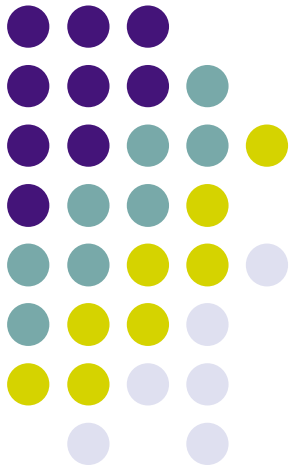
Polarized ^{3}He injection test plan and issues

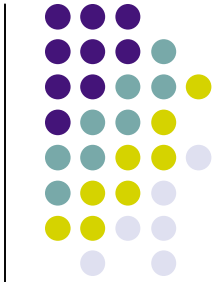
H. Gao, T. Mestler, X.Qian, Q. Ye, X.F. Zhu
(Duke)
And others in EDM Collaboration



Oct 6, 2006

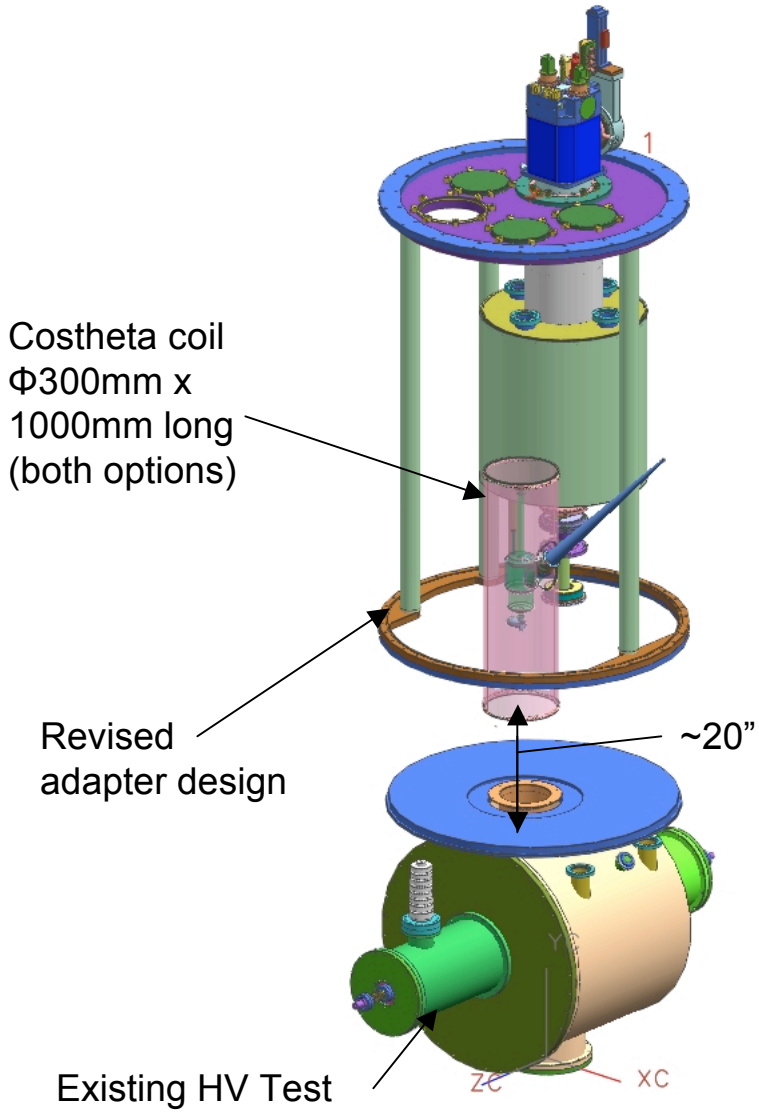
nEDM Collaboration Meeting

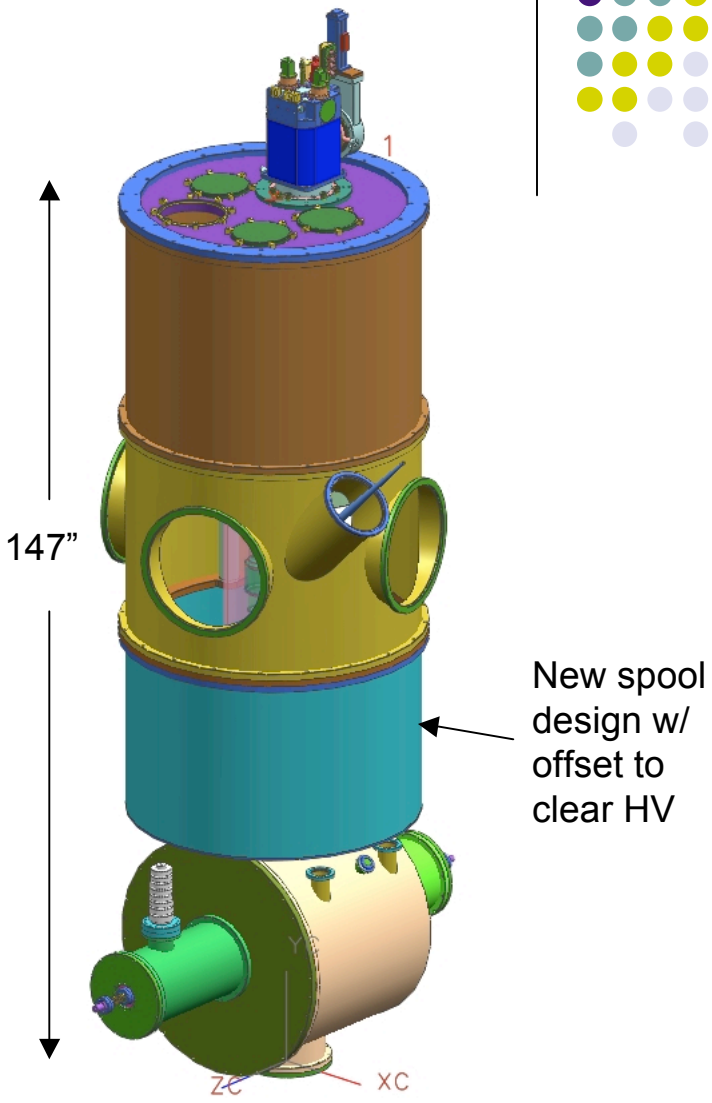
Outline

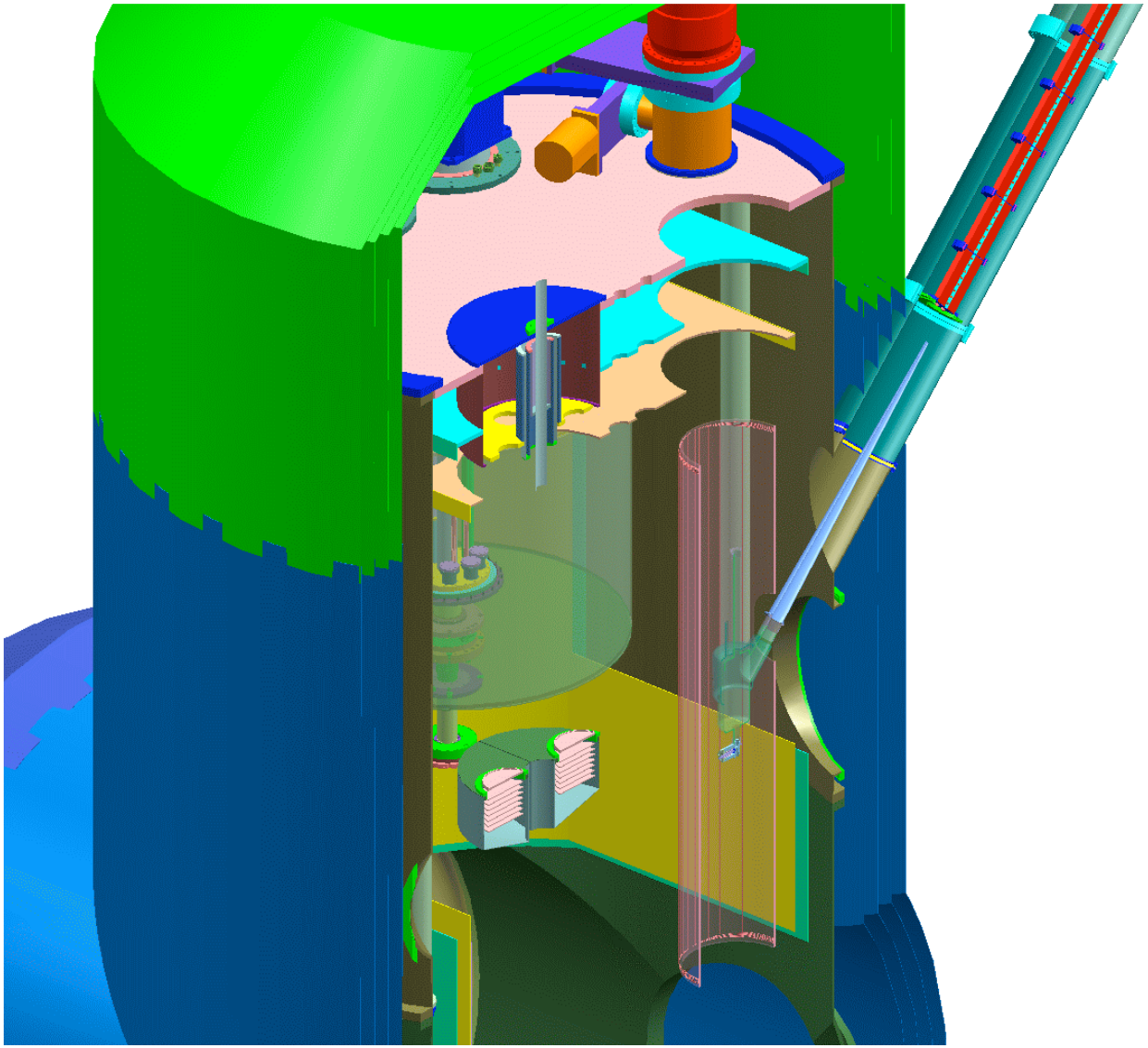


- Introduction and goals
