Marco's estimation of the power consumption for DUNE

Dave Christian and I have estimated an upper limit on the power required by the ASICs on the FEMB as 47 mW per channel delivered at 2.5 V. This number is obtained in the following table, assuming linear voltage regulators (that have an efficiency equal to Vout/Vin) are used to step down the 2.5 V at the input of the FEMB to the various voltages required to power LArASIC (1.8 V), ColdADC (2.25 V and 1.1 V) and COLDATA (2.25 V and 1.1 V). The total power per chip estimated from the following table is 88mW (LArASIC), 507 mW (ColdADC), 195 mW (COLDATA), and the total power on the FEMB, including that dissipated in the linear voltage regulators is 6 W (2.4 A at 2.5 V), that corresponds to 47 mW per channel.

ASIC	Current per channel	Current per chip	Chips per FEMB
LArASIC (1.8V)	3mA	48mA	8
ColdADC (2.3V)		196mA	8
ColdADC (2.25V)		23mA	
ColdADC (1.1V)		4mA	
COLDATA (2.25V)		60mA	2
COLDATA (1.1V)		55mA	

The power to the FEMB is provided by a set of seven AWG20 wires that have a length of 9m (upper APA) or 22m (lower APA). The resistance of the cable bundle is 41 mΩ (upper APA) or 101 mΩ (lower APA). To account for the voltage drop along the cables and the returns, the WIB needs to provide (operation in warm) 2.7 V to the upper APA and 3.0 V to the lower APA. For one FEMB the power dissipated in the cables is 0.5 W for the upper APA and 1.2 W for the lower APA.

When operating in liquid argon (LAr), the cable resistance is reduced by a factor 3 (i.e. 14 mΩ and 34 mΩ for the upper and lower APA, respectively), which means that the WIB needs to provide 2.6 V and 2.7 V to the two APAs, reducing the total power dissipated in the cables to 0.25 W and 0.5 W for the upper and the lower APA respectively. This means that when operating in LAr the amount of power dissipated in the cables and therefore in each APA frame is at most 5W per side tube. In the following we consider only the worse case scenario of warm operation.

The WIB has to provide 2.4 A at 2.7 V for each FEMB attached to the upper APA and 2.4 A at 3.0 V for each FEMB attached to the lower APA. The WIB receives 12V from the PTC and uses a DC-DC converter to reduce this voltage to the required value. We assume an efficiency of 0.8 for the DC-DC converter. For each FEMB the WIB requires 0.68 A (upper APA) or 0.75 A (lower APA). There are 4 FEMBs attached to each WIB, which means that each WIB requires 2.7 A (upper APA) or 3.0 A (lower APA) at 12V. To this one needs to add the power required by the FPGA and the optical components, which we assume to be 20W (this number is based on the power consumption of a full WIB in ProtoDUNE). This brings the total current required by a WIB to 4.4 A (upper APA) or 4.7 A (lower APA).

In each WIEC the five WIBs are powered from a single PTC, that has to provide 22 A at 12V (upper APA) or 24 A at 12 V (lower APA). The PTC receives the power from a WIENER PL506 which provides 48 V. DC-DC converters are used inside the PTC to reduce this voltage down to 12 V, and we again assume an efficiency of 80% for the conversion. The WIENER PL506 must provide 6.9 A (upper APA) or 7.5 A (lower APA) at

48V. The connection between the WIENER PL506 and the PTCs is realized with AWG10 cables that have a length of up to 20m. The voltage drop on the cables and the returns is 0.9 V and 1.0 V for the upper and lower APAs, respectively. The total power provided by the WIENER PL506 is 335 W and 360 W for the upper and lower APAs, respectively. Of this 130 W and 144 W are inside the cryostat for the upper and lower APAs, respectively. The power dissipated in the WIBs is 132-156W and that dissipated in the PTC is 66-50W.