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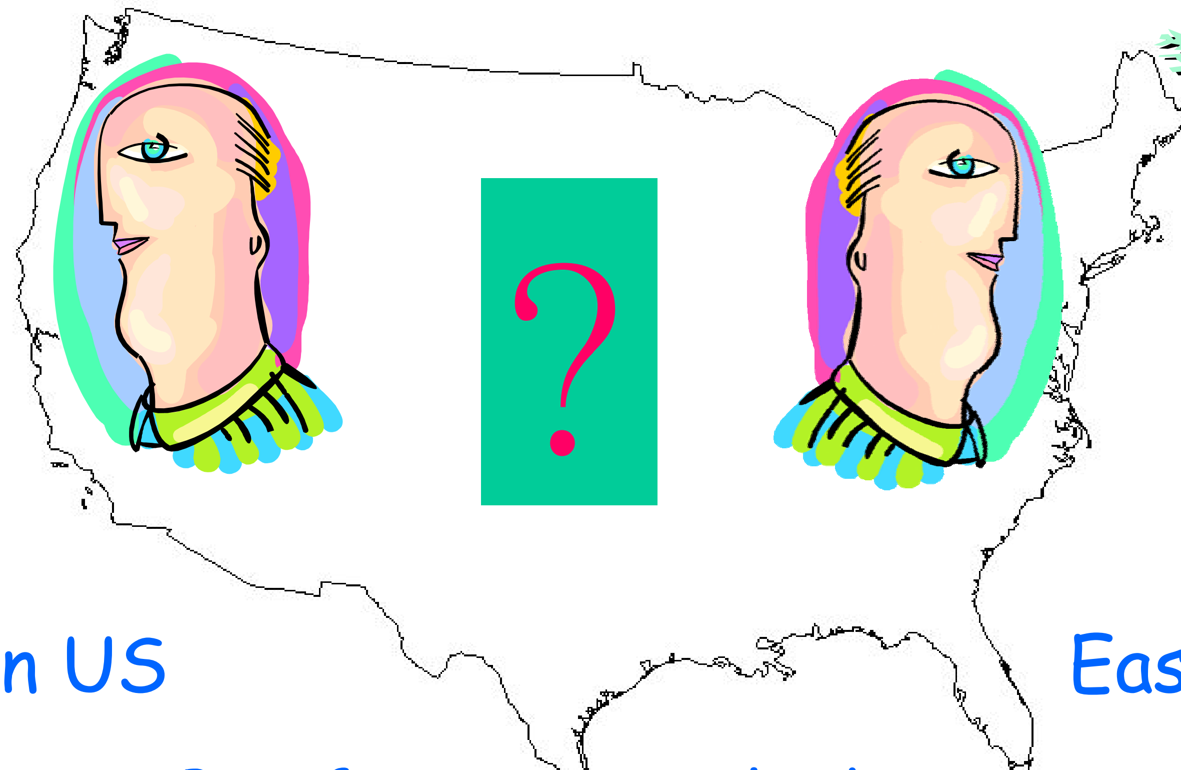
US Perspective on LC and Update on X-Band LC

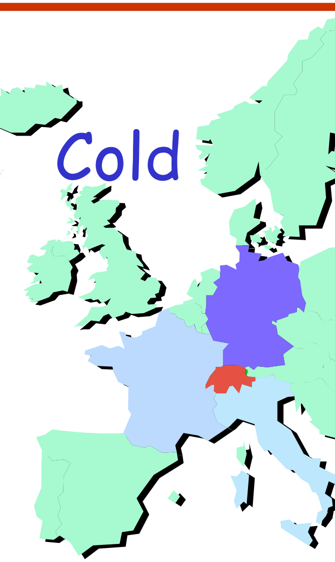
Nan Phinney

La Thuile Rencontres de Physique
March 3, 2004

Global Perspective on LC

Warm





Cold

Western US

looks across Pacific

–> X-band LC

Eastern US

looks across Atlantic

–> SC LC

(Prof. Sugawara Jan 03)

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US LC Technology Comparison Study

ALCPG defined physics requirements

- 500 GeV upgradeable to ≥1 TeV, 500 fb^{-1} in 4 years
- 2 IRs, energy flexibility between $\sqrt{s}$ = 90-500 GeV
- crossing angle to allow downstream E, P, Lum diagnostics
- (future) possibility of $\gamma\gamma$, e^-e^-, e^+ polarization

Charge:

- develop designs for an X-band and SC LC, sited in US
  - using common cost, schedule, and risk estimation methods
  - starting from GLC/NLC and TESLA
  - but modified to meet ALCPG goals
- compare luminosity, energy reach, availability, sites, cost & risk

