New Digital LLRF System for CNAO Linear Accelerator

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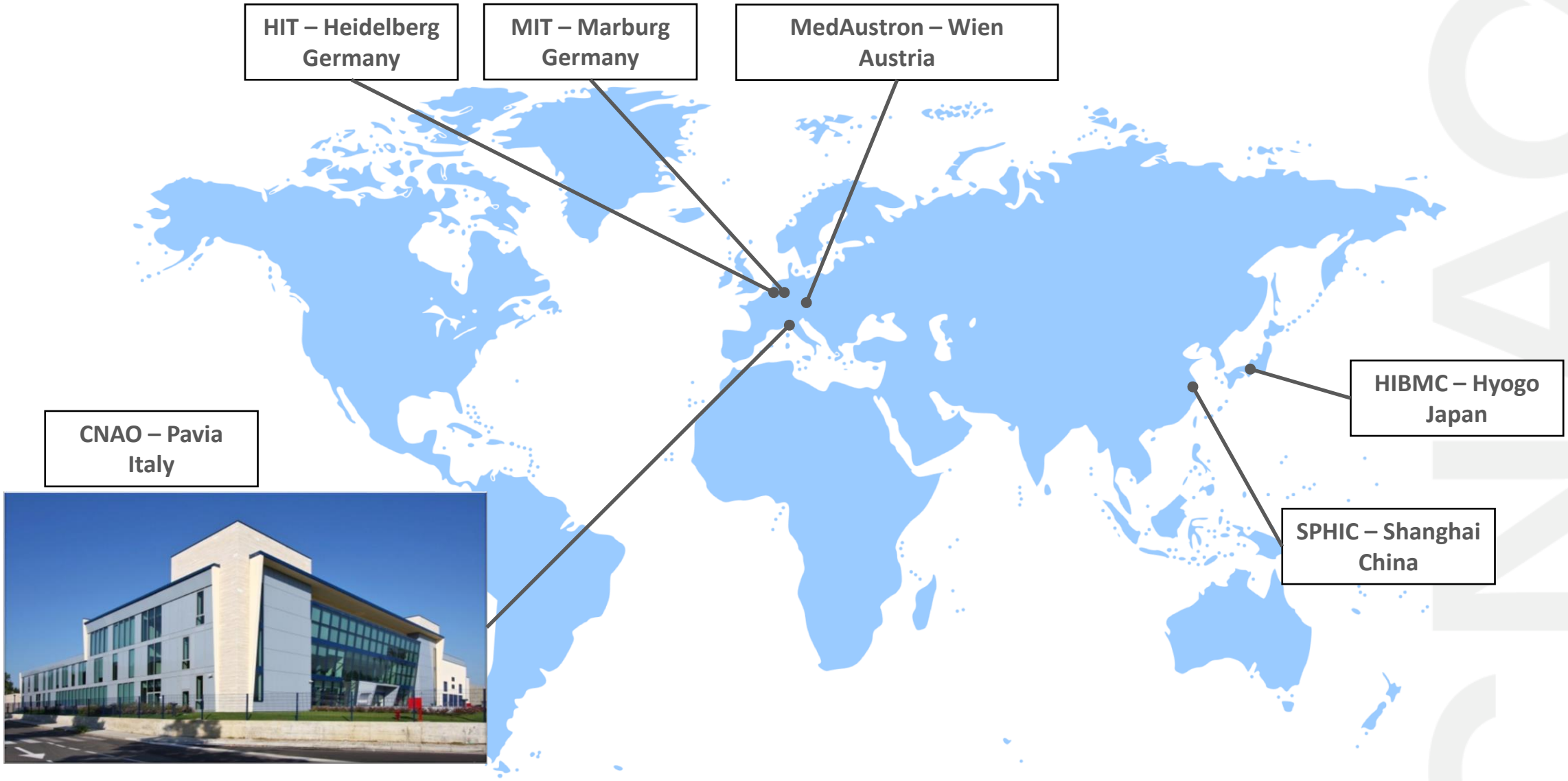
Libera Workshop 2022

Summary

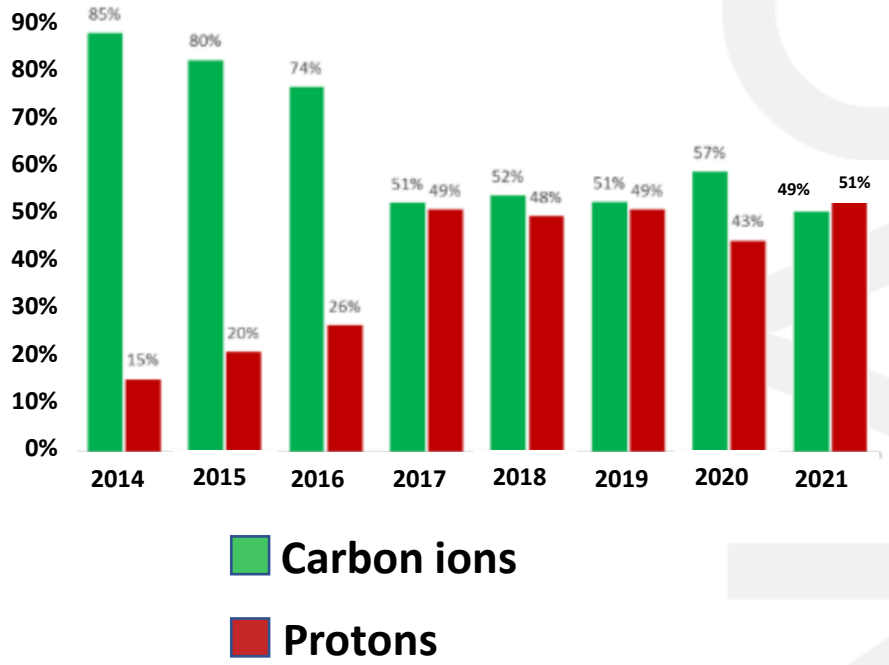
- CNAO overview
- Current LINAC system
- New features with Libera LLRF
- Final considerations

National Center for Oncological Hadrontherapy



CNAO figures

- Chondrosarcomas and chordomas of the skull base and column
- Soft tissues sarcomas
- Intracranical meningiomas and brain tumors
- Brain stem and spinal cord tumors
- Bone sarcomas and osteosarcomas
- Adenoid cystic carcinoma of salivary glands and sinonasal tumors
- Tumors in patients affected by genetic syndromes
- Retreatment of already radio treated areas

