



Staging in the TDR



Known (☺) Physics

- **~125 GeV 'that new boson'**
 - $125+91=216$ GeV cm \rightarrow 250 GeV
- **173 GeV Top quark**
 - $2 \times 173 = 346$ GeV cm \rightarrow 350-400 GeV
- **Higgs self coupling (t-coupling) ???**
 - ≥ 500 CM (up to 650 ??)
- **TeV and beyond....?**

Staging / Upgrading





250 GeV CM (as first stage)

Relative to TDR 500 GeV baseline (1312 bunches)

Two stage compressor (5-15 GeV)

Half linacs solution
 $G = 31.5 \text{ MV/m}$

POSITRON linac straightforward

~50% ML linac cost (cryomodules, klystrons, cryo etc.)

~50% ML AC power

ELECTRON linac needs 10Hz mode for e+ production
 $\Delta E = 135 \text{ GeV}$ instead of 110 GeV (+25 GeV)

~57% ML linac cost (cryomodules, klystrons etc)

10Hz needs (1/2 linac \times 10Hz/5Hz):

100% ML AC power (1/2 linac \times 10Hz/5Hz)

80% cryo cost (50% static + 100% dynamic)

Total Main Linac infrastructure

| | |
|-------------------|-----|
| Linac components: | 50% |
| Cryogenics: | 65% |
| RF AC power | 75% |



Civil Engineering (Tunnel)

- **Build tunnel/shafts only for 250 GeV** ~70% TDR \$
 - Cheapest option!
 - Energy extension now requires major civil construction (+cost)
 - conceptually the same as for TeV upgrade option
 - Shorten schedule ~2 years (guess)

- **Build full 500 GeV machine tunnel** ~77% TDR \$
 - Assume install low energy linac first
 - long 125/150 GeV transport line in 'empty tunnel.'
 - Energy upgrade now just adds accelerator to tunnel
 - Options for 'adiabatic' upgrading
 - Implications for mass production scenarios (long term investment may now look attractive)
 - Additional upfront costs. May need to sell/cost entire project upfront
 - More expensive but over a longer time scale.
 - Shorten schedule <2 years since all tunnels need to be constructed.



Details! for discussion

- **May consider more conservatism for 'energy overhead'**
 - known physics targets!
- **(Integrated) luminosity requirement for LHF**
- **Positron polarisation for LHF?**
 - 10Hz and 25GeV additional e- linac unattractive
 - Should certainly focus on this operational area