

1. Physics capability at ~ 500 GeV -- highlights
2. Special operating conditions
3. What energy/luminosity will we ultimately need?
4. Some scenarios
5. How does the world community proceed?

A necessarily telegraphic tour through the many results shown here, focussing on some more general issues. The views are mine, and of course can be argued with! The many good results and ideas are yours!

Linear ee Colliders

(Napoly, Raubenheimer,
Chin, Wilson, Tauchi,
Markiewicz)

		TESLA	JLC-C	NLC/JLC-X *
$\mathcal{L}_{\text{design}}$	(10^{34})	3.4 → 5.8	0.43	2.2 → 3.4
E_{CM}	(GeV)	500 → 800	500	500 → 1000
Eff. Gradient	(MV/m)	22 → 35	34	50
RF freq.	(GHz)	1.3	5.7	11.4
Δt_{bunch}	(ns)	337 → 176	2.8	1.4
#bunch/train		2820 → 4886	72	190
Beamsstrahlung	(%)	3.2 → 4.4		4.6 → 8.8

* US and Japanese X-band R&D cooperation, but machine parameters may differ

$\mathcal{L} = 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ for 10^7 sec. year
gives 100 fb^{-1} per year

- TESLA : Design report spring 2001; German funding decision ~ 2002?
- NLC : aim complete R&D for Design Rept 2003
- JLC : set milestones end 2000: Design Rept ~2003

CLIC : multi-TeV, 30 GHz, 150 MV/m gradient with drive beam power source in R&D phase

Physics at the ~ 500 GeV Collider

Excellent summaries from the working groups of recent progress - don't repeat.

("The Case for a 500 GeV e^+e^- Linear Collider" , American Linear Collider Working Group: hep-ex/0007022)

Higgs studies:

(Battaglia, Desch, Okada)

The LC should do an excellent job of profiling the Higgs; this is probably the premier case for LC500 .

- determine its J^{PC} unambiguously
- accurate mass and width
- measure branching ratios (couplings) for all dominant decays; distinguish SM from Susy higgs over much of parameter space; verify the coupling to mass
- measure Higgs self couplings; determine the potential
- Are parameters SM or not?
If Susy Higgs, get independent parameter determination ($\tan \beta$, M_A etc.) from that in sparticle sector (but with model assumptions until H/A seen)

We usually say that Higgs sector controlled by (M_A , $\tan \beta$). But without assumptions, there are **many** Susy soft parameters in the Higgs sector, including CP-viol. phases. These complicate the phenomenology and require more measurements (& also weaken the existing LEP limits).

Physics at ~ 500 GeV - Higgs

Crucial to measure Higgs couplings, demonstrate coupling to mass. Studies for $m_{\text{Higgs}} = 120$ GeV with $E_{\text{CM}} = 350$ GeV, 500 fb^{-1} give couplings of Higgs to fermions, WW, ZZ at few % level

