# Collider Outlook and Plans

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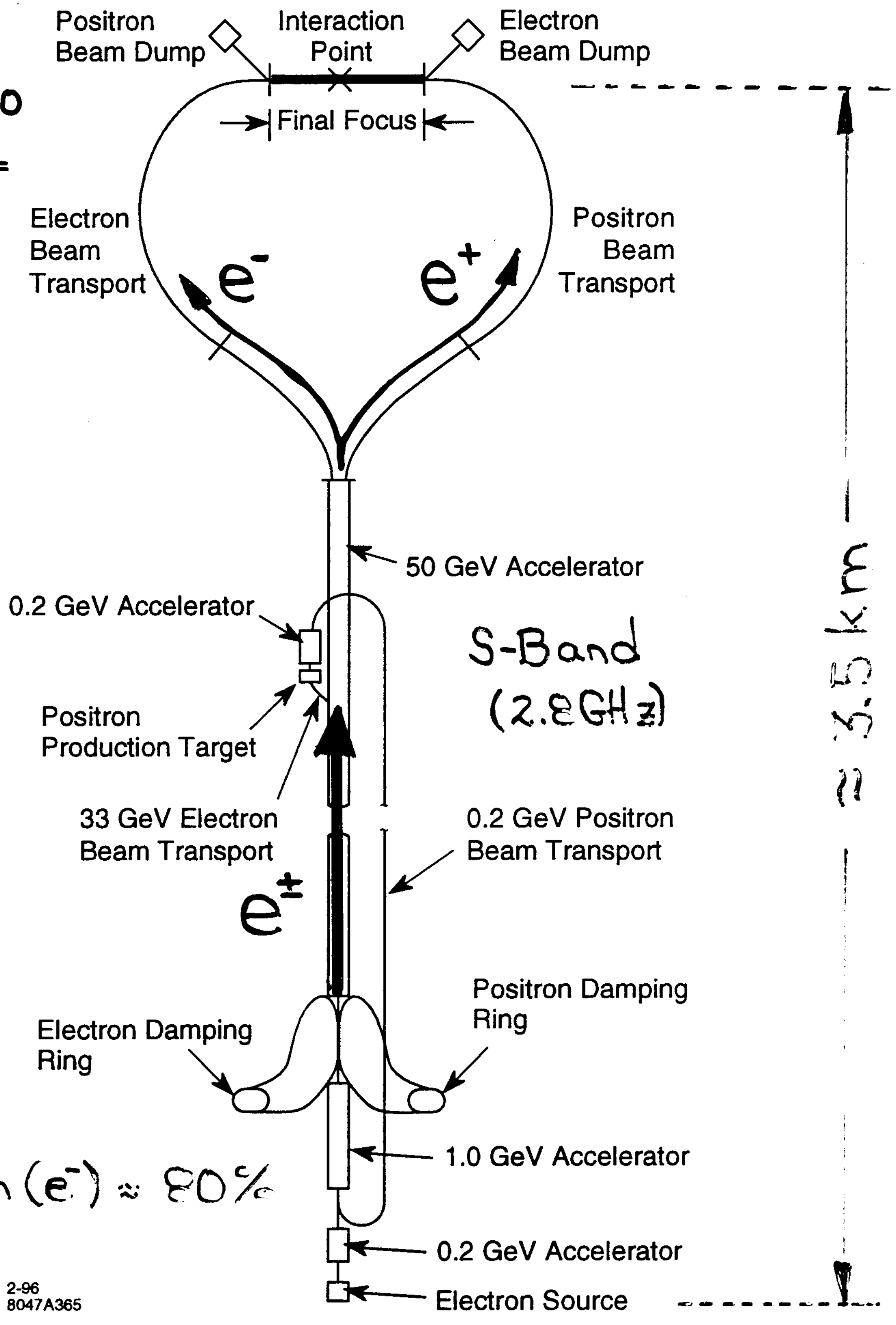
September 1998

