Issues and Challenges of Fast Reactors: Imaginative Breakthrough vs. Business as Usual

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DISCUSSION ON BREEDING

Excerpt from Report N–1729. (Notes on meeting of April 26, 1944).

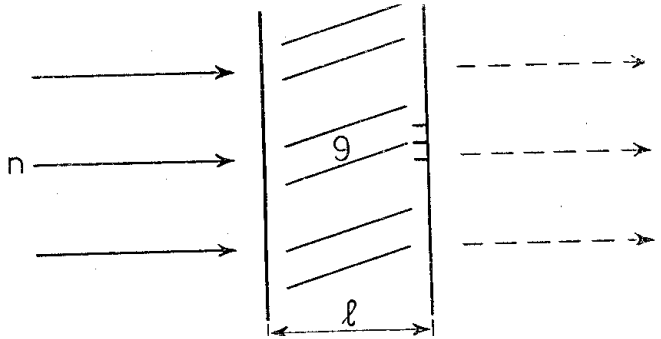
Present: FERMI, ALLISON, SZILARD, WIGNER, WEINBERG, SEITZ, MORRISON, COOPER, VERNON, TOLMAN, WATSON, OHLINGER.

This leads to the equation

$$(1) \qquad \text{Breeding ratio (without losses)} = \frac{\nu_9 + \beta\nu_8 - 1 - \alpha - \beta}{1 + \alpha} .$$

What value of this ratio can we hope to obtain in a " fast " pile (with a core of 9 surrounded by 8) ?

The most important term in (1) is $\nu_9 - \alpha - 1$. It can be evaluated essentially by a single experiment:



Neutron excess discovered!!

The neutron beam traversing a layer l cm thick of 9, is decreased by absorption and swelled by fission neutrons. The intensity of the transmitted beam is changed by a factor of

$$1 + \sigma_f l (\nu_9 - 1) - \sigma_f \alpha l$$

or

$$1 + l [\sigma_f (\nu_9 - \alpha - 1)].$$

A simple transmission experiment thus permits to evaluate the expression in square brackets. The result of such an experiment, performed at Y is

$$\nu_9 - \alpha - 1 = 1.85$$

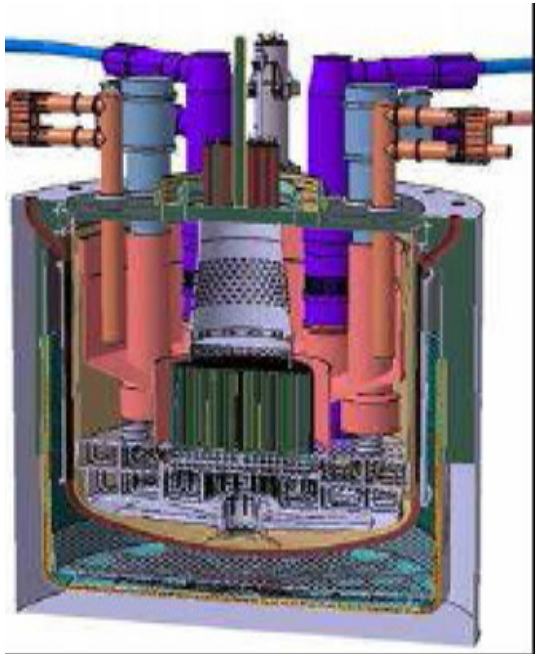
FR flexibility: breed, burn, or breed while burning

This is the gateway towards major opportunities

Whenever an option is considered for sustainability and optimized waste management, the initial Fermi intuition is confirmed and a fast neutron spectrum is consistently required

A major medium/short term challenge

- At present, there is a convergence on the choice of Na as coolant, with oxide or metal (e.g. for high CR) fuel: how to account for innovation?
- Irradiation capabilities are, and will stay for some time, scarce.
- It seems also sensible to explore/develop a viable back-up option:
  - Lead and Nitride fuel?
  - Gas and Carbide fuel?
  - Other?



"The proof is in the pudding"

Both 1) an innovative Na-cooled Prototype and 2) an Experimental Reactor for a back-up option should/could be joint international initiatives

Medium term challenges

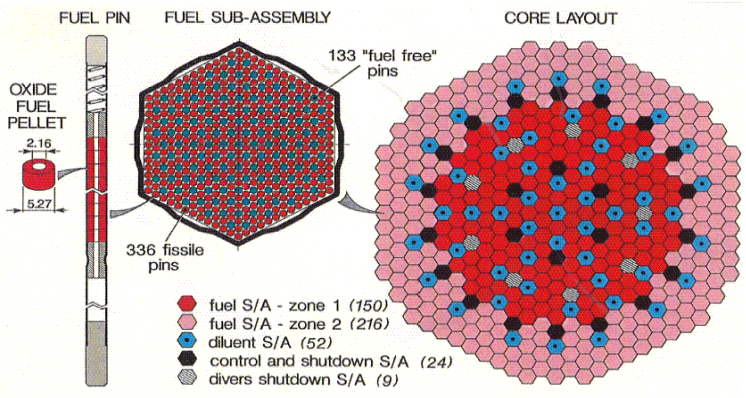
- Availability and reliability (a major utility requirement).
- Reversibility (from burner to breeder and vice versa: prepare for new technologies breakthrough)
- Convergence of safety approaches. Revisit re-criticality
- Fuel and clad performance: beyond 20-30 at% BU and beyond 200 dpa. Transient behaviour of MA-loaded fuel
- Plant simplification (intermediate circuit) and cost
- Conversion ratio higher than 1.5 and non-proliferation concerns
- Reduce uncertainties in all fields (advanced simulation and validation experiments)

Preliminary answers available for each of these challenges.

