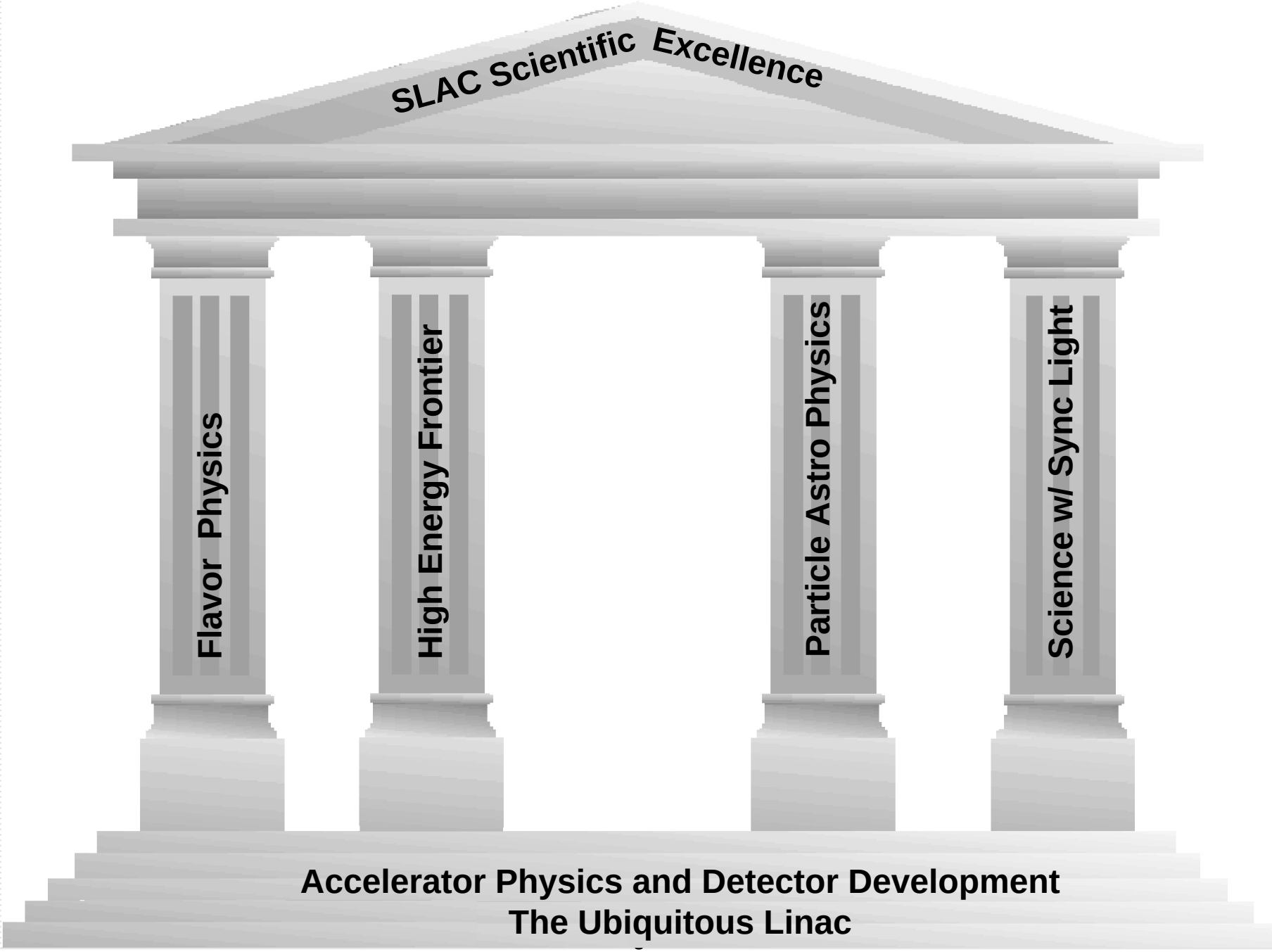
Overview of SLAC HEP Program

Persis S. Drell
Research Director


SLAC Scientific Excellence
Flavor Physics
High Energy Frontier
Particle Astro Physics
Science w/ Sync Light
Accelerator Physics and Detector Development
The Ubiquitous Linac

Focus of Current and Future SLAC Scientific Program

- SLAC program is addressing compelling scientific questions facing the field
  - Where did the antimatter go? (B-Factory)
  - Are there new symmetries and forces of nature? (B-Factory, NLC)
  - Why are there so many particles? (B-Factory)
  - What is Dark Matter? How can we make it in the lab? (LSST, JDEM, GLAST, NLC)
  - Can we solve the mystery of Dark Energy? (LSST, JDEM, NLC)
  - Is there grand unification of particles and forces? (NLC, EXO)
  - What are neutrinos telling us? (EXO)
  - Are there extra dimensions of space? (NLC)
- SLAC science program extremely broad

Major SLAC HEP/Particle Astrophysics Research Programs

- Flavor Physics
  - BaBar
  - Measurement of $m_{\nu e}$ (EXO)
- Particle Astrophysics and Cosmology
  - GLAST
  - KIPAC
    - LSST, JDEM,…
- High Energy Frontier
  - Linear Collider
  - Advanced Accelerator R&D
  - E158: Parity Violation in Moeller Scattering

Program Review Overview

- Plenary Talks: High level program overviews
  - Speak to Charge
- Breakouts:
  - Theory: Fireside Chat
    - Includes astro theory and phenomenology
  - Advanced Accelerator
    - Details of ongoing work; tour of NLCTA
  - BaBar: Details of
    - Detector upgrades, computing, physics output, SLAC effort, collaboration strength, roadmap for future
  - Particle Astro: Details of
    - KIPAC Non-Doe programs
      - Nustar, Exist, NEXT, POGO, ….
        - Planting seeds, not all will grow
    - GLAST science
    - SNAP participation
    - Astro Theory Observational efforts

