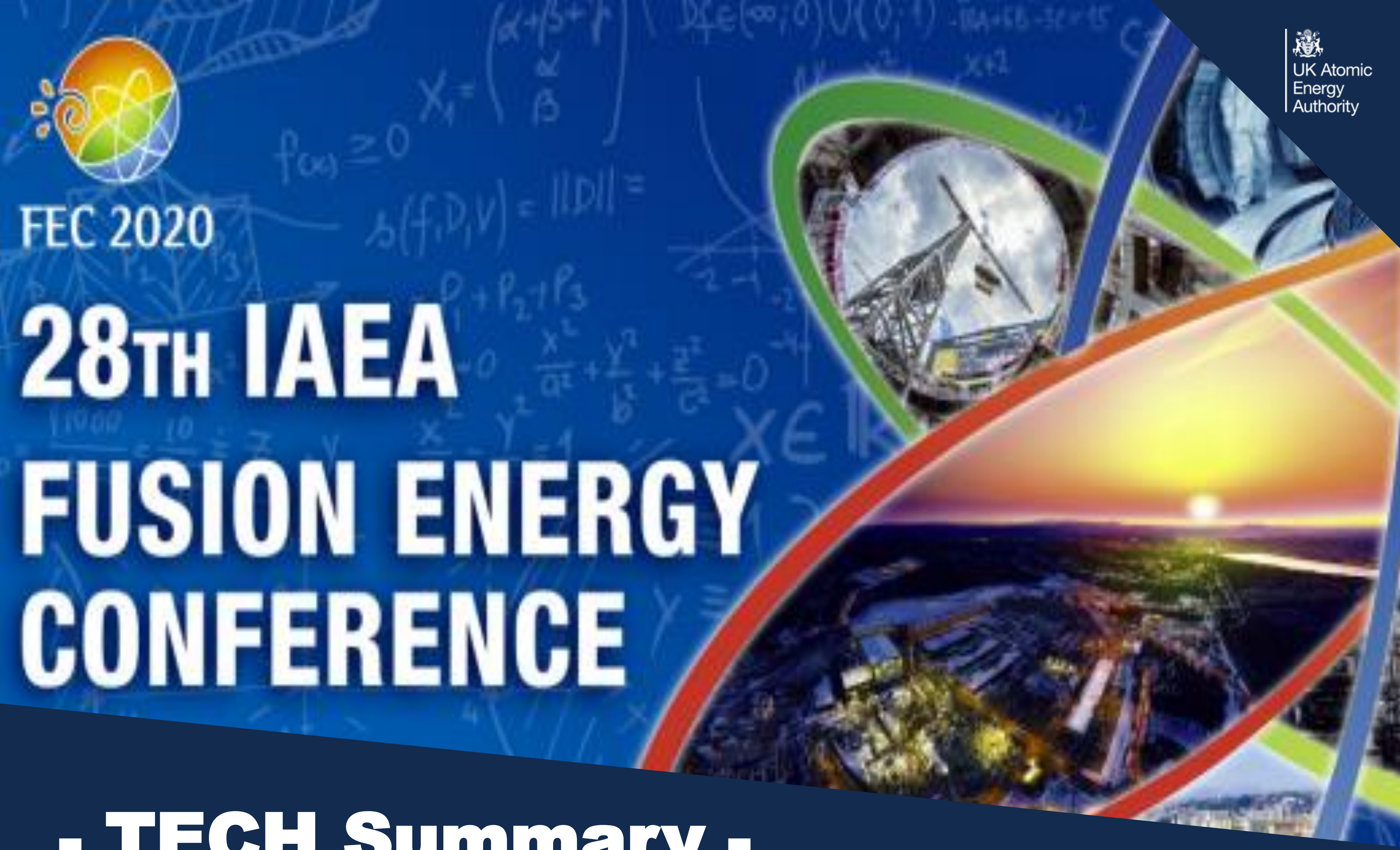
UK Atomic
Energy
Authority



FEC 2020

28TH IAEA FUSION ENERGY CONFERENCE

- TECH Summary -

Dr M. Gorley, Chief Technologist, UKAEA.

TECH area oral summary

UK Atomic
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ITER 9 Talks

- Completion of component constrictions: field coils, heating and current dive systems.
- Plasma control and protection
- Test Blanket Models.

DEMO & Advance Technology 7 Talks

- Overview of DEMO progress (J-DEMO)
- Remote handling
- Systems codes and conceptual designs
- Superconducting advancements

Divertor and Heating 10 Talks

- Fantastic EU, Japan divertor overview
- Divertor component representative testing
- New manufacturing methods
- Advanced Heating and current drive tests

Materials and material systems 6 Talks

- IFMIF/EVEDA
- Neutron irradiation test results (Steels)
- Handbooks, strategy
- Plasma materials interactions
- Multi-physics modelling

Related OV talks:

Bernard Bigot, Preparation for Assembly and Commissioning of ITER.
Yutaka Kamada, Completion of JT-60SA Construction and Contribution to ITER.
Jerome Bucalossi, Operating a full tungsten actively cooled tokamak: overview of WEST first phase of operation

Overview – TECH Summary

UK Atomic Energy Authority

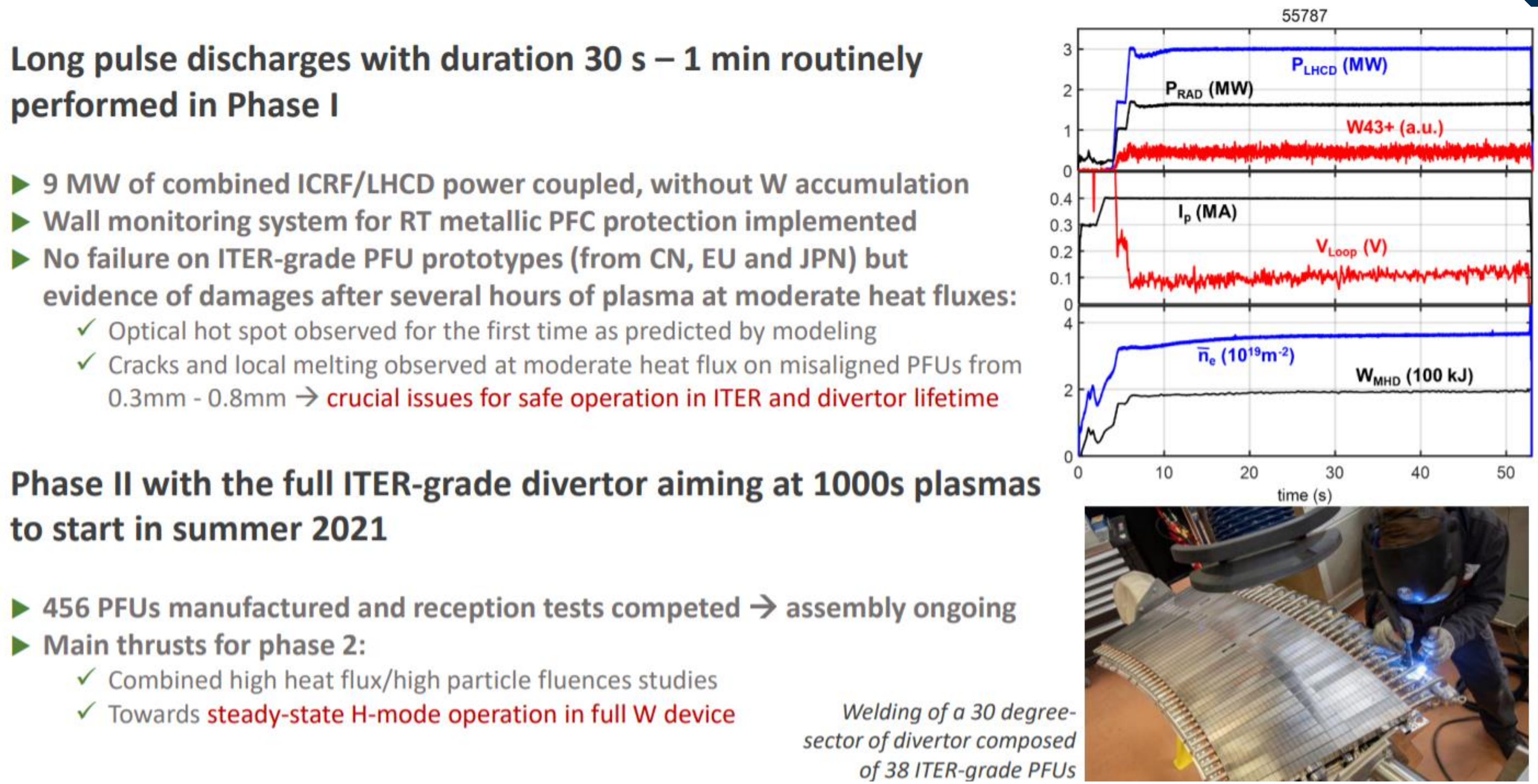
OV. Bernard Bigot

- ❑ITER construction has made enormous progress since IAEA FEC 2018 despite the challenges due to the pandemic and many FoAK.
- ❑Challenges remain ahead to complete assembly, commissioning, demonstrate First Plasma and go on executing the Research Plan

Support of ITER Members fusion communities is essential to success

Overview – TECH Summary

OV. Jerome Bucalossi



Long pulse discharges with duration 30 s – 1 min routinely performed in Phase I

- 9 MW of combined ICRF/LHCD power coupled, without W accumulation
- Wall monitoring system for RT metallic PFC protection implemented
- No failure on ITER-grade PFU prototypes (from CN, EU and JPN) but evidence of damages after several hours of plasma at moderate heat fluxes:
  - ✓ Optical hot spot observed for the first time as predicted by modeling
  - ✓ Cracks and local melting observed at moderate heat flux on misaligned PFUs from 0.3mm - 0.8mm → crucial issues for safe operation in ITER and divertor lifetime

