IKAR TPC

Status of the preparation for PRM experiments 2023

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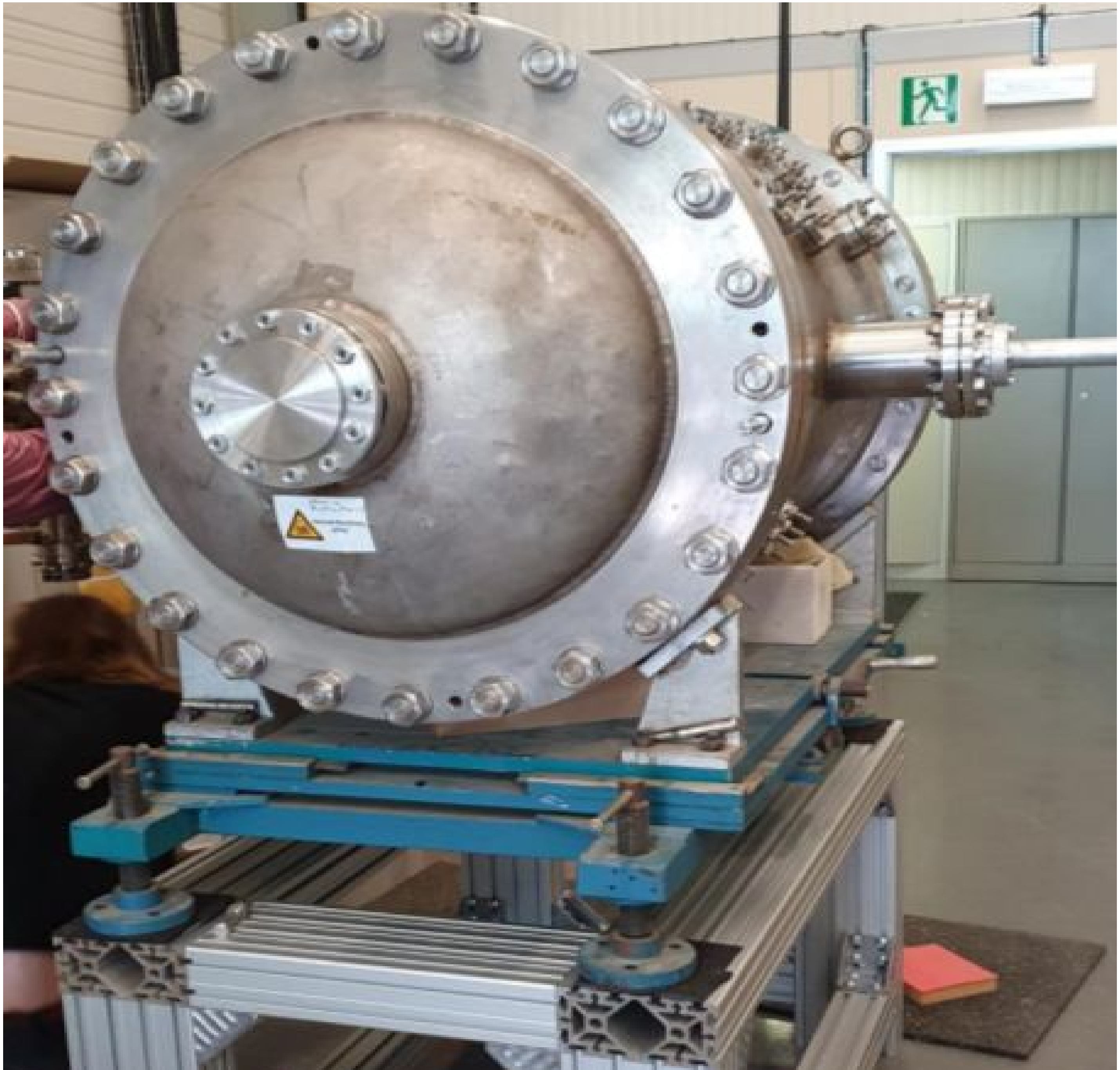
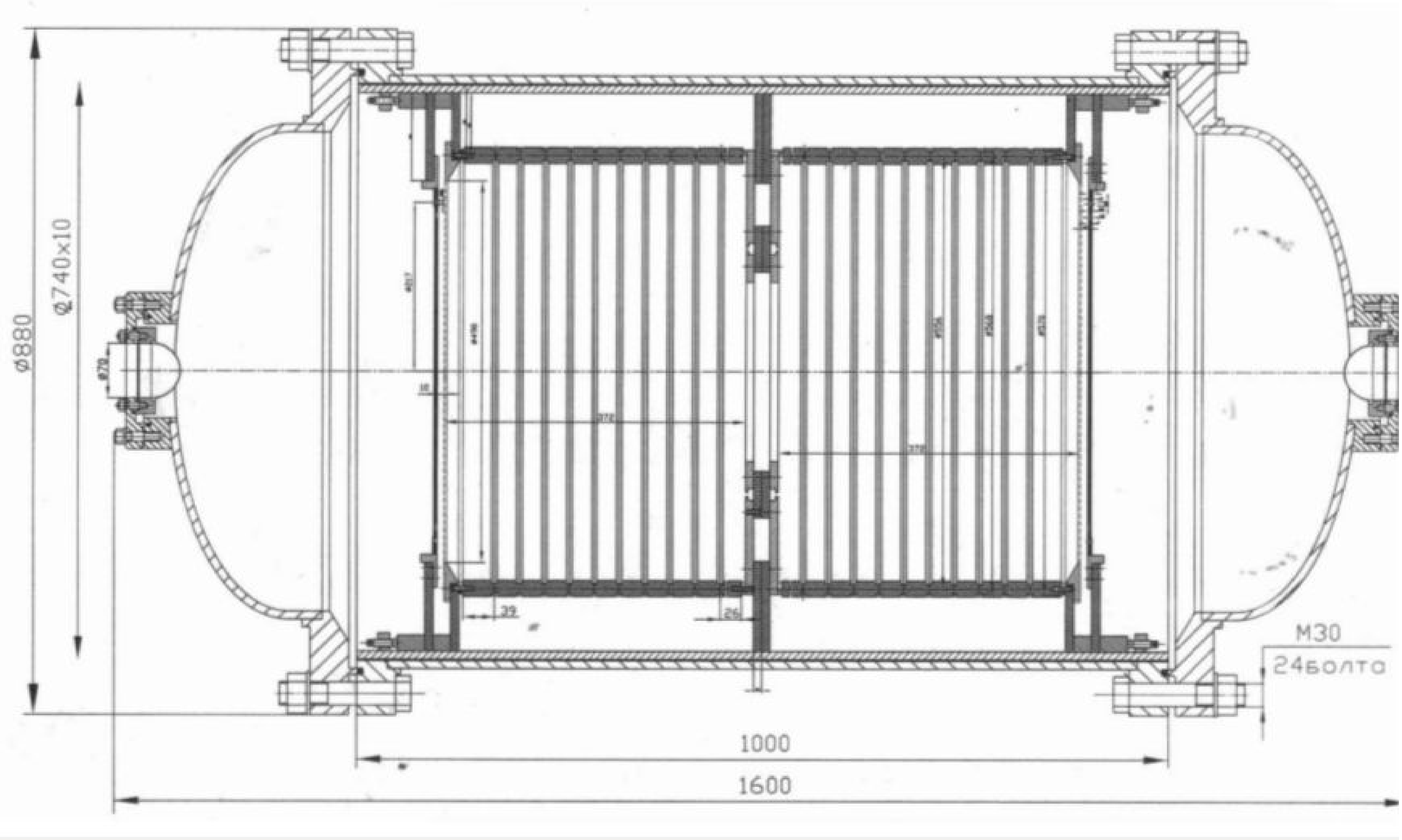