Flavor Physics

- **BaBar**
- EXO

B-Factory Science Program

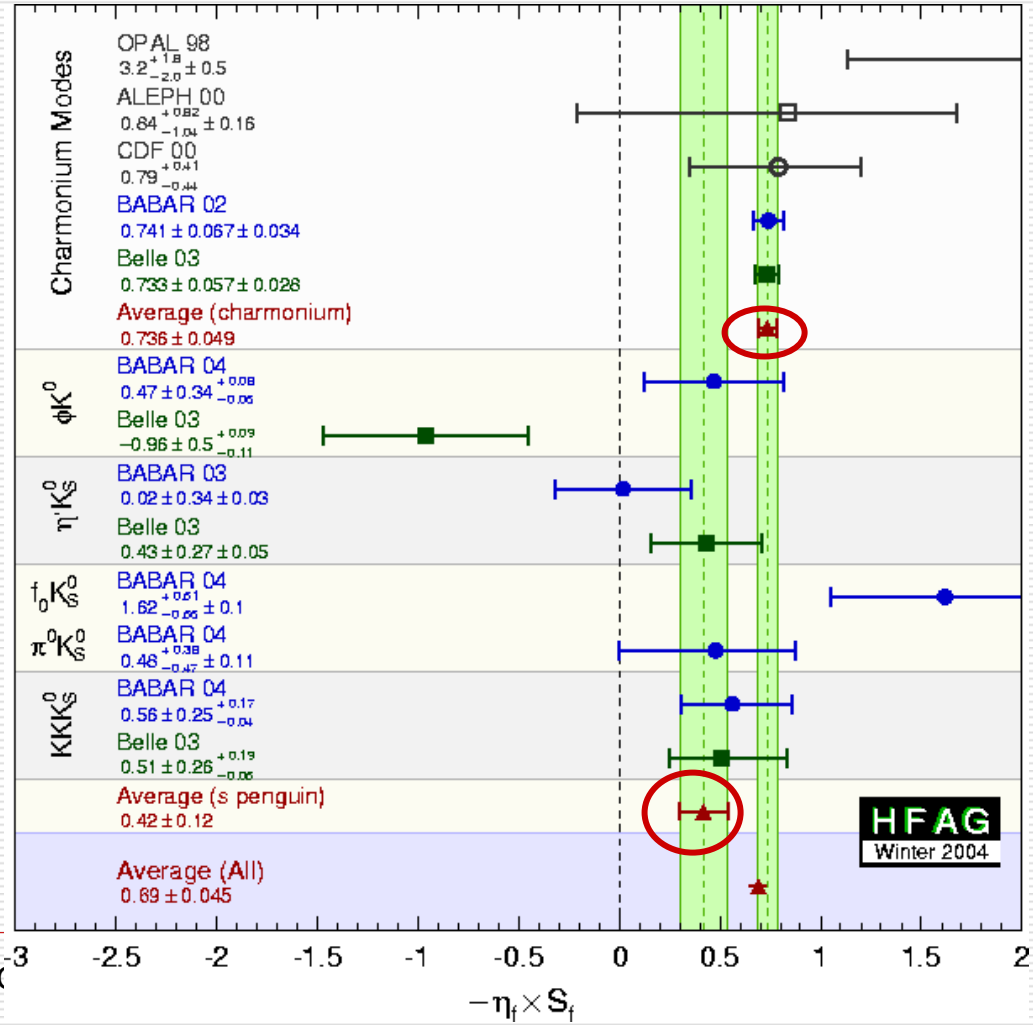
- B-Factory science drivers:
  - What happened to the antimatter?
    - B mesons a laboratory for study of CP violation
      - Discovery measurement in 2001
      - CP in charmonium (b→c) modes now measured to +-7%
      - Quark mixing by weak interactions not the whole story
      - Major progress in α from B->ρ+ρ-
  - Are there new symmetries/forces of nature?
    - Unique access to flavor sector of 'new physics'
      - CP in b→sss modes provides crucial testing ground for SUSY
      - Intriguing discrepancy!
  - Can we determine the pattern and properties of the quarks and leptons?
    - e+e- b factories are also τ and charm factories
      - Surprises of last year: new charm strange quark states

Intriguing Hint?

If central value remains as is, this would become ~4 sigma by 2005

charmonium (b → c) modes

b→s$\bar{s}$s modes
~ 2.4 sigma below charmonium modes



B-Factory Program

- PEP-II Accelerator
  - Collides e+ and e- 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 ~600 physicists from 77 institutions in 10 countries
  - Strong laboratory support for premier program
  - Strong International Collaboration Leadership
    - Spokesman: Marcello Giorgi (Pisa/INFN)
    - Spokesman Elect: David MacFarlane (UCSD)
    - Analysis Coordinator: Jeff Richman (UCSB)
    - Technical Coordinator: Bill Wisniewski (SLAC)
    - Computing Coordinator: Stephen Gowdy (SLAC)

The *BaBar* Collaboration

10 Countries
77 Institutions
593 Physicists

USA [38/300]

California Institute of Technology
UC, Irvine
UC, Los Angeles
UC, Riverside
UC, San Diego
UC, Santa Barbara
UC, Santa Cruz
U of Cincinnati
U of Colorado
Colorado State
Florida A&M
Harvard
U of Iowa
Iowa State U
LBNL
LLNL
U of Louisville
U of Maryland
U of Massachusetts, Amherst
MIT
U of Mississippi
Mount Holyoke College
SUNY, Albany
U of Notre Dame
Ohio State U
U of Oregon
U of Pennsylvania
Prairie View A&M U
Princeton U
SLAC
U of South Carolina
Stanford U
U of Tennessee
U of Texas at Austin
U of Texas at Dallas
Vanderbilt
U of Wisconsin
Yale

Canada [4/20]

U of British Columbia
McGill U
U de Montréal
U of Victoria

China [1/5]

Inst. of High Energy Physics, Beijing

France [5/51]

LAPP, Annecy
LAL Orsay
LPNHE des Universités Paris VI et VII
Ecole Polytechnique, Laboratoire Leprince-Ringuet
CEA, DAPNIA, CE-Saclay

Germany [4/31]

Ruhr U Bochum
Technische U Dresden
Univ Heidelberg
U Rostock

Italy [12/101]

INFN, Bari
INFN, Ferrara
Lab. Nazionali di Frascati dell' INFN
INFN, Genova & Univ
INFN, Milano & Univ
INFN, Napoli & Univ
INFN, Padova & Univ
INFN, Pisa & Univ & ScuolaNormaleSuperiore
INFN, Perugia & Univ
INFN, Roma & Univ "La Sapienza"
INFN, Torino & Univ
INFN, Trieste & Univ

The Netherlands [1/5]

