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EXPERIMENT AUTOMATION AGENTS (EAA)

Vision Language Model Agents For Accessible And Automated Beamline Operations

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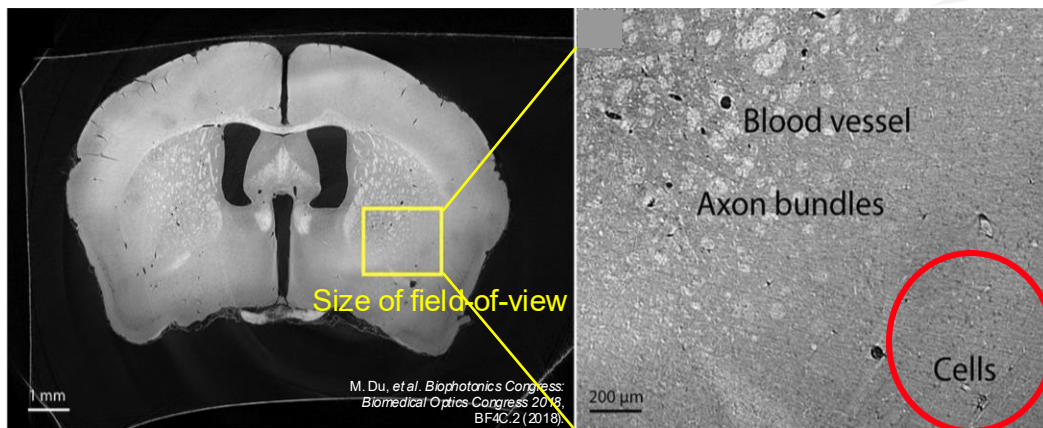
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Why are Vision LLMs (VLMs) use for automated experiments

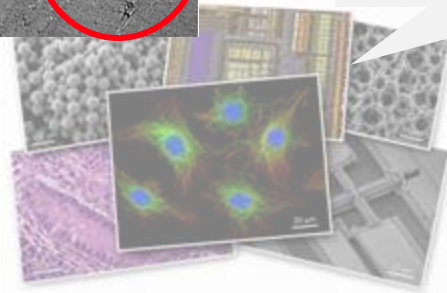
Consider the problem of automated search for small features in large samples...

Challenge 1: large sample size vs. small FOV (high resolution needed to identify cells)

→ need to run many scans, checking each image



Challenge 2: algorithms need to be re-designed, models need to be re-trained/fine-tuned for different sample types and/or target features



