



Lessons and solutions learned from marrying Blulce and EPICS

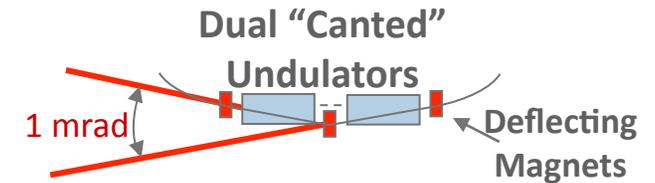
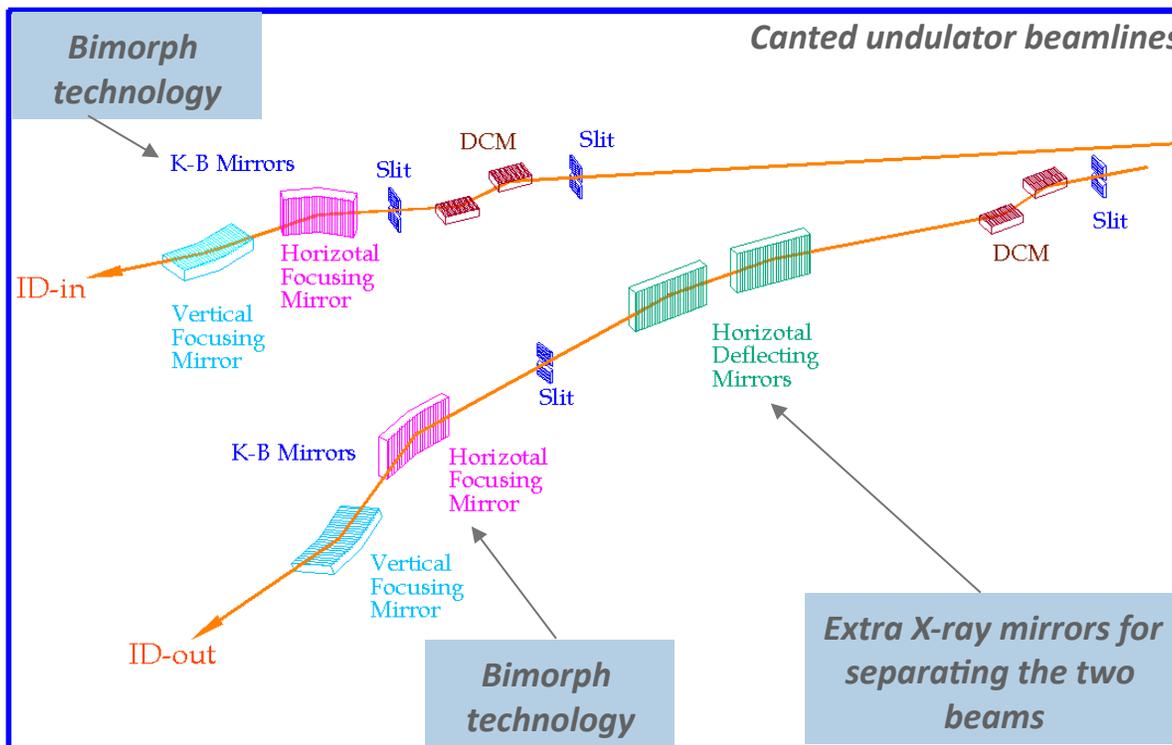
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Derek Yoder and Robert Fischetti

General Medicine and Cancer Institutes Collaborative Access Team
(GM/CA CAT) at the Advanced Photon Source
Biosciences Division, Argonne National Laboratory