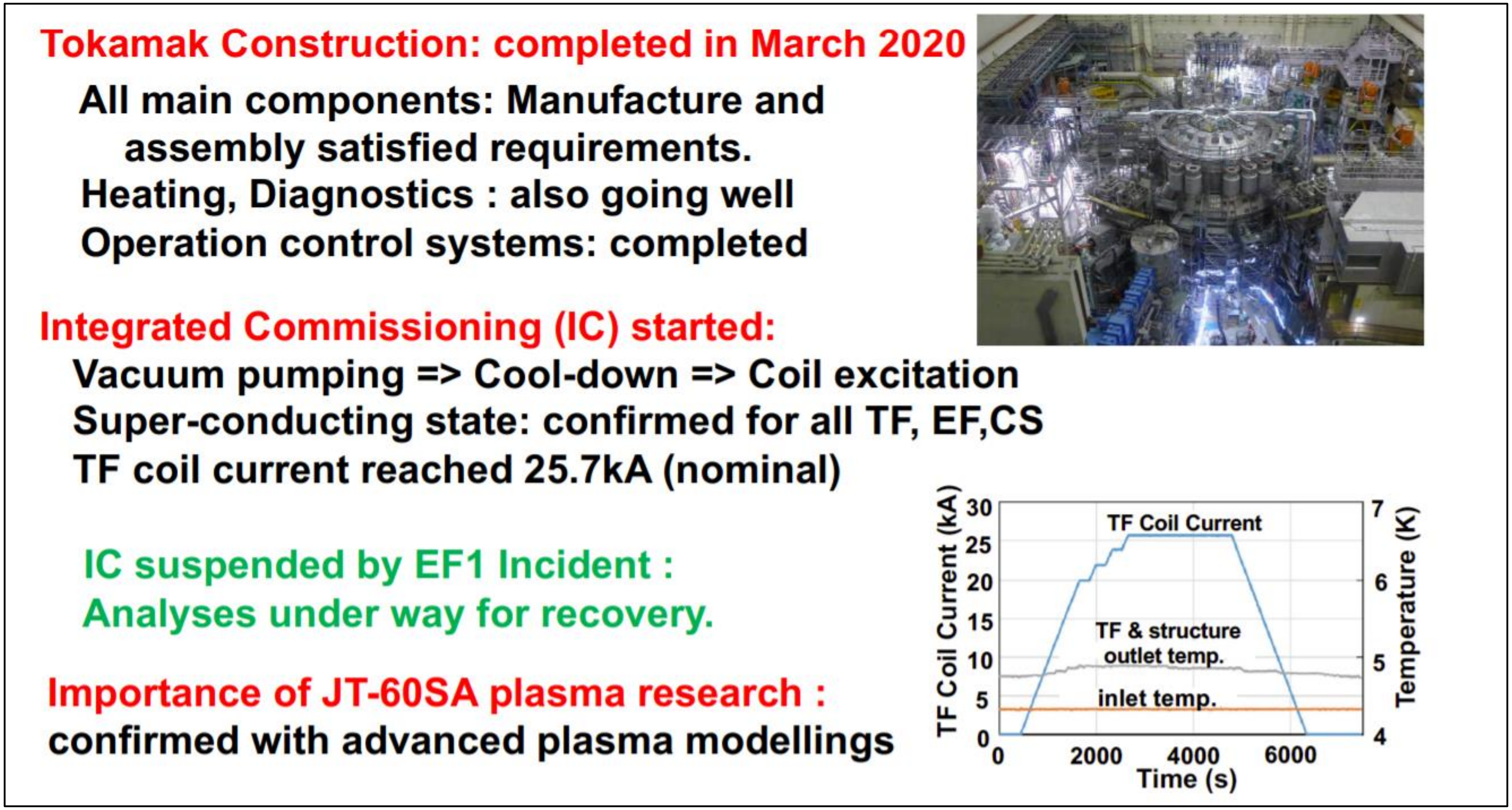
Phase II with the full ITER-grade divertor aiming at 1000s plasmas to start in summer 2021

- 456 PFUs manufactured and reception tests competed → assembly ongoing
- Main thrusts for phase 2:
  - ✓ Combined high heat flux/high particle fluences studies
  - ✓ Towards steady-state H-mode operation in full W device

Welding of a 30 degree-sector of divertor composed of 38 ITER-grade PFUs

Overview – TECH Summary

OV. Yutaka Kamada



Tokamak Construction: completed in March 2020

All main components: Manufacture and assembly satisfied requirements.

Heating, Diagnostics : also going well

Operation control systems: completed

Integrated Commissioning (IC) started:

Vacuum pumping => Cool-down => Coil excitation

Super-conducting state: confirmed for all TF, EF,CS

TF coil current reached 25.7kA (nominal)

IC suspended by EF1 Incident :

Analyses under way for recovery.

Importance of JT-60SA plasma research :

confirmed with advanced plasma modellings

JT-60SA contributes to ITER and enhances international collaborations

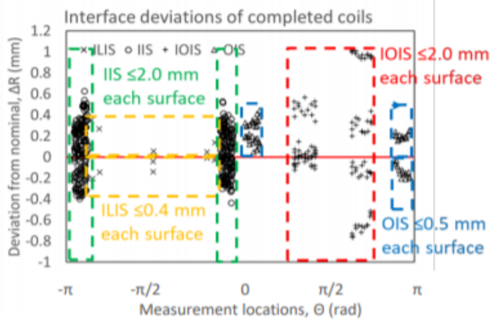
ITER – TECH Summary

TECH-1/1. Mio Nakamoto

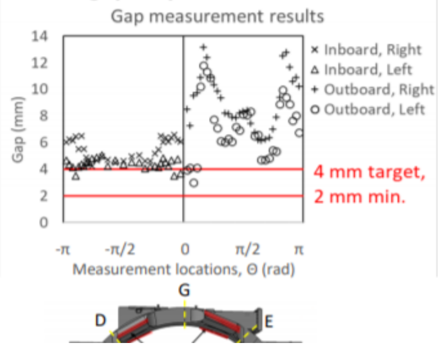
- The first ITER Toroidal Field Coil (TFC) has been successfully completed by Japan Domestic Agency (JADA).
- In the TFC fabrication, there were 3 major requirements and several challenges to achieve those requirements:

Requirements	Challenges
Intercoil interface tolerances	- Welding deformation control
Minimum gap requirement between winding pack (WP) and TFC structure (TFCS)	- High viscosity resin injection into the narrow gap - Maintaining the gap through TFCS welding
Current center line (CCL) positional tolerances	- Precise positioning of WP within TFCS - Maintaining WP shape and positions through fabrication steps

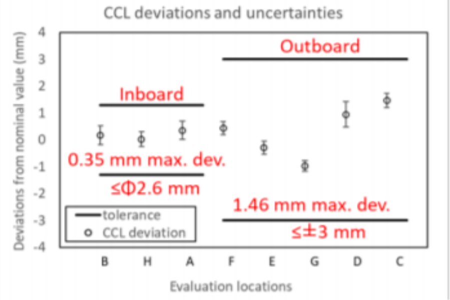
- The details of those challenges and the solutions established during preparation are introduced in the presentation along with the implementation results.
  - **Interface requirement:** satisfied!
    (tolerances are indicated with dot-line boxes.)



  - **Min gap requirement:** satisfied!



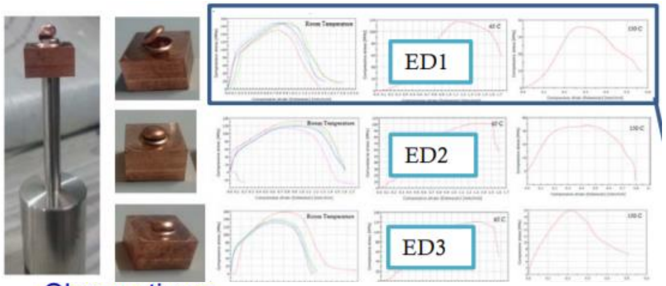
  - **CCL position requirement:** satisfied!
    (uncertainty range is shown with bars.)



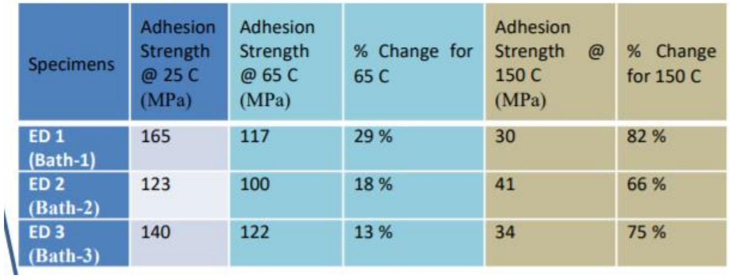
Precision engineering at it's finest. Near current limits? – DEMO beware

ITER – TECH Summary

TECH-1/2. Jaydeepkumar Joshi & Gianluigi Serianni

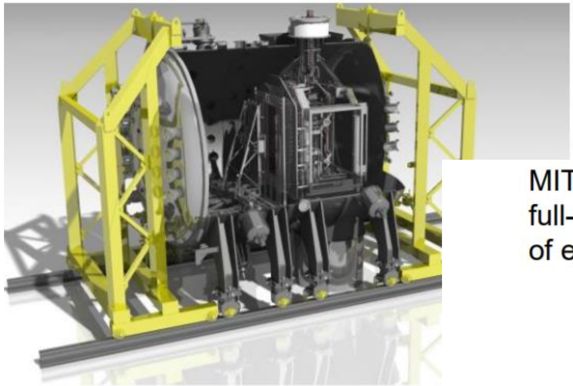


Pusl Observations:

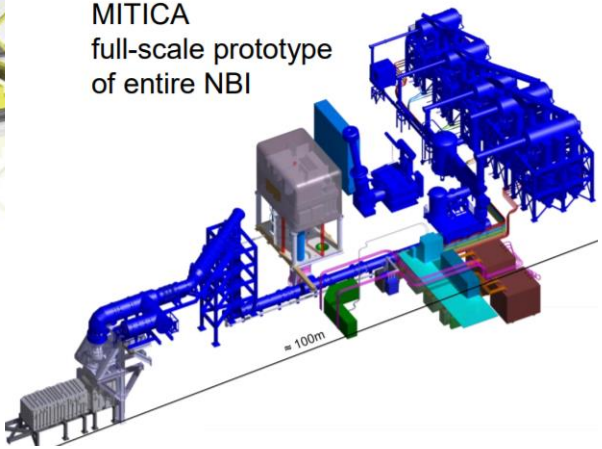


Specimens	Adhesion Strength @ 25 C (MPa)	Adhesion Strength @ 65 C (MPa)	% Change for 65 C	Adhesion Strength @ 150 C (MPa)	% Change for 150 C
ED 1 (Bath-1)	165	117	29 %	30	82 %
ED 2 (Bath-2)	123	100	18 %	41	66 %
ED 3 (Bath-3)	140	122	13 %	34	75 %

SPIDER
full-scale prototype of ion source



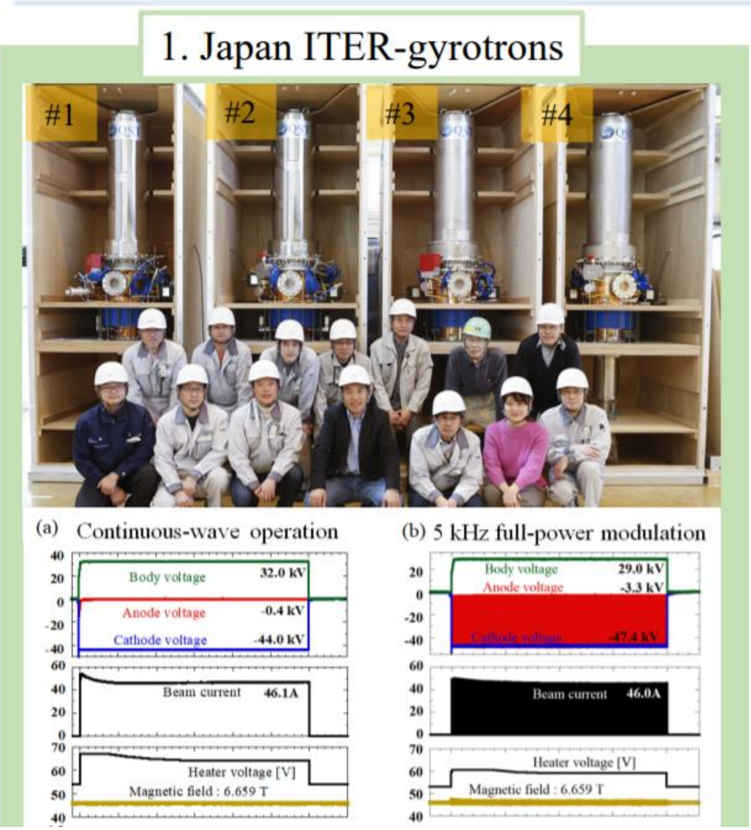
MITICA
full-scale prototype
of entire NBI



ITER is construction and plasma preparations. Yet ITER also advance our TECH knowledge and system for DEMOs.