Main parameters of the IKAR pressure vessel

Pressure vessel inner diameter	740 mm
Vessel length	1600 mm
Total volume	0.55 m^3
Maximal operating pressure	8 bar
Total weight with the small support	~ 1500 kg

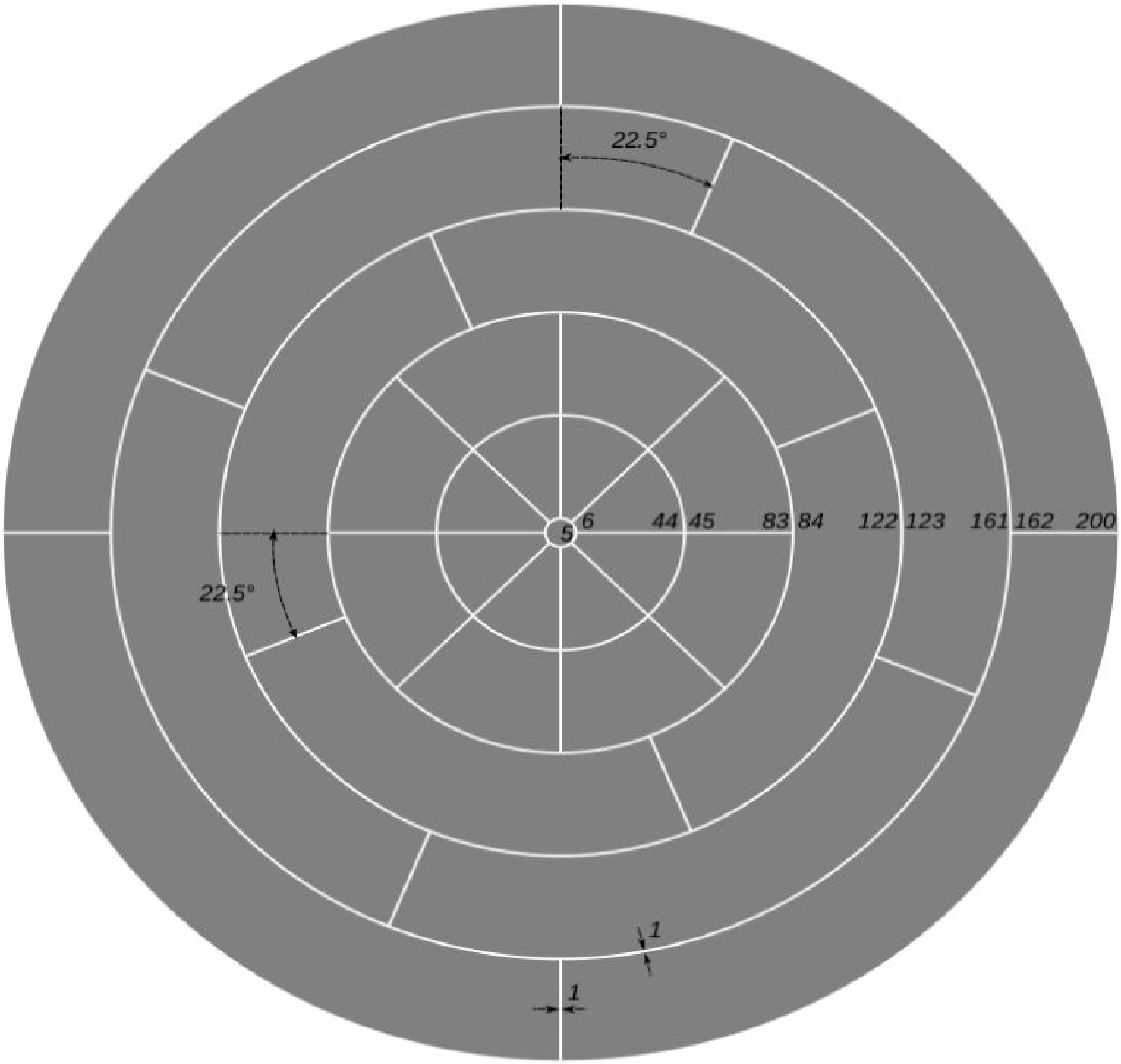
IKAR TPC



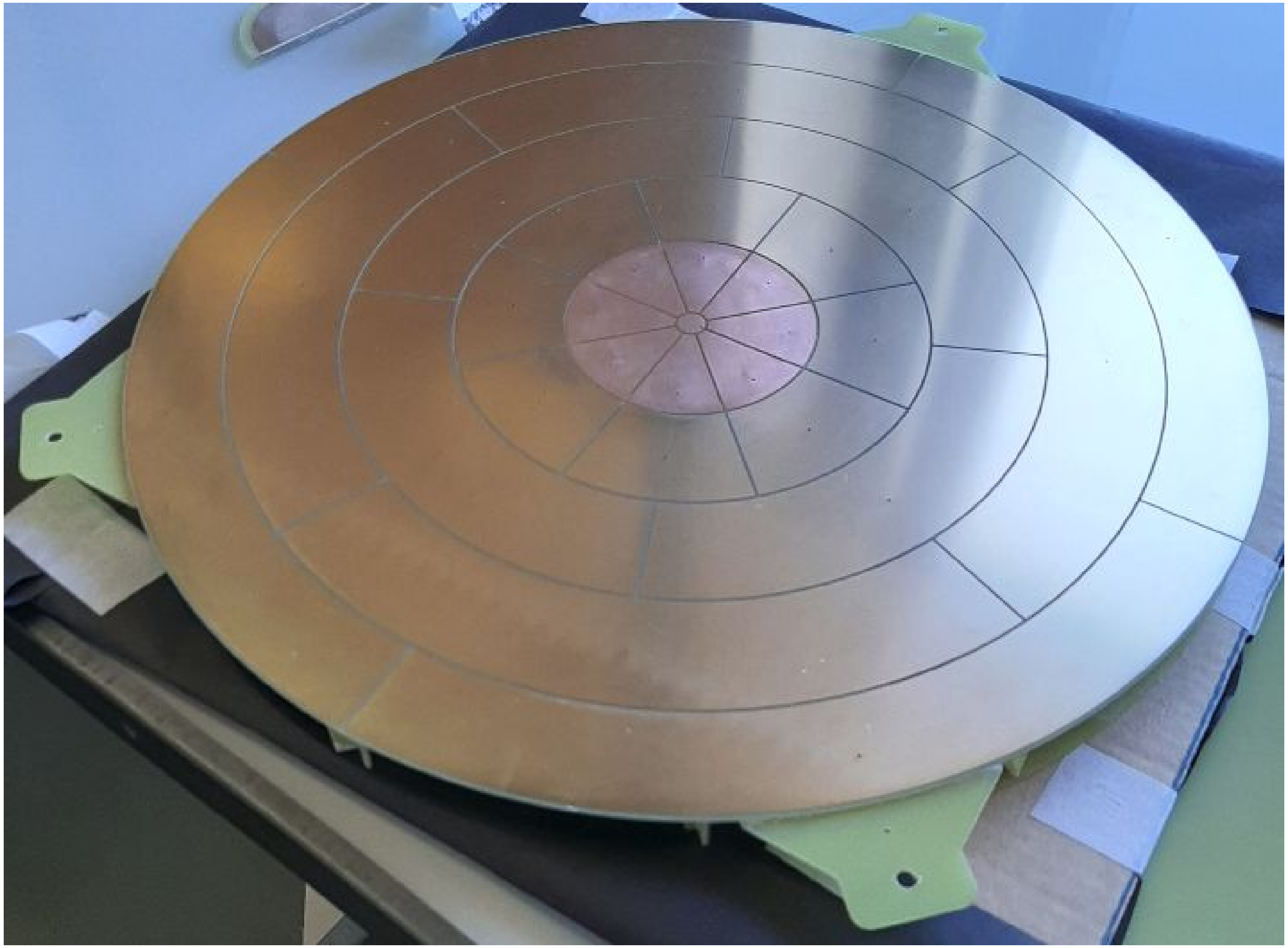
Inner IKAR structure

Two drift cells 372 mm (cathode – grid distance)
Grid – anode distance 10 mm
Diameter of the cathode 570 mm
Grid diameter 590 mm, useful diameter 490 mm
Anode diameter 490 mm

Geometry of the anode plane



