

# Status of STT Activities

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*SAND Meeting  
15 March 2022*

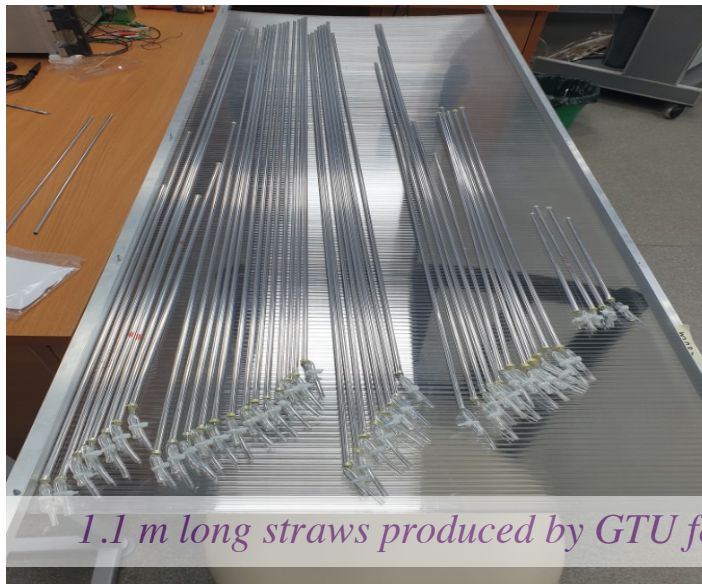
- ◆ *New STT working group is being formed following the charge received from the SAND TL and CL on 08 March 2022.*
- ◆ *WG activities are related to the design and construction of the STT for SAND, with the final goals assigned being the completion of the detector installation and its readiness for operation.*
- ◆ *Initial WG chairs: G. Sirri, S. Di Falco, R. Petti*
- ◆ *Dedicated mailing list being created (DUNE-ND-SAND-STT) with initial enrolments from the list of people who expressed interest in the related activities.*
  - ⇒ *Encourage any interested people to subscribe once activated*
- ◆ *Will circulate a Doodle survey to select the most convenient time for the WG meetings.*

# Status of STT prototyping

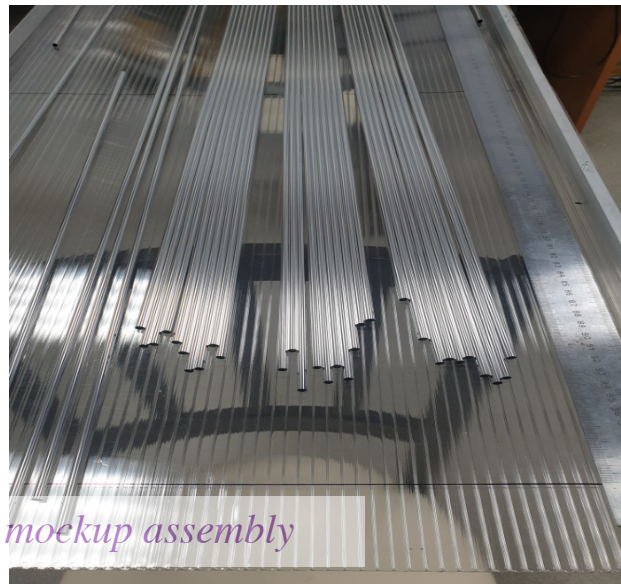
(based on talk by RP at DUNE collaboration meeting in January 2022)

## STRAW PRODUCTION

- ◆ *Production of straws with **ultrasonic welding technology**:*
  - JINR line producing 5m long straws  $\sim$  6 straws/hour;
  - GTU line producing  $<2$ m long straws  $\sim$  80 straws/day.
- ◆ *Demonstrated **double Al** coating on inner and outer surfaces:*
  - Protection against humidity for more reliable long term operation;
  - Improved gas tightness from reduction of diffusion through straw walls;
  - May simplify ground connections through external layer.
- ◆ *Tested/compared **different straw types** ( $4.9 \pm 0.05$  mm):*
  - Wall thickness  $12 \mu\text{m}$  with single Al metallization  $70 \text{ nm}$ ;
  - Wall thickness  $20 \mu\text{m}$  with single Al metallization  $70 \text{ nm}$ ;
  - Wall thickness  $20 \mu\text{m}$  with double Al metallization  $70 \text{ nm} + 40 \text{ nm}$ .



*1.1 m long straws produced by GTU for moekup assembly*



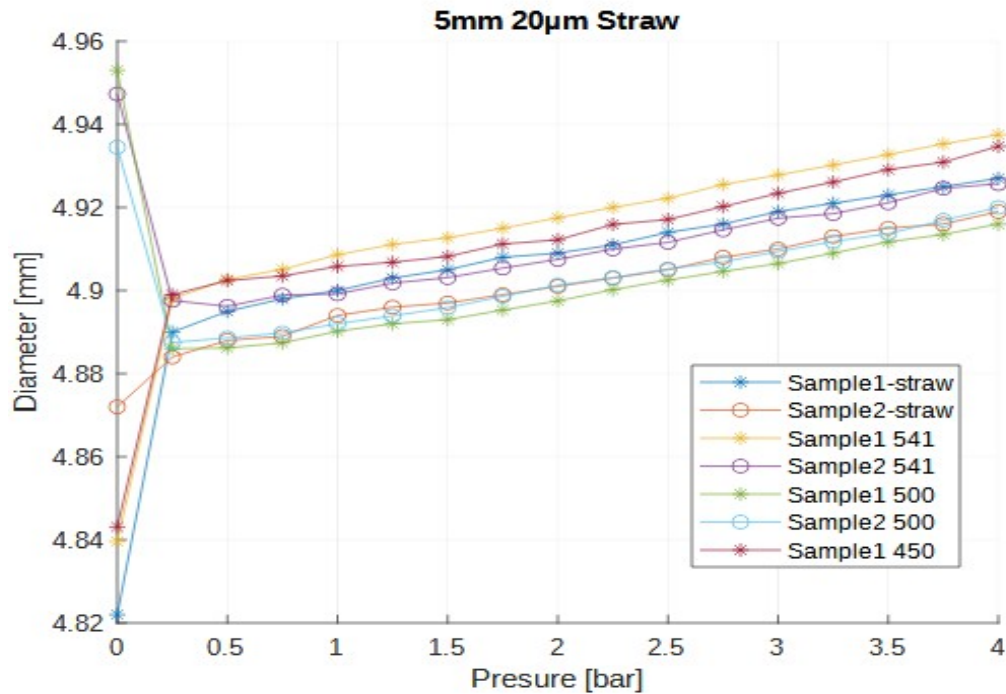
*5 m long straws produced at JINR for the gluing tests*

- ◆ *Measurement of maximal internal pressure* achievable without plastic deformations.
  
- ◆ *Measurement of radial deformations* vs. *internal gas pressure (GTU)*:
  - *Straws with 4.9mm diameter, 20  $\mu\text{m}$  walls, produced by both JINR and GTU;*
  - *Comparison of different types of mylar film and Al metallization.*
  
- ◆ *Measurements of straw elongation and tension* vs. *internal gas pressure (GTU)*:
  - *Straws with 4.9mm diameter, 12  $\mu\text{m}$  & 20  $\mu\text{m}$  walls;*
  - *Studied tension drop with increase of internal pressure starting from initial pre-tension.*
  
- ◆ *Measurement of straw relaxation* vs. *time and humidity* starting from initial tension.

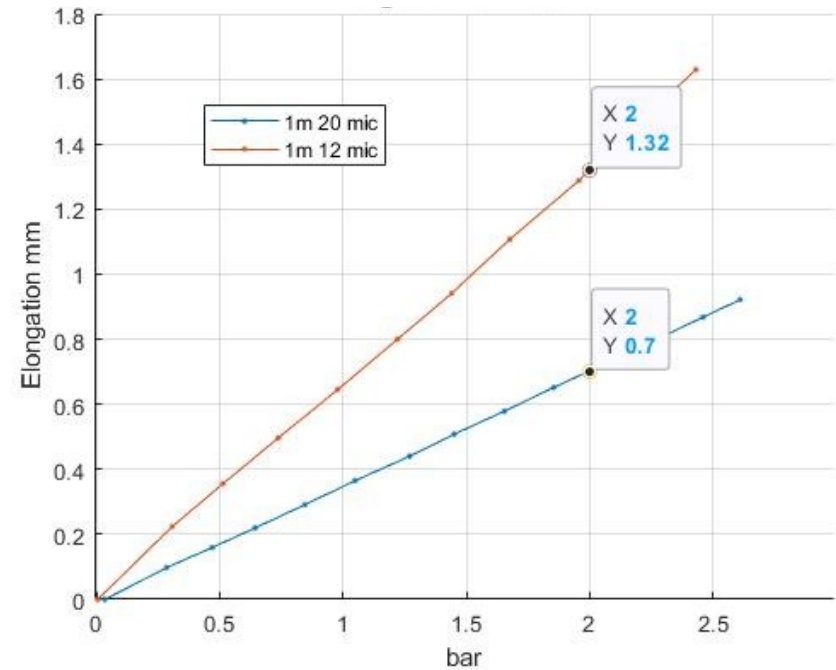
G. Adamov, N. Tsverava (GTU)

<i>Production</i>	<i>Diameter</i>	<i>Wall</i>	<i>Metallization</i>	<i>Length</i>	<i>P<sub>max</sub> tested</i>
<i>JINR</i>	<i>4.92 mm</i>	<i>20 μm</i>	<i>Single 70 nm</i>	<i>20 cm</i>	<i>6 bar</i>
<i>GTU</i>	<i>4.96 mm</i>	<i>20 μm</i>	<i>Double 70+40 nm</i>	<i>20 cm</i>	<i>6 bar</i>





