Thickness of the Kamaboko Tunnel Shield Wall under Different Assumptions

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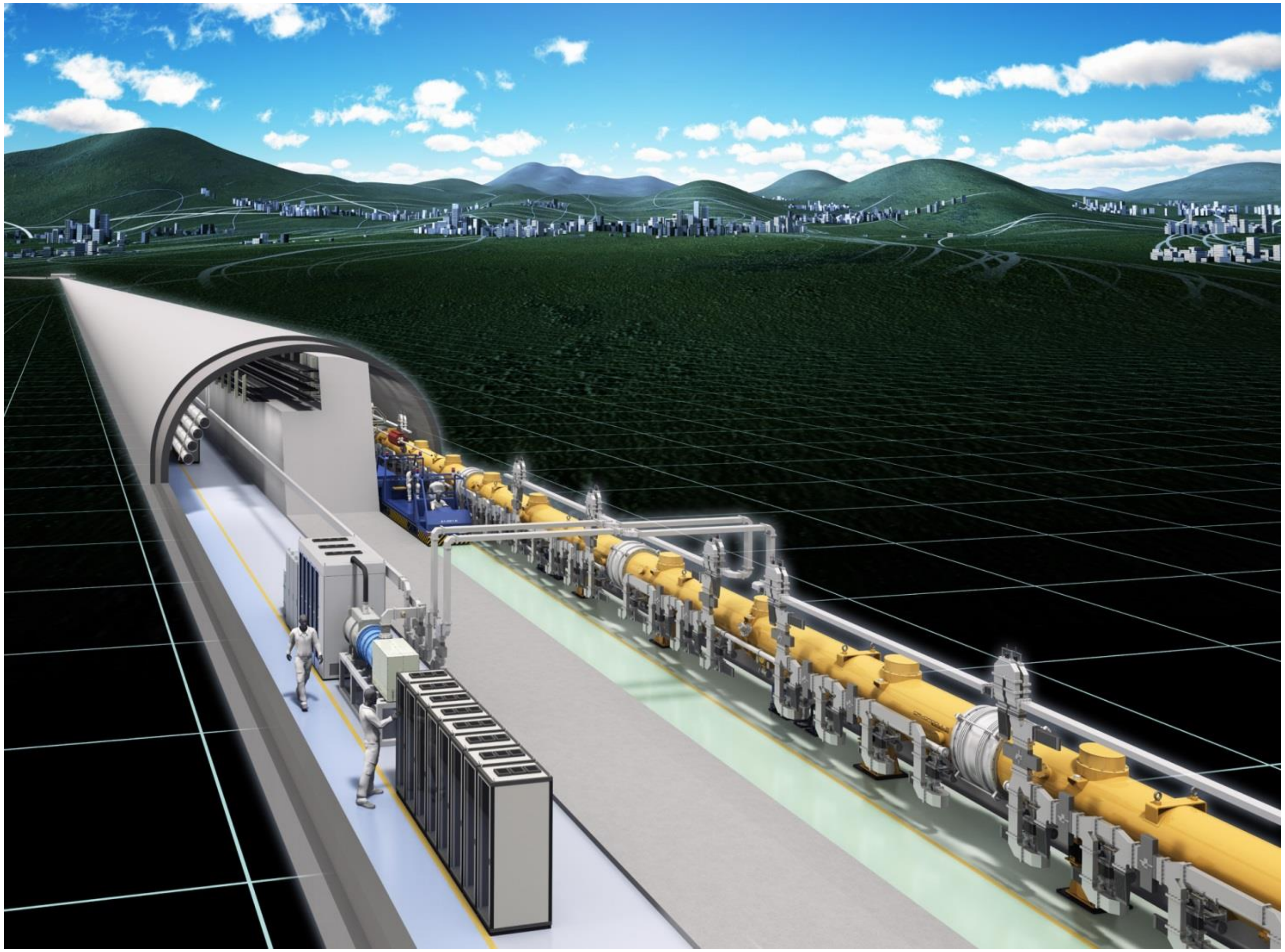
THE “GREAT” WALL



History of Shielding

- RDR 2007 Assumed site independent twin tunnel design, one beam tunnel and one service tunnel which can be accessed by people (Rad workers) at any time.
- SB 2009 Study single tunnel designs and operational “Availability” of accelerator systems in different scenarios.
- Began developing RF systems for a Single Tunnel Linac.
- DRFS with many 800kw klystrons in a variety of configurations all inside the tunnel.
- KCS Klystron Cluster with 20 x 10 MW tubes combined in surface buildings, delivered to and distributed in the tunnel through over-moded wave guide.
- By 2011 both systems were accepted as having acceptable availability but site dependent choice and more R&D still required.
- 2011 Kamaboko tunnel with shield wall proposed for selected Japanese deep site.
- Development of KCS an DRFS stops and we are back to two tunnel equivalent in preparation for the TDR.
- 2013 In the TDR the choice of RF distribution system is site dependent. KCS on the surface for shallow tunnel and some form of DRFS in a deep tunnel.
- Japan proposes a real (deep) site and we go with Kamaboko tunnel with a wall!