IKAR anode plane (29 pads)

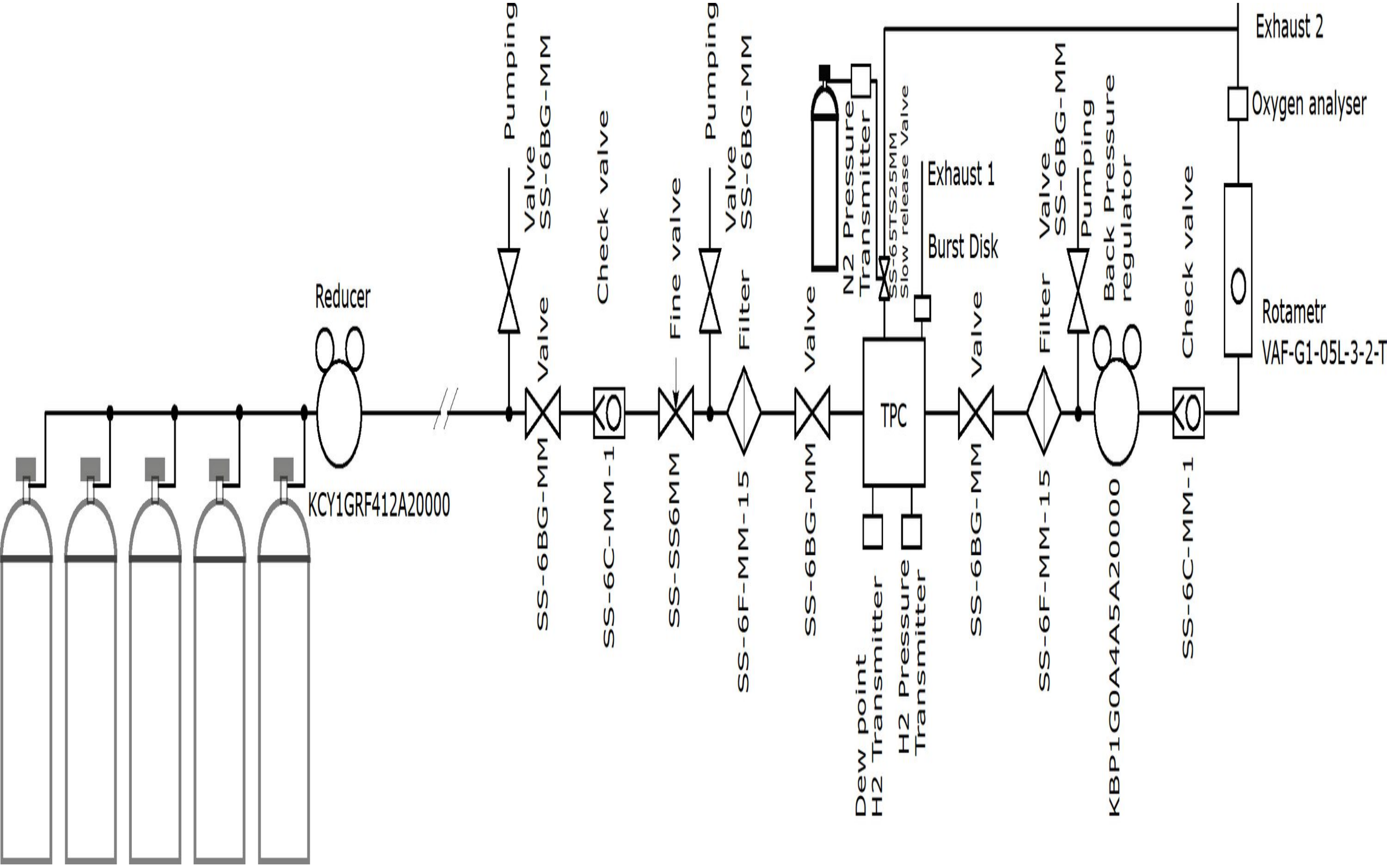


IKAR electric field

The IKAR is operated up to -25 kV on the cathode and -2.0 kV on the grid. The field uniformity in the drift gap is improved by a set of copper rings (field shaping rings) The field shaping rings (Cu wire, 7 mm) have outer diameter 570 mm, distance between the rings 31 mm. To obtain proper intermediate potentials, the rings will be connected to a voltage divider made of 12 HV resistors (2G Ohm), placed inside of IKAR.

