The ORION Facility at SLAC

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AAC Workshop, June 15, 2000

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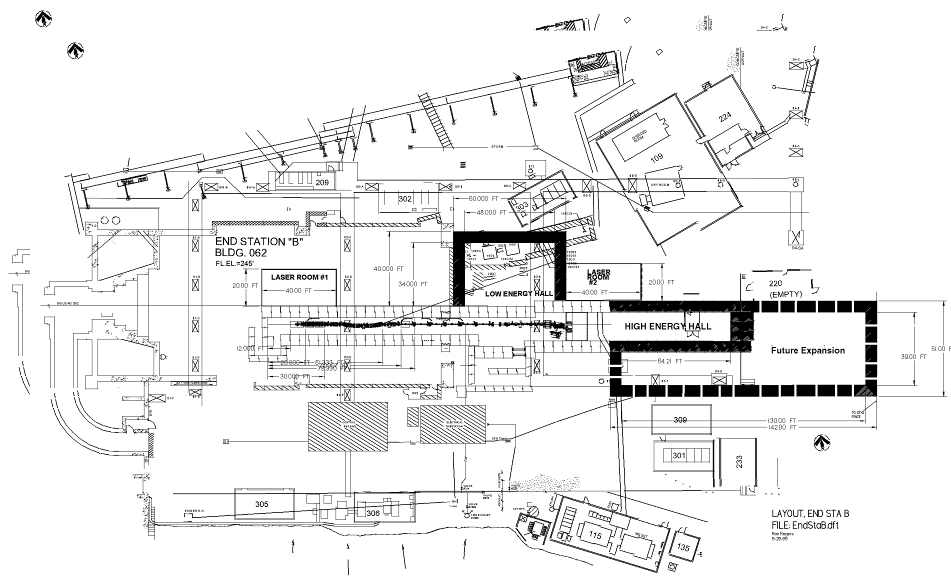
http://www-project.slac.stanford.edu/orion/

Introduction

Advanced accelerator research is crucial for the future of particle physics.

Success will depend on many factors including involvement of scientists inside and outside the traditional accelerator physics community, university faculty and students, and facilities and resources of the national laboratories.



ORION

- A user facility that would attract scientists with a passion for advanced accelerator research.
- A facility where the resources needed for that research are readily available.
- The accelerator, beamlines, instrumentation, etc. are available and user friendly so that physicists & engineers can concentrate on the physics and technology of future accelerators.
- I would like to see it develop a critical mass and become a focus for advanced accelerator research.

Introduction

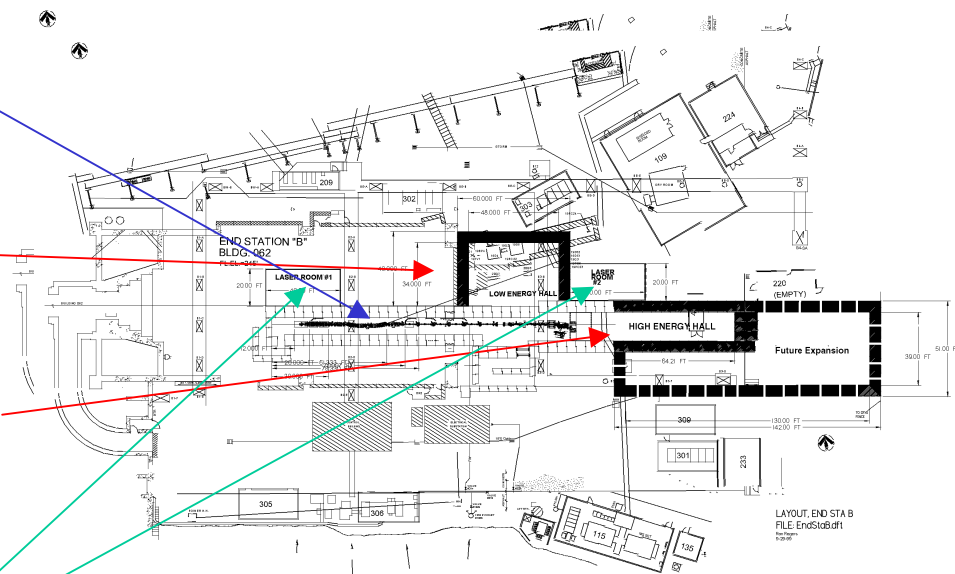
Based on the NLCTA (NLC Test Accelerator) - 300 MeV, 11.4 GHz linac with a ~ 200 nsec long beam with X-band bunches