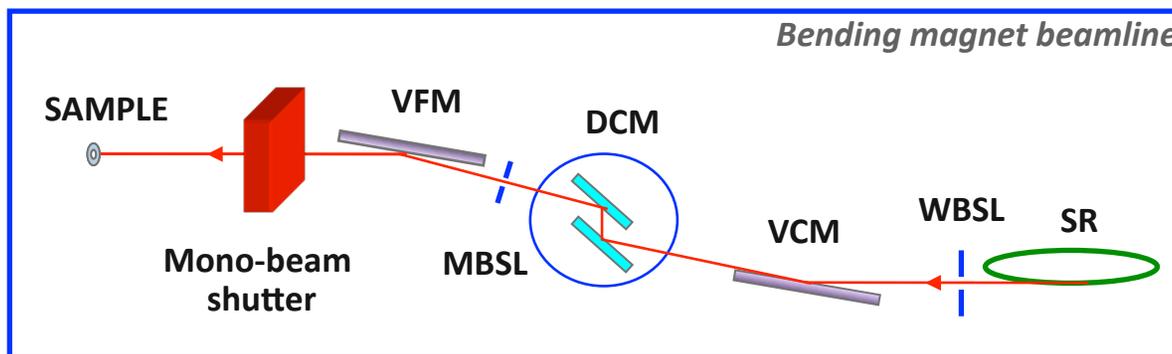


GM/CA CAT: three dedicated beamlines for MX crystallography



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



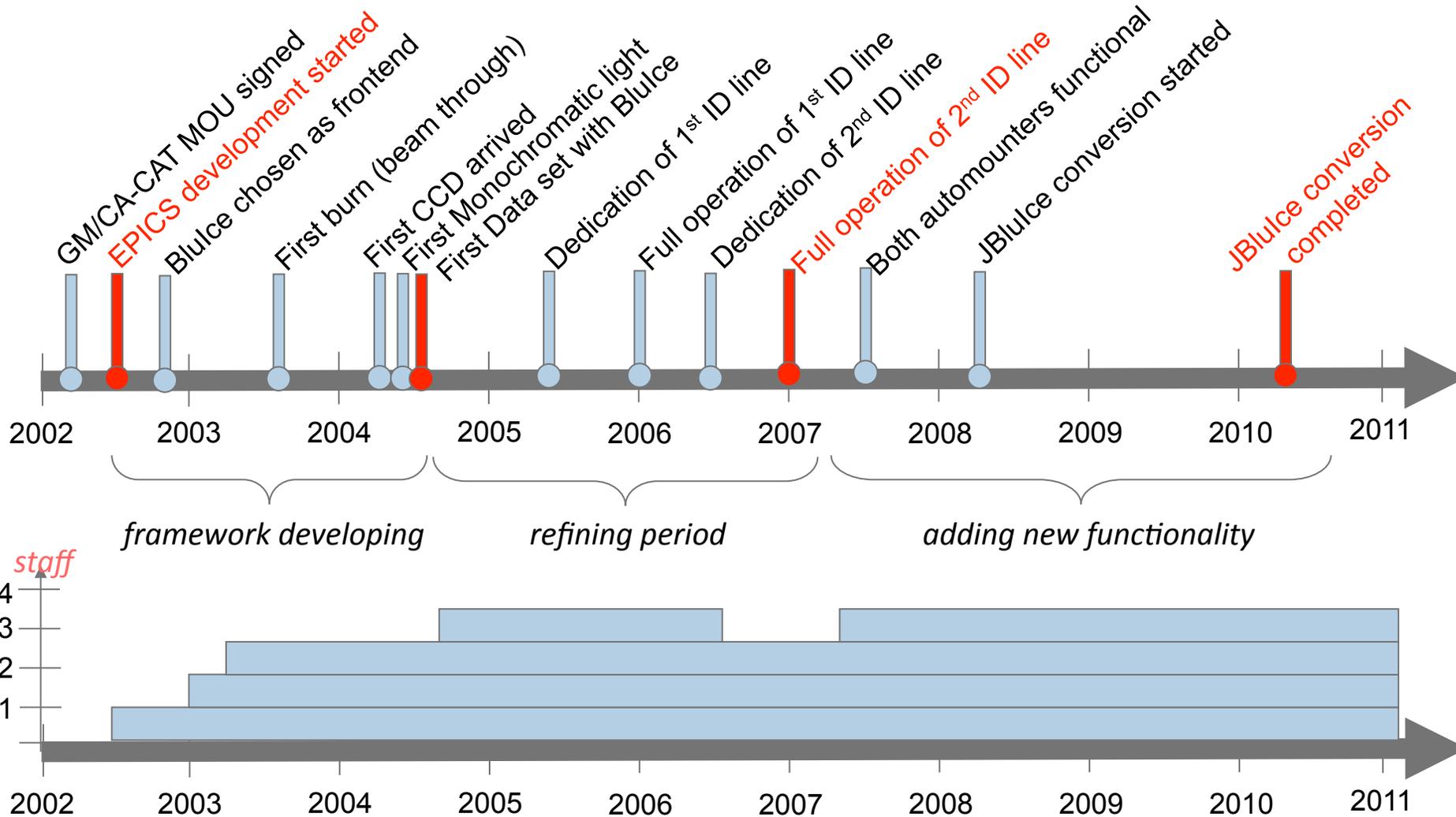


Initial choices

- Have both physicists and software developers in the controls team => 2+2
- Listen users what they want as an interface => Blulce
- Listen developers how to implement it best => EPICS
- Do not re-invent the wheel: make best use of what is available => Blulce & 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)

Phi: 0.000 deg
 Omega: 270.000 deg
 Kappa: 0.000 deg
 Distance: 500.000 mm
 Vertical: 0.000 mm
 Horizontal: 0.000 mm
 Attenuation: 0.0 %
 Energy: 16000.002 eV
 Beam Width: 0.120 mm
 Beam Height: 0.150 mm
 Beamstop: 40.005 mm

Resolution Predictor
 1.86 Å
 2.55 Å
 38.75 Å

09 Dec 2004 12:11:14 This client is now in control of the beam line.
 Idle Hutch: closed Abort Energy: 16000.002 eV Network: Active Shutter: open 01:01:11 PM

Run 1 (inactive)
 Prefix: test
 Directory: /data/actl
 Detector: 2-40mm x 150mm
 Distance: 400.991 mm
 Axis: Phi
 Delta: 1.00 deg
 Time: 1.00 s

Current Position
 Phi: 91.00 deg
 Omega: 270.00 deg
 Distance: 400.99 mm

Dose Control
 Enable
 Normalize
 Dose Factor: 1.01

Frame
 Start: 1 97.00 deg
 End: 90 167.00 deg

Wedge: 180.00 deg
 Energy: 7879.985 eV

Brightness: 2000 Zoom: 1.000
 File Name: /data/scott/microload/verload.ang

09 Dec 2004 11:37:50 Al_8 open
 Idle Hutch: open Abort Energy: 7879.985 eV Network: Passive Shutter: open 11:54:07 AM

Cassette: left: undefined
 Directory: /data/song/ Default
 Detector: hinned

Port ID	Protein	Comment
1 A1 c_A1	0	0
2 A2 c_A2	0	0
3 A3 c_A3	0	0
4 A4 c_A4	0	0
5 A5 c_A5	0	0
6 A6 c_A6	0	0
7 A7 c_A7	0	0
8 A8 c_A8	0	0
9 B1 c_B1	0	0
10 B2 c_B2	0	0
11 B3 c_B3	0	0
12 B4 c_B4	0	0

Screening Status: screening done
 Mount Next Crystal
 Loop Alignment
 Stop
 Collect Image
 Collect Image
 Stop

Screening Tasks
 c_A4 Mount Next Crystal
 c_A4 Loop Alignment
 c_A4 Stop
 c_A4 JPEG Snapshot
 c_A4 Collect Image
 c_A5 Mount Next Crystal
 c_A5 Loop Alignment
 c_A5 JPEG Snapshot
 c_A5 Collect Image
 c_A1 Mount Next Crystal
 c_A1 Loop Alignment
 c_A1 Stop
 c_A1 JPEG Snapshot
 c_A1 Collect Image
 c_A1 Dismount

09 Dec 2004 12:11:14 This client is now in control of the beam line.
 Idle Hutch: closed Abort Energy: 16000.002 eV Network: Active Shutter: open 01:04:00 PM

Scan Mode
 MAD Scan
 Excitation Scan

Select an X-ray Absorption Edge
 Edge: Se-K
 Energy: 12658.000 eV

Scan Parameters
 Prefix: MB-test-GuKa
 Directory: /data/csp/sr/micro
 Edge: Se-K
 Energy: 8041.565 eV
 Time: 30.000 s