ITER – TECH Summary

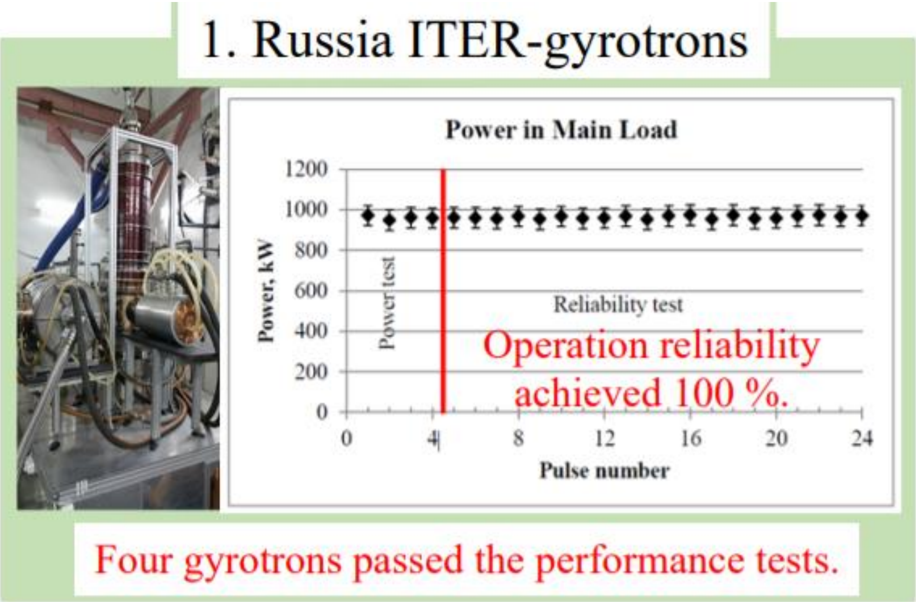
TECH-1/3. Ryosuke Ikeda & Grigory Denisov



1. Japan ITER-gyrotrons

(a) Continuous-wave operation

(b) 5 kHz full-power modulation



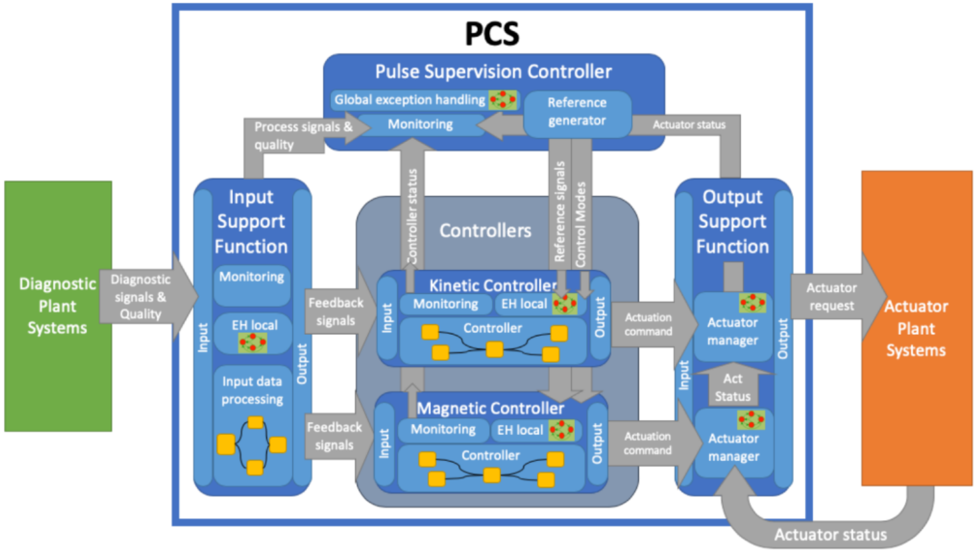
1. Russia ITER-gyrotrons

Four gyrotrons passed the performance tests.

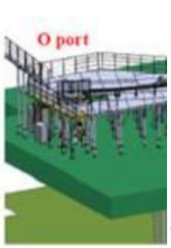
Japan & Russia gyrotrons have passed the performance tests and are readying for ITER First Plasma

ITER – TECH Summary

TECH-1/4&5. Timothy C. Luce, Larry R. Baylor & Joseph Snipes

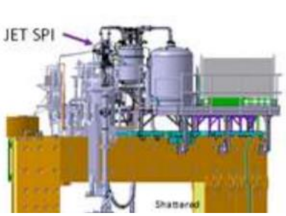


KSTAR SPI Installation and Operation



JET SPI Installation and Operation

JET SPI is mounted vertically from the top of Octant 1 [3.4].

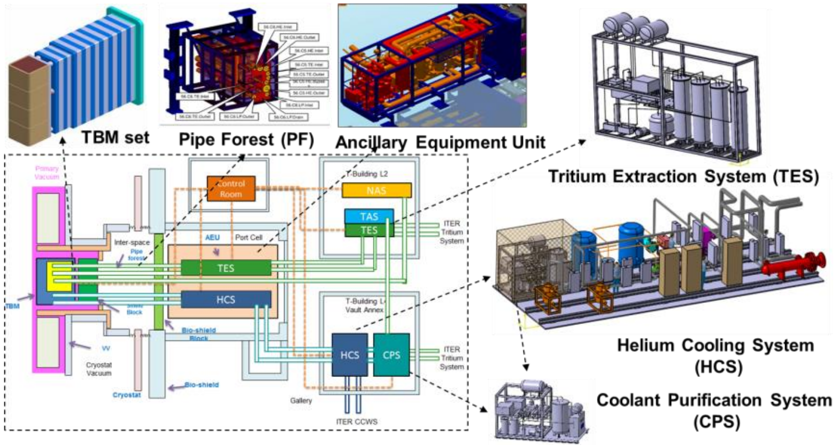


ORNL

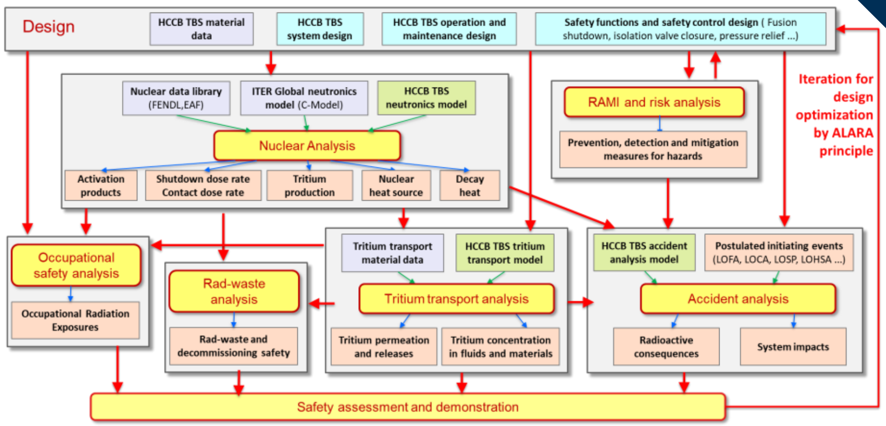
Disruption mitigation a key to ITER operations. Designing for ITER → testing in leading experimental tokomaks

ITER – TECH Summary

TECH-1/6. Xiaoyu WANG



HCCB TBS Schematic



Design | HCCB TBS material data | HCCB TBS system design | HCCB TBS operation and maintenance design | Safety functions and safety control design (Fusion shutdown, isolation valve closure, pressure relief ...)

Nuclear data library (FENDL,EAF) | ITER Global neutronics model (C-Model) | HCCB TBS neutronics model

Nuclear Analysis

Activation products | Shutdown dose rate Contact dose rate | Tritium production | Nuclear heat source | Decay heat

RAMI and risk analysis

Prevention, detection and mitigation measures for hazards

Iteration for design optimization by ALARA principle

Occupational safety analysis

Occupational Radiation Exposures

Rad-waste analysis

Rad-waste and decommissioning safety

Tritium transport material data | HCCB TBS tritium transport model

Tritium transport analysis

Tritium permeation and releases | Tritium concentration in fluids and materials

HCCB TBS accident analysis model | Postulated initiating events (LOFA, LOCA, LOSP, LOHSA ...)

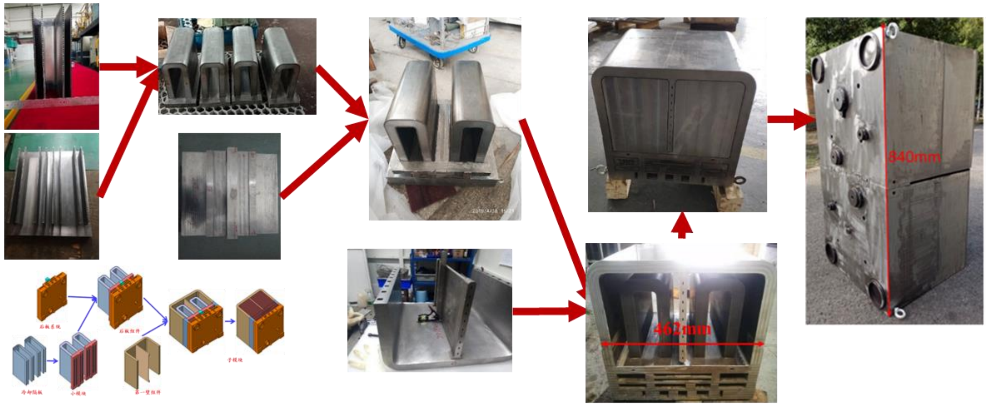
Accident analysis

Radioactive consequences | System impacts

Safety assessment and demonstration

Overview of Safety assessment and demonstration

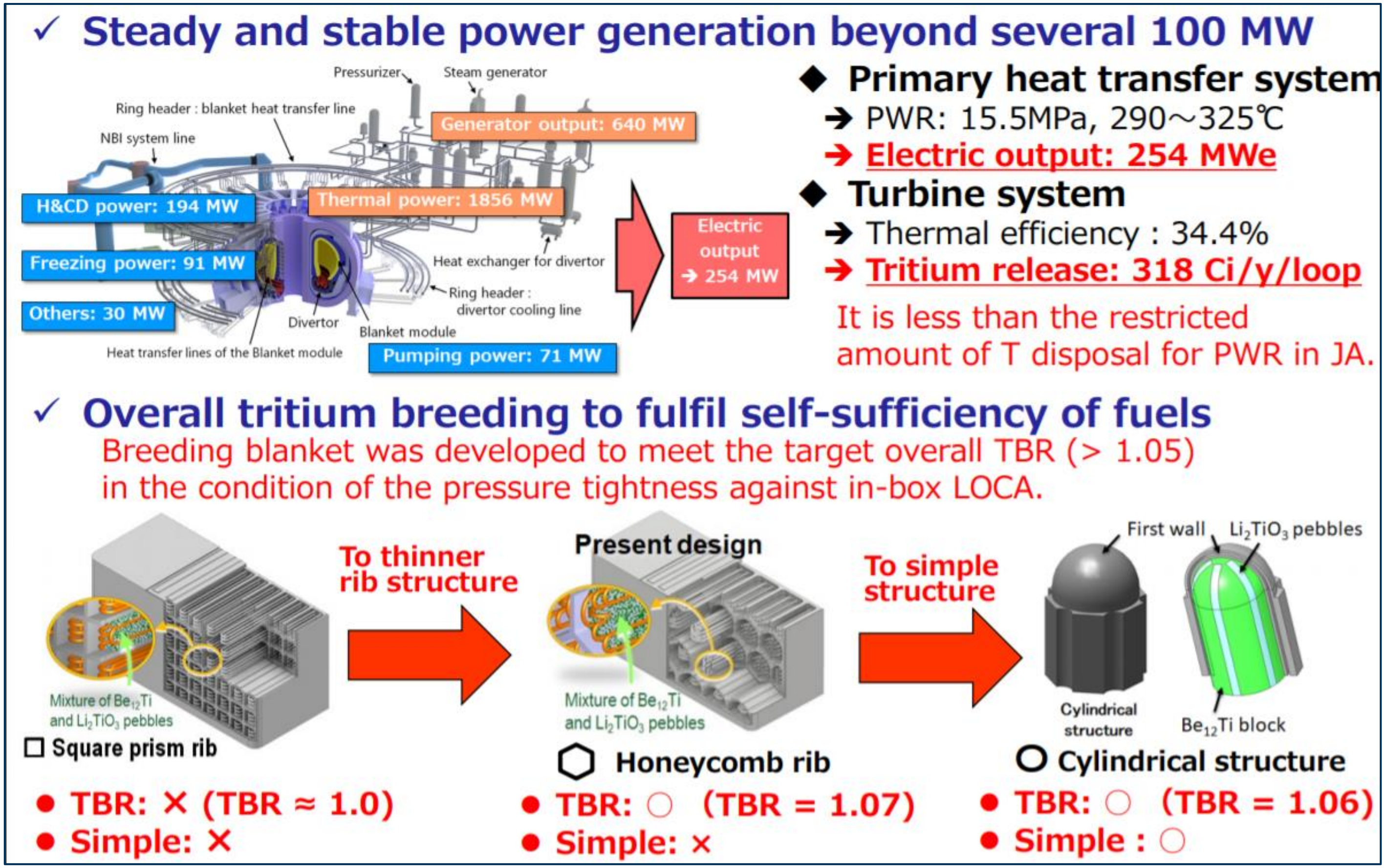
Fabrication processes for semi-prototype of HCCB TBM



