... for a brighter future

A U.S. Department of Energy laboratory
managed by The University of Chicago

Eclipse, Java, Scientific Software, Etc.

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Presented at the European Synchrotron Radiation Facility ESRF

May 3, 2007

Grenoble, France

Outline

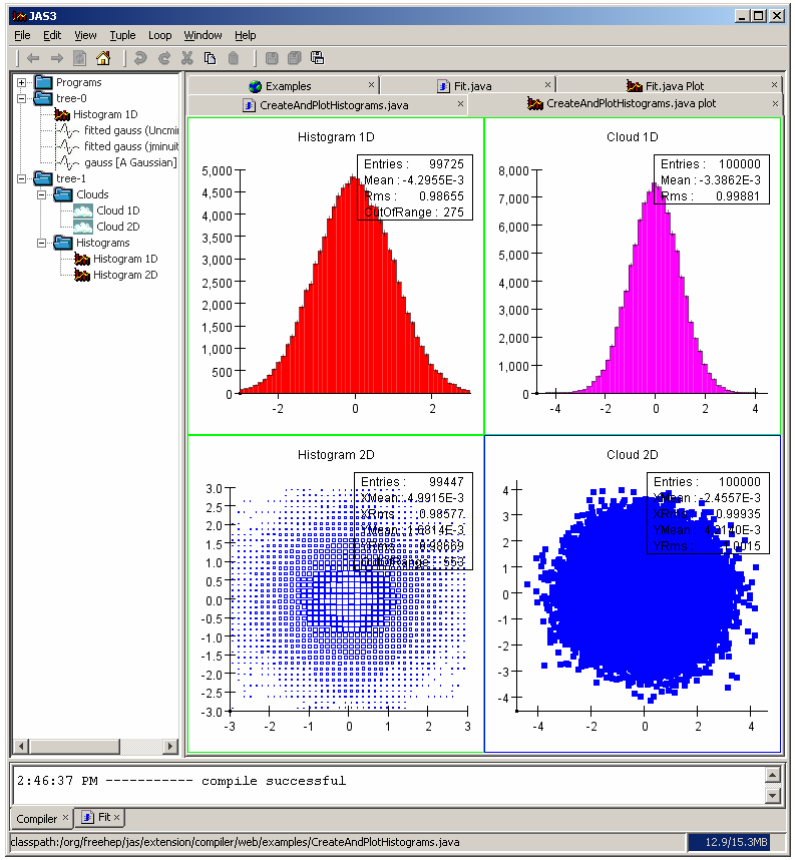
- Scientific Software and Examples
- Java
- Eclipse and Examples
- Eclipse RCP Applications
- AWT and SWT
- X-Ray Software Development at the APS

Scientific Software

- The language of choice used to be FORTRAN
  - There are still many legacy FORTRAN codes in use
- C and C++ have become popular
  - Grid computing now tends to be done in C
- Many scientists use Python
  - Reasonably powerful, yet easy to use
  - Allows them to do science rather than software
- There are now a number of significant scientific projects using Java
  - Many started out as C, but have evolved to Java
- Java is now an acceptable, if not the preferred, language for scientific software development

Java Analysis Studio (JAS3)

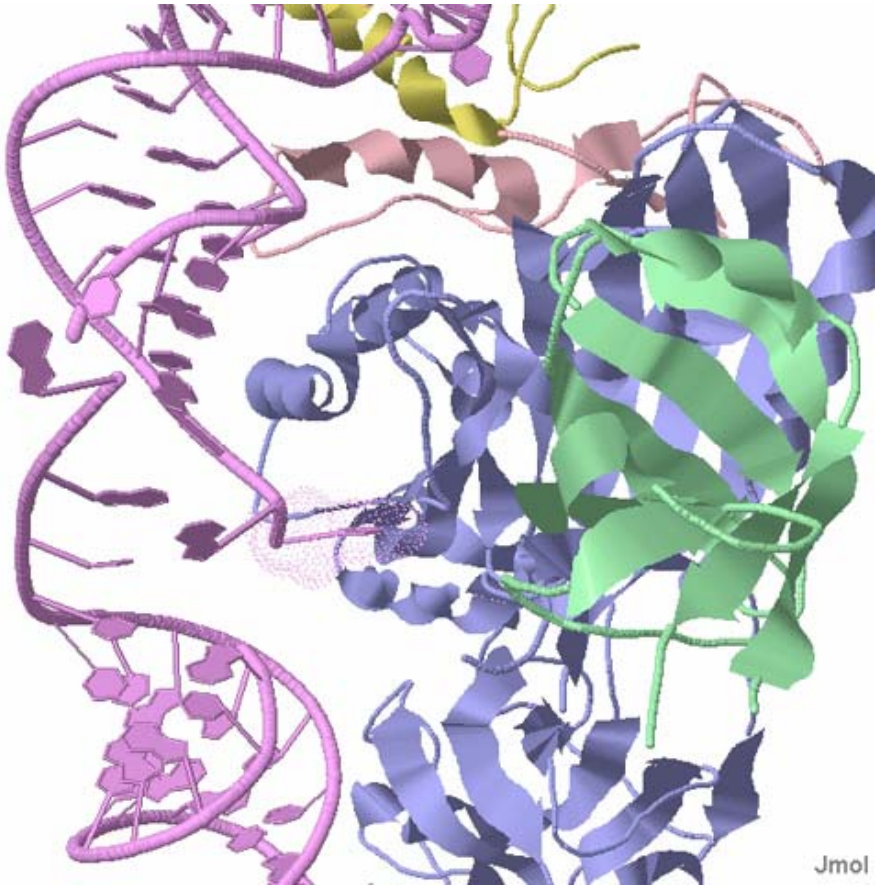
- Developed by and for the High-Energy physics community
- Plotting of 1d, 2d, 3d Histograms, XY plots, Scatter plots, *etc*.
- Open source
- Attractive plotting
- Fitting, other mathematical analysis
  - Primarily from CERN
- Highly modular structure
  - Uses plug-ins



JMol – Molecular Viewer

- Commonly used as an applet that can be integrated into web pages to display molecules in a variety of ways
- Also has a standalone application and a development tool kit that can be integrated into other Java applications
- Interactive, 3D
- Free, Open Source

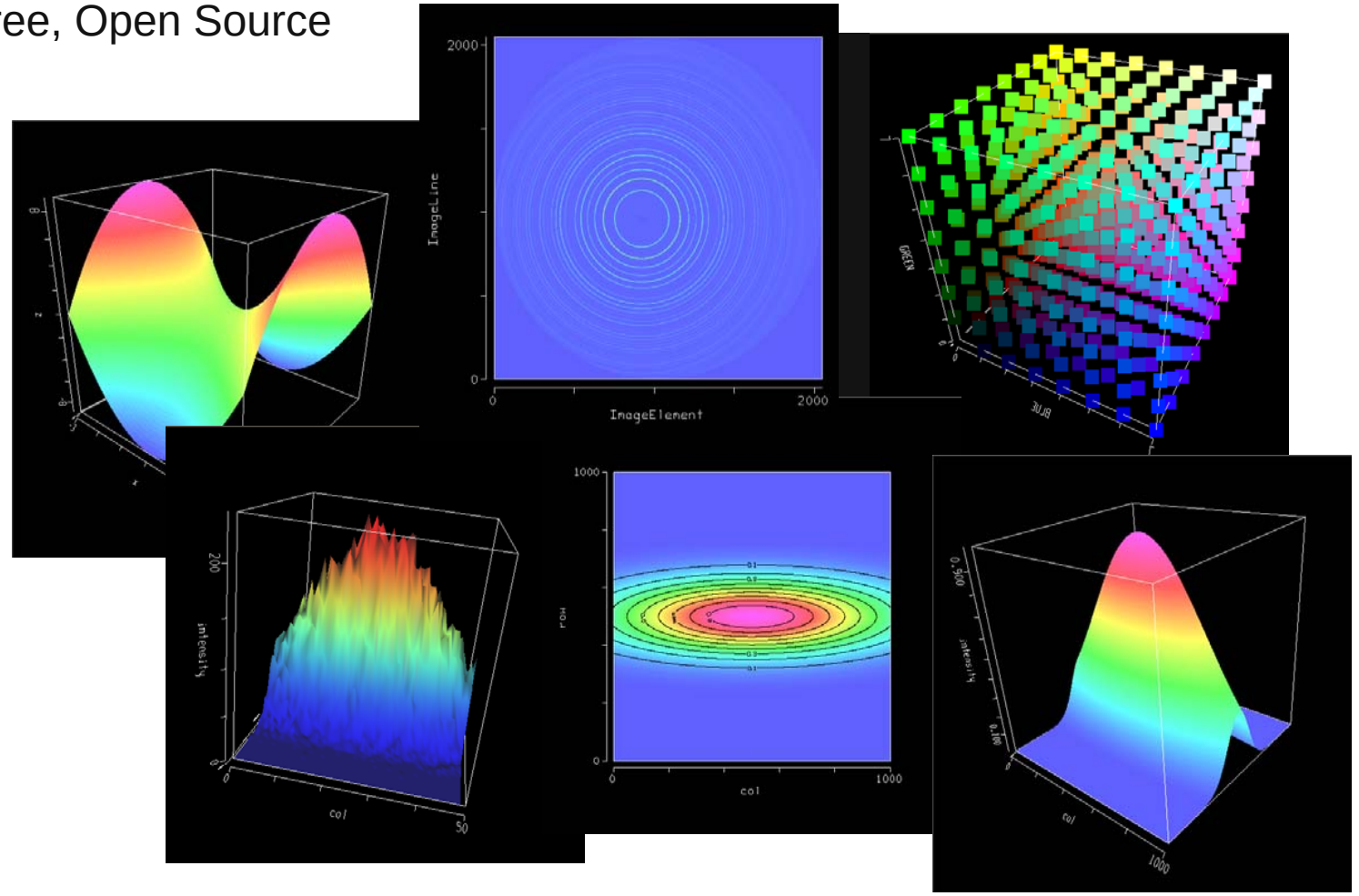
- One of several Java Molecular Graphics packages



Crystal structure of an H/ACA box RNP from Pyrococcus furiosus (PDB CODE: 2HVY)

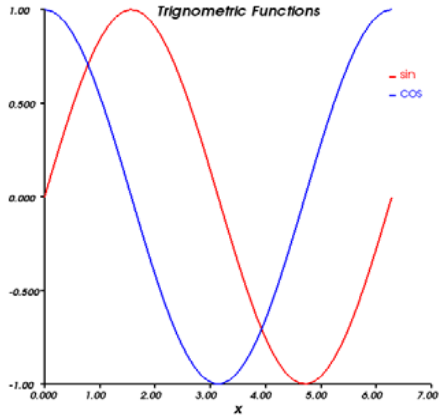
VisAD

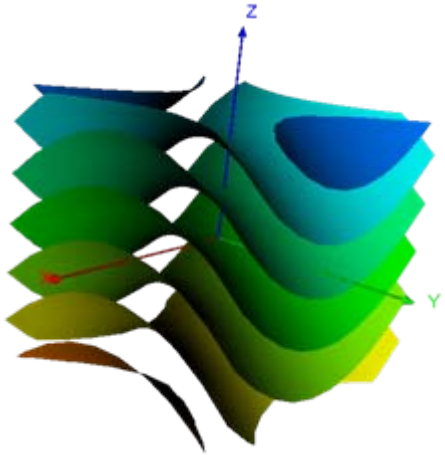
- Space Sciences and Engineering Center (SSEC) and others
- Extensive 2D and 3D visualization package
- Free, Open Source

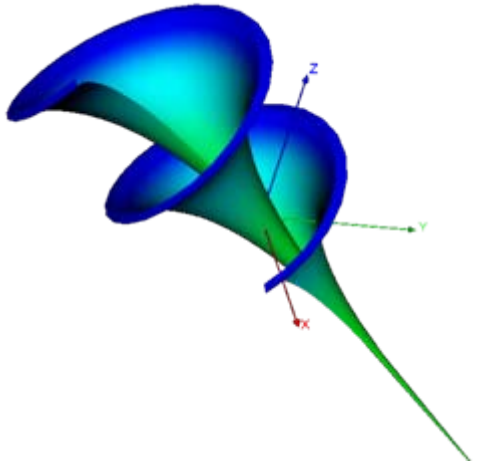


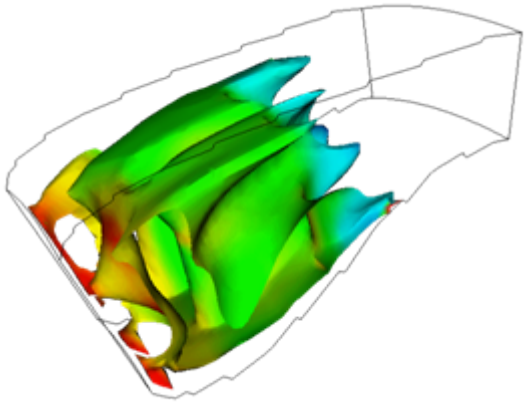
VTK

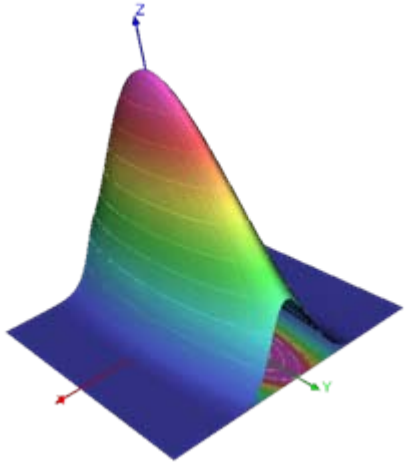
- Software system for 3D computer graphics, image processing, and visualization
- Used by thousands of researchers and developers around the world
- Written in C++
- Has Java wrappers
  - Also, Tcl/Tk, Python
- Free, Open Source





