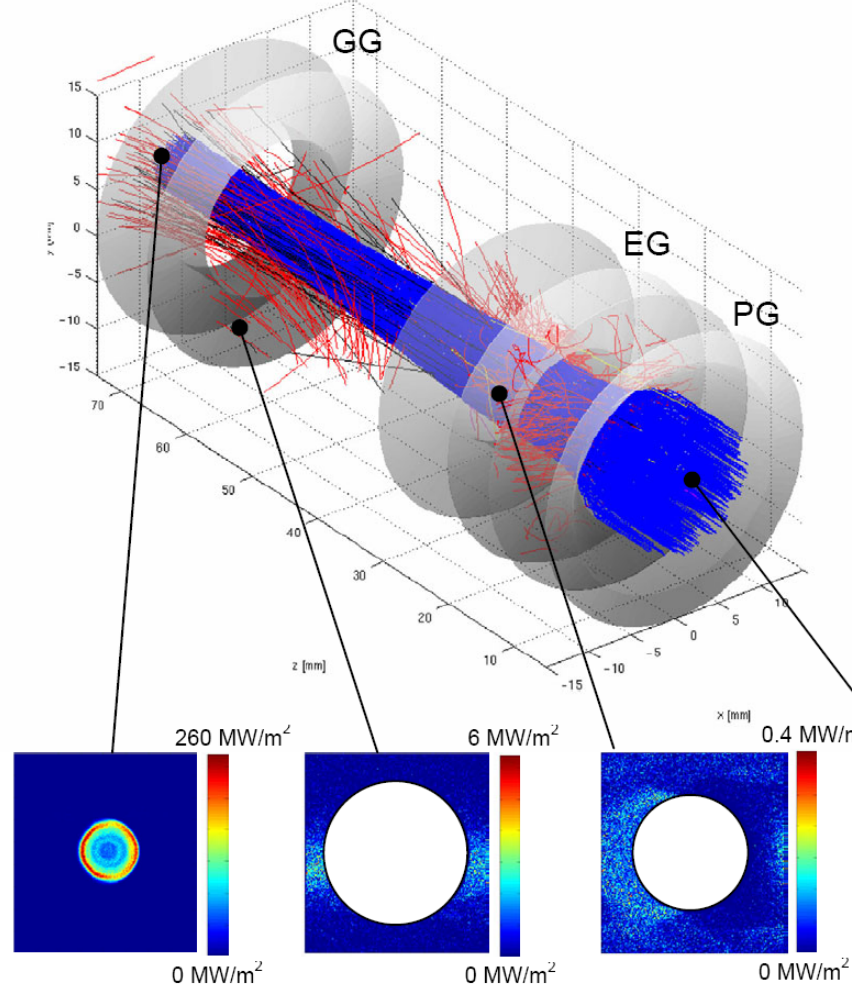


Secondary particles and Thermal load

(a) Simulation of H^+ (34.2 mA/cm²) and related species (**secondary e^-** , H_0 , H^+ , H_2^+)

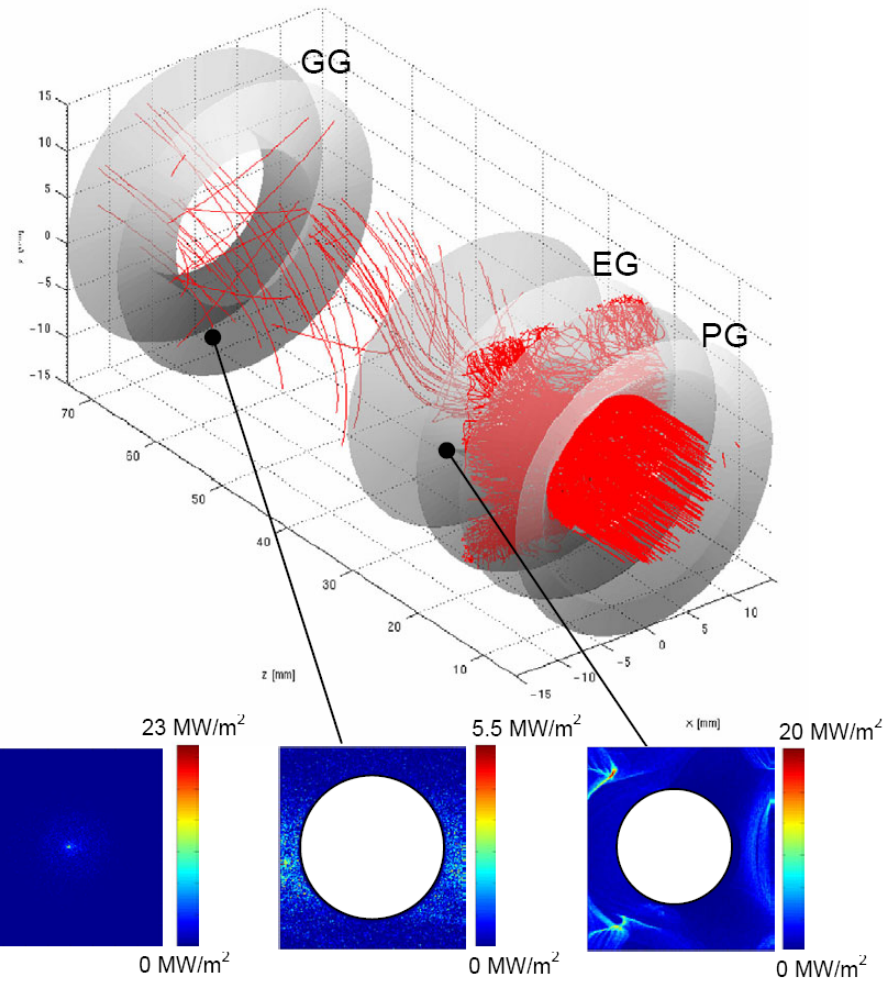


Transmitted beam:
 4890 W per aperture
 6259 kW whole grid

Heat load on GG:
 75 W front + 91 W cyl.
 215 kW whole grid

Heat load on EG:
 13 W front + 9 W cyl.
 28 kW whole grid

(b) Simulation of **co-extracted e^-** (34.2 mA/cm²)

