Status report on CNAO

Marco Pullia [CNAO Foundation]
on behalf of the CNAO collaboration

What is the CNAO Foundation

No profit organisation (Foundation) created with the financial law 2001 to build the national center for hadrontherapy designed by TERA Foundation

In 2001 CNAO is created

At the end of 2003 CNAO acquires the project and hires the design group

Today CNAO is co-ordinating the construction of the whole center.

Main goals

- To treat patients using hadrontherapy
- To perform clinical and radiobiological reasearch

CNAO Organisation

E. Borloni	*President*	
G. Azzaretti	**F - Policlinico San Matteo**	*Vice-president*
G. Di Benedetto	**F – "Fondazione Policlinico"**	
G. De Leo	**F - Istituto Neurologico C. Besta**	
C. Ciani	**F - Istituto Europeo di Oncologia**	
U. Amaldi	**F - Fondazione TERA**	
S. Zurrida	**F - Istituto Nazionale dei Tumori**	
R. Petronzio	**PI - Istituto Nazionale di Fisica Nucleare**	
G. Coggi	**PI - Università di Milano**	
A. Pedotti	**PI - Politecnico di Milano**	
G. Goggi	**PI - Università di Pavia**	
P. Capitelli	**PI - Comune di Pavia**	

Collaborating Institutions

NATIONAL

INFN: co-direction, involvement/responsibility in many technical issues (15), formation

Town of Pavia: land and authorisations

University of Milan: medical coordination and formation

Polytechnic of Milan: patient positioning, radioprotection and authorisations

University of Pavia: electrical plant, power supplies and betatron, safety, formation

Province of Pavia: logistics and authorisation

University of Turin: interface beam-patient, TPS

INTERNATIONAL

CERN: special magnets, dipole measurements and diagnostics (+ PIMMS heritage)

GSI: linac and special components

LPSC (Grenoble): optics, betatron, low-level RF, control system

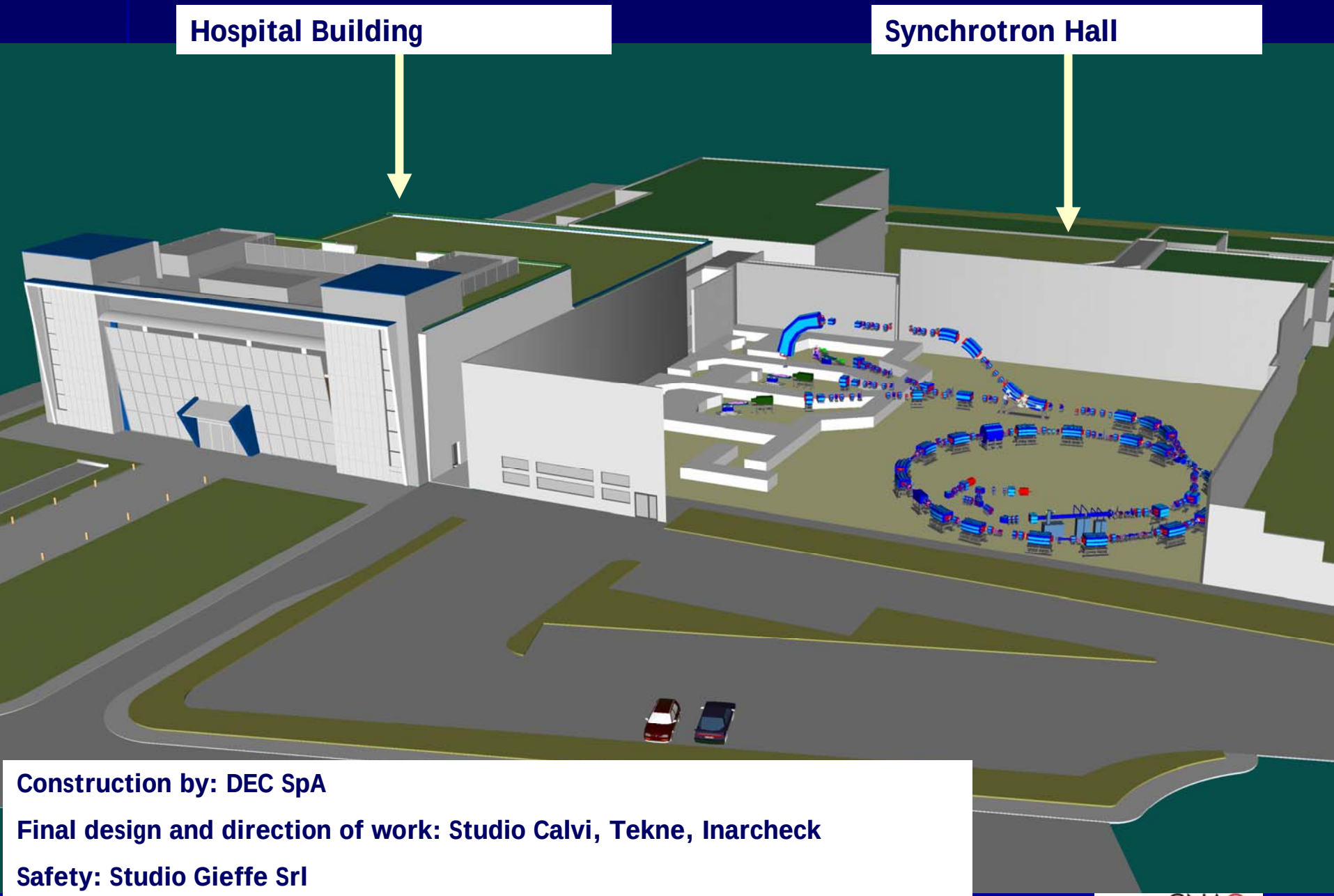
NIRS (Chiba): medical activities, formation

What is the CNAO

The **CNAO** will be the first italian center for deep hadrontherapy.

It will be a synchrotron based proton – carbon ion treatment center.

It is presently under construction in **Pavia**.



