All Hands 2006 Notes

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Welcome to you all and thank you for taking the time to come to this PPA All Hands Presentation. I appreciate the opportunity to talk to you and I look forward to your comments.

15 months ago Jonathan reorganized the laboratory in a major way…this was the first major reorganization of the laboratory structure is its 40+ year history. While many of you may carry a sense of what the Technical Division was or the Research Division was, I think we are all still adjusting to what the Directorate of Particle and Particle Astrophysics 'is' and so I'm going to start by just talking about who we are.

There are 397 of us in PPA…400 to good approximation….and half of us are physicists of one sort or another. We have close to 100 engineers and technical support people in the Directorate, between 55 and 70 students depending on the time of year, a handful of administrative support people and 5 safety professionals.

You can see that education and training is a very large part of our mission, since over 25% of the directorate is postdocs and graduate students.

If we look at just the physicists (including faculty), half of use are doing accelerator physics (ILC, accelerator research and accelerator systems division) and the other half of us are distributed between experimental and theoretical particle physics and particle astrophysics.

We are organized into 5 divisions and a project (GLAST). Our org chart has filled out and settled down considerably over the last six months. A little later I'll talk about how this org chart will be evolving over the next few years, but right now, having talked about who we are, I'd like to a bit about what we do.

44 years ago SLAC was founded with a mission to understand what the Universe is made of at its most basic and fundamental level. What are the building blocks of nature? What are the forces that glue these building blocks together to make the matter we see around us. This is still what we do. Our current mission statement says that we strive "To make discoveries in particle and particle astrophysics to redefine humanity's understanding of what the universe is made of and the forces control it"

We have made enormous progress over the years, discovering new particles and understanding new forces. But in the last few years, nature has pulled an enormous surprise on us.

When we look out into the cosmos we find that our current understanding of the Universe is profoundly incomplete. We have learned that we do not know what most of our

Universe is made of. We now know that we in particle physics have developed a deep understanding of the matter that makes up only about 4% of the Universe. We can explain only these small slices of the cosmic pie. Normal matter, including all the chemical elements, neutrinos, the interstellar gas clouds and the stars, is only about 4% of the Universe. About 96% of the Universe is made from forms of energy and matter whose fundamental nature is a mystery to us.

Experimental observations have forced us to conclude that most of the matter in the Universe is not made of the same building blocks that you and I are made of..the familiar quarks and leptons we have been studying for the past 4 decades. You and I are made of the same stuff as the stars that shine in the heavens…luminous matter. This mysterious new matter is called 'dark matter' because it does not form objects like stars that generate light.

About 22% of the entire Universe is made of Dark Matter

We have also discovered that the vacuum of empty space is filled with something we call 'dark energy' that exerts a mysterious force that is accelerating the expansion of the Universe. We have no idea what this mysterious dark energy is or why it exists.

Dark energy accounts for about 74% of the universe.

We face yet another problem. Why are we here? Based on all we understand about quantum mechanics, we believe that back at the birth of our universe the big bang produced equal amounts of matter and antimatter. However, today, 13 billion years or so later, our observations indicate we live in a Universe of matter. We believe that in the hot early Universe, most of the matter and antimatter annihilated with each other, but somehow a tiny imbalance between particles and antiparticles developed as the Universe cooled. For every 10 billion matter and antimatter particles that annihilated away into pure energy, 1 single matter particle was left over…..that left over matter became us.

These are just three of the big questions we have to confront if we are going to make progress on our mission to understand what the universe is made of, and what are the forces that control it.

We have two main strategies that we use to study the Universe. With energetic particle accelerators, we can create, in the laboratory, some of the particles that have not existed since the very early universe. Once we create them we can study how they behave and interact. With this strategy, SLAC played a crucial role in the spectacular progress we have made in the last 40 years in understanding the normal matter…the luminous matter…of the Universe.

But as observations of the cosmos have taught us, there is more going on in the Universe than we imagined. It has taken experiments on the cosmic scale to reveal the existence of dark matter and dark energy, and I believe it will ultimately take accelerator based experiments to really understand what they are.

There was a great experiment done 13 billion years ago when the Universe was born in the Big Bang. We can't repeat that experiment, but with observatories on the earth or in orbit, we can observe the relics from the evolution of the universe as they exist today. We can do archaeology, so to speak, with the relics of the Big Bang.