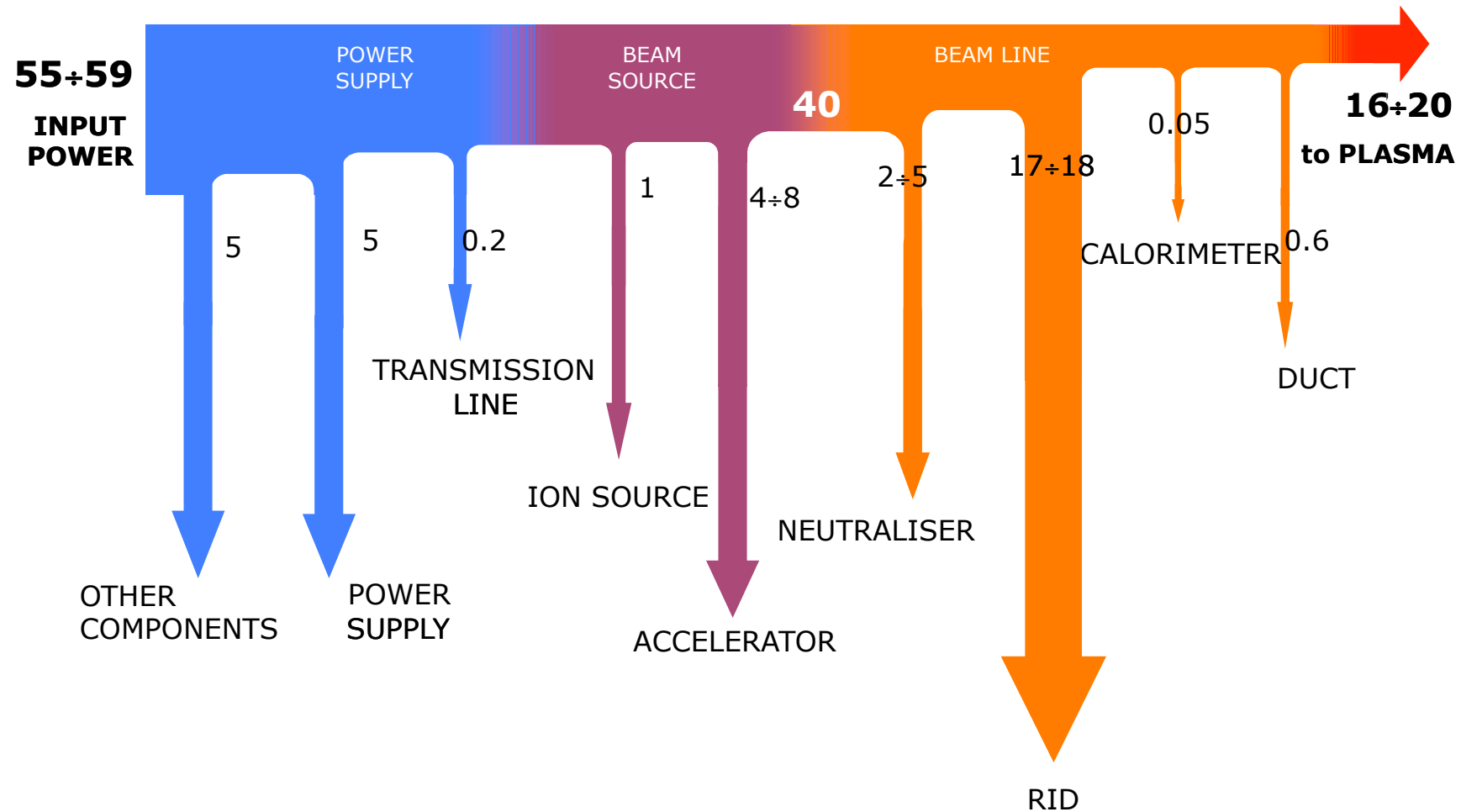


Back-streaming ions:
 45 W per aperture
 58 kW whole grid

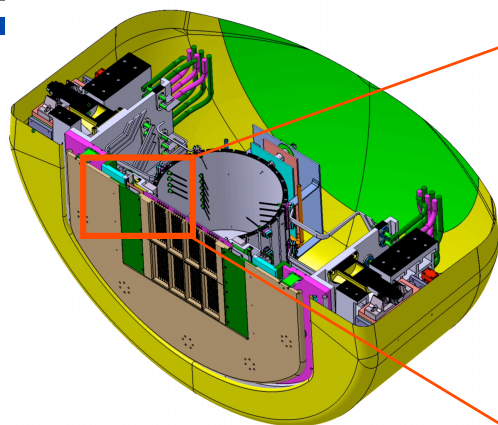
Heat load on GG:
 82 W front + 87 W cyl.
 220 kW whole grid

