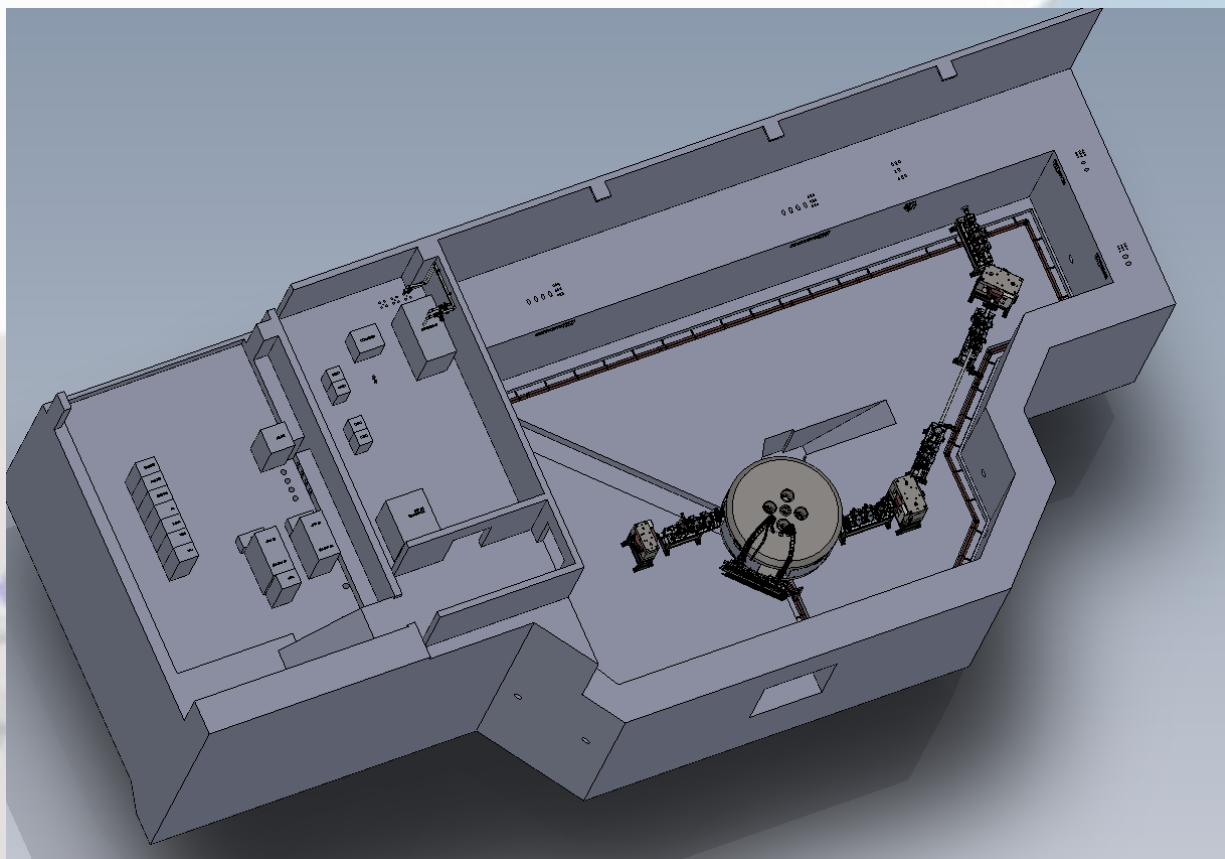




# **WORK PACKAGE #5**

## **CYCLOTRON AND BEAMLINE**

**SPES MEETING**  
**OCTOBER 10<sup>TH</sup> 2016**

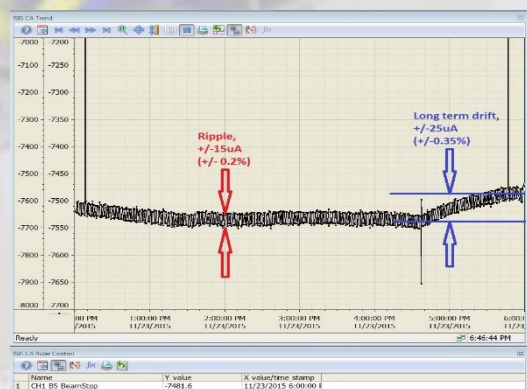
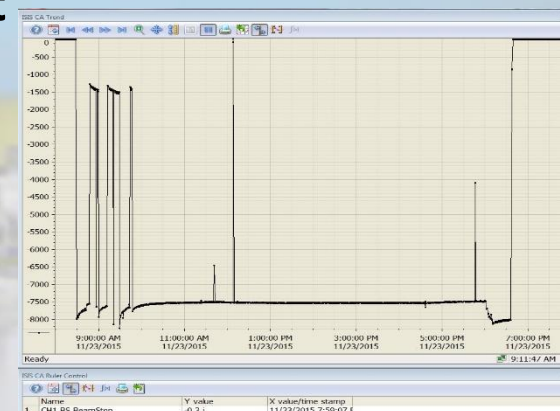
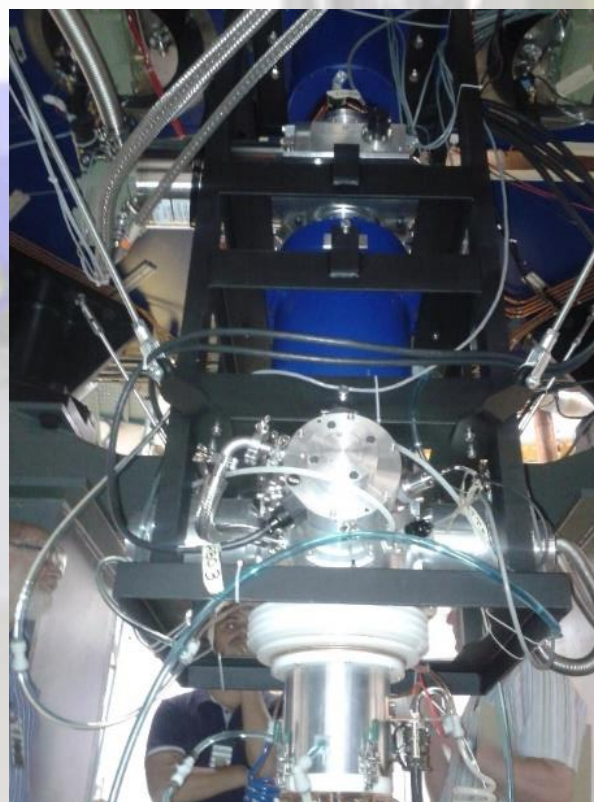
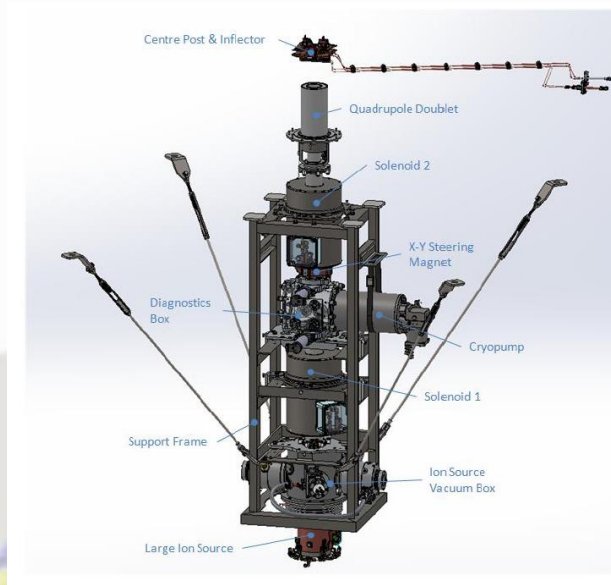


## The Mission:

- the cyclotron
- one complete beam line
