Report from STT Working Group

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SAND meeting
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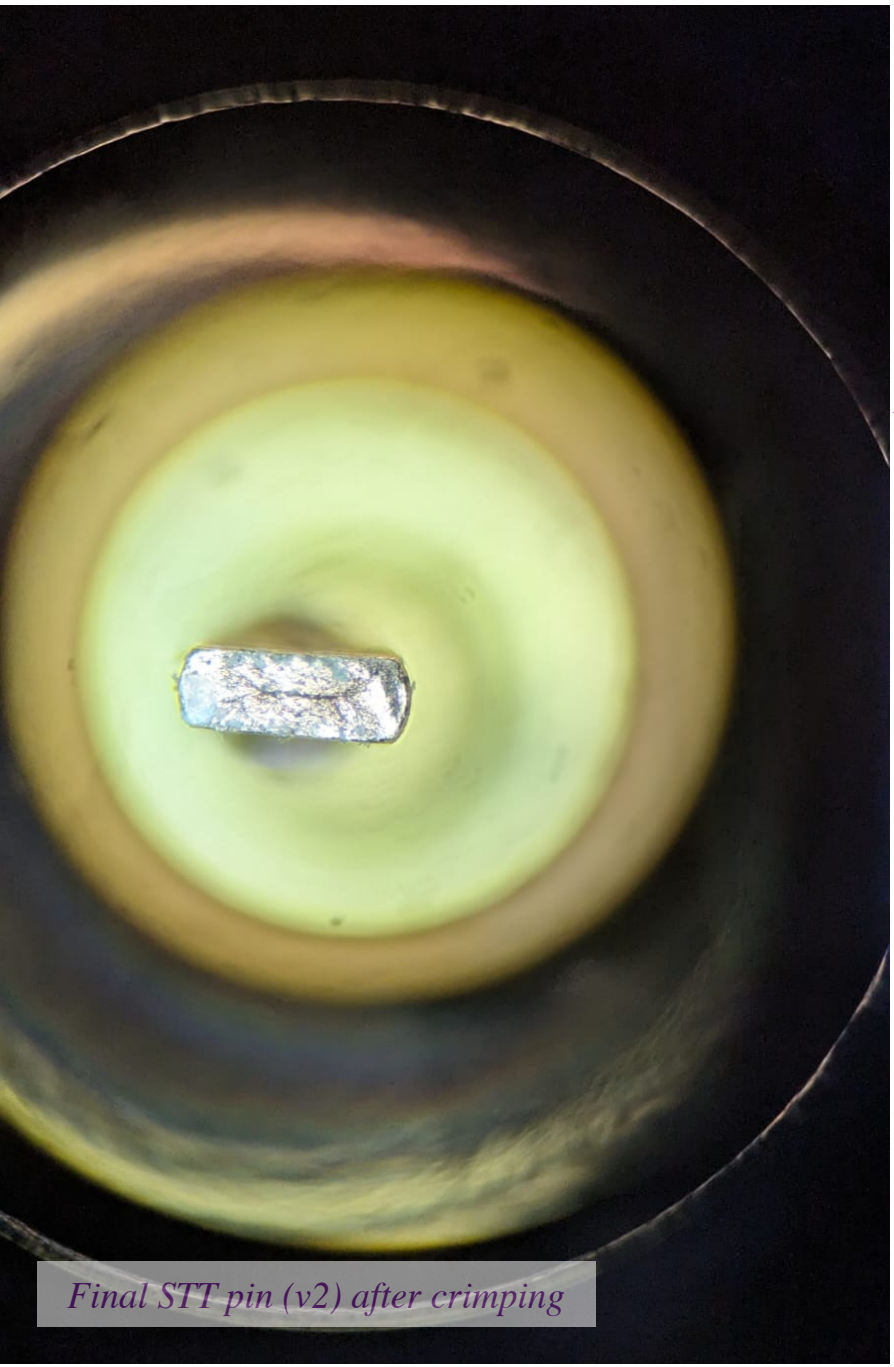
OUTLINE

Focus on progress since 03/19 SAND meeting:

- *Tests of the final design of the crimping pins and supplier selection;*
- *Tests of wire spacers with 4m straws;*
- *Updated C-fiber frame and preparation for Pisa prototype;*
- *Thermal analysis of 4m STT module with new readout boards;*
- *Study of gas flow in full scale 4m STT modules;*
- *C and CH_2 targets for STT modules;*
- *Super-module assembly and module configurations.*

Material presented during WG meetings (Wednesdays, 8:00am Central Time / US) available on Indico:
`https://indico.fnal.gov/category/1402/`

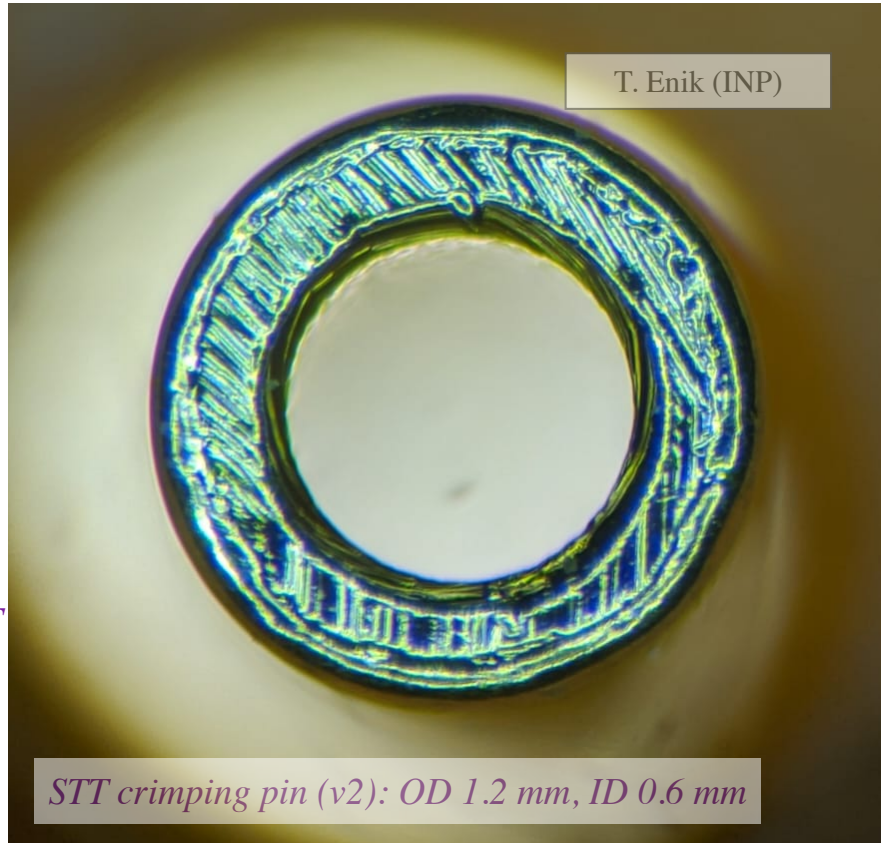
TESTS OF CRIMPING PINS



Final STT pin (v2) after crimping

Final version of STT crimping pins (v2) improved quality of central hole and gold plating

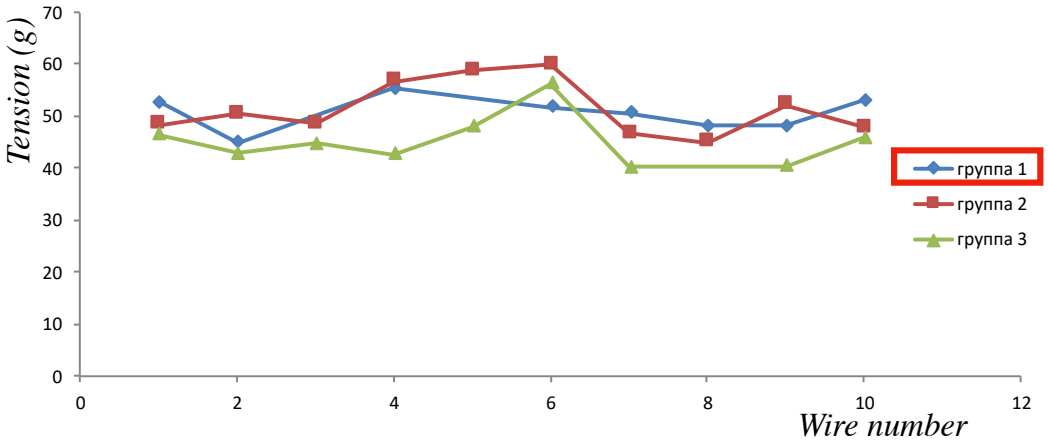
(better quality than ATLAS pins)