Task Force included both US warm and cold advocates

- BNL, Cornell, FNAL, LBNL, SLAC, TJNAF

Task force membership

1. Accelerator physics and technology design task force
   - Chris Adolphsen (SLAC)
   - Gerry Dugan[1,2] (Cornell)
   - Helen Edwards (Fermilab)
   - Mike Harrison[2] (BNL)
   - Hasan Padamsee[2] (Cornell)
   - Tor Raubenheimer[2] (SLAC)
2. Site-specific civil design (CA and Fermilab sites) task force
   - Dave Burke[2] (SLAC)
   - Clay Corvin (SLAC)
   - Dave Finley[2] (Fermilab)
   - Steve Holmes[1,2] (Fermilab)
   - Vic Kuchler (Fermilab)
   - Marc Ross (SLAC)

[1]Primary liasion to USLCSG Accelerator Subcommittee
[2]USLCSG Accelerator Subcommittee member

DESY points-of-contact:
Cost/schedule and siting: Franz Peters
Design: Stefan Choroba

3. Cost and schedule task force
   - Dave Burke[1,2] (SLAC)
   - John Cornuelle (SLAC)
   - Dave Finley[2] (Fermilab)
   - Warren Funk (Jefferson Lab)
   - Peter Garbincius (Fermilab)
   - Mike Harrison[2] (BNL)
   - Steve Holmes[2] (Fermilab)
   - Ted Lavine (SLAC)
   - Cindy Lowe (SLAC)
   - Tom Markiewicz (SLAC)
   - Hasan Padamsee[2] (Cornell)
   - Brett Parker (BNL)
   - Kem Robinson (LBNL)
   - John Sheppard (SLAC)
4. Availability Design and Specification
   - Paul Czarapata (Fermilab)
   - Helen Edwards (Fermilab)
   - Tom Himel[1] (SLAC)
   - Marcus Huening (Fermilab)
   - Nan Phinney (SLAC)
   - Marc Ross (SLAC)

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US Reference Designs

Basic approach:

- define a US SC or NC machine we would be willing to build
- applying similar levels of conservatism for both

SC design:

- upgradeable to 1 TeV, higher initial gradient to reduce cost
- more & improved diagnostics, additional overheads and margins
- longer e^+ source > 150 GeV for E range, better stability, yield
- two tunnels for reliability, 2 IRs, X-angle, etc.

NC design:

- add undulator e^+ source to allow polarized e^+ upgrade

Report should be released very soon

Conclusions from US Study

General:

Both options are at comparable levels of development
Both can reach ~ 625 GeV energy with reduced luminosity

Cold option has ~ 25% higher design luminosity
Cold option is ~ 42% longer (47 km)

Both options can upgrade to 1 TeV without additional tunnels.
- Warm can reach ~ 1.3 TeV
- Cold has ~ 25% higher design luminosity, but cannot reach > 1 TeV

Cost & Schedule:

> 2/3 of costs are technology independent, equal for cold & warm

Costs specific to cold are twice those specific to warm

Given adequate funding, both can be built on same schedule,
but commissioning takes longer for cold because of shared tunnels

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Conclusions from US Study (2)

Availability:

Based on MC simulation of failures, repairs, access, recovery, MD

Both options can have comparable availability for 2-3% extra cost

An undulator-based e^+ source has a major impact on operability
could reduce delivered luminosity by 20% for stable operation, and by > 50% during first few years

Single tunnel has lower uptime, improvem't costs ~ balance savings

Risk Assessment:

Based on highest level parameters – energy, luminosity, availability

Risks are comparable for both designs
- greatest risks in BDS, MPS, controls – not in RF systems
- cold has higher risk in DRs – inherent with pulse structure
- warm has higher risk in main linac rf and emittance control

X-Band
R&D
Status

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Why X-band is the right choice?

The technology is demonstrated

- TRC R1s and R2s for RF have been met (or due soon)

It is a complete project – all systems are prototyped

- test facilities verify the designs for subsystems
  - ATF, ASSET, E-158, FFTB, GLCTA, NLCTA + more
- SLC verified the integrated system

There is a strong US-Japan collaboration

- most of the team that will build the LC have expertise in X-band

It is the path to higher energies

- 1.3 TeV in phase II and a stepping stone to multi-TeV
- CLIC only viable option - chance to learn necessary techniques
- upstream systems ~ identical to CLIC, could be reused

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NLC Collaboration

SLAC

Fermilab

BROOKHAVEN NATIONAL LABORATORY

BERKELEY LAB

Department of Energy • University of California
Lawrence Livermore National Laboratory
Science in the National Interest

UC Davis
Ohio State

Los Alamos
Stanford

http://www.kek.jp/
文部科学省 高エネルギー加速器研究機構
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION
KEK
JLC

