

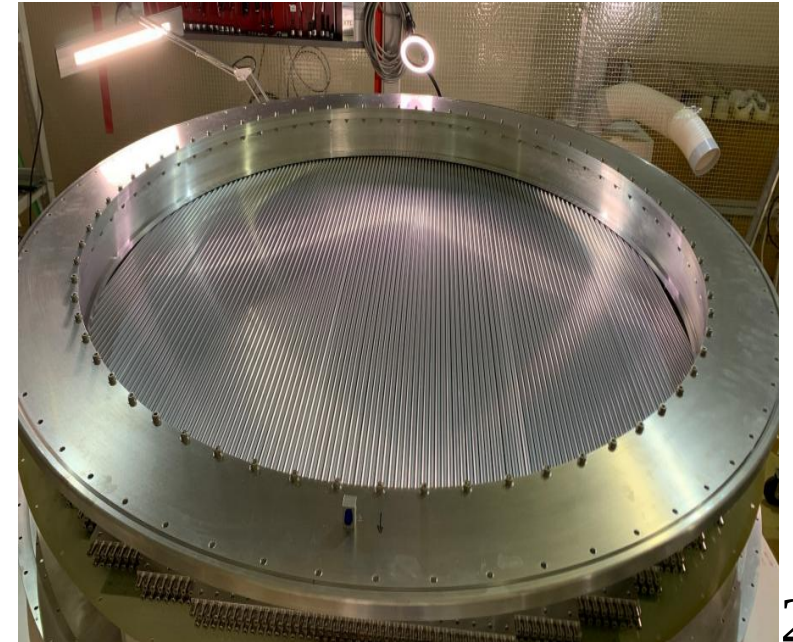
Ultrasonic welding technology for future Straw Trackers



Temur Enik for the StrawTrackerRD team

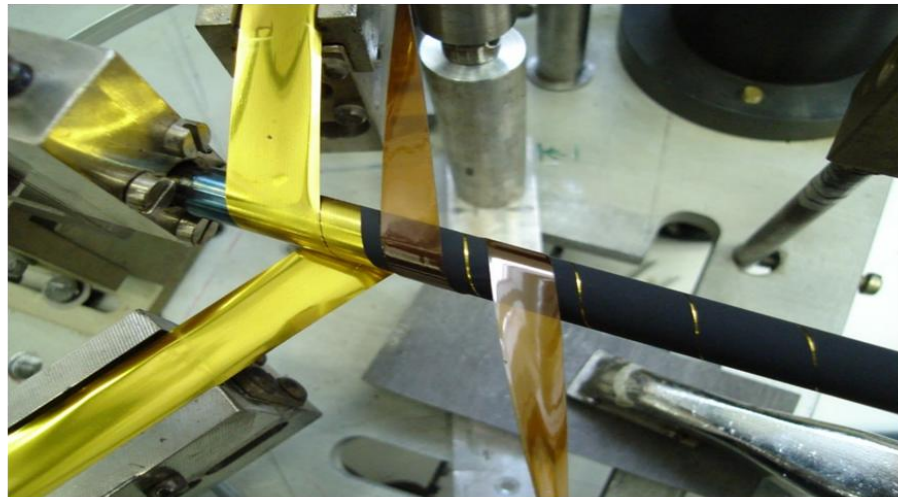
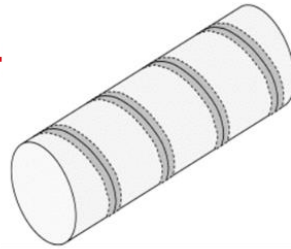
Why is Straw Tracker?

- thin walls - small material budget from 12 μm
- it is possible to work in a vacuum
- large area – up to 5 m
- reasonable production cost
- good spatial resolution (100-200 μm)
- 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

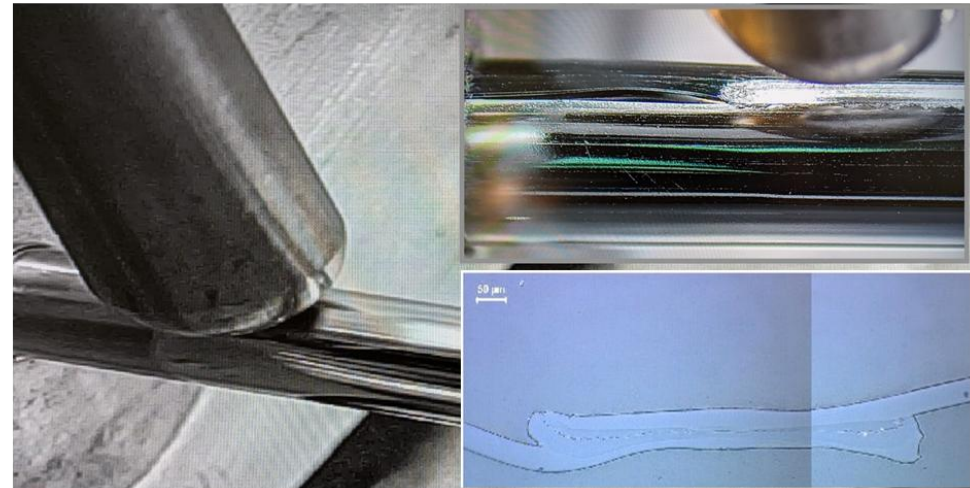
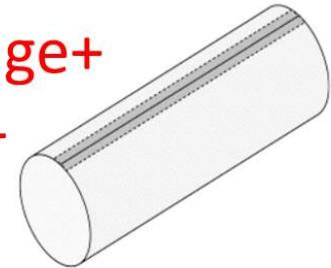
- radiation resistance+
- shape retention+
- diffusion of gases-
- elastic deformation range-
- sensitivity to humidity-



