Polarized ^{3}He Target in Hall C

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Jefferson Lab

Hall C Users meeting
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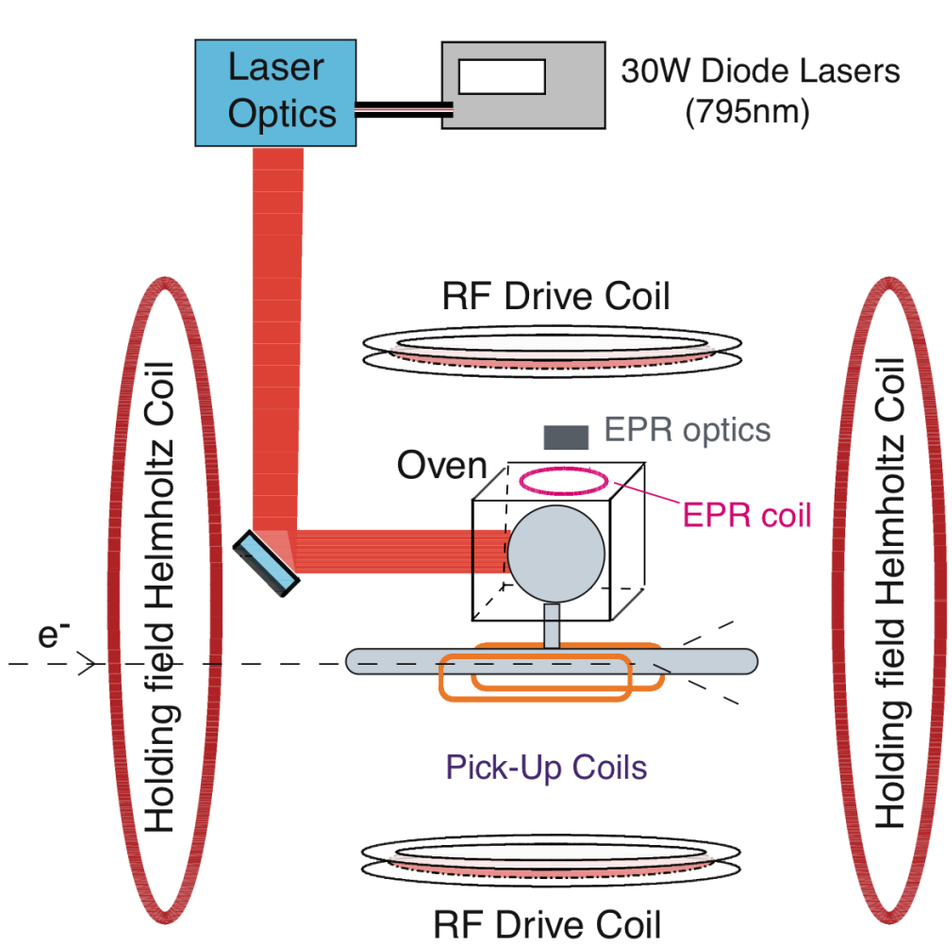
The 6 GeV era Hall A polarized ^{3}He System

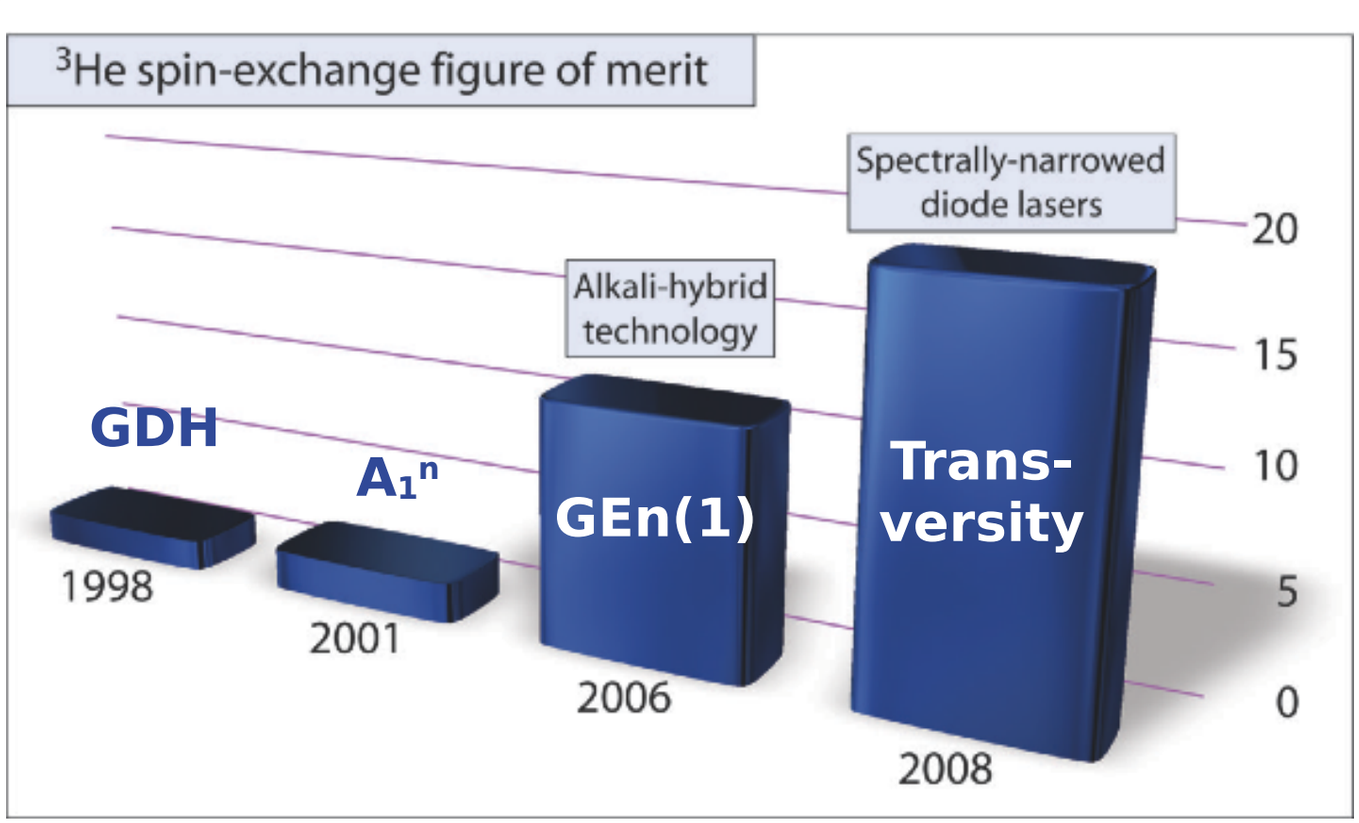
Improvements in spin-exchange optical pumping rates:

- change from Rb only to Rb-K mixture (hybrid cell)
- use of Spectrally-narrowed diode lasers

Results:

- **spin-up time shorten from about 24 hrs to 5 hrs**
- **in-beam polarization increases from about 40% to 60-65%**



