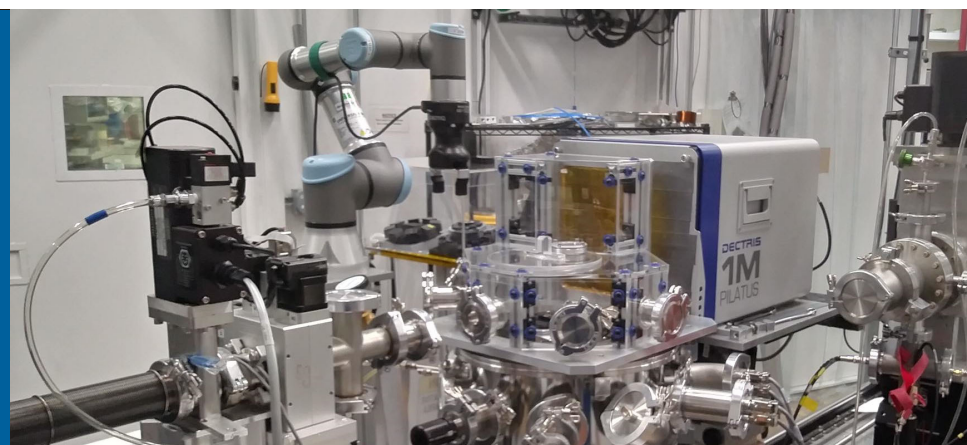


TWG MEETING



# AUTOMATING SAMPLE HANDLING FOR THE GRAZING INCIDENCE X-RAY SCATTERING INSTRUMENT AT 8-ID-E



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MIKE FISHER (BI)

19 May 2022

# TEAMWORK

## acknowledgments

- XSD funding for remote access
- Friendly users:
  - Jie Xu, ANL-NST
  - Yeonju Kim, ANL-NST