Low Energy Hall for experiments with ~50 MeV beam available most of the time

High Energy Hall for experiments with ~300 MeV beam that would have to be scheduled together with NLC RF development

Two injectors - the present long-pulse injector & a single bunch, RF gun

Two laser rooms for RF gun laser and experimental laser



Brief History

Study initiated in April '99 & completed in October '99

Workshop in February '00

Reviewed & endorsed by DOE at SLAC's annual review, by SLAC faculty & SLAC Scientific Policy Committee

Now part of the SLAC program

The ORION Workshop

ORION Workshop

February 23 - 25, 2000
Chairs: Chan Joshi & Bob Siemann
Program Coordination: Dennis Palmer
Working Groups

High Gradient RF & RF Power Production	Hans Braun (CERN)
Plasma Acceleration	Tom Katsouleas (USC)
Laser driven Accelerators and Structures	Ilan Ben-Zvi (BNL)
Particle & Radiation Sources	Jamie Rosenzweig (UCLA)

This was an important workshop for the ORION project

- It was the first opportunity for the advanced accelerator community to learn about ORION
- SLAC could gauge potential interest ~ 80 people attended
- Possible experiments were discussed
- Significant issues were identified

The ORION Workshop

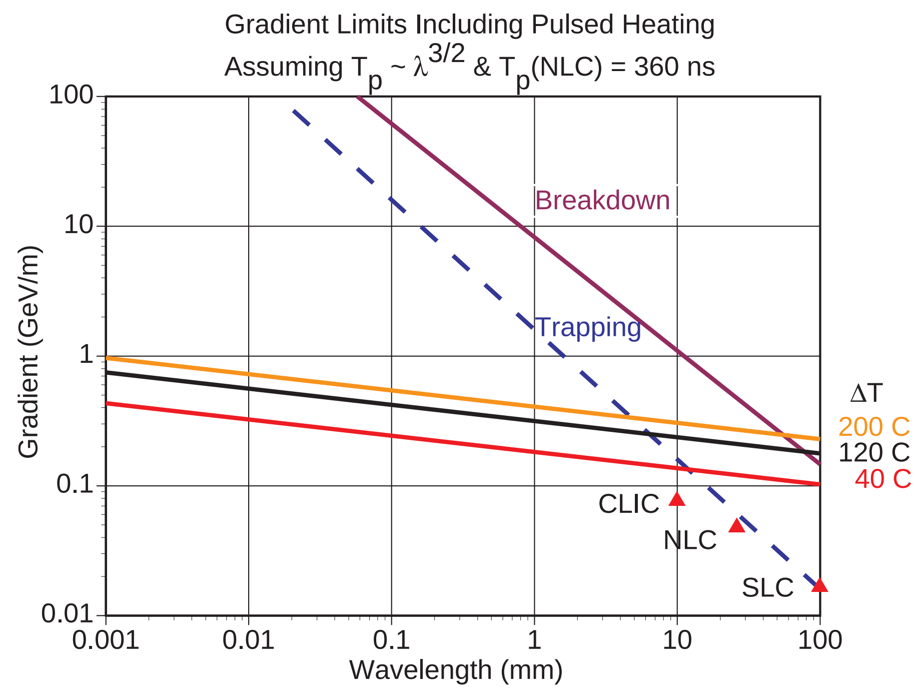
RF Experiments

Breakdown, dark current trapping and pulsed heating are the phenomena that determine accelerating gradients.

Knowledge of breakdown is phenomeno-logical and is based on limited data from a variety of travelling- and standing-wave structures.

