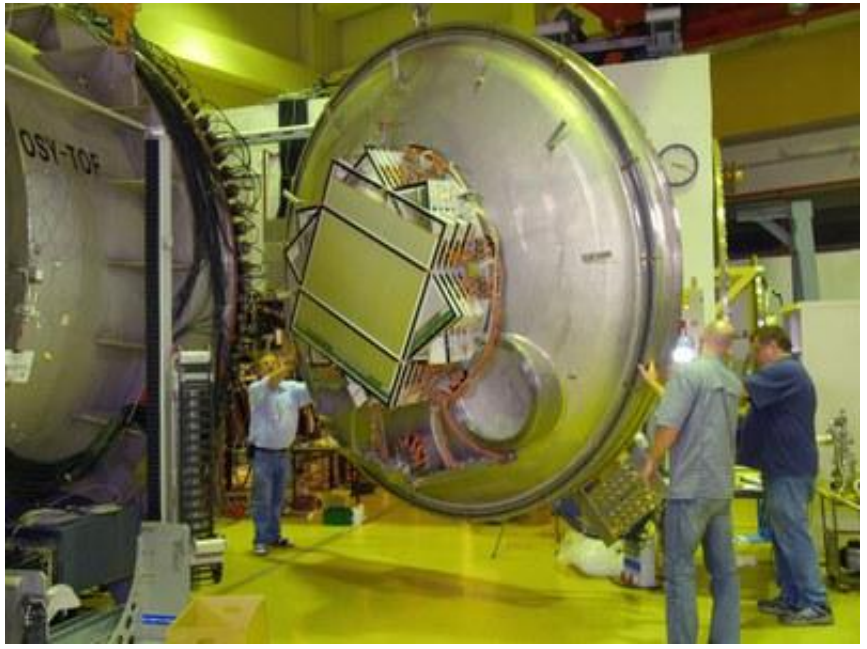
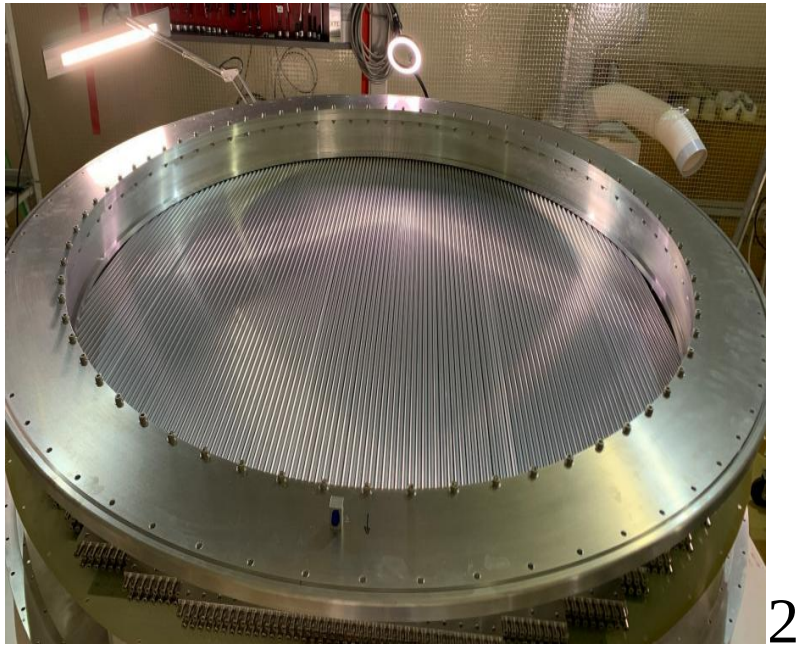
# Ultrasonic welding technology for future Straw Trackers

**Temur Enik for the StrawTrackerRD team**

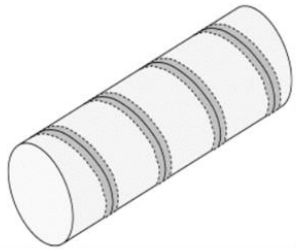
# Why is Straw Tracker?

- thin walls - small material budget from 12 um
- it is possible to work in a vacuum
- large area – up to 5 m
- reasonable production cost
- good spatial resolution (100-200 um)
- possibility to use time-over-threshold or ionization charge measurements for noise reduction or particle identification at low momenta
- can work with over pressure over large areas