*Measurement of radial deformation vs. pressure for straws 1.1 m long*



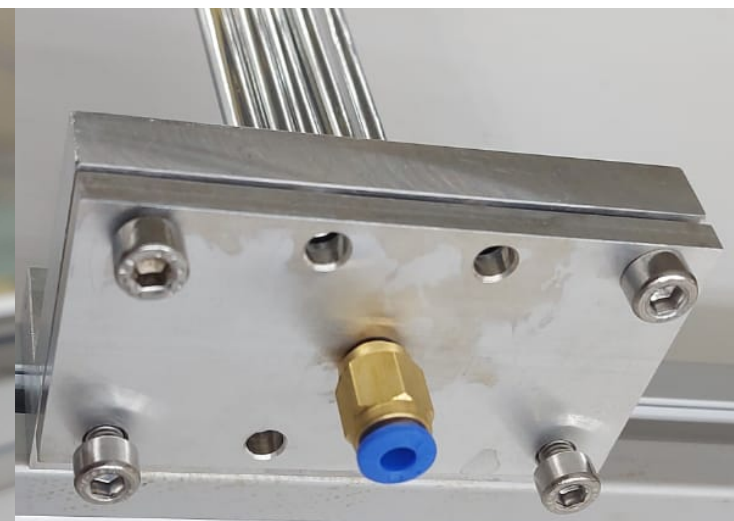
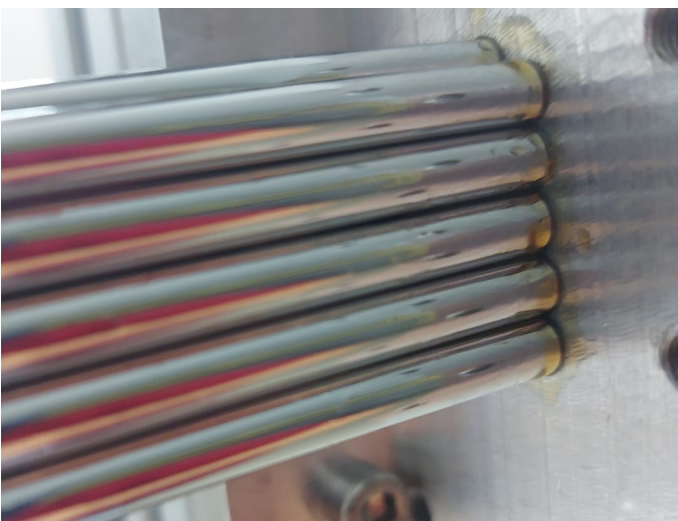
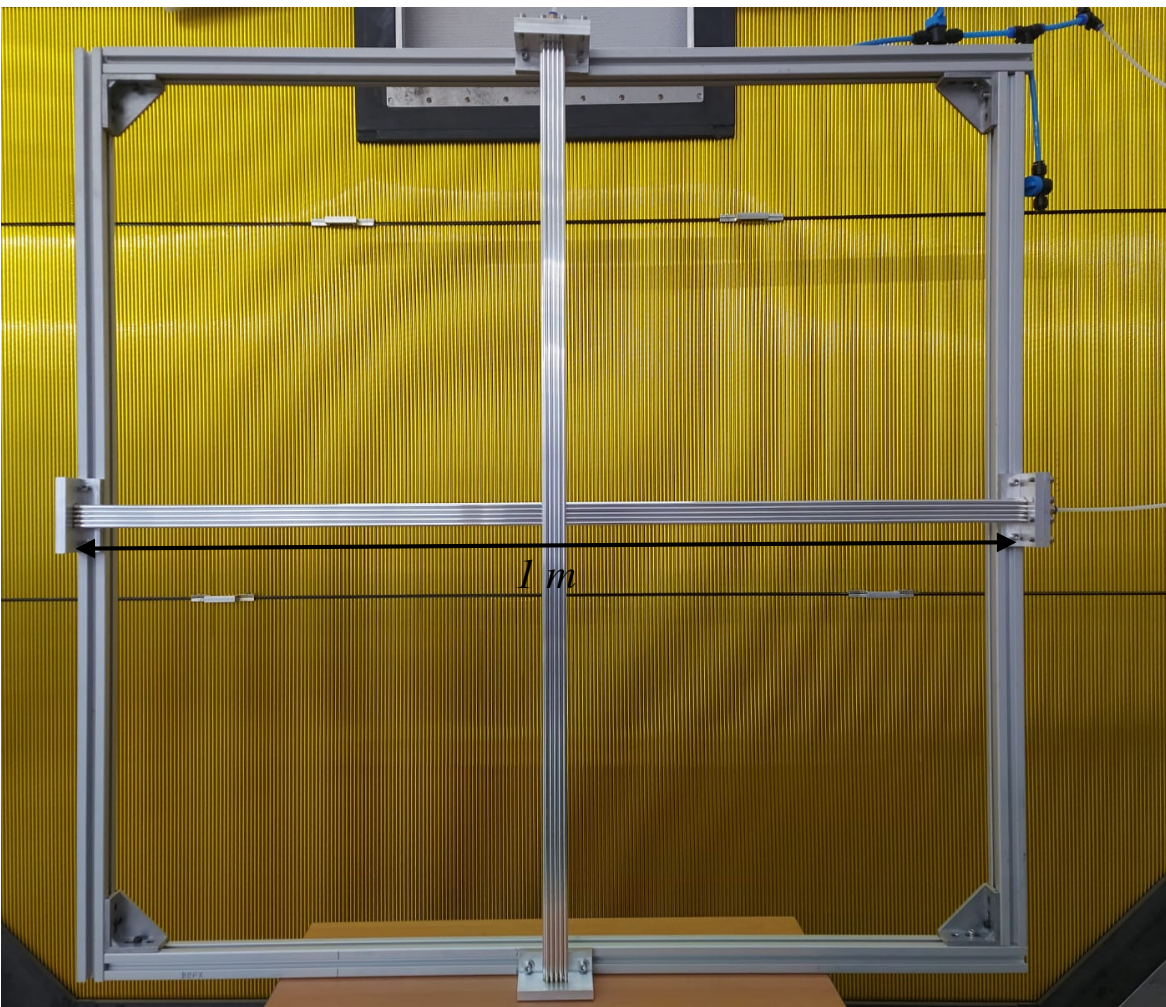
*Measurement of elongation and tension vs. pressure for straws 1.0 m long*

- ◆ *Completed first gluing tests of a XXYY straw layer assembly (JINR):*
  - *Built test stand 1m × 1m allowing a variation of internal gas pressure in the glued straws;*
  - *Straws glued together with ELK5 (NA64) epoxy and internal overpressure;*
  - *Initial spacing left between glued points ~20 cm.*

⇒ *Validation of the concept of XXYY glued assembly*
  
- ◆ *Measurement of deformations of glued XXYY assembly vs. internal gas pressure.*
  
- ◆ *Additional measurements on XXYY glued assembly:*
  - *Gas leak test to verify damages to straw walls;*
  - *Straw resistivity to check metallization damage induced by pressure.*

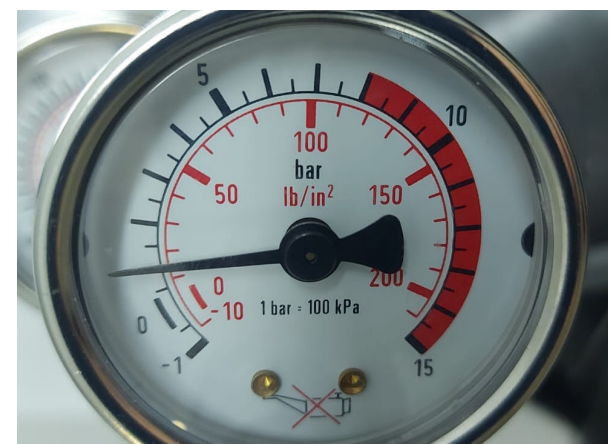


*Gluing and pressure tests  
of a XXYY straw layer  
assembly at JINR*





*Straws glued together with epoxy ELK5 (~ 20cm spacing)*



*Cycle multiple times  
complete glued XXYY assembly  
from 0 bar to 4 bar (relative):  
no problems nor apparent damages  
for the straw assembly*

- ◆ *Mockup prototype(s) 35cm × 35cm for preliminary validation tests:*
  - *Completed design of mock frame (Hamburg, UofSC);*
  - *Machining of first plexiglass mockup frame being completed in Hamburg;*
  - *Required straws produced by GTU (4.9mm diameter, 20 μm walls);*
  - *End-plugs machined from simplified design;*
  - *Assembly of first mockup prototype at JINR.*
  
- ◆ *Main goals of mockup prototype(s):*
  - *Validate assembly procedure using same geometry/frame as in STT;*
  - *Test the connection/gluing of straws to the frame;*
  - *Test sealing and gas leaks vs. internal pressure;*
  - *Evaluate different design options.*
  
- ◆ *Additional mockup prototypes expected to be built at various collaborating institutions following the completion of the first one at JINR.*

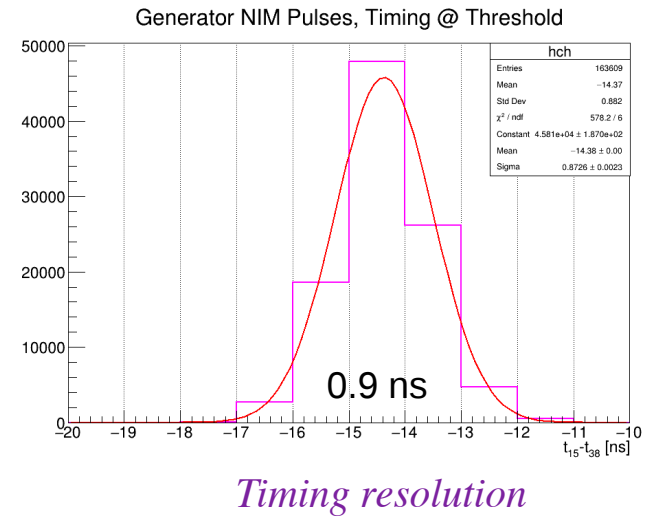
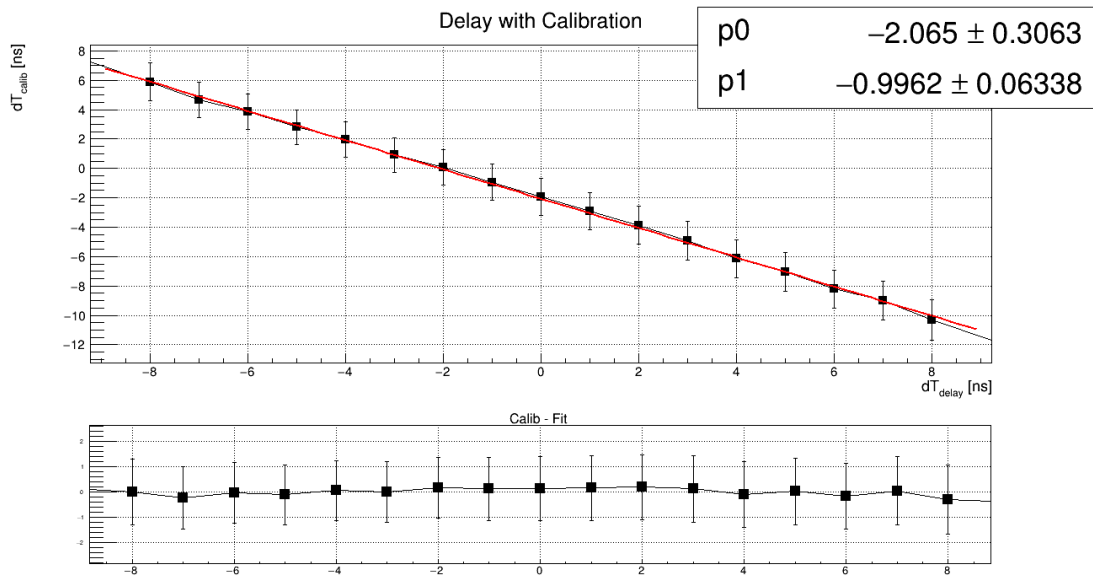
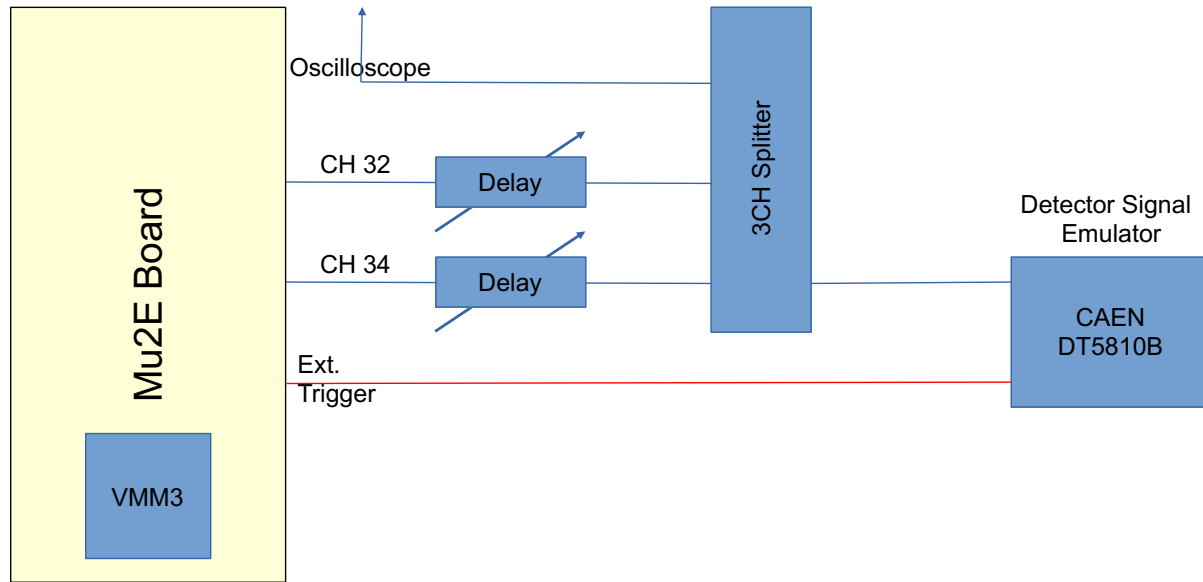


