A Polarized Target for E1039 (SPINQUEST) at FermiLab

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Outline

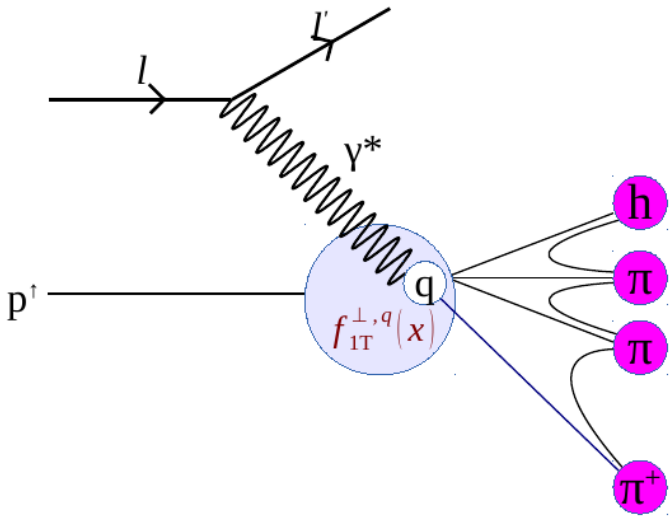
- Physics of Interest
- The Experimental Setup
- The Target System
- Beam Effects
- Schedule

What is SPINQUEST (E1039) ?

- Polarized Drell Yan
- $P + P^{\uparrow} \rightarrow [\mu^{+} + \mu^{-}] + x$
- Probe of Valence Sea Quark
- Asymmetry in μ PAIR Production. Sivers Function

Accessing Quark Sivers TMDs

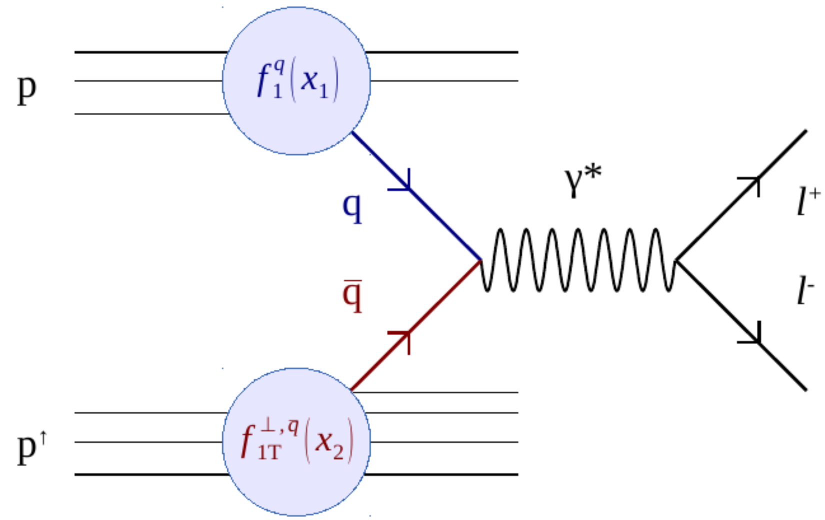
Polarized Semi-Inclusive DIS



$$A_{UT}^{SIDIS} \propto \frac{\sum_q e_q^2 f_{1T}^{\perp,q}(x)\otimes D_1^q(z)}{\sum_q e_q^2 f_1^q(x)\otimes D_1^q(z)}$$

- L-R asymmetry in hadron production
- Quark to Hadron Fragmention function
- Valence-Sea quark: Mixed

Polarized Drell-Yan

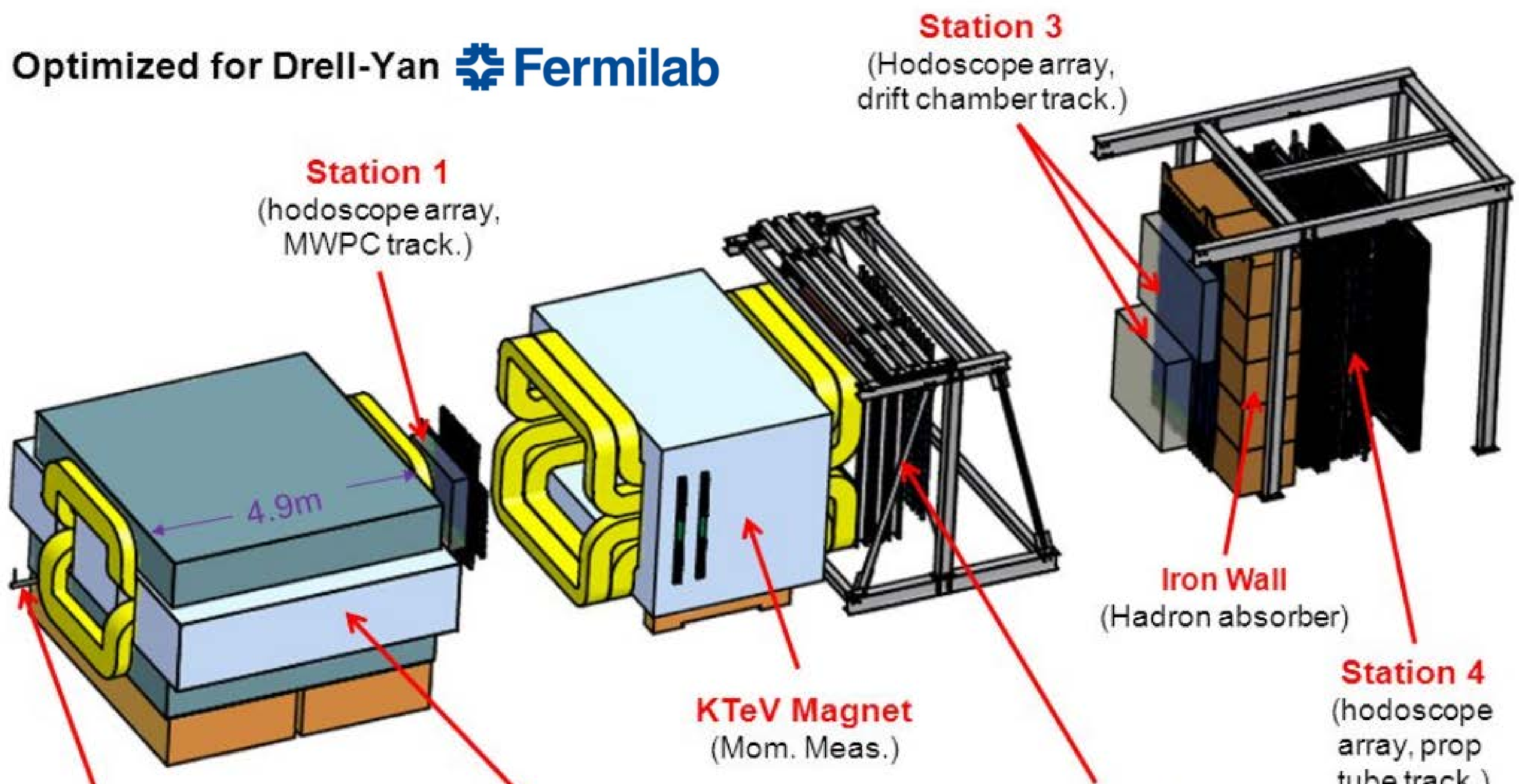


$$A_N^{DY} \propto \frac{\sum_q e_q^2\left[f_1^q(x_1)\cdot f_{1T}^{\perp,\bar{q}}(x_2)+1\leftarrow\rightarrow 2\right]}{\sum_q e_q^2\left[f_1^q(x_1)\cdot f_1^{\bar{q}}(x_2)+1\leftarrow\rightarrow 2\right]}$$

