Overview of SLAC Theory

JoAnne Hewett

Deputy Associate Laboratory Director, Science

Director, Elementary Particle Physics Division

June 21st, 2016

U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Theoretical Physics @ SLAC

Mission of our Group

- Scientific center of excellence in theoretical physics
  - broad view across subdisciplines – connected to lab programs: Event Generation, QCD, Heavy Flavors, Collider Physics, BSM Pheno, Model Building, Particle-Astro interface, Formal Theory
- Provide support to SLAC, US & International HEP programs
  - Work with on-going experiments
  - Define future programs
  - Perform scientific service for the community

Significant role in Snowmass and P5

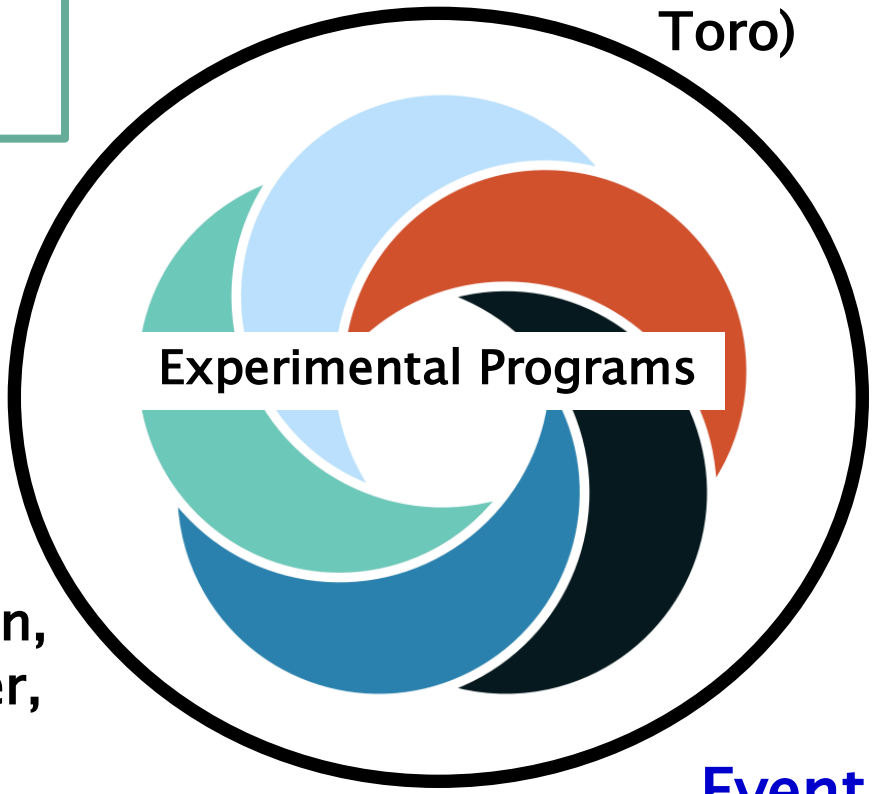
- Provide center of excellence for training young scientists

Particle Theory Program: At a Glance

Fully integrated with SLAC's programs!

Dark Matter
(Hewett, Rizzo, Schuster, Toro)

Neutrinos
(Friedland)



Formal Theory
(Dixon)

BSM Pheno
(Hewett, Peskin, Rizzo, Schuster, Toro)

QCD (Brodsky, Dixon, Höche)

Higgs Physics
(Dixon, Hewett, Peskin, Rizzo)

Event Generation
(Höche)

Transition achieved in budget neutral manner!