# The Stanford Linear Collider

$$e^+e^- \longrightarrow Z^0$$

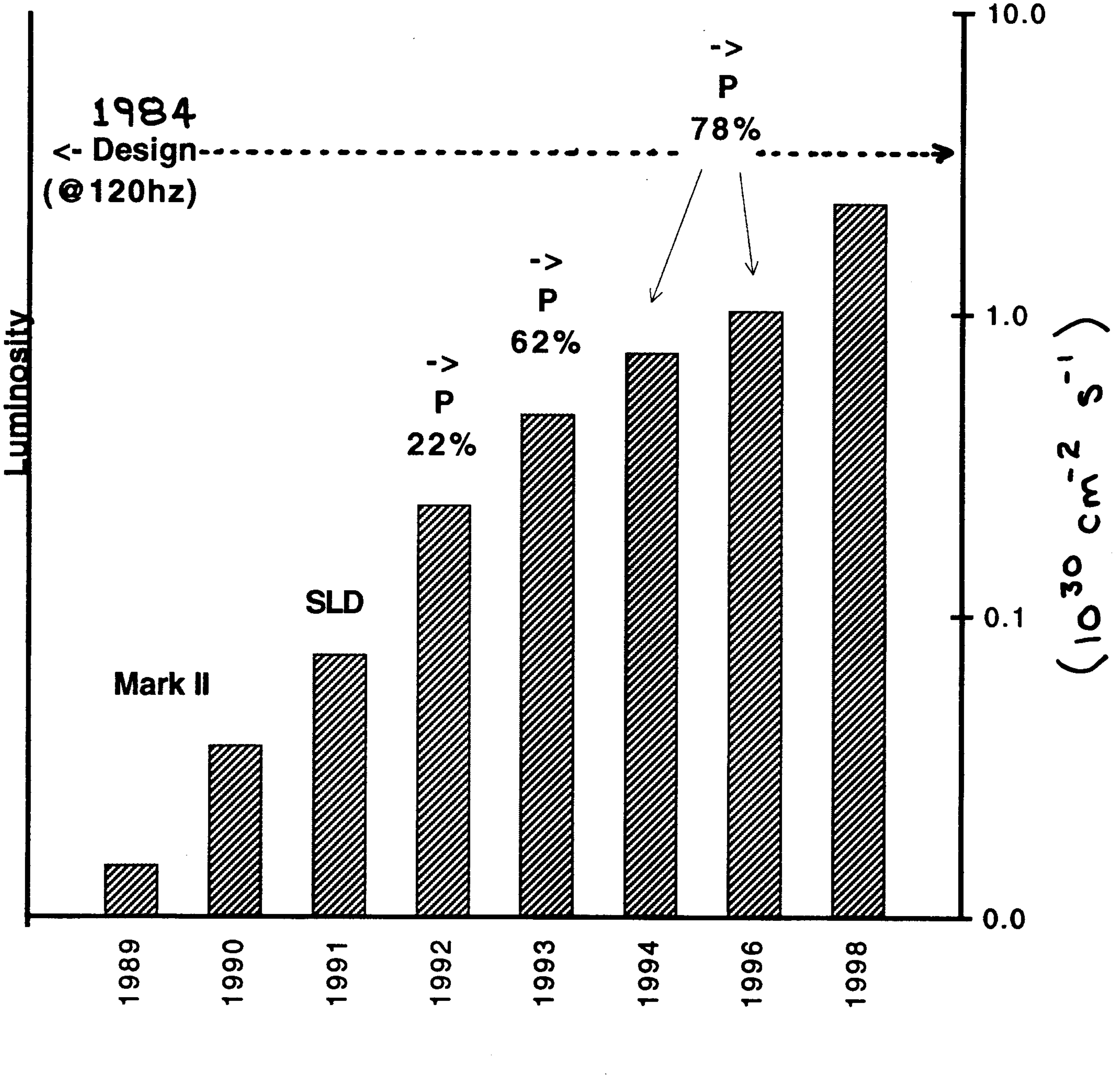


S-Band (2.8GHz)

Polarization ($e^-$) ≈ 80%

2-96
8047A365

# SLC Performance History



# Collider Design Choices

$$L = \underset{\substack{\uparrow \\ \text{Physics}}}{\frac{1}{4\pi E}} \bullet \underset{\substack{\uparrow \\ \text{Beam-Beam} \\ \text{(Physics)}}}{\frac{N H}{\sigma_x^*}} \bullet \underset{\substack{\uparrow \\ \text{Collider} \\ \text{Technology}}}{\frac{P}{\sigma_y^*}}$$

$\Rightarrow$ Higher Beam Power
or
Smaller Beam Spots

Linear Collider Design Parameters ($E_{cm}$ = 500 GeV)

| | RF Freq (GHz) | RF Grad (MV/m) | Total Length (km) | Beam Power (MW) | $\sigma_y$ (nm) | Luminosity $(10^{33}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1})$ |
|---|---|---|---|---|---|---|
| SuperC | 1.3 | 22 | 30 | 11 | 5 | 30 |
| S-Band | 3.0 | 21 | 30 | 7 | 15 | 5 |
| X-Band | 11.4 | 70 | 11 | 5 | 5 | 7 |
| 2-Beam | 30 | 120 | 7 | 4 | 5 | 6 |

# INTERNATIONAL LINEAR COLLIDER TECHNICAL REVIEW COMMITTEE REPORT

# 1995

Prepared for the Interlaboratory Collaboration for R&D Towards TeV-scale Electron-Positron Linear Colliders

Institutions spanning the globe.

ILC - TRC
1995

### Table 3.1

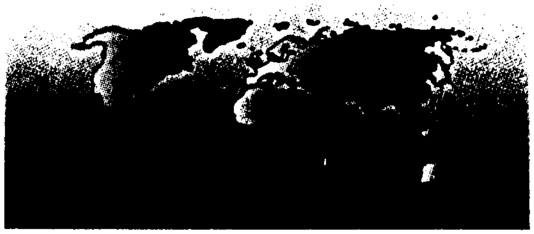
### Linear Colliders: Overall and Final Focus Parameters – 1 TeV (c.m.)