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-

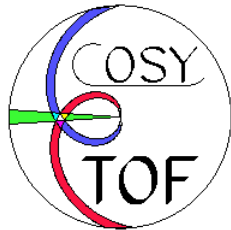
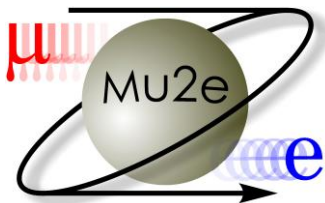
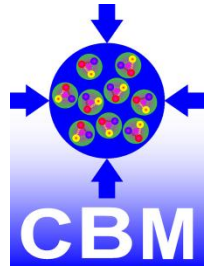
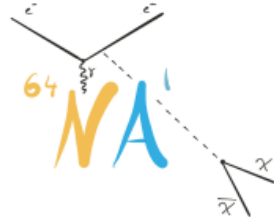


NA62, COMET, SHiP, DUNE, SPD...

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

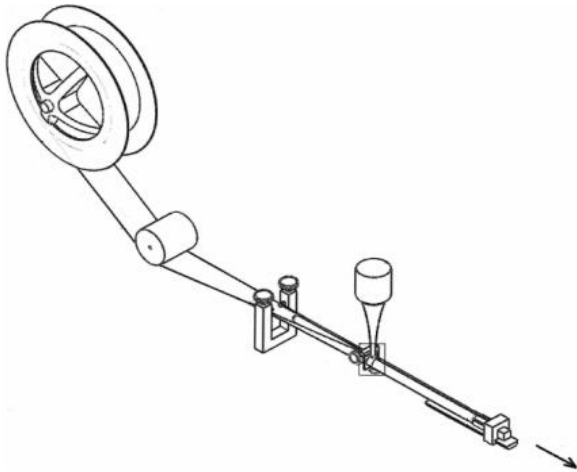
- NA62
- SPD
- KEDR
- COMET
- SHiP
- DUNE
- OKA
- VES
- SPASCHARM
- ...



UltraSonic Welding

welding along the tube

sliding Mylar film,
ultrasonic head at fixed position



technology development : JINR

fixed Mylar film,
ultrasonic head is sliding

development :

- JINR - thin wall straws
- IHEP Protvino (125 μm)
more details: [presentation](#) by
Rinat Fakhrutdinov at TIPP2026

spiral winding + welding

development :

- commercial
by Jeffery L Lacy (US)

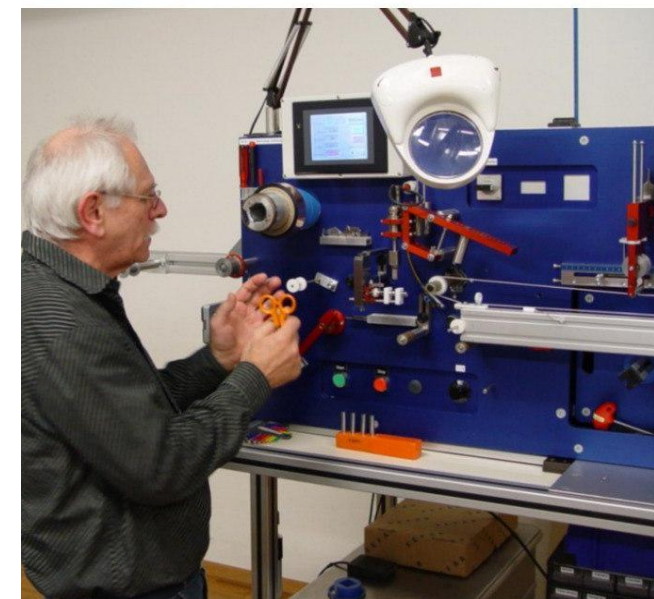
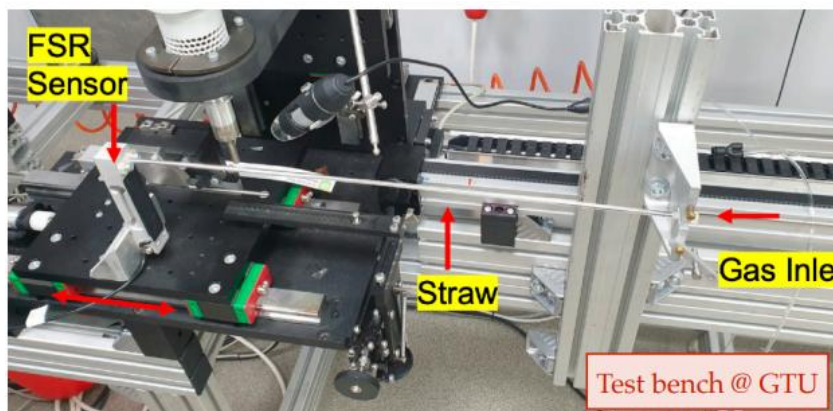
Method of manufacturing boron coated straws for neutron detection through
spiral winding and welding

