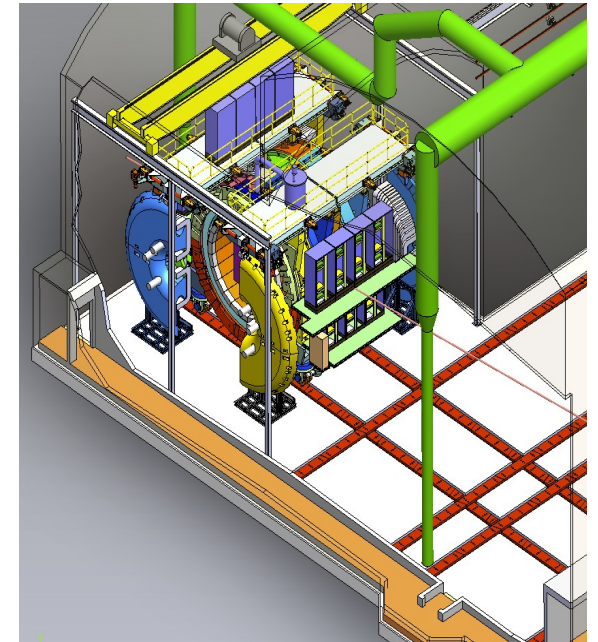
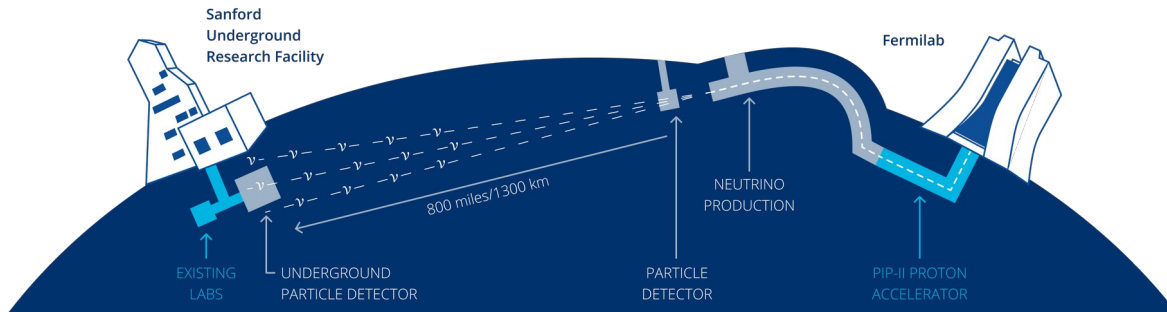
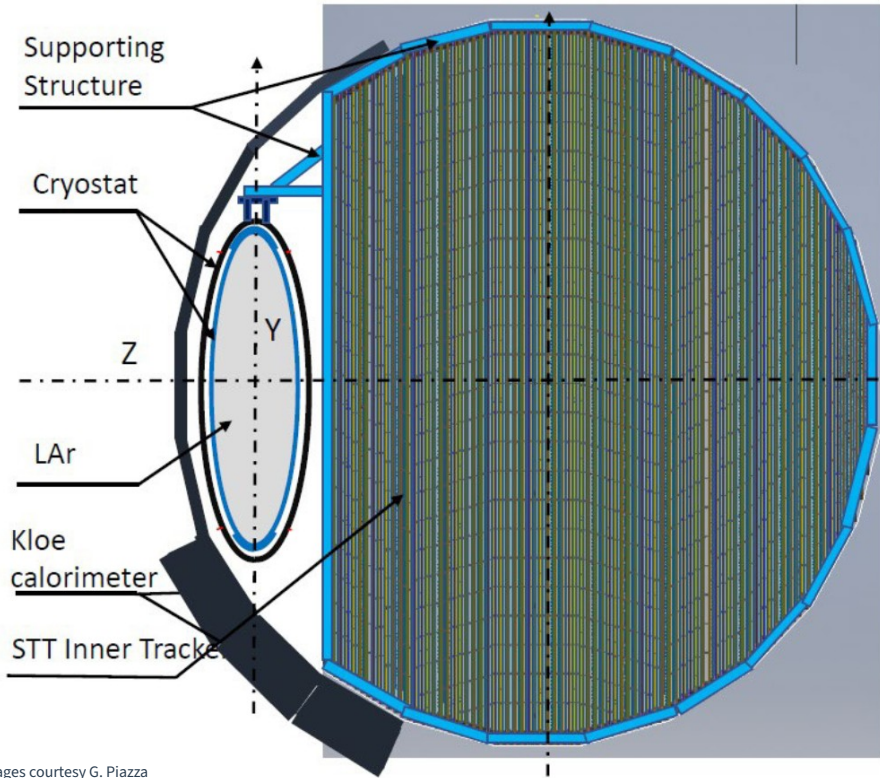


