*March 27, 2002,* *CBN02-4*

# FIELDS FOR POSSIBLE PARTICIPATION IN LINEAR COLLIDER ACTIVITY

## Personal impressions of Alexander A. Mikhailichenko

## LC OPERATION

♣M.Tigner, ***A Possible Apparatus for Electron Clashing-Beam Experiments***, Il Nuovo Chimento, 37, 1228 (1965).

First linear collider scheme. Low energy. Recuperation required to meet reasonable energetic.

♣U. Amaldi, ***A Possible scheme to obtain*** $e^-e^-$, ***and*** $e^+e^-$ ***collisions at Energies of Hundreds of GeV,*** Physics Letters, Vol. 61B, number 3, 313(1976).

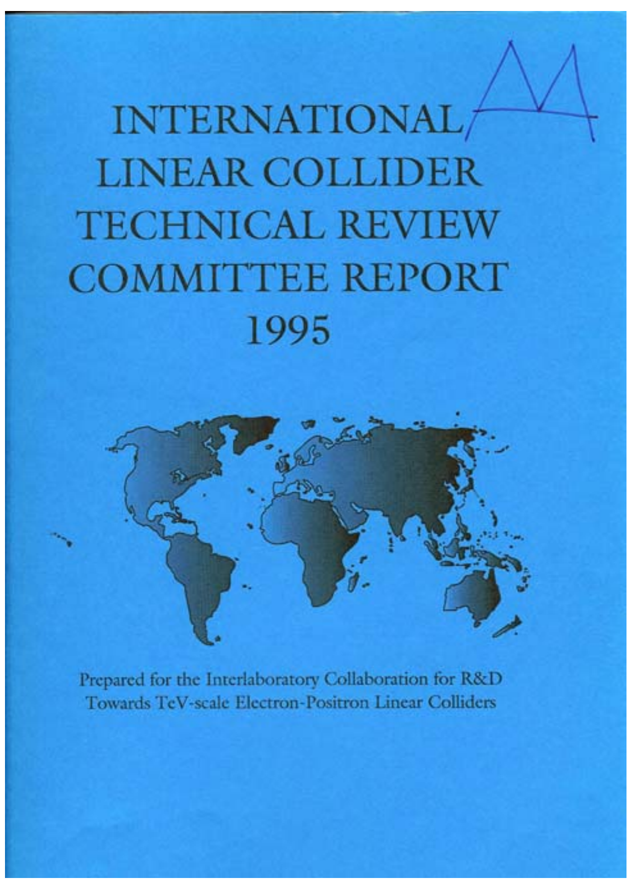
Importance of linearly accelerated colliding beams at high energy to avoid huge SR losses.

♣V. Balakin, O. Brezhnev, A. Mikhailichenko, A. Novokhatsky, V. Smirnov, N. Soliak, ***Physical Foundation for Linear Collider,*** ICFA Seminar on Future Perspectives in High Energy Physics, Upton, 5-10 October 1987, Proc., pp. 244-266.

Basic physics of linear collider stable operation, including BNS, flat beams, polarization, gradient limits.

♣G. Loew, Editor, ***International Linear Collider Technical Review Committee Report, 1995.***

First description of different approaches to the problem.



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# RING

♣A.Mikhailichenko, V. Parkhomchuk, ***Damping ring for Linear Collider***, *BINP 91- 79*, 47 pp., also talk at KEK, Tsukuba, Japan, March 28-April 5, 1990.

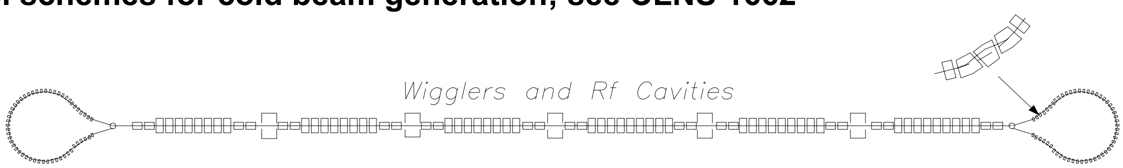
Importance of vertical emittance, IBS for vertical emittance, comparison of classes of damping rings for low emittance, low impedance, Ions.

