Whither neutrons, or wither neutrons?

Robert McGreevy

ISIS, STFC Rutherford Appleton Laboratory, UK

Science and Technology Facilities Council

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*"How now spirit, whither wander you?" (*A Midsummer Night's Dream)

"Age cannot wither her, nor her custom stale." (Anthony and Cleopatra)

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All opinions expressed are solely my own and do not represent the views or opinions of my employer!

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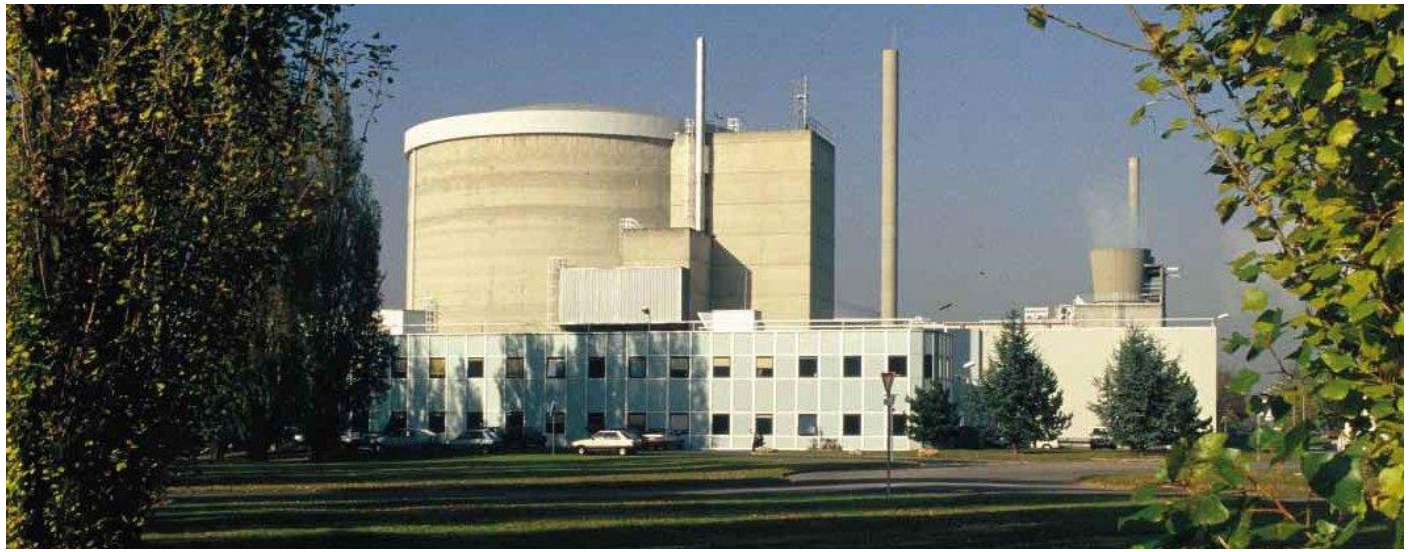
2019: Annus horribilis for European neutrons



Farewell Orphée, BER-II and Jeep-II

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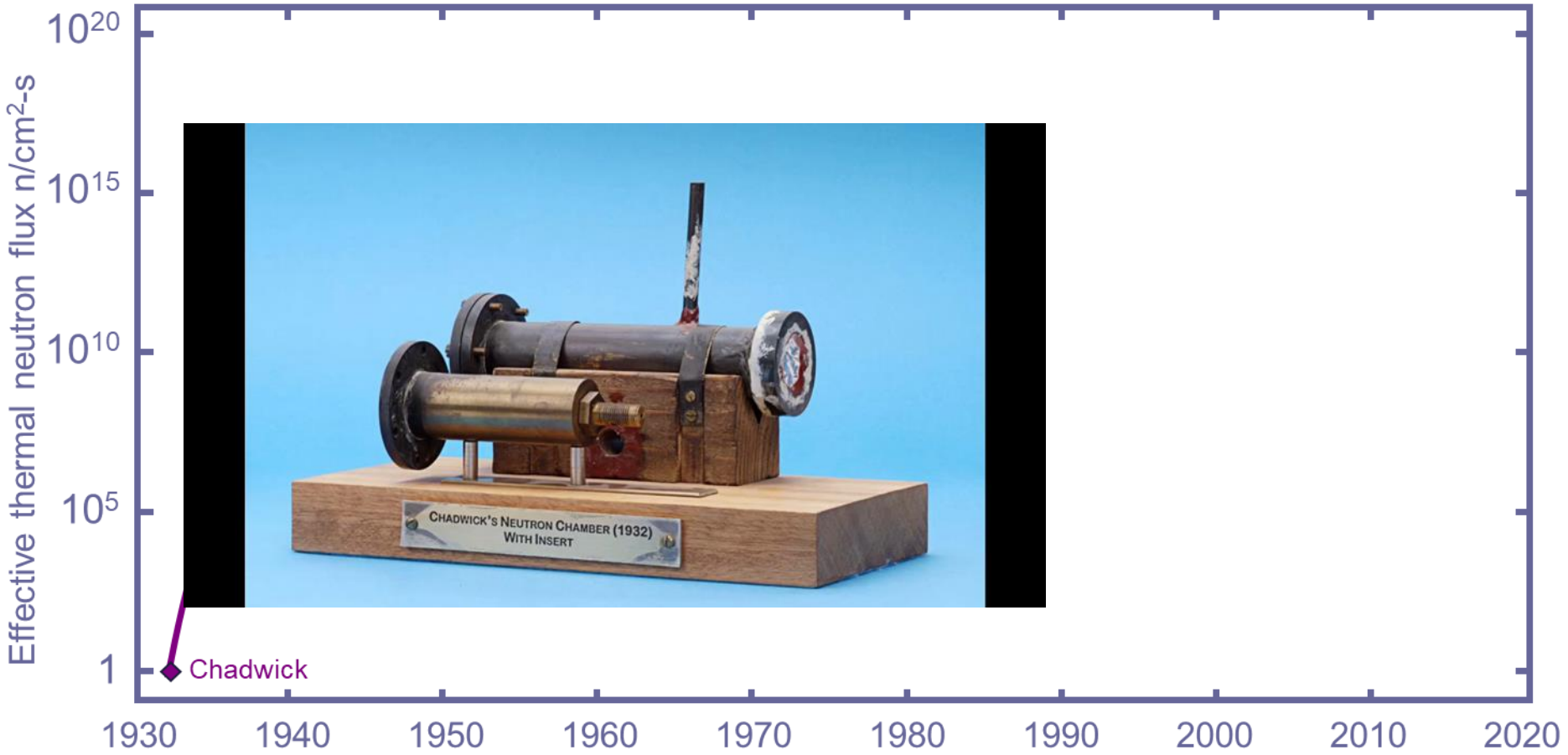
Some neutron history …



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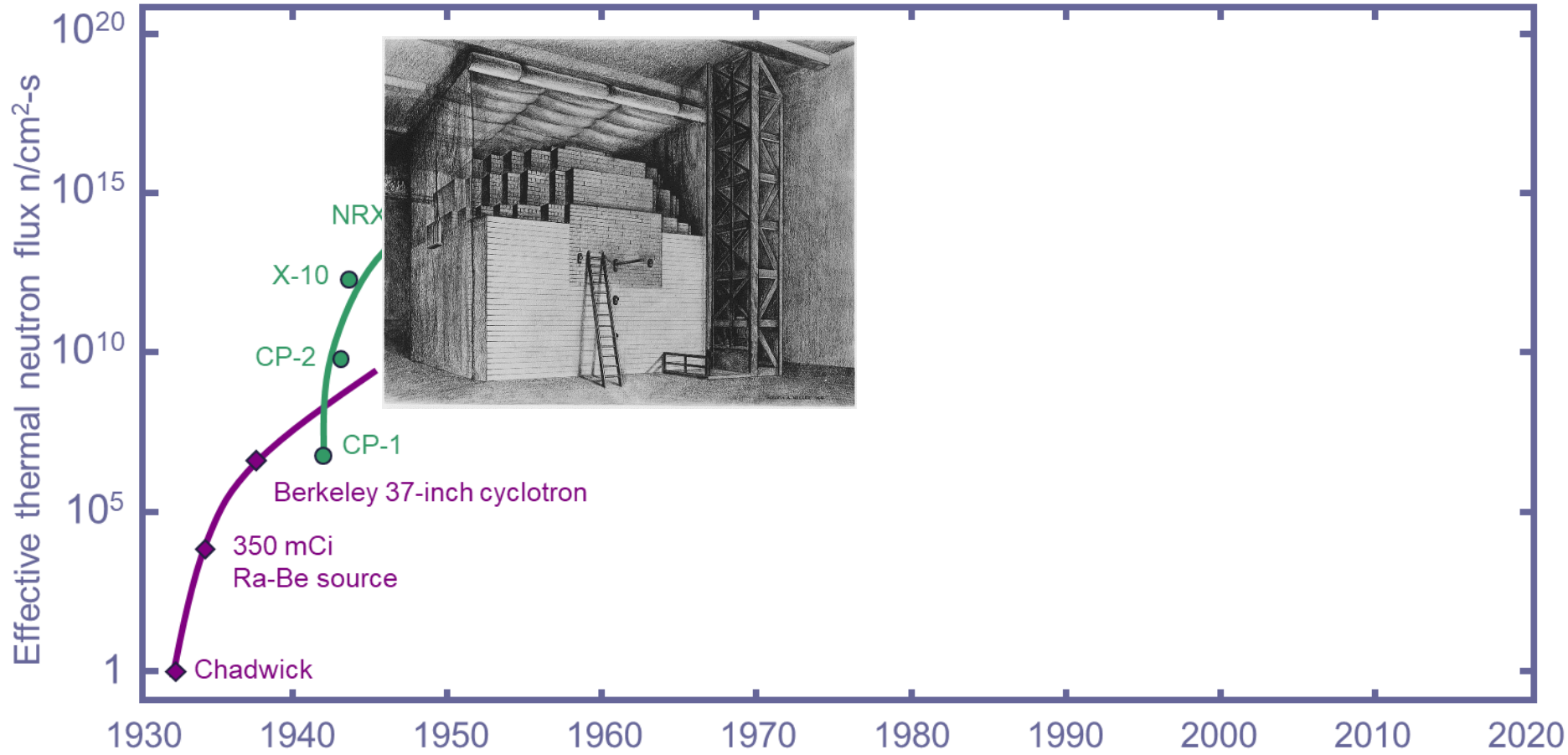

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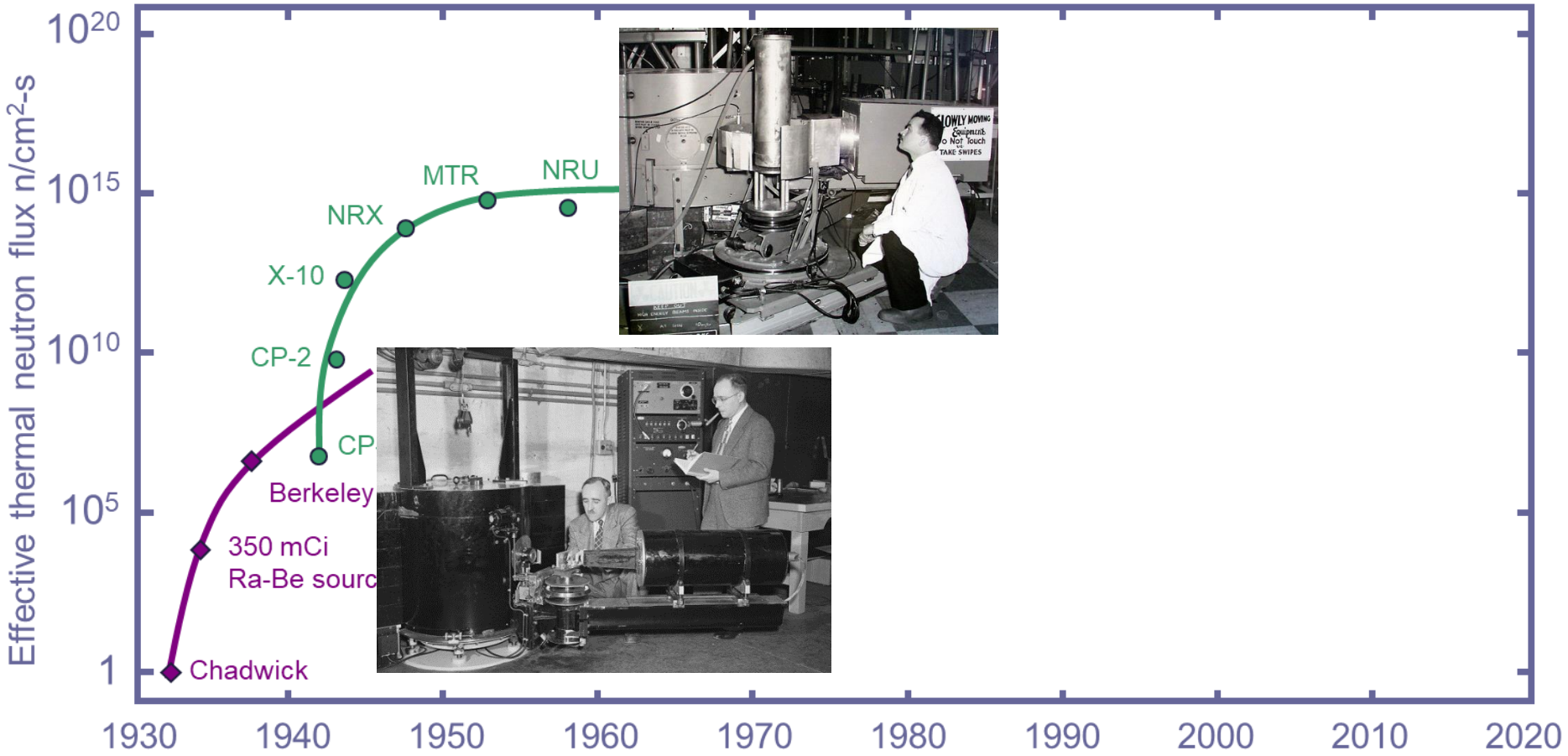