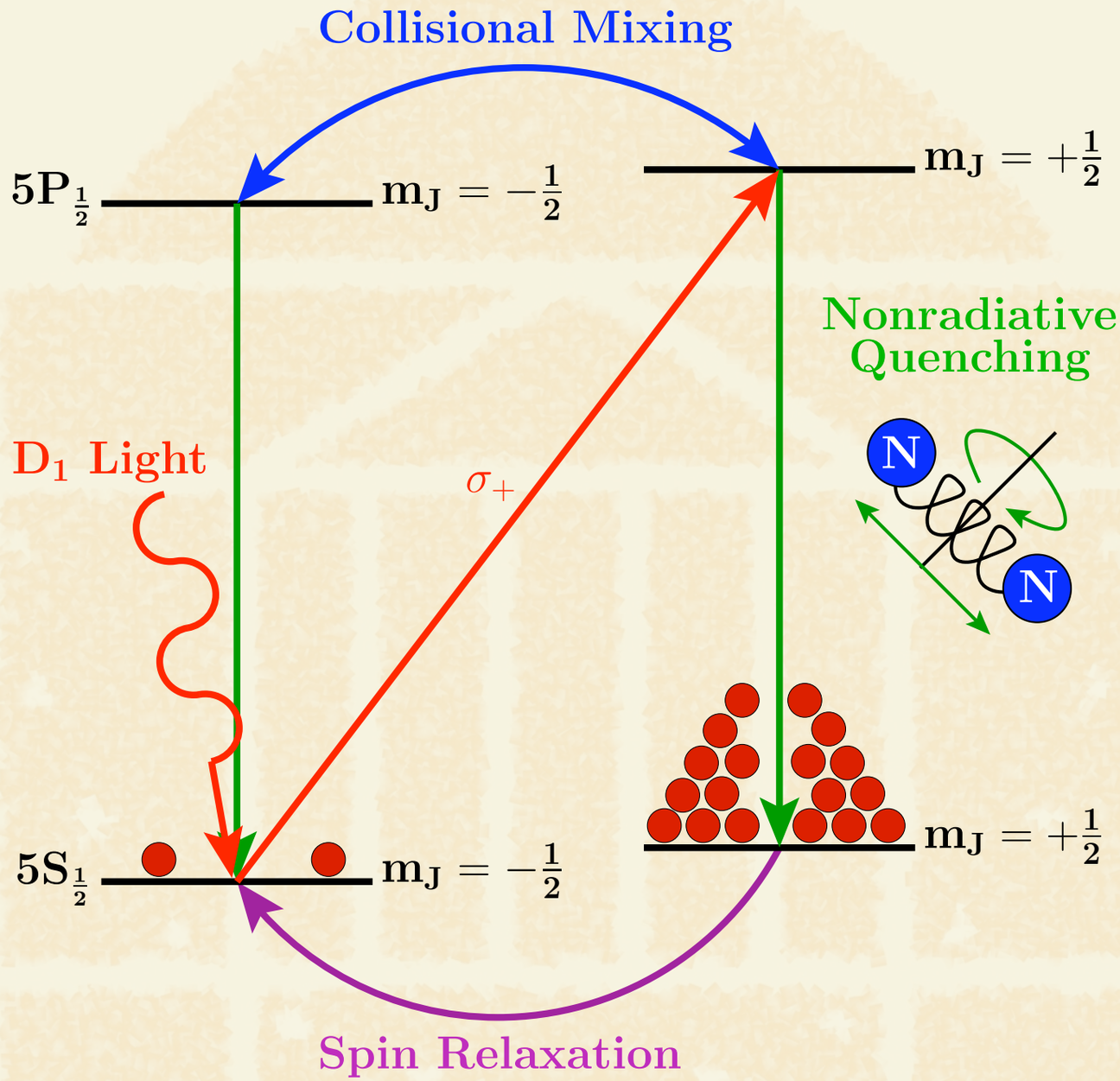


Spins polarized per second weighted by polarization squared

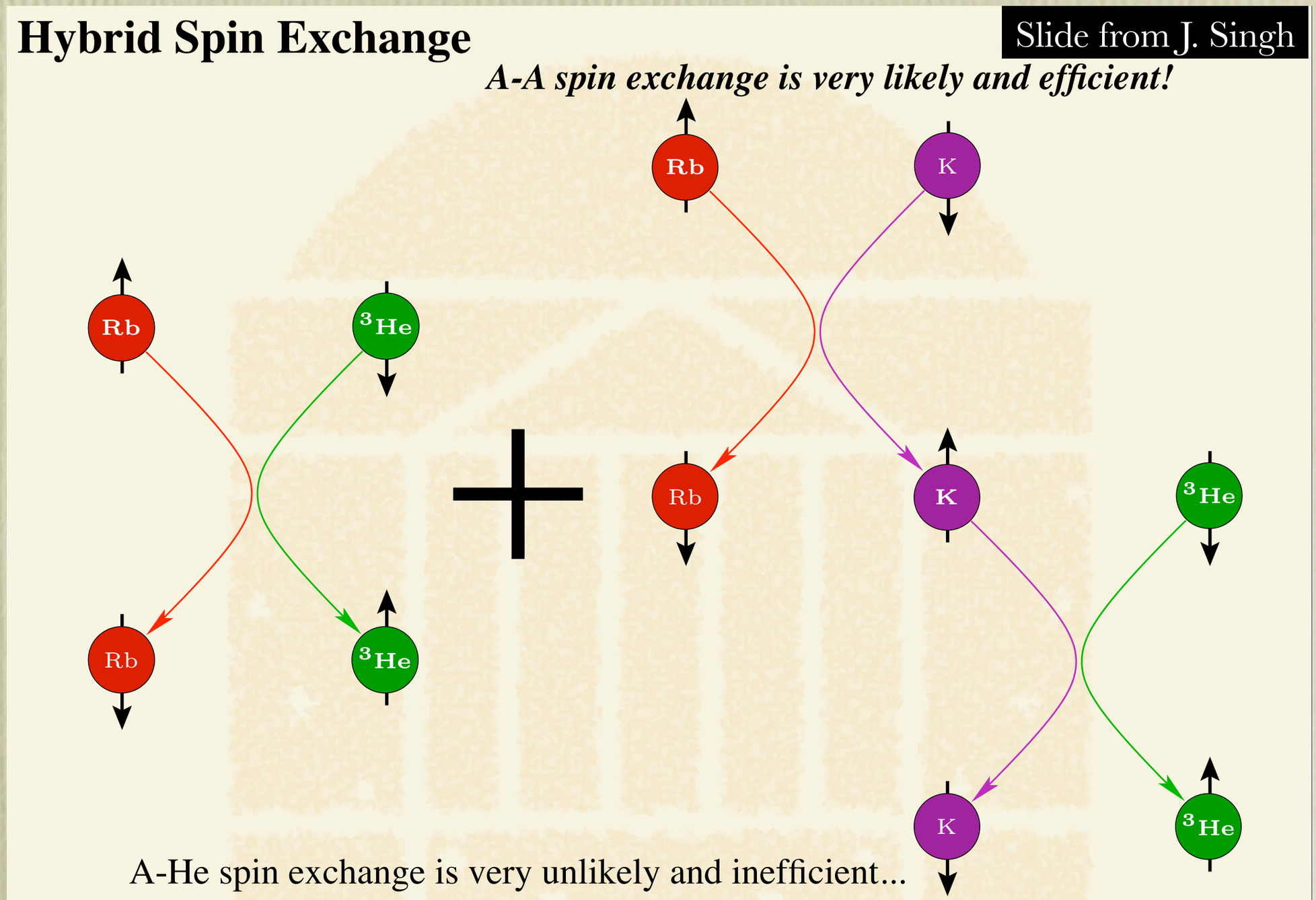
Optical pumping (still on Rb)