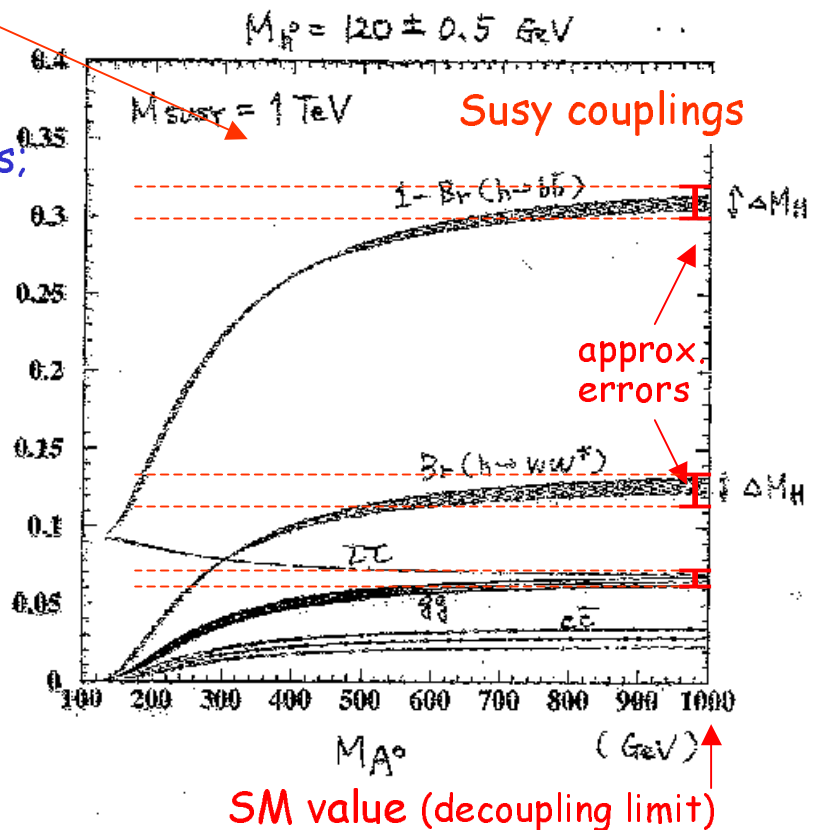
Knowledge of couplings crucial for probing non-SM Higgs sectors.

Reproduce, verify these results; extend to other Higgs masses; study higher mass case.

Measurement of $t\bar{t}H$ Yukawa couplings also crucial; can be done but need higher energy (> 700 GeV) and high luminosity (10% for 500 fb^{-1})

Higgs self coupling (HH production) determines the Higgs potential. Need 1 ab^{-1} for 20% measurement?

Study the Susy parameter determination from the Higgs sector alone; go to fully model independent studies including CP violating phases, non-tree level etc.



Physics at ~ 500 GeV - Susy

Susy :

(Godbole, Martyn)

The LC complements the LHC (will do sleptons, sneutrinos, gauginos well); electron polarization (positron?) is essential to disentangling states and processes. LC adds crucial understanding of Susy and its underlying structure.

- Determination of masses, J^{PC} , \mathcal{CP} phases, mixing angles in chargino, neutralino and stop sectors
- Explore the model independent Susy world of 105 soft parameters -- **for kinematically accessible sparticles**. Probe the character of Susy breaking, and hence the underlying nature of EWSB. **We must explore Susy independent of mSUGRA, GMSB, AMSB, χ MSB, frameworks, and understand Susy breaking.** LHC cannot do this.



Are we assured that ~ 500 GeV is enough to see substantial portions of Susy spectrum?

There are plausibility arguments that say yes:

- if Susy is to produce EWSB and yield observed m_Z , m_W without 'excessive' fine tuning
- if the LSP is the dark matter particle
- if Susy CP violating phases produce the cosmic baryon asymmetry

It is highly likely that at least the lighter gauginos, sleptons, stop are accessible.

Physics at ~ 500 GeV - Susy

But these assumptions need not be wholly true;

We need to retain some flexibility to adjust the energy based on Tevatron/LHC results.

reaction	Point 1 GeV	2 GeV	3 GeV	4 GeV	5 GeV	6 GeV
$\chi_1^0 \chi_1^0$	336	336	90	160	244	92
$\chi_1^0 \chi_2^0$	494	489	142	228	355	233
$\chi_1^+ \chi_1^-$	650	642	192	294	464	304
$\chi_1^+ \chi_2^-$	1089	858	368	462	750	459
$\tilde{e} \tilde{e} / \tilde{\mu} \tilde{\mu}$	920	922	422	1620	396	470
$\tilde{\tau} \tilde{\tau}$	860	850	412	1594	314	264
Z h	186	207	160	203	184	203
Z H/A	1137	828	466	950	727	248
$H^+ H^-$	2092	1482	756	1724	1276	364
$\tilde{q} \tilde{q}$	1882	1896	630	1828	1352	1010

← LHC mSugra points (are these representative? and only mSugra!)