- L-R asymmetry in Drell-yan production
- **No Quark Fragmention function**
- Valence-Sea quark **Isolated**

Experimental Setup for E1039

Detector Pack

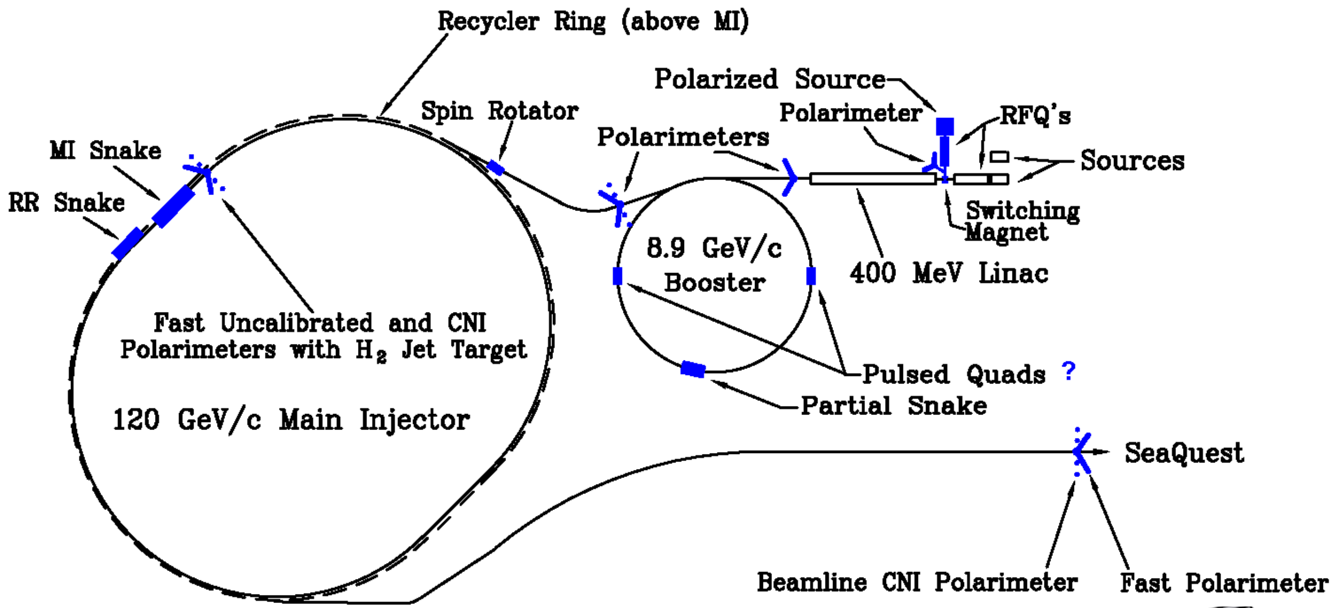


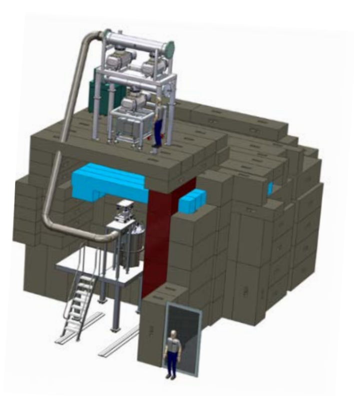
Target Cave: Under Construction

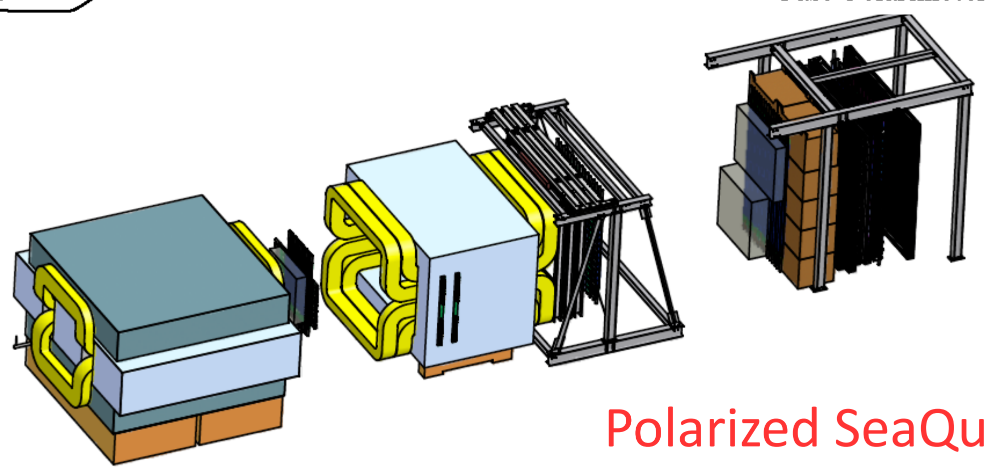
Solid Iron Magnet
(focusing magnet, hadron absorber and beam dump)

Station 2
(Hodoscope array, drift chambers track)

Experimental Setup for E1039







Polarized SeaQuest

Polarized target on the Intensity Frontier

Highest Intensity proton beam on polarized target with 4.4×10^{12} over 4.4s spill

- 8 cm long target cell of solid:

  NH_3 and ND_3

- Several watts of cooling power:

  14,000 m^3/hour pumping

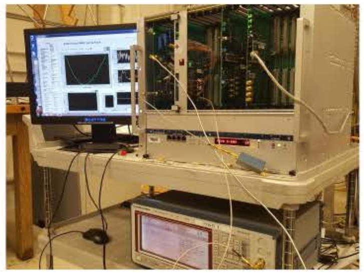
- 5T vertically pointing SC magnet:

  Pushing critical temp each spill

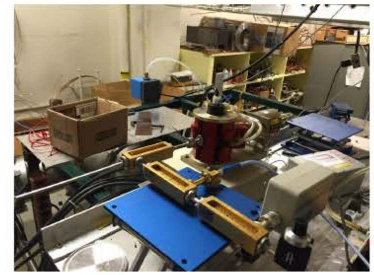
- Luminosity of around 2×10^{35} cm^{-2} s^{-1}

