SLAC: Opportunities and Goals

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SCA

9 Feb 2011

Outline

- Executive Summary
- Current projects status
  - Accelerator based
    - BABAR
    - ATLAS
    - xrootd
    - HEP Theory
    - Accelerator Modeling
  - Non-accelerator based
    - Fermi
    - EXO & CDMS
    - KIPAC
- Scientific Computing Applications
  - Data Handling
- LCSim
- Future Directions
- Issues

Executive Summary (I)

- Supporting 3 active (Fermi, EXO, ATLAS T2) and 1 ramping down (BABAR) experiments
  - Issues
    - Fermi – maintaining a complex operation for 10 years
    - BABAR – what to do with their large collection of compute resources
- Hardware: ~8000 cores, 3 PB disk
- Formed Scientific Computing Applications department in PPA to leverage support for common efforts:
  - pipeline processing, data monitoring, visualisation, collaborative apps (eg collaboration databases), etc
    - Being applied to LSST, SCDMS, EXO, Fermi; hope for CTA
    - Issue: there is not a stable funding base to work from
  - xrootd: gaining ground as key element of cluster file access in LHC
    - Issue: support for and collaboration on a growingly popular product
  - GEANT4 team (see Makoto Asai's talk)

Executive Summary (II)

- Accelerator modeling: develops state-of-the-art parallel electromagnetic codes for the accelerator community to support the design and optimization of present and future accelerator facilities at the energy and intensity frontiers.

- HEP Theory is now more computing intensive with emphasis on LHC simulations
  - needs to integrate into the Lab environment to obtain cycles more efficiently

- LCSim has been developed for Linear Collider detector simulations/ reconstruction studies.
  - Issue: support hinges on success of Lepton Collider White Paper/proposal

- Future efforts expected on DES, LSST and the Cosmology Computing Initiative

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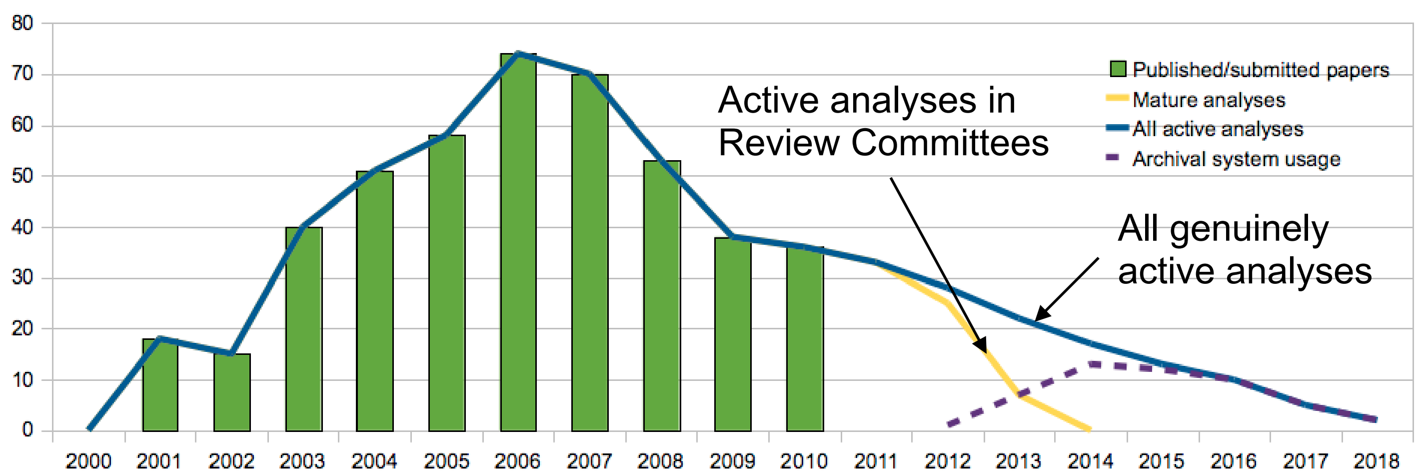
BaBar Data and Legacy

- BaBar has collected data from Oct 22nd 1999 to Apr 7th 2008
  - 800TB of raw data, 1.2 PB from the last data reprocessing
- 446 published/accepted papers to date
- 126 active analyses
- BaBar (and Belle) data will not be superseded by LHC data
  - Belle II and SuperB will do it in 5-10years
- The BaBar Long Term Data Access (LTDA) project aims to preserve both the data and the ability to do analysis until at least 2018 and will provide support for >50 publications foreseen beyond 2012
  - Need to account for the dwindling resources (both manpower and money)



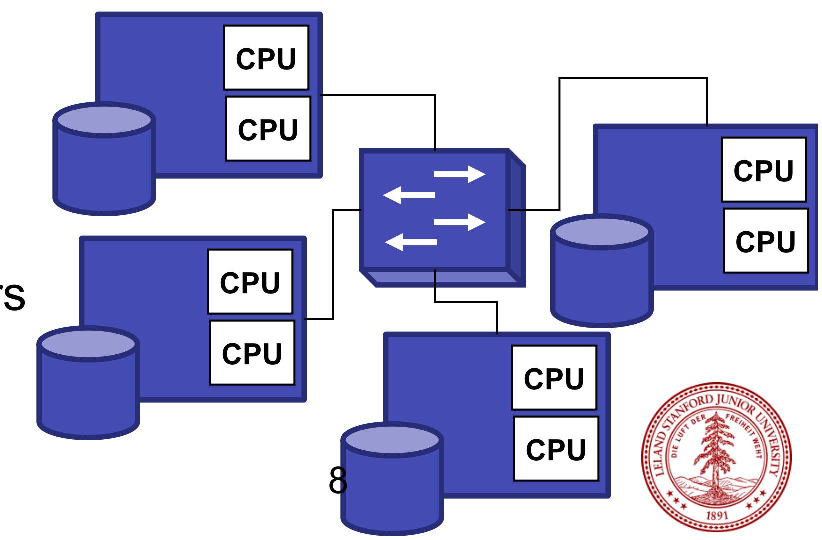
NATIONAL ACCELERATOR LABORATORY

The LTDA

- Insure the ability to do analysis on the BaBar data beyond 2012 preserving:
  - Data, conditions and calibrations
  - Releases and tools
  - Databases
  - Capability of doing production
  - Capability of running user jobs
  - Documentation
- Providing a stable environment
  - Last validated OS enclosed in a virtualization layer running the BaBar Framework
- Open formats
  - Data format is based on root which is open and will be part of the system
  - Databases will move away from Oracle and will be stabilized on MySql
  - Code is written in open formats: C/C++, Tcl, Perl, Python.
- Data Storage
  - 2PB will be stored on tape in two TierA sites (SLAC, CCIN2P3)
  - Limited access due to limited tape drives, and limited tape library support fees
  - Most used data will sit on disk

LTDA Hardware

- As the Collaboration shrinks the Tier sites will fade away and all work will collapse at SLAC on a dedicated computing farm
- LTDA Prototype at SLAC
  - strong collaboration of PPA & CD to acquire the prototype system finalize the setup details (OS, networking, account administration, security, storage, ...
  - We expect to have the basic functions up by Q1.
- Half system will be ready by Fall 2011, full deployment in Spring 2012
- The LTDA farm model is self contained, modular, expandable, exportable
  - 60 Dell R510 with two 6-core CPUs and 24TB of disk
  - Distributed storage and computing resources
    - Actively used data on disk
    - Each node provides both CPU and storage
- Manpower: 1FTE will be added in March
  - New Research Associate position filled
- Issue: will roll off some 5000 cores in next 2 yrs



LTDA and DPHEP

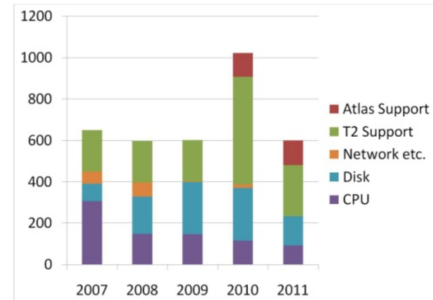
- The BaBar LTDA Project is also part of the Data Preservation in HEP Study Group
  - http://dphep.org/
  - Next workshop: May 16th-18th 2011 at FNAL
- The DPHEP is a ICFA panel and promotes experiment level projects of data preservation in all the major labs in order to avoid loss of data after the collaborations are dissolved or are too small to support their infrastructure
- The DPHEP also promotes inter-collaboration communication
  - Sharing experiences
    - BaBar, H1/Zeus, Belle, Bes III, Jade, …
  - Defining common projects
    - Data preservation
      - Virtualization and archival infrastructure, data migration and validation, …
    - Documentation
      - Extension and enhancement of documentation by storing figures, n-tuples/root-tuples, and other legacy documents
    - Outreach
      - Standard format tools

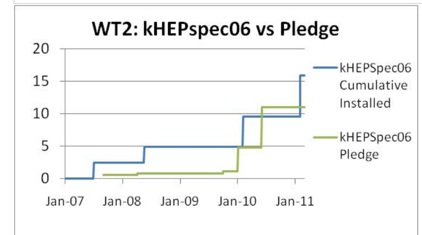
ATLAS Western Tier 2

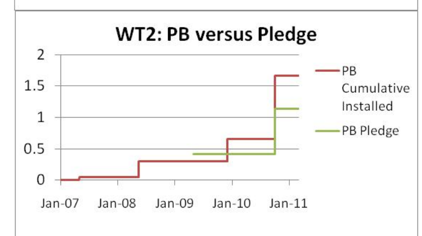
- The only DOE-funded Tier 2
- Delivers a solid CPU+Disk service to ATLAS
- CPU resources integrated into SLAC's batch farm
- Averages over 200% of "pledged" CPU due to opportunistic use of batch farm
- Center of xrootd expert support for ATLAS
  - "Atlas Support" on "WT2 Funds" chart
  - xroot development for ATLAS funded separately
- Projected Capacity

