MIT NUCLEAR REACTOR LABORATORY

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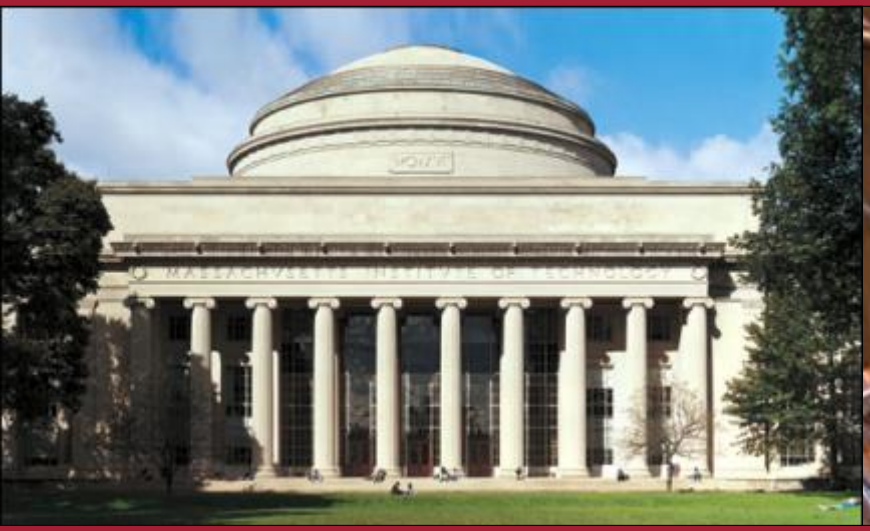

