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

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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 um)
- 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]

Straw production technologies:

<u>ultrasonic welding (USW)</u>

Running/Future Detectors:



Straw material:

winding

Kapton, PET



ATLAS, LHCb, Amber, *NA64, Mu2e,* COSY-TOF, Panda, *CBM, ...*

USW Straw Trackers for future experiments*

	SHiP @ SPS [2]	DUNE (SAND) [3]	SPD @ NICA [4]
Diameter [mm]	20	5	10
Length [m]	4	up to 4	2.4
Film thickness [um]	36	20 ^T	2360 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)

*Collaborations which INP contributes to

<u>Advancing the USW technology : production quality control</u>

During production:



Post-production:



Production lines: mostly laboratories laboratories, industrial

PET

SHiP,

• lower wall permeability to gas and better mechanical stability under large overpressure – very attractive for vacuum and overpressure applications USW:

- 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



- 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

destruction of the

aluminum oxide



visual control of seam quality







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

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 ultrasonic head with

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

Film with Al metalization

cleaning the

side-band

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

Readout electronics for the future Straw Trackers

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



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

- Straw response: Garfield++[10]
- Electronics response to the Garfield-generated signals: LTspice[11]



Validation of the simulation approach: straw time resolution as a function of the local muon track coordinate

- => 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

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



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

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

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