NLC - The Next Linear Collider Project

Summaries, Discussion on Plans and Collaboration, Ground Motion Workshop Outcome

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The 22nd Advanced ICFA Beam Dynamics Workshop on Ground Motion in Future Accelerators
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Brief summary of the first day
(review and fast motion)

• A lot of interesting information

• LIGO
  – technical solutions
  – passive/active stabilization
  – analysis of the system

\{ Extremely interesting for Linear Collider community \}

• SLAC correlation studies

\{ LIGO correlation studies and plans (very systematic approach) \}

\{ Mutually interesting \}

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Brief summary of the first day
(review and fast motion)

- **ESRF** - vast experience on localization of external cultural noise sources
  - again stresses necessity to avoid such noise hunting for the LC by proper site selection

- **ALS, ESRF, etc** Girder problem discussion
  - Girder cannot be perfect!
  - (perfect = ground)

  =>$\Rightarrow$ need a lot of attention for linear collider

*Engineering development at light sources is one of the gems that we should study and benefit from...*
Brief summary of the first day
(review and fast motion)

• Interaction region engineering
  – try to avoid noises in detector region by design

• A lot of data from different places
  – ? Review different methods of data analysis (methods, software)
  – maybe come to a common method
  – try to analyze these data in terms of geology and cultural noise dependence (urbanization density)
Brief summary of the second day
(slow motion)

- Terrific day

- We have made huge progress in understanding slow motion => systematic, diffusive, …?
  - NO single model
  - very important step towards each other
  - there are NO unresolvable contradictions between different approaches

A.Seryi
Brief summary of the second day
(slow motion)

- Slow motion is very hard to study for very serious reason
  - need array of precise sensors => good statistics in time and space!
- How do we together proceed to understand the problem better and resolve more details?
- LEP motion analysis: should be continued
  - CERN, SLAC, SUST, ...
- What are other major questions that we should and can answer?
- Slow (and fast) longitudinal motion
  - Is there any peculiarities?
  - LIGO, SLAC, ...

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Brief summary of the second day
(slow motion)

• Short time scale stability of some tunnels in Japan is very high.
  – Can we make measurements at LEP with same/similar technique as in KEK?
  – Can it be done by CERN+KEK+SLAC+FNAL+ESRF+BINP+…?

• LEP tunnel is unique place…
  – back to the fast motion and cultural noise:
  – is there dependence on geology (along LEP)?
  – Is there (and how much) influence of on-surface activity (airport, city) on the in-tunnel noise level?
  – Can we make joint study by measuring vibration level all around the ring? => CERN+SLAC+FNAL+ESRF+…?
Brief summary of the second day (slow motion)

- Presentations by Chris Laughton, Joe Lach, Noboru Yamamoto and David Martin has brought us back from models to real life which is much more complex.
  - How to make balance between good and affordable tunnel?
  - Is there a need to discuss the linear collider tunneling options more?
  - Would a special workshop on tunneling for LC help?
Very brief summary of the third day
(modeling, counteraction methods)

• **Ground motion modeling** and evaluation of its effect
  – we are in quite a good shape
  – modeling of cultural noises difficult but is being improved

• **Counteraction methods**
  – a lot of options
  – passive, active methods, …

• **LIGO** has shown us a **benchmark** what ultimately can be done
  – we have a lot to learn and will continue to collaborate with LIGO on this subject

• We seem to be on a good track...
Plans of studies...

- Ground motion and vibration studies in SLD
- Vibration stabilization R&D at SLAC
- SLAC-UBC vibration stabilization R&D
- SLAC-FNAL-Budker INP slow motion studies in FNAL MI tunnel, SLAC PEP-II tunnel and Aurora mine
- Cultural noise versus depth studies in FNAL NUMI tunnel
- FNAL-SLAC studies of SC quad magnetic center motion
- ...

This transparency about SLAC plans was prepared couple of weeks ago
Now we have a lot more ideas what we should study
and what we can do together!

A. Seryi
**LEP motion**

- **LEP** motion data analysis will continue
  - CERN, SUST, SLAC jointly!

- Need to include measurement errors into modeling and data analysis

- Our joint understanding how to do it seem to be converging, so we are, hopefully, in good shape here
Need to get better statistics on dependence on spatial separation

Need to clarify dependence on geology
FNAL-SLAC-BINP slow motion studies

- Planning to use new Hydrostatic Level System to study slow motion in three different geology:
  - PEP-II at SLAC (sandstone)
  - Main Injector at FNAL (glacial till)
  - Aurora deep tunnel (dolomite)

- HLS development in Budker INP - 3rd version of probes - results start to seem good

- FNAL-SLAC-BINP agreement: ready to be signed

+ other labs?
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Slow motion (min-days) at LEP

Relevant for linear collider

• How stable is it?

