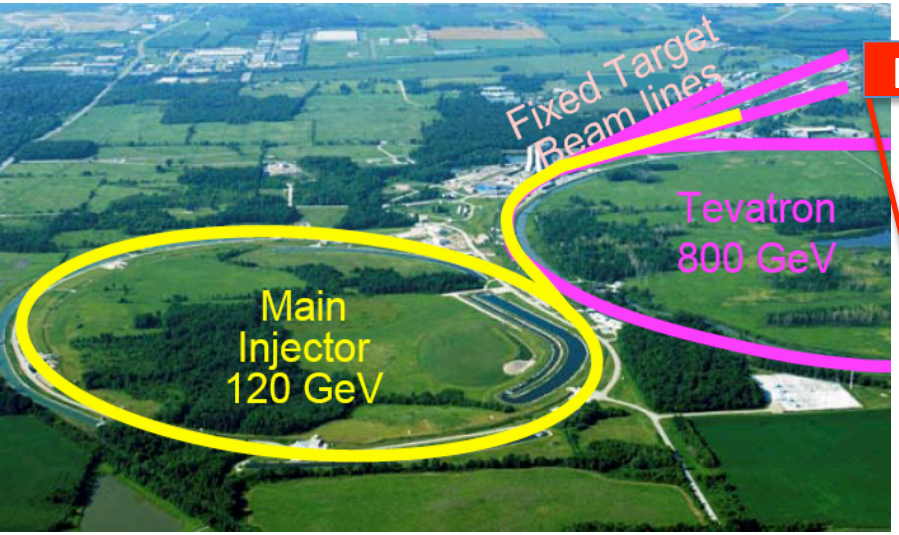
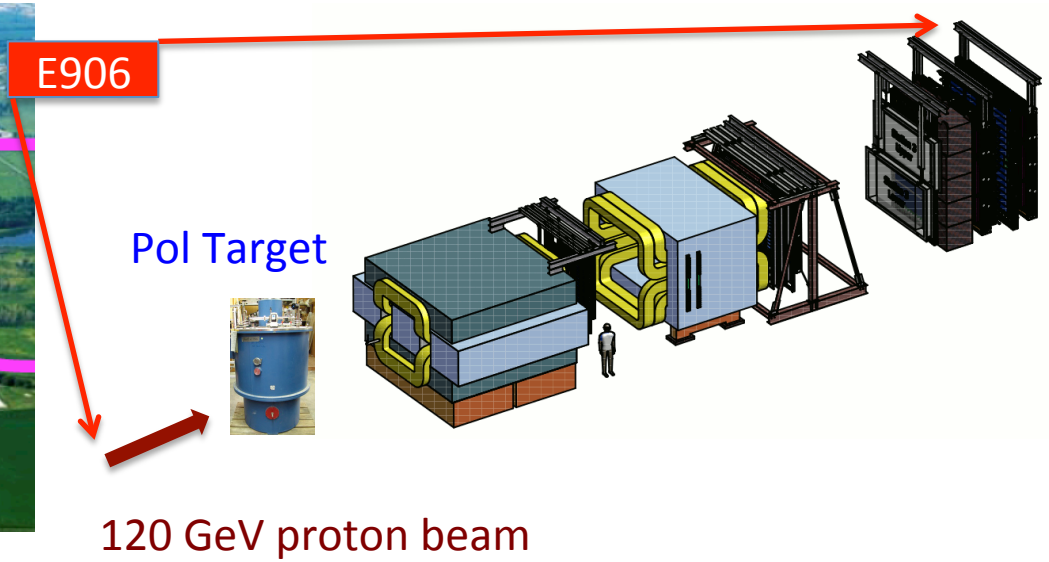
Transition from E906 to E1039

