Status of the ThomX X-line

ThomX MAC meeting, 20-21 march 2017, LAL Orsay

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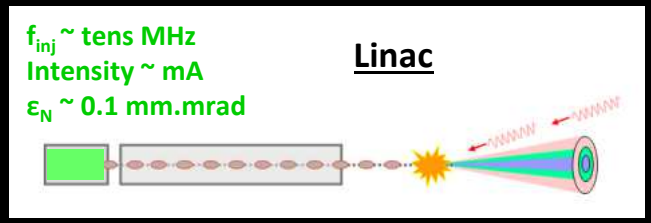
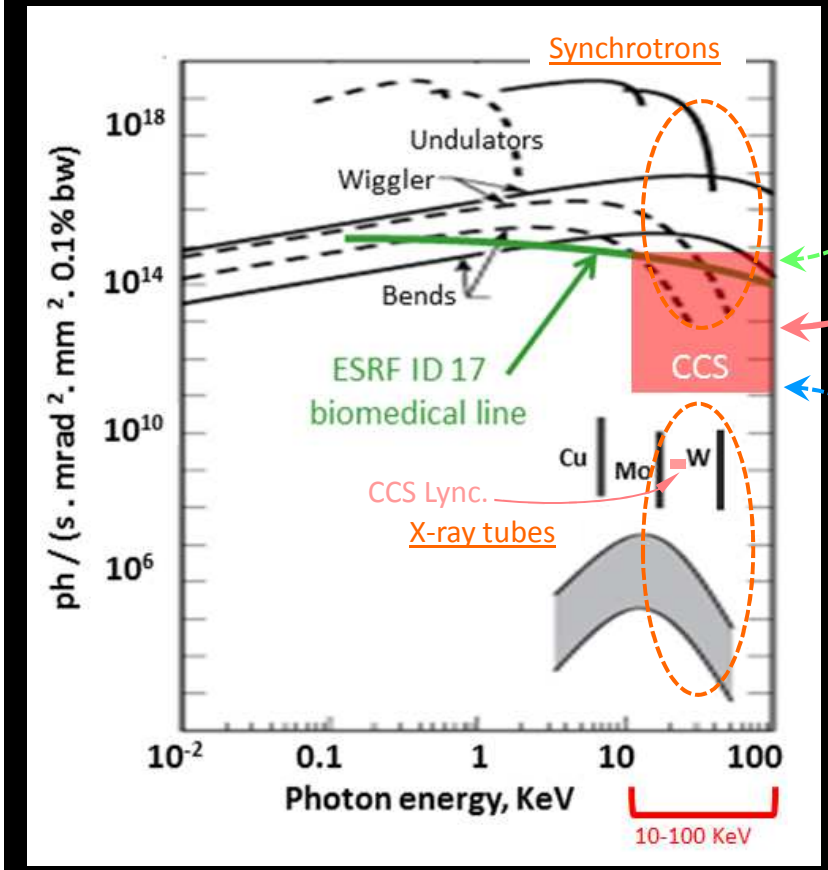
Compact Compton projects (X-ray flux > 10^{12} ph/sec)

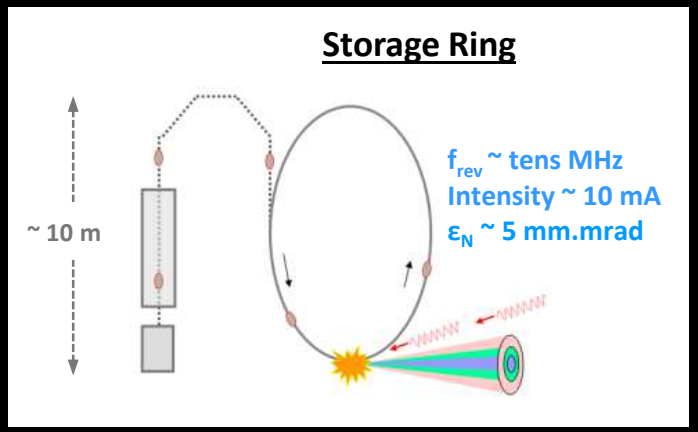
Next future CCS
(supra machine)



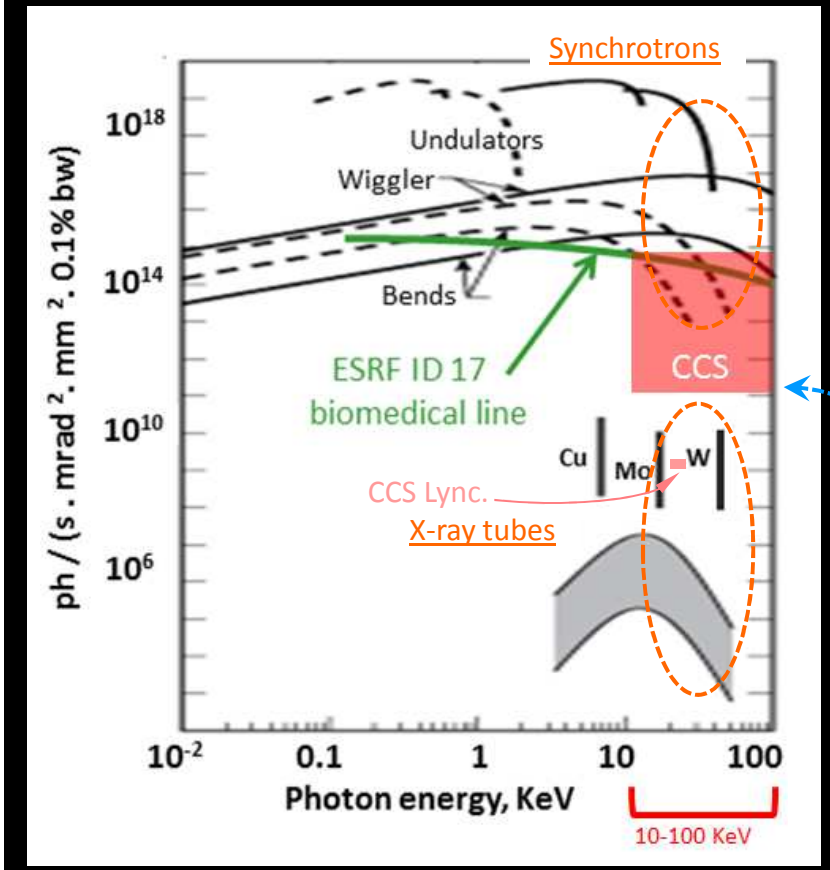


- Compactness (surface ~ 100 m^2)
- Intensity 10^{12} – 10^{14} ph/sec
- Energy tunable beam
- High X-ray energy 20-100 keV
- Brightness 10^{11} – 10^{15}

