FUSION FOR ENERGY

EUROfusion

Overview of IFMIF-DONES and testing of materials for DEMO

Town Meeting on IFMIF/ELAMAT Complementary Scientific Program. April 14-15, 2016

A. Ibarra (CIEMAT, ENS Project Leader)

H. Dzitko (F4E/BFD-IFMIF Unit)

GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD · Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas · ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile · KIT Karlsruher Institut für Technologie · INFN Istituto Nazionale di Fisica Nucleare · IFPiLM · cea · RACE · FUSION FOR ENERGY · wigner · SCK•CEN · RB · VTT · LIETUVOS ENERGETIKOS INSTITUTAS

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Outline

- Fusion materials irradiation and DEMO
- IFMIF and IFMIF/EVEDA
- IFMIF-DONES
- Objetives of the meeting

Outline

- Fusion materials irradiation and DEMO
- IFMIF and IFMIF/EVEDA
- IFMIF-DONES
- Objetives of the meeting

2014 scenarios

The 2014 EU Roadmap to a Fusion Power Plant In EU (presently under review) is based on a scenario with an early construction of DEMO

That means early selection of DEMO technologies and immediate specific needs for fusion materials database

MAG Report (2012)

DEMO will probably have two operational phases:

- **First one: focused on startup and feasibility evaluation (low availability): 20 dpa**
- **Second one: focused on availability increase: 50 dpa**

A neutron source is needed for materials qualification,

- **Short-term mission and requirements linked to DEMO needs**
- **Long-term mission and requirements linked to the Power Plant needs**

Critical materials to be irradiated for DEMO: Reference steels (as structural material), Cu alloys (as interface material between W and steel) and W (high dpa dose: as first-wall material and structural divertor material.

critical materials: those where a Design Code is needed for design and licensing

Neutron source requirements

to produce **fusion-like neutrons**

- Intensity large enough to allow accelerated (as compared to DEMO) testing,

> 10 dpa(Fe)/fpy

- Damage level above the expected operational lifetime,

20 dpa(Fe) in 1.5 y/50 dpa(Fe) in 3.5 y

- irradiation volume large enough to allow the characterization of the macroscopic properties of the materials of interest required for the engineering design of DEMO (and the Power Plant)

300 cm3

- **Irradiation conditions (neutron flux, temperature) to be homogeneous for standarised specimens:** Over a gauge volume flux gradient <10% and temperature gradient within ±3% with the long time stability in the same order must be satisfied

T: 250-550ºC

Neutron source requirements

to produce **fusion-like neutrons**

- Intensity large enough to allow accelerated (as compared to DEMO) testing,

> 10 dpa(Fe)/fpy

- Damage level above the expected operational lifetime,

20 dpa(Fe) in 1.5 y/50 dpa(Fe) in 3.5 y

- irradiation volume large enough to allow the characterization of the macroscopic properties of the materials of interest required for the engineering design of DEMO (and the Power Plant)

300 cm3

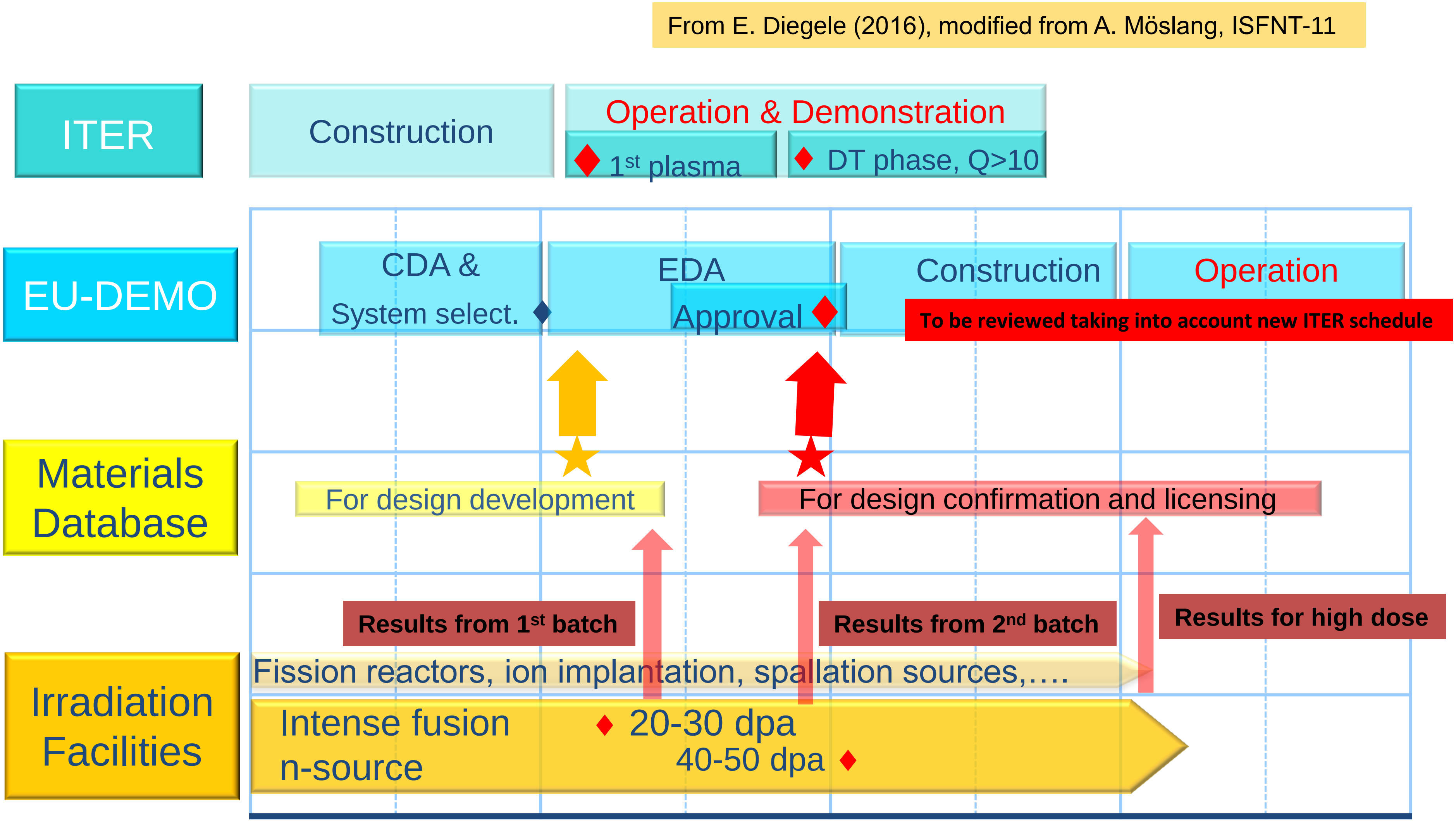
The most feasible approach based on

Li(d,xn) sources

±3% with the long time stability in the same order must be satisfied

T: 250-550ºC

And when are they needed?....