The DUNE Experiment and the SAND detector

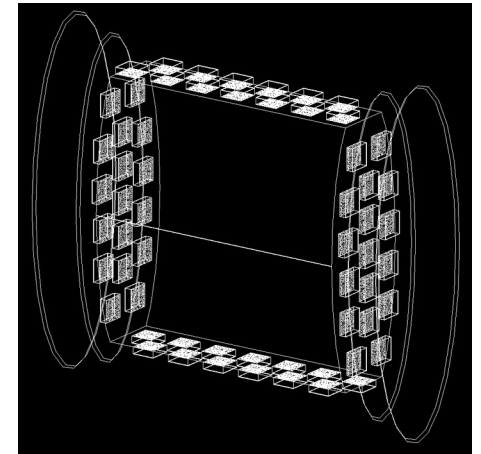
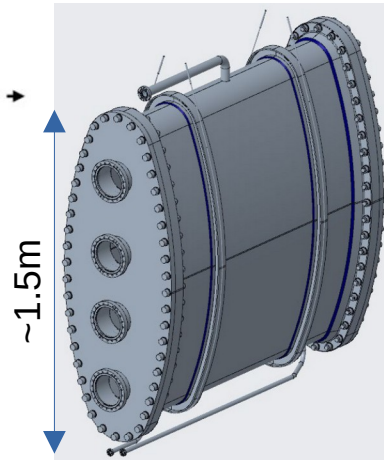


- DUNE is a large US-based neutrino experiment
- SAND is one of the “Near Detectors”, hosted at Fermilab, near Chicago
 - SAND is enclosed by a 0.5T superconducting magnet

GRAIN, the Active Argon Target in SAND



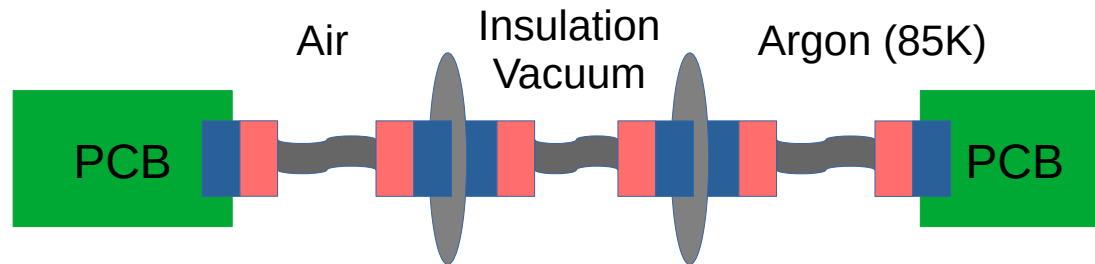
- A 1-ton target in a “thin” cryostat
 - Detect Liquid Argon scintillation light
 - > 60k Silicon PhotoMultipliers



Images courtesy G. Piazza

Readout system

- 64 “Camera” PCBs
 - One 1024 channel custom cryogenic ASIC
- 8 cameras connected to each feedthrough
 - DN160CF flange on both inner and outer vessel
 - Air – vacuum and vacuum – Liquid Argon



Electrical connections

- Each of the 8 camera board requires the following connections
 - 3-4 x LVDS clock/data lines operating at 625 Mbps (100 Ω differential)
 - 1 x ~100 MHz analog signal (likely 100 Ω differential or 50 Ω single ended)
 - 6-8 x single ended “slow” data lines
 - At least 6A current for core power
 - At least 3 more auxiliary power/bias lines (up to 50V, but low current)

Connection Density is an issue

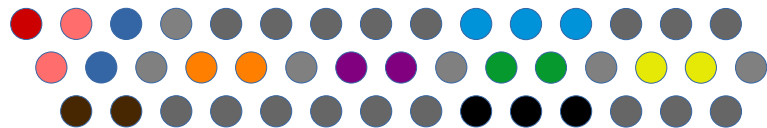
- Ideally we would route the 100 Ohm lines over a pair of coaxial
 - Most likely cannot fit, even using coaxial in combination SUB-D
 - Would require up to 64 coaxial connectors and ~100 standard pins



