Linear Collider
Luminosity and Margins
(personal talk presenting my opinion)

- General Comments
  - History
  - Presence
  - Future
- Parameters Choices for Linear Colliders
  - What is new ?
- Technology Choices
  - Risk
  - What Limits the Gradient?
  - Technical Feasibility?
  - R&D cost
  - Pre Operations Cost
  - Commissioning Time
  - Operations Cost
  - Energy versus Luminosity
- What If ?
- Summary

Fundamental Question!

- Do we want to do Lepton collider high energy physics in the future, or are we at a point were we don't need this / can not afford to do this?

- If yes:
  - There is only on way foreseeable in the near term (20 y) future: Linear Collider

- If not:
  - I can stop my talk here

- If yes, but …
  - That's an endless discussion I have been part of for too long and I m not going to go there.

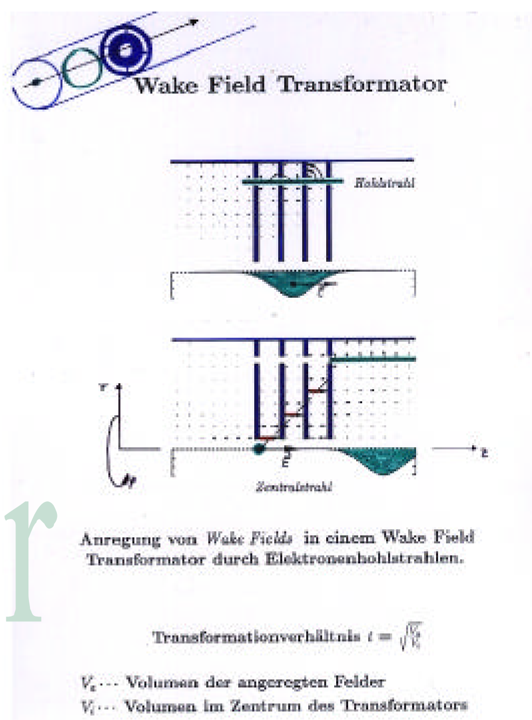
- For the sake of the next 45 minutes lets assume, yes! And I give you my opinion which is what Hugh asked for.

History

- High gradients are the only viable route to high energies for $e^+ e^-$ colliders
  - Synchrotron radiation loss get too high (~ $B^2\rho^2$)
  - Linear Cost (linear collider) is going to undershoot quadratic cost increase for storage rings

- Beginning of the 80's:

  ("The Challenge of Ultra High Energies", Proceedings of the ECFA RAL Workshop, Oxford, September 1982, ECFA 83/68)
  - Wakefield Accelerators
  - Plasma Wakefield
  - Two Beam Accelerators (CLIC and Wake Field Transformer)
  - Laser Acceleration
- All this is not new…
- Why did they all pass out ?



Beam Power

Beam Power

Key Design Issues

$$L \propto \frac{N^2 \cdot f_{rep}}{4p \cdot s_x \cdot s_y}$$

[Luminosity is proportional to Beam power]

$$P_b = E_{cm} \cdot N \cdot f_{rep}$$

$$L \propto \frac{N \cdot P_b}{E_{cm} \, 4p \cdot s_x \cdot s_y}$$

$$L \propto \frac{P_b}{E_{cm}} \left[\frac{d_E}{e_{n,y}} \right]^{1/2} H_D$$

DE/E_0 pro Bunch < one percent

Þ DW/W < two percent

W_{stored} ~ $Grad^2/F^2_{rf}$

Complexity is dependant:

-on DE/E_0 ~ F^2_{rf}

-on De/e ~ F^3_{rf}

? GHz

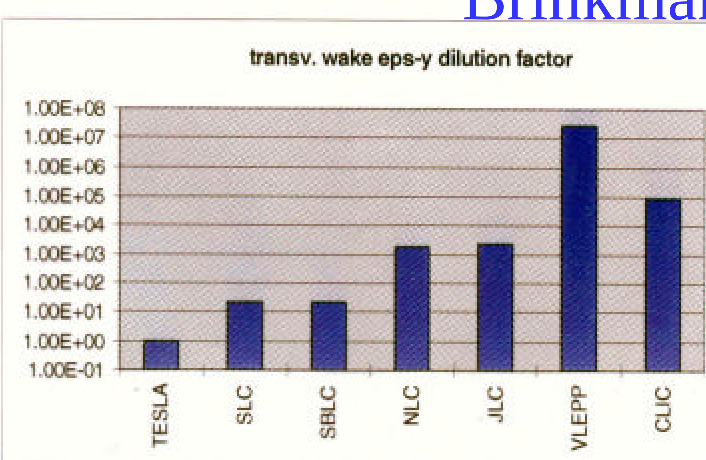
Frequency Scaling

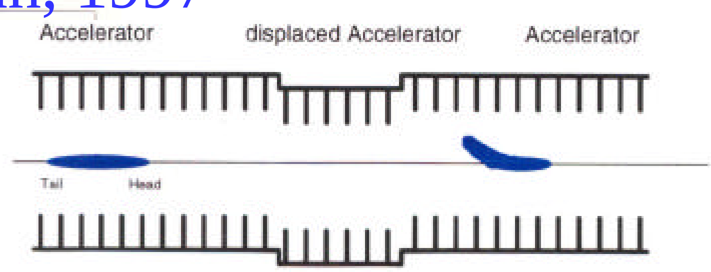
- $V = \text{const.}^* (P_{tot}\ L\ r_o)^{½}$ [V and L are const]

Parameter		F depend	F Preference		
			high	low	
Shunt impedance per unit length		$f^{0.5}$	x		
RF loss factor Q		$f^{-0.5}$		x	
Filling time		$f^{-1.5}$	x		
Total RF peak power		$f^{-0.5}$			
No. of rf feeds		$f^{1.5}$			
RF peak power per feed		f^{-2}	x		
RF energy stored		f^{-2}	x		
Beam loading		$f^{0.5}$		x	
Beam aperture		f^{-1}		x	
Maximum electric field		$f^{0.5}$	x		
RF peak power per source		f^{2}		x	
relative Dimensional tolerances		$f^{0.5}$	x		

"Blue Book" 1968

Brinkmann, 1997





$$\frac{\Delta\varepsilon}{\varepsilon} \propto \frac{N_e^{\,2} f^6{}_{rf} F_{geom}{}^2 \sigma_z}{g^2 \varepsilon_y} \times \delta y^2{}_{align} \langle\beta\rangle$$

tolerances range from δy_c = 500µm (TESLA), 50µm (SBLC) to 10µm (X-band, CLIC) ⇒
use ***beam-based*** methods to relax installation tolerances:

Single/Few Bunch Colliders

- Early Paper on Linear Collider Design:
  - Many reason to go to fewer, a few or single bunch colliders (1-10 or so)
  - At that point higher frequency is definitely more efficient because of strong dependence on F ($F^{3/2}$)

Overview Of Linear Collider Concepts

Name	TESLA 1.3 GHz	SBLC 3 GHz	JLC-C 5.7 GHz	JLC-X NLC-X 11.4 GHz	Vlepp 14 GHz	CLIC 30 GHz
Techno-logy	sc-Niob Cavities	Cu structures & klystrons				Two Beam
Challenge	gradient Q0, cost	high rf peak power and power conversion efficiency				Wakefield drive beam
grad. MeV/m	25	17	32	58	32	91	78
L km	32	36	22	22	14	10	12
σ_y nm	19 /15	15	3.0	3.1	3.2	4	7.4
P_{beam} MW	16 /22	7	3.1	3.6	4.4	2.4	4.9

All Designs have $L \approx 5 \times 10^{33}$ and $P_{ac} \approx 100$ MW at 500 GeV cms

"The higher the F, the lower P_b

The Technical Review Committee

1995-
1999

ILC-TRC

Table 1.1
Linear Colliders: Overall and Final Focus Parameters - 500 GeV (c.m.)