Shield Wall Today

- The baseline design is 3.5 meter but this is very conservative and we need to review the assumptions.
- 18 MW being lost is unrealistic but even with the best machine protection system, in some future scenario perhaps one might have to consider beam losses of close to a megawatt in a few places in the machine.
- The wall could be thinner but probably not much less than 2.5 m (my best guess) as long as there is the potential for high power beams on the other side.
- One could have a variable thickness wall tailored to local conditions but this would be very restrictive in the future as it would be very difficult to change.
- Let us re-open, in 2015, the question of a single tunnel.

- **WHAT IS NEW?**

Single Tunnel Today

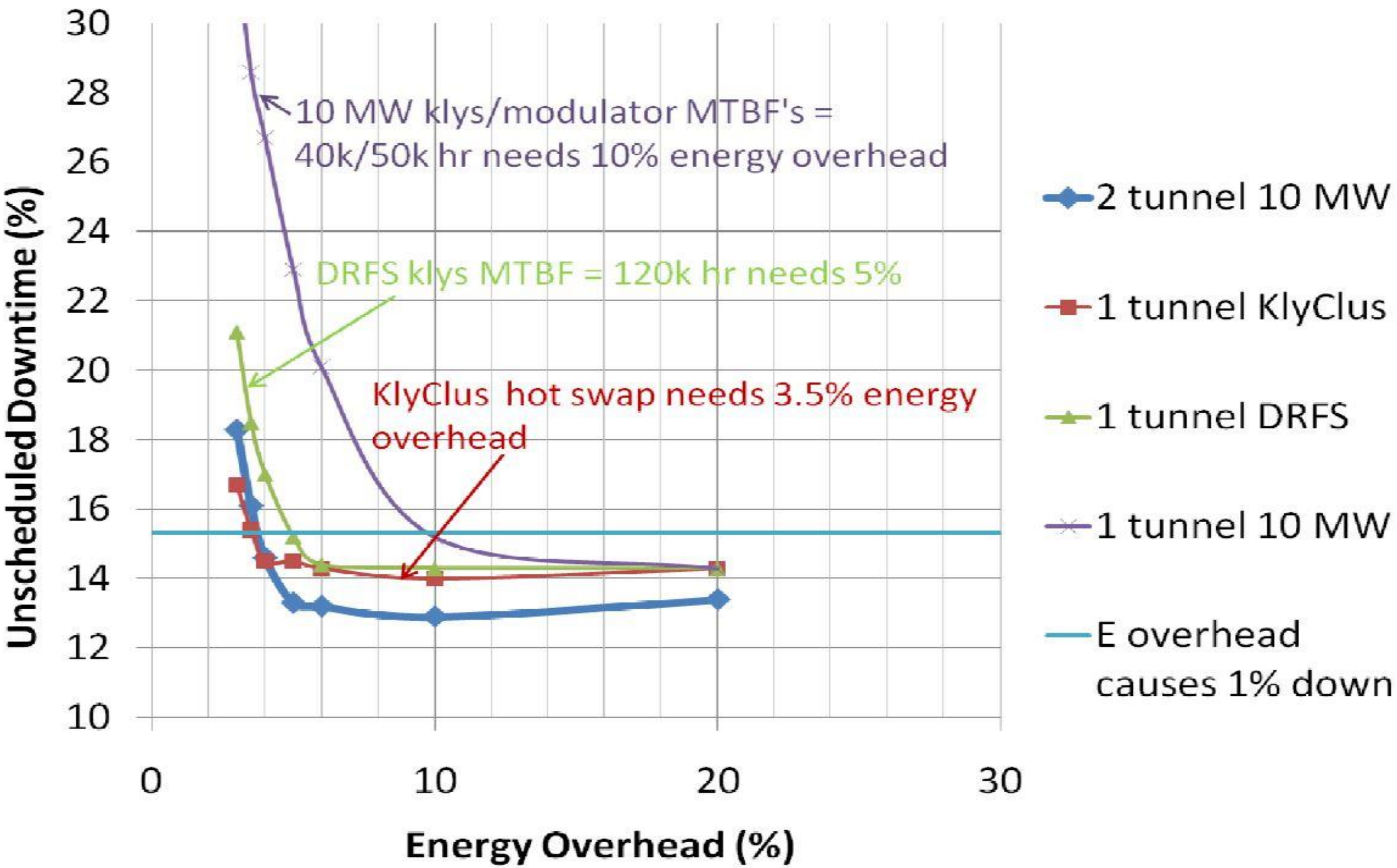
- Today we have only one site and it is deep underground and the only option for a single tunnel for the linac RF systems is to have the klystrons etc in the tunnel with both beams and the RF off for any access for maintenance, other system commissioning or development.

- In the past the Availsim assumptions had 40 to 50 Khrs for the MTBF of the "new' 10MW tubes and this meant that you needed a >10% energy overhead (installed spares) to maintain the desired availability goal.