Nagoya

CERN

CLIC

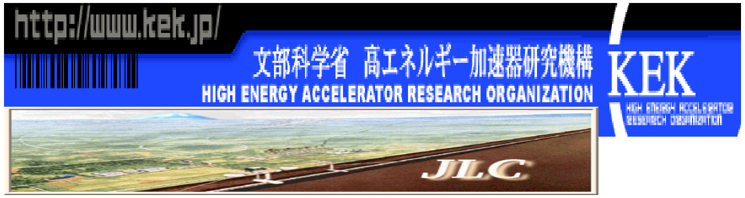
British Columbia

Queen Mary
Brunel

BINP

DEUTSCHES ELEKTRONEN-SYNCHROTRON
DESY

GLC Collaboration



Japan (63)

S. Korea (13) China (10) India (7) Taiwan (7)

121 Institutions
on author list
for JLC Roadmap

Australia (2) Philippines (2) Vietnam (2) Singapore (1) Thailand (1)

USA (6) Germany (2) Russia (2) UK (2) France (1)

GLC/NLC Accelerator Design Basis

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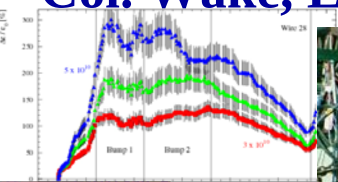
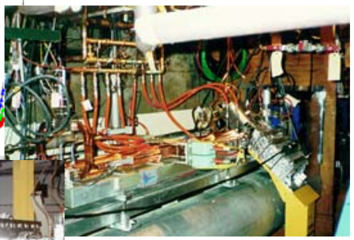
Bunch Comp.

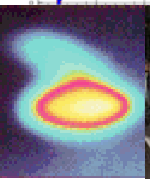
SLC and FEL's

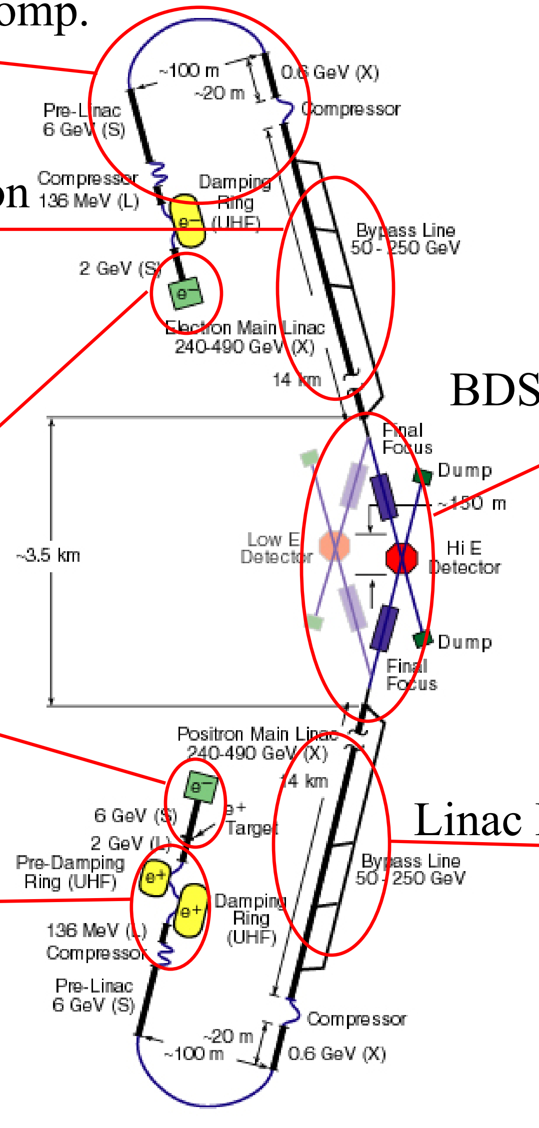
SLC, FFTB, ASSET, Col. Wake, E-158

ε preservation

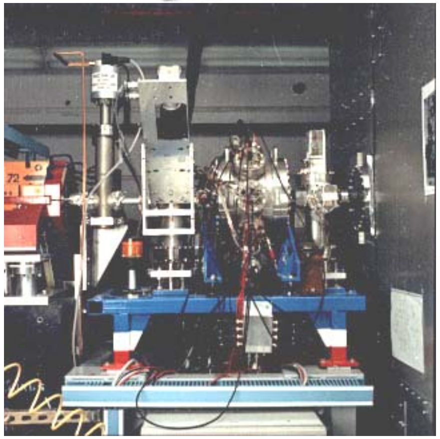








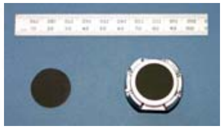
SLC and FFTB



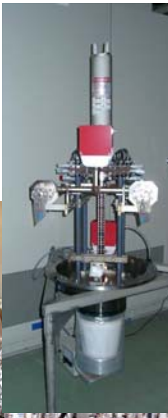
BDS & IR

SLC, E158, Nagoya Univ.

