Establishing requirements for ground motion and vibration
Material for discussion with NLC Conventional Facilities groups during the NLC collaboration meeting at Fermilab

Suggested plan of discussion:
1) In which terms, quantities should we establish requirements?
2) What are the requirements?
3) How to ensure that requirements are fulfilled?

- Ground motion and vibrations misalign NLC elements, thus may spoil beam quality and may cause the beams to miss each other at the collision point.

- We need to ensure that ground motion and vibrations are tolerable throughout the NLC.

- To ensure the appropriate conditions, we should establish requirements and then work to achieve them.

Establishing the requirements. Suggestion on timescale:
To create skeleton of the draft before MAC in May
To have 1st draft before Snowmass 2001
• We know pretty well how to evaluate the effect of ground motion on the beam.

• However, we need quite sophisticated description of ground motion in order to evaluate its effect accurately:
  o We care about noise level
  o We also care about correlation of motion
    ▪ Effectively, we describe ground motion by 2D power spectrum $P(\omega, k)$ and not by $p(\omega)$ that would be typical for other fields of science and engineering
  o The effect of ground motion is also an integral effect:
    ▪ For example, we may tolerate such and such motion at frequency $f_1$, OR such and such motion at frequency $f_2$, but not simultaneously
    ▪ In some sense, there is infinite number of acceptable power spectra $P(\omega, k)$ where the motion would be distributed differently over frequency $\omega$ and wave-number $k$

• Therefore, by the nature of the problem, an accurate requirements cannot be straightforward

• A straightforward requirement would be too inaccurate or too stringent to fulfill
  o We cannot just require, for example, that the goal is to not increase the natural ground motion of a site by more than factor of two

• How, given this complexity, to come with conceivable requirements? Need efforts from both sides:
  o Need to reasonably simplify the criteria
  o But be prepared for more complex criteria than what may have been established in practice
  o Expect that criteria will evolve and drift
The requirements cannot be uniform and global
The responsibility should be clear

Suggestion: create 3 layers of requirements

1\textsuperscript{st}: Requirements for a **bare site**
(existing site with no conventional facilities built)

2\textsuperscript{nd}: Requirements for **bare site + conventional facilities**
I.e. all buildings, tunnels are built and all consumable media
(water, air, electricity, etc.) are delivered to required places,
but no components of the collider are installed

3\textsuperscript{rd}: Requirements for **bare site + CF + collider**
 Completely developed site

Example: CF responsible to deliver tunnel with acceptable noise
level on the floor (version: on the girder). All on girder generated
noise is responsibility of another groups. Each group would have
its “vibration budget”.

Suggestion: specify 4 areas within the machine

- Injectors
- Main linac
- Beam delivery
- Interaction region
What quantities are relevant and should be specified in requirements?

Preferably these quantities should be measurable with well-established techniques.

Choices for such quantities:

- Power spectrum of motion $p(\omega)$ for characterization of amplitudes
- And/or integrated (in certain frequency band) spectrum

Since correlation of motion depend on wave velocity in the ground, which depends on geology, we may use

- Profile of shear velocity versus depth
- And/or profile of Young modulus and density versus depth

(relevant depth range may be different for the case of deep and shallow tunnel)

Are these quantities measurable?

- Spectrum of motion $P(\omega)$ is measurable.
  - For bare site it is measurable at surface.
  - What about measurements at bare site at certain depth? Can we do test boring and measure the noise level?

- Profile of share velocities is measurable.
  - Is there depth limit for such measurements?
- Density and rigidity may be known from test boring
So, what requirements should we use?
Suggestions:

For **bare** site:

- Specify range of acceptable power spectra $p(\omega)$
- Specify range of acceptable share velocity profiles

  These two are not independent. A site with lower velocity will have to be quieter

(may need to add requirements on location of cultural sources in vicinity)

For **bare+CF** site

  Specify by how much the power spectra $p(\omega)$ may be increased by added equipment in different frequency bands

These all need to be discussed, extended, documented and then we need to try applying these criteria to our work.