ProtoDUNE DP electrical connections and grounding
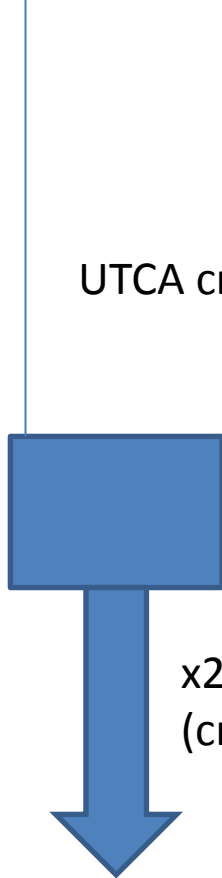
Charge readout FE electronics and DAQ:

220 V AC from main isolation transformer

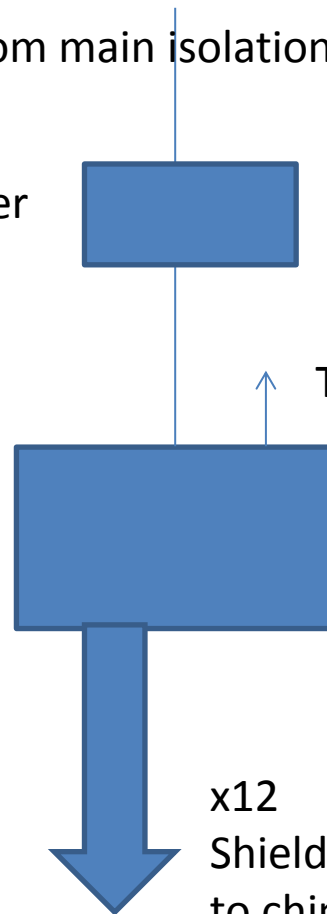220 V AC from main isolation transformer

Additional isolation transformer

UTCA crates x12

To slow control

LV PS
+ filter box

x20 VHDCI shielded cables to warm flange
(cryostat GND)

x12
Shielded cables
to chimneys

DAQ has only optical links in output (data, white rabbit)

Warm flanges
(Cryostat GND)

CRP:

Copper braid GND from the CRP frame to cryostat (signal chimneys)

Twisted pair cables x60 with GND connections

To HV FT

x72 HV LEM connections

x4 HV extraction grid

To SC FT

x60 twisted pair cables to pulsing

CRP
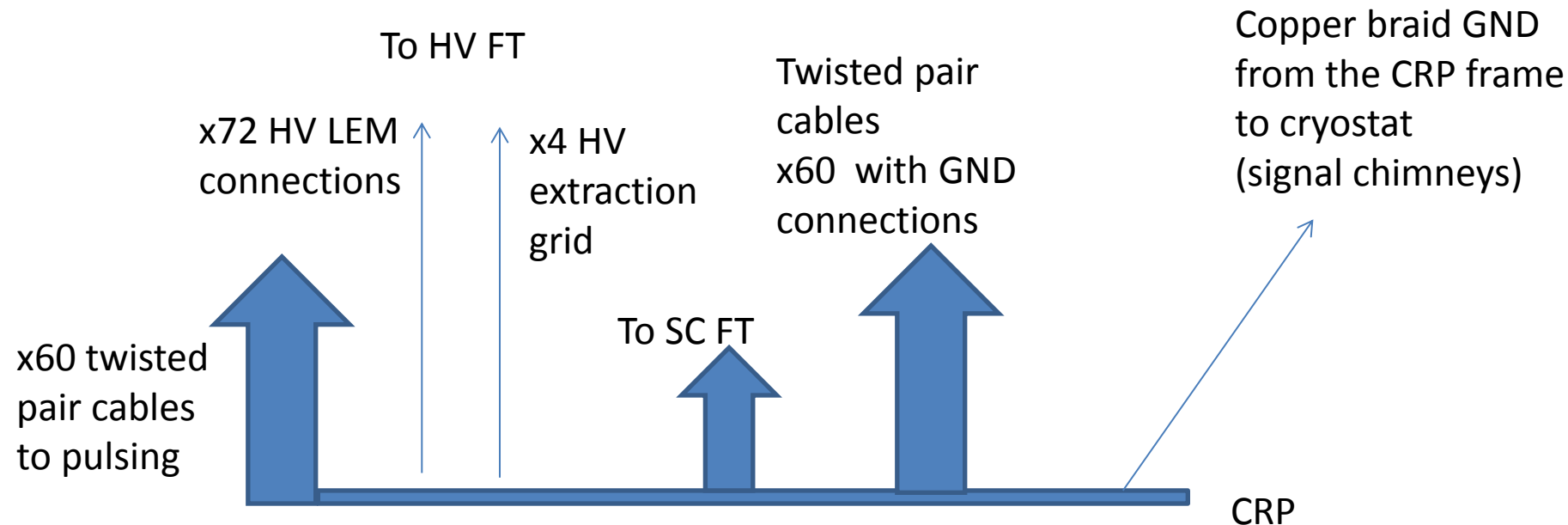
Anode PCBs GND back-strips connected to CRP frame

