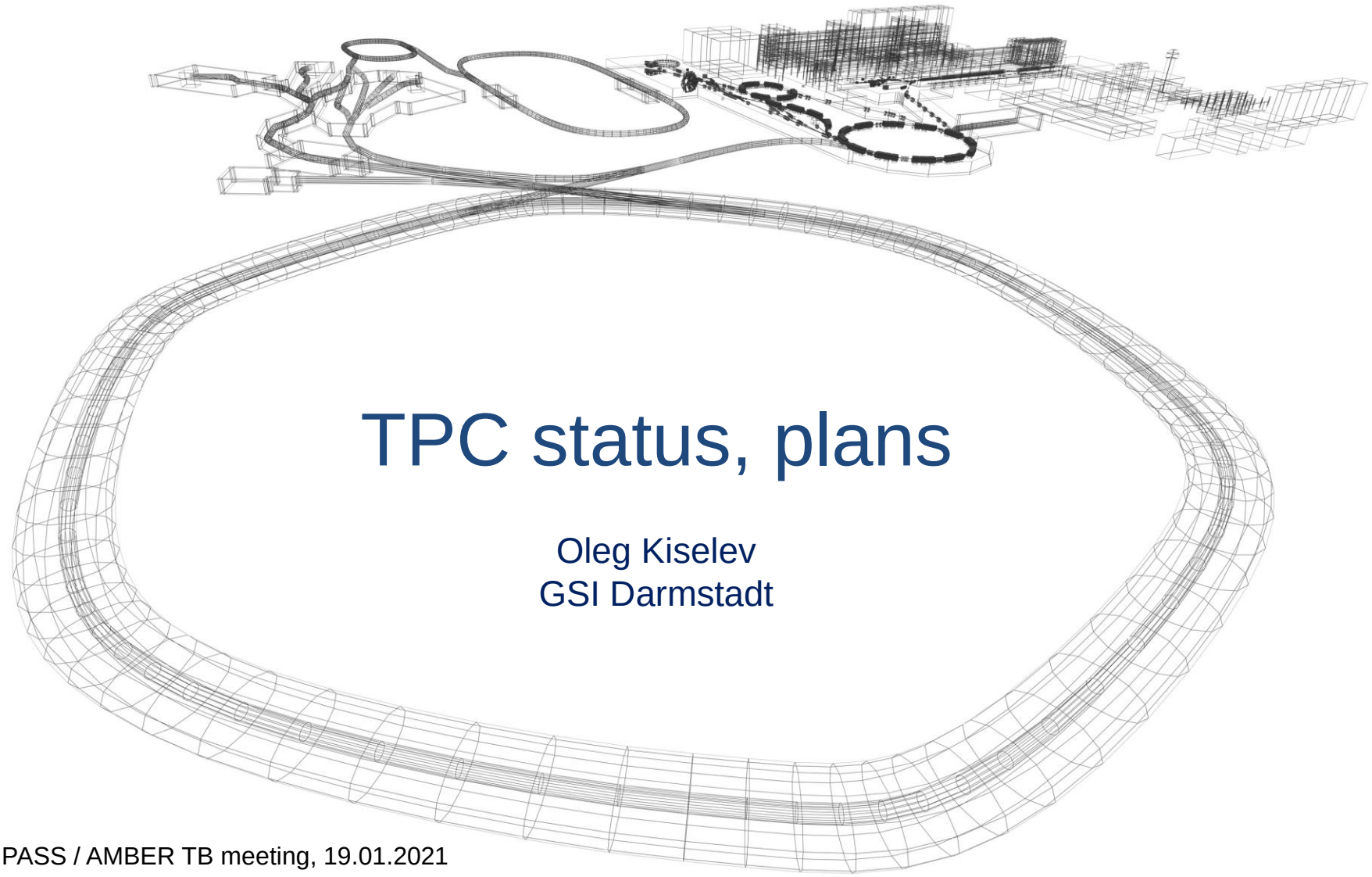
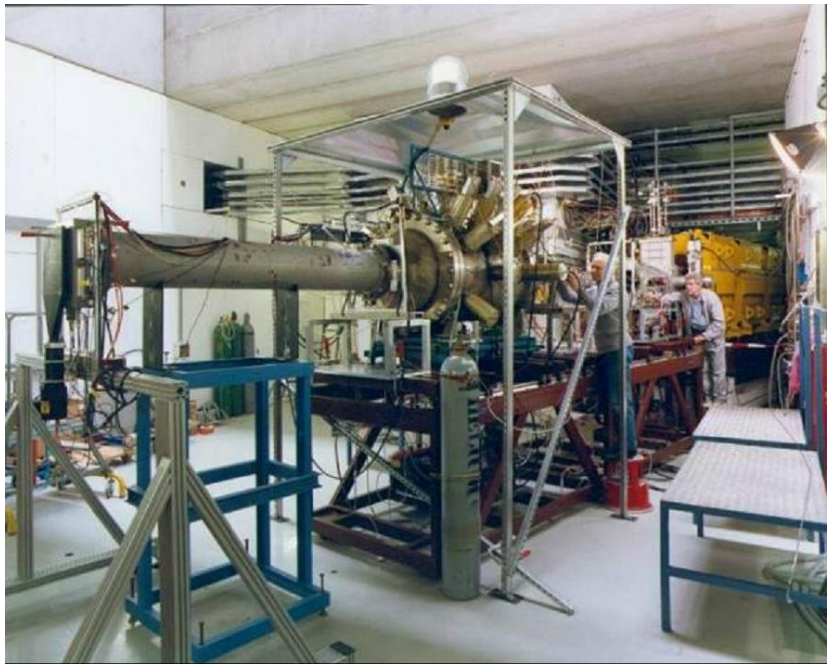
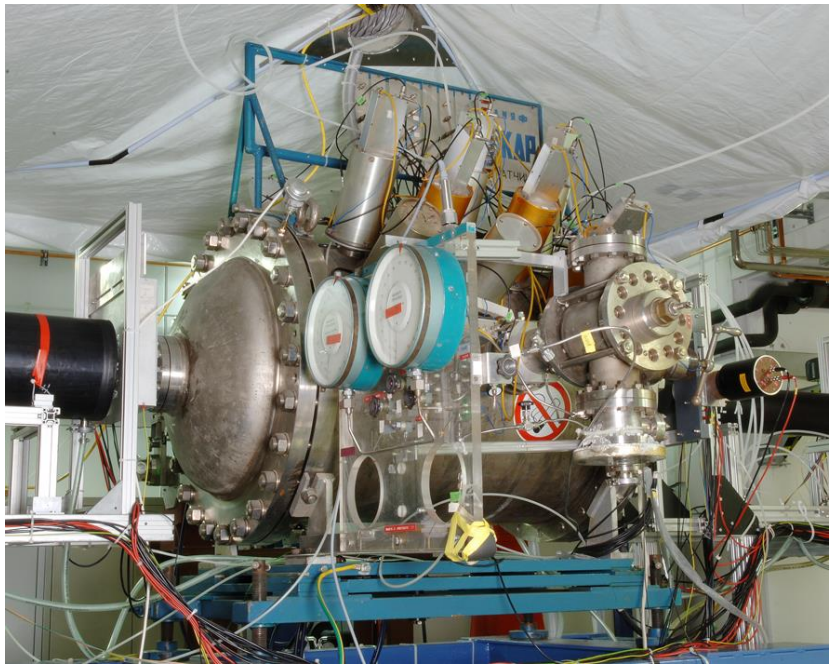