Construction by: DEC SpA

Final design and direction of work: Studio Calvi, Tekne, Inarcheck

Safety: Studio Gieffe Srl

CNAO coordinator: F. Gerardi

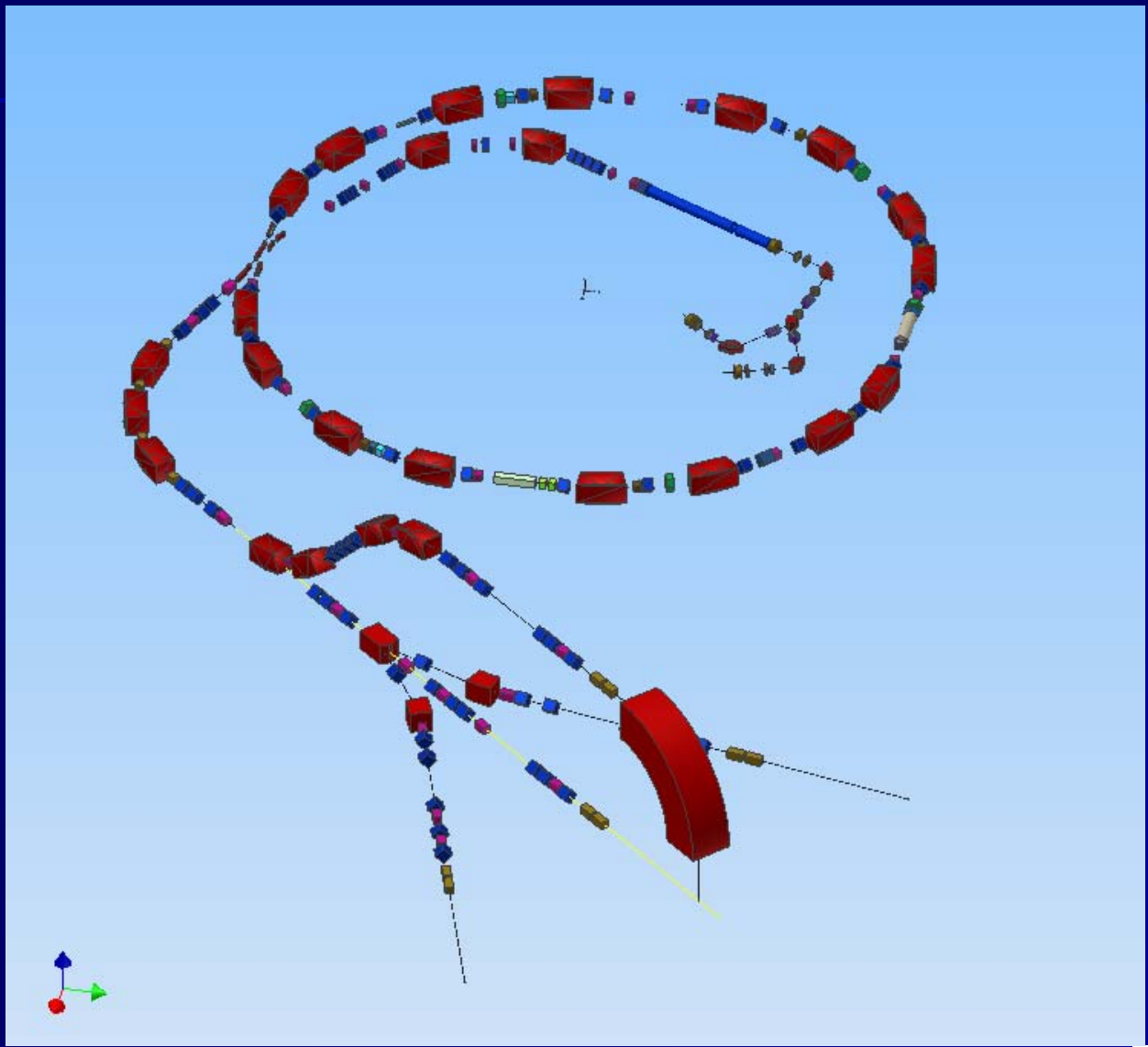
fondazione CNAO

March 2008

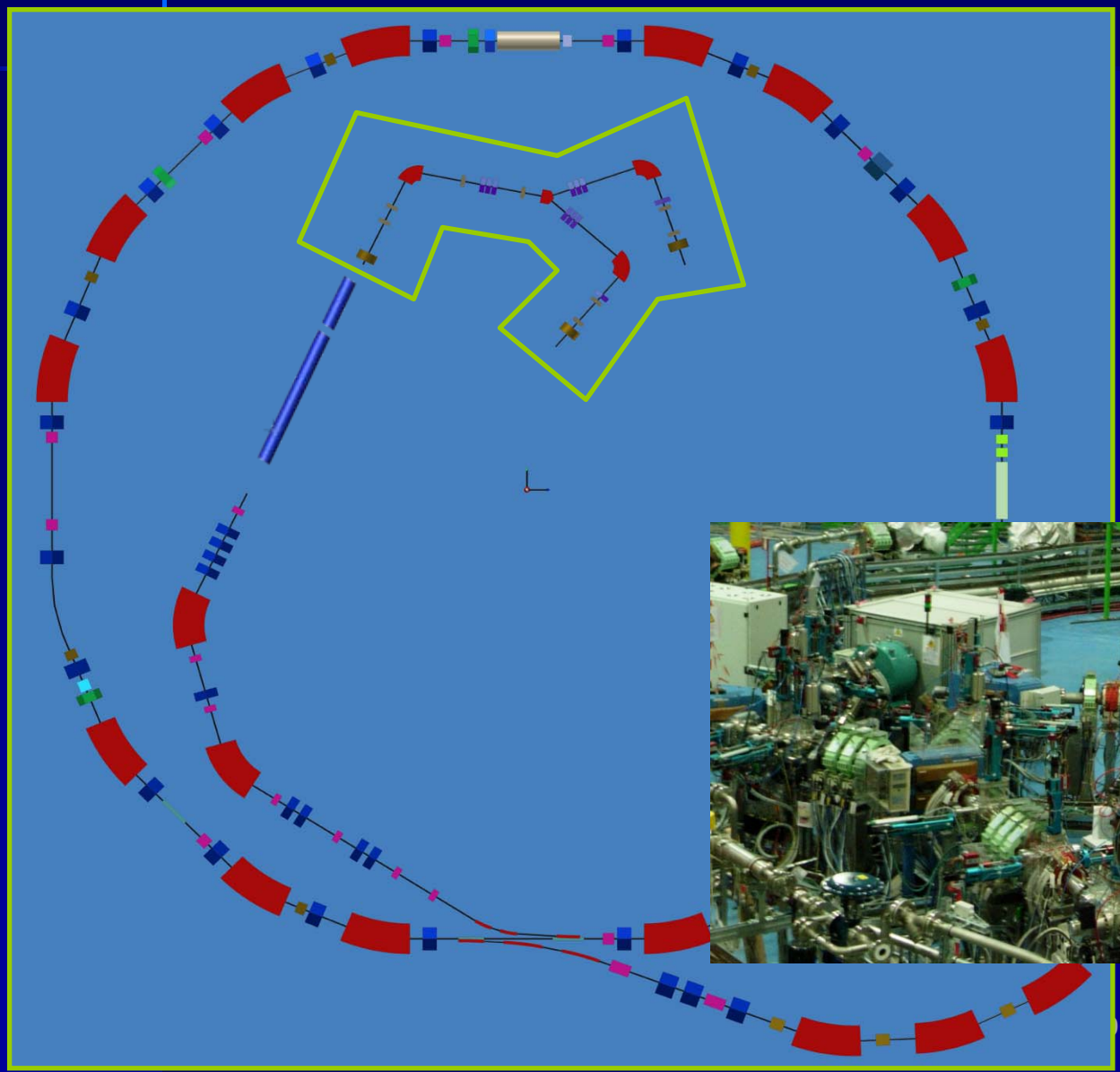
November 2005

Just for comparison

The CNAO accelerator system



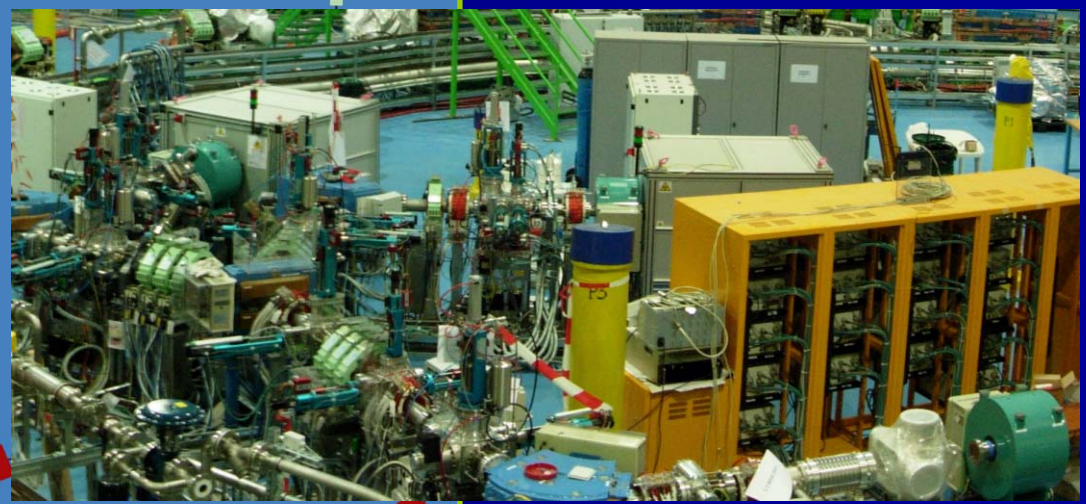
LEBT



LEBT

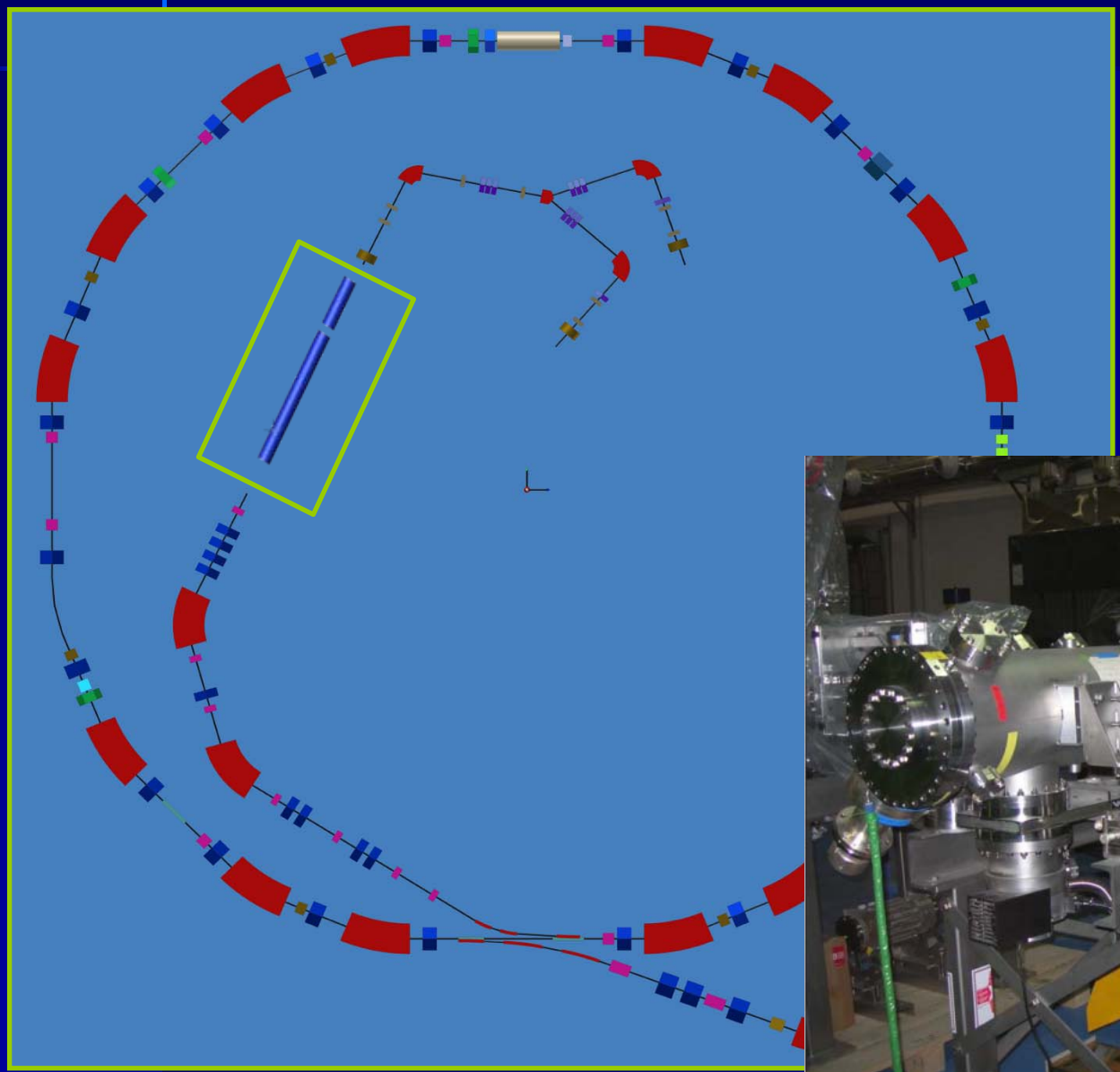
0.008 MeV/u H^{3+}
0.008 MeV/u C^{4+}

I ~ 0.7 mA (H^{3+})
I ~ 0.2 mA (C^{4+})



