Polarized ^{3}He Target for A1n/d2n in Hall C

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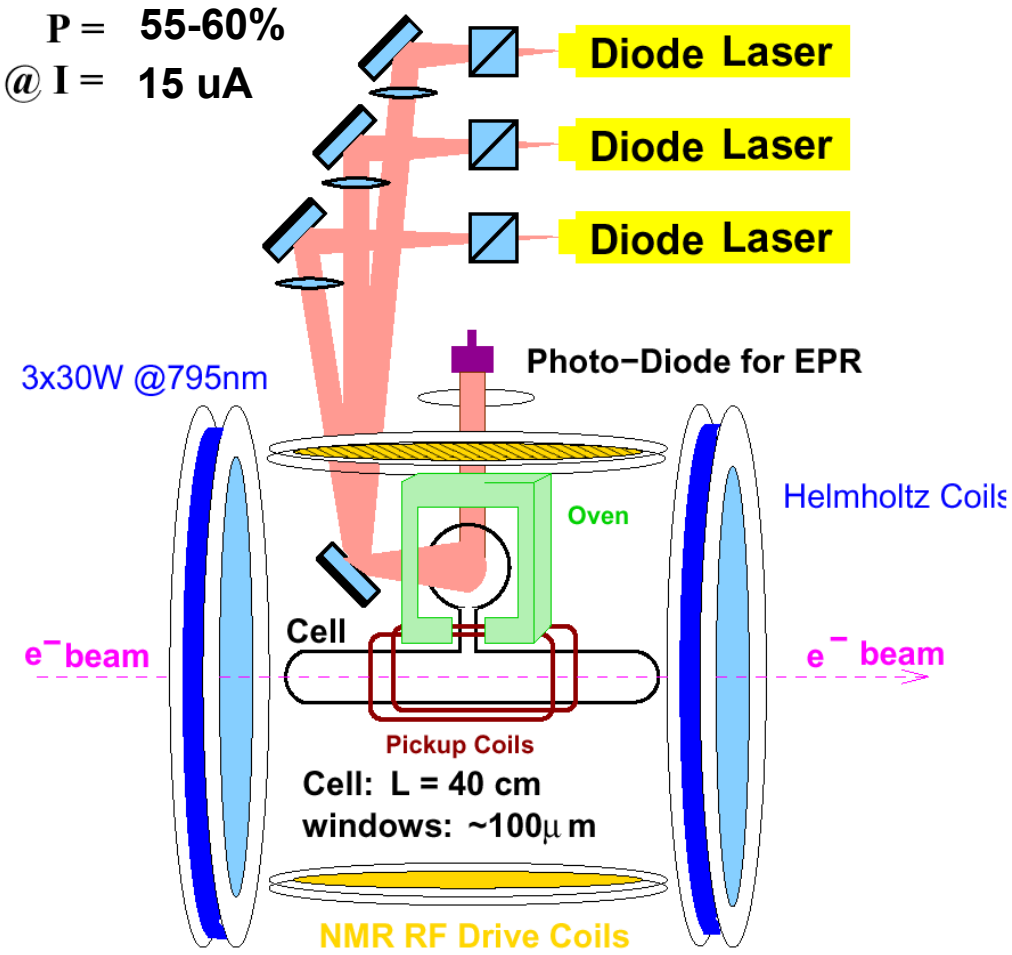
A1n/d2n Collaboration Meeting, June 15, 2018

- Polarized ^{3}He target: introduction and 6 GeV performance
- Target for A1n/d2n
  - Upgrade
- Current status and plan
  - Engineering/mechanical
  - Target system
- Summary

JLab Polarized ^{3}He Target



✓Effective pol neutron target

✓longitudinal, transverse
(and vertical)

✓Luminosity=10^{36} (1/s)
(highest in the world)
upgrade : x2 (stage I)
additional x3 (stage II)

✓High in-beam polarization
60% (>70% no beam)

✓13 completed experiments
9 approved with 12 GeV (A/C)

Polarized ^{3}He Performance for 6 GeV Experiments

- **luminosity/cell: 10^{36} with 15 uA on 40 cm cell,**
  ~10 atm ^{3}He, 3-inch diameter sphere pumping chamber

- **polarization:**
  < 40% in 1998
  with K-Rb hybrid pumping and narrow-width lasers
  improved to > 70% (no beam) in 2008
  ~ 60% (with beam/flip)
  ~ 55% (average for transversity experiment)

- **polarimetry:**
  - ✓ **NMR-AFP/water +EPR, with Rb only, reached 3%**
  - ✓ **transversity: Rb-K hybrid and longer transfer tube**
    total uncertainty @ target, only reached ~ 5%
    diffusion (2-3%), κ_0 for EPR (2-3%).

- **Excellent training ground for students**

Polarized He3 Target Upgrade for A1n/d2n

Hall C A1n/d2n goals:

- 30 uA on 40 cm , ~10 atm, L ~ 2.2×10^{36} $cm^{-2}s^{-1}$
- In-beam polarization ~ 55-60%,
- Polarization measurement precision ~ 3%

Approaches:

- Re-use existing Helmholtz coils and most existing hardware, electronics and optics
- Convection flow
- Target cell, pumping chamber size 3.5", glass cell
- Polarimetry ~ aim for 3%, Pulse NMR calibrated with AFP NMR
  absolute calibration with EPR, AFP-NMR with water optional
- Modification to Hall C pivot area and new platform/laser optics line

A lot of work, many tasks completed (Nguyen Ton/Kai Jin's talks)
but significant amount of work remain to be done before the installation