- Issues
- Plan and timeline

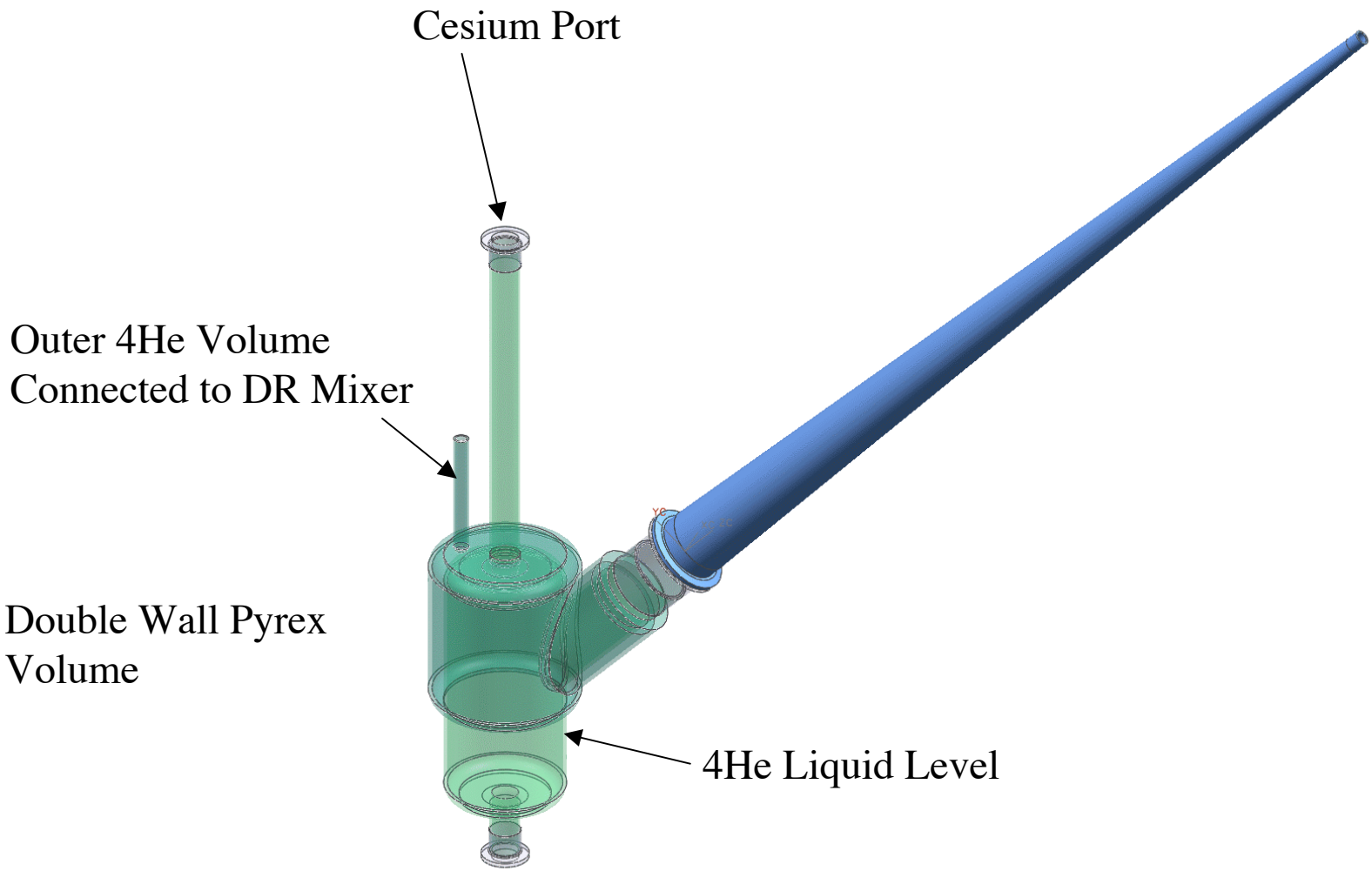
Dual Use Test Cryostat – Option A





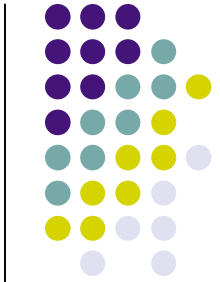


3He Injection/Collection Geometry



Collection volume in the current design? Prefer smaller collection volume

Goals



- Inject 3He from ABS and collect
- 3He polarization maintained
- Plan to use AFP NMR to establish that 3He is collected and polarized

