Spallation Neutron Source Status Review

Presented at the

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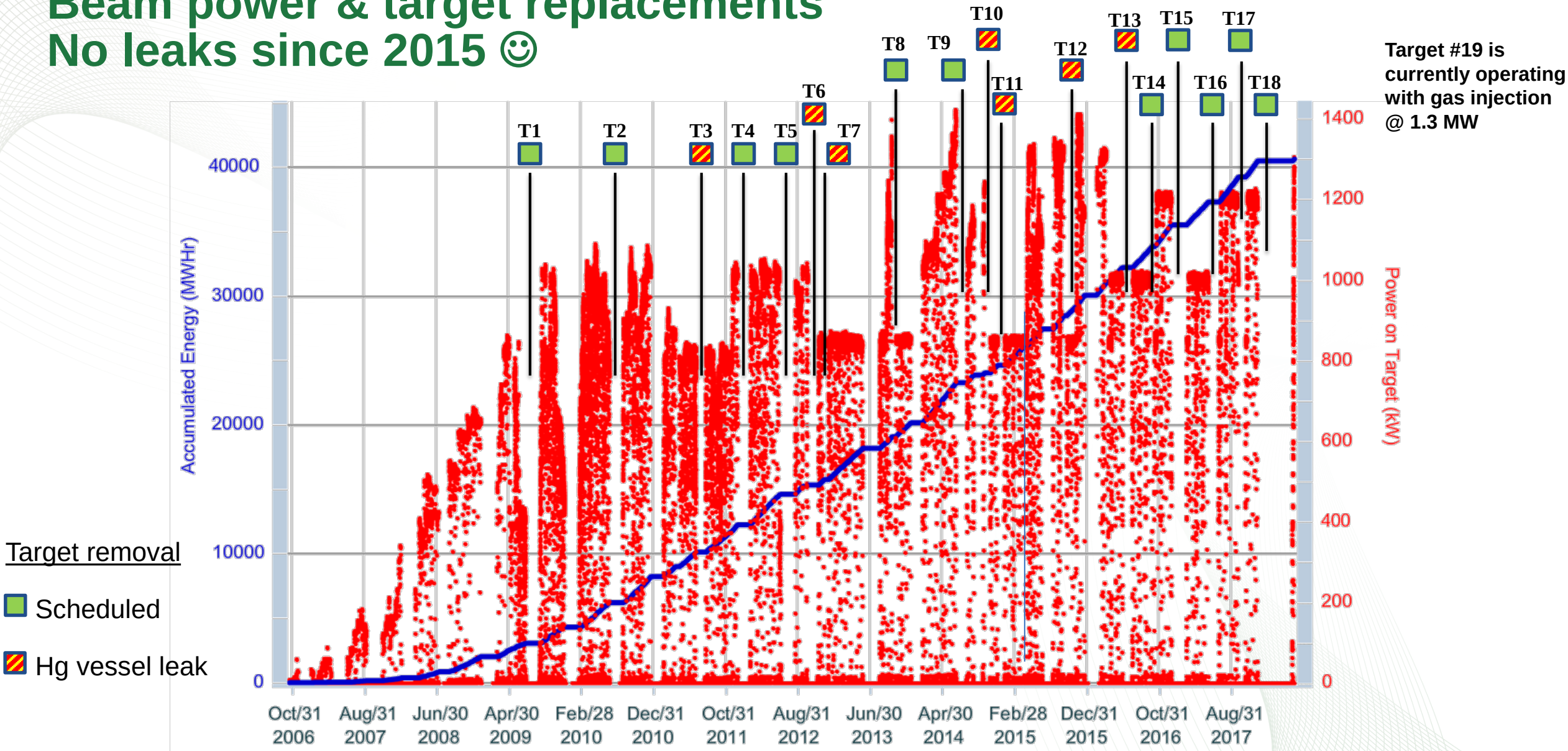
OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

Since last HPTW in Oxford April 2016

- No target leaks
- Power on target now 1.3 MW
- Replaced Inner Reflector Plug
- First use of gas injection in SNS mercury target
- Mercury target vessel strain measurements
- First SNS aluminum proton beam window
- Upgrades will bring 2 MW to the SNS mercury target