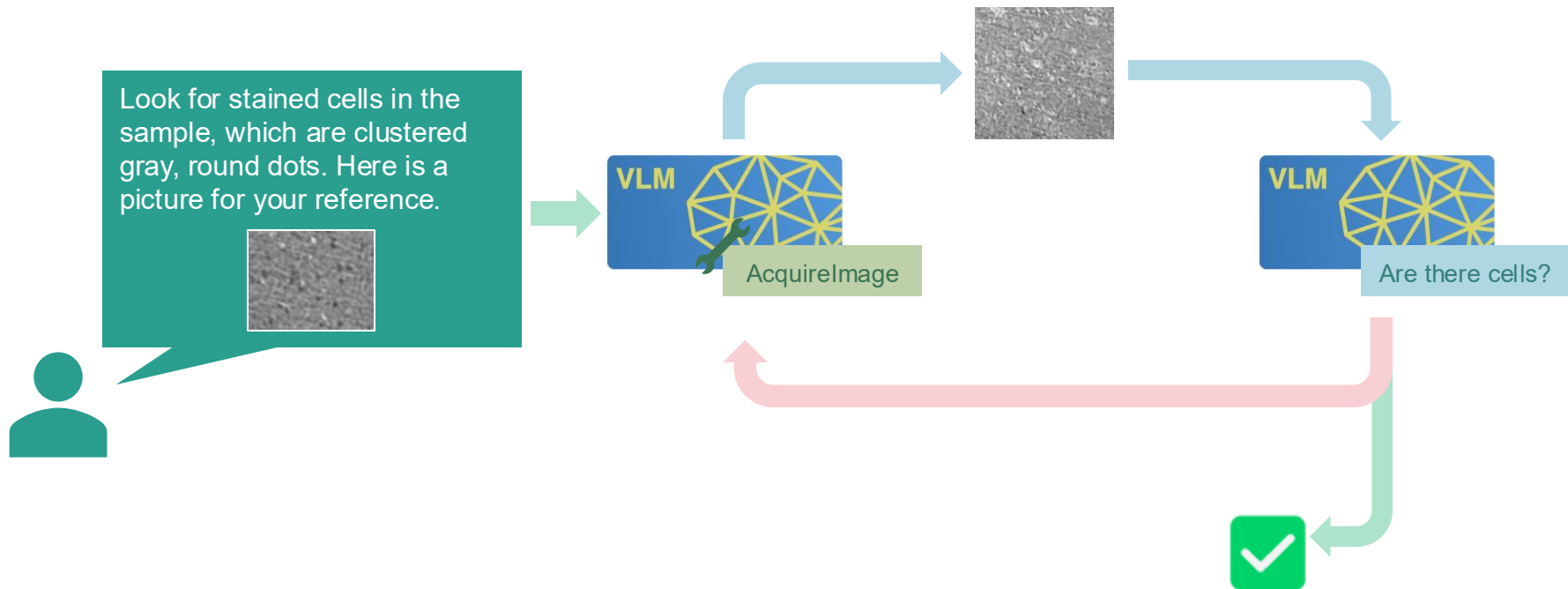
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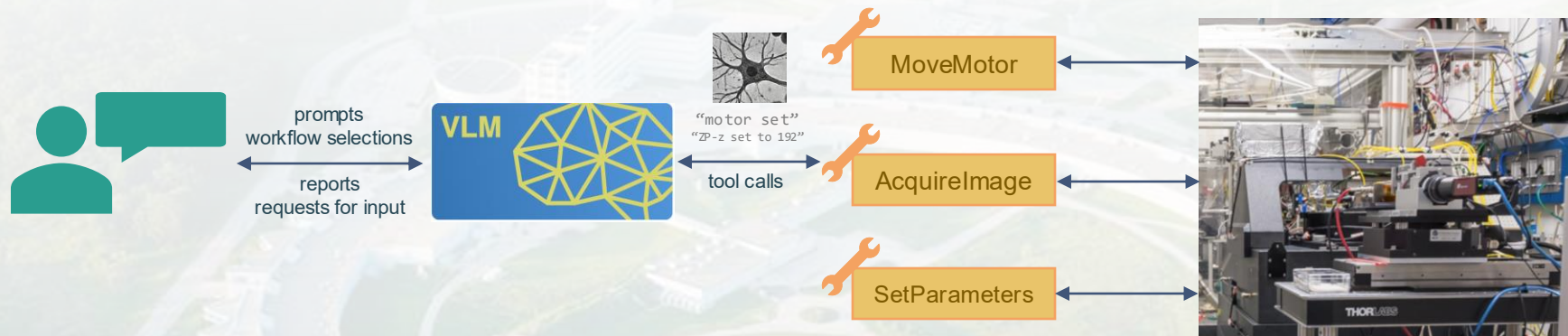
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Why are Vision LLMs (VLMs) use for automated experiments