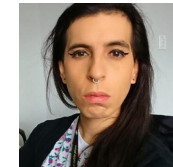
Ben Davis



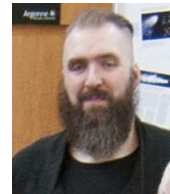
Eric Dufresne



Mike Fisher



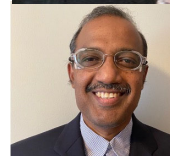
Ignacia Guerra



Don Jensen



Altaf Khan



Suresh Narayanan



Kelly O'Connell



Qingteng Zhang

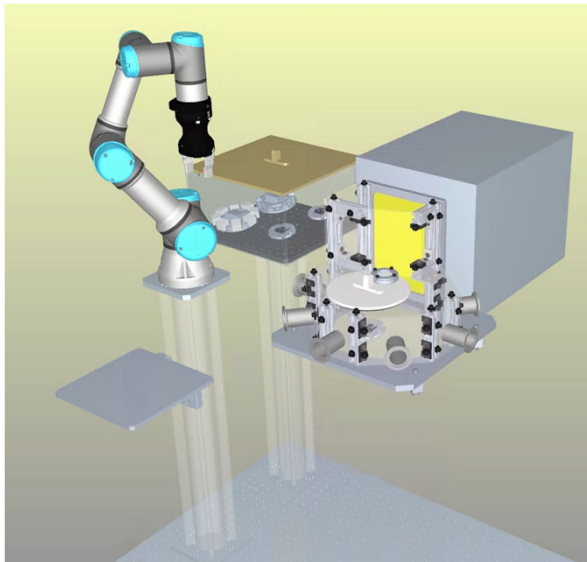


Ray Ziegler

# SAMPLE HANDLING

## Remote access/ex situ work

- Handle for AI-guided Experiments
- Efficiencies to optimize APS-U



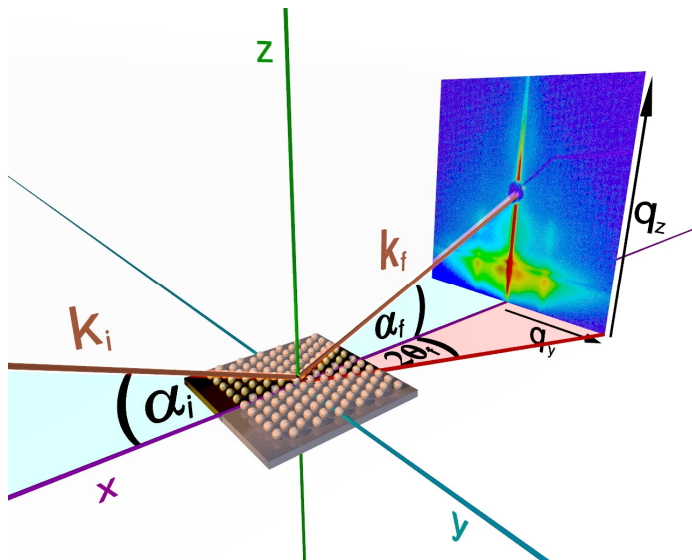
*Animation by Ben Davis*

## Challenges

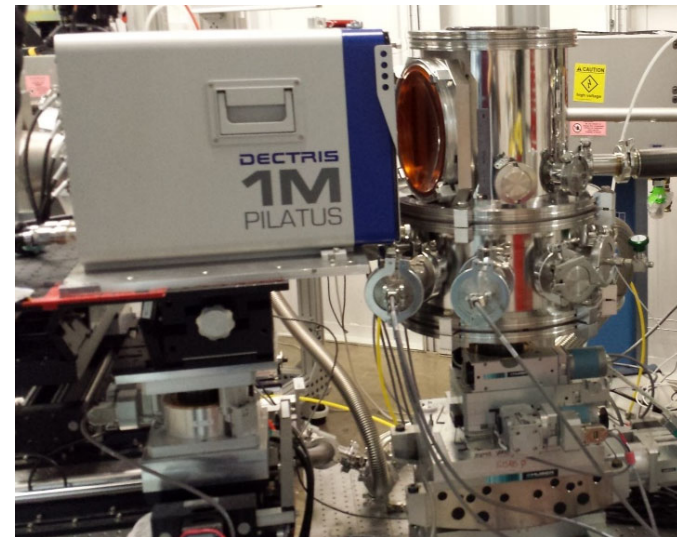
- Adapting existing infrastructure
- Safety
- Programming
- Scaling up remote access program
- Metadata capture

# GRAZING-INCIDENCE SCATTERING AT 8-ID-E

## Probing structure and kinetics of thin films



A. Meyer, Institute of Physical Chemistry, University of Hamburg,  
<http://www.gisaxs.de>

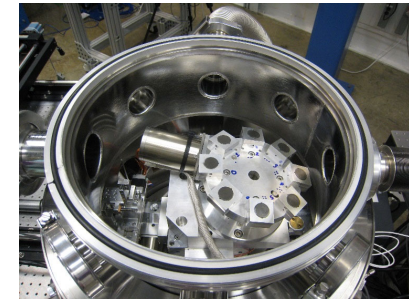
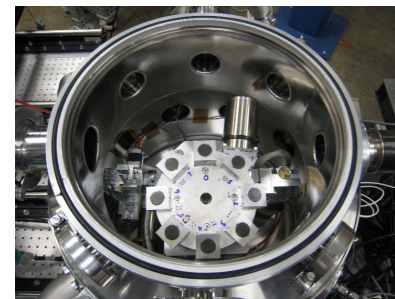
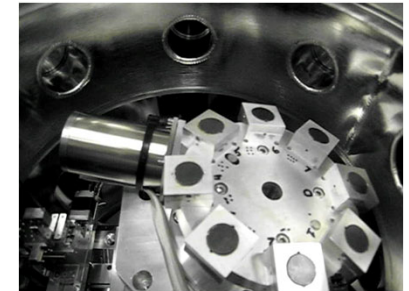
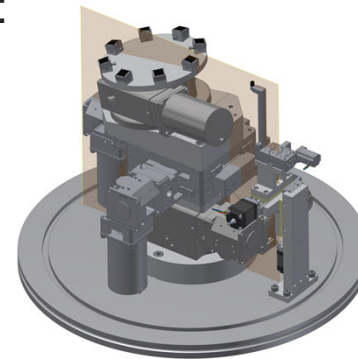
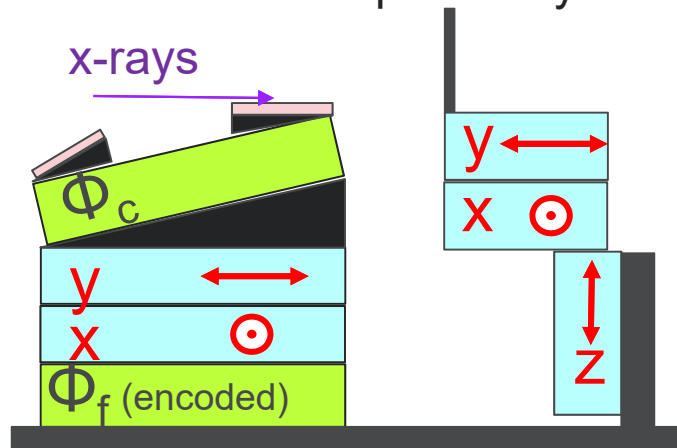