TPC status, plans

Oleg Kiselev
GSI Darmstadt

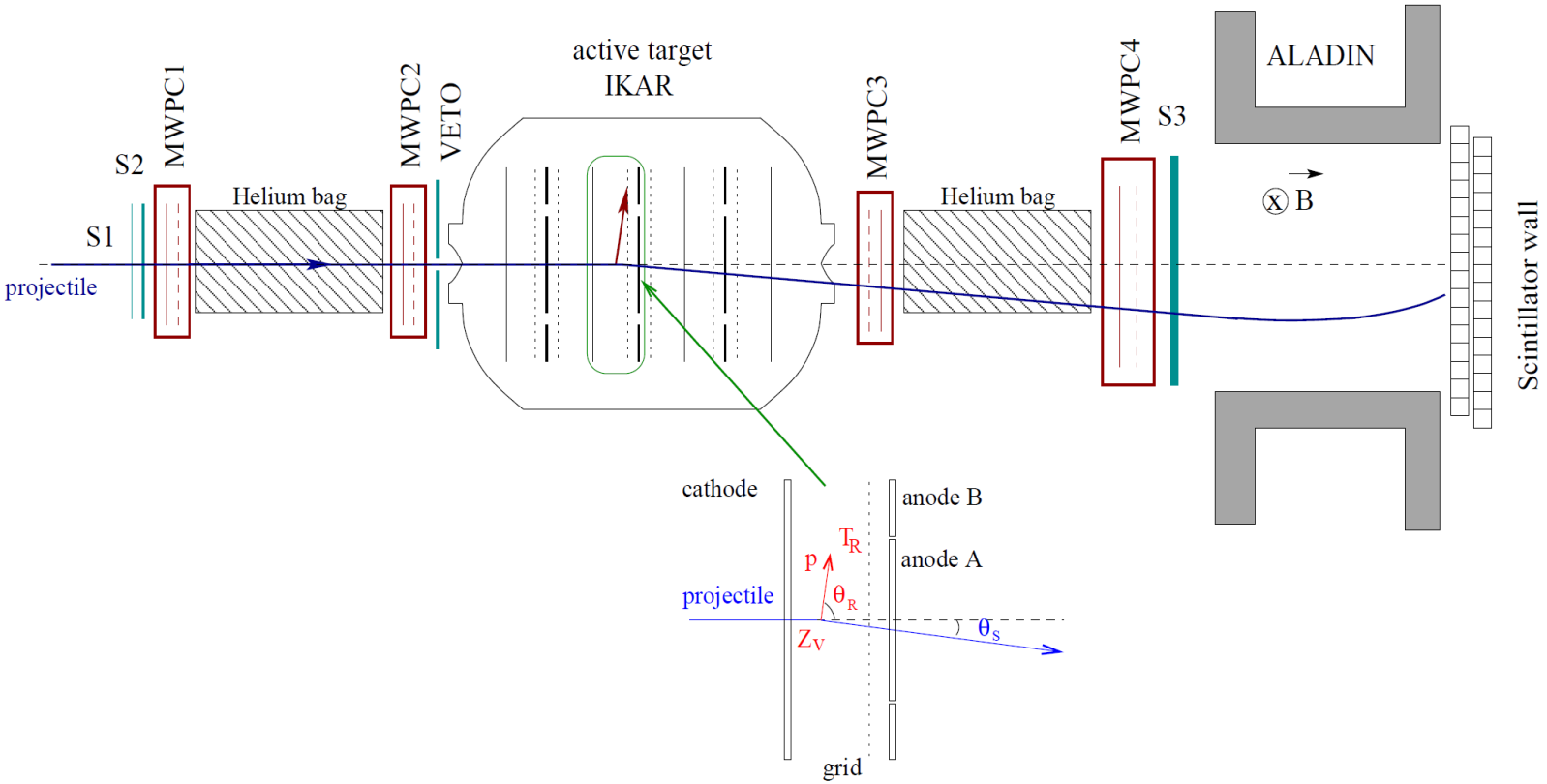
Experiments with IKAR TPC at GSI





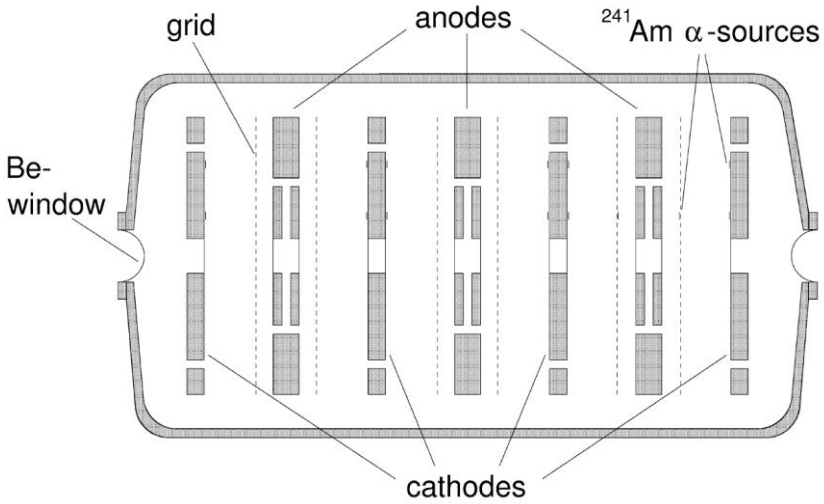
- Several experiments at GSI with exotic beams (^{6,8}He, ^{11}Li, ^{8}B, ^{12,14}Be, ^{15,16,17}C) performed
- Full setup with tracking, trigger detectors and the TPC at 3 different locations

