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RF Signal Distribution (Cabling)

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1 Overview

The RF distribution system consists of a set of RF sources, a number of distribution amplifiers and the long haul cabling between electronics racks. This document describes the design of the cabling system. It consists of

- the rack-mounted patch panels,
- the long haul coaxial cables,
- the mounting and routing of the cables,
- the isolation transformers, and
- a cable plan.

The system is design with about 45% spare capacity.

2 Applicable Documents

The applicable documents can be located through the following wiki pages:

- [RF Design](#): Overview
- [RF Distribution Layout](#): List of long haul cable runs
- [RF Patch Panels](#): Panels, cables and isolation
- [RF Source](#): OCXO source stabilized to GPS
- [RF Distribution Amplifier](#): 8 output amplifier for RF signals

3 Rack Locations

Rack locations are described in [D1003142](#). The RF sources are located in the electronics room. The racks are ISC-C4 and ISC-C3 for the corner station and ISC-C1 in the end stations. The majority of the long haul RF signal distribution originates in one of these racks and terminates in one of the field racks. The field racks in the corner station are

- PSL-R2: Electronics for the PSL (reference cavity, premode cleaner, master oscillator),
- PSL-DR: Diode room for the PSL (ALS fiber distribution),
- ISC-R1: Electronics to lock the mode cleaner and to operate the ALS,
- ISC-R2: Electronics for the reflection port,
- ISC-R3: Electronics for the anti-symmetric port,
- TCS-R1: TCS electronics,
- TCS-R2: TCS electronics.
- TCS-R4: mechanical room, mezzanine

The table below lists the nominal cable length between the racks following the cable trays. Due to high costs only 75% of the initial cable runs will be laid down. The savings are indicated in separate columns.

Table 1: Nominal cable length between racks

| Ifo | Location | Racks | | Length (m) | Qty | Save | Orig. (m) | Save (m) | Ext. (m) |
|----------------------------|----------|--------|--------|------------|-----|------|-----------|----------|----------|
| H1 L1 | LVEA | ISC-C4 | ISC-R1 | 52 | 12 | 1 | 624 | 52 | 572 |
| | | | ISC-R2 | 50 | 12 | 4 | 600 | 200 | 400 |
| | | | ISC-R3 | 44 | 12 | 5 | 528 | 220 | 308 |
| | | ISC-C3 | PSL-R2 | 55 | 12 | 3 | 660 | 165 | 495 |
| | | | TCS-R1 | 44 | 2 | 0 | 88 | 0 | 88 |
| | | | TCS-R2 | 48 | 2 | 0 | 96 | 0 | 96 |
| | | ISC-R1 | PSL-R2 | 6 | 2 | 0 | 12 | 0 | 12 |
| | | | PSL-DR | 48 | 2 | 0 | 96 | 0 | 96 |
| | EX | ISC-C1 | ISC-R1 | 26 | 12 | 4 | 312 | 104 | 208 |
| | EY | ISC-C1 | ISC-R1 | 26 | 12 | 4 | 312 | 104 | 208 |
| | Total | | | | | | | 3328 | 845 |
| H2 | LVEA | ISC-C4 | ISC-R1 | 81 | 12 | 1 | 972 | 81 | 891 |
| | | | ISC-R2 | 80 | 12 | 4 | 960 | 320 | 640 |
| | | | ISC-R3 | 52 | 12 | 5 | 624 | 260 | 364 |
| | | ISC-C3 | PSL-R2 | 84 | 12 | 3 | 1008 | 252 | 756 |
| | | | TCS-R1 | 81 | 2 | 0 | 162 | 0 | 162 |
| | | | TCS-R2 | 42 | 2 | 0 | 84 | 0 | 84 |
| | | ISC-R1 | PSL-R2 | 6 | 2 | 0 | 12 | 0 | 12 |
| | | | PSL-DR | 15 | 2 | 0 | 30 | 0 | 30 |
| | EX | ISC-C1 | ISC-R1 | 41 | 12 | 4 | 492 | 164 | 328 |
| | EY | ISC-C1 | ISC-R1 | 41 | 12 | 4 | 492 | 164 | 328 |
| | Total | | | | | | | 4836 | 1241 |
| Grand total (H1 & H2 & L1) | | | | | | | 11492 | 2931 | 8561 |

4 Cable Selection

We require a loss no larger than 3 dB between the RF source and the amplifier. We allocated up to 1.2 dB to the isolation transformer and the local cabling. This leaves 1.8 dB of maximum loss for the long cable runs. The longest runs are part of the H2 system and are about 80 m. The highest frequency of interest in aLIGO is around 135 MHz. However, all our main signals are at 80 MHz or below. Therefore, the requirement for cable losses are 2.2 dB per 100 m at 80 MHz or lower.

