Generating 3D Models of Complex Structures For Engineering Planning

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Research Engineer

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
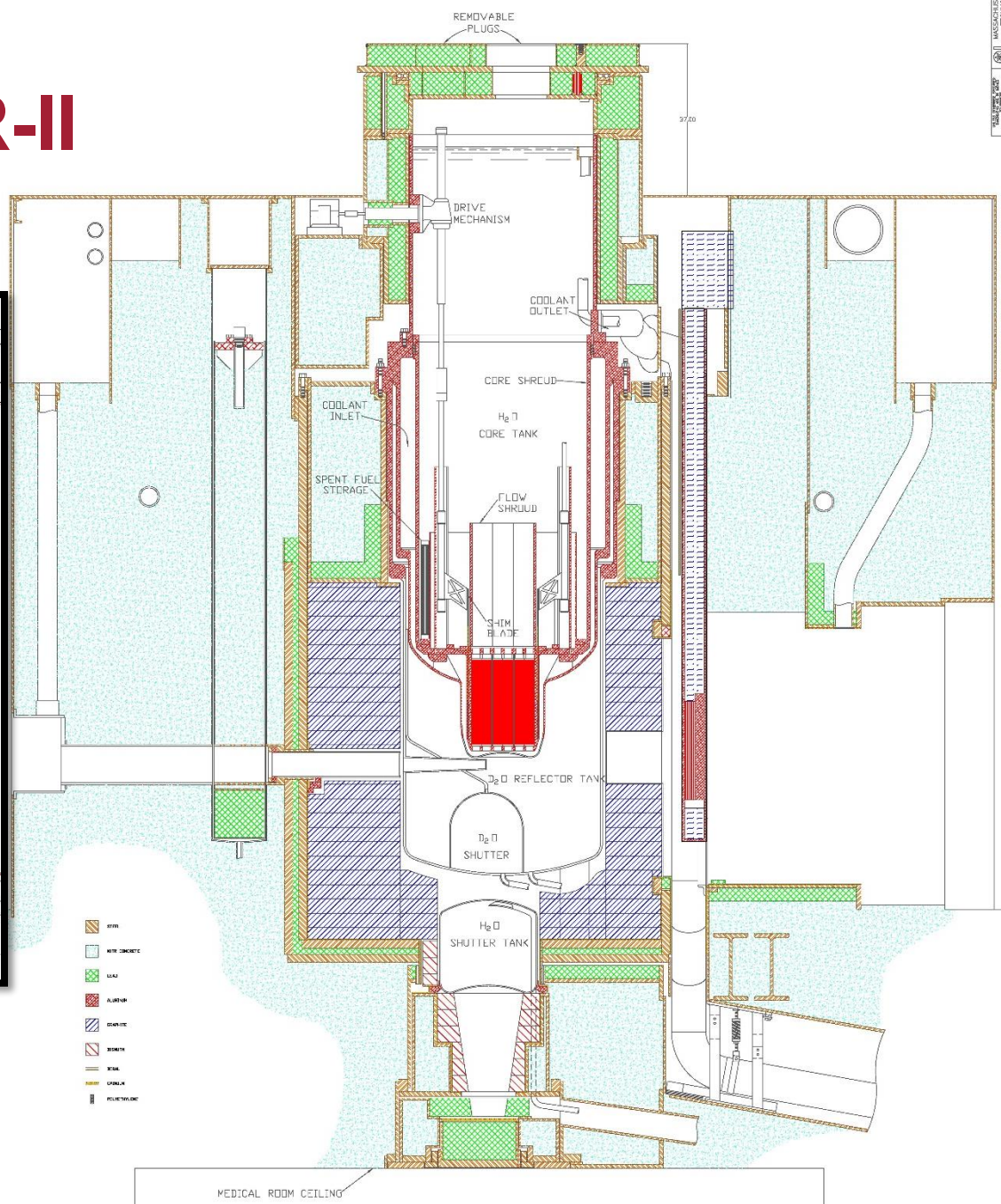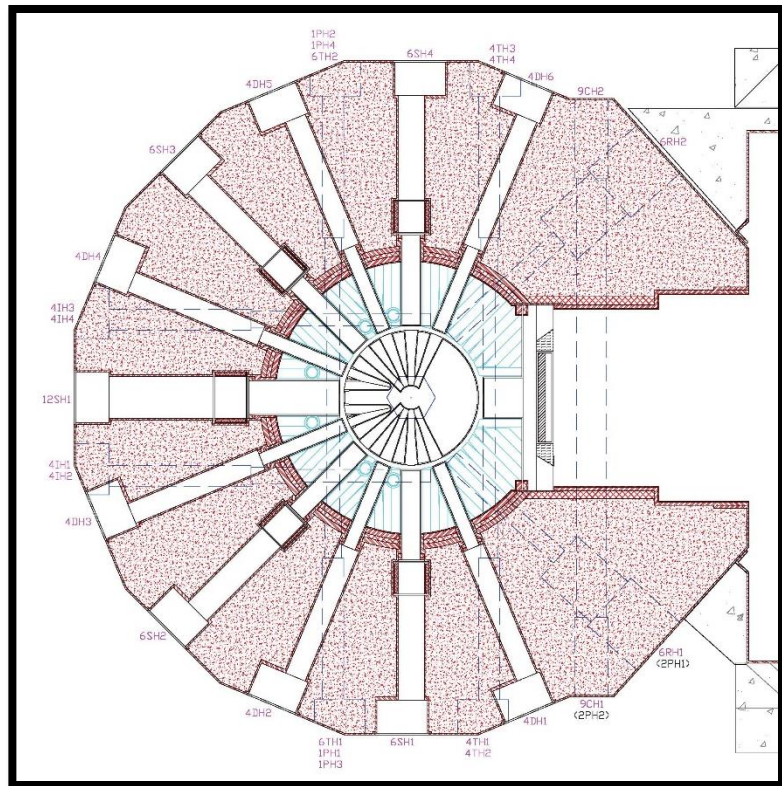
Drawings courtesy of D. Carpenter