T. Enik (INP)

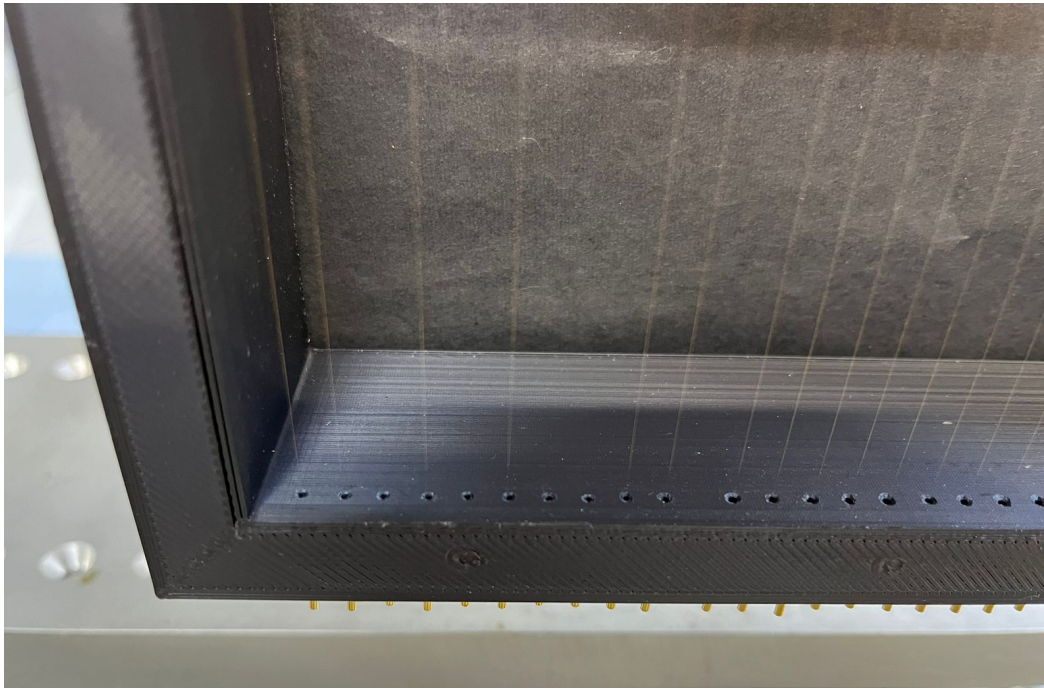
STT crimping pin (v2): OD 1.2 mm, ID 0.6 mm

ATLAS pin: OD 0.7 mm, ID 0.1 mm

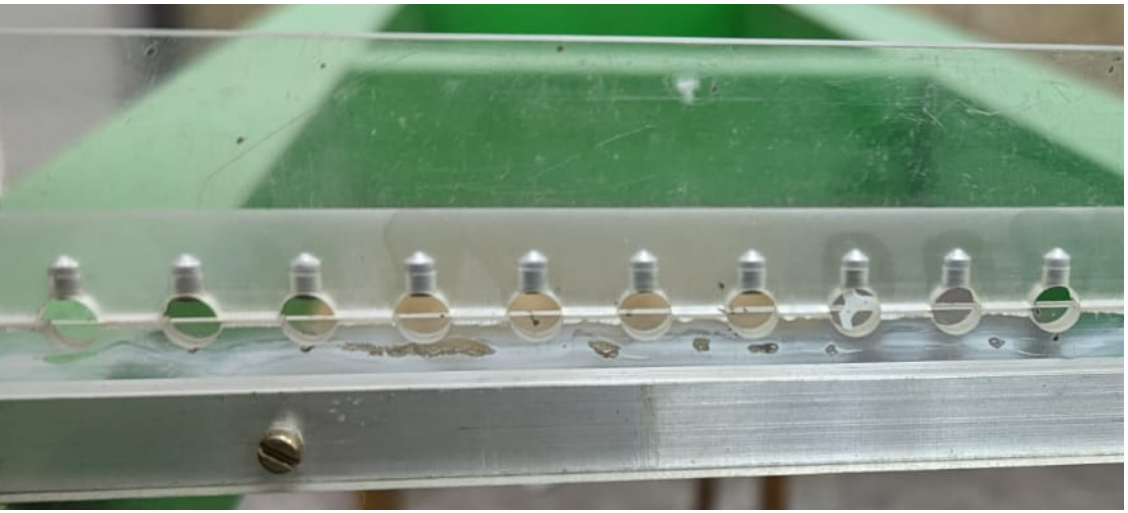


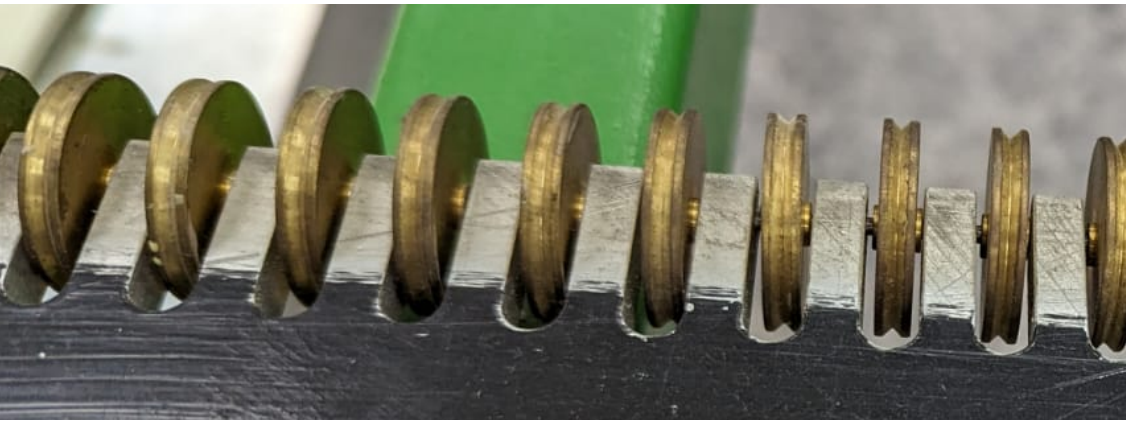
Samples of 1,000 pins (v2)
from 3 different Chinese vendors

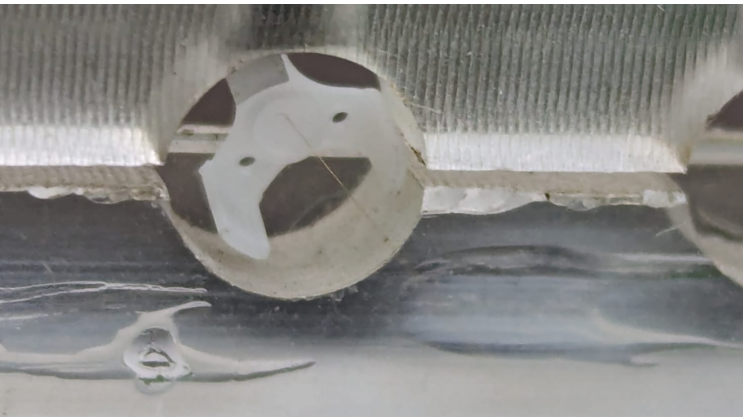
Comparison of different samples after
crimping 20 µm wire with ATLAS tool
and selection of final vendor



TESTS OF SPACERS WITH 4m STRAWS







Tooling developed for COMPASS to glue spacers on 4m long wires before insertion into straws

