Updated Tritium Breeding Requirement in Fusion Nuclear Science Facility (FNSF)

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With input from
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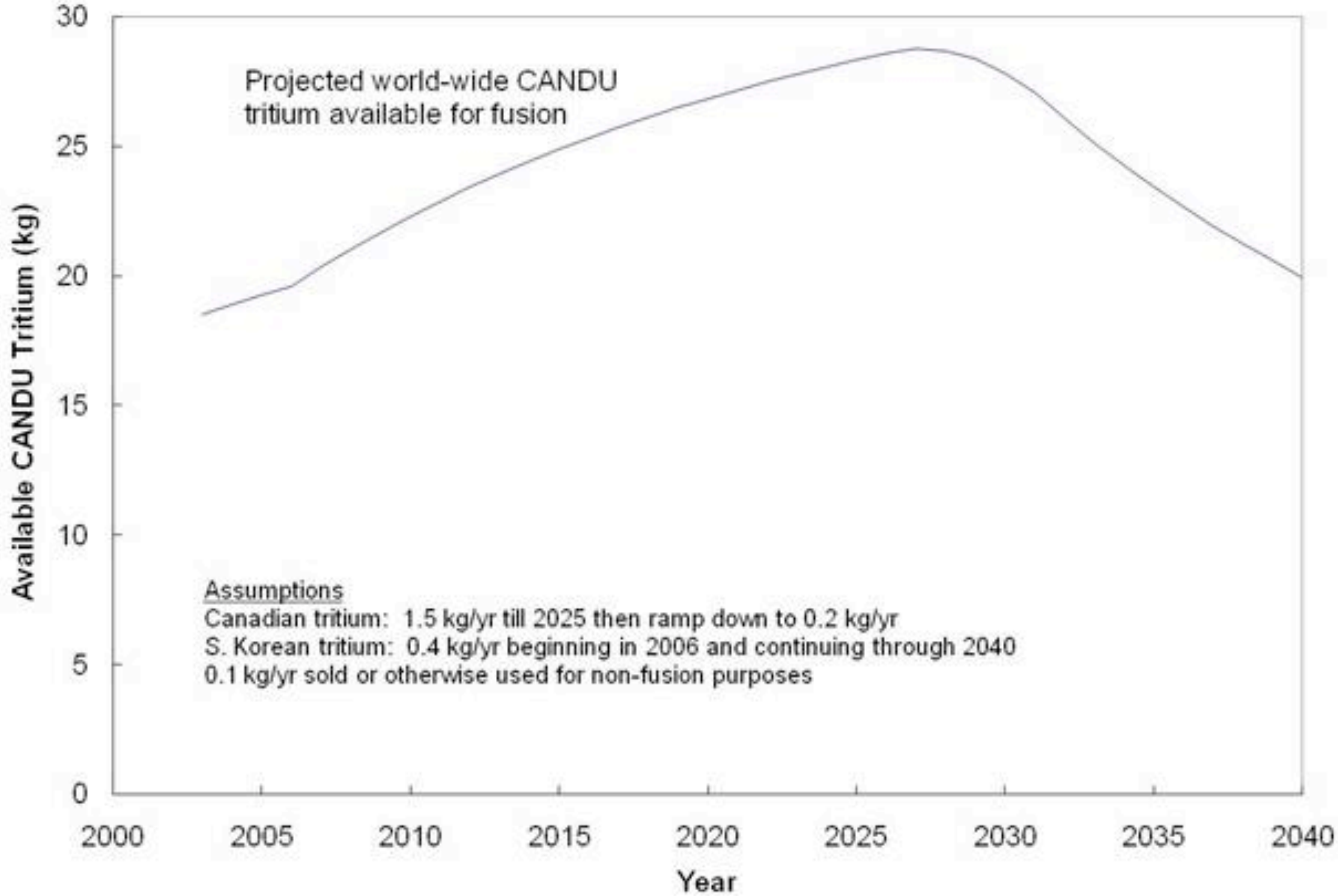
Objective

- Determine the required TBR in the FNSF as a function of fusion power and available external tritium supply
- TBR determined for three options
  - Required FNSF TBR to ensure it does not run out of tritium fuel during its lifetime
  - Required FNSF TBR to ensure that 5 kg of tritium is available at end of ITER and FNSF operation for startup of DEMO
  - Required FNSF TBR to ensure that 10 kg of tritium is available at end of ITER and FNSF operation for startup of DEMO
- Assume that ITER has priority over FNSF for using external tritium supply from CANDU reactors

Projected World-Wide CANDU Tritium

(from Scott Willms, LANL)



