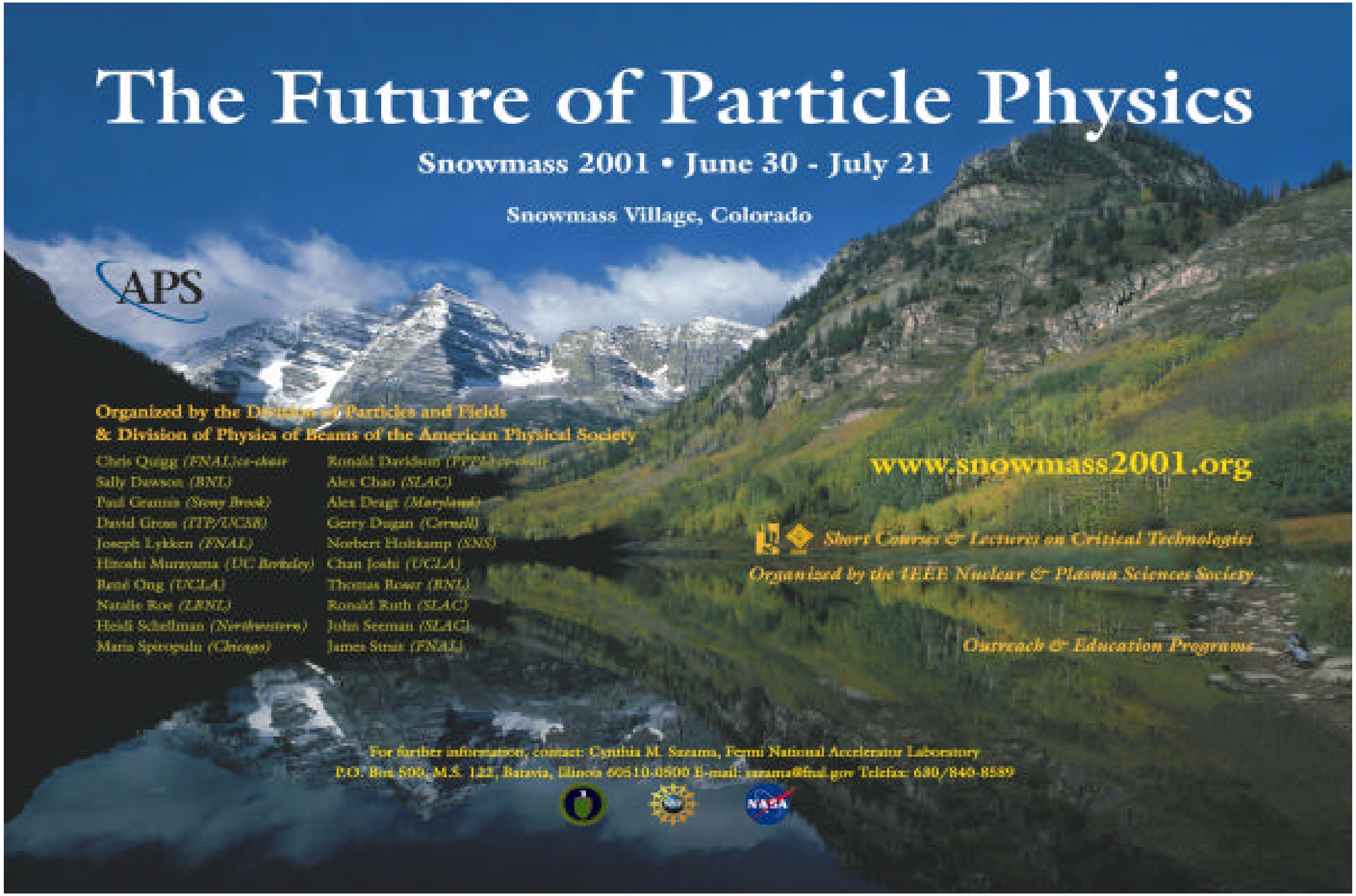
Report from Snowmass Linear Collider WG

R. Brinkmann, TESLA Coll. Meeting Frascati 5 Nov. 2001



M3 Snowmass Working Group on Linear Colliders

Summary Part-I

Conveners: R. Brinkmann, T. Raubenheimer and N. Toge

- Attendance during M3 sessions : ~ 30 – 40 colleagues
- # of scheduled sessions: 11
- # of M3 talks: 33
- Joint sessions with T1, T2, T5, T6, T9 and M1
- Several sessions/meetings/panel discussions organised by E3

