Lessons and solutions learned from marrying BluIce and EPICS

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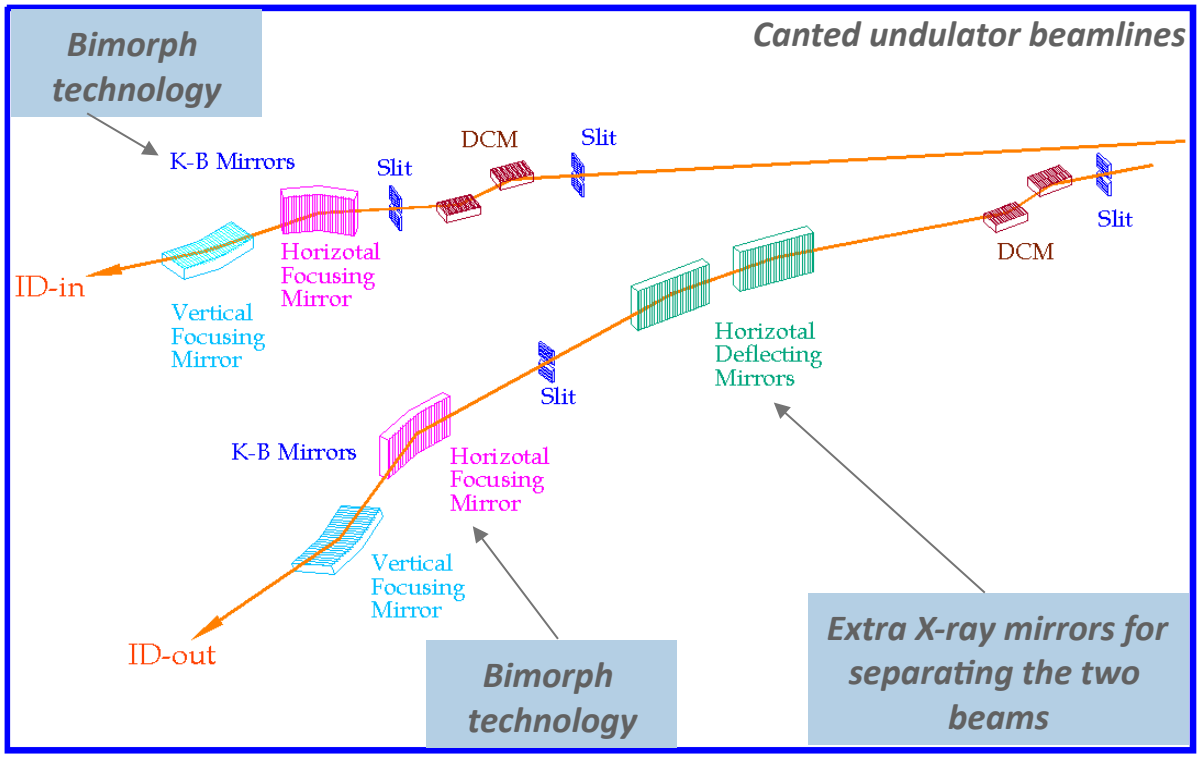
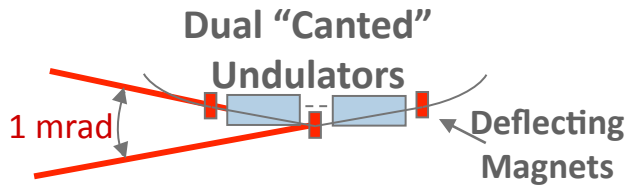
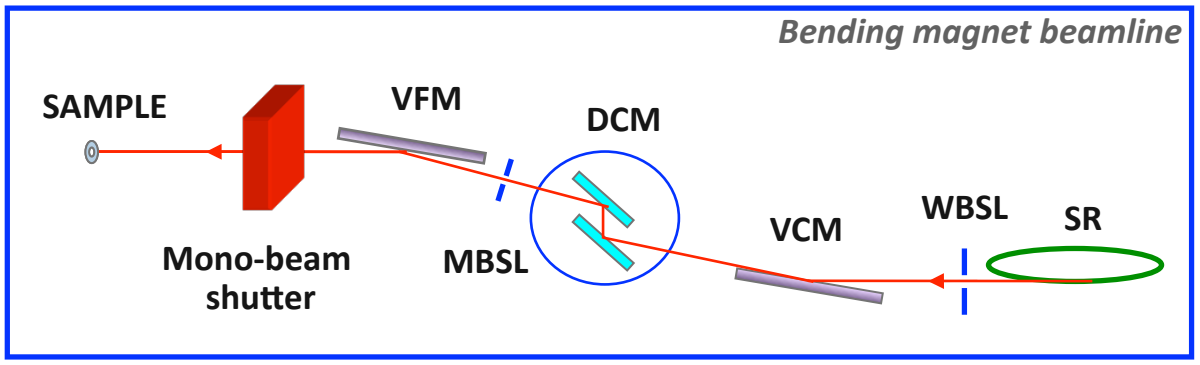
GM/CA CAT: three dedicated beamlines for MX crystallography







Hardware:

- Delta Tau PMAC motion controllers
- 4k x 4k Rayonix CCD detectors
- ALS-style sample automounters
- On-axis visualization system
- Axis and iQeye video servers
- Mini-beam collimators
- Bimorph focusing mirrors