RED:
reactions accessible at
500 GeV

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RED:
reactions accessible at
1000 GeV

Physics at ~ 500 GeV - if no Susy

(Kim, Kilian, Orr, Dobrescu, Arkani-Hamed)

Look for manifestations of Strong coupling

- Anomalous $WW\gamma$, WWZ couplings: $\Delta\kappa_{\gamma/Z} \sim 5 \times 10^{-4}$, $\lambda_{\gamma/Z} \sim 6 \times 10^{-4}$ (500 fb^{-1}) should see observable effects of strong coupling.
- Anomalous $t\bar{t}Z$ vector/axial vector form factors should be sensitive to strong coupling effects with $\sim 100 \text{ fb}^{-1}$
- Strong coupling models typically modify the oblique corrections and affect the precision Z measureables, top and W mass. High statistics Z/W samples should reveal their effects.
- Top see-saw models produce heavy Higgs composite states, with mixing of CP eigenstates. LC can disentangle these through width and BR measurements

Large extra dimensions:

- See Kaluza Klein towers through interferences, possible graviton effects, modification of Higgs properties, new particles, $t\bar{t}$, WW production, ee scattering... Quantum number determination and branching ratios complement the LHC picture of LED's.

Physics at ~ 500 GeV

- ◆ Top Quark studies
 - mass determination to 200 MeV
 - anomalous ttZ / $tt\gamma$ couplings
 - spin correlations
- ◆ QCD studies
 - α_s to 1% from $\gamma\gamma$ qq, Giga Z
 - BFKL dynamics through $\gamma\gamma$ scattering
 - Photon structure function
- ◆ Electroweak measurements
- ◆ Surely other new topics ! (number of new words heard here -- Torsion, magnetic neutrinos, non-commuting space-time ...)

Physics at ~ 500 GeV

Conjecture :

Whatever causes EWSB, whether the SM Higgs alone or physics beyond the SM, the Linear Collider will see measurable effects at 500 GeV.

cannot be proven rigorously!

But there is a very strong plausibility that the LC will have a crucial role, no matter what the character of new physics is, and that without the LC we will not understand the new physics.



LEP/SLC made no discoveries; but LEP/SLC elucidation of the SM was an overwhelming success! LC should do the same for Beyond the Standard Model.

Special operating conditions

There are several special operating conditions for the Linear Collider that may add important physics capabilities, but also create extra complexity or costs. How should we view these options?

- ❑ Positron polarization
- ❑ Gamma gamma collisions
- ❑ Low energy collisions (M_Z , WW threshold, ZH cross section maximum)
- ❑ $e^- e^-$ collisions

Need for these options tend to depend on the physics scenario that we find ourselves in.

- ❑ Use of Linear Collider for X-ray synchrotron radiation studies

Positron Polarization

The need for **electron** polarization is clearly recognized, and is expected to be present at $\sim 90\%$. What is the case for **positron** polarization? (studies based on $\sim 50\%$)

(getting e^+ polarization is not as simple as e^- ; either use polarized photons from undulator magnets to pair produce e^+e^- , or backscattering from high power lasers. These schemes need further development, and the stability of e^+ polarization from pulse to pulse needs to be determined.)

What does e^+ polarization buy us?

If we want to reduce the error on $\sin^2\theta_W$ to 0.00002 with giga-Z samples using A_{LR} , etc., it would be highly desirable to have polarized e^+ (to reduce the error on effective polarization). Such precision would improve the determination of S and T by about a factor of 8. Need for this is dependent on physics scenario.

(Moenig, Kilian)

Higgs pair production (Higgs potential) cross section increases with positron polarization ($\times 2$ for $P_+ = 1$).

(Desch, Okada)

Polarized positrons allow improvements in Susy parameter determinations (gaugino mixings, masses) near threshold. Positron polarization can help dial in different processes; improves precision of parameter determination, but higher statistics without positron polarization could yield these results. (Martyn)

Ultimately e^+ polarization will be desired; the possibility should be built in.

