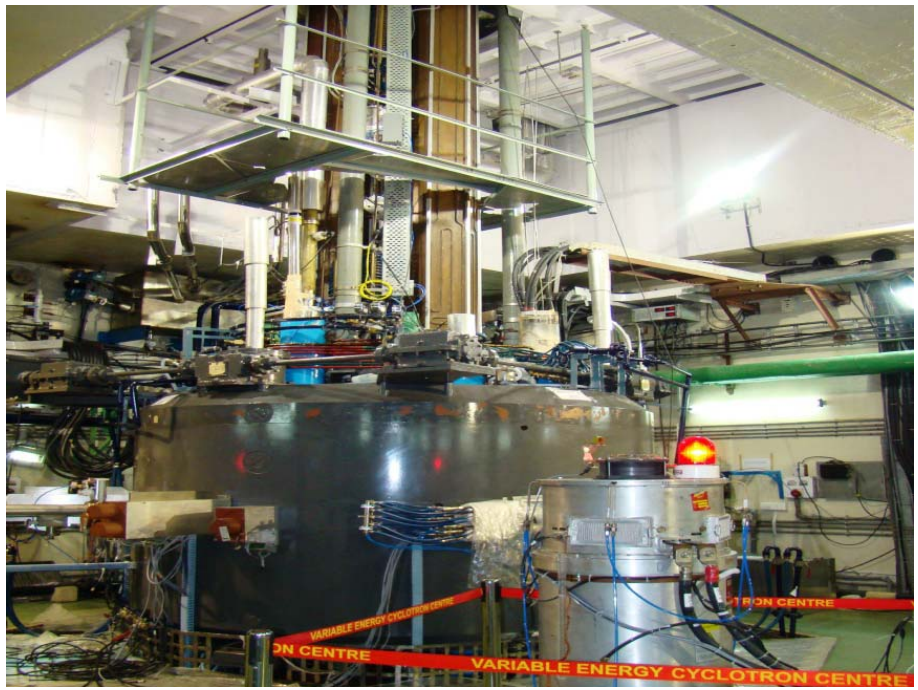
FIRST BEAM ACCELERATION IN KOLKATA SUPERCONDUCTING CYCLOTRON AND ITS PRESENT STATUS

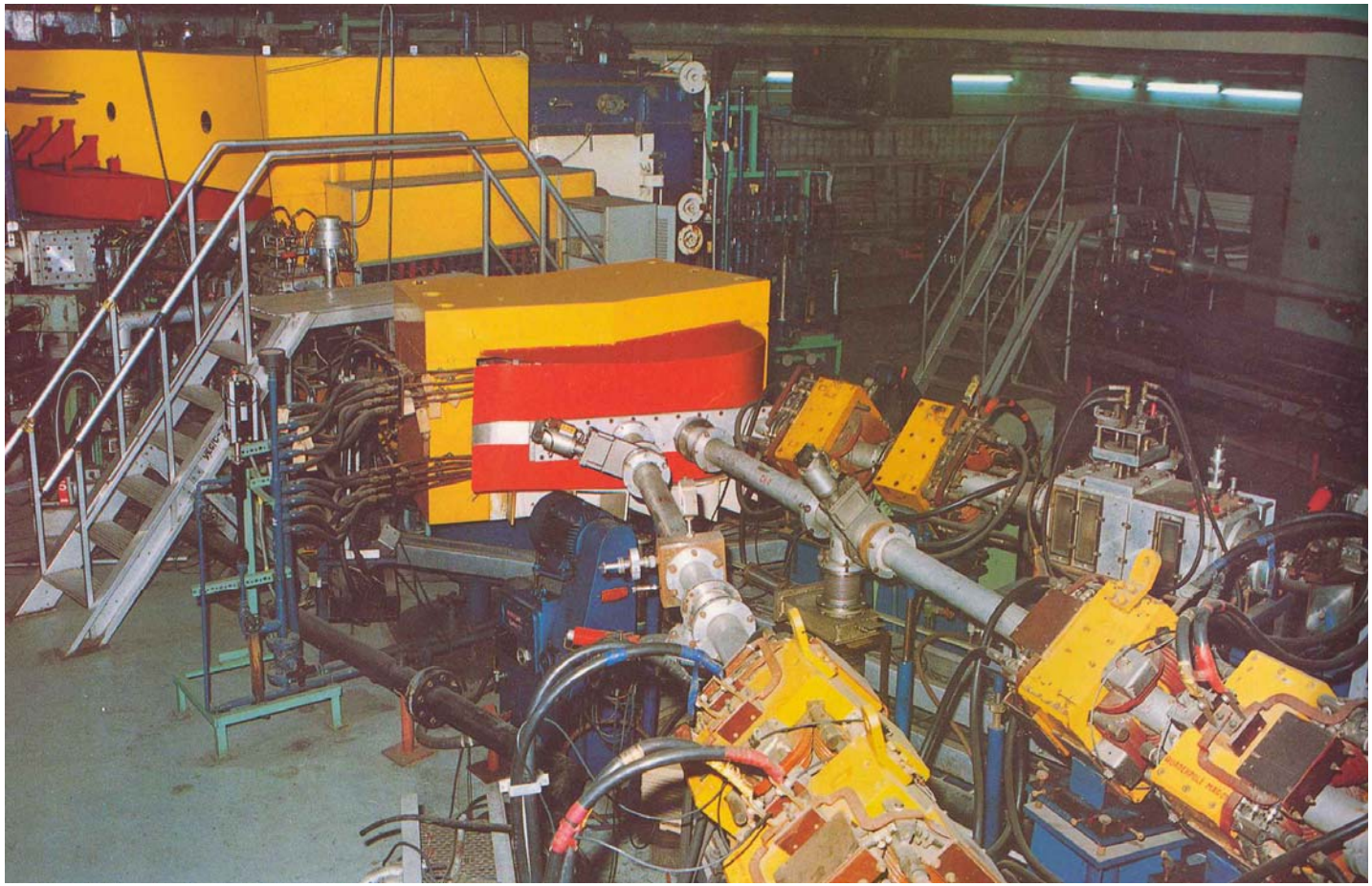
C MALLIK

On behalf of VECC staff

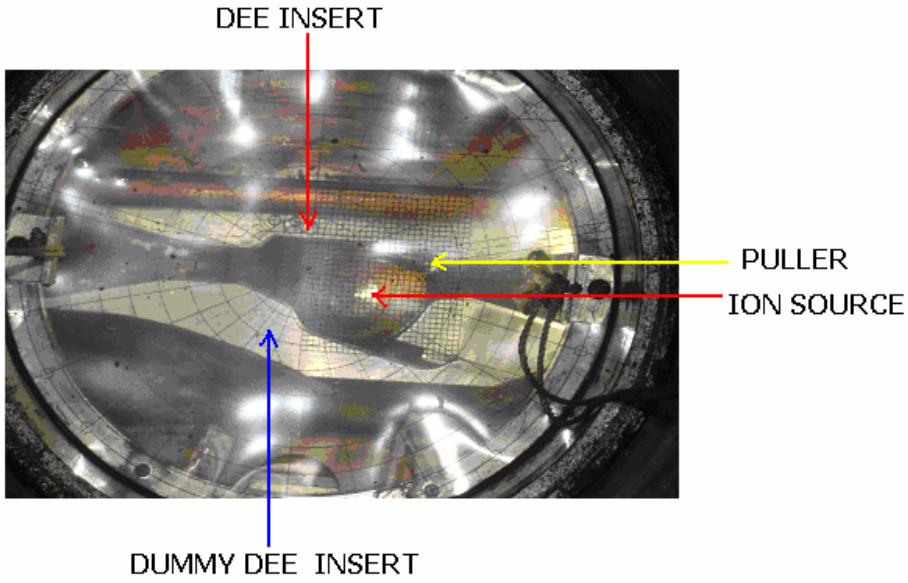
Variable Energy Cyclotron Centre
Kolkata, India



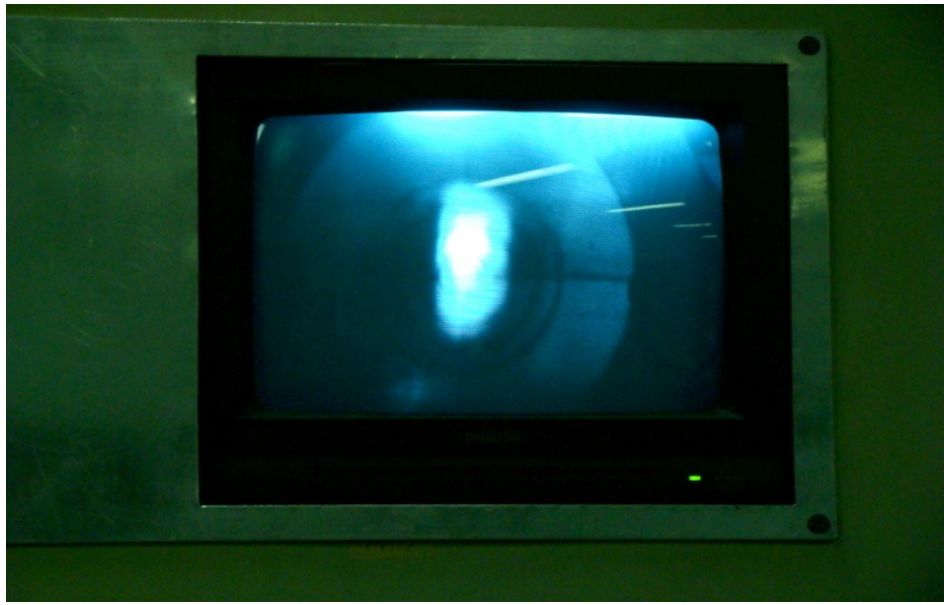
CYCLOTRONS 2010, LANZHOU



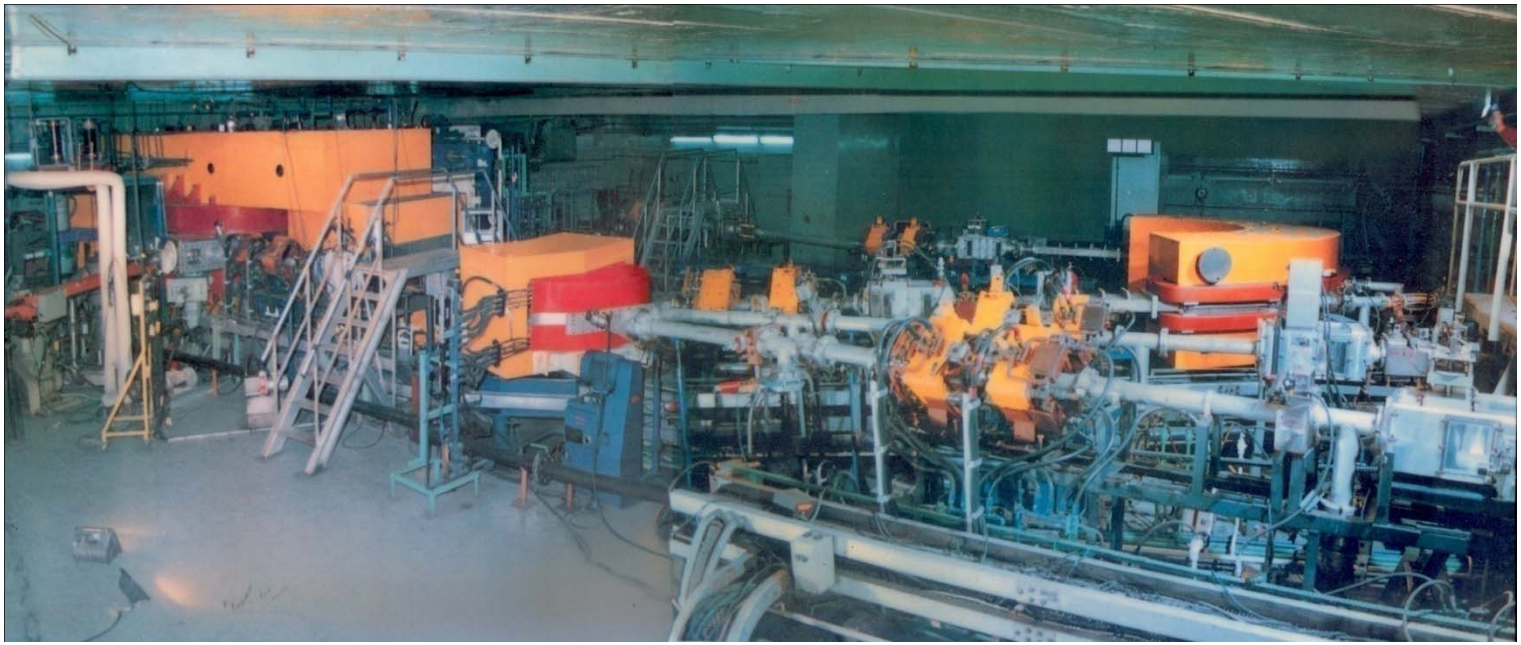
1978-1996	**Alpha, proton, deuteron**
1996-2007	**Light Heavy Ions (m<40)**
2007-09	**Modernisation of subsystems**
Dec 2009	**Recommissioning Starts**

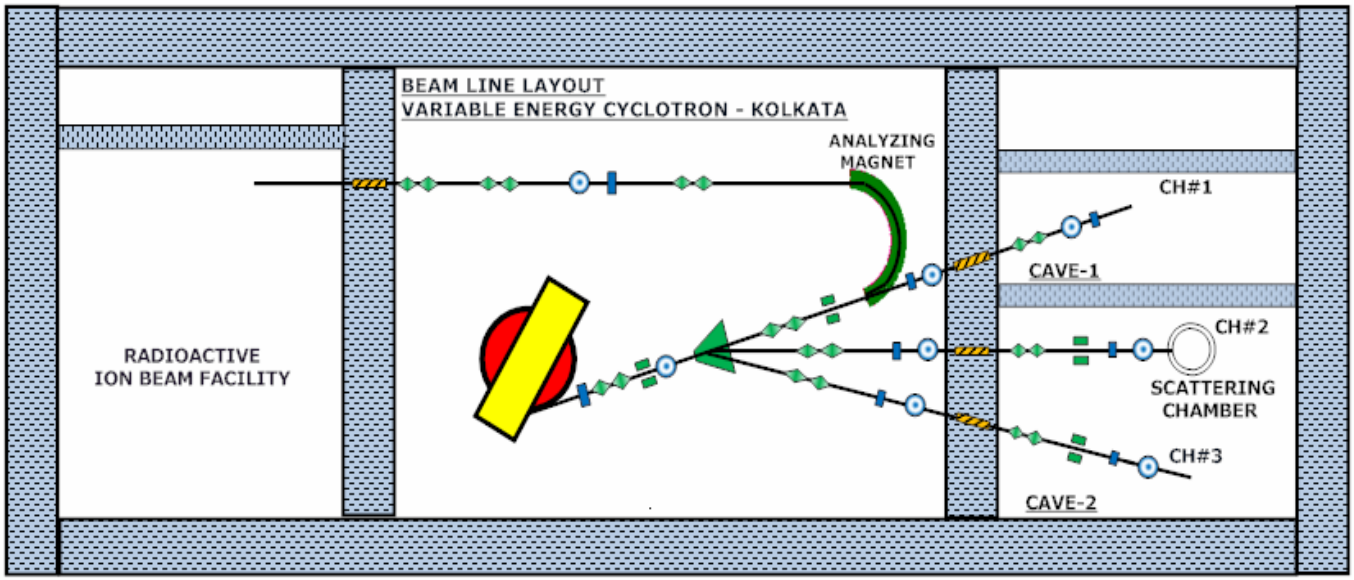


First alpha beam after re-commissioning (Jan 2010)