Project started 3/2002, first mono light 6/2004, first data set 7/2004

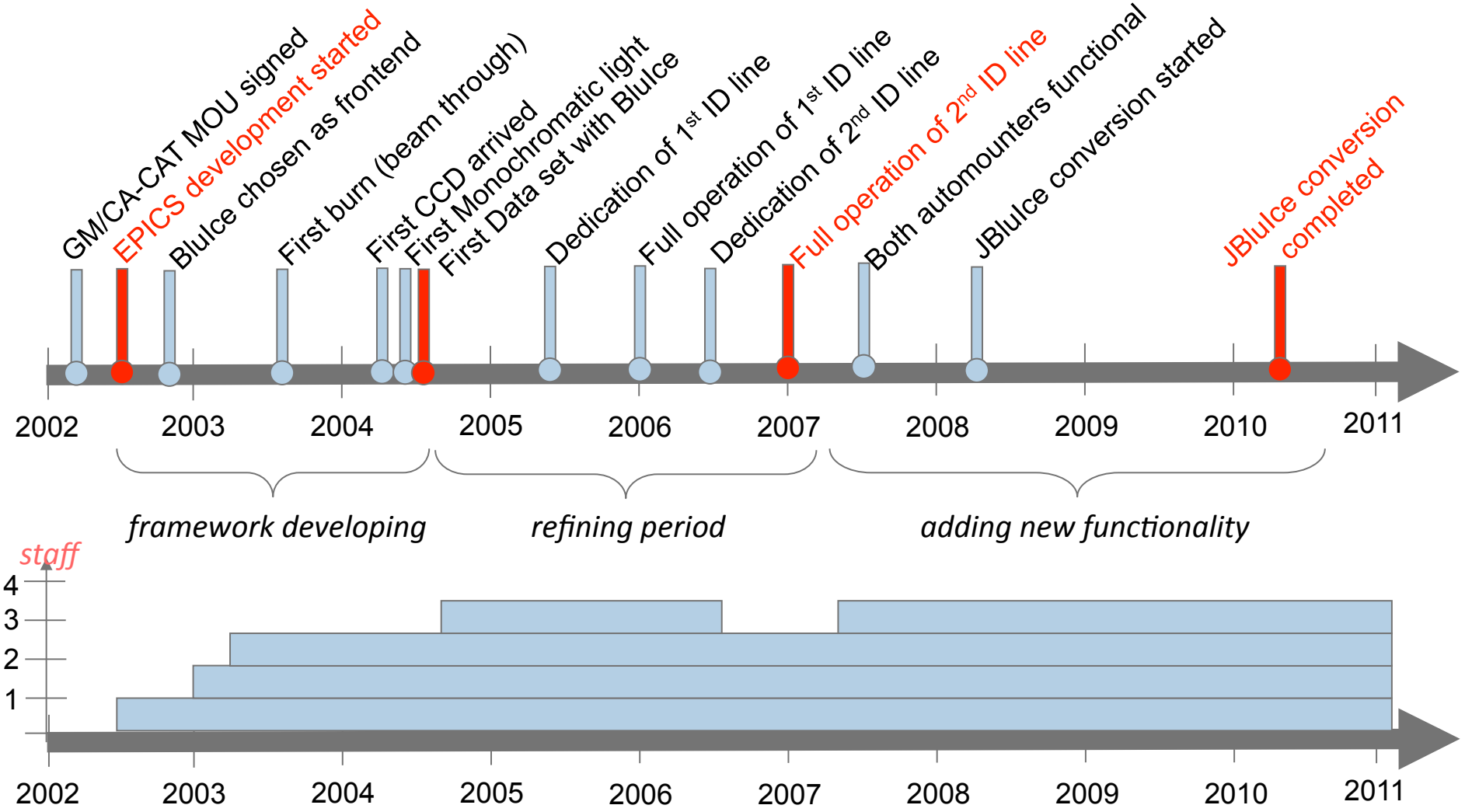
Challenges for GM/CA CAT control system

- High expectations: MX automation is the highest in SR field
- Typical experiment: 1 day; controls learning: 1 hour
- Users travel between multiple facilities: want similar interface (aka rental cars)
- Remote access is often: full automation and safeguards
- Inexperienced users: often blood test attitude – safeguards again
- Large share of sample screening: preferred to do things fast (on-the-fly scanning)
- Pipeline to data processing software
- Short terms: choice of electronics & basic controls in 1 year, GUI controls after 1 more year

Initial choices

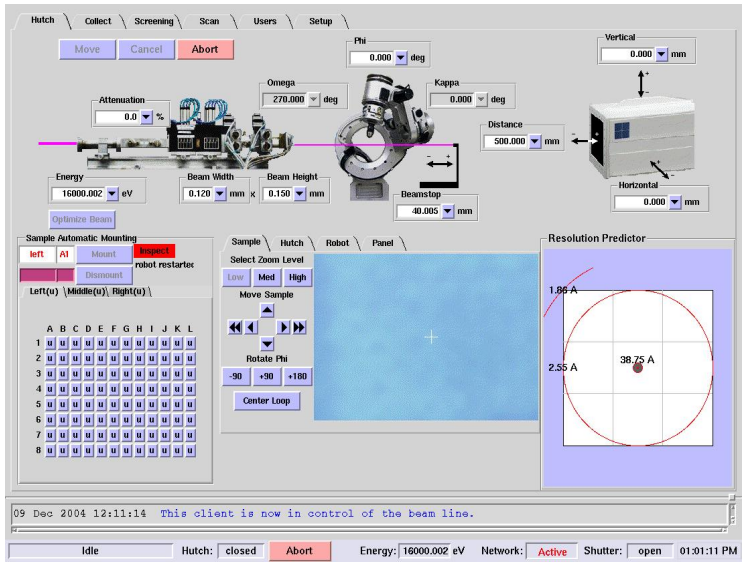
- Have both physicists and software developers in the controls team => 2+2
- Listen users what they want as an interface => BluIce
- Listen developers how to implement it best => EPICS
- Do not re-invent the wheel: make best use of what is available => BluIce & EPICS
- Stick to big projects with long lifetime and wide community => EPICS => Java/Eclipse
- Pick universal motion controller with on-the-fly scanning capability => Turbo PMAC
- Try to make software at all beamlines as close as possible => mySQL config

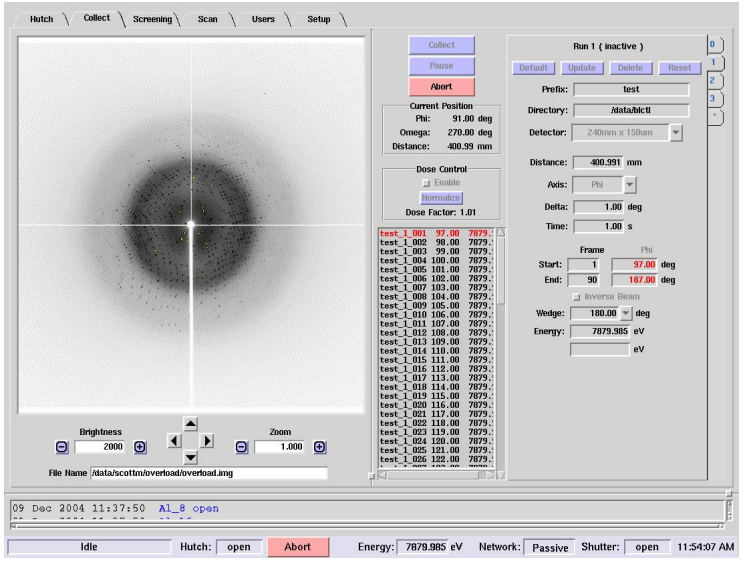
GM/CA-CAT software project timeline and staffing

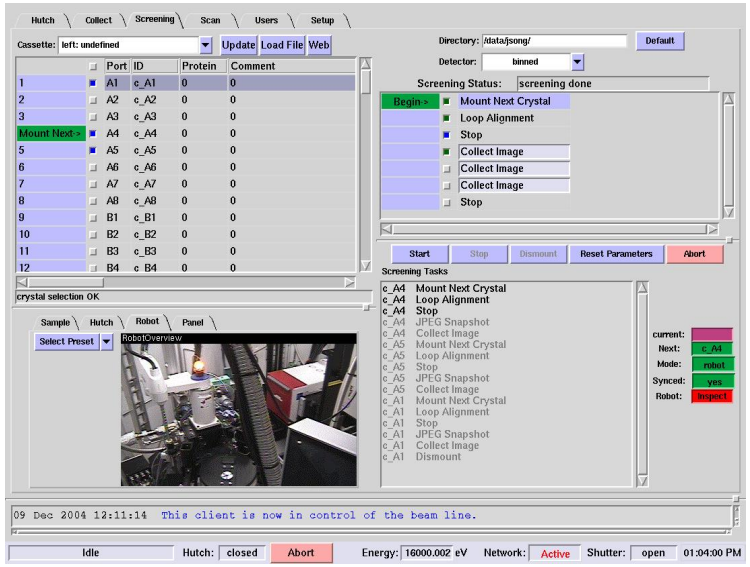


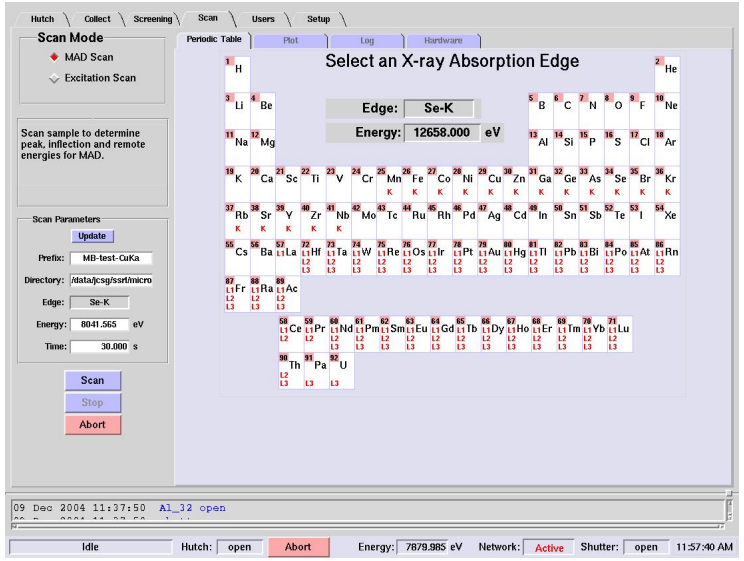
Shared developers duties: Linux/Windows system administration, SAN storage, network, user accounts (LDAP), cyber security (patching), remote access, daily support for users & staff, hardware tuning.