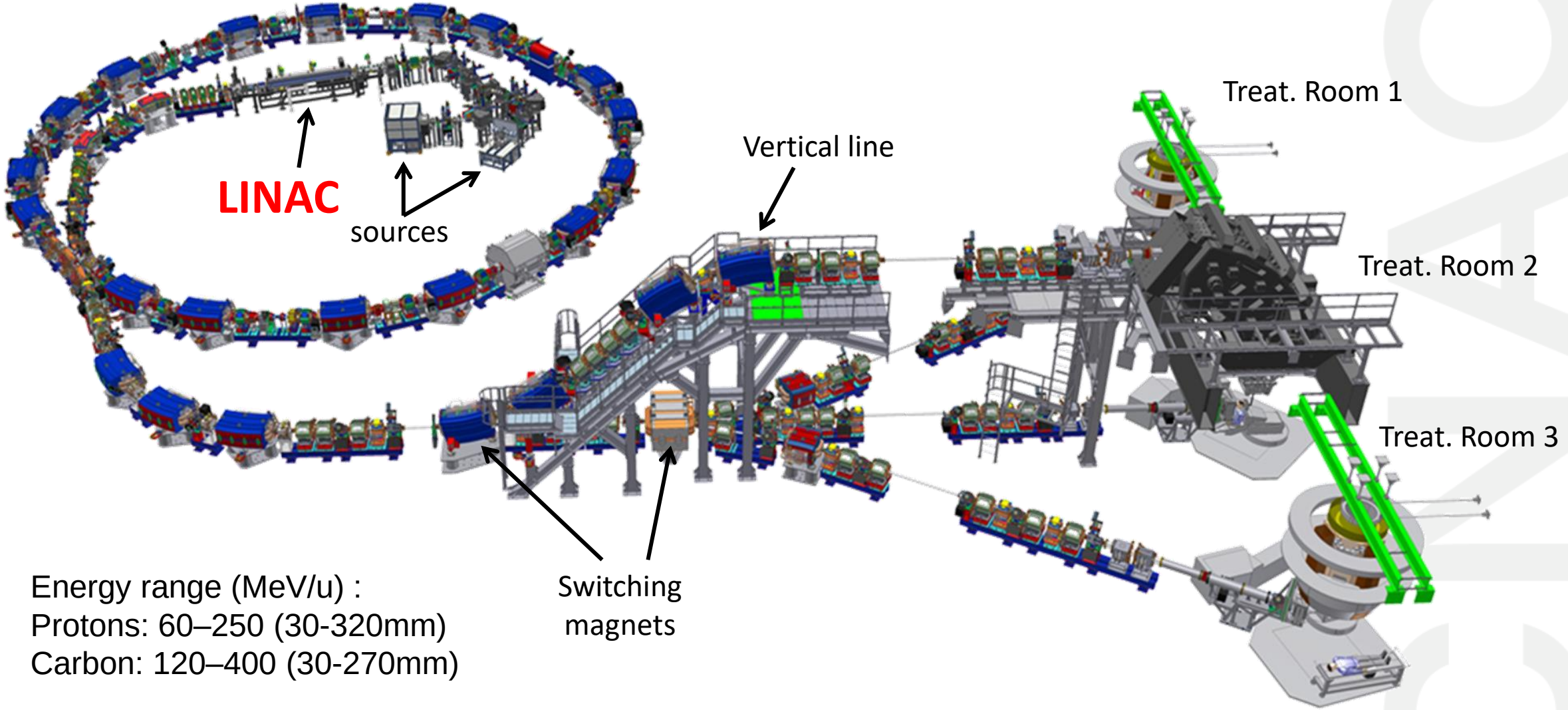


- 3800 patients treated since 2011
- 562 patients treated in 2021
- 2022 projection: +5% vs 2021

Project goals

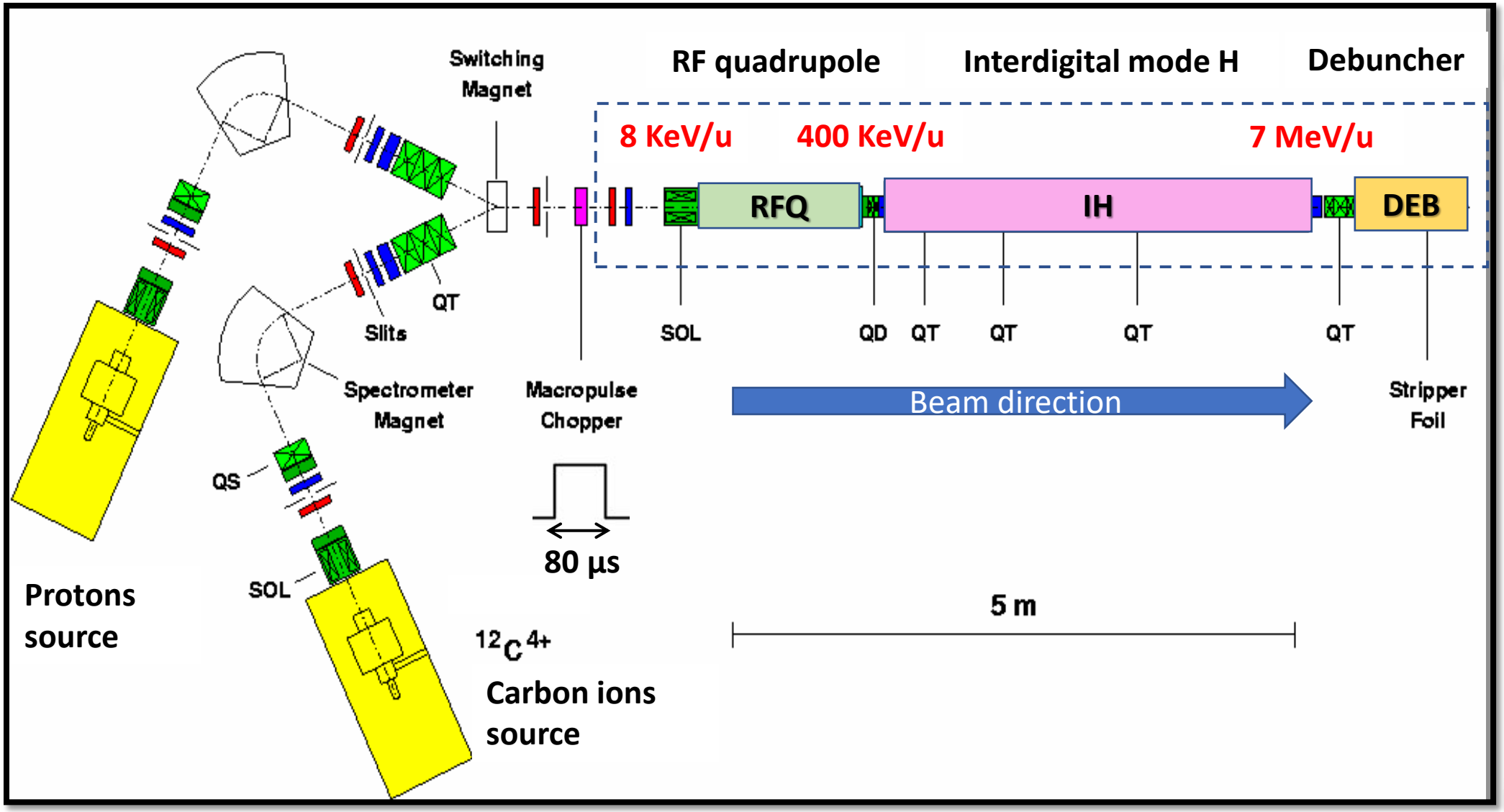
- Reduce treatment timing
- Improve machine reliability and stability

