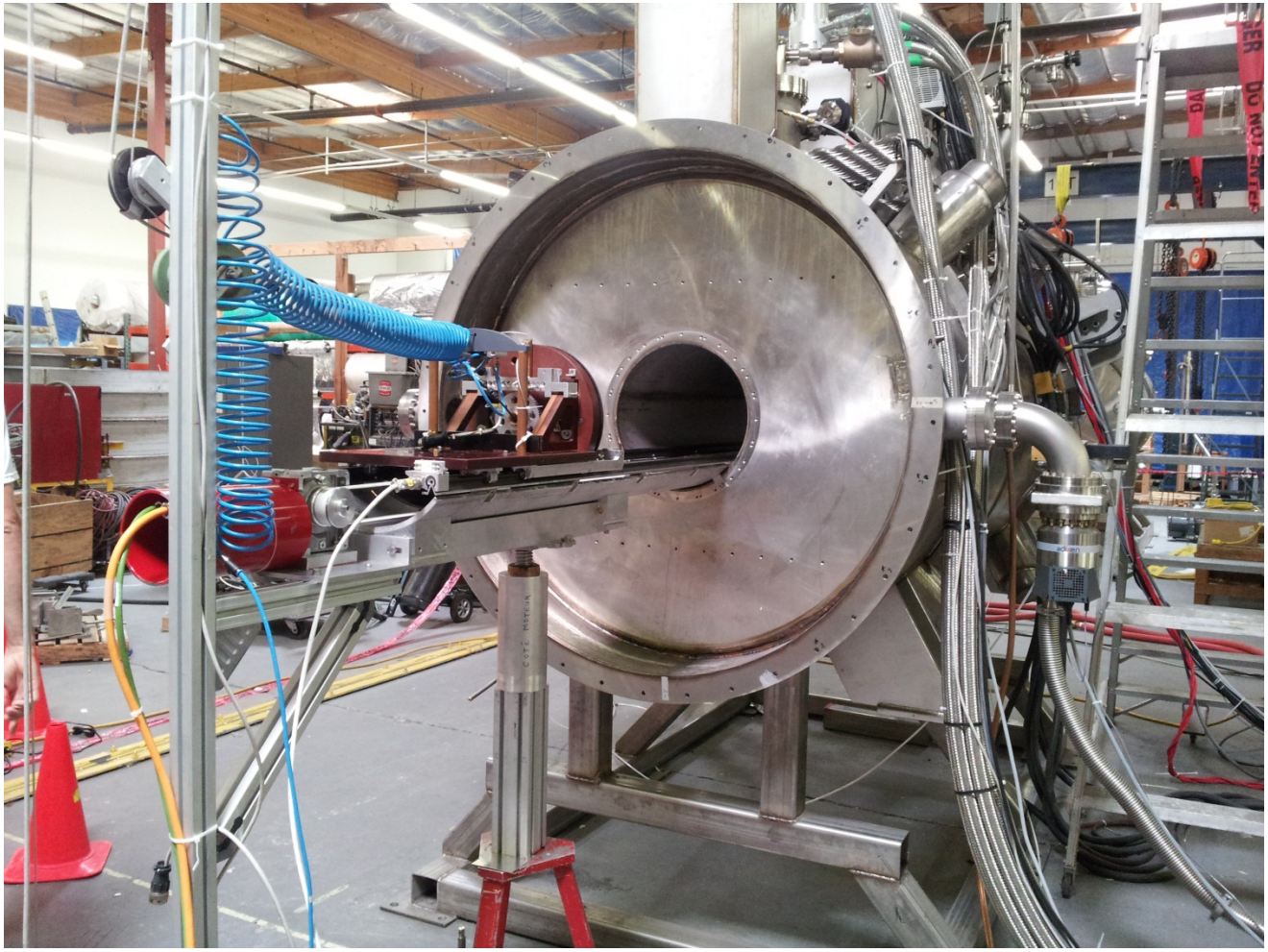
Mapping of MICE Magnets



M.A Leonova MAP spring 2014

Mapping MICE Magnets

- SS2 = SSU mapping completed 5 – 20 June 2013
- SS1 = SSD mapping completed 6 – 22 March 2014
- FC
  - Last week the mapper was unpacked and installed by CERN group
  - Mapping to start soon (Next week?)