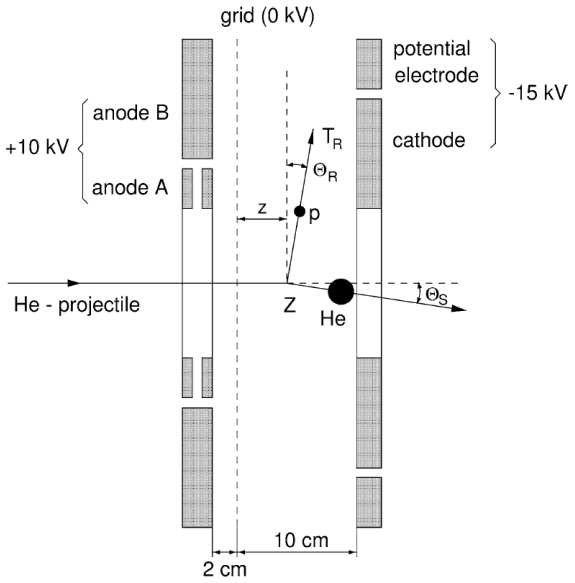
Experiments with IKAR TPC at GSI



"Classical" ionization chamber, built at PNPI
Pressure up to 10 bar
Diameter of inner anodes – 20 cm, of outer – 40 cm
Normally filled with pure H_2 but D_2, He are also possible
6 independent detection modules in the same gas volume

IKAR TPC, operational principals





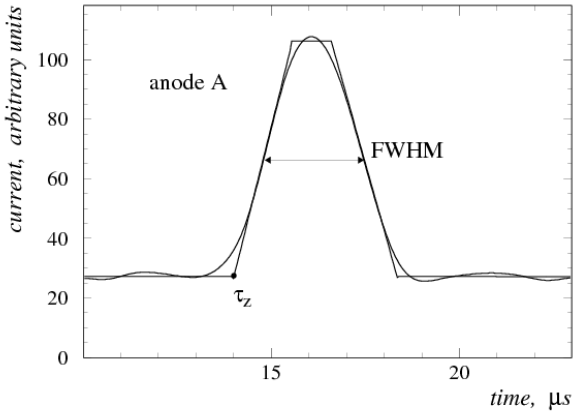
- Electrodes out of Al, 140 µm
- Be windows, 0.5 mm
- Energy and time of drift measured by FADCs
- Energy resolution – 35-40 keV
- Energy threshold <100 keV
- Dynamic range for protons – 5.2 MeV

Pulse shape analysis

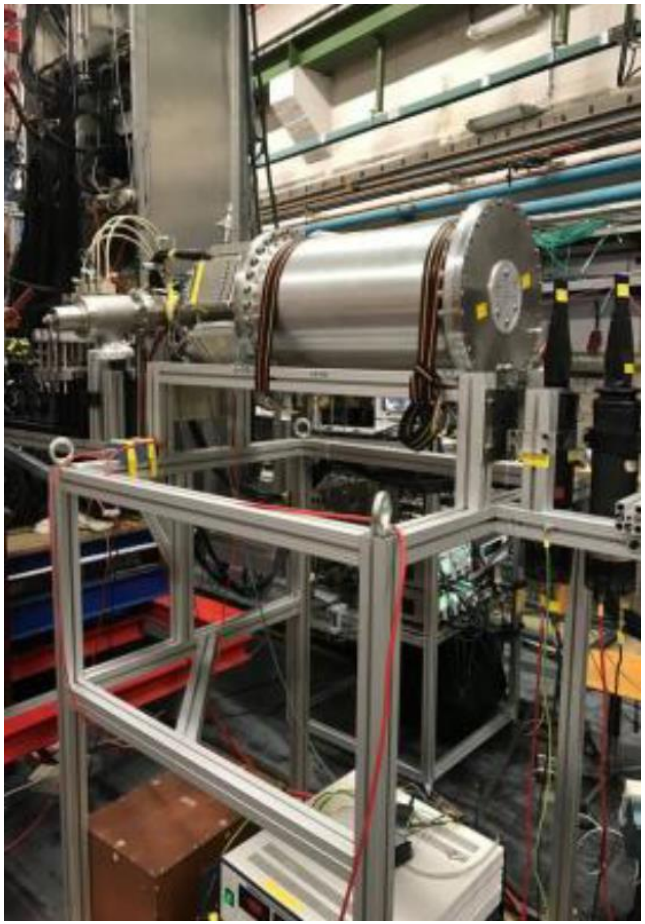
Integral - recoil energy T_R

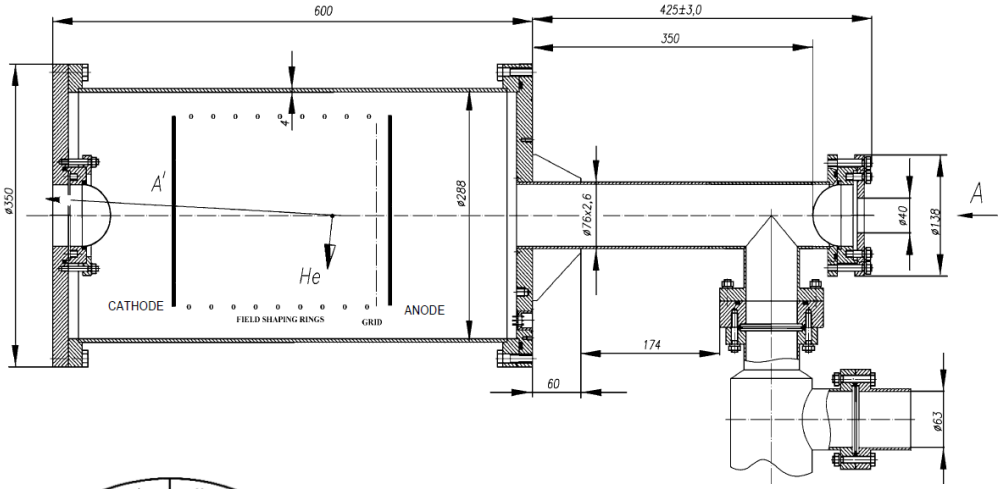
Risetime - recoil angle Θ_R ($\delta\Theta_{R\ FWHM} < 0.6°$)

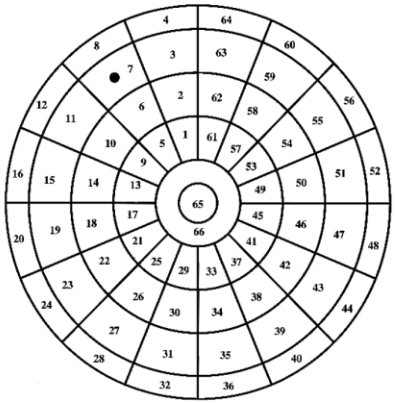
Start - vertex point Z_V ($\delta z_{FWHM} < 110\ \mu m$)