ITER TBM testing represent critical validation testing for our fusion futures. They are foundation of ITER to DEMO bridge

DEMO & Advance Technology – TECH Summary

TECH-2/1. Youji Someya



✓ **Steady and stable power generation beyond several 100 MW**

◆ **Primary heat transfer system**

➔ PWR: 15.5MPa, 290～325℃

➔ **Electric output: 254 MWe**

◆ **Turbine system**

➔ Thermal efficiency : 34.4%

➔ **Tritium release: 318 Ci/y/loop**

It is less than the restricted amount of T disposal for PWR in JA.

✓ **Overall tritium breeding to fulfil self-sufficiency of fuels**

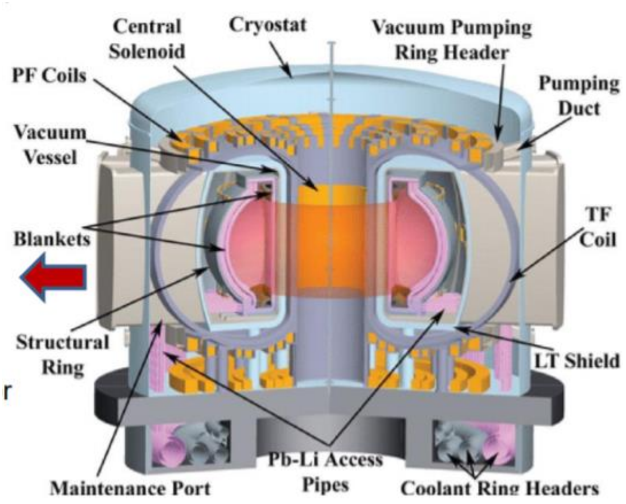
Breeding blanket was developed to meet the target overall TBR (> 1.05) in the condition of the pressure tightness against in-box LOCA.

☐ **Square prism rib**	⬡ **Honeycomb rib**	○ **Cylindrical structure**
● **TBR: ✕ (TBR ≈ 1.0)**	● **TBR: ○ (TBR = 1.07)**	● **TBR: ○ (TBR = 1.06)**
● **Simple: ✕**	● **Simple: ×**	● **Simple : ○**

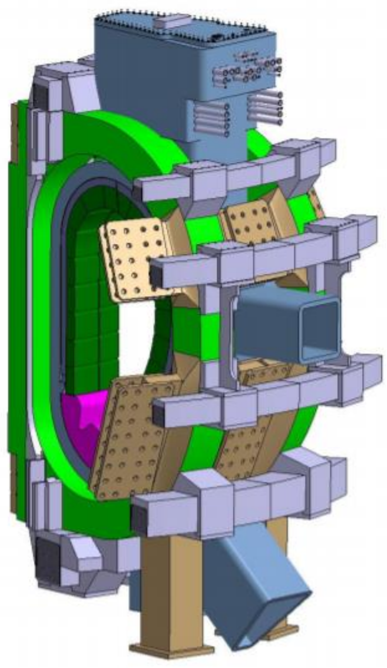
Holistic DEMO design highlight issues, and find solutions!

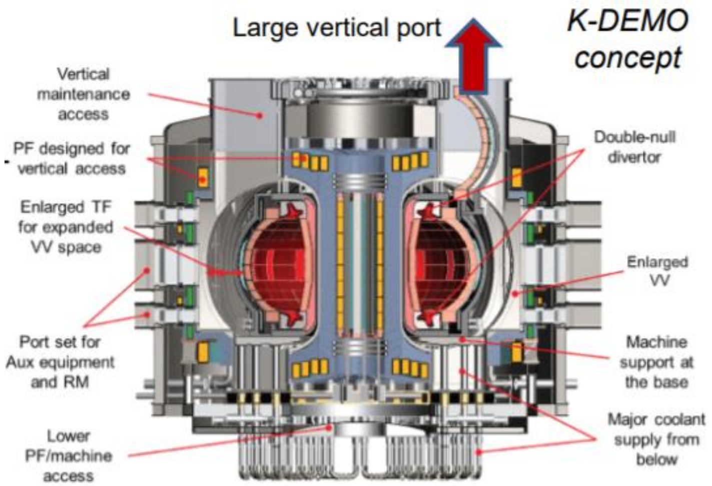
DEMO & Advance Technology – TECH Summary

TECH-2/2. Oliver Crofts



ARIES-ACT1 concept



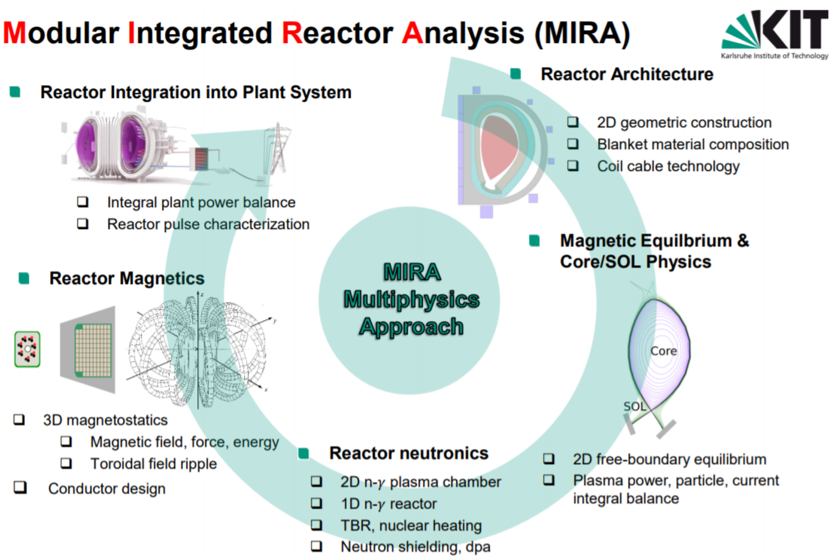


Architecture can dominate remote handling methodology

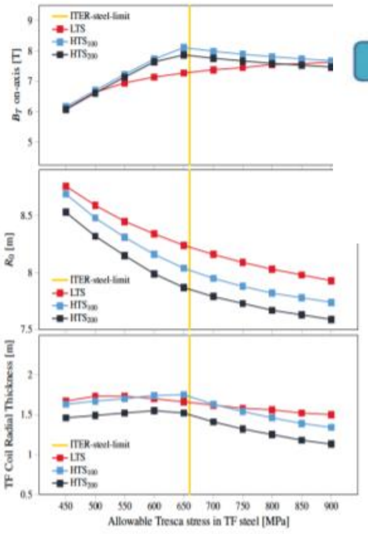
DEMO & Advance Technology – TECH Summary

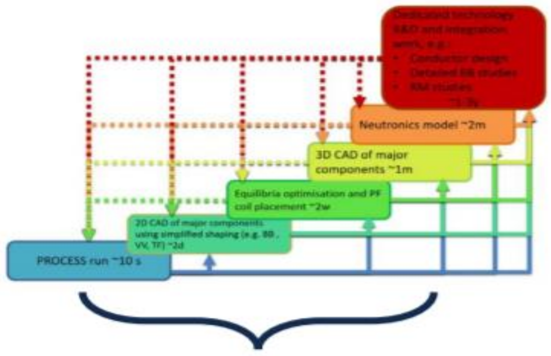
TECH-2/3. Fabrizio Franza & James Morris

Modular Integrated Reactor Analysis (MIRA)



- **Reactor Integration into Plant System**
  - ☐ Integral plant power balance
  - ☐ Reactor pulse characterization
- **Reactor Architecture**
  - ☐ 2D geometric construction
  - ☐ Blanket material composition
  - ☐ Coil cable technology
- **Magnetic Equilbrium & Core/SOL Physics**
  - ☐ 2D free-boundary equilibrium
  - ☐ Plasma power, particle, current integral balance
- **Reactor Magnetics**
  - ☐ 3D magnetostatics
    - ☐ Magnetic field, force, energy
    - ☐ Toroidal field ripple
  - ☐ Conductor design
- **Reactor neutronics**
  - ☐ 2D n-γ plasma chamber
  - ☐ 1D n-γ reactor
  - ☐ TBR, nuclear heating
  - ☐ Neutron shielding, dpa





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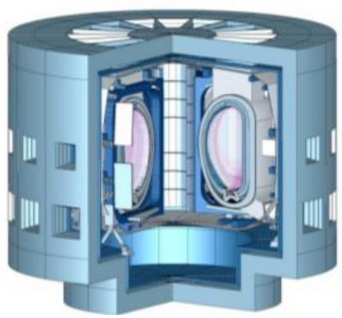


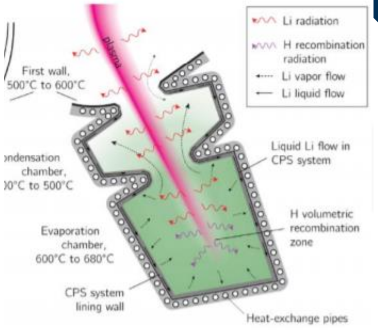
BLUEMIRA – an optimised start point for all future fusion reactor designs?

DEMO & Advance Technology – TECH Summary

TECH-2/4. Jonathan Menard

Overview of US FPP.