NIKHEF, Amsterdam

Norway [1/3]

U of Bergen

Russia [1/11]

Budker Institute, Novosibirsk

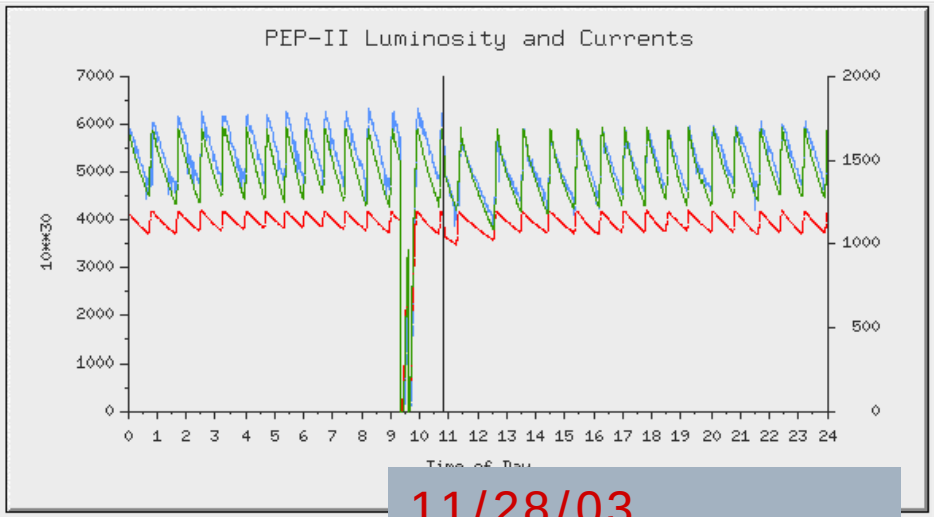
United Kingdom [10/66]

U of Birmingham
U of Bristol
Brunel U
U of Edinburgh
U of Liverpool
Imperial College
Queen Mary , U of London
U of London, Royal Holloway
U of Manchester
Rutherford Appleton Laboratory

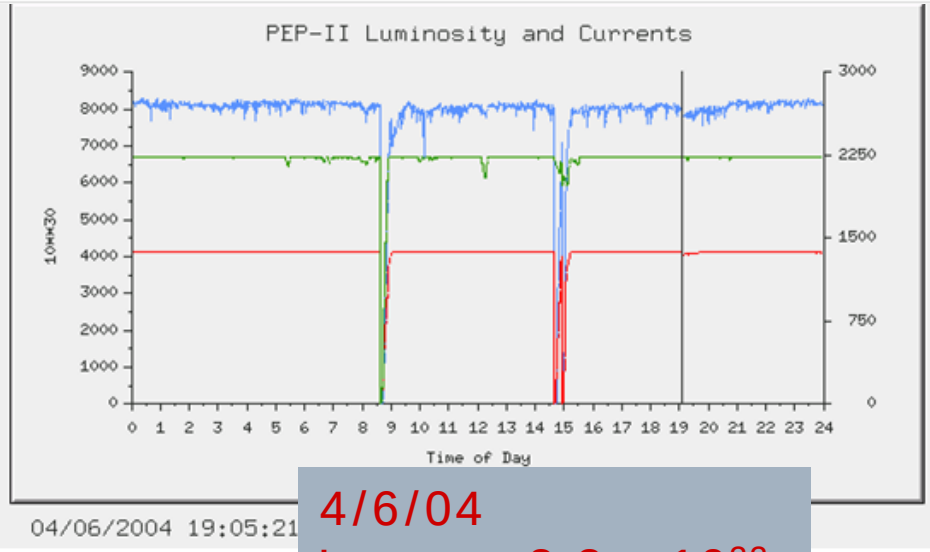
PEP-II: Accomplishments of Past Year

- Director led task force
  - Raise currents
  - Improve reliability
  - Trickle injection

Impact



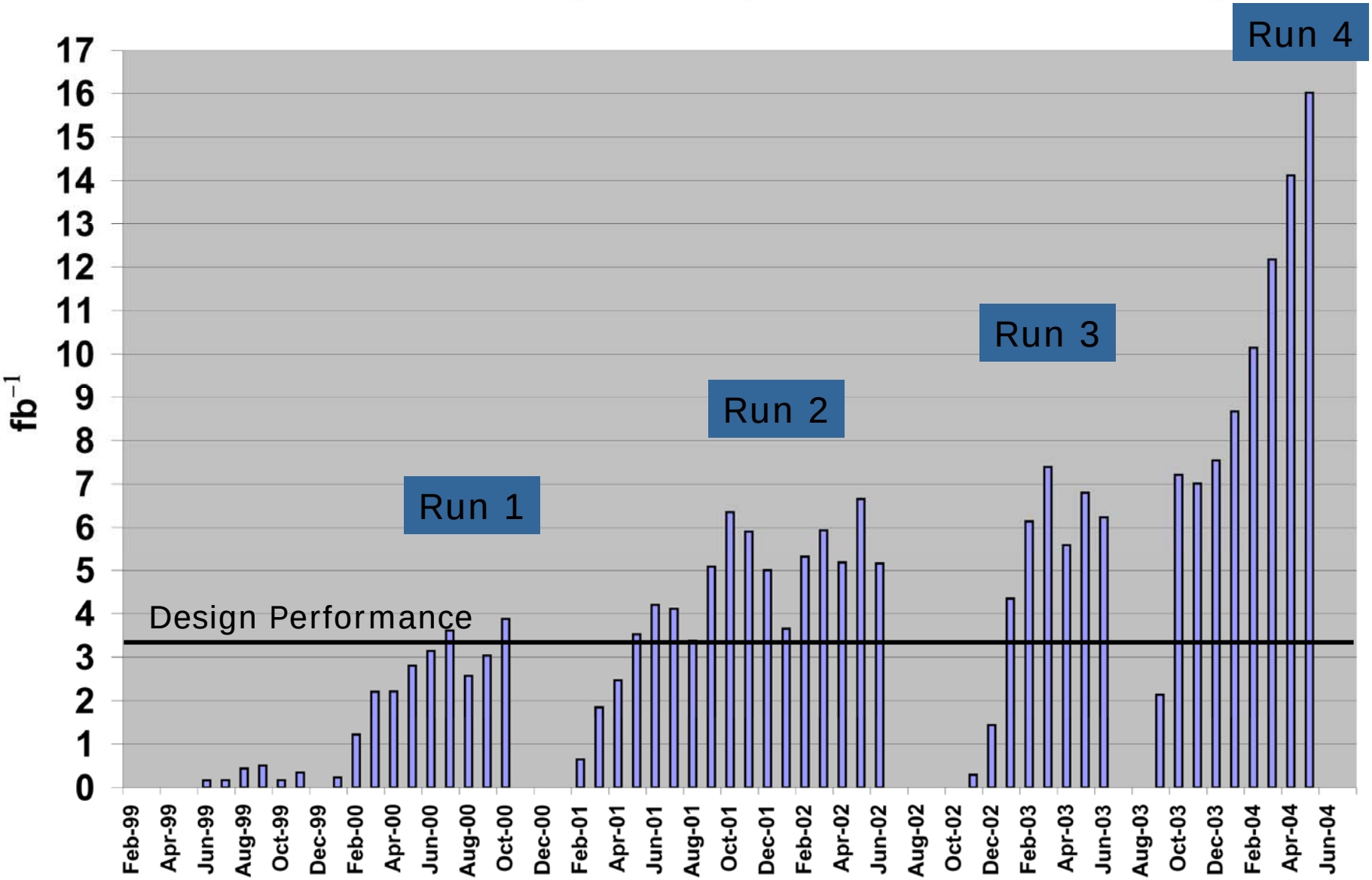
11/28/03
$L_{\_peak}$ = 6.8 x 10^{33}
Int $L_{\_day}$ =384