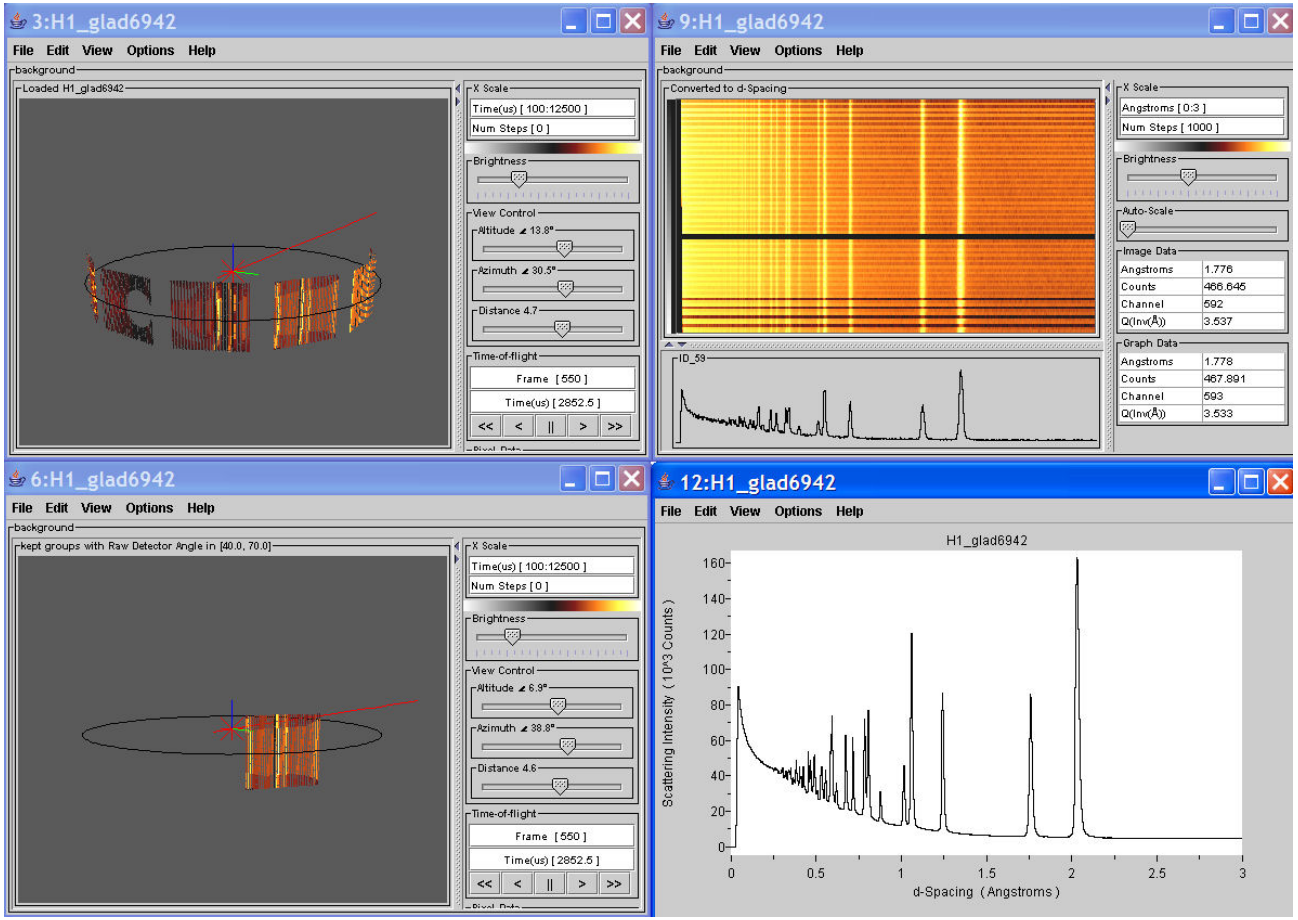






ISAW

- The primary tool for analyzing neutron scattering data at the IPNS
- Has an extensive and sophisticated interface



From: John Hammonds, IPNS

Java ?

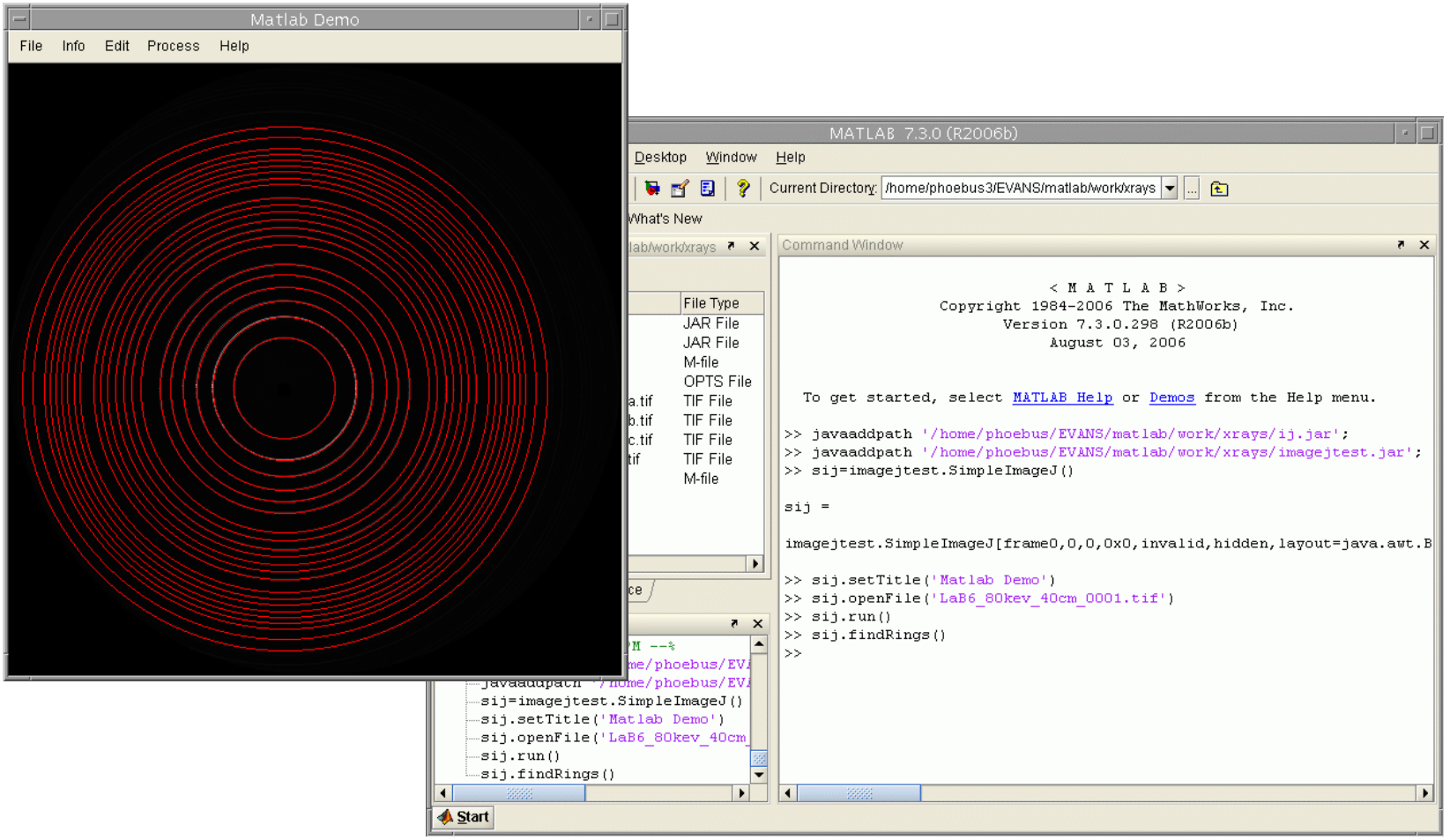
- Java has become a major language
- The reason is that most commercial development uses J2EE
  - There is money to be made improving Java and its tools
- Applications have performance approaching applications written in C
- There is already extensive scientific development in Java
- In my opinion, there is no other viable choice for high-quality, cross-platform, GUI development
  - Huge API
  - Write once, run anywhere
  - Easy to code (compared to C or C++, anyway)
  - Good performance
  - Excellent development tools

Java Development Tools

- Spell checks as you go
  - No “write – compile – load – run – figure out what happened” cycle
  - Probably the one most significant productivity enhancement
- Provides content assist
  - Probably the next most significant productivity enhancement
- Compiles as you write
  - Cycle is now “write – run”
- Massive refactoring
  - e.g. Change a variable name in all your files in all your projects
- Wizards and Tools to help at every stage
  - e.g. Generate getters and setters for all your properties
  - e.g. Add and/or clean up imports
- The above are just a small sample
  - Some of these are available for other languages
  - But usually not at the level they are for Java

Java in Matlab

- Matlab has extensive support for Java
  - Your favorite software framework can also be used in Matlab



Eclipse

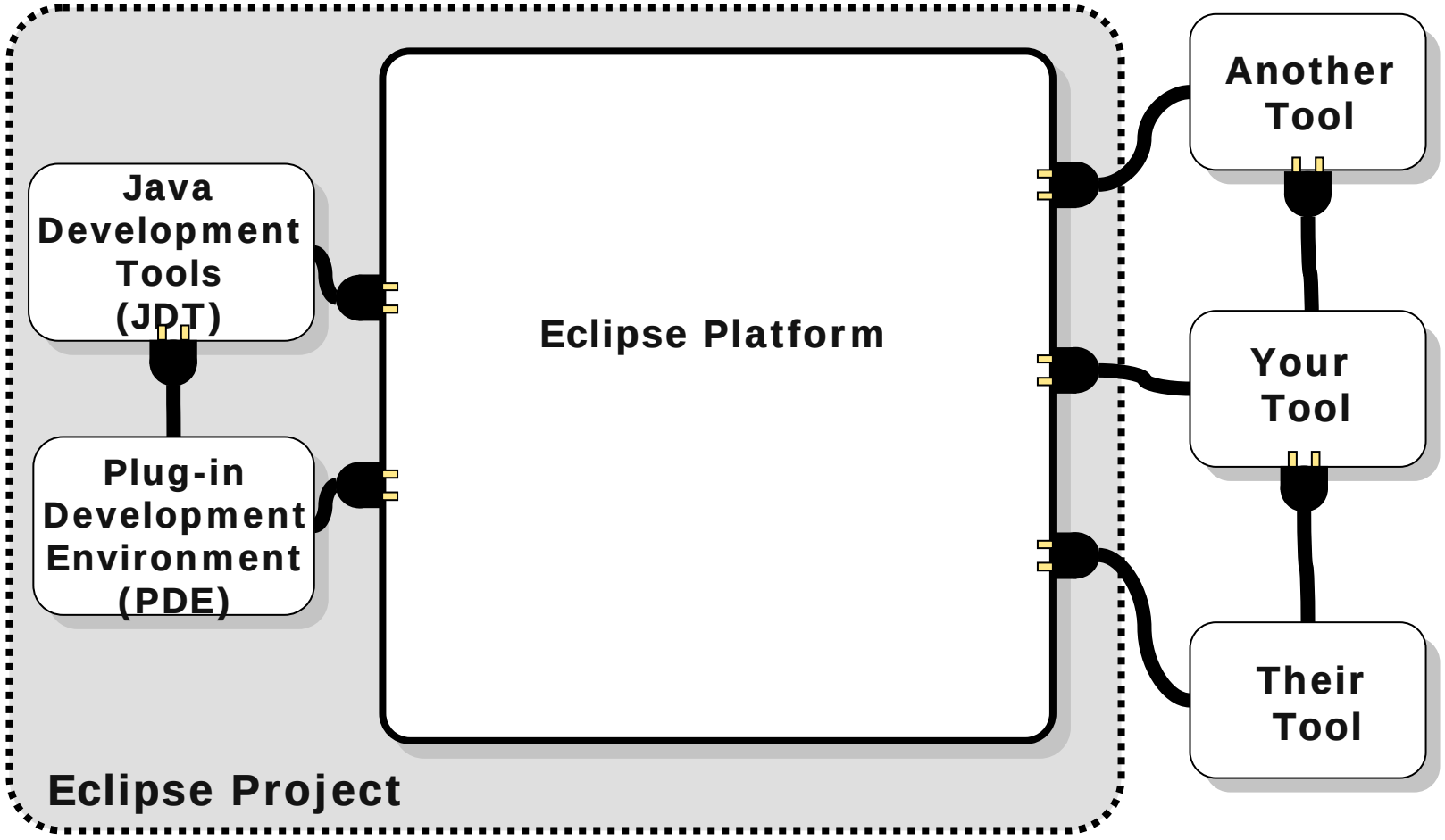
- Eclipse is an Open Source community
- It was started in 2001 by IBM
  - IBM donated a lot of research
  - Controlled the early development, but later relinquished control
- It is now controlled by the Eclipse Foundation
  - Strategic members contribute up to $500K and 8 developers
  - Currently 17 strategic members
  - Currently more than 150 developers