Particle Theory Program: At a Glance

SLAC

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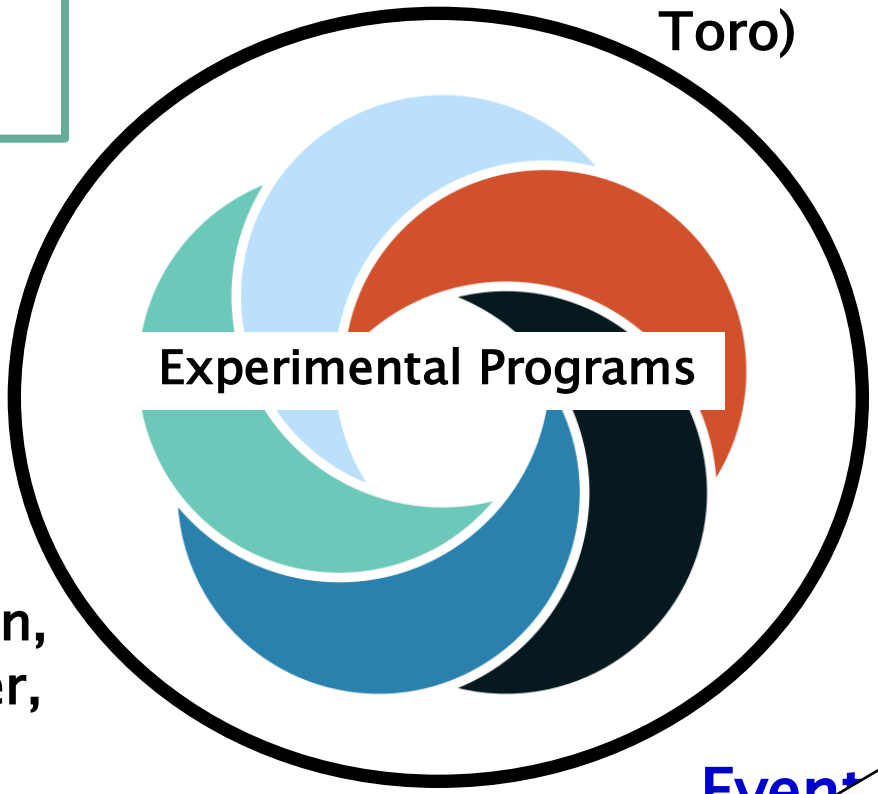

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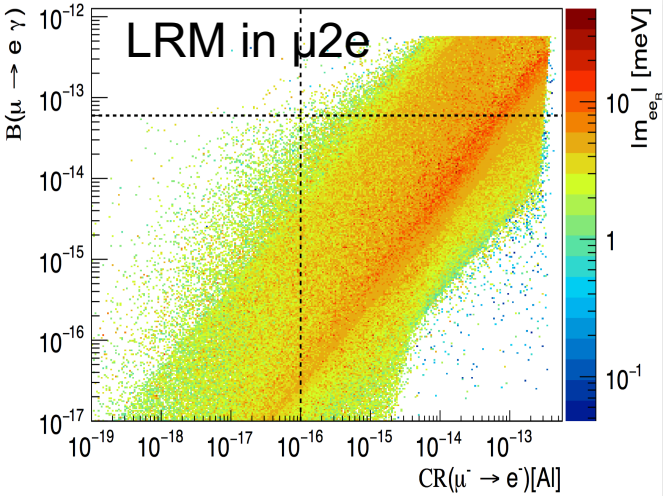
Event [illegible] **tion**
(H[illegible]

Unique to nat'l program

Transition achieved in budget neutral manner!

Theory: Recent Science Highlights

- BSM
  - LFV with Left-Right Symmetry (Hewett, Rizzo)
  - Warped Geometries at 750 Gev (Hewett, Rizzo)
  - Left-Right Symmetry at 2 Tev? (Hewett, Rizzo)
  - ATLAS pMSSM study (Rizzo)
- Dark Matter
  - Simplified models of DM (Rizzo)
- Higgs
  - Simplified Higgs models (Hewett, Rizzo)
  - Physics at ILC Review (Peskin)
  - Interference in h➔γγ + 2-jets (Dixon)
  - hh + 2-jet production (Dolan)
- QCD
  - W+jet production ratios (Dixon)
  - NLO corrections to hh production (Lewis)
  - Light-Front Holography (Brodsky)
  - Maximum conformality and top-quark asymmetry (Brodsky)
- Event Generation
  - Combining parton showers & NNLO matrix elements (Hoeche)