DNP Target System

LANL-UVA



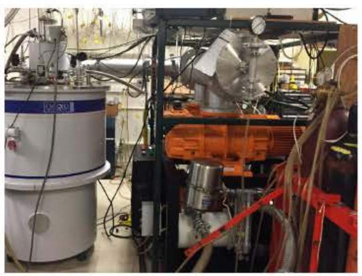
Insert

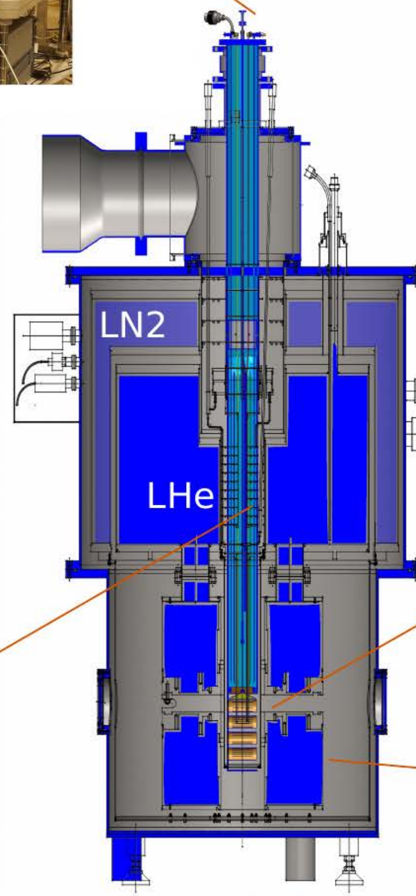


CPI-EIO

NMR

Microwave





Pumps

Target material

NH_3 ND_3

Produced at UVA

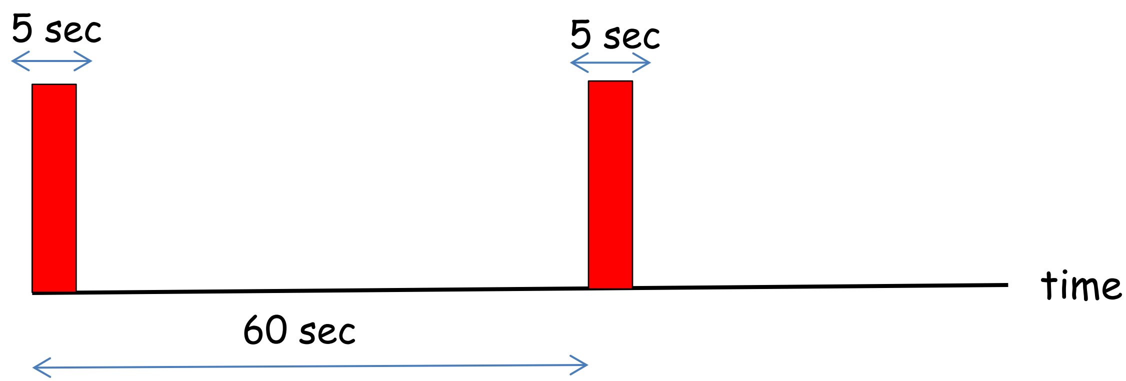
Fridge

UVA-LANL

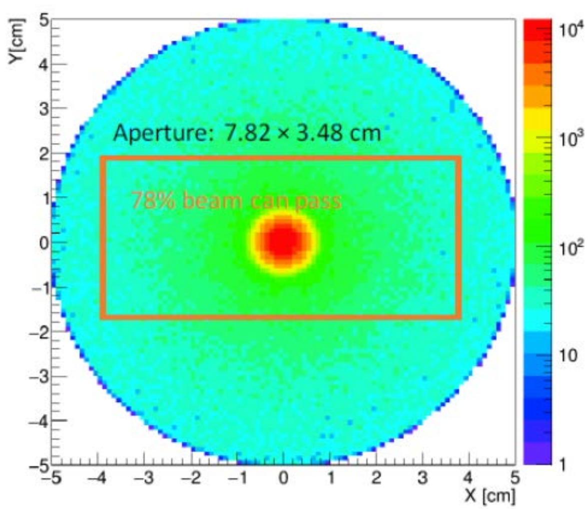
Magnet

SpinQuest Experimet at FNAL

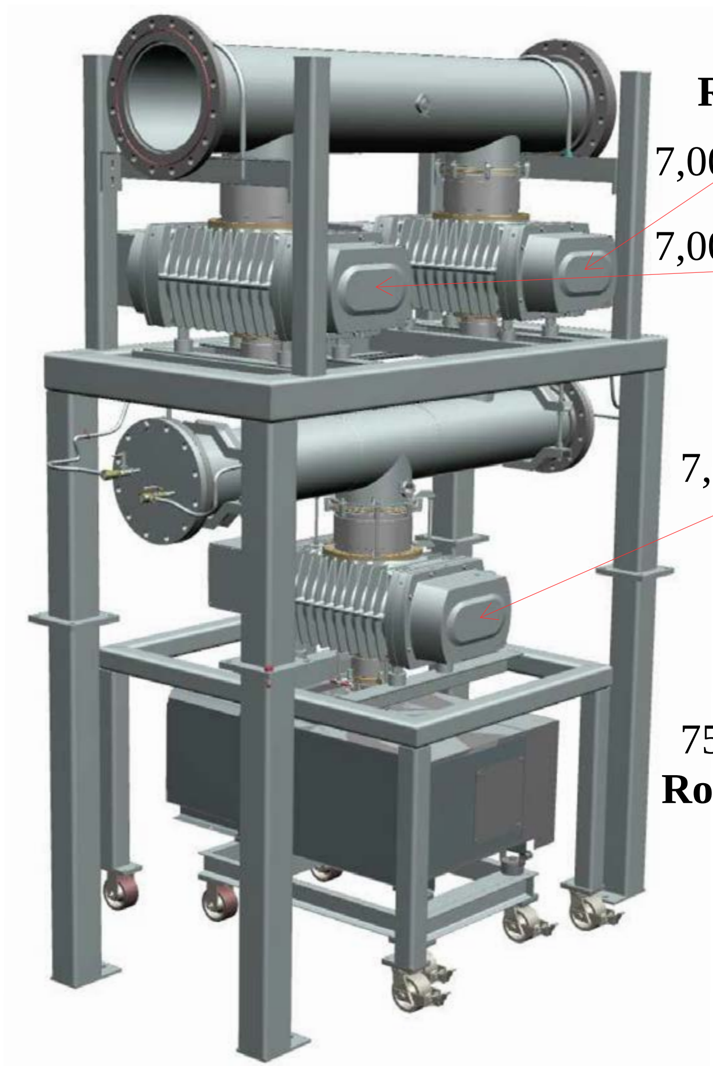
Time-Structure of the Beam ~ $5\ 10^{12}$ / 5sec. pulse



