Status and plans of very high voltage system

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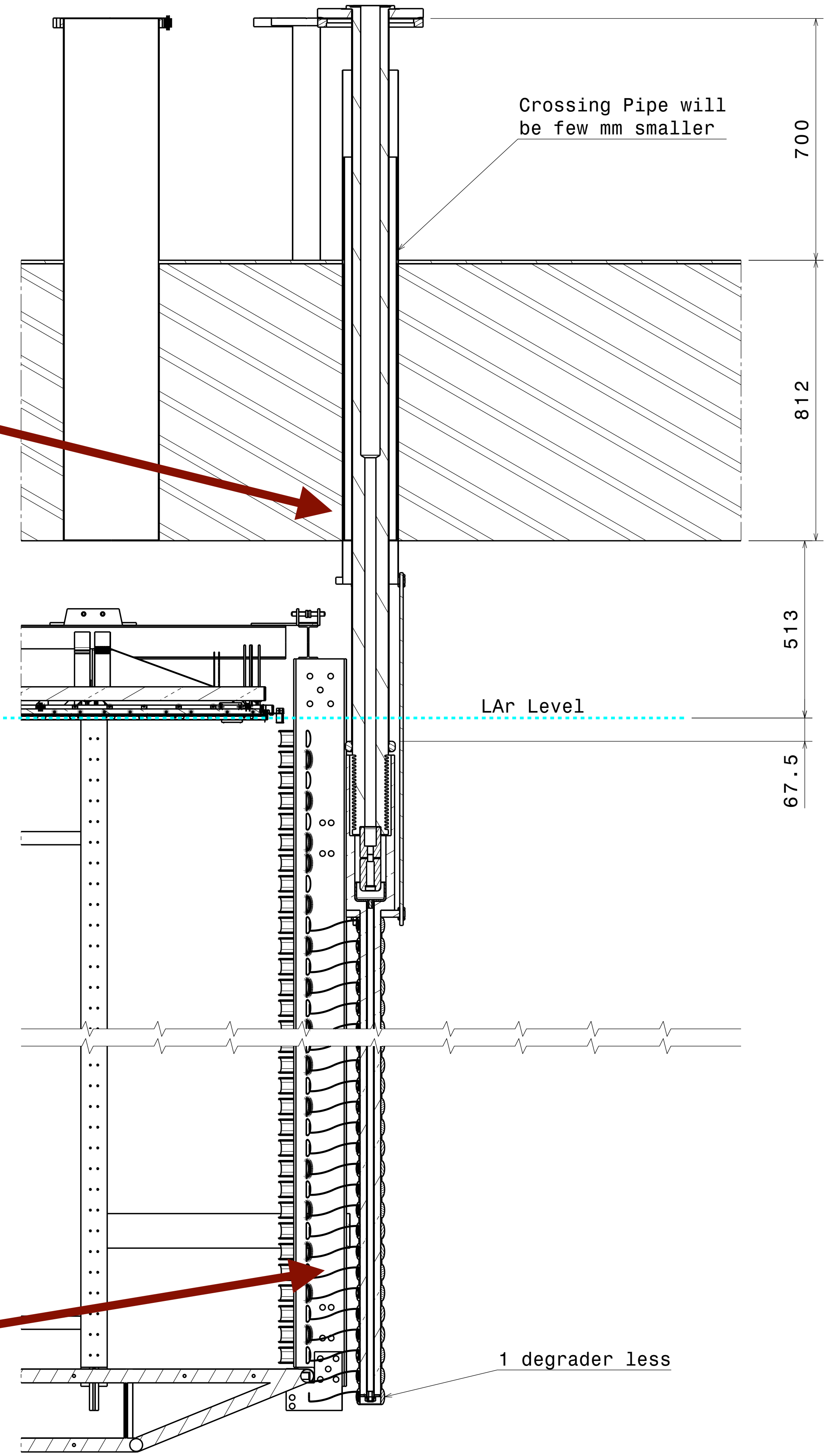
ProtoDUNE-DP Integration meeting 11.08.2017

Reminder: VHV system for DP

1. Generation of VHV:
   -300 KV PSU

2. Transmission of VHV:
   1. Cable
   2. Feedthrough



3. Connection between HVFT and cathode: Degrader

Agreement between SP/DP HV groups

February 10th, 2017: Joint Meeting with SP to discuss about PSUs for ProtoDUNE detectors organised by Eric James:

- **Assistants:** Eric James, Flavio Cavanna, Dario Autiero, Sarah Lockwitz, Andrew Renshaw, Franco Sergiampietri, Flor De Maria Blaszczyk, Sebastien Murphy, Laura Molina Bueno.
- **Summary:** Because of the large cost, it may not be possible to order a third 300kV Heinzinger HV supply for use as a joint ProtoDUNE-SP/ProtoDUNE-DP spare. What was agreed on the meeting was:

PSU	Cable diameter [mm]	Detector
Heinzinger 300kV	22	3x1x1/ProtoDUNESP
New Heinzinger 300 kV	38	ProtoDUNEDP
200 kV PSU from UCLA	38?	Spare for ProtoDUNE-SP
100 kV	14	3x1x1

- Joint HV group between SP and DP. The goal is to coordinate the HV tests and HV requirements.

DP High voltage power supply

New Heinzinger power supply already at EHN1 with similar characteristics to the 3x1x1 300 kV PSU + the ETHERNET option.

Output voltage: approx. 0 up to 300,000 V DC adjustable
Output current: approx. 0 up to 0.5 mA adjustable
Input voltage: 230V 50Hz

Voltage stabilization

Reproducibility:	≤0.1% U_{nom}
Stability:	≤0.001% U_{nom} over 8h
Ripple:	≤0.001%pp U_{nom} ±50mV
Temp. Coefficient:	≤0.001% U_{nom} /K

Current stabilization

Reproducibility:	≤0.1% I_{nom}
Stability:	≤0.05% I_{nom} over 8h
Ripple:	≤0.05%pp I_{nom} ± 500µA
Temp. Coefficient:	≤0.01% I_{nom} /K

Option 02, Interlock Connection
Interlock connection for integration of system control into external power off loops.
Output power off via NC contact
(default condition is contact closed, = power ON).

Please notice that even after disconnection voltage could be on output until the output capacity has discharged completely.

Option 04, 4.5 digit digital displays
instead of 4.5 digits for voltage and current

Option 22, Coarse/Fine
Setup control and coarse/fine assignment of set point via additional 10-turn-potentiometer separately for voltage and current.

Standard ratio coarse/fine = 99%/1%

Option 76 - digital interface 16bit - LWL
Interface RS232, 16bit
for voltage and current monitoring and setup
Incl. fibre optic converter
Built in into new unit item 1

DP High voltage cable

- The new HV cable is already in Franco's lab.
- What is missing is the male connector to the feedthrough, $Ø_{in}$=38mm

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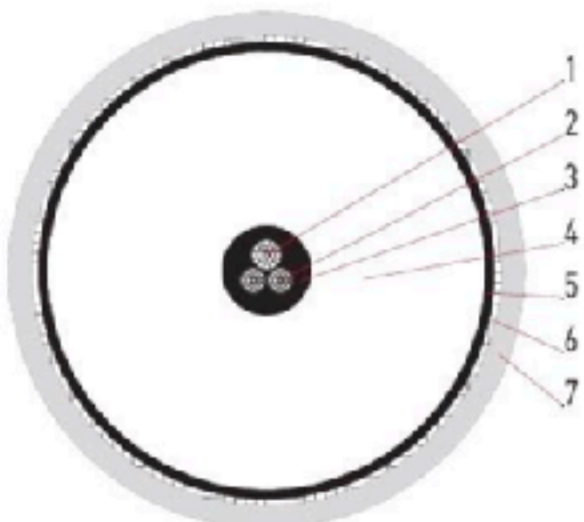
250kV$_{DC}$ – EPR Dielectric