CNAO machine

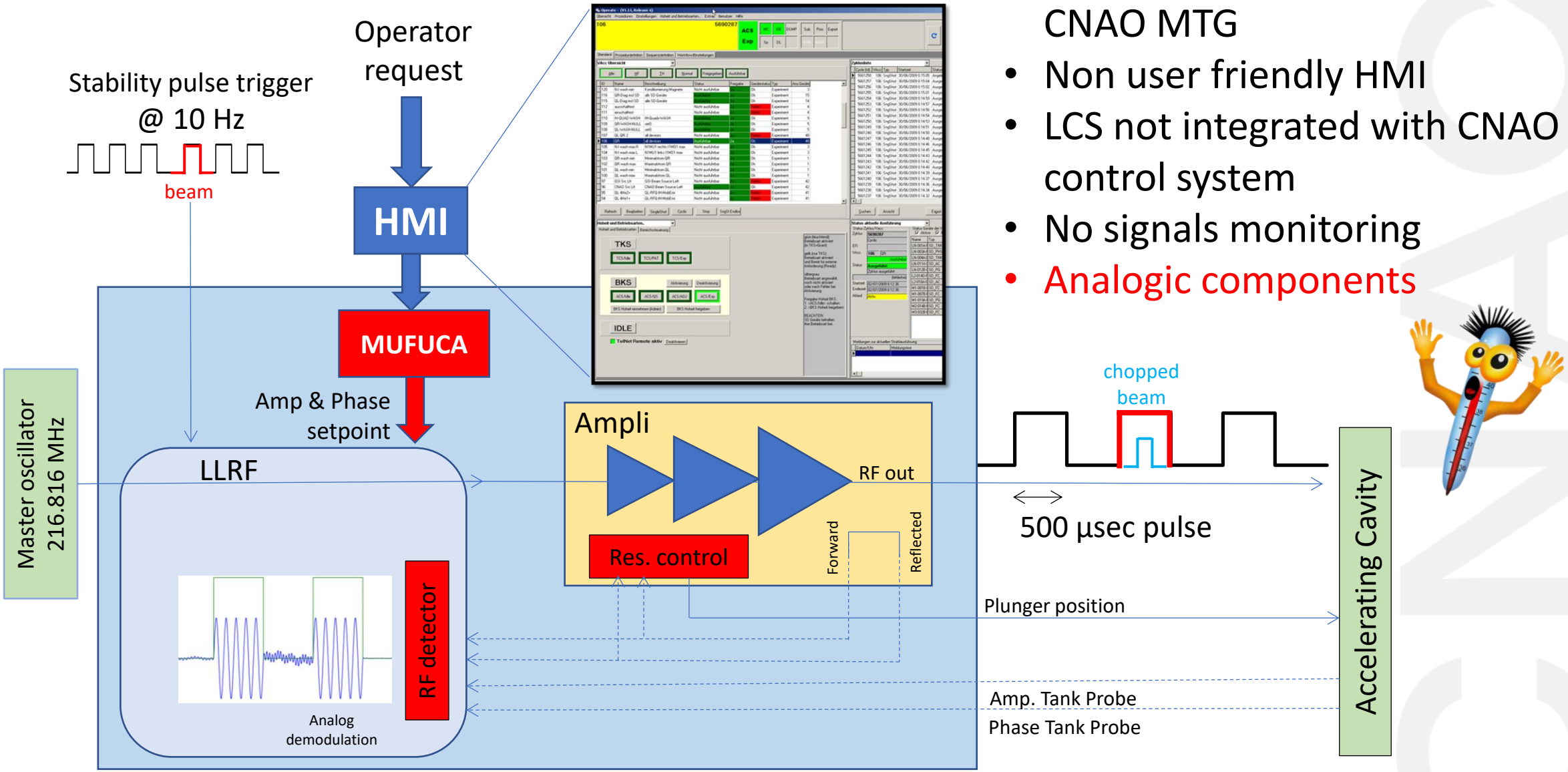


Energy range (MeV/u) :
Protons: 60–250 (30-320mm)
Carbon: 120–400 (30-270mm)

LINAC system

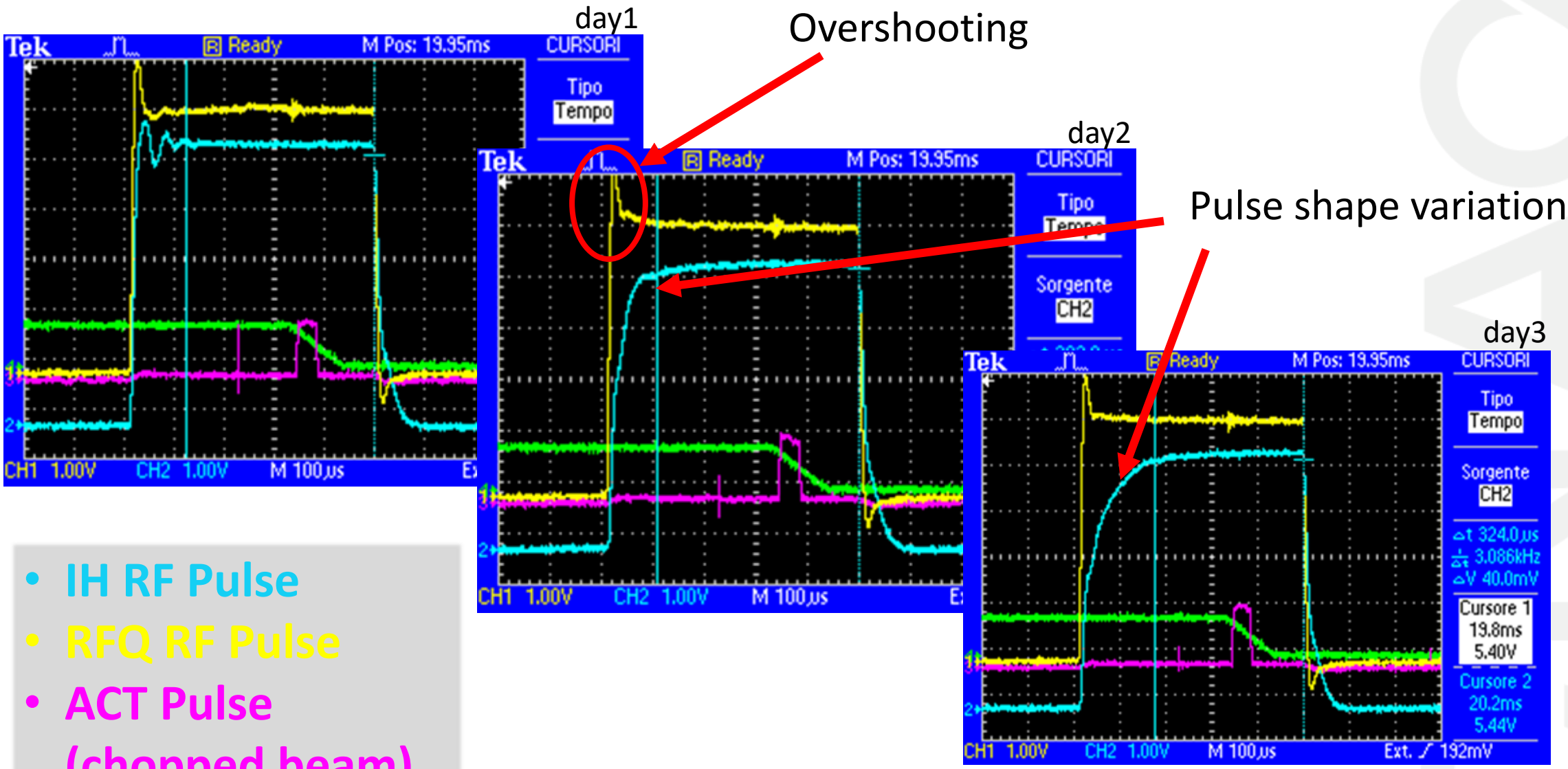


Current LINAC Control System (LCS)



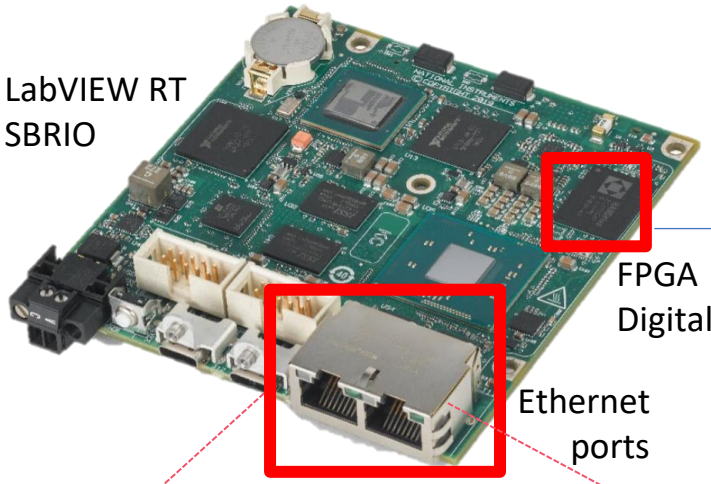
- No direct connection with CNAO MTG
- Non user friendly HMI
- LCS not integrated with CNAO control system
- No signals monitoring
- Analogic components

