OAK RIDGE National Laboratory

Oak Ridge Spallation Neutron Source Proton Power Upgrade Project and Second Target Station Project

Workshop on the future and next generation capabilities of accelerator driven neutron and muon sources

STFC Rutherford Appleton Laboratory
August 14, 2018

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Ring Systems Group Leader

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

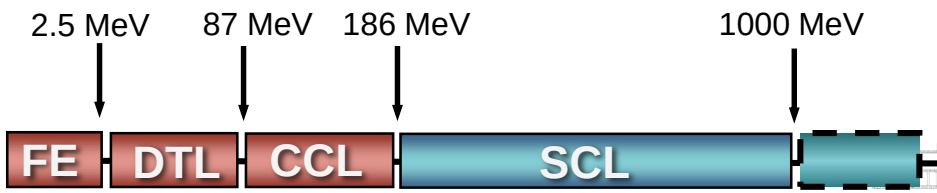
U.S. DEPARTMENT OF ENERGY

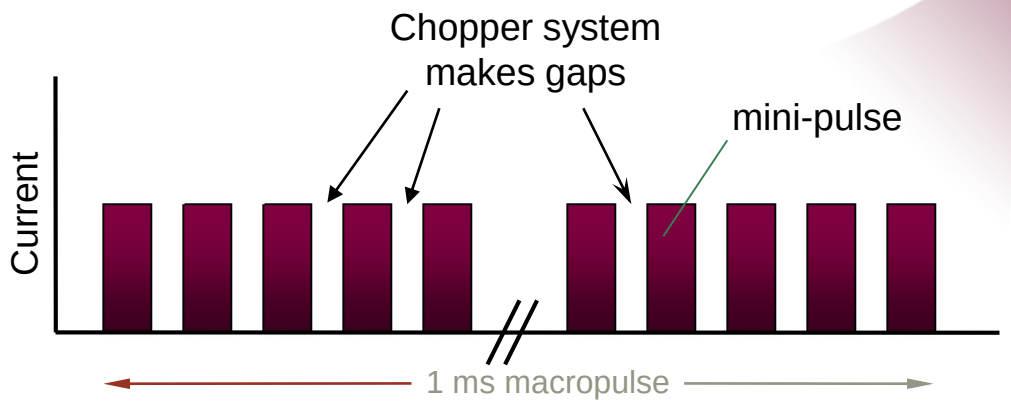
SNS Accelerator Complex Today

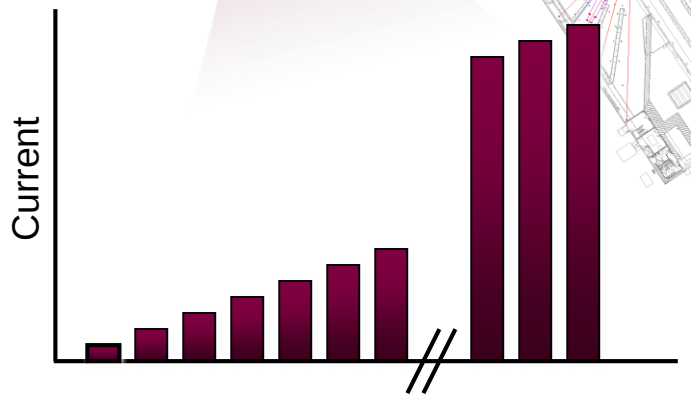
Front-End:
Produce a 1-ms long, chopped, H^- beam

