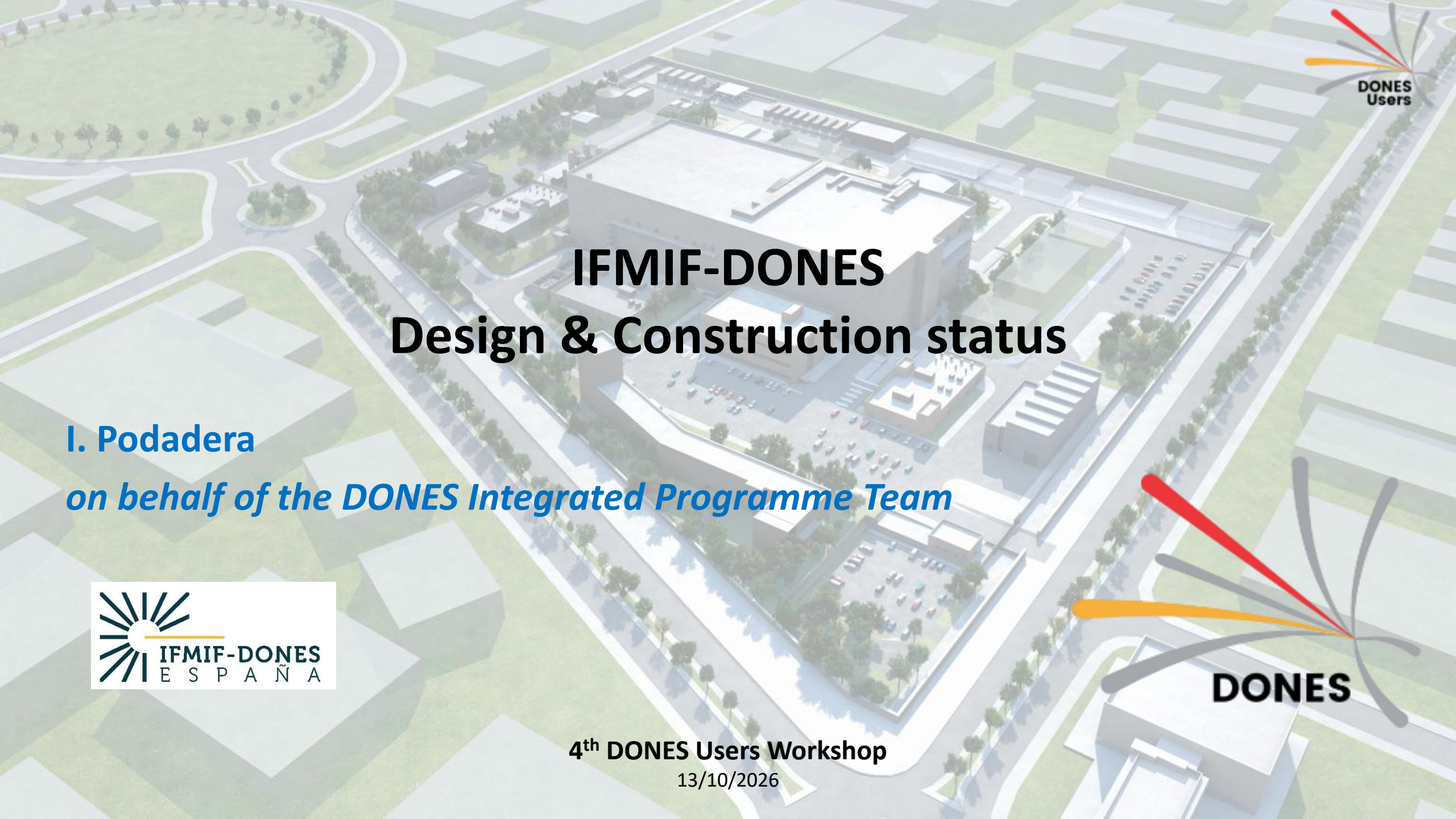


IFMIF-DONES
Design & Construction status

I. Podadera

on behalf of the DONES Integrated Programme Team

4th DONES Users Workshop

13/10/2026

Outline

1. IFMIF-DONES general status
2. Site, Building and Plant Systems
3. Test Systems
4. Lithium Systems
5. Accelerator Systems
6. Control Systems
7. Conclusions and Outlook

Outline

1 IFMIF-DONES general status

2 Site, Building and Plant Systems

3 Test Systems

4 Lithium Systems

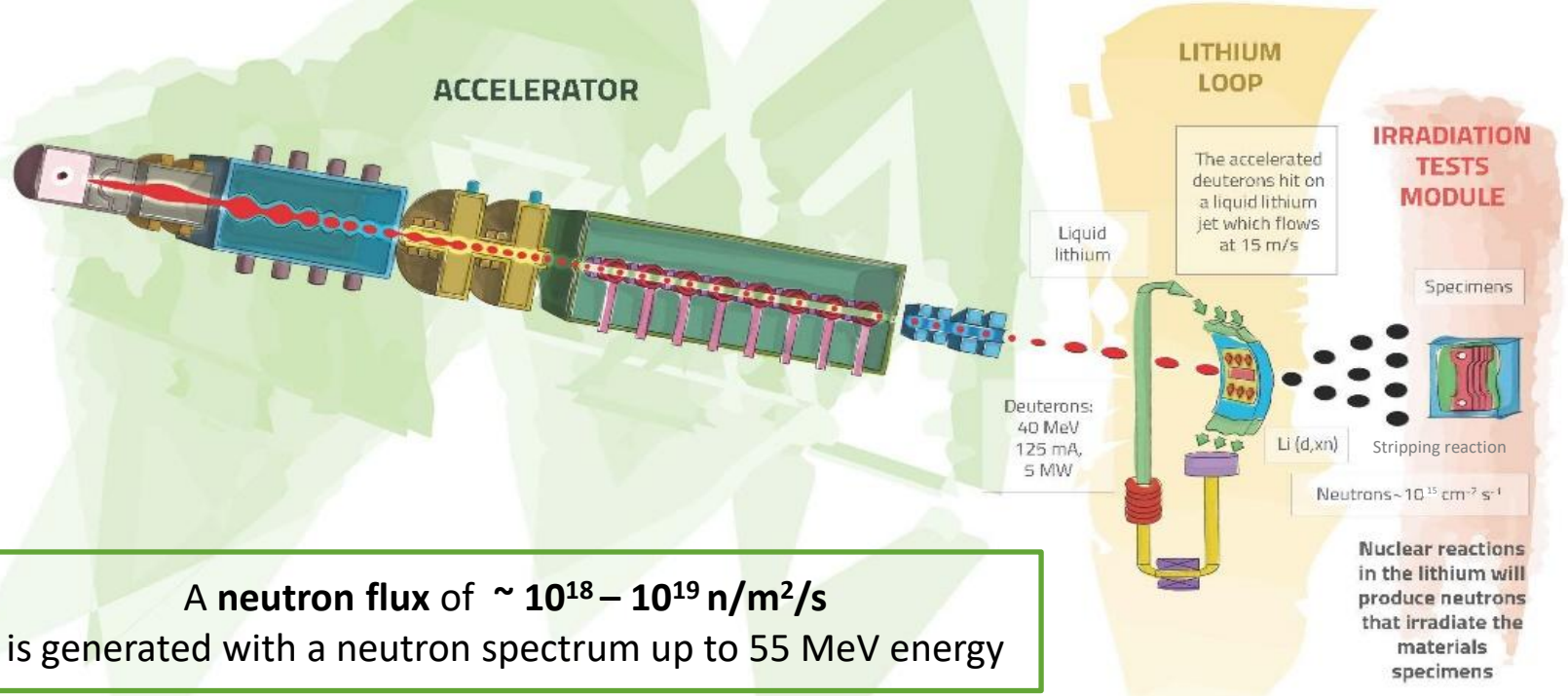
5 Accelerator Systems

6 Control Systems

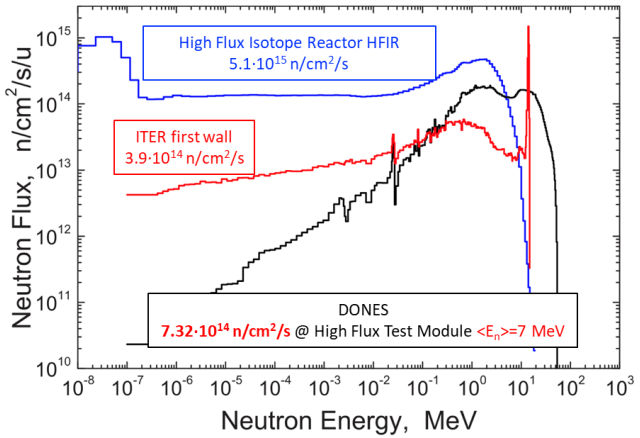
7 Conclusions and Outlook

IFMIF-DONES Mission

An accelerator based **fusion-like neutron source** for the generation of data used for design, licensing and testing of materials to be used in the **DEMO and other fusion reactors**



A **neutron flux** of **~ 10^{18} – 10^{19} n/m²/s**
is generated with a neutron spectrum up to 55 MeV energy



High Flux Test Module requirements

Dpa	20 dpa_{NRT} (<2.5 years, 300 cm^3) 50 dpa_{NRT} (<3 years,100 cm^3)
Temperature	Controlled 250 – 550 C
Dpa gradient	<15% (gauge volume)
Temperature gradient	<3% (gauge volume)

Facility able to irradiation multiple irradiation modules simultaneously

IFMIF-DONES Facility

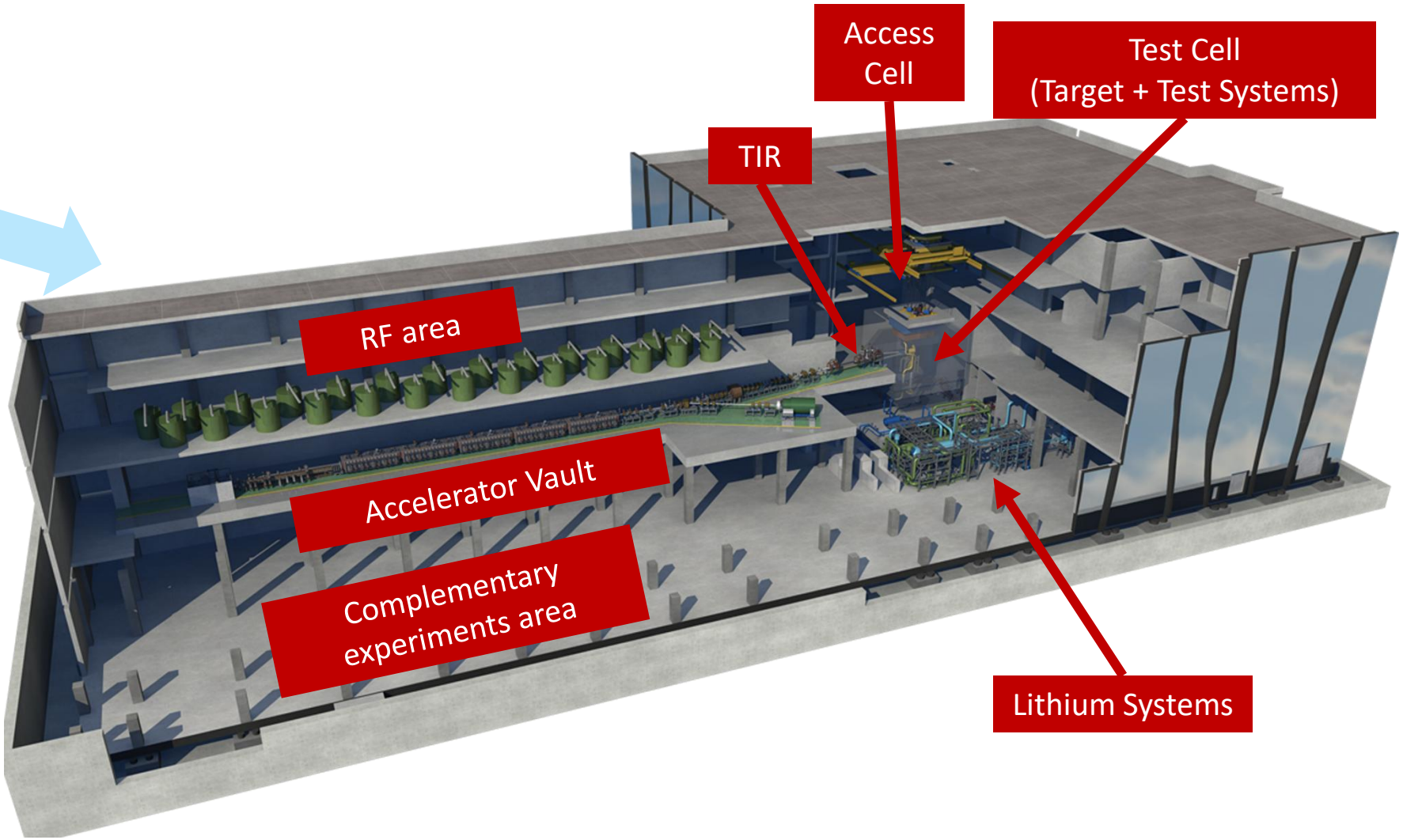
70% Target Availability
30 years Operation