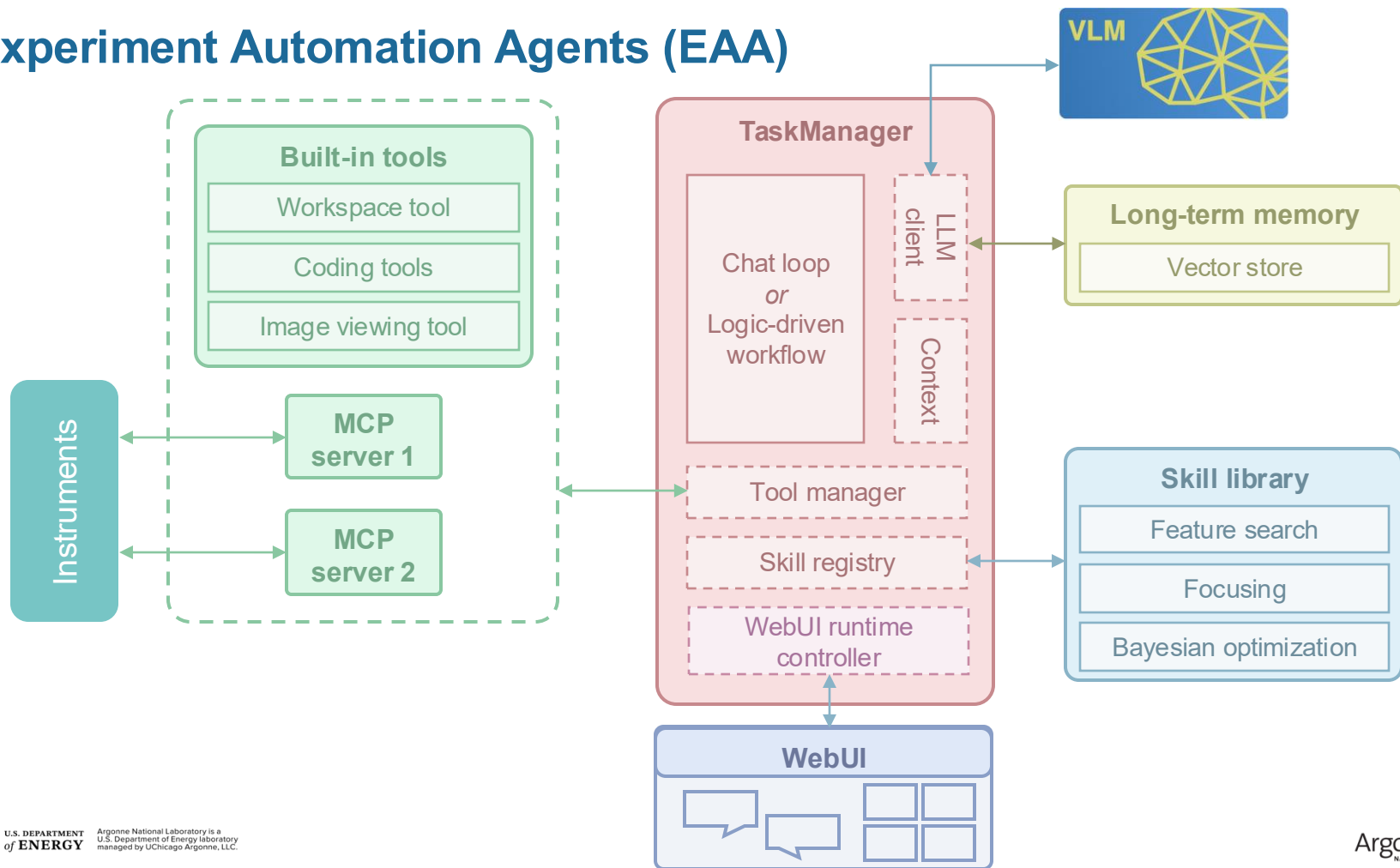
No code, no re-design.
Imagine a simple workflow with VLM...



Vision-capable agentic harness for automated experiments



Experiment Automation Agents (EAA)



Engineering challenges for experiment instrument control

Tools may yield images, but not all APIs allow images in tool responses

MCP servers have their own async event loops that may clash with instrument control libraries