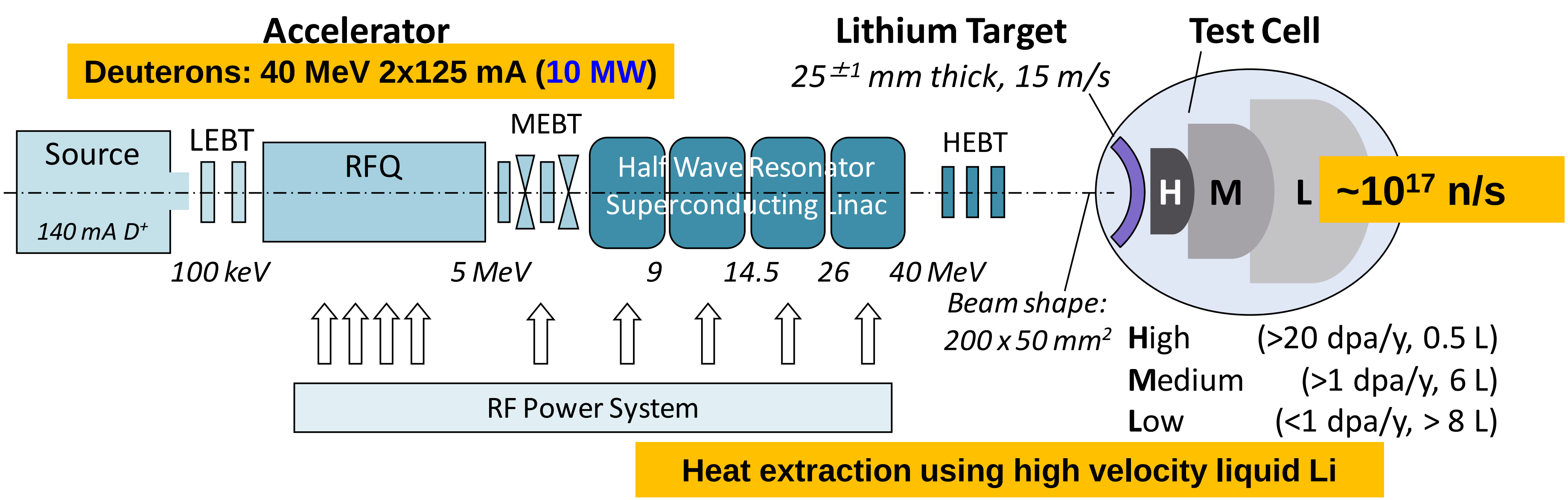
Outline

- Fusion materials irradiation and DEMO
- IFMIF and IFMIF/EVEDA
- IFMIF-DONES
- Objetives of the meeting

Main systems of IFMIF

- Long history towards a Li(d,xn) facility: FMIT, ESNIT, IFMIF
- Since 2007, IFMIF/EVEDA project included in the EU-JA Broader Approach Agreement (around 150 M€)

The IFMIF plant consists of 3 key systems:
1) A 40 MeV Deuteron Accelerator system with 2 identical LINACs;
2) A Lithium Target system providing intense high energy neutron beam;
3) A Test Facility with High, Medium and Low Flux Test Modules.