Quest for graphical interface: Blulce (listen what users want)









http://smb.slac.stanford.edu/

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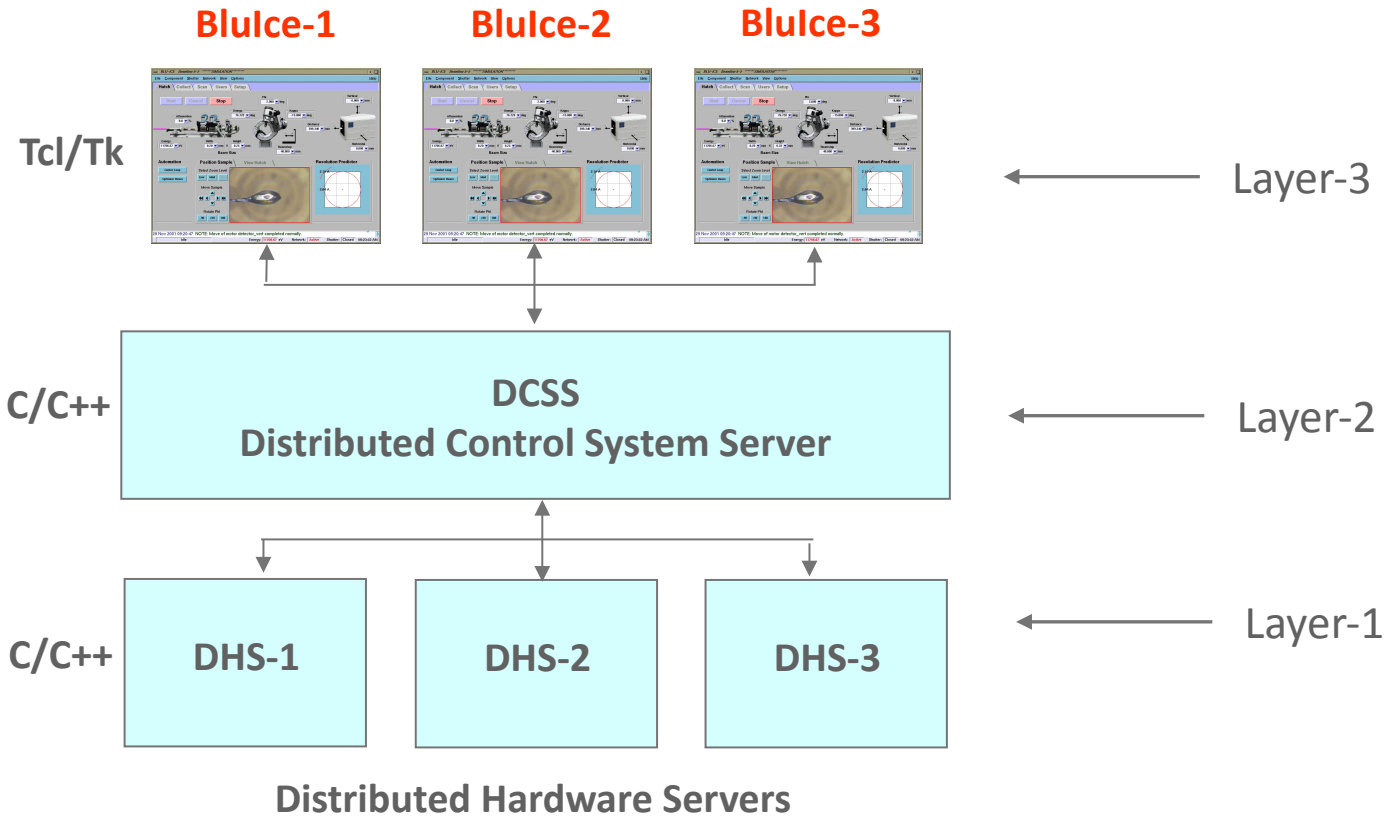
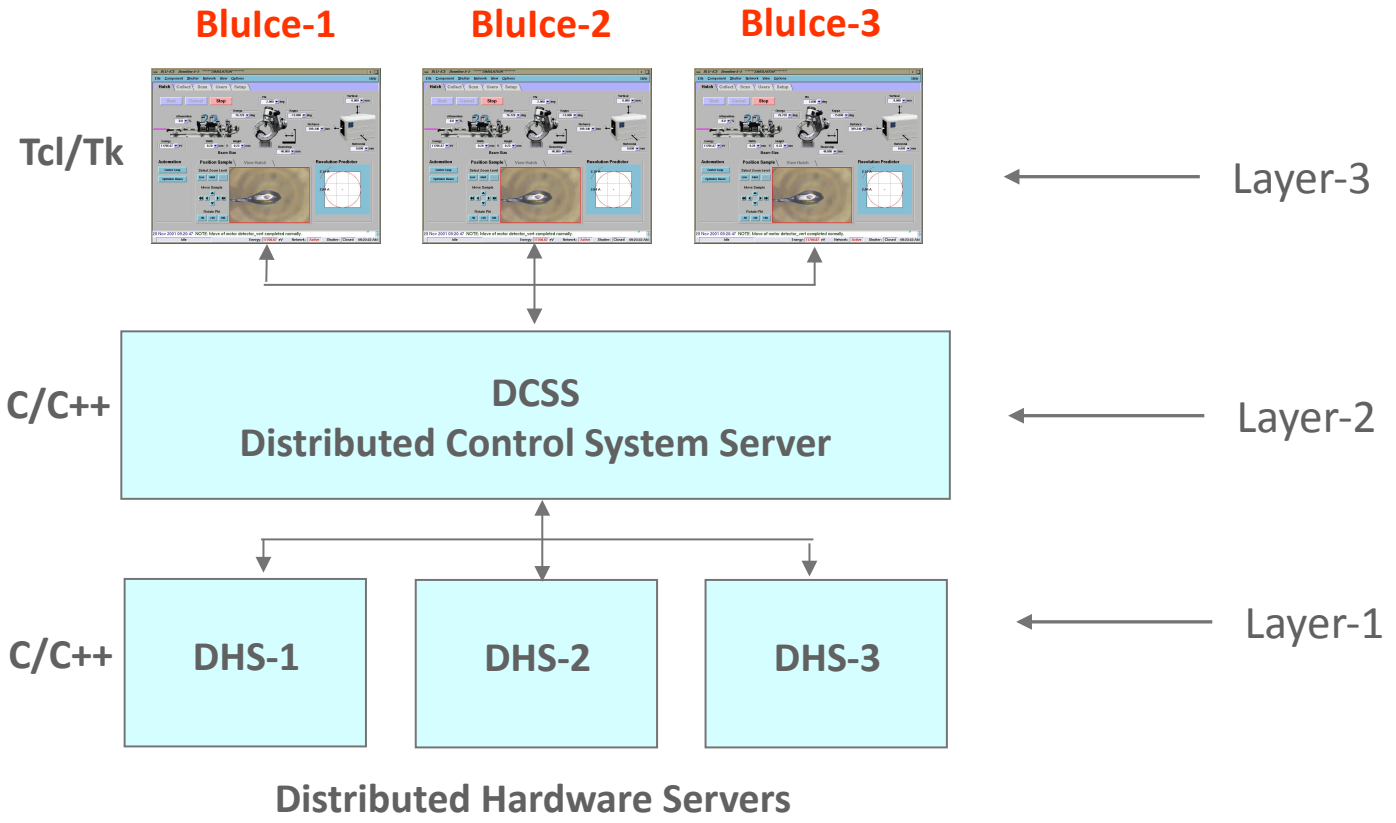
Reasons for picking BluIce

