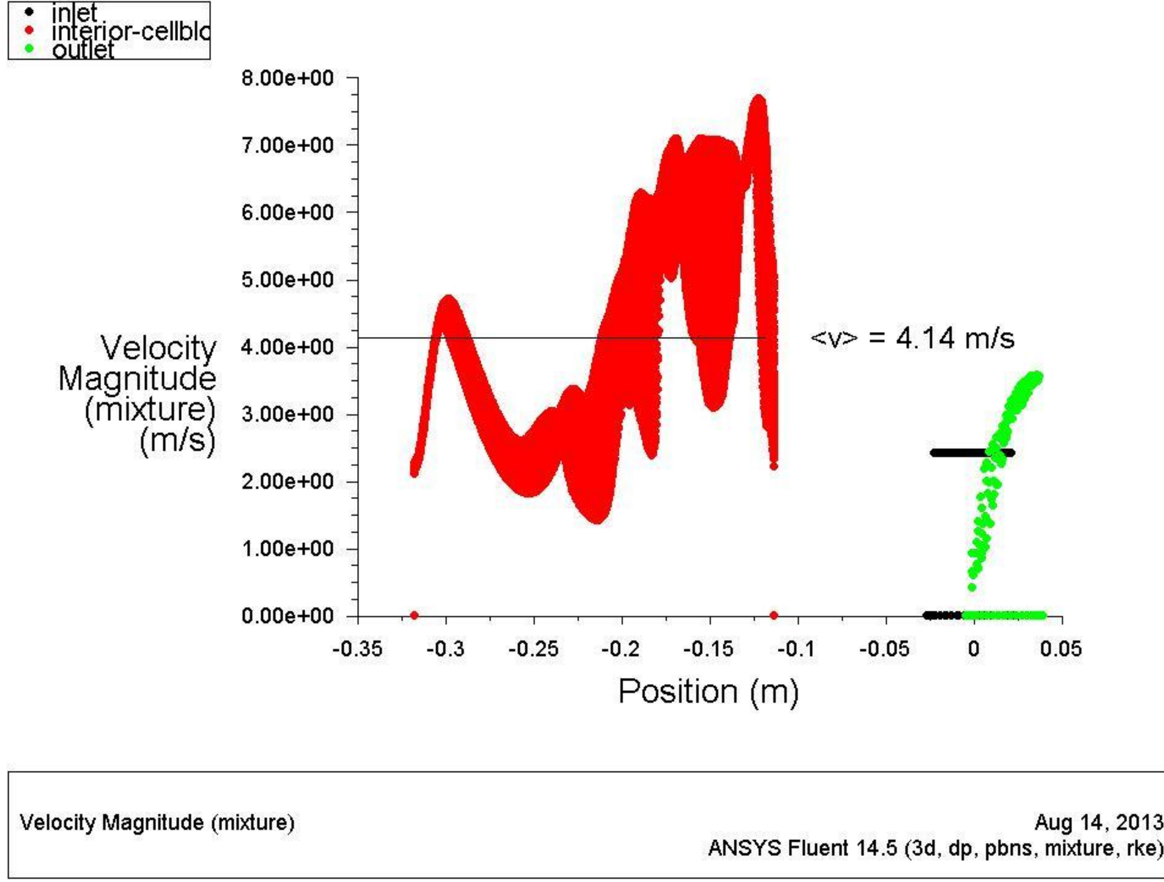
- Cell-block volume 1.9 liters with 2 cells, one 20 cm and one 10 cm long
- Cell diameter 6.28 cm, beam-in cell diameter 1.6 cm

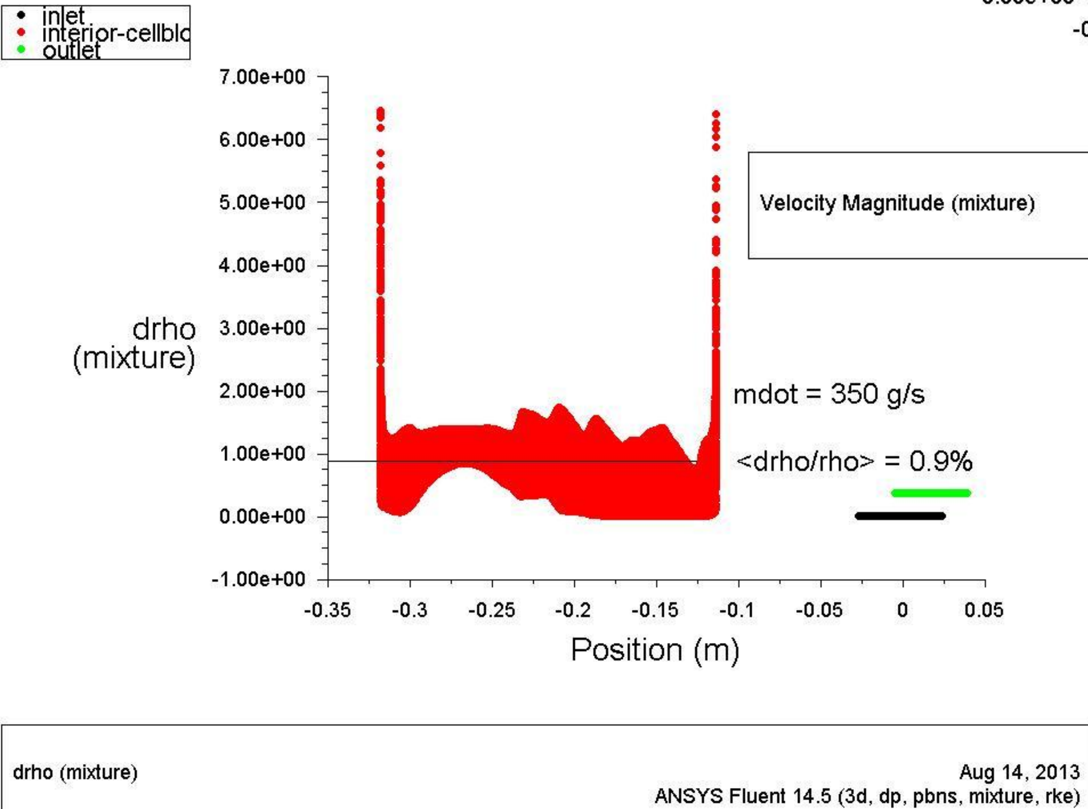
- For a beam envelope of 4 mm the in-beam plane acceptance/clearance is 100 mrad
- Nominal running point would be 20 K, 35 psia
- Beam volume 2x2x200 $mm^3$