♣V.V. Anashin, I.B.Vasserman, V.G.Veshcherevich, B.I. Grishanov, I.A. Koop, V.I. Kupchik, I.G. Makarov, A.A. Mikhailichenko, O.A. Nezhevenko, V.N. Osipov, E.A. Perevedentsev, V.M. Petrov, I.K. Sedlyarov, A.N. Skrinskii, E.M.Trachtenberg, Yu.M. Shatunov, V.P. Yakovlev, ***Prototypes of the Damping Ring and the Buncher for the VLEPP Project***, XIII international conference on high energy accelerators, Novosibirsk, USSR, Aug 7-11, 1986, pp 159-163. , BINP 84-114, SLAC-TRANS-0224, Oct 1986. 14pp. Published in Novosibirsk Accel. Part. Conf.,1986, v.1:159 (QCD183:I5:1986).

First operational damping ring designed specially for linear collider.

**POSSIBLE PARTICIPATION:**

**Novel schemes for cold beam generation; see CLNS 1662**




### SC RF Cavity

SC RF for Damping: more compact
Capacitive input
Avoid non-round shapes for HOM evacuation.

### Wigglers

Optimization
Tracking codes/analytical mapping

### Diagnostics

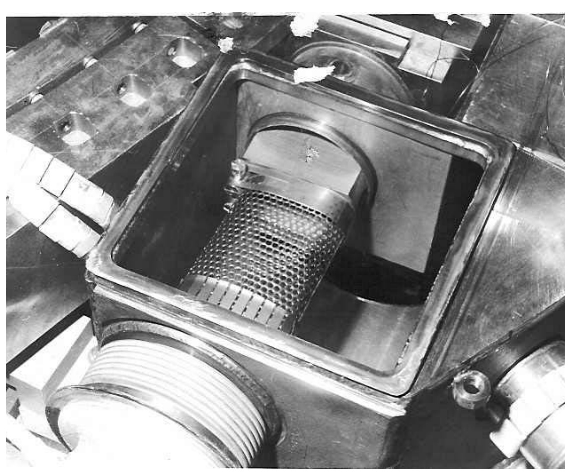
Vertical emittance $\gamma\varepsilon_z \cong 10^{-10} - 10^{-11} m \cdot rad$

### Beam dynamics

Optics
Ions/electrons
Optical stochastic cooling

### Impedances

Smooth vacuum chamber, sliding joints, vacuum ports etc.



**BEP's straight section around septum magnet**

# POSITRON GENERATION

## Importance of collisions with polarized particles.

♣V. Balakin, A. Mikhailichenko, ***Conversion System for Generation of Highly Polarized Electrons/Positrons***, BINP 79-85, Novosibirsk, 1979.

Polarized positron/electron generation with the help of **circularly polarized gammas**. Considered static helical magnetic field, electromagnetic wave, channeling in crystals. Translated by SLAC in 1979.

♣J. Barley, A.Mikhailichenko, V.Medjidzade, ***New positron source for CESR***, CBN 01-19.

Doubled positron accumulation rate at CESR so far. Can be ***tripled*** from the level achieved.

### TEST FACILITY AT SLAC

Proposals for test polarized positron production at SLAC for the first time done in:

♣ E.G. Bessonov, A.A. Mikhailichenko, ***Some aspects of the undulator radiation formation for conversion system of the Linear Collider***, BUDKER INP 92-43, Novosibirsk, Jun 1992, 26 pp.

Analytical calculations

♣ A.D. Bukin, A.A.Mikhailichenko, ***Optimized target strategy for polarized electrons and positrons production for linear collider***, BUDKER INP 92-76, Novosibirsk, 1992.

Numerical calculations.

♣ A. A. Mikhailichenko, ***Use of undulators at High energy to produce polarized positrons and electrons,*** in SLAC-R-502, p.229, 1997.

