The role and activities of IFERC in the Broader Approach Agreement

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The Broader Approach Agreement: background

2004: the long ITER Negotiations are blocked by two site proposals

Cadarache **versus** **Rokkasho**

EU, China, Russia

Japan, Korea, US

(India had not joined the ITER negotiations)

To unblock the deal, EU and JA negotiate a "host / non-host" agreement, where the non-host of the ITER site can chose projects on its territory that contribute to the development of fusion energy (⇒…Broader Approach to Fusion Energy…), and receives certain concessions in ITER.

In 2005 an agreement is reached.

IFERC

The Broader Approach Agreement: background

The BA agreement is signed in 2007 between Euratom and JA

- An equal contribution of 338 M€ per party over 10 years
- In Europe, France, Italy, Spain, Germany, Switzerland and Belgium make a voluntary contribution (90% of the total value).
- F4E is the Implementing Agency for Euratom.

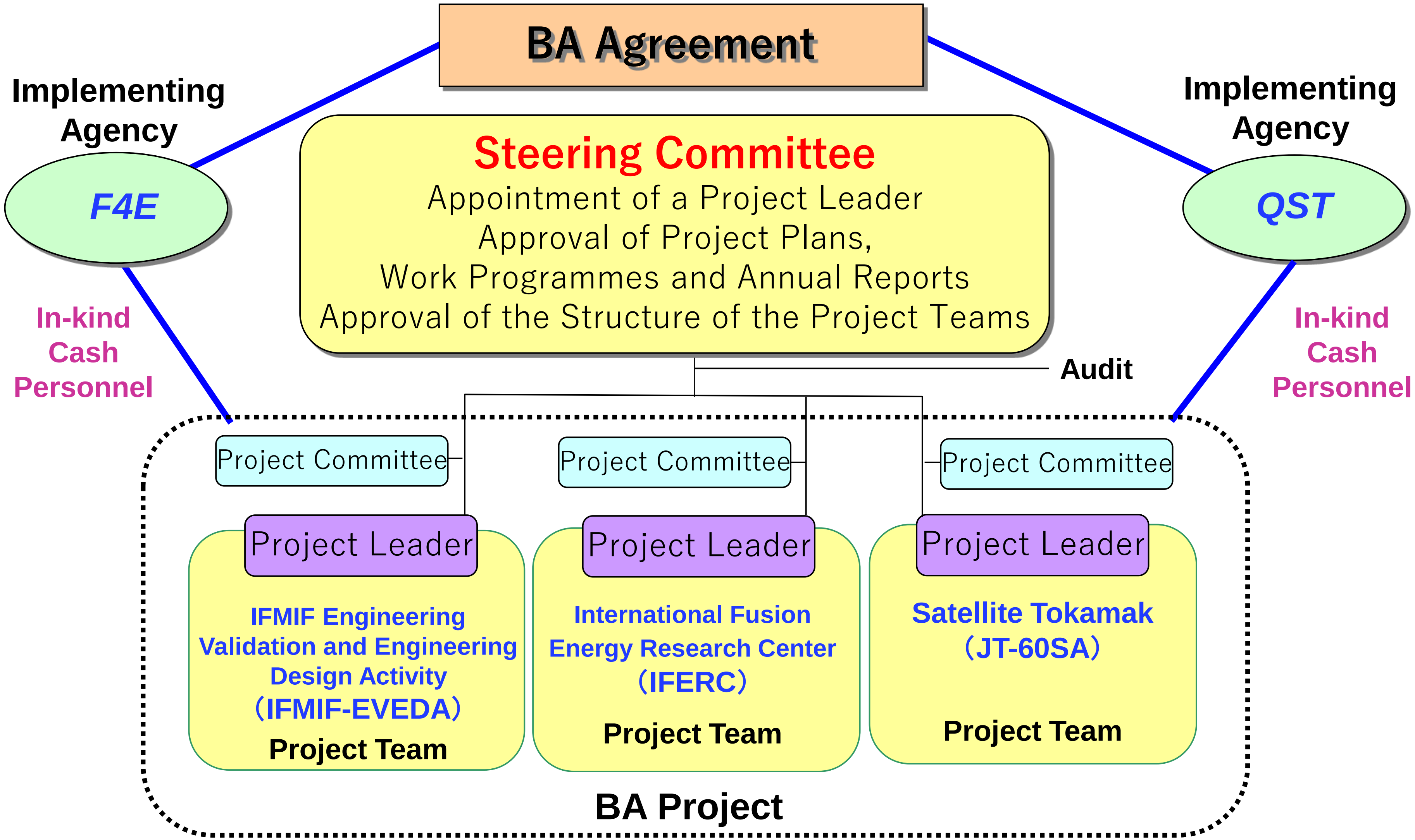
The 3 Projects chosen by Japan:

1) **Upgrade of the tokamak JT60U in Naka → JT60-SA**

2) **IFMIF-EVEDA: design and prototype construction and testing for a future material irradiation facility: to be sited in Rokkasho, ex ITER site. This project was much supported by EU**

3) **And a series of smaller projects, generically called IFERC, which had to**
   - **Fulfill the expectations of the local politicians to have something visible related to ITER in the area ⇒ … REC or the ITER Remote Experimentation Centre**
   - **Be consistent with the two sides roadmaps to fusion energy ⇒…DEMO Design, and research in DEMO relevant materials**
   - **Cover some obvious needs of the two fusion communities ⇒… A good supercomputer!**

