The CNGS Target Station

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The CNGS Target Station

OUTLINE

1. The driving parameters
2. The CNGS target station "as-built"
3. Material choices
4. Handling
5. Summary

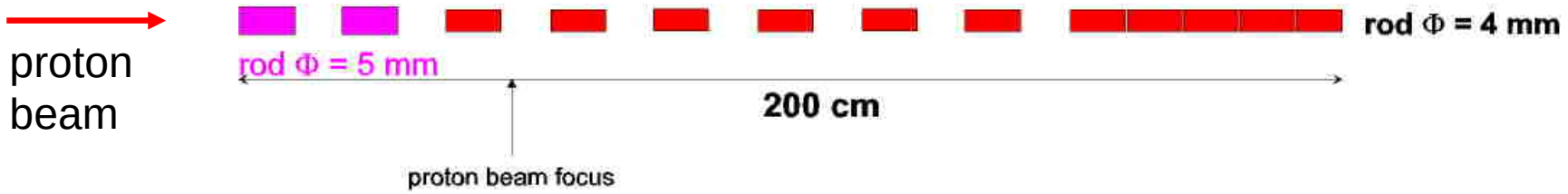
Driving Parameters

The CNGS Target has to …

… reliably intercept a 400 GeV proton beam every 6 s in a double fast extraction with two 10μs-long spills at 50 ms distance. The nominal beam intensity is 4.8×10^{13} protons per cycle, but an ultimate intensity of 7×10^{13} protons has been considered in view of a possible beam upgrade. The beam σ is 0.5 mm. The design average beam power is 750 kW.

The target elements

10 cm long carbon rods, Ø = 5mm and/or 4mm

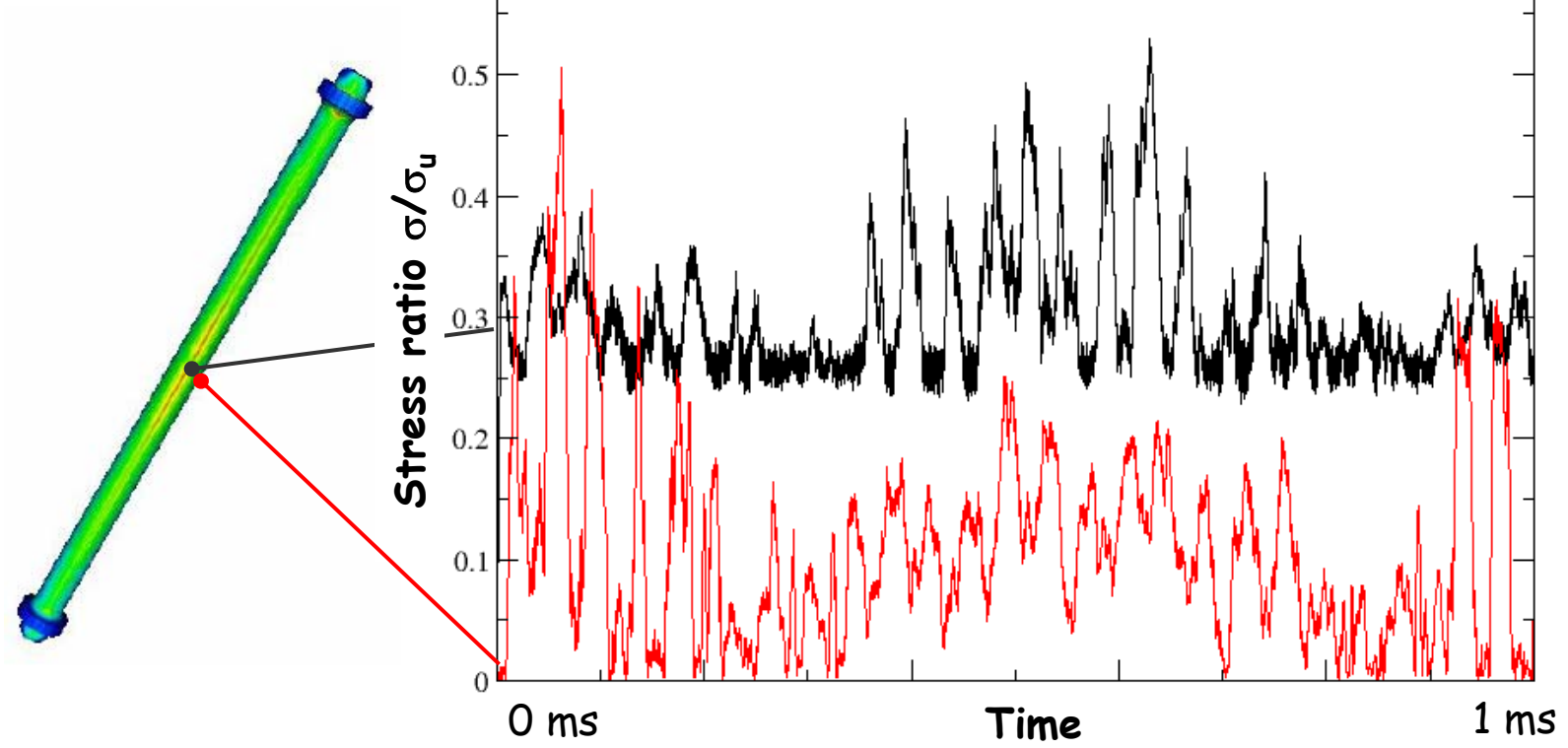


Note: - target rods thin / interspaced to "let the pions out"