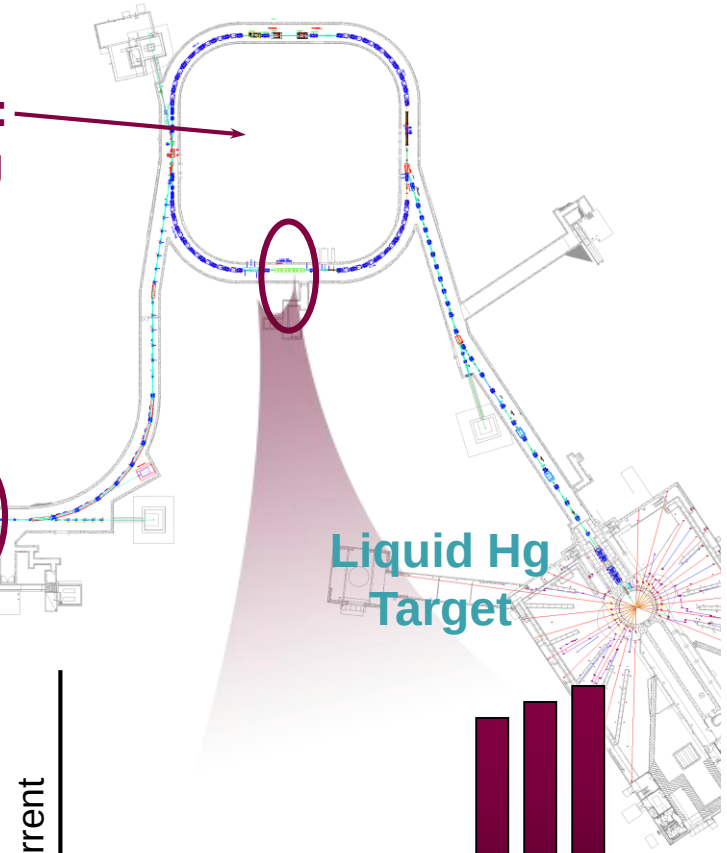
1 GeV LINAC

Accumulator Ring:
Compress 1 ms long pulse to 700 ns





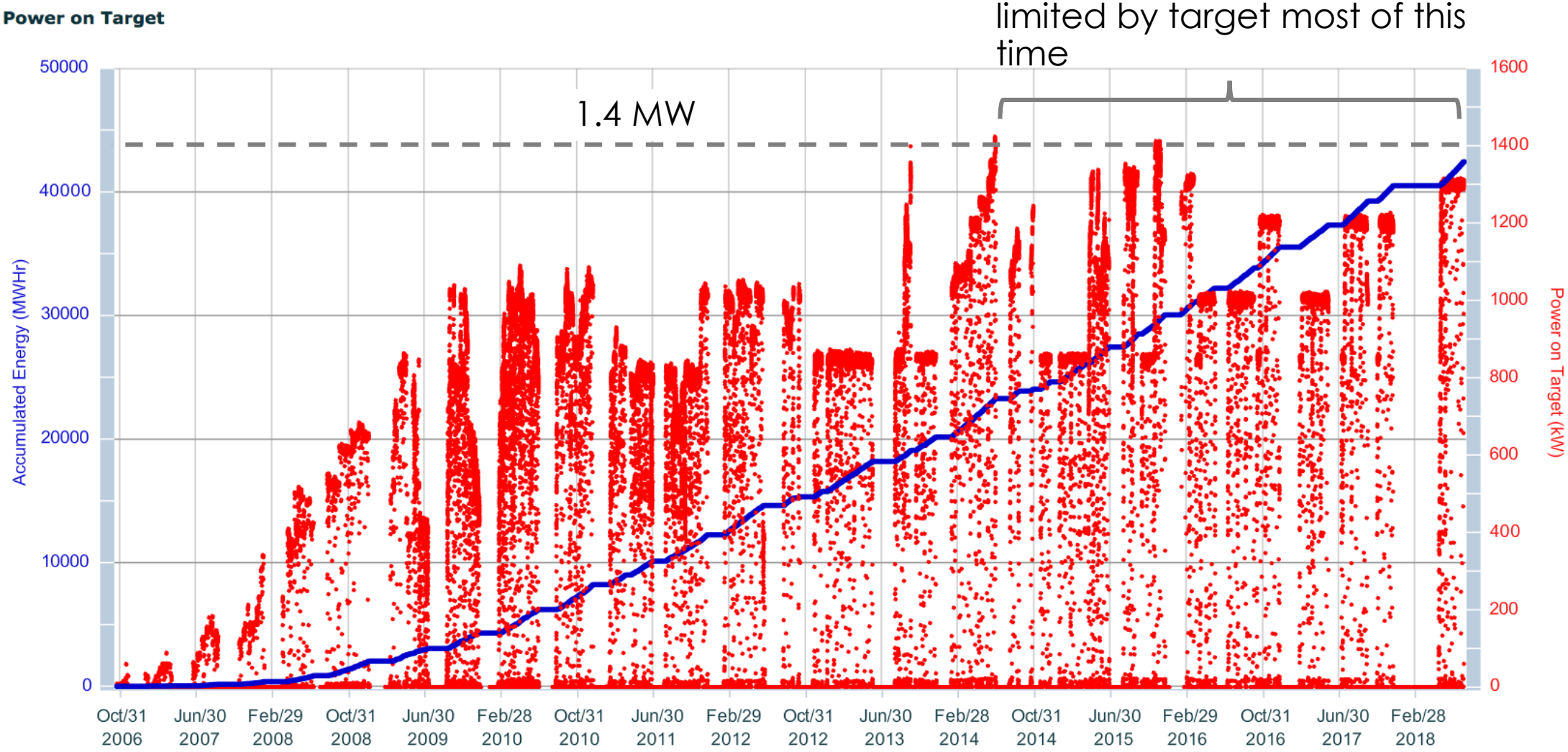




Design parameters: 60 Hz, 1.4 MW

SNS beam power history

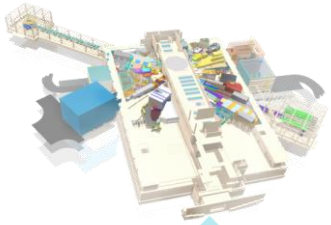
Beam power administratively limited by target most of this time



Availability for latest run cycle is 94%
Plan to operate at 1.4 MW starting September 2018

