Polarized Target Activity at the University of Virginia

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Items Studied

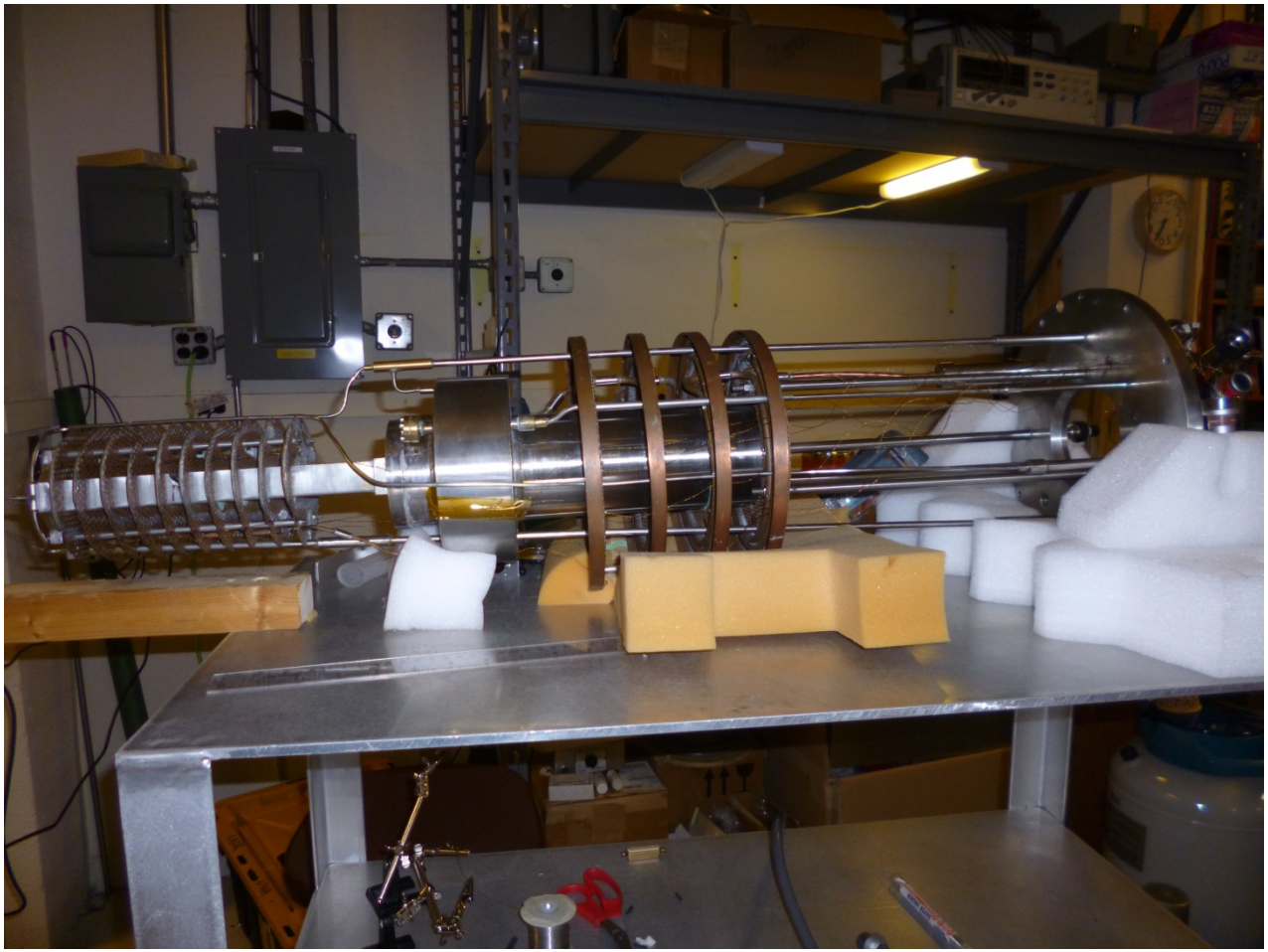
- Polarized Target Development for E1039 at FermiLab. P + P(
  Cryogenics, NMR, microwaves, AFP, Freezing and irradiating NH_3 , ND_3 .
- Tensor Polarization Studies : >30% tensor polarization in ND_3 by Jlab.
  RF Hole Burning
- Refurbishing dilution refrigerator for use at HIGS.
  polarized d-butanol target, polarized photon beam
- Design of Two cell Target for JLab
  Use of Comsol.
- Production of CD_3 and CD_4 for irradiation
  Polarization studies
- Polarization of protein samples
  In collaboration with ORNL

Magnet

- 5T magnet from storage at LANL. Longitudinal Field. Last used ~ 2000.
- Shipped to UVA for evaluation. Reached 5 T, stayed in Persistent mode ~ hours
- No quench: Shipped to Oxford Instruments for coil rotation
- Magnet damaged during shipping: to cryostat not to coils.
- Rotation of coils and redesign of cryostat plus other “minor” repairs and changes
- Magnet tested and field mapped. ~ 10^{-4} uniformity over target volume.

- Magnet tested and field mapped. ~ 10^{-4} over target volume
- Magnet shipped back to UVA – no damage
- Tested OK at UVA