$\gamma\gamma$ Collisions

(Takahashi)

Can make $\gamma\gamma$ collisions by backscattering from high power lasers at $\sim 80\%$ of energy of e^+e^- collisions. Recent developments in lasers are promising; special handling needed for beam masks, mirrors, etc.

In the case that there is a low mass Higgs, we want to measure its width accurately. LHC cannot do it below $200 \text{ GeV}/c^2$.

Measurement of $\text{BR}(H \rightarrow \gamma\gamma)$ and $\sigma(\gamma\gamma \rightarrow H)$ can give Γ_{higgs} to 5% (200 fb^{-1}). This gives constraints on unseen Higgs decays.

$\gamma\gamma \rightarrow$ Higgs allows tests of CP violation with circularly polarized γ 's. $\gamma\gamma \rightarrow H$ or A ; helps disentangle.

Potential for studying longitudinal W scattering in $\gamma\gamma$ collisions, searches for excited leptons, large extra dimensions.

$\gamma\gamma$ production of charginos offers clean determinations of gaugino mass matrix parameters.

Photon collisions could be of importance in some physics scenarios, but not as a first line need for the linear collider.

Low energy running

(Moenig, Kilian)

Proposal (NLC) to operate a pickoff beam up to $\frac{1}{2}$ max. energy, in unused time slices of machine. High energy interaction region nearly straight ahead; low energy region at larger angle bend. Two detectors sharing collisions. At TESLA, some running at Z-pole, WW threshold. "Giga-Z"

In 30 fb^{-1} , one can collect $\sim 10^9$ Z's, about 10^8 b-pairs, 3×10^7 τ pairs.

Revisiting the Z-pole with these statistics corresponds to ~ 100 LEP-I runs, with polarization. Estimated improvements in precision Z measurements:

$\sin^2\theta_W$: ± 0.00021	\rightarrow	0.000013	(X1/15)
$\Gamma(Z \rightarrow \ell\ell)$: ± 0.09	\rightarrow	0.04 MeV	(X1/2)
$R_b^{\text{exp}}/R_b^{\text{th}}$: ± 0.0035	\rightarrow	0.0007	(X1/5)
$A_b^{\text{exp}}/A_b^{\text{th}}$: ± 0.017	\rightarrow	0.001	(X1/15)

Operating at the WW threshold could improve the W mass accuracy to 6 MeV (100 fb^{-1}).

These measurements could improve S and T accuracy to about 0.02 (X8 improvement), to the level where tiny modifications from heavy new fermions could be sensed. Constrain not only SM, but Susy models.

These precision measurements indirectly predict Higgs mass to 4%, and severely constrain models of new physics.

Low energy running

10^9 bb pairs at Z pole (10^{10} Z !) could be of interest: R_b, A_b, CKM parameters $\rightarrow (V_{ub}, B \rightarrow \pi\pi, b$
svv , B_s mixing ...)

If there is a low mass Higgs, might use the low energy beam line at energy of maximum Z+H production as a Higgs factory - provide dedicated Higgs studies while going to higher energy in the other experiment. Would want more luminosity for the Higgs than for Giga-Z .

□ While the utility of low energy running depends somewhat on physics scenario, most such scenarios give strong reasons to do it. Is the experimental community supportive of a low energy detector? Does it require a separately optimized detector? Would there be a strong interest in forming such a collaboration for this physics ?

$e^- e^-$ Collisions

$e^- e^-$ collisions can be provided, both with large polarization, but at somewhat reduced luminosity. Often cleaner than e^+e^- .

Some Susy studies (e.g. selectron production and properties) can be improved using polarized electron scattering. Search for $\tilde{e} \rightarrow \mu \tilde{\chi}$ (if ν 's mix, why not sleptons?)

A variety of searches for new phenomena, complementary to e^+e^- , such as lepton compositeness, studies of strong WW scattering, searches for extra dimensions are made possible with $e^- e^-$ collisions.

□ The utility of $e^- e^-$ collisions will depend somewhat on the physics scenario. If there is no Susy, searches in $e^- e^-$ may well be of increased interest. It is not thought that the $e^- e^-$ facility drives the LC design issues strongly, but it should be kept in mind during design.

