

## CPA/FC/HV Review

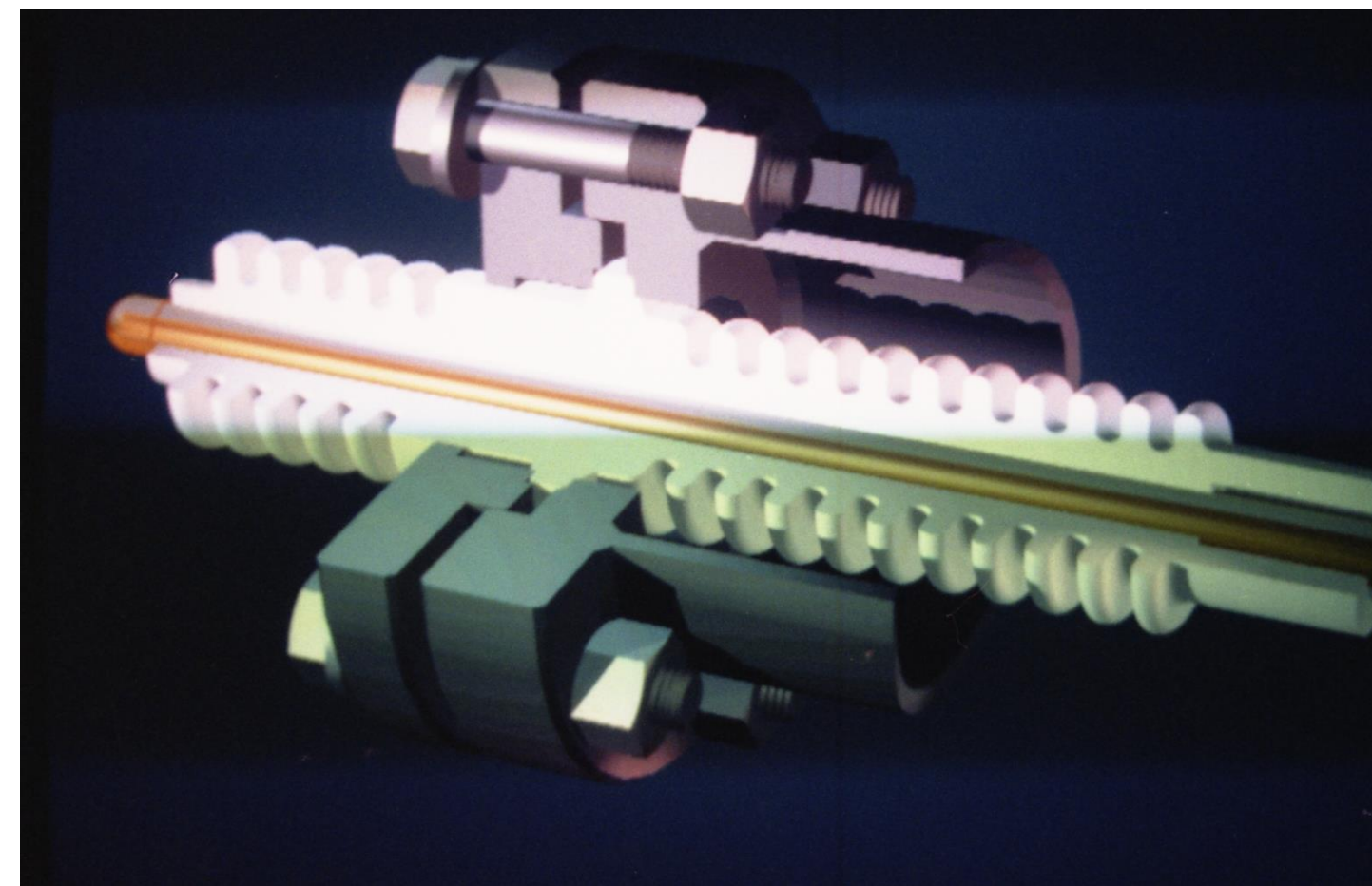
CERN – 9 November 2016

# HVFT for ProtoDUNE SinglePhase TPC

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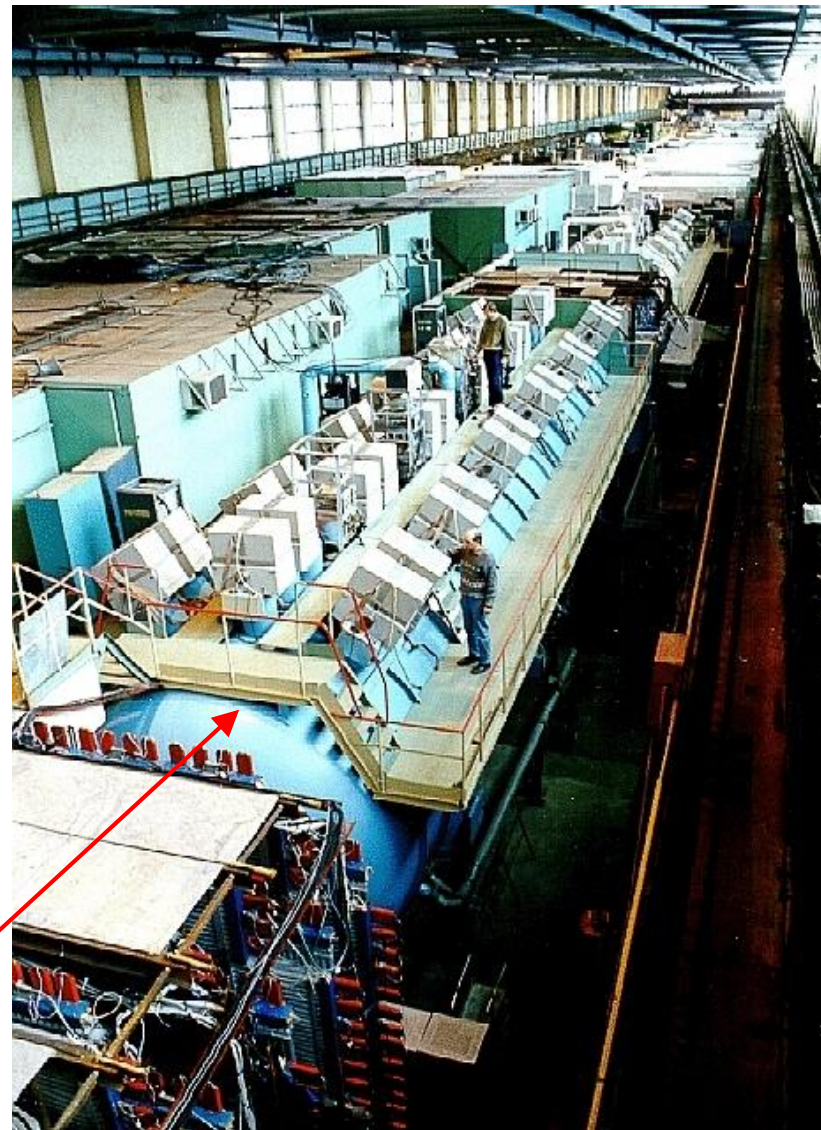
# Past experience and references

Cryo/Thermo-fitting technology developed basing on many years experience



1<sup>st</sup> HVFT for BARS (Big Argon Spectrometer)  
IHEP – Protvino (RU) (1985)

N. 72 required



HVFT for  
ICARUS (1999)

