Status of HV power supply and HV feedthrough for the 6x6x6

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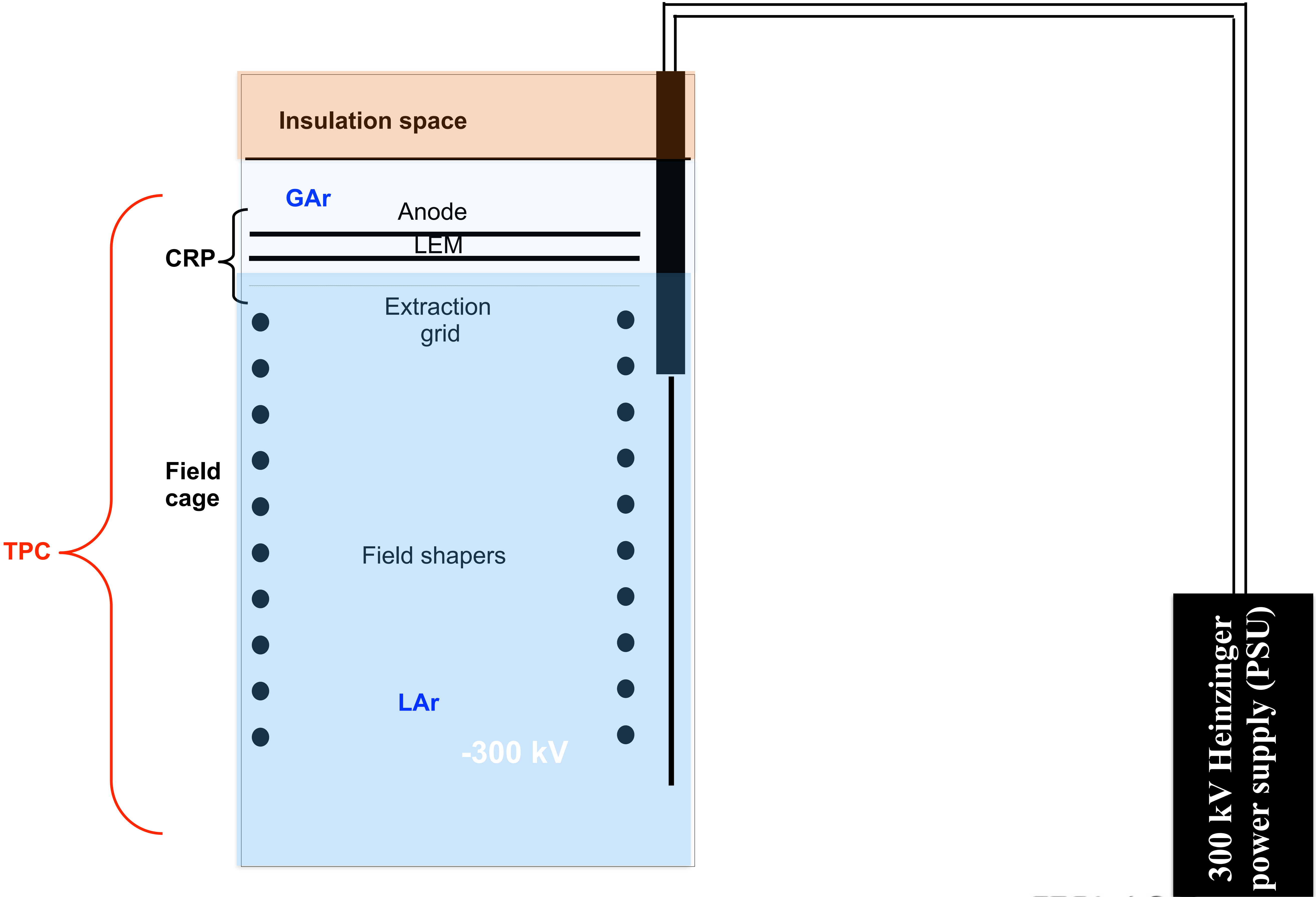
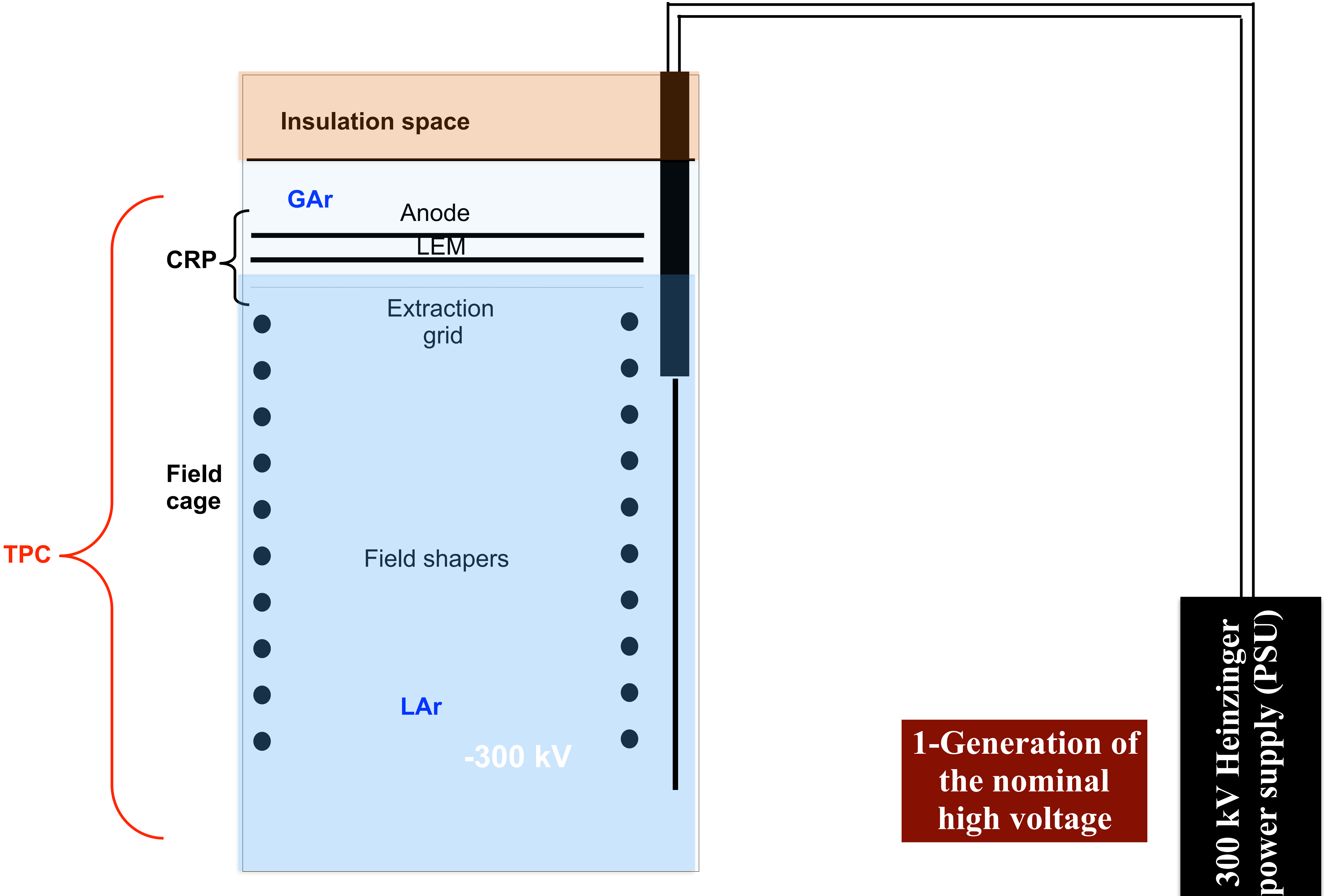
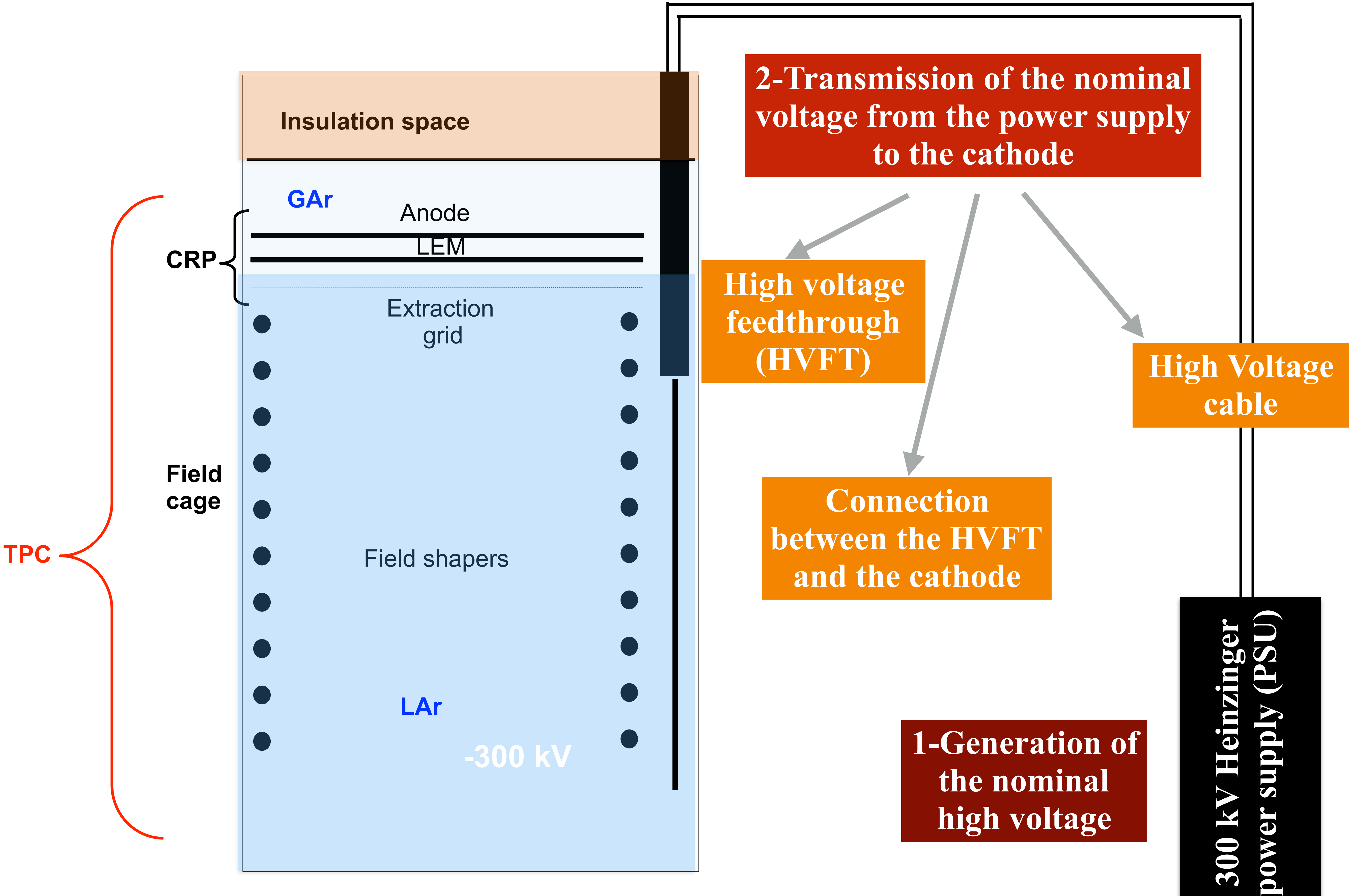
High voltage system



