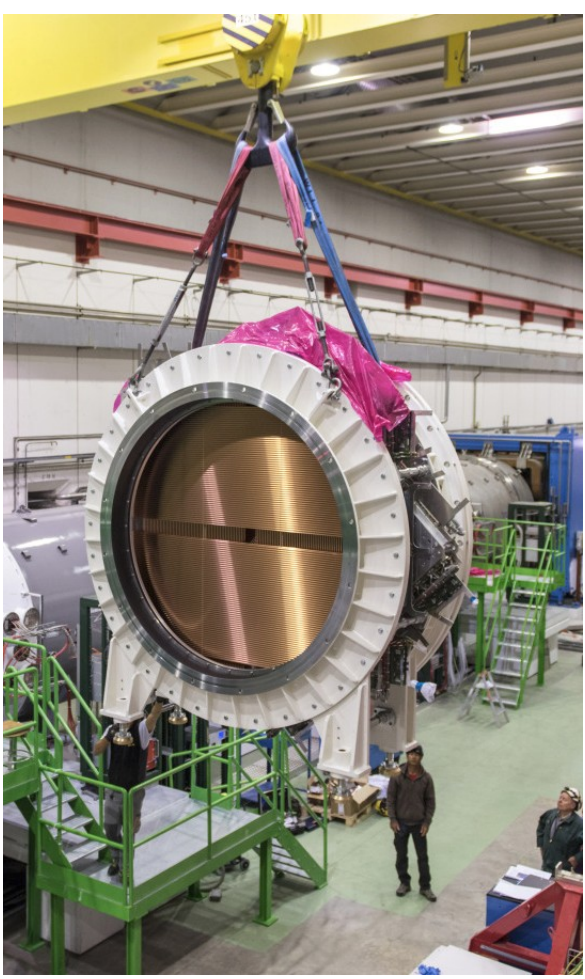


Ultrasonic welding technology for future Straw Trackers and performance studies with small-size tracker prototypes

V. Bautin, S. Bulanova, T. Enik, E. Kuznetsova, A. Mukhamejanova, Y. Mukhamejanov, S. Romakhov, N. Saduyev, S. Sakhiyev, K. Salamatin, D. Sosnov
for the **StrawTrackerRD** team

Why a Straw Tracker?

- Thin walls - small material budget
- 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 (PID) at low momenta

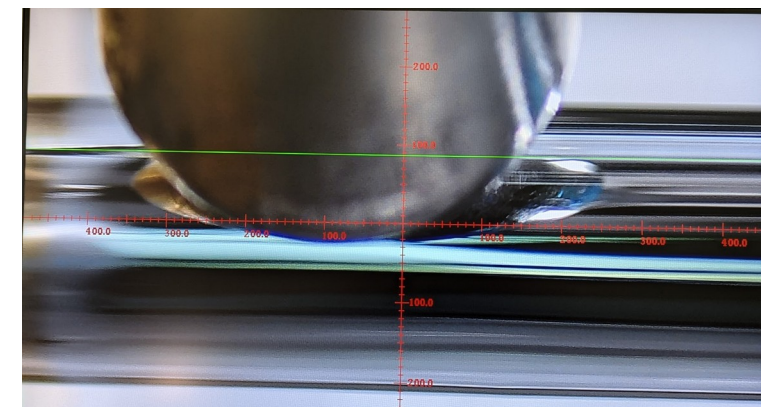


Installation of the NA62 Straw Tracker[1]

	SHiP @ SPS [2]	DUNE (SAND) [3]	SPD @ NICA [4]
Diameter [mm]	20	5	10
Length [m]	4	up to 4	2.4
Film thickness [μm]	36	20	36
Metalization [nm]	50(Cu)+20(Au)	70(Al) double-side	70(Al)
Operation pressure	1 atm	2 atm	1 atm
N of straws	~20 000	~250 000	~30 000
Occupancy [kHz]	10-100	<1	15-150
Readout (under development)	time + time-over-threshold, rising edge shape (optional)	time + charge (PID)	time + charge (PID)

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:

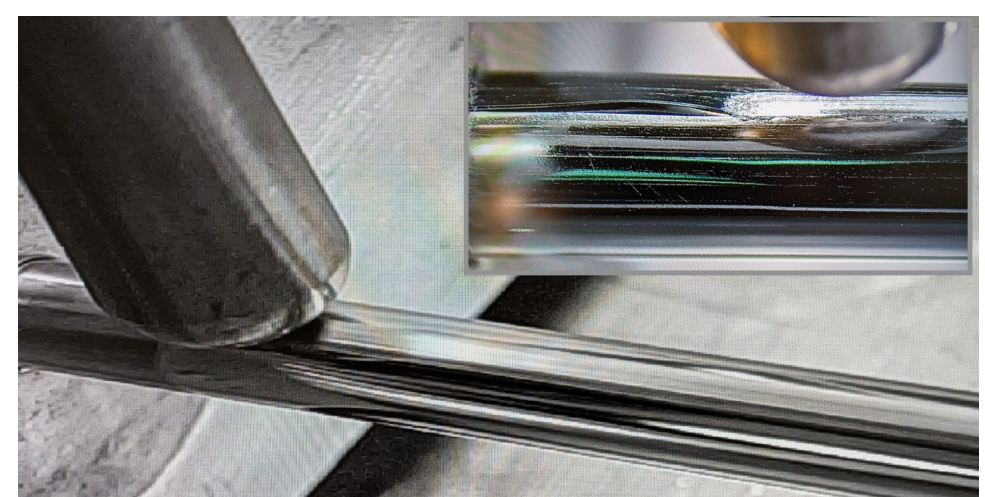
Short-term test: several minutes - NA62: 3 atm, DUNE: 5 atm
Long-term test: ~month - NA62: 1 atm, DUNE: 3 atm

NA62 tracker made of USW straws successfully operates in vacuum for ~10 years

Straw production technologies:

ultrasonic welding (USW)

Running/Future Detectors: NA62, COMET, SHiP, DUNE, SPD, ...



Straw material: PET
Production lines: mostly laboratories

winding



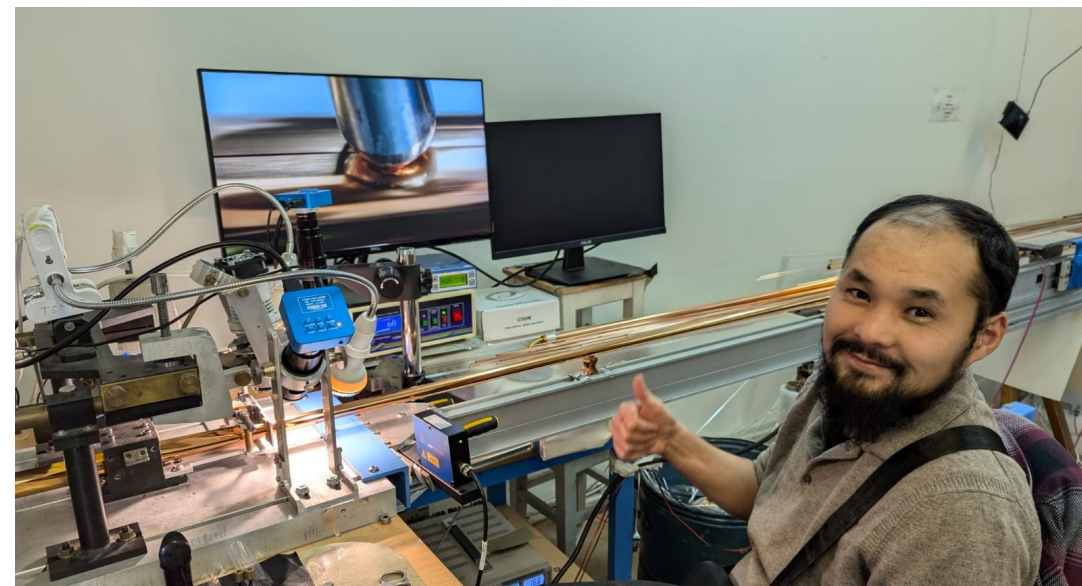
Kapton, PET
laboratories, industrial

USW:

- lower wall permeability to gas and better mechanical stability under large overpressure – very attractive for vacuum and overpressure applications
- lower sensitivity to humidity
- larger range of elastic deformation though less hardness

USW production lines

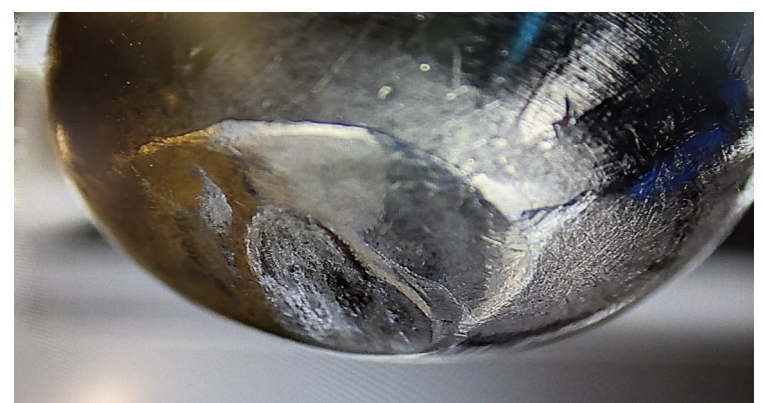
- JINR (Dubna) – operational for mass production up to 5.5 m straw length with speed of 2 m/min
- GTU (Tbilisi) - operational
- SEFAR (Swiss industrial company) - operational
- PNPI (Gatchina) - developing
- INP (Almaty) – developing mass production lines



Advancing the USW technology :

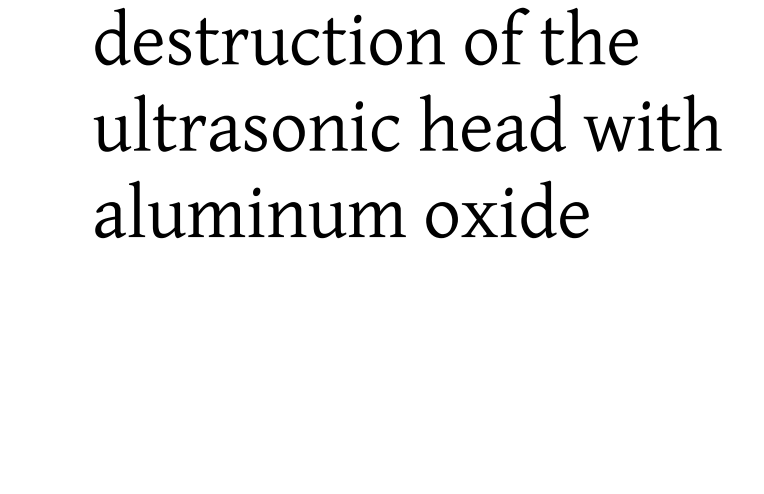
- Four mass production lines for 12 m straws are under construction to launch in 2025: two in JINR and two lines at INP (Kazakhstan)
- Staff training ongoing