In the end, what we learn from the astrophysical observations of the relics of the big bang must agree with the data from particle accelerators recreating the particles and forces of the early universe. The two ends of the exploration must meet. We will answer the challenging questions that confront us by combining what we learn from the most powerful and insightful observations and experiments in each of these approaches.

We, at SLAC, are deeply engaged in a broad program of theoretical and experimental investigation to attack this science. We are running experiments now, designing tools for the near term future, and developing technologies for the long term future. Accelerator builders and instrument builders work hand in hand with the theorists who help guide our understanding.

I'd like now to talk about our scientific programs in PPA, and how they are evolving over the next few years. We are a lab and a Directorate in transition. In 2009 when the B-factory turns off, we will no longer have a large, forefront, accelerator based High Energy Physics program on site. We will be serving a user community at accelerator facilities off site. A vibrant program of accelerator research will continue with on site facilities. Our involvement with non-accelerator efforts will grow. We will continue to have a strong theoretical effort to help guide us. The future of PPA is a balance of accelerator based and non accelerator based efforts. The style in which we do business will change. However the scientific opportunities and excitement will continue to be very high!

Our highest priority in PPA is the successful completion of the B-factory. We will run B-factory accelerator operations to the end of FY08 (Sept 30, 2008). Data analysis and science will continue for several years after that.

The B-factory is a spectacularly successful science program. Over 600 physicists from around the world work on BaBar and they are studying the details of the mechanisms that are responsible for subtle differences in the way matter and antimatter behave and which may be responsible for the imbalance between matter and antimatter we now see in the Universe. The BaBar experiment won't get us to the final answer, but by the time the B-factory turns off on September 30, 2008, it will have created and studied CP violation in samples of billions of bottom quarks…you would have to go back to microseconds after the big bang to have had that many of them ever before. CP violation is a critical ingredient in order for a matter anti-matter asymmetry to have developed in the early universe. Our problem is that what we are seeing in the B-factory is about 10 billion times too small to explain the amount of matter we see today in the Universe…something else must be going on!

The B-factory will stop operations as the Linac Coherent Light Source (LCLS) is ramping up to operations. LCLS is going to be the world's first x-ray laser, using the last 1/3 of the SLAC linac to produce incredibly intense, short bursts of x-rays that will revolutionize the frontiers of photon science. At that time, the accelerator systems division in PPA, which has so magnificently operated PEP-II, the LINAC, FFTB and other accelerators before that, will move to PSD to operate LCLS. Now that doesn't mean that every individual will have to move. We each are motivated differently and have different career goals. In 2009 the ILC program will be growing and there will be opportunities there as well. We will be completing the relocation of the FFTB to the south arc of the SLC…a project called SABER. There will be lots to do, but the main job for those of you who operate accelerators so well will continue, and the primary focus of accelerator operations on site will be operating the linac for LCLS.

As the B-factory ramps down, we will see a new energy frontier for particle physics open at the LHC…the Large Hadron Collider at CERN. SLAC is a member of the ATLAS collaboration, we will host a Tier 2 computing center here, and we are participating in the LHC Accelerator Research Program to ensure that LHC can reach its luminosity goals, and we will participate in the commissioning of the LHC accelerator. Some of our accelerator physicists and computing professionals will be deeply involved in these efforts, along with experimental physicists.

We are all hoping that there will be lots of surprises at the LHC. We even have good reason to be optimistic that is going to be true. At the LHC, we may discover a particle that could account for the dark matter in the Universe. We might not be able to prove it's the dark matter candidate though. Involvement with the LHC program will keep SLAC high energy accelerator based science on the frontiers and we will play a critical role in support of our user community, helping them be effective collaborators and participate fully in the science.

However LHC is not the last frontier! The consensus of the high energy physics community is that an electron positron linear collider is an essential tool to fully explore the energy frontier at the TeV scale…the energy of the LHC. This is a position that we at SLAC have long advocated, and we are major players in helping to realize the International Linear Collider. We have a large and broad effort in ILC R&D and SLAC staff are playing leadership roles in the realization of this machine and its detectors.

Recent developments are very encouraging for future of the ILC. The FY07 President's budget has a doubling of the ILC R&D. A recent National Academy report, EPP2010, came out very strongly for the importance of the ILC in the national and international science portfolio. We have a Secretary of Energy (Bodman) and a Deputy Secretary of Energy (Orbach) who are supporting us strongly.