- the first part of the second beam line
- the “turn key system”
  - Ancillary systems
  - Control system
  - Safety system
- The integration
- The training for the operation
- Operation and maintenance team building



## Source and injection line test November 2015

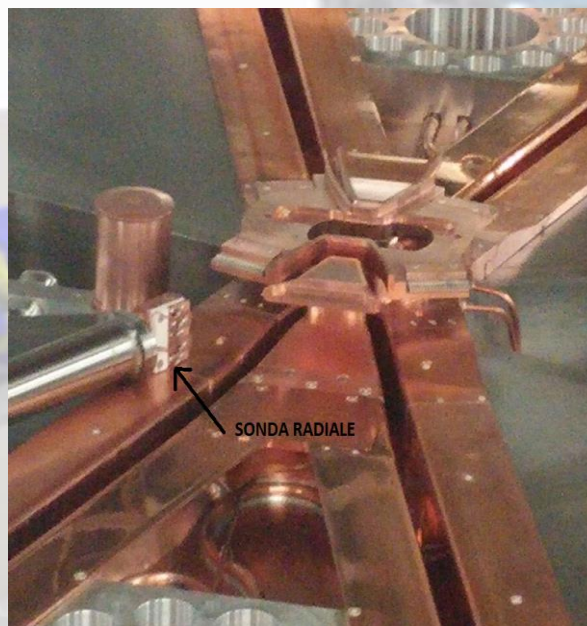




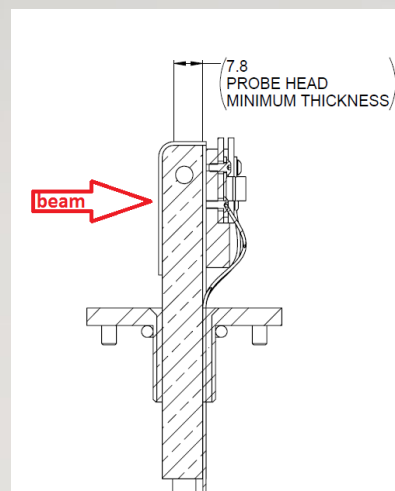
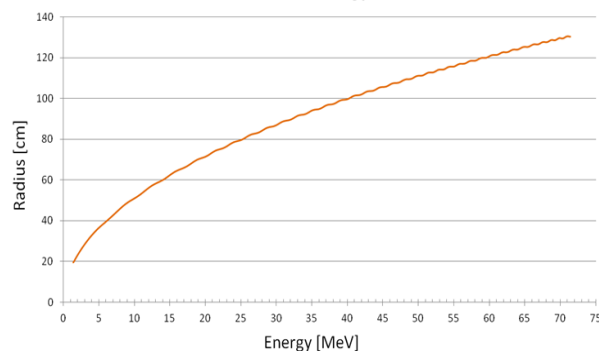