- target shall be robust to resist the beam-induced stresses
- target needs to be cooled (particle energy deposition)

Estimated Target Stress

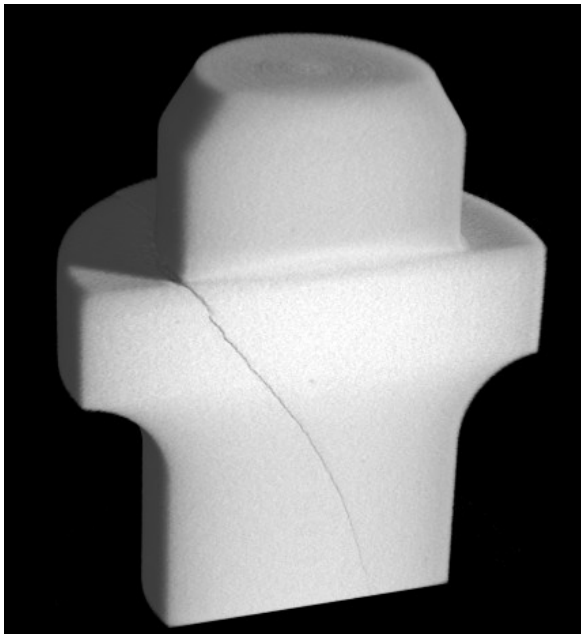
May 2005 - Measured material properties



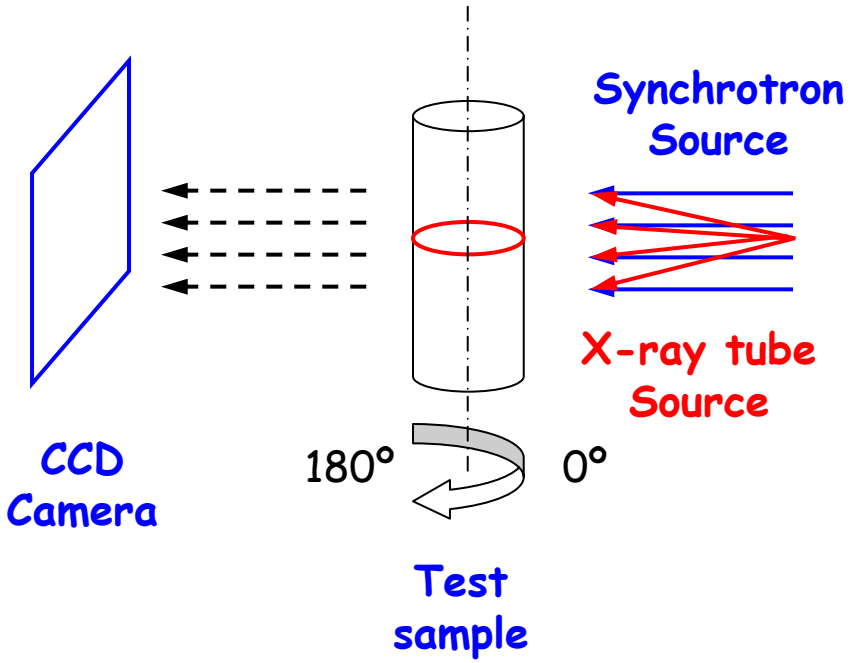
Based on the measured material properties, the estimated stress values are at most 50% of the limit value under worst loading conditions (1.5mm off-axis, ultimate proton spill on a cold baseline target without damping).

