The recommendation submitted in the Director's review suggested considering doing the Proton Power Upgrade with six cryomodules rather than seven. This would require achieving an average operating gradient of 18.7 MV/m with a field emission onset greater than 17 MV/m. To evaluate this recommendation, a technical evaluation, cost impact, and risk assessment were performed. Because of this increased gradient, it would be necessary that a PPU spare cryomodule be fabricated to allow repairs of a PPU cryomodule while maintaining beam energy with adequate margin.

After analyzing this scenario, it was determined that this is technically feasible. Because there would be twenty-four PPU cavities, three high voltage converter modulators would be deployed in the "eight-pack" configuration. A simulation showed that 83kV with 13.32A would yield 772kW which is sufficient for the proposed reduction in cryomodules. The klystrons would have to operate at 760 kW. The klystrons are capable of 800 kW and the datasheets show that the tubes were tested to approximately 88kV producing 900kW of power. The fundamental power coupler should also handle the increased power but procedures would have to be modified to process the coupler up to 800 kW at full duty. Technically, this approach is feasible.

To evaluate the cost impact of this change, we study the SCL and RF portions of the WBS. Utilizing an average operating gradient of 16 MV/m in seven cryomodules enables SNS to utilize the existing high beta spare with a reduced gradient of 13.3 MV/m if a PPU cryomodule had to be removed from the tunnel for repair. The 1.3 GeV beam energy is preserved with two and a half cavities held in reserve. For the case of 18.7 MV/m, using the existing high beta spare would result in less than one and a half cavities in reserve. This scenario would reduce the energy margin from 42MeV to 25 MeV. Therefore, for the 18.7 MV/m case, a spare PPU cryomodule should be included in the project. For the 16 MV/m case, an additional PPU spare is not necessary. The SCL scope of PPU would require the same amount of cryomodules in either approach. There is no cost impact in the SCL portion of PPU with this approach.

The cost savings would be realized in the RF portion of the PPU scope. There would be a reduction of equipment from the RF scope including four klystrons and one transmitter. This represents approximately $1M in savings in klystrons and $2M in savings for the transmitter. This results in a total savings of $3M.

It was suggested to increase the gradient since ESS will have a gradient specification of 20 MV/m. However, ESS will run at a repetition rate of 14 Hz versus the SNS rate of 60 Hz. Currently, SNS can operate cavities at higher gradients when employing lower repetition rates. There is considerable risk in elevating the average operating gradient beyond what has been achieved in the operating machine. The field emission onset is also a critical component of the specification because the 0.81 beta cavity is susceptible to collective effects from cavities within the same cryomodule. Currently, cavities are operated at 1.5 MV/m above field emission onset or below. A field emission onset of greater than 17 MV/m would be very challenging for this cavity design.

With the increased risk and marginal cost savings realized, it is in the best interest of the project to procure, install and commission seven PPU cryomodules.