224cm Cyclotron Used as Feeder for Radioactive Ion Beam Facility





MID-2007 TO JUNE-2009

INTEGRATION OF DIFFERENT SUBSYSTEMS

- RADIOFREQUENCY SYSTEM
- 14 GHz ECR ION SOURCE
- INJECTION LINE
- RF POWER DRIVER
- BEAM DIAGNOSTICS SYSTEM
- BEAM CHAMBER VACUUM
- SUPERVISORY CONTROL SYSTEM
- SAFETY SYSTEM

RF CONDITIONING

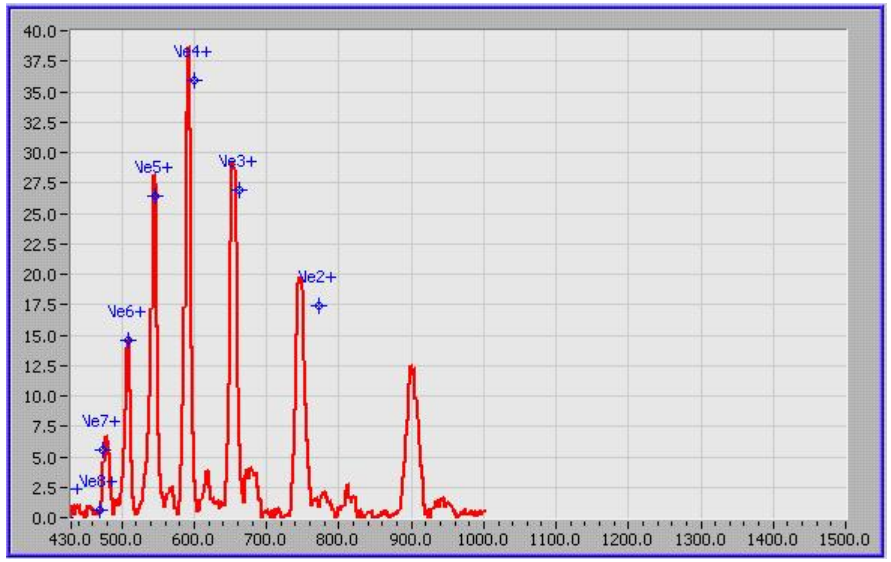
Cyclotron with RF assembly

Control Room

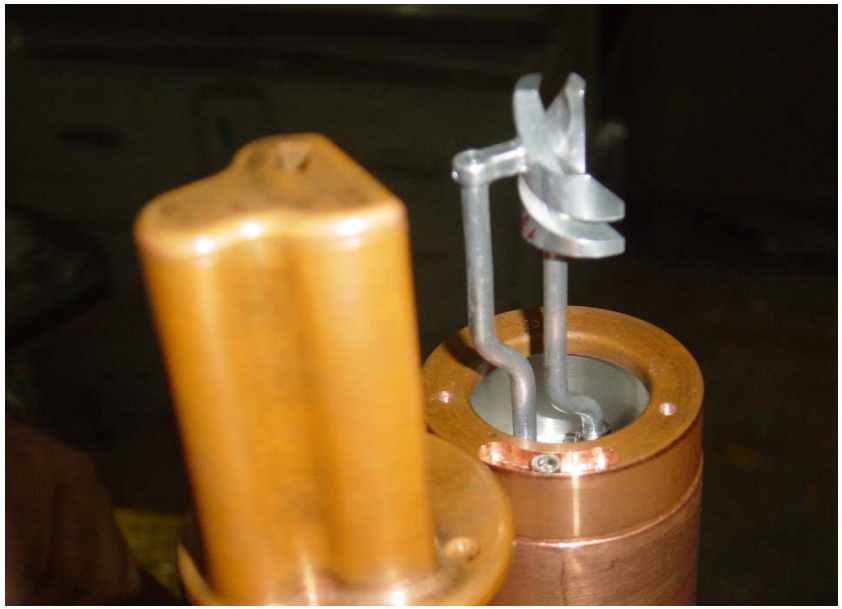
14 GHz ECR Ion source for Superconducting cyclotron