- Out of the box it looks like a Java IDE (Integrated Development Environment)
- It is really a Plug-in manager
  - That happens to come with Java Development plug-ins
  - You can make it be most anything you want

Eclipse Consortium Strategic Members

* Strategic Consumer

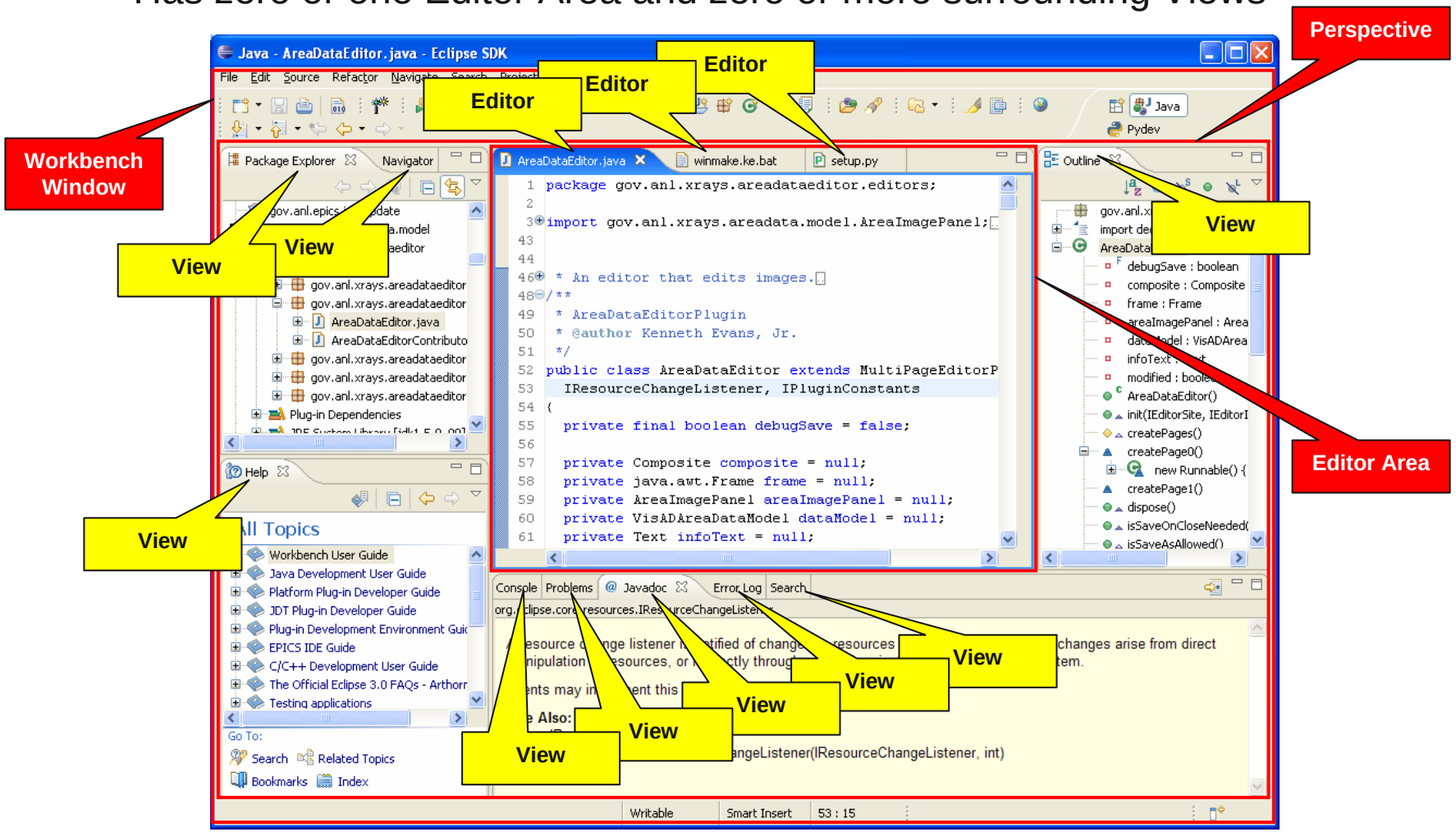
Eclipse is Very Extensible and Very Flexible



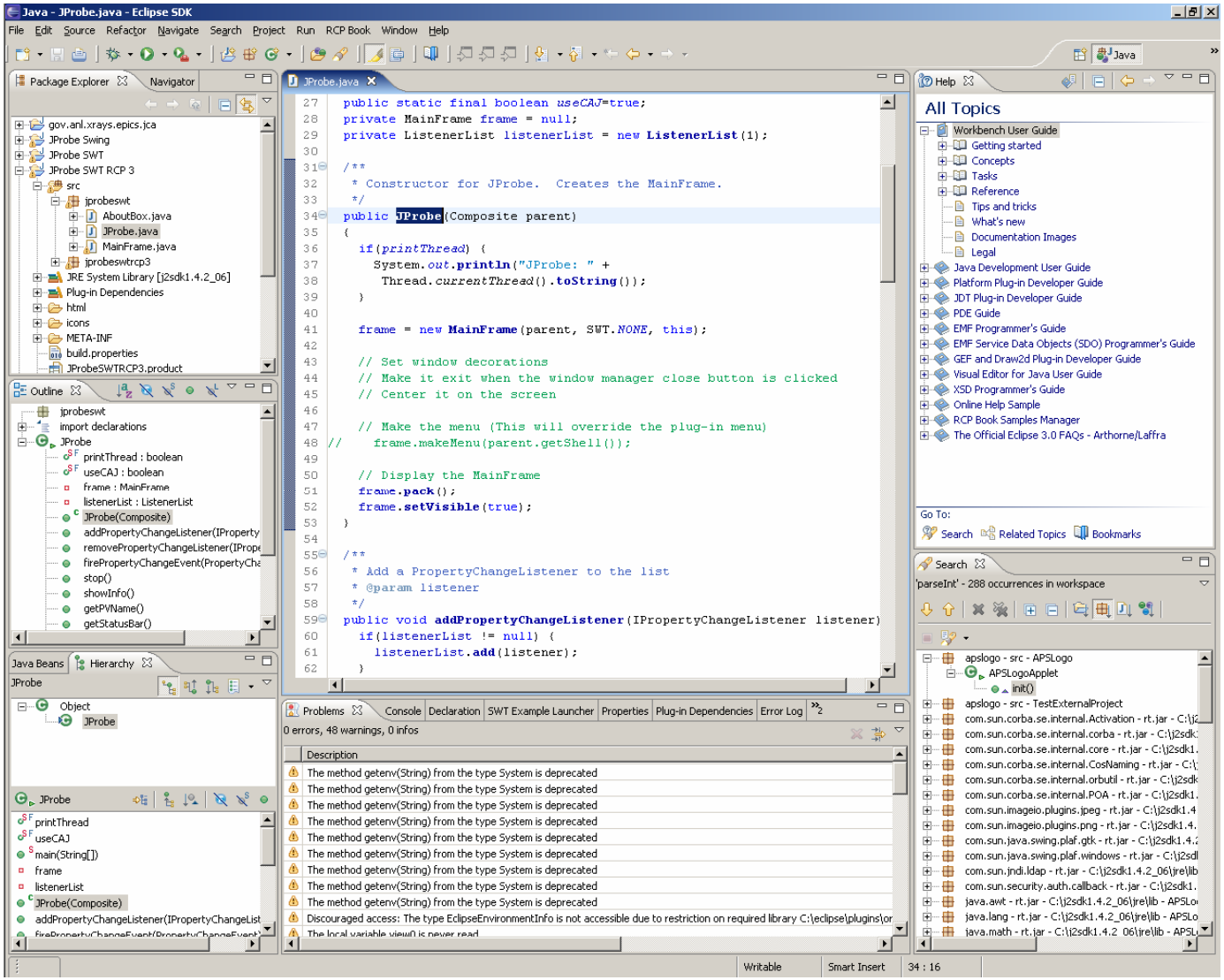
Modified From: Tony Lam, ICALEPCS Presentation, October 2005

Eclipse Layout Fundamentals

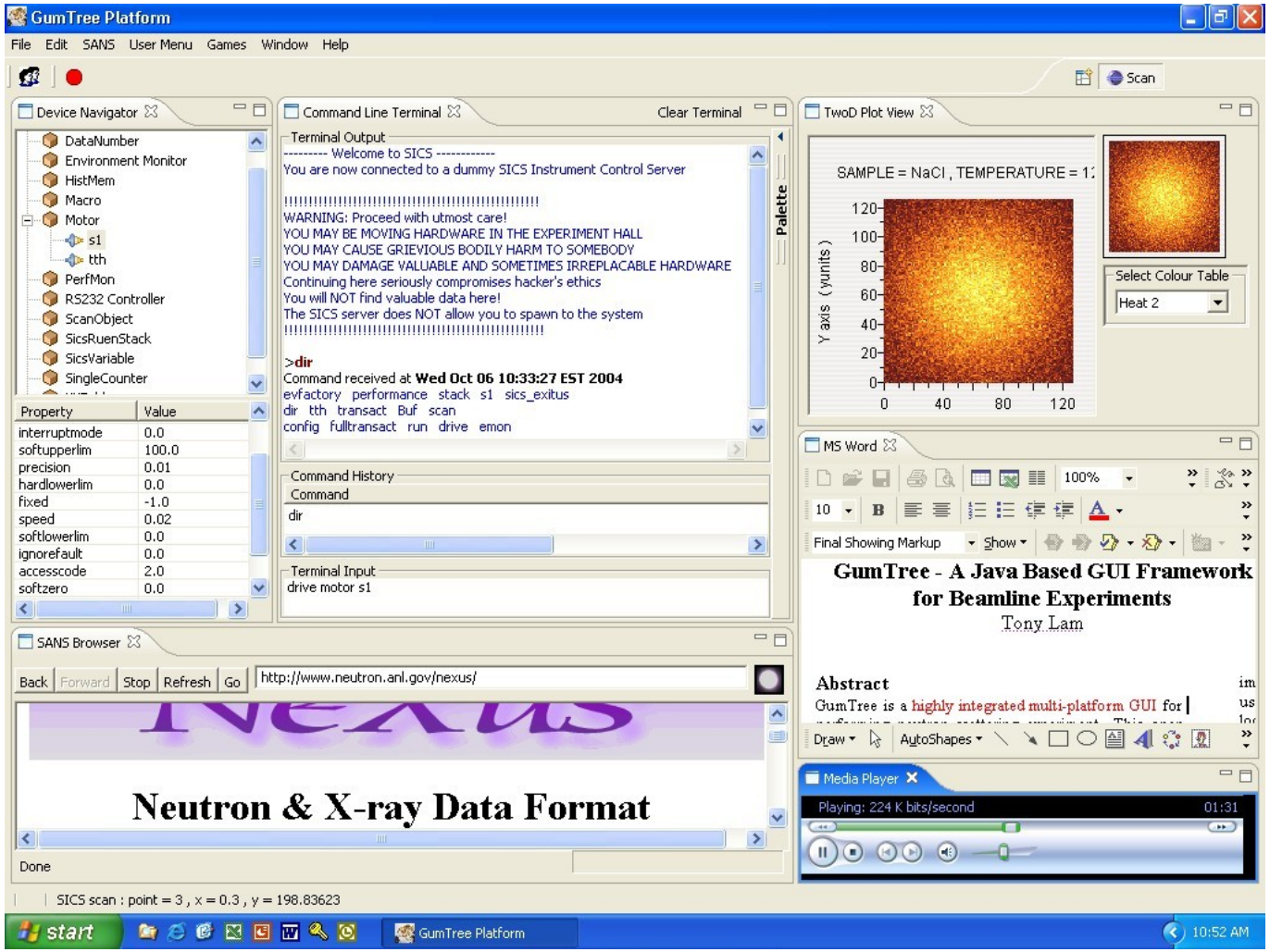
- Perspective: A particular layout of a Workbench window
  - Has zero or one Editor Area and zero or more surrounding Views



