Progress report for A_1^n target -April 2012

- Design and construction
- Prototype cell tests
- Project management.

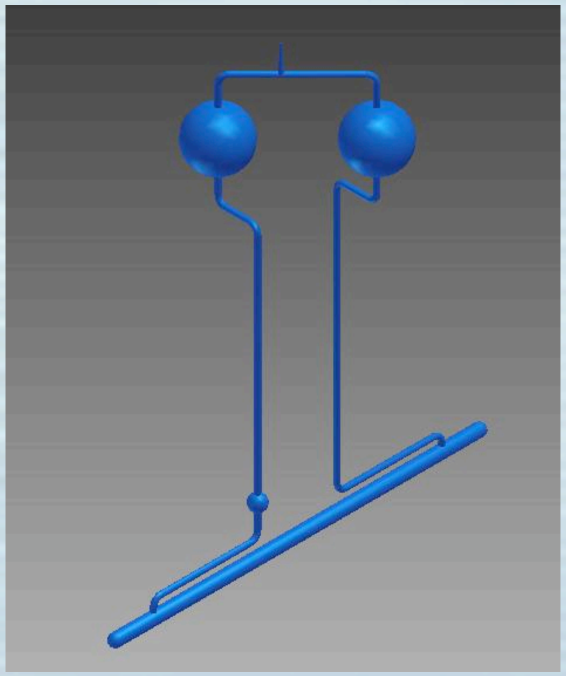
G. Cates – April 4, 2012

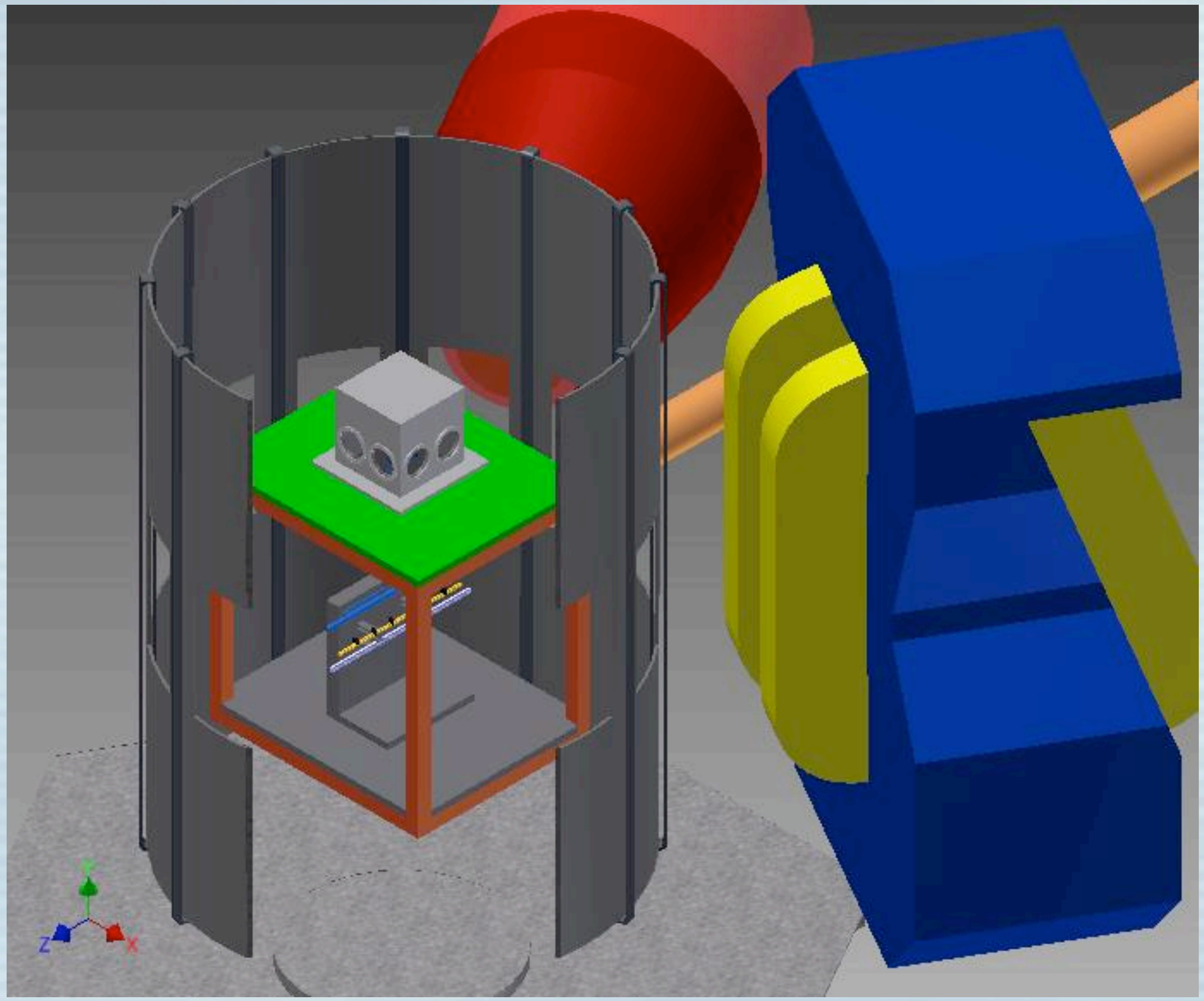
Constraints on the Hall A A_1^n target
(have not changed since January)

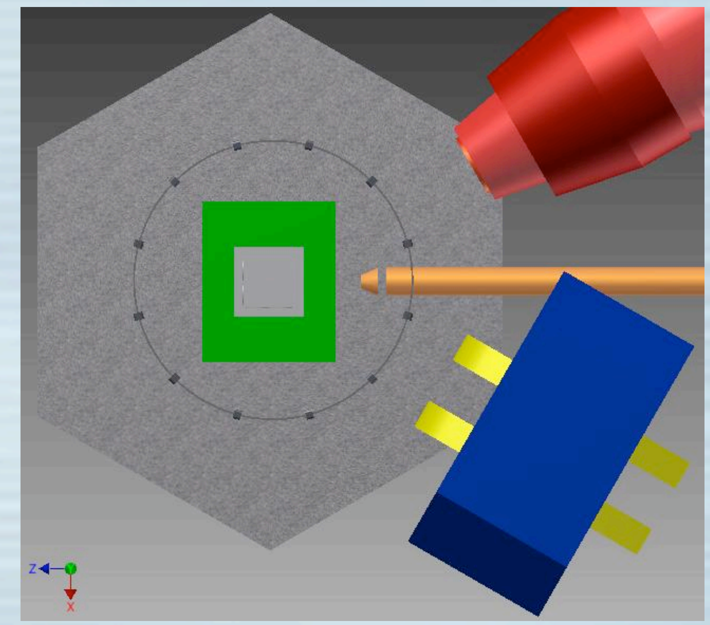
- Must provide 63% polarization with 30 μA on 60 cm target or equivalent, resulting in three times luminosity of Transversity experiment.
  - Convection is necessary to reduce polarization gradients.
  - Cell must be reasonably stable against rupturing despite beam current twice that of Transversity.
  - Radiation shielding of the pumping chamber is desirable.
  - Magnetic field gradients must be sufficiently low to provide acceptable $1/T_1$ as well as acceptable losses during polarimetry (whatever technique is used).