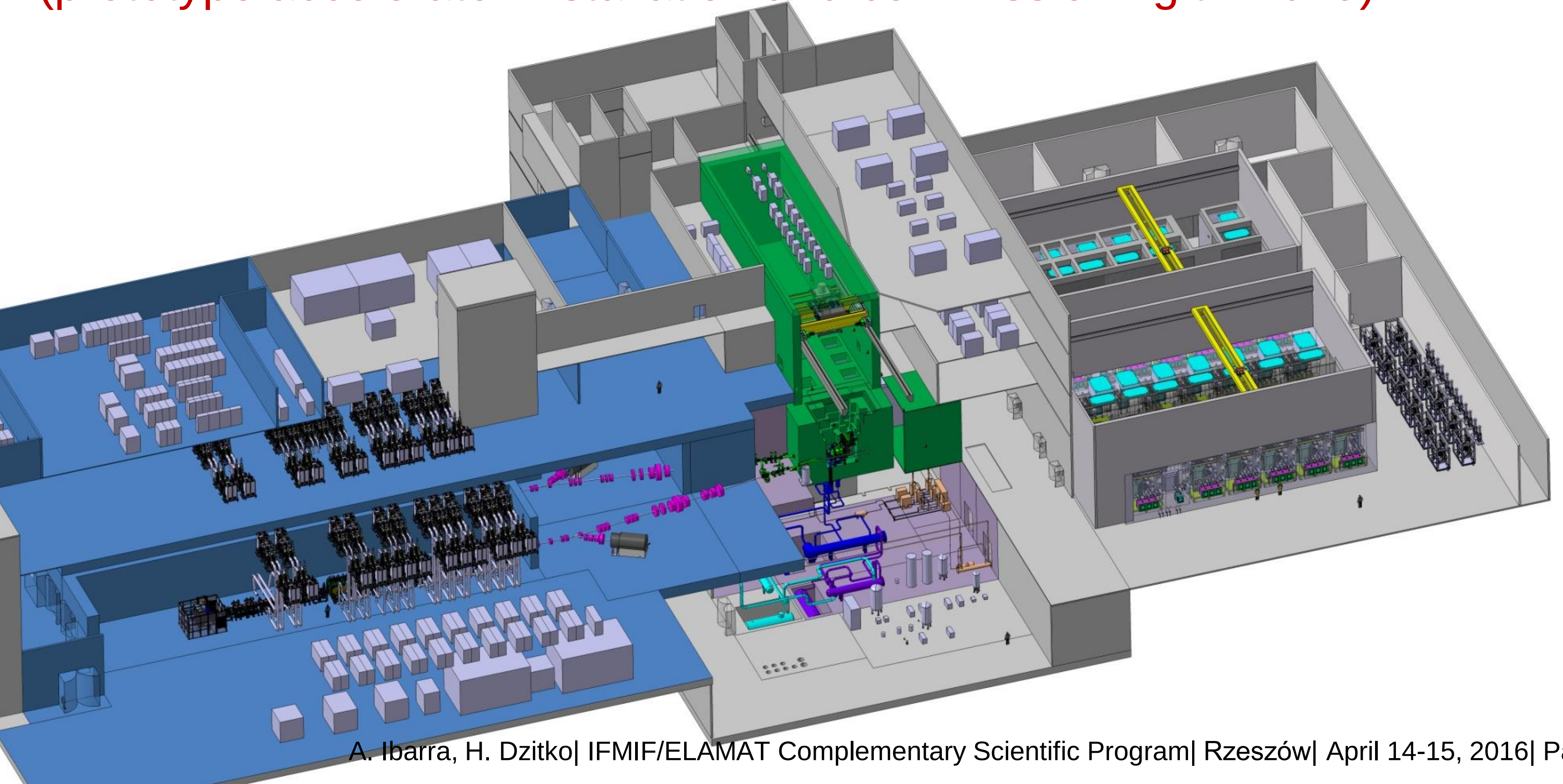


The Engineering Design Activities (EDA)

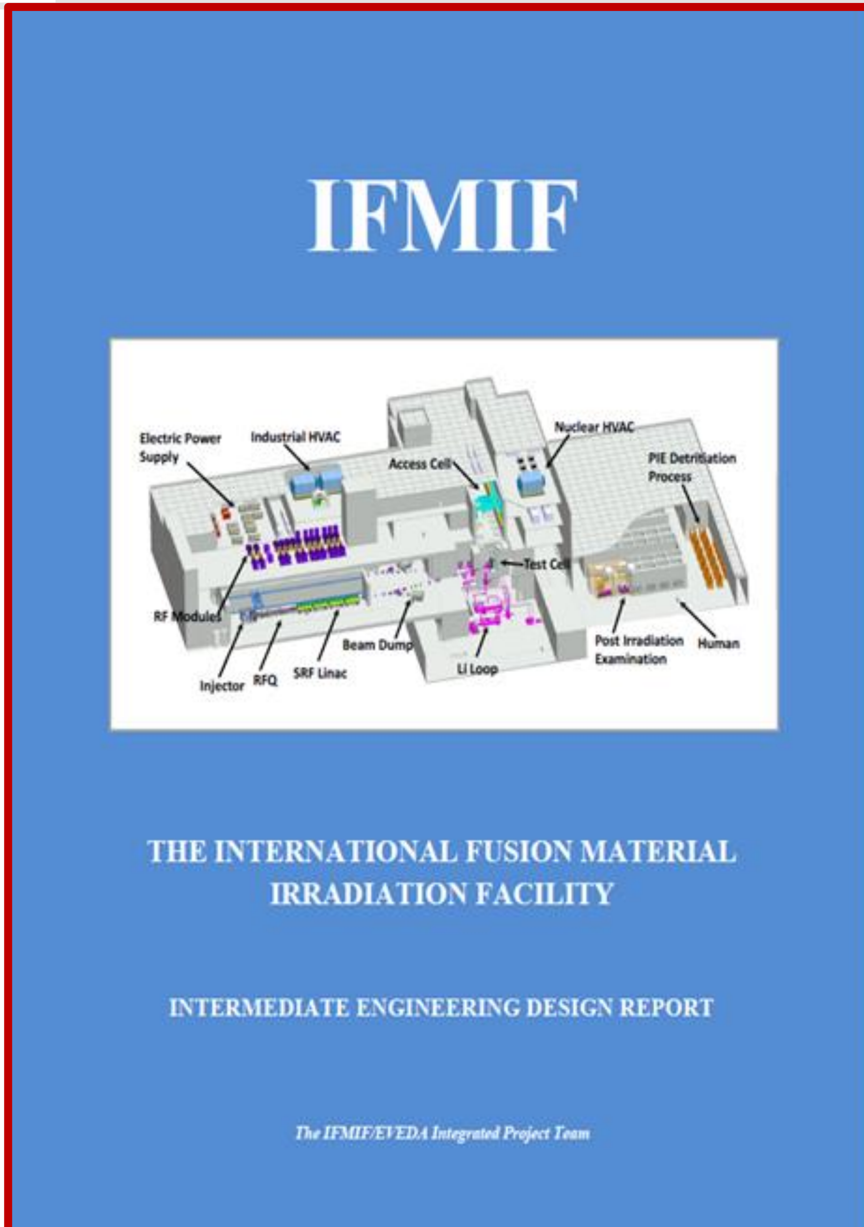
=> Intermediate IFMIF Engineering Design Report (IIEDR)
issued in June 2013

The Engineering Validation Activities (EVA)

=> Experimental support to the IIEDR mostly finished 2015
(prototype accelerator installation and commissioning till 2019)