Heat load on EG:
 450 W front + 41 W cyl.
 630 kW whole grid

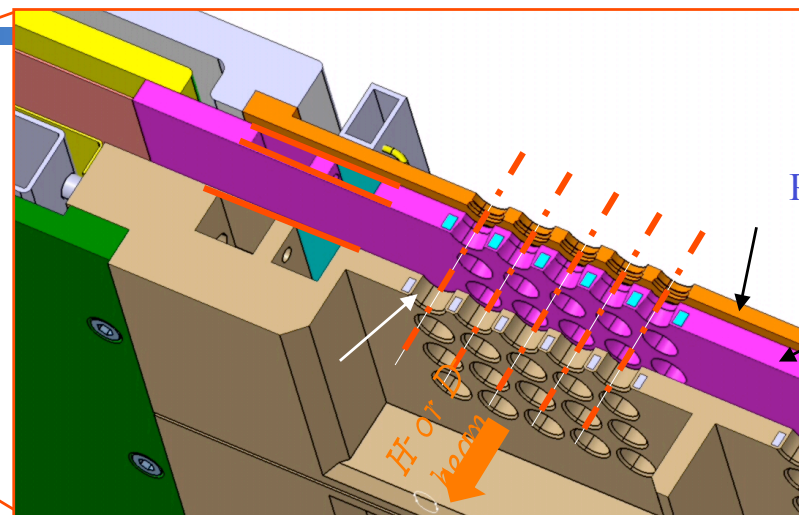
Power balance [MW] with 1MeV D Beam



Grids design



Section view of Beam source in SINGAP configuration



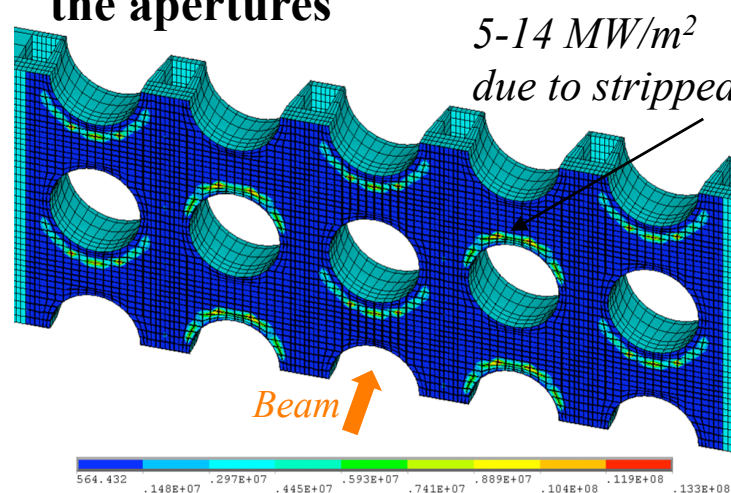
Detail of plasma, extraction and pre-acceleration grids

Plasma grid

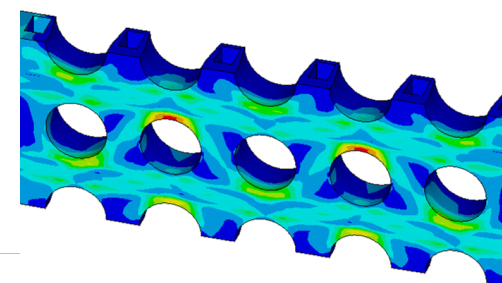
Extraction grid

Pre-acceleration grid

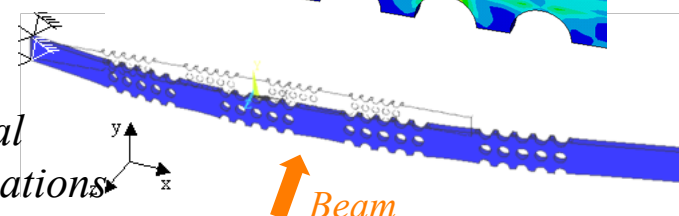
Extraction and acceleration grids are subjected to large power densities around the apertures



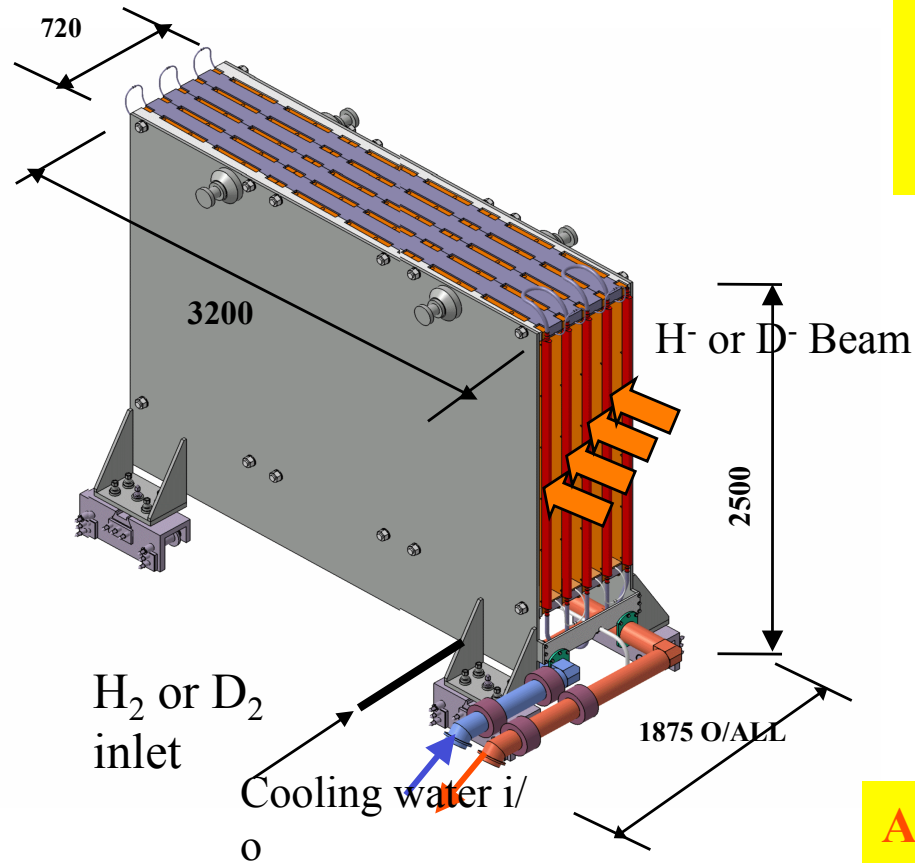
Thermal stresses



Thermal deformations



Neutraliser requirements



Power deposition from ion beam interception:

- on channel walls 4.2 MW (max. 0.5 MW/m²)
- on leading edges 0.4 MW (max. 2.2 MW/m²)
- Total power 4.6 MW