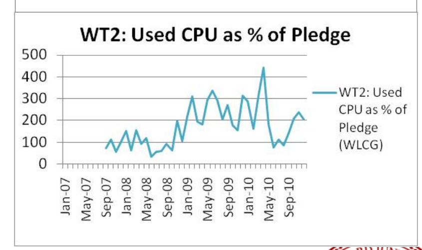
	2011	2012	2013	2014	2015	2016
CPU kHS06	19	24	29	36	48	61
Disk PB	2.1	2.6	3.3	3.5	4.8	6.0

Use of WT2 Funds $k









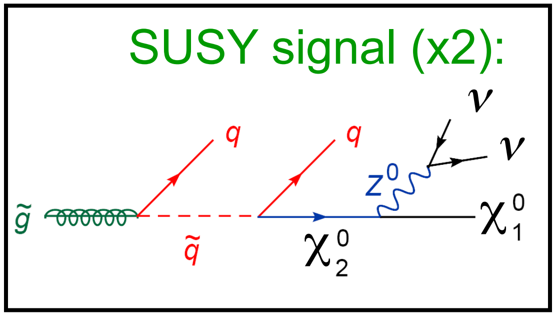
HEP Theoretical Physics

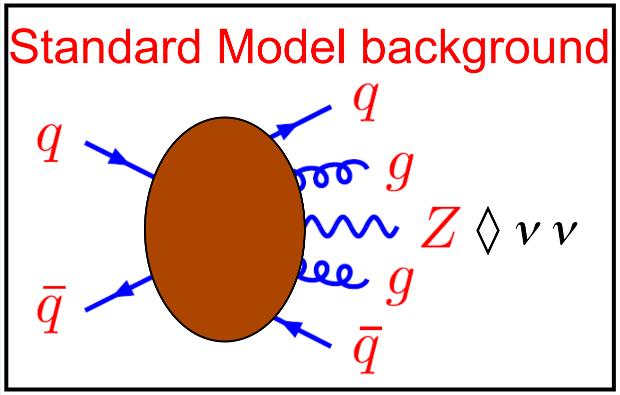
- Performing ever more precise simulations for LHC physics (Standard Model backgrounds and New Physics signals)

- New staff member joining the group in the Fall (Hoeche)
  - Specialty is development and maintenance of Sherpa, a sophisticated event generator, widely used by collider experiments
  - SLAC will become lead lab for Sherpa
  - Will also join BlackHat team
  - Result in increased demand for cycles for theoretical physics

BlackHat[+SHERPA] Motivation: Control SM backgrounds to dark matter production at LHC, & to other new physics

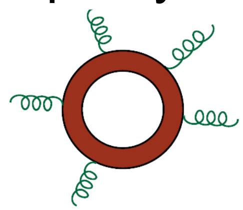
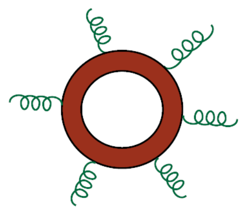
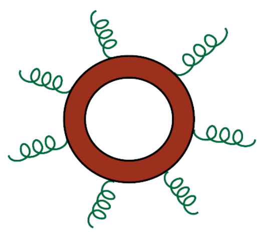
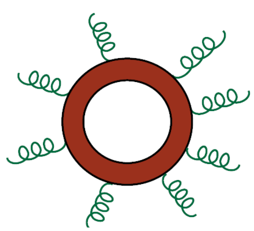
- Dark matter escapes detector
  → no clean mass bump to reconstruct
- Typical events have
  missing energy + jets (+ leptons?)
- For example, supersymmetry:
  Gluinos → squarks → neutralinos (dark matter)
  - Signal: Missing energy + jets
  - Background: *Z* + jets *Z* → neutrinos
- Need to understand the dominant background:
  pp → *Z* (or *W*) + n jets, n=1,2,3,4.
  See CMS paper, 1101.1628
- **BlackHat** collaboration (SLAC theorists + UCLA + Saclay + ...) is providing the best available predictions for the Standard Model backgrounds, based on next-to-leading order QCD.
- LO → NLO QCD reduces uncertainties from "factor of 2" to ~ 20 %.





NLO Computations for Multi-Jet Final-States are Difficult

Feynman diagrams become intractable

# of jets	# 1-loop Feynman diagrams (gluons only)	
3		810
4		10,860
5		168,925
6		3,017,490

On-shell methods, exploiting **analyticity**, are more efficient for multi-gluon + quark processes

Methods developed in collaboration between SLAC, UCLA, Saclay dating back to 1994.

Now automated in a C++ program, **BlackHat,** interfaced to **SHERPA** for real emission + process control

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Accelerator Modeling under ACD

With funding from

- *SLAC/Accelerator Research Division – 5.5 FTE*
- *SciDAC (OHEP, OACSR, and OBES) – 3.5 FTE,*

the Advanced Computations program develops the software solutions for the national and international accelerator community by focusing on

- *Parallel Code Development in Electromagnetics (EM)*
- *R&D in applied math and computer science under SciDAC*
- *Accelerator Modeling for Accelerator Science and Accelerator Development*
- *High-performance Computing to support Large scale Discovery simulations*

to advance the electromagnetic simulation tools to benefit the RF design of existing and future accelerator facilities in the US and beyond.

This unique capability allows accelerators to be modeled and designed with an accuracy and at a scale previously not possible.

It has the potential to replace commercial software thus lowering the project cost throughout the DOE accelerator complex.

Parallel EM Code Suite ACE3P and User Community

ACE3P (Advanced Computational Electromagnetics 3P) Code Suite
https://slacportal.slac.stanford.edu/sites/ard_public/bpd/acd/Pages/Default.aspx

- conformal, higher-order, C++/MPI parallel finite-element based electromagnetic codes
- supported by SLAC and DOE HPC Grand Challenge (1998-2001), SciDAC1 (2001-06), SciDAC2 (2007-12)

Modules include

Frequency Domain:	**Omega3P**	– **Eigensolver (damping)**
	S3P	– **S-Parameter**
Time Domain:	**T3P**	– **Wakefields and Transients**
Particle Tracking:	**Track3P**	– **Multipacting and Dark Current**
EM Particle-in-cell:	**Pic3P**	– **RF Gun and Klystrons**
Multi-Physics:	**TEM3P**	– **EM, Thermal & Structural Analysis**

ACE3P Code Workshop – http://www-conf.slac.stanford.edu/cw10/default.asp

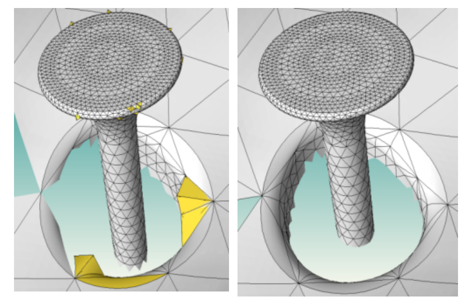
CW09 (15 attendees from 13 institutions)

CW10 (36 attendees from 16 institutions) that include *SLAC – 10, Cornell – 5, CERN – 2, LLNL – 2, NSCL – 2, LBNL – 1, Jlab – 1, Darsbury – 2, PSI – 2, U of London – 2, U of Manchester – 2, U of Oslo – 1, ODU – 1, FarTech – 1, Beam Power -1. Kitware - 1*

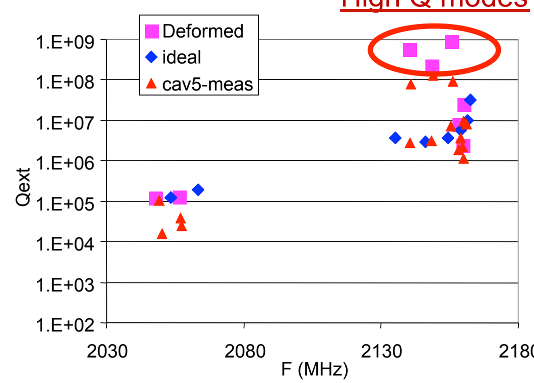
Computational Science R&D under SciDAC

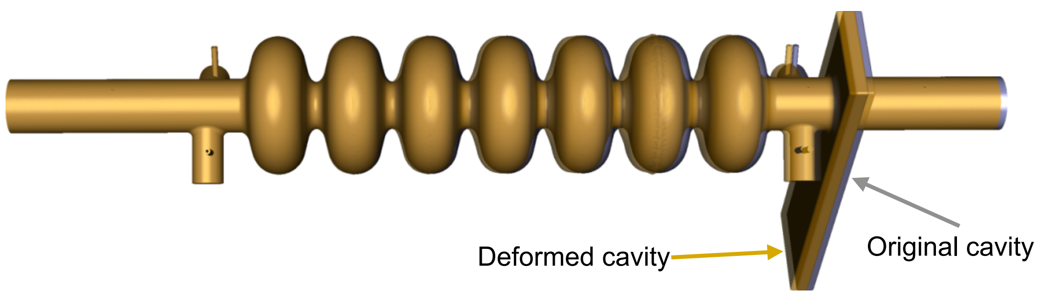
- R&D on computer science and applied math is an essential component of the SciDAC ComPASS effort on electromagnetics
- It facilitates the collaboration with the **SciDAC** Centers for Enabling Technologies & Institutes such as TOPS, ITAPS, CSCAPES, CScADS, and IUSV in developing the technologies that enable large-scale simulations
- Achievements include scalable solvers for TOPS (LBNL) and advanced meshing techniques for ITAPS (RPI)
- Collaborations in **experimental diagnosis, advanced computing and applied math** solved the Jlab Beam Breakup problem. Solutions to the inverse problem identified the BBU instability due to **Cavity being 8 mm shorter** – predicted and confirmed later from measurements

