Preliminary design of the electrical feeding devices for the HL LHC superconducting powering

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W.Bailey[2], A.Ballarino[1], R.Betemps[1], I.Falorio[1], Y.Leclercq[1], V.Parma[1], F.Pasdeloup[1], Y.Yang[2]
CERN, Geneva, Switzerland[1], University of Southampton, United Kingdom[2]

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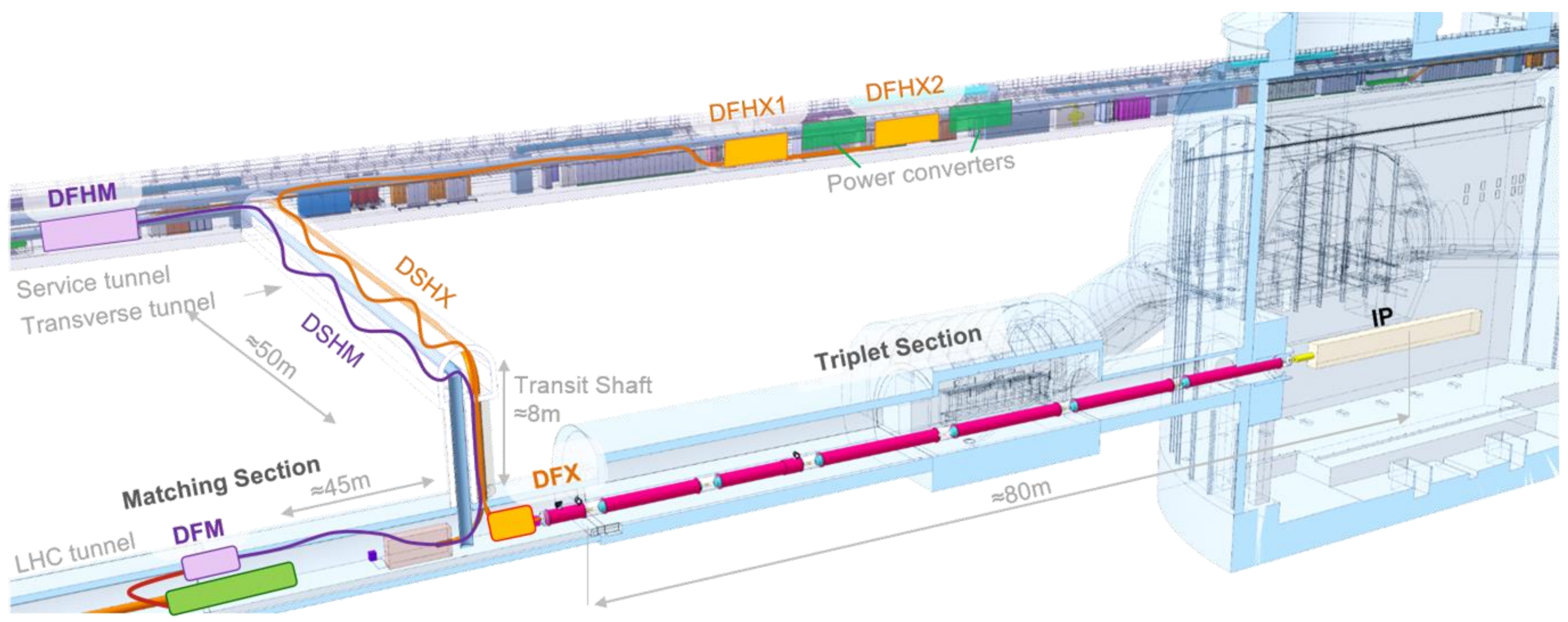
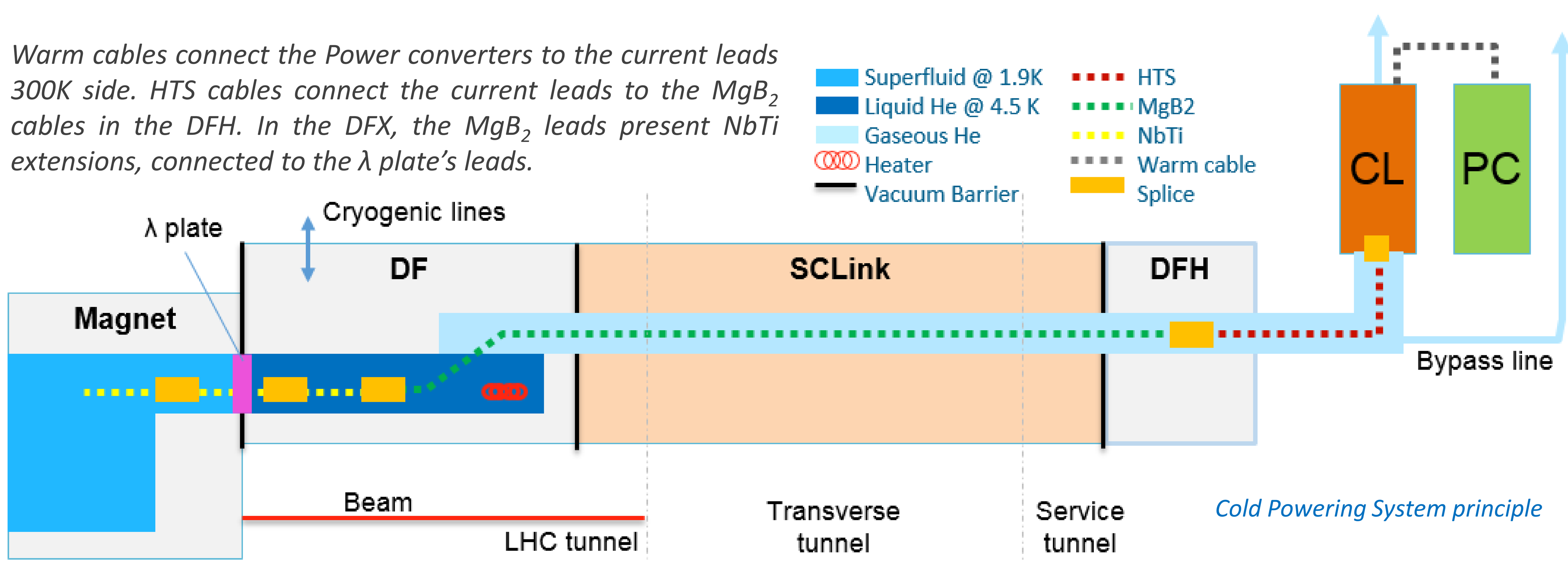
Abstract. The High Luminosity LHC (HL-LHC) project aims at upgrading the LHC collider after 2025 to increase its luminosity by about a factor of five. As part of this upgrade, new magnets will require an electrical powering system where the power converters are placed in a newly dug service gallery to shield them from the radiations emanating from the colliding beams. The electrical powering will be ensured via a superconducting line, in MgB2, housed into a flexible cryostat of length up to 140 meters, and carrying currents along diverse circuits between 0.6 kA and 18 kA. At the extremities of the flexible cryostats, electrical interconnection devices allow connecting the superconducting cables to the magnets in the LHC tunnel and to the current leads and power converters in the service galleries. Moreover, the devices ensure a regulated cooling by a vapour mass flow of helium through the continuous powering chain up to 10 g.s-1, at about 1.3 bar, and in the 4.5-17 K temperature range. This paper presents the technical requirements and the preliminary design of the electrical interconnection devices. The operating modes during transient and nominal phases are presented as well as the thermo-mechanical and cryogenic flow layouts. Integration and assembly in the LHC machine are also explained, including specific safety aspects and maintainability requirements.