>

New in
2001

Result

2002

Click here to update your machine information for Table 1.1.	TESLA TRC 12/95	TESLA Updated* 8/98	SBLC TRC 12/95	SBLC Updated* 10/96	JLC (C) TRC 12/95	JLC (C) Updated* 9/99	JLC (X) TRC 12/95	NLC TRC 12/95	JLC/NLC** Updated* 12/98
Initial energy (c.m.) (GeV)	500		500		500		500	500	500
RF frequency of main linac (GHz)	1.3		3		5.7		11.4	11.4	11.4
Nominal luminosity (10^{33} cm^{-2} s^{-1})†	2.6	16.2	2.2	3.16	7.3	5.02	5.1	5.3	5.1(4.2)
Actual luminosity (10^{33} cm^{-2} s^{-1})†	6.1	30	3.75	5.3	6.1	7.18	5.2	7.1	6.54(5.45)
Linac repetition rate (Hz)	10	5	50		100		150	180	120(100)
No. of particles/bunch at IP (10^{10})	5.15	2	2.9	1.1	1	1.11	.63	.65	.95
No. of bunches/pulse	800	2820	125	333	72		85	90	95
Bunch separation (nsec)	1000	337	16	6	2.8		1.4		2.8
Beam power/beam (MW)	16.5	11.3	7.26	7.25	2.9	3.07	3.2	4.2	4.5(3.7)
Damping ring energy (GeV)	4	3.2	3.15		2	1.98	2	2	1.98
Unloaded/loaded † (MV/m)	25/25	21.7/21.7	21/17		40/32	44/34	73/58	50/37	72.3/55
Total two-linac length (km)	29	30	33	32	18.8	16	10.4	15.6	10.5
Total beam delivery length (km)	3	2.5	3		3.6		3.6	4.4	NA
$\gamma\epsilon_x/\gamma\epsilon_y$ (m-rad × 10^{-6})	20/1	10/.03	10/.5	5/.25	3.3/.05		3.3/.05	5/.05	4.5/0.1
β_x^*/β_y^* (mm)	25/2	15/.4	22/.8	11/.45	10/.1	15/.2	10/.1	10/.1	12/0.12
σ_x^*/σ_y^* (nm) before pinch	1000/64	553/5	670/28	335/15.1	260/3	318/4.3	260/3.1	320/3.2	330/4.9
σ_z^* (μm)	1000	400	500	300	120	200	90	100	120
Crossing Angle at IP (mrad)	0	0	3	6	6	8	6.1	20	20(6)
Disruption D_x/D_y	.56/8.7	.3/33	.36/8.5	.32/7.1	.2/18	.25/17.9	.096/8.3	.07/7.3	0.12/7.9
H_D	2.3	1.8	1.8	1.68	1.4	1.7	1.4	1.34	1.36
Upsilon sub-zero	.02	.02	.037		.14	.21	.12	.089	.11
Upsilon effective	.03	.03	.042		.144		.12	.09	.11
δ_B (%)	3.3	2.8	3.2	2.8	6.5	4.1	3.5	2.4	3.7
n_γ (no. of γ per e)	2.7	2.0	1.9	1.4	1.5	1.5	.94	.8	1.1
N_{pairs} (p_T^{min} = 20 MeV/c, θ_{min} = 0.15)	19	31	8.8	7.1	10.3	20.1	2.9	2	9.8
$N_{hadrons}$/crossing	.17	.13	.1	.04	.23	.13	.05	.03	.07
N_{jets} × 10^{-2} (p_T^{min} = 3.2 GeV/c)	.16	.3	.14	.1	.66	.37	.14	.08	.2

Gus Voss and S-Band

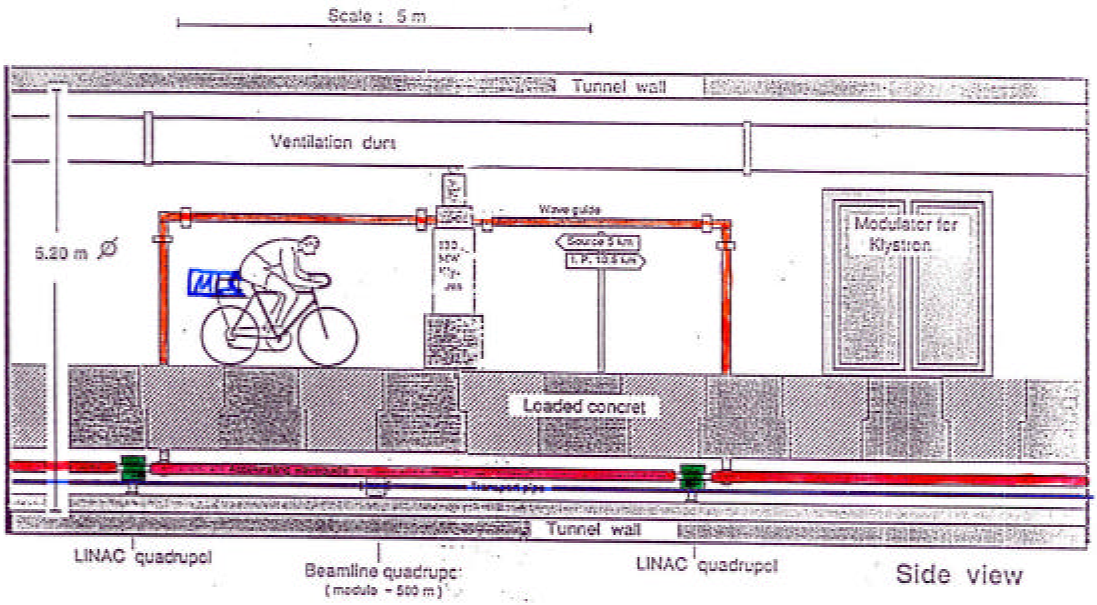
Presented at: “ Beam Power is the figure of Merit”

Linear Collider Workshop Tsukuba, Japan 1990

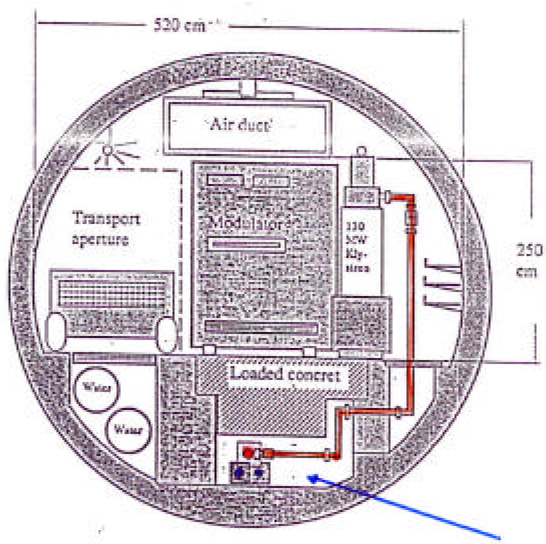
	DESY - Darmstadt		1984 ICFA B. Richter	
Energy	2× 250	2× 500	2× 1000	GeV
Luminosity	$2.6 \cdot 10^{33}$	$2.7 \cdot 10^{33}$	10^{33}	$cm^{-2} s^{-1}$
Power/beam	~~15~~ 7.22	~~39~~ 5.6	~~14~~ 4.5	MW
Disruption	.83/7.6	.9/10.1	2/2	
Dimensions at IP without disruption	316/35	223/25	100/100	nm
Bunch length	0.5	0.4	2	mm
N = part./bunch	$2.1\ 10^{10}$	$2.8\ 10^{10}$	$1.4\ 10^{10}$	
Beamstrahlg. parameter	0.15	0.42	0.3	
rms-energy spr.	2	2	10	%
ε norm.	$10^{-5}/10^{-6}$	$10^{-5}/10^{-6}$	$4\ 10^{-6}/4\ 10^{-6}$	m
Bunches/rf pulse	172	50	12	
Bunches/s	8600	2500	2000? (2160)	s^{-1}
Acc. gradient	17	34	20	MV/m
Length of each linac	15	15	50	km
No. of klystrons	2×1225	2×2451	2×3500	
Total power	101/110	~~280~~ 290	390	MW
I ave.	100 mA	1448	?	mA

