Designing Safety into a High-power Neutron Spallation Source

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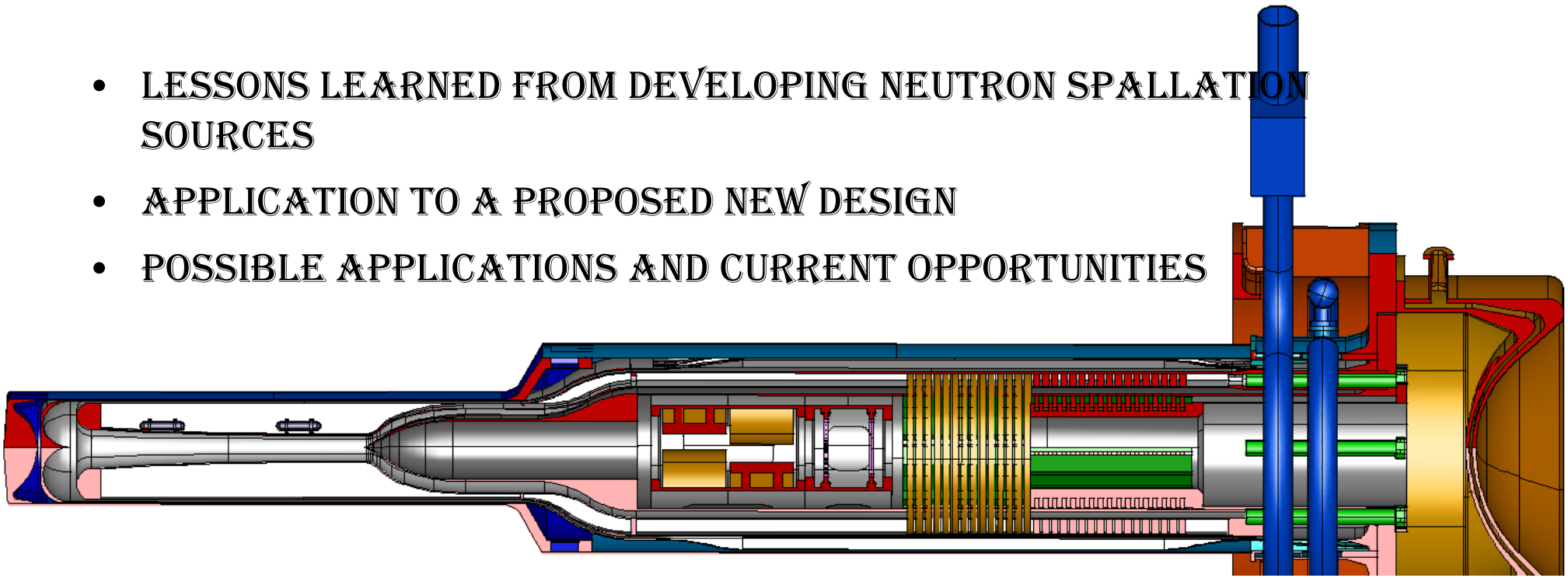
- Lessons learned from developing neutron spallation sources
- Application to a proposed new design
- Possible applications and current opportunities



Purpose of a compact neutron source

Neutron sources are used in laboratories

- SINQ - Villigen Switzerland,
- JSNS –Hokkaido Japan,
- SNS - Oakridge USA

Further installations are planned (ESS in Lund SE, MYRRHA in BE)

- Life sciences / Material sciences / Nuclear physics

Industrial applications are possible:

- power from Thorium / spent Uranium / ADS
- Isotope production for medical purposes
- Irradiation facility for nuclear materials