Near future CCS = almost current ("hot" machines)



Compact Compton projects → ThomX

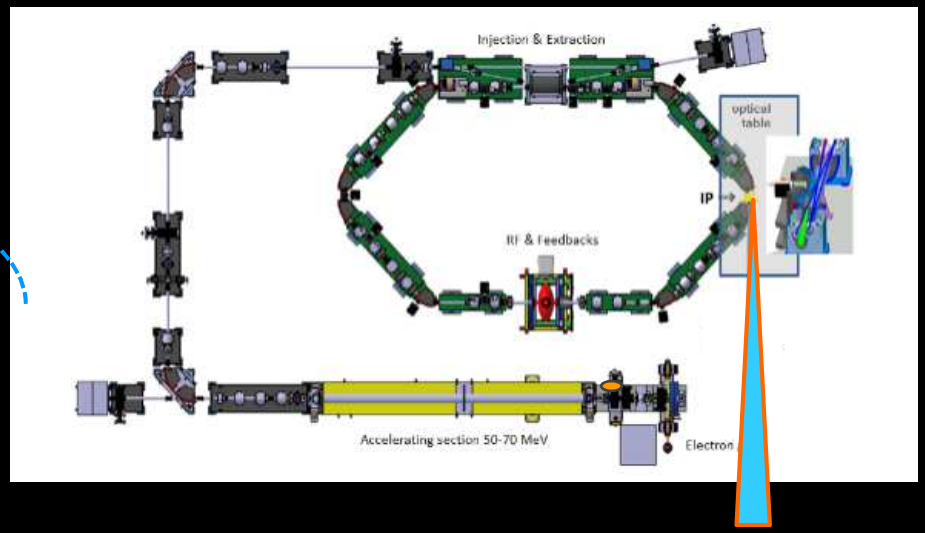


Flux 10^{13}

Brigth. 10^{11}

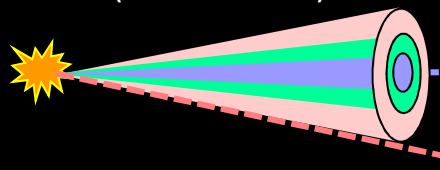
E_x on-axis 30-90 keV

Trans. size 30-100 µm



Conical beam

(Ee = 50 MeV)



on-axis photons → 45 keV

10 mrad → 22 keV

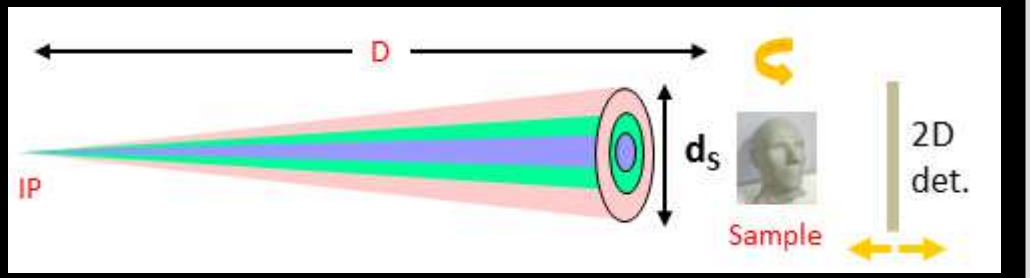
Applications: 2 ways to use a Compton beam

1. Using the 2D divergent beam

(biomedical and cultural heritage applications)

- Conventional radiography
- K-edge substraction imaging
- Phase contrast imaging
- Magnification
- RADIOTHERAPY

IMAGING



Pink beam (1% - 30% bw)
Flux ~ 10^{11} - 10^{13} ph/s
Several cm diameter beam

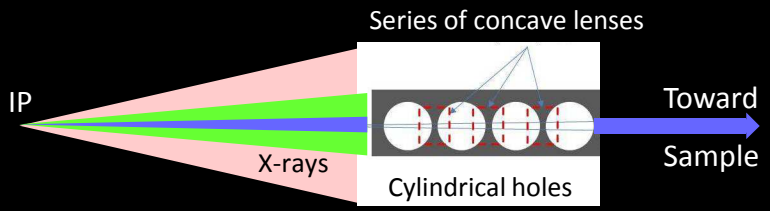
→ Measure large sample with no more need to move it (patient, materiel …)

2. Using the central part of the beam

(cultural heritage / material science applications)

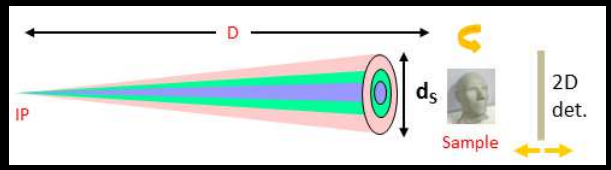
- Fluorescence Spectroscopy
  → chemical composition
- Diffraction
  → structural analyses

Focus device : Refractive lenses



Quasi-monochromatic beam (~ 1% - 0.01 % bw)
Flux ~ 10^{8} - 10^{10} ph/s
Sub-mm diameter beam

Application: Imaging



1. Using the 2D divergent beam

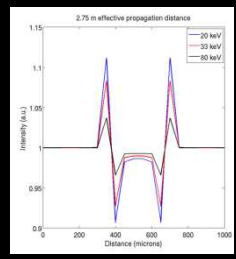
(biomedical and cultural heritage applications)

- Conventional radiography
- K-edge substraction imaging
- Phase contrast imaging
- Magnification
- RADIOTHERAPY