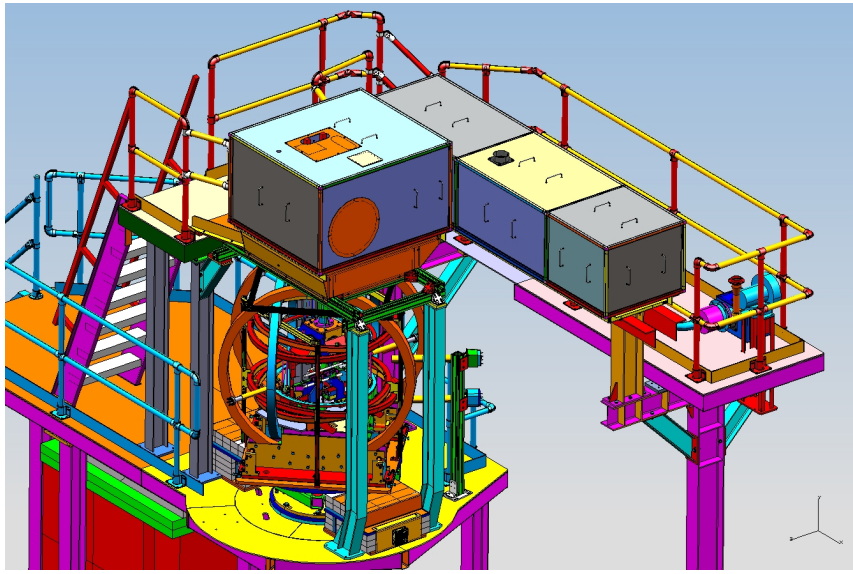
Also started looking into preparation for hall installation

identifying installation requirements: space, shielding, electronics, cables, …

Progress Summary

Engineering/Design:

- target design complete:
  oven, ladder, support, optical line,
  enclosure, pivot area, access platform, …
- installation design mostly complete



Mechanical:

- New parts ordered
- Target ladder manufactured
- Pivot area modified (poster cut)
- Existing parts (in storage) checked
  need test in advance

Field gradients at target area: (talk by Gordon Cates)

- Study bender field at the target region
  and magnetic material nearby
- Correct field gradients with correction coils

Progress Summary (cont.)

- **New oven manufactured/installed/tested**
- **Target cells**

✓ prototyping convection cell extensively tested,

✓ cell production started

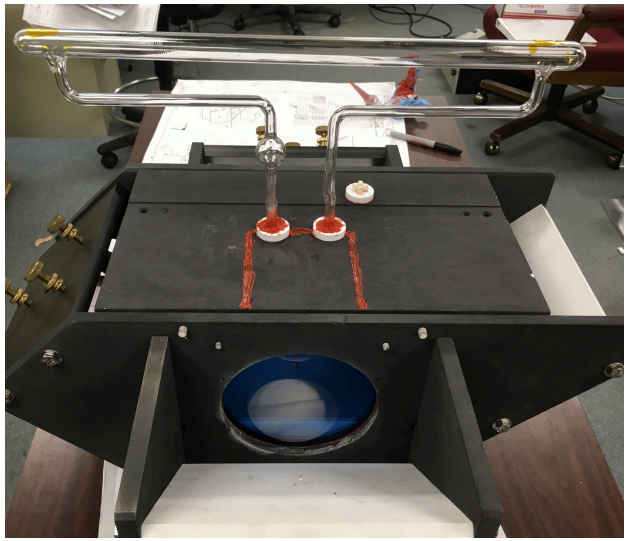
○ 1st good cell: lifetime > 48 hours, tested at UVa, now at JLab for full characterization

○ five cell ordered and production started

○ five more cell order will be placed in FY18

○ order more in FY19 until reaching the goal of having 6-8 good cells.

○ produce/characterize ~one cell per month



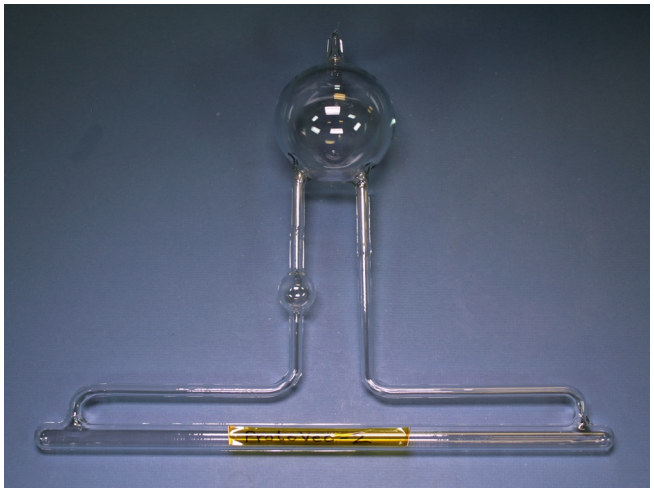
- **Lasers/long optical fibers:**

✓ five new lasers delivered/tested
more will be ordered as spares and for future

✓ ten long fibers delivered, tested

✓ five 4-1 combiners ordered, prototype tested

✓ polarization compensation study complete



Progress Summary (cont.)

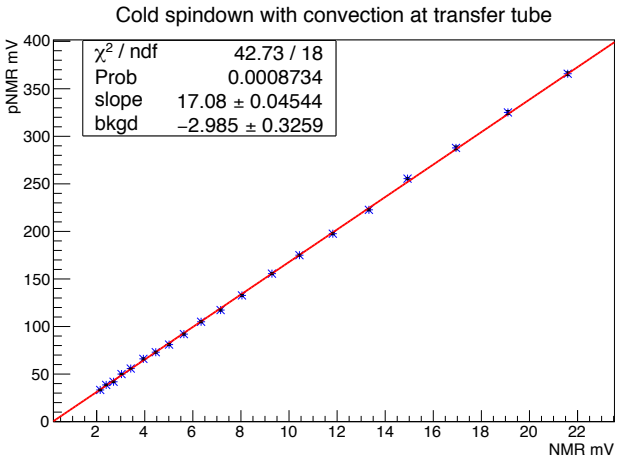
- **Polarimetry:**

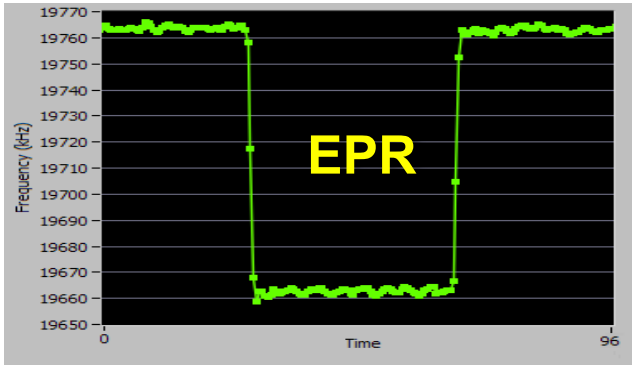
✓ pulse NMR systematic study/calibration (Nguyen Ton)