4/6/04
$L_{\_peak}$ = 8.3 x 10^{33}
Int $L_{\_day}$ =638

Last updated:
6/1/2004 7:32

PEP-II Monthly Integrated Luminosity



BaBar: Accomplishments of Past Year

- On track to add 100fb-1 to analyzed data sample by end of run 4
- Preparation for IFR replacement
  - Summer 2004
- New computing model
- Physics!!

	BABAR	Belle
<2003	34	54
2003	47	28
2004 (May)	14	9
Total*	96	91

* Total papers published and submitted

PEP-II Plans for Future

- In the next year:
  - Lower β^*
  - Shorter bunches
  - Increase current
  - Add RF
  - Add cooling
- Longer range:
  - Continue to lower β^*
  - Continue to raise currents
  - Increase number of bunches
  - Hardware completed Fall 2006
- Goal
  - Increase to $L_{peak} = 2.4 \times 10^{34}$ by Summer 2000

BaBar Plans for Future

- Hardware upgrades near term
  - Summer 2004
    - Replace 2 sextants of IFR (m detector)
    - Trigger upgrade
  - Summer 2005
    - Replace 4 sextants of IFR
    - DC electronics
    - Possible silicon intervention
- Long term plans
  - Strong collaboration commitment to 2010
  - Detector in excellent shape to 2010 with minor mods
  - Physics targets:
    - "Sin2β is not a measurement, it's a physics program"
      - 2006: 10-25% measurements of b->s modes
      - 2010: suite of measurements probing complementary aspects of flavor physics all at 5-10% level

Flavor Physics

- BaBar
- **EXO**

EXO: Enriched Xenon Observatory

- Search for $\beta\beta0\nu$ decay in $^{136}Xe \rightarrow {}^{136}Ba^{++} e^- e^-$
  - Observation of decay would provide direct evidence on:
    - Lepton number violation
    - Neutrinos are Majorana fermions
    - Set neutrino mass scale
- EXO Philosophy
  - Excellent energy resolution (separates $\beta\beta0\nu$ from $\beta\beta2\nu$)
  - Positive ID Ba Ion (Ba tagging)
- EXO goal: $\langle m_{\nu e} \rangle \sim$ 10's of meV

EXO: R&D Progress in Past Year

- Progress in Past Year
  - Single ion Ba+ tagging at different residual Xe pressures
  - Improved LXe energy resolution
  - Xe purification for long e- lifetime
  - Procurement/qualification of low background materials
  - Isotopic enrichment of large amounts of 136Xe
- Goals for 2005
  - Continue to study single ion Ba+ tagging at different residual Xe pressures
  - Demonstrate Ba ion lifetime and grabbing from LXe
  - Single ion Ba tagging in LXe
  - Construction of 200kg Prototype

EXO: Future Plans

- 200kg prototype
  - Study detector performance (no Ba+ tagging)
  - Look at backgrounds
  - Measure $2\nu\beta\beta$ mode with 1-2 year run
  - Sensitivity of ~0.2 eV to $0\nu\beta\beta$ mode
- Goal: Completion of R&D effort in next 2-3 years
  - Successful R&D would lead to proposal for full EXO

Particle Astrophysics and Cosmology

- GLAST
- KIPAC: Kavli Institute for Particle Astrophysics and Cosmology
- FLASH

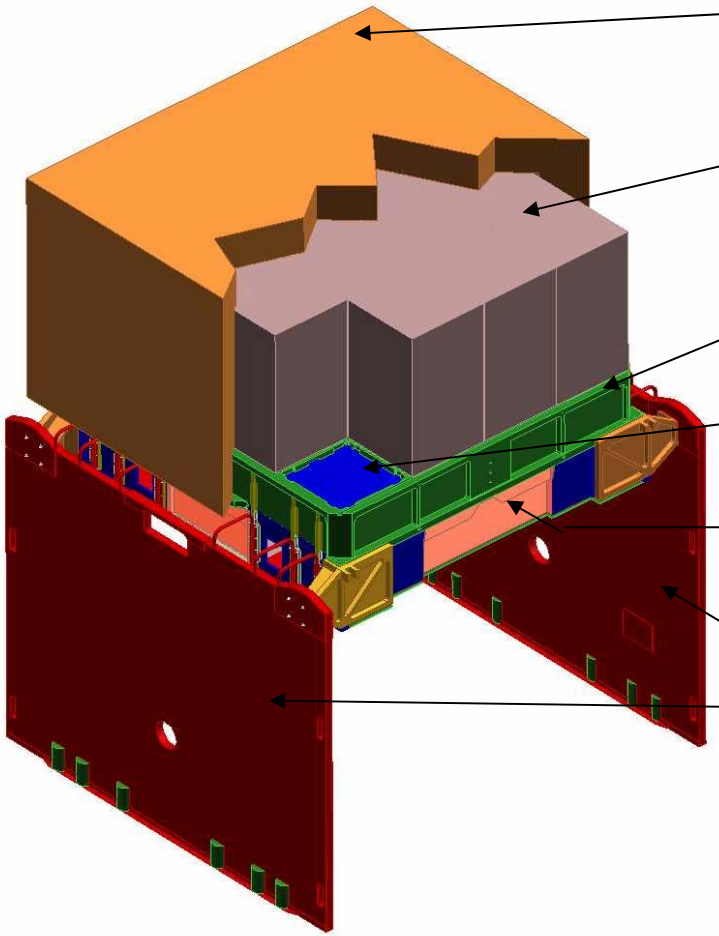
Particle Astrophysics and Cosmology at SLAC