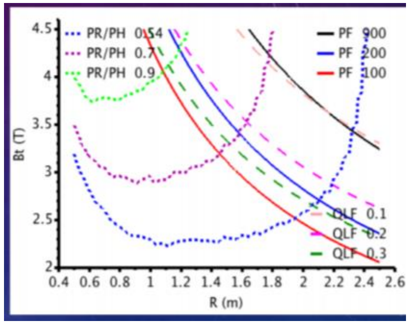
Nice adaptations prepossessed such as Li in divertors



TECH-2/5. Shishir Deshpande

Studies on spherical tokamak

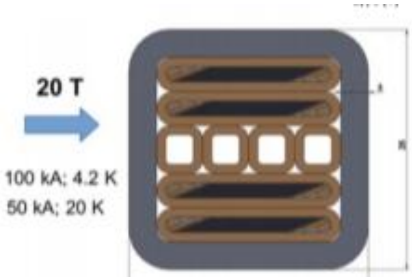
Baseline info coming from work on ITER



TECH-2/6. Alexander Molodyk

Development in HT superconductors

Importantly worked from industrial developments



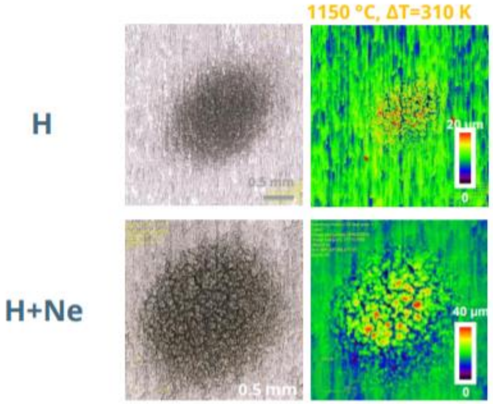
Divertor and Heating– TECH Summary

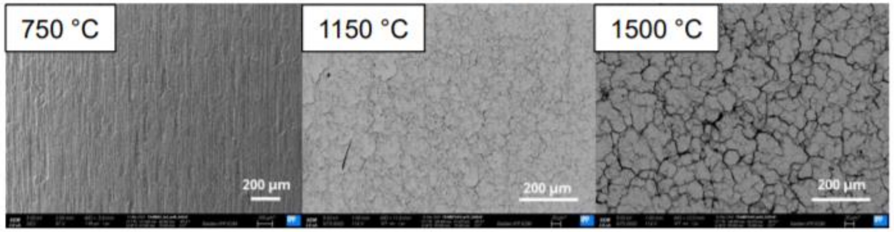
TECH-3/1. Thomas Morgan

1. W Mock-up chain exposed to combined plasma and up to 10^6 ELM-like (laser) pulses in Magnum-PSI

2. Comparing to similar e-beam data indicates additional effects due to plasma (surface modifications, “rounded” roughened surfaces)

3. Increasing surface base temperature leads to a decrease in resistance to fatigue cracking





4. Seeding impurities increase surface roughening compared to pure H discharges

5. Results indicate importance of plasma effects on fatigue damage of W

Established teams, established facilities, constantly upgrading → supporting our progressive fusion path

Divertor and Heating– TECH Summary

TECH-3/2. Nobuyuki Asakura & Rudolf Neu

- EU and JA BA-DDA study covers common aspects of divertor physics and engineering design: water-cooled single-null divertor and appropriate geometry for plasma detachment.
- Both concepts handle similar thermal heating power (P_{heat}), and require large total radiation fraction ($f_{rad} = P_{rad}/P_{heat} \geq 80\%$) in order to reduce the peak heat load (≤10 MWm^{-2}):

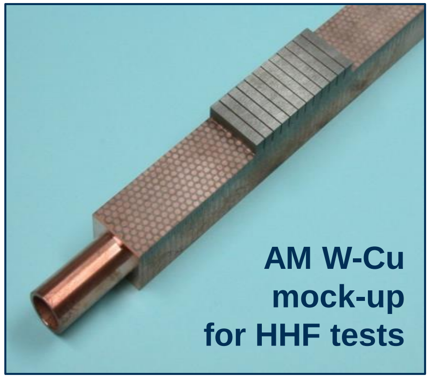
Divertor power handling is determined by requirements of f_{rad}^{main} and the plasma performance.

JA DEMO challenge (steady-state operation):
Lower I_p and higher HH with ITER-level f_{rad}^{main}
⇒ Large divertor power handling: P_{sep}/R ~30MWm^{-1}

EU DEMO challenge (pulse operation):
Higher I_p and ITER-level HH with large f_{rad}^{main} by high-Z seeding ⇒ ITER-level P_{sep}/R =17MWm^{-1}

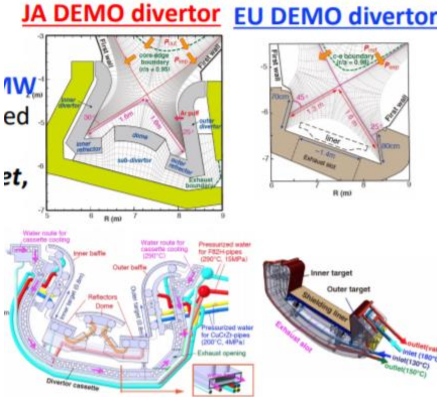
- **Same leg length (1.6 m: longer than ITER)** but **different geometry** (**JA:** ITER-like closer baffle, **EU:** rather open without dome and baffle) were proposed as baseline designs.

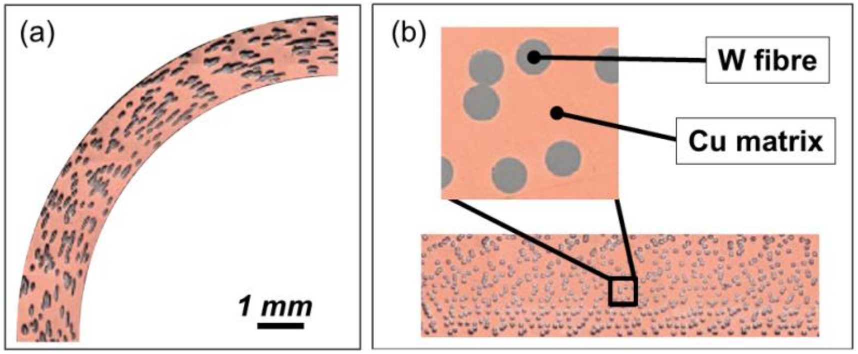
JA DEMO divertor EU DEMO divertor



AM W-Cu mock-up for HHF tests

JA DEMO divertor EU DEMO divertor

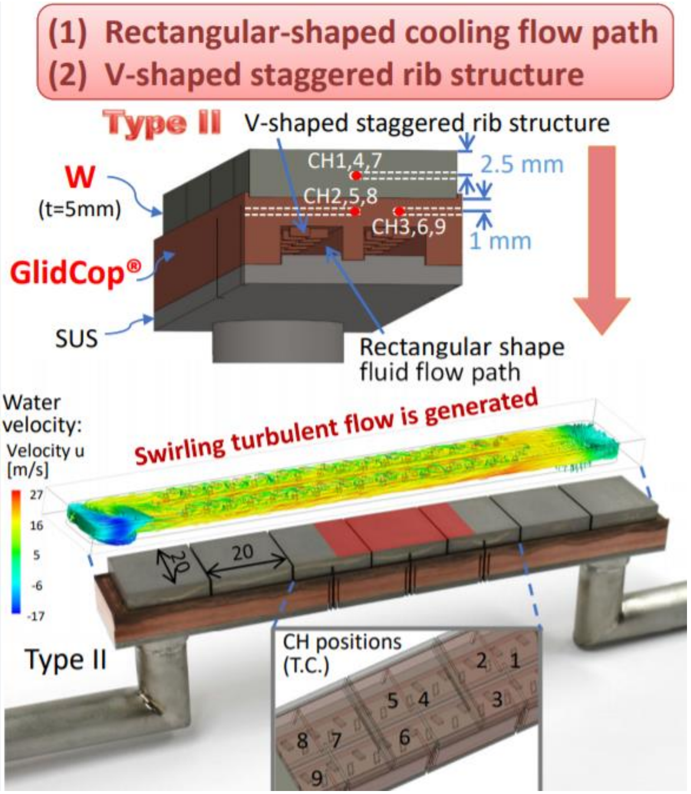


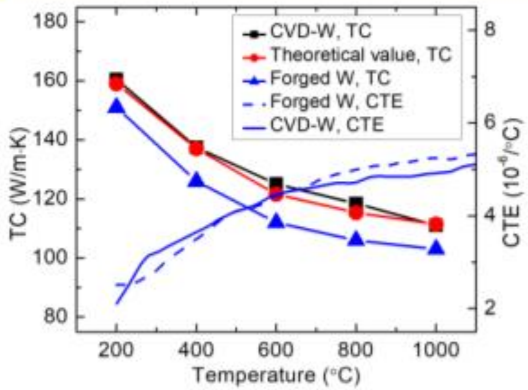


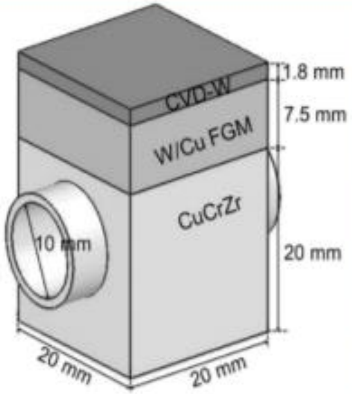
Steady state and pulsed operation. Divergent regimes, but co-learning from developing solutions

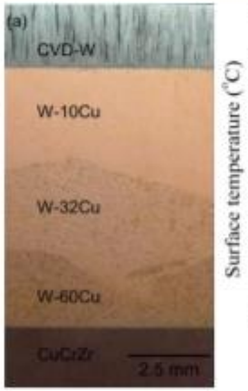
Divertor and Heating– TECH Summary

TECH-3/3. Masayuki Tokitani & Zhe Chen





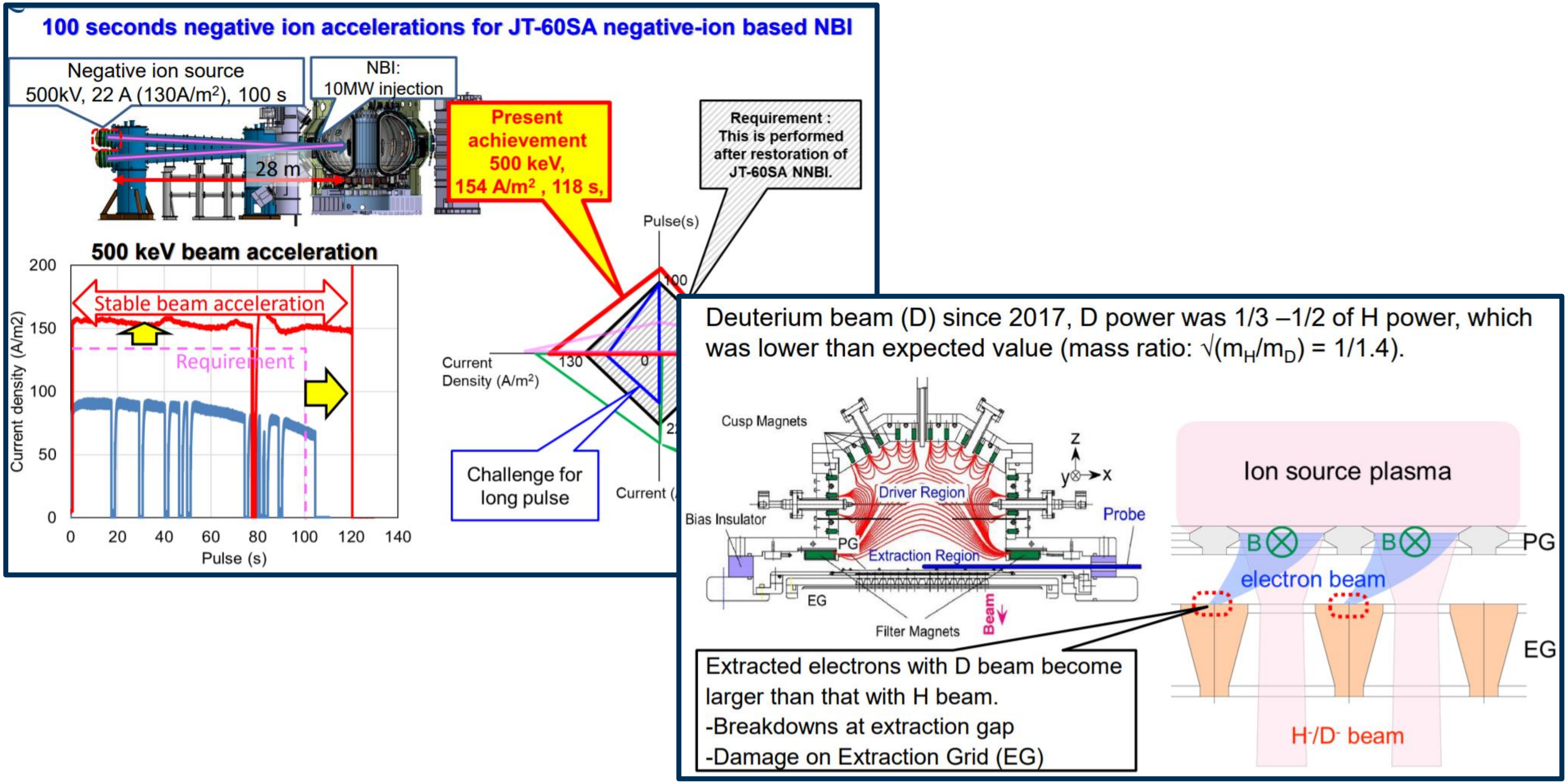




Advanced manufacturing, opening the design space for DEMOs

Divertor and Heating– TECH Summary

TECH-3/4. Mieko Kashiwagi & Katsuyoshi Tsumori



100 seconds negative ion accelerations for JT-60SA negative-ion based NBI

Negative ion source 500kV, 22 A (130A/m^2), 100 s

NBI: 10MW injection

Present achievement 500 keV, 154 A/m^2 , 118 s,

Requirement : This is performed after restoration of JT-60SA NNBI.