Undesired behaviours



- IH RF Pulse
- RFQ RF Pulse
- ACT Pulse (chopped beam)

New LCS configuration with Libera LLRF



LabVIEW RT
SBRIO

FPGA
Digital interface

Ethernet
ports

Stability Pulse

LLRF rack

Master oscillator
216.816 MHz

Ethernet switch

LLRF IH

LLRF RFQ

LLRF DEB

RF out

digitals

probes

Amplifier

Amplifier

Amplifier

Cavity

Cavity

Cavity

Read /write nodes
& signals

Telnet client

OPC-UA Server

Slow Timing
receiver

events

CNAO CTRL system

CNAO
Master Timing
Generator

WinCC
SCADA

CNAO CTRL room
User Interface

CNAO
database

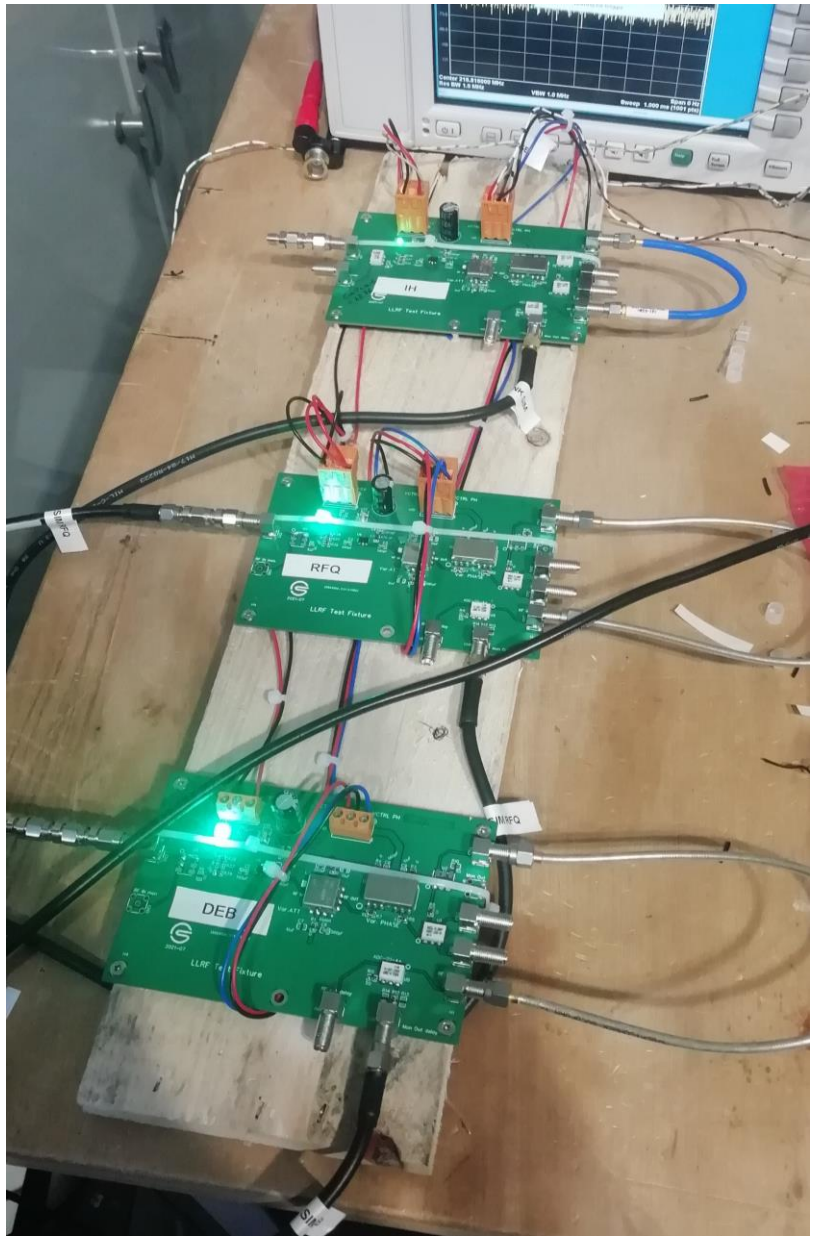
LLRF
Libera
GUI

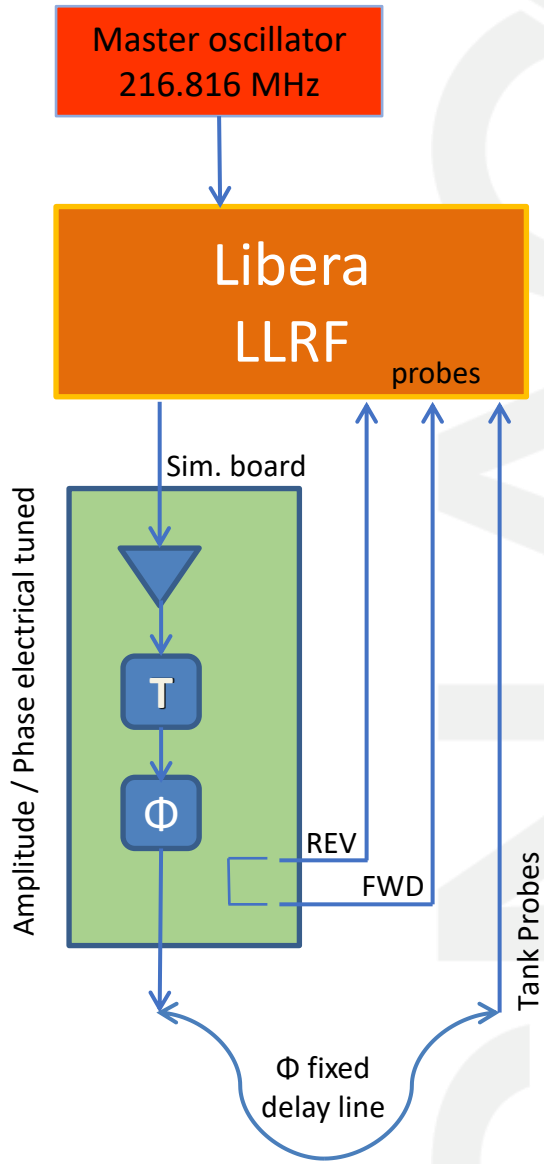
Totem PC

👍 Digital sampling

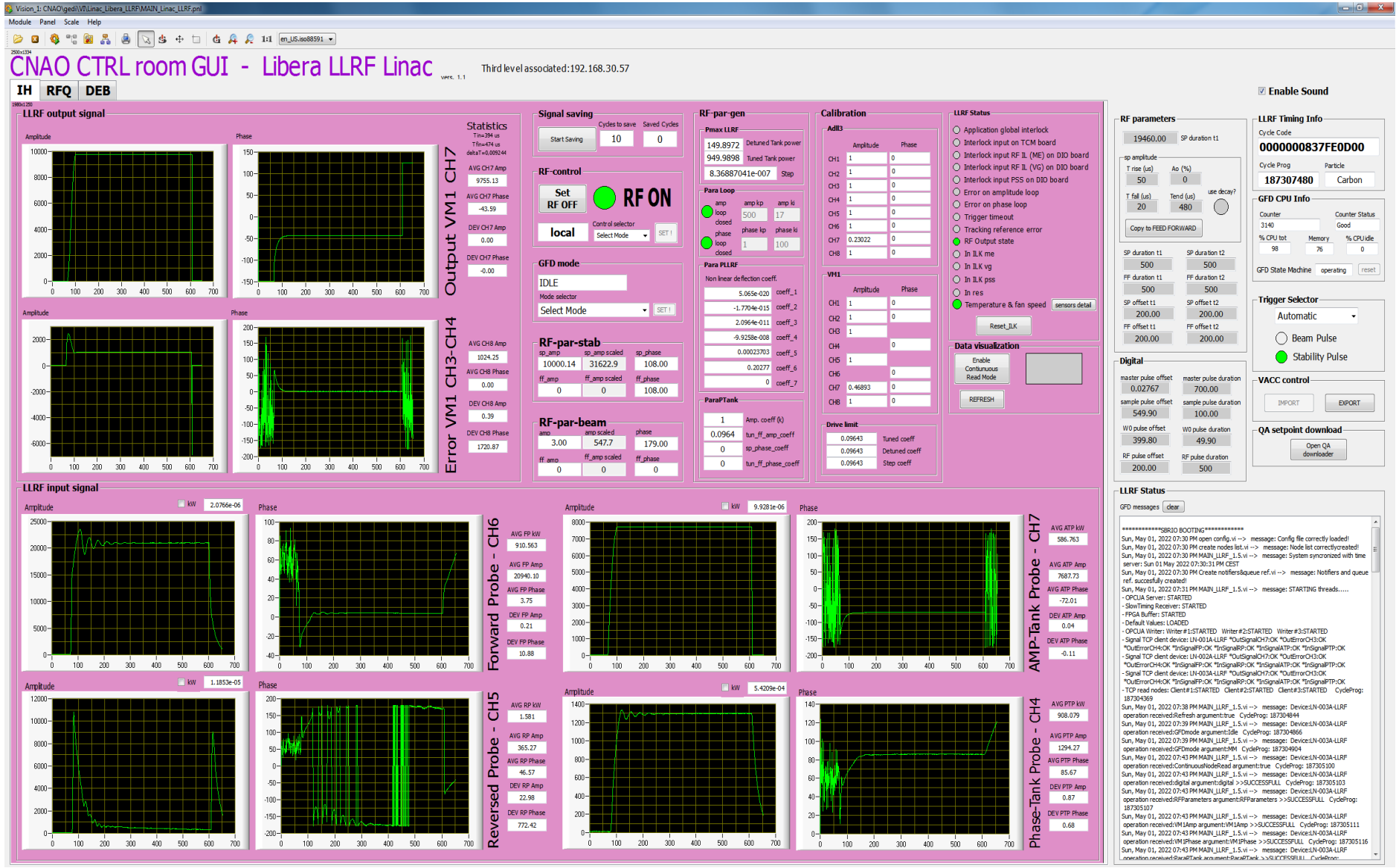
