Design, commissioning et acceptance d'une ligne de recherche en protonthérapie

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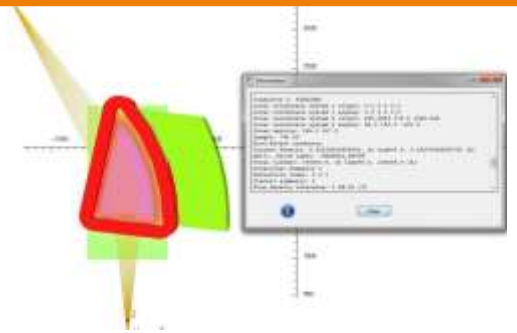
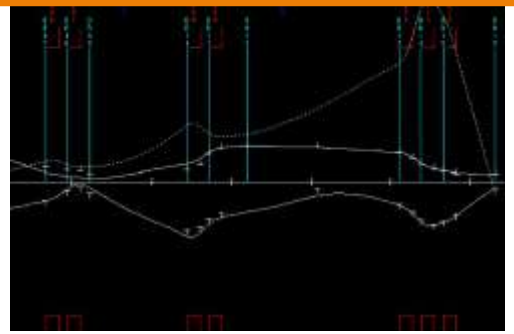
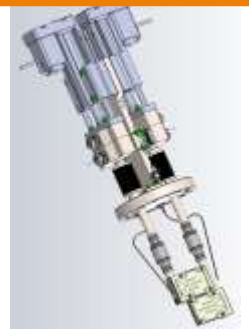
Sigmaphi Beamlines Systems:

Turnkey systems – From beam optics... to commissioning






- ❑ Heavy ion beamlines
- ❑ Beamlines for prontontherapy
- ❑ Other beamlines …

2017

- ✓ Beam optics

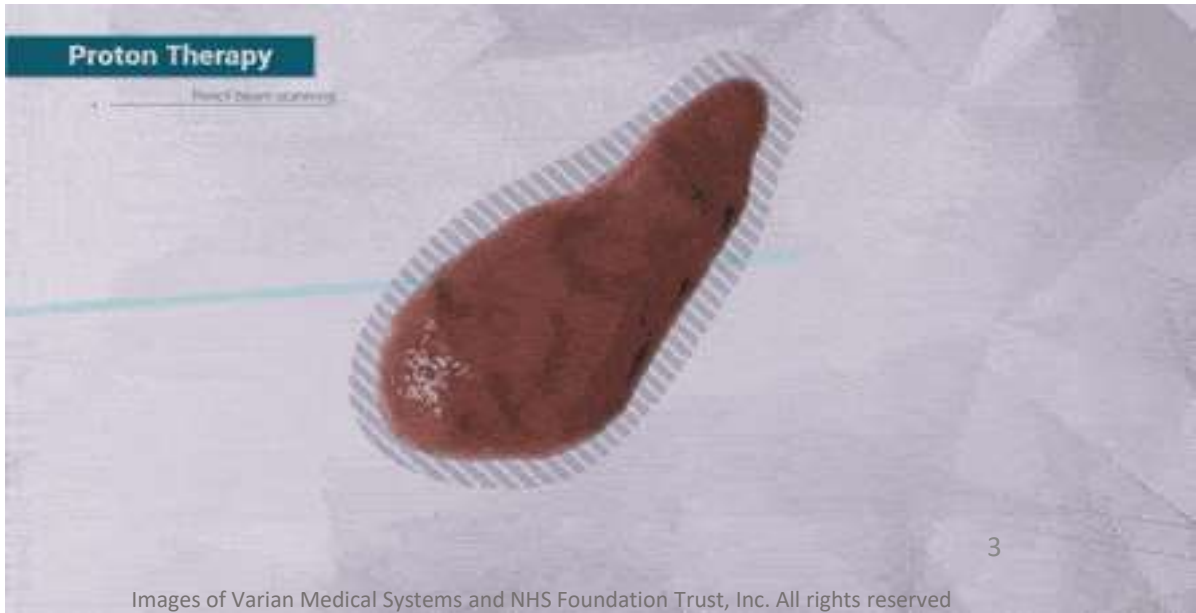
- ✓ Magnetic design for all magnets/optimization with power supplies
- ✓ Mechanical supports and positioning structures
- ✓ Vacuum line design and equipment (pumps, gauge…) down to 10^{-11} mbar
- ✓ Power supplies
- ✓ Diagnostic systems (slits, collimators, scintillators, BPM, faraday cup…)
- ✓ Control system (software and hardware integration)