- Dedicated control system for MX crystallography, used at 7 SSRL beamlines
- Well thought tabbed interface: Hutch, Collect, Scan, Screen, and etc.
- One GUI instance is a master at a time (allowed to control the hardware)
- **Preferred by users**



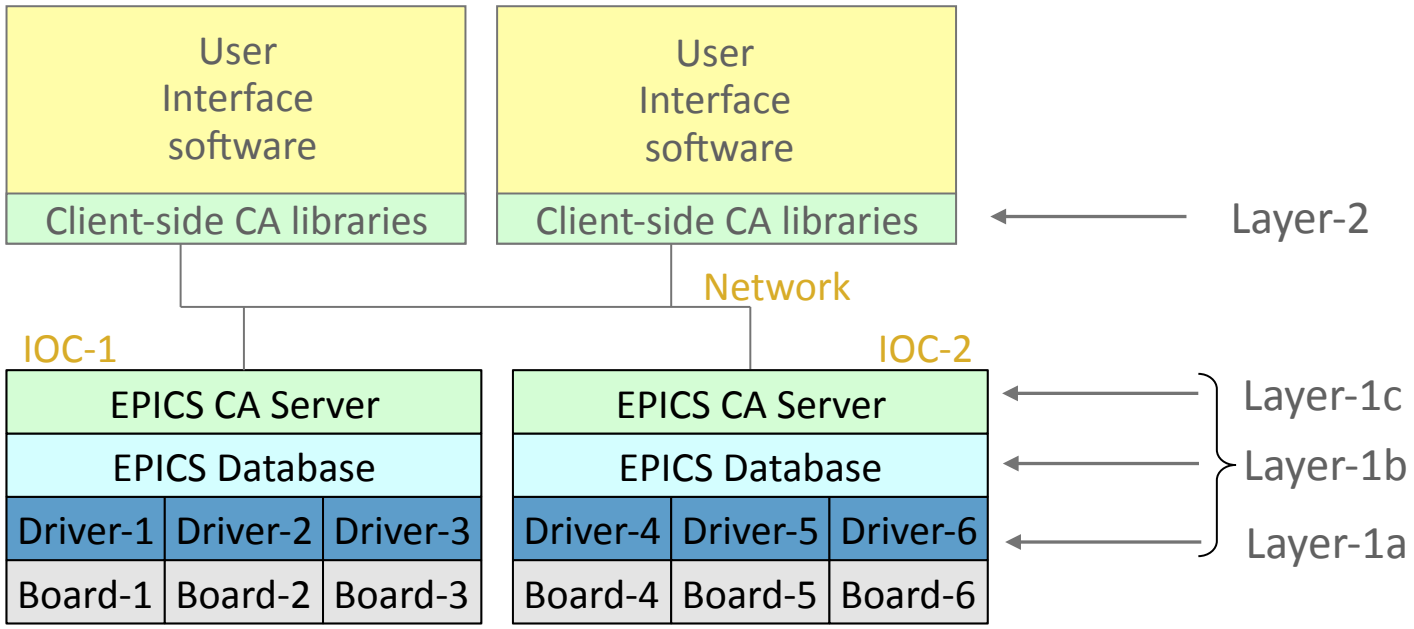
Why not using BluIce as a sole base?

- Very small selection of drivers
- DCSS makes programming easier, but masks advanced hardware access
- DCSS is a single master: not designed to monitor if others can change hardware states
- Use of Tcl/Tk for graphical interface: bad debugging tools, shortage of libraries

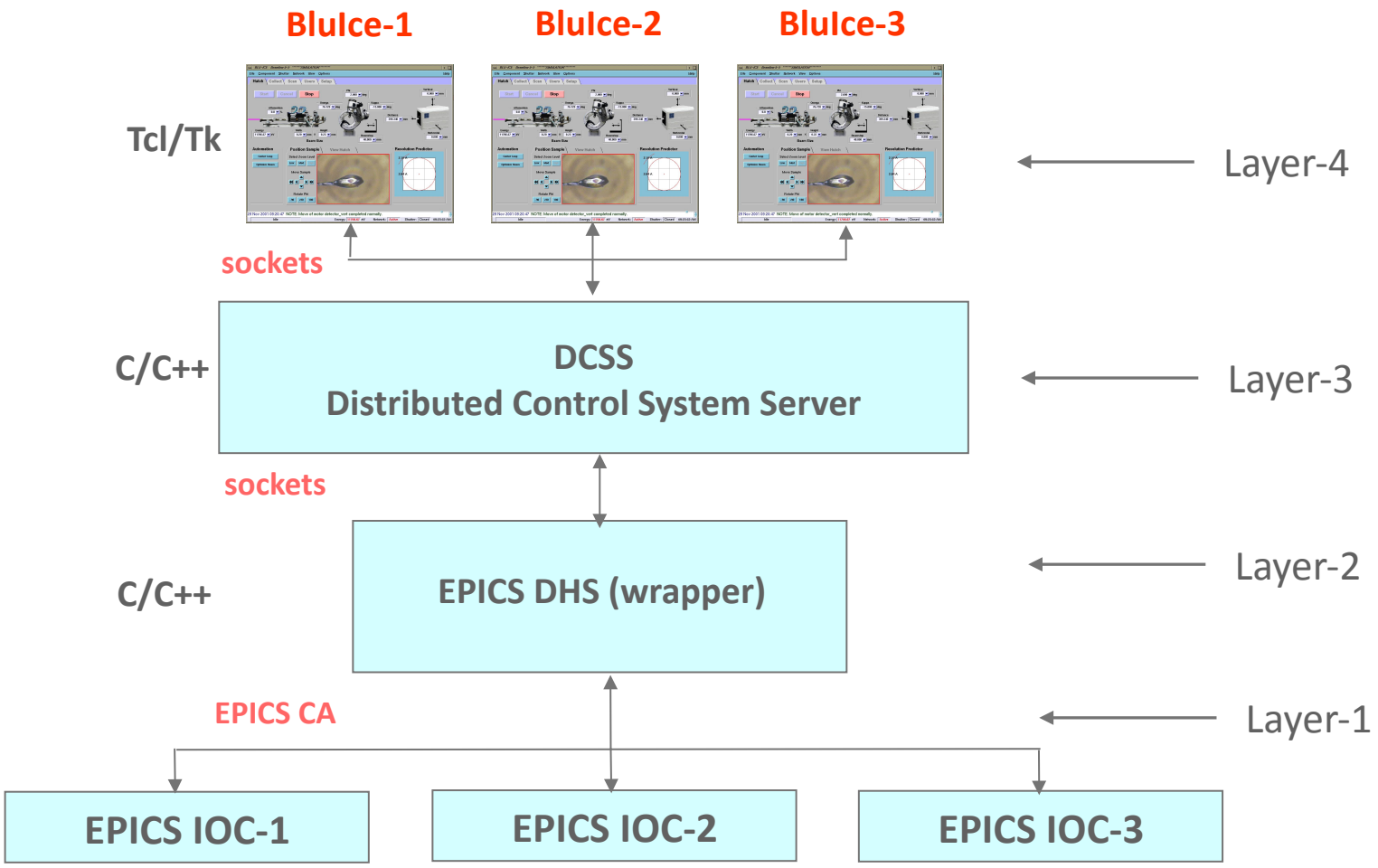


Why EPICS?

