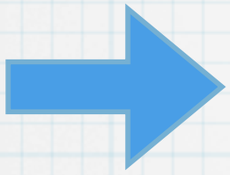
e-Labs: Online Student Investigations Using Grid Techniques

Elizabeth Quigg
Education Office
Fermi National Accelerator Lab

www.i2u2.org/elab/cosmic

Outline of Talk



* Introduction to the Cosmic Ray e-Lab
* Overview of the Web Portal
* Implementation
* Scaling Up
* Current Development
* Lessons Learned
* Invitation / Credits

Our Mission: To Bring the Research World to the Classroom

To develop web-based e-Labs for students to exploit the power of the Grid and support collaborative learning

Grid Tools,
Methods,
& Ideas

The Partners

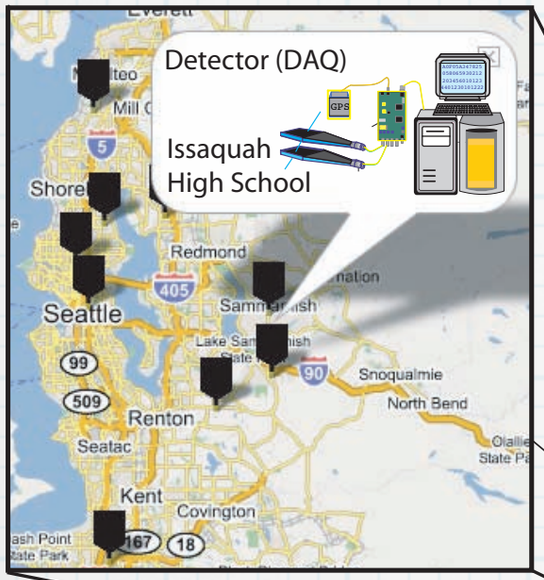
* GriPhyN (Grid Physics Network) - developers of cutting-edge Grid infrastructure led by Ian Foster

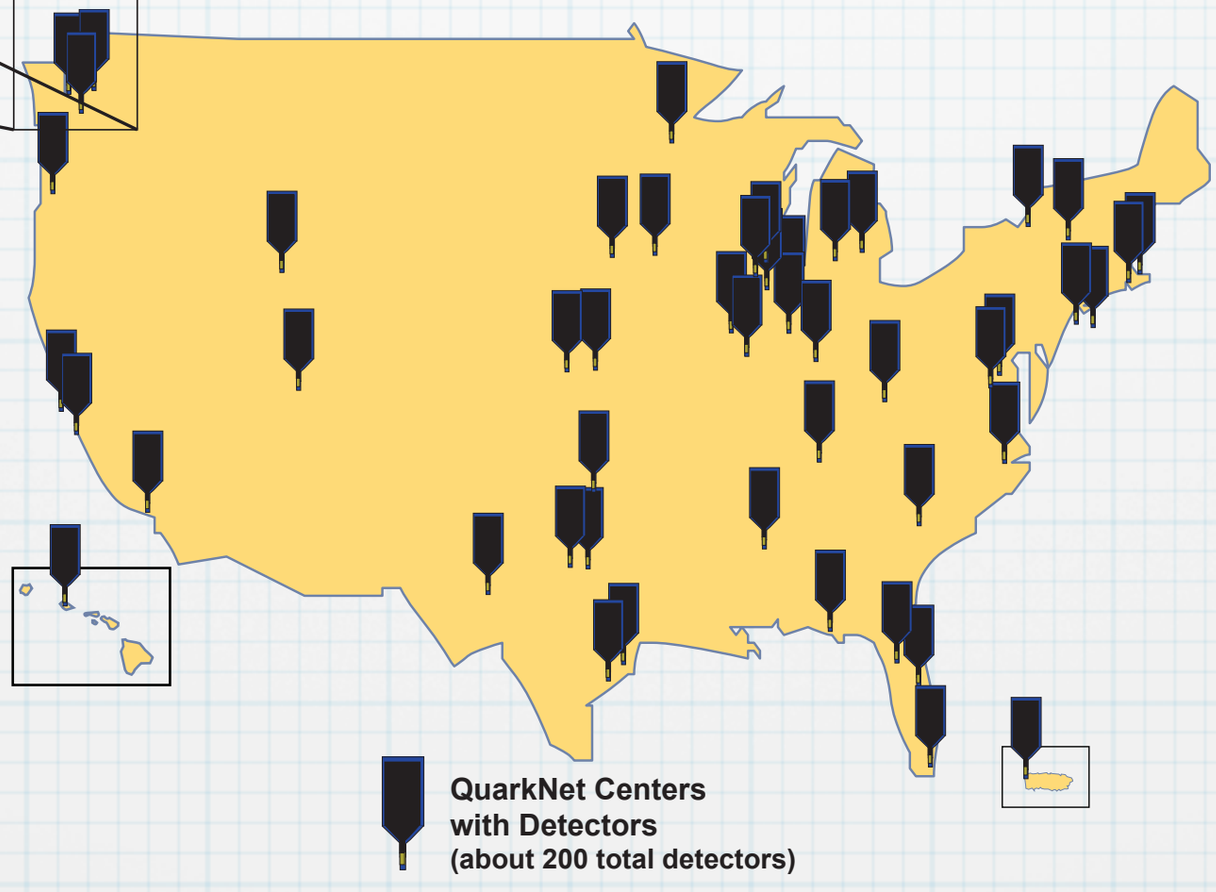
* QuarkNet - a research community of particle physicists, high school teachers & their students.

Prototype e-Lab

The Cosmic Ray e-Lab Project for high school students & their teachers

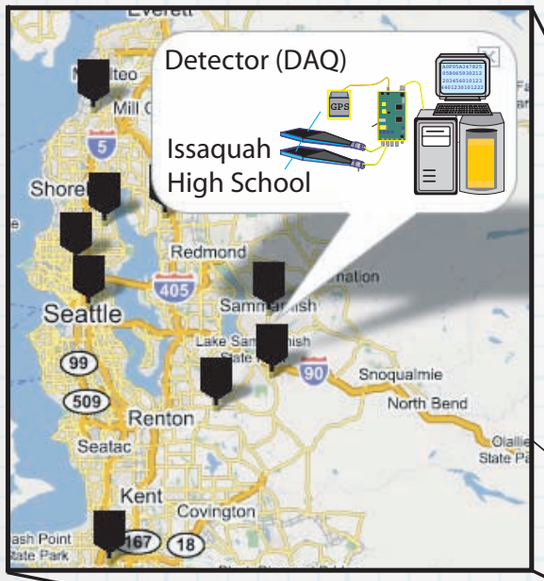
Data from Cosmic Ray Detectors in High Schools