150 MW Klystron mit 2.25 μs Flat Top

Tunnel Layout

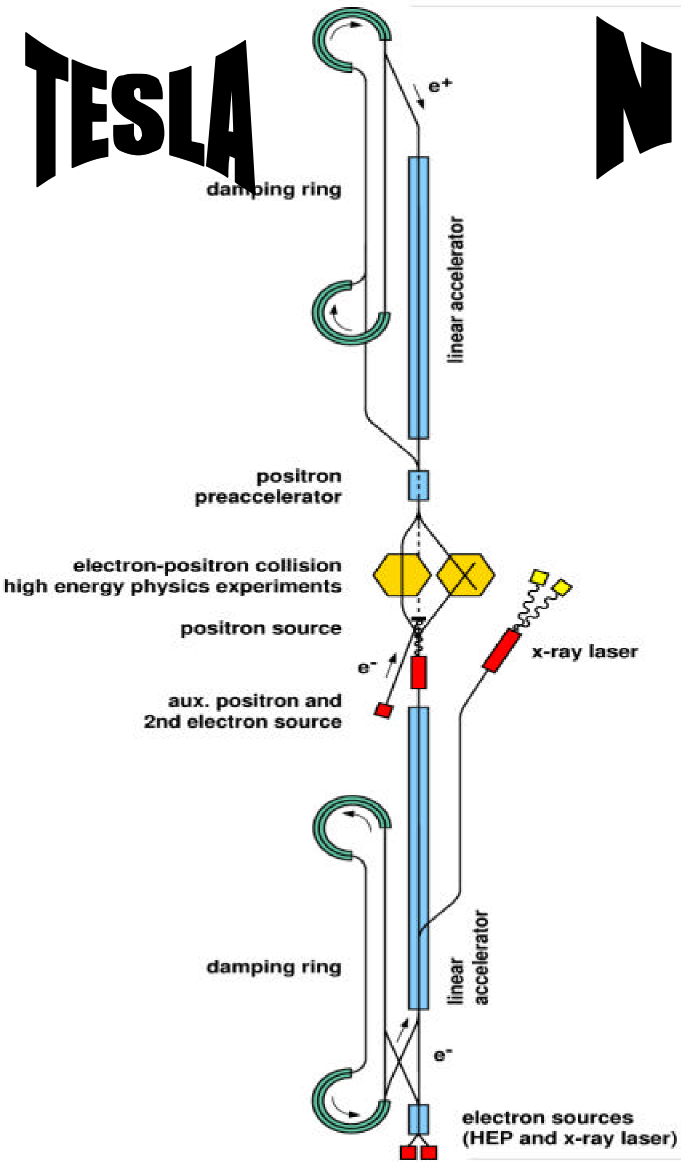


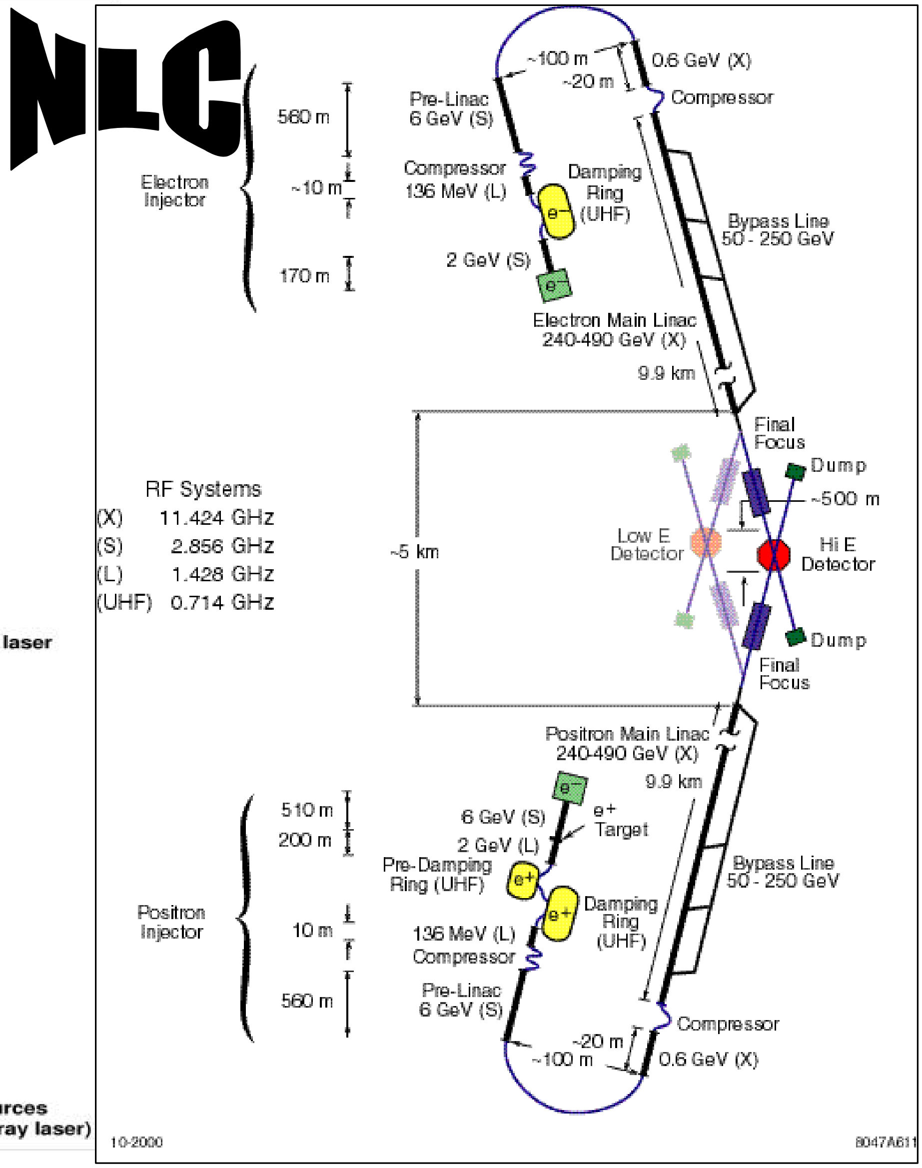
How could such a tunnel look like?

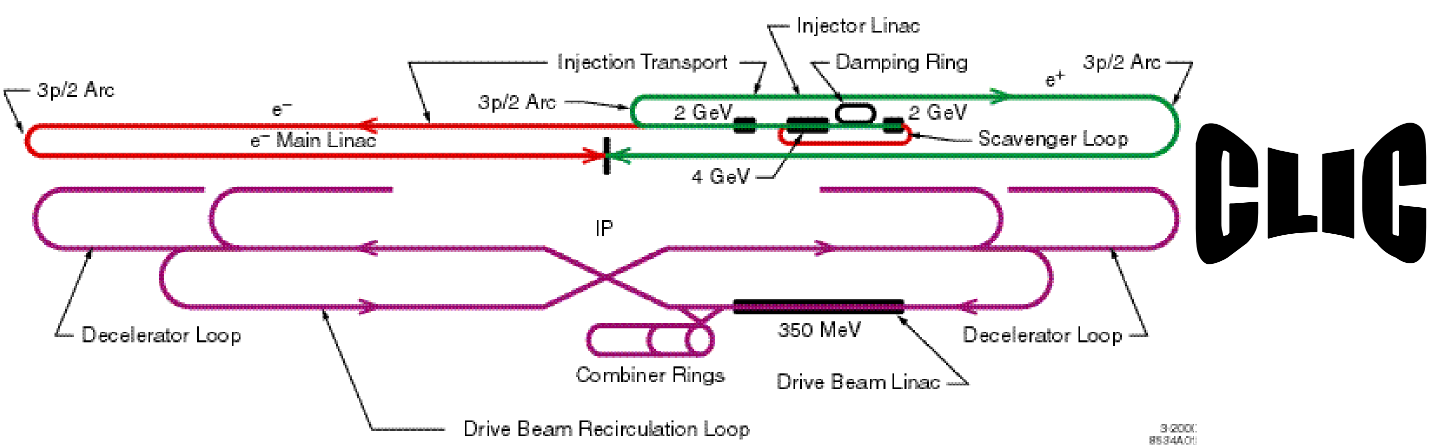


A new generation of „manikins" is required to work in the tunnel!

Geometry, Infrastructure, and Complexity (KISS)







Many Years Later: Today

- Operating SC Cavities at >30 MV/m
- PPM focused klystrons > 70 MW peak Power
- Operating and efficient RF system @ 1.3 GHz
- Damped and detuned Structure design
- …..
- …
- ..