SNS Upgrade Plans

FTS
- 24 instrument positions
- 19 instruments built

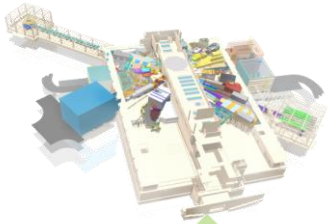


1.4 MW

Accelerator today

Now

FTS
- 24 instrument positions
- 19 instruments built



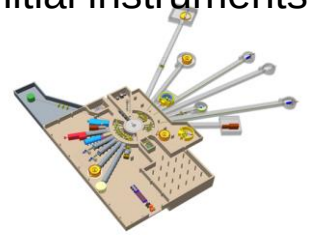
2 MW

0.8 MW

Accelerator after PPU

After PPU Upgrade

STS
- 22 instrument slots
- 8 initial instruments

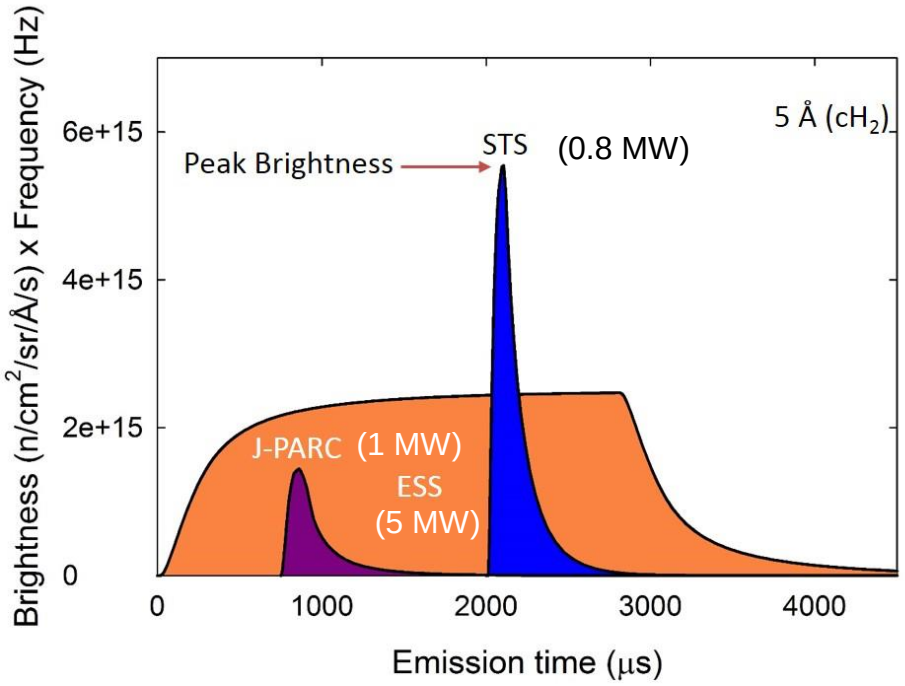


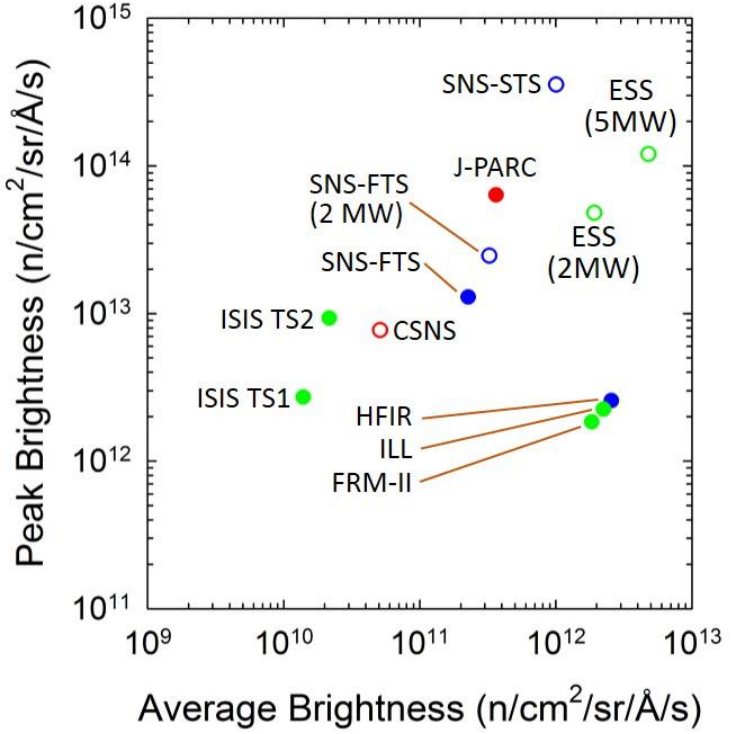
After STS Upgrade

- Proton Power Upgrade project doubles accelerator power capability
  - Near term, ~$240 M. CD-1 awarded April 2018. FY18 budget $36M.
  - 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

Second Target Station: world class cold neutron performance

5 Å – long wavelength comparison





- STS will be the highest peak brightness long wavelength neutron source

PPU Parameters: power increase with energy and current

- PPU delivers 2.8 MW capable accelerator
- Prior to STS, accelerator will run at 2 MW to FTS

	SNS 1.4 MW	PPU full upgrade capability	PPU FTS 60 Hz operation
Proton beam power capability (MW)	1.4	2.8	2.0
Beam energy (GeV)	1.0	1.3	1.3
RFQ output peak beam current (mA)	33	46	46
Average linac chopping fraction (%)	22	18	41
Average macropulse beam current (mA)	25	38	27
Energy per pulse (kJ)	23	47	33
Pulse repetition rate (Hz)	60	60	60
Macro-pulse length (ms)	1	1	1
FTS decoupled moderator brightness/pulse (AU)	1	2.04	1.43
FTS coupled moderator brightness/pulse (AU)	1	2.16	1.51

33% energy increase

50% current increase

No change

PPU system upgrades

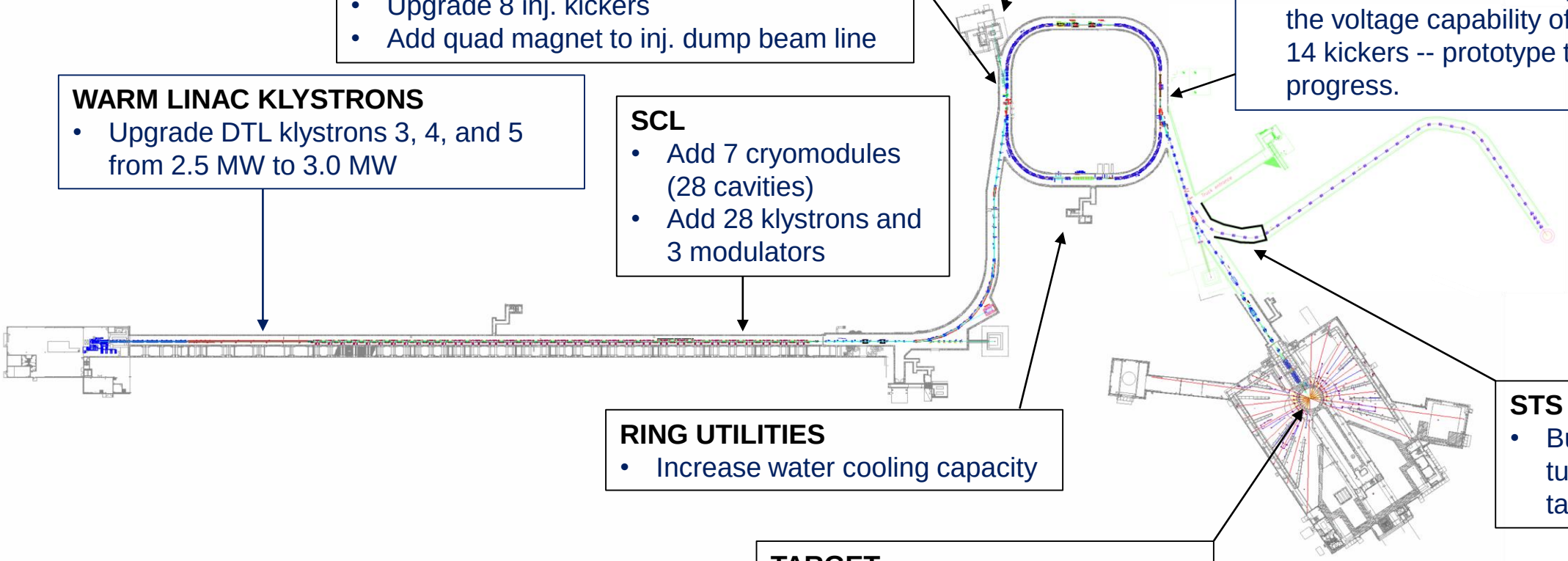
INJECTION DUMP
- Re-assess 150 kW power rating
- Add view screen imaging system