Feb. 26<sup>th</sup> 2016

## First acceleration test without extraction 3 $\mu$ A @70 MeV

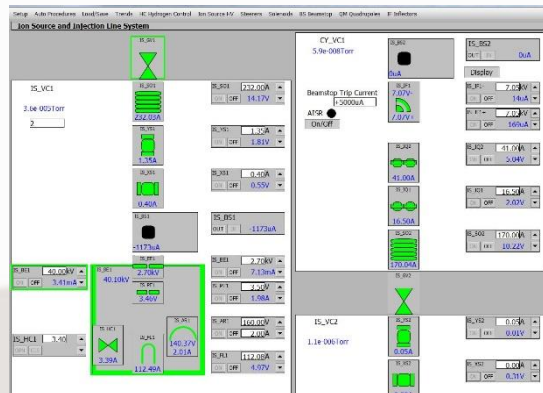


Radius vs Energy

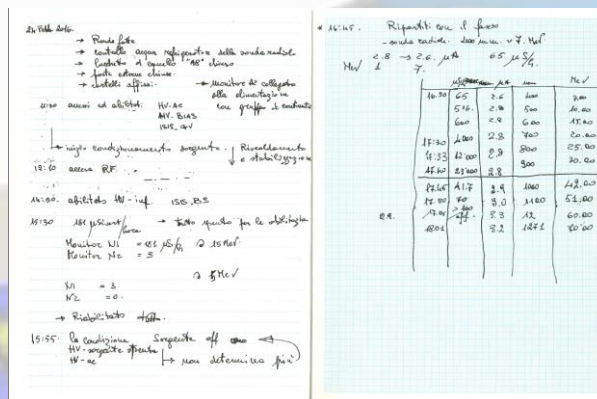




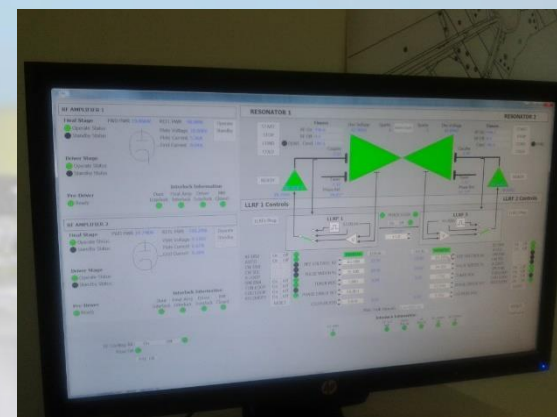
## Injection Line



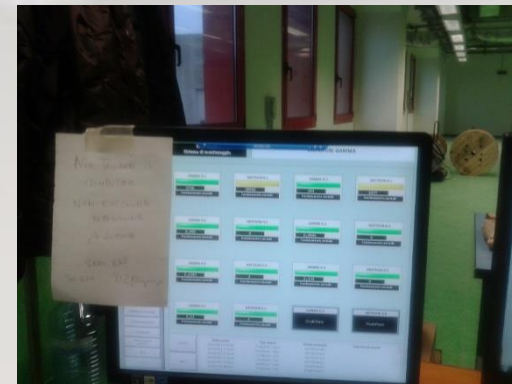
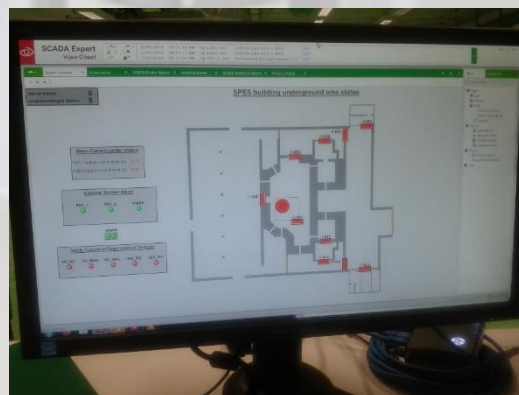
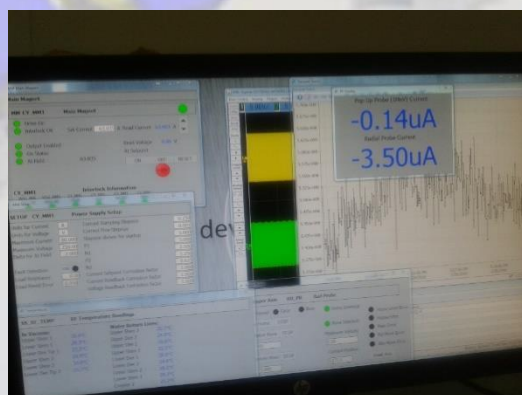
## Old fashion logbook