Alkali Optical Pumping

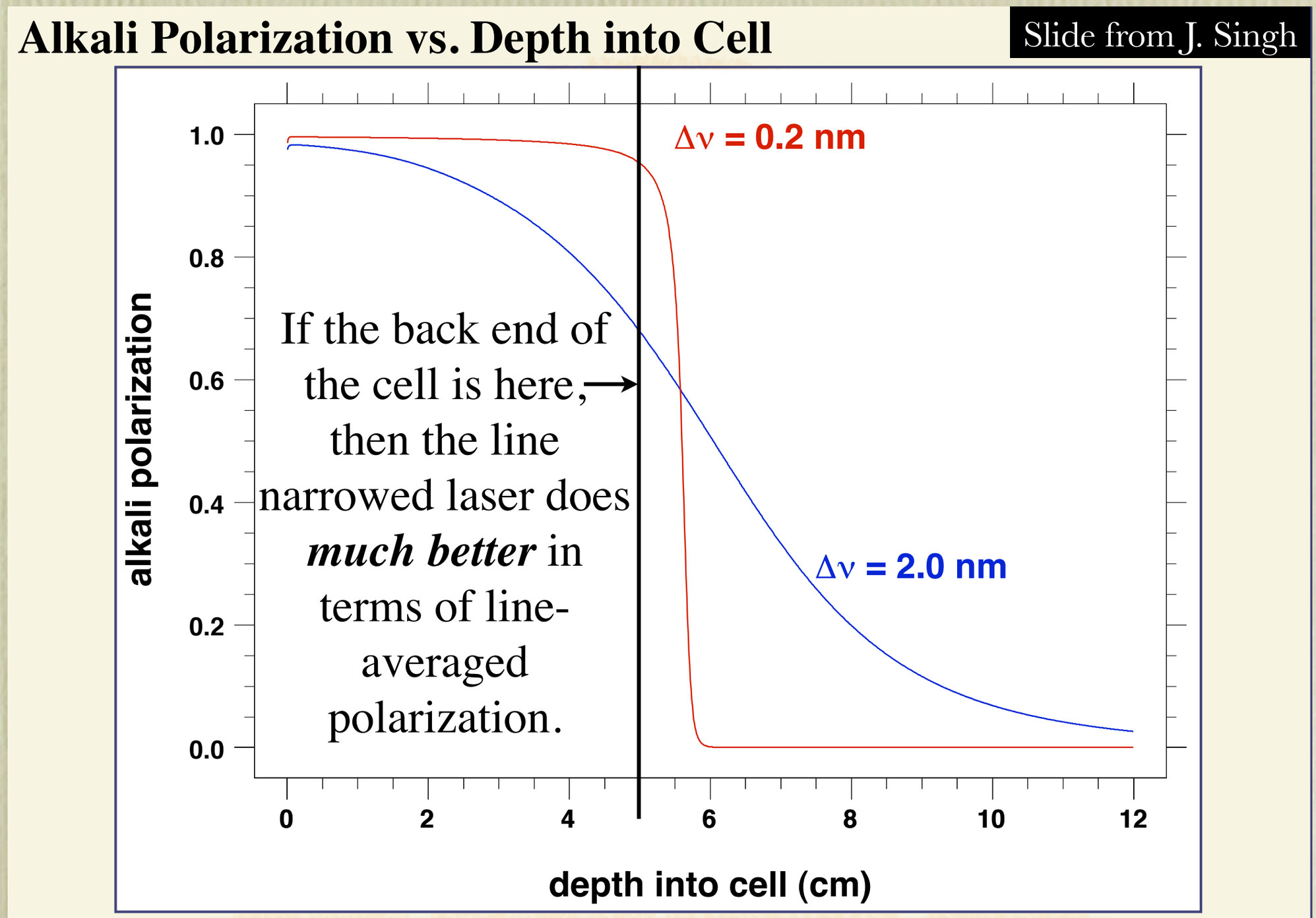
Slide from J. Singh



Addition of Potassium: spin exchange rate much faster



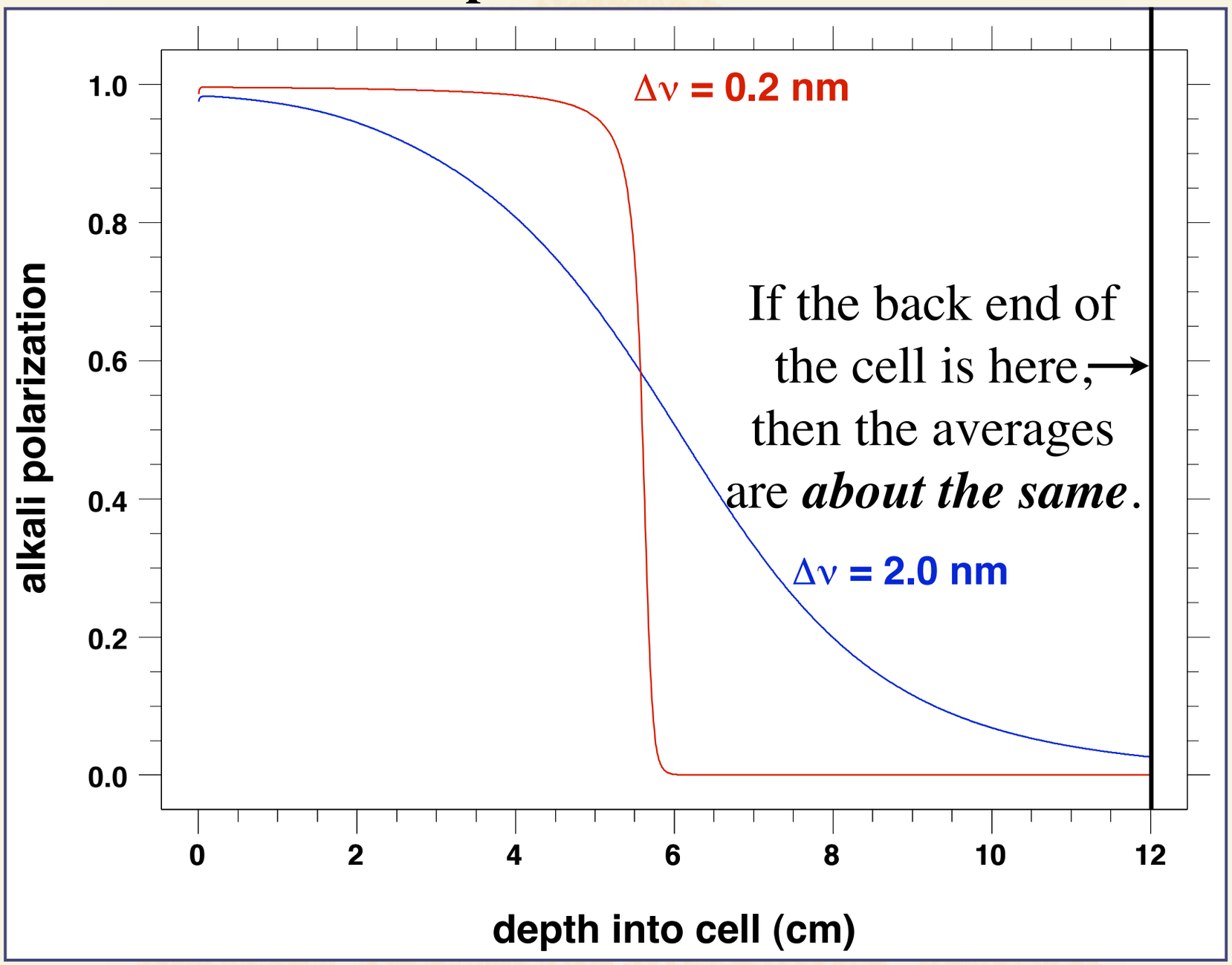
Narrowed laser vs. broad laser



Narrowed laser vs. broad laser

Alkali Polarization vs. Depth into Cell

Slide from J. Singh

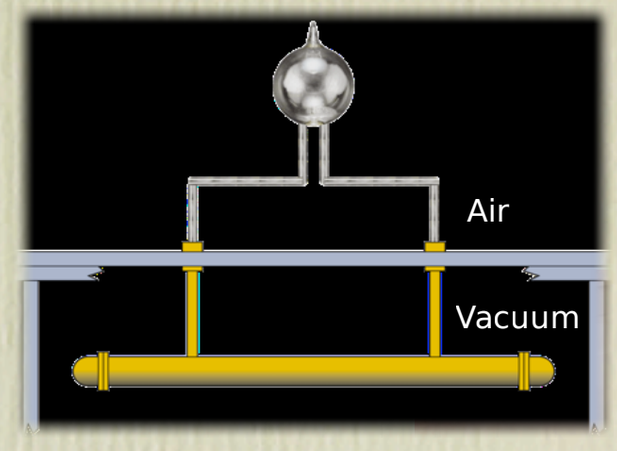


Requirements for A_1^n and d_2^n

(from updated proposals)

GEN-II target:

- ✓ 60 cm Alkali-hybrid cell, 12 amg
- ✓ 2 transfer tubes for convection
- ✓ Gold-plated Aluminum target chamber
- ✓ Pulse NMR



A_1^n

- Target: 60% polarization with 60μA and 3% rel. syst. on polarimetry
- Beam: 85% polarization and 1% rel. syst. on polarimetry

(684hrs DIS + Res) + (169 hrs calib./comm./overhead) =
853 hours (35.5 pac days) total

d_2^n *(update PAC36)*

- Target: 55% polarization with 30μA and 3% rel. syst. on polarimetry
- Beam: 80% polarization and 1.5% rel. syst. on polarimetry

(125hrs * 4 conf.) + (200hrs calib./comm./overhead) =
700 hours (29 pac days) total

R&D topics

Holding field:

- Should be uniform in the pumping chamber. With convection, the polarized gas in circulating fast in the target chamber.
- Two small solenoids, one for the pumping chamber and one for the target chamber.
- Concerns on the Hall C iron platform were expressed.
- Need an estimate of the fringe field from the SHMS.
- Holding field/coil under design and simulation.

Target:

- Two-pumping-chambers cell will allow to increase the gas volume to be polarized and the laser power.
- Metallic target chamber to allow higher beam current.
- Many efforts are being focused on the glass-metal sealed.

R&D topics

Lasers:

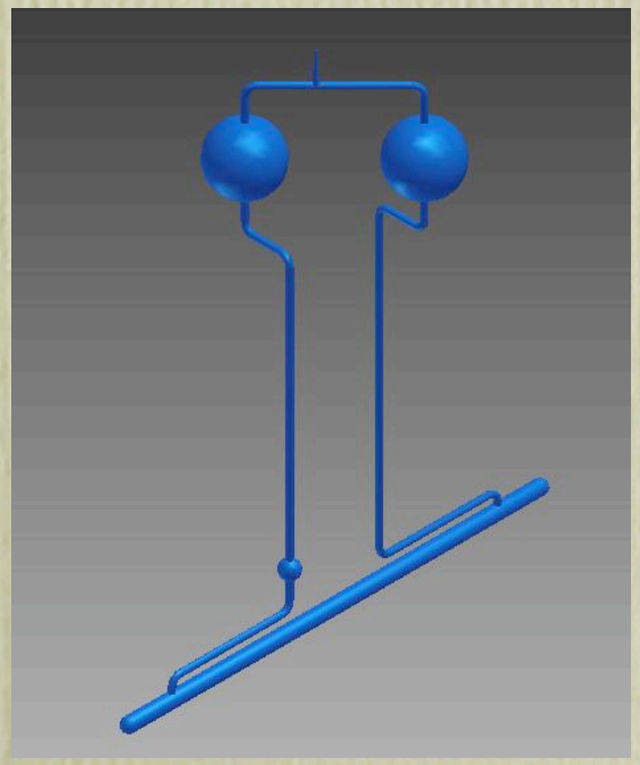
- Laser procurement is an big issue. The COMET production was discontinued.
- Possibility of procurement with Laser Operations LLC.