Things need to be done

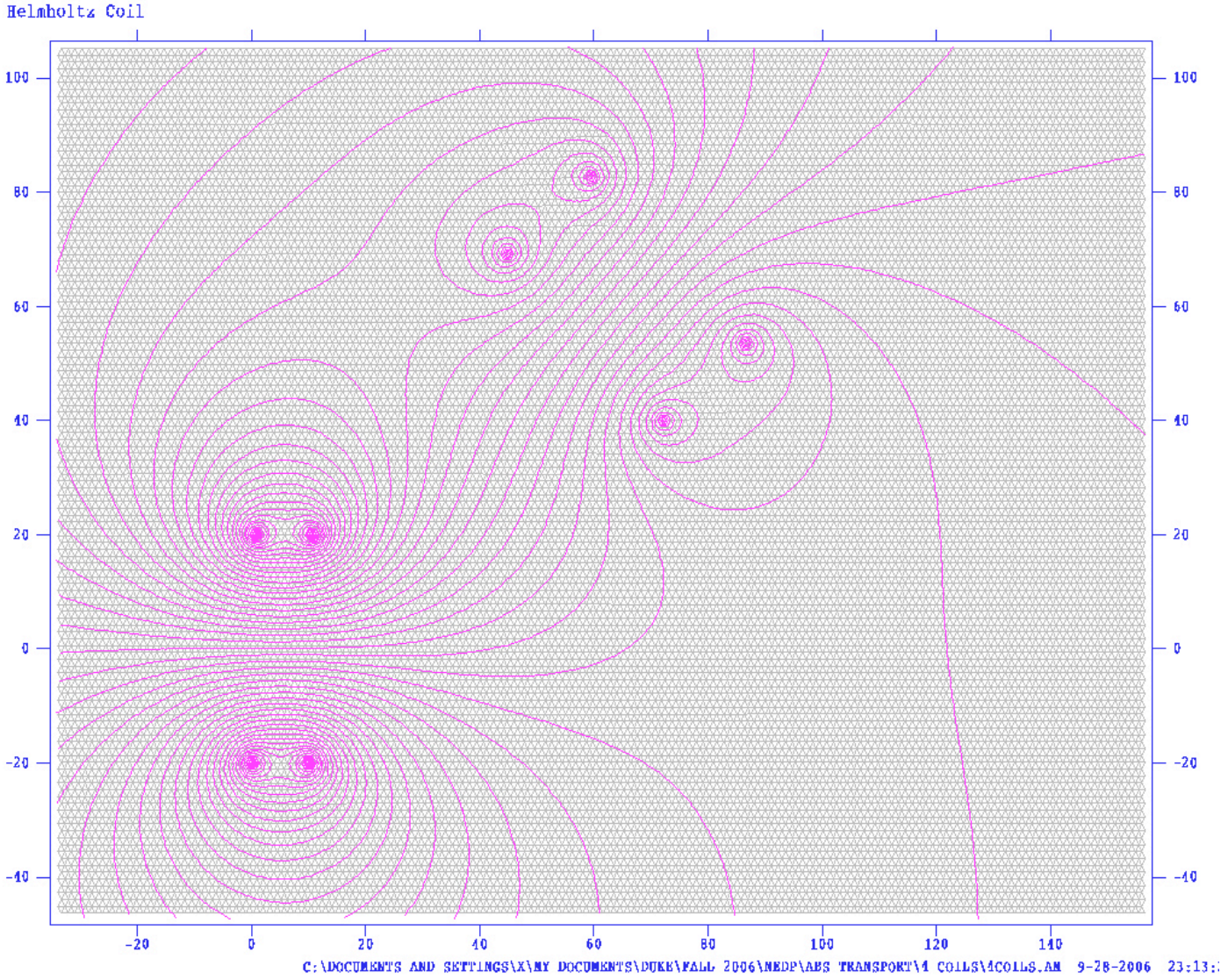
- Coils for spin transport from ABS to the collection volume and the support structure
- Collection volume construction and in-situ Cesium coating, injection tube, shutter/valve
- Suppressing of 4He film: film burner versus Cesium ring
- AFP NMR measurement of 3He polarization

(relative) inside the collection volume

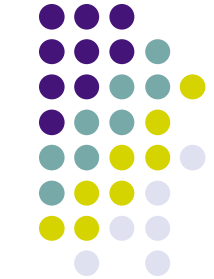
Transport coils design

- Preliminary design completed
  - Two sets of coils, one Helmholtz and one non-HM
  - Magnetic field ranges between 4 - 20 Gauss in the transport region
  - Simulations have been performed
    - Demonstrate that spin follows the field direction
    - Relaxation due to magnetic field gradient not an issue
- Next step
  - Jan's design work complete first, visit of TUNL
  - Fine tune the coil design
  - Construct and test the coil system, build the support structure for the coils

Transport coil Design by Troy Mestler (Duke Undergraduate)



Estimation of 3He NMR signal size I

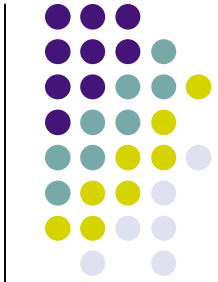


- Expected number of 3He in the collection volume 10^{16} and polarization ~100%
- Duke NMR result so far: $3.3*10^{20}$, 54 cc, polarization~ 5% (estimate @ 1.9K), signal size 0.3 mV $\leftrightarrow 1.7 * 10^{19}$ (100% polarized)