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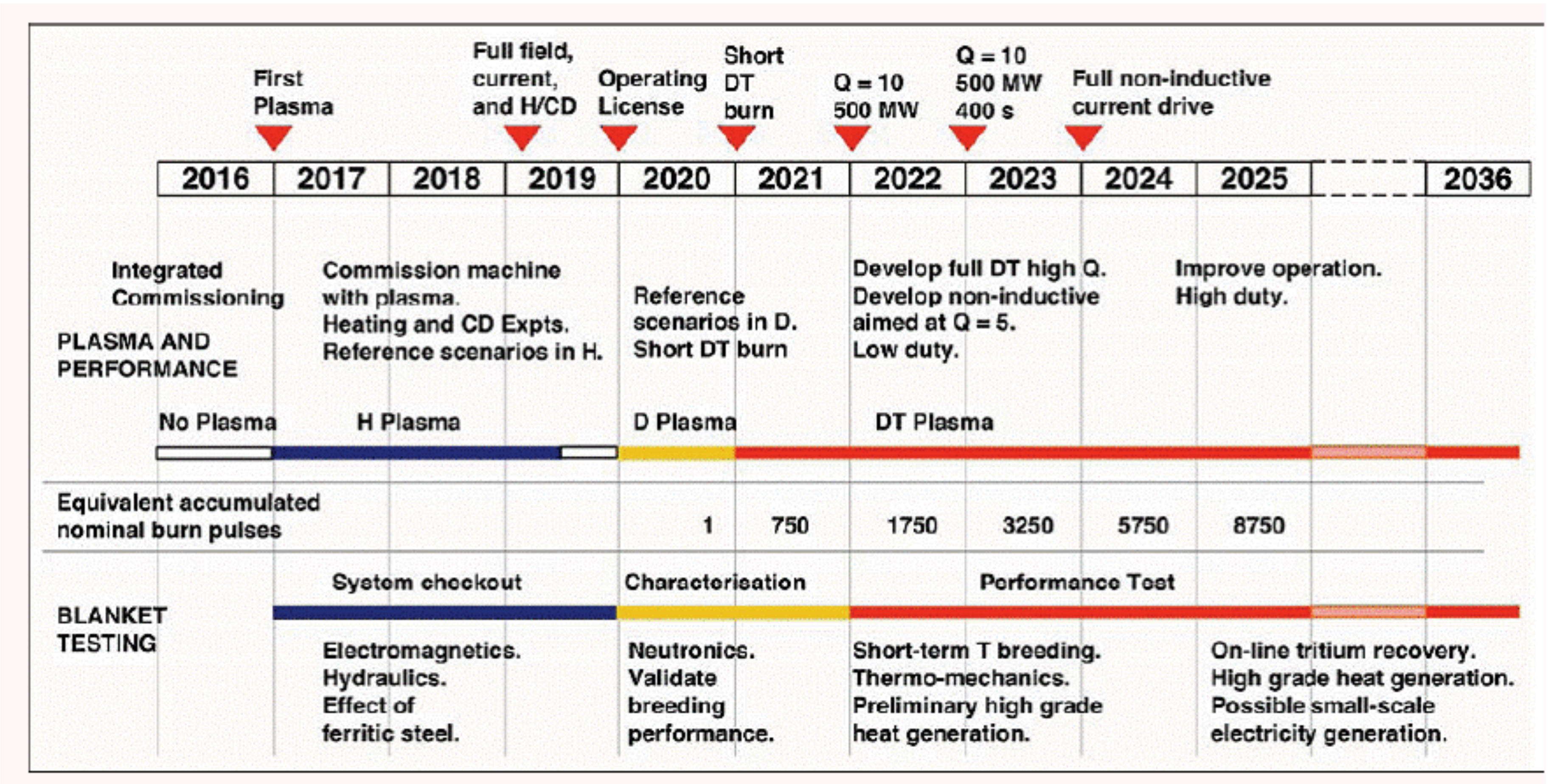
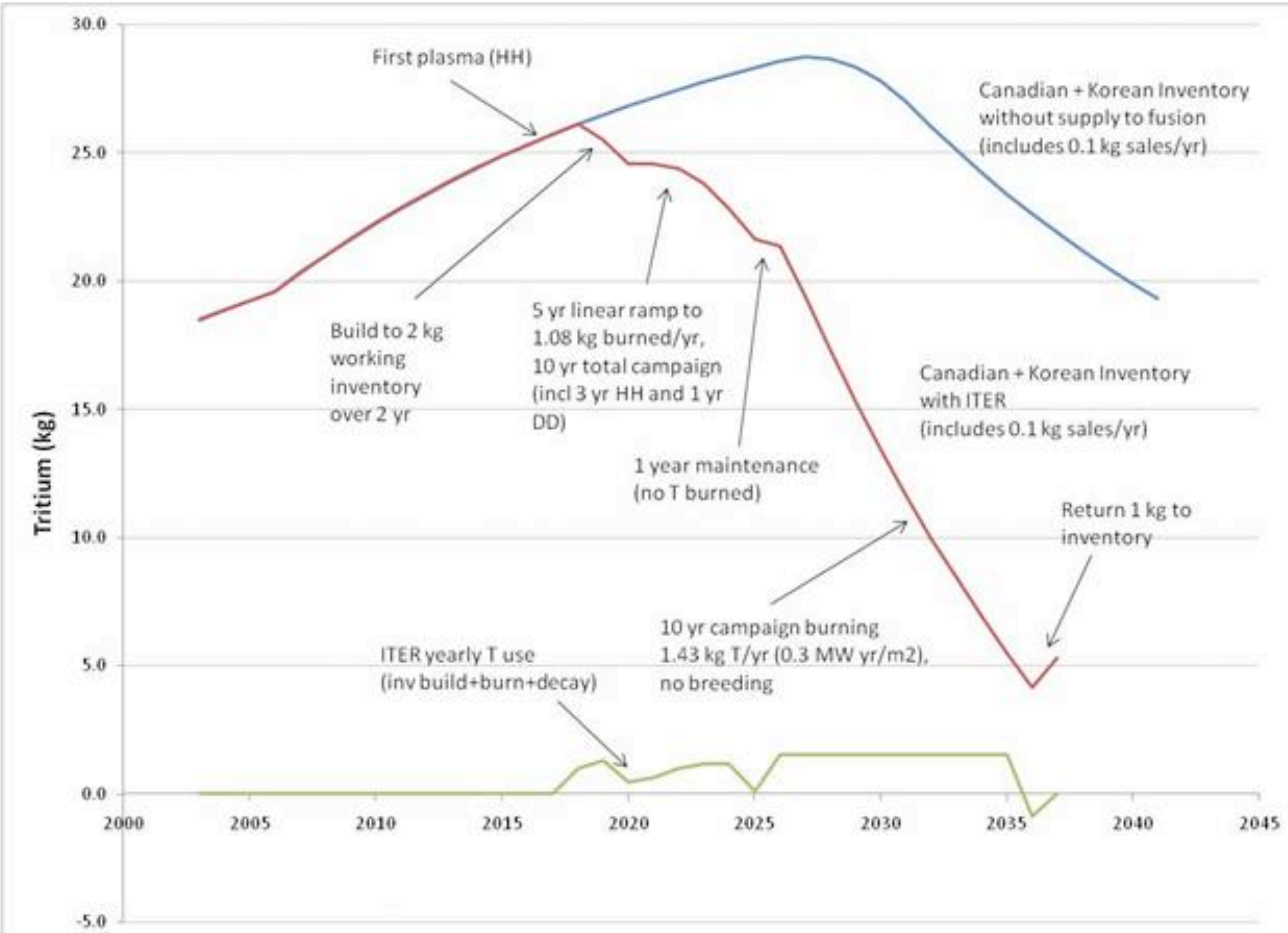
Initial ITER Schedule