Used at  
present also in  
the ArDM  
experiment at  
Canfranc



**BARS, the liquid argon detector-target for tagged neutrino beams at the IHEP of Serpukhov**

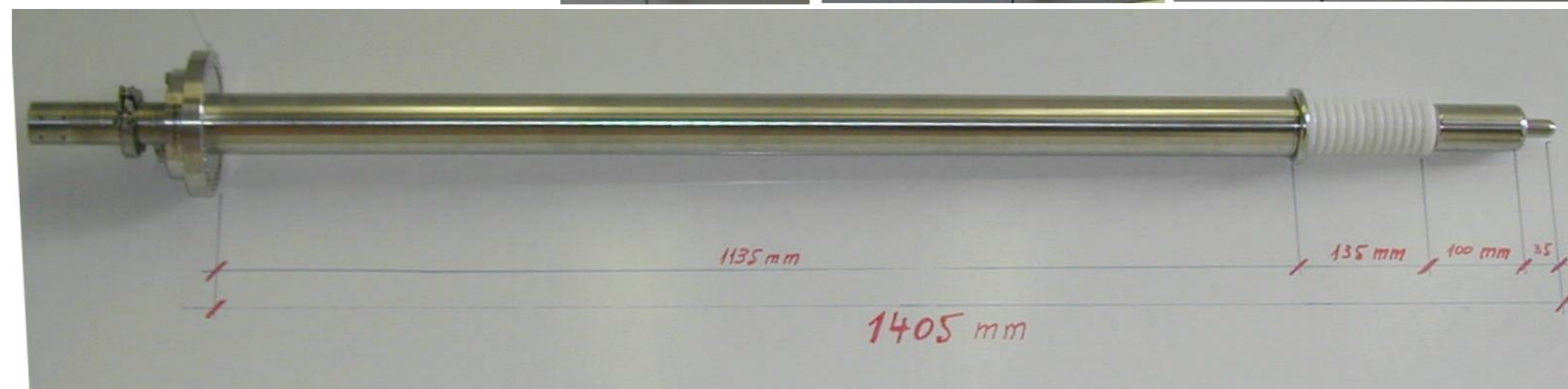
*F. Sergiampietri*

[Fourth International Conference On Calorimetry In High Energy Physics, La Biodola, Italy  
September 1993, Proceedings, P. 357](#)

**MARS-2: a “current sensitive” liquid argon calorimeter**

*C. Cerri, G. Gennaro, M. Ragadini, F. Sergiampietri, G. Spandre, S. P. Denisov,  
R. N. Krasnokutsky, A. A. Lebedev, S. A. Medved, V. S. Mikhailov, N. I. Naumov, E. A. Rasuvaev,  
R. S. Shuvalov, D. A. Stoyanova*

[Nucl. Instrum. Meth. A 227 \(1984\) 227](#)

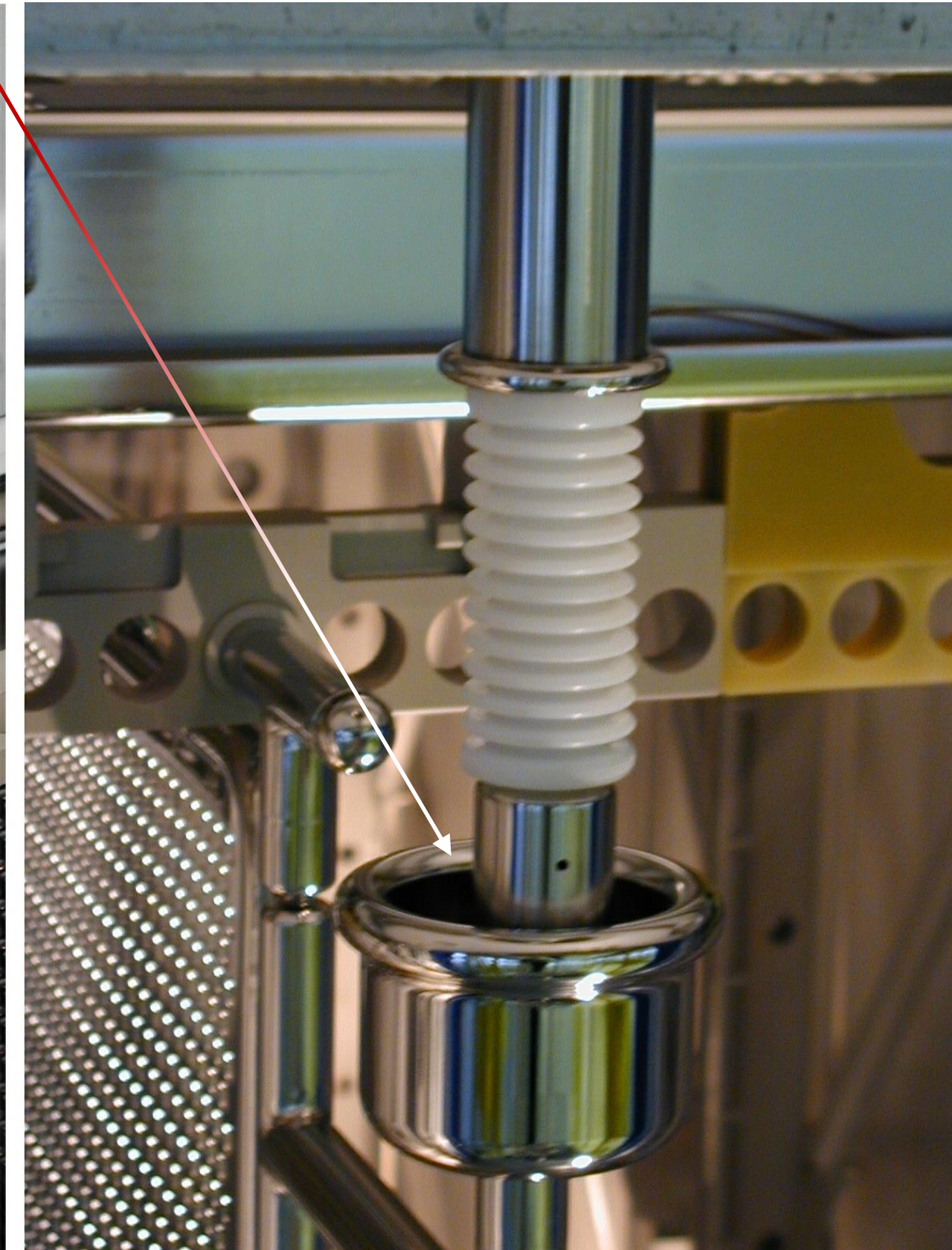
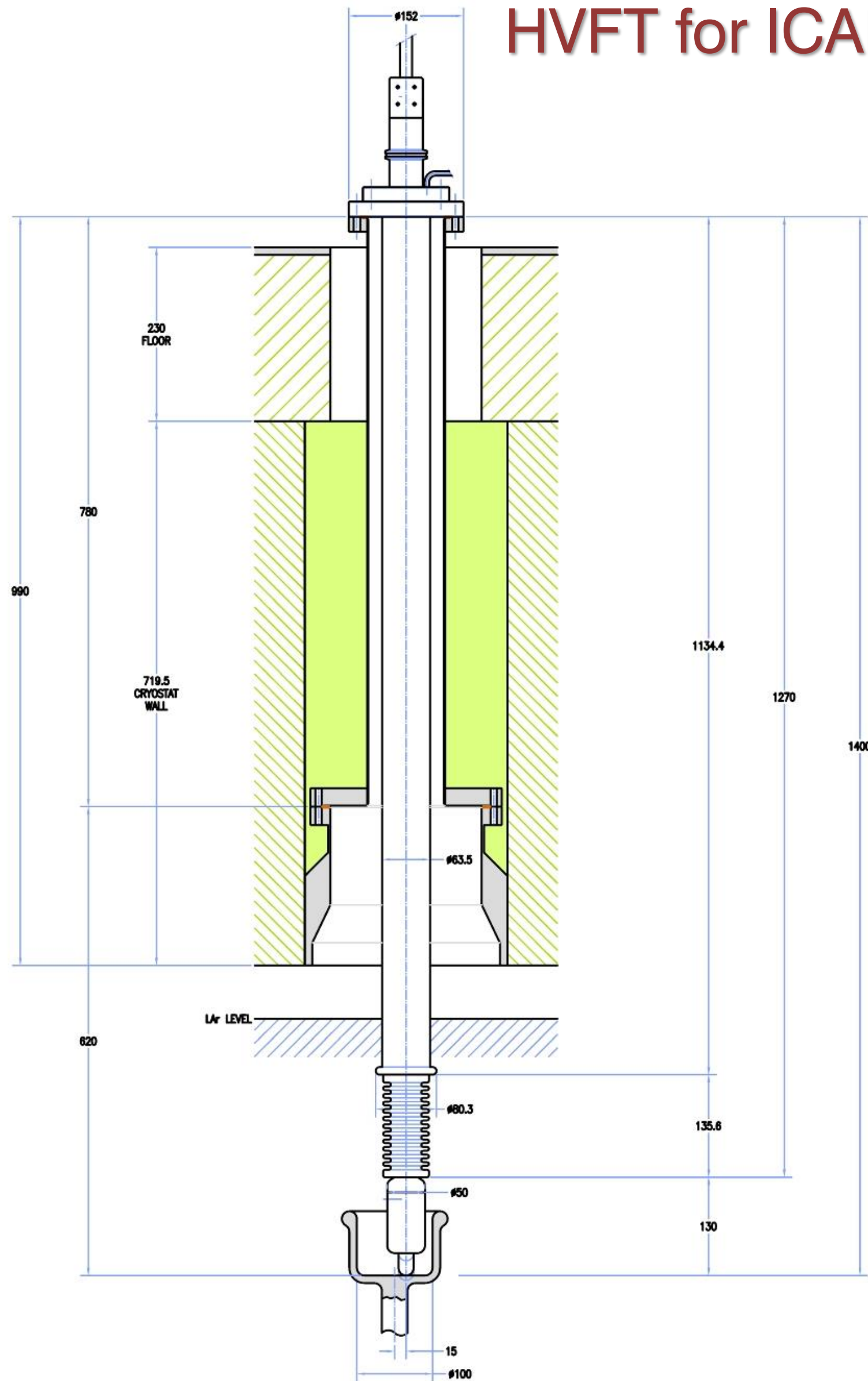