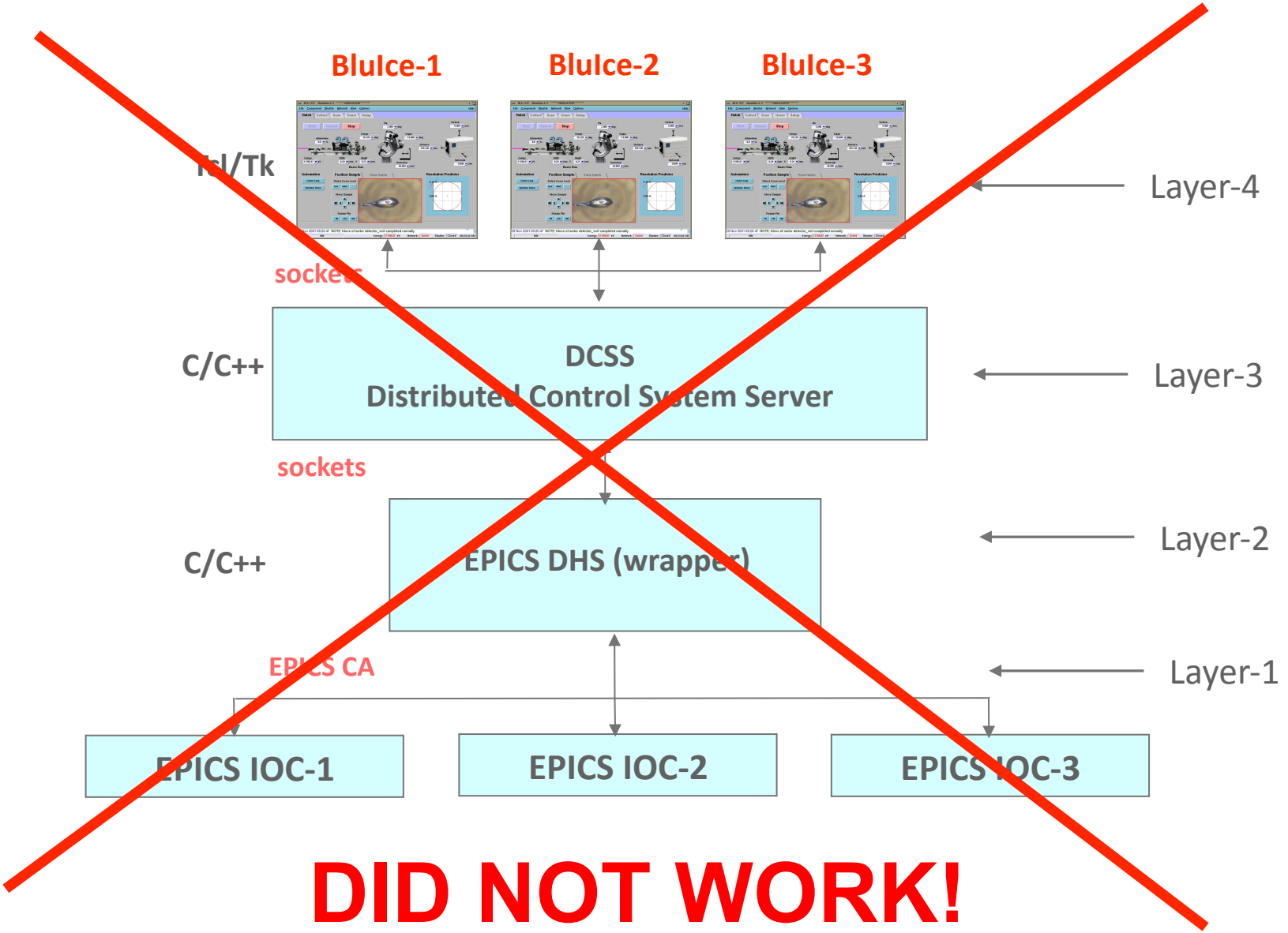
- Well established toolkit for building distributed controls
- Wide community including many synchrotrons
- Wide choice of drivers including synApps
- API for programming clients in most of existing languages
- Good choice of debugging tools (MEDM, Striptool, caMonitor)
- State Notation Language
- **Preferred by developers (local expertise)**