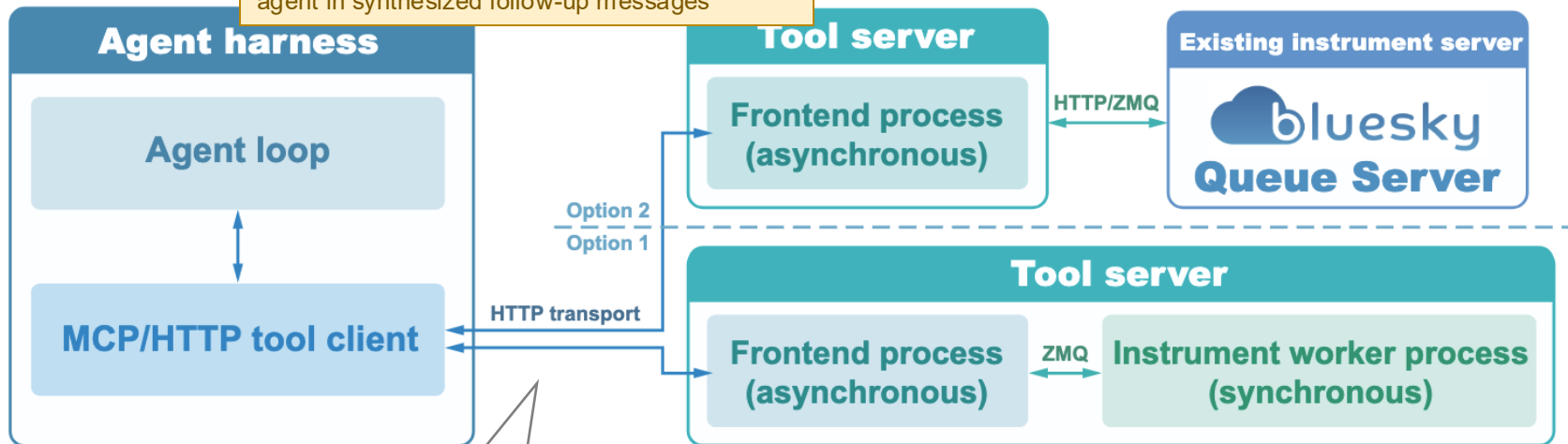


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Engineering challenges for experiment instrument control

Returning tool-yielded images as paths to images on disk or as *base64*-encoded data allows the harness to get the image based on a defined contract, and deliver the images to the agent in synthesized follow-up messages