Table 2: Cable Selection

| Cable | Manufacturer | Ø (mm) | Bending radius (cm) | Loss (dB) 100 m 80 MHz |
|----------------------|-----------------|--------|---------------------|------------------------|
| HELIAX LDF4-50A | Andrew | 16 | 13 | 2.0 |
| HELIAX LDF2-50A | Andrew | 11 | 9.5 | 3.1 |
| HELIAX LDF1-50A | Andrew | 8.8 | 7.6 | 3.6 |
| 9310 (RG58) | Belden | 4.9 | | 11 |
| RF400 (low loss RG8) | Belden | 10.3 | 10 | 3.7 |
| RF500 (7976A) | Belden | 12.7 | 13 | 2.9 |
| RF600 (7977A) | Belden | 15.0 | 15 | 2.3 |
| LMR-400 | Times Microwave | 10.3 | 10 | 3.7 |
| LMR-500 | Times Microwave | 12.7 | 13 | 2.9 |
| LMR-600 | Times Microwave | 15.0 | 15 | 2.3 |

From the above table the preferred cable is the LDF4-50A from Andrews. For a given diameter it has the lowest loss and the smallest bending radius. Alternate cables are the RF600 from Belden and the LMR-600 from Times Microwave Systems.

A table listing losses as function of frequency for advanced LIGO cable runs using the LDF4-50A cable is given below.

Table 3: Cable Losses for H1 (LDF4-50)

| Freq. (MHz) | ISC-C3 PSL-R2 | ISC-C4 ISC-R2 | ISC-C3 TCS-R1 | ISC-C3 TCS-R2 | EX/EY ISC |
|-------------|---------------|---------------|---------------|---------------|-----------|
| 9 | 0.32 | 0.26 | 0.26 | 0.28 | 0.15 |
| 24 | 0.57 | 0.46 | 0.46 | 0.50 | 0.27 |
| 35 | 0.70 | 0.56 | 0.56 | 0.61 | 0.33 |
| 45 | 0.79 | 0.63 | 0.63 | 0.69 | 0.38 |
| 80 | 1.07 | 0.86 | 0.85 | 0.93 | 0.51 |
| 135 | 1.40 | 1.12 | 1.11 | 1.22 | 0.66 |

Table 4: Cable Losses for H2 (LDF4-50)

| Freq. (MHz) | ISC-C3 PSL-R2 | ISC-C4 ISC-R2 | ISC-C3 TCS-R1 | ISC-C3 TCS-R2 | EX/EY ISC |
|-------------|------------------|------------------|------------------|------------------|--------------|
| 9 | 0.49 | 0.30 | 0.47 | 0.24 | 0.24 |
| 24 | 0.88 | 0.54 | 0.84 | 0.43 | 0.42 |
| 35 | 1.07 | 0.66 | 1.02 | 0.53 | 0.51 |
| 45 | 1.21 | 0.74 | 1.16 | 0.60 | 0.58 |
| 80 | 1.63 | 1.00 | 1.56 | 0.81 | 0.78 |
| 135 | 2.14 | 1.31 | 2.05 | 1.06 | 1.03 |

The majority of RF inputs are designed for 10 dBm whereas the outputs are designed for 13 dB. For shorter runs the loss may not add up to 3 dB and the inputs have to be adjusted using attenuators. Type N attenuator are available from Mini-Circuits with part numbers UNAT-1, UNAT-2 and UNAT-3 for 1 dB, 2 dB and 3 dB, respectively.

5 Patch Panels

A standard patch panel is used. It is 2U high (3.5”) and contains 6 N feedthrough adapters across. The feedthrough adapters are type N and are isolated, i.e., Pasternack PE9382. The panel is about 5” recessed to accommodate an optional isolation transformer (balun). The patch panel is shown in D1100TBD-v1. The required patch panels are listed in the table below.