Design and Construction

Elements of proposed conceptual design for Hall A A_1^n target





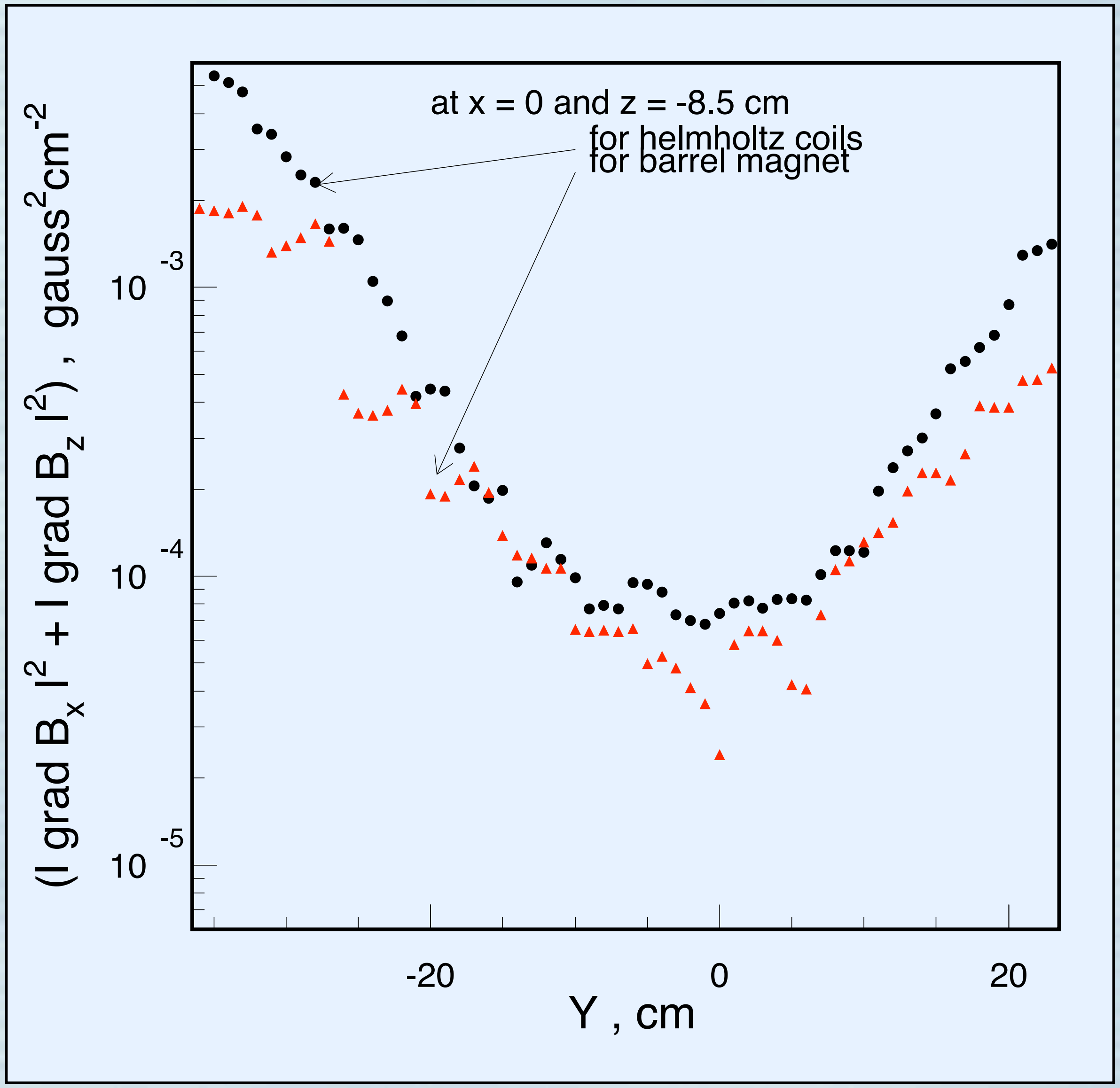


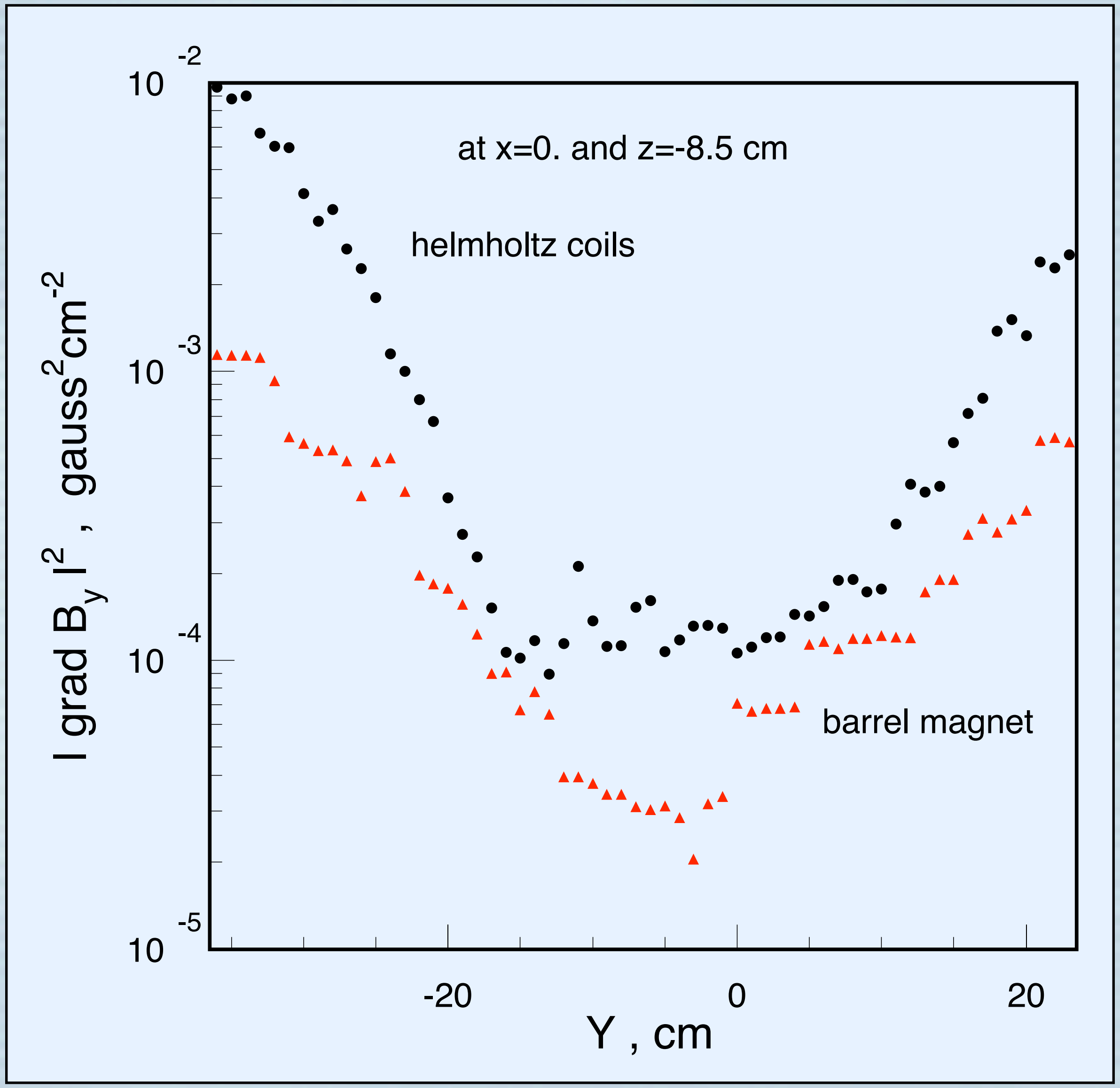
- Convection-driven double-pumping chamber cell to handle high current.
- "Target Box" for reduced cost while maintaining mechanical rigidity despite significantly increased weight (at least a factor of two).
- GEM Trackers in BigBite will accomodate much higher singles rates, and hence luminosity.

Magnetic field Solution

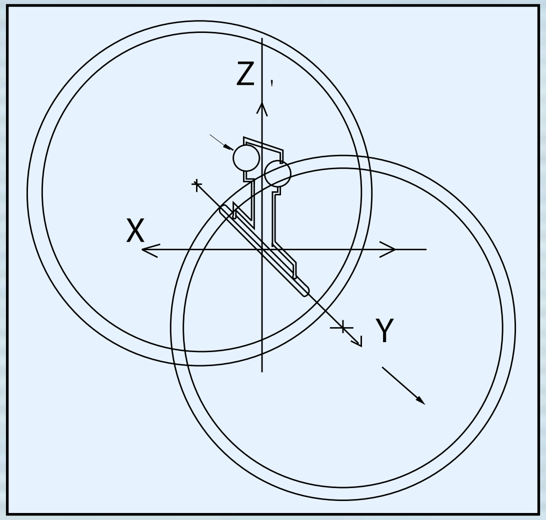
- Radiation shielding will require a significantly larger target cell.
- Barrel design provides excellent homogeneity over the entire A1n "Mark I" target cell design.
- Helmholtz geometry is an extremely tight fit, and cannot provide adequate homogeneity over the larger target cell.
- The barrel design would allow us the smoothest incremental transition to the next-generation targets. In particular, it would insure that AFP could be used while we transition to new polarimetry methods.

