CERN LINAC3 SLITS CONSOLIDATION

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RIKEN & J-PARC

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1. Background

- CERN's LINAC3 provides ion beams to the complex.
- Multiple SLITs are used for **charge state separation, diagnostics and emittance measurements.**
- The beamline of LINAC3 possess in total five different SLITs, each with different constrains and requirements.

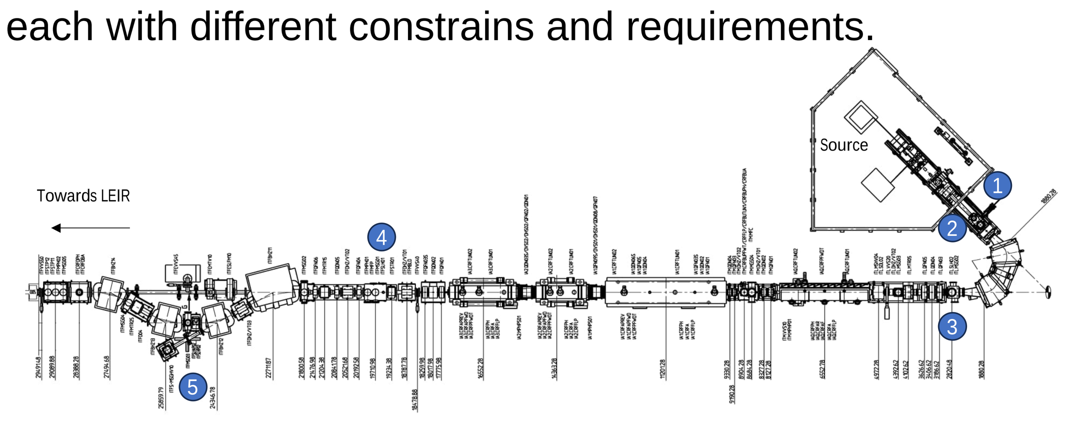


Figure 1: SLITS 'distribution along the LINAC3 beamline

- **Present challenges**
  - **Ageing equipment** dating from the **1970**'s for LINAC1.
  - **Lack of documentation** and drawings.
  - **No spare parts** for the subcomponents.
  - **Not adapted to new functional requirements**.
  - They are no mean to measure the SLIT with respect to other beam line components.
  - Aging of components, leading to mechanical blockage.
- **Consolidation program**
  - Redesign all the SLITS in order to meet new operational requirements, simplify the mechanical system and follow best radiation protection practises.
  - The study started with the **SLIT ITF.SLH01**.