✓ EPR study (Kai Jin)

✓ κ_0 measurement (W&M/UVa) in progress (Averett/Cates)

will continue study to understand and improve systematics





- **Cell characterization:**

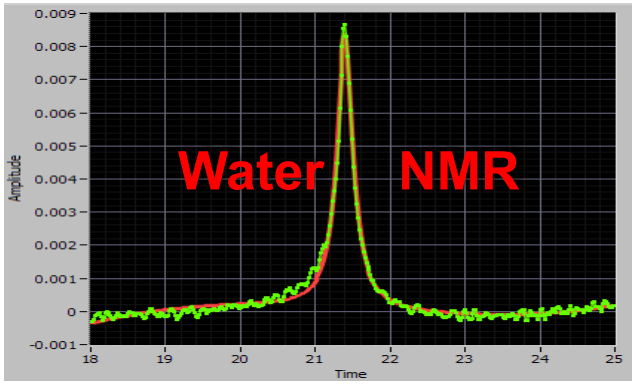
✓ Density measurement (August Williams)

✓ Wall and window thickness measurements

✓ Maximum polarization

✓ Spin up

✓ Spin down/ AFP loss study



Peoplepower/User Contributions

At JLab: students + engineer/designer + JP (supervisor/coordinator)

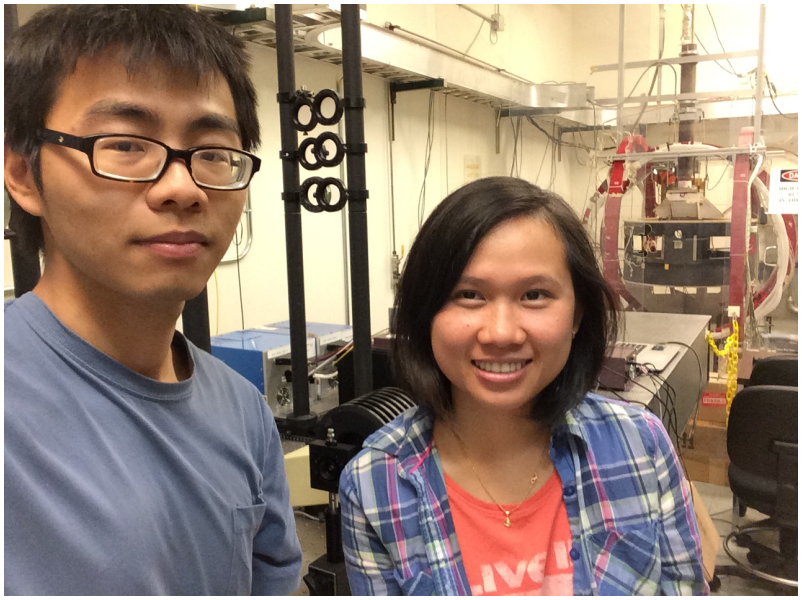
- two graduate students, Kai Jin and Nguyen Ton (UVa, Xiaochao's group) work under JP's supervision for 3 years, ramping down effort

  One new student, Junhao Chen (W&M, Todd's group) started recently

  Expect to have 1-2 more students

At user target labs :

- UVa (Gordon Cates):
  - cell fabrication
  - $\kappa 0$ measurement
- W&M (Todd Averett)
  - $\kappa 0$ measurement
  - Reference cell system/cooling jets
- Kentucky (Wolfgang Korsch)
  - field direction measurement

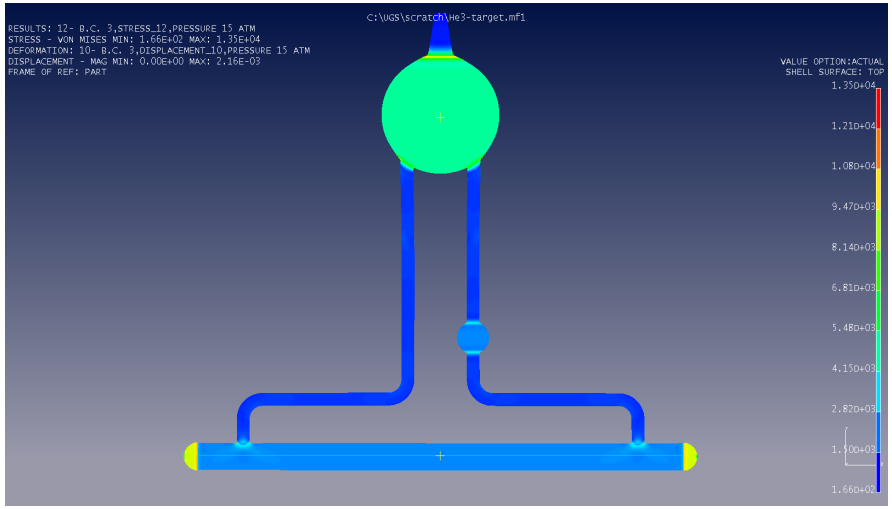


Working at JLab polarized 3He target lab
Kai Jin (UVa), Nguyen Ton (UVa)