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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

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Generating 3D model for status updates
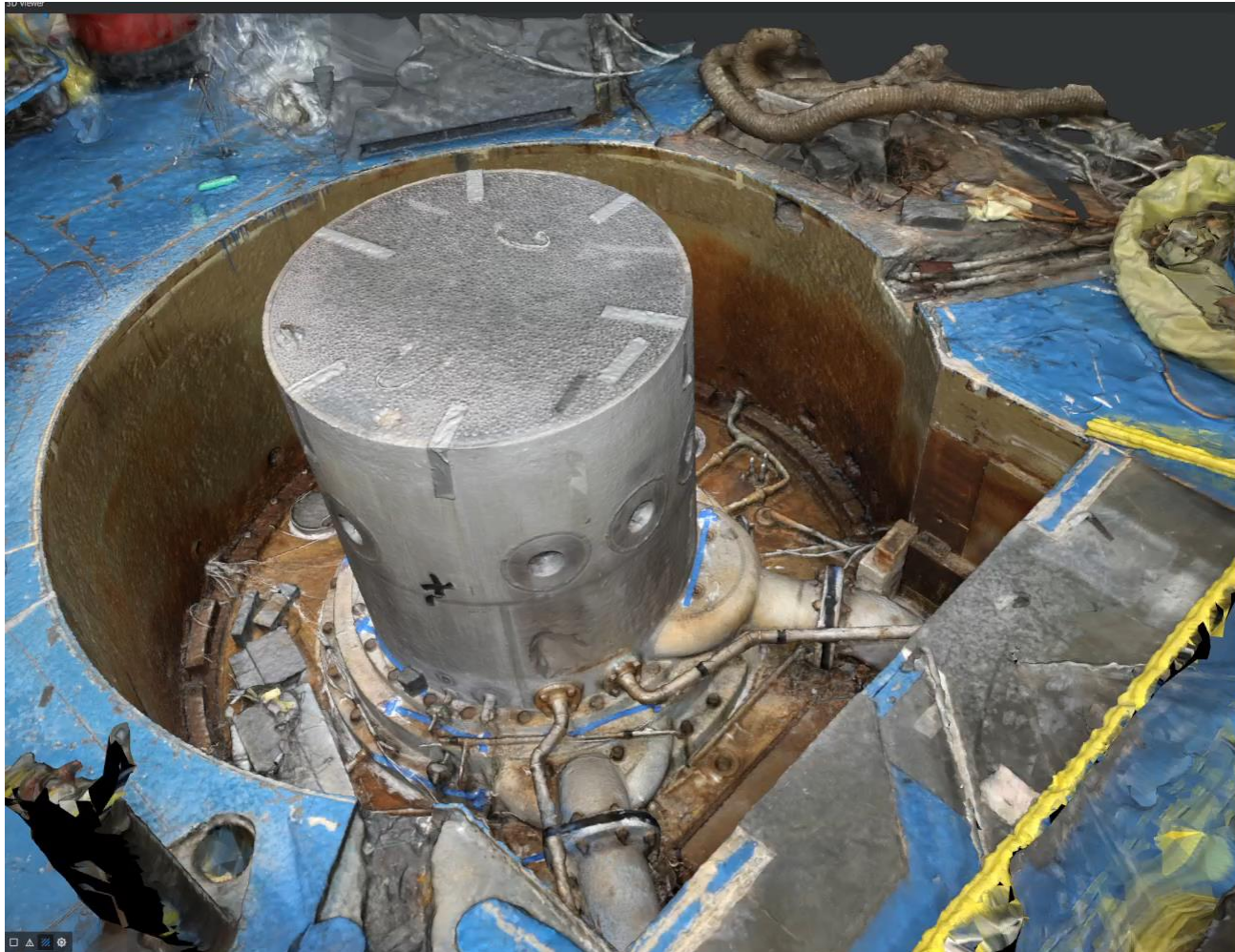
What is Photogrammetry