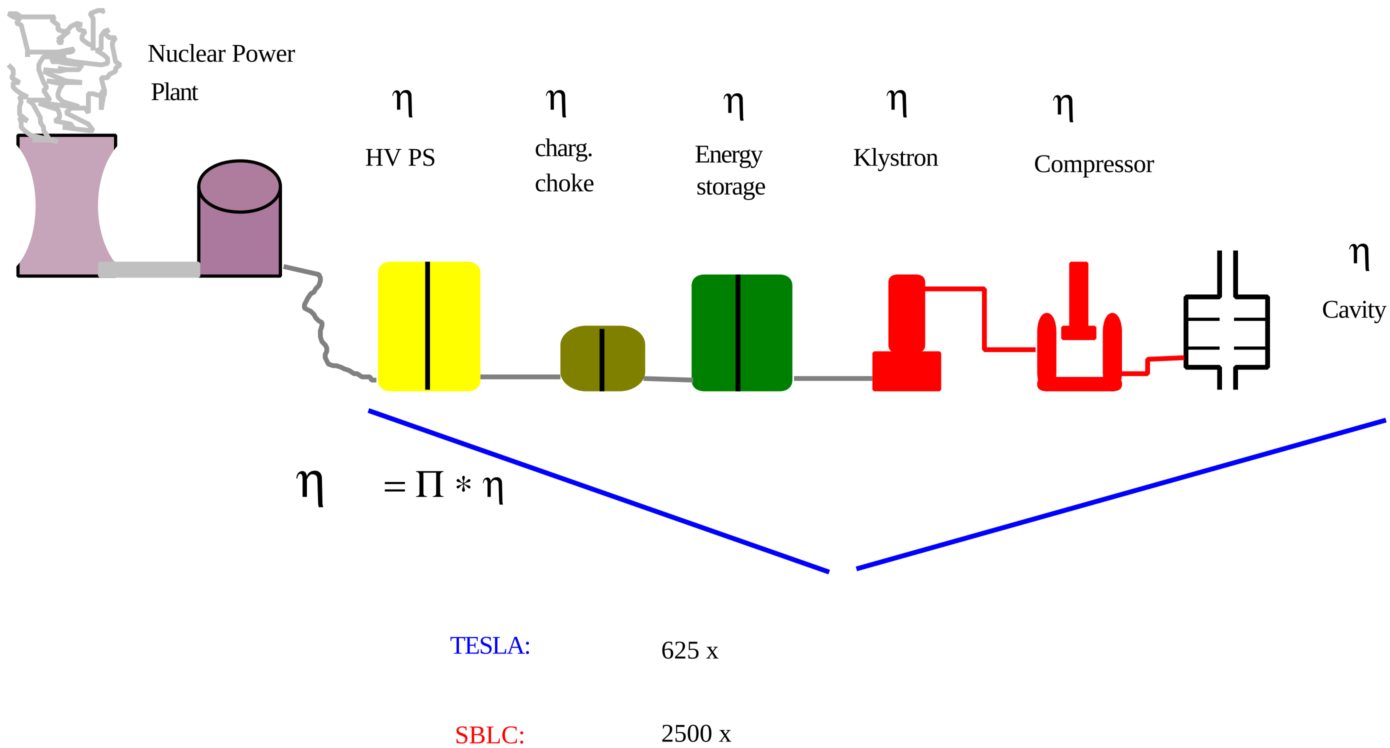
- <u>Have we answered the fundamental question?</u>
  - TESLA:
    - Can one achieve the gradient in reasonably large scale production ?
    - Is the technology cost competitive?
  - NLC:
    - Can one make an efficient cost effective power source (>6000)?
    - Does the technology promise higher gradients and the route to higher energies?

  - Can one produce small spot sizes?
  - Can we achieve the luminosity goal with reasonable assurance?
  - Have the test facilities produced what they promised in the time anticipated?
  - Do we understand enough technical details to deploy a major construction project?

Future

- The Role of the Test Facilities
  - Proposed to test the major technical components
  - None of them would allow large scale test of beam dynamics issues of acceleration of small emittance beams
  - None would show indication of emittance growth
  - None of them would show effects of ground motion
  - None of them would allow the test of sophisticated feedback systems
  - All of this has been seen and worked on at the SLC, which is a 35 year old accelerator – this has been a test bed for many of the things that will limit luminosity in a LC
  - Typically accelerators developed in steps of x10 or so…
  - With a large linear accelerator, we try to make a step of 250 from the test facility to a LC
  - Is there anything we can not predict today…? There is many for sure! (SLAC and BBU), (HERA and dust), (SC magnets and persistent currents) …. + all the engineered screw ups.

Efficiency

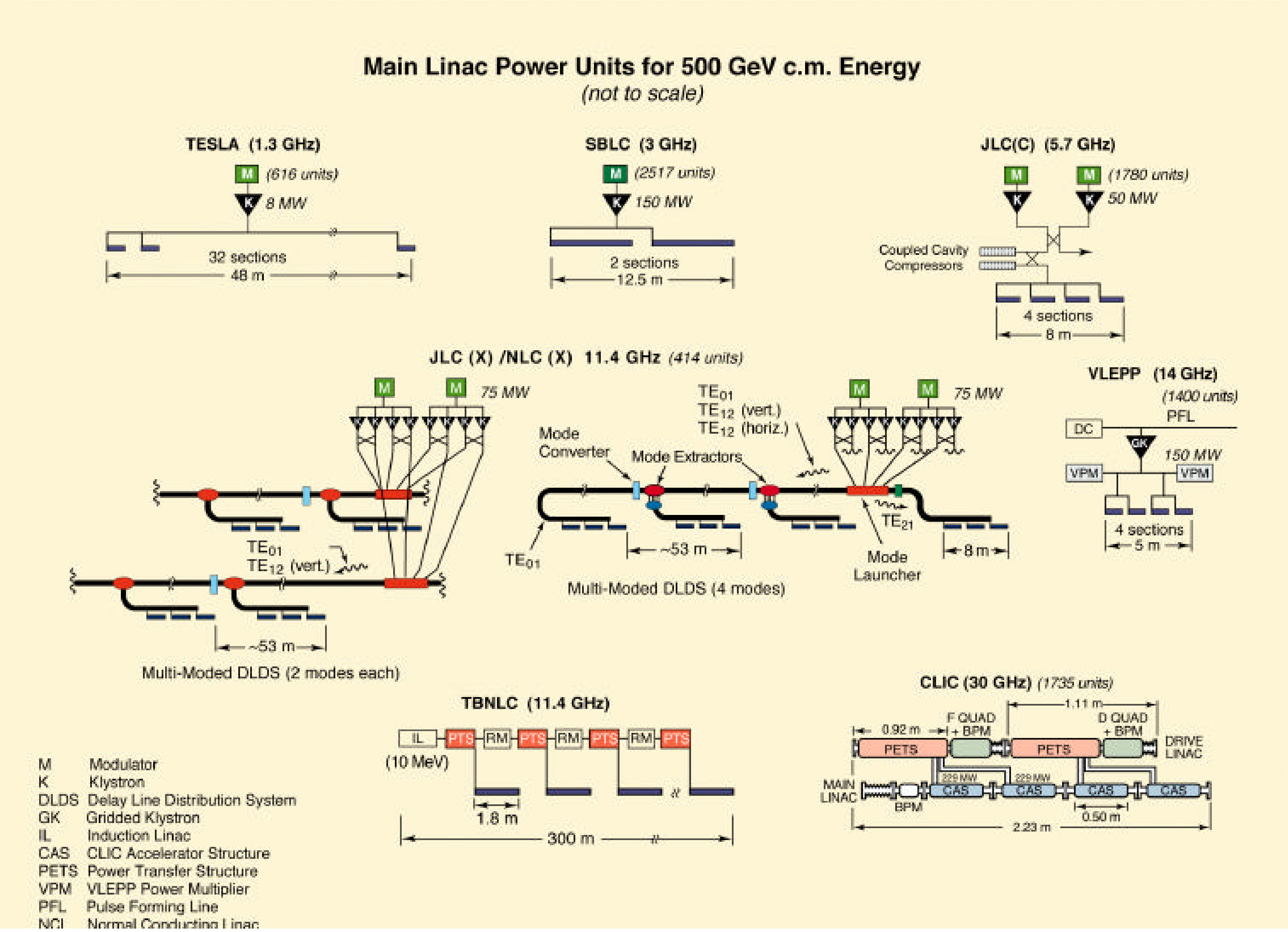


- Total AC to beam efficiency is the product of the efficiency of all subsystems
  - One needs a thorough understanding of all these numbers before one can make a judgement call on “feasibility”

- How do accelerator physicists optimize this:
  - RF and beam pulse get too long: cost and efficiency is dominated by energy storage
  - Pulses get too short: inefficient because of leakage inductance and stray capacitance

Power Distribution Systems (KISS II)

- Complexity
  - Layout of the facility
  - Layout of the linear accelerator
  - How many different components does one have to build, operate and maintain
  - “Every Linac proposal has a million cells…”
  - NLC: ~2000 Klystrons, TESLA: 20 000 couplers



Cost Optimization for a Linear Accelerator

- Three parts:
  - Linear cost (tunnel, rf structure, land etc) ~L
  - RF cost (G^2) ~1/L
  - Fixed cost (office buildings, project cost etc)
- Cost Optimum at RF Cost ≡ Linear Cost