Linear Collider for synchrotron radiation

(Arthur)

The use of the linear collider to provide short bunch, high energy photons gives new capabilities in many branches of science -

- structural studies of biomolecules and particles at angstrom resolutions and short times
- exploration of warm plasmas, equations of state in planetary interiors, ion beams etc.
- high field atomic physics; exotic atomic states
- nanoscale dynamics in condensed matter; collective effects, short time correlations, ...
- x-ray laser and x-ray imaging
- femtosecond chemistry

Broadening the scientific base for the Linear Collider enhances the prospects for its success. Outreach to the light source community, and building a machine that is capable of use for such experiments is of benefit to us all. SLAC LCLS and DESY have pioneered this connection. It should be fostered in LC proposals.

What energy/luminosity will we ultimately need?

A. Higgs Studies ...

Getting the Higgs BRs is critical to understanding its character; high statistics samples may be needed if M_{higgs} is high where fermionic BRs decrease.

Measuring Higgs trilinear self-couplings is a crucial test of the Higgs mechanism and determines the potential. High statistics needed (1000 fb⁻¹ for 10 - 20% determination).

Precision profile of SM Higgs requires high statistics at ~500 GeV

Measuring top Yukawa coupling (ttH) requires energy upgrade (> 700 GeV) and substantial statistics.

Susy Higgs (H, A, H⁺) tend to be heavy. Want to study these if they exist, determine mass, decays, mixings. The LHC is unlikely to study these states. Likely to need 1 TeV LC.

Susy Higgs and top Yukawa couplings will likely need energy upgrade

Energy/luminosity need

B. If there is Susy ...

In the MSSM, there are > 100 soft parameters in the Lagrangian, including a set of CP-violating phases. We will need to measure them all, not just the 5 mSUGRA parameters, to make contact with the underlying theory of EWSB, and possibly string theory.

To do this, will need to find all the gauginos, sleptons, etc. to disentangle the mixing angles, phases, trilinear terms etc. This will surely require higher energy.

If the LSP is the dark matter in the universe, this imposes some constraints on LSP mass; a 500 GeV LC accesses about 60% of dark matter parameter space; cover it all with ~ 1.25 TeV.

Getting the higher mass superpartner states (and the heavier Susy Higgs) will likely require energy upgrade to at least 1 TeV. It is important to build this upgrade capability into the design.

Energy/luminosity need

C. If non-Susy physics beyond the SM

The states in strong coupling models tend to be higher in mass to evade the precision constraints from Z-pole measurements.

Anomalous ($t\bar{t}H$) couplings are typical case; to reach needed sensitivity, need high luminosity and higher energy.

Strong coupling models modify $W_L W_L$ scattering. Need > 1 TeV to extend LHC results.

Extra U(1) groups predict additional Z' states; LC sensitive to $\sim 10X$ cm energy, so 500 GeV LC is about same sensitivity as LHC. Roughly double reach with 1 TeV LC.

Probes for large extra dimensions -- KK states, new Z' , possible spin 2 states, γ /monojet final states -- all benefit directly from added energy. Need LC energy of 1 TeV to improve the LHC reach?

Non-Susy extensions to SM would likely bring need for higher energy LC.

Energy/luminosity need

The LC 500 GeV program is rich and rewarding, but there is every likelihood that physics will drive energy increase. A linear collider project should be seen as an evolutionary effort that has a long lifetime, several phases and expanding energy reach.

Several measurements are likely to need 100's fb^{-1} . There will be a variety of machine settings needed to explore the new physics (different energies, several polarizations, possible $\gamma\gamma$ runs, ...). The total run plan (time, energy, beams) needed for some scenarios of physics should be developed. Compromises will be needed!