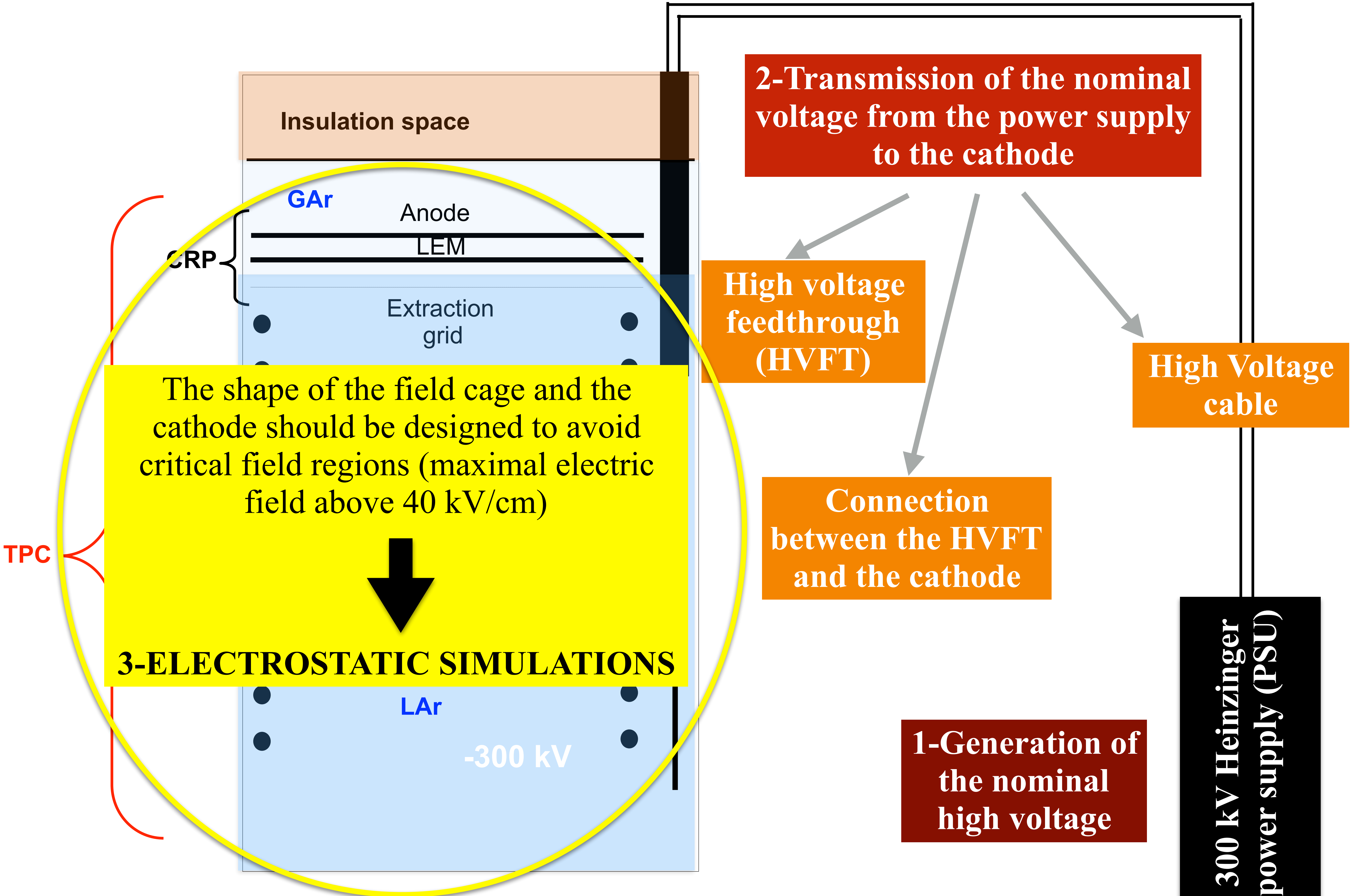
High voltage system



High voltage system



High voltage system



Where we are?

High voltage power supply

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

A regular, on-order-of monthly meeting, will be organised in the context of the Joint Single-Phase/Dual-Phase HV Working Group to continue these technical discussions moving forward. From SP Francesco Pietropaolo and Bo Yu will join also these meetings and, from DP Animesh, Cosimo, Jae and Yann too.

Where we are?

High voltage power supply

Order of the new PSU already done by Franco 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

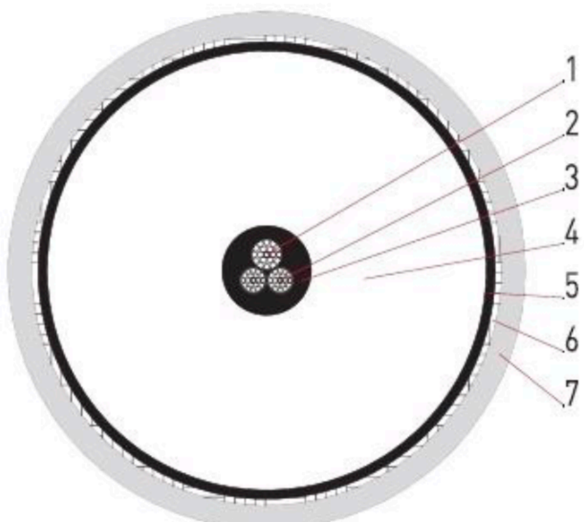
Where we are?

