CURRENT STATUS OF THE SUPERCONDUCTING CYCLOTRON PROJECT AT KOLKATA

Jayanta Debnath

On behalf of
SCC Project Team, VECC

CONTENTS:

- VECC Superconducting Cyclotron - a brief review
- Beam extraction trial
- Field mapping (2013)
- Future plan

VECC Superconducting Cyclotron

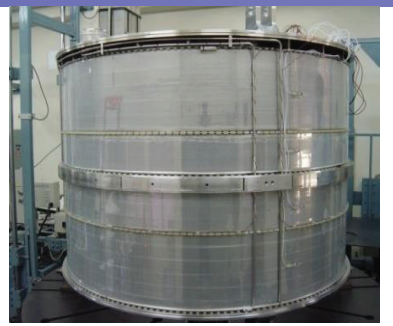
Major milestones:

➢**Commissioning of SC magnet**	2005
➢Magnetic Field mapping	2006
➢Commissioning of RF system	2008
➢**First internal beam**	**2009** August
➢Enhancement of LHe Plant Capacity	2010
➢**Cooling of LHe Cryo-panel**	Early 2011
➢Improvement of Internal Beam Current	July 2011
➢**Beam Extraction Trial & diagnosis**	**Up to 2012**
➢Magnetic Field Re-mapping	April 2013

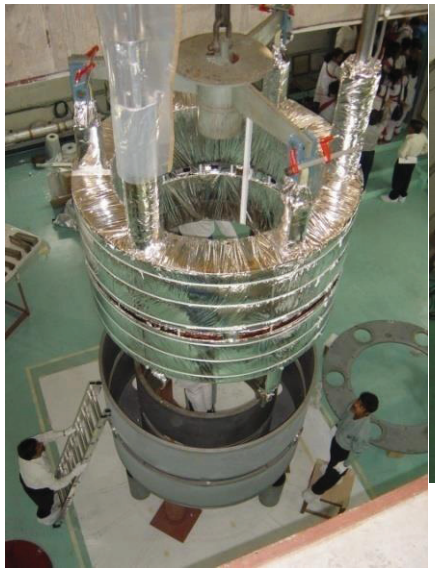
Fabrication of Magnet & Cryo-state

Spiral Pole tips

Pole base & Return Yoke



Liquid Nitrogen Shield

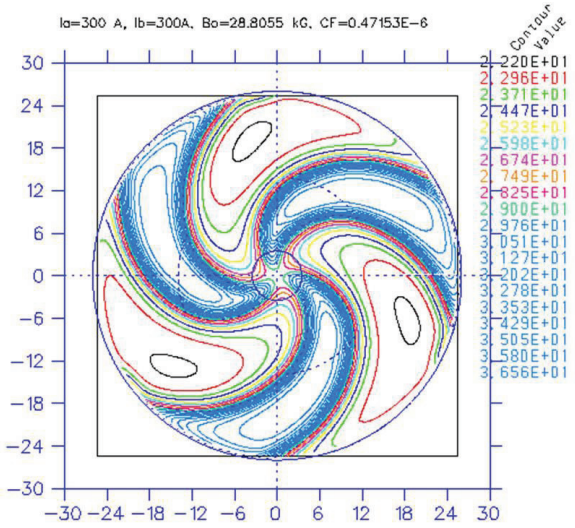


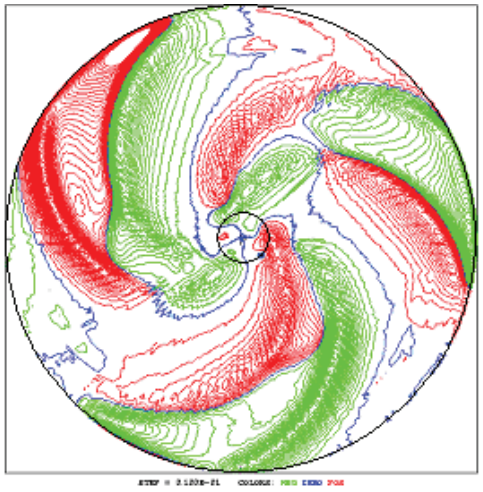
Multilayer Insulation and vacuum chamber

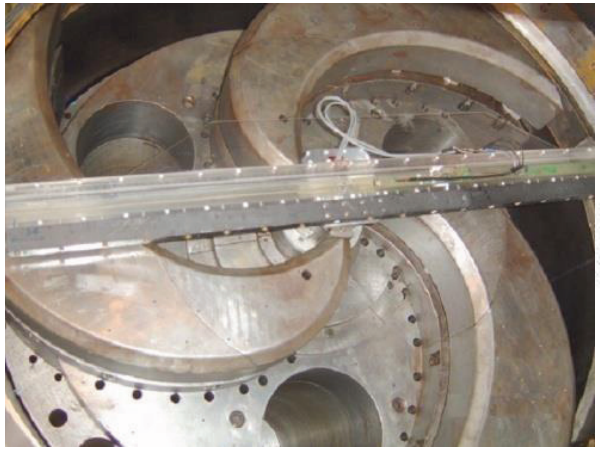
Cryostat with Median plane inserts

Commissioning of Magnet & Field Mapping 2006

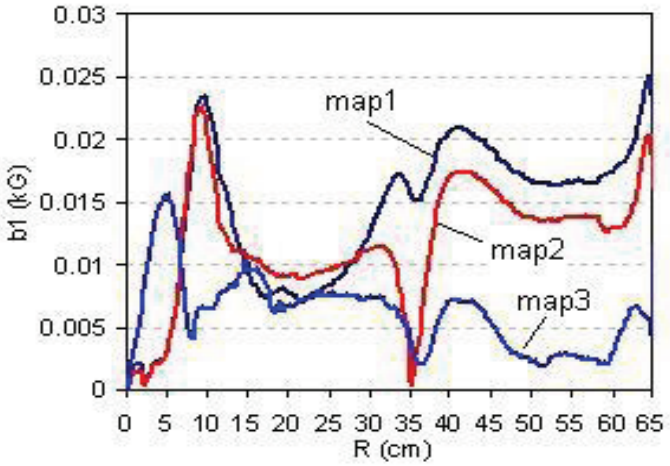
Magnet with LHe Transfer Line



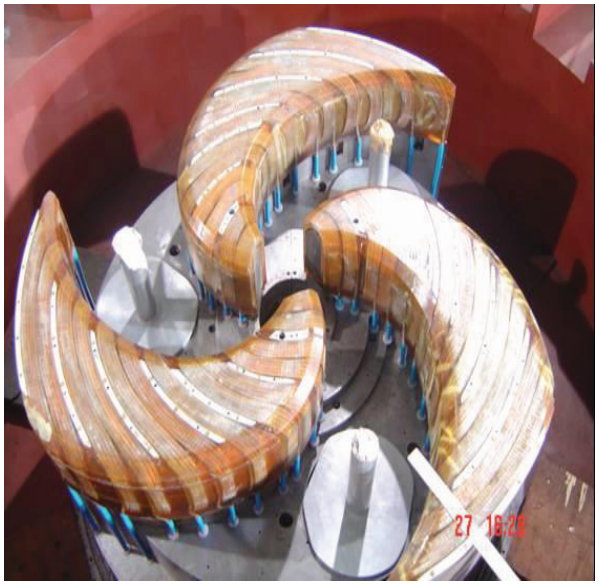




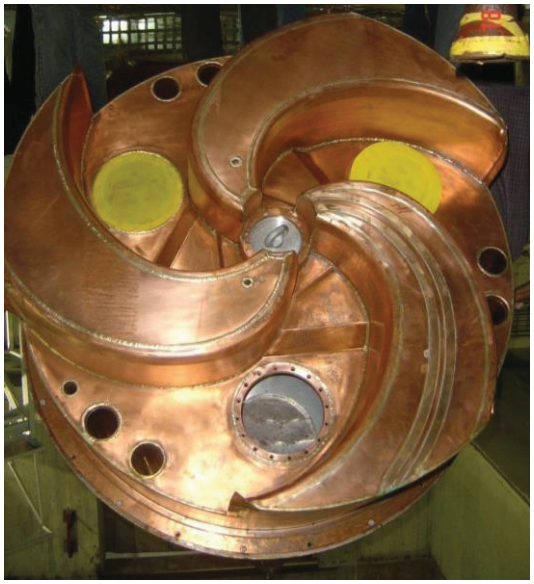
Magnetic Field Mapping (2006)



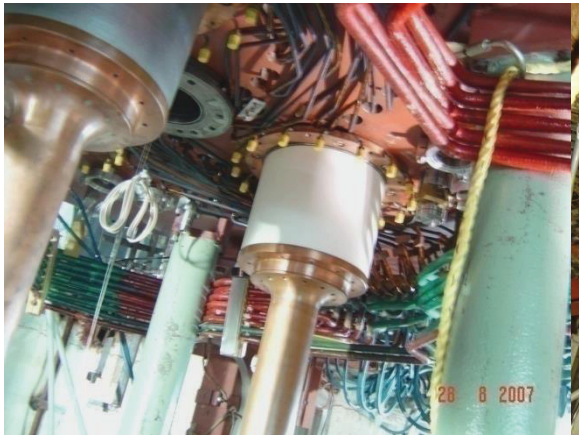
Installation of Trim Coils and RF System 2006-07

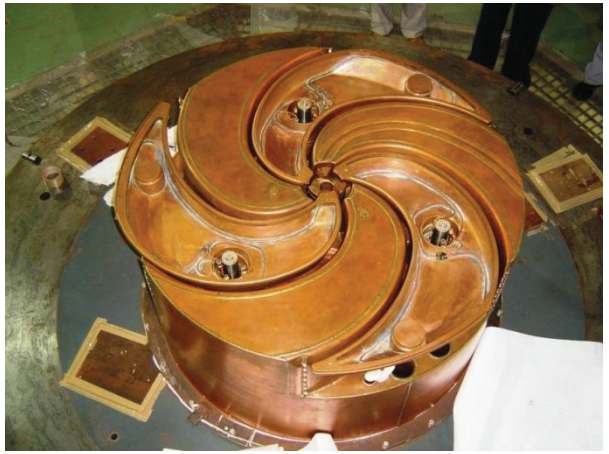


Trim Coils



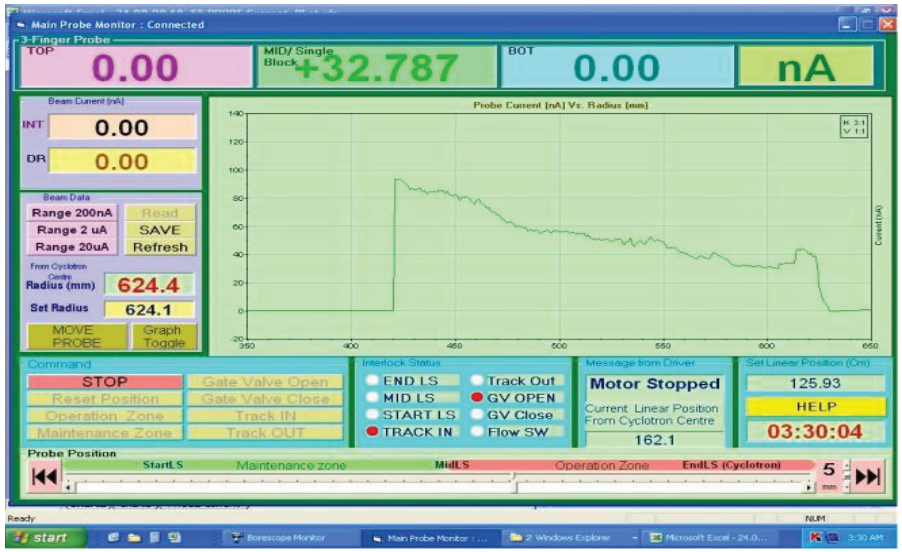
Lower RF Liner



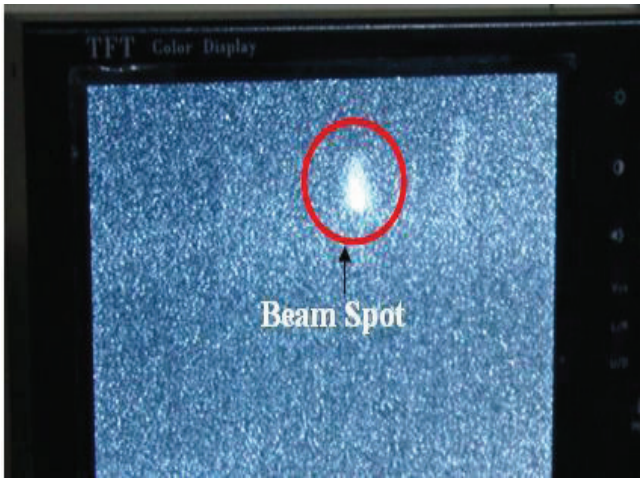


Injection Beam Line commissioning 2007

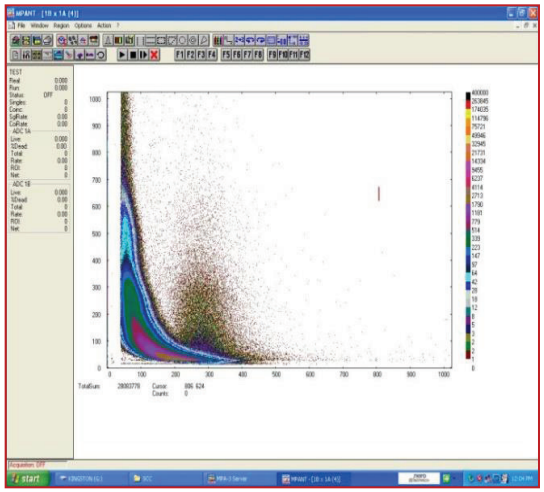
August 25, 2009: SC Cyclotron Accelerates Internal Beam