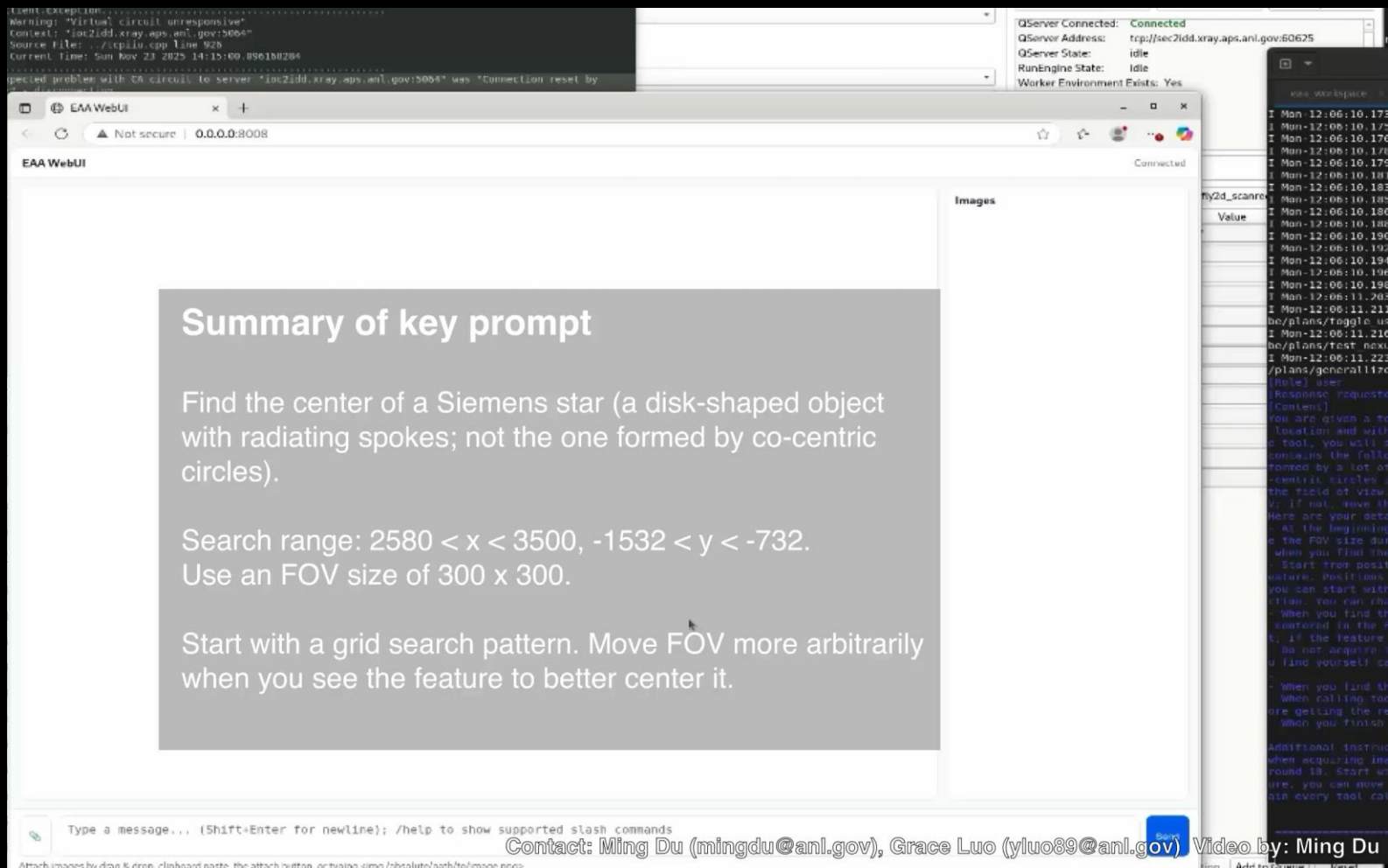


```
{
  "img_path": "/path/to/image.png"
}

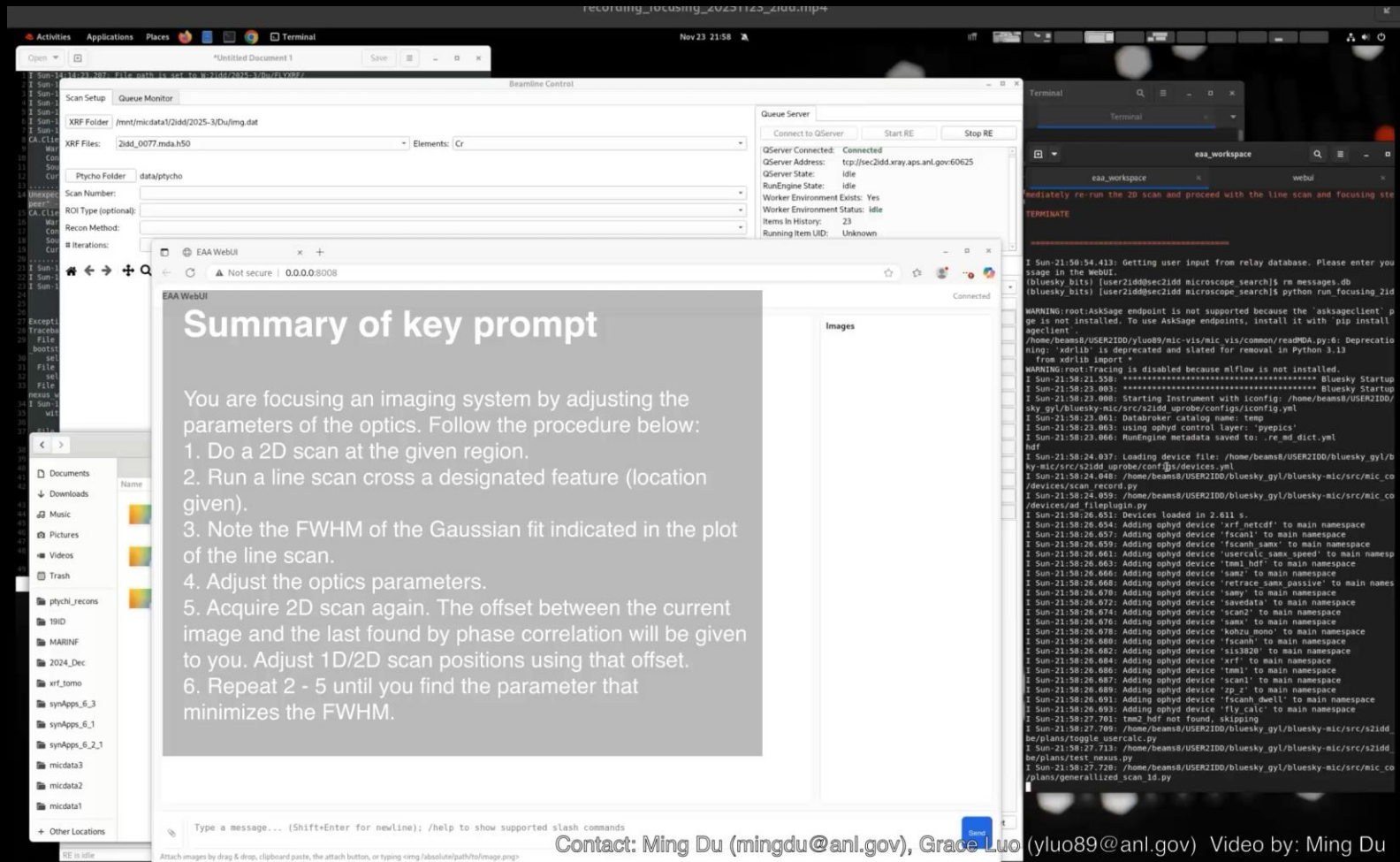
{
  "encoded_data": {
    "type": "image/png",
    "dtype": "uint8",
    "shape": [1024, 1024, 3],
    "data": "<base64-encoded-data>"
  }
}
```