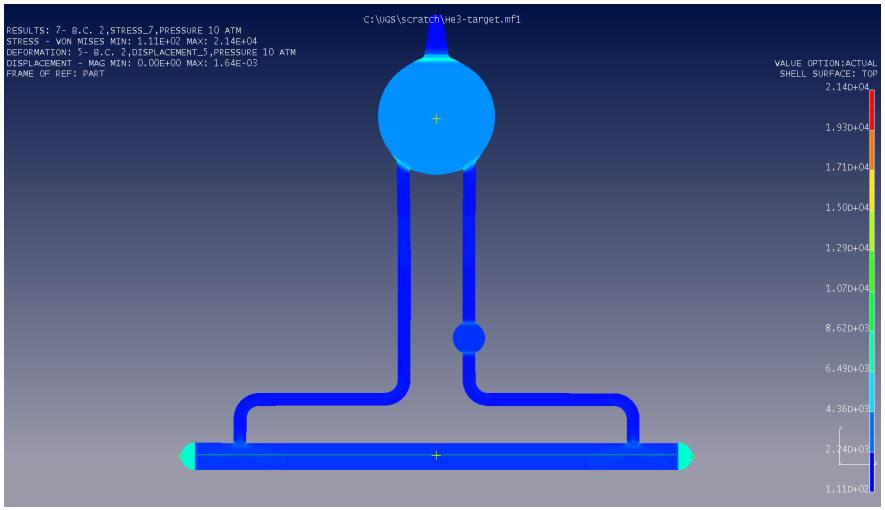
Cell Window Heating (Silviu) and Stress Study (Steve)

- FEA Model prepared for He3 Glass target cell using Pyrex materials properties in place of Ge-180.
- Simple Linear and static results shown for pressures and pressure plus temperature load.
- Max stress is 21.4ksi for beam heating case and 10atm pressure, compared to 13.5ksi for 15atm case. 1.6 increase in stress.

  → corresponding to 24 atm



15 atm @ Room Temperature



10 atm @ End caps @ 651K

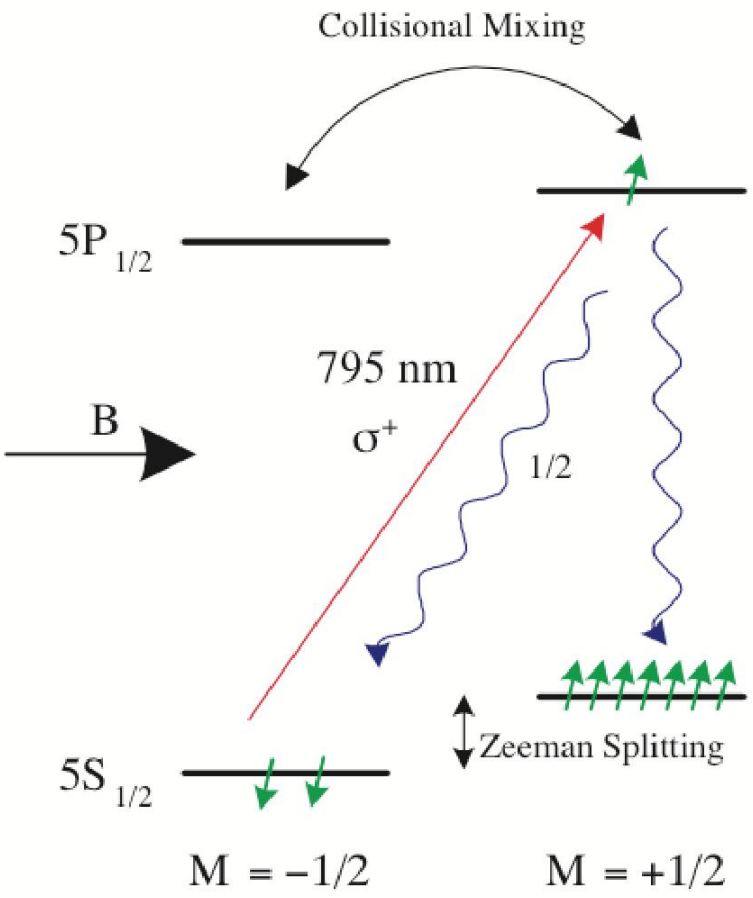
Summary

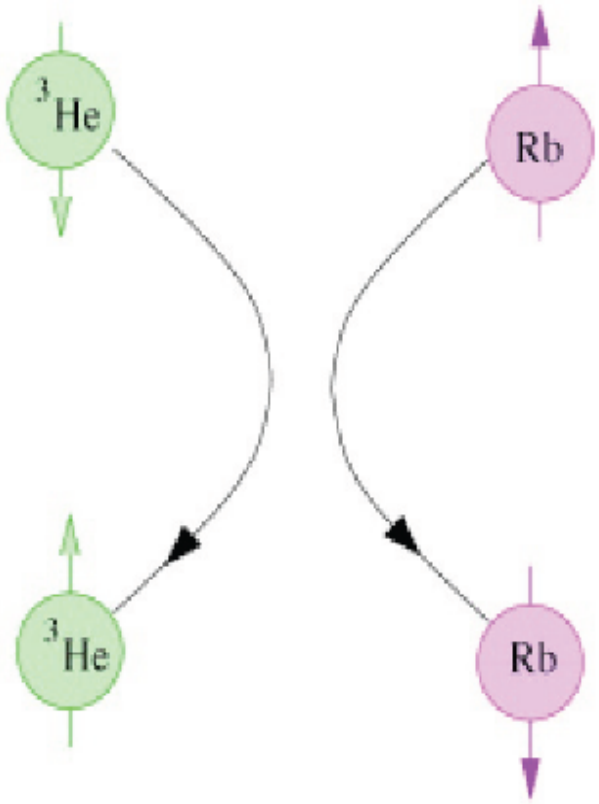
- **Polarized 3He target reliably used for many 6 GeV experiments in Hall A**
- **Upgrade (double luminosity) and make it work in Hall C**
- **A lot of progresses:**
  - **Engineering/Design complete, parts fabricated and delivered**
  - **Hall C pivot area work (post cut) complete**
  - **New oven tested, convection cell extensively tested.**
  - **pulsed NMR established, reached 1% precision in cross calibration**
  - **New lasers, new optical fiber cables**
  - **1st good cell delivered**

  cell production started and on-going (UVa)
- **Long to-do list:**
  - **pNMR with lock-in/ DAQ**
  - **Optimize EPR with final setup, temperature study**
  - **Water calibration in target lab, cross check EPR**
  - **Pressure broadening (density) and wall/window thickness measurements**
  - **Full cell characterizations**
  - **Study and reduce systematics**
  - **COMPASS (UKy), Reference cell (W&M), …**