BEAM INJECTION FROM TOP OF THE CYCLOTRON

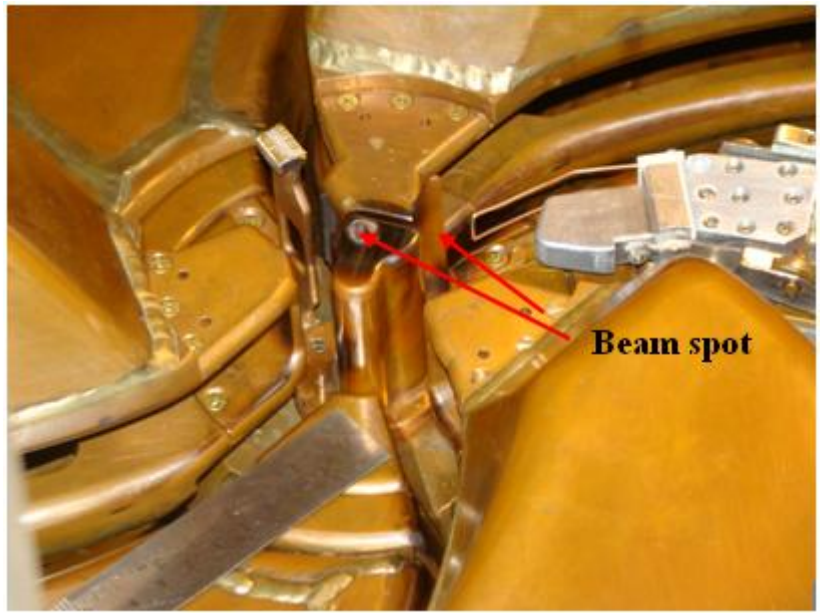
ECR and Injection beam line



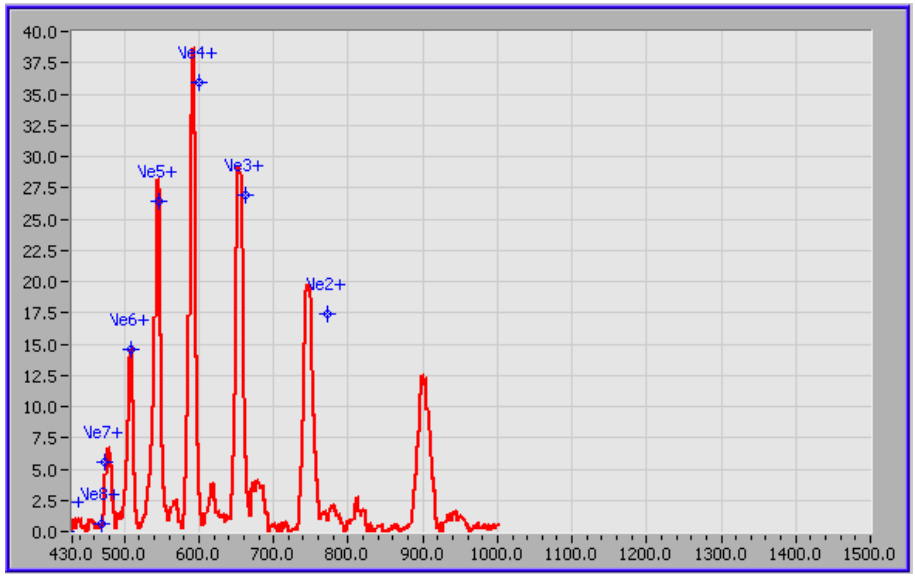
Various charge states of Neon from ECR

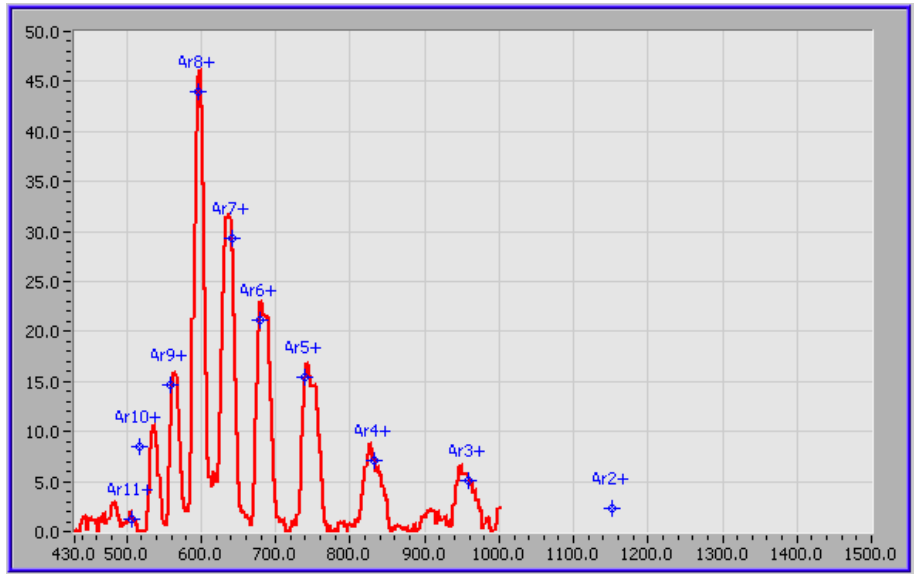


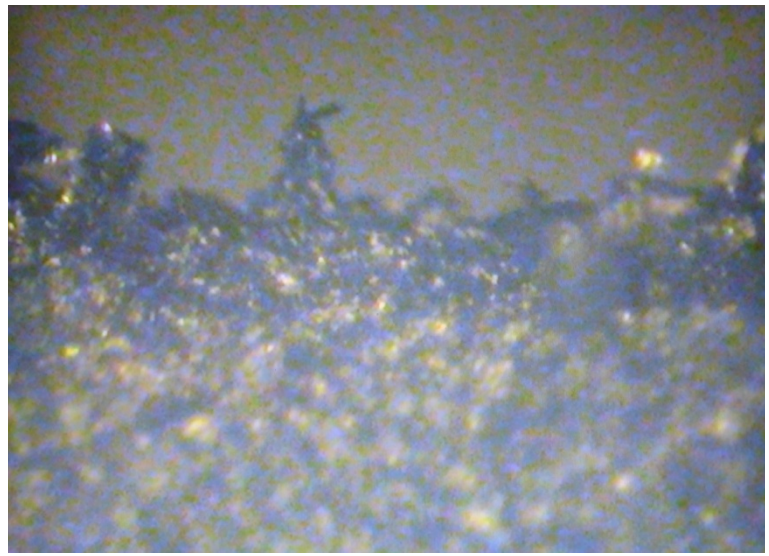
Spiral Inflector and its housing

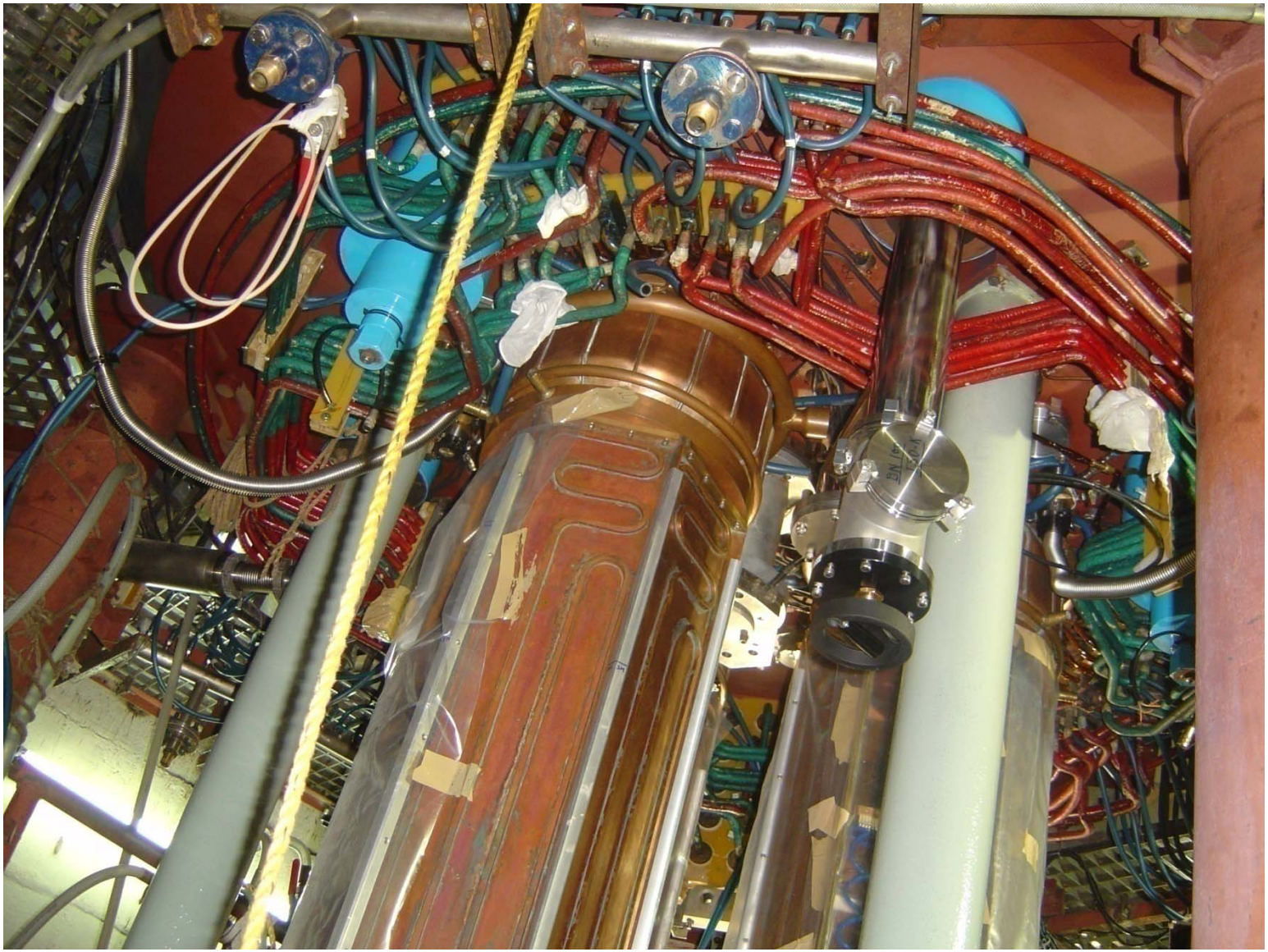


Beam mark on inflector cover

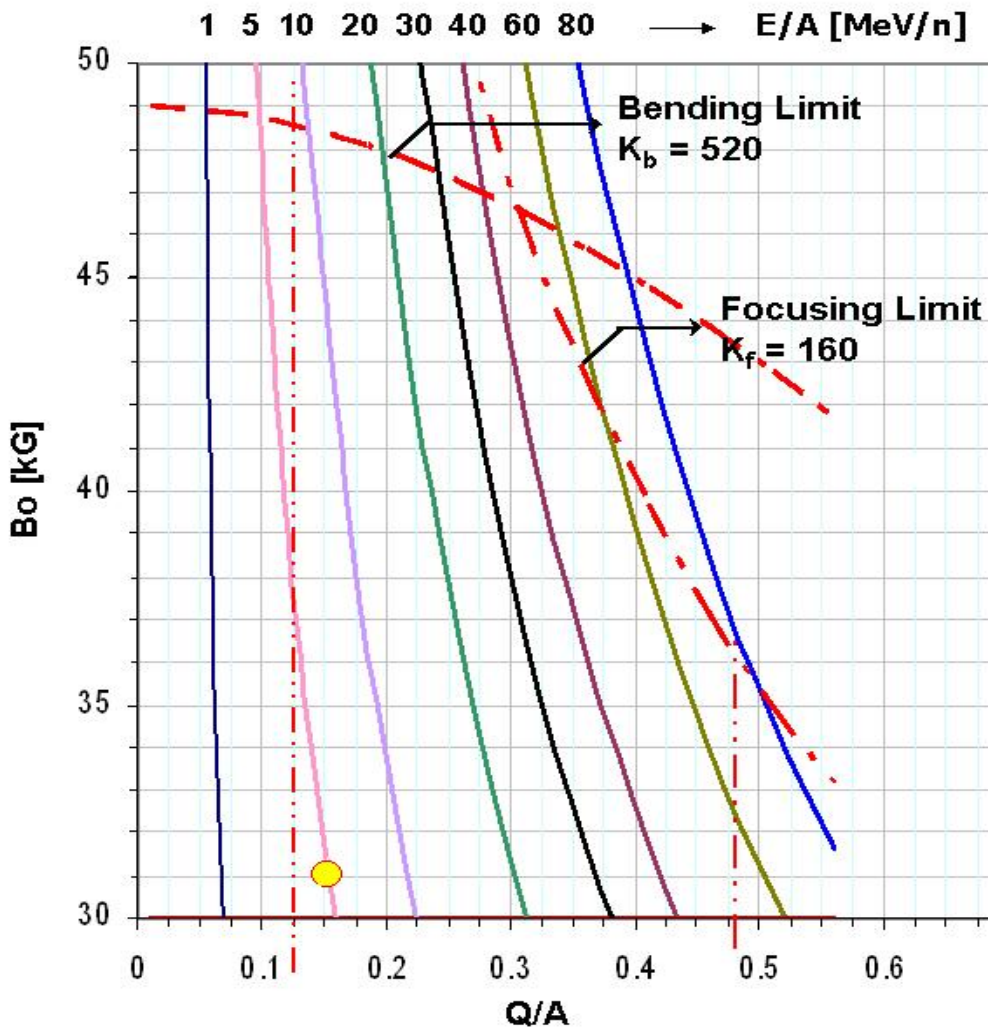

Ne4+
Ne5+
Ne3+
Ne6+
Ne2+
Ne7+
Ne8+
40.0
37.5
35.0
32.5
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
430.0 500.0 600.0 700.0 800.0 900.0 1000.0 1100.0 1200.0 1300.0 1400.0 1500.0


Ar8+
Ar7+
Ar6+
Ar9+
Ar5+
Ar10+
Ar4+
Ar3+
Ar11+
Ar2+
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
430.0 500.0 600.0 700.0 800.0 900.0 1000.0 1100.0 1200.0 1300.0 1400.0 1500.0





Lower RF cavity assembly showing the
outer conductor spinning, hexagonal panels, trim coil leads, etc.



Ion Ne 3+,

Q/A = 0.1487,

V_{ECR}=4.408 kV,

T=4.44 MeV/u,

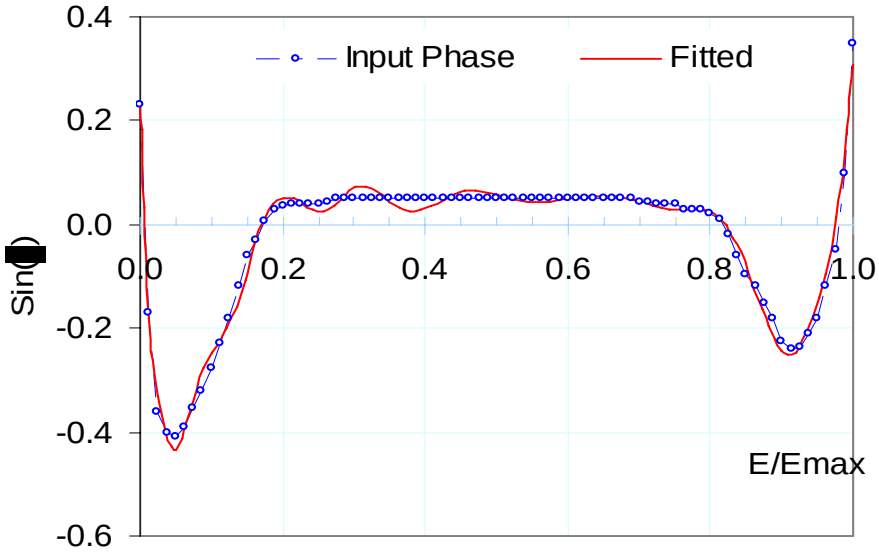
harmonic mode h=2,

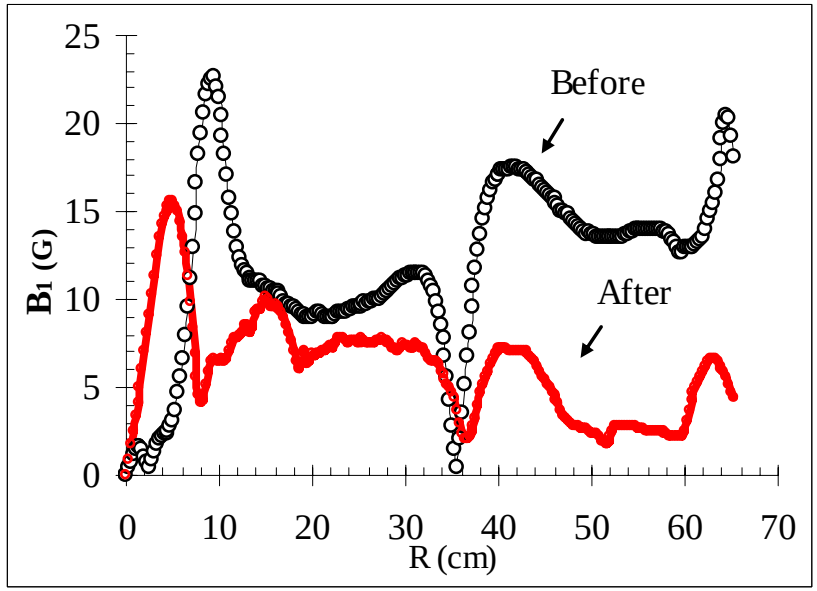
ν_{RF}=14.001 MHz,

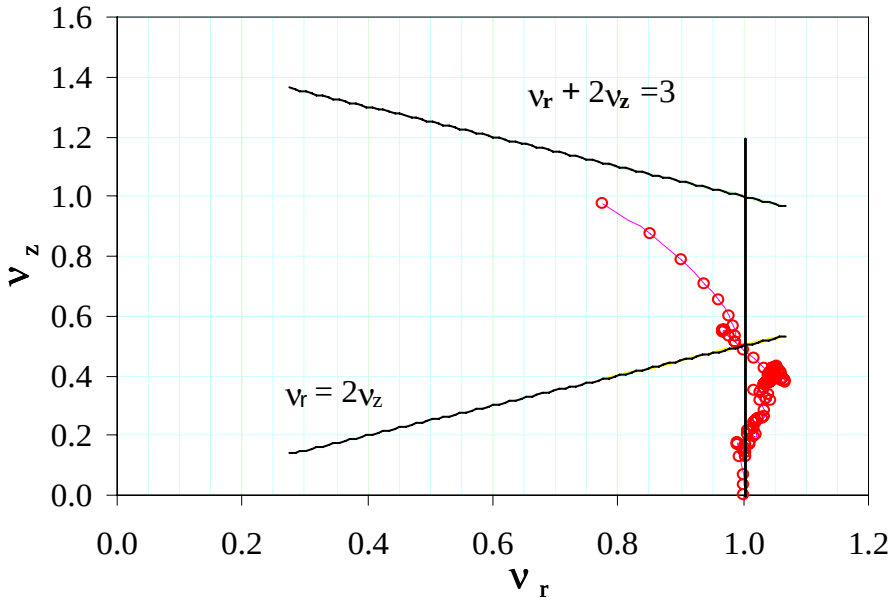
B_0=30.9 kG,

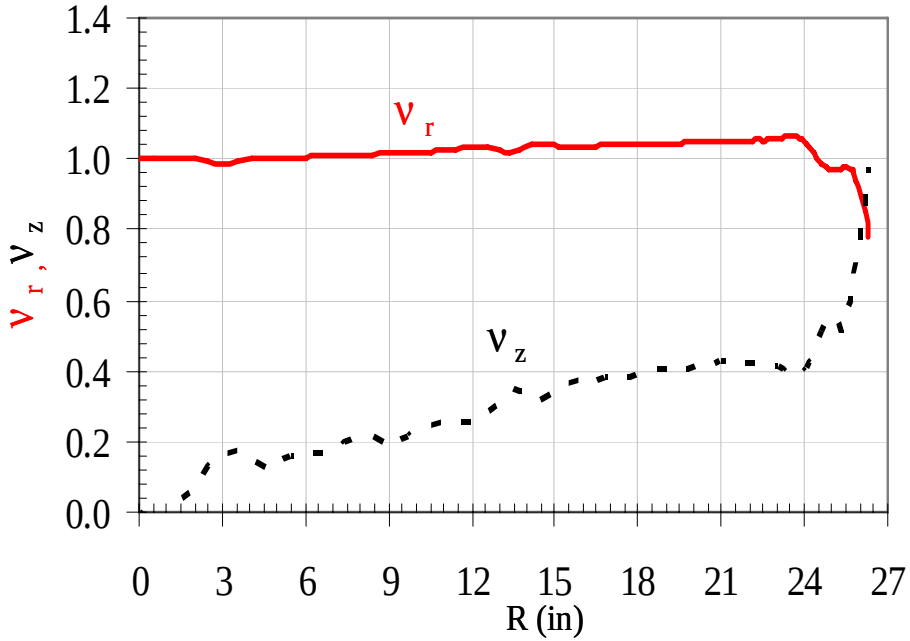
V_{Dee}= 41 kV,

R=26.24 inches


Input Phase
Fitted
Sin(ϕ)
E/Emax
0.4
0.2
0.0
-0.2
-0.4
-0.6
0.0
0.2
0.4
0.6
0.8
1.0

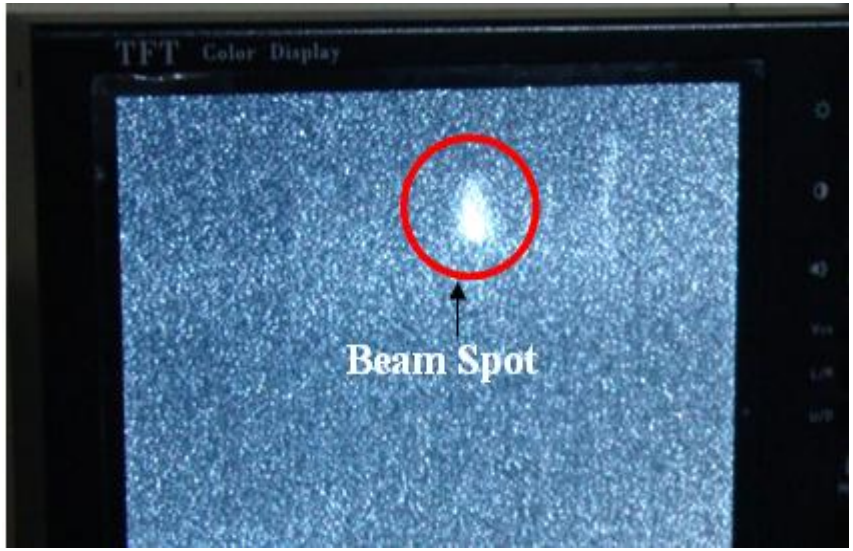

Before
After
B1 (G)
R (cm)
25
20
15
10
5
0
0
10
20
30
40
50
60
70


νr + 2νz =3
νr = 2νz
νz
νr
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2

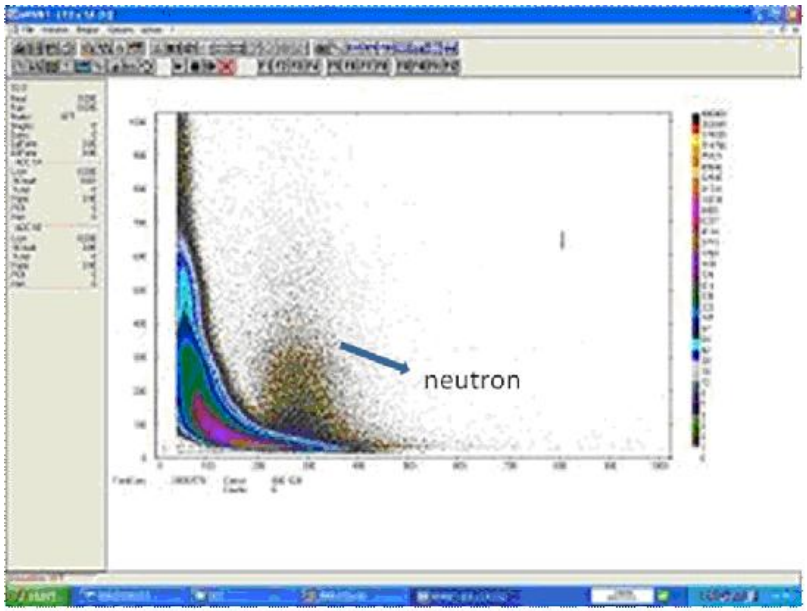

νr
νz
νr , νz
R (in)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
3
6
9
12
15
18
21
24
27