👍 Pulse shaping

Commissioning





Commissioning



- Alarms display and log
- Import/export parameters from/to CNAO database
- Signal statistics and trends
- Automatic procedures
- SBRIO state machine control

Initial results

- Faster troubleshooting

Expected benefits

- Improved system stability
- Failure events reduction

Further LLRF implementations

- Plunger control integration in LLRF
- TOF measurements with LLRF

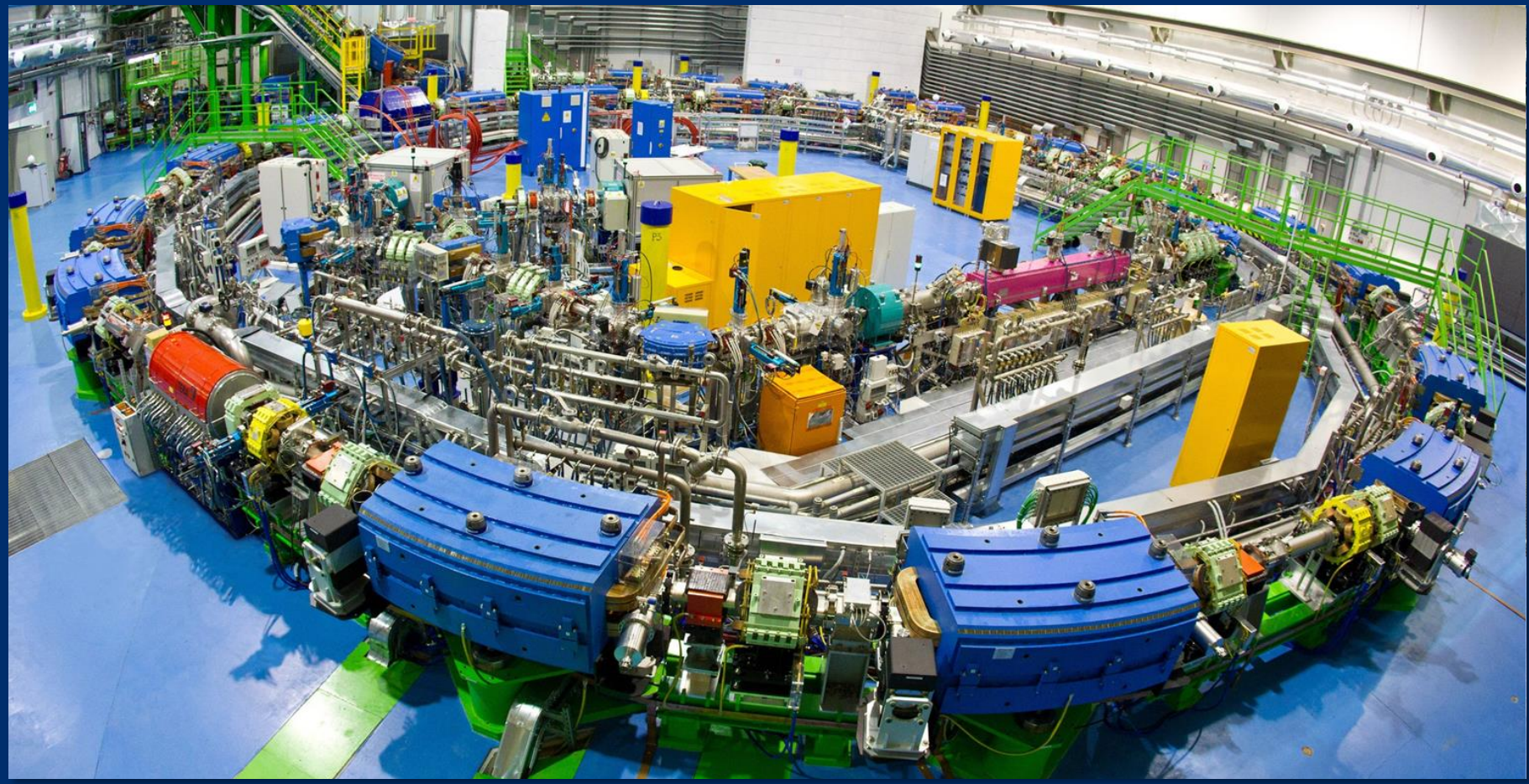
CNAO tomorrow: the third source

From 2023…

- **AISHa** source for Helium, Lithium, Oxygen and Iron for new clinical protocols (He, O, Li) and biological/material experiments for space radiation research.

Thanks for your attention

… and a special remark for Borut Baričevič!