External Tritium Supply Available for FNSF

(from Scott Willms, LANL)



<u>Assumptions</u>:

- 2016 ITER start with 2021 DT
- 2 kg working inventory that builds up over 2 years prior to DT
- At end of 20 ITER operation half of working inventory lost to waste

FNSF Assumptions

- 2021 FNSF start (same time as DT start in ITER)
- 1 year HH followed by 1 year DD operation
- 3 years DT operation at 10% availability followed by 10 years DT operation at 30% availability
- Fusion power in the range 50-400 MW considered
- A tritium inventory is maintained at all time during DT operation to cover hold-up in chamber components, tritium processing system, and needed reserve
- This working inventory is assumed to be 0.4 kg at 100 MW fusion power (scaling from ITER)
- Working inventory scales linearly with fusion power and builds up over the 2 years preceding DT operation
- At end of 15 year FNSF operation half of the working inventory is lost to waste with the rest added to supply available for DEMO
- Tritium burn rate is 55.6 kg/GWy
- Tritium decays at rate of 5.5% per year

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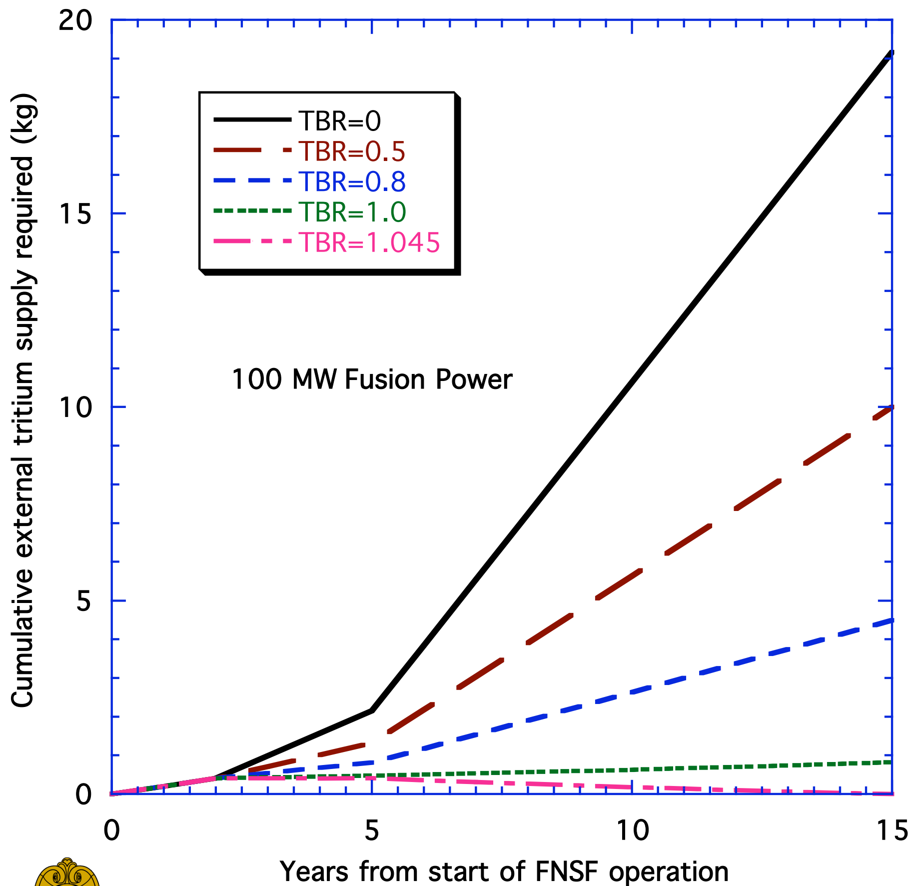
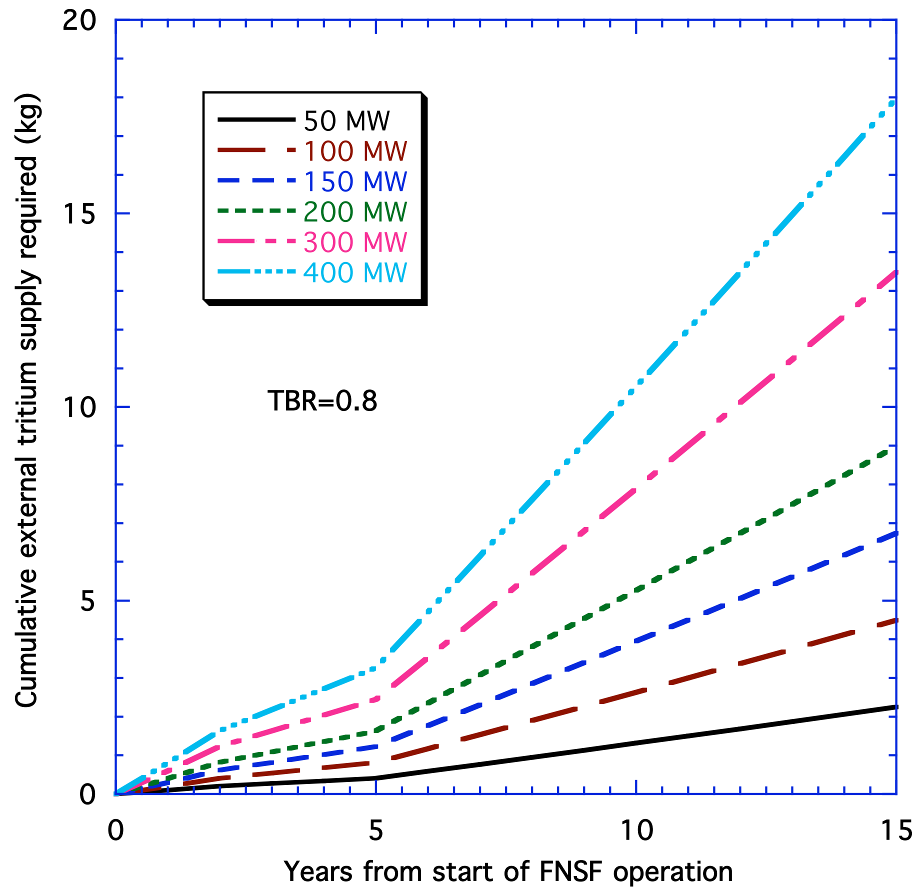
Total External Tritium Supply Required by FNSF