The long pulse beam has harmonic content

$$I(n) = I_0 \exp(-n\omega_0\sigma_t)$$



Breakdown can be studied up to *~ 100 GHz* in travelling-wave structures with *I_0 = 2 A using the 300 MeV beam.*

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Plasma Acceleration Experiments

Experiment	***Energy* (MeV)**	***Charge* (nC)**	**σ_z (psec)**	**σ_r (μ)**	**ε (mm-mrad)**	**$\Delta\gamma/\gamma$**	**L_p (m)**	**n_o (cm^{-3})**	***Output***	***Issues***
Two-Bunch PWFA	300	1, 0.2	1 .2-.5	70μ	70	0.1	1m	5×10^{14}	500 MeV beam	Phasing 2 Bunch lengths
Bunch Shaping	300								Half-Gaussian	Isochronous bend
High Trans. Ratio Experiment		(4)	(4)				(.5m)	(1×10^{16})	(1.5 GeV)	
Electron Hose Instability	300	1	1	50	10	0.1	1m	1×10^{15}	Onset/saturation Blowup of beam	Simulations pending
Hi De-magnification Lens	300	1	1	400	3.5	0.01	0.15	1×10^{12}	4 μ spot	Aberrations/ diagnostics
Energy Compensation	300	1	1 ps + tail	50-100	5	0.1	0.3m	2×10^{14}	1% energy spread	200 fs streak camera
SMPWA								1×10^{21} gas	Acceleration?	Impact ionization Simulations!
E-Beam Slicing	50	1	1	20-40	3.5	0.1	0.15	4×10^{17}	Energy mod. 1MeV	TiSa laser Hi Vosc
E-Beam Steering	50 or 300	1	1	50-100	10	0.1	0.3	1×10^{14}	Deflected e-beam	--
Laser Guiding	50 or 300	1 kA	0.5-1	20	60	N/a	0.5m	1×10^{15}	Laser Transported 100 LR	Split photo-Cathode laser
Ion Channel Laser @ 50 MeV	50	1 nC/ps	>0.05	<60	5	0.05	0.2m	1.4×10^{15}	630 nm, 10^{10} gain .02-10^6 γ/e	Hosing? Models
Ion Channel Laser @ 300 MeV	300	1 nC/ps	>0.05	60	4	0.03	1.5m	4×10^{14}	80 nm	Gain?
Coh. Plasma Cherenkov Radiation	50 or 300	1 or 0.25	1 0.5	200	100	0.1	1m	4×10^{14} to 1×10^{16}	200 Ghz+ 1-10kW	Sharp Boundary/ B-field diffraction
Positrons									Many possibilities	

Notes: σ_z = bunch length; σ_r = spot size (assumed round); ε = normalized emittance; $\Delta\gamma/\gamma$ = fractional energy spread; L_p = plasma length; n_0 = plasma density