**Design, construction and tests of the ICARUS T600 detector.**

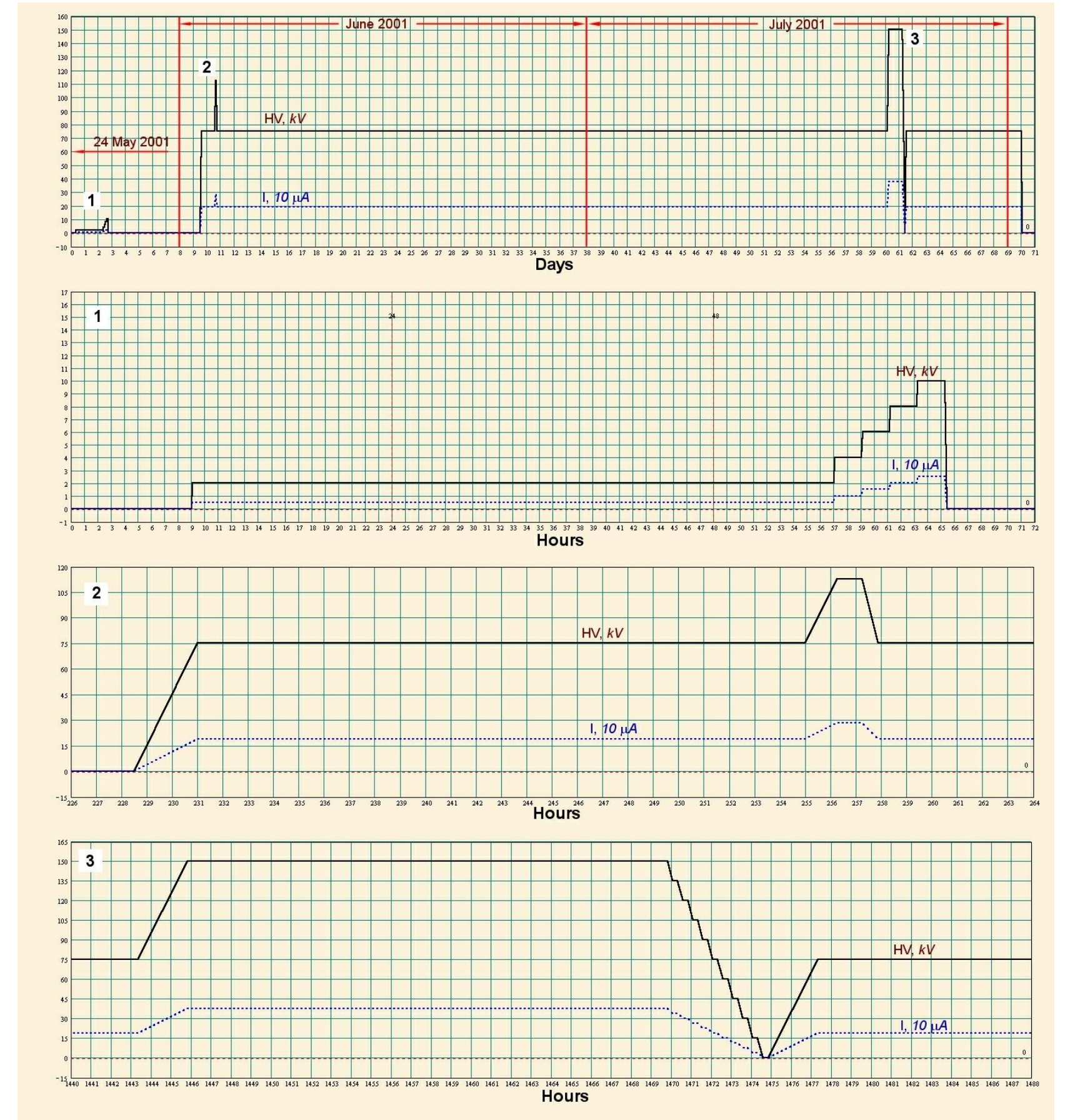
*ICARUS Collaboration (S. Amerio et al.)*

[Nucl. Instrum. Meth. 221 A527:329-410, 2004](#)

# HVFT for ICARUS with elastic vertical/transverse sliding contact



# HV FT for ICARUS



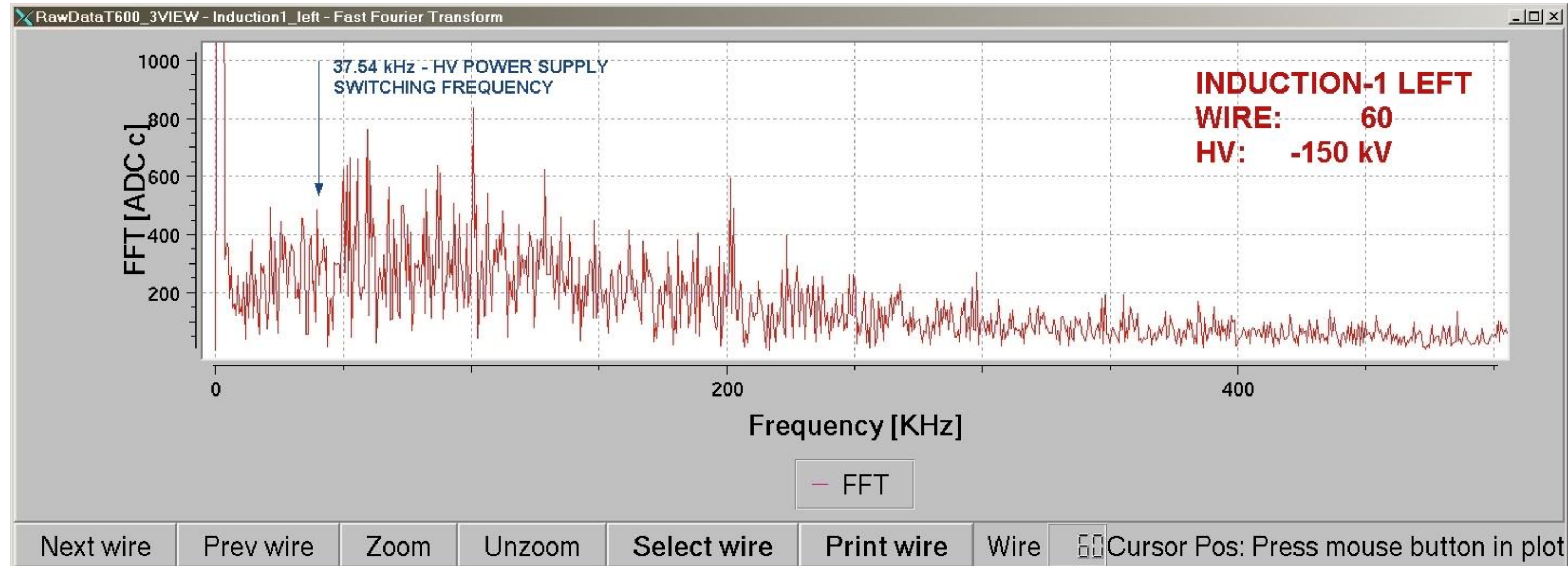
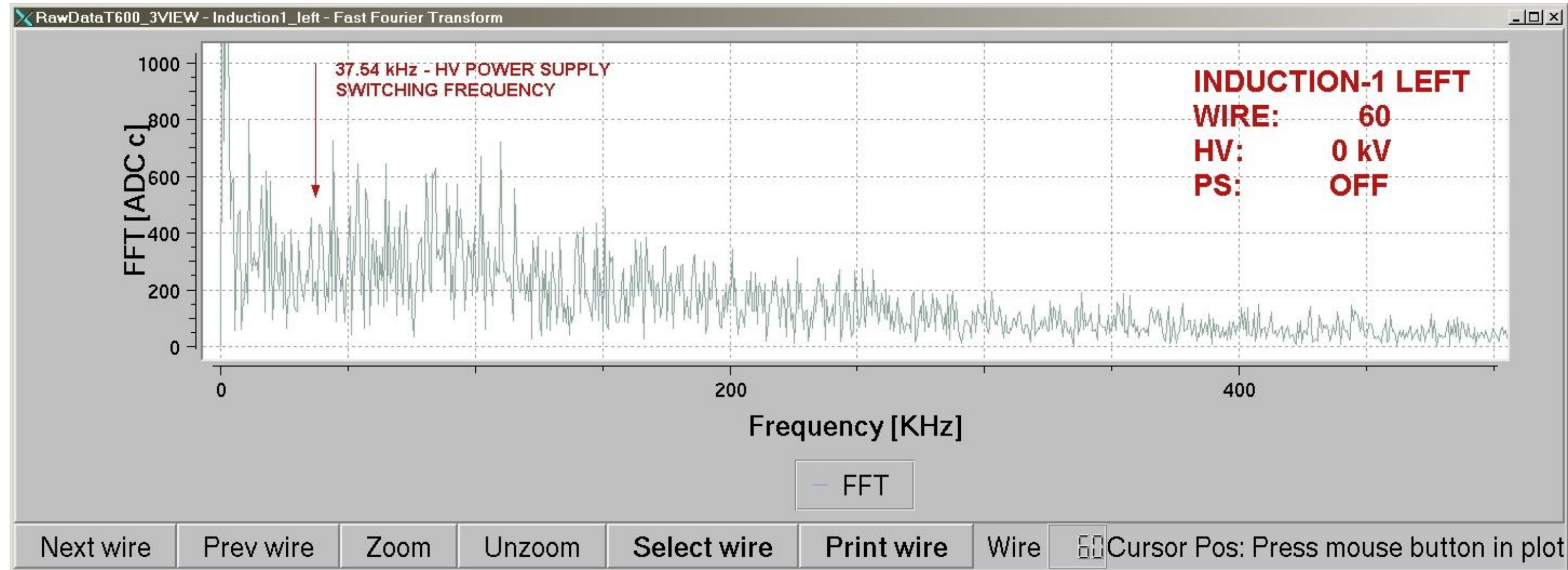
HV FT for ICARUS (1999)