Spatial-Profile of the Beam



Oerlikon Pump Stack



Roots

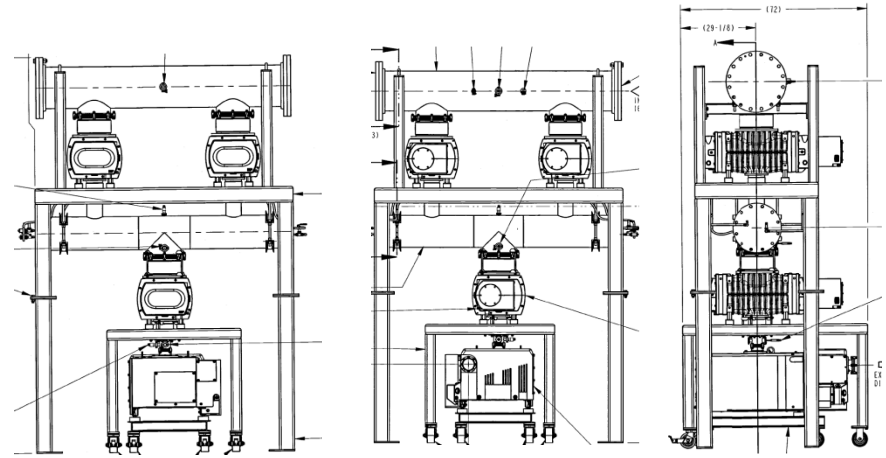
7,000 m^3 /hr

7,000 m^3 /hr

7,000 m^3 /hr

755 m^3 /hr

Rotary Vane



14,000 m^3 /hr

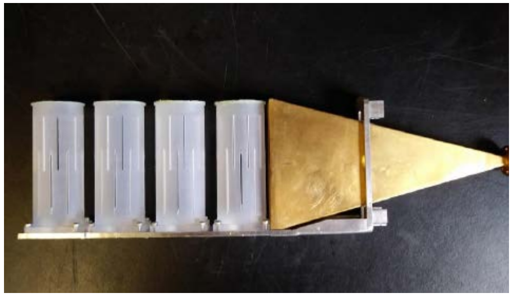
Pumping capacity

Assembled and test FNAL now ready for installation

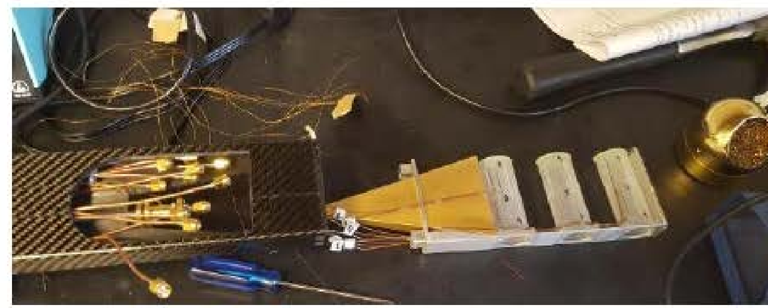
5T Superconducting Magnet

- **Rotated For Transverse**
  - original design S. Penttila, Oxford Instrument
  - LANL owned Magnet set for 20 years
- **Feasibility Study**
  - Shipped to UVA 2013
  - Cooldown in June of that year
  - Shipped to Oxford Instruments for rotation
- **Back To UVA**
  - Third cooldown: good hom. Over 5T in 8cm
  - Many cooldowns since
  - Systems runs smooth and stable but consumes lots of liquid helium
  - 500 L just to cool it after liquid nitrogen pre-cool
  - 160 L per day with boil-off, sep, and fridge

Target Inserts



8 cm



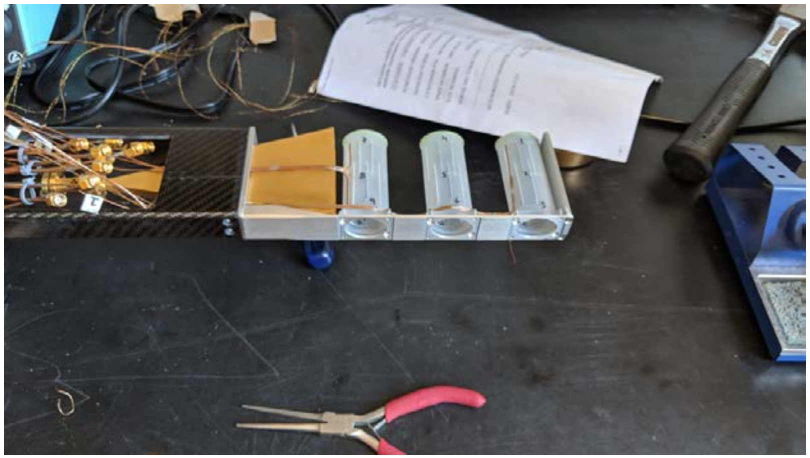
- Two inserts in progress for experimental use: One with four target cups (large), one with three target cups (small).

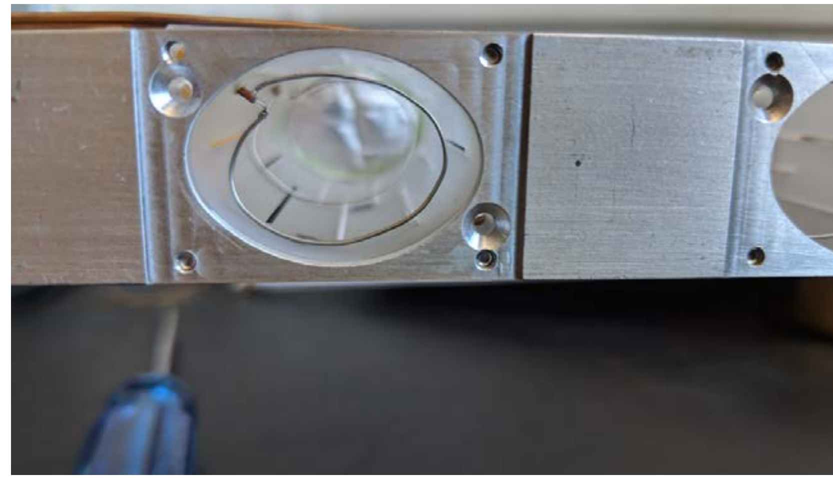
- Inserts surrounded by carbon fiber shell for thermal conductivity and guidance.

- Work on each insert being done in parallel. Currently, wiring is being done for,
  - NMR coils around target cups.
  - Temperature sensors

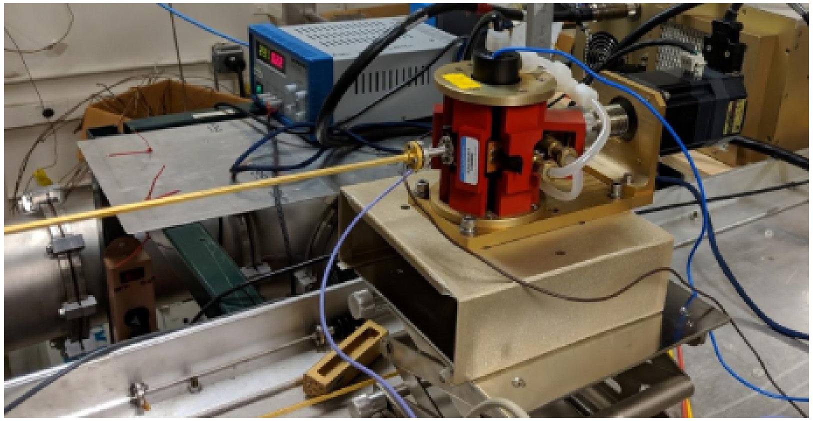
- 3 or 4 target cells per insert
- 3 coils per target cell
- 9-12 NMR lines running out of cave

Target Insert





Microwave System



Microwave Generator

Need temperature sensor and chiller flow monitor.

- Thermistor can be used for generator temperature read back.
- Flow meter to monitor chiller flow rate.
- For safety purposes, an interlock would be useful.

EIP Frequency Counter Model(588C)

Need remote readout only.

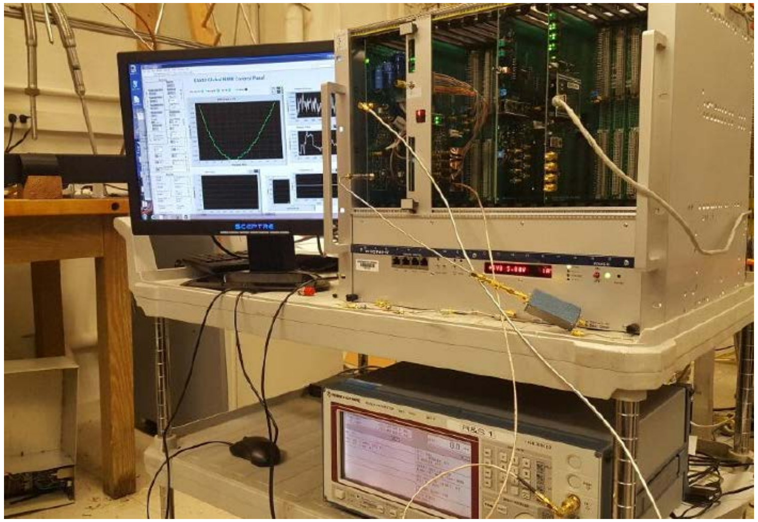
The position to frequency calibration in Labview changes as the EIP warms up and we want to be sure that the calibration is stable.