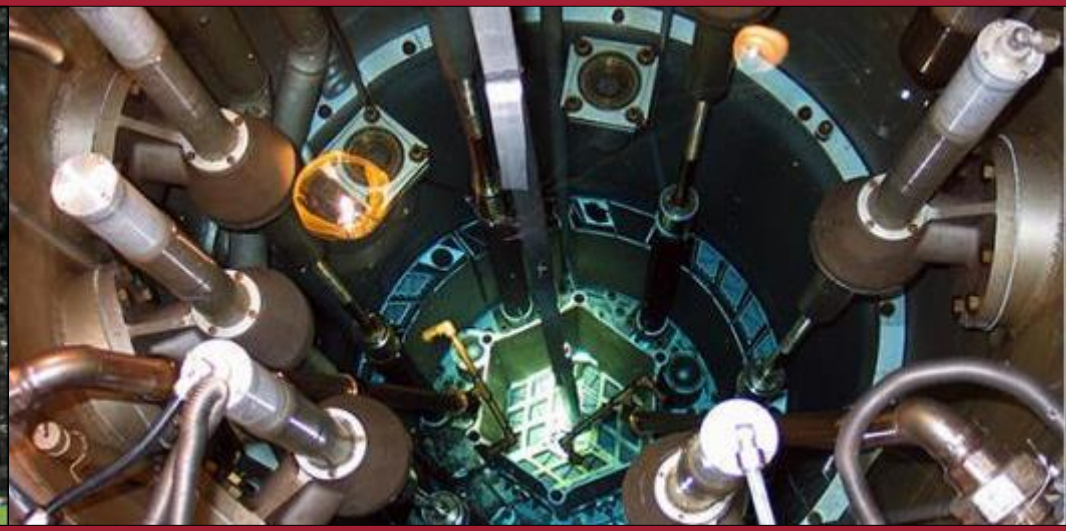

Generating 3D Models of Complex Structures For Engineering Planning

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June 18th-22nd, 2023
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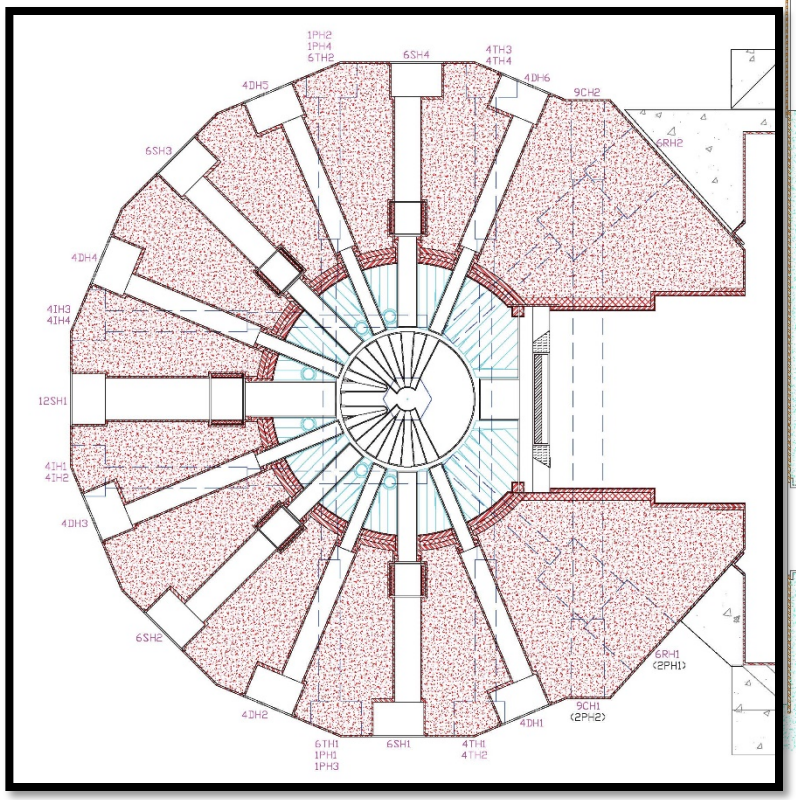
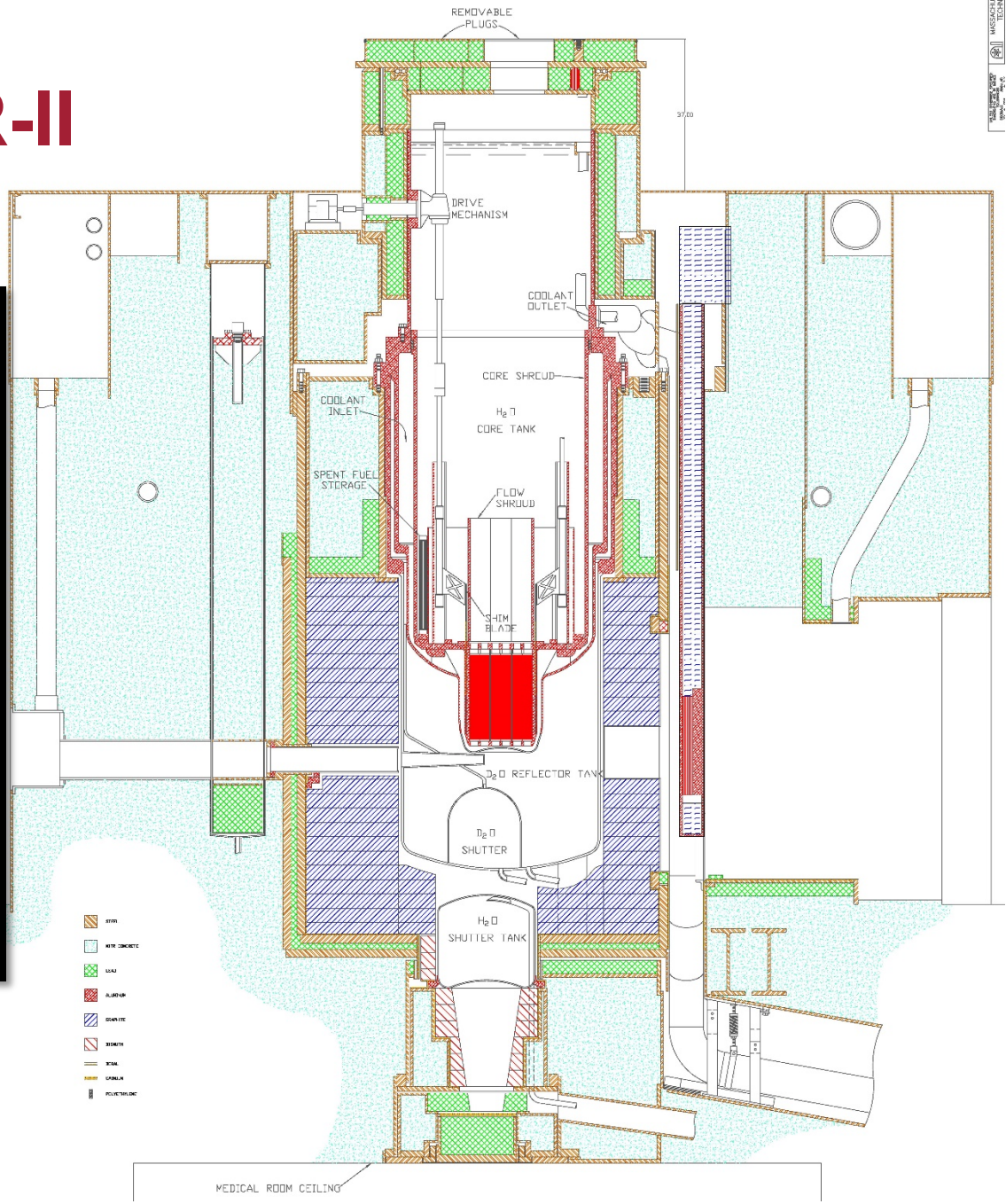
TRTR/IGORR

MIT Research Reactor (MITR-II)

- MITR-I constructed 1956-1958
- Core and process systems redesigned for MITR-II
  - Light water cooled and moderated, heavy water reflected
  - First criticality on August 14th, 1975
- Primary/Secondary systems rebuilt in 2010 for relicensing and power uprate up to 6.0 MW
- Operates 24/7 except during scheduled outages

