

SLAC: Present and Future



*David B. MacFarlane
Assistant Director, Particle and
Particle Astrophysics (PPA) Directorate*

Stanford
Linear
Accelerator
Center

Presented at the 9th International Workshop on Accelerator Alignment

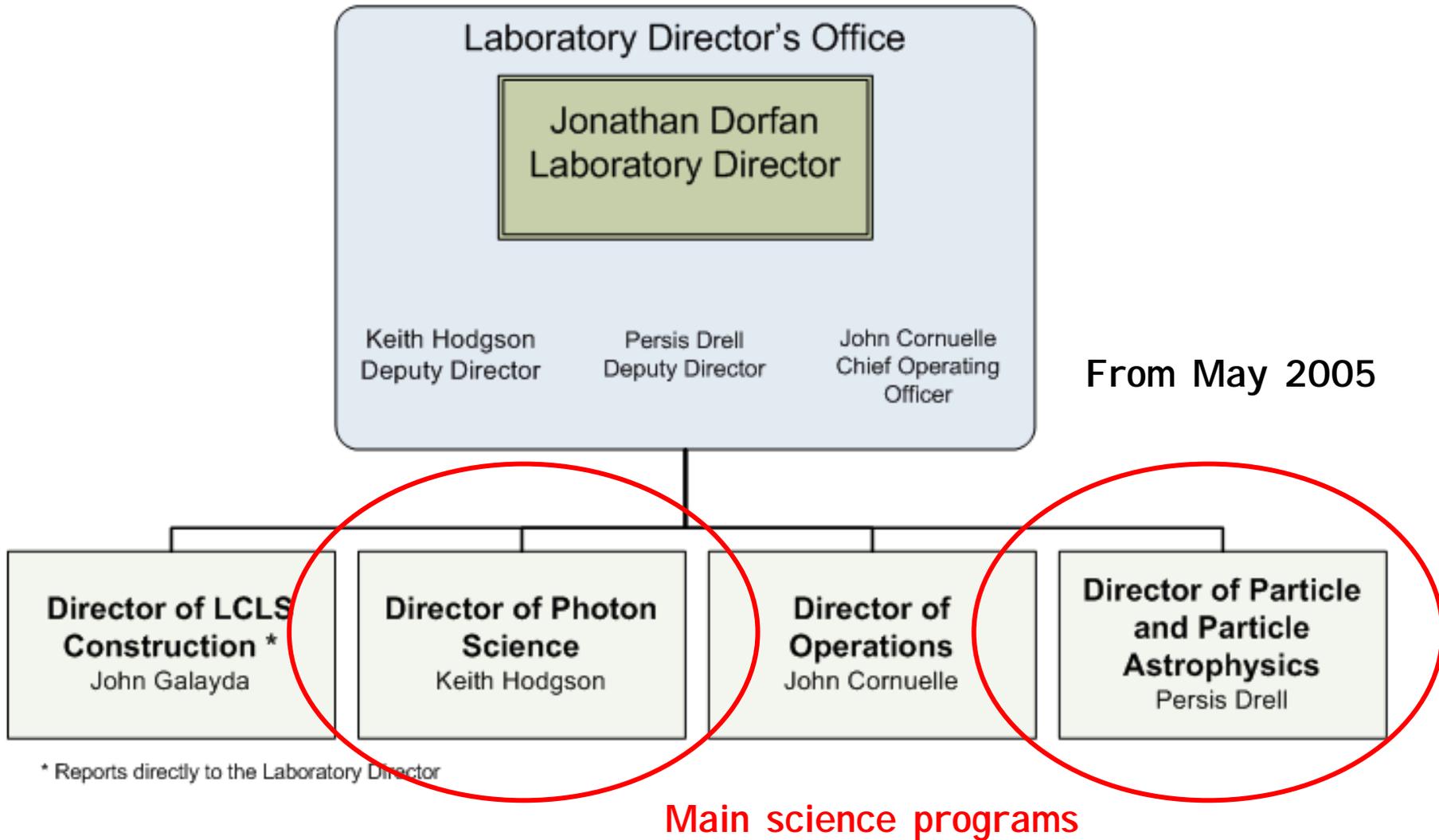
SLAC: a laboratory in transition

- *Research directions are evolving dramatically*
 - Balance of program elements and focus of effort are changing in substantial ways, following the imperative of fundamental physics questions that need to be addressed
- *Photon science is rapidly expanding with LCLS and SPEAR3*
 - In 2009, the major onsite accelerator-based facilities will both be primarily serving photon science
- *Particle physics & particle astrophysics will remain an essential part of SLAC as a national laboratory*
 - Will no longer be centered on a forefront onsite accelerator
 - Will most certainly be serving a broad national and international user community
 - Exploitation of the unprecedented *BABAR* data set
 - TeV-scale physics at the LHC and the ILC
 - Particle astrophysics at GLAST, LSST, and SNAP
 - Major non-accelerator efforts such as EXO
 - Will continue to pursue a vibrant accelerator research program



Stanford Linear Accelerator Center

Directorate Level Organization



SLAC science in 2006

- o SPEAR3 operating for broad range of photon science
- o PEP-II and *BABAR* accumulating data at record luminosity
 - Exploring *CP* violation and rare decays in *B* decays with unprecedented sensitivity
- o GLAST completed and being mated with spacecraft for 2007 launch
- o World's first x-ray laser, the LCLS, under construction, promising future exploration of ultra-fast science at the atomic scale
- o Leading partner in the development of the reference design and technical solutions for the International Linear Collider and an ILC detector
- o Leading the development of the design for the world's largest digital camera for LSST
- o Kavli Institute for Particle Astrophysics and Cosmology attracting bright young talent
- o Breakthroughs in advanced accelerator techniques continue to be actively pursued
- o EXO-200 under construction for deployment early next year

