

UCLA

Chan Joshi
Warren Mori
James Rosenzweig



Tom Katsouleas

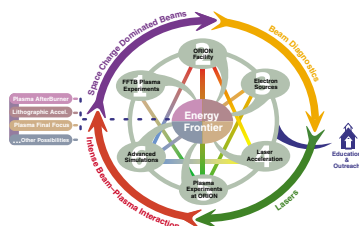


Bob Byer
Bob Siemann

THE ORION CENTER
for
ADVANCED ACCELERATOR AND
BEAM PHYSICS

Bob Siemann
Presentation to

Dept. of Energy, Nov 7, 2001

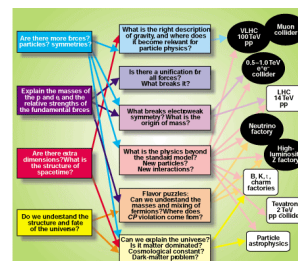


High Energy Physics Discoveries ⇔ Accelerator Innovation

"Starting from the 1930's, accelerator energy has increased – about a factor of 10 every six to eight years ... this spectacular achievement has resulted from a succession of technologies rather than from construction of bigger and better machines of a given type." W. K. H. Panofsky, 1997

Particle Physics Discoveries

- 2 v 's
- J/ψ
- quarks in p, n
- bottom
- CP violation
- τ
- W & Z
- top



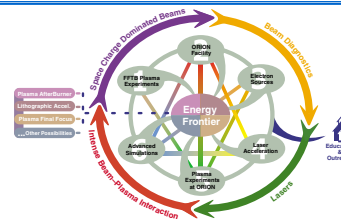
Fundamental questions and the experimental facilities that can address them. M. Tigner, Jan 2001 PHYSICS TODAY (figure adapted from one by P. Drell)

The ORION Center - Background

- **Tigner subpanel (1980)** – Documented the need for increased advanced accelerator research
 - Led to establishment of the **advanced accelerator program** that has made important contributions - superconducting materials, plasma beat-wave acceleration, beam dynamics, optical bunching of electron beams, ...
- Today, the **importance to & challenge from high energy physics have increased significantly**. This has been recognized by the recent HEPAP subpanel.
- Today, a **larger community devoted to accelerator innovation** is needed to impact the future of accelerator-based particle physics
 - Issues are sufficiently complex that they require closely interacting, critical-mass groups with breadth of knowledge.
 - Combine intellectual contributions, resources and infrastructure from universities and national laboratories - **particle physicists & people at the forefront of other sciences and technologies**
- **The ORION Center has been formed by a university/laboratory collaboration to meet the challenge from high energy physics.**

The ORION Center

- Shared Goal – The Energy Frontier
- Shared Techniques and Technologies Forming a Foundation
- Complementary Research
- Outstanding People
- Unique Facilities
- Opportunities for the General User Community
- International Support from CERN, DESY & KEK



"This proposal is outstanding in its synergy. The assembling of the physical and intellectual resources proposed will make possible progress that cannot otherwise be achieved."

The ORION Center – The People

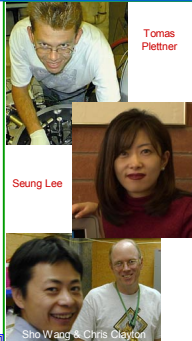
- PI's with diverse scientific backgrounds, shared interests in advanced accelerator research & recognized leaders in their fields

- Bob Byer, Chan Joshi, Tom Katsouleas, Warren Mori, Jamie Rosenzweig, Bob Siemann
- Expertise in lasers, plasmas, simulations, source physics, conventional accelerators, beam diagnostics

- Experienced, motivated associates

- Chris Clayton, Eric Colby, Viktor Decyk, Mark Hogan, Jean-Noel Leboeuf, Ken Marsh, Patric Muggli, Bob Noble, Dennis Palmer, Chuang Ren, Jim Spencer, Frank Tsung, Dieter Walz

"The groups involved are first rate and, if progress is to be made in this important area, this collaboration will be the one to do it."