Overview of MITR-II



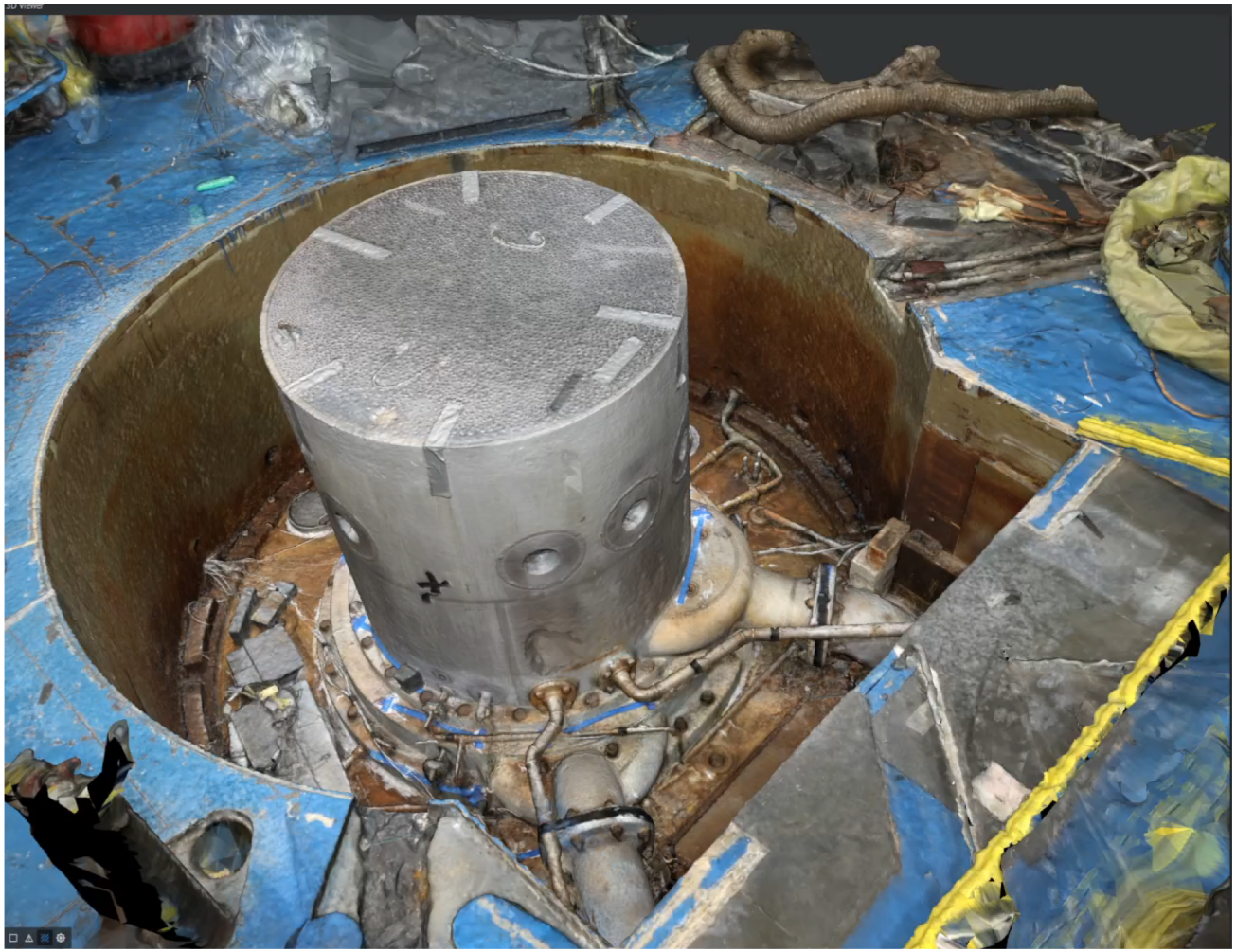


Drawings courtesy of D. Carpenter

Documenting Disassembly

- Dec 14 2022
  - Vertical port plug removed, flooding of thimble confirmed
  - Disassembly and leak discovery process begins
- Disassembly Documentation & Planning
  - Disassembly caused increased dose rate hazards
  - Engineering planning meetings staring at 2D Drawings resulted in observing discrepancies between as-designed and what actually existed
  - Static images / slideshows have a tradeoff between detail and position

Generating 3D model for status updates



What is Photogrammetry

- Generating a 3D model of a complex space from 2D images
  - No exotic hardware required, purely computational based geometry generation, accelerated by a modern GPU
  - Find staff member who enjoys photography and point them at the subject

+

Images examples

- The more image ‘data’ the better
  - Having a wide visible area allows for better image-to-image matching