- bw 2-3%
- Small source size (to have transv. coherence)

- 45 keV, bw 2-3%
- d_S = 3 cm (D ~ 10 m)
- 4.10^{11} ph/s

a 300 µm nylon wire



[TDR ThomX]

(Hospital sources:
large focal spot size,
broad spectrum,
low flux)

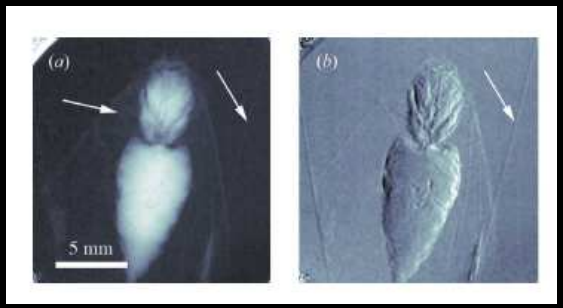
2. Using the central part of the beam

(cultural heritage / material science applications)

- Fluorescence Spectroscopy
  → chemical composition
- Diffraction
  → structural analyses

[Synch. Rad. 16, 2009, 43-47]

CS Lyncean Tech. (only CCS in operation in the word)

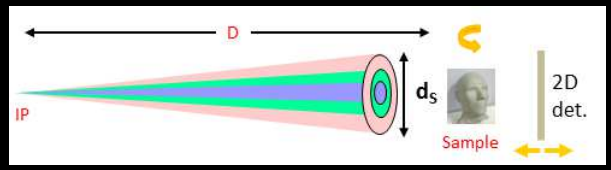


standard absorption phase-contrast

13.5 KeV , 3% bw
10^9 ph/sec
σ = 165 µm

Proof of principle

Application: Therapy



1. Using the 2D divergent beam

(biomedical and cultural heritage applications)

- Conventional radiography
- K-edge substraction imaging
- Phase contrast imaging — IMAGING
- Magnification
- RADIOTHERAPY

- High energy (~ 80KeV)
- bw ~ 10%

- 80 keV ± 10 keV
- d_S = 3 cm (D ~ 10 m)
- ~ 10^9 ph/s/mm^2

Ex. : Human head tumor irradiation
(tumor deliver dose ~ 10-20 Gy)

- ThomX → 0.5 Gy/min
  → ~ 20 min of irradiation
- ESRF/ID17 = ~ 10^9 ph/s/mm^2

(Hospital sources → broad spectrum,
and continuously operation not possible)

[Phys. Med. 31 (2015) 596-600]

2. Using the central part of the beam

(cultural heritage / material science applications)

- Fluorescence Spectroscopy
  → chemical composition
- Diffraction
  → structural analyses

Application: Diffraction

1. Using the 2D divergent beam

(biomedical and cultural heritage applications)

- Conventional radiography
- K-edge substraction imaging
- Phase contrast imaging
- Magnification
- RADIOTHERAPY

IMAGING

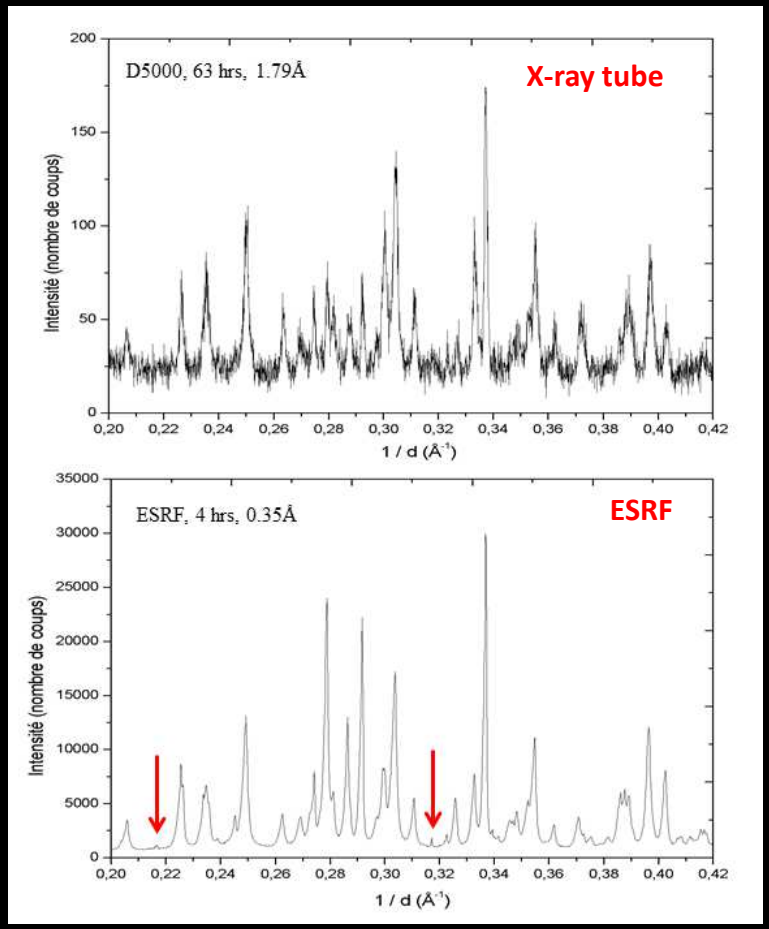
2. Using the central part of the beam

(cultural heritage / material science applications)

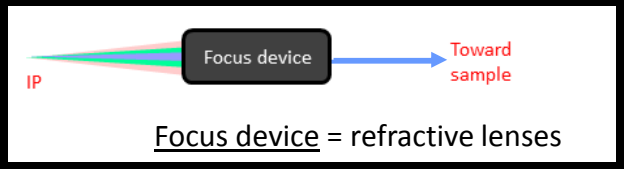
- Fluorescence Spectroscopy
  → chemical composition
- Diffraction
  → structural analyses