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

2236

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

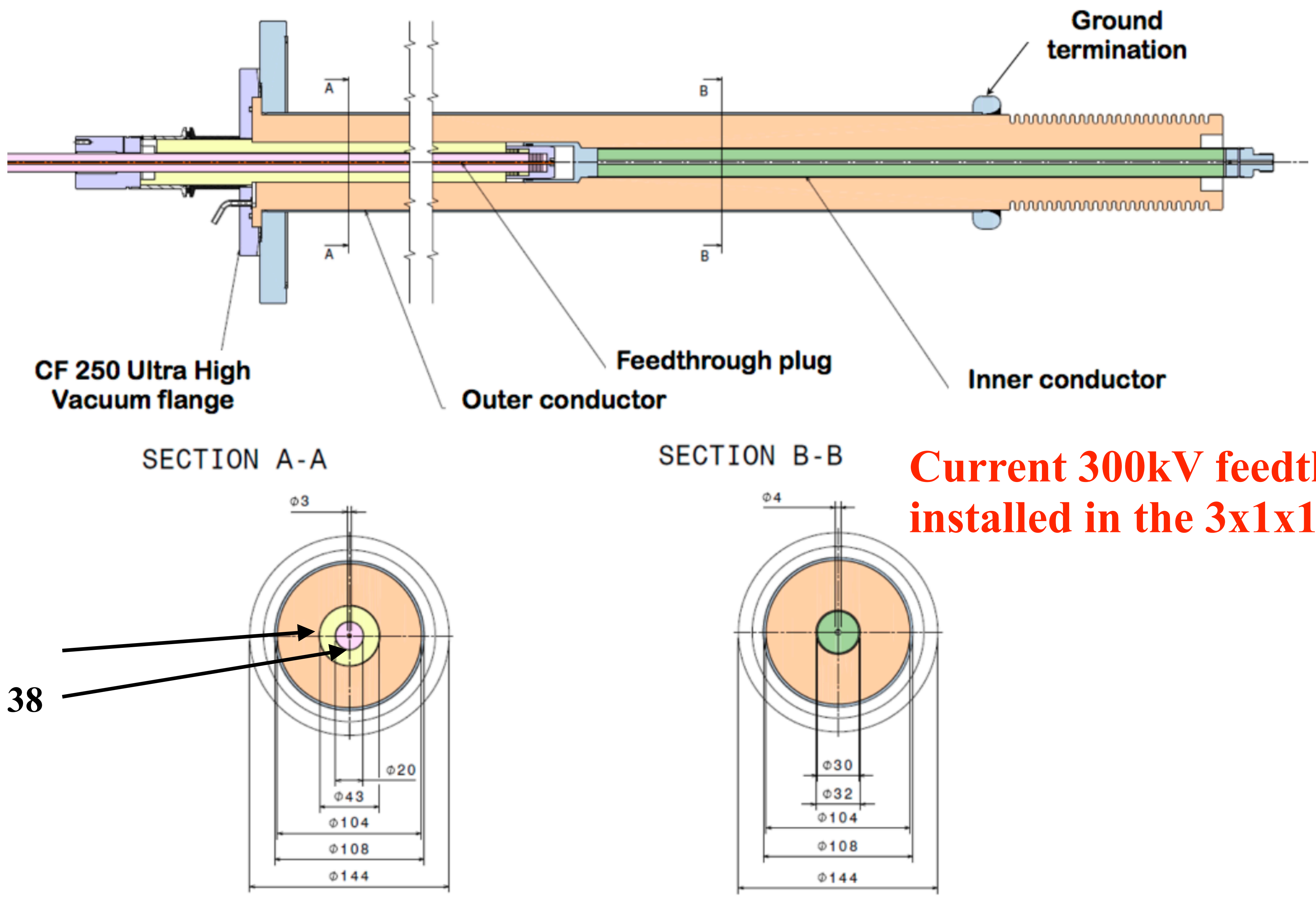
TECHNICAL DATA

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

Where we are?

High voltage cable

- 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 are work in progress.



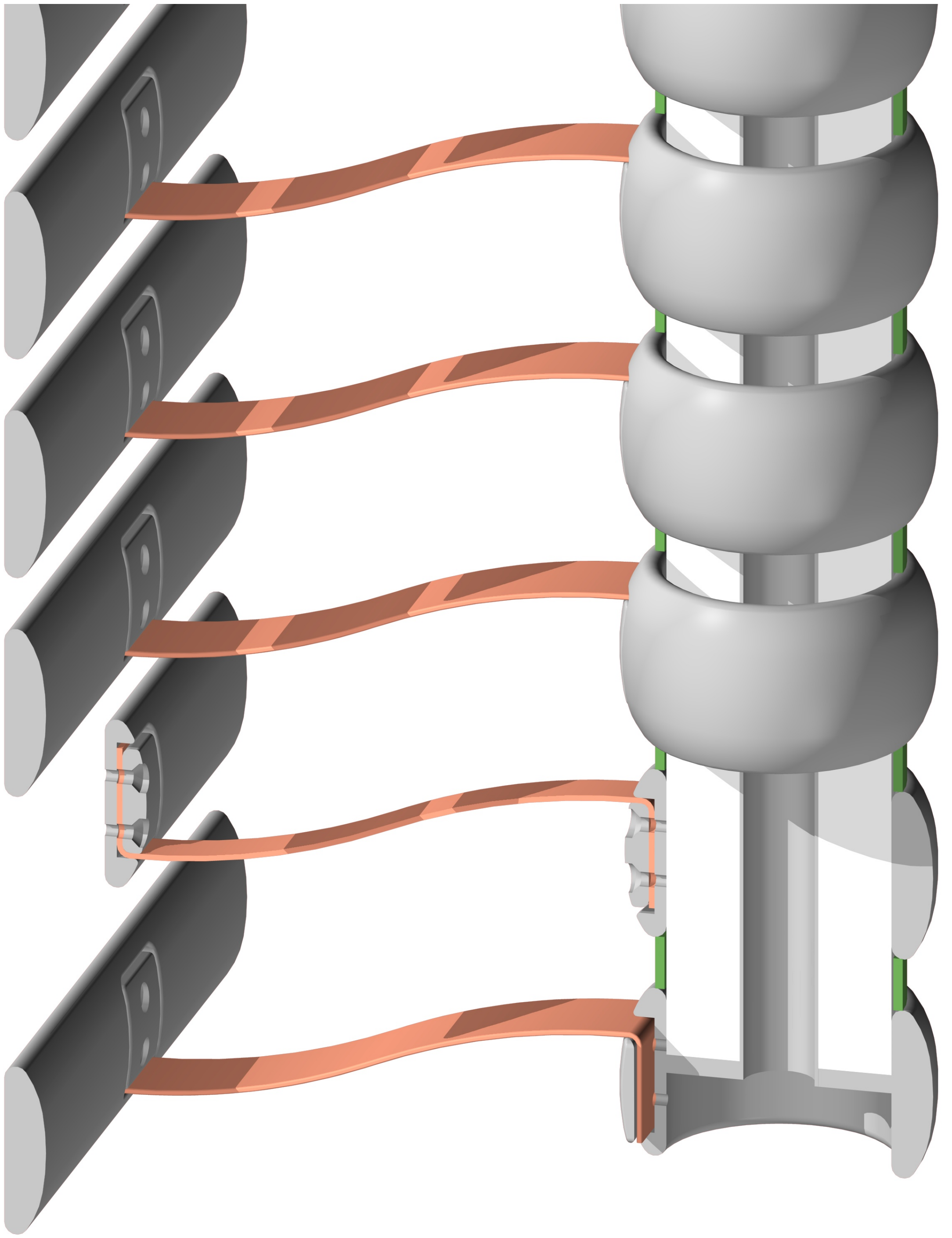
Current 300kV feedthrough installed in the 3x1x1.