M3 Group Schedule Overview

Tue. 7/3	Linac Technology	
Wed. 7/4	*E3 – M3 Design overview and luminosity performance*	*Holiday*
Thu. 7/5	*T1 background at e+e- LC*	
Fri. 7/6	Damping rings	*T1 gamma-gamma IR*
Sat. 7/7	M3 – T5 Emittance preservation	M3 – T5 cont'd
Mon. 7/9	*M3 – T6 tunneling and conventional facilities*	*M3 – T6 cont'd*
Tue. 7/10	Discus.: MPS, DR experiments	
Wed. 7/11	Beam delivery design	*T1,T2 on IR magnets*
Thu. 7/12	Plenary	M3 – T5 Emit. Preserv. Cont'd
Fri. 7/13	High energy limitations and upgrade paths	
Sat. 7/14	M3 – T1 – T6 active stabilization	M3 – T1 – T6 cont'd
Mon. 7/16	RF structures and HOM	*T group session*
Tue. 7/17	*M1 – M3 high-E Muon coll.*	*T group session*
Wed. 7/18	Summary preparation	Summary Preparation

Summary: Reinhard / Tor / *other*

Linear Collider parameter overview

	NLC/JLC	**JLC-C**	**TESLA**	**CLIC**	SLC
f / GHz	11.4	5.7	1.3	30	2.9
E-cms / GeV	500 – 1000	500	500 – 800	3000 – 5000	100
g / MV/m	50	36	23 – 35	150	~20
Lumi / 10^{34}	2 – 3.4	0.7	3.4 – 5.8	~10	.0003
Power p. beam / MW	6.6 – 13.7	3.2	11.2 – 17	~15	0.04
σ_y at IP / nm	2.7 – 2.1	4.4	5 – 2.8	1	500
Site length / km	30	~25	33	~35	3.5
Site power / MW	180 – 300	130+x	140 – 200	~300?	
Cost[§] (stage-I)	~3.5B$		3.14B?+7,000 p.y.		?

§ no escalation and contingency included

Development of NLC/JLC X-Band rf components (modulators, klystrons, pulse compression, acc. cavities) over past decade

- Integrated system test of prototype components ***with beam*** at NLCTA 1997
  ⇒ E_{acc} = 40MV/m, beam loading compensation (ΔE/E = 0.3%) ok

- **ASSET: verification of HOM damping & detuning, rf-BPM**

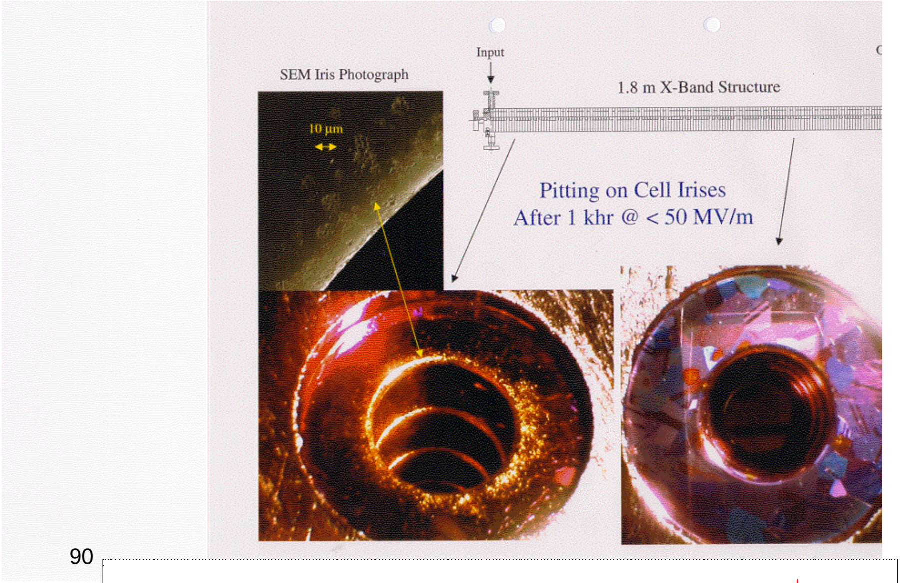
Ongoing R&D program:

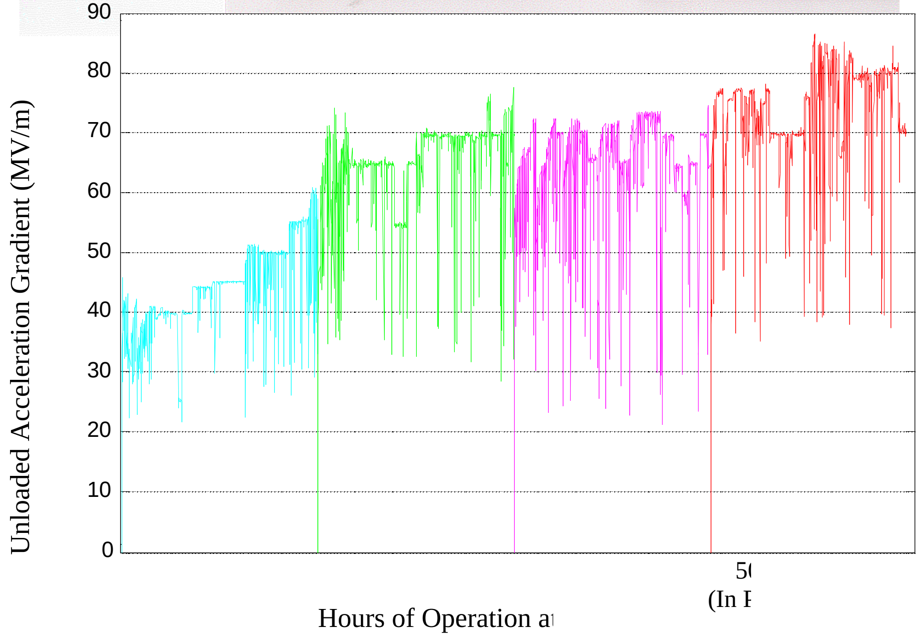
- **Accelerator cavities for higher gradients (55MV/m loaded, 70MV/m unloaded)**
  ⇒ eliminate iris damage problem with new design (shorter 1.8m ⇒ 0.9m, group velocity 12%c ⇒ 3…5%c)

- **Improve power efficiency and reduce cost**
  ⇒ 8-pack of 75MW ppm focused 75MW klystrons, solid state inductive stack modulator, DLDS rf distribution/compression scheme