8-ID-E GIWAXS since ~ 2014  
PUP with Paul Nealey, Wei Chen  
design by Mike Fisher

# INFRASTRUCTURE: MULTI-SAMPLE GIXS CHAMBER

Vacuum ( $10^{-3}$  torr) environment with azimuthal rotation for 8 samples

- Sample-selection rotation stage on wedge:  
1 sample in beam
- Sample x-y motion and  $> 90^\circ$  rotation
- Internal beamstop with x-y-z motion



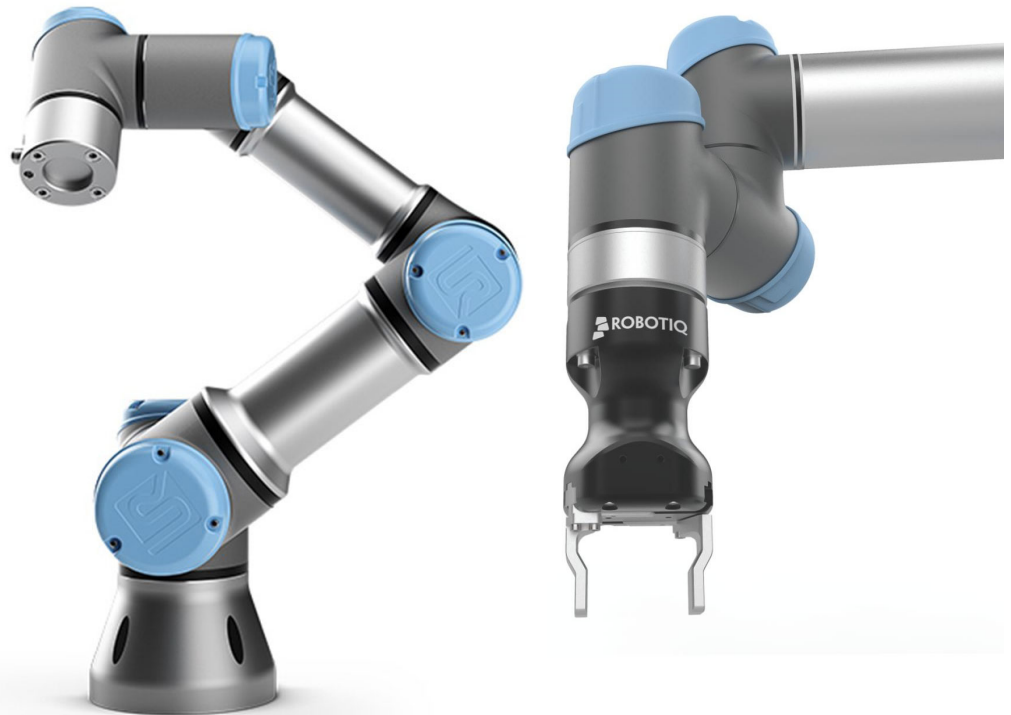
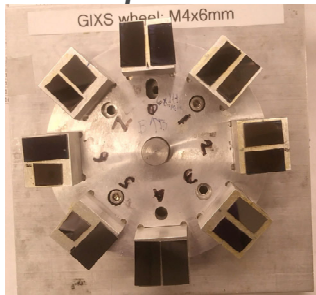
# REMOTE ACCESS

## Robotic sample handling

Change from Vacuum to He  
Robot changes sample wheel  
Reservoir of sample wheels

**Goal:** *direct human intervention:  
only 1/day (or 1/weekend!)*

**Human-enabled remote access:**  
*1 sample wheel/day ~ 4-5 hours.*



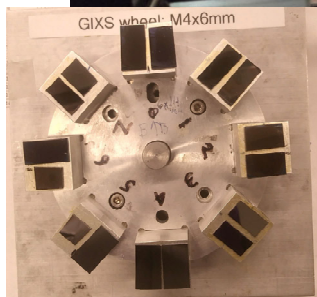
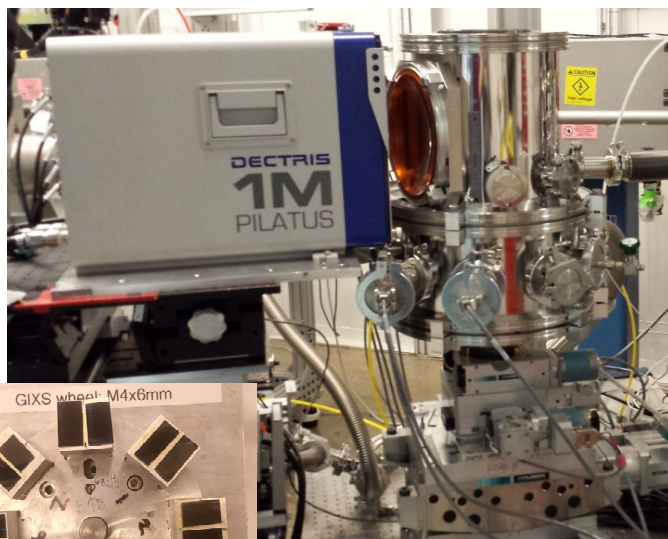
Universal Robots UR3e  
Robotiq Hand-E gripper  
Robotiq wrist camera (not shown)