A 4m straw is held under tension in vertical position with a support profile

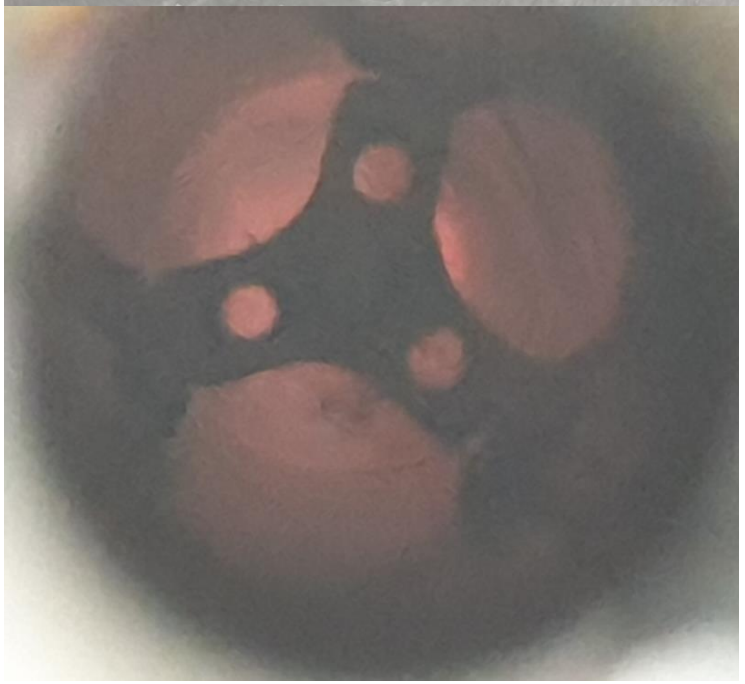
The wire with glued spacers is attached to ordinary thread

The wire is inserted into the straw and the ordinary thread pulled down

The straw is terminated with end-plugs and wire crimping pins

TESTS OF SPACERS WITH 4m STRAWS

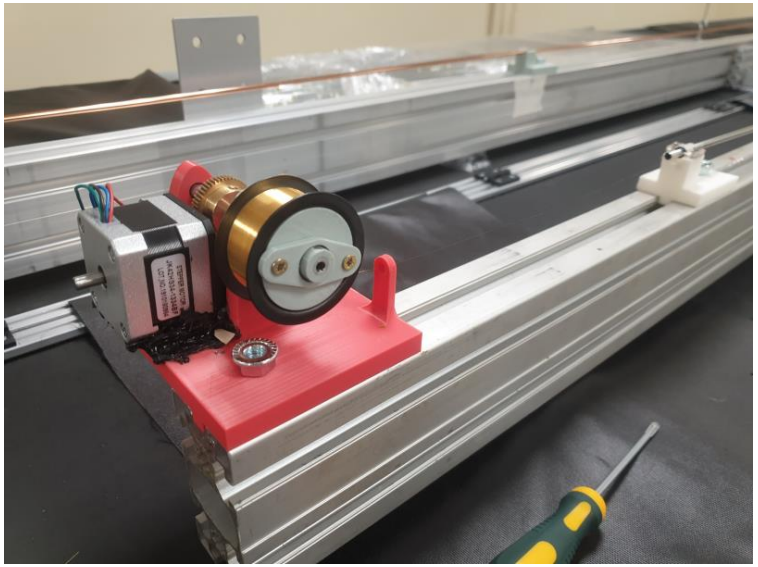
N. Tsverava (GTU)

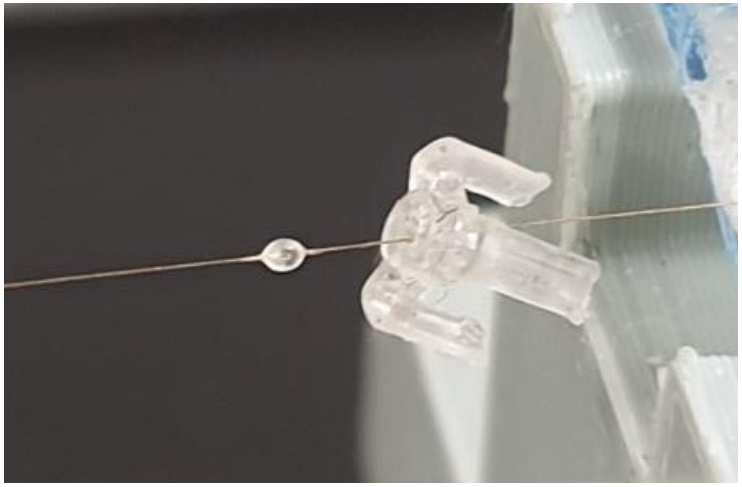


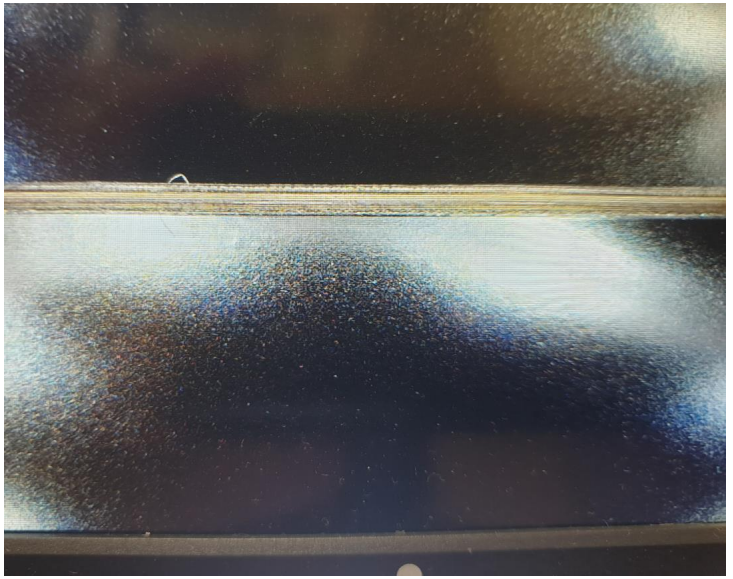
Wiring of 4m straws with 3 spacers in horizontal position

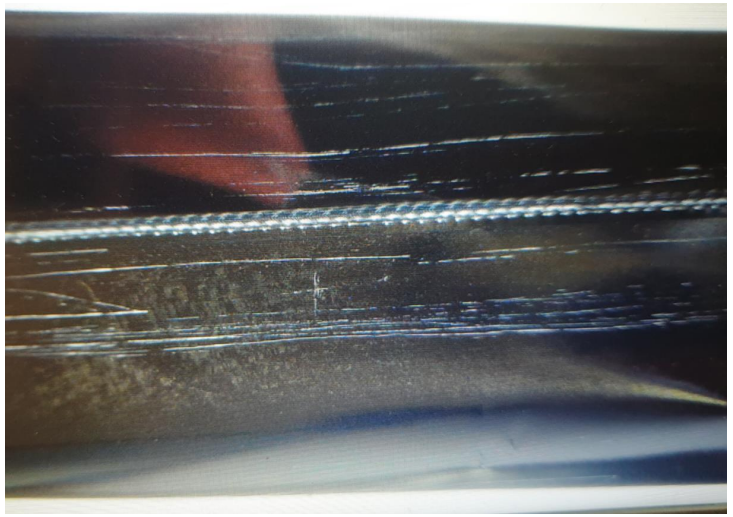
Wire is pulled inside the straws

Optimized with spacers produced with UV 3D printing (100 μm hole)