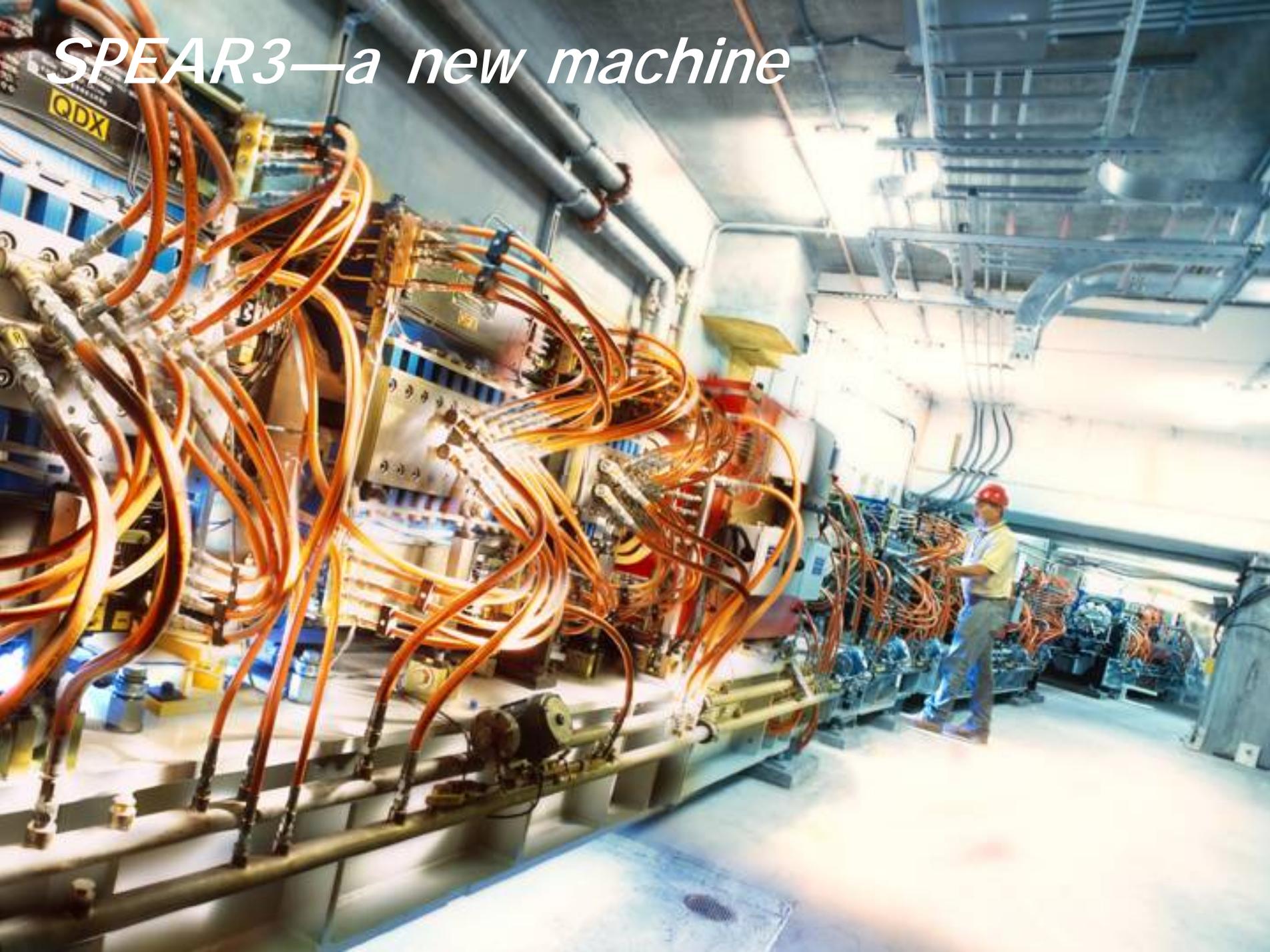


SLAC photon science future

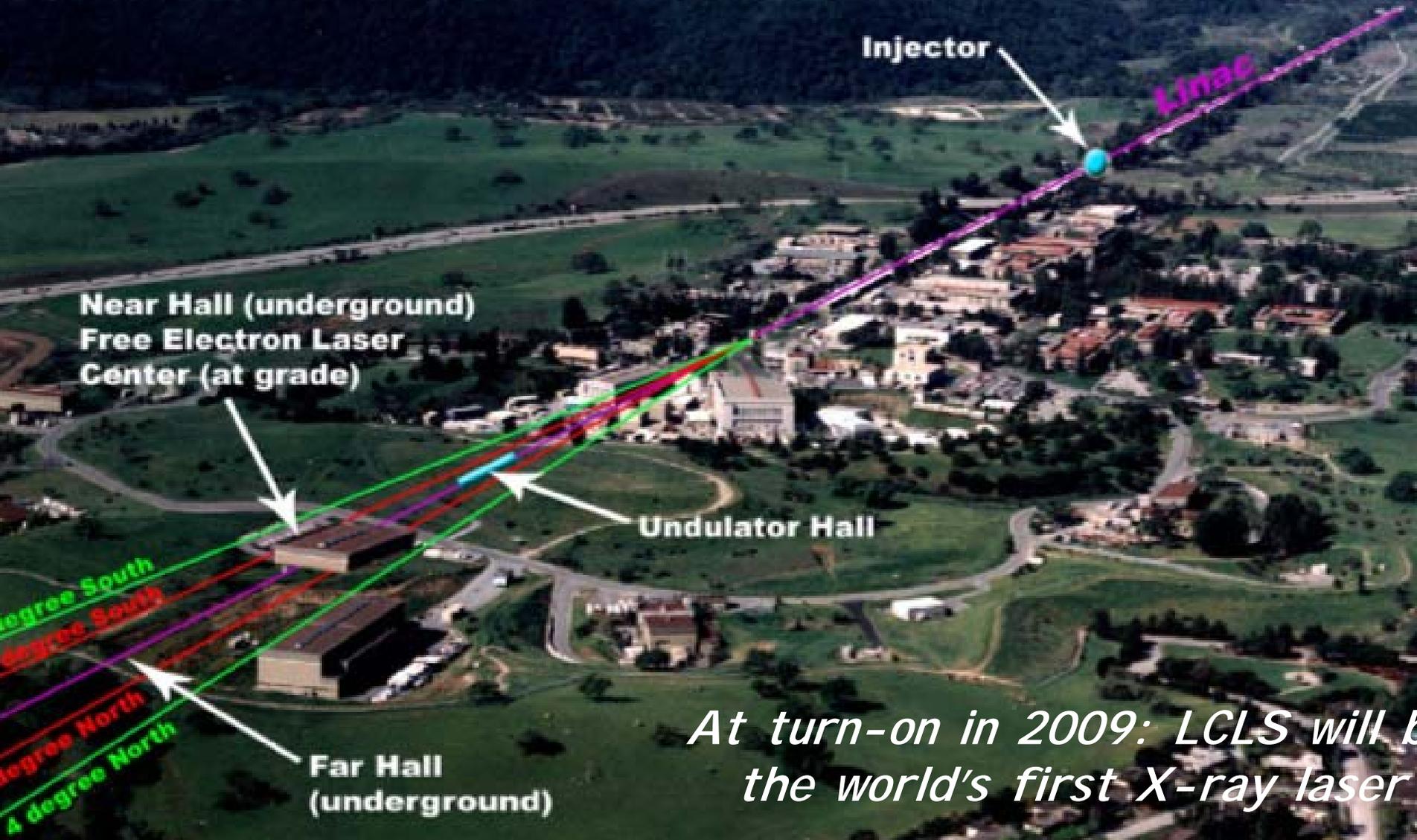
- *X-Rays have opened the Ultra-Small World—Realm of SPEAR3—Operating Now*
 - o 10^{12} photons/sec from high brightness undulator
 - o Energies ranging from 400 eV to 40 keV
 - o 50 ps pulse length
 - o Limited coherence at x-ray wavelengths
- *X-ray Lasers will open the Ultra-Small and Ultra-Fast Worlds—Realm of LCLS—First Light 2009*
 - o 10^{12} photons/pulse
 - o Energies from 800 eV to 9 keV
 - o 200 fs pulse length at commissioning, evolving to 10-30 fs within 1-2 years
 - o Fully coherent at x-ray wavelengths