Positive laboratory test at CERN, 1999: **HV = -150kV**

Tested in ICARUS at **-150kV**, for 24h in Pavia (2001) and for several days at LNGS (2013)

# HV FT for ICARUS

HVPS residual ripple on the wire chamber with RC filter on the HV cable



# HV test of a Rogowsky profile pair in LAr (WA105)

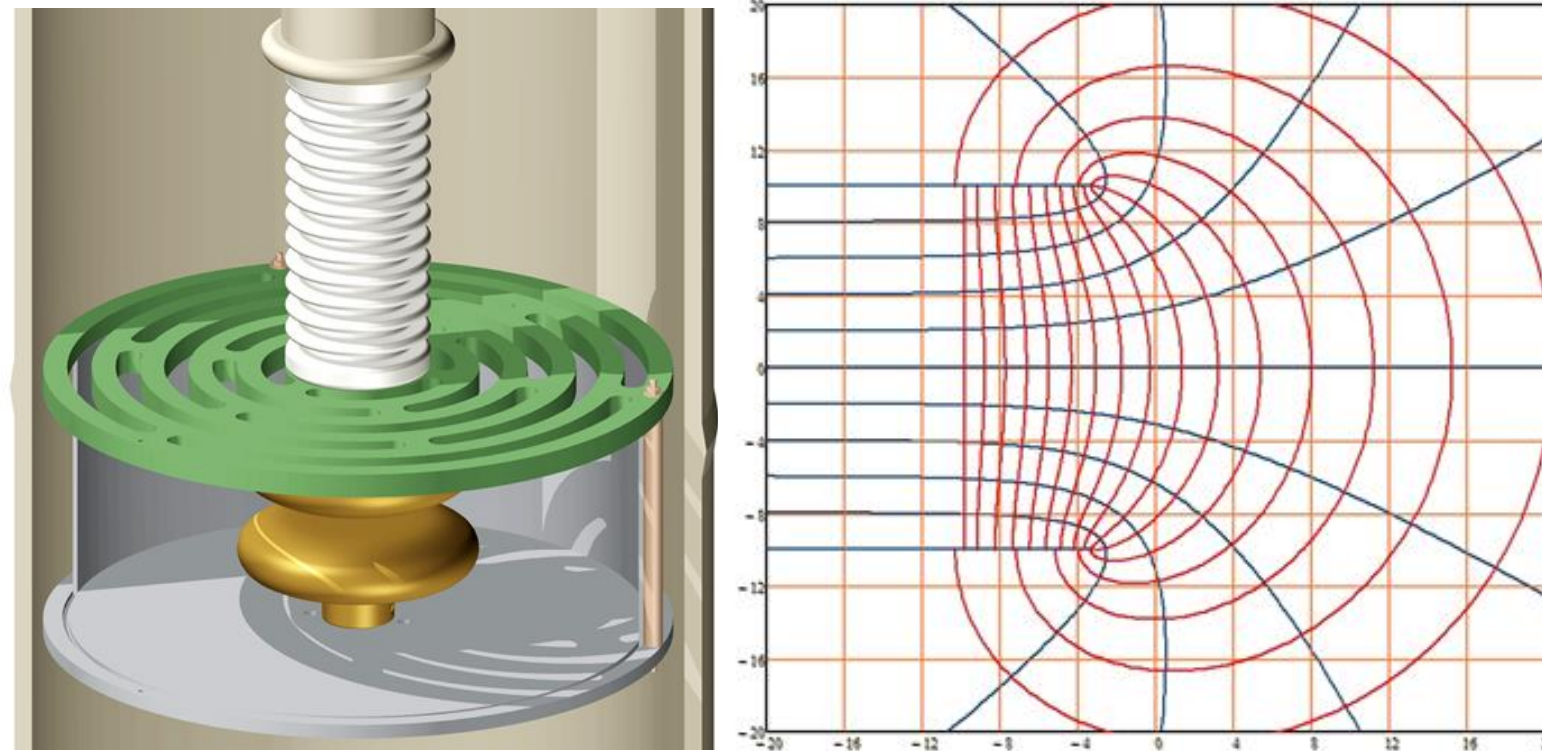
## Evidence of electric breakdown induced by bubbles in liquid argon