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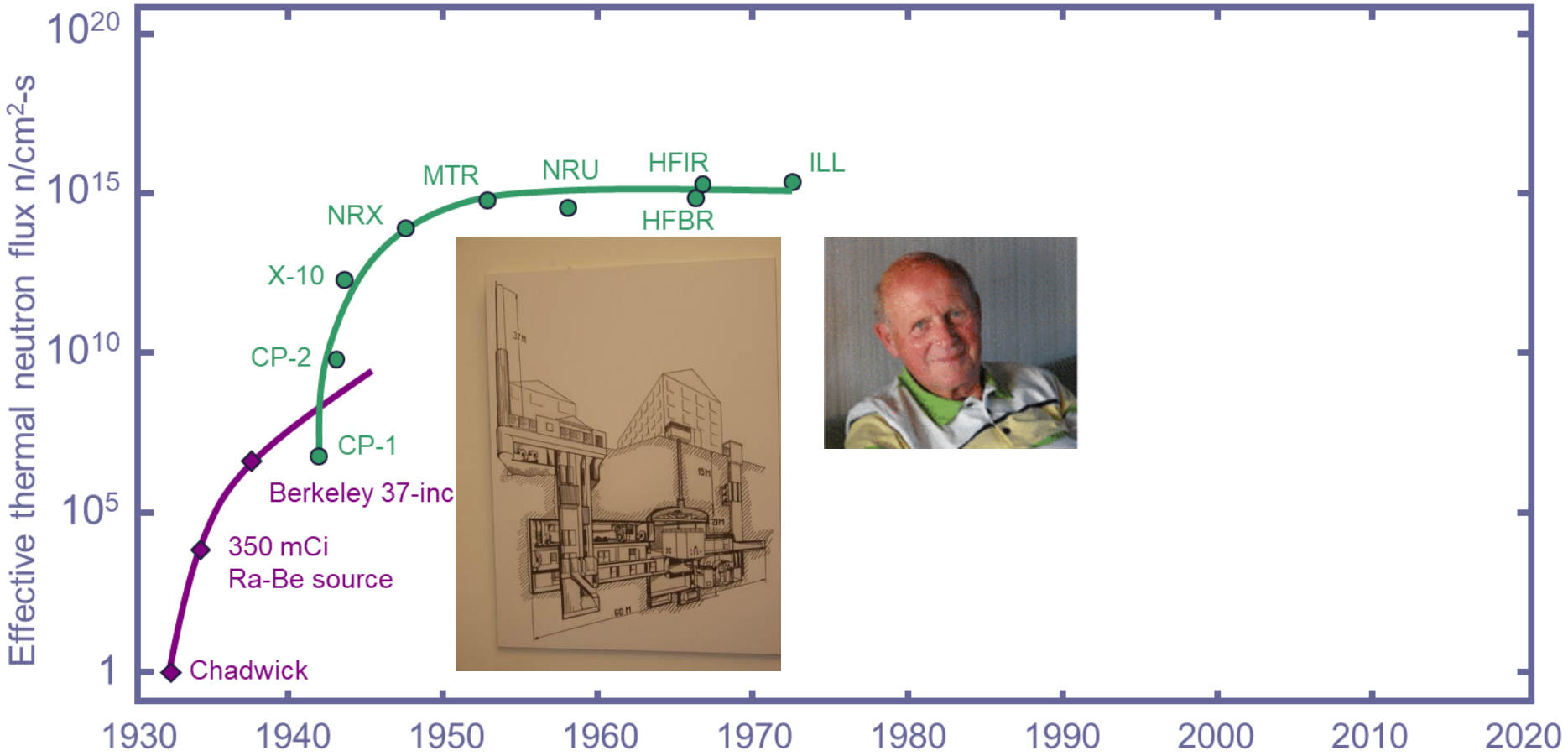

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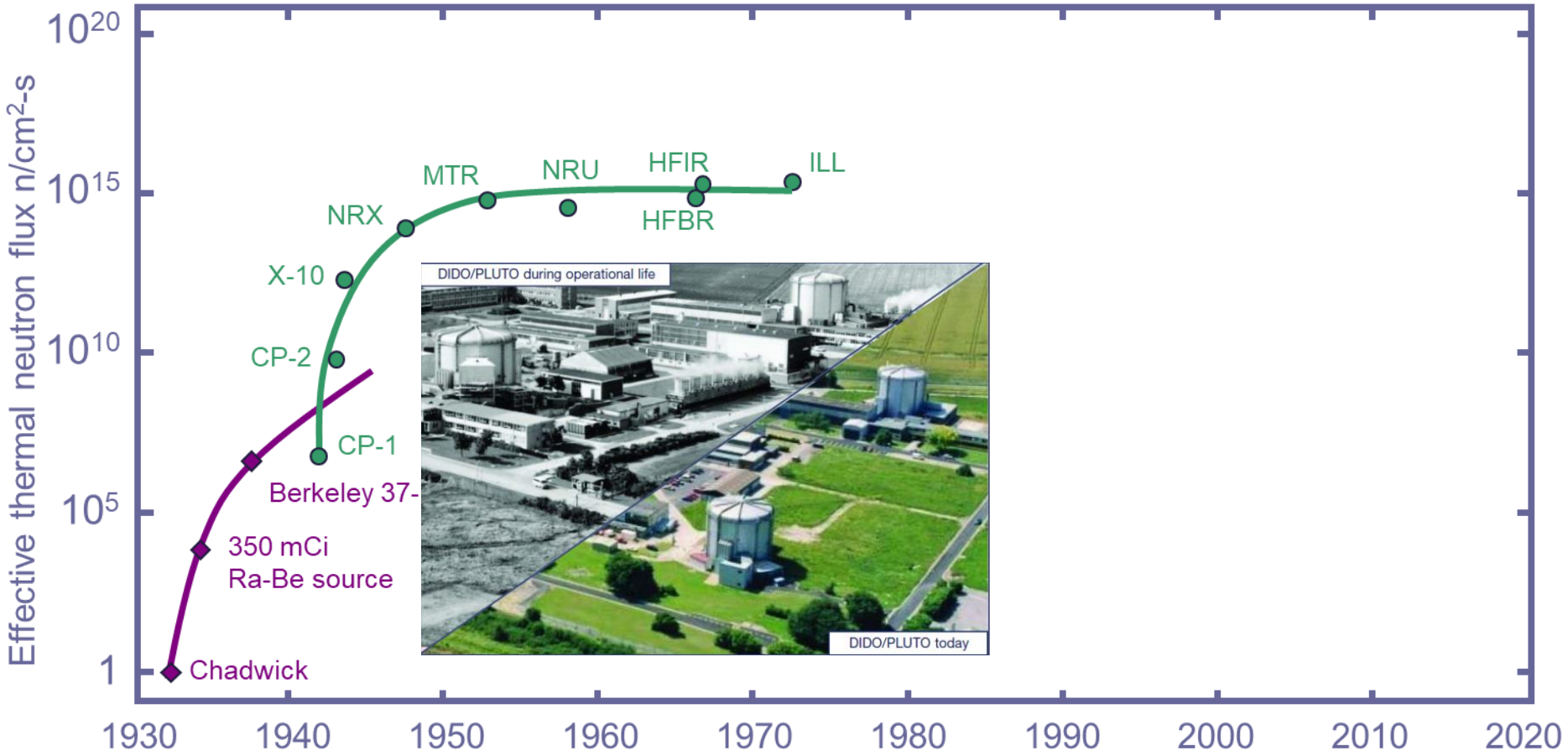

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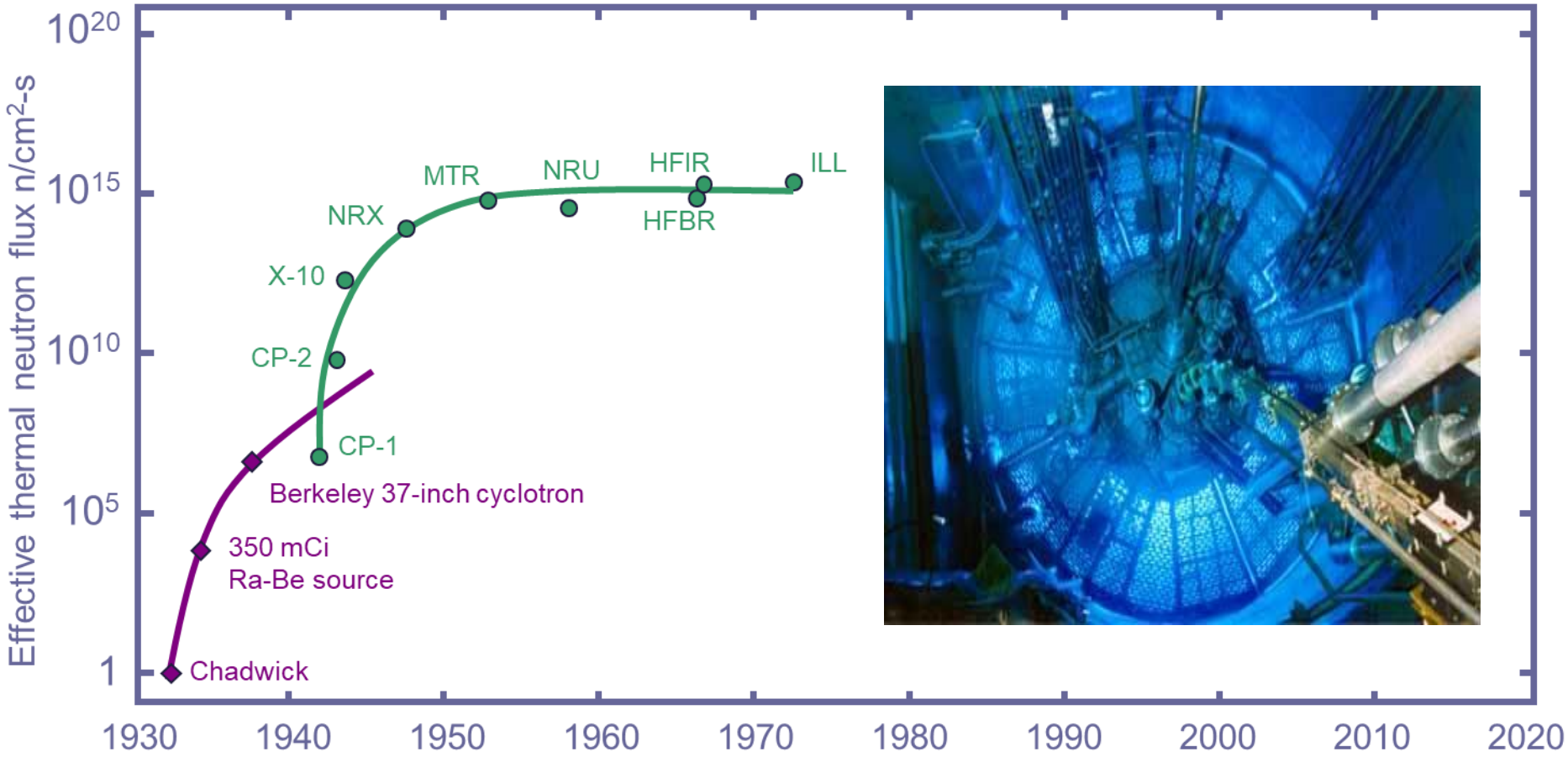

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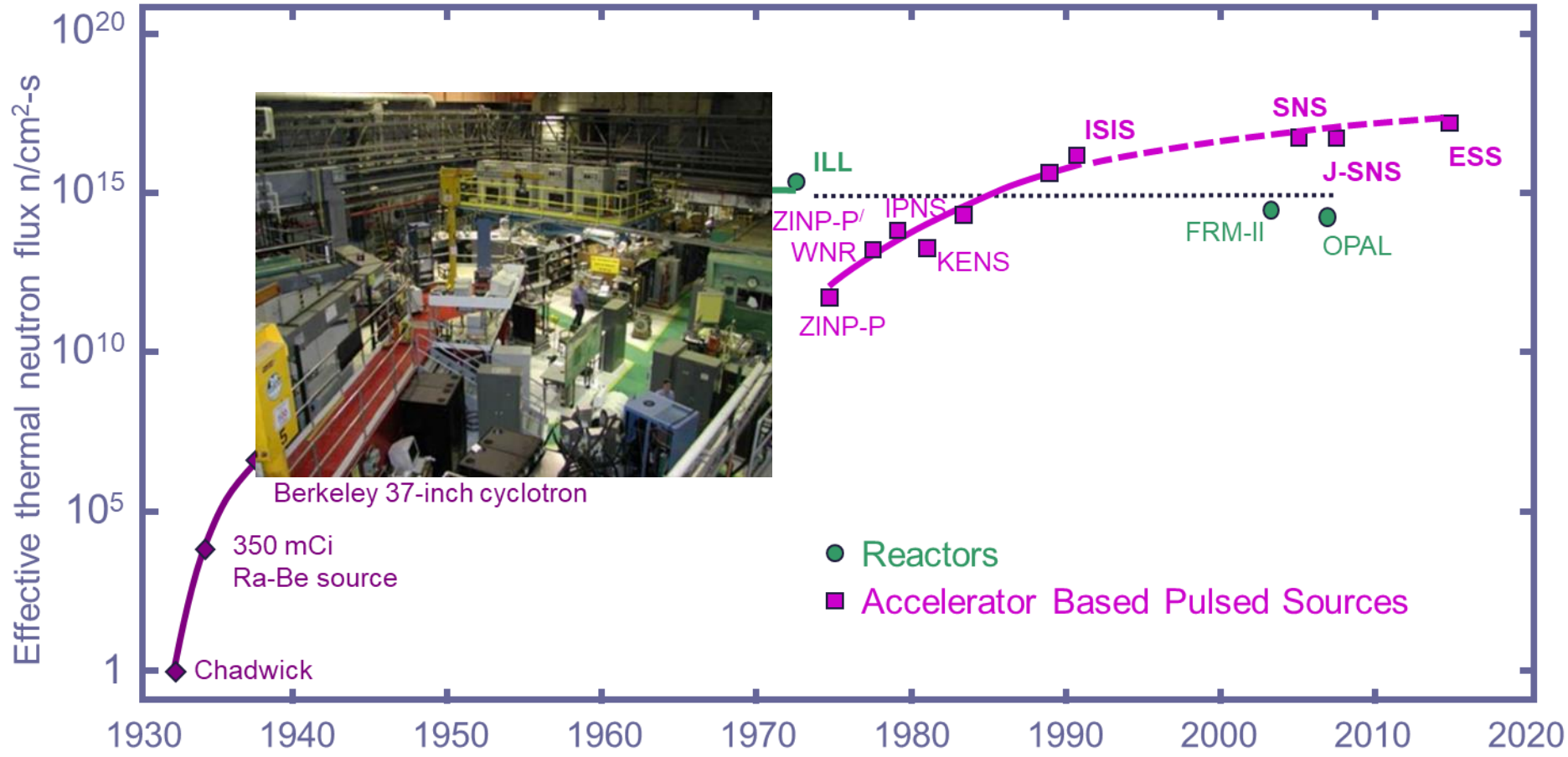