Mesh correction



High Q modes

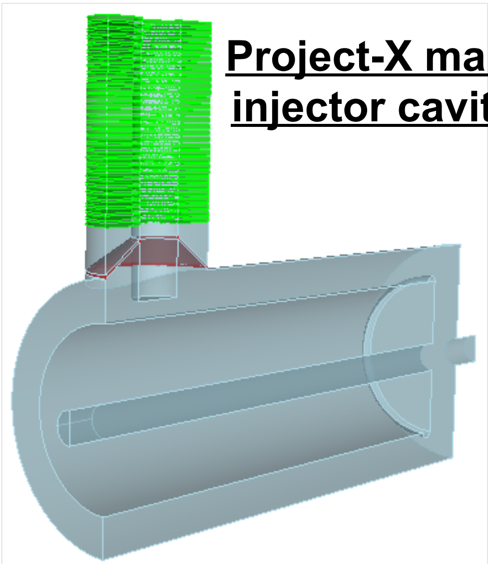




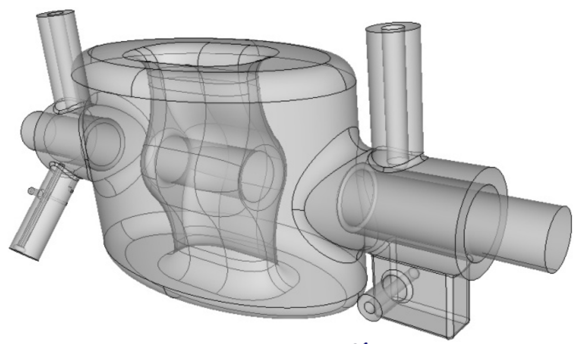
Modeling for Accelerator Science and Development

ACE3P has been applied to a wide range of accelerator projects in Accelerator Science and Development including CLIC, LHC, Project-X, and high gradient R&D

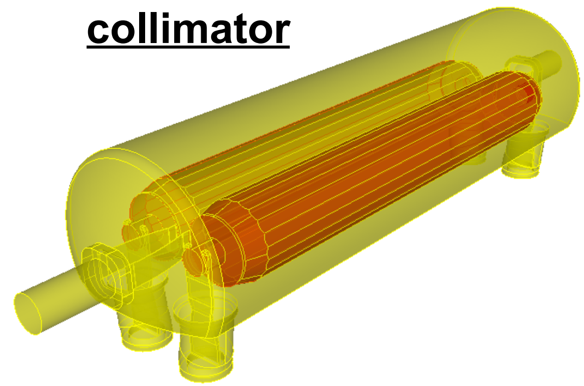
Project-X main injector cavity



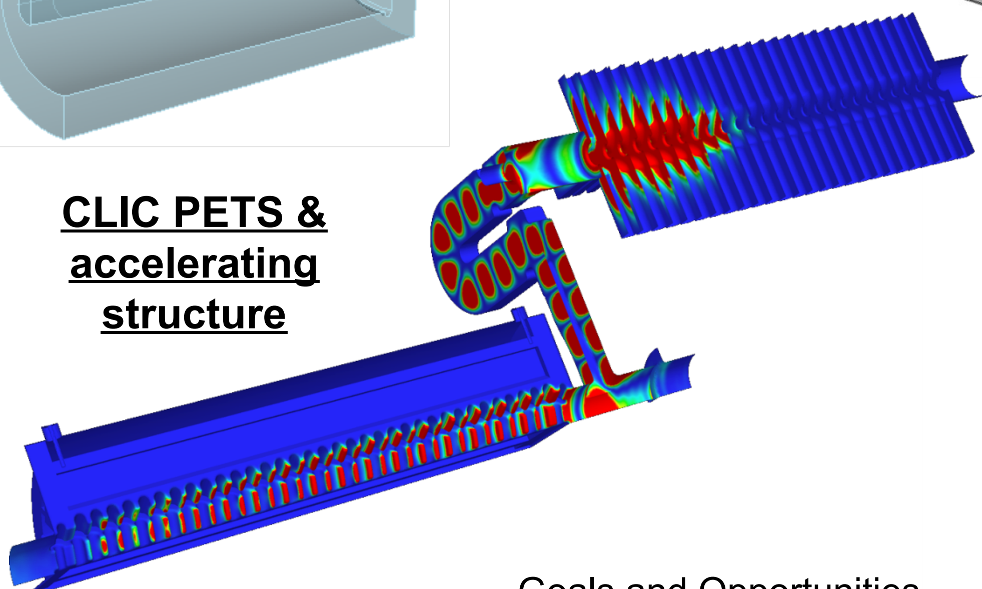
LHC deflecting cavity



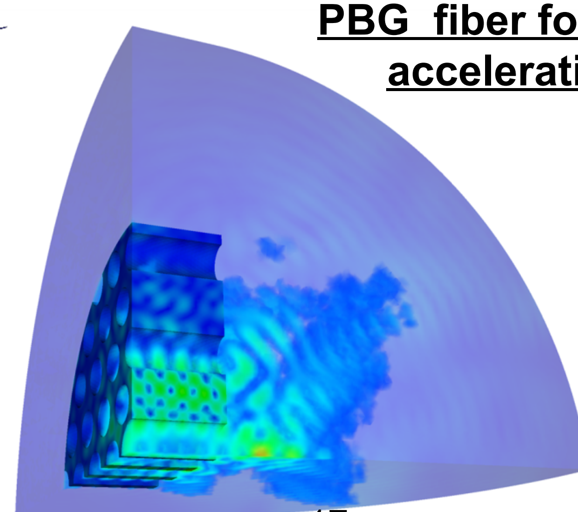
LHC rotatable collimator



CLIC PETS & accelerating structure

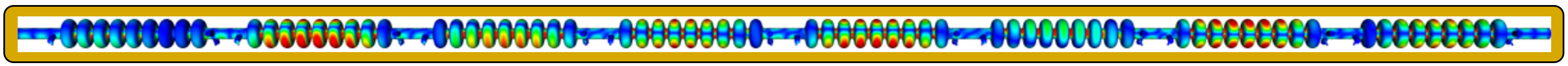


PBG fiber for laser acceleration

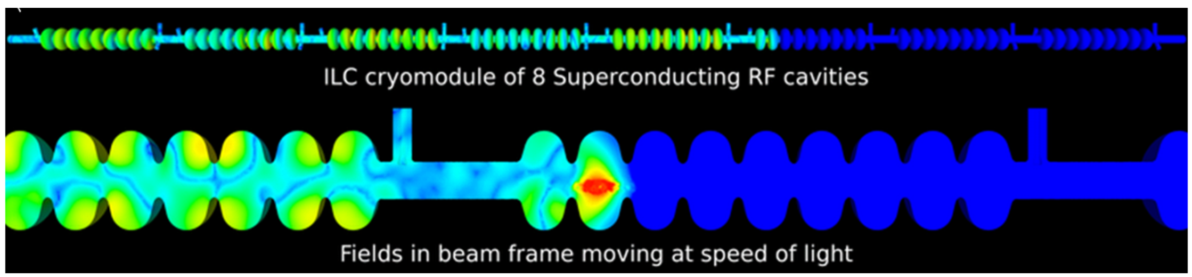


HPC for Large-scale Simulation

Simulating a cryomodule of 8 cavities for the ILC in frequency and time domain



Omega3P - 3 million-element mesh, ~20 million DOFs, 1024 CPUs (Seaborg), 300 GB memory, 1 hour per mode.



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T3P - 80 million-element mesh, ~500 million DOFs, 4096 CPUs (Jaguar), 4 seconds per time-step

ASCR resources –

NERSC (1) *Advanced Modeling for Particle Accelerators* **- 1M CPU hours**, renewable

(2) *SciDAC ComPASS Project –* **1.6M CPU hours,** renewable (shared)

(3) *Frontiers in Accelerator Design: Advanced Modeling for Next-Generation BES Accelerators* **- 300K CPU hours**, renewable (shared) each year

NCCS (1) **INCITE award** - *Petascale Computing for Terascale Particle Accelerator: International Linear Collider Design and Modeling* - **12M CPU hours** in FY10