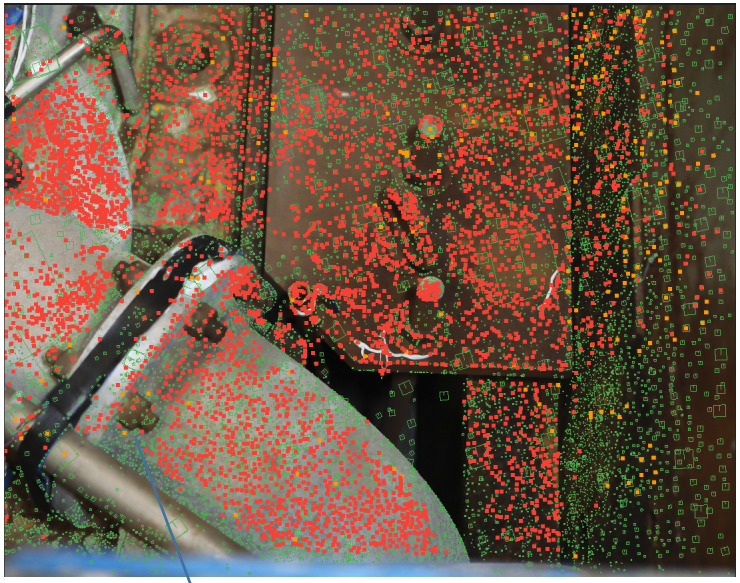
Lots of in-focus details with plenty of reference geometry

Too few nearby geometry markers to reference from

What is a landmark or feature?

- Dense reference points result in better meshes
  - No exotic hardware required, purely computational based geometry generation, accelerated by a modern GPU

Similar features to other images matched as red marks



Too few nearby geometry markers to reference from

How many images

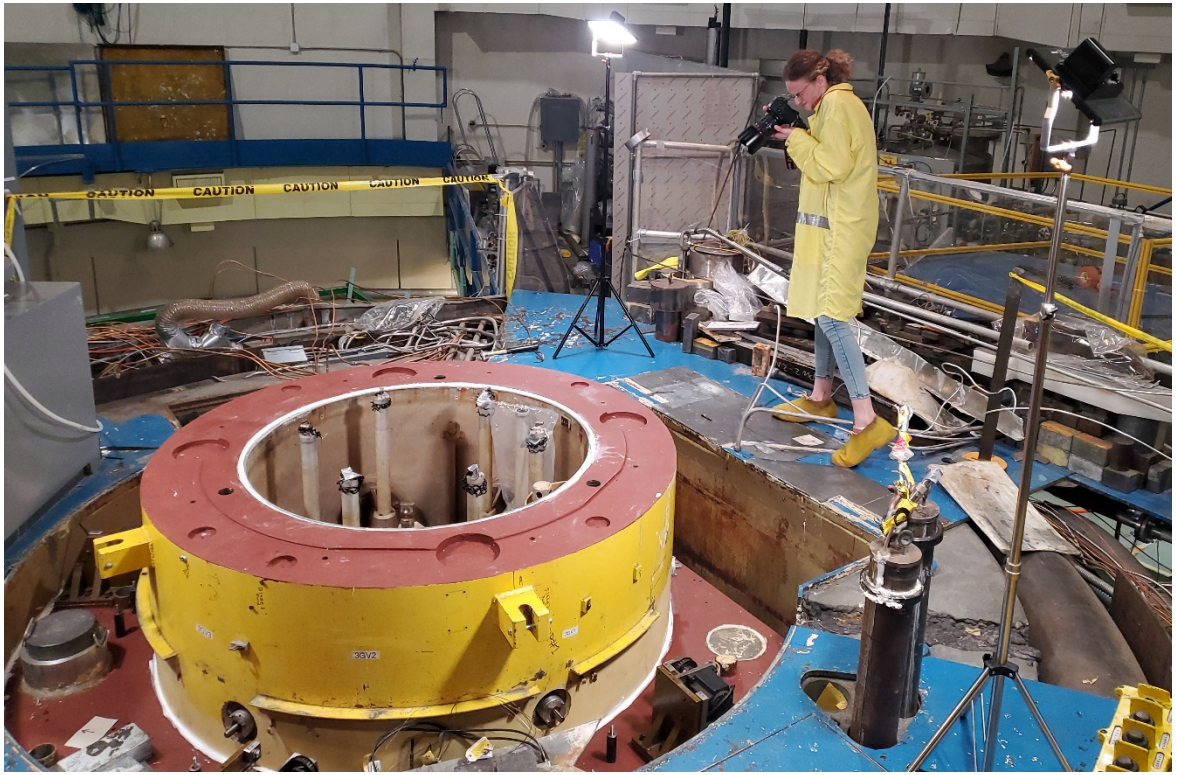
- To generate this model 237 images were used
  - Camera view points synthetically displayed in model indicating direction / position
  - Number of images proportional to resolution required and depth of detail needed

Challenges

- Reflective surfaces
  - Stainless plumbing can cause havoc on generating accurate 3D meshes.
  - Making reflective surfaces matte is a simple ‘hardware solution’ to a complex computational problem
  - Talc powder or ‘institutional dust’ reduces noise on reflective surfaces
- Information ‘light’ images
  - Areas of interest (a valve, or small detail) require significant amount of reference images
  - Image position data is extracted in relation to other images so copious reference images are required to allow detail