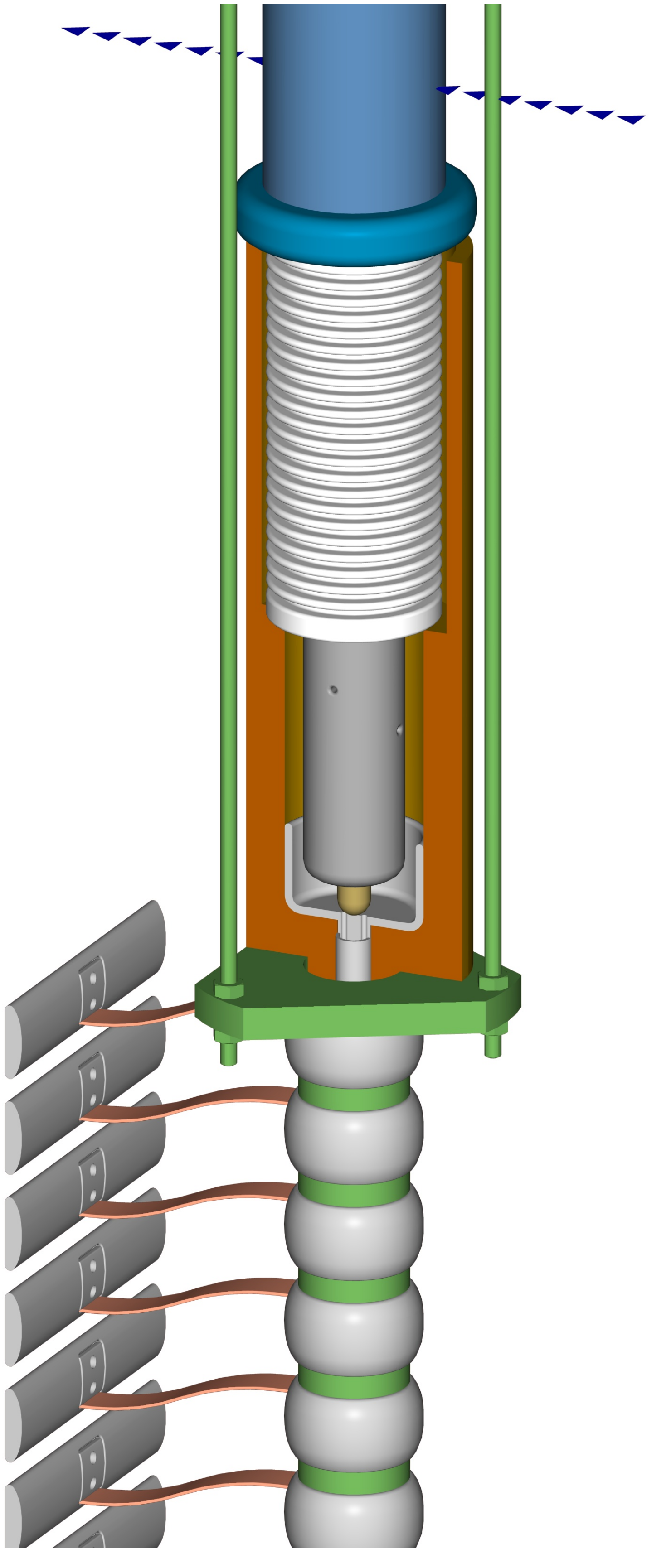
New cable diameter is 38 mm.

Where we are?

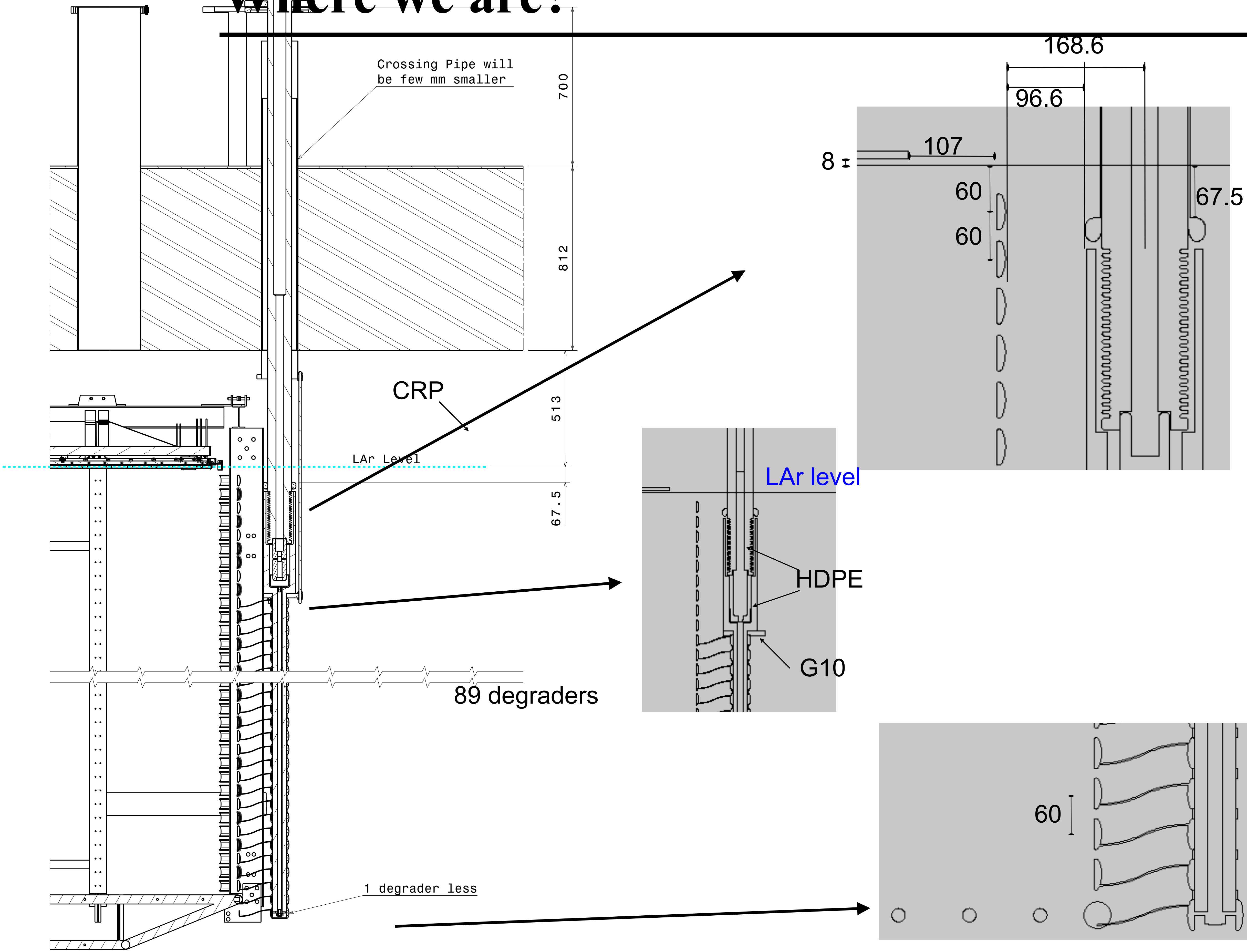
High voltage transmission from the HVFT to the cathode

- Preliminary design done by **Franco**.
- Options to be decided: **with** or **without** degrader