(to cover burn, inventory, decay)

Has Strong Dependence on TBR and P_f





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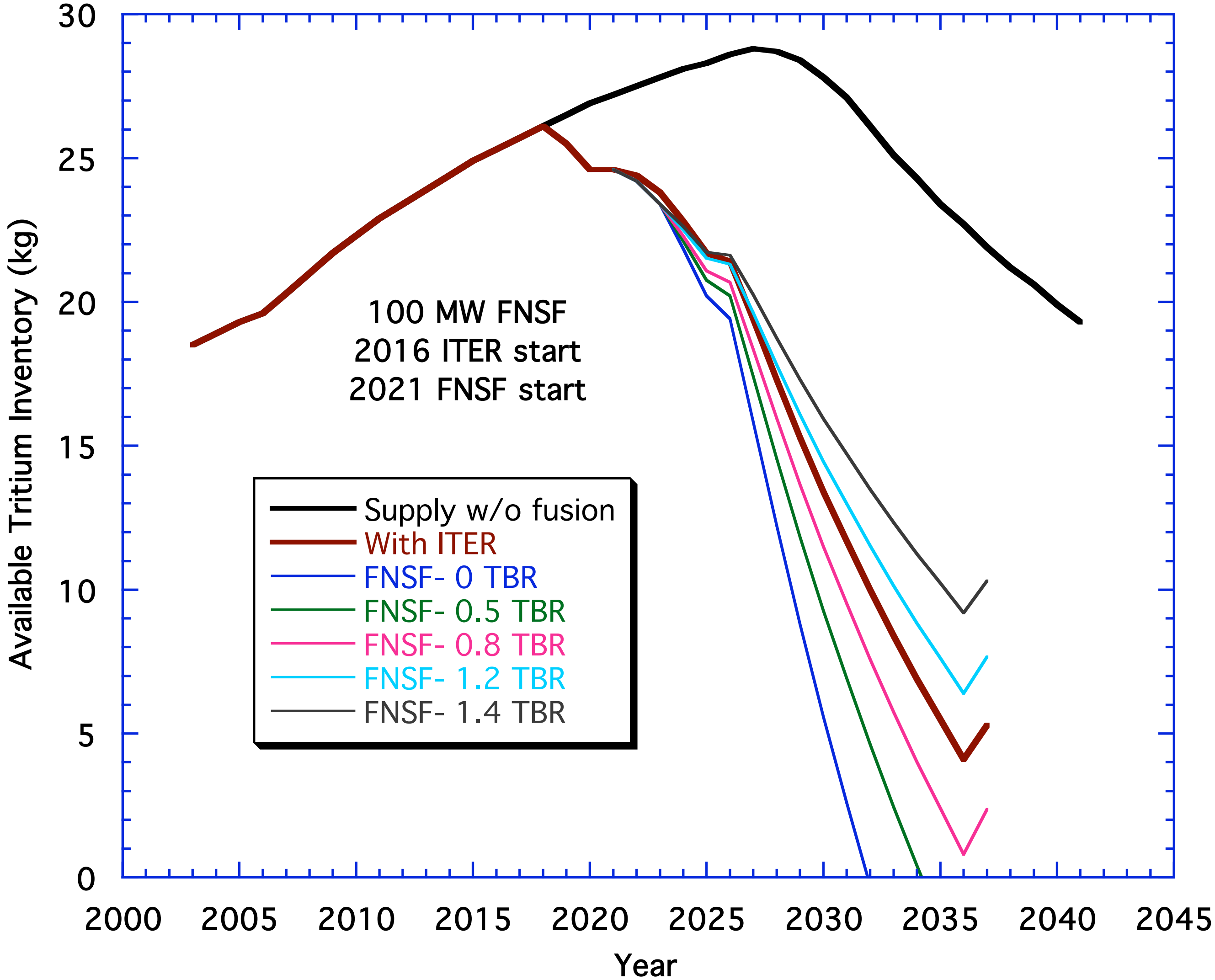
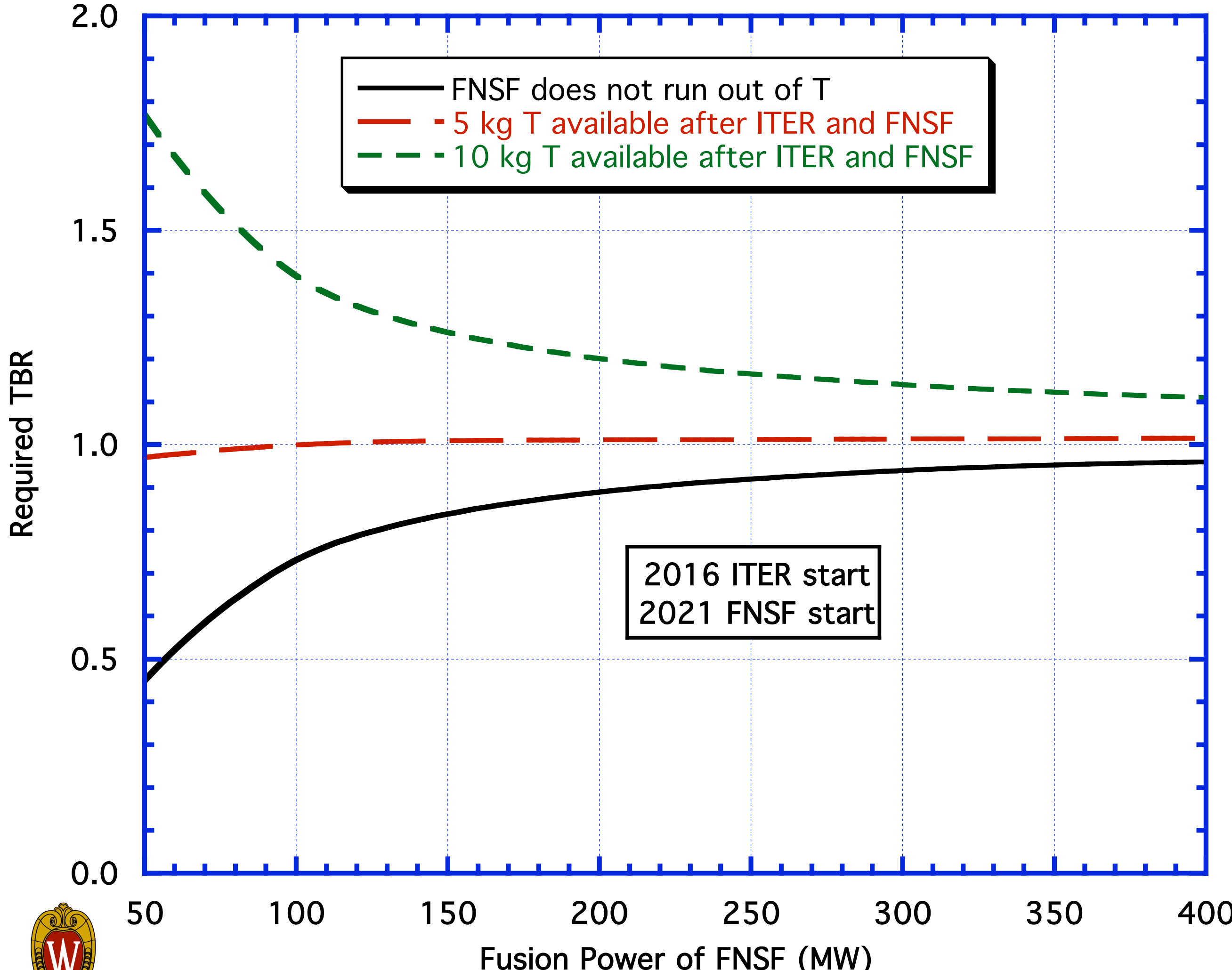
Tritium Inventory Available for DEMO at End of ITER and FNSF Operation Depends Strongly on TBR in FNSF



Required TBR in FNSF



- TBR required to ensure that FNSF does not run out of tritium supply during its operation increases as fusion power increases
- Incremental TBR required to provide a given additional tritium for DEMO is larger for lower fusion power FNSF