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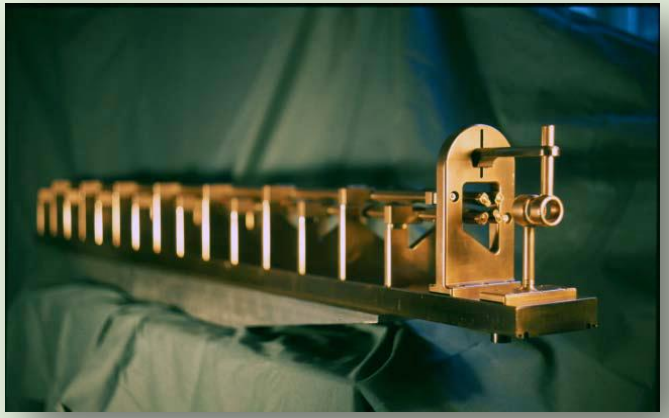
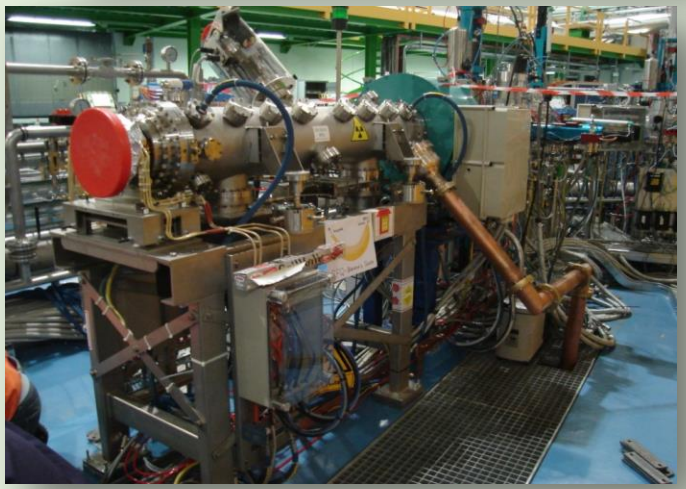
LINAC - cavities