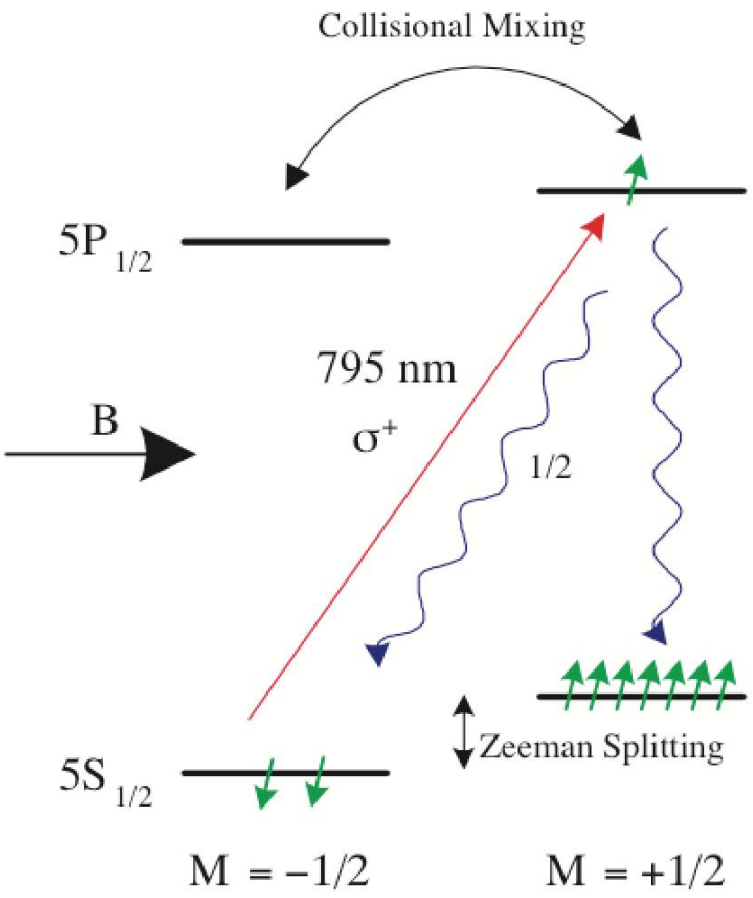
Backup

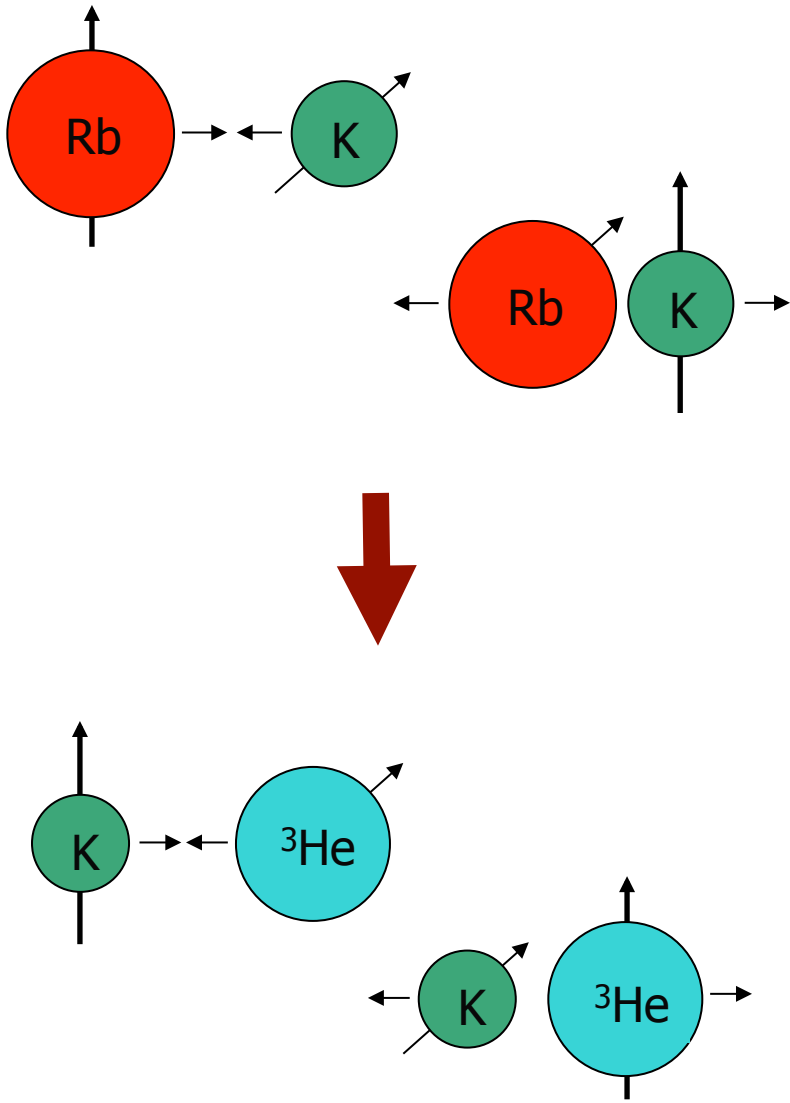
Spin exchange Optical Pumping for ^{3}He