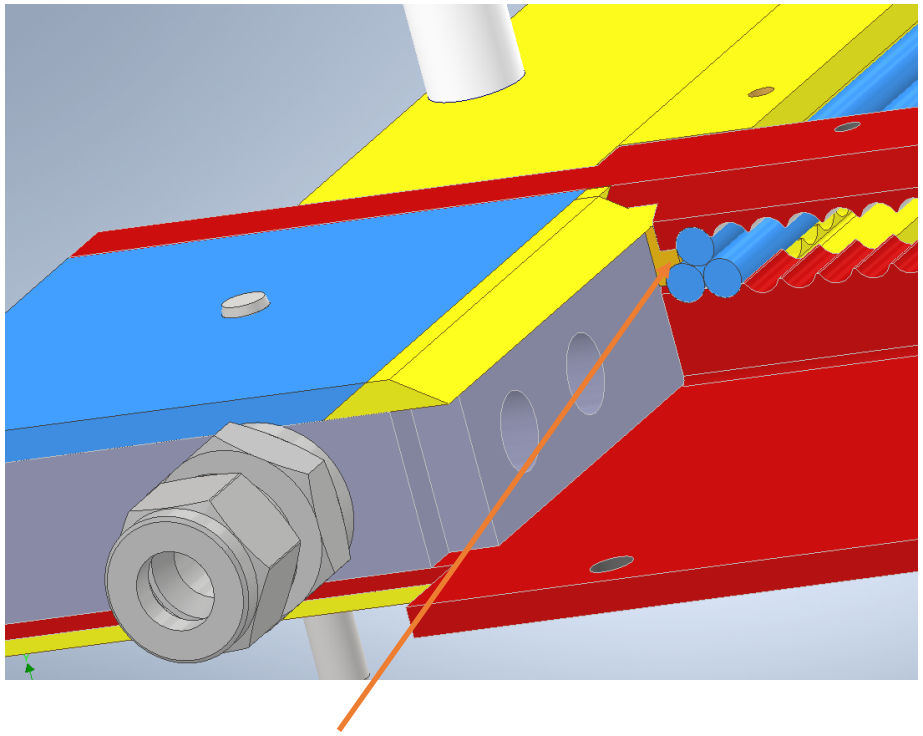




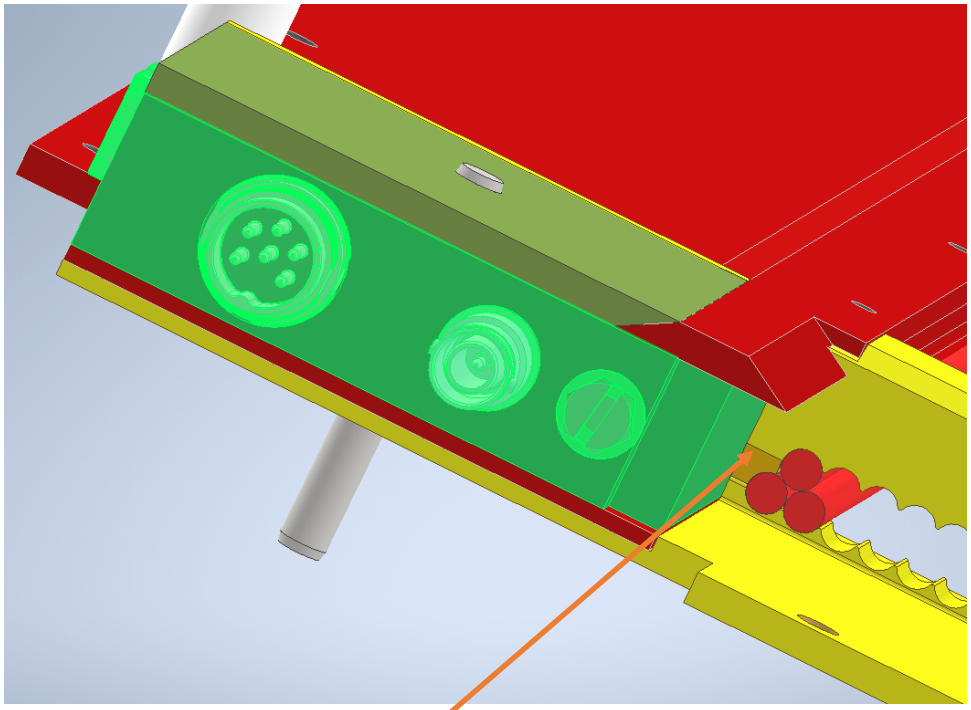


- *Drop of dual-component cyanoacrylate glue on the wire to block spacer mechanically;*
- *Successful wiring if spacer within tolerances and with smooth external surface;*
- *Some scratching of internal metallization observed due to roughness of 3D printed spacer surface.*