- Quasi-monochromatic beam - Tunable energy

Diffraction patterns



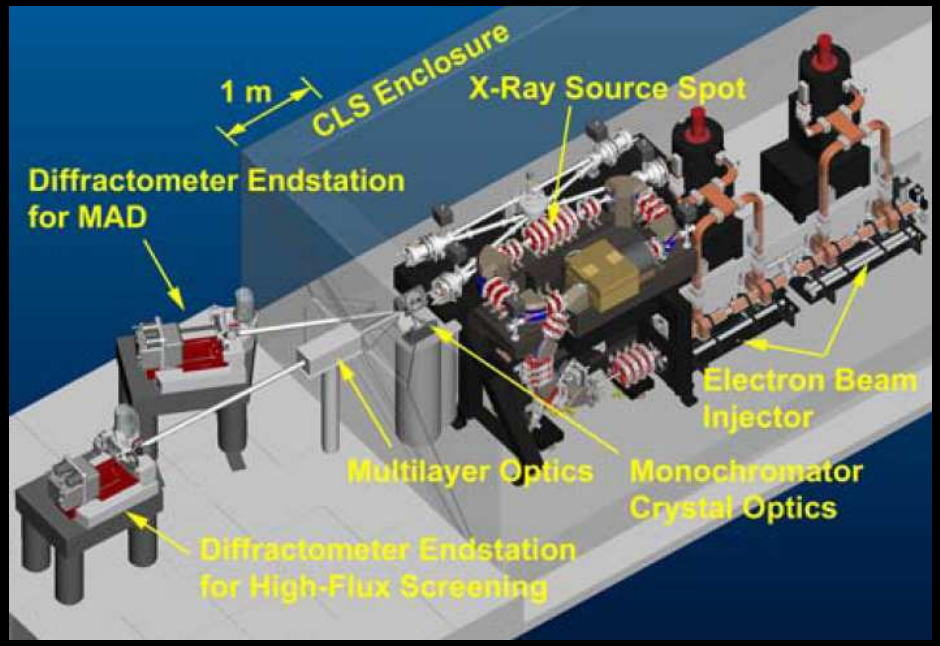
→ ESRF: minor phases present in the powder visible



Focus device = refractive lenses

Diffraction → Structural analyses First determination of the 3D structure of a protein at CS Lyncean Tech.

Knowledge of the structure of a protein → acceed to its function in the cell

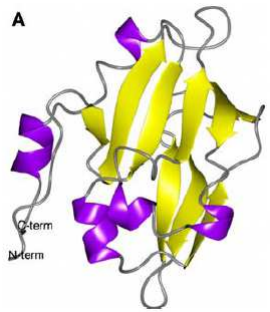


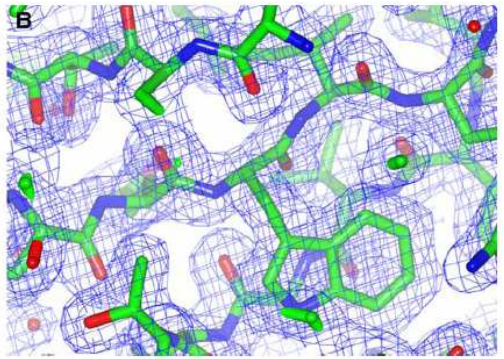
5.10^6 ph/sec E=15 KeV

X beam : 120 µm on crystal ΔE/E = 1.4%

Protein MytuGCSPH (crystal size : 250 X 250 X 100 µm)

Fig. 6 Structure and electron density of MytuGCSPH. **a** Overview of the structure for MytuGCSPH in ribbon representation. **b** Electron density from the MytuGCSPH CLS data set at 2.0 Å resolution centered around Trp 14





[J. Struct. Funct. Gen. 11, 2010, 91-100]

(Flux and results comparable with the same analysis realized at a rotating anode)

The X line

Beam transfer

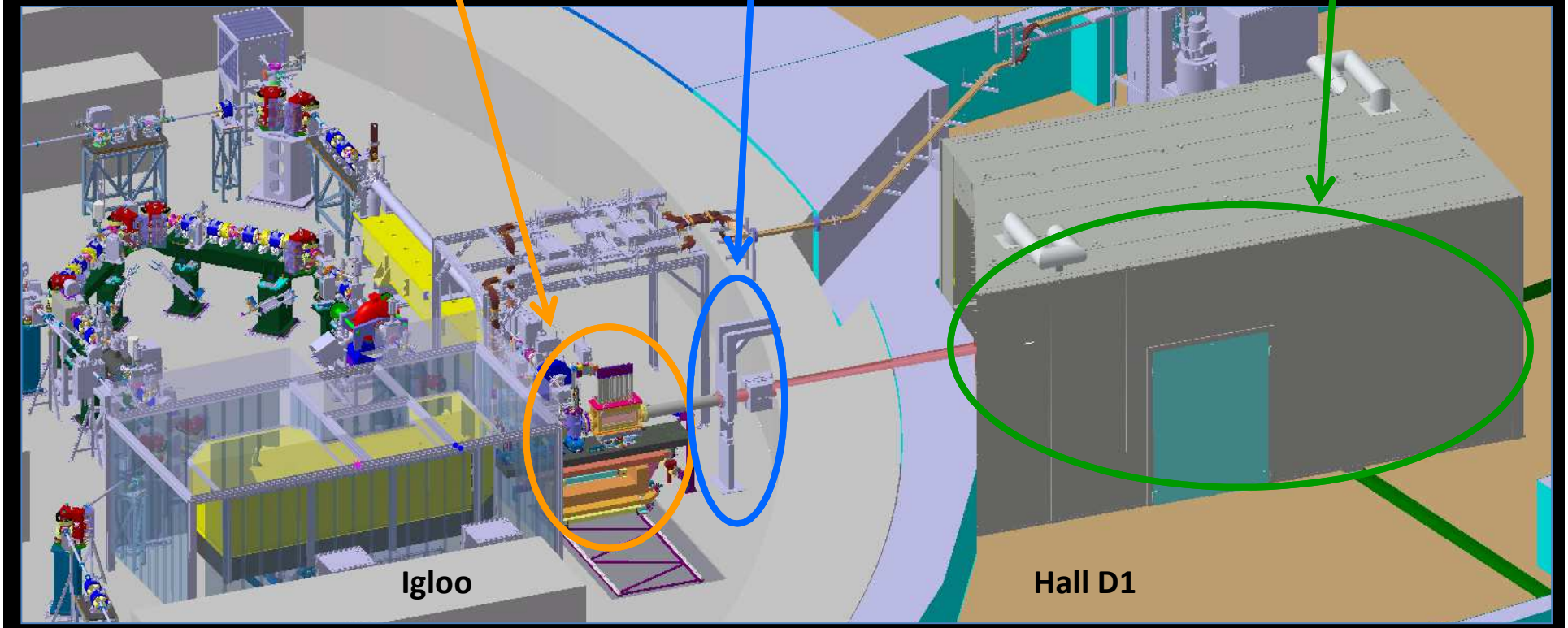
Security beam shutter
Connection pipe

"Table 2" (hall D1)