**POSSIBLE PARTICIPATION**

### Undulator fabrication

Fabricate ~4 m long undulator with ~2mm period. Test at SLAC.
Collaboration under arrangement.

### Collection optics

Similar to that one used for CESR

### Dynamics of target

Impulse heating

### Diagnostics

Gamma polarization (10-60 MeV)
Positron polarization (5-60 MeV)

→ **Broad field for participation**

# PRIMARY ELECTRONS

**POSSIBLE PARTICIPATION:**

Polarized /unpolarized
**RF guns with laser**
Cinematically bunched beams
Flat ones.

# RF GENERATORS

♣ A.A. Mikhailichenko, ***UHF generator* , *An Invention***, Author's certificate USSR. N 1356872, Priority 10 of March 1987.

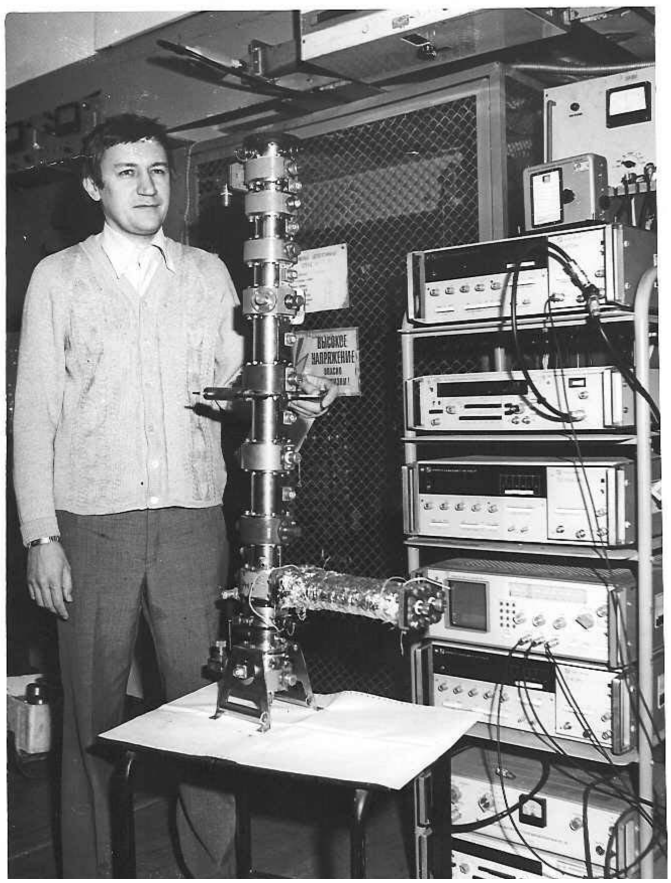
New type of RF amplifier/generator with theoretical efficiency 100%, practically unlimited power.

♣ A.A.Mikhailichenko, ***RF Window for high power in X and S band***, Nuclear Instruments & Methods, 355(1995), 645.

RF window for practically unlimited power.

♣V.E.Balakin, Yu.G. Bamburov, O.N. Brejnev, A.D. Bulatov, M.N. Zakhvatkin, B.V. Ivanov, I.V. Kazarezov, Yu. Kluev, A.I. Kojemiakin, E.N. Kokin, M. Kondrat'ev, G.S. Krajnov, G.I. Kuznetsov, D.E. Kuklin, A.N. Lukin, A.A. Mikhailichenko, A.V. Novokhatsky, M.A. Oleinikov, E.G. Pokhlebenin, Yu.A. Semenov, N.A. Soliak, N.G. Khavin, G.I. Yasnov, B.I. Yastreba, ***Test of accelerating structure of the VLEPP***, VIII all Union Conference on High Energy Accelerators, 1982, Proc., vol.2., p.410.

First test of combined standing wave structure operating at 7GHz. Tested new Klystron-type device for RF generation:



Focusing lenses are visible here between the cavities.