- SLAC's HEP mission has broadened to include particle astrophysics and cosmology
  - Science Drivers for Particle Astrophysics program
    - Understanding the "Quantum Universe"
      - What is Dark Matter? How can we make it in the lab?
      - Can we solve the mystery of Dark Energy?
  - Look for opportunities where SLAC plays unique and enabling role
    - Intellectual Leadership
    - Engineering, Project Management, Ability to leverage off existing resources
    - Technical Expertise
      - E.g. GLAST

GLAST

- GLAST: γ-ray Large Area Space Telescope
  - GLAST measures direction, energy and time of celestial gamma rays from 20MeV – 300 GeV
  - Will Survey entire sky every 3 hours
    - Dark Matter Searches
    - Endpoints of Stellar Evolution: Black Holes, Neutron Stars, Sne remnants
    - Active Galactic Nuclei and Gamma Ray Bursts
    - Discovery!
  - Joint Particle Physics/Particle Astrophysics venture
    - Involves 5 nations, 9 funding agencies
- Fabrication project has been challenging

LAT Instrument



Anti Coincidence Detector

16 Silicon Tracker Modules

Grid

16 CsI Calorimeter Modules

Electronics Modules

Radiators

Mass 3000 Kg
Power 650 Watts

GLAST: Events of Past Year

- CNES withdrew financial support for project
- New project manager; organizational changes
- Project successfully rebaselined
  - Cost growth: $17.2M
  - Launch delay: 3 months
  - Strong support from NASA, DOE, SLAC & Stanford
- Successful CDR/CD-3 review
- LAT engineering model tested
- NASA Confirmation Review 12/4/03—Successful!
- Flight hardware in fabrication
- Funding profile problems (helped by Stanford, NASA)

GLAST: Future Plans

- Next Year:
  - Work to hold Schedule
    - As transition to fabrication of flight hardware encountering more difficulties than anticipated
    - The laboratory continues to put the highest priority on successful and timely completion of the project
  - Delivery of Flight hardware to SLAC
    - Integration and Test
  - Build up of ISOC and preparation for science
- Longer Term:
  - Launch 2/07
  - Science!
    - First year all sky survey
  - 5 year mission; extendable to 10 years

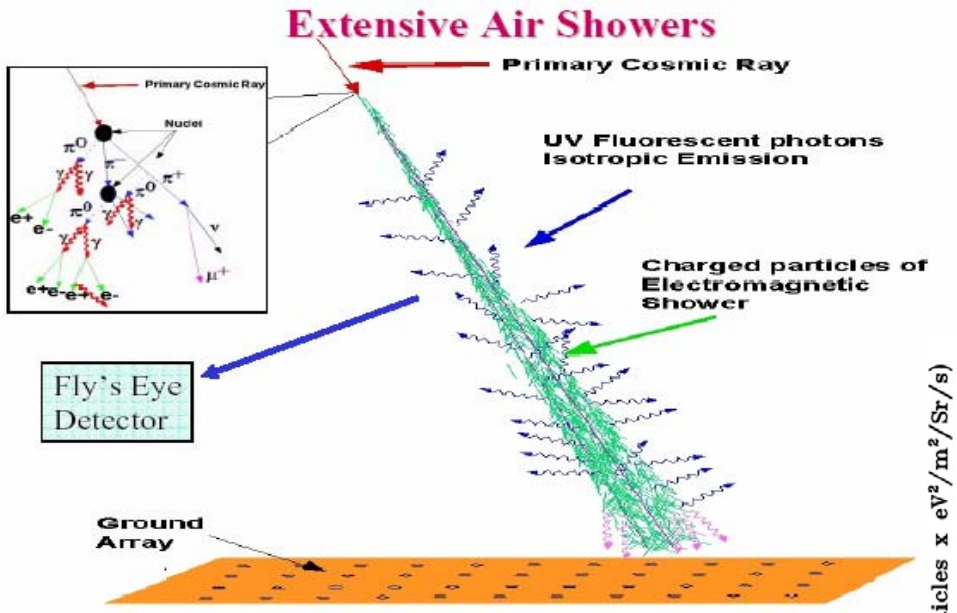
KIPAC: Kavli Institute for Particle Astrophysics and Cosmology

- Institute of Stanford University
  - Institute building on the SLAC site funding by gift from Fred Kavli
- Director reports to Stanford Dean of Research
  - 9 new faculty
    - Most if not all will be joint campus/SLAC
  - Director and Deputy Director recruited
    - Roger Blandford (CalTech)
    - Steve Kahn (Columbia)
  - Establishes Stanford/SLAC/DOE as intellectual force in field
- Institute brings in funds from NASA and NSF in addition to DOE funds through SLAC
  - Highly leveraged by > $20M investment by Stanford University
- Growing fast!
  - > 20 new people including 3 professional staff, 8 postdocs, 5 students, and lots of visitors