Helium Refrigerator

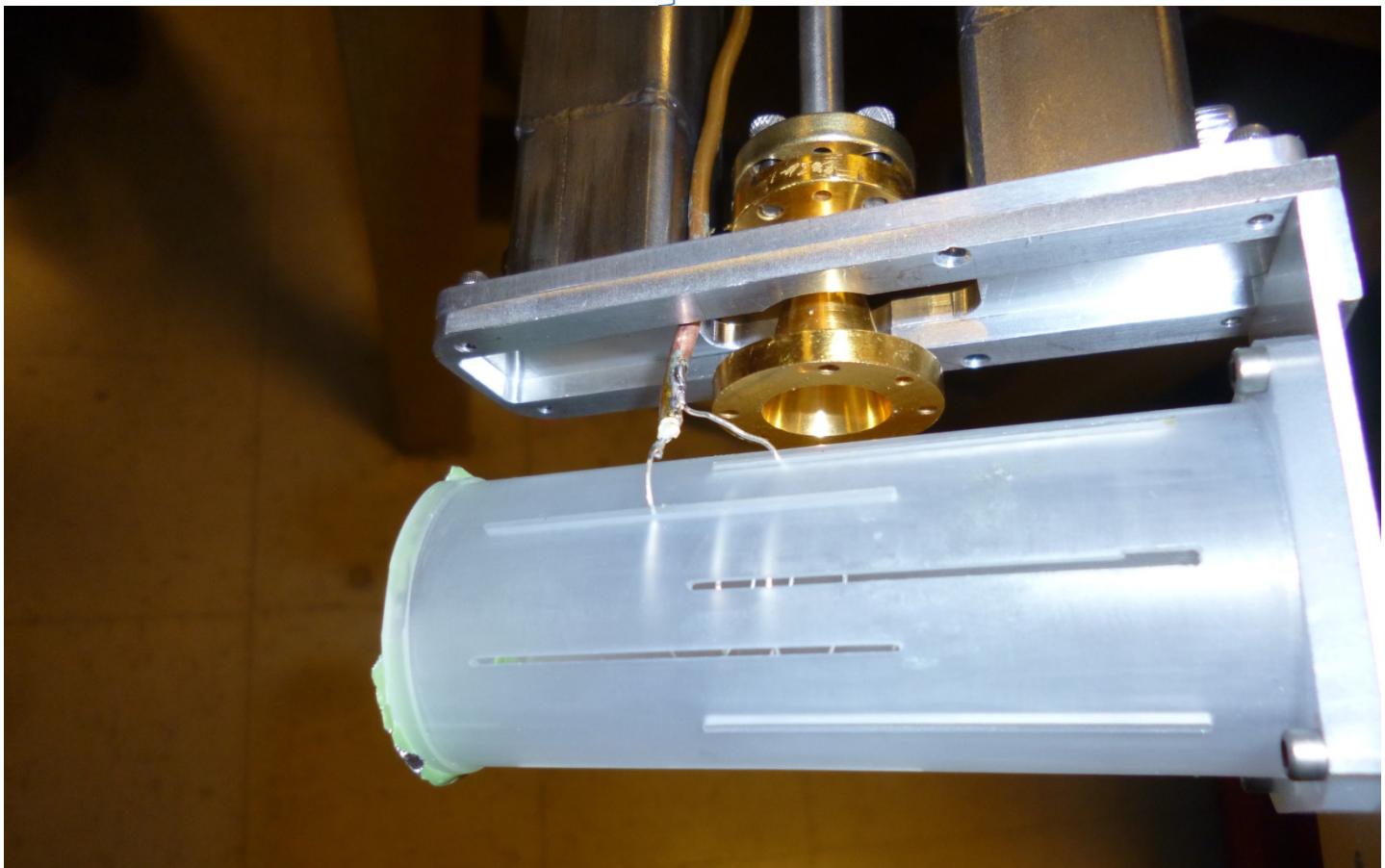


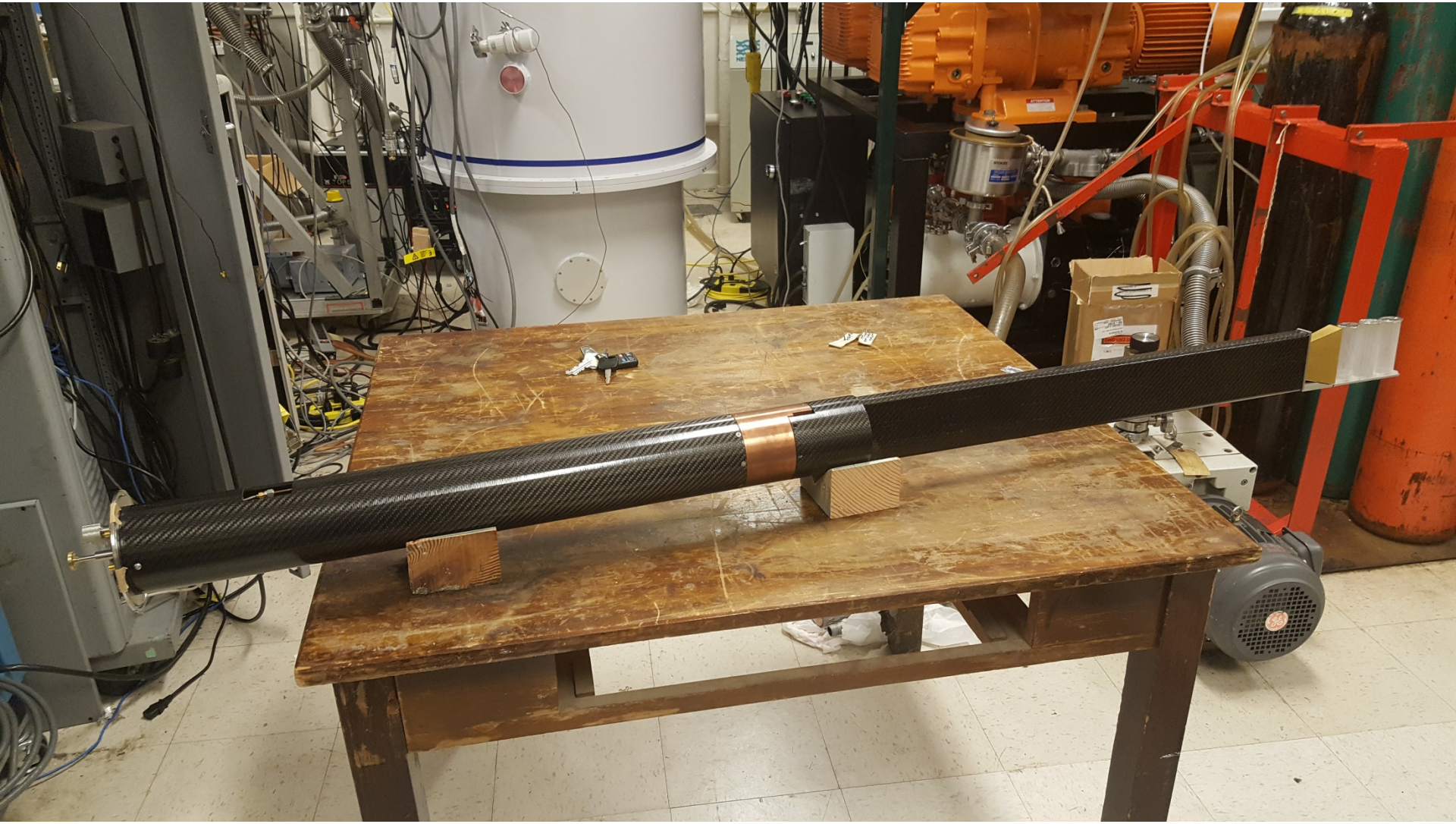
Refrigerator and Target Stick

- Two (or three) Ammonia Targets
- One carbon target
- One empty target

Elipsoidal cells to match FermiLab beam, 7.9 cm long

3 NMR coils per cell





Pumping System

- >1 watt microwave power
- Max Beam 10^{13} protons/5 seconds every minute!
- Likely max ~ 5. 10^{12} protons
- Therefore pumping system of ~ 14000 $m^3\ hr^{-1}$ 2 X 7000 m^3/hr Roots->
- 1 X 7000 m^3/hr Roots->
- 1 X 840 m^3/hr Rotary Vane
- 