Table 5: Patch Panels

| Panel | Location | Destination | Signals | Comment |
|-------|----------|--------------|---------|--------------------------|
| 1 | ISC-C4 | ISC-R1 | 6 | Corner, rack position 39 |
| 2 | ISC-C4 | ISC-R1 | 6 | Corner, rack position 37 |
| 3 | ISC-C4 | ISC-R2 | 6 | Corner, rack position 35 |
| 4 | ISC-C4 | ISC-R2 | 6 | Corner, rack position 33 |
| 5 | ISC-C4 | ISC-R3 | 6 | Corner, rack position 31 |
| 6 | ISC-C4 | ISC-R3 | 6 | Corner, rack position 29 |
| 7 | ISC-C3 | PSL-R2 | 6 | Corner, rack position 39 |
| 8 | ISC-C3 | PSL-R2 | 6 | Corner, rack position 37 |
| 9 | ISC-C3 | TCS-R1/R2/R4 | 2/2/1 | Corner, rack position 35 |

| | | | | |
|----|-----------|------------------|-------|--------------------------|
| 10 | ISC-R1 | ISC-C4 | 6 | Corner, rack position 39 |
| 11 | ISC-R1 | ISC-C4 | 6 | Corner, rack position 37 |
| 12 | ISC-R1 | PSL-R2/DR | 2 | Corner, rack position 35 |
| 13 | ISC-R2 | ISC-C4 | 6 | Corner, rack position 39 |
| 14 | ISC-R2 | ISC-C4 | 6 | Corner, rack position 37 |
| 15 | ISC-R3 | ISC-C4 | 6 | Corner, rack position 39 |
| 16 | ISC-R3 | ISC-C4 | 6 | Corner, rack position 37 |
| 17 | PSL-R2 | ISC-C3 | 6 | Corner, rack position 39 |
| 18 | PSL-R2 | ISC-C3 | 6 | Corner, rack position 37 |
| 19 | PSL-R2 | ISC-R1 | 2 | Corner, rack position 35 |
| 20 | TCS-R1 | ISC-C3/TCS-R2/R4 | 2/2/1 | Corner, rack position 39 |
| 21 | TCS-R2 | ISC-C3/TCS-R2 | 2/2 | Corner, rack position 39 |
| 22 | EX-ISC-C1 | EX-ISC-R1 | 6 | EX, rack position 39 |
| 23 | EX-ISC-C1 | EX-ISC-R1 | 6 | EX, rack position 37 |
| 24 | EX-ISC-R1 | EX-ISC-C1 | 6 | EX, rack position 39 |
| 25 | EX-ISC-R1 | EX-ISC-C1 | 6 | EX, rack position 37 |
| 26 | EY-ISC-C1 | EY-ISC-R1 | 6 | EY, rack position 39 |
| 27 | EY-ISC-C1 | EY-ISC-R1 | 6 | EY, rack position 37 |
| 28 | EY-ISC-R1 | EY-ISC-C1 | 6 | EY, rack position 39 |
| 29 | EY-ISC-R1 | EY-ISC-C1 | 6 | EY, rack position 37 |
| 30 | PSL-DR | ISC-R1 | 2 | Corner, diode room |
| 31 | TCS-R4 | TCS-R1/ISC-C3 | 1/1 | Corner, mechanical room |

There are 31 patch panels per detector, or 93 in total. Patch panels 9, 12 and 31 fan into multiple destinations. All other patch panels are connected to exactly one other one and are connected 1:1. Each patch panel incorporates an attachable aluminum strip to label the individual signals. Labels can be manufactured through Frontpanel Express as required.

6 Ground Isolation

In order to avoid ground loops between the different rack locations an isolation transformer is installed on the destination end of each RF signal line. The balun is described in E1100596-v1 and [D1101077-v1](#).

Table 6: Location of Balun Isolation Transformers.

| Location | | | Frequency (MHz) | Comment |
|----------|-------|--------|------------------------|----------------------|
| Location | Panel | Signal | | |
| ISC-C4 | 2 | 1 | 79.400 | Return ALS DIFF VCO |
| | | 2 | 79.400 | Return ALS COMM VCO |
| | | 3 | 79.400 | Return PSL VCO |
| ISC-C3 | 9 | 1 | ~40 | Return TCS AOM |
| ISC-R1 | 10 | 1 | 71.000 | Distribution |
| | | 2 | | Spare |
| | | 3 | | Spare |
| | | 4 | 24.078 | MC Distribution |
| | | 5 | 9.099/8.684 | Main modulation |
| | | 6 | 5 th harm. | Auxiliary modulation |
| ISC-R2 | 13 | 1 | 9.099/8.684 | Distribution |
| | | 2 | 5 th harm. | Distribution |
| | | 3 | 2 nd harm. | Demodulation |
| | | 4 | 3 rd harm. | Demodulation |
| | | 5 | 10 th harm. | Demodulation |
| | | 6 | 15 th harm. | Demodulation |
| ISC-R2 | 14 | 1 | 79.200 | ALS Fiber |
| | | 2 | | Spare |
| ISC-R3 | 15 | 1 | 9.099/8.684 | Distribution |
| | | 2 | 4 th harm. | Distribution |
| | | 3 | 5 th harm. | Distribution |
| | | 4 | 2 nd harm. | Demodulation |
| | | 5 | 10 th harm. | Demodulation |