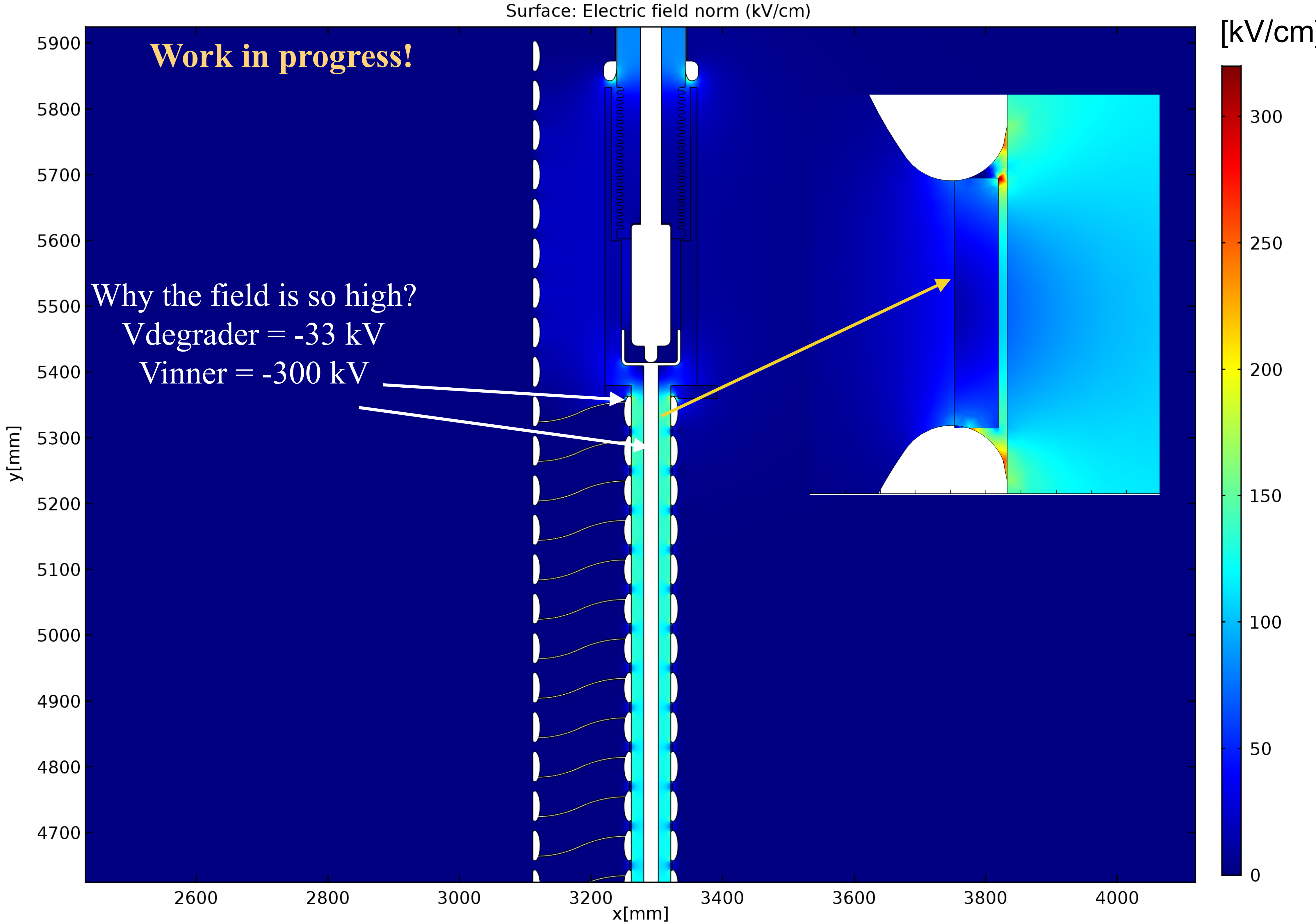


Where we are?



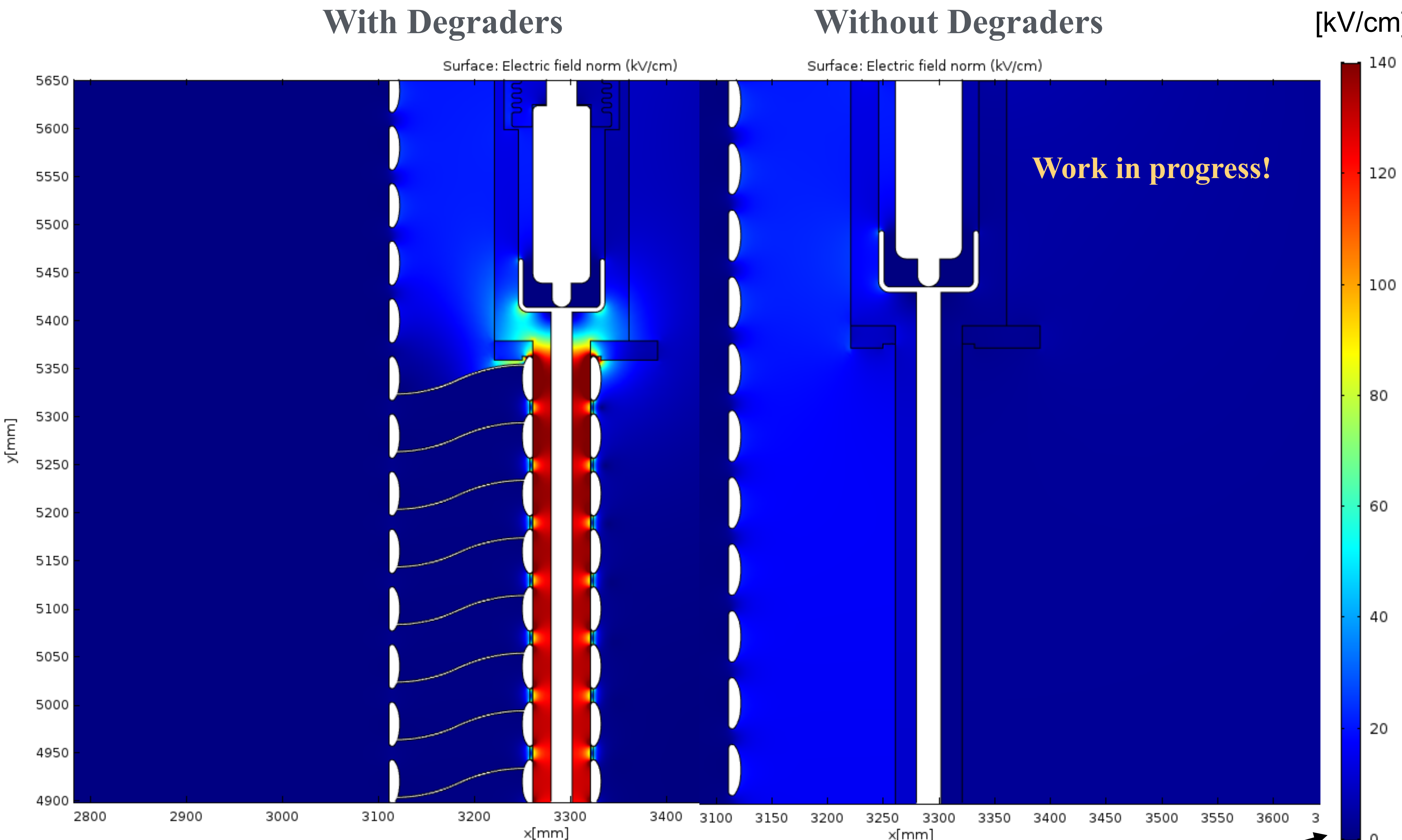
Crossing Pipe will be few mm smaller
700
812
513
67.5
CRP
LAr Level
89 degraders
1 degrader less
168.6
96.6
107
8
60
60
67.5
LAr level
HDPE
G10
60

Where we are?



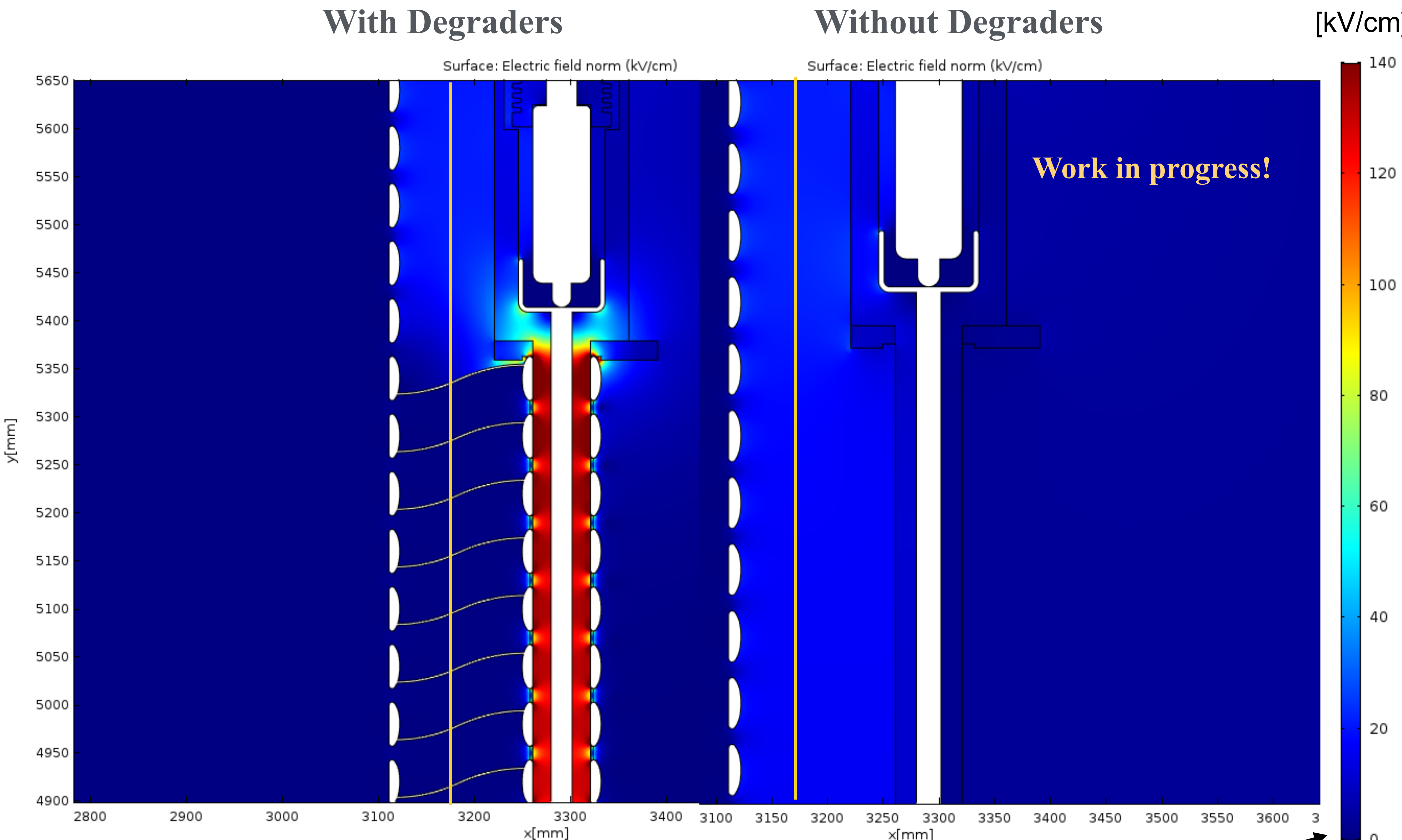
Electric field locally higher than our guideline, electric field in LAr below 40 kV/cm

Where we are?