Inventors: Jeffrey L Lacy
Publication date: 2021/4/13
Patent office: US
Patent number: 10974300
Application number: 15603233

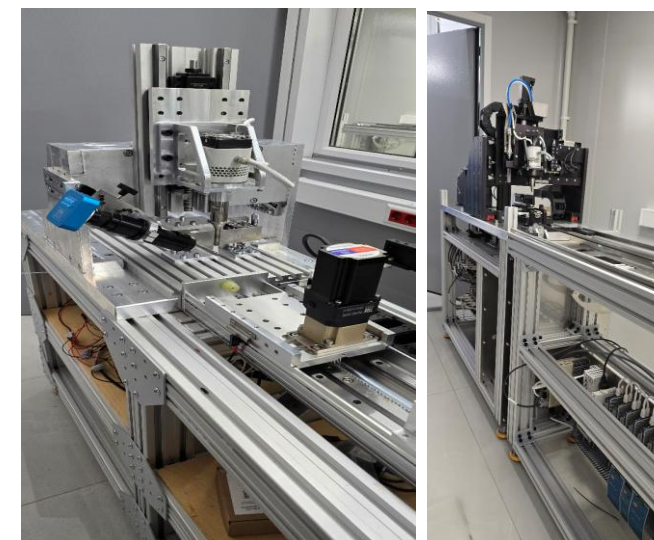


- BINP Novosibirsk
more details: [the link](#)

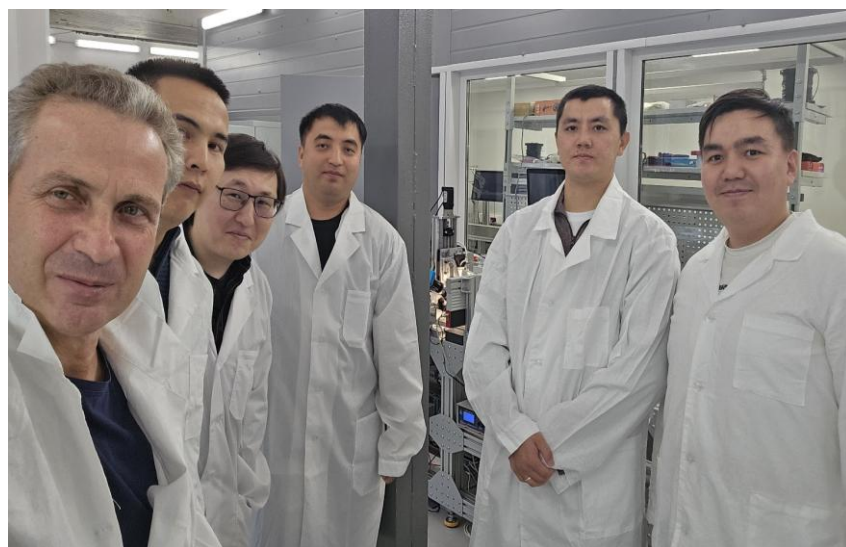
Straw welding-production lines



- JINR (Dubna) – operational for mass production  Joint Institute for Nuclear Research
- GTU (Tbilisi) - operational  GEORGIAN TECHNICAL UNIVERSITY SINCE 1922
- 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 