RING INJECTION
- Replace 2 chicane magnets
- Replace inj. dump septum magnet
- Upgrade 8 inj. kickers
- Add quad magnet to inj. dump beam line

RING EXTRACTION
- Add 2 more kickers to the existing 14 kickers.
- But there is another way: to upgrade the voltage capability of the existing 14 kickers -- prototype testing is in progress.

WARM LINAC KLYSTRONS
- Upgrade DTL klystrons 3, 4, and 5 from 2.5 MW to 3.0 MW

SCL
- Add 7 cryomodules (28 cavities)
- Add 28 klystrons and 3 modulators



Future beam line to second target station

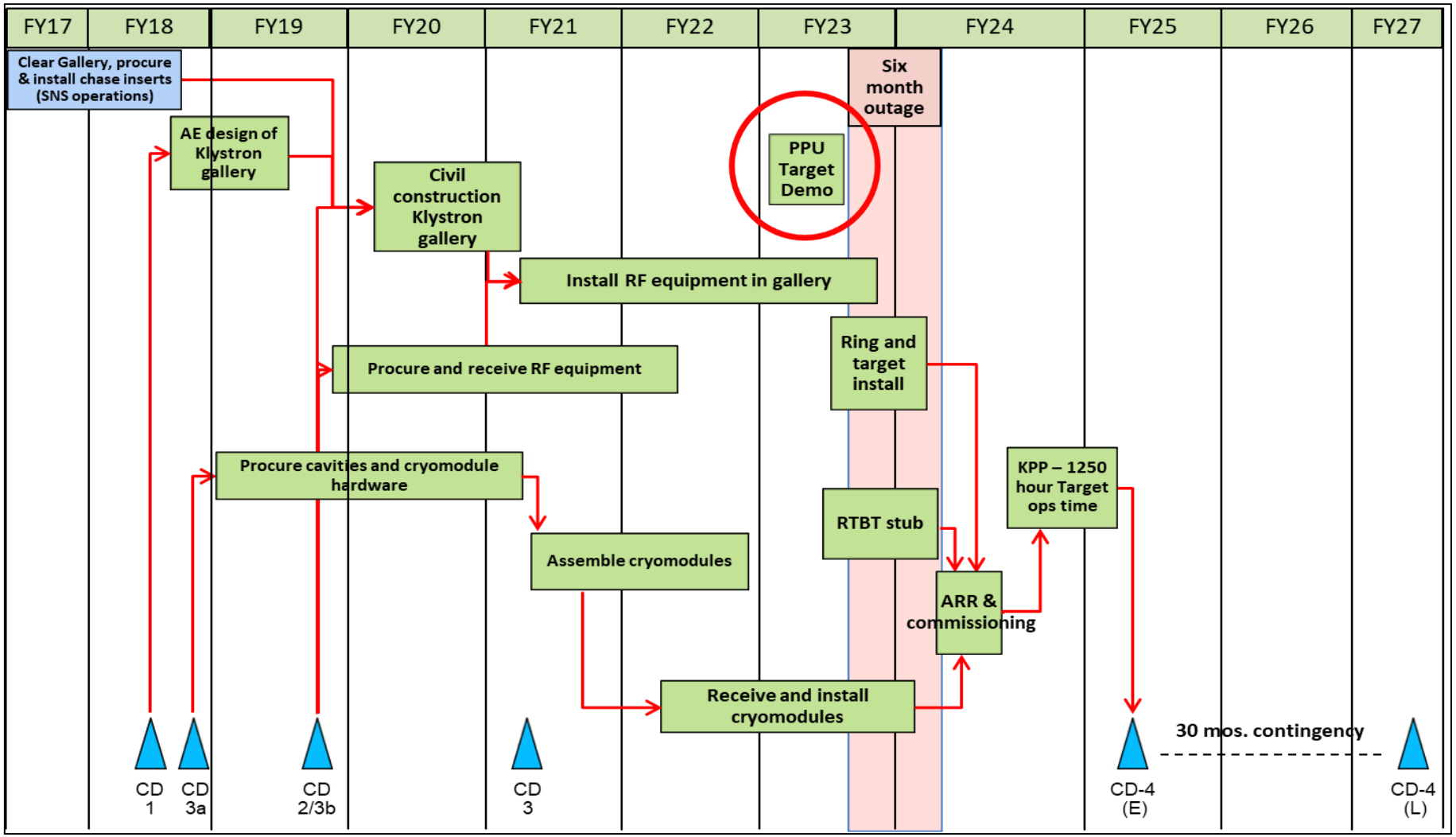
RING UTILITIES
- Increase water cooling capacity