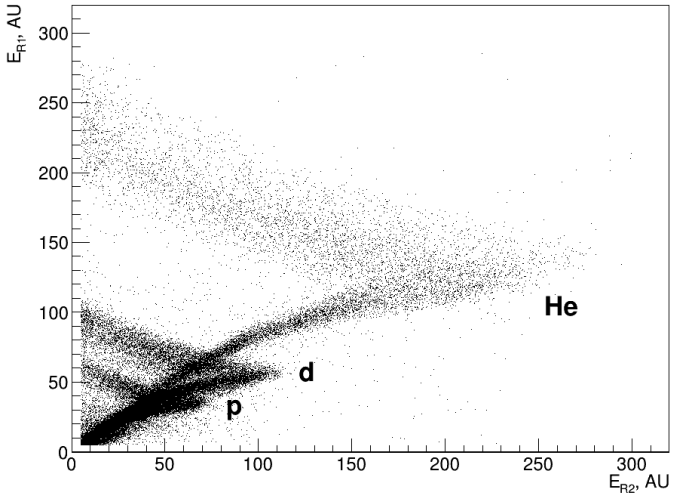
ACTAF2 prototype





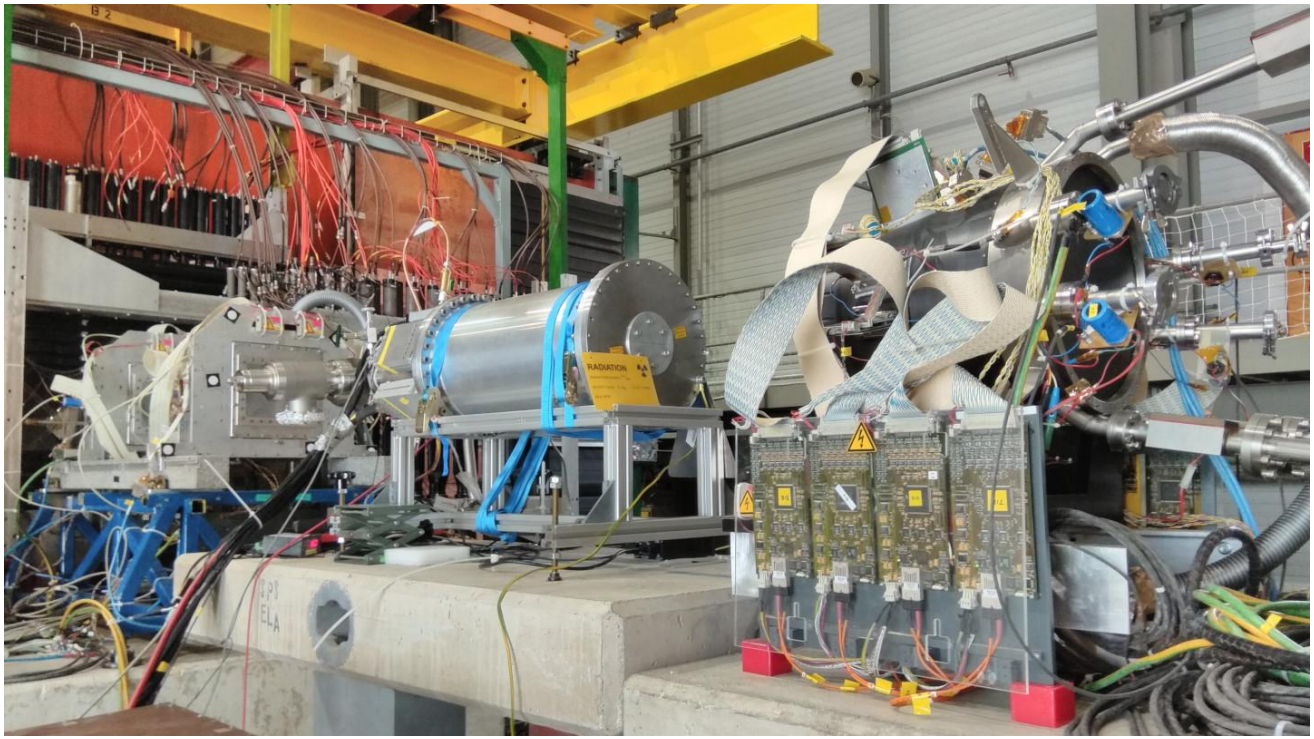


Energies on anode rings 1 and 2



- 40 liter prototype made within the Active Target project for R3B/FAIR
- Several beam tests made at GSI and Mainz

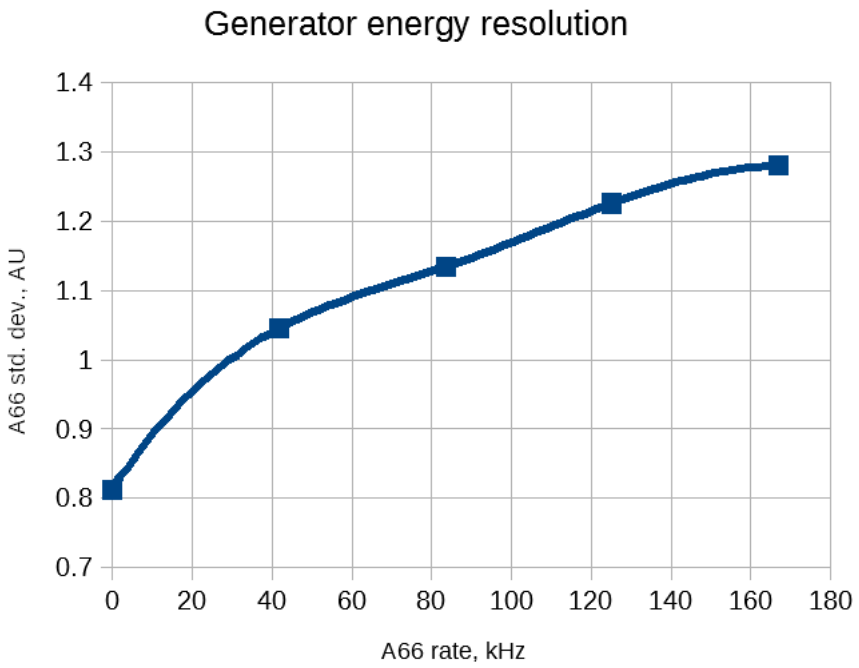
ACTAF2 prototype at COMPASS



Beam test in 2018
TPC between 4 tracking stations
Tracking via Si microstrip detectors
Muon rate – up to 2 MHz

E_μ = 190 GeV
Wide beam (RMS ≈ 20 cm)
Duty cycle: ~20% (spill — 5 s)