Non-destructive target tests

X-ray Micro-tomography

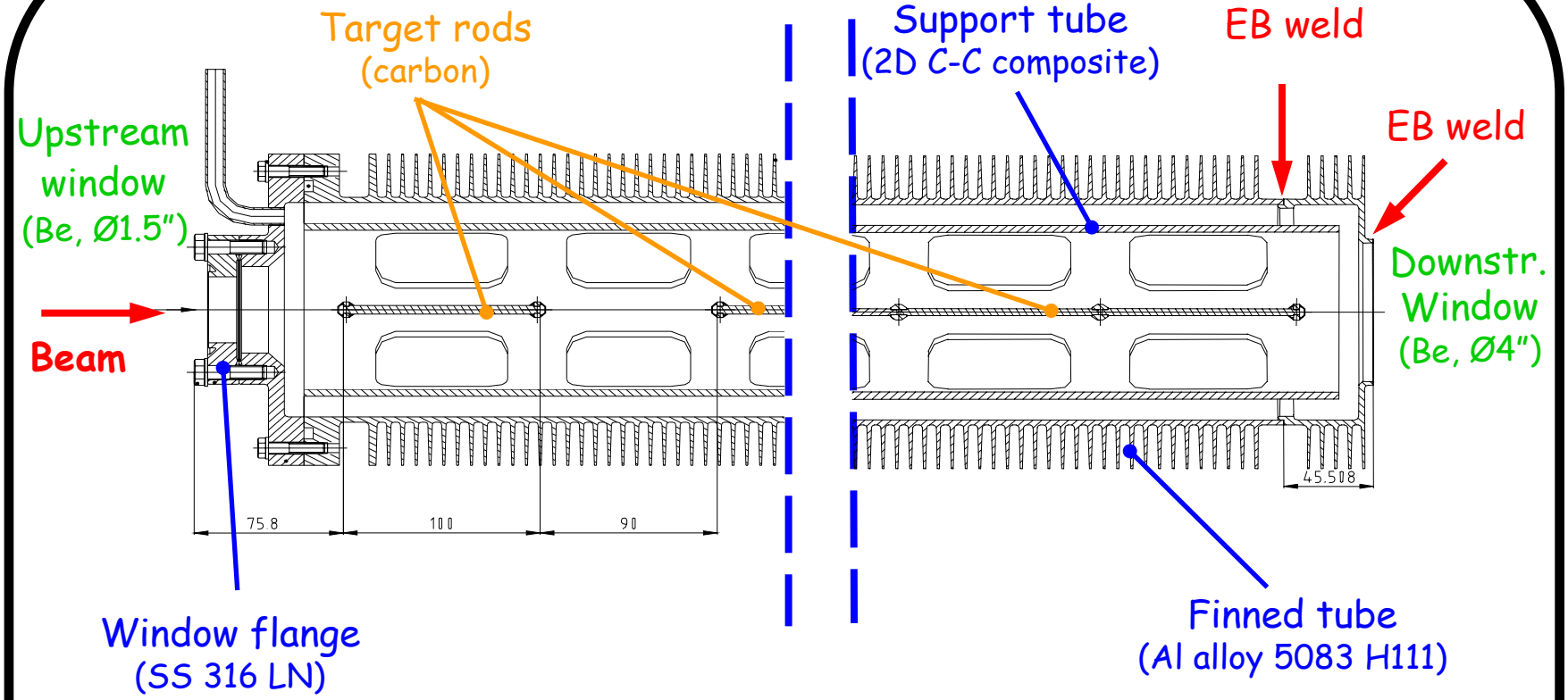


3D Cross-section of the Re-build object



Prototype target rods have been examined by X-ray microtomography. Hidden defects have been identified which could act as crack starters. They have been avoided by modifying the machining procedure.

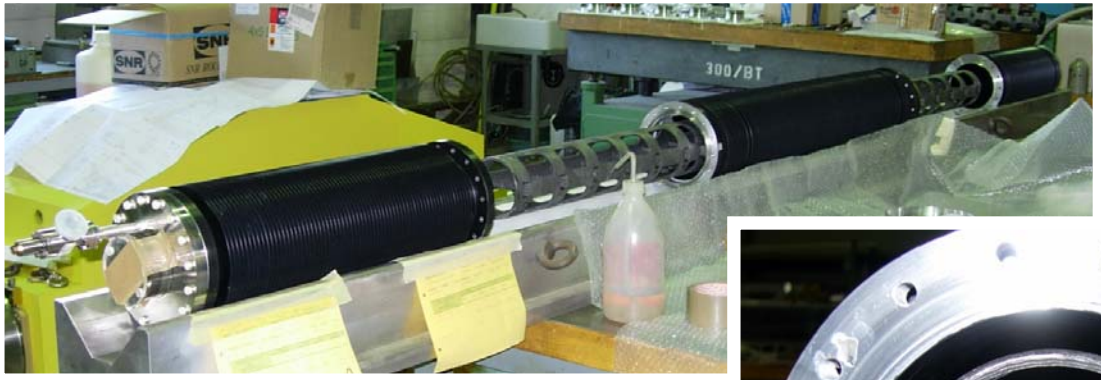
The Target Unit



The target unit is conceived as a static sealed system filled with 0.5 bar of He.
The tube has annular fins to enhance convective heat transfer.
Light materials are used to limit the heat load.