Main Probe Monitor : Connected
3-Finger Probe
TOP
0.00
MID/ Single Block
+12.602
BOT
0.00
nA
Beam Current (nA)
INT
0.00
DR
0.00
Beam Data
Range 200nA
Range 2 uA
Range 20uA
Read
SAVE
Refresh
From Cyclotron Centre
Radius (mm)
673.6
Set Radius
674
MOVE PROBE
Graph Toggle
Probe Current (nA) Vs. Radius (mm)
H 3:1
V 1:1
Current (nA)
140
120
100
80
60
40
20
0
-20
350
400
450
500
550
600
650
Command
STOP
Reset Position
Operation Zone
Maintenance Zone
Gate Valve Open
Gate Valve Close
Track IN
Track OUT
Interlock Status
END LS
MID LS
START LS
TRACK IN
Track Out
GV OPEN
GV Close
Flow SW
Message from Driver
Motor Stopped
Current Linear Position From Cyclotron Centre
167.23
Set Linear Position (Cm)
120.73
HELP
08:27:37
Probe Position
StartLS
Maintenance zone
MidLS
Operation Zone
EndLS (Cyclotron)
5
mm
Ready
NUM
start
Borescope Monitor
Main Probe Monitor : ...
main_probe_data_an...
Microsoft Excel - Pho...
8:27 AM

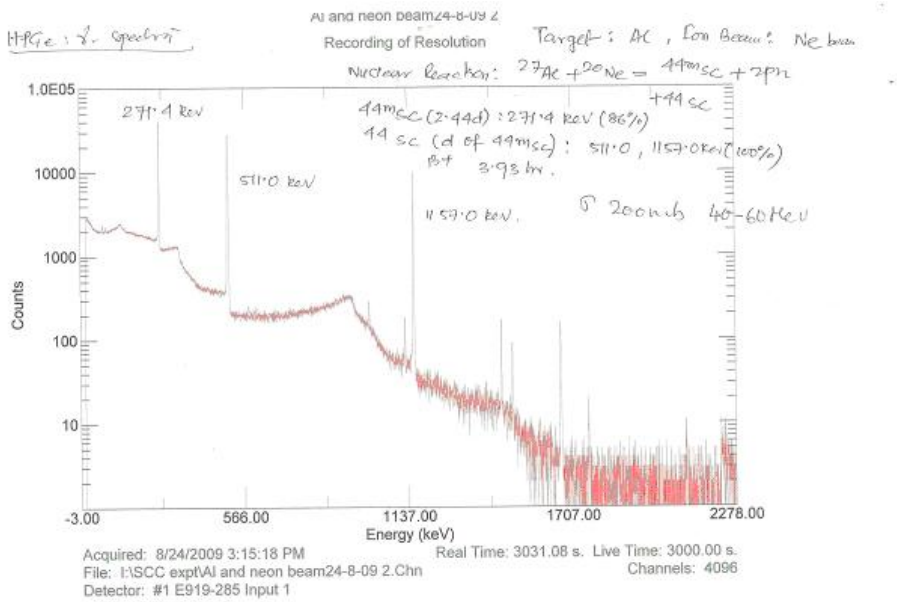
Beam current profile along radius



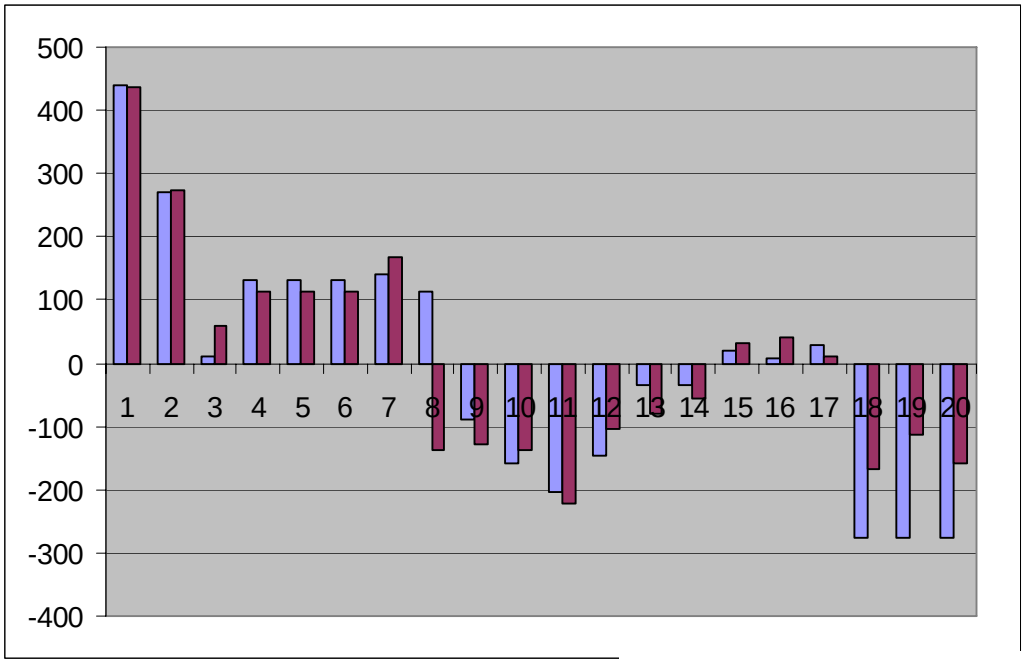
Accelerated Ne3+ Beam on viewer probe



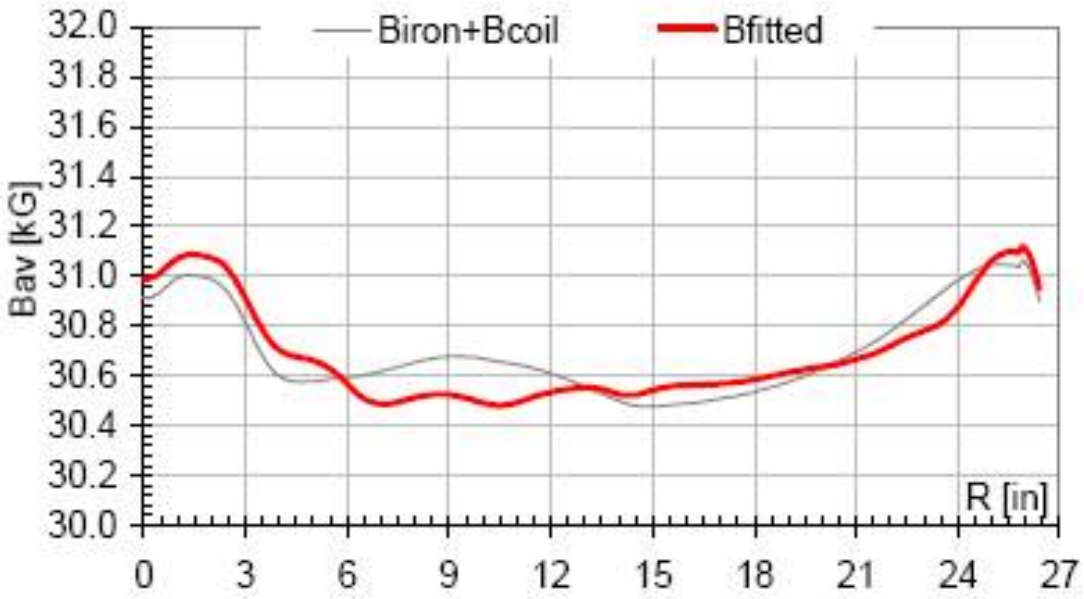
Neutron and gamma spectrum



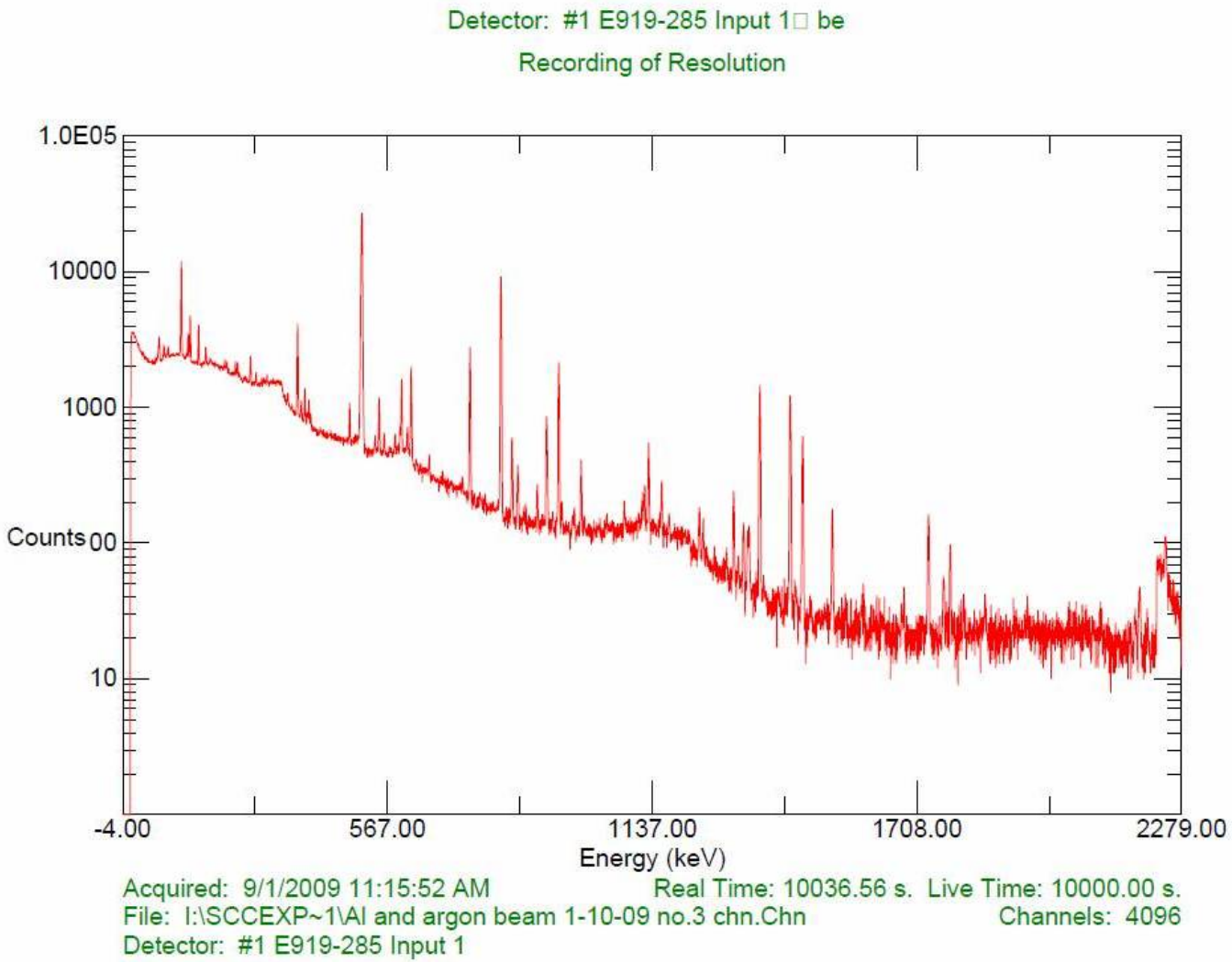
Gamma spectrum of activity of Al target irradiated by Ne beam



CURRENT SETTINGS COMPARISON



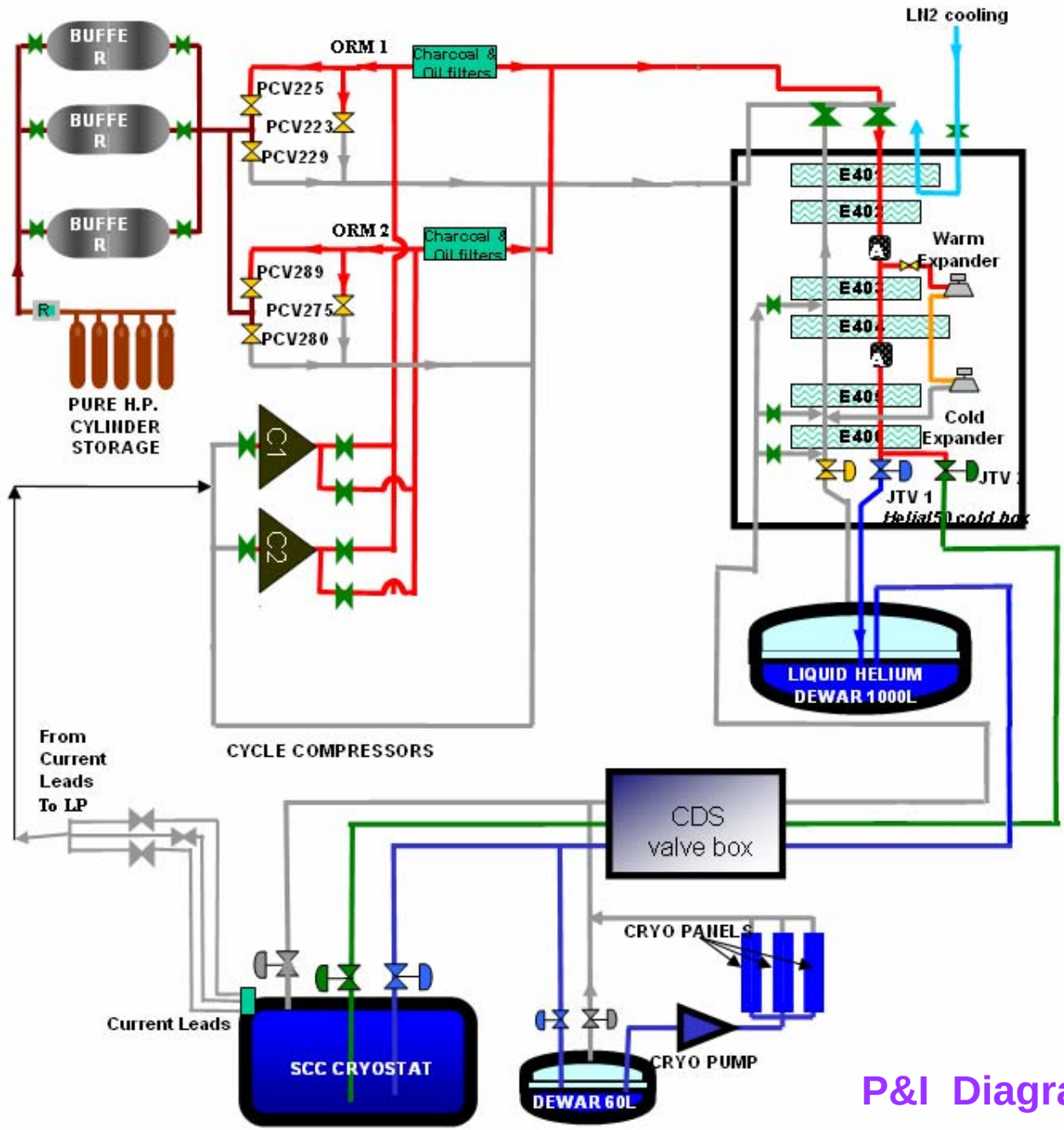
GAMMA SPECTRUM OF ISOTOPES PRODUCED BY ANALOGUE BEAM ARGON(6+) BEAM ON ALUMINIUM TARGET