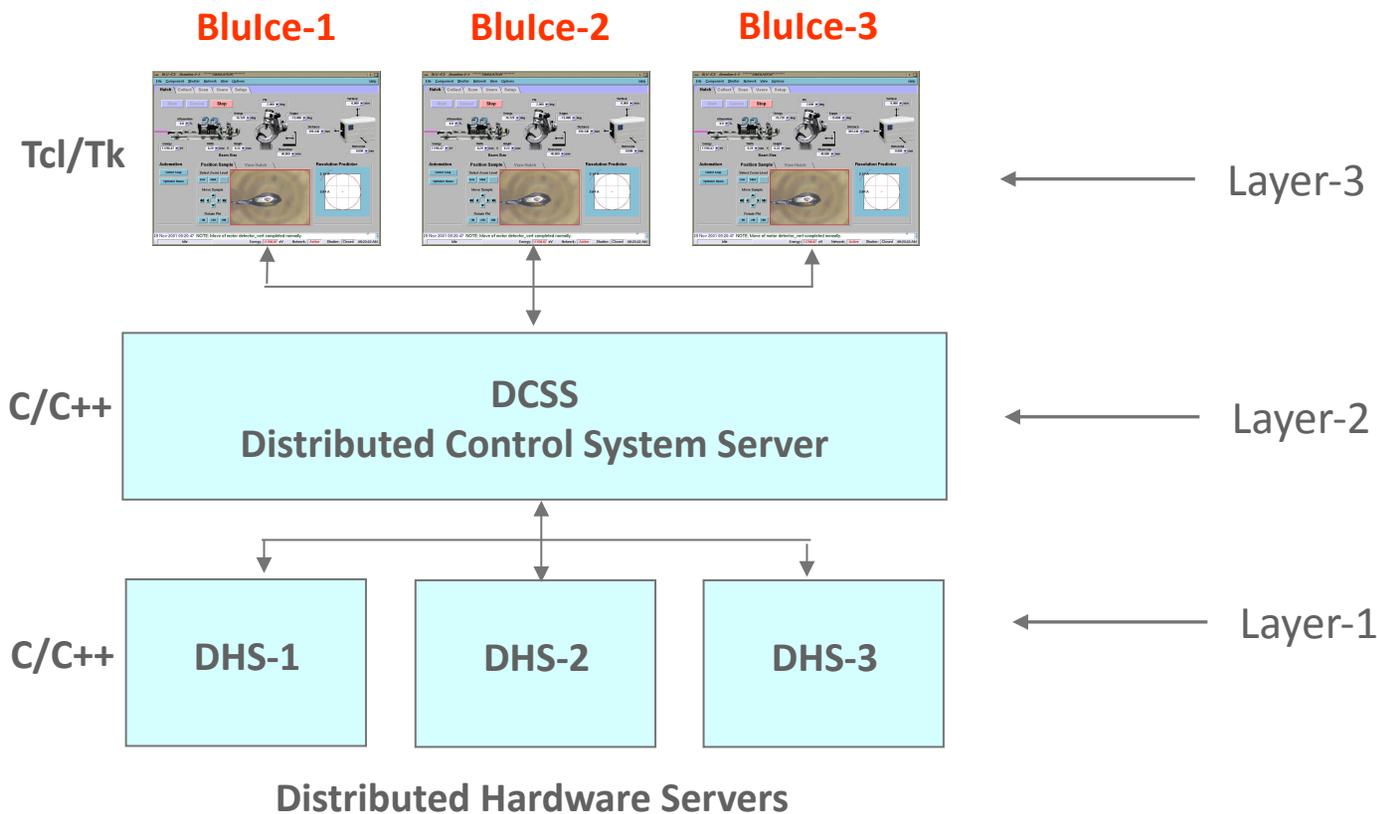
09 Dec 2004 11:37:50 Al_32 open
 Idle Hutch: open Abort Energy: 7879.985 eV Network: Active Shutter: open 11:57:40 AM

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



Reasons for picking Blulce

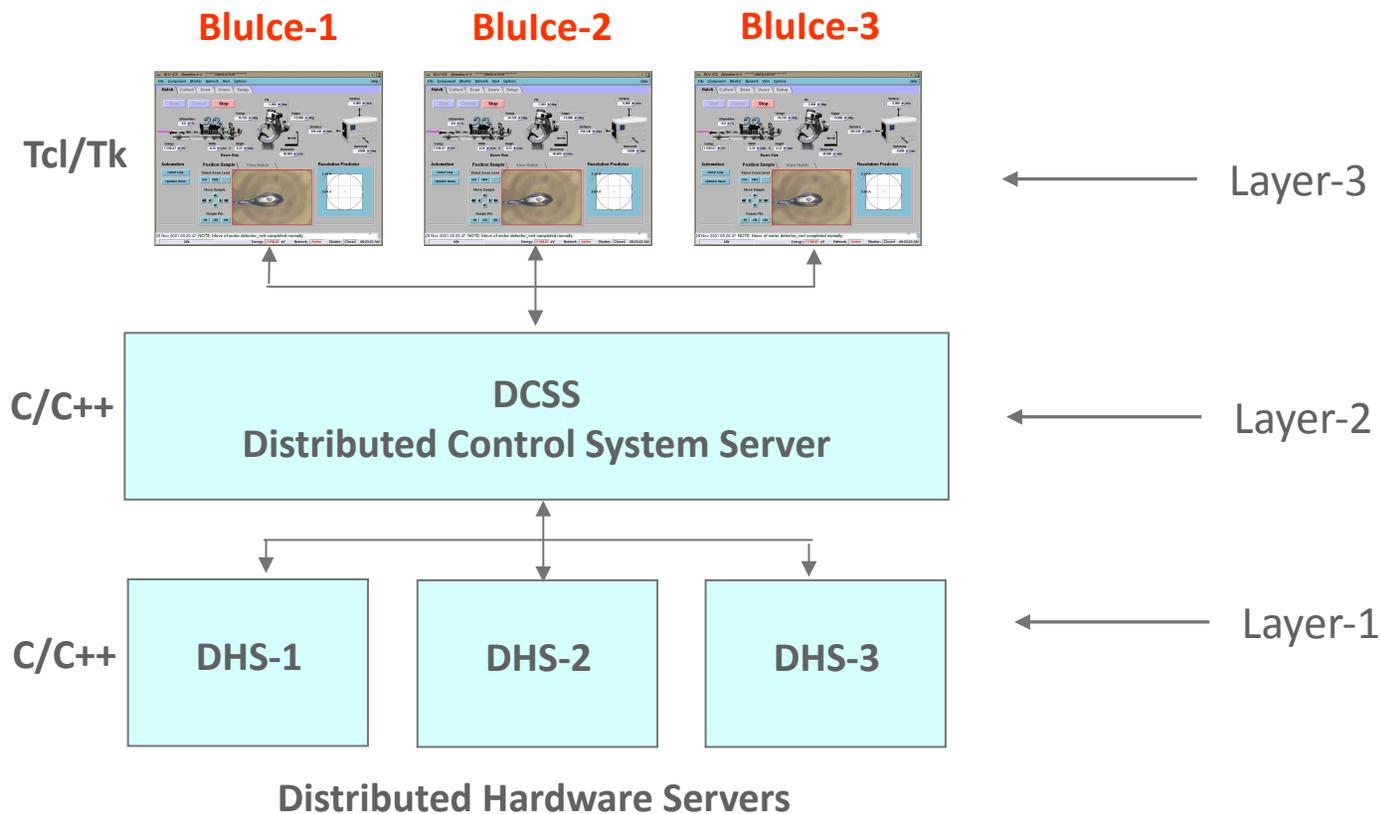
- Dedicated control system for MX crystallography, used at 7 SSRL beamlines
- Well thought tabbed interface: Hutch, Collect, Scan, Screen, and etc.
- One GUI instance is a master at a time (allowed to control the hardware)
- Preferred by users