SPEAR3—a new machine



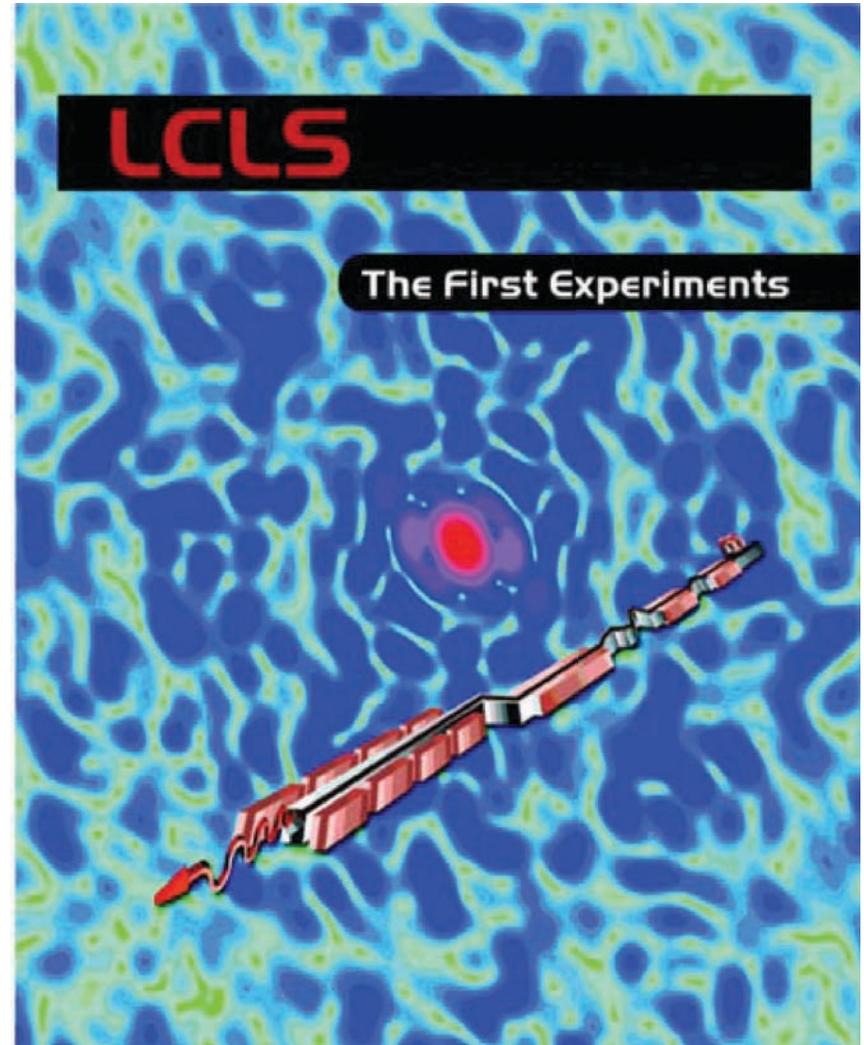
Linac Coherent Light Source (LCLS)



*At turn-on in 2009: LCLS will be
the world's first X-ray laser*

LCLS: remarkable opportunities for discovery

- *Femtochemistry and biology*
- *Nanostructured materials*
- *Atomic physics*
- *Plasmas and warm dense matter*
- *Imaging of nanoclusters and single biomolecules*
- *X-ray laser physics*



Particle physics: exciting but challenging times

➤ *Excitement*

- The Standard Model is fabulously successful, but...
 - Dark Matter and Dark Energy make up 95% of the Universe
 - We don't understand why the Universe is matter dominated
 - We don't understand the fundamental nature of the neutrino
- Compelling questions confront us
 - Within this decade tools coming on line to make progress in our understanding
 - Developing tools for discovery in the next decade

➤ *Challenge*

- Premier US HEP accelerators will turn off by the end of the decade and the frontiers of HEP will be off shore
- Long term health and future of the field of HEP relies on ILC
 - Not a certainty! Timescale for physics end of next decade
- Need to balance near, medium and long term priorities of the field



SLAC particle & astrophysics future

- *Successful completion of B-Factor program*
 - Highest priority for SLAC PPA Directorate
- *Physics at the energy frontier*
 - ILC, LHC, and fundamental accelerator research
- *Investigations of dark matter and dark energy*
 - GLAST, LSST, and SNAP
- *Investigation of fundamental nature of the neutrino*
 - EXO-200 and full EXO observatory
- *All elements supported by strong program of theoretical investigations*



Timelines for program elements

➤ *Science in the near future (now to 2012)*

- *BABAR* operations to 9/2008, physics exploitation through 2012 or beyond
- GLAST launch and science exploitation (2007-2012/2017)
- TeV-scale physics at LHC with Atlas and LARP
- Proof-of-principle experiments in accelerator research

➤ *R&D for mid-term physics (2012 and beyond)*

- R&D for the ILC and LCD
- Development of the LSST CCD camera design
- Construction and operation of EXO-200 & development of Ba⁺⁺ tagging for full EXO
- Contributions to SNAP

➤ *R&D for long-term future (2020 and beyond)*

- High-gradient accelerator program with SABER
- Frontier accelerator research: laser, plasma-based techniques





BABAR & PEP-II

B-Factory physics program

➤ *Present and future physics goals*

- Highly constrained and redundant set of precision tests of weak interactions in the Standard Model
 - Legacy of fundamental constraints on future New Physics discoveries
- Searches for physics beyond the Standard Model
 - Sensitivity to New Physics at LHC mass scales
- Potential for discovery from large data sample across range of heavy quark and lepton flavor, two-photon and ISR physics