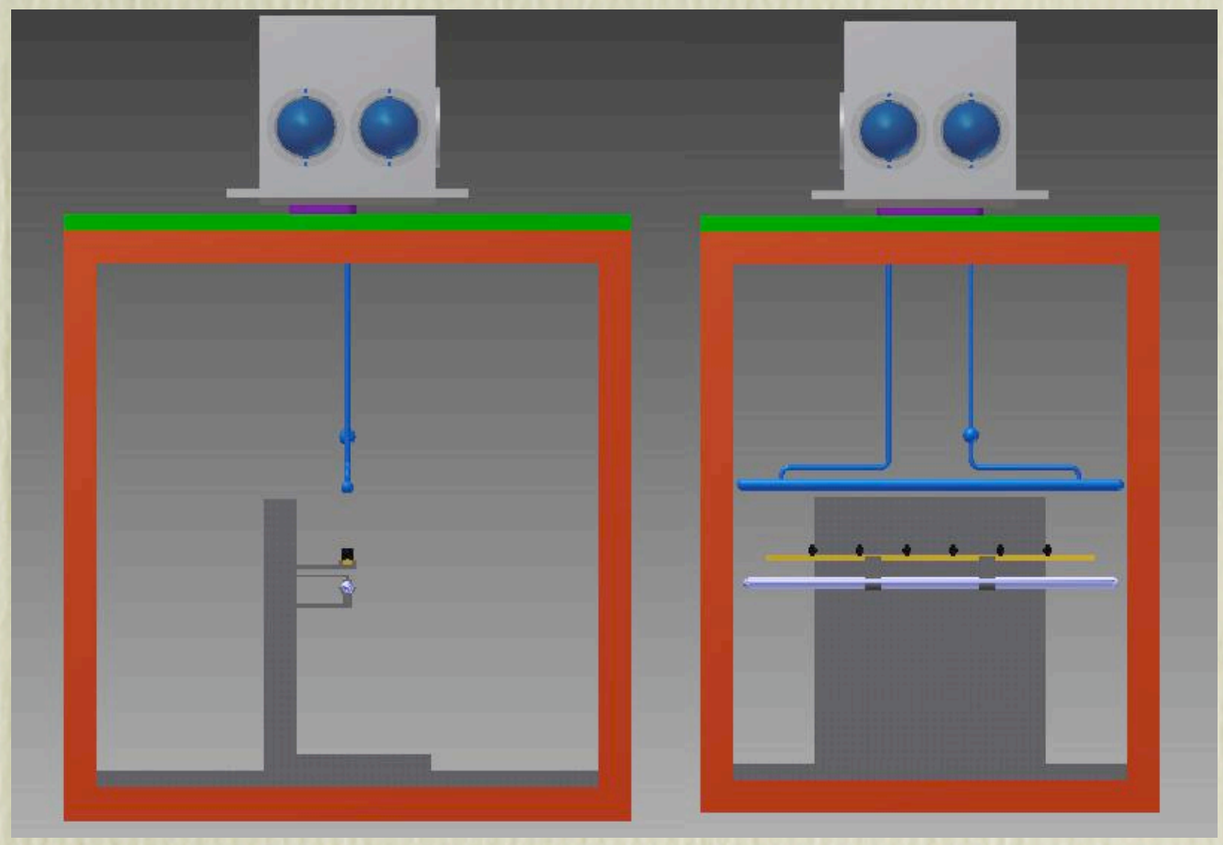
Polarimetry:

- AFP will be used only for calibration.
- Pulse NMR is under development.
- EPR will still work.
- With convection, the polarization gradient between the pumping chamber and the target chamber will be significantly reduced. So polarimetry in the pumping chamber should be sufficient.
- A detailed study of the gas dynamics was recently published: Dolph, Singh et al.

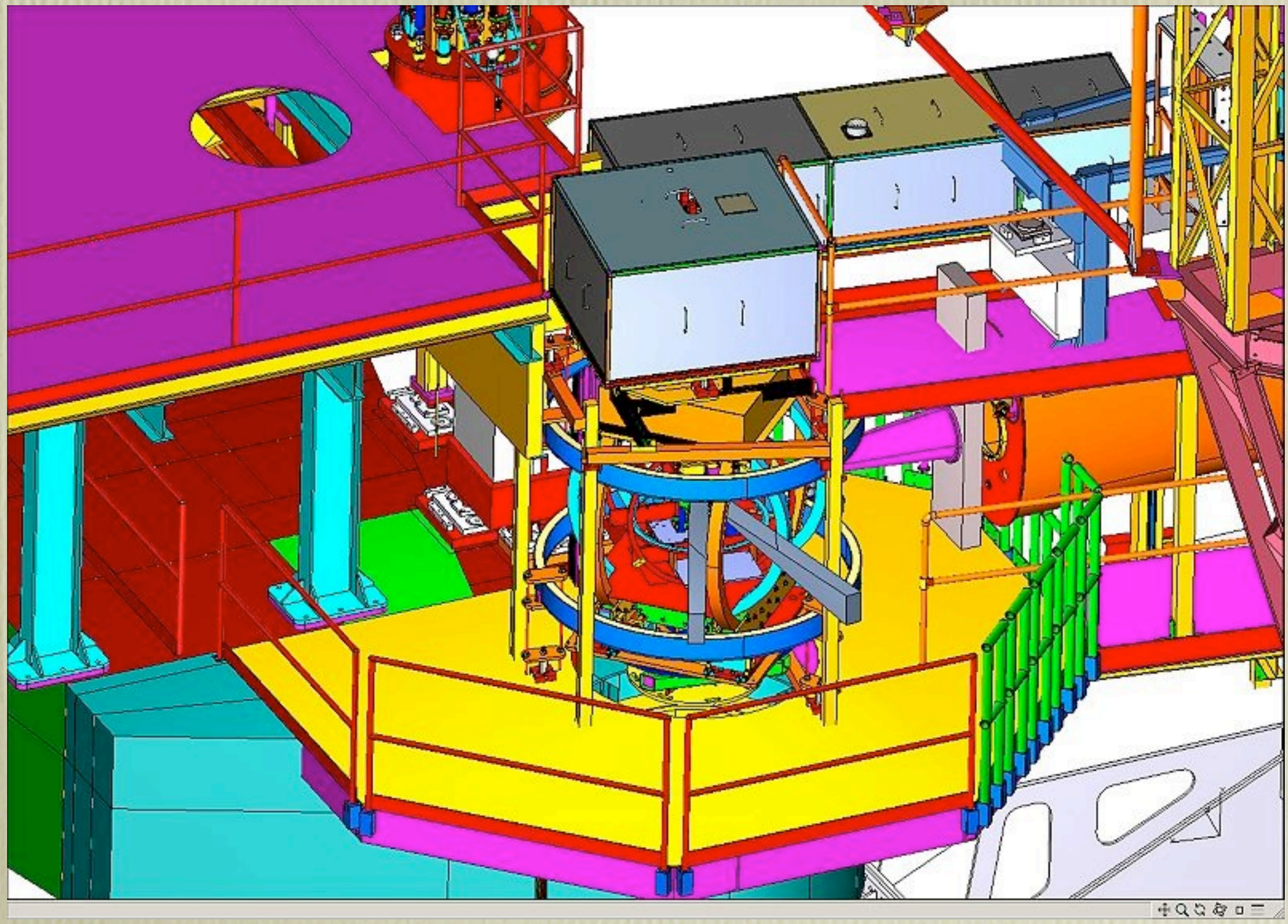
Cell design

- Metallic target chamber necessary to handle 30-60 μA
- Convection
- Polarimetry: EPR, Pulse NMR, AFP NMR only for calibration
- Two-pumping-chamber cell allows more laser power
- More laser power is needed for the increase in gas volume: from 2-3 STP liters to 6-7 STP liters





Hall A polarized ^{3}He system on Hall C pivot



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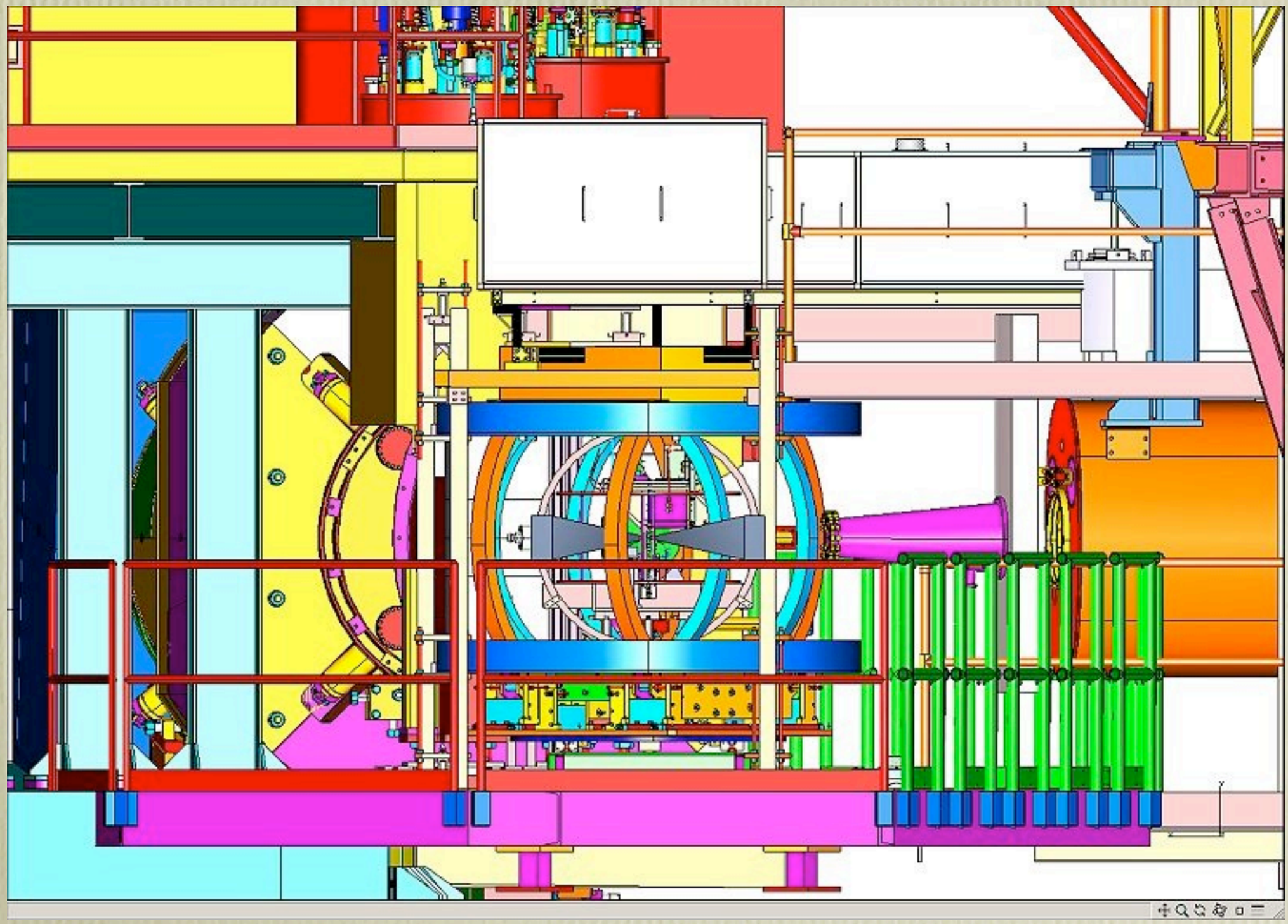