STS STUB
- Build first part of beam tunnel to future second target

TARGET
- Increase power capability from 1.4 to 2.0 MW

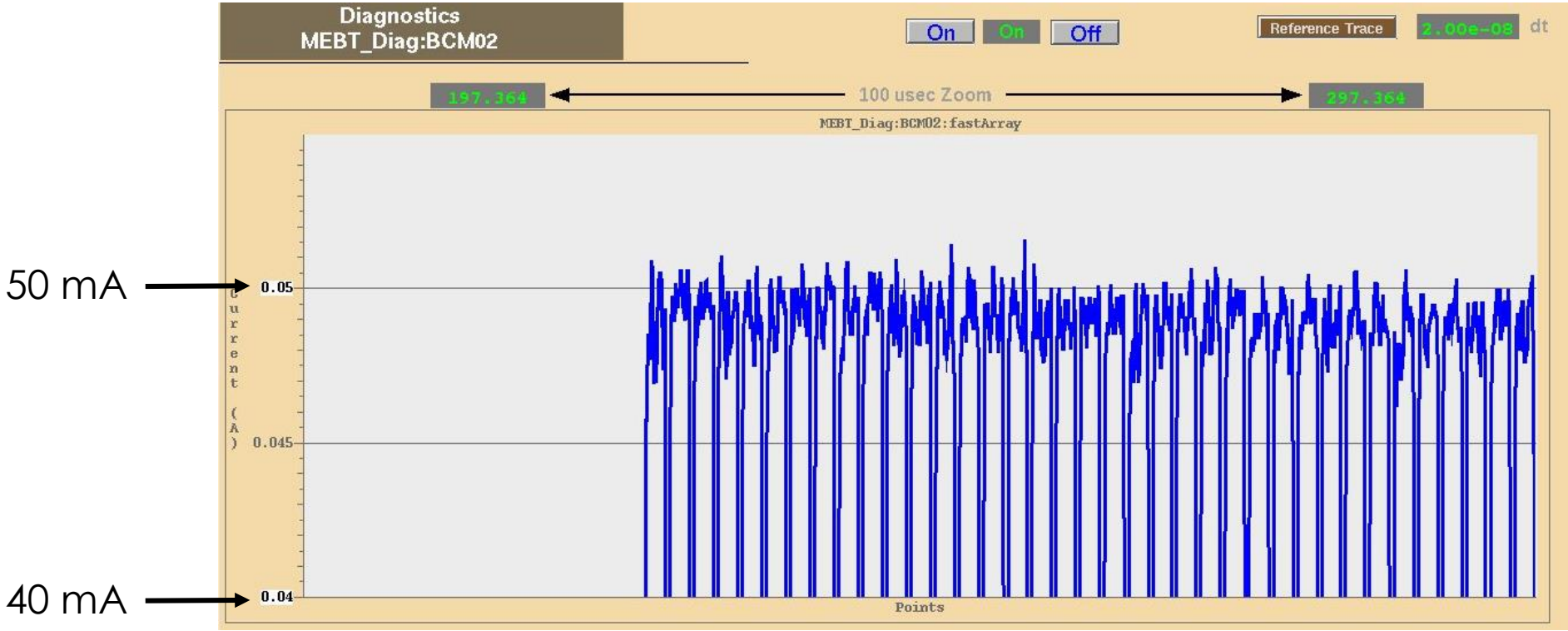
PPU notional schedule

- Holding 6-month outage/early finish firm
- Includes a pre-6 month outage PPU target demo, possibly at > 1.4 MW



Front end

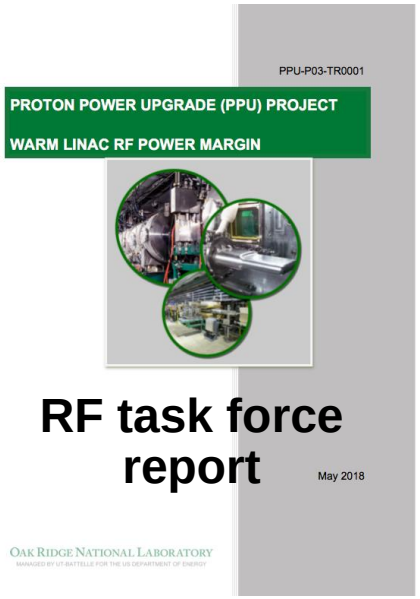
- The new RFQ installed in 2018 allows higher peak currents
- 48 – 50 mA is easy to achieve. PPU requirement is 46 mA.



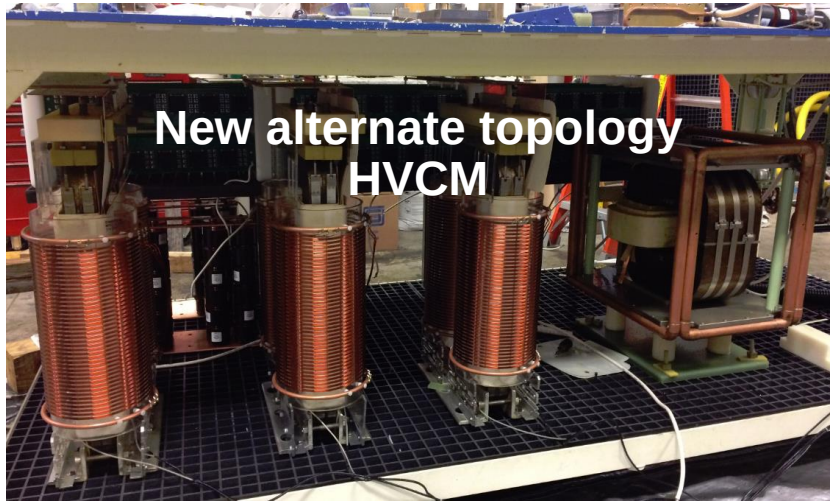
Screen shot of BCM in MEBT on July 2, 2018

RF Progress

- RF task force conducted measurements to determine required warm linac upgrades
  - 3 of 6 DTL klystrons require upgrades from 2.5 to 3.0 MW
  - CCL RF is OK