Gradients near target chamber



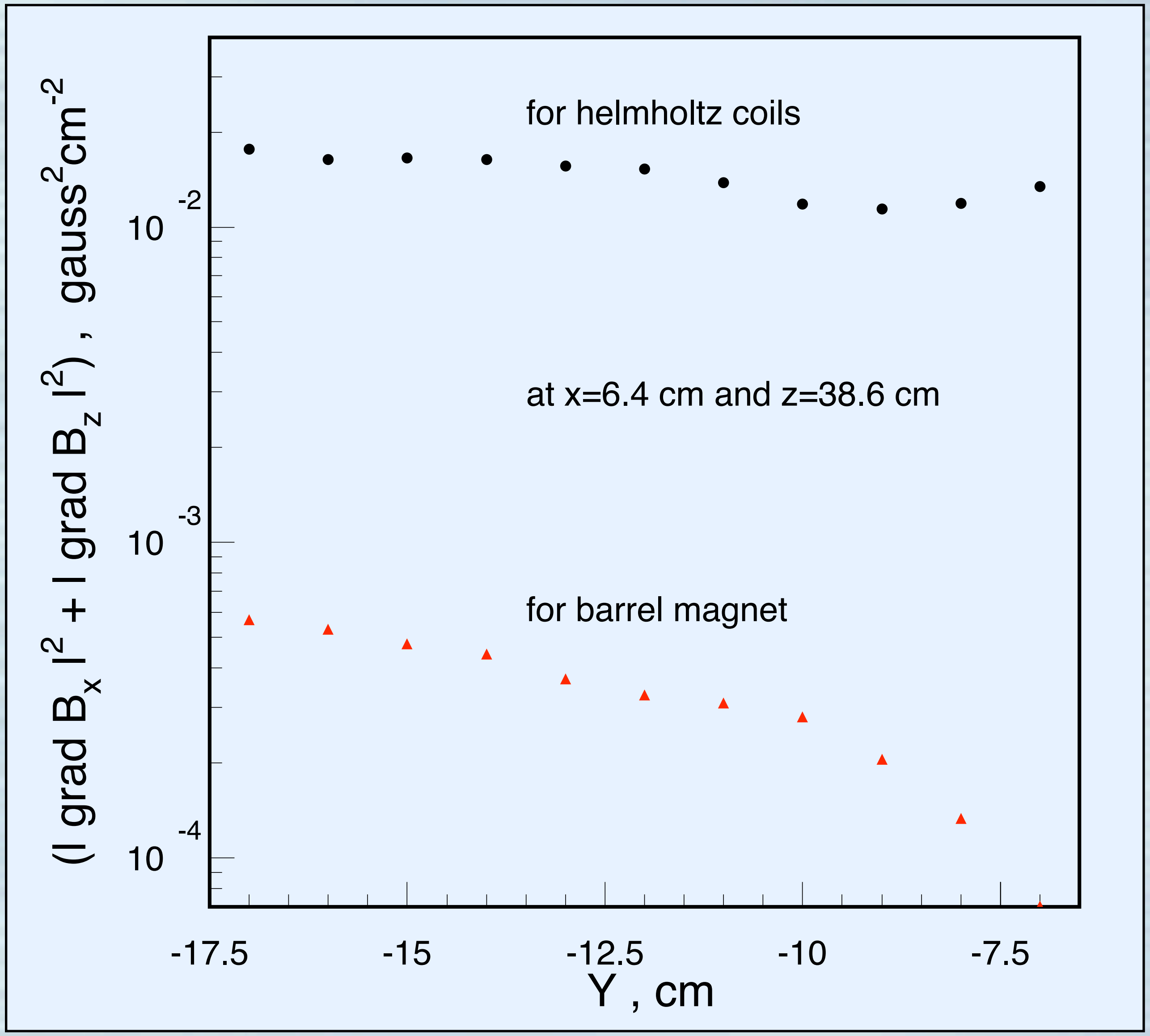


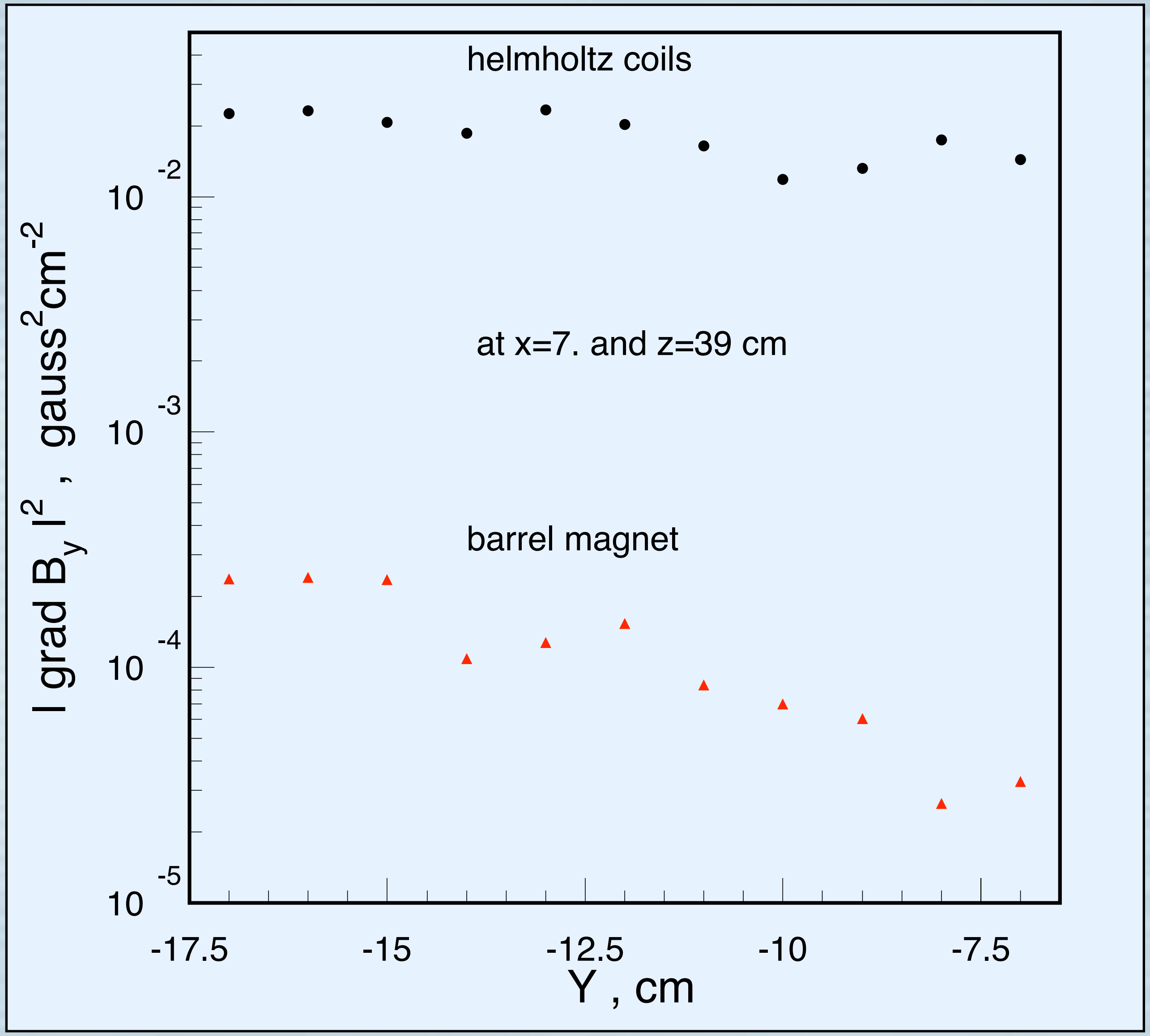
Gradients above of 2.78×10^{-3} G^2/cm^2 (53 mG/cm) corresponds to $1/T_1$ = 1/200 hrs.

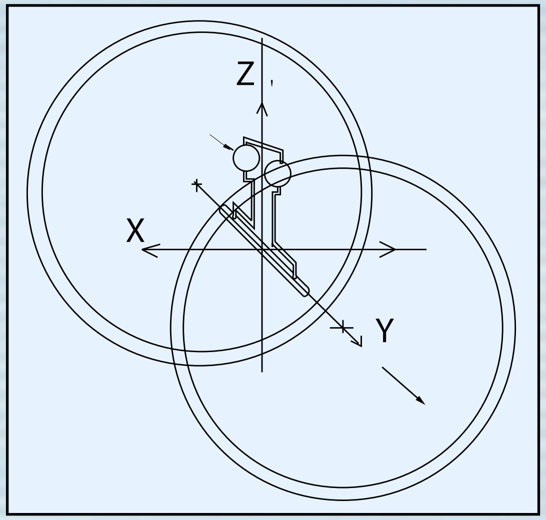


Here, to limit AFP losses, our rule of thumb has been to keep gradients under 10 mG/cm, or gradients squared under 1×10^{-4} G^2/cm^2.