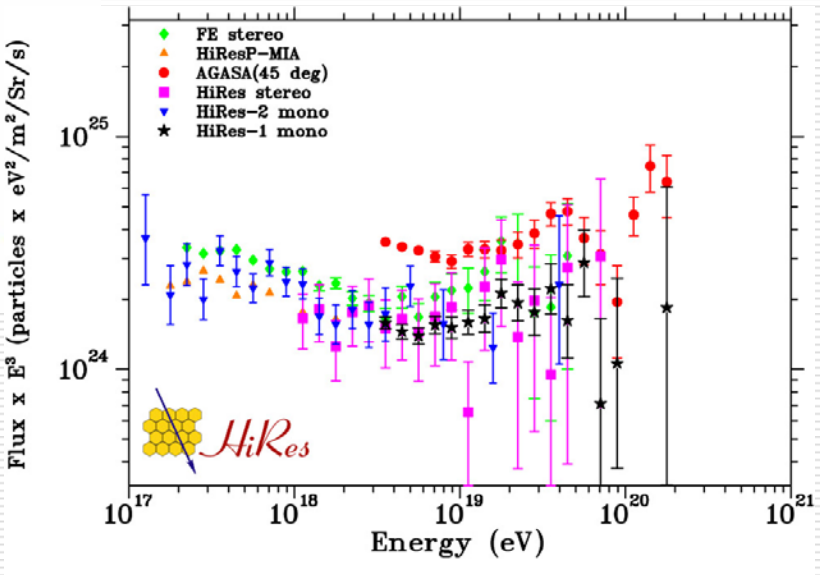
Particle Astrophysics and Cosmology: The Future

- Potential SLAC/KIPAC Projects
  - SNAP Collaboration (JDEM)
    - 2m telescope, 0.7 sq deg field in space
      - Study high z SNe ➔ Dark Energy
      - Weak Gravitational lensing ➔ Dark Matter
      - Strong Lensing➔ Small scale structure
  - LSST
    - 8.4 m telescope, 8.6 sq deg field on the ground
      - Weak lensing survey of entire sky ➔ Dark matter power density spectrum➔ Constraints on Dark Energy
- Many other NASA funded KIPAC Projects under discussion (NuStar, Exist, Next, POGO, …)
  - Focus of breakout session
- Theory effort already very productive
- Search for next 2 faculty underway

FLASH (E165)



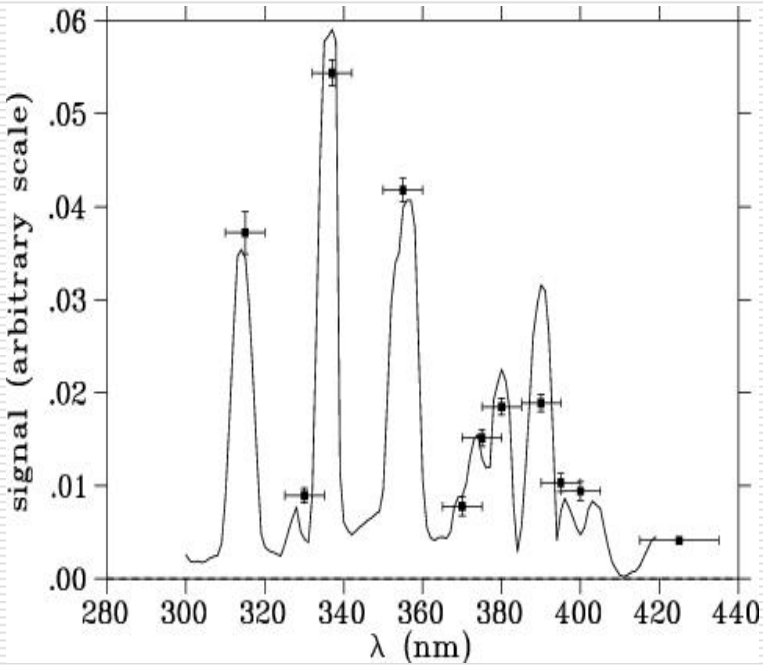
• Uses the high energy electron beam to make measurements of the fluorescence yield from extensive air showers



• Goal 10% or better in energy of cosmic ray

FLASH (E-165) Cont.

- Objectives
  - Spectrally resolved fluorescence yield to better than 10%.
    - Effects of atmospheric impurities.
    - Dependence on electron energy.
- First run 9/03
- Second run 6/04



High Energy Frontier

- **Linear Collider**
- E158
- Advanced Accelerator R&D

The Linear Collider

- Linear Collider Science Drivers
  - Are there new symmetries and forces of nature?
  - What is Dark Matter? How can we make it in the lab?
  - Can we solve the mystery of Dark Energy?
  - Is there grand unification of particles and forces?
  - Are there extra dimensions of space?
- Linear collider essential to establish quantum nature of the ‘dark universe’.

Strategic Look at Linear Collider

- High Energy e+e- LC highest priority new machine for world community
- SLAC leads field in development of LC design and technology
  - Champion of warm RF technology
  - SLAC will play leadership role independent of technology choice
- How will the technology choice impact the lab?
  - Scope of SLAC's role in LC approximately independent both of the technology adopted for the Linear Collider, and of its site.
  - SLAC will invest heavily with intellectual capital
    - LC can not happen without strong SLAC participation.

NLC Program

- R&D Progress in past year
  - Both TRC R1 challenges met
    - 65MV/m accelerating gradient
    - Pulse compression in SLED-II design
  - International Technology Recommendation Panel had 2-day site visit at SLAC
  - Possible technology recommendation by August
- Plans for near future (Internationally)
  - Formation of globally federated design group

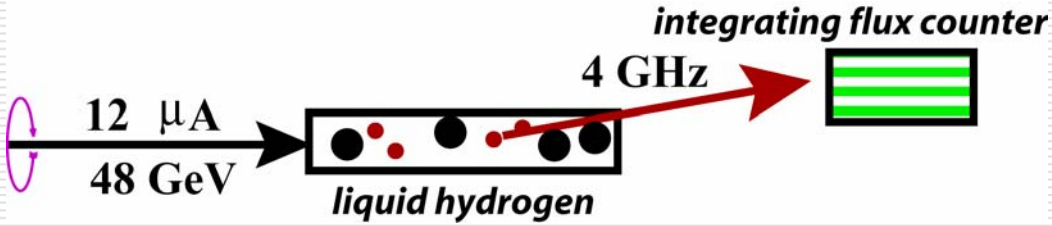
LCD Program

- Need to grow program of linear collider detector R&D (ALCSG)
  - SLAC is working with LBNL and FNAL to provide opportunities for user community to engage
- Simulation Effort
  - Supports national and international effort
- Concept Development
  - Integrated detector approach base on Silicon
  - One of several approaches in the community
- Beam Instrumentation (L, E, P)
  - Linac Beam offers unique opportunities
    - LOI at EPAC encouraged