Why not using Blulce as a sole base?

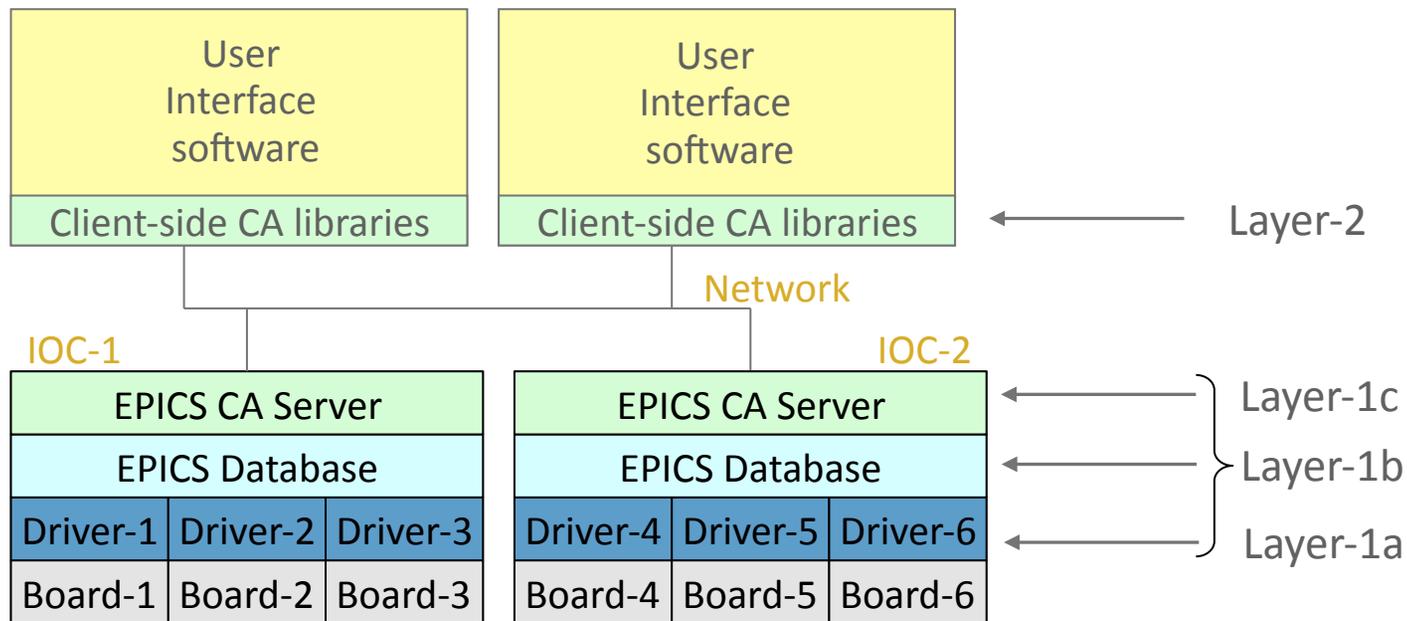
- Very small selection of drivers
- DCSS makes programming easier, but masks advanced hardware access
- DCSS is a single master: not designed to monitor if others can change hardware states
- Use of Tcl/Tk for graphical interface: bad debugging tools, shortage of libraries