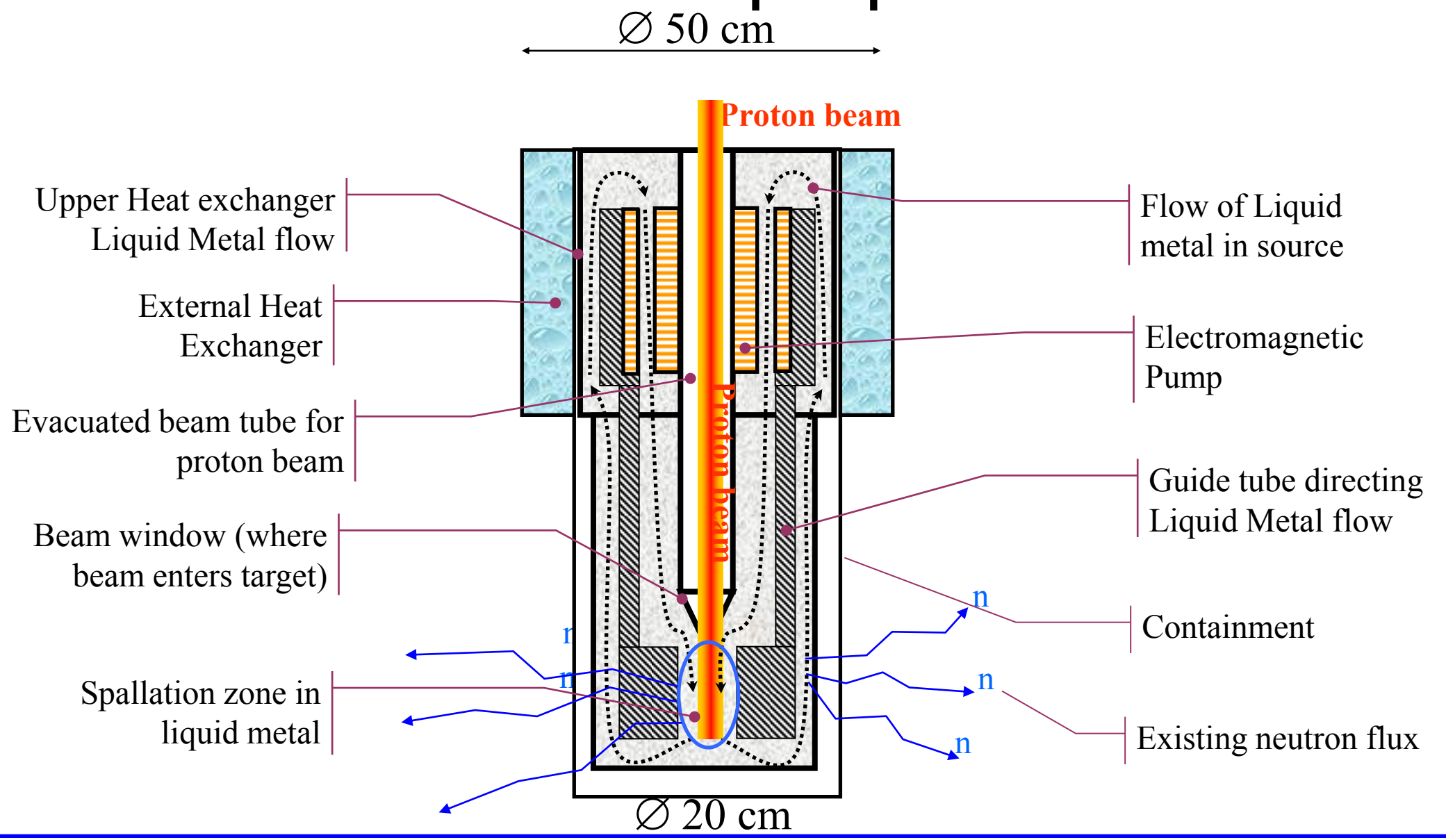
Neutron spallation source development

- 2006 MEGAPIE with iradiation
  - First Liquid Metal neutron source
  - Megawatt range
- 2009 EURISOL without iradiation
  - High speed compact Liquid metal source
  - 4 MW range
- 2011 ESS
  - Liquid metal vs Solid target
  - 4 to 10 MW range