500 keV beam acceleration

Challenge for long pulse

Deuterium beam (D) since 2017, D power was 1/3 –1/2 of H power, which was lower than expected value (mass ratio: $\sqrt{(m_H/m_D)} = 1/1.4$).

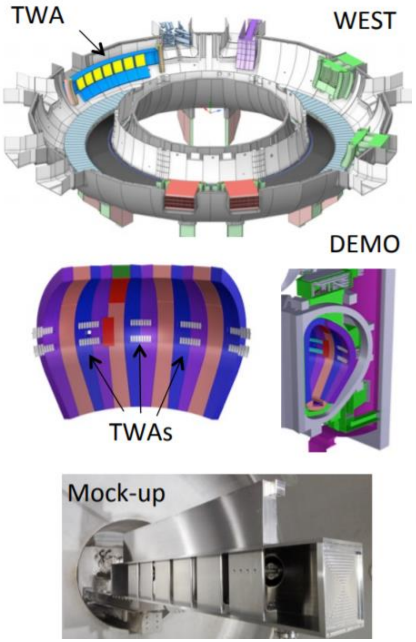
Extracted electrons with D beam become larger than that with H beam.
-Breakdowns at extraction gap
-Damage on Extraction Grid (EG)

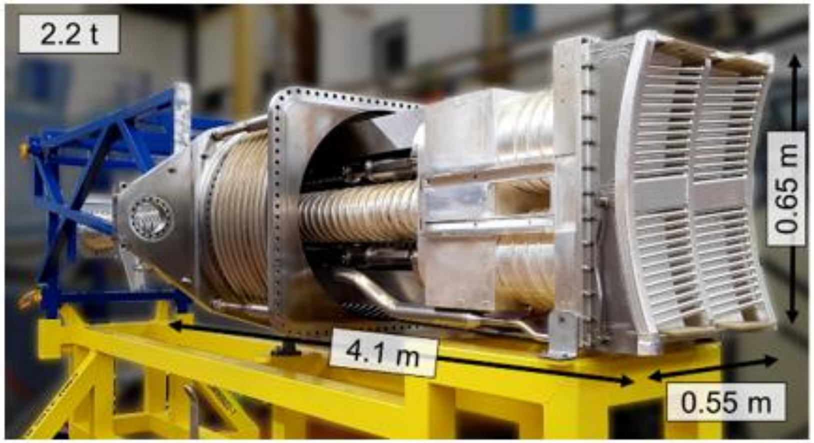
Divertor and Heating– TECH Summary

TECH-3/5. Julien Hillairet & Riccardo Ragona

Travelling Wave Array antenna

- TWA proposed to be tested on **WEST** as demonstrator for a fusion reactor relevant actuator
- Design extrapolated to **DEMO** and fully integrated in the blanket
- First stage with a high power (2 MW) mock-up **successfully** completed in TITAN facility



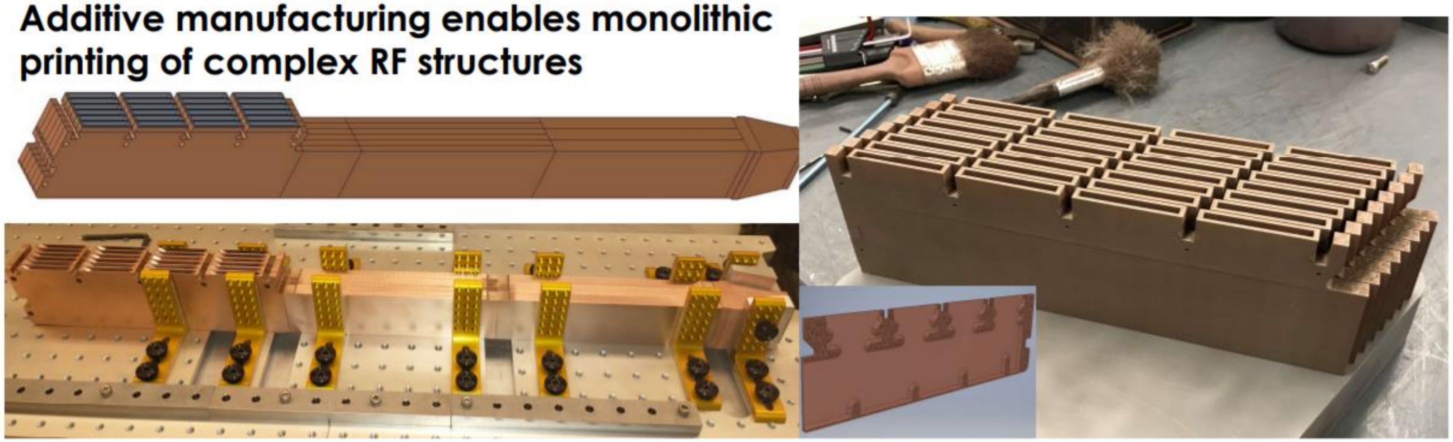


Ion-Cyclotron Resonance Heating System

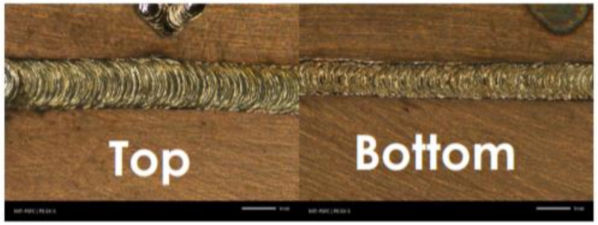
Divertor and Heating– TECH Summary

TECH-3/6. Andrew Seltzman

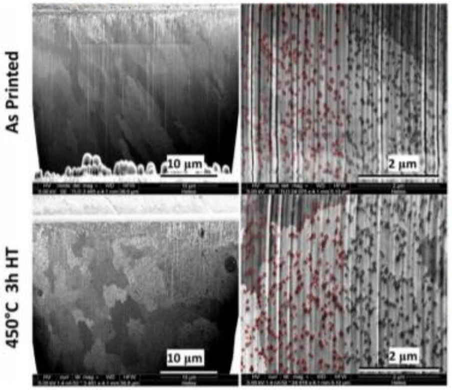
Additive manufacturing enables monolithic printing of complex RF structures



Laser welding results in 450 MPa UTS, smooth top and bottom surfaces



Heat treatment selects tensile properties



As Printed

Yield=500 MPa
UTS=740 MPa

450C 3h

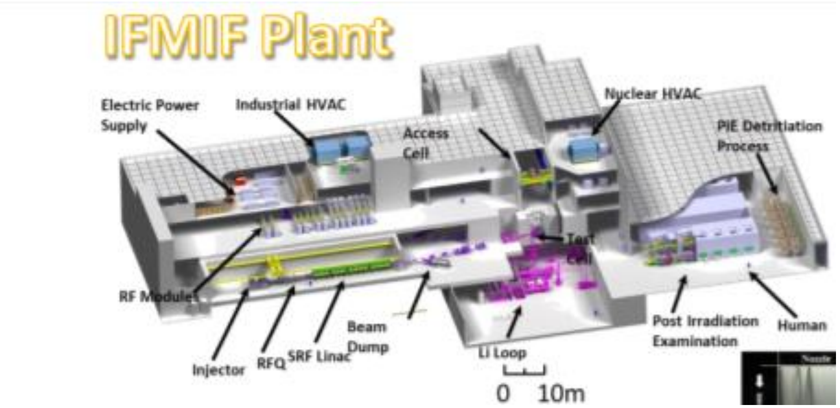
Yield=790 MPa
UTS=970 MPa

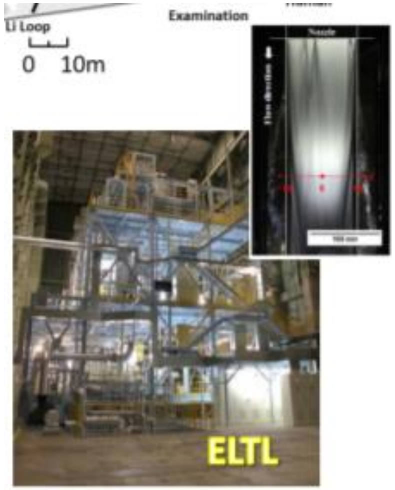
Additive manufacturing opening design options

Material, PMI, and Neutron Source – TECH Summary

TECH-4/1. Philippe Cara

IFMIF/EVEDA

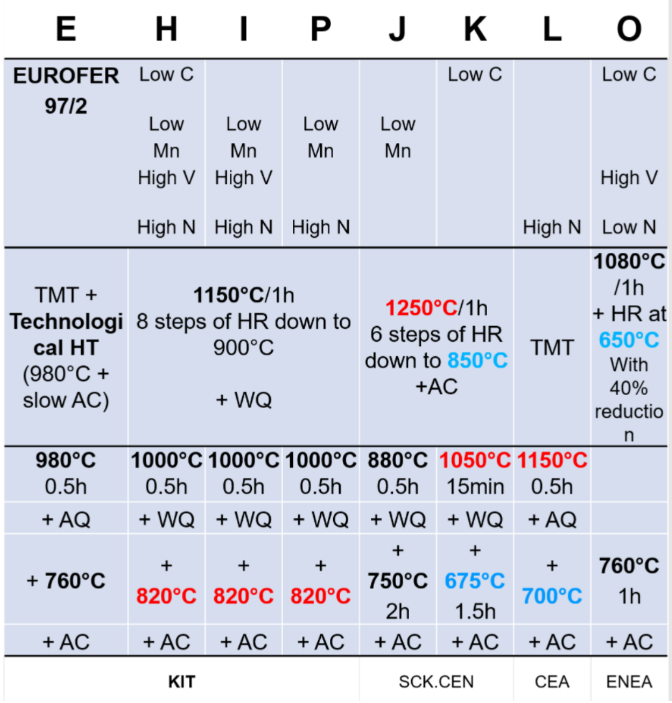




Most roadmaps for fusion power necessitate experimental materials damage from fusion irradiation spectrum. We must realise these facilities soon or change our roadmaps

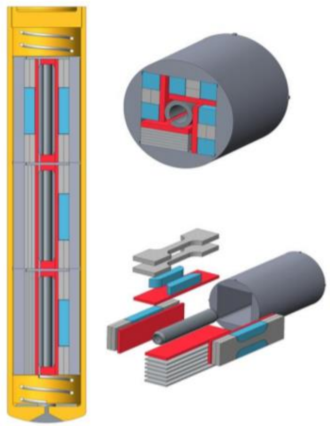
Material, PMI, and Neutron Source – TECH Summary