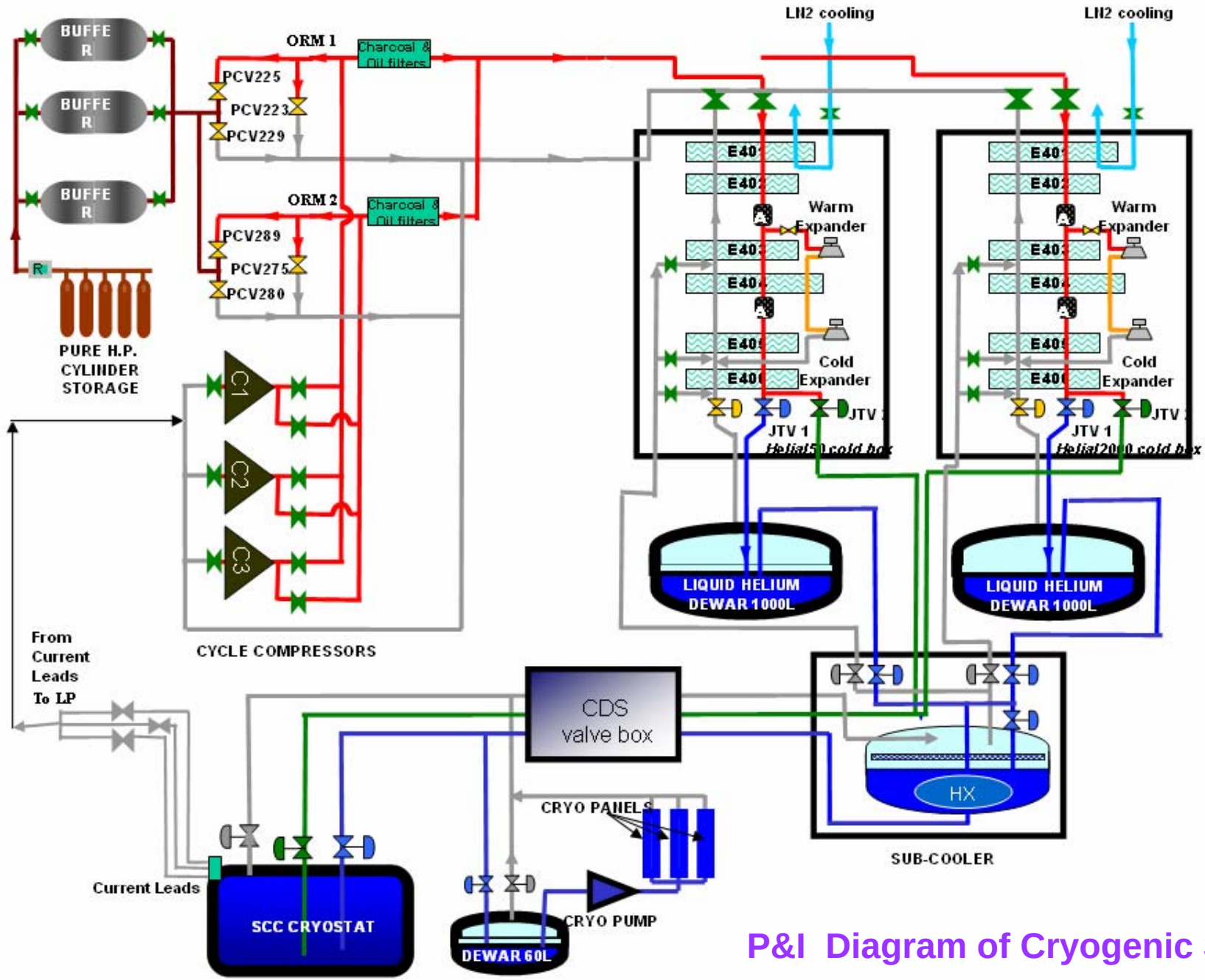
Capacity of refrigerators

Existing Refrigerator **Helial 50**	Without LN2 pre-cooling Flow rate- **49 g/sec**	With LN2 pre-cooling
Liquefaction mode:	**50 lph (Guranteed)**	100 lph(Designed)
Refrigeration mode for 4.5K temp. level:	**250 W (Guranteed)**	280 W (Designed)
Mixed mode at 4.5 K	**115 W + 15 lph (Guaranteed)**	-------

New Refrigerator **Helial 2000**	Without LN2 pre-cooling Flow rate- **85 g/sec**	With LN2 pre-cooling
Liquefaction mode:	**85 lph (Guranteed)** 85 lph (Designed)	176 lph (Designed)
Refrigeration mode for 4.5K temp. level:	**415 W (Guranteed)** 500 W (Designed)	530 W (Designed)
Mixed mode at 4.5 K	**360 W + 12 lph (Guaranteed)** 360 W + 25 lph (Designed)	360 W + 76 lph (Designed)



P&I Diagram of Cryogenic System



P&I Diagram of Cryogenic System

New He Liquefier Installed : Why?

- **Introduction of new refrigerator/liquefier of higher capacity (415 W@4.5K) - Helial-2000 (Air Liquide, France)**
  - Redundancy as the existing one (250 W @ 4.5 K) is old and require periodic maintenance.
  - Additional capacity to cater more refrigeration load (Especially, at higher excitation Cryostat Annular space vacuum degrades).
  - LHe supply for new projects in Cryogenics.

- **Provision of Sub-cooler**
  - Reduction of flash loss or increase of liquid fraction.
  - Reduction of pressure drop and return gas (LP) flow.

Overhauling of Helial-50 Helium Plant

1. **Expander Valve Control operation has been modified as warm expander speed feedback.**

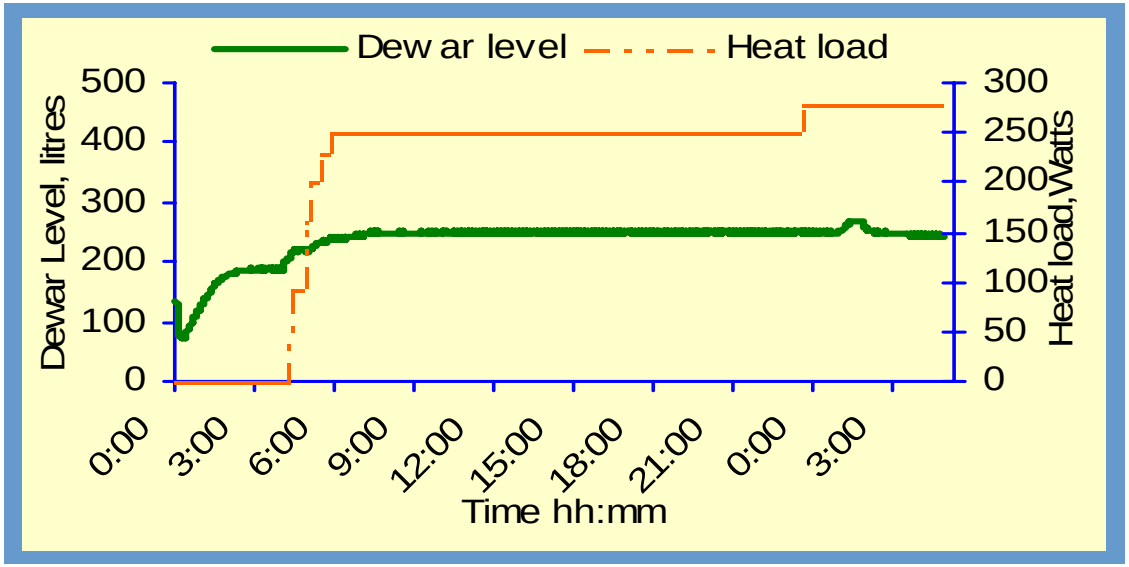
   Earlier, valve controlled mostly in manual mode seeing cold expander LP, dewar level, etc. Unable to handle refrigeration load at higher excitation.

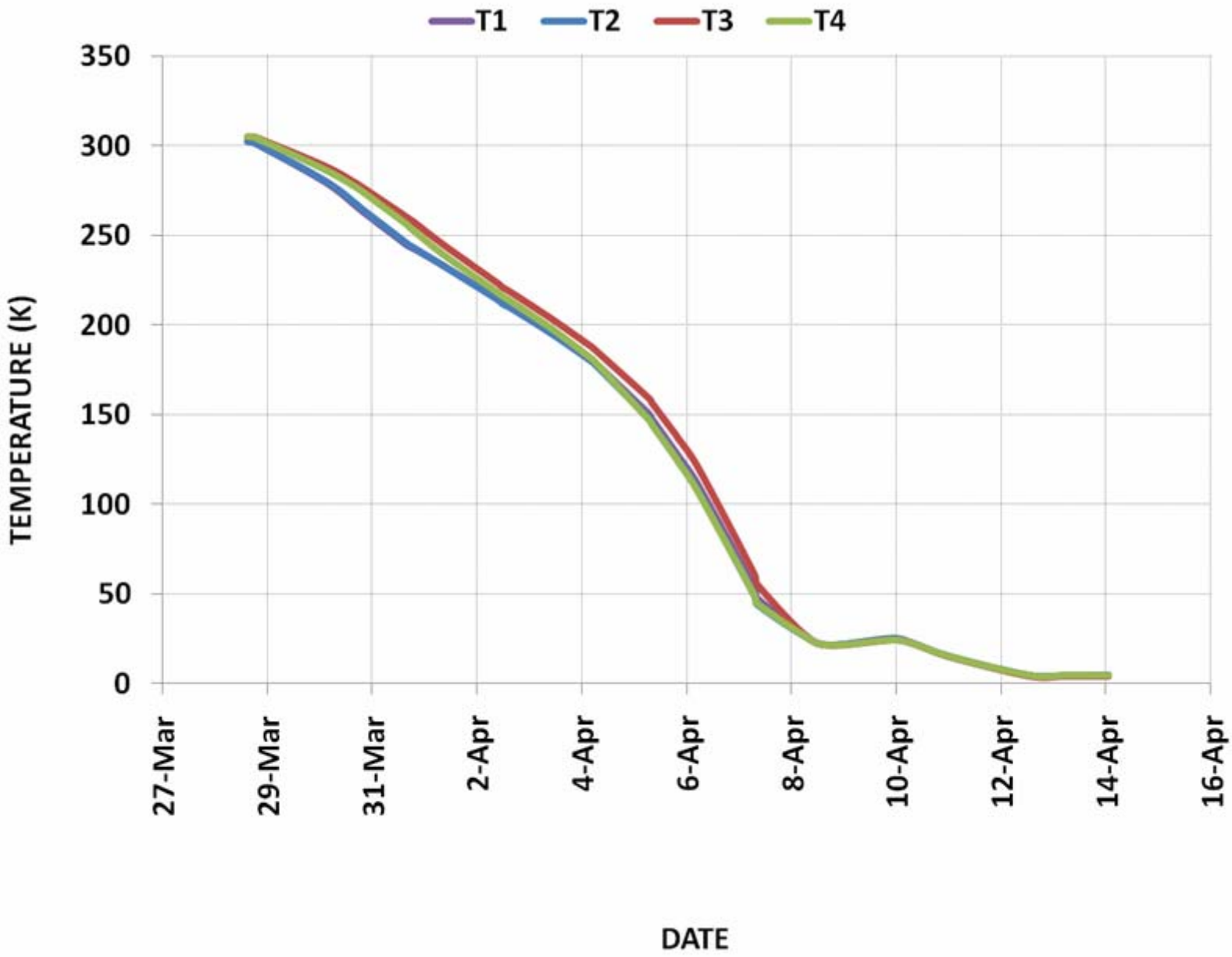
2. **Cernox sensors mounted on the cold box.**

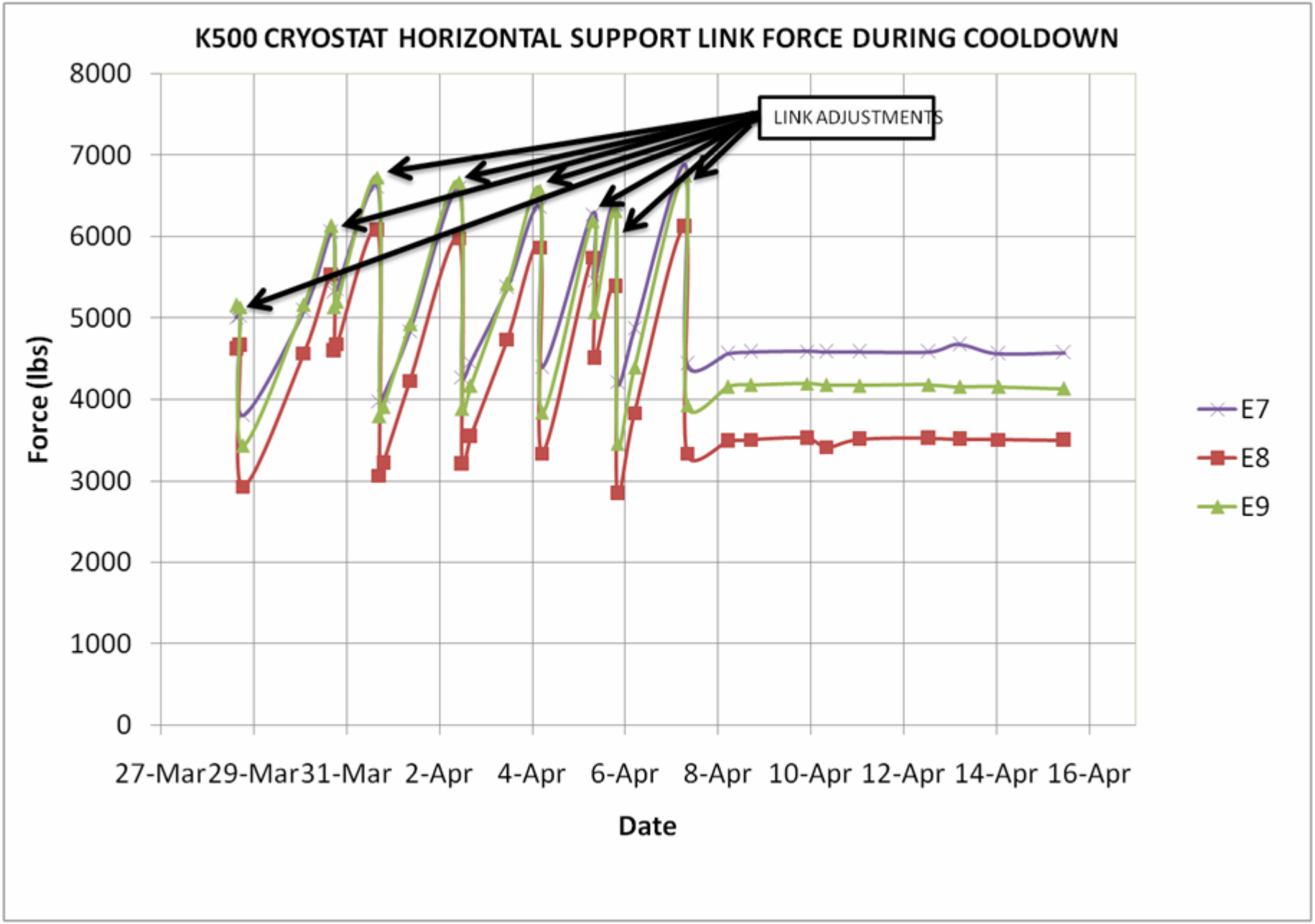
   Earlier Cryogenics Linear Temperature Sensors (CLTS) sensors are not very reliable.

