Q3

- Main linac starting gradient, upgrade gradient, and upgrade path
- Results of WG5 discussions

Three Upgrade Options

1 : Half-Empty

- Build tunnel long enough (41km) for one TeV, but install only 500 GeV worth of cryomodules in first 22 km of tunnel for 500 GeV phase.
- 35 MV/m installed gradient, 31.5 MV/m operating gradient for 500 GeV (gradient choice rationale discussed in WG5 summary, and later).
- Fill second part of tunnel (19 km) with 36 MV/m cavities (gradient choice discussed later), install more RF/refrigeration

2: Half-Gradient

- Build tunnel long enough for one TeV (44km). Populate complete tunnel with cavities in phase1 (35 MV/m installed gradient) Operate cavities at half gradient (about 16 MV/m) in Phase 1.
- Increase operating gradient to 31.5 MV/m and add RF and refrigeration for upgrade

3 : Half-Tunnel

- Build first half of tunnel for 500 GeV (22km) and fill it with full gradient cavities (35 MV/m installed gradient, 31.5 MV/m operating gradient, discussed later).
- Build second half of tunnel (19km) and add 36 MV/m cavities and RF/refrigeration for upgrade.

Pros/cons of upgrade paths

- Initial cost:
  best = 3: half-tunnel; worst = 2: Half-gradient (all modules)

  - Cryomodules + RF + Refrigeration + 2Tunnel model costs
  - Option 1 = 1.15, Option 2 = 1.6, Option 3 = 1.0
  - Option 2 is least risky, most flexible for physics and initial energy reach

- Upgrade cost:
  best = 2 half-gradient; worst = 3 half-tunnel.
  - Option 1 = 0.7, Option 2 = 0.4, Option 3 = 0.9

- Total cost (initial + upgrade):
  best = 1: half-empty; worst = 2:half-gradient
  - . Option 1 = 1.85, Option 2 = 1.97, Option 3 = 1.9

- Option 1 (half-empty), the second half of the installed cavities will be higher gradient due to more years of R&D. This allows the total tunnel length to be shorter.

Pros/cons of upgrade paths, con’t

- Initial schedule

  Best = 3 half-tunnel, worst = 2 half-gradient

  – Option 3 takes longer to start up due to largest module production and installation

- Upgrade schedule:

  best = 2: half-gradient; worst = 3: half-tunnel.

  Option 2: The extra RF to upgrade half-gradient can be installed while ILC is running if there are 2 tunnels.

  Option 2 does not require interruption for module production and installation,

  Option 2 does not take advantage of gradient advances to come

- Upgrade viability:
- worst = 3: half-tunnel. Has civil construction. Need to check if tunnel boring machines vibrate the ground too much to allow tunneling during running. If so, upgrade is not viable.

WG5 Preferred Choice is :

Option 1 (Half empty)

Option 1 (half-empty) is significantly less <u>initial project cost</u> than option 2 (half-gradient).

- Cost Model estimates Option 2 ~1.36 x Option 1
  - (Linac + RF + Cryo + tunnels)
- Cost Model estimates Option 1 ~ 1.15 x Option 3
- Option 3 (Half-tunnel): Upgrade viability may be questionable, physics impact of digging new tunnel in vicinity of machine (this is a higher level discussion topic than WG5)

Cavity Gradient/ Shape - 500GeV

- Shape Options (to be discussed by Saito)
  - TESLA
  - Low-Loss
  - Re-entrant
  - Superstructure

- Pros/Cons (to be discussed by Saito)

Cavity gradient/ shape - 500GeV
Repeat of Friday Summary - Proch

- Preferred Choice: TESLA shape
  - Performance and cost best understood
- Gradient Choice 31.5MV/m

  Based upon
  - Critical field 41MV/m (TESLA shape)
  - Practical limit in multi-cells = 90% critical field = 37MV/m (5% sigma spread)
- Lower end of present fabrication scatter (= 5%)
  - TESLA shape: 35 MV/m
  - Vert dewar acceptance criteria: 35MV/m or more (some cavities must be reprocessed to pass this)
  - Operating gradient = 90% x installed gradient = 31.5MV/m
    - Allows for needed flexibility of operation and commissioning
    - Gives operating overhead for linac and allows individual module ultimate performance.
  - Choice of operating gradient does not include fault margin

    e.g 2 - 5 % additional cryomodules to be determined by availability considerations