F. Bay, C. Cantini, S. Murphy, F. Resnati, A. Rubbia, F. Sergiampietri, S. Wu

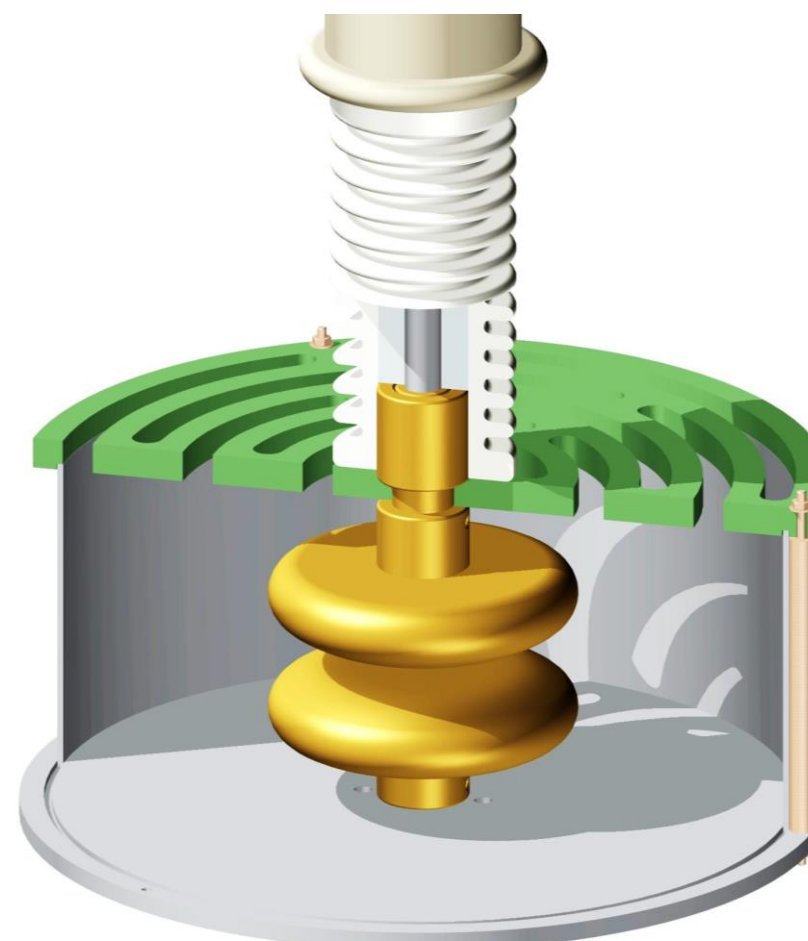
<http://arxiv.org/abs/1401.2777>

W. Rogowski,

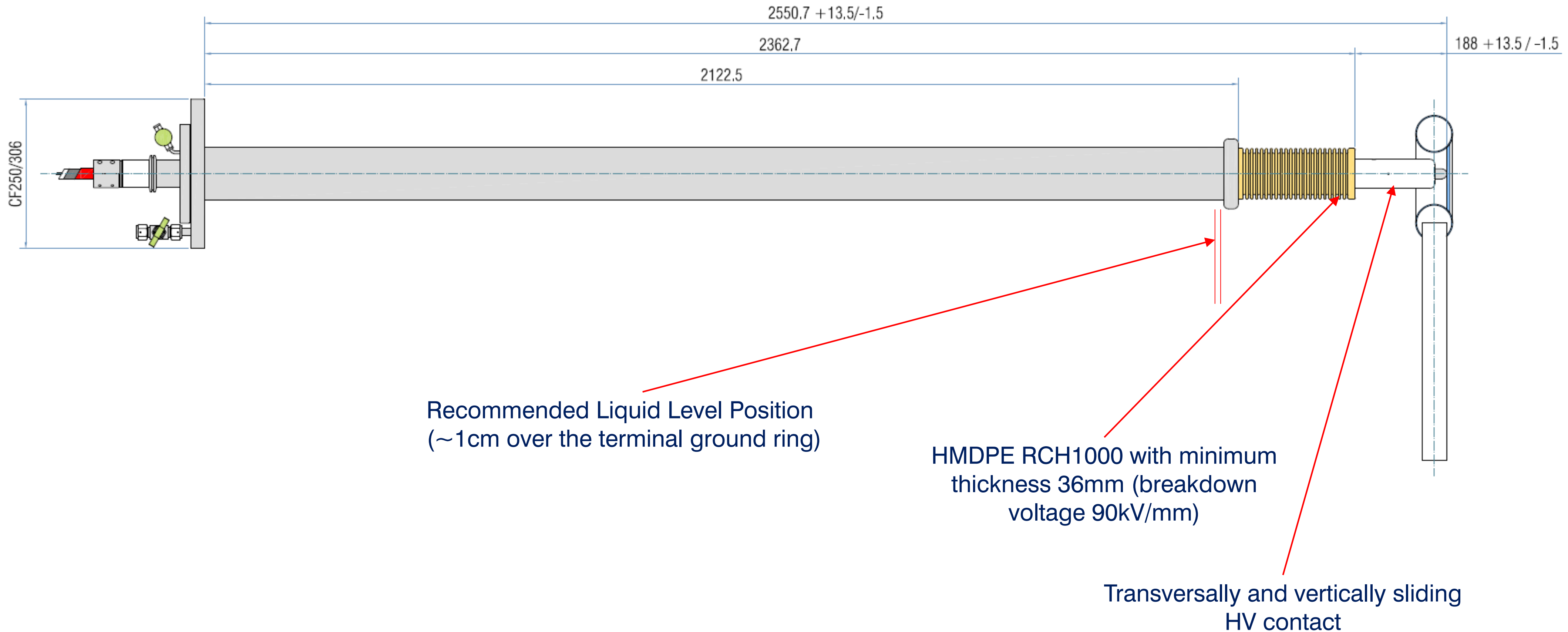
[Arch. Electrotech., 12\(1923\), 1](#)