Slow Control (SC)
Temperature probes x36 (4 wires, no GND)
Level meters x5 (coax, GND)
Distance meters x4 (coax, GND)
Heaters x4 (2 wires)

Low HV PS:
- LEM
- Extraction grid
- First field cage ring
- PMTs

CRP
To SC FT

Cryo-cameras x4 (Raspberry –pi flat cables)
LEDs (2 wires)
Purity monitors x4 (3 HV coax)
Temperature probes x24 (4 wires, no GND)
Heaters x4 (2 wires)
Level meters x2 (2 coax , GND)

Non CRP
Tank Inst. FT

To instrumentation flange   **PMTs:**
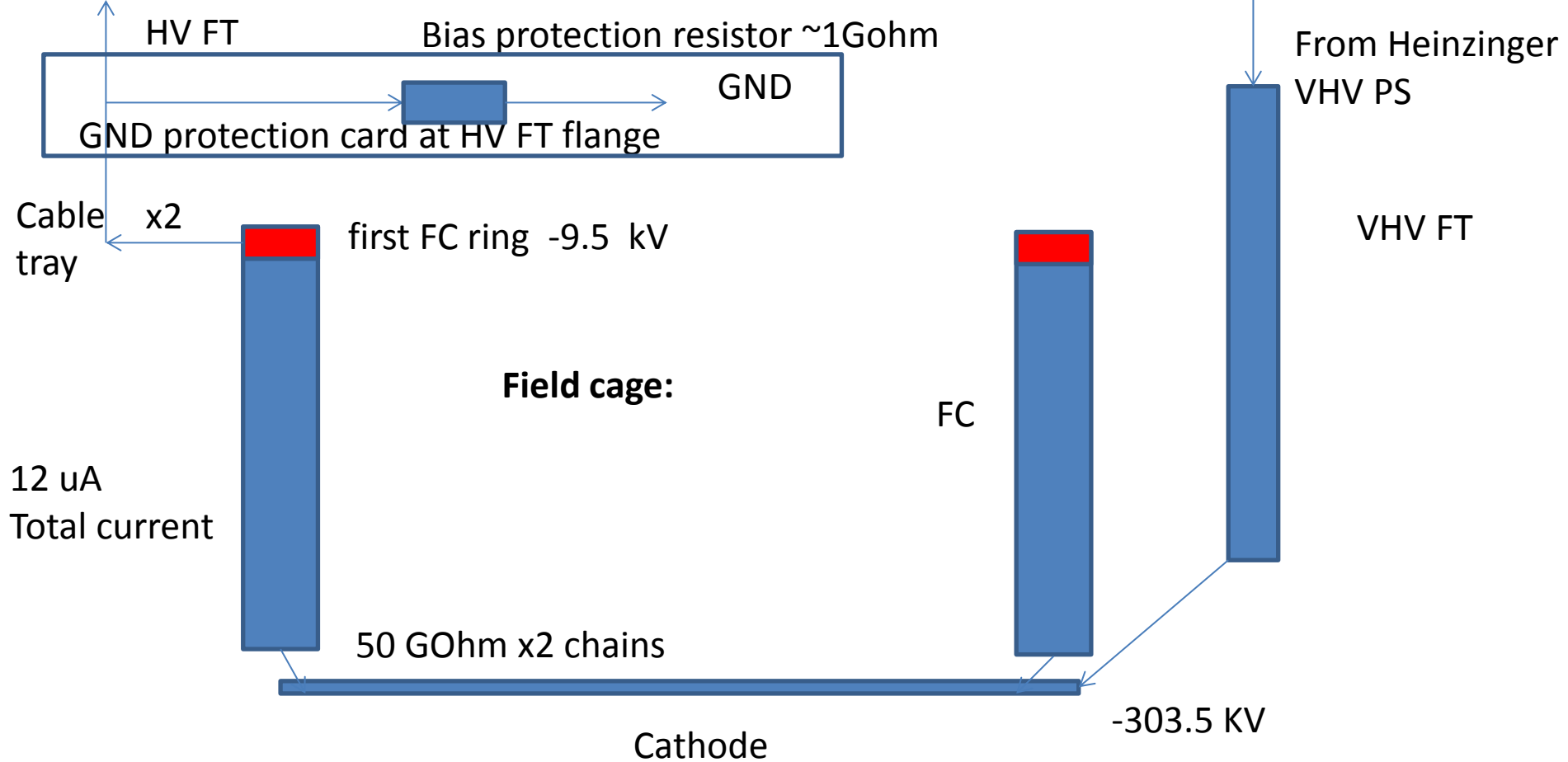
x36 via 2 cable trays in cryostat corners

