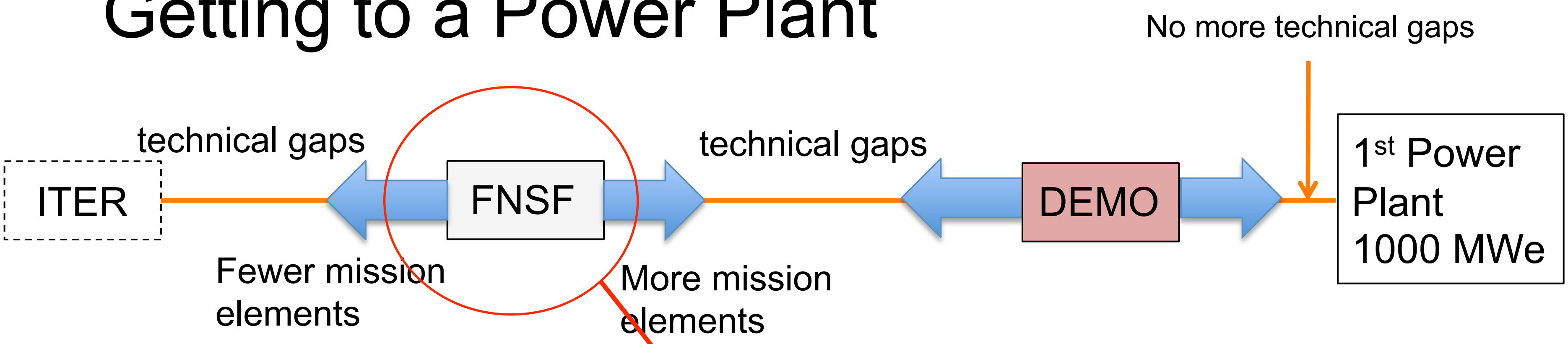
Getting to a Power Plant

C. Kessel, PPPL



*this line is not time, it is the fusion plasma and fusion nuclear parameter space defined by

Life of plant peak neutron fluence, MW-yr/m^2
Peak neutron fluence to replace the first wall and blanket, MW-yr/m^2 (dpa)
Average and peak (outboard midplane) neutron flux, MW/m^2
Fusion power, MW
Tritium breeding ratio (sustainment)
Net tritium consumption over plant life, kg
Plasma fusion gain (P_{fuson}/P_{inject})
Engineering gain ($P_{elec,gross}/P_{recirculating}$)
Plasma performance, $\beta_N H_{98}/q_{95}$
Peak heat flux on divertor/FW, MW/m^2
Divertor/FW lifetime to replacement, years
Plasma on time in a year, %
Life of plant, years
Plasma pulse duration (what are limits), days
Plasma duty cycle
Overall plant availability…….

The first Fusion Nuclear facility

Why a FNSF?

The FNSF will provide the *fully integrated environment* (T, B, q'', q''', pressure/stress, chemical/corrosion, plasma-vacuum, hydrogen, flows, fusion nuclear) for *fully integrated components* like the FW/blanket, shield, vacuum vessel, magnets, divertor, and launchers/diagnostics

the FNSF must provide a technical basis for DEMO by demonstrating pathes to

1. tritium breeding, extraction, fueling and exhaust, and processing, reaching a tritium breeding ratio of ≥ 1, providing self-sufficiency
2. the heat extraction and electricity production
3. the integrated blanket (first wall, breeding zone, shield, and vacuum vessel) concept
4. the power and particle handling in the plasma chamber, the divertor and first wall concepts
5. the long plasma durations
6. all support technologies (magnets, pellet injector, heating and current drive, vacuum systems, remote maintenance, diagnostics, etc.)
7. reliable, safe, maintainable, and inspectible operation

How do we put our program in a position to design, construct and operate the first fusion nuclear facility?