➢Generating a 3D model of a complex space from 2D images

  o No exotic hardware required, purely computational based geometry generation, accelerated by a modern GPU

  o Find staff member who enjoys photography and point them at the subject
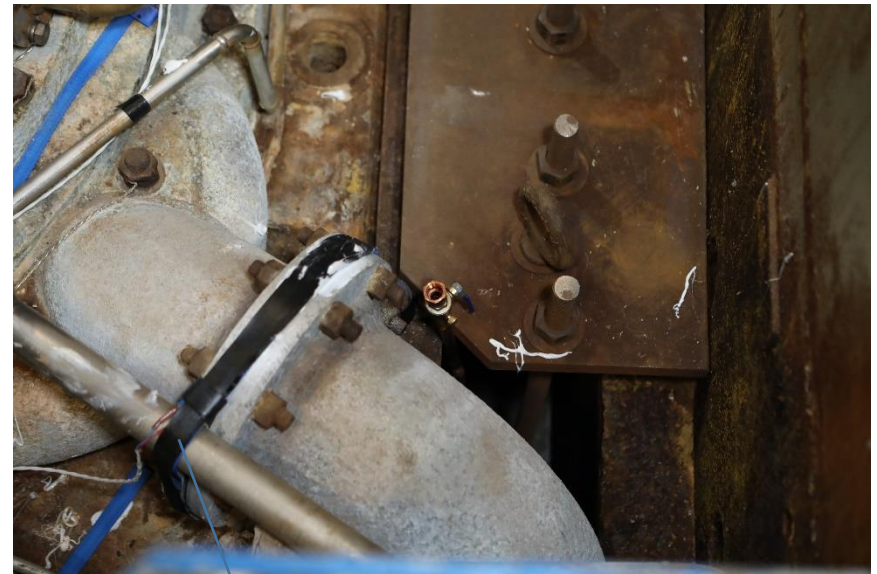

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Images examples

➢ The more image 'data' the better

  o Having a wide visible area allows for better image-to-image matching

Lots of in-focus details with plenty of reference geometry
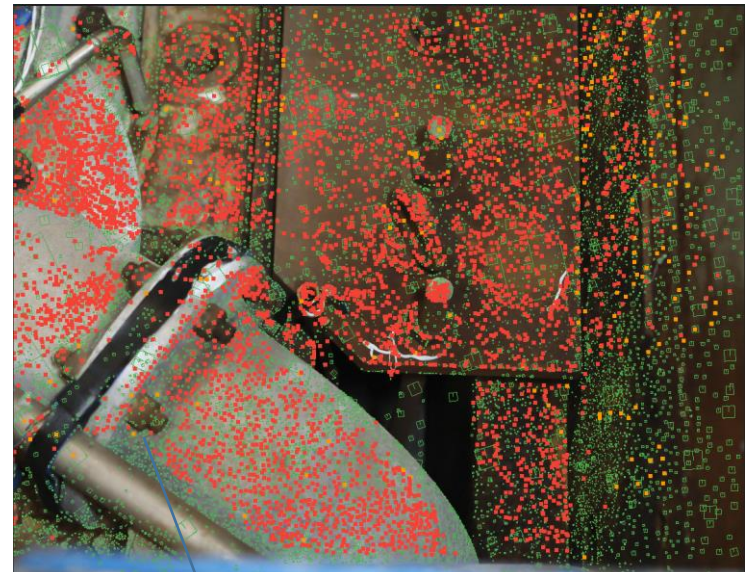
Too few nearby geometry markers to reference from

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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

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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

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Challenges

➢ Reflective surfaces
- o Stainless plumbing can cause havoc on generating accurate 3D meshes.
- o Making reflective surfaces matte is a simple 'hardware solution' to a complex computational problem
- o Talc powder or 'institutional dust' reduces noise on reflective surfaces