PMT x36
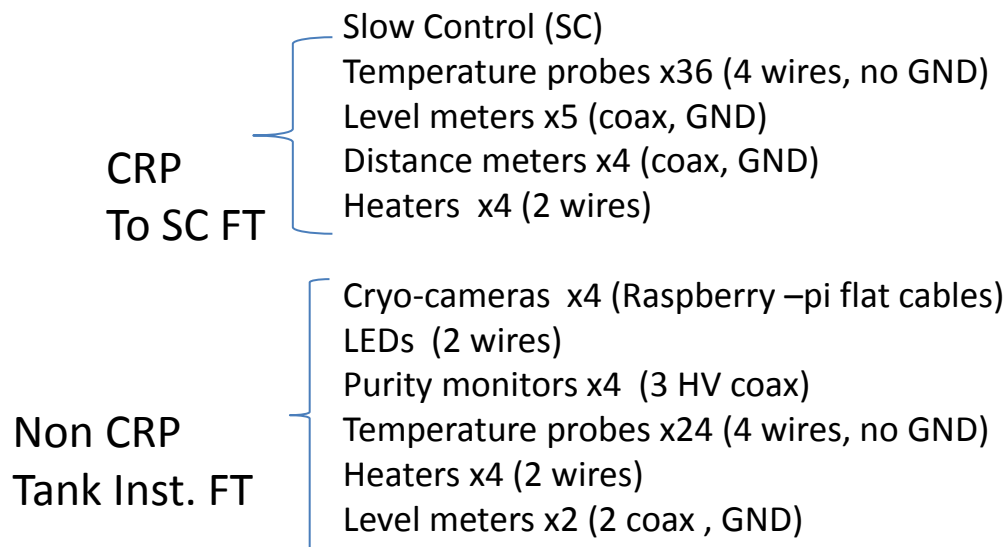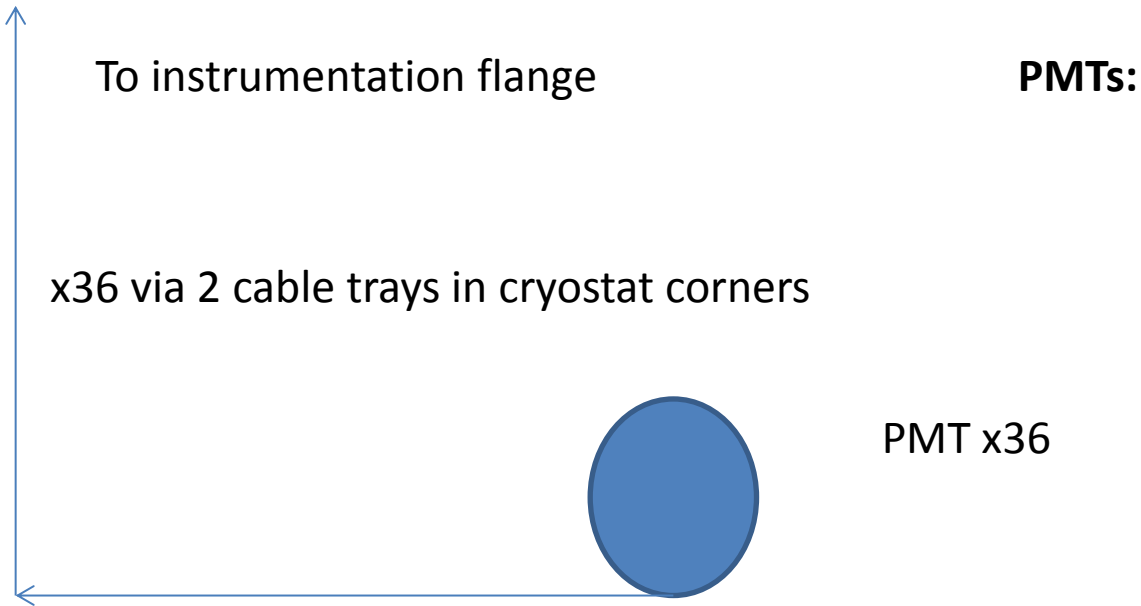
x36 Coax cables (HV+signal) going to cable tray, GND from coax