Some scenarios

(Komamiya)

What we need from Linear Collider experiments differs with how physics results from LEP2, Tevatron, LHC, B factories play out ... for example:

1. There is a Higgs below 130 GeV and evidence for Susy from Tevatron/LHC:

at ~ 500 GeV (and below): measure the Higgs properties (width, quantum #s, BRs, self-couplings)

measure the accessible Susy particles masses, Q#s, mixings to delineate the generic Susy model.

at ~ 1 TeV: find the remaining sparticles and heavy Higgs; determine the full soft Susy Lagrangian and connect to the nature of physics at much higher scales.

Scenarios:

2. There is a Higgs below 180 GeV and no evidence for Susy.

at ~ 500 GeV and below: measure the Higgs parameters with as good accuracy as possible. This is critical to probe non-SM effects directly in the Higgs sector.

Return to the Z-pole and WW threshold to make big improvements on the precision measurements to help point the way to new physics beyond the SM.

Measure anomalous WWV couplings accurately.

at ~ 1 TeV or above, study anomalous ($t\bar{t}H$) couplings, seek deviations in WW scattering, seek direct evidence of states from strong coupling, large extra dimensions, etc. High energy will be key here.

Scenarios:

3. There is a Higgs above 180 GeV and no evidence for Susy.

(we now have SM discrepancy! Higgs outside precision constraint)

at ~ 500 GeV and below: Now will have trouble measuring Higgs BRs apart from WW/ZZ . Determine Higgs J^{PC} . Direct measure of Γ_H from $\gamma\gamma$ scattering may be crucial. CP-violation?

Return to the Z-pole and WW threshold to help point the way to new physics beyond the SM.

Note that in this case, though we learn less about the Higgs from its decays, the LC is still better than the LHC, or any other colliders before a μ Collider at the Higgs pole.

at ~ 1 TeV or above, anomalous ($t\bar{t}H$) couplings, deviations in WW scattering, evidence of states from strong coupling, large extra dimensions, etc.

Scenarios:

4. There is no Higgs and no evidence for Susy.

at ~ 500 GeV and below: Close the invisible Higgs (at LHC) window and other loopholes. Probe the anomalous WWV and top couplings.

Return to the Z-pole and WW threshold for precision measurements to help point the way for next step in this non-SM world.

5. Have Higgs, Susy, and other new physics signatures all together.

The world is so complex that the Linear Collider works for years to unravel the new physics. The LC, both at 500 GeV and above are essential for progress.

Scenarios:

Are there scenarios in which the Linear Collider is not needed?

I think not - in scenarios examined, there are identified phenomena that need to be studied with the well-controlled initial state accessible from e^+e^- collisions, starting at 500 GeV.

In the event that we see little new (only Higgs or nothing), we still have to **understand why the SM works so well**, and this requires closing loopholes in LHC searches, refining precision measurements, and probing for new phenomena that would escape LHC.

But the detailed choices of energy, colliding particles, polarization, will depend on the scenario Nature gives us. **The Linear Collider project needs to retain the flexibility for evolving from the initial ~500 GeV stage to meet the needs.**

How does the world community proceed?

(this is a personal point of view, colored by the U.S. outlook - but we need to engage these issues as a world community over the coming year.)

1. Timelines:

- We expect Tesla design report in spring 2001; decision 2002?
- Japan JLC proposal in few years
- US NLC R&D over next 2-3 years leading to proposal
All 3 regions conducting studies of physics priorities for next ~20 years during coming year.

Alternate new projects:

- μ Storage Rings could only be ready for decision ~2010;
 - μ Collider or multi-TeV ee collider only much later in that decade;
 - VLHC needs physics input from LHC/LC and development of cost-effective magnets.
 - Very large underground laboratories
- ⊕ CERN is evaluating its future beyond LHC

How do we proceed?

2. Should the LC be the next world machine at high energies?

- I believe it is inevitable that the **LC decision is the next that must be taken by the worldwide community.** We are developing real proposals in the very near term. Potential alternatives are much further in the future
- It may be that not all regions will propose a LC in their region, or it may be that we will not convince governments to supply the funding needed. **But we will reach a decision soon.**
- We should expect at most one linear collider in the world.
- Worldwide support for the LC concept (somewhere) will be essential if it is to succeed. Arguing against the LC will likely not enhance the prospect for a subsequent large project.
- Particularly in the US community, we must engage the LC question, and consequence of opting for other paths. Snowmass 2001 affords the chance to confront as a community.
- LC should not be the last frontier accelerator in the world! There is room - and need - for coherent international planning.