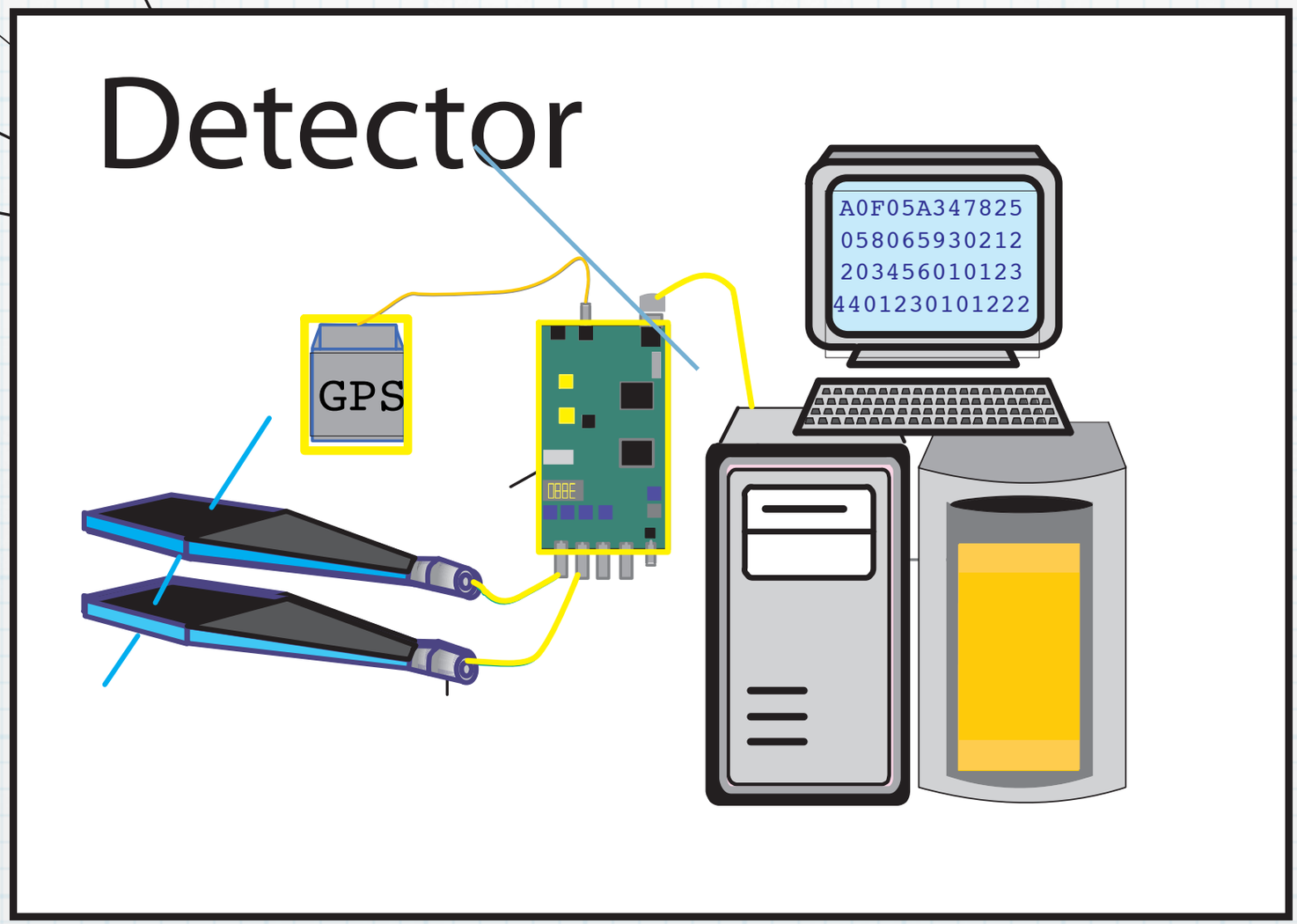




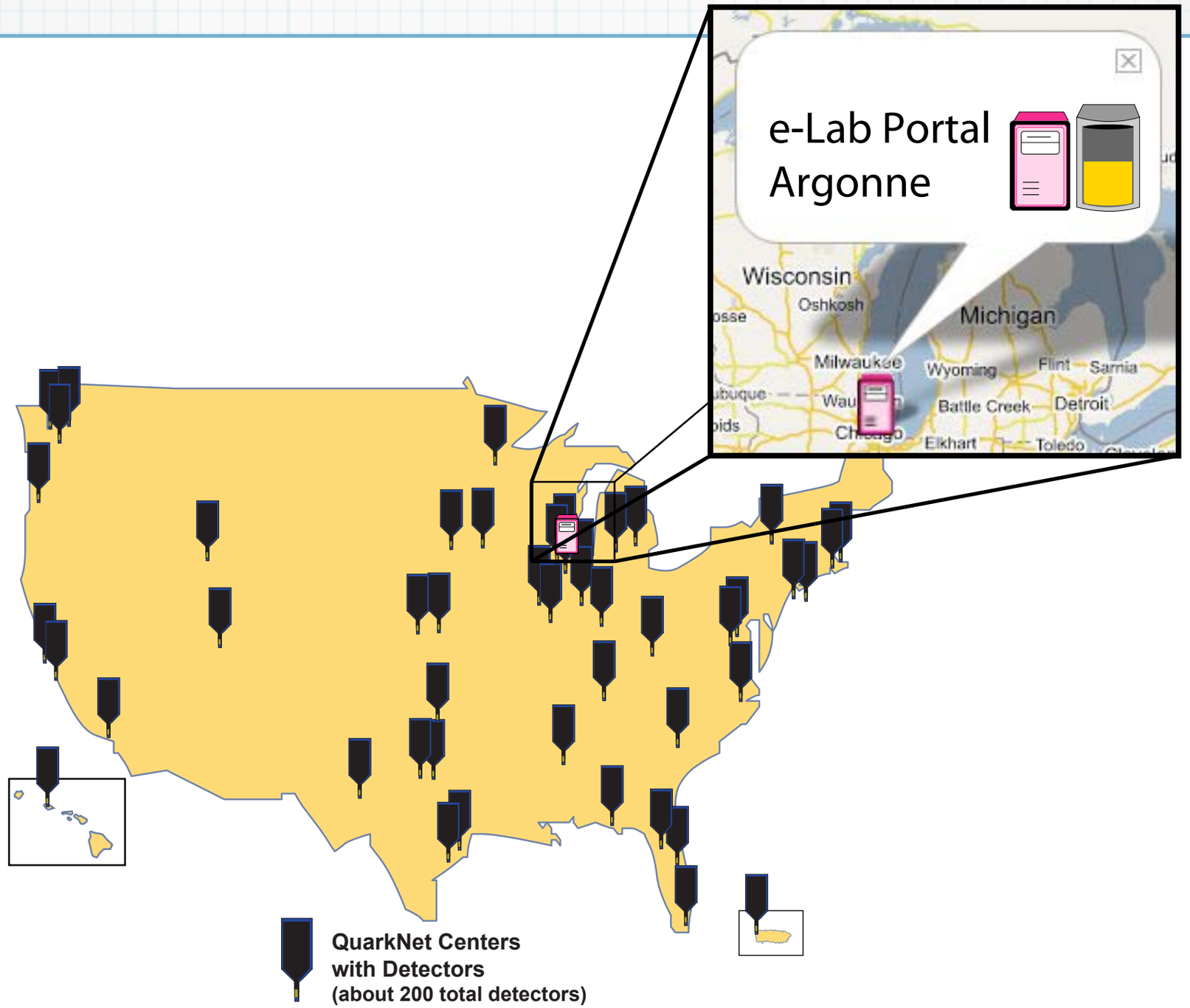
QuarkNet Centers with Detectors (about 200 total detectors)

Data from Cosmic Ray Detectors in High Schools





Central Repository for Data
Cosmic Ray e-Lab Portal



Outline of Talk

* Introduction to the Cosmic Ray e-Lab
* Overview of the Web Portal
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Web-based e-Lab

Cosmic Ray e-Lab

Logged in as group: fermigroup

Logout
My Logbook

Home | Library | Upload | Data | Posters | Site Index | Assessment

Join a national collaboration of high school students to study cosmic rays.

Why cosmic rays?

Spending all your time in a shower ?

When you're sleeping or sitting in class, cosmic rays shower the earth and everything on it.

What are cosmic rays ?

Where do they come from ?

Where do they hit ?

Some cosmic rays have so much energy that scientists are not sure where they come from. A number of reseach projects are looking at this question.

Who are we?

We're a collaboration of high school students and teachers collecting and analyzing cosmic ray data to answer some of these questions. We're working with computer scientists to provide cutting edge tools that use grid techniques to help you share data, graphs, and posters and collaborate with other students nationwide.

Who can join?

You! Think about steps you'd take to investigate cosmic rays. How would

Web-based e-Lab support:

* data uploads
* data sharing
* analysis tools
* logbook
* publication of findings
* collaboration

Viewing Data in Web Browser

Cosmic Ray Collaboration

Logged in as group: fermigroup

Logc
My Logbo
Assessme

Home | Resources | Upload | Data | Posters | Site Index

View Data | Performance | Lifetime | Flux | Shower | View Plots

hoose data for the flux study.

Fermilab Batavia IL Everyone

City | Issaquah | Search Data

▸ Advanced Search

Results **1 - 1** of **1** for **Issaquah** (**1.001** seconds)

▾ **Issaquah High School**
Issaquah, WA
56 data files: 0 blessed, 0 stacked, 1,021,658 total events.

▸ April 2004 8 files
▸ May 2004 31 files
▸ June 2004 14 files
▾ October 2004 select all 3 files

Tue 19 | Wed 20 | Thu 21

Help

Tutorial on flux study

Step-by-Step Instructio

Analyze

Run Flux Study

Legend

Unstacked data
Stacked data
Blessed data
Add/View comments

Viewing Data in Web Browser

Show details (metadata)

data for file 143.2004.1020.0

Go to time

Hours: Minutes: Seconds: Go

```
1: 9D046DD8 AB 01 00 01 00 01 00 01 9B429D43 000000.783 201004 A 07 2
   +0003
2: 9D046DD9 01 24 00 01 00 01 00 01 9B429D43 000000.783 201004 A 07 2
   +0003
3: 9D046DEB 21 2A 00 01 00 01 00 01 9B429D43 000000.783 201004 A 07 0
   +0003
4: A22F90FD 80 01 00 01 00 01 37 01 A03A2E00 000002.783 201004 A 07 2
   +0003
5: A22F90FE 00 01 00 01 00 01 01 22 A03A2E00 000002.783 201004 A 07 2
   +0003
6: A22F910A 00 01 2F 01 00 01 00 01 A03A2E00 000002.783 201004 A 07 2
   +0003
7: A22F910B 00 01 01 25 00 01 00 01 A03A2E00 000002.783 201004 A 07 0
   +0003
```

Viewing Data in Web Browser

Show data

Metadata for file 143.2004.1020.0

blessed: false
chan1: 8808
chan2: 11261
chan3: 10175
chan4: 10980
city: Issaquah
comments:
creationdate: 2004-11-01 21:14:02.0
detectorid: 143
enddate: 2004-10-20 23:59:59.0
group: IssaquahAlpha
julianstartdate: 2453298.50001157
origname: Issaquah

Analyzing Data - Find Data

Cosmic Ray Collaboration

Logged in as group: fermigroup

Logou
My Logbook
Assessment

Home | Resources | Upload | Data | Posters | Site Index

View Data | Performance | Lifetime | Flux | Shower | View Plots

Choose data for the shower study.

Fermilab Batavia IL Everyone

State | WA | Search Data

▶ Advanced Search

Results **1 - 5** of **5** for **WA** (**0.327** seconds)

▼ **DeVry University**
Federal Way, WA
1 data files: 0 blessed, 0 stacked, 236,109 total events.

▼ October 2004 1 file

Wed 20

▼ **Issaquah High School**
Issaquah, WA
1 data files: 0 blessed, 0 stacked, 41,224 total events.

▼ October 2004 1 file

Help

Tutorial on shower study

Step-by-Step Instructions

Analyze

Run shower study

Legend

- Unstacked data
- Stacked data
- Blessed data
- Add/View comments

Analyzing Data - Setting Parameters

Look for showers in your data.