High Energy Frontier

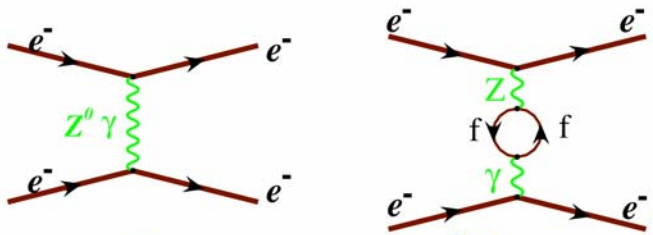
- Linear Collider
- **E158**
- Advanced Accelerator R&D

SLAC 158



A_{LR} = 0.18 ppm

$\delta(A_{LR})$ = +/- 7% +/- 3%

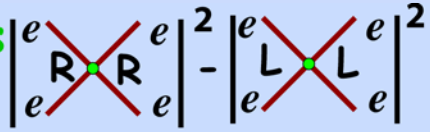


$g_{ee} \alpha (1 - 4 \sin^2\theta_W)$

E158 Collaboration

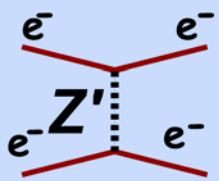
- UC Berkeley
- Caltech
- Jefferson Lab
- Princeton
- Saclay
- SLAC
- Smith College
- Syracuse
- UMass
- Virginia

compositeness
Λ~ 15 TeV



New Physics

new forces
$M_{Z'}$~ 1.0 TeV



E-158 Beam Parameters

120Hz Production Running

Run 1: April 23 – May 27, 2002
Run 2: October 10 – November 13, 2002
Run 3: July 10 – September 6, 2003

Parameter	Proposal	Achieved
Intensity at 48 GeV	6×10^{11} / pulse	5.3×10^{11}
Intensity at 45 GeV	3.5×10^{11}	4.3×10^{11}
Polarization	80%	85%
Repetition Rate	120 Hz	120 Hz
Intensity jitter / pulse	2% rms	0.5% rms
Energy jitter / pulse	0.4% rms	0.03% rms
Energy spread	-	0.15% rms
Delivered Charge* (Peta-E)	345K	410K

*proposal number for delivered charge allows 20% inefficiency factor for beam quality cuts and experimental efficiency

SLAC E158: Past Year

- Run 1 result is final and published in PRL.
- Run 2 result is preliminary and was first released last fall.
  - Preliminary: $\sin^2\theta_W = 0.2366$ +/- 0.0018 +/- 0.0014 (I+II)
- Run 3 is still blinded
  - Preliminary result in next 1-2 months
  - Final result published in fall.

Fate of Fixed Target Program

- New Proposals
  - Real Photon Experiments cancelled
  - DIS-Parity LOI to EPAC in June
    - Excellent science, recommended by EPAC
      - Prescott experiment (x 20 precision)
    - Insufficient resources (~$5M) to do in timely way
- Future Fixed Target Experiments in the Endstation?
  - Not a programmatic priority
  - Facility will be kept in operational shape for test beams, LCD R&D, future accelerator R&D, etc..
  - Loss of experimental facility to HENP community

