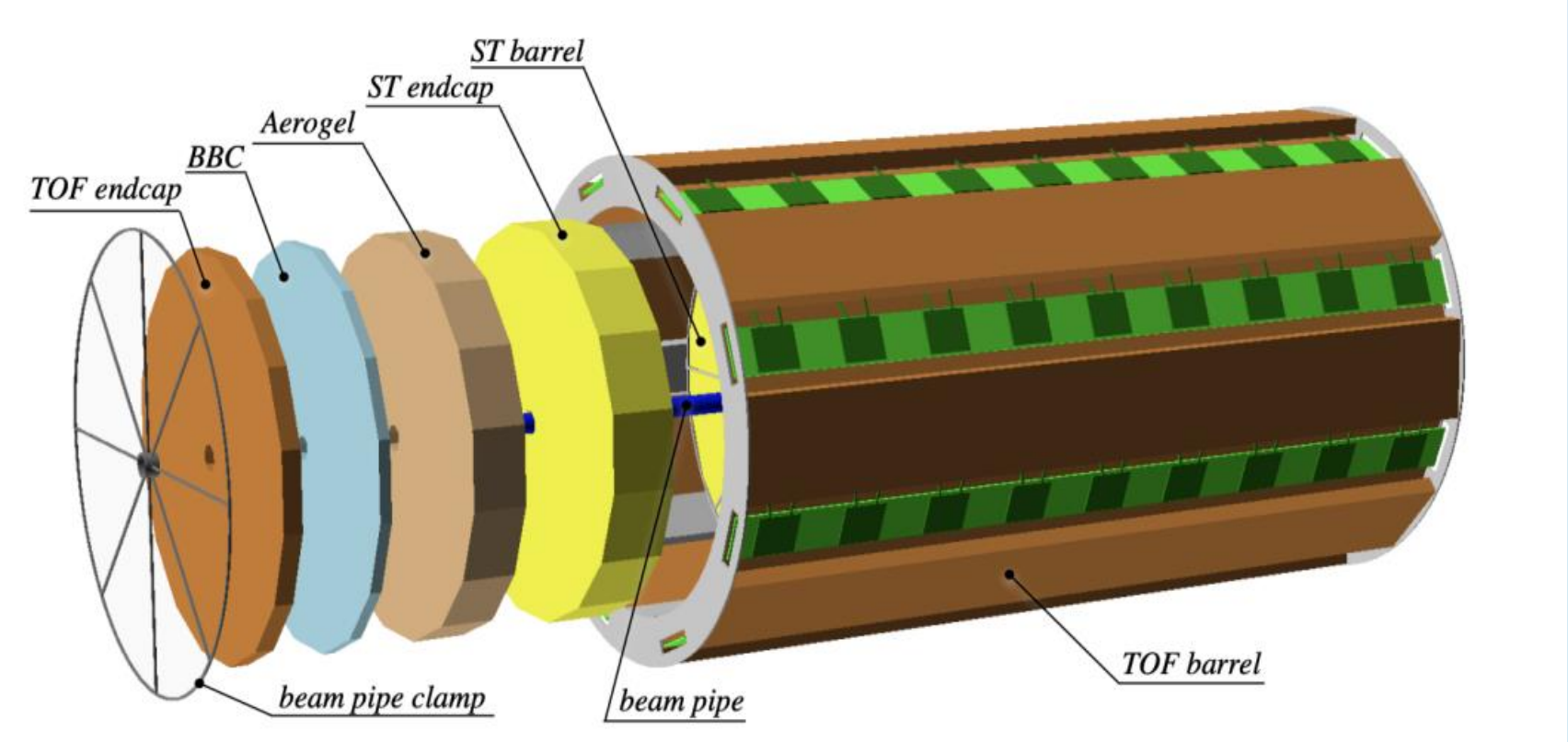
SPD ST end-cap

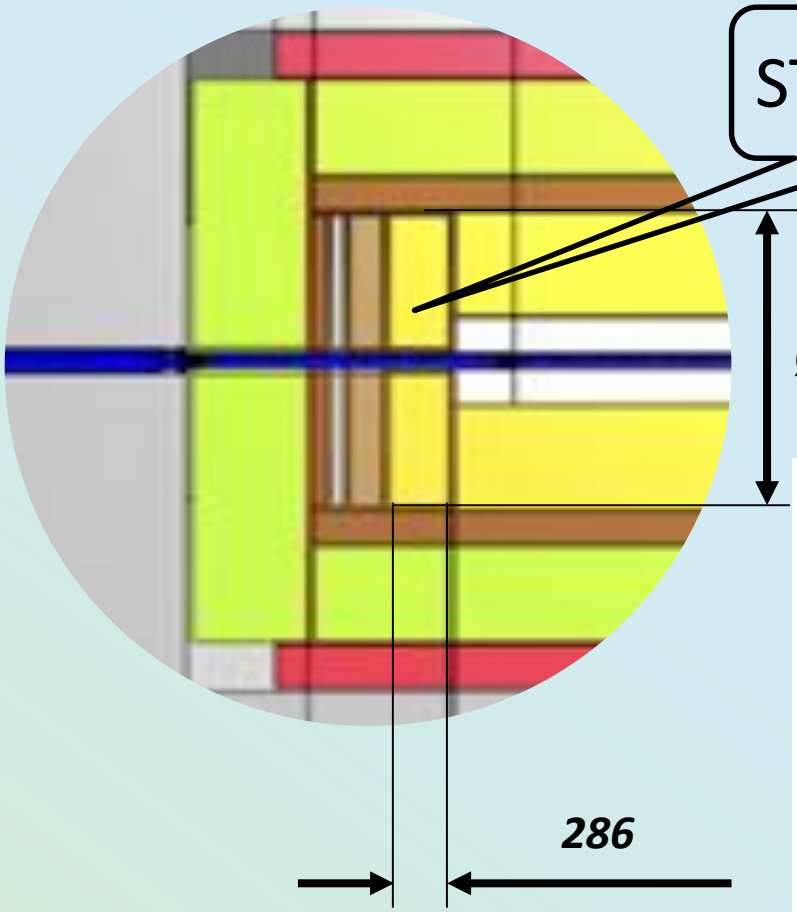
Straw Tubes end-cap

- *Straw Tubes end-cap*