FRAME AND PROTOTYPE UPDATES



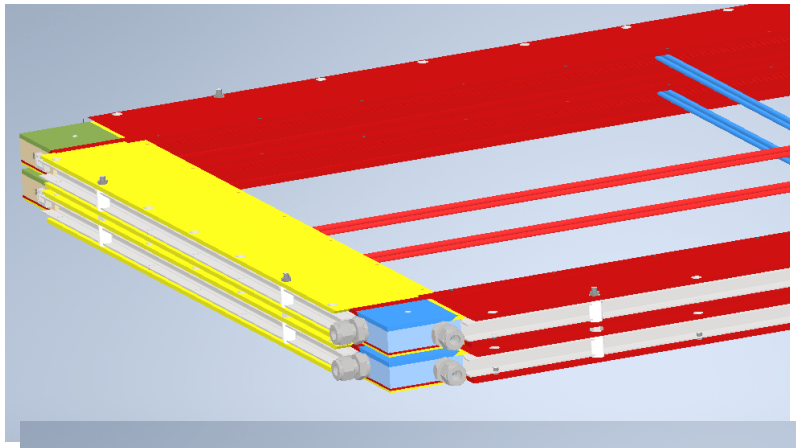
3D printing piece

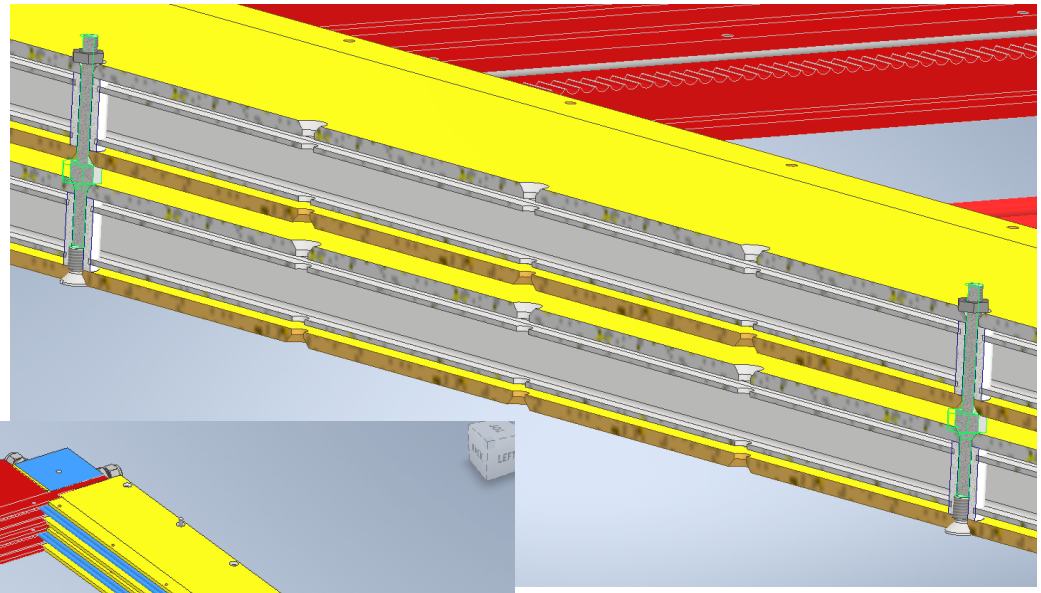


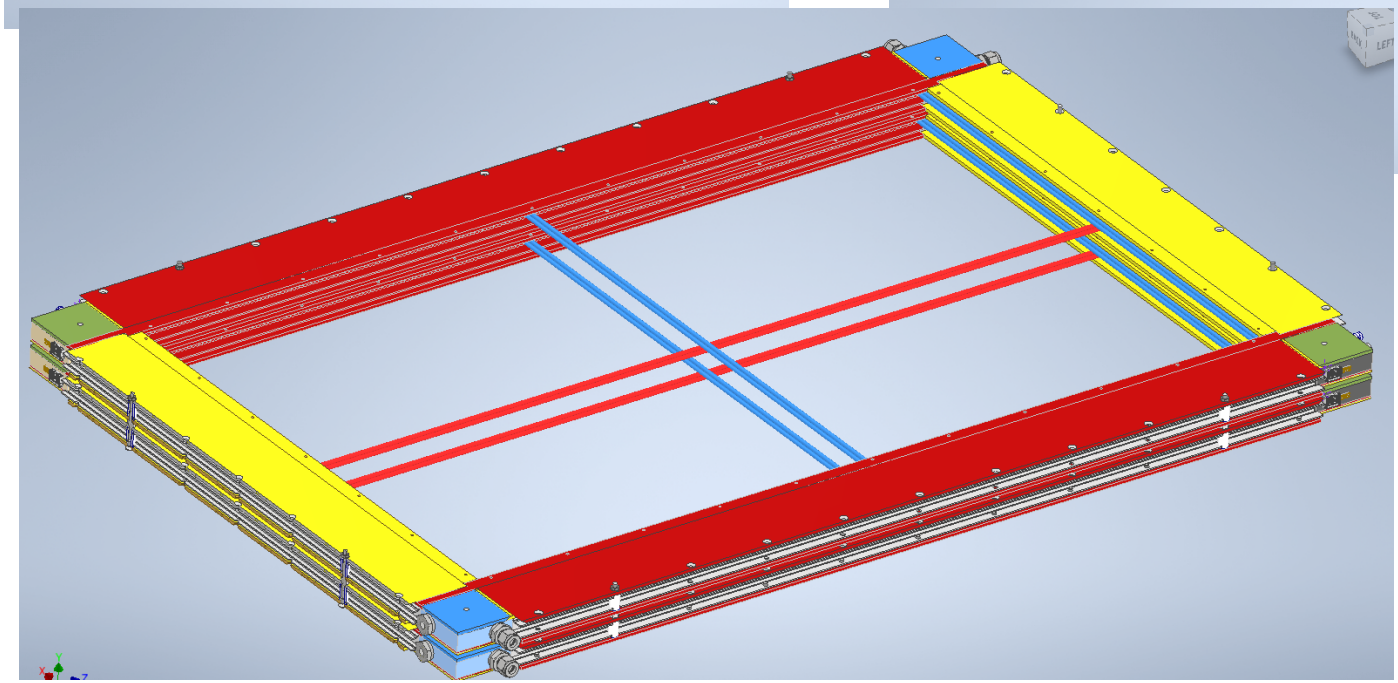
3D printing piece

- *Straw diameter increased by 50 µm to eliminate need of paper spacers during assembly;*
- *Small modification of C-fiber frame to improve sealing procedure;*
- *Updated corner blocks with independent gas and electrical connections for XX and YY layers.*

$\Longrightarrow$ *Production of updated frame in progress for the second Pisa prototype*