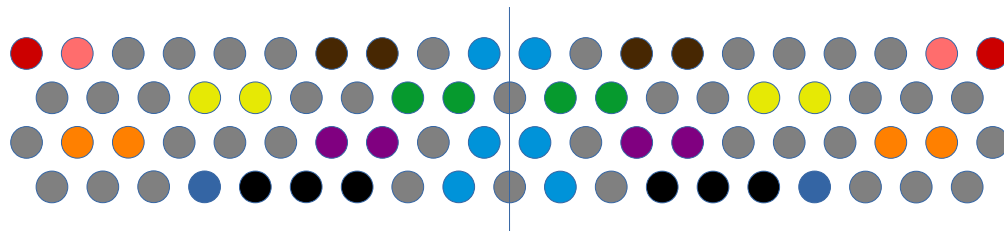
- Using fewer lines requires a circuit in Argon to split/merge signals
 - Adds complexity, power dissipation, single point of failure

Workaround, still to be tested

- Use a smart layout of the pins on a regular high density Sub-D
 - Approximate a coaxial connection
 - “close enough” to 100 Ohm impedance to carry LVDS
 - Preliminary testing suggests signal quality is ~OK, must check crosstalk



DB-44 (15-15-14)
Fits one camera

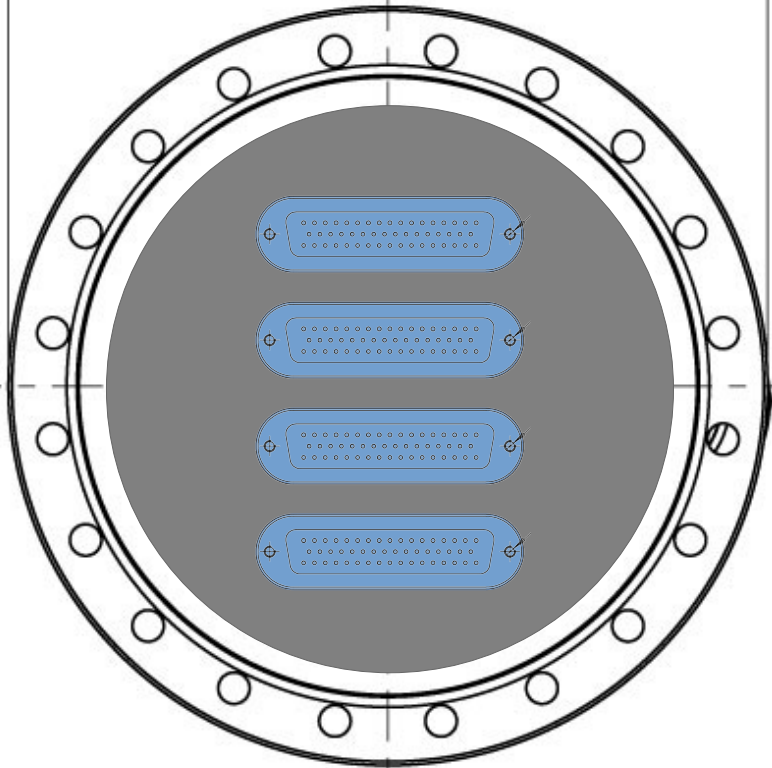


DD-78 (20-19-20-19)
Fits two cameras

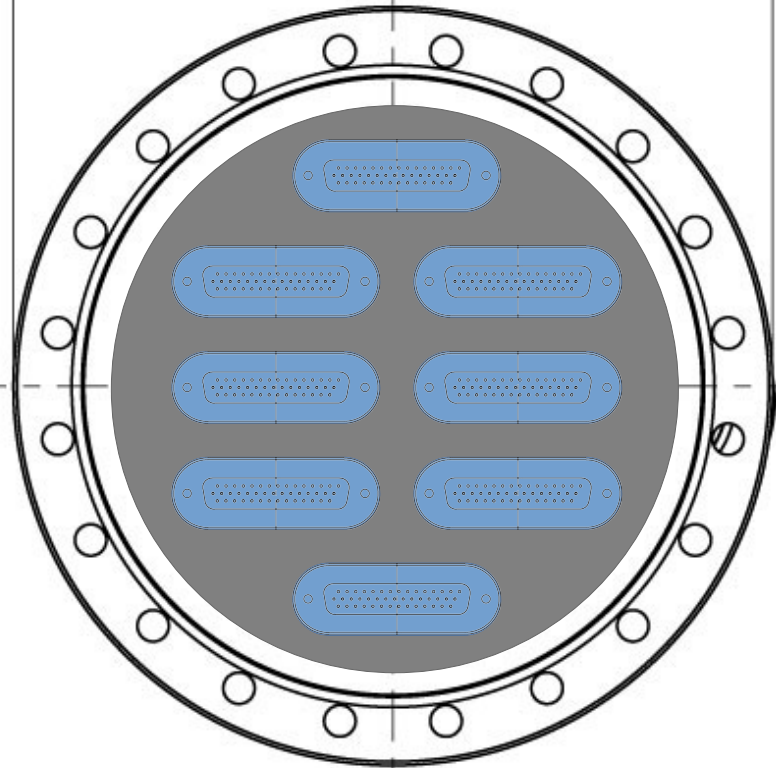
- DATA p/n
- FCTL p/n
- FCLK p/n
- PRBE p/n
- Vcore ~1.5V
- Vaux ~3.3V
- GND
- HV ~50V
- HV gnd
- SCLK p/n
- SDI/SDO/SS