e+ / e- sources



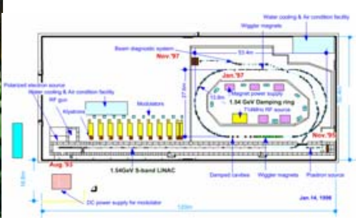
KEK and SLAC X-band RF

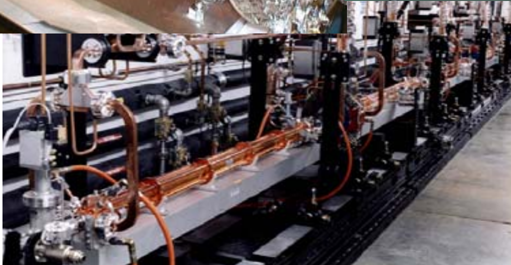


Linac RF

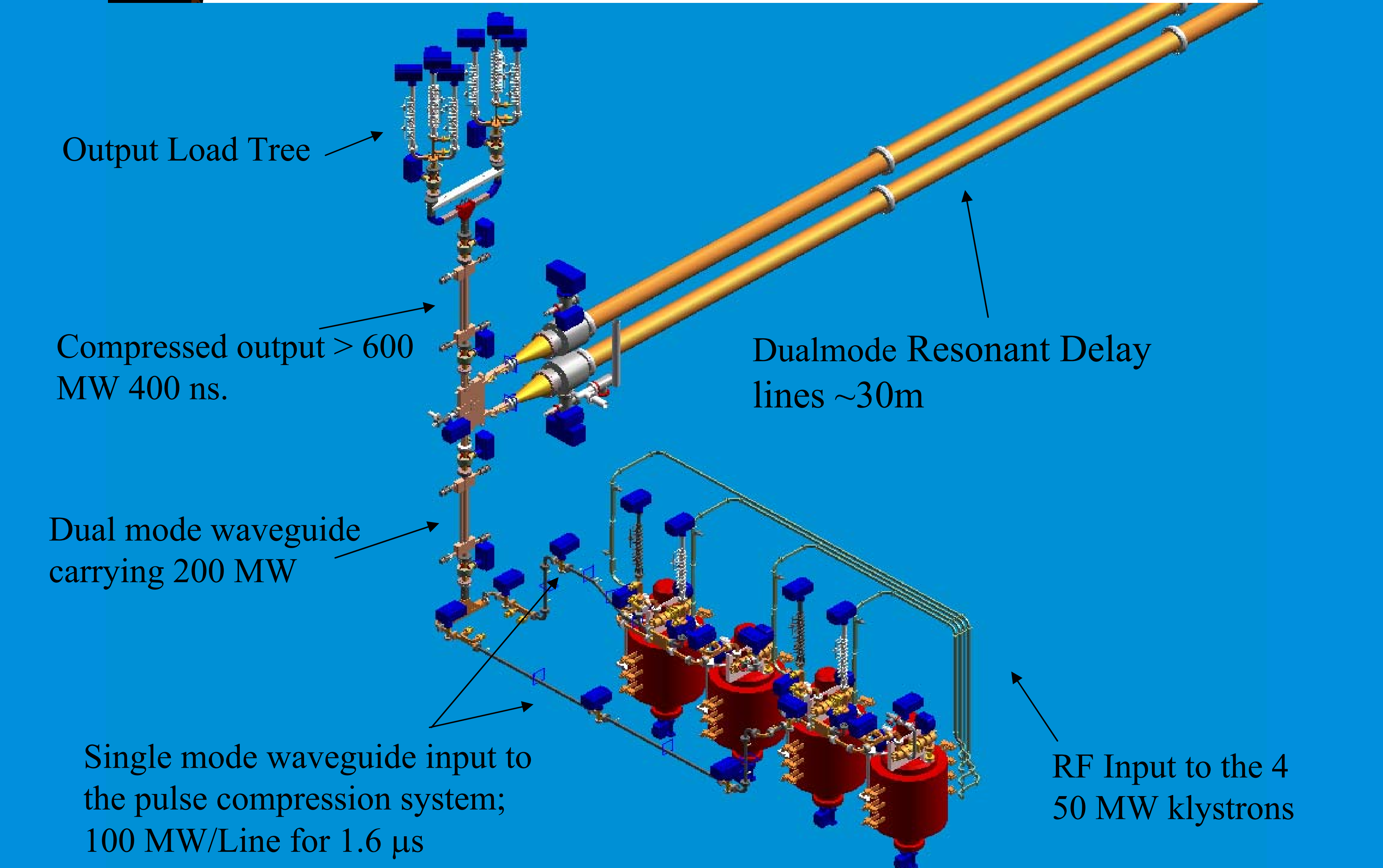
ATF, 3rd gen. SRS, SLC

DR's





SLED-II Demonstration (TRC R1-2)