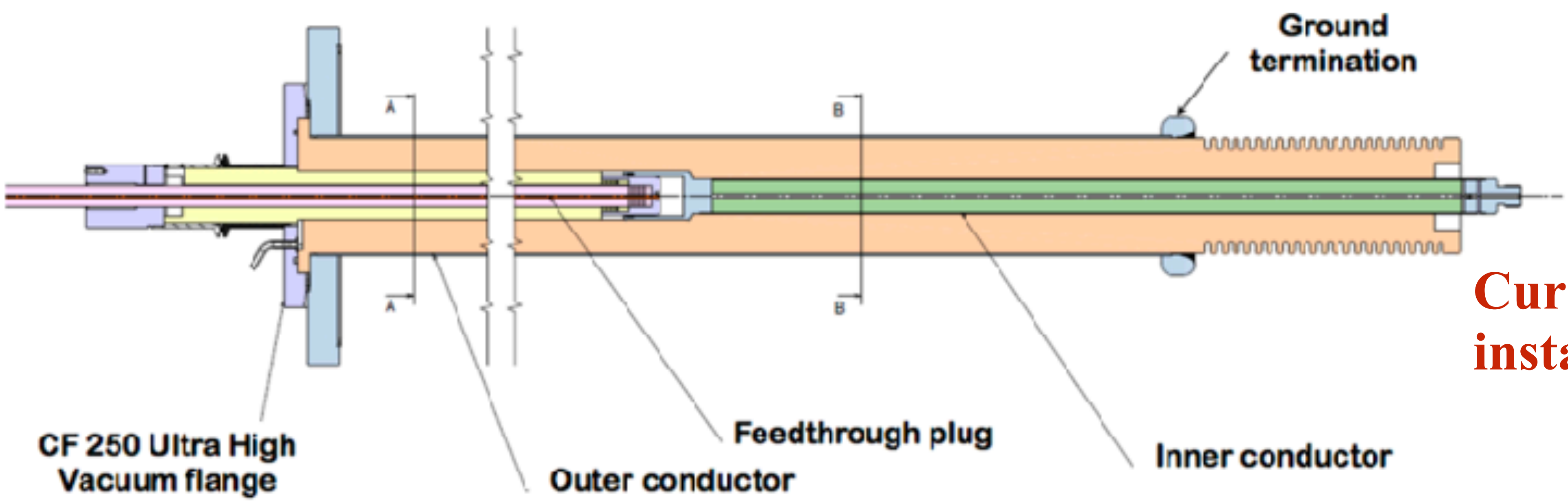
1. Conductor	1x bare Cu/Sn AWG12 (19x0.46mm t.p.c.)	
2. Conductor	2x Cu/Sn AWG14 (19x0.37mm, t.p.c.), Tefzel Insulated, Rated Voltage: 5kV$_{DC}$	
3. Semicon	Semiconductive EPR (black)	Ø 6.6mm
4. Dielectric	EPR	Ø 32.5mm
5. Semicon	Semiconductive EPR (black)	Ø 33.8mm
6. Braid	Cu/Sn (Coverage ≥ 80%)	Ø 34.8mm
7. Jacket	PVC	Ø 38.2mm

▪ TECHNICAL DATA

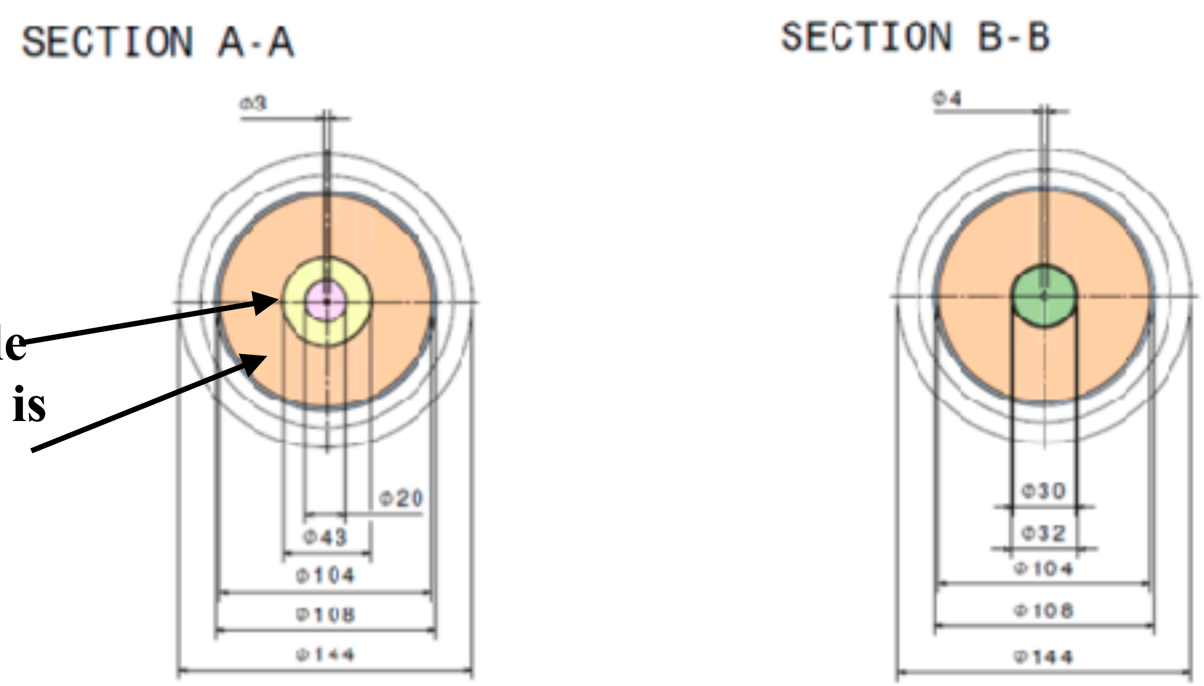
Number of Conductors	3
Rated Voltage	320kV$_{DC}$ / 100kV$_{AC}$
Impedance	61Ω
Capacitance	102pF/m
min. Bend Radius (static)	190mm
Operating Temperature	-51°C - +60°C
RoHS Compliant	Yes
Weight	1.64kg/m
Color	black
Status	Special S