Heating cycles during ITER lifetime:

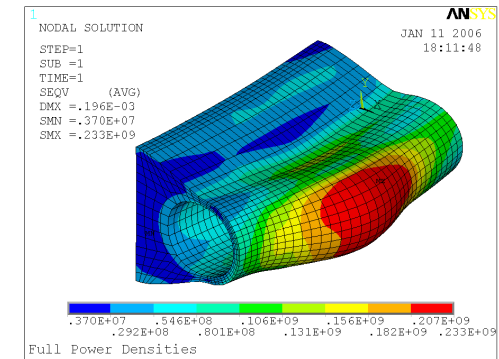
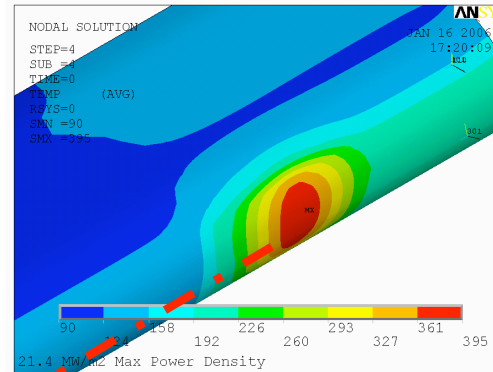
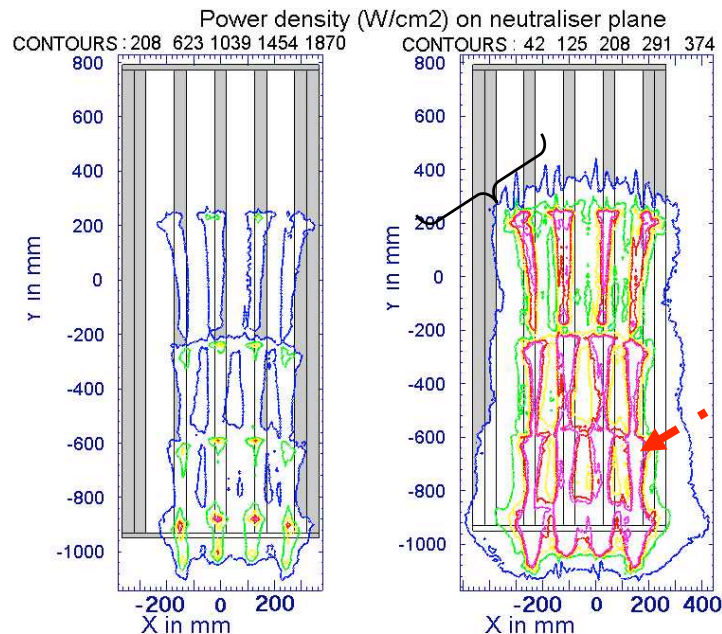
- Beam on/off 5×10^4
- Breakdowns 4.5×10^5

Additional power deposition due to electrons (stripping losses in SINGAP):

- on leading edges 2.7 MW (max. 26-30 MW/m²)

Neutraliser : thermo-mechanical issues

Electron power loads on leading edges
(front view) in SINGAP configuration

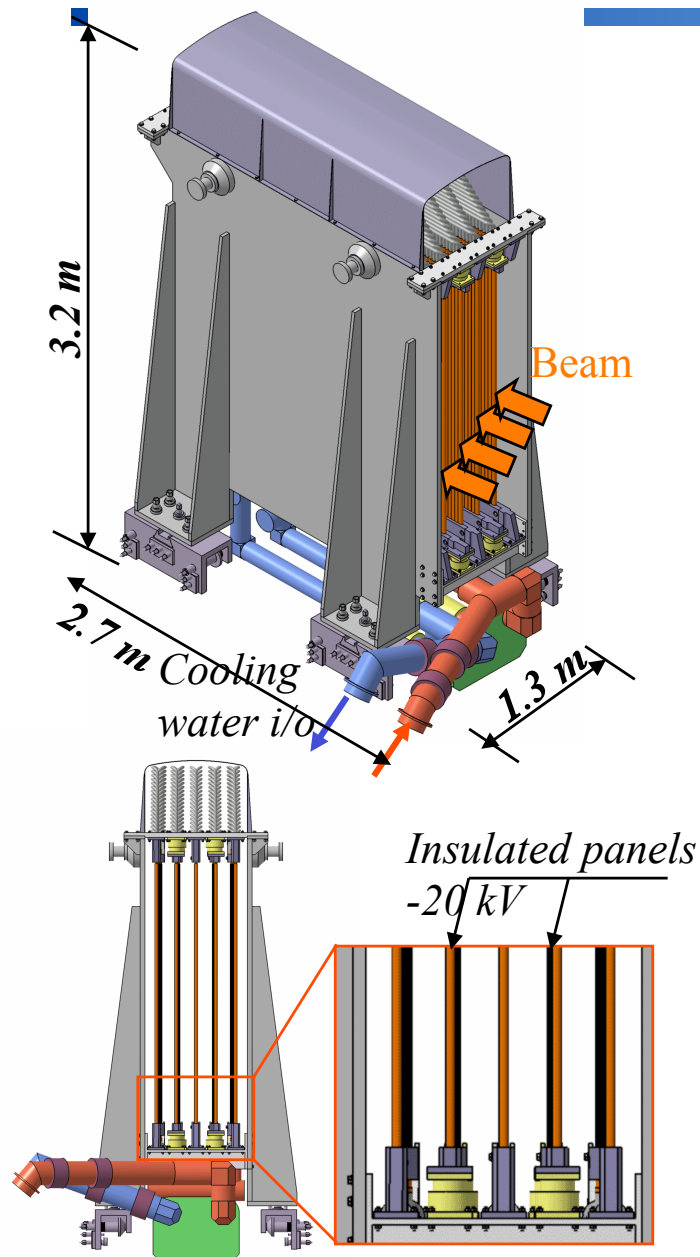


Peak power densities cause large temperature gradients and bending stresses on leading edges .