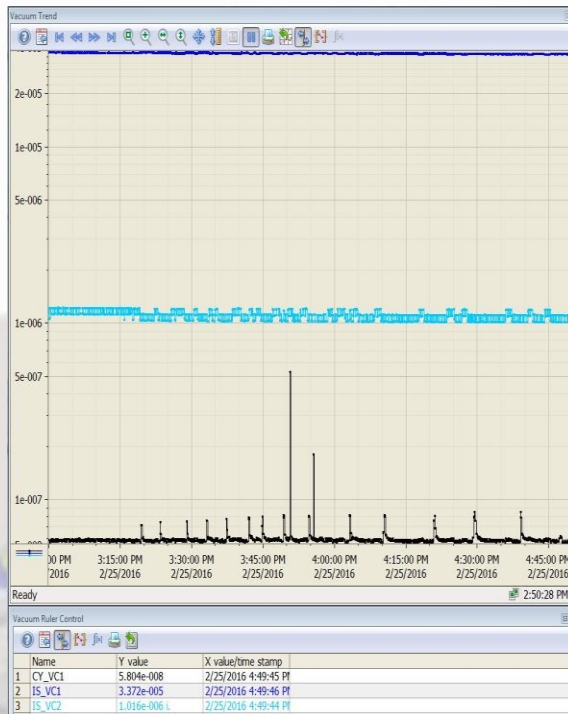
## Cyclotron control system HMI



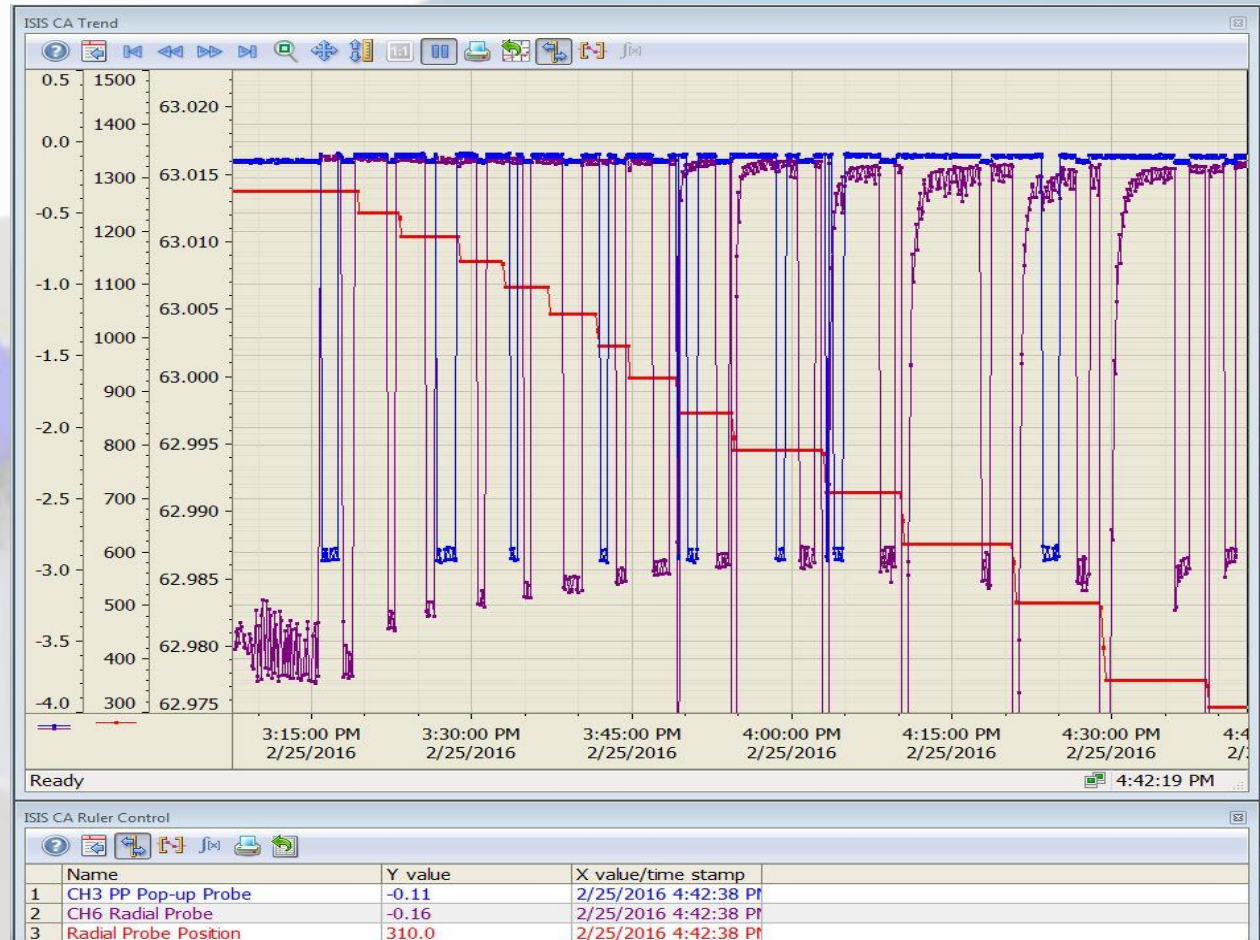
## Machine control system and safety system integration