Ammonia Irradiation

- Freeze ammonia gas into icicle.
- Crush and sift to collect fragments of size ~2mm. Smaller fragments also collected.
- Take to NIST and irradiate with electrons at ~14 MeV under liquid Argon to total of ~ 10^{17} electrons cm^{-2} . At a beam of 10 μA takes two and a half hours for a target of 20 g to be irradiated

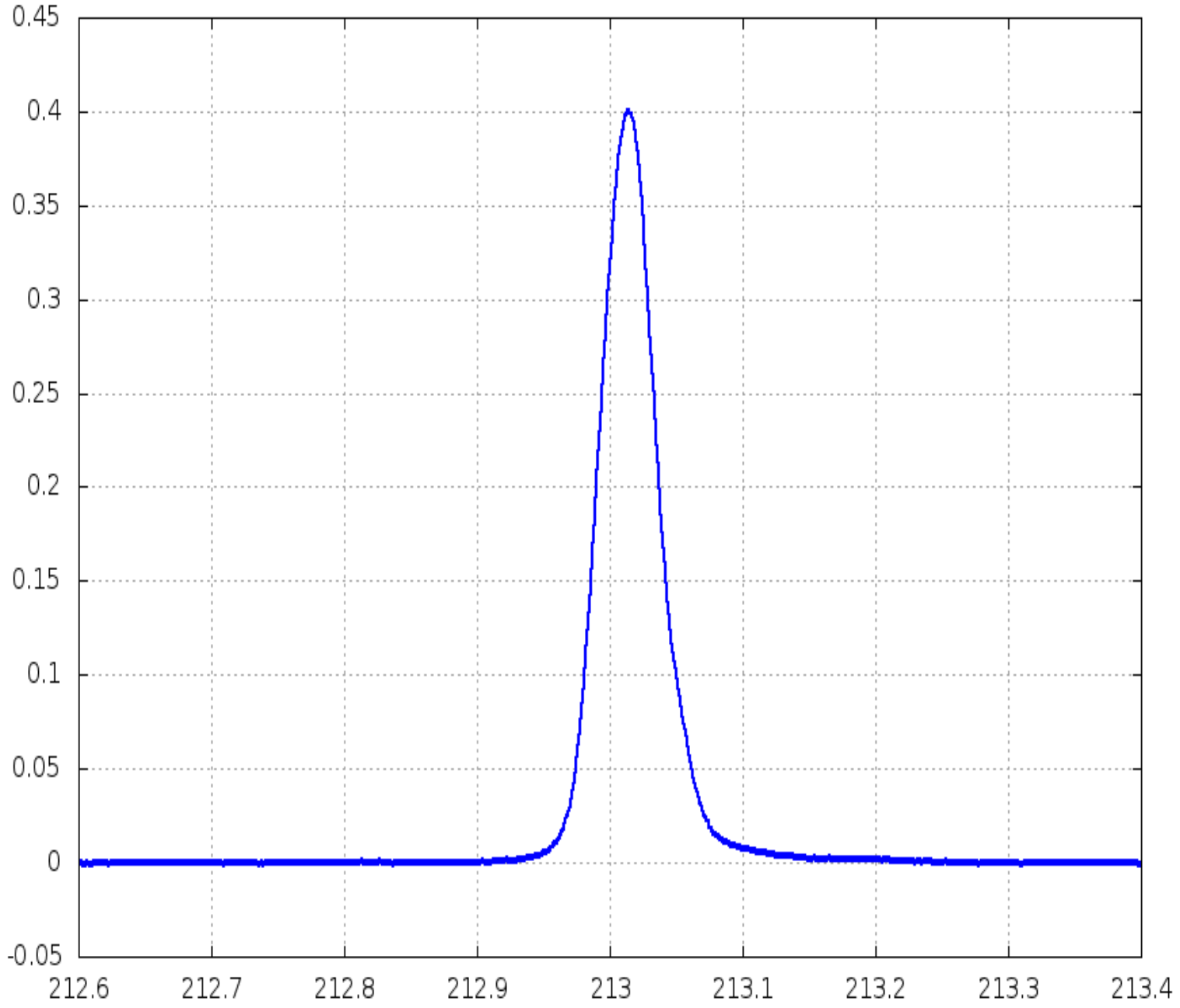
Ammonia irradiation Contd.

Problems

- Production of ^{39}Cl from ^{40}Ar
- Cannot use LN_2 → Explosions
- Processes tedious
- Will need ~ 1 Kg of target material for E1039.
- Currently have ~400g on hand, but only ~100g has been irradiated so far

Adiabatic Fast Passage(AFP)