How do we proceed?

3. Is the Linear Collider too expensive?

- One hears, particularly in the US, that the likely cost of the LC is too large to sell to the government.
- I believe that ANY future collider of any of the types we have been discussing falls into at least comparable cost categories. So, this issue is not for the LC alone, but is endemic to HEP future progress.
- The cost of the LC is seen by some as the primary driver toward the initial stage at ~ 500 GeV. They ask: "Will such a stage address the crucial next questions? "

The question of where EWSB comes from is the most crucial question before us - and we are confident that the 500 GeV LC will give us powerful understanding of how it works. We believe that the LHC will not give us full understanding. It is likely that upgrades to the LC will be needed in future, but the first phase is the best bet we can make to provide windows to tell us where to go next.

- Cost **is** a factor, and we must press all ways to control it. But we must not lose sight of the probable need for future evolution in the design.

How do we proceed?

4. Where will the LC be?

- Most adherents of a LC say that they want this machine, and are happy for it to be anywhere in the world. **But, I suspect that what this usually really means** is that they want it in their region, with substantial contributions from other regions.
- It seems likely that in fact the strongest factor for siting the LC will be a decision by one region to pay most ($\sim 2/3??$) of the cost.
- The LC had better be a worldwide collaboration, both for machine and for detectors. We are entering an era of very few accelerators, and the health of HEP in all regions requires that we all participate strongly in each. The corollary of this is that **each region has a strong need for some frontier collider in their region**, to keep the regional community strong.
- We need some global planning to keep this balance alive. Should envision some synthesis of the present planning exercises.
- In the near future, Europe will take the energy frontier with the LHC. Asia and North America will need to develop future facilities.

How do we proceed?

5. We need to further develop internationalism in HEP accelerator projects

5. Internationalism means making new compromises - for example, if the LC is in one region, it will be desirable that the **other regions play major roles.**
6. The development of the 'international control room' and more generally, the full collaboration in design, building, operating the collider, is very important. **Each region needs major accelerator projects to keep its machine scientists engaged and productive.**

We might envision that major portions of the LC - *injector & damping rings; rf delivery and main linac; final focus and beam delivery; etc* - could well be the responsibility of different regions from design to operation. The global accelerator concept should be developed to facilitate this decentralization.

5. **This globalization of the accelerator will be tough!** An accelerator project needs to be controlled at a tighter level than the international detectors we have built so far. The globalization should be built into the projects from the start. Making the physics case and detector designs should be inter-regional.

How do we proceed?

6. Technical Evaluation of LC proposals

- There has been discussion of a **worldwide panel to evaluate the machine technical proposals** (**not approval or site issues**) The aim would be to try to have some common framework for looking at the performance parameters, the R&D needs and the technical risks. Cost assessments should be made in defined frameworks. We should understand issues related to upgradability in energy and luminosity, or application to two beam drive upgrades for the different proposals.
- We should **welcome the Directors' endorsement of such a review**; it will give the world community an equal footing comparison, and will clarify the choices we must make.
- Drafting the charge, setting the committee, and finding the appropriate responsible body will be delicate. ICFA should play here, but the issues involved connect to us all. There needs to be involvement of bodies representative of the broad community -- EPS, JPS, APS, IUPAP ...

Conclusion

- The physics case for the LC with a 1st stage at ~ 500 GeV is very strong. We need a linear collider to study EWSB in any scenario. We know enough to make the choice now.
- With present lack of understanding of how EWSB is manifested, flexibility of Linear Collider design (energy, \mathcal{L} , beam particles) is essential. The LC will be an evolving facility.
- The cost will be high. Unless we internationalize so as to satisfy the needs of all regions and allow productive collaboration, we jeopardize the prospect of the LC, or any other new frontier facility anywhere.