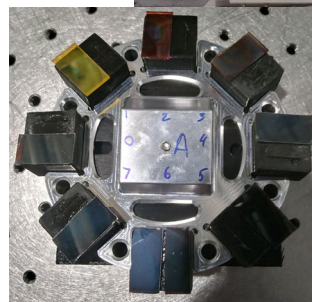
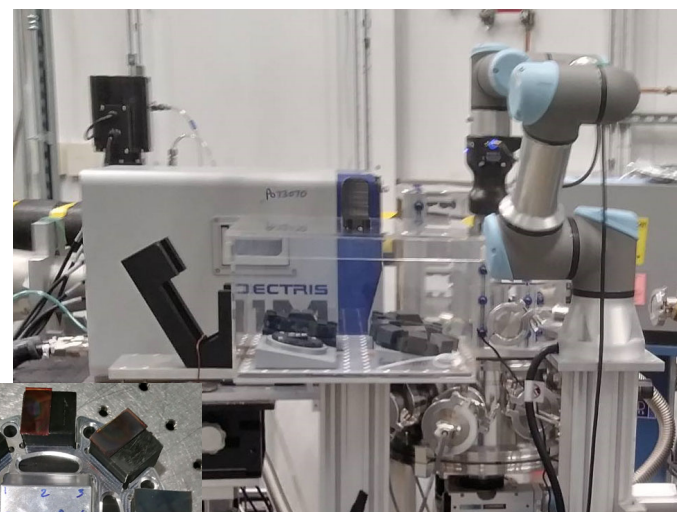
# GIWAXS BEFORE AND AFTER

## Installation complete

■ 2014

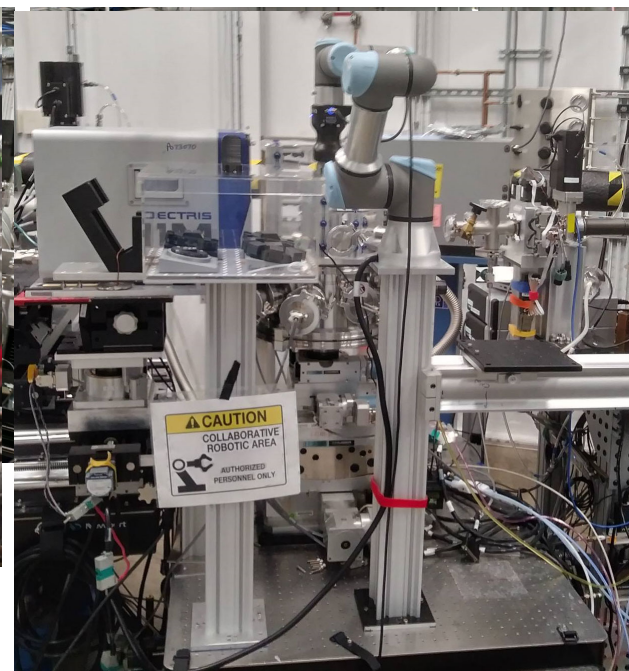
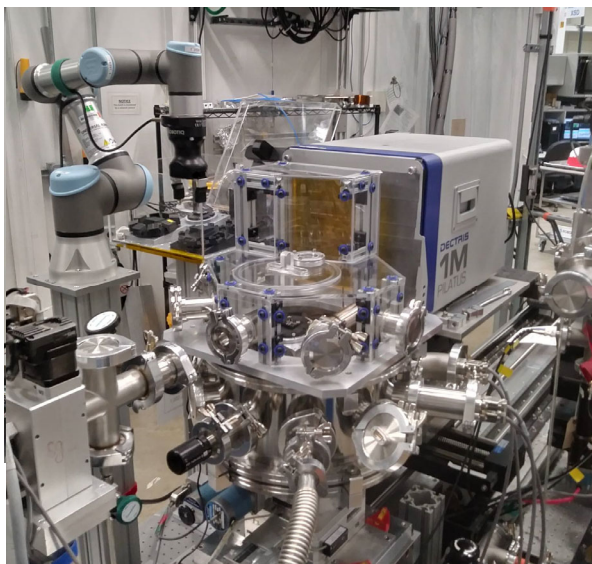
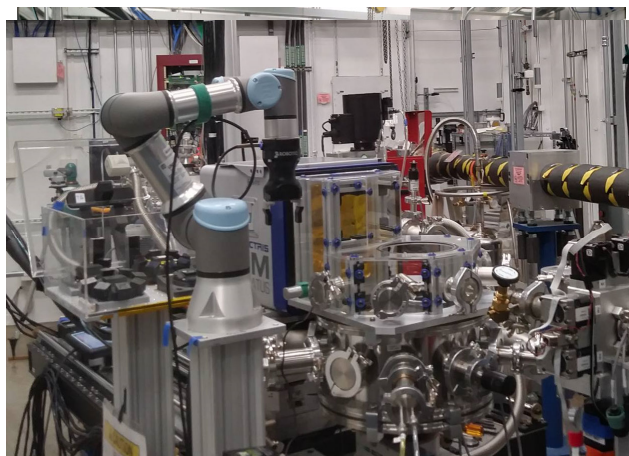