The ORION Workshop

Ion-Channel Laser

- 1 nC/psec bunch - typical requirement for many experiments
- At 50 MeV

  $n_0 = 1.4\times10^{15}$ cm^{-3}

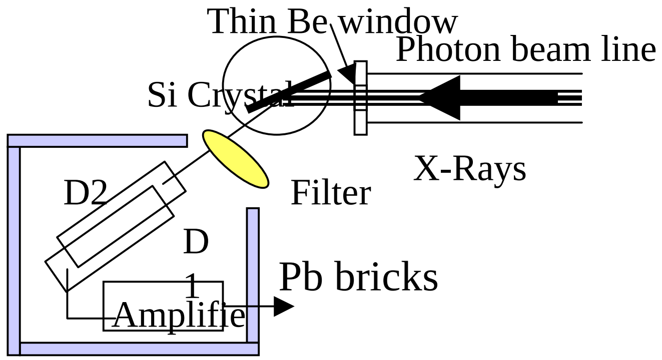
  630 nm visible light

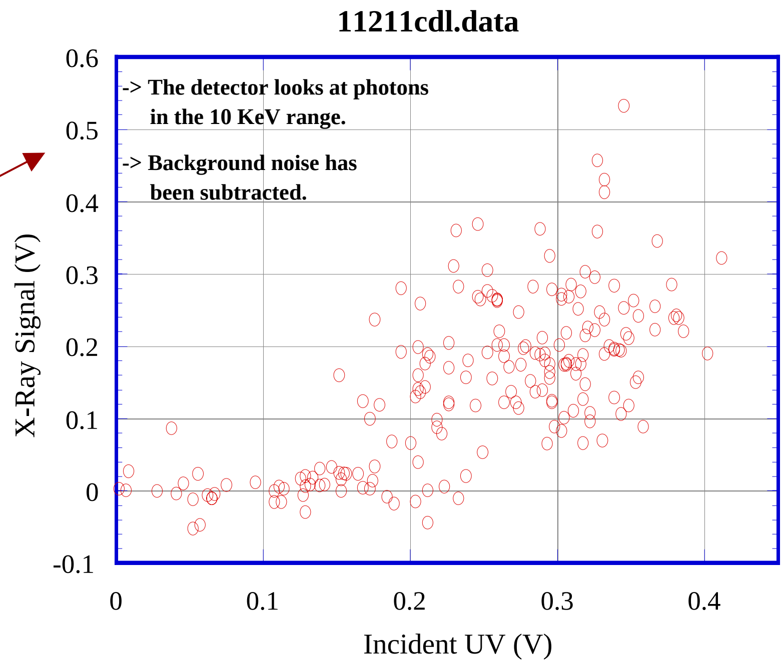
- At 300 MeV

  $n_0 = 4\times10^{14}$ cm^{-3}

  80 nm UV radiation

Sho Wang (UCLA, E-157) - spontaneous x-ray emission from a 30-GeV beam





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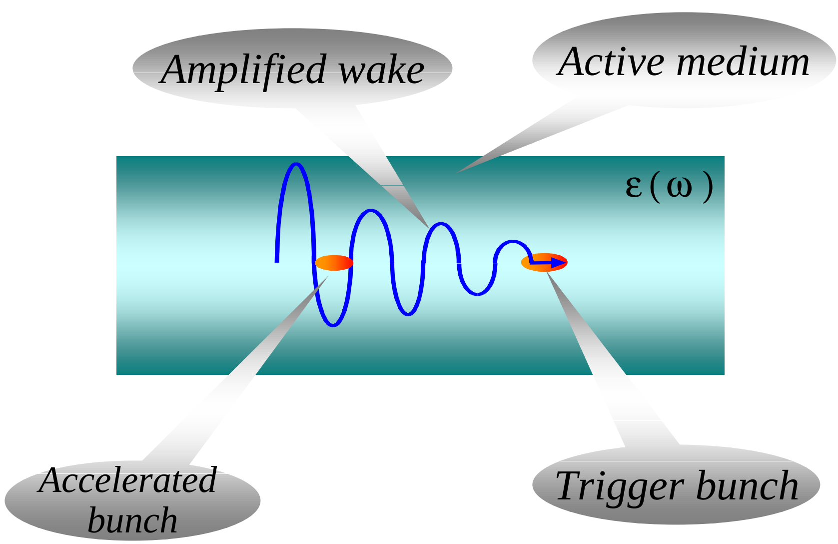
Laser Acceleration Experiments

Four possible experiments reviewed for electron beam, laser, diagnostics & other requirements.

Guided strongly by experience at the ATF & LEAP



Laser Acceleration Experiments

QUANTITY/ EXPT	LEAP	TOP	INVERTED MEDIUM	AGLA
Electron Beam				
Energy	> 30 MeV, < 60 MeV	50 MeV	300 MeV	300 MeV best
Pulse length	~ 1 psec	Any OK	3 psec	Covered by columns on left
Particles	10^6 to 10^8	10^7	$<10^9$	
Energy Spread	0.1% FWHM	0.10%	Same	
Normalized Emittance	1 µm	1 µm		
Charge Stability	10% FWHM	10% FWHM		
Timing Stability	< 1 psec	1 psec		
Energy Stability	< 1/2 expected effect = .5*100 keV	0.10%		
Pointing Stability	3 µm at expt.	10 µm		
Electron Beam Diagnostics				
Spectrometer	10 % acceptance, 0.01% resolution	0.01%	100 MeV range around 300 MeV, 0.03% resolution	
Charge	needed	0.1 pC/pulse	Needs to see a low charge seed bunch, 10^4-10^6 particles	
Position	needed	<10 µm		
Emittance	needed	0.1 µm		
Pulse Length	needed	needed		
Laser				
Energy	1 mJ/stage	.1 - 1 GW		1 TW
Pulse Length	1 - 10 psec	10 nsec		10's-100 fsec OK
Wavelength	1 µm	10 µm		1 micron
Mode Quality	$m^2 < 2$	TM_{10}		
Energy Stability	5% FWHM	5% FWHM		
Timing Stability	(Laser Pulse Length)/3	100 psec		
Pointing Stability at Expt	3 micron	10 micron		
Laser Diagnostics				
Energy	Shot-to-Shot at Experiment	Power meter	0.5 - 1 µm detection	
Position	Monitor Position in Transport Line			
Pulse Length	Streak Camera	Optical Microbunching Diagnostic	Streak Camera	
Other				
Space on Beam Line	Matching 2m, experiment 2m, downstream 2 × 2 m			
Space Around Beam Line	1.5 × 2.5 m table			
Control Room Space	Light analysis room nearby with two optical tables			
Access Time	20% of run time			
Run Time	48 hrs/week × 12 weeks for one experimental study	10% as much		
Safety	Radiation and laser safety compatible with access to one experimental area while lasers and beams are present in another area			
Special Requirements			Two bunch e with variable (short) delay	