Choice of BluIce-EPICS interface: initial attempts

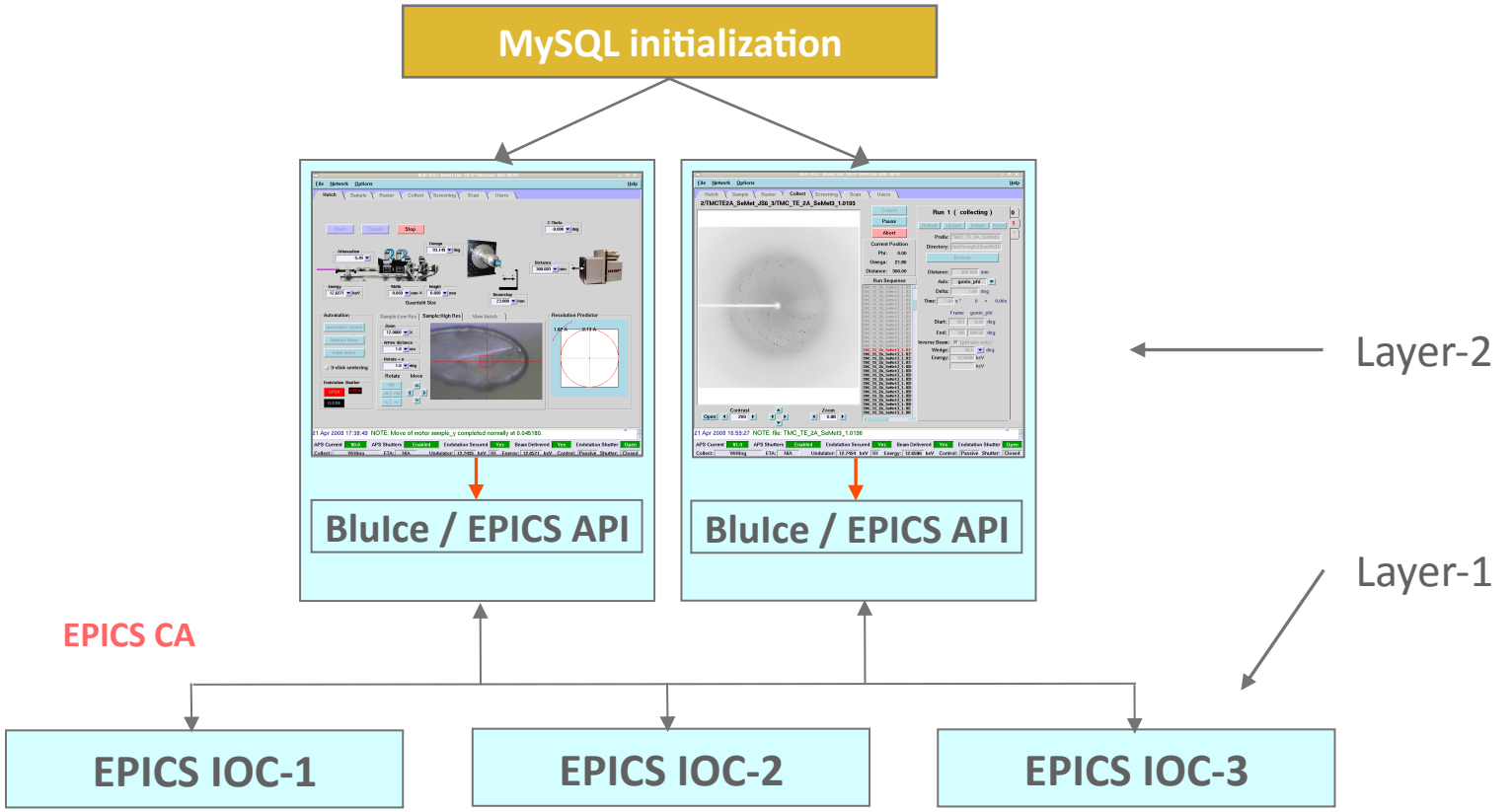


Choice of BluIce-EPICS interface: initial attempts



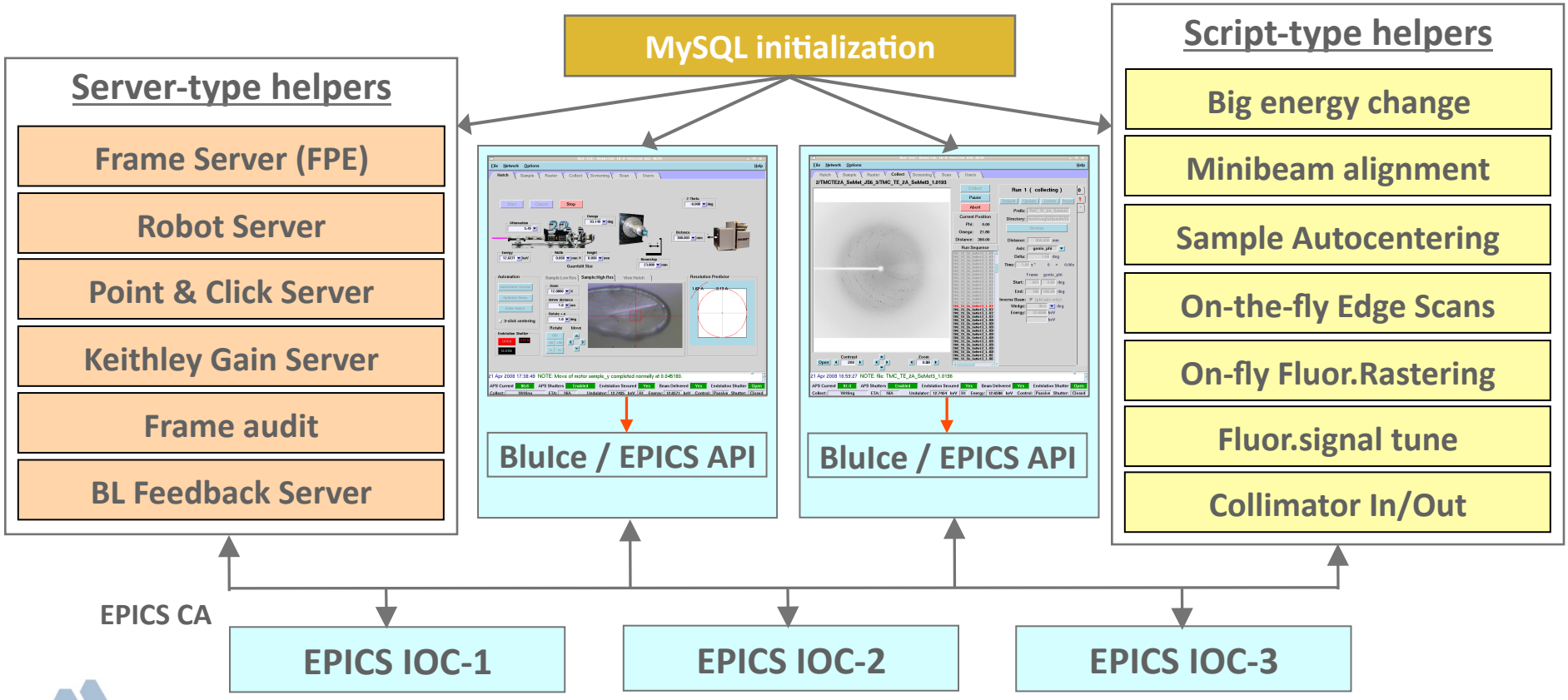
Choice of BluIce-EPICS interface: chasing speed

- Keep BluIce GUI, but convert them into standard EPICS clients like MEDM
- Communication between GUI instances via EPICS DB using callback mechanism
- Initialization via MySQL
- Less layers than in BluIce, but **heavy GUI**

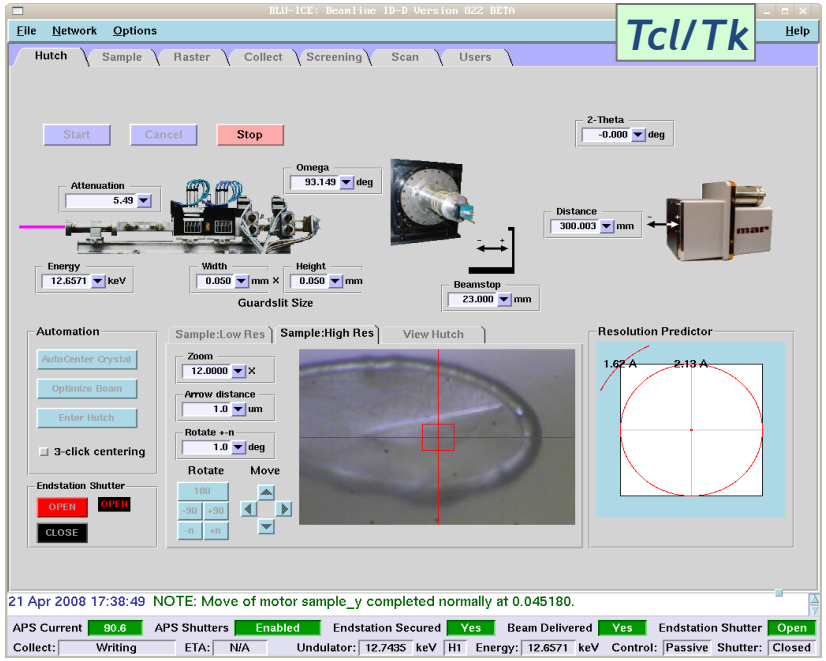


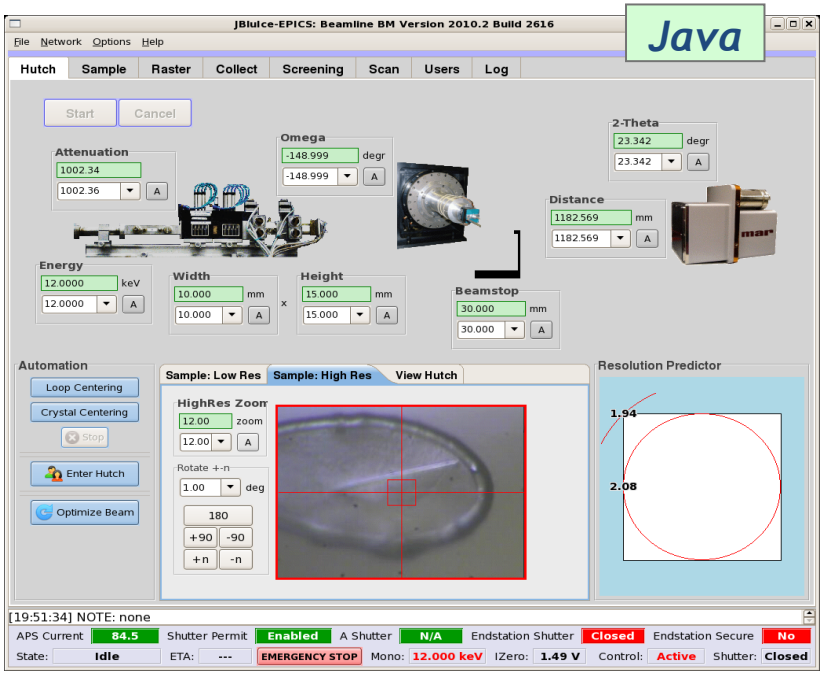
Choice of BluIce-EPICS interface: helpers