➤ *B-Factory program operates until end of FY2008*

- Final upgrades to machine and detector during fall 06 shutdown

➤ *Ultimate goal: deliver to BABAR $\sim 1ab^{-1}$ by end of FY2008*

SLAC is committed to delivering *B* Factory luminosity



PEP-III luminosity records

Optics and alignment
play a crucial role in
this progress

Peak Luminosity

$12.069 \times 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$

1722 bunches 2900 mA LER 1875 mA HER

August 16, 2006

Integration records of delivered luminosity

Best shift (8 hrs, 0:00, 08:00, 16:00)	339.0 pb ⁻¹	Aug 16, 2006
Best 3 shifts in a row	910.7 pb ⁻¹	Jul 2-3, 2006
Best day	849.6 pb ⁻¹	Aug 14, 2006
Best 7 days (0:00 to 24:00)	5.385 fb ⁻¹	Jul 27-Aug 3, 2006
Best week (Sun 0:00 to Sat 24:00)	5.111 fb ⁻¹	Jul 30-Aug 5, 2006
Peak HER current	1900 mA	Aug 15, 2006
Peak LER current	2995 mA	Oct 10, 2005

Best 30 days **19.315** fb⁻¹ **Jul 19 – Aug 17, 2006**

Best month **17.036** fb⁻¹ **July 2004**

Total delivered

410 fb⁻¹



Longer-term plans for BABAR

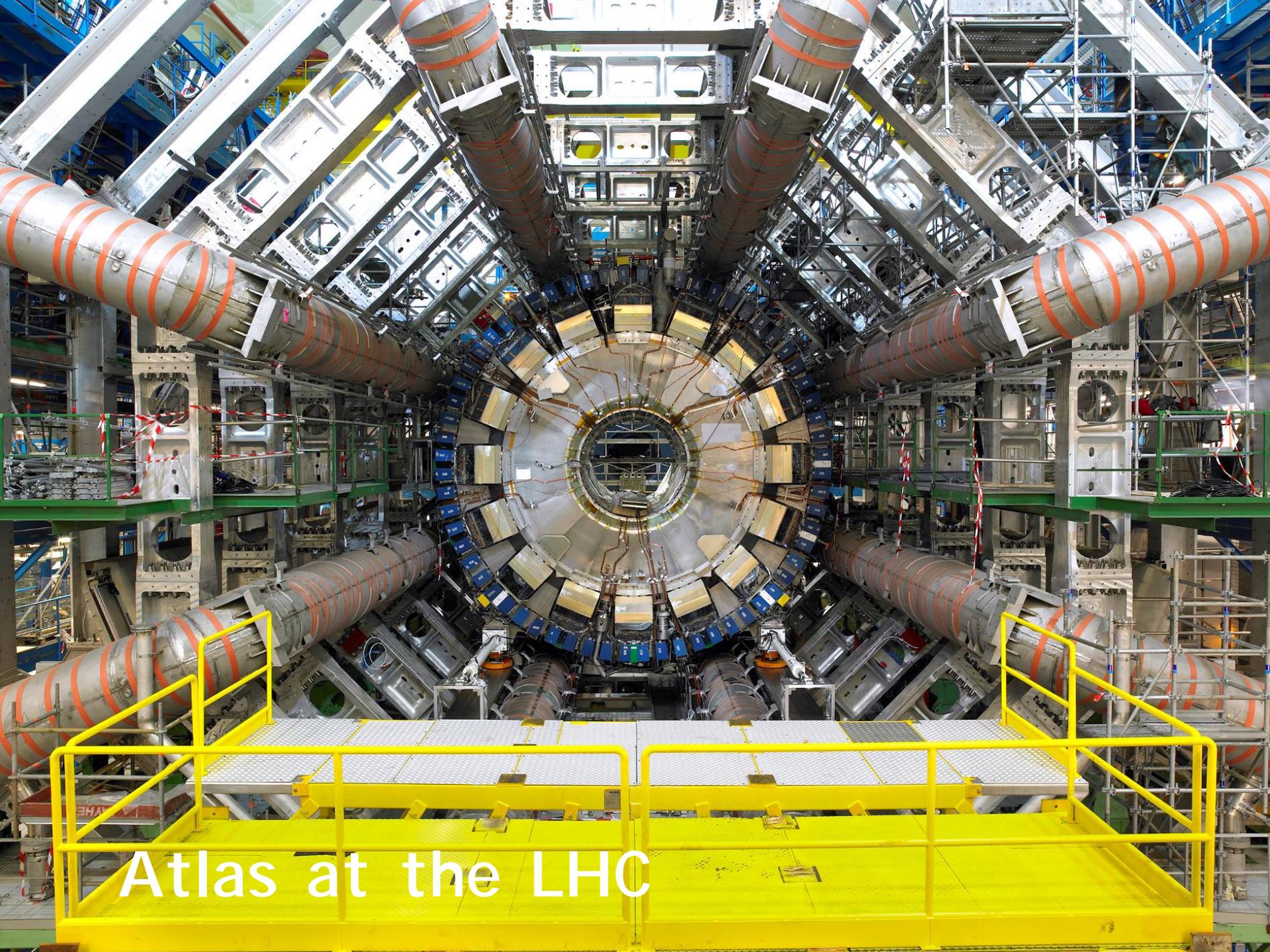
➤ *Post data-taking phase beyond 2008*

- Physics analysis will continue at a vigorous rate for 2-3 years after end of data taking
 - Analogous to physics produced from summer 2004 data
- Data sample will offer a long-term legacy beyond this, with an expectation that analysis will continue at a reduced level well into the next decade

➤ *Ideas for Super B Factories are vigorously pursued*

- Physics case based on sensitivity to new physics in beauty, charm and tau sectors, as a complement to LHC discoveries
- Mature Super KEKB proposal to upgrade KEKB to $4\text{-}8 \times 10^{35}$
- INFN moving to prepare a design concept based on linear collider ideas for a new very high luminosity facility ($>1 \times 10^{36}$)





Atlas at the LHC

The Energy Frontier: LHC

- *Participation in LHC accelerator research program (LARP)*
 - Designing collimators for LHC & LHC upgrades
- *SLAC now a member of Atlas*
 - Four major areas of participation identified working closely with our Atlas university and laboratory colleagues
 - Growing efforts in HLT and DAQ, pixel detectors and tracking, GEANT4 and simulation, already having impact
 - Proposal for Tier 2 Center accepted and already being implemented
 - Supported by all west coast Atlas institutions and US Atlas community
 - Partnering with UCSC and LBNL to develop a strong west coast hub for Atlas physics exploitation