Field shaping rings

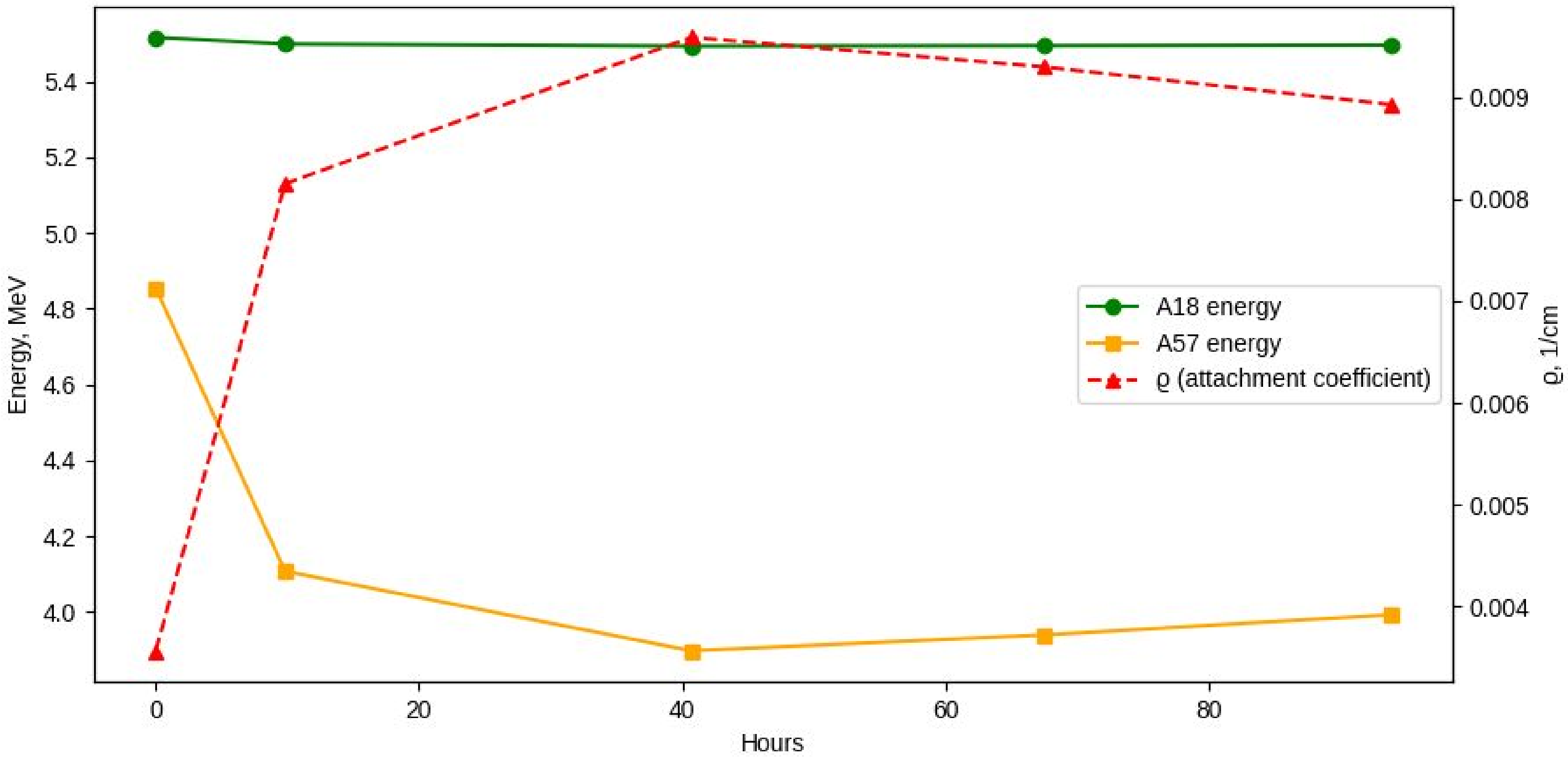
Gas filling scheme



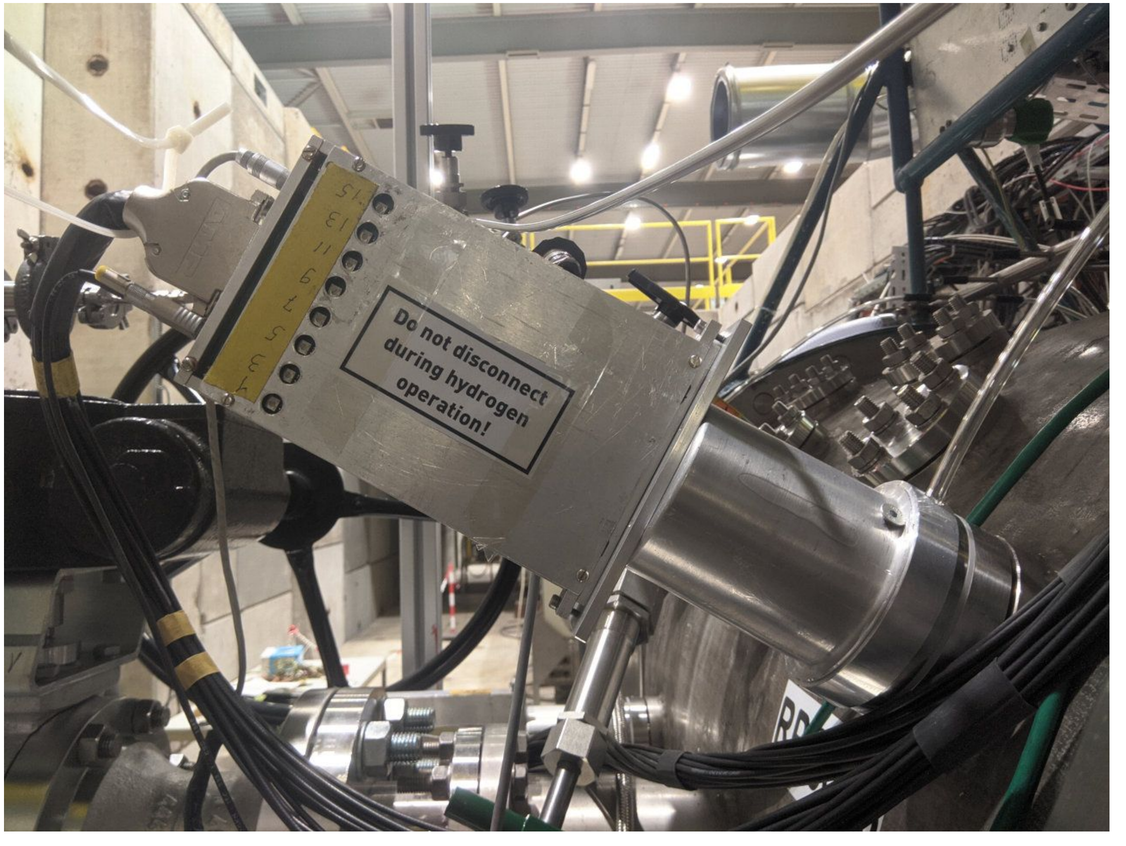
Control of the gas impurity

Alpha sources (Am241) had been deposited on the two cathodes and on the one grid. The difference between of the positions of the alpha spectrum on the cathode and grid gives the direct information about electro-negative impurities (O_2 and H_2O) in the gas.

Alpha spectrum



Amplifiers for IKAR TPC



Conclusion

1. The IKAR TPC can operates with hydrogen at pressure up to 8 bar and the intensity of the muon beam up to 5 MHz.
2. The level of the impurity (O2 and H2O) in hydrogen was ~ 1ppm and can be improved using additional purification system.
3. The electronic noise for all channels (60) of the amplifiers are less 40 keV (need absolute calibration).

Thank you for attention !

Goals of the pilot run