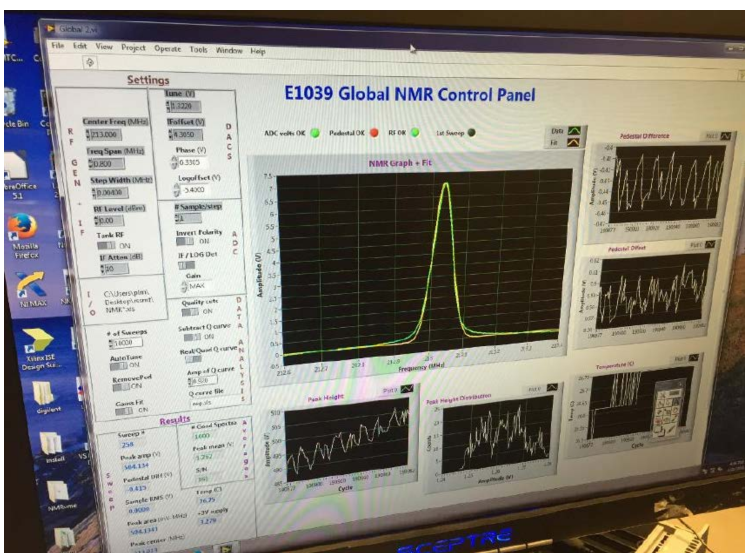
EIP Power Supply

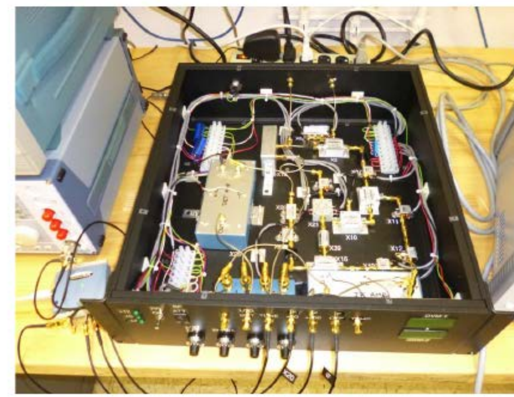
Power supply tested and working properly but need remote control due to placement in hall.

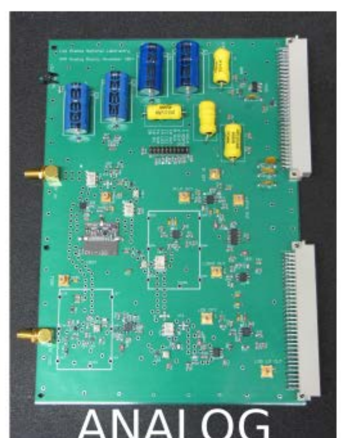
Efforts to develop communications (RS-232) libraries to begin soon.

NMR System - VME based









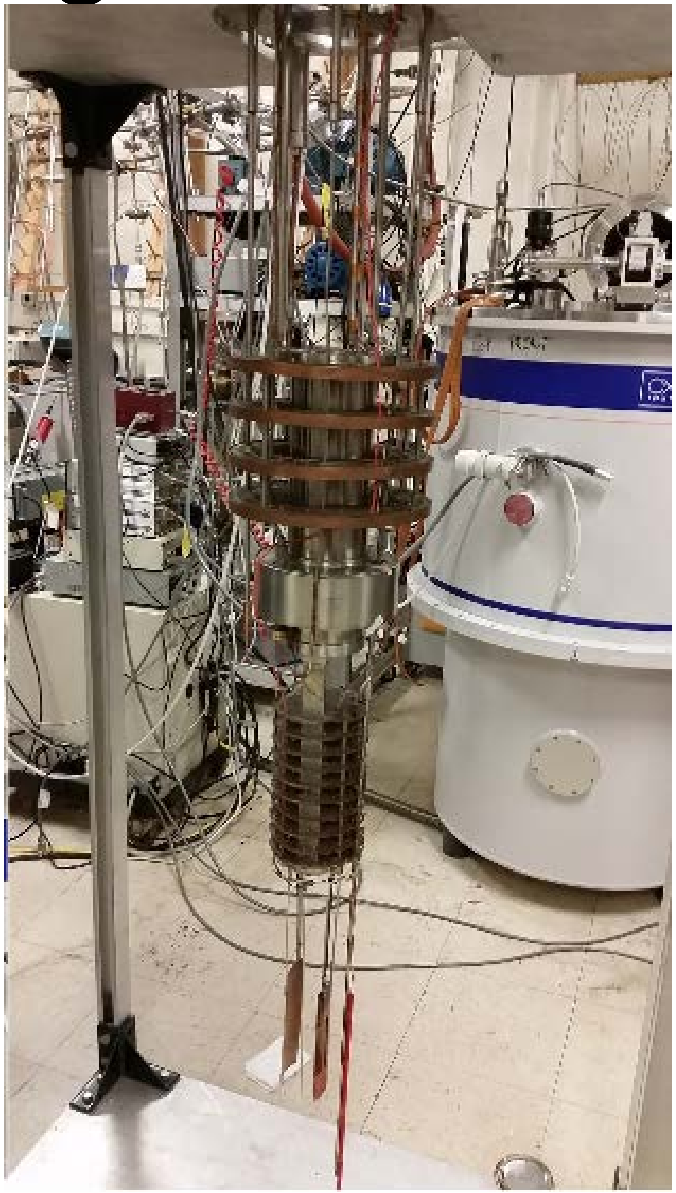
Evaporation Refrigerator

Evaporation Fridge

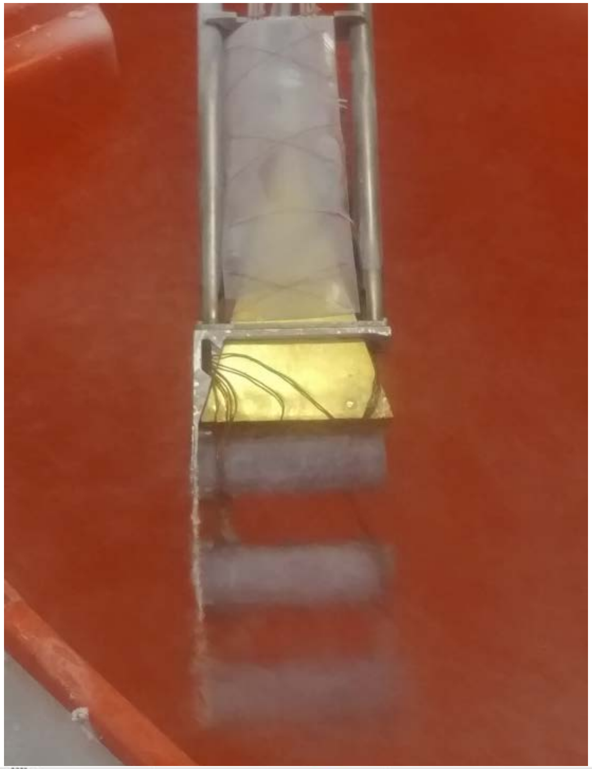
- Separator replaced and added guide ring to help with installation.
- Modified the insert channel and installed copper annealing plates.
- Installed level probe to monitor helium level.
- Positioned the helium delivery line to be out of beamline.
- Added eight new temperature sensors on system.
- Installed new run and bypass valves with software controls for run and bypass valves. Run valve has PID control, bypass manual/remote.
- Temperature monitor system working in Labview.
- Made two nose pieces with specialized window.
- Installed new liquid helium pressure probe (old probe was leaking).

Still to do:

- Need to do cold test for both new valves.
- Need to make new turret flange.
- Helium test nose pieces. Already leak tested.
- Test liquid helium probe.

