SoLID Cryogenic Target Update

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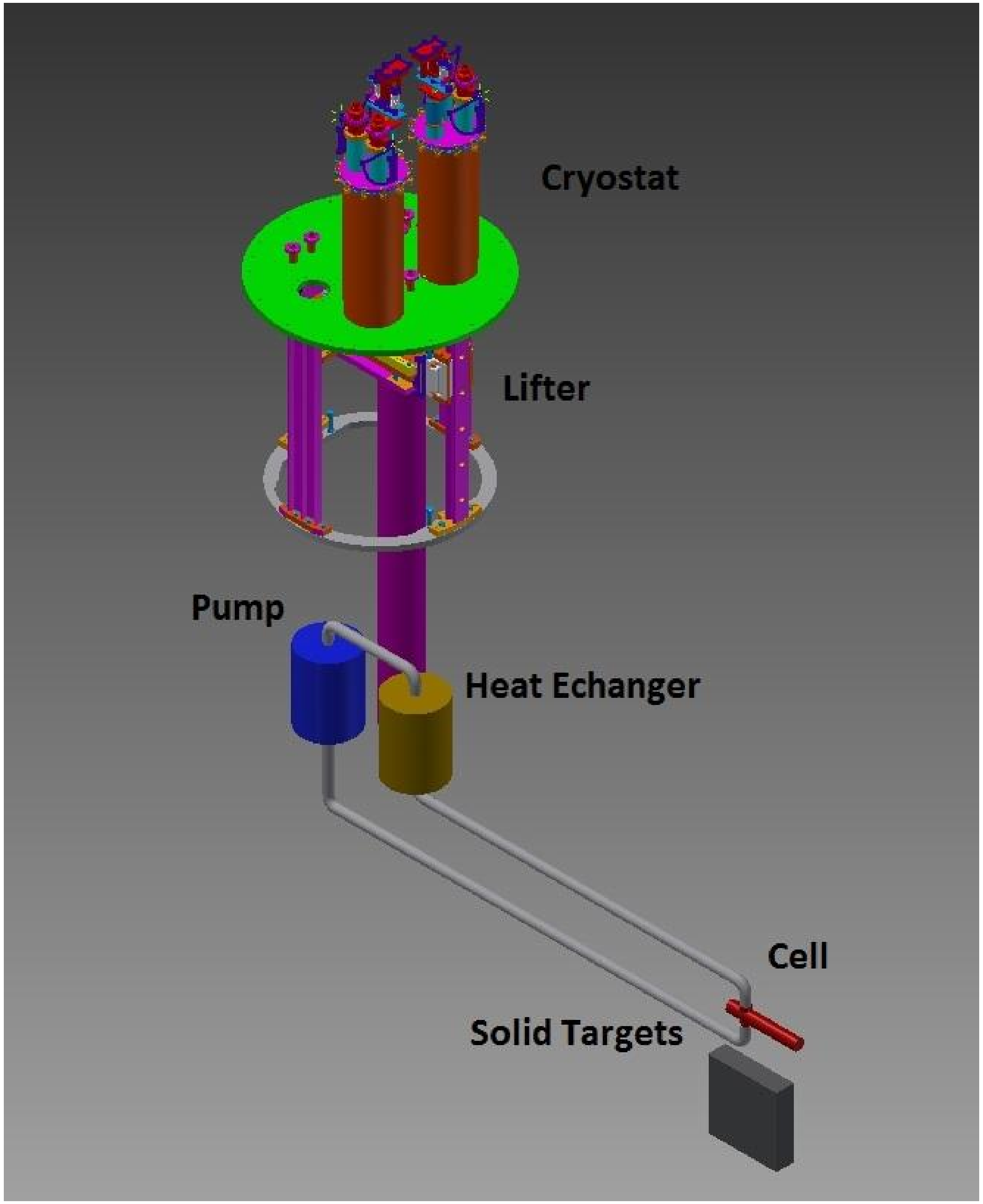
3-22-2013