Beam direction



- LH2 density loss (%) along the beam axis for 100 µA beam rastered at 2 mm
- Vertical spread is the density loss distribution in the raster area at that location
- End-points are generated by heating at the Al windows



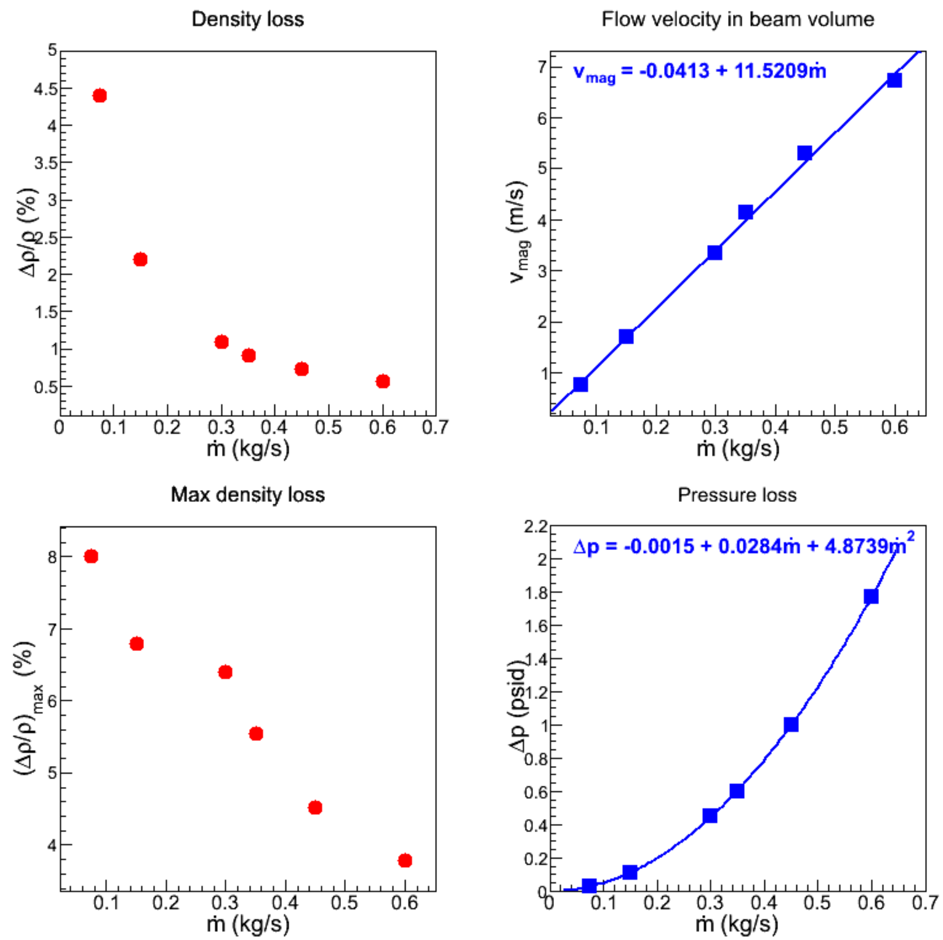




- Fluid velocity distribution along the beam axis in the beam volume (same conditions as above)

# CFD Predictions for the New Cell

- Cell-block volume 1.9 liters with 2 cells, one 20 cm and one 10 cm long
- Cell diameter 6.28 cm, beam-in cell diameter 1.6 cm

- $\Delta\rho/\rho$ ~ 1% reached for mass flows greater than 300-350 g/s
- Dramatic improvement in performance between 100 g/s and 300 g/s, not much more gain above 400 g/s
- Pressure drop expected over the cells-block: 0.45 psi@300 g/s and 0.6 psi@350 g/s
- A new LH2 pump is needed to achieve this performance! (the old pump could give some 3-5% density loss)



# Hardware Status and Plans

## Target loop

- Cell-blocks designed, need to be engineered
- New HXs
- LH2 pump (highest risk component) looking for solutions
- Engineering needed for the whole target loop

## Target system

- Version “0” of a 3D CAD model generated
- Engineering needed to sit the target loops in their chamber
- Assess the performance of the LH2 pump cold (2014)
- Assess the target in the Hall in-situ with LH2 (2015)

# Manpower

- Designers: Chris Wicker (EngDiv), summer student Billy Barrios (CalStateLA)
- Design Authority: looking into it (this is the engineering part)
- Ph.D. thesis student: Michael Moore (ODU) – responsible for assessing the new target system
- Looking to a M.Sc. student to help develop the LH2 pump over the next year
- Looking for a technician to help with target assembly over the next year or so
- Hall C staff: G. Smith (part-time), S. Covrig