DP/SP High voltage feedthrough

- Minor changes need to be done in the design respect to the one 300kV feedthrough already installed in the 3x1x1, to accept the new HV cable
- 3D drawings prepared and send to CINEL (missing an updated 2D).
- Three identical HVFT have been ordered to CINEL, one for DP, one for SP and one spare



Current 300kV feedthrough installed in the 3x1x1.



New cable diameter is 38 mm.

Everything is ready to change to the 100kV power supply:

- The adaptor is made and the 100KV PSU has been tested.
- Ethernet connection also has been tested with the current PVSS system

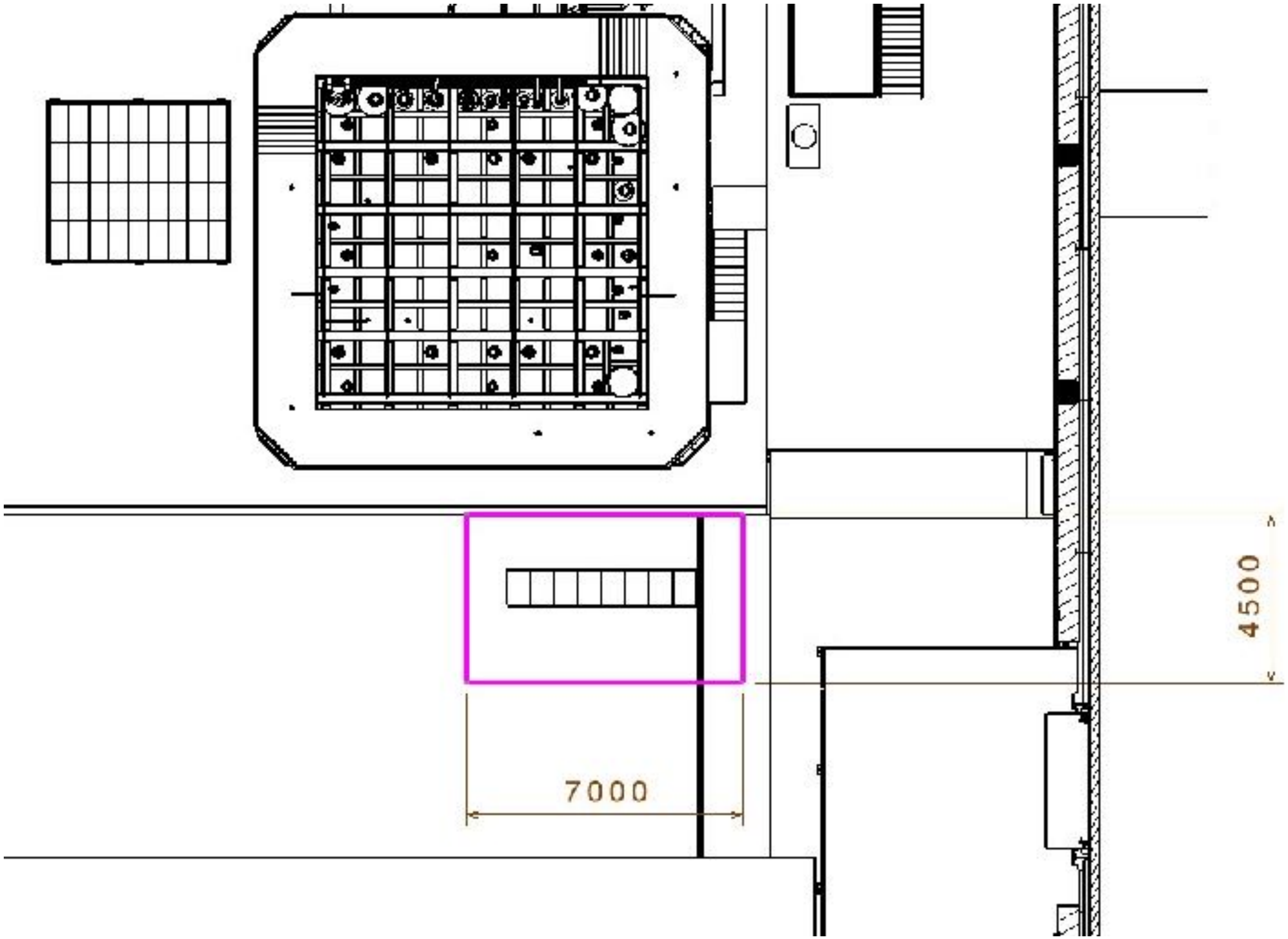
What is missing?