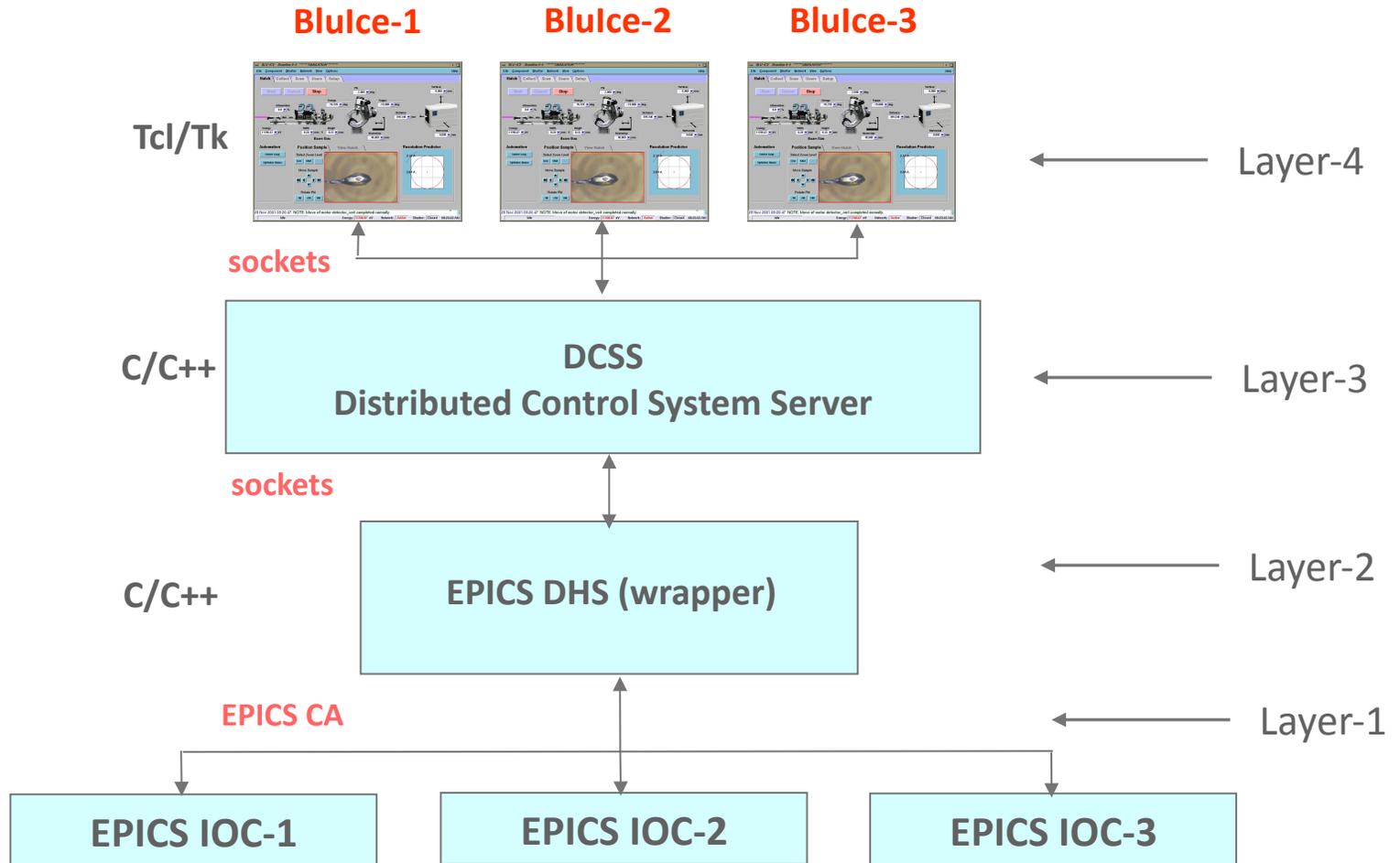
Why EPICS?