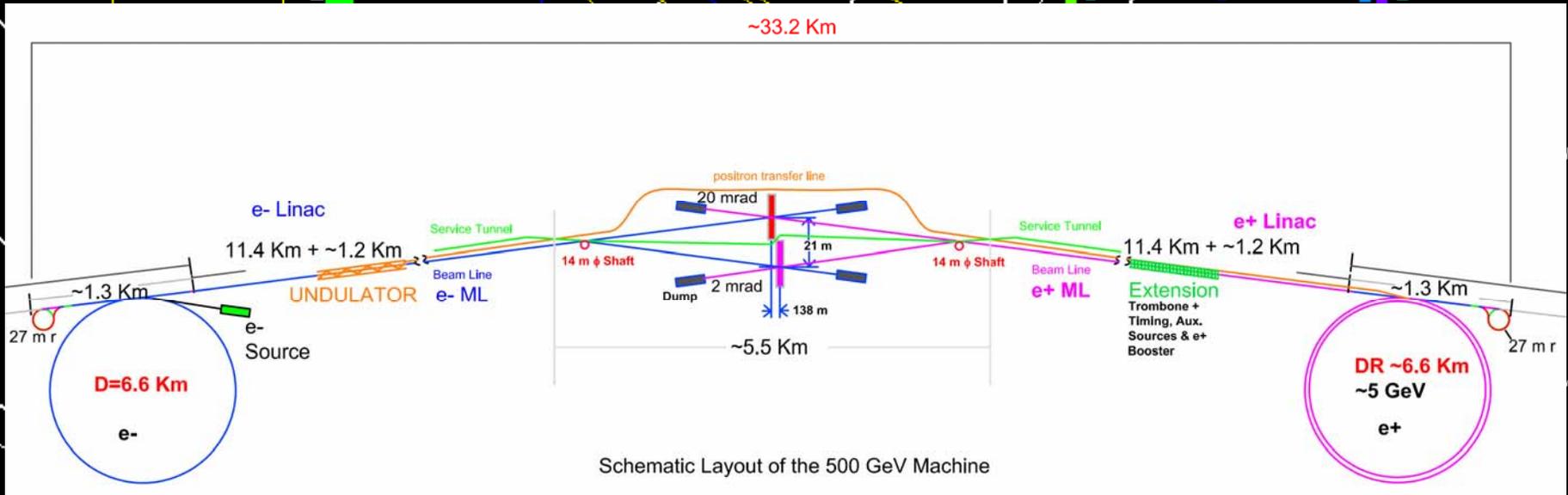
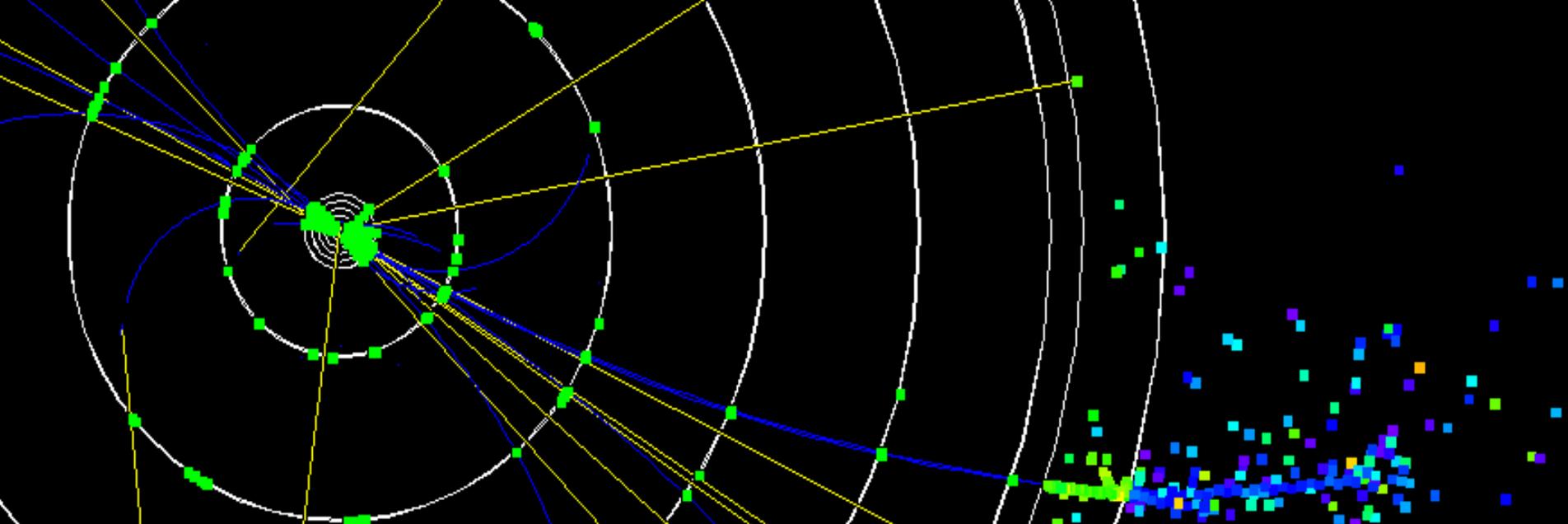


SLAC areas of involvement

- *With advice from Atlas and US Atlas managements, and many US/Atlas users, identified 4 related areas of initial contribution:*
 - Pixel detector commissioning and calibration, based on experience at Mark II, SLD, & *BABAR*
 - Higher level trigger, building on extensive SLD & *BABAR* expertise
 - Core and Atlas-specific GEANT4 simulation
 - Tier 2 computing center & eventually a west-coast physics center in partnership with LBNL, UCSC, and the larger Atlas user community
- *Roles are connected to each other, to our physics interests, and to our user community*
- *Consistent with likely roles on ILC detector as well*