➢ Information 'light' images
- o Areas of interest (a valve, or small detail) require significant amount of reference images
- o 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
  o Portable battery powered light stands to keep reactor components illuminated resulted in better meshed images
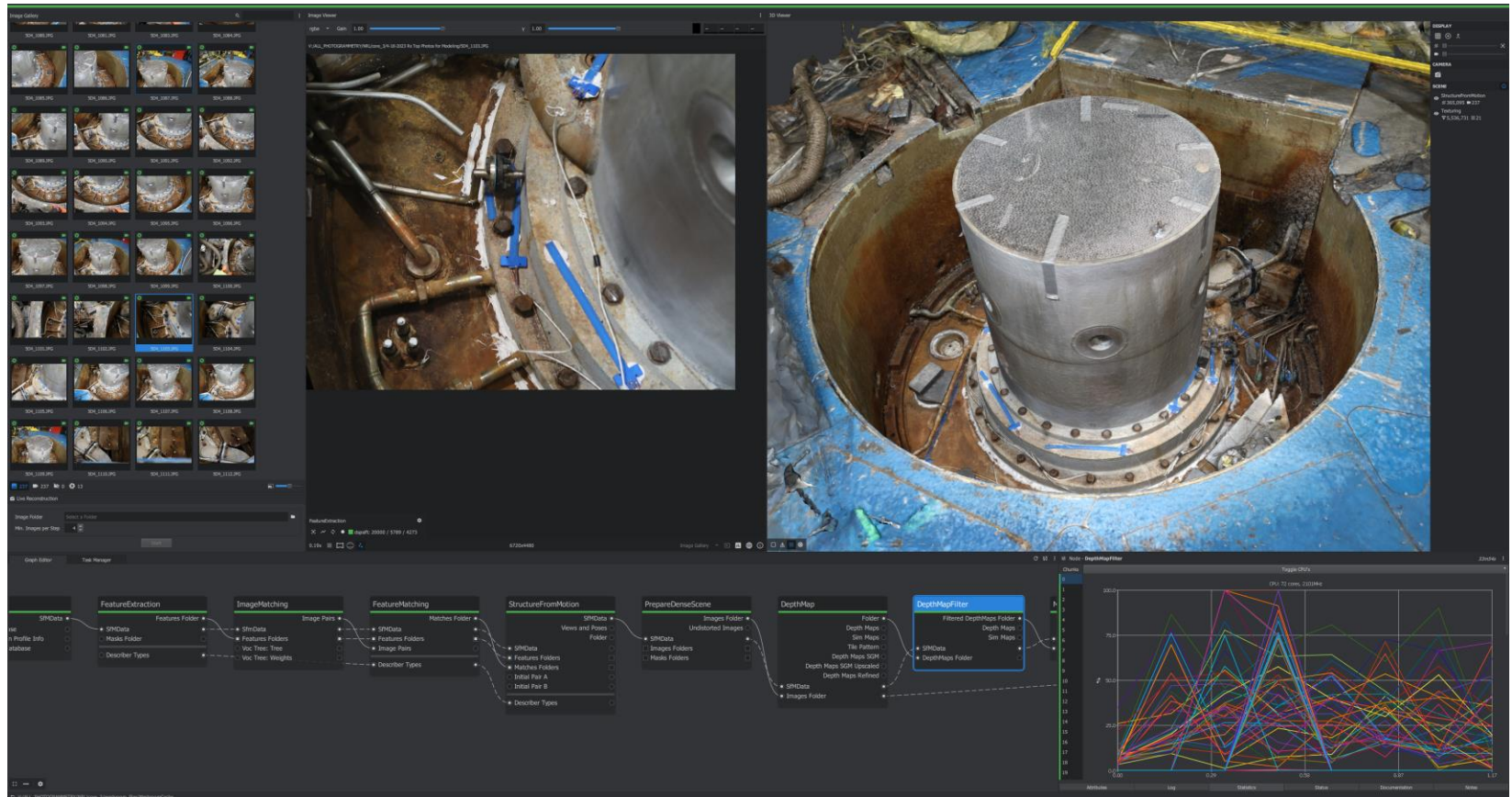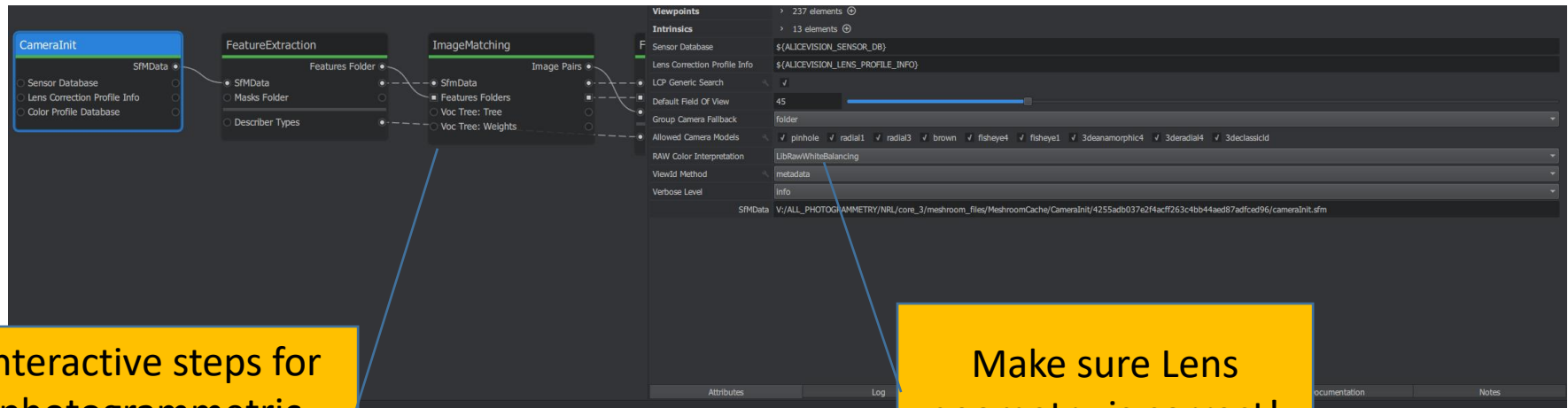
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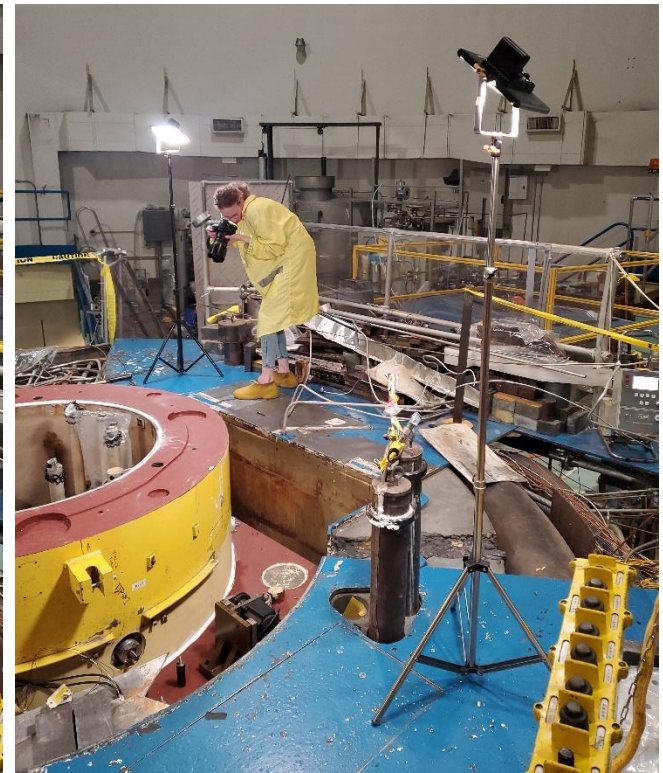
Software