| | TESLA | SBLC | JLC (C) | JLC (X) | NLC | VLEPP | CLIC |
|---|---|---|---|---|---|---|---|
| Initial energy (c.of .m.) (GeV) | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| RF frequency of main linac (GHz) | 1.3 | 3 | 5.7 | 11.4 | 11.4 | 14 | 30 |
| Nominal Luminosity ($10^{33}$ cm$^{-2}$s$^{-2}$)† | 7.48 | 3.25 | 6.4 | 10 | 10.4 | 17.3 | 1.7-7.6 |
| Actual luminosity ($10^{33}$ cm$^{-2}$s$^{-2}$)† | 12.8 | 6.3 | 6.3 | 9.17 | 14.5 | 13 | 2.20-10 |
| Linac repetition rate (Hz) | 5 | 50 | 50 | 150 | 120 | 300 | 4000-1800 |
| No. of particles/bunch at IP ($10^{10}$) | 1.8 | 2.9 | 1.44 | .7 | 1.1 | 20 | .8 |
| No. of bunches/pulse | 2260 | 50 | 72 | 85 | 75 | 1 | 1-10 |
| Bunch separation (nsec) | 354 | 10 | 2.8 | 1.4 | 1.4 | – | .67 |
| Beam power/beam (MW) | 16.5 | 5.8 | 4.2 | 6.4 | 7.9 | 4.8 | 2.6-11.7 |
| Damping ring energy (GeV) | 4.0 | 3.15 | 2.0 | 2.0 | 2.0 | 3.0 | 2.15 |
| Main linac gradient, unloaded/loaded†† (MV/m) | 25/25 | 42/36 | 58/47 | 73/58 | 85/63 | 100/91 | 80/78 |
| Total two-linac length (km) | 58 | 33 | 26.6 | 21.8 | 18.7 | 14 | 17.6 |
| Total beam delivery length (km) | 4 | 4 | 6 | 6 | 6.8 | 4 | 2.4 |
| $\gamma\epsilon_x/\gamma\epsilon_y$ ($m\text{-}rad \times 10^{-8}$) | 1400/6 | 1000/10 | 330/4.8 | 330/4.8 | 500/5 | 2000/7.5 | 390/20 |
| $\beta_x^*/\beta_y^*$ (mm) | 25/0.7 | 32/0.8 | 41/0.1 | 10/0.1 | 25/0.1 | 200/0.1 | 10/0.18 |
| $\sigma_x^*/\sigma_y^*$ (nm) before pinch | 598/6.5 | 572/9 | 372/2.2 | 184/2.2 | 360/2.3 | 2000/2.7 | 200/6.0 |
| $\sigma_z^*$ ($\mu$m) | 500 | 500 | 120 | 90 | 100 | 750 | 200 |
| Crossing Angle at IP (mrad) | 0 | 3 | 6.0 | 6.1 | 20 | 6 | 1 |
| Disruptions $D_x/D_y$ | 0.2/14 | .26/16.2 | .07/12.1 | .1/8.9 | .05/7.6 | .2/165 | .22/7.4 |
| $H_D$ | 1.64 | 1.68 | 1.32 | 1.42 | 1.35 | 2.0 | 1.32 |
| Upsilon sub-zero | .053 | .06 | .28 | .33 | .27 | .12 | .17 |
| Upsilon effective | .053 | .06 | .29 | .33 | .27 | .15 | .18 |
| $\delta_B$ (%) | 2.5 | 6.5 | 9.6 | 9.0 | 7.4 | 26.6 | 7.7 |
| $n_\gamma$ (no. of $\gamma$'s per $e$) | 1.2 | 1.4 | 1.4 | 1.2 | 1.1 | 5.0 | 1.52 |
| $N_{pairs}(p_T^{min}) = 20$ MeV/c, $\theta_{min} = 0.15$) | 7.3 | 7.6 | 13.8 | 4.9 | 7.0 | ? | 3.4 |
| $N_{hadrons}$/crossing | .16 | .19 | .55 | .19 | .25 | ? | .13 |
| $N_{jets} \times 10^{-2}(p_T^{min}) = 3.2$ GeV/c | .66 | .80 | 5.3 | 1.9 | 2.3 | ? | .95 |

† For the sake of uniformity, the nominal luminosity is simply defined as $N^2/4\pi\,\sigma_x^*\,\sigma_y^*$ times the number of crossings per second, and in all cases assumes head-on collisions, no hour-glass effect and no pinch. The actual luminosity incorporates all these effects, including crossing angle where applicable. NLC calculations assume crab-crossing.

†† The loaded gradient includes the effect of single-bunch (all modes) and multibunch beam loading, assuming that the bunches ride on crest. Beam loading is based on bunch charges in the linacs, which are slightly higher than at the IP.

# ILC-TRC



http://www.slac.stanford.edu/xorg/ilc-trc/ilc-trchome.html

# World-Wide Effort on Future Collider Facilities

"Options for Future Colliders at CERN", J. Ellis, E. Keil, G. Rolandi; CERN-EP/98-03, CERN-SL 98-004, CERN-TH/98-33 (1998).