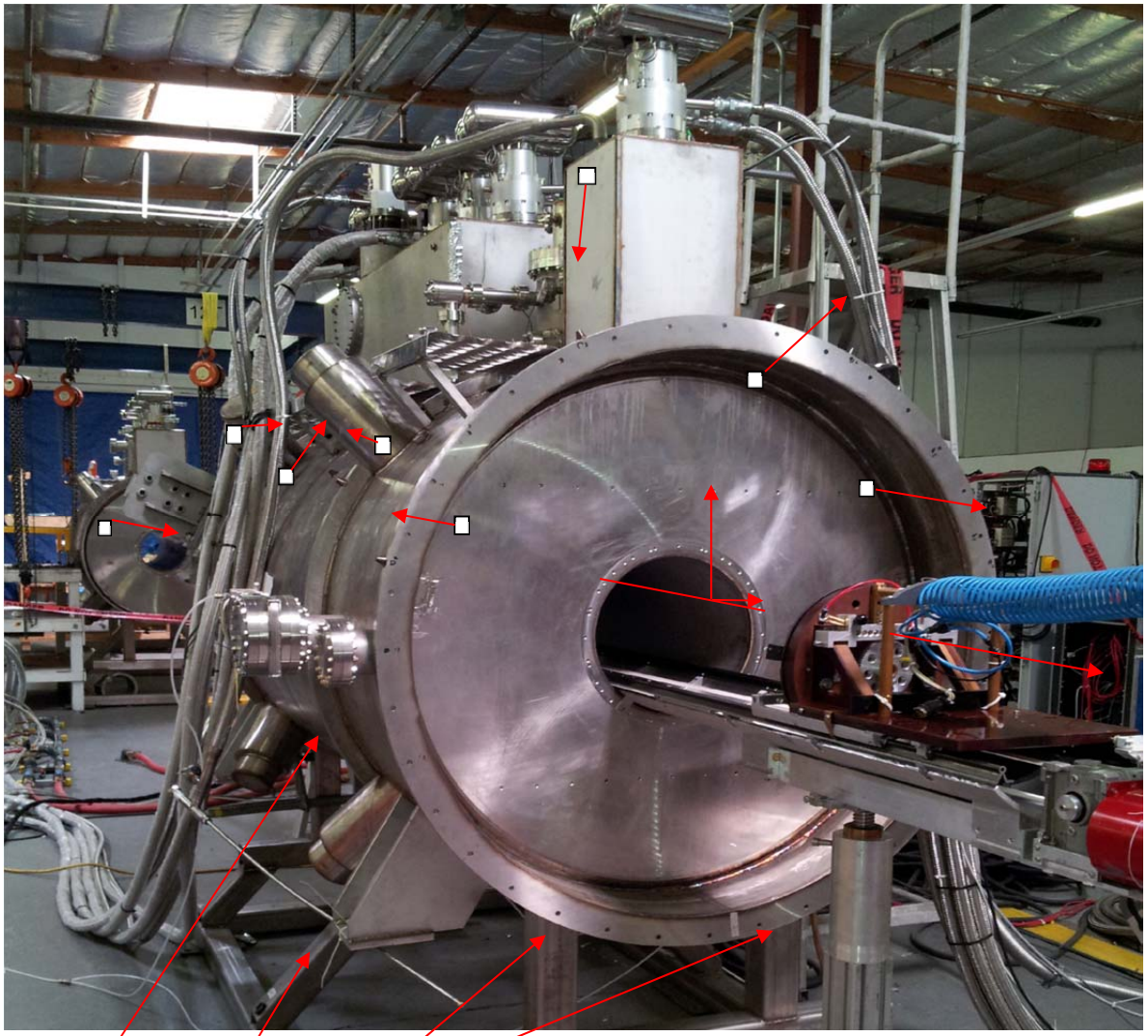
SSU and SSD Field Measurements

➢ Survey

– without the shield plate
– with the shield plate

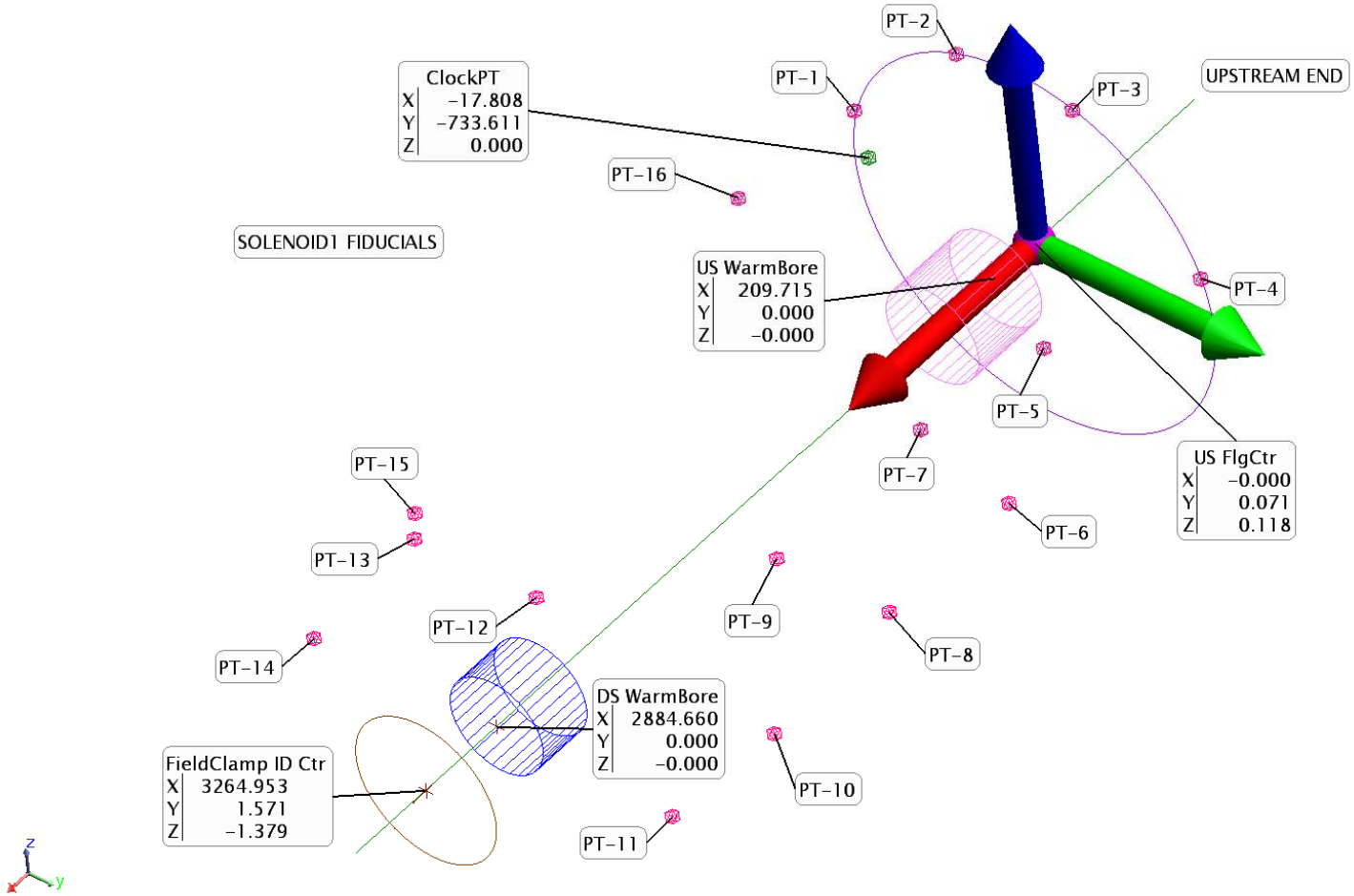
- Surveyed of fiducial markers:
  - done from 4 stations to get the best fit
  - establish a coordinate system with X axis along the cold mass axis (beam axis)
    Z axis vertical
    Y axis completes (x,y,z) right coordinate system
    origin at the DS end of cold mass for SSU
    origin st US end of Vacuum Vessel for SSD
- Mapping Device measurements:
  - mapper axis as the disk moved through the magnet
  - both rails to get disk rotation as it moves through the magnet
- Calibration of longitudinal positions vs. encoder of the Mapping Device
  - 50 cm steps
  - 2 cm steps