➢Meshroom

   o 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!

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Software

➢ Meshroom

○ Driven in small interactive graphical 'steps', each of which has some tuning associated to achieve good results
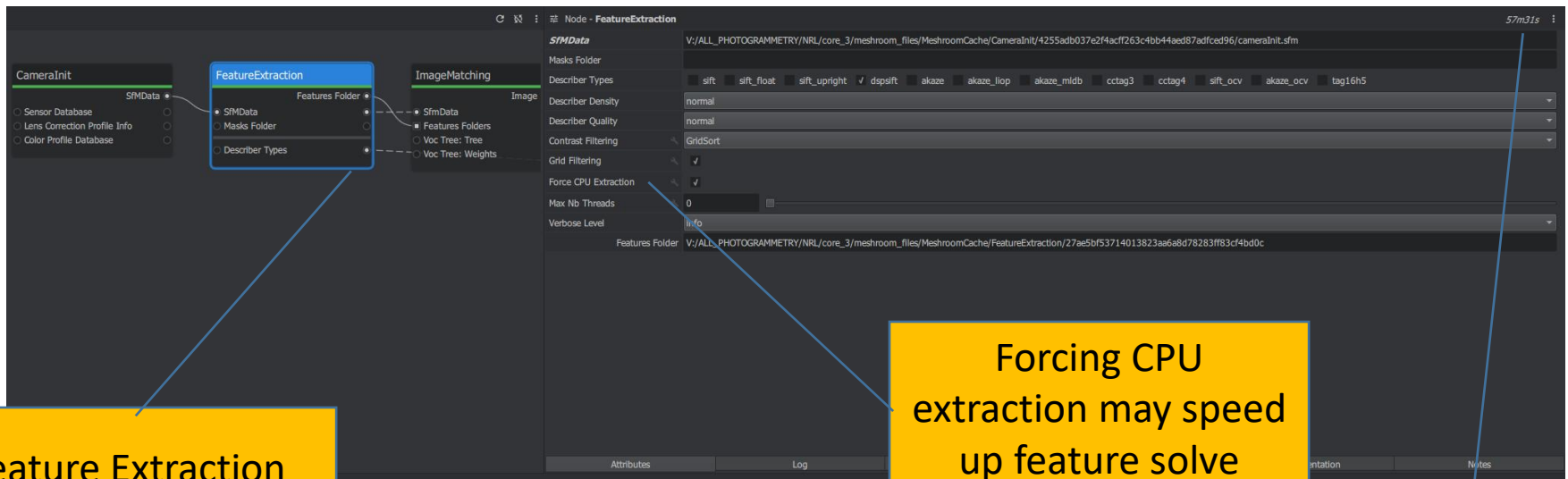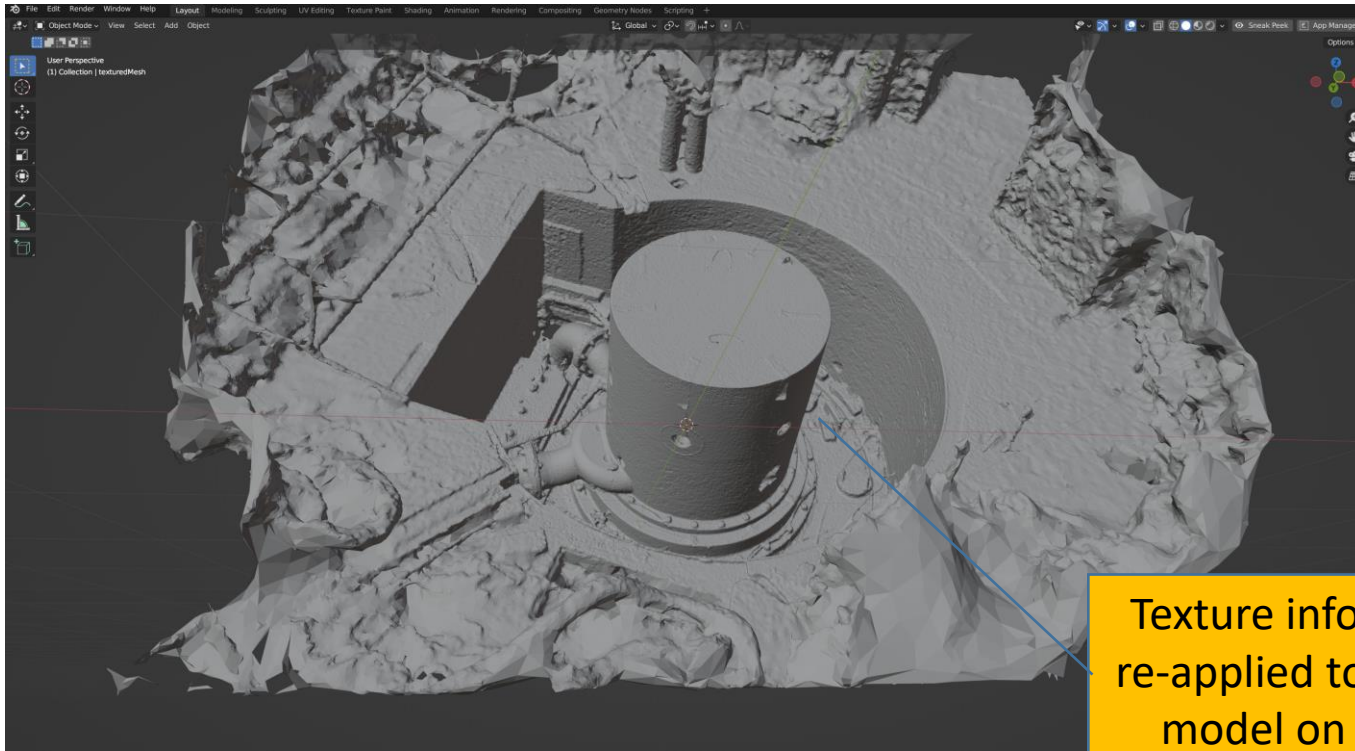