The ORION Workshop

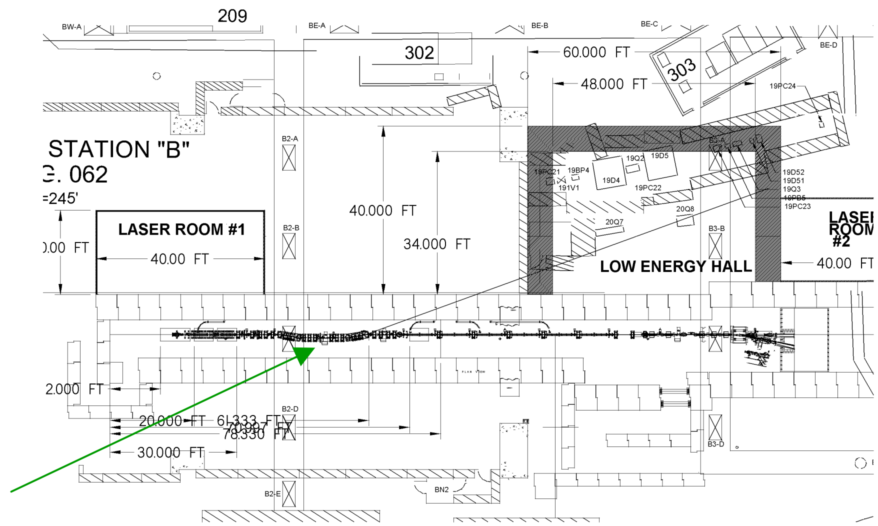
Particle & Radiation Sources

This working group dealt with significant technical issues

- Must have long pulse capability for RF experiments and high brightness, single pulse beam for other experiments.

Comments and recommendations from the working group

- The alternative of an S-band rather than an X-band RF gun should be given serious consideration
- The chicane at the end of the injector does not have to be bypassed for high brightness beams
- ORION should include a separate shielded area for RF gun and injector development.



The group also pointed out that ORION, properly equipped, could serve as a user facility for soft X-ray physics or photo-nuclear physics

- This is not the intent - ORION is intended as a user facility for accelerator research

What's Next?

SLAC has made ORION part of its program and is committed to operate it as a user facility for accelerator research.

Interrelated issues

- Technical aspects
- Establishing an advocacy, planning & advisory group
- Raising construction $
- Establishing the ORION project at SLAC

Technical Aspects

- ORION configuration - experimental hall sizes & shapes, laser room sizes & shapes, inclusion of a gun development area
- Radiation & laser safety for convenient access & set-up while other experimenters are using the beam
- Injector complex - X-band or S-band, accommodating the single-pulse and long pulse injectors

What's Next?

We are establishing a group of interested parties to help us plan ORION and to be advocates for it in fund raising activities. Membership

- Members of the university user community
- Representatives from other laboratories (non-US & US) with an interest in pursuing research at ORION
- Representatives of funding agencies
- ORION project management at SLAC
- Informal discussions have just started with possible interested parties

Raising $

- SLAC is committed to operate ORION as a user facility for accelerator research
- However, we do not have the estimated 3.5 - 5 M$ needed for construction.
- Therefore, one of the next and necessary steps is to raise that money.
- We are working on that and will be asking help from the above group.

What's Next?

Establishing the ORION Project at SLAC.

- Part of Accelerator Research Dept. B at SLAC
- A physicist in charge of ORION construction - TBD
- A project engineer - D. Walz

Concluding Remarks

ORION will be a user facility for accelerator research where the accelerator, etc. are available and user friendly so that physicists & engineers can concentrate on the physics and technology of future accelerators.

SLAC has made ORION part of its program and is committed to operate it.

I hope many of you will find it a stimulating place for some of your research in the future.

Thanks to those who have helped make ORION a reality