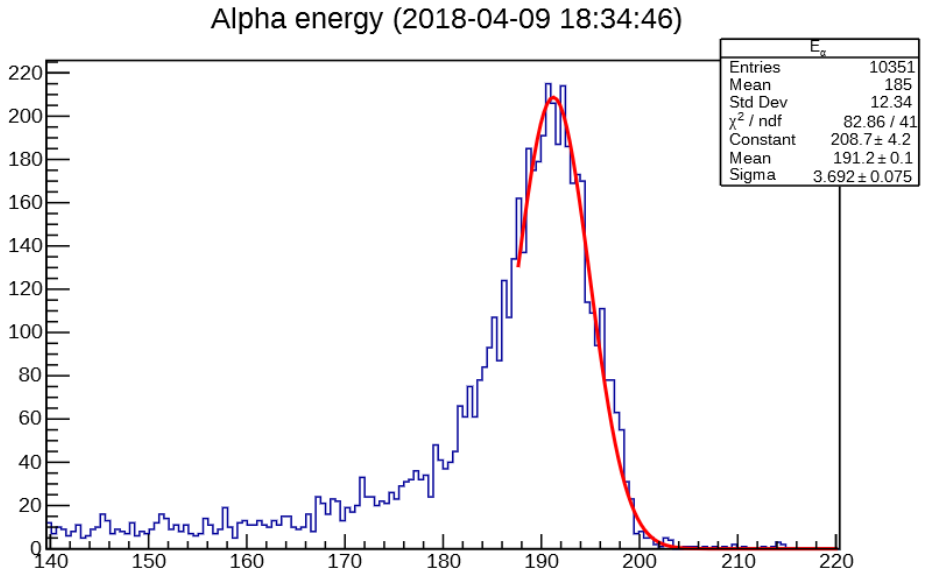
TPC energy resolution vs beam rate

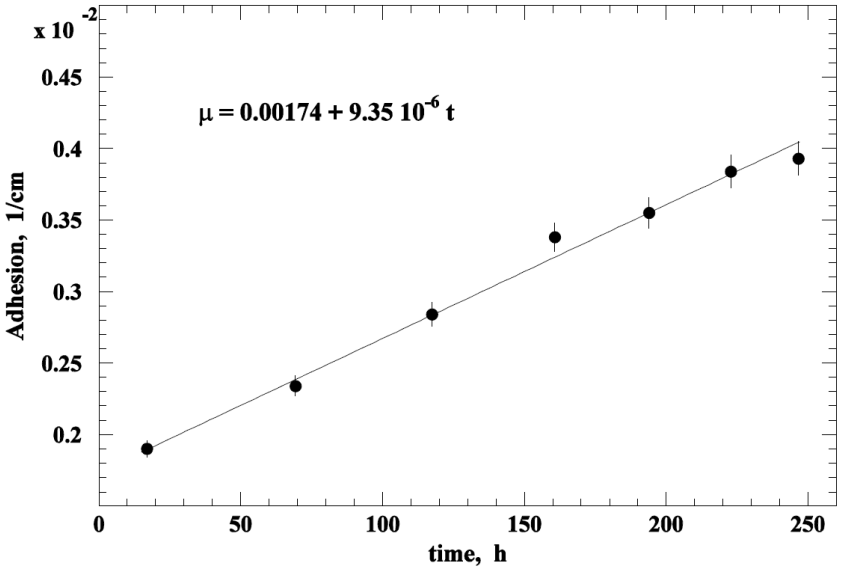


Threshold 200 keV and lower possible

- Test pulses injected to all anodes at the same time
- Measured vs beam intensity
- At 300 kHz beam rate energy resolution ~40 keV

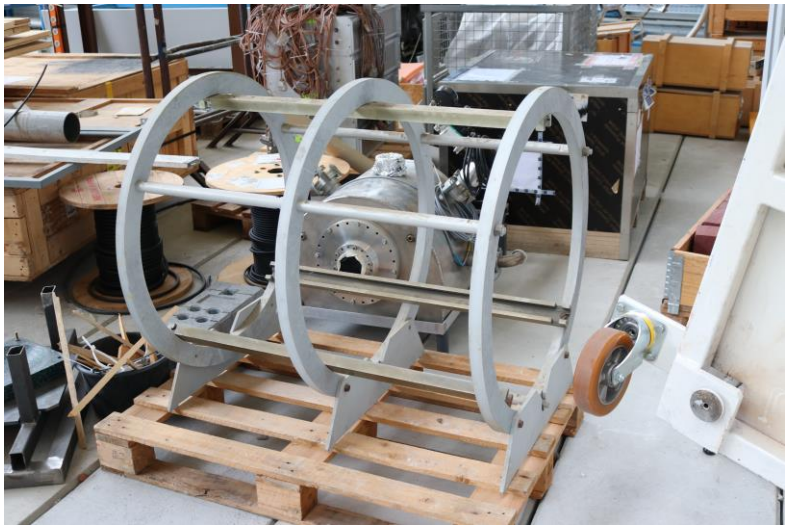
Gas quality check during each experiment





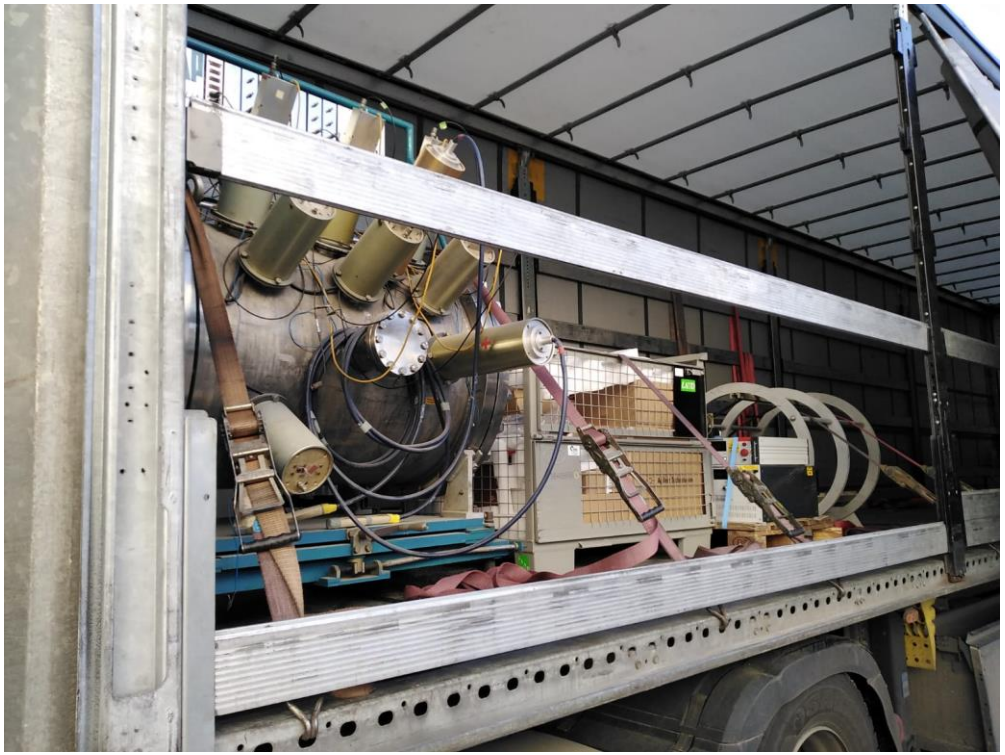
- α-spectrum measured several times per day
- Shift of the maximum ~1%/day (~1 ppm O_2) – very sensitive to the impurities
- Refilling – once per week