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

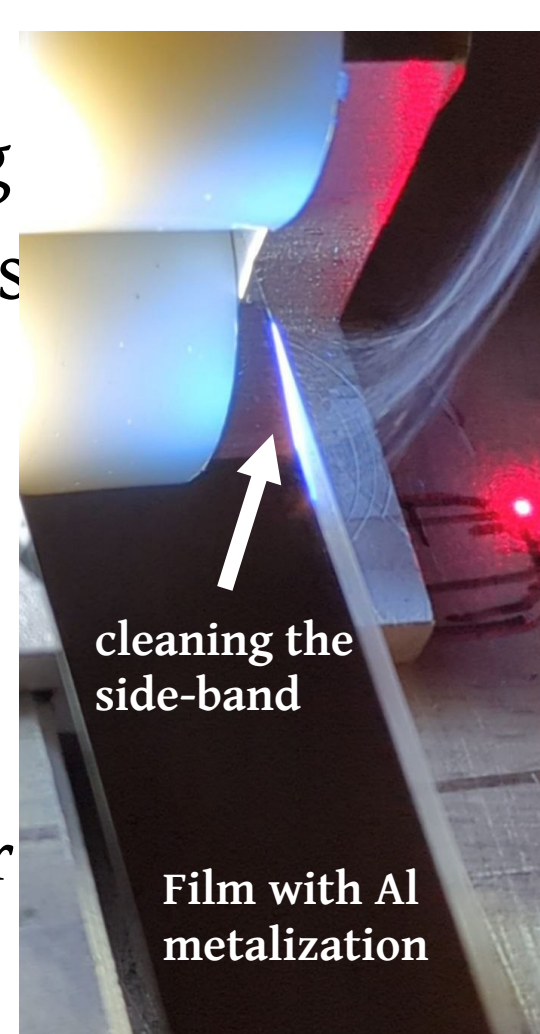


Double Al-metalization:

- allows to increase the straw quality keeping its cost low compared to Cu/Au-coated films
- however makes USW problematic
- removing the metalization from the film side-band improves the production process



removing the Al-coating with a laser during the welding process



cleaning the side-band

Film with Al metalization

Requirements for the PID option

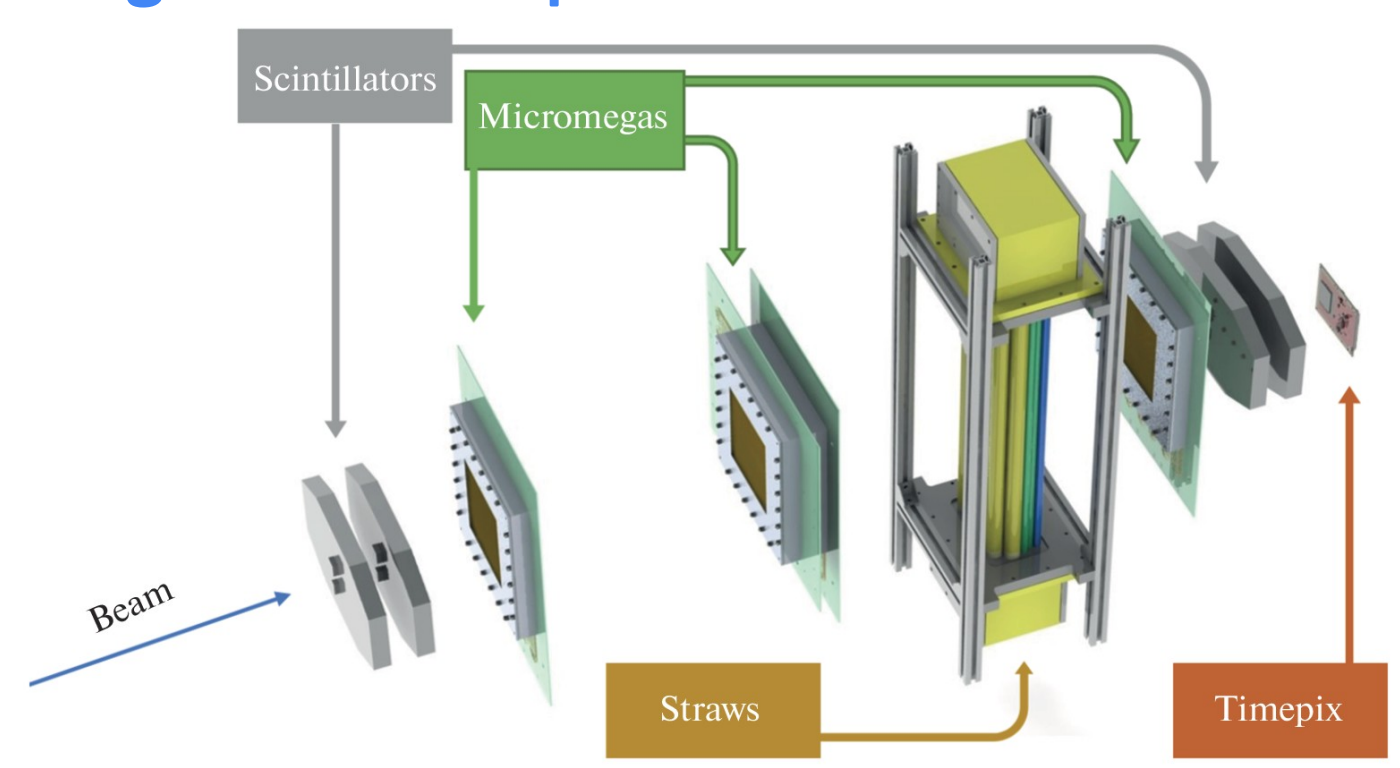
- Tracking : precise time-at-threshold measurements – requires short peaking time
- Additional PID option: reliable charge measurements – requires long peaking time and large dynamic range