There are risks here. While the long term health and future of the field of HEP relies on ILC but it is not a certainty! There is a multiyear R&D program being supported by Office of Science. The step after that, which we don't have yet, will be the commitment from DOE and our government to build the facility.

We believe the risk is worth it because the science payoff is so great. We are anticipating that evidence for new forces and interactions will be seen at the LHC and the ILC will do the precision studies that let us understand these new physics interactions. ILC is where we can really nail down the dark matter particles and prove that dark matter candidates seen at the LHC really account for the dark matter of the Universe by measuring their detailed properties. We might also hope to get some hints on what dark energy is all about from the precision measurements we can make at such a machine.

However even the ILC is not the final frontier! We will want higher energy accelerators after the LHC and ILC…and we don't know how to build those machines yet. To continue to push the energy frontier and to develop the accelerator technologies of the future that will benefit all fields of science, research in fundamental accelerator science is required. It is how we can make the future machines of the next decades feasible and affordable. We have a rich and active program in accelerator research exploring revolutionary new acceleration mechanisms such as laser acceleration and plasma acceleration. The FFTB was a wonderful facility for accelerator research experiments but it has been removed to make way for the LCLS as it cuts across the research yard. The final runs produced spectacular results…producing the highest energy electrons ever on the SLAC site.

We are planning to relocate the FFTB to the south arc of the SLC in a new facility called SABER that should be fully operational independent of the LCLS by the end of 2009 and we will have some running at SABER before that as LCLS commissioning allows.

Accelerator based high energy physics is what this lab was born to do and we will continue to be major players in the national and international program going forward. But the high energy experiments will no longer be on our site. We will still have a vibrant science program based on accelerators. We will still have a strong program of accelerator research based on the unique facilities we have here, and we will still serve the national user community in critical ways.

However, as I said before, understanding the cosmos is presenting SLAC with a whole new menu of scientific challenges and opportunities. Solving these new mysteries has required that we develop new tools in addition to the accelerators we have used so successfully for so long.

The accelerators are still very, very important, but we need to be able to do experiments that study the cosmos as well. As the laboratory had broadened into particle astrophysics with the building of GLAST, and the founding of the Kavli Institute, we are becoming leaders in meeting some of the new the scientific challenges of the future.

GLAST will be launched from the Kennedy Space Center in 2007. We built the primary instrument for the mission. Right now the instrument is undergoing 'shake and bake' tests to make sure it can withstand the rigors of the space environment. When it launches

I plan to broadcast the launch live in the Kavli auditorium so that we can all celebrate SLAC's first major venture into space.

GLAST will survey the gamma ray sky and study some of the most catastrophic and cataclysmic events in the Universe such as stars collapsing into black holes and active galactic nuclei that are sending jets of matter spewing into space. I am showing here a simulation of what the first 55 days of GLAST data will look like. You can see a gamma ray burst, a solar flare and, surprisingly, the moon in gamma rays. GLAST will also hunt for dark matter in our galaxy since it is sensitive to some of the decay products from dark matter annihilations that may be occurring. And there is more to come.

With the founding of the Kavli institute, we are going to be involved in more space projects and ground based telescopes in the future. The scientific focus of the SLAC based part of the Kavli institute is exploration of 'the dark universe'. This is where particle astrophysics and particle physics overlap.

One of the new non accelerator projects that SLAC will lead is the LSST. LSST is a ground based telescope that will survey the entire visible sky every few days. It will produce huge amounts of data and off line analysis will be used to study dark energy and dark matter among many other scientific targets. Our part of the telescope is the camera. This project is in R&D with a goal to move to full construction in 2009.

We are also involved in a space based mission called SNAP that will launch sometime in the next decade and use supernovae to study dark energy. LBNL is the lead lab on SNAP. We are participating in aspects of the electronics and in the science.

The Kavli institute has been a wonderful addition to SLAC. It is providing focus and leadership to a broadening scientific program as we are using non accelerator approaches to attack the exciting science. The building is a lovely addition to our campus. I think we are all a bit jealous of its occupants…and Kavli is fostering a wonderful intellectual community that is proving to be a magnet for postdocs and graduate students.

One of the KIPAC postdocs, Marusa Bradac, was in the news last week for her beautiful work with her collaborators showing how in the bullet cluster where two clusters of galaxies are passing through each other, the dark matter and luminous matter have separated from each other. The demonstrated difference in the behavior of the dark matter and the luminous matter is an important result.