The Broader Approach Agreement governance



The first years of IFERC: construction of a research centre

Administration building

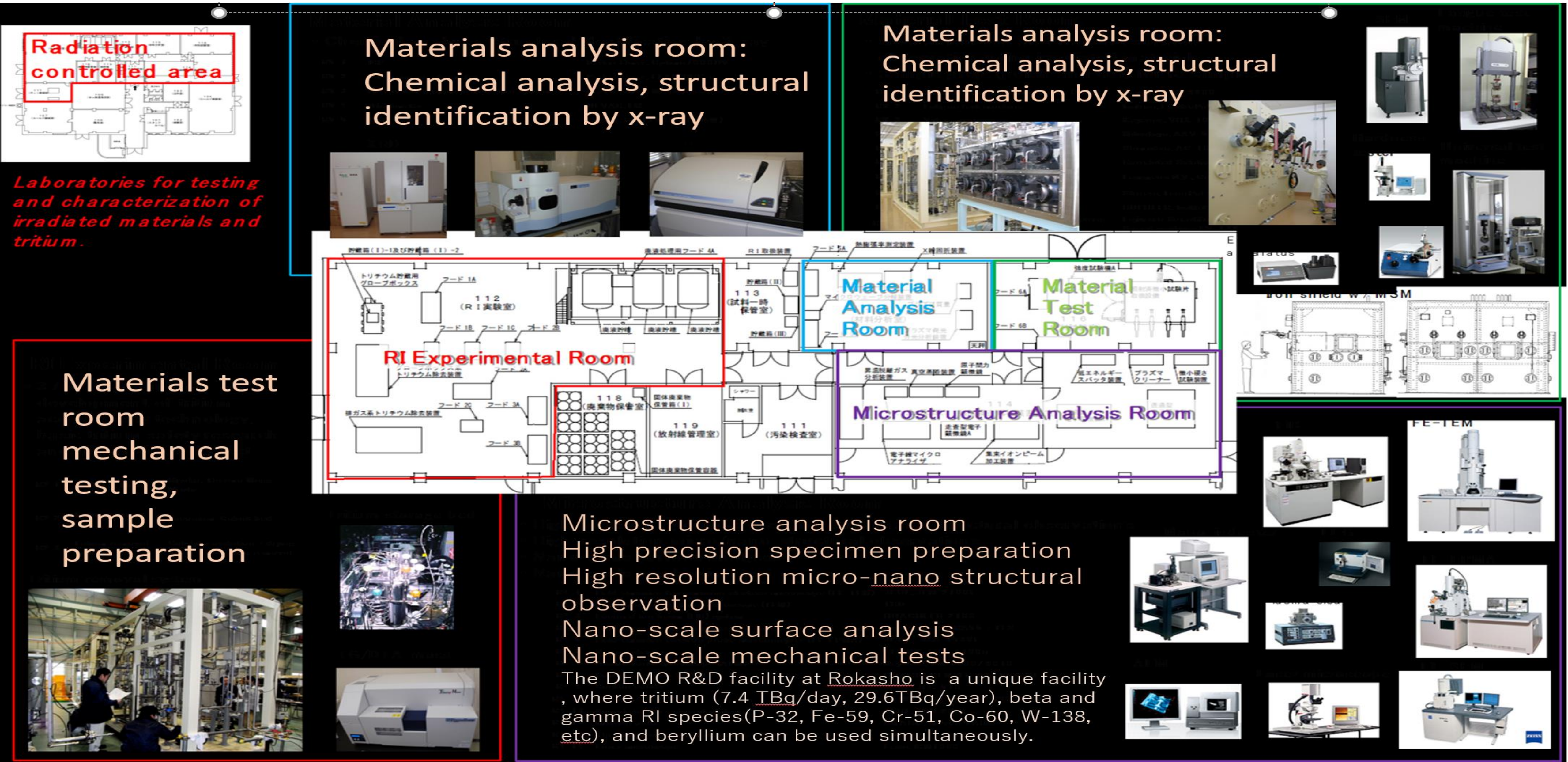
Computational Simulation Centre (CSC) building

ITER Remote Experimentation Centre (REC) building

Services: cooling plant for CSC

IFERC

Construction of a materials characterization laboratory



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Computational Simulation Centre (CSC)

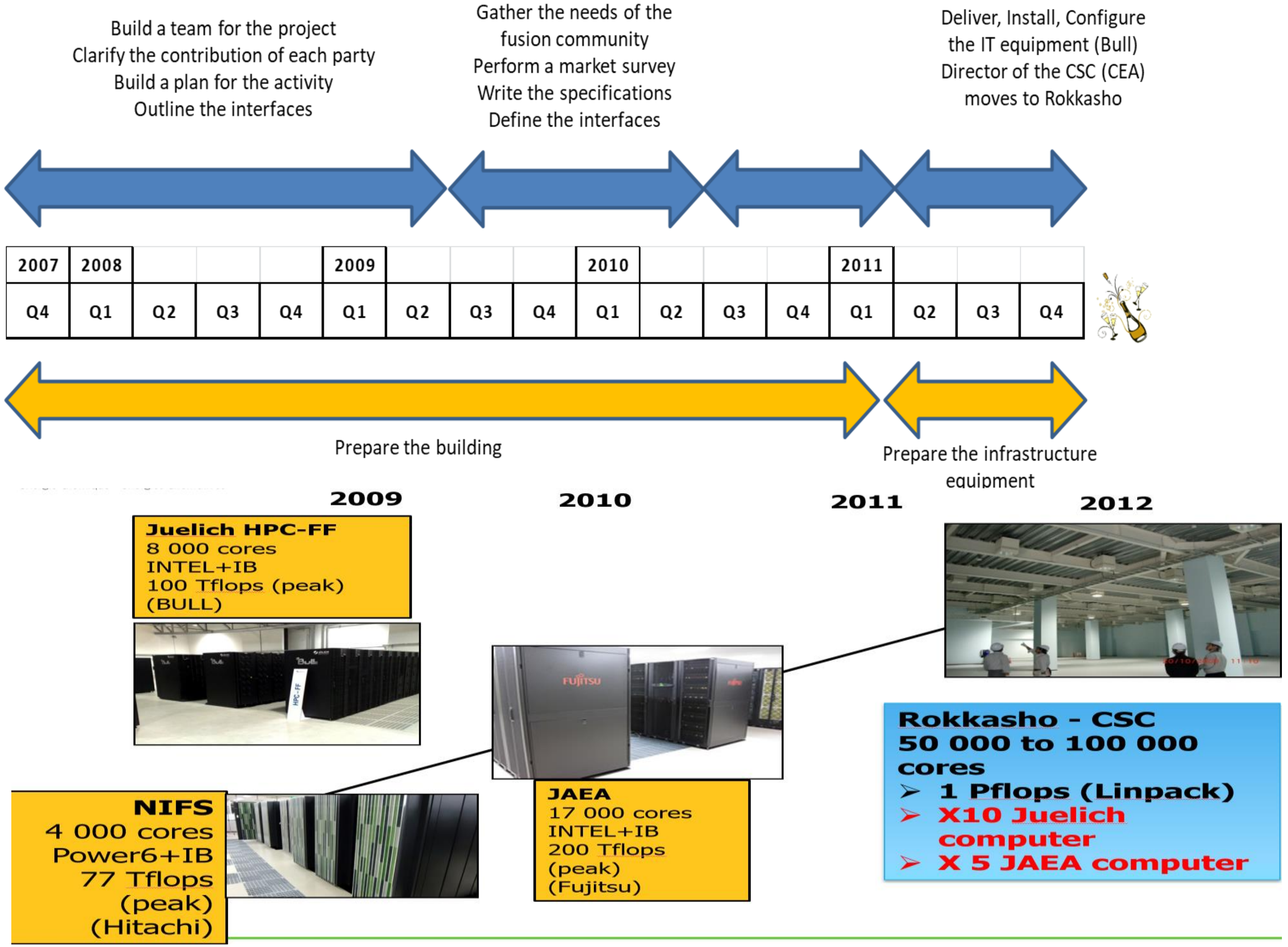
CSC in BA phase I: HPC Helios procurement