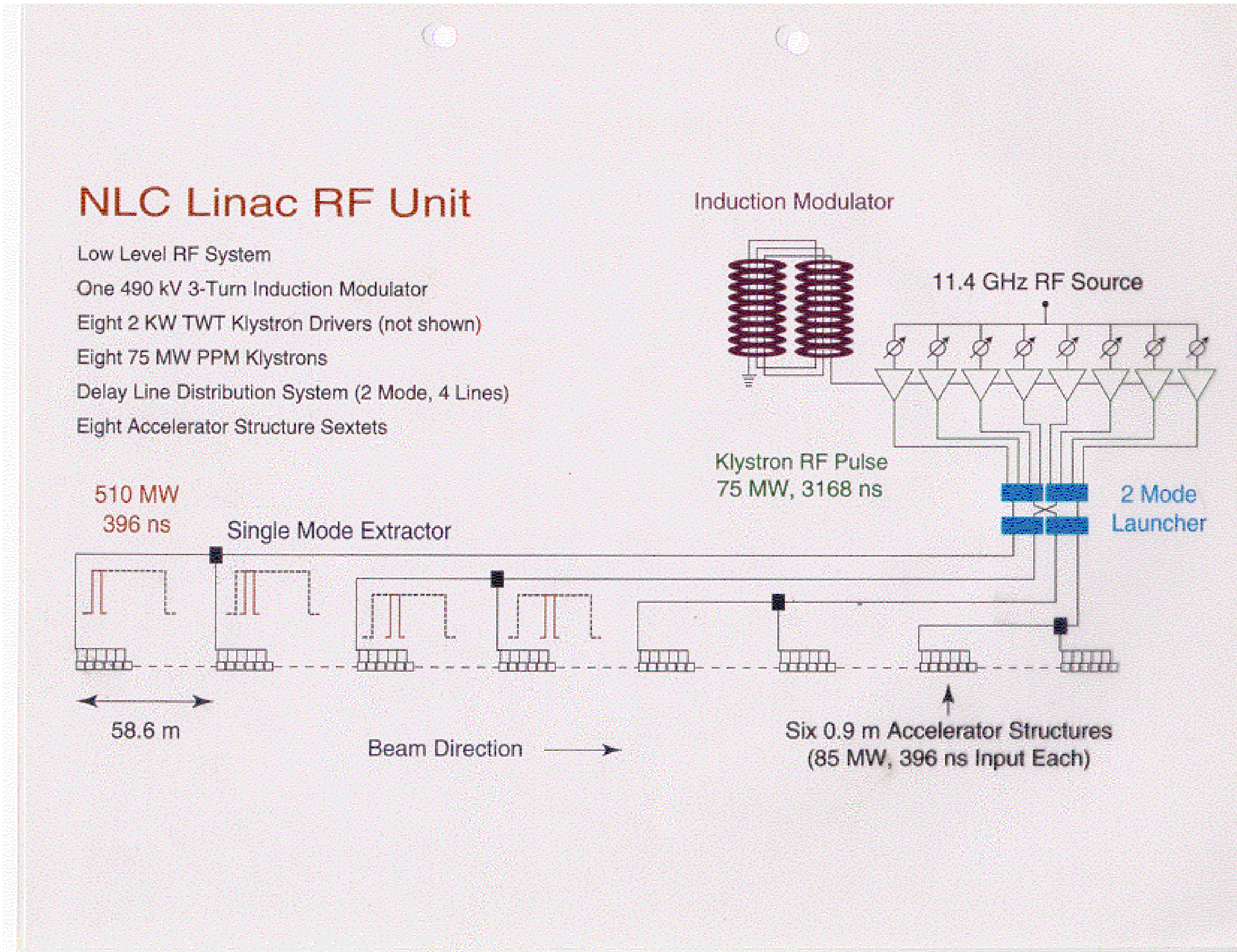
RF breakdown/Iris damage problem

- Reduction of v_g 12%→3%, 1.8m→0.6m structures (latest news)
- After successful long-term survival test, need to modify phase advance/cell and add HOM detuning & damping
- Also under study: input coupler & cell layout, short standing wave cavities