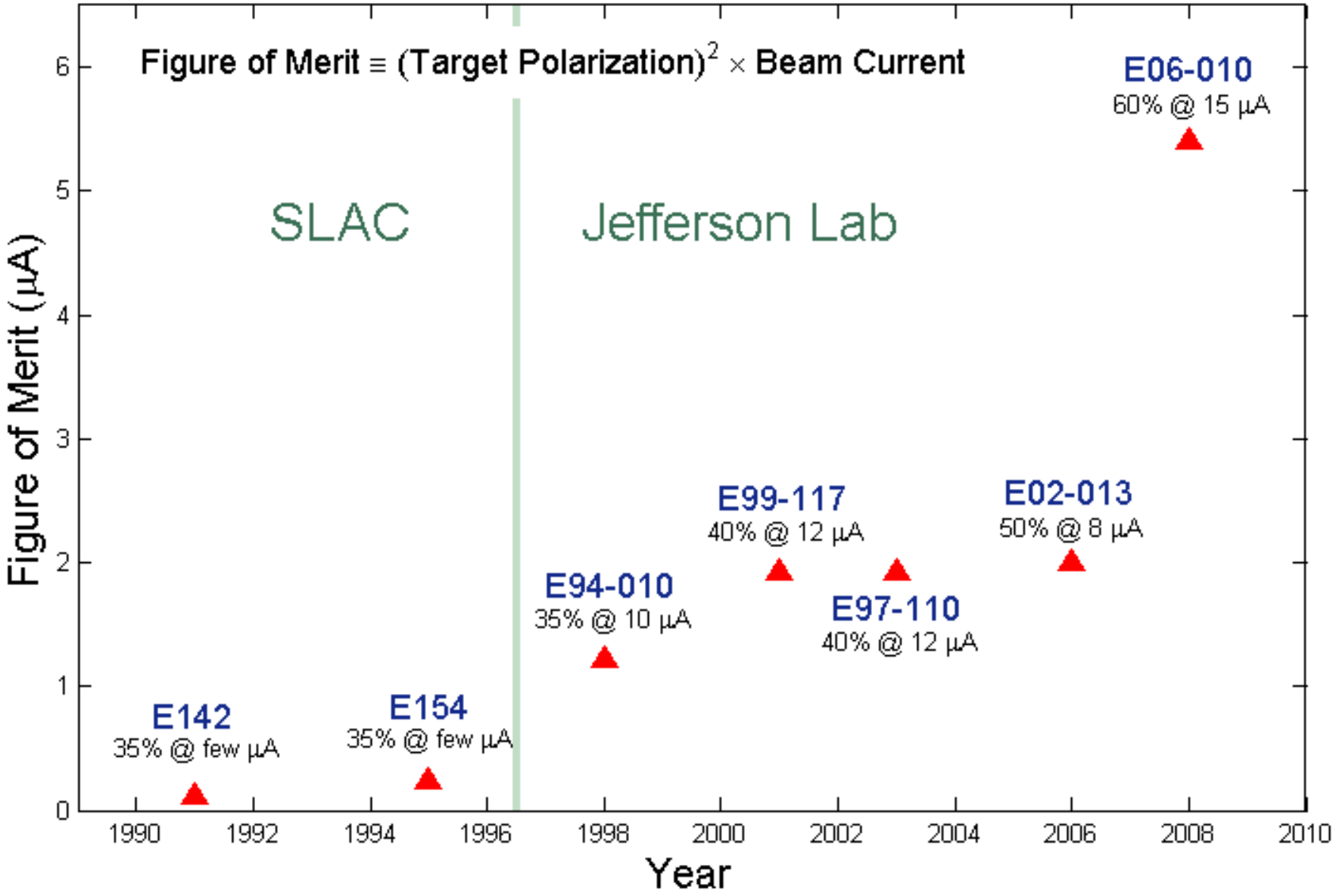


Rb-K Hybrid Optical Pumping Spin Exchange

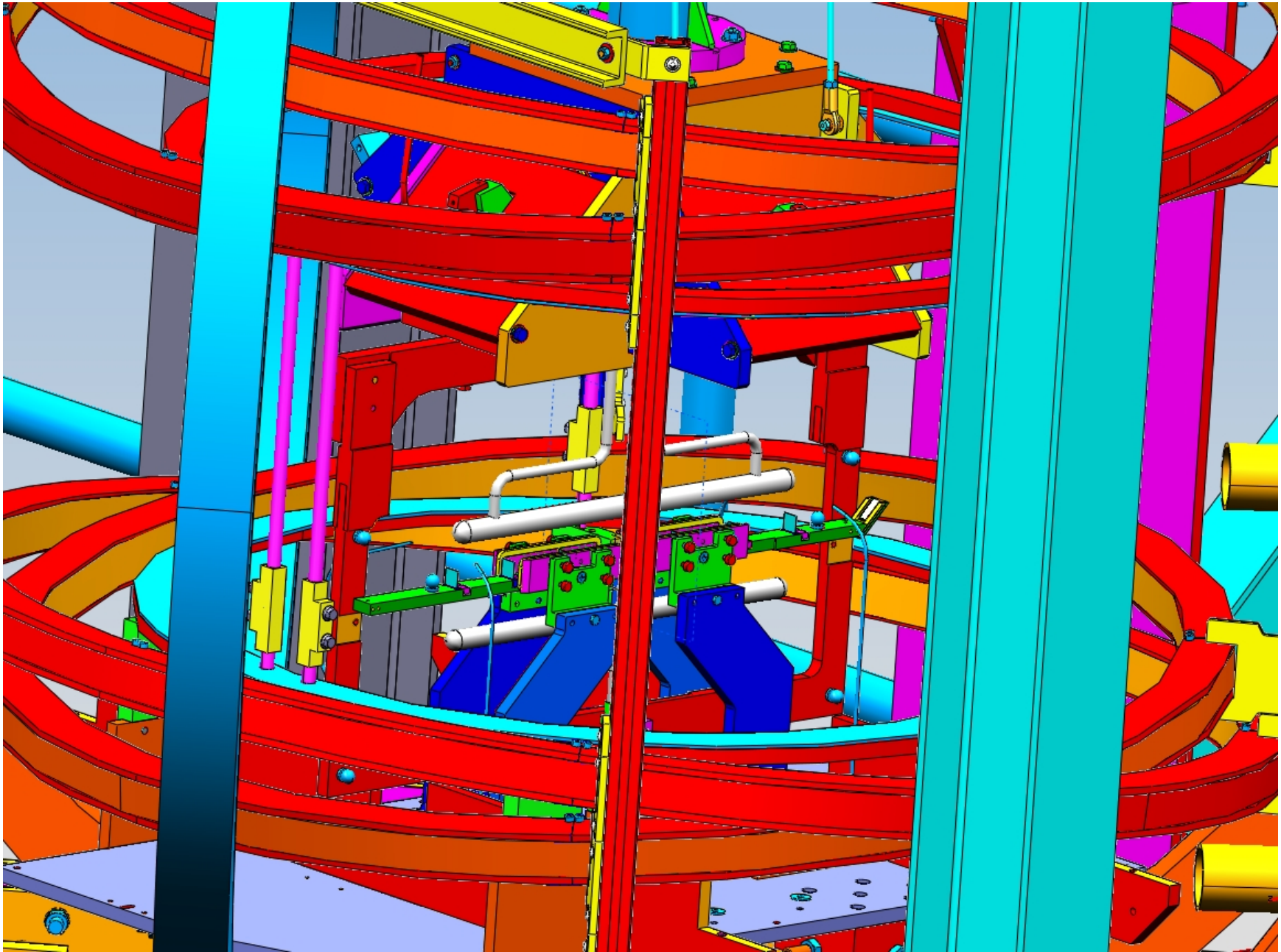