Site, Building & Plant Systems

+

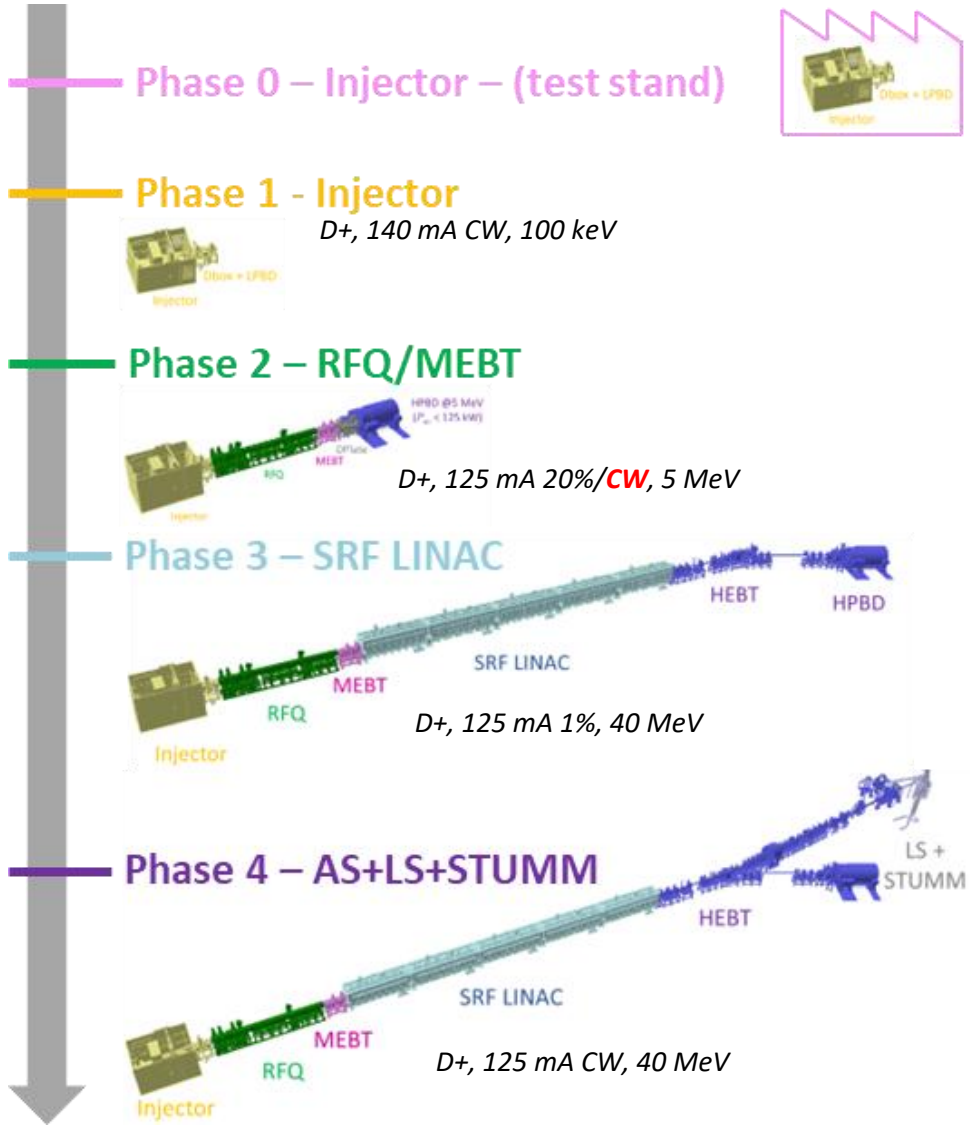
CICS



Commissioning & Operations Plan

- Main target → **Neutrons production with 40 MeV d(Li,xn)**
- **Staged Commissioning** similar to LIPAc and other facilities
- **Global Operation Modes** and **Control Logics** defined
- Lessons-learned from **LIPAc** and other facilities

Id.	Description	Beam destination
BE1	**Nominal operation**	**Lithium target**
BE2	Nom. Phase 1	DB2@Injector
BE3	Nom. Phase 2	HPBD@MEBT
BE4	Nom. Phase 3	HPBD@HEBT
BE5	Pulse p+ Phase 1	DB2@Injector
BE6	Pulse D+ Phase 1	DB2@Injector
BE7	Pilot p+ Phase 2	HPBD@MEBT
BE8	Pilot D+ Phase 2	HPBD@MEBT
BE9	Pilot p+ Phase 3	HPBD@HEBT
BE10	Pilot D+ Phase 3	HPBD@HEBT
BE11	Pilot D+ Phase 4	Lithium target
BE12	Experimental areas	Target@R026
BE13	Variable profile	Lithium target



General status

Most systems are advancing, including reviews with members from external institutes



- **Site and Buildings:**
  - **Preliminary design** passed
  - **Site preparation and MB foundations** preparation started
  - **Main Building Foundations** review and construction starting next months



- **Plant Systems:**
  - **Preliminary design** passed
  - **Final Design** mid next year

- **Test Systems:**
  - **Final design** passed last year
  - **Manufacturing design** ongoing

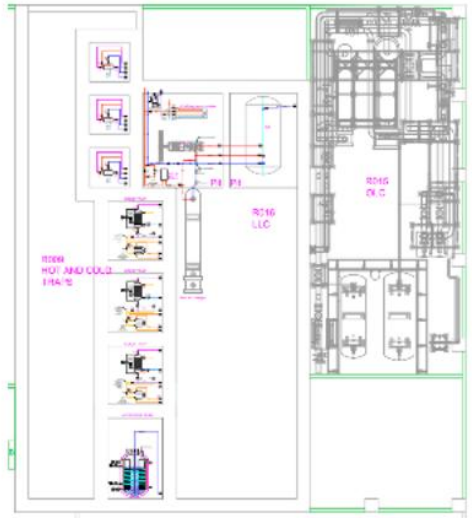
- **MEBT and HEBT without TIR:**
  - **Final design** passed last year
  - **MRR** preliminary scheduled for end of this year

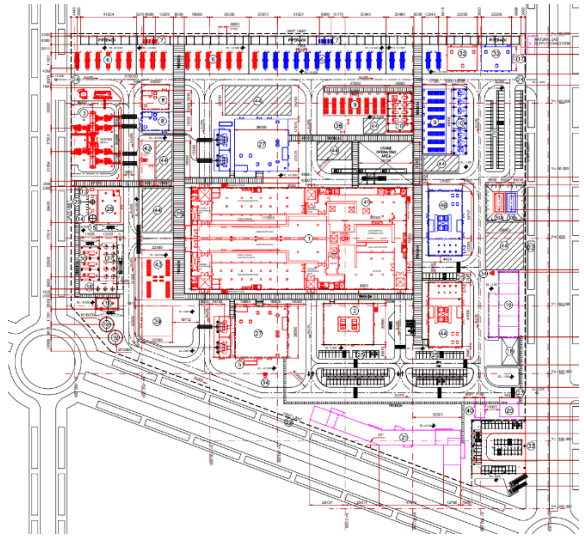
Technical developments

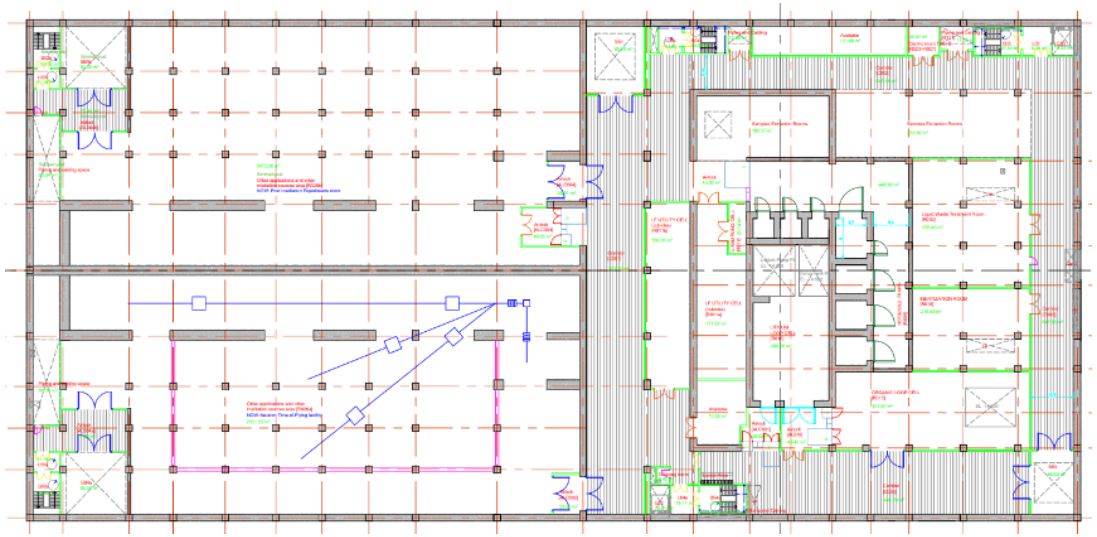
Priority has been the consolidation of the SBP design and the interfaces with other systems

Current developments with impact on the site and buildings execution:

- **Accelerator Vault arrangement**
- **Hot cells arrangement**
- Requirements of **LICS cubicles**
- Requirements of **Other Irradiation Modules**







Conferences & scientific events

EPICS WS



Galicia Biodays



RSEF 2026





ECEE'26



ISLA-9



SLHiPP'12
@ ESS



IPAC'26
(invited poster)



COSIRES



DONES XCITECH



LINAC 2026
(invited oral + 2028)



SOFT'34
(plenary)