The main goal is to demonstrate operation of the hydrogen TPC (the recoiled proton detector) in combination with the muon tracking system (measurement of the muon scattering angle) and the magnetic spectrometer (measurement of the scattered muon momentum).

The pilot run counting rates for the TPC.

σ (TR $\geq$ 0.5 MeV) = 0.25 mb = 0.25 $\cdot 10^{-27}$ cm^2
ρ = 5,4 $\cdot 10^{19}$ protons $\cdot$ cm^{-3} (1 atm)
N_p (1 atm) = 5,4 $\cdot 10^{19}$ cm^{-3} x 40cm = 2.16 $\cdot 10^{21}$ protons $\cdot$ cm^{-2}
N_p (8 atm) = 2.16 x 8 x2 = 3.4 $\cdot 10^{22}$ protons $\cdot$ cm^{-2}
I_{beam} = 2 $\cdot 10^6$ s^{-1}
N_R ($T_R \geq$ 0.5 MeV) = $I_{beam} \cdot \sigma \cdot N_p$ = 2 $\cdot 10^6$ x 0.25$\cdot 10^{-27}$ x3.4 $\cdot 10^{22}$ = 16 counts/s

For duty factor 1/8 N_R ($T_R \geq$ 0.5 MeV) = 2 counts/s
(~700 000 per 100 hours).

Readout rate 40 kHz (with tracking detectors).

