

# Strategic Overview: Particle and Particle Astrophysics

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# An Exciting and Challenging Time in Field of Particle Physics

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- The Standard Model of quarks and leptons is fabulously successful---and fabulously incomplete
  - It only describes ~5% of the Universe
  - Compelling Questions confront us
- Within this decade a new accelerator is coming on line with potential to make dramatic progress in our understanding
  - LHC
  - We are also developing the accelerator for discovery in the next decade: ILC
- Non accelerator strategies essential components achieving our scientific goals
- Long term health and future of the field of HEP relies on ILC
  - Excellent progress towards international realization of such a machine---but not a certainty
- Budgets are constrained

# SLAC PPA Program: Exploiting the present and preparing for the future

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- Science now or soon
  - B Factory (operations to 2008)
  - GLAST (2007 – 2012/17)
  - SLAC Participation in the LHC (2007 and beyond)
  - Proof of principle experiments in accelerator research
- R&D for science in the next decade (2010 and beyond)
  - ILC (2016?)
  - LSST (first light 2012??)
  - JDEM (20??)
  - EXO (2012?? if R&D successful)
- R&D for farther future
  - Accelerator Research

# Programmatic Priorities

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- For the near term:
  - We must focus on B-factory performance and delivery of science to our largest user community
  - We must launch GLAST and develop the ISOC
    - Deliver the science to the user community
- For the mid term:
  - We must continue in our leadership role for the ILC
    - Highest priority new facility for the world community
  - We must work to provide additional opportunities for science to our user community in ~2012
    - e.g. LHC, LSST, EXO, JDEM,...
- For the long term:
  - The R&D in accelerator science is our hope for the future of the field
    - To make the next accelerator \*after\* the ILC technically feasible and affordable

# Near Term Program: Science Now or Soon

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- B-factory
- GLAST
- SLAC Participation in the LHC

# B-Factory Program

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- PEP-II Accelerator
  - Collides e<sup>+</sup> and e<sup>-</sup> with unequal beam energies at  $E_{CM}=10.58$  GeV
  - Premier tool for studying physics of heavy flavor
- BaBar Detector
  - Optimized for B-physics at asymmetric energy collider
  - Run by International Collaboration of ~623 physicists from 80 institutions in 11 countries
- Program of Rich Physics
- B-factory program operates until end of FY2008
  - Goal: Deliver to BaBar: ~1ab-1 end of FY2008
- Laboratory committed to delivering luminosity
  - Focused task force approach to ensure success

Journal Papers	BABAR	Belle
Total	189	162

# BABAR Physics Goals

Physics	Impact	Alternative Facilities	FY2006 450 fb <sup>-1</sup>	FY2007 650 fb <sup>-1</sup>	FY2008 1000 fb <sup>-1</sup>
Precision measurement of $\sin 2\beta$	Fundamental constant of the SM, whose precision is only limited by statistics	Uniquely small systematic errors at the $B$ Factories			Improve present error by factor of two to 2%
Precision measurement of $CP$ asymmetry in $b \rightarrow s\bar{q}q$ penguin modes	Primary approach to new physics in loop decays; $b \rightarrow s\bar{s}s$ presently discrepant with SM predictions at $2.4\sigma$ level when averaged over all available modes	LHC <b><math>b</math> has limited capability for most of these modes</b>	Potentially reach the $4\text{--}5\sigma$ level for average of all $b \rightarrow s\bar{s}s$ modes		Potentially reach the $4\text{--}5\sigma$ level for individual $b \rightarrow s\bar{s}s$ theoretically-clean modes
Precision measurement of unitarity angle $\alpha$	Fundamental constraint on the UT	Most modes and isospin analysis unique to $B$ Factories		Discovery of $B^0 \rightarrow \rho^0 \rho^0$ if it has SM branching fraction	Isospin analysis in $B \rightarrow \rho\rho$ allows better than $10^\circ$ measurement
Precision measurement of unitarity angle $\gamma$	Fundamental tree-level constraint on phases and amplitudes originating from any new physics beyond the SM	Unique theoretically clean measurement at the $B$ Factories, complementary to methods at LHC <b><math>b</math>; UT constraints on all future LHC discoveries</b>	Pioneering $10\text{--}15^\circ$ measurements		Determine to $5\text{--}10^\circ$ precision