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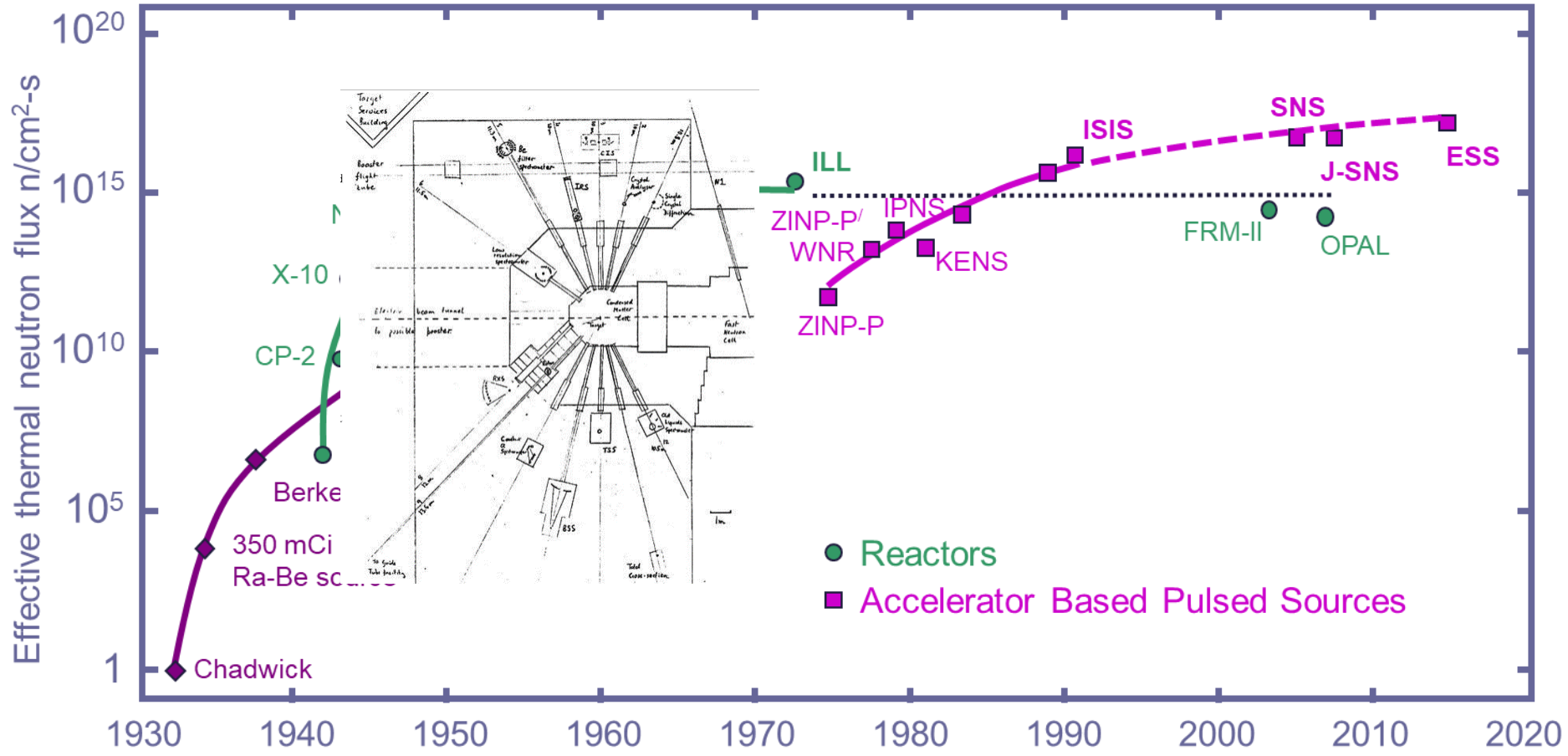

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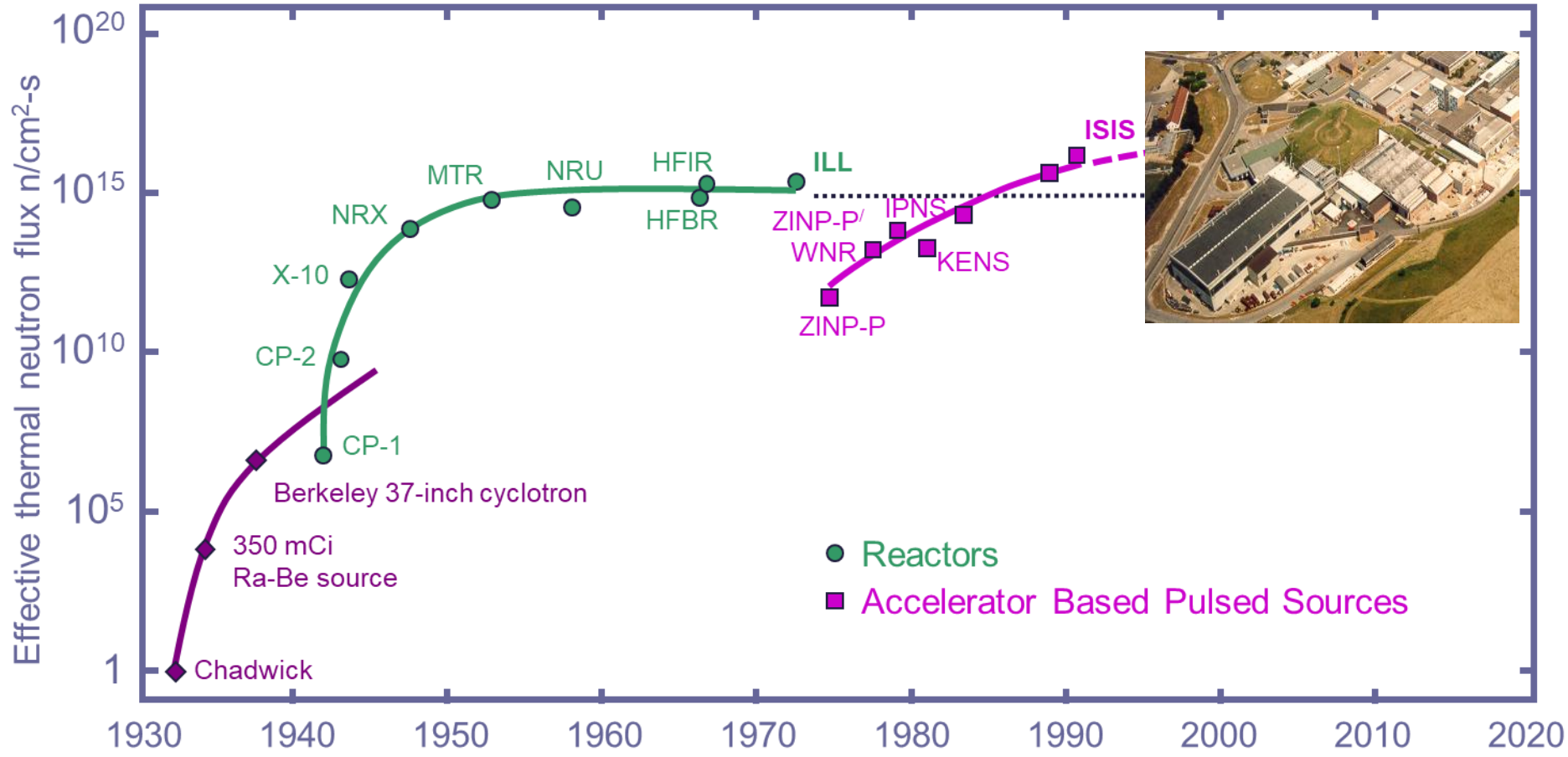

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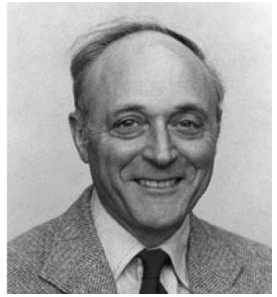
Some neutron history …

User programmes

- Early programmes ‘parasitic’ at materials testing reactors; mainly used by local scientists (staff)
- UK Neutron Beam Research Committee (1966) expanded access to the broader university research community
- Institut Laue Langevin (1971) first research reactor purpose built for an external user community. Also pioneered the use of neutron guides
- User programmes now common at synchrotrons etc.

A survey of the users' community in evidence during the past year indicated 102 FTE users and 284 part-time users, of which the numbers 70 and 255, respectively, indicate approximately the user activity at the national laboratories, including the National Bureau of Standards. (1978)

Peter Egelstaff



Gordon Squires

Bill Mitchell

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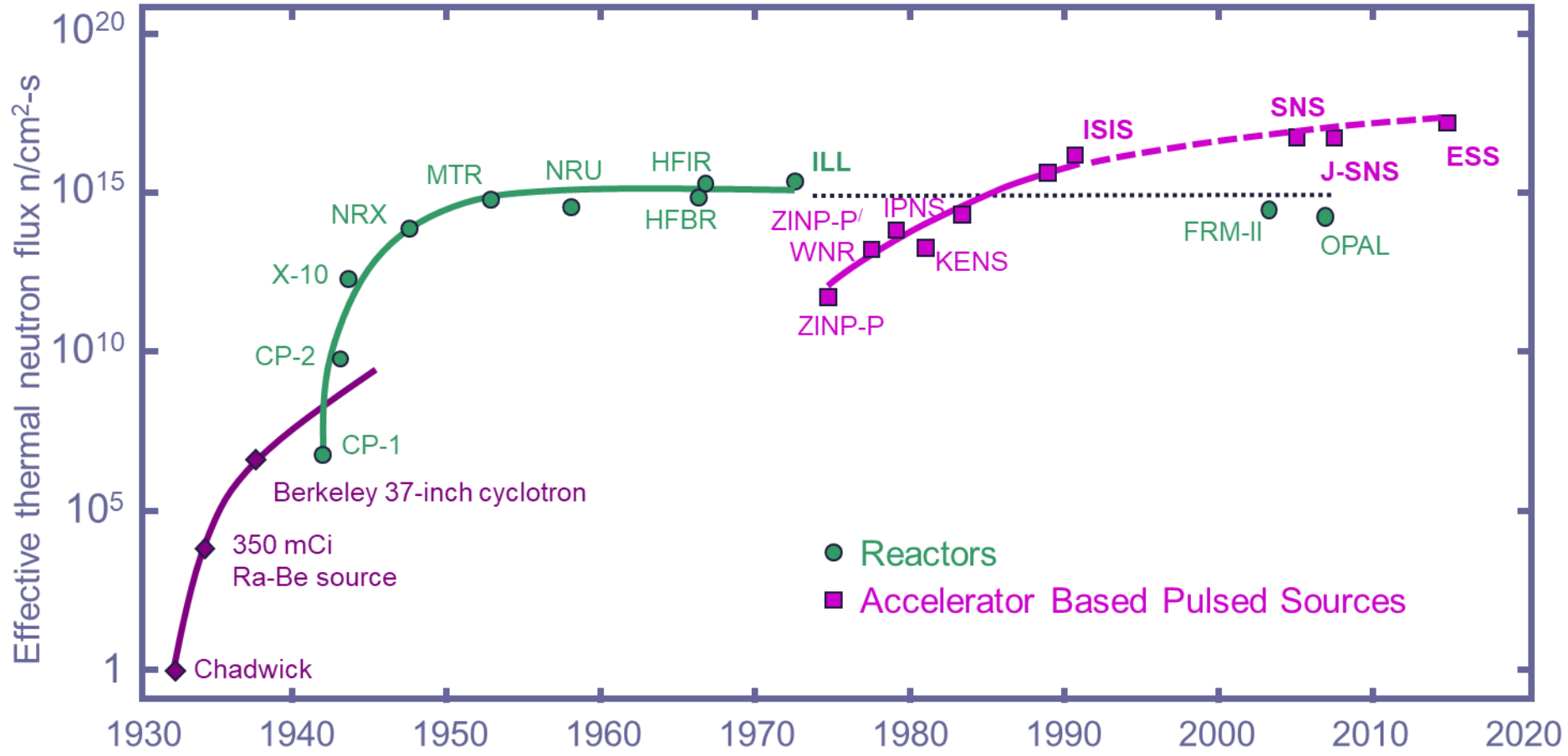

(Updated from *Neutron Scattering*, K. Skold and D. L. Price, eds., Academic Press, 1986)

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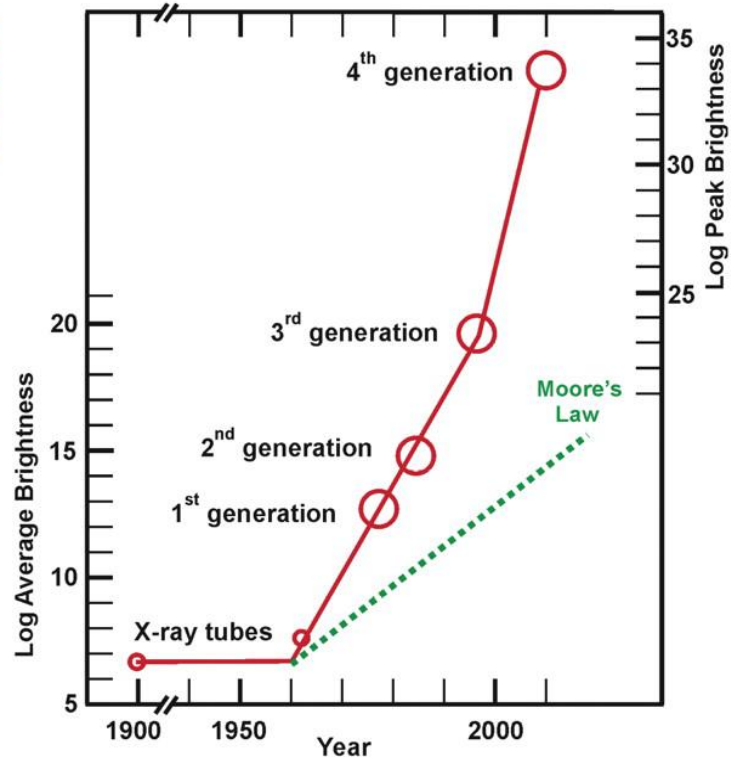
Some synchrotron history …

- 1895 Discovery of X-rays
- 1947 Observation of synchrotron radiation
- 1950's-1960's Parasitic use of particle accelerators such as DESY
- 1981 First dedicated synchrotron source ('second generation') at Daresbury, UK
- 1994 First 'third generation' source at ESRF
- 2009 Hard X-ray FEL LCLS
- 2016 MAX-IV



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Neutrons will no longer be needed …

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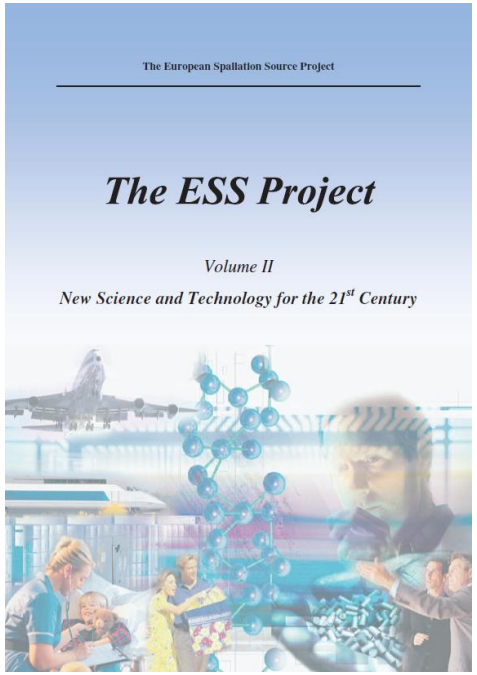