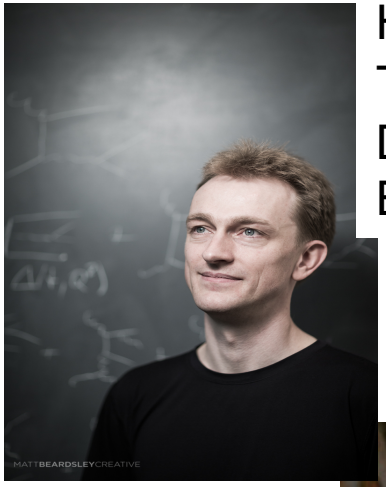


- Neutrinos
  - SB Neutrino Oscillations (Friedland)
- Formal
  - 4-loop six gluon NMHV (Dixon)
  - Ultraviolet divergences in quantum gravity (Dixon)

Very active group!!

Theory: Recent Recognition (2014-2015)

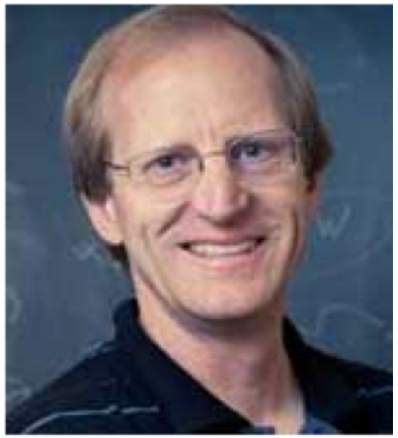
- Internationally recognized group: Numerous prizes in last 2 years!



Höche:
Tung Prize
DPF Primakoff Award
Early Career (FY13)

Bjorken:
Wolf Prize
EPS HEP Prize

Dixon:
Sakurai Prize



Brodsky:
Pomeranchuk Prize

Quinn:
Compton Prize

Training of Young Scientists: RA's FY17

Nikita Blinov
BSM, Baryogenesis

Silvan Kuttimalai (ECA)
QCD, Event Generation

Asher Berlin
Dark Matter Models

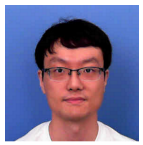
G. Papathanasious*
Scattering Amplitudes

Raffaele D'Agnolo (LDRD)
BSM, Collider Physics,
Dark Matter Models

Stefan Prestel (ECA)
QCD, Event Generation

Dulat Falko
QCD, Collider Physics

Brian Shuve*
BSM, Collider Physics,
Dark Matter Models



Sunghoon Jung*
BSM, Collider Physics

Hendrik Vogel
Neutrinos

Baseline = 7 RAs

* Obtained faculty positions in FY16

Where are they now?

SLAC

Research Associates FY11 & Since:

Yang Bai (Wisconsin)
Tim Cohen (Oregon)
Matt Dolan (Melbourne)
Rouven Essig (Stonybrook)
Sebastian Franco (Durham)
Stefan Höche (SLAC)
Diego Hofman (Amsterdam)
Sunghoon Jung (Seoul)
Jared Kaplan (Johns Hopkins)
K.C. Kong (Kansas)
Ian Lewis (Kansas)
Ye Li (FNAL RA)
G. Pappathanasiou (Athens)
Brian Shuve (Harvey Mudd)
Gonzalo Torroba (Bariloche)
Giovanni Villadoro (Trieste)
Roberto Volpato (Padova)
Devin Walker (Washington)
Hua-Xing Zhu (MIT RA)

(institutions represent faculty or staff positions unless indicated)

In last 20 yrs, ~95% RAs have obtained faculty positions
http://www.slac.stanford.edu/grp/th/alumni.pdf

Where are they now?

SLAC

Graduate Student Alumni (since ~1990):

Allan Adams (MIT)
Jonathan Feng (UC Irvine)
Eder Izaguirre (BNL)
Andrew Larkowski (Reed College)
Mariangela Lisanti (Princeton)
Liam McAllister (Cornell)
John McGreevy (MIT)
Maxim Perelstein (Cornell)
Frank Petriello (ANL/Northwestern)
Arvind Rajaraman (UC Irvine)
Yael Shadmi (Technion)
Matt Strassler (Rutgers/Harvard)

(institutions represent faculty/staff positions)