The Computer Simulation Centre CSC was defined in the "Broader Approach" Agreement : to set-up and operate a new high end international supercomputer center for conducting simulations in the field of fusion

Performance: HPC with more than 1 Petaflop/s (LP) – optimized for the needs of the fusion codes

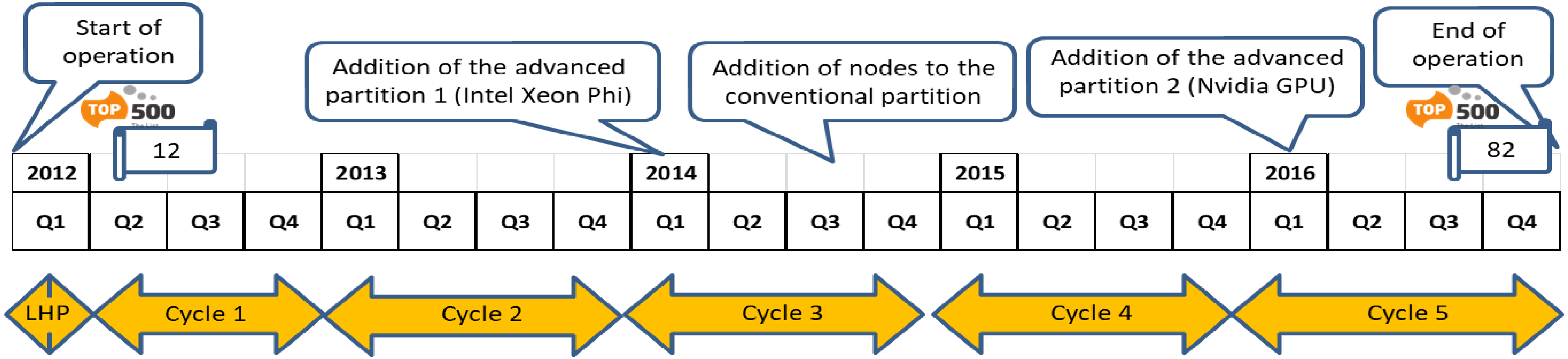
Operation: January 2012 to December 2016

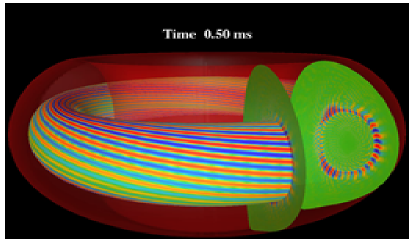
Contribution of Europe: supply of a supercomputer (+ operation and maintenance) as part of France voluntary contribution to BA



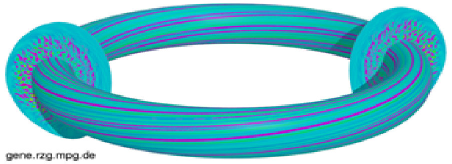
The HPC planned for IFERC was multiplying the resouces available to fusion scientists by a factor of 5 (JA) and 10 (Europe)