SSU Survey

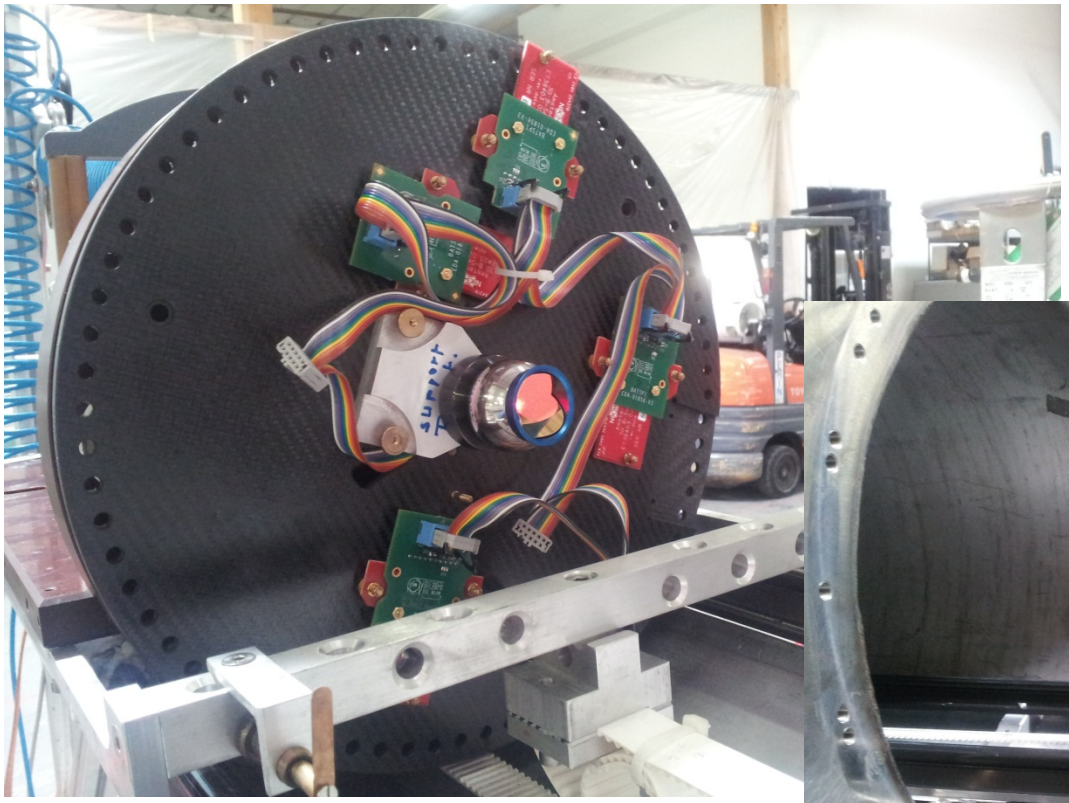


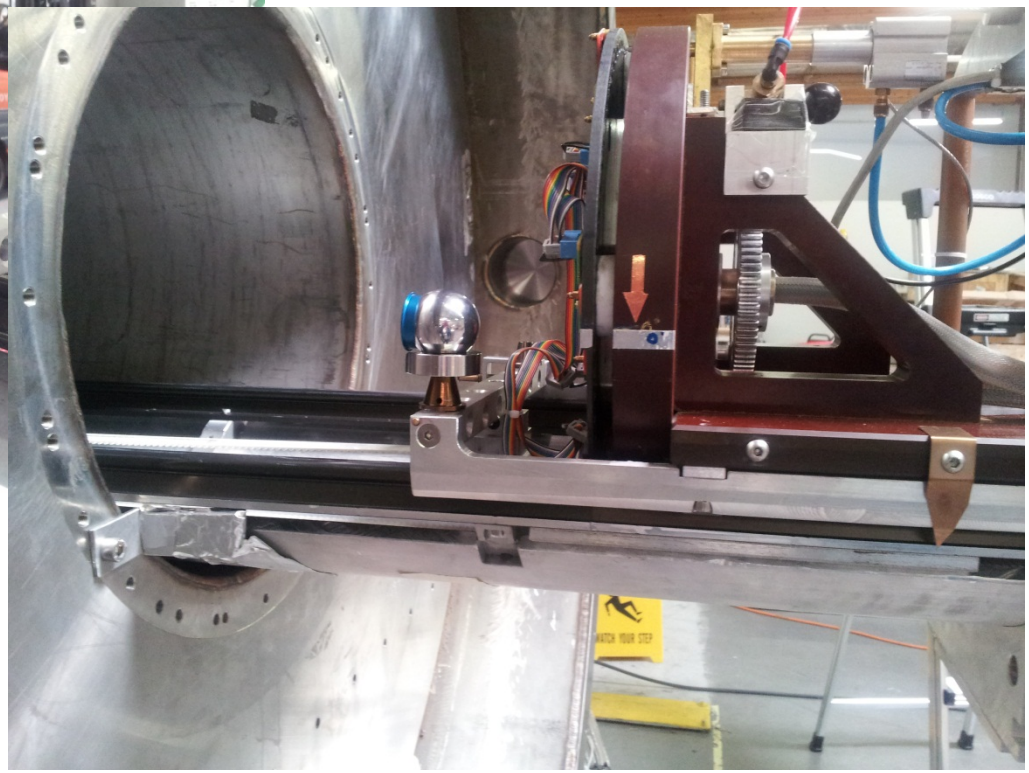
All suports are not welded to the magn. Note the clamp being