# BABAR Physics Goals

Physics	Impact	Alternative Facilities	FY2006 450 fb <sup>-1</sup>	FY2007 650 fb <sup>-1</sup>	FY2008 1000 fb <sup>-1</sup>
Discovery of $B \rightarrow \rho\gamma$	Provides a unique determination of CKM matrix elements $ V_{ub} / V_{cb} $ ; likely before $B_s^0$ - $\bar{B}_s^0$ mixing discovery	Complementary to measurements based on eventual observation of $B_s^0$ - $\bar{B}_s^0$ mixing, either at the Tevatron or LHCb	First hints	Discovery if it has SM branching fraction	Precise measurement of BF
Search for $D^0$ - $\bar{D}^0$ mixing	Highly suppressed in the SM and therefore an ideal place to search for new physics in charm mixing diagram	Unique to $B$ Factories, CLEO III and BES	Hint if 1% mixing amplitude		Discovery if 1% mixing amplitude
Search for lepton-flavor violation in $\tau \rightarrow \mu\gamma$ or other tau decays	Expected to be significantly enhanced in many extensions of the SM accommodating neutrino mass, but extremely small in the SM itself	Unique to $B$ Factories; constrains Higgs sector in the LHC era			Limits reach $2 \times 10^{-8}$ sensitivity
New discovery in heavy hadron spectroscopy	Improved understanding of QCD in non-perturbative regime	Unique capabilities at $e^+e^- B$ Factories, CLEO III and BES	Discoveries possible anytime	Discoveries possible anytime	Discoveries possible anytime

# GLAST

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- GLAST:  $\gamma$ -ray Large Area Space Telescope
  - GLAST measures direction, energy and time of celestial gamma rays from 20MeV – 300 GeV
    - Gamma rays probe cosmological distances in a largely unexplored energy range
    - Great potential for Discoveries:
      - Fundamental Physics (dark matter,..)
      - Cosmic Particle Acceleration (SNR, jets, ..)
      - Physics of Relativistic Outflows (GRB's, Pulsars, ..)
  - Joint Particle Physics/Particle Astrophysics venture
    - Involves 5 nations, 9 funding agencies
- Fabrication project has been challenging!
  - Project successfully rebaselined summer 03 after CNES withdrew financial support
  - Transition to flight production much more painful than anticipated and production anomalies summer/fall led to second rebaseline winter 05

# Success!



# ACD Installed



# GLAST Moving Forward

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- Instrument is assembled
  - ACD put on 11/05
  - Final electronics boxes before x-mas
  - Currently commissioning DAQ and FSW before ship to NRL for environmental testing
- Delivery to Observatory Integration in summer
  - Mate with spacecraft and GBM and test
- Launch September 2007
  - Kennedy Space Flight Center
- Focus at SLAC transitioning to build up of ISOC and preparation for science



SIRTF Launch on a  
Delta II Heavy

# SLAC Participation in LHC

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- Motivations:
  - Energy frontier Physics. Synergy between LHC and ILC.
  - Experience in detector and operations relevant for ILC.
  - To maintain a healthy work force for ILC
  - Strong user interest from traditional SLAC user community
  - Our experience on detector/computing are seen as valuable assets which could help ATLAS to prepare for the first physics at LHC.
- Strongly supported by our theory community
- Application to join ATLAS submitted to collaboration last month
- LHC joins GLAST as 'anchor' for lab PPA program

# R&D for science in the next decade: 2010 and beyond

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- ILC
- LSST
- JDEM
- EXO

# ILC

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- High Energy  $e^+e^-$  LC highest priority new machine for world community
  - SLAC has led field in development of LC design and technology
  - SLAC has always been committed to playing a leadership role in ILC independently of choice of RF technology
  - SLAC has accelerator expertise in all subsystems of the collider
  - R&D program now restructured to address critical issues for cold machine
- SLAC fully supports GDE effort
  - SLAC staff are co-leading 4 of the technical subgroups

# ILC Machine R&D activities

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- Accelerator Design and CDR
  - e+e- sources
  - Damping ring design
  - Beam Delivery System
  - Instrumentation and control systems
- Goals for near term:
  - End of CY06: CDR
- Goals longer term:
  - CY08/09: TDR

# ILC Detector Program

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- Need to grow program of linear collider detector R&D
  - SLAC is working with LBNL and FNAL to provide opportunities for user community to engage
- Simulation Effort
  - Supports national and international effort
- Concept development for a detector based on Silicon
  - One of several approaches in the community
- Effort is investment limited—particularly engineering
  - Opportunities to grow with GLAST roll off