Gradients near pumping chamber







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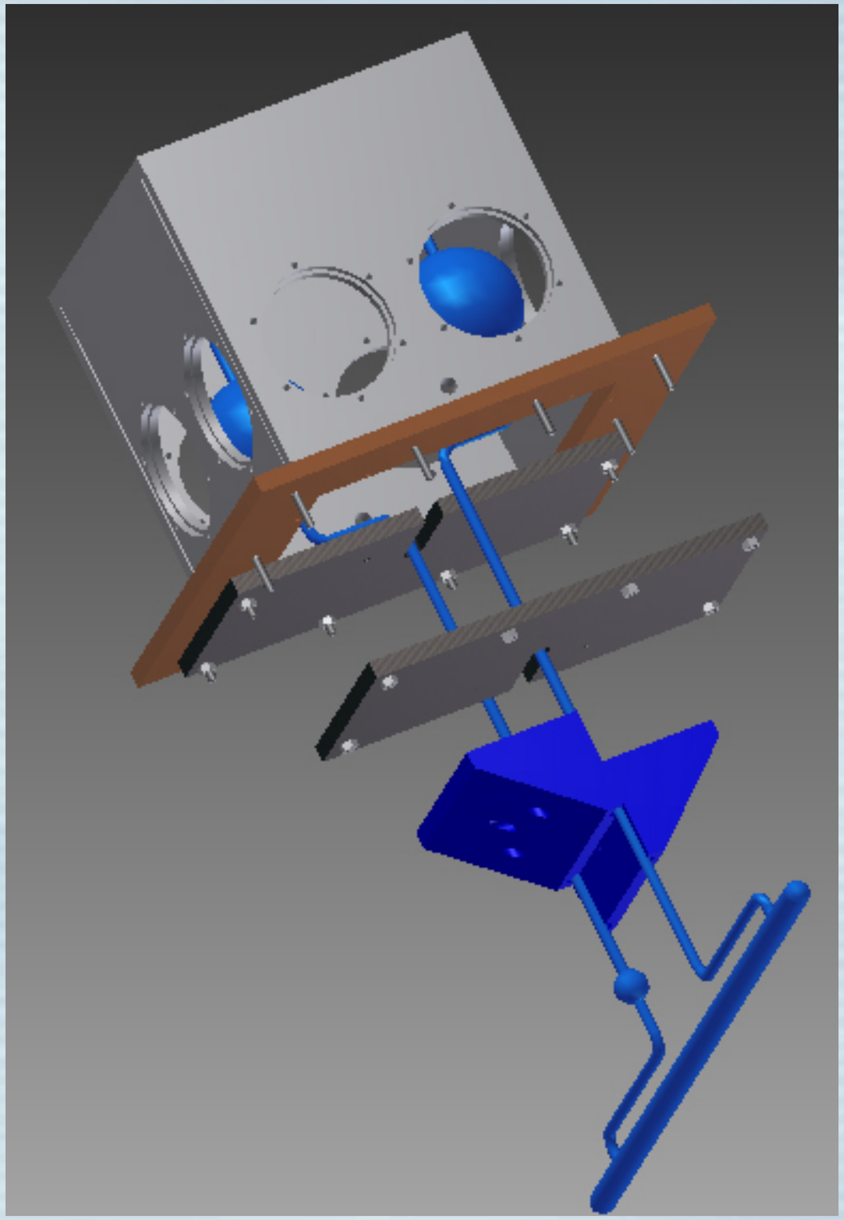
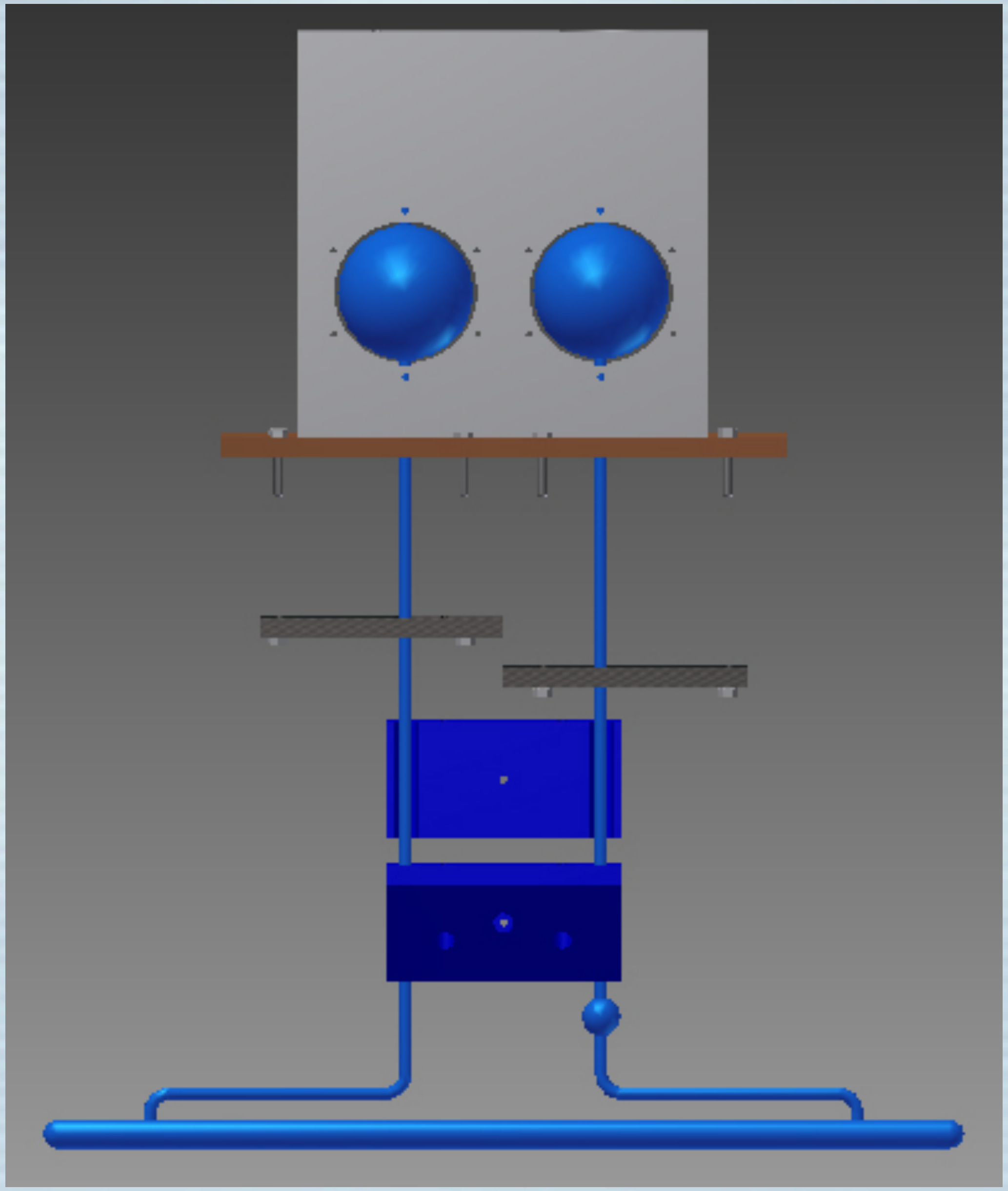
Detailed Oven Design Being Built at UVa





- Conceptual design by Delano Wilson and G. Cates reported in January.
- Detailed design now being finalized by Al Tobias and Maduka Kaluarachchi
- Ceramic materials ordered.
- Window orders in preparation.
- Will be used for proof-of-principal tests at UVa.

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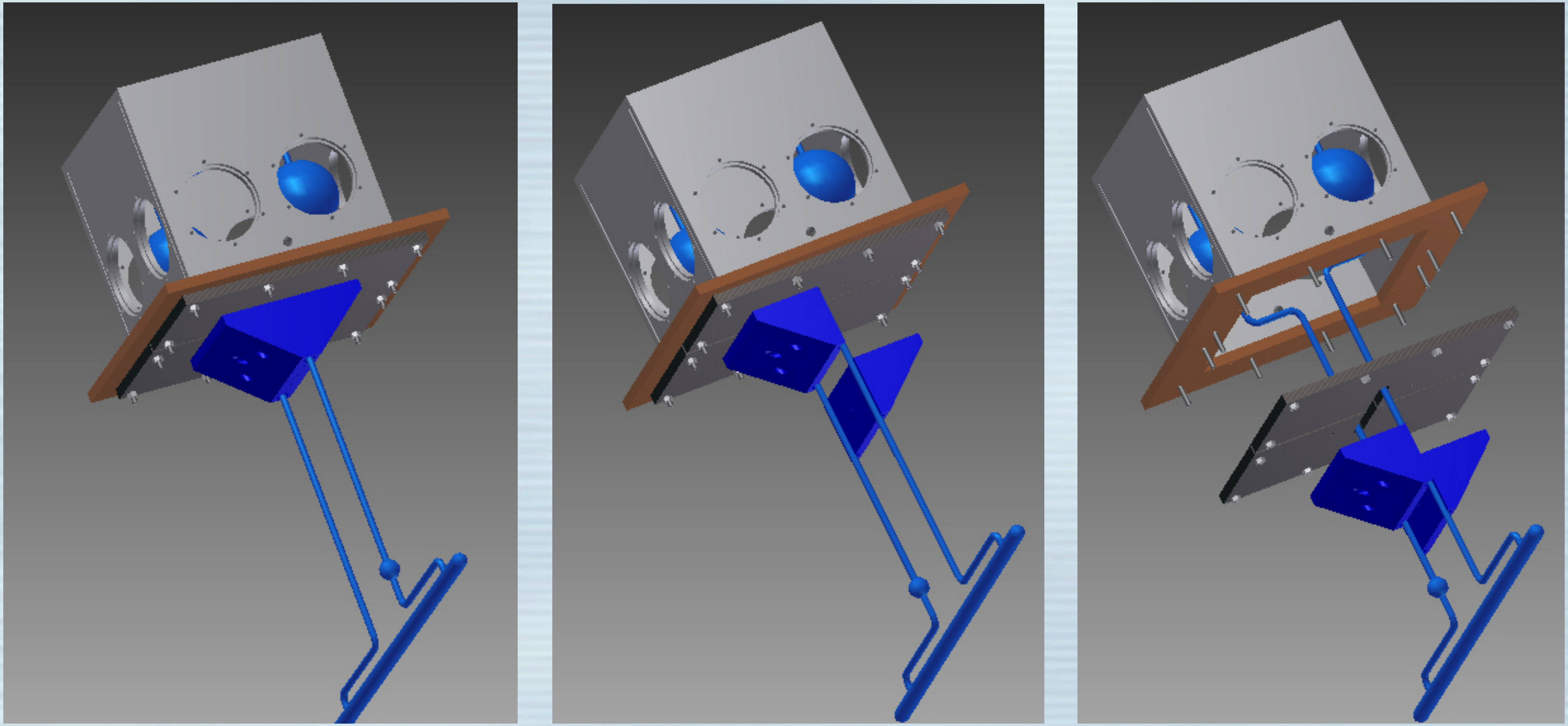

