Cavity Tuner Reliability Considerations

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Outline

- No new work. Just present info from my 05Jul06 memo
- Statement of problem
- Back of envelope calculation
- MTBF?
- Effect?
- Requirement

The potential problem

1. If the cavity tuner assembly has an MTBF of 5E5 hours and
2. If it takes a month to repair and
3. If the cavity will become detuned within months if not tuned or it will be permanently damaged on warmup,

Then

- We will have a big problem.
- We still have a problem even if assumption 3 is false if we ever have to warm the linac for any reason.

Show why and then examine the (uncertain) assumptions

Why a problem?

- Availsim with those assumptions and a 3% energy headroom says we must warm up and perform repairs during a 9 month run.
- Back of envelope calculation:
  - **In 9 month (6570 hr) run 6570/5E5 = 1.3% of tuners will fail. Uses nearly half of 3% energy overhead.**
  - **Other things break too, so this is too much.**
  - **With 20,000 cavities, this is 262 broken tuners/yr**
  - **To repair would have to warm whole linac and repair 10% of the cryomodules.**
- Far from acceptable

Assumption 1: MTBF

- An SNS reliability study used 175,439 hours for the MTBF of their tuner assemblies. The source for that information is given as Daly/Wiseman(7-Aug-01). I haven't been able to find that source.
- Typical manufacturer MTBFs for stepping motors are in the 100,000 hour range. For motors spinning constantly at hundreds or thousands of RPM. No info on how to adjust this for infrequently used motors.
- The SLC Arcs had thousands of warm infrequently used stepper motors. None failed during a 5 year period giving an MTBF > 8E6 hours. There were 2 mechanical failures, giving an MTBF of 4E6 hours.
- 8 TTF and 2 A0 photo-injector tuner motors died but they were murdered (wrong electronics and no liquid helium.

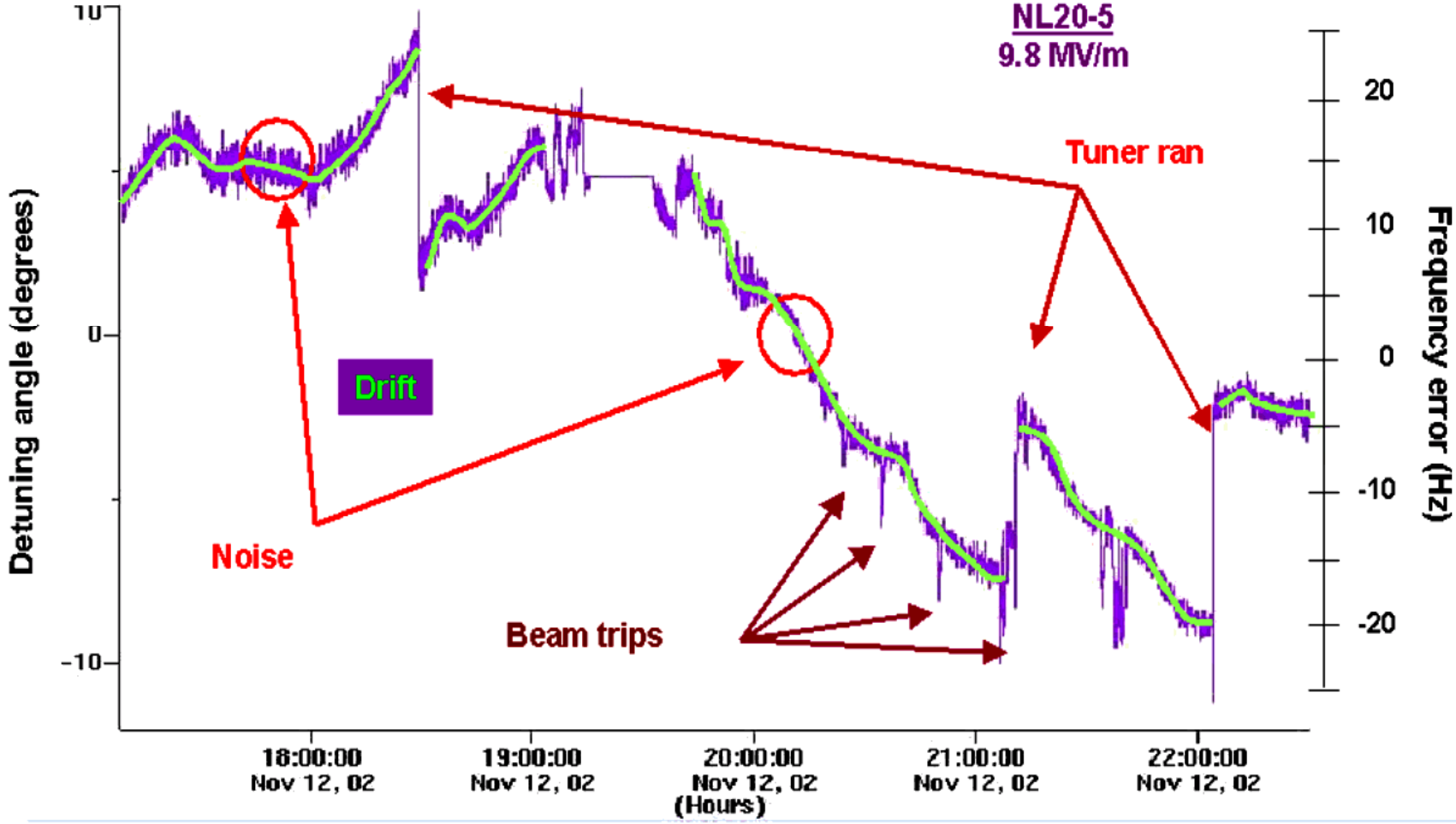
Assumption 2: 1 month to repair

- If we have to warm up and cool down 2.5 km of linac, this is the time I've been given by the cryo people.
- Changes at the factor of 2-4 level don't effect the conclusions.
- If fixing the parts that break does not require a warm-up, then the problem goes away. Note that all designs have some tuner parts in the cold volume.

Assumption 3: The cavity will become detuned

- Unarguably detunes if we warm up and cool down the linac for some other reason.
- Jlab periodically uses their tuners in an automated fashion.
- TTF does not, but does rarely adjust them manually.
- My guess is ILC will adjust them like Jlab to avoid a 1% loss in energy gain due to detuning. However, if 10% of the tuners were broken, this would not be a big energy loss.

Jlab tuning


NL20-5
9.8 MV/m
Tuner ran
Drift
Noise
Beam trips
Detuning angle (degrees)
Frequency error (Hz)
10
0
-10
20
10
0
-10
-20
18:00:00
Nov 12, 02
19:00:00
Nov 12, 02
20:00:00
Nov 12, 02
(Hours)
21:00:00
Nov 12, 02
22:00:00
Nov 12, 02

Conclusion

- If we think we will ever need to warm up and cool down a significant fraction of the linac for any reason (almost certainly the case) or if assumtions 2-3 are true (may be false)
- Then the cold tuner mechanism must either be easy to repair in situ or must have an MTBF > several million hours.
  - **The exact value is determined by the fraction of the cryomodules we are willing to repair when we warm up.**
- This is a **requirement** that the tuner design must meet.