■ 2022



# SAMPLE HE ENCLOSURE/ROBOT LAYOUT

Installed 8-ID-E

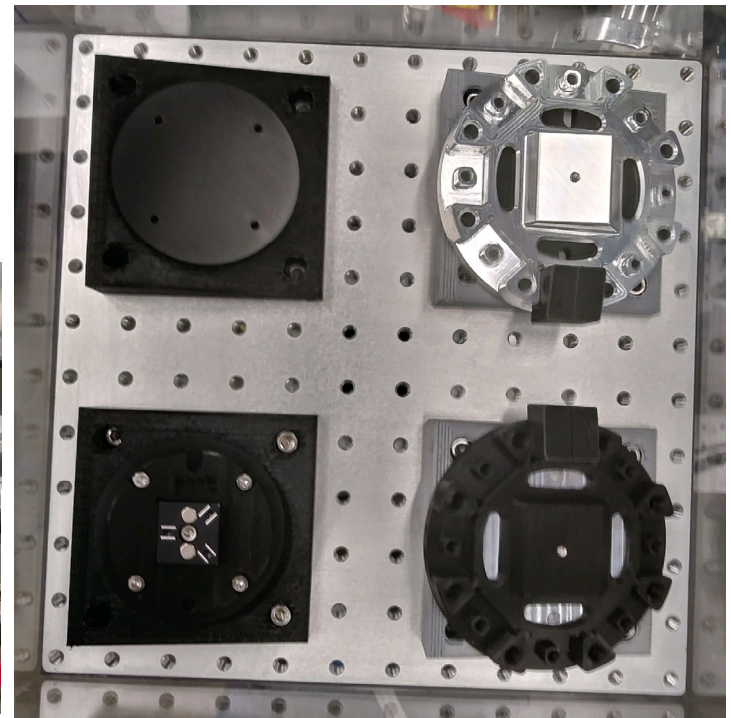
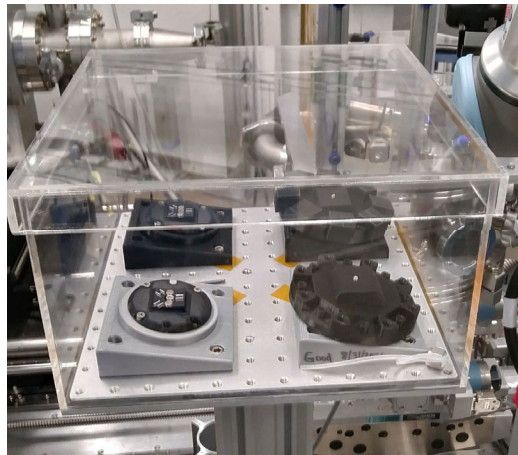
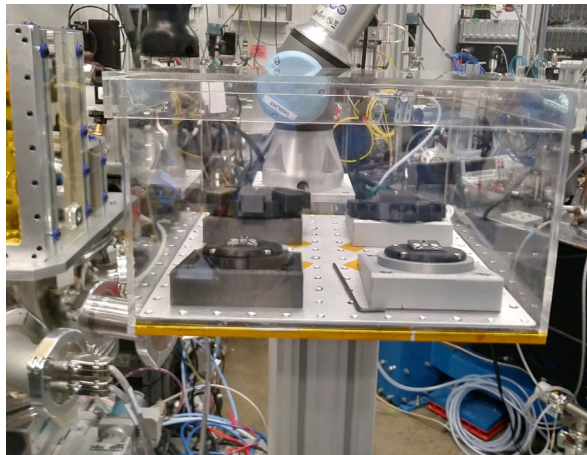