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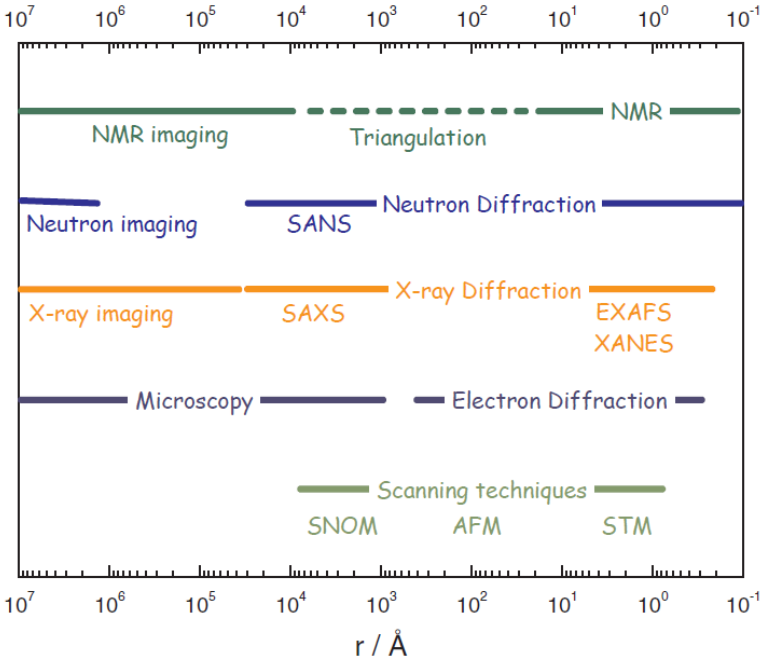

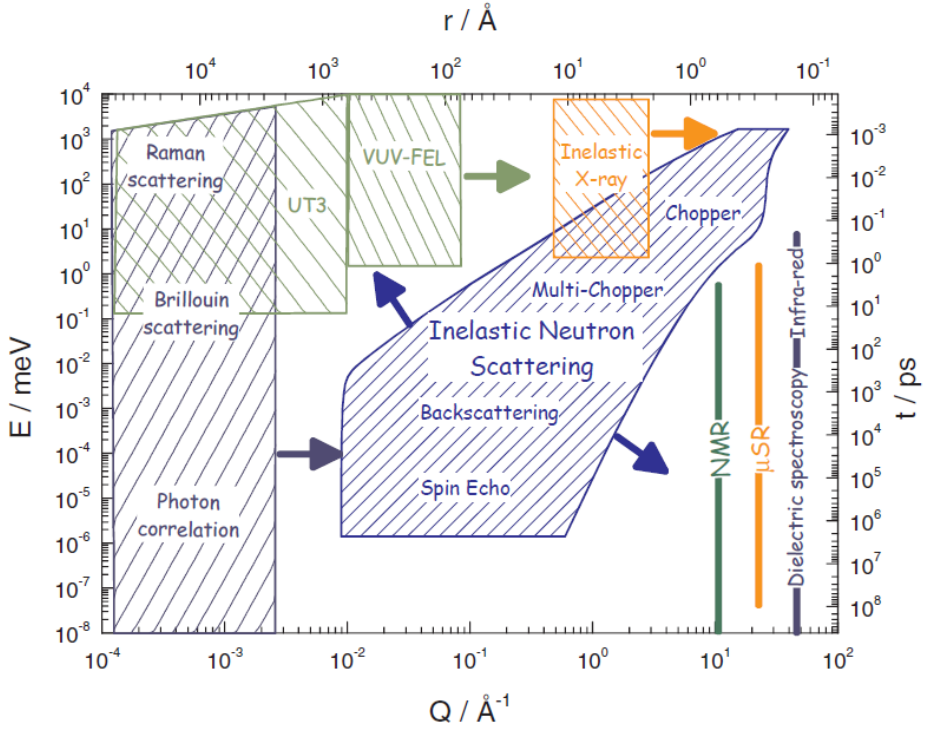

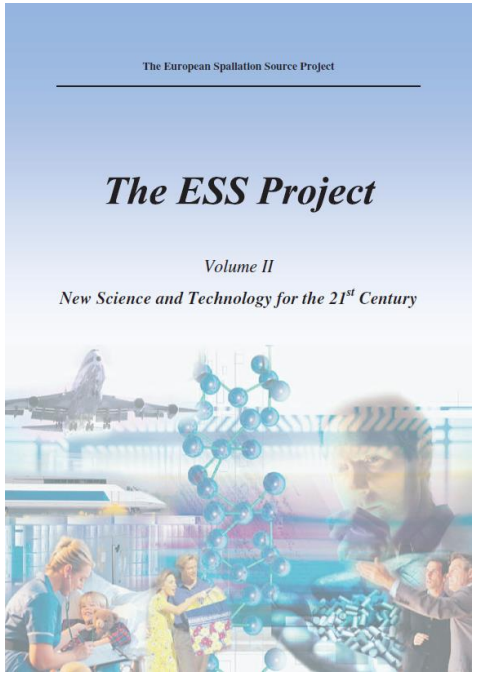

5. *Neutron Scattering and Complementary Experimental Techniques*

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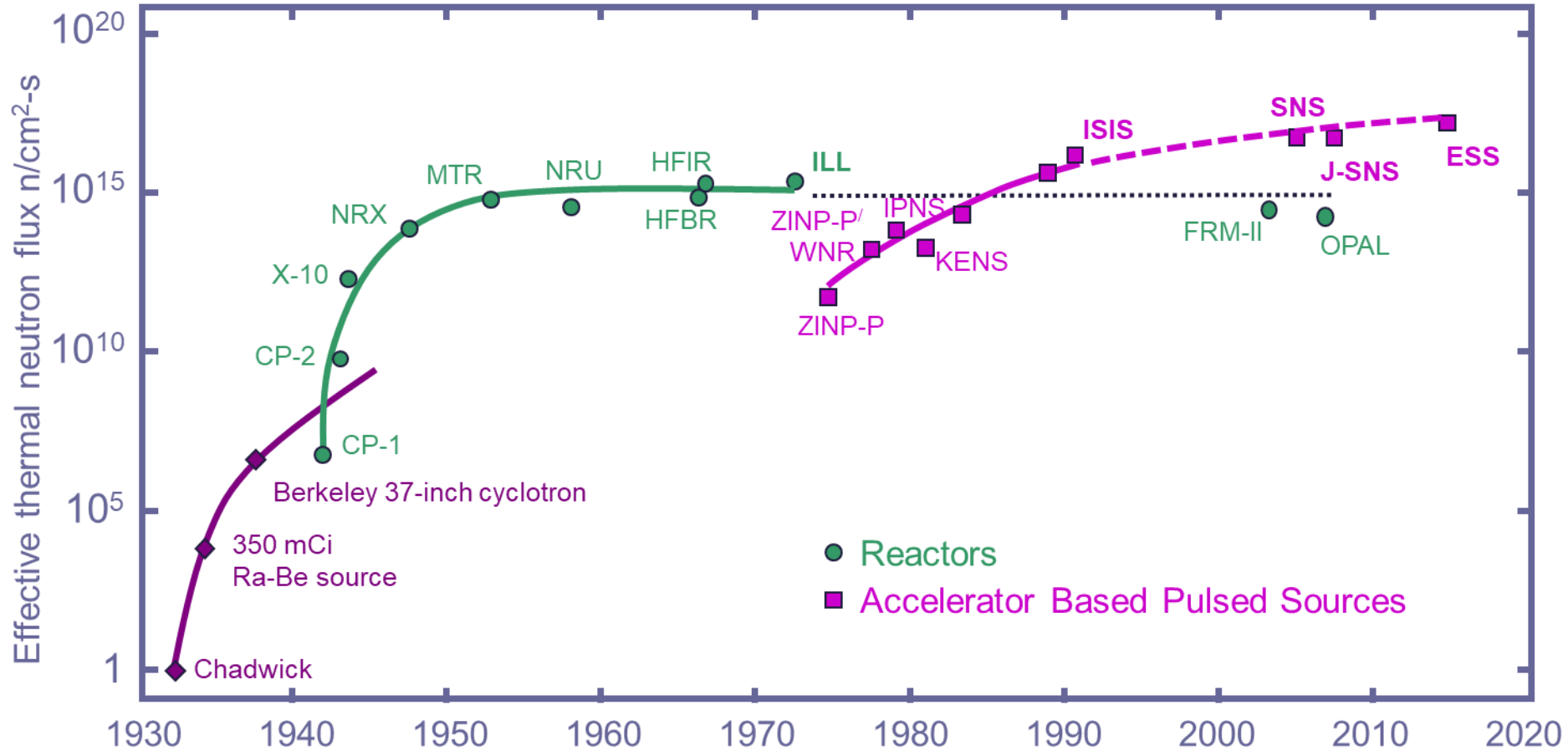
Some neutron history …



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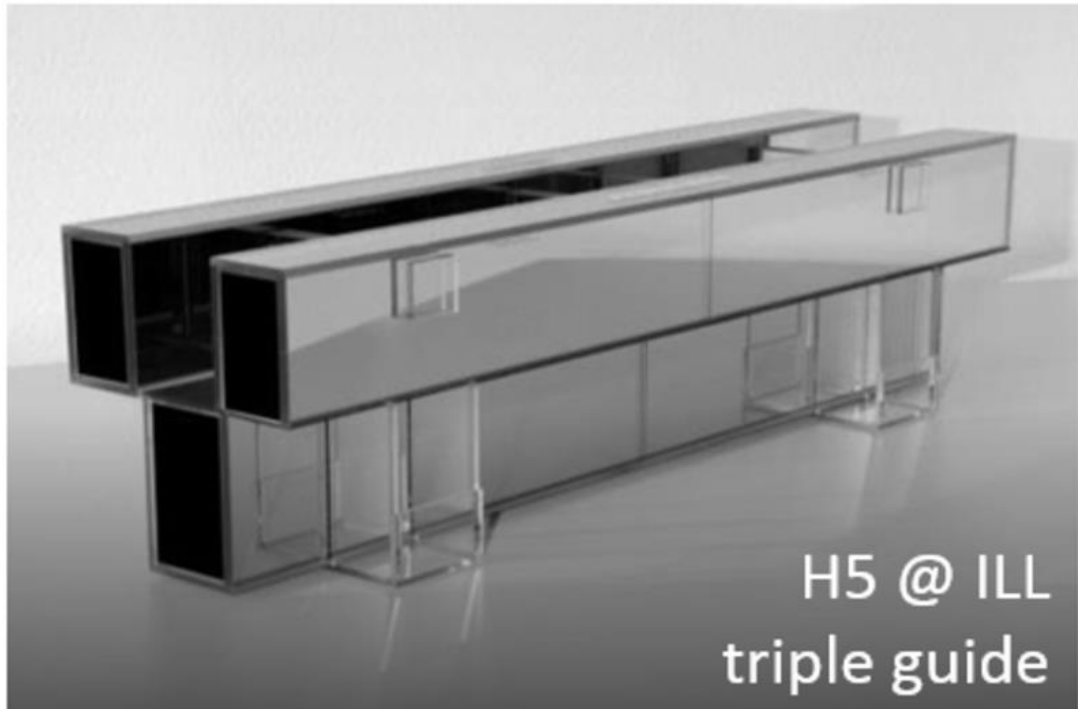
Neutron instrumentation gains – optics, detectors



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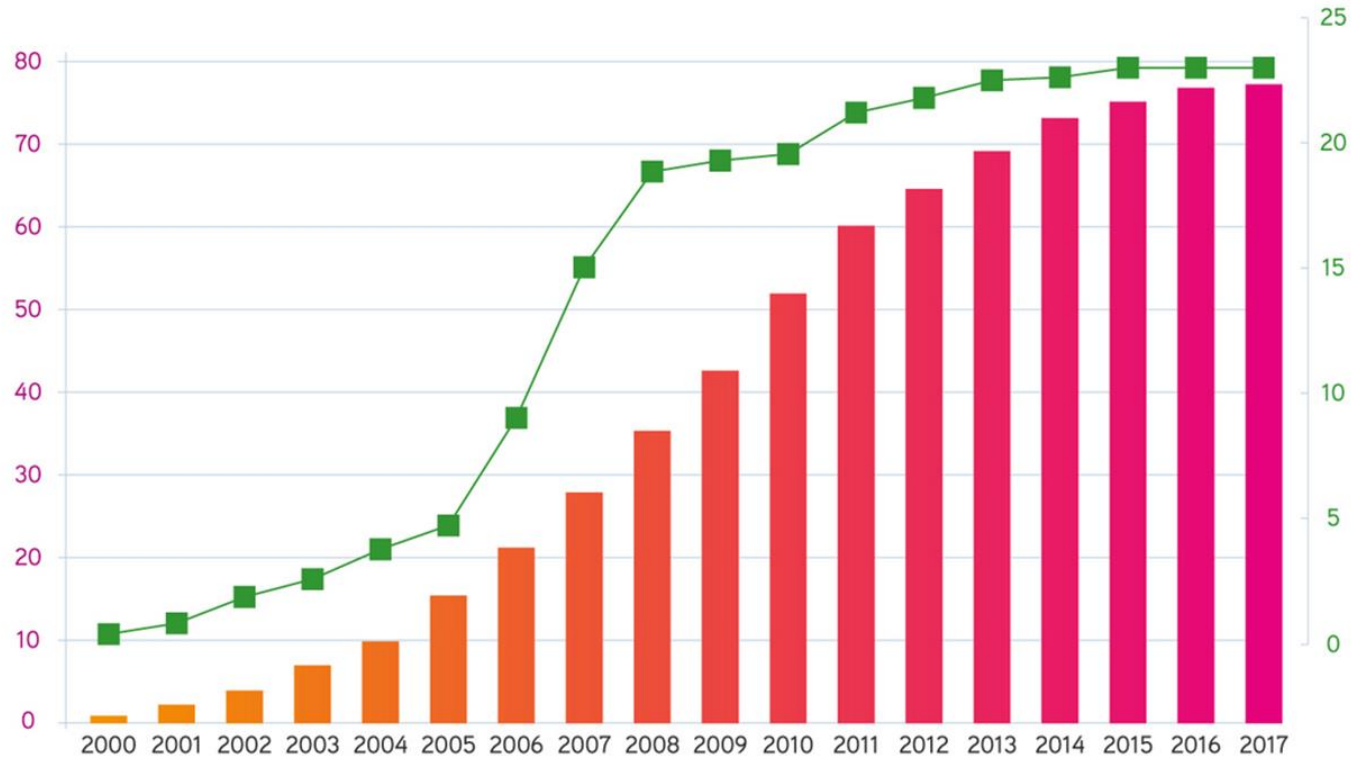
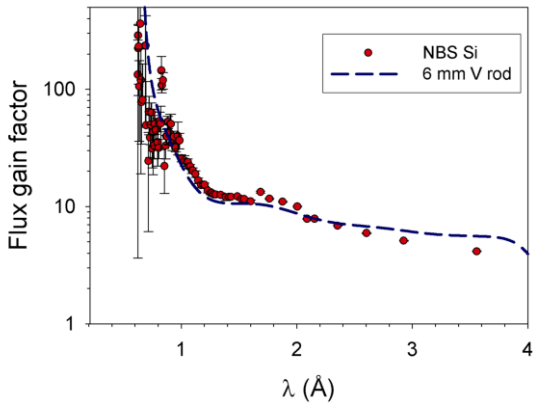
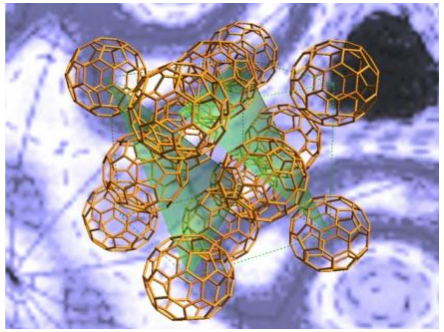