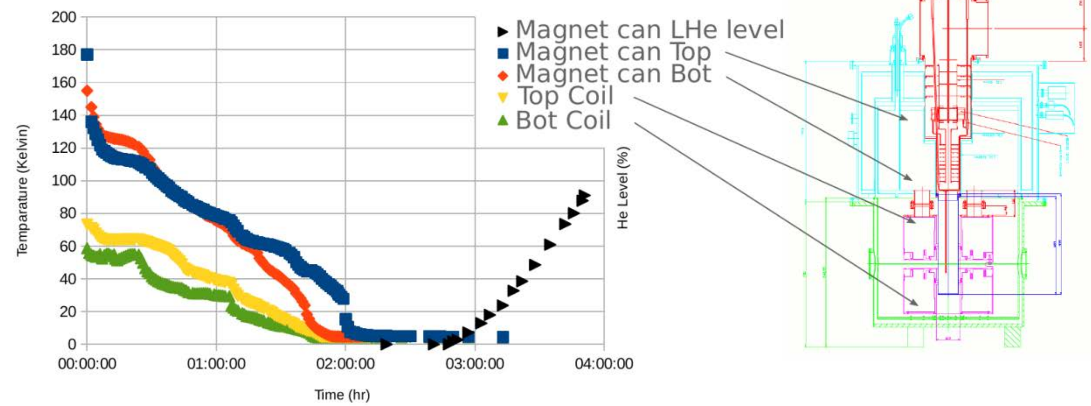


Cryogenic Performance



~2.5 hrs to bring resistors to 4K

~1 hr to to fill magnet can

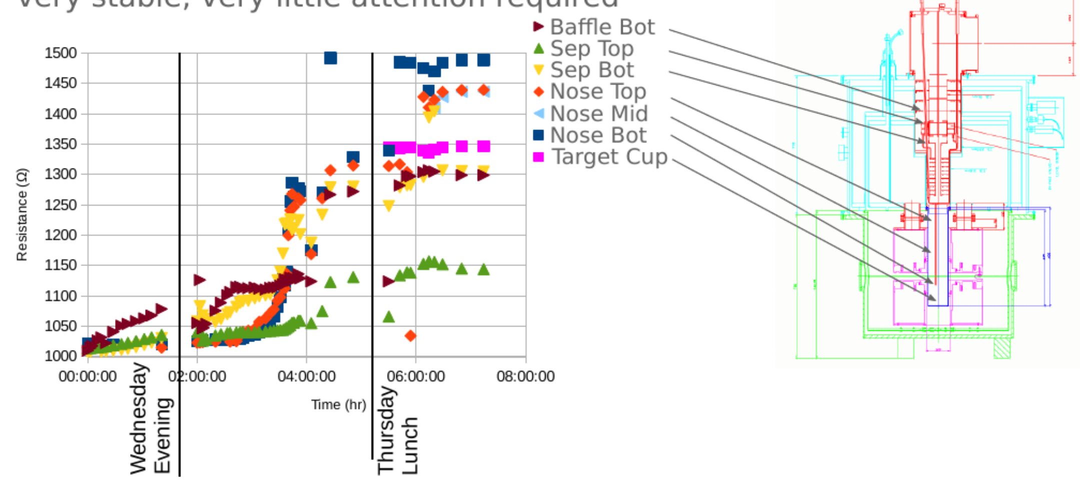


Fridge performance

separator and nose fill

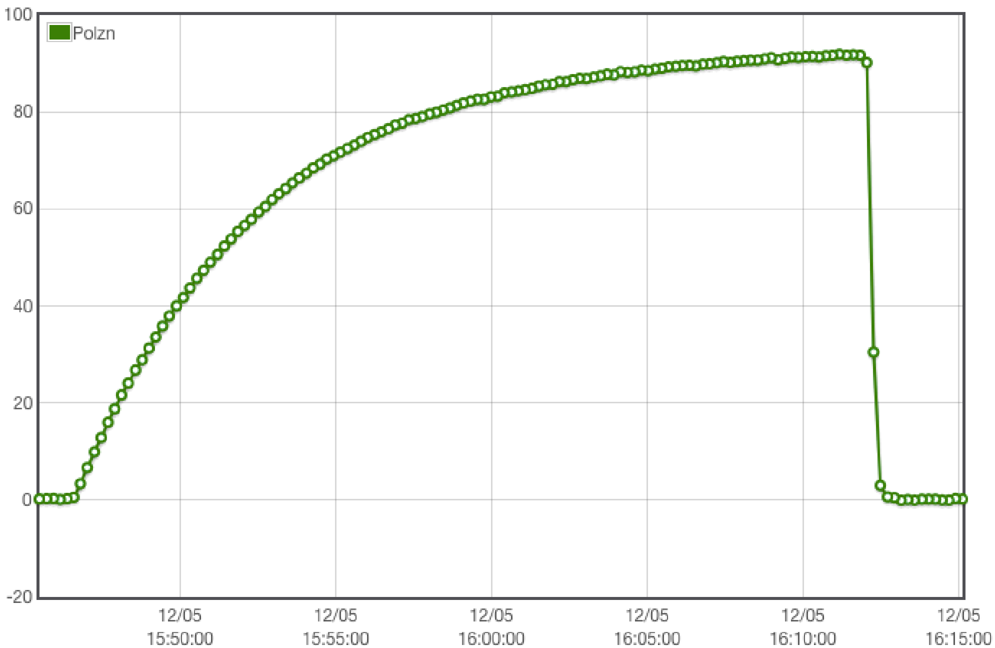
~1hr to fill the nose after a night on standby