# LSST-Large Synoptic Survey Telescope

- 8.4 m ground based telescope
  - Wide field of view
  - Weak lensing survey of entire sky
  - Dark matter power density spectrum
  - Constraints on Dark Energy
- Proposed as joint DOE/NSF project
  - SLAC lead lab on camera development
  - First light ~2012
- R&D effort growing with GLAST roll off

- \* Dark matter and dark energy with weak lensing  
Full LSST survey will cover 20,000 square degrees, and resolve over 4 billion high-redshift ( $z \leq 3$ ) galaxies!
- \* Dark matter and dark energy with supernovae  
LSST will detect 250,000 type I-a supernovae ( $z \leq 1$ ) per year!
- \* Cluster survey and baryon oscillations.
- \* Gravitational micro-lensing.
- \* Strong galaxy & cluster lensing: physics of dark matter.
- \* Multi-image lensed SN time delays: separate test of cosmology.
- \* QSO time delays vs  $z$ : independent test of dark energy.

# The LSST Collaboration

*Brookhaven National Laboratory*

*Harvard-Smithsonian Center for Astrophysics*

*Johns Hopkins University*

*Las Cumbres Observatory*

*Lawrence Livermore National Laboratory*

*National Optical Astronomy Observatory*

*Ohio State University*

*Pennsylvania State University*

*Research Corporation*

*Stanford Linear Accelerator Center*

*Stanford University*

*University of Arizona*

*University of California, Davis*

*University of Illinois*

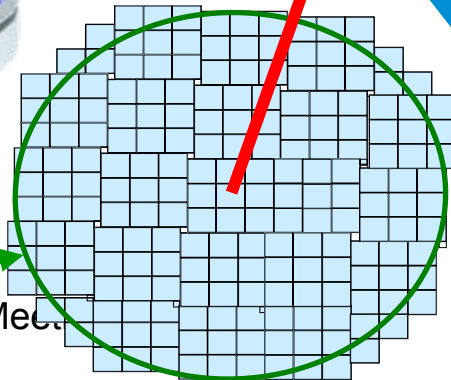
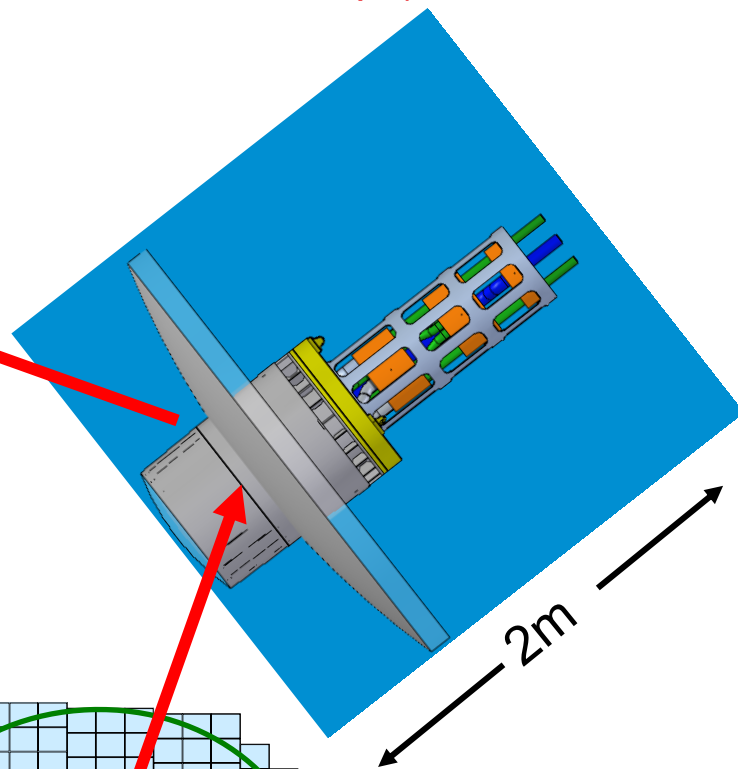
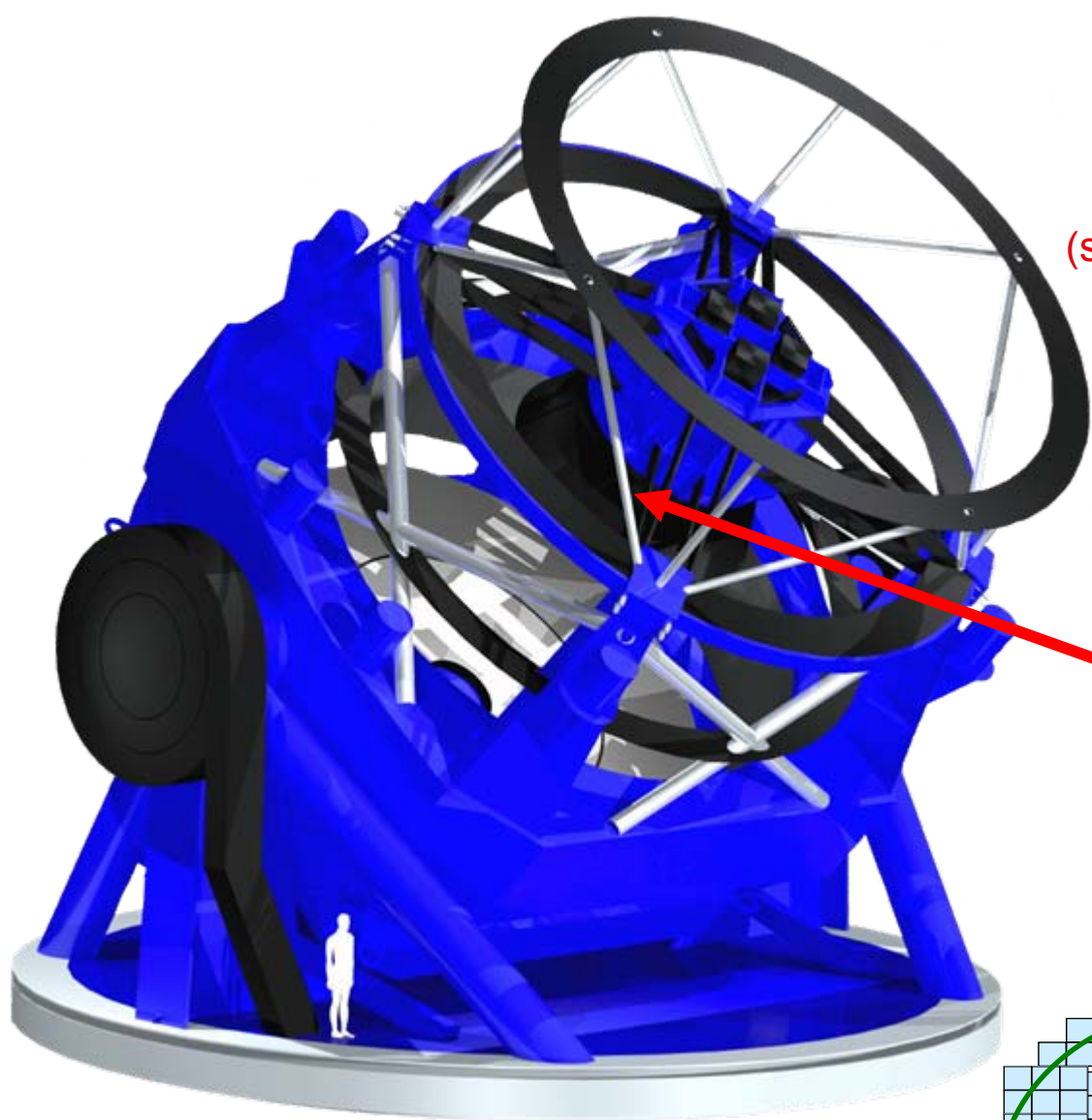
*University of Pennsylvania*