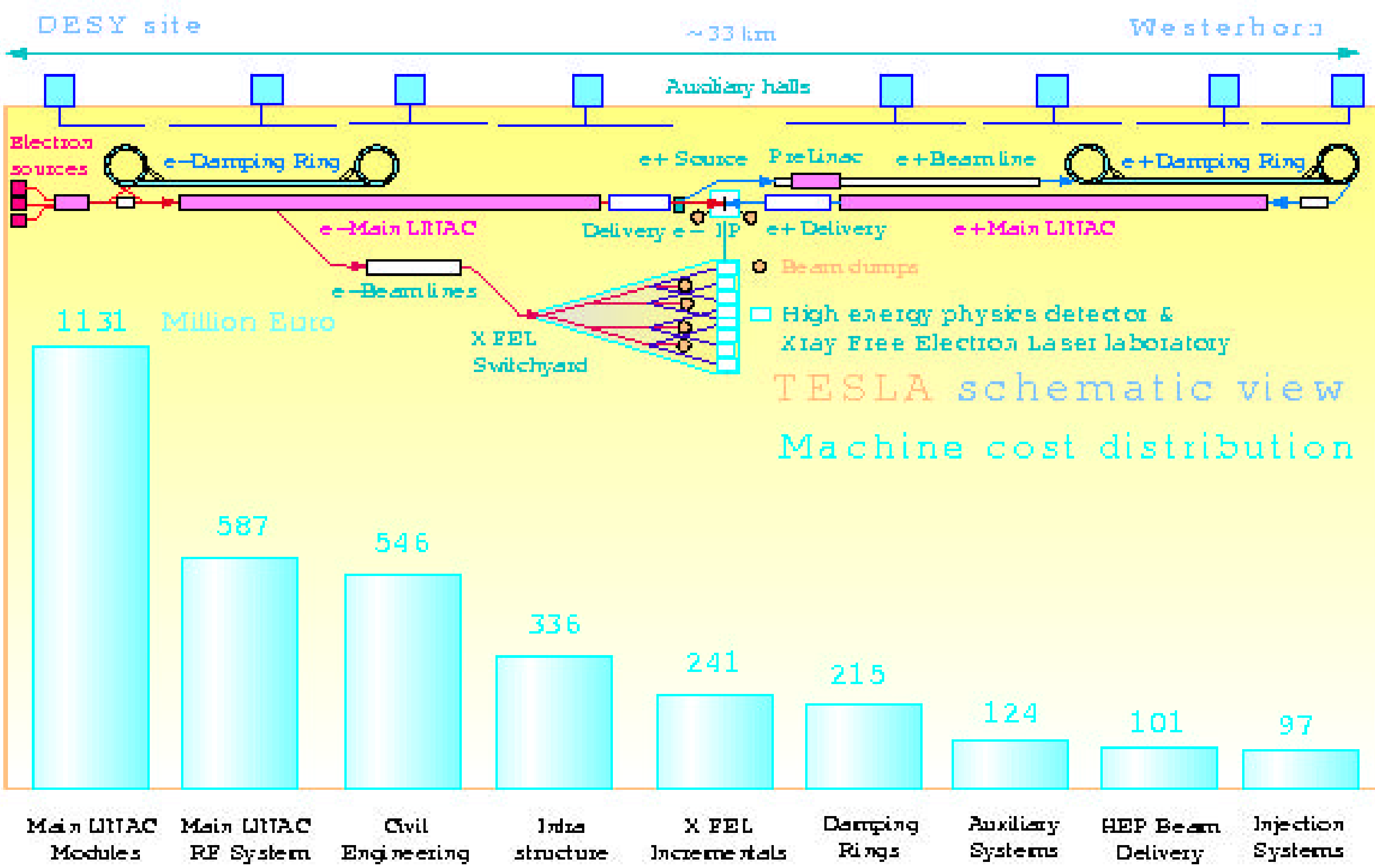
Assumption: (Fixed cost is small and may be it isn't)

1. If fixed cost is small, the cost optimized gradient is independent of the energy of the machine!
2. If fixed cost is small, this is a technology independent question with a technology independent answer!
3. If fixed cost is small, then a technology which is cost competitive at a specific energy is competitive at any energy!

- There is a variety of reasons not to follow this rule:
  - Available space
  - Cost of power
  - "Sex appeal of technology"
  - Available infrastructure
  - For certain designs the fixed cost might not be small

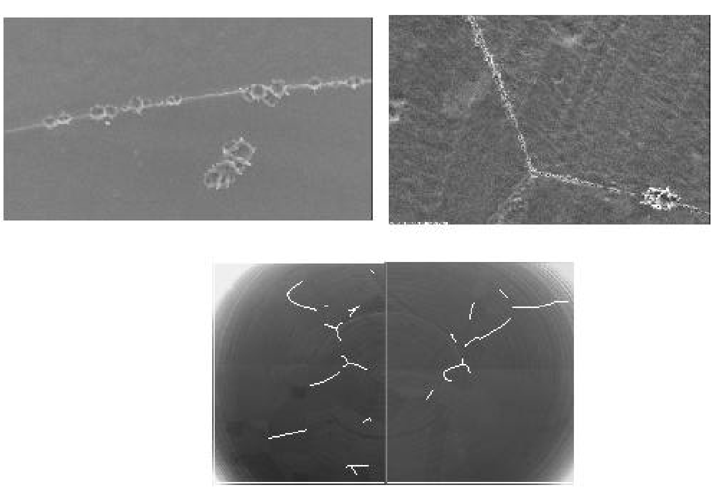
Example

- SC Linac dominated by accelerating structure cost
- NC linac dominated by cost to provide rf power

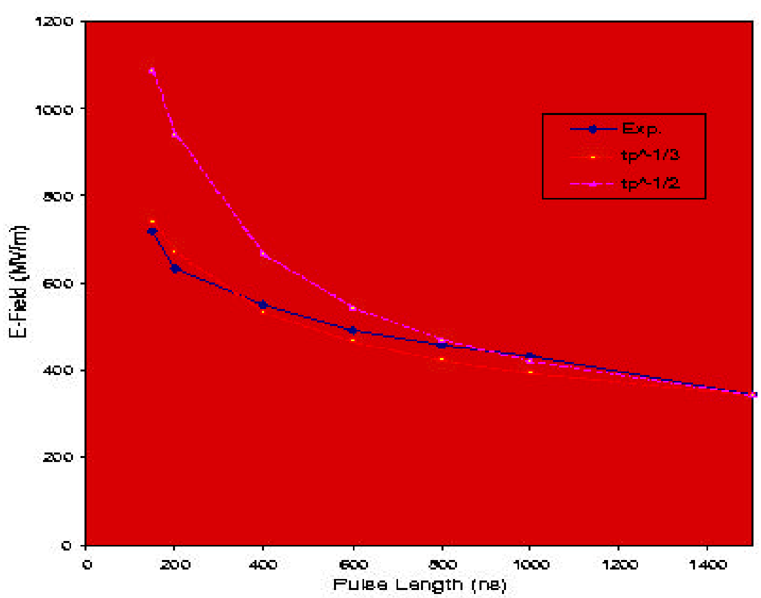


What Limits Gradient?

- Field emission ?
- Plasma discharge
- How does it scale (recently: P.Wilson, earlier J. Wang et al)?
  - As a function of Frequency: Maximum E_{surf}: ~ $\sqrt{F}$
    - Can we get there?
  - As a function of Pulse length: Pulse length: ~ ln(1+1/x)
- Standing or Traveling Wave?
- Group velocity
- Normal or superconducting?
- TESLA cell: ~ 10 J; NLC cell: 0.04 J

