Working Group on Environmental Control

½ final summary

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Charge

- For the next generation of large accelerators (NLC, TESLA, VLHC, Muon source), look into
  - Civil engineering of accelerator tunnels
  - Ground motion and vibrations
  - Alignment

- Examine these issues in terms of performance and cost-effectiveness

- In particular, consider
  - Site requirements for the machines under discussion
  - How tunneling methods are affected by them
  - Specify the R&D efforts needed to define the scope of the most critical challenges, prioritize the efforts

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Activity summary

- **Ground motion workshop** ← This ½ summary
  - Fast; slow; diffusive; systematic ground motion, effect on NLC, TESLA, VLHC
  - Tunnel and vibration interaction; influence of geology, location, depth, shallow site resonances
- **Tunneling workshop** ← Chris Laughton
  - Two day dialog with invited experts on tunneling, design, construction, ground and site investigation
- **Stabilization workshop** ← Report by T1
  - Feedbacks to stabilize beam and collisions; active stabilization of focusing elements
- **NPSS Technology school** (ground motion, tunneling, conventional alignment, beam-based alignment)
- **NPSS Noon lecture** (ground motion in future accelerators)

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Ground motion and stability

- The considered machines (NLC, TESLA, VLHC, Muon source) are feasible
- Basis of confidence – vast data on ground motion (spectral, correlation) and understanding of its properties
- Particular concerns for each of the machine are summarized below

VLHC

- **VLHC:** Ground motion produces emittance growth
- Relevant frequency range f > 250Hz
  for ~0.3nm quad vibration
  initial emittance ε_n=1.5μm doubles in 2.5 hours

- 0.3nm of quad vibration at F> **250Hz is not crucial – natural ground motion much smaller**
  (also, the tolerance can be eased ~10 times with feedbacks)
- In deep tunnel, ground motion ~ OK for VLHC
- Concerns: equipment generated vibrations, and
- Ground-magnet motion difference
  (girder , cryostat mechanics)

(high field VLHC with 87.5 TeV beam)

Two effects of ground motion in Linear Colliders

frequency

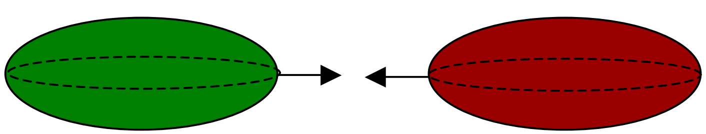
'slow motion'

'fast motion'

$F_c \sim F_{rep} / 20$

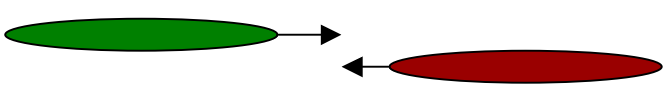
Beam offset due to **slow motion** can be compensated by feedback

May result only in beam emittance *growth*



Beam offset **c**annot be corrected by a pulse-to-pulse feedback operating at the F_{rep}