- ◆ *Tests and calibration of FE boards from Mu2E (BNL) with VMM3 at JINR:*
  - *Timing calibration using signal generator and timing resolution;*
  - *Readout of small straw tracker and tests with  $^{55}\text{Fe}$  source & cosmics.*
  
- ◆ *Testbeam exposure of small straw tracker with VMM3 readout in RD51 at CERN:*
  - *Two double layers  $XX+YY$  with straws staggered by half diameter ( $20\text{cm} \times 20\text{cm}$  active area);*
  - *Independent tracking system with 3 GEM detectors ( $\sigma \sim 50\mu\text{m}$ ) equipped with VMM3 readout;*
  - *Setup installed in H4 beamline (JINR) and exposed to  $\mu, \pi$  with  $E \sim 160$  GeV;*
  - *Usable data taken in Oct.-Nov. 2021 (JINR, PNPI, UofSC).*
  
- ◆ *Ongoing analysis of testbeam data:*
  - *DAQ instability found at high rates in Time-over-Threshold mode being investigated;*
  - *Stable data taking when operated with peaking time.*

⇒ *New testbeam exposure with VMM3 readout at CERN in May 2022*

# TIMING CALIBRATION

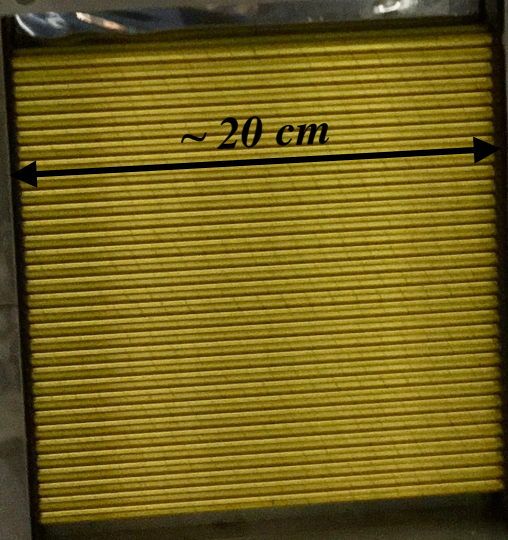
Vitalii Bautin (JINR)



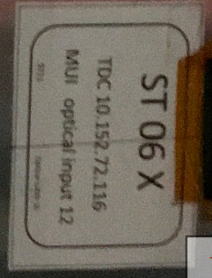
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VMM3a readout  
(64 YY straws)

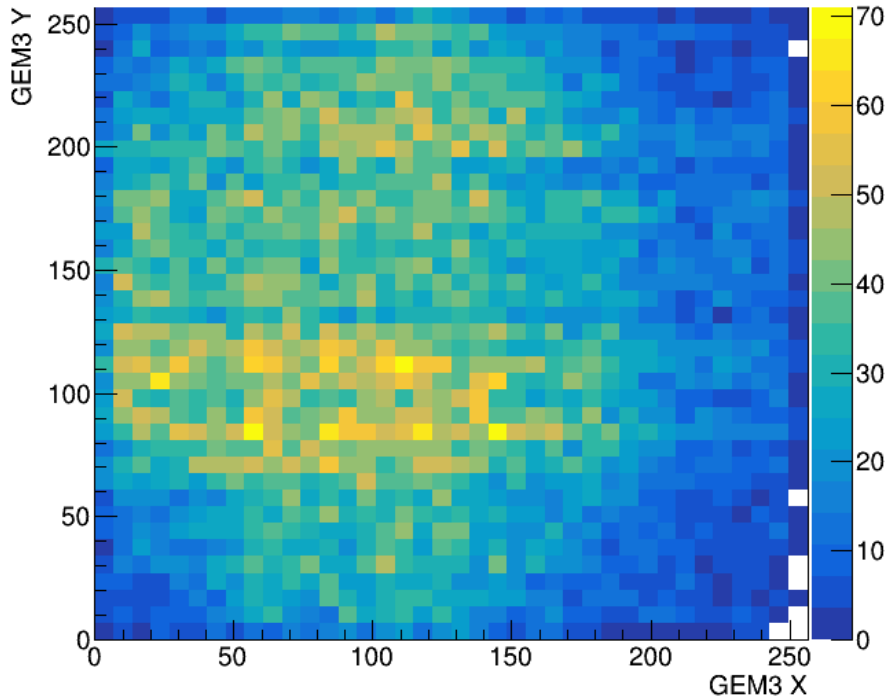


Straw tracker:  
two double layers  
XX + YY

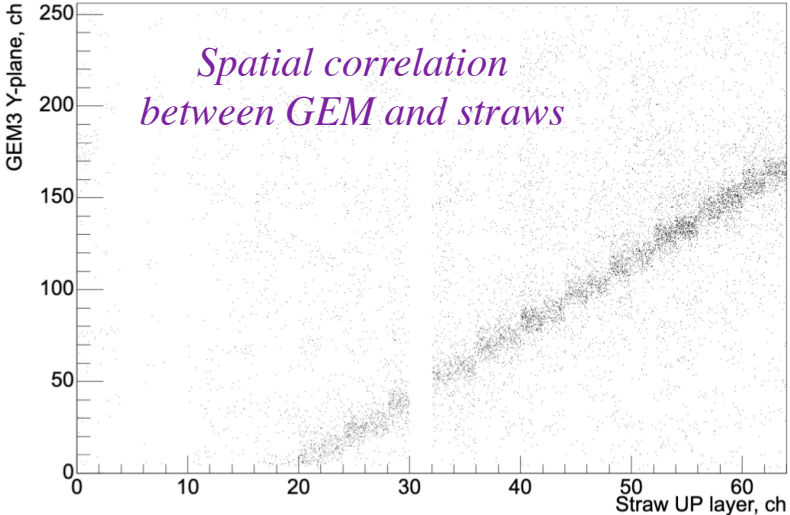


VMM3a readout  
(64 XX straws)

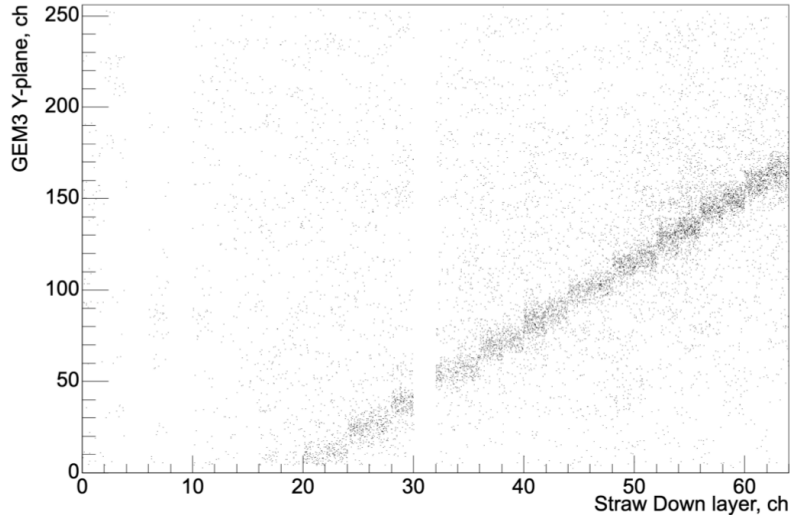
M. Demichev (JINR)



*Beam profile seen by GEM 3 tracker*



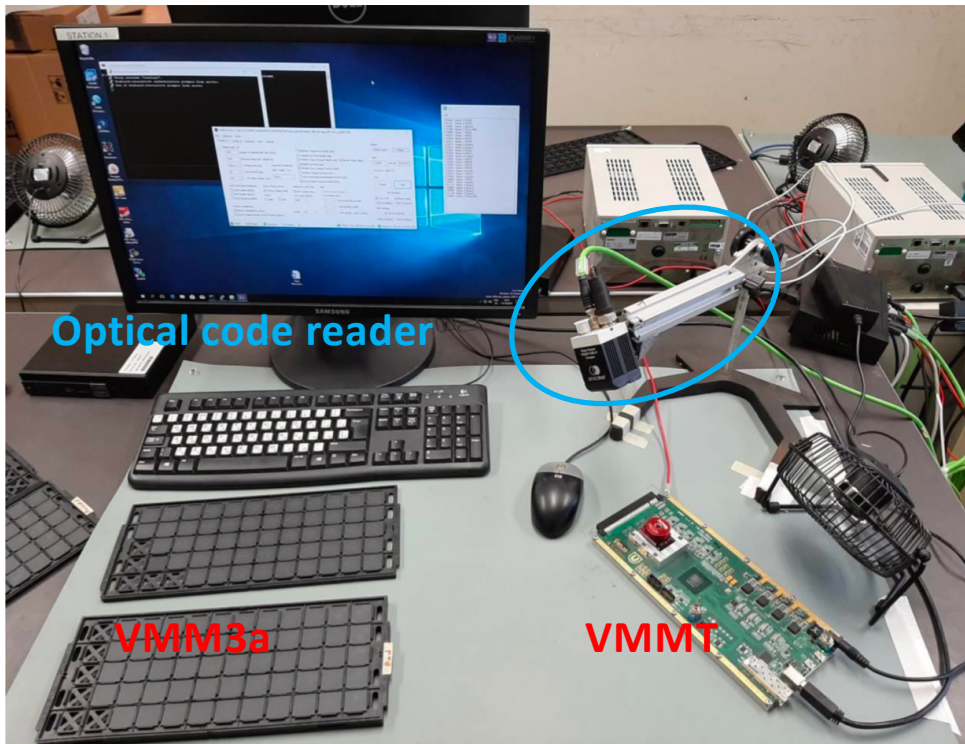
*Spatial correlation between GEM and straws*





## VMM3a TESTING

- ◆ Procedure to test and validate VMM3a ASICs used for 42,000 chips in ATLAS NSW



- ◆ Automatized VMM3a test stand
- ◆ Optical system to read serial numbers of the VMM3a chips being tested
- ◆ VMMT: multi-functional test board for testing and characterization of VMM3 ASICs developed by Tomsk State University (Russia) for ATLAS

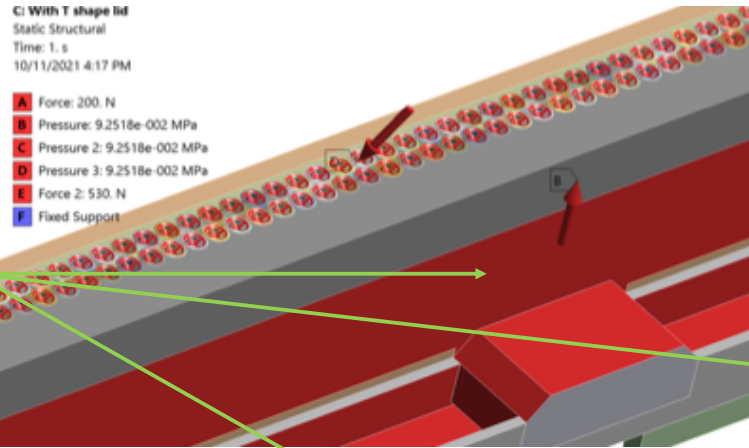
- ◆ All VMM3a chips procured by UofSC tested at CERN using ATLAS NSW procedure: average yield about 70% for best selection (green) for a total of 150 chips.