fondazione CNAO

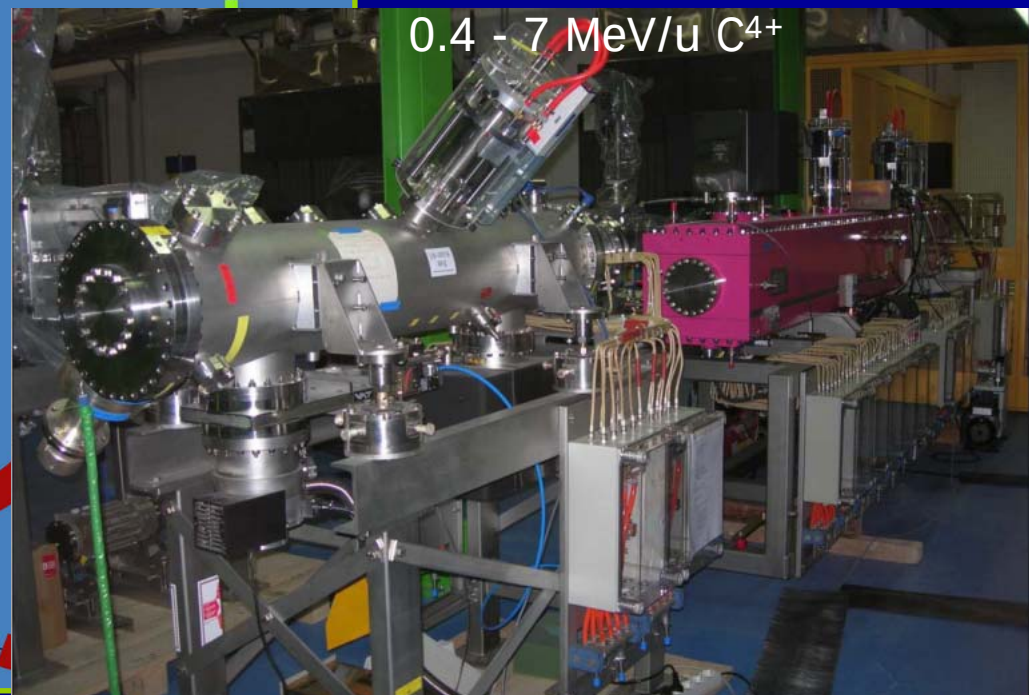
LINAC



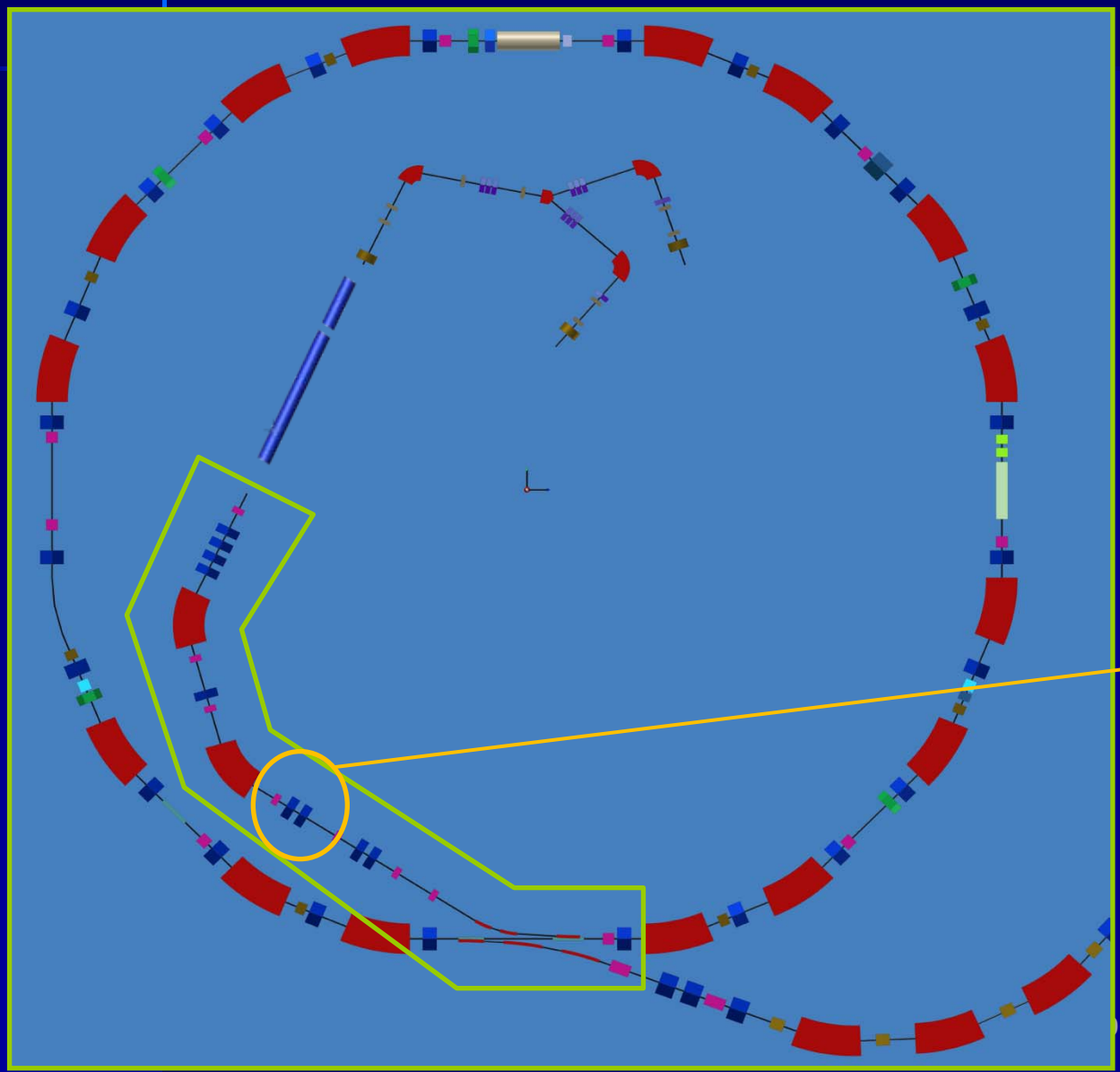
RFQ-LINAC

RFQ
0.008 - 0.4 MeV/u H^{3+}
0.008 - 0.4 MeV/u C^{4+}

LINAC
0.4 - 7 MeV/u H^{3+}
0.4 - 7 MeV/u C^{4+}



MEBT

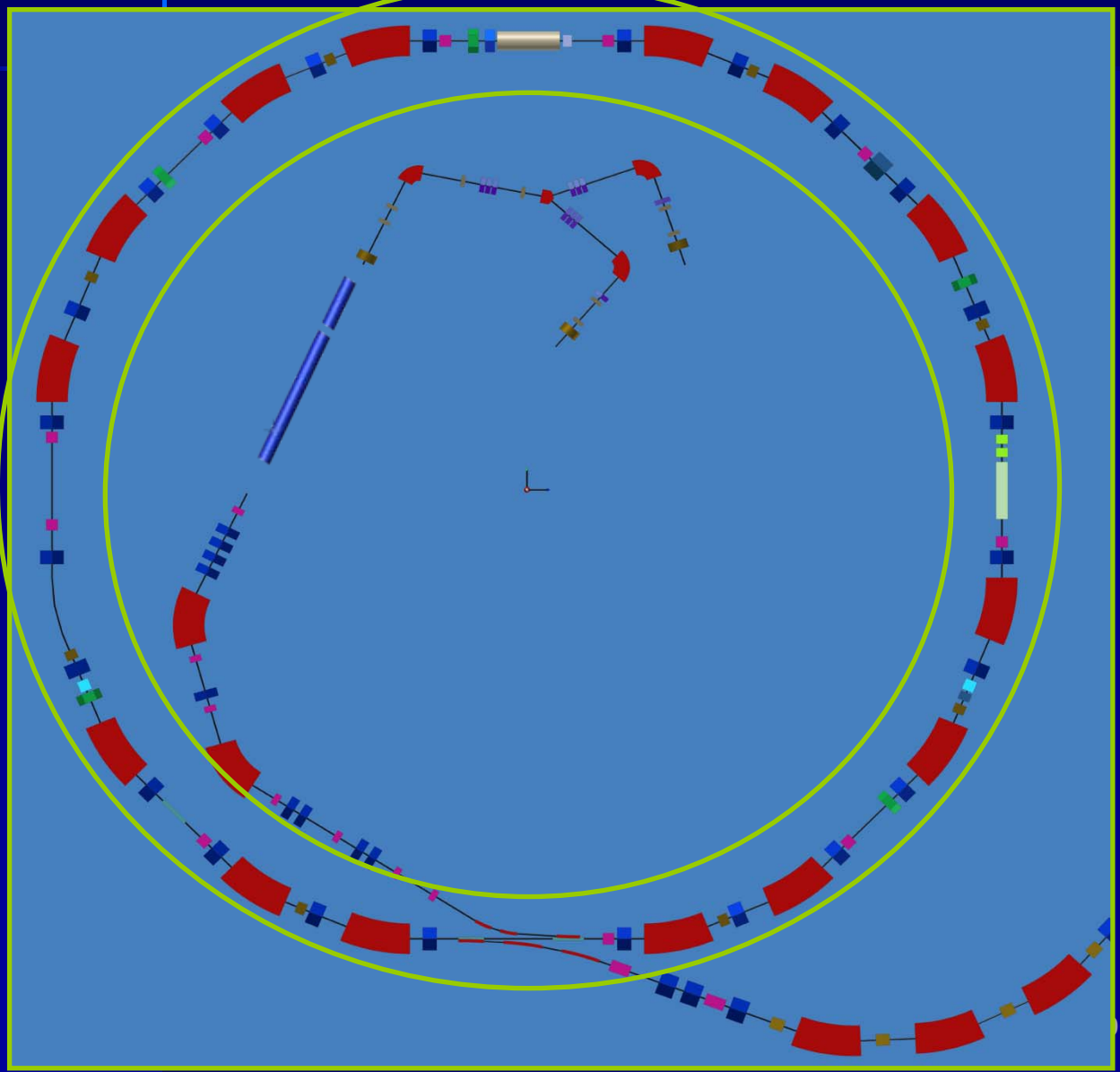


MEBT

7 MeV p
7 MeV/u C^{6+}

I ~ 0.7 mA (p)
I ~ 0.15 mA (C^{6+})

Synchrotron



Synchrotron

Based on PIMMS

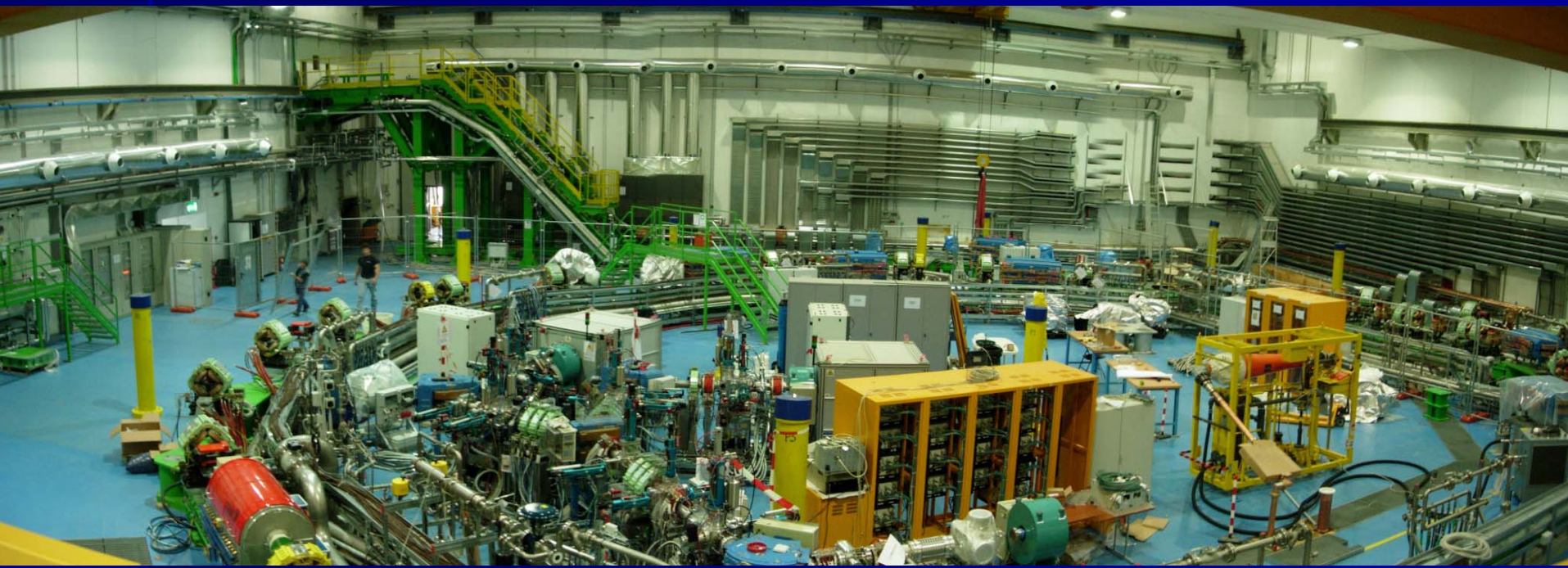
7-250 MeV p
7-400 MeV/u C

I ~ 0.1-6 mA (p)
I ~ 0.03-1.5 mA (C)