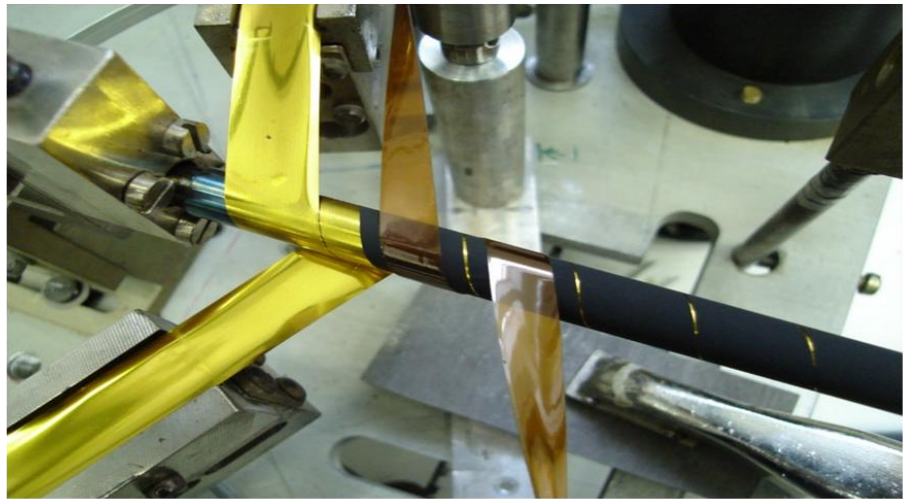




## STRAW winding

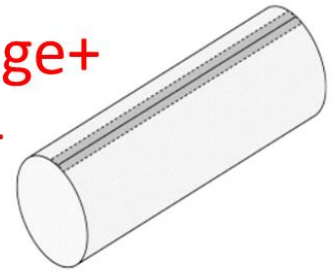


- radiation resistance+
- shape retention+
- diffusion of gases-
- elastic deformation range-
- sensitivity to humidity-

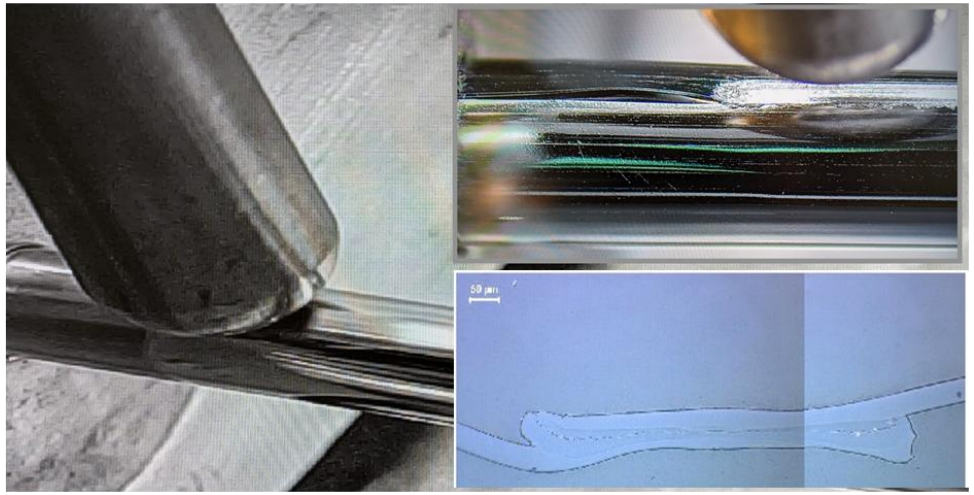


ATLAS, LHCb, COMPASS, COZY-TOF, NA64, Mu2e, PANDA, CBM...

## STRAW welding



- elastic deformation range+
- sensitivity to humidity+
- diffusion of gases+
- retains shape under-pressure-
- radiation resistance-



NA62, COMET, SHiP, DUNE, SPD...

# The straw trackers in the different experiments

## Straw winding

- ATLAS
- LHCb
- COMPASS
- COZY-TOF
- NA64
- Mu2e
- PANDA
- CBM
- SVD-2
- Glue-X
- Muon g-2
- …

## Straw welding

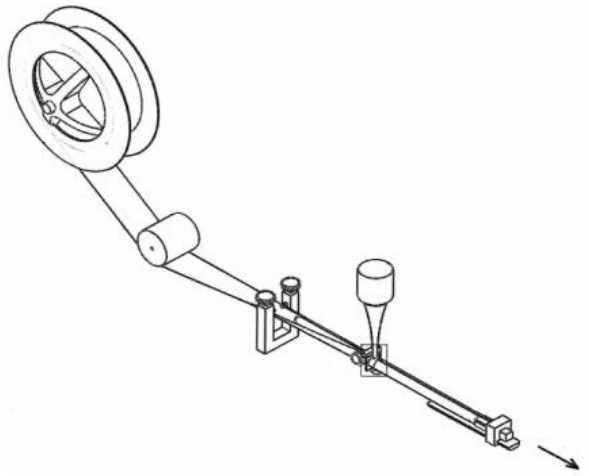
- NA62
- SPD
- KEDR
- COMET
- SHiP
- DUNE
- OKA
- VES
- SPASCHARM
- …

UltraSonic Welding

welding along the tube

spiral winding + welding

sliding Mylar film,
ultrasinic head at fixed position



technology development : JINR

fixed Mylar film,
ultrasinic head is sliding

development :

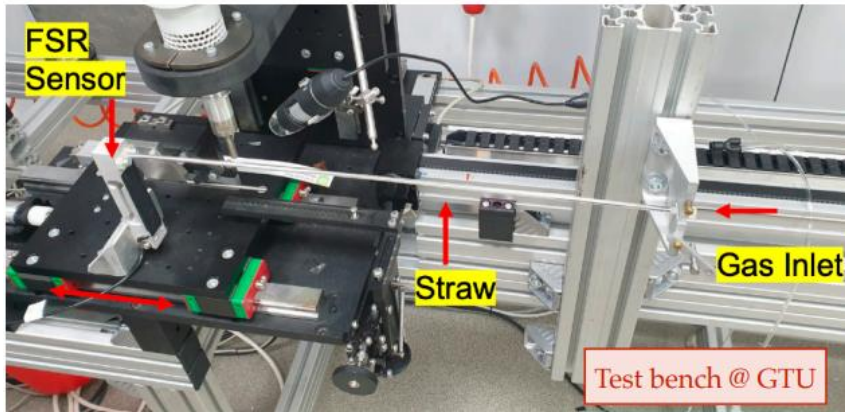
- JINR - thin wall straws
- IHEP Protvino (125 um)
  more details: presentation by Rinat Fakhrutdinov at TIPP2026

