S-Band Waveguide Reconfiguration Options for the LCLS RF Gun and L0 Klystron Feeds.

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Abstract

This note highlights the possible re-configuration options for the existing WR284 S-band waveguide in the klystron gallery, to enable those existing 5045 klystrons to power the RF Gun and the L0 accelerating structures for LCLS. A reconfiguration decision based on the pros and cons for each option is subsequently identified.

Existing S-Band Station Configuration

Figure 1 Existing LINAC S-Band 5045 Klystron Feeder System

The existing LINAC klystron feeder system is shown in Figure 1, indicating that the 5045 klystron (not shown for clarity) connects to a WR284 pump tee and its associated valve, which in turn is fed from the main LINAC vacuum manifold. A waveguide valve then protects the LINAC vacuum in the event that the klystron is to be replaced or removed. RF power is then transferred into the SLED cavity and then output to a dual feed power divider,

which drives 2 accelerating structures in the beam tunnel. The existing LINAC klystrons at 20-6, 20-7 and 20-8 have been chosen to power the new LCLS RF Gun, L0 and L1 LINAC accelerating structures respectively. This reconfiguration for LCLS would mean that high energy beams of up to 50 GeV could no longer be achieved and so whatever re-configuration option is adopted must have the capability of resuming its original configuration if and when needed. A second requirement of the reconfiguration process is that once configured for LCLS, the WR284 S-band waveguide cannot be tied to the main LINAC vacuum system, there must be isolation between the injector and LINAC vacuum, so that a vacuum leak in either can be localized via the fast beam pipe valves. Three different alternatives have been identified which would enable the klystron output power to be appropriately rerouted.

Option 1 Repositioning the 5045 Klystron

Figure 2. Repositioning the 5045 Klystron

By splitting the WR284 waveguide feed immediately after the klystron and before the pump tee (as shown in Figure 2), the klystron can be repositioned longitudinally down (or up) the klystron gallery by ~ 1 ft to enable connection into the new LCLS WR284 waveguide. Both the vacuum manifold valve and the WR284 waveguide valve will be closed, which requires additional pumping capability on the new LCLS waveguide along with its own vacuum valve.

For this option, the modulator cable should remain short and therefore minimize any performance deterioration that may be required if a longer cable is required. All the existing klystron controls and interlocks remain the same without any configuration changes. Another advantage with this option is that the reconfiguration (in either direction) does not require breaking injector or LINAC vacuum. An estimate of ~ 1 day would be required to reconfigure back to high energy beam mode if necessary. The klystron support however would need to be

Option 2 Installing a Second 5045 Klystron

Install second klystron to new WR284 Gun feed (with its own isolated vacuum pump and valve). Operate from existing modulator $\therefore$ only able to use 1 of these 2 tubes at a time.

Klystron separation ~ 3 ft

Leave original klystron configuration as-is

Inevitably the 2nd klystron would require a longer modulator cable (additional inductance) and some klystron performance degradation would be anticipated. It would take approximately 2 days to switch and test all the klystron controls and interlocks when reconfiguring back again. The additional 5045 klystron for this option would be absorbed using an available spare tube.

Interrupting the existing WR284 waveguide feed after the SLED cavity and before the power divider and subsequently removing the power divider completely, would allow for reconnection into the LCLS waveguide after the SLED cavity. Depending on the RF power

requirements for the LCLS system, the SLED cavity could be de-activated if necessary. Figure 4 shows how the LCLS feed would integrate, indicating that only the LINAC vacuum manifold valve would require to be closed, with additional valve and pumping available in the new LCLS waveguide feed. The existing accelerating structure waveguide feeds would then require terminating with either loads or shorting plates to contain the beam induced RF power.

Figure 4 Removal of the Existing Power Divider

This, more invasive approach would require the LINAC vacuum to be vented when reconfiguring back to high energy beam running and it is anticipated that up to 5 days would be required to implement the hardware changes and appropriately pump down the LINAC sector once more.

LCLS RF Power Requirements

RF Gun

The RF power requirements for the dual feed RF Gun for LCLS are detailed below, indicating that 44 MW of RF power would be required from the 20-6 klystron, to achieve 30 MW peak at the RF Gun itself.

- Power at the Gun = 30 MW peak
- Parasitic losses = 1.7 dB (250 ft of WR284)
- Klystron power = 44 MW (existing 20-6 klystron)

LINAC L0-1 Structure

The L0 LINAC section comprises 2 S-band accelerating structures, each with different gradient and RF power requirements. The first of these structures L0-1 requires up to 57 MW from the klystron to generate up to 23 MV/m of accelerating gradient in the structure.

- Accelerating gradient = 21 (23)¹ MV/m
- RF power at the structure = 35 (42) MW peak
- Parasitic losses = 1.3 dB (190 ft of WR284)
- Klystron power = 47 (57) MW (existing 20-7 klystron)

LINAC L0-2 Structure

The L0-2 accelerating structure requires substantially more RF power to provide the necessary accelerating gradient of up to 28 MV/m.

- Accelerating gradient = 24 (28) MV/m
- RF power at the structure = 46 (62) MW peak
- Parasitic losses = 1.3 dB (190 ft of WR284)
- Klystron power = 62 (84) MW (existing 20-8 klystron)

The net energy gain from these 2 accelerating structures for the L0 LINAC will then be 135 MeV nominally and 153 MeV maximum.

Proposed Reconfiguration Solution

A conservative estimate of maximum peak RF power from a typical 5045 S-band klystron has been made at 60 MW. This would then mean that, certainly for the L0 accelerating structures, the 20-7 and 20-8 klystrons would need to be operated in SLED mode and would consequently favour Option 3. The RF Gun however does not require SLED output power capability meaning that all 3 Options are viable solutions.

In order to standardize on the hardware changes needed for the reconfigured stations and also provide adequate RF power overhead, the proposed scheme chosen for each klystron waveguide reconfiguration is **Option 3**, for **BOTH** the L0 accelerating structures **AND** the RF Gun system.

¹ Figures in parenthesis indicate maximum values required, otherwise the nominal value is stated.