2. SLITs functional specifications

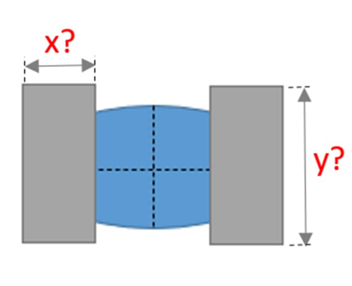
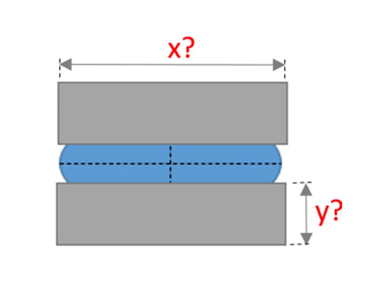
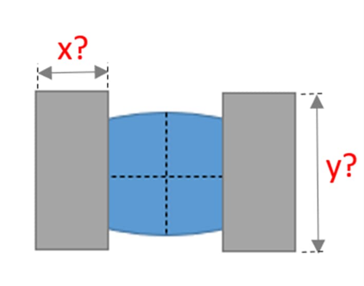
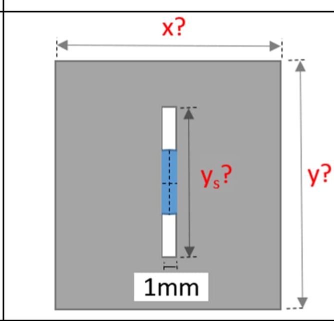
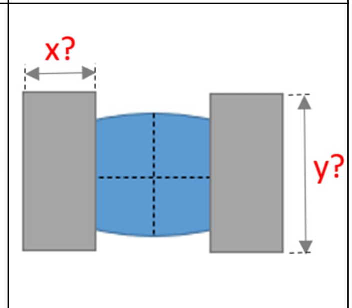
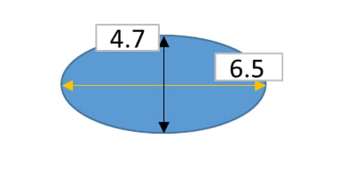
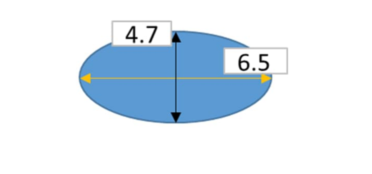
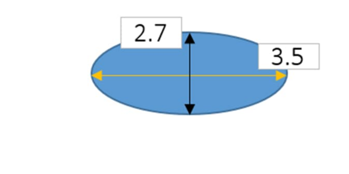
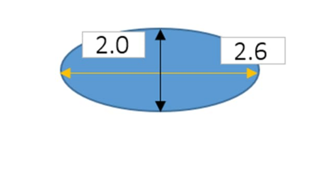
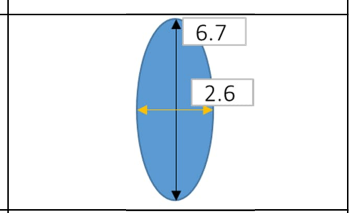
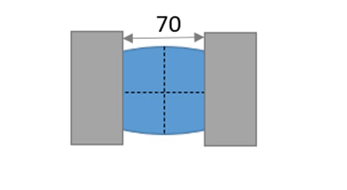
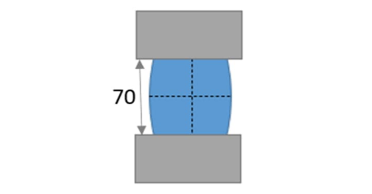
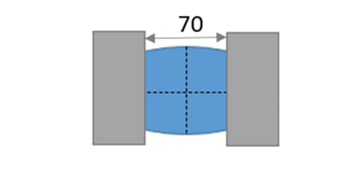
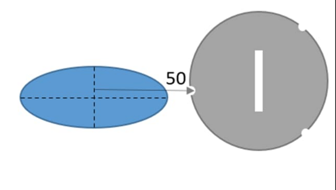
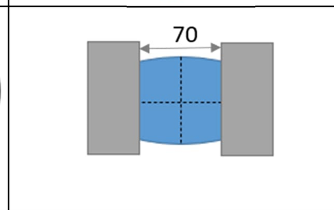
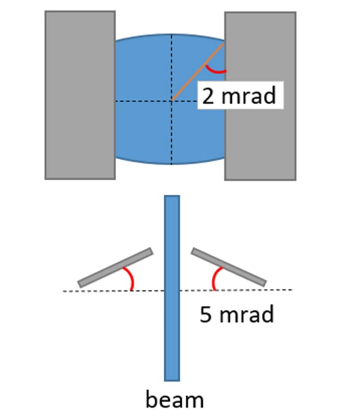
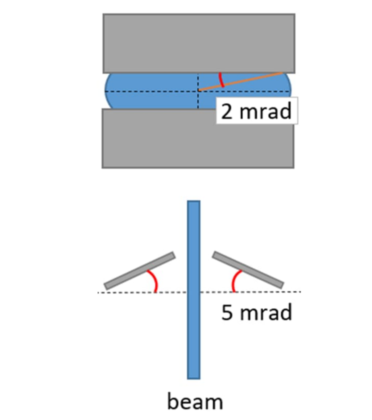
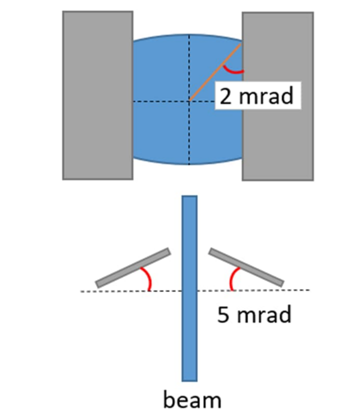
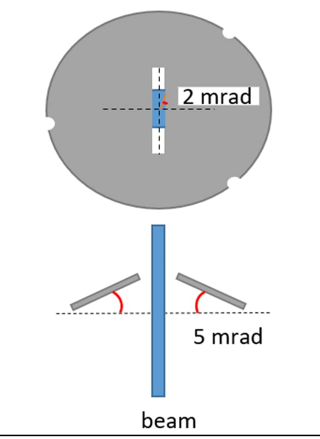
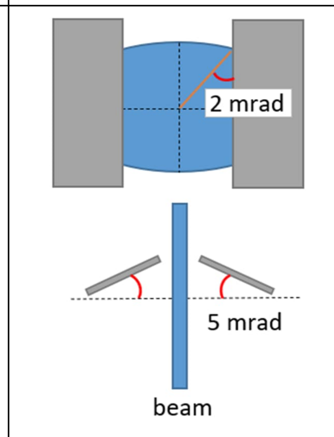
		① ITL.SLH01	② ITL.SLV01	③ ITL.SLH02	④ ITF.SLH01	⑤ ITF.SLH02