- Way of inverting an ensemble of spins.
- Use RF sweep around Larmor frequency
  eg. 213 MHz at 5 T
- After P. Hautle Thesis ~ 20 years ago on solid targets.
- Achieved NH_3 ~ 57%
- d – butanol ~ 88%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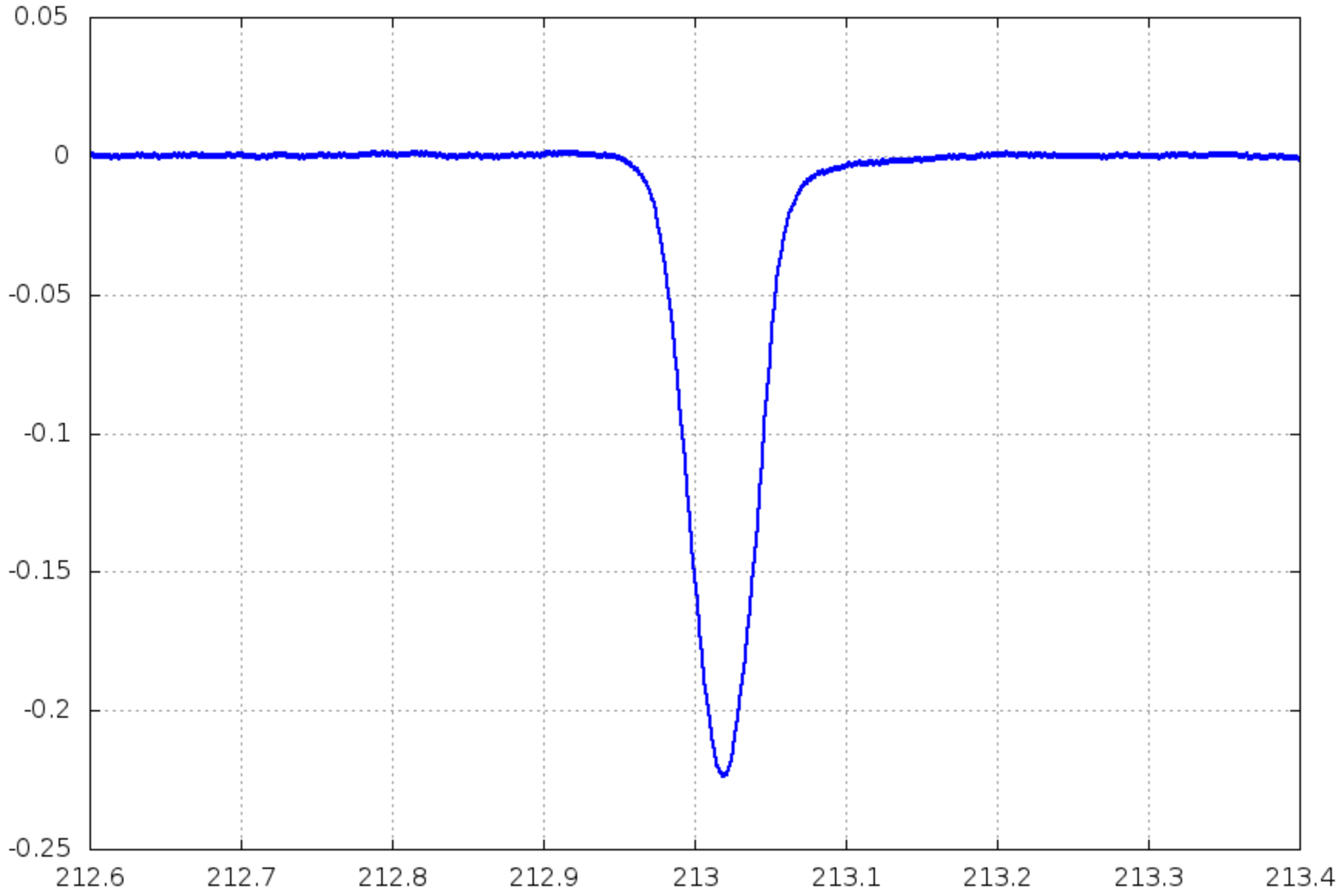