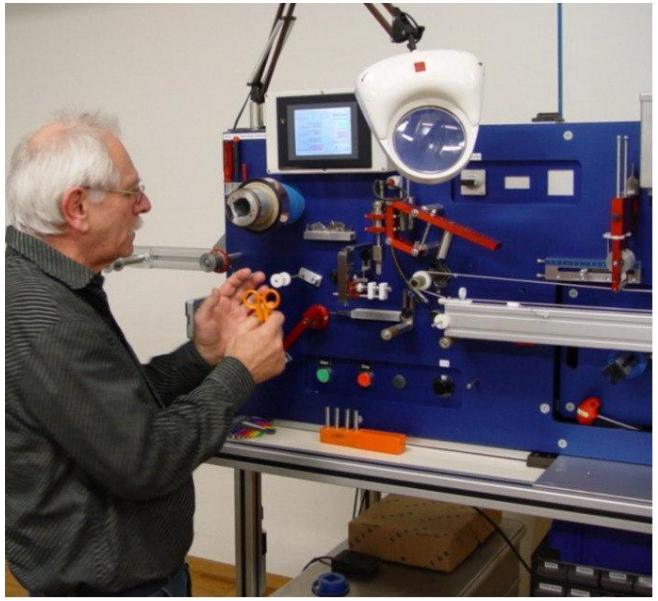
development :

- commercial
  by Jeffery L Lacy (US)


- BINP Novosibirsk
  more details: the link

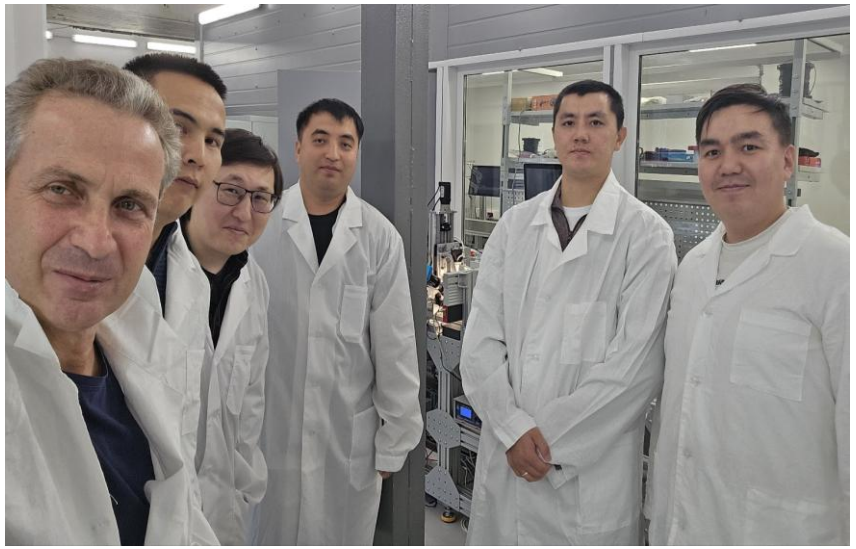
# Straw welding-production lines



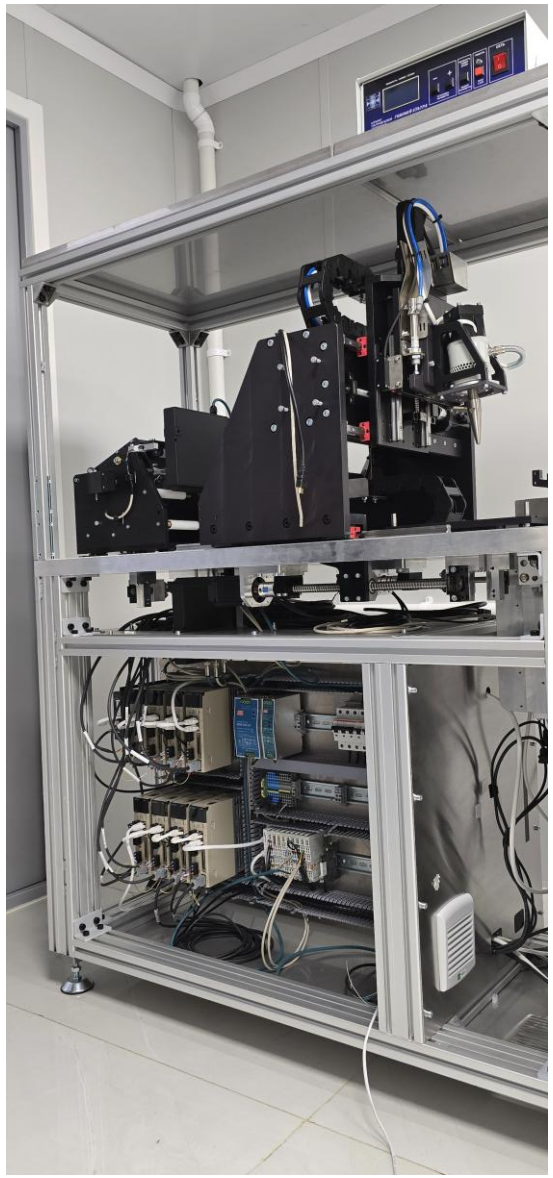
- JINR (Dubna) – operational for mass production
- GTU (Tbilisi) - operational
- SEFAR (Swiss industrial company) - operational
- PNPI (Gatchina) - developing
- INP (Almaty) - developing mass production lines
- IHEP (Protvino) - operational for mass production
- PTI (Houston industrial company)-operational
- BINP (Novosibirsk)-on hold