SSD Survey

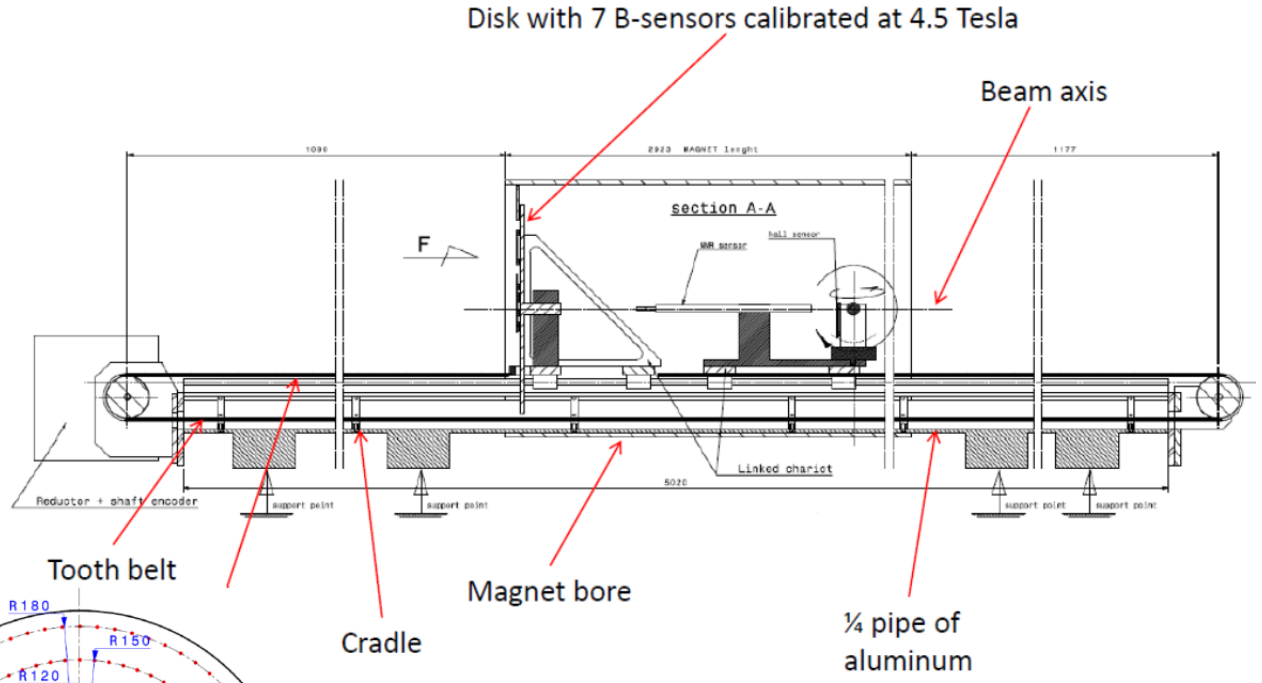

PT-2
ClockPT
X -17.808
Y -733.611
Z 0.000
PT-1
PT-3
UPSTREAM END
PT-16
SOLENOID1 FIDUCIALS
US WarmBore
X 209.715
Y 0.000
Z -0.000
PT-4
PT-5
PT-7
US FlgCtr
X -0.000
Y 0.071
Z 0.118
PT-6
PT-15
PT-13
PT-12
PT-9
PT-8
PT-14
DS WarmBore
X 2884.660
Y 0.000
Z -0.000
FieldClamp ID Ctr
X 3264.953
Y 1.571
Z -1.379
PT-10
PT-11
z
y

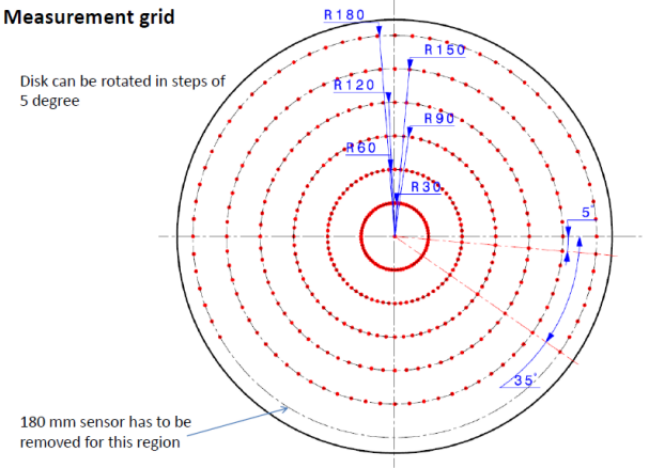
SSU and SSD Survey





Mapping Apparatus



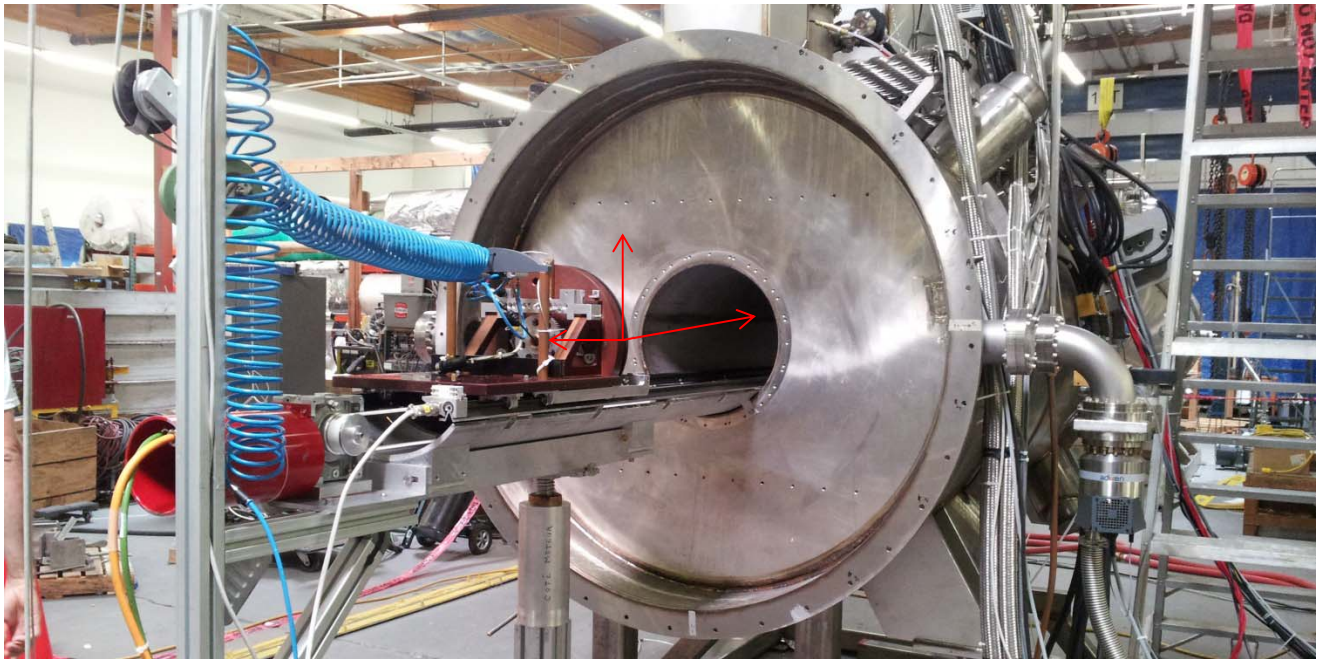


The system is characterized by the following uncertainties:

- ± 0.5 mm probe radial position;
- ± 1 mrad disk rotation angle;
- < 0.5 mm longitudinal position;
- ± 2 mT magnetic field measurement (in 1 to 4 T region).