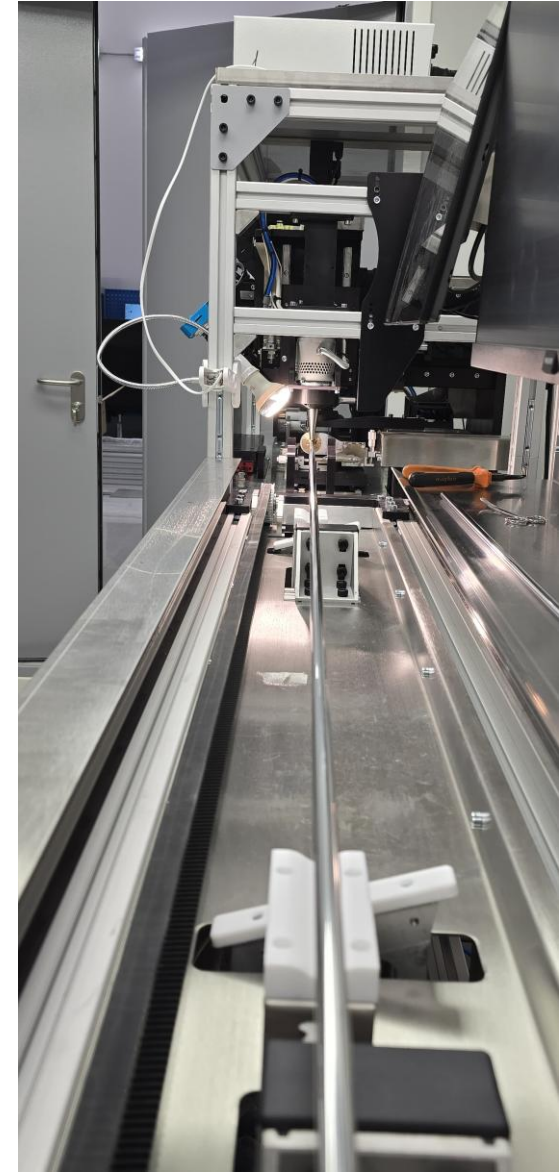
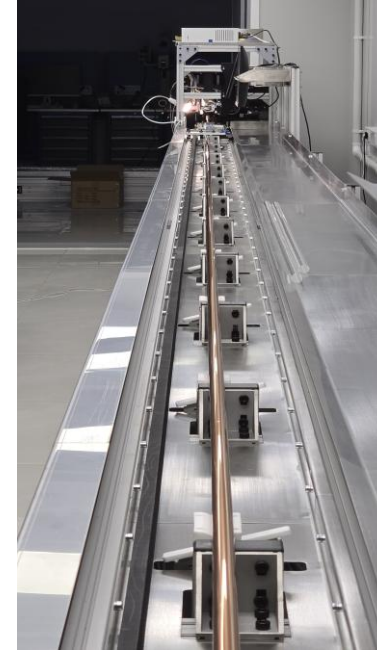
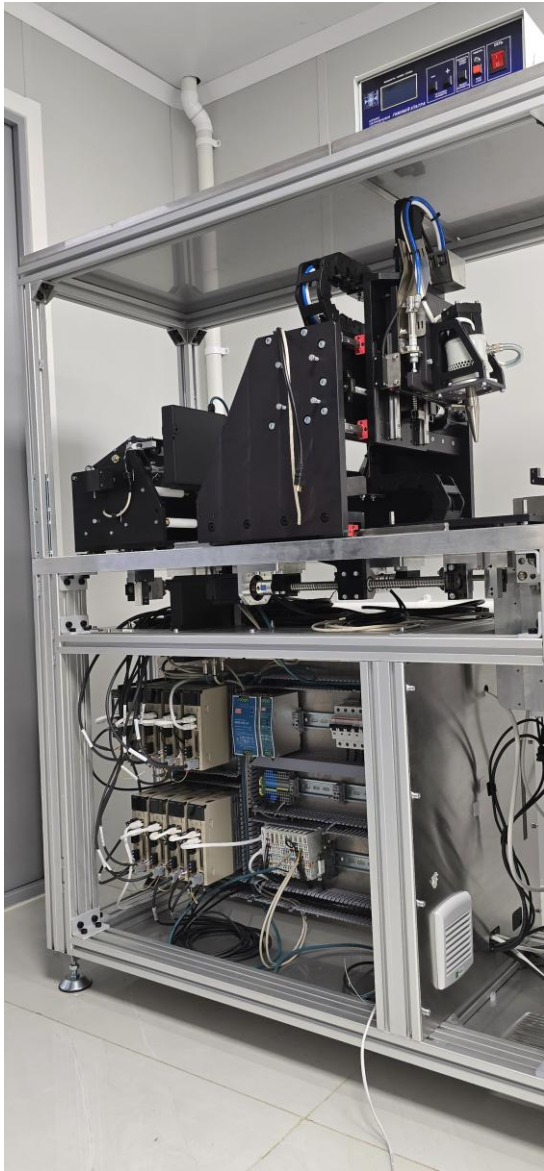
Straw production line and assembling place at INP(Almaty)



- The line was manufactured and successfully tested at JINR
- INP(Almaty) engineers and physicists took an active part in the development 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



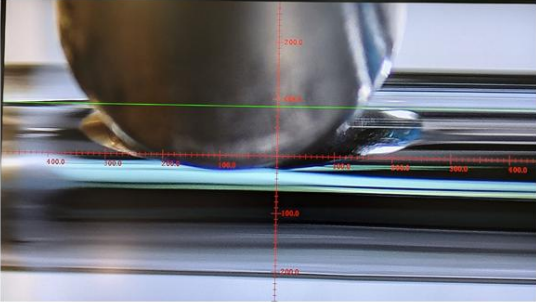
New Straw production line and assembling place JINR