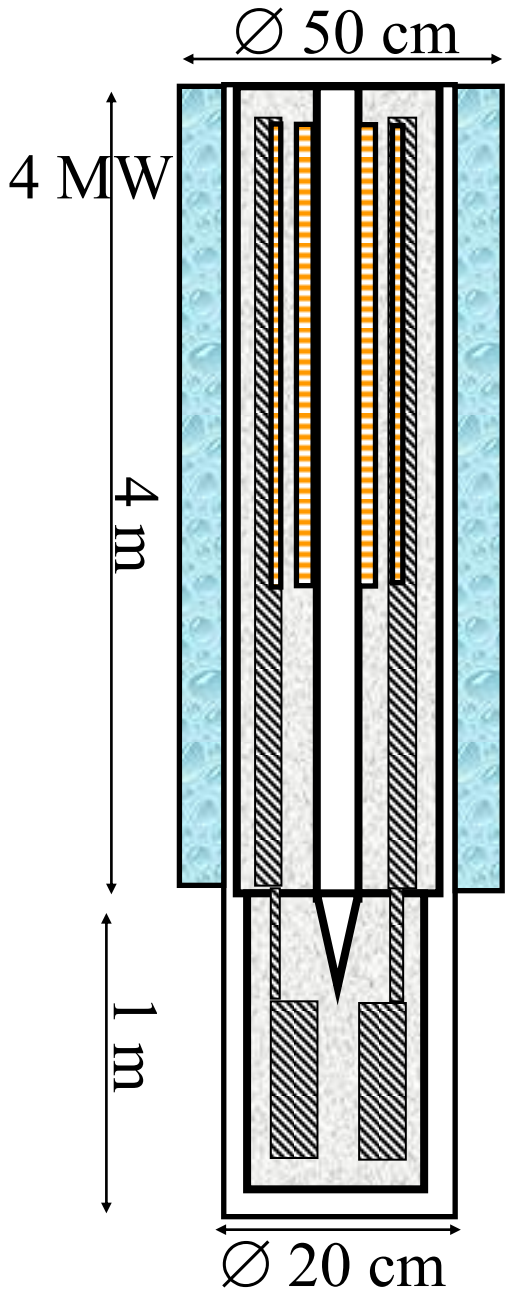
Lessons learnt

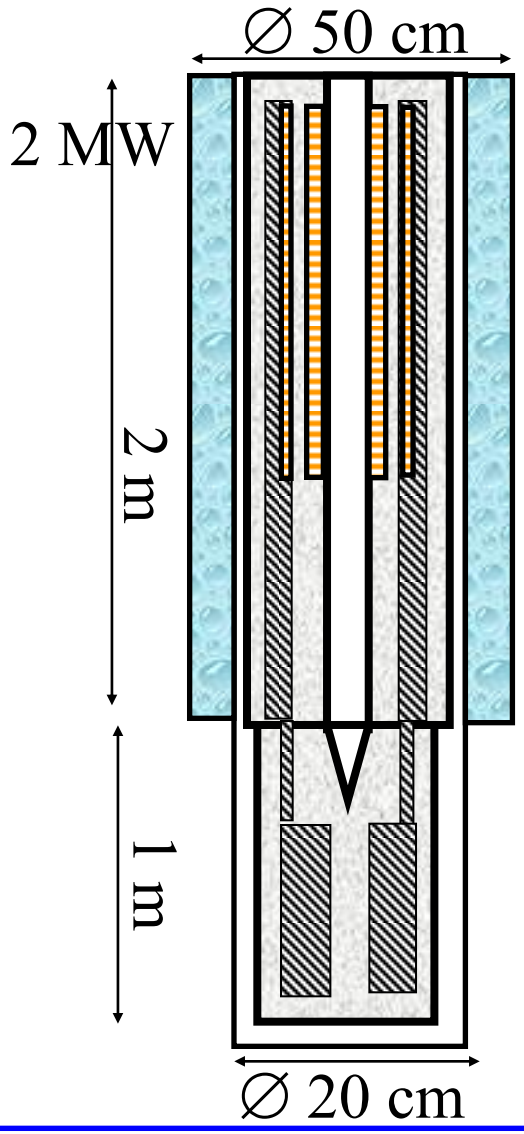
Relevance	Relevant Safety Guideline
System	Multiple containment strategy is vital Natural circulation is of little value Leaks must not flow into the path of the beam Leak analysis and mitigation strategy in place No organic cooling liquid inside source
	Development using multi-physics analysis
Component	Calibrated electro-magnetic pumps are reliable High-grade finishes reduce drag losses
	T91 /316 stainless steel are an appropriate choice
Signal	Diversify flow-meter instrumentation Instruments in- and outside of source (beam) Ensure leak detection using diverse sensors
	Pressure transducers and TCs are resilient