Understand The Graph

You're analyzing...	Chan1 events	Chan2 events	Chan3 events	Chan4 events	Raw Data	
DeVry University 10/20/2004 0:0:1	54464	59615	55896	66134	View	Statistics
Issaquah High School 10/20/2004 0:0:1	8808	11261	10175	10980	View	Statistics
Juanita High School 10/20/2004 0:0:1	29786	41720	33541	21884	View	Statistics
Liberty High School 10/20/2004 0:0:4	2054	6364	2373	6071	View	Statistics
Meadowdale 10/20/2004 0:0:3	6170	14557	17733	15474	View	Statistics
Total	101282	133517	119718	120543	Compare files	

Enter the analysis parameters and click Analyze to create a shower plot.

Analysis Controls

? Detector of 0-0-0 point: 119

? Event Gate (ns): 100

? Event Coincidence Level: 2

Detector Coincidence: 1

Plot Controls

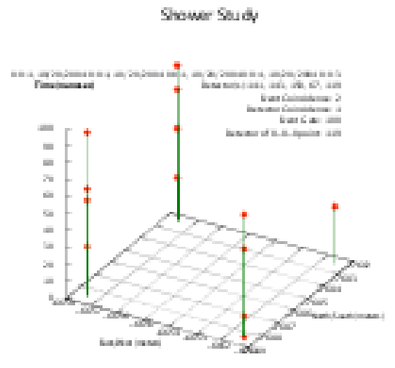
Analyze

Analyzing Data - Results

Shower Study Candidates

Event Date	Event Coincidence	Detector Coincidence
Oct 20, 2004 4:20:13 PM CDT	13	1 (150)
Oct 20, 2004 8:07:18 PM CDT	11	1 (150)
Oct 20, 2004 7:36:36 PM CDT	11	1 (150)
Oct 20, 2004 4:35:48 PM CDT	11	1 (119)
Oct 20, 2004 7:30:01 PM CDT	10	1 (150)
Oct 20, 2004 5:11:03 PM CDT	10	1 (150)
Oct 20, 2004 4:11:56 PM CDT	10	1 (150)
Oct 20, 2004 3:30:13 PM CDT	10	1 (150)
Oct 20, 2004 11:19:42 AM CDT	10	1 (141)
Oct 20, 2004 10:09:42	10	1 (141)

Click on the image for a larger view



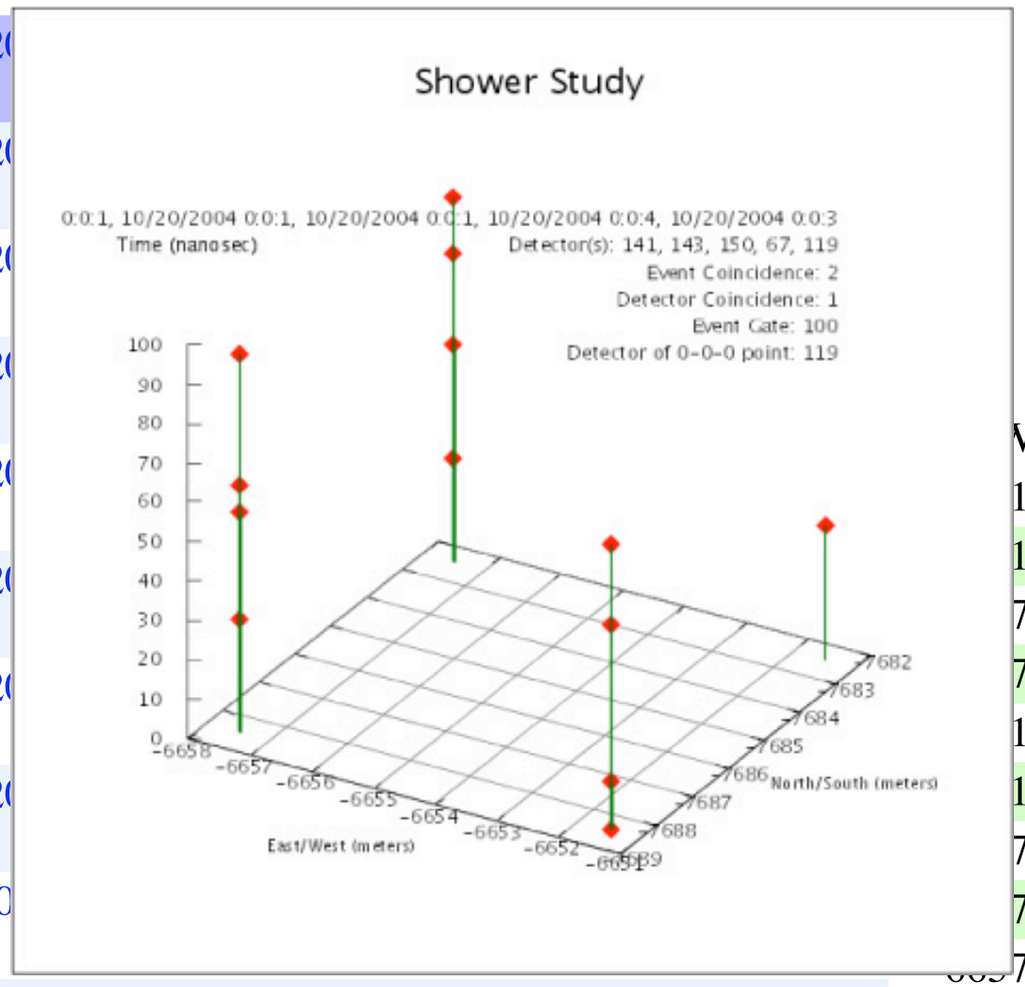
Plot Datapoints:

East/West	North/South	Time	Detector	Channel
-6651.5	-7688.4	0.0	150	4
-6651.5	-7688.4	12.0	150	4
-6657.5	-7682.4	26.3	150	2
-6657.5	-7688.4	28.5	150	3
-6651.5	-7682.4	33.8	150	1
-6651.5	-7688.4	51.8	150	4
-6657.5	-7682.4	54.8	150	2
-6657.5	-7688.4	55.5	150	3
-6657.5	-7688.4	62.3	150	3
-6651.5	-7688.4	72.0	150	4

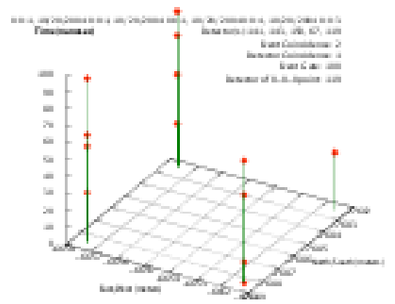
Analyzing Data - Viewing Plot

Shower Study Candidates

Event Date	Event Coincidence	Detector Coincidence
Oct 20		
Oct 20		
Oct 20		
Oct 20		
Oct 20		
Oct 20		
Oct 20		
Oct 20, 2004 10:09:42	10	1 (141)



Click on the image for a larger view



Plot Datapoints:

West	North/South	Time	Detector	Channel
1.5	-7688.4	0.0	150	4
1.5	-7688.4	12.0	150	4
7.5	-7682.4	26.3	150	2
7.5	-7688.4	28.5	150	3
1.5	-7682.4	33.8	150	1
1.5	-7688.4	51.8	150	4
7.5	-7682.4	54.8	150	2
7.5	-7688.4	55.5	150	3
7.5	-7688.4	62.3	150	3
-6651.5	-7688.4	72.0	150	4

Searching for Plots

Cosmic Ray Collaboration

Logged in as group: anthro

Logout
My Logbook

Home | Resources | Data | Posters | Site Index | Assessment

View Data | Performance | Lifetime | Flux | Shower | View Plots

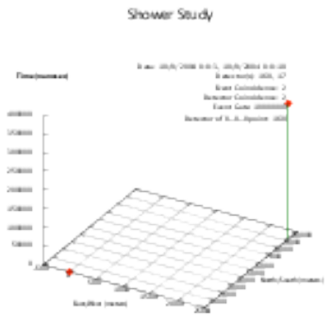
Search for and view plots.

Show plots by: anthro - mmead - Fermilab - Batavia - IL - Everyone

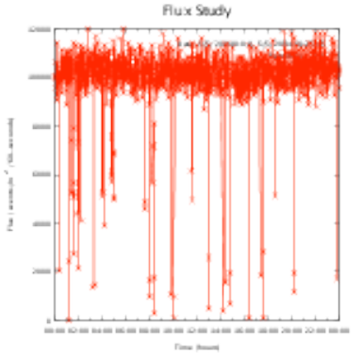
Name | Search Plots

(Optional) Limit search by creation date:

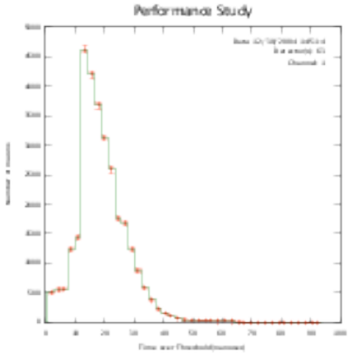
Date: 1/1/2004 to 12/30/2050



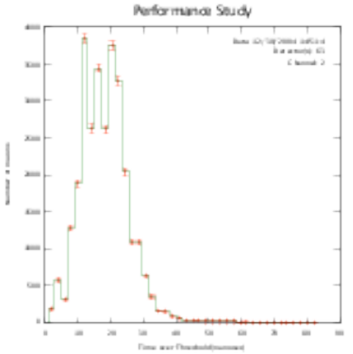
04-10-09unl-zoo-plot.png
Group: CROP
Created: Mar 16, 2005
View/Add Comments



05may.png
Group: Sharkuser
Created: Jan 17, 2005
View/Add Comments



123004_1.png
Group: AHS1
Created: Dec 30, 2004
View/Add Comments



123004_2.png
Group: AHS1
Created: Dec 30, 2004
View/Add Comments

Building on the Work of Others

Cosmic Ray Collaboration

Logged in as group: anthro

Logout
My Logbook

Home | Resources | Data | Posters | Site Index | Assessment

View Data | Performance | Lifetime | Flux | Shower | View Plots

Search for and view plots.