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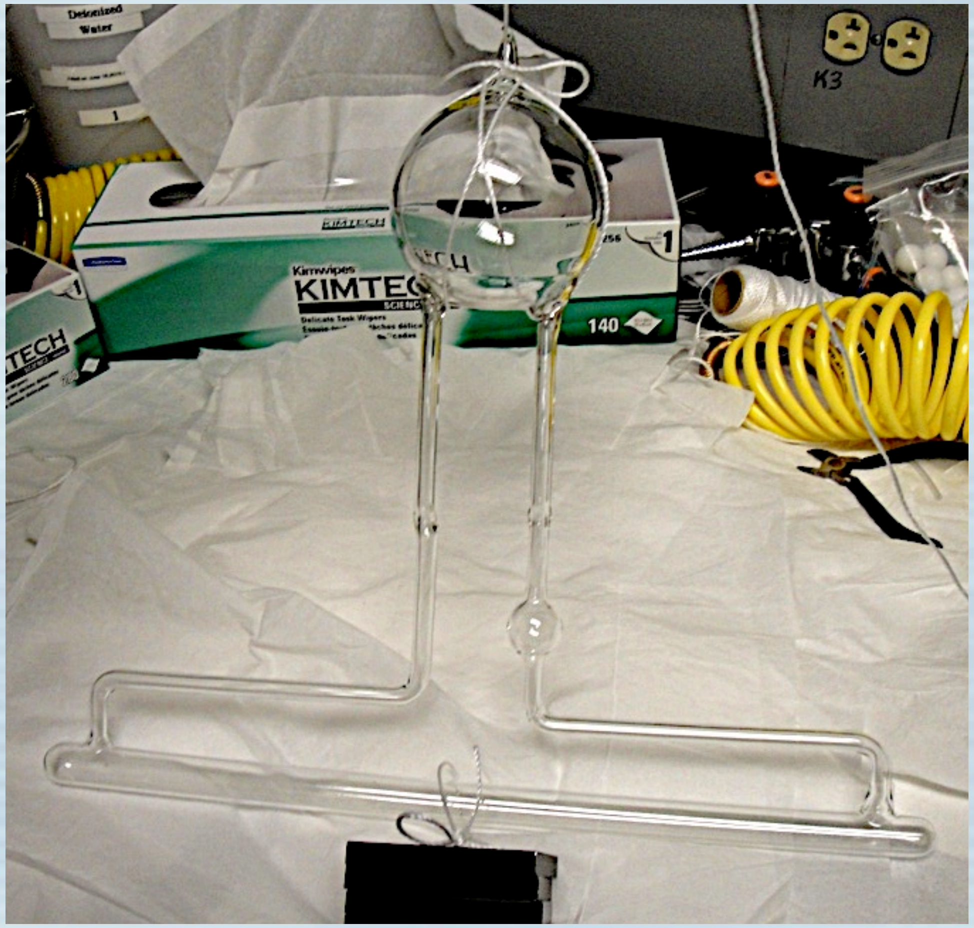
Prototype Cell Tests

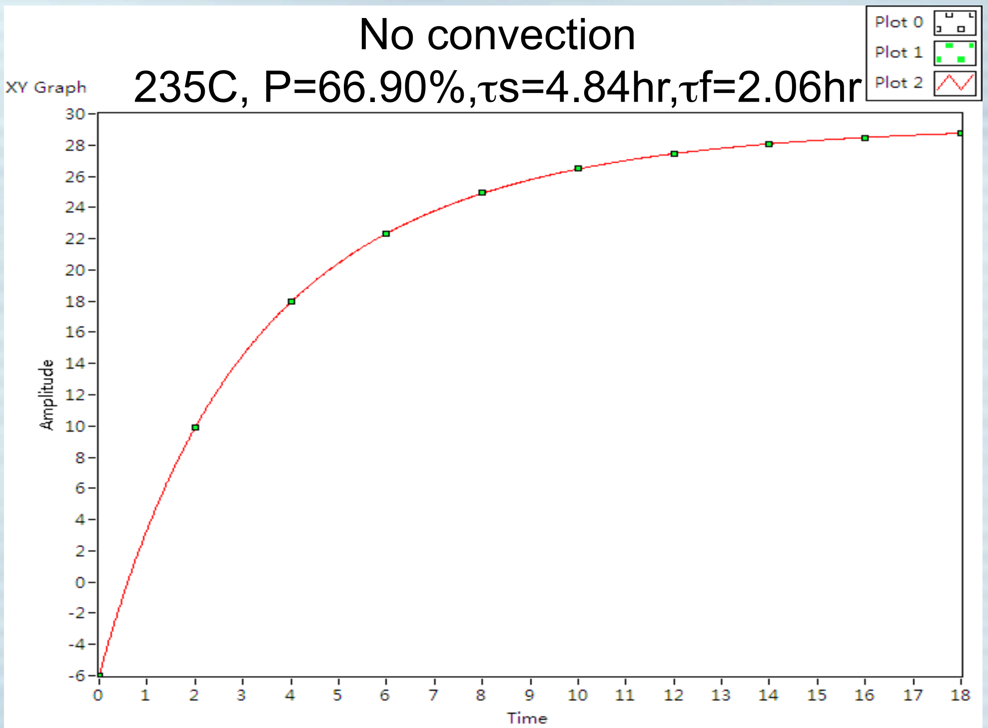
Protovec-I Studies

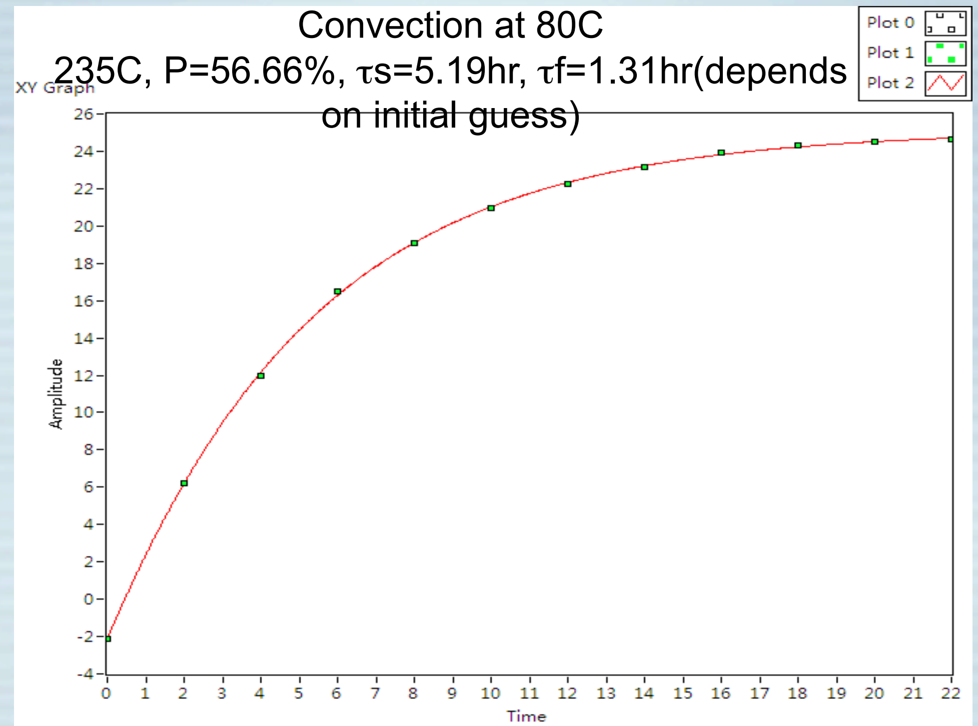
(half-size A1n target)