Beam power & target replacements
No leaks since 2015 ☺



Target #19 is currently operating with gas injection @ 1.3 MW

Target removal

- Scheduled
- Hg vessel leak

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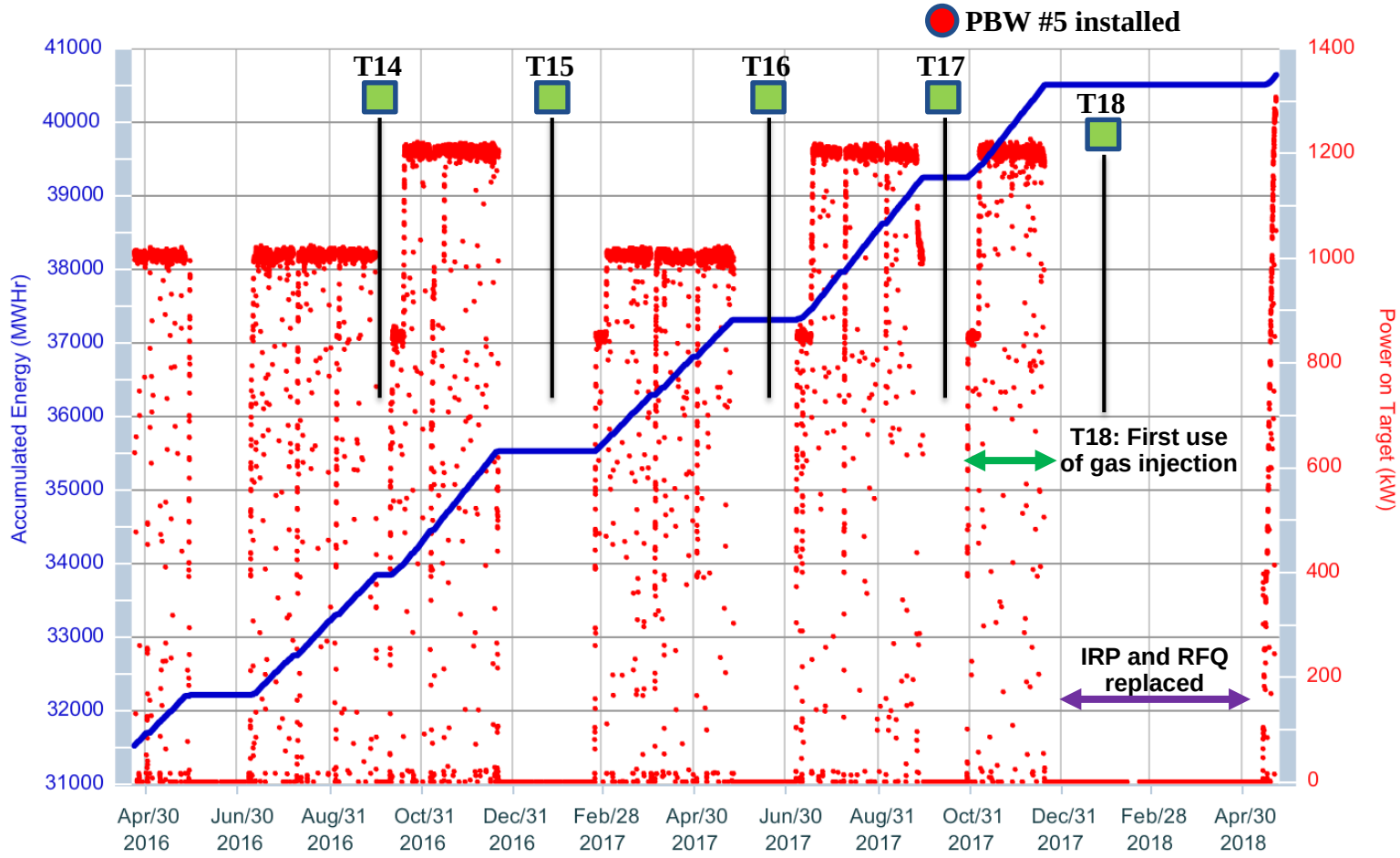
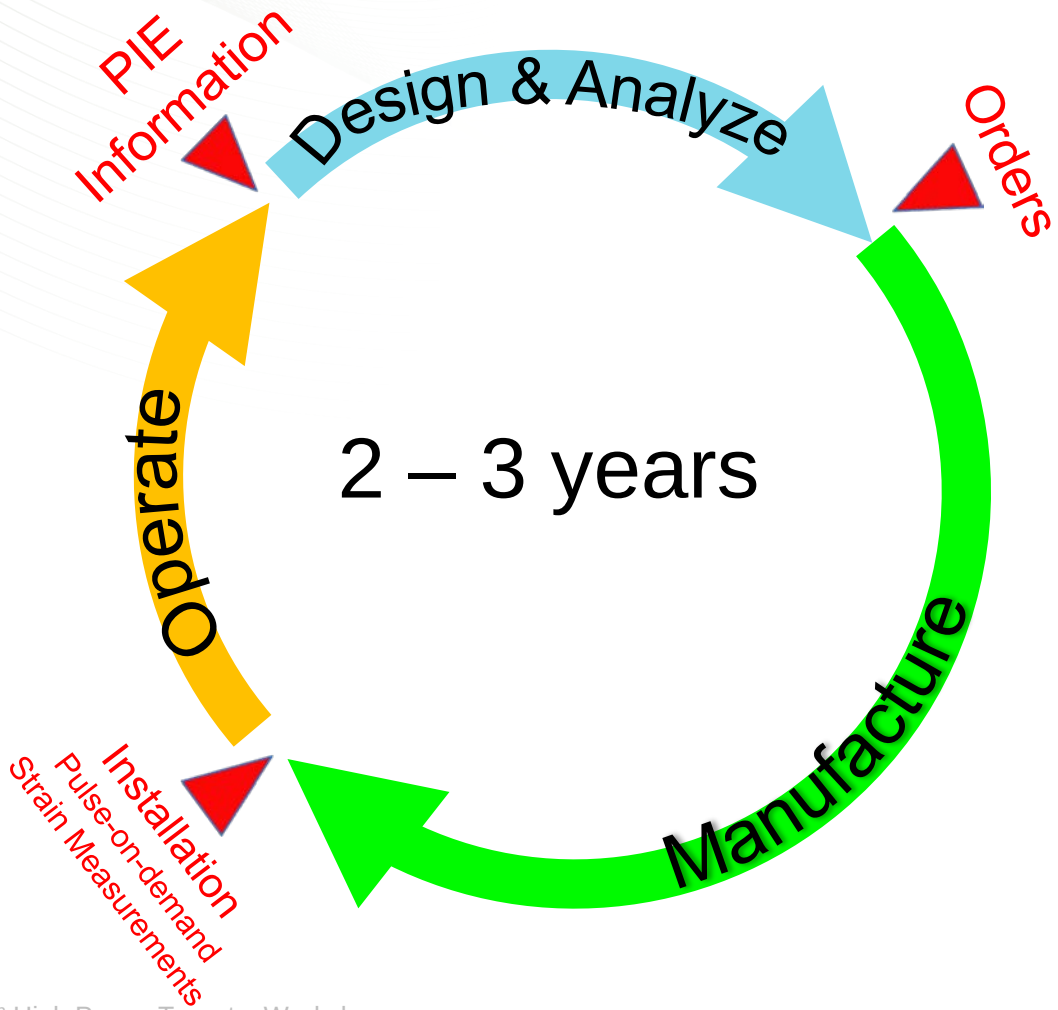
Target operations are following a step-wise, data-driven plan toward reliable operation at 1.4 MW

Winder

- Three targets per year
  - Opportunities to deploy changes in design and operation faster
  - Mitigating risk of leaks