4th DONES Users WS



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Old site layout

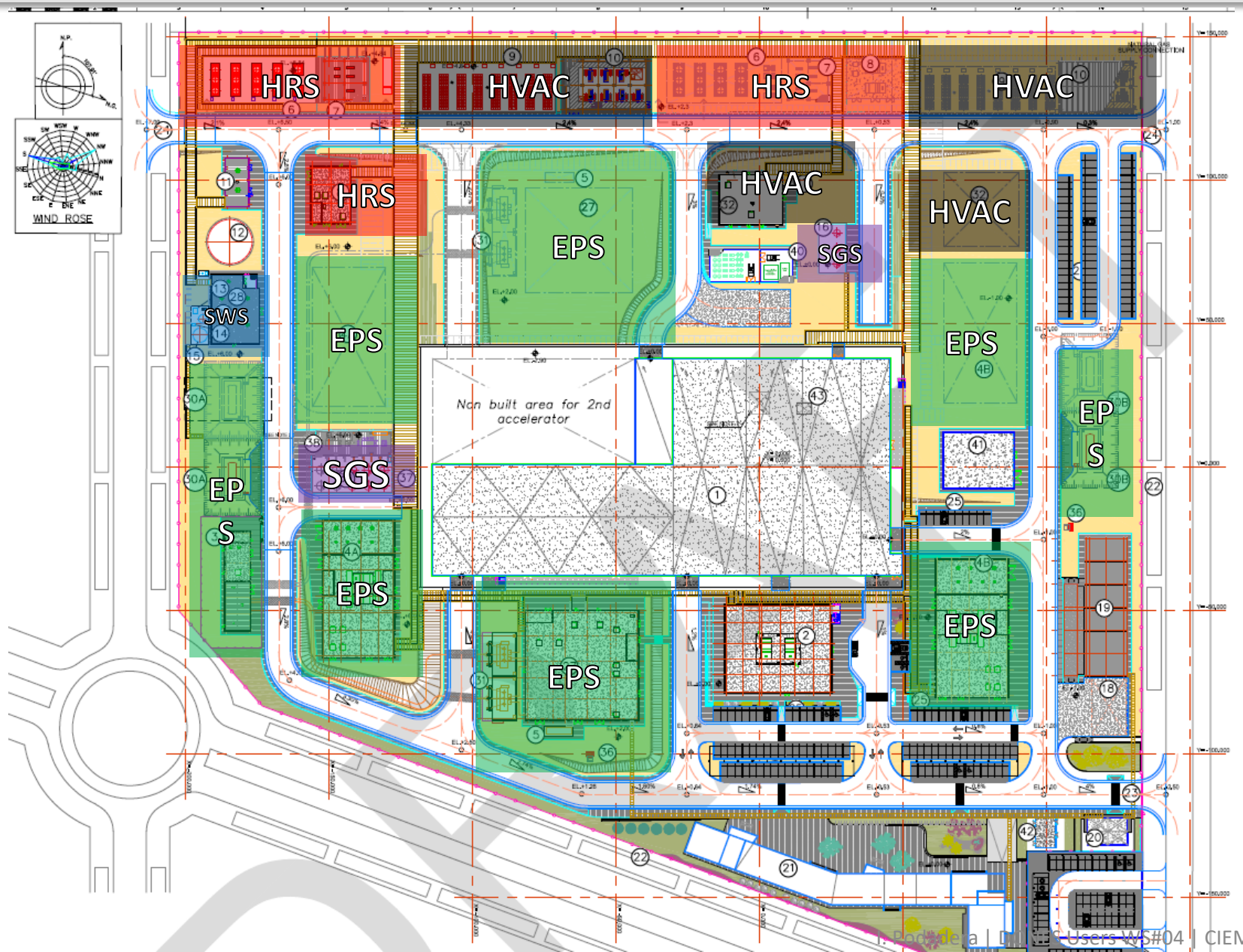
HVAC

HRS

EPS

SWS

SGS



EUROfusion

New Site Layout

HVAC

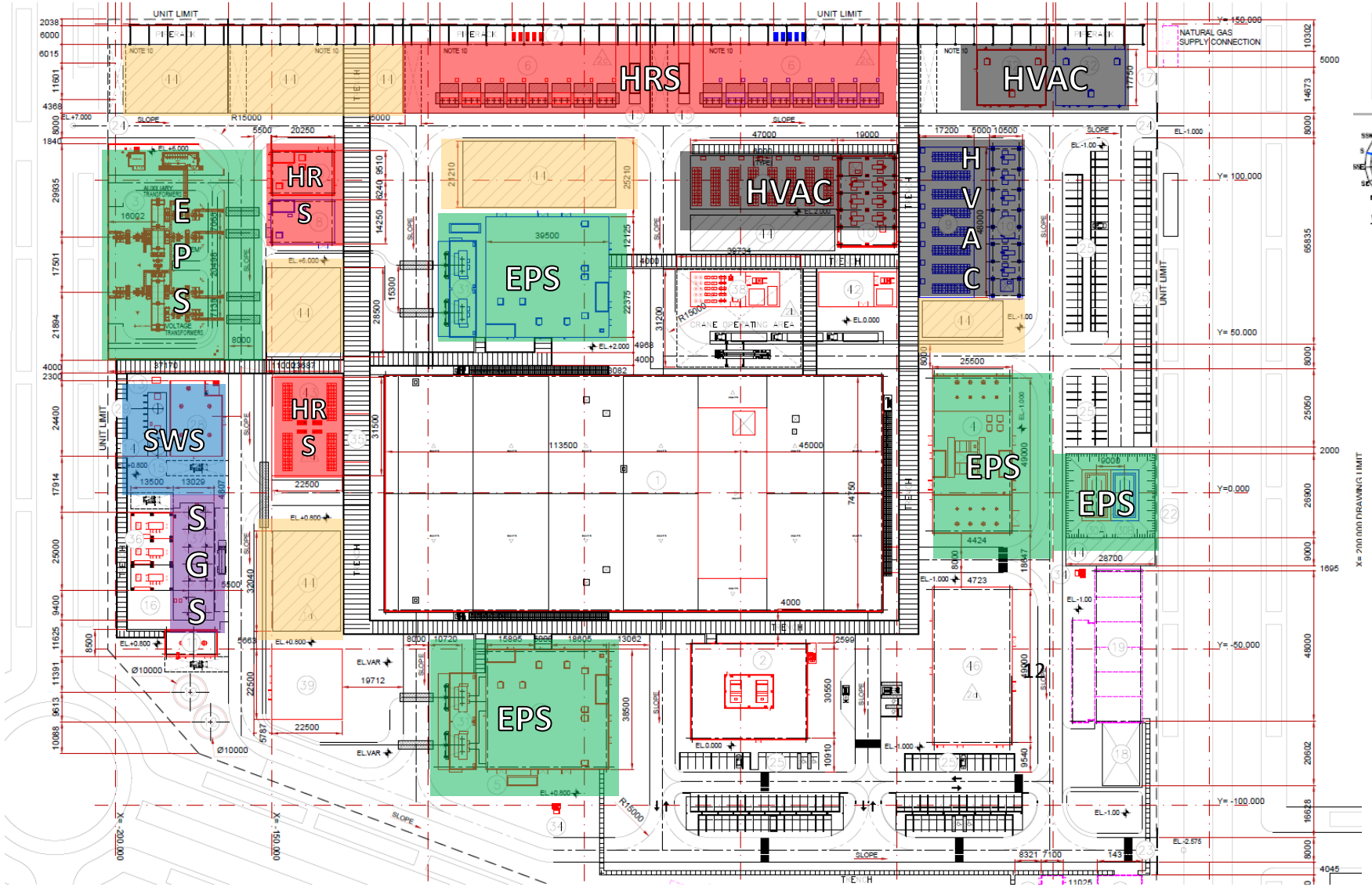
HRS

EPS

SWS

SGS

44
(Space available)



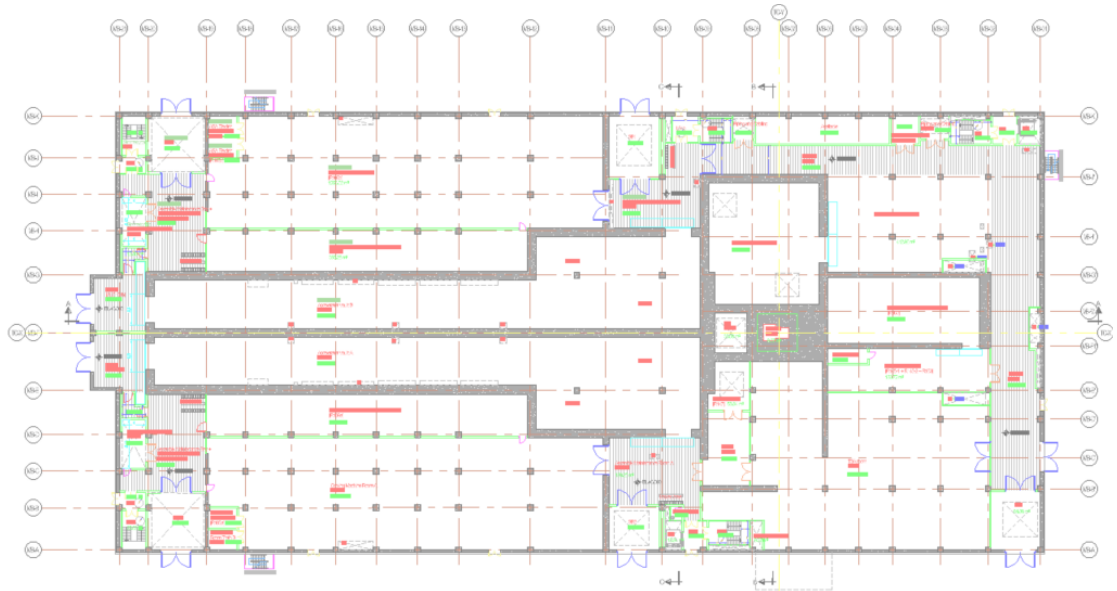
Main Building

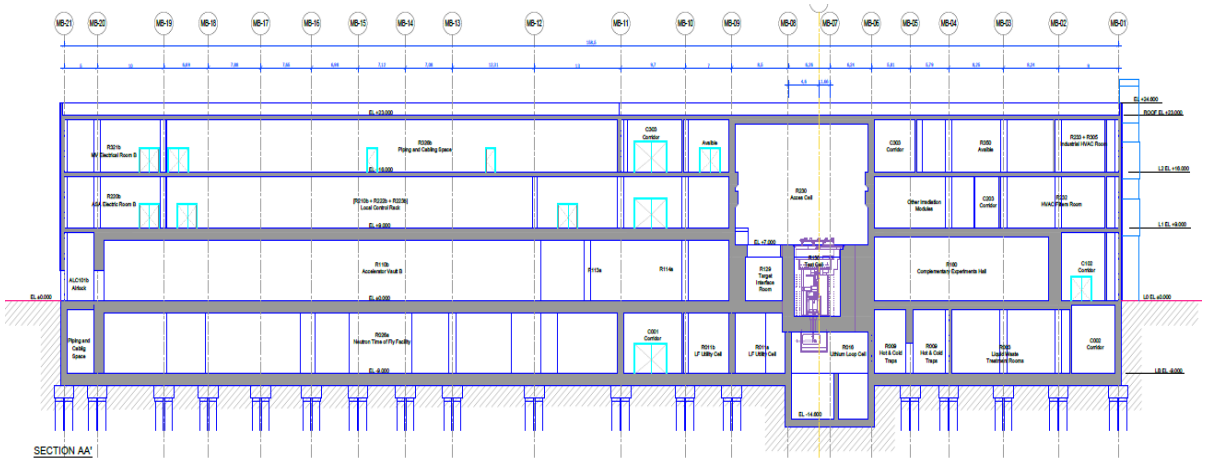
From **L-shape to rectangular** → space for 2nd accelerator built from the very beginning

First floor underground

Modification of the foundations → No need of seismic isolators

Space reserved for complementary experiments in two areas (behind Test Cell and underground)

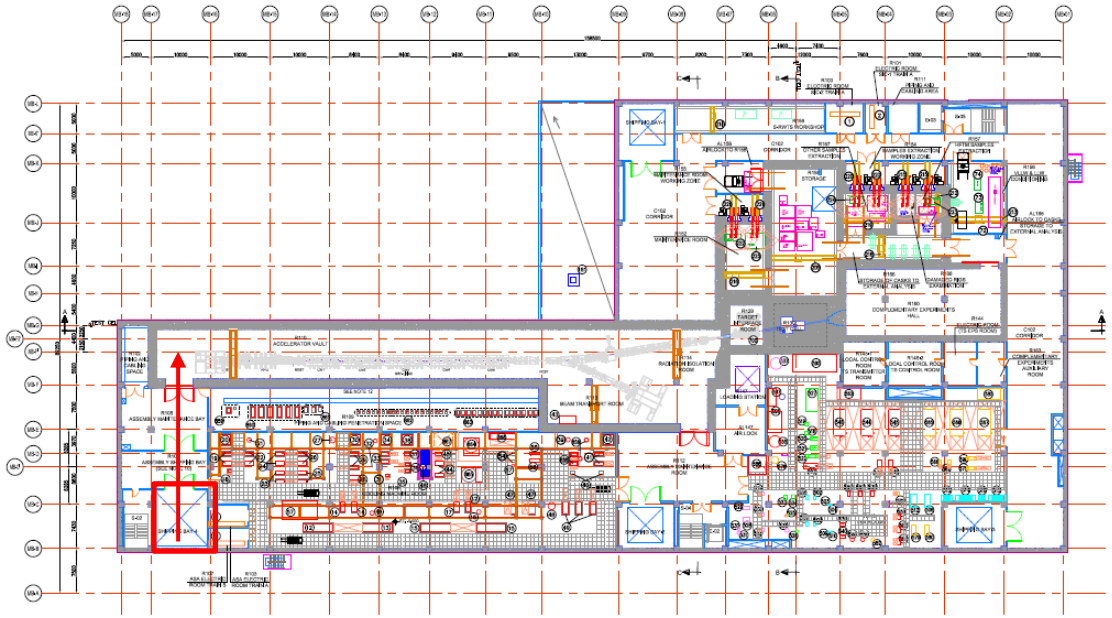




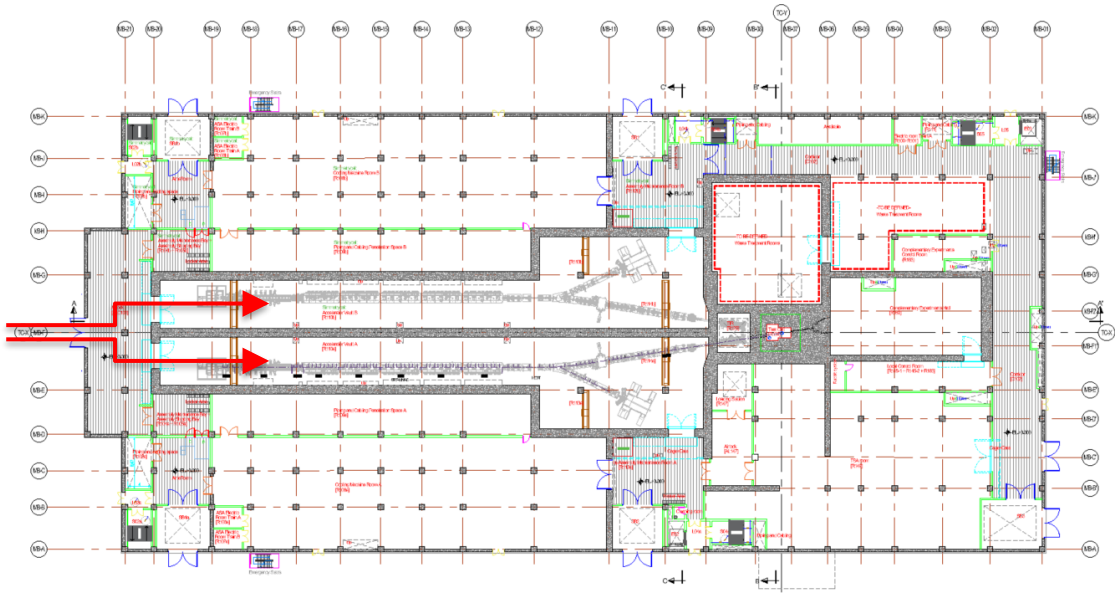
Main Building

- **Direct Access to R110 AV**

Old Design



New Design

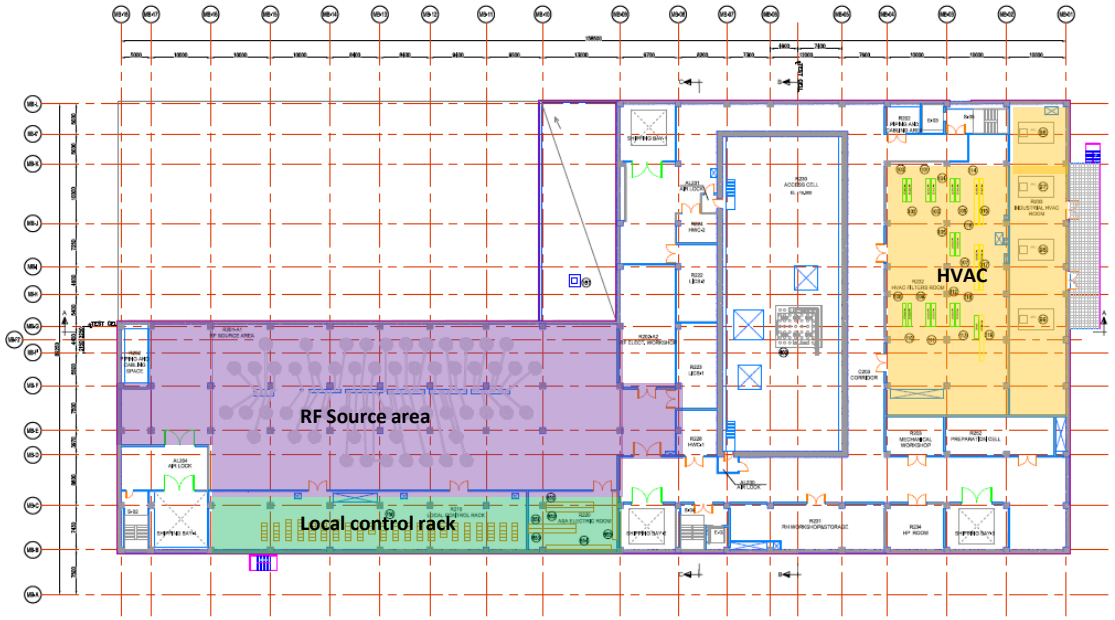


Creation of direct access to R110 AV, through an Airlock from the main road.