- 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

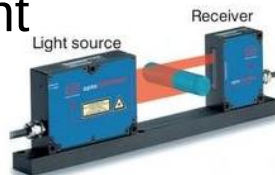


Fig. 5 Sensor unit SU

A measurement system consists of:



Fig. 6 Controller CU

- laser
- receiver
- controller

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

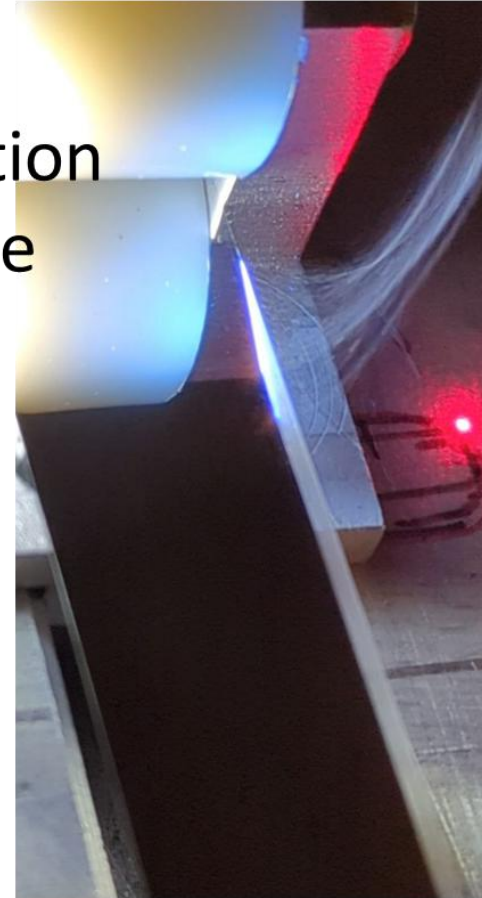


Advancing the USW technology : production from double-side Al-metalized film



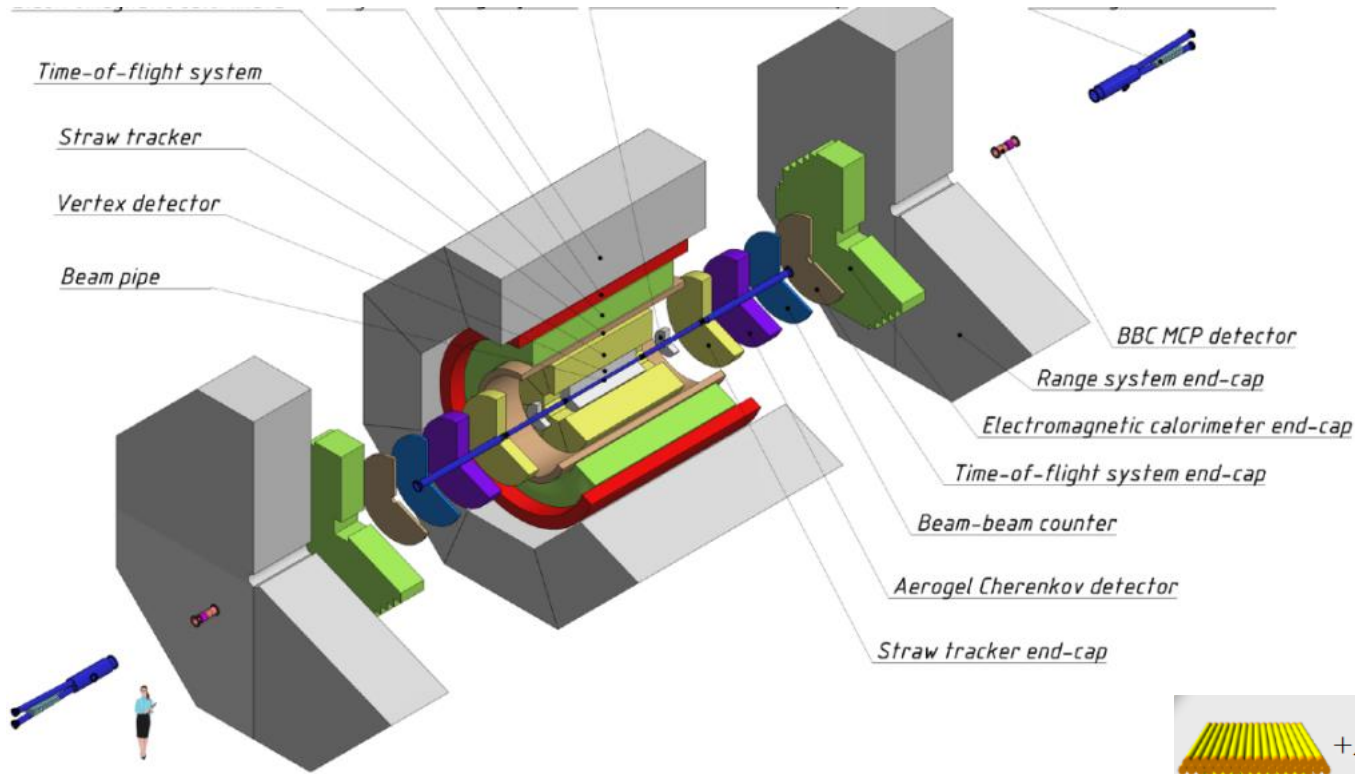
the process of destruction of the ultrasonic head under the influence of aluminum oxide