  - Managing supply and fabrication time
- Stable power operation aides understanding of cavitation erosion rates



Our challenge is to improve targets while encumbered by a ~3 year time lag



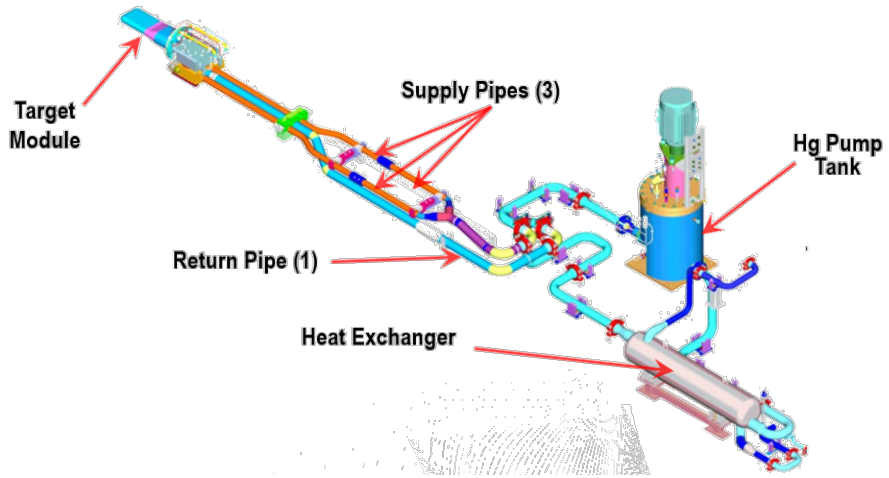
Strategy of Target Management Plan

- Leverage information to improve design
  - Predictive models
  - Engineering judgments
- Remain versatile (allowing for contingencies)
- Maintain spare inventory

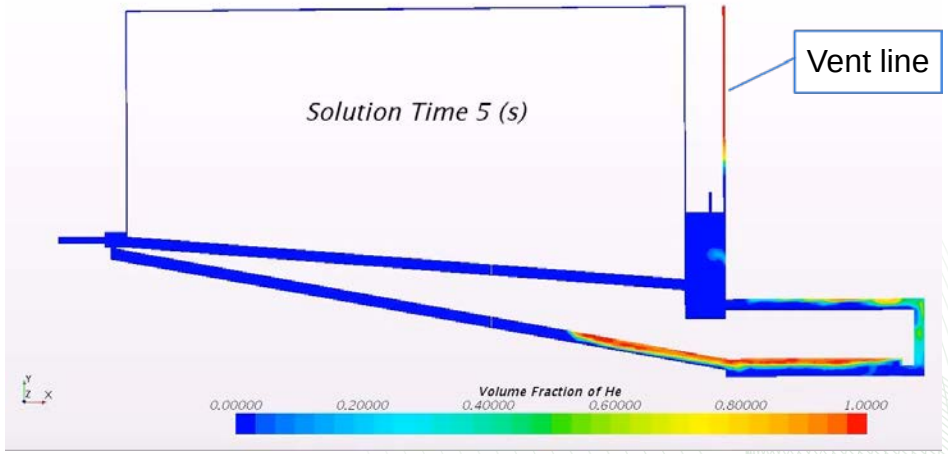
Target gas injection initiated in the SNS mercury target