RFQ

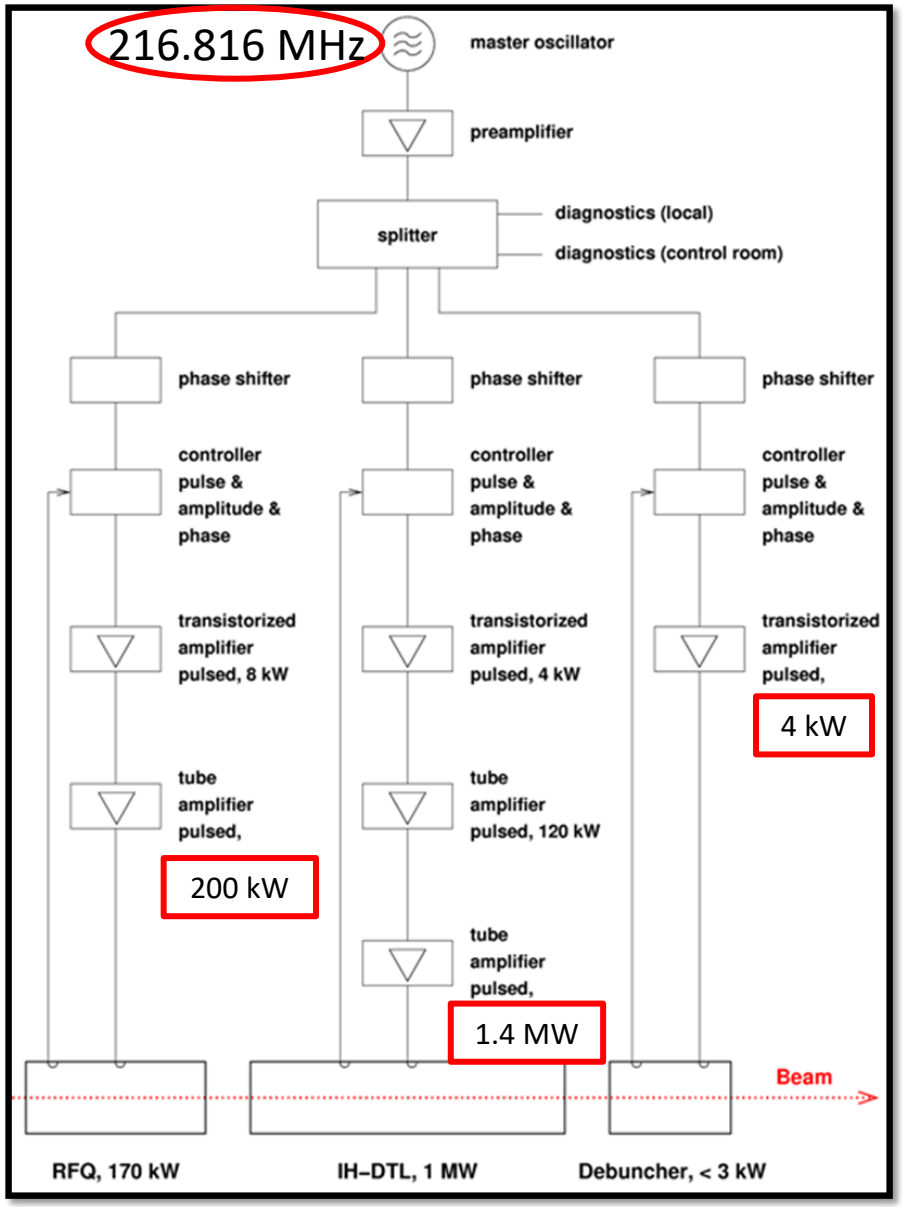


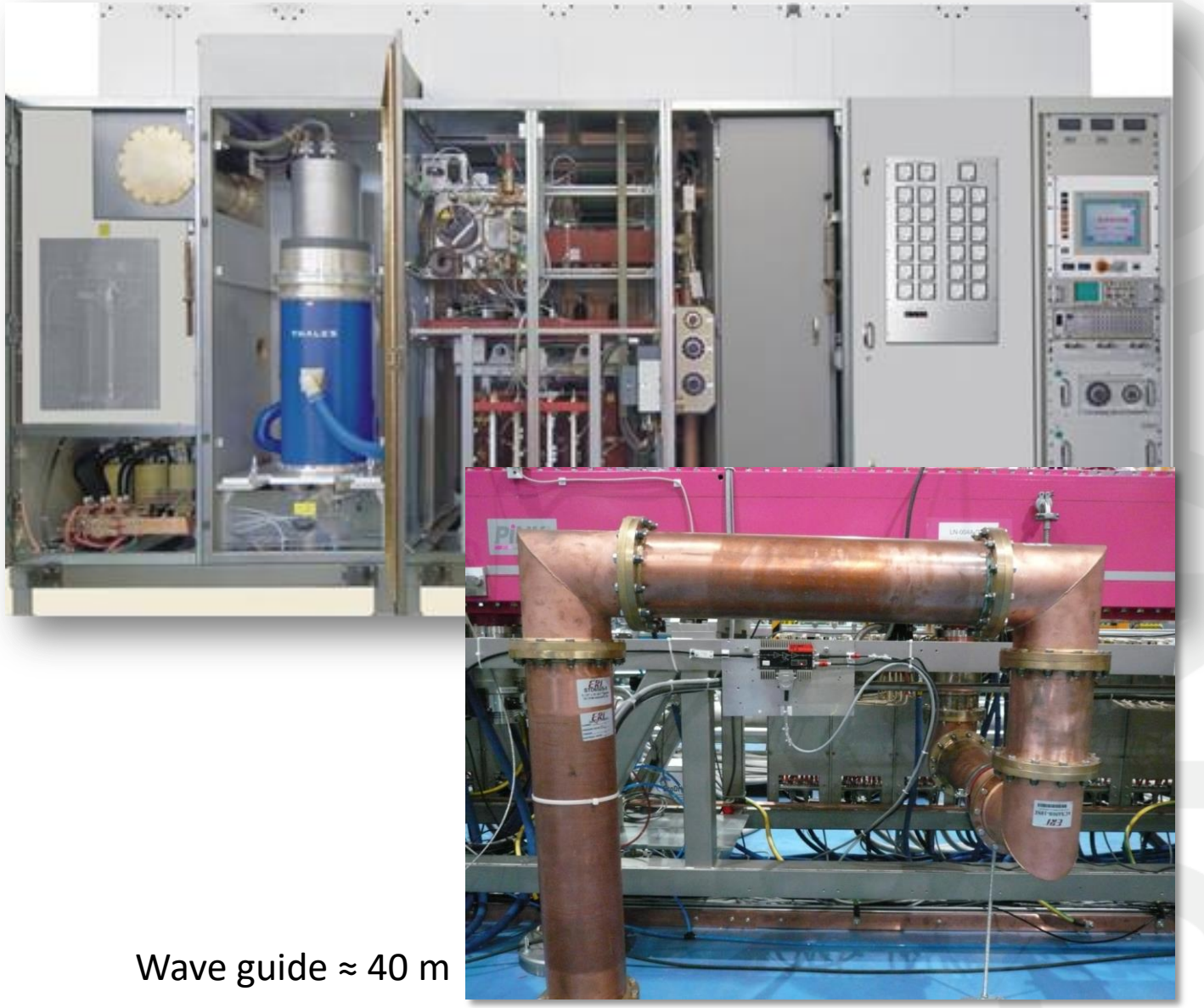


IH

DEB

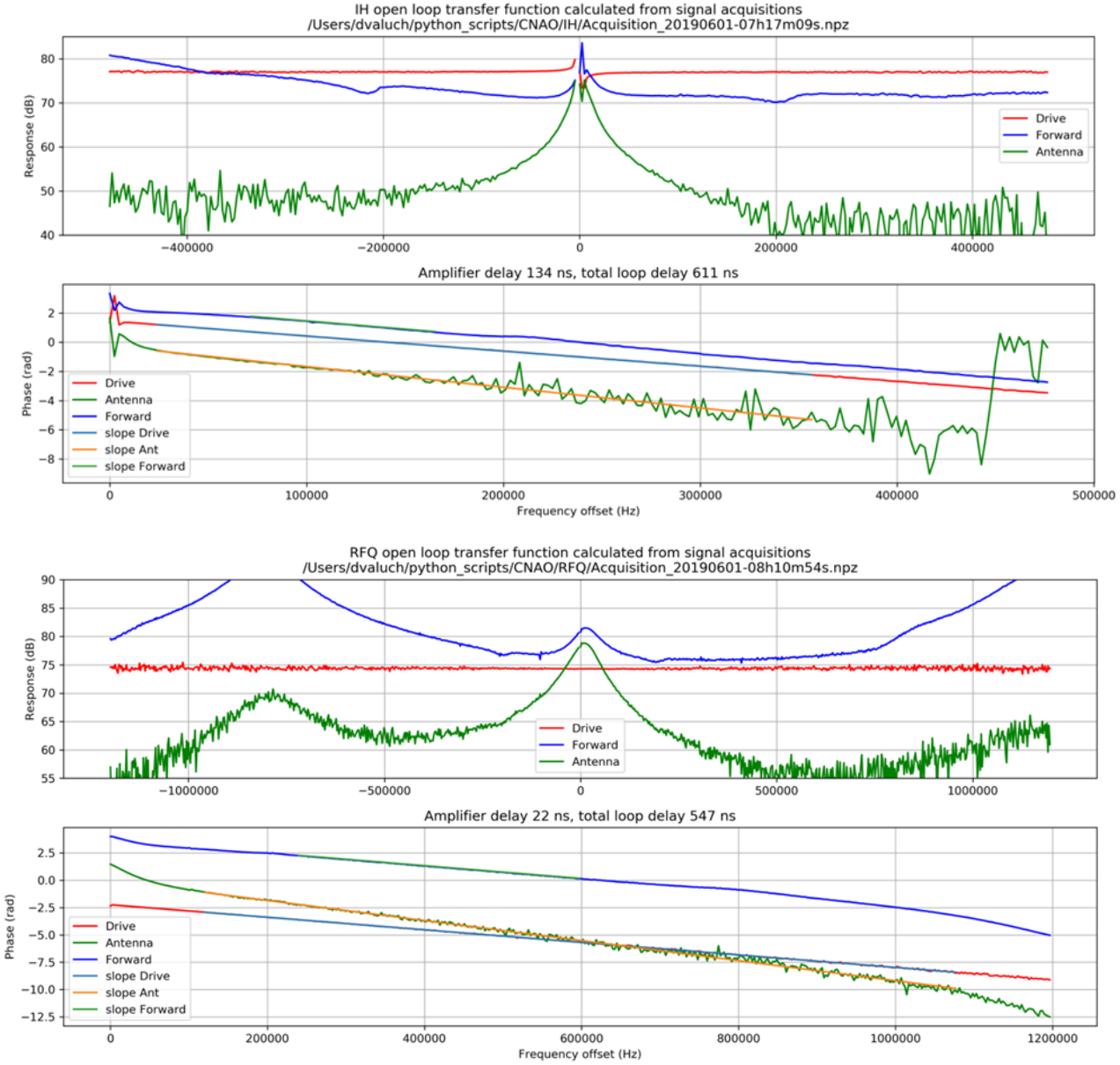
LINAC - RF amplifiers





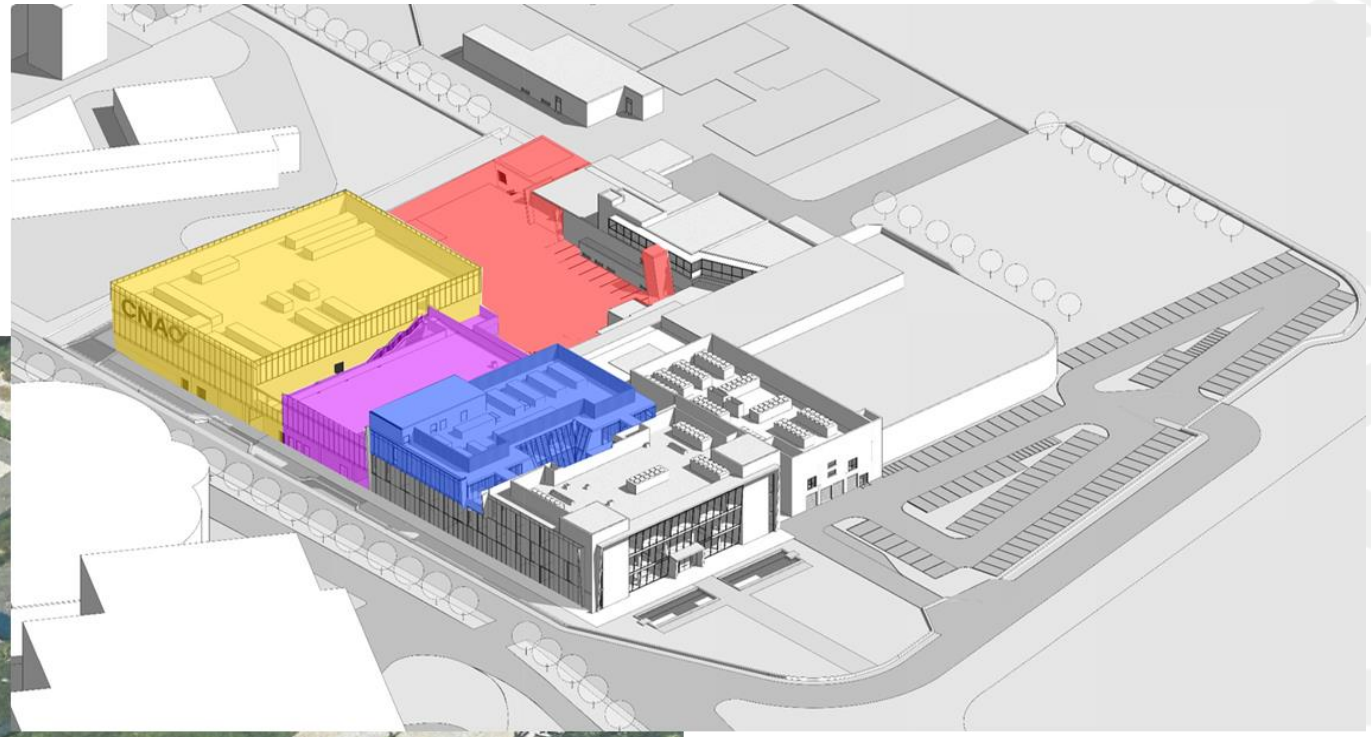
Wave guide ≈ 40 m

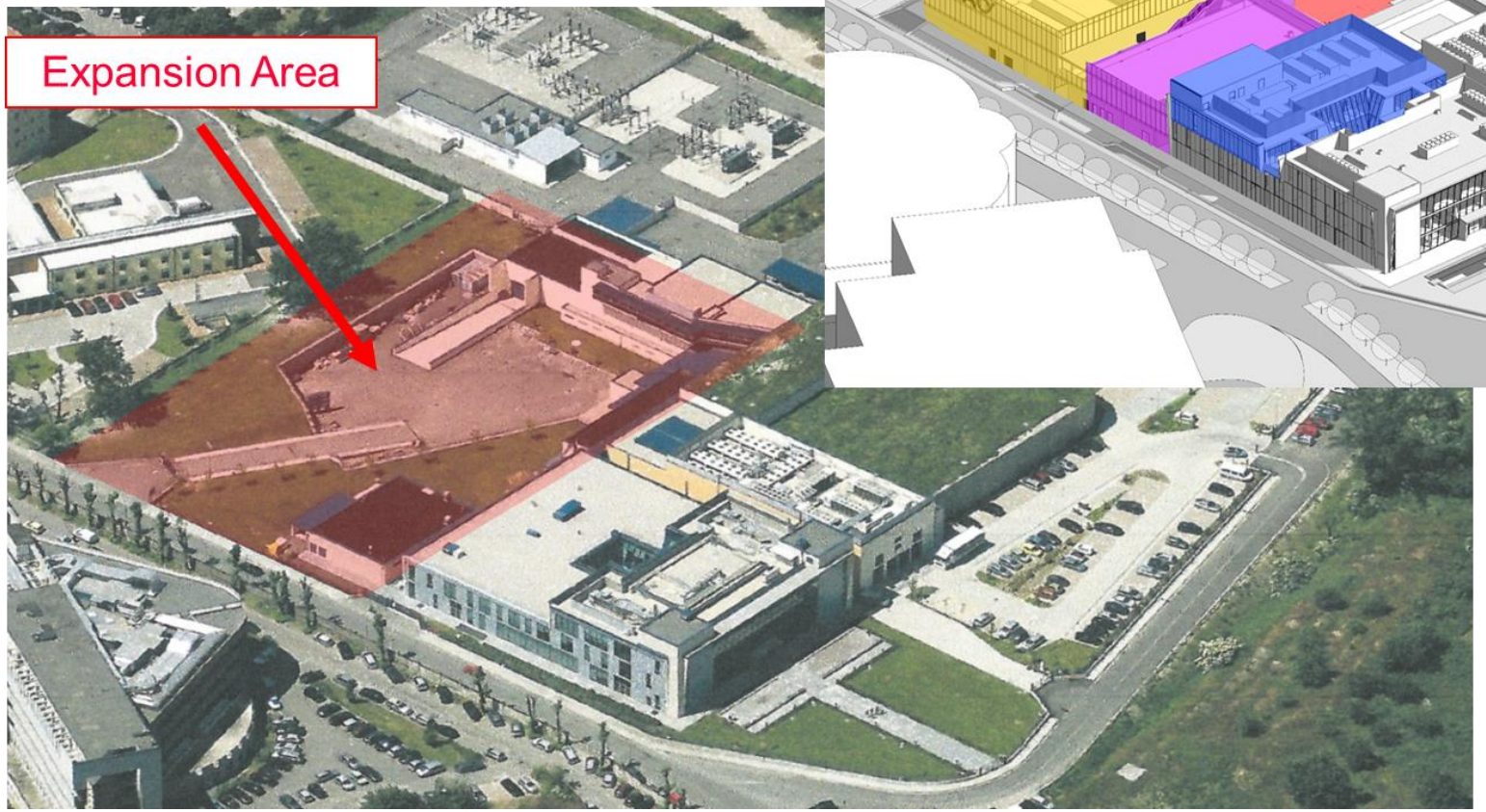
Transfer functions



CNAO tomorrow: expansion

Project approved and financed in 2019 by Ministry of Health