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

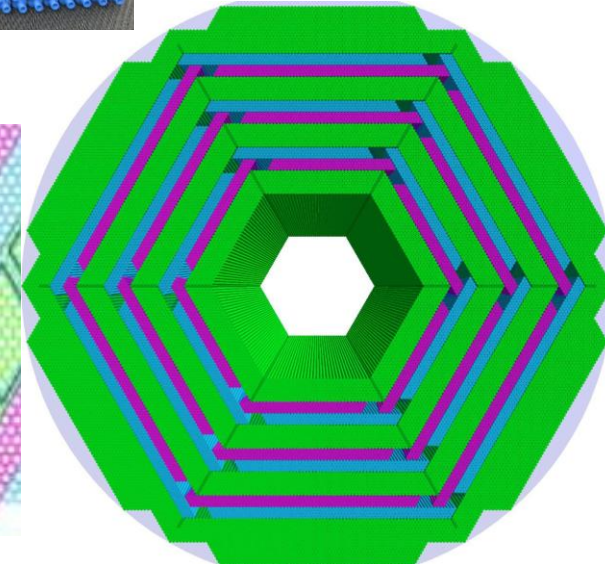
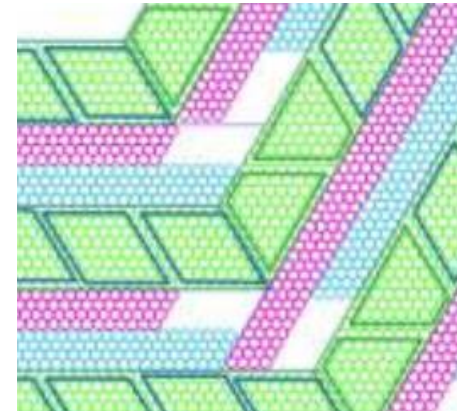
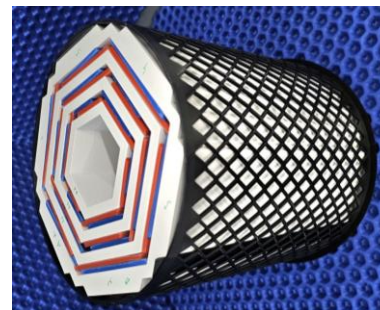
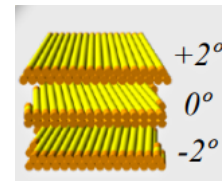
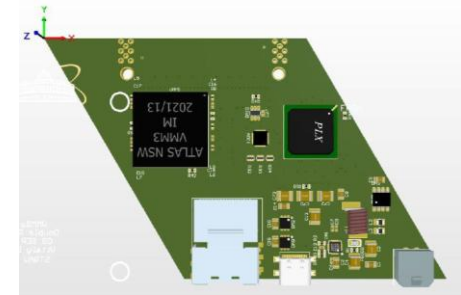
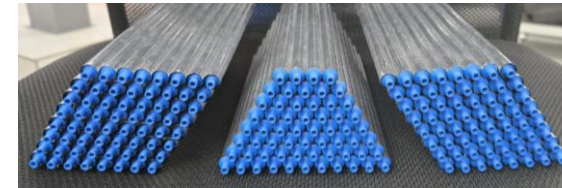


Removing the metallization made it possible to achieve the required quality

SPD Straw Tracker



- Main tracker system of SPD ~2m long, D~1.6 m
- Straw diameter 10 mm, thickness 36 μm PET
- Spatial resolution of 150 μm
- Barrel is made of 6 modules with up to 30 double-layers, with the ZUV orientation ($0, \pm 2^\circ$)
- Endcaps are made of 12 double-layers with the XYUV orientation
- Rate $O(100 \text{ kHz})$
- ~20000 straws