Causes beam offsets at the IP



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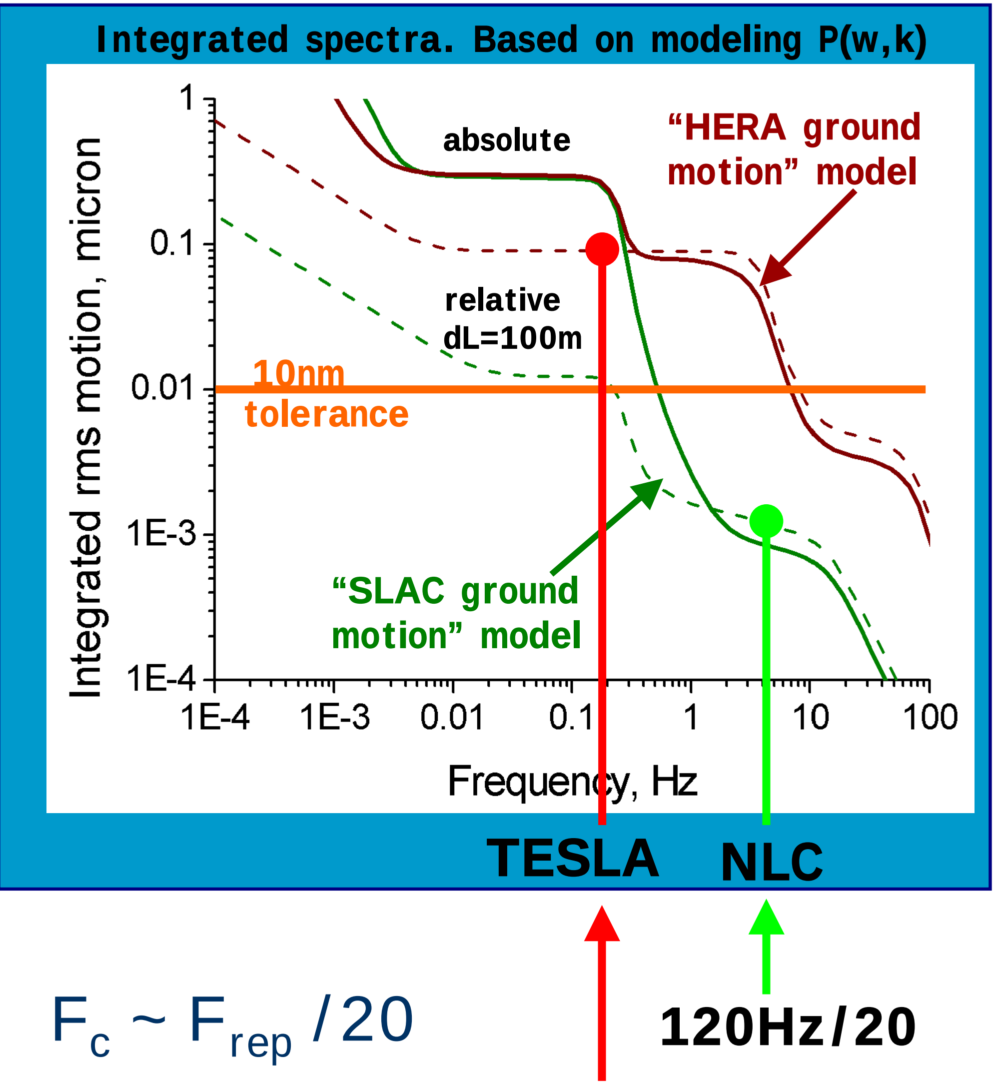
Fast Ground Motion in NLC and TESLA



For linac quadrupoles, tolerance roughly 10nm for both
(-> $0.25\sigma_y$ NLC ; $0.1\sigma_y$ TESLA)

Rep.Rate of bunch trains:

120Hz @ NLC -> F_C ~ 6 Hz

5Hz @ TESLA -> F_C ~ 0.2 Hz

NLC is OK at quiet site

TESLA is OK with fast correction within bunch train

$F_c \sim F_{rep} / 20$

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'Slow' Ground motion at NLC and TESLA

- Diffusive or ATL motion: $\Delta X^2 \sim A_D T L$
- Produce misalignments and result in emittance growth
- TESLA : Low wakes -> smaller σ_E and $\Delta\varepsilon$ $(\sim \sigma^2_E)$

Place	A $\mu m^2/(m \cdot s)$
HERA R.Brinkmann,et al.	$\sim 10^{-5}$
FNAL surface V.Shiltsev,et al.	$(1\text{-}10) \cdot 10^{-6}$
SLAC*	$\sim 5 \cdot 10^{-7}$
Aurora mine* V.Shiltsev,et al.	$(2\text{-}20) \cdot 10^{-7}$
Sazare mine S.Takeda,et al.	$\sim 5 \cdot 10^{-8}$

* Further measurements in Aurora mine, SLAC & FNAL are planned

TESLA: Undisruptive realignment ~every month — OK for TESLA

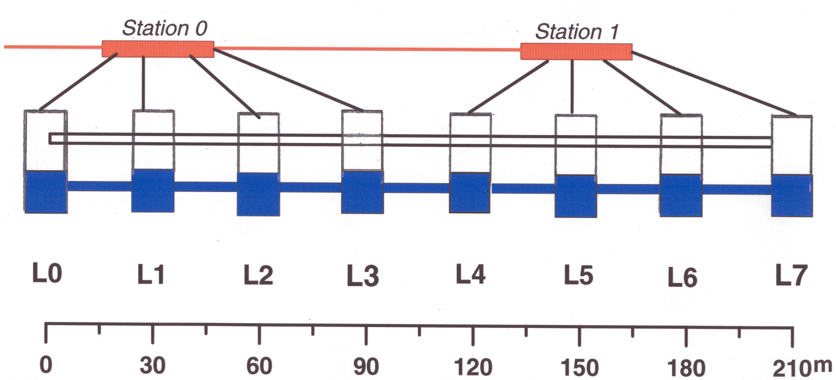
NLC: Undisruptive realignment ~every 5hrs — OK for NLC