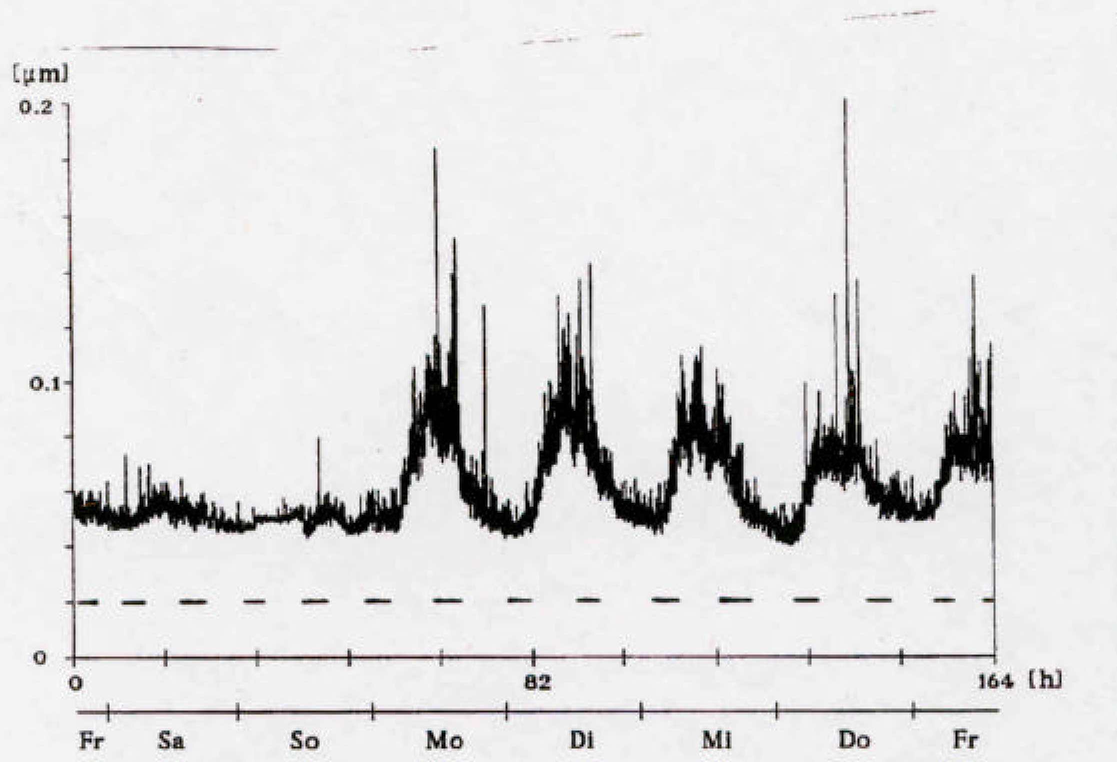


Top: Grain boundaries provide sites for breakdown (150 MV/m). Bottom: Melting along grain boundaries compared to total surface area.



Ground Motion

- Cultural noise: Accelerators in populated areas….

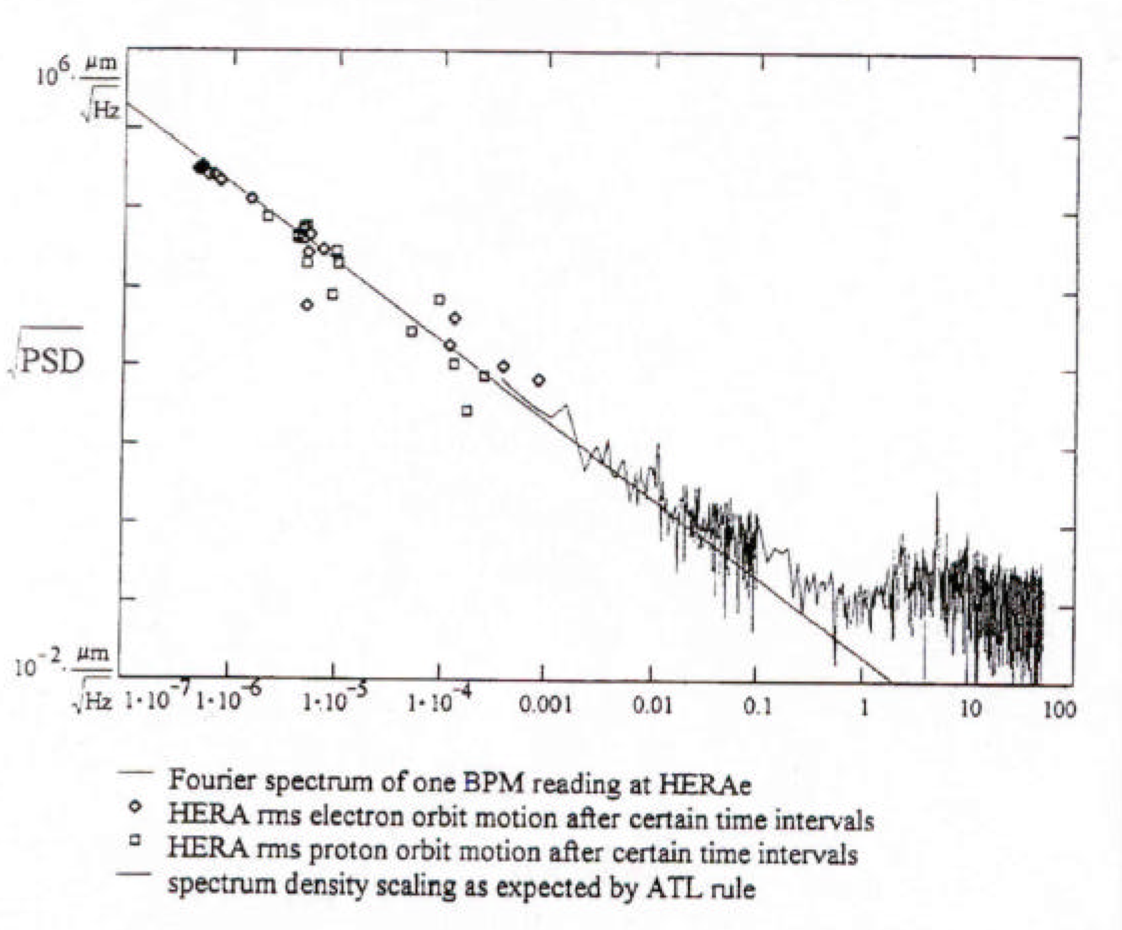


Long term measurement of rms–ground motion in the HERA tunnel during 1 week.

The ATL Rule

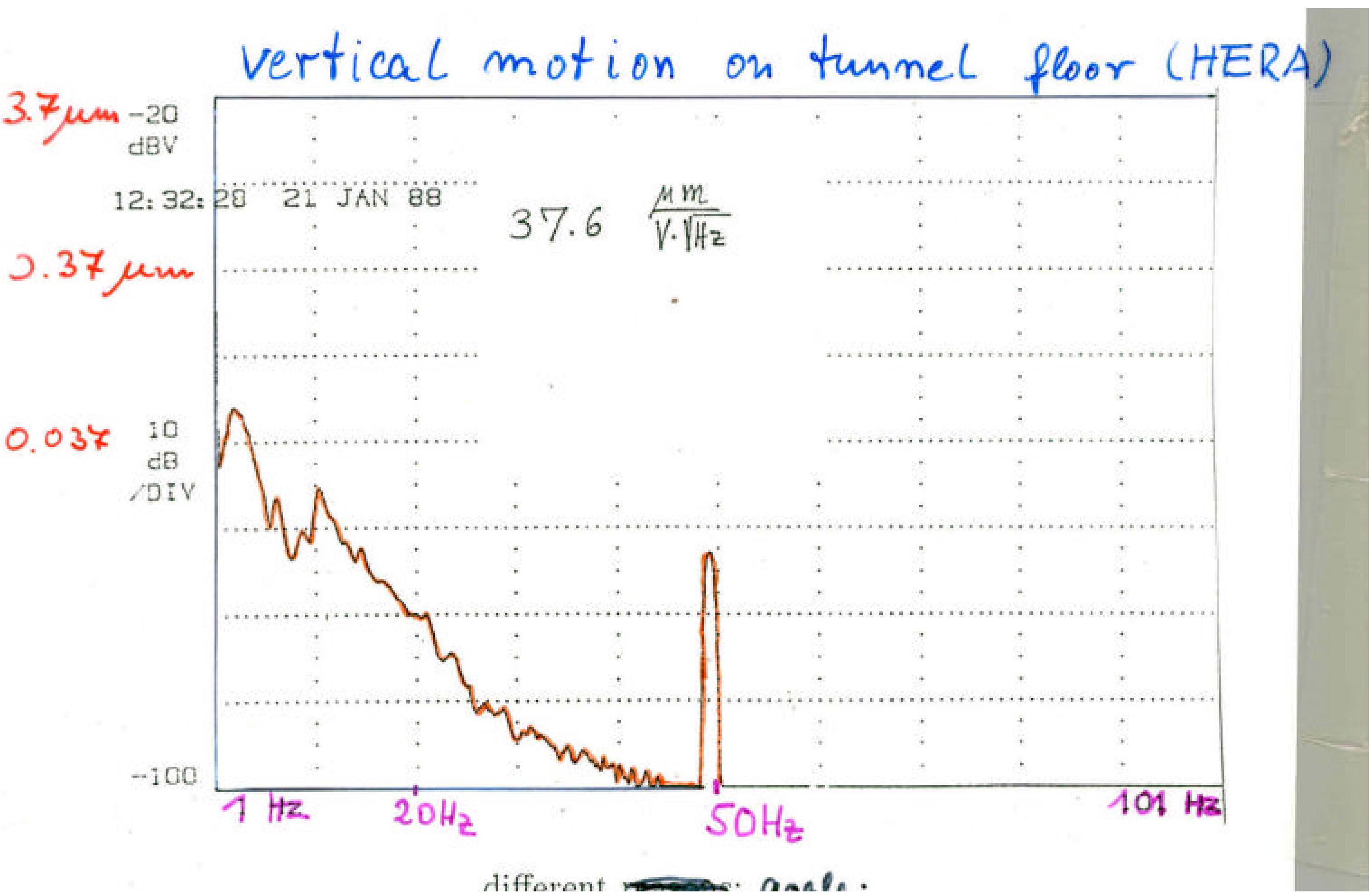
- ATL rule: Has been proposed, measured, disregarded, refined, fought over …