3. **Several attenuators has been implemented for constant dewar level operations.**

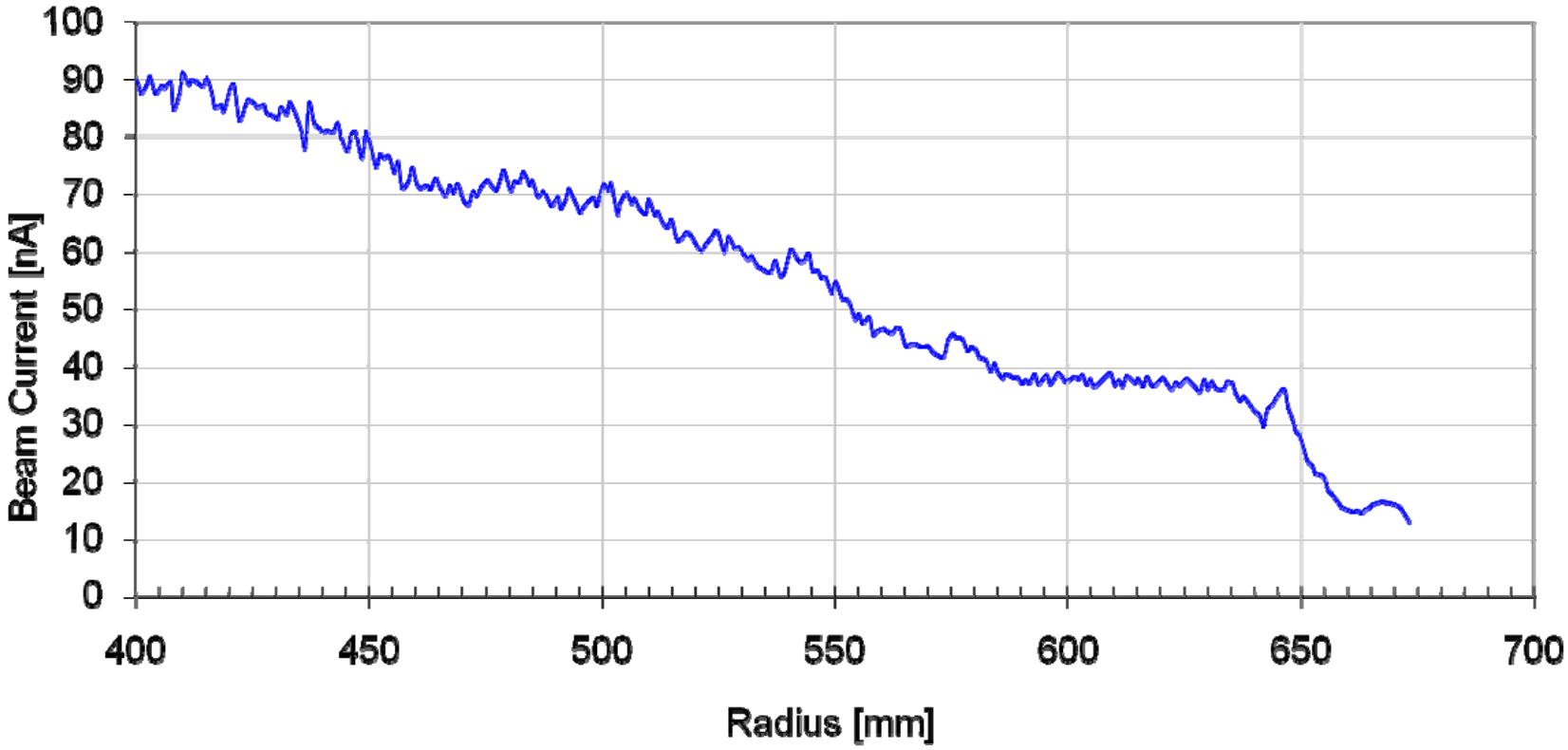
Performance After Overhauling

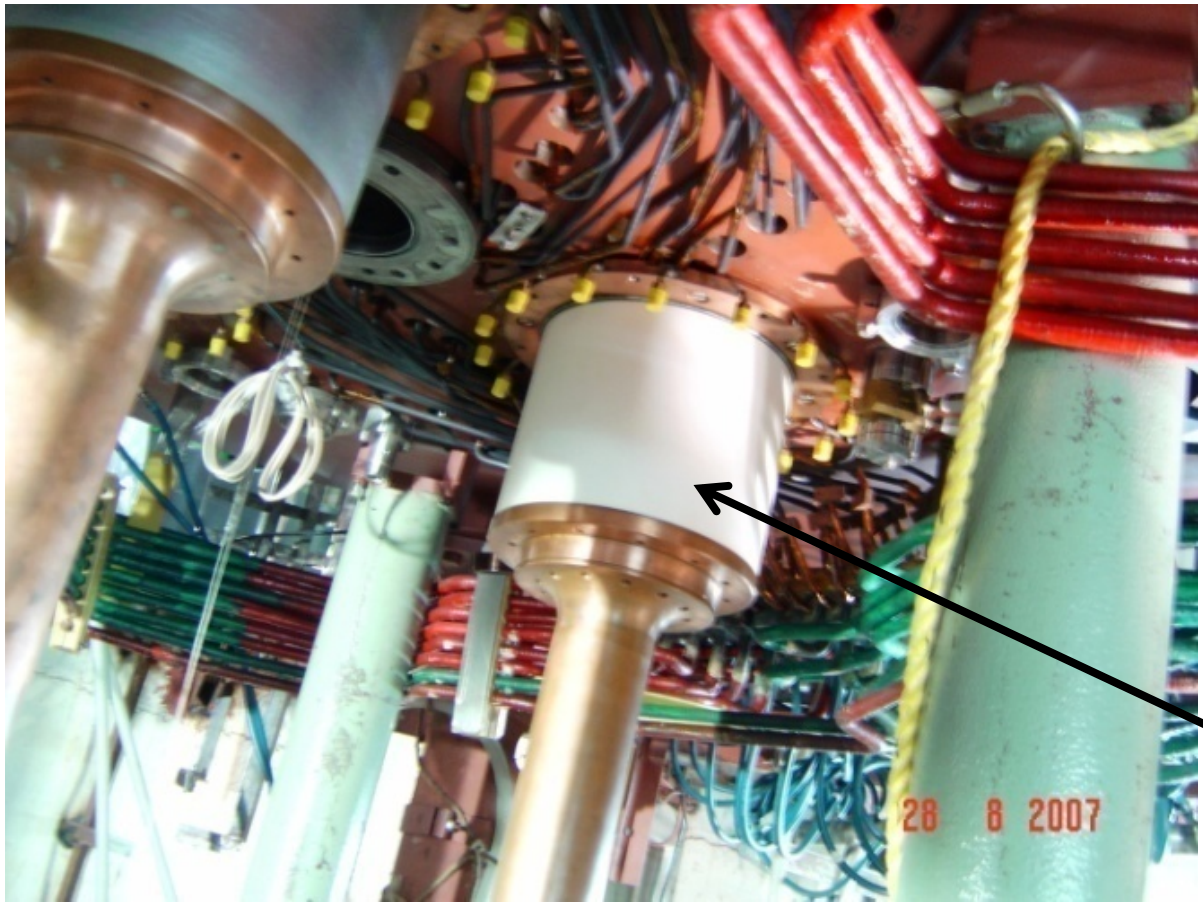



T1
T2
T3
T4
350
300
250
200
150
100
50
0
TEMPERATURE (K)
27-Mar
29-Mar
31-Mar
2-Apr
4-Apr
6-Apr
8-Apr
10-Apr
12-Apr
14-Apr
16-Apr
DATE

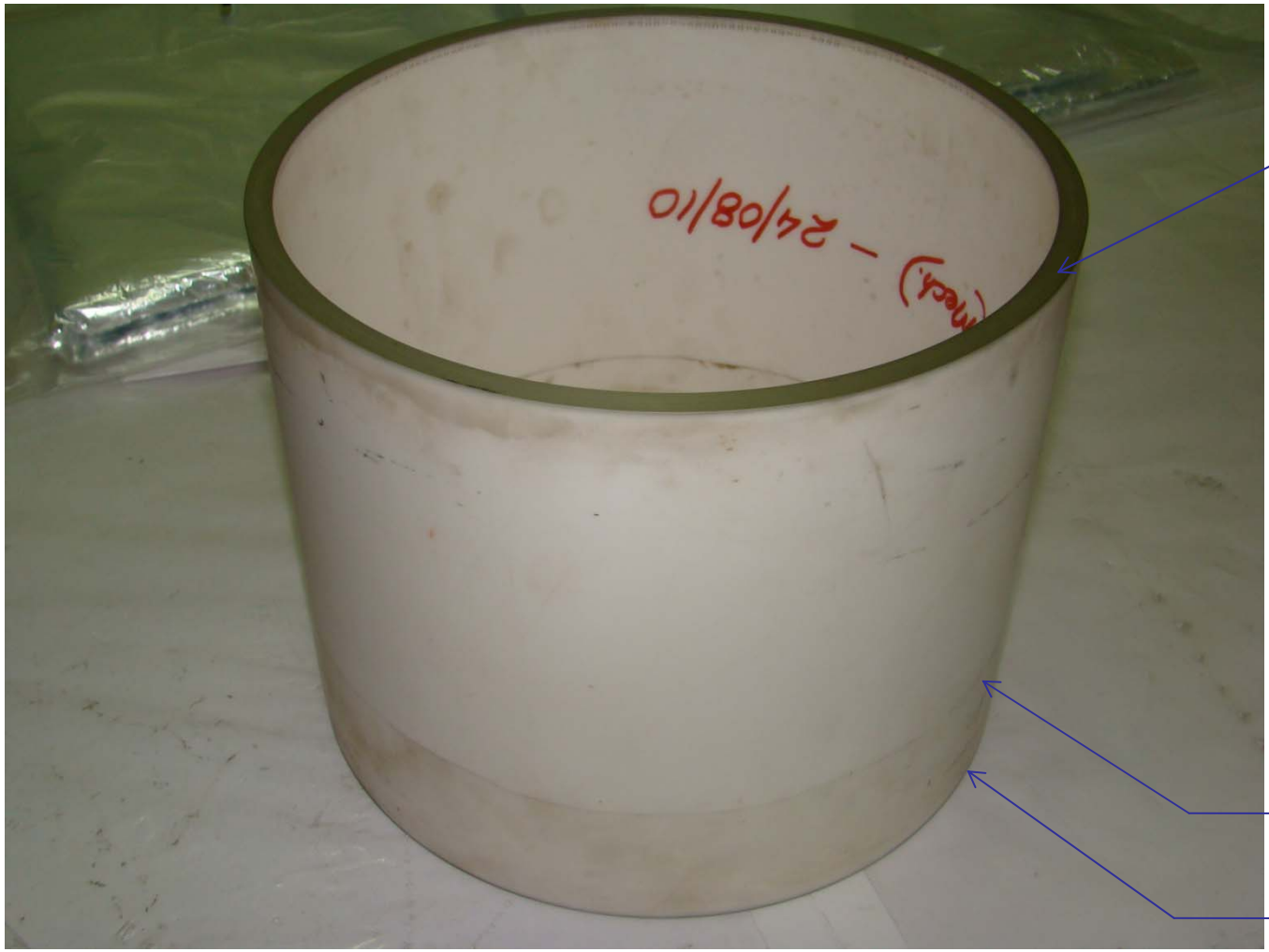

K500 CRYOSTAT HORIZONTAL SUPPORT LINK FORCE DURING COOLDOWN
LINK ADJUSTMENTS
Force (lbs)
8000
7000
6000
5000
4000
3000
2000
1000
0
27-Mar
29-Mar
31-Mar
2-Apr
4-Apr
6-Apr
8-Apr
10-Apr
12-Apr
14-Apr
16-Apr
Date
E7
E8
E9

18TH AUGUST 2010




28 8 2007

CERAMIC FOR UPPER ‘B’ CAVITY



The crack is about 2 ½” above the ground end. It is exactly similar to the earlier ceramic failures. This is fourth time happening. The previous ones were ceramics for lower ‘A’ cavity once and upper ‘C’ cavity twice.

CREAMIC FOR UPPER ‘B’ CAVITY

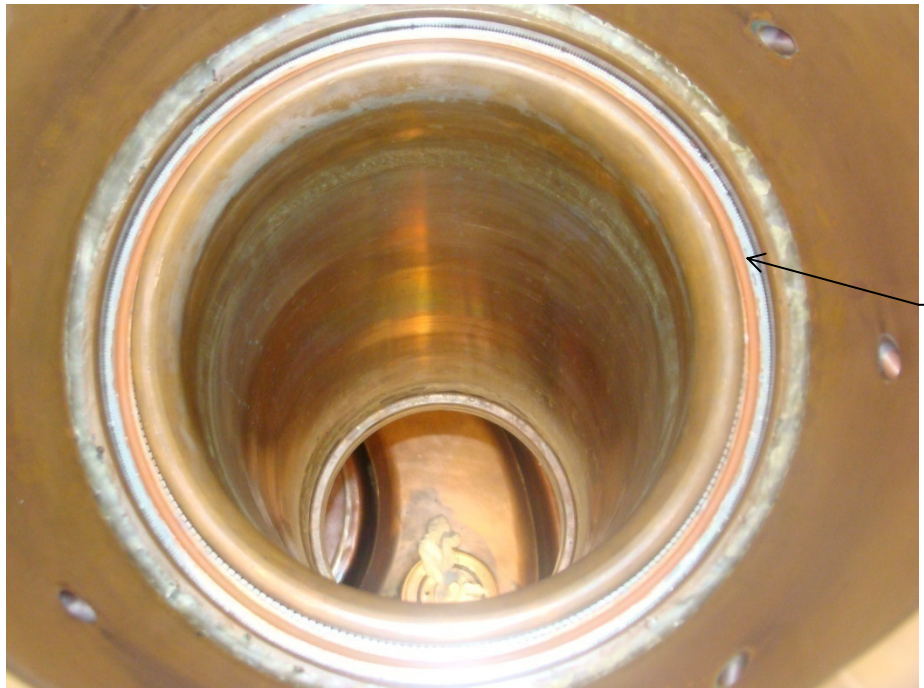
- The ceramic inside surface is clean. Outside surface has a few black styrration marks, these marks are much less compared to the last failure.

- The vacuum rise was extremely fast at the time of failure. It went from 10^{-7} mbar to 35 mbar within a second.