## PREPARATION FOR 1.2m × 0.8m PROTOTYPE

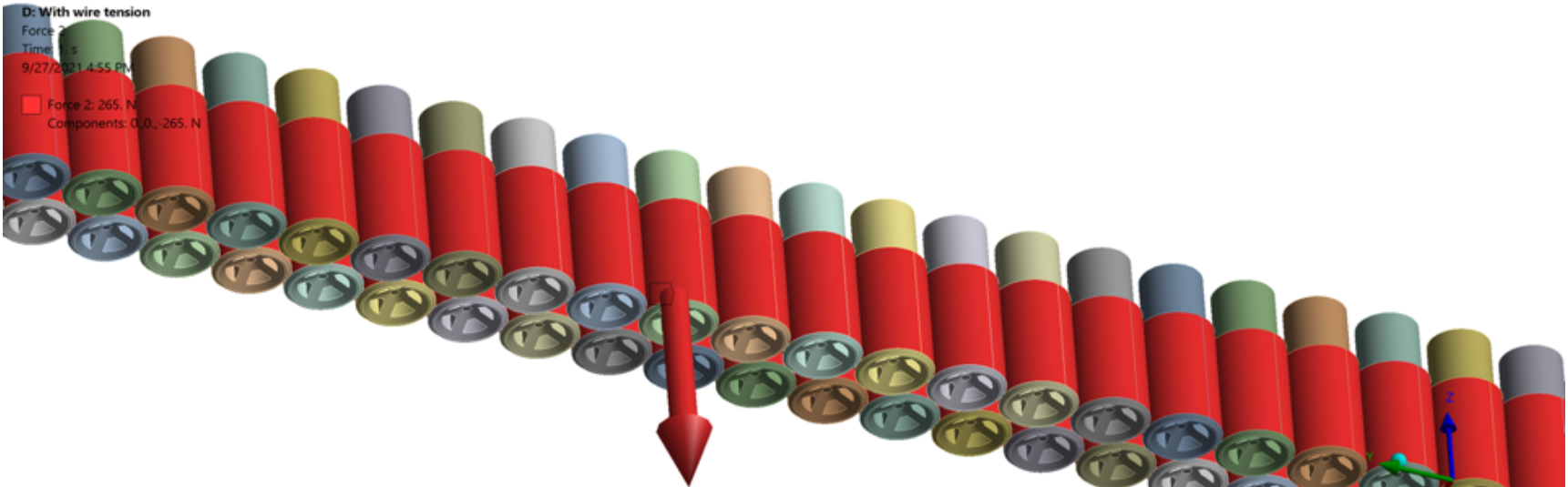
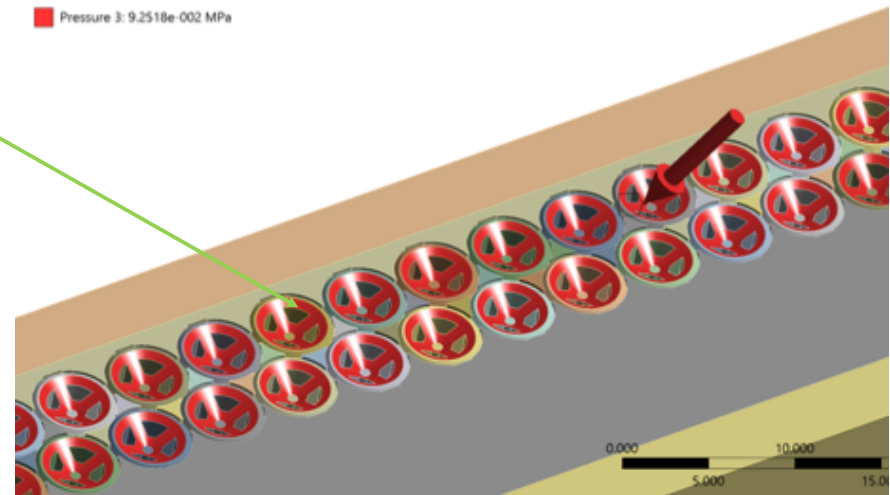
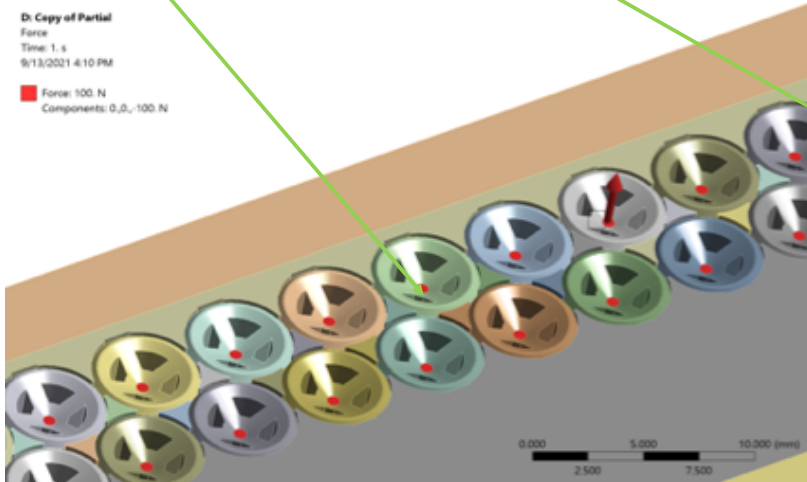
18

- ◆ *Prototype 1.2m × 0.8m based on design & parts as in full scale STT modules:*
  - *Build at JINR with help from GTU & other institutions;*
  - *Maximal size compatible with existing tooling & similar to NA64 detectors recently built at JINR;*
  - *4 straw layers XYYX: 672 straws total, no target, no radiator;*
  - *C-composite frame and assembly as in STT modules.*

⇒ *Aim to build the prototype in 2022 (summer?)*
  
- ◆ *FE analysis of deformations induced by gas pressure, wire and straw tension:*
  - *Removable lids giving access to gas manifolds and FE boards, gas tightness (O-rings, etc.);*
  - *Connection of individual straws to C-composite frame and related gas sealing;*
  - *Study interplay between internal overpressure and wire/straw tension.*
  
- ◆ *Evaluating options for procurement of required components.*
  
- ◆ *Contributing institutions:*  
*JINR, GTU, IIT Guwahati, Panjab, Duke, INFN, Hamburg, UofSC.*

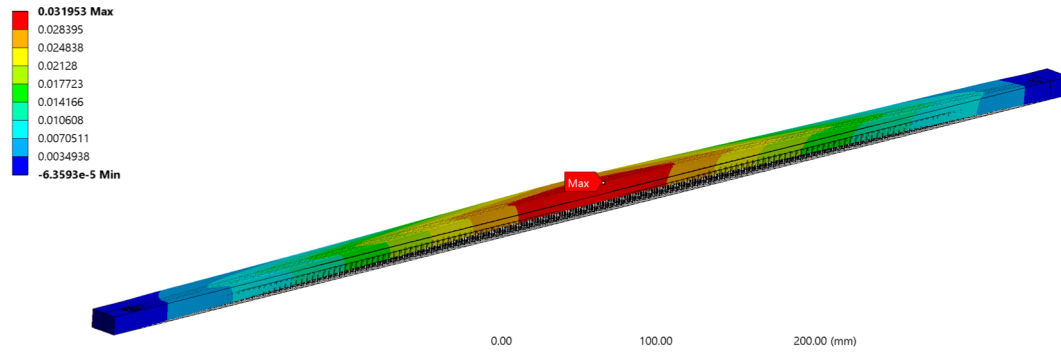


Applied pressure:  
0.092 MPa  
Applied Force:  
100N (for 336 wires)



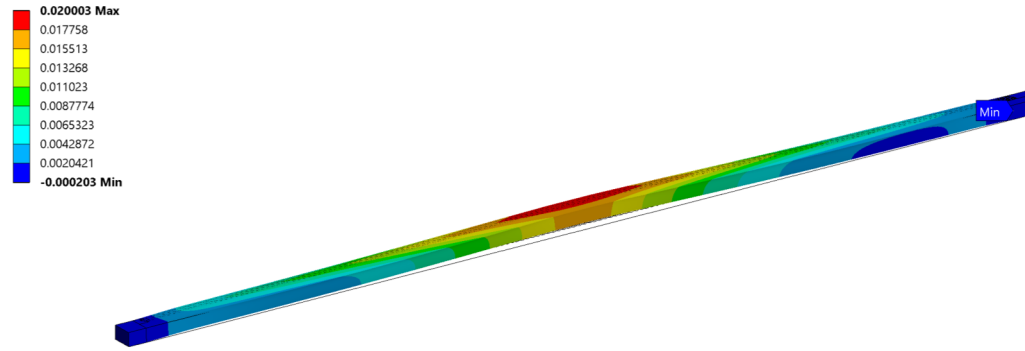
Gas pressure only:

+Z 0.032 mm  
-Z 0 mm



Gas pressure + wire tension:

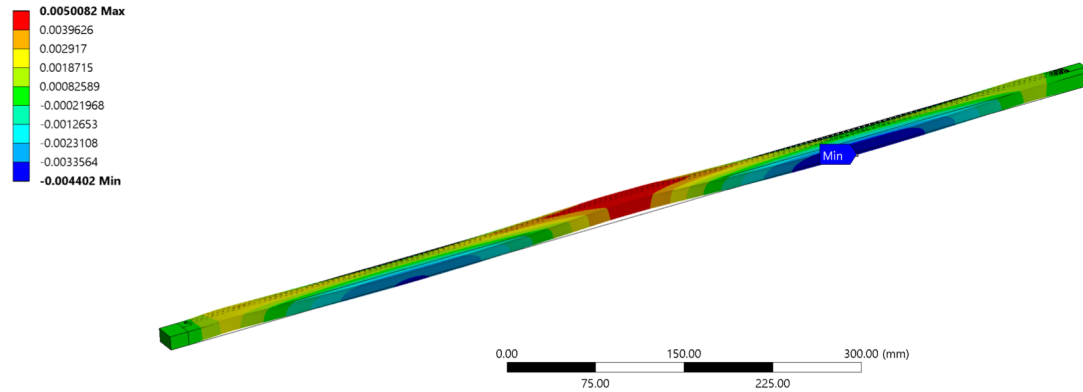
+Z 0.02mm  
-Z 0.0002mm

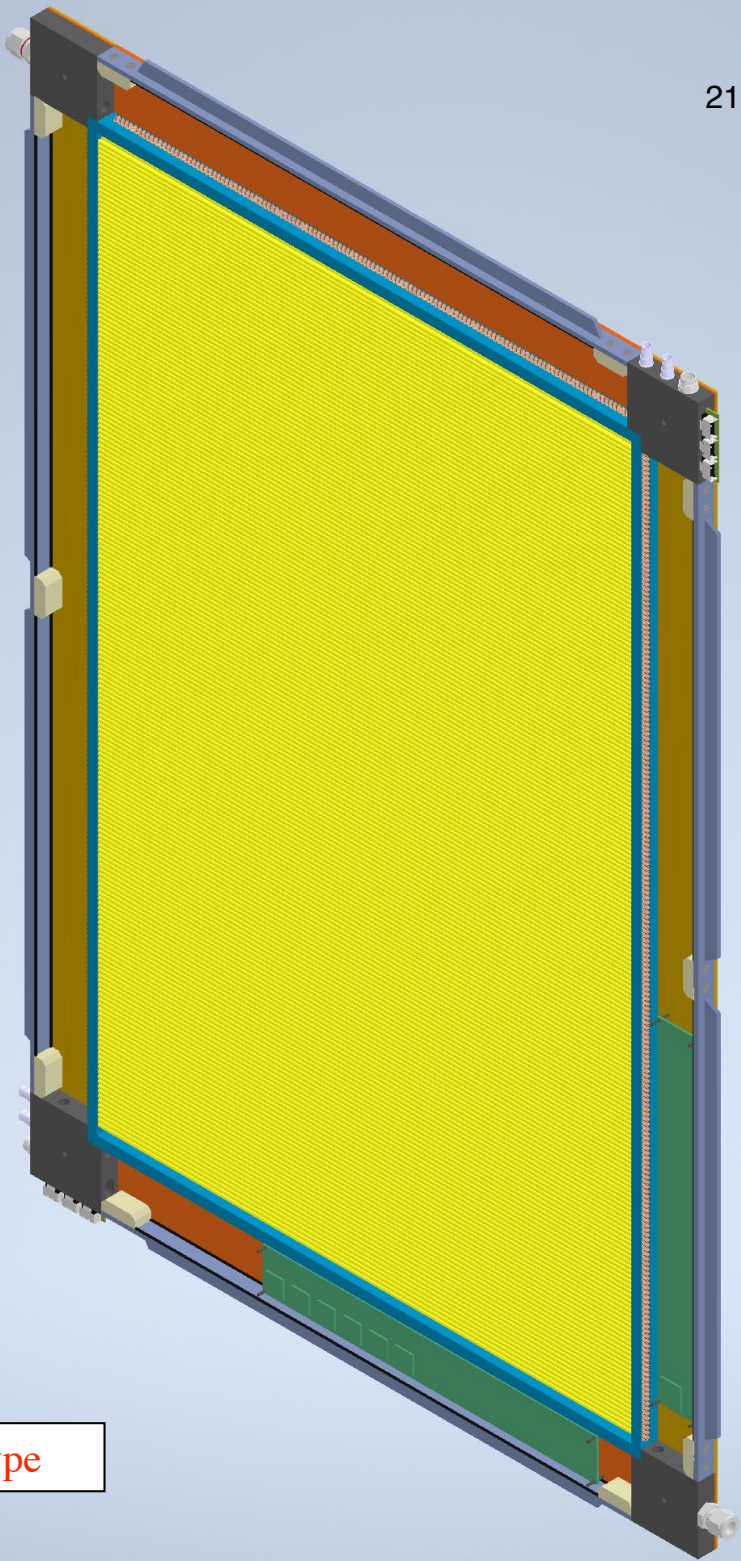
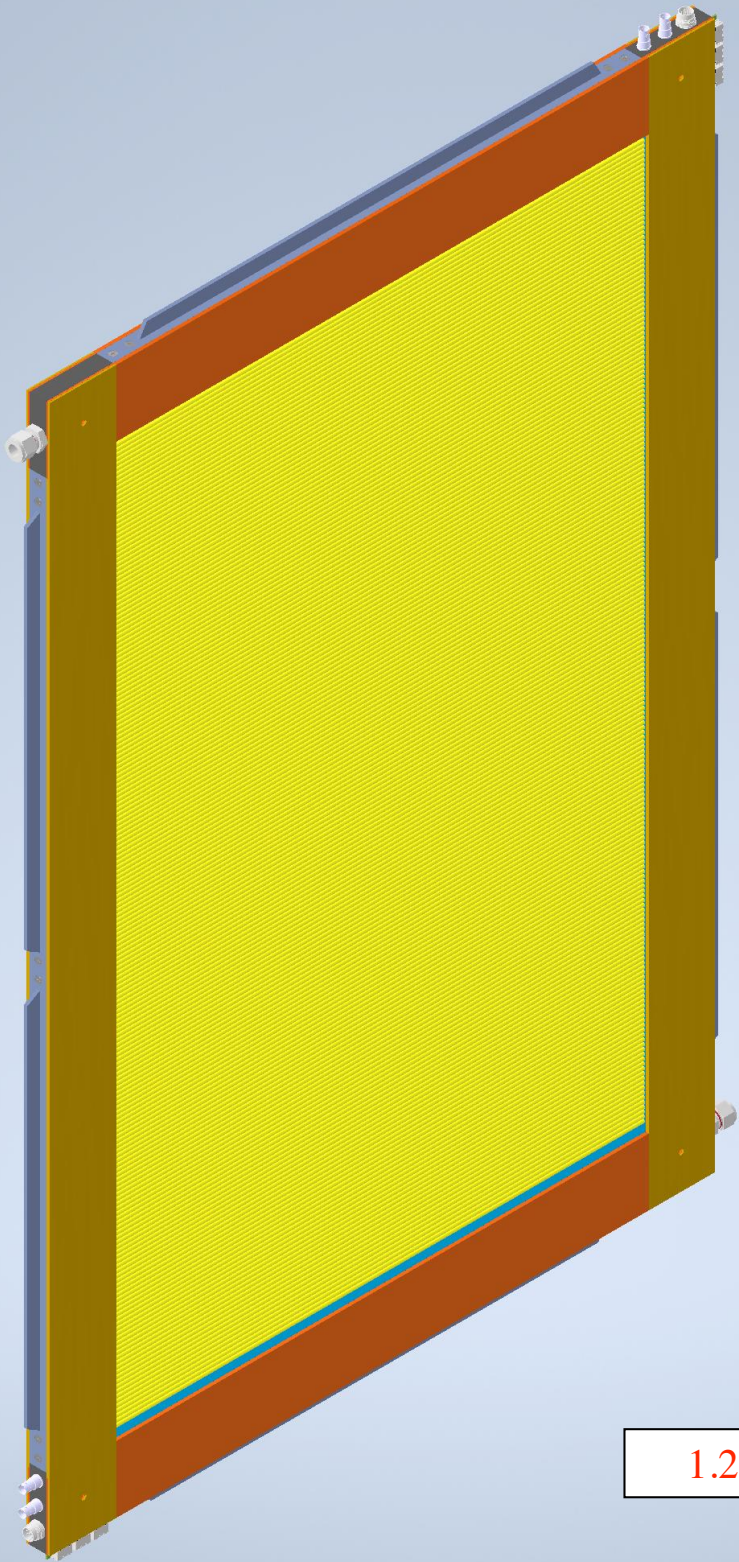


Gas pressure + wire tension

+ tension from straw walls:

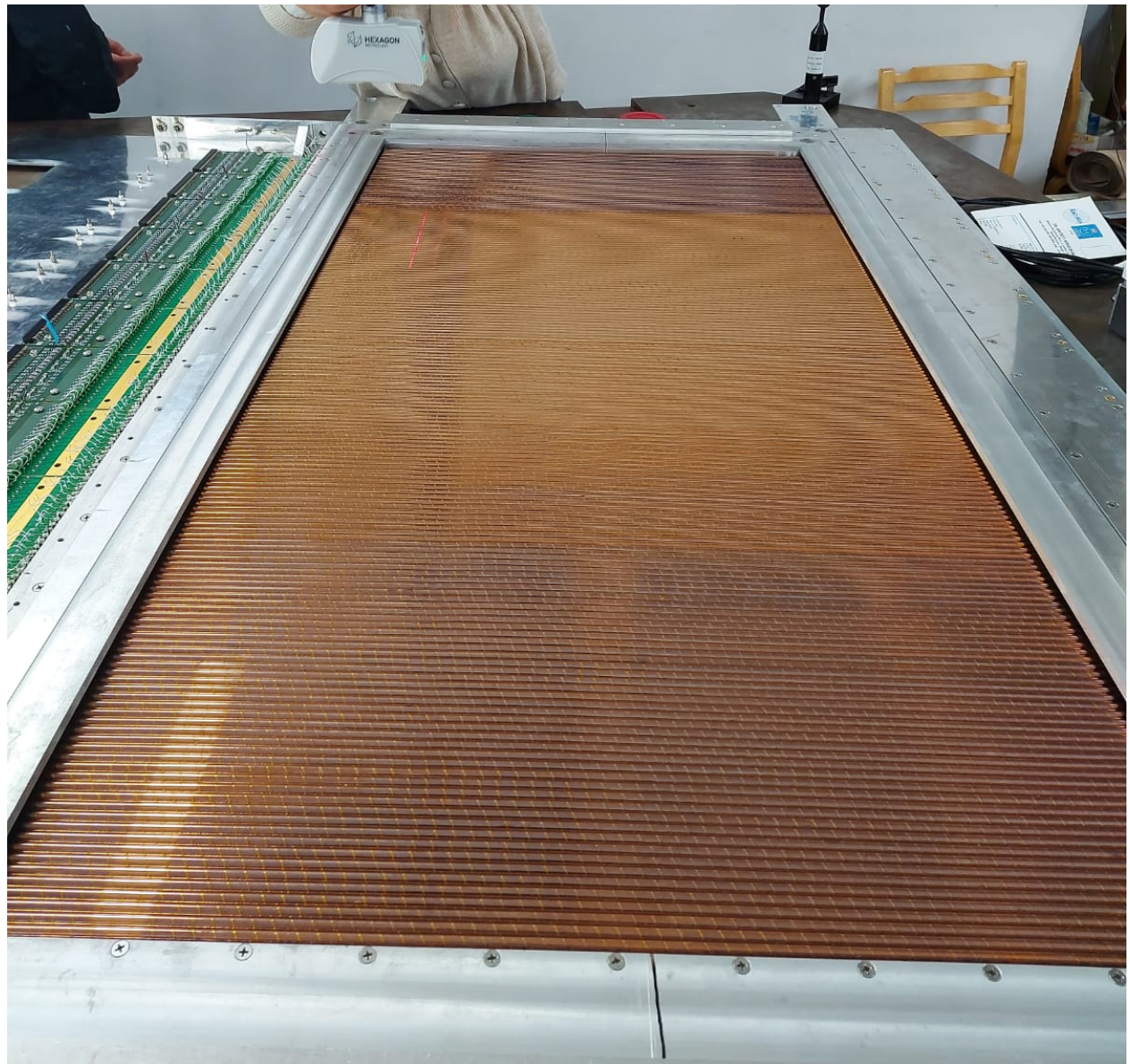
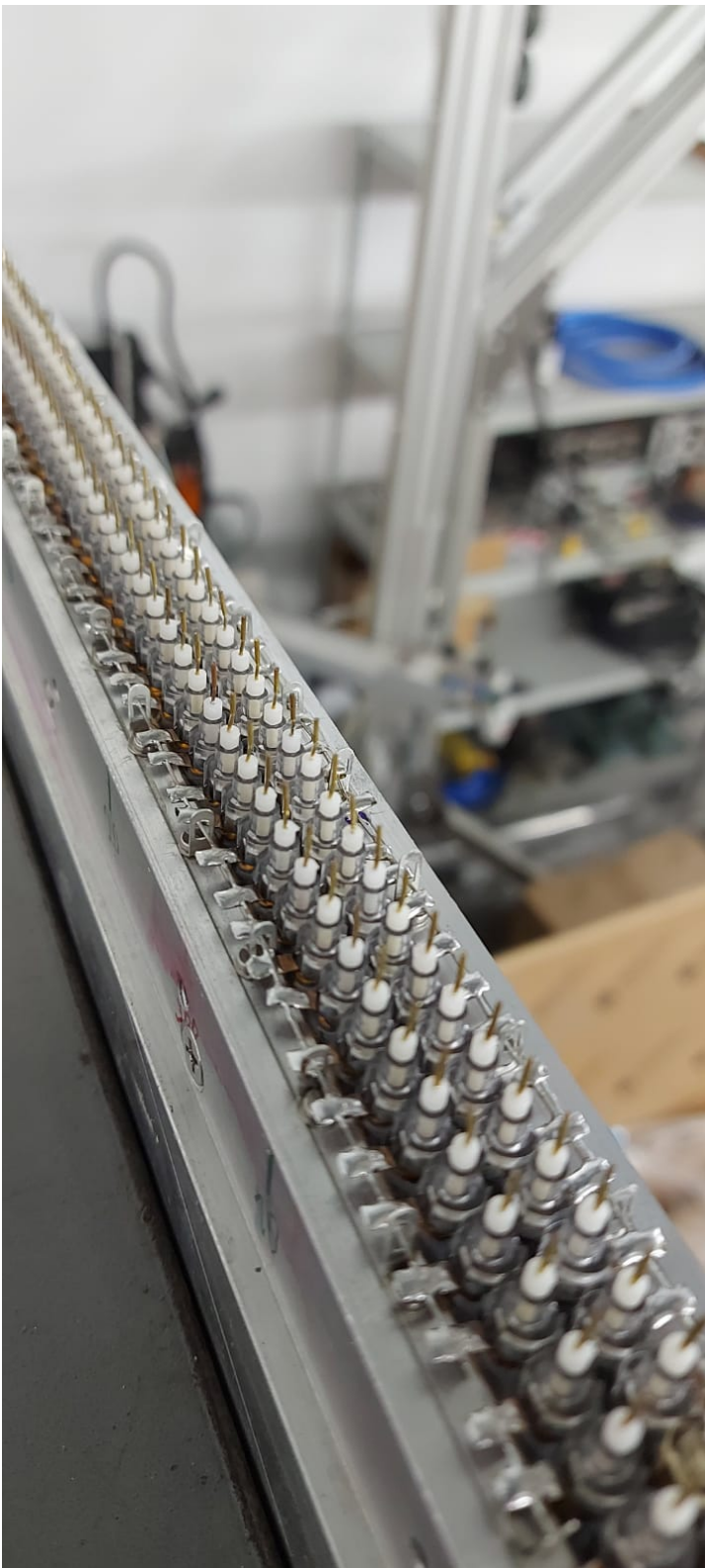
+Z 0.005mm  
-Z 0.004mm



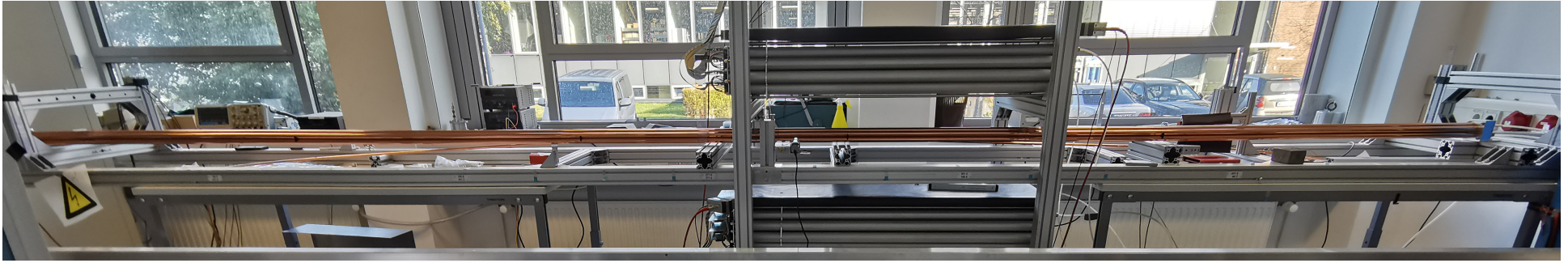


1.2 m x 0.8 m prototype

**Backup slides**



*JINR built 7 detectors 1.2 m x 0.6 m for NA64  
sent to CERN in August  
6 detectors will be on beam from October 29*



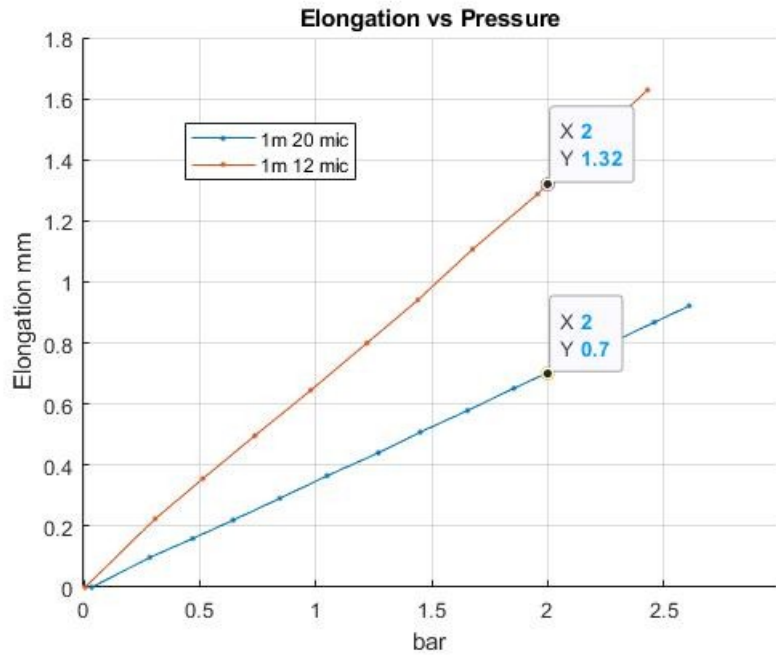
*Test of 5m long straws for SHiP at the University of Hamburg*

*Test of 1.8m long straws for STT  
at Panjab University*

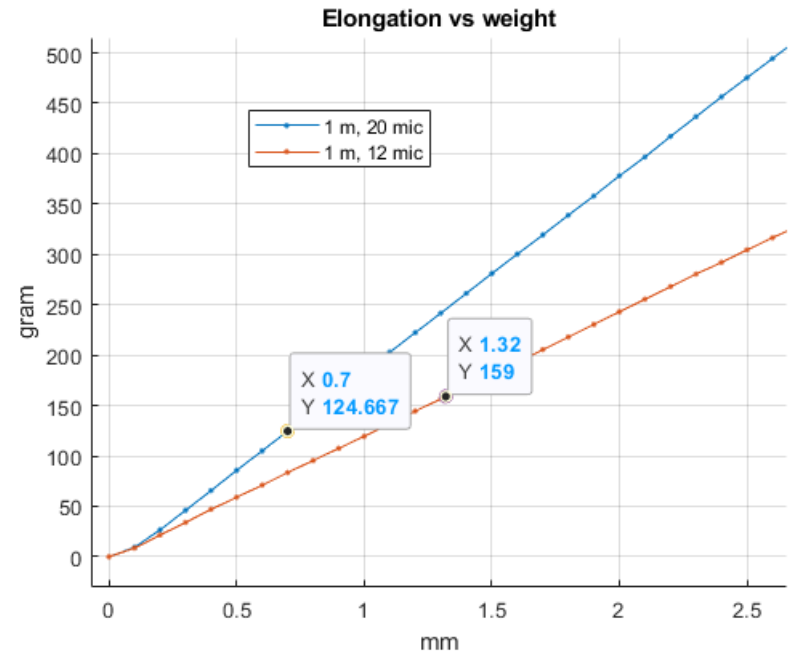




Elongation of fixed tube based on pressure change



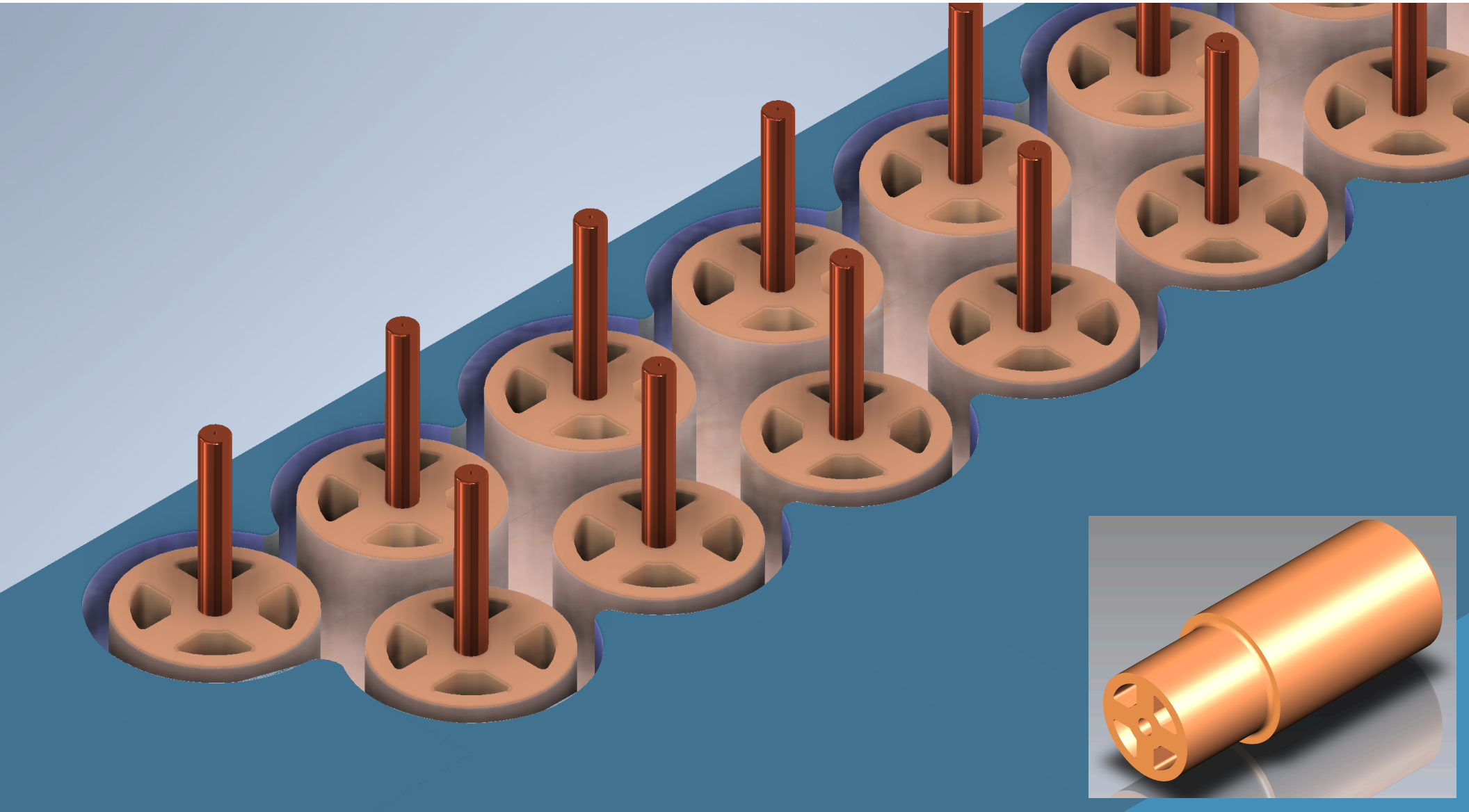
Tube elongation with weights with no pressure