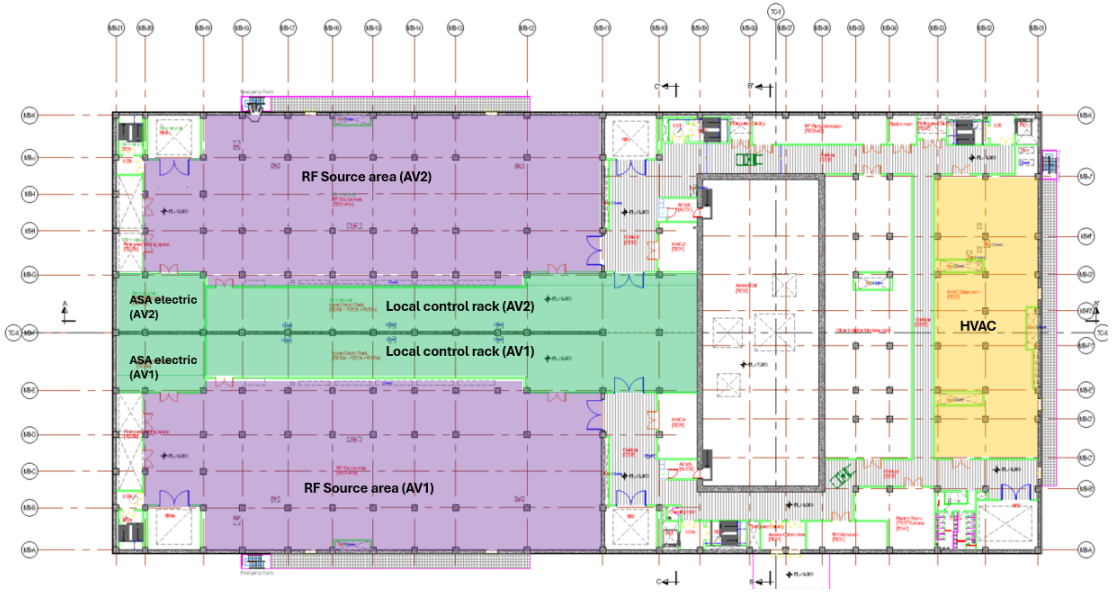
Main Building

- **Resizing of technical spaces**

Old Design



New Design



Civil works starting

Final Design & Construction Phase Ongoing!







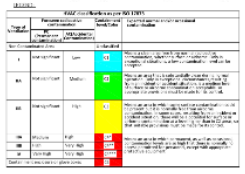


HVAC

- Reclassification of spaces (zoning)
- Review of differential pressures and airflows to ensure dynamic confinement
- Conventional and Radiological

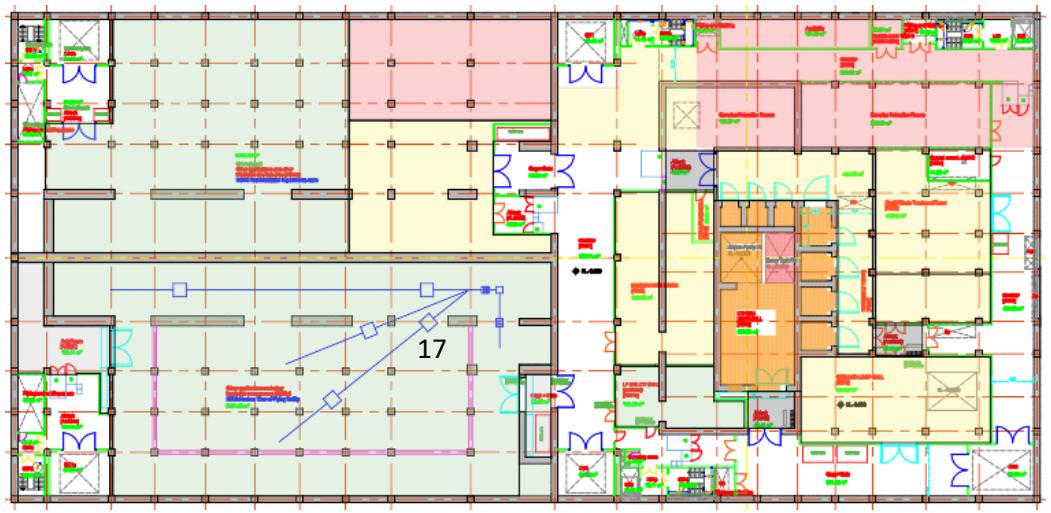
Old Design





EUROfusion

New Design

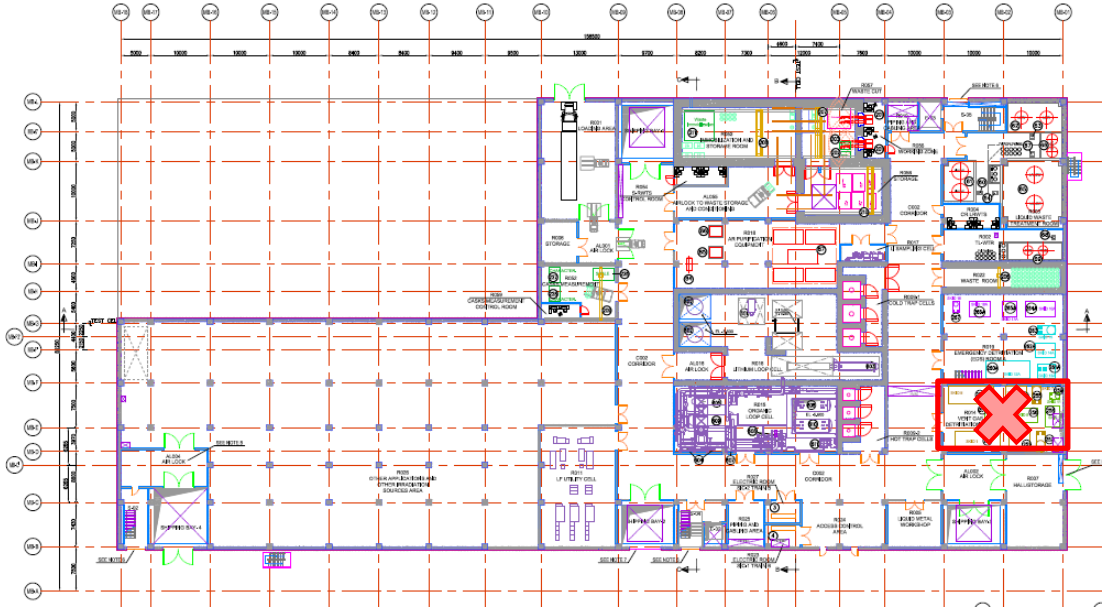


Class	Pressure	Depression value
Free Contamination areas	No-pressure areas	Atm
C1	Δ P1	-20 Pa
C2	Δ P2	-60 Pa
C3	Δ P3	-80 Pa
C4	Δ P4	-110 Pa

Detritiation System

- **Removal of the VDS (Vent Detritiation Subsystem)**

Old Design



Detritiation only need in case of accidental scenarios →

EEDS (Emergency Exhaust Detriation System)

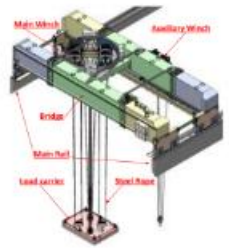
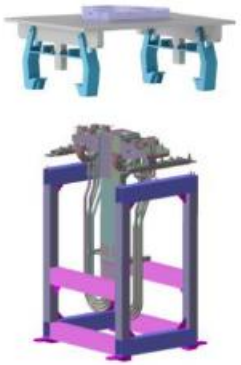
- **G-RWTS VDS and GDS disappearing means less consumers for HRS**
  - Reduction in piping and penetrations in level 0
  - Evaluation of efficiency, spatial impact, interference and costs

Remote Handling & Hot Cells

Cranes & Manipulators

Payload of HROC reduced thanks to the modification of the USP design

Minimization of number of RH cranes to optimize the maintenance → assessment of the use in BTR/RIZ and Li rooms area

HROC	ACMC	Lift Frame for PCPs	Multipurpose System for the HFTM
			

RH Test bed under development at IFMIF-DONES site for procedures testing and operators training

Hot Cells

Area reserved of more than 1000 m^2 in the **underground level** and 1500 m^2 in the **ground floor**

Now **S-RMTS** organized in Radioactive Components subsystem and Waste Treatment subsystem

Optimized workflow → Components treatment in the Basement and Waste treatment in the Ground floor



Outline

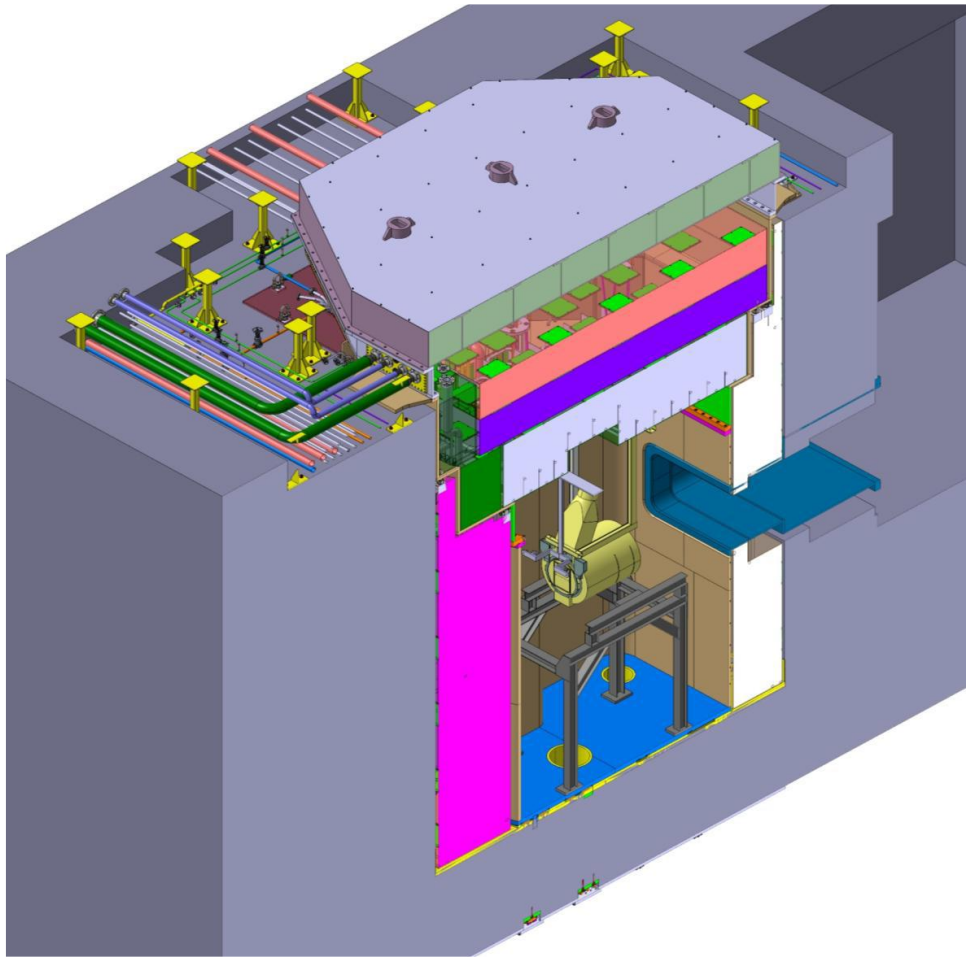
1. IFMIF-DONES general status
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Test Systems updates

Test Cell:

- Housing the **target** and the **test modules**
- First **safety confinement barrier**
- Design and manufacturing following **RCC-MRx**
- New design of **drainage system** at the bottom of the cell
- Upgrade of the number and location of piping and **safety isolation valves**
- Discussions ongoing about **lithium recovery** strategy
- Assessment of the **PCP** handling

- **Space reserved at TC for Other Irradiation Modules and their ancillaries in the MB (700 m2)**
- **Penetrations for NBT/NBS prepared in the Main Building**



Mockup of the Test Cell from VATIST pre-operational prototype (work carried out within the DONES-VATIST contract, a CDTI PPP initiative, funded by ERDF under the 2021–2027 Multi-Regional Operational Program for Spain)

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Target System Design : Beam on target req.

Update of Beam on Target Requirement

Beam Energy	40 MeV
Beam current	125 mA
Beam horizontal size (90% beam)	17 cm for the reference beam – Flexibility to modify from 10 to 20 cm
Beam vertical size (90% beam)	5 cm
Angle incidence	9°
Beam position	± 5 mm
Average power density in beam size (90% beam)	~480 W/mm^2
Maximum beam power density	<700 W/mm^2
Beam tails	< 0.2 W mm-2 beyond 22 cm in horizontal
Maximum beam extension	25 cm in horizontal direction 10 cm in vertical direction

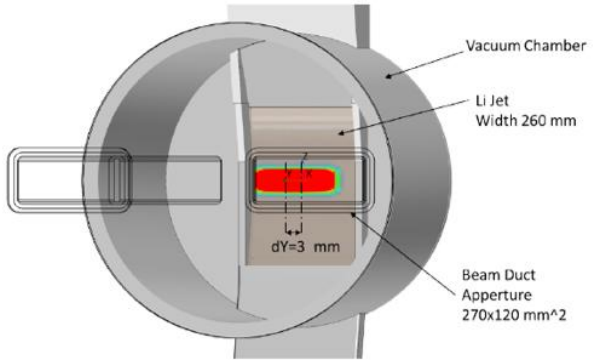


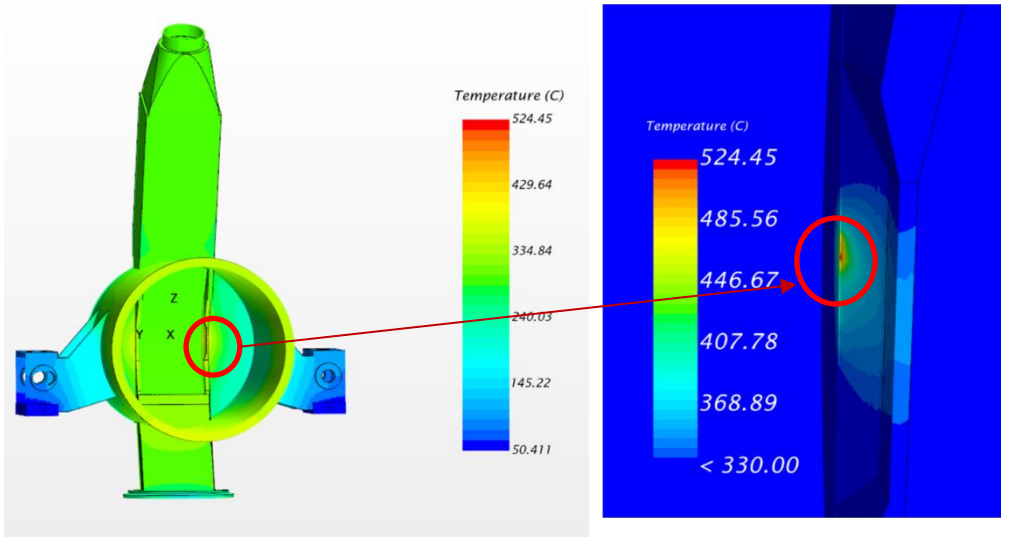
Temperature distribution in target structure

Themo-mechanical implications

- Nominal reference beam is Ok (from TSY point of view).
- Narrow misalignment margin of D+ beam w.r.t target (3 mm).