# SAMPLE RESERVOIR, 1<sup>ST</sup> GENERATION

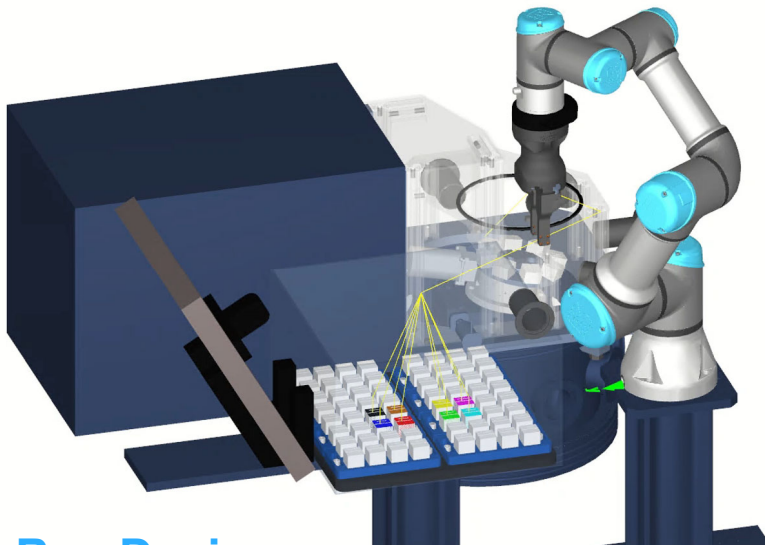
Acrylic box, holds 4 sample wheels

- Future generation with moving parts to hold more wheels
- 7" walls, maintain inert atmosphere