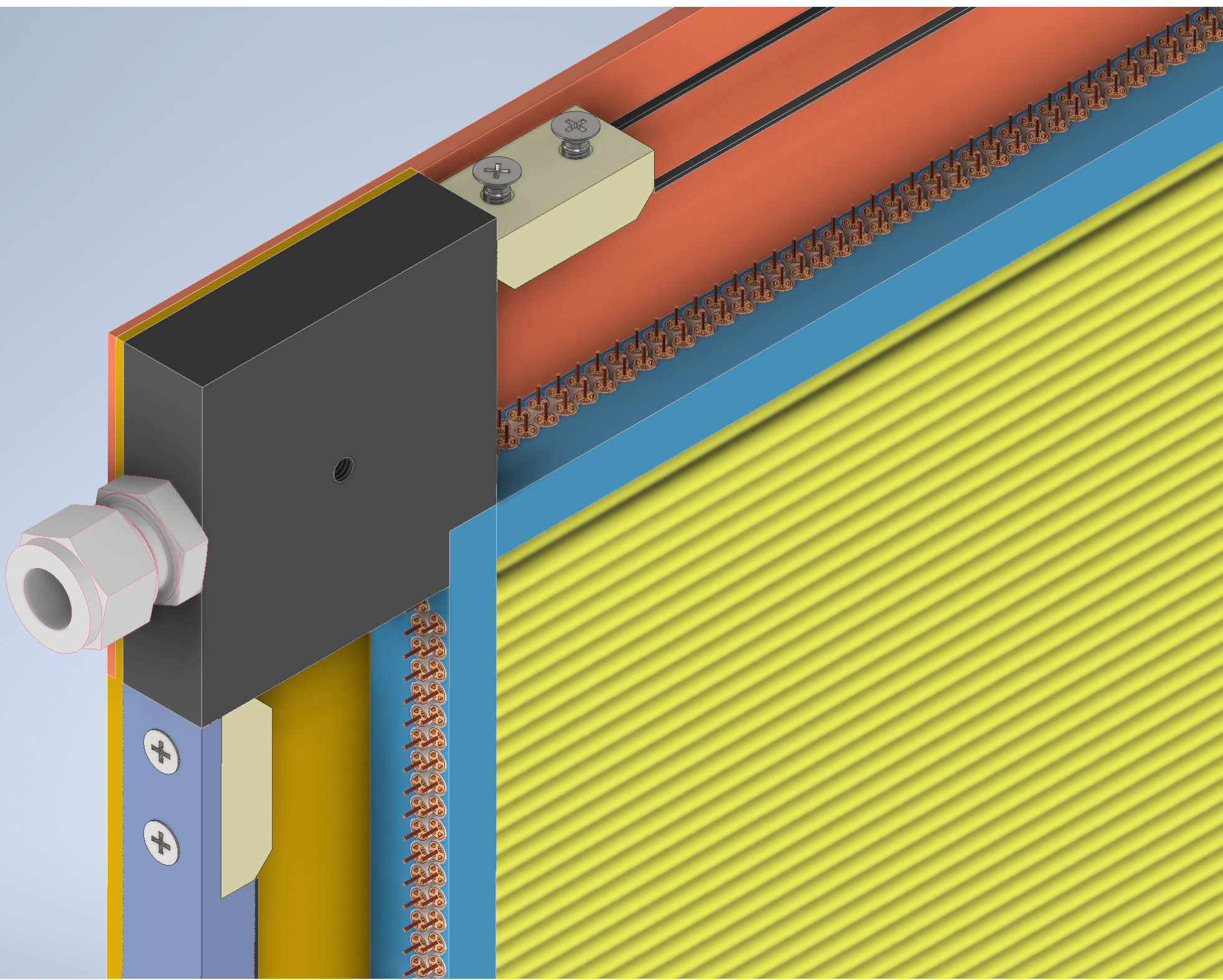


*Measurement of elongation and tension with straws 1.0 m long, 5 mm diameter*

Straw numbers	Length	Diameter	Thickness	Elongation at 1 bar (relative)	Weight
1	1 m	5 mm	12 $\mu$ m	0.66 mm	78.5 g
1	1 m	5 mm	20 $\mu$ m	0.35 mm	56 g
1	0.5 m	5 mm	12 $\mu$ m	0.276 mm	35 g
1	0.5 m	5 mm	20 $\mu$ m	0.17 mm	44 g
400	1 m	5 mm	12 $\mu$ m		31.4 kg
400	1 m	5 mm	20 $\mu$ m		22.4 kg

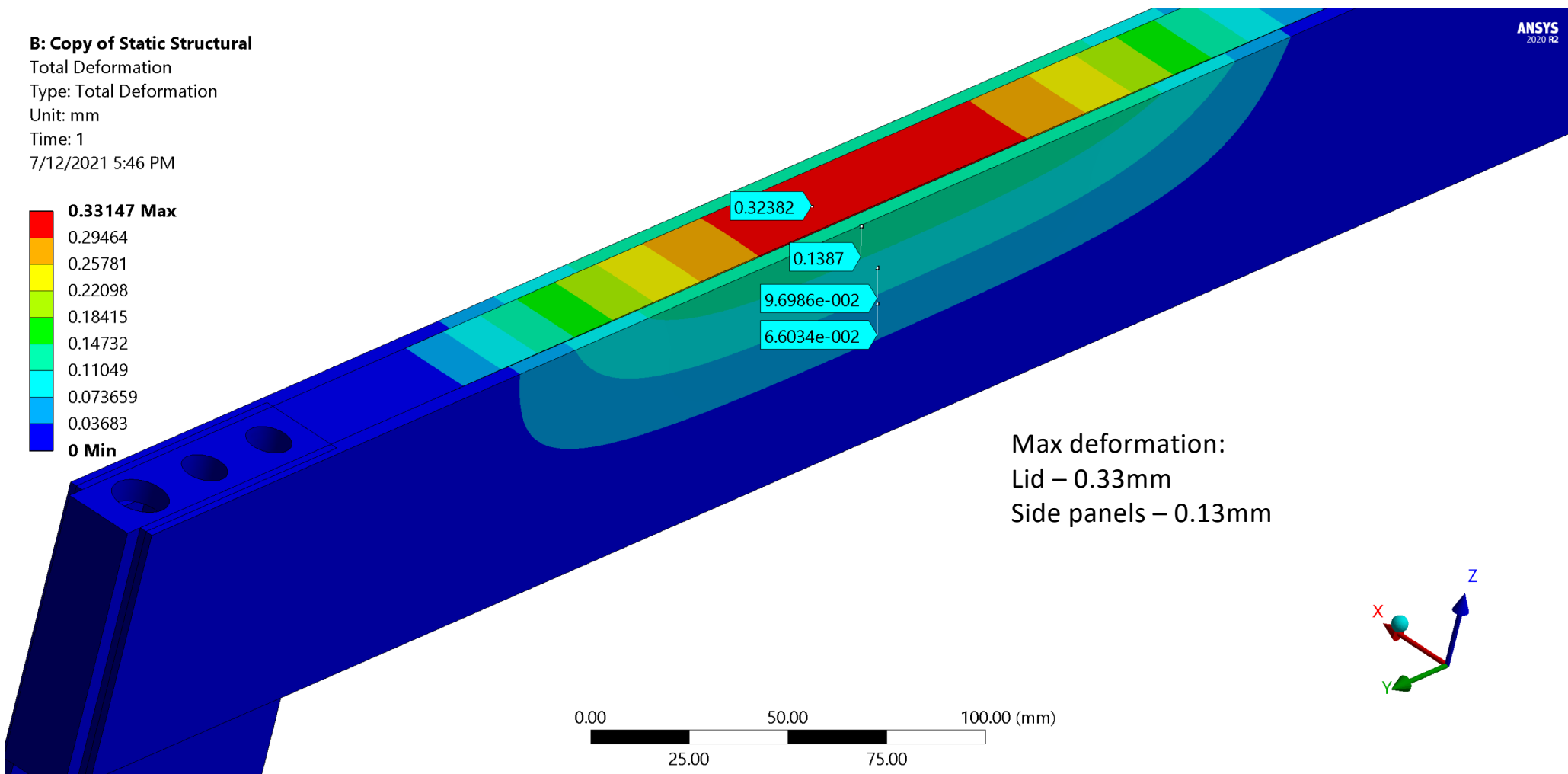
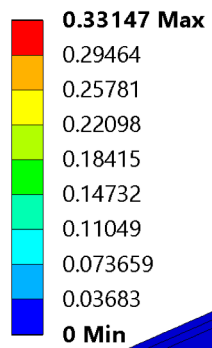
*Expected maximal elongation for 4m long straws ~2.6 mm  
similar maximal frame deformation expected with assembly based on pressurized straws*