CRACK PENETRATED THOUGH FULL THICKNESS

UPPER ‘B’ CAVITY CERAMIC

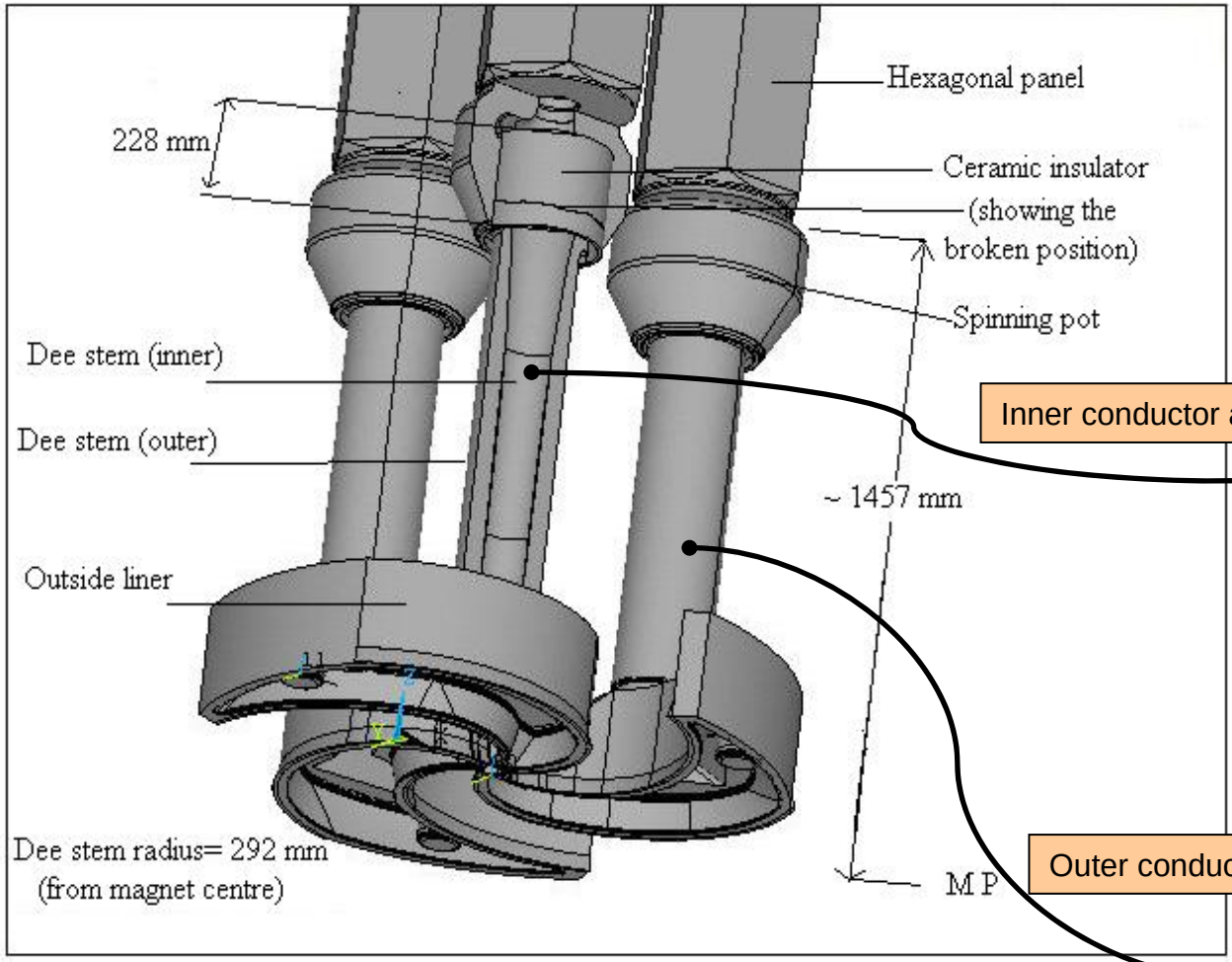
This time the o-rings have shown no damage, no burning, no heating evidence, no deformations also. The o-rings look like the new ones.

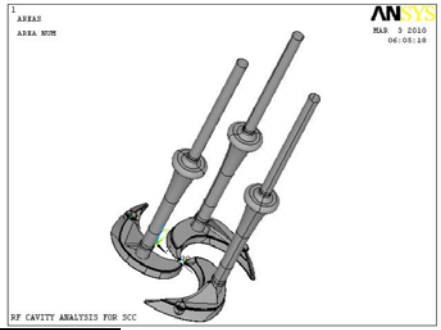


Silicon O-ring

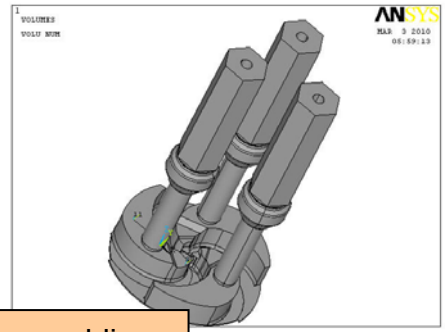
Outer Conductor Spinning

ANSYS™ MODEL



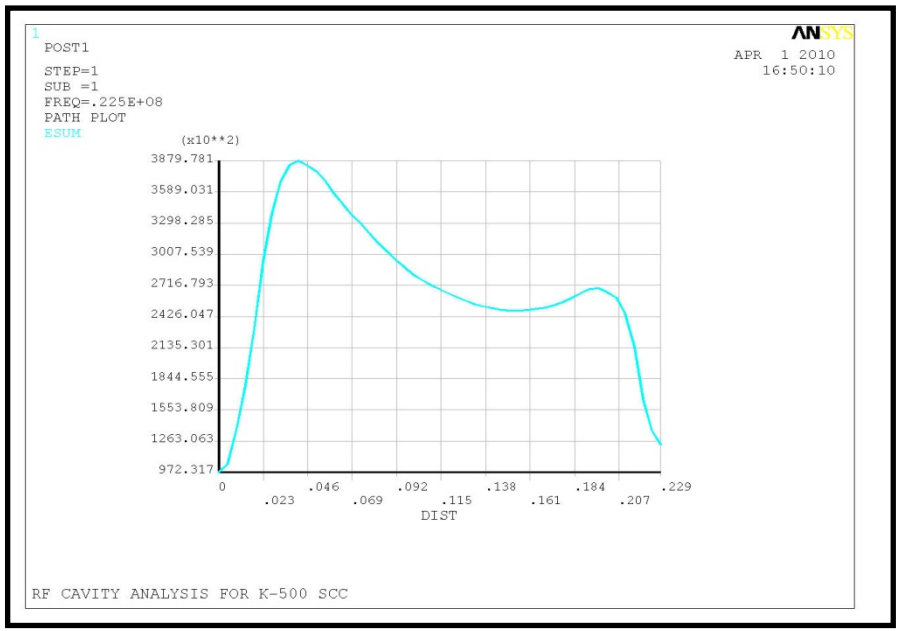


Inner conductor assemblies

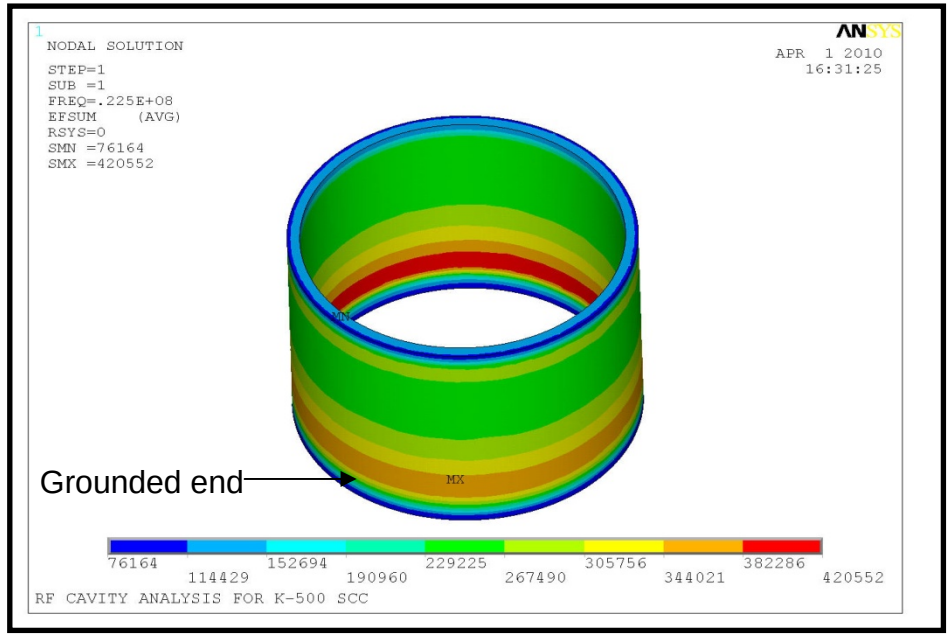


Outer conductor assemblies

Electrical field distribution in the ceramic insulator



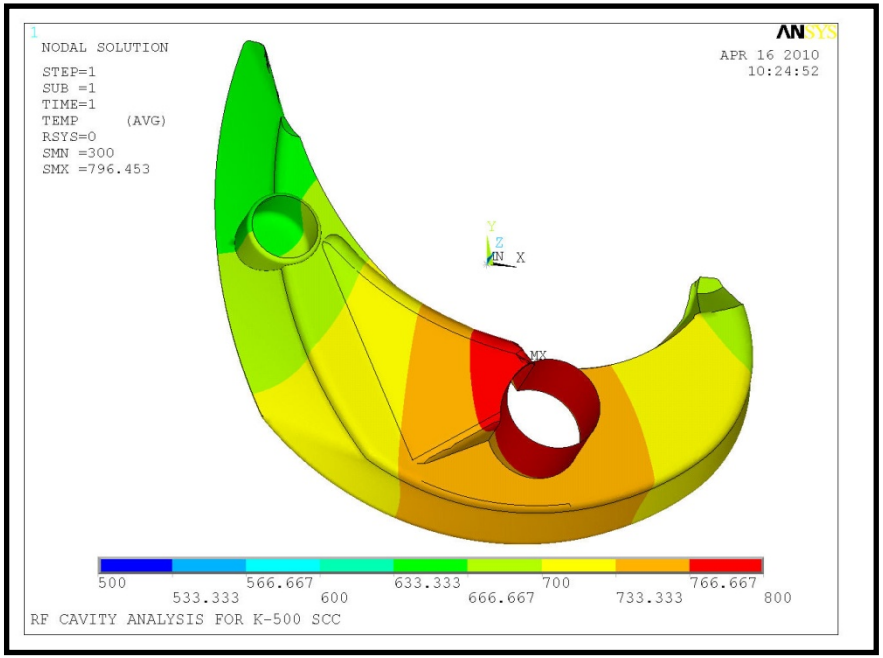
Electric field (0 end is grounded) along the length of ceramic



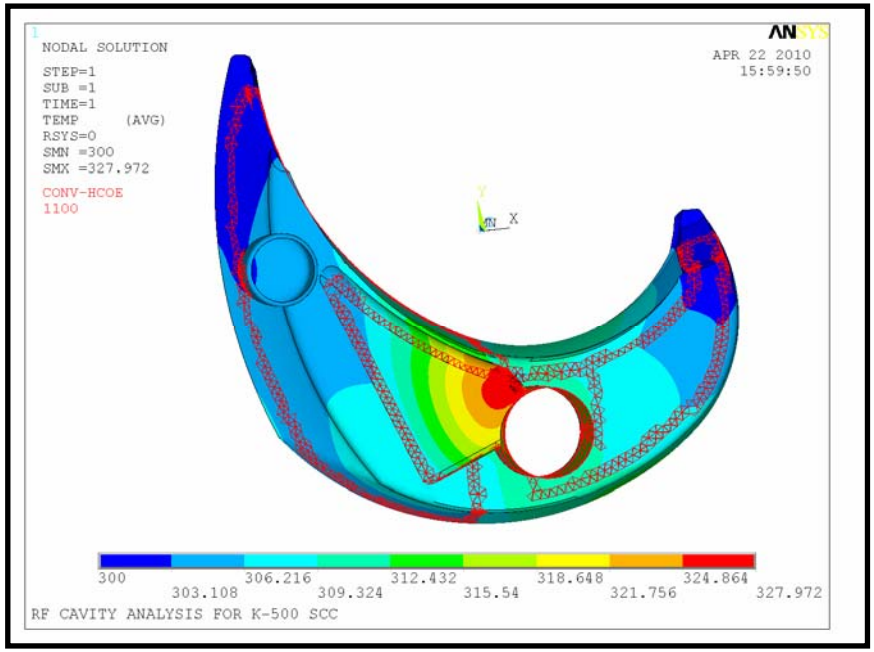
Electric field contour (Volt/mts)

Temperature distribution inside Dee (with and without cooling)

Without cooling

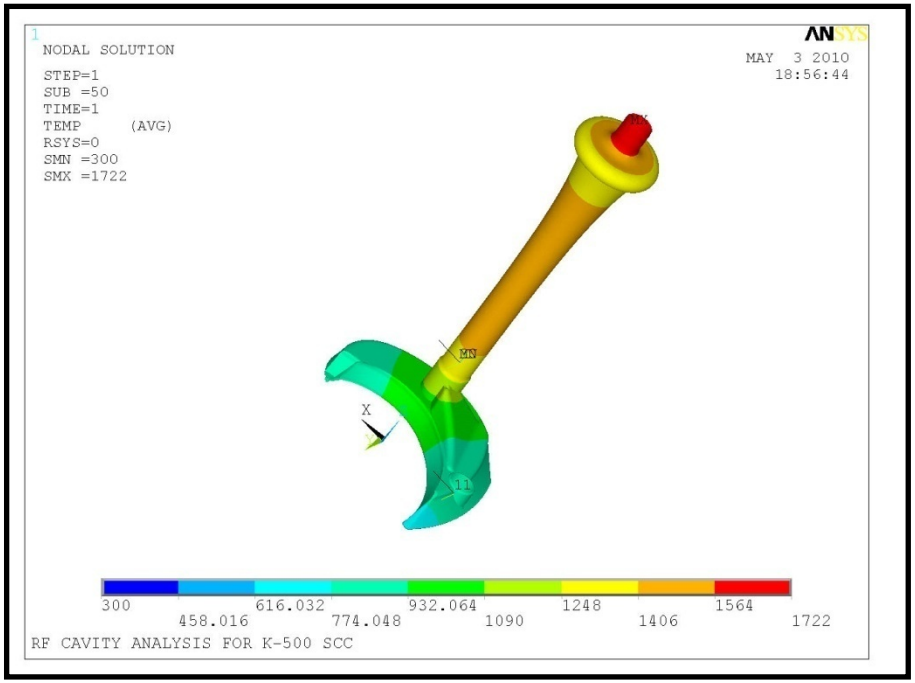


With cooling water (3 lpm)