Baseline = 6 Stanford Graduate Students

SLAC Alumni in the News

SLAC

Johns Hopkins Scientist to Lead TRIUMF

18 March 2014

Johns Hopkins University Scientist to Lead Canadian Natio

Next Director of TRIUMF B

William H. Goldstein named director of LLNL

Arkani-Hamed director of CFHEP

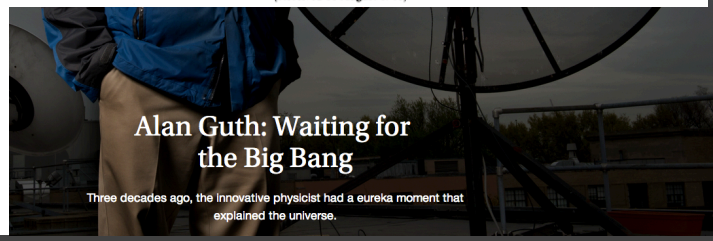
PHYSICAL REVIEW D VOLUME 23, NUMBER 2 15 JANUARY 1981

Inflationary universe: A possible solution to the horizon and flatness problems

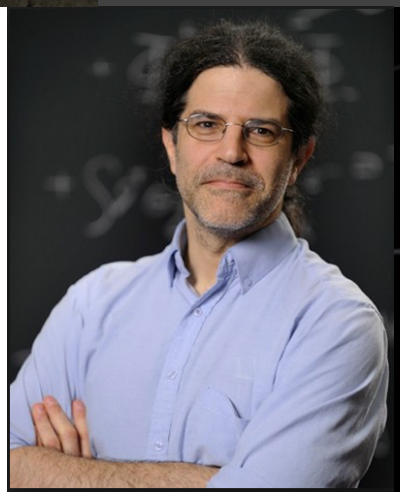
Alan H. Guth*

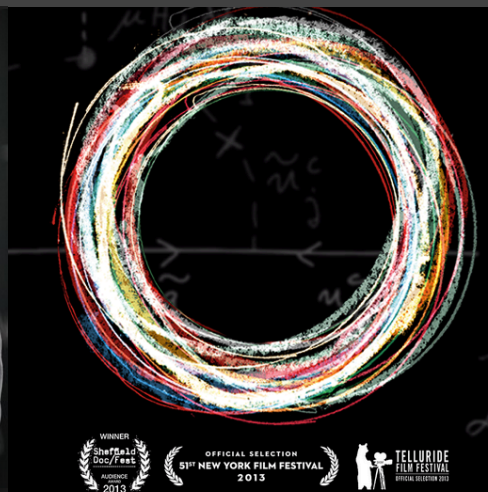
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

(Received 11 August 1980)



PARTICLE**FEVER**



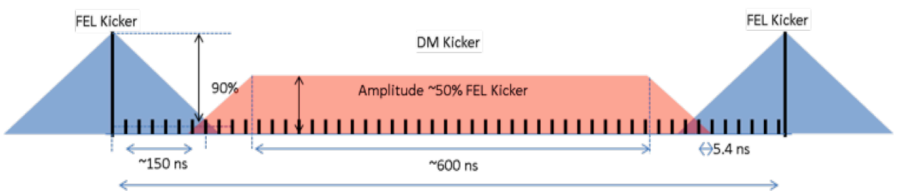


Impact on SLAC Programs

- ATLAS
  - ATLAS STA (Rizzo)
  - pMSSM data set (Hewett, Rizzo)
  - Simplified Models (Schuster, Toro)
  - Sherpa (Höche)
  - Comix (Höche)
  - Blackhat (Dixon, Höche)
  - Higgs Cross Section Working Group Advisory Cmtte (Dixon)
- Dark Matter
  - Collaboration with KIPAC Experimenters to define SUSY reach in indirect detection (Hewett, Rizzo)
  - DASEL/APEX/HPS (Schuster, Toro)
- Neutrinos
  - DUNE Supernova Neutrino WG co-convener (Friedland)
- CMB/Inflation
  - Silverstein/Senetore has led the theory effort to motivate future CMB expts @SLAC and elsewhere