Possible layouts

Two cameras on each DD-78

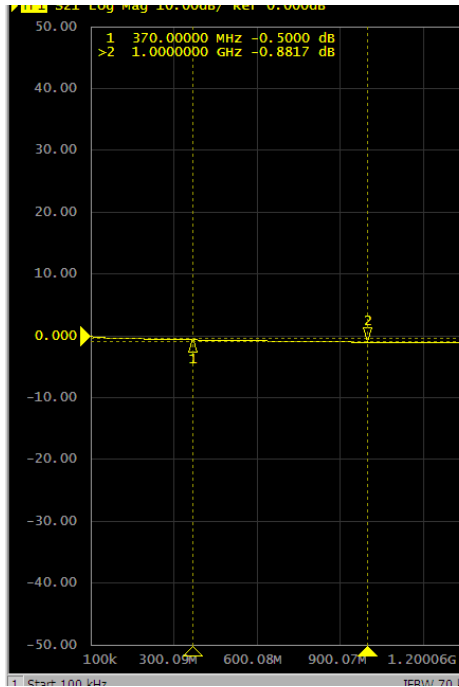


One camera on each DD-44

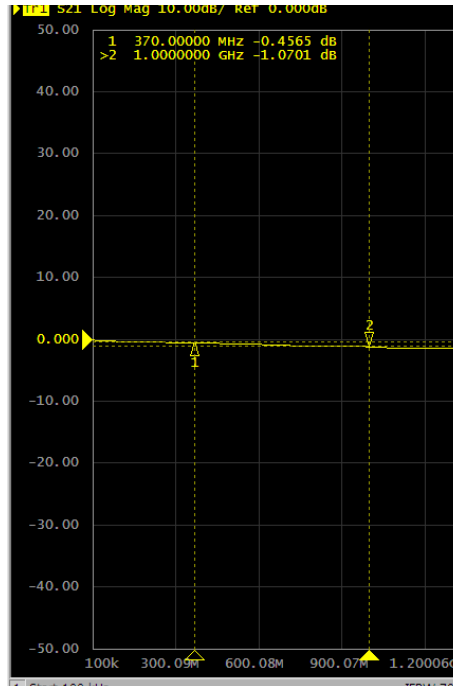


Early test results

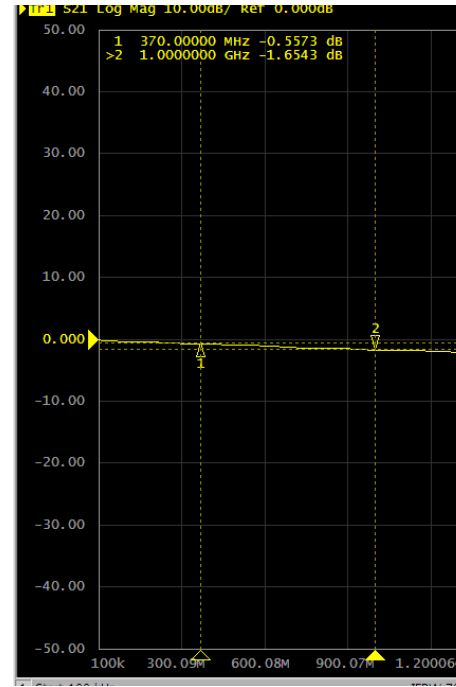
SMA



HD SUB-D



Regular SUB-D



6 x SUB-D