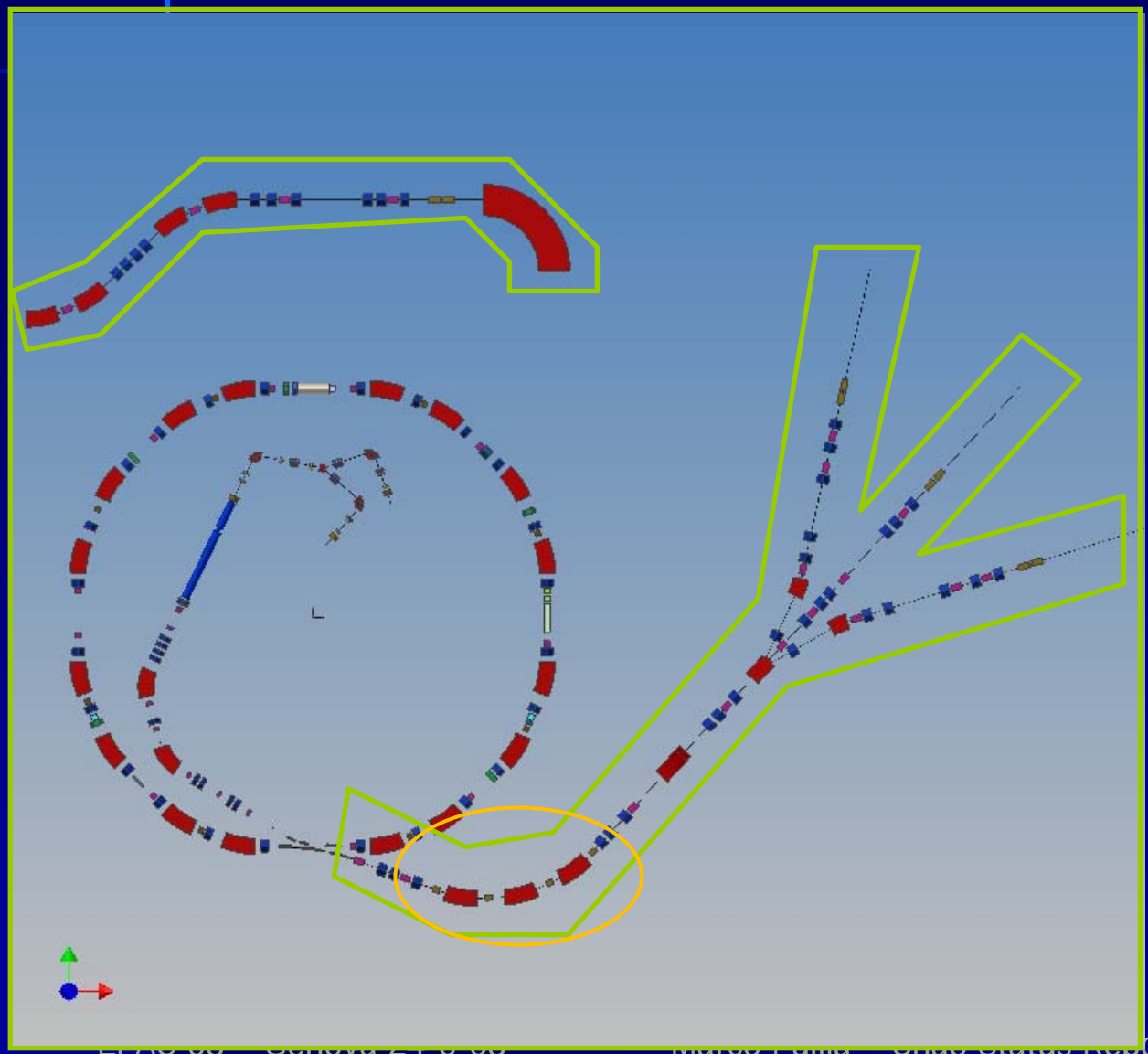
Slow extraction

fondazione CNAO

Synchrotron hall today



HEBT



HEBT

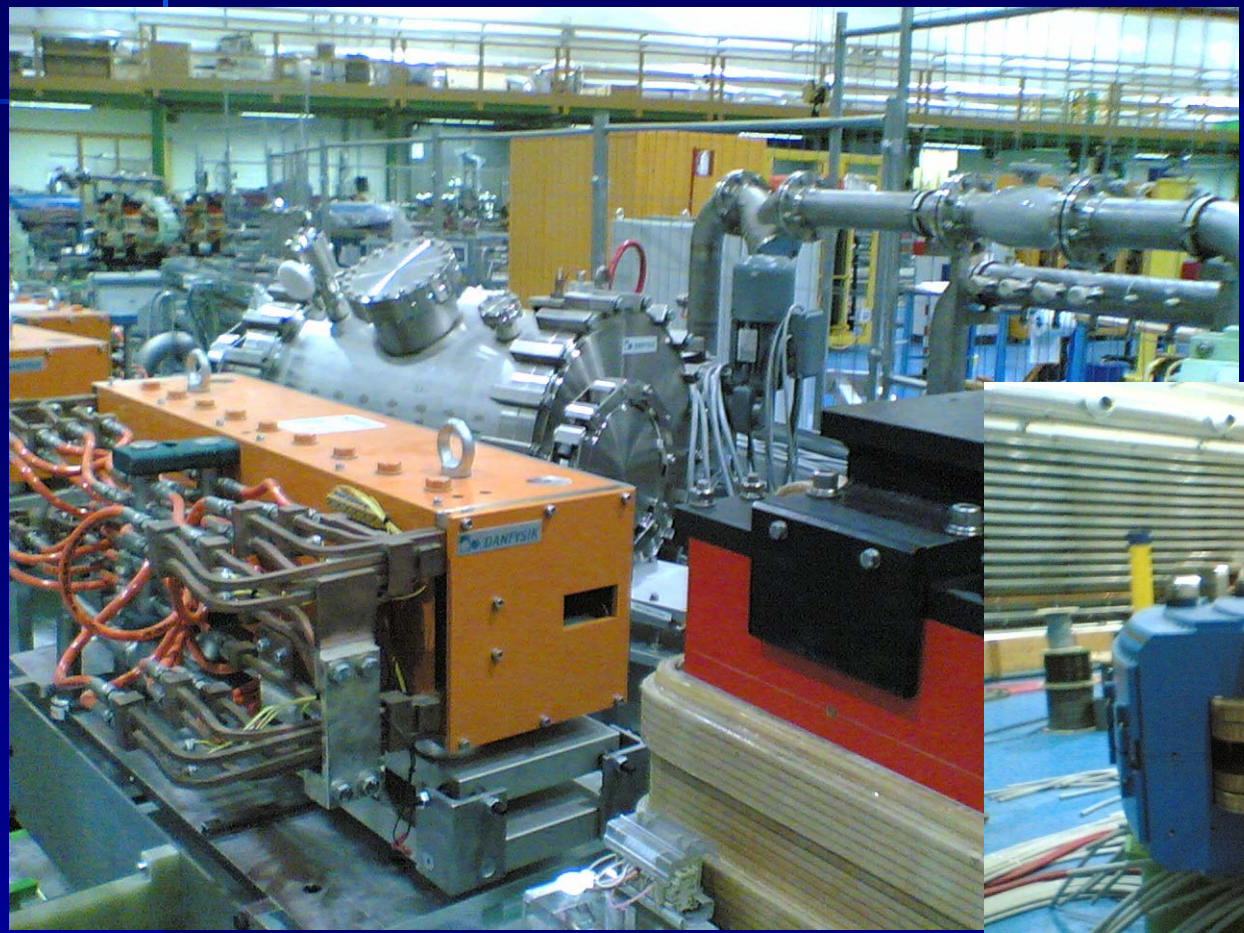
60-250 MeV p
120-400 MeV/u C

< 10^{10} p/spill (~2nA)
< 4 10^{8} C/spill (~0.4nA)