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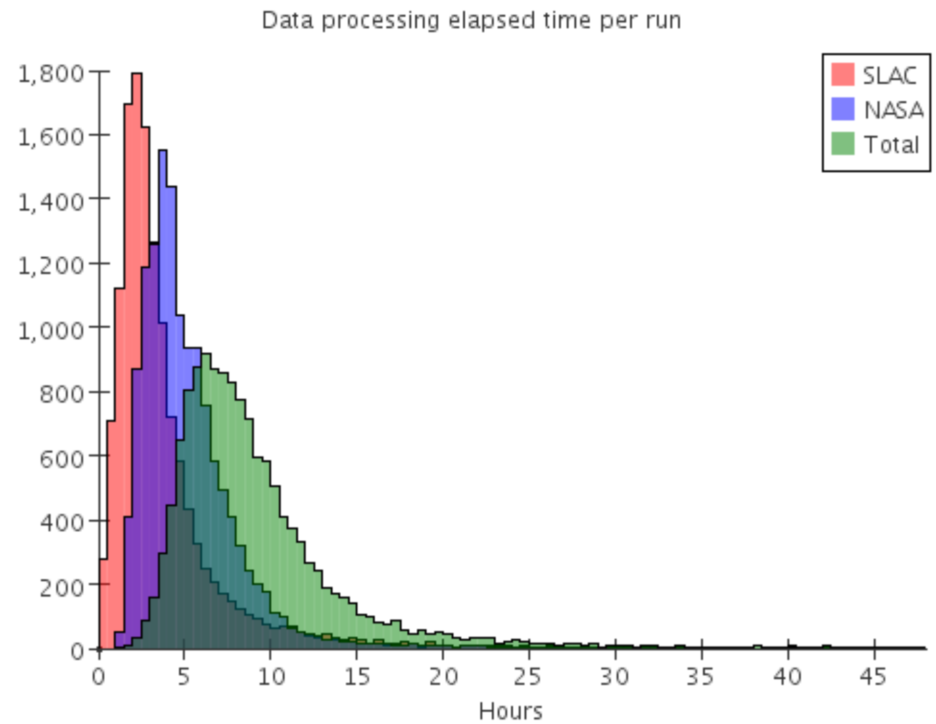
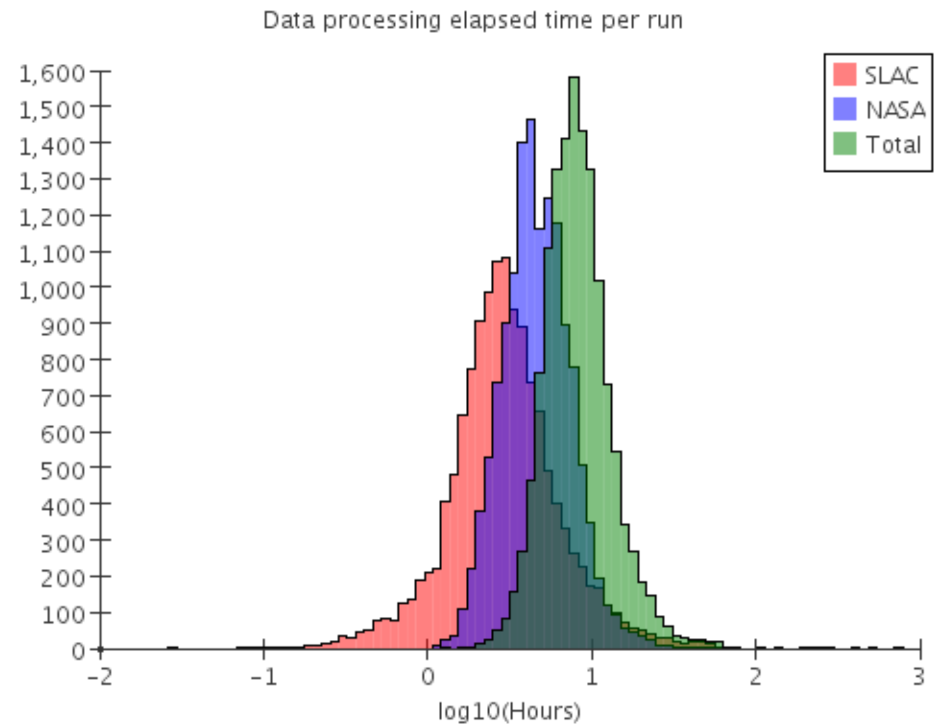

Data processing elapsed time per run
SLAC
NASA
Total
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0
5
10
15
20
25
30
35
40
45
Hours


Data processing elapsed time per run
SLAC
NASA
Total
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
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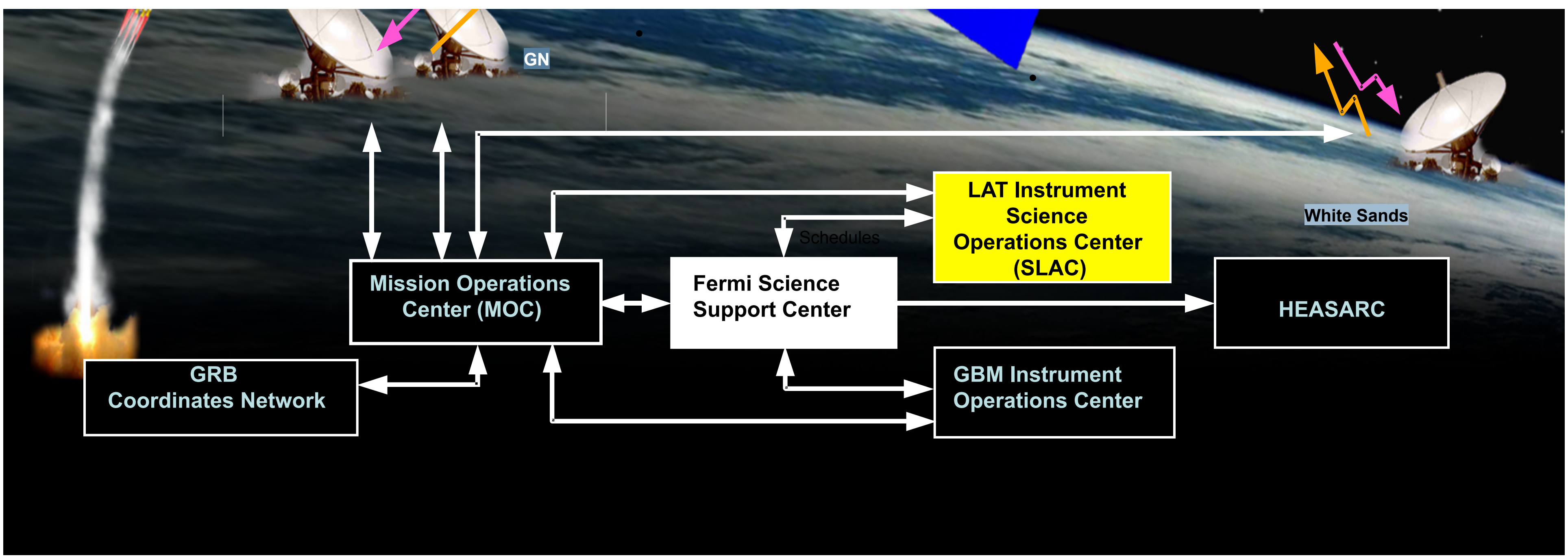
700
600
500
400
300
200
100
0
−2
−1
0
1
2
3
log10(Hours)


GN
White Sands
LAT Instrument Science Operations Center (SLAC)
Schedules
Mission Operations Center (MOC)
Fermi Science Support Center
HEASARC
GRB Coordinates Network
GBM Instrument Operations Center

Data Processing Flow

- Downlink from Goddard Space Flight Center (FASTCopy) ~8/day
  - 15 GB total daily
- Half-pipe
  - Automatic response to downlink
  - Decode & repackage incoming data
  - Trigger Level 1 Processing
- Level 1 Processing
  - Full event reconstruction: factor ~x50 expansion on raw data! 750 GB/day
  - Monitoring plots for Instrument Science Operations Ctr
  - Transfer science summary files to Goddard Science Support Ctr - 200 MB/day
  - Trigger ASP
- ASP (Automated Science Processing)
  - GRB and Flare detection
  - Spectral analysis
- RSP (Routine Science Processing)
  - Automated Science Group processing
- Final science analyses

+ annual bulk reprocessing
+ simulations

Data Storage and Catalog

Show: ☐ MC ☐ beam test ☐ obsolete
Update

Folders

- ASP
- Data
  - Flight
    - LEOScience
    - Level1
      - LCI
      - LPA
        - ACDPEDSANALYZER
        - ACDPLOTS
        - CAL
        - CALGAINSANALYZER
        - CALHIST
        - CALHISTALARM
        - CALPEDSANALYZER
        - CALTREND
        - COMPAREDFM
        - DIGI
        - DIGIHIST
        - DIGIHISTALARM
        - DIGITREND
        - DIGITRENDALARM
        - FASTMONERROR
        - FASTMONHIST

Folder /Data/Flight/Level1/LPA

Output from Level 1 processing of on-orbit data Edit description

Name	Type	Files	Events	Size	Created (UTC)	Links
RECON	Group	1931	3,803,647,787	52.7 TB	25-Jun-2008 16:43:00	Files
CAL	Group	1954	3,790,237,100	13.3 TB	25-Jun-2008 16:35:11	Files
SVAC	Group	1953	3,848,209,867	9.0 TB	25-Jun-2008 16:29:03	Files
DIGI	Group	1954	3,855,037,479	8.0 TB	25-Jun-2008 15:22:31	Files
FASTMONTUPLE	Group	1954	0	3.7 TB	25-Jun-2008 15:34:54	Files
MERIT	Group	1954	3,852,358,312	2.9 TB	25-Jun-2008 16:25:29	Files
GCR	Group	1954	3,852,208,291	92.6 GB	25-Jun-2008 16:32:57	Files
FASTMONTREND	Group	1954	0	58.9 GB	25-Jun-2008 15:57:51	Files
LS1	Group	1954	69,293,586	50.7 GB	25-Jun-2008 16:29:02	Files
DIGITREND	Group	1954	0	45.8 GB	25-Jun-2008 15:25:58	Files
MAGIC7HP	Group	1732	0	37.2 GB	08-Jul-2008 18:20:31	Files
CALHIST	Group	1954	0	26.4 GB	25-Jun-2008 15:32:55	Files
TKRANALYSIS	Group	1953	0	23.8 GB	25-Jun-2008 16:40:49	Files
RECONTREND	Group	1954	0	23.7 GB	25-Jun-2008 16:39:44	Files
RECONHIST	Group	1953	0	16.4 GB	25-Jun-2008 16:42:37	Files
LS3	Group	1954	0	14.7 GB	25-Jun-2008 16:29:02	Files
MAGIC7	Group	250	0	7.4 GB	25-Jun-2008 15:13:53	Files