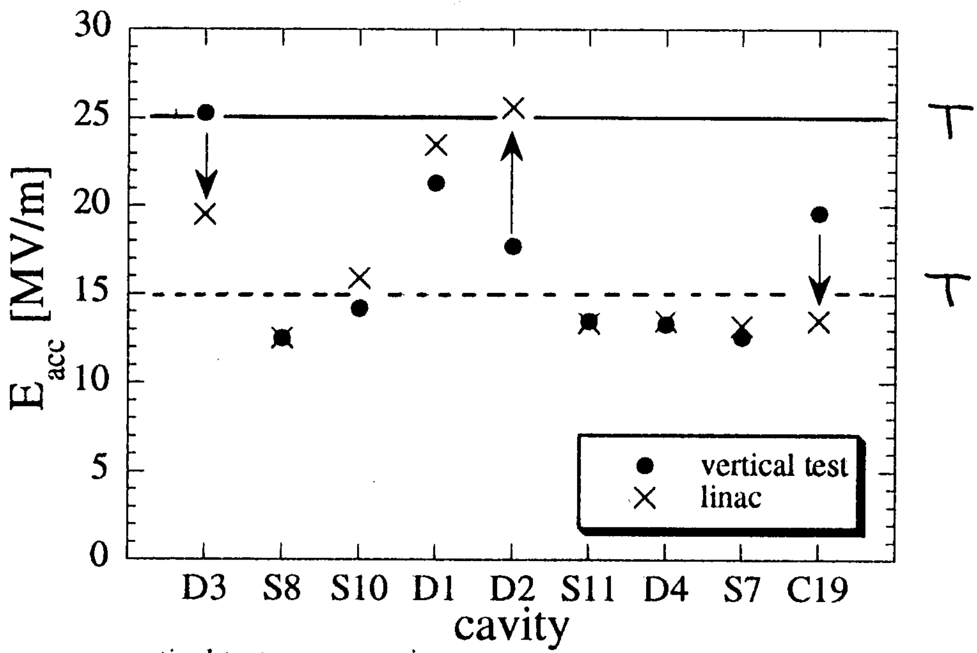
| Lab | Collider | FTE 1997 | Budget 1997 | Cost | Period | Currency |
|---|---|---|---|---|---|---|
| CERN | CLIC | 25 | 1.8* | 21* | 89–97 | MCHF |
| DESY[36] | TESLA | 83 | 16 | 48 | 94–97 | MDEM |
| Fermilab[37] | VLHC | 10 | 1 | 25[a] | 5 | MUSD |
| KEK[38] | JLC[b] | 25–30 | 0.7* | 5.9* | 93–97 | GJPY |
| SLAC[39] | NLC | 50–60 | 8 | 75[c] | 90–97 | MUSD |
| USA[40] | $\mu^+\mu^-$ | 27 | 3[d] | 32[e] | 6 | MUSD |

Table 6: Estimated resources appropriated here and elsewhere for future collider studies, in terms of full-time employees (FTE) and annual expenditure for 1997 (FY98 in US). The integrated cost over the period shown is also given, for the past by calendar years, for the future by number of years. The asterisk * marks cases in which the capital expenditure does not include personnel costs.