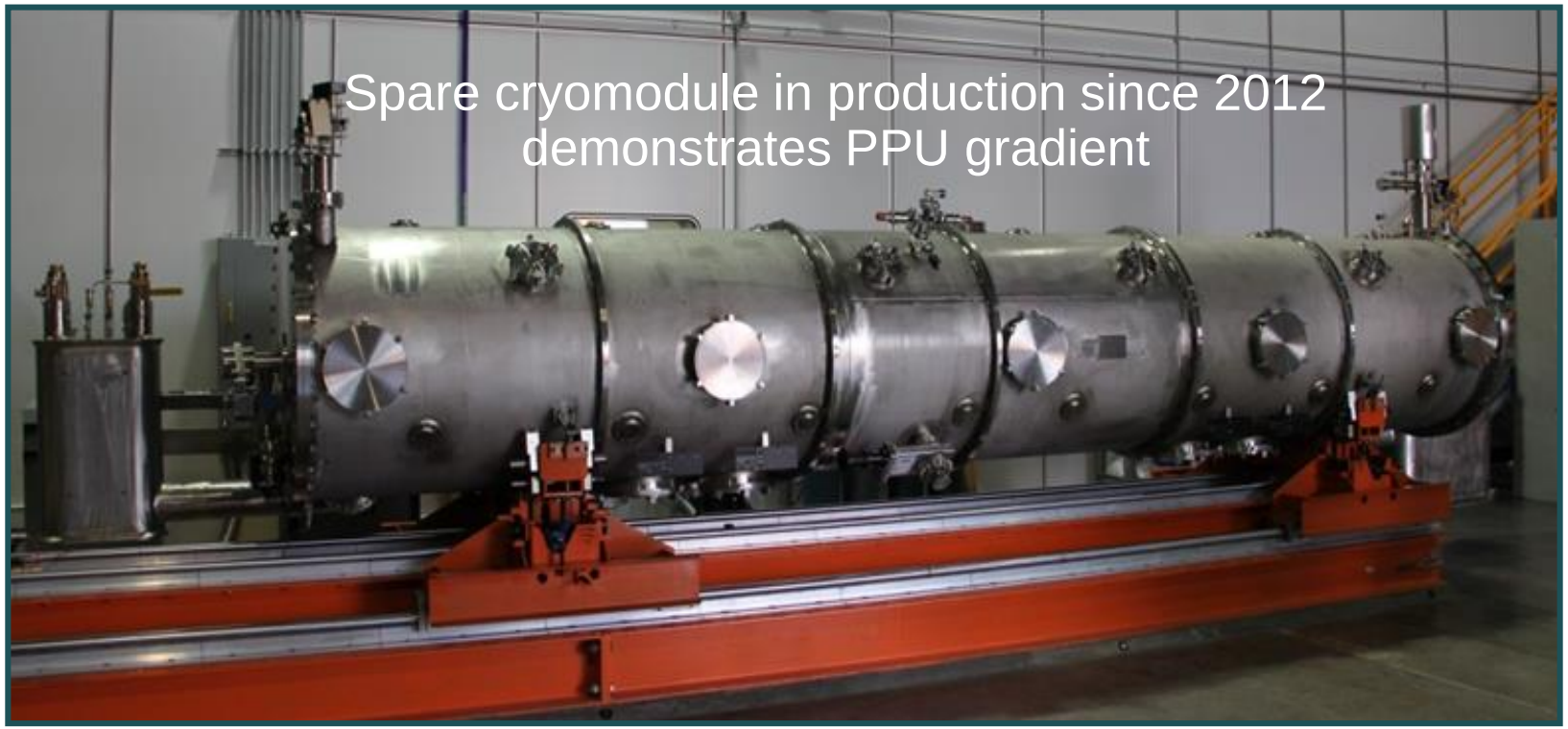


- Initiated testing of new high voltage convertor modulator (HVCM) design proposed to power new RF systems



SRF progress

- SRF / M. Howell
  - Initiate cavity long lead procurements (Nb, cavity qualification equipment, cavities)
  - With J-Lab, initiate cryo-module engineering baseline activities



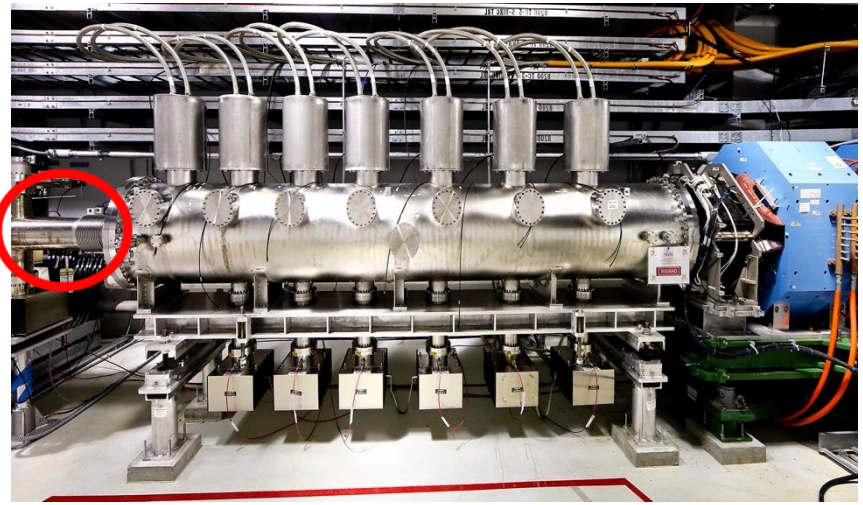
Ring progress

- Injection region
  - FNAL selected to design the magnets and oversee fabrication
  - Beam measurements made to verify final design requirements