Feature Extraction can take a while

Forcing CPU extraction may speed up feature solve

57 minutes on a small model of 237 images

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Software

➢Blender

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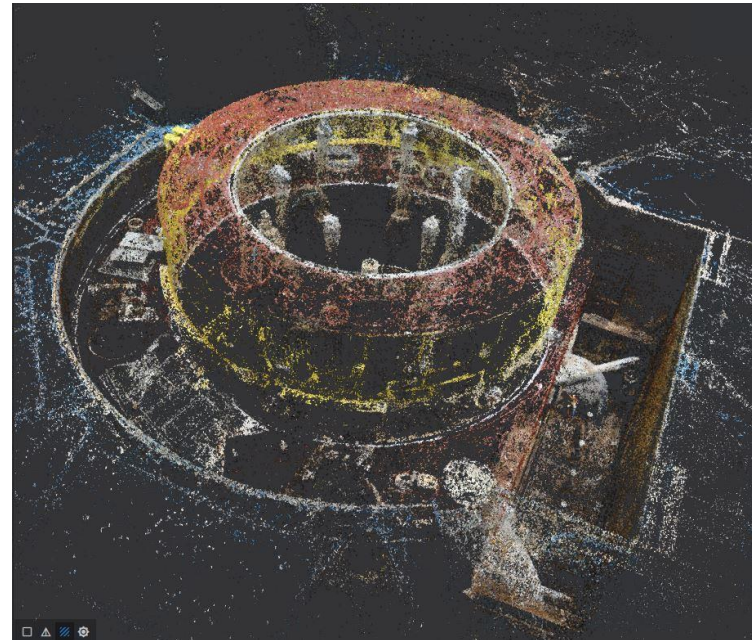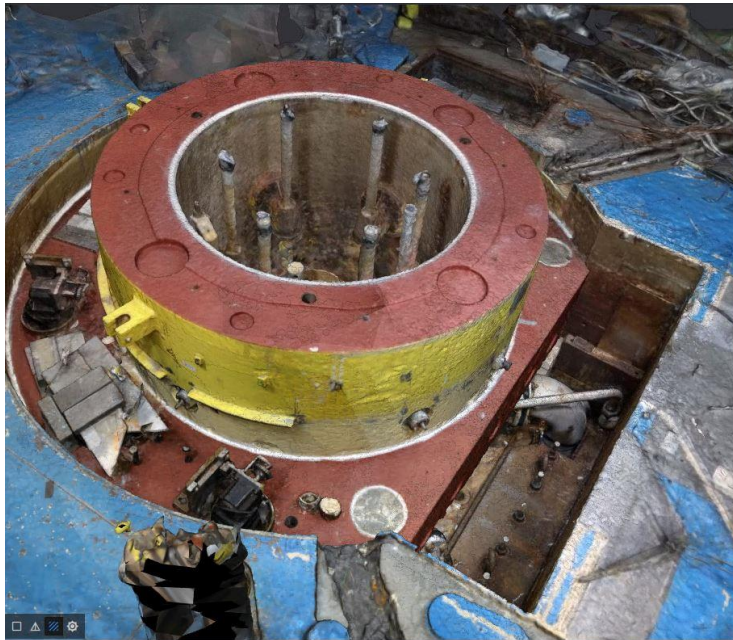