*University of Washington*



# LSST Camera

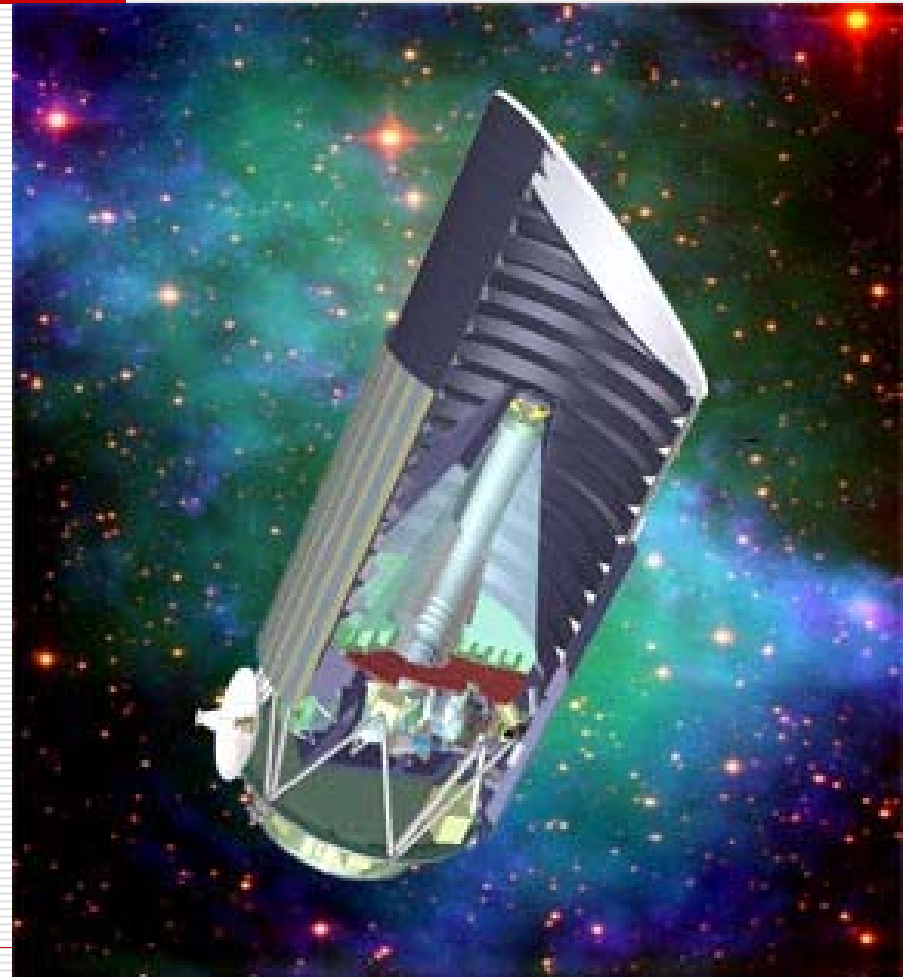
(shown with the secondary mirror of the telescope)



3.2 Giga-Pixel  
10  $\mu\text{m}$  CCD Array  
20

# JDEM/SNAP

- 2m space based telescope—LBNL lead lab
- Study high  $z$  SNe → Dark Energy
  - Weak Gravitational lensing → Dark Matter
  - Strong Lensing → Small scale structure
- Joint project DOE and NASA
  - SLAC involvement in OCU and possibly electronics
- R&D effort growing with GLAST roll off



# EXO: Enriched Xenon Observatory

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- Search for  $\beta\beta 0\nu$  decay in  $^{136}\text{Xe} \rightarrow ^{136}\text{Ba}^{++} e^- e^-$
- EXO Philosophy
  - Excellent energy resolution (separates  $\beta\beta 0\nu$  from  $\beta\beta 2\nu$ )
  - Positive ID Ba Ion (Ba tagging)
- Strategy:
  - Currently EXO 200 is being built
    - Study detector performance (no Ba+ tagging)
    - Look at backgrounds
    - Measure  $2\nu\beta\beta$  mode with 1-2 year run
    - Sensitivity of  $\sim 0.2$  eV to  $0\nu\beta\beta$  mode
  - Continue R&D on Ba tagging for next 2-3 years
    - In parallel with EXO 200 operations
- Successful R&D would lead to proposal for full EXO (ton scale experiment)
  - EXO goal:  $\langle m_{\nu e} \rangle \sim 10$ 's of meV

# Strategic Elements of Accelerator Research

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- Accelerator Research for Future Machines
  - High Gradient Studies for CLIC type machine
  - Development of L-band power sources for ILC
- Proof of Principle Studies of New Acceleration Mechanisms:
  - Plasma Acceleration
  - Laser Acceleration