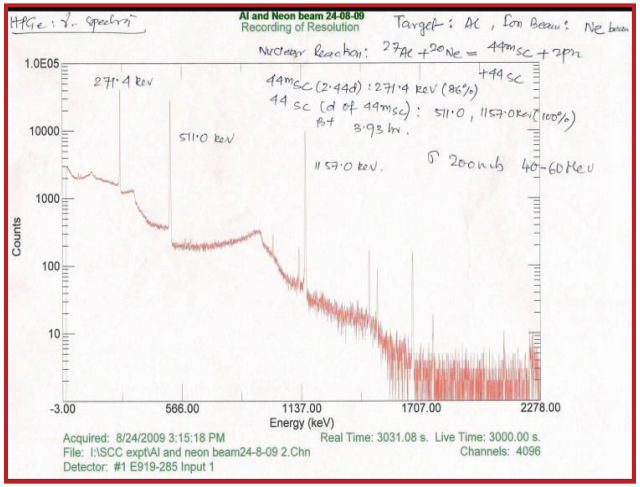


Beam current profile along radius



Accelerated Ne3+ Beam on viewer probe

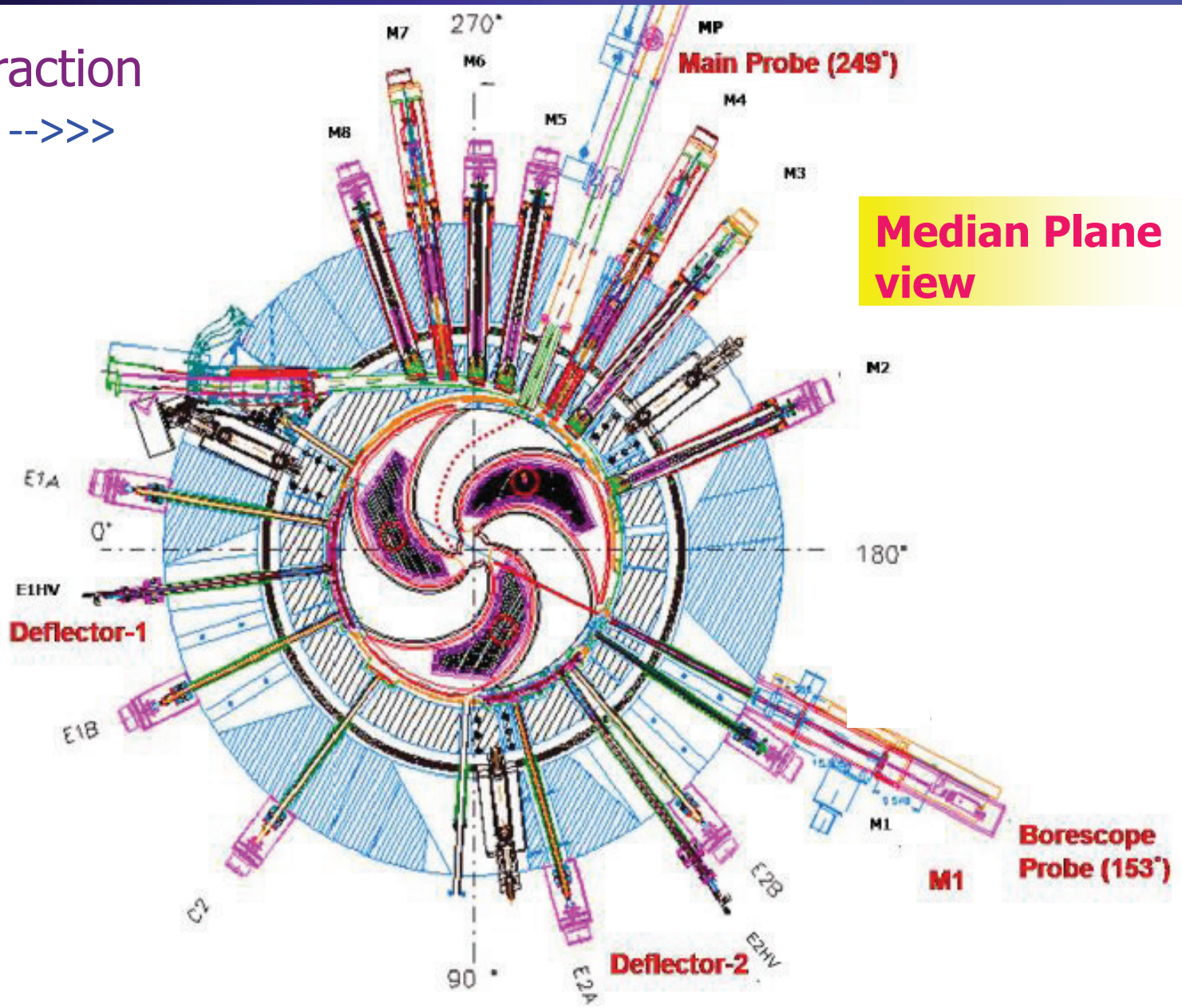




Neutron and gamma spectrum from Ne + Al nuclear reaction

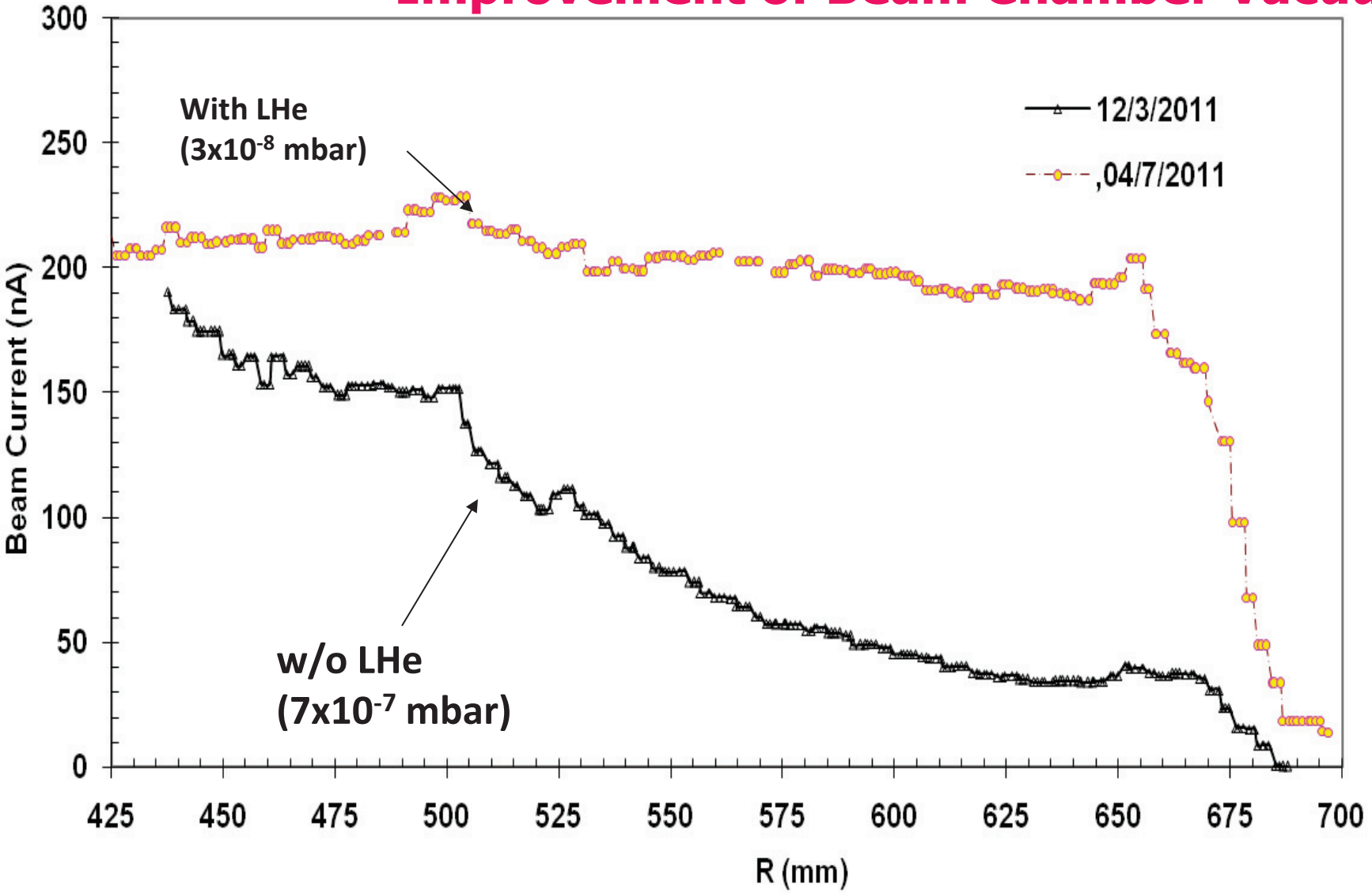
Installation of Extraction System 2009

Beam Extraction Trial 2010 -->>>

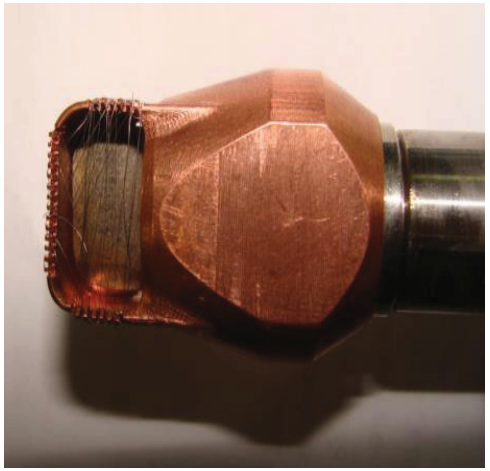


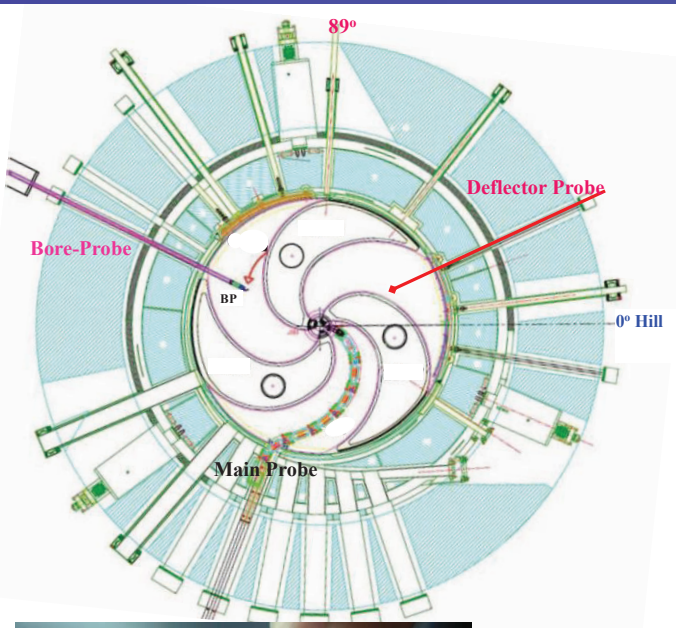
Installation of Liquid Helium Cryo-Panel 2011