**All areas with unique strengths at SLAC
matched to a national laboratory role**





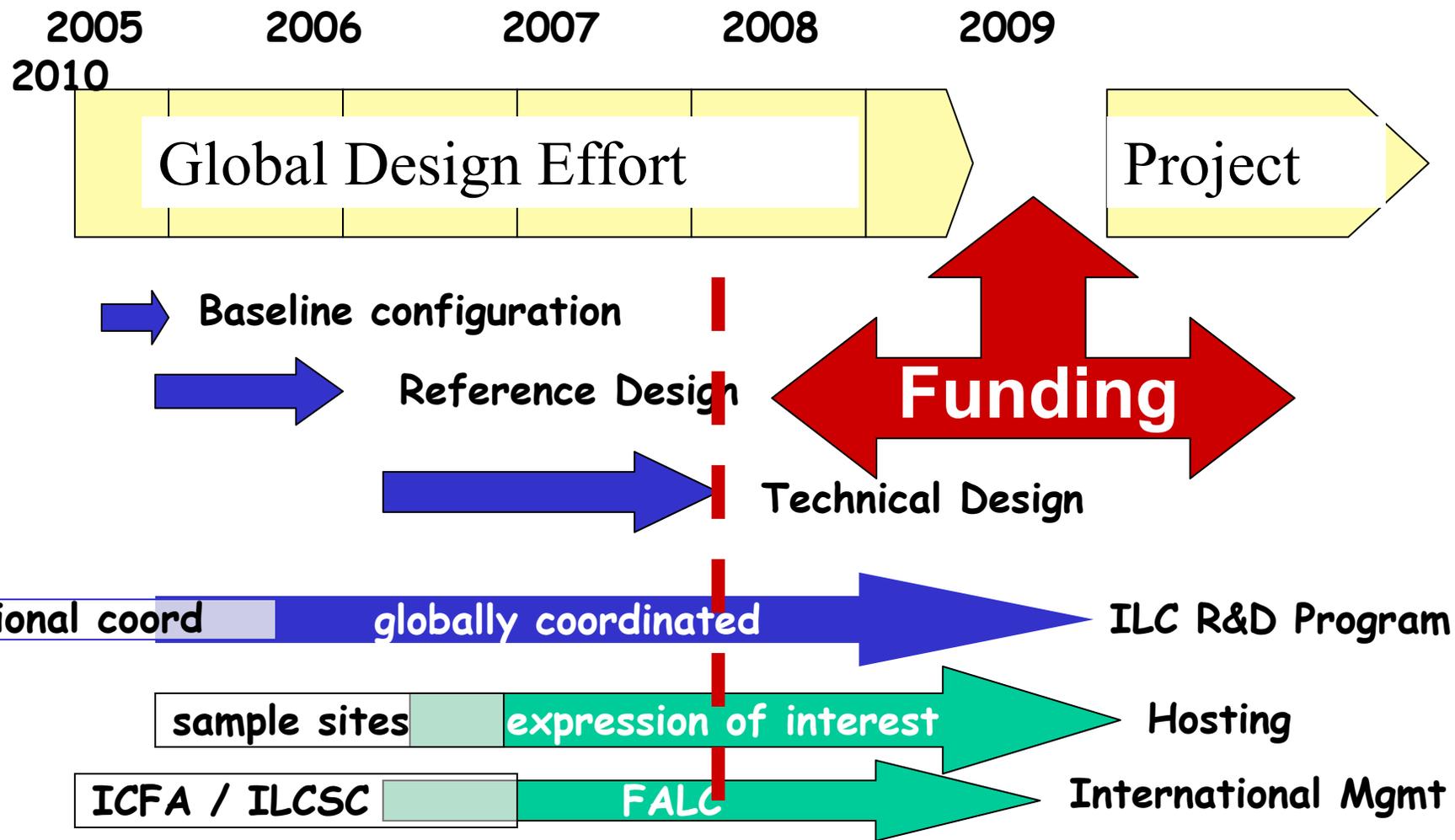
ILC machine & detector

The Energy Frontier: ILC & LCD

- *Committed to the ILC as highest priority new facility for international particle physics*
 - Broadly involved in all aspects of the ILC machine design and development
 - Partnering with university community in developing concept for detector
- *Major focus of SLAC ILC effort as part of GDE coordinated effort*
 - RF power sources, operational issues, particle sources, beam delivery system, machine-detector interface and instrumentation
- *Developing ILC detector concept in partnership with university community*
 - Focus on R&D for silicon tracking, particle-flow calorimetry, detector simulation, and overall detector concept



Global Design Effort schedule



The ILC effort at SLAC

➤ *Large and broad effort*

- 60 FTEs made up of about 80 people

➤ *Major focus of ILC effort*

- RF power sources (modulators, klystrons, RF distribution)
- Operational issues (highly available hardware, beam instrumentation, beam tuning techniques, and Machine Protection System)
- Particle sources (Polarized electron source and Positron source)
- Beam delivery system and Machine-Detector Interface

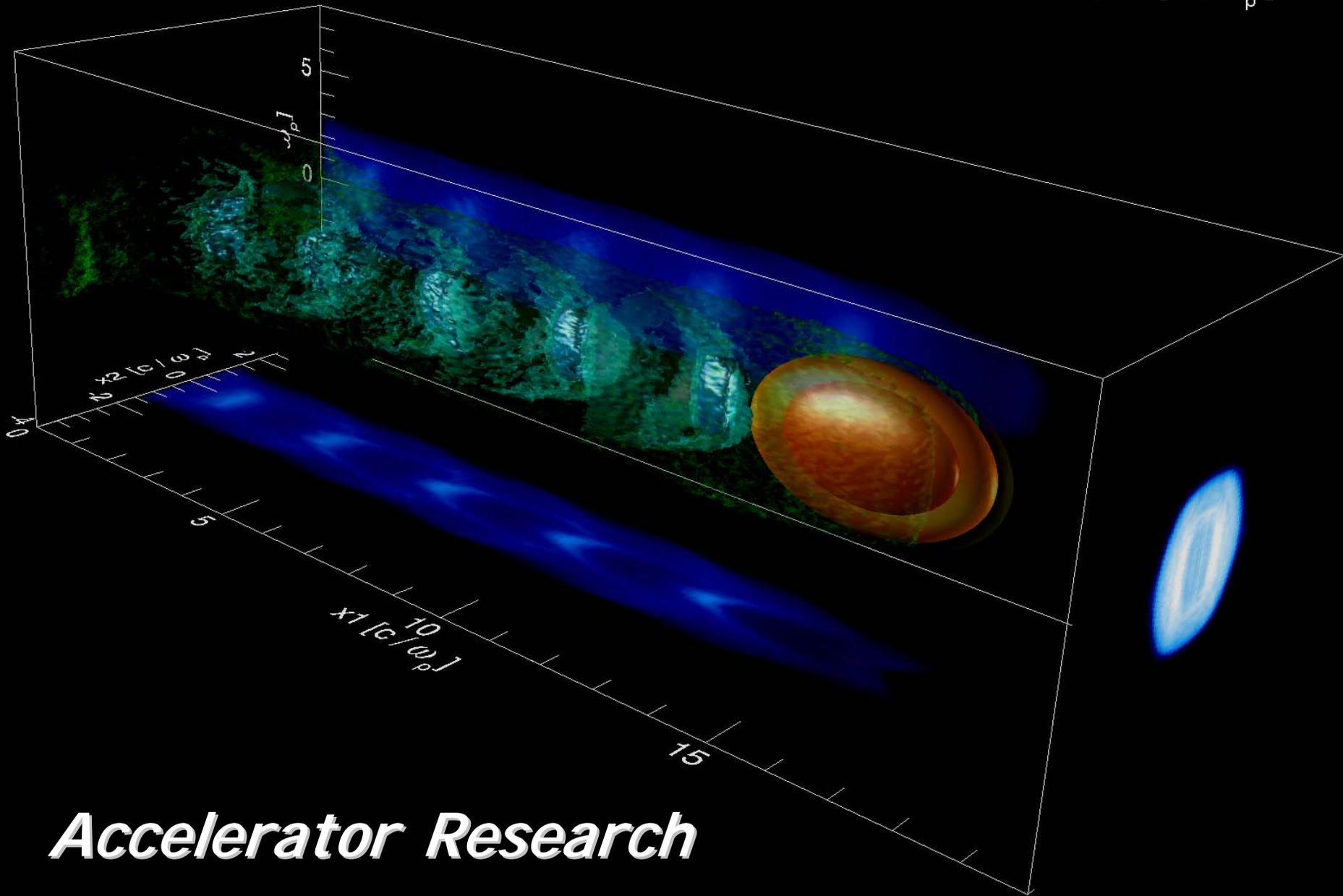
➤ *SLAC is playing a critical role in the ILC & the GDE*