- Essential for reliable, long-lived high power operation of SNS targets
- Small gas bubbles reduce the pressure wave caused by the pulsed beam
  - The pressure waves drive high-cycle fatigue of the mercury vessel and erosion damage from mercury cavitation
- While gas injection is good for the target vessel, it poses a risk that mercury could escape from the hot-cell

Barbier



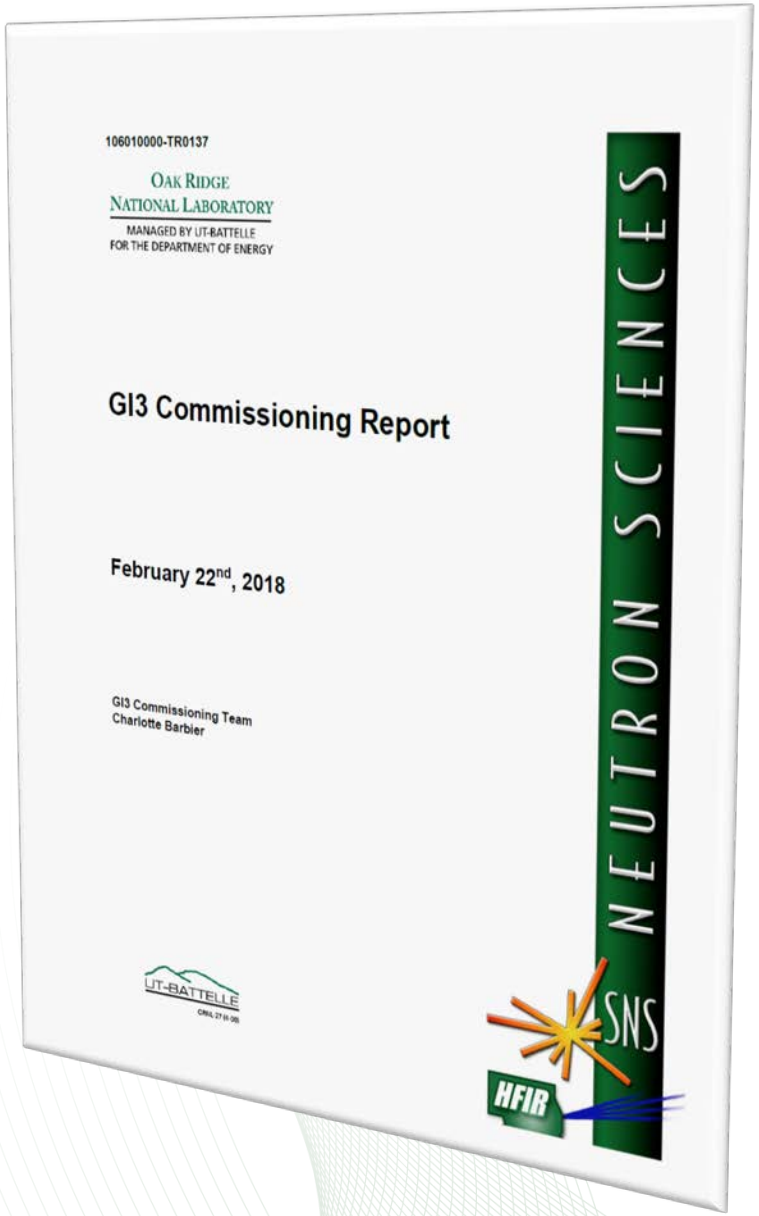
Bounding event for safety analysis



E. Dominguez-Ontiveros

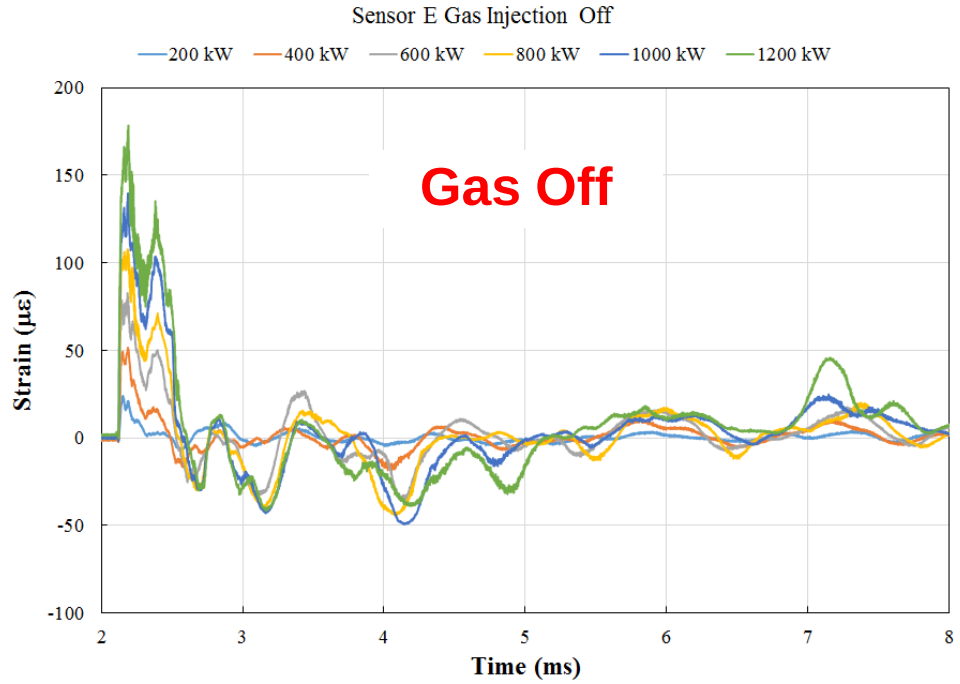
Gas injection results are positive

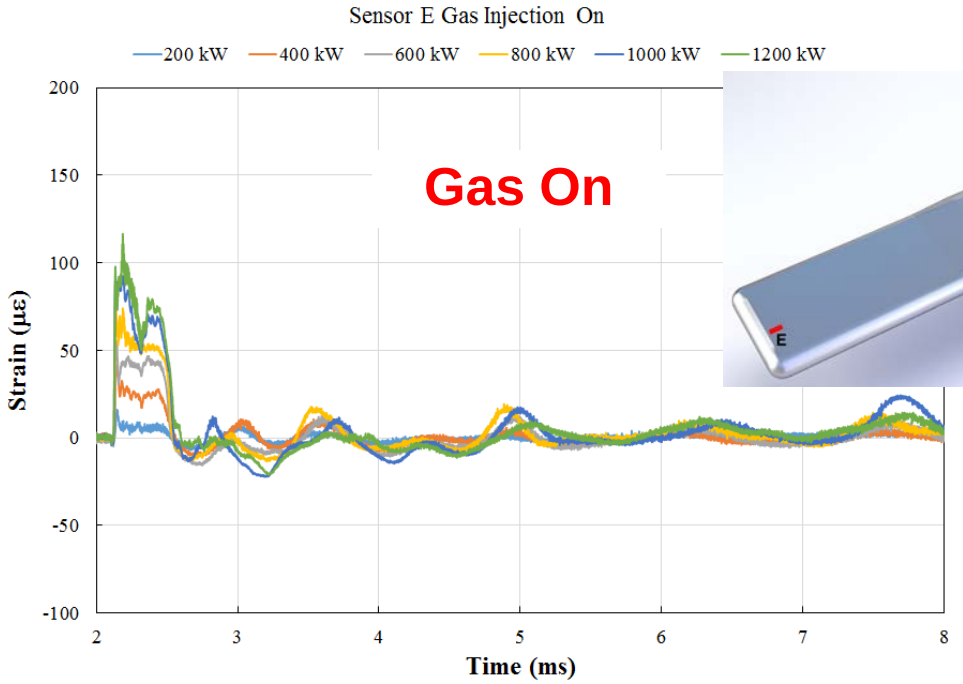
- Significant strain reduction was achieved *Blokland, Liu*
  - Indications are that more gas will be better
- Gas appears to have mitigated cavitation at some locations, changed pattern in others *McClintock*
- Gas flow did not interfere with loop operation or site emissions *Barbier*
  - However, higher radiation dose rates were observed at the mercury pump
- Approval to routinely operate gas injection granted
- Increasing the gas rate is planned
  - Further strain reductions
  - More uniform strain reduction

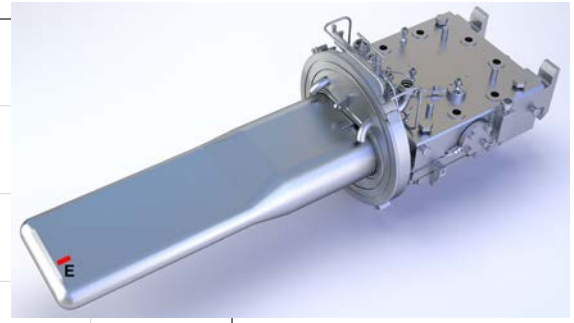


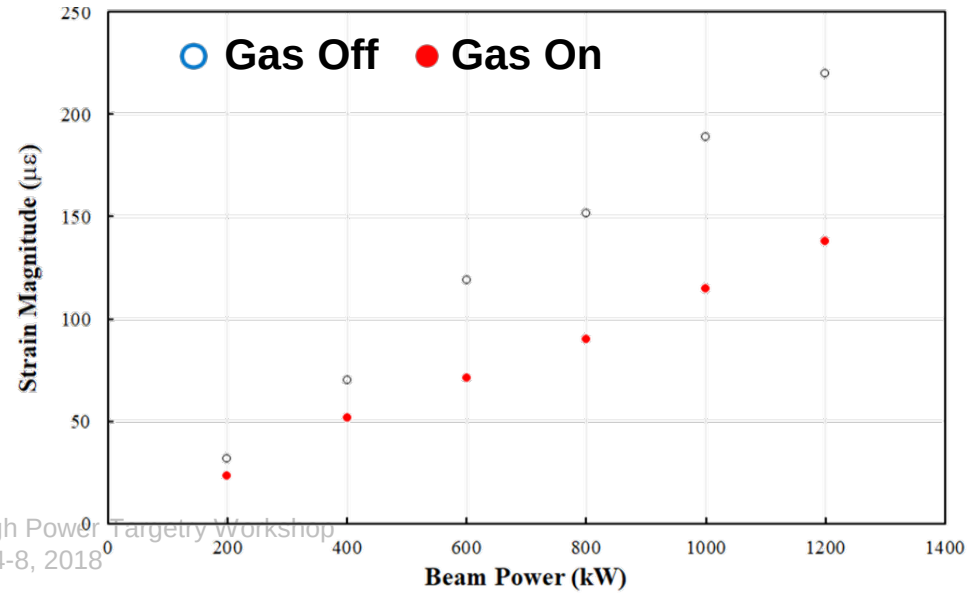
Sensor “E” results: up to 40% reduction with gas on