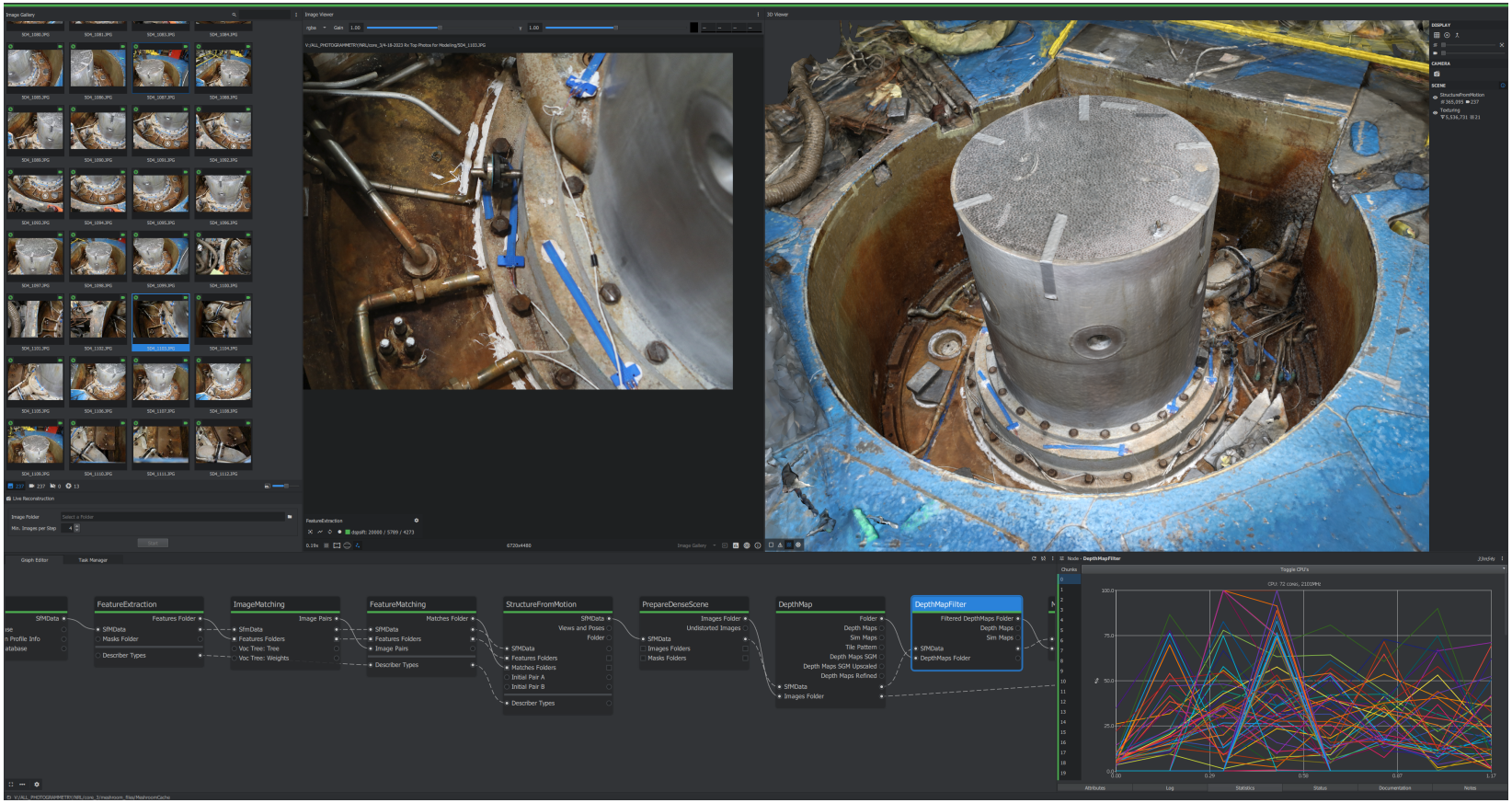
Lighting

- Adequate lighting was key to resolving detail
  - Portable battery powered light stands to keep reactor components illuminated resulted in better meshed images