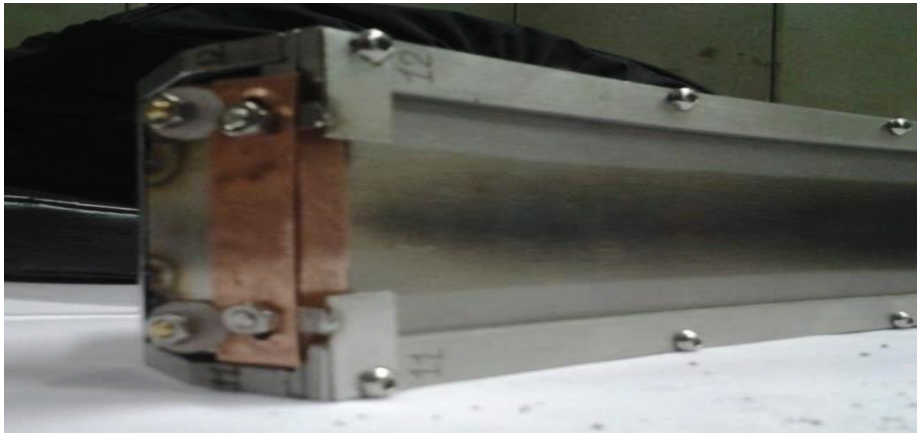
Improvement of Beam Chamber Vacuum

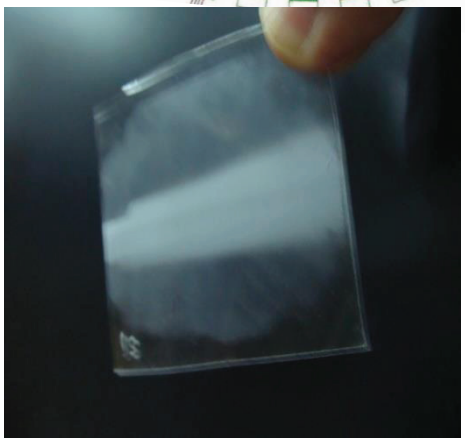


Beam Extraction Trials 2011 ……







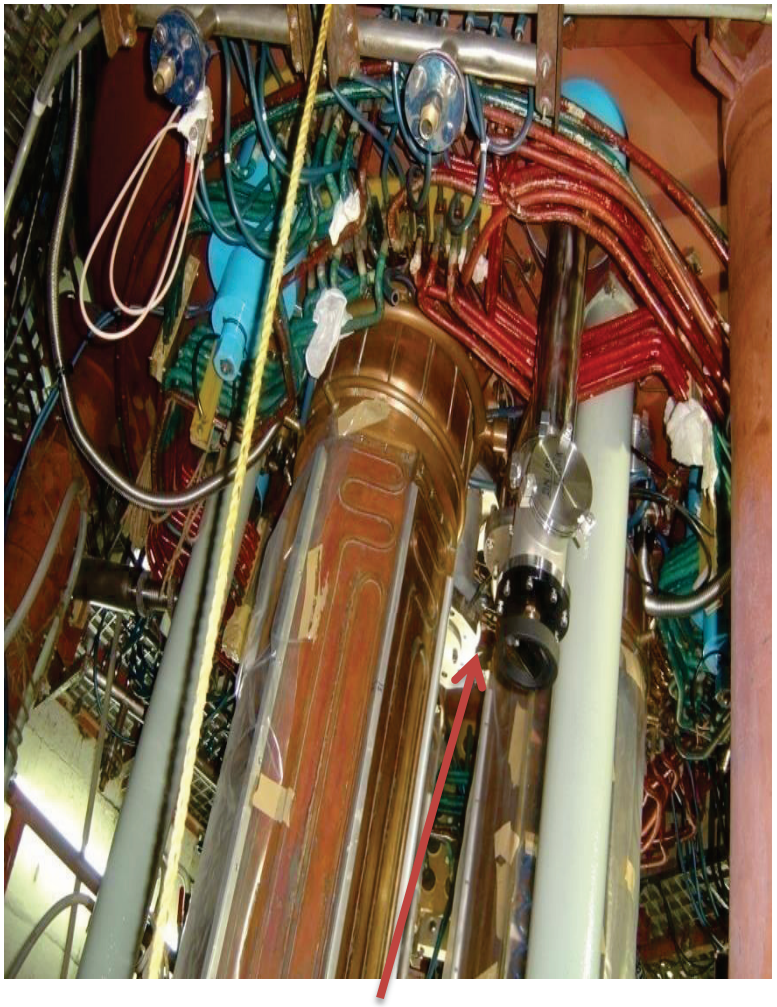


Diagnosis of Beam Extraction Problem

- **Dee voltage measurement**
- **Improvement in RF Phase stability**
- **Measurement of Beam off-centering**
- **Measurement of Beam Phase**
- **Inflector Rotation online**

Dee Voltage Measurement Using CdTe X-ray detector

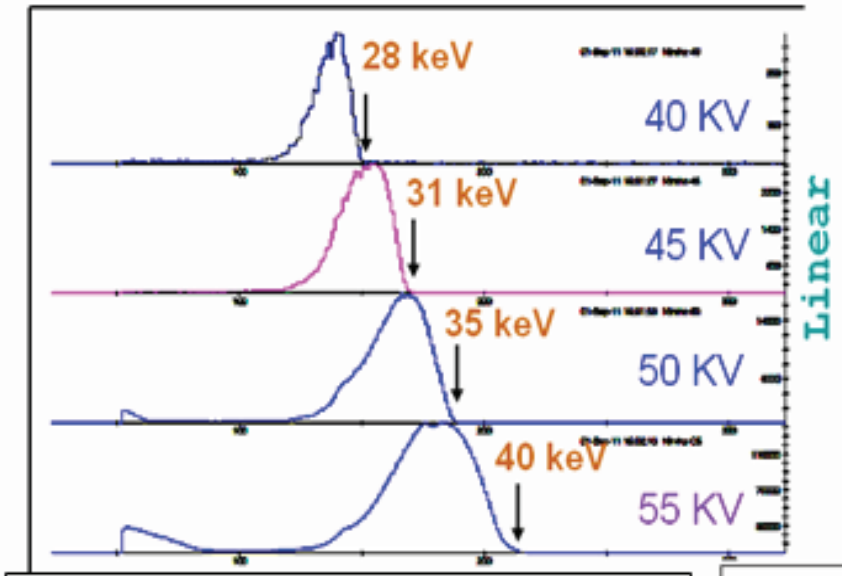
X-RAY DETECTOR WITH ITS FEED THROUGH AND CABLINGS



Port for inserting X-ray detector

X-RAY DETECTOR ON ITS HOLDING SETUP

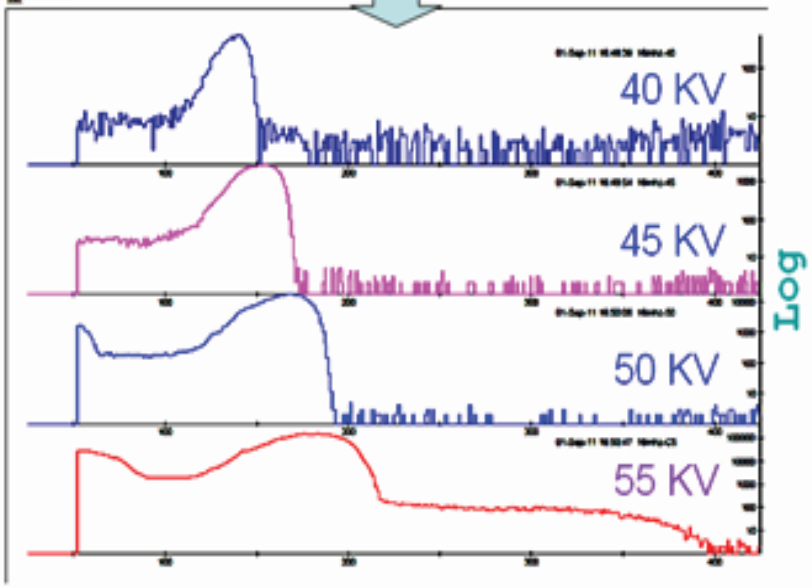
Dee Voltage Measurements



The End point has been "chosen" in the linear plot as the end of the "semi Gaussian" shape.

The data were taken for about 5 – 10 min duration each except for the 55 KV data which has been taken for 4 hrs.

The spectra look some what different in semi-Log plot.



Use of Bremstrahlung technique to determine the actual dee voltage. This measurement is very important as asymmetry in dee voltage leads to deterioration in beam quality by inducing coherent oscillation in the beam.

RF Voltage and Phase vs. Time

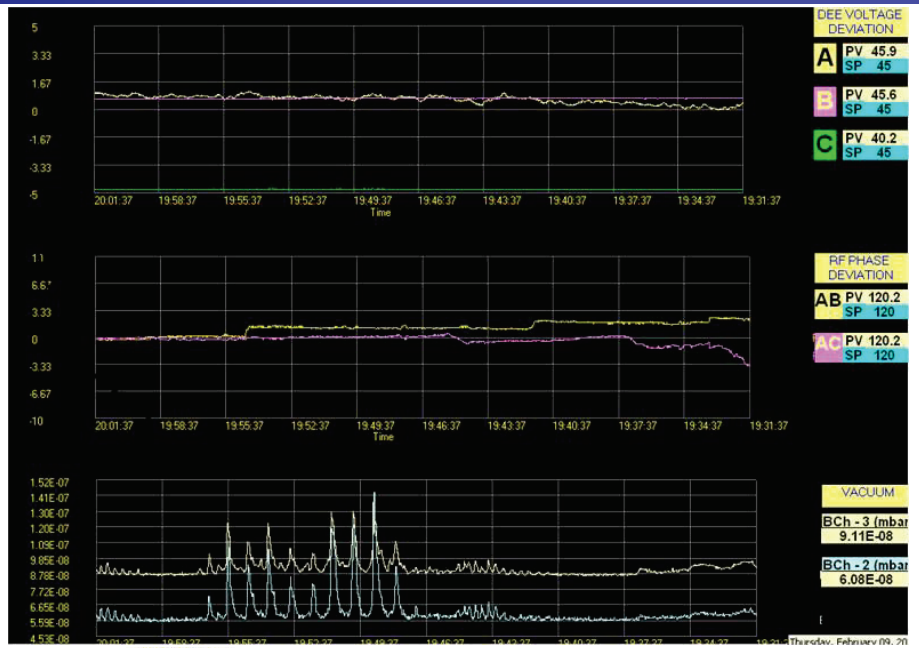
Earlier

- Previous Phase Stability ± 0.5^0 to 1^0. New phase control loop based on DDS technique achieved stability within ± 0.2^0.