SLED-II Demonstration (TRC R1-2)

Full power test in NLC Test Accelerator - Jan 2004

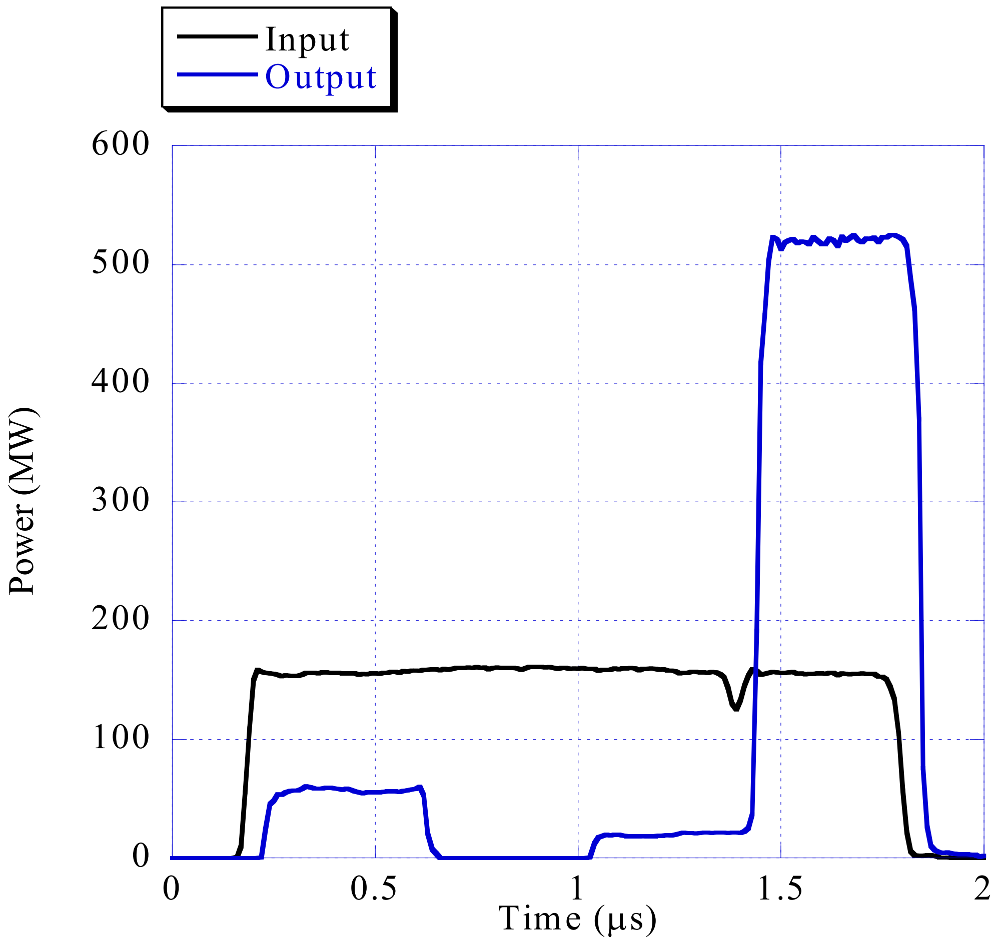
- Rapid turn on
- Easy commissioning & robust operation