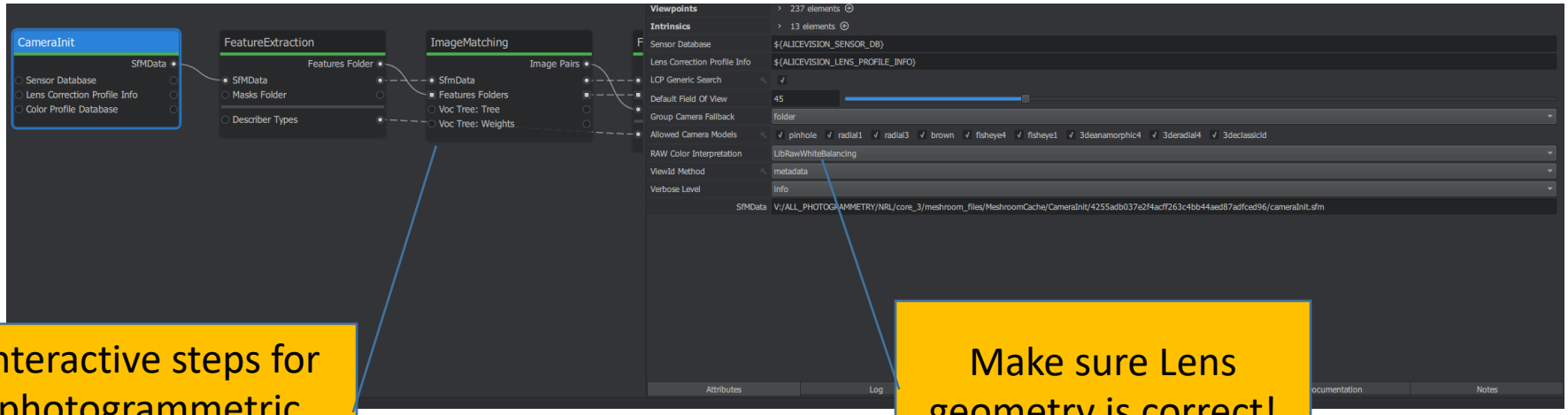
Software

- Meshroom
  - Open source software for 3D reconstruction, available on github



Software

- Meshroom
  - Driven in small interactive graphical ‘steps’, each of which has some tuning associated to achieve good results

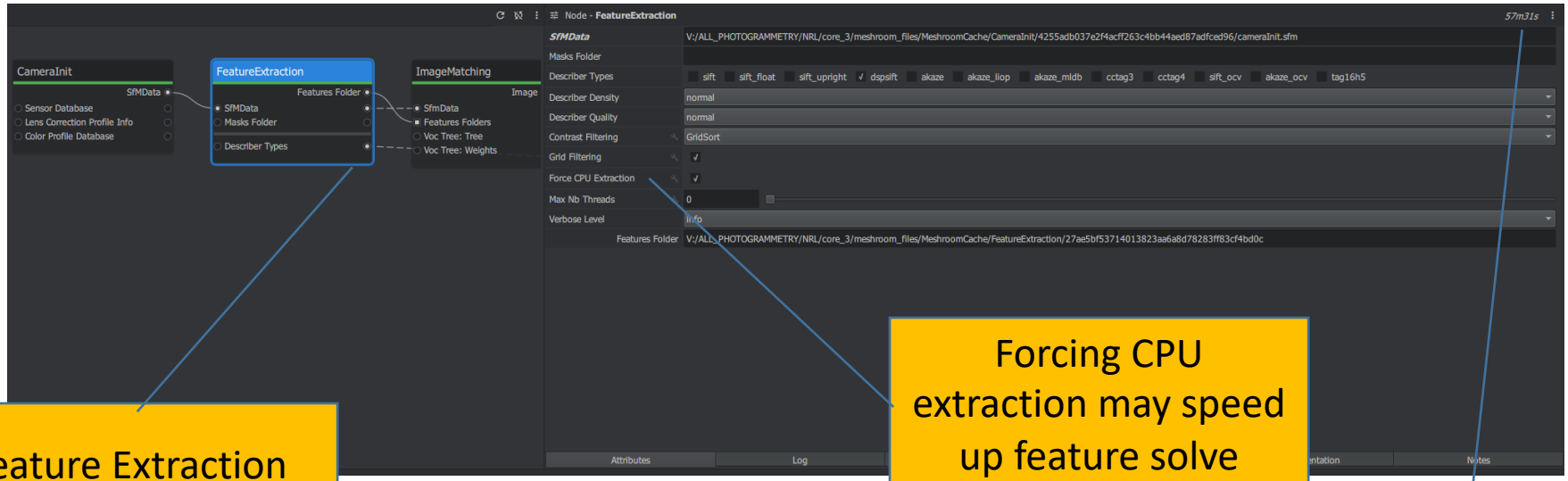


Interactive steps for photogrammetric solve

Make sure Lens geometry is correct!

Software

- Meshroom
  - Driven in small interactive graphical ‘steps’, each of which has some tuning associated to achieve good results