EDA Phase successfully finished



IFMIF INTERMEDIATE ENGINEERING DESIGN REPORT

AUTHORS AND CONTRIBUTORS

European Union

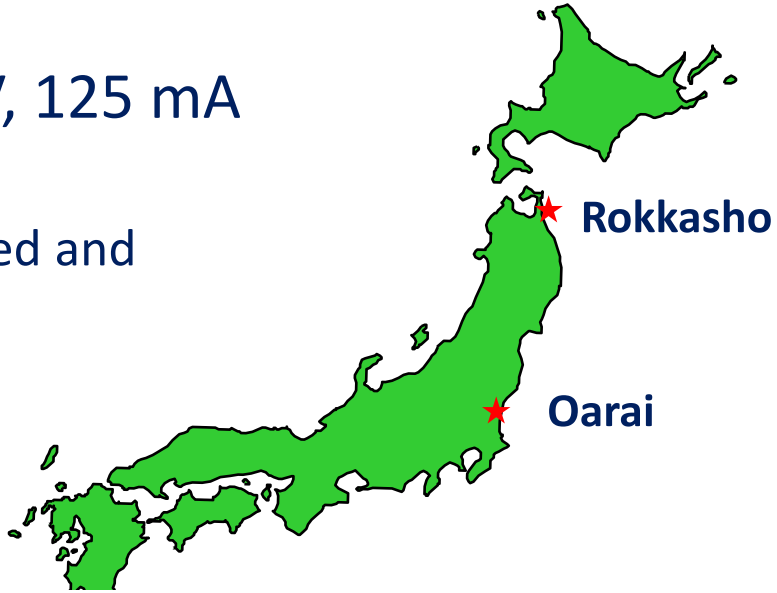
Japan

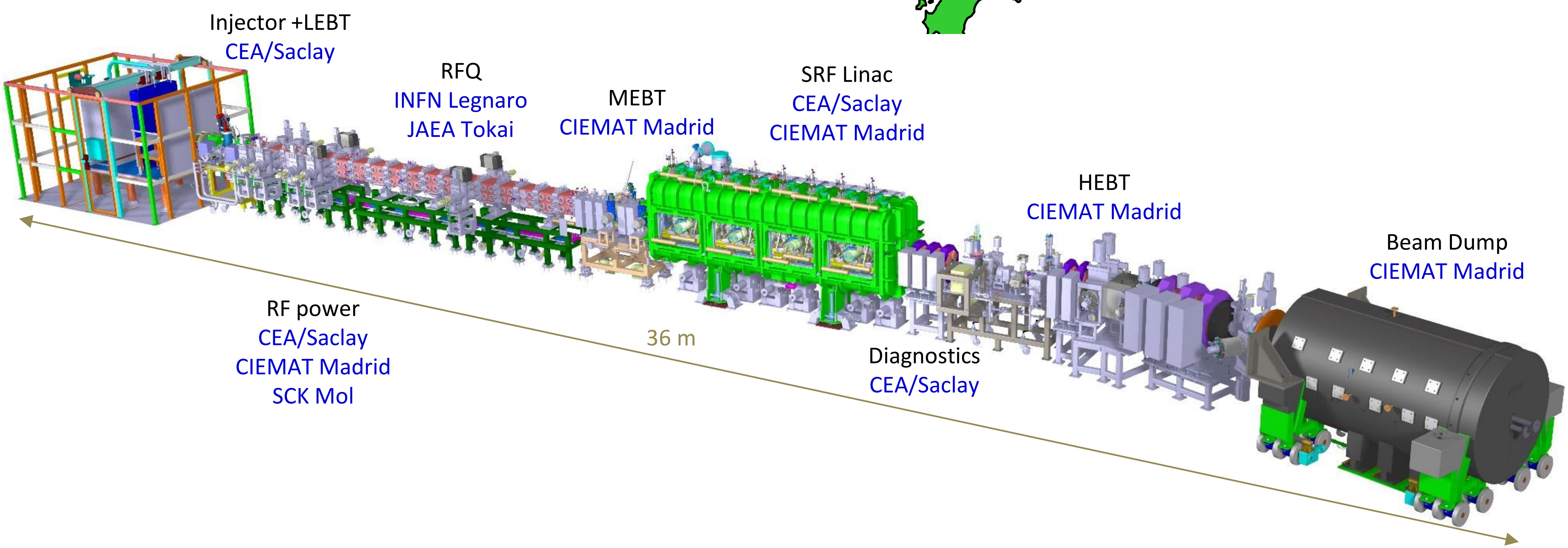
Project Team

Accelerator Validation: LIPAc

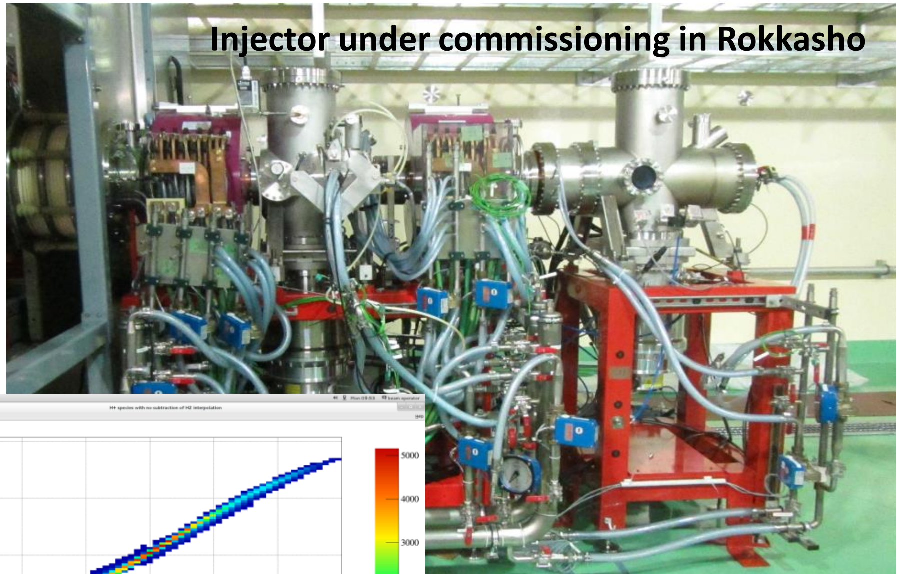
Prototype accelerator: D, 9 MeV, 125 mA

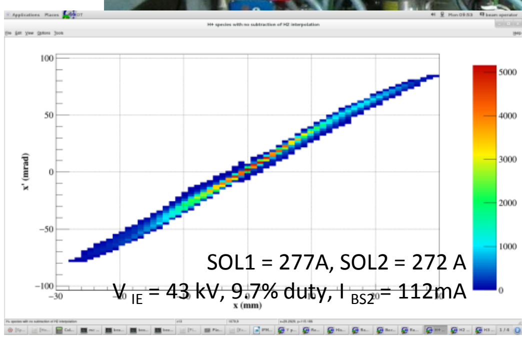
Designed and manufactured in Europe, installed and commissioned in Rokkasho