Barrel-type coil design

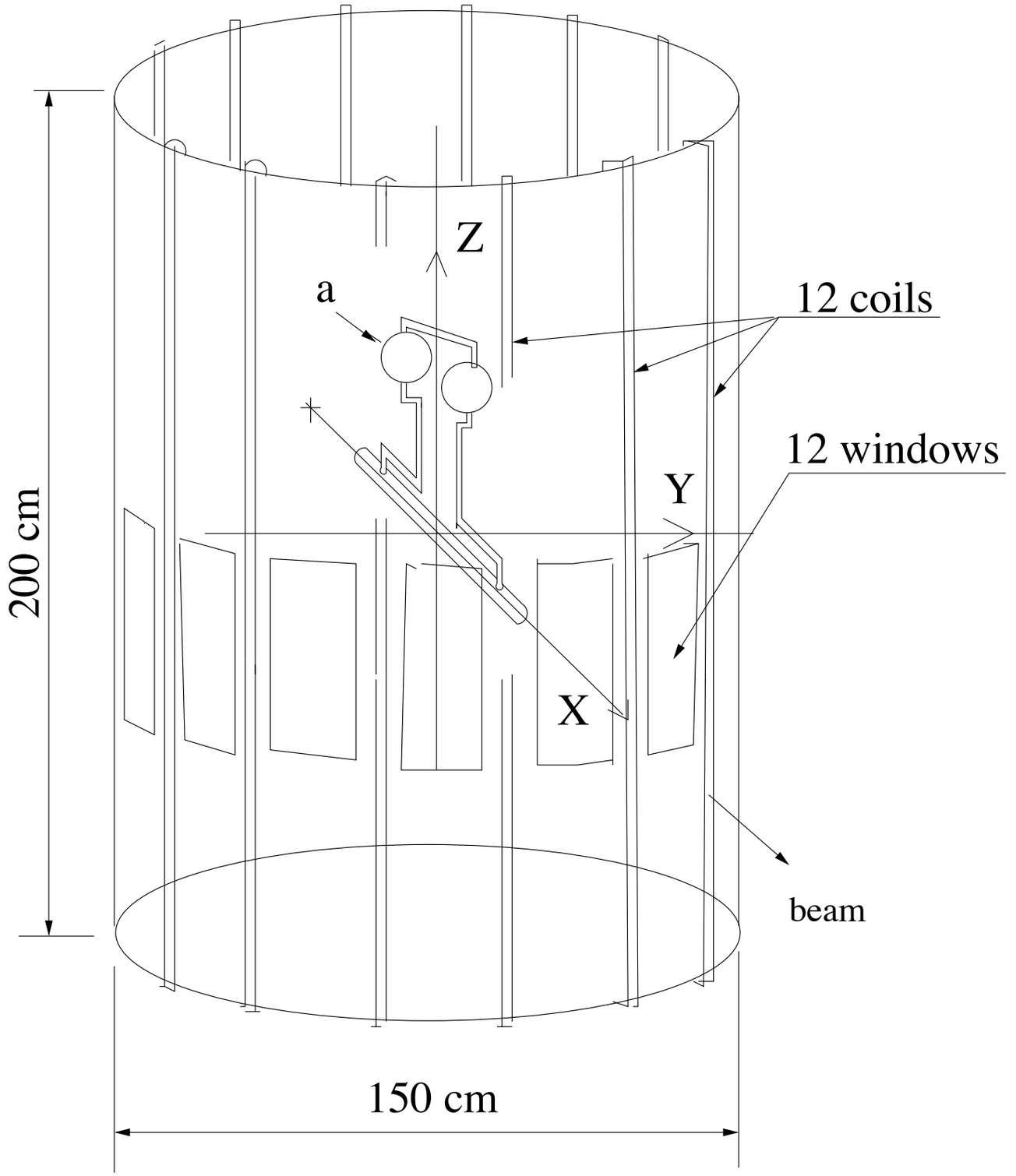
From Vladimir Nelyubin's talk at the Hall A collaboration meeting:

The barrel type magnet provides holding field for new target cell with inhomogeneities:

$$\left[|\vec{\nabla}B_y|^2 + |\vec{\nabla}B_z|^2\right]^{\frac{1}{2}} \sim 20\frac{\mathrm{mG}}{\mathrm{cm}}$$

The angle between directions field in the target and pumping chamber is $\sim 0.7^o$.

The first consideration show that barrel type magnet is very promising. To decrease gradient we plan optimize sizes of the barrel magnet.

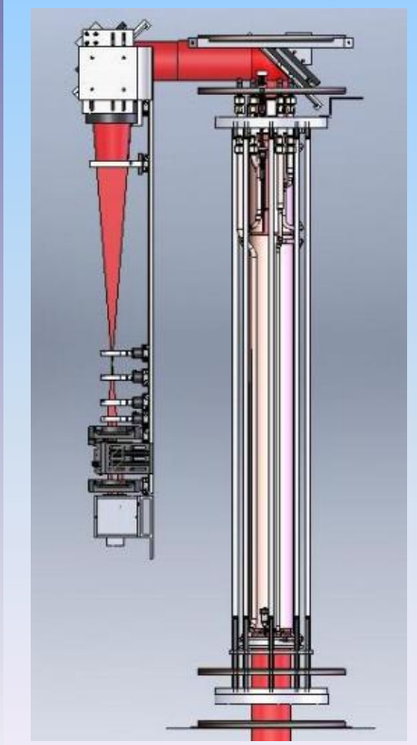


Possible next generation polarized ^{3}He target

Xemed LLC

An *ex situ* high pressure target

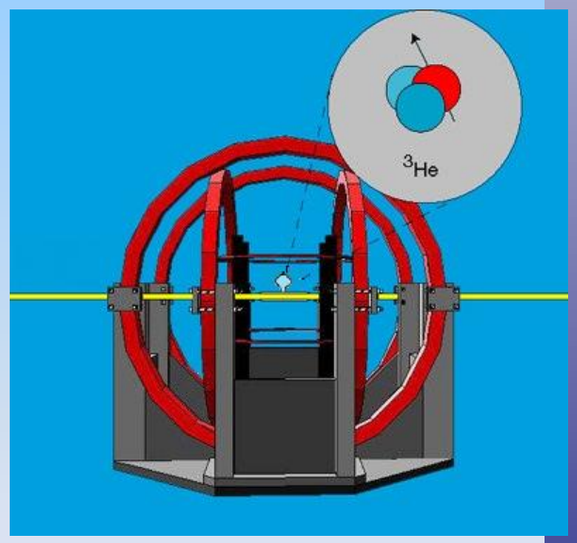
- Continuous SEOP within a large volume vessel
- Compress polarized ^{3}He by 20:1 pressure ratio and deliver to titanium target cell at 1 scfm
- Requires compression ratio ~20, immersion in magnetic field, rubidium-free gas leaving polarizer, <3% polarization loss
- Throttle polarized gas back into the polarizer, de Laval nozzle



Requires two ports, entrance and exit

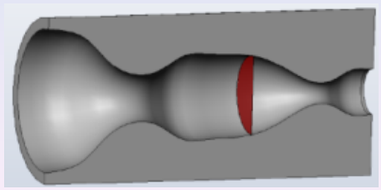
15 Bar

238 Bar



1 cm x 40 cm titanium target cell

Recirculating at 1.0 scfm



Summary

- **New design polarized target should be able to reach about 8 times more luminosity than "Transversity" target:**