Blokland, Liu







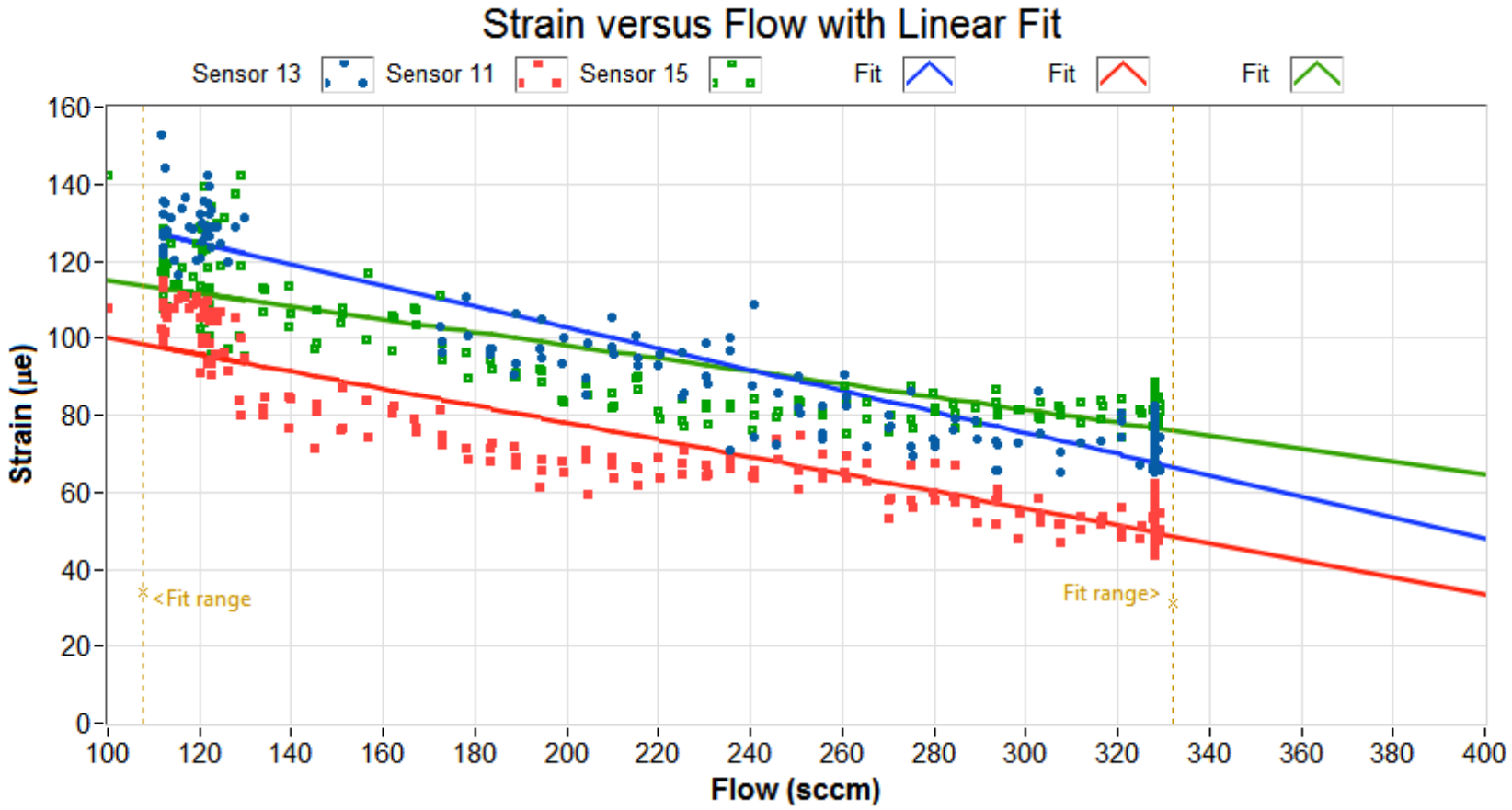


Beam Power (kW)	Strain Magnitude (με)		Strain Reduction (%)
	Gas injection off	Gas injection on	
200	31.73	23.06	27.3
400	70.06	51.50	26.5
600	118.76	70.95	40.3
800	151.79	90.09	40.6
1000	189.04	114.75	39.3
1200	219.97	137.64	37.4

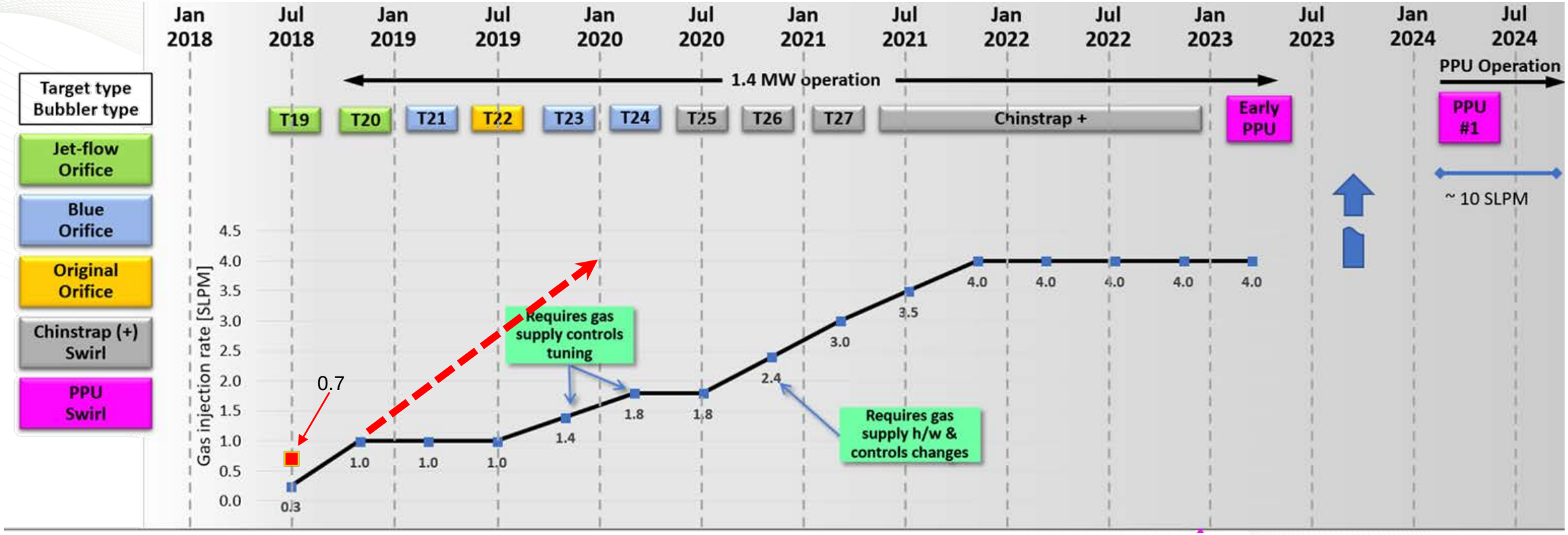
Testing indicated strain dependence on gas flow rate

Blokland

- Increasing gas flows are planned



Gas rates will be raised for 1.4 MW target lifetime goals and to inform future upgrades to 2 MW