Existing potential solutions

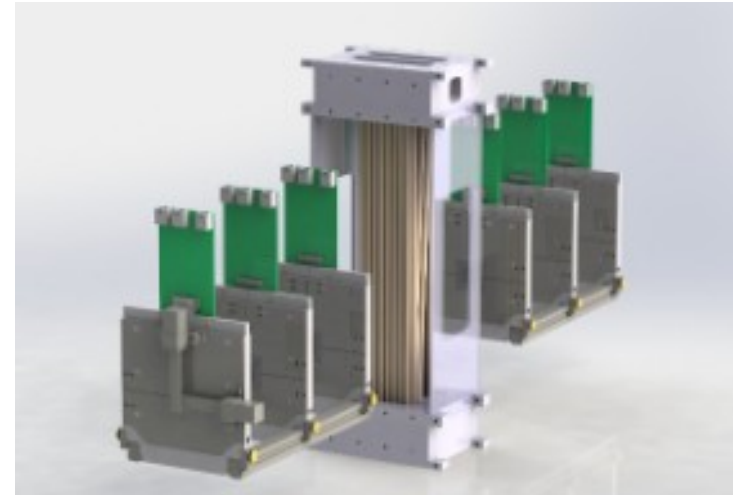
- VMM3a[5] – rejected[6] due to latching in the time-at-threshold mode
=> VMM3a with external digitization may be a solution – under study
- TIGER[7] – developed for GEM readout so has too high amplification for straw signals
=> development of ToRa* ASIC is expected
* poster at board 54 of VCI2025
- ALTAS MDT ASD[8] – under study

Readout electronics for the future Straw Trackers

Measurements of time and spatial resolution with existing readout options at SPS H4 beam line at CERN