Construction status of LIPAc


Injector under commissioning in Rokkasho




MEBT at Rokkasho site

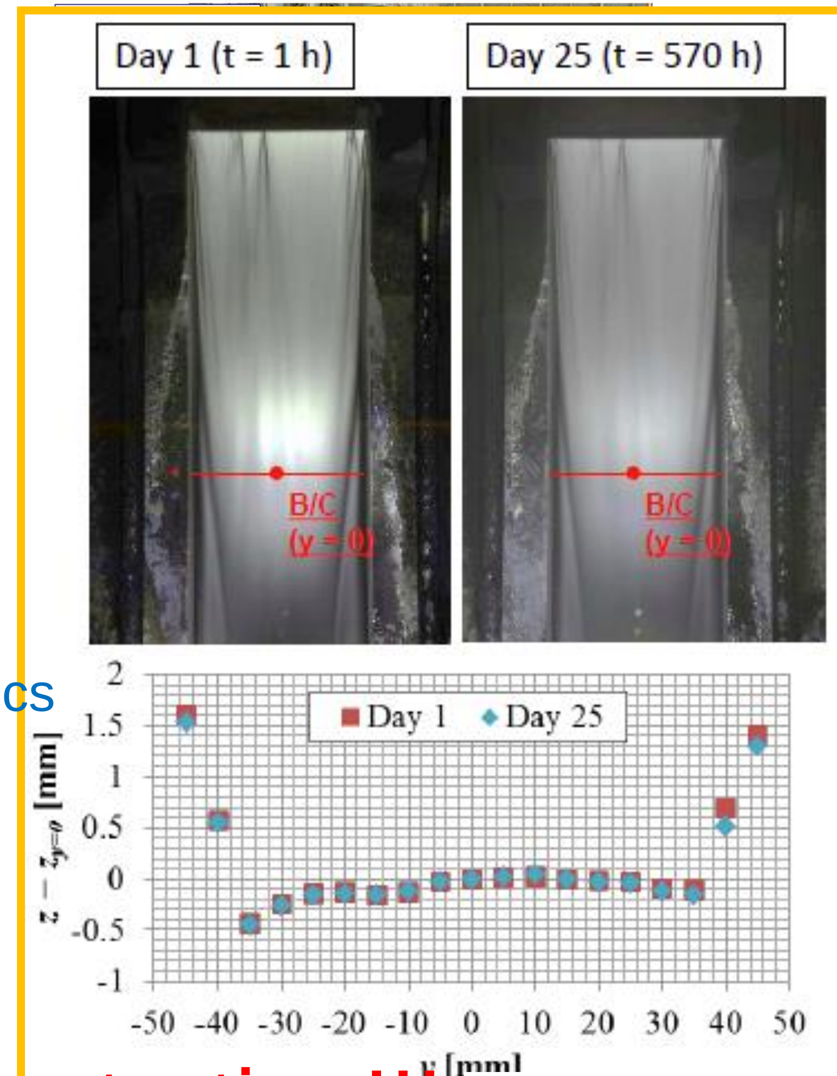

RFQ recently installed at Rokkasho

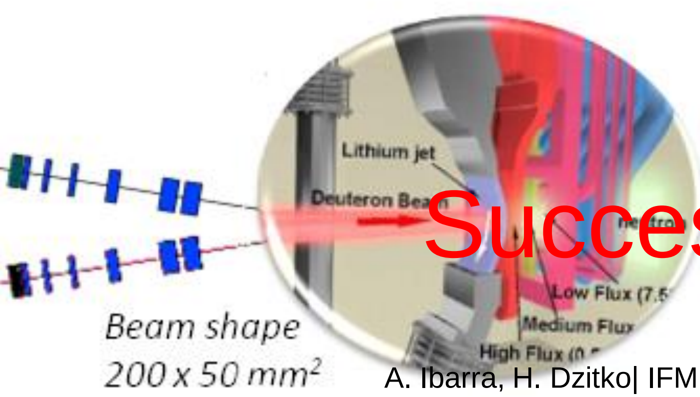

RF sytem partially installed at Rokkasho

Target Facility Validation

Objective: To demonstrate the feasibility of operational conditions:

- Lithium temperature at 250 °C
- Flow speed at 15 m/s
- Stable flow with +/- 1 mm amplitude
- 10^{-3} Pa on free surface
- Long term operation stability
- Free surface interferometry diagnostics
- Impurities in lithium < 10 ppm
- (cold and hot trapping)





Succesful demostration!!!

Outline

- Fusion materials irradiation and DEMO
- IFMIF and IFMIF/EVEDA
- IFMIF-DONES
- Objetives of the meeting

The 2014 EU Roadmap concluded that DEMO requirements can be fulfilled with a smaller neutron source

IFMIF-DONES (Demo-Oriented Neutron Source)

Main technical characteristics

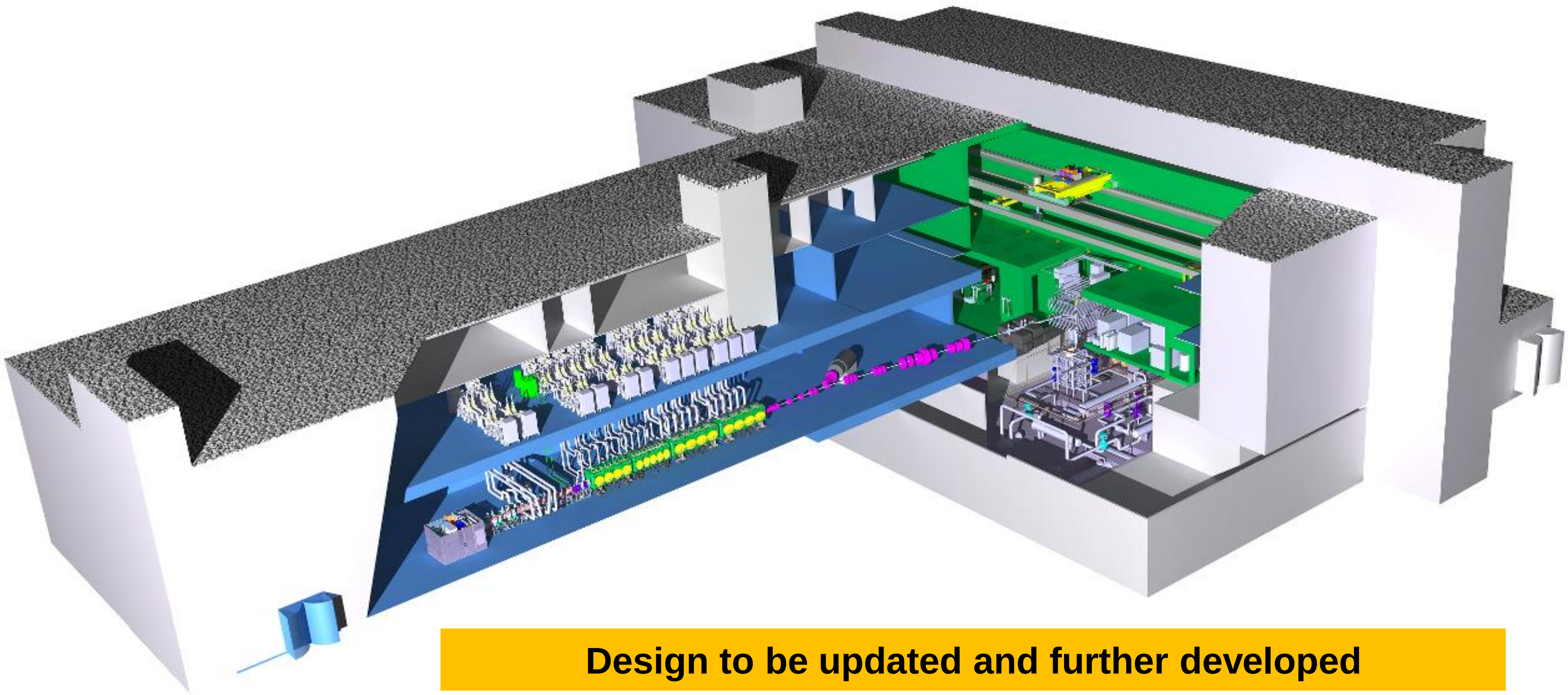
Based on IFMIF Preliminary Engineering Design…