*scale adjusted to be able to compare both cases

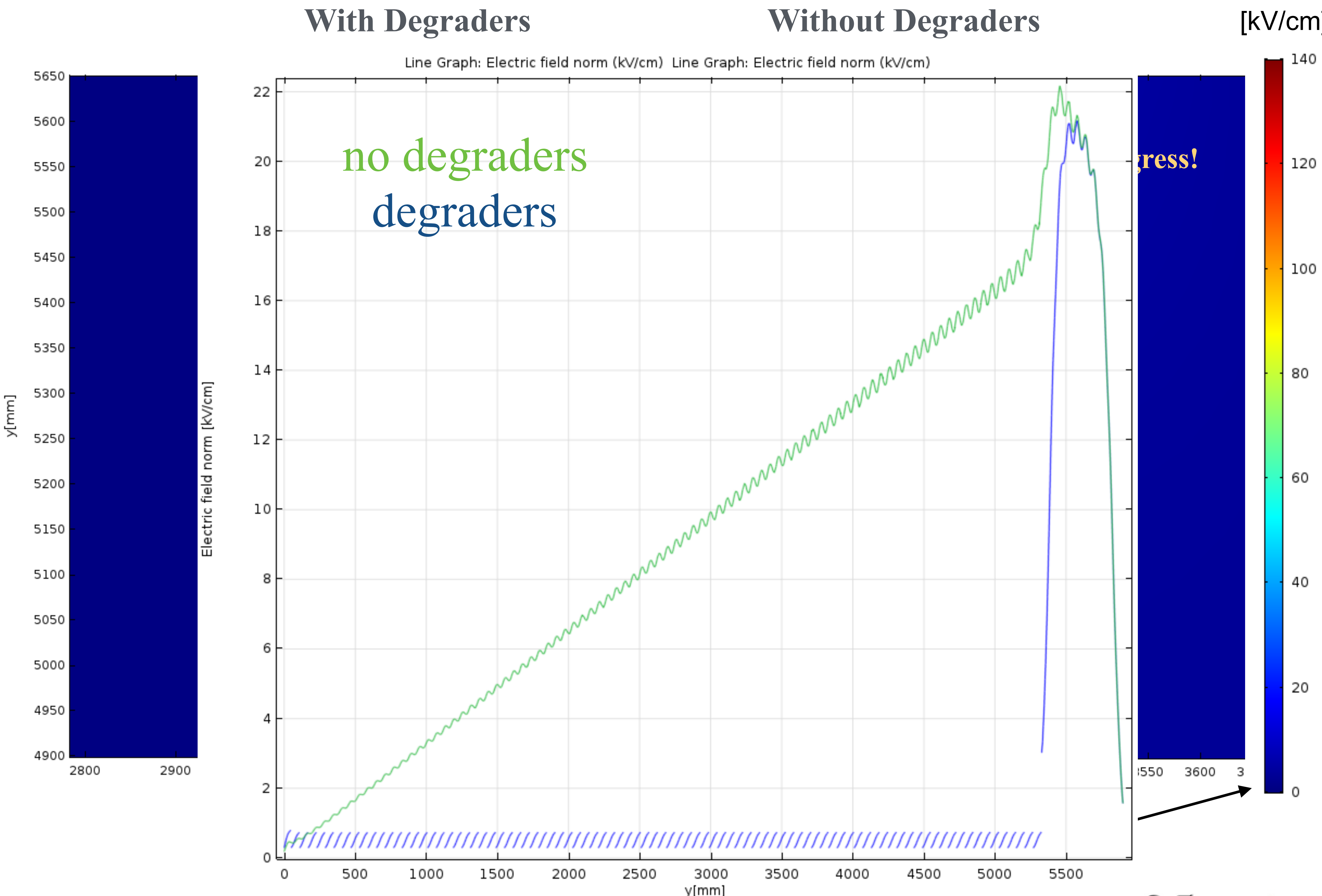
Where we are?



*scale adjusted to be able to compare both cases

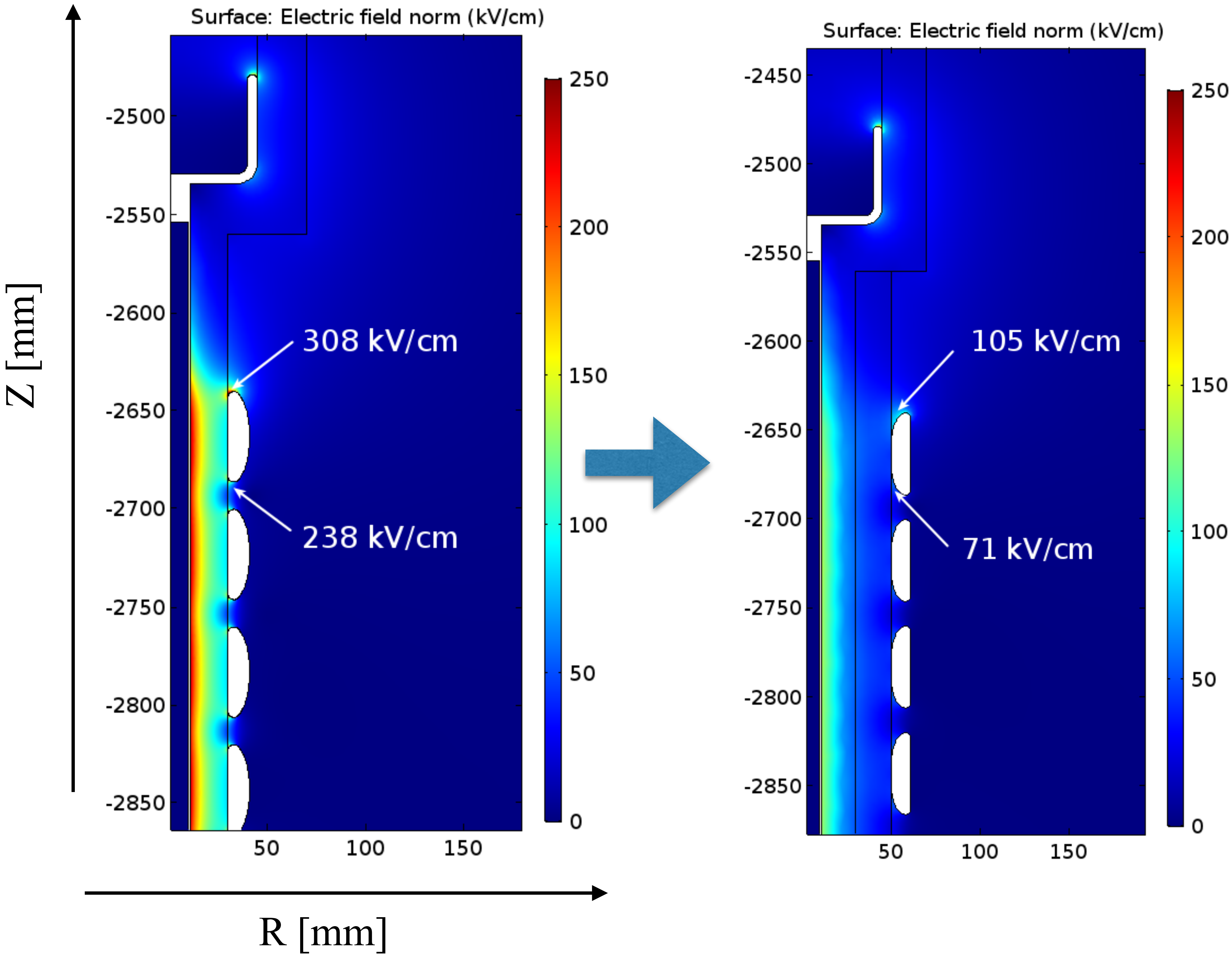
Where we are?