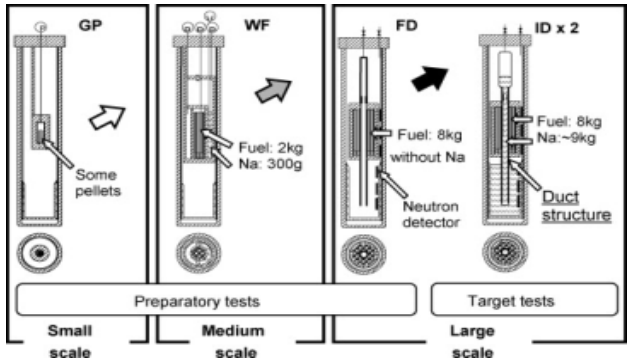
Medium term challenges

- ***Availability***: look at the record of BN-600! Also remind the progressive increase of the load factor for LWRs during the last three decades…

- ***Reversibility***: an early demonstration successful attempted in the frame of the CAPRA project



- ***Recriticality***: the EAGLE experiment and the FAIDUS concept

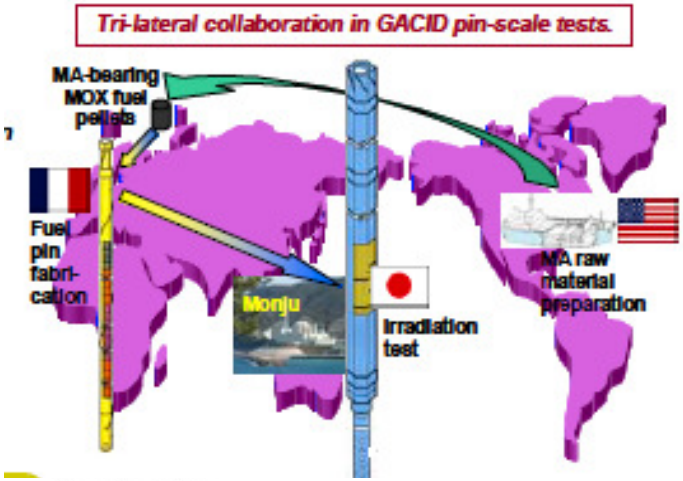


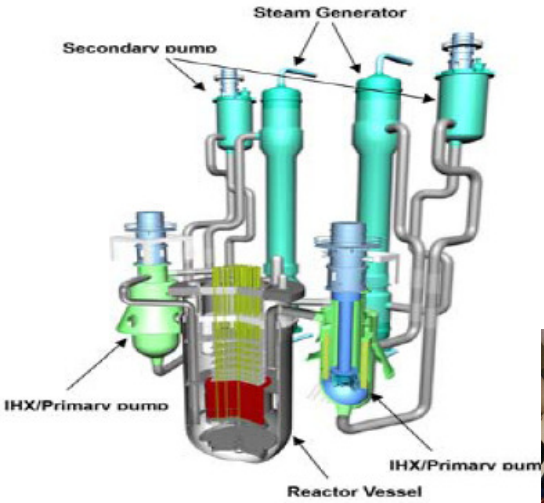
Medium term challenges

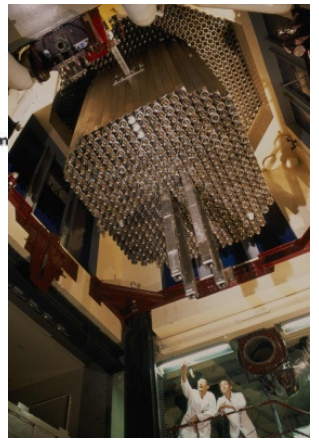
- ***Fuel and clad performance***: **new ODS and fuel fabrication routes. MA in the fuel: GACID; METAPHIX experiment follow-up; Availability of TREAT?**

- ***Plant simplification*** **etc.: JSFR cost evaluation**

- ***Reduce uncertainties:*** **advanced simulation and validation experiments, if facilities are upgraded and kept available**



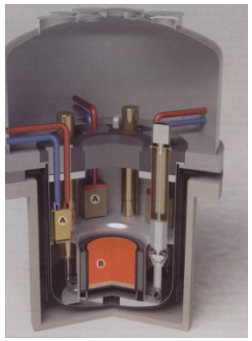




Long term challenges

- Need to revisit the standard choice of a solid fuel?
- Simplified fuel cycle and waste management
- Reprocessing? Mostly associated to the choice of a solid fuel…
- Potential for ultra long life cores?

  Traveling-wave reactors?



- Innovative materials (gateway towards higher T and burn-up)
- Advanced simulation and future fuels design

Fast reactors offer a wide range of possible transformational concepts
Prepare for a « hundred years later… » celebration in…2044!

New actors. New agendas

This is an exciting time:

- **The Monju restart-up**
- **new builds…**

The Hanuman Jump

- **new strategic requirements for fast reactor mission**
- **emergence of regional visions**

How will coexist competition and enhanced international cooperation?

Final remarks

- R&D needs will still dominate the scene for the next 10-20 years

- „Business as usual“ is not a guarantee for success. „Imaginative breakthrough“ will be needed to innovate and to cope with the most crucial issues

- International cooperation will be essential:
  - to share experimental facilities
  - To converge on safety approach
  - to provide cutting edge opportunities for education and training
- Hopefully the revival represented by this conference will be confirmed by an expansion of innovative ideas and their realization.

Thank you for your attention