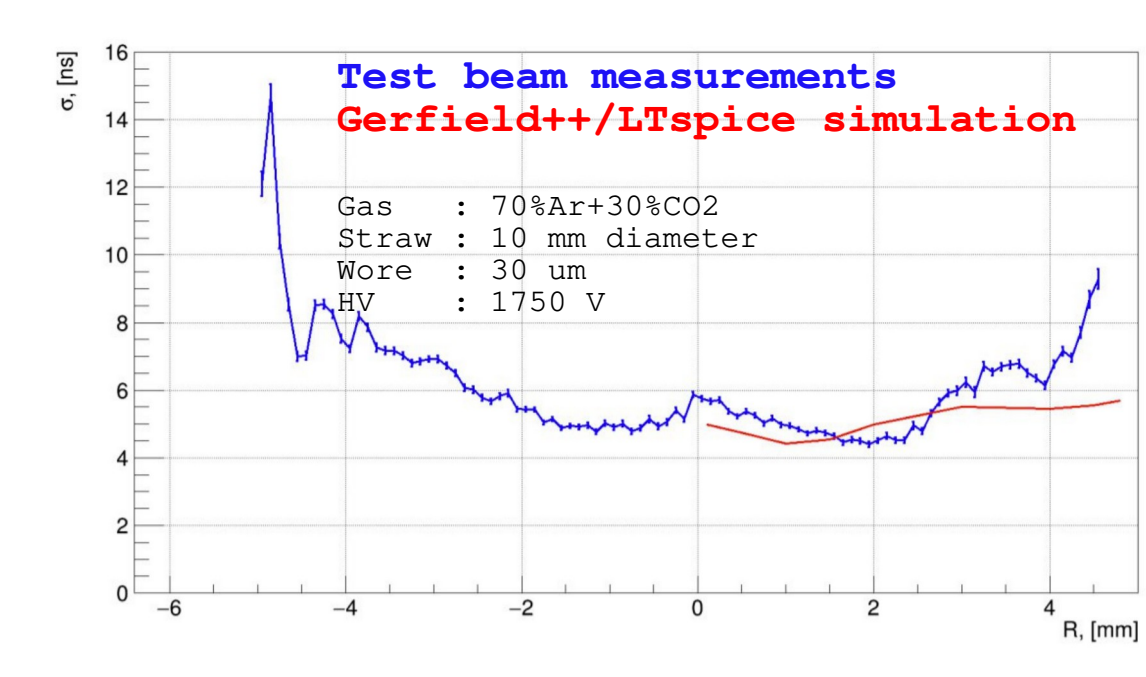


StrawTrackerRD setup (large acceptance option)
t0: scintillator coincidence — resolution ~400 ps
Reference tracking: micromegas+TIGER readout
- track resolution: ~100 μm



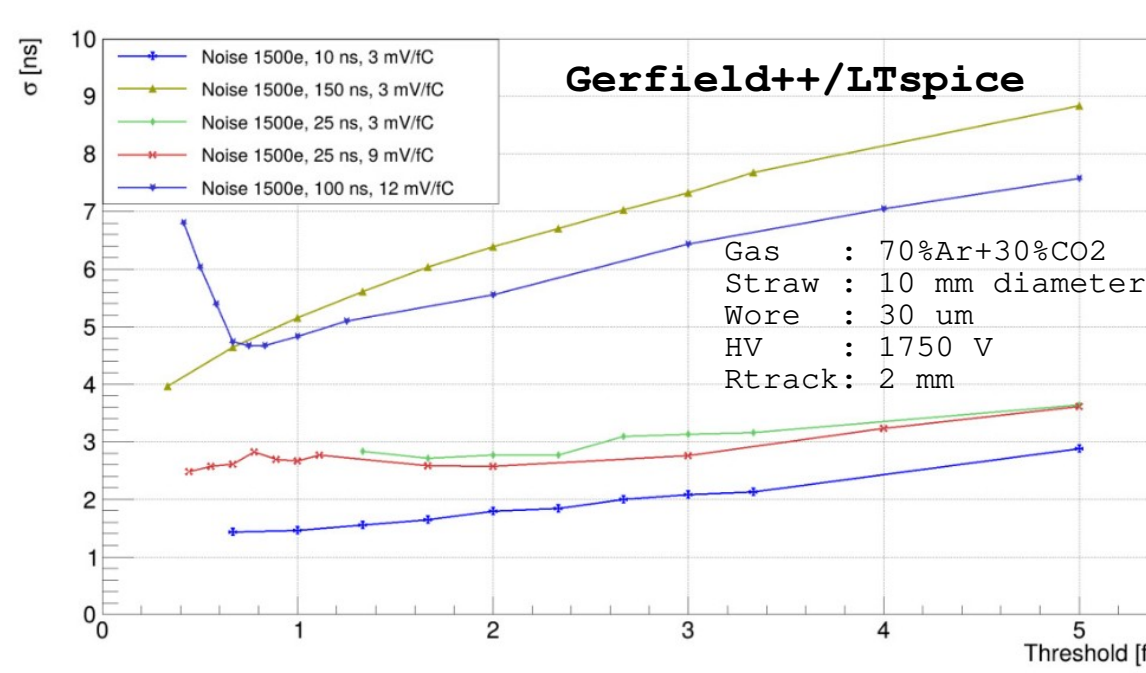
Optional: precise reference tracking based on AZALEA telescope[9]:
track resolution ~9 μm

Simulation studies of future readout options and validation with the muon beam data acquired with available readouts



Test beam measurements
Garfield++/LTspice simulation

Gas : 70%Ar+30%CO2
Straw : 10 mm diameter
Wire : 30 μm
HV : 1750 V



Simulation studies with different readout models: straw time resolution as a function of the discriminator threshold for VMM3-like architecture with different peaking time and gain options