Cryotarget

- Completely New Design
  - Build on designs of previous systems
- Cell Design
  - Bulk boiling and density fluctuations need to be considered
  - Axial flow tube cell
  - Acceptance will drive design elements
- High magnetic field
  - H_2,D_2 must be unpolarized
  - Material selection
  - Major components must be outside field
- Refrigerator will have impact on design



Conceptual Design

Outside the field

1. Heat Exchanger
2. Cryostat
3. Pump
4. Lifter (30" of travel)
5. Piping

Inside field

1. Cell
2. Solid targets
3. Piping
4. Instrumentation
5. Support system

Power

- Cooling Requirements
  - 800+ W of beam heat load
  - 250+ W of overhead
    - Pump heating and efficiency/friction losses
    - Heater control
    - Transfer line losses
- Refrigerators
  - CHL has been removed from CRYO commitment to Halls
  - ESR I
    - ~1 kW (slightly more at 20K)
  - ESR II
    - More than adequate for this target

Cell Design

- Acceptance will drive much of geometry
  - Max angle of 35^o
  - Qweak max angle of $\sim 12^o$
- Modest boiling and density fluctuation requirements
- Requires careful selection of materials
- Must meet requirements of 10 CFR 851
  - Either meets Code and/or equivalent measures
  - receives extensive testing and review
- Requires close collaboration with Hall A designers and Experiment

Polarization of D2

- D2 will polarize in high B field at 20K
  - D2 has a very long relaxation time $T_1 > 1$ hr
- Assuming Qweak style pump (15 l/s)
  - Dwell time in high field for one circuit is < 3 sec
  - Dwell time outside the field ~ 10 sec.
- Total polarization will be some fraction of 100 ppm
- Beam will disassociate D2
  - Enhance the polarization of D2
  - We don't know how to quantify this
- Measurement of D2 polarization will be an extensive project

Scattering chamber

- Must accommodate the motion of the target stack
- Can be optimized for acceptance and window thickness
  - Positioning of the downstream window close to the cell exit
  - Design a strut supported scattering chamber exit window
    - minimizes the impact on acceptance
    - minimizes the required thickness of the exit window

Conclusions

- Major design and engineering effort
  - Design requirements must be determined in timely fashion
  - Cost of this effort is non trivial
- Polarization of D2 may be an issue
  - Measurement of this polarization will be challenging
- Refrigeration for this target will most likely exceed current ESR capacity
- This system will be significantly larger than the standard pivot target
  - Installation will be complicated because of geometry

SoLID Polarized Proton Target

- Existing JLab targets are optimized for longitudinal running
  - Magnet opening angle parallel to field: $\pm 55^o$
  - Opening angle perpendicular to field: $\pm 19^o$
- SoLID experiments focus on transverse polarization and require opening angle $\geq \pm 25^o$

Recommendation:

Design new 5T magnet and integrate into existing JLab system

SoLID Polarized Proton Target

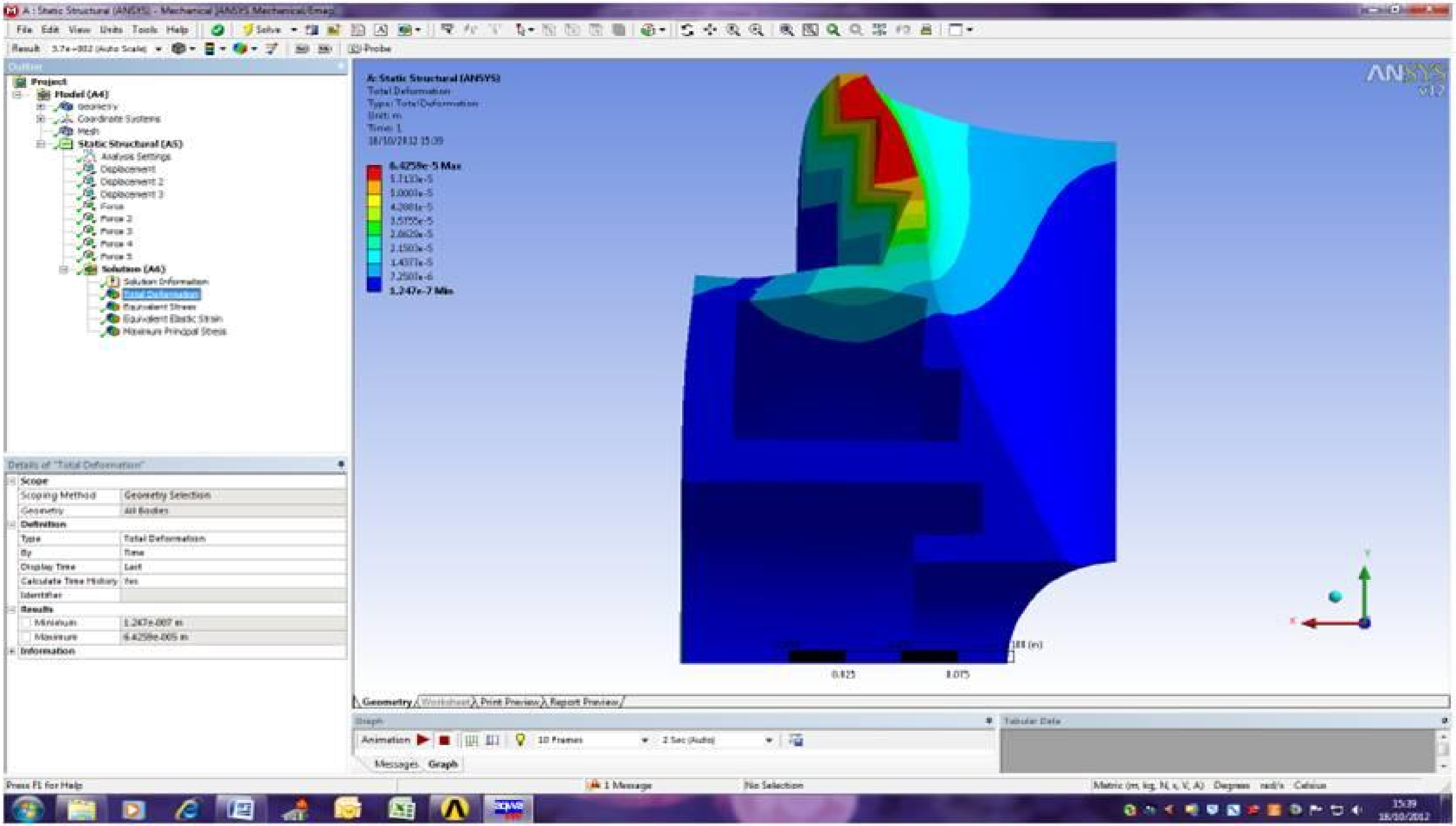
- Oxford Instruments Design Study (Nov. 2012):
  - Initiated by Don Crabb, UVa
  - Describes a high homogeneity, 5 tesla magnet w/ ± 25^{o} split
  - Helmholtz configuration of 14 superconducting coils in series
  - Operating current for 5 tesla is 106 amps
  - Design, dimensions, and current are similar to Hall B & C polarized target magnets
  - Detailed ANSYS study was performed of forces acting on the coils

Conclusion

"Analysis indicates that 5 tesla with ±25 split access is realisable…"

Design Report rfq 13241, Oxford Instruments Nanotechnology Tools LTD, Nov.12, 2012

SoLID Polarized Proton Target



Top view, 1/8th of one set of Helmholtz coils. Magnetic field is left-to-right.