IKAR TPC in waiting mode



- Stored for few years after the last experiment in 2011
- Filled with Nitrogen at 1.5 bar
- Light blue (large) support eventually will be used for other devices
- Cylindrical structure - is a holder for the inner electrodes of IKAR

IKAR transport to CERN



- Full setup checked and packed
- Everything is ready to go to CERN

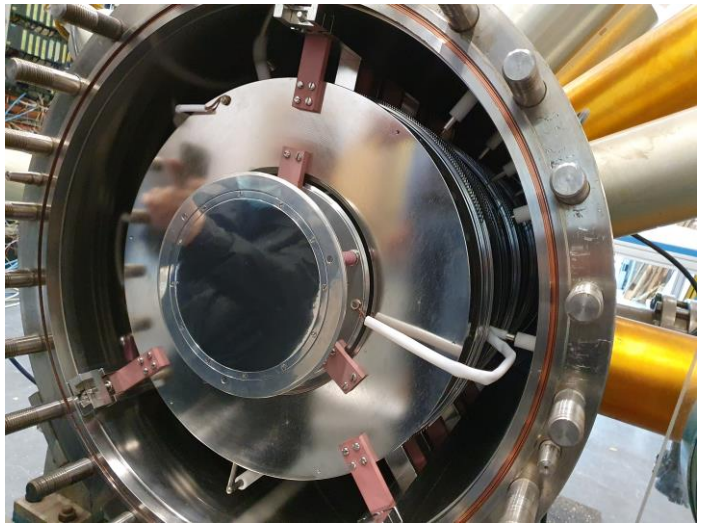
IKAR transport to CERN

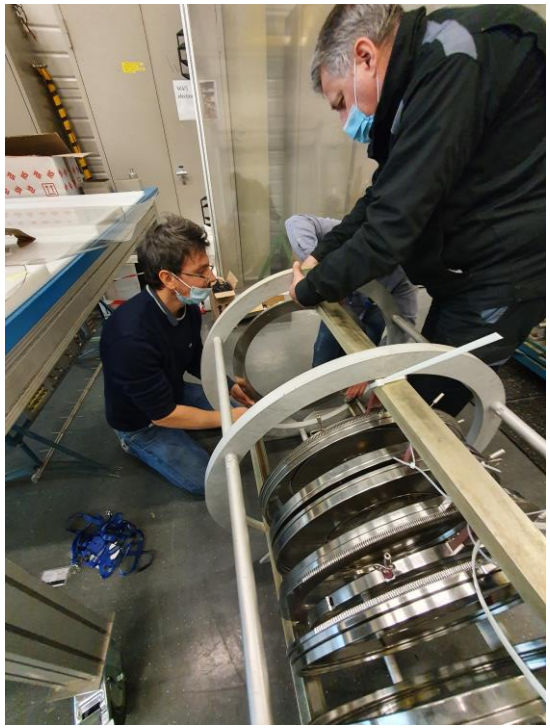
- High voltage cathode power supply, Heinzinger, 100 kV
- High voltage grid power supply, Heinzinger, 20 kV, with HV cables and a small filter.
- High voltage cathode filter with two HV cables
- Single-board microprocessor Raspberry Pi 3 Model B+ with a power supply, two UBS-RS232 adapters and two RS232 cables.
- Turbo molecular pump PMP Pfeiffer with control unit DCU Pfeiffer and module TM-700
- Forvacuum pump Agilent IDP-10
- PC DELL OPTIPLEX 755
- VME crate with VME processor, FADCs, other electronics (11 modules)
- NIM crate with electronics (8 modules)
- Flanges for IKAR TPC: 1 flange for cathode HV, two flanges for grid HV and four flanges for multi-pin connectors.
- Pressure transducer PAA33-X Keller AG with a steering device
- 7 preamplifiers (16-channel each) with corresponding cables
- LV power supply Voltcraft VLP-2403 OVP