Show details (metadata)

plot for file 1230004_1.png

Run this study again

View Provenance Run this study again

Building on the Work of Others

Cosmic Ray Collaboration

Logged in as group: anthro

Logout
My Logbook

Home | Resources | Data | Posters | Site Index | Assessment

View Data | Performance | Lifetime | Flux | Shower | View Plots

Do you trust the detector? Analyze its performance before you use the data for other studies.

You're analyzing...	Chan1 events	Chan2 events	Chan3 events	Chan4 events	Raw Data
Alan Shephard High School 10/1/2004 0:0:1	21241	0	3	15380	View Statistics
Total	21241	0	3	15380	Compare files

Click **Analyze** to use the default parameters. Control the analysis by expanding the options below.

▼ **Analysis Controls**

Channel Number: 1

Number of Bins: 60*2

▶ **Plot Controls**

Analyze

Educational Components based Development at Fermilab: 13 Years of Online Projects

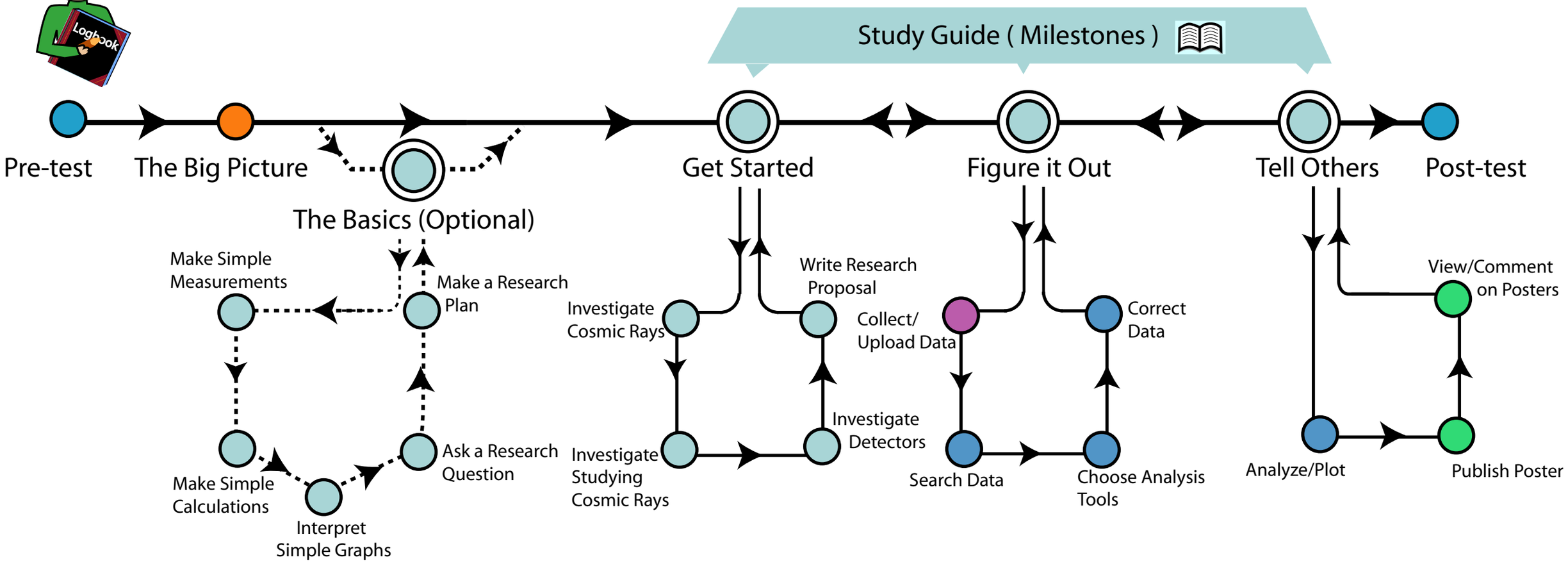
* Long-running expertise in online education projects
* Home of LInC, Leadership Institute Integrating Internet, Instruction and Curriculum
* Research base from NCREL, U.S. Department of Education

Study Guide with References

Your Workflow Map

At these points in your workflow, a teacher monitors your progress by commenting on the entries you make for each milestone in your logbook. Read the comments!

All your Study Guide milestones involve looking at references in the QuarkNet/Grid site and on the Web.



Study Guide with References

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Study Guide (Mil

Pre-test
The Big Picture
The Basics (Optional)
Get Started
Figure it

Make Simple Measurements
Make a Research Plan
Make Simple Calculations
Interpret Simple Graphs
Ask a Research Question

Investigate Cosmic Rays
Write Research Proposal
Collect/ Upload Data
Investigate Studying Cosmic Rays
Investigate Detectors

Search Data
Choose Analysis Tools
Analyze/Plot
Publish Poster

All research starts with things you know. The path winds through areas of knowledge that you don't know, but will need to master. The starting point is the simple and well understood.

Let's describe cosmic rays in simple terms.

Log it!

References

Cosmic Extremes - Excellent cosmic ray overview available to print (pdf file)

SLAC: high energy cosmic rays - read about cosmic rays

NASA: cosmic ray pages - larger perspective

COSMICOPIA: cosmic rays in the news: - current trends

COSMUS: cosmic ray simulation: - centered on Chicago (need QuickTime plugin)

Close Window

Student Logbook

All Entries

- general

Milestones from Research Basics and Study Guide

- if entry exists

Research Basics

- simple measurements
- simple calculations
- simple graphs
- research question
- research plan

A: Get Started

- cosmic rays
- cosmic ray study
- detector
- research proposal

B: Figure it Out

- collect upload data
- search parameters
- analysis tools

Logbook Entry for Group "anthro"

Click to add a logbook entry. Click to view your teacher's comments.

Comments: Number of teacher comments (number unread). New comments by your teacher are marked as .

Research Basics

simple measurements - Notes on simple measurements

01/06/2005 04:11	I find it hard to use meters instead of inches.
12/15/2004 01:50 comments: 3	I wonder why this is called "simple". It doesn't seems so.
12/15/2004 10:34	Try for more.
12/15/2004 10:06	Should I be using metric units for this? Yes I think I should. In fact, I should forget about the units I am use to.
12/07/2004 06:45	I am trying to figure out how to convert my geometry to the right units.
11/30/2004 08:50 comments: 3	Let's see if we can get a different time.
11/30/2004 08:48	I will also try to get use to the energy units.

Comments from Teachers

Comments on Your Logbook Entries for "General Notes"

Comments in red are new. Be sure you read them.

Click to add a logbook entry for "general".

Log Date	Log Entry	Date	Your Teacher's Comments
01/12/2005 01:55	Here's a chance to test the new version.	01/12/2005 02:02	I think you are getting the hang of this. Good work.
01/07/2005 05:37	I think we can use the new version of this. It seems to be working now.	01/07/2005 05:39	I am glad that you think we are ready for this. It seems to be better.
		01/07/2005 05:38	I am glad that you think we are ready for this.
12/15/2004 10:00	I am testing new changes to see if they work. I think this is going to work. I can see why the bottom does not update.	01/07/2005 10:57	I am adding a very long one so that I can test my software to display an elipsis if we make it really long as I am doing here and here and her.
		01/05/2005	THey did not work as I hoped. Let's try

Student Posters

An Experiment to Measure the Rate of Small Showers

6 Detectors in One Building--FNAL's Kuhn Barn

03/11/2005
Thomas Jordan

Abstract

We arranged six readouts (DAQs or detectors) from several area schools and 23 scintillators in a grid that was about 10 meters square. We evenly spaced the detectors inside this square and collected data for nearly 16 hours. We expected to see more events with coincidnences between readouts in this small arrangement as the primaries that create small showers are much more frequent than those that make huge showers.

Procedures

We collected readout boards from Alan Shepard High School, Proviso West High School, University of Illinois-Chicago as well as a few from Fermilab. We set up the experiment in Fermilab's Kuhn barn to avoid the snow and ice. (We also wanted to stay warm!)

Setup included: installing GPS, arranging counters, connecting readouts and cabling to the computers.

We set the coincidence trigger on each readout board to twofold. This is to remove some of the "background" caused by single, uncorrelated muons. We are most interested in showers here so we decided to ignore those.

Results

I only show the most energetic showers here. There are many more results to come from these data but on three occassions, we observed events that triggered at least two readouts with more than 10 signals in less than 100 ns. The first two that I show triggered on three readouts!

Discussions & Conclusions

This early analysis indicates the arrangment of 6 detectors into a small footprint worked. We observed 3 three events (gate = 100 ns) with more than 10 particles in each event.

There are many more events in the data than what we show here. Look for those with fewer particles or shorter gates. Further questions can include:

Other Educational Components

* References
* Tutorials and Background
* Animations
* Glossary
* Site Help
* Rubric to measure progress

Teacher Pages

Teacher Home - Bookmark It!

Abstract:

Students experience the environment of scientific collaborations in this series of investigations into high-energy cosmic rays. From start to finish this is a student-led, teacher-guided project. Schools with cosmic ray detectors can upload data to the web. A virtual data portal enables students to share this data and associated analysis code with students at other schools whether or not those schools have their own cosmic ray detectors.