DIMENSIONS						
TYPE		Independent: left, right	Independent: top, bottom	Independent: left, right	left, right	Independent: left, right
OPERATION BEAM ENERGY		2.5 keV/u	2.5 keV/u	2.5 keV/u	Unstripped beam at 4.2 MeV/u	Stripped beam at 4.2 MeV/u
OPERATION BEAM 1 SIGMA						
MAXIMUM OPENING						
MINIMUM POSITION (both edges)		-15mm	-15mm	-15mm	±20mm	-15mm
MAXIMUM ROTACIONAL TOLERANCES						
ELECTRICAL INSULATION		Yes	Yes	Yes	Yes	Yes
CYCLES PER YEAR	Incomplete cycle	1000	1000	1000	1000	1000
	Complete cycle	100	100	100	100	100
OPERATIONAL VACUUM		8x10^{-9} mbar	8x10^{-9} mbar	8x10^{-9} mbar	8x10^{-9} mbar	8x10^{-9} mbar
SPEED		5 mm/s	5 mm/s	5 mm/s	5 mm/s	5 mm/s
MATERIAL		(Tantalum)	(Tantalum)	(Tantalum)	Tantalum	(Tantalum)
CONTROL SPECIFICATION		Yes	Yes	Yes	No	Yes
POSITIONAL PRECISSION		0.1 mm	0.1 mm	0.1 mm	0.1 mm	0.1 mm
PROSITIONALL ACCURACY		0.5 mm	0.5 mm	0.5 mm	0.5 mm	0.5 mm