Work is in progress to :

- assess optimization of cross section and cooling parameters to satisfy ITER fatigue lifetime requirements.
- design new systems to deflect and dump the electrons

Deviated and focused electrons lead to local peaks of power density up to **25 - 33 MW/m²**



Residual Ion Dump

Function:

Deflecting by an electrostatic field and dumping on actively cooled panels the ions emerging from the neutraliser.

A bias potential up to - 20 kV is applied and modulated (± 5 kV/50 Hz) to reduce the power densities on the channel walls.

Power deposition from ions and neutrals deposition:

- Total power (for 7 mrad beam divergence) 18.5 MW
- Peak power density on panels 6 MW/m²

Required heating cycles during ITER lifetime:

- Beam on/off 5×10^4
- Breakdowns 4.5×10^5

Calorimeter

Hydraulic connections

- 2 water coolant headers

Electrical connections:

- No connection

Gas line connections:

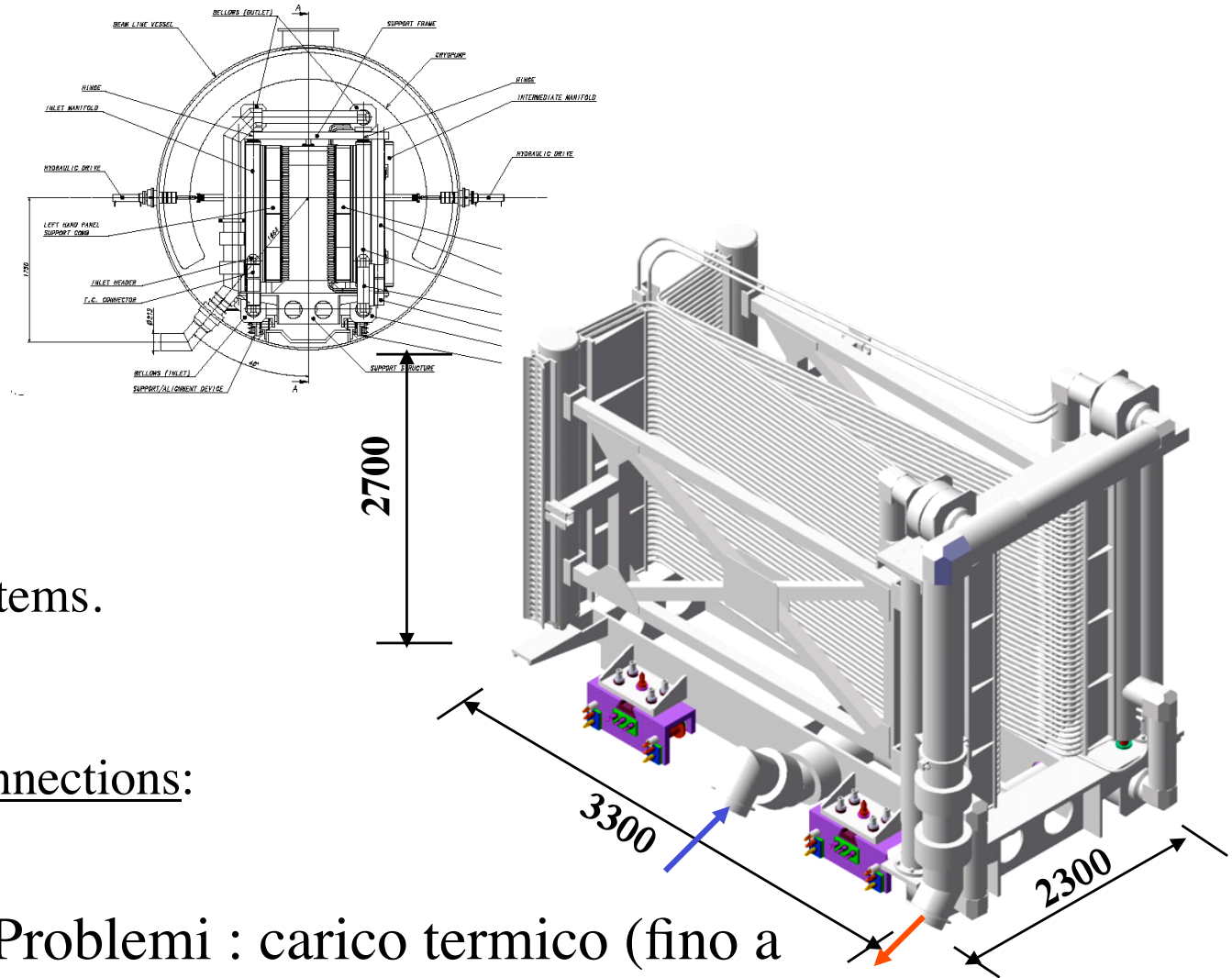
- No connection

Mechanical connections:

- 4 support/alignment systems.
- 2 hydraulic drives

Diagnostic/monitoring connections:

- 273 thermocouples
- 1 water flow meter

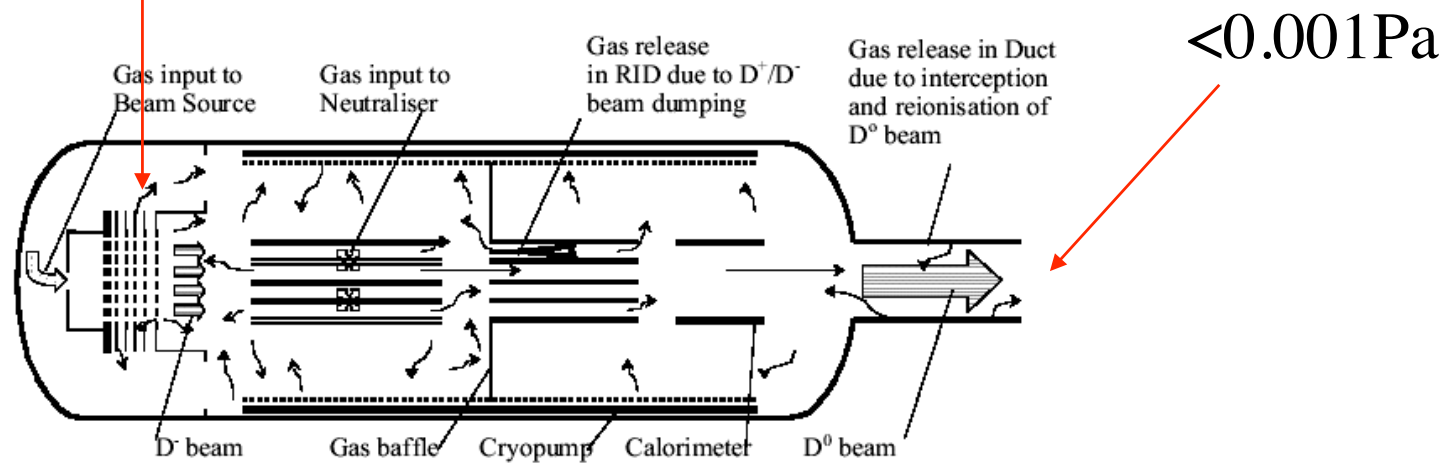


Problemi : carico termico (fino a 20MW/m^2 per 1 ora)

NBI in ITER: Gas flow

Gas input from: 0.3Pa

- a) source
- b) neutraliser
- c) surface



N 53 GR 421 01-06-20 W 0.1

Gas output:

Pumping: 15-30 m³Pa/s

Cryo-pump: S~50m²

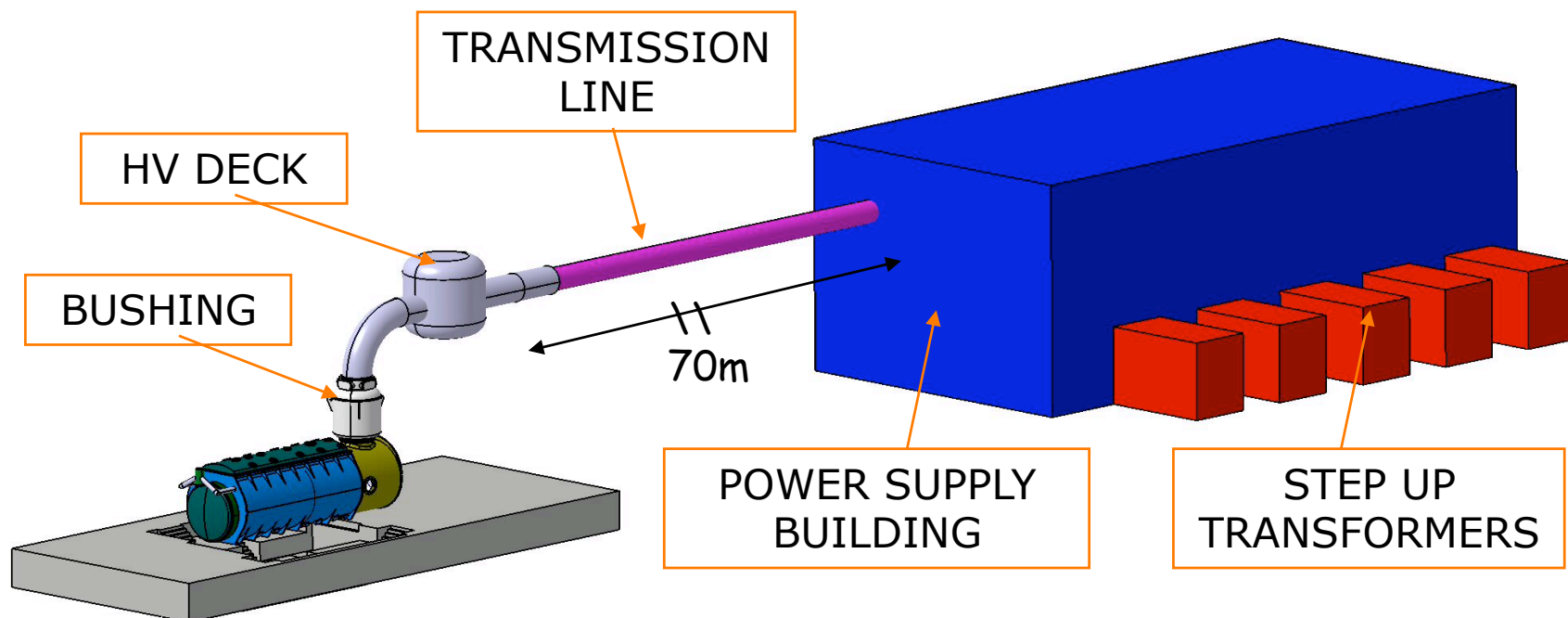
The Power Supply and Voltage Distribution System

The Power Supply (PS) and Voltage Distribution System provides the High Voltage (HV) to the accelerator grids (AGPS) and supplies the ion source (ISPS) and the auxiliary components.

The power is transmitted to the ion source and the acceleration grids via a HV transmission line, SF6 insulated for -1MV dc to ground.

PS for the ion source (IS) and pipes for IS and grids cooling are hosted inside the HVD insulated in SF6

An HV bushing provides the interface between the TL (in SF6) and the ion source and the acceleration grids in vacuum.