A final program I want to mention is EXO. The science target is to determine the fundamental nature of the elusive neutrino by looking at very rare decays of xenon to test if the neutrino is its own antiparticle. If EXO sees a signal, a whole new path to understanding the matter dominance of the universe may be opened up to us. We will also get our best shot at measuring the absolute mass of the electron neutrino. Right now EXO-200 is being assembled and will start to take data in a cavern in Carlsbad New Mexico in the New Year. The full sized EXO might be taking data early in the next decade.

Over the next years we have a very large program, the B-factory, that will wind down, and we have new programs that will grow. People, our most precious resource, will evolve from older programs to newer programs…that process is already happening. Transitions are not new for this laboratory! We have transitioned from the fixed target era to SPEAR, to PEP, to SLC, to the B-factory, to GLAST, and now to a growing ILC and LCLS, to LHC, LSST, EXO and SNAP! It was extremely gratifying to have a major national academy study, EPP2010, put forward a strategic vision for the field of particle physics with priorities for investment and to see that the SLAC PPA program aligns exceptionally well with the national agenda that they articulate.

However I have to acknowledge that transitions also challenging. I believe that the biggest challenge we face as a laboratory between now and 2009 is the balance of the B-factory priorities with LCLS. Both programs have to be successful. We recognize this challenge and it is being actively and aggressively managed

We are also aggressively planning for the transitions we are facing. We have developed a detailed operations scenario for the laboratory in 2009 (TWG process) to understand what is needed to support the operating facilities in the LCLS era. In this process we have developed a detailed funding and manpower plan that we are discussing with our sponsors. We are seeing that the laboratory will grow on the timescale of the end of the decade. The growth in Photon Science is driven by the new science opportunities at LCLS. In PPA, the B-factory will ramp down, but ILC and LHC will grow, GLAST continues for up to a decade, and the big new initiatives, LSST and EXO, are starting to move into construction by the end of the decade.

Transitions can be unsettling, but I see PPA positioned well for the next decade. We will continue to have a vibrant science program. We will continue to serve our user community, although in new ways. Let's go back to the org chart and walk through the anticipated changes between now and 2009

- Accelerator Systems Division Moves to PSD
- GLAST moves under KIPAC 60 days after launch
- ILC grows
- Accelerator Research grows with support from BES
- EPP and Particle astro rearrange between programs
- Engineering support (REG) redistributes from GLAST and BaBar to LSST, EXO LCD…increasing support for accelerator research

We are privileged to be able to participate in exciting science. And with that privilege comes the responsibility to do our work safely. Thanks to all of you for the focus on and attention to safety in your daily work. Thanks to all of you for the effective way in which you are integrating safety into the planning and execution of your activities. In my walkthroughs and meetings with you about safety in the workplace, I always learn from you and I am impressed with the dedication to safety that I see. Safety is an individual responsibility for every one of us here at SLAC.

As I conclude, I would like to remind you that much of what we do has an impact on and excites people far beyond our community here at SLAC and in our field. Just as we are excited by our science….so are many, many others outside the lab, albeit with differing levels of understanding. We see it in the popular interest in the theoretical developments in string theory. We see it in the news coverage of the recent results on Dark Matter from Marusa and her colleagues at KIPAC. We see it in the tremendous attendance at the public lecture series here on campus.

A particularly important realization of this for me came in a conversation with 3 kids who live on a potato farm in Canada north of Toronto. On a visit with them a few summers ago they were asking me about what we do at SLAC as we sat out in the dark Canadian night on the edge of the fields, and when I told them that scientists at SLAC were working on an instrument, the large area telescope for GLAST, that would be launched into space in a few years, one of them said, pointing to a satellite drifting overhead, ….'So in a few years you will come back and show us GLAST moving across the night sky?' The answer, after a little homework on my part, is 'yes I will'. Millions of people will see GLAST as it orbits the earth. I'm looking forward to seeing it up there!

The science we do here at SLAC motivates us, but it also excites and inspires others as we make progress in understanding the nature of the Universe in which we live. We are addressing fundamental questions that mankind has asked for centuries and the surprises of dark matter and dark energy in the last decade remind us how far we still have to go. We will continue to be arrogant in our confidence that we can accomplish our goals; but we cannot help but be humble in the vastness of the quest. To quote Einstein: "The eternal mystery of the world is its comprehensibility."