Presentation to FNSPA Core Group
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Comments on

Design Evolution of the ITER First Wall

and Applications to FNSPA

Fusion Technology 01658

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with input from

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- **Design of ITER first wall and shield**
- **Personal conclusions on lesson for FNSPA**

Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

The ITER design has a long history.

ETR/FED & INTOR
late 70's and 80s
& ITER
1985

- **ETR/FED - US design activity**
  Fusion Engineering Design Center, ORNL
- **International Effort**
  Prof. Bill Stacey (G-Tech), US Leader
- **Reagan-Gorbachov – US/USSR/EU/China**
  (mutually acceptable agreement, neutral subject, fusion)

ITER CDA, EDA & RC
1990s – 2000+

- **International partners, possible project**
- **International project precursor**
  US withdraws in 1999, rejoins in 2003
- **Baseline design**

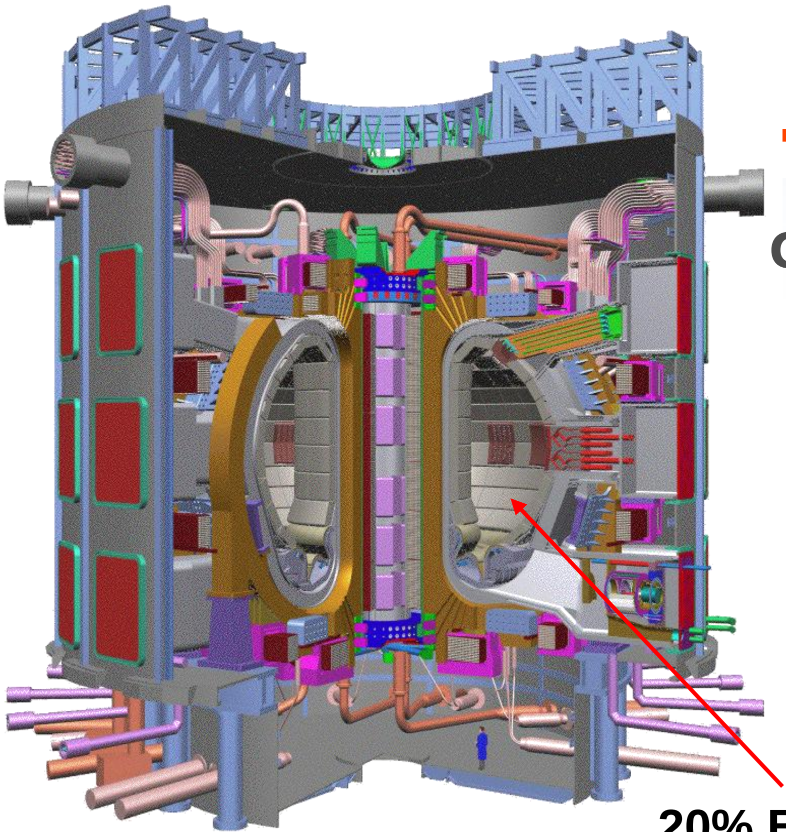
ITER Project
2005-6

- **ITER Agreement, site, legal entity**
  project started, Broader Agreement (EU-Japan)
- **Detailed design**
  more international partners

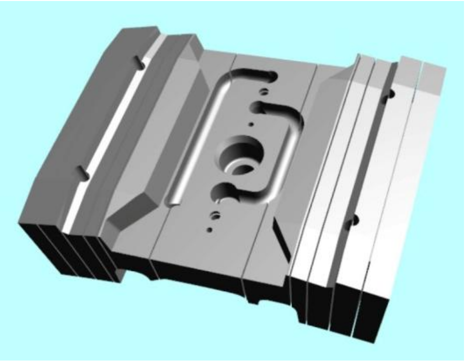
to present

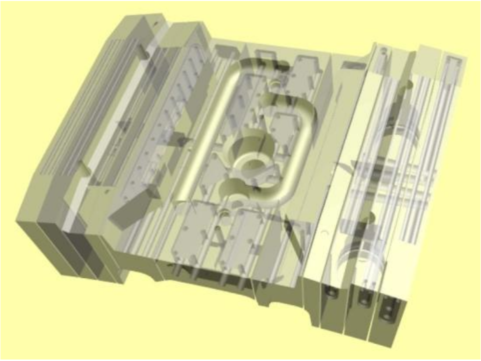
- **Design requirements, procurement**
  more design changes, new management

First Wall & Shield



Current ITER design for typical FWS module

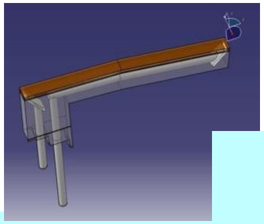




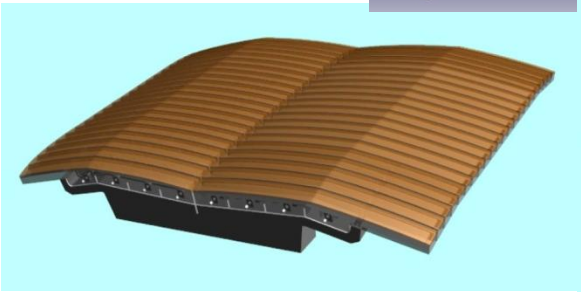
Basic shield block, with cooling channels shown (right)