Injection chicane

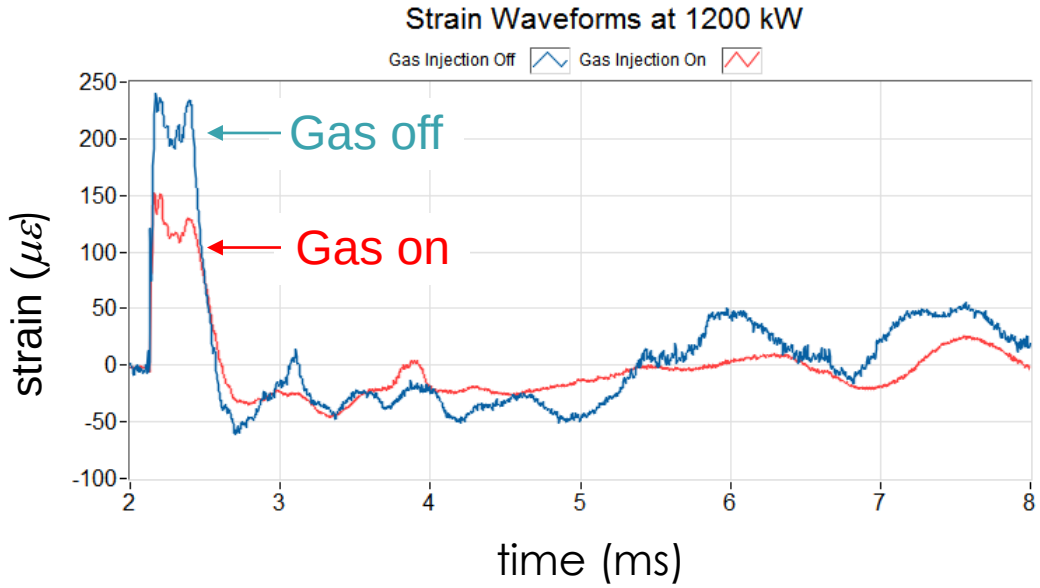
- Extraction region
  - Baseline plan: add additional kickers in provided space
  - A prototype resonant charging supply is being tested now. We hope this can be used to increase the voltage on the existing kickers instead of installing new ones.

Kicker magnets

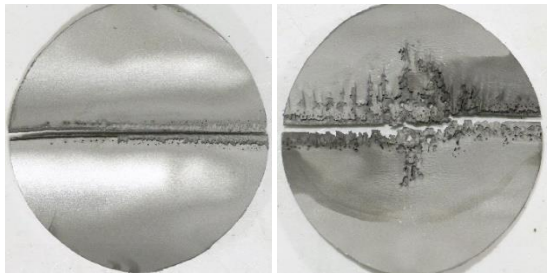


Target Progress: gas bubble injection implemented in operations Nov. 2017

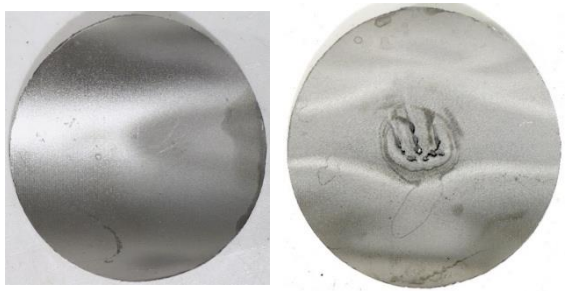
- Measured vessel strain from pressure pulse reduced 10-70% with gas on



- Core samples from target nose indicate erosion mitigation with gas on



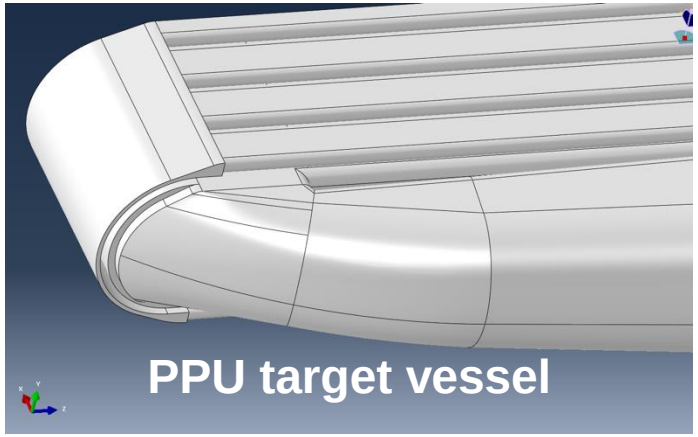
Gas off: Target 17

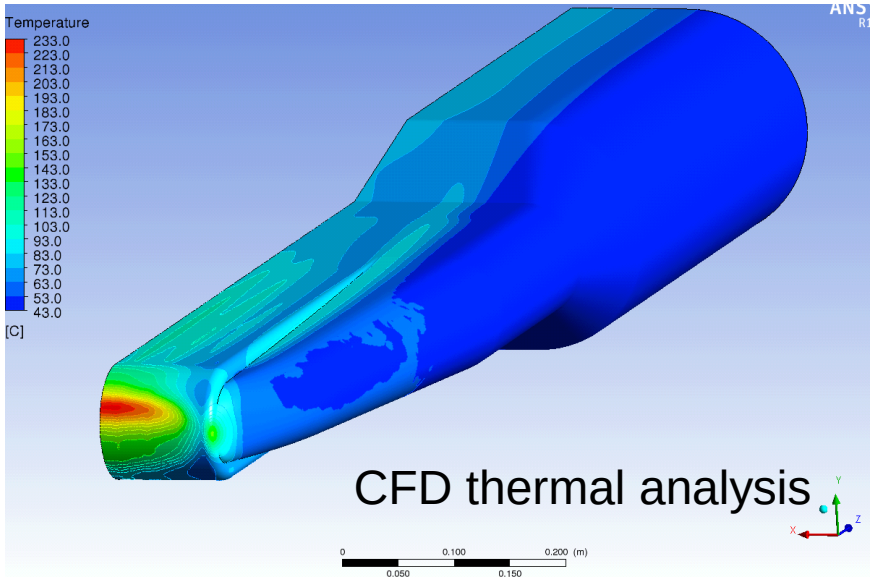


Gas on: Target 18

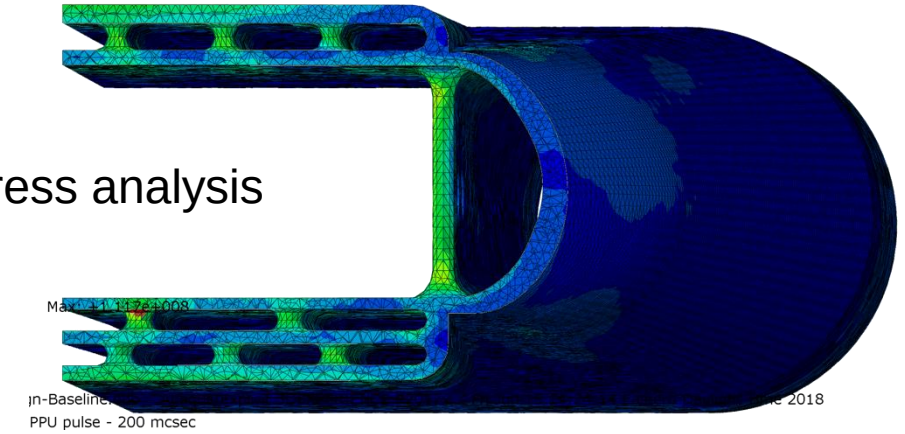
Target Progress: target design

- 2 MW target design developed
  - Simplified flow deployment in corners (tapered shape)
  - Eliminated unnecessary feature (center baffle)
  - Includes a gas-wall “curtain” in the nose region