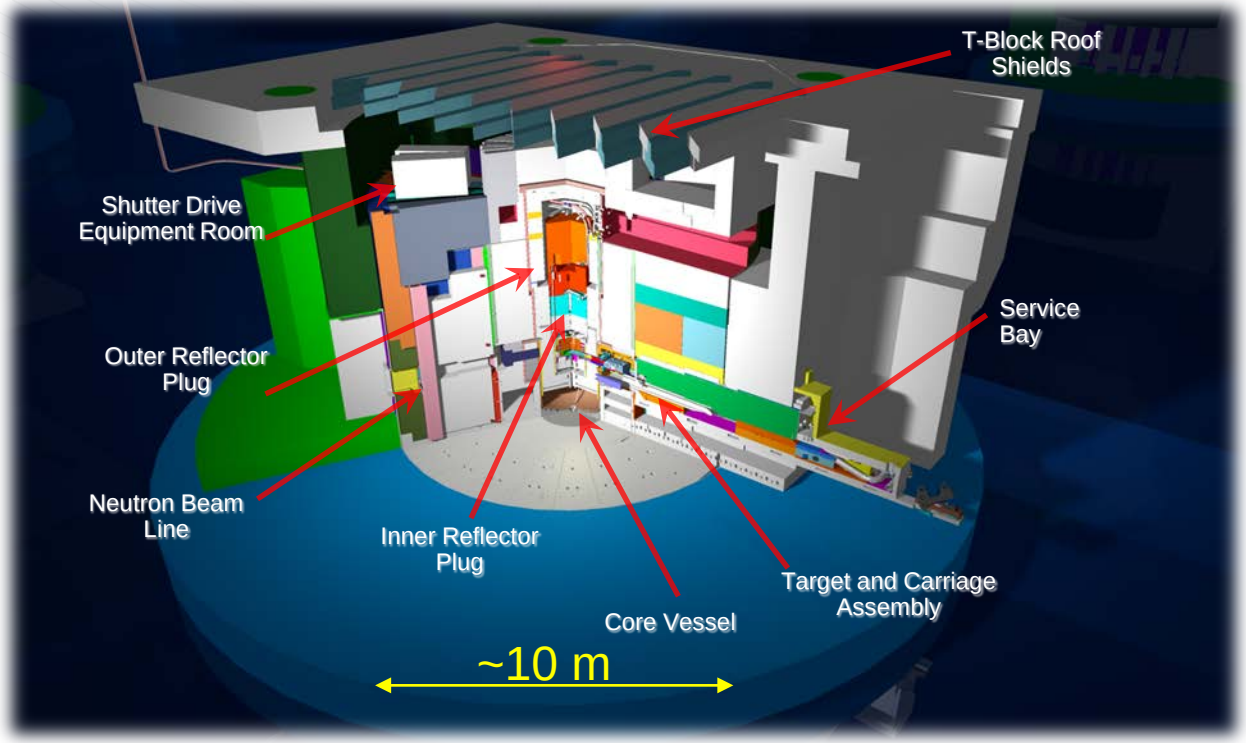


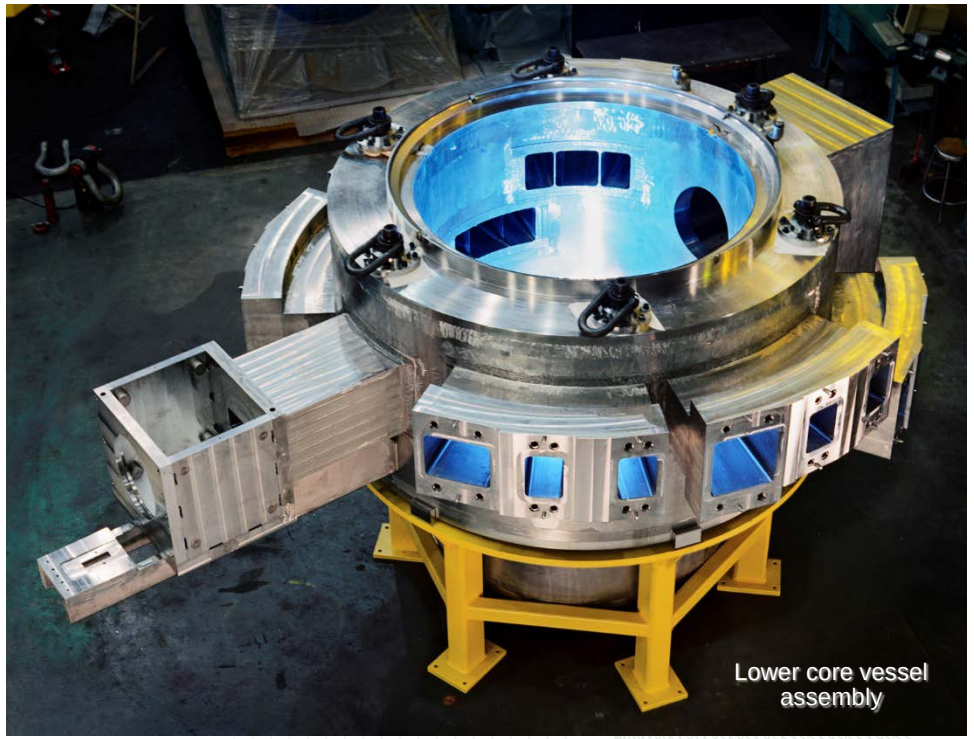
- PPU: Proton Power Upgrade Project
  - Doubles power of accelerator; will support a Second Target Station
  - Will send 2 MW of power to the First Target Station & extends facility lifetime

Operational difficulty: water inside the core vessel

Dayton

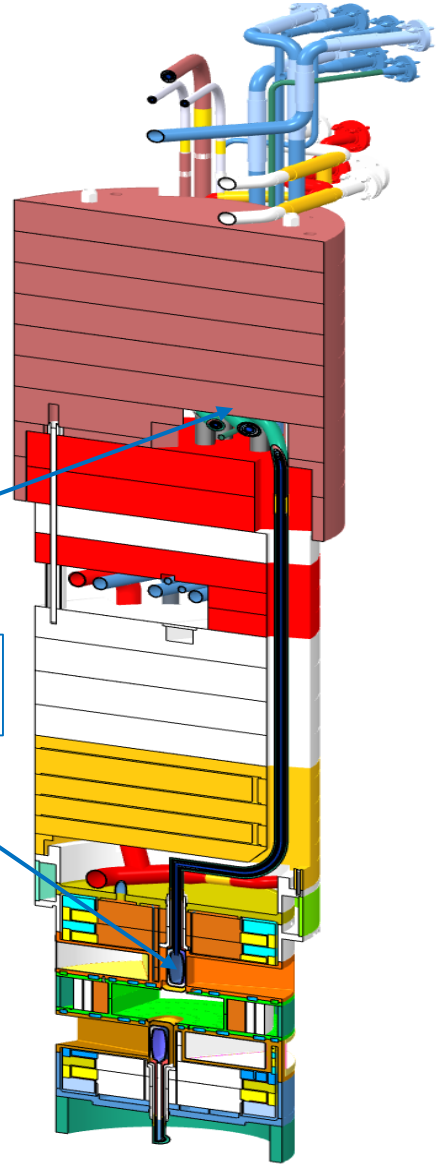
- The core vessel contains the inner and outer reflector plugs, neutron moderators, core vessel inserts, and interfaces with the target and proton beam window seals



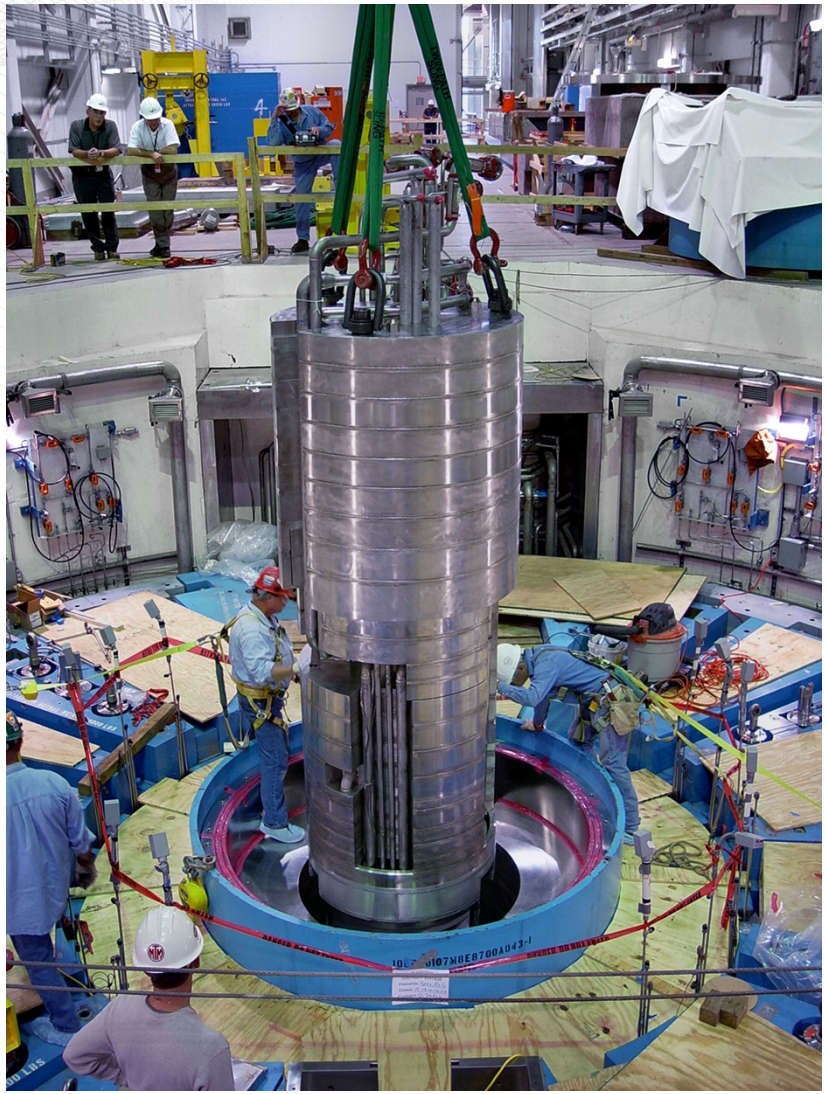


Water leaks inside core vessel were identified in Fall 2016

- The first leak was small at approximately 0.5 gallon / day
  - Located in the proton beam window (PBW)
  - Issue was resolved after PBW changeout
- A second leak was identified in November
  - The leak rate continued to increase and required an engineering solution
  - After an intense effort to design and install a leak collection system, the second leak was successfully managed