Beam characterisation
X-user experiments

Table 1 (igloo)

Continuous beam monitoring
Focus device

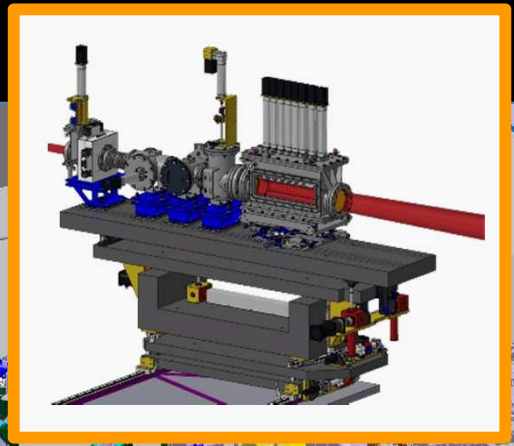


The X line

Table 1 (igloo)

Continuous beam monitoring

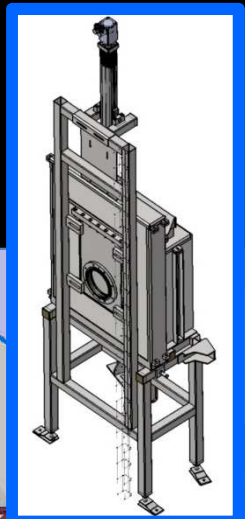
Focus device



Beam transfer

Security beam shutter

Connection pipe

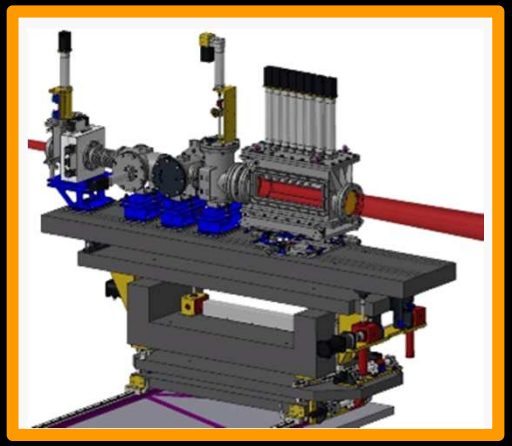


"Table 2" (hall D1)

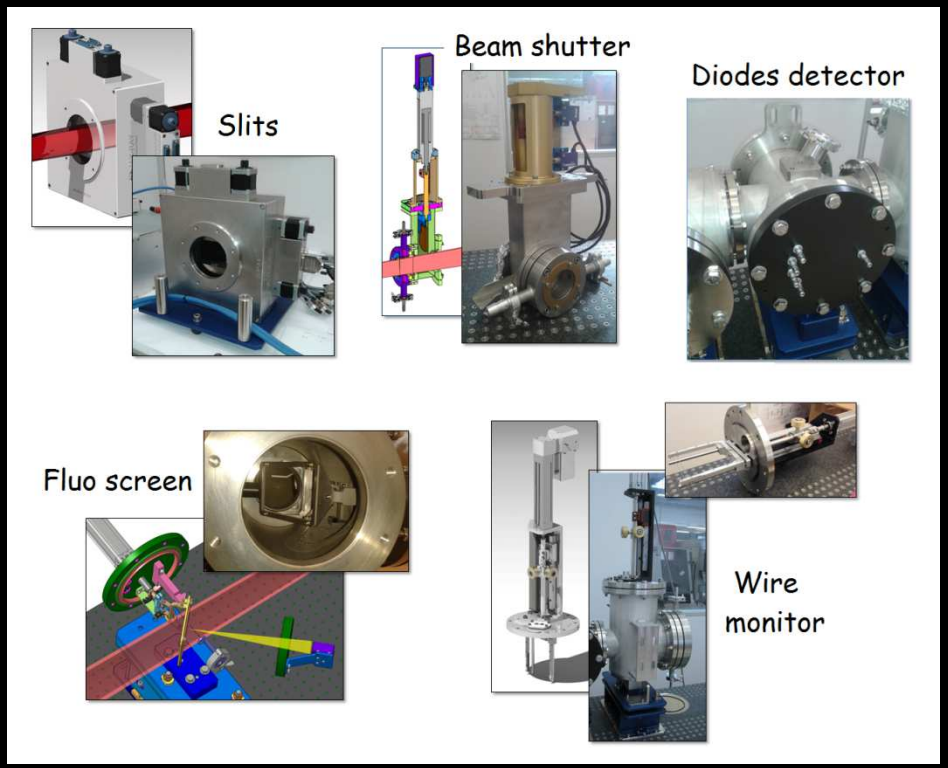
Beam characterisation

X-user experiments

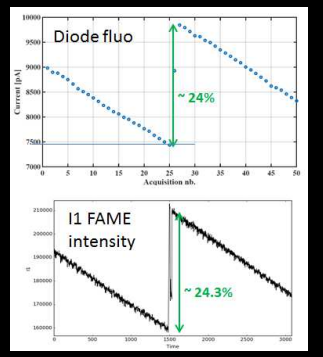
Table 1 (Beam monitoring & Focus device)