very stable, very little attention required



Results of All the Work

95%



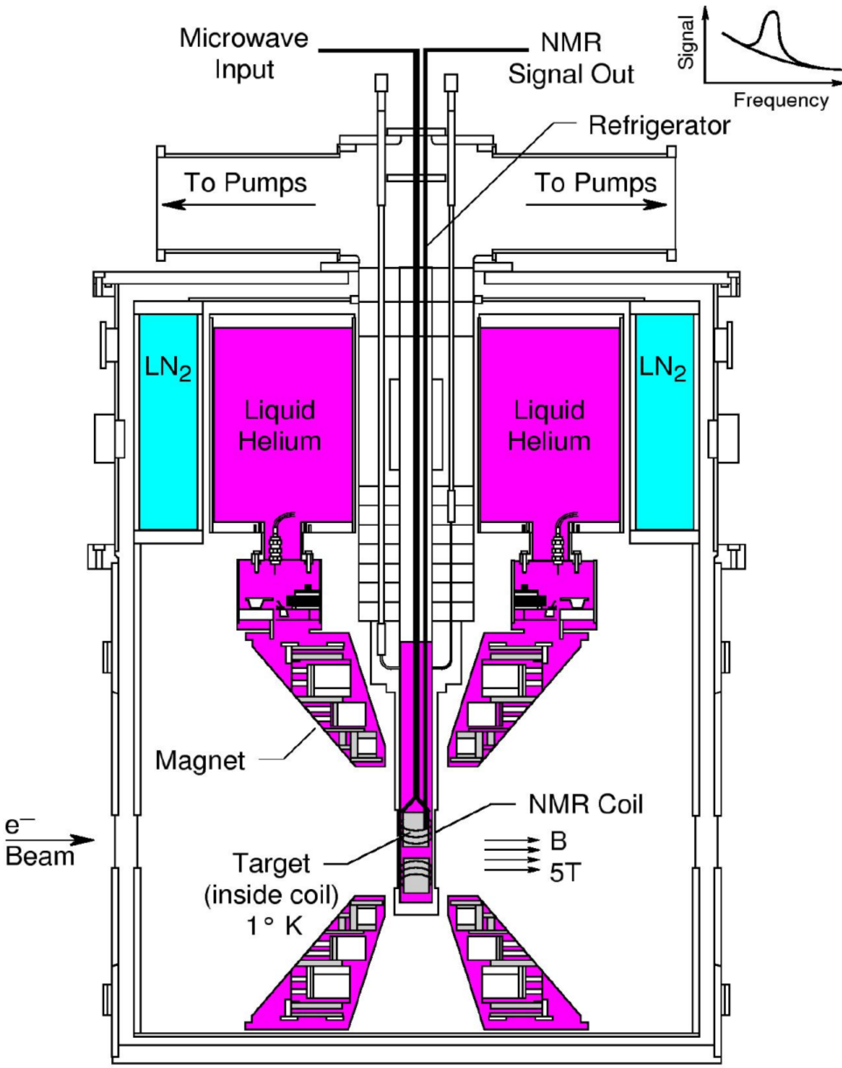
Proton Polarization

Beam Effects

- Quenches
- Radiation Damage to Target Material

Final preparations and run

put vacuum chamber back together



le

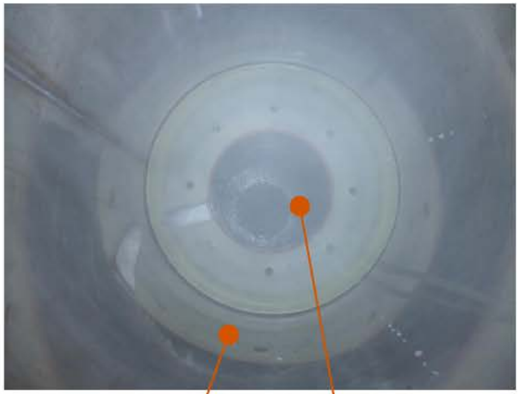
leak test chamber

rim of the
fridge shell

bottom
net coils

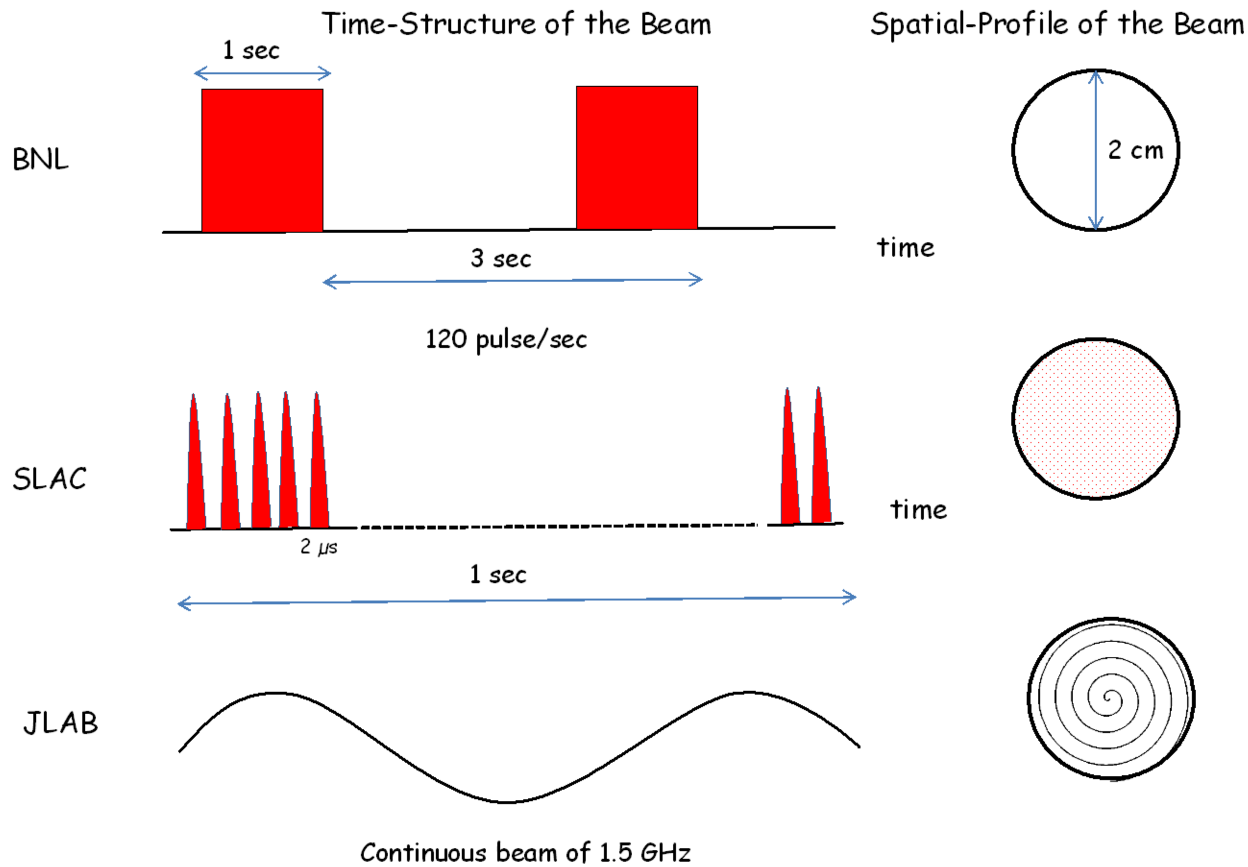
m window

chamber



fridge shell

nose filled
with LN2



Time-Structure of the Beam
Spatial-Profile of the Beam
1 sec
BNL
2 cm
3 sec
time
120 pulse/sec
SLAC
time
2 μs
1 sec
JLAB
Continuous beam of 1.5 GHz

Quenches

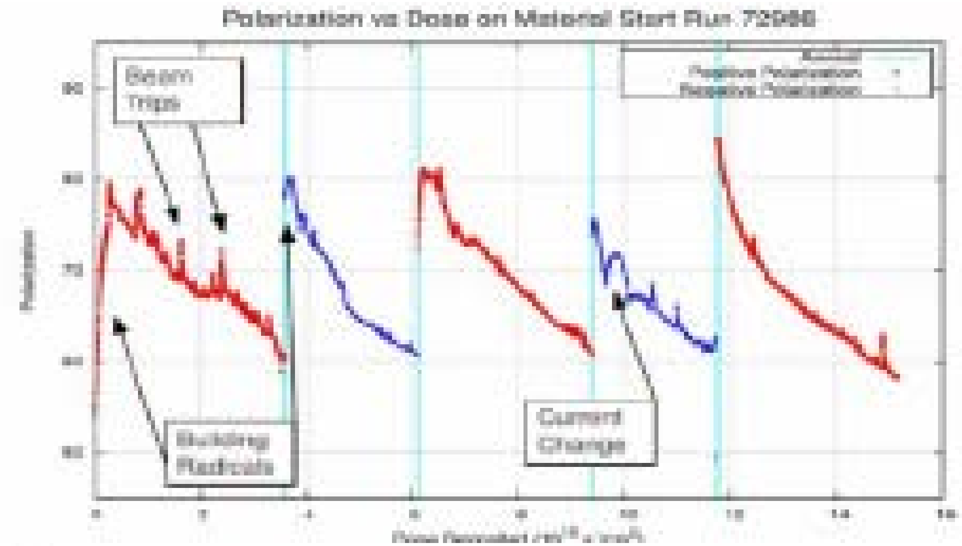
- At SLAC ran stably at ~ 6 . 10 ^{11} electrons/sec (~100 nA)
- At JLAB stable running at 100 nA at < 6 GeV Hall C) In Hall B very stable running at <10 nA
- BNL stable running at ~3. 10^{11} protons/sec (Beamline limited)