  1 μV $\leftrightarrow 5.5 * 10^{16}$ (100% polarized),

noise ~ 8 μV (single coil) in our experiment at 1.9 K, and 25 Gauss

Estimation of 3He NMR signal size II



- Caltech NMR results, PRA 47, 468 (1993)

smallest NMR signal measured from 90 cc cell of 0.05 torr 3He (room temp), polarization~50% $\leftrightarrow$7.5 * 10^{16} (100% polarized), at 25 Gauss and room temperature

Noise expects to be reduced when it is colder (Duke results: a factor of ~3 improvement from room temperature $\rightarrow$ 1.9 K)

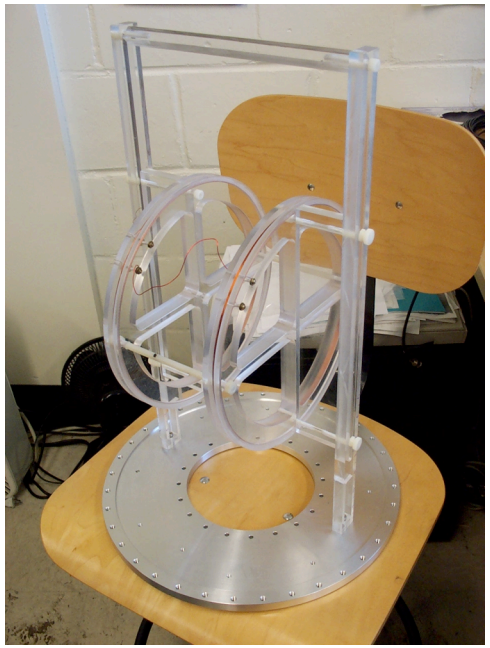
NMR measurement

- Feasible, however challenging
- Cos(theta) B field 25 Gauss or larger preferred
- Collection volume on the order of 100 cc preferred
- Improvement in signal to noise ratio by
  - Adding additional filters
  - two coils system
  - adding a set of nulling coil system
  - Reduce noise to 2 μV? 400-500 mK will help
  - Add NMR sweeps together
- Goal: signal:noise = 1:1