Achieved ~600 MW

- > 20% higher than design

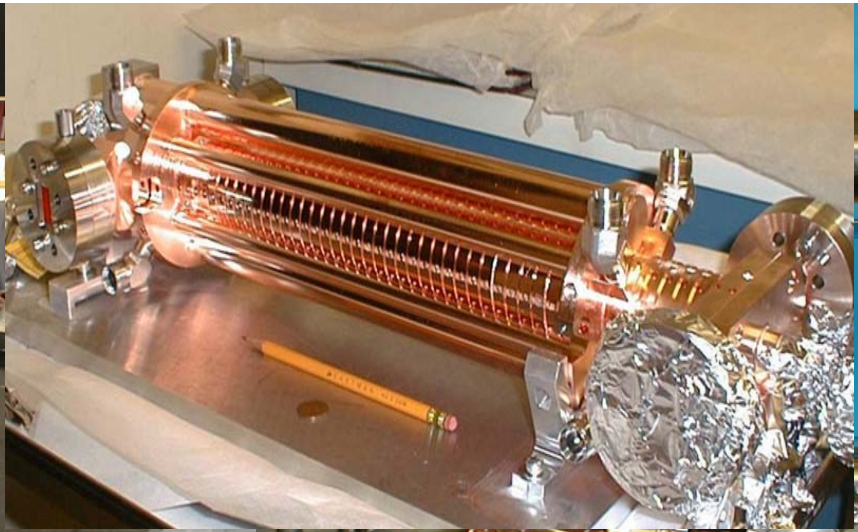
Now operated 24/7

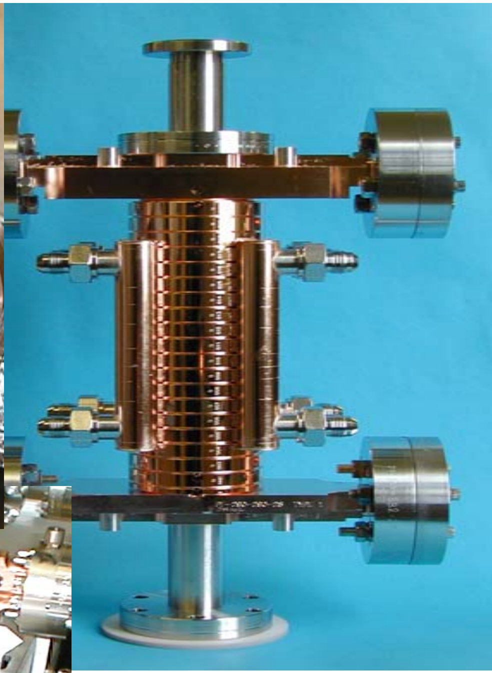
- > 500 hours stable operation with pulse-flattening feedback

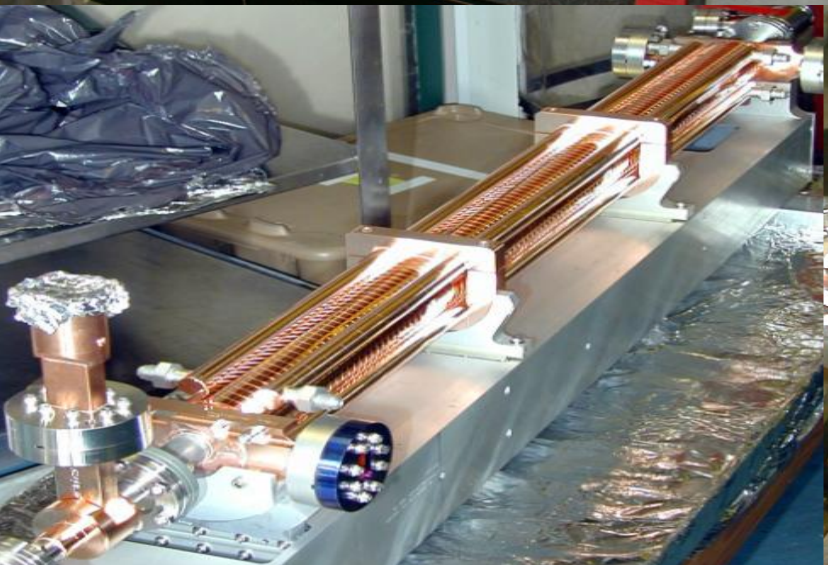


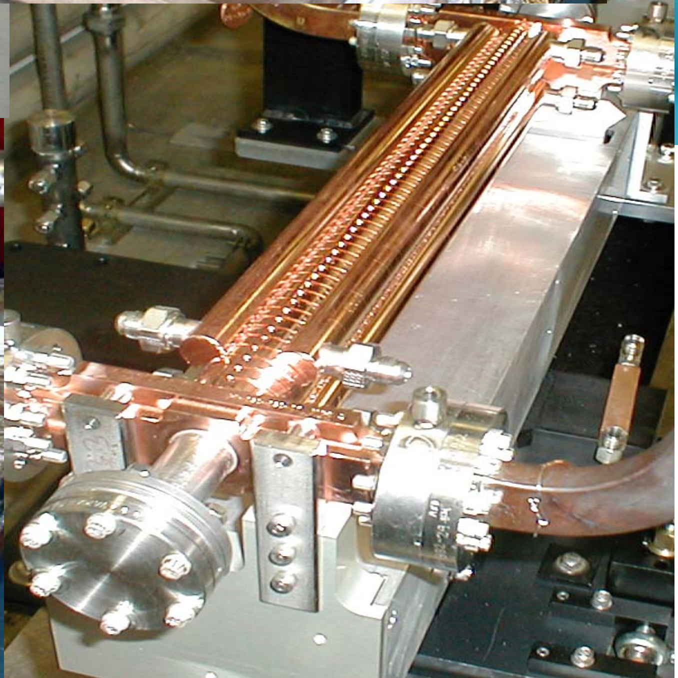
Sami Tantawi (1/27/2004)