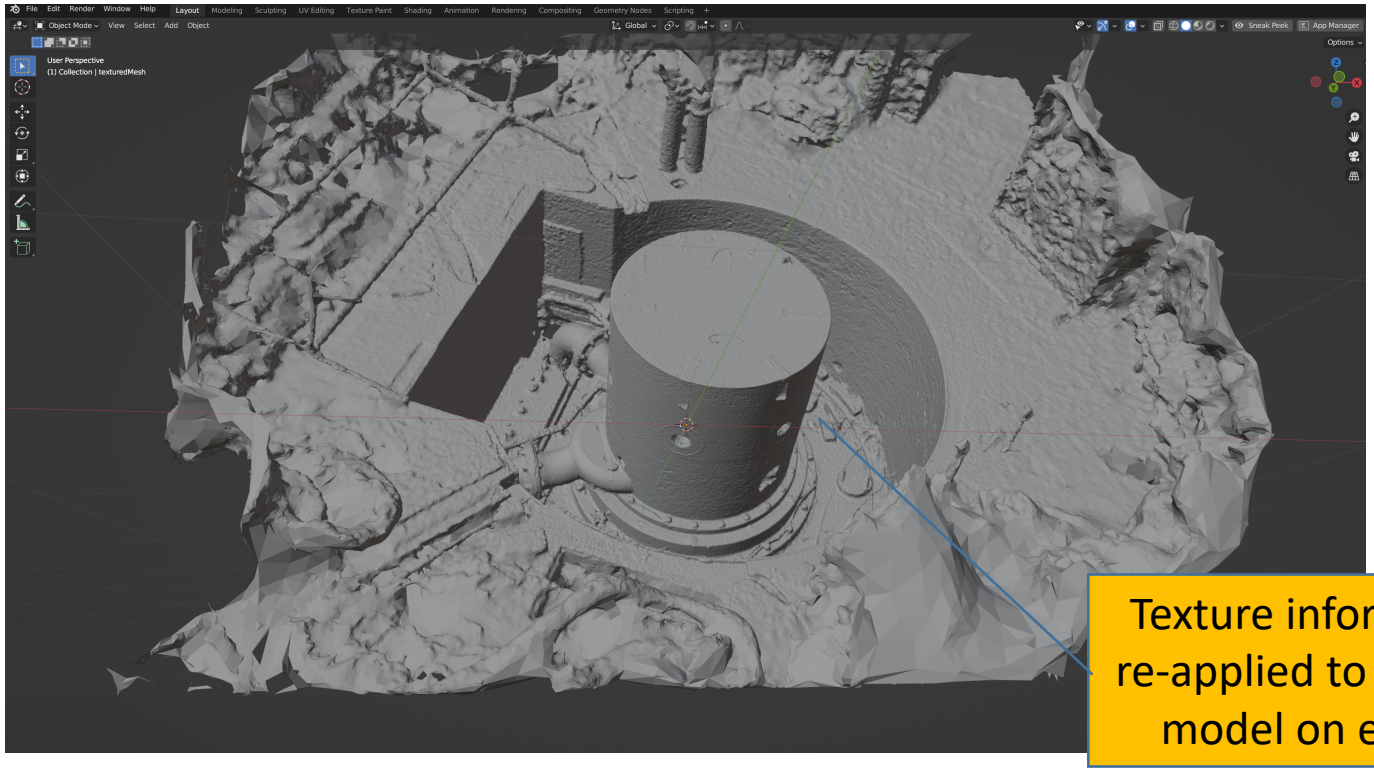
Feature Extraction can take a while

Forcing CPU extraction may speed up feature solve

57 minutes on a small model of 237 images

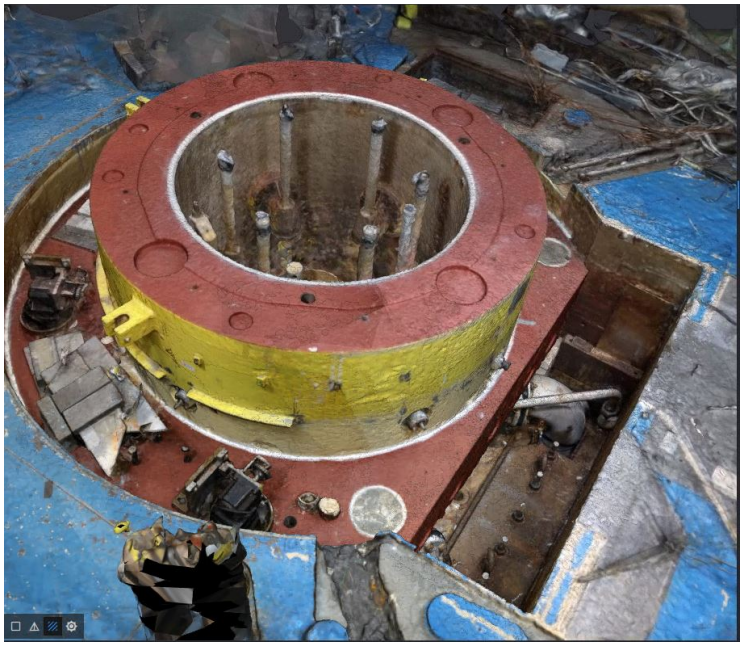
Software

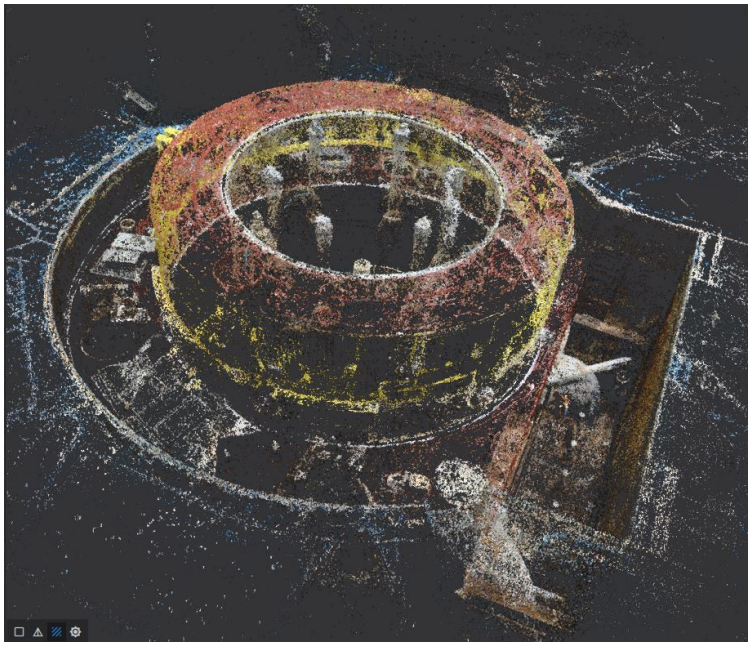
- Blender
  - Open Source 3D CAD modeling tool
  - Model simplification, edge trimming and filling in missing areas