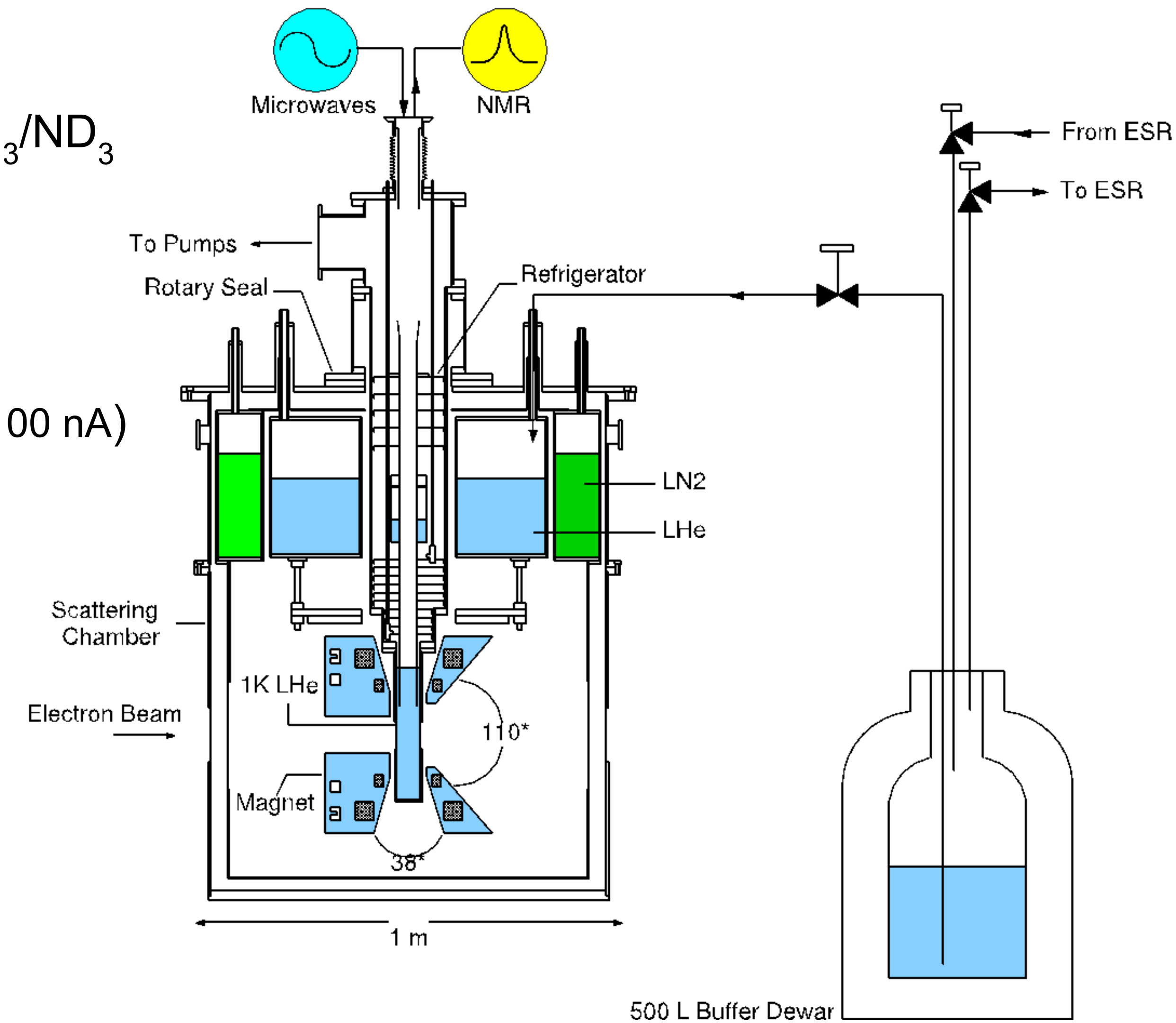
Design Report rfq 13241, Oxford Instruments Nanotechnology Tools LTD, Nov.12, 2012

JLab/UVa Polarized Proton Target

- Used multiple times at SLAC and JLab Hall C
- Last used in Hall A in 2012 (g2p/Gep)
- Replace original magnet (inoperable) with Hall B magnet
- Major upgrade to nearly *every* system component
  - New magnet *suspension* system
  - New magnet *rotation* system
  - New 1 K refrigerator
  - New/refurbished/rebuilt pumping system
  - New ASME-compliant quench relief
  - New sample insert (2 NH_3 + 3 background samples)
  - New insert motion mechanism
  - New cryo lines