The CNGS Target Station as-built

The target units



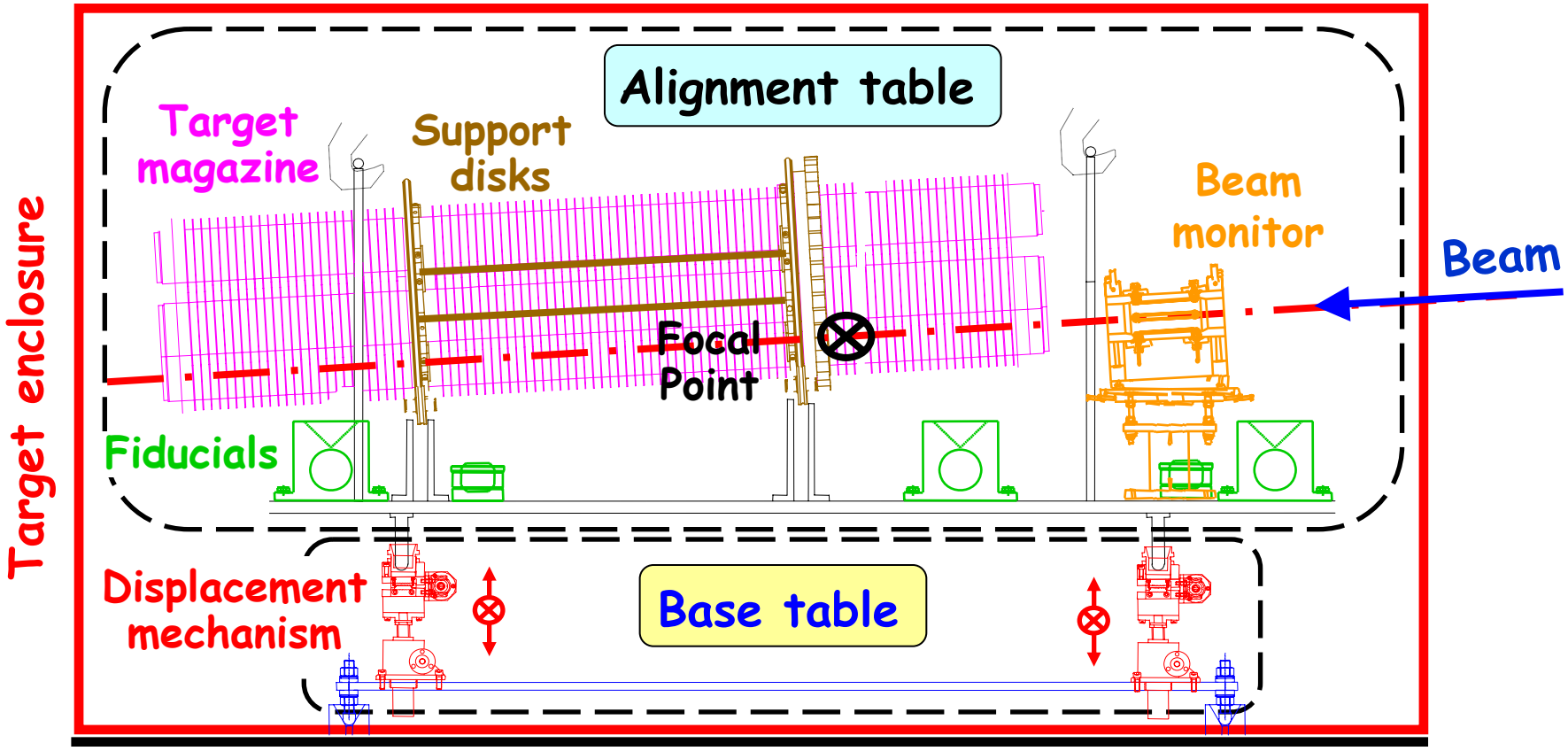
Five units (1 active unit + 4 in-situ spares) are hosted in a target magazine.
An additional spare magazine has been supplied, for a total of 10 targets..

The first target magazine…

…Is equipped as follows:

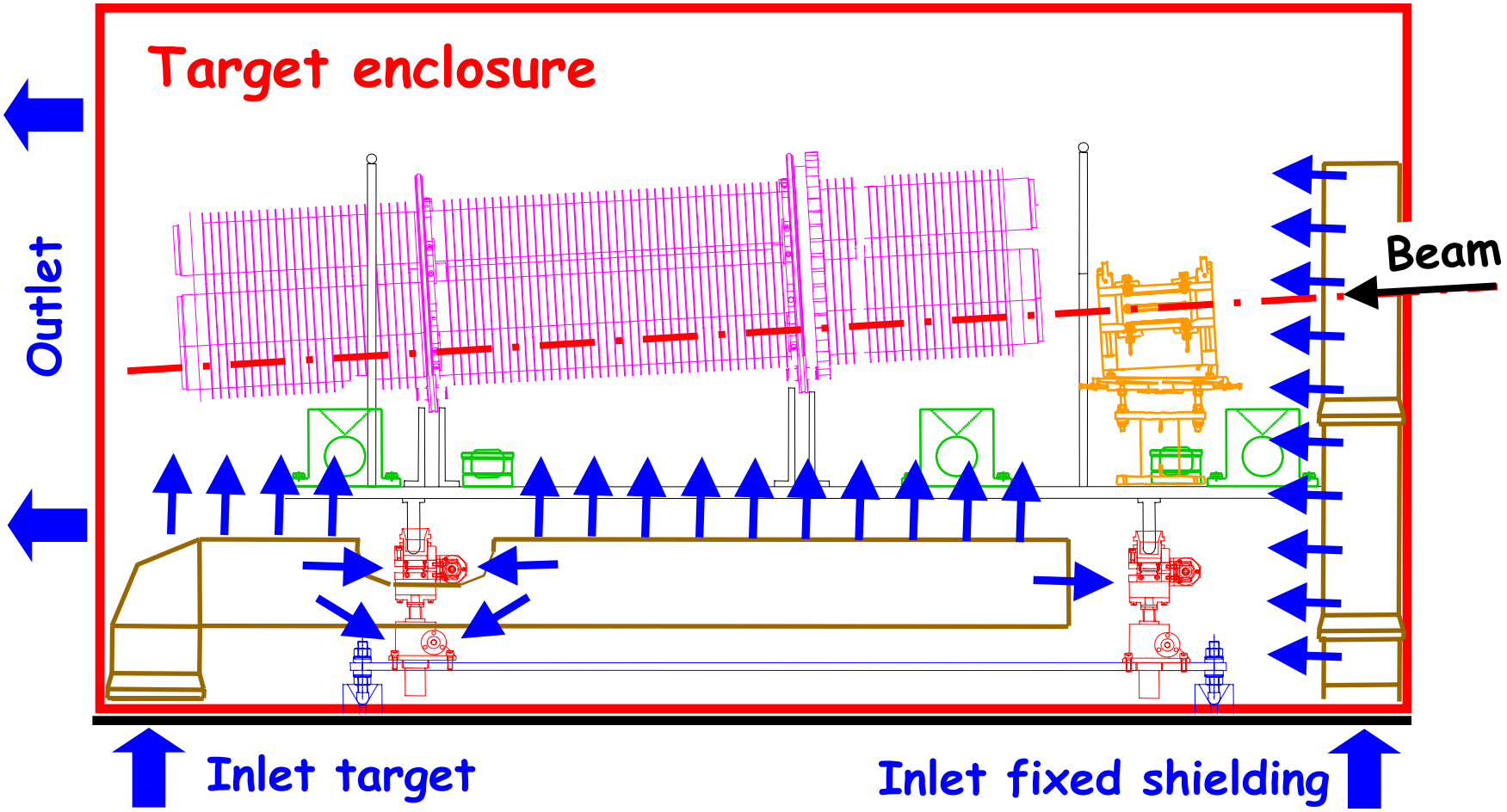
1. Graphite target with baseline geometry under helium (Graphite 2020PT by Carbone Lorraine);
2. Carbon target with baseline geometry under helium (Sintered Carbon SC24 by Sintec Keramik);
3. C-C composite target with baseline geometry under helium (Aerolor A035 by Carbone Lorraine);
4. Carbon target with baseline geometry under vacuum (Sintered Carbon SC24 by Sintec Keramik);
5. *"Safe" target:* Graphite target with all ∅5mm rods under helium (possibility to increase the beam size, 2020PT);.