CSC in BA phase I: HPC Helios exploitation

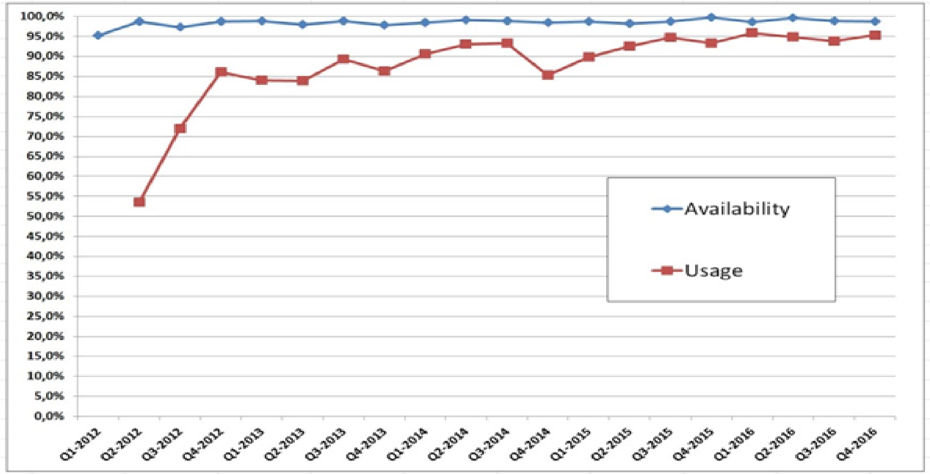




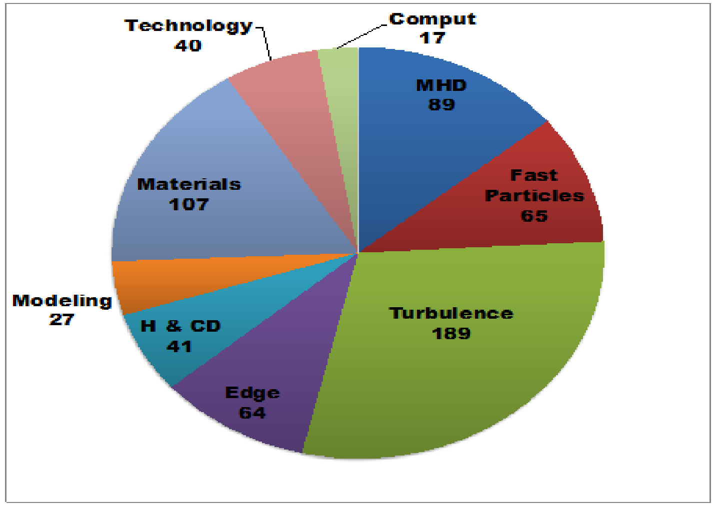
MEGA / Y. Todo



Gene / F. Jenko

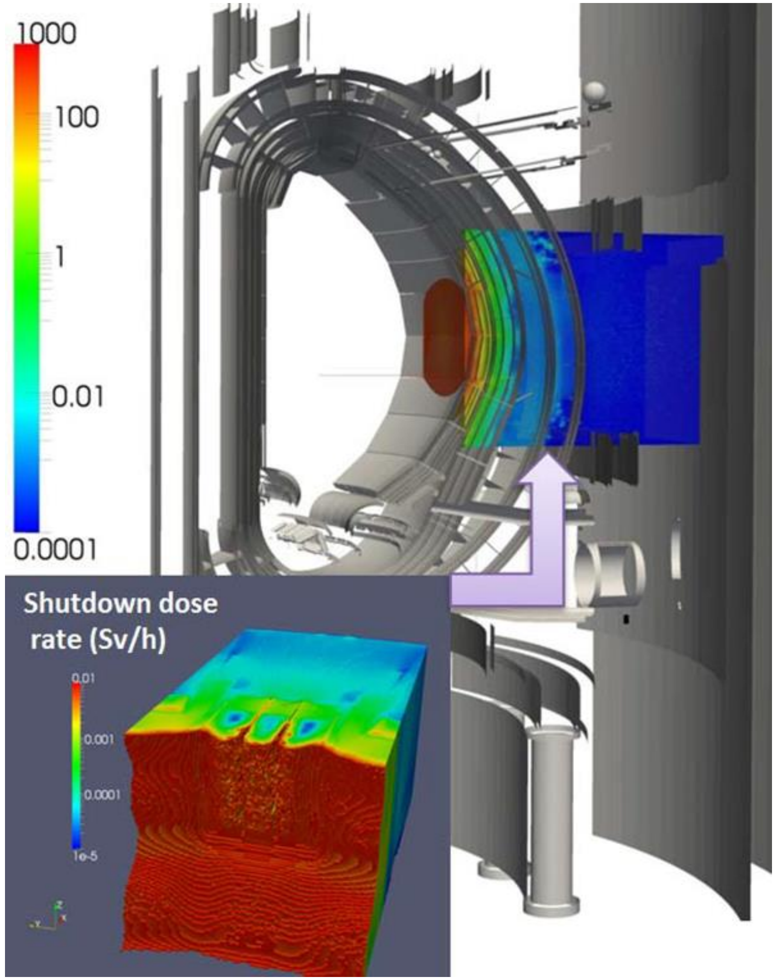


Availability and usage of the conventional partition

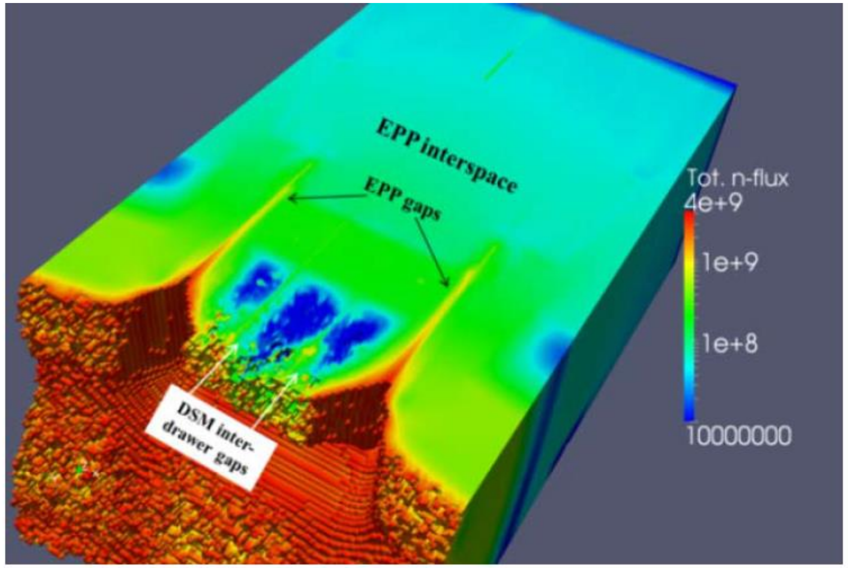


Cumulated number of peer-reviewed papers in 9 categories

CSC in BA phase I: HPC Helios exploitation (2)



- In addition to the large number of physics papers in support of ITER, Helios was also used in support of ITER construction : example, neutronics calculations for shield modules



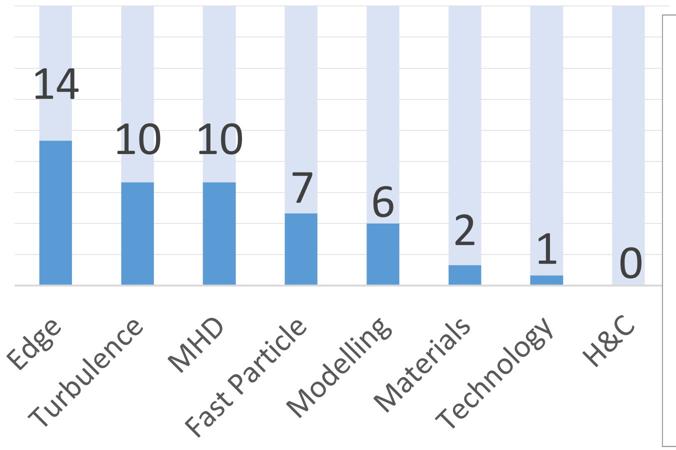
Neutron flux 3D-map at Diagnostic Shield Module (DSM) in ITER Equatorial Port [MCHIFI, Dieter Leichtle]

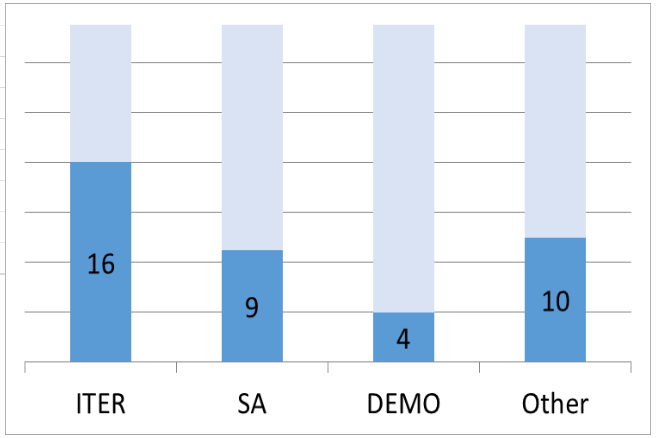
BA phase II: CSC today

- CSC manages the JFRS-1 (JA) and Marconi (EU) resources allocated to BA,
- Supports high priority Projects: ITER, JT-60SA, DEMO
- Conducts analysis : 27 projects conducted on JFRS-1 for the current analysed, and results used for the preparation of the next cycle
- Shares experience and best practices in the design and operation of HPC centres for fusion users
- Plans for the future HPCs: porting of codes to accelerated HPC partitions