- One full energy (40 MeV) accelerator with angular incidence
- Full size IFMIF Test Cell: only half cooling needed
- Full size IFMIF Li loop: only half cooling, half purification system needed
- Reduced number of irradiation modules to be used: no need of Tritium online measurements and strong simplification of PCPs
- Minimum irradiated materials (modules, target,…) manipulation in the plant: irradiated HFTM transferred in a cask to an external facility, if possible
- Waste management reduced to the minimum: all wastes transferred in casks to external facilities

- Reuse of some LIPAc IFMIF-EVEDA components feasible
- **Upgrade to full IFMIF feasible**

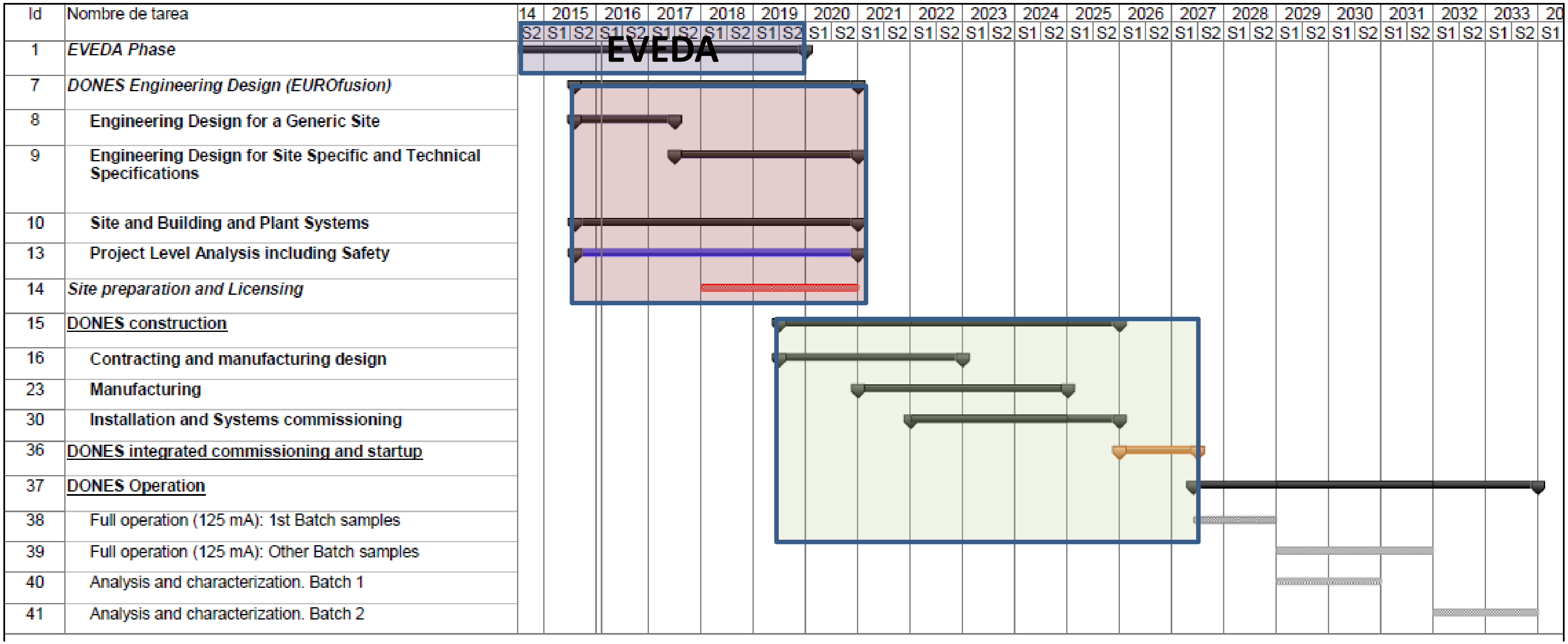
Technical description

Based on the IFMIF IIEDR a **preliminary conceptual design is available**, including facility configuration, systems design, preliminary safety evaluation, 3D CAD,…



Design to be updated and further developed

Reference Time Schedule



“feasible” time schedule based on the assumption that engineering design activities are developed continuously in the near future and manufacturing activities will start only after the end of IFMIF/EVEDA project AND on **F4E budget availability assumptions**

Time to be ready for operation: 10-12 years

Site decision to be taken in 2016-17 (F4E already asked to EU countries for proposals; EU-JA scope discussions are going-on)

The ENS project

F4E: EU Joint Undertaking in charge of the implementation of the EU contribution to ITER and the Broader Approach (incl. IFMIF)