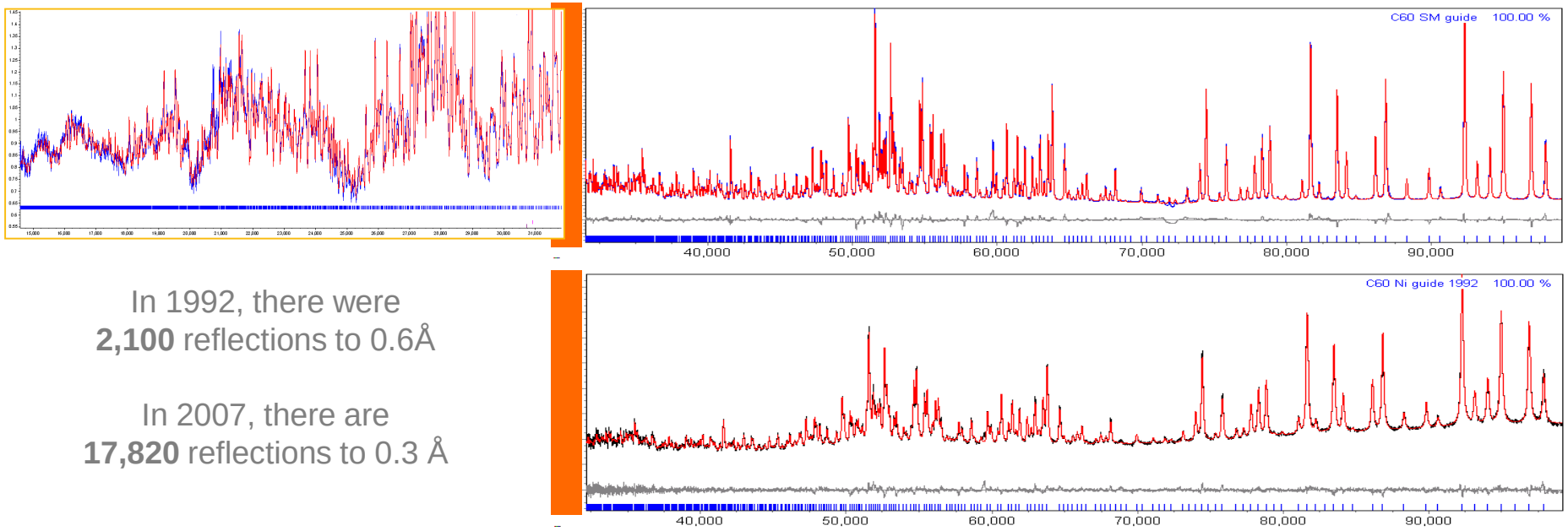
The ILL Millenium programme – how visible is the outcome?

HRPD@ISIS supermirror upgrade





Office of Basic Energy Sciences
Serving the Present, Shaping the Future



In 1992, there were
2,100 reflections to 0.6Å

In 2007, there are
17,820 reflections to 0.3 Å

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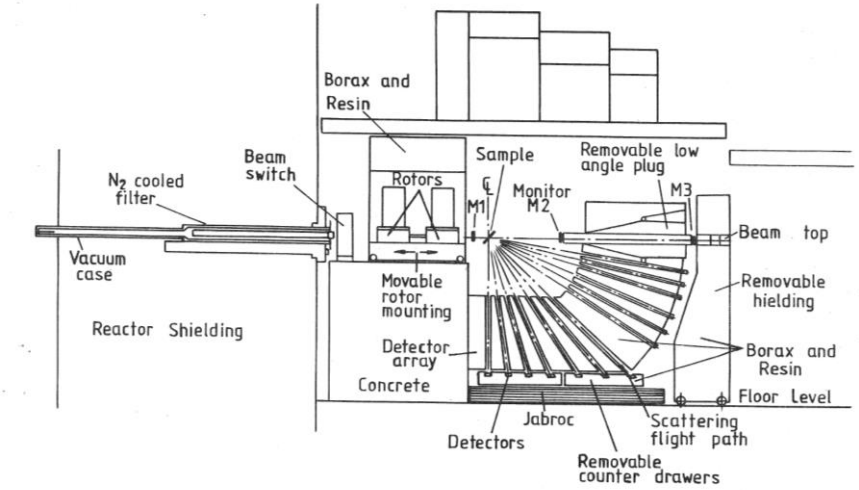
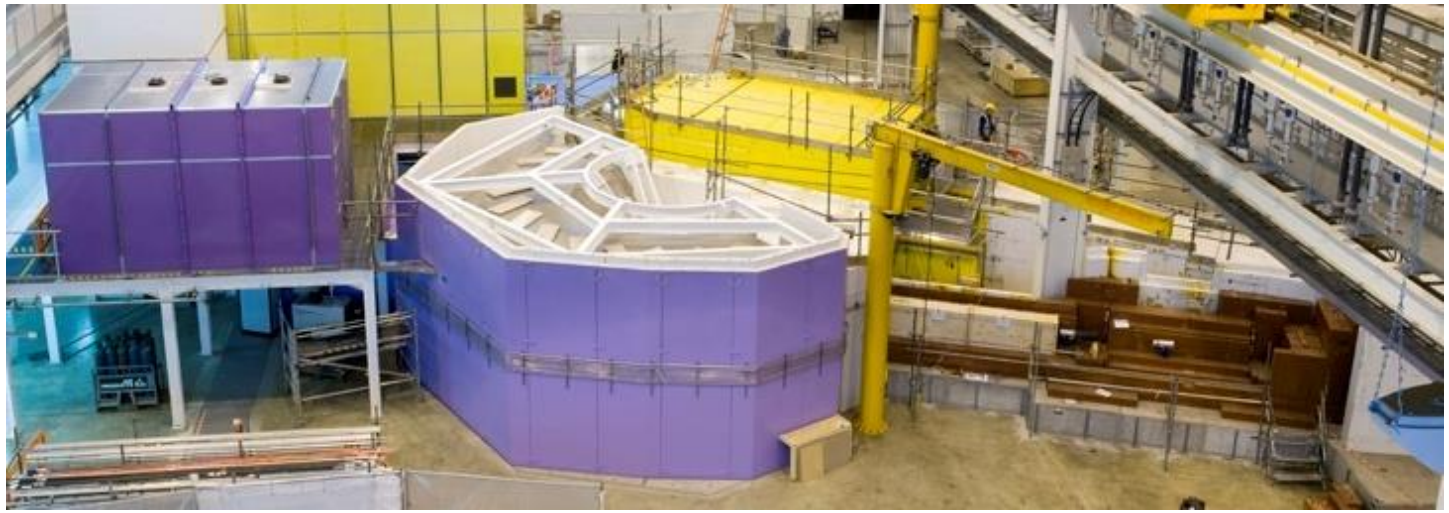
Plus ça change, plus c’est la même chose?





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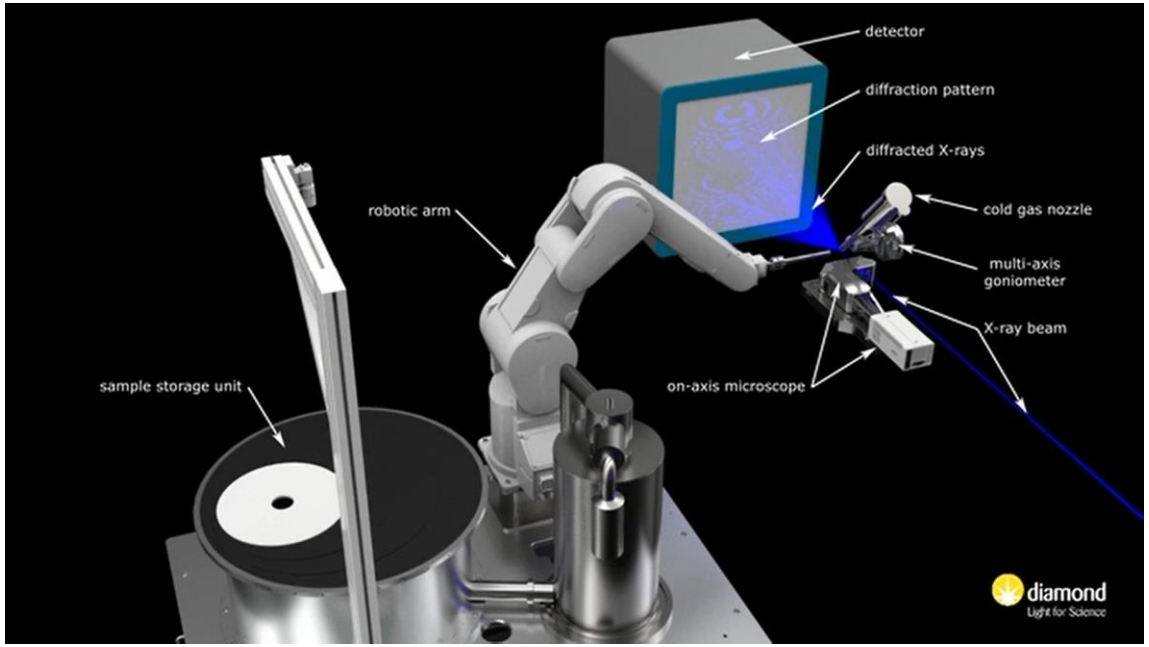
10 is not the same as 10^5

ESS 2002: "The goal of the ESS project is to combine the vastly enhanced, unique source quality with the most advanced instrumentation concepts. In this way the sensitivity of observing small signals or fast processes in real time (which is the main limitation of neutron scattering in general) is increased …"

STS 2019: "The STS offers opportunities to perform experiments that are beyond the reach of other neutron sources.

- *Time-resolved measurements of kinetic processes and beyond-equilibrium matter.*
- *Smaller sample and beam sizes needed for characterization of new materials.*



… and you can't use the same factor of 10 twice!

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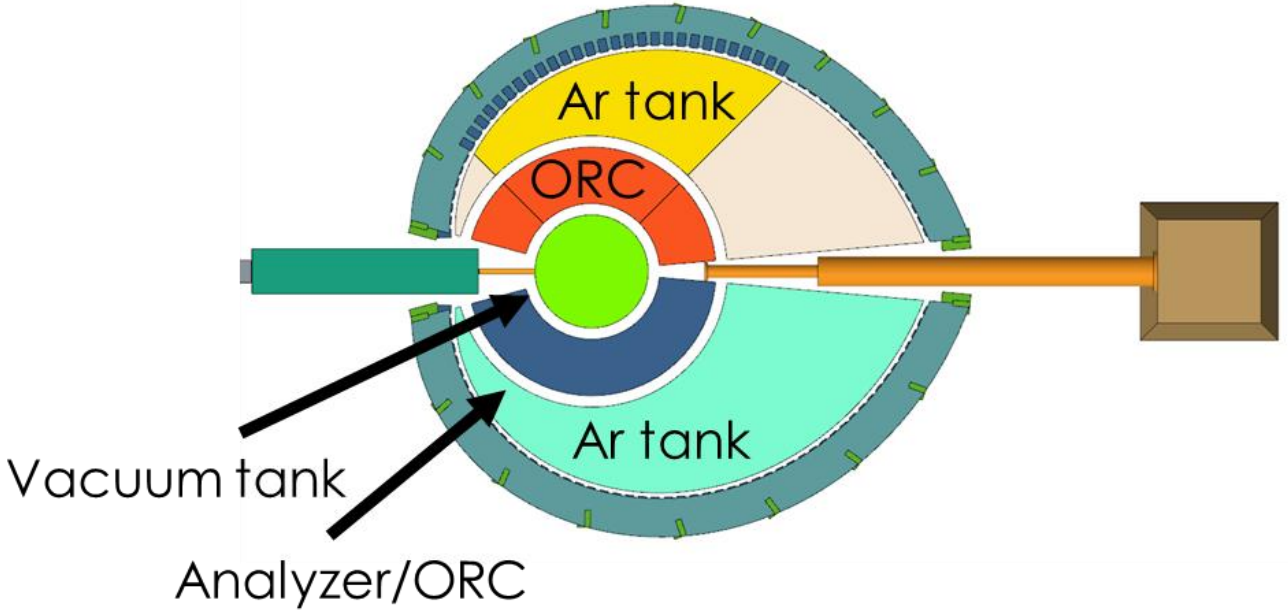
And can we cope with a factor of 10 anyway?



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So what should we do?

So what should we do?