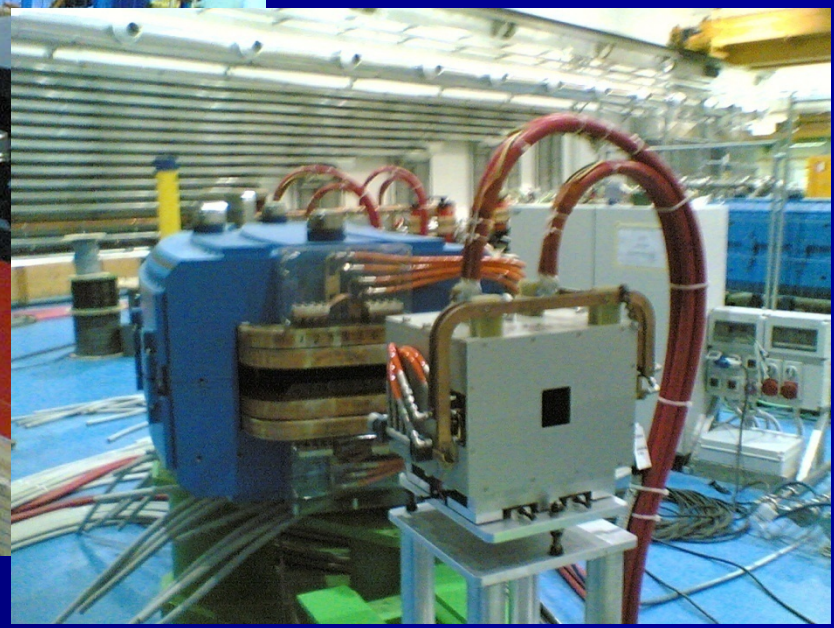
The first magnets have been put in place