- 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)**



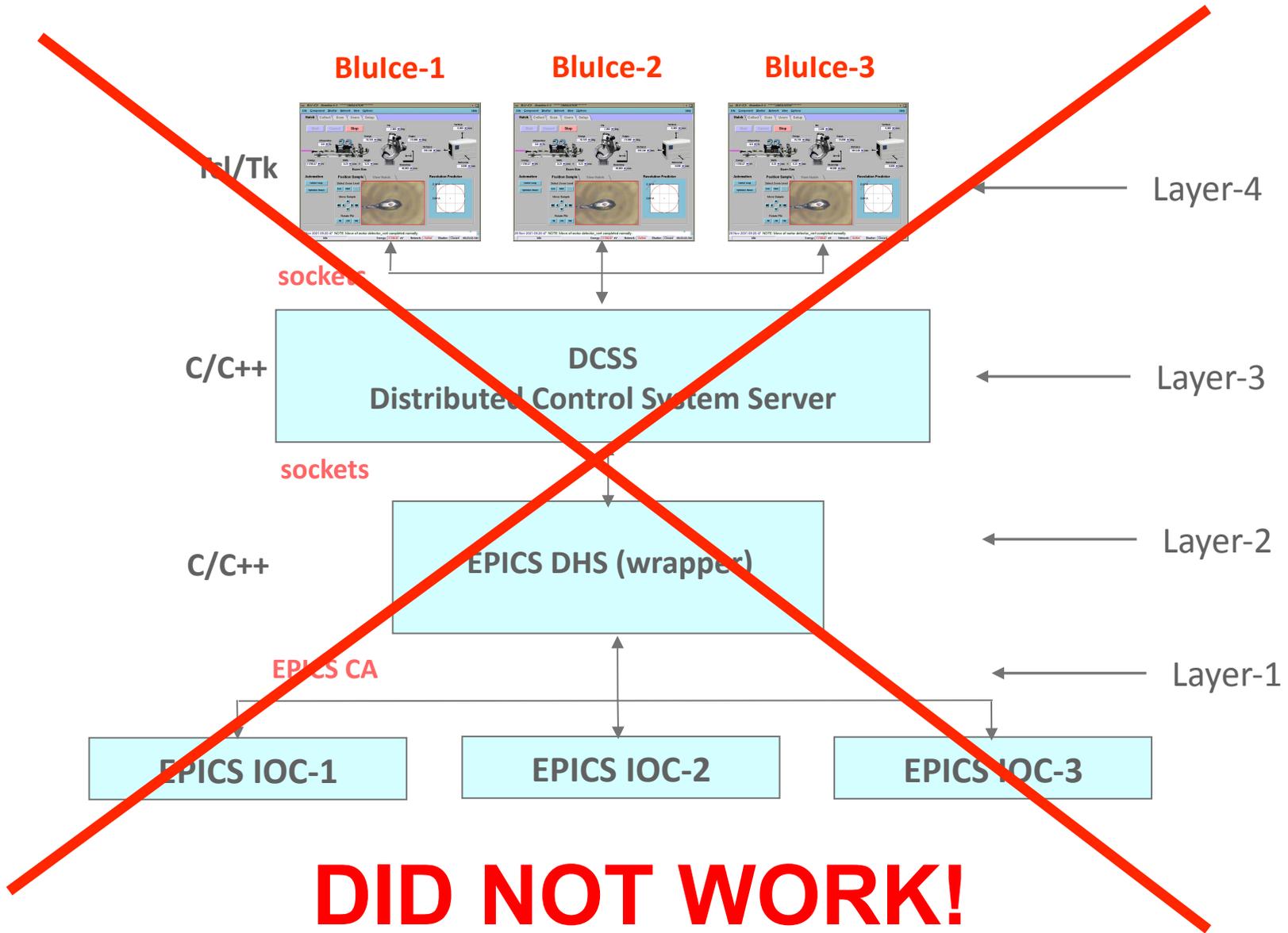


Choice of Blulce-EPICS interface: initial attempts





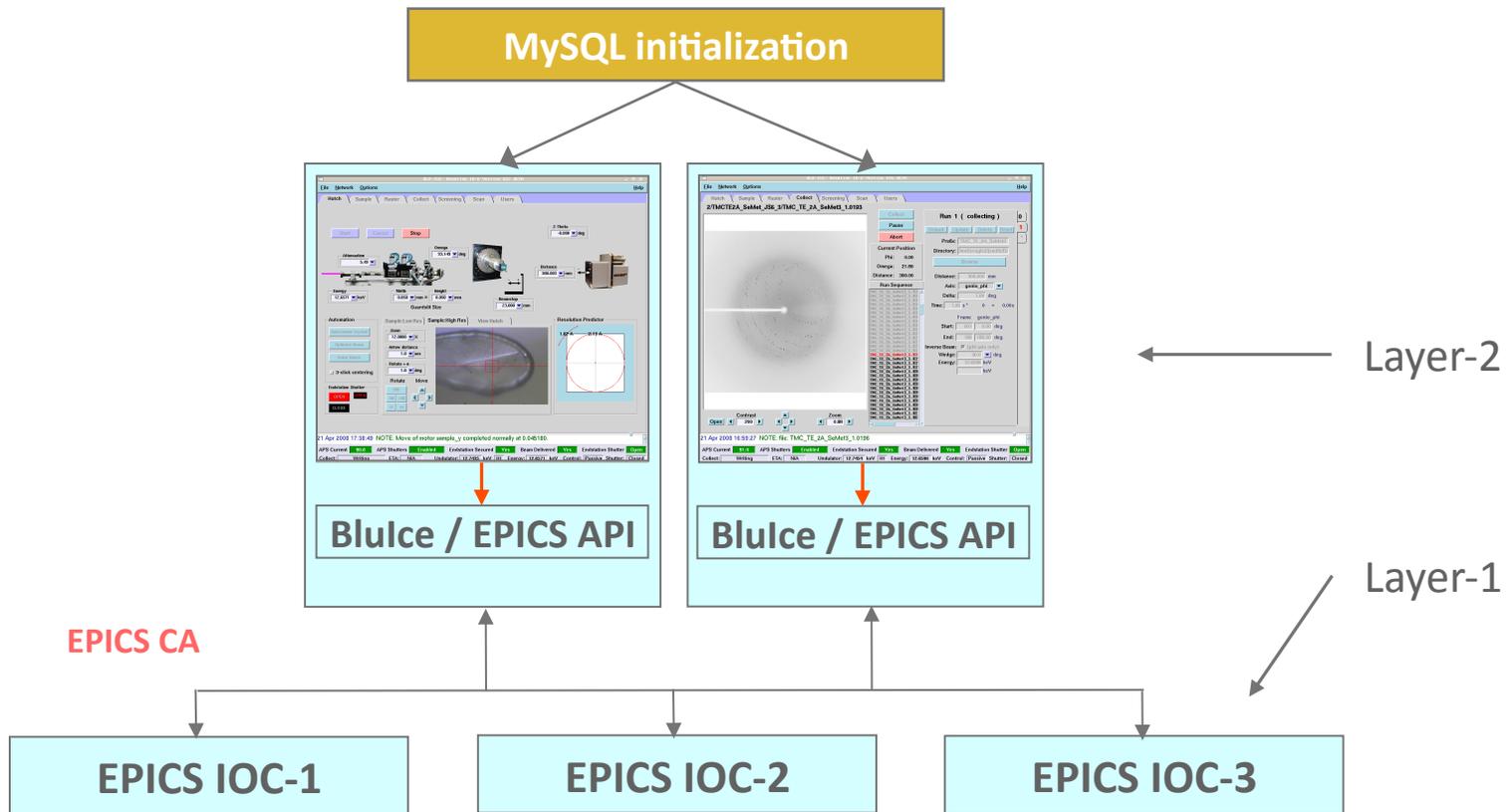
Choice of Blulce-EPICS interface: initial attempts





Choice of Blulce-EPICS interface: chasing speed

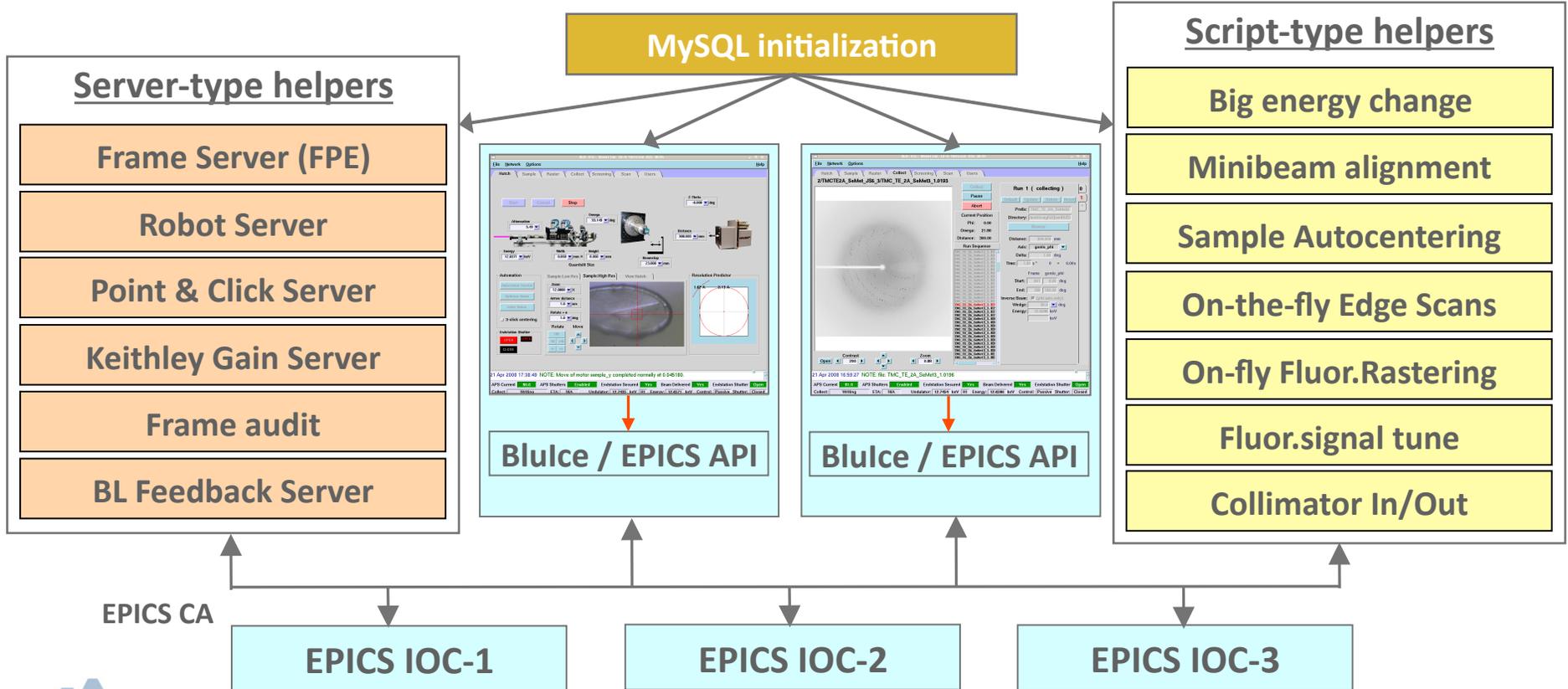
- Keep Blulce GUI, but convert them into standard EPICS clients like MEDM
- Communication between GUI instances via EPICS DB using callback mechanism
- Initialization via MySQL
- Less layers than in Blulce, but **heavy GUI**