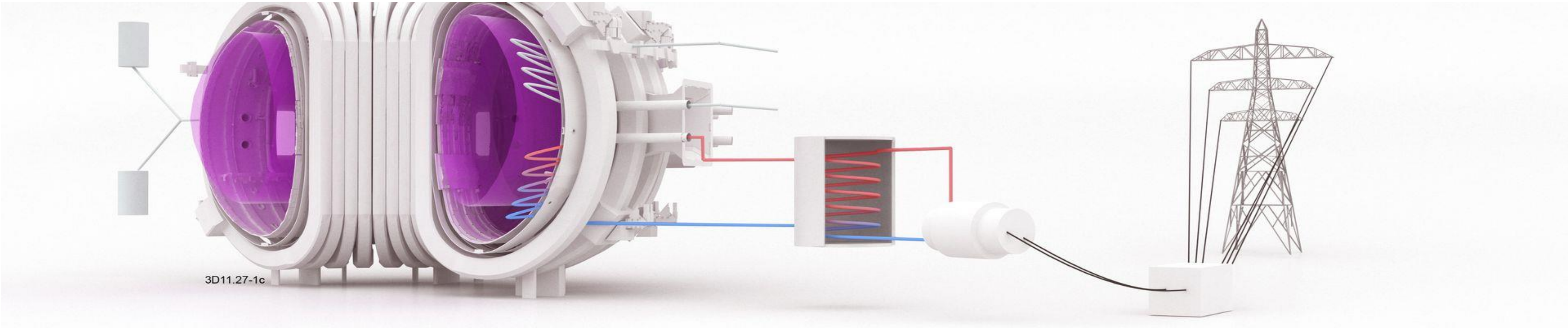
Source of computer time	Amount of computer time	Projects	Period of time
EU and JA voluntary contribution IFERC-CSCPA01-JA.EU	916 k-node-hours M/SKL 412 k-node-hours M/KNL 858 k-node-hours JFRS-1	5 EU-JA projects	April 2019 – March 2020 (extended to Sept. 2020)
JA host contribution BA phase II (for FY 2020)	4350 k-node-hours JFRS-1	20 EU projects	April 2020 – March 2021
JA host contribution BA phase II (for FY 2020)	4419 k-node-hours JFRS-1	7 JA projects	April 2020 – March 2021
EU voluntary contribution IFERC2-CSCPA01-JA.EU (for FY 2020)	47 k-node-hours M100	7 JA projects	Sept. 2020 – March 2021
JA host contribution BA phase II (for FY 2020)	9000 k-node-hours JFRS-1	To be selected	April 2021 – March 2022
EU voluntary contribution IFERC2-CSCPA01-JA.EU (for FY 2021)	105 k-node-hours M100	To be selected	April 2021 – March 2022

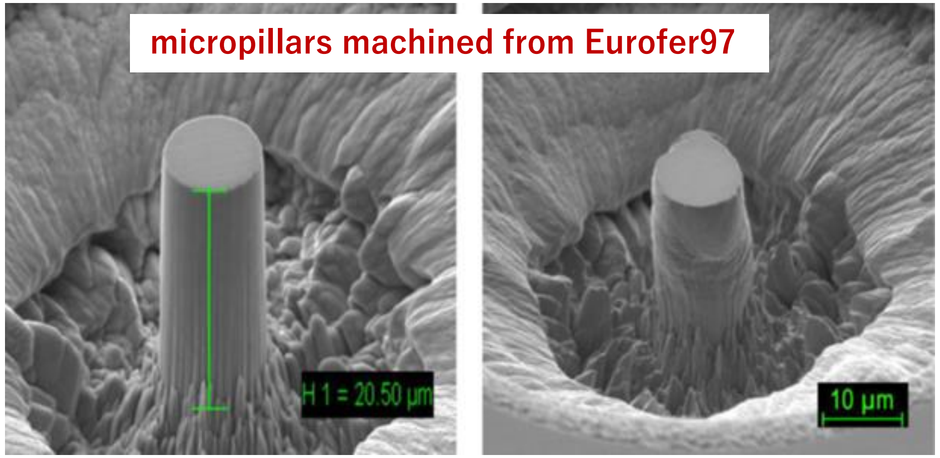
Note: M/SKL means Marconi SKL nodes (conventional), M/KNL means Marconi KNL nodes (many-core accelerated), M100 means Marconi100 nodes (GPU accelerated)

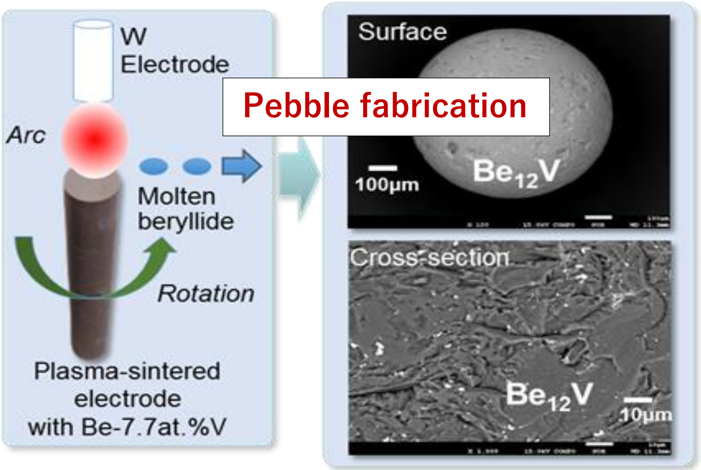




DEMO : DEMO Design Activities and R&D

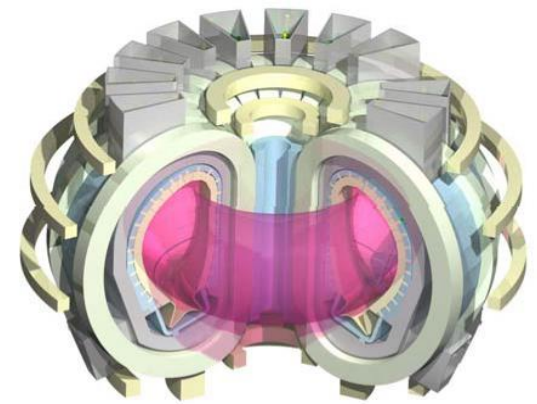




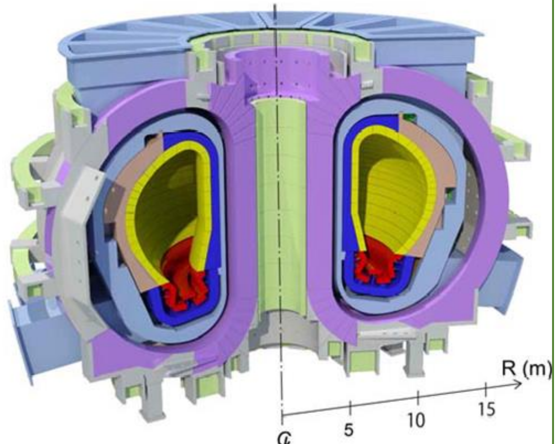


DEMO Design Activities: BA Phase I achievements

Convergence of designs



JA, 2014



JA, 2017

Pre-conceptual design

- Initially, each side pursued its own DEMO programme and shared results, but a convergence of designs has evolved

EU: DEMO1 (pulsed) – R_p = 9.1 m, B_{max} = 12.3 T, κ_{95} = 1.6 and P_{net} ~ 0.5 GW (P_{fus} = 2 GW)

JA: DEMO-2014 (SS) – R_p = 8.5 m, B_{max} = 12.1 T, κ_{95} = 1.65-1.7 and P_{net} ~ 0.2-0.3 GW (P_{fus} ~ 1.5 GW)