→ Precise enough beam on target positioning measurement is advisable.





Target System Design : Lithium Vapor

Several analysis in lab. and ELTL:

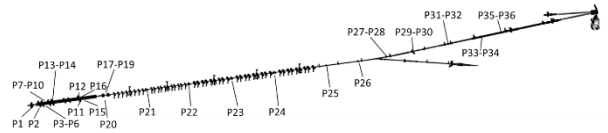
- Experimental results in vacuum.
- Validation of corrected analytical models.

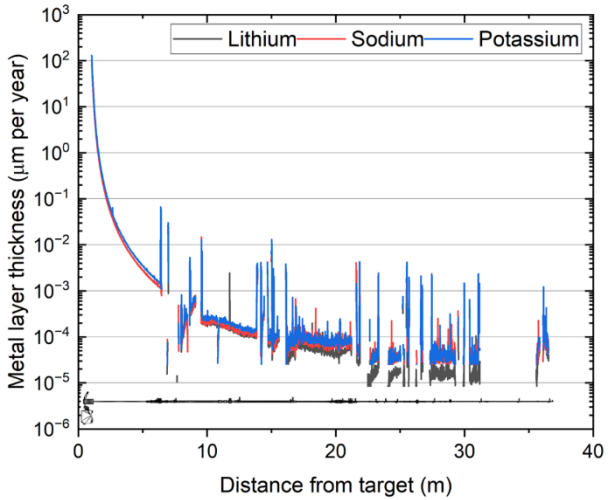
Annual vapor generation:

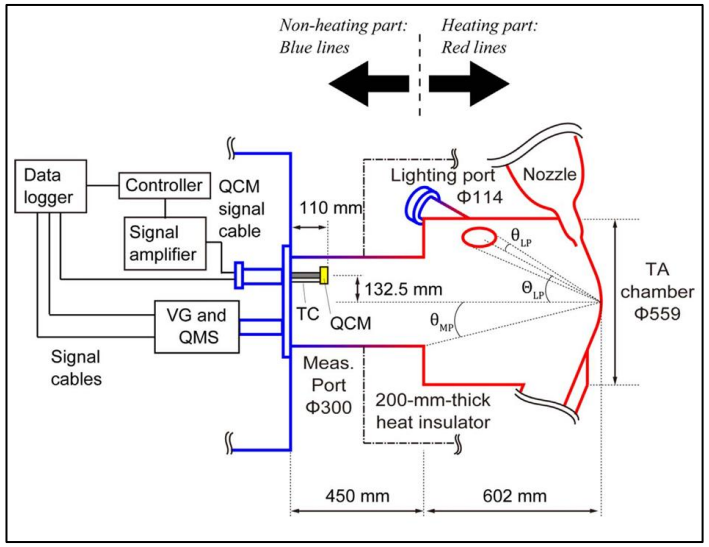
T = 250°C	T = 300°C
≈4 g/year	≈77 g/year*

*estimate

Kanemura, Takuji, et al. "Analytical and experimental study of the evaporation and deposition rates from a high-speed liquid lithium jet." Fusion Engineering and Design 122 (2017): 176-185.





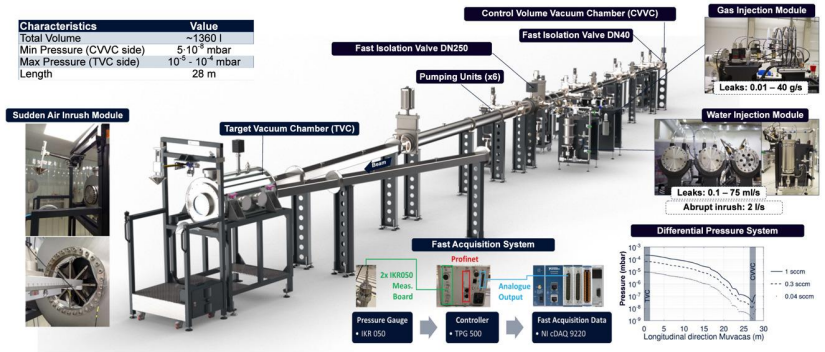


Numerical evaluation of liquid metal deposition along accelerator line, HEBT (based on Molflow)

Complete IFMIF-DONES vacuum and lithium accelerator analysis (2024)

→ Exponentially decreasing deposition with travel distance (limited HEBT penetration).

→ Key: to control the pressure and temperature in the Target



MuVaCas facility:

- Differential Vacuum Pressure

Conclusion:

- The migration of Lithium towards HEBT line should be reduced (TIR)
- Local traps is advisable to be analyzed to minimize Li deposition

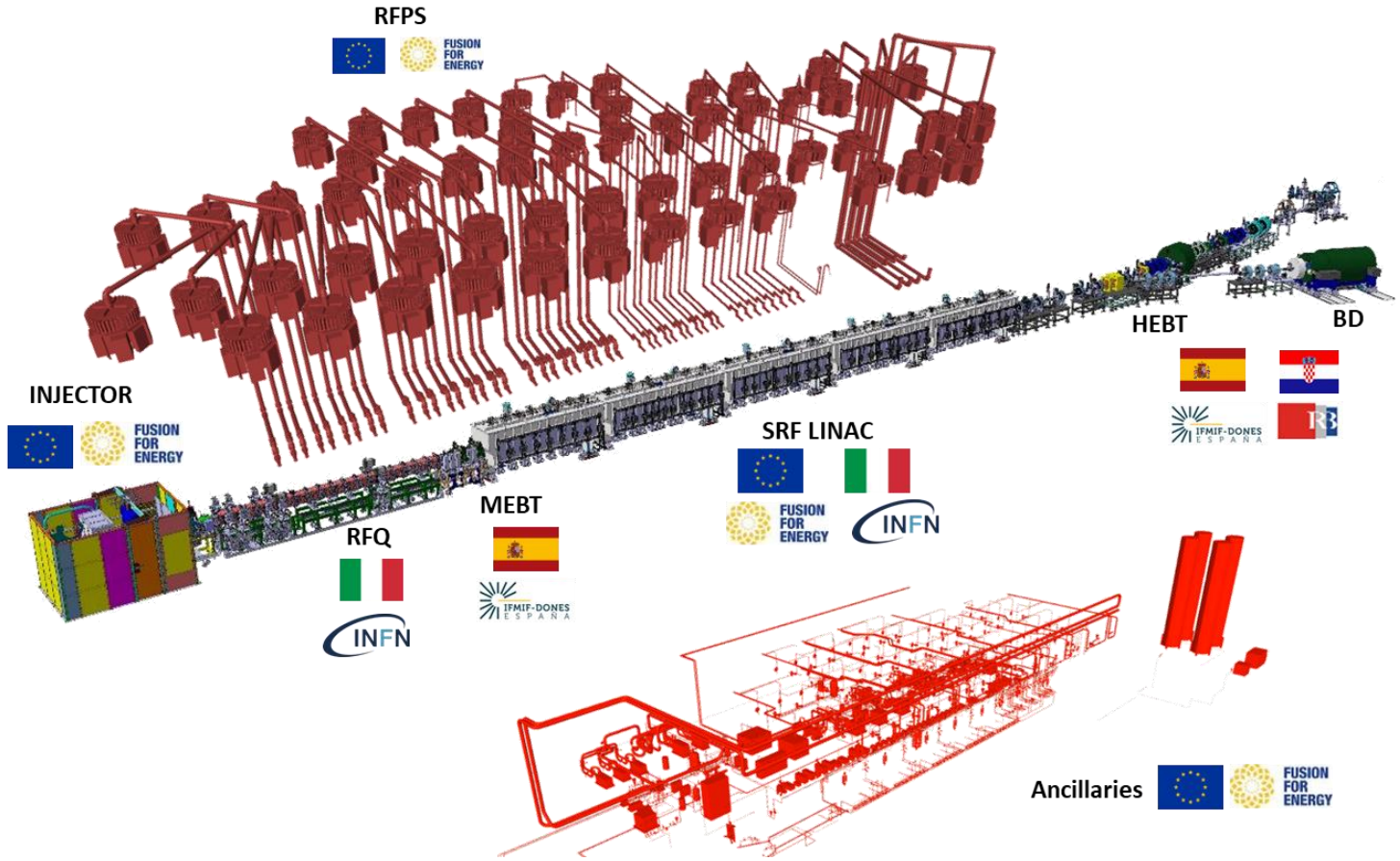
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Accelerator Systems- overall status

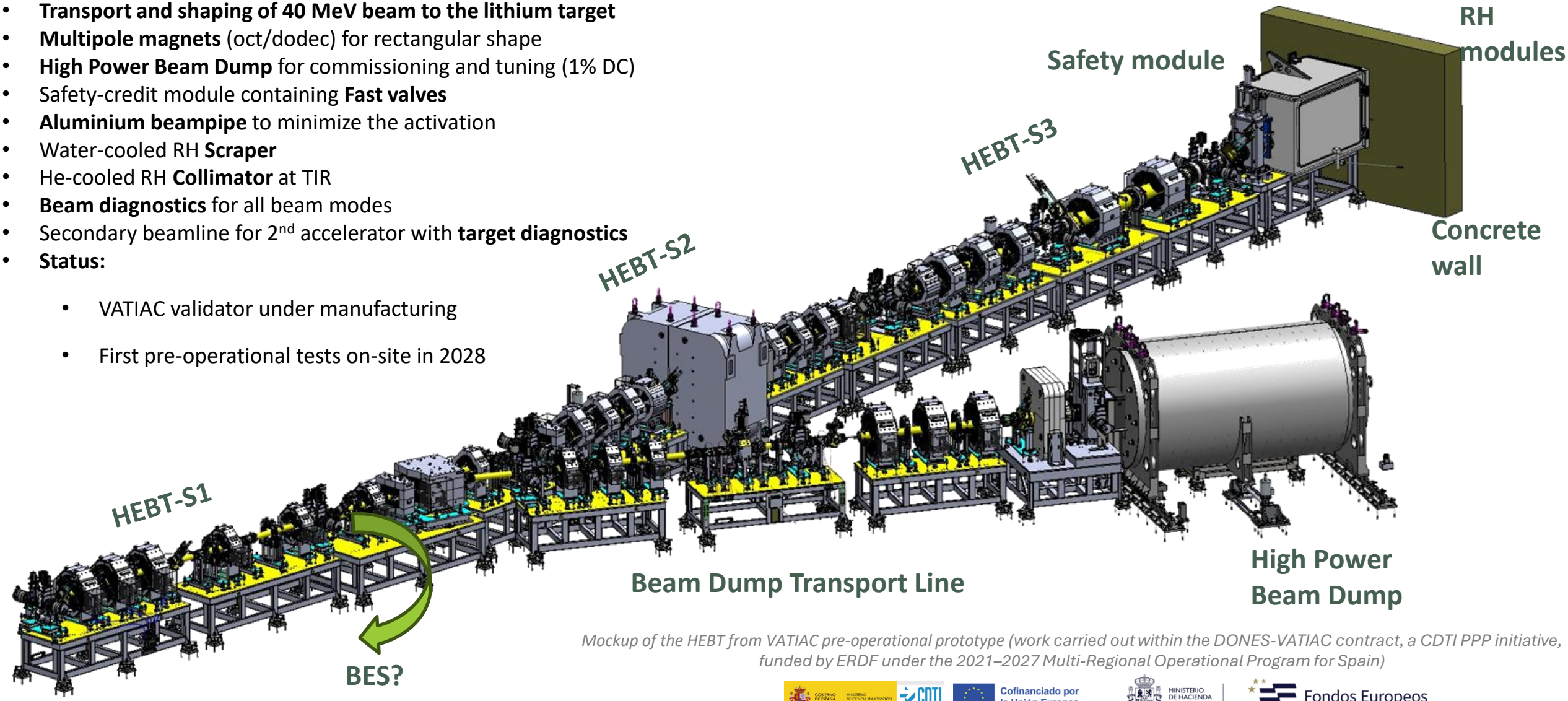
All **Providing Parties** identified

- **MEBT** and **HEBT (w/o TIR)** under Manufacturing
- **Injector**, **RFQ** and **RFPS** starting procurements soon
- **ASA** , **HEBT-TIR** and **SRF LINAC** under design



HEBT & BD

- **Transport and shaping of 40 MeV beam to the lithium target**
- **Multipole magnets** (oct/dodec) for rectangular shape
- **High Power Beam Dump** for commissioning and tuning (1% DC)
- Safety-credit module containing **Fast valves**
- **Aluminium beampipe** to minimize the activation
- Water-cooled RH **Scraper**
- He-cooled RH **Collimator** at TIR
- **Beam diagnostics** for all beam modes
- Secondary beamline for 2nd accelerator with **target diagnostics**
- **Status:**
  - VATIAC validator under manufacturing
  - First pre-operational tests on-site in 2028



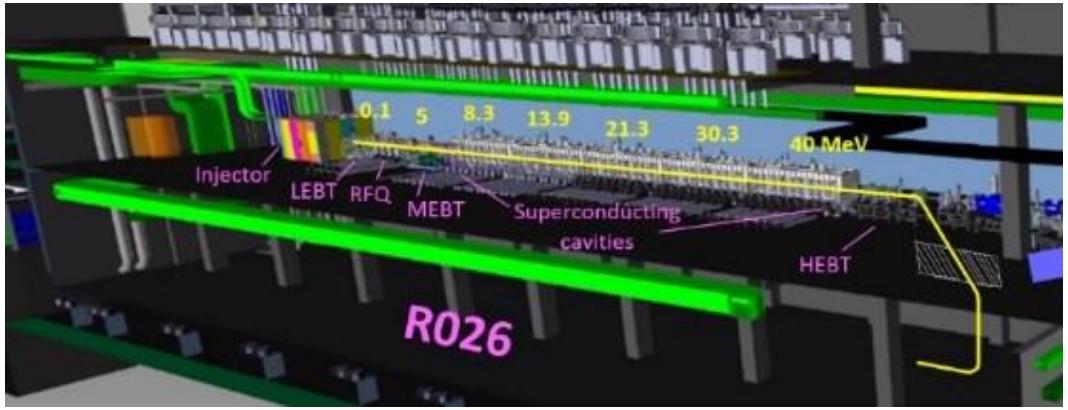
Mockup of the HEBT from VATIAC pre-operational prototype (work carried out within the DONES-VATIAC contract, a CDTI PPP initiative, funded by ERDF under the 2021–2027 Multi-Regional Operational Program for Spain)