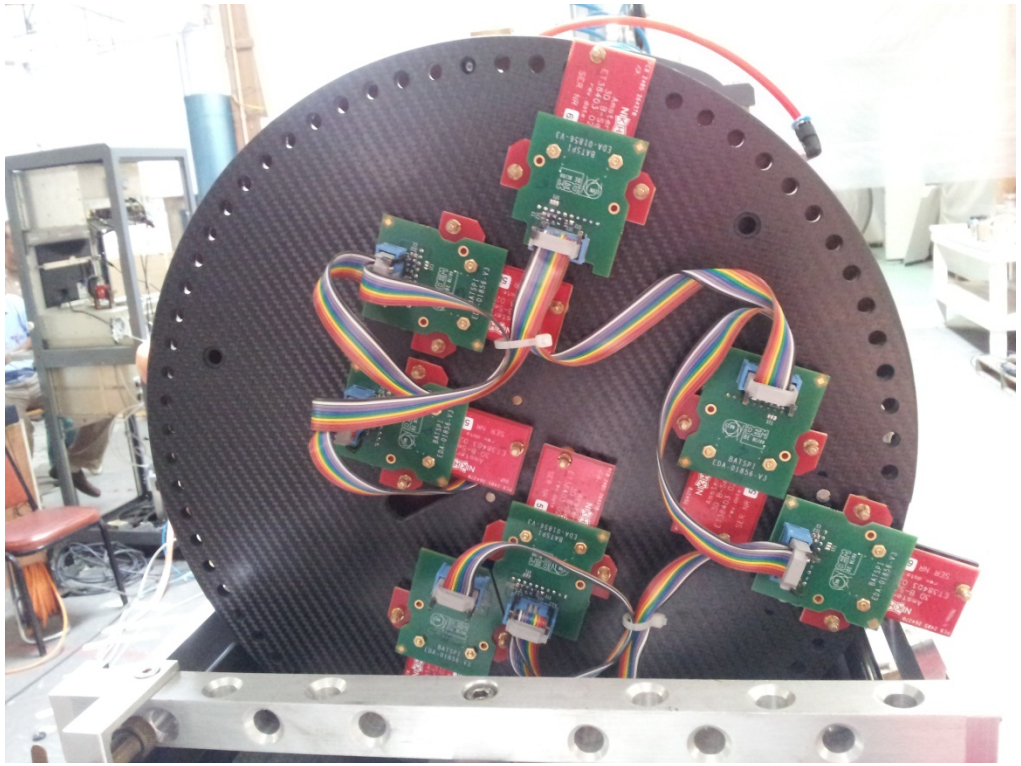
SS2 Field Measurements

- Mapping Device



X axis along the magnet on direction: SSU opposite to beam direction; SSD in direction of the beam
Z axis vertical
Y axis completes (x,y,z) right coordinate system

SS2 Field Measurements

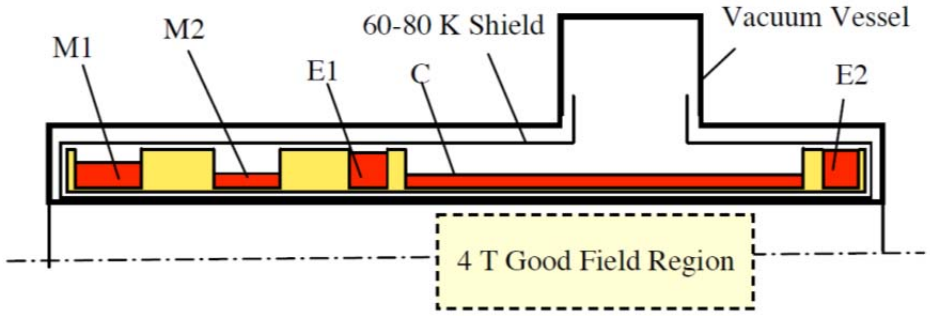


Two main modes of mapping:

- "fast" map:
  5-cm longitudinal steps
  4 disk rotation positions:
  0° & 180° and 40° & 220°

- "full" map:
  2-cm longitudinal steps
  20° disk rotation steps

SS Design



Vacuum vessel bore is 40cm in diameter.
Each solenoid has five superconducting Nb-Ti coils wound on a single aluminum mandrel.

	Match 1	Match 2	End 1	Center	End 2
Inner Coil Radius (mm)	258	258	258	258	258
Coil Thickness (mm)	46.165	30.925	60.905	22.125	67.783
Coil Length (mm)	201.268	199.492	110.642	1314.30	110.642
Current Center Axial Position* (mm)	124.00	564.00	964.00	1714.00	2464.00
Current Center Radial Position* (mm)	281.083	273.463	288.453	269.063	291.891
Coil Average J (A mm-2)	137.67	147.77	124.28	147.66	127.09
Number of Layers per Coil	42	28	56	20	62
Number of Turns per Layer	115	114	64	768	64
Total Number of Turns	4830	3192	3584	15360	3968
Design Current (A)**	264.83	285.60	233.68	275.52	240.21
Coil Self Inductance (H)^	12.0	5.0	9.0	40.0	11.3
Coil Stored Energy (MJ)**	0.42	0.20	0.26	1.55	0.32
Peak Field in Coil (T)**	5.30	4.32	5.68	4.24	5.86
Temperature Margin at 4.2 K (K)**	~1.6	~1.8	~1.5	~2.0	~1.5

* Based on Z = 0 is at the match coil end of the magnet cold mass (The center of MICE in these coordinates is at Z = -3487 mm) R = is the axis of the magnet (the MICE axis).
** This is at the maximum design current, which is based on the worst-case currents for the five coils.
^ The inductance of the two end coils and the center coil in series is about 74 H.