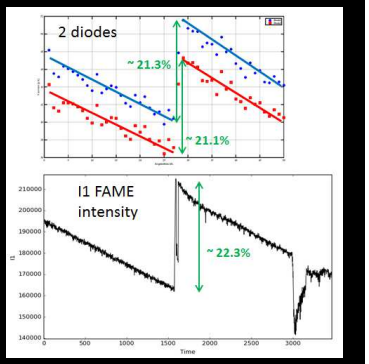


Beam shutter - Beam monitoring



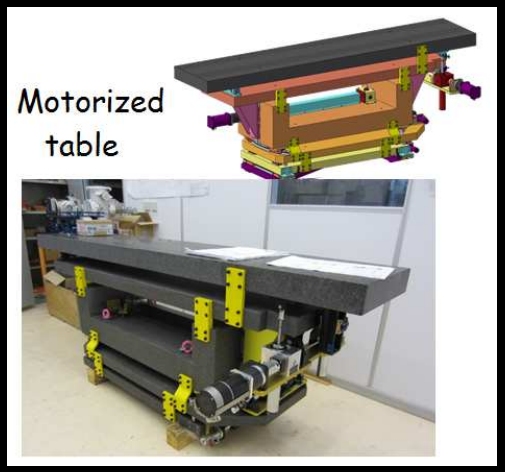
ESRF beam tests
(almost all ok)





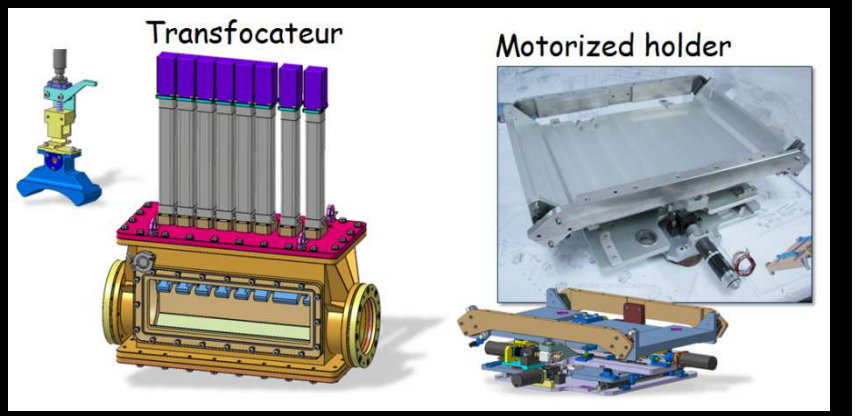
Motorized Table

→ Mounting Ok
→ Mvt qualification in progress

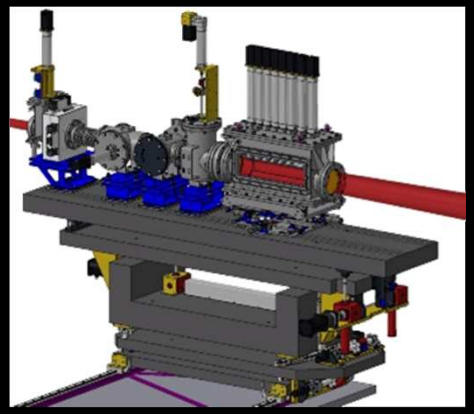


Transfocator (focus device) + its holder

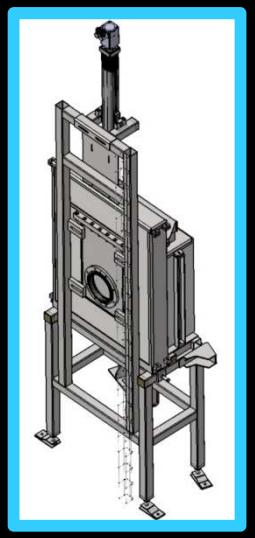
→ Lenses delivered soon
Mecanics received
→ Mounting foreseen soon



Security shutter + shieldings (X-ray hole igloo-hall D1)



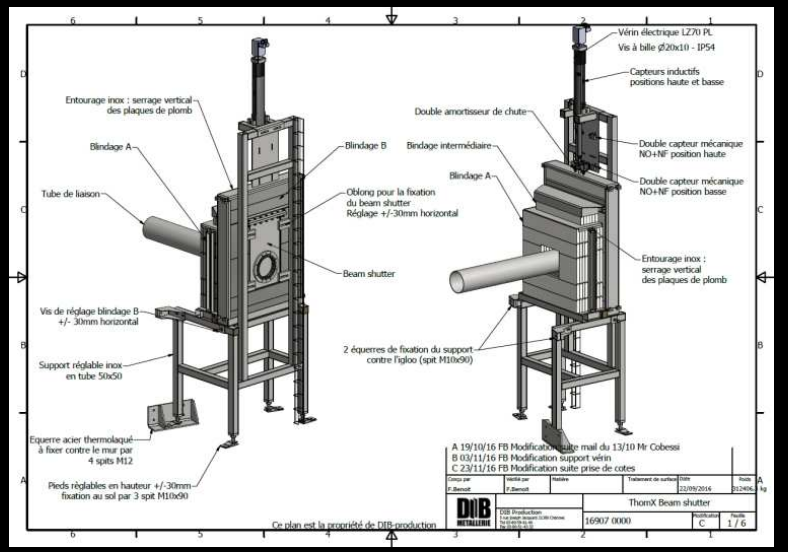
Beam monitoring
Focus device



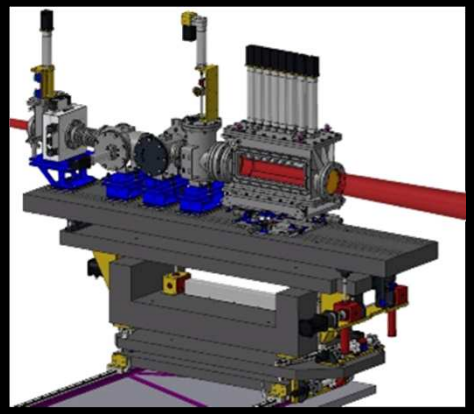
Security beam shutter + shieldings

→ Specifications: Radioprotection + Security + X-line

→ The realization began



Experimental X-hutch (hall D1)