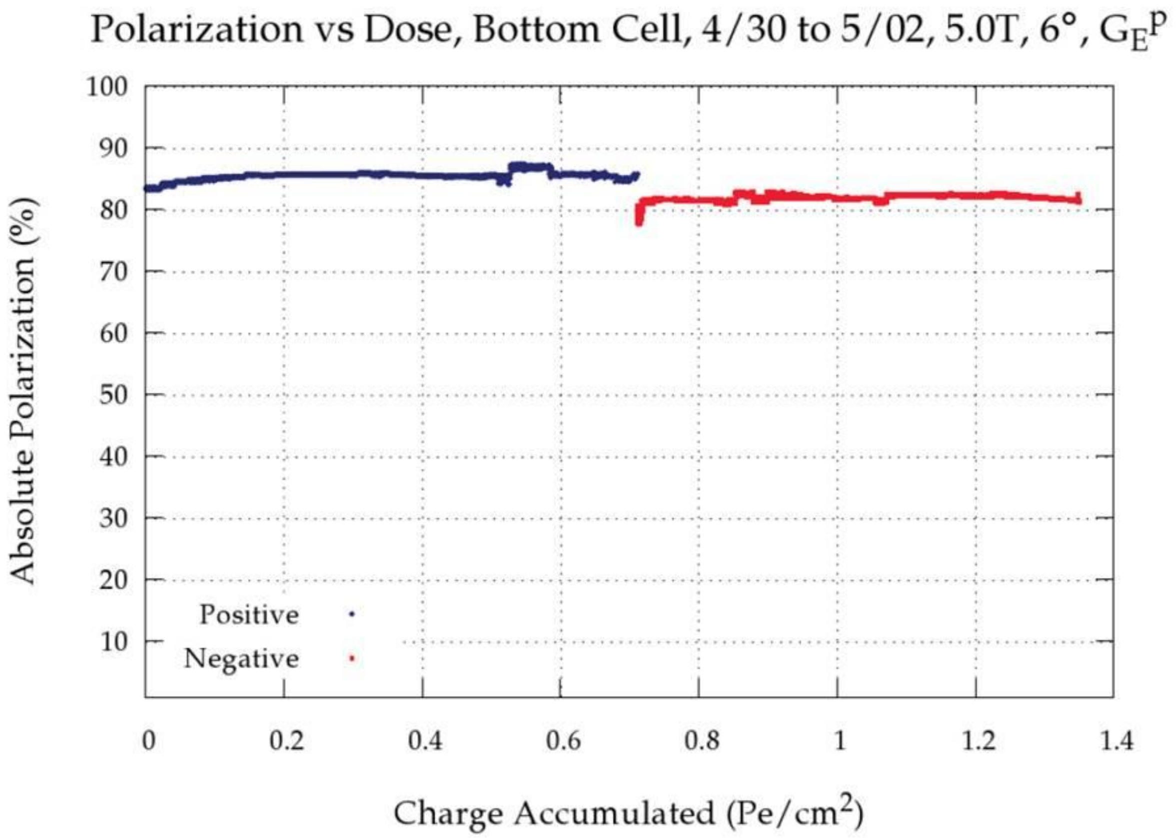
JLab/UVa Polarized Proton Target

- Dynamically Polarized NH_3/ND_3
- 5 tesla, 1 kelvin
- $P_p \approx 90\%$, $P_d \approx 40\%$
- **L** $\approx 10^{35}$ protons/cm^2/s (100 nA)



JLab/UVa Polarized Proton Target

- Performance during g2p/Gep was exceptional
  - Highly reliable
  - High average polarization



JLab/UVa Polarized Proton Target

- G2p/GeP: Hall B Magnet was utilized in place of original, inoperable magnet
- Suspension system used for g2p/Gep will simplify integration of the SoLID transverse magnet

Suspension/Alignment bracket

ConFlat flanges replace indium seals for LHe service

5 T magnet from Hall B polarized target