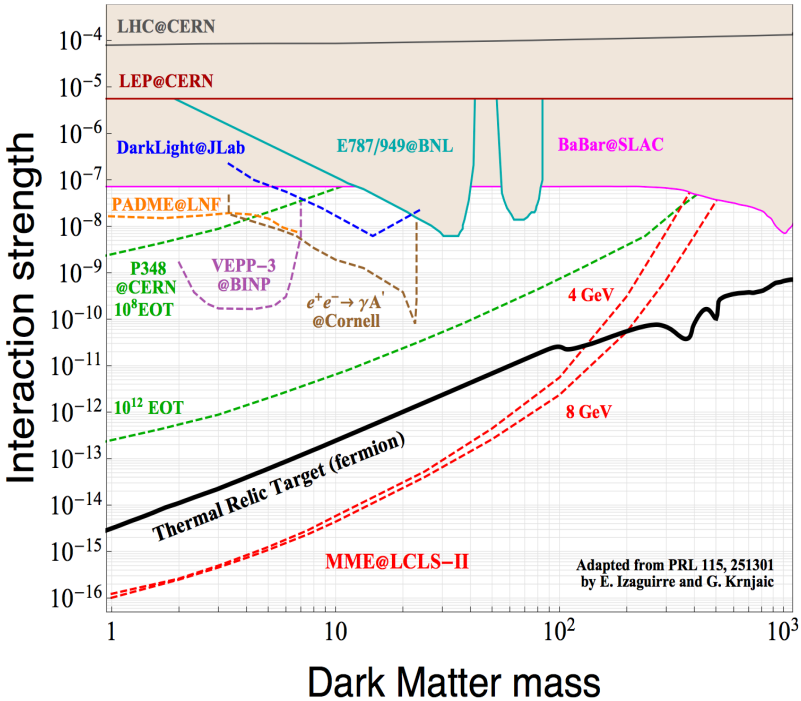
Leadership of SLAC Programs: DASEL

- DArk Sector Experiments at LCLS-II
  - » High repetition MHz e^- beam is ideal tool
  - » In between FEL bunches, linac accelerates ~200 gun dark current bunches for free



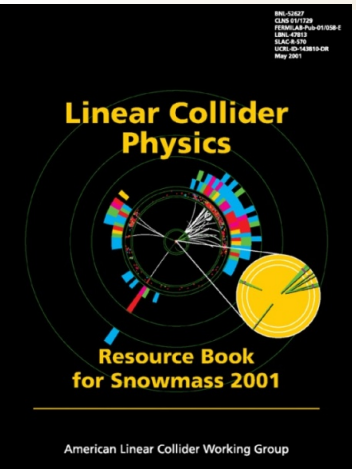
  - » Study underway to determine what it takes to use this beam without impact to LCLS-II
  - » Joint effort by SLAC accelerator, experimental, theoretical physicists

Proposed missing momentum experiment (LDMX)