| Location | | | Frequency (MHz) | Comment |
|--------------|-------|--------|-----------------|---------------------------------------|
| Location | Panel | Signal | | |
| PSL-R2 | 17 | 1 | 21.500 | Modulation |
| | | 2 | 21.500 | FSS |
| | | 4 | 35.500 | Modulation |
| | | 5 | 35.500 | PMC |
| | | 6 | 35.500 | Injection Locking |
| PSL-R2 | 18 | 2 | 80.000 | ISS AOM |
| PSL-R2 | 19 | 1 | 79.4 | PSL VCO |
| TCS-R1 | 20 | 6 | ~40 | TCS AOM |
| TCS-R2 | 21 | 3 | ~40 | TCS AOM |
| | | 4 | ~40 | TCS AOM |
| EX ISC-C1 | 22 | 5 | 39.7 | Return PLL Beat Note |
| | | 6 | 79.4 | Return ALS laser VCO |
| EX ISC-R1 | 24 | 1 | 71.000 | ALS laser VCO |
| | | 2 | 24.4 | ALS Modulation |
| | | 3 | 24.4 | ALS Demodulation |
| | 25 | 1 | 24.4 | ALS WFS A Demodulation |
| | | 2 | 24.4 | ALS WFS B Demodulation |
| EY ISC-C1 | 26 | 5 | 39.7 | Return PLL Beat Note |
| | | 6 | 79.4 | Return ALS laser VCO |
| EY ISC-R1 | 28 | 1 | 71.000 | ALS laser VCO |
| | | 2 | 24.4 | ALS Modulation |
| | | 3 | 24.4 | ALS Demodulation |
| | 29 | 1 | 24.4 | ALS WFS A Demodulation |
| | | 2 | 24.4 | ALS WFS B Demodulation |
| PSL-DR | 30 | 1 | 79.4 | ALS fiber AOM |
| TCS-R4 | 31 | 2 | 10.000 | Frequency standard TCS RF synthesizer |

7 Cable Routing and Mounting

Cables are run inside the existing advanced LIGO cable trays. The cables are bundled into 10 runs consisting of up to 12 individual coaxial cables. Stainless steel cable ties are used to keep the bundle together and to mount it to the cable tray. Cable ties are MLTFC4S-CP316 or MLTFC4H-LP316 from Panduit for the larger bundles and MLTFC2S-CP316 or MLTFC2H-LP316 for the smaller bundles. The corresponding tool is Panduit GS4MT. There should be a cable tie roughly every 60 cm. If a mounting clip is required, one can use Panduit MTM2H-Q, Panduit MTM1H-C or Panduit MPWM-H56-Q depending on the circumstances.

Table 7: List of cable runs and bundles.

| From | | To | | Bundle | Length (m) | | Comment |
|-----------|-------|-----------|-------|--------|------------|----|---------------------|
| Location | Panel | Location | Panel | | H1/L1 | H2 | |
| ISC-C4 | 1/2 | ISC-R1 | 10/11 | 11 | 52 | 81 | ALS/MC |
| ISC-C4 | 3/4 | ISC-R2 | 13/14 | 8 | 50 | 80 | Reflection port |
| ISC-C4 | 5/6 | ISC-R3 | 15/16 | 7 | 44 | 52 | Anti-symmetric port |
| ISC-C3 | 7/8 | PSL-R2 | 17/18 | 9 | 55 | 84 | PSL |
| ISC-C3 | 9 | TCS-R1 | 20 | 2 | 44 | 84 | TCS X |
| | | TCS-R2 | 21 | 2 | 48 | 42 | TCS Y |
| | | TCS-R4 | 31 | 1 | | | TCS mezzanine |
| ISC-R1 | 12 | PSL-R2 | 19 | 2 | 6 | 6 | MC |
| | | PSL-DR | 30 | 2 | 48 | 15 | ALS |
| TCS-R1 | 20 | TCS-R2 | 21 | 2 | | | TCS X-Y |
| | | TCS-R4 | 31 | 1 | | | TCS mezzanine |
| EX-ISC-C1 | 22/23 | EX-ISC-R1 | 24/25 | 8 | 26 | 41 | EX |
| EY-ISC-C1 | 26/27 | EY-ISC-R1 | 28/29 | 8 | 26 | 41 | EY |