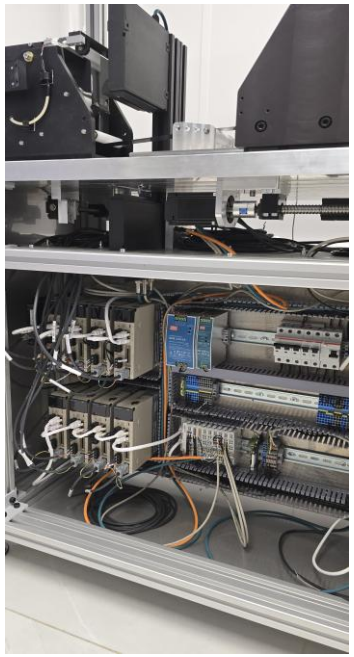
# Straw production line and assembling place at INP(Almaty)

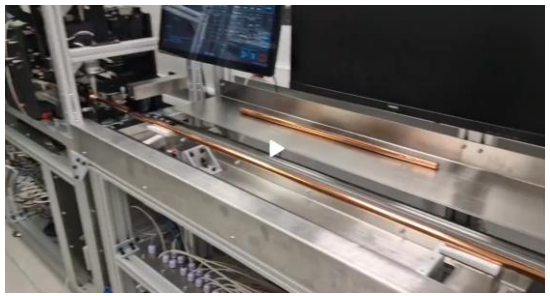



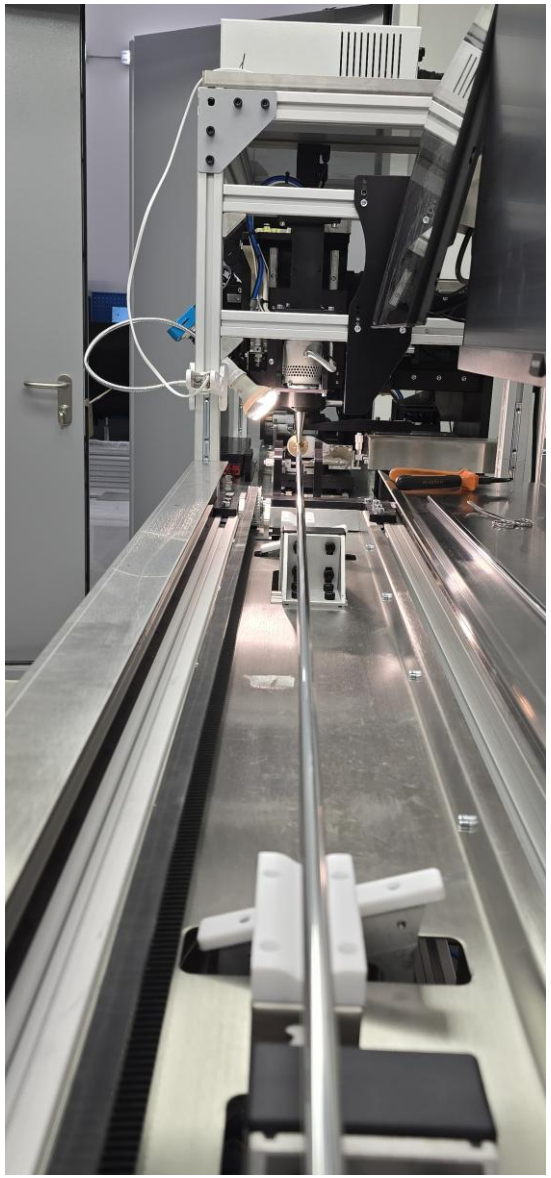
- The line was manufactured and successfully tested at JINR
- INP(Almaty) engineers and physicists took an active part in the developt and testing
- At the moment, the line is disassembled and ready for shipment to Almaty.
- Commissioning work is planned to be carried out in February
- Production is scheduled to start at the end of April

# New Straw production line and assembling place JINR





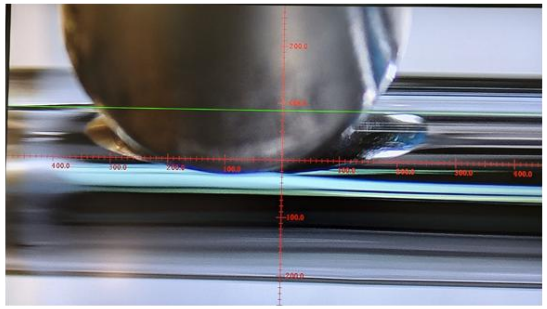





- Area ~200 sq.m., clean room~100 sq.m, machine shop and assembling hall~50 sq.m and 8,5 m high
- Production line length~12m
- Fine-tuning work began successfully and the first 12 meter straw was welded
- The possibility of integrating AI into the production and quality control process is provided