Table 1: Functional requirement for the different LINAC 3 SLITS.

3. Thermal characterization

Thermal contact conductance

- Higher average power imposes the need for efficient cooling. However, indirect cooling is desired to simplify the mechanical design. The latter enhances the need for efficient heat transmission from the SLITs blades (in vacuum) to the outside.
- To define the materials and the design of the blade support, thermal contact conductance (TCC) measurements of various material combinations have been conducted on a test bench.

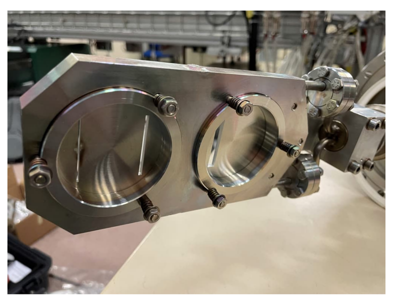


Figure 2: Assembly support-blade of the current SLIT

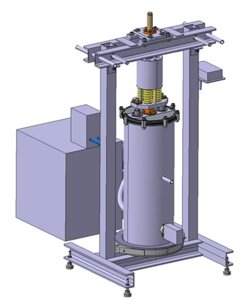


Figure 3: TCC test bench 3D model

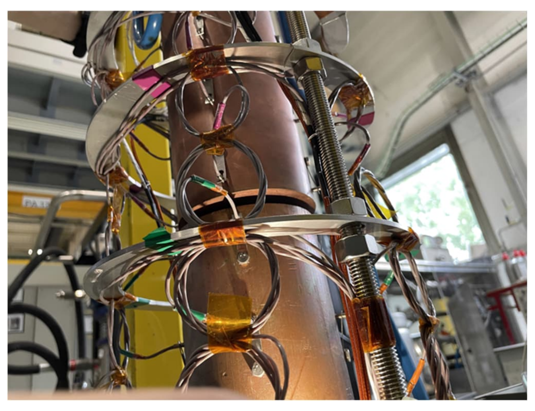


Figure 4. Distribution of the thermal sensors along the copper blocks of the TCC

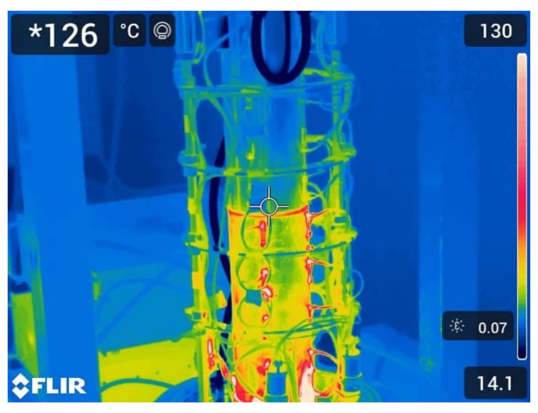


Figure 5: Tantalum and stainless-Steel sample for thermal conductance assessment captured with a thermal camera

Table 2: Results for the most similar case to the SLIT: 170W and 396kPa.

	~Peak temperature (℃)	~Gap temperature	~TCC (W/m^{2}K)
Tantalum	134	70	755
St. steel	269	206	321
Ta-St. steel	242	182	714
CuCr1Zr	105	43	1256
Ta-CuCr1Zr	148	83	1212*

- Tantalum blade bolted to a CuCr1Zr support is required to efficiently diffuse the heat from the new SLITs.

*For the thermomechanical simulations, a thermal conductance **of 500 W/m²K** is used.

Emissivity

- To include the correct emissivity in the thermomechanical simulations, emissivity measurements of the Tantalum blade at the intended operational temperature range (250℃) have been performed.

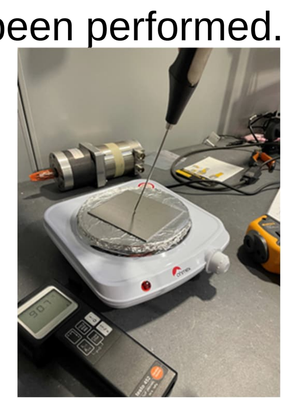


Figure 6: Taking measures with a contact thermometer

Figure 7: Taking measures with an infrared thermometer, changing the emissivity until having the same temperature

- The tantalum blade emissivity for the specified range of temperatures is **0.16**.

4. Thermomechanical analysis of the new arm assembly: ITF.SLH01

- Different beam scenario have been studied via FEM calculations, taking the data from the thermal characterization campaigns. At the most critical operational case (Oxygen ions), the tantalum blade can reach up to 156°C
- To extract the heat from the blade, the support arm will be made of CuCr1Zr. The heat is then extracted already outside the SLITs' tank via cooling fins in air.