SSU Field Measurements

➢ Overview of Field Measurement Studies

	No Virostek Plate						**With** Virostek Plate				
	0 A	50%	80%	100%	30 A		0 A	50%	80%	100%	Other
Flip Mode	31-32 43-44		33-34	35-36	M1: 37-38 M2: 39-40 ECE: 41-42 E1: 51-52 E2: 53-54	Flip Mode	23-24 29-30			25-28	
	0 A	50%	80%	100%	95%		0 A	50%	80%	100%	10 A
Solenoid Mode	49-50	12 55-59	1-4 11	45-46	5 6-10	Solenoid Mode	16 18-19 20	13	14 15	21-22	17

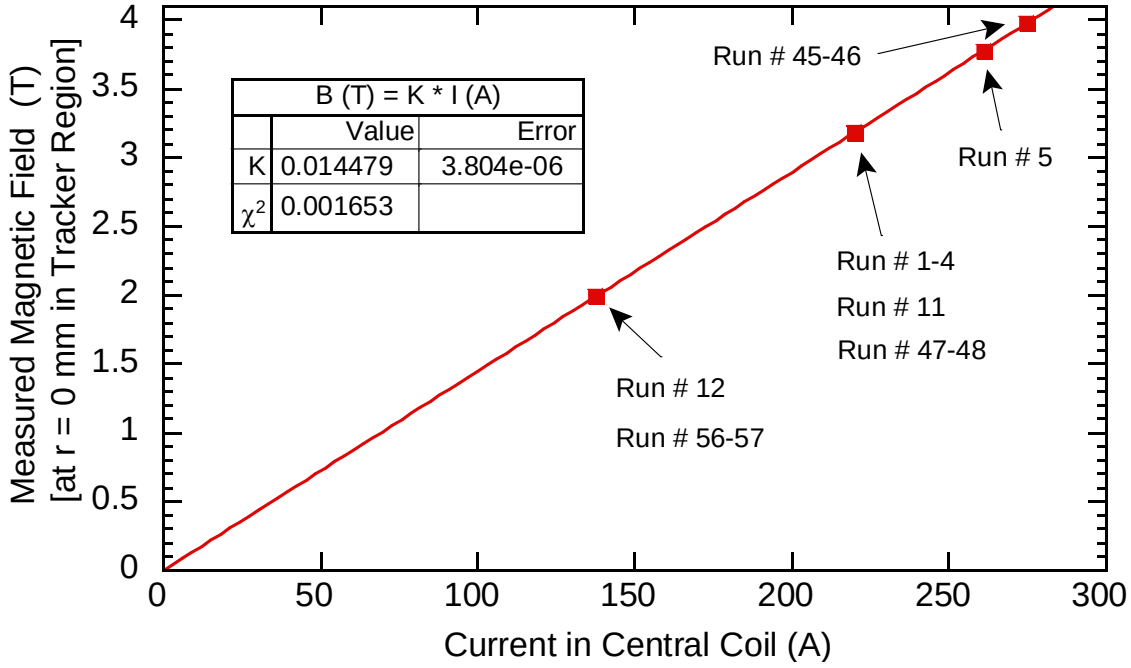
SSD Field Measurements

- Overview of Field Measurement Studies

Run numbers were re-started

	No Virostek Plate						**With** Virostek Plate				
	0 A	50%	80%	100%	Other		0 A	50%	80%	100%	Other
Flip Mode				69-70		Flip Mode	19-20	21-22	23-24 27-28 29-34	25-26	
	0 A	50%	80%	100%	30 A		0 A	50%	80%	100%	Other
Solenoid Mode	42 46	56-57	58-59 60-65	66-67	E2: 43 E1: 45 M1: 48-49 M2: 50-51 All: 52-53 C: 54-55	Solenoid Mode	41	400	38-39	36-37	

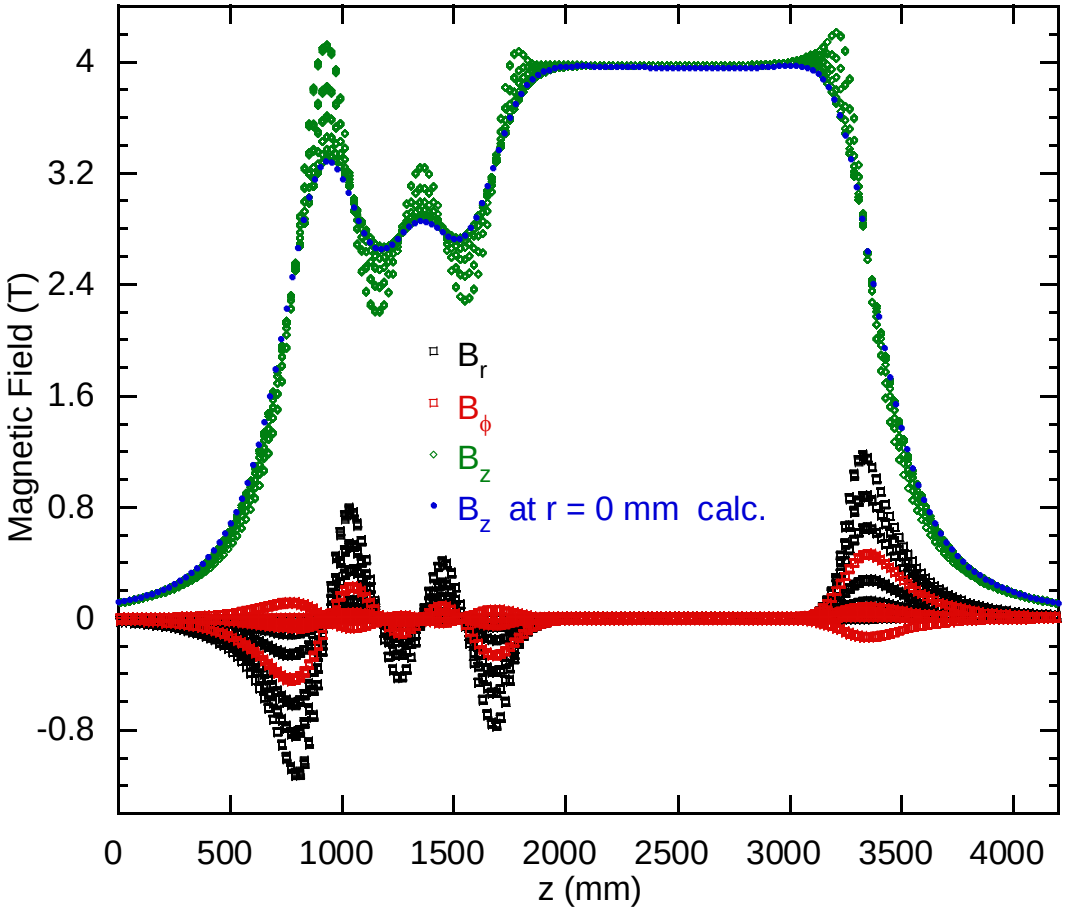
SSU Field Measurements



Magnetic field linearity study:

The currents in the coils were stable to ~0.05A (maximum variance) over ~2.5-hour measurement, reproducible to ~0.03A.