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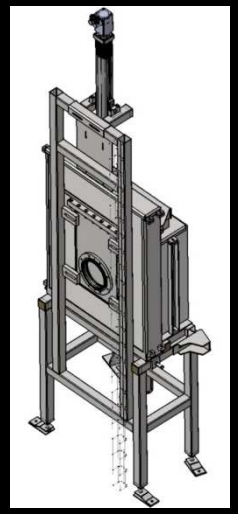
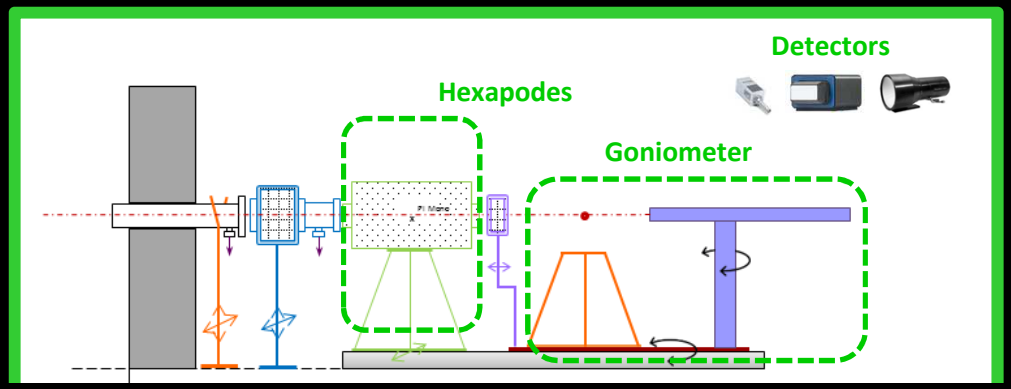
Focus device



Security beam shutter
Connection pipe

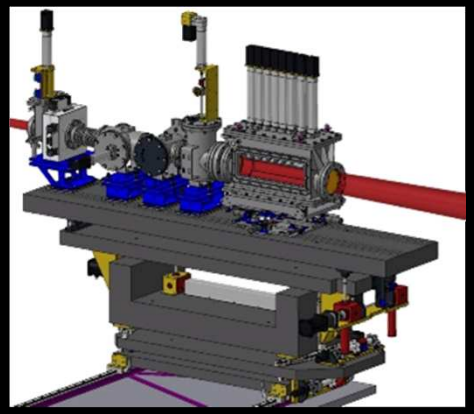


Highly versatile equipment

Hexapodes, Goniometer,
Monochromator, Detectors

→ Ability of adaptation to a particular analysis technique

Experimental X-hutch (hall D1)



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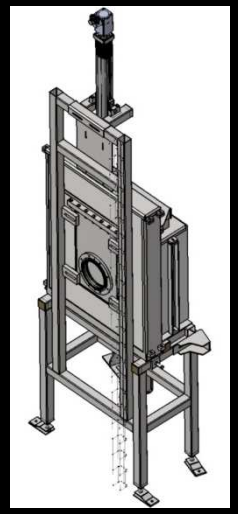
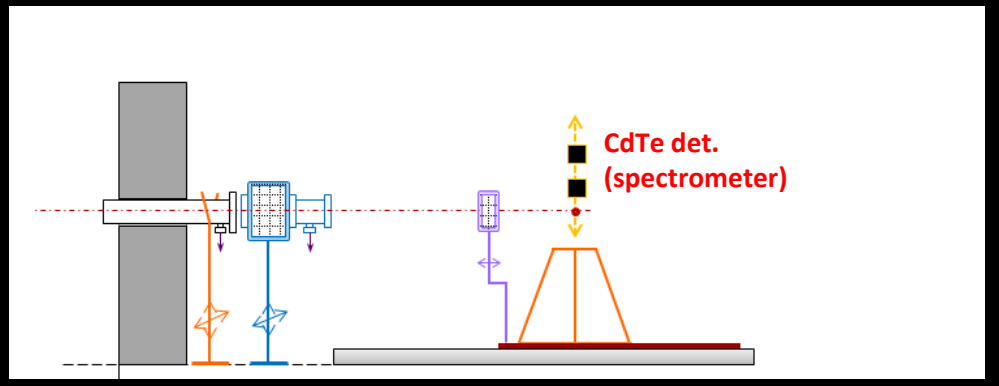
Focus device



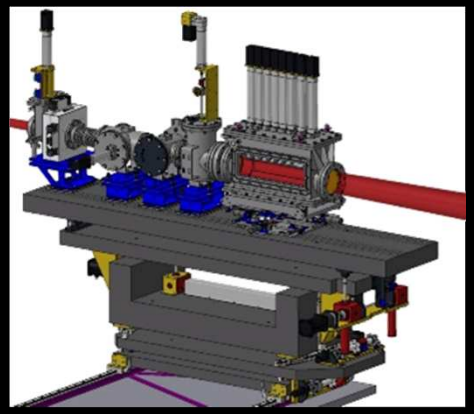
Security beam shutter
Connection pipe



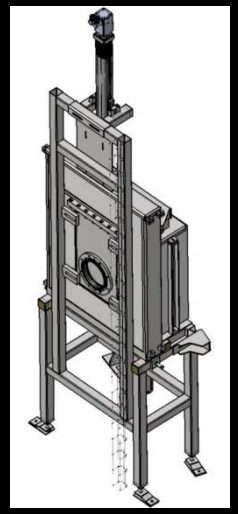
Highly versatile equipment

➡ Dosimetry - Beam characterisation

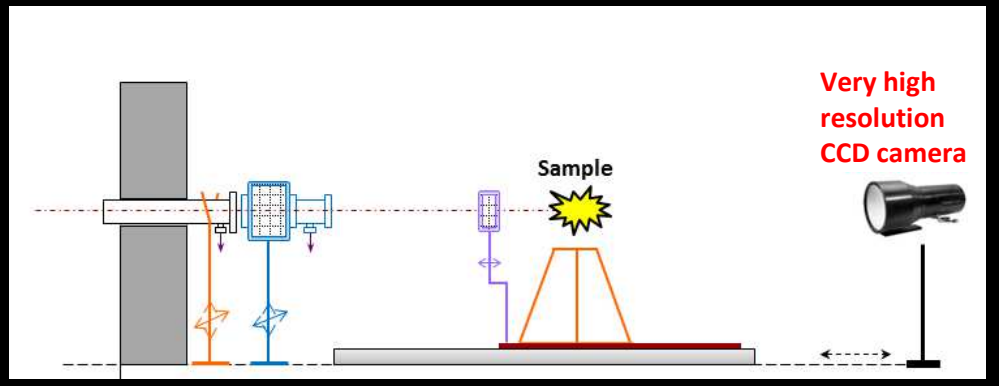
Experimental X-hutch (hall D1)