Critical design issues

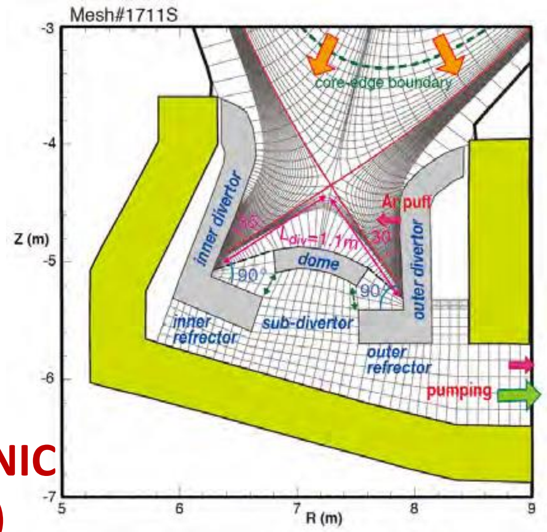
- Large technology gaps between ITER and DEMO identified: divertor heat exhaust, remote maintenance, in-vessel components (blanket and divertor, including **materials**' issues).

Joint work

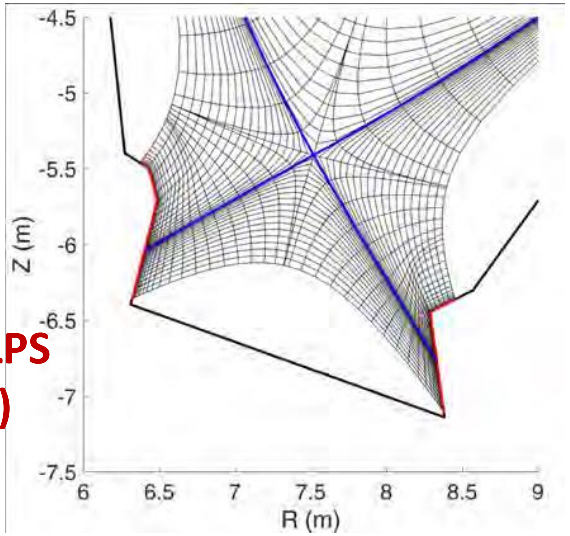
Proposals of EU-JA joint work for the DDA final report were agreed and started:

- (1) Divertor model in system code (PROCESS),
- (2) DEMO physics: ELM mitigation strategy
- (3) SONIC and SOLPS simulations for EU divertor level (Psep~150MW),
- (4) Study on shielding and water activation for Breeding Blanket design,
- (5) SC magnet design,
- (6) BoP: Tritium permeation.

Benchmarking design tools



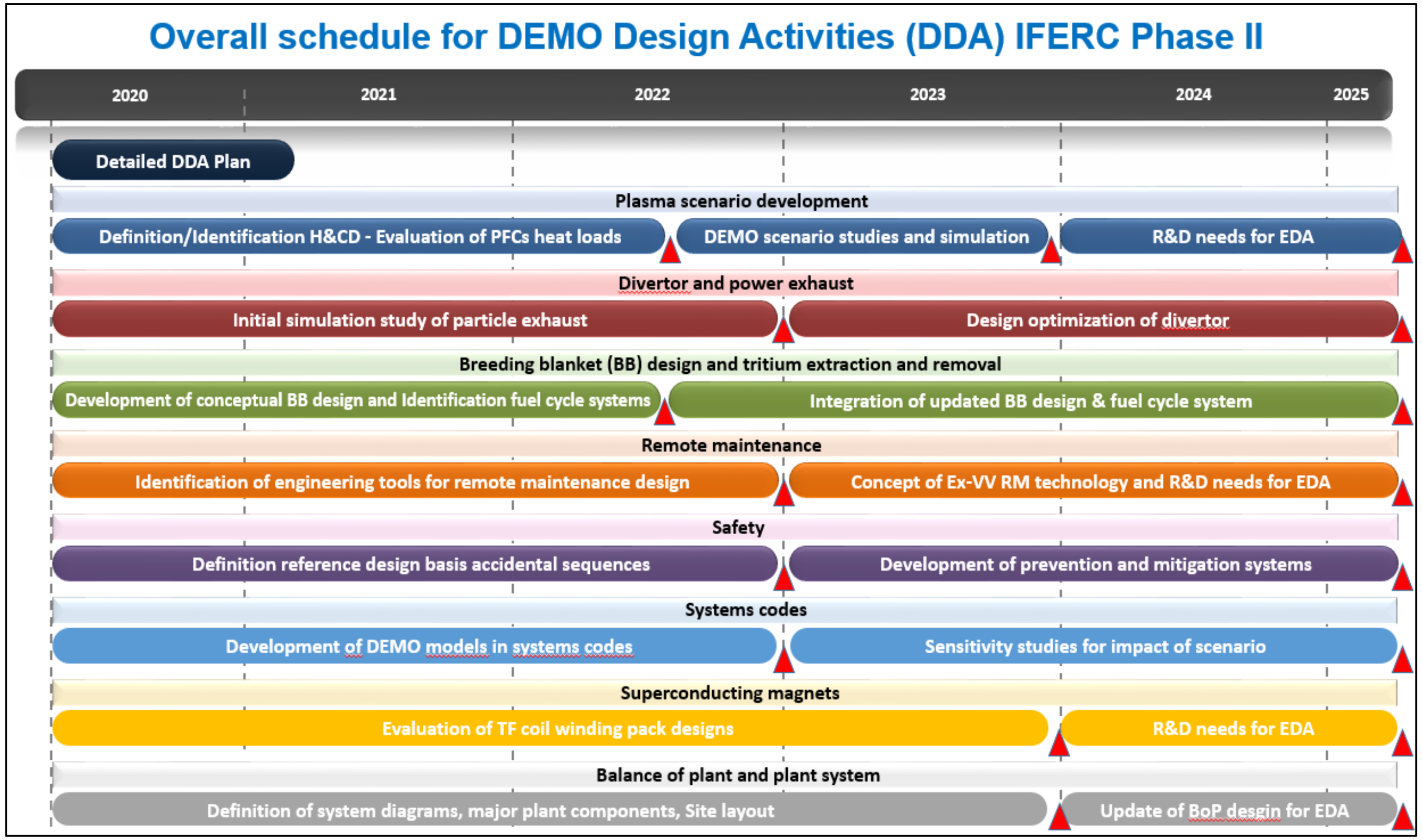
SONIC (JA)