Target Assembly

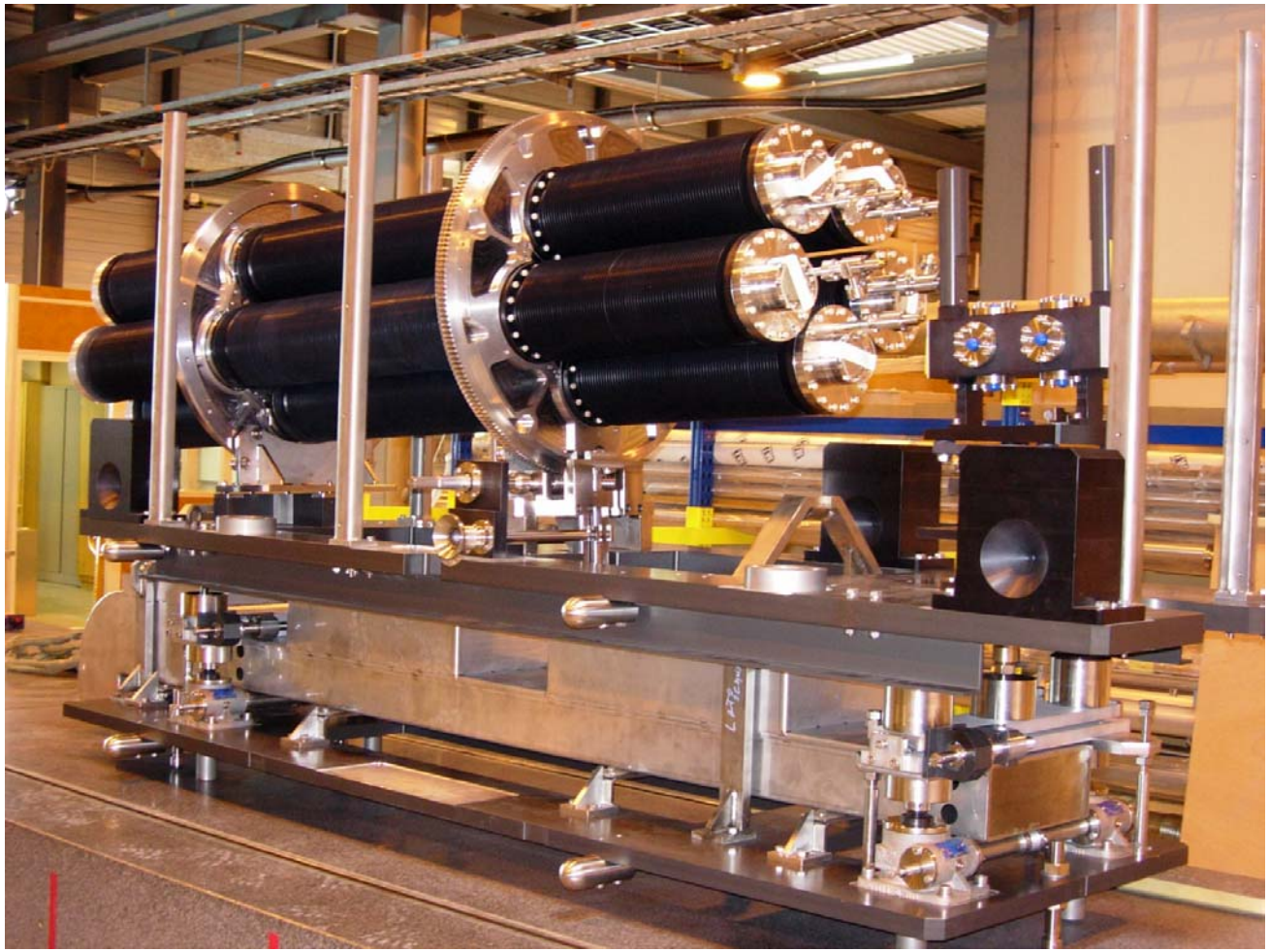


The target magazine is mechanically coupled to a beam monitor. Both are aligned in the lab and are remotely handled as a single component (the « alignment table »). They rest on the « base table », bearing the displacement mechanisms. The target cooling system is not shown.