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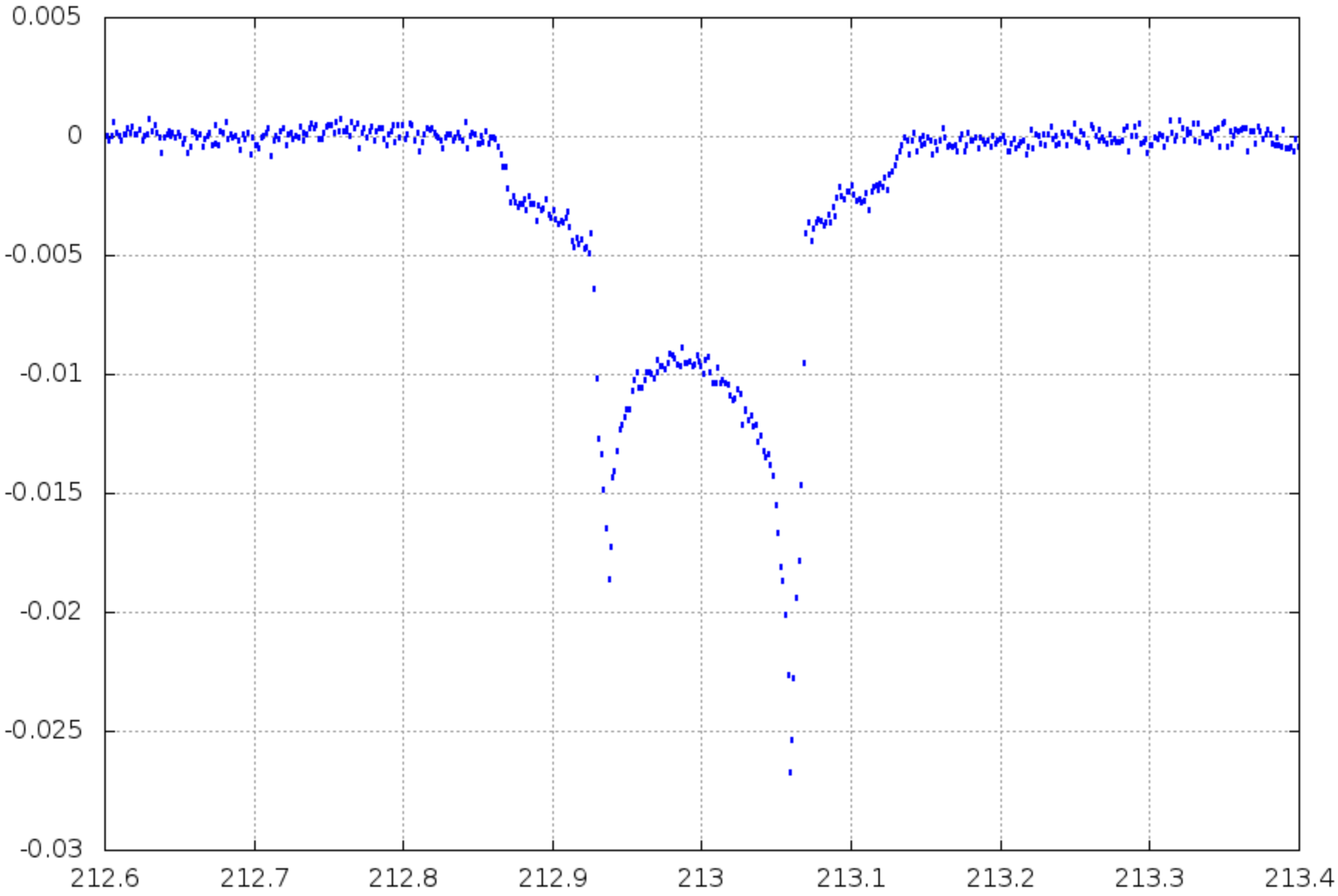
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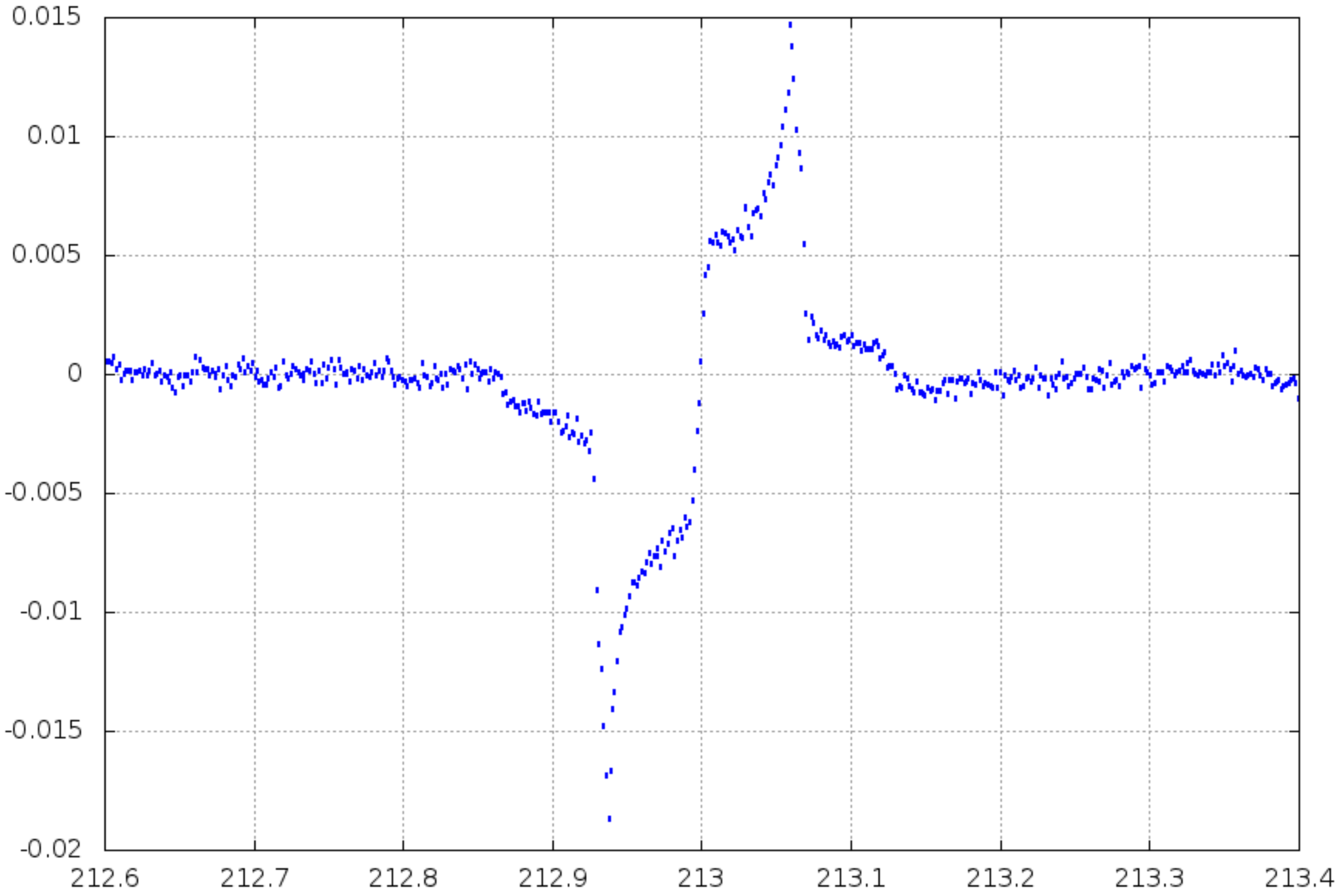
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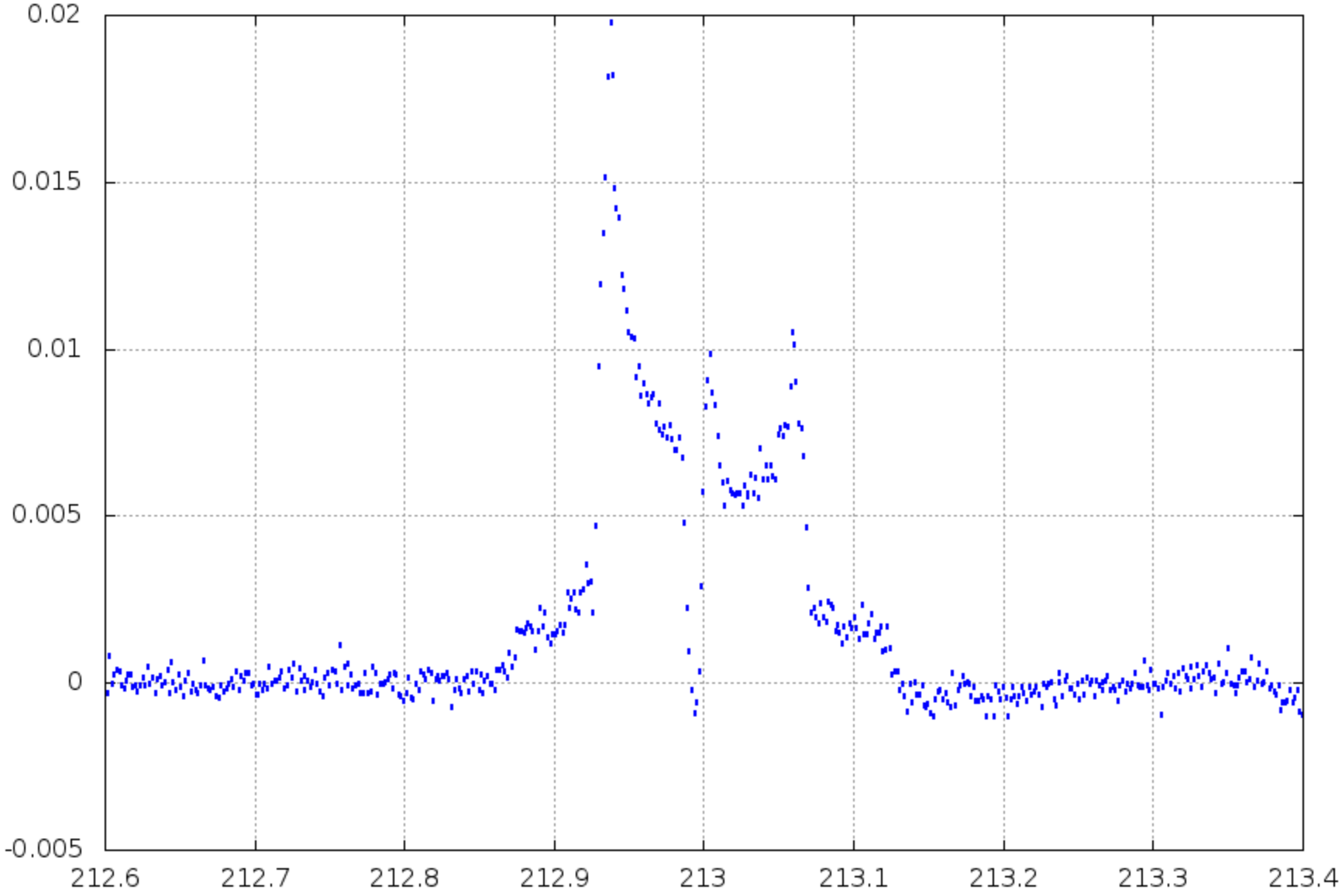
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Tensor Polarization