Eclipse as a Java IDE

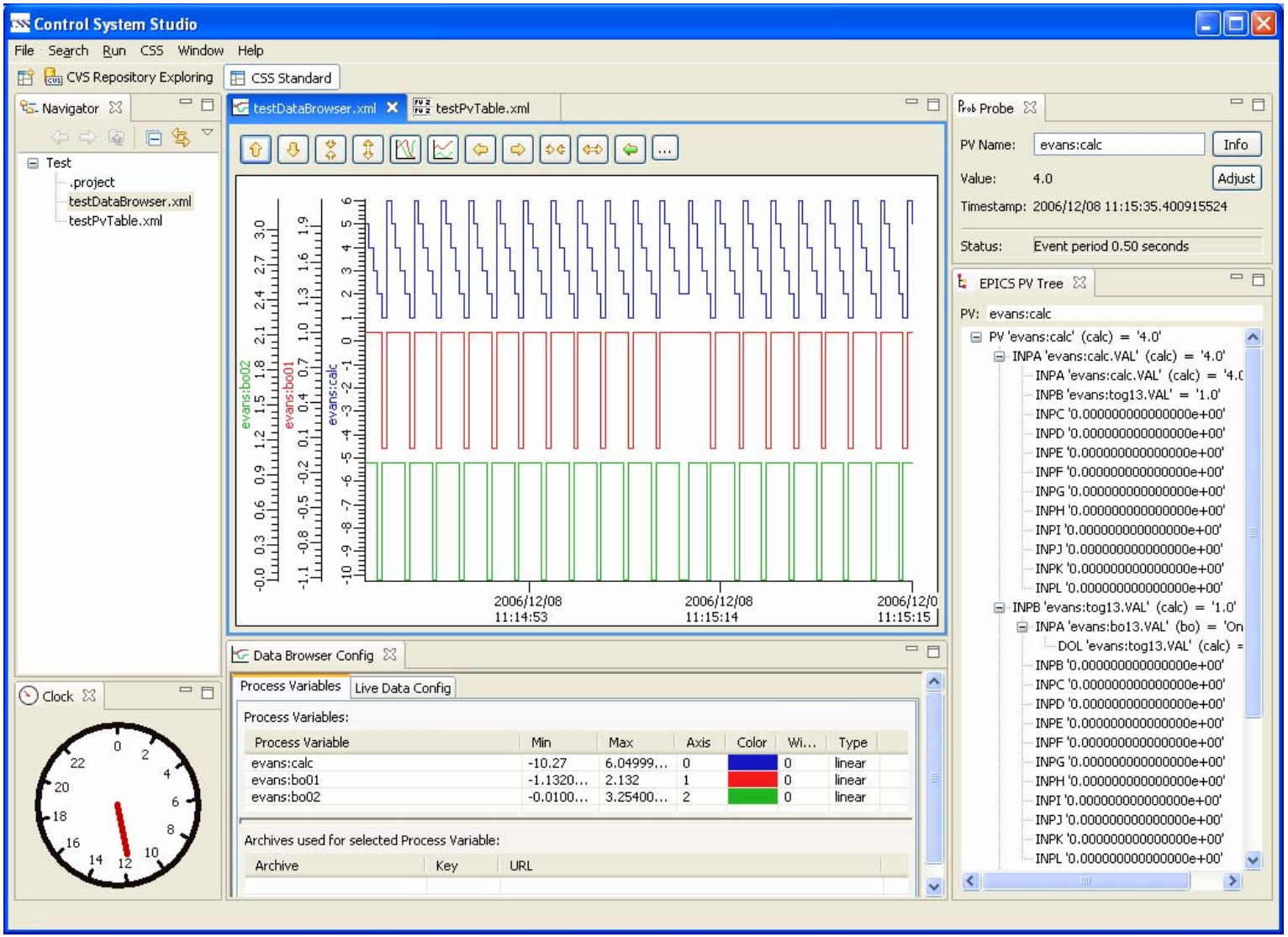


GumTree (ANSTO)