IKAR transport to CERN

- TPC itself, HV, vacuum devices, electronics safely arrived CERN on 19.11

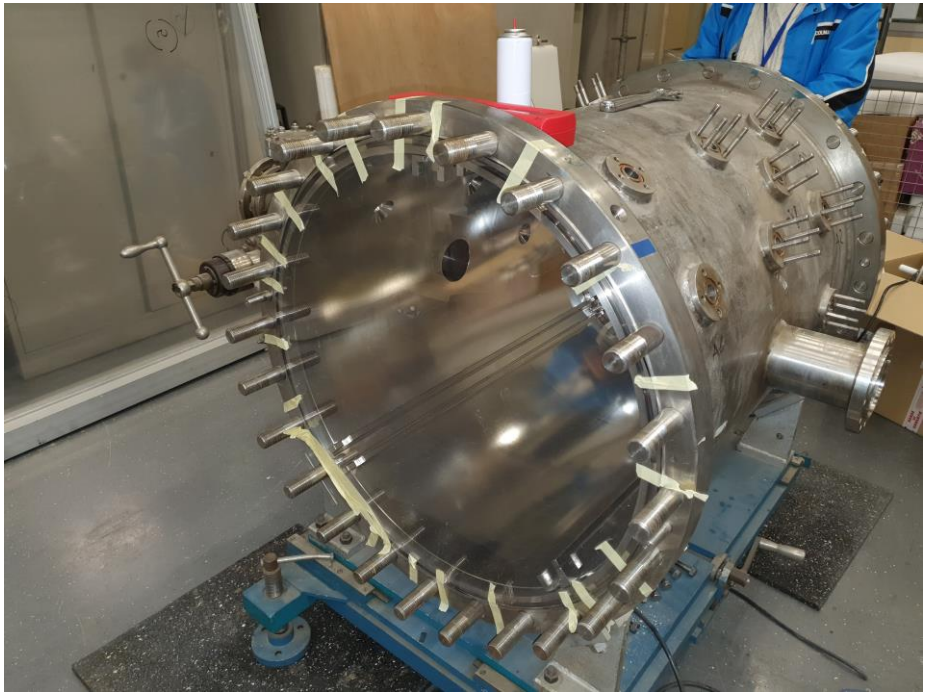
IKAR dismounting

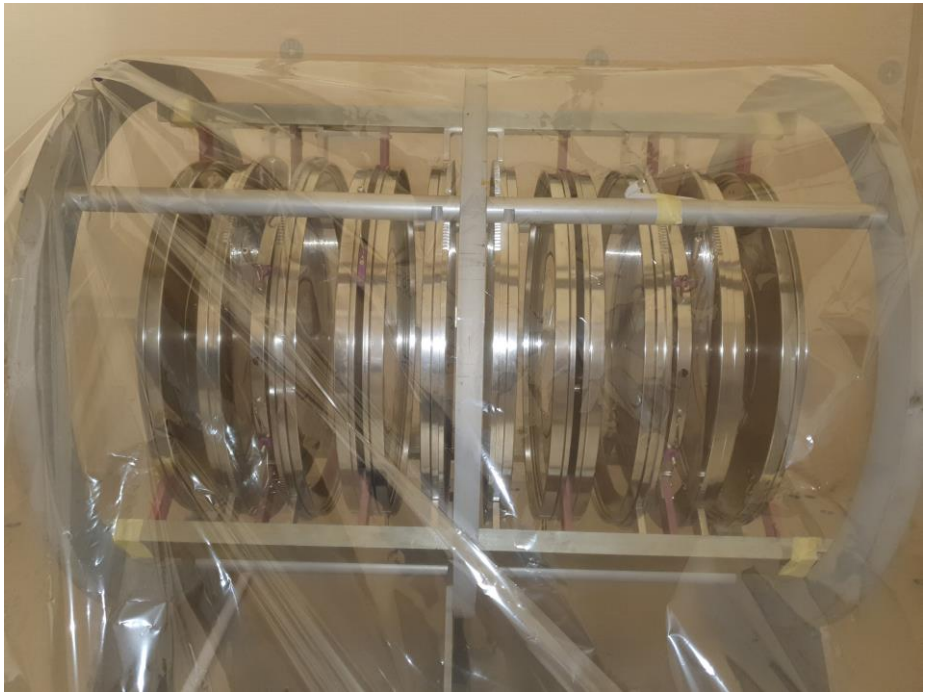




- Large endcap removed
- Inner structure took out and placed into the support frame

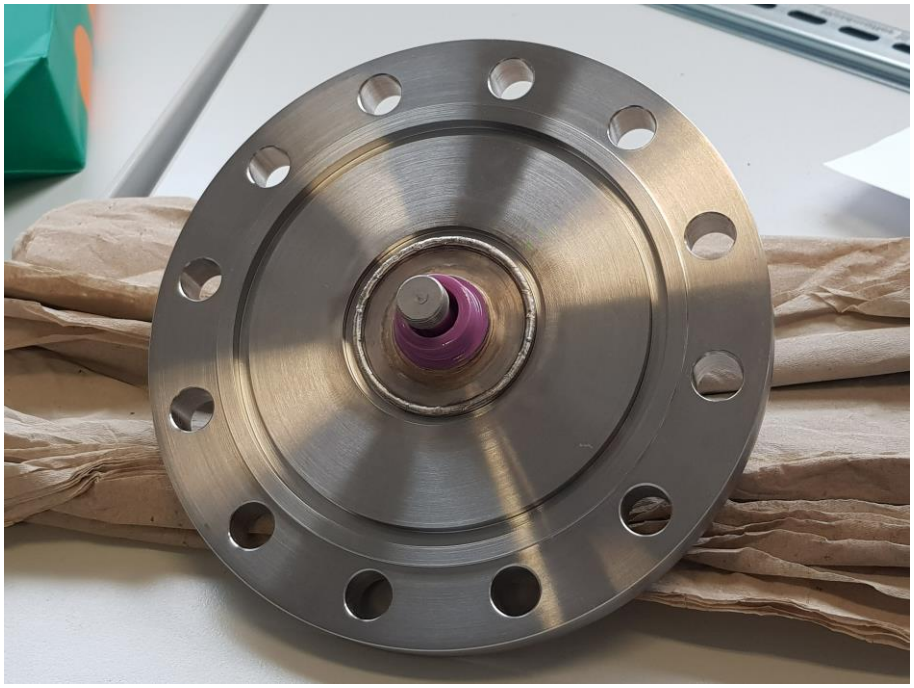
TPC dismounted





- The whole inner electrodes are removed
- All old flanges are removed
- The vessel is ready for the reassembling

HV flange

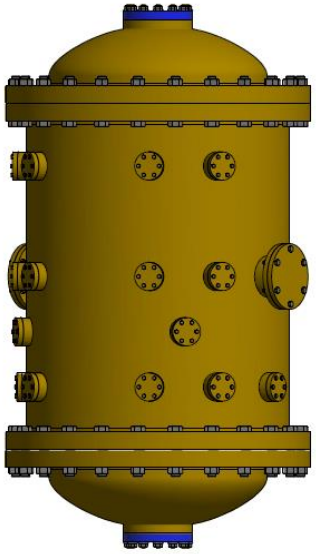


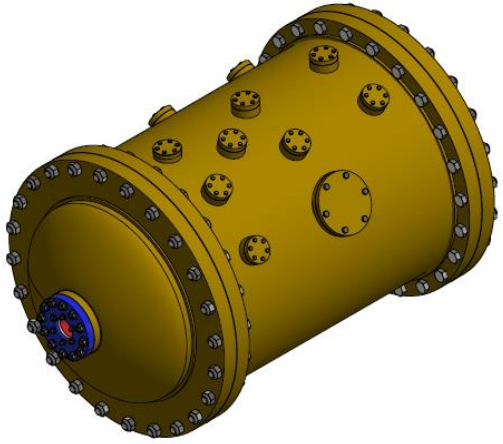
- New flanges produced at GSI
- Flange is stanless steel, feedthrough is Kovar
- He-tightness proved
- Ready for mounting

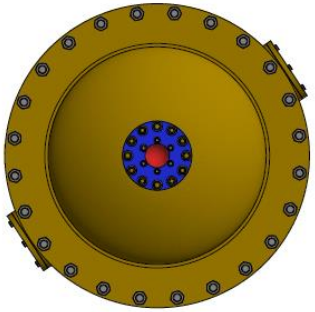
Grid flange

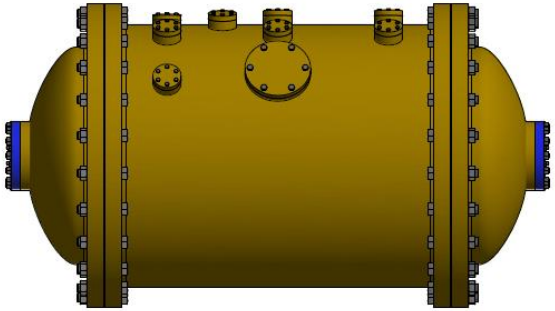
- New flanges produced at GSI
- Flange parts are from stanless steel, feedthrough is Kovar
- He-tightness proved
- Ready for mounting

IKAR, drawings









S. Levorato

DRAWN levorato	01/10/2020	
CHECKED		TITLE
QA		
MFG		
APPROVED		
		SIZE D / DWG NO IKAR_TPC / REV
		SCALE 0,15 : 1 / SHEET 1 OF 1

IKAR TPC, main parameters

Pressure vessel inner diameter	740 mm
Vessel length	1600 mm
Total volume	0.55 m^3
Maximal operating pressure	10 bar
Spherical Be windows	70 mm diameter, 0.5 mm thickness
Total weight with the small support	~ 1500 kg