- ✓ Installation of the complete beamline
- ✓ Alignment of the supports and magnets
- ✓ Commissioning with or without beam

The Christie NHS Foundation Trust Proton Beam Therapy

- Protontherapy center in Manchester UK
- First treatments in 2018
- Adults and pediatrics cancer treatments
- VARIAN® 4 rooms solution with 240 MeV cyclotron and 3 gantry rooms
- Pencil Beam Scanning system
- 4th room designed for research and funded by The Christie charity

The Christie
NHS FOUNDATION TRUST



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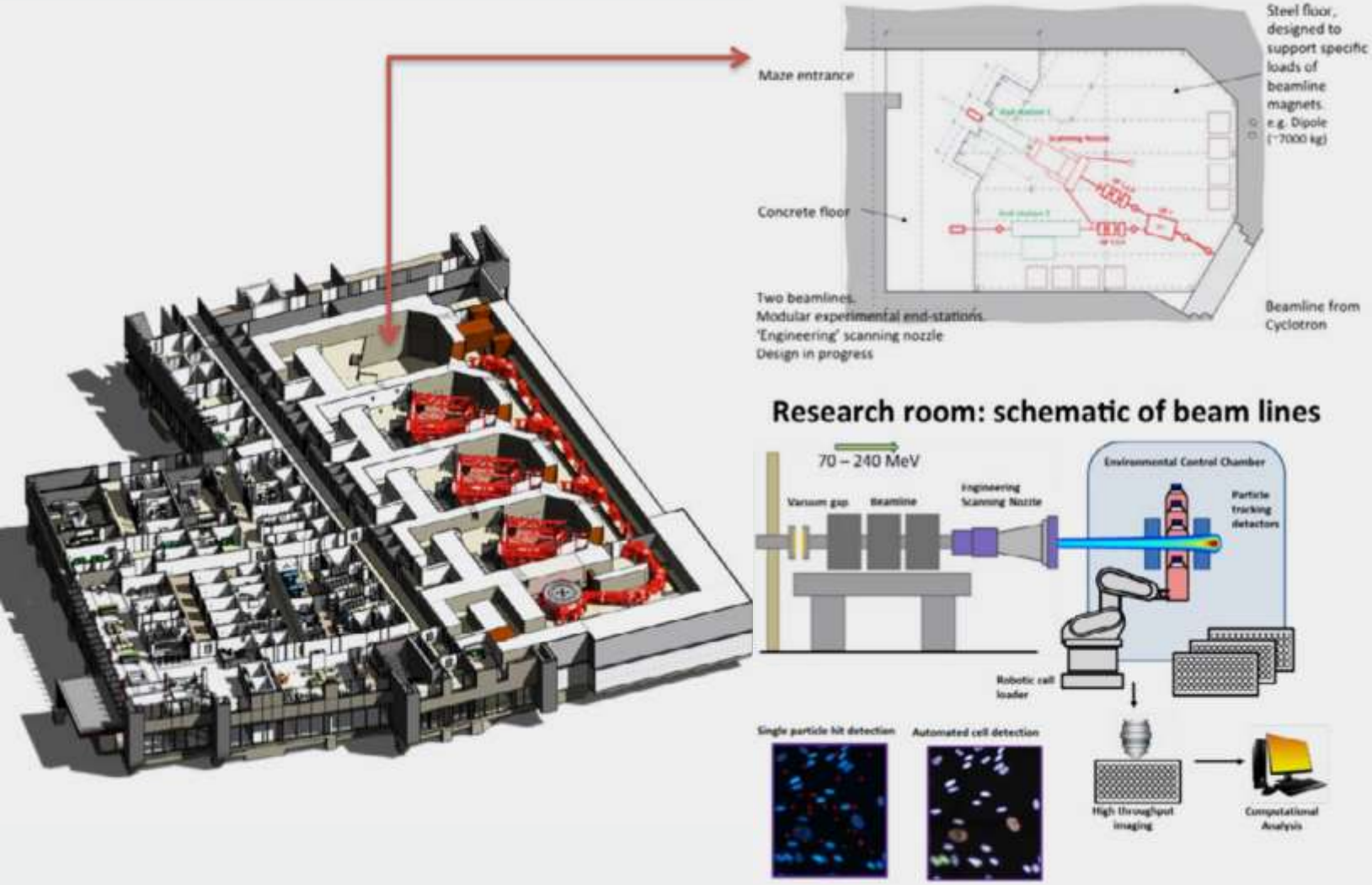
Scope of Proton Research Beamline