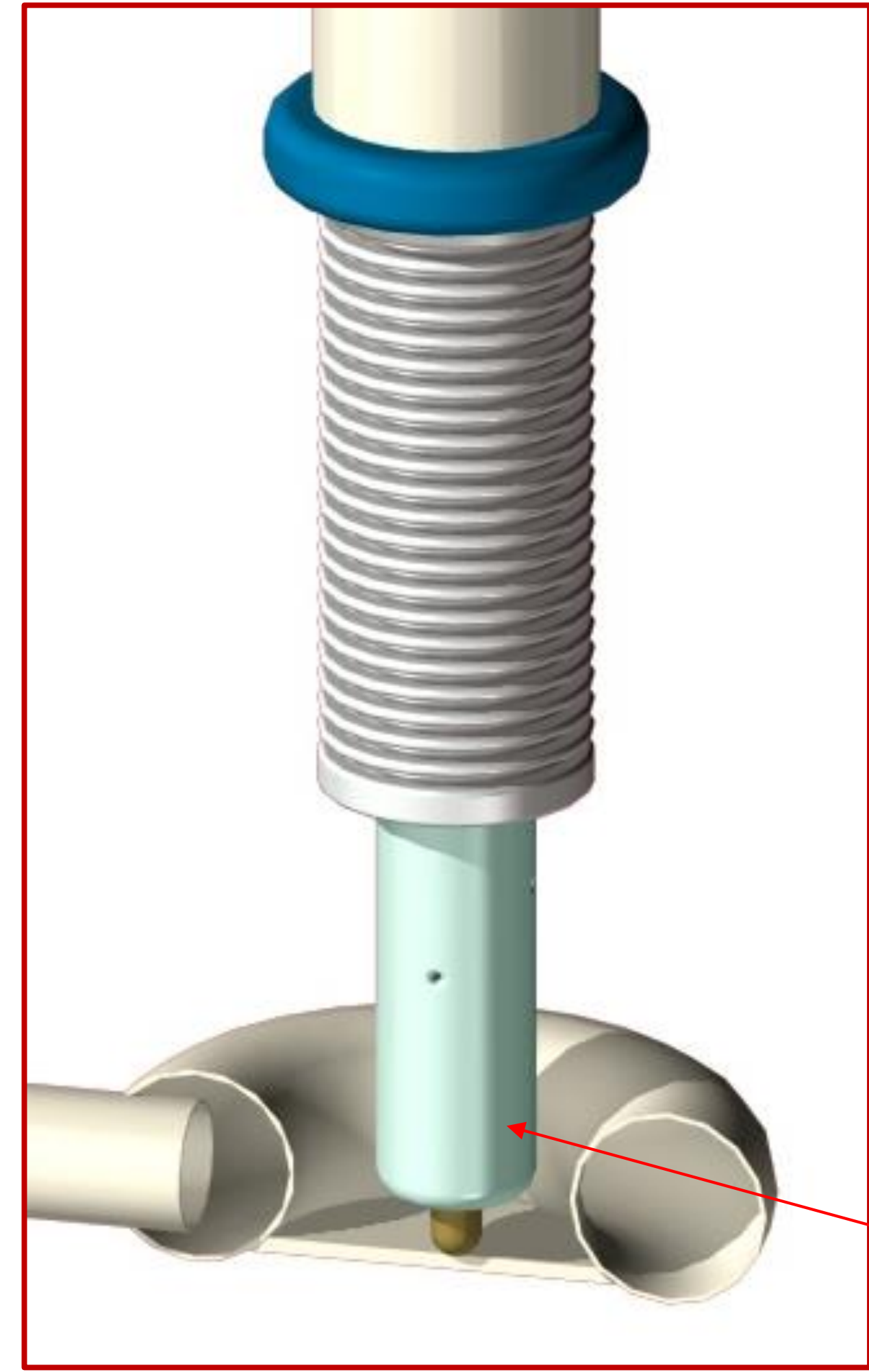
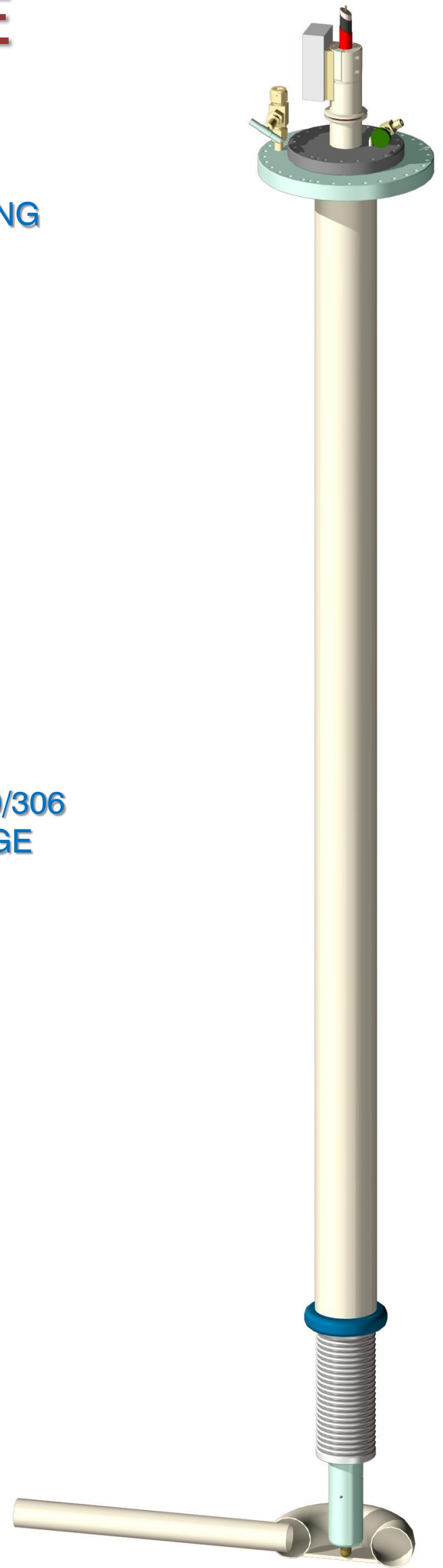
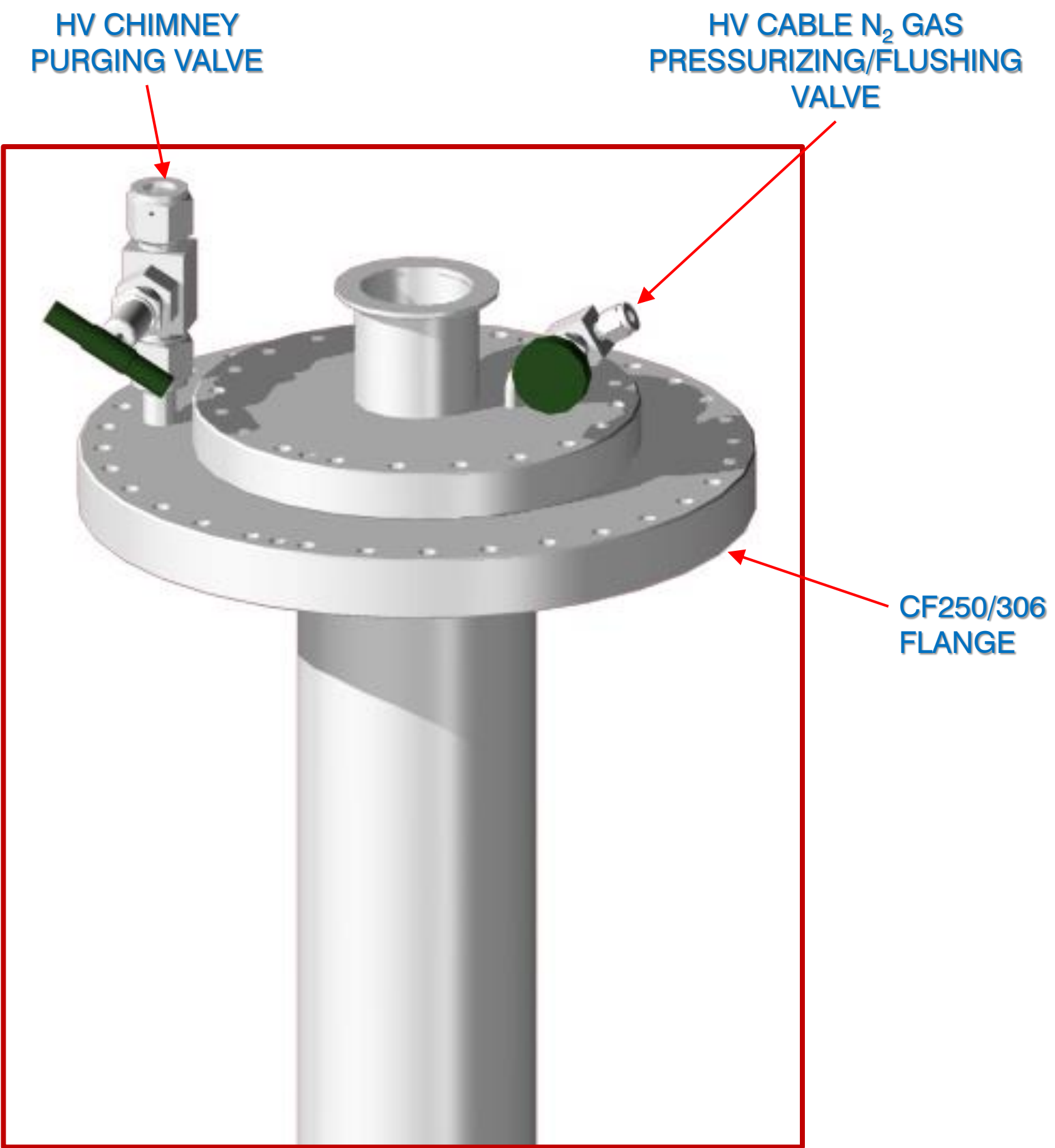
Positive results (100.0kV - 0.000mA) with a HV-to-GND gap of **1cm**  
when the LAr is quite