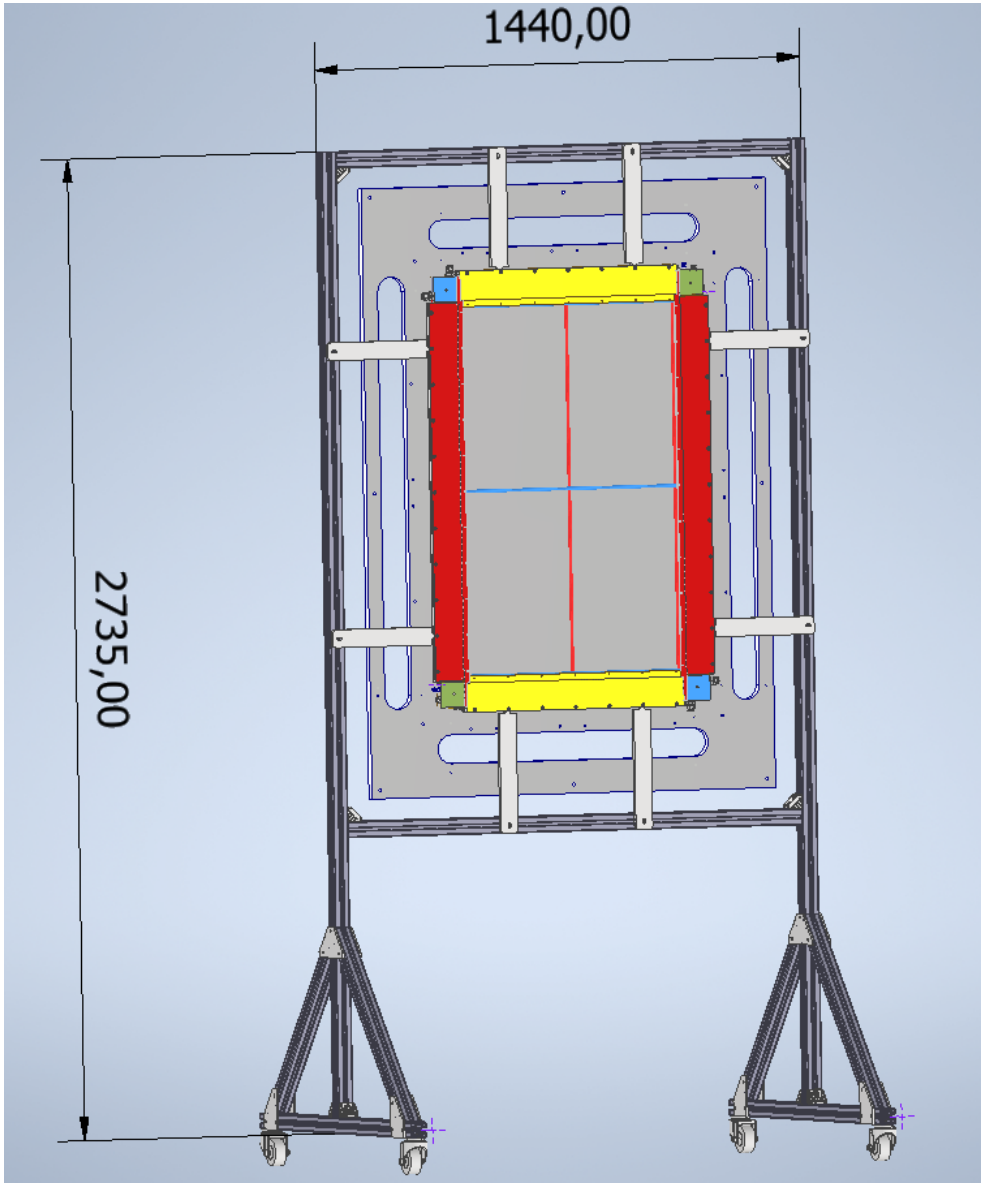






Locking of two modules with threaded Al rods

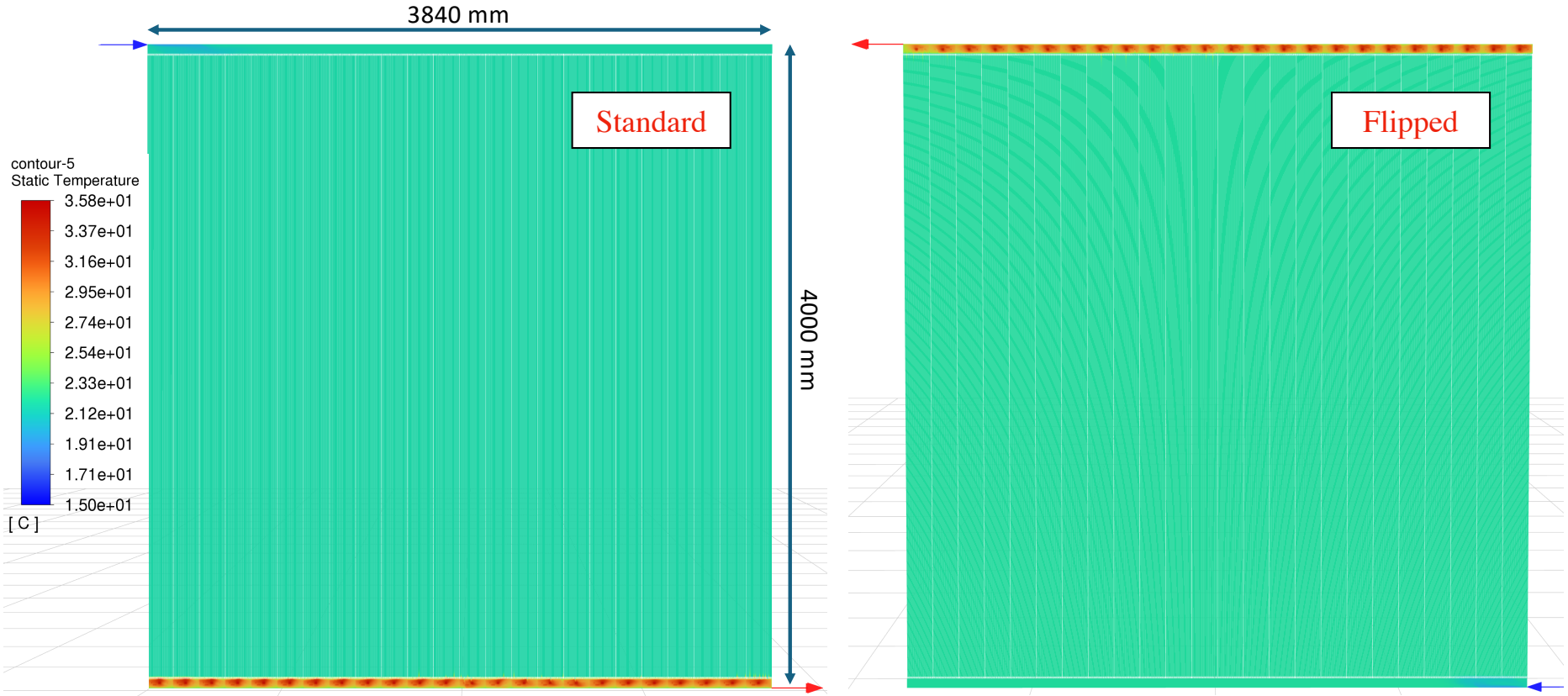
Test of super-module assembly



CERN prototype mounted on dedicated stand to be used at testbeam

THERMAL ANALYSIS

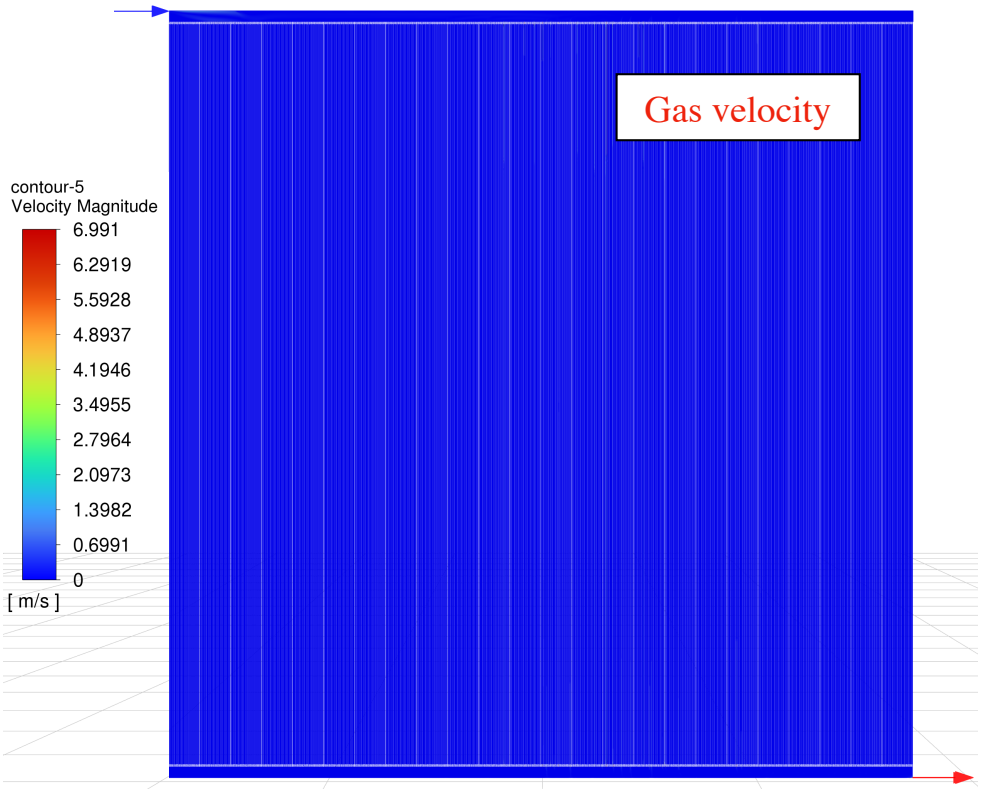
O. Kemularia (GTU)

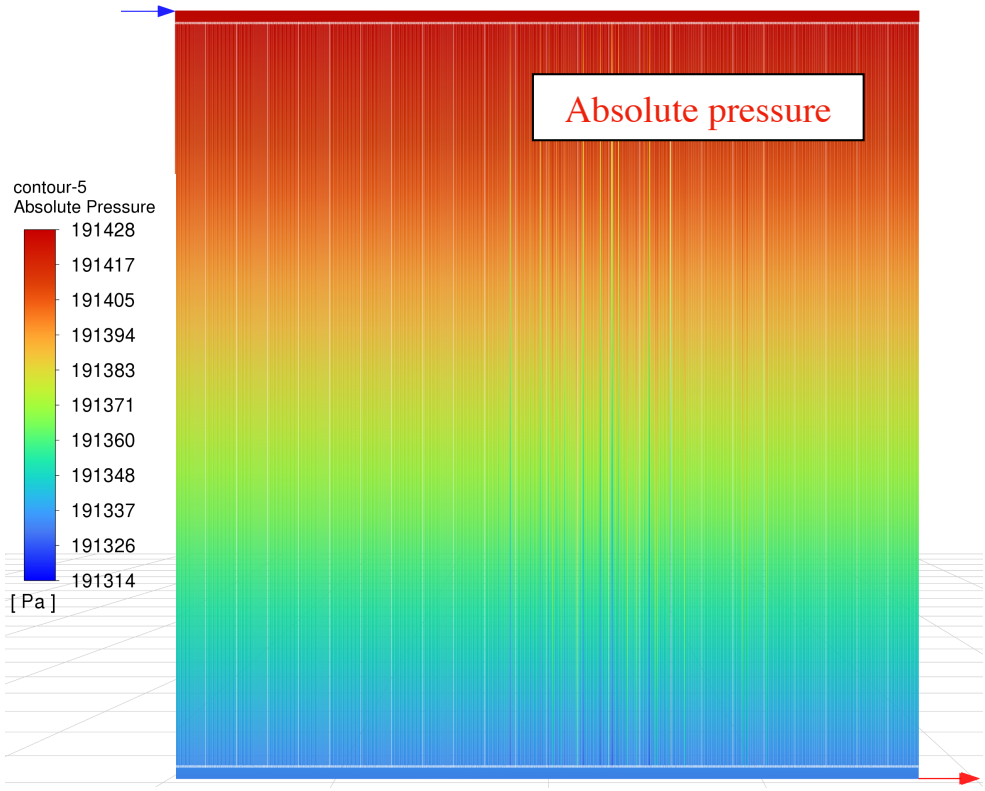


- *Thermal analysis of full scale 4m STT module with 24 integrated readout boards;*
- *Self-cooling design with expected total power dissipation about 0.65 W per board (mostly ASIC)*

$\Longrightarrow$ *Maximal temperatures obtained well below 40^0 C allow extended board lifetime*

GAS FLOW STUDIES





- *Study of gas flow within a 4m STT module to verify uniformity and inlet/outlet design;*
- *Check local gas velocity and pressure inside manifolds/straws for both standard and flipped modules*

$\Longrightarrow$ *We can achieve steady state with uniform gas flow across the 4m STT module*