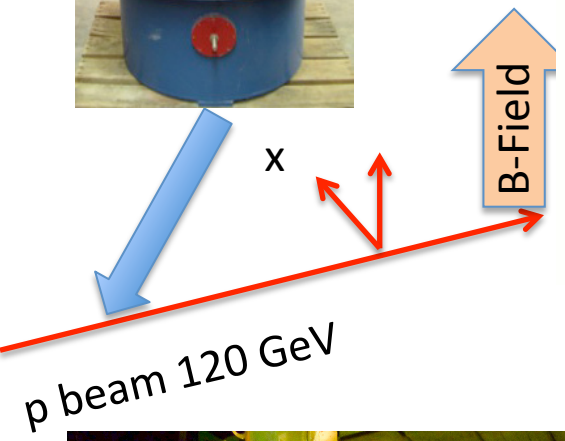
Ming Liu

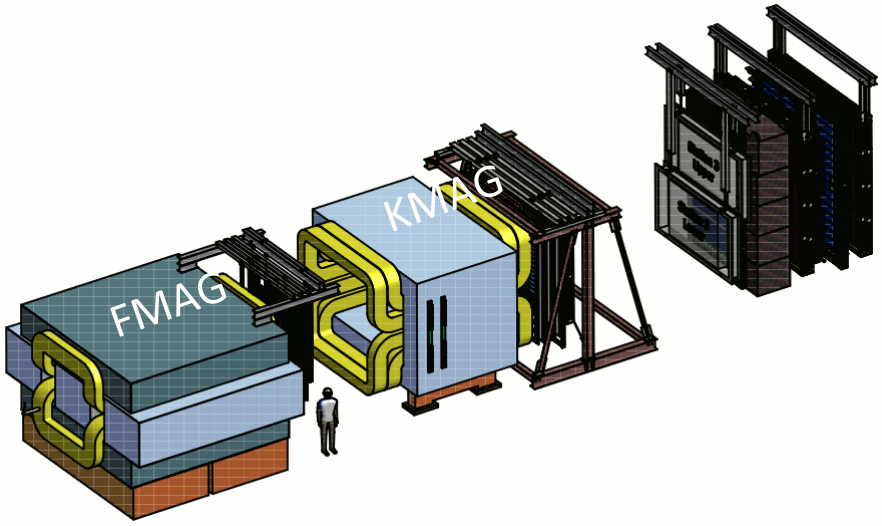
P-25





E1039 vs E906: To Do List



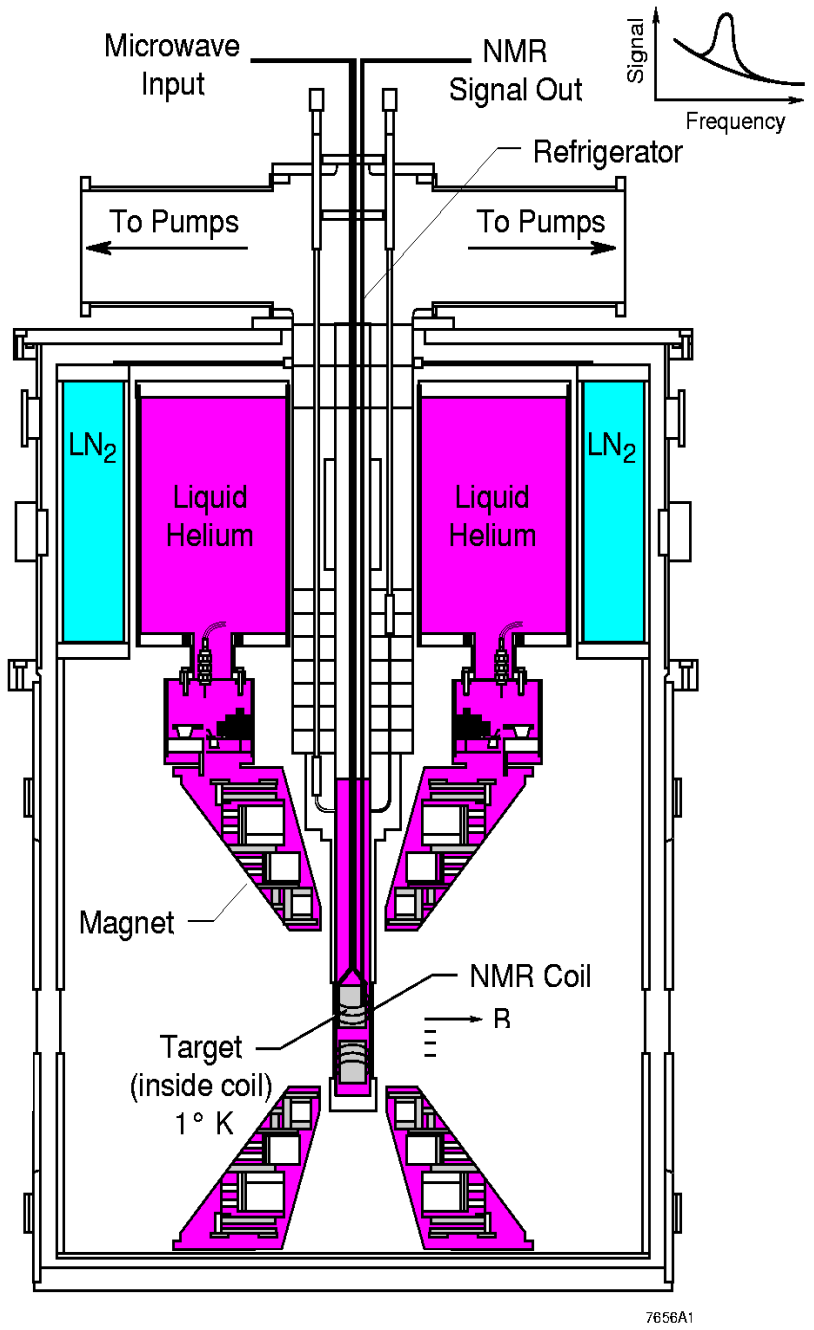


- Beam line
- Target
- Mechanical
- Cryogenics
- Electrical
- Cooling
- Safety
- Shielding

E906 Targets: LH2, LD2, C, Fe, W

LANL High Density Polarized Proton (NH_3) Target

- Superconducting dipole magnet
  - Temperature ~ 1 K
  - Magnetic Field: 5 Tesla
  - 8cm long NH_3 target
- Proved capable of handling high luminosity
  - up to ~ 10^{35} (Hall C)
    ~ 10^{34} (Hall B)



Required Modifications to E906 Setup

Target and Beam Control

- Some changes @IR
  - New space for operation, target change etc
  - New target stand (a platform)
  - Radiation shielding around the target area
  - SM0 focusing magnet(?, Cost and Schedule)
  - B-field shielding for the target(SM0?)
- Target operation and maintenance
  - Service lines, Power, Cryogenic systems
  - NMR system, radiation shielding for electronics, network access
  - Space for target changes etc.
  - Target magnet quench protection
- Beam control
  - A new final focusing quadrupoles (Q3 near target)
  - Beam collimator, target magnet quench protection
  - Beam spot position/direction/size monitors
  - Beam position/direction stability
  - Luminosity monitors, Cerenkov, new telescopes
- Fermilab Engineering and Safety Review

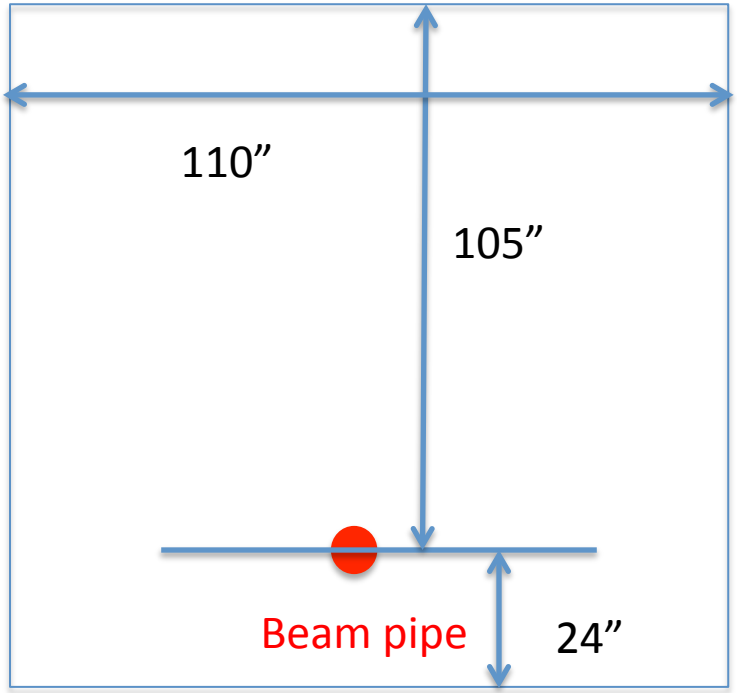
DAQ and Spectrometers

- Spectrometers
  - No change for chambers
  - New switches to Reverse fields of FMag and KMag for spin asymmetry systematic control
- Triggers
  - A new trigger road map to optimize signal from target
  - Rate capability not an issue, expect lower beam intensity in E1039 than that in E906
- DAQ
  - Current E906 OK for Drell-Yan channel, J/Psi can use more DAQ bandwidth
  - Higher rate capability could help “relative luminosity” and other J/Psi and Psi physics measurements
  - Slow control target related information into DAQ data stream
- Physics asymmetry systematic controls
  - Precision relative luminosity
  - Beam position and direction
  - Additional beam monitoring telescopes

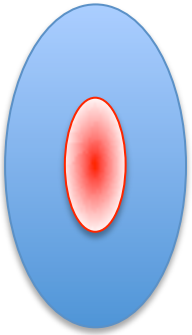
The Experimental Hall: No Change

E906 Target Area

- Targets are rad. shielded
- Too Small for Pol. Target
- Issues with target and beam dump separation



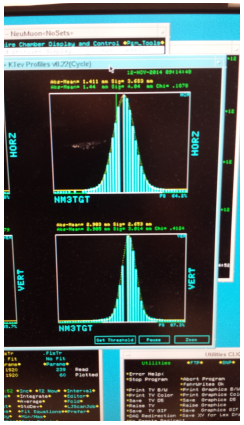
New Beam Collimator, Focusing Q3 and Target



Target Cross Section: 18 x 28 mm^2

Beam cross section:
well contained within
4 sigma, dR< 1x10^{-4}

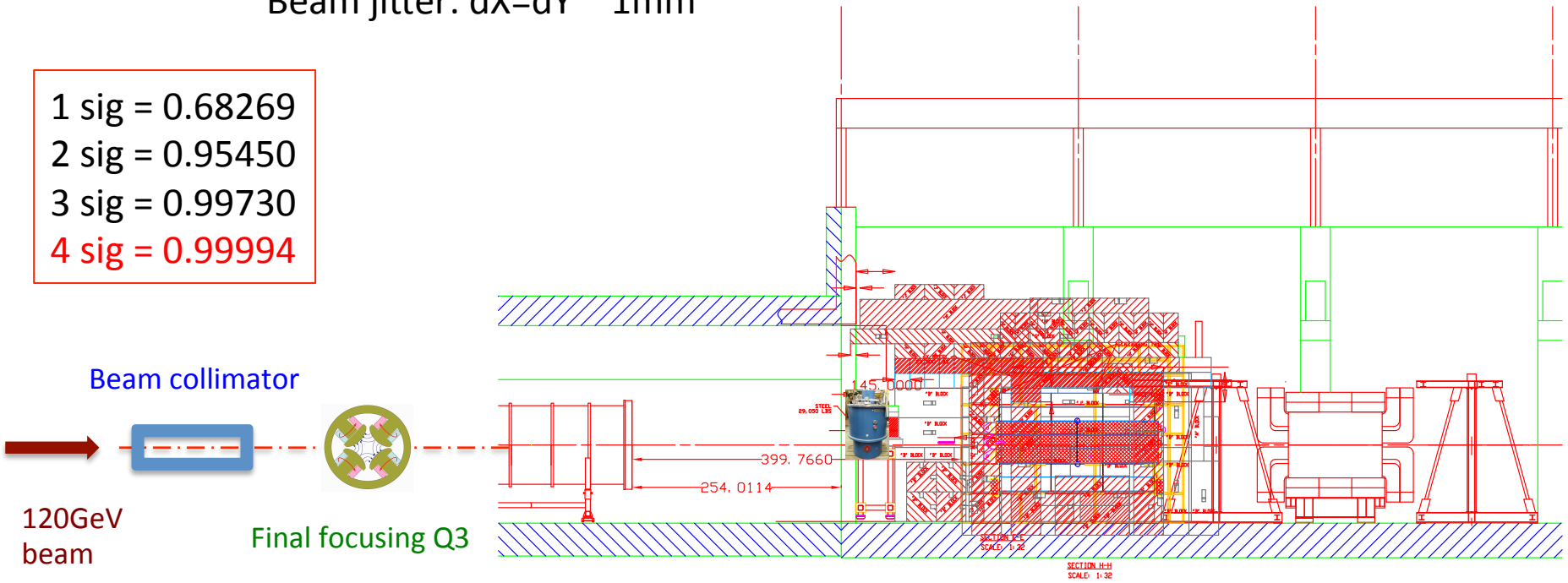
sigX = 18/2/4 = 2.2 mm
sigY = 28/2/4 = 3.5 mm
Beam jitter: dX=dY ~ 1mm