Context & Cold Powering System principle

- The High Luminosity LHC project requires the installation of new magnets focusing the beam on each side of the 2 interaction points (ATLAS and CMS). The resultant higher levels of radiation require the electronics to be installed in newly dug parallel galleries to provide sufficient shielding and allow access for intervention.
- To connect the magnets to the power converters, each side of the interaction point presents two cold powering systems made of:
  - A superconducting link (DSHx or DSHm) carrying up to 19 MgB_2 cables over 100 to 140 m
  - A connection box to the magnets (DFX or DFM)
  - A connection box to the current leads (DFHx or DFHm)



Warm cables connect the Power converters to the current leads 300K side. HTS cables connect the current leads to the MgB_2 cables in the DFH. In the DFX, the MgB_2 leads present NbTi extensions, connected to the λ plate's leads.



Cold Powering System principle

The cryogenic layout and operation modes shall ensure maximum temperatures of the cables and electrical connections as well as continuous mass flows

Table 1. Temperature requirements for electrical leads and connections in operation.

Item		NbTi lead	MgB_2 lead	HTS lead	NbTi-NbTi connection	MgB2-NbTi connection	MgB2-HTS connection
Maximum Temperature	[K]	5.5	17	50	5.5	5.5	17

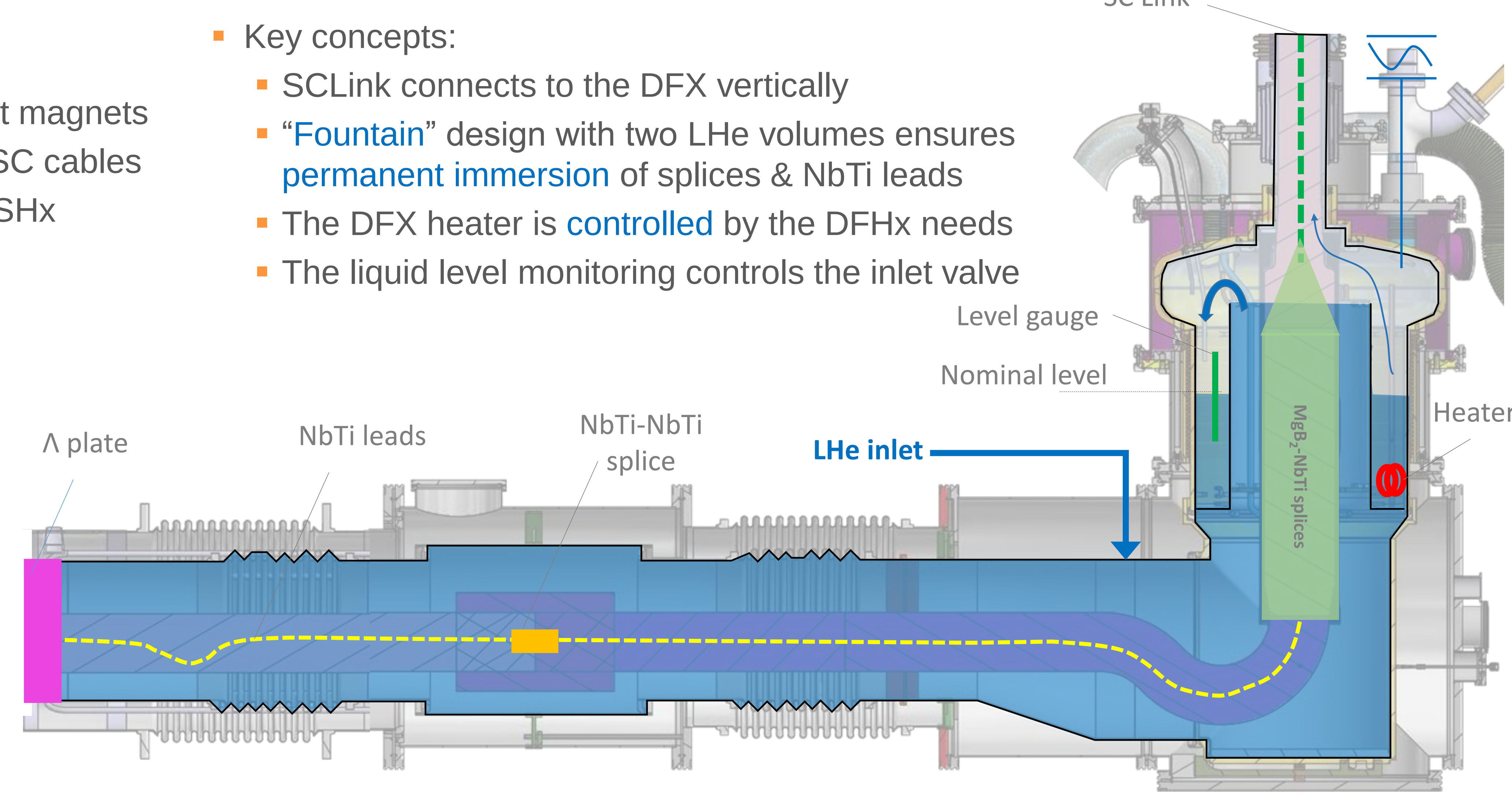
Table 2. Helium mass flow through the cold powering chain of cryostats.