# TESLA

## SRF Cavity Results

→ TESLA 800

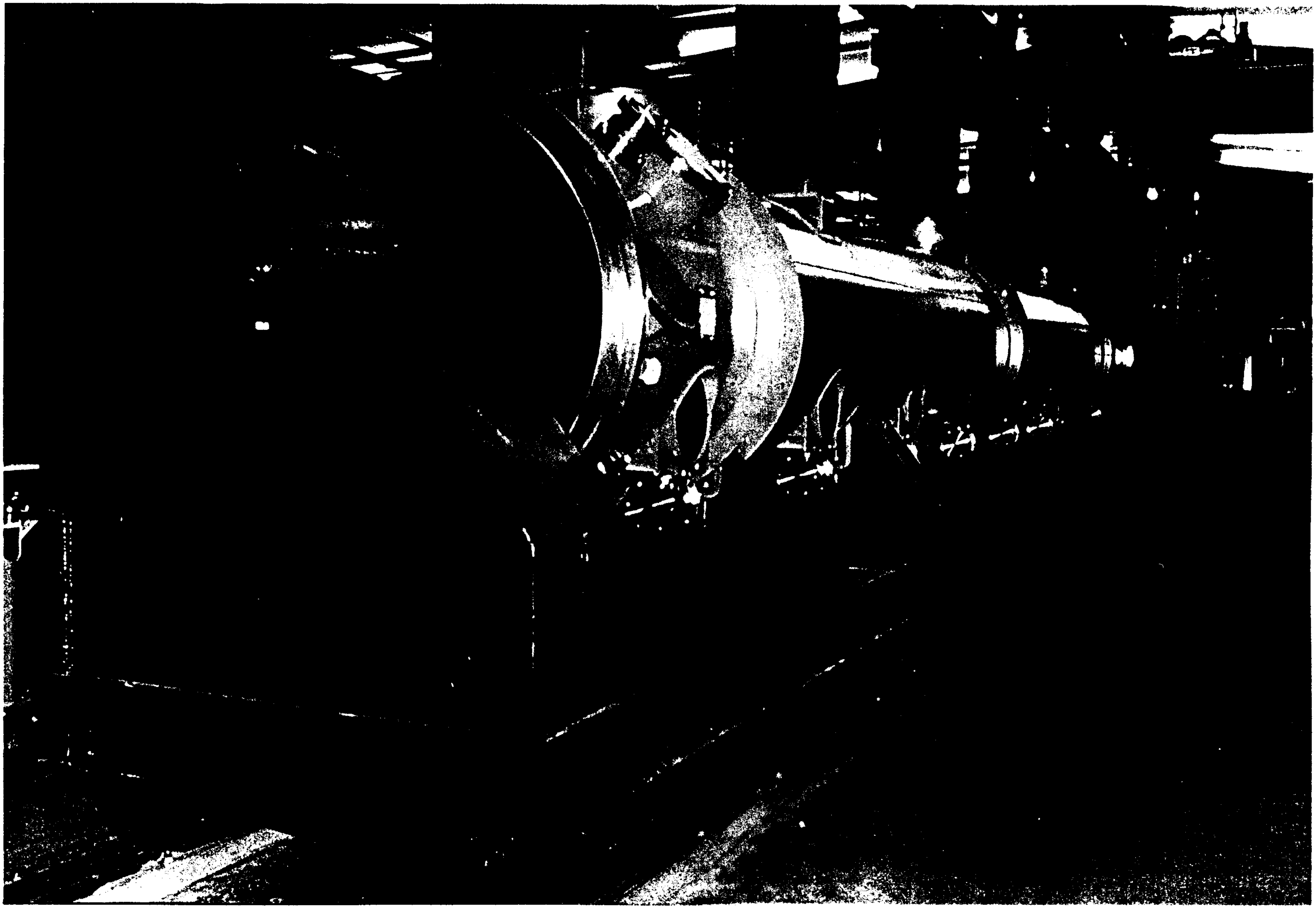


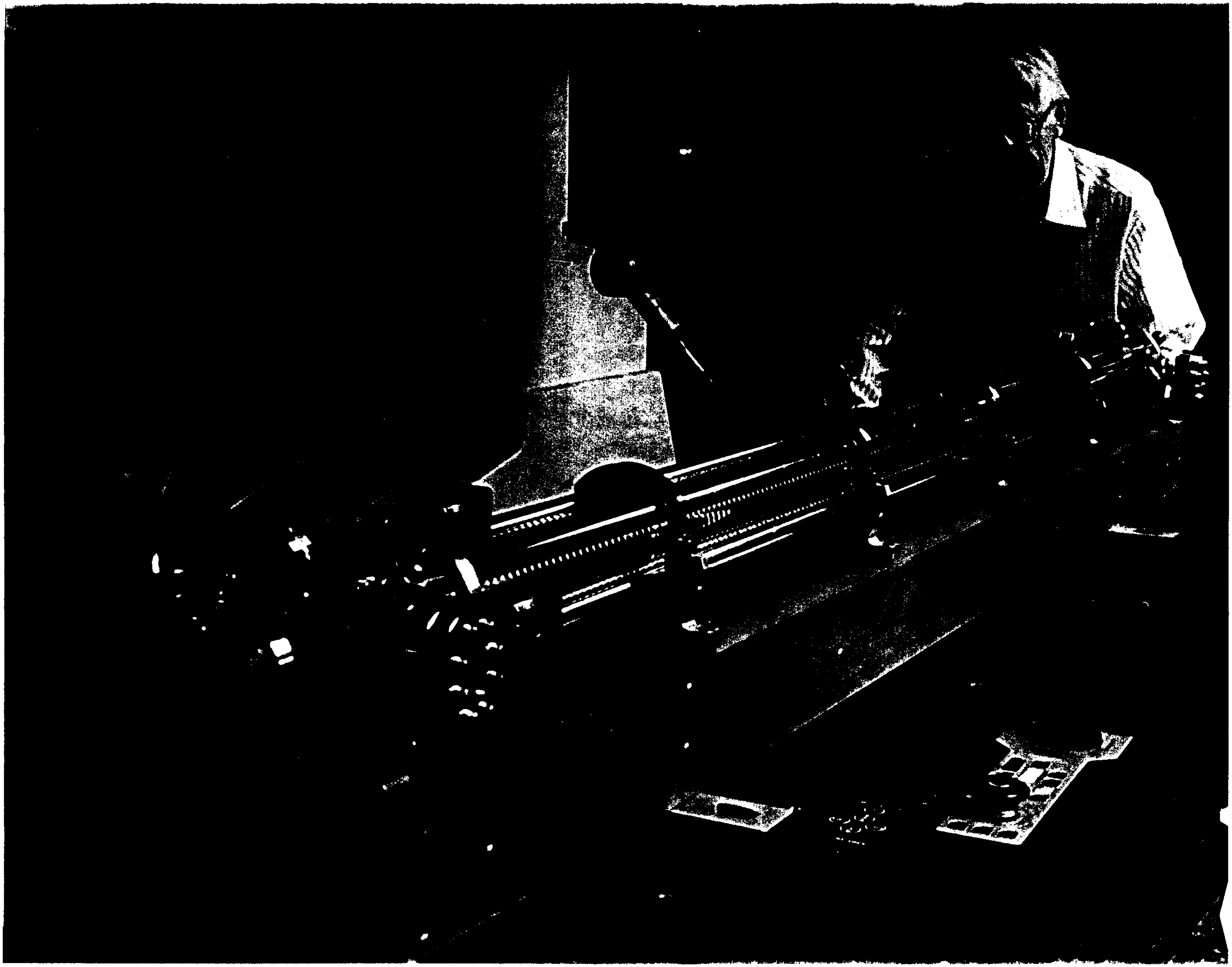
TESLA 500

TTF Goal

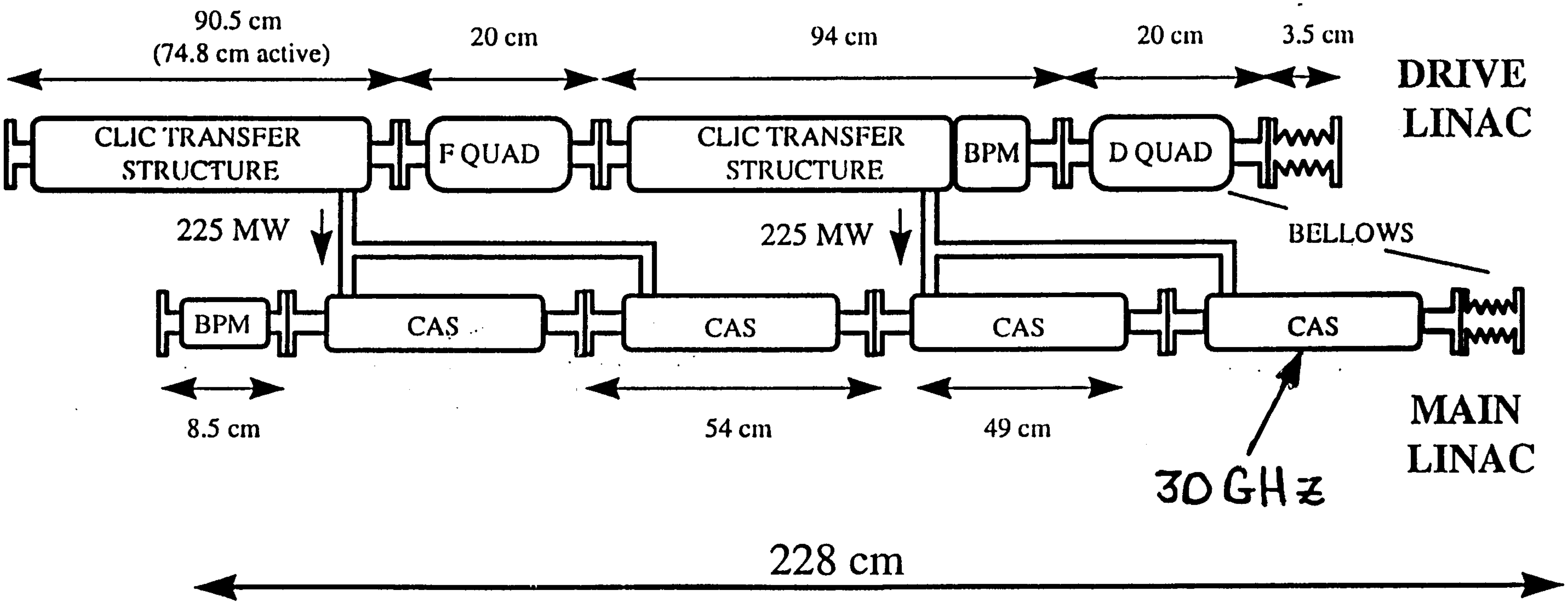
vertical test: cw operation
linac: 305 μs rise time, 800 μs constant gradient at 10 Hz rep. rate

Assembled into first cryomodule for TTF.





# CTF 2 Schematic



## National Research Council
## National Academy of Sciences
## Committee on Elementary-Particle Physics

B. Winstein (Chair)
1998

> "The committee recommends support of an international effort leading toward a complete design and cost estimate of an electron linear collider that would be able ultimately to reach a center-of-mass energy of 1.5 TeV and a luminosity of $10^{34}$ $cm^{-2}$ $s^{-1}$."

## U.S. Department of Energy
## HEPAP Subpanel on
## Planning for the Future of US High Energy Physics

F. Gilman (Chair)
1998

> "The Subpanel recommends that SLAC continue R&D with Japan's KEK toward a common design for an electron-positron linear collider with a luminosity of at least $10^{34}$ $cm^{-2}$ $s^{-1}$ and an intial capability of 1 TeV in the center of mass, extendible to 1.5 TeV."