To begin, students check the performance of the detectors they have chosen for their study. They can then perform one of three investigations: muon lifetime, muon flux or extended air showers. Students post the results of their studies as online posters. Then the real scientific collaboration begins. Students can review the results of other studies online comparing data and analyses. Using online tools, they can correspond with other research groups, post comments and questions, prepare summary reports, and in general participate in the part of scientific research that is often left out of classroom experiments.

Logout
If you are not **margaret**,
Logout

Teacher's Private Logbook

Teachers: View Your **Private** Logbook on Student Research Groups

Student Logbooks

By Milestone

By Group

Your Logbook:
general

Select a Research Group

anthro
lovinspoonful
macro
socio
All Groups

Click to add/edit logbook entry.

For all groups for teacher "mmead"

anthro

12/15/2004 02:43	This group is having trouble with measurement. Maybe we should do some classwork.
12/15/2004 02:43	This group is having trouble with measurement.
12/15/2004 02:42	This group is having trouble with measurement.
12/08/2004 05:44	This group has been working very well for the past few weeks. They are particularly keen on searching for good data.
12/08/2004 02:19	I am Margaret and I am making notes on anthro

socio

12/08/2004 05:50	These students work very well together. I am pleased with their work.
12/08/2004 02:19	I am Margaret and I am making notes on socio

Comments on Student Logbooks

Teachers: View and Comment on Logbooks of Student Research Groups

By Group

My Logbook

general

Select a Milestone:

Research Basics
simple measurements
simple calculations
simple graphs
research question
research plan

A: Get Started
cosmic rays
cosmic ray study
detector
research proposal

B: Figure it Out
collect upload data
search parameters
analysis tools
data error

C: Tell Others

Click **Read more** to read full log entry and reset "new log" status.

Click to add and view comments on a logbook entry.

Log Status: New log entries are marked as New log entry. Number of your comments (number unread by students.)

All logbook entries for your research groups for "General Notes"

Group: "anthro"

01/12/2005 01:55 comments: 1	Here's a chance to test the new version. . . .Read more
01/07/2005 05:39	I think we can use the new version of this. It see . . .Read more
01/07/2005 05:37 comments: 2	I think we can use the new version of this. It see . . .Read more
12/15/2004 10:00 comments: 3	I am testing new changes to see if they work. I t . . .Read more
12/15/2004 09:50	I am testing new changes to see if they work. . . .Read more
11/30/2004 08:46 comments: 3	I have been trying to go through all the milestone . . .Read more

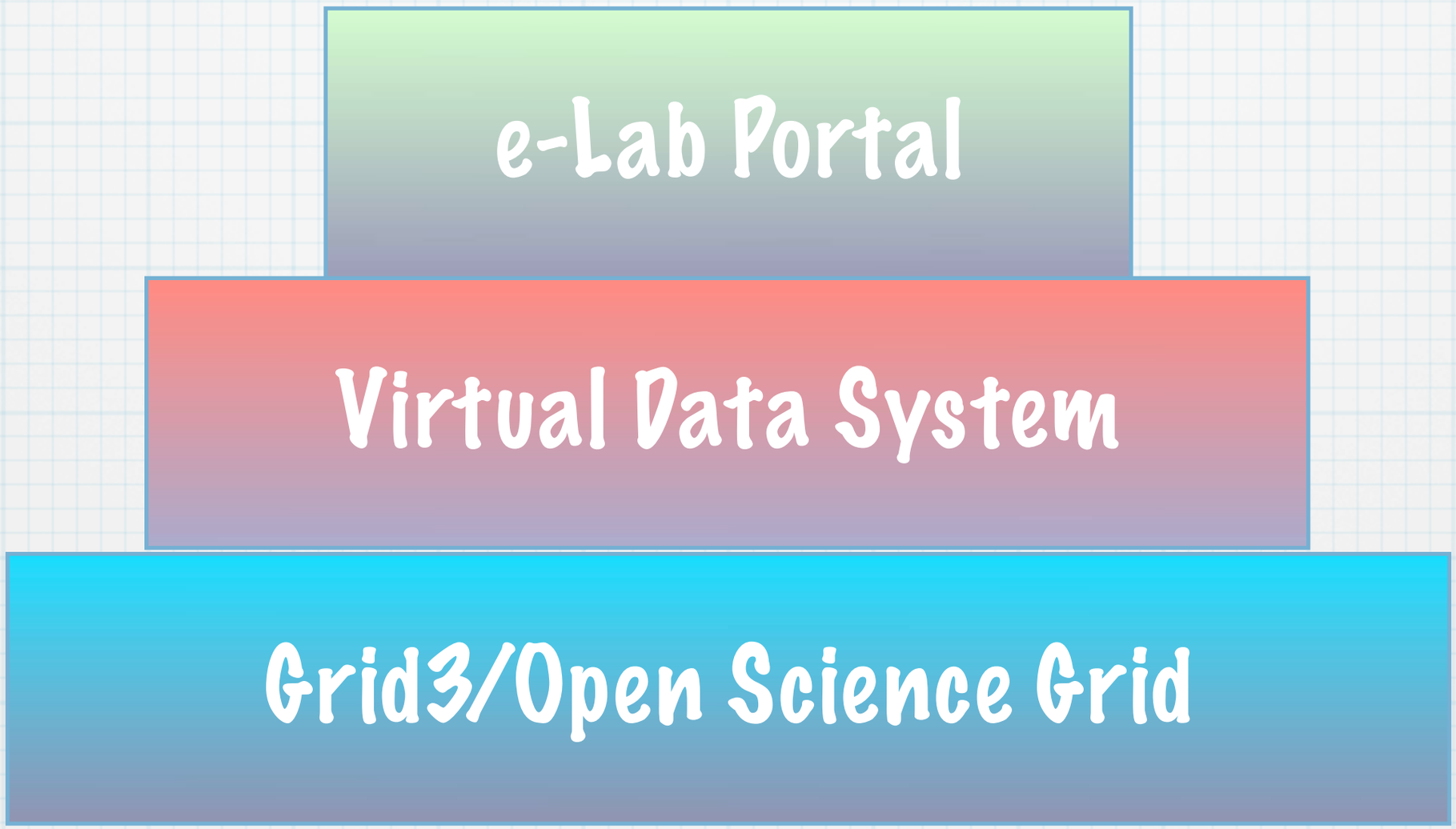
Outline of Talk

* Introduction to the Cosmic Ray e-Lab
* Overview of the Web Portal
* Implementation
* Scaling Up
* Current Development
* Lessons Learned
* Invitation / Credits

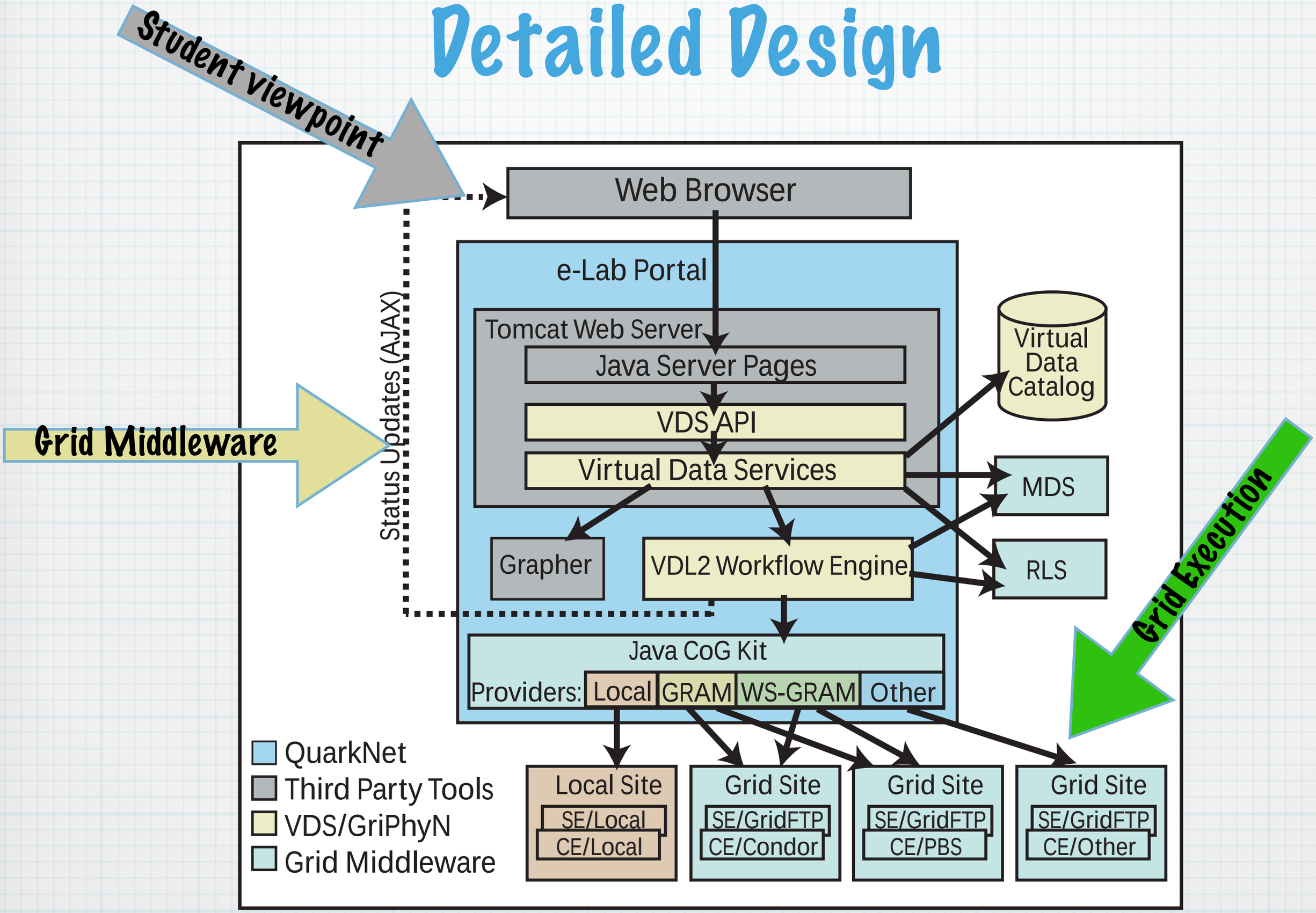
Design Basics for Portal

* Requires the GriPhyN Virtual Data System (VDS)
* Serves JavaServer Pages from Apache Tomcat
* Interfaces to local and Grid planners
* Uses PostGres database for user registration and logbooks.