**B: Copy of Static Structural**

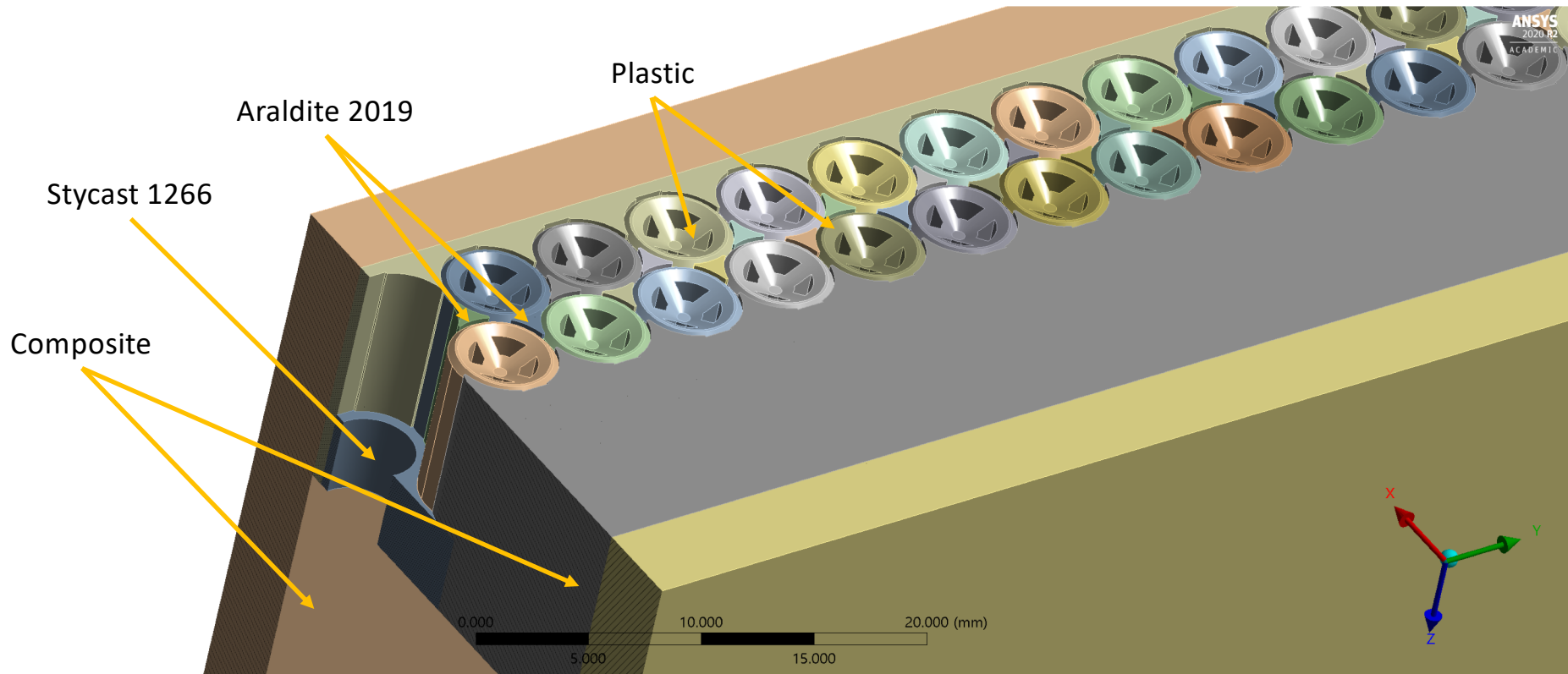
Total Deformation  
Type: Total Deformation  
Unit: mm  
Time: 1  
7/12/2021 5:46 PM

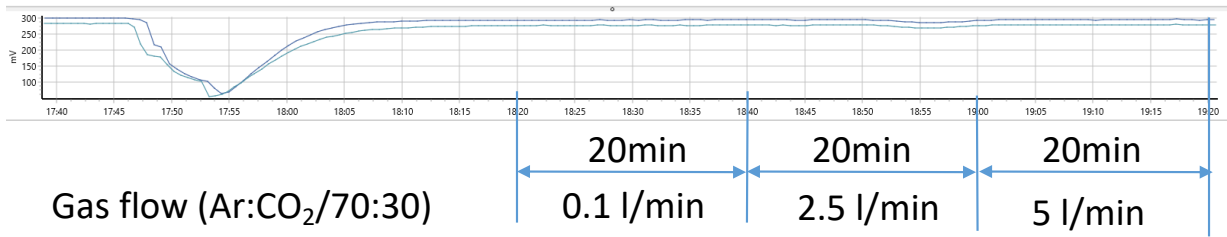
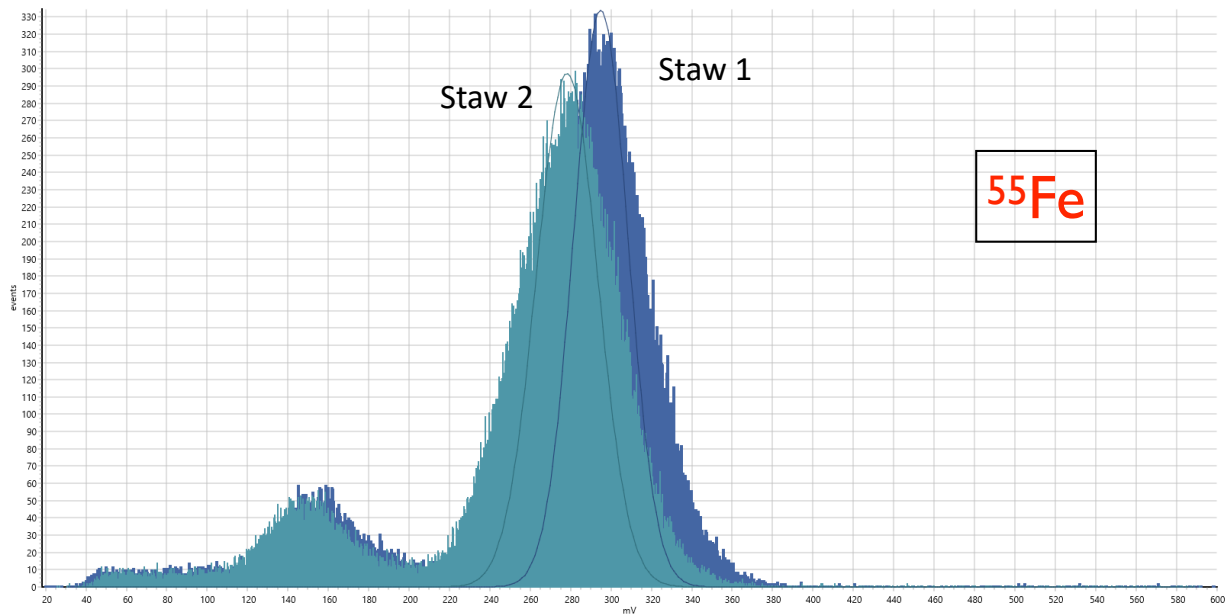


Max deformation:  
Lid – 0.33mm  
Side panels – 0.13mm

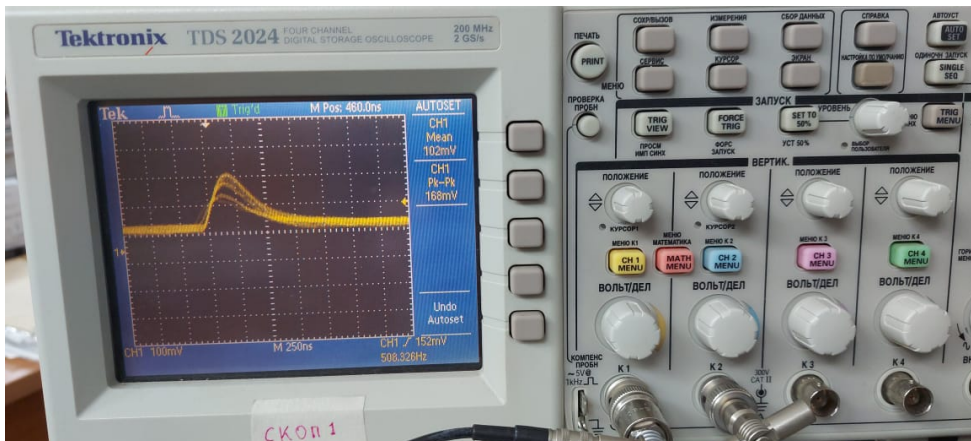
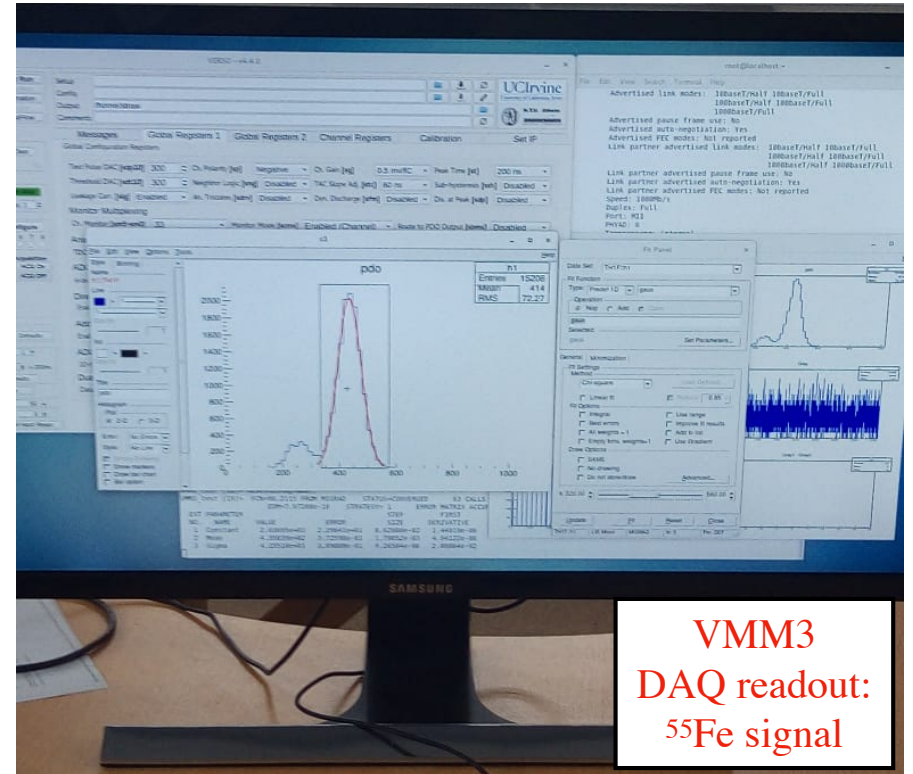
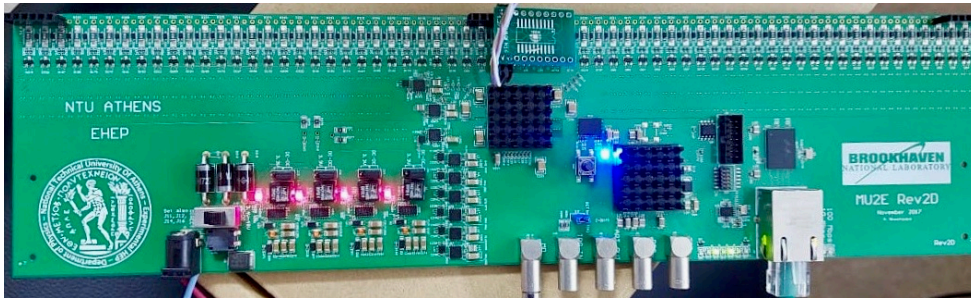
Geometry

9/13/2021 3:45 PM





*Monitoring of gas gain with increased gas flow up to 2,000 times nominal (JINR)*



*Validation of VMM3a readout with the prototype at JINR:  
signals from cosmic rays and  $^{55}\text{Fe}$  source with Ar/CO<sub>2</sub> 80/20  
using FPGA-based DAQ readout with existing VMM3 firmware+software*