Low Power Option: Linac Implications

Chris Adolphsen
Chris Nantista
SLAC

Bunch Spacing

- With either full compliment of bunches of half the number, have some flexibility to vary the bunch spacing.
  - DR spacing much shorter than that in linac
- For example, choosing a longer spacing
  - Decreases the beam current (I)
  - Reduces the input power per cavity (~ I) and hence the number of fixed-power rf sources (reduces cost).
  - Lengthens the fill time and bunch train (~ 1/I), which increases the dynamic cryoload (increases cost).
- The cost minimum is very shallow about the RDR design choices (cost uncertainties too large to compute precise minimum within +/- 50%)

Practical Constraints

- Longer spacing
  - More chance of HV/RF breakdown in modulators/klystrons due to the longer rf pulse length (not so for cavities, which can run CW).
  - The smaller cavity bandwidth makes it harder to regulate the gradient.
  - Losses in the waveguide distribution system grows as more cavities are fed per klystron (although could use low loss circular mode, but the pipe size would be large).
- Shorter spacing
  - More chance of rf breakdown in the couplers due to the higher power (although could use a waveguide coupler, but the cryo heat load would increase significantly).

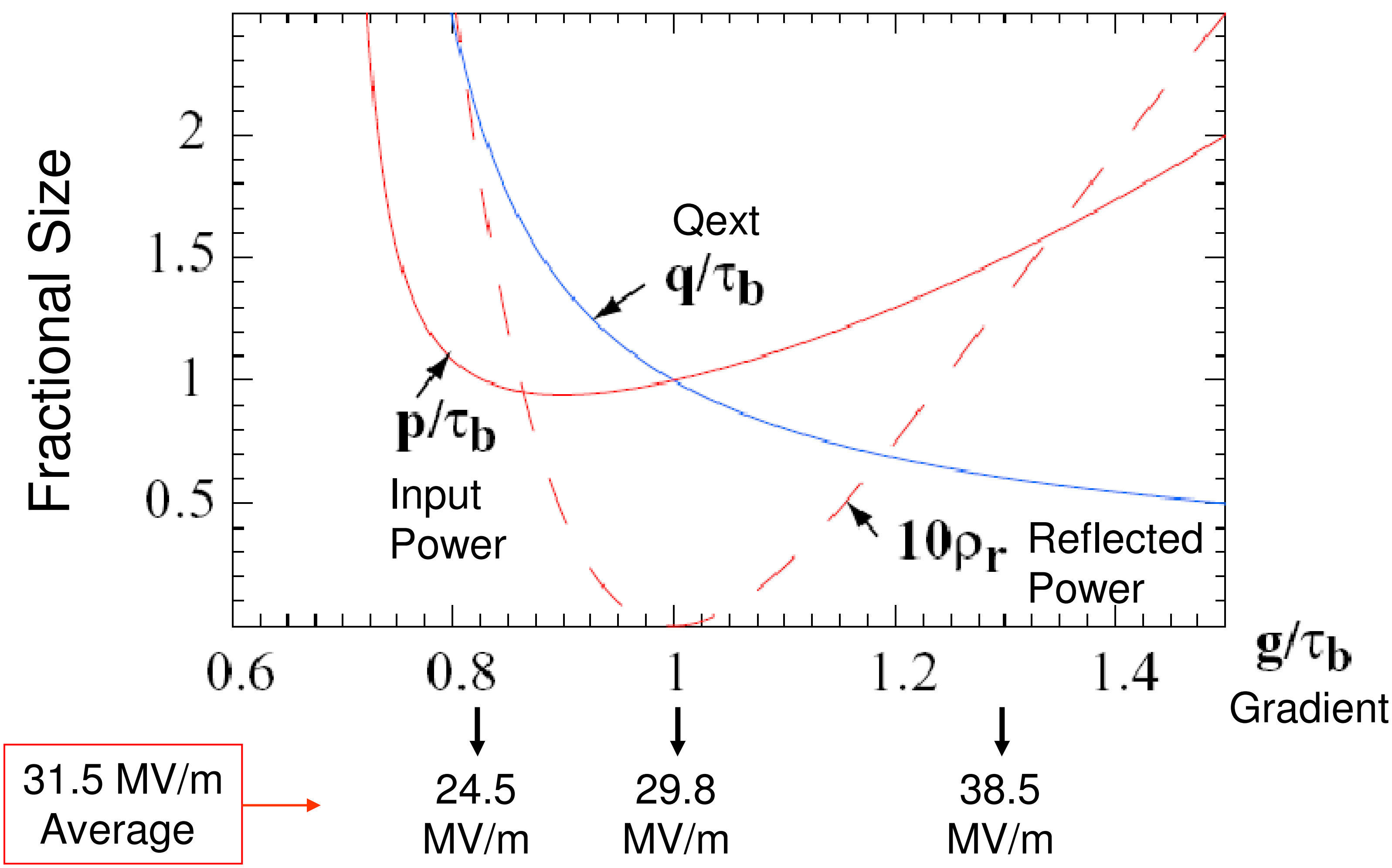
Half Bunch Options

- 50% Current ('Half Current')
  - Reduces number of rf sources by 50% and AC power by 24%
  - RF pulse lengths increases for 1.56 ms to 2.16 ms where there are no data on reliability for the 10 MW system (in fact, there is little at 1.56 ms).
  - Required cryo capacity increases by 7%
- 69% Current ('Same Pulse Width')
  - Reduces number of rf sources by 31% and AC power by 26%
  - RF pulse length unchanged at 1.56 ms
  - Required cryo capacity decreases by 7%
  - Cost savings about the same (perhaps less by about 20 M$) when factor cost of rf system (including learning curves), electrical and water/cryo cooling.

Bandwidth Concern

- For the RDR, the cavity BW is 370 Hz (Qext = 3.5e6)
  - RMS frequency spread from microphonics generally below 5 Hz at FLASH
  - Lorentz Force Detuning is several hundred Hz, but the piezo controllers can reduce it below 50 Hz (residual increases as gradient^2)
- If accommodate a spread in cavity gradients, Qext will be double for the lowest gradients (-20%)
- If halve current, Qext will double again, so the lowest gradient cavities will have a BW of 93 Hz (close to that being considered for CW ERLs)
- This will make it harder to achieve a constant gradient during the pulse.

Flattop Operation with a Spread of Cavity Gradients



Summary

- 'Same Pulse Width' option more appealing for several reasons including the higher cavity BW
- KCS and DRFS have pro and cons as to changing current
  - KCS can be more easily configured for higher currents although klystron pulse length may be near the limit at 1.6 ms
  - DRFS distribution is quantized but not likely pulse width limited due to the lower power
- Will refine beam current choice in near future