> "The Subpanel recommends that SLAC be authorized to produce a Conceptual Design Report for this machine in close collaboration with KEK."

# Report of the Subcommittee on Future Projects of High Energy Physics in Japan

S. Komamiya (Chair)
1998

> "The $e^+e^-$ Linear Collider project is the next principal project for research in high energy physics in Japan."
>
> "The center-of-mass energy of the collision in its first phase will be 250-500 GeV. After completion of the first phase, the second phase upgrade to the center-of-mass energy greater than or approximately equal to 1 TeV will be made."

> "The $e^+e^-$ Linear Collider project should be open to the international research community, and Japan should play the leading role as its host country."

# The Next Generation Linear Collider Design Philosophy and Technology Choice

- Build on success of the SLC.

- Extrapolate room-temperature microwave technology (2.8 GHz → 11.4 GHz).

  Higher accelerating fields.

  → Cheapest route.

  Extensive experience with methods and technologies.

  → Low risk.

- Discarded Options

  Superconducting linacs (DESY)

  Expensive. → Not suitable for TeV energies.

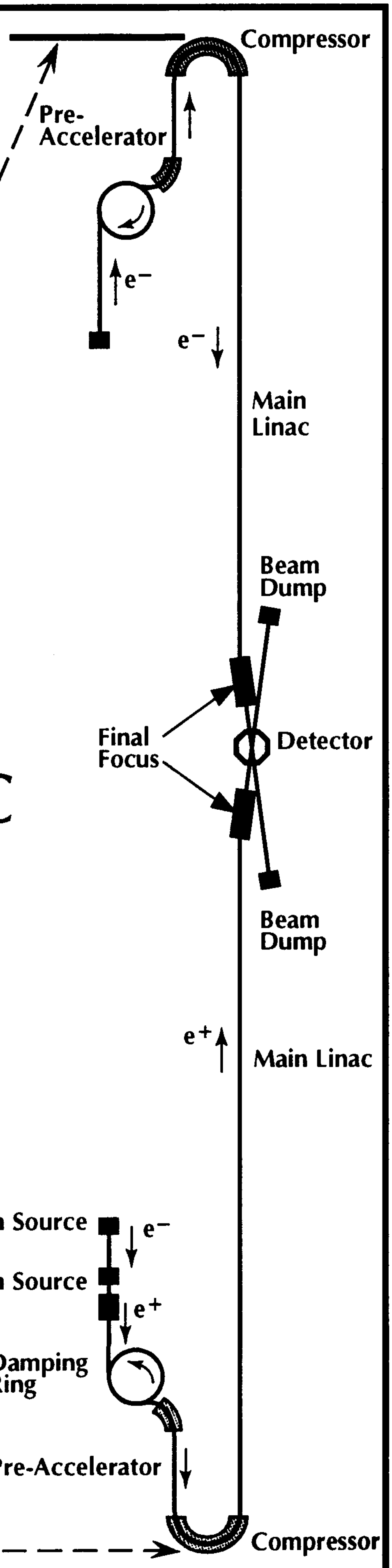
  Two-Beam linacs (CERN)

  No experience. → High risk.