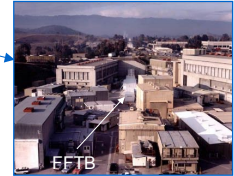
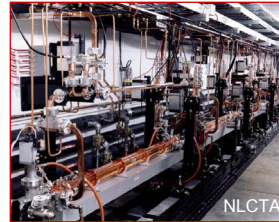


Advanced accelerator research is exciting to students and young scientists

The ORION Center – The Facilities

- Unique facilities for advanced accelerator research

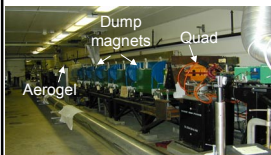
FFTB – 30 GeV e^- & e^+ beams. New potential of e^- beams with $\sigma_z < 100 \mu\text{m}$



ORION Facility (to be constructed in part with funds from the ORION Center Proposal) based on the NLCTA - ~65 & 350 MeV e^- beams

"The initial use of the FFTB and subsequently ORION facilities will allow a range of experiments impossible elsewhere."

The Final Focus Test Beam (FFTB)



FFTB Dump Line/Spectrometer



E-162 Plasma Chamber and Experimenters

The only place in the world where e^+ experiments can be performed!

	e^-, e^+	e^+
Energy	28.5 GeV	
Energy Spread	~ 0.3%	1.5%
Number of Particles, Charge	$= 2 \times 10^{10}$ / bunch, 3.2 nC/bunch	
Spot Size	$= 5 \mu\text{m}$	
Bunch Length	$= 0.6 \text{ mm}$	$< 100 \mu\text{m}$
Normalized Emittance	$5, 0.3 \times 10^{-8} \text{ m rad},$ or $2.5, 2.5 \times 10^{-8} \text{ m rad}$	
Peak Current	$< 600 \text{ A}$	3500 A
Repetition Rate	1-10 Hz	

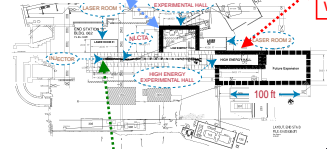
NEW!

- A new compressor that will give $\sigma_z < 100 \mu\text{m}$ for e^- 's is being designed.
- SLAC Proposal E-164 would use this short bunch & would be the first FFTB activity that is part of the ORION Center.

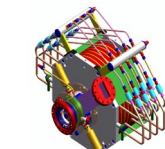
The ORION Facility – An Upgrade to the NLCTA for Advanced Accelerator Research

Low Energy Hall for experiments with $E \sim 65 \text{ MeV}$, 3 beam lines

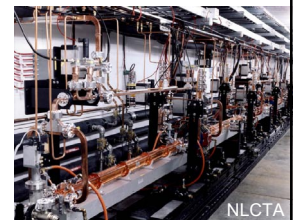
High Energy Hall for experiments with $E \sim 350 \text{ MeV}$, 1 beam line



Chicane and beam transport used for tailoring longitudinal phase space



Injector – 1.6-cell RF gun



NLCTA

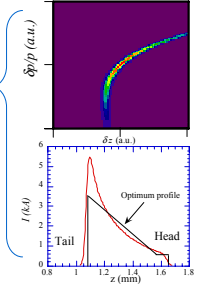
The ORION Facility

These parameters have come from anticipated experimental beam requirements

Table 2.2: General Design Parameters of the ORION Facility	
Beam Energies	7 MeV (Source); 7-67 MeV (LE Hall); 67-350 MeV (HE Hall)
Charge per Bunch	0.25 nC optimum, adjustable up to a nominal maximum of 1 nC
Number of Bunches	1 or 2 (split charge)
Transverse Emittance	$\leq 2 \times 10^{-6}$ m, normalized rms (0.25 nC)
Bunch Length	1.8 psec, rms (0.25 nC, from source), 0.2 psec, rms (0.25 nC, compressed)
Energy Spread	0.8% rms for 1.8 psec bunch length
Charge Stability	$\pm 2.5\%$ pulse-to-pulse
Bunch Timing Jitter	0.50 picosec, rms
Repetition Rate	10 Hz
Average Beam Power	0.67 W at 67 MeV; 3.5 W at 350 MeV (1 nC bunches)
Electron Source	1.6 cell, S-band (2.856 GHz) Photoinjector
Drive Laser	Commercial Ti:Sapphire, 266 nm wavelength, 1 mJ output
Source RF System	SLAC 5045 Klystron; Solid-State, NLC-type Modulator
Injector Linac	Two X-band (11.4 GHz), 0.9 m, 30 MV, NLC structures
High-Energy Linac	Four X-band, 1.8 m, 72 MV, NLC structures

Flexible Electron Source \Rightarrow Opportunities (Two Examples)

1. High transformer ratio **plasma acceleration** can be studied by using bunch compression ($R_{56} < 0$) to produce a ramped profile with a sharp cutoff
 - Multi-GeV/m gradients !
2. **Laser acceleration** requires low Q and low σ_E/E ($\propto \sigma_t^2$)
 - Photoinjector drive laser will be capable of $\sigma_t = 300$ fsec to reach $\sigma_E/E < 0.1\%$
 - A photoinjector with reduced performance is part of the E-163 proposal to begin laser acceleration experiments at the NLCTA. It has the potential to be upgraded to the flexible ORION injector.