Separating the tool server into an async frontend process and a synchronous backend, or simply letting the MCP server query the execution server provided by the control library, avoids async-related crash

Demo 1 @ APS 2-ID-D: automated feature search



Demo 2 @ APS 2-ID-D: automated XRF microscope focusing



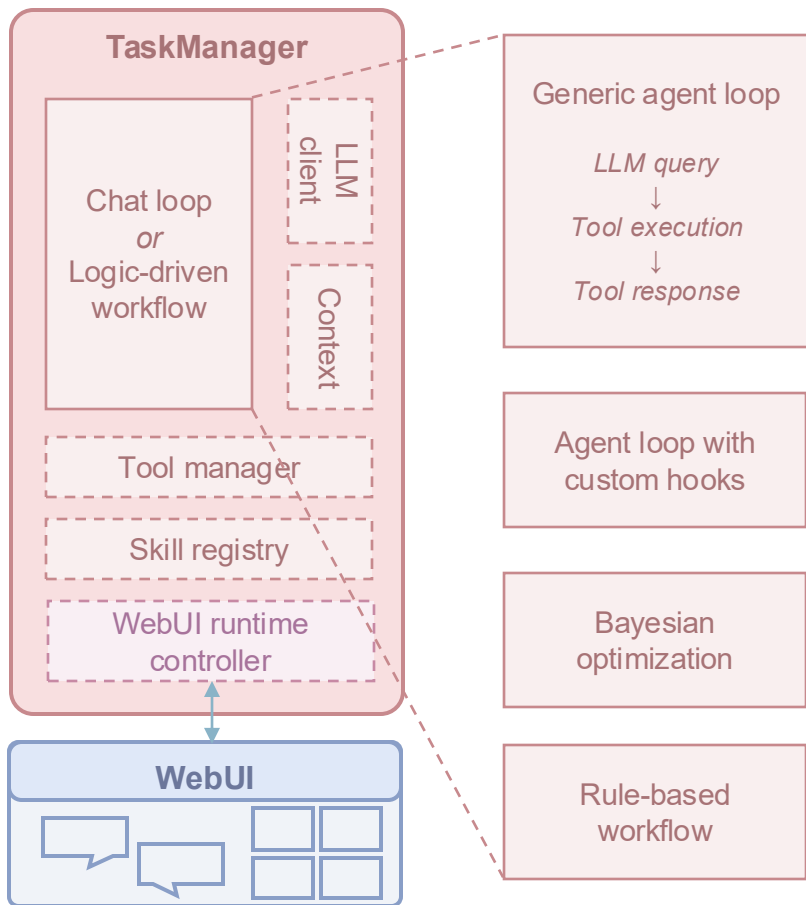
Summary of key prompt

You are focusing an imaging system by adjusting the parameters of the optics. Follow the procedure below:

1. Do a 2D scan at the given region.
2. Run a line scan cross a designated feature (location given).
3. Note the FWHM of the Gaussian fit indicated in the plot of the line scan.
4. Adjust the optics parameters.
5. Acquire 2D scan again. The offset between the current image and the last found by phase correlation will be given to you. Adjust 1D/2D scan positions using that offset.
6. Repeat 2 - 5 until you find the parameter that minimizes the FWHM.