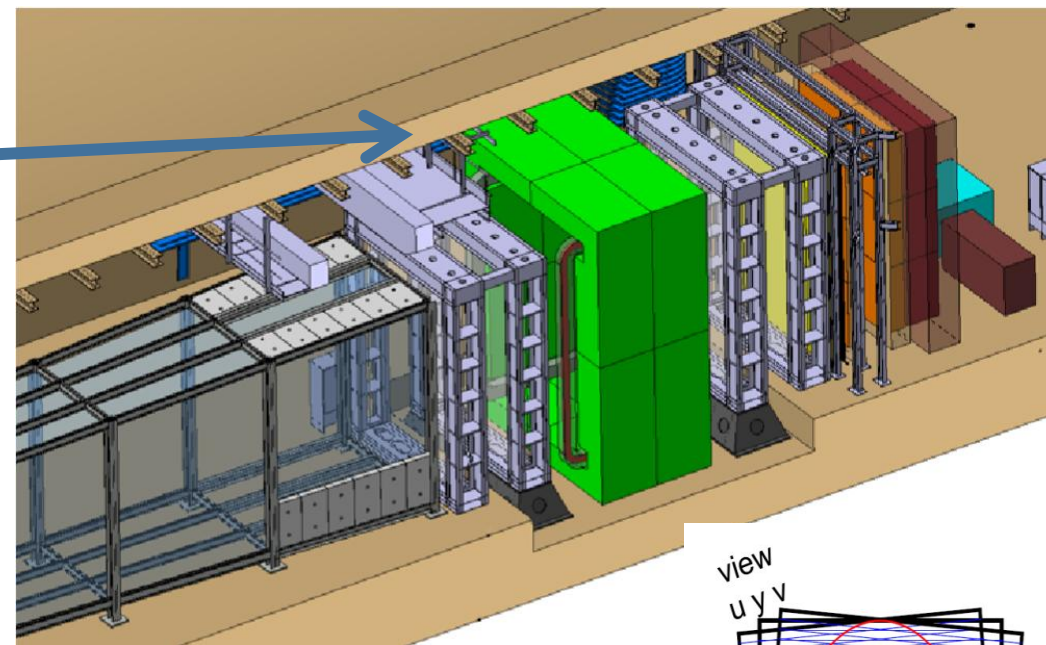
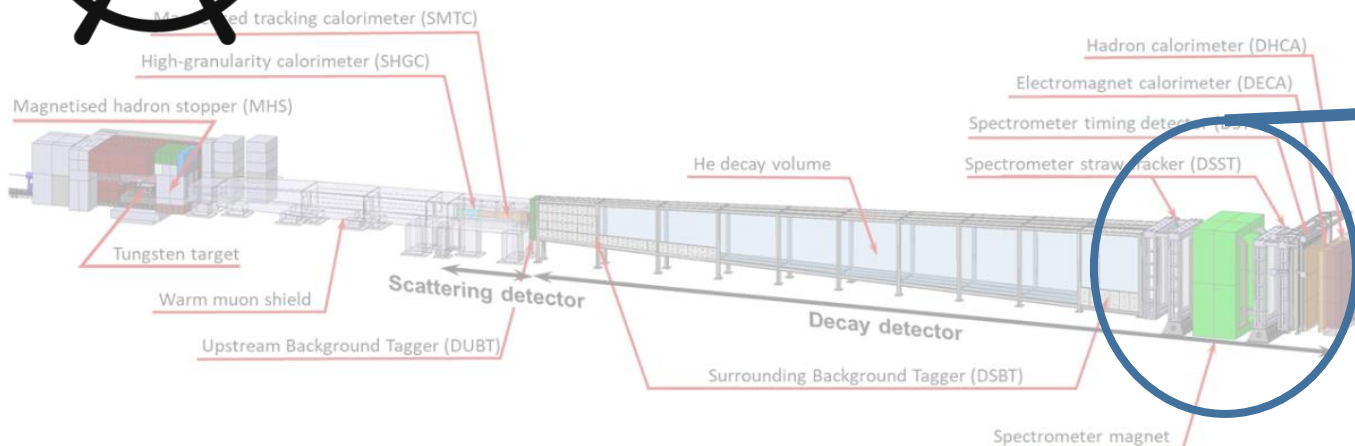


The main idea is to divide the entire detector into modules of 64 channels (rhomb and trapezoid), which allows replacing blocks of 64 channels if needed. Then all the modules are assembled into a closed cylindrical volume and, under overpressure, are tightly fixed in place.