X-Band test Structures



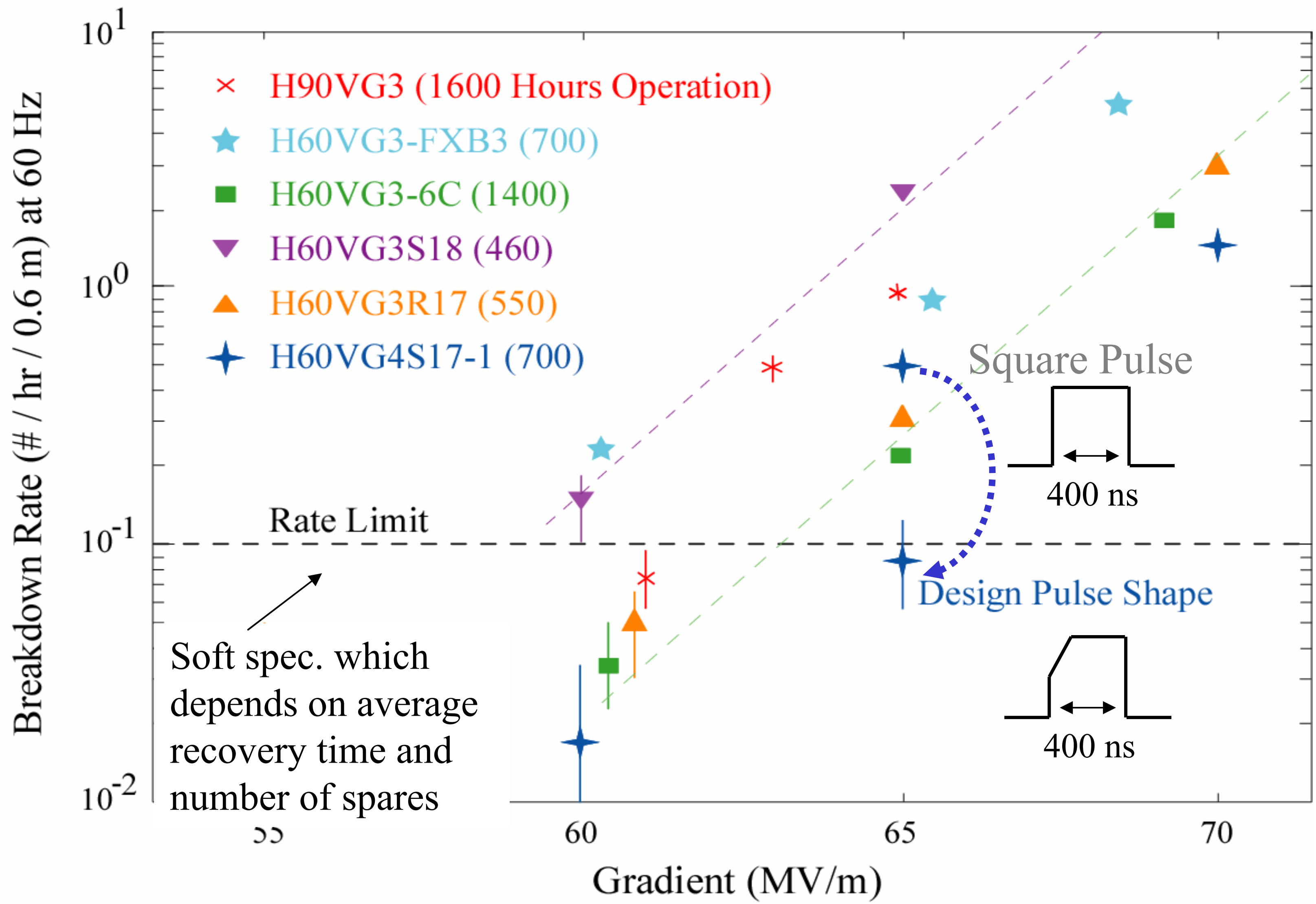






Structure High Gradient Performance

(Breakdown Rate -vs- Unloaded Gradient)