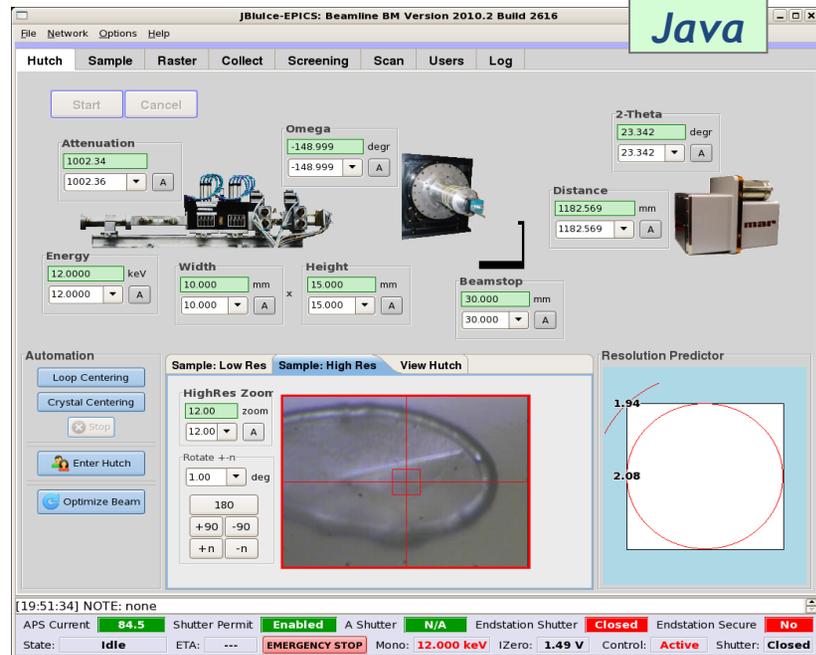
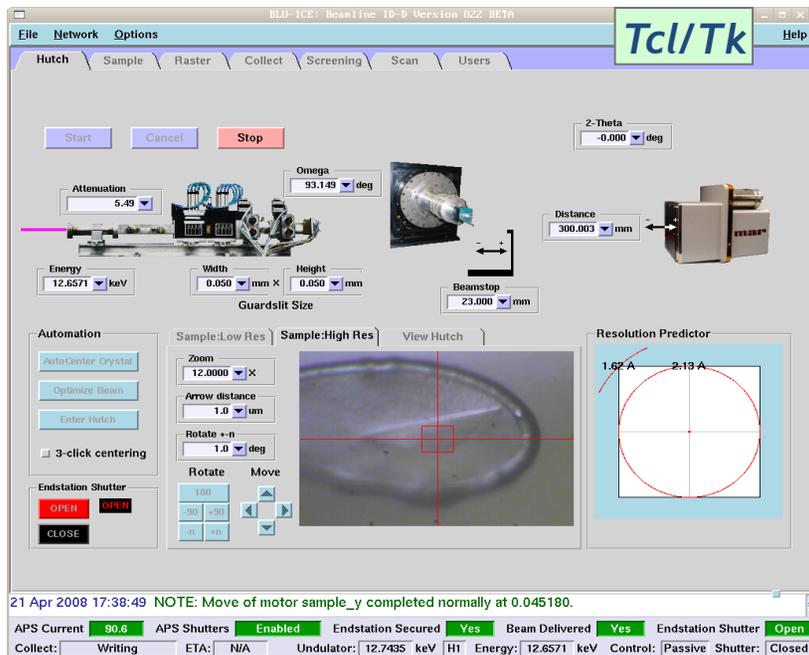
Choice of Blulce-EPICS interface: helpers

- Keep Blulce 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 Blulce, 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 JBlulce 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)



JBlulce-EPICS as of today: core tabs

Hutch

19:51:34] NOTE: none
 APS Current: 84.5 Shutter Permit: Enabled A Shutter: N/A Endstation Shutter: Closed Endstation Secure: No
 State: Idle ETA: --- EMERGENCY STOP Mono: 12.000 keV IZero: 1.49 V Control: Active Shutter: Closed

Sample

19:36:19] NOTE: [collimatorCtrl.pl
 APS Current: 102.4 Shutter Permit: Enabled A Shutter: Open Endstation Shutter: Open Endstation Secure: Yes
 State: Idle ETA: --- EMERGENCY STOP Mono: 12.700 keV IZero: 0.04 V Control: Active Shutter: Closed

Raster

Status	X	Y	Frame	Row	Col	Spot Total	In-Resolution Total
DONE	75.0	-105.0	1	1	3	29	24
PROCESSING	0.0	-105.0	2	1	2		
WRITING	-75.0	-105.0	3	1	1		
MOVING	75.0	-105.0	4	2	3		
	0.0	-70.0	5	2	2		
	-75.0	-70.0	6	2	1		
	75.0	-35.0	7	3	3		