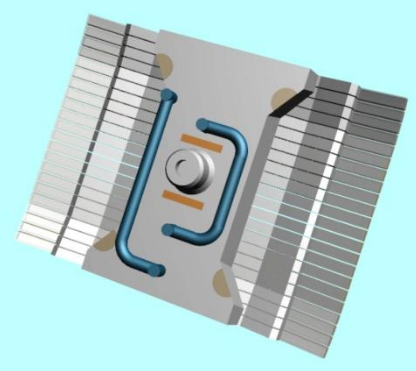
20% Blanket/Shield

US ITER in-kind contribution



Hypervapotron
FW finger





First wall, shield block sign shown (right)

Mike Ulrickson *(Sandia)* is the technical leader of US design and R&D for the FWS and also is the ITER coordinator for the Blanket Integration Product Team (BIPT, international FW partners).

Design Drivers - Loads

Plasma heat load from conduction along field lines

- Power e-folding length has a range of values
- Power to a surface depends on surface shaping and e-folding length (compromise)

Mechanical allowable

- Determined from a combination of rules and regulations

> - ASME boiler code
> - Modifications by French Nuclear Regulations
> - Modifications by ITER (somewhat untested because fusion is new reactor concept)

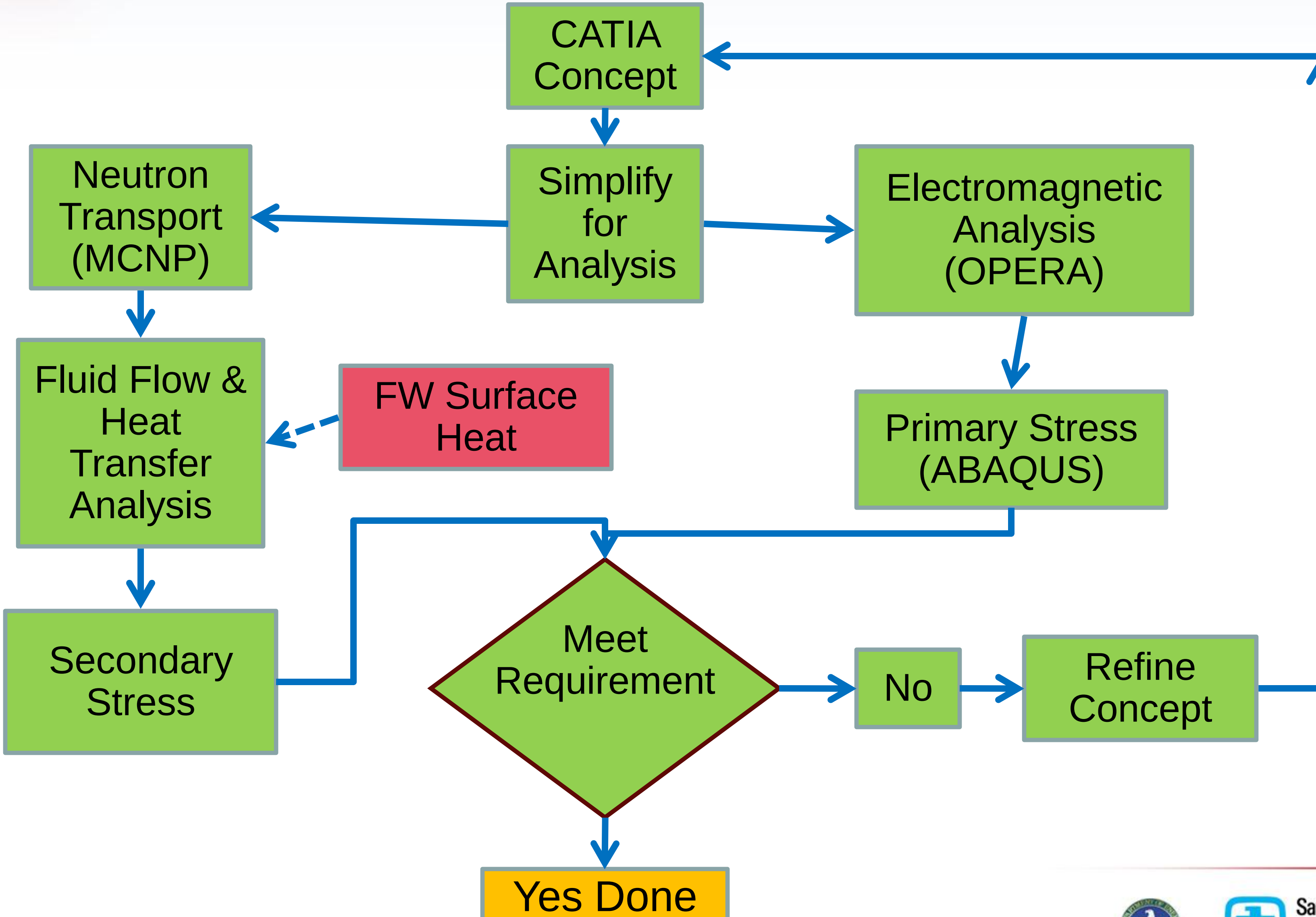
Neutron heating

- Depends on component composition
- Depends on water content (compromise)