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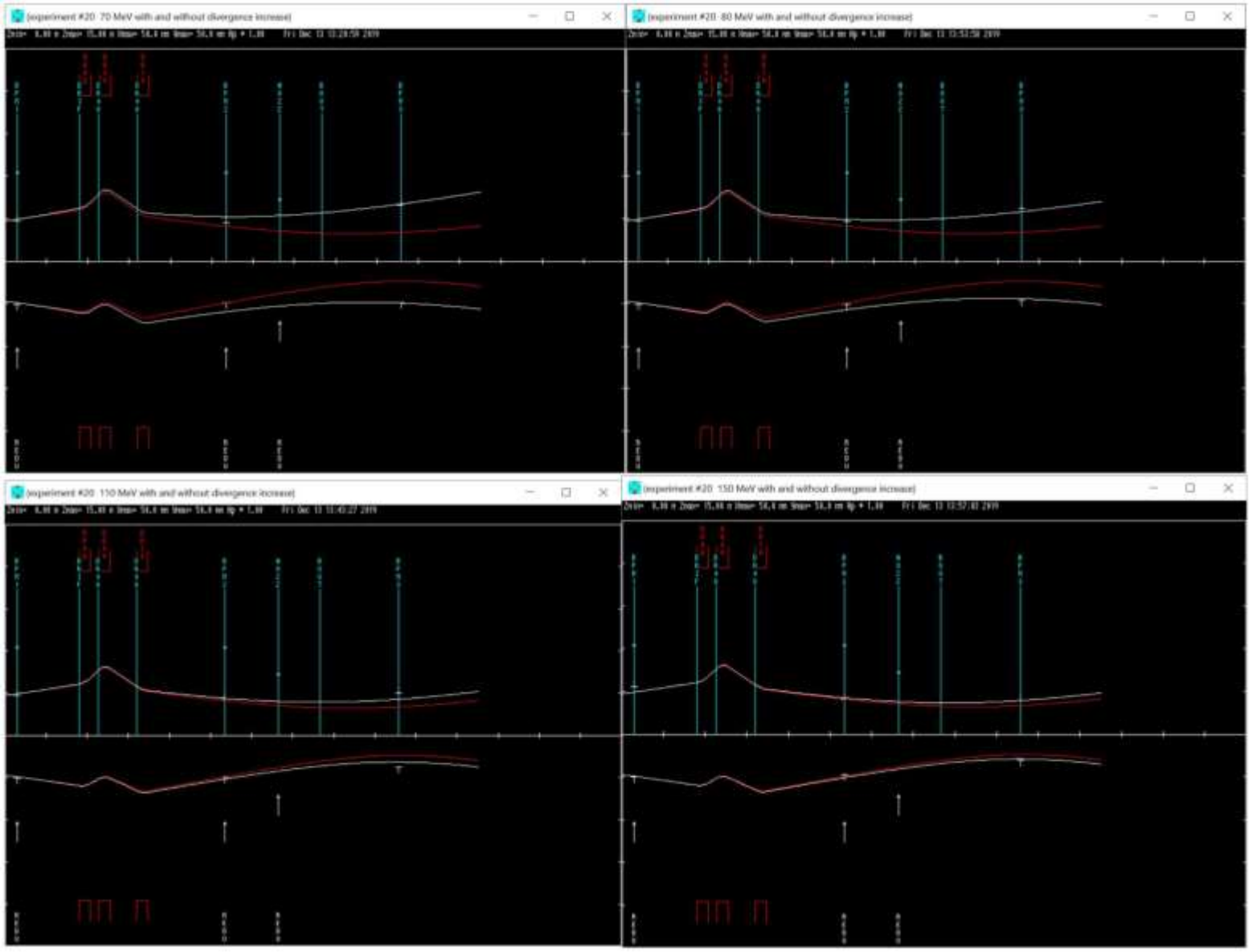
- Turnkey Proton Beamline for physics and biology research. From Optic design to… Commissioning with beam
- Beam monitoring: 2x BPM and 1 Faraday Cup
- Vacuum system capable of maintaining a pressure below 1x 10^{-6} mbar
- Complete Control and Command system
- Beam ballistic equivalent to the medical system at isocenter (target):
  - Energies from 70 to 240 MeV
  - Max Field size 300x400mm^2
  - Spot spacing < 2mm
  - Horizontal scan speed > 20m.s^{-1}
  - Vertical scan speed > 10m.s^{-1}
  - Spot size between 2 and 7mm sigma
  - Absolute Spot position accuracy < 0,5mm
  - Homogeneity Index < 3% inside 100x100mm^2
  - Absolute Dose accuracy < 2% (above 0,1Gy/layer)