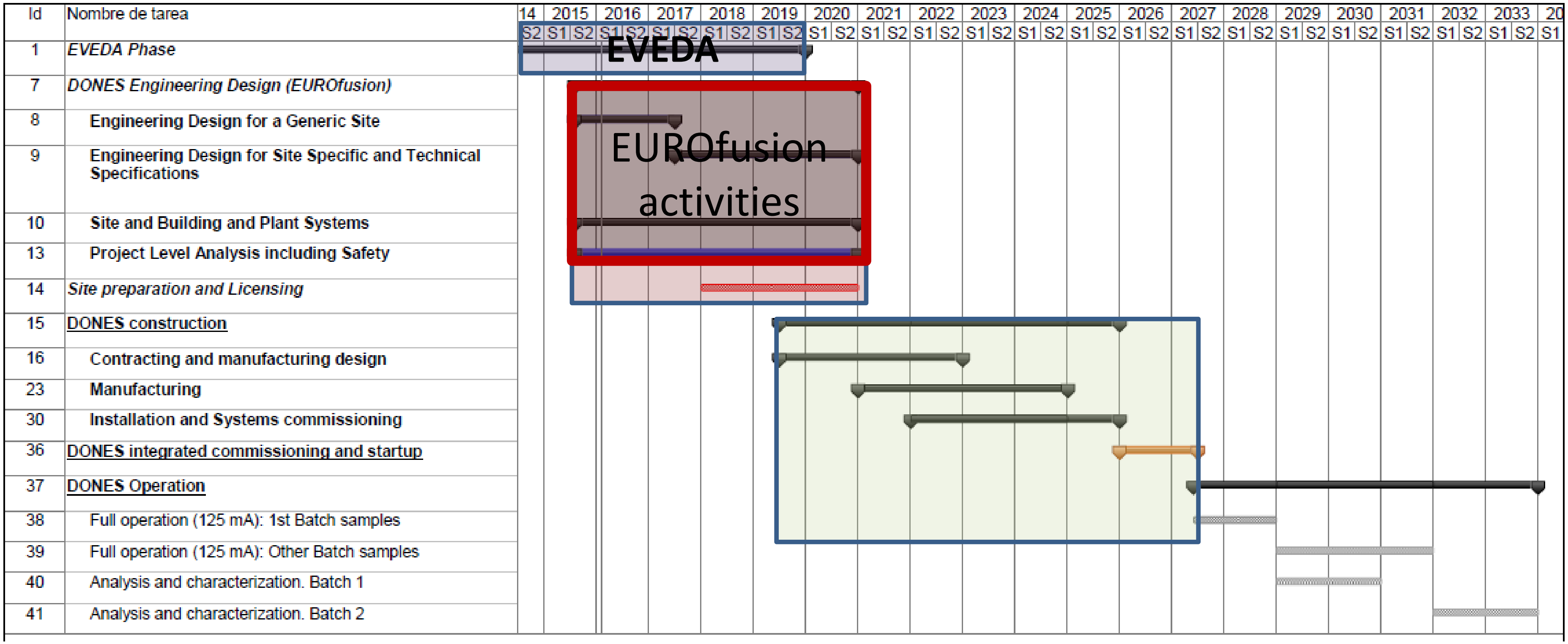
EUROfusion Consortium: Consortium of Research Labs in charge of the complementary Fusion R&D activities

Based on an agreement between F4E and EUROfusion, next steps up to 2020–beyond IFMIF/EVEDA- on the development of the neutron source project will be implemented by the so-called ENS project in the framework of the EUROfusion Consortium and in close collaboration with F4E.

- Objectives of the ENS project
  (as of the EUROfusion Consortium Workprogramme):