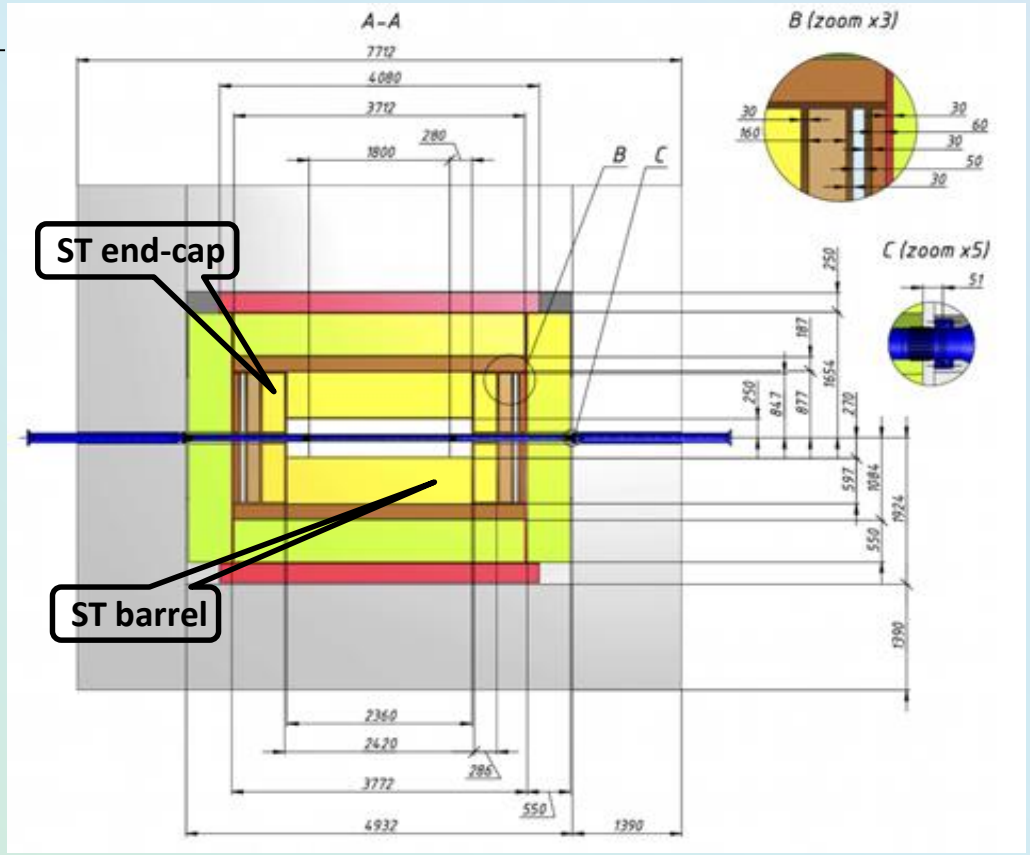


The end-caps of ST, Aerogel, BBC, and TOF are mounted one-by-one by moving them along the beam pipe