Design and Beam Optics



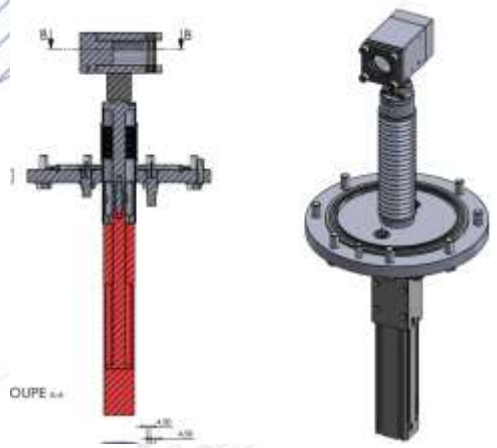
Objectives:

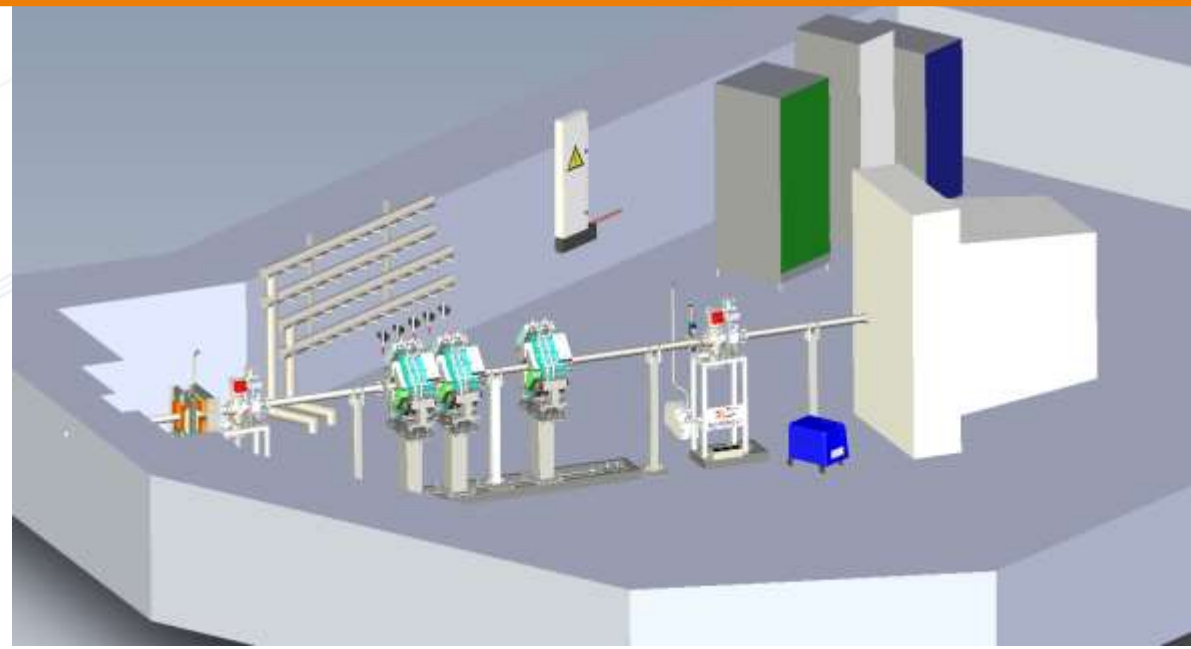
- Optic tuning to fit Customer needs
- Position optimization of homemade or supplier's diagnostics devices
- Optimisation of the characteristics of the magnets
- Optimization of the couple magnet - power supplies
- Overall cost optimization