Test Facility for NBI :Status R&D

R&D at $V \sim 1\text{MV}$ ($I \sim 100\text{ mA}$) at present in two test facilities:
Naka (J) and Cadarache (F)

Negative ion NBI best performance in JT-60U :

2.6 MW of 360 keV beams for 10 s in H.

3.4 MW of 418 keV beams for 0.3 s in H

6.2 MW of 381 keV beams for 1.65 s in H.

5.8 MW of 400 keV beams for 0.86 s in D.

ITER requirements

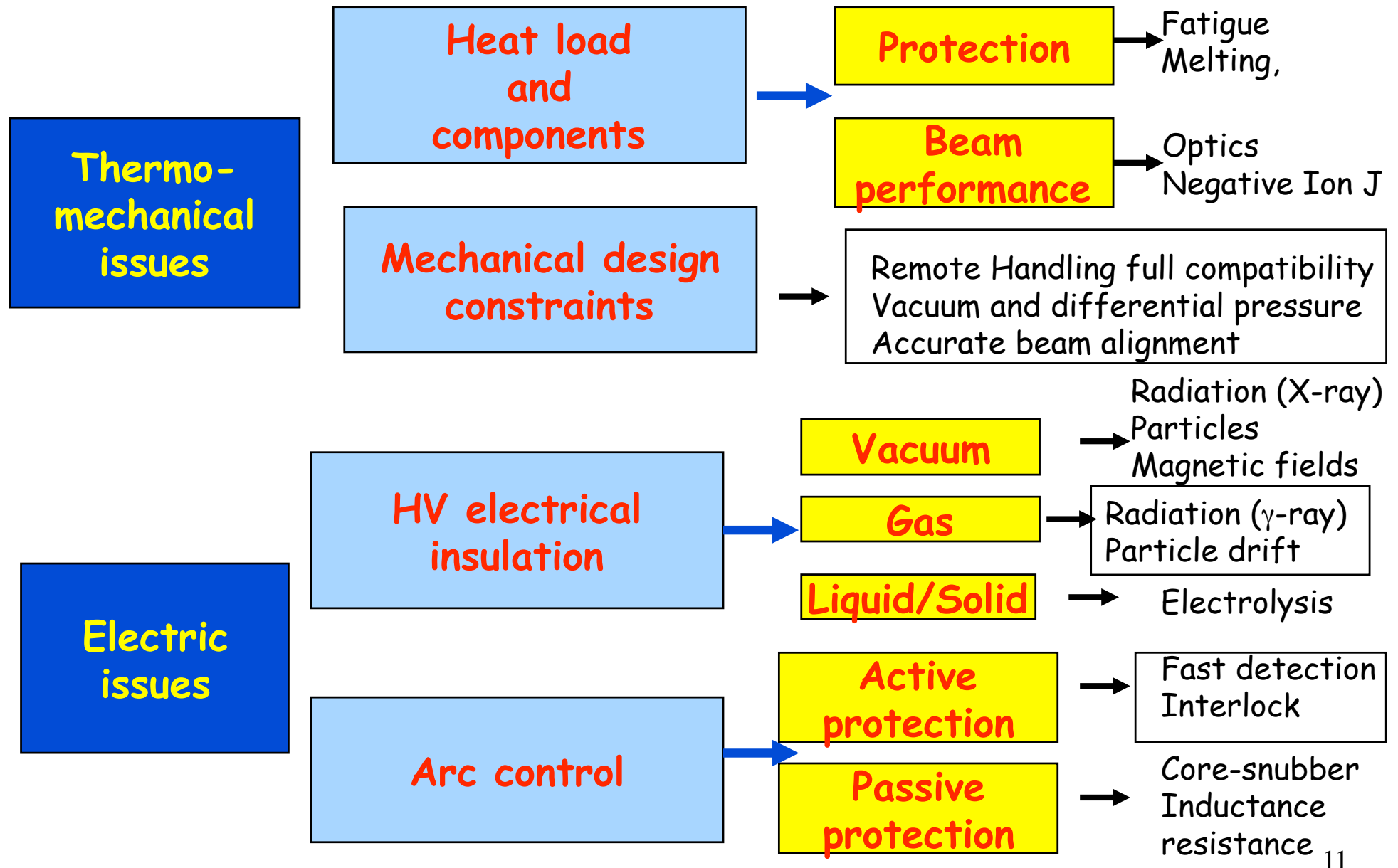
Power delivered to the plasma per injector 16.5MW