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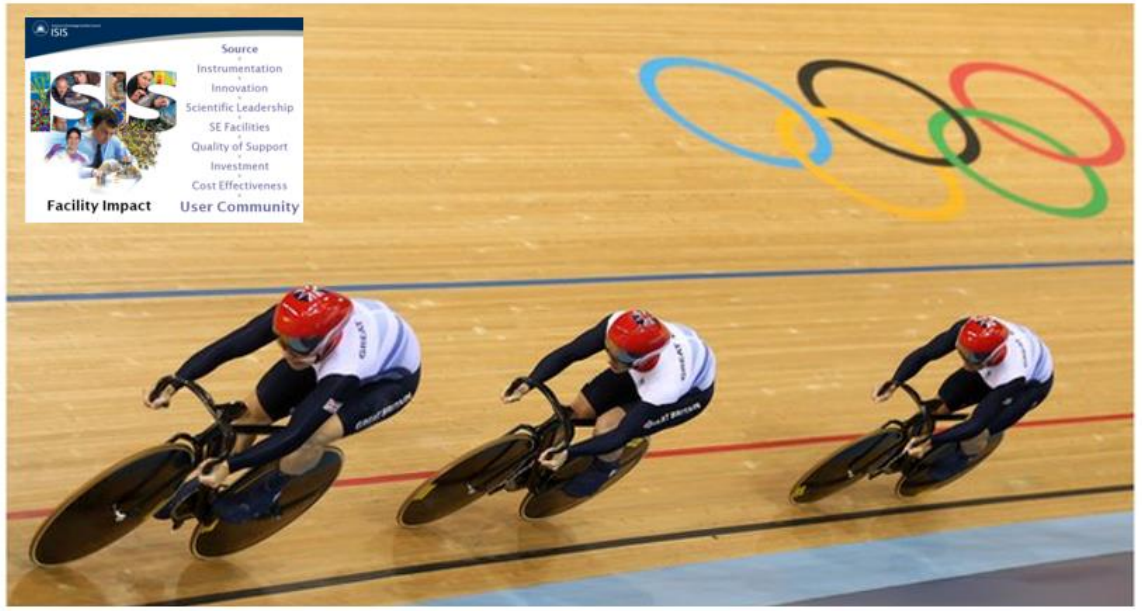
Accumulation of Advantages



The science case

The science case

Challenges don't go away …

- Energy
- Health/ageing
- Environment
- Food security
- …

Neutron physics hasn't changed …

- Length and time scales
- Light atoms/contrast variation
- Magnetism
- Weak interaction
- Simple cross-section



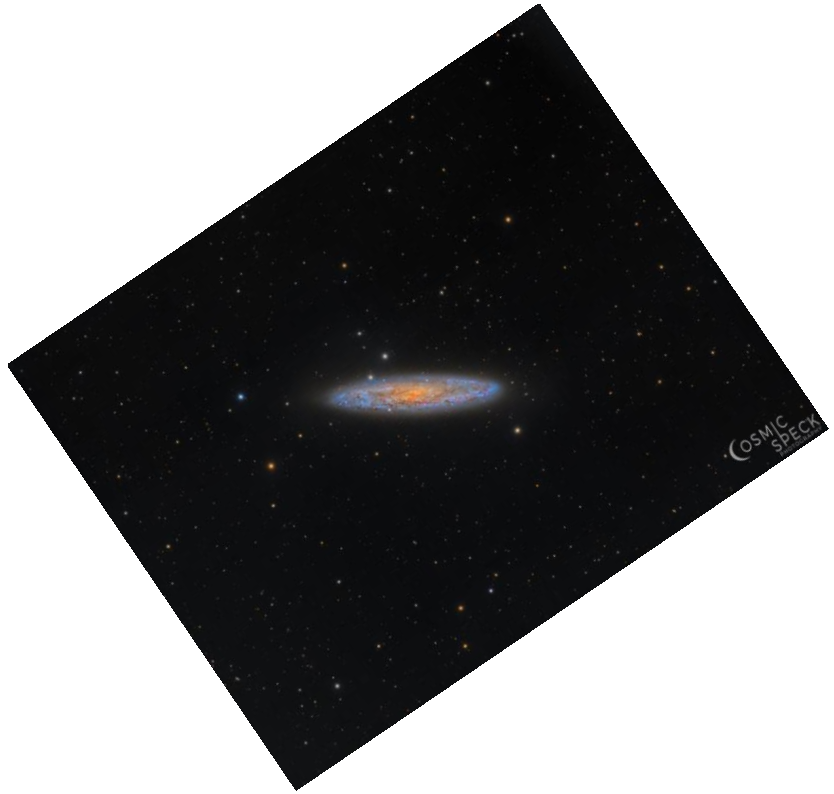

What advantages?

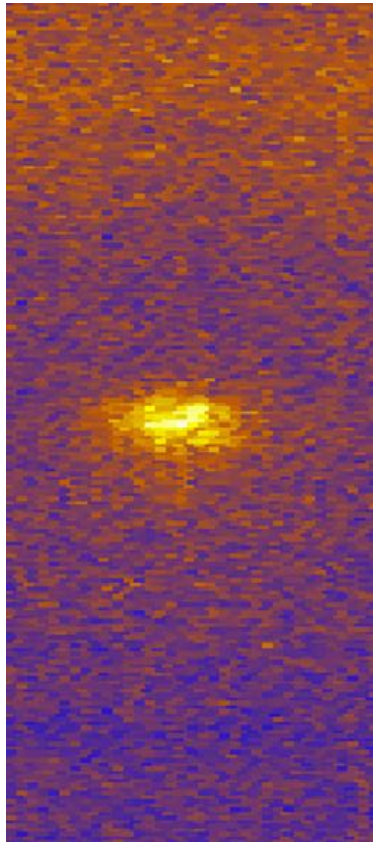
What advantages?

- Signal to noise, not just signal
- Sample environment (experimental complexity)
- Software/modelling
- Data

What advantages?

- Signal to noise, not just signal





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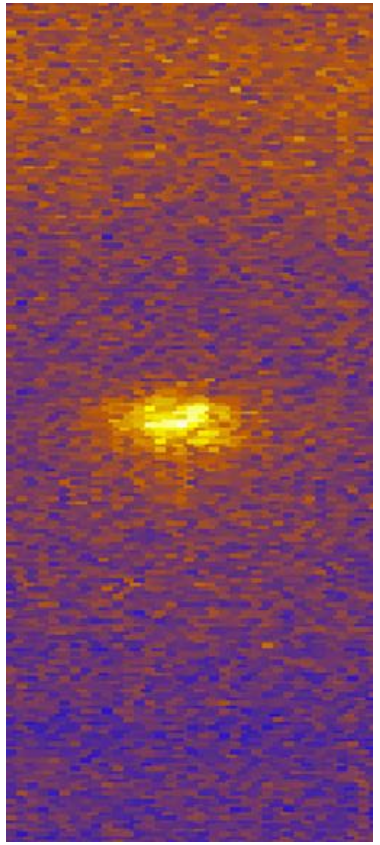

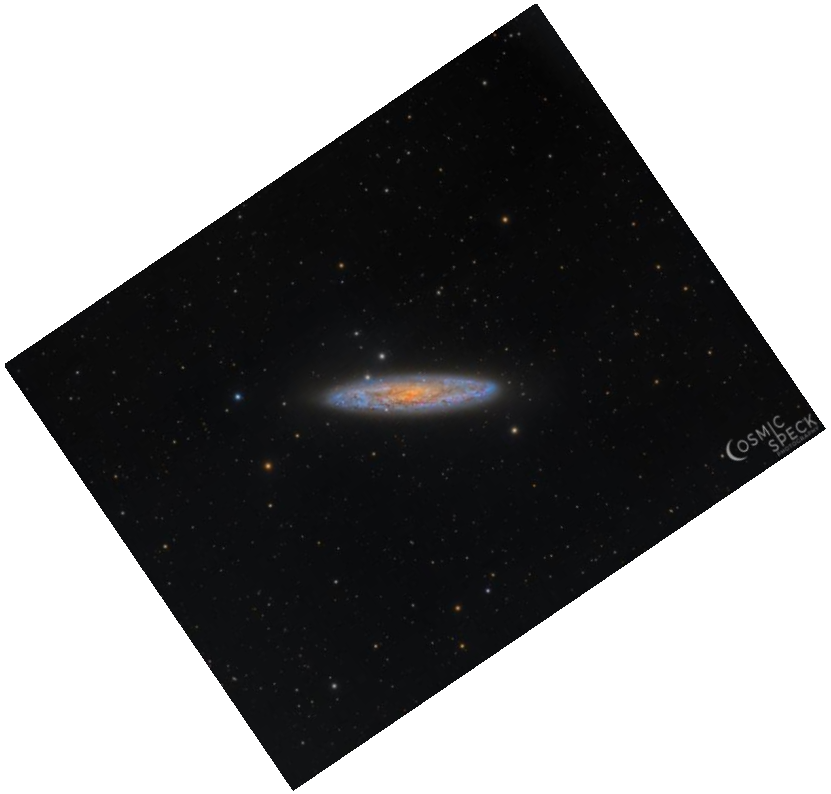

$(2.5\ \mu m)^3$

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What advantages?

- Sample environment (experimental complexity)

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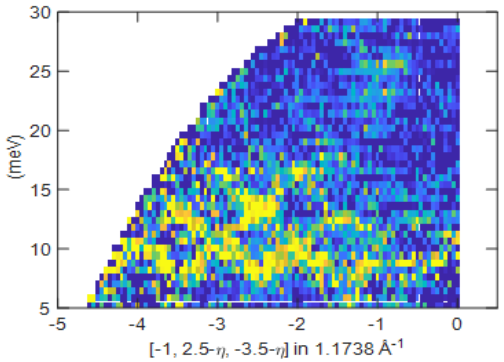
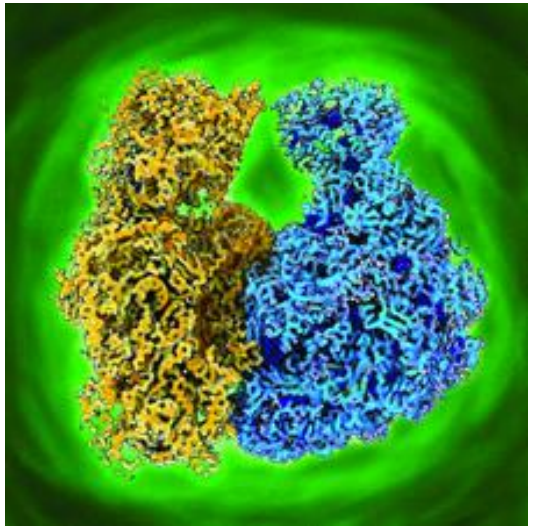
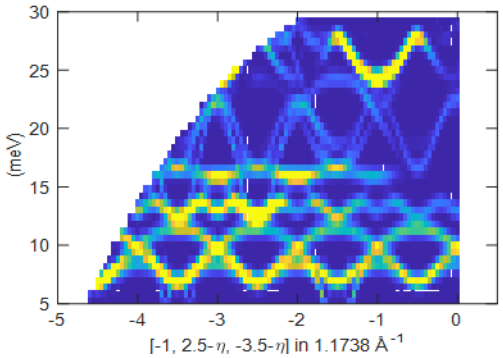
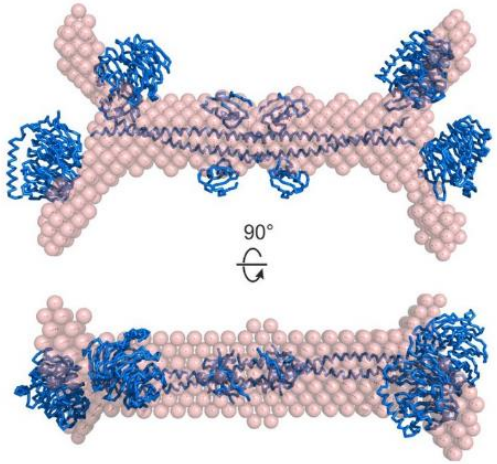
What advantages?

- Software/modelling









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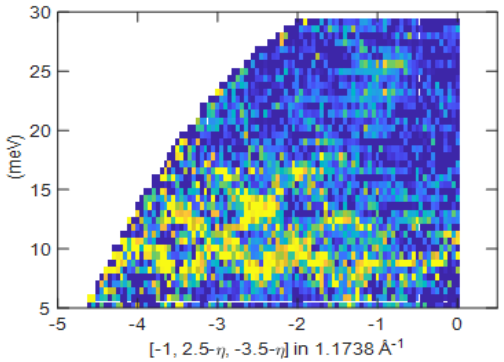
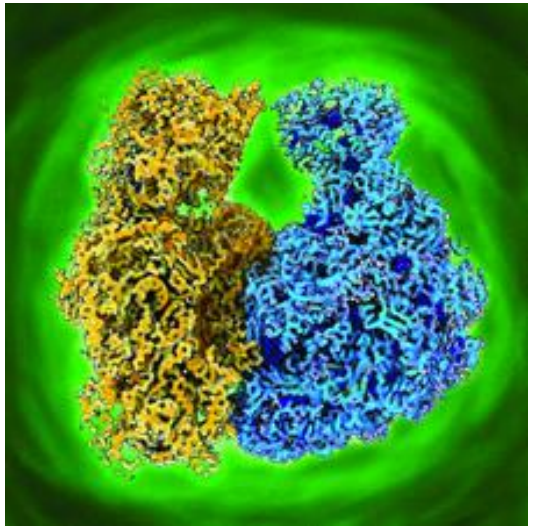
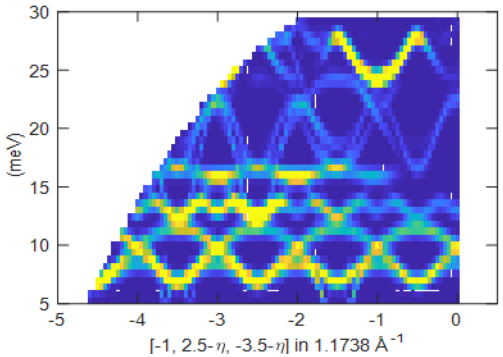
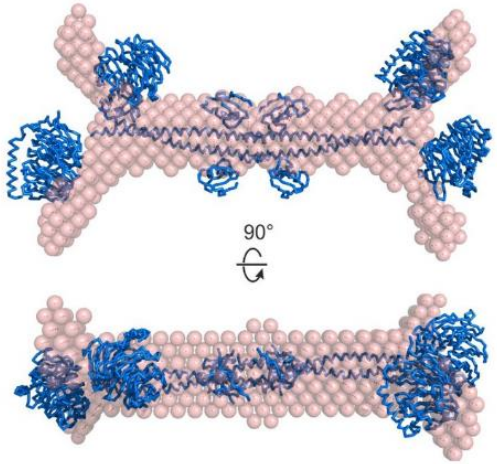
What advantages?

- Software/modelling
  Machine learning?