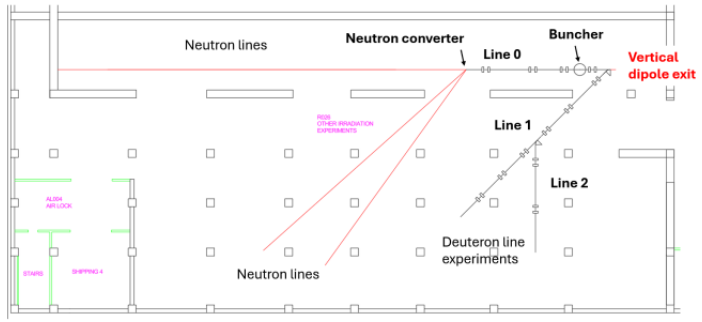
HEBT & BD

Beam Extraction System (BES) @ 40 MeV for complementary experiments under assessment

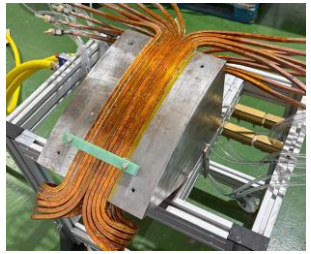
Reference layout: multi-meander line kickers (tens of kV) + electrostatic kicker + septum magnet

Projects for protos of kickers and septum magnets under assessment

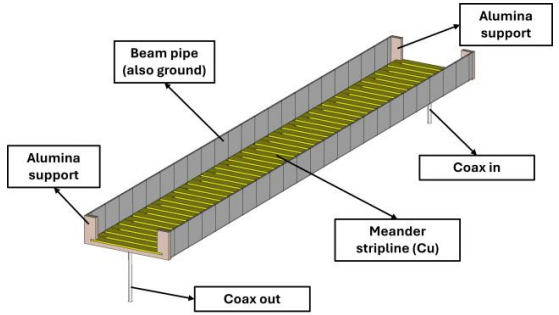




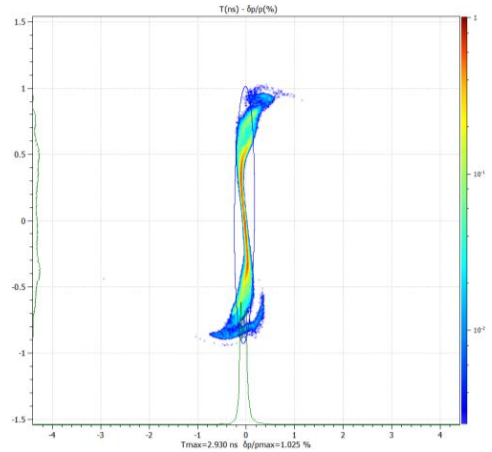
L. Bellan et al., IPAC'26, THP4116, 2026

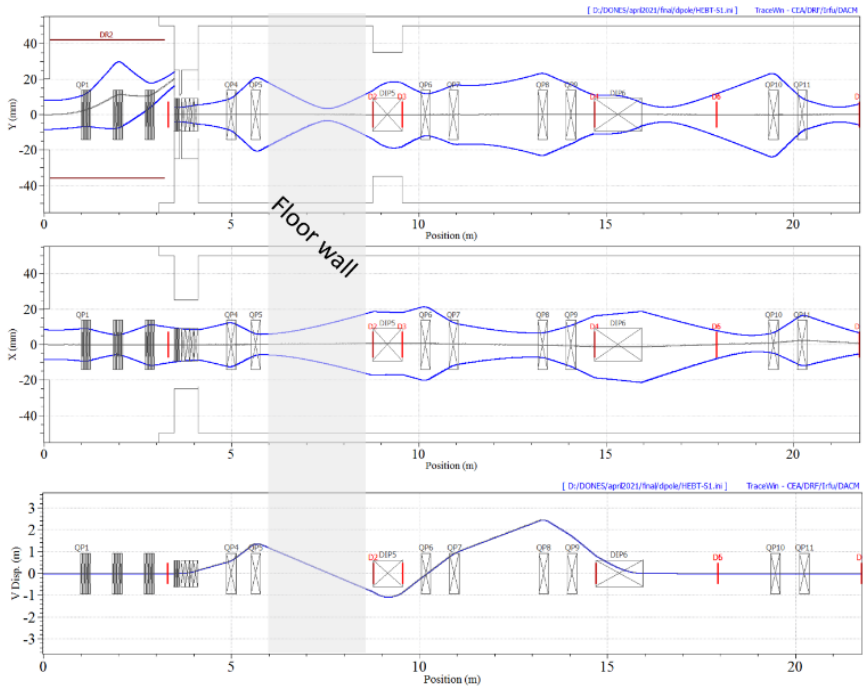


SUPRASYS



M. d'Andrea, LINAC2024, TUPB073

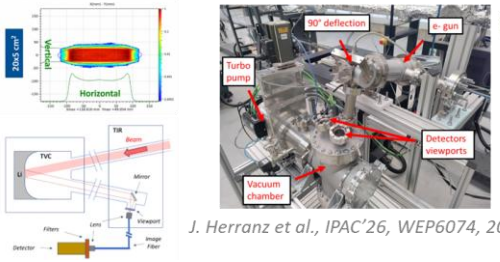




Beam Diagnostics

- Most beam diagnostics already validated @ **LIPAc** (Japan)
- Some **critical diagnostics** identified related with the high power beam and radiation background

Lithium OTR Light Detector:
To validate the OTR light from liquid lithium

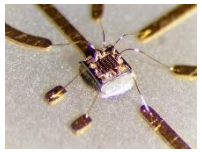


J. Herranz et al., IPAC'26, WEP6074, 2026

HEBT@TIR:
- Characterization and monitoring of **beam profile & footprint**
- Beam monitors under high radiation environment and Remote Handling maintenance

SRF LINAC:
- Measurement of **microlosses** (<1 W/m) @ cryogenic environment → CVD's
- Transverse profile @ Warm Sections

uBLM

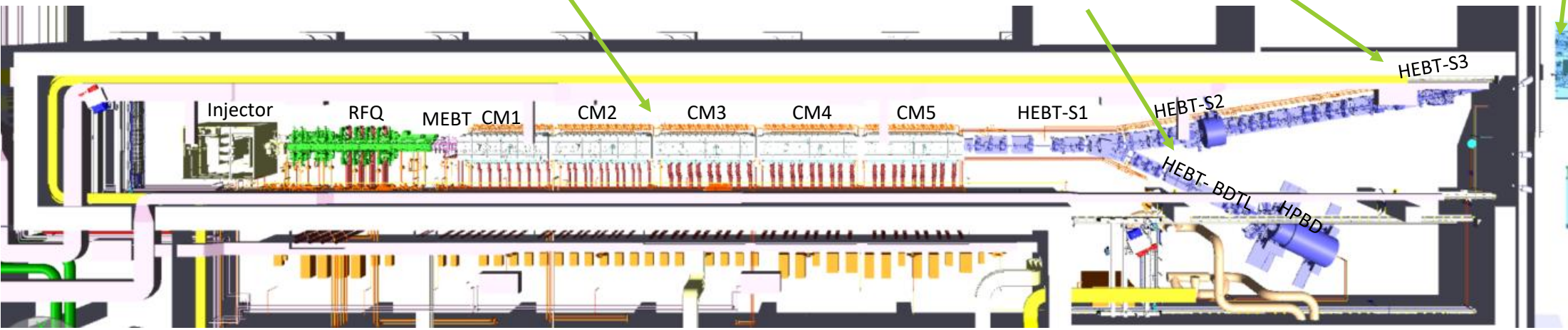


HEBT:
Non-interceptive profile monitors in multipoles section

Accelerator:
Monitors for lossless beam transport



HEBT/BDTL:
Monitors for longitudinal beam **characterization**



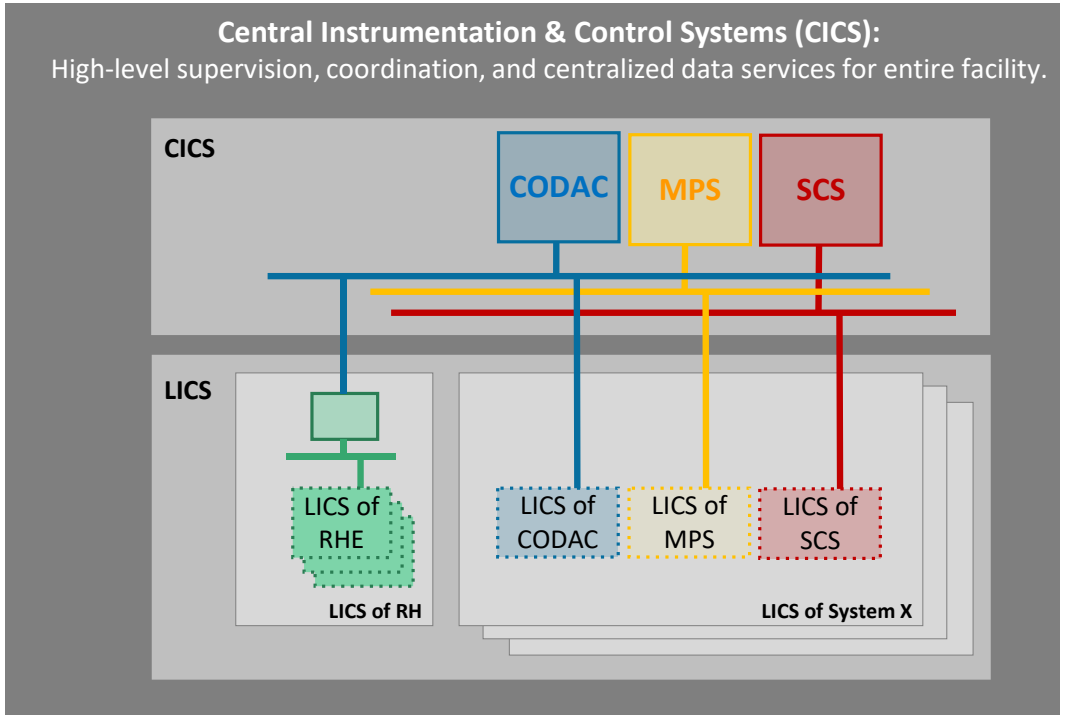
A. Ortega, IBIC'25, MOCC02, 2025

Outline

1. IFMIF-DONES general status
2. Site, Building and Plant Systems
3. Test Systems
4. Lithium Systems
5. Accelerator Systems
6. **Control Systems**
7. Conclusions and Outlook

Control systems framework

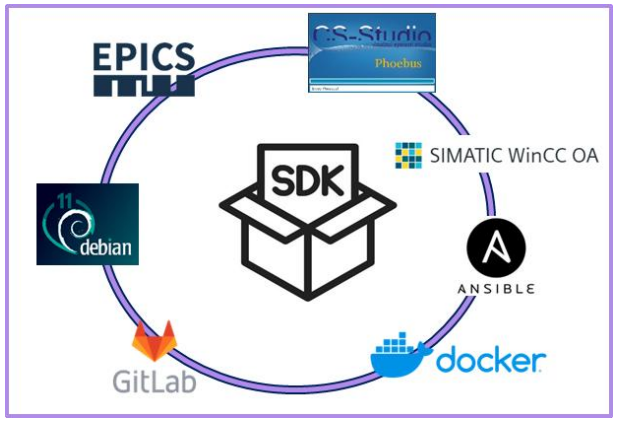
- **CICS-LICS** architecture: harmonized through guideline
- Segregated **architecture** in three systems: routine control & communication (CODAC) , Machine Protection (MPS) and Safety (SCS)
- **Distributed control** based on EPICS framework (CODAC, MPS)
- Virtualization & containerization
- **Configuration management**: SW & HW
- **Timing and synchronization** based in White Rabbit standard



Safety Control System (SCS):
- It implements the safety functions regarding personnel or environment.
- Independent from CODAC & MPS.
- Complying with relevant standards for radiation safety.
- Subsystems:
  - Plant Safety Subsystem (PSS)
  - Occupational Safety Subsystem (OSS)
  - Personal Access Safety Subsystem (PASS)
  - Radiation Monitoring System for the Environment and Safety (RAMSES)
  - Individual Radiological Monitoring Subsystem (IRMS)

Control, Data Access and Communication (CODAC) System:
- It implements the orchestrated conventional control functions of all system of the facility.

Machine Protection System (MPS):
- It implements the machine protection functions against:
  - ✓ failures of the facilities system/component,
  - ✓ failures of CODAC system,
  - ✓ possible incorrect operation.