QuarkNet/Grid: Big Picture



Detailed Design

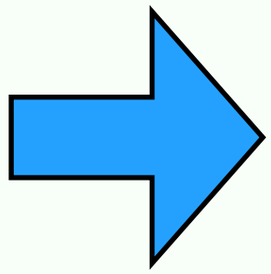


Transformations & Derivations

* Transformations stitch together code into one workflow for local or grid execution.
* Derivations invoke transformations with specific inputs, like a function call.

```
TR Quarknet.Cosmic::LifetimeStudy(
        inout combineOut,
        none detector,
        none extraFun_alpha_guess,
        none extraFun_alpha_variate,
        none extraFun_constant_guess,
        none extraFun_constant_variate)
```

Transformation



```
DV Quarknet.Cosmic::LifetimeStudy>
anonymous(
        combineOutfile,
        180,
        2.3,
        7,
        1.73,
        100.27)
```

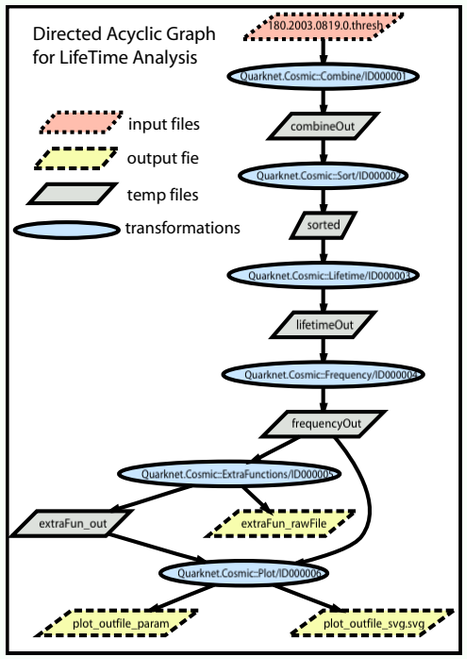
Derivation

Provenance

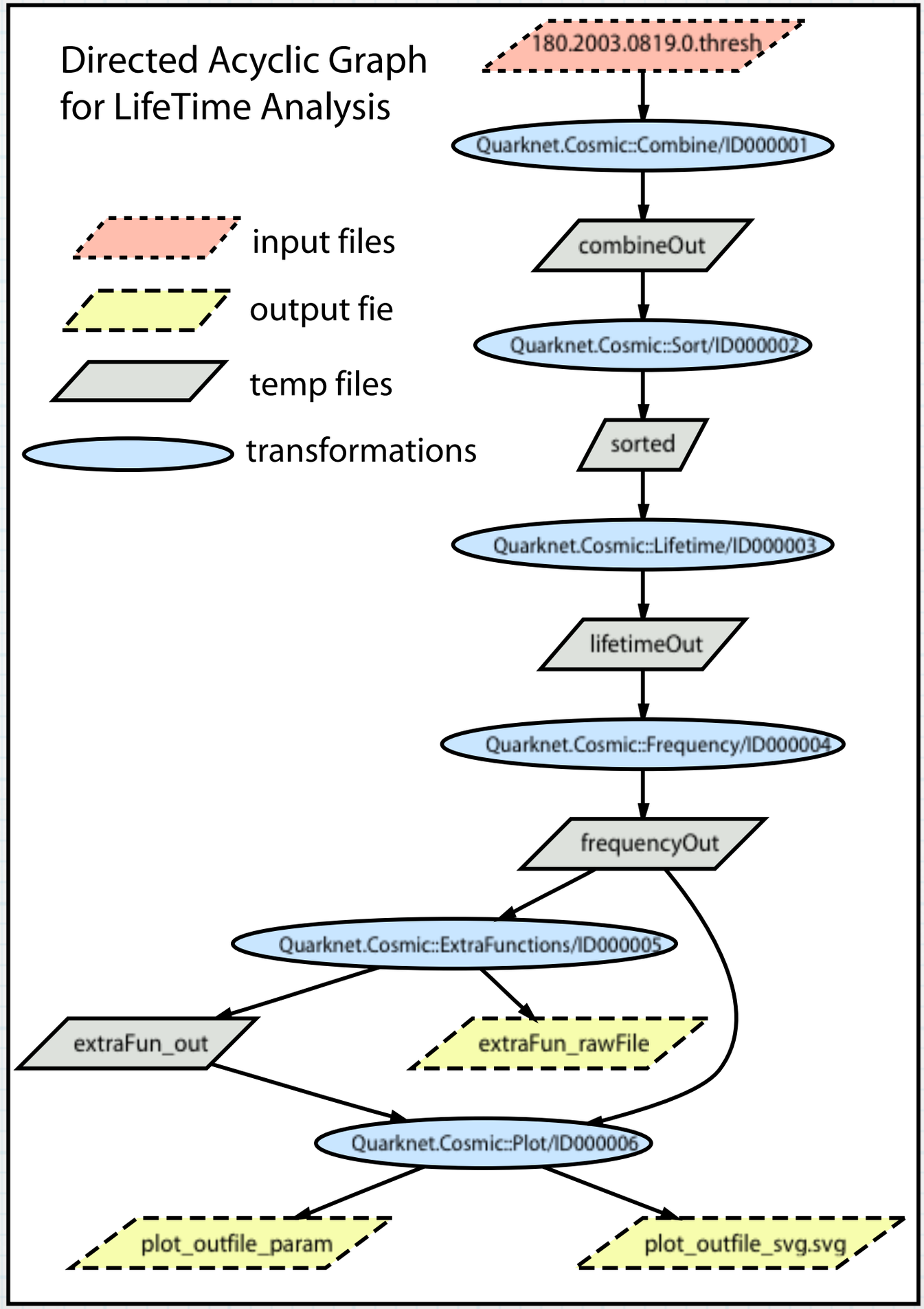
* Provenance is the audit trail for the computation of a data product.
* Students collaborate by extending others computations using provenance.

```
TR Quarknet.Cosmic::LifetimeStudy(
        inout combineOut,
        none detector,
        none extraFun_alpha_guess,
        none extraFun_alpha_variate,
        none extraFun_constant_guess,
        none extraFun_constant_variate)
```

Virtual Data Language



Provenance


Directed Acyclic Graph
for LifeTime Analysis
input files
output fie
temp files
transformations
180.2003.0819.0.thresh
Quarknet.Cosmic::Combine/ID000001
combineOut
Quarknet.Cosmic::Sort/ID000002
sorted
Quarknet.Cosmic::Lifetime/ID000003
lifetimeOut
Quarknet.Cosmic::Frequency/ID000004
frequencyOut
Quarknet.Cosmic::ExtraFunctions/ID000005
extraFun_out
extraFun_rawFile
Quarknet.Cosmic::Plot/ID000006
plot_outfile_param
plot_outfile_svg.svg

Metadata

* Data about data
* Exist on transformations, files and virtual files

Metatag	Value
author	Thomas Jordan Liz Quigg Eric Gilbert Bob Peterson
city	Batavia
date	2004-11-1000:00:00.0
group	Fermilab
name	poster_decays.data
plotURL	users/.../fermigroup/plots
project	cosmic
school	Fermilab
state	IL
teacher	Jordan
title	Possible Particle Decays
type	Poster
year	AY2004

Metadata: Arbritrary Schemas

Facilitate many functionalities in the portal:

* searches
* comments of data, plots, posters
* references
* glossary
* variable annotations

Outline of Talk

* Introduction to the Cosmic Ray e-Lab
* Overview of the Web Portal
* Implementation
* Scaling Up
* Current Development
* Lessons Learned
* Invitation / Credits

From Case Study . . .