TECH-4/2. Esther Simondon & Michael Rieth



E	H	I	P	J	K	L	O
EUROFER 97/2	Low C Low Mn High V High N	Low Mn High V High N	Low Mn High N	Low Mn	Low C	High N	Low C High V Low N
TMT + **Technological HT** (980°C + slow AC)	**1150°C**/1h 8 steps of HR down to 900°C + WQ			**1250°C**/1h 6 steps of HR down to **850°C** +AC		TMT	**1080°C** /1h + HR at **650°C** With 40% reduction
980°C 0.5h	**1000°C** 0.5h	**1000°C** 0.5h	**1000°C** 0.5h	**880°C** 0.5h	**1050°C** 15min	**1150°C** 0.5h	
+ AQ	+ WQ	+ WQ	+ WQ	+ WQ	+ WQ	+ AQ	
+ **760°C**	+ **820°C**	+ **820°C**	+ **820°C**	+ **750°C** 2h	+ **675°C** 1.5h	+ **700°C**	**760°C** 1h
+ AC	+ AC	+ AC	+ AC	+ AC	+ AC	+ AC	+ AC
KIT				SCK.CEN		CEA	ENEA

- Target dose of **2.5 dpa ± 0.38 dpa**

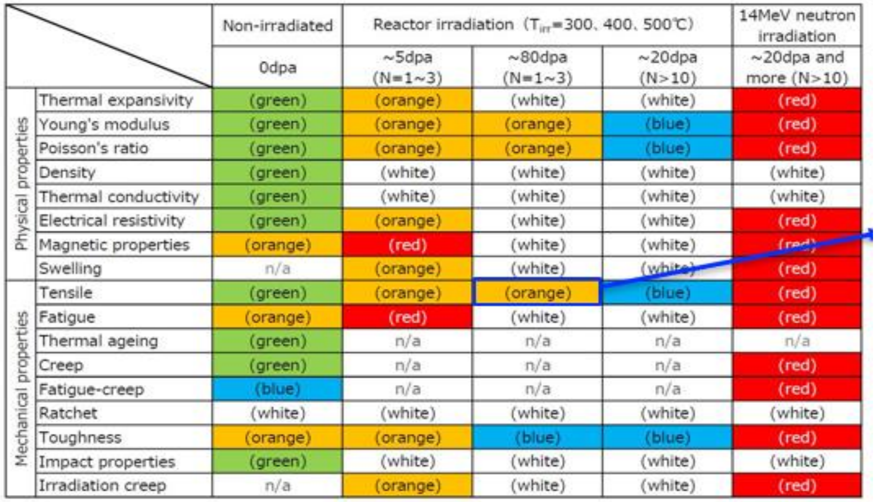


- The surface operation temperature could be extended from 550 °C (this is the maximum for EUROFER) to 650 °C (for 100 heat flux pulses of 2 minutes and for additional 7 cycles of 2 hours each, heat flux of 0.9 MW/m², simple helium cooling without flow promoters).
- Extremely robust and crack-resistant HIP joining process for the EUROFER/ODS-steel plating demonstrated and industrial-scale fabrication processes with very high tolerances against manufacturing imperfections for advanced blanket first wall proven
- Production route of 100 kg ODS steel powder and plate fabrication verified. Up-scaling to the several 10-ton ranges is feasible.

Material, PMI, and Neutron Source – TECH Summary

TECH-4/3. Takashi Nozawa

Status and challenges in development of MPH

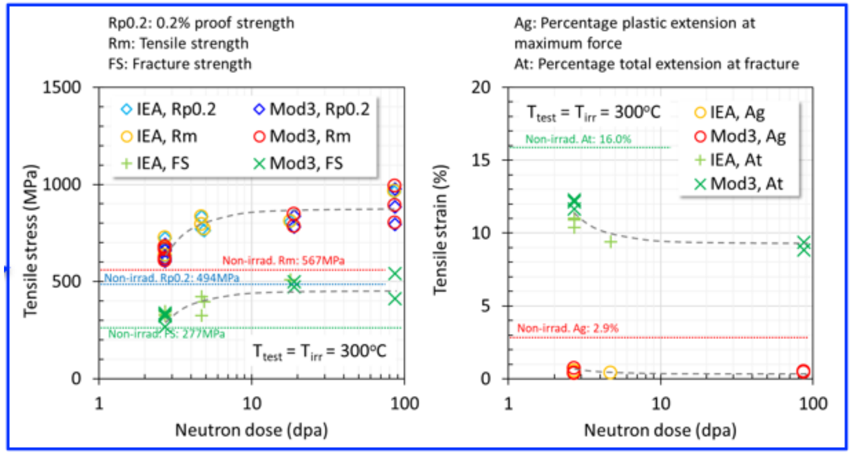


		Non-irradiated	Reactor irradiation (T$_{irr}$=300, 400, 500℃)			14MeV neutron irradiation
		0dpa	~5dpa (N=1~3)	~80dpa (N=1~3)	~20dpa (N>10)	~20dpa and more (N>10)
Physical properties	Thermal expansivity	(green)	(orange)	(white)	(white)	(red)
	Young's modulus	(green)	(orange)	(orange)	(blue)	(red)
	Poisson's ratio	(green)	(orange)	(orange)	(blue)	(red)
	Density	(green)	(white)	(white)	(white)	(white)
	Thermal conductivity	(green)	(white)	(white)	(white)	(white)
	Electrical resistivity	(green)	(orange)	(white)	(white)	(red)
	Magnetic properties	(orange)	(red)	(white)	(white)	(red)
	Swelling	n/a	(orange)	(white)	(white)	(red)
Mechanical properties	Tensile	(green)	(orange)	(orange)	(blue)	(red)
	Fatigue	(orange)	(red)	(white)	(white)	(red)
	Thermal ageing	(green)	n/a	n/a	n/a	n/a
	Creep	(green)	n/a	n/a	n/a	(red)
	Fatigue-creep	(blue)	n/a	n/a	n/a	(red)
	Ratchet	(white)	(white)	(white)	(white)	(white)
	Toughness	(orange)	(orange)	(blue)	(blue)	(red)
	Impact properties	(green)	(white)	(white)	(white)	(white)
	Irradiation creep	n/a	(orange)	(white)	(white)	(red)

(*) color code :

- ✓ White (blank) for properties not addressed, lack of data
- ✓ Black : potential showstopper identified
- ✓ Red : lack of data and potentially challenging
- ✓ Blue : lack of data, NOT challenging
- ✓ Orange : data available, results not good enough, further optimization needed
- ✓ Green : data available, results are good, concept is mature

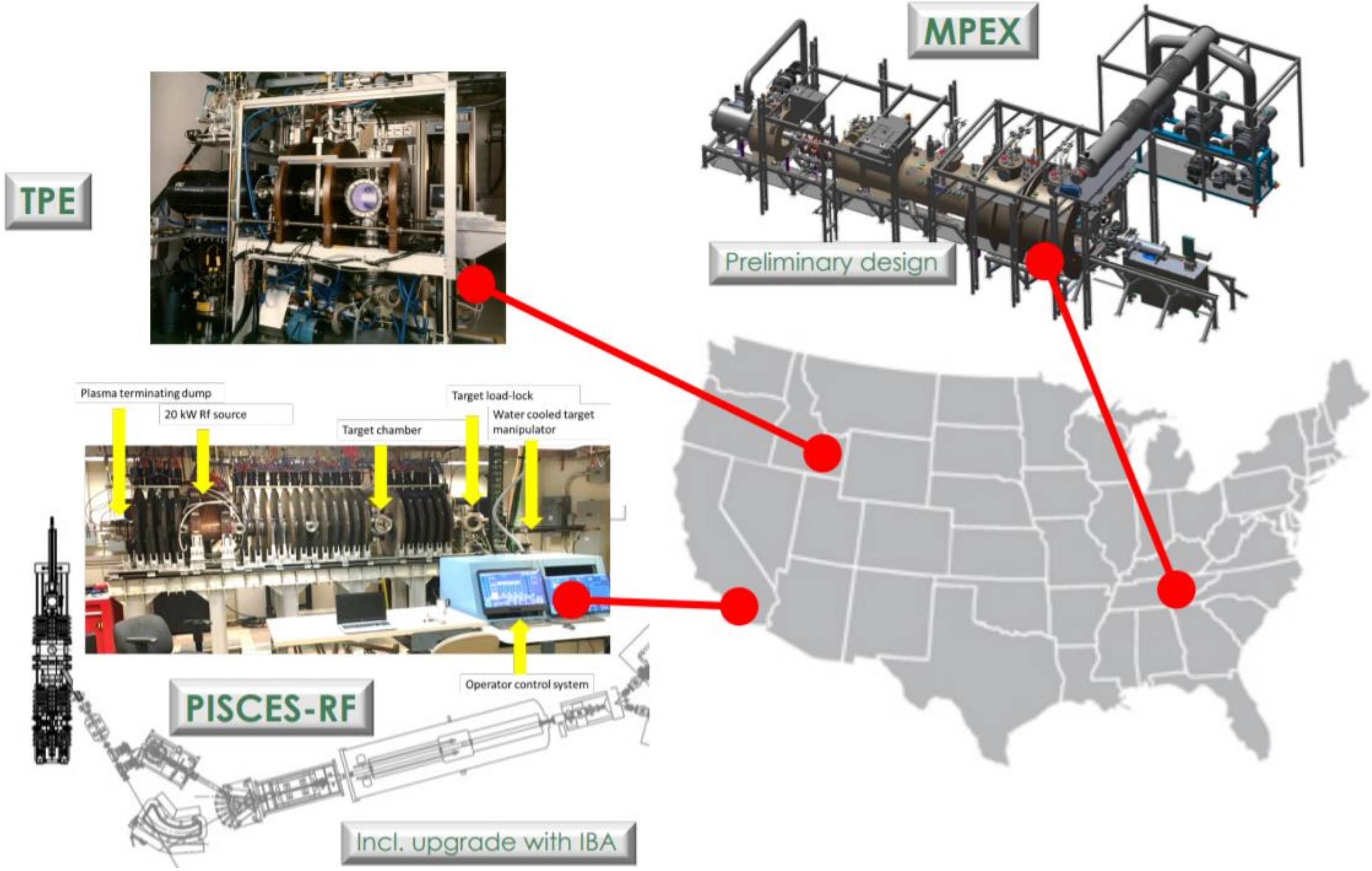
n/a : not applicable, N: number of valid data



Important to find criticality of irradiation effects on all properties→ they may be "showstoppers"

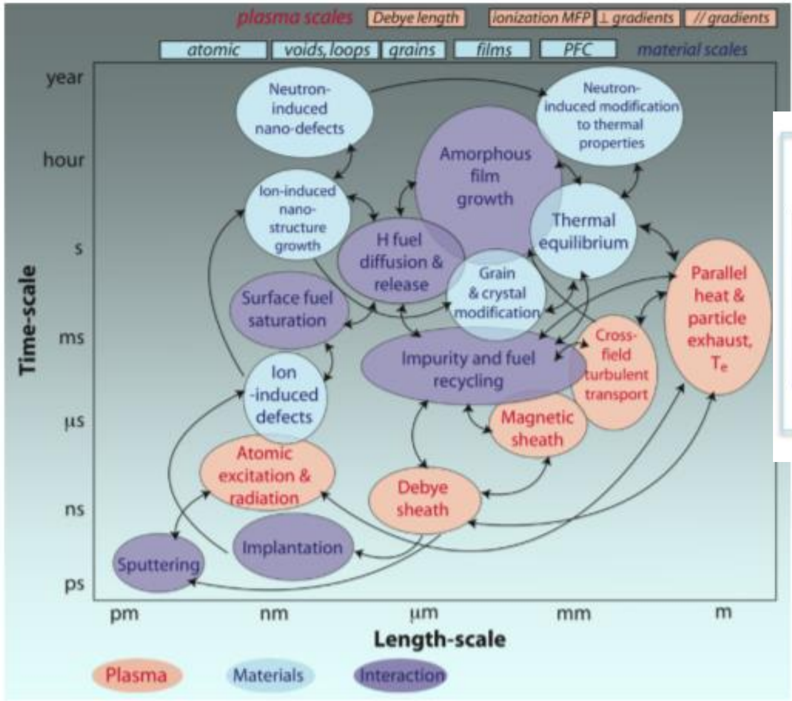
Material, PMI, and Neutron Source – TECH Summary