The total run of large cable bundles is 885 m which requires an estimated 1500 cable ties. The total run of small cable bundles is 328 m which requires an estimated 550 cable ties.

8 Cable Plan

There are a total of 59 cable runs per detector, or 177 in total. The number of currently used signal lines is 41 per detector, or 123 in total. Gray highlighted runs will not be installed initially.

Table 8: Cabling for long haul RF signals

| From | | | To | | | Frequency (MHz) | Comment |
|----------|-------|--------|----------|-------|--------|------------------------|----------------------|
| Location | Panel | Signal | Location | Panel | Signal | | |
| ISC-C4 | 1 | 1 | ISC-R1 | 10 | 1 | 71.000 | Distribution |
| | | 2 | | | 2 | Spare | |
| | | 3 | | | 3 | Spare | |
| | | 4 | | | 4 | 24.078 | MC Distribution |
| | | 5 | | | 5 | 9.099/8.684 | Main modulation |
| | | 6 | | | 6 | 5 th harm. | Auxiliary modulation |
| ISC-C4 | 2 | 1 | ISC-R1 | 11 | 1 | 79.400 | Return ALS DIFF VCO |
| | | 2 | | | 2 | 79.400 | Return ALS COMM VCO |
| | | 3 | | | 3 | 79.400 | Return PSL VCO |
| | | 4 | | | 4 | Spare | |
| | | 5 | | | 5 | Spare | |
| | | 6 | | | 6 | Spare | |
| ISC-C4 | 3 | 1 | ISC-R2 | 13 | 1 | 9.099/8.684 | Distribution |
| | | 2 | | | 2 | 5 th harm. | Distribution |
| | | 3 | | | 3 | 2 nd harm. | Demodulation |
| | | 4 | | | 4 | 3 rd harm. | Demodulation |
| | | 5 | | | 5 | 10 th harm. | Demodulation |
| | | 6 | | | 6 | 15 th harm. | Demodulation |
| ISC-C4 | 4 | 1 | ISC-R2 | 14 | 1 | 79.200 | ALS Fiber |
| | | 2 | | | 2 | Spare | |
| | | 3 | | | 3 | Spare | |
| | | 4 | | | 4 | Spare | |
| | | 5 | | | 5 | Spare | |
| | | 6 | | | 6 | Spare | |

| From | | | To | | | Frequency (MHz) | Comment |
|----------|-------|--------|----------|-------|--------|------------------------|------------------------|
| Location | Panel | Signal | Location | Panel | Signal | | |
| ISC-C4 | 5 | 1 | ISC-R3 | 15 | 1 | 9.099/8.684 | Distribution |
| | | 2 | | | 2 | 4 th harm. | Distribution |
| | | 3 | | | 3 | 5 th harm. | Distribution |
| | | 4 | | | 4 | 2 nd harm. | Demodulation |
| | | 5 | | | 5 | 10 th harm. | Demodulation |
| | | 6 | | | 6 | | Spare |
| ISC-C4 | 6 | 1 | ISC-R3 | 16 | 1 | | Spare |
| | | 2 | | | 2 | | Spare |
| | | 3 | | | 3 | | Spare |
| | | 4 | | | 4 | | Spare |
| | | 5 | | | 5 | | Spare |
| | | 6 | | | 6 | | Spare |
| ISC-C3 | 7 | 1 | PSL-R2 | 17 | 1 | 21.500 | Modulation |
| | | 2 | | | 2 | 21.500 | FSS |
| | | 3 | | | 3 | 21.500 | Spare |
| | | 4 | | | 4 | 35.500 | Modulation |
| | | 5 | | | 5 | 35.500 | PMC |
| | | 6 | | | 6 | 35.500 | Injection Locking |
| ISC-C3 | 8 | 1 | PSL-R2 | 18 | 1 | 35.500 | Spare |
| | | 2 | | | 2 | 80.000 | ISS AOM |
| | | 3 | | | 3 | | Spare |
| | | 4 | | | 4 | | Spare |
| | | 5 | | | 5 | | Spare |
| | | 6 | | | 6 | | Spare |
| ISC-C3 | 9 | 1 | TCS-R1 | 20 | 1 | ~40 | TCS AOM Return |
| | | 2 | | | 2 | 71.000 | SEI CPS clock |
| | | 3 | TCS-R2 | 21 | 1 | | Spare |
| | | 4 | | | 2 | | Spare |
| | | 5 | TCS-R4 | 31 | 2 | 10.000 | TCS frequency standard |