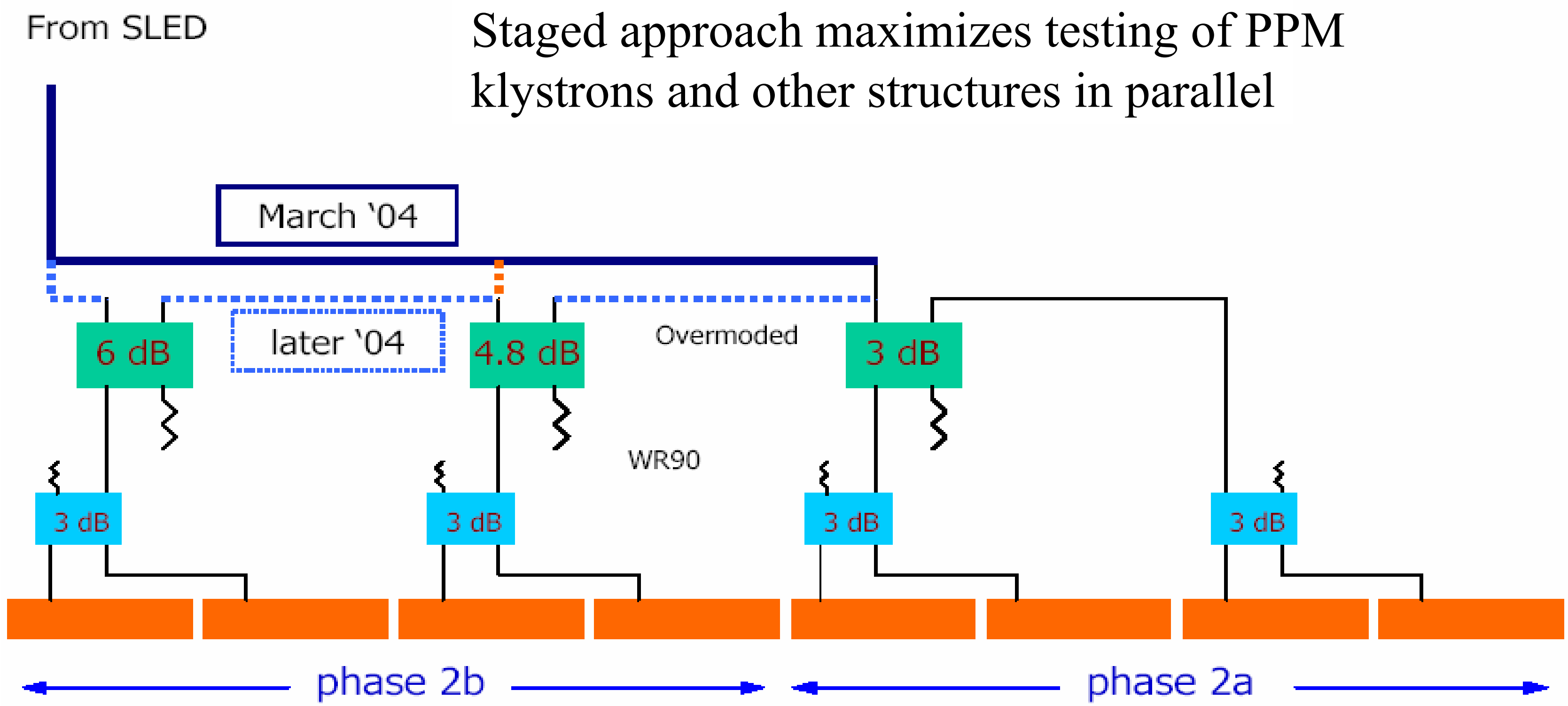


GLC/NLC RF Sub-unit Tests (TRC R2-2)

Goal is to demonstrate a full rf power unit in 2004

- 2-pack modulator, 2 PPM klystrons, SLED-II, 8 60-cm structures
- Rf power unit is replicated ~1000 times in each linac
- Two phases: Phase 2a in Spring 2004, Phase 2b in the Fall 2004

Staged approach maximizes testing of PPM klystrons and other structures in parallel



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TRC R&D Rankings

Ranking 1

R&D needed for feasibility demonstration of the machine

Ranking 2

R&D needed to finalize design choices and ensure reliability of the machine

Ranking 3

R&D needed before starting production of systems and components

Ranking 4

R&D desirable for technical or cost optimization

TRC Rankings Score Sheet

	TESLA	JLC-C	JLC-X/NLC	CLIC	Common
R1	1	1	2	3	0
R2	6	2	2	6	9
R3	17	2	15	>7	26
R4	5	1	5	N/A	7

TRC Score Sheet (Details)

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Completed 5~6 of the 13 TRC R1 and R2 items identified for the X-band design with expectations of completing 4 to 5 more in 2004

R1-1	Gradient	**Mostly Done**
R1-2	SLED-II	**Done**
R2-1	Klystron	**Done**
R2-2	RF Unit	Completion expected in 2004
R2-3	E-cloud	Active program with demonstration planned in 2006
R2-4	Ions	Active program with benchmarks planned in 2004
R2-5	DR kicker	**Done**
R2-6	DR ε	**Done** - ATF & ALS results better than simulation!
R2-7	LET tuning	Active program with results expected in 2004
R2-8	Instrumentation	Active program with many elements done
R2-9	Linac Vibration	Active program with demonstration in 2005
R2-10	Availability	**Done** - 1st pass with important conclusions
R2-11	LET tuning	Active program with results expected in 2004

Personal Conclusions

For the health of international HEP,
  the LC should be located in the US or Japan

The US should bid to host the LC

The US will participate with any location or technology

X-band is the best choice

- The technology is demonstrated
- Design is complete & lower risk – all systems prototyped
- There is a strong experienced team to build it
- It is the path to higher energies, > 1 to multi-TeV
  and it is less expensive