C. Carvajal et al., ICALEPCS2025, TUAG005, 2025

Outline

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Conclusions & Outlook

The **IFMIF-DONES accelerator** is fully into the **Construction Phase**

Civil works for the site and main building preparation started one month ago

IFMIF-DONES Design is always trying to accommodate the needs from the DONES Users including potential upgrades but…

First Experimental Programme would help to consolidate the requirements

DONES

DONES Users

Thank you for your attention!

www.ifmif-dones.es



Cofinanciado por la Unión Europea

MINISTERIO DE HACIENDA

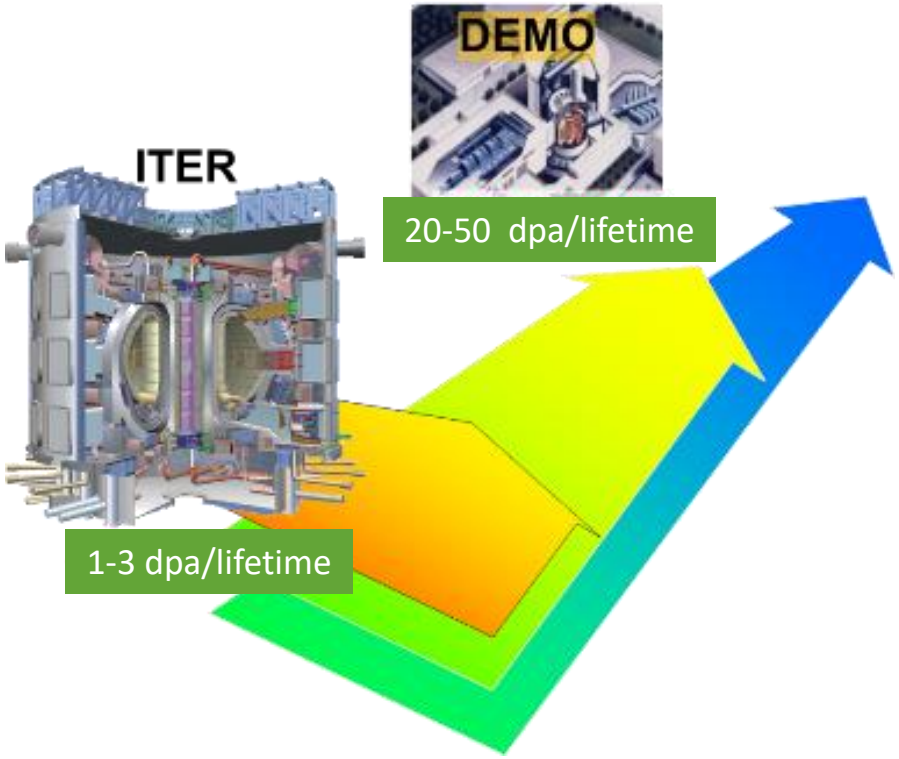
Fondos Europeos

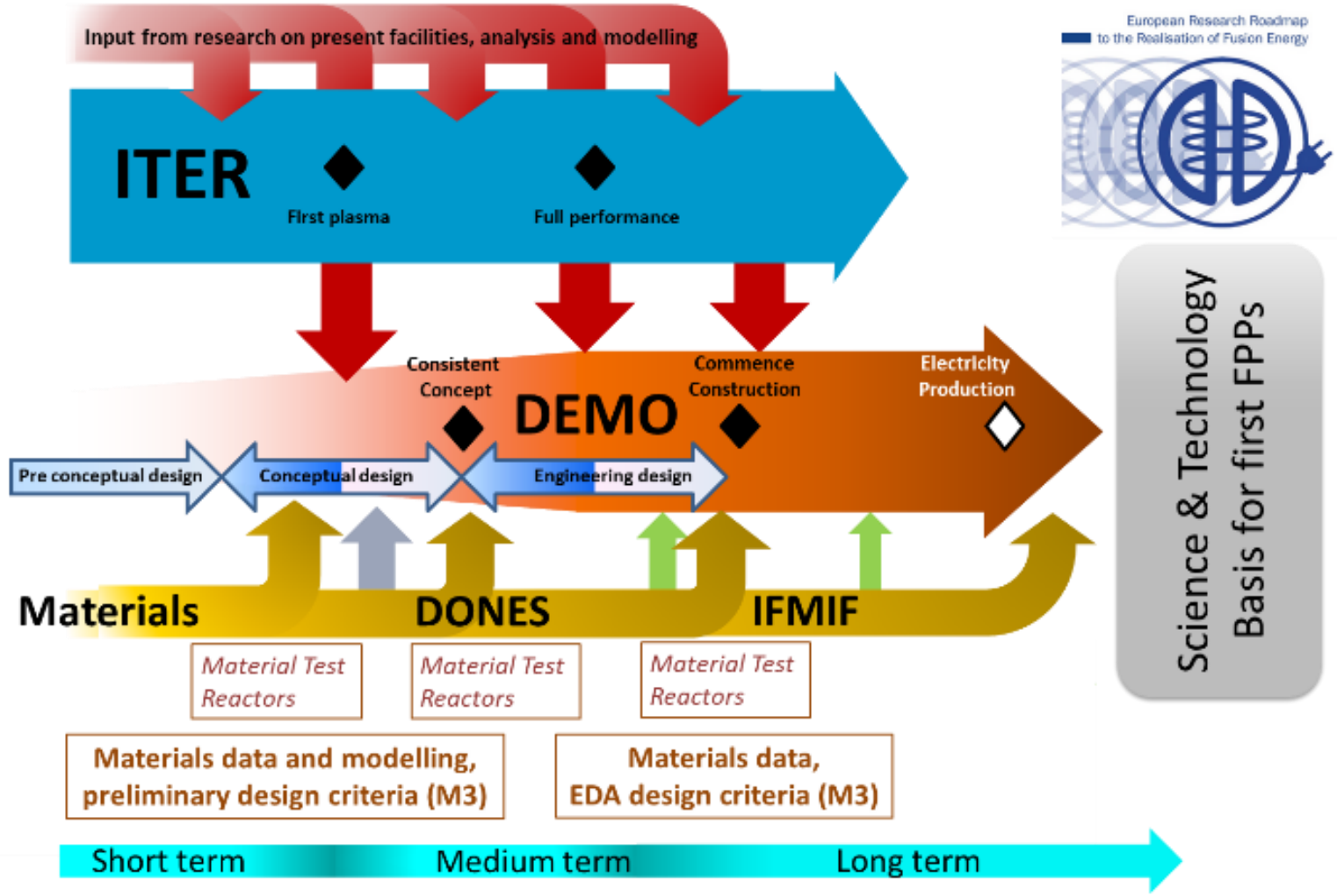
Junta de Andalucía

The authors acknowledge the financial support provided by the European Regional Development Fund (ERDF) 2021–2027 for the development of the IFMIF-DONES project. This support is granted through the Agreement between the Ministry of Science, Innovation and Universities and the IFMIF-DONES Spain Consortium for the execution of the DONES TOPS project, co-funded by the ERDF under the Pluriregional Programme of Spain 2021–2027, and through the Agreement between the Regional Ministry of Universities, Research and Innovation of the Government of Andalusia and the IFMIF-DONES Spain Consortium for the financing of the DONES BASE project, under the Andalusia ERDF Programme 2021–2027.

Why IFMIF-DONES ?

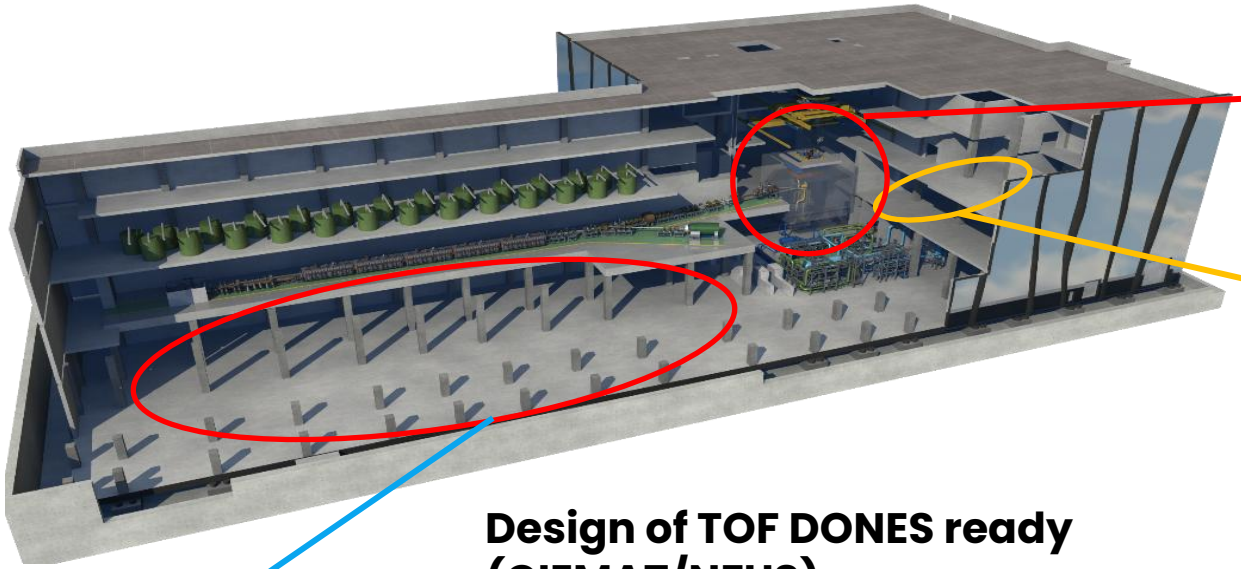
One of the main differences between **ITER** and **DEMO** is the radiation dose: at DEMO more than
two orders of magnitude higher



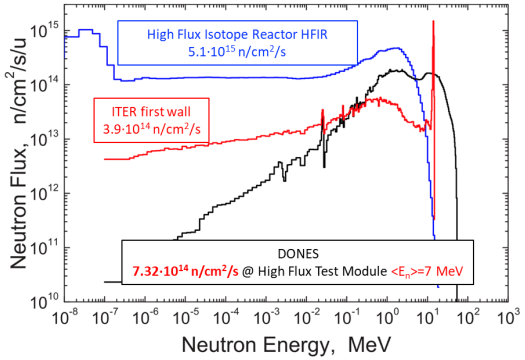


Facility & users

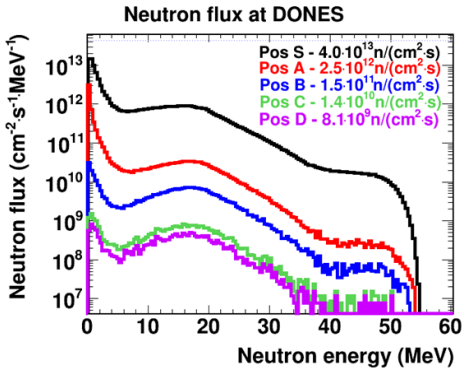
Three main experimental areas – First **Experimental Programme** to be presented this year



Test cell – Main neutron experimental area (fusion users)

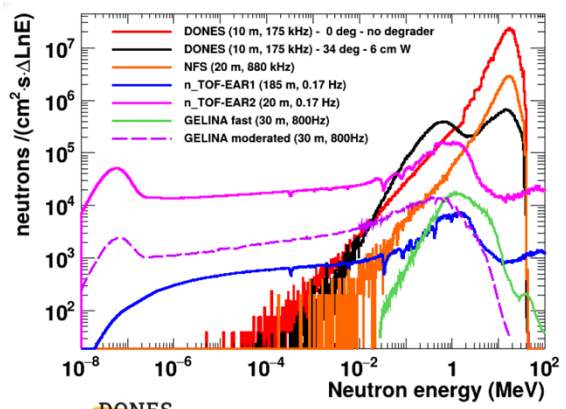


Area for complementary experiments with continuous neutron beam

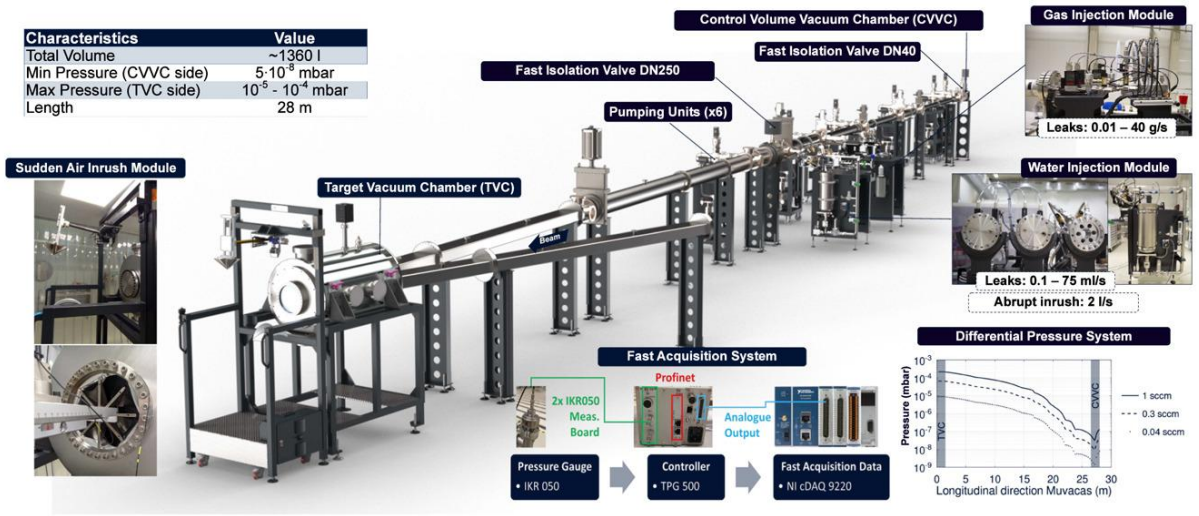


Area for complementary experiments with deuteron beam

Design of TOF DONES ready (CIEMAT/NFUS)



Ongoing research prototypes



A. Sabogal et al., Fus. Eng. Design, 222, 115473, 2026

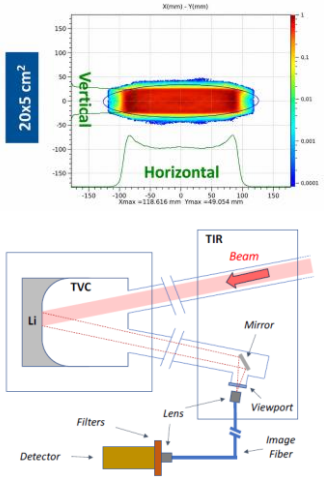
MuVACAS:
To validate protection of vacuum-related safety scenarios

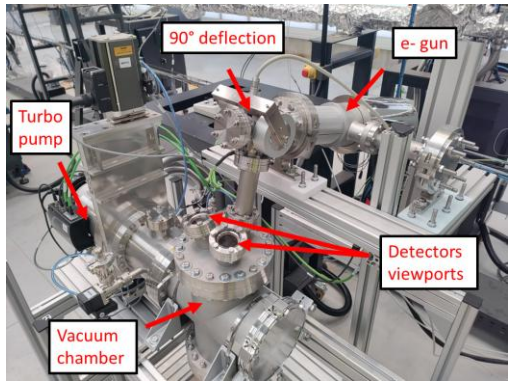
Quick Disconnecting System (QDS): To validate RH connection system at the target