Section	Nominal [g.s^{-1}]	Design [g.s^{-1}]
Triplet	5	10
Matching	2	3

DFX cryogenic features

- DFX basic functions:
  - Electrical interface SCLink & triplet magnets
  - Ensure operating temperature of SC cables
  - Supply 4.5 K GHe mass flow to DSHx
- Key concepts:
  - SCLink connects to the DFX vertically
  - "Fountain" design with two LHe volumes ensures permanent immersion of splices & NbTi leads
  - The DFX heater is controlled by the DFHx needs
  - The liquid level monitoring controls the inlet valve

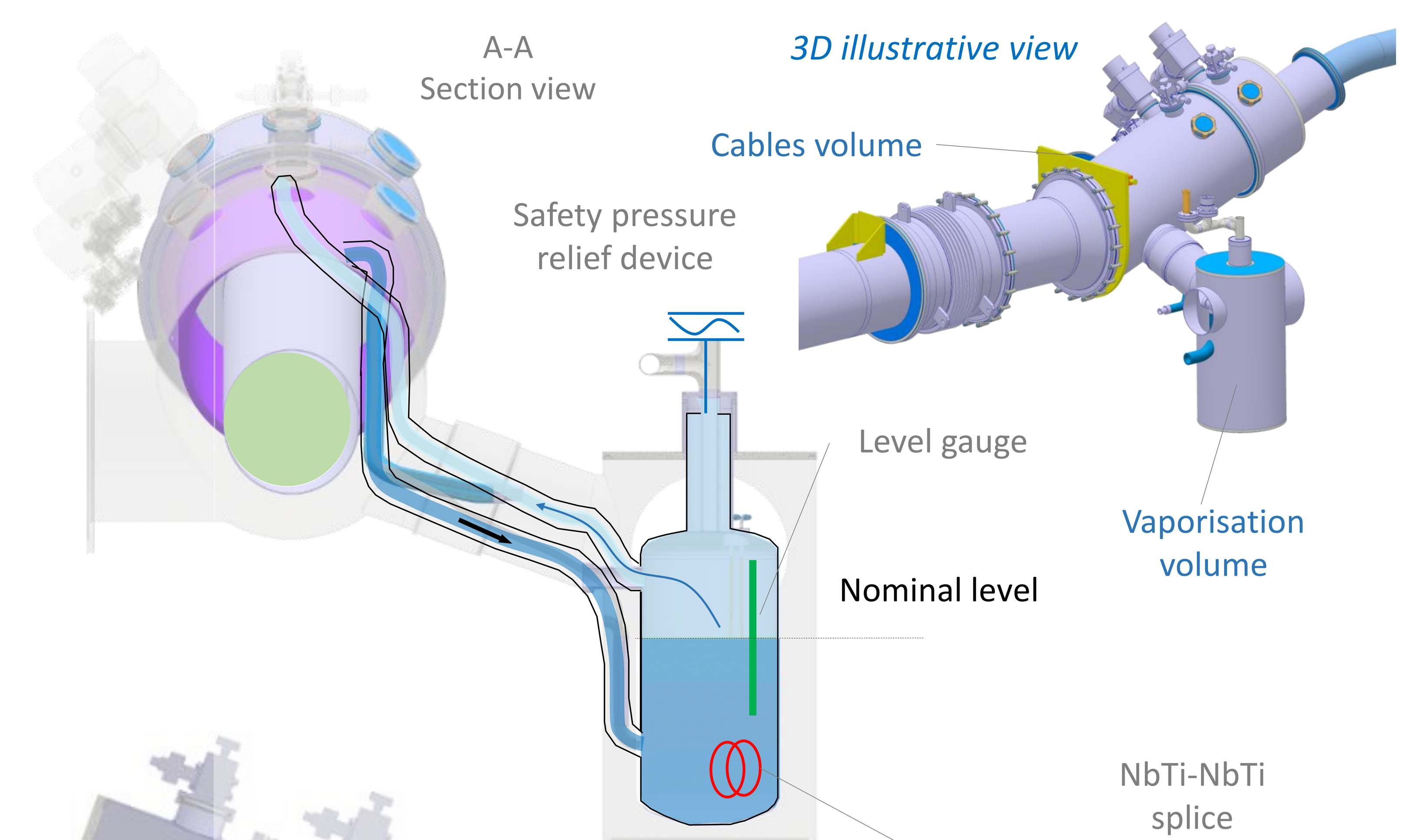
Principle:
LHe is injected in the lower volume, submerges splices and overflows in outer volume where it is vaporised to create a Ghe mass flow through the SCLink.