- Bring both design and operational experience to the GDE
- Leadership of RDR as well as members on all Boards
- Strong R&D program aligned with ILC priorities



| Phasespace x3x2x1 |

Time = 28.00 [1 / ω_p]



Accelerator Research

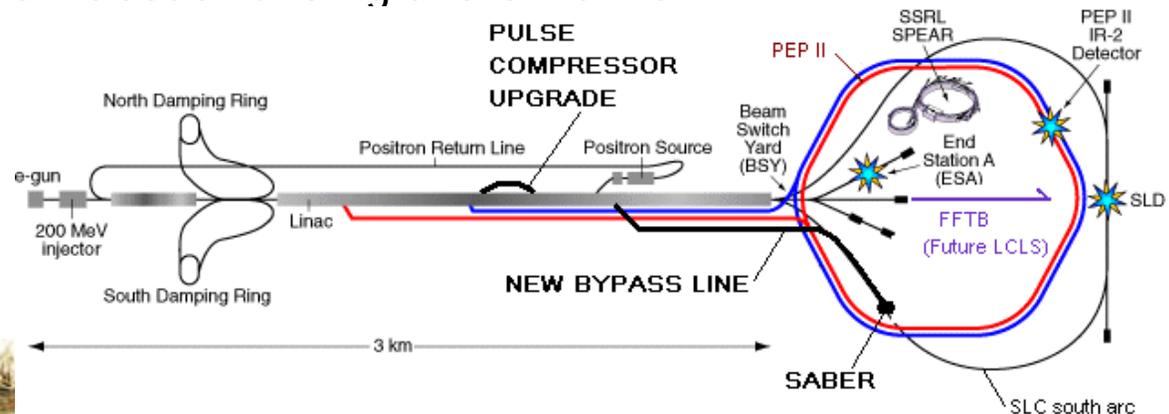
The energy frontier: accelerator research

- *Push the envelope with operating accelerators*
 - Supporting PEP-II and flavor factories worldwide
- *Study beam physics and develop accelerator technology for next generation facilities*
 - ILC, future multi-TeV linear colliders & high gradient research
- *Push the state-of-the-art in computational tools*
 - Bridging the gap between theory and technology
- *Explore advanced accelerator research in collaboration with university community*
 - Laser acceleration
 - Plasma wakefield acceleration
- *Exploit unique facilities*
 - Final-focus test beam (FFTB & soon SABER)
 - NLC Test Accelerator (NLCTA)



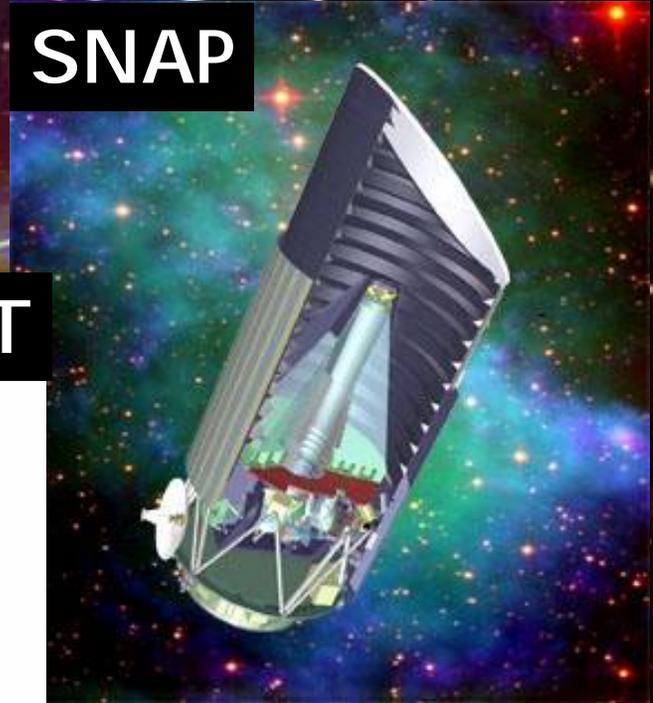
FFTB final experiments

- *Final FFTB running shared between SppS and Plasma wake-field experiment (E167)*
 - End of the line for spectacular facility
 - Disassembled to make way for LCLS
- *Spectacular results from final E167 run*
 - Demonstrated 42GeV of acceleration in 1.2m column of plasma
 - Highest energy electrons ever made at SLAC
- *SABER (FFTB replacement) in development*
 - White paper outlining science case 11/05
 - Workshop with community 2/06
 - In discussions with DOE about funding and timeline

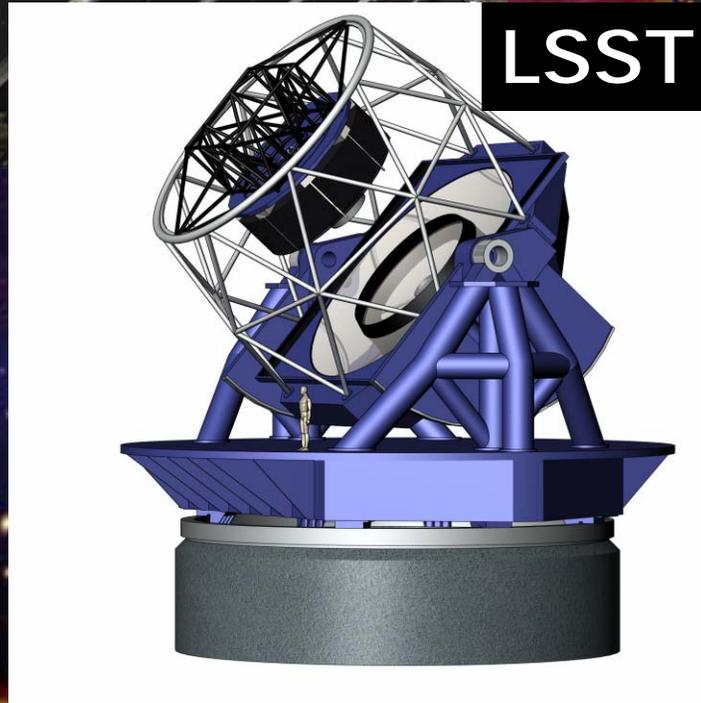




GLAST



SNAP



LSST

Particle Astrophysics and Cosmology

Kavli Institute for Particle Astrophysics and Cosmology



Founded 2003
Director: Roger Blandford
Deputy Director: Steve Kahn
~120 members
Two new buildings, labs

Instrumentation, data analysis,
particle astrophysics, relativity,
computational astrophysics,
observational cosmology,
theoretical cosmology...