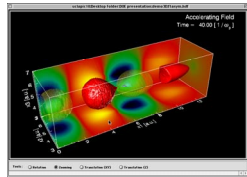
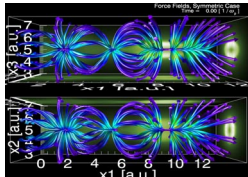


Computational resources

Hierarchy of parallelized particle simulation tools

- 3D fully explicit electromagnetic PIC: OSIRIS (mature)
- 3D quasi-static PIC: quickPIC (in development)
- Advanced diagnostic and visualization packages for parallel code data

Current capability: Modeling full scale of experiments in 3D
Goals for ORION: 1. Reduce turn around time from months to hours to minutes
2. To give realtime feedback for direct interaction with experiments



The ORION Center Proposal

The ORION Center will bring people together in a collaborative environment where facilities and resources are available for rapid progress.

- SLAC will host the ORION Center and provide
 - Routine operation and maintenance
 - User support including training, office & lab space
 - 60 MeV, 350 MeV & 30 GeV beams
 - Available technical equipment – e.g. klystrons & modulators
- Proposal includes support for the university based PI's to perform research at ORION. This will be a major part of their activities.
- It also includes some of the funds needed to construct the ORION Facility at the NLCTA.
 - Available SLAC equipment and infrastructure will leverage these funds

The ORION Center Proposal

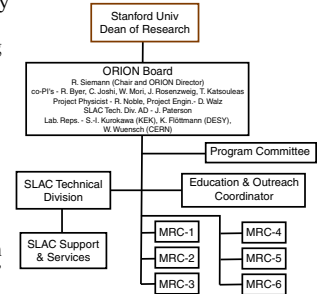
- There will be beam time, experimental support, instrumentation, etc. for a general user community
 - This will include help with staging experiments, data acquisition, advanced diagnostics, beam preparation techniques, ...
- Closely coordinated computer simulations and real-time analysis
 - One of the keys to understanding experimental results
- Education and outreach
 - Partnership programs with local community colleges, Classic graduate education, WWW site based on SLAC "Virtual Visitor Center"

International Collaboration



These laboratories have named people to the Board that would manage the Center

- A. Wagner** – "The ORION facility at SLAC, proposed as a user-driven facility for efficient testing of advance accelerator concepts, will provide the elements needed for combining the non-laboratory talent with large accelerator laboratory infrastructure."
- H. Sugawara** – "We have found that the project is important and useful for advanced accelerator research and so we are very much interested in the ORION project."



International Collaboration

Deutsches Elektronen-Synchrotron DESY
Chairman of the Board of Directors



Professor Dr. Robert Siemann
Applied Physics Department
Stanford University
SLAC, 256-23
2575 Sand Hill Road
Menlo Park, CA 94025
U.S.A.

24 January 2001

Dear Bob,

Particle accelerators have played a crucial role in establishing our understanding of Nature's fundamental constituents and the forces between them. Progress in high energy physics during the past 40 years has made possible by constant investment in advanced accelerator (R&D) technology. The technology needed for higher energies and luminosities. As we enter a new century, it is imperative that we continue a worldwide program in advanced accelerator technology development so as to meet the challenges of our current research.

In order to succeed it is that the accelerator laboratories and the worldwide University community, i.e. its users, collaborate actively in the R&D program, making best use of the know-how, ideas, experience and large-scale facilities and their capacity of fresh connections.

The ORION facility at SLAC, proposed as a user-driven facility for efficient testing of advance accelerator concepts, will provide the elements needed for combining the two laboratory talent with the large accelerator laboratory infrastructure. I believe that ORION will be necessary and important to the worldwide advanced accelerator R&D effort. We are pleased about the leadership which you and your colleagues at UCLA and USC are taking to help SLAC realize ORION, and we encourage the NSF to support the ORION Center which will be the critical enabling element in ORION's realization.