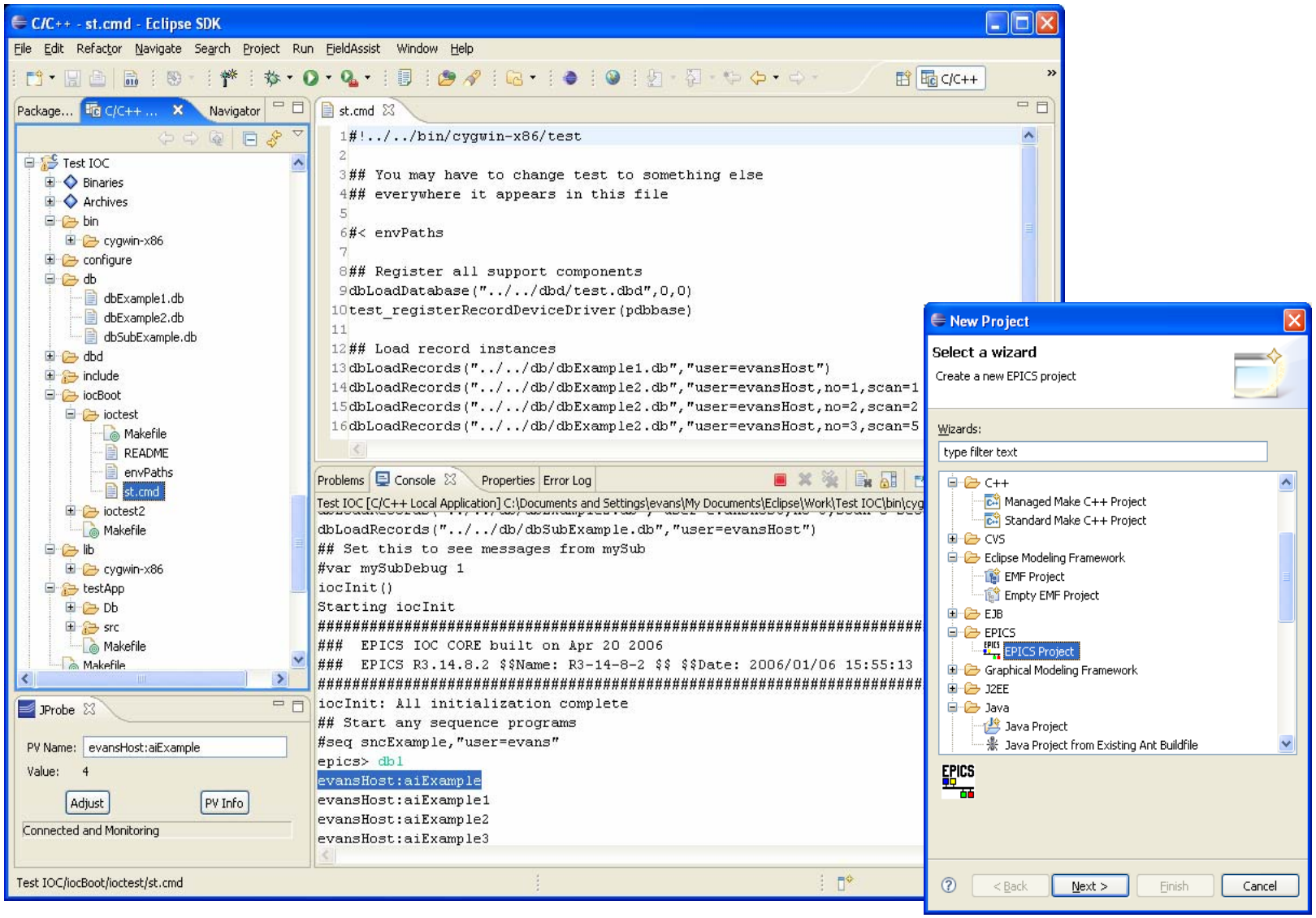


From: Tony Lam, ICALEPCS Presentation, October 2005

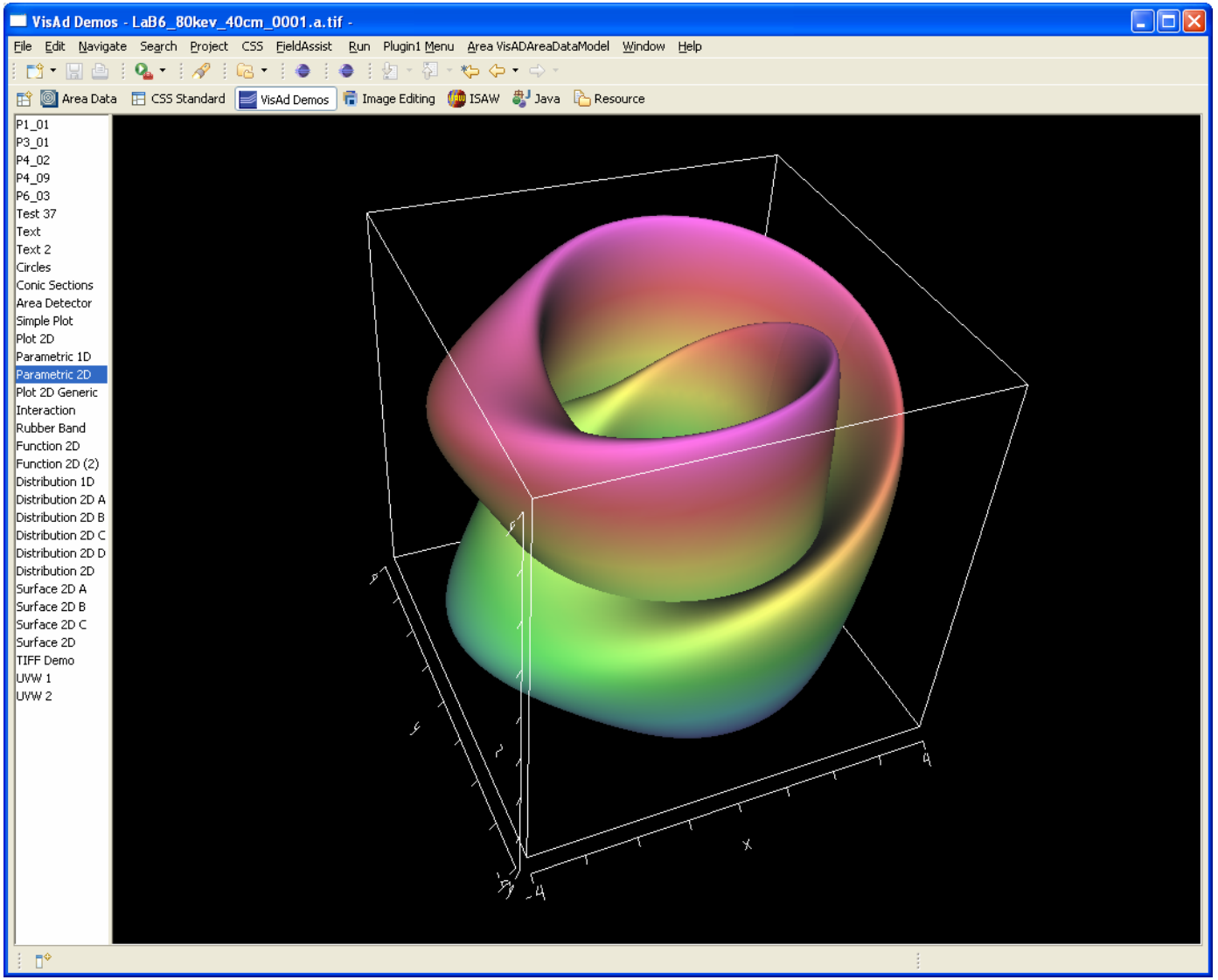
EPICS Control System Studio



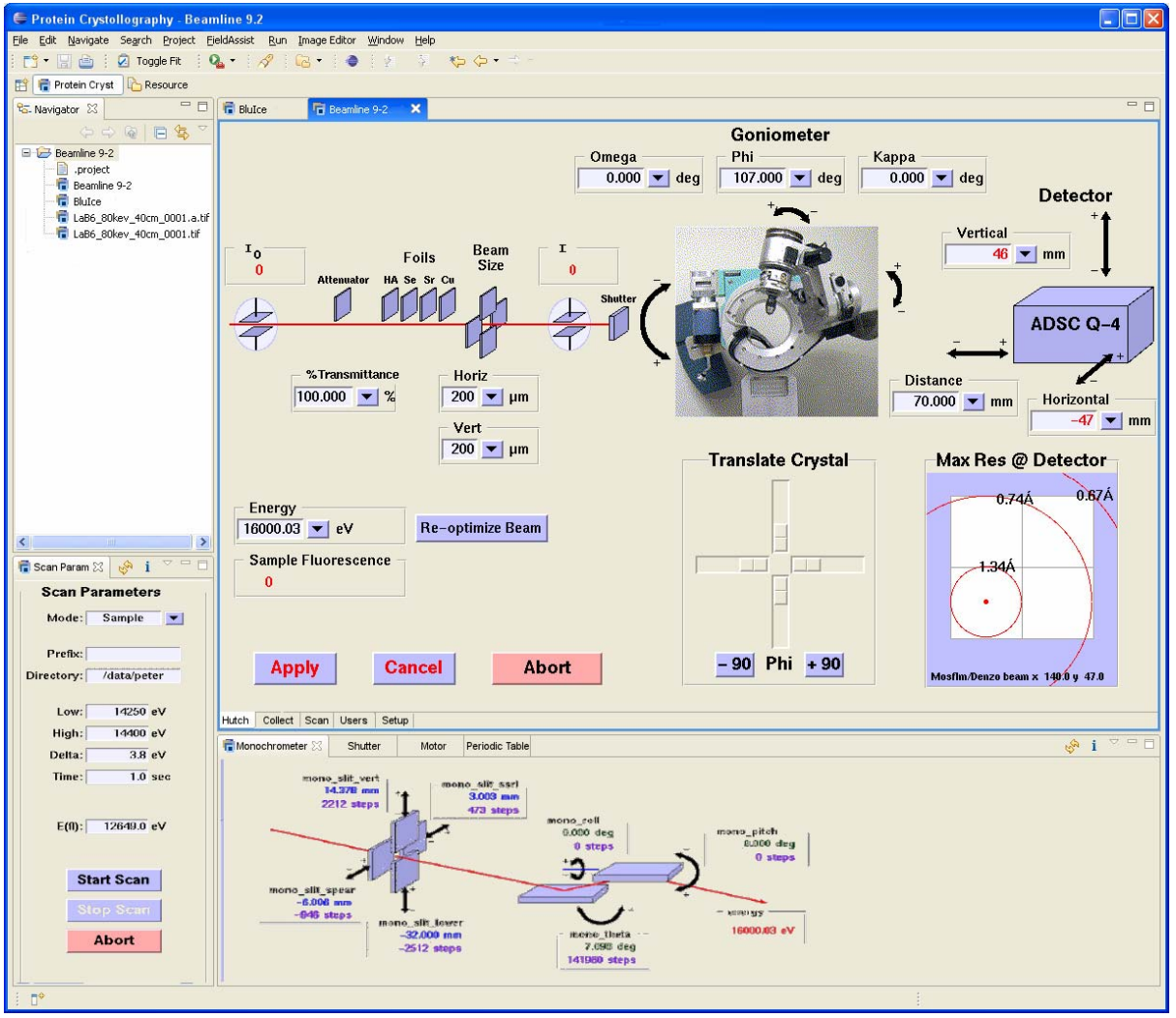
EPICS IDE : IOC Development



A Perspective Can be a Single Application



X-Ray Experiment



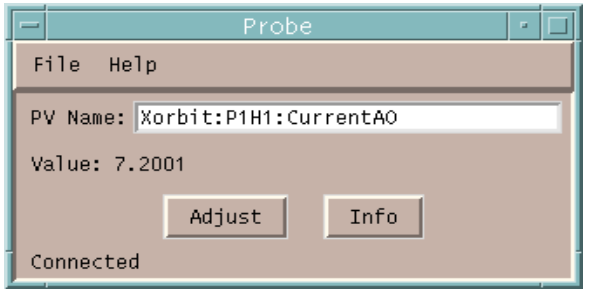
Images from: BLU-ICE and the Distributed Control System, NOBUGS III, January 2000

Rich Client Platform (RCP)

- "Rich Client" is a term from the early 1990s that distinguished applications built with Visual Basic and the like from "Console" or "Simple" applications
- Eclipse is particularly suited to Rich Client applications
- The possibility of using the Eclipse platform for applications was there from the beginning, but foreshadowed by its use as an IDE
  - In the early days it required hacking to make Rich Clients
- RCP is now (as of Eclipse 3.1) supported by the interface and encouraged
- You essentially use Eclipse as a framework for your application
  - You inherit all of its built-in features
  - As well as those from other community plug-ins
- You include only the plug-ins you need
- Is a very extensible development platform
  - You can use plug-ins developed by others as needed
  - Others can use yours and extend them

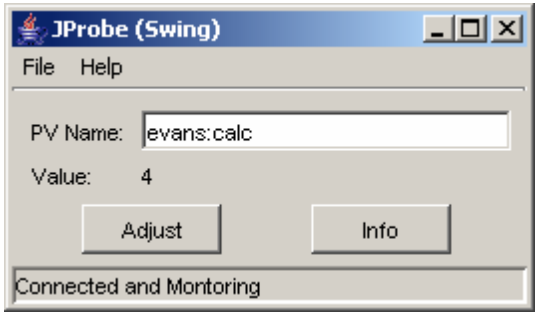
Eclipse as a Rich Client Platform

- Looks like an application, not an IDE
- Inherits a lot of functionality
  - Persistence (Properties and Preferences)
  - Help
  - Featured About dialog (like Eclipse's)
  - Splash screen
  - Dockable windows, and much more …

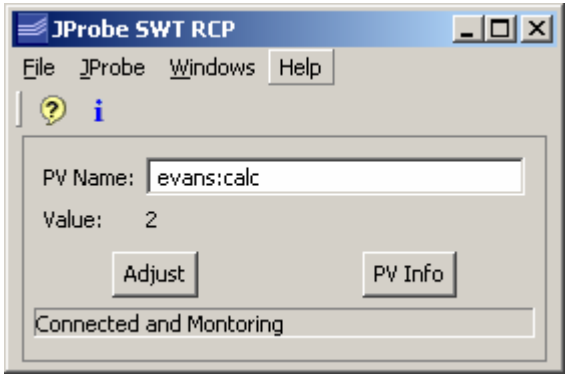


Pyre Application

probe.py --frame.pvName=Xorbit:P1H1:CurrentAO

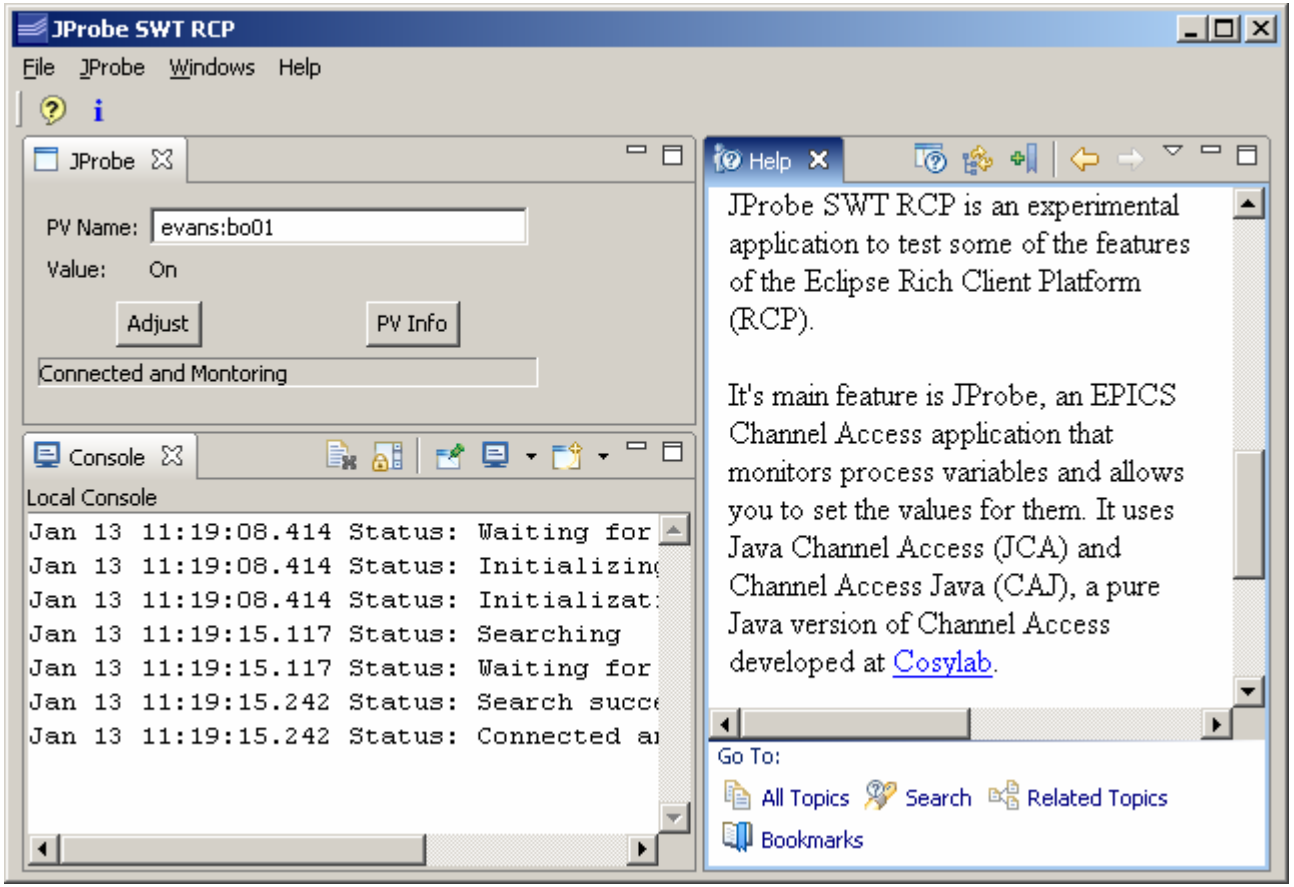


Java Application

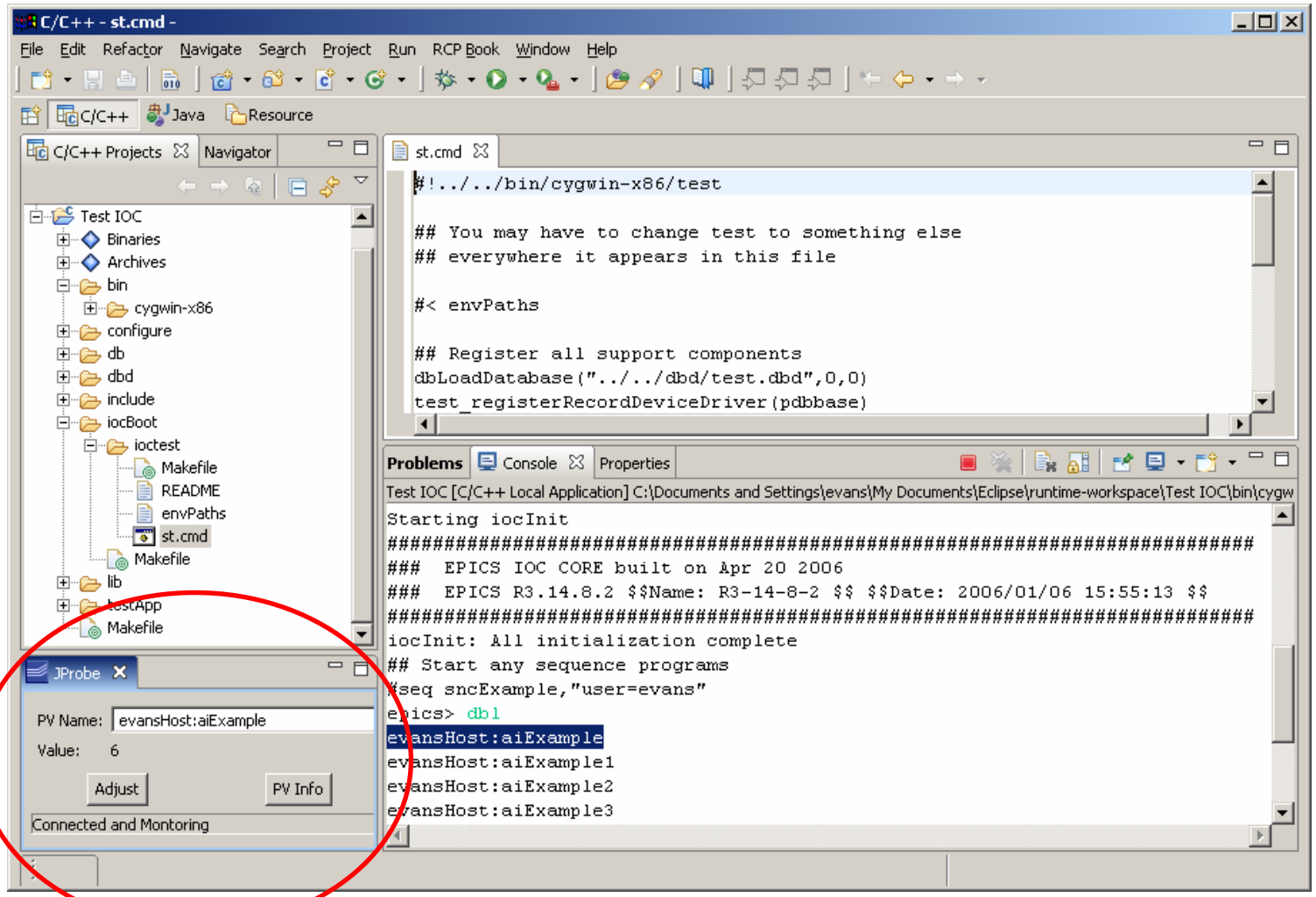


RCP Application

Probe on Steroids
Leveraging the Eclipse Framework



An RCP Application is also a Plug-In

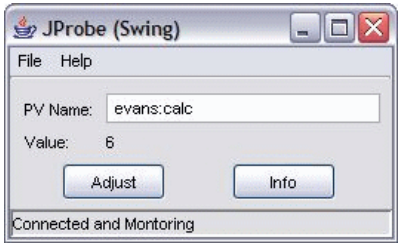


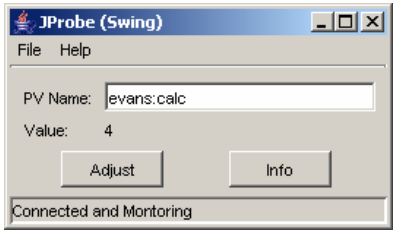
AWT vs. SWT - You Have to Decide

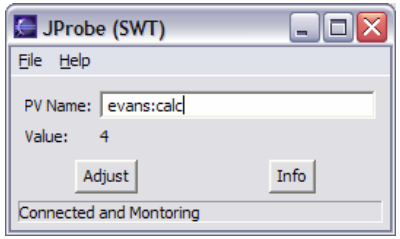
- AWT / Swing (Abstract Windowing Toolkit)
  - Write once, run anywhere
  - Formerly ugly, with bad performance
  - Now look and work well
  - Use garbage collection
  - Come with the JDK and JRE
- SWT / JFace (Standard Window Toolkit)
  - The important fact is that Eclipse uses SWT, not AWT
  - Supposed to look better, run faster
  - A thin wrapper around native widgets
  - SWT components must be disposed (vs. garbage collected)
    - *Owing to need to free native resources*
  - Need JNI libraries for each platform
  - Distribution is through the Eclipse Foundation, not Sun