Chopper

Special Magnets



UniPv



Septa and fast magnets delivered and installed

Power supplies

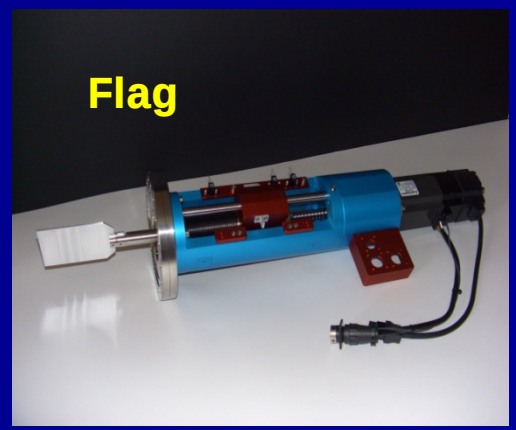
More than 180 machines

Beam Diagnostics

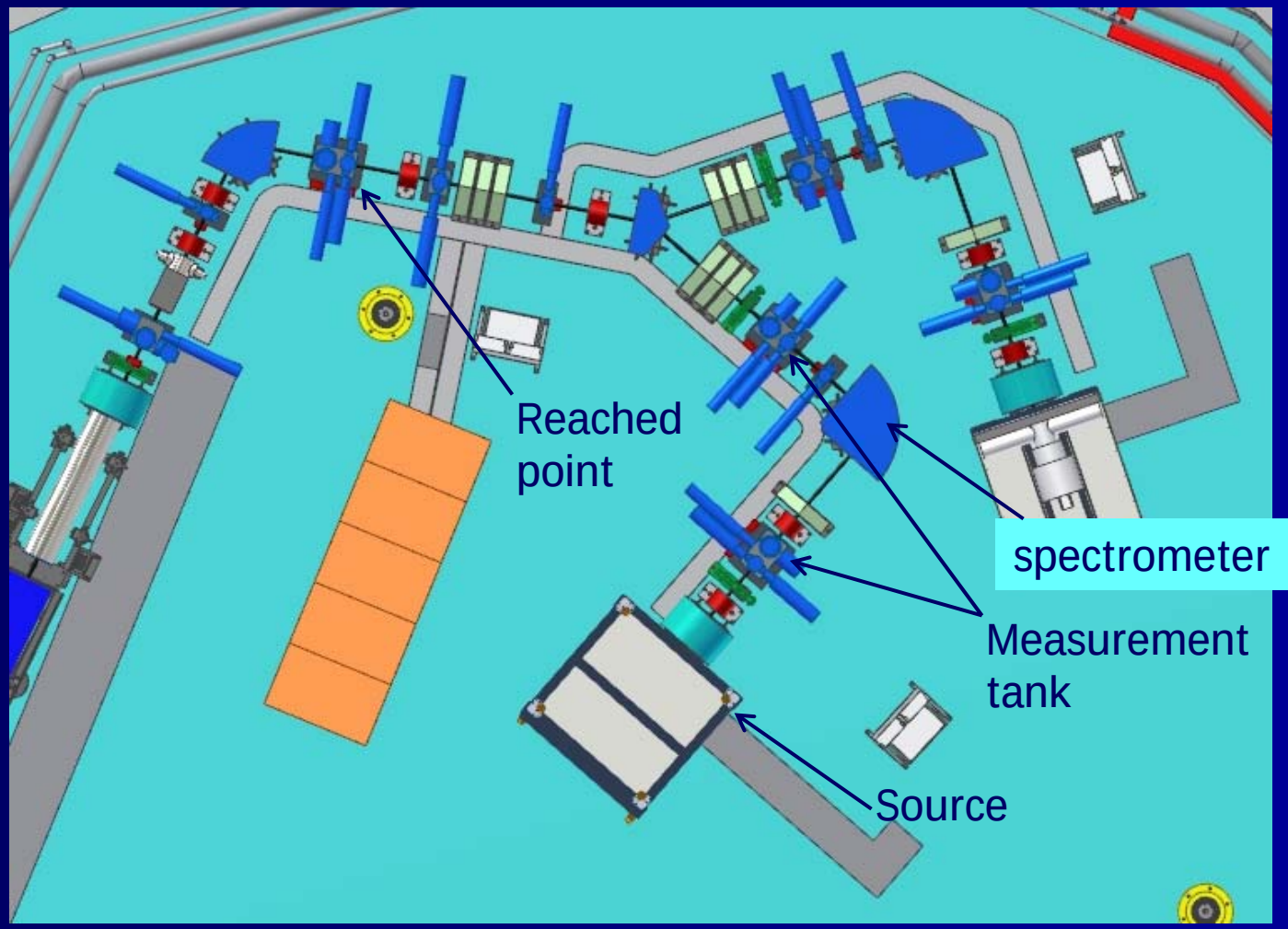
Beam Position Monitor

Designed and specified by CNAO-INFN-CERN

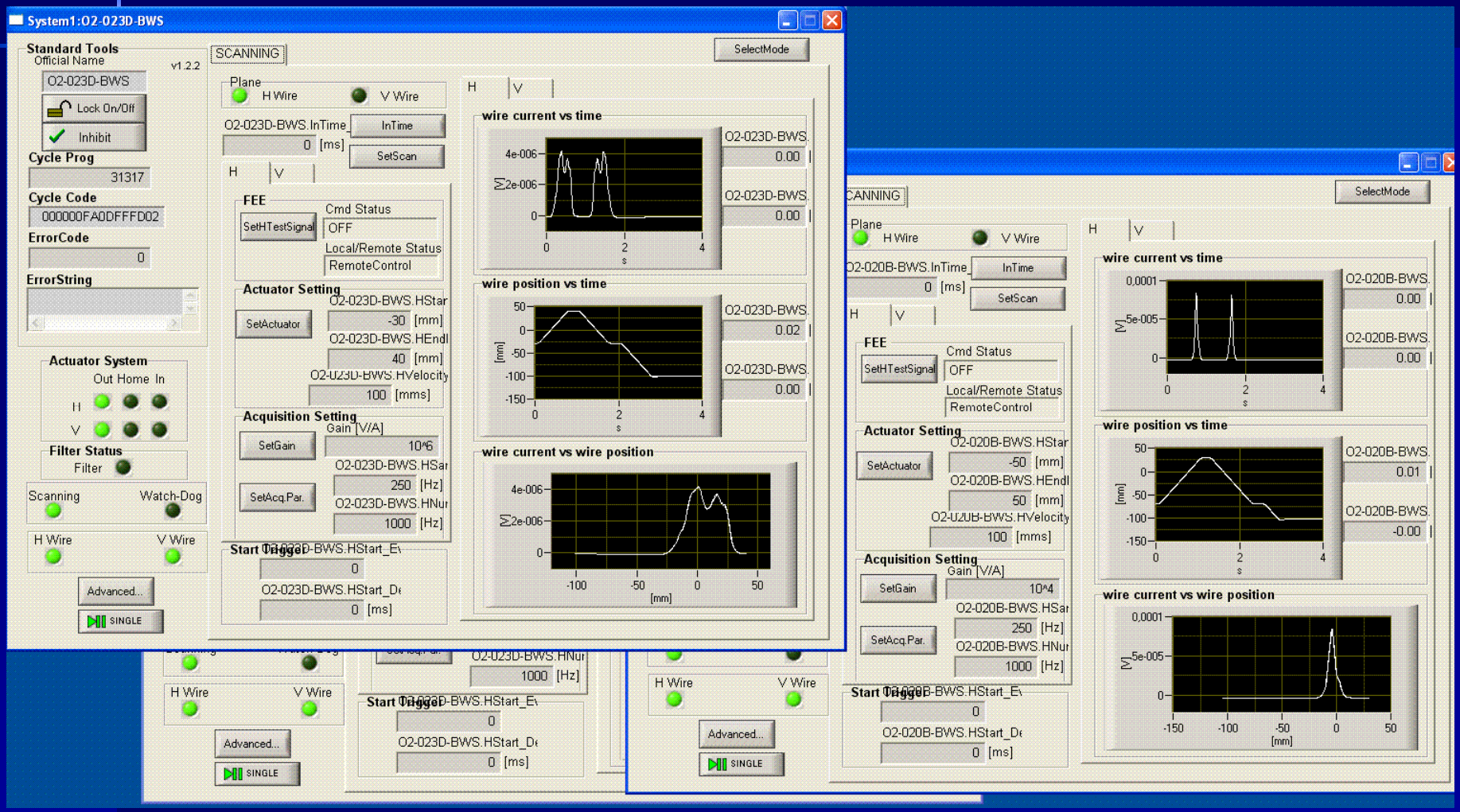
LEBT Measurement station



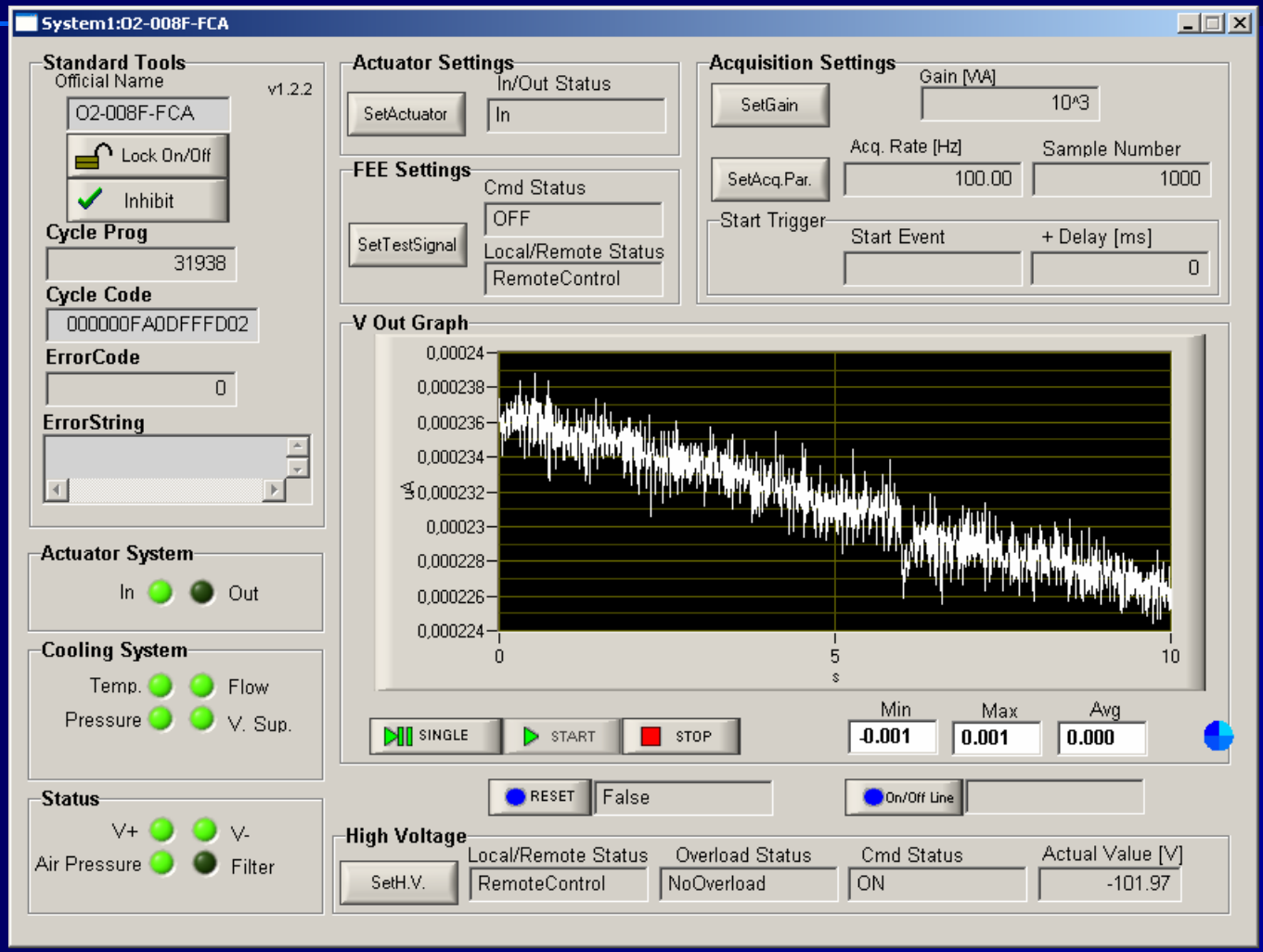
Sources and LEBT commissioning



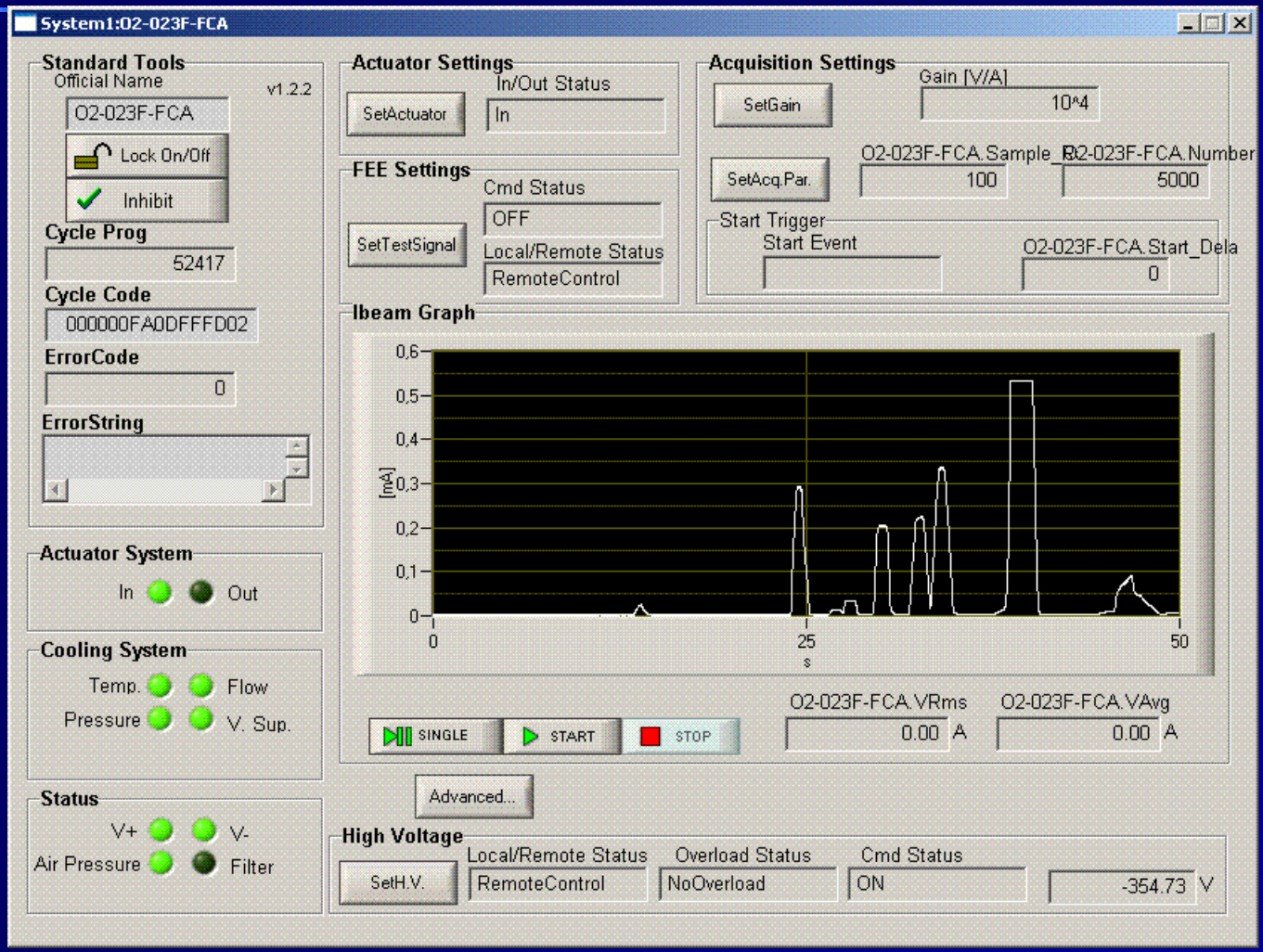
Beam profiles



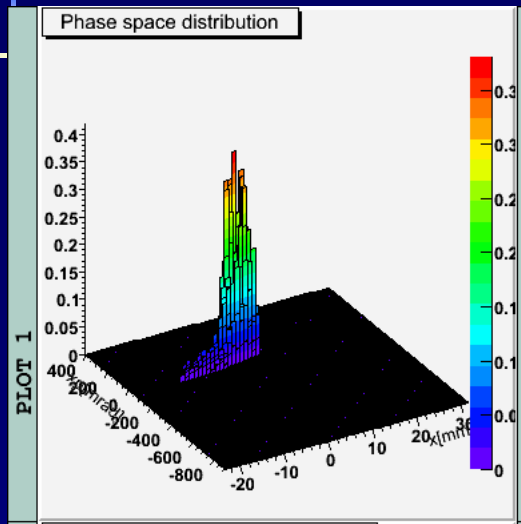
Beam current

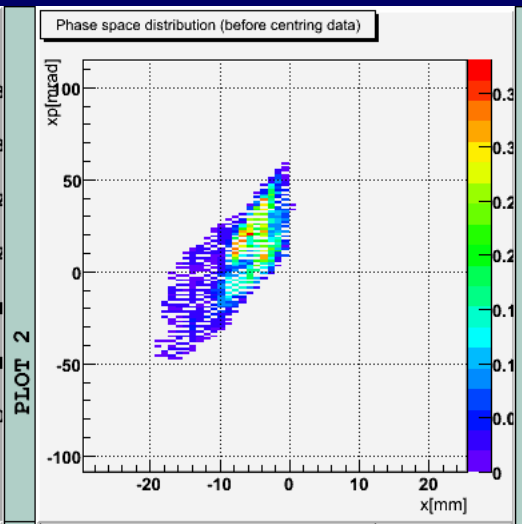


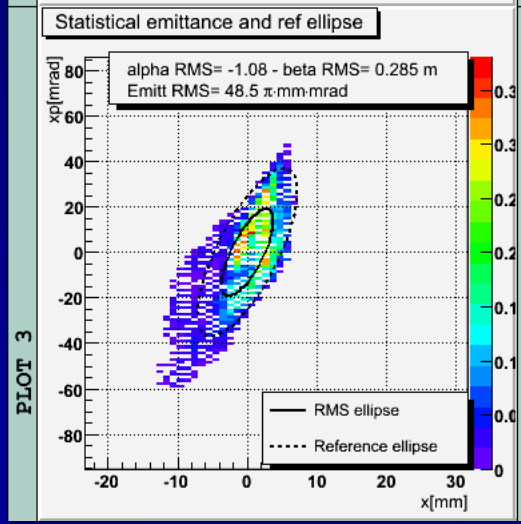
Spectrum

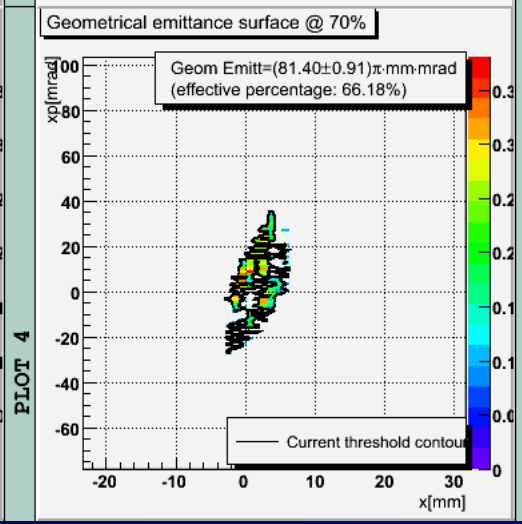

System1:O2-023F-FCA
Standard Tools
Official Name
v1.2.2
O2-023F-FCA
Lock On/Off
Inhibit
Cycle Prog
52417
Cycle Code
000000FA0DFFFD02
ErrorCode
0
ErrorString
Actuator System
In
Out
Cooling System
Temp.
Flow
Pressure
V. Sup.
Status
V+
V-
Air Pressure
Filter
Actuator Settings
SetActuator
In/Out Status
In
FEE Settings
SetTestSignal