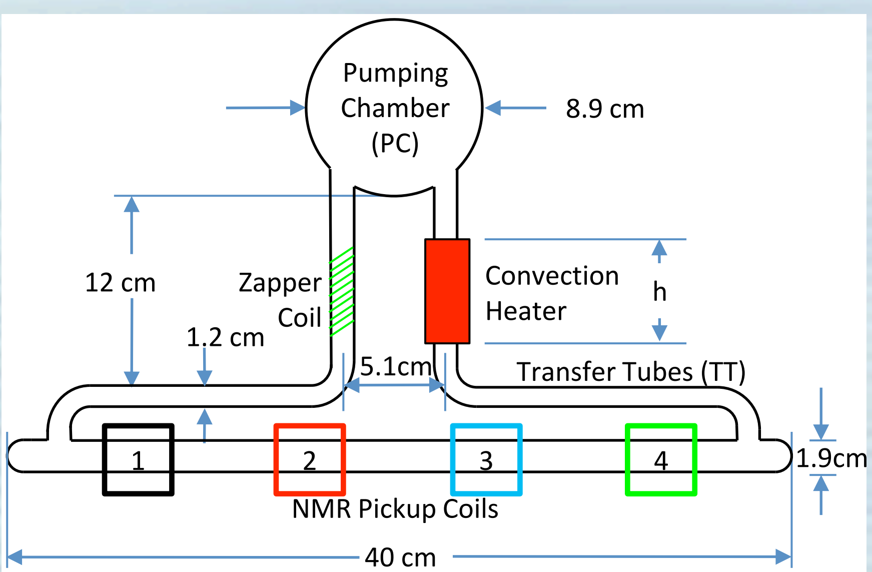
- Lifetime studies (around 23 hours).
- Comparison of AFP and PNMR studies.
- Polarization without convection (up to 67%)
- Polarization with convection (up to 60.6%)
- Faraday-rotation studies:
  - D = [K]/[Rb] = ~7.2 (good value)
  - X = perhaps as big as 0.6 (probably not great)
  - dependence of [Alk] on convection speed (minimal).
- Polarization limit using PNMR losses to simulate spin-relaxation due to beam under full 30 μA conditions.



Protovec I results presented in January 2012

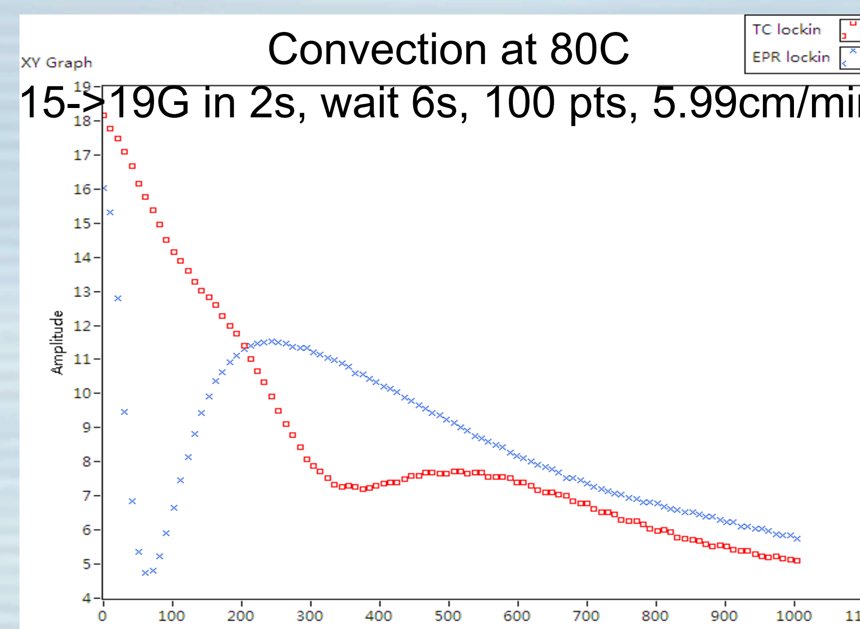




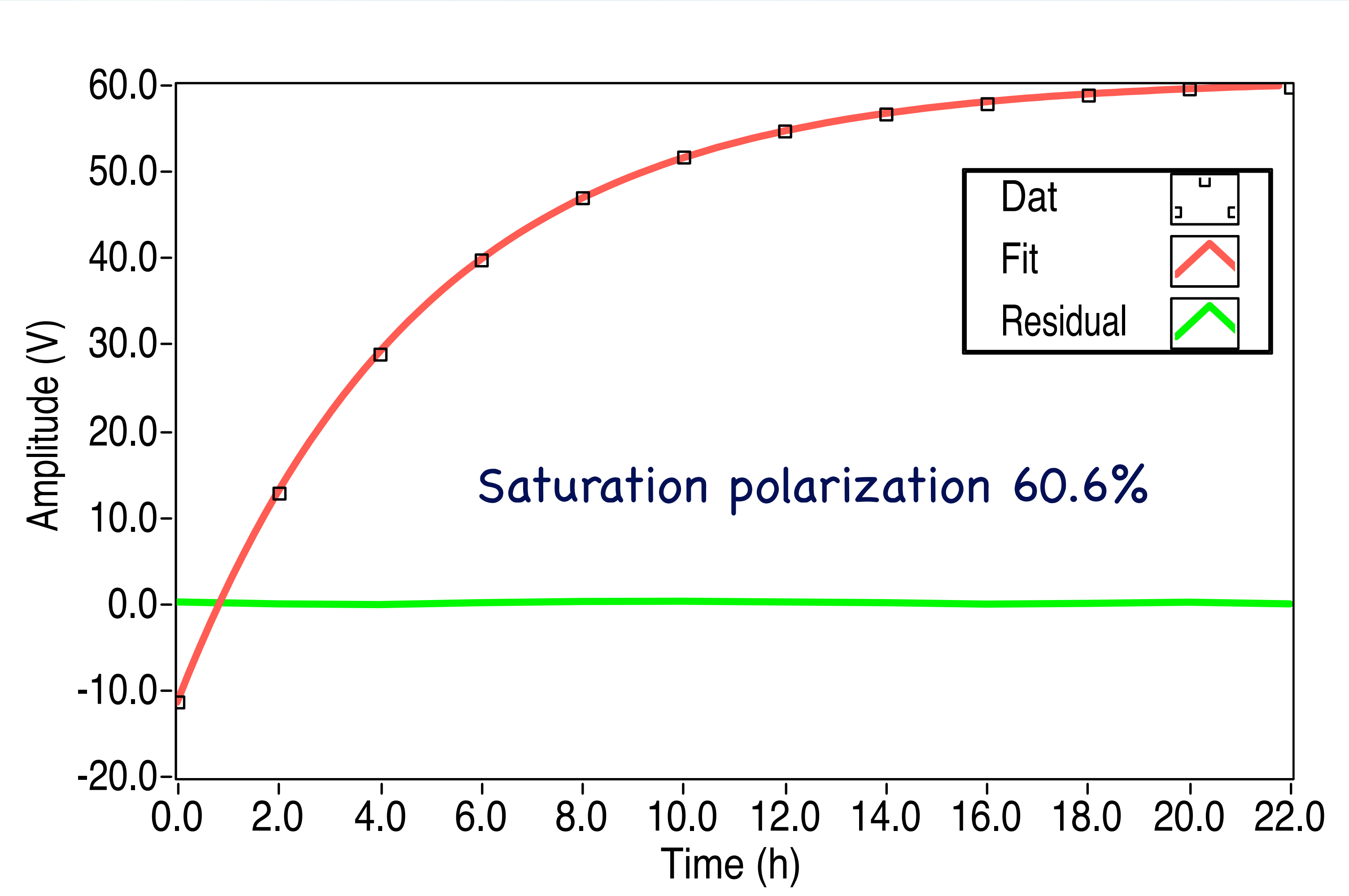


Dolph, Singh, et al., PRC v84, pg 065201 (2011)

- Convection provides well-controled circulation of the gas.
- New half-volume A_1^n cell is the first in which we have simultaneously achieved high polarization.
- 57% was achieved with an unoptimized system, 3 (instead of 4-5) lasers,



New Protovec I results for April 2012



Spin-up test of Protovec I:
Oven set point: 245 C
Convection speed: 6 cm/min (80C)
Pol. measurement: every 2 hours