# Advancing the USW technology : production quality control

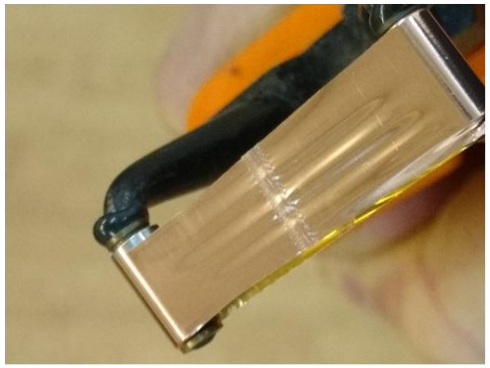
## During production:



visual control of seam quality

visual control of the position of the ultrasonic head

## Post-production:



express stress test at the beginning and at the end of the seam

overpressure tests guarantee good long-term operation stability

## Overpressure tests:

Short-term test: several minutes - NA62: 3 atm, DUNE: 5 atm

Long-term test: ~month - NA62: 1 atm, DUNE: 3 atm

Continuous measurement of outer straw diameter during production


Fig. 5 Sensor unit SU

Fig. 6 Controller CU

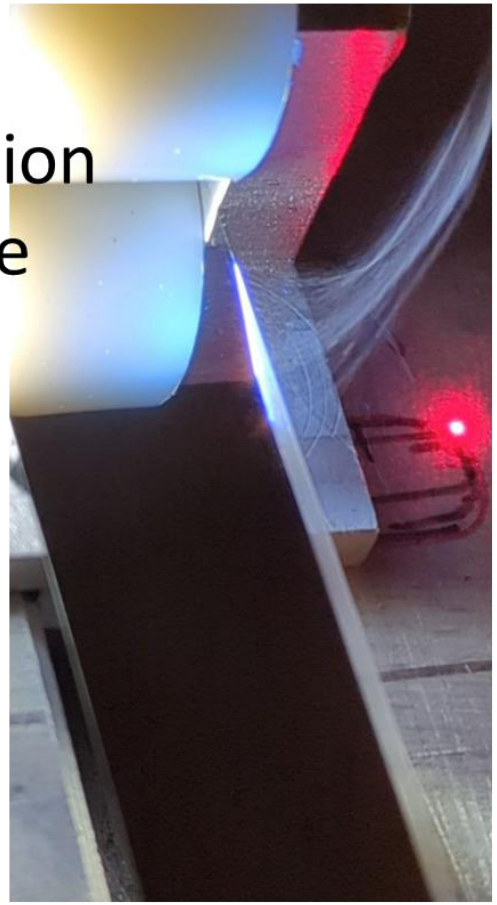
A measurement system consists of:
- laser
- receiver
- controller

Measurement of the inner straw diameter (both straw ends) with tools;

# Advancing the USW technology : production from double-side Al-metalized film

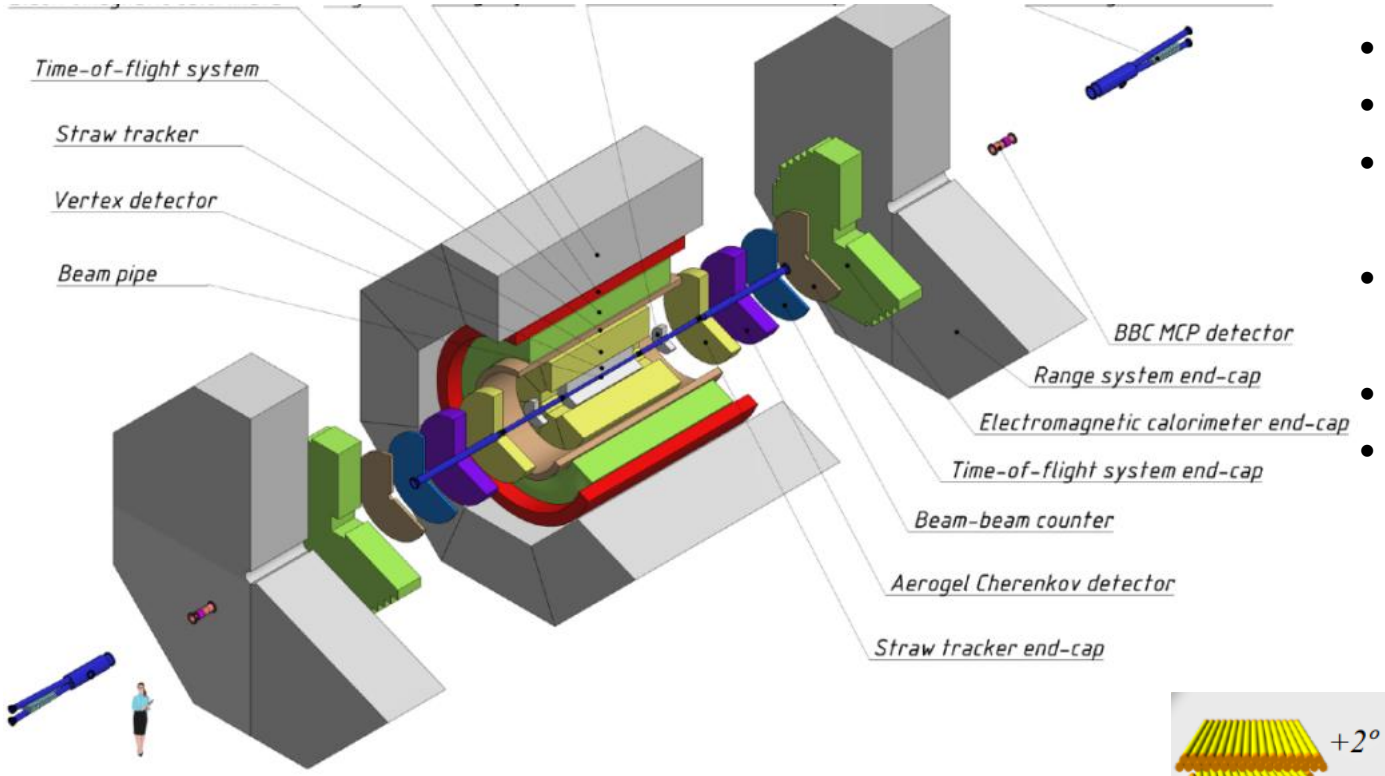
the process of destruction of the ultrasonic head under the influence of aluminum oxide