Cmd Status
OFF
Local/Remote Status
RemoteControl
Acquisition Settings
SetGain
Gain [V/A]
10^4
SetAcq.Par.
O2-023F-FCA.Sample_R
100
O2-023F-FCA.Number
5000
Start Trigger
Start Event
O2-023F-FCA.Start_Dela
0
Ibeam Graph
[mA]
0,6
0,5
0,4
0,3
0,2
0,1
0
0
25
50
s
SINGLE
START
STOP
O2-023F-FCA.VRms
0.00 A
O2-023F-FCA.VAvg
0.00 A
Advanced...
High Voltage
SetH.V.
Local/Remote Status
RemoteControl
Overload Status
NoOverload
Cmd Status
ON
-354.73 V

Emittance









EMITTANCE MEASUREMENT PROGRAM

Input file name:
\\DatixSLABWS-080605-174819.txt

Data elaboration parameters:
Bias thr 0%, Noise thr 3%, centred

♦ PLOT 1

3D plot of elaborated data used to compute RMS and Geom emittance.

♦ PLOT 2

Top-view of not centred data.
Barycenter: x=-6.318 mm, xp=11.807 mrad

♦ PLOT 3

Top-view of elaborated data. RMS and reference ellipses plotted on it.

Reference ellipse: beam charge inside 86%, alpha=-1.08, beta=0.285 m, emitt=180 π·mm·mrad

RMS ellipse: beam charge inside 38%, alpha=-1.08, beta=0.285 m, emitt=48.5 π·mm·mrad

♦ PLOT 4

Top-view of elaborated data contributing to the Geom emitt computation.

Required=70.0%, Effective=66.2%
Current threshold=0.095 uA

Maximum discrepancy between 70.0% and 66.2% geom emitt is 216.45π·mm·mrad

Geom Emitt at 66.2%=(81.40±0.91)π·mm·mrad

fondazione CNAO

Summary of commissioning so far

- Analysis line:
  - 1 solenoid
  - 1 spectrometer
  - 2 diagnostics tanks
- Measurements:
  - Spectrum
  - Profile
  - Current (36h)
  - Emittance…
- Hardware:
  - Sources
  - Power supplies
  - Magnets
  - Beam diagnostics
  - Vacuum
  - Cooling
  - Control system
  - …

Acknowledgements

- CNAO is the fruit of a large and complex collaboration. What has been shown is the result of many years of work and many joined efforts, which I want to acknowledge. I therefore want to thank all those people and institutions who have contributed.

Conclusions

CNAO construction is almost finished

Commissioning has started

CNAO is no more a dream, it’s becoming true

- **Thank you for your attention**