# HVFT for Single-Phase ProtoDUNE



# HVFT for Single-Phase ProtoDUNE



ELASTIC SLIDING CONTACT

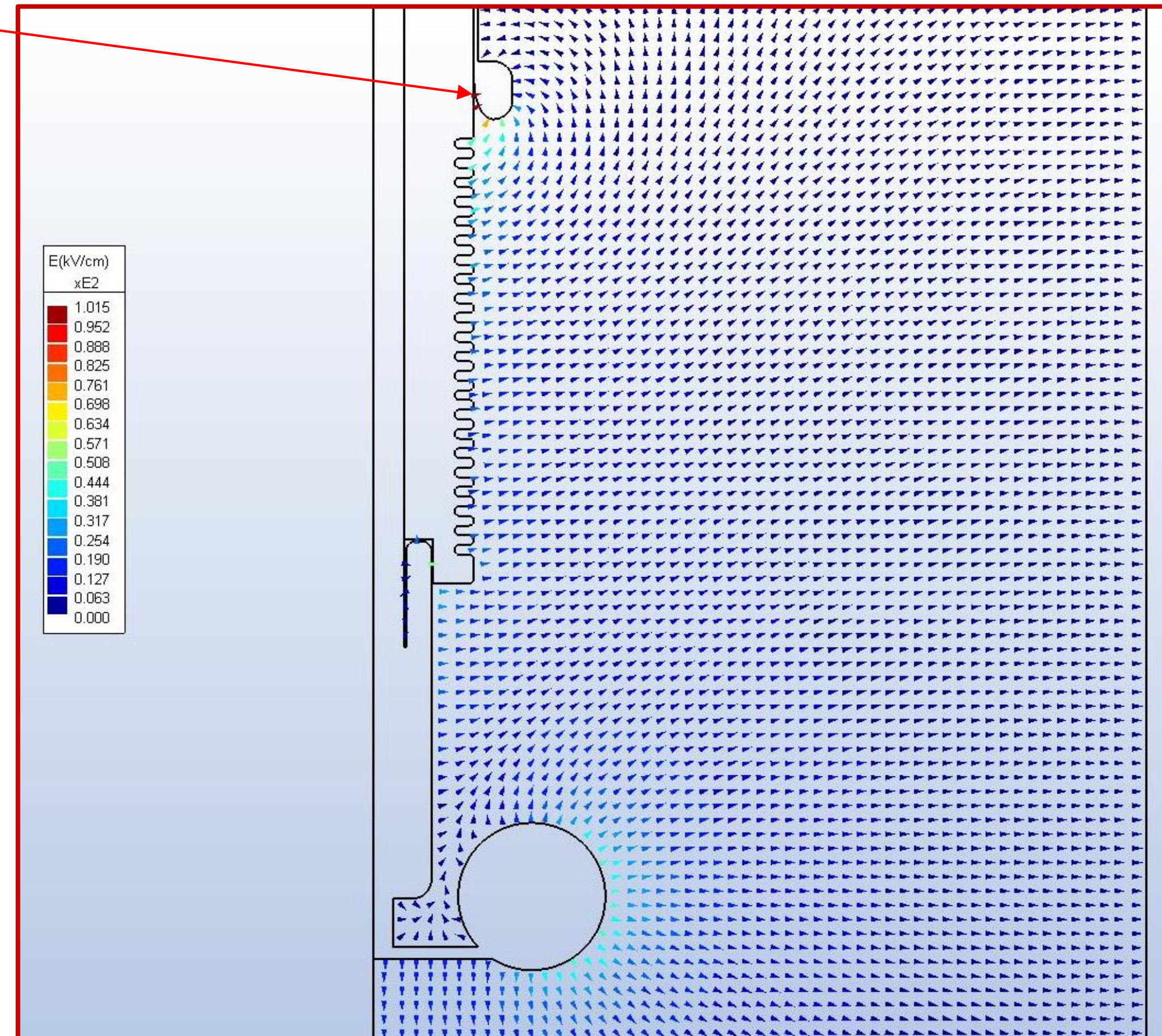
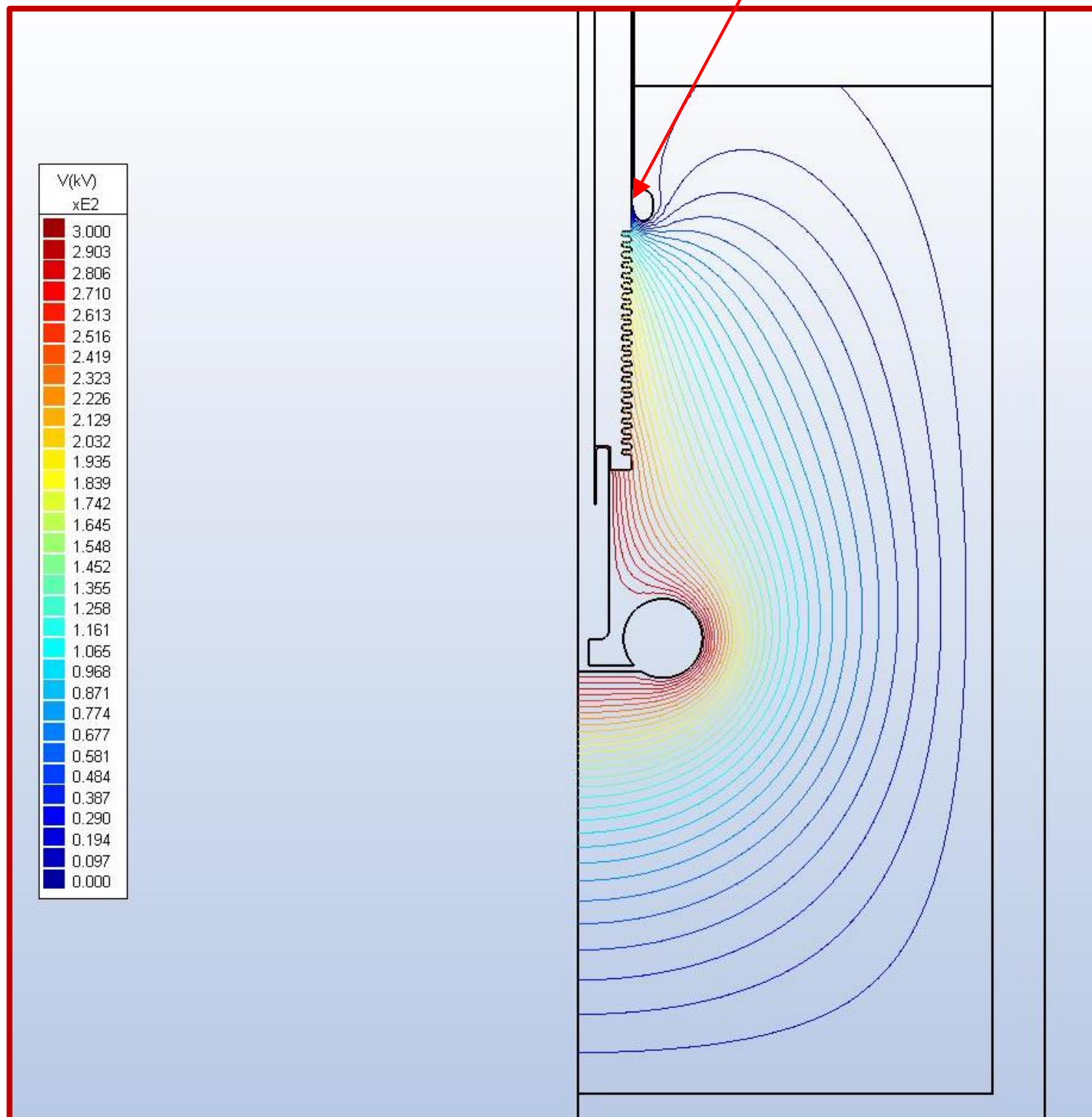
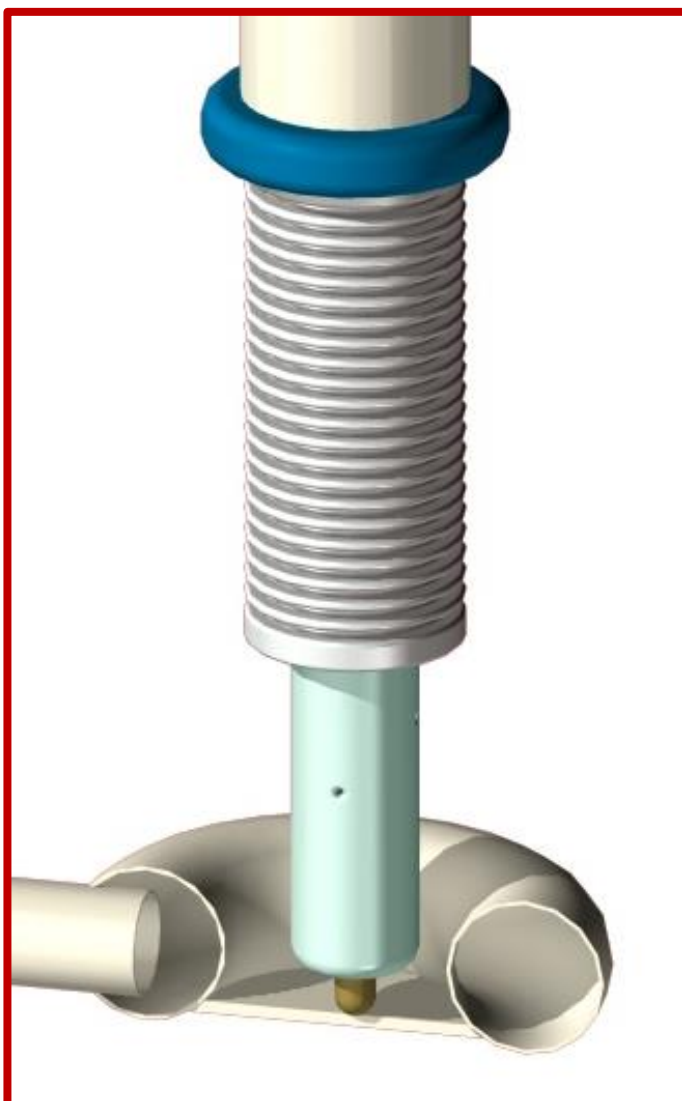