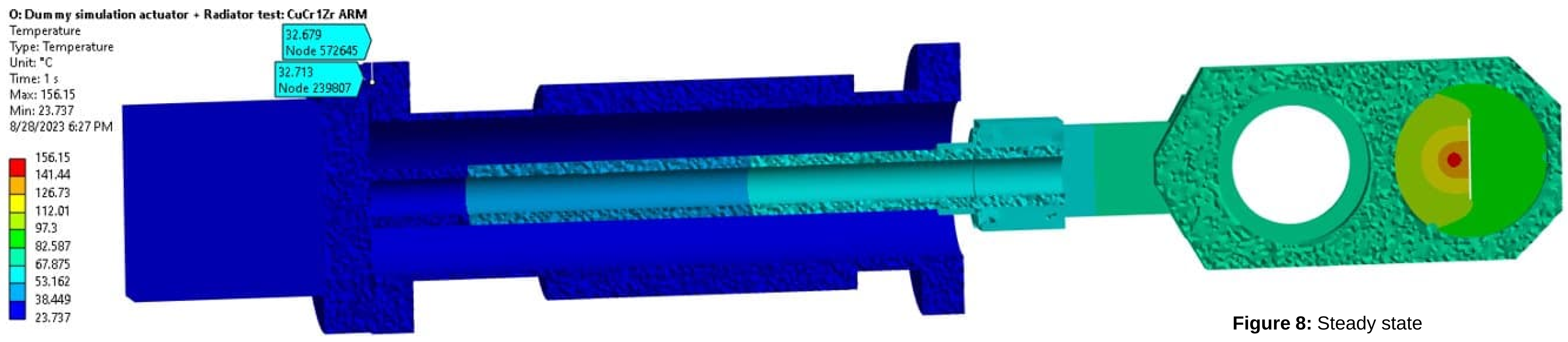


Figure 8: Steady state

5. Design

- The SLIT blade will be mounted on an arm. This arm, which is in the vacuum, will move into the different operational positions with a 1 axis motorized manipulator.
- The motion of the manipulator will be performed via a stepper motor while the position of the manipulator will be made with a resolver. Commercial components will be used for the vacuum manipulator.
- The system will be embedded in a vacuum tank connected to the beam line. It will be mounted on an alignment table to position with precision the slit blade with respect to the ion beam in LINAC 3.
- An ion pump will be connected to the SLIT tank.

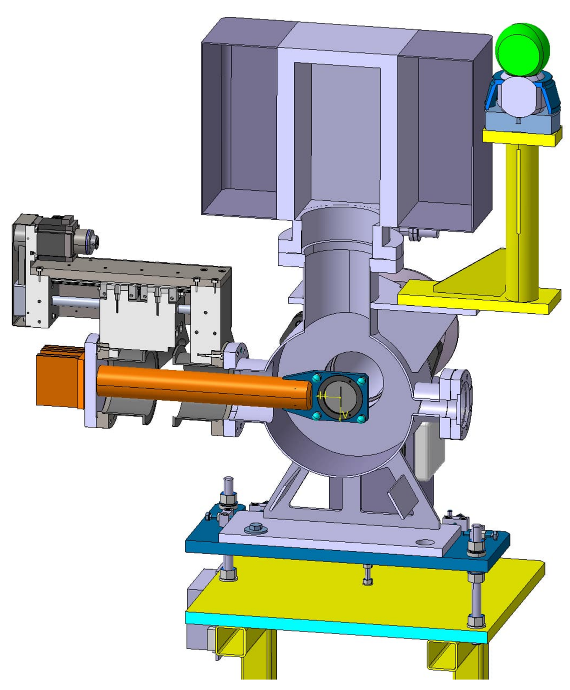


Figure 9: New ITF.SLH01 SLIT 3d cross section

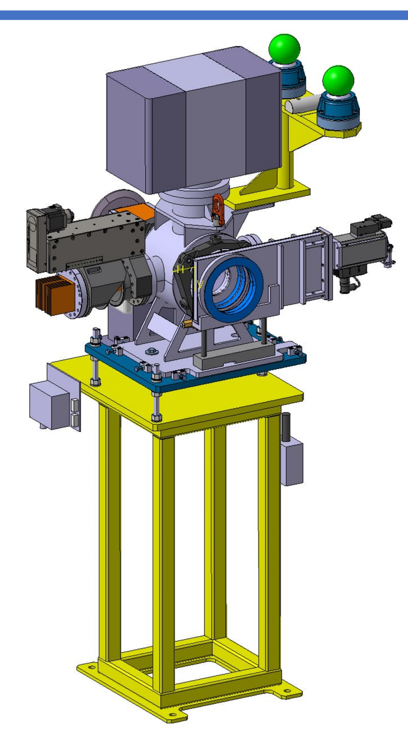


Figure 10: New ITF.SLH01 SLIT 3d assembly

6. Conclusions and next steps

- A preliminary design cable of extracting the heat in an optimized manner has been validated for ITF.SLH01. Thermal characterization campaigns have been performed and provided the required inputs for the thermo-mechanical calculations.
- The finalization of the mechanical design is ongoing. A final thermomechanical assessment will be followed.
- The production of the first new LINAC 3 SLITs is foreseen to start in 2024.
- Special effort is being made to use the same (or a scaled design) for the other 4 SLITS.

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