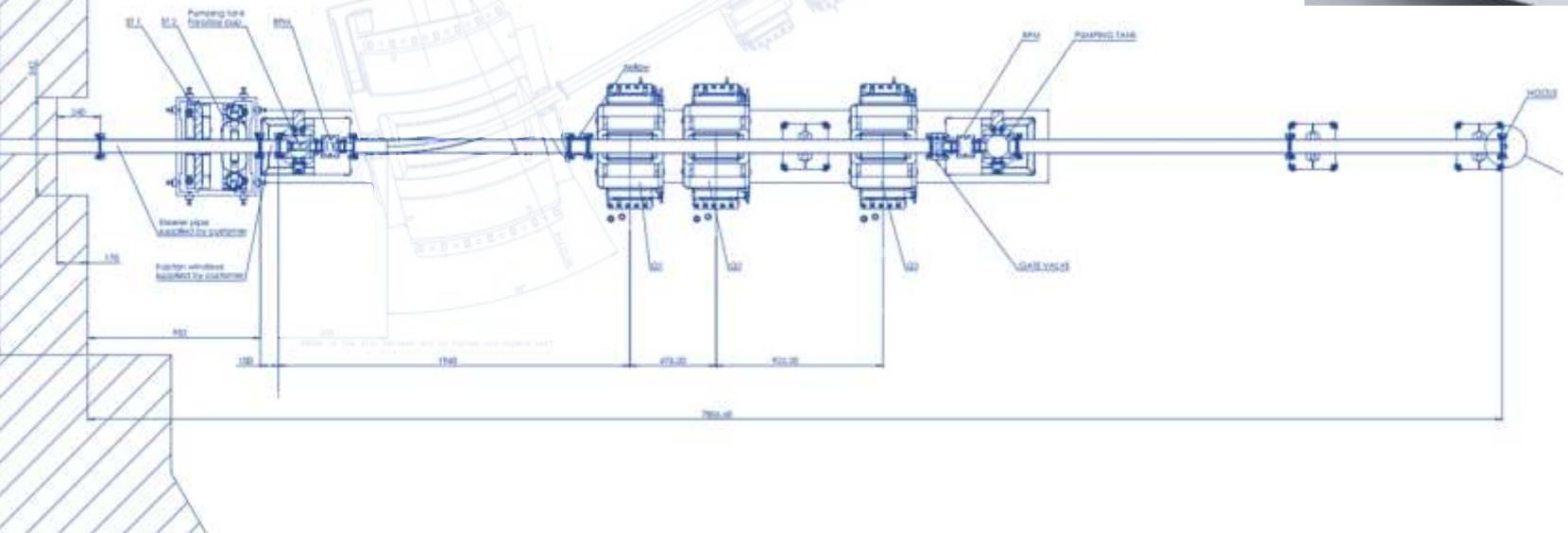
The Christie setup:

- Nozzle and Scanning magnets are already installed – position is fixed

Design and Beam Optics







- Design of the complete beamline
- Design of the Faraday cup
- Specification of the cabling
- Specification/Integration of the:
  - 2x BPM
  - Vacuum system and electronic
  - DC & AC power supplies

Beamline Production Made in Vannes, France

Sigmaphi Productions:

- Production of the magnets
- Production of vacuum chambers
- Production of the Faraday cup
- Assembly of the sub-systems
- Magnetic tests (mapping and harmonic)
- Vacuum leakage test
- Performance and Factory test without beam
- Documentation
- Packing and shipment of all equipment

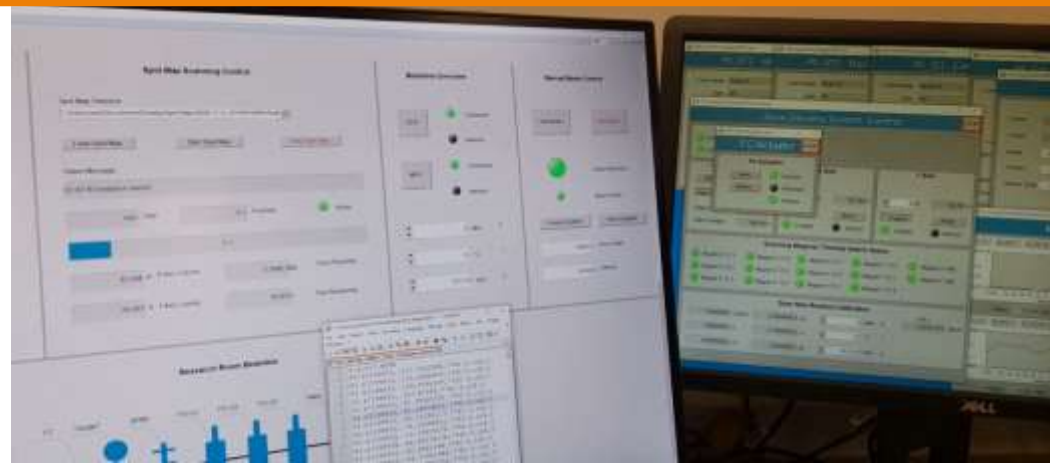
Selected suppliers:

- Vacuum system – primary and secondary pumping from Pfeiffer®
- Beam profile monitors and electronics from Pyramid Technical Consultants®
- Scanning Power supply from Copley-Analogic®
- Control and command system from Cosylab®

Beamline Installation & Commissioning

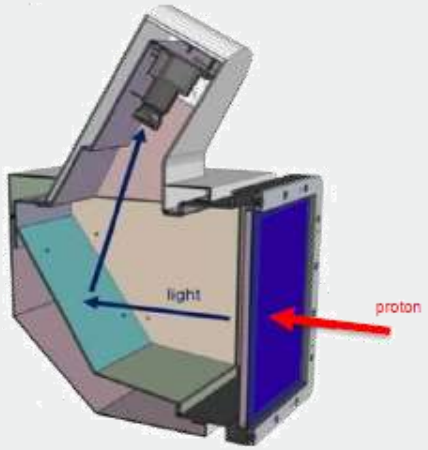
- Installation and alignement of the stands & magnets with laser tracker
- Installation of the vacuum chambers
- Installation & commissioning of the 2x BPM
- Installation & commissioning of the vacuum system
- Interface to the customer system
- Installation of the electrical cables
- Installation of the Cooling pipes
- Installation & commissioning of the DC power supplies of Quadrupoles and Steerers
- Installation & commissioning of the scanning power supply
- Installation & commissioning of the control and command system

Beamline Installation & Commissioning



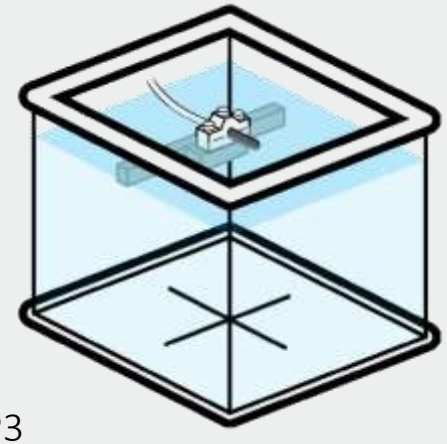
Acceptance with beam

Equipment used:



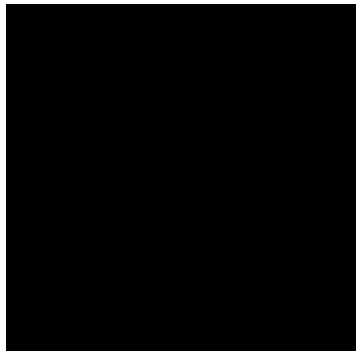
IBA LynxPt

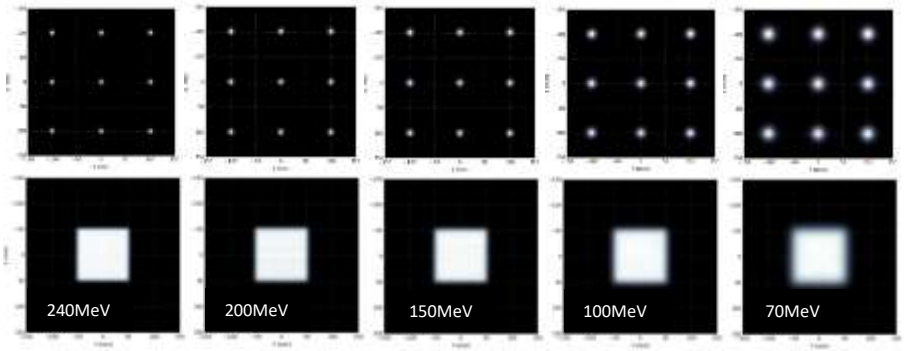
2D scintillator 300x300mm^2 0.5mm resolution