Texture information re-applied to Blender model on export
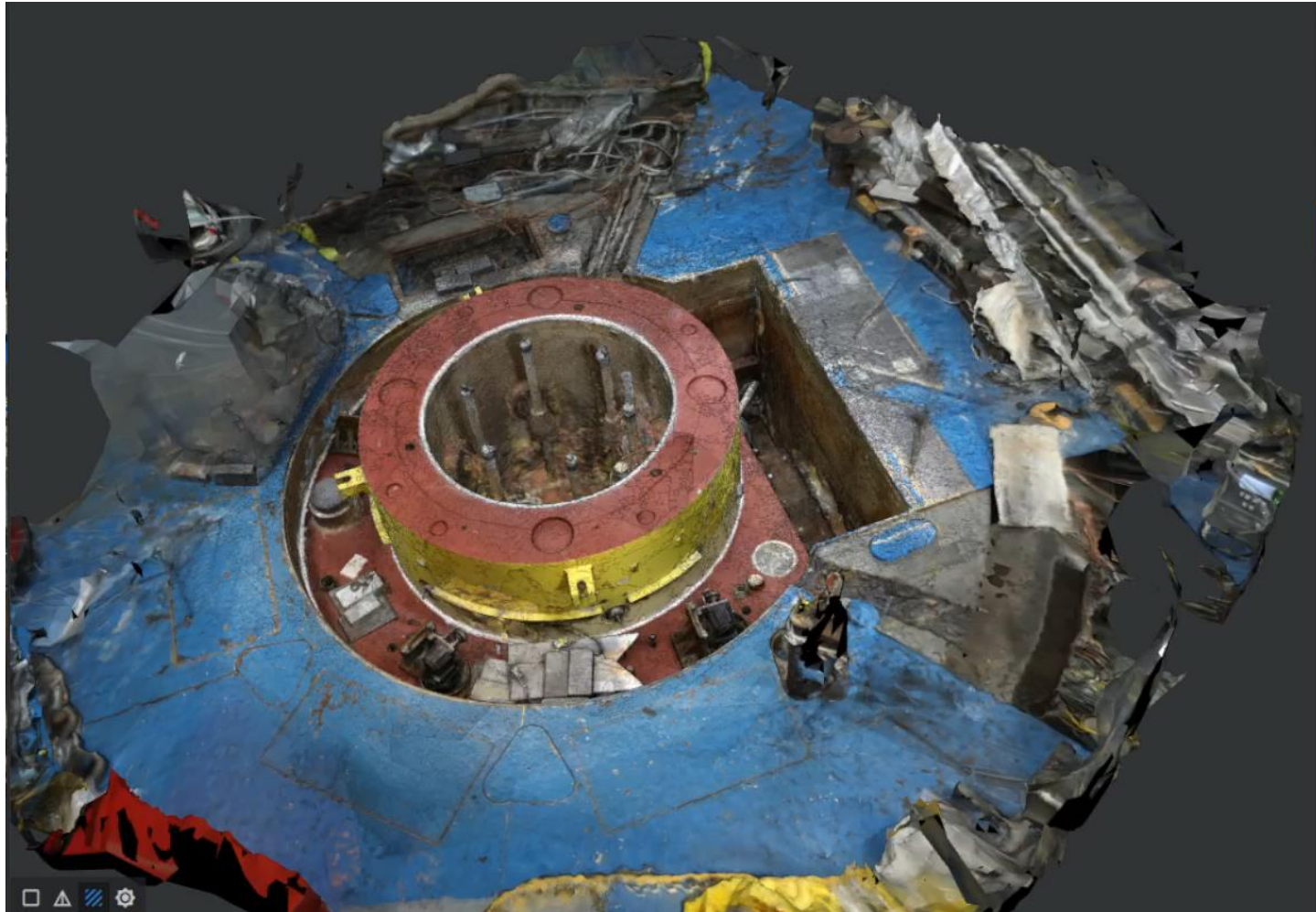
What's the Point (cloud)

➢Generating a 3D model that's portable

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

Generating 3D model for status updates

Hardware install discussions

➤ Using 3D models, its easier to decide where to install things

  o 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

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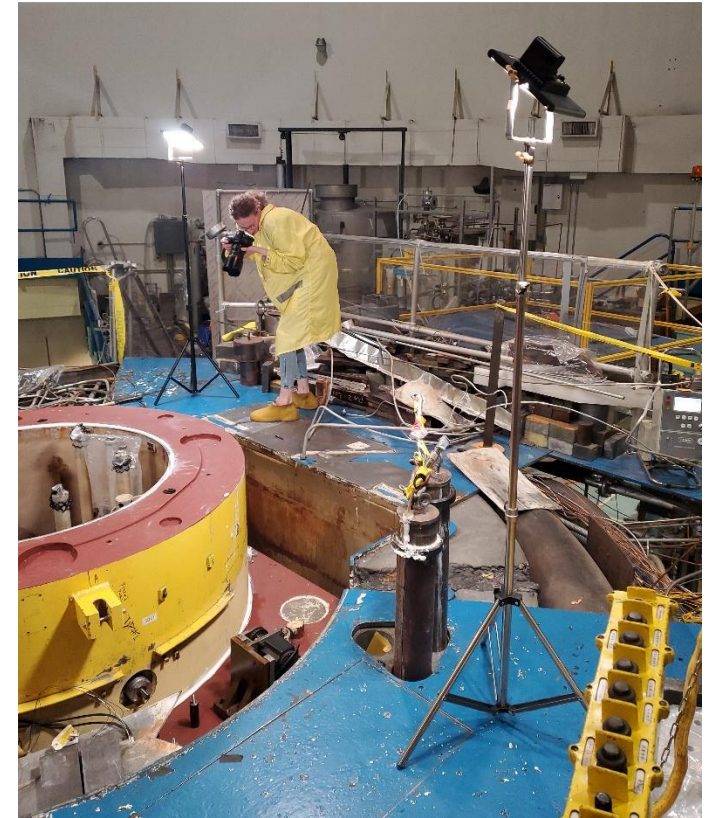
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Questions?

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