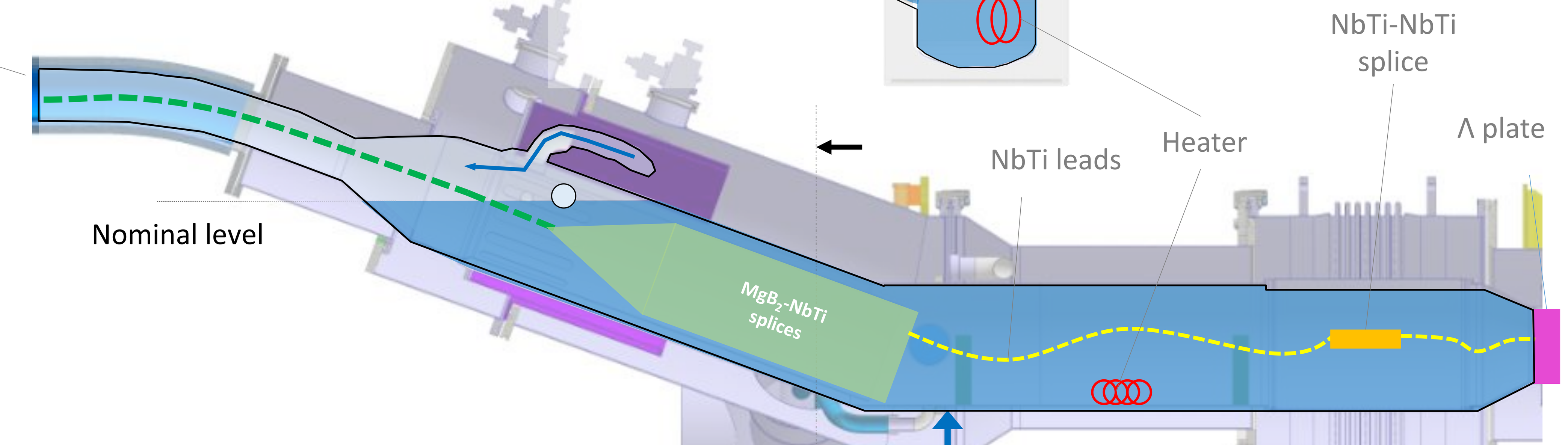
DFX cryogenic concept in nominal configuration

DFM cryogenic features

- DFM basic functions:
  - Electrical interface SCLink & matching section
  - Ensure operating temperature of SC cables
  - Supply 4.5 K GHe mass flow to DSHm
- Key concepts:
  - SCLink connects to the DFM angularly
  - "Fountain" design with two LHe volumes ensures permanent immersion of splices & NbTi leads
  - The DFM heater is controlled by the DFHm needs
  - The liquid level monitoring controls the inlet valve



Principle:
LHe is injected in the main volume, submerges splices and overflows in a side reservoir where it is vaporised to create a Ghe mass flow routed back to the SCLink inner volume.



DFM cryogenic concept in nominal configuration
Courtesy A.Kolehmainen