  - ➡ **Hall C is planning to use the same target system as Hall A A_1^n.**
  - ➡ **Every steps are being coordinated between Hall A and Hall C.**

- **Next generation polarized ^{3}He target might be a Xemed-type target which will allow another order of magnitude improvement in luminosity:**

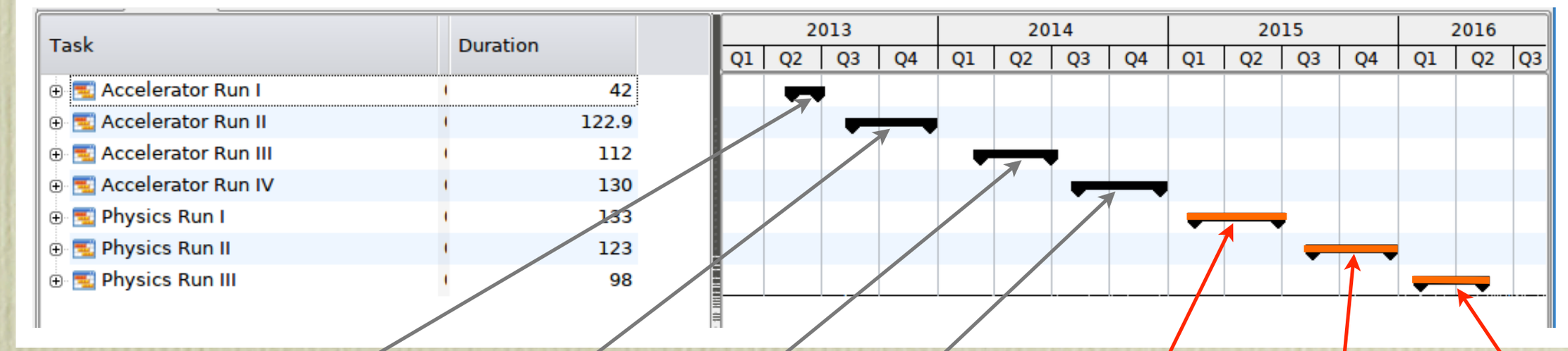
  - ➡ **Access to exclusive experiments and low cross-sections kinematical regions.**
  - ➡ **Need LOIs and/or proposals to push for this target.**

Extra slides

Accelerator projected schedule

From Arne's talk at the Hall A collaboration meeting:

Task	Duration
Accelerator Run I	42
Accelerator Run II	122.9
Accelerator Run III	112
Accelerator Run IV	130
Physics Run I	133
Physics Run II	123
Physics Run III	98



no physics

beam to Hall-A
(1 week for detector checkout)

beam to Hall-D
(3 weeks for transport tests)

Hall-A physics
(up to 3 pass)

Hall-A eng./physics
(up to 3 pass)

Hall-B&C
(detector tests)

Hall-D engineering run

Hall-A Physics

Hall-B&C ?

Physics in all Halls

Hall-A Physics

Hall-B&C engineering runs

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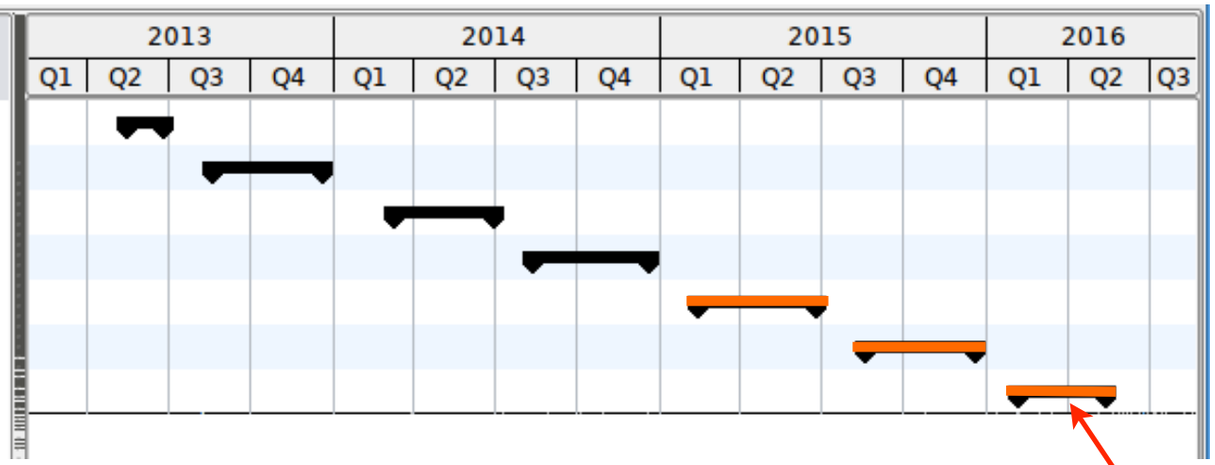
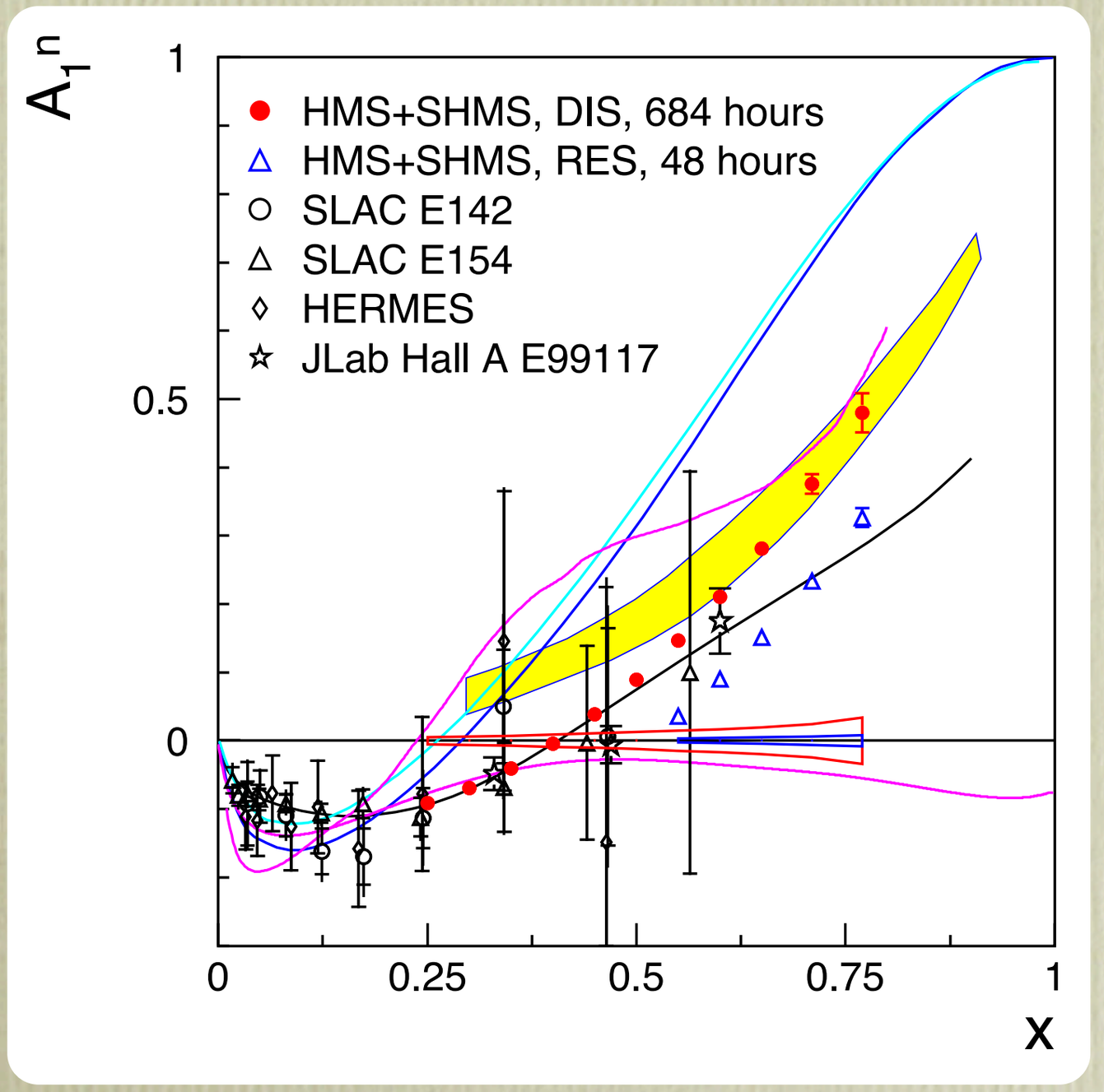
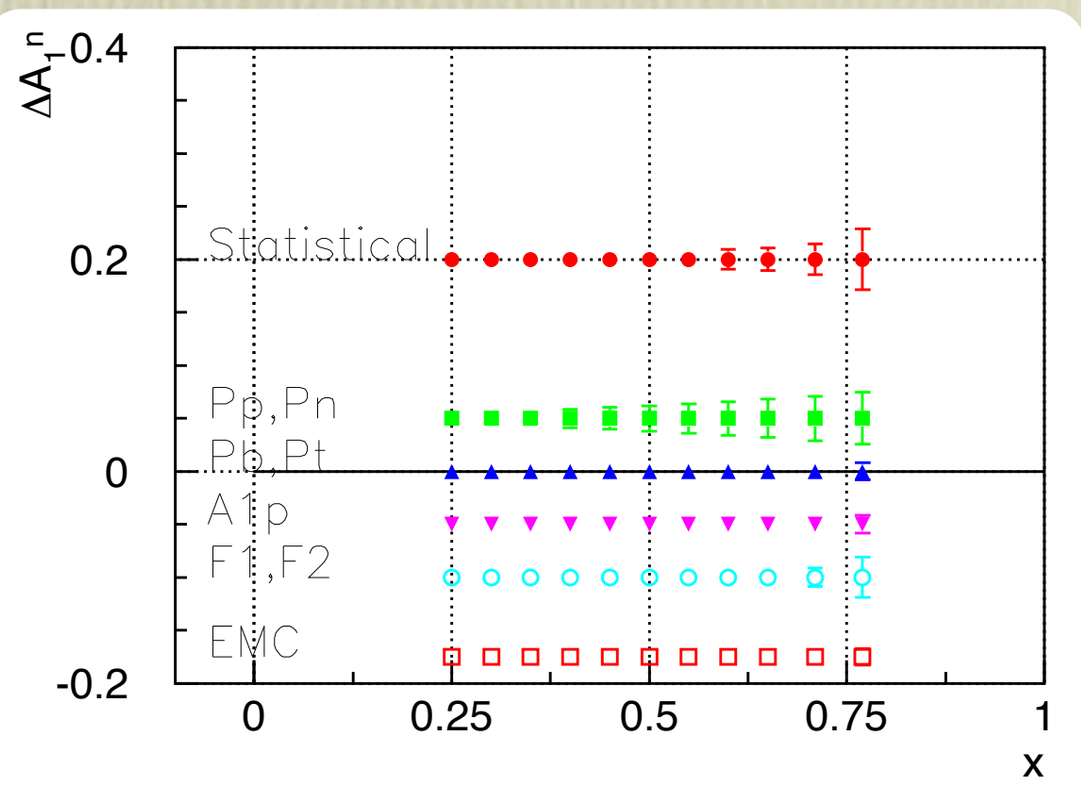