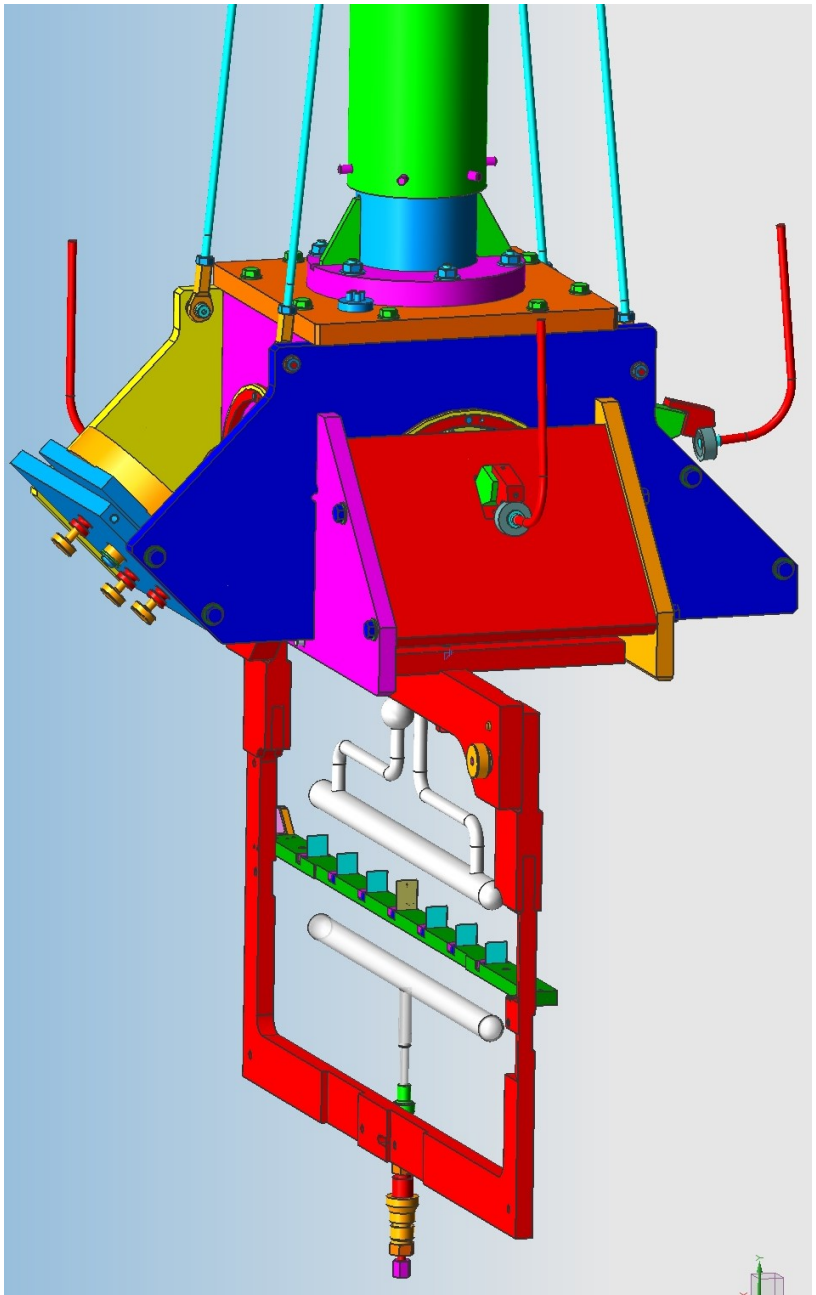
Performance History for High Luminosity Polarized ^{3}He