KIPAC is a major new opportunity for the SLAC user community



Particle astrophysics and cosmology

- *Tremendous scientific opportunities to explore the dark universe, recognized as priority by EPP2010*
- *Large Synoptic Survey Telescope (LSST)*
 - Best matched instrument for ground-based weak lensing measurements to use dark matter to map properties of dark energy
 - Focus on development of CCD camera & corresponding DAQ challenges as well matched to HEP experience
- *Participation in Joint Dark Energy Mission*
 - Partnering under leadership of LBNL in the SNAP concept
- *Gamma Ray Large Area Space Telescope (GLAST)*
 - Moving towards launch in fall 2007, with growing understanding of GLAST's role in dark matter campaign
 - Center for scientific program (ISOC) based at SLAC



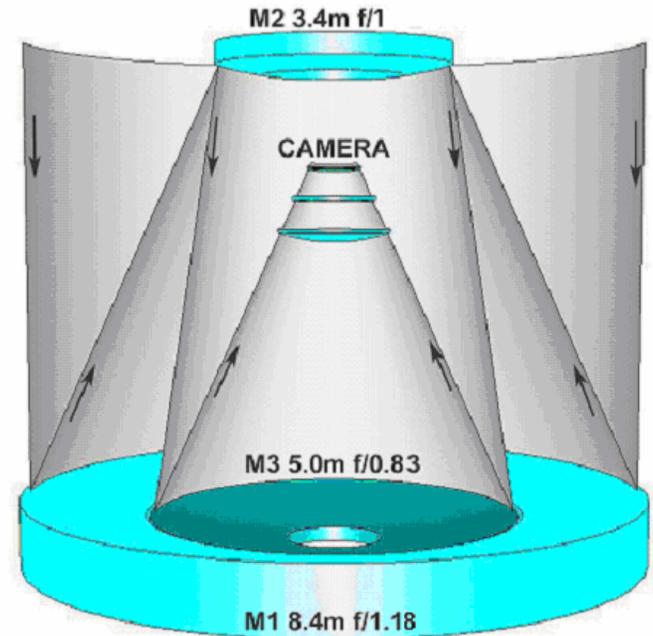
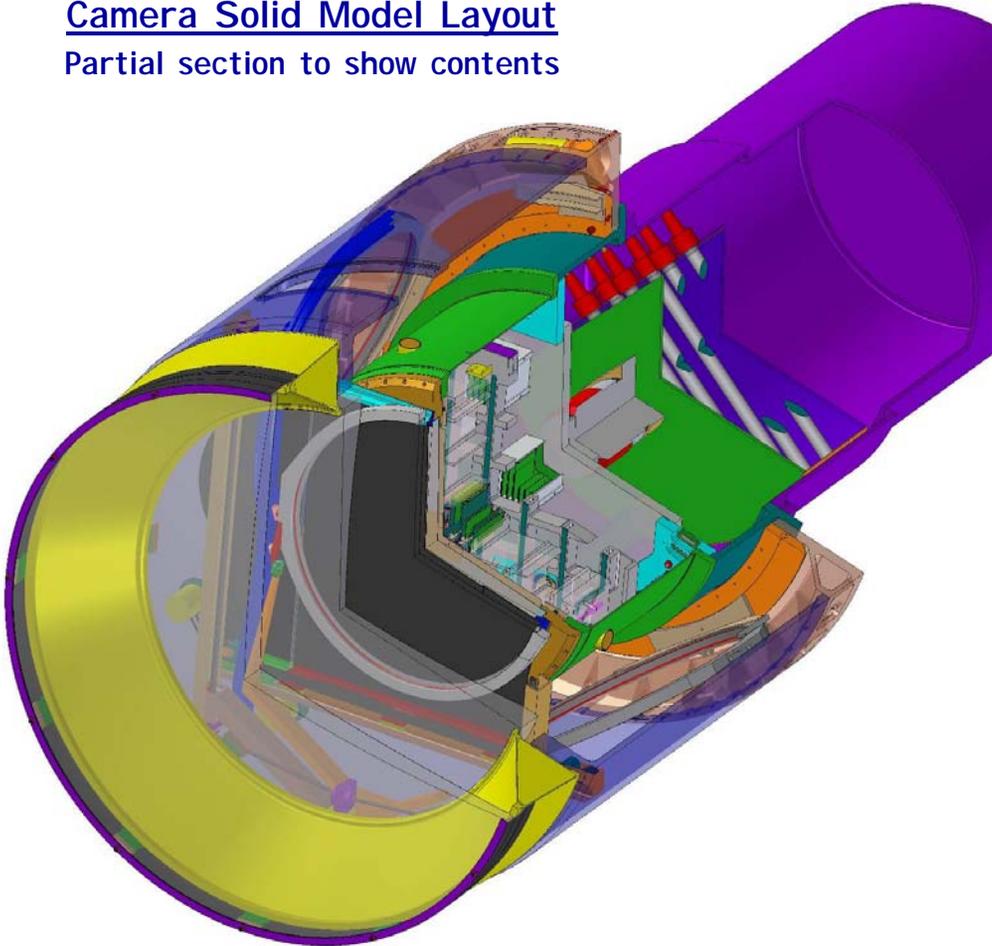
GLAST instrument status

- *Gamma Ray Large Area Space Telescope (GLAST) continues to march towards launch*
 - Growing understanding of GLAST's role in dark matter campaign
 - Baltz, Battaglia and Peskin; hep-ph/0602187
- *Instrument is fully assembled*
 - Shipped from SLAC in May
 - Instrument level environmental tests in conducted at NRL
- *Environmental testing completed!*
- *On track for Fall 2007 launch*
 - In transit to be mated with launch vehicle



3.2 Gpixel camera for LSST

Camera Solid Model Layout
Partial section to show contents



LSST optical layout

Significant alignment challenges in assembly and sensor placement



Vision for SLAC science in 2012

- o World's first x-ray laser, the LCLS, into 4th year of operation, allowing exploration of ultra-fast science at the atomic scale
 - Ultrafast Science Center leading science exploitation
 - First round of LCLS upgrades about to get underway
- o GLAST well into its first 5-year mission, with tremendous science program centered on the Science Operations Center
- o Leading partner in the construction of the International Linear Collider and an ILC detector
- o SPEAR3 supporting a large user community in photon science
- o LSST coming online at its Baja site, with the world's largest digital camera built by a SLAC-led team
- o Kavli Institute for Particle Astrophysics and Cosmology a leading institute attracting the world's best
- o Breakthroughs in advanced accelerator techniques continue to be actively pursued
- o Full EXO deep underground searching for neutrinoless double beta decays