Further Comments on starting cavity gradient - 500GeV

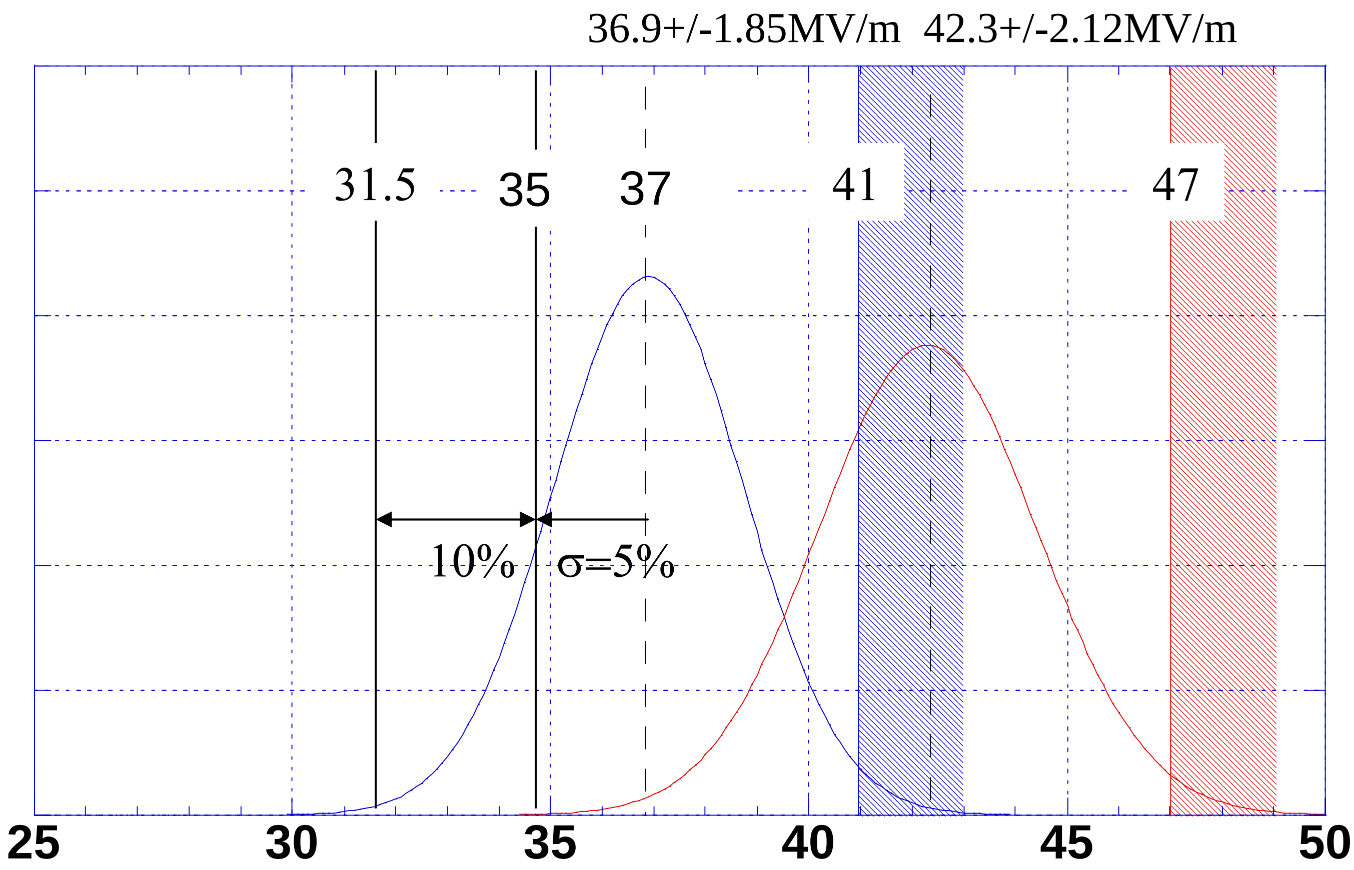
- R&D to address remaining risk
  - Significant R&D necessary to achieve the specified module gradient and spread.
  - System tests and long-term tests of 35 MV/m modules needed as spelled out by R1 and R2 of TRC
  - R&D needed in BCD cavity processing & BCD material (though other R&D efforts may prove beneficial e.g. single crystal)
  - This R&D effort needs to be organized internationally, Discussions underway
  - Must also address how to industrialize the processing for reliable and reproducible performance

Upgrade gradient choice (depends on shape) discussed on Friday Summary - Proch

- Theoretical RF magnetic limit:
  - Tesla shape: 41 MV/m
  - LL,RE shape: 47 MV/m
- Practical limit in multi-cell cavities -10%
  - TESLA shape. 37 MV/m
  - LL, RE shape: expected 42.3 MV/m
- Lower end of present fabrication scatter (- 5%)
  - TESLA shape: 35 MV/m
  - LL, RE shape: 40 MV/m
- Operations margin -10 %
  - TESLA shape: 31.5 MV/m
  - LL, RE shape: 36 MV/m

Assume cavities can reach avg of 90% of limit with 5%rms in Vert dewar

Most Tesla cavities should be able to reach 35MV/m accept
Most LL/RE cavities should be able to reach 40 MV/m accept
But note there is a low energy tail that fails



Assume cavities can reach avg of 90% of limit with 5%rms in Vert dewar (The plot distributions show 85%)

Most Tesla cavities should be able to reach 35MV/m accept
Most LL/RE cavities should be able to reach 40 MV/m accept
But note there is a low energy tail that fails