NLC: Undisruptive realignment ~every 2 days

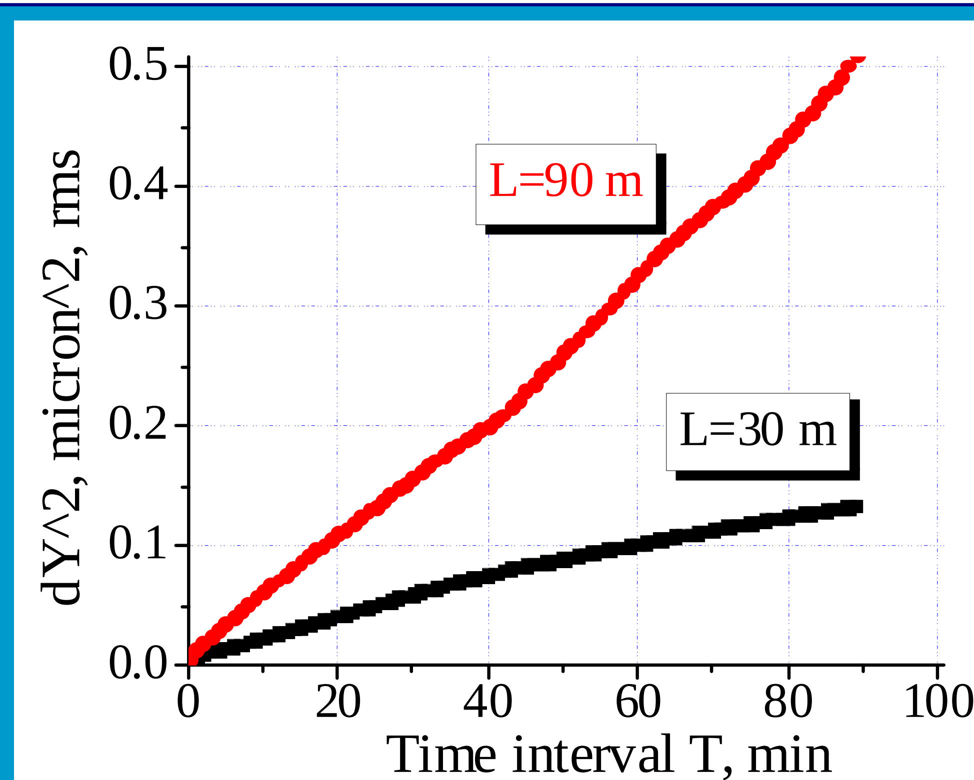
Undisruptive = can collide while realigning

Slow ATL motion
is not easy to measure

- **Slow motion in Aurora mine exhibit ATL behavior**
- **Here A~ $5*10^{-7}$ $\mu m^2/m/s$**



hydrostatic level system



Slow motion in Aurora mine
[A.Chupyra, J.Lach, V.Shiltsev, et al.]

Further studies are planned

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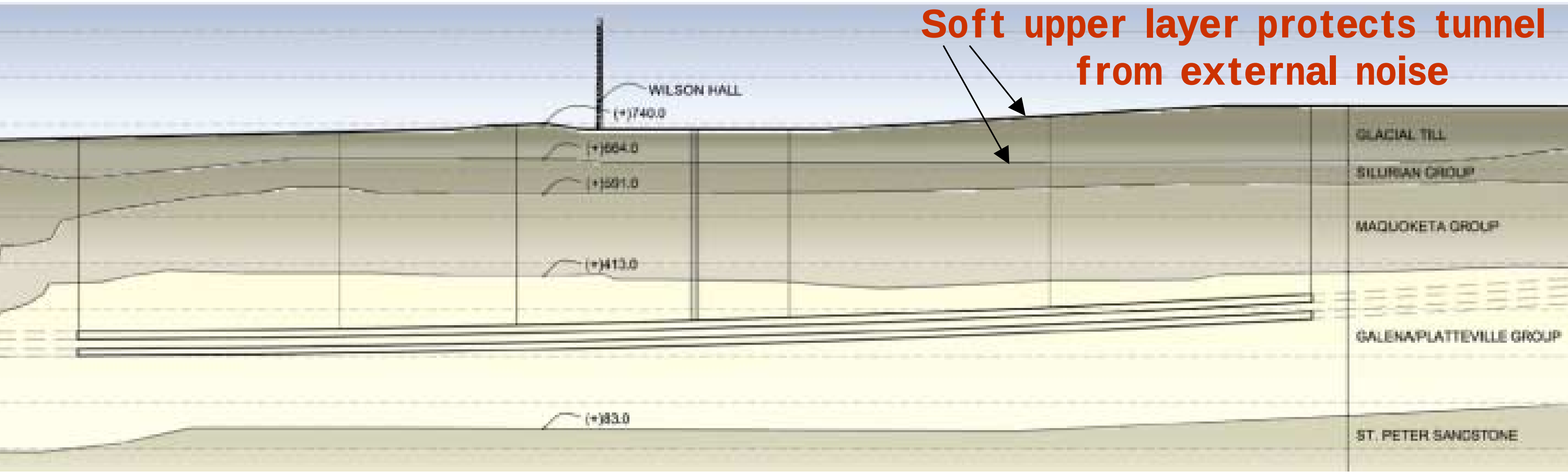
NLC deep tunnel sites (IL,CA)
example: N-S layout at Fermilab