| From | | | To | | | Frequency (MHz) | Comment |
|-----------|-------|--------|-----------|-------|--------|-----------------|----------------------|
| Location | Panel | Signal | Location | Panel | Signal | | |
| ISC-R1 | 12 | 1 | PSL-R2 | 19 | 1 | 79.4 | PSL VCO |
| | | 2 | | | 2 | | Spare |
| | | 3 | PSL-DR | 30 | 1 | 158.4 | ALS AOM |
| | | 4 | | | 2 | | Spare |
| TCS-R1 | 20 | 3 | TCS-R2 | 21 | 3 | ~40 | TCS AOM |
| | | 4 | | | 4 | ~40 | TCS AOM |
| | | 6 | TCS-R4 | 31 | 1 | ~40 | TCS AOM |
| EX ISC-C1 | 22 | 1 | EX ISC-R1 | 24 | 1 | 71.000 | ALS laser VCO |
| | | 2 | | | 2 | 24.4 | ALS Modulation |
| | | 3 | | | 3 | 24.4 | ALS Demodulation |
| | | 4 | | | 4 | | Spare |
| | | 5 | | | 5 | 39.7 | Return PLL Beat Note |
| | | 6 | | | 6 | 79.4 | Return ALS laser VCO |
| EX ISC-C1 | 23 | 1 | EX ISC-R1 | 25 | 1 | 24.4 | ALS WFS A Demodul. |
| | | 2 | | | 2 | 24.4 | ALS WFS B Demodul. |
| | | 3 | | | 3 | | Spare |
| | | 4 | | | 4 | | Spare |
| | | 5 | | | 5 | | Spare |
| | | 6 | | | 6 | | Spare |
| EY ISC-C1 | 26 | 1 | EY ISC-R1 | 28 | 1 | 71.000 | ALS laser VCO |
| | | 2 | | | 2 | 24.4 | ALS Modulation |
| | | 3 | | | 3 | 24.4 | ALS Demodulation |
| | | 4 | | | 4 | | Spare |
| | | 5 | | | 5 | 39.7 | Return PLL Beat Note |
| | | 6 | | | 6 | 79.4 | Return ALS laser VCO |
| | | | | | | | |

| From | | | To | | | Frequency (MHz) | Comment |
|--------------|-------|--------|--------------|-------|--------|--------------------|--------------------|
| Location | Panel | Signal | Location | Panel | Signal | | |
| EY ISC-C1 | 27 | 1 | EY ISC-R1 | 29 | 1 | 24.4 | ALS WFS A Demodul. |
| | | 2 | | | 2 | 24.4 | ALS WFS B Demodul. |
| | | 3 | | | 3 | | Spare |
| | | 4 | | | 4 | | Spare |
| | | 5 | | | 5 | | Spare |
| | | 6 | | | 6 | | Spare |

9 Bill of Material

| Qty. | Part Number | Distributor | Comment |
|--------|---------------|---------------|------------------------------------|
| 93 | D1101479-v1 | LIGO | Patch panel |
| 360 | PE9382 | Pasternack | Isolated N feedthrough adapter |
| 8500 m | LDF4-50A | Andrew | Heliac cable |
| 360 | 12EZNM | Andrew | Connector N male |
| 2 | 12-HPT | Andrew | Manual hand prep tool |
| 150 | D1101077-v1 | LIGO | Balun |
| TBD | UNAT-n | Mini-Circuits | Type N attenuator (n dB) |
| 1500 | MLTFC4H-LP316 | Panduit | Stainless steel cable ties, 200 mm |
| 550 | MLTFC2H-LP316 | Panduit | Stainless steel cable ties, 360 mm |
| 2 | GS4MT | Panduit | Installation tool |