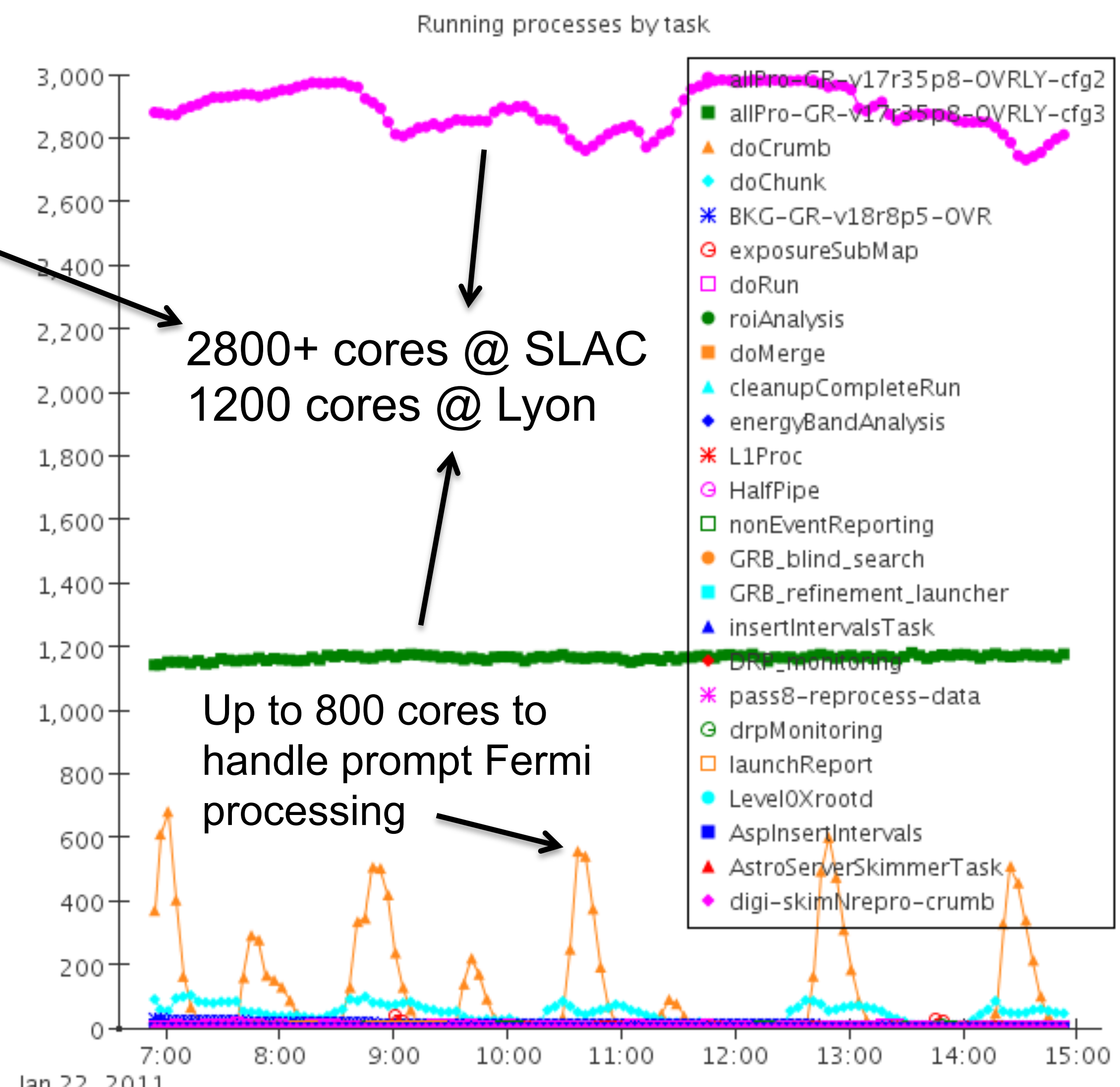
Data resides in xroot (some NFS, and some, temporarily, in AFS)

Catalogue gives file location and user-supplied metadata

Data Processing Engine: Pipeline

Note: 1200 cores above our allocation. Obtained from general queues.

- Java-based web app for control & monitoring
- xml interface for constructing processing tasks
- Abstraction of underlying batch system: LSF, BQS; recently added Condor for CDMS sims



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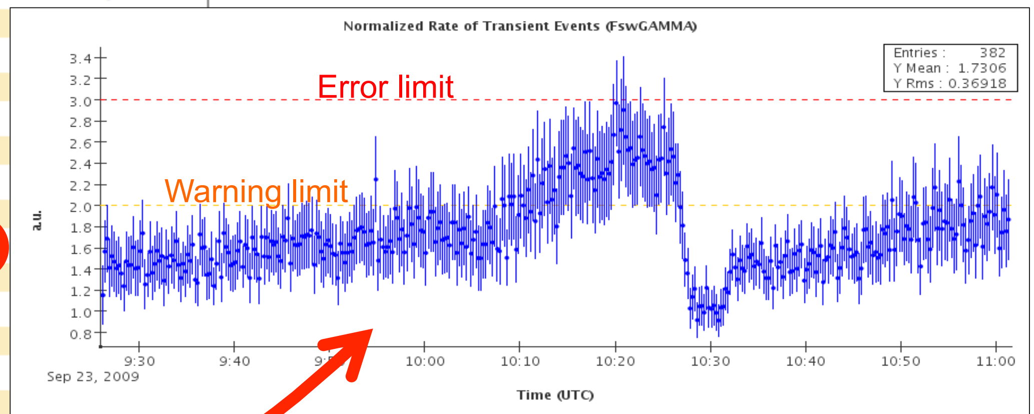
Data Monitoring: ex. Alarms

Alarms for run 275390766

Mode	Type	Error	Warning	Undefined	Clean
acdPedsAnalyzer	Hist	0	0	0	14
calGainsAnalyzer	Hist	0	0	0	18
CalPed	Hist	0	0	0	2
calPedsAnalyzer	Hist	0	0		
Digi	Hist	0	0		
Digi	Trend	0	0		
FastMon	Hist	0	0		
FastMon	Trend	0	0		
fastMonError	Trend	0	0		
Merit	Hist	0	0		
Merit	Trend	0	1		
Recon	Hist	0	0		
Recon	Trend	0	0		
TkrMon	Trend	0	0		
verifyFt2Error	Trend	0	0		
verifyLog	Trend	0	0		



WARNING Status

Severity	Mode	Type	Variable Name	Algorithm	Value	Limits	Details
5	Merit	Trend	OutF_NormRateTransientEvts	values	2.97 +- 0.81	[-1.0E10 | -1.0E10 | --- | 2.0 | 3.0]	View

- Automated alarms are used to alert duty scientists to anomalies
- Use fixed limits and reference histograms
- Many quantities are highly orbit dependent, so particle fluxes, geomagnetic variables must be taken into account
  - 20 different alarm algorithms

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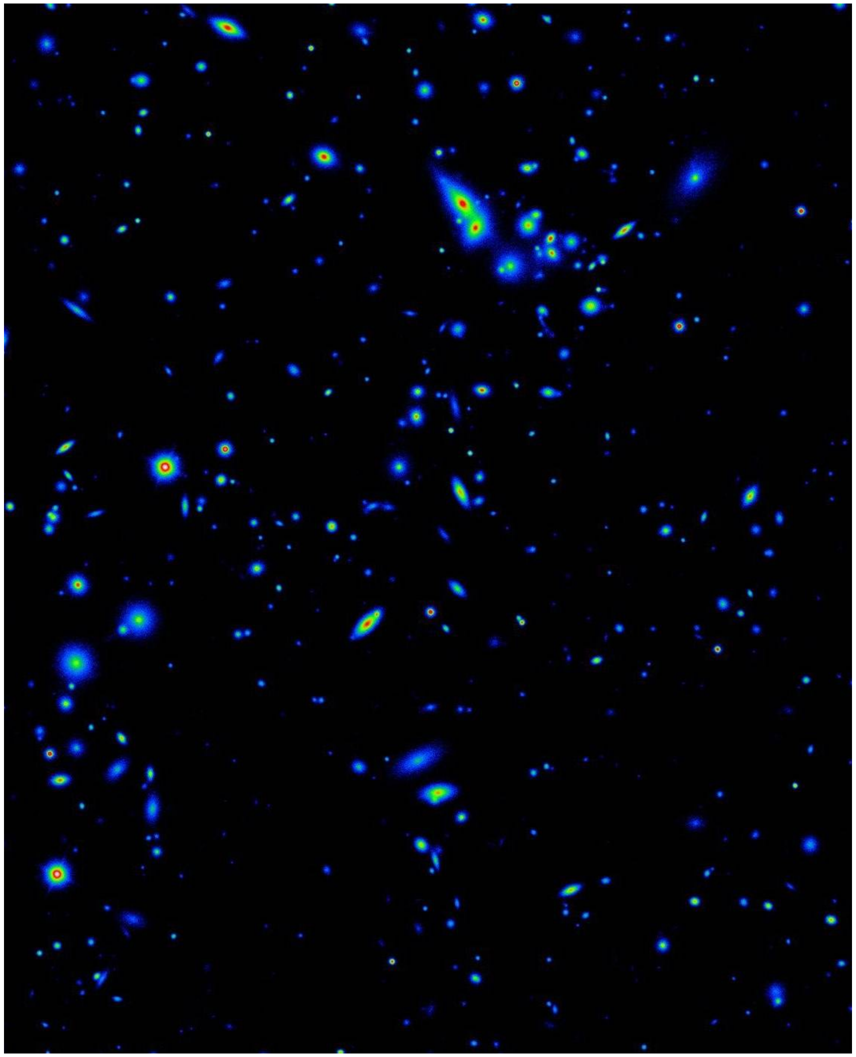
KIPAC Astro Support

- KIPAC community bridges SLAC, SU campus and many off-site collaborators (~150 total)
- Overlaps multiple projects
- Provides productive computing environment
- Hardware
  - MPI cluster w/fast net/ storage
  - GPGPU testbed
  - Small SMP machine
  - NFS storage (>250TB)
  - 3D visualization
  - 48Mpix tiled display

- Software and services
  - ~100 packages for common use
  - Hardware monitoring
  - Tape backups/archive
  - DB and web servers for collaborative use
- Staff
  - Stuart Marshall
  - Glenn Morris
  - Ralf Kaehler
  - Jeff Wade (SU)
  - Yemi Adesanya (CIO)