- Tunnel can be placed **~100m deep in geologically (almost) perfect Galena Platteville dolomite platform**
- **Top ground layer is soft – this increase isolation from external noises**
- **Rigid rock** of Galena Platteville **provide good correlation of fast motion and low diffusive motion**

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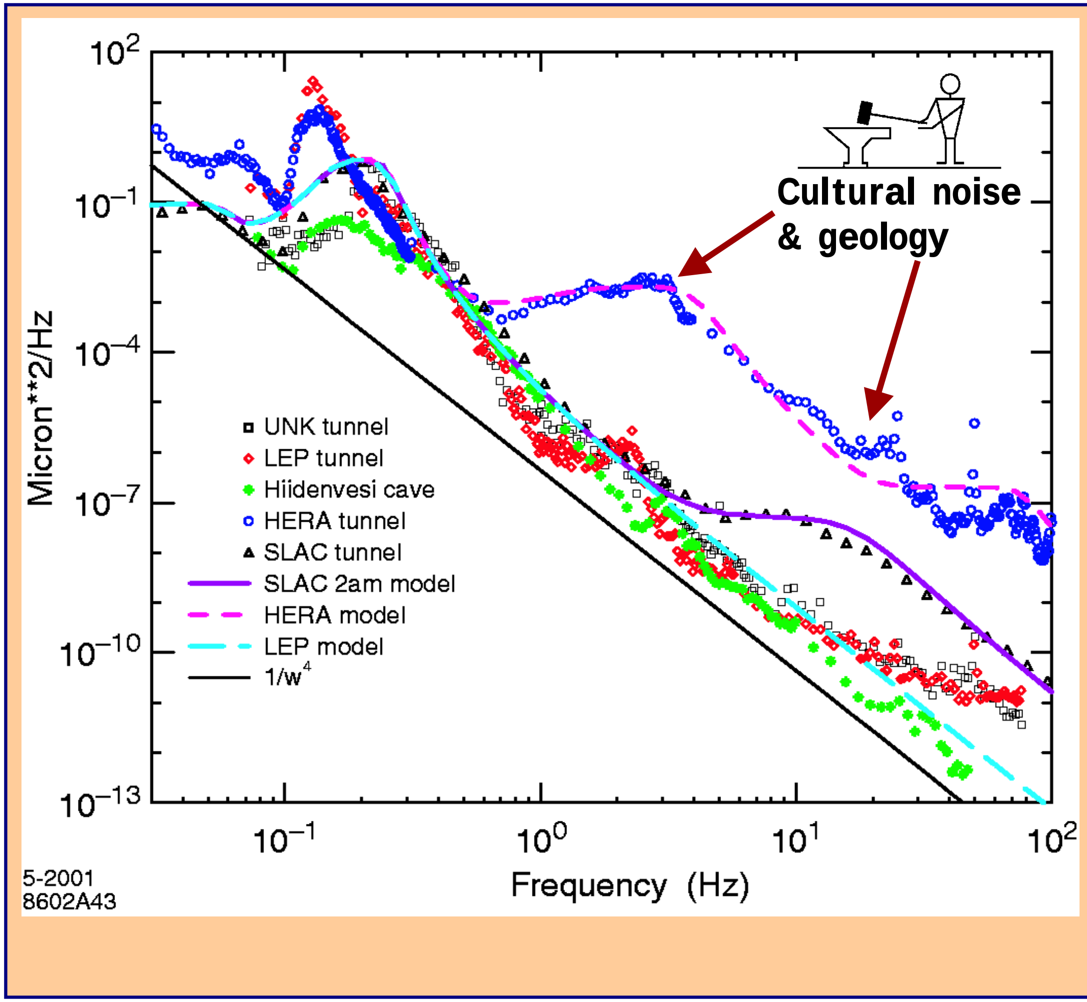
Issues of concern and further work

- Cultural noise may greatly increase vibration in the tunnel
- Local geologic factors (soil and rock stiffness, structure and water table) may strongly influence (increase or decrease) the in-tunnel vibration amplitude
- Site-specific models of vibration propagation need to be studied in more detail



Some recommendations on ground motion and stability

- Investigation of slow motion and vibration at representative sites

- Understand effect of depth, layered ground structure, site resonances
  - Optimize configuration to minimize noise

- Develop / apply methods for damping in-tunnel generated noises