E906 beam:
SigX = 4.0mm
SigY = 3.0mm

$$f(x,\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

1 sig = 0.68269
2 sig = 0.95450
3 sig = 0.99730
4 sig = 0.99994



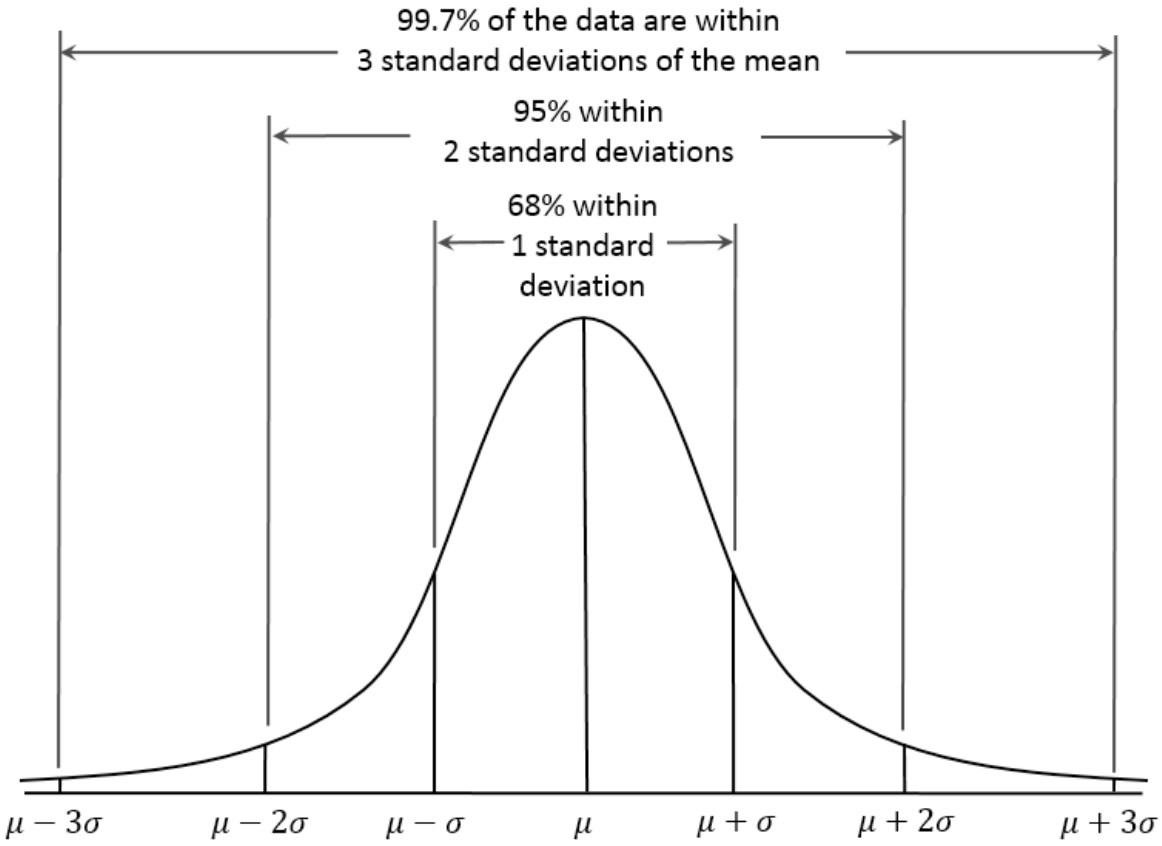
Beam on Target: 4 sigma
Relative Luminosity better than $1x10^{-4}$

Expected Raw Asymmetry:

~1%/10~20 ~ 5×10^{-4}

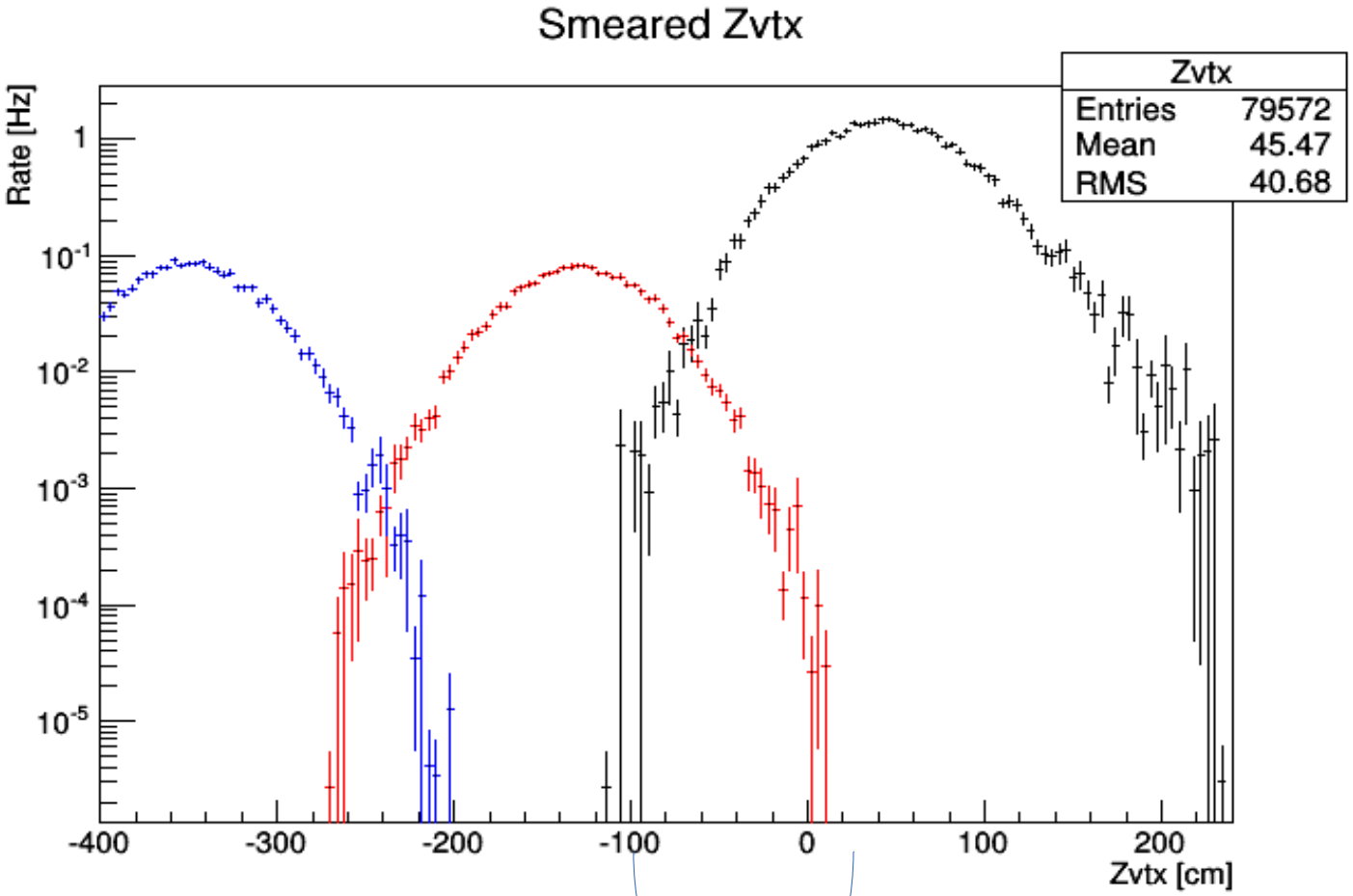
$A = (N^+/R - N^-)/(N^+/R + N^-)$

R = relative luminosity
dR <~ $1x10^{-4}$



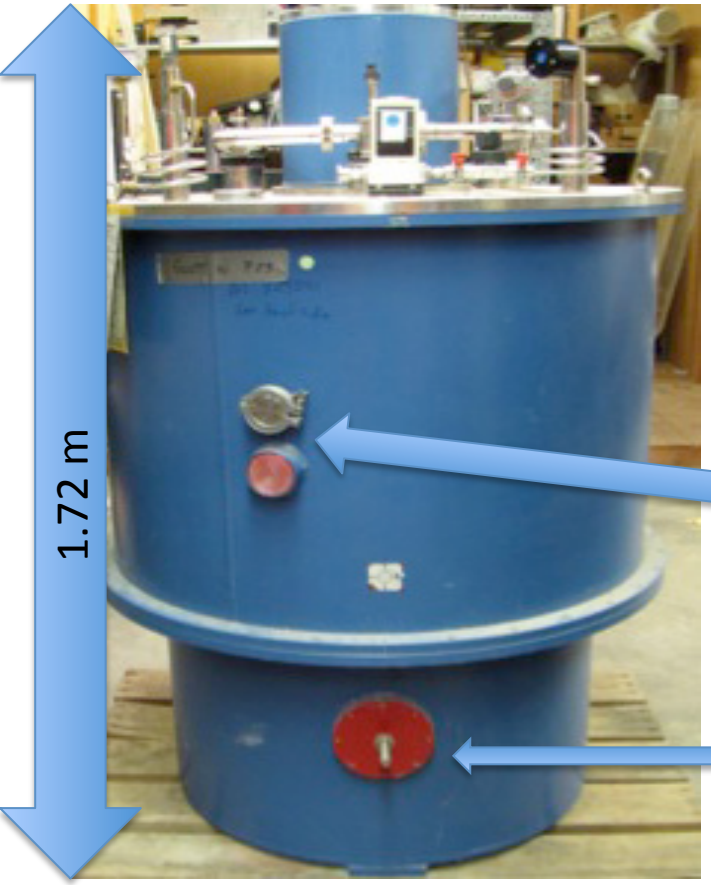
Target and Beam Dump Event Separation

move the target upstream: Z=-3.5m



Target stick movement: 3.6m to ceiling (tight)

Polarized Target Operation



Mechanical issues:

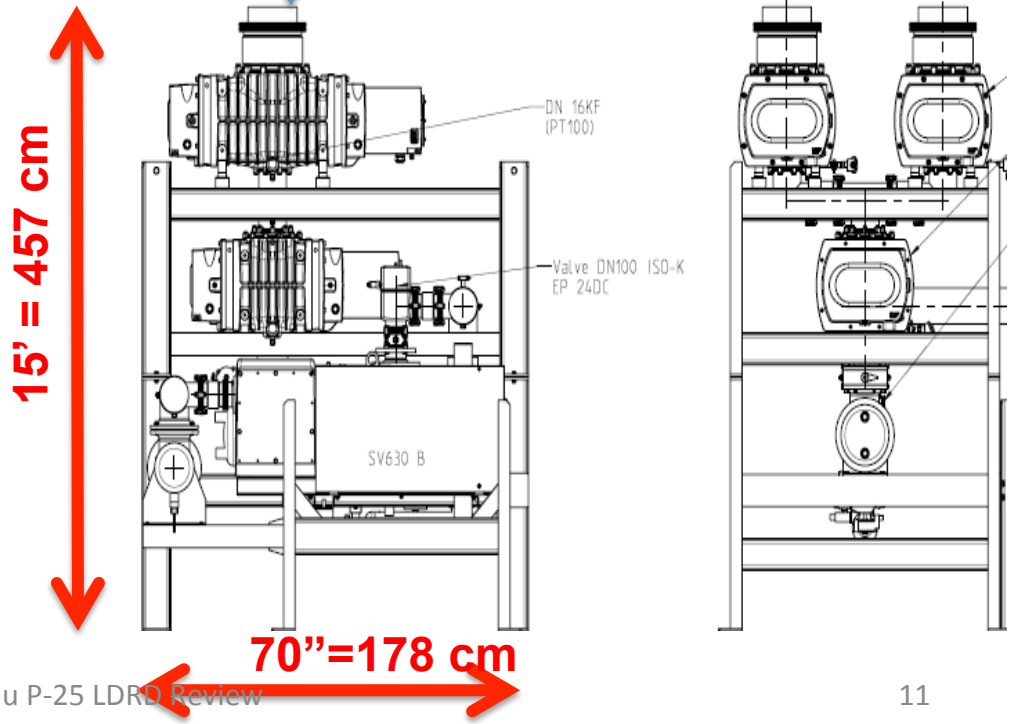
- Need platform to work around for target insert changes, helium refill, Nitrogen refill
- Stand of target magnet
- Crane or Gantry to lift target, max 2000 lb
- New position -350 cm upstream of FMAG
- Pump connections for evaporation cooling
- Pump connection for separator
- Pump connection for main vacuum
- Placement of liquefier system

Beam entry (8' above ground)

Root Pump, Microwave and Mechanical Support

- Chiller for microwave
- Where to locate pump?
  - Cave or outside?
- Connect exhaust of magnet to pump

172cm



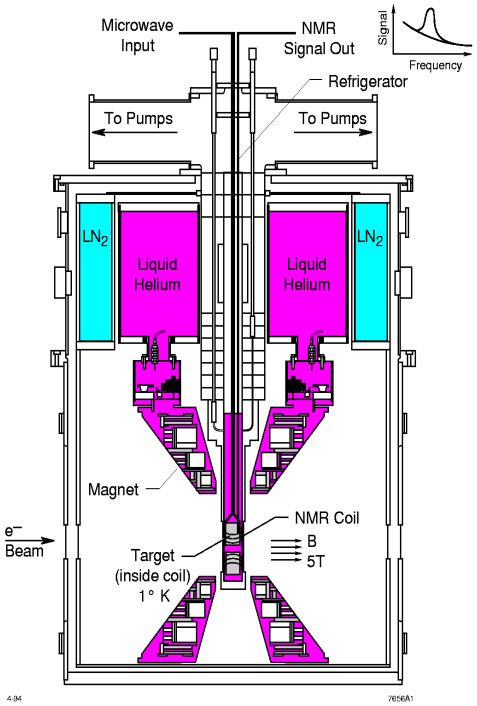
Outside of E906 Target Area

Current E906 Cryogenic Services

New Polarized Target Area

new services and modifications needed to operate the polarized target:

- pumps, cryo, electrical, microwave, NMR



Z = -3.5m

Shielding and Beam Line Work

Radiation Shielding

- Cave/ceiling shielding for new target position
- electronics around target
  - microwave tube
  - microwave power supply
  - NMR electronics
  - control electronics
  - Magnet power supply, controls
- Calculations for target activation
- Target area radiation monitoring

Beam line and spectrometer

- Beam size requires additional Quads
- Collimator upstream of target
- Beam position interlock, loss monitors
- Third magnet between target and FMAG?