AFP losses per meas: ~1.6%

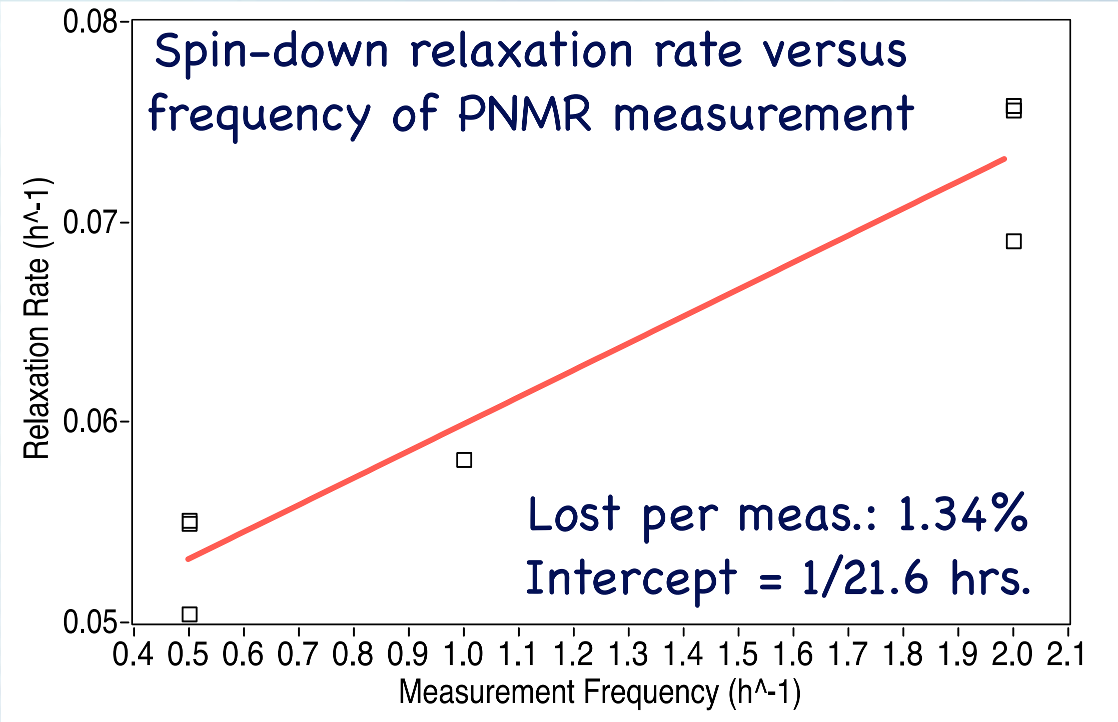
Saturation Polarization: 60.6 %

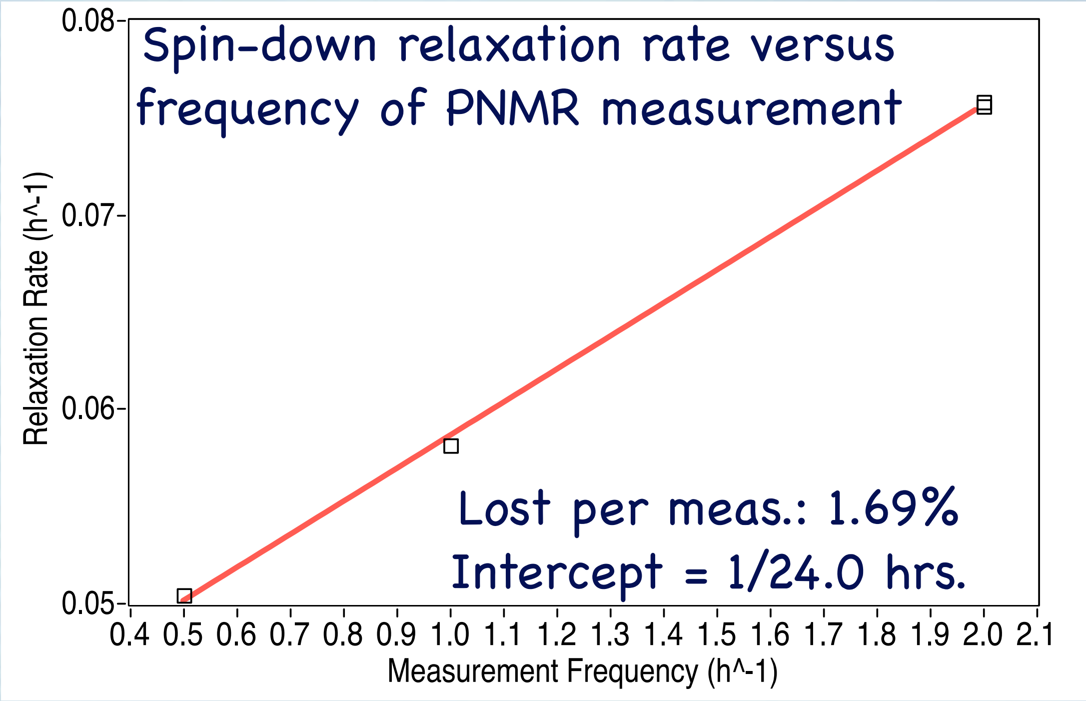
Laser Power: ~40-50 Watts actually incident on cell

Protovec I is only a so/so cell in terms of its intrinsic parameters. Even so, we have seen it break the 60% mark on more than one spin-up, an example of which is shown above. It is not clear whether the above spin-up represents optimal conditions. Certainly, the laser power was not very high at all. We note that a spin-up under identical conditions, but with a measurement frequency of around once per four hours, or even once per eight hours, would probably yield a few percent higher polarization.

Simulated In-beam test for Protovec I

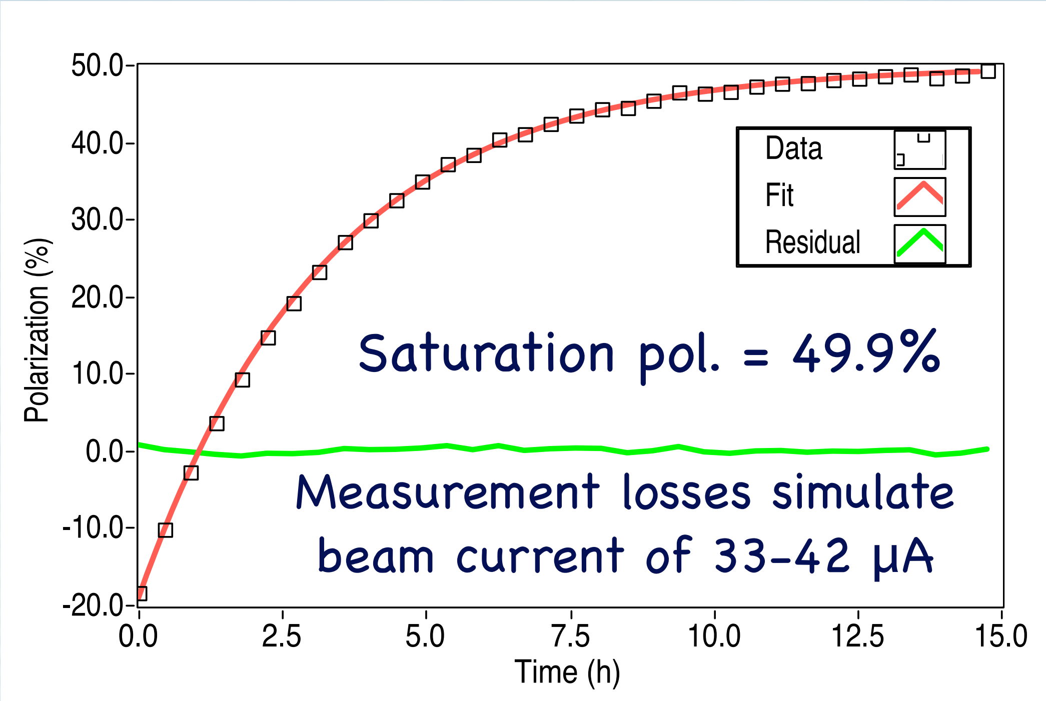
Described on this slide is a test in which we simulated beam depolarization by inducing relaxation using PNMR.





We are observing some variation in the losses per PNMR measurement which are not yet well understood.

At right is a spinup in which polarization was measured every 0.447 hours. Using the two estimates given above for PNMR losses per measurement, the spinup at right corresponds to a beam current on a 60 cm long cell of 33-42 μA



Lessons learned thus far from Protovec I

- Even a cell with modest intrinsic parameters can achieve over 60% polarization WITH ONGOING CONVECTION even with laser power well under the desired amount.
- Faraday rotation studies indicate only minor change in alkali density when inducing convection. This is good news. We can compenstate by slightly higher over temperatures.
- Ever-more-accurate simulations indicate we need a much larger cell to achieve high polarization when running at higher luminosities (30-60μA on a 60cm cell).
- Simulated in-beam tests with Protovec I showed greatly reduced polarization of around 50% for the equivalent of 33-42μA.
- Larger cells are CRITICAL to the success of A1n and GEN.

Have finally established a path to metal end-cap cells

- Tested glass-to-metal seals from Larson up to 20 atmospheres.
- Larson, at our request, demonstrated that they can make glass-to-metal seals using GE-180 and a small amount of transition glass.
- Found supplier (Materion Electrofusion) for berylium windows. They will be silver soldered to a copper collar, and then e-beam welded to the glass-to-metal seals. Quote is $2K/window.
- Epnor will gold plate the polished glass-to-metal seals including the berylium window. They say they can handle the Be no problem.
- Construct cell.