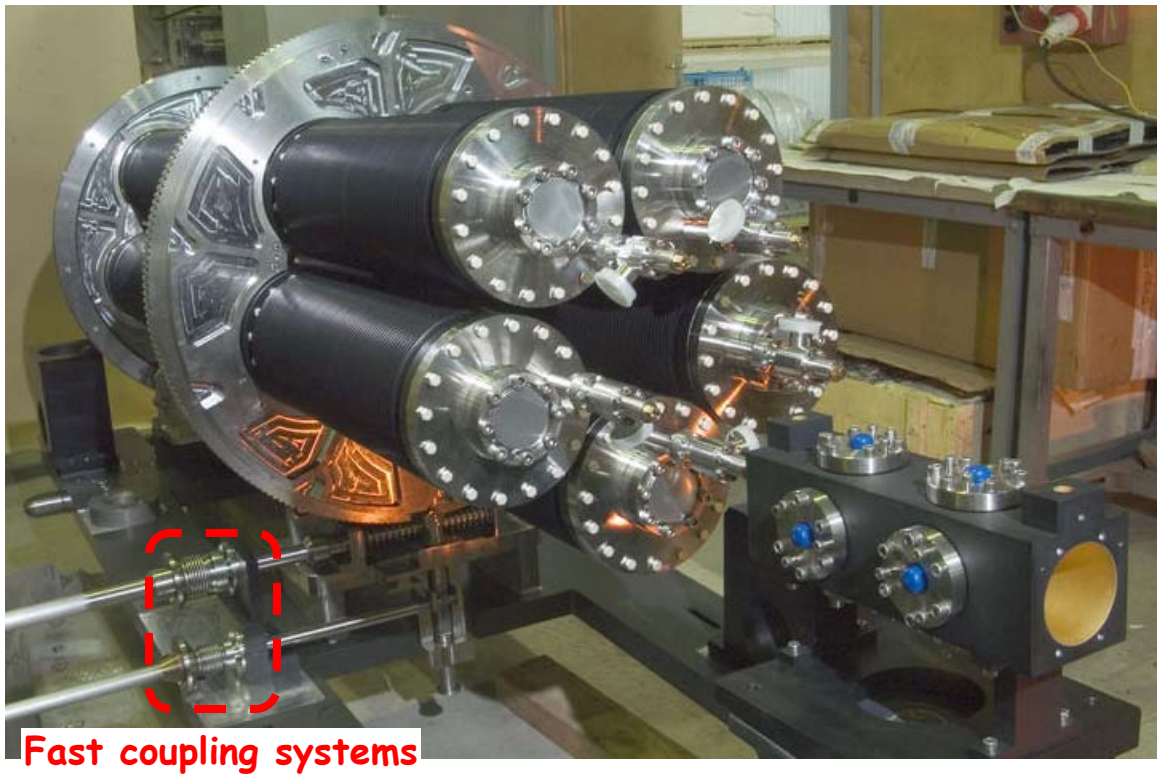
Air cooling
Schematic side view



The target Assembly



The alignment table

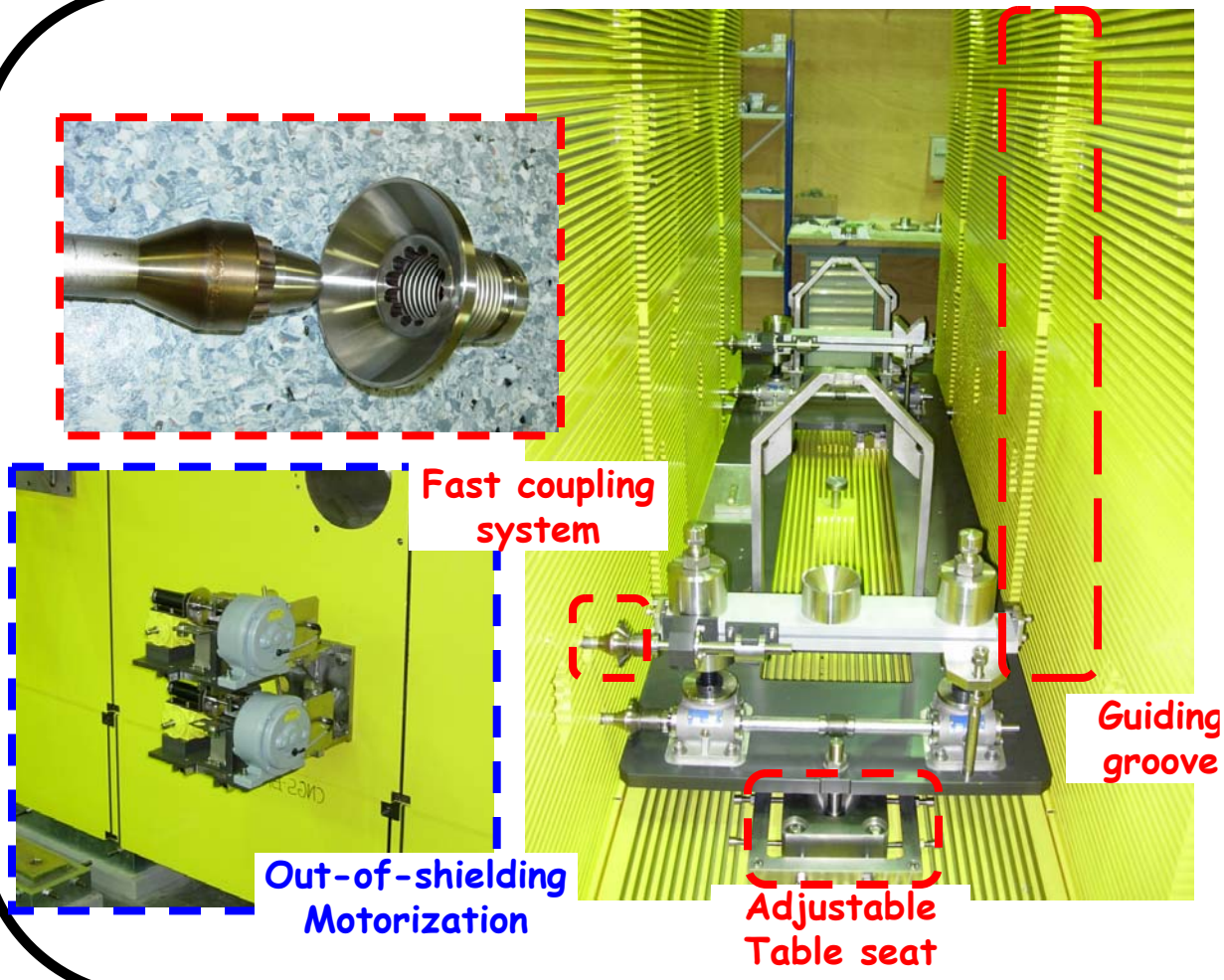


Fast coupling systems

Indexing finger

Grey (or black) components are made of (black) hard anodized aluminium, while silvery parts are in stainless steel. No other material is otherwise used.

Handling principles



The base table is placed automatically by guiding grooves on three adjustable seats.

The motorization driving the table mechanisms is located out of the shielding.