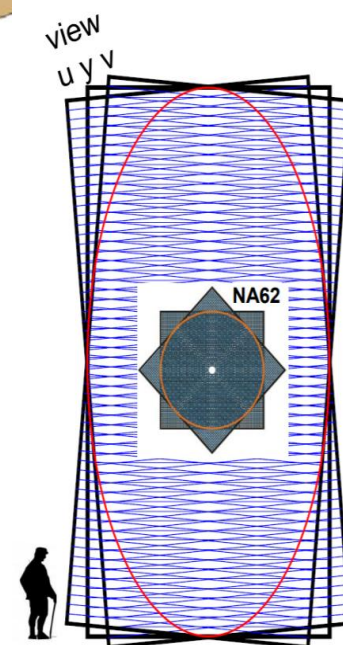


SHIP

Search for Hidden Particles at the High-Intensity ECN3 Facility

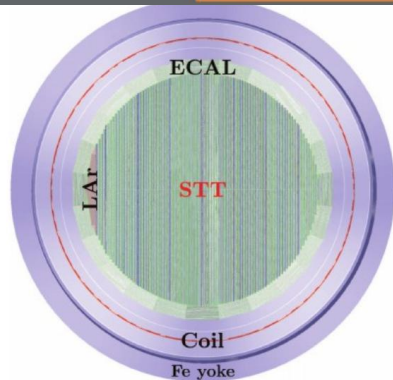
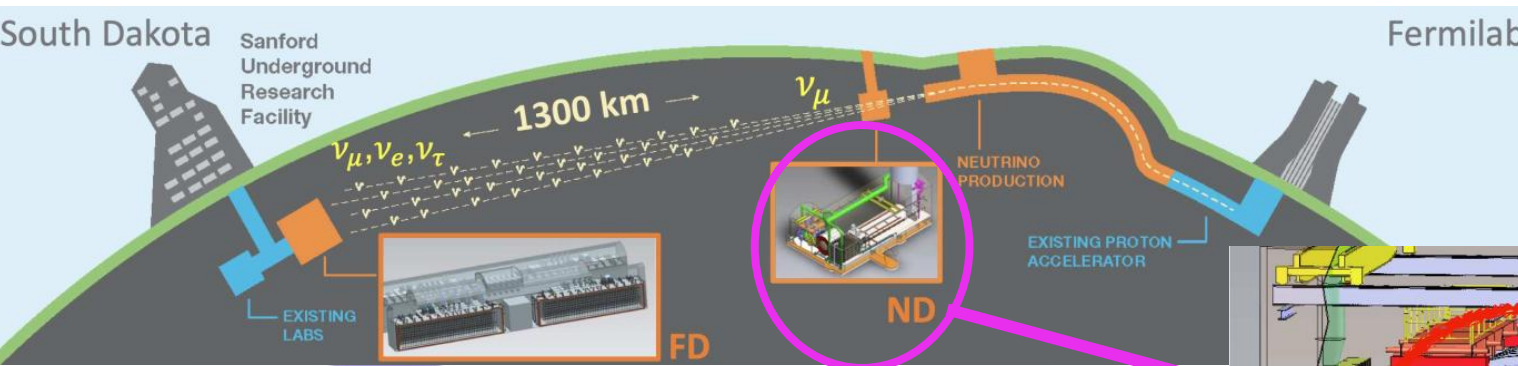


- Sensitive Area 4x6 m²
- Wall thickness- 36 μm
- Ultra light straw detectors ~20000 straws 4 XYUV station
- Straw tube with 20 mm diameter, anode 30 μm diameter
- Length straw 4m
- Spatial resolution 160 μm

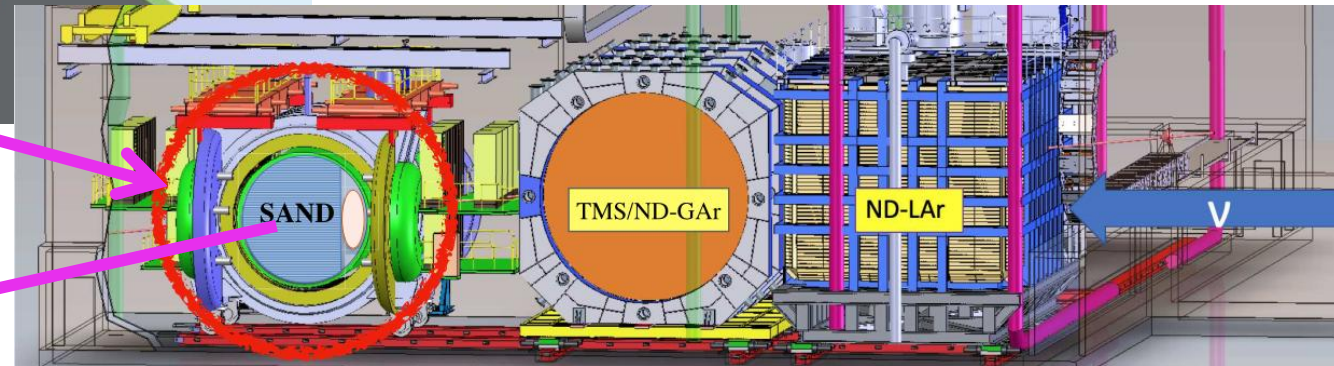
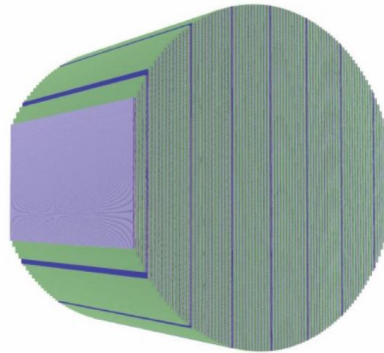




DEEP UNDERGROUND NEUTRINO EXPERIMENT



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 μm
 metallization: 70 nm double side Al
 wire diameter: 20 μm
 operation pressure: 2 bar



Thank you for your attention