With Degraders | **Without Degraders**



Where we are?

- Improved design done by **Franco to minimise the high electric field locally**.

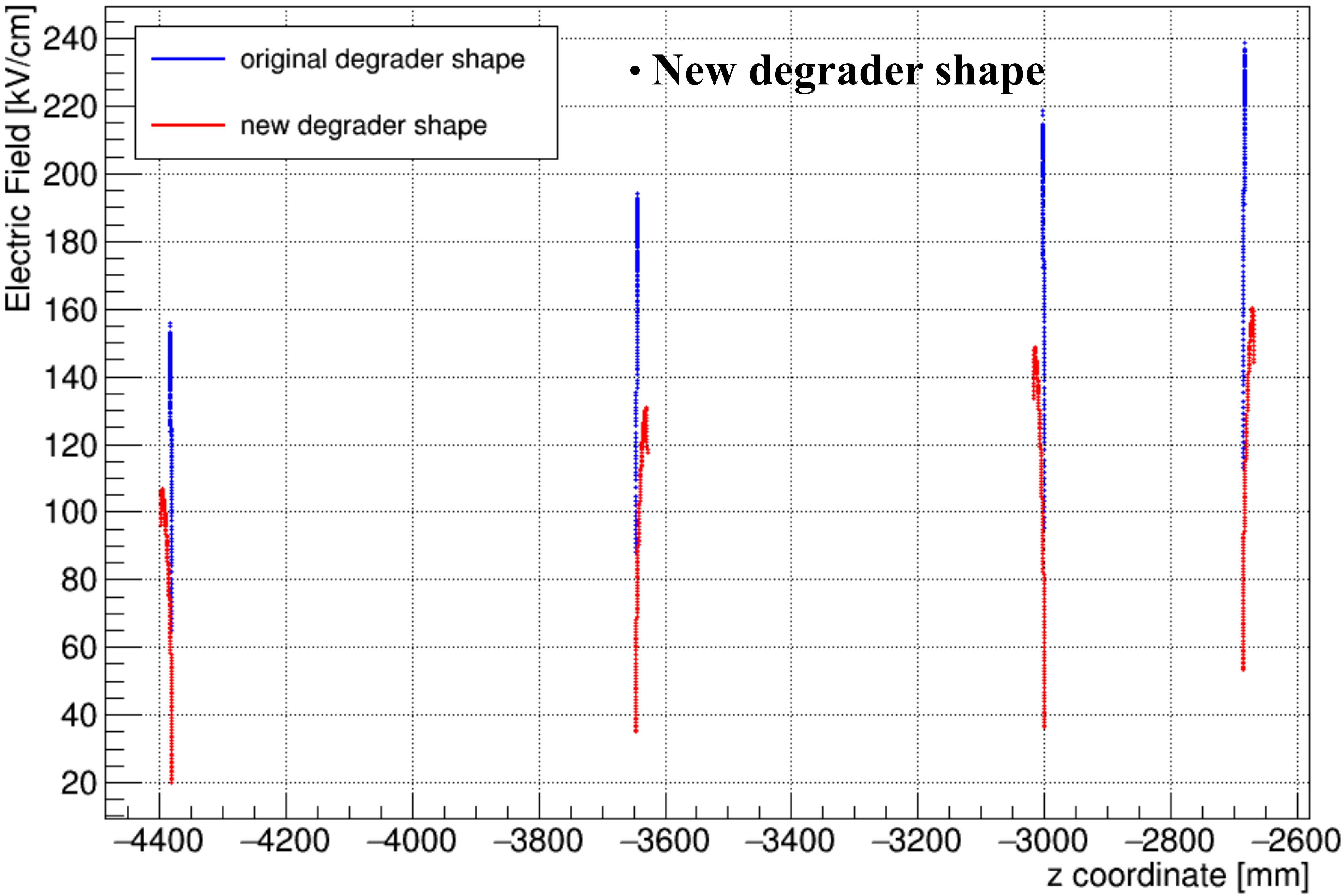


Main changes:

- **HDPE thicker**
- **New degrader shape**
- **No G10 spacers**

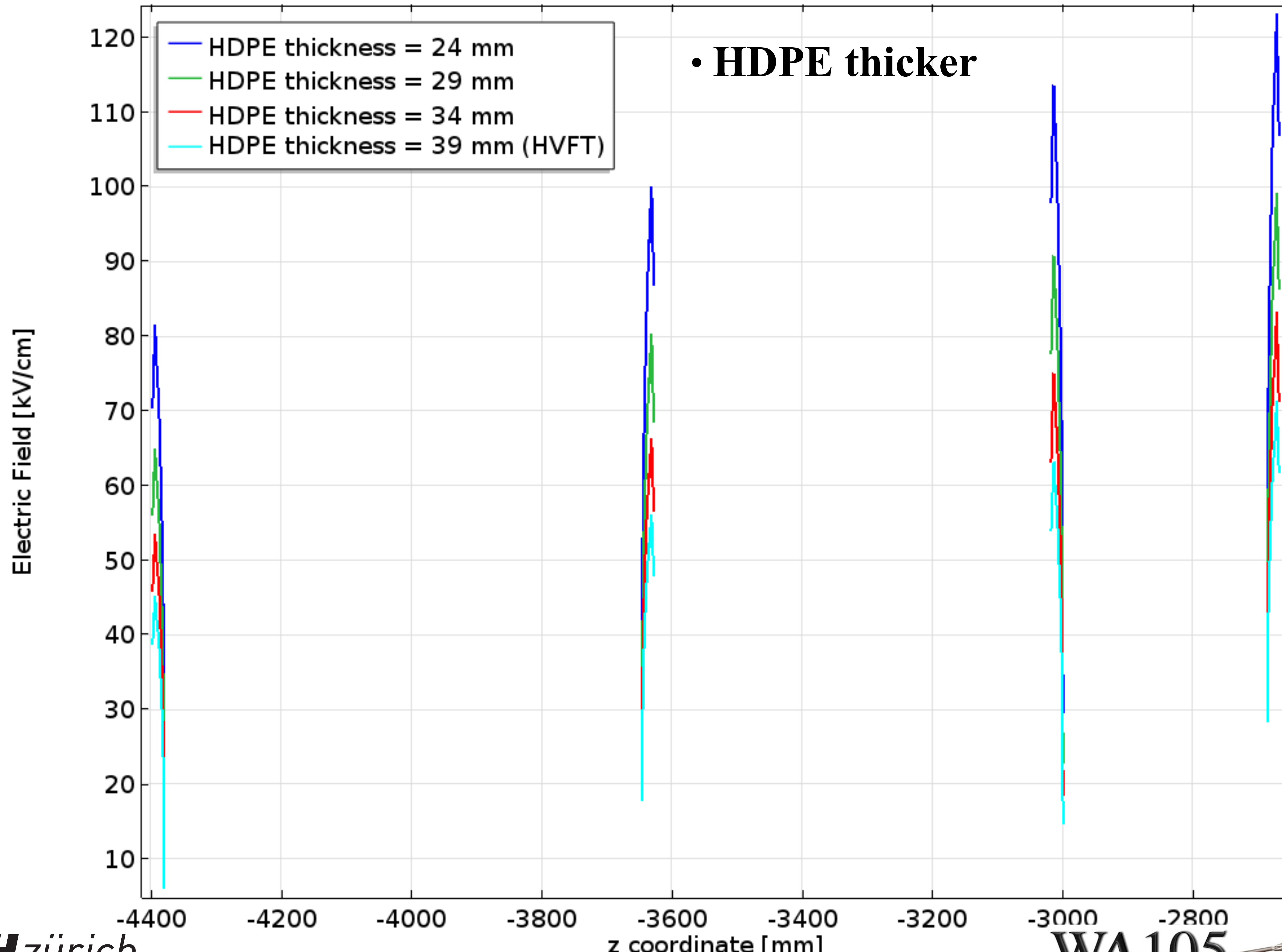
We need to verify mechanically the design

Where we are?