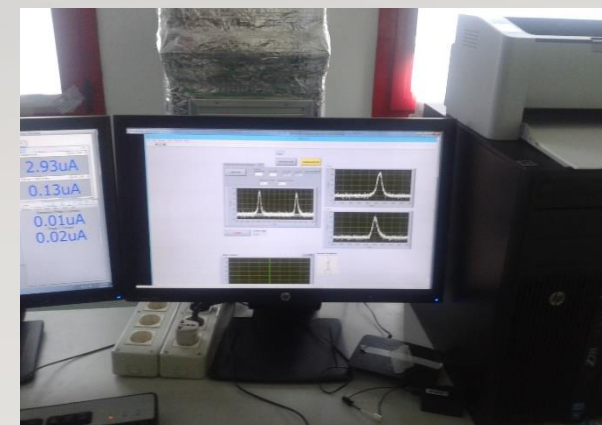
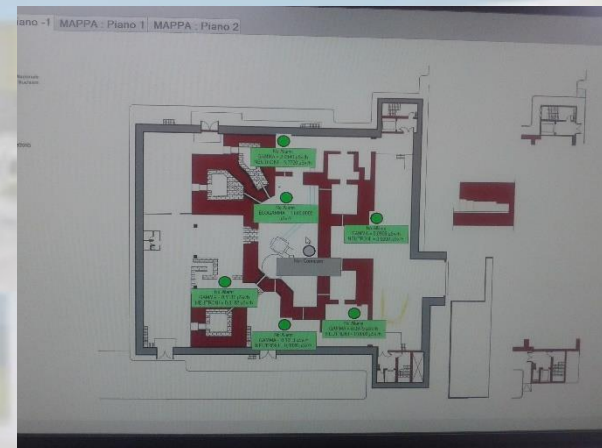
Vacuum level inside the  
Cyclotron:  
5.8 e-8 Torr (7.7 e-8 mbar)



Test results with 3 microA on the radial probe



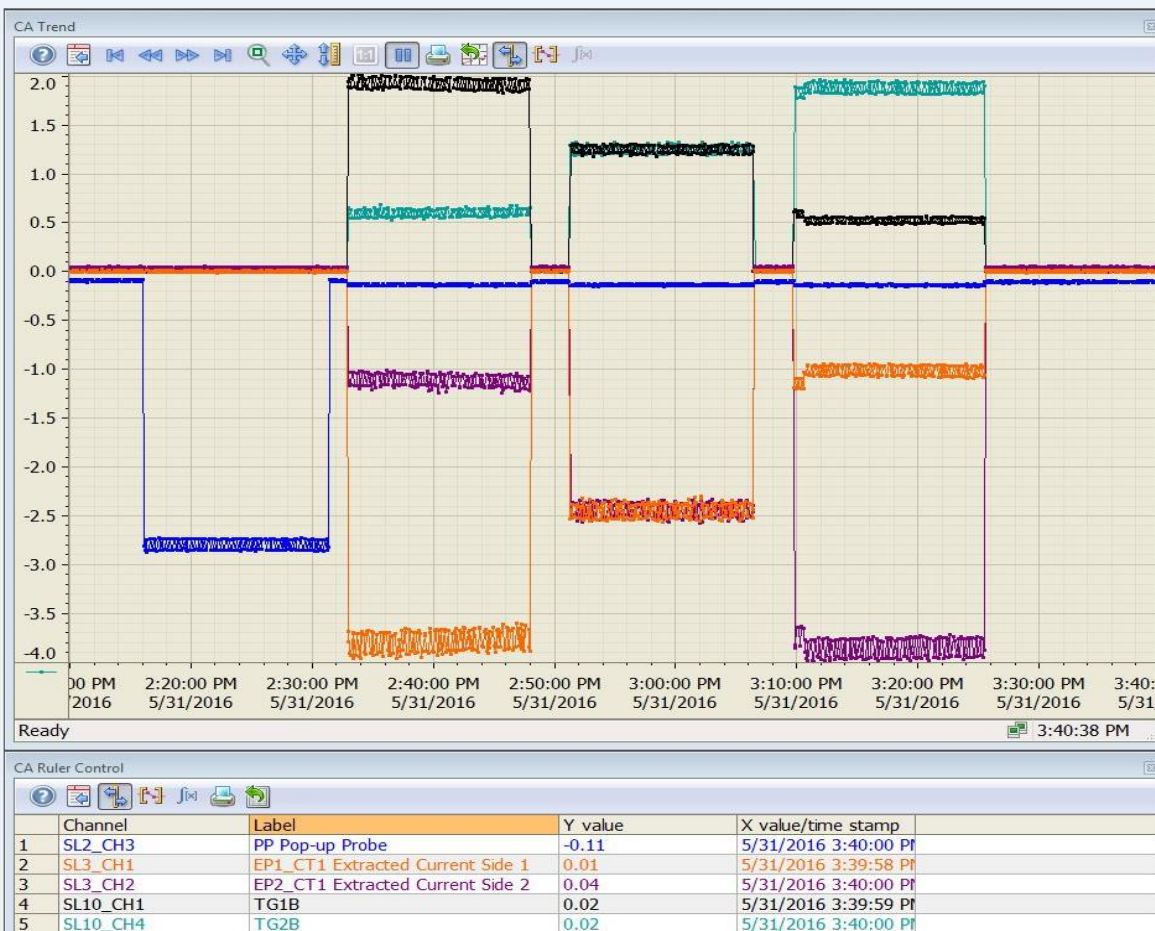
**May 31<sup>st</sup> 2016:** first test for the beam extraction. Successful 3 microA total dual extraction