# Next Linear Collider

Stanford Linear Accelerator Center is a world leader in research and development efforts towards a cost-effective Next Linear Collider (NLC).

The NLC will be 10 times more powerful than the SLC.



N
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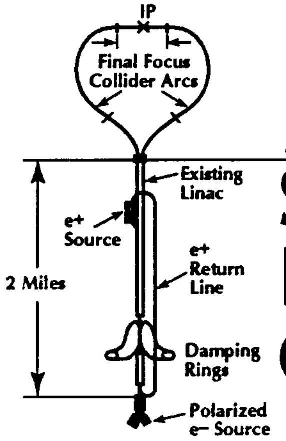
X10

## Stanford Linear Collider



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# KEK - SLAC Collaboration on Linear Colliders

1996 SLAC NLC ZDR (Snowmass)
KEK JLC Design Study

SLAC-KEK Workshop at KEK launched working groups:
- Parameters
- Accelerator Structures
- Pulse Handling

1997 Common "optimization" process . . .

Examples of Technical Optimization

| | SLAC | Status | KEK |
|---|---|---|---|
| Klystron | 75 MW | ← | 130 MW |
| Rf Phasing | Δt | - - - - ? - - - - | Δf |
| Pulse Handling | SLED II | → | DLDS |
| Structure | 1.8m RDDS | ← | 1.3 m DS |

1998 Memorandum of Understanding

Expanded SLAC-KEK Study Groups

# リニアーコライダー設計最適化のための国際検討グループに関する
# 高エネルギー加速器研究機構（KEK）
# と
# スタンフォード線形加速器センター（SLAC）
# との
# 覚書き

## 1．序

高エネルギー加速器研究機構（KEK）とスタンフォード線形加速器センター（SLAC）は、次世代の高エネルギー電子・陽電子リニアーコライダーを目指す加速器物理と技術に関し、長年にわたる協力により、多くの成果を上げてきた。両研究所の研究者および技術陣は、ともに常伝導加速管を用いるマイクロ波技術に基づいたコライダーの開発に力を入れており、これら技術の基本要素およびコライダー設計上の諸課題とにつき、両研究所間で広範な協力研究が行われている。

TeV級リニアーコライダーに必要な加速器技術の開発は、近年著しく進展した。今日では、リニアーコライダーのためのクライストロン・パルス圧縮器・加速管などの原型モデルに基づいた、高周波系のシステム構築が進んでいる。最終収束試験ビーム施設（FFTB）の試験では、コライダー運転に必要な程度までにビームを収束し、かつ計測できることが実証されている。このFFTBは、SLACとKEK主導の広範な国際協力により、SLACに建設されたものである。KEKの試験加速器施設（ATF）では、フル・スケールのダンピングリングが稼動し始めている。これもまた、KEKとSLAC主導の国際協力により推進されている活動である。ATFでの試験研究は、リニアーコライダーで必要とされる高度に凝縮されたビームを用意するための、入射器系の最終設計の指針を与えるものである。

大型科学プロジェクトにおける国際協力の重要性は、高エネルギー物理学や他の研究分野での経験が教えている。大規模な共同作業の成功のためには、プロジェクトの立案の初期からパートナーたり得る研究者が関与し、また研究機関執行部がその共同関係の構築に努めることが必要である。関係者の意識的な努力によって初めて、共同研究参加者間の合意と敬意とが形成されることは、歴史の示すところである。KEK機構長とSLAC所長は、リニアーコライダーのための共同関係が、参加研究者コミュニティの自律性と主体性とに沿った形で発展することを願っている。本文書は、この目標を達成するひとつの進め方につき、その基本的要点を述べるものである。

## 2．リニアーコライダーの国際的設計プロセス

常伝導マイクロ波技術に基づくTeV級リニアーコライダーの初期設計作業は、日米の研究者・技術者がそれぞれに、また協力作業もまじえつつ進めてきた。その作業の結果は、NLC第ゼロ次設計報告書およびJLC設計検討書という文書にまとめられている。SLACとKEKは、上記の検討結果とそれを支える開発研究とが相俟って、TeVエネルギー領域の物理の解明が期

# 2nd KEK-SLAC International Linear Collider Study Group (ISG) Meeting

## Second Circular (Tentative), 7/6/98

Go back to (J)LC Home Page.
Go back to ISG Page.

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## 1. What is KEK-SLAC ISG Meeting?

This is the second meeting in its series for the KEK-SLAC International Linear Collider Study Group (ISG). The first meeting was held at SLAC in January, 1998.

The KEK-SLAC ISG was formed in 1998, based on a Memorandom of Understanding between KEK and SLAC on development of Linear Colliders, which utilizes room-temperature RF technologies for the main linacs.