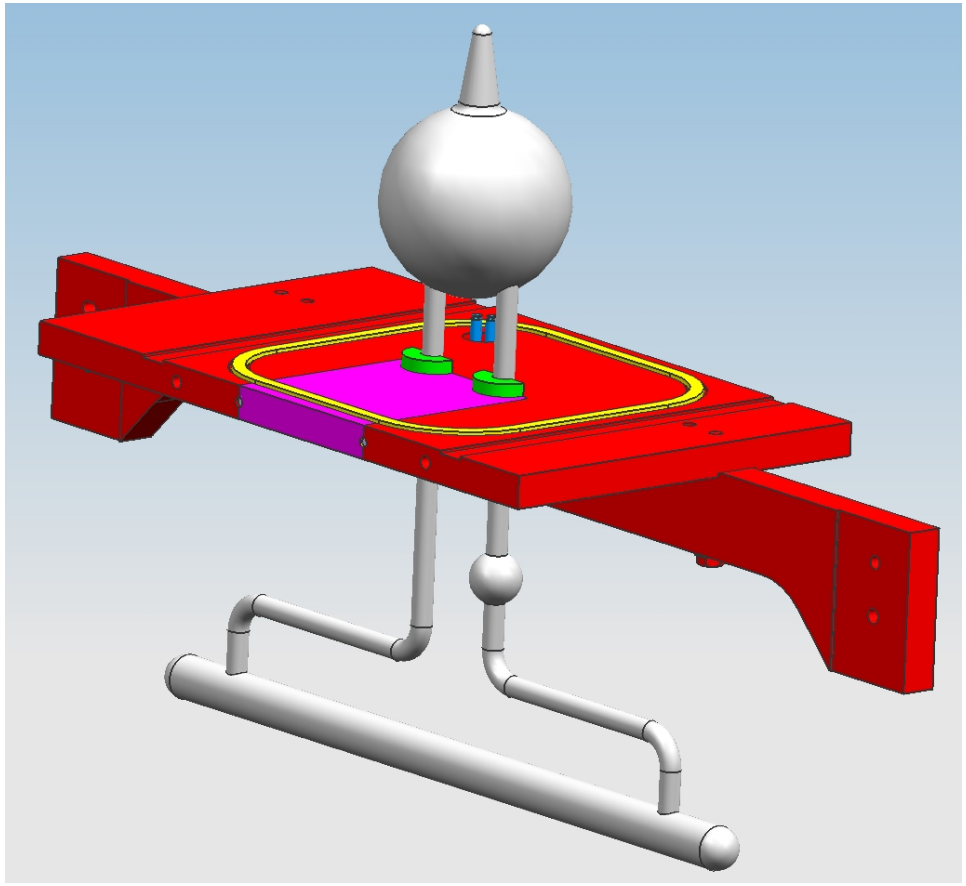


Target System in Hall C

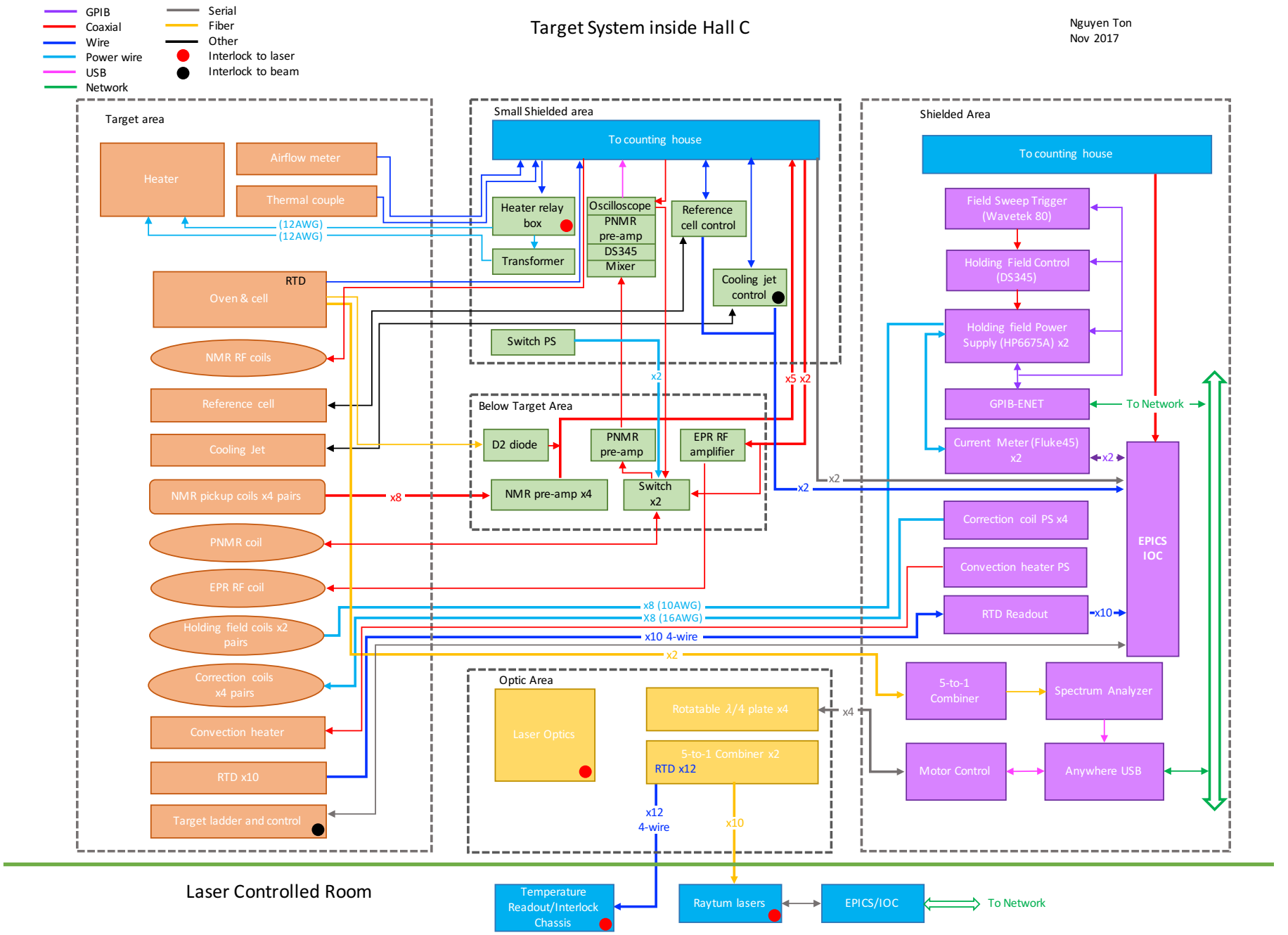


Target Oven, Ladder and Cell





Target Control System Layout/Electronics/Cables



Reference Cell Broken During Transversity