To be ready for IFMIF/DONES construction in 2020

Reference Time Schedule

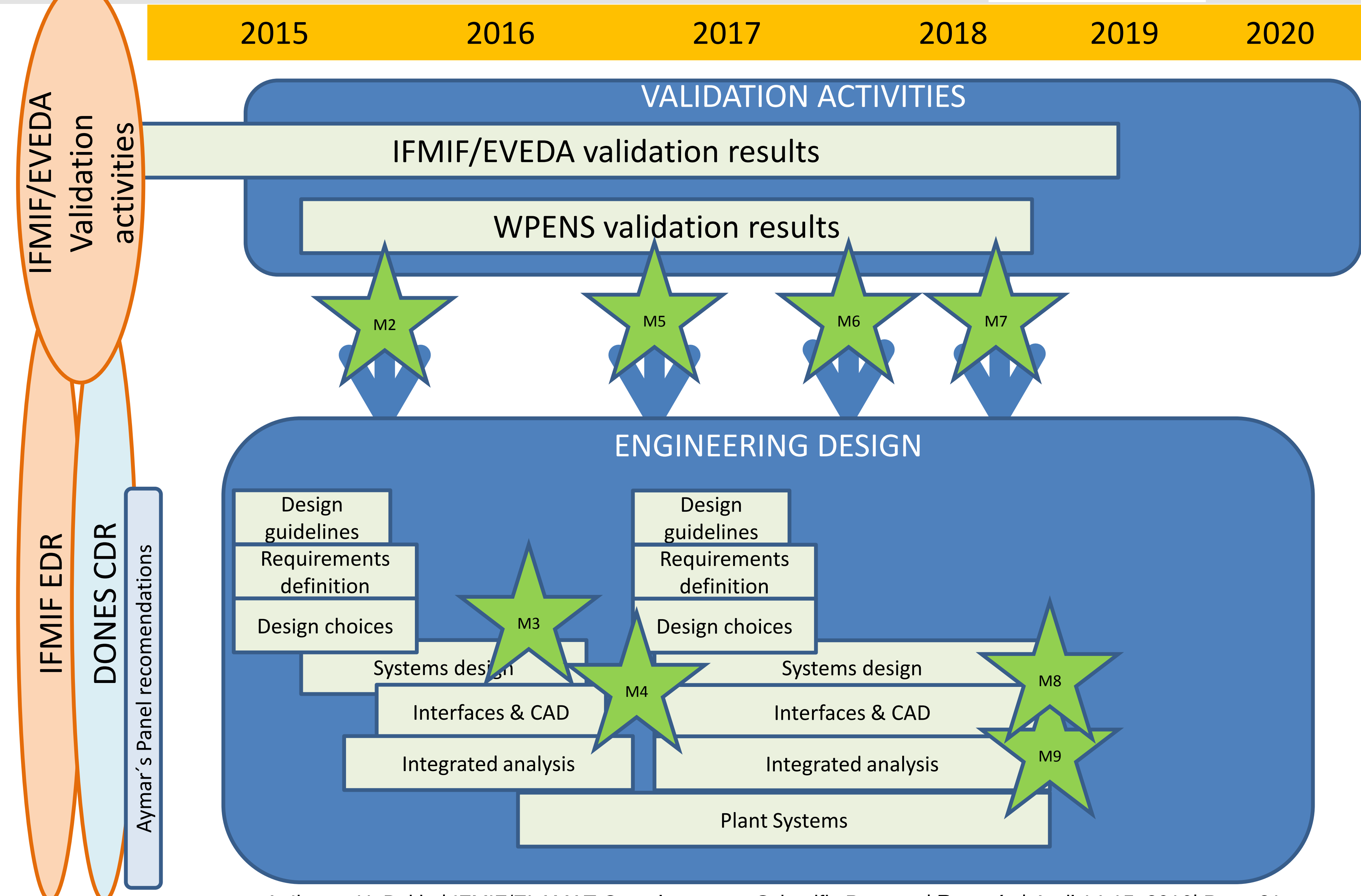


"feasible" time schedule based on the assumption that engineering design activities are developed continuously in the near future and <u>manufacturing activities will start only after the end of IFMIF/EVEDA project</u> AND on **F4E budget availability assumptions**

Time to be ready for operation: 10-12 years

<u>**Site decision to be taken in 2016-17** (F4E already asked to EU countries for proposals; EU-JA scope discussions are going-on)</u>

General design approach



Outline

- Fusion materials irradiation and DEMO
- IFMIF and IFMIF/EVEDA
- IFMIF-DONES
- Objetives of the meeting

Objectives of the meeting

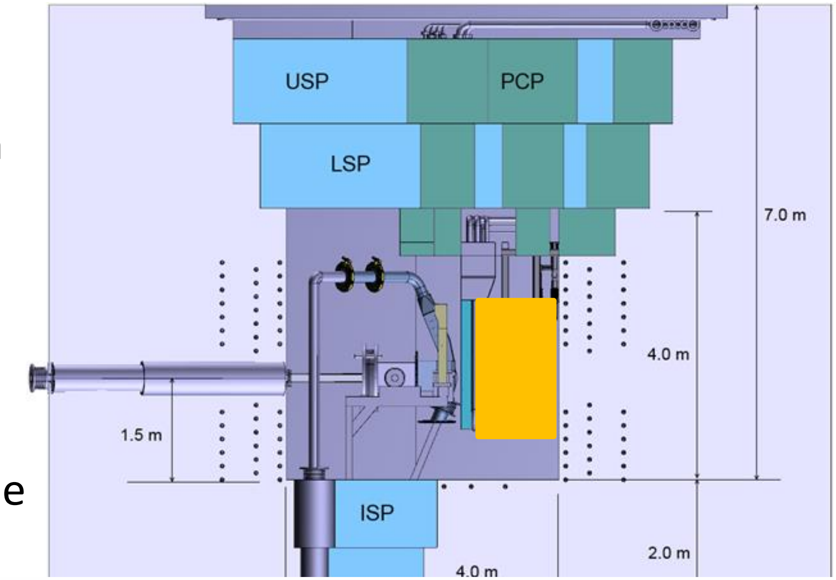
To answer the question:

- **Can IFMIF-DONES be used for other science and/or technology applications?**

- **If so, develop science case and main requirements**

(preliminary decision on additional objectives to be included in IFMIF-DONES engineering design will be taken by the ENS PL mid-2016)

Boundary conditions for new applications



<u>Main IFMIF-DONES mission</u>: irradiation of fusion materials

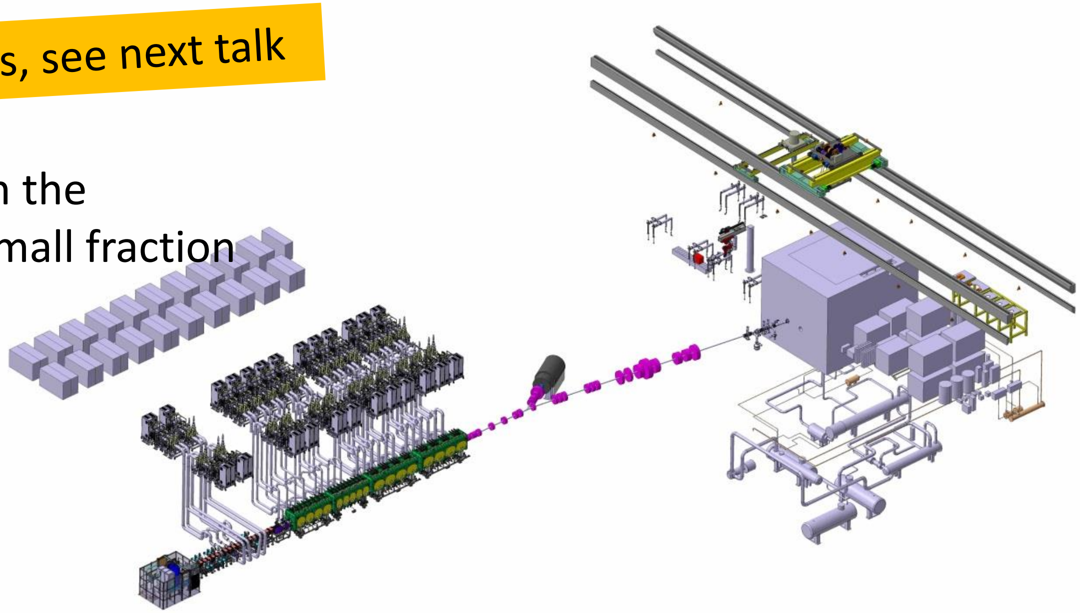
They requires several years of continous irradiation.

So, complementary applications can use:

1) Neutrons available behind Irradiation Module either inside Test Cell or in a new additional Experimental Hall

For details on neutronics, see next talk

2) Deuterons can be extracted from the accelerator beam but in a very small fraction (a few percent)



End