RF Voltage

RF Phase

Vacuum

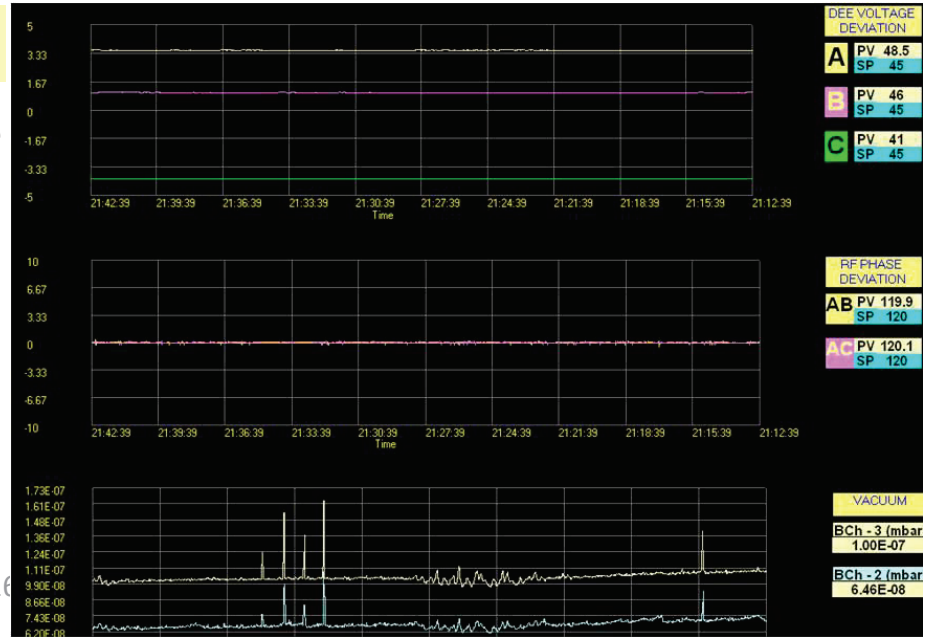


Now

RF Voltage

RF Phase

Vacuum

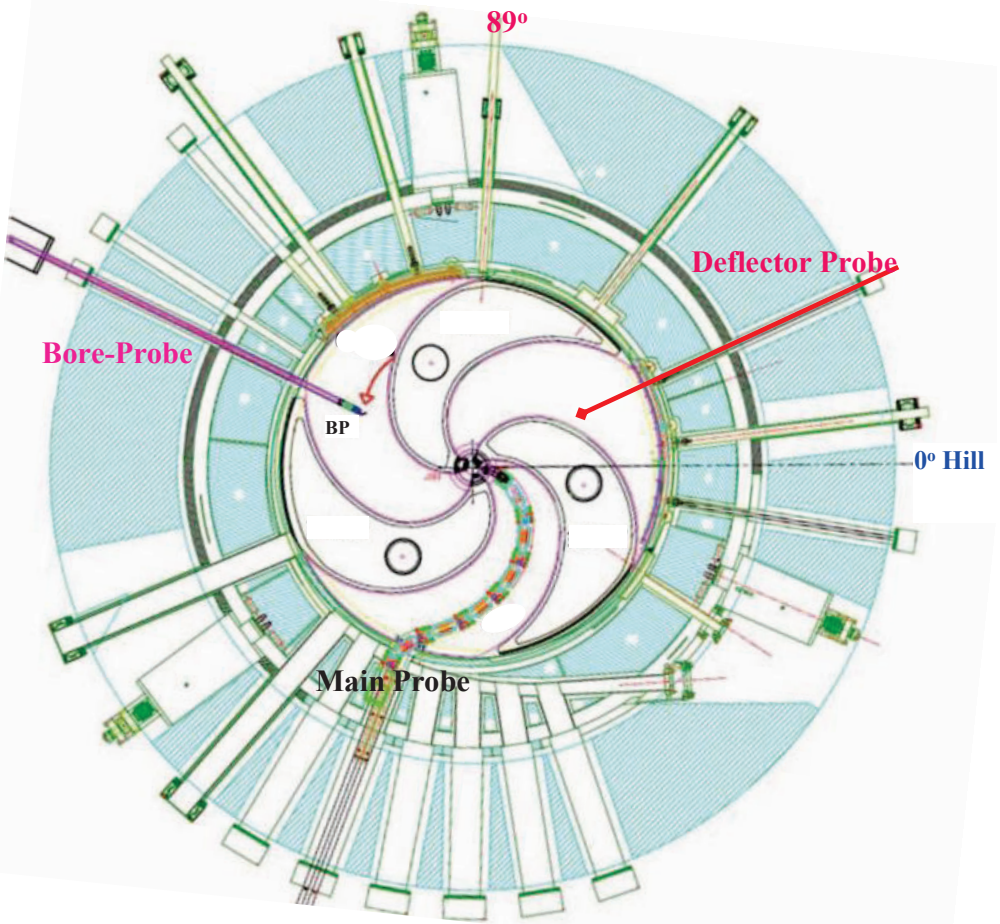


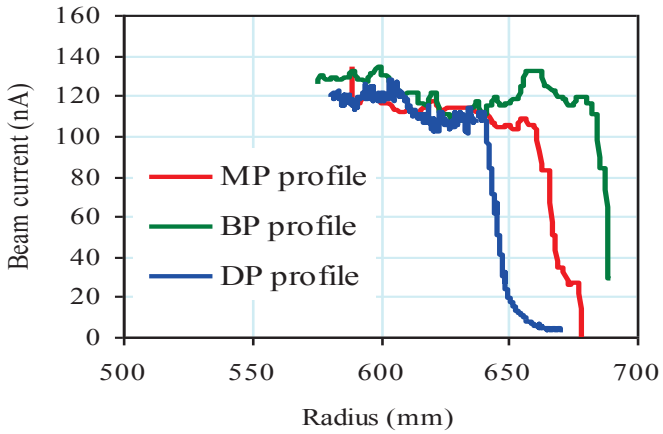
Reference:

S. Som et. Al.," Radio frequency cavity analysis, measurement, and calibration of absolute Dee voltage for K-500 Superconducting cyclotron at VECC, Kolkata" Rev. Sci. Instum 84, 023303 (2013)

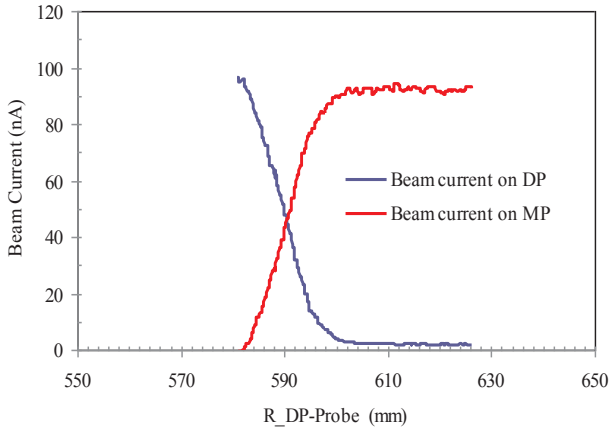
Orbit Off-Centering Measurement by Shadowing Method

Measurement with three probes by shadowing technique

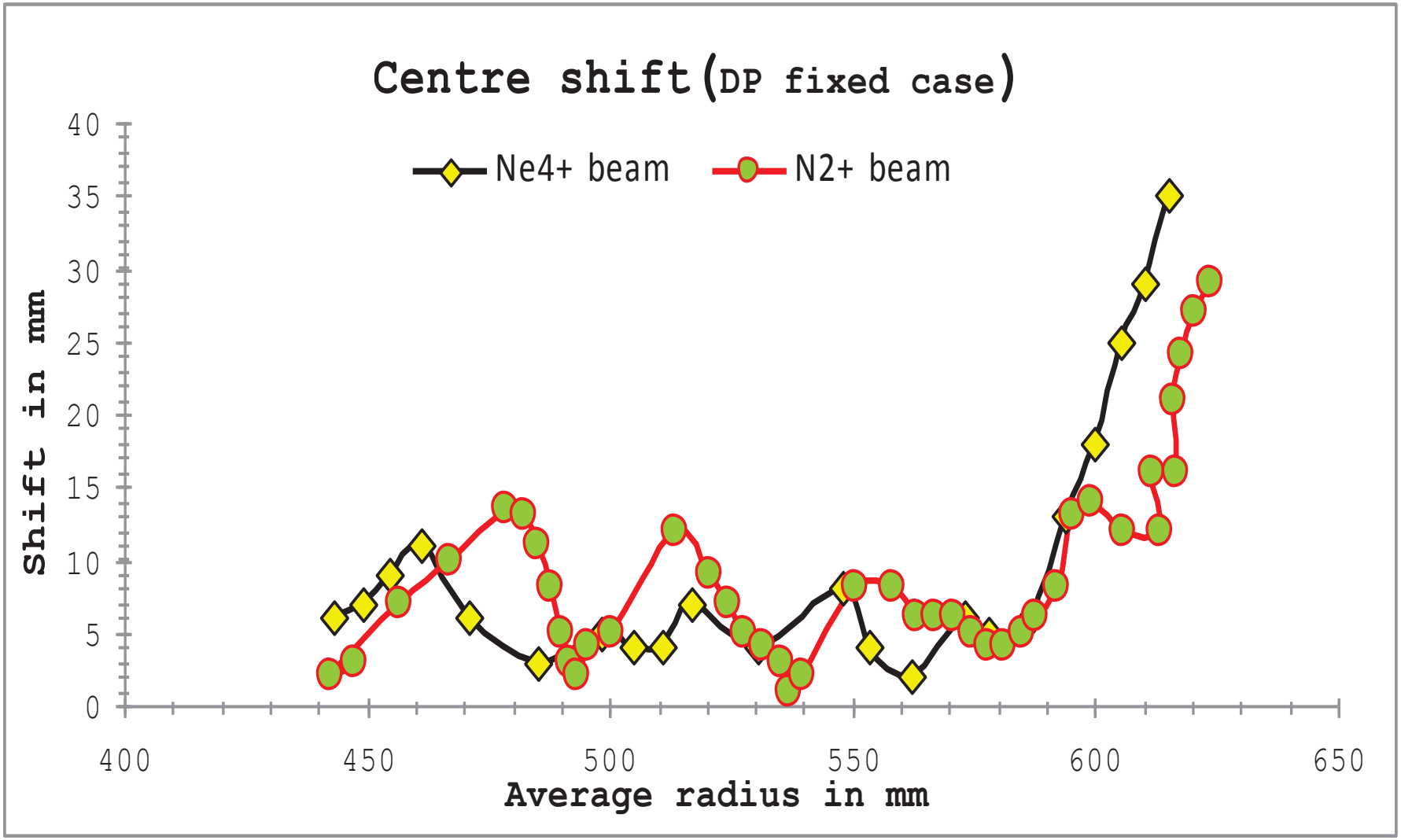




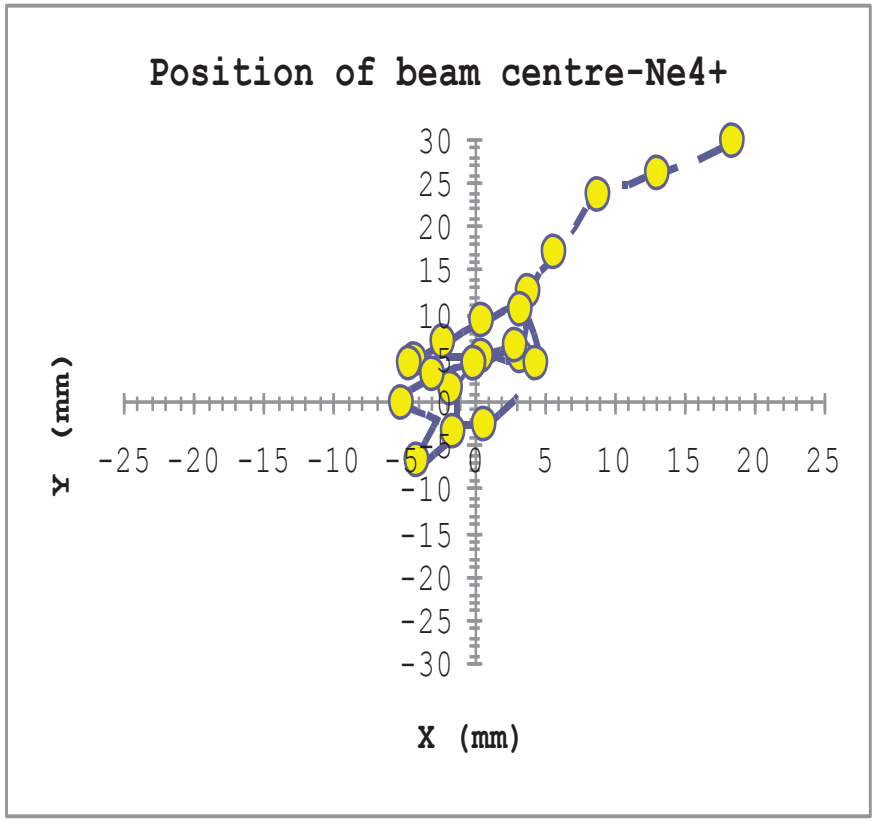
MP is fixed at 600 mm, DP is moving

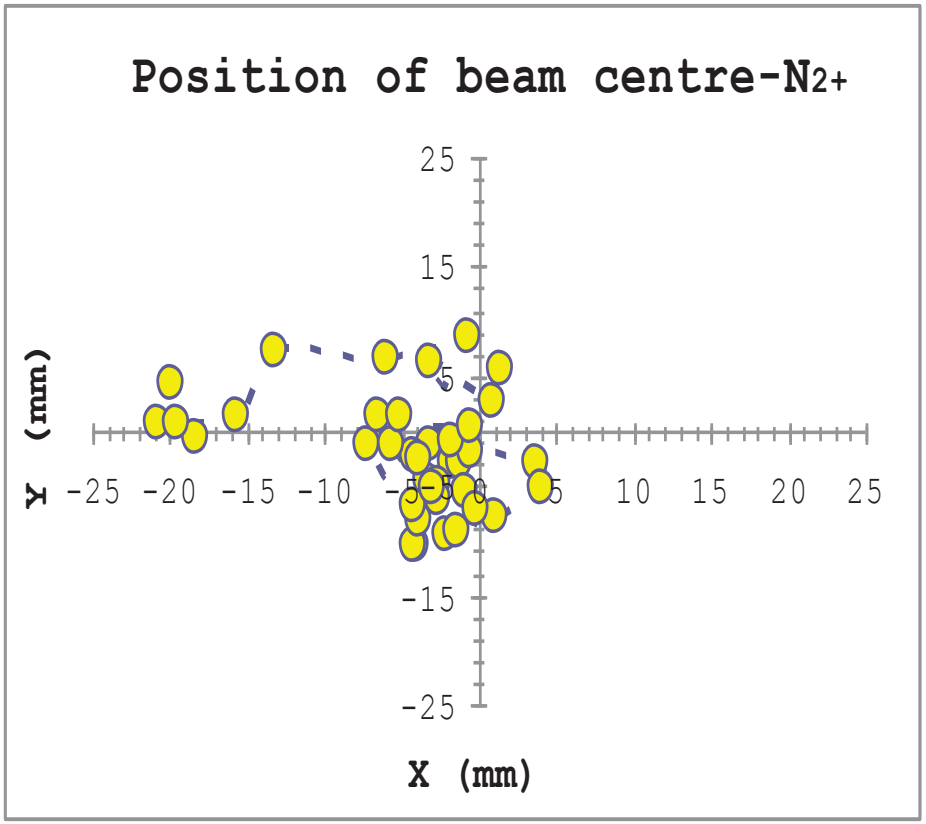


Beam off-centering measurement



Beam off-centering measurement





Beam off-centering measurement

Beam centering measurement with three probes by shadowing technique

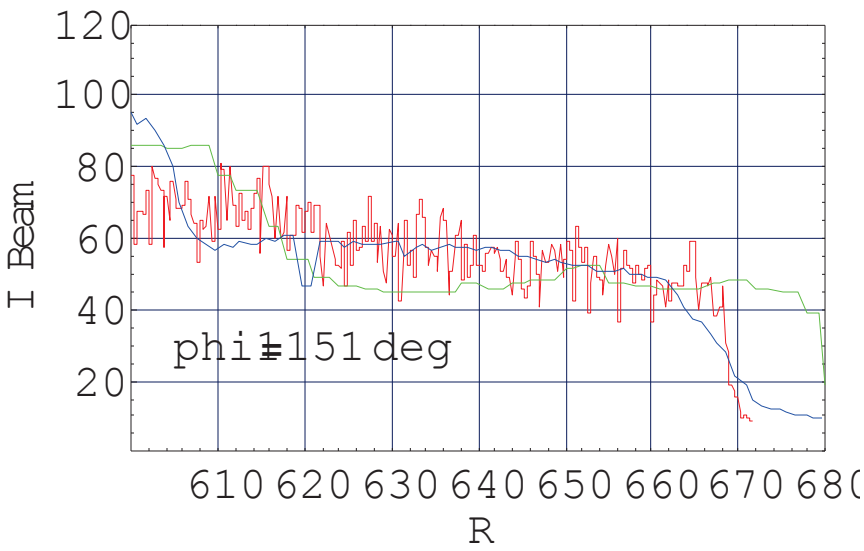
Observation:

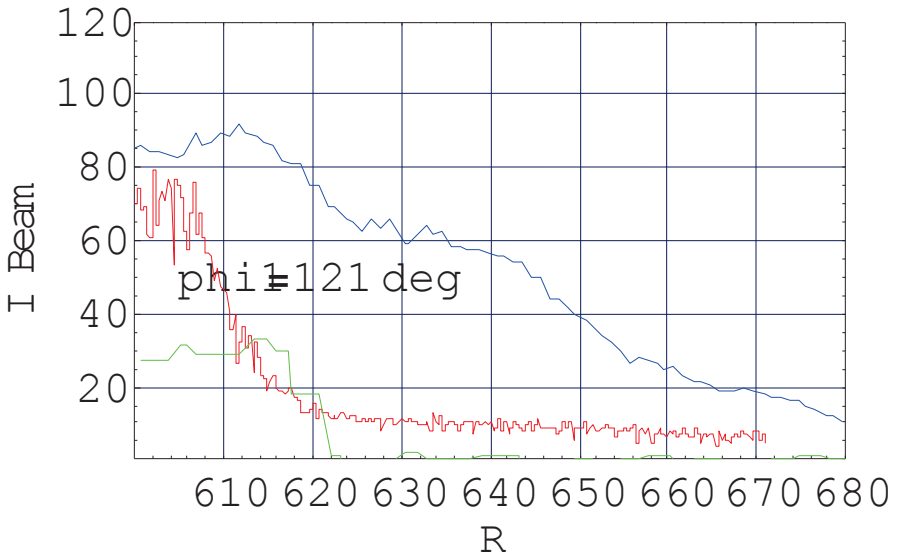
Beam gets off-centered after 600 mm radius Deflector position at 667 mm

Beam off-centering measurement

Beam profile on DP (25°), Bp (154°) and MP with different ϕ_1, b_1 =10 G

Red: DP Green: BP Blue: MP

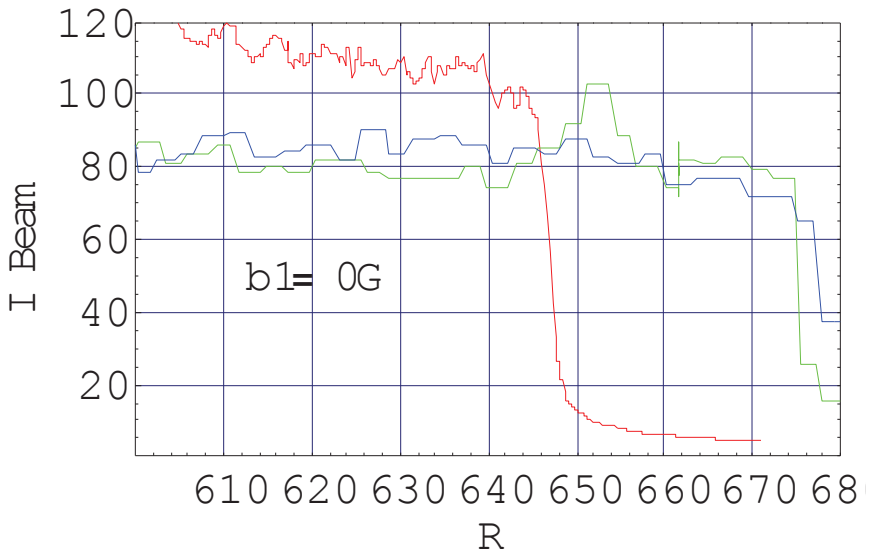


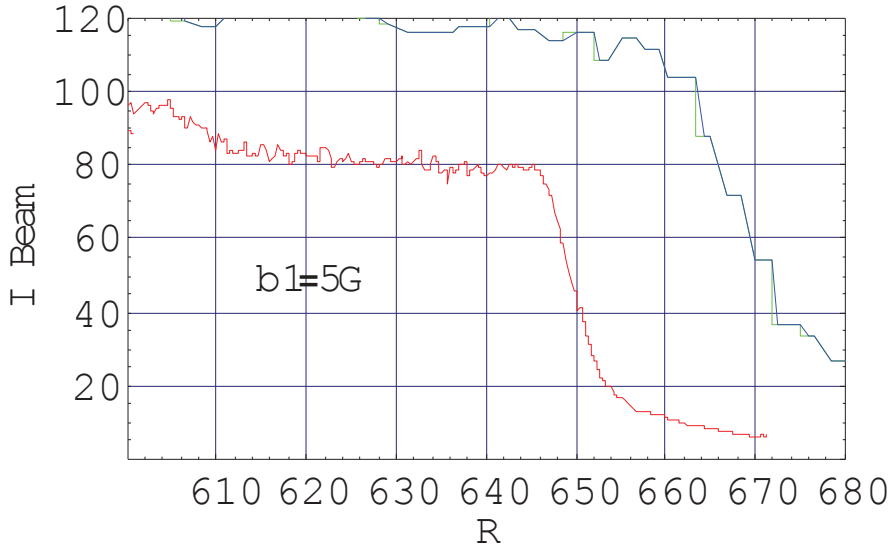


Beam off-centering measurement

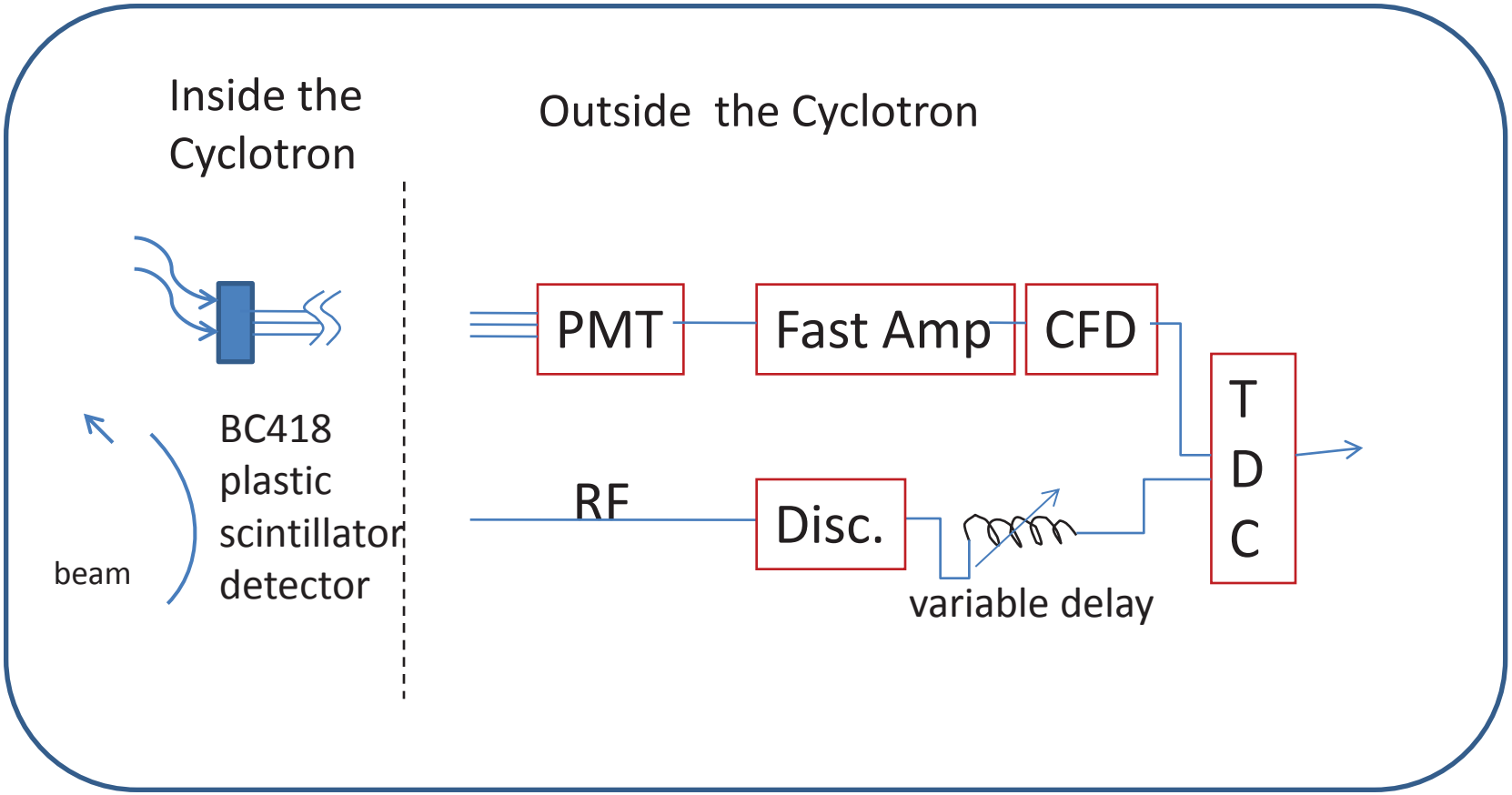
Beam profile on DP (25°), Bp (154°) and MP with different b_1 at ϕ_1=151°

Red: DP Green: BP Blue: MP





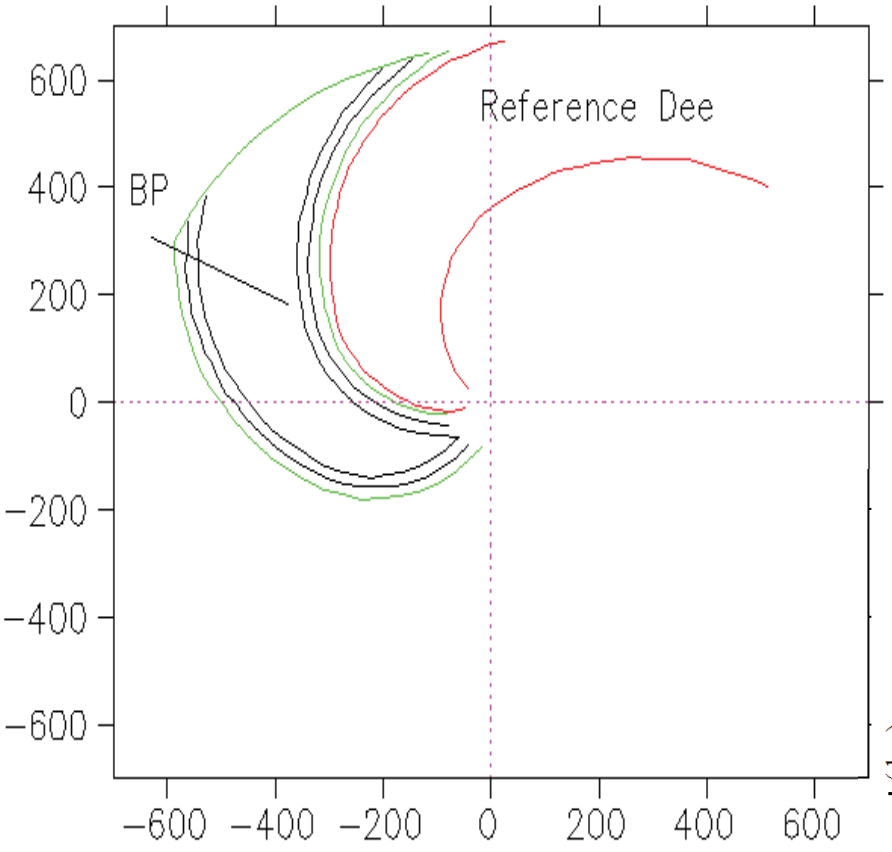
Beam phase measurement using plastic scintillator detector