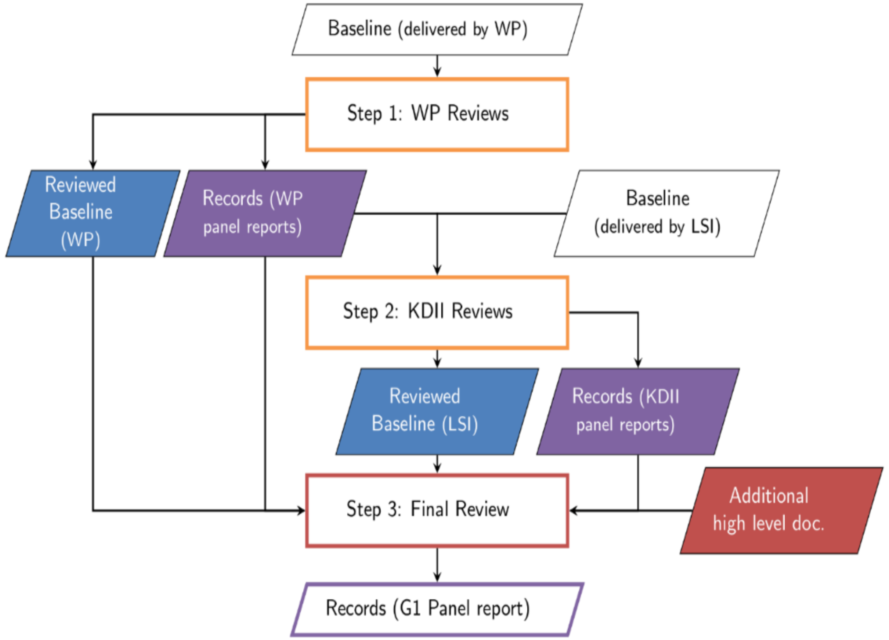
SOLPS (EU)

DEMO Design activities in Phase II

In Phase II, 8 priority areas identified for joint work



In addition, the two sides agree to share experience of major reviews to go from pre-conceptual phase to conceptual phase: Gate Review results in EU (2020)



DEMO R&D: Research in Blanket Materials in BA Phase I

Based on the common interests of EU and JA, **5 generic DEMO R&D tasks for blanket** were defined at the beginning of the BA:

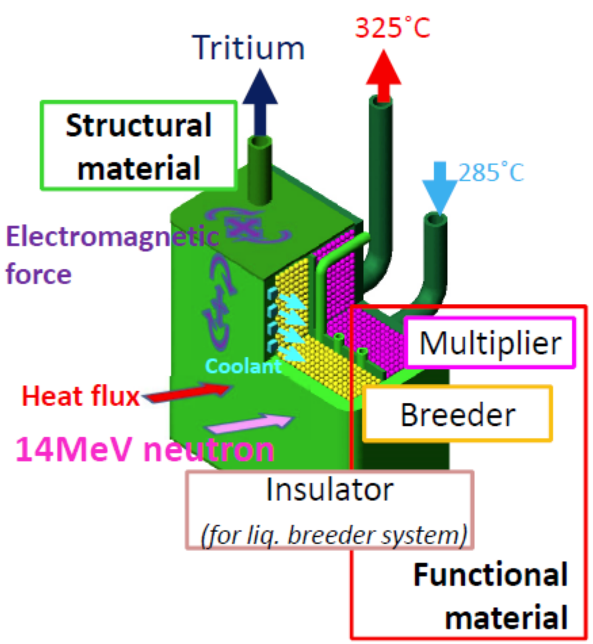
T1) SiC/SiC Composites

T2) Tritium Technology

T3) Materials Engineering

T4) Advanced Neutron Multiplier
T5) Advanced Tritium Breeders.

Requirement for the blanket system



- Required function
  - Shield the high energy fusion neutron
  - Breed Tritium (TBR > 1.05)
  - Convert neutron energy into heat
- Expected performance
  - Assure safety and reliability throughout the assumed service period under the assumed operation mode.
  - Reduce radioactive level which is consistent with waste management and recycle strategy.
  - Ensure maintenance and inspection service are feasible.

★ **Material development for blanket system is expected to provide sound engineering bases for**
- ✓ ***Safety, reliability and realizability of blanket designs***
- ✓ ***waste management, recycle, maintenance and inspection scenarios***

DEMO R&D: Research in Blanket Materials in BA Phase II

In BA Phase II: The emphasis is in creating a repository of knowledge for future reactor construction: engineering databases, handbooks, lessons learned form ITER construction, etc.

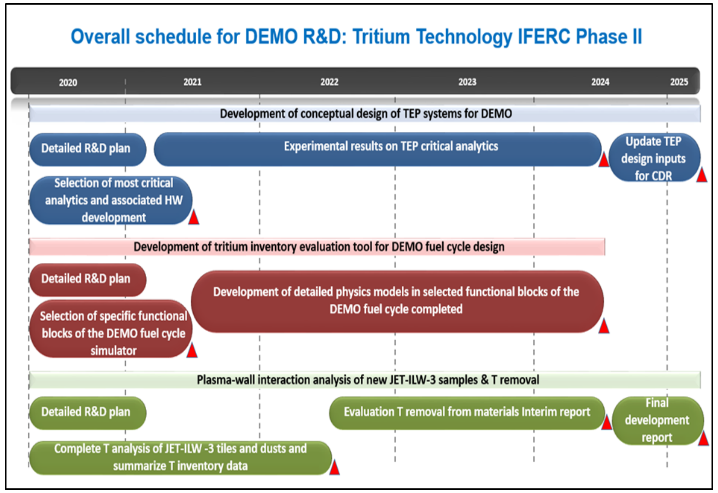
- ***To contribute to DEMO Design in the following 4 areas:***

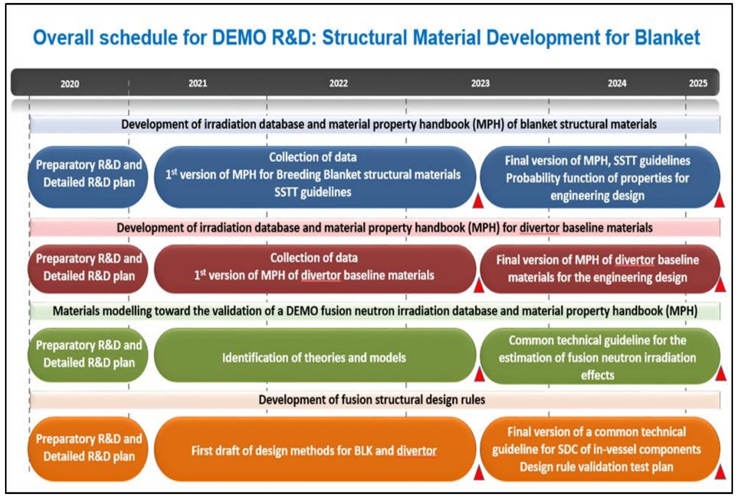
1) **Tritium technology** related to continuous recovery and inventory evaluation of bred tritium