the process of removing metallization from the edge of the tape using a laser during welding

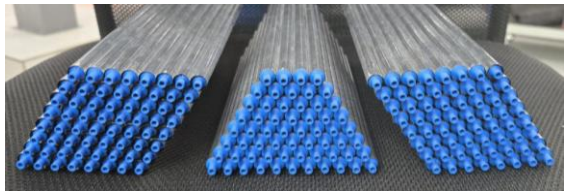


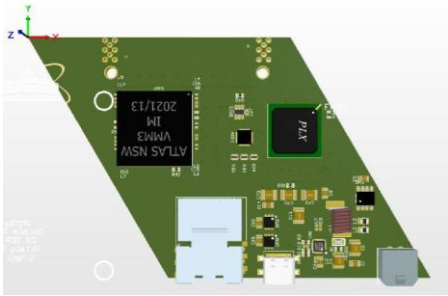
Removing the metallization made it possible to achieve the required quality

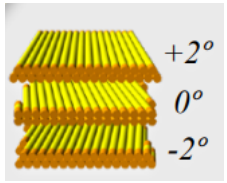
# SPD Straw Tracker



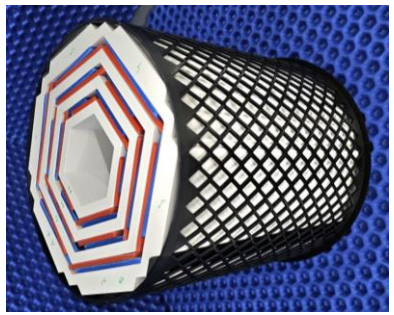

- Main tracker system of SPD ~2m long, D~1.6 m
- Straw diameter 10 mm, thickness 36 um PET
- Spatial resolution of 150 um
- Barrel is made of 6 modules with up to 30 double-layers, with the ZUV orientation (0,+/-2º)
- Endcaps are made of 12 double-layers with the XYUV orientation
- Rate O(100 kHz)
- ~20000 straws

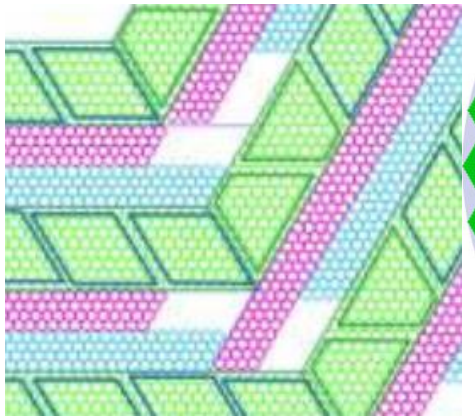


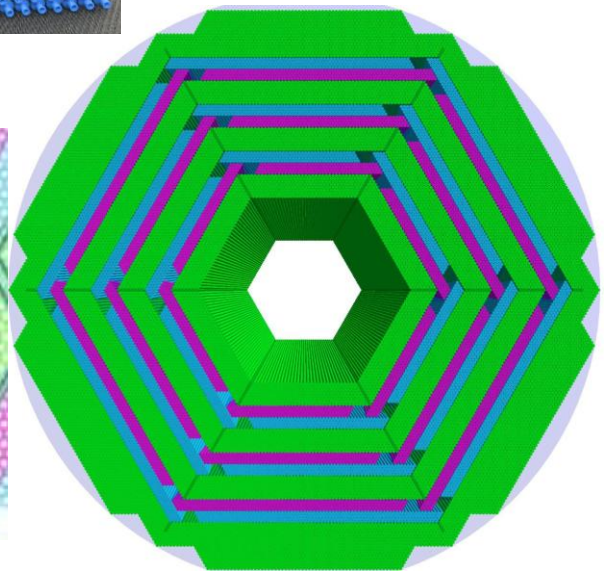





The main idea is to divide the entire detector into modules of 64 channels(rhomb and trapezoid), which allows replacing blocks of 64 channels if needed. Then all the modules are assembled into a closed cylindrical volume and, under overpressure, are tightly fixed in place.