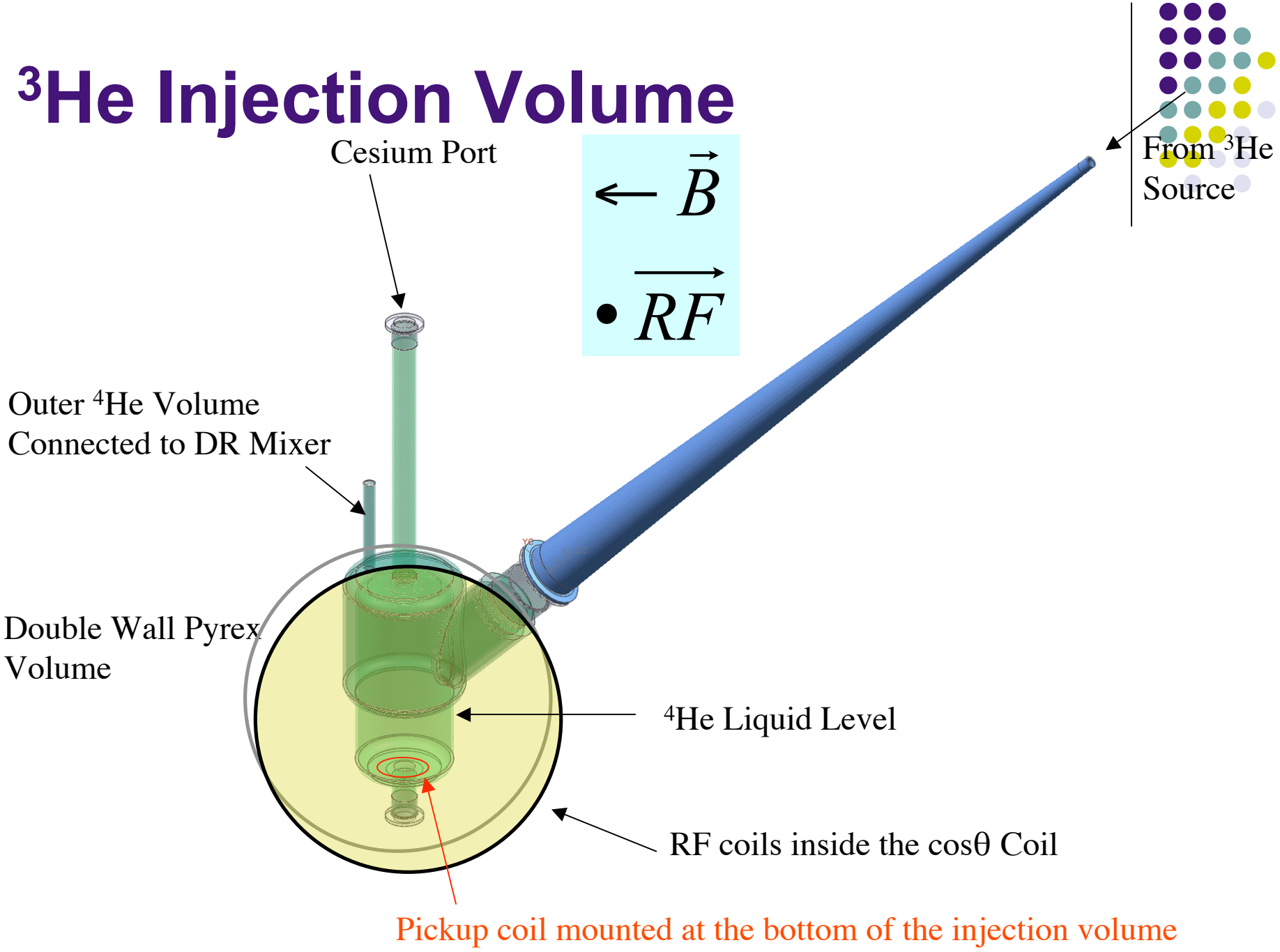
  need to collect $5*10^{16}$ ^{3}He in the collection volume, longer collection time?

  Increase ABS flux?