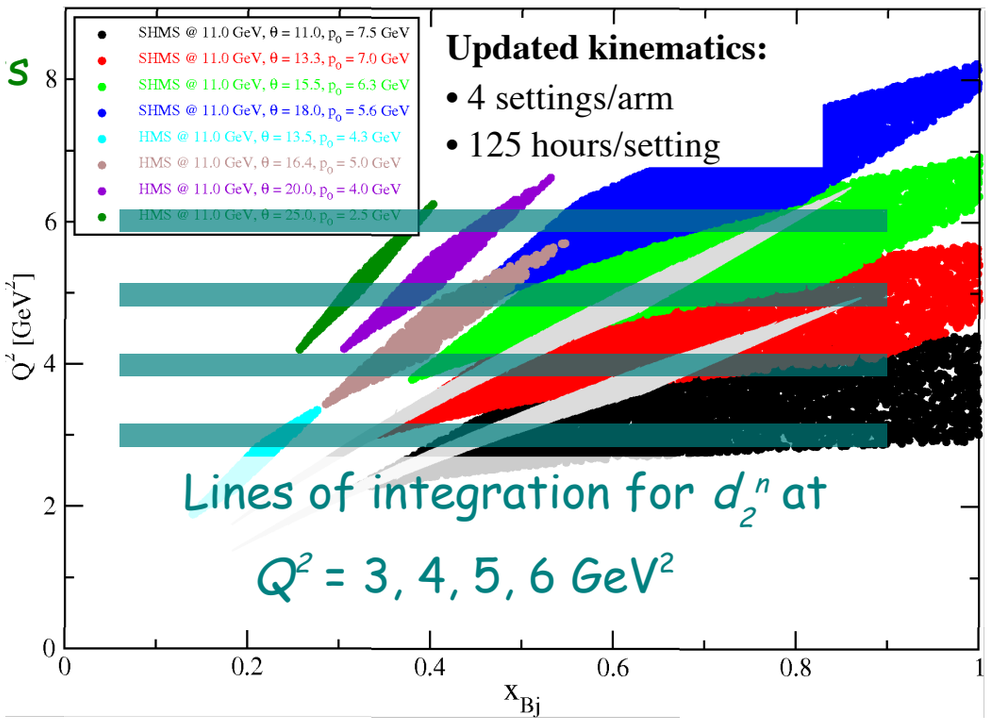
"Optimistic" earliest run seems to be late 2016