More on Service Needs

Electrical and Water Cooling

- Pump: 460V
- 3rd magnet: 2000A,200V
- all magnets need field direction switches
- Network close to target
- Oxygen deficiency monitors
- regular 220 and 110 outlets.
- 2.3 lt/min cooling H2O
- Need to calculate flow

Cryogenics: Liquid ^{4}He and N_2

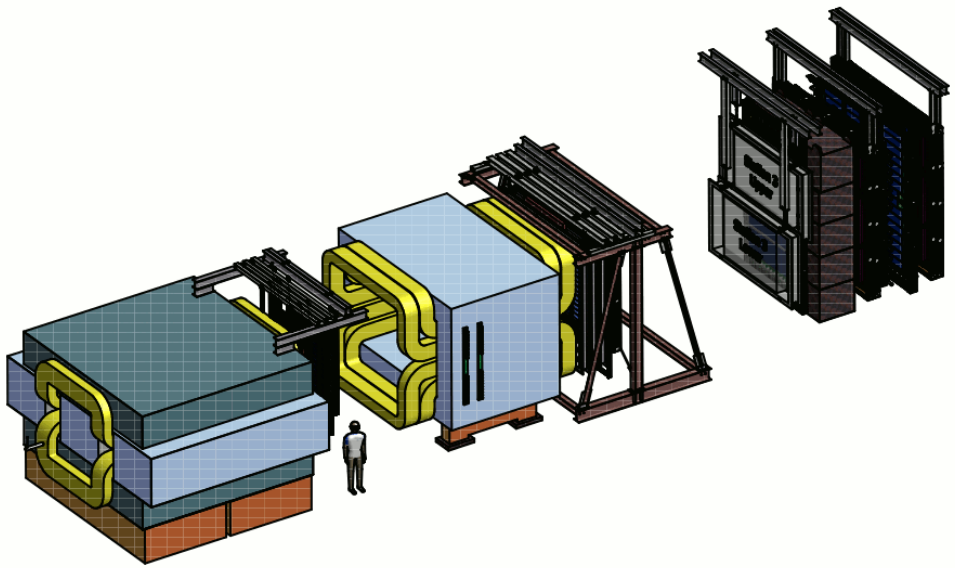
- ^{4}He closed loop system
- Placement of ^{4}He liquifier
- Access for ^{4}He and LN_2 dewars
- Transfer lines for ^{4}He and liquid Nitrogen
- Exhaust to liquefier connection, balloon?

Safety and Monitoring

- Oxygen deficiency monitor
- Quench lines to outside building
- Target vacuum windows
- Activation analysis for target
- Fermilab Engineering and Safety Reviews of cryo, electrical, vacuum, water cooling etc.

E906 vs E1039

- Fixed target dimuon experiments for Drell-Yan and J/Psi productions in p+p and p+A
  - Common Forward Muon Spectrometers
  - Very different target systems
- E906 Targets: "simple"
  - 10~20% of nuclear interaction length
  - LH2 and LD2, ~50cm long, operate at 20K
  - C, Fe and W
- E1039 polarized target:
  - NH3 operate at 1K, 5T B-field



Summary: Tasks

Target and Beam Control

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  - New target stand (a platform)
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- Physics asymmetry systematic controls
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  - Beam position and direction
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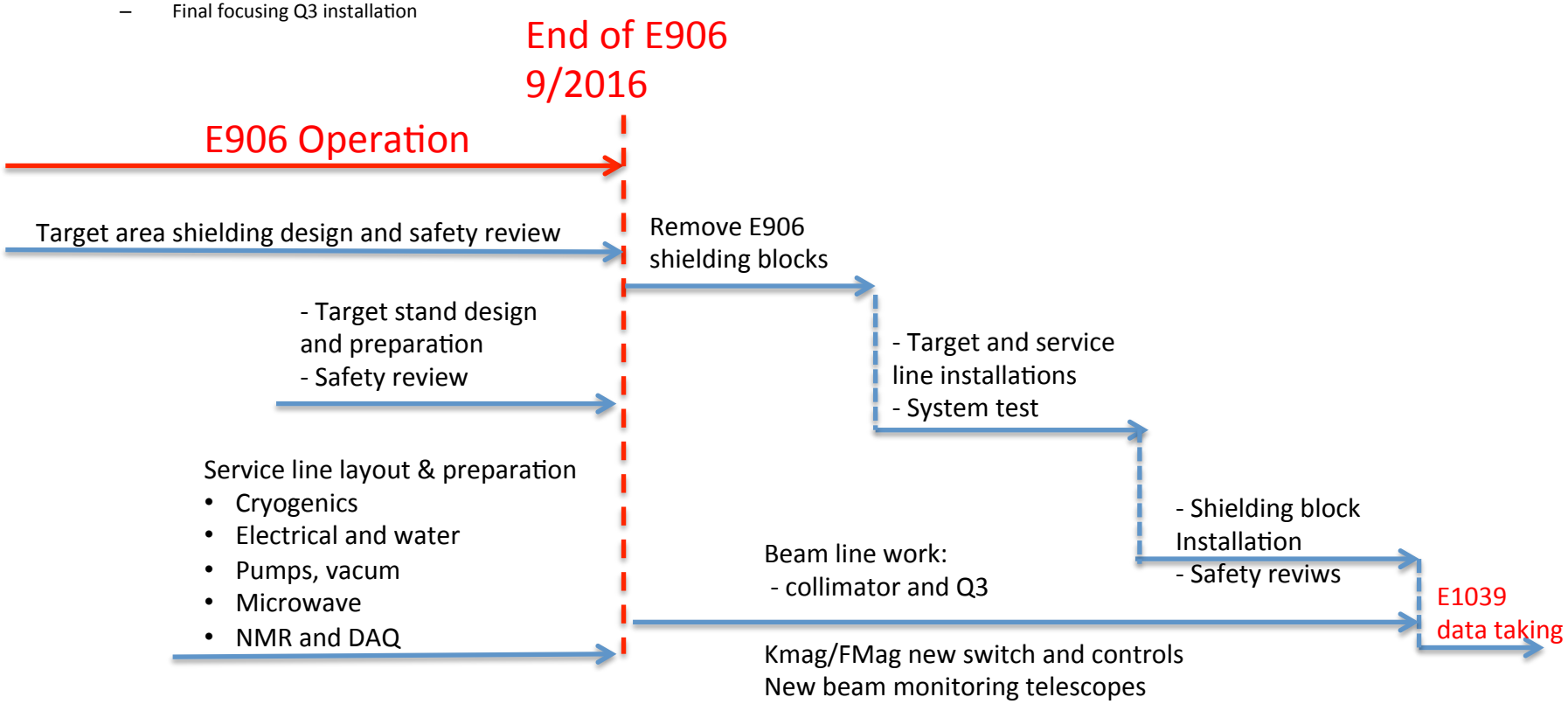
Schedule and Timeline