G. Benzoni et al., Fus. Eng. Design, 215, 2025
A. Rodríguez et al., Proc. ISFNT16, 2025

Lithium OTR Light Detector:
To validate the OTR light from liquid lithium



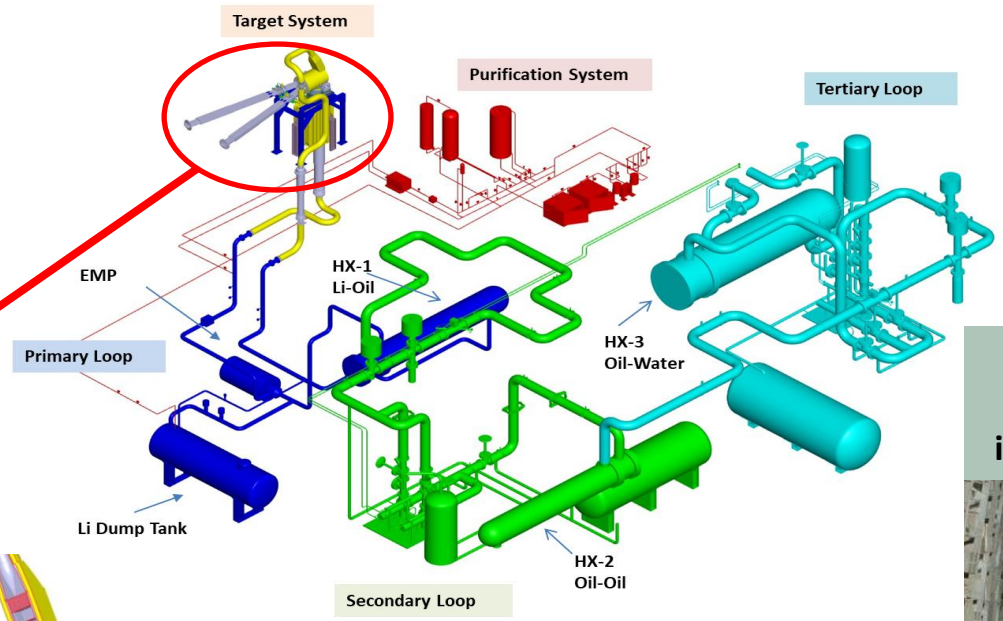


J. Herranz et al., IPAC'26, WEP6074, 2026

Liquid Lithium Target

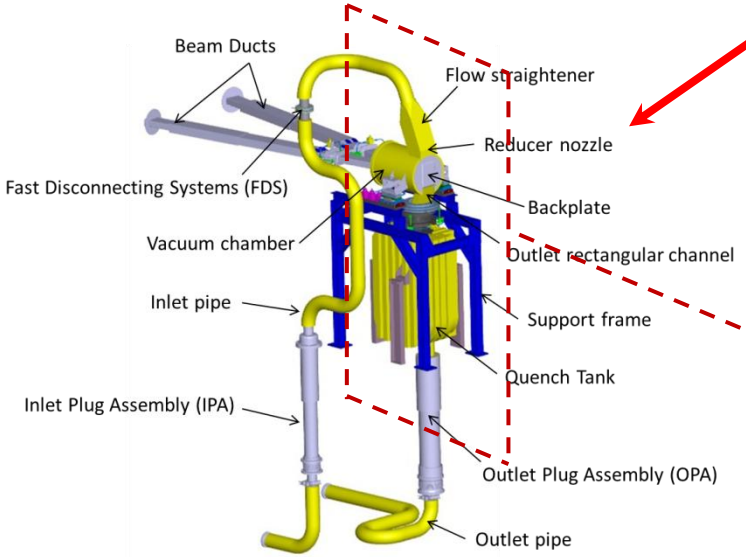
- **5 MW** power handling (ready for 10 MW)
- **Interaction beam-target** (vac chamber, transients, vaporization...)
- Three **heat rejection loops** (Li-Oil, Oil-Oil, Oil-Water)
- **Impurities** control and monitoring
  - Corrosion issues (affected by N content)
  - Radioactivity inventory (Be-7, Tritium, ACP…)

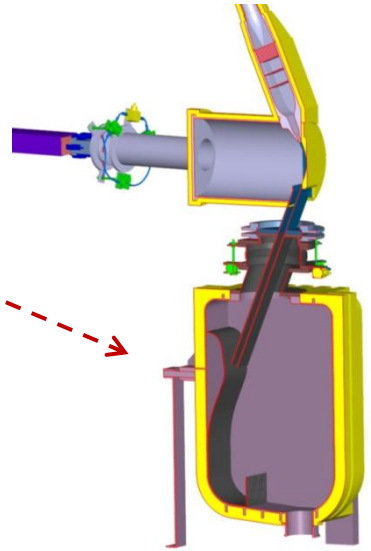
Lithium loops



Li volume ~14 m³
Li flow rate: ~100 l/s

Target Assembly





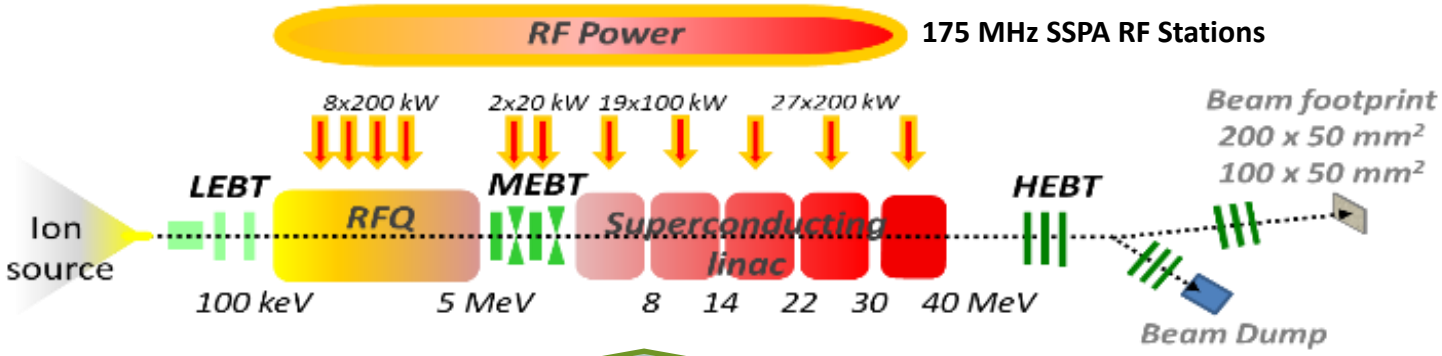
Heat flux: 500 MW/m²
Jet thickness: 25 ± 1 mm
Li inlet T: 300 °C
Li velocity: 15 m/s
Chamber pressure: 10^{-2} Pa

IFMIF/EVEDA ELTL validation results implemented in the design



H. Kondo, Fus. Eng. Design, 96-97, 117-122, 2015

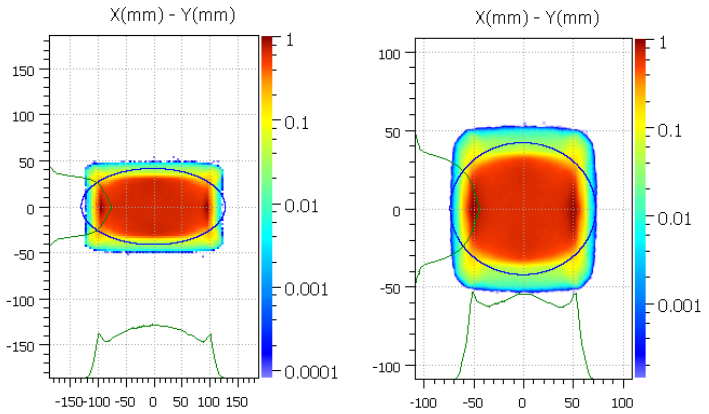
LINAC parameters



Ancillaries

Vacuum, Cryogenics, Water cooling,
Gas and electric distribution…

Beam footprint @ target



20x5 cm² footprint
(reference)

10x5 cm² footprint
(optional)

D+ CW 175 MHz SC LINAC

125 mA / 40 MeV → **5 MW**

Total length of ~**100 m**

Windowless liquid **Li target**

20 y, 87% **target availability**

Hands-on **maintenance (<1 W/m)**

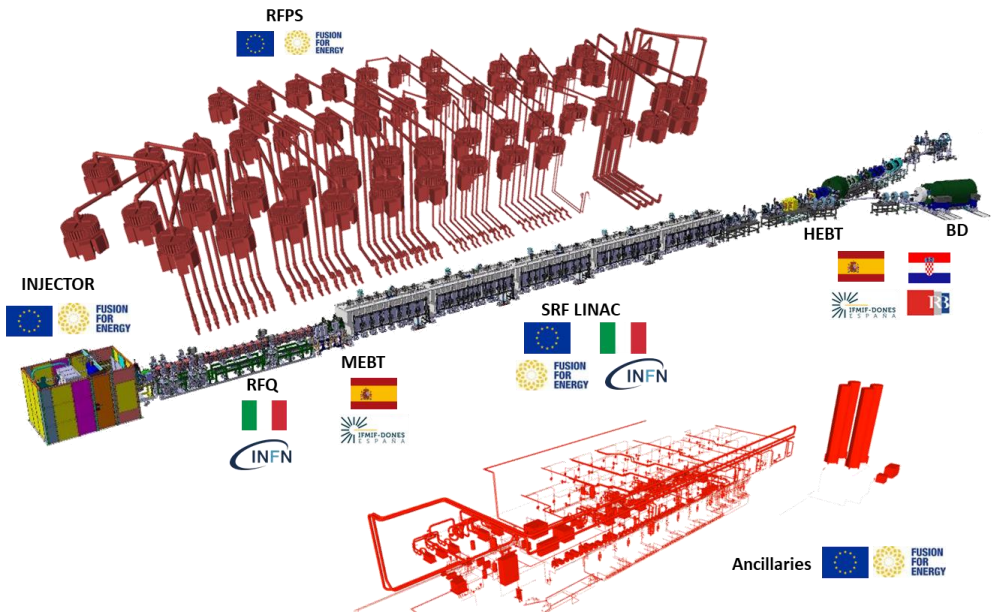
Target-beam at 9° angle →

possibility to upgrade

with 2nd mirror accelerator (10 MW)

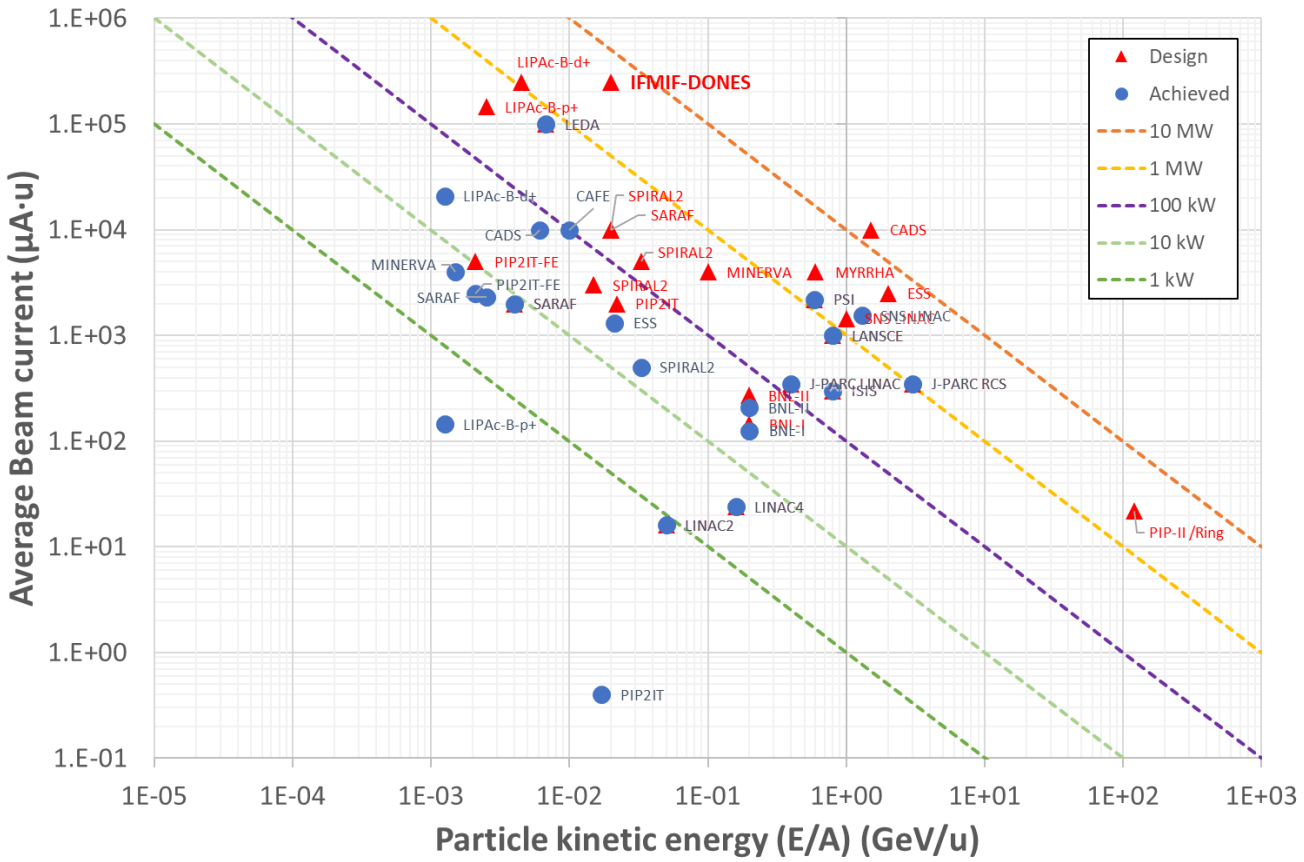
Independent **EMC mesh**

embedded into the Building



The 5 MW deuteron LINAC

40 MeV / 125 mA CW / 5 MW SC LINAC



- Highest **D⁺ current** LINAC
- One of the highest **average beam power & perveance**
- Top **H⁺ & D⁺ Injector** performance
- Longest **RFQ**
- High **Beam loading** in resonant cavities
- Record of light hadrons current through **SC cavities**

Facility (Accelerator, target…) design considering feasibility upgrading to 10 MW!