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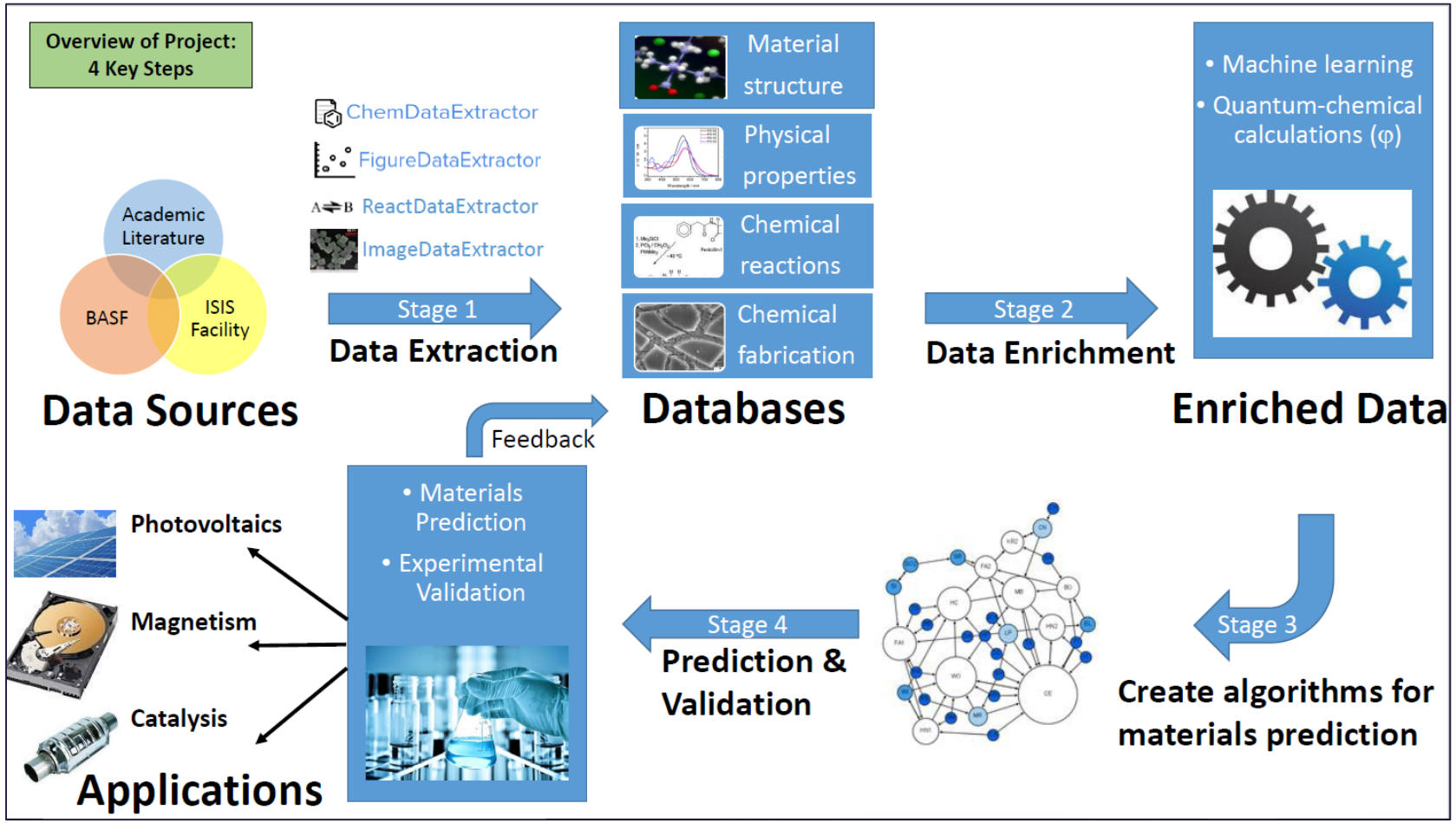
What advantages?

- Data



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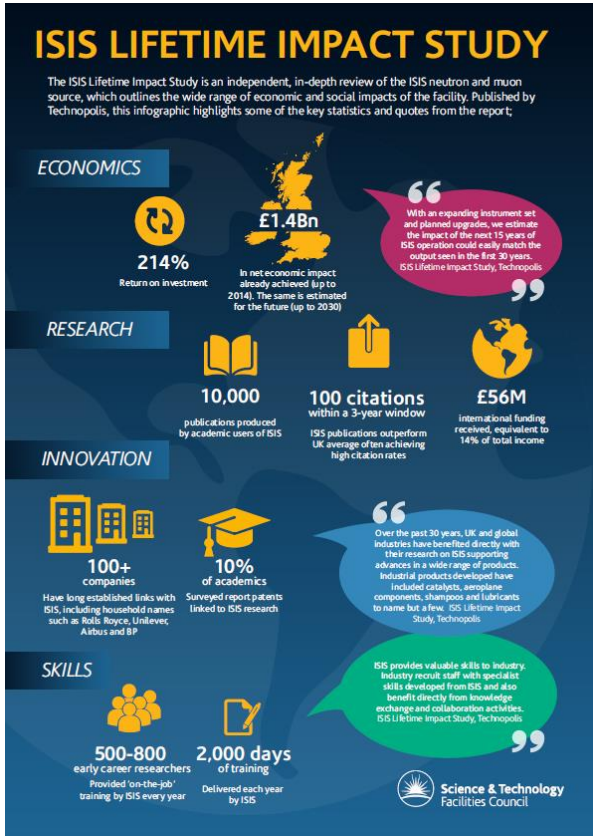
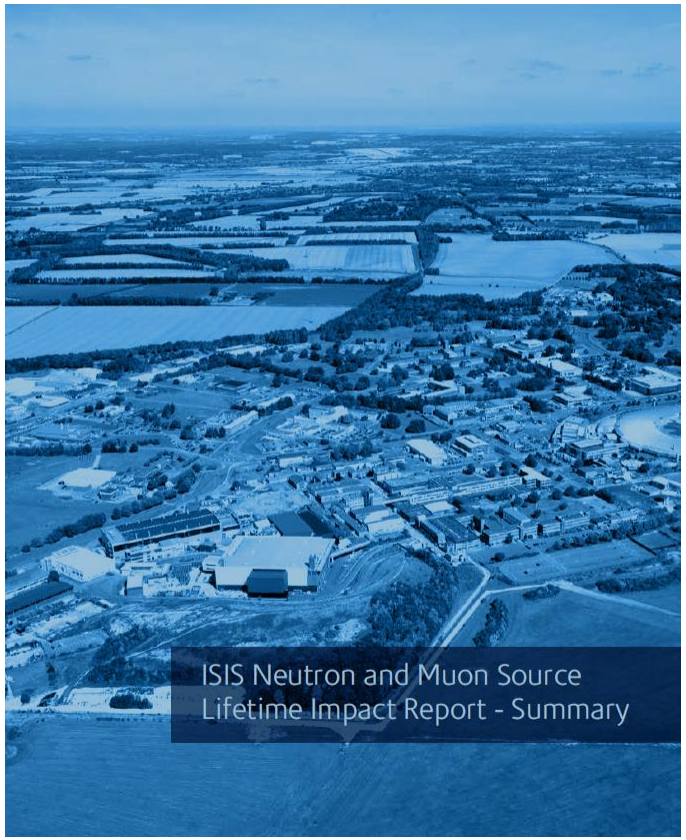
The business case

- Scientific impact
- Economic and social impact





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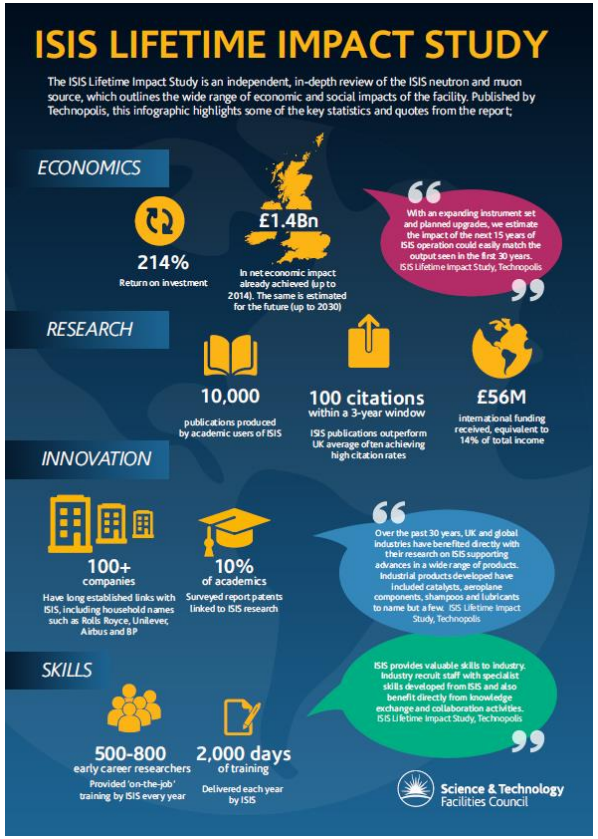
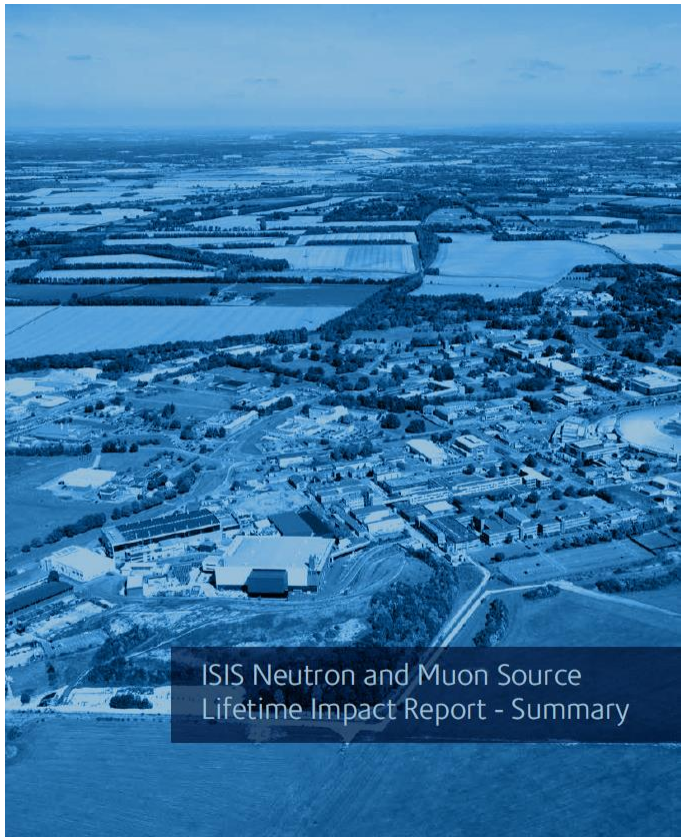
The business case

- Scientific impact
- Economic and social impact

But … neutrons are not cheap!

- Be efficient
- Add value





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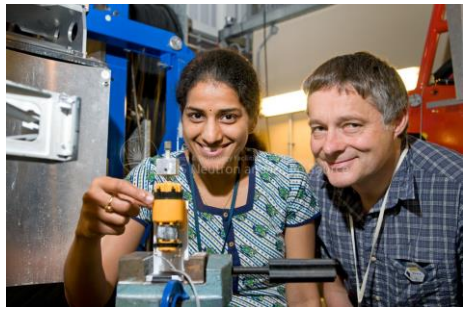
The business case

- How many users?
- Impact is proportional to the number of users
- 4 instrument days supports one unique user so ‘do the math’





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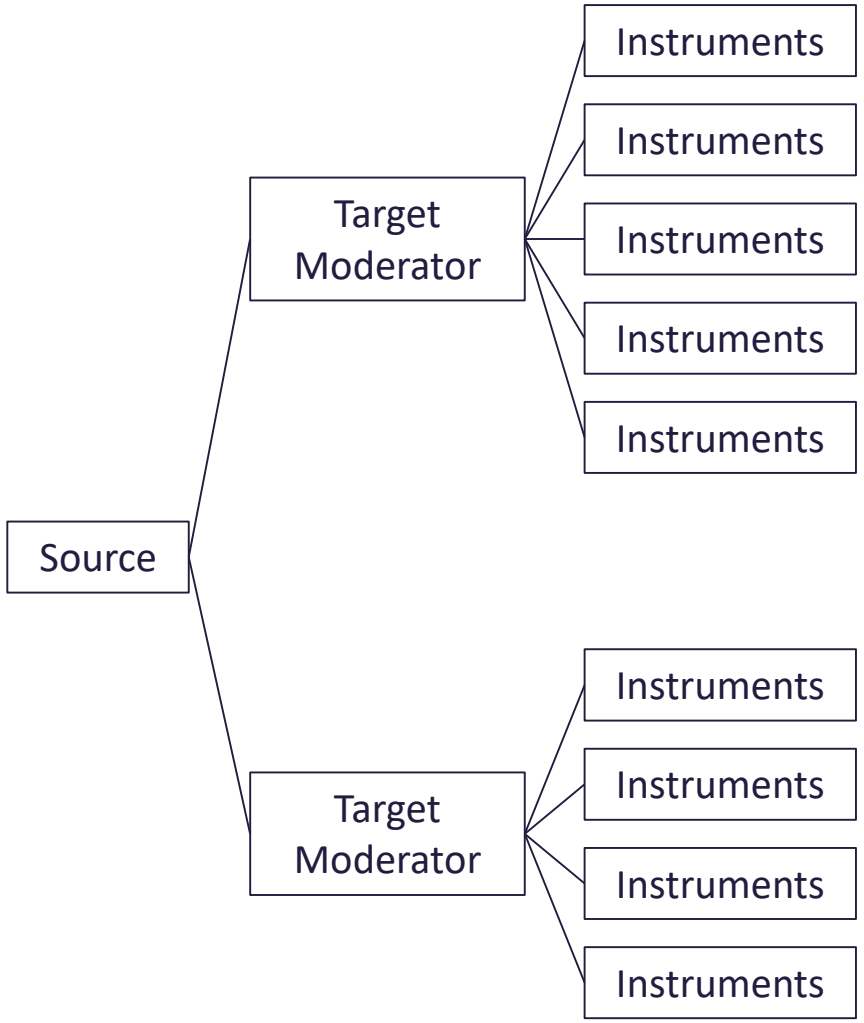
The business model



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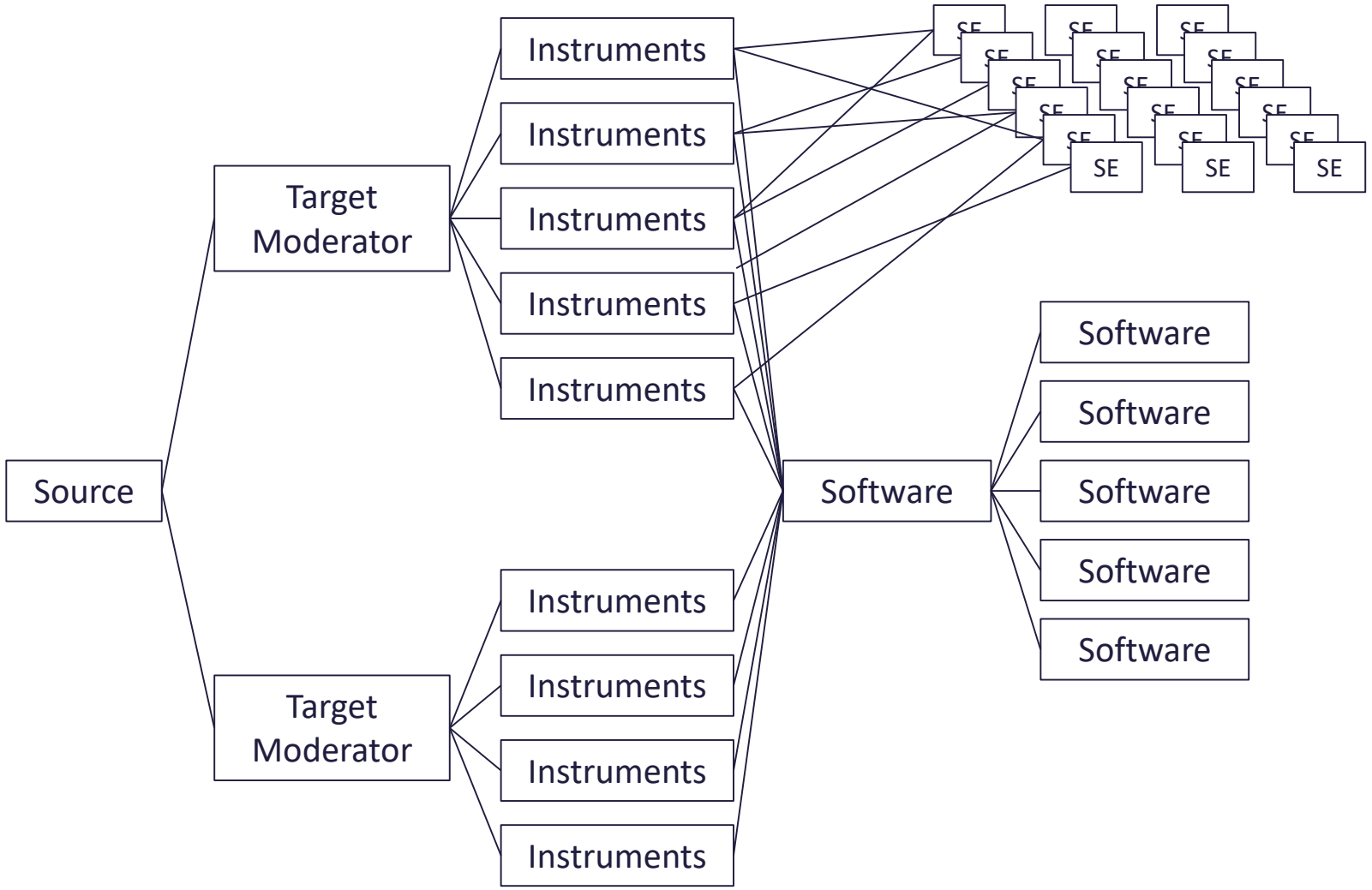
The business model