- Requirement from Jlab that a deuteron tensor polarization of 30% be demonstrated in ND_3 before being approved to run experiments E12-13-011 (b_1 structure function for the deuteron) and E12-15-005 (A_{ZZ} asymmetry) Usual way is to try and reach high vector polarization where for a Boltzmann distribution: $A = 2 - [4 - 3P^2]^{1/2}$

Tensor Polarization (contd)

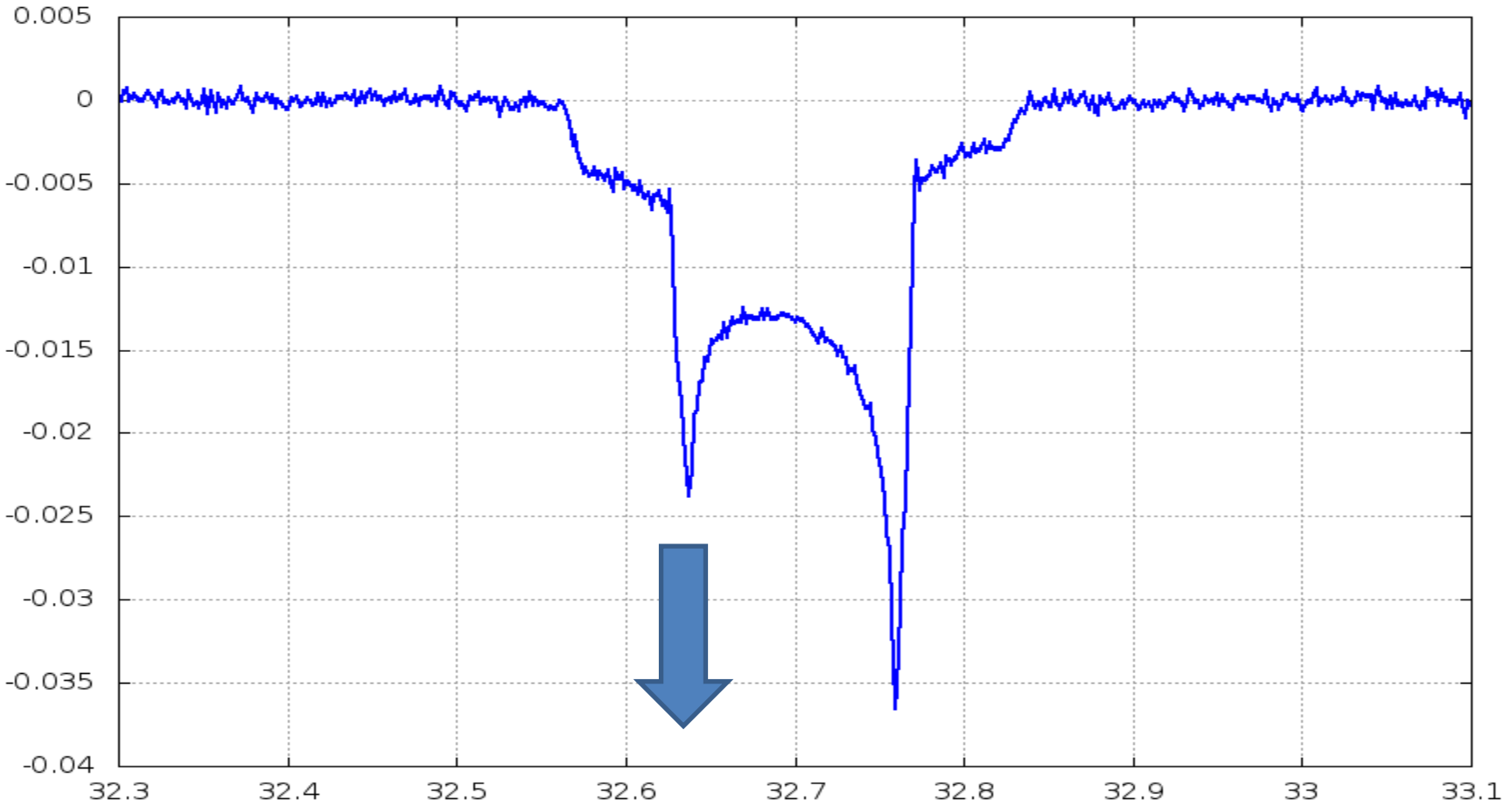
- Under our conditions; 5 T, 1 K
- P = 0.5 , A ~ 0.2 ,
- A = 0.3, P ~ 0.61

MANIPULATE RF LINE TO INCREASE TENSOR POLARIZATION – HOLE BURNING.

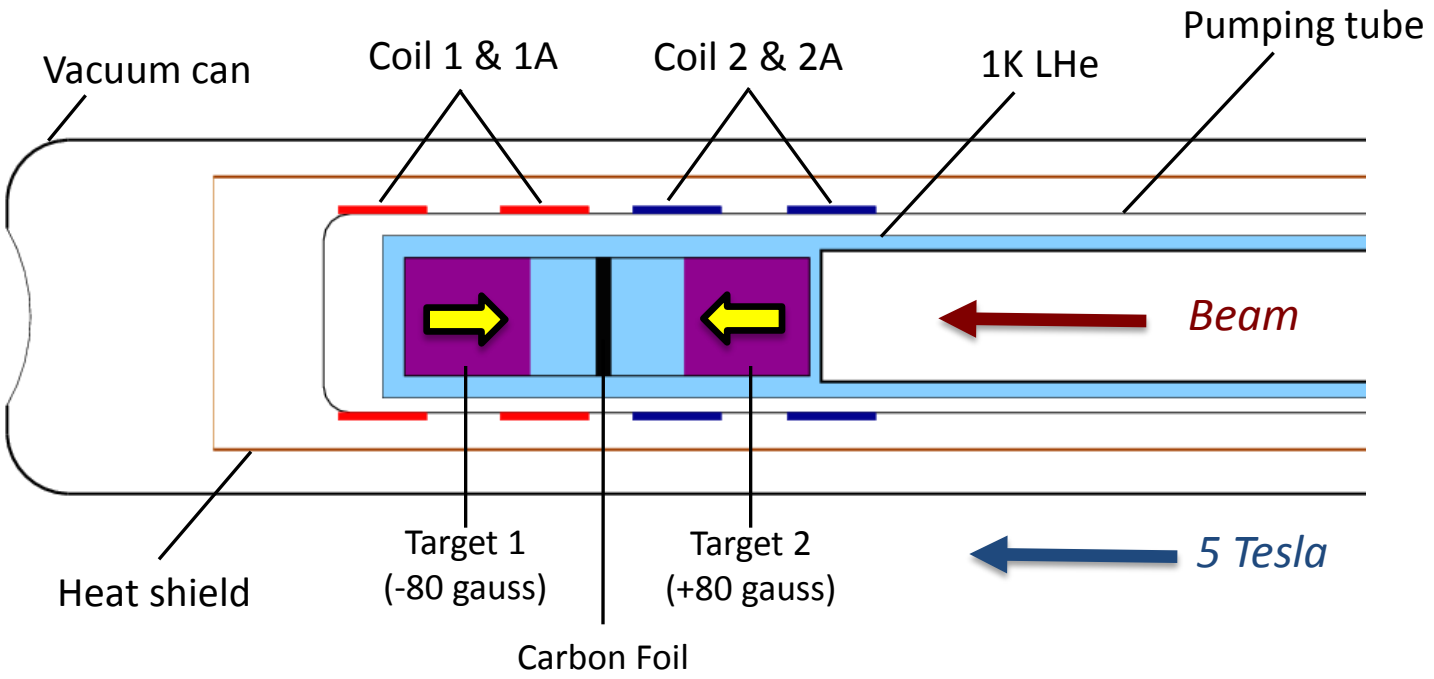
ULTIMATELY OBTAIN NEGATIVE VALUES. A -> 1 -> -2