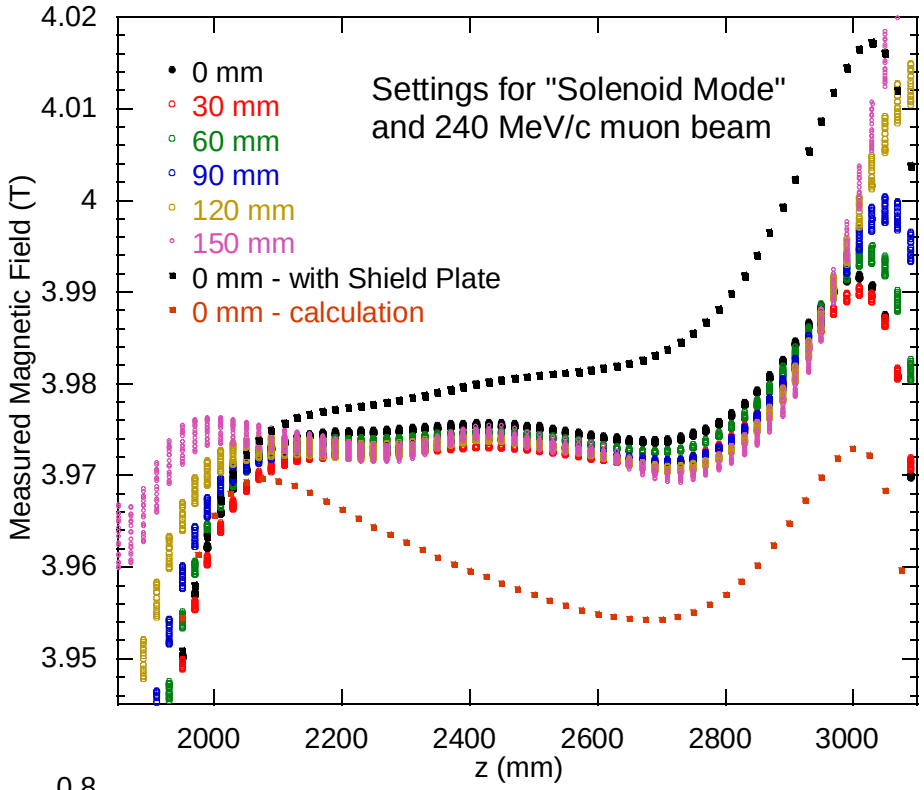
SSU Field Measurements

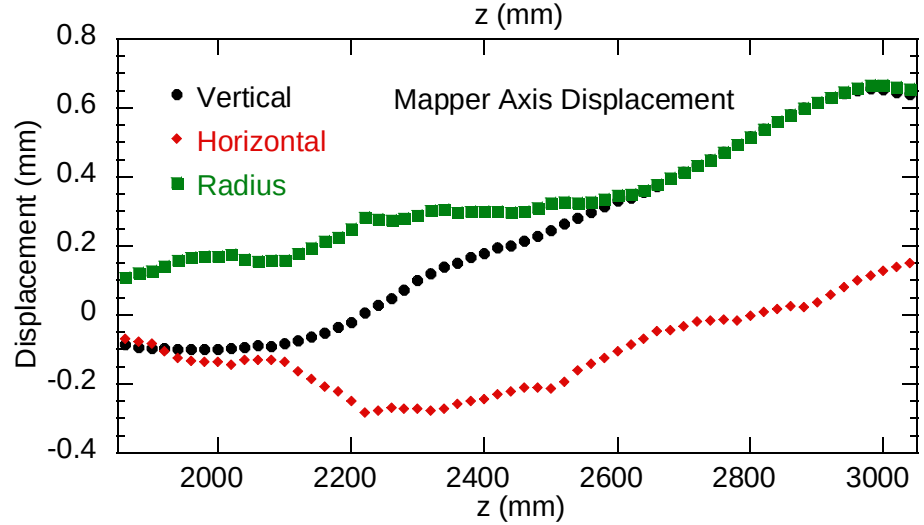


Measured field components, and a numerical calculation of the longitudinal field on magnetic axis using “as-built” coil parameters.

Measurements for all 3D Hall probes at different radii are plotted (0 mm – 18 mm), thus, the scatter in the points

