ARDB

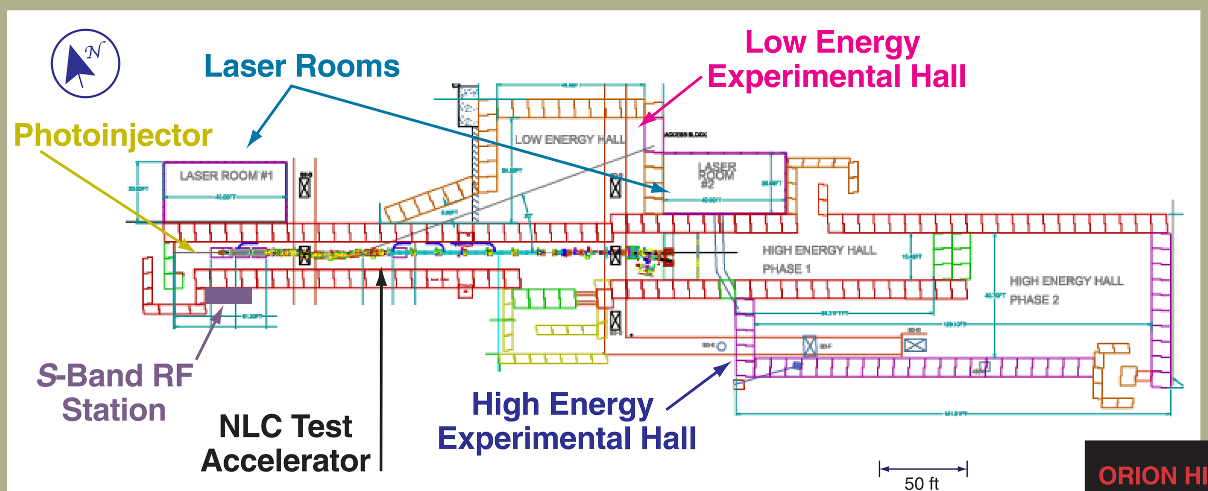
Advanced Accelerator Research

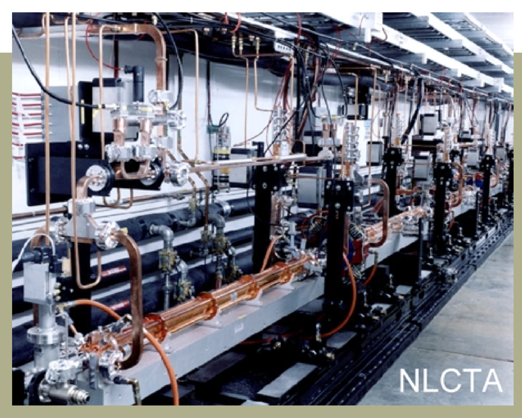
The accelerator research program at SLAC performs research on accelerator technology and particle beam physics pushing both energy and luminosity in high-energy electron colliders. One aspect is research into new techniques and devices for high-gradient acceleration and focusing for electron linear colliders up to 5 TeV. Work involves collaborations with physicists from several universities, other laboratories and the private sector.

ORION: AN ADVANCED ACCELERATOR RESEARCH FACILITY

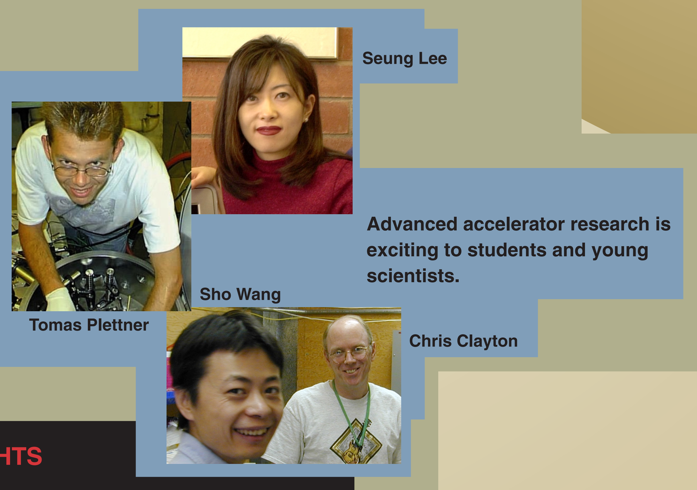
The ORION facility is envisioned to be a User-oriented facility that will attract scientists with a passion for accelerator research. This facility will have the needed resources readily available for scientists to carry out their advanced research. A sketch of the facility is shown below.