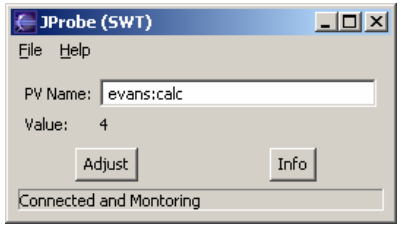
AWT vs. SWT - More Considerations

- It is not easy to convert between them
- The SWT look is not obviously better
- The performance difference may not be there either, today
- Eclipse uses SWT
  - They are supposed to mix and match, but ???
- Sun is unlikely to include SWT support in the JDK and JRE soon



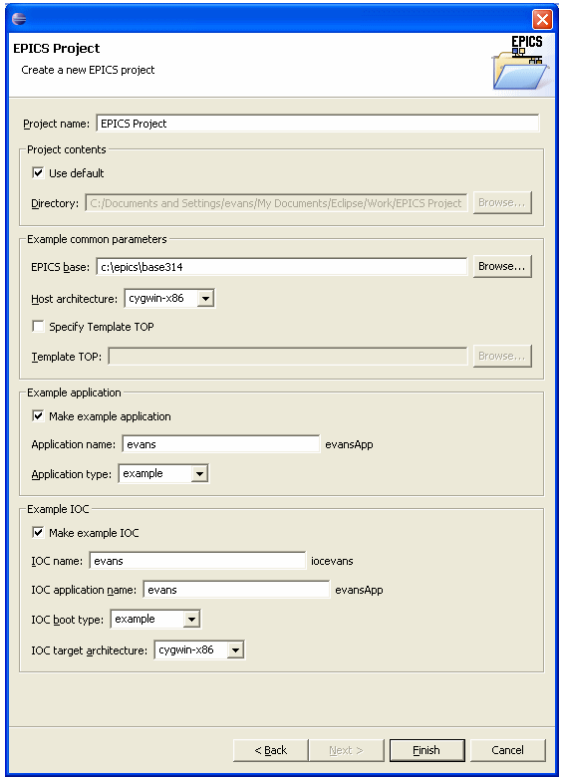


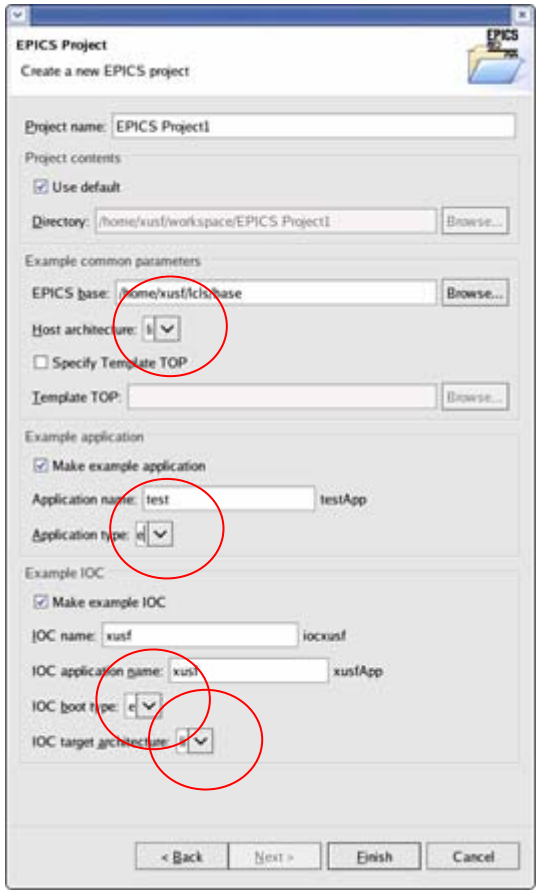




SWT Platform Dependence

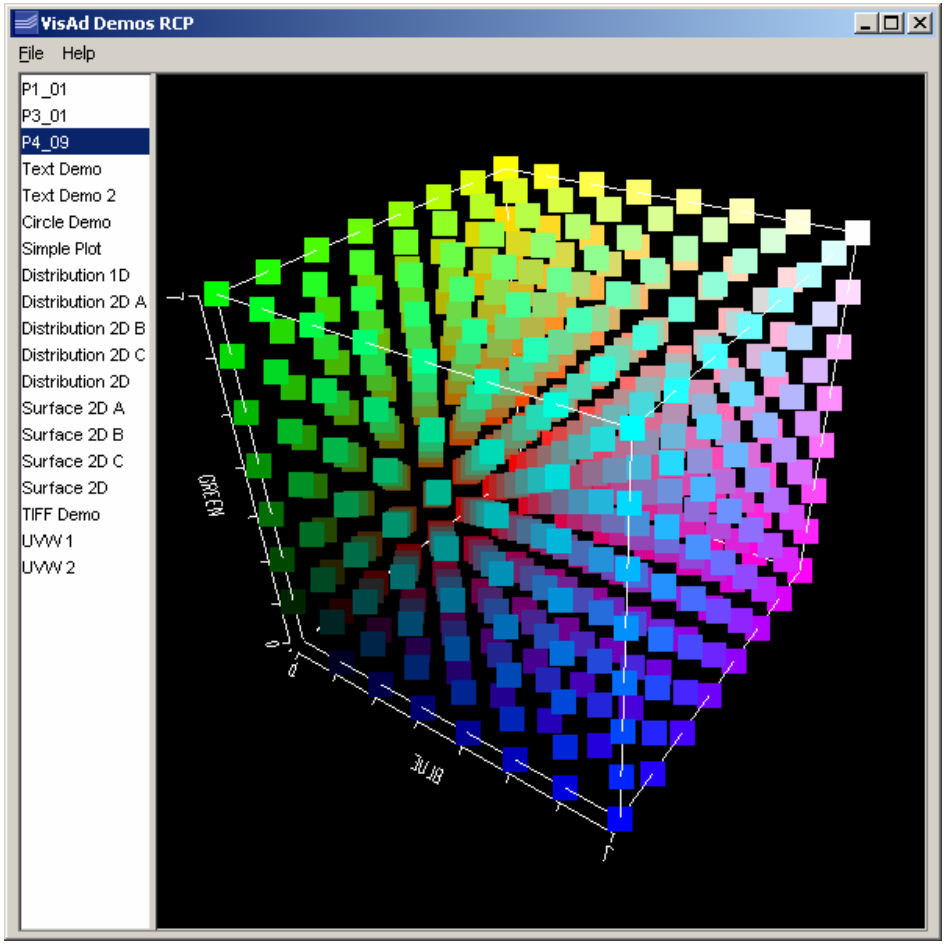
- Example: Working Windows dialog doesn't work right on Linux





Combining Swing and SWT - SWT_AWT Bridge

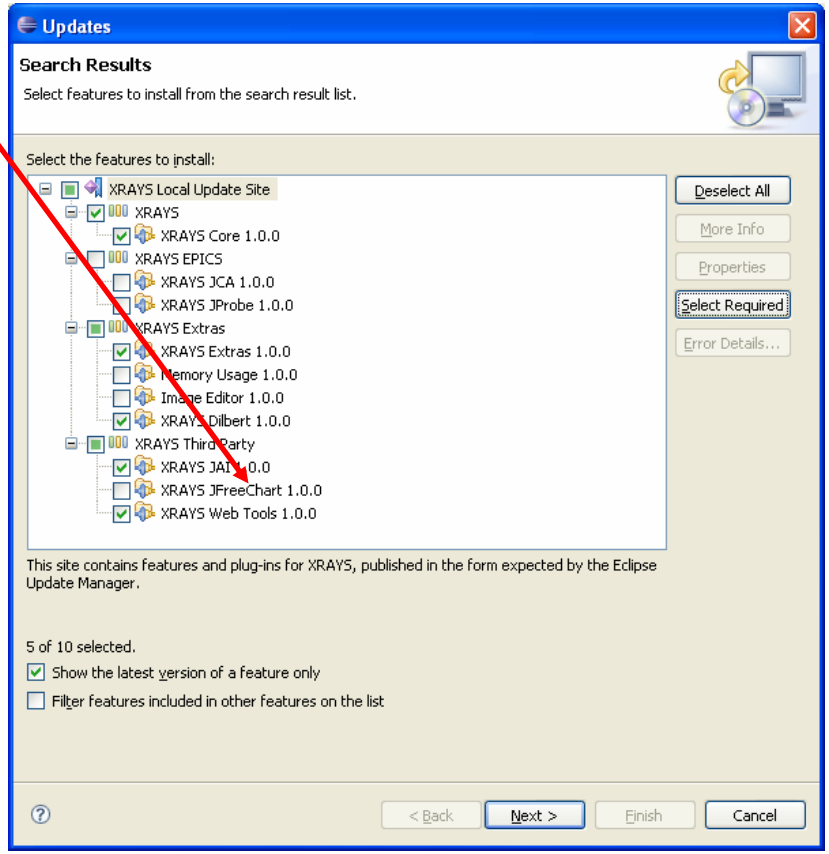
- ContentPane of JFrame is embedded in an SWT Composite
- Menu Initialization is separate from other UI initialization
  - Standalone Swing version uses Swing menus
  - RCP versions uses RCP workbench menus
  - Both can call same instance methods (or not)
- This application also uses JAI and J3D
  - Both are Java extensions
  - Don't play well with Eclipse



Deployment is a Major Reason for Using Eclipse

- Both Java and Eclipse are multi-platform
- Updates are easily made through the Eclipse update mechanism
- You can wrap 3rd party applications in your own plug-ins
  - For example:

    The Feature “XRAYS JFreeChart” contains gov.anl.xrays.jfreechart which wraps JFreeChart
  - Including DLLs and Shared Objects
- Guarantees they are versions that work with your applications on all supported platforms
- Makes it easy for the user to install and update both your stuff and the 3rd party stuff



Eclipse Bottom Line

- Is a very powerful and extensible IDE and Framework
- Is also an IE - A way to organize your work
- Is Open Source
- Has a community
- Is supported by most of the industry
- Has a large number of developers (>150)
- Has significant financial backing
- Are many 3rd-party Plug-ins, both free and commercial
- Are more than 60 open-source projects
  - From Web Tools to Code Profilers
- Is continuing to expand and improve rapidly
- Is free
- Downsides
  - Is a continually changing, moving target

Lessons Learned

- Eclipse as a workbench seems more attractive than Eclipse RCP applications
- Writing full-fledged Eclipse plug-ins entails a fairly steep learning curve
- The SWT / AWT dichotomy is a nuisance but not a real impediment
- The best (perhaps only feasible) way to handle 3rd party libraries is to wrap them in a plug-in
- Eclipse solves a number of thorny problems
  - Especially deployment and commonality
- We don’t see a better alternative

X-Ray Software Development at the APS

- Best described as “Uncoordinated”
- Wide variety of languages
  - FORTRAN, C, C++, Perl, Tcl/Tk, Python, Java, …
- Visualization relies on (different) commercial products
  - IDL, IGOR, Matlab, …
- Each beamline tends to do its own thing
- Modeling and Analysis is not well integrated with Data Acquisition
- Lack of real-time data reduction
- Little high-performance computing
- Little remote access
- No common data format

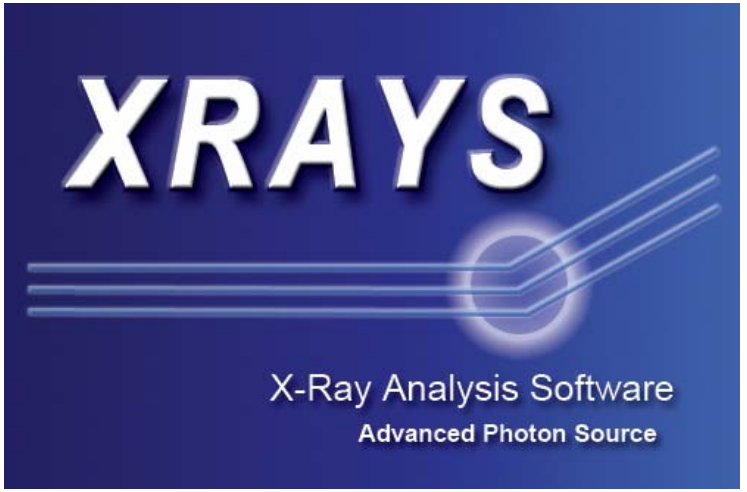
- A Scientific Software Section was formed to help remedy this situation