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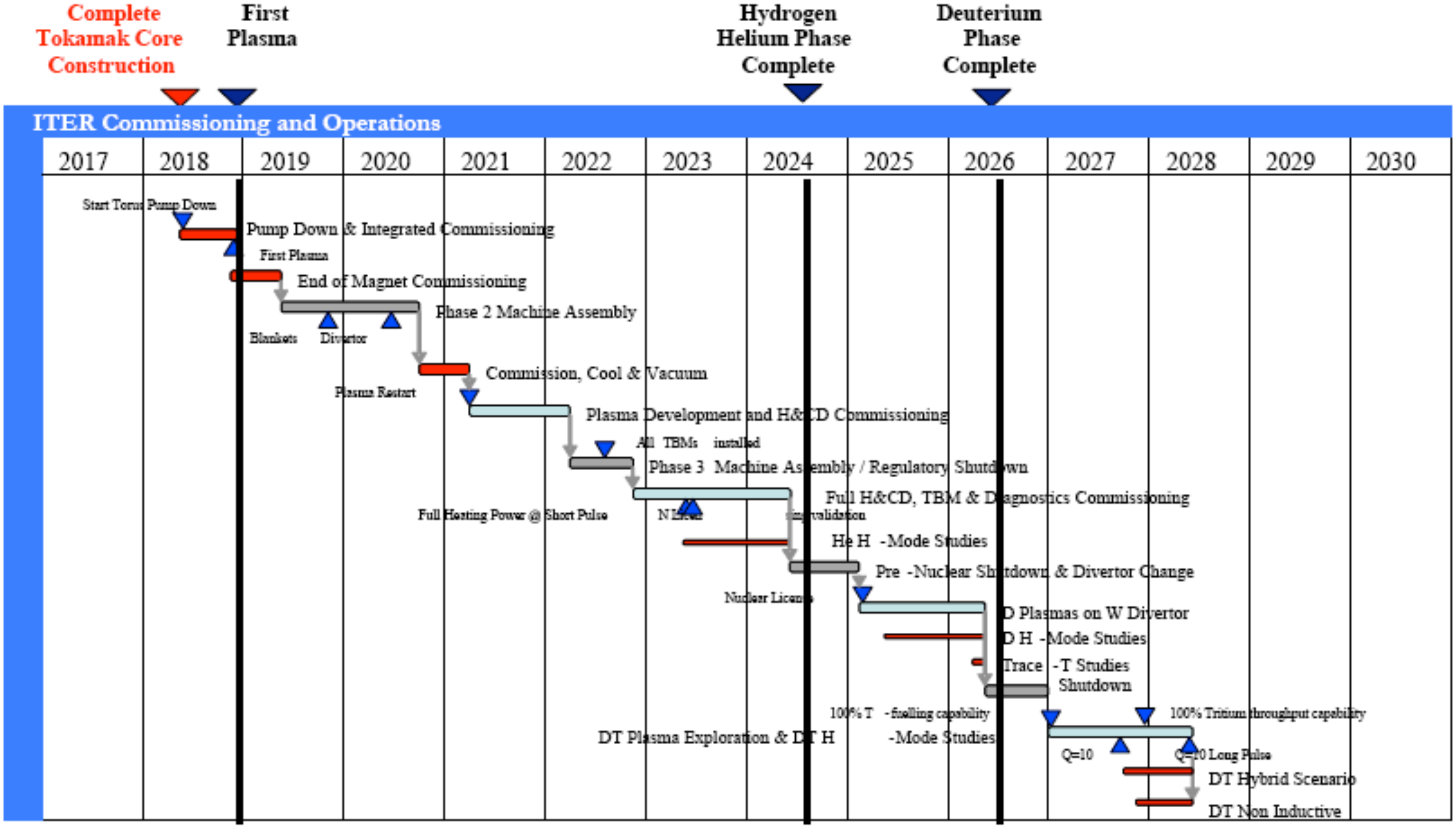
Current ITER Schedule



Start of DT operation delayed by 5 years

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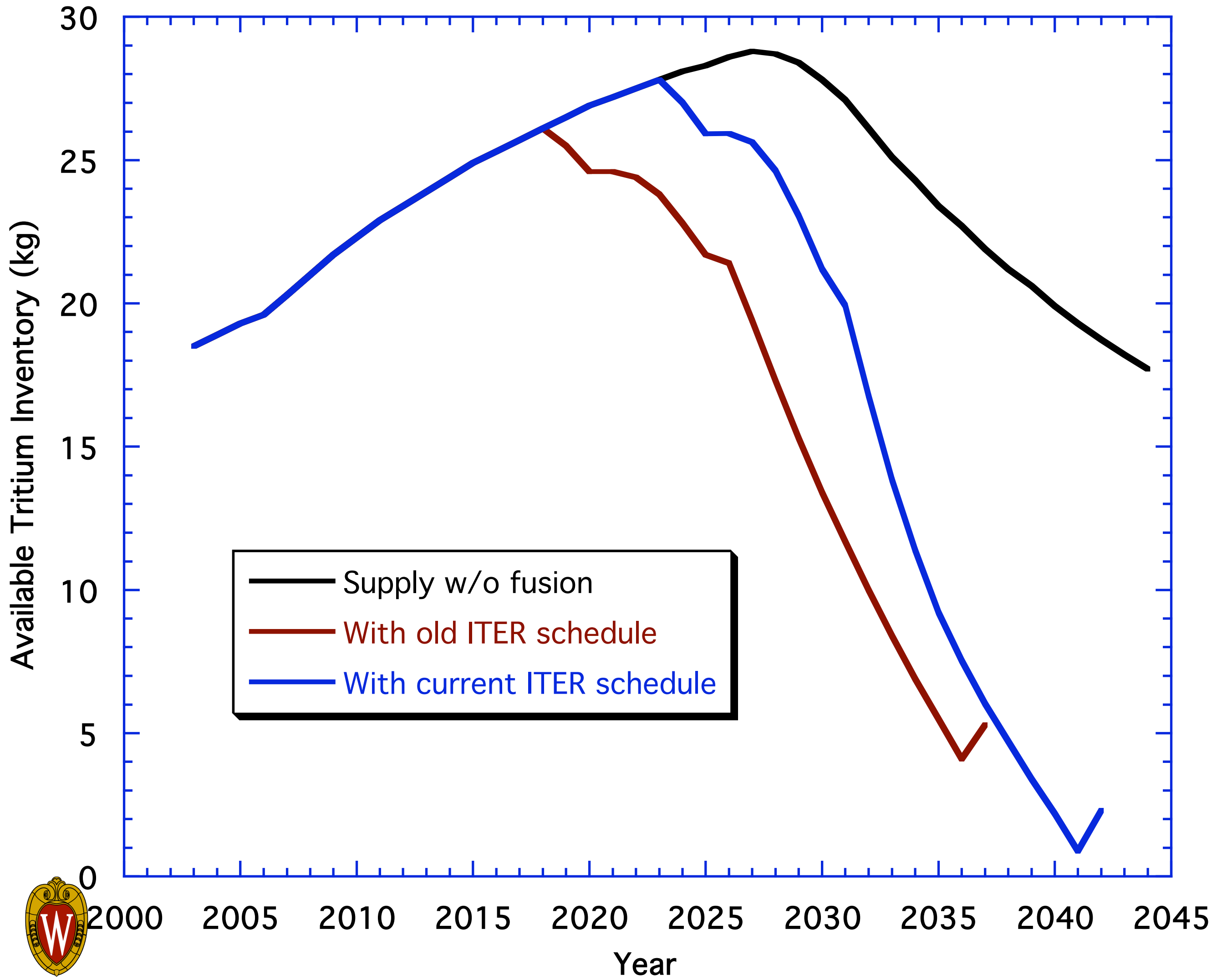
Expected External Tritium Supply Available for FNSF with Current ITER Schedule