Interfaces

- Coolant manifolds, coils, and mounts prespecified
- First Wall to Shield Block interface (by ITER)

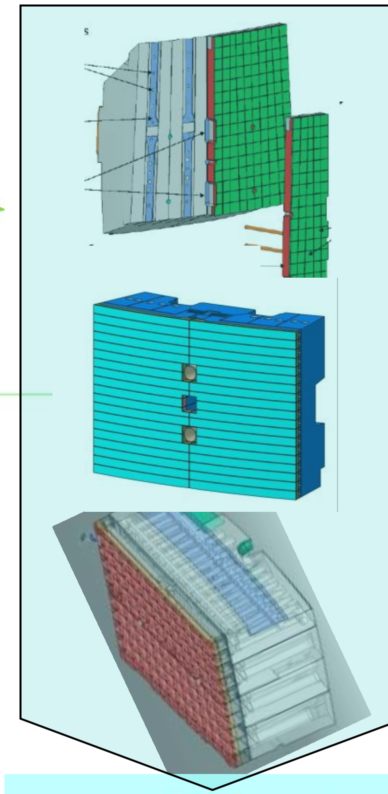
Design by Analysis Process



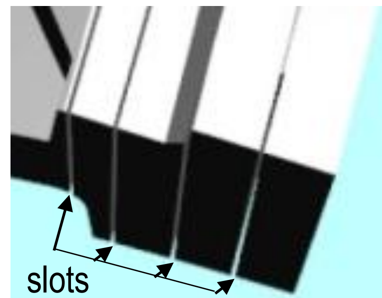
Design Evolution

The ITER design and the scope of US work on the FWS have evolved due to the changing requirements realized by the project.

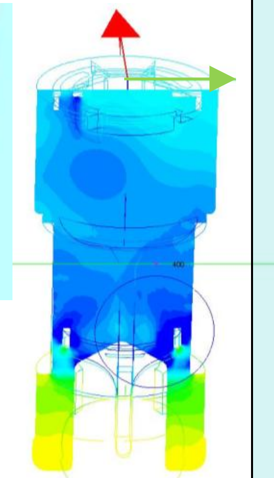
Example 1 (big change): Much higher transient heat loads (from 0.5 to 5MW/m^2 peak) required total redesign of the FW.



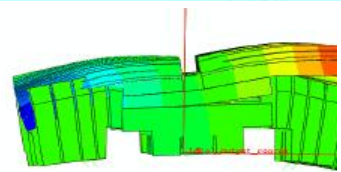
Examples of smaller changes:



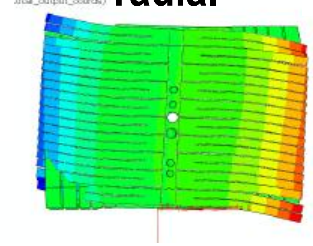
Better EM analyses refined
a. subdivision (slots) in shield,
b. first wall finger design,
c. increased loads for wall mounts.



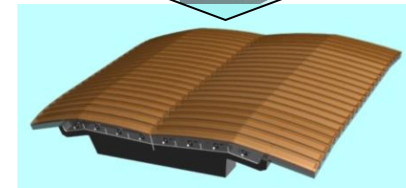
FW flow hub

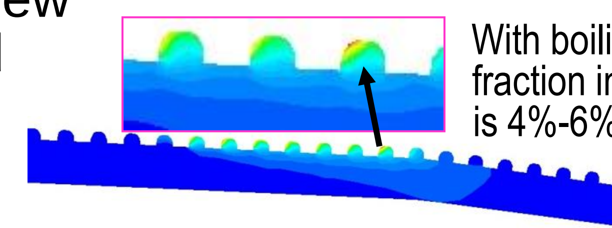


Better analyses of coolant flow with CFD models replacing heat transfer correlations led to many redesigns:
d. FW flow hub,
e. shield plenum behind FW,
f. distribution of channels in shield,
g. hypervapotrons for new Enhanced Heat Load FW modules.



Disruption, EM analysis BM4





With boiling, the vapor fraction in the grooves is 4%-6% on average.

Design Evolution

The ITER design for the FW and shield has changed dramatically for various reasons that include:

a. the style of management of the design process

b. improved understanding of heat loads and power flow

c. more and improved detail design analysis

d. supporting design R&D on components

e. design integration of subsystems

f. forcing function of required details for procurement

g. others …

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Changes from these (b-d) are HARD TO PREDICT in a DESIGN STUDY.