- **Power supplies:** Cable for spare PSU coming from UCLA.
- **Cables:** Adaptors for the new feedthrough and cables for filters.
- **Feedthroughs:** The order was already made by Franco and the feedthroughs should arrive in November.
- We need final 2D and 3D drawings of the feedthroughs
- **DP degrader:** Final drawings and simulations. Who is going to be in charge of the production and when is going to be ready.

Plans for DP/SP High voltage tests

HV tests will be done in EHN1 are together with SP (Sarah and Flor). Two types of tests are foreseen:

- **HV PSU:** The test will be performed by the end of October depending on the dates when Sarah can come to CERN.
- **HVFT:** The test will be done on January depending on when the feedthroughs arrive.



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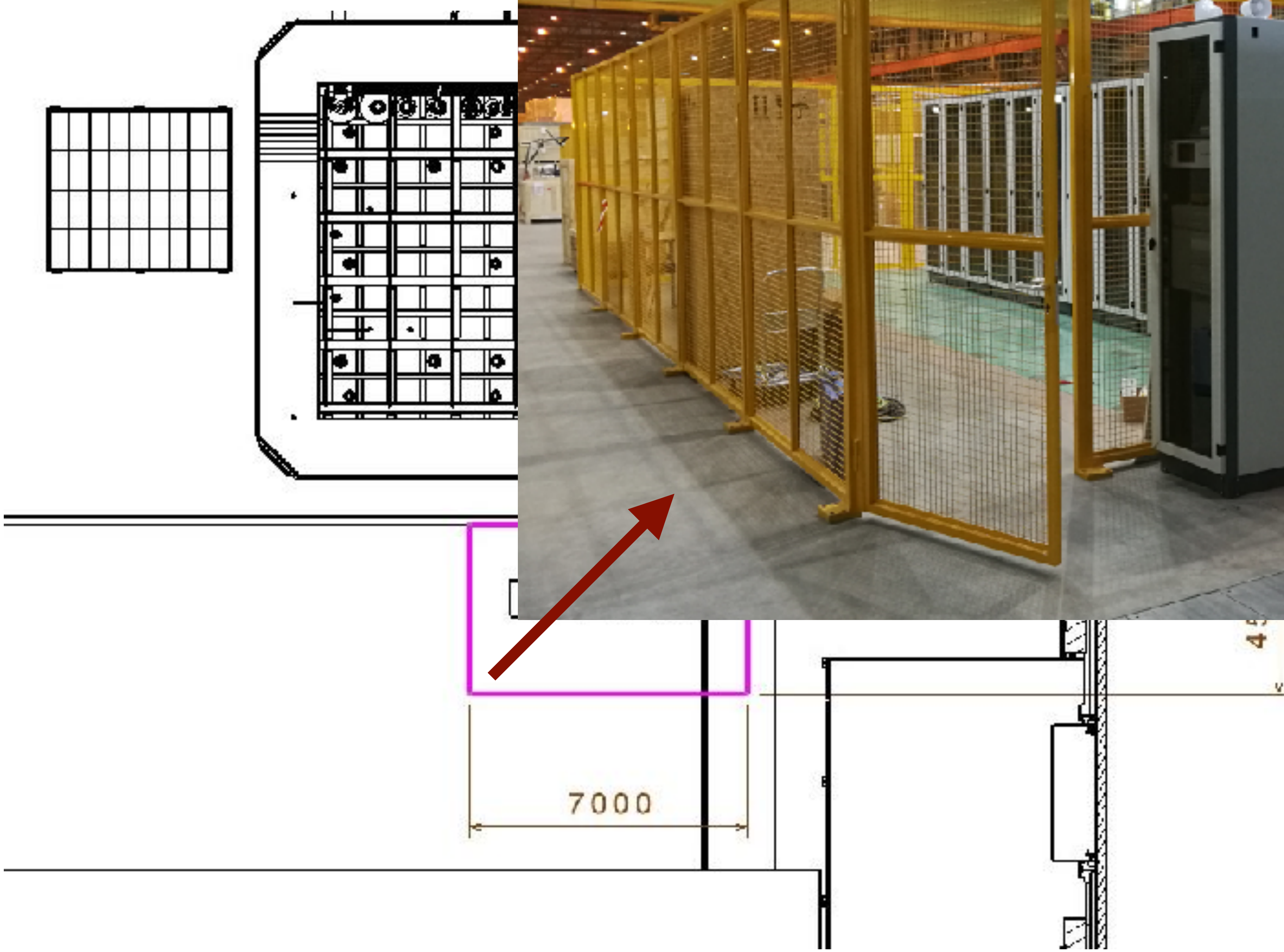