**POSSIBLE PARTICIPATION:**
**Modulators**
**Klystrons**
**Alternative (two beam)**

**No visible places for participation**

# FF OPTICS

♣ V.E. Balakin, A.V. Aleksandrov, A. Mikhailichenko (Novosibirsk, IYF), K. Floettmann, F. Peters, G.A. Voss (DESY), V. Bharadwaj, M. Halling, J.A. Holt (Fermilab), J. Buon, J. Jeanjean, F. Le Diberder, V. Lepeltier, P. Puzo (Orsay, LAL), G. Heimlinger, R. Settles, U. Stierlin (Munich, Max Planck Inst.), H. Hayano, N. Ishihara, H. Nakayama, K. Oide, T. Shintake, Y. Takeuchi, N. Yamamoto (KEK, Tsukuba), F. Bulos, D. Burke, R. Field, S. Hartman, R. Helm, J.Irwin, R. Iverson, S. Rokni, G.Roy, W. Spence, P. Tenenbaum, S.R. Wagner, D. Walz, S. Williams (SLAC), ***Focusing of Sub-Micron Beams for TeV-Scale*** $e^+, e^-$ ***Colliders,*** **SLAC-PUB-95-6691, Mar 1995. 4pp., Phys. Rev. Letters, Vol.74 (1995), 2479-2482.**

First test of Final Focus hardware, principles, lenses, magnets, stabilization, measurements of sub-micron sizes and lot more. Good example of international collaboration. D. Burke -chairman

**POSSIBLE PARTICIPATION:**

## Novel approaches for shortage of delivery system:

New methods in chromatic compensation

Adiabatic Final Focus

## Diaphragms:

Nonlinear focusing elements as diaphragms

## Stabilization:

Active stabilization of FF lenses

## Design of quads and other magnets:

Actual optimization, design and drawings

*Left to right, V. Kamenov, V. Medjidzade, and A. Mikhailichenko of the Institute of Nuclear Physics at Novosibirsk, USSR, examine one of the first quadrupole magnets delivered from Siberia to Stanford for use in the new Final Focus Test Beam facility to study the focussing of submicron beam spots of electrons and positrons. (Not pictured are V. Alexandrov and A. Chernyshov).*

neutrino problem' – the number of neutrinos detected on the Earth is only a fraction of those expected to be emitted by the sun (January/February, page 11).

According to Glashow, this latest neutrino finding 'proves that Nature's bag of tricks is not empty and demonstrates the virtue of consulting her, not her prophets'.


### Zagreb neutrino

*At the Ruder Boskovic Institute in Zagreb, Yugoslavia, an experiment has reported evidence for a 17 keV neutrino in the radiation spectrum (internal bremsstrahlung) emitted from electron capture (from atomic shells) in a germanium-71 source.*

### STANFORD
### First magnets for Test Beam Facility

The first quadrupole magnets for the Final Focus Test Beam (FFTB) were delivered to the Stanford Linear Accelerator Facility (SLAC) in February.

The task of the international FFTB effort is to investigate the magnetic focusing systems needed to handle submicron beam spots for the next generation of electron-positron linear colliders (November 1990, page 11).

As part of this international collaboration, the FFTB high precision lenses have been designed and fabricated by the Institute for Nuclear Physics, Novosibirsk (INP), where a group has taken responsibility for delivery of the main quadrupole, dipole, and sextupole elements of the FFTB beamline.

These first magnets will soon be followed in early spring by 30 identical units, and the entire complement will arrive at SLAC in the summer.

Extensive tests and measurements made in the Soviet Union and SLAC testify to the care and exactness with which this hardware has been fabricated and assembled. The goal of the FFTB project to produce nanometre beam spots requires careful control and compensation of the magnetic fields in the beamline.

Quadrupole fields accurate to one part in a thousand must be generated in lenses with centimetre apertures and focusing strengths as large as a half a tesla. This has been achieved by machining special contours into the poletips of the lenses, and by maintaining fabrication and assembly tolerances to within a few microns.

On schedule, the Final Focus Test Beam is planned to begin operations in the fall of 1992 and will provide valuable feedback for the design and construction of the next linear collider.