Scientific Software Section

- Specific goals:
  - Combine existing analysis and visualization codes with beamline data acquisition software and transform these codes into easy-to-use software
  - Provide a scientific workbench program that is easy to use and learn and from which users can access all the software that is necessary to manage the entire scientific work flow
  - Create new analysis and visualization applications that can be used on all beamlines and that are easily integrated into the standard workbench
  - Develop a software framework, perhaps more than one, that provides tested and debugged scientific routines, such as fitting and visualization, which can be used by developers to create applications
  - Create an interface to the facilities necessary to provide high-performance computing
  - Provide documentation, distribution, maintenance, and support

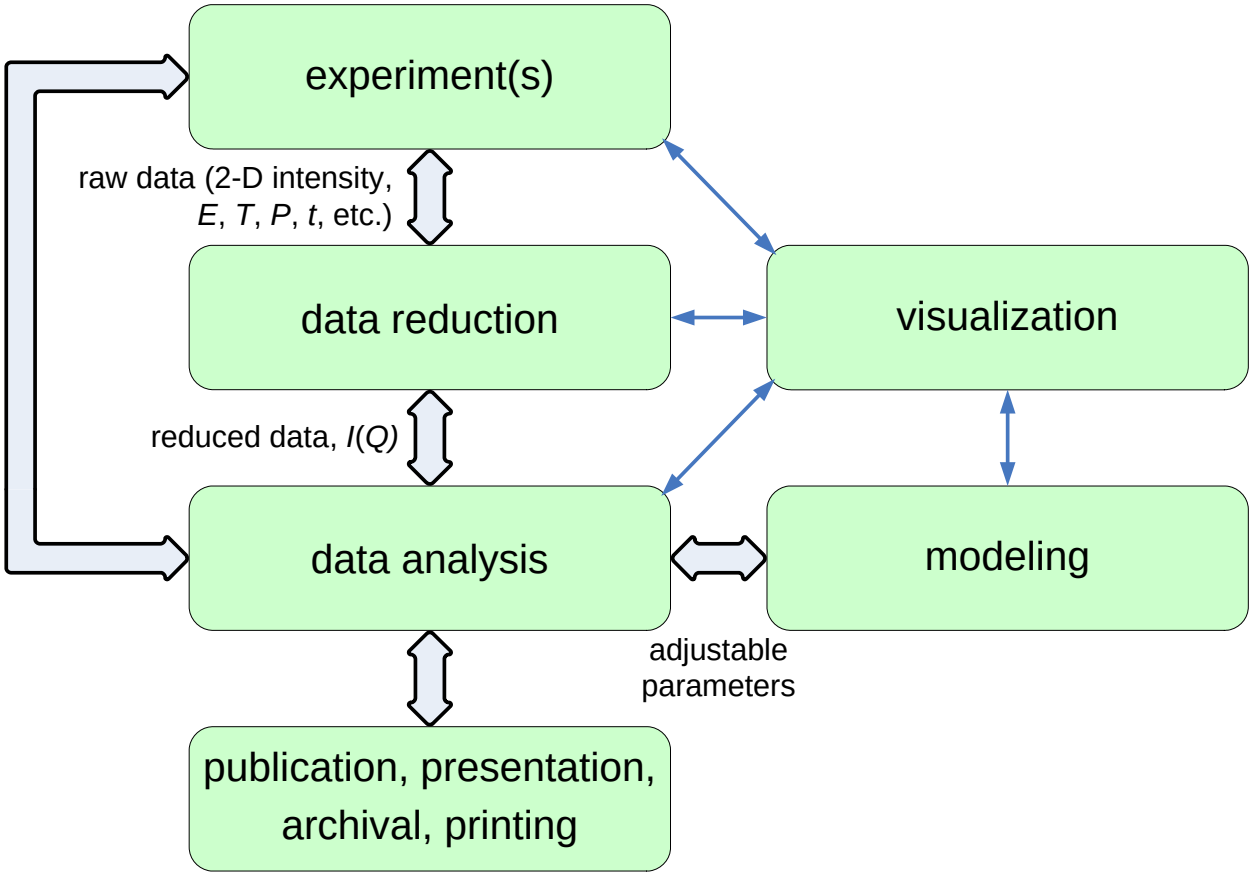
Scientific Software Section Web Page

XRAYS



- Stands for X-Ray Analysis Software
  - (or X-Ray Software)
- It is expected to grow into a large suite of analysis and visualization applications
- These will include:
  - Scientific workbench program
  - New analysis and visualization applications
  - Updating and coordination of existing analysis and visualization applications
  - A framework of software routines that developers can use to write applications
- It currently consists mostly of exploration and prototype applications
  - This is the groundwork for what we really want to do
  - More than 1200 Java source files in 60 projects
  - 38 Java projects intended for distribution (gov.anl.xrays.xxx)
  - 10 ready-to-deploy features (collections of projects) in 4 categories

We Want to Manage the Entire Experimental Data Flow



XRAYS Rationalization for Eclipse

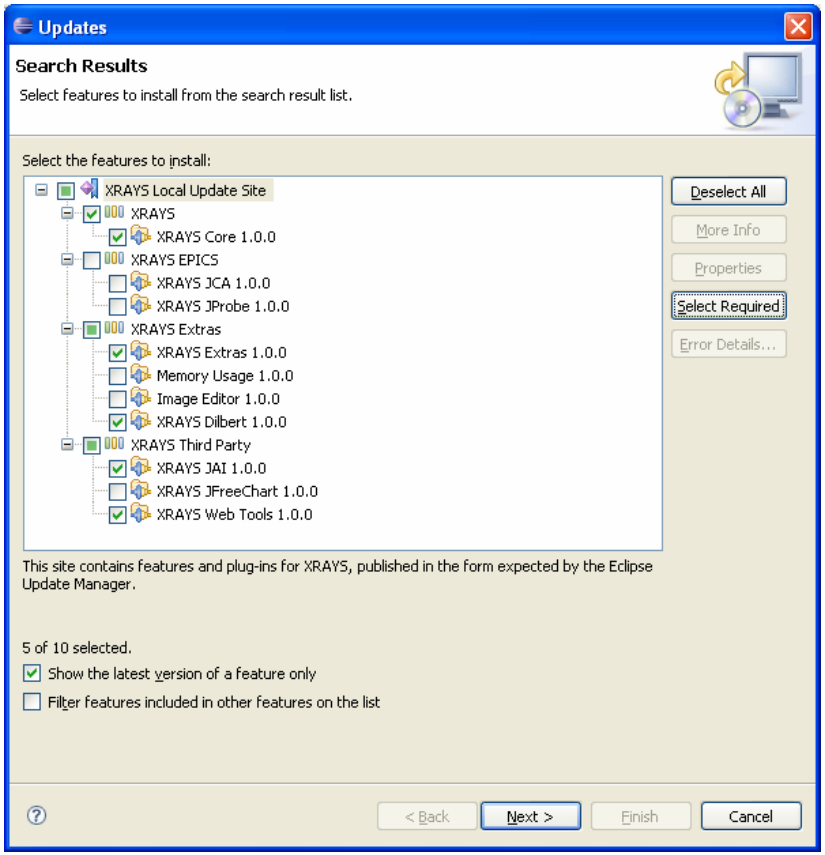
- Providing coordination is a primary goal
- Resources are limited
- Have to choose something
  - Eclipse seems like the best choice
  - Powerful, flexible, extensible
  - Open-source
  - Huge community with many projects
- Java development environment leads to high productivity
- Deployment via plug-ins appears to solve many problems

- We intend to use Eclipse, not as an IDE, but as a workbench
  - Something users will use

- Downsides
  - Most x-ray beamline staff and users are not using Eclipse now
  - 95% will be unhappy [with anything we do]

Ready to Deploy Now

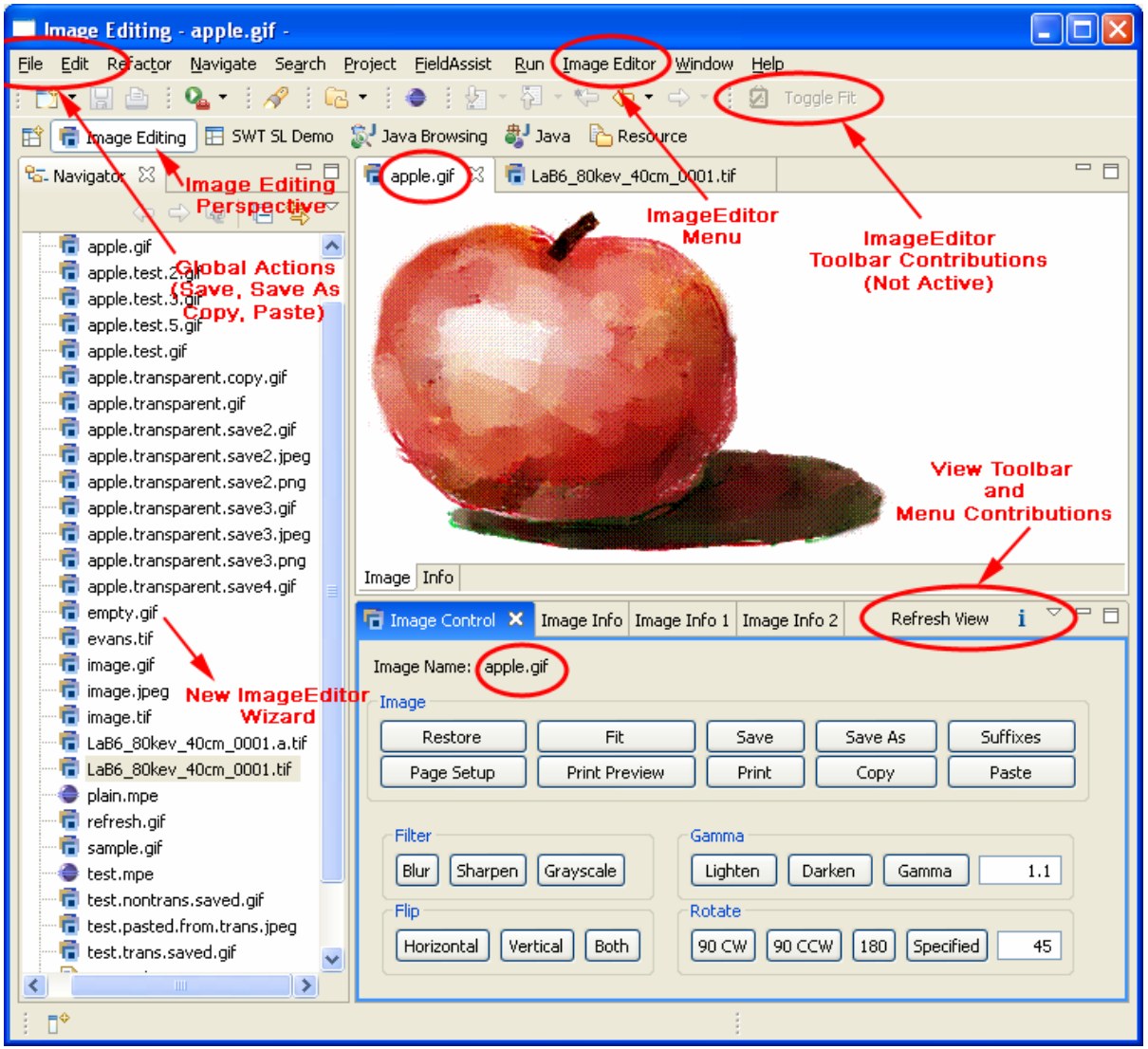
- These Eclipse projects are ready now to be made available through the Eclipse update mechanism
- Waiting for license and license-related issues