The ORION facility concept is predicated on the fact that
¥Advanced accelerator research is crucial for the future of particle physics.
The goal is to understand the physics and develop the technologies essential for reaching high energies.
¥Success in advanced accelerator work will depend on many factors including involvement of scientists inside and outside the traditional accelerator physics community, university facility and students, and facilities and resources of the national laboratories.





ORION is a collaboration of CERN, DESY, KEK, Stanford, UCLA, and USC. Inquiries from other institutions are welcome.



Advanced accelerator research is exciting to students and young scientists.

ORION HIGHLIGHTS

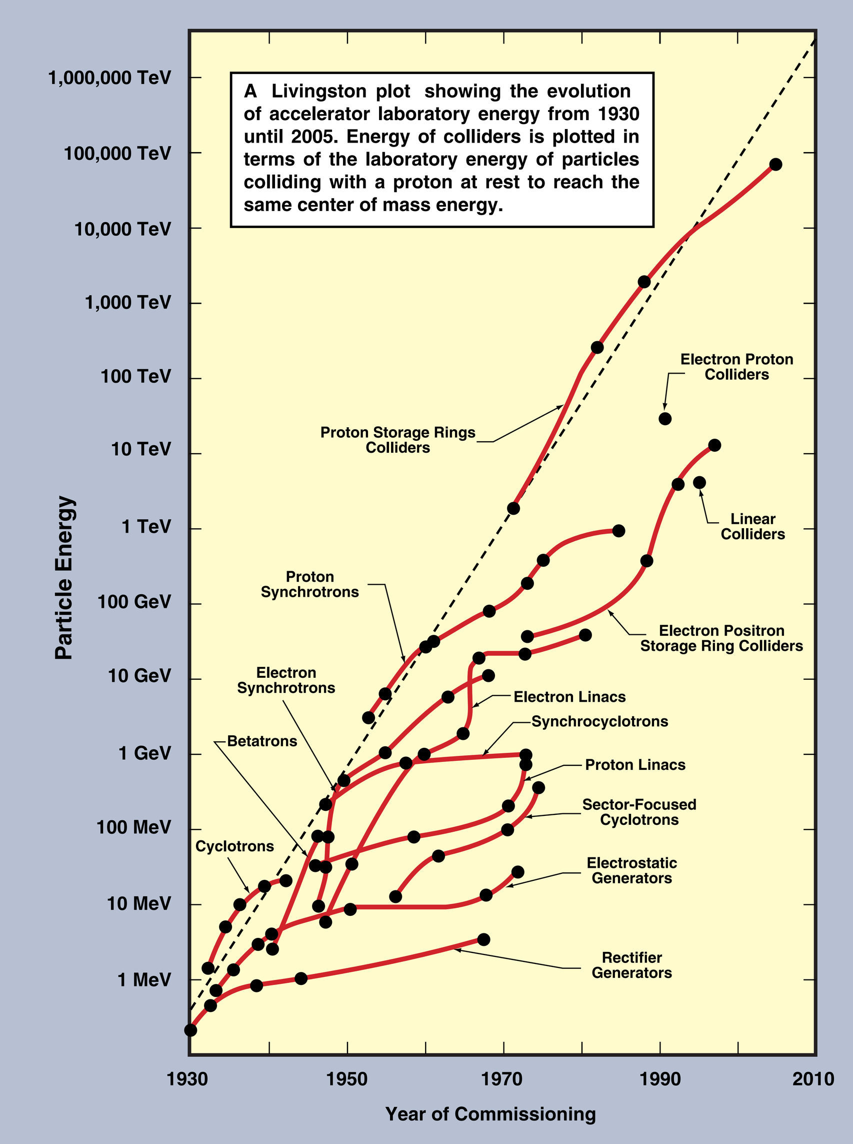
Based on the NLCTA (NLC Test Accelerator) 300 MeV, 11.4 GHz linac with a new injector — a single bunch, RF gun