Finite element stress analysis



Conventional Facilities Progress

- Klystron gallery building cleared out, prepared for PPU activities
  - Waveguide and cable conduit inserts assembled and inserted in chases to the tunnel

- A/E contract issued for design work (Cannon Design)
  - CF + technical equipment layout
  - Uses BIM (Building Information Modeling) approach
  - Kick-off meeting held July 18-19

PPU Challenges

- The ring injection chicane is very complicated and crowded
  - The new design will build on the tools and experience we've already developed to address the past issues we've had in this area
  - Particle tracking simulations with 3D fields will be used to verify design
- The 2 MW target requires a lot of development
  - We've only recently built targets that can operate at 1.4 MW
  - Mercury flow, gas bubbles, and gas curtains are key

Summary and conclusions

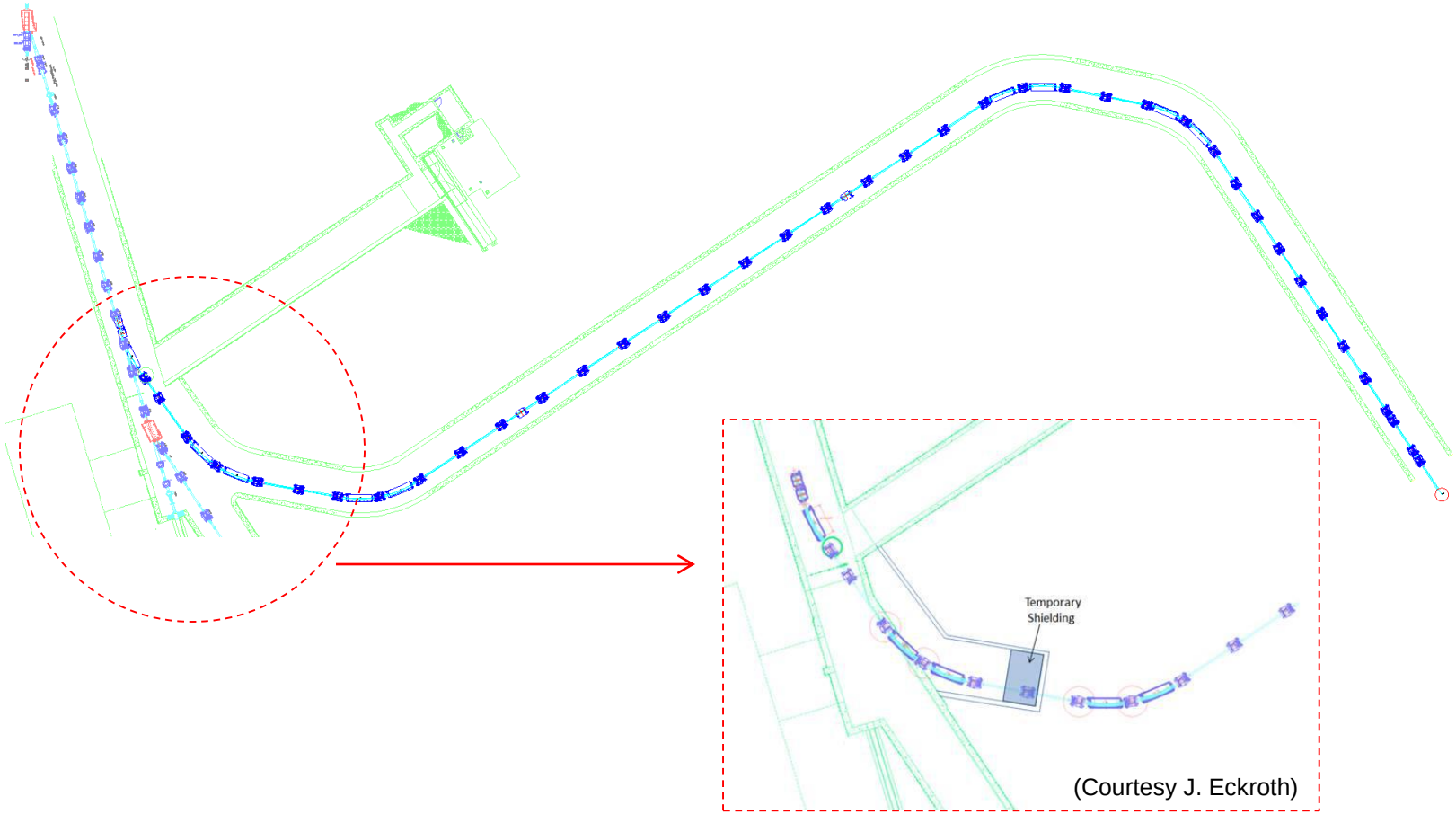
- CD-1 for PPU awarded April 2018. The project is making good progress.
  - We're aiming for completion in 2024 – 2025
- CD-0 for the STS project was awarded in 2009, but then put on hold
  - We're optimistic that it will be restarted soon

Thank you for your attention!

Backup slides

R2T2 beam line and stub

- Initial R2T2 beam line layout complete
- Conceptual design of R2T2 stub in progress



(Courtesy J. Eckroth)

(Courtesy Survey and Alignment Team)