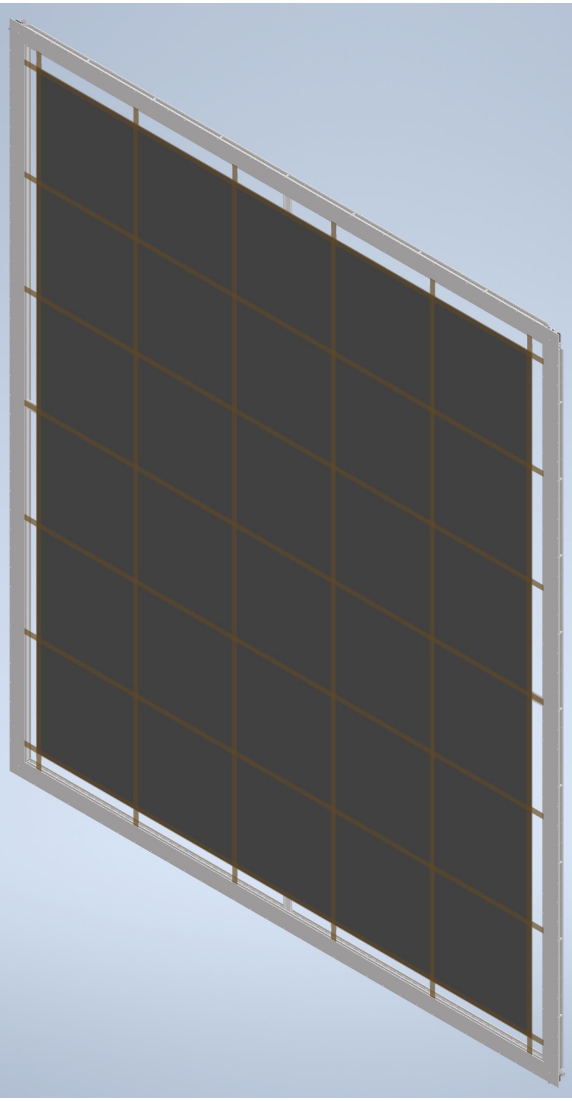
C AND CH_2 TARGETS

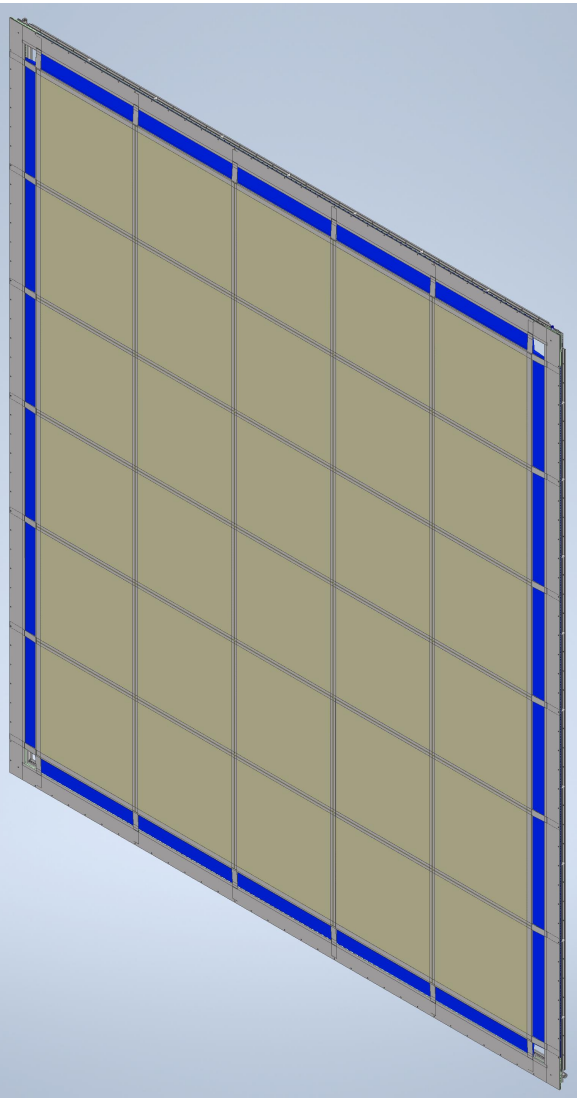
RP (USC)

Frame of the STT tracking module (4m × 3.3m) based on design of 1.2m CERN prototype (F. Raffaelli)

+

Graphite target installed





Frame of the STT tracking module (4m × 3.3m) based on design of 1.2m CERN prototype

+

Radiator (CH_2)

+

Polypropylene (CH_2) target installed

- *Tracking module XXYY common to all STT modules*
- *Both C and CH2 targets made of 595mm × 595mm tiles held together by C-fiber/polypropylene tapes*

CONFIGURABLE MODULES

✦ *CH_2 targets and radiators can be individually removed/replaced from tracking modules*

$\Longrightarrow$ *Flexible design allowing different configurations*

✦ *Target + radiator mounted onto base STT tracking module*

- *Default configuration corresponding to the nominal CH_2 fiducial mass (6.89 mm total per module);*
- *Electron identification from TR (Xe/CO_2 70/30): $\sim 10^3$ pion rejection for $E > 0.5$ GeV.*

✦ *Only target mounted onto base STT tracking module*

- *Fiducial mass reduced by $\sim$ 30% (5 mm CH_2 per module), gas mixture Ar/CO_2 70/30;*
- *Option to add extra STT modules using extra 5.7 mm space, resulting in +20% increase.*

✦ *Only radiator mounted onto base STT tracking module*

- *Fiducial mass reduced by $\sim$ 70% (1.89 mm CH_2 per module), gas mixture Xe/CO_2 70/30;*
- *Low-density run with increased resolution for precision measurements and/or reduced backgrounds.*

SUPER-MODULE ASSEMBLY

- *Default super-module with 1 C + 9 CH_2 modules*

  $\Longrightarrow$ *Both number of modules and their spacing can be modified after installation*

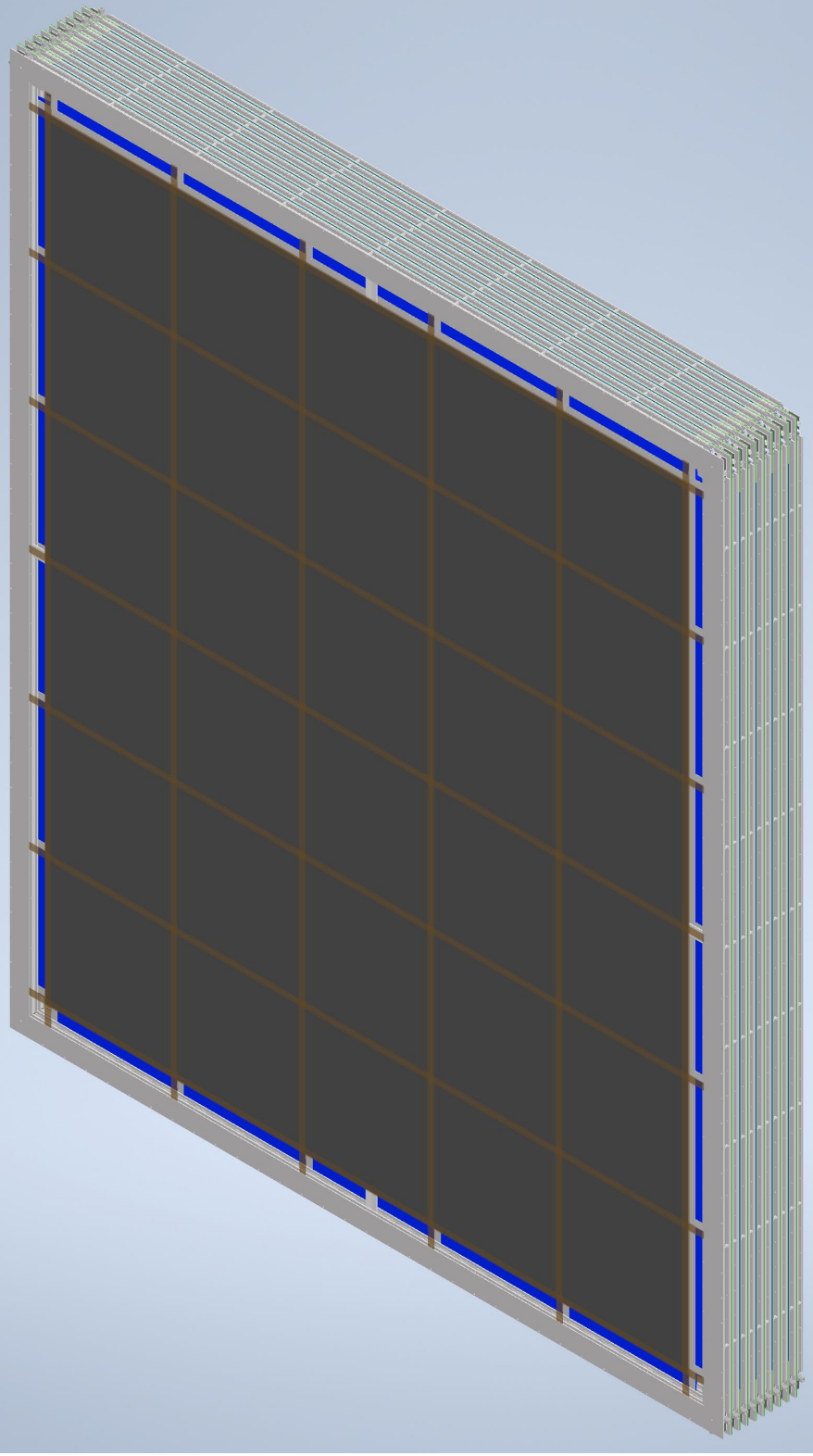
- *Locking mechanism with screwed Al rods on both sides of C-fiber frames (F. Raffaelli) can be tested with the 1.2m prototypes*