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Task managers are not just for LLM agents



LLM-driven with high autonomy

- Interactive ad-hoc tasks without pre-defined workflow
- Automated processes heavy with semantics-based decision making

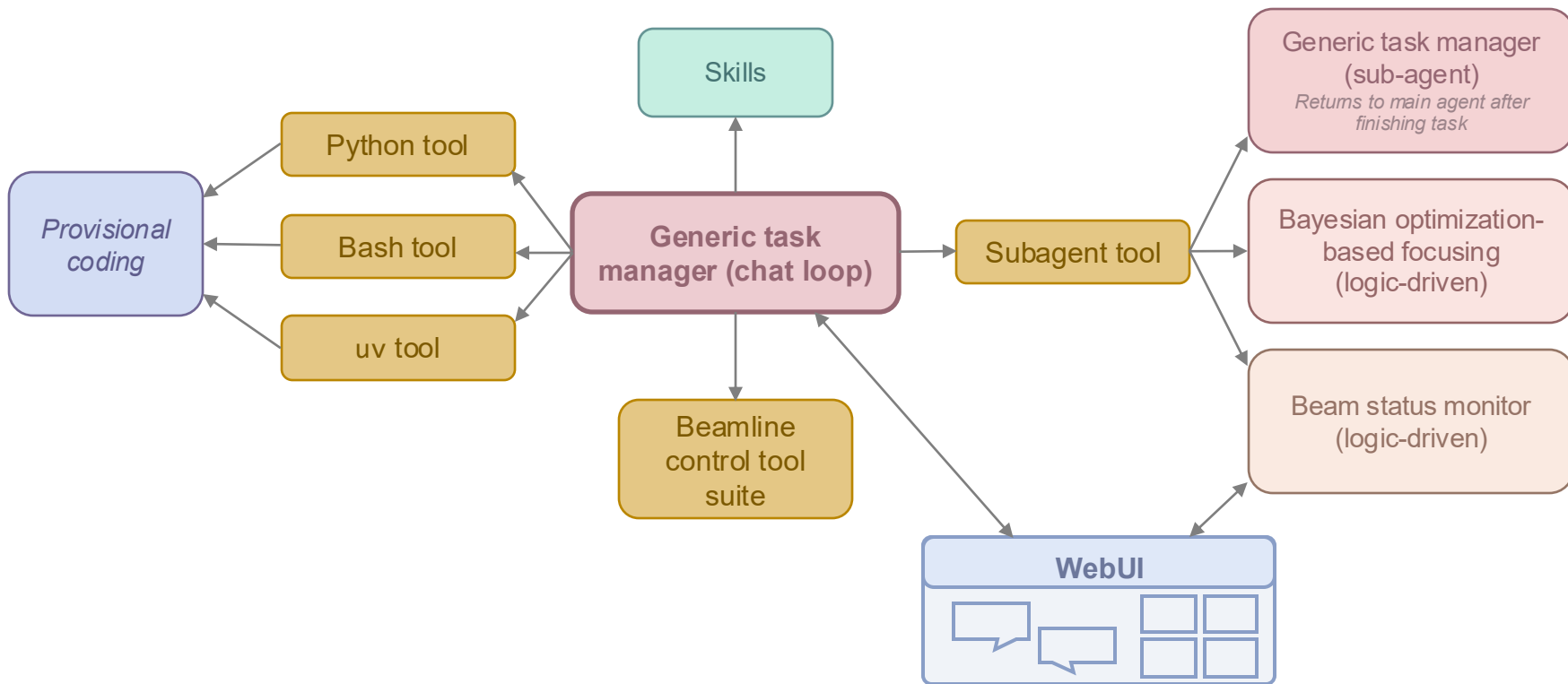
LLM-driven with rule-based middleware

- Automated alignment with image registration set to run after every call to the image acquisition tool

Logic-driven with embedded LLM queries

- Bayesian optimization-guided optimization
- Mathematically proven optimal search pattern
- Defined alignment procedures

Using a chat agent as a universal entry point and user interface



Example: launching a BO-driven focusing task from chat

**EAA**
Agentic AI Assistant for
Instrument Control

Chat

Visualizations

Tools

Settings

Agent Process

Connected

EAA WebUI

Help

Main Agent

```
n_initial_points=3,  
initial_sampling_window_size=(2.0,),  
n_max_iterations=20,  
parameter_change_step_limit=1,
```

EAA can make mistakes. Verify critical results.

 **Images (0)**

No images yet.

 **Live Log**

No log entries yet.

Acknowledgements



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NORTHWESTERN
UNIVERSITY

Jelena Popovic

Publication

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Pre-print

Du, M., Luo, Y., Banerjee, S., Wojcik, M., Popovic, J., & Cherukara, M. J. (2026). EAA: Automating materials characterization with vision language model agents. *arXiv preprint arXiv:2602.15294*.



<https://github.com/AdvancedPhotonSource/EAA>



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