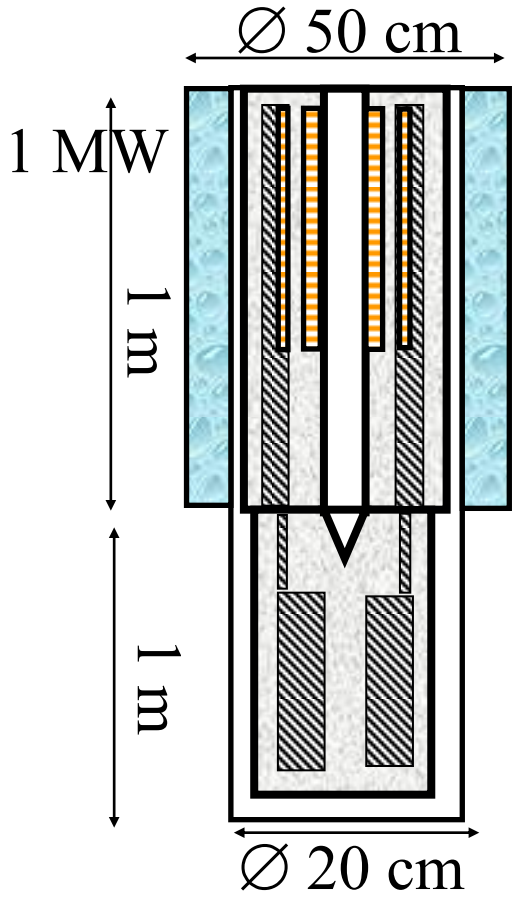
MW Class proposal



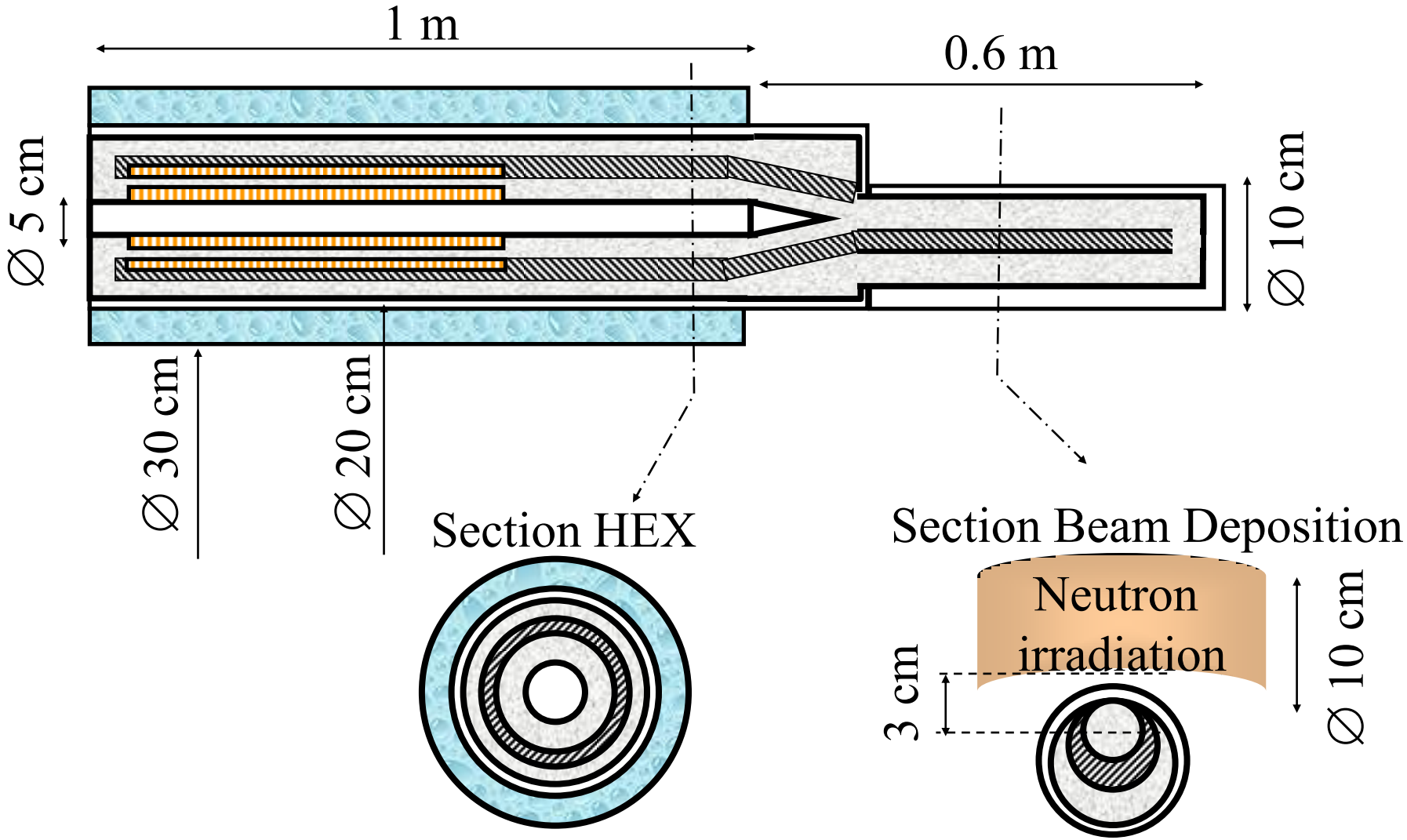
Modularity



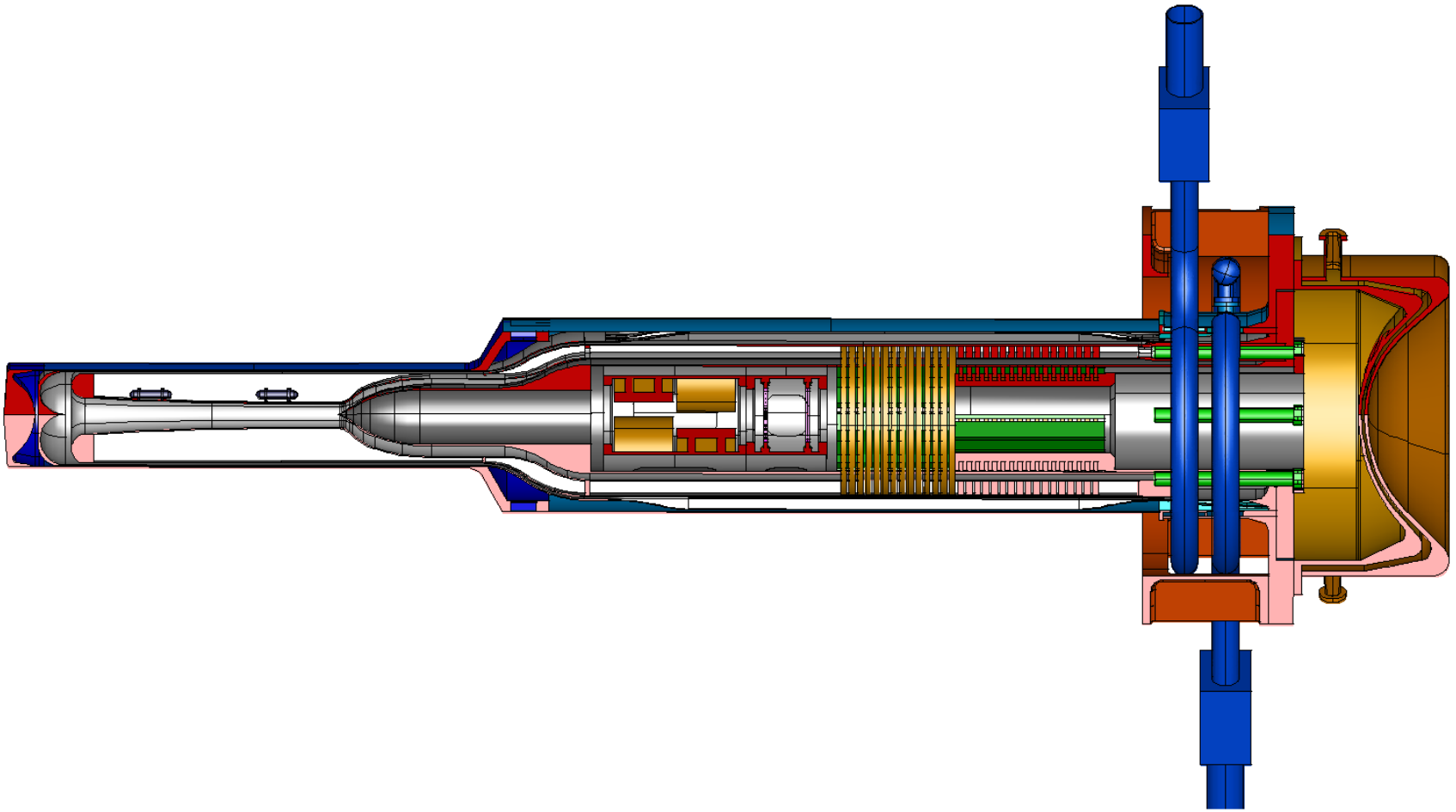




Small Power units < 100 kW



New Design



Way Forward

- Design, build and test with end-use focus
- Key goals : Output:
  - Build and test thermally at 4 MW or 100 kW (test data)
  - Demonstrate capability 10 kW - 10 MW (analysis)
  - Demonstrate neutronic performance (analysis)
  - Design test under irradiation (drawings)

Tests for validating the source

- Hydraulics inside the target. Electromagnetic Pump trips
- Thermal cooling at the beam window under normal operations and during pump trips. (strain gauges / TCs)
- Structural integrity of the target under the impact of a water leak from the heat exchanger
- Hydraulic performance of the heat exchanger, in particular transients consecutive to a pump trip
- Structural integrity of the containment under a double perforation of the target leading to liquid metal leaking

Thank you