## Experimental results and paper signed



### TEST RESULTS

Test Description	BCSI (signature and date)	INFN LNL (signature and date)
<ul style="list-style-type: none"> <li>performance specified</li> <li>measured value</li> </ul>		
<u>Beam current to 1MeV probe:</u> Measured $2.80 \pm 0.04 \mu\text{A}$ Date and time <u>MAY 31, 2016 2:16pm</u>	No signature required	No signature required
<u>Beam current ratio 80/20:</u> Faraday cup 1 current $1.93 \pm 0.03 \mu\text{A}$ Faraday cup 2 current $0.60 \pm 0.02 \mu\text{A}$ Ratio as measured: <u>76:24</u>	 MAY 31, 2016	
<u>Beam current ratio 50/50:</u> Faraday cup 1 current $1.25 \pm 0.02 \mu\text{A}$ Faraday cup 2 current $1.25 \pm 0.02 \mu\text{A}$ Ratio as measured: <u>50:50</u>		
<u>Beam current ratio 20/80:</u> Faraday cup 1 current $0.53 \pm 0.02 \mu\text{A}$ Faraday cup 2 current $1.88 \pm 0.03 \mu\text{A}$ Ratio as measured: <u>22:78</u>		

Ion Source vacuum  $3.23 \pm 0.01 \times 10^{-5}$  Torr, Cyclotron vacuum  $5.1 \pm 0.8 \times 10^{-8}$  Torr.

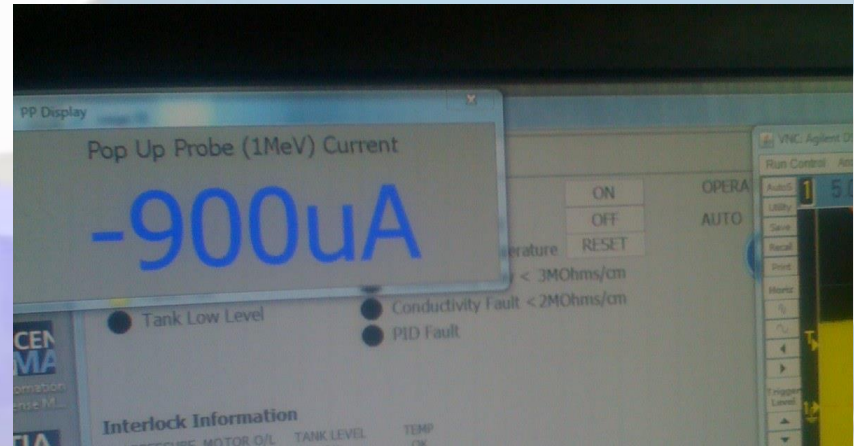
BCSI Operator DAVID DU, Date and time MAY 31, 2016, 3:36pm



# Beam commissioning

## Acceleration to 1MeV:

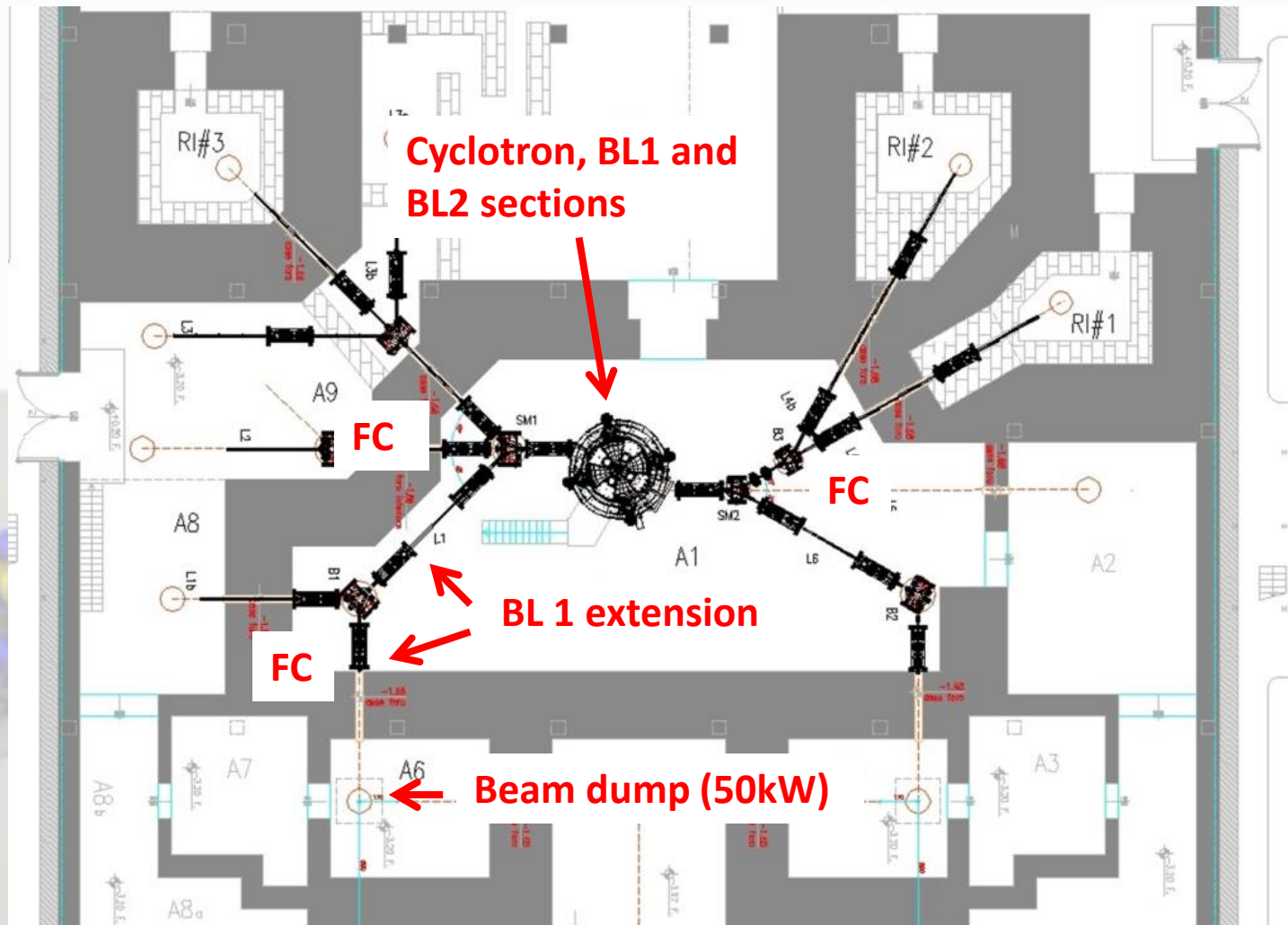
- 900 $\mu$ A for 8.5mA (source)  
(max source output 15mA)
- Injection efficiency 10.3%
- Beam ripple within  $\pm 1\%$   
of the average value
- Stability better than 5 $\mu$ A