SLAC NATIONAL ACCELERATOR LABORATORY

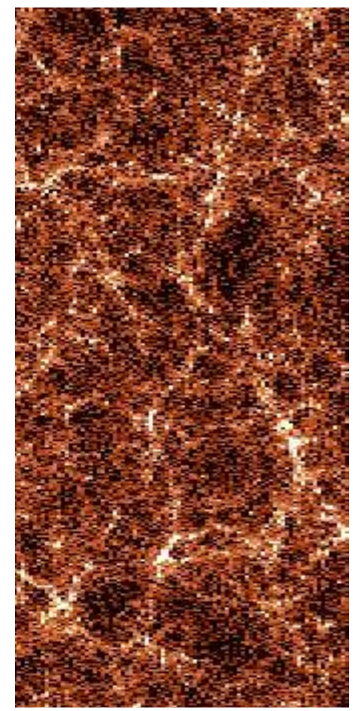
LSST computing support under PPA



- **LSST image simulation effort**
  - Photon-by-photon monte carlo is high fidelity end-to-end
  - Catalogs include full galaxy SED and morphology models
  - Simulation propagates through atmosphere, mirrors, optics, and silicon
  - Data Management is using the "PT1.1" simulation set, ~2M cpu-hours with SLAC producing ~1/3
  - Other simulation projects include
    - strong-lensing time evolution
    - weak-lensing shear systematics

DES simulations at SLAC (proposed)

- Project:
- Catalog level simulations support all DES science groups
- end-to-end simulations of full DES survey volume
- Analysis support for both simulated and observational data
- reanalysis of accumulated data each year
- 10 sims in year 1, ramp rate at 5-10 more per year
- Computational Scope:
- ~700K cpu hours per simulation
- 50TB storage per simulation
- initially SLAC and external resources (teragrid)
- ~1000 core-years are needed in first year
- purchase ~750 cores/year for 5 years
- maintain 100+ TB spinning disk and tape storage



Outline

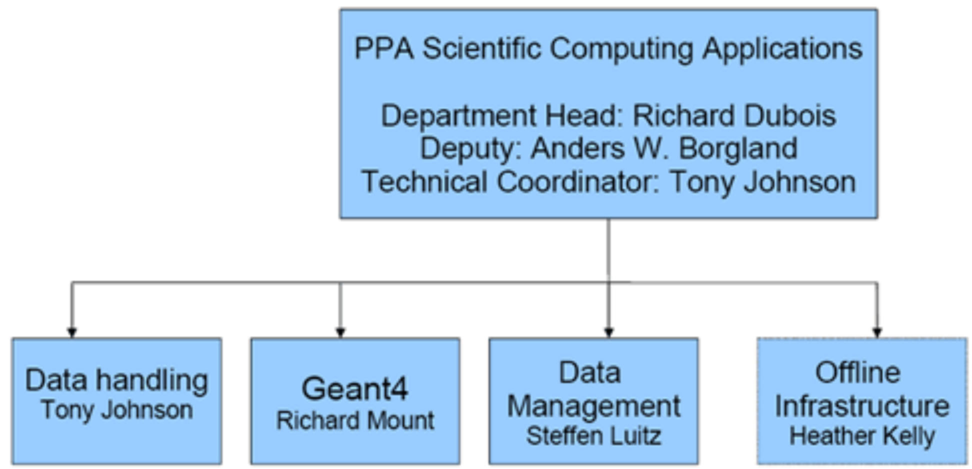
- Executive Summary
- Current projects status
  - Accelerator based
    - BABAR
    - ATLAS
    - xrootd
    - HEP Theory
    - Accelerator Modeling
  - Non-accelerator based
    - Fermi
    - EXO & CDMS
    - KIPAC
- **Scientific Computing Applications**
  - **Data Handling**
- LCSim
- Future Directions
- Issues

SCA in a Nutshell

- Created in 2010 in a merger of most of the Fermi offline team and the Computing Division Scientific Applications group
  - Staff from Fermi, GEANT4, xrootd, ATLAS and BABAR
  - Computing Coordinators from all PPA projects are involved
- Mission
  - Coordinate scientific computing in PPA amongst its projects
  - Be the face of scientific computing to the Lab and CD
  - Leverage expertise to support multiple PPA and Lab projects
  - Provide advice to PPA Management on computing issues
  - Work to improve the scientific computing environment at the Lab
  - Reach out to collaborators outside SLAC

Financial and Manpower

- 23 FTEs operated as a Professional Center
  - Extract travel & M&S from 3% Center overhead
- $4M in labor costs
- $50k travel
- $10k M&S



FTEs:	6	5	7	2
	Web apps Pipeline Data Monitoring	Core G4 Expt support	Core xrootd Expt support Embedded developers	C++ framework Build tools Conditions DBs

Geant4 presented in a separate talk

xrootd

- A structured cluster architecture for low latency data access
  - Efficiently and autonomously clusters vast amounts of storage
  - Originally, developed for HEP BaBar by SLAC and INFN
  - Now supported by a collaborative team based at CERN and SLAC
    - Provides primary data access for LHC analysis at CERN
    - Globally clusters all ALICE analysis sites
      - US ATLAS and soon CMS will do similar site federation
    - Provides large scale opportunistic clustering at RHIC/BNL
    - Provides a foundation for PROOF analysis
  - Over 12 independent experiments use **xrootd** at SLAC and IN2P3
    - Antares, ATLAS, BaBar, CMS, Compass, dchooz, EXO, Fermi, Hess, Indra, Opera, Panda, Virgo
  - Available via OSG/VDT and CERN Root/PROOF distribution
- Victim of success?
  - 1 FTE at SLAC to support quickly growing community!

SCA Data Handling Group

- Mission
  - Develop and deploy data handling, visualization and analysis tools.
  - Actively encourage infrastructure reuse between experiments
  - Invest in new technologies for use on future experiments
  - Build collaborations with the Computing Department, LCLS and other laboratories
- Current experiment involvement
  - Fermi Gamma-Ray Telescope LAT
  - Enriched Xenon Observatory (EXO)
  - LSST Camera Control System
  - SuperCDMS
  - Linear Collider R&D
- Manpower
  - Core team ~6 FTE: limiting resource

Data Handling Group: Product Matrix

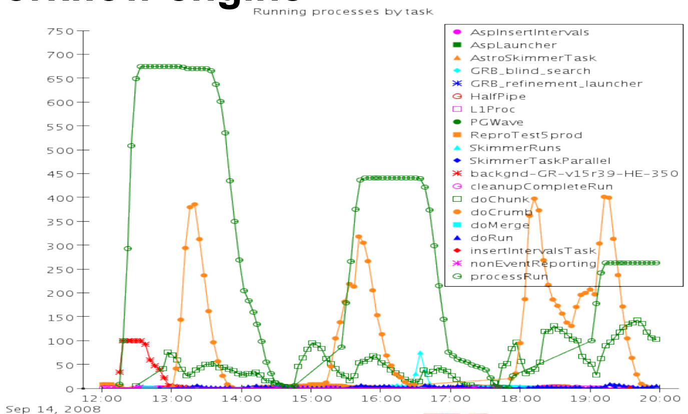
Product	Fermi	EXO	Super CDMS	LSST	Heavy Photon	LCSim	Geant4 Other[2]
Web Framework	Yes	Yes	Yes	Yes			
Data Monitoring	Yes	Yes		Yes			
Collaboration Tools	Yes	Yes					
Data Catalog	Yes	Yes	Yes				
Communication Tools	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Processing Pipeline	Yes	Yes	Yes				
Analysis Tools (AIDA)	Yes[1]	Yes[1]		Yes			Yes
Event Display (WIRED)	Yes					Yes	Yes
Analysis GUI (JAS)	Yes				Yes	Yes	

Data Handling Group: Future Plans

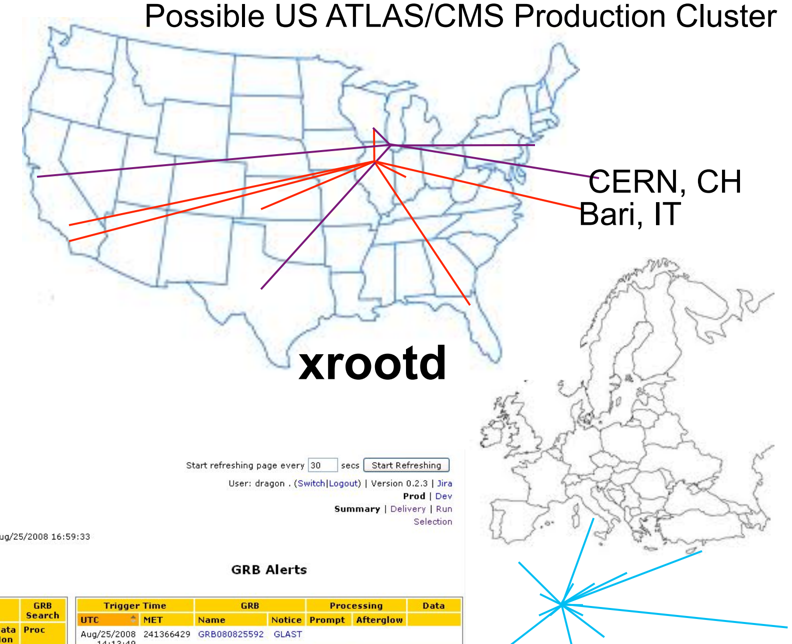
- Add more interactivity to web applications
  - Exploit Google Web Toolkit
- Improved plotting to be used by all products
  - Including HTML5 support
- Improve interoperability of toolkit with Root
  - Support for writing root files in addition to reading
- Look at more potential customers
  - CTA, heavy photon, …
- Continue to look at new technologies for future
  - Cloud computing, cloud based distributed data analysis
    - Limited by manpower
- Develop cross-lab collaborative projects
  - Current experiment specific funding makes this challenging