Our strategy is to pursue in parallel two efforts:
1) A partially metal test cell (PMTC) for spin-relaxation measurements and
2) a berylium window cell to test for mechanical and vacuum integrity.

Details of the path to the partially metal test cell (PMTC)

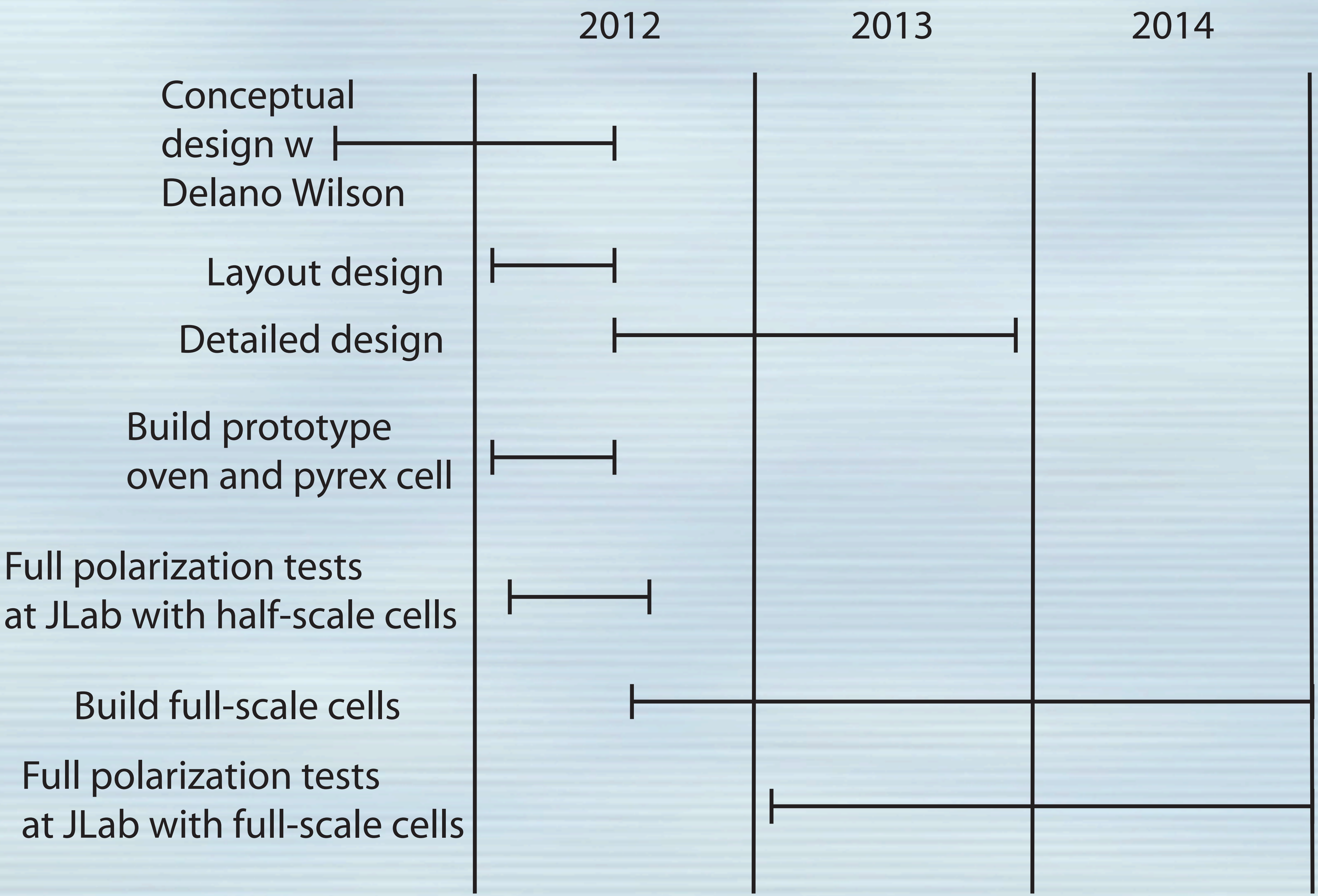
- Obtain raw materials from Larson for glass-to-metal seals.
- Mechanical (local) and electropolishing (out sourced).
- Larson will fabricate glass-to-metal seals.
- Epnor will gold plate the glass-to-metal seals
- Glass-to-metal seals incorporated into partially metal test cell (PMTC).
- Fill PMTC with ^{3}He and alkali mixture.
- Test PMTC (performance need only be as good as our last test of gold-coated PMTC.

We expect to begin testing the new PMTC between October 1 and November 1 of 2012.

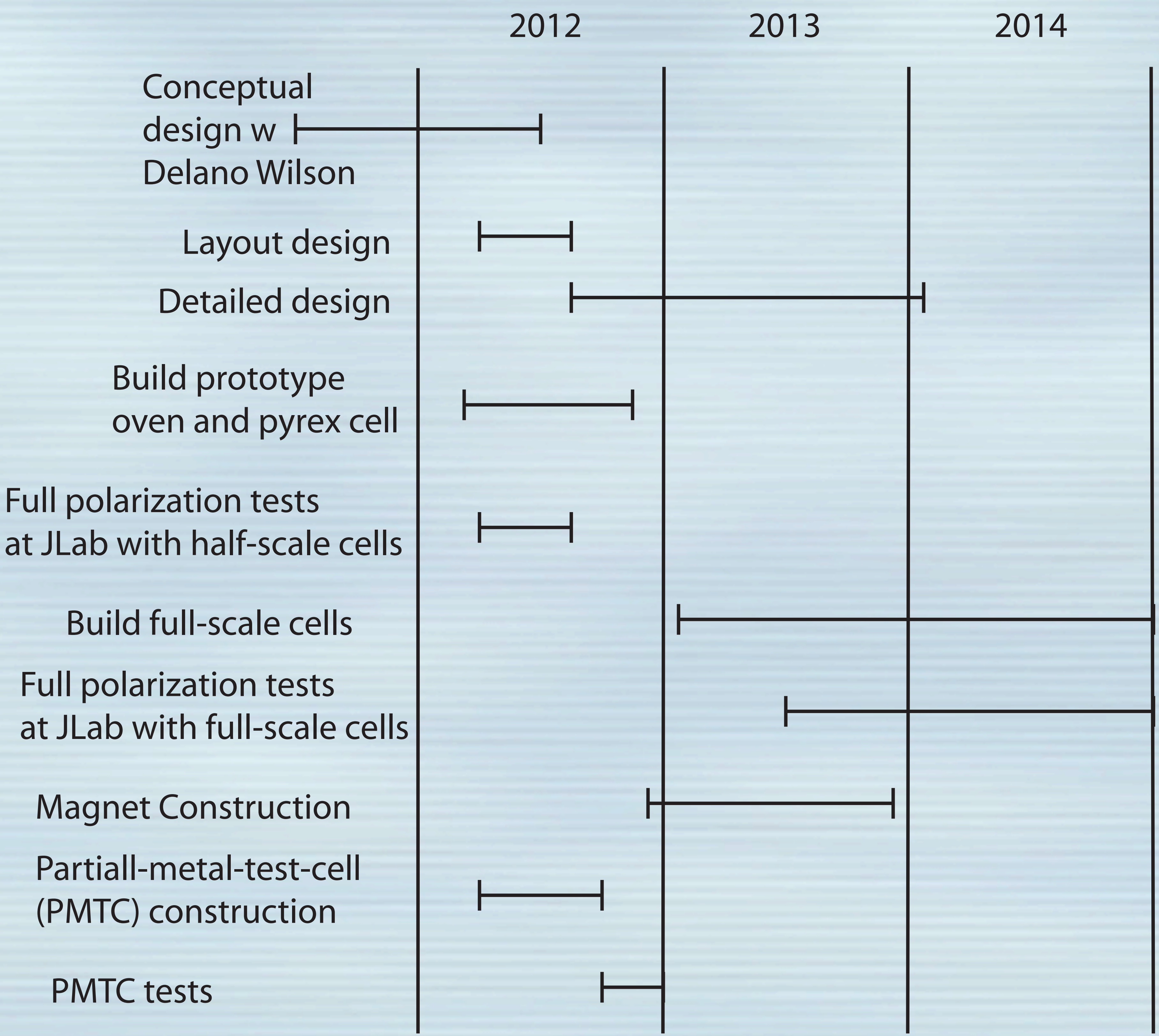
Project Management

- Updated Time Line
- List of unassigned target-related jobs.

Very Incomplete Time line



Still rough but updated timeline



Outstanding jobs

This covers only jobs that do not appear on the previous slide.

- Full magnetic field calculations with BigBite
- Magnetic field direction measurement
- Reference cell system
- JLab Laser System (for 10-12 lasers)
- Beamline/shielding design and construction
- Background study of beamline/shielding.

This list clearly needs to be expanded, but at least it is a starting point.