Beam energy 1 MeV

Ion species D⁻

Pulse length $\leq 3,600\text{ s}$

Main technological issues: summary



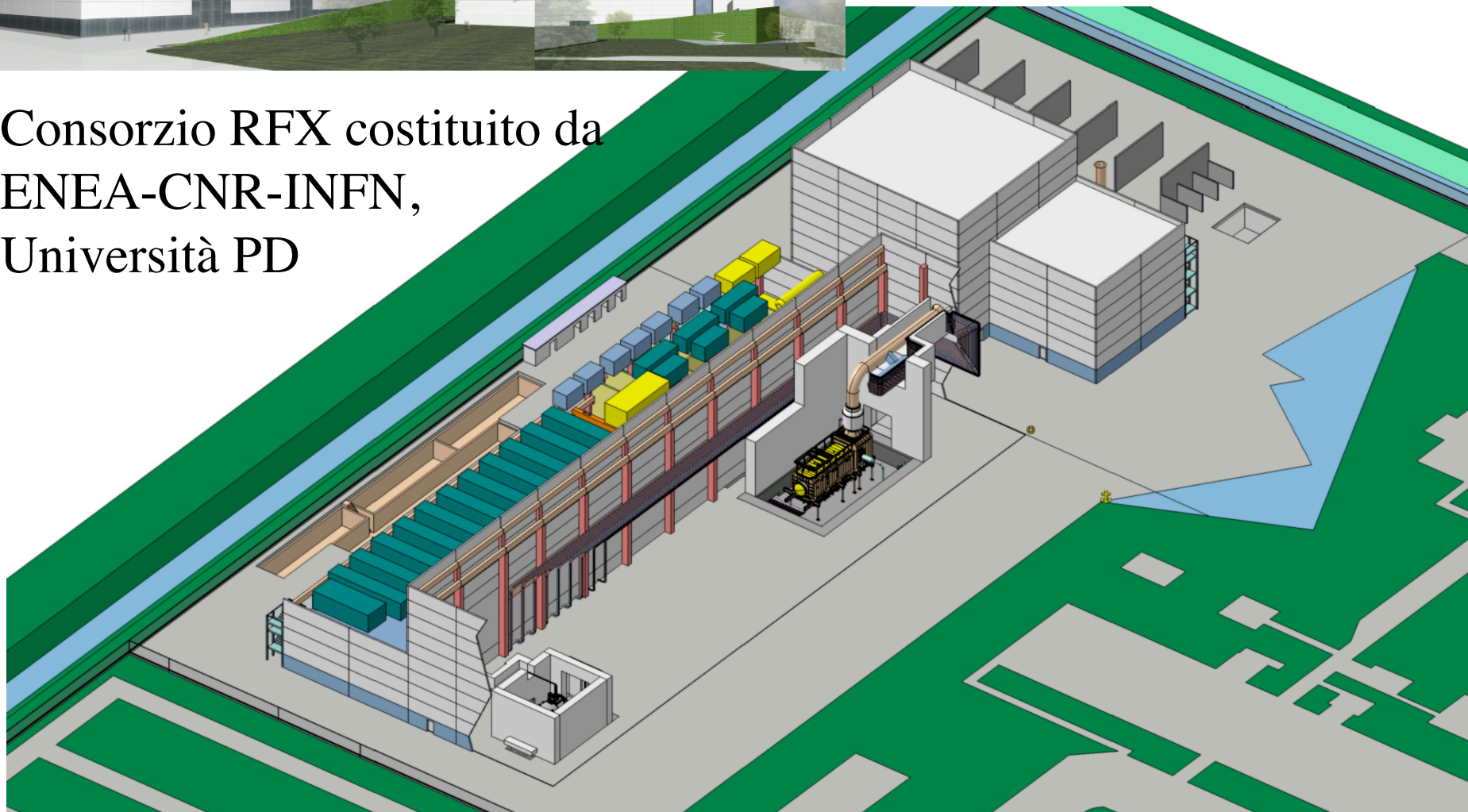
Test Facility

- As most of the issues are strongly coupled, those of them still open can be tackled and solved only by testing a full scale NBI at full performance in D and H.
- A Test Facility where to install and operate a NBI system before operation in ITER has been approved and will be realized in Padova at Consorzio RFX
- Such a Test Facility should also allow adjustments and modifications aimed to optimise the system and will assist ITER during operations
- Status : buildings ready for call for tender

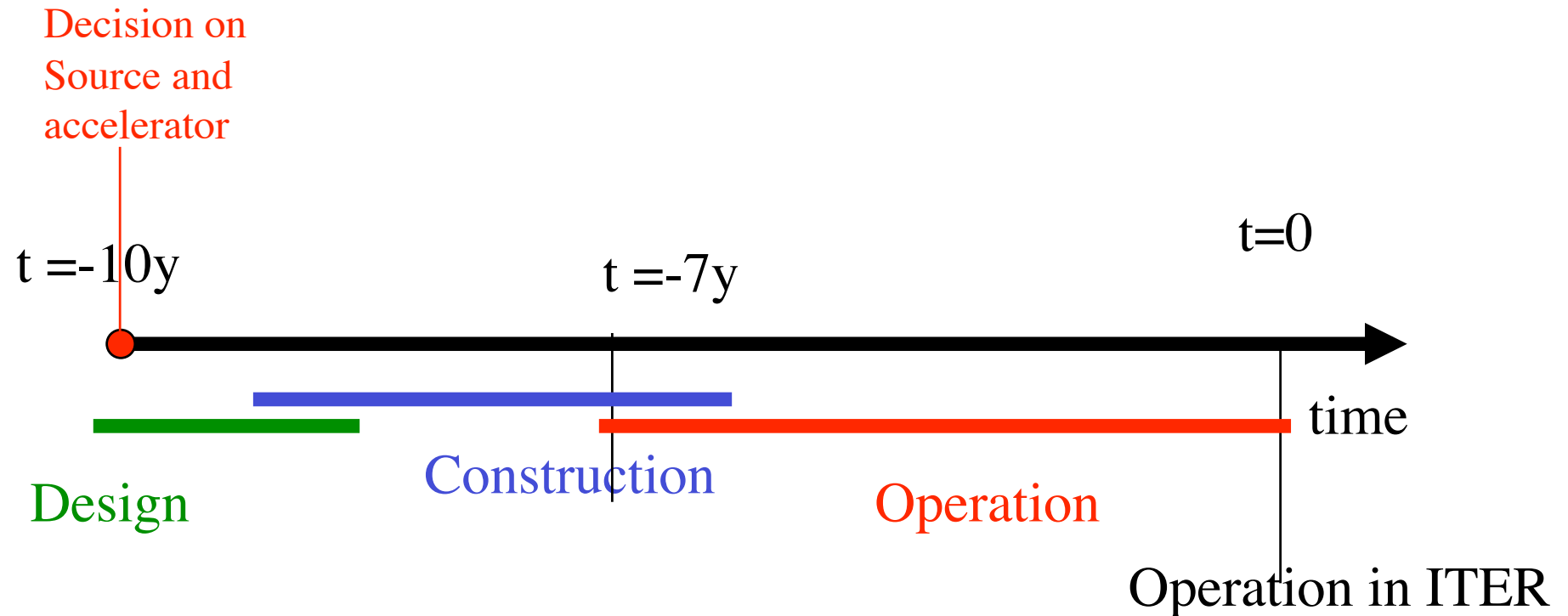
Test Facility per NBI da realizzare a Padova presso Consorzio RFX



Consorzio RFX costituito da
ENEA-CNR-INFN,
Università PD



Test Facility for NBI: planning



Work in progress (EU and JA) to optimise procurement and operation planning, in particular Source operation in parallel to full injector construction