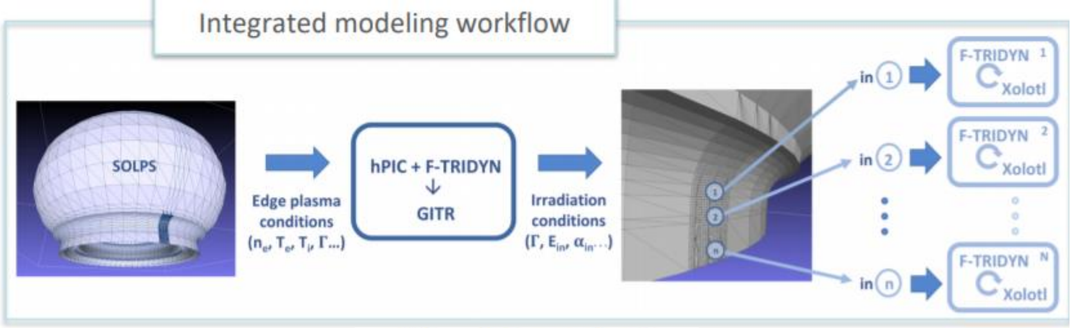
TECH-4/4. Juergen Rapp



Material, PMI, and Neutron Source – TECH Summary

TECH-4/5. Ane Lasa





- The integrated model (Fig.) was benchmarked against PISCES experiments

Entering the delivery era for fusion, our materials models must blend near term approximations with these long term developments to support DEMOs

Many thanks for 107 fantastic poster contributions in TECH area

624, Salah El-Din El-Morshedy. 625, Thomas Brown. 633, Nawal Prinja. 639, Poulami Chakraborty Srivastava. 640, Sergey Ananyev. 646, Allen Boozer. 654, Vladimir Slugen. 670, Hyun Kyung Chung. 671, Irina Tazhibayeva. 687, Donato Aquaro. 705, Rajesh Maingi. 708, Fumito Okino. 717, Junichi Miyazawa. 722, Takuya Goto. 723, Satoshi SATO. 724, Satoshi Ito. 734, Masashi Kisaki. 751, Katsuhiro Shimada. 756, Tsuyoshi Kariya. 760, Hiroyuki Noto. 762, Alexey Vertkov. 764, SULABH GUPTA. 765, Mikhail Zharkov. 775, Trey Gebhart. 779, Gregory Wallace. 819, Keisuke Mukai. 822, Go Matsunaga. 823, Keitaro Kondo. 827, Hiroyasu Utoh. 828, Akihiro Shimizu. 830, Takahiro Shinya. 836, Longwen Yan. 838, Juro Yagi. 839, Yuji Torikai. 845, Akira TONEGAWA. 847, Dmitry Terentyev. 848, Andrius Tidikas. 849, Yusuke Shibama. 864, Francesco Paolo Orsitto. 876, Ryoji Hiwatari. 877, Kazuya Hamada. 882, Nagato Yanagi. 890, Hiroyuki Tobari. 895, Satoshi Konishi. 900, Nicolas Mantel. 911, MATHILDE DIEZ. 912, Caoxiang Zhu. 932, David Gates. 967, Régis Bisson. 974, Alexey Zhirkin, Alexey Zhirkin. 976, Christian Grisolia. 979, Hennie van der Meiden. 1001, Roger Raman. 1003, Masayuki Ono. 1034, David Rapisarda. 1054, Marco Cavenago. 1059, Rafael Vila. 1061, Petr Khvostenko. 1062, Richard Majeski. 1069, Somsak Dangtip. 1070, Chen Chen. 1088, Christian Hopf. 1100, Amro BADER. 1101, Viacheslav Chernov. 1110, Hai-Shan Zhou. 1114, SUNWONE KWON. 1115, Arman Miniyazov. 1121, Greg Bailey. 1129, Louis ZANI. 1132, Igor Sokolov. 1133, Xiang Liu. 1140, Mikhail Rozenkevich. 1142, Gerd Gantenbein. 1150, Xavier COURTOIS. 1157, Sergey Konovalov. 1163, Alexey Zhirkin, Alexey Zhirkin. 1180, Oleg Sotnikov. 1192, Jing Wu. 1193, Jiming Chen. 1197, Dirk Wünderlich. 1198, Shen QU. 1205, Xiujie Zhang. 1211, Vinay Menon. 1218, Qixiang CAO. 1227, Joao Claudio Fiel. 1238, Stefan Gerhardt. 1241, Baoping Gong. 1243, Quan Bai. 1245, MAINAK BANDYOPADHYAY. 1253, Vipulkumar Tanna. 1264, Mukti Ranjan Jana. 1266, bharatkumar doshi. 1270, ANKUSH DEOGHAR. 1273, Aleksandr Burdakov. 1274, Ranjana Gangradey. 1277, Paritosh Chaudhuri. 1289, Suraj Pillai. 1297, Lee Packer. 1307, P.N Maya. 1308, Chiara Mistrangelo, Leo Bühler. 1324, Piyush Prajapati. 1331, Mikhail Subbotin. 1333, Yury Shpanskiy. 1337, Christine Hoa. 1339, Egemen Kolemen. 1346, Zahoor Ahmad. 1348, Leopoldo Soto.

Personal highlights: 633, Nawal Prinja & 708, Fumito Okino.

Special note: 1346, Zahoor Ahmad. 1348, Leopoldo Soto. 624, Salah El-Din El-Morshedy. 1132, Igor Sokolov.

Conclusions

ITER 9 Talks

- Completion of component constrictions: field coils, heating and current dive systems.
- Plasma control and protection
- Test Blanket Models.

DEMO & Advance Technology

7 Talks

- Overview of DEMO progress (J-DEMO)
- Remote handling
- Systems codes and conceptual designs
- Superconducting advancements

Divertor and Heating 10 Talks

- Fantastic EU, Japan divertor overview
- Divertor component representative testing
- New manufacturing methods
- Advanced Heating and current drive tests

Materials and material systems 6 Talks

- IFMIF/EVEDA
- Neutron irradiation test results (Steels)
- Handbooks, strategy
- Plasma materials interactions
- Multi-physics modelling

Closing Thoughts

UK Atomic Energy Authority

- ITER is so challenging, yet progressing every day.

The lessons learned from ITER construction are key to fusion power, we must capture and use for DEMO.

- We have ITER and increased funding on many DEMOs.

This bring industrialist interests in our the work. The community must learn to send out our challenges and let industries solve them, and not try to lead on everything in DEMO designs.

- Recent years have seen increasing work in private fusion companies.

Established programmes and experienced staff should help these endeavours so there, often disruptive, developments can support our global efforts.

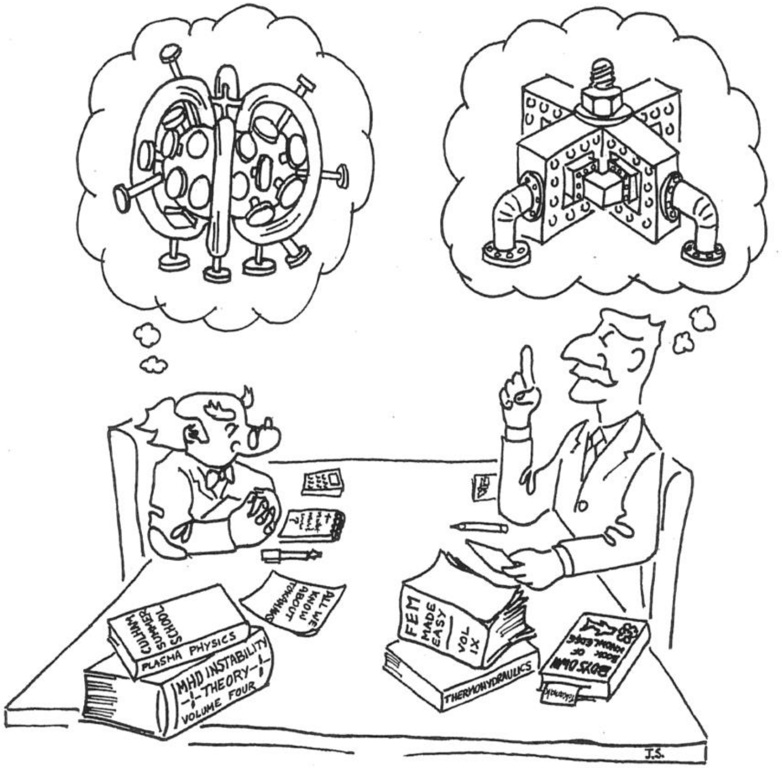
- I hope our next FEC TECH talks can see:

Great TBM progress, more industrialist talks, more private fusion talks and more talks on representative scale testing in facilities like MITICA (NBI) and CHIMERA (In-vessel component testing).

UK Atomic
Energy
Authority

> “We strive to realise a humankind changing endeavour - fusion power. Summarising FEC2020 TECH area was a privilege.
>
> Many Thanks to all for your dedicated work and see you at 29th FEC!”

Mike Gorley, May 2021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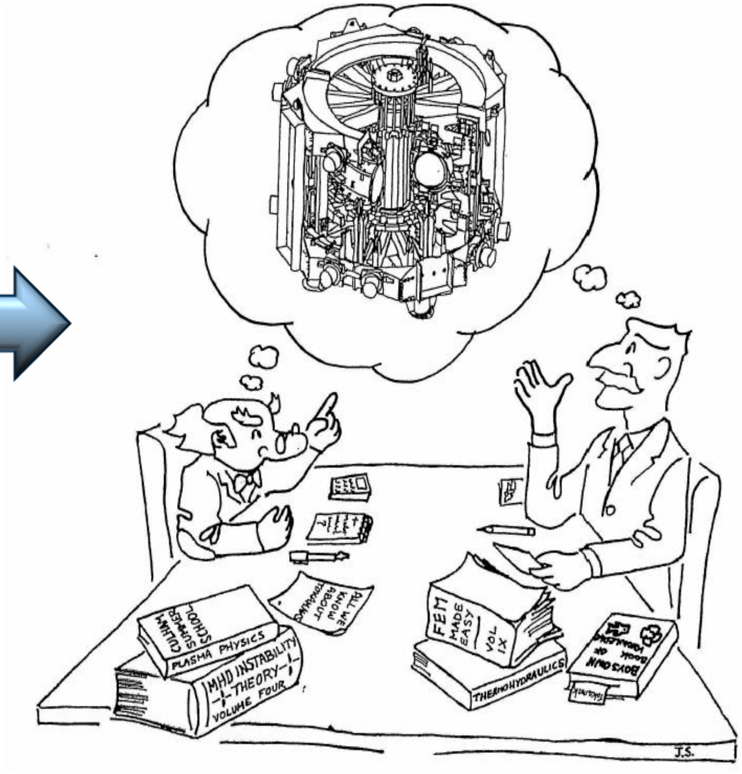
PLASMA PHYSICS
MHD INSTABILITY THEORY VOLUME FOUR
ALL WE KNOW ABOUT TOKAMAKS
FEM MADE EASY VOL IX
THERMOHYDRAULICS
BOYS OWN BOOK OF KNOWLEDGE
J.S.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