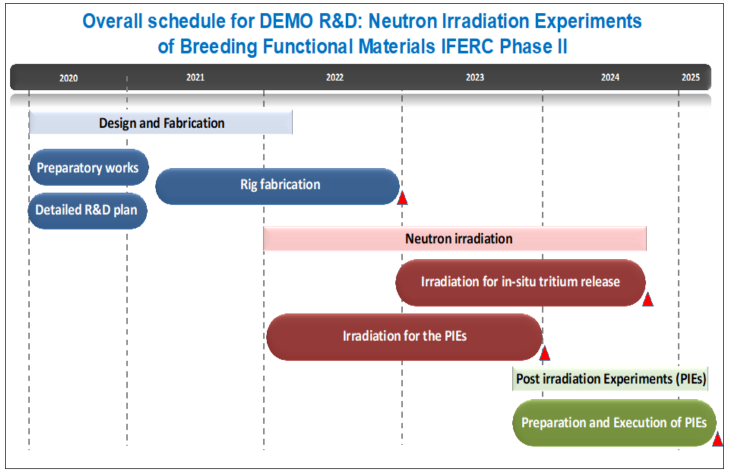
2) Development of **structural materials** for fusion DEMO in-vessel components including compilation of Material Properties Handbook

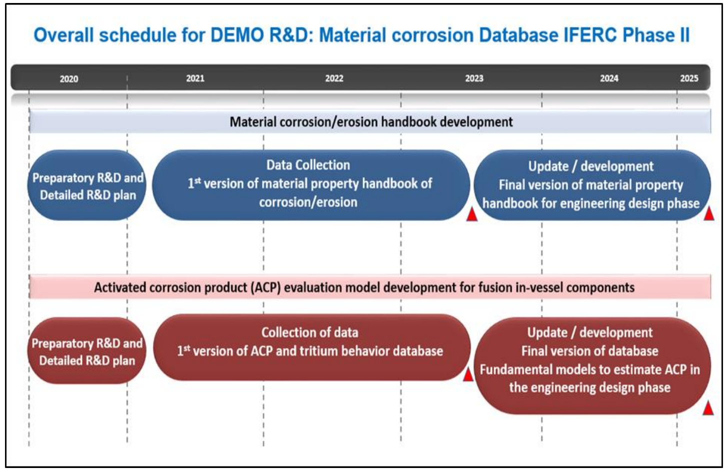
3) **Neutron irradiation** experiments of **breeding functional materials**

4) Development of **material corrosion database**

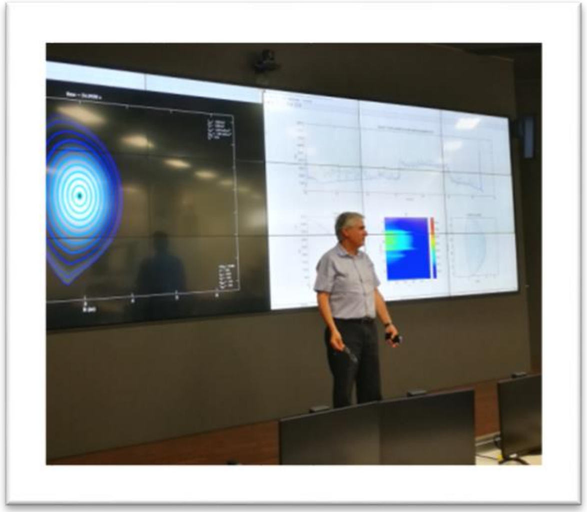








(ITER) REC: Remote Experimentation Centre



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(ITER) REC: Remote Experimentation Centre

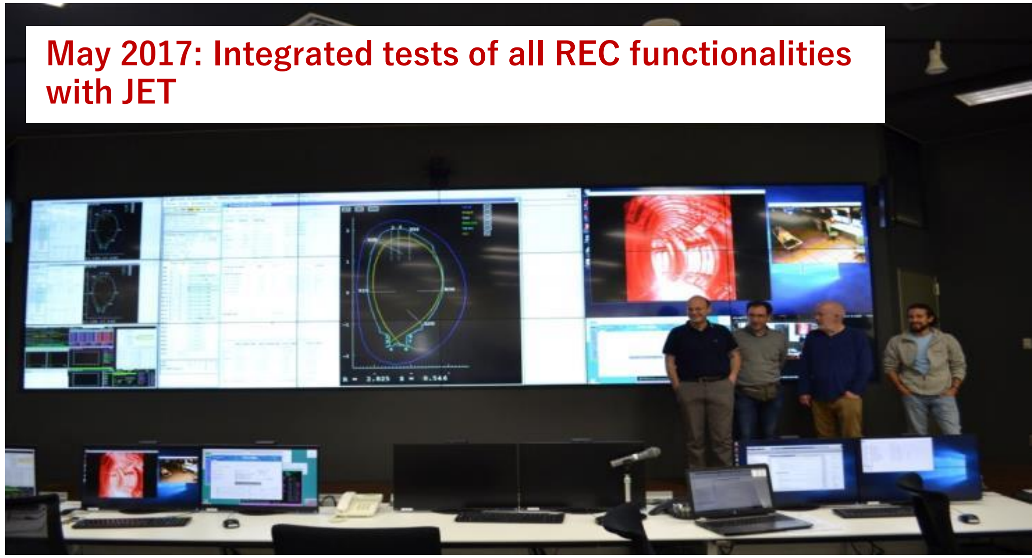
BA Phase I

Remote Experimentation Control room built,

1) EU made a contribution to the equipment in the control room: plasma wall, servers
2) Software: adapted for data access: RES (JA), EDAS
3) Customisation of control oriented simulation codes: eTOS (JA), CREATE 2D, METIS, …
4) Tests: synchronous replication of LHD data, transmission tests with IO and JET, remote data access with RFX (MDSplus), transfer of data using CSC tape library, ….
5) **Two major integrated tests**

BA Phase II

- To prepare the remote participation for ITER via collaboration with IO (CODAC)
- To collaborate with IFMIF-EVEDA (remote control room) and JT60-SA**: this has become particularly urgent because of COVID and the need for remote commissionning.**
- To investigate and develop REC-related issues: fast data transfer, data storage and analyses of large scale data.


May 2017: Integrated tests of all REC functionalities with JET


November 2018: Remote experimentation operation session with WEST, France

Conclusions

- IFERC Project progressing according to plan
- Strong emphasis given to all support activities for the ITER Project, and the other BA Projects
- Collaboration with ITER will now start: support to ITER, and lessons learned from ITER construction
- CSC: continues to promote simulation activities and good practice
- DDA: Results of the JA and EU current programmes and reviews will be shared, and joint work is now planned progressing to a conceptual design phase
- DEMO R&D: emphasizes the creation of tools for future reactor construction such as handbooks, design rules, engineering databases in fusion materials
- REC will develop and test remote participation tools in collaborations: with IO in the final stages of definition, with IFMIF/EVEDA already under implementation, and with STP just started

THANK YOU FOR YOUR ATTENTION !