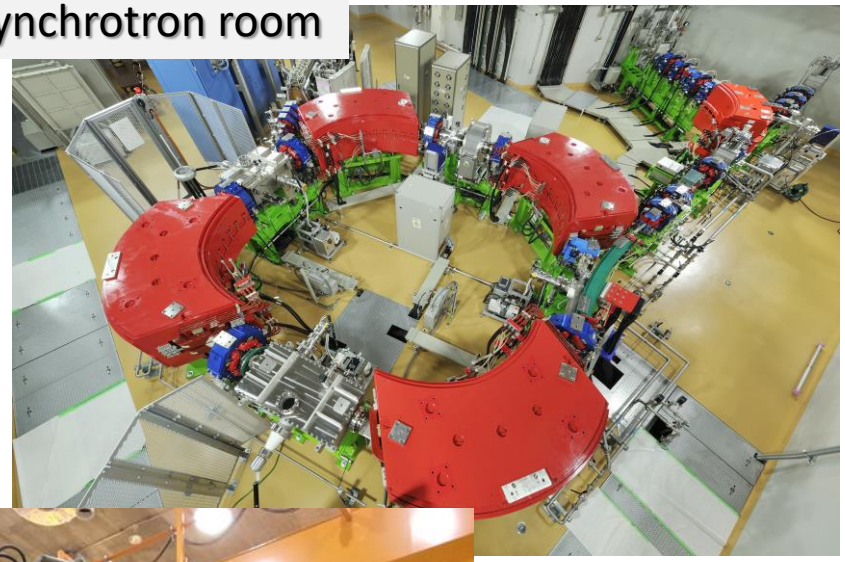


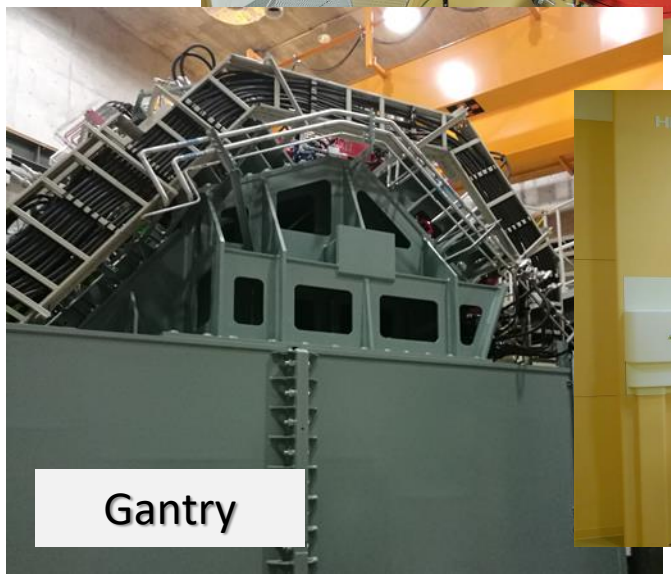
CNAO tomorrow: expansion

Single room facility with gantry for protons

Contract signed with Hitachi:
December 5th, 2019
Operational end 2023

Synchrotron room





Gantry

Treatment room

CNAO tomorrow: BNCT

Collaboration agreement signed
September 2020
Operational end 2023

alpha α beam™