### DESY
### H1 detector ready for tests

Finishing touches are now being made to the two big detectors – H1 and Zeus – to exploit the new HERA electron-proton collider soon to be commissioned at the German DESY Laboratory, Hamburg.

A collaboration of more than 30 groups from ten countries, H1 is now nearly complete in HERA Hall

## IP/ DETECTOR

**Detector for linear collider must be universal ($e^+e^-$, $e^-e^-$, $\gamma\gamma$, $\gamma e^{\pm}$).**

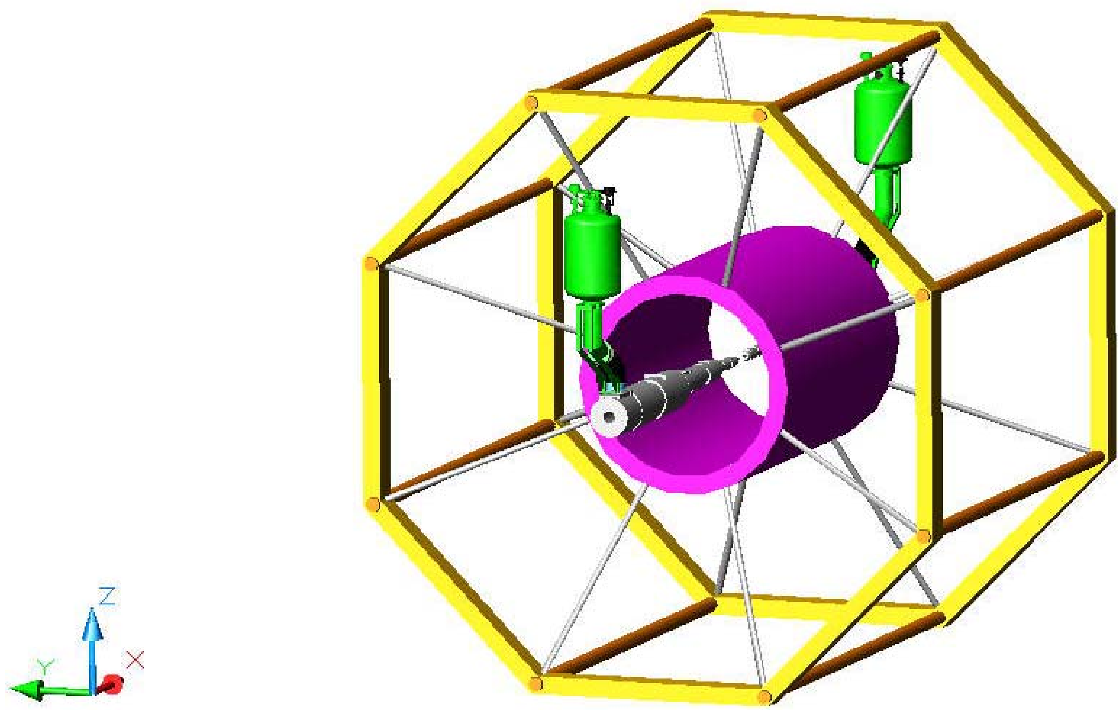
**It must take advantages associated with both polarized colliding particles**

The magnet yoke serves as a flux return and in muon identification system.
For future collider yoke will weight within thousands tons.

♣A. Mikhailichenko, ***Do detectors need a yoke?*** CBN (Cornell U., LNS). CBN-01-20, Oct 2001. 6pp.

**Frame Detector /Possible participation as leaders,**

♣ A. Mikhailichenko, *Detector for linear collider,* CBN 02-3, Cornell U., LNS 2002**.**




**Frame detector. This concept allows modular design. Sectors filled with muon identification hardware.**

Advantages are evident. Internal parts of detector can be made easy accessible. The same is valid for electronics and cables.
The possibility for lightweight alloy utilization. Aluminum and titanium alloys are good for this.
Detector becomes a lightweight unit as a whole.
As the yoke is eliminated, there is possible now to consider 70-100 kG field .
This might be interesting for future photon collider as well, as it helps in arrangements of the photon beam optics and it's maintenance.