• How does tunnel engineering and geology affect the stability?

• Can we measure this jointly?
  – CERN, KEK, SLAC, … ?
Cross checks of slow motion measurements may be necessary?

Frequency Scanning Interferometer triangulation network? Question of resolution and drifts...

Hydrostatic level system with 2 sets of different probes?

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Specifics of interaction region

- **Tight space** allowance inside the detector
- **Impossible** to make **good supports** for final quads
- **Additional Noises** produced by detector
- **Possibly, noises occurring** inside the final quads
- ...
Vibration stabilization R&D

- **Studies at SLAC**
  - 6 degrees of freedom, one small object => two small objects => two realistic objects with internal modes
  - Control system with on-line math capabilities for feedback
  - Time domain simulations of 3D motion of the object
  - Frequency domain simulations of the correction algorithms
  - Optimization of feedback

- **SLAC studies will be done in collaboration with:**

- **University of British Colombia (UBC)**
  - One degree of freedom, use of interferometer

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**NEW:**
Collaboration with other labs: CERN, maybe DESY, KEK …
Collaboration with LIGO
Our confidence may benefit from...

- “Full” scale interaction region test facility
  - apply various inertial / optical feedback/fedforward method to stabilize final doublets to nanometer level
  - use beam to test that magnetic centers are also properly stable

- SLC-SLD IR may be a good test bench
  - not used now but it’s conceivable to bring them in shape again
  - about 400nm colliding beam spot size achieved - good start already
  - going under 100nm and even below, 50-70nm could be eventually possible
    - for this one would replace final triplet by FD with sextupoles and retune FF a la New NLC FF

- Going from 50nm beam collisions to 3nm as in NLC is much more smooth step then from 400nm to 3nm

Is there enough interest from outside of SLAC?
In deep tunnels like LEP (~100m depth) there is almost no increase of PSD for $f>1$Hz due to on surface sources, that is typically seen in shallow tunnels (TT2A, SLAC, etc.).

\textit{i.e. cultural noises, generated on surface, almost do not penetrate} to ~100m depth.

\textbf{Correlation} properties in deep tunnels are much more \textbf{favorable} because the surrounding strata is more strong and sound velocities higher. \textbf{Slow motion} is also much \textbf{lower} in solid strata.

\textbf{How to hide from ground motion?}
Rayleigh wave is a major carrier of \textit{“cultural noises”} generated on surface

Amplitude of Rayleigh wave decrease \textbf{exponentially} with depth (more complicated in multi-layered earth)

\textbf{From the ground motion point of view:}
almost \textbf{any} deep tunnel is better than \textbf{any} shallow tunnel, because the \textbf{noise level is lower, correlation is better} and \textbf{slow motion is smaller}
Deep tunnel...

- What are requirements for multi-TeV collider with ~0.5 nm beam?

- How to ensure that existing (or future => 30 years ahead) urbanization do not bother us and the we deal only with noise that we created (and can control)?

- How better is deep tunnel?
GM studies in NUMI tunnel

- NUMI tunnel -- good place to study noise versus depth
- Optimal timing: middle of 2001

+ other labs?
What is cultural noise level at LEP due to the on-surface activity?

Probably can be jointly studied by CERN, ESRF, SLAC …
Studies of magnetic center motion

- **FNAL-SLAC**: plan to study magnetic center jitter in LHC superconducting low beta quads
  - Helium flow?
  - Amplification of vibrations by internal structure?
  - Flux freezing by cold Al inner bore?

+ **CERN** is certainly interested
+ **other labs**?

[G.Sabbi, et al., Fermilab-Conf-97/183]

A.Seryi
More of real life issues

- Tunneling options - a lot of choices, considerations and optimization
  - need special discussion of the subject
  - need to bring expertise from different field

- Girder design - very important. We tend to postpone the problem so far, but:
  - good girder = less than factor of two amplification
  - poor girder can be much worse
  - A lot of engineering experience from synchrotron light sources
Conclusion

• **New links between people**
  – should try to keep this our group in contact
  – inform each other what happens and discuss what needs to be done

• **A lot of new ideas, possibilities and plans**
  – need to go on and work on this plans together

• **Hopefully, we will have a lot of new interesting results soon**
  – next workshop on Ground Motion in Future Accelerators in 1-1.5 years?