## Acceleration to 70MeV and extraction:

- Radial Probe has been used, beam monitored in 5MeV steps
- Beam extracted, tune optimised at 100 $\mu$ A on target

# Installation at INFN LN Legnaro

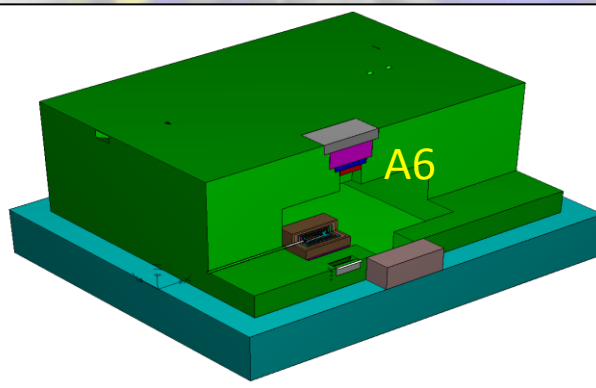
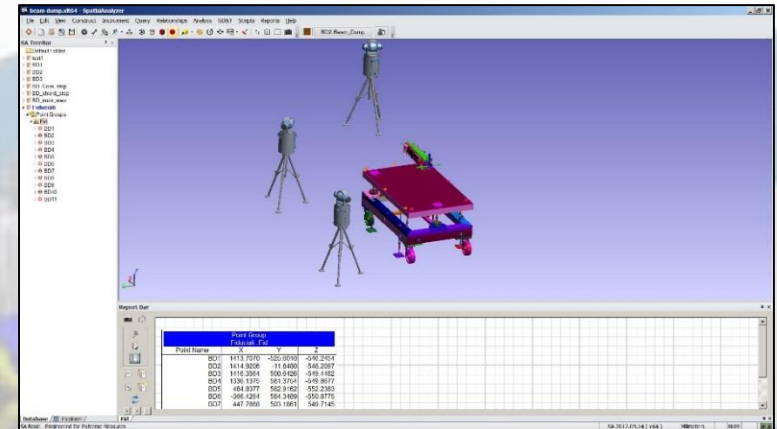




## Alignment Strategy

Beam Dump system was aligned with **laser** track instrumentation. Alignment Procedure steps of the entire device were defined:

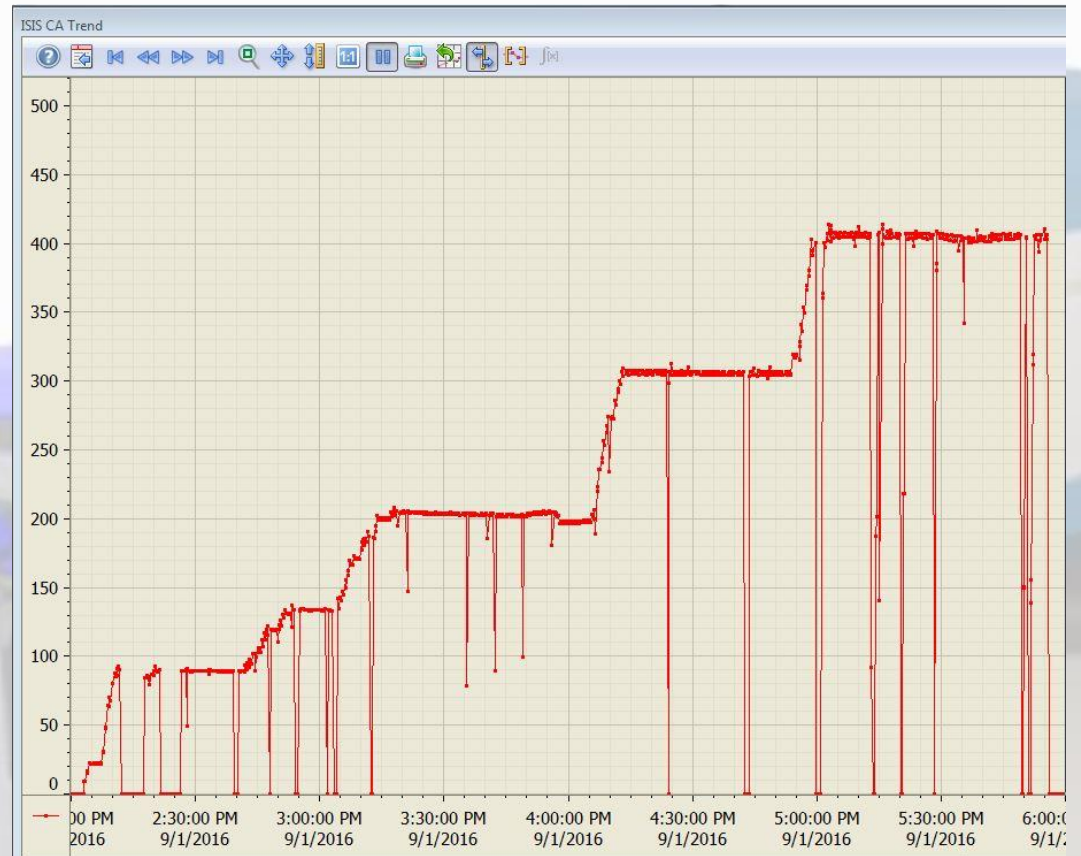
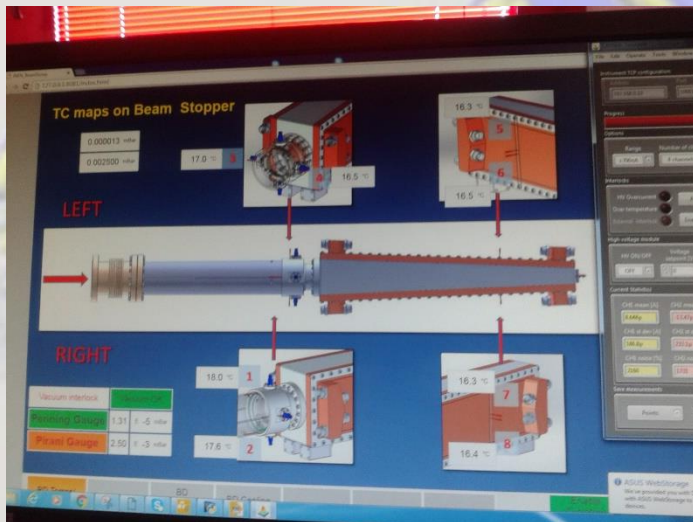
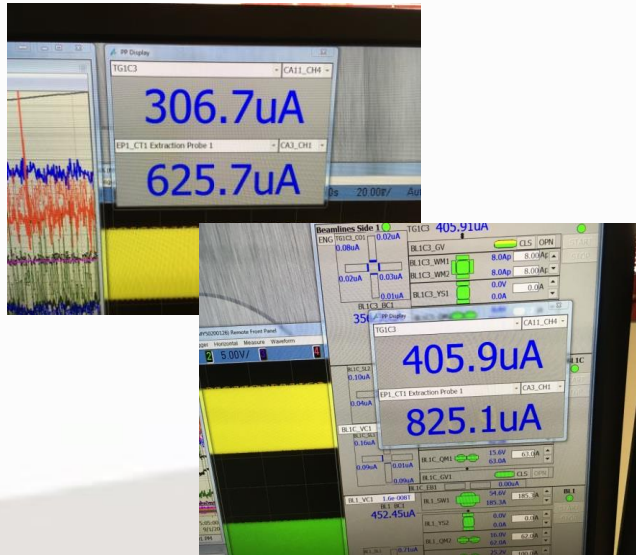
- Fiducialization of BD;
- Network Measurements in A6;
- Beam line fiducialization;
- BD placement and alignment;



It's ready for alignment in A6 room!



Tuned in 100 $\mu$ A increments: 100, 200, 300 and 400 $\mu$ A.







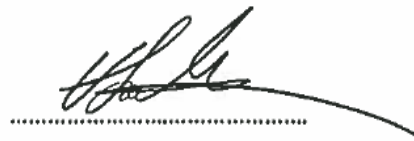
## Proposal

Based on the 70p Second Contract Amendment executed on January 29<sup>th</sup> 2016, Best proposes the following revised milestone schedule.

Milestone	Target
MS0: Contract effective date	Complete
MS1: Submitting technical docs to INFN-LNL for approval	Complete
MS2: Start of development and manufacturing	Complete
MS3: Start of cyclotron factory tests	Complete
MS4: Delivery of cyclotron to INFN-LNL (leaving Ottawa)	Complete
MS5: Beginning of installation at INFN-LNL	Complete
MS6: End of installation and start of on-site test	Complete
MS7: Cyclotron subsystems commissioning	done
MS8: Beam acceleration at 70MeV inside the cyclotron	done
MS9: Dual beam operation test	done
MS10: End of Site Acceptance Test	End of October beginning of november
MS11: Completion of minor activities highlighted during the commissioning.	Beginning of 2017

This memorandum is official when approved by one of the following:

Vasile Sabaiduc  
Director of Operations  
Best Cyclotron Systems Inc.





## What to do list

- **Complete the Site Acceptance Test**
- **Follow the training made by BEST**
- Operate the machine by ourselves
- Organize the workshop(s) for the maintenance
- Organize the storage for the spare parts, new and used stock house
- Organize the hardware refurbishing





M. Maggiore, P. Antonini, D. Campo, A. Calore, L. Pranovi, **M. Calderolla**  
L. Calabretta, C. De Martinis  
LNL infrastructures personnel