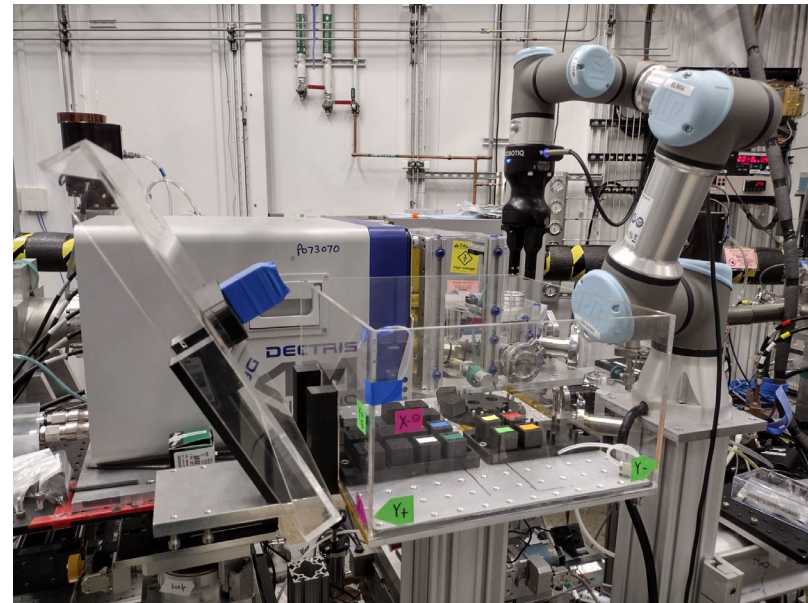


# ALTERNATE SCHEME: MOVE SINGLE BLOCKS

Higher sample density, reservoir can last a weekend



Ben Davis

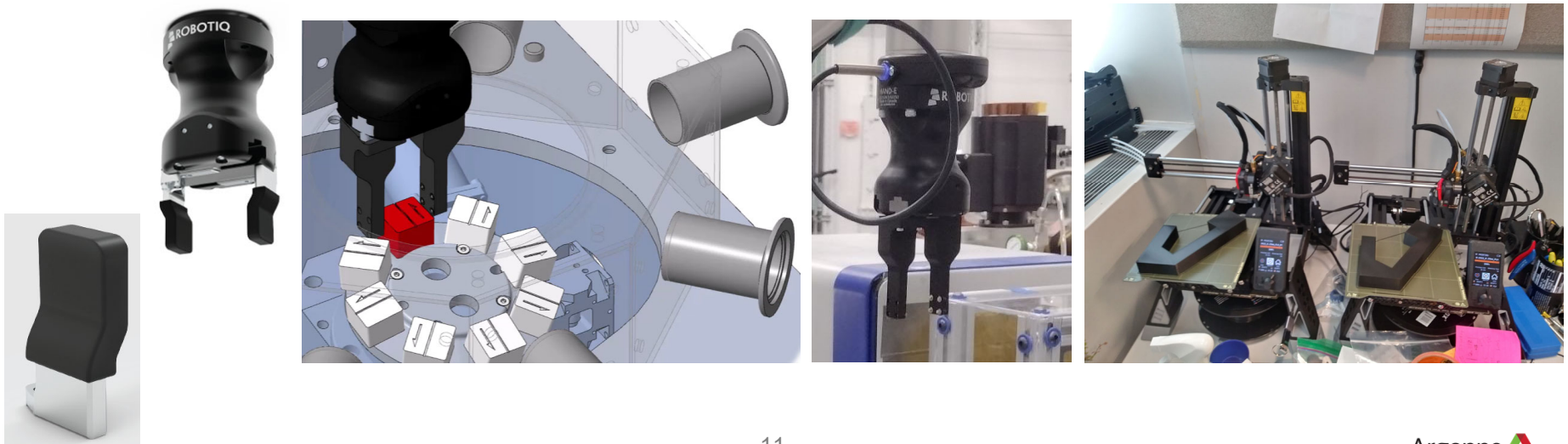


*Under development....*

# ALTERNATE SCHEME CHALLENGES

## Mechanical (re)design aided by in-house 3D printing

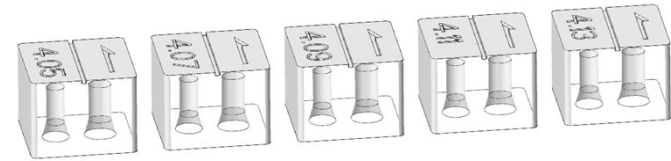
- Longer, thinner fingers
- Virtual testing in RoboDK
- Test with 3D-printed prototypes



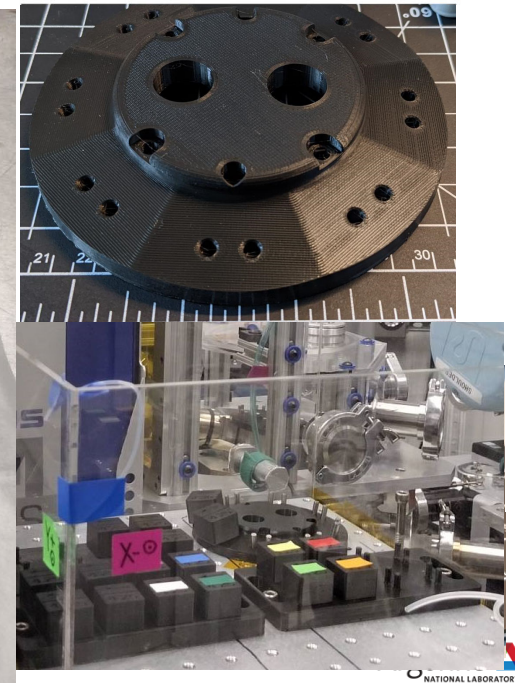


# 3D PRINTING: PROTOTYPING AND DISTRIBUTION

User-printable pallets, sample blocks.  
Fix samples to blocks and ship to APS



Evolution of sample wheels, blocks





# SAFETY

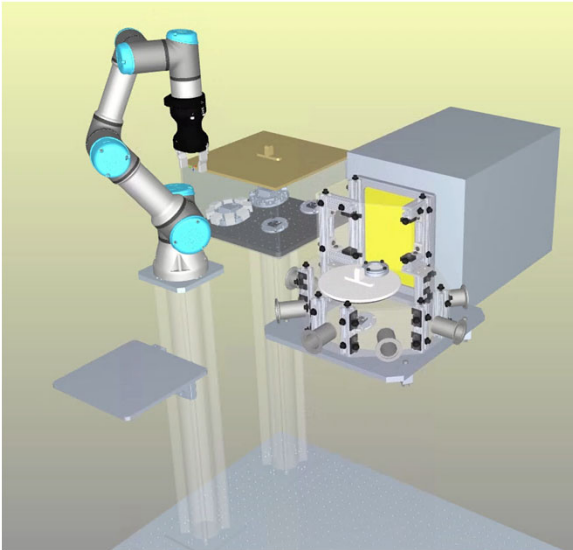
## Key switch controls mode. Key required for programming