Picture Gallery

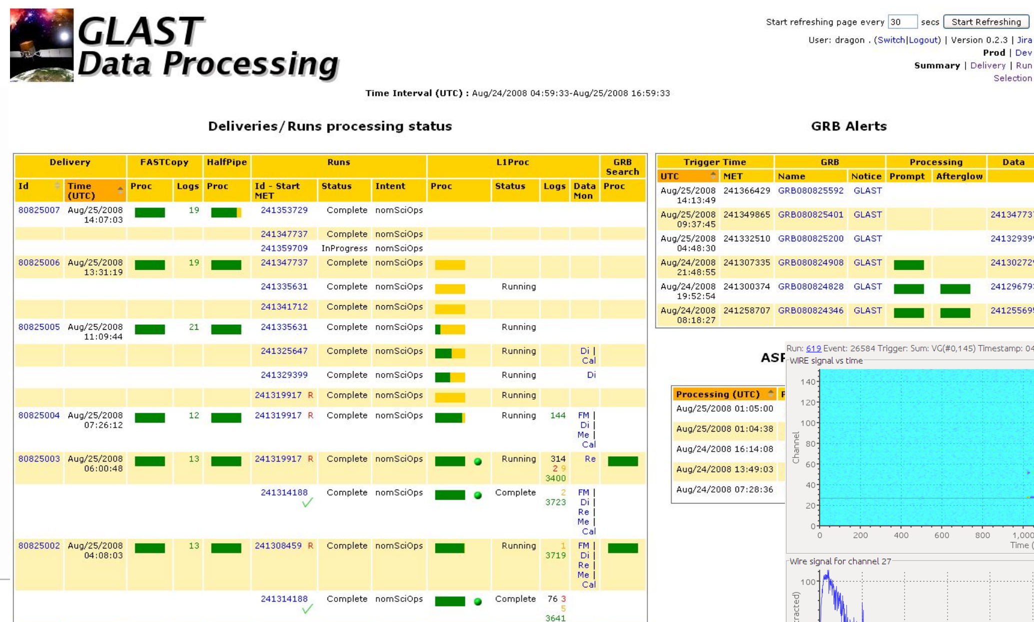
Workflow engine



Possible US ATLAS/CMS Production Cluster



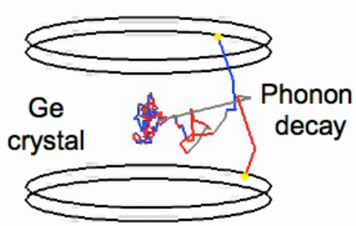
ALICE Production Cluster



SIMULATION

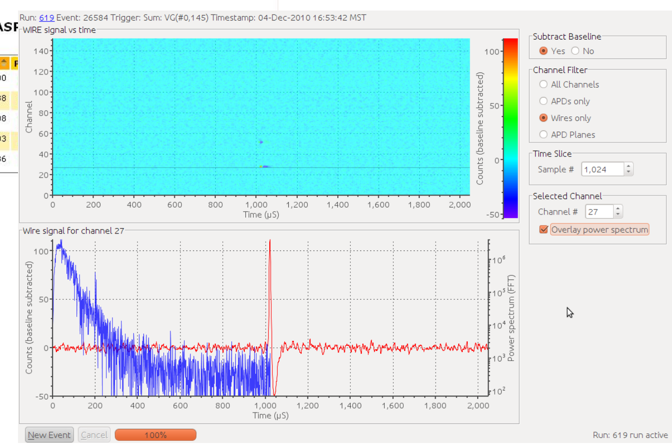
SuperCDMS/G4

Top electrodes



bottom electrodes

Colors correspond to different phonon polarization states (FT,ST,L)



NATIONAL ACCELERATOR LABORATORY

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Bumps on the road to a Lepton Collider

- Post sticker shock, DOE is allergic to ILC
  Despite this, LC support remains strong at CERN and in Japan
- LHC delays have postponed the LC timetable and revived questions of what energy is needed. We're waiting for exciting new physics results to justify and guide the next step.
- Collider Options are multiplying. Which to choose?
  * CERN has stepped up CLIC support and has scheduled the CLIC Machine and Detector CDR for 2011
  * Fermilab has revived Muon Collider Studies for machine and detector

These developments don't force us to change our goals, but do necessitate changing our strategy. Pursuing SiD at ILC is not enough.

Strategy

- **Keep alive the ILC option**
  Complete the *Detailed Baseline Design* in 2012, which will document an optimized detector, baseline technologies, R&D proofs of principle, realistic simulations, benchmarked physics performance, and costs.

- **Engage with CLIC detector studies**
  Help modify SiD as needed for the CLIC environment and higher CLIC energies. Provide simulation and reconstruction software, help benchmark the physics, and contribute to the CLIC Detector CDR.

- **Evaluate physics capabilities of all Lepton Collider options**
  Support studies of all the options so that an objective comparison of their strengths and weaknesses can inform a future decision. Do this in the context of the "white paper" proposal.

"White Paper" Proposal

"*Outline of a US Strategy towards Physics & Detectors at Future Lepton Colliders*" was presented to the DOE Electron Review in June. At DOE's request, a full proposal is being prepared.

- Understand the machine capabilities, limitations, and timetables for each lepton collider option.
- Establish detector requirements at each collider, accounting for the very different machine environments
- Facilitate development of suitable detector concepts, exploiting the existing SLAC software framework for simulation and benchmarking
- Coordinate the necessary physics studies and detector R&D needed to establish concept viability
- Compare the physics potential of all the options on an equal footing.

SLAC Simulation/Reconstruction Toolkit has been essential for concept development

- **SLIC provides full detector simulation in Geant4**
  - runtime detector description in XML
  - stdhep input
  - standard LCIO output

- **org.lcsim reconstruction/analysis suite**
  - XML detector geometry description
  - LCIO input and output
  - Java-based reconstruction & analysis framework
  - AIDA histogramming and fitting
  - WIRED 3-D event display

- **SLAC Sim/Recon is playing a critical role in new detector development**
  - SiD benchmarking and performance studies for LoI
  - CLIC CDR studies
  - HPS tracking, Atlas tracking studies, Super B studies

- **Expand Sim/Recon role for future lepton collider studies**
  - Expand user support and document new tool releases
  - Expand AIDA analysis support; develop interoperability with ROOT
  - Develop Standardized Detector Geometry descriptions

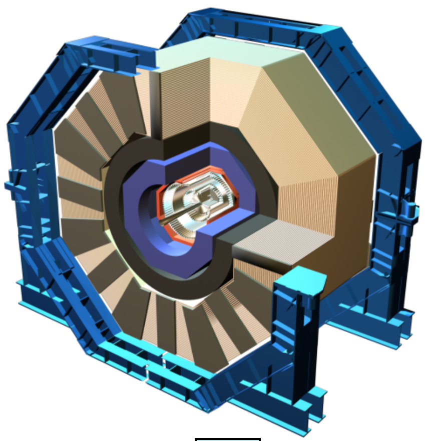
Make LCSIM available for all Lepton Collider Studies

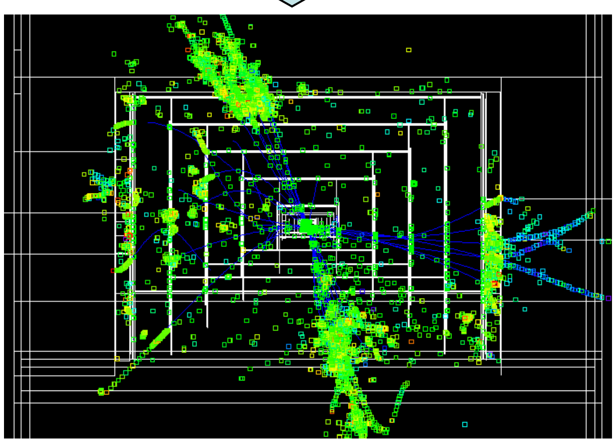
lcio – success story

- Common HEP object/event data model & persistency format
- Fully documented, with multiple language bindings
  - C++, Java, FORTRAN, python, root
- Used throughout all aspects of ILC physics & detector studies
  - MC simulation, Test Beam data, Mock Data challenges
  - Across platform, language and concept
  - Can run simulation or reconstruction in one framework, analysis in another.
    - Generate events in Jupiter, analyze in MarlinReco.
    - org.lcsim to find tracks in Java, LCFI flavor-tagging to find vertices using MarlinReco (C++) package.
- Achieved what CDF/D0, CMS/ATLAS, TeVatron/LHC couldn't.