- With the current ITER start delay almost all tritium supply will be used by ITER and FNSF has to be self-sufficient in tritium in addition to providing initial startup inventory for DEMO
- TBR required in FNSF will be higher than with previous ITER schedule

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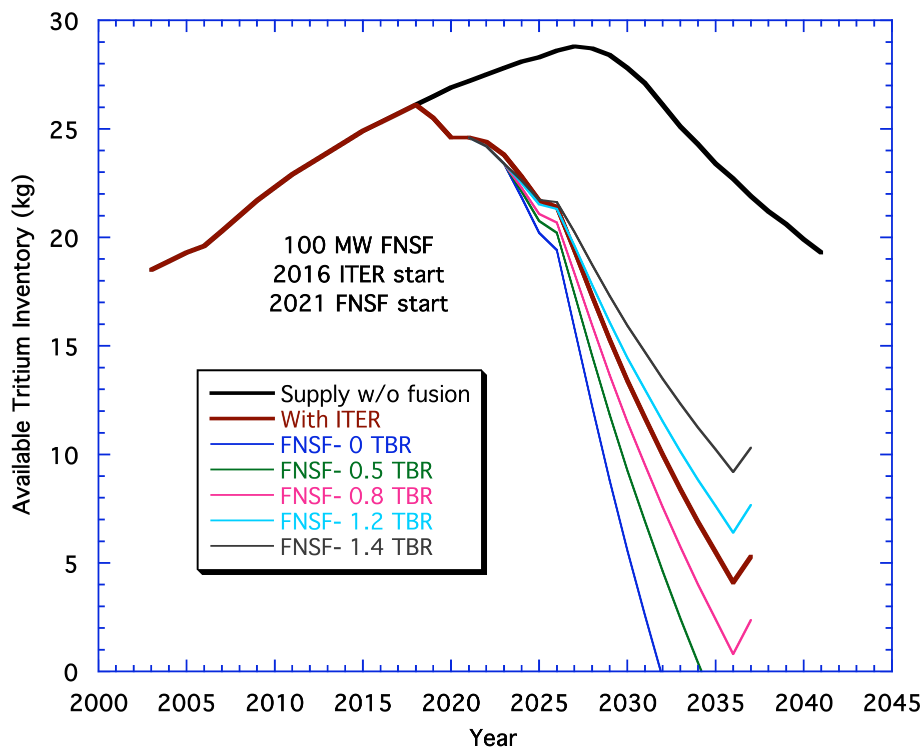
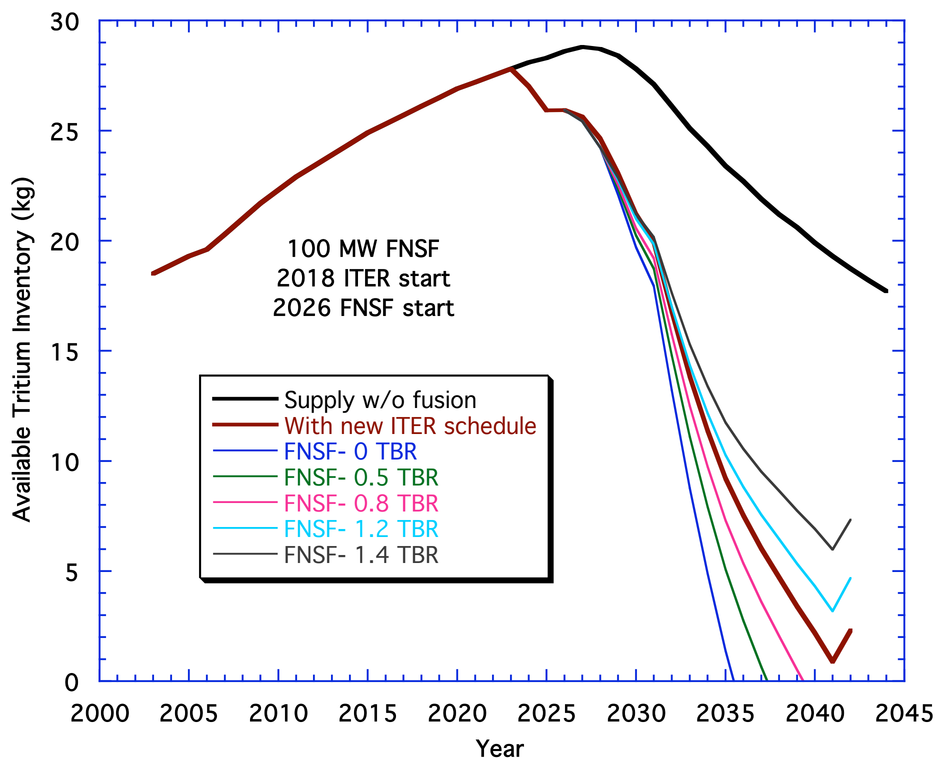
Tritium Inventory Available for DEMO at End of ITER and FNSF Operation Reduced with Delayed ITER and FNSF