- Built-in force sensors stop robot in case of collision
- Want to avoid unintended human contact
- Key switch parts now available as kit from vendor
- SOP authorized
- Initial testing required enclosure, safety mat.
- Now 8-ID-E is our enclosure
- Users limited to pre-programmed routines



# PROGRAMMING: HYBRID APPROACH

Combine RoboDK, scripting and teach pendant “Polyscope” as needed



- **RoboDK** → **.urp**: (bad) coordinate transforms
- **RoboDK** → **.script**: works
- RoboDK does not manipulate gripper
- Script commands control gripper
- Teach pendant: insert commands, but difficult to edit RoboDK waypoints (in angle space)

# CONTROLS: EPICS, SPEC

- VNCviewer gives remote access of teach pendant display/controls
- IOC created PVs for programs to load, run/pause/stop
- Spec: epics\_put or Linux: channel access to control robot
  - Hardware signal 1: robot in motion
  - Hardware signal 1: unscheduled stop
  - Higher level control logic
- Development needed for user-friendly UIs, access to more PVs

# SPEC MACRO/UR3 IOC

```
def swapwheel '
  global UR3SWAPS
  UR3SWAPS = 0
  while (UR3SWAPS < 10) {
    p date()
    start_time = time()
    eprint "Wheel swaps completed: " UR3SWAPS
    PkR1
    RlSam
    PkSam
    RlR1
    PkR2
    RlSam
    PkSam
    RlR2
    end_time = time()
    eprint "seconds elapsed: " end_time - start_time

    UR3SWAPS++
  }
}

def PkSam '
  epics_put("8idgur3e:RuntimeStrings.AA", "/programs/f2021/PkSam.urp")
  sleep(2)
  epics_put("8idgur3e:PlayProgram.PROC", 1)
  sleep(2)
  ur3moveHI=epics_get("8idg:softGlueB:BUFFER-1_OUT_BI")
  while (ur3moveHI) {
    sleep(0.5)
    ur3moveHI=epics_get("8idg:softGlueB:BUFFER-1_OUT_BI")
  }
  eprint "PkSam done."
```

noscan\_ur3StrProtoProgContr.ui

Enter filename:  Loaded Program:

Disconnect Refresh Play Pause **Stop**

Remote Status:

softGlue\_BUFFER.ui

8idg:softGlueB: **BUFFER 1**

UR3moveHI  $\rightarrow$  BUF-1  $\rightarrow$



# SAFEGUARD STOP ABORTS MACRO

```
Terminal
File Edit View Search Terminal Help
RLSam done.
PkSam done.
RLR4 done.
seconds elapsed: 959.146
Sat Jan 29 16:09:46 2022
Wheel swaps completed: 4
PkR1 done.
RLSam done.
PkSam done.
RLR1 done.
PkR2 done.
RLSam done.
PkSam done.
RLR2 done.
PkR3 done.
RLSam done.

Sat Jan 29 16:20:37 2022. UR3 stopped. Exiting..

99.FOURCGIS>
99.FOURCGIS> # Task 10a: Move from Home to Shelf, grip Lid
100.FOURCGIS>
```

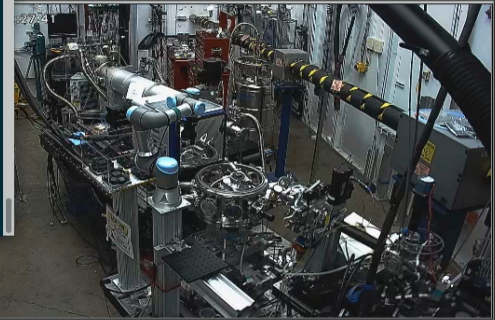
```
[screen 0: 8ldgur3e]
164.54.116.127:29999 read 17
164.54.116.127:29999 write 5
164.54.116.127:29999 read 17
164.54.116.127:29999 write 5
```

S6130 Network Camera - Konqueror

Help

ex.html?Language=0&ViewMode=pull

WV-S6130 Network Camera



2,783 Images of 2,784 loaded.

Days	Hours	Minutes	Seconds
123	23	11	46

Show Waypoints

**Safeguard Stop**

Log/Play

Zoom

Auto mode

Brightness

Normal

# OUTLOOK

## Future developments

- 8-ID-E shutting down August 2022
- Robot returns to chem lab for development during APS-U
  - User friendliness
  - Integrate with automated workflows, alignment
  - Integrate with AI-guided experimentation
  - Automate metadata capture
  - Robust packaging for sample transport
- Migrate to new GIXS home at 9-ID CSSI feature beamline

**THANK YOU!**