  - Compare to operation of HERA in a 6 km long tunnel below the city:
  - data extracted from Orbit drifts and direct measurement over 8 decades in frequency
    (Brinkmann, Montag, Rossbach, Schiltsev etc)



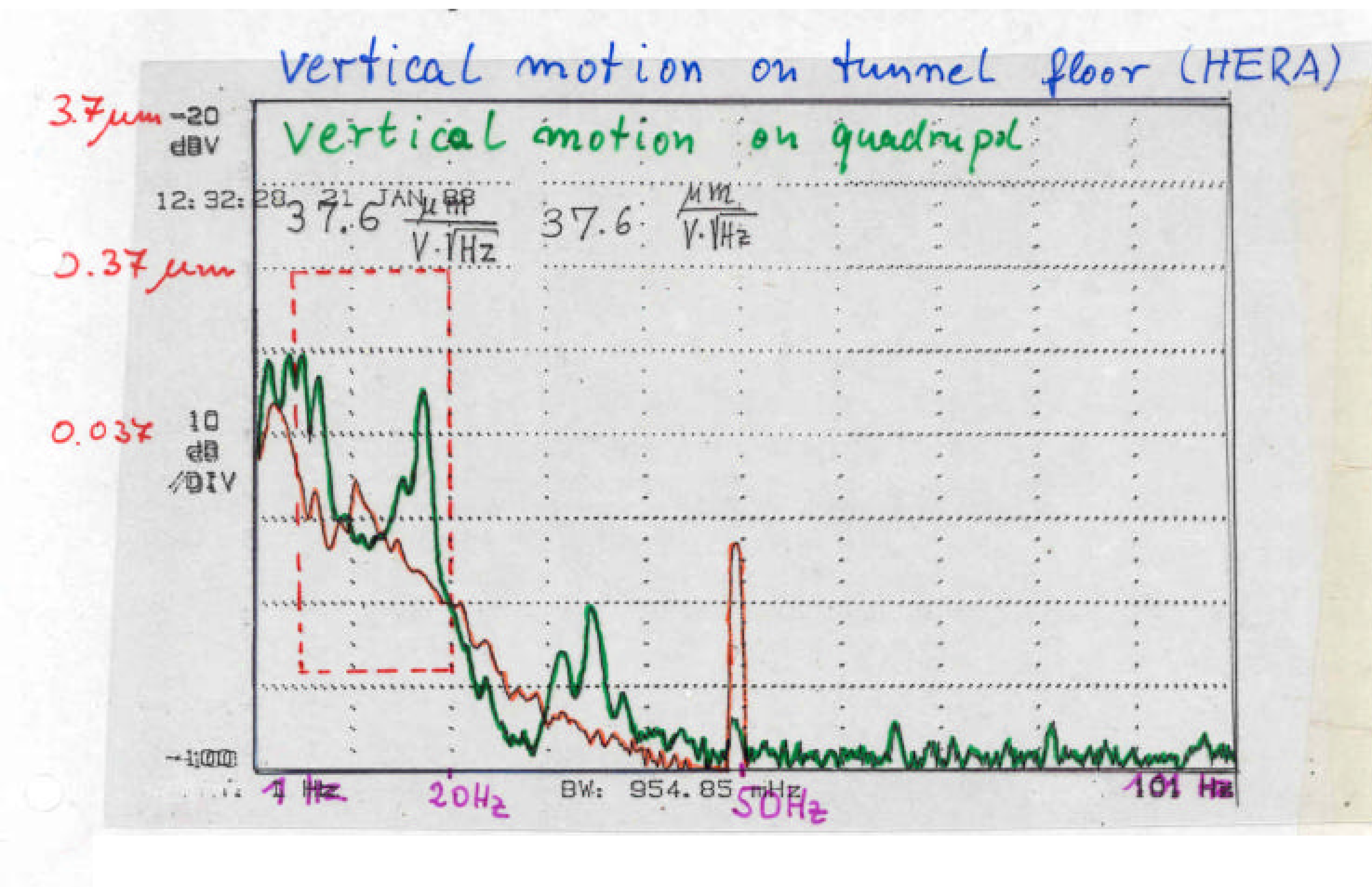
Ground Motion in Tunnel

- Measurement of vertical motion in a real tunnel environment with operating equipment
- Will not be able to afford submarine technology



Induced Motion

- NLC: How to prevent this with 180 000 gal/min flowing through the tunnel ?
- TESLA: How do you get to the quadrupoles to fix it in a cryostat?



Technical Feasibility

- How do we define feasibility ?
  - Neutrino Source Feasibility Study I:
    - If one can define today an R&D program with reasonable probability of success in n years (n<10), it is technically feasible.
    - Andy Sessler: It is technically feasible!
    - Burton Richter: At this point it is not!

- For a construction project ?
  - Test of all major technical subcomponents
  - Assurance for success in “mass production”
  - Test of critical issues on a reasonably large scale
    - Does one need a 0.2 %, a 1 % or a 10 % prototype ?
  - Expertise for all the other things that are necessary
    - Tunnels
    - Water distribution
    - Electric power distribution

R&D Cost

- How much has been spent on LC R&D worldwide?
  - Since 1990 probably 150 FTE's per year plus the M&S which we can see today..
  - Integrated that is certainly a good fraction of what one would consider a 10 % prototype of a linear collider
- The Test Facilities
  - What is the right scale?
  - What is the cost for a 10% test accelerator ?
  - Do we have programs that can do physics with these intermediate type linacs:
    - 4th generation light sources and spallation neutron sources for the sc rf
    - We need to find a good one for an x-band linac..

Risk

- Energy versus Luminosity
  - If the scaling laws turn out to be right than higher gradient and cheaper rf systems might allow the route to higher energies. At this point that is not a sure bet.
  - If maximum Luminosity (and especially L/$) is the driving force then making a sc linac to work is advantageous
  - Inflation of Luminosity numbers…
- Are these accelerators ready to go into construction?
  - On the scale we are talking we carry significant risk (SLAC and BBU)
  - The only viable route is 300 GeV to 500 to 800 and higher. These intermediate steps are crucial to reduce risk and ensure success.
  - To talk about 1 TeV and more at this point is a spreadsheet game…

The Advantage of Continuous Construction Projects

- Continuous Flow of good people
  - Younger people leave our field…?
  - Doing R&D for 10 ++ years is not going to open up a career path

- Experience going from the last generation to the next

- Money for R&D
  - Building a 1 GeV proton linac with superconducting cavities is probably giving more money for R&D then any other program going on…

Affordability

- Can we afford a linear collider?
  - Can we afford any next generation accelerator based HEP program ?
- Preoperation
  - How long will it take to commission this accelerator?
  - Look at the performance of recent large scale accelerators: HERA, LEP, RHIC .. Can we live with that?
- Operating budget
  - Is a significant fraction of the worldwide HEP money
  - For a single country: -> it will terminate all other programs
  - For an international collab: Probably… ok