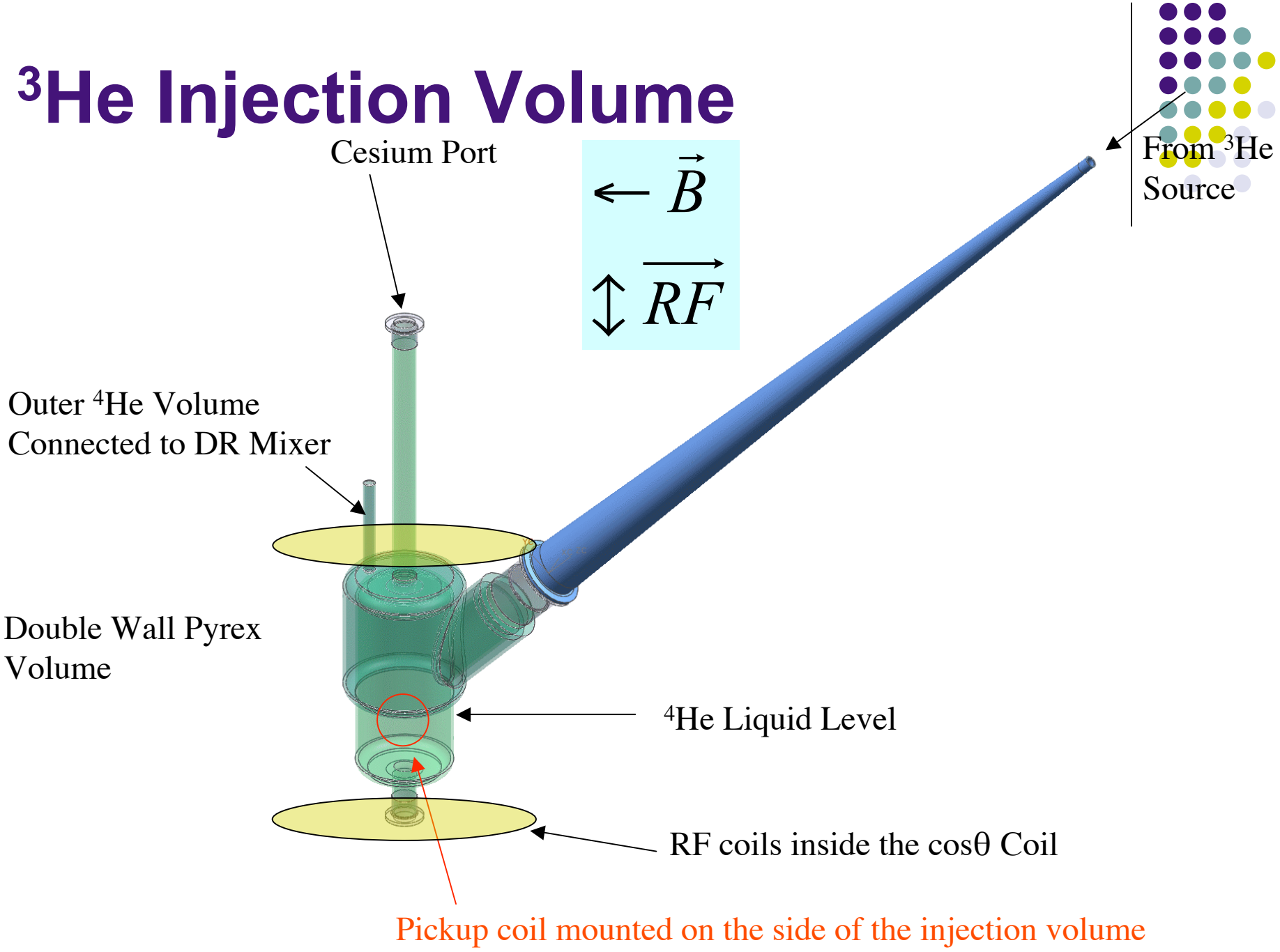
(D. Budkar's magnetometer?)



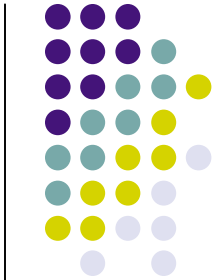
^{3}He Injection Volume



^{3}He Injection Volume



Pulsed NMR



- Candela, Hayden, Nacher, PRL73 (1994) 2587
  - Number of 3He total 8 * 10^{18}, measured pol 56%
  - B field 4 Gauss
  - Measure frequency shift due to 3He magnetization in the liquid using pulsed NMR
  - Geometry: tube inner diameter 0.6 mm, formed into 2 cm wide U

Temperature consideration for the collection volume

- Conditions: the injection tube on the order of 1 m
- Requirement: mean free path of ^{3}He be

  ~ 1 m or greater

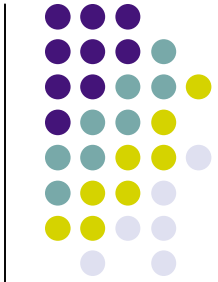
Extrapolation from experiments at higher temperatures:

T=0.4 K, mean free path 12 cm

T=0.3 K, mean free path 71 m (X.F. Zhu)

Proposed to start the test with collection volume temperature between 0.3 -0.4 K

Cesium Ring, Film Burner and HEAVAC Heater (issues)



- Can we operate film burner (D. Haase)and maintain the collection volume temperature between 0.3-0.4 K at the same time?
- Effectiveness of Cs ring and the long-term effectiveness of Cs ring
- Do we need a ``HEAVAC'' (helium vapor compression) heater?

Near term action items

- Finalize the design of the injection tube
  - Dimensions
  - Material: pyrex glass?
  - Shutter (?) between ABS and the injection tube
- Design and the construction of the collection volume
  - Can we make it on the order of 100 cc?
- Decision on Cesium ring versus film burner

Have all components ready to be shipped to LANL May 31, 07