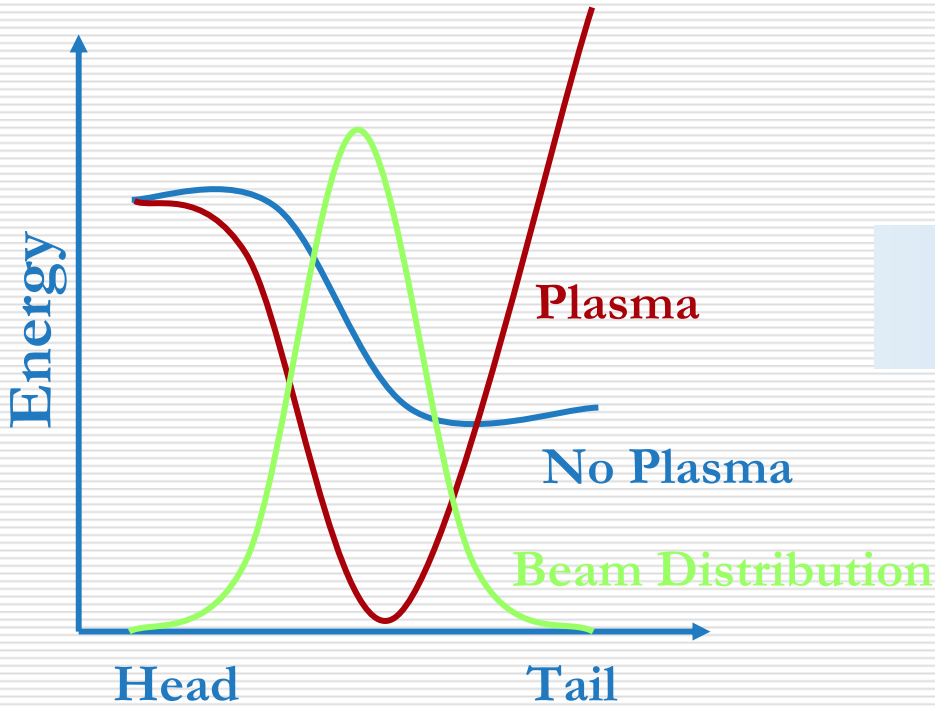
High Energy Frontier

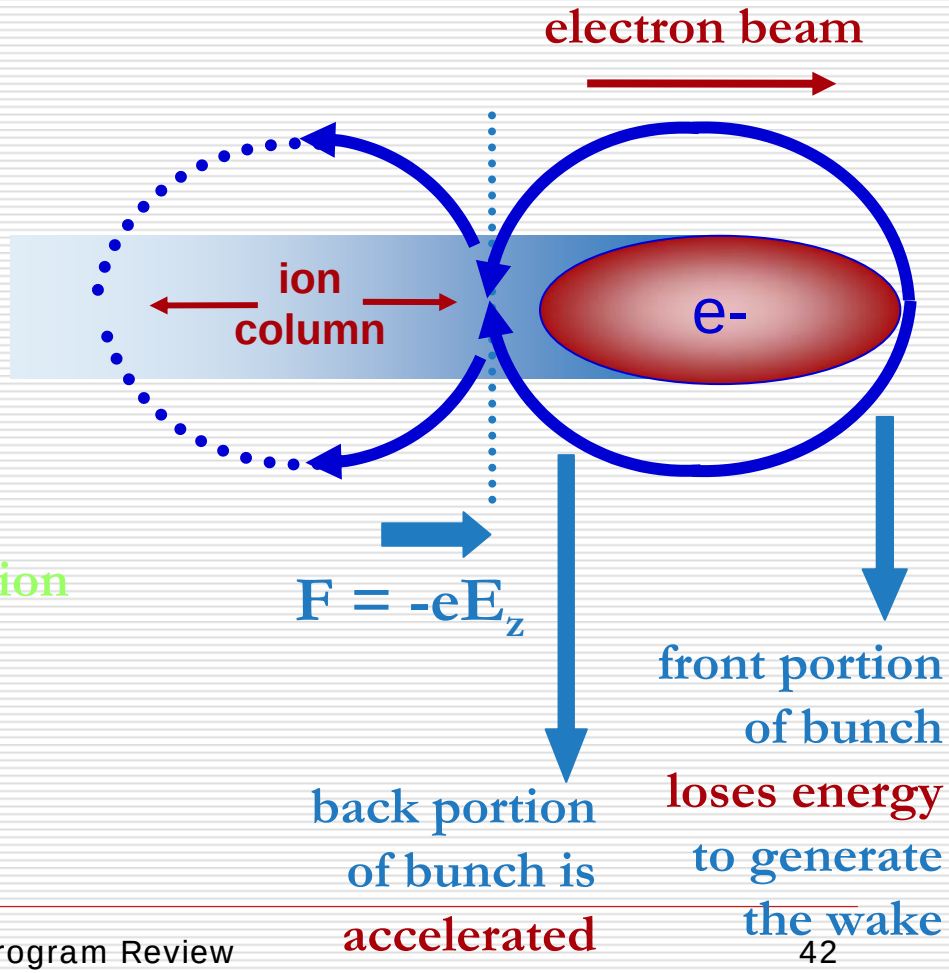
- Linear Collider
- E158
- **Advanced Accelerator R&D**

Advanced Accelerator R&D

- Preparing for challenges of longer term future
- Explore underlying physics
- Proof of principle experiments
  - E164/E164X – Plasma wake field acceleration program using Short Pulse Source
    - Producing surprising results
  - LEAP/E163 – Laser Acceleration in Dielectric Microstructures
    - In construction, hope to complete in next year.

Plasma Acceleration

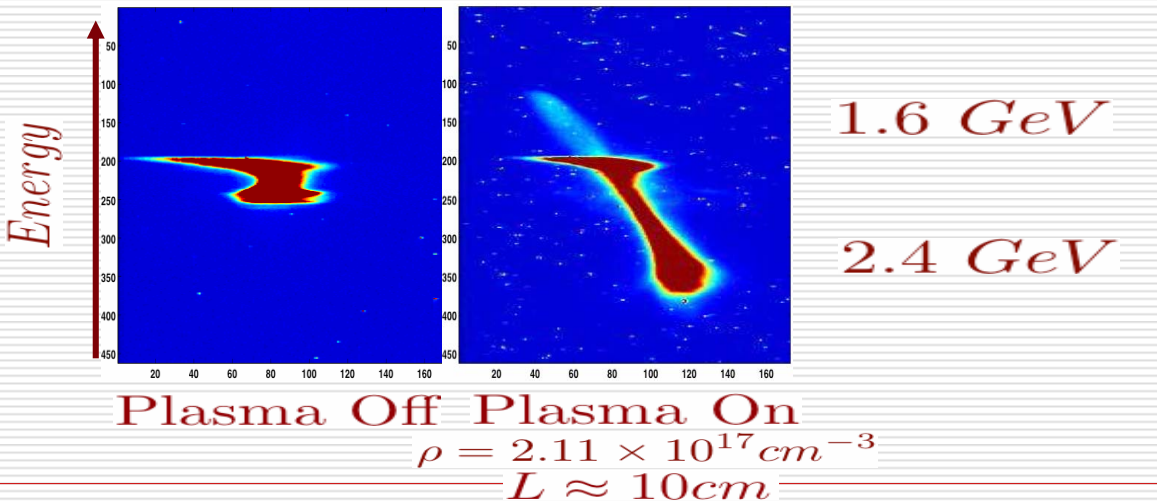




Plasma Acceleration

- Past year
  - Generated short (<100fs) pulses
    - Wake Field Amplitude ~ $1/\sigma_z^2$
  - Demonstrated acceleration in plasma

High-gradient acceleration of particles possible over a significant distance



Theoretical Physics

SLAC Theory Group

- Primary mission: to advance theoretical high-energy physics, and to train young scientists.
  - In addition, some members interact strongly with the SLAC experimental program
  - Interests of the group span a range of extremely challenging problems of relevance to national and international program
  - Group well integrated with ITP on campus
  - Increasing opportunities for interactions with KIPAC

Theory Group: Programmatic Connections

- Members of the Theory faculty and staff have strong connections to the various experimental programs here at the lab and elsewhere:
  - Linear Collider
    - Peskin, Rizzo, Hewett, Pierce
  - LHC
    - Dixon, Anastasiou
  - Cosmology
    - Kachru, Silverstein, Alexander, Maloney, Pierce
  - Low-energy and exclusive QCD
    - Brodsky
  - B-Physics
    - Hewett, Quinn, Becher, Hill

Computing

Computing

- Forefront computing at SLAC underlies many of the experimental programs.
- Key strength:
  - bringing application scientists, applied mathematicians and computer scientists together
  - creates revolutionary new approaches, both application-specific and generic.
- One of world's leading efforts in data-driven computing and large scale data management
  - necessitated by the huge explosion of data from the BaBar detector.
- Major additional efforts focus on applications in accelerator modeling and particle simulations.
  - Positioned to support new applications that use computation as a tool for discovery in particle astrophysics, cosmology, and bio-molecular simulations.
- Revolutions in science increasingly founded on, and driven by, computing.
  - Future focus on transforming the interaction between scientists and their data to transform the science being performed.

Summary

- Enormous opportunities for world class science at SLAC
- SLAC's programs and leadership central to national and international effort
- Programs are science driven, innovative, flexible and responsive to scientific drivers