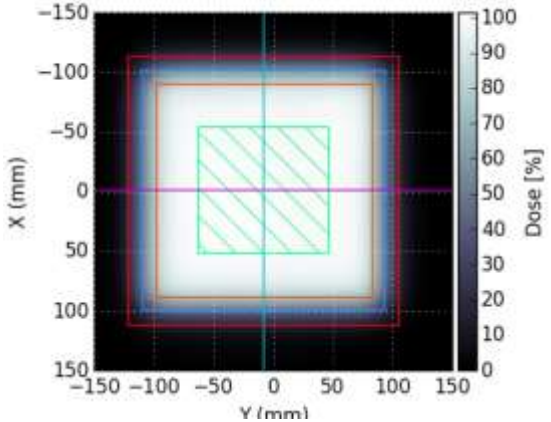


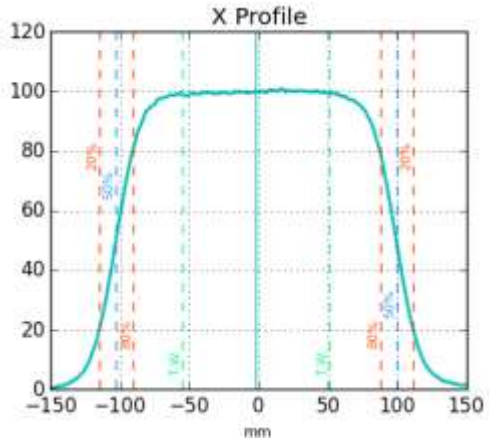
PTW MP3

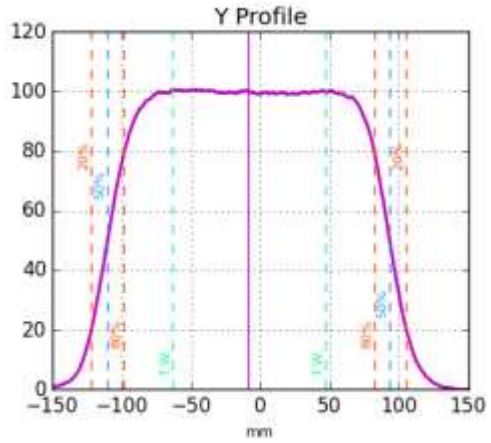
Water tank with ionisation chambers











X Results

Center [mm]	-1.71
FS50 [mm]	202.12
FS90 [mm]	164.66
LP80-20(-) [mm]	24.06
LP80-20(+)] [mm]	24.0
T.W. [mm]	106.0
Homog. T.W.[%]	1.22
Homog. 2D T.W. [%]	1.68
Symmetry [%]	0.13

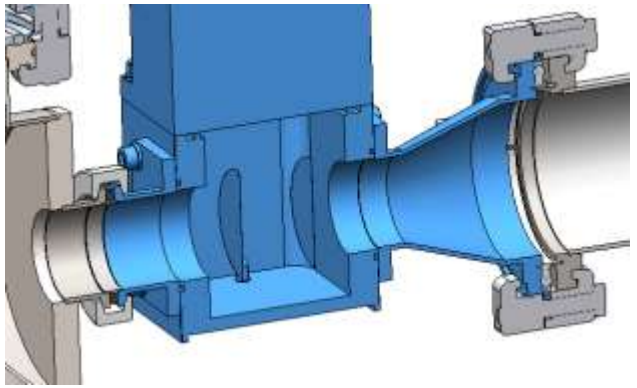
Y Results

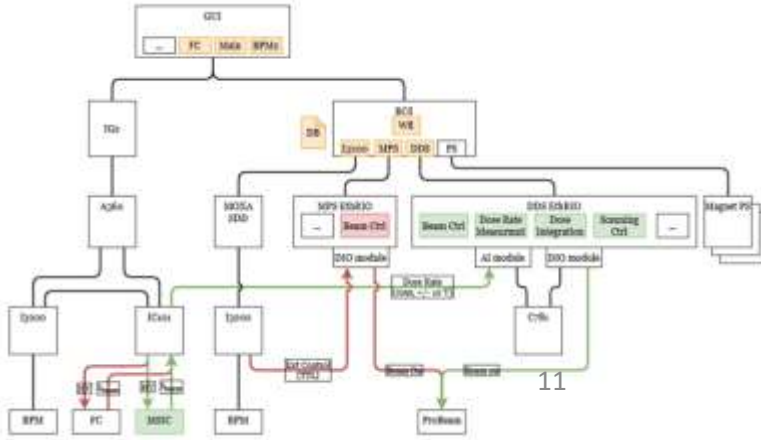
Center [mm]	-8.34
FS50 [mm]	203.68
FS90 [mm]	167.32
LP80-20(-) [mm]	23.73
LP80-20(+)] [mm]	23.24
T.W. [mm]	109.72
Homog. T.W.[%]	0.9
Homog. 2D T.W. [%]	1.68
Symmetry [%]	0.08

What went wrong !