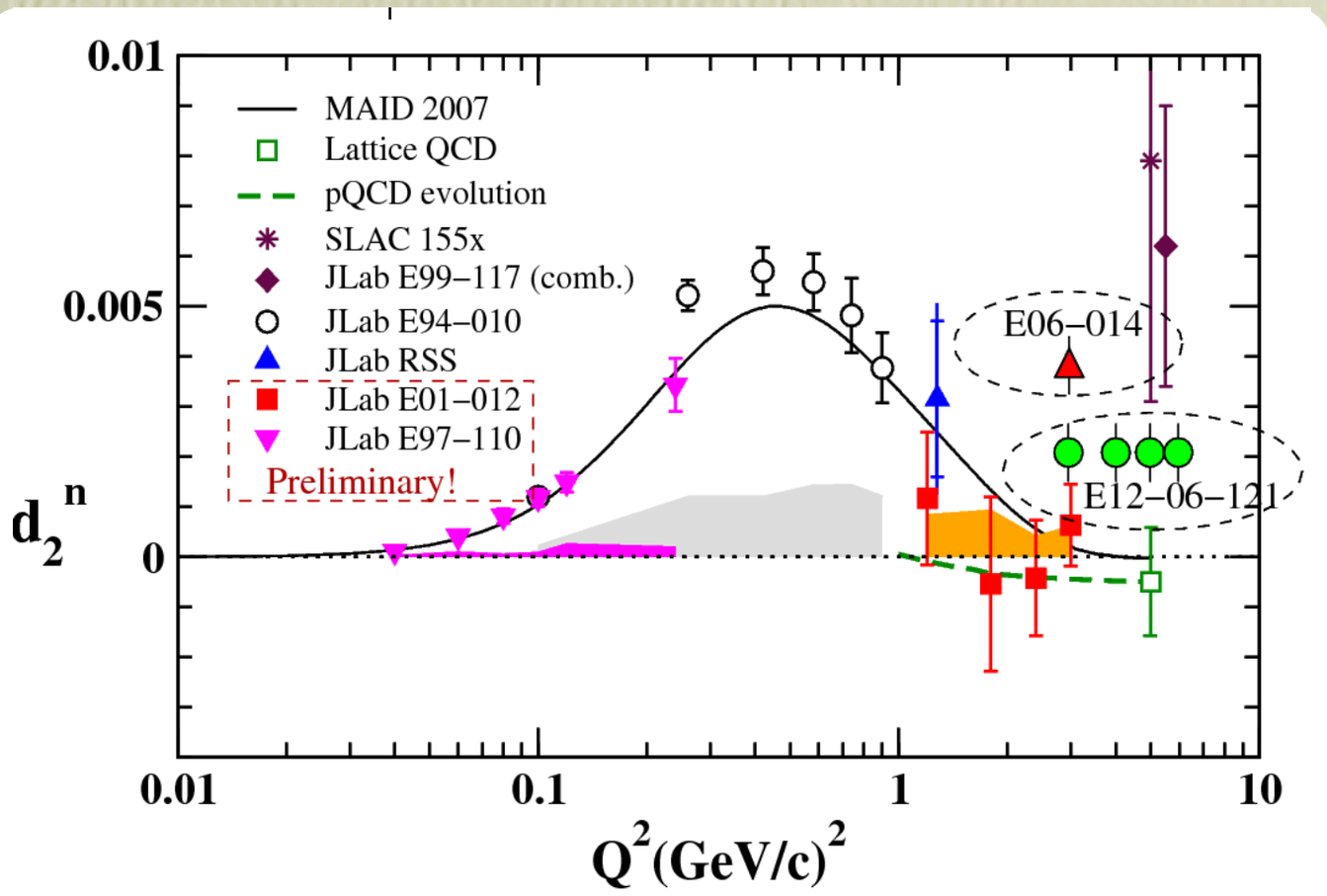
Projected precision for A_1^n



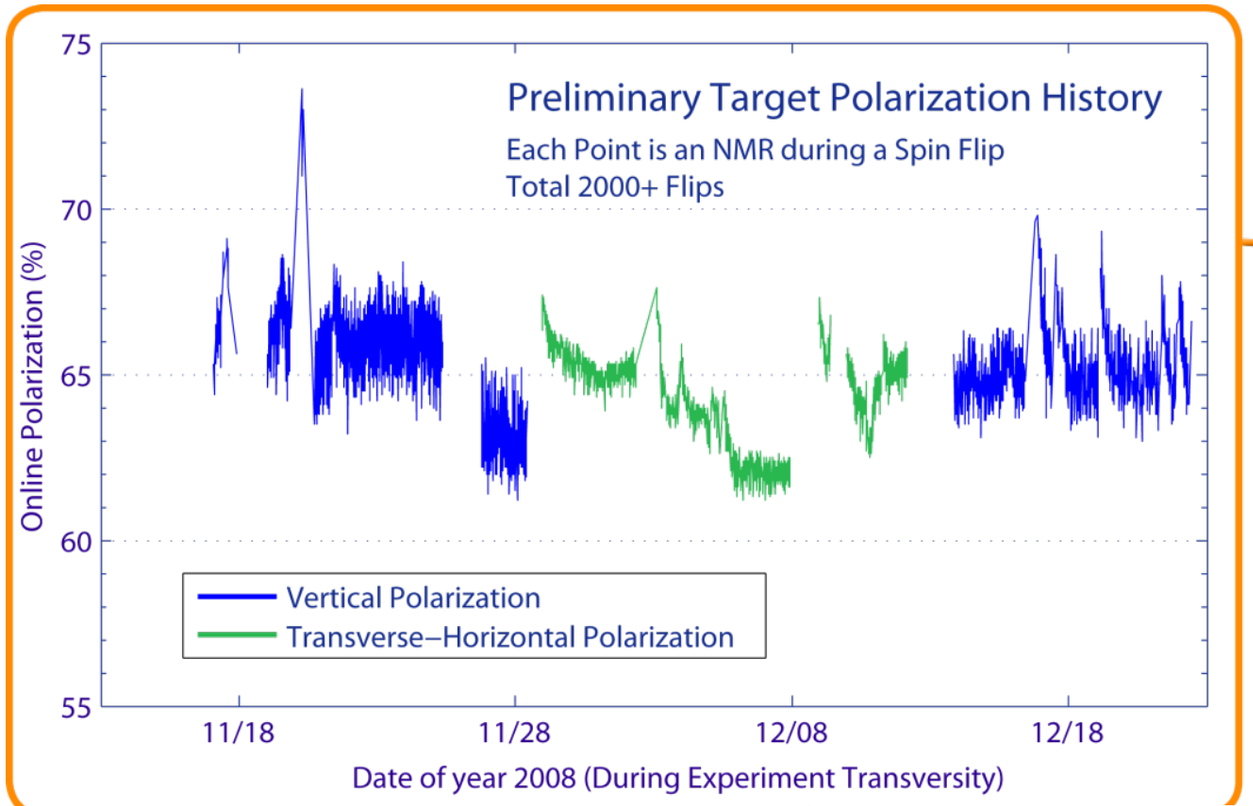


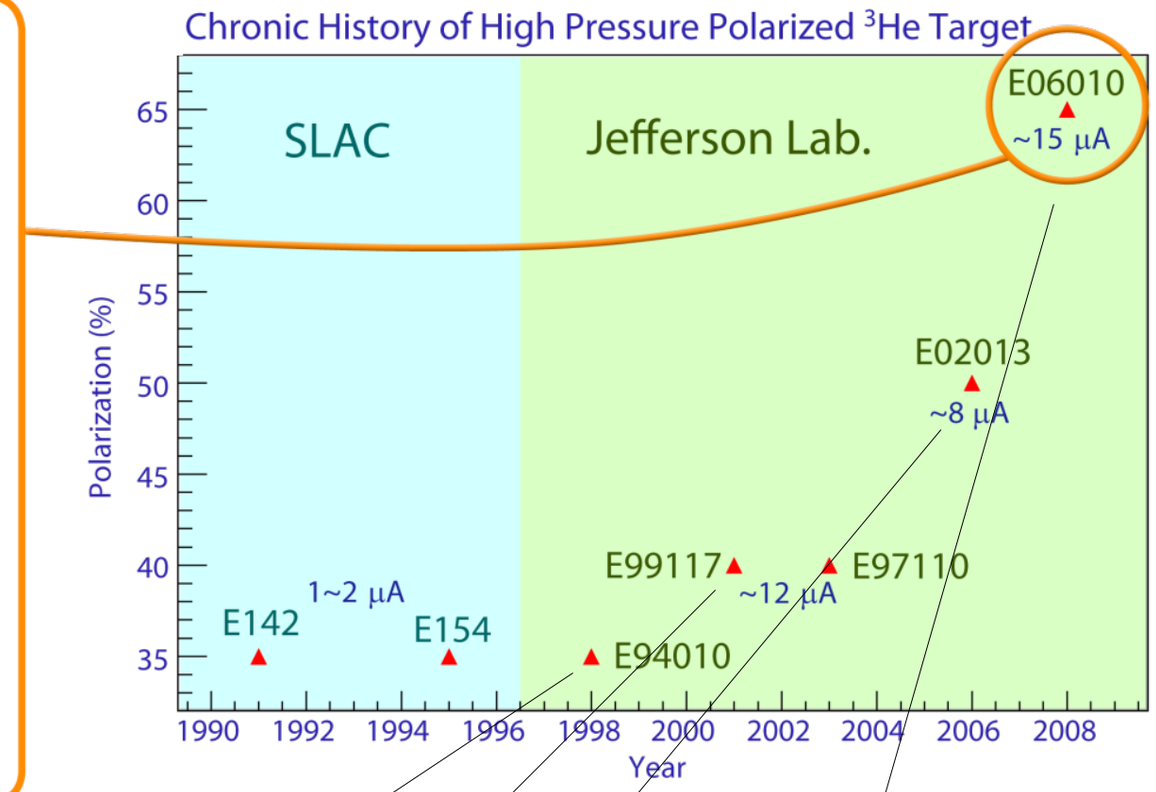
Projected precision for d_2^n

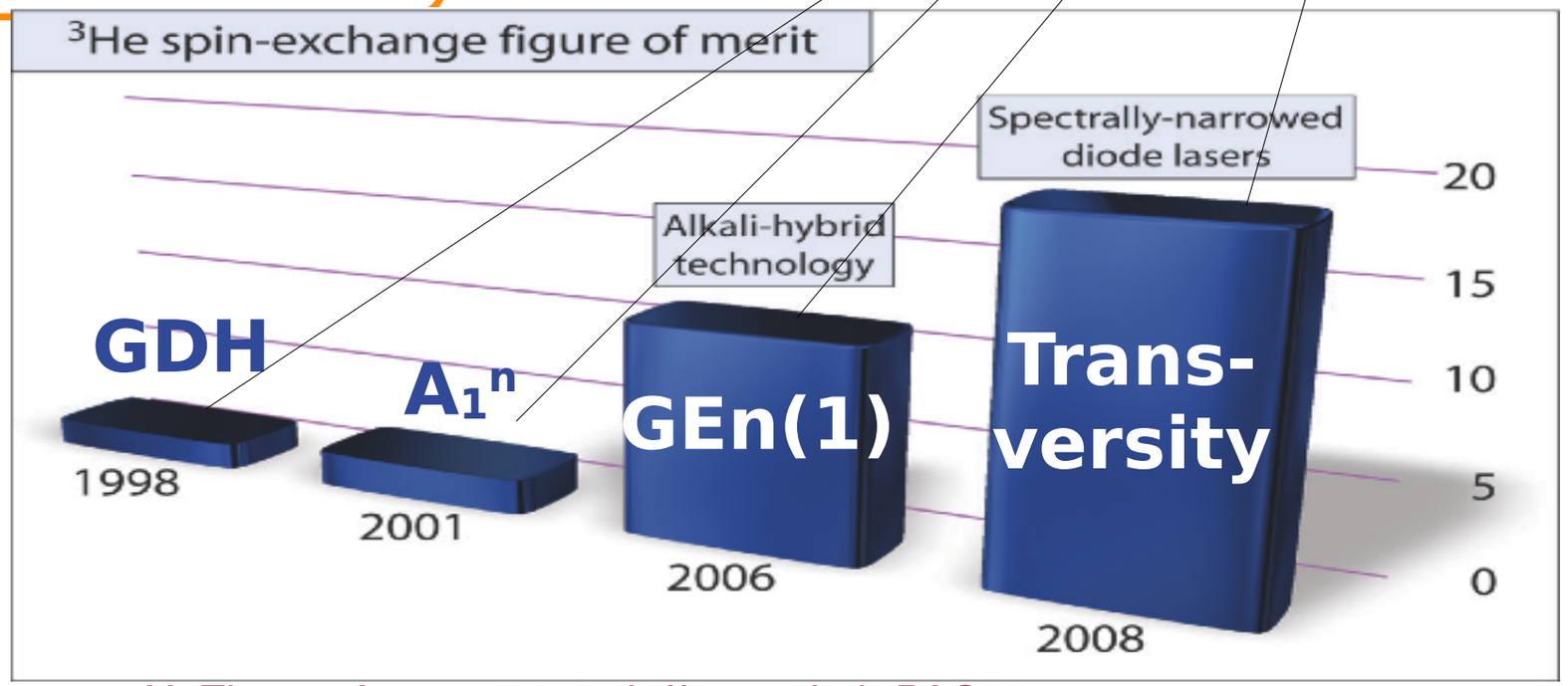




Improvements on the Polarized 3He Target 1991-2006-2009







Spins polarized per second weighted by polarization squared

X. Zheng, August 2010, Jefferson Lab PAC36