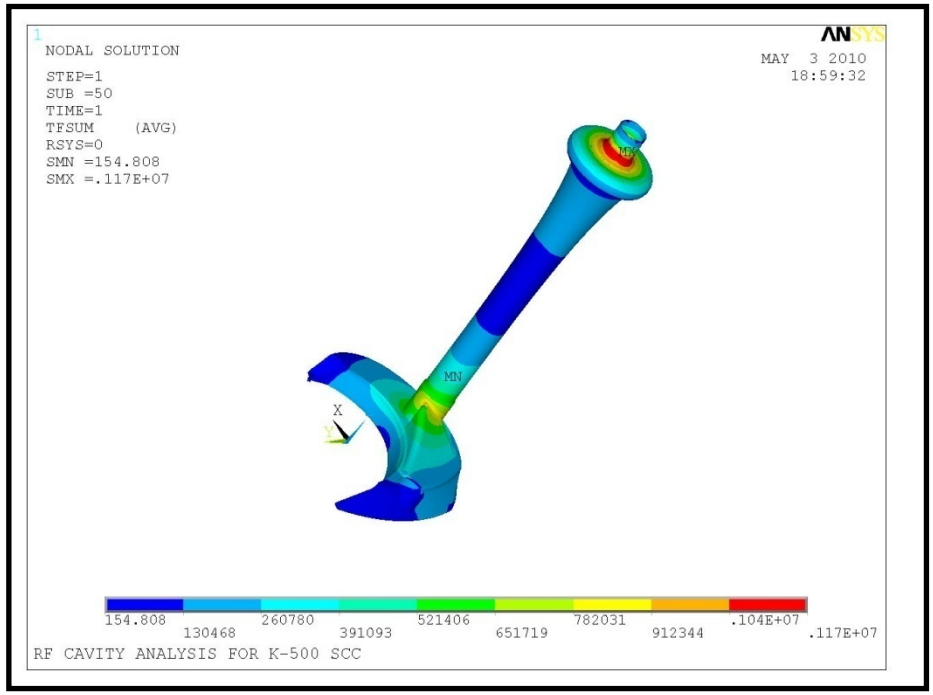


Surface loss distribution (Inner conductor, without cooling)

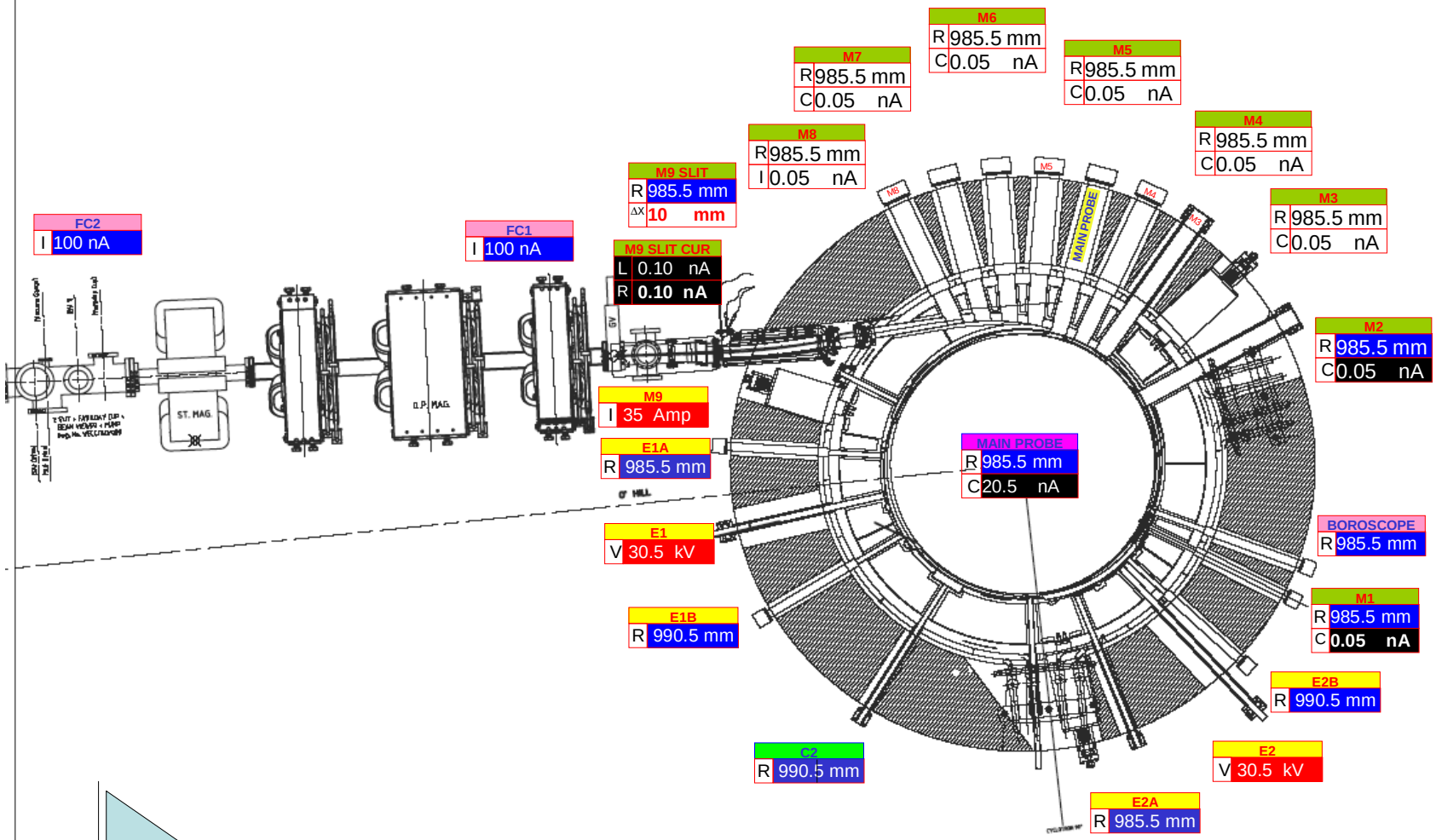
Temperature distribution



Heat flux distribution

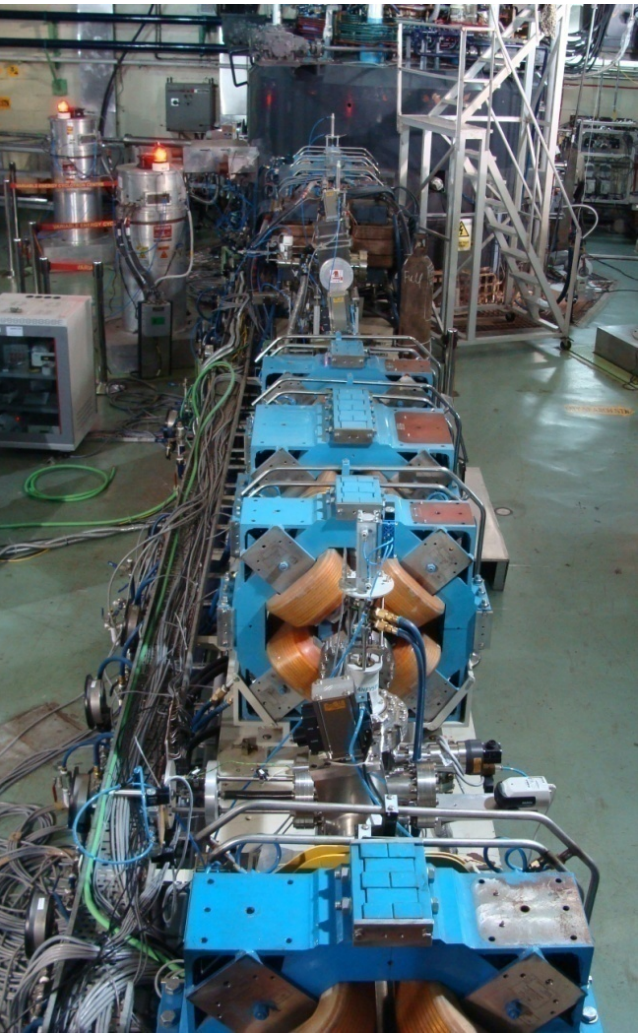


EXTRACTION CONTROL SYSTEM LAYOUT

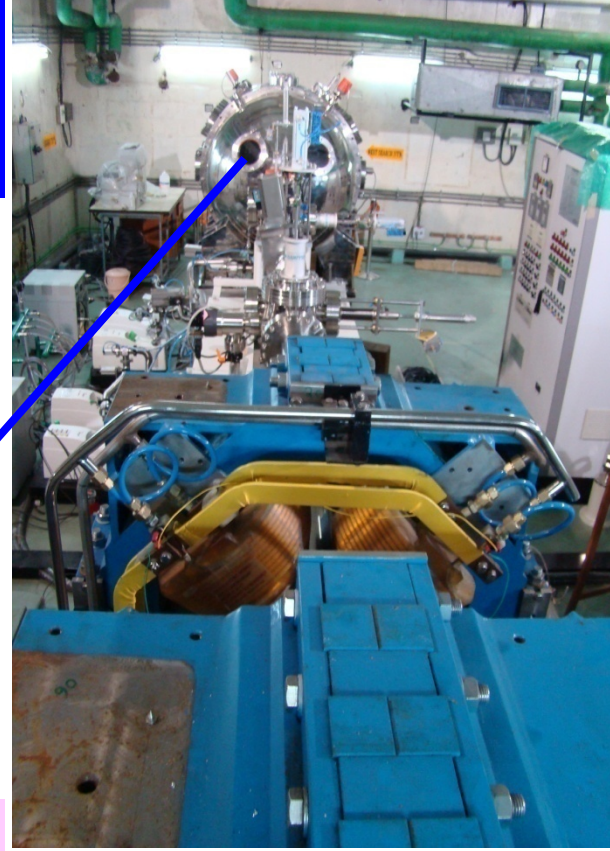


VAULT DOOR

In the superconducting cyclotron at VECC Kolkata

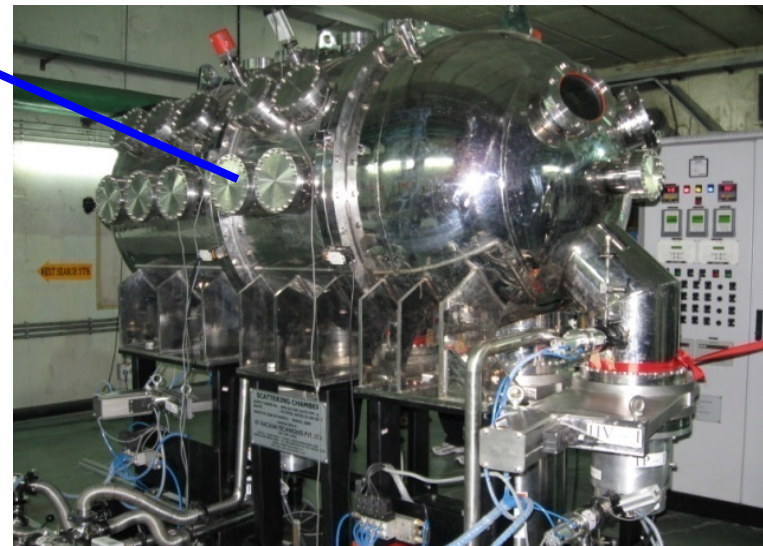


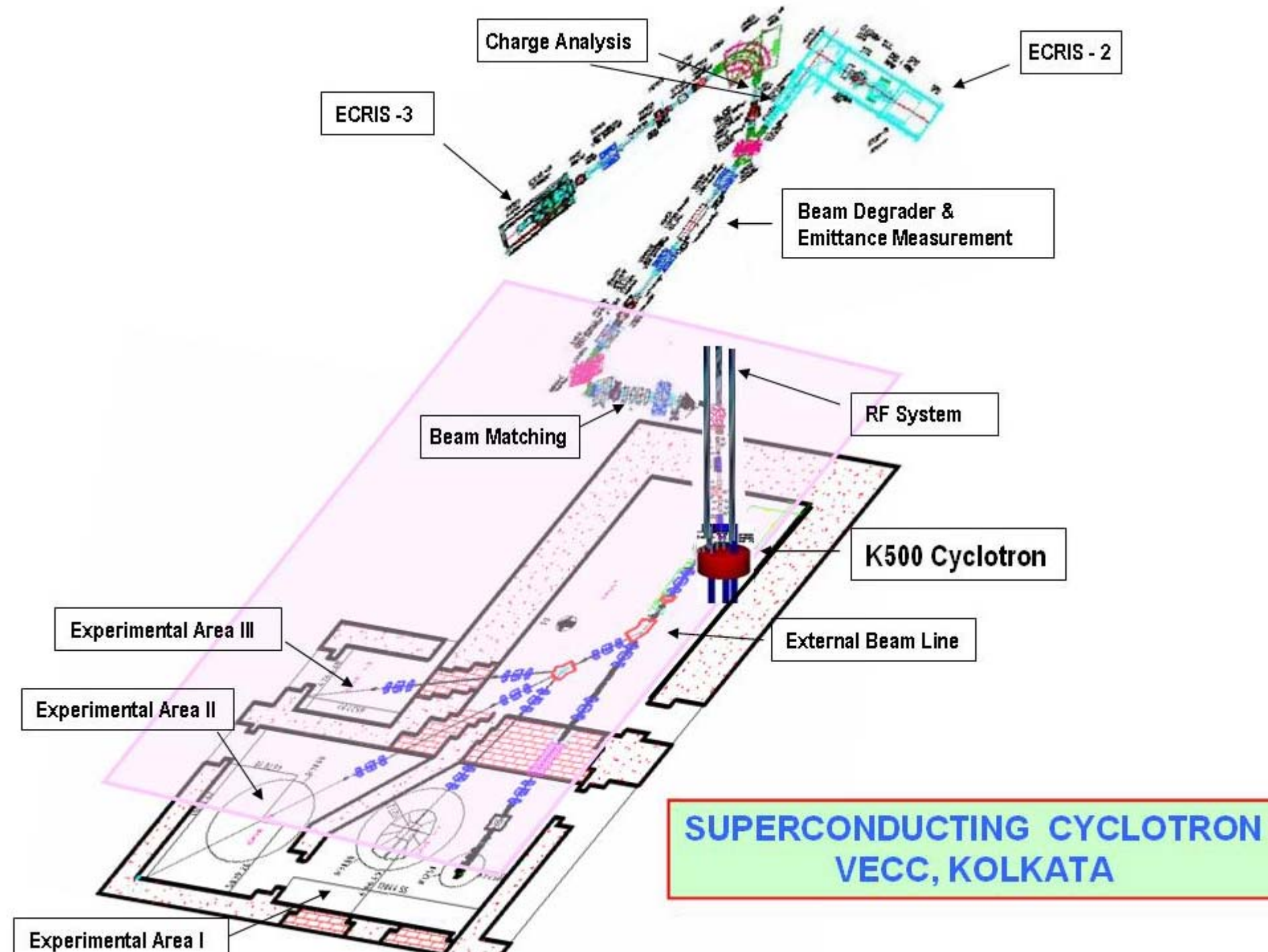
After achieving beam acceleration preparations are underway for extraction and beam delivery in experimental station.



Experimental Station # 1

Target Chamber




Charge Analysis
ECRIS - 2
ECRIS -3
Beam Degrader &
Emittance Measurement
RF System
Beam Matching
K500 Cyclotron
Experimental Area III
External Beam Line
Experimental Area II
Experimental Area I
SUPERCONDUCTING CYCLOTRON
VECC, KOLKATA

THANKS


© 2006 Europa Technologies
Image © 2006 DigitalGlobe
Google
Pointer 22°35'35.12" N 88°23'43.93" E elev 15 ft
Streaming 100%
Eye alt 10469 ft