What's the Point (cloud)

- Generating a 3D model that's portable
  - With our simplified 3D model we can generate browser-viewable simplified models and render with simple tools (3JS, etc)
  - This allows displaying in-presentation or at engineering meetings without dragging a copy of meshroom or blender





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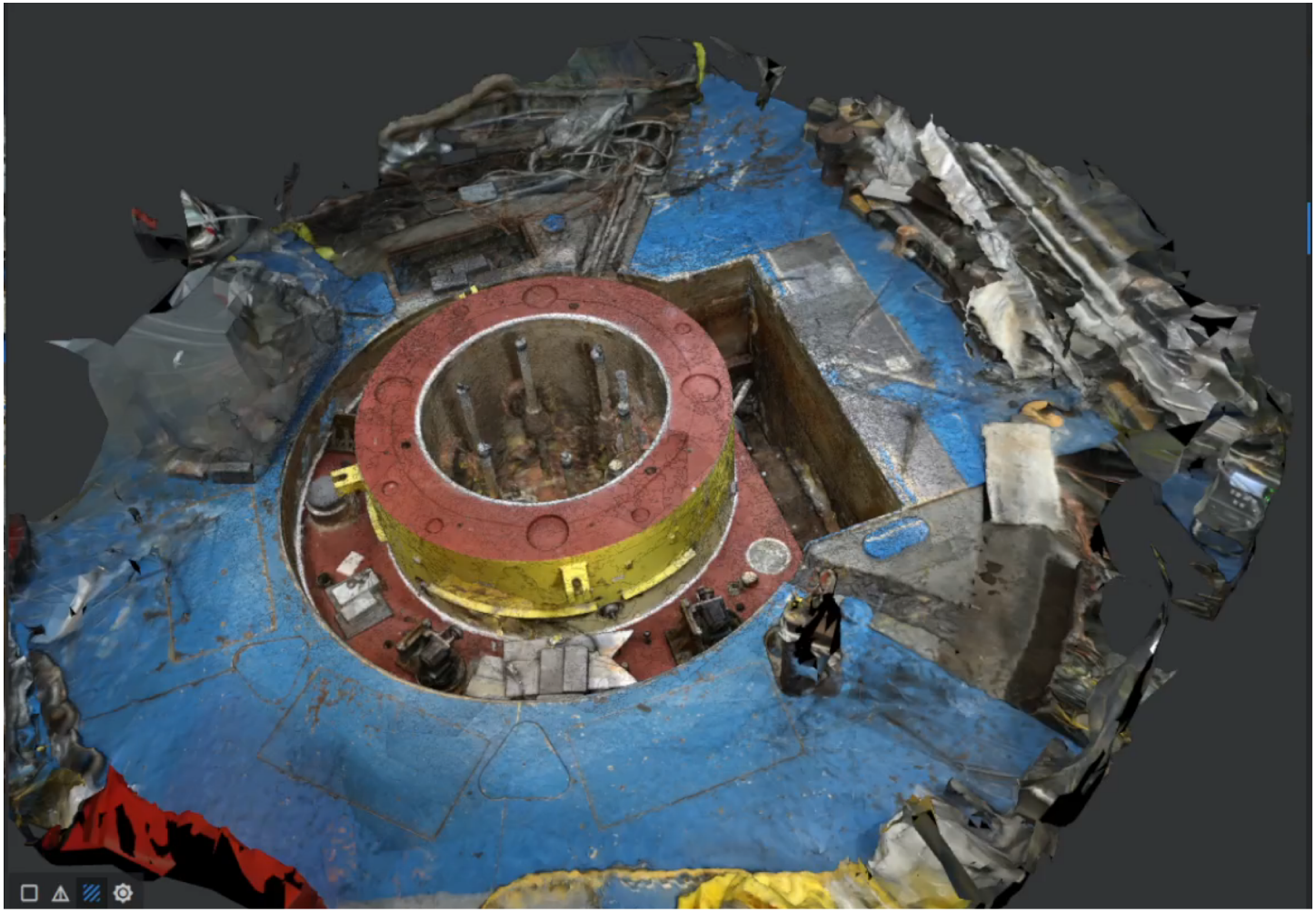

Hardware install discussions

- Using 3D models, its easier to decide where to install things
  - Location of leak detection hardware (blue) was a topic of scrutiny, using models to draw where the hardware should go got buy-in from all parties involved

Acknowledgements

NRL Operations and Maintenance Staff

Taylor Tracy

John DiCiaccio

Paul Nawazelski

Adam Grein

Questions?