QuarkNet GriPhyN Data Intensive Science iVDgL US ATLAS US CMS

. . . to Education Virtual Organization

ADLER PLANETARIUM & ASTRONOMY MUSEUM

CHEPREO
CENTER FOR HIGH ENERGY PHYSICS RESEARCH & EDUCATION OUTREACH

MARIACHI

LIGO

PHYSICAL SCIENCES
INFORMATION TECHNOLOGY
EDUCATION

UNDERSTANDING THE UNIVERSE
Education & Outreach

STAR

Grid3

QuarkNet

GriPhyN
Data Intensive Science

iVDgL

US ATLAS

US CMS

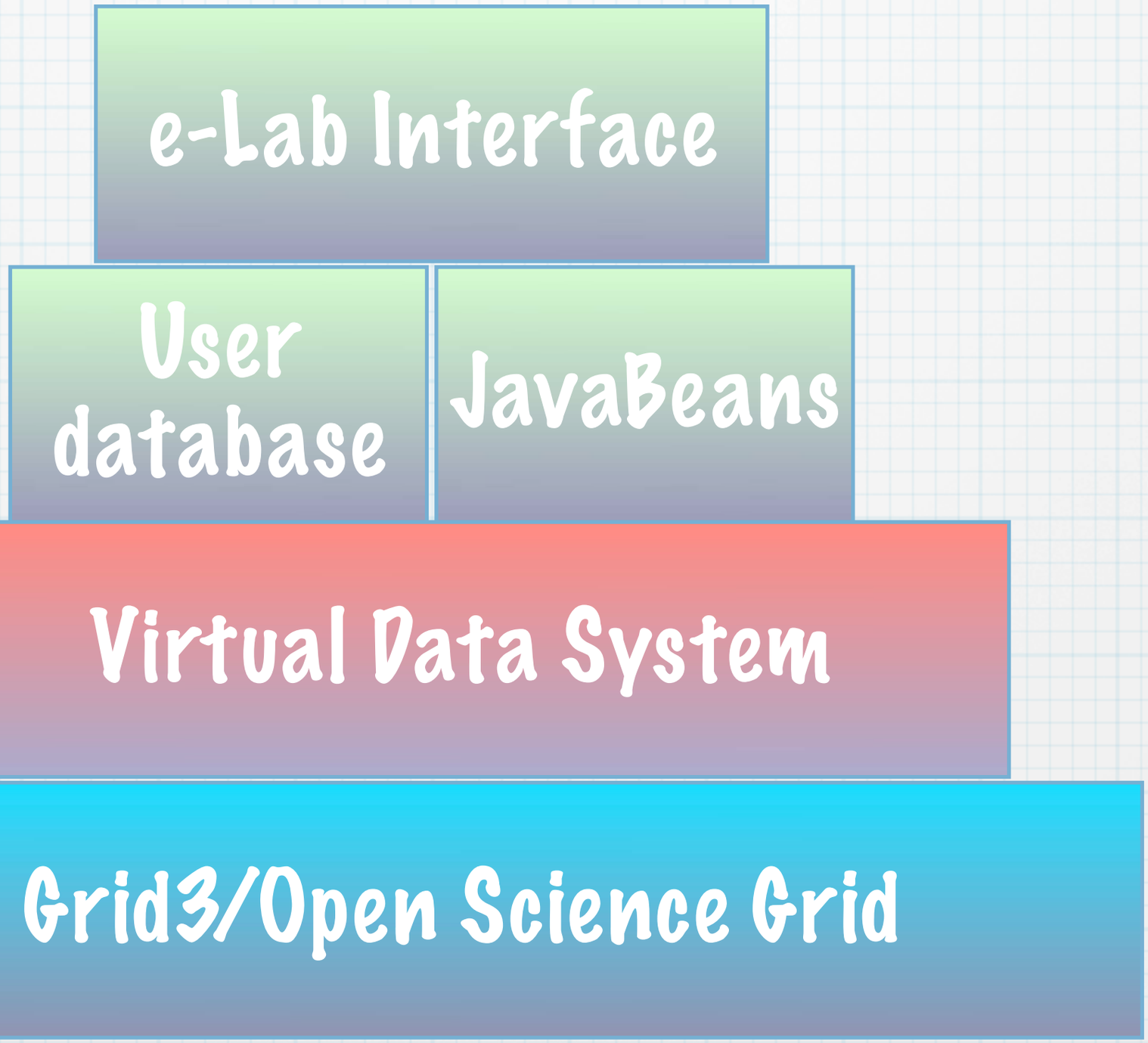
Open Science Grid

Interactions in Understand the Universe
http://ed.fnal.gov/uueo/i2u2.html

Scaling = Rethinking Our Original Design

* The Cosmic e-Lab started as a pilot program with primary focus on a working model.
* Now, we aim to support new e-Labs using the same tools, look and feel, general architecture, etc.
* CMS test beam data and LIGO are currently in development.

Building Blocks



User Database for VO

* VO means Virtual Organization.
* VOs have users that come from many different institutions, and may only have a common interest binding them together.
* The e-Lab VO consists of developers, scientists, teachers and most