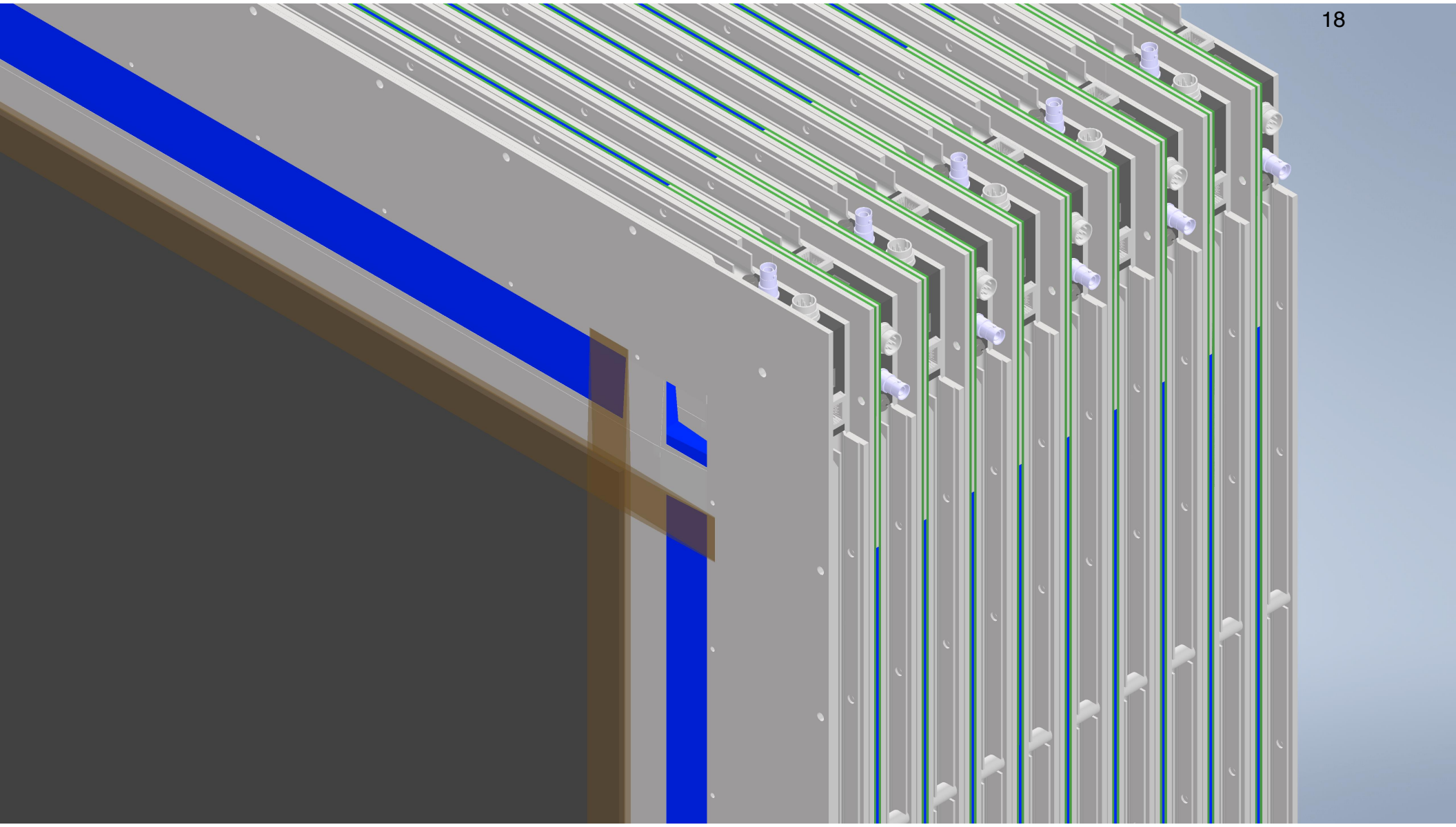
- *Flip readout location between even and odd tracking modules (left-right and up-down)*

  $\Longrightarrow$ *Improved track reconstruction and rejection of ghost tracks*

- *Super-module assembly basic STT unit to be considered for installation in the magnet*

Super-module assembly (4m × 3.3m) including 1 C + 9 CH_2 STT modules with target+radiator clamped together





Details of a super-module assembly including 1 C target module and 9 CH_2 target modules

Backup slides

PROTOTYPING & TESTS

Demonstrate all aspects of the STT design in increasing order of complexity:

- ☑ *Produce straws of required quality & maximal length with ultrasonic welding (UW)*
  $\Longrightarrow$ *Validation of model production lines at JINR (5m) and GTU (2m)*
- ☑ *Verify UW straws fulfill requirements from STT conceptual design & assembly procedure*
  $\Longrightarrow$ *Measurement of maximal internal pressure, radial and longitudinal deformations vs. pressure, relaxation vs. time and humidity, gas tightness, etc.*
- ☑ *Verify XXYY straw layer assembly*
  $\Longrightarrow$ *Gluing and pressure tests of 1m $\times$ 1m XXYY test assembly*
- ☑ *Verify assembly procedure of XXYY straws to frame, gas tightness, etc.*
  $\Longrightarrow$ *Assembly and tests of mockup prototype with plexiglass frame*
- ☑ *Verify module design with C-composite frame and related performance*
  $\Longrightarrow$ *Complete 1.2m $\times$ 0.8m prototype with XXYY straws and actual STT frame design*
- ☐ *Verify full scale module ("module 0") with maximal straw length and complete assembly*
  $\Longrightarrow$ *Complete 4m $\times$ 3m prototype with XXYY straws and C-composite frame*

Demonstrate readout performance:

- ☑ *Verify charge measurement with ^{55}Fe source & cosmics*
  $\Longrightarrow$ *Readout small STT prototype with Mu2e FE boards with VMM3 ASICs*
- ☑ *Verify time measurement with signal generator*
- ☑ *Verify time and charge measurement at testbeam*
  $\Longrightarrow$ *Readout small STT prototype with FE boards with VMM3 and Tiger ASICs*

	VMM3	TIGER
Number of channels	64	64
Clock frequency	10...80 MHz	160...200 MHz
Input capacitance	<300 pF	<100 pF
Dynamic range	Linearity within ±2% up to 2 pC	50 fC
Gain	0.5, 1, 3, 6, 9, 12, 16 mV/fC	12 mV/fC
ENC (energy branch)	<3000 e^-	<1500 e^-
TDC binning	~1 ns	50 ps
Maximum event rate	4 MHz/ch	60 kHz/ch
Consumption	15 mW/ch	12 mW/ch