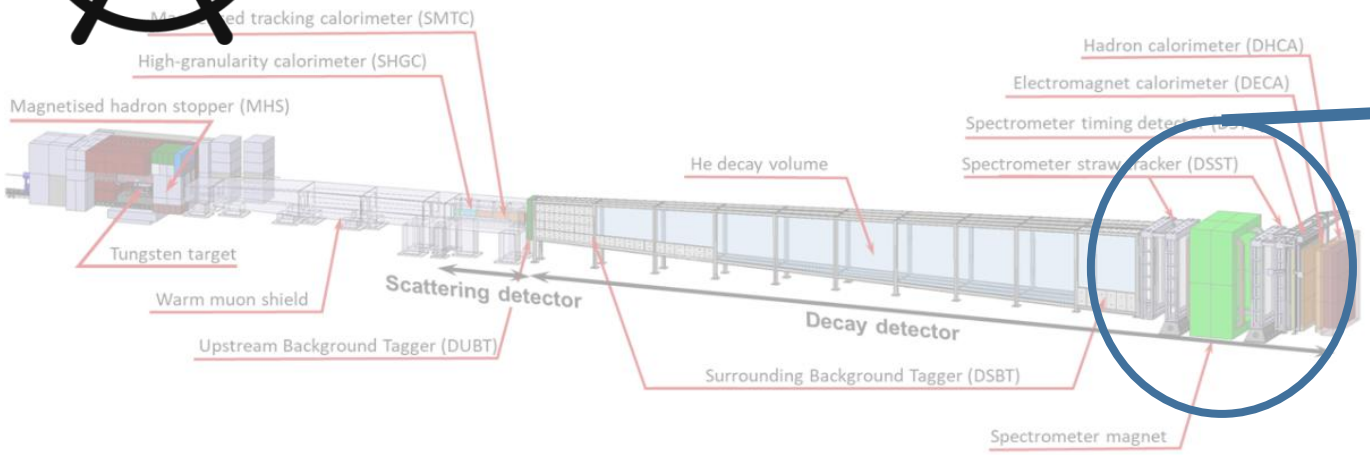


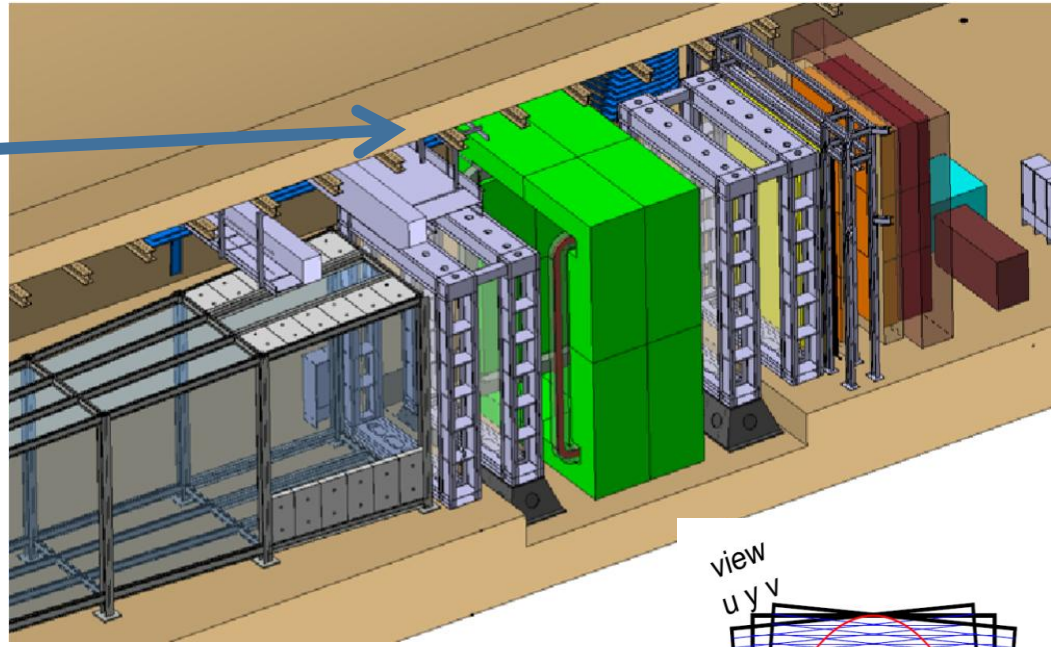




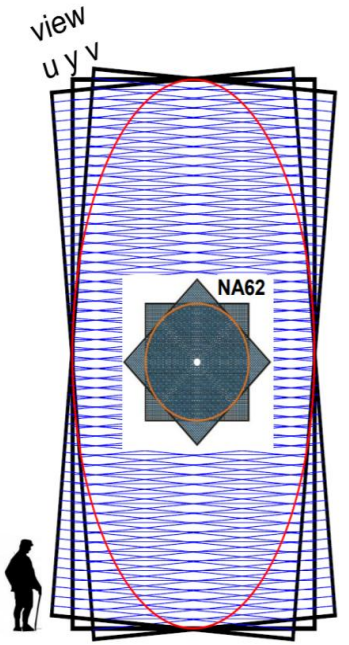
# SHiP

## Search for Hidden Particles at the High-Intensity ECN3 Facility

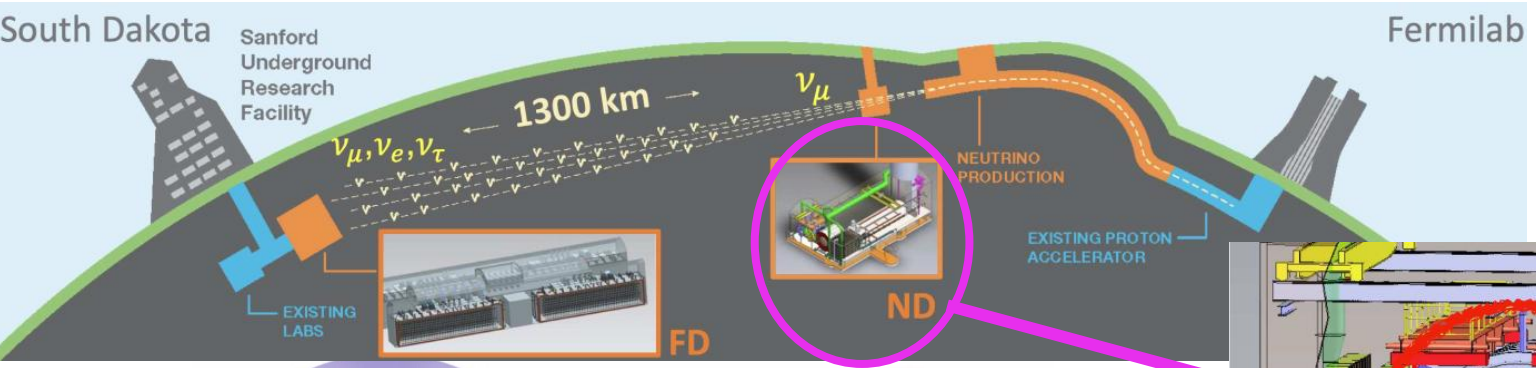


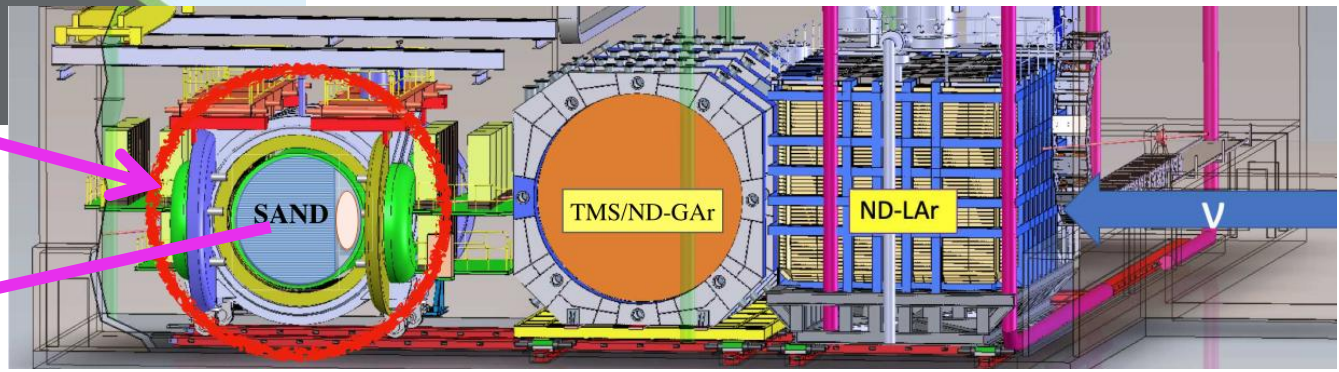



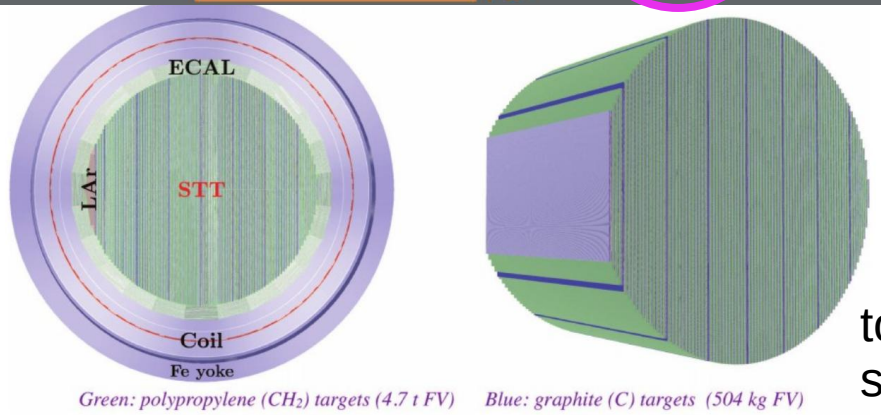
- Sensitive Area 4x6 m2
- Wall thinkness- 36 um
- Ultra light straw detectors ~20000 straws 4 XYUV station
- Straw tube with 20 mm diameter, anode 30 um diameter
- Length straw 4m
- Spatial resolution 160 um



DEEP UNDERGROUND NEUTRINO EXPERIMENT




*Green: polypropylene ($CH_2$) targets (4.7 t FV)* *Blue: graphite (C) targets (504 kg FV)*

total number of straws: ~200000
straw diameter: 5 mm, wall thickness 20 um
metallization: 70 nm double side Al
wire diameter: 20 um
operation pressure: 2 bar

# Thank you for your attention