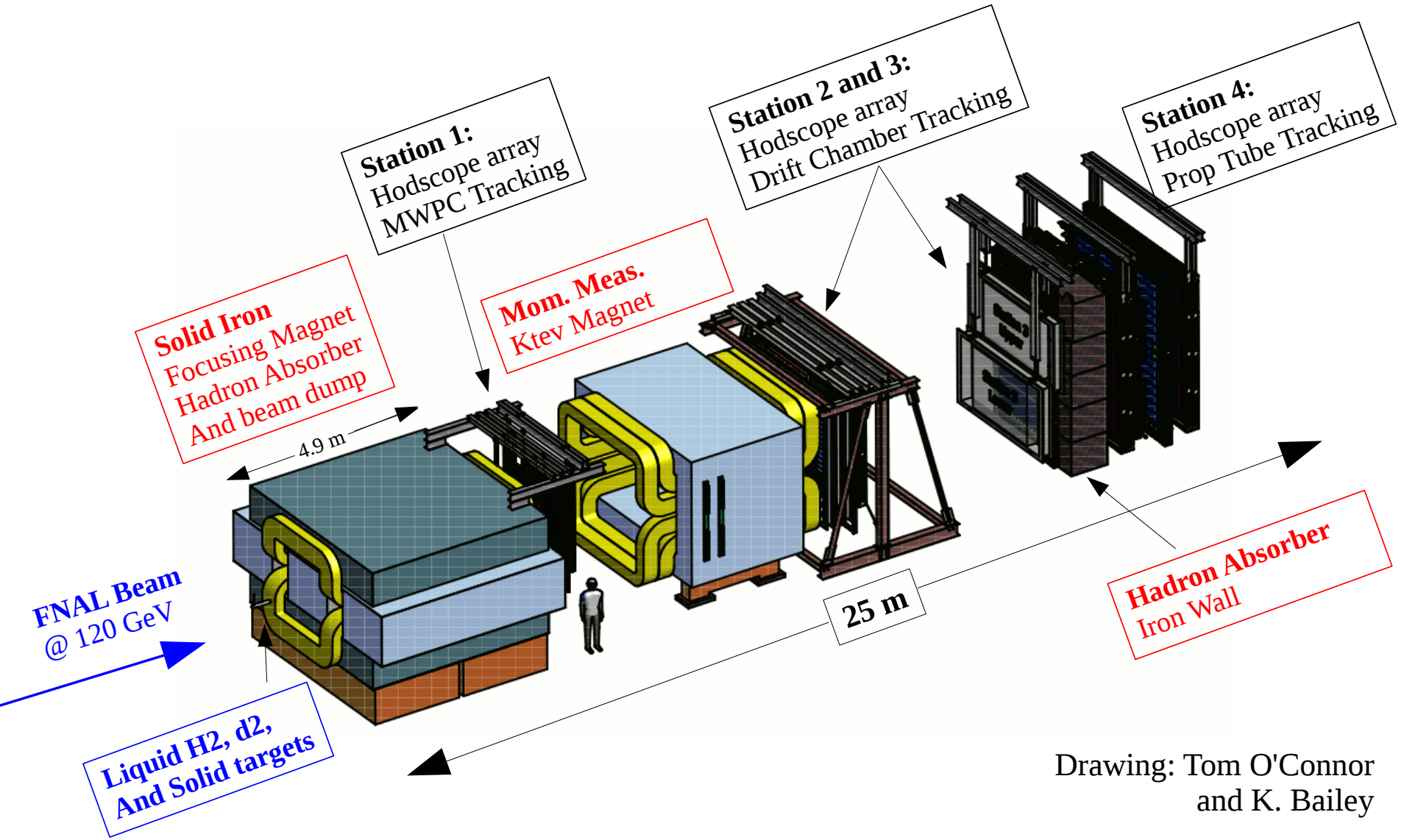
1. New target area and radiation shielding design and safety review

2. A new target stand and safety review
3. Electrical and cooling water layout design and installation
4. Cryogenics System layout design and installation
   - LN_2 and L^4He
5. New beam monitoring telescopes

6. Beam line modifications
   - Collimator design and installation
   - Final focusing Q3 installation



Current E906 Setup



Drawing: Tom O'Connor
and K. Bailey

Polarized Target Drell-Yan Transverse Single Spin Asymmetry @Fermilab

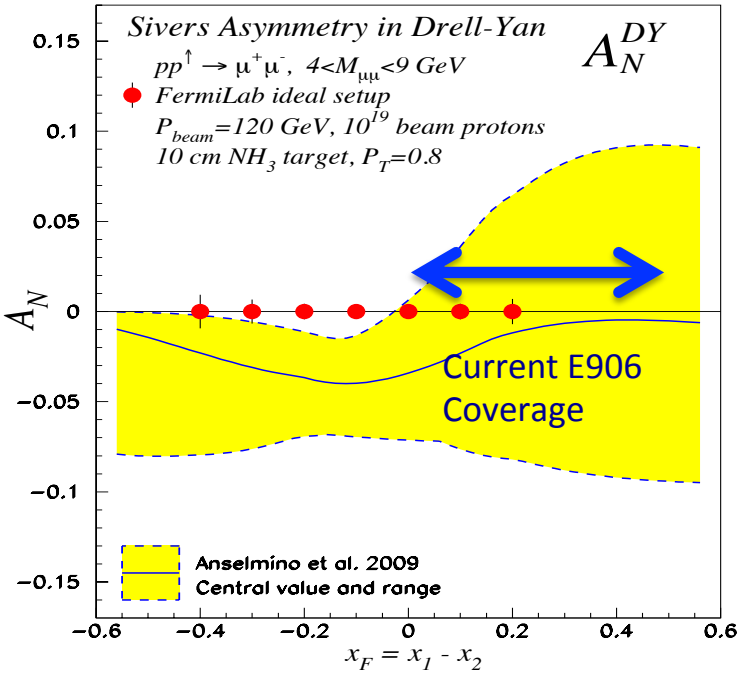
Sea-Quark Sivers Effects

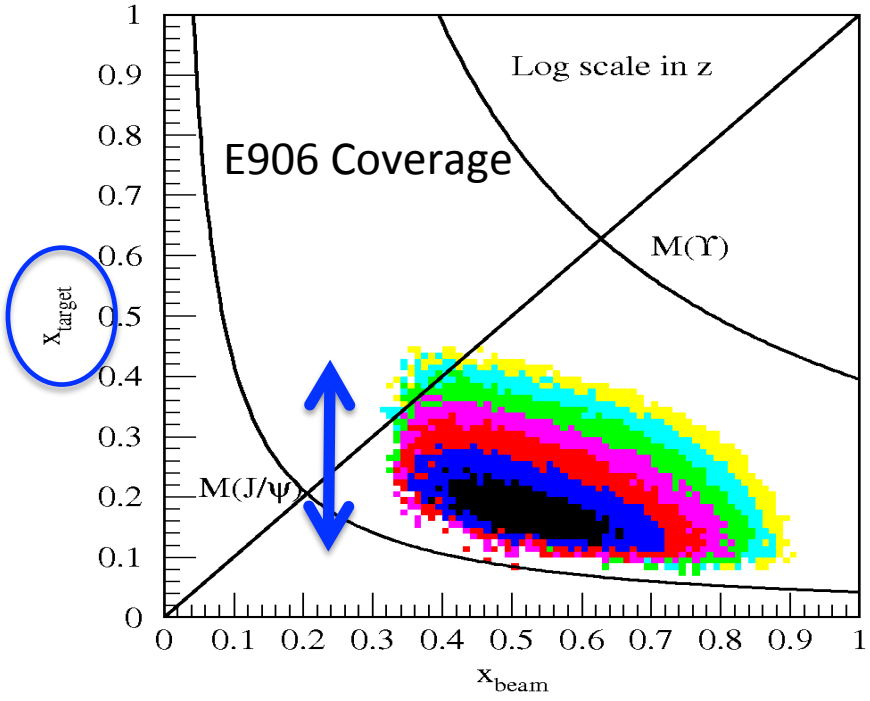
- The first precise measurements of seaquark Sivers distributions
- @ large x = 0.1~0.4, significant Sivers Asymmetry observed in pol. SIDIS
- Sea-quark's Sivers Funcs poorly known

$$\frac{d^2\sigma}{dx_t dx_b} = \frac{4\pi\alpha^2}{9x_1x_2s}\sum e^2[q_b(x_b)\bar{q}_t(x_t) + \bar{q}_b(x_b)q(x_t)]$$