OBTAINED A = 38% WITH A SMALL TARGET OF D - BUTANOL

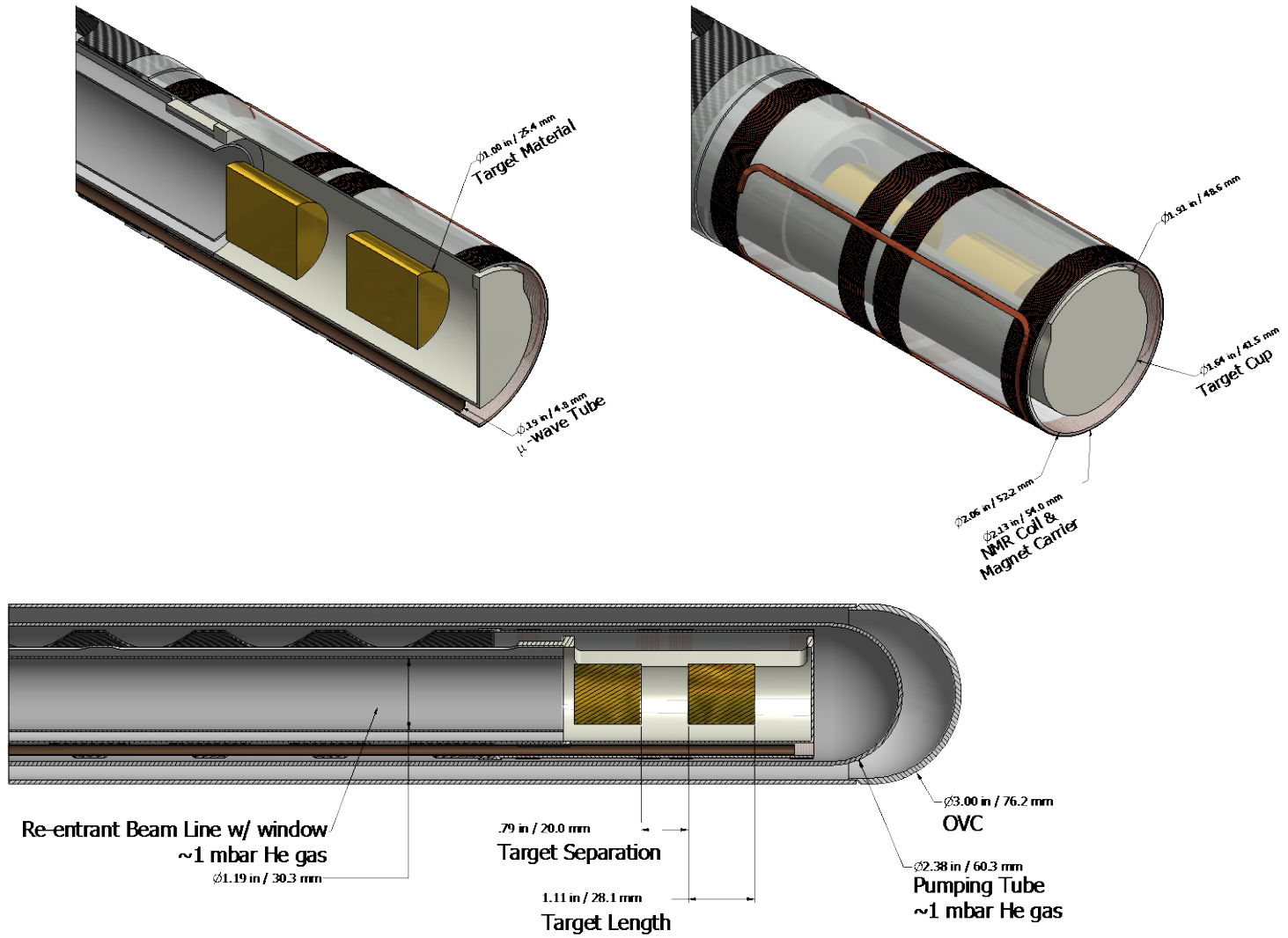
RF Hole Burning



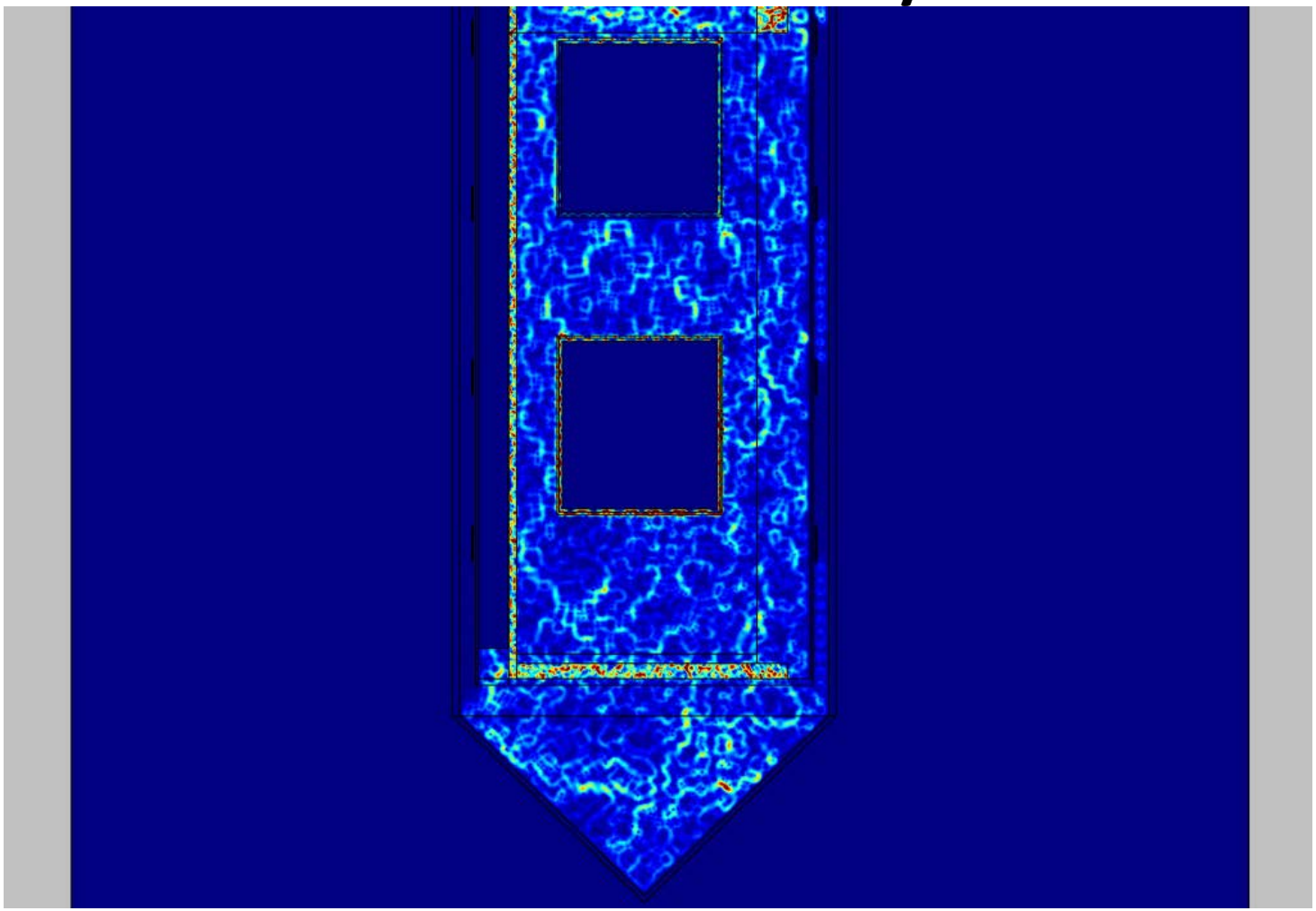
Two Targets, opposite polarizations

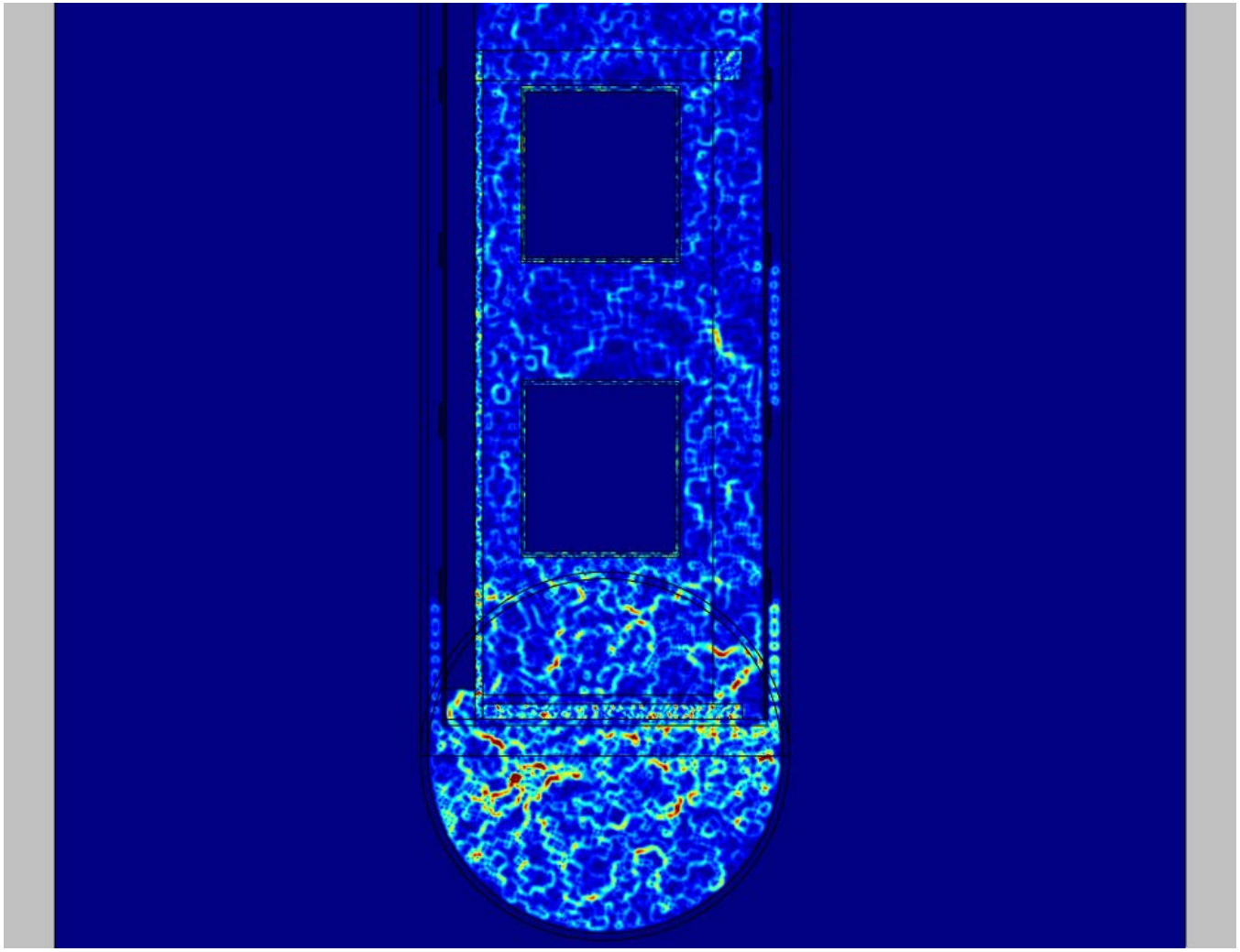


PolTar12: conceptual design



Conical Cavity





Ethane & Methane

- After a period of neglect have set up a freezing apparatus to make target beads of CD_3 and CD_4 and then irradiate them for polarization.
- Problem: Beads float on LN2 and fizz around.
- Need to capture and keep under LN2
- CD_4 studied previously by Borghini and Glattli.
- CD_3 ????

Dilution Refrigerator for High Frost

- Dilution Refrigerator to be used at HIγS at Duke university. Polarized photon beam to be used first to look at deuteron break-up -> GDH Sum rule.
- Dilution refrigerator designed at CERN by Niinikoski then modified and used at HZG (Germany) and then given to UVA.
- Remodified and repaired at UVA

Dilution Refrigerator (contd)

- Leaks fixed, damage (by persons unknown) repaired, etc etc
- Have reached ~120 mK, but have not been able to run long enough to tune for 3He/ ^{3}He ratio.
- Latest problem – pump in ^{3}He circuit failed.
- Next cooldown – in ~ 1month

Protein Polarization

- In collaboration with Josh Pierce @ORNL have been polarizing the protons (and eventually deuterons) in various samples of protein doped with TEMPO by chemists at ORNL. Some samples have shown promise, but unfortunately not “horse urine”, the only one I can prounce.
- Will be used in scattering experiments with polarized neutrons at SNS.