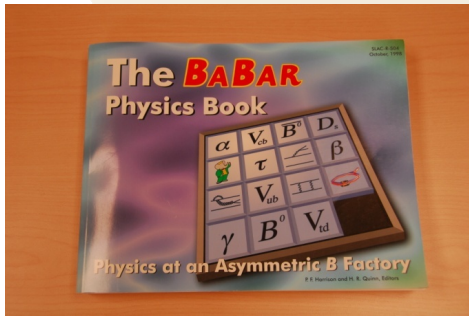


History of Strong Support to HEP Programs

SLAC

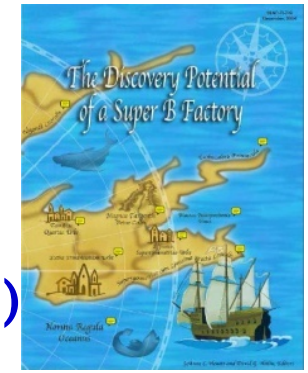


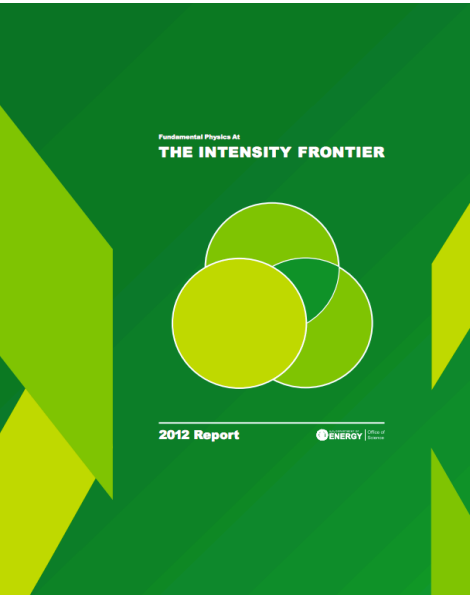
The BaBar Physics Book
Helen Quinn ed (1998)



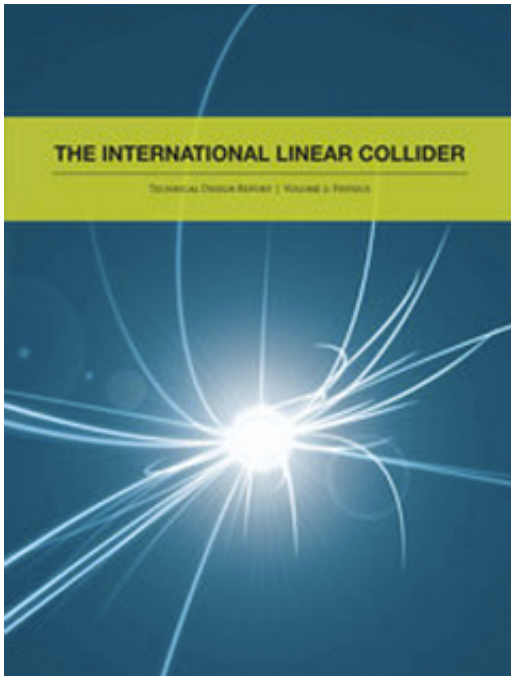
Linear Collider Physics Resource Book
Michael Peskin ed (2001)

Discovery Potential of Super-B Factory
JoAnne Hewett ed (2004)





Physics Chapter ILC TDR
Michael Peskin ed (2013)



Fundamental Physics at the Intensity Frontier
JoAnne Hewett ed (2012)