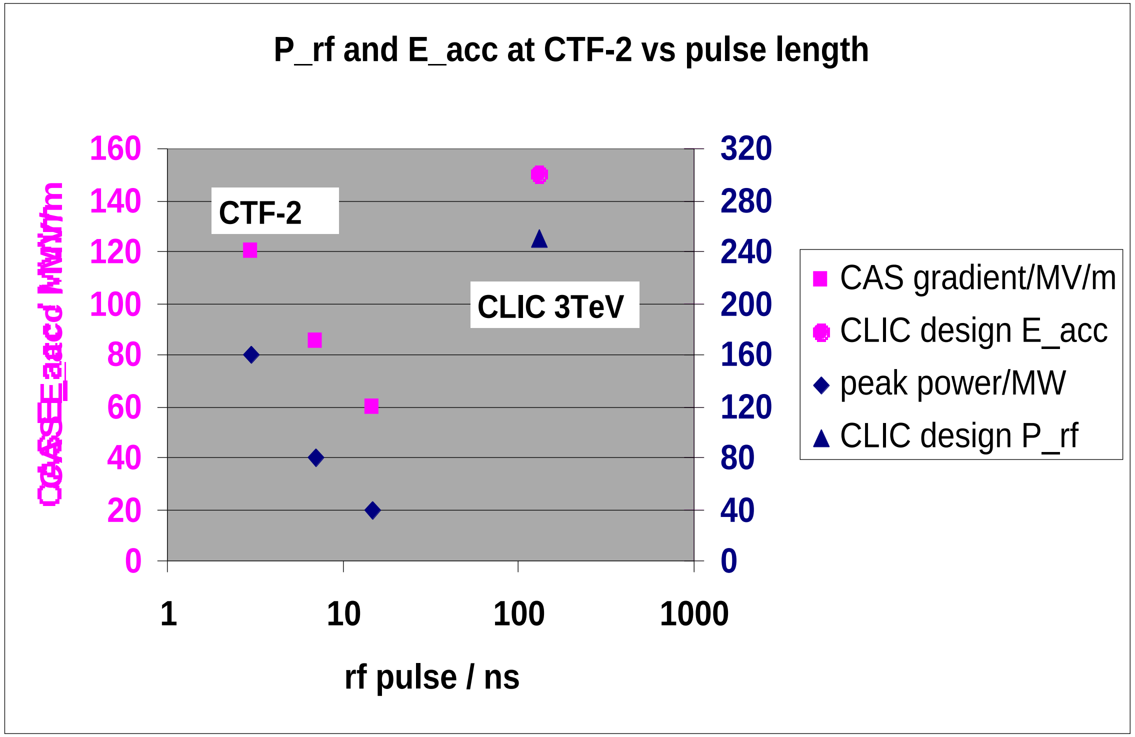


Integrated system test of one NLC linac unit 2004



CLIC R&D towards very high gradients

- CTF3 (-2006): demonstrate drive beam concept and main linac acceleration at 30GHz/150MV/m
- Near term: investigate (theoretical & experimental) rf breakdown and iris damage



TESLA: critical issues discussed at and after Snowmass
1. S.c. linac technology

- Insufficient operation experience at TTF linac with TESLA500 design parameters ***can't deny: only few days at max. g=22…23MV/m, never simultaneously max. g with full pulse length and beam current***
- G=35MV/m & superstructures needs years R&D and tests at linac ***essentially correct***
- Dark current critical (radiation in the tunnel) ***correct, limit is rather heat load than radiation***
- Modified HOM damping needs beam tests (2.58GHz mode) ***negotiable, but if we understand problem & solution, why don't we modify couplers a.s.a.p.?***

2. Beam dynamics

- Alignment tolerances vary with correlation length: 0.5mm (cav.) →0.14mm (module)→0.05mm (λ_β/4) ***have modified alignment model for simulation studies: 0.3mm cav. to module axis, 0.2mm module to ref. point, 0.02mm ref. points over 500m from hydrostatic leveling system; can tune out static effect of W_trans with bumps, reduce dynamic (jitter) effect with BNS damping***
- Structure tilt tolerance 0.1mrad from RF kicks ***no consensus yet, should be cured by orbit correction (DF or shunt methods) with 10μm BPM resolution***
- Kicks from input and HOM couplers ***under study, consequences not yet perfectly clear (to me)***

Beam dynamics (cont'd)

- Effect of correlated $\Delta\varepsilon$ on luminosity ("banana effect") much more severe than uncorrelated $\Delta\varepsilon$ (kink instability with high D_y) ***very painful, find up to 20% lumi loss from corr. $\Delta\varepsilon/\varepsilon$=1%. Half of loss recovered with IP feedback "on", more recovered with empirical IP steering; can cure static corr. $\Delta\varepsilon$ and limit dynamic $\Delta\varepsilon/\varepsilon$<1%. Design lumi marginally ok, but smaller bunchlength desirable***

3. Other subjects

- Damping ring design considered risky and studies incomplete; e.g. space charge, beam-ion, electron cloud, kicker design and tolerances ***more attention on DR would be good, but I don't see fundamental problems in the present design***
- Positron source viewed as unproven concept; operational complications; "energy gap" 200…300 GeV ***photon production and conversion needs proof??? Advantages (heat load, no extra drive linac, potential for polarised e+, outweigh disadvantages); energy gap can be closed by half rep-rate, but then only half lumi***
- Commissioning and operation strategies, reliability, failure handling, machine protection,… ***broad field with much too little work done yet***