Beam monitoring
Focus device



Security beam shutter
Connection pipe

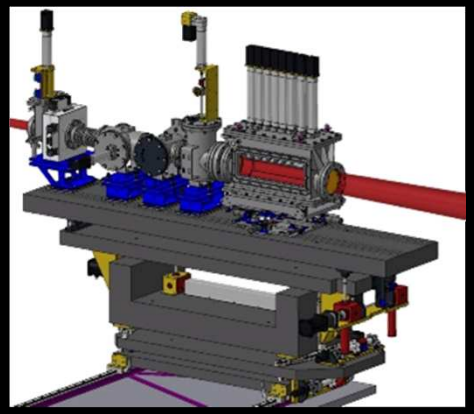


Highly versatile equipment

Dosimetry - Beam characterisation

➡ Medical Imaging - Radiobiology - Radiotherapy

Experimental X-hutch (hall D1)



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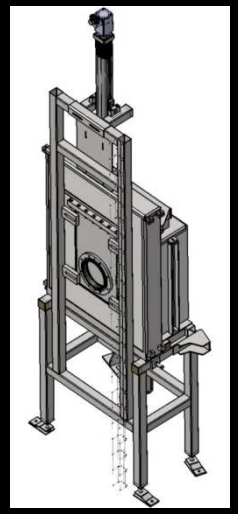
Focus device



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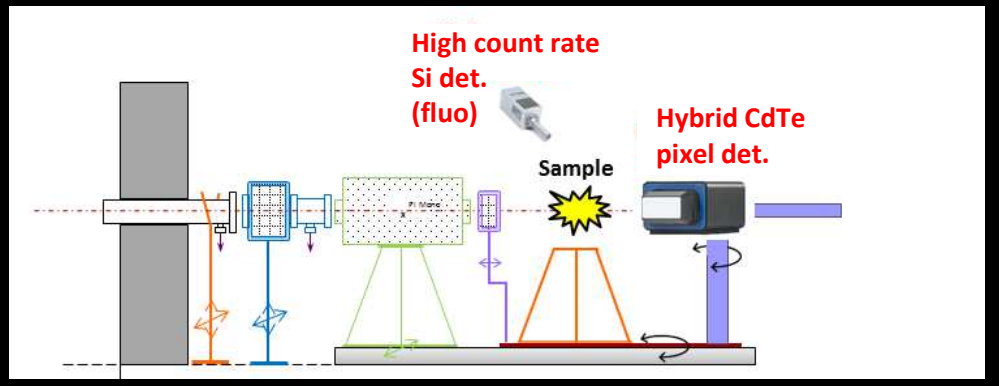
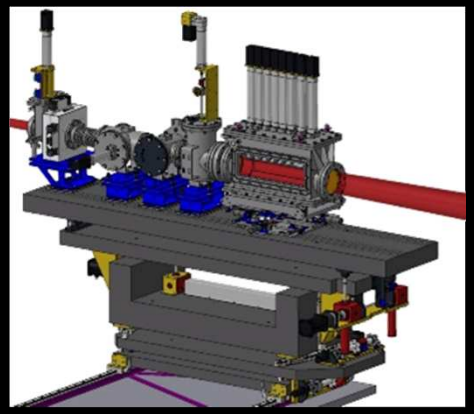


Highly versatile equipment

Dosimetry - Beam characterisation

Medical Imaging - Radiobiology - Radiotherapy

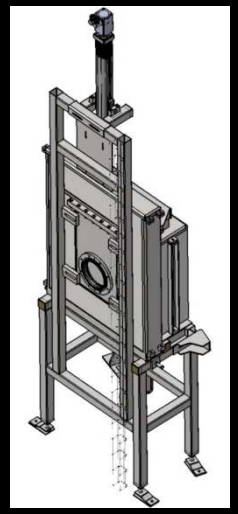
➡ Fluorescence - Diffraction



Beam monitoring
Focus device

Installation
inside Igloo

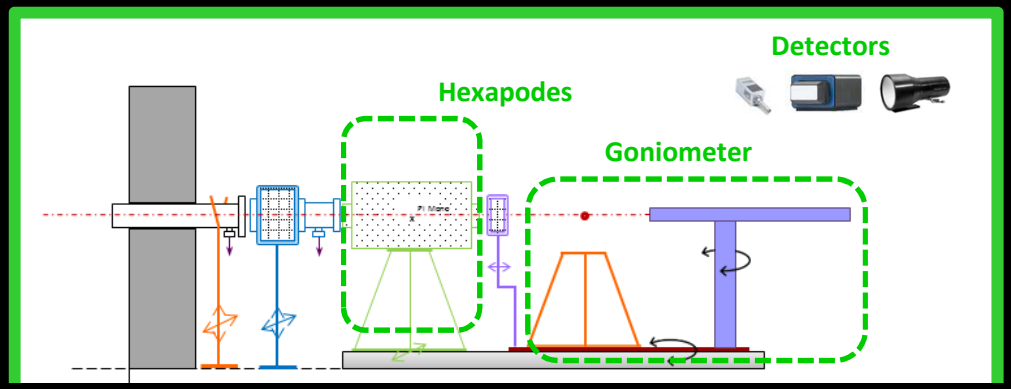
< end 2017



Security beam shutter
Connection pipe

Installation
inside Igloo

< end 2017



Experimental X-hutch (hall D1)

- Detectors: calls for tender next published
- System Hexa - Gonio:
  - Specifications for the call for tender almost ok
  - Complex and expensive devices
    → Delivery in situ has to fit the first X-ray beam

~ mi-end 2018