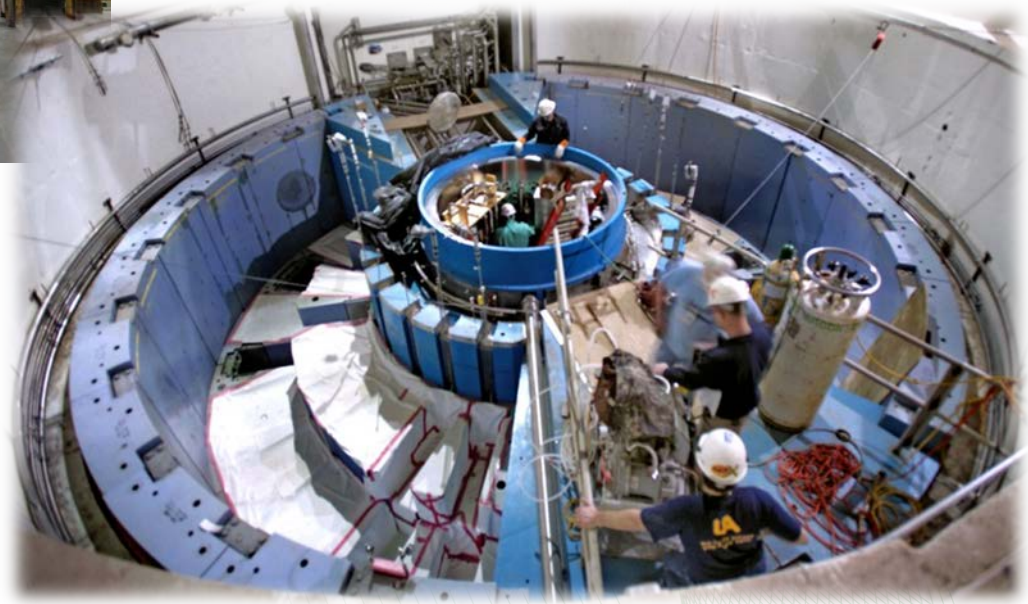


The Inner Reflector Plug (IRP) is a large, complex and limited-life component of the neutron source



- Planned lifetime was 32 GWh (~early 2016)
- Delivery of replacement was delayed
- Replacement completed early 2018 – 40 GWh
- Coolant changed to D_2O

Dayton

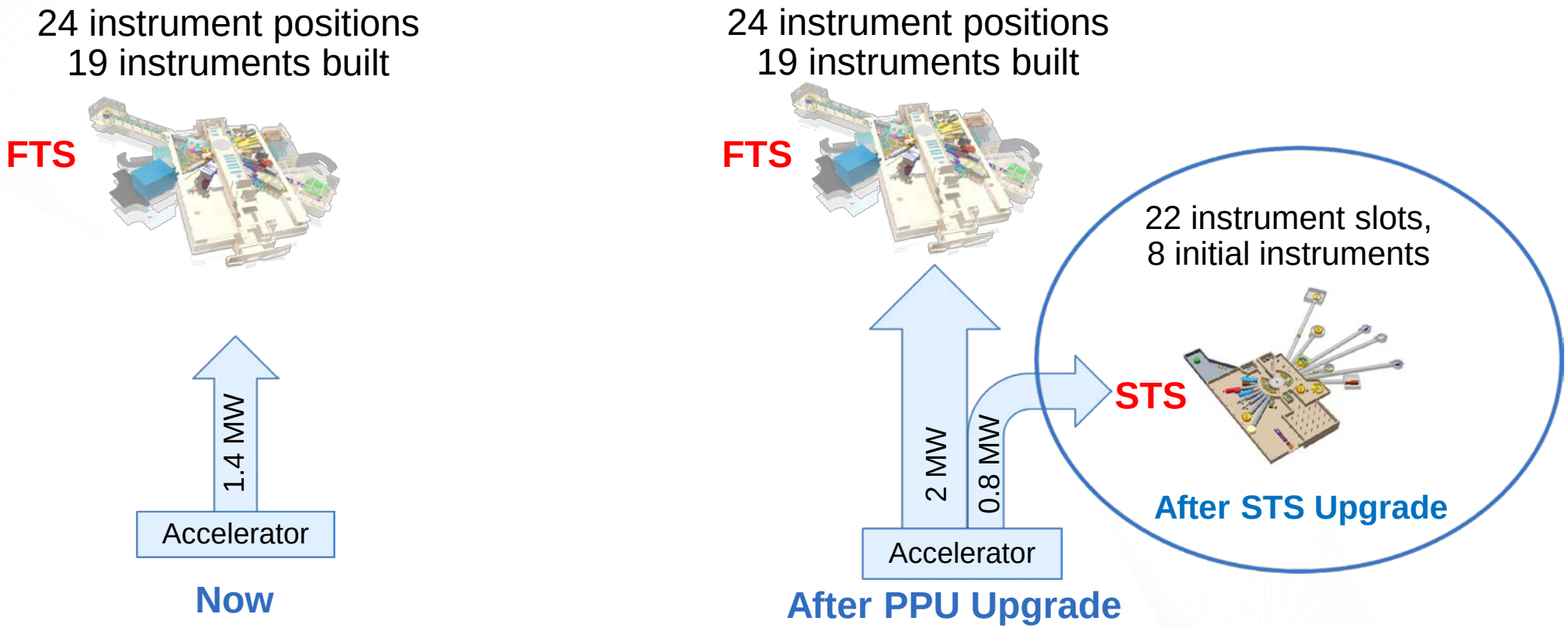


Photos of the original IRP-1 installation

Operation with water in the core vessel corroded the aluminum proton beam window

- During the IRP replacement process an inspection camera was positioned inside the core vessel to inspect the neutron and proton beam windows
  - Both are made from aluminum
- While the neutron windows appeared in good shape, corrosion of the PBW was apparent
- This PBW remains in service, but will be replaced at an earlier than planned
  - PIE will be conducted to characterize corrosion

SNS Upgrade Plans

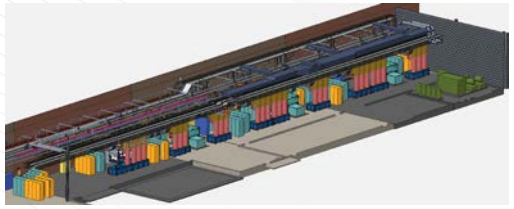


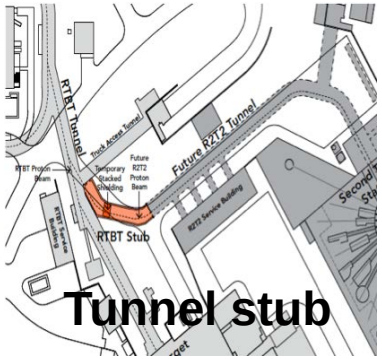
- Proton Power Upgrade project doubles accelerator power capability; **CD-1 granted April 2018**
  - Total cost ~$240M
  - Increases FTS capability & capacity and provides accelerator basis for STS
- Second Target Station provides new instrument hall with world class cold neutron brightness
  - Delayed from PPU start, ~$1.5B