N_R ($T_R \geq$ 0.5 MeV) = 16x 1/8 x 1/50 = 0.04 s^{-1}
(~14 000 per 100 hours).
N_R (0.5 MeV $\leq T_R \leq$ 2.0 MeV) 10 800 /100 h
N_R (2.0 MeV $\leq T_R \leq$ 5.0 MeV) 2 160 /100 h
N_R (5.0 MeV $\leq T_R \leq$ 10.0 MeV) 720 / 100 h

Goals of the pilot run

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I. As concerns the TPC alone:

I.1 Measurement of the beam induced noise in various TPC pads in function of the beam intensity (from 0.2 MHz to 2.0 MHz) and in function of the H_2 pressure (from 2 atm to 8 atm). With the help of a high precision pulse generator.
I.2 Study of the background in TPC related to the wide profile of the muon beam.
I.3 Demonstration of the sufficient safety control in operation of the hydrogen TPC in the muon beam.

Goals of the pilot run

The main goal is to demonstrate operation of the hydrogen TPC (the recoiled proton detector) in combination with the muon tracking system.

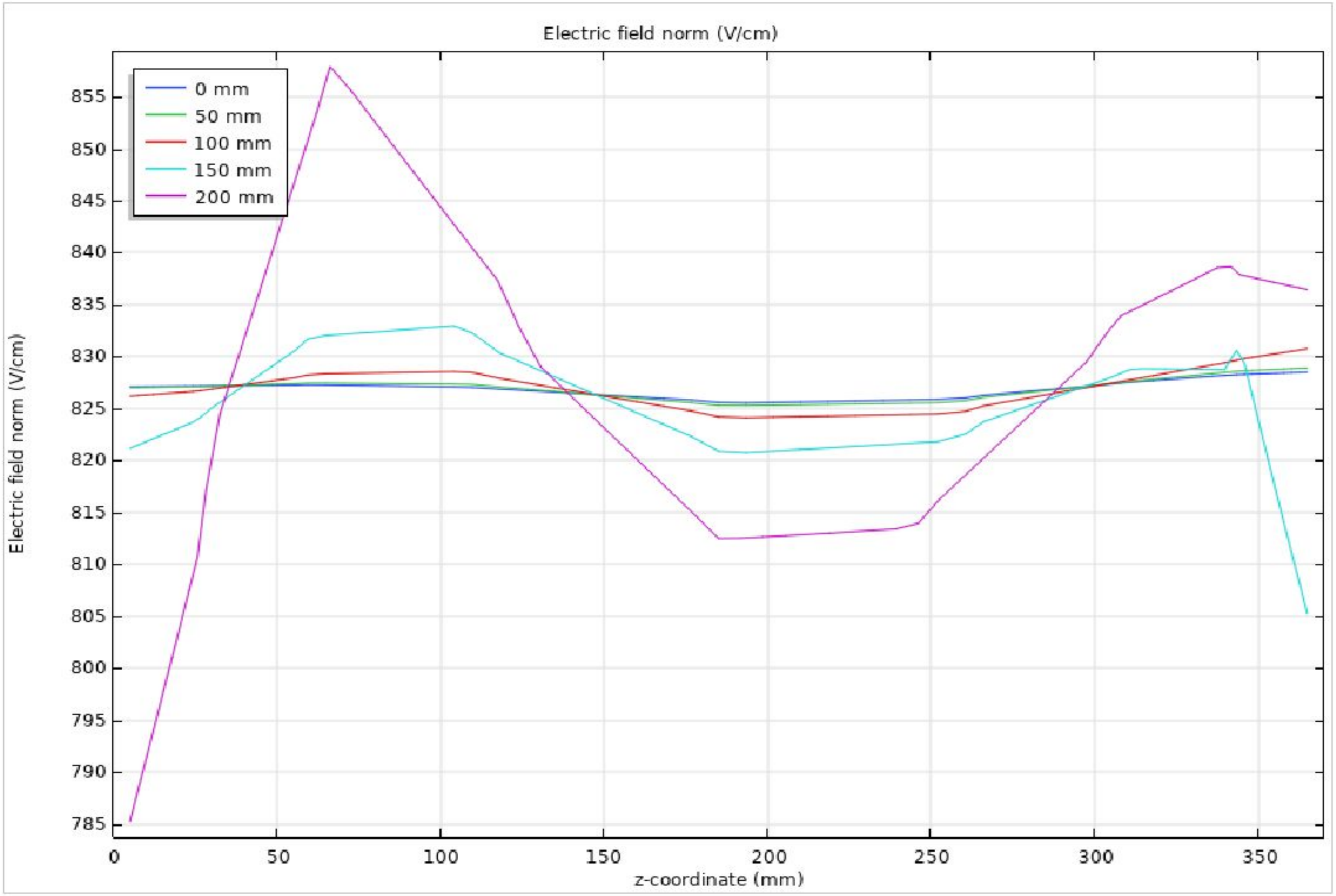
2. Using the whole setup:

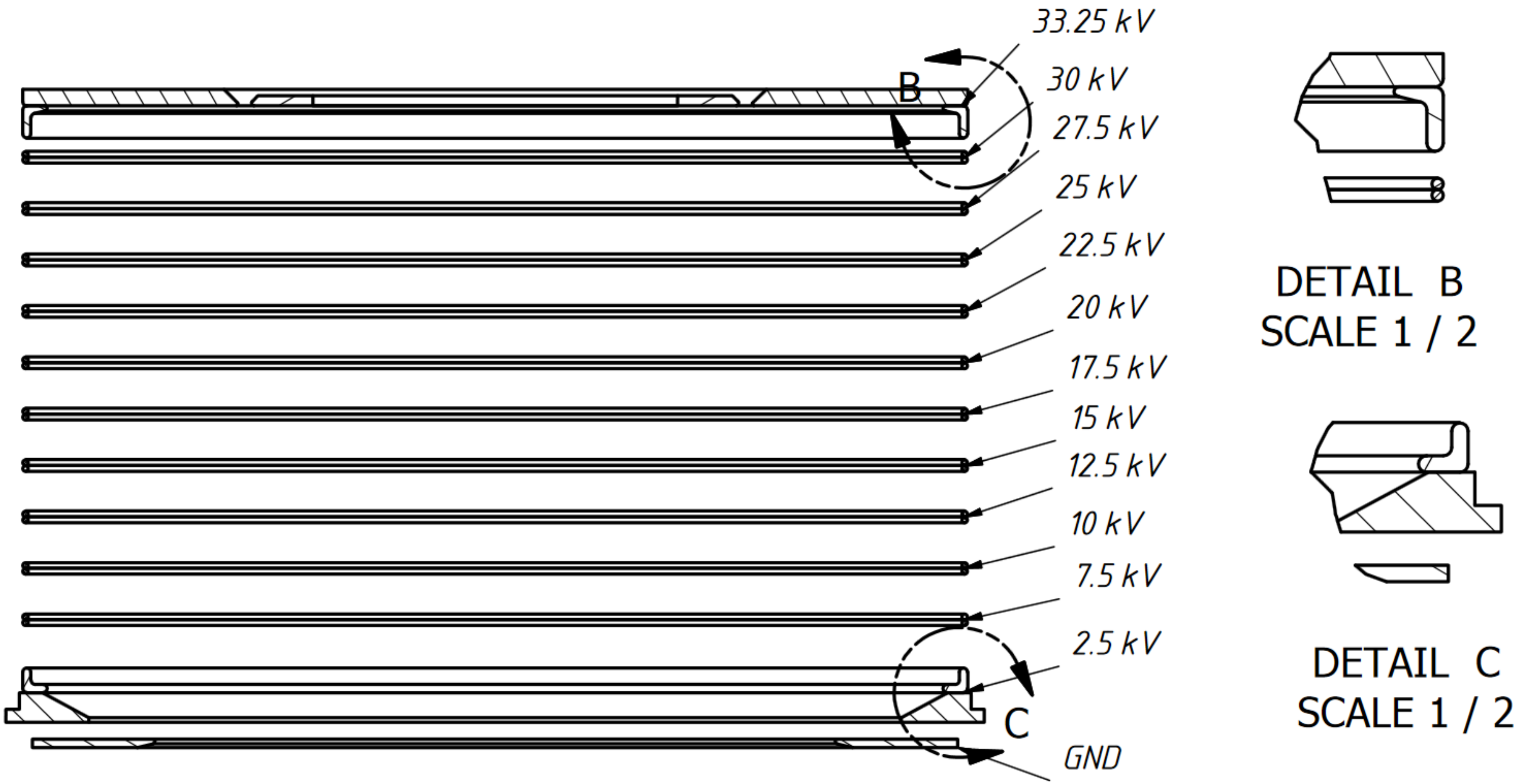
2.1. Study of the efficiency in finding the correct vertex in TPC.
2.2. Study of the recoiled proton energy resolution.
2.3. Study of the drift time resolution.
2.4. Study of the ionization electron losses during the drift time. Requirements to the H_2 gas putity. Measurements with the recoiled protons and with the alpha sources.
2.5. Demonstration of the correlation between the Q^2 value determined by the recoiled proton energy $Q^2 = 2MT_R$ and that determined by the muon scattering angle θ_μ and momentum P_μ : $Q^2 = (P_\mu \cdot \theta_\mu)^2$
2.6. Study of the efficiency of the muon tracking system.
2.7. Study of the muon tracking angular resolution .

Grid and Cathode

The grid is made of a stainless-steel ring with steel wire, 100 μm diameter, wound with 1.5 mm step. The cathode is made of a stainless-steel disk with a thickness of 10 mm.

IKAR electric field





33.25 kV
30 kV
27.5 kV
25 kV
22.5 kV
20 kV
17.5 kV
15 kV
12.5 kV
10 kV
7.5 kV
2.5 kV
GND
B
C
DETAIL B
SCALE 1 / 2
DETAIL C
SCALE 1 / 2

IKAR anode cables