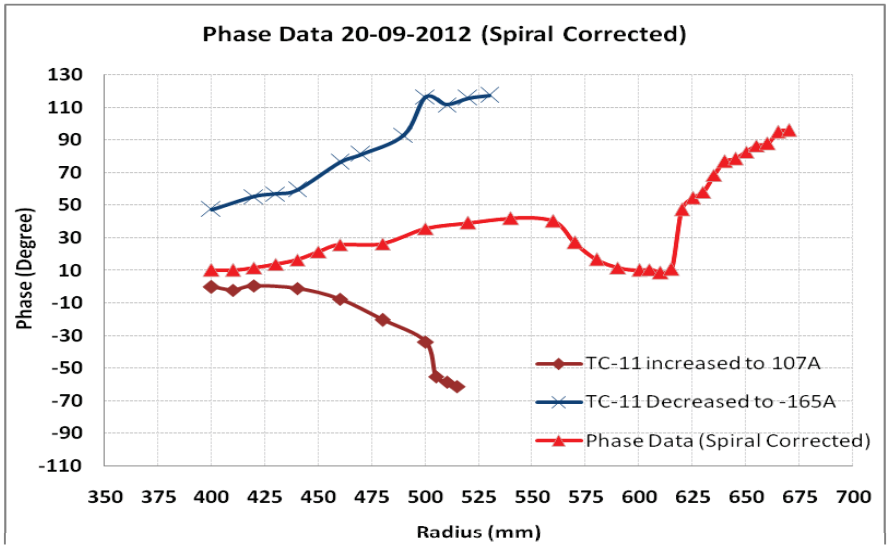


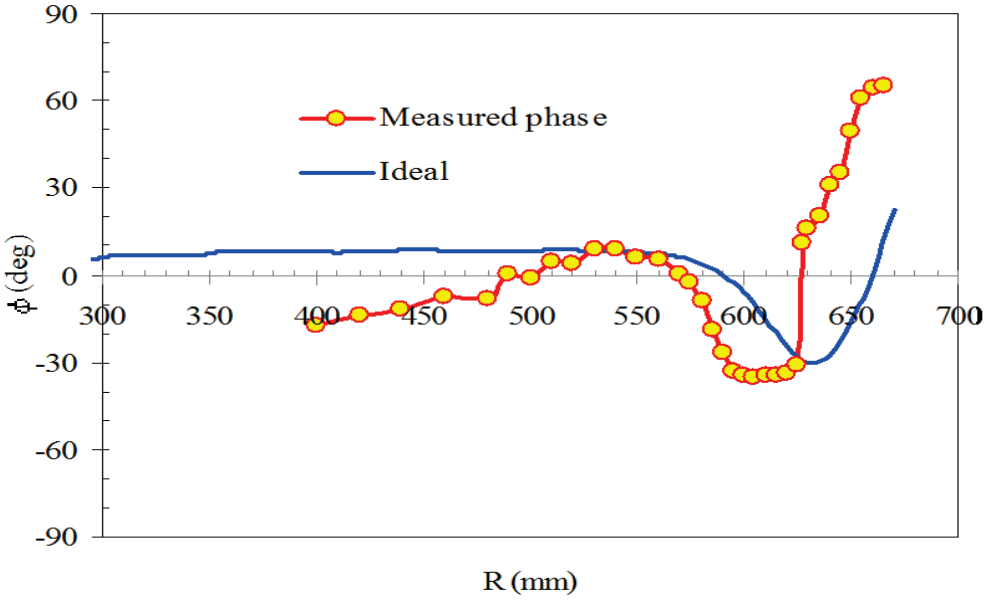
Reference:

T. Bhattacharjee et. Al.," Development of a fast scintillator based beam phase measurement system for compact superconducting cyclotron" Rev. Sci. Instum 84, 053303 (2013)

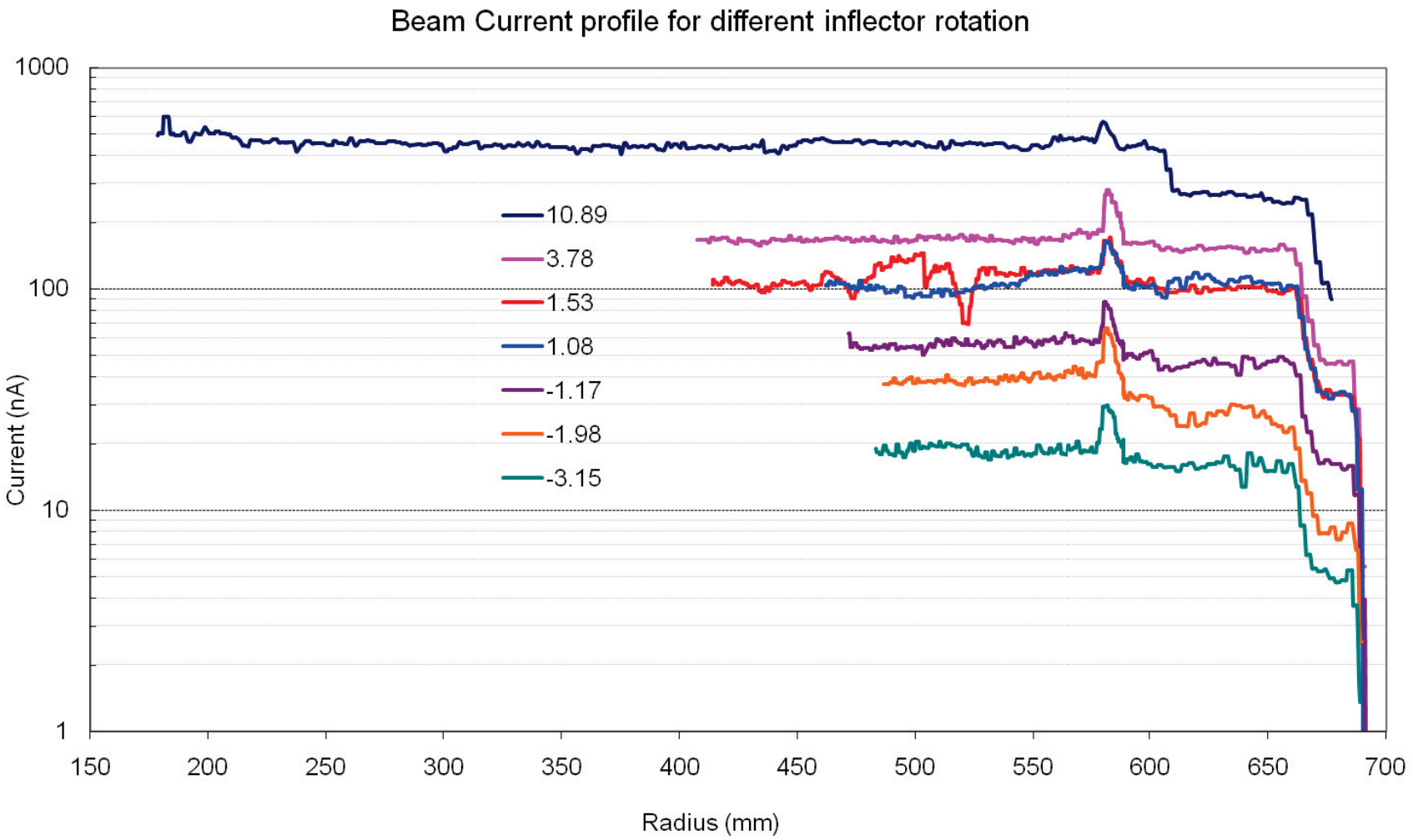
Beam Phase measurement



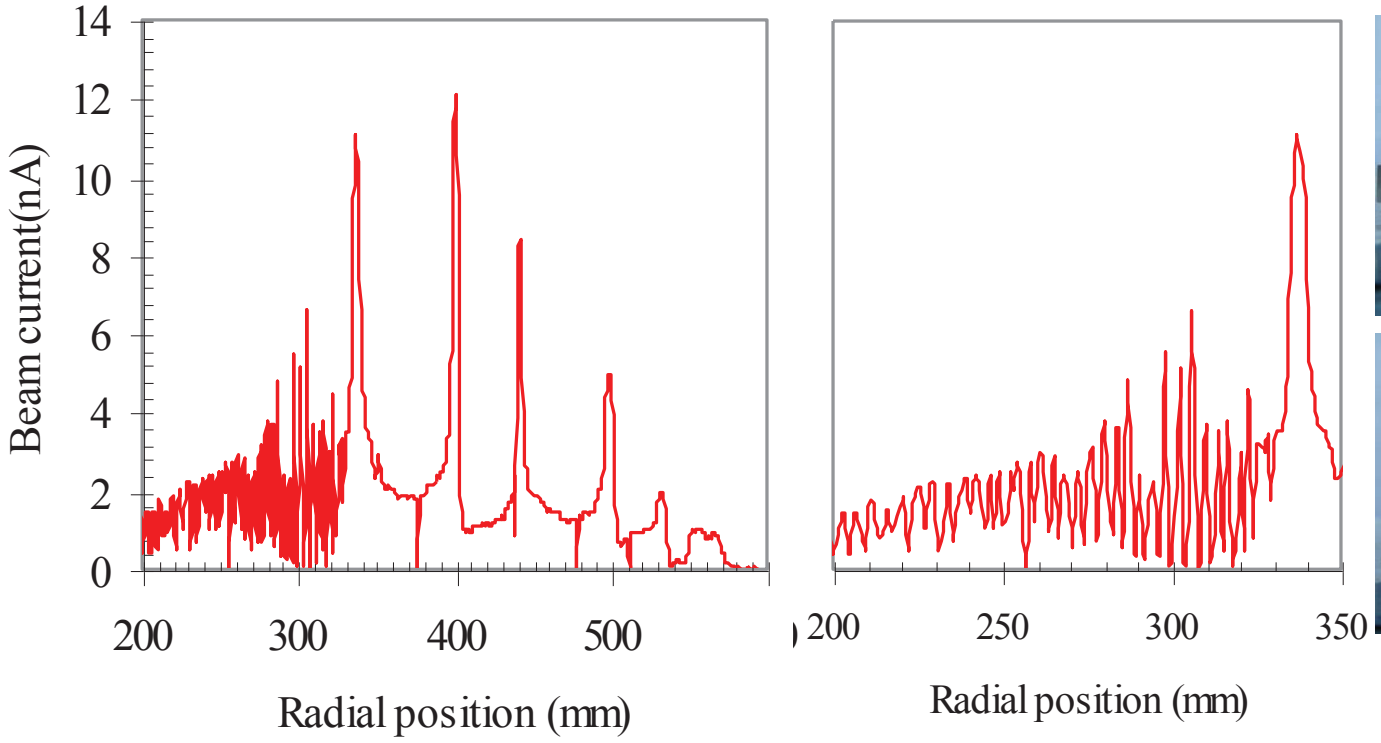


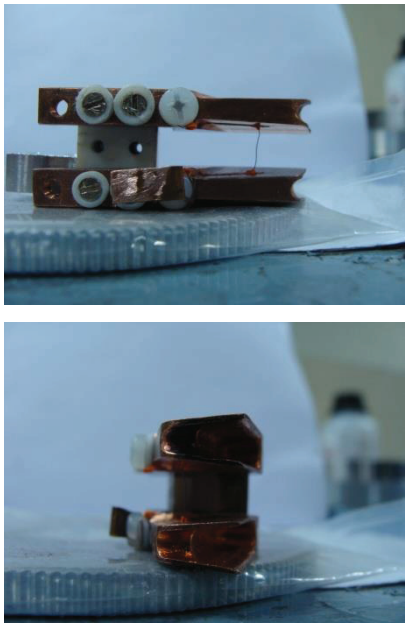


Online Rotation of Inflector



ΔR probe profile





ΔR Probe

Expanded view of ΔR probe current from 150 mm to 350 mm shows the separate turn patterns which is basically a function of energy gain per turn with added effect of orbit centering etc.

Field Re-mapping: Search coil calibration

Ne4+, 19 MHz, h=2 Operation. Ia/Ib=448.9/281.09 A
Exploration for the 2nd NMR location (for Locking) for search coil calibration:

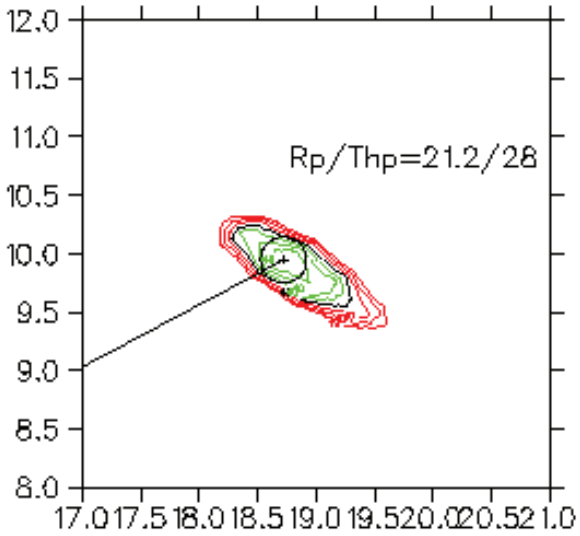


Fig1. Ia/Ib=448.9/281.09 A
1G different contours at the Hill-Centre

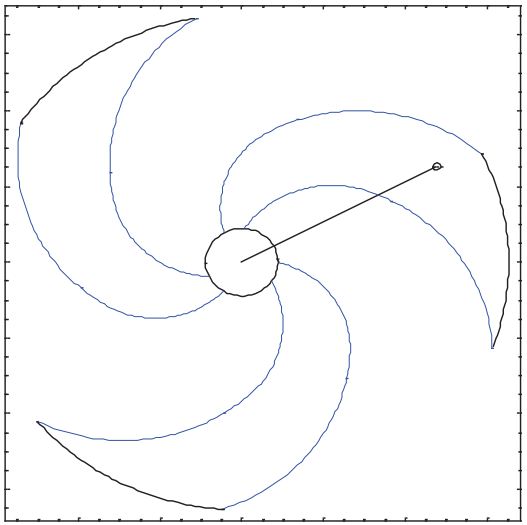
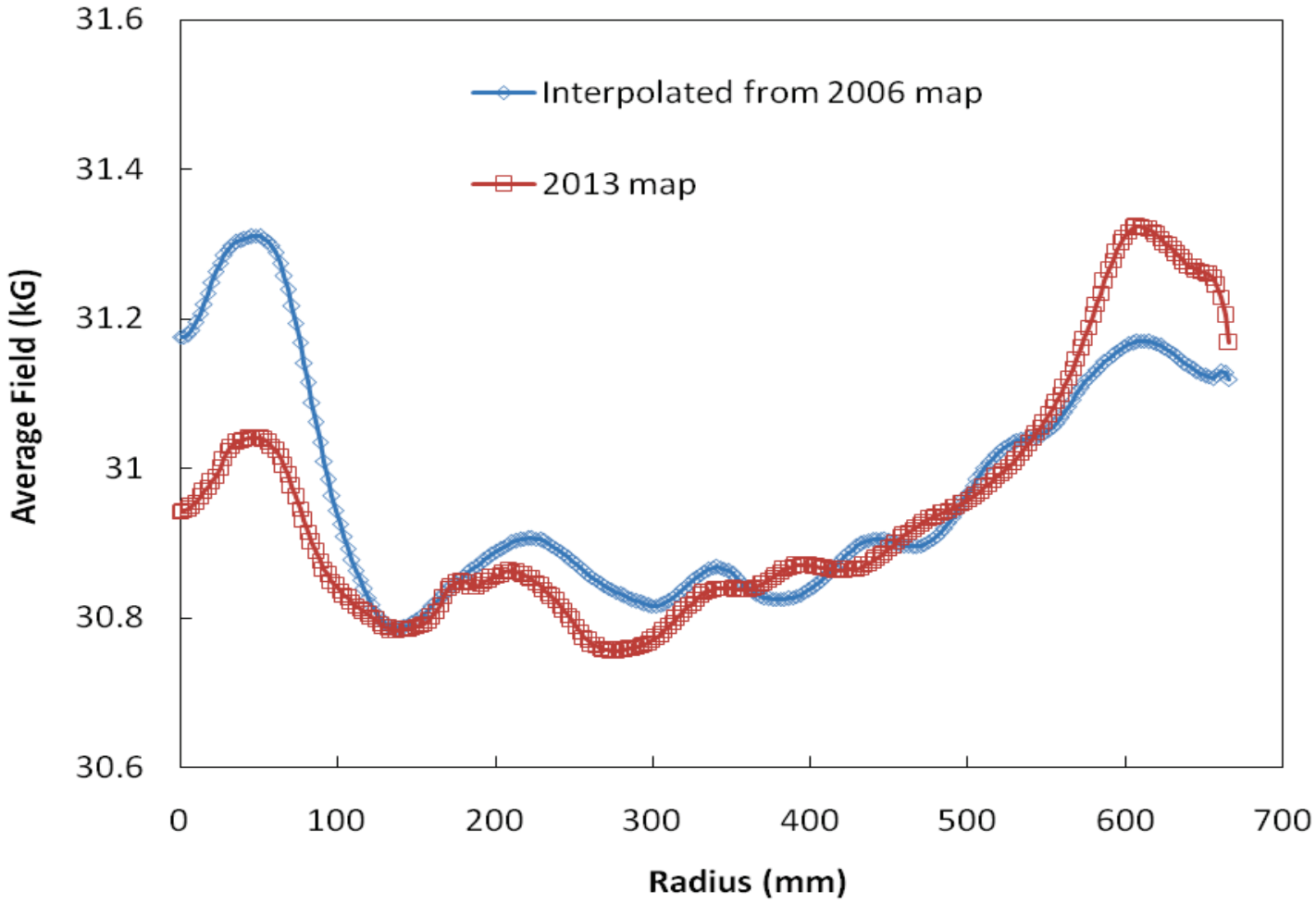


Fig2. NMR position on the Sector-C

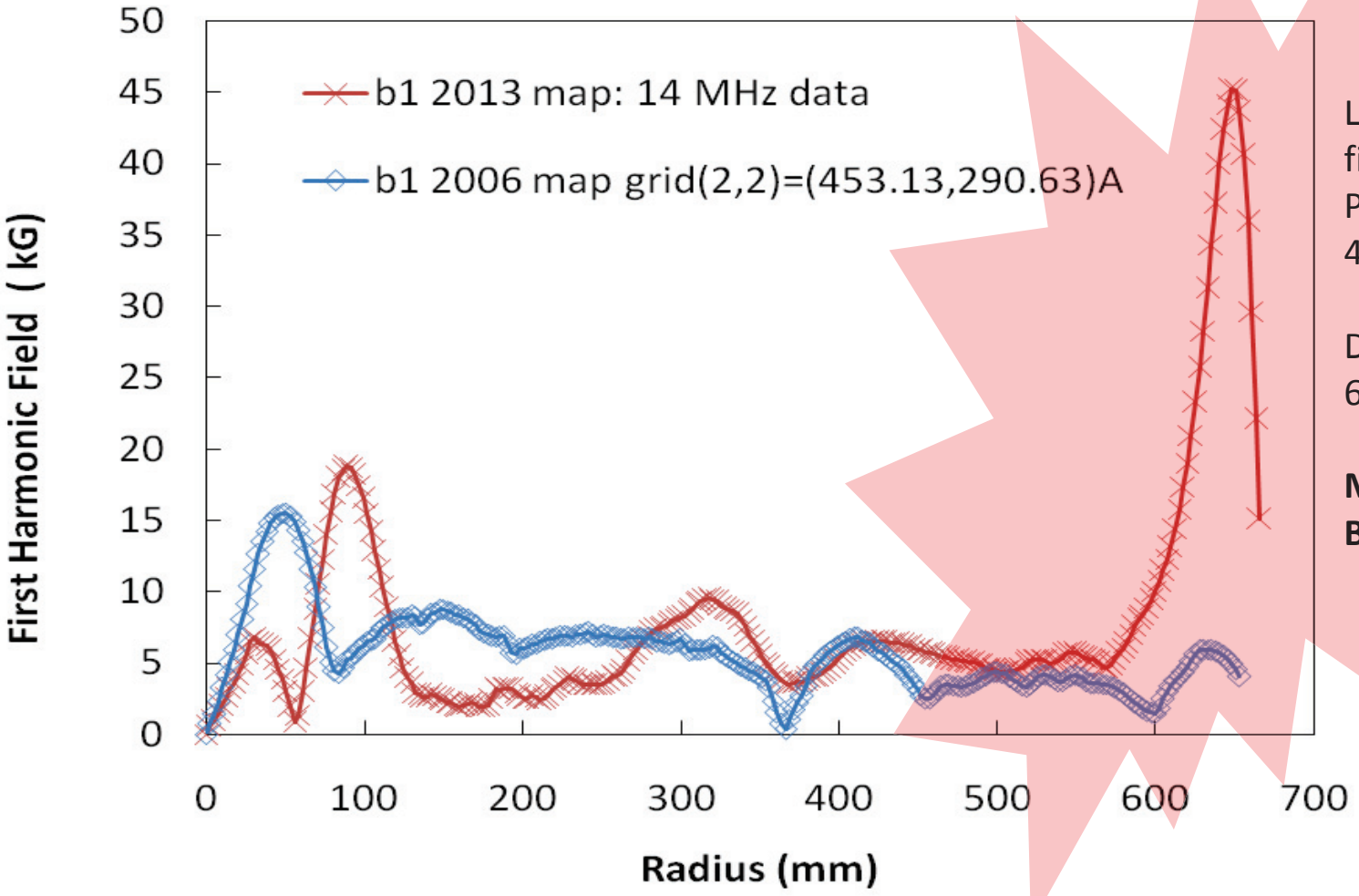
Average magnetic Field

Ne^{4+} in 2nd harmonic mode of operation at RF frequency 19 MHz



Coil	Current (A)
I_alpha	448.9
I_beta	281.09
TC-0	-133.33
TC-1	162
TC-2	-56.6
TC-3	0
TC-4	41.3
TC-5	-19
TC-6	-192.3
TC-7	0
TC-8	-54.6
TC-9	116
TC-10	0
TC-11	168.3
TC-12	151.9
TC-13	195.8

1st harmonic field:

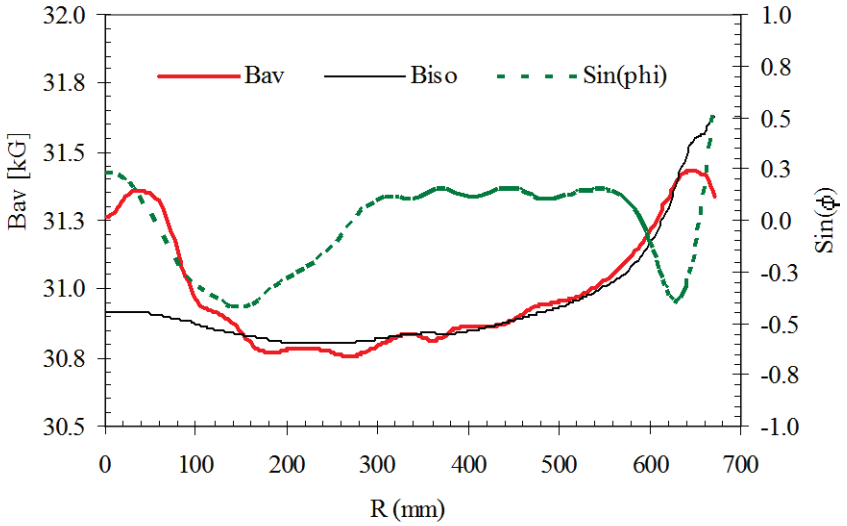


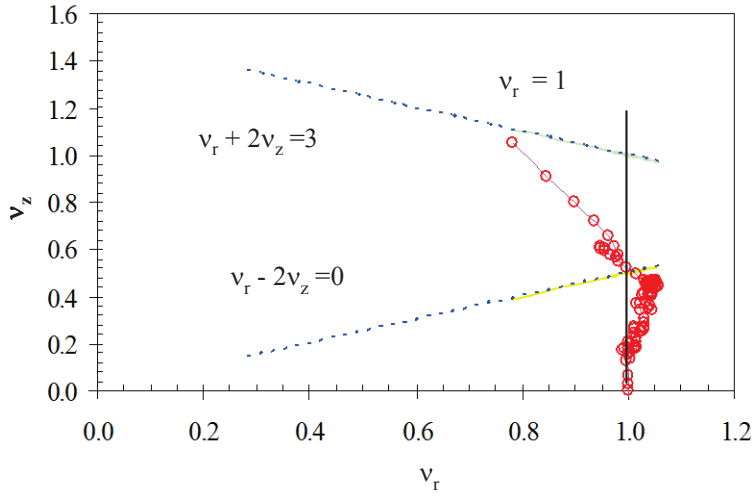
Large first harmonic field from 610 mm. Peaks at 650 mm, 45 Gauss !!!

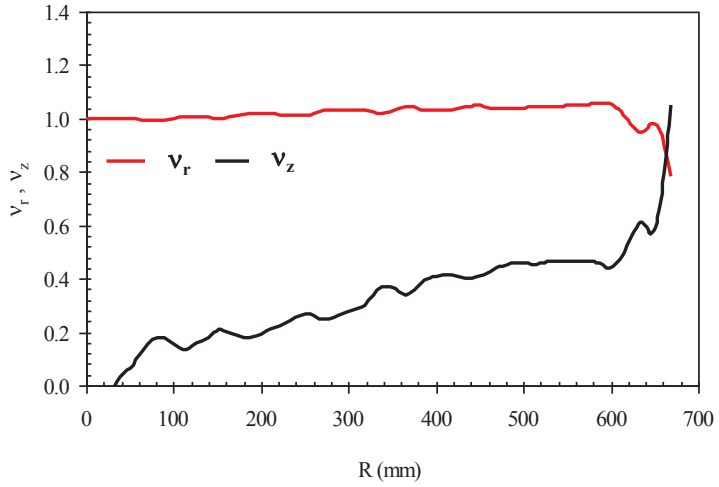
Deflector position is 667 mm

MAIN HURDLE FOR BEAM EXTRACTION

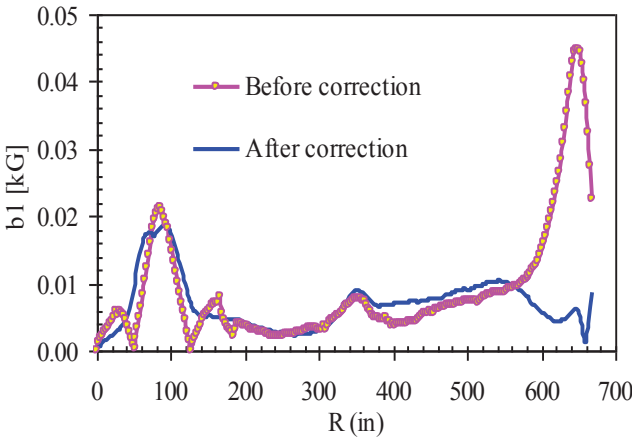
Beam off-centering simulations:

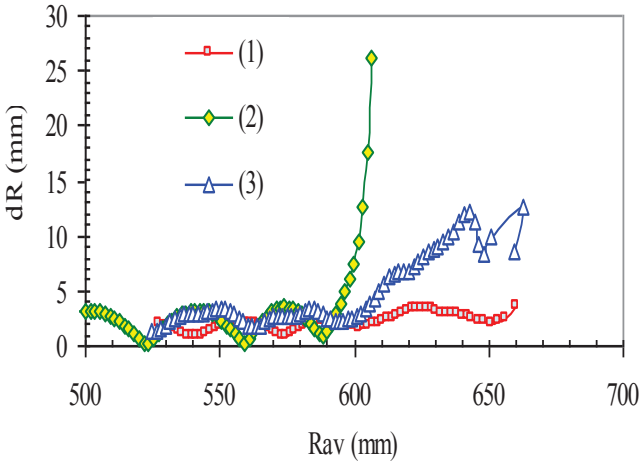


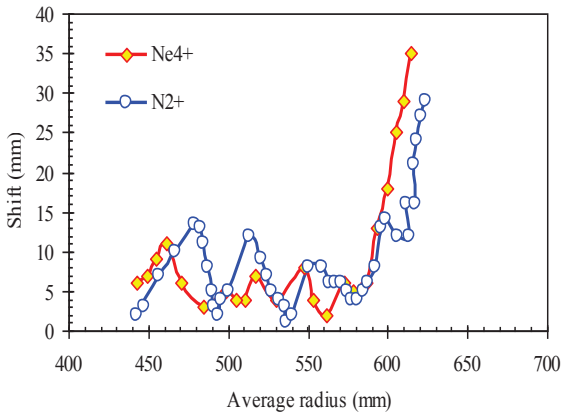


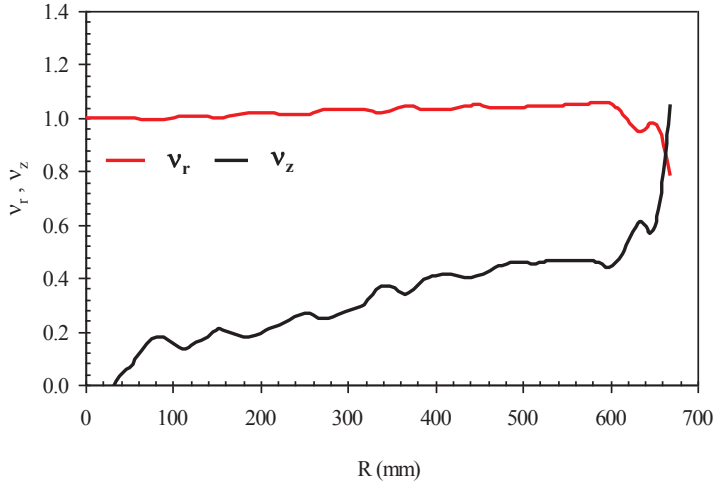


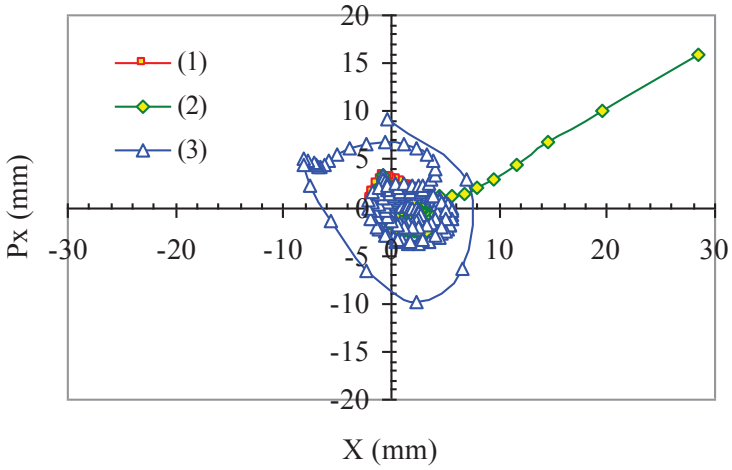
Beam off-centering simulations:



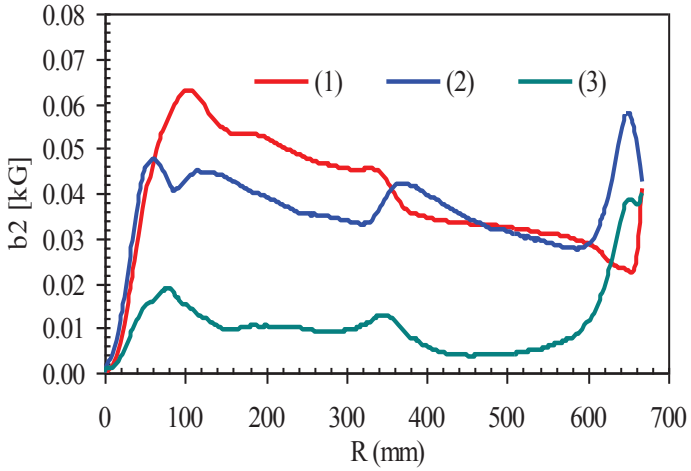


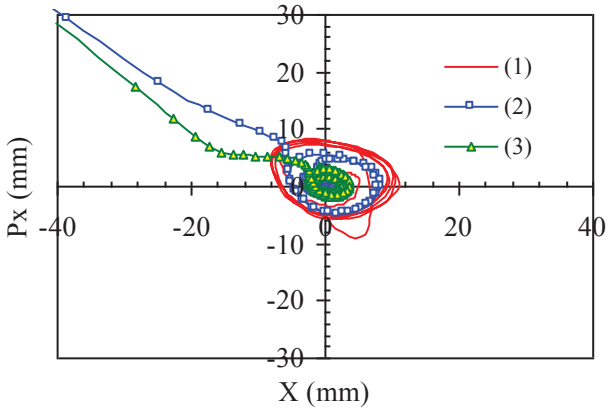


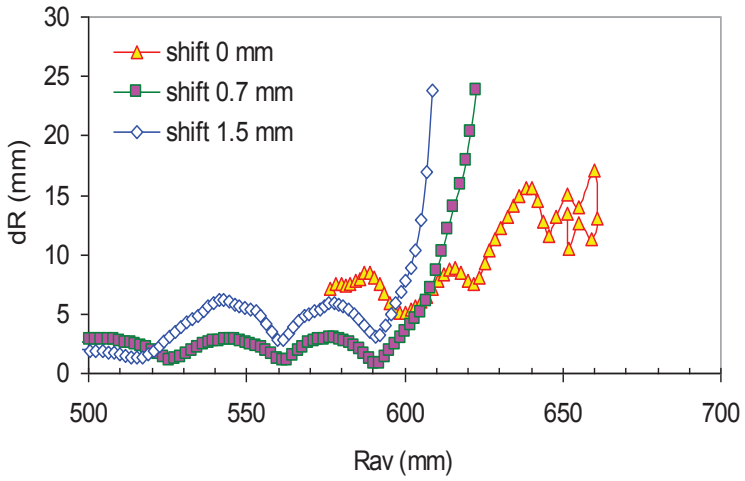


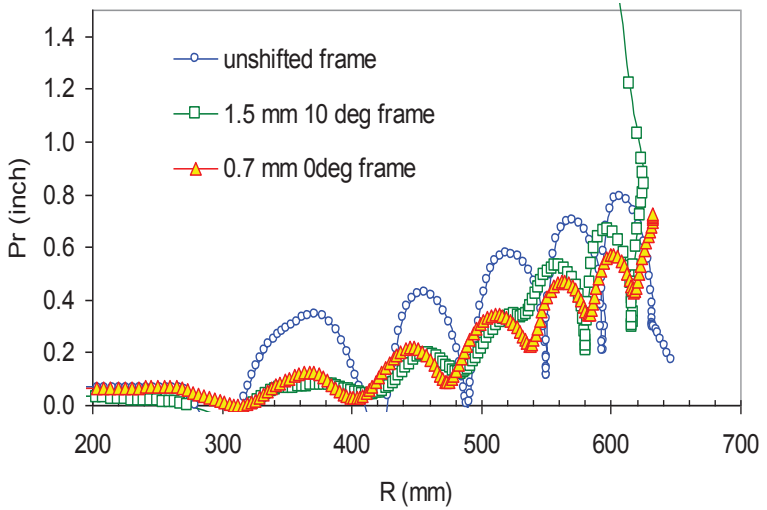


Beam off-centering simulations:

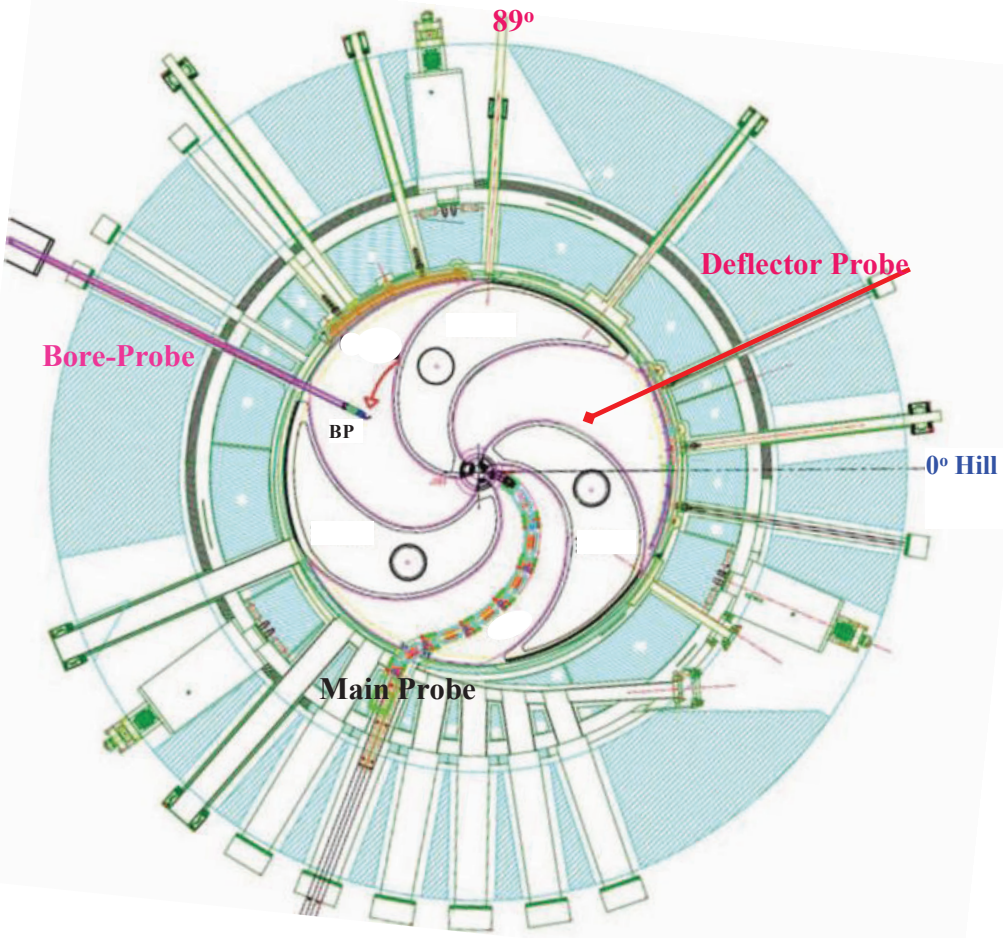


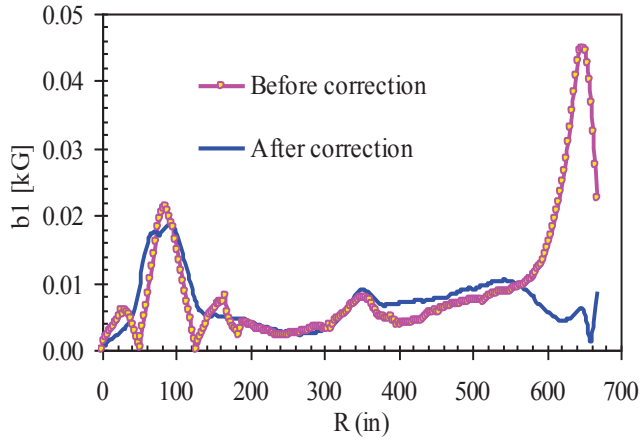


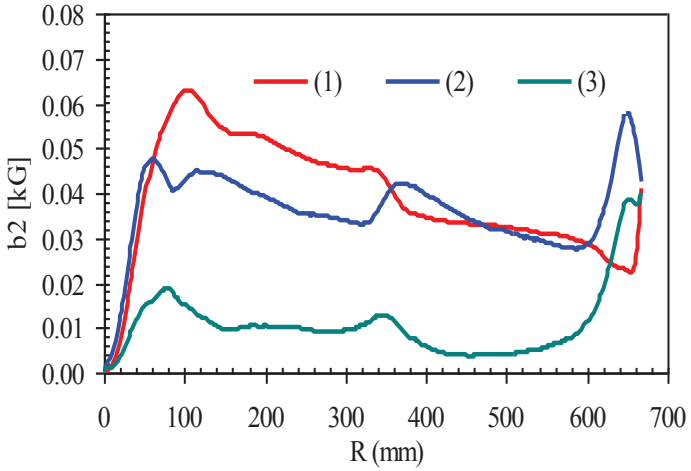




Shimming







The Machine is ready for Beam Trial, We are starting Beam Tuning

Thank You