- Keep BluIce GUI, but convert them into standard EPICS clients like MEDM
- Communication between GUI instances via EPICS DB using callback mechanism
- Initialization via MySQL
- Less layers than in BluIce, but heavy GUI
- Multiple "helpers" for complex tasks; communication with helpers also via EPICS DB.
- Helpers are fully stand-alone and can be written in any languages – deploy staff effort



Transition to JBluIce in 2010 (see talk by Mark Hilgart)





Motivations for the transition: stick to a bigger project

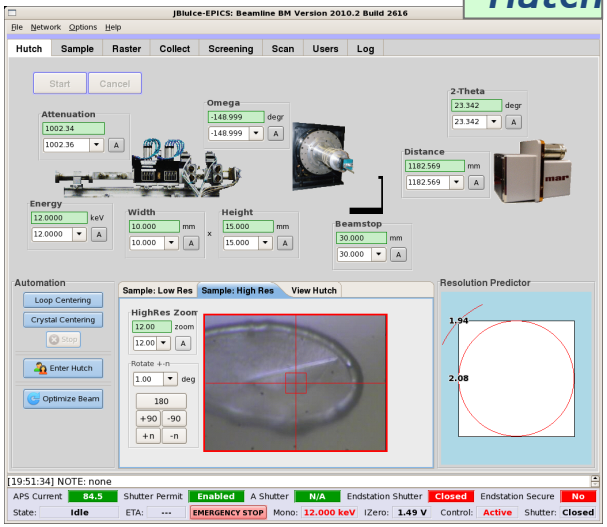
- Use extensive Java libraries (250:1 compared to Tcl)
- Simplify development and debugging through use of Eclipse RCP, the industry-leading IDE
- Secure future development by moving to a widely used and widely taught language

Gradual transition process:

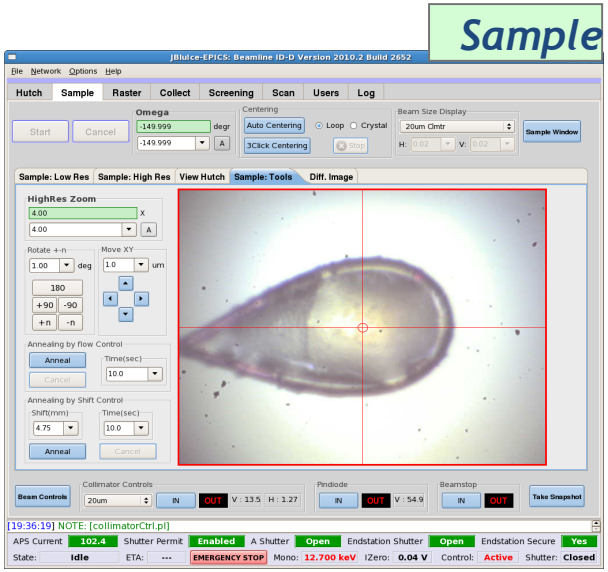
- Transition was done in 2.5 years without any interruption to users
- Possible due to all pieces communicating via EPICS (same as helpers)

JBluIce-EPICS as of today: core tabs

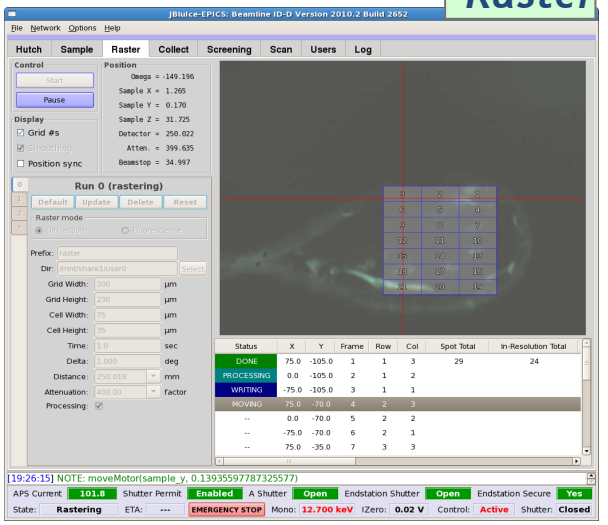
Hutch



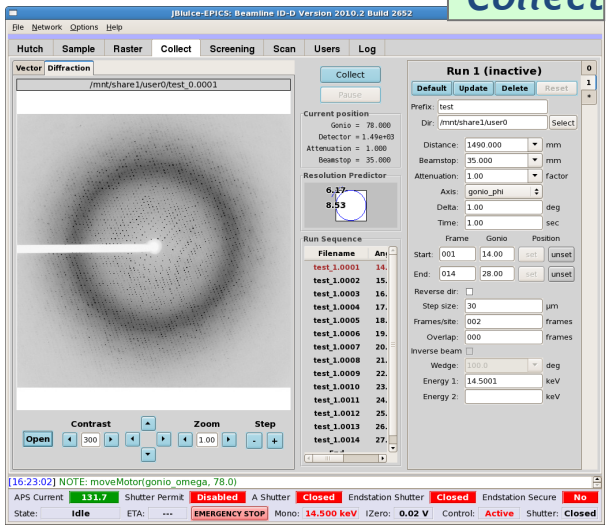
Sample



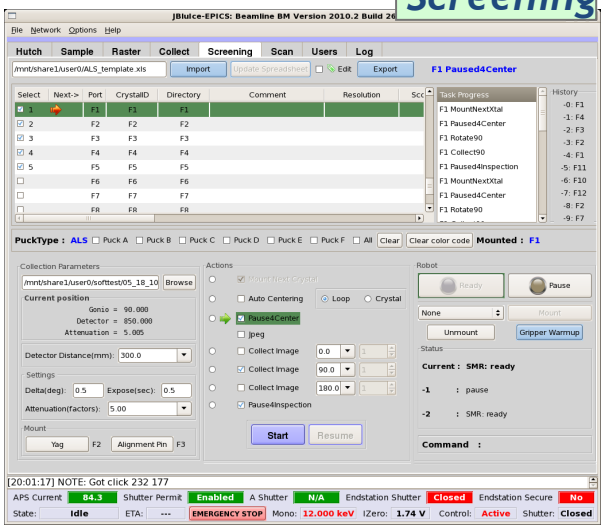
Raster



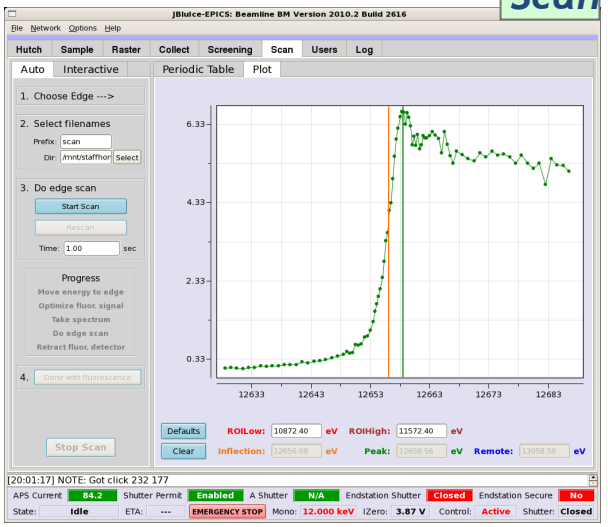
Collect



Screening



Scan



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Conclusions and plans

Worked best:

- ✓ Sticking to user-preferred interface (BluIce) and large, well-supported backend (EPICS)
- ✓ Choosing universal motion controller (PMAC)
- ✓ Making all components interact via EPICS PVs: allowed helpers & gradual Java transition
- ✓ Helpers in any language: gave flexibility and could use beamline staff hands
- ✓ JBluIce transition: easier GUI changes, easier development, more libs, secured project
- ✓ Regular listening & prioritizing users input kept driving new features (EOR forms)

Did not work:

- ❖ the seemed-most-obvious way to merge BluIce and EPICS
- ❖ listening users on how to implement features they wanted

Future plans:

- o framework is settled for now
- o more automations & safeguards, fast detectors, micro crystallography, data processing

Acknowledgements

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- *Alex Urakhchin*

GM/CA CAT Crystallographers:

- *Michael Becker*
- *Craig Ogata*
- *Ruslan Sanishvili*
- *Nagarajan Venugopalan*
- *Ward Smith (now at NIH)*

GM/CA CAT Management:

- *Janet Smith (U. Michigan)*

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More about GM/CA CAT at: http://www.gmca.anl.gov

Thank you !

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APPENDIX-1: JBluIce-EPICS source code and manuals

The source code of JBluIce-EPICS is managed through Subversion.

The source code as well as the user manuals including several video tutorials are available at the GM/CA CAT web site:

http://www.gmca.anl.gov/userprogram/jbluice-epics.html

JBluIce-EPICS uses Eclipse, an open source IDE, as a development platform. The core application and the helpers depend on a number of freeware packages:

1. EPICS base, synAps, SNL, CAJ, PEZCA.
2. mySQL server.
3. Java and several extensions: MySQL Connector/J, JExcelApi, and PDFRenderer.
4. Eclipse RCP; includes Eclipse runtime, SWT, JFace, Workbench.
5. Apache commons libraries for HTTP post support: codec, httpclient, and logging packages.
6. Perl 5 or later and several popular Perl extensions downloadable from Perl CPAN archive: PDL, ImageMagick, DBD-mysql, MIME-Lite, and Perl/Tk.

JBluIce also interfaces: WebIce, XREC, DISTL, CHOOCH, ADXV; more to come.

APPENDIX-2: Remote Access

Users want:

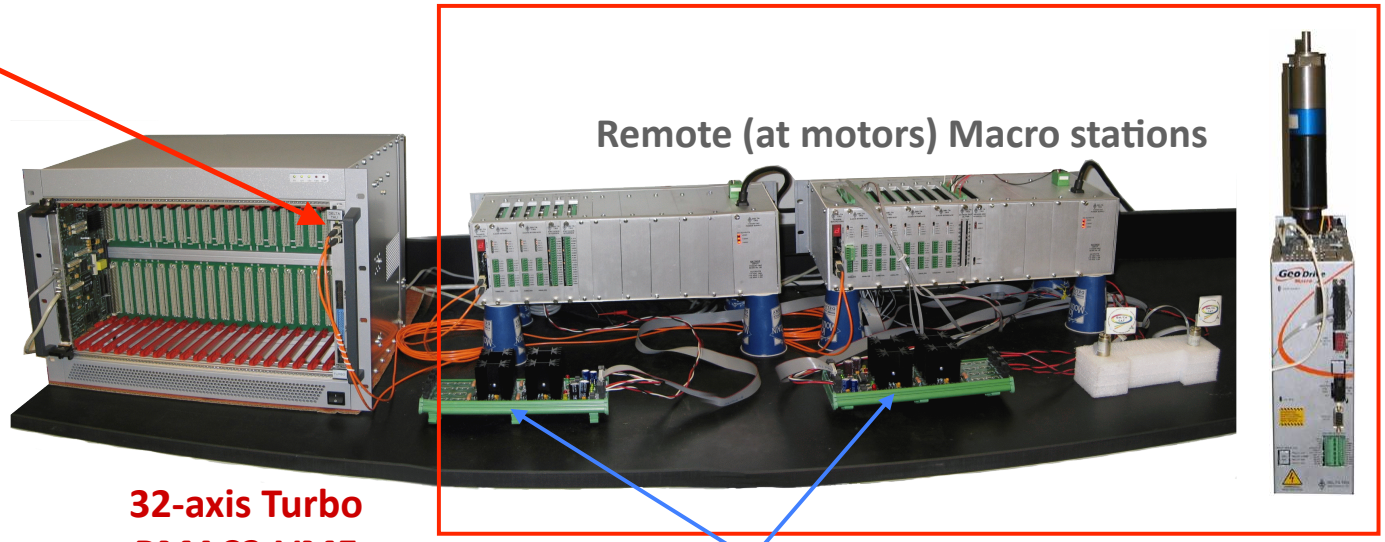
- remote data collection,
- remote data processing,
- remote data backups

We can provide:

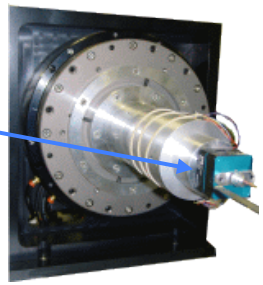
- remote data collection, but with a lot of effort & re-inventing the wheel
- remote backups (more-less easily)
- no remote data processing with some commercial software like hkl2000.
- **Solution:**
- Use NOMACHINE NX – industry standard
- Open 3 workstations per beamline: collection, processing, backups
- Extra security with IP domain in ssh config

APPENDIX-3: Choice of motion controller

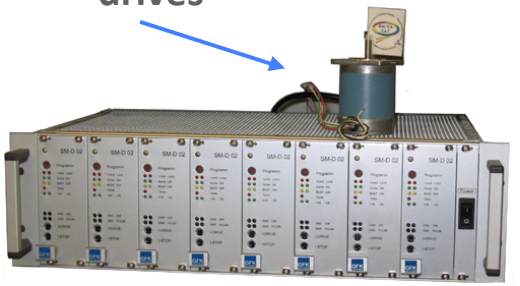
- 2-3 PMAC boards can control the whole beamline
- Works with virtually all types of motors: uniform controls
- Distributed control (fiber ring): shorter cables, less noise
- On-the-fly motion synchronization of motor assemblies
- Custom motion programs
- Analog & Digital IO



Air Bearing Gonio (brushless servo) & piezo XY head



Stepper drives



APPENDIX-4: EPICS developments

- Most parts of EPICS layer were available out of box. This included:
  - ✓ The basic infrastructure for booting controllers (MVME & Linux)
  - ✓ EPICS DB managers and Channel Access servers
  - ✓ A number of device drivers including support for Struck multiscaler, Canberra MCA, Acromag ADC & Digital I/O, Systran & Xycom DAC and etc.
- Some EPICS drivers were developed in house by extending existing drivers:
  - ✓ CCD detector interface was updated to the latest Rayonix remote interface
  - ✓ Delta Tau PMAC driver was extended to work with Turbo PMAC2
  - ✓ HYTEC-8402 DAC driver was supplied with option to do on-the-fly DAC scans
- Several State notation servers were implemented (helpers):
  - ✓ Frame Processing Engine
  - ✓ ALS-style sample automounter server
  - ✓ Keithley 428 Current Amplifier server

APPENDIX-5: BluIce developments

- Initial development: converting BluIce calls into CA calls in EPICS API
- Further developments: mostly driven by users: new tabs, new buttons
- Some in core GUI (diffraction rastering, vector collection, attenuation) and some in helpers
- Incorporating communications with new EPICS devices and helpers
- Support for iQeye cameras and new image server; interface to WebIce
- Adding safeguards all over