The 2nd KEK-SLAC ISG meeting is to be held at KEK in the second week (13th Monday, through 16th Thursday) of July, 1998. Except for daily summary sessions in the morning, the majority of the meetings are to be done in the form of Woking Group (WG) sessions, where the attendants are expected to actually do some real work.

The meeting is open to anyone who are collaborating with members of KEK and SLAC on accelerator development for future linear colliders, whether from academic or industrial standpoint. There are no attendance fees to be charged. KEK dormitory rooms are available for academic members of Accelerator- and High Energy Physics- community who are visiting KEK for this meeting from remote sites.

For inquiries, contact *Nobu Toge* at toge@accad1.kek.jp, or at fax +81(298)64-3182.

Next Meeting: January at SLAC.

# NLC
## Test Facilities

NLCTA (SLAC) 1996

X-Band
(11.4 GHz)

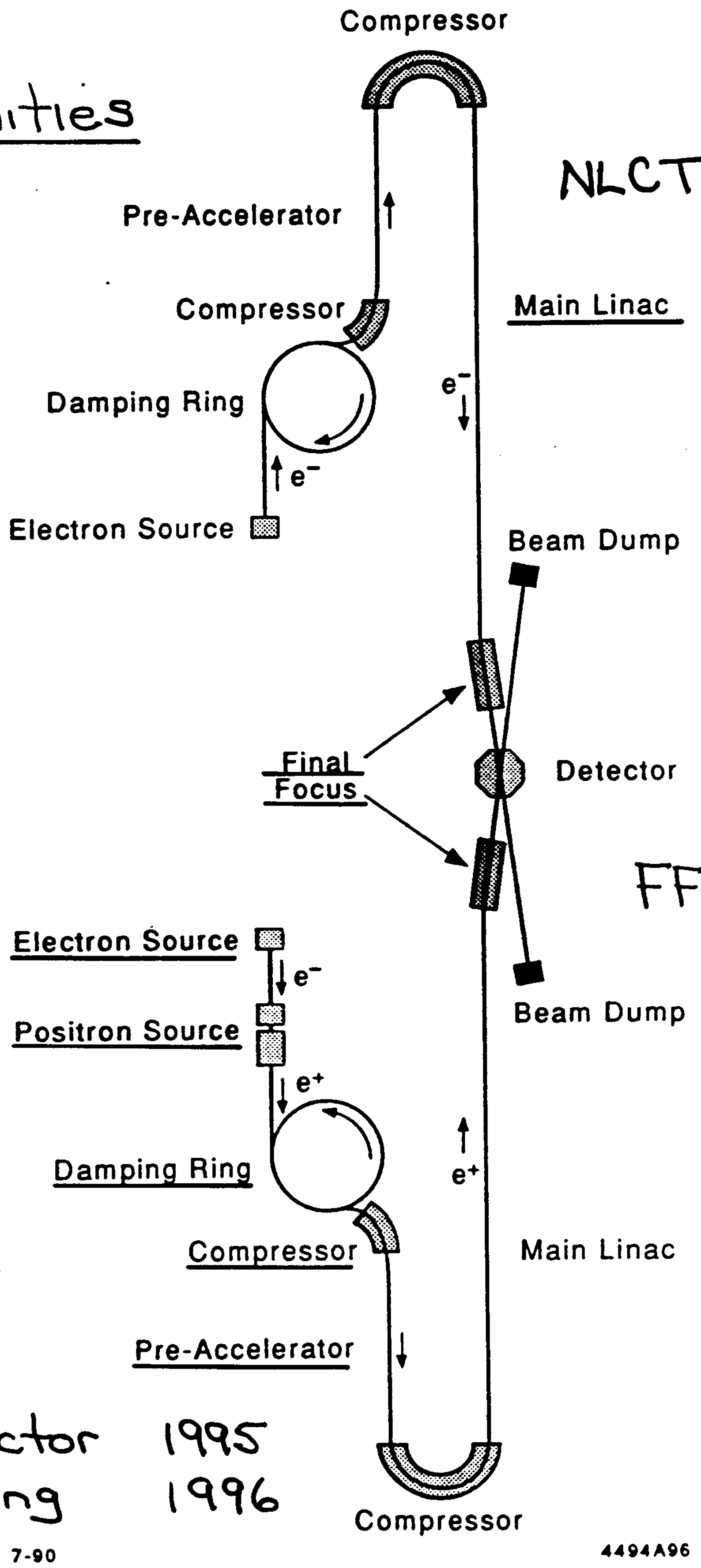
## SLC

1988- 1998

FFTB (SLAC) 1994

ATF (KEK)

Source/Injector 1995
Damping Ring 1996



Schematic Layout of the Next Linear Collider

# LINEAR COLLIDER ROADMAP

| | U.S. | | JAPAN |
|---|---|---|---|
| 1996-7 | ZDR/Snowmass | | JLC DS |
| 1998 | HEPAP Recommends CDR for Int. Collider | SLAC-KEK MOU | JHEPC Affirms Int. Collider |
| 1999 | DOE "Mission Need" (CD-1) | | |
| 2000 | | | |
| 2001 | Prel. CDR<br>HEPAP<br>DOE Baseline (CD-2) | Int. Tech. Design (SLAC-KEK)<br>US-Japan Negotiations Site Selection | JHEPC Strategy Recommendation<br>Monbusho-STA Merger Complete |
| 2002 | | | |
| 2003 | DoE Construction Start (CD-3) | Int. Construction | Monbusho Funds Construction |