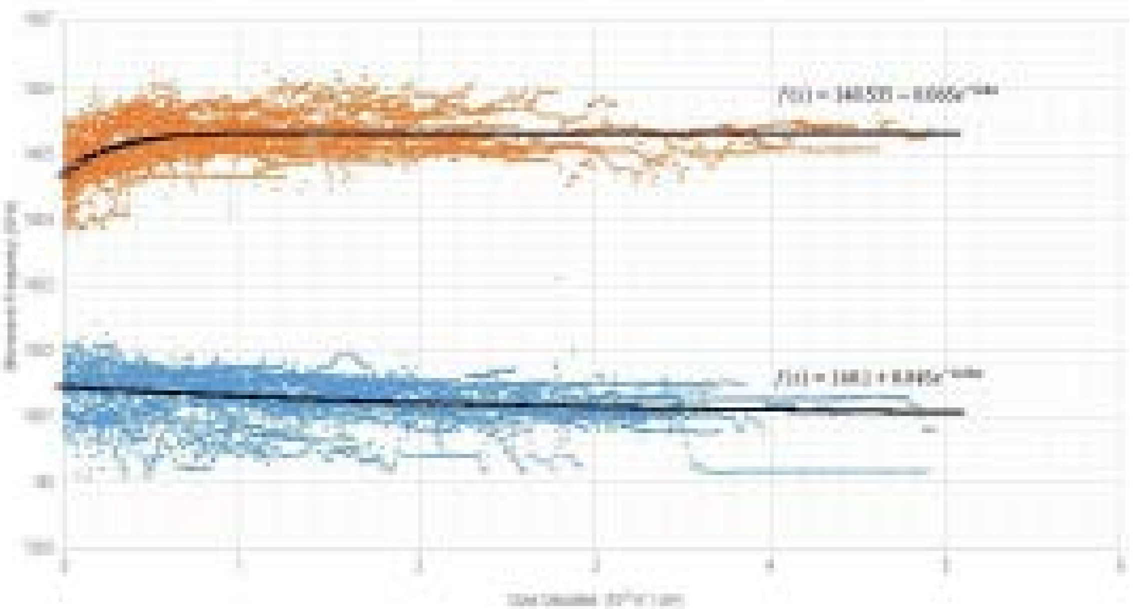
But with a Teflon target (2.5 x density) Quench!!

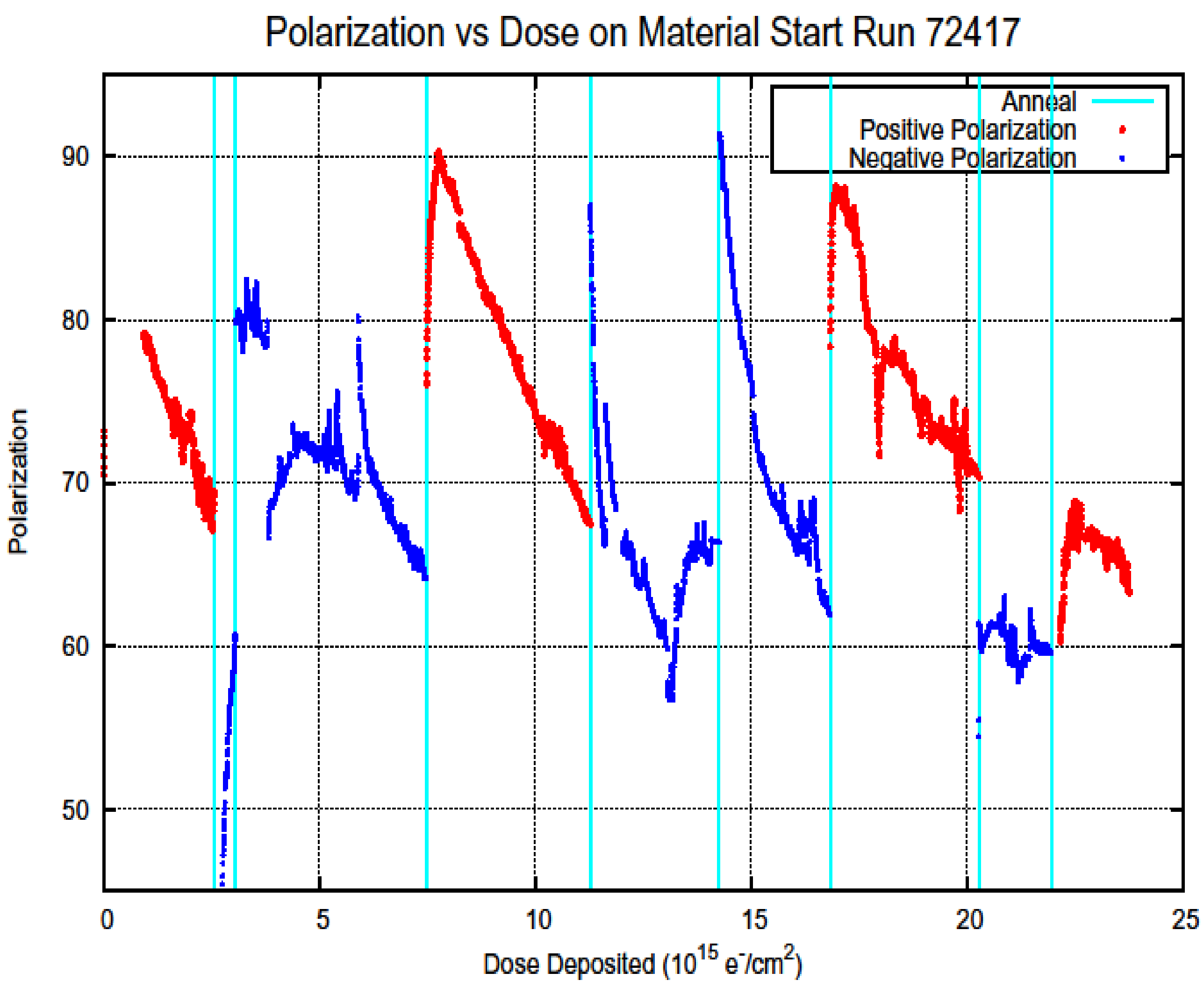
Stable running at 2.5 times less beam

Radiation Damage

- Ammonia still best material for rad. Resistance and achievable polarization.


Beam Trips
Building Radicals
Current Change




Polarization vs Dose on Material Start Run 72417
Anneal
Positive Polarization
Negative Polarization
Polarization
90
80
70
60
50
0
5
10
15
20
25
Dose Deposited (10^{15} e^-/cm^2)

Insider Schedule

Near Term Goals
• Some spectrometer commissioning with cosmic rays
• Trigger configuration testing
• Long term counters/chambers
• Coarse alignment of spectrometer (reconstructed cosmic tracks)

Hall schedule:
• Complete electrical installation for cryo platform: 9/20
• Initial Target Magnet Survey: 9/12
• Install cryo platform decking: 9/23
• Install target in cave: maybe require Inspector (Safety Review)

➡ Need to be running in control room for overnight runs
➡ Running Event Display
➡ Online detector monitoring
➡ Slow controls (detector voltages/currents, environmental monitoring)
➡ Target vacuum plumbing

Accelerator Operations:
➡ Accelerator shutdown underway

SPINQUEST

Please Join The Effort (dustin@virginia.edu)

- https://spinquest.fnal.gov/
- http://twist.phys.virginia.edu/E1039/

Thank You