19:26:15] NOTE: moveMotor(sample_y, 0.13935597787325577)
 APS Current: 101.8 Shutter Permit: Enabled A Shutter: Open Endstation Shutter: Open Endstation Secure: Yes
 State: Rastering ETA: --- EMERGENCY STOP Mono: 12.700 keV IZero: 0.02 V Control: Active Shutter: Closed

Collect

Filename	Ani
test_1.0001	14
test_1.0002	15
test_1.0003	16
test_1.0004	17
test_1.0005	18
test_1.0006	19
test_1.0007	20
test_1.0008	21
test_1.0009	22
test_1.0010	23
test_1.0011	24
test_1.0012	25
test_1.0013	26
test_1.0014	27

16:23:02] NOTE: moveMotor(gonio_omega, 78.0)
 APS Current: 131.7 Shutter Permit: Disabled A Shutter: Closed Endstation Shutter: Closed Endstation Secure: No
 State: Idle ETA: --- EMERGENCY STOP Mono: 14.500 keV IZero: 0.02 V Control: Active Shutter: Closed

Screening

Select	Next->	Port	CrystalID	Directory	Comment	Resolution	Sec
1	F1	F1	F1				
2	F2	F2	F2				
3	F3	F3	F3				
4	F4	F4	F4				
5	F5	F5	F5				
	F6	F6	F6				
	F7	F7	F7				
	F8	F8	F8				

12:01:17] NOTE: Got click 232 177
 APS Current: 84.3 Shutter Permit: Enabled A Shutter: N/A Endstation Shutter: Closed Endstation Secure: No
 State: Idle ETA: --- EMERGENCY STOP Mono: 12.000 keV IZero: 1.74 V Control: Active Shutter: Closed

Scan

Defaults	ROI Low	ROI High	Inflection	Peak	Remote
	10872.40	11572.40	13858.08	12608.56	13058.56

12:01:17] NOTE: Got click 232 177
 APS Current: 84.2 Shutter Permit: Enabled A Shutter: N/A Endstation Shutter: Closed Endstation Secure: No
 State: Idle ETA: --- EMERGENCY STOP Mono: 12.000 keV IZero: 3.87 V Control: Active Shutter: Closed



Conclusions and plans

Worked best:

- ✓ Sticking to user-preferred interface (Blulce) 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
- ✓ JBlulce 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 Blulce and EPICS
- ❖ listening users on how to implement features they wanted

Future plans:

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





Acknowledgements

Former members of GM/CA CAT Controls:

- *Satish Devarapalli*
- *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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Presentation for NOBUGS, October 12, 2010





APPENDIX-1: JBlulce-EPICS source code and manuals

The source code of JBlulce-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/jblulce-epics.html>

JBlulce-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.

JBlulce 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

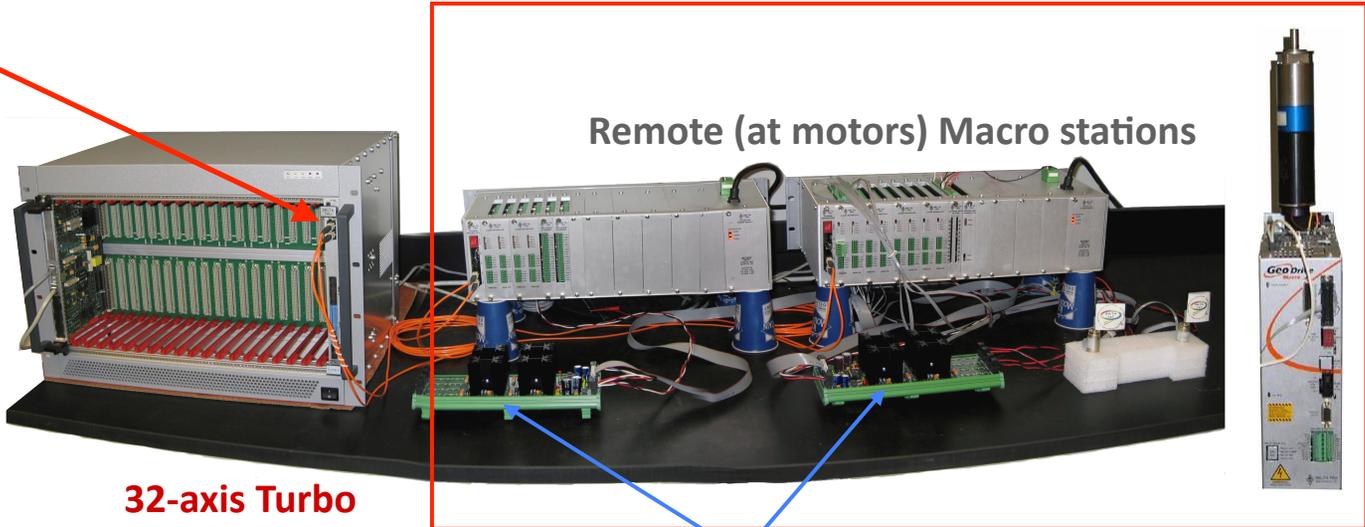
Works with virtually all types of motors: uniform controls

Distributed control (fiber ring): shorter cables, less noise

On-the-fly motion synchronization of motor assemblies

Custom motion programs

Analog & Digital IO



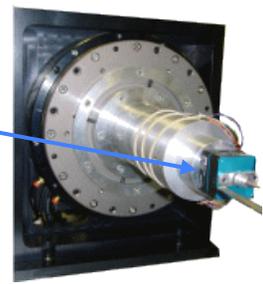
32-axis Turbo PMAC2-VME UltraLite motion controller

Remote (at motors) Macro stations

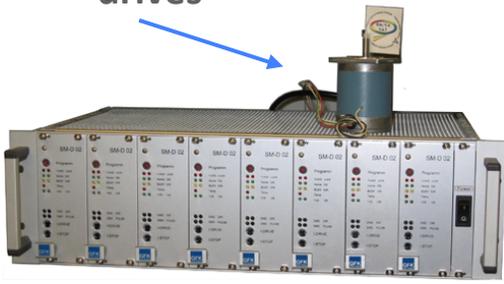
Servo motor amplifiers

Geo-Drive (all in one)

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: Blulce developments

- Initial development: converting Blulce 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