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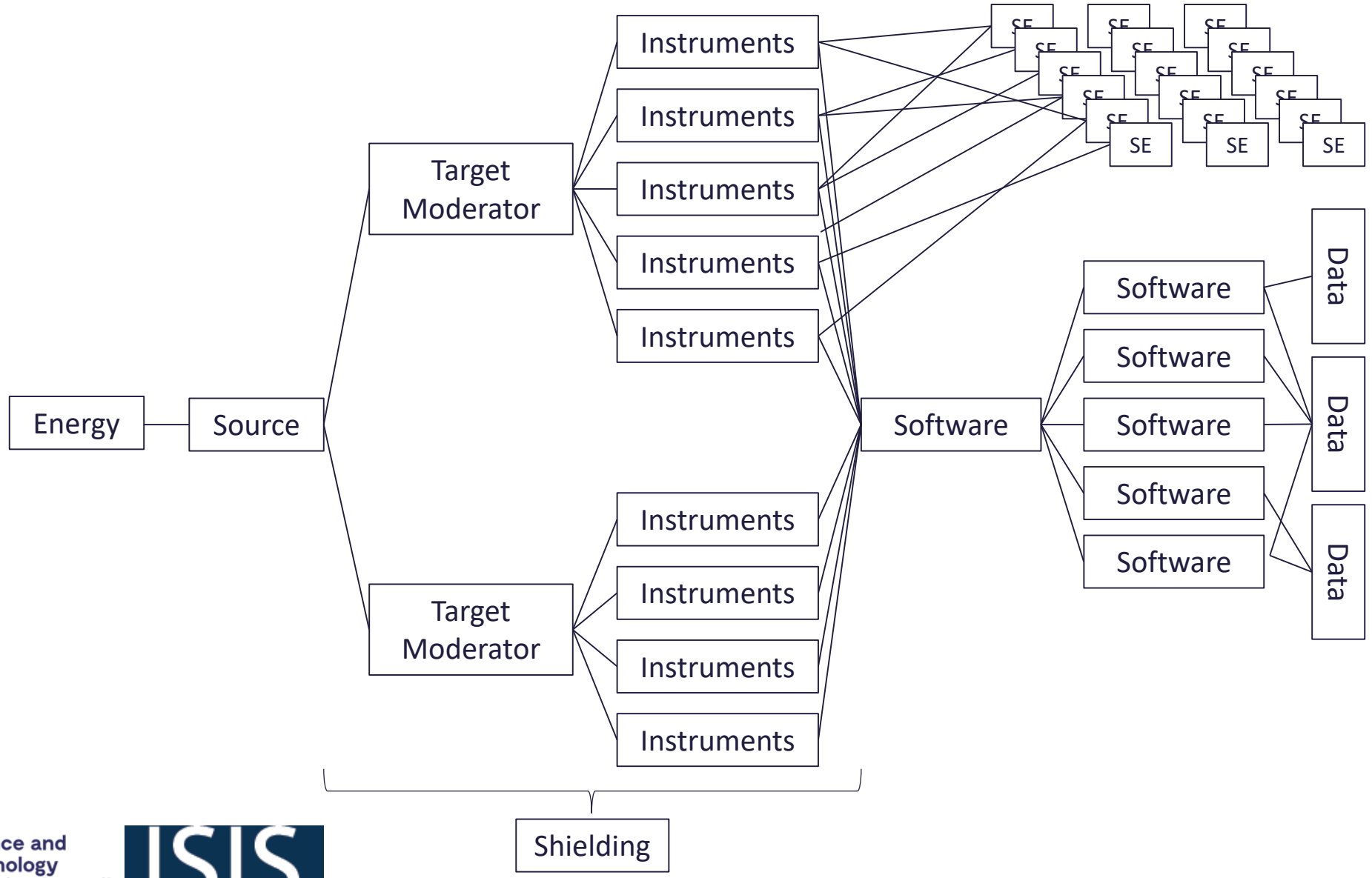
The business model



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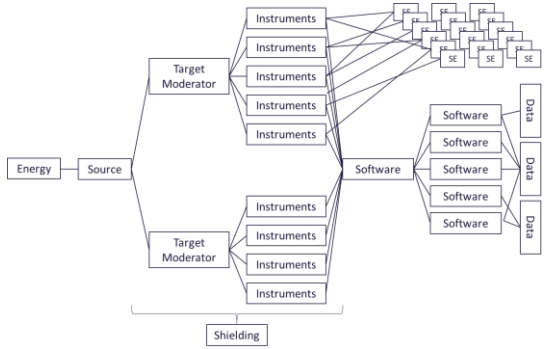
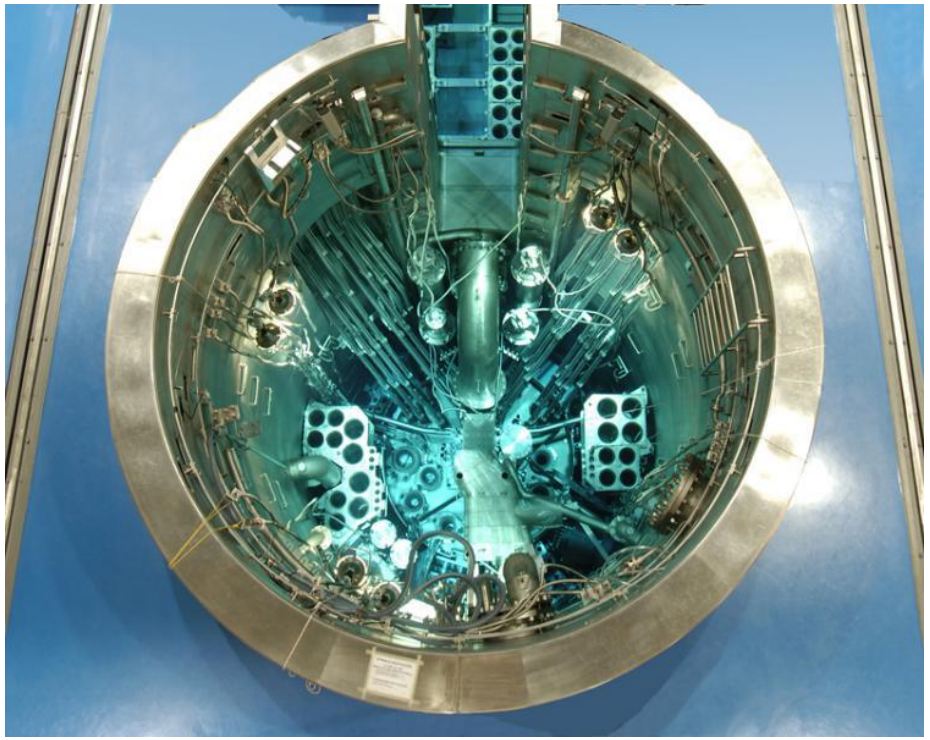
Reactors



- Reactor business model – single or multi-purpose
- ILL *“you will not see it’s like again”*
- Multipurpose medium flux reactors (e.g. OPAL) are probably the best value for money
- But few countries want to build new reactors



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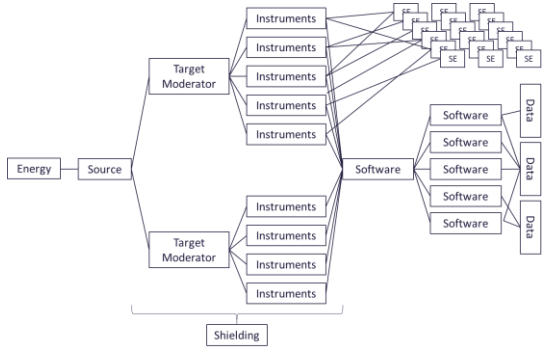
ESS

- ESS business model – capability (brightness)



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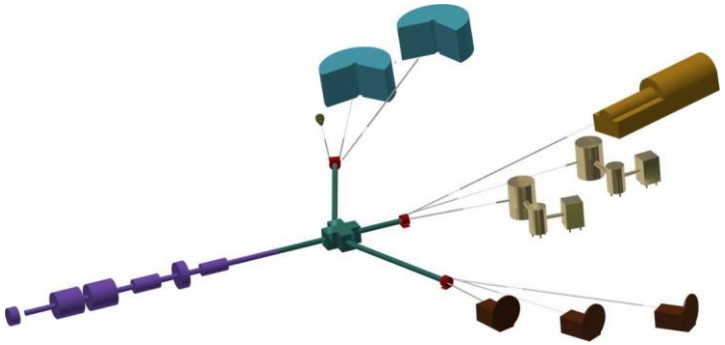
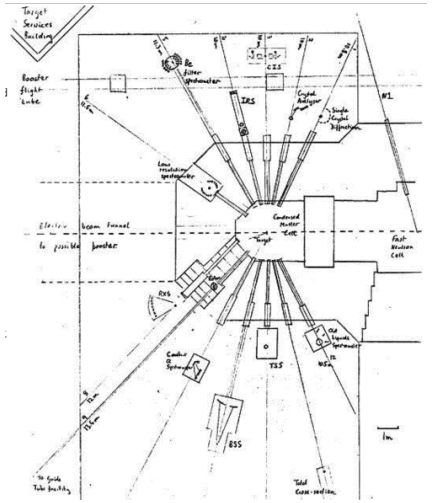
Compact sources

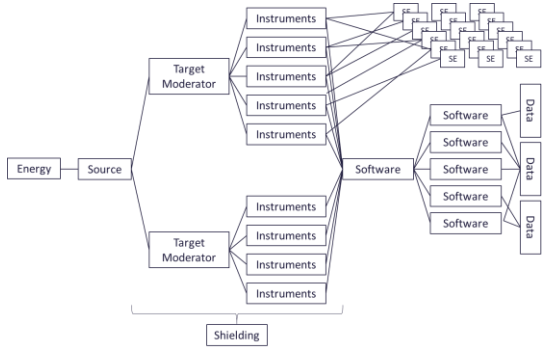
- Compact source business model – local

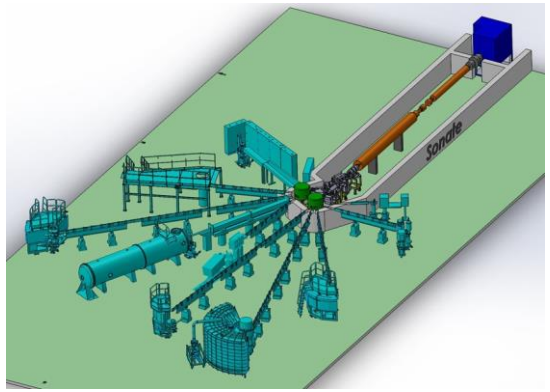


Jülich High Brilliance Source

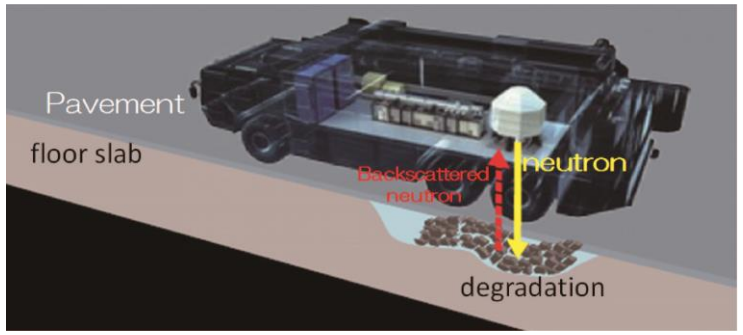


Harwell Linac





LLB SONATE



RIKEN - RANS

Hokkaido University Electron Linac

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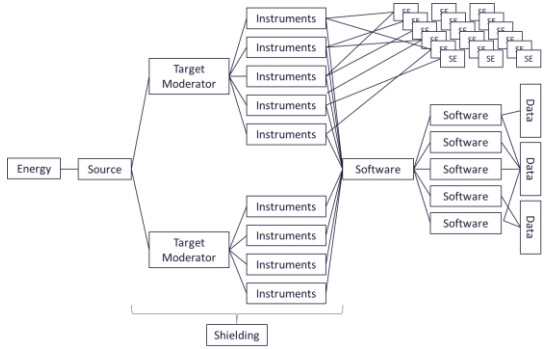
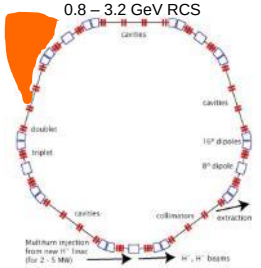
ISIS-II

- ISIS-II business model – optimised?

  - SP, LP or compact source
  - Frequencies
  - FFA, RCS, SR
  - Stand alone or re-use
  - Multiple target stations (including muons)

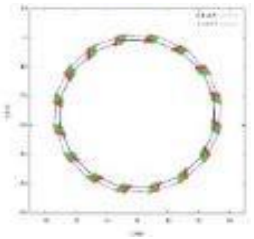


0.8 – 3.2 GeV RCS



0.4 – 3.2 GeV FFAG

0.5 – 1.2 GeV FFAG



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Whither neutrons, or wither neutrons?

- Neutron facilities need a completely different approach from synchrotrons
- Chasing source + instrument performance is necessary but not sufficient – it will never be truly transformative for neutrons
- Technical performance does not imply scientific importance
- Recognise that neutrons are not cheap!
- We must ‘accumulate advantages’
- But … what is the optimum combination and operating regime?

Whither neutrons, or wither neutrons?

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