$$\approx \frac{4\pi\alpha^2}{9x_1x_2s}\sum e^2[q_b(x_b)\bar{q}_t(x_t)]$$

Pol. Target

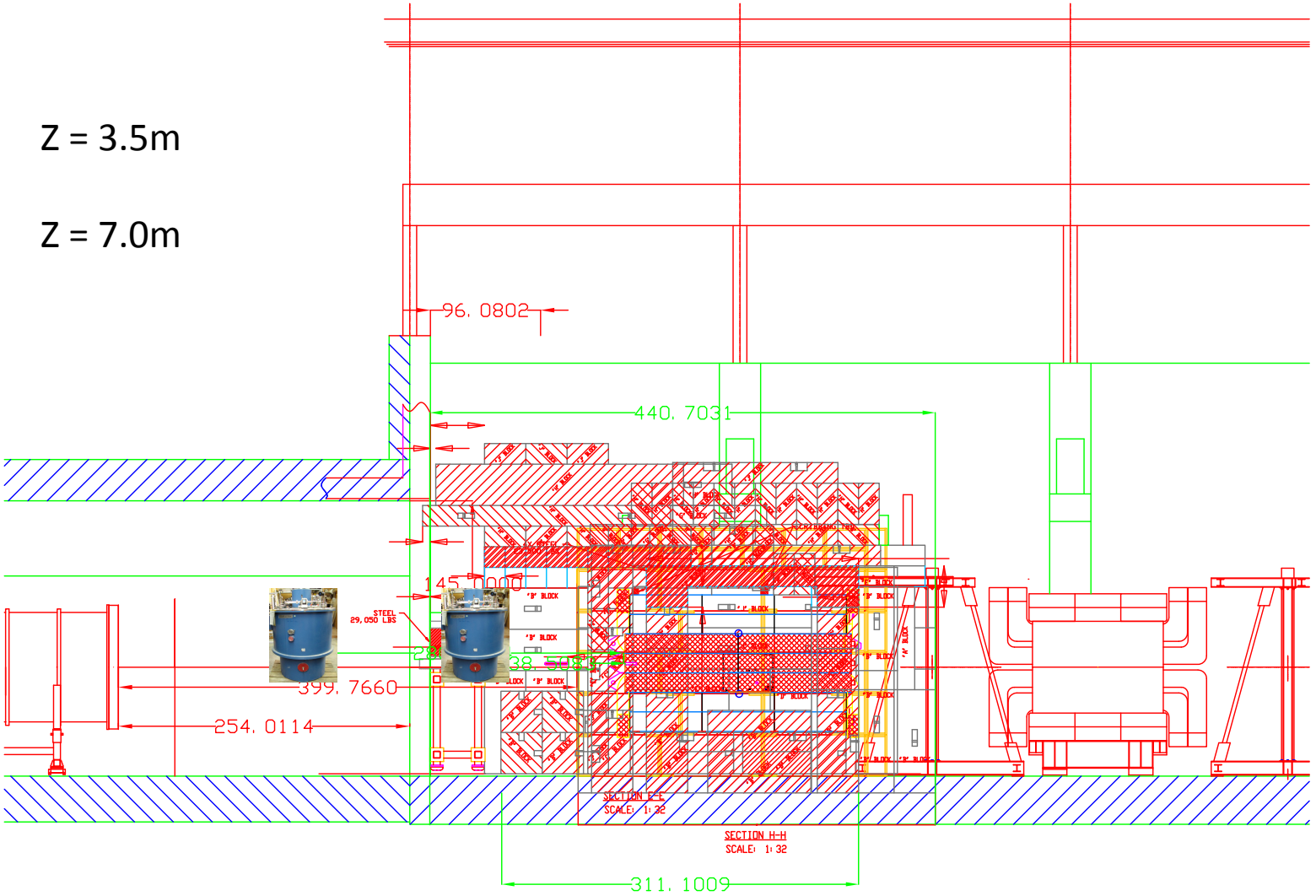




E906->E1039

Z = 3.5m

Z = 7.0m



A New Focusing Magnet?

Refocus dimuons from target to improve acceptance

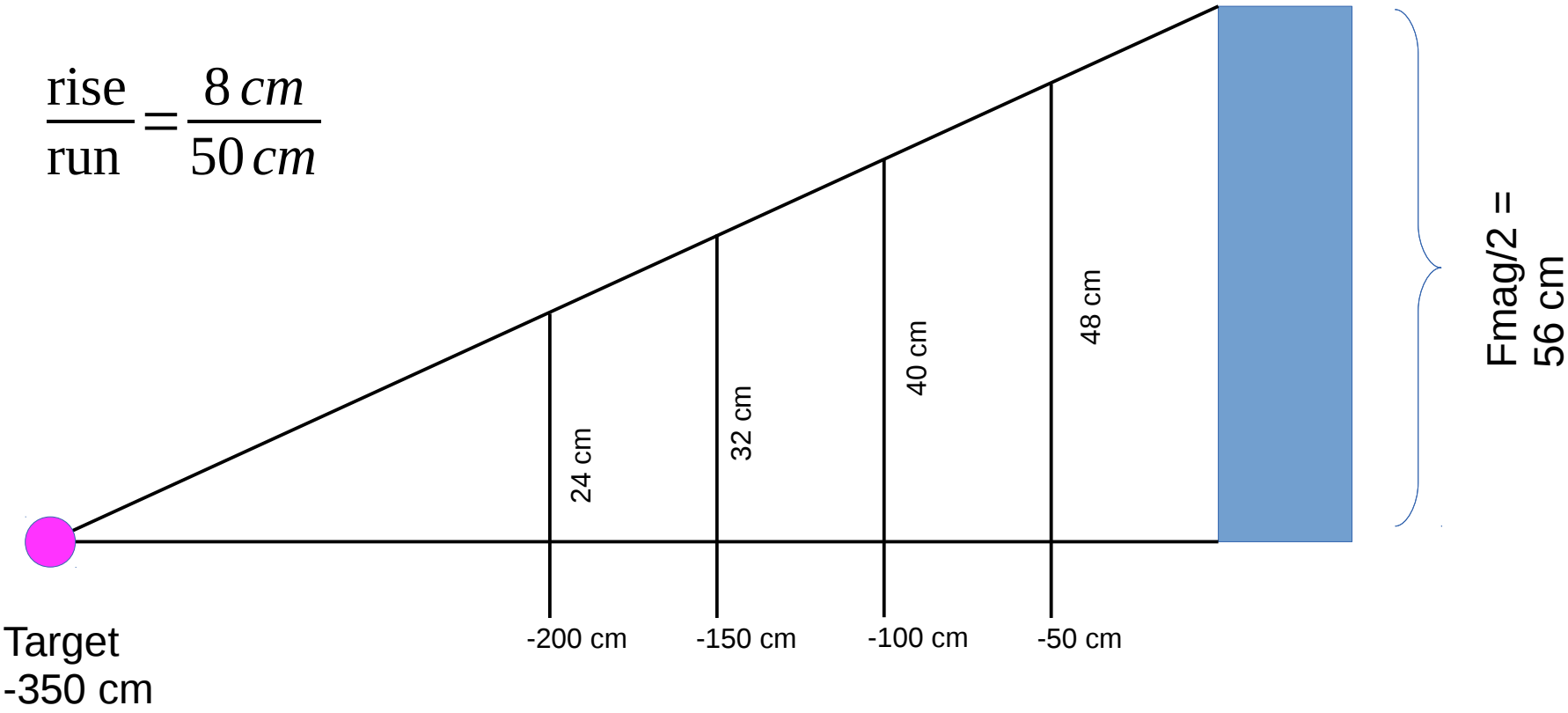
- Option-1: BNL 48D48 magnet:
  - a large aperture magnet, up to 3.5 T*m
  - 18.5” x 48” x 48”; 48” = 1.22m
  - CAD/BNL reluctant to give it away, they may need it. Need to write a memo to BNL ALD if we want to get it to Fermilab.
  - Possible window for 2016 – 2019, as there is no currently planned usage of this magnet