Confinement devices

Present confinement devices

ITER

Long pulse Asian confinement devices

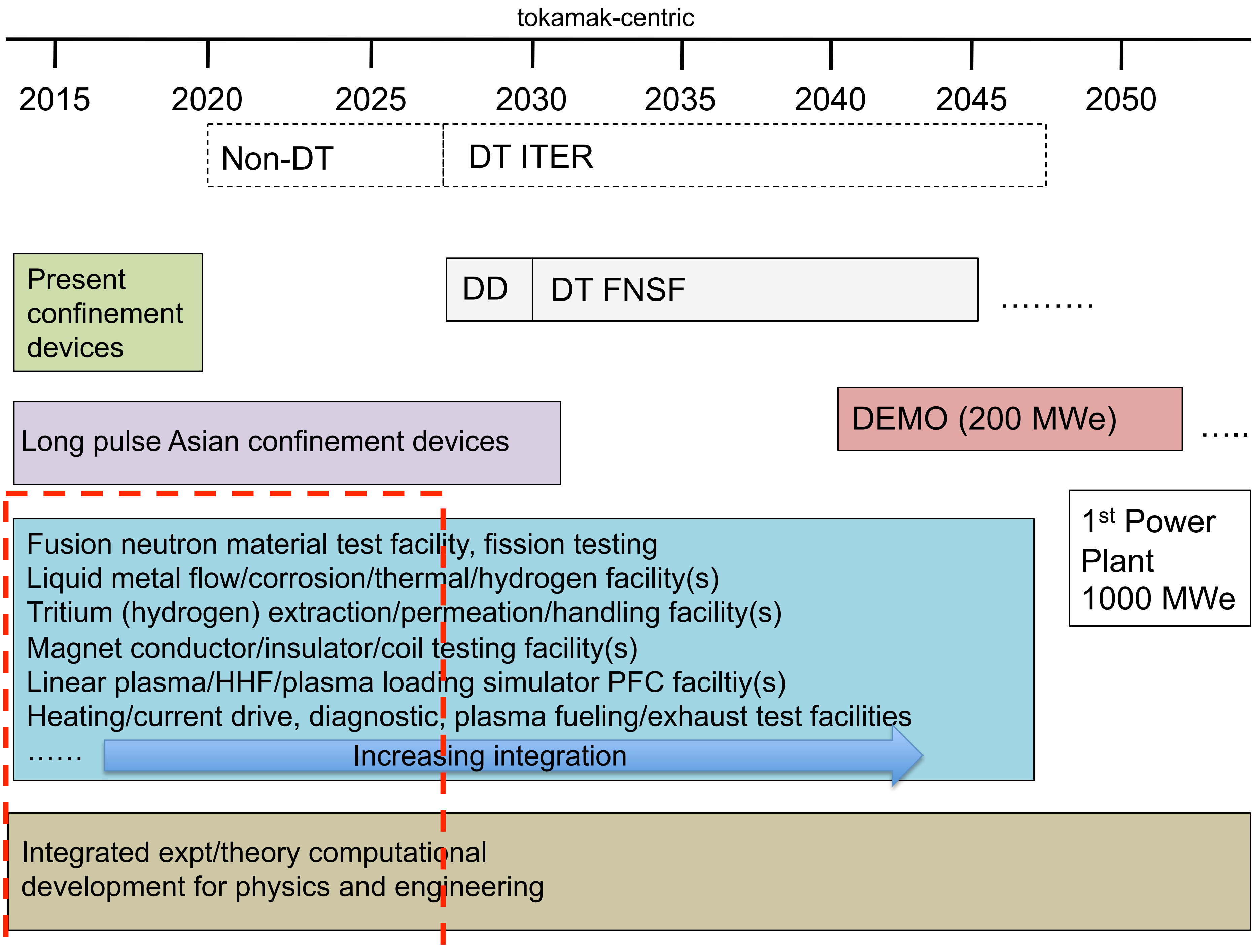
Predictive capability

Integrated expt/theory computational development for physics and engineering

Non-confinement facilities

Fusion neutron material test facility, fission testing
Liquid metal flow/corrosion/thermal/hydrogen facility(s)
Tritium (hydrogen) extraction/permeation/handling facility(s)
Magnet conductor/insulator/coil testing facility(s)
Linear plasma/HHF/plasma loading simulator PFC faciltiy(s)
Heating/current drive, diagnostic, plasma fueling/exhaust test facilities
……

Increasing integration →


tokamak-centric
2015
2020
2025
2030
2035
2040
2045
2050
Non-DT
DT ITER
Present confinement devices
DD
DT FNSF
....
Long pulse Asian confinement devices
DEMO (200 MWe)
.....
1st Power Plant 1000 MWe
Fusion neutron material test facility, fission testing
Liquid metal flow/corrosion/thermal/hydrogen facility(s)
Tritium (hydrogen) extraction/permeation/handling facility(s)
Magnet conductor/insulator/coil testing facility(s)
Linear plasma/HHF/plasma loading simulator PFC faciltiy(s)
Heating/current drive, diagnostic, plasma fueling/exhaust test facilities
......
Increasing integration
Integrated expt/theory computational development for physics and engineering

Fusion Nuclear Science Pathways Assessment

http://www.pppl.gov/pub_report//2012/PPPL-4736-abs.html

*FESAC Materials Science and Technology Research Opportunities (Zinkle)

"…is targeting the identification of research activities necessary to advance fusion nuclear science within the US fusion program over the next 5-10 years, ….. the research should establish the technical basis for a fusion nuclear science facility (FNSF) and ultimately a demonstration fusion power plant (DEMO). "

Focused on 8 areas:

- Material science (structural, blanket, corrosion, magnet, diagnostic, design criteria)
- Power extraction and tritium sustainability
- Plasma facing components and PMI
- Safety and environment
- Enabling Technologies
  - Magnets
  - Heating and current drive systems
  - Fueling, pumping, and particles
  - Measurement issues

- Section on DEMO/power plant description/assumptions
- Section on Plasma duration and sustainment

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