Tunnel Options

- Consider two main options:
  1. TESLA style: **1** tunnel with modulators in sparse support buildings
  2. **2** full tunnels with virtually all active equipment in the support tunnel

- Each option could be
  a. In a **deep** tunnel
  b. Near the **surface** (with support equipment on the surface)

Pros/cons of 1 vs 2

- Cost: favors 1. USTOS estimates 1 is 5% cheaper then add 3% for availability improvements for a net 2% of total project cost
- Availability risk: favors 2. With same MTBFs, 1 tunnel is down 30.5% (or 22% with robotic repair) instead of 17% for 2. (2 tunnels with equip tunnel only accessible with RF off gives 23% down.) Can make better MTBFs, but increases costs and carries risk.
- Commissioning: favors 2. Subtle electronics problems that require hands on with a scope and beam to understand will be very slow to solve.
- Radiation: favors 2. Radiation damage and single event upsets to electronics in accel tunnel will pose a challenge. (Note even in 2 tunnel case, some electronics may be put in the accel tunnel)

Pros/cons of 1 vs 2

- Pulse transformers disturb damping rings: favors 2. only if pulse transformers are used.
- Commissioning/upgrade: favors 2. Installation in support tunnel can go on while commissioning/running occurs in accelerator tunnel.
- Unless one wants to improve the cost estimate, no further work is needed to decide on BCD.
- My conclusion: 2

Needed MTBF Improvements

Device	Improvement factor **A** for 2 tunnel conventional e+ source	Improvement factor **B** for 1 tunnel undulator e+ source, 6% energy overhead	Improvement factor **C** for 1 tunnel undulator e+ source, 3% energy overhead	Nominal MTBF (hours)
magnets - water cooled	**20**	20	20	1,000,000
power supply controllers	**10**	**50**	50	100,000
flow switches	**10**	10	10	250,000
water instrumention near pump	**10**	10	**30**	30,000
power supplies	**5**	5	5	200,000
kicker pulser	**5**	5	5	100,000
coupler interlock sensors	**5**	5	5	1,000,000
collimators and beam stoppers	**5**	5	5	100,000
all electronics modules	**3**	**10**	10	100,000
AC breakers < 500 kW		**10**	10	360,000
vacuum valve controllers		**5**	5	190,000
regional MPS system		**5**	5	5,000
power supply - corrector		**3**	3	400,000
vacuum valves		**3**	3	1,000,000
water pumps		**3**	3	120,000
modulator			**3**	50,000
klystron - linac			**5**	40,000
coupler interlock electronics			**5**	1,000,000
linac energy overhead		**3%**		3%

Pros/cons of deep vs surface

- Cost: favors surface. Cut and cover construction is cheaper. I have detailed numbers.
- Ease of finding site: favors deep. Sites with right topology and bareness are few are far between. Eased somewhat if can have vertical bends in the linac.
- My conclusion:

Carry both options until site is selected