Plans for DP/SP High voltage tests

1.HV PSU tests:

- What do we need:
  - **Control program:** for DP similar PVSS program to the 3x1x1. SP will have the program ready by October.
  - **Resistor to ground (a load):** We can use the filter resistors of SP (they have two filter resistors in series), but the problem is they can not go more than 50-60 kV. Sarah thinks that If there was a way to suspend the output of the feedthrough cable in transformer oil, one could go to 300 kV but draw no current. The second part of the test would have to be voltage limited with the output of the second filter going to ground.
- Plans:
  - **Test ethernet connection:** **Already tested in the 100 kV power supply.**
  - **Set a voltage and keep it during days:** Monitor current and voltage display as a function of time
  - **Test ramp up and ramp down speed**
  - **With a low voltage set, which is the response of the power supply when ethernet is disconnected.**
  - **If we lose the power, which is the response of the system.**
  - **If we lose PVSS control, how the system behaves.**
  - **Set and verify the interlocks. Similar procedure to 3x1x1.**
  - **Prepare detailed documents for safety regarding the tests and all the elements involved. Should be finalised by the end of August.**

Plans for DP/SP High voltage tests

2.HV feedthrough tests:

- What do we need:
  - **PSU:** ready and tested before
  - **HV cable and male adaptor:** the cable is ready and we need the adaptor**.**
  - Cables for the filters (for SP)
  - **HV feedthrough:** The feedthroughs should be ready by November. We need to follow the production process over these months.
  - **Dewar for the tests:**
    - Find a dewar where the feedthrough can fit and prepare an extension/adaptor for the flanges if is needed.
    - Very important to have a decent purity. It would be a good idea to plan to use a dewar with recirculation system where we can install a purity monitor (probably the 3l setup can be used?).
    - Gas analysers in case we can not install purity monitors.
    - Be sure that the dewar has a cooling system, coil out cryocooler.
    - Camera inside
    - Slow control system
- Plans:
  - **Monitor thermodynamic conditions of the Argon during the tests**
  - **Maximum voltage as a function of the purity (if is possible)**
  - **Breakdown voltage in presence of bubbles or instabilities**
  - **Ramp up to the target voltage (DP -300kV, SP -180KV) and keep it during days.**
  - **Monitor voltage and current stability.**
  - **Record the number of discharges in case we have, and monitor the response of the power supply after and during them.**