In the upcoming weeks, DESY will nominate one of its accelerator scientists to participate as a member of your central steering committee. Once we have a better idea of what is needed to complete ORION, we can explore the possibility of contributions towards its realization.

Yours sincerely,

Arbeitswagen

Arbeitswagen

cc: D. Trites

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KEK HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION



Professor Jonathan Dorfan
Director
Stanford Linear Accelerator Center
P.O. Box 6849
Stanford, CA 94305-4849
U.S.A.

January 25, 2001

Dear Professor Dorfan,

After I was introduced to the ORION project by you last summer, I submitted Professor Shiroku Kankawa of Accelerator Laboratory as a member of KEK. We have been also examining the project and thought about the possible way of participation in it. We were found that the project is important and useful for advanced accelerator research and so we are very much interested in the ORION project. We think it is a good idea that the ORION project should be pursued under international collaboration. As a first step towards this direction, Professor Kankawa is now planning to propose a collaboration on ORION to the Japan-US Cooperation in the Field of High Energy Physics.

With best regards,

Shiroku Kankawa
Director-General

cc: Professor Robert H. Siemann, SLAC
Professor Shiroku Kankawa, KEK

Statements of Support

- Max Nikias, USC Dean of Engineering**
 - "This proposal takes advantage of recent advances on advanced accelerators at these institutions and the availability of a unique beam physics facility at SLAC to carry out cutting-edge physics on beams and plasmas."
 - USC has a strong commitment to and interest in interdisciplinary research of the type proposed here"
- Charles Kruger, Stanford Vice Provost & Dean of Research and Graduate Policy**
 - "It would bring faculty, staff and students to SLAC to work with unique, state-of-the-art facilities in a research area crucial for high-energy physics."
 - "We are especially supportive of the ORION Center because it builds bridges between SLAC and the Stanford campus in fundamental physics research."
- Jonathan Dorfan, SLAC Director**
 - "My laboratory as well as the potential User community of ORION strongly support the promotion and construction of this facility and the exciting future research to be done there."
 - Letter of support has major commitments that make the ORION Center feasible
- Attendance at this meeting by **Roberto Peccei & Maury Tigner**

[illegible][illegible]

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	5 Year Total
MRC 1 – Experiments at the FFTB (T. Katsoulas, USC & C. Joshi, UCLA)	\$600K	\$600K	\$150K	---	-	\$1,350K
MRC 2 - Construction and Operation of ORION, an Advanced Accelerator Research Facility (R. Siemann, Stanford)	\$1,800K	\$1,800K	\$1,250K	\$1,250K	\$1,250K	\$7,350K
MRC 3 – Electron Sources (J. Rosenzweig, UCLA)	\$300K	\$300K	\$300K	\$300K	\$300K	\$1,500K
MRC 4 – Laser Acceleration (R. Byer, Stanford)	-	---	\$450K	\$450K	\$450K	\$1,350K
MRC 5 – Plasma-Beam Physics (C. Joshi, UCLA & T. Katsoulas, USC)	---	---	\$450K	\$600K	\$600K	\$1,650K
MRC 6 - Full-Scale Computer Modeling Of Advanced Accelerators (W. Mori, UCLA)	\$300K	\$300K	\$400K	\$400K	\$400K	\$1,800K
Shared Experimental Facilities [1]	\$1,600K	\$1200K	\$300K	\$300K	\$300K	\$3,700K
Seed Funding and Emerging Areas [1]	-		\$25K	\$25K	\$25K	\$75K
Education and Human Resources and Outreach [1]	\$100K	\$100K	\$100K	\$100K	\$100K	\$500K
Administration [1]	\$50K	\$50K	\$50K	\$50K	\$50K	\$250K
Total	\$3,000K	\$3,000K	\$3,000K	\$3,000K	\$3,000K	\$15,000K

1) Included in the MRC's above

Progress in accelerators is inexorably linked with advances in particle physics

- New investments in accelerator research are critically important today.
- Recommendation 5 of draft subpanel report: “We recommend that vigorous long-term R&D aimed towards future high-energy accelerators be carried out at high priority within our program. ...”

The ORION Center is a unique opportunity to establish a university/national laboratory collaboration in this field that is vital for the future of particle physics

- Has had extensive, very positive reviews
- Brings together a critical mass of individuals with a passion for advanced accelerator physics
- Builds on the resources and investments that have been made in facilities at SLAC