36 coax cables from flange to dedicated uTCA crate, for the electrical
connection see charge readout uTCA crates

External cryostat instrumentation:

- Pressure sensors x12 to slow control racks (2 wires)
- Pulser x3 flat cables 20 pins per CRP (SC flange), power from 220 V AC distribution
- Pulser x12 coax to warm flanges, power from 220 V AC distribution
- FE electronics SC x12 multi-wire shielded cables to SC distribution box with raspberry pi
- Temperature probes chimneys x12 (4 wires)
- Distance meters box (16 coax inputs from CRPs, x16 2-wires output)

- CRP motors x12 power (400V AC)
- CRP motors x24 end switches (2 wires)
- CRP motors x12 SC (profibus network)
→ Connections to CRP motorisation control rack

- X2 Raspberry pi readout boxes (Ethernet + 220 AC)
- Purity monitor boxes x4 (24 V DC, 1 coax connection to readout, 3 coax output to flange for sensors connection)
- Light readout calibration system x2 (24V DC, slow control connection)
- Heinzinger VHV (220 V AC, Ethernet to SC, SUB-D 15, 2 wires for interlock, cable to VHV FT)

HV FT   Bias protection resistor ~1Gohm

GND

GND protection card at HV FT flange

From Heinzinger
VHV PS

Cable   x2
tray

first FC ring -9.5 kV

VHV FT

Field cage:

FC

12 uA
Total current

50 GOhm x2 chains

Cathode

-303.5 KV

The HV FT integrates a protection box with a resistor terminated to ground.
The same kind of protection could be integrated on the cable tray. The external solution
at the level of the HV FT, while protecting from accidental disconnections of the first FC
ring HV cable provides also the possibility of replacing the protection resistor if necessary

Ground grid:

Ground grid

GND copper braid to cable tray in the cryostat corner
(low impedance path for discharges)