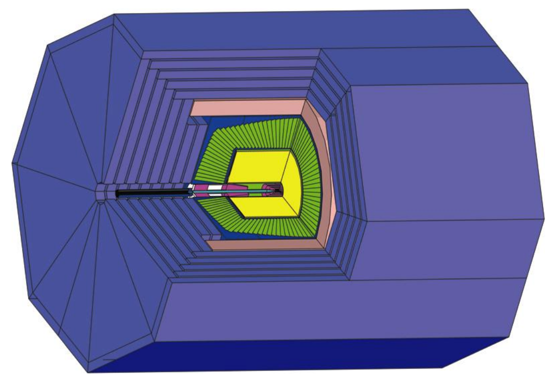
ILC Full Detector Concepts

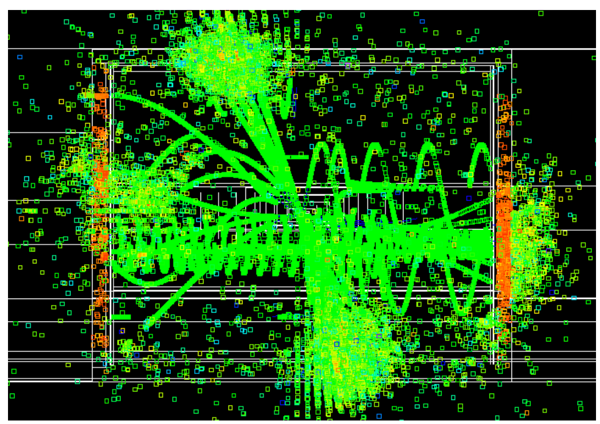
SiD



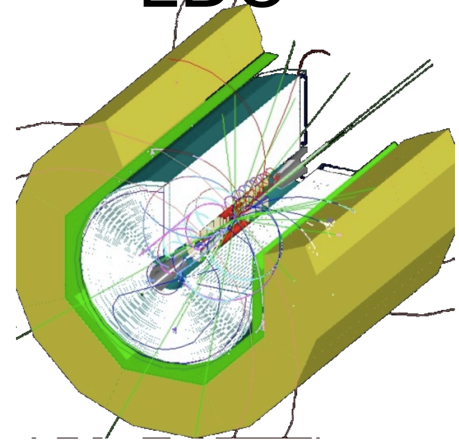


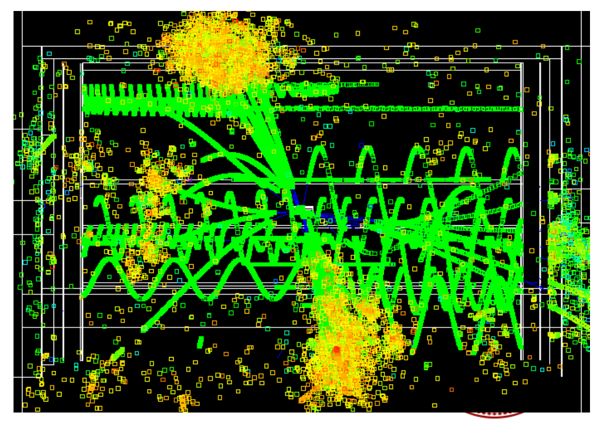
GLD





LDC





LCSim Path Forward

- Committed to supporting the ongoing CLIC CDR studies (2011) and the ILC DBD physics & detector studies (2012).
- Implement LCIO2.0 improvements to the event data model.
- Continue cooperation and collaboration with international LC simulation efforts on common software, e.g.
  - LCFI: vertex finding, jet flavor tagging
  - PandoraPFA: Particle Flow Algorithm
- Engage with European 7th Framework Program, AIDA (Advanced European Infrastructures for Detectors at Accelerators)
  - spec. Work Package 2: Geometry & Reconstruction toolkits for HEP
- Support future lepton collider detector studies at ILC, CLIC, and Muon Collider with expanded infrastructure as part of the Lepton Collider Framework Proposal to DOE.

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Future Directions

- leverage/stabilise SCA to support multiple experiments for applications
- replace BABAR capacity with DES & CCI needs (xfer to ATLAS, Fermi as well?)
- consolidate/expand G4 team in support of existing and new projects.
- consolidate/expand xrootd support as it grows in international use
- look to support CTA and LSST as they grow. Possibility of data centers for both.
- Facilitate HEP Theory getting cycles; CCI proposal acceptance; work with SCA
- continued support of existing projects

Issues

- A stable funding base for the SCA professional center
  - Difficult to start new ventures and survive ebb and flow of effort without core support
- How to weather the decline in BABAR computing resources
- Maintaining xrootd at an appropriate level in view of its success
- Support for LCSim depends on White Paper/proposal success
- Successful outcome of the CCI proposal
- GEANT4 futures

} See subsequent talks

Backups

Monte Carlo Event Generators

Role of event generators is to perform precise comparison of theoretical calculations with collider data

SLAC theory has large involvement in the development of

- Blackhat: Specialized NLO Generator
  - perform higher order computations in perturbative QCD at NLO (Next-to-Leading-Order) for targeted production processes
  - use new methods developed by Dixon's group to numerically compute 1-loop virtual diagrams
  - Fastest NLO event generator on the market
  - Can handle more complex processes compared to other generators
- Sherpa: Multipurpose Generator
  - Generates all production processes at LO
  - Used extensively by the ATLAS Collaboration
  - Includes radiation, hadronization and showering with matrix element matching

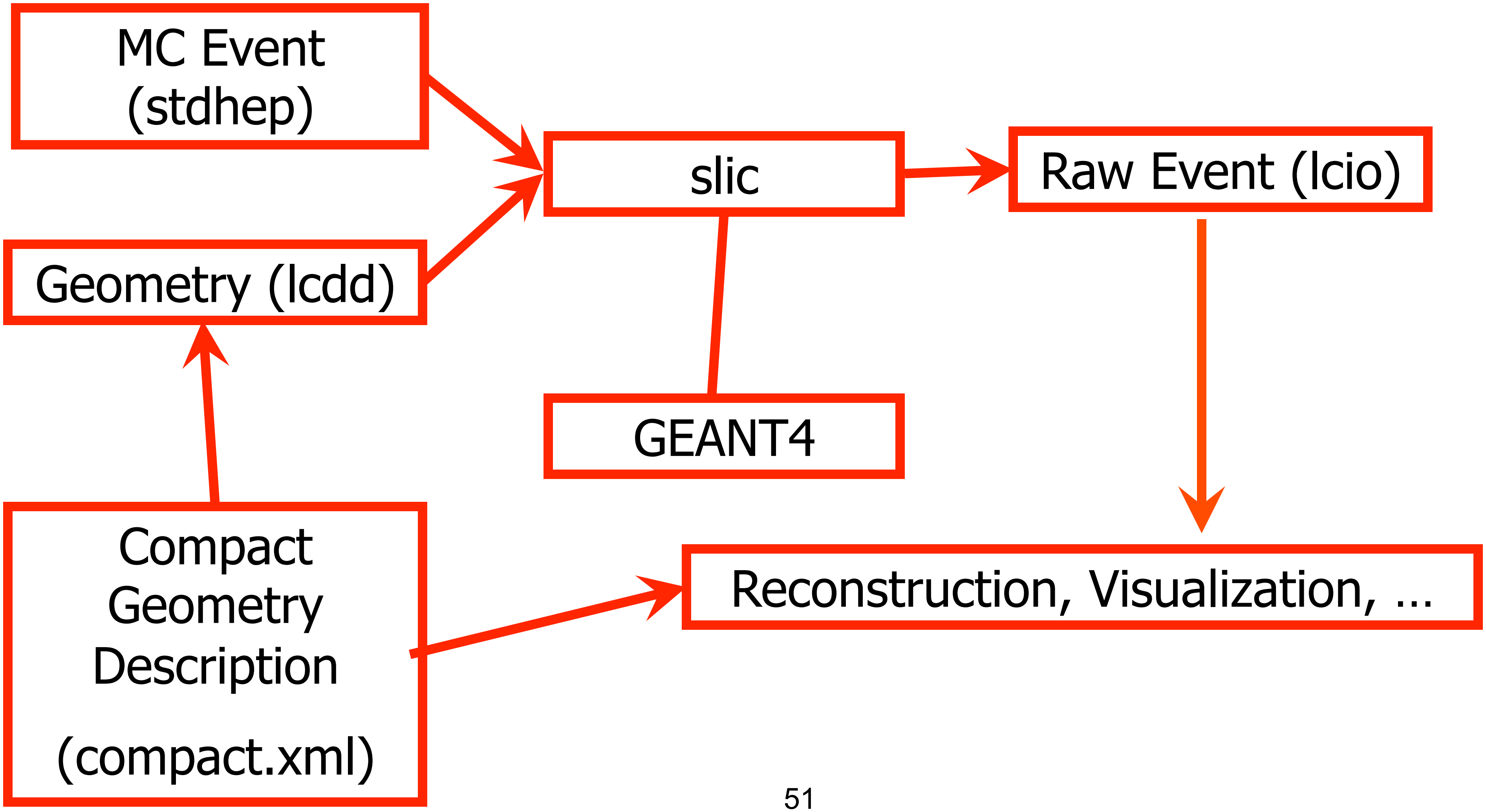
eXtremely Large Data Bases

- Series of events
  - Started in 2007 as an invitational workshop
  - 2009: first international event (Lyon, France)
  - 2010: introduced open conference, huge interest, 150+ attendees
  - 2011: introducing additional yearly international satellite workshops
    - First in June 2011, Edinburgh, UK
- Community
  - Data-intensive industrial and scientific users
  - Big data solution providers (academia/research and vendors)
- Main focus
  - Complex, large-scale data analytics

XLDB

- Philosophy
  - Identify trends, commonalities, roadblocks
  - Bridge the gap between db users and solution providers
  - Facilitate development and growth of practical technologies
- Tangible results
  - SciDB – open source array-based Data Management System
  - Use cases from different scientific domains
  - Science benchmark
- 100% SLAC initiative
  - Initiated and organized all 4 events (2 at SLAC)
  - Co-founded SciDB
  - Hosting XLDB mailing lists, forum, wiki, coordinating use cases
  - More at http://xldb.slac.stanford.edu

LC Detector Full Simulation



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slic: Full Detector Response Simulation

- Use Geant4 toolkit to describe interaction of particles with matter and fields.
- Free the end user from having to write any C++ code or be expert in Geant4 to define the detector.
- Thin layer of custom C++ provides access to:
  - Event Generator input, Detector Geometry & Detector Hits
- Detectors fully described at run-time with easy-to-use format.
  - In principle, as fully detailed as desired.
- Build static executables on Linux, Windows, Mac.
- Event input via stdhep, particle gun, …
- Detector input via GDML, lcdd
- Response output via LCIO using generic hits.

org.lcsim HEP Event Reconstruction

- Java based reconstruction and analysis package
  - Runs standalone or inside Java Analysis Studio (JAS)
  - Full Event Reconstruction
    - Event background overlays at detector hit level, with time offsets.
    - Complex readout digitization (CCD pixels, Si μ-strips, TPC pad hits)
    - *ab initio* track finding and fitting for ~arbitrary geometries
    - Multiple calorimeter clustering algorithms
    - Individual Particle reconstruction (cluster-track association, PFA)
  - Physics Tools (Jet Finding, Vertex Finding, Flavor Tagging)
  - Analysis Tools (including WIRED event display)
- Write once, run anywhere
  - Exact same libraries run on all platforms (Windows, Mac, Linux(es), Grid) using the Java Virtual Machine.