SLAC Theory Workshops

Series of targeted workshops on topical issues

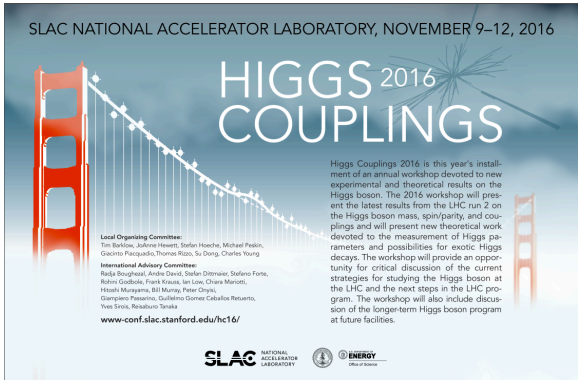
- Typically 80–100 attendees

Physics at a 100 TeV pp Collider: April 2014

- Discussed physics environment
- Explored physics opportunities

Dark Sectors Workshop: April 2016

- Explored future opportunities for dark sector experiments



Higgs Couplings: November 2016

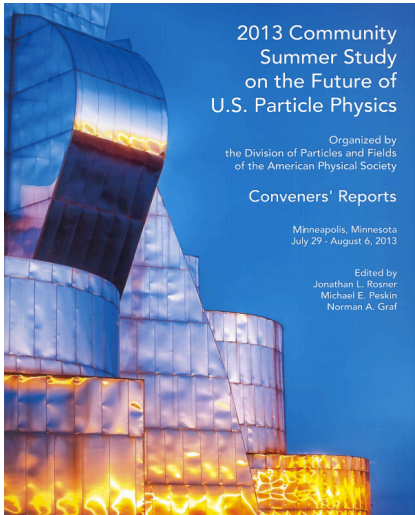
- Host international Conference

SLAC Theory @ Snowmass

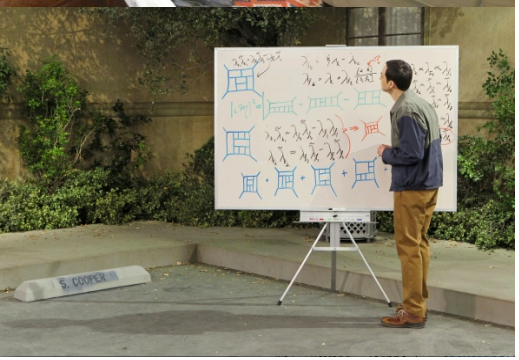
- Strong leadership from SLAC Theory: Frontier Conveners
  - **Energy Frontier**
    - Chip Brock (Michigan State), Michael Peskin (SLAC)
  - **Intensity Frontier**
    - JoAnne Hewett (SLAC), Harry Weerts (Argonne)
  - **Cosmic Frontier**
    - Jonathan Feng (UC Irvine), Steve Ritz (UC Santa Cruz)
- Computing Frontier Subgroup leader: Höche
- Inflation Theory Document/Community Letter: Silverstein
- Proceedings Editor: Peskin
- Group contributed 26 papers authored by
  - » 6 faculty/staff, 4 RAs, 3 students
- P5: Hewett

Building for Discovery

Strategic Plan for U.S. Particle Physics in the Global Context



Education and Outreach



Lance's work featured on Big Bang Theory

Quantum "Graviton" Particles May Resemble Ordinary Particles of Force

Maybe unifying the forces of nature isn't quite as hard as physicists thought it would be

By Zvi Bern, Lance J. Dixon and David A. Kosower

Lance Dixon writes for *Scientific American*

21 public lectures
given in 4 countries
by Brodsky, Dixon, Hewett, Kachru, Peskin, Silverstein

SLAC Physicist Explores Parallel Universes Sunday Night on Discovery Channel

September 1, 2011
by Mike Ross
Are parallel universes real?

The answer ... ion
program tha ... n.
Sunday.

The progran ... adcast
later on Scie ... es.

Back in Apri ... C's
Master Cont

"The main p ...
concerning the antimatter content of the universe," Hewett said. "We also spent two or three hours filming a scene where I play checkers with myself. The red checkers represented the matter in the universe and the black checkers antimatter. At the end of the game only one red checker was left, to indicate that the universe is now only full of matter."

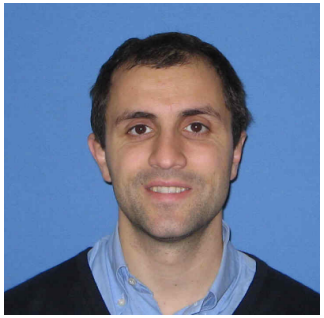
JoAnne Hewett discusses CP Violation on *Through the Wormhole* with Morgan Freeman

SLAC physicist JoAnne Hewett in the Main Control Center during filming of her episode of "Through the Wormhole," which airs on Sunday at 8 p.m. on the Discovery Channel. (*Photo by Melinda Lee.*)

KIPAC Theory

Tom Abel

Cosmological Sims
KIPAC Director
PAC Division Director

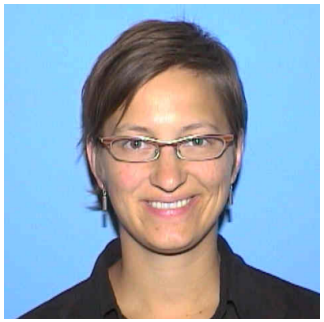


Leonardo Senatore

Inflation
CMBS4

Roger Blandford

γ-Ray Astronomy
Crafoord Prize 2016



Risa Wechsler

DM/CE Sims
DESI co-spokesperson

Scientific excellence
Strong Engagement in SLAC & National programs

Summary: SLAC Theory

SLAC

- Significant impact on SLAC, US & International program
  - Excellence in scientific research
  - Unparalleled track record in training of young scientists
  - Leadership in defining future HEP program
  - Strong commitment to scientific community service
  - Successfully bridge between

Expt ⇔ laboratory ⇔ university theory programs

Strong National Lab theory programs are vital to health of US theoretical physics