Eclipse for Users, not Developers

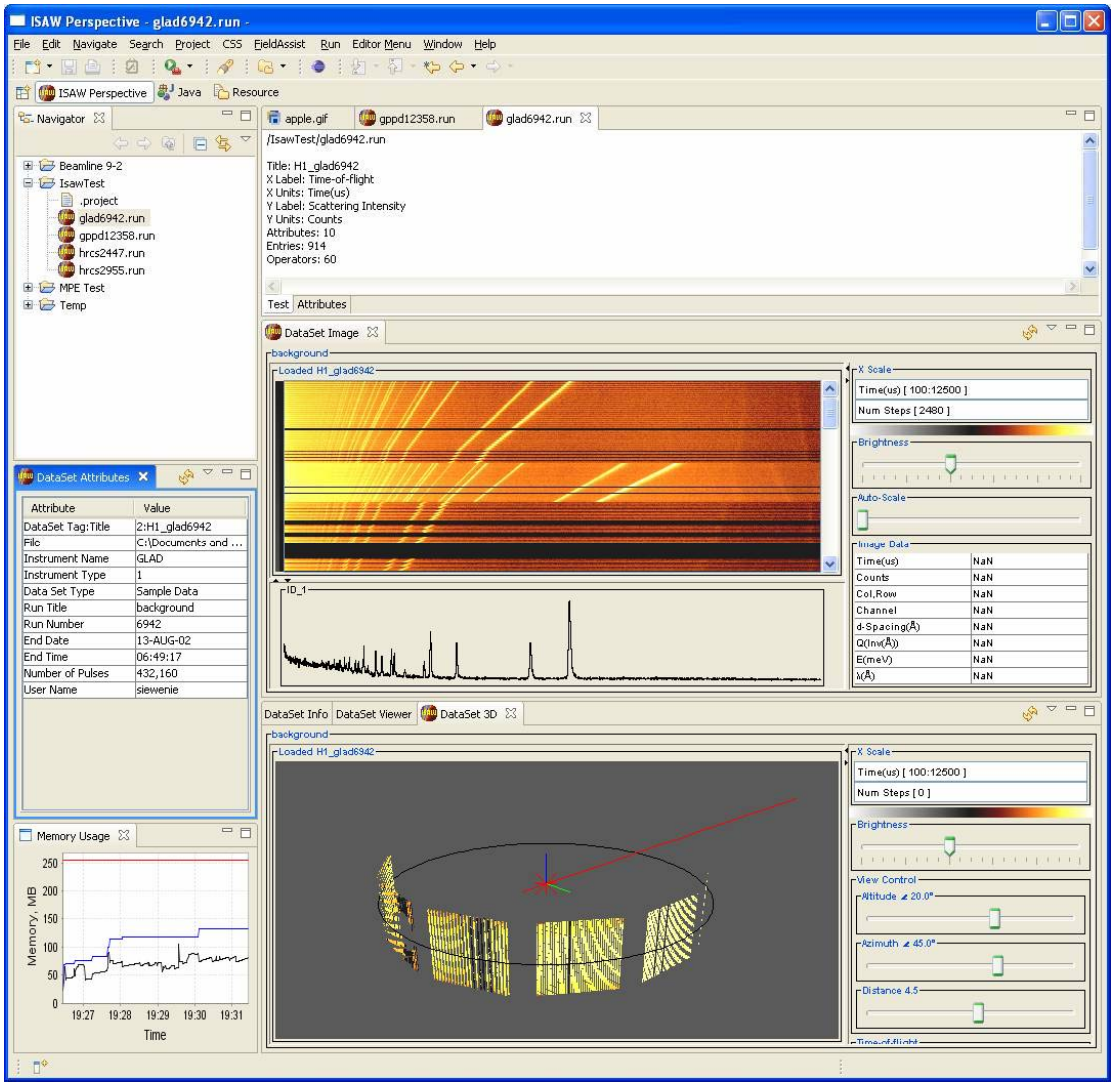
- We intend to use Eclipse as a workbench
- Something a user can come in and be up and running with in a short time
  - Probably with community help
- Each user can use and customize it in his or her own way
  - (That is what Eclipse provides)
- They will probably use it for more than one thing
  - That is why the layout by Perspective is important
  - You just switch perspectives to change tasks
- I think this paradigm is better than using RCP applications
  - You provide the plug-ins
  - The user manages the Workbench as he or she pleases

Image Editor as an Experiment Prototype

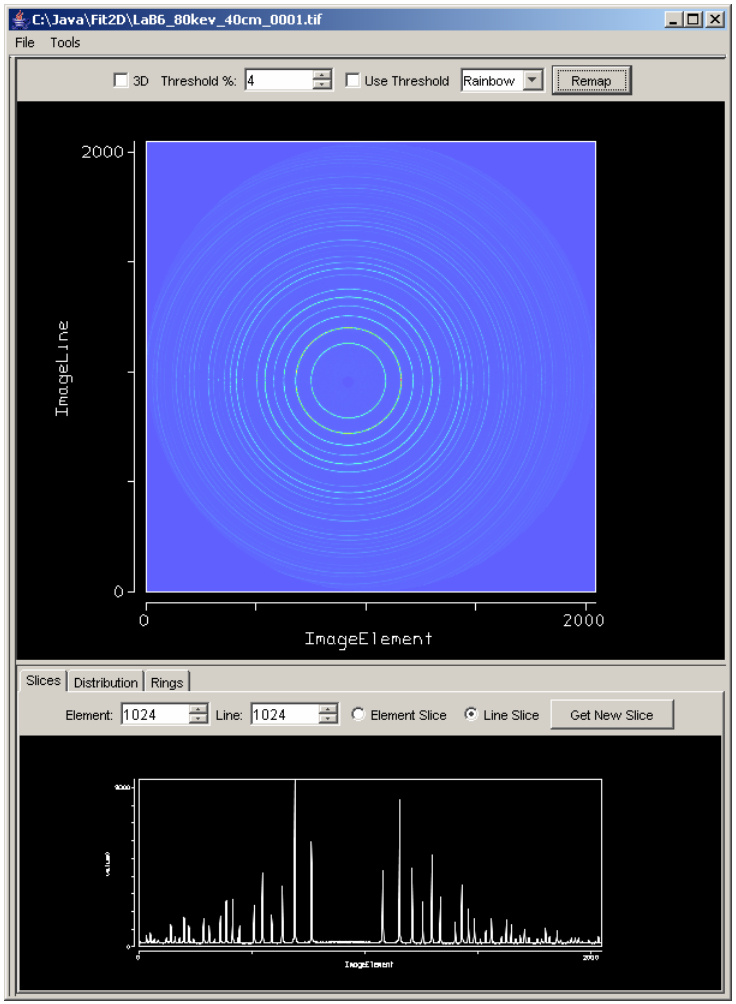


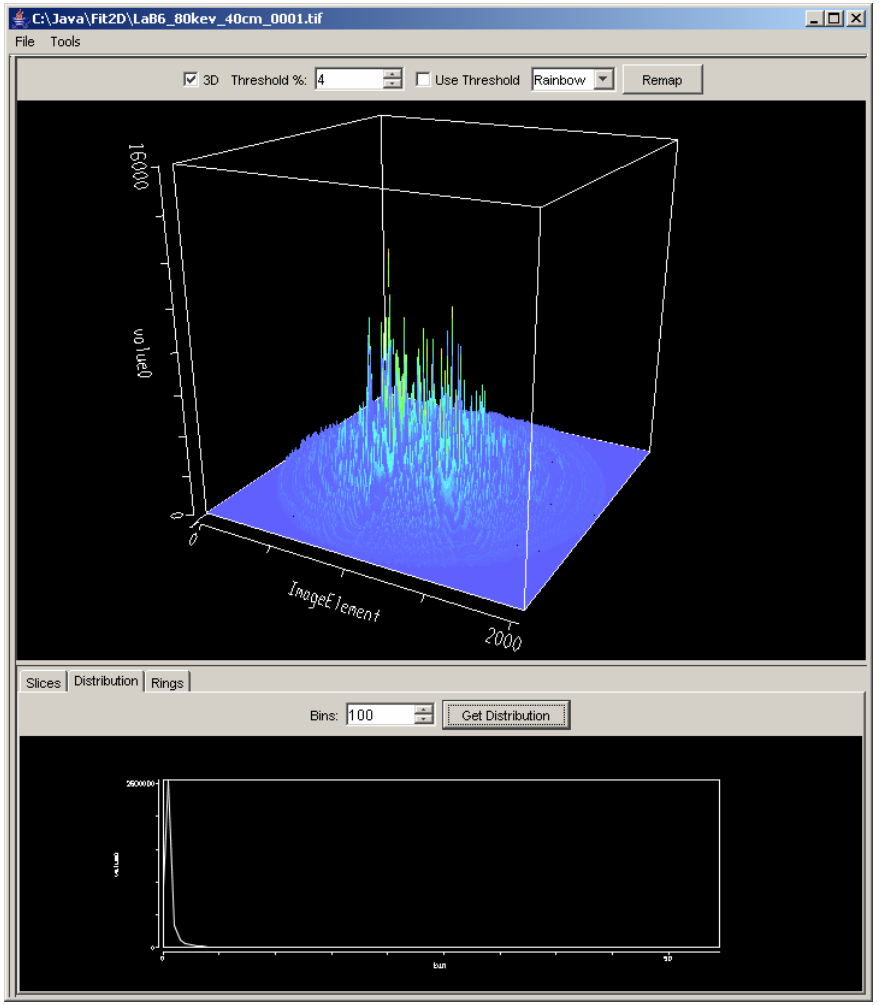
Prototype Implementation of ISAW

- Includes:
  - A Perspective
  - An Editor for ISAW DataSets
    - *.run, .isd*
  - Some Views
- All work together
  - Views change when the edited file changes

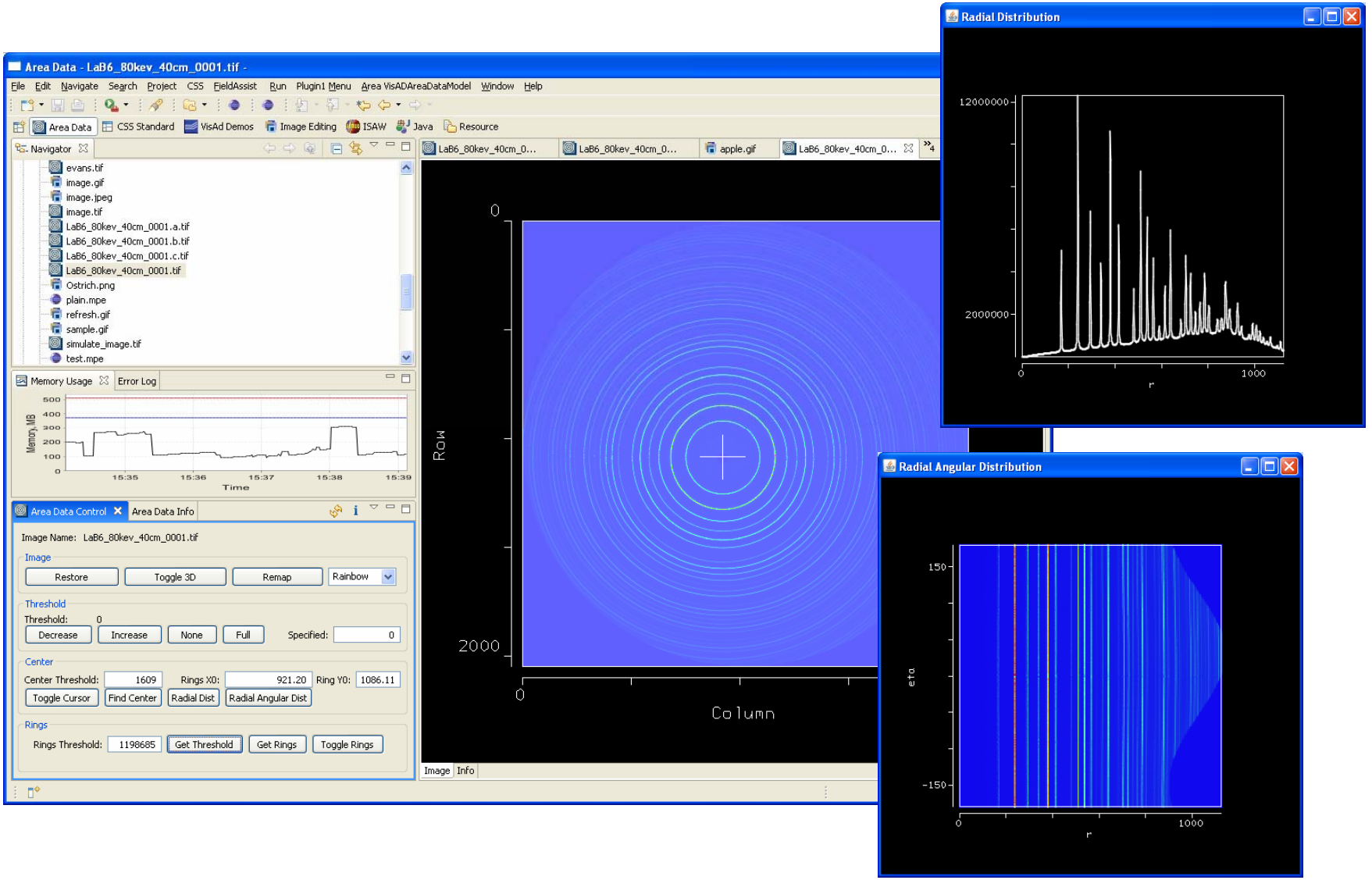


Prototype Image Analysis Tool using VisAD Graphics





Now Incorporated Into Eclipse



Longer Term

- Resources are currently limited
- Eclipse and Java applications are where we are starting
  - These are client-based applications
  - Partly driven by the fact that x-ray data is localized
- We expect to incorporate high-performance computing
  - Typically means clusters and grid computing
  - These are server based
  - Data on centralized servers is more typical of other communities
  - Eclipse is not the obvious tool
- We cannot limit ourselves to Java
  - There are legacy FORTRAN codes that need to be incorporated
  - There are many other languages
    - *In particular, Python is heavily used in scientific communities*
    - *C and C++ will continue to be important*
- The licensing and other legal structure need to support all of these

Thank You

This has been a

Scientific Software Presentation

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