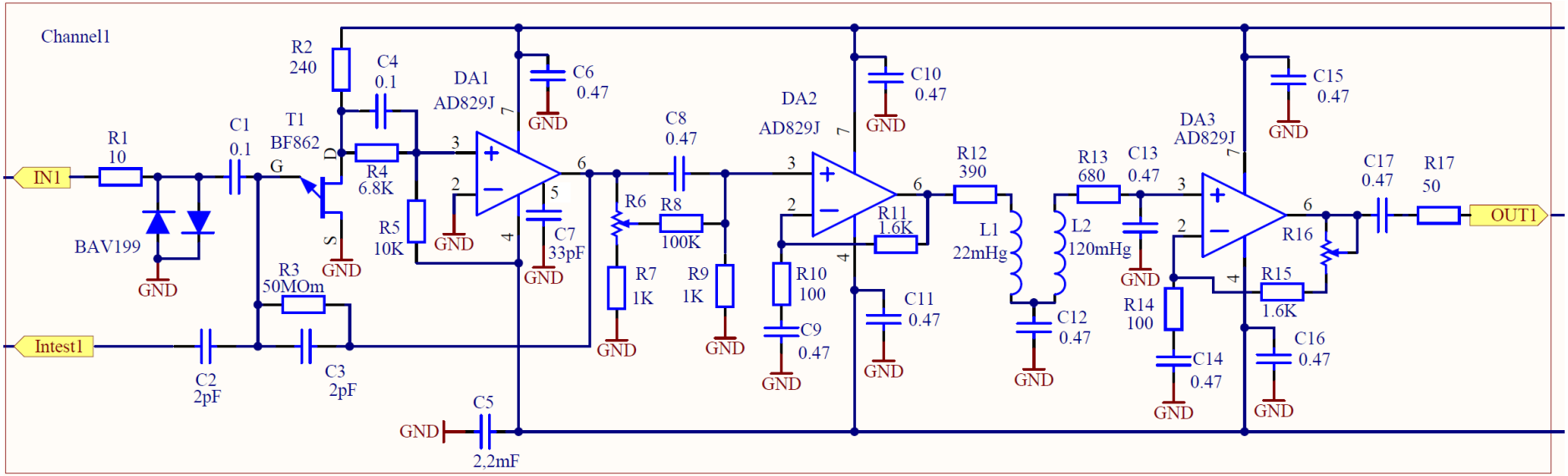
Six 100 mm drift cells
Anode plane consists of a 194 mm in diam. central pad surrounded with two rings
The outer diameter of the largest ring is 480 mm

Two drift cells 400 mm (cathode – grid distance)
Grid – anode distance 10 mm
Diameter of the cathode 570 mm
Grid max diameter 570 mm, useful diameter 490 mm
Anode diameter 490 mm
Field shaping rings (Cu wire, 2 mm), on 4 isolators Macor or Caprolon/policaproamid each, outer diameter 570 mm,
distance between the rings 40 mm

High-pressure valve

- Many companies make large valves for high pressure but they are not clean
- Many companies make large valves for high vacuum, very clean but they can not hold high pressure
- Custom made valve is under production
- Several months production time and very expensive
- Pressure up to 30 bar (usable for main TPC too)
- Vacuum down to 10^{-6} mbar
- Adapters to the TPC flange and to the turbovacuum pump need to be designed

IKAR preamplifier - shaper



- Low noise preamplifier
- Best (up to now) available operational amplifier (AD891) for this setup
- Signal shaping for better signal/noise
- 16-ch boards

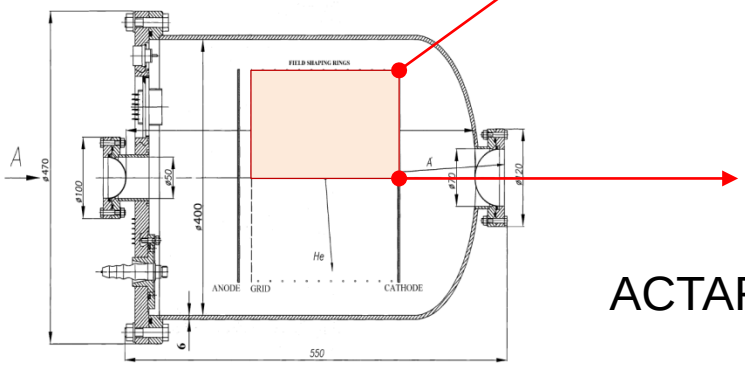
PNPI, Gatchina

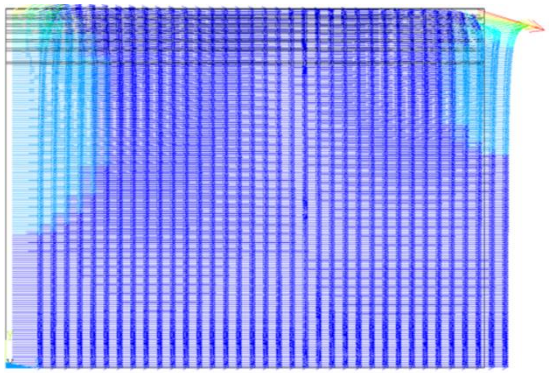
No gas amplification -> very small signals

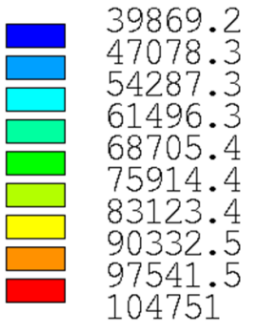
FADC

- Struck SIS3316 VME FADC
- 14 bit @250 MHz (we use at 25 MHz)
- 16 channels
- Range: -2,5 – +2,5 V
- Modes: triggering or self-triggering
- Clock PLL lock
- Reading of raw ADC values or 2/4/8 points averaging
- Energy threshold via Moving Average Window (MAW)
- Readout via VME bus or optics
- Raw data readout or signal processing with imbedded FPGA
- ***Modification of the firmware for PRM planned within Q1-Q2 2021***

ANSYS FEM calculations of the E field







E_z (V/m)

ACTAF2 detector

ANSYS 18.0 licences:
Mechanical
Mechanical CFD
Mechanical Emag with Maxwell 3D
ANSYS office in Darmstadt -> support

- Field shaping rings optimisation
- Distance between the rings, number of the rings
- Optimum potentials on each ring
- Caclulated field maps can be used for the MC simulations

Timeline

- Production of the electrodes – mid February / PNPI
- Flanges check – end of February
- Start of reassembling – mid March
- High-pressure valve ready – end of March / GSI
- Pressure test of the assembled TPC – mid April
- Heating and pumping - May
- Tests of the TPC setup (chamber, HV system, vacuum system, slow control, electronics, DAQ) – August
- Full TPC setup ready – August/September

Proton range in hydrogen