The connection is realized through the shielding by shafts provided with fast coupling systems.

Target magazine exchange 1/2

(Courtesy of S.Roesler - CERN SC-RP)

Handling steps

1. Install lights **(1)**
2. Disengage motorization shafts **(1)**
3. Disconnect cables on patch panel **(1)**

Remote

4. Open shielding cap
5. Lift target magazine with crane and transport to trailer
6. Close shielding cap
7. Move trailer to radioactive storage chamber

8. Transport of new target magzine
9. Open shielding cap
10. Lift new target magazine into target station
11. Close shielding cap

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12. Open shielding plugs, insert alignment bars and place spheres **(1)**

Remote

13. Observe alignment spheres and adjust position

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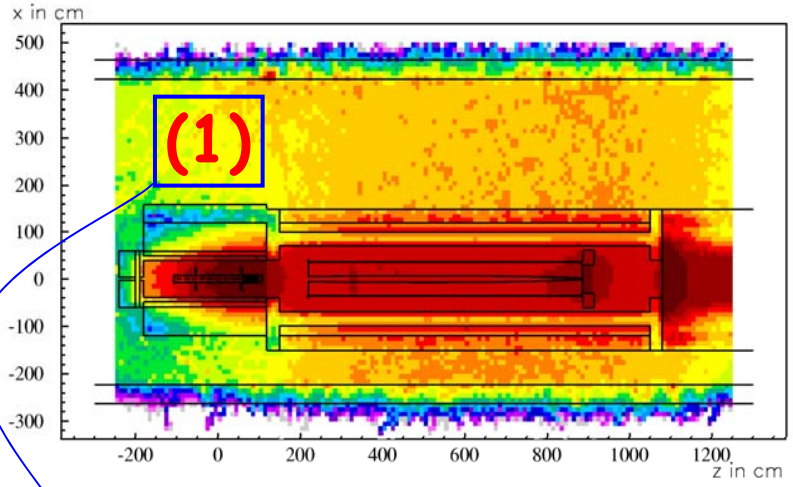
14. Remove spheres and alignments bars, close shielding plugs **(1)**
15. Engage motorization shafts **(1)**
16. Connect cables on patch panel **(1)**
17. Remove lights **(1)**



Residual Dose Equivalent Rate (mSv/h)

200 days irradiation, 1 day cooling

8×10^{12} protons/s

Dose Rate (uSv/h)	
1 day	30494
1 week	470
1 month	254
2 months	190
4 months	149
6 months	124

Target magazine exchange 2/2

(Courtesy of S.Roesler - CERN SC-RP)

Intervention step	Duration (min)	Location	ld [µSv]	lw [µSv]	Accumulated lm [µSv]
Install lights	1.	1	508	7	4
Disengage motorization shafts	5.	1	2541	39	21
Disconnect cables on patch panel	2.	1	1016	15	8
Open shielding cap	-	remote	0	0	0
Lift target magazine with crane...	-	remote	0	0	0
Close shielding cap	-	remote	0	0	0
Move trailer to radioactive storage chamber	-	remote	0	0	0
Transport of new target magzine	-	remote	0	0	0
Open shielding cap	-	remote	0	0	0
Lift new target magazine into target station	-	remote	0	0	0
Close shielding cap	-	remote	0	0	0
Open shielding plugs, insert alignment bars...	2.	1	1016	15	8
Observe alignment spheres and adjust position	-	remote	0	0	0
Remove spheres and alignments bars, ...	1.	1	508	7	4
Engage motorization shafts	5.	1	2541	39	21
Connect cables on patch panel	5.	1	2541	39	21
Remove lights	1.	1	508	7	4
Total: [µSv]			~~11181~~	172	93

Checked by handling tests

CERN design criterion :
2 mSv/person/intervention

Summary headlines

The project has delivered…

- **A new operational target station**
  - Complying with the specifications at "ultimate" beam intensity;
  - Successfully tested (mechanics, electronics, in local and remote);
- **Spare sub-assemblies**
  - A complete spare target assembly ("base+alignment tables");
  - A double of all motorizations and potentiometers;
  - A double of electronic components (rack, cables);
- **A set of tools to maintain it**
  - "Hardware" tools (handling, alignment, transport, testing);
  - "Software" tools (detailed procedures for testing and handling);
- **Trained personnel to operate the target**
  - Preventive and exceptional maintenance
    4 technicians (2 Mech. + 2 Electr)
  - Alignment (2 Geometers);
  - Remote operation (1 Engineer);
  - Radiation protection (2 Technician);
  - Handling (2 crane/transport operators).

Engineering target limits

1. **Fast fracture**
   1. Dynamic stresses (-> beam time structure)
   2. Static stresses (-> beam profile)
2. **Thermal stability**
   1. Change of phase (-> Cooling)
   2. Chemical reactions
3. **Radiation damage**

The CNGS Target Station as-built

The target within its shielding