Proton Power Upgrade Technical Scope

Conventional Facilities:

Klystron gallery



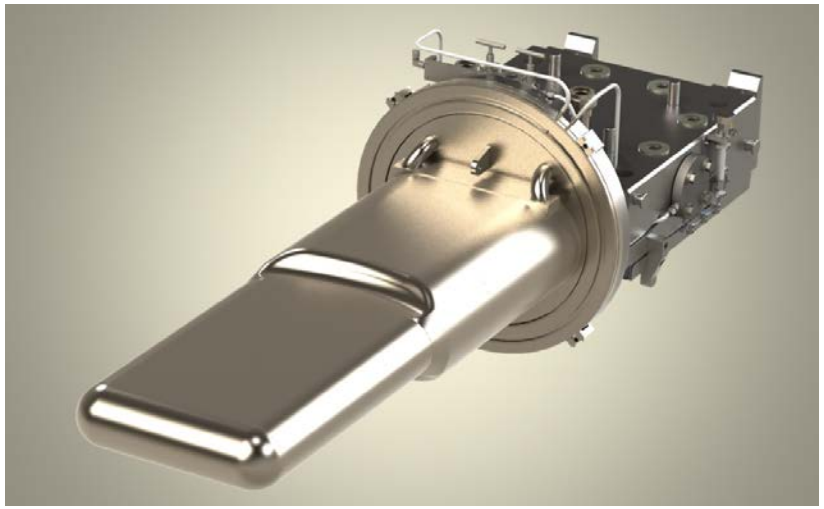


30% increase in proton energy

Basis for WBS Structure

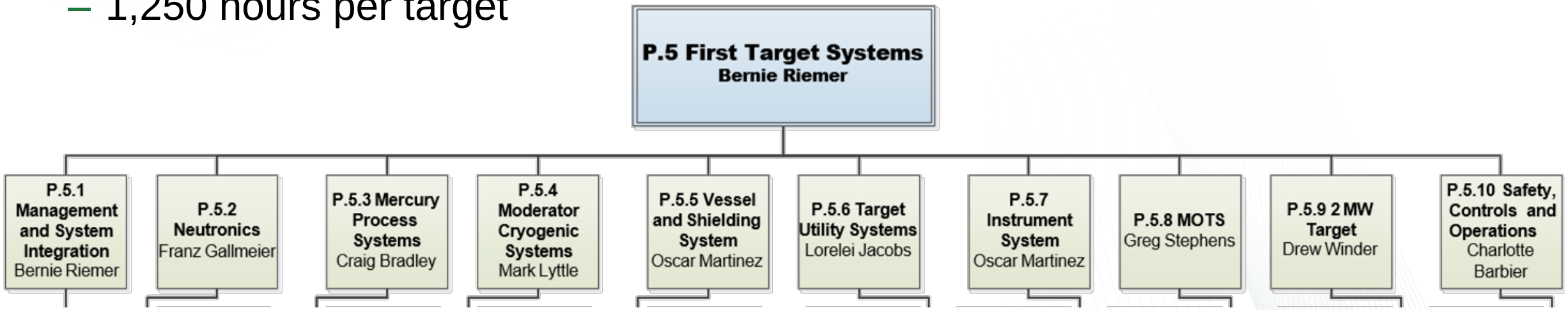
Target systems:

- **2 MW target vessel**
- **Support system upgrades**



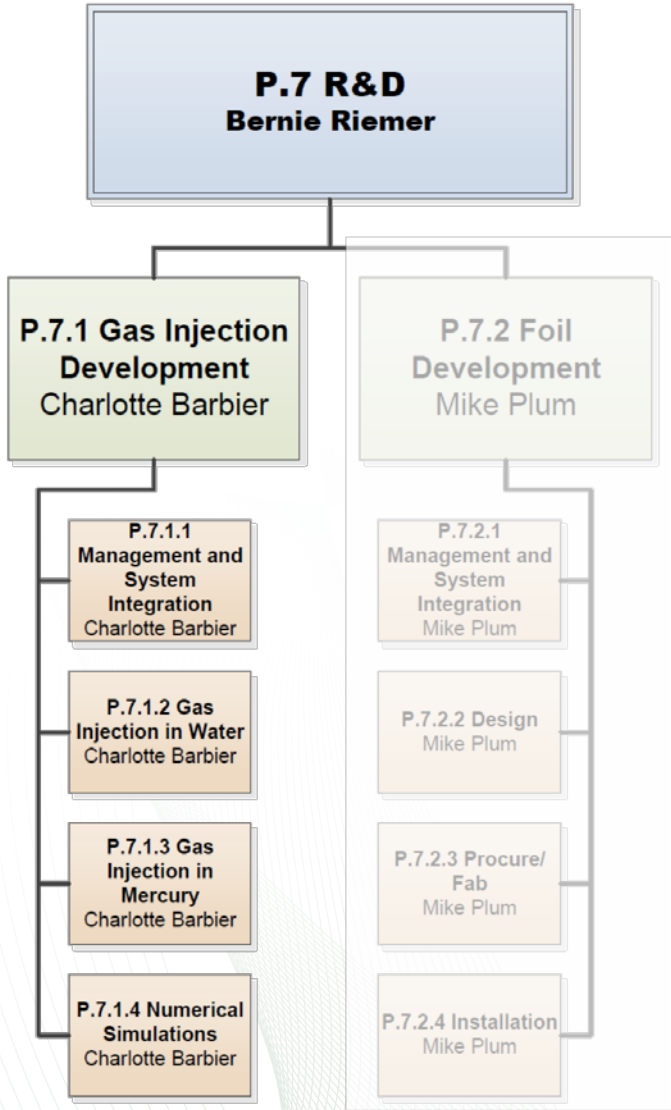
WBS for PPU FTS Systems scope is more than the target

- Requirement is to assure reliable operation of the First Target Station at 1.3 GeV, for at least 2.0 MW, at 60 Hz
- FTS lifetime extended to 60 years
- Target consumption rate of no more than 4 per year
  - 1,250 hours per target



PPU R&D for target gas injection

- PPU gas injection R&D is addressing:
  - Swirl bubbler design & performance
    - Technology from J-PARC
  - Bubbler gas rate
  - Gas wall design & gas rate
  - Gas hold-up characterization in mercury process loop
  - Gas gas-liquid separator design
- A combination of experiments and simulations is being employed



Much achieved at SNS since HPTW-6

- No target leaks have occurred at the SNS since 2015
- Regular operation at 1.4 MW begins this September
- Target gas injection has started
  - Significant pulse strain reductions achieved
  - Cavitation damage results are encouraging
  - Increasing gas injection is planned
- Water leaks inside the core vessel posed operational difficulties but were successfully managed
- First replacement of the inner reflector plug was completed
- The Proton Power Upgrade project will enable operation of two target stations and send 2 MW to the mercury target