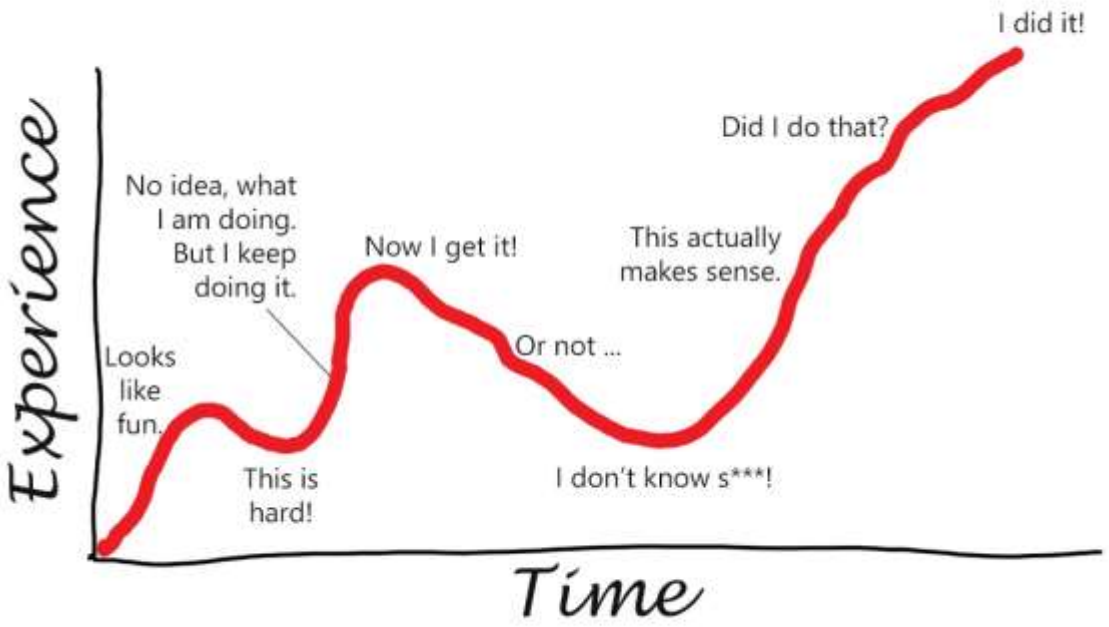
- Beam scrapping
- Dosimetry accuracy
- Control and command performance
- Speed scanning performances
- Interface to Varian Control system
- Acceptance under Covid Lockdown

UPGRADES



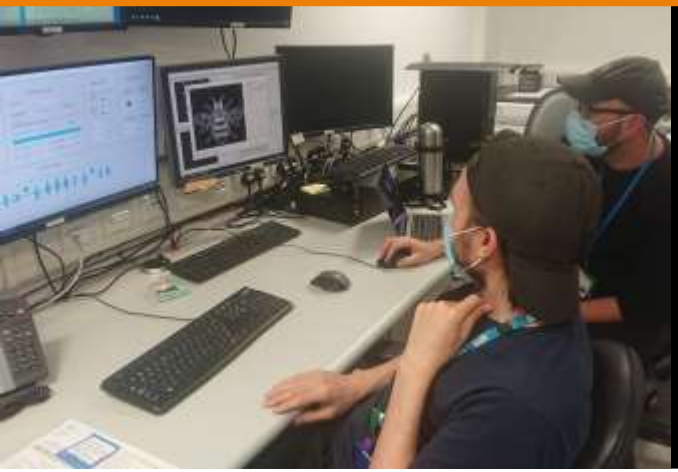


Conclusion



- Commissioning and upgrades finished in 14 months
- Beamline accepted by customer after remote dosimetry acceptance
- Sigmaphi improved its management of scanned beamline turnkey system project for medical customers
- Sigmaphi increased its knowledge in the beam dosimetry field and enlarged its beamline team strength
- Sigmaphi is currently working with The Christie for future updates and additional beamlines projects
- Sigmaphi is working on similar projects with clinical centers and laboratories in order to improve protontherapy treatments

The Christie news



- Customer commissioning done (planning system)
- Proton Robotic Hypoxia Cabinet implemented
- Mechanistic Modelling of DNA Damage & Repair

Merci pour votre attention

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