Framework

Cosmic Ray
e-Lab

Analysis Code

VDL Workflows

Data

Content

Registration

Comments

Logbook

Study Guide

Workflows

Execution

Search

References

Glossary

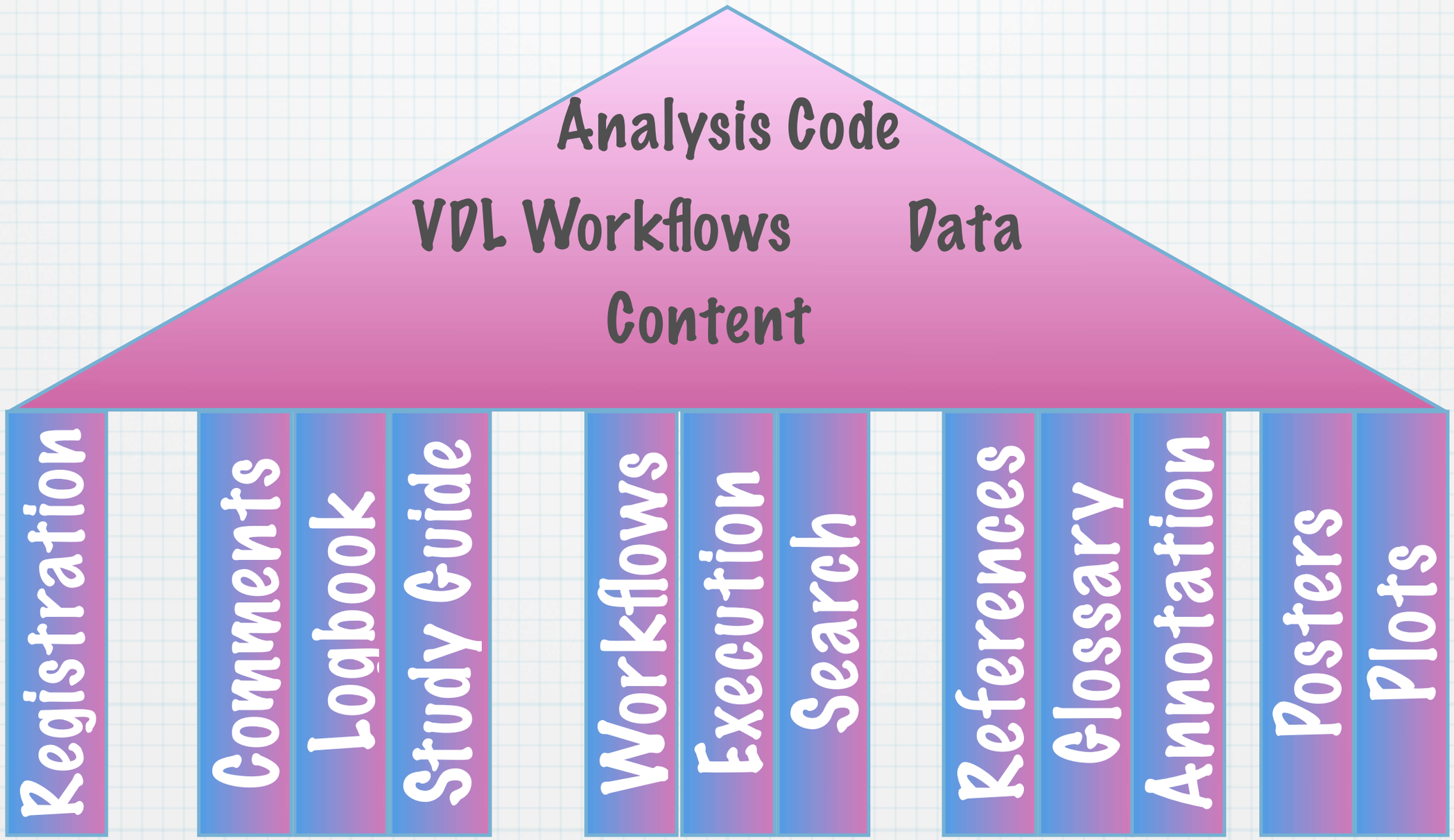
Annotation

Posters

Plots

e-Lab Independent Components

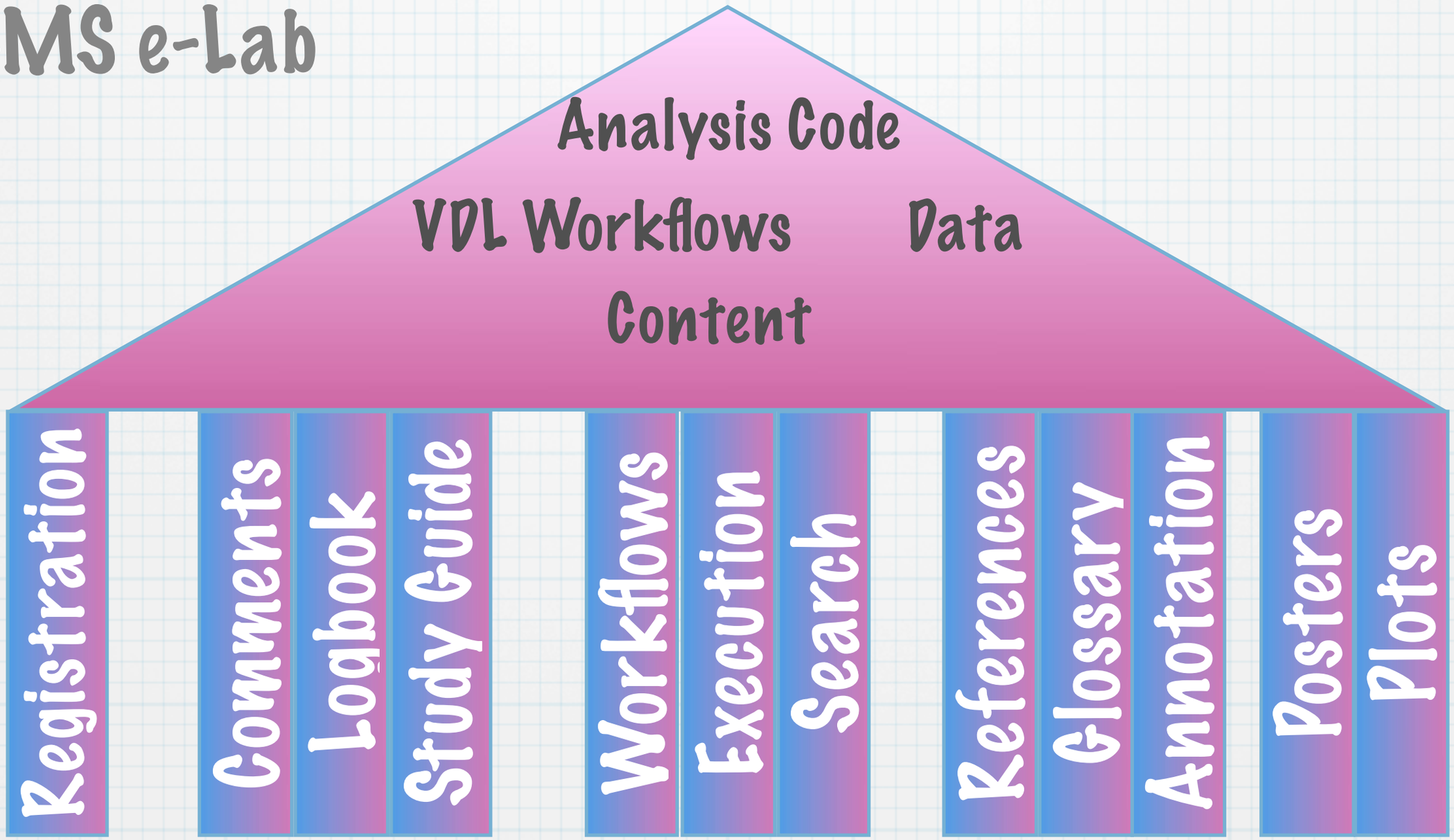
Framework



e-Lab Independent Components

Framework

CMS e-Lab



e-Lab Independent Components

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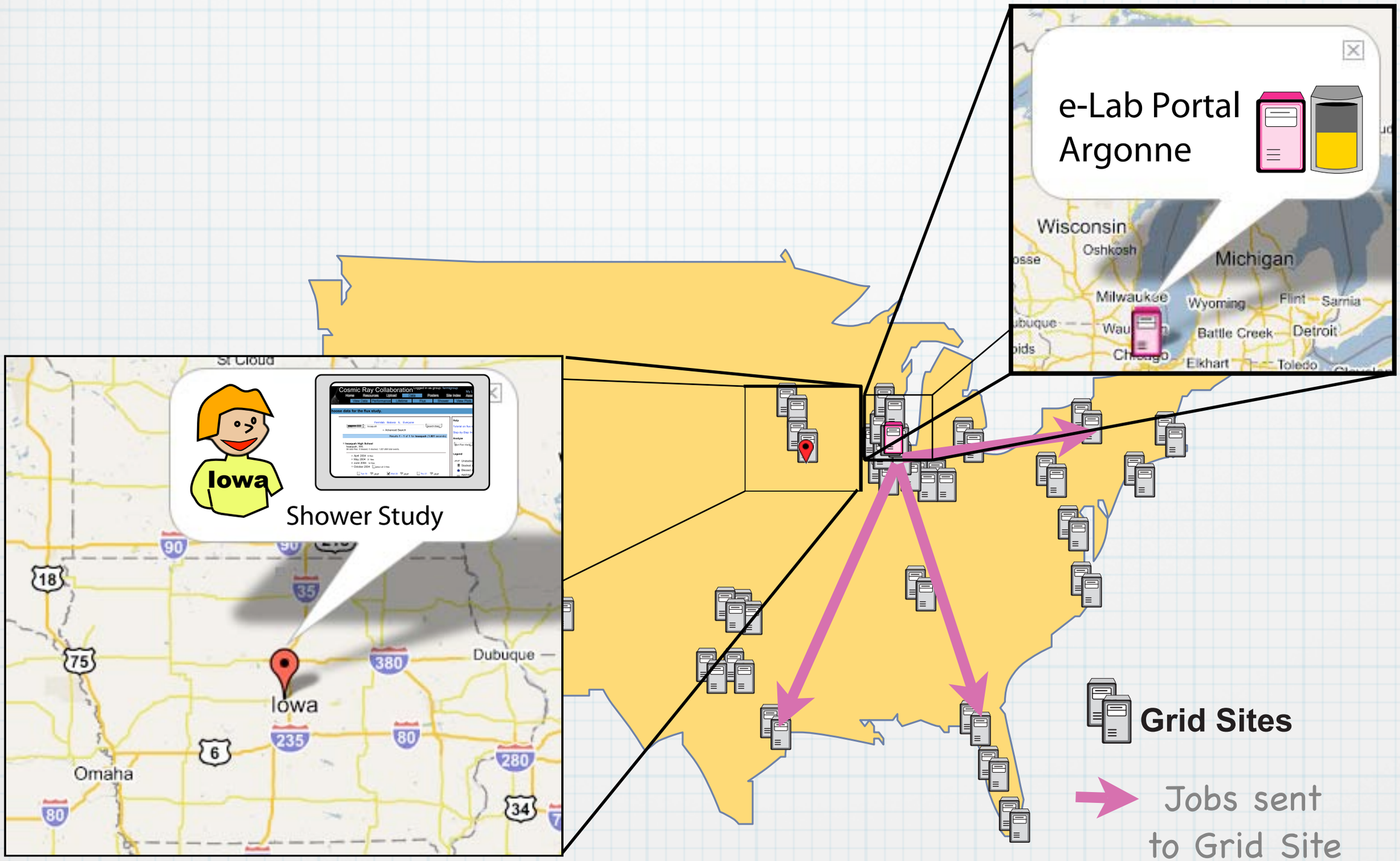
Currently Developing

* Grid Execution
* Newer VDL and Grid middleware
* More e-Labs (LIGO), i-Labs (Adler)
* Educational Content from Teachers
* Transformations (Analysis Code)

Using the Grid to Handle Calculations with Lots of Data



Using the Grid to Handle Calculations with Lots of Data

Calculate the flux for your data file. Remember, flux = particles / time / area

Understand The Graph

You're analyzing...	Chan1 events	Chan2 events	Chan3 events	Chan4 events	Raw Data
Fermilab Apr 21, 2006 23:55:51 GMT	92	67	35	49	View Statistics
Total (1 files 243 events)	92	67	35	49	Compare files

Analyze these same files in study: lifetime shower

Click **Analyze** to use the default parameters. Control the analysis by expanding the options below.

▽ **Analysis Controls**

? Channel Number: 1

▷ **Plot Controls**

▽ **Execution Controls**

? Run mode:

○ Local
◉ Local and Grid
○ Grid

Analyze

Select Grid Execution

Using the Grid to Handle Calculations with Lots of Data

ID	Name	Status	Results
3603	FluxStudy	Completed	See results
3649	FluxStudy	Completed	See results
4098	FluxStudy	Running; 71 % Completed	

Currently Developing

CMS e-Lab using test beam and ROOT

Home | Library | Data | Posters | Site Index

Join a national collaboration of high school students to CMS test beam data.

How small is small?

How small is so small that we can get no smaller ?

Why do objects have mass ?

How do scientists "see" particles much smaller than an atom ?

Understand how a 12,000 ton detector "sees" electrons, muons and other particles.

Who are we?

We're a collaboration of high school students and teachers analyzing data from the Compact Muon Solenoid Collaboration, CMS, experiment at CERN in Geneva, Switzerland to answer some of these questions. We're working with computer scientists to provide cutting edge tools that use grid techniques to help you share data, graphs, and posters and collaborate with other students nationwide.

Who can join?

You! Think about steps you'd take to investigate particle collisions at the highest accelerator energies. How would you get started? What do you need to know? Can you analyze data?

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Lessons Learned
We have users!

* 235 teachers in 219 high schools
* 491 student research groups
* 31,200 analyses run
* 230 detectors in high schools
* 7484 data files (about 7500 days worth)
* 87 posters published

Lessons Learned

* Grid work is bleeding-edge and harder than it looks.
* Professional development for teachers is critical.
* Developers must work within technical constraints of schools.
* It's premature to understand how the Grid enhances education.
* Computer Scientists learn from e-Labs.

An Invitation

Join us in building new e-Labs using data from experiments at your labs

RSVP: e-labs@fnal.gov

Credits

* Fermilab - Marge Bardeen, Eric Gilbert, Tom Jordan, Liz Quigg, Bob Peterson, Students: Nick Dettman, Paul Nepywoda, Hao Zhou
* Argonne/University of Chicago - Mike Wilde, Ben Clifford, Mihael Hategan, Douglas Sheftner, Tiberiu Steff-Praun, Student: Yong Zhao
* QuarkNet/Notre Dame Center - Dan Karmgard, Thomas Loughran, Pat Mooney, Lynda Rose