**Stabilization of doublets is easy.**

# FUTURE OF LINEAR COLLIDERS

♣ A. Mikhailichenko, ***Particle acceleration in microstructures excited by laser Radiation.*** *Basic principles*, CLNS 00/1662, *February 11, 2000* .

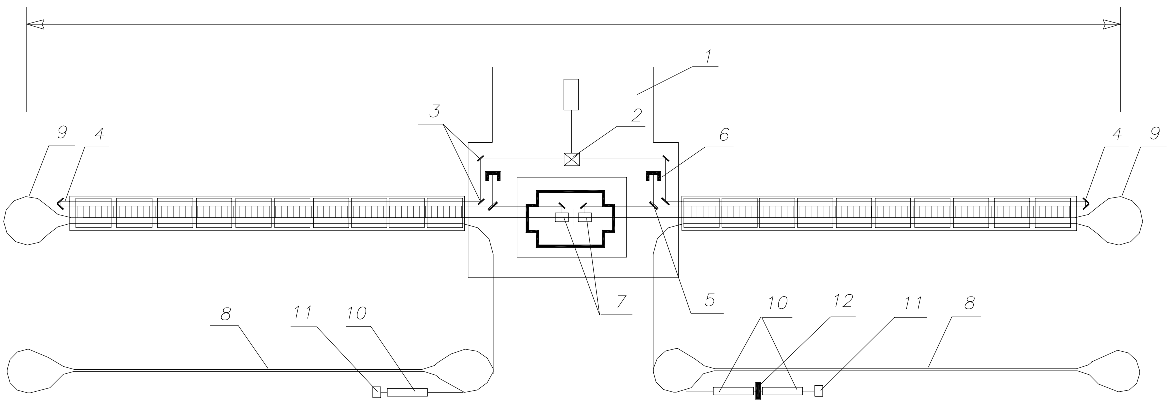
**Usage of new nano-technologies**

**Local excitation of accelerating structures to avoid damage**

**Traveling Laser Focus techniques**

## Linear collider with polarized electrons and positrons.

*2x1km / 2x10TeV*




Laser Linear Collider (LLC) complex. 1–is a laser master oscillator platform, 2 –is an optical splitter, 3,4–are the mirrors, 5–is a semi-transparent mirror, 6–is an absorber of laser radiation. 7–are the Final Focus Systems. 8–are the damping systems for preparing particle's beams with small emittances, 9–are the bends for particle's beam. 10–are the accelerating X-band structures, 11–is an electron gun, 12–is a positron converter. The scheme with the damping rings as sources are shown here.