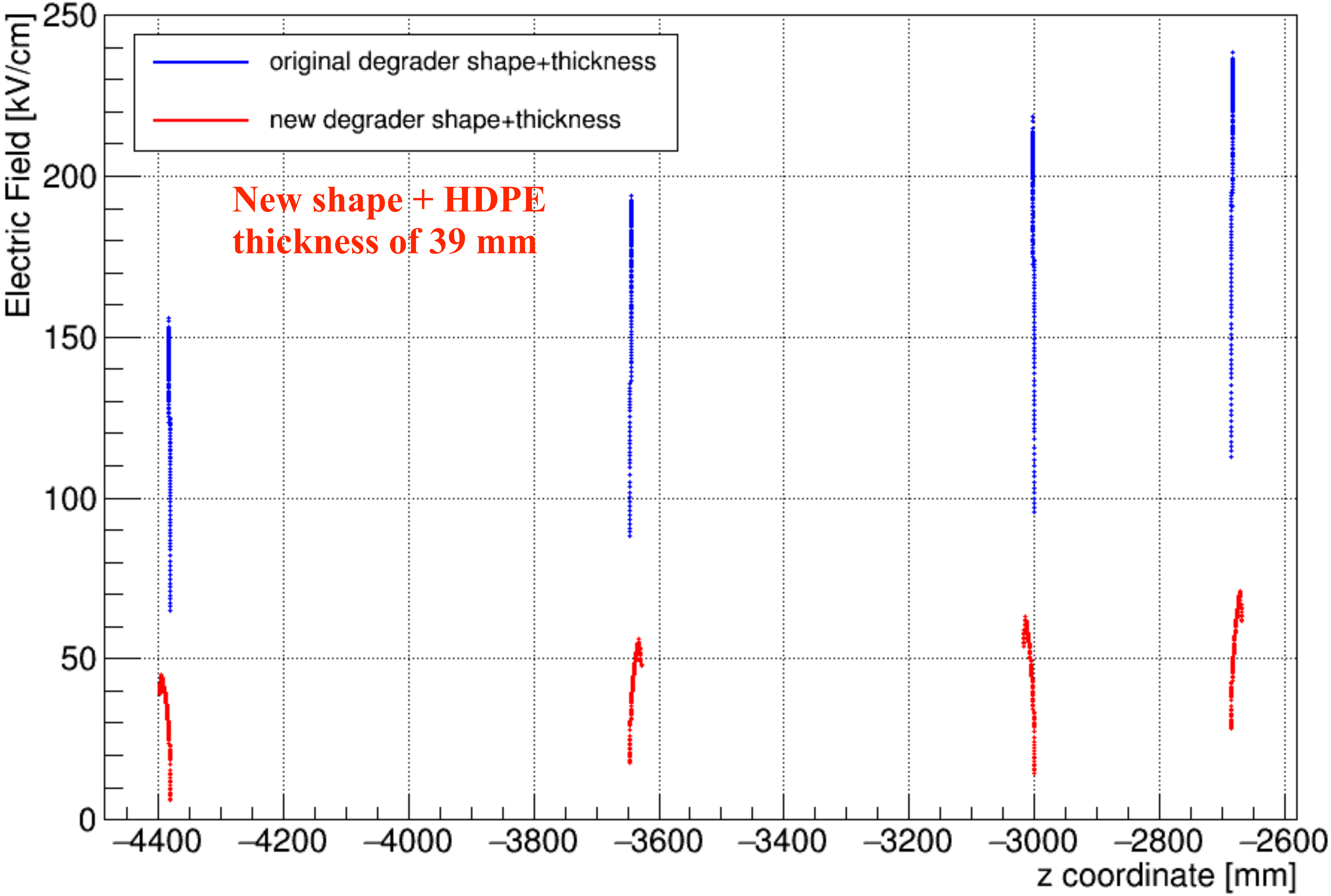
original degrader shape
new degrader shape
• New degrader shape
Electric Field [kV/cm]
240
220
200
180
160
140
120
100
80
60
40
20
–4400
–4200
–4000
–3800
–3600
–3400
–3200
–3000
–2800
–2600
z coordinate [mm]

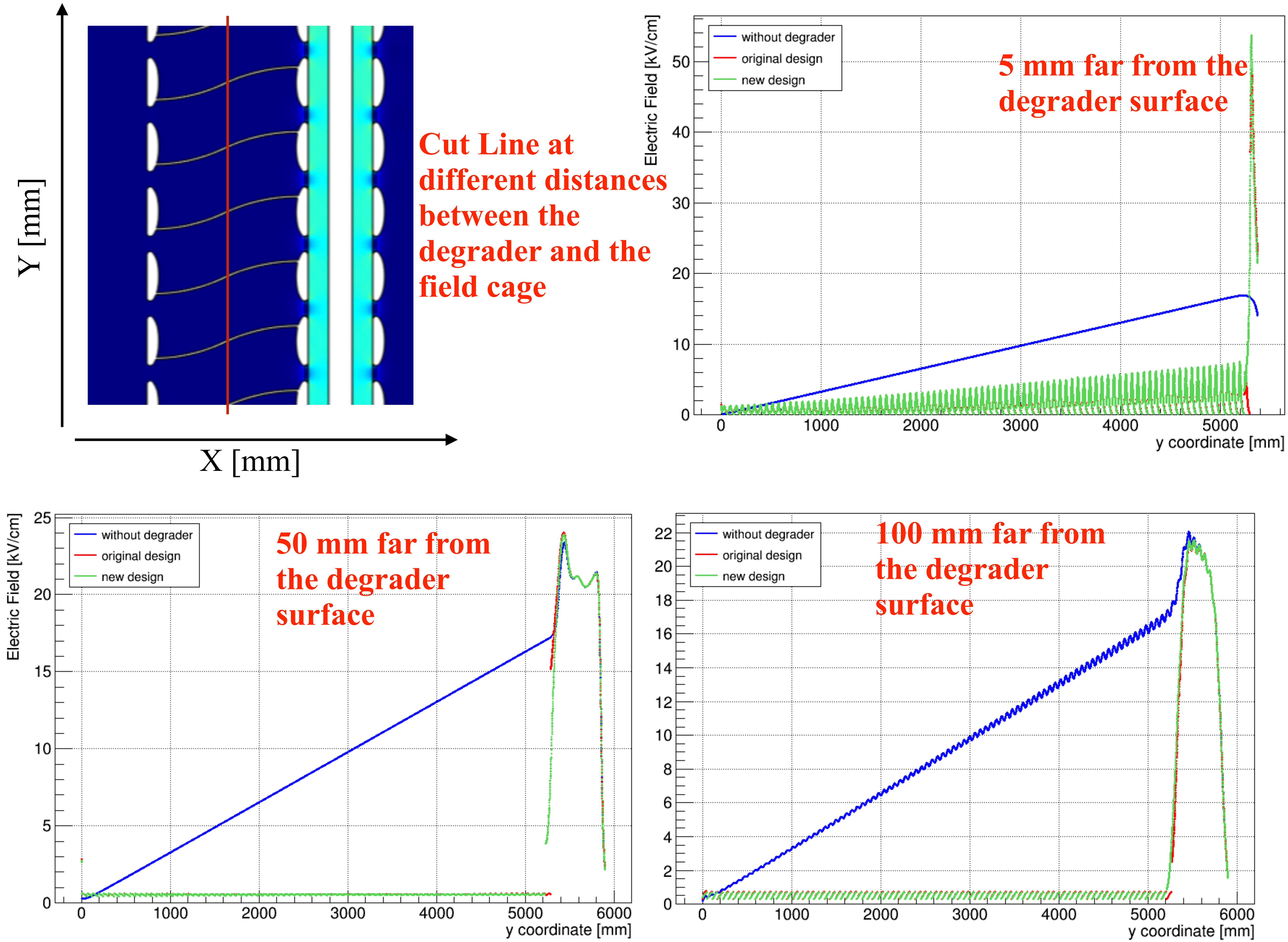
Where we are?



HDPE thickness = 24 mm
HDPE thickness = 29 mm
HDPE thickness = 34 mm
HDPE thickness = 39 mm (HVFT)
• HDPE thicker
Electric Field [kV/cm]
z coordinate [mm]
120
110
100
90
80
70
60
50
40
30
20
10
-4400
-4200
-4000
-3800
-3600
-3400
-3200
-3000
-2800

Where we are?


Electric Field [kV/cm]
z coordinate [mm]
original degrader shape+thickness
new degrader shape+thickness
New shape + HDPE thickness of 39 mm
0
50
100
150
200
250
–4400
–4200
–4000
–3800
–3600
–3400
–3200
–3000
–2800
–2600



Y [mm]
X [mm]
Cut Line at different distances between the degrader and the field cage
Electric Field [kV/cm]
y coordinate [mm]
without degrader
original design
new design
5 mm far from the degrader surface
50 mm far from the degrader surface
100 mm far from the degrader surface

What is missing?

- Electrostatic simulations of the HVFT plus its connection to the cathode have been performed.
- **Finish the quoted drawings for the HVFT and ask for an offer**
- **Decide if we use a degrader or not for the connection between the cathode and the HVFT.**