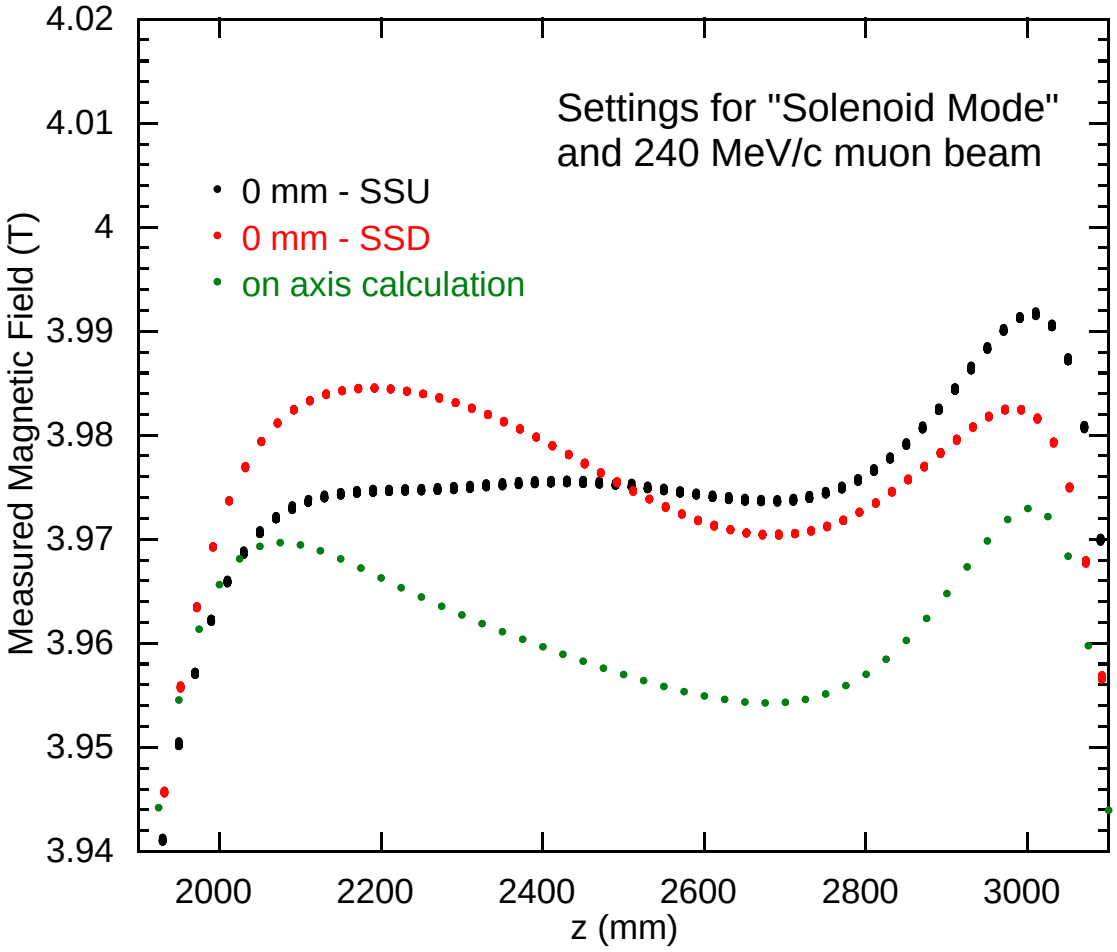
SSU Field Measurements





B_z magnetic field component in the tracker region: measurements for 3D Hall probes at different radii for a case without shielding plate, measurements at 0 mm for a case with shielding plate, and a numerical calculation on axis (no shielding plate) using "as-built" coil parameters and measured coil currents.

SSD Field Measurements



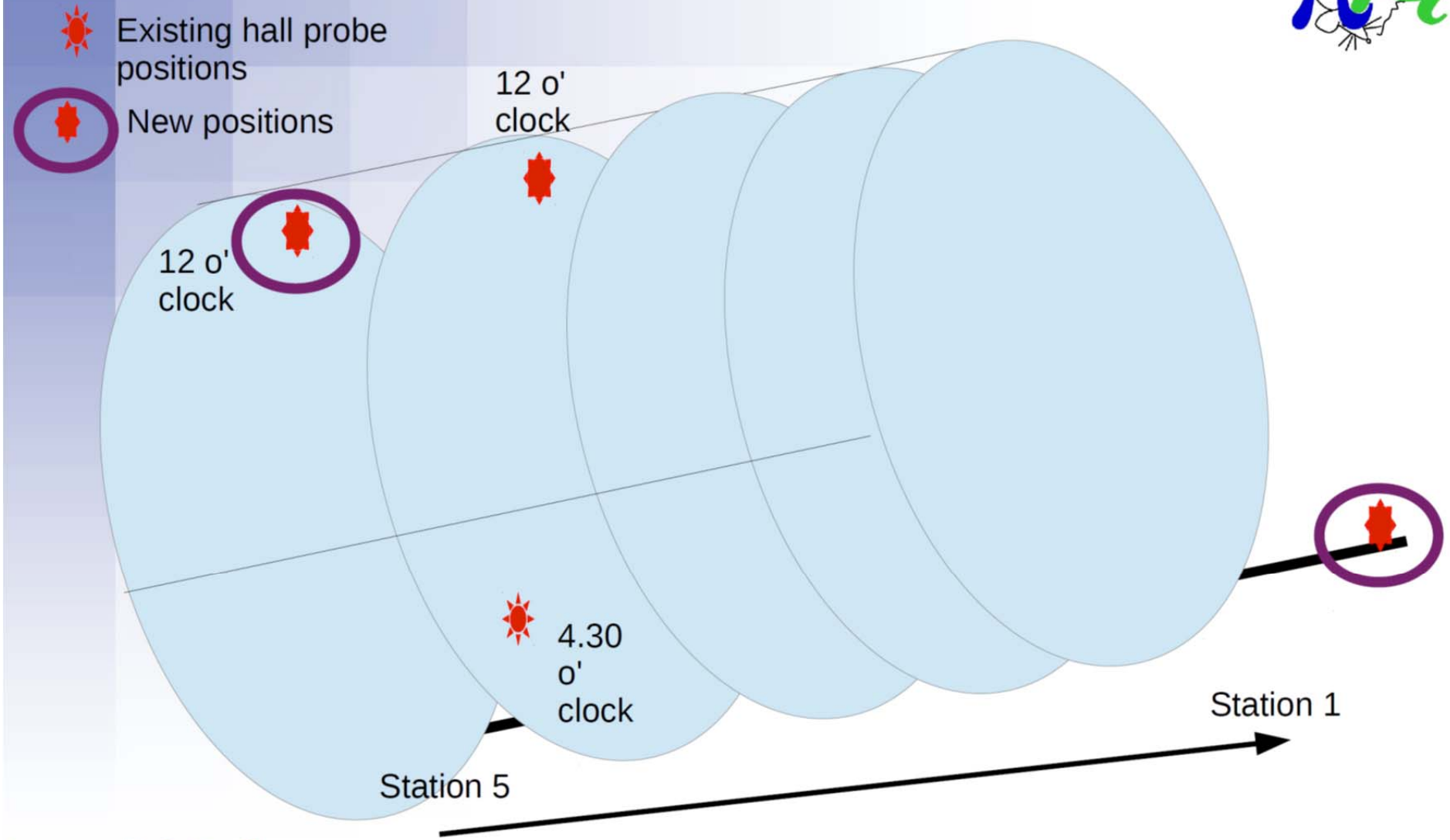
Correcting data for survey, may improve the apparent field uniformity in the tracker region.
An ~3% discrepancy between measurements and simulation is likely due:

- field calculation was done for warm dimensions;
- the # of turns in coils E2, C, and E1 possibly not as specified;
- other?

Thus, the currents in the coils need to be adjusted to achieve the desired field configuration and uniformity.

The effect of shielding plate on magnetic field inside the solenoid indicating that reduction of current in the outer coil (E2) is required.

Hall Probe Positions



See Victoria Blackmore’s talk at CM38
on Field Mapping