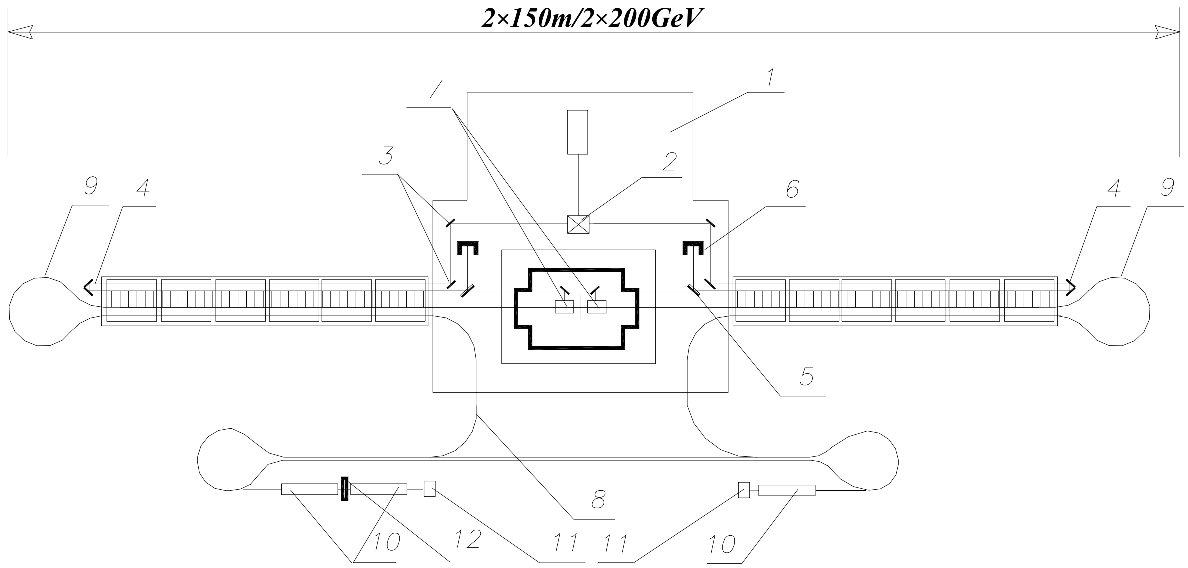
Parameters of the Laser Linear Collider

| Parameter | $\lambda_{ac} \cong 10\mu m$ | $\lambda_{ac} \cong 1\mu m$ |
|---|---|---|
| Energy of $e^{\pm}$ beam | $3\times3$ *TeV* | $30\times30$ *TeV* |
| Total two-linac length | $2\times1$ *km* | $2\times1$ *km* |
| Main linac gradient | 3 *GeV/m* | 30 *GeV/m* |
| Luminosity/bunch | $10^{34}cm^{-2}s^{-1}$ | $10^{34}cm^{2}s^{-1}$ |
| No. of bunches/pulse | 10 $(\leq 100)$* | 30 $(\leq 300)$* |
| Laser flash energy/Linac | 300*J* | 300*J* |
| Repetition rate | 160 *Hz* | 160 *Hz* |
| Beam power/Linac | 2.3 *kW* | 760*W* |
| Bunch population | $10^{7}$ | $10^{6}$ |
| Bunch length | $1\mu m$ | $0.1\mu m$ |
| $\gamma\varepsilon_x / \gamma\varepsilon_y$ | $\approx 10^{-8}/10^{-9} cm\cdot rad$ | $5\cdot10^{-9}/1\cdot10^{-10} cm\cdot rad$ |
| Damping ring energy | 2 *GeV* | 2 *GeV* |
| Length of section/Module | 3*cm* | 3*cm* |
| Wall plug power** | $2\times0.5$ *MW* | $2\times0.5$ *MW* |

*–Maximal possible number.

**–Laser efficiency $\approx 10\%$ . The power for supplemental electronics not included.

## Modest 2x200 GeV version




Laser Linear Collider (LLC) complex. 1–is a laser master oscillator platform, 2 –is an optical splitter, 3,4–are the mirrors, 5–is a semi-transparent mirror, 6–is an absorber of laser radiation. 7–are the Final Focus Systems. 8–are the damping systems for preparing particle's beams with small emittances, 9–are the bends for particle's beam. 10–are the accelerating X-band structures, 11–is an electron gun, 12–is a positron converter. The scheme with the damping rings as sources are shown here.

Parameters of Laser Linear Collider.

| Wavelength | $\lambda_{ac} \cong 1 \mu m$ |
|---|---|
| Energy of $e^{\pm}$ beam | 200 $\times$200 *GeV* |
| Total two-linac length | 2 $\times$ 200 *m* |
| Main linac gradient | 1.2 *GeV/m* |
| Luminosity/bunch | $10^{32} cm^{-2} s^{-1}$ |
| No. of bunches/pulse | 10 $(\leq 100)$* |
| Laser flash energy/Linac | 3*J* |
| Repetition rate | 160 *Hz* |
| Beam power/Linac | 5 *W* |
| Bunch population | $10^5$ |
| Bunch length | 0.1 $\mu m$ |
| $\gamma\varepsilon_x / \gamma\varepsilon_y$ | $\approx 10^{-8} / 10^{-9} cm \cdot rad$ |
| Damping ring energy | 2 *GeV* |
| Disruption parameter | 1.4 |
| Length of section/Module | 3*cm* |
| Wall plug power** | 2$\times$ 5*kW* |