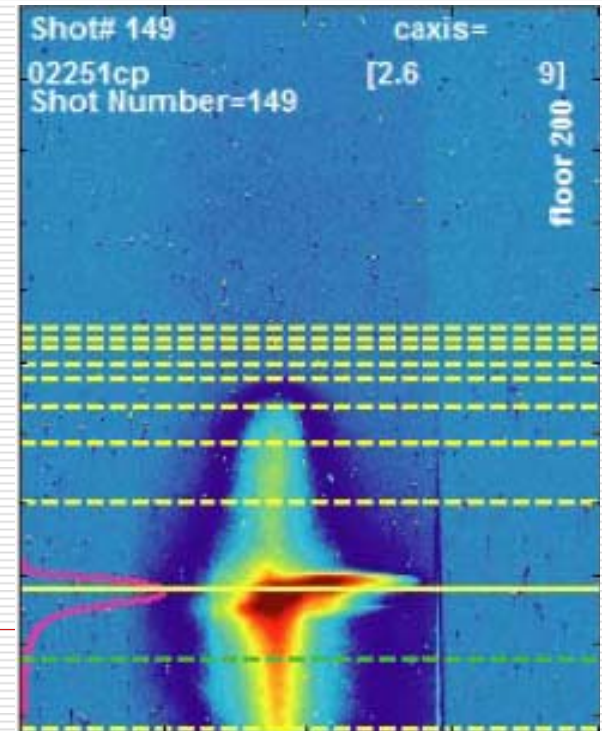
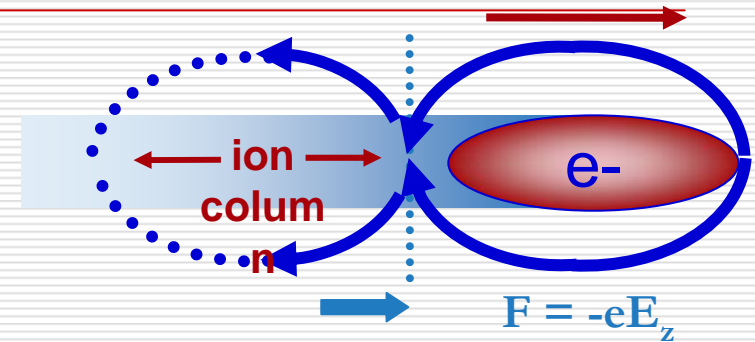
# Accelerator Research for Future Machines

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- Accelerator Research for ILC
  - We are developing plans for R&D effort into alternative sources of L-band power for ILC
    - Plug and play replacement to multi beam klystron at lower cost
    - More innovative technologies: high risk but high gain
- High Gradient R&D for  $e^+e^-$  colliders past the ILC
  - National program being encouraged by DOE

# Proof of Principle Studies of New Acceleration Mechanisms

- Accelerator Research
  - E164/E164X running successfully (Plasma wake field acceleration)
    - Show energy doubling of electrons in a 30 GeV beam
    - Highest energy electrons ever at SLAC!
  - Laser acceleration experiment progressing in NLCTA
    - Demonstrate and develop new methods for accelerating electrons with laser radiation using solid-state structures
    - First runs this year



# Looking Forward: The Mission for SLAC PPA Post BaBar

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- Our scientific mission looking forward has two major elements:
  - Accelerator based research at the energy frontier
    - ILC, LCD, LHC, Accelerator Research
  - Investigations of Dark Matter and Dark Energy (non-accelerator)
    - GLAST, LSST, JDEM
- In addition:
  - We are committed to full exploitation of the B-Factory investment and the BaBar data set
  - We are doing R&D to develop a 'best in class' experiment to determine the fundamental nature of the electron neutrino—EXO
  - KIPAC is developing particle astrophysics in other directions that will be funded by NASA

# Looking Forward: Budget News from DOE is good!

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- **Overall HEP budget and priorities in FY 2007:**
  - Tevatron and B-factory supported for full scheduled operations
  - LHC Support (Operations and Computing) up 8% as construction completes
  - Core research program at the universities (6%) and laboratories (2%) increased
  - **Initiatives for the future of HEP:**
    - **ILC R&D doubled (\$30M→\$60M)**
    - **Start of new neutrino initiatives**
      - Electron Neutrino Appearance Experiment (EνA)
      - Reactor Neutrino Detector
    - **Investment in long-term accelerator R&D increased \$28M→\$33M**
    - **Dark Energy R&D increased \$3M→\$13M**

# Agenda and Goals for the Meeting

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- Overview of LAT project and GLAST mission
  - Mission Status
  - Project Status
  - Collaboration Status
    - Collaboration Task List and Collaboration Agreements
- Report on Education and Public Outreach Activities
- Discussion of ISOC
- Approval of CY06 Budget
- Presentation of CY07 Budget (for approval at next meeting)
- Approval of October Minutes