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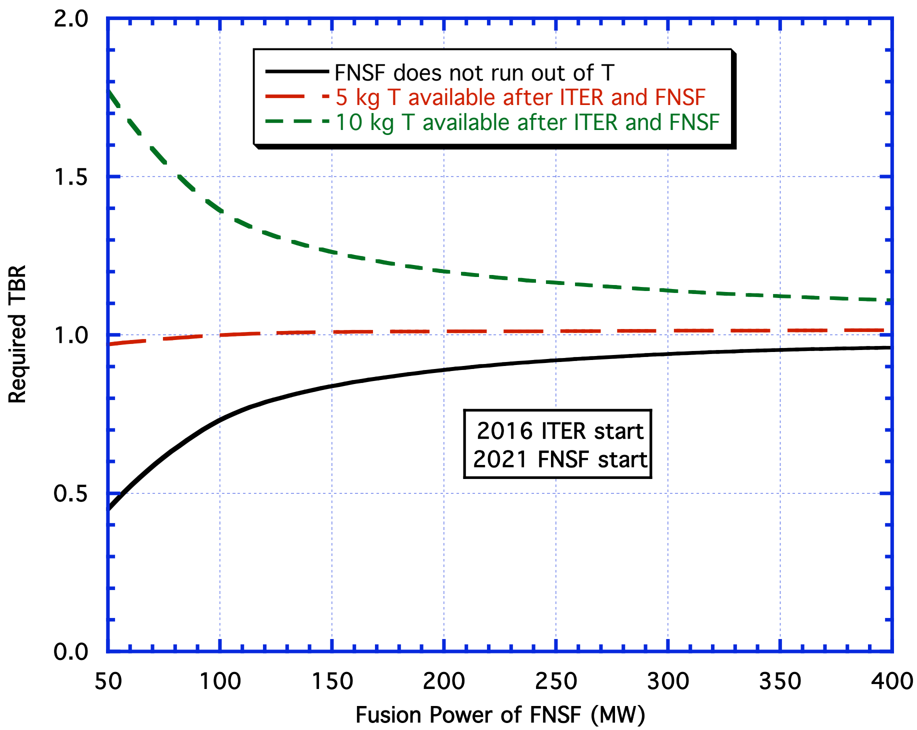
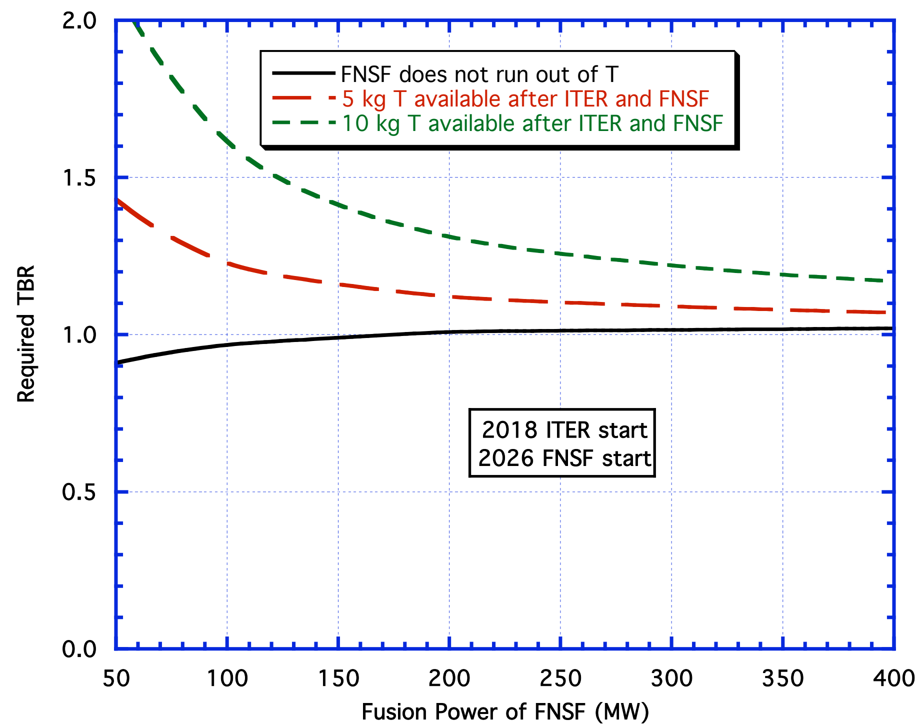
Required TBR in FNSF is Higher with Delayed ITER and FNSF





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Conclusions

- With the limited external supply and taking into account the initial ITER operating schedule (2016 start), any next step FNSF should provide significant part of its tritium need
- With available external tritium supply, a small fusion power and a modest TBR are required for FNSF to have enough tritium for its operation
- Another part of FNSF mission is to provide the initial tritium inventory needed for startup of DEMO. This increases the required TBR in FNSF. Incremental TBR required to provide a startup tritium inventory for DEMO is larger for low fusion power FNSF and large initial startup inventory for DEMO (significantly greater than 5 kg)
  - To achieve this mission, FNSF can have a TBR that increases with time with possible extension of its operation at a higher TBR
- With the current ITER start delay almost all tritium supply will be used by ITER and FNSF has to be self-sufficient in tritium in addition to providing initial startup inventory for DEMO

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