- This needs to be changed based on experience. The tubes were designed (by three manufacturers) to have lifetimes of > 100 Khrs. They are multibeam tubes with low cathode loading and low voltage and they should have lifetimes comparable to the 800 kw tubes in the DRFS system design. So far, experience indicates that this is a valid assumption and could be used in a single tunnel with only a 4.to 5 % energy overhead as is required in the twin tunnel models for maintenance and availability.

- **DO WE NEED A WALL? YES BUT THINNER?**

Downtime versus Energy Overhead from TDR



A Thin Wall Possible Design

- In the given site, now the only site under study, there are kilometers between exits and personnel safety depends on having more frequent (few hundred meters) escape routes. This means we need some firewall between two parts of the tunnel, with periodic access between them. This separator wall has to be fireproof and reasonably air tight for smoke or oxygen deficiency hazards.
- A 30 cm thick concrete wall would satisfy this problem but there are more!

1) Shielding against long term radiation damage to electronic components in normal operation. Could be done locally or with the wall, if thick enough to satisfy the following.
2) Personnel shielding from dark currents while RF processing , and testing or maintenance with all systems ON but NO primary beam.

- ***The on-going studies of dark current behavior are very important and probably determine the minimum wall thickness at (I hope) ≤ one meter!***
  Note one is not concerned with captured dark current in this case as one can alternate klystron phases to prevent acceleration.
- **IN THIS NEW SCENARIO, DURING A SCHEDULED MAINTENANCE DAY (or an unscheduled access) ALL BEAM IS OFF BUT ALL POWER SUPPLIES AND RF ARE ON AND ACCESSABLE BEHIND THE THINNER GREAT WALL.**

  ONE CAN STILL MONITOR OR LOCALLY TEST MOST OF THE HARDWARE BUT HAVE NO BEAM INFORMATION.

THIS SCENARIO IS WORTH CONSIDERATION

Impact of No Beam During Access

- Impact not as bad as one initially thinks. PS's and RF stay on and warm.

- In the linac to change klystrons or work on equipment on every two week maintenance days, the beams have to be safely turned off upstream OR the Beam Containment System will or should. This means no beams anyway in the linac during most maintenance days.

- 2 to 3 Klystrons, minimum, every 2 weeks will require a change and processing time. This assumes ≥ 100Khrs MBTF and 4 to 5 % energy overhead.

- This means no E+ on most maintenance days without using an auxiliary e- source. For one day every two weeks! Not worth tuning up for one day?

- Thin wall will benefit central region if one changes from twin to Kamaboko tunnel

- The impact appears small during routine operation but could be larger during commissioning ? OK for hardware commissioning like "in situ' RF processing.

- Energy Overhead is crucial for the Linac and Redundancy in the Central Region

RELATED INFO ON SPECIAL REGIONS

In several sections of the central region there will be no dark current and one would be tempted to say that we only need a 30 cm fire safety shield but there are high power beams in these sections and the potential for long term damage to control or beam diagnostic electronics. Therefore at this time I would assume a uniform wall thickness in all Kamaboko section tunnels. It is possible that for this type of damage we will need special attention given to areas near beam dumps.

Table 10.1
Maximum power handling capabilities of the beam dumps.

E-1	SC Tune-up Dump	311 kW[‡]	E+1	SC Tune-up Dump	311 kW[‡]
E-2	EDRX Tune-up Dump	220 kW	E+2	PDRX Tune-up Dump	220 kW
E-3	RTML Tune-up Dump	220 kW	E+3	RTML Tune-up Dump	220 kW
E-4	BDS Tune-up Dump	14 MW	E+4	BDS Tune-up Dump	14 MW
E-5	Primary E- Dump	14 MW[†]	E+5	Primary E+ Dump	14 MW[†]
E-6	RTML Tune-up Dump	220 kW	E+6	RTML Tune-up Dump	220 kW
E-7	E- Fast Abort Dump	250 kW	E+7	E+ Target Dump	200 kW[†]

[†] Always ON
[‡] 45 kW always ON

From TDR 10.6

Does this list include all necessary kickers and dumps for machine protection?

CENTRAL REGION REDUNDANCY IN THE TDR

- **E- SOURCE TO E- DR** ***GOOD REDUNDANCY***
- 2 Guns and 2 Laser Systems Installed
- Buncher:- has a spare klystron and accelerator structure Installed
- 5 GeV Booster :- It has 21 cryomodules + 3 spare, plus a spare klystron Installed
- Energy Compressor :- It has 2 x 5 Mw klystrons Installed

- **E+ SOURCE TO E+ DR** ***POOR REDUNDANCY***
- Spare Undulator Sections but not Installed? No mention!
- Spare Target, Flux Concentrator and Capture sections. No mention in TDR.
- Spare Klystrons for warm RF, Booster Linac and Energy Compressor Could be
- installed as is done in E- Injector along with spare cryomodules.
- Timing Chicane Needs design and entry in CFS layout and lattice.
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- **THESE LISTS NEED TO BE, UPDATED, AGREED UPON AND BE INCORPORATED INTO CFS LAYOUTS, TIMING AND LATTICE DESIGN**