REVIEW SCHEDULES

Month	Date	Area	Topic	WBS	Type	Location
Oct-00	4	Ring	Extraction Kicker Power Supplies	1.5.9.2		BNL
	5	Ring	Collimation and Shielding			BNL
	5	Ring	Stripper Foil			BNL
	5	Controls	Machine Protection System Review			ORNL
	10	Survey and Allignment	Survey and Allignment			ORNL
	11	Linac	Cryomodule	1.4.10-2.3	PDR	Jlab
	11	Linac	Cryomodule End Caps	1.4.10.3	FDR	Jlab
	12	DTL	DTL Intermediate DR	1.4.2	Intermed.	
Nov-00	11,12	Diagnostics	Beam Diagnostics, MEBT Instrumentation		FDR	LBNL
	16-17	Linac	CCL System PDR	1.4.4	Prel.	LANL
Dec-00	6	Linac	Cryomodule/End Can	1.4.10.2-3	FDR	Jlab
	6	Linac	SRF Coupler	1.4.	PDR	Jlab
	6	Linac	Warm Beam Pipe Vacuum Controls FDR			
	6,7	Diagnostics	Diagnostics Review			ORNL
	12	HEBT Interface	ICD Meeting			LANL
	17	Fac.	CTF		Final	
Jan-01	12	SRF Magnet Cooling	SRF Magnet Cooling FDR	1.4.9.2.2		
	16	Linac	Linac RF Controls	1.4.?	Final	LANL
	19	CCL-DTL	Vacuum Final Design Review		Final	
	19	Linac	DTL-CCL Vacuum Controls			
Feb-01	13	FE-Linac	MEBT Wire Scanner		Final	LBNL
	15-16	FE-Linac	Commissioning Workshop			LANL
	23-24	Linac	Linac/Magnet Power Supplies Systems Workshop		Workshop	LANL
	27	Linac	BPM-Phase			LANL
Mar-01	19	Linac	DTL-CCL Water FDR	1.4.x.5	Final	
Apr-01	11	DTL	DTL CCL Vacuum System	1.4.2	Final	
	13	CCL	CCL System FDR	1.4.4	Final	
	18	Linac	SRF Cavity Pre-Bid	1.4.	Prelim.	Jlab
	18-19	Linac	Cryo Design Review	1.4		JLab
	18	Linac	Transmitter Review-Maxwell	1.4.		
	26-27	Linac	Workshop on LLRF Controls	1.4	Jlab	
May-01	1	Linac	DTL System	1.4	Final	LANL
	15-18	Linac	DTL Mecanical Review	1.4.	Final	LANL
	23	Linac	CHL-RF Facilities	1.4	Final	SF
	24	Linac	Converter-Modulator	1.4.	Final	LANL

Too many reviews, and
Not enough experienced
Project leaders

Summary

- What is the right set of parameters for a Linear Collider ?
  - Less is better..
  - Potential is what we want..
  - I don’t know: But if
    - The high energy physicist do not help defining a viable route to higher energies and higher Luminosities, I do not believe that we get there in 1 step.
    - The high energy physicists do not get involved enough to understand the trade offs themselves, we will not come to a decision on what to built next.
- Are the parameters that are presented today realistic?
  - They are 4 orders of magnitude above those from the last operating LC
  - Certainly for NLC and TESLA there is no clear indication that these numbers are not possible..
- You got all the information .. Use it!
  - “the stakeholders have to get back into the business” M.T.

HEPAP Sub-Panel

….
Therefore, it is timely for the U.S. program to examine its long-term research directions and needs in terms of maintaining its traditional role among the world leaders in HEP research.

Thus, we are charging the subpanel to undertake a long range planning exercise that will produce a national roadmap for HEP for the next twenty years. The subpanel should describe the discovery potential and intellectual impact of the program and recommend the next steps to be taken as part of an overall strategy to maintain the United States in a leadership role in HEP. In considering the many scientific opportunities facing the field and some potentially large associated costs, the plan will have to address some difficult questions, weigh options, and set priorities. In particular, the subpanel should weigh the scientific promise and programmatic importance of both accelerator and non-accelerator based efforts in relation to their expected costs. To be most helpful, the plan should indicate what funding levels the roadmap would require (including possible construction of new facilities), and what the impacts and priorities should be if the funding available provides constant level of effort.

1. MAJOR INTELLECTUAL CHALLENGES & SCIENTIFIC APPROACHES:
What are the central questions that define the intellectual frontier of HEP? The reach of the subpanel's considerations should include the accelerator-based particle physics program, related activities in astrophysics and cosmology, theory, and the proper balance of these elements. Describe these questions in relation to the tools, existing and new, required to effectively explore them.
2. STRATEGY REGARDING THE ENERGY FRONTIER:
The leading discovery tool in HEP in the 20th century, and as far into the future as one can see, is the energy frontier accelerator/storage ring. In the context of the worldwide scientific effort in particle physics, formulate a plan that optimizes the U.S. investment of public funds in sustaining a leadership role at the high energy frontier, including a recommendation on the next facility that will be an integral part of the U.S. program.
3. MEETING TECHNOLOGY CHALLENGES:
Identify technology developments essential for new instruments and facilities required to address the central questions noted above, and how these developments are captured in R&D plans. Explain the connection and importance of these R&D activities to the U.S. HEP program over the 20-year span of the plan developed by the subpanel.
4. BROAD IMPACTS AND INTELLECTUAL RENEWAL OF HEP:
Summarize the wide-ranging impacts of the field on society; and recommend ways in which the excitement and the broad, long-term benefits of HEP can be maintained and conveyed to students at all levels, to society at large, and to government.

There have been several high quality strategic HEP planning efforts in the past few years, and we expect the subpanel to take advantage of the wisdom and information contained therein. Those excellent reports notwithstanding, there is a need for the community to go further in the present exercise. Specifically, the long-range plan must contain a broad vision of the future of HEP in terms of resources needed; and further, it must enjoy the widespread support of the U.S. HEP community. Although we want the community to enunciate its vision of the future in the way that seems most appropriate, the subpanel's plan must also be responsive to the specific charges given above.

The long-range plan should have a concise executive summary that is accessible to government officials, the press, and scientists in other fields. In addition, a briefing book consisting of presentation material should be produced to facilitate communication of the long-range vision to diverse audiences. …. If this quest is to be successful, it will require a unified and vibrant HEP community.

The SNOWMASS Program

Find a Consensus ?? When and Where ….

Does the field want a consensus ?

		THIS AGENDA IS PRELIMINARY, INCOMPLETE, AND SUBJECT TO REVISION						
				Version of 26 April 2001				
	Saturday June 30	Sunday July 1	Monday July 2	Tuesday July 3	Wednesday July 4	Thursday July 5	Friday July 6	Saturday July 7
Morning	Arrival	Plenary	Plenary	Working Groups E&M	Working Groups E&M	Working Groups P&T	Working Groups E&M	Working Groups E&M
Noon						NPSS Lecture 1	NPSS Lecture 2	
Afternoon	Arrival	Plenary	Working Groups P&T	Working Groups P&T	Fourth of July Holiday	Teach-in: Accelerator R&D	Working Groups P&T	Working Groups P&T
Twilight	SVPA Cookout	Welcome Reception				Informal Reception		
Evening			Lab Directors Forum	Global Accelerator Network		Town Meeting		
Technology School						Topic 1	Topic 2	
			<............... International Laboratory Directors ....>					
Outreach Special Events								SCIENCE WEEKEND
			<............... QuarkNet Teacher Training ....>					
		Sunday July 8	Monday July 9	Tuesday July 10	Wednesday July 11	Thursday July 12	Friday July 13	Saturday July 14
Morning		OPEN?	Working Groups E&M	Working Groups P&T	Working Groups E&M	Plenary	Working Groups E&M	Working Groups E&M
Noon			NPSS Lecture 3	NPSS Lecture 4	NPSS Lecture 5		NPSS Lecture 6	
Afternoon		OPEN?	Working Groups P&T	Teach-in: String Theory	Working Groups P&T	Plenary	Teach-in: Nonaccelerator Experiments	Working Groups P&T
Twilight				Informal Reception		Mid-Snowmass Night Party	Informal Reception	Bastille Day
Evening			Outreach & Education		Popular Lecture?		Physics of the Universe	
Technology School			Topic 3	Topic 4	Topic 5		Topic 6	
			<............... (Nonaccelerator Emphasis ?) ....>					
Outreach Special Events		SCIENCE WEEKEND					HEPAP	HEPAP
			<............... ? ....>					
		Sunday July 15	Monday July 16	Tuesday July 17	Wednesday July 18	Thursday July 19	Friday July 20	Saturday July 21
Morning		OPEN?	Working Groups E&M	Working Groups E&M	Working Groups E&M	Working Groups E&M	Plenary	Departure
Noon			NPSS Lecture 7	NPSS Lecture 8	NPSS Lecture 9			
Afternoon		OPEN?	Working Groups P&T	Working Groups P&T	Working Groups P&T	Plenary	Plenary	Departure
Twilight						END OF RUN PARTY		
Evening			Thematic Survey	Young Physicists Forum	Working with Governments			
Technology School			Topic 7	Topic 8	Topic 9			
			<............... ? ....>					
Outreach Special Events								
			<............... SALTA Teacher Training ....>					

Might be the only place !