# HVFT for Single-Phase ProtoDUNE

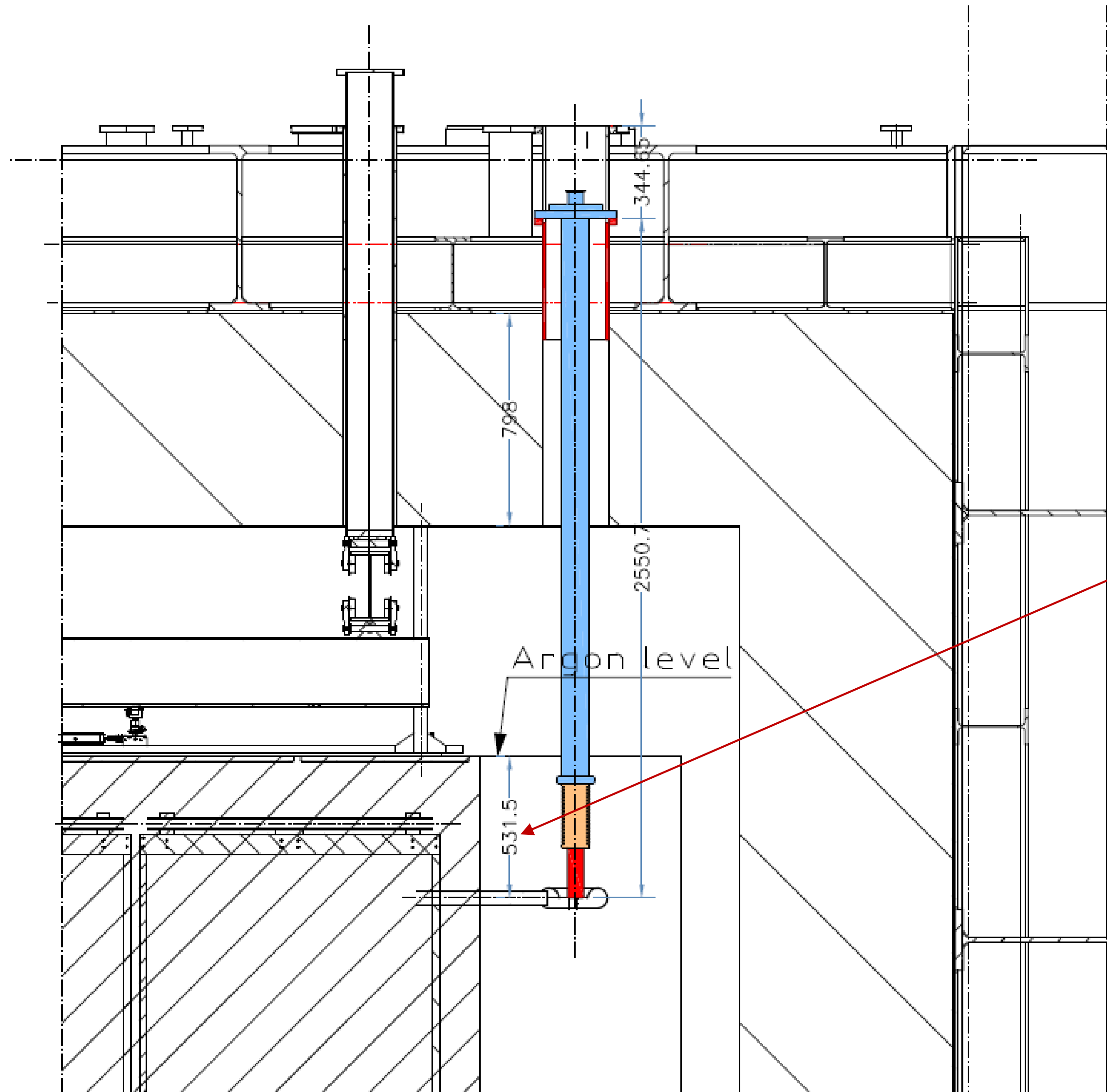
MAXIMUM FIELDS RESULTS  $\sim \frac{1}{3}$  HVPS VOLTAGE/cm  
(60.9kV/cm @180kV and 101.5kV/cm @300kV)

ELECTRIC FIELD INTENSITY at 300kV

EQUIPOTENTIAL LINES at 300kV



# Insertion of the HVFT in the Single-Phase ProtoDUNE (to be finalized/adjusted)



Distance  
Liquid level – Bottom of female  
contact 454 mm

# HV experience made for WA105 3x1x1

A similar design for the HVFT has been adopted for the WA105 DP 3x1x1 detector.

Differences essentially only on the HV terminal in LAr.

A  $\sim 300\text{kV}$  preliminary test of HVFT made on beginning of September 2016.

C. Cantini et al., "First test of a high voltage feedthrough for liquid Argon TPCs connected to a 300 kV power Supply", <https://arxiv.org/abs/1611.02085>.



# -300 kV Power Supply from Heinzinger



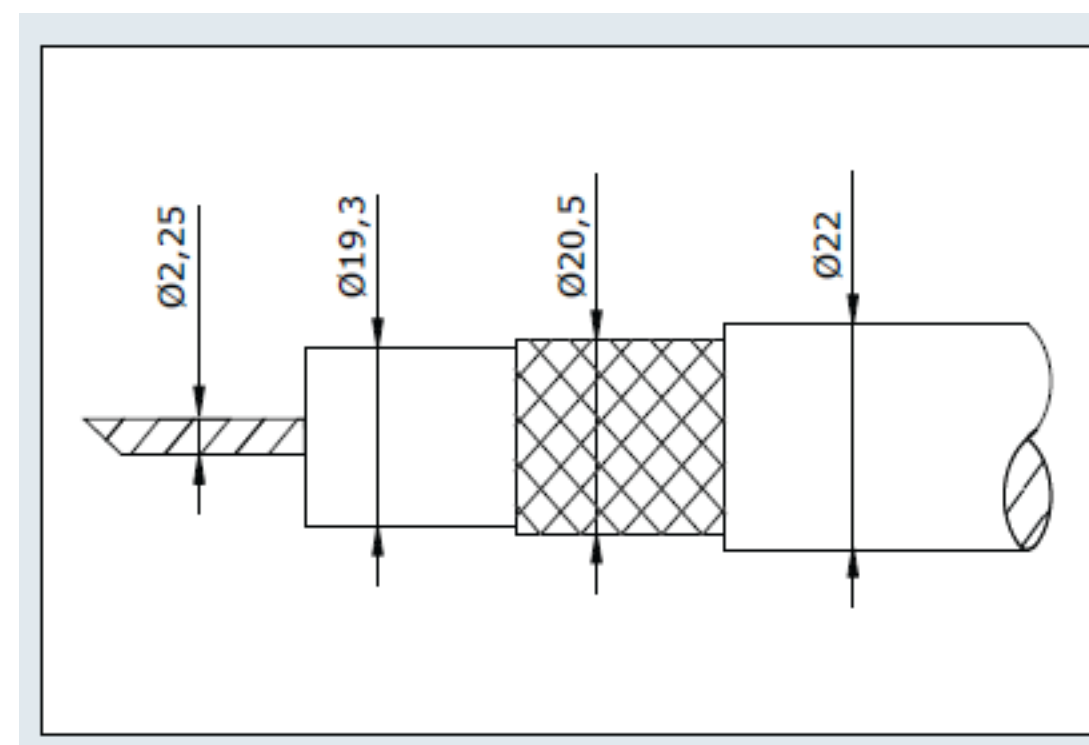
Residual ripple:  $\leq 0.001\% U_{\text{NOM}} \pm 50\text{mV}$

Residual Ripple at -300kV  $\leq 3\text{V} \pm 50\text{mV}$

Can be reduced by the RC filter in the load:

Example: with a fieldcage-to-GND capacitance of 5.5nF and a switching frequency of 34kHz, a series resistor of  $\sim 850 \Omega$  required.

## 300 kV HV cable parameters



Isolation voltage	300 kV DC
Capacity	101 pF/m
Inductance	0,3 $\mu\text{H}/\text{m}$
Impedance	67 $\Omega$
Center wire Material	Cu
Diameter	2.25 mm
Dielectric Material	PE
Diameter	19.3 mm
Screening Material	CuSn
Diameter	20.3 mm
Covering Material	PVC
Diameter	ca. 22 mm
Color	red
Bending radius	min. 440 mm
Temperature resistance up to ca	60°C



## Further studies for the HVFT

Possible extension of the outer part of the HVFT (over the CF250 top flange) to guarantee a warm connection with the HVPS.

Possible Heinzinger-CERN joint study for  $\geq 600\text{kV}$  PS directly integrated with HVFT.

Study and design ongoing...