- BNL 18D36 magnet:
  - Smaller gap: 6” (15.2cm), up to 2.0 T*m
  - 6” x 18” x 36”, 36” = 91.4cm

Pure geometry, no field

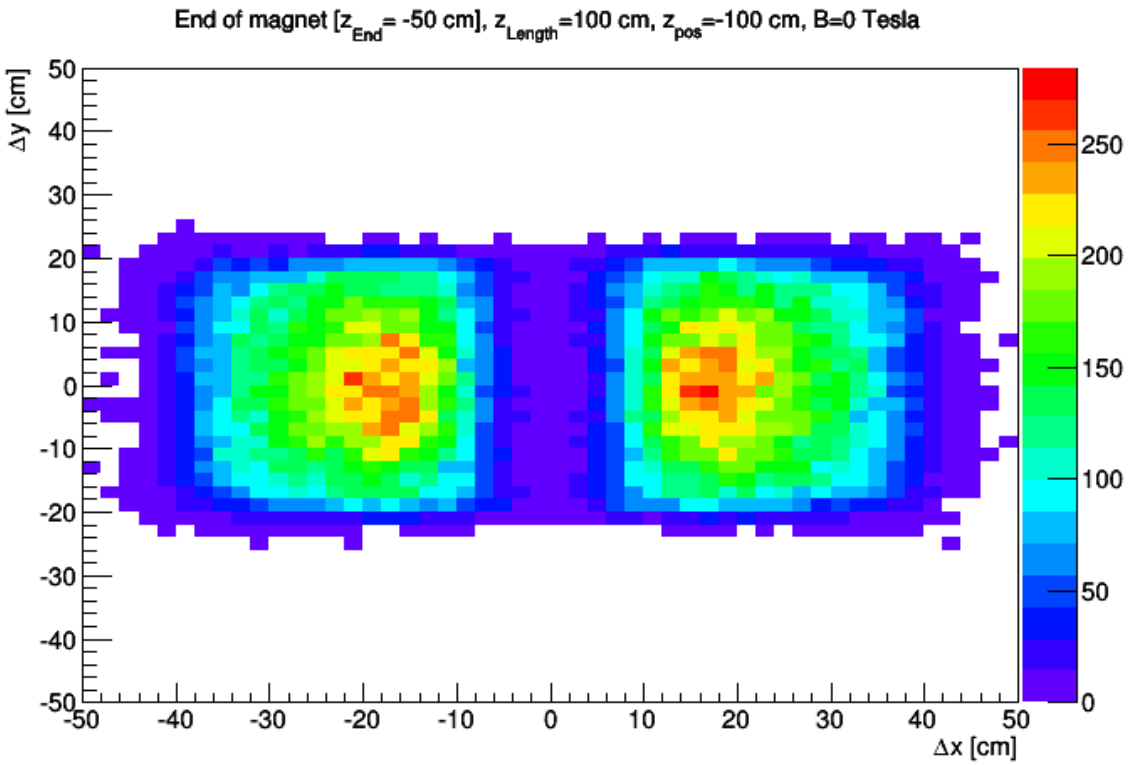
See more details in
Kun/David's simulation talk

$$\frac{\text{rise}}{\text{run}} = \frac{8\,cm}{50\,cm}$$



Drell-Yan Signal Acceptance

$$Z_{endmag} = -50 \text{ cm}$$



$y_{Max} = \pm 48$ cm

$$\Delta y = \frac{p_{x,0}}{p_{z,0}} \times \Delta z = \frac{p_{y,0}}{p_{z,0}} \times (300\,cm)$$

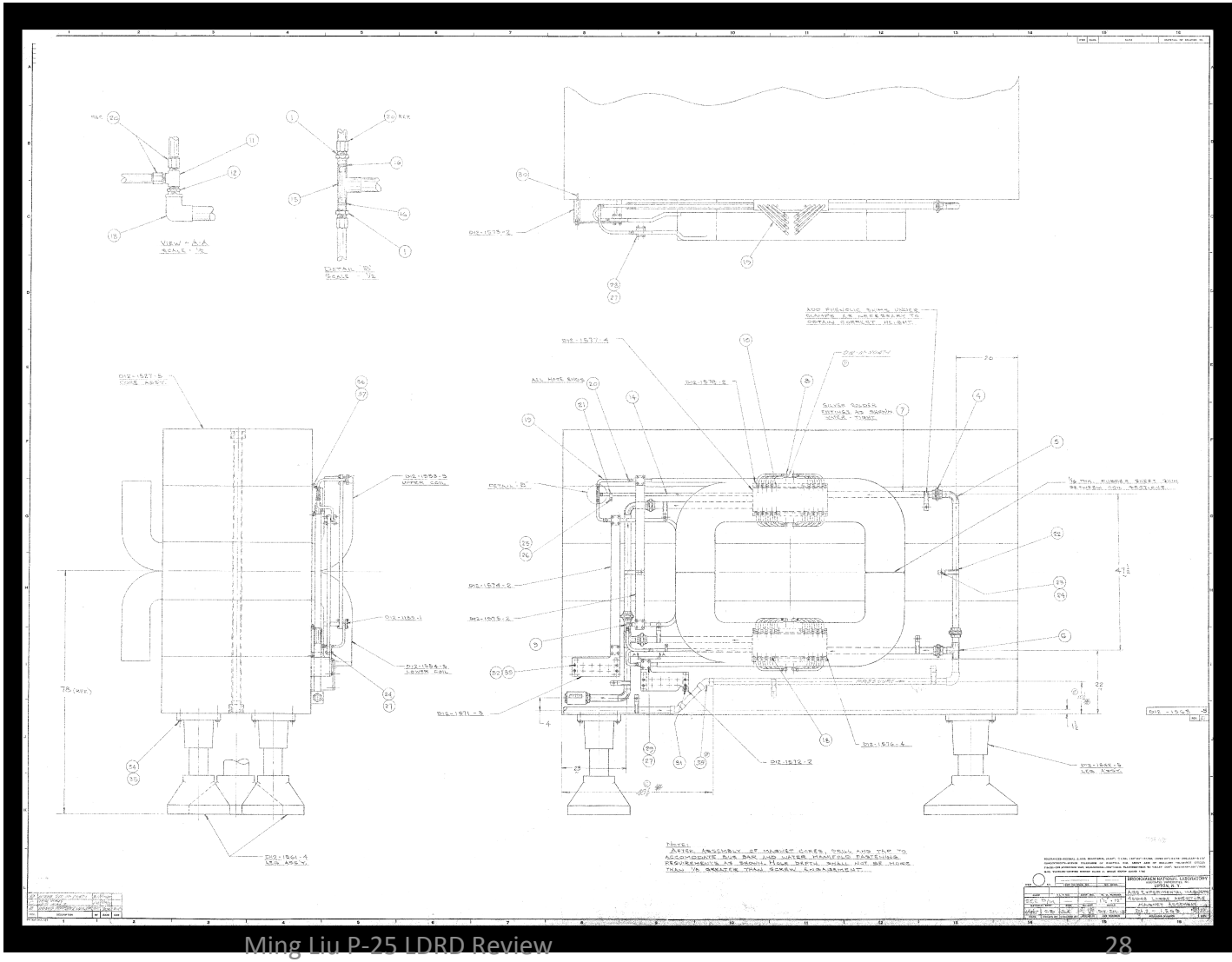
48D48 Magnet

- One at BNL, NOT in use yet, an official request to BNL needed

Y_Gap = 18” =45.7cm

X_Gap = 48” =122cm

Field = up to 3.5 T*m



BNL Smaller 36D36 Magnet

- Several of them at BNL
  - Y_Gap = 6” = 15.2 cm
  - X_Gap = 18” =45.7cm
  - Field up to 1000kGx2.54cm = 2.5 T*m
  - OK for signal muon tracks
  - Impact on background understudy