Low Energy Hall for experiments with ~65 MeV beam available most of the time

High Energy Hall for experiments with ~300 MeV beam that will be scheduled together with the NLC RF development

Two laser rooms - for RF gun laser and experimental laser

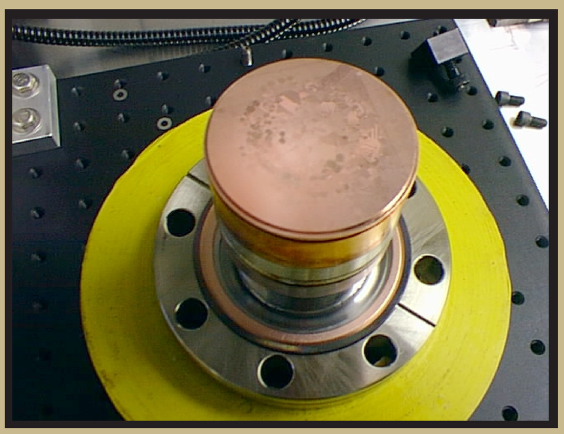
THE LIVINGSTON CURVE



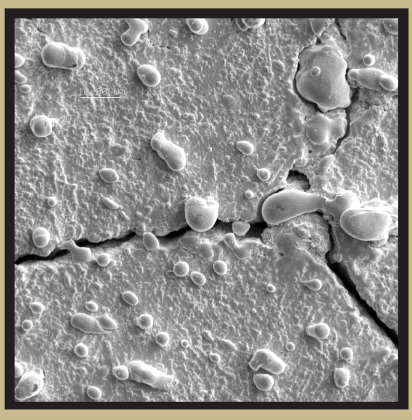
The Livingston curve shows the exponential growth in CM energy that has come from new accelerator physics and technology. This growth has been followed by profound discoveries — CP violation in K s, two ν s, J, quarks, Ψ, τ, gluons and QCD, W, Z, top quark. The ORION center would directly address crucially important new accelerator ideas.

PULSED HEATING CAVITY

A structure operated at high gradient is subject to Ohmic heating, and at 1GeV/m, this could easily amount to over 100 ¡C temperature rise. It is important then to have an accurate assessment of the mechanism and limits of damage due to cyclic fatigue from pulsed temperature rises. For this purpose experiments have been done using a TE011 mode cavity at X-Band. Damage in the form of cracks and grain growth is shown to occur on the surface of fully-annealed OFE copper after 55 million pulses at 120 ¡C pulsed temperature rise. The damage is shown as a ring on the surface of the copper test piece where the maximum heating has occurred.



Damage appears as a ring on the surface where maximum heating has occurred.

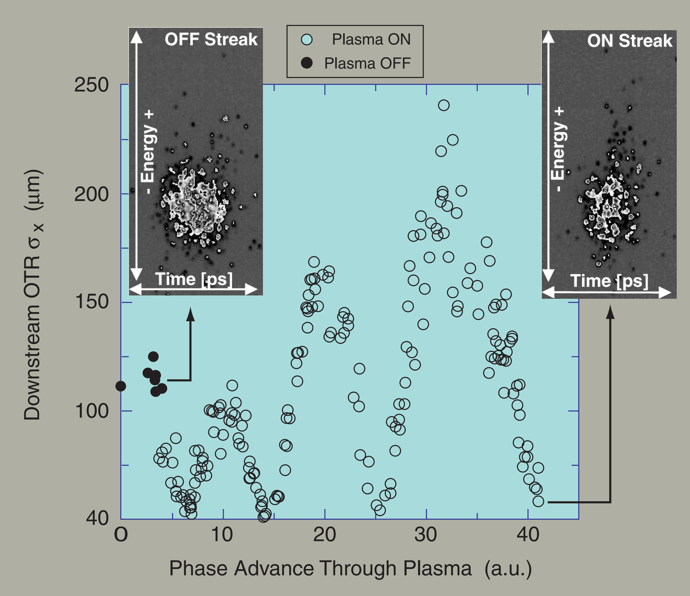


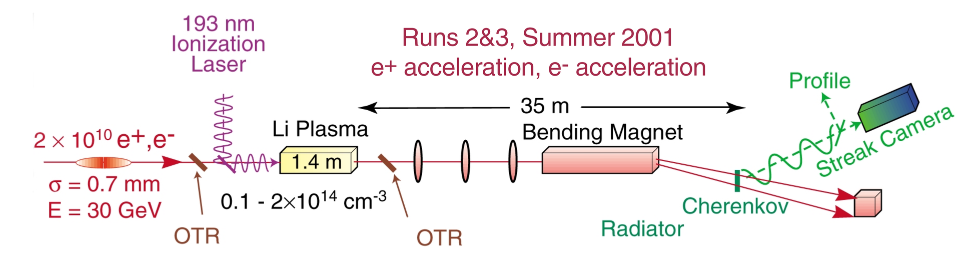
Damage in the form of cracks and grain growth after 55 million pulses at 120 degrees C pulsed temperature increase is shown.

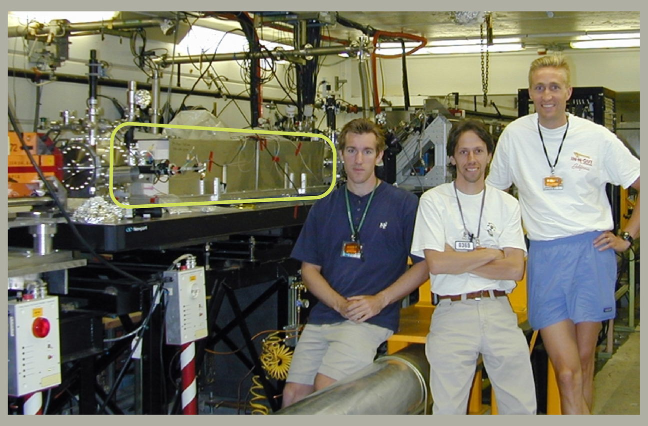
PLASMA WAKEFIELD ACCELERATOR

Although the concept of a "plasma-wave accelerator" has been around for over twenty years, and small-scale experiments have demonstrated the principle in short, millimeter and centimeter-long plasmas, the SLAC experiment is the first to use long plasmas to obtain energy gains of interest to accelerator builders. The acceleration chamber containing the plasma is in fact the same length as a typical fluorescent light tube, about one and a half meters. The energy increase per meter of electrons in these first experiments has already been measured to be about five to ten times higher than in the copper accelerator cavities of the SLAC linac.

Precise diagnostic techniques were essential for measuring plasma effects on beam particles. To determine the energy gained by electrons from the plasma wake, a dipole magnet was used to bend the beam after the plasma region. Higher energy particles are bent less by the dipole than lower energy ones, and the beam ends up being spread transversely according to energy. Passing this spread bunch through an aerogel cell, the emitted Cherenkov radiation was then time-resolved in a "streak camera" in which light is recorded along a CCD (charge-coupled device used in digital cameras) according to when it arrives. The figure to the right shows the 16 picosecond "streak" image of the bunch in which early light from the bunch s head is at the left and light from the tail is on the right. A few tail-particles, which gained about 150 MeV, are seen above the lower-energy beam core, which was bent preferentially downward by the dipole. When the laser is off and no plasma is formed, no acceleration is seen.

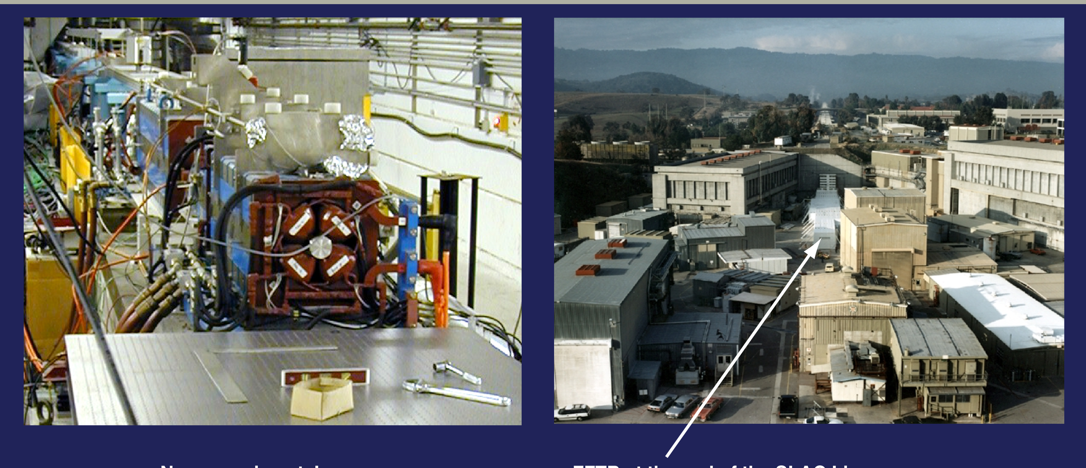






Pictured with the plasma accelerator chamber (outlined in green) are researchers Brent Blue, Patric Muggli and Mark Hogan.

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

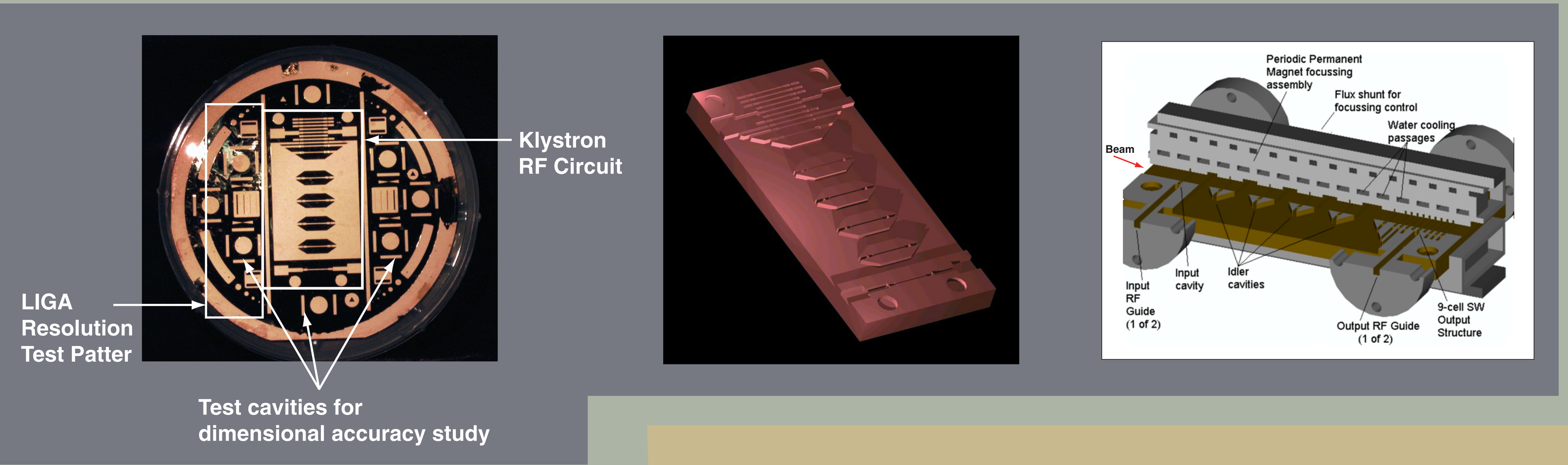


New experimental area

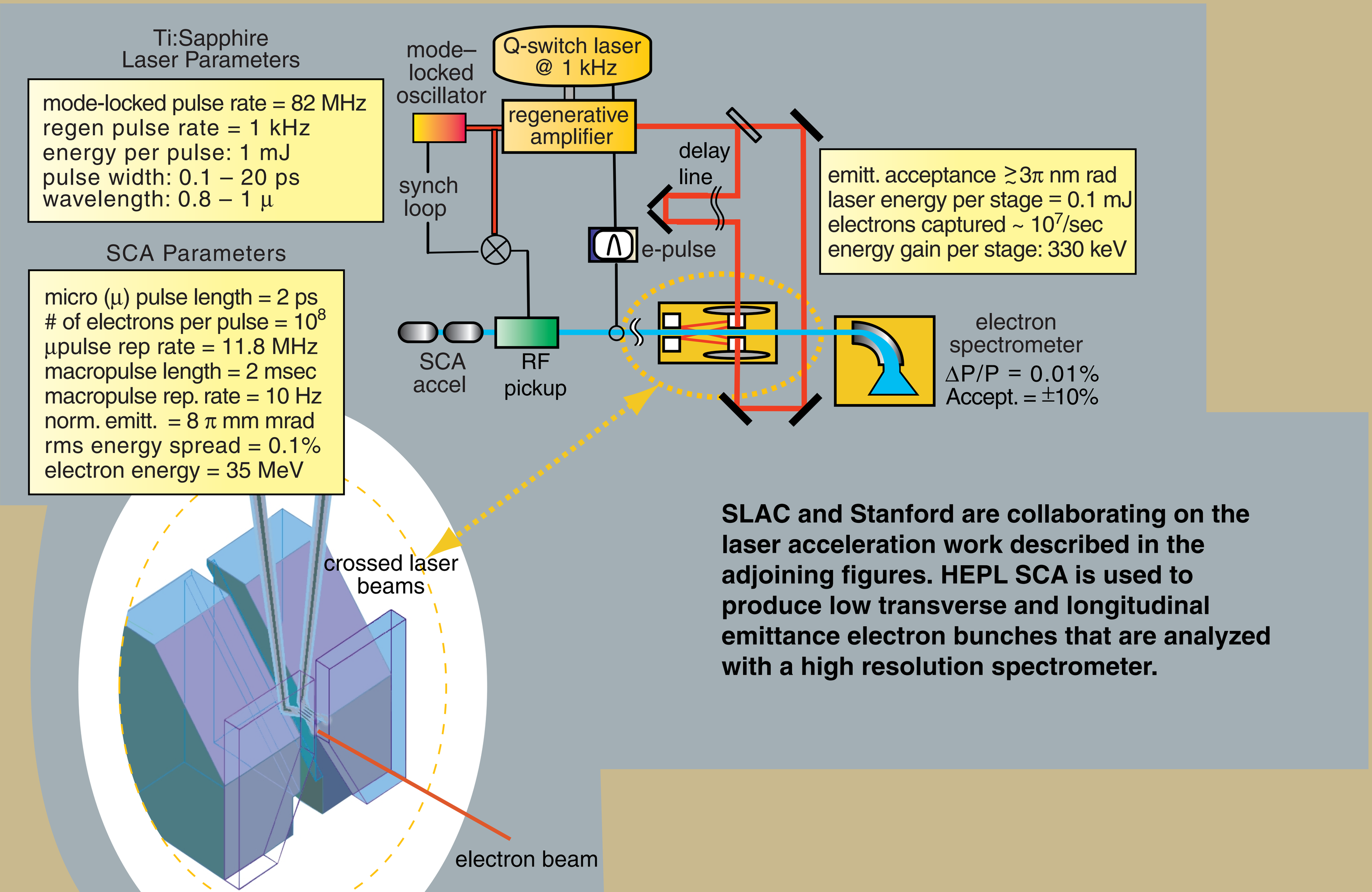
FFTB at the end of the SLAC Linac

MILLIMETER—WAVE SHEET BEAM KLYSTRON DEVELOPMENT

The electromagnetic waves powering accelerators are produced by high-voltage electron tub amplifiers, or klystrons fabricated to a precision set to the operating wavelength, 3.3 mm of W-Band. Seen is an actual W-Band klystron made by deep X-Ray lithography, or "LIGA", a process consonant with mass production, as seen on the "chip". LIGA yields exceptional precision and permits high aspect ratio. A miniature klystron design is shown and consists of an input cavity, idler cavities, and a multi-cavity output circuit. The machining tolerance is 1 micron. To surpass all conventional linacs in gradient, at W-Band a power of only 300 kW is required.

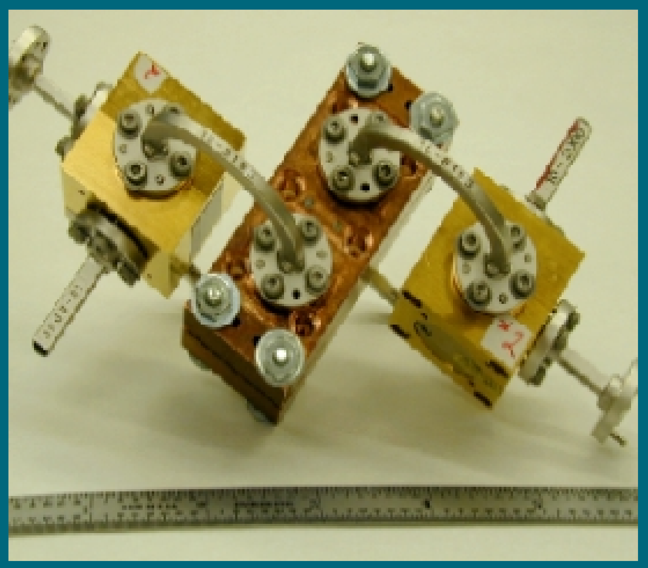


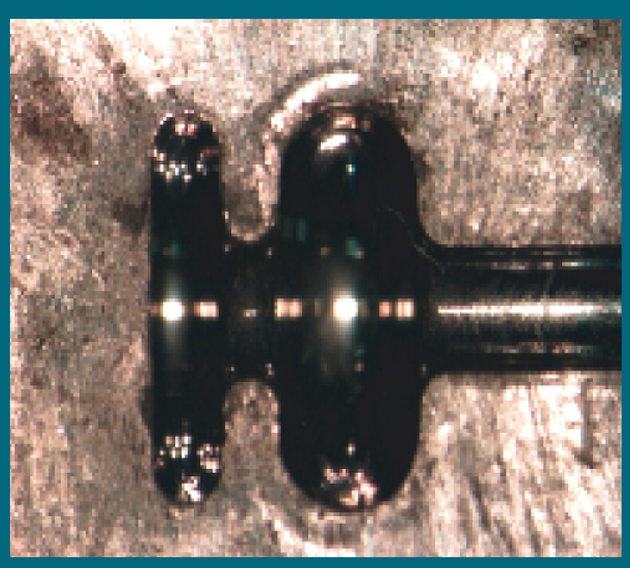
LASER ELECTRON ACCELERATION PROJECT



SLAC and Stanford are collaborating on the laser acceleration work described in the adjoining figures. HEPL SCA is used to produce low transverse and longitudinal emittance electron bunches that are analyzed with a high resolution spectrometer.

W-BAND ACCELERATOR RESEARCH





Major RF components of the W-Band Photoinjector are shown in the above photographs. The Zipper W-Band Traveling Wave Accelerator (left), and the W-Band RF Gun (right), both provide excellent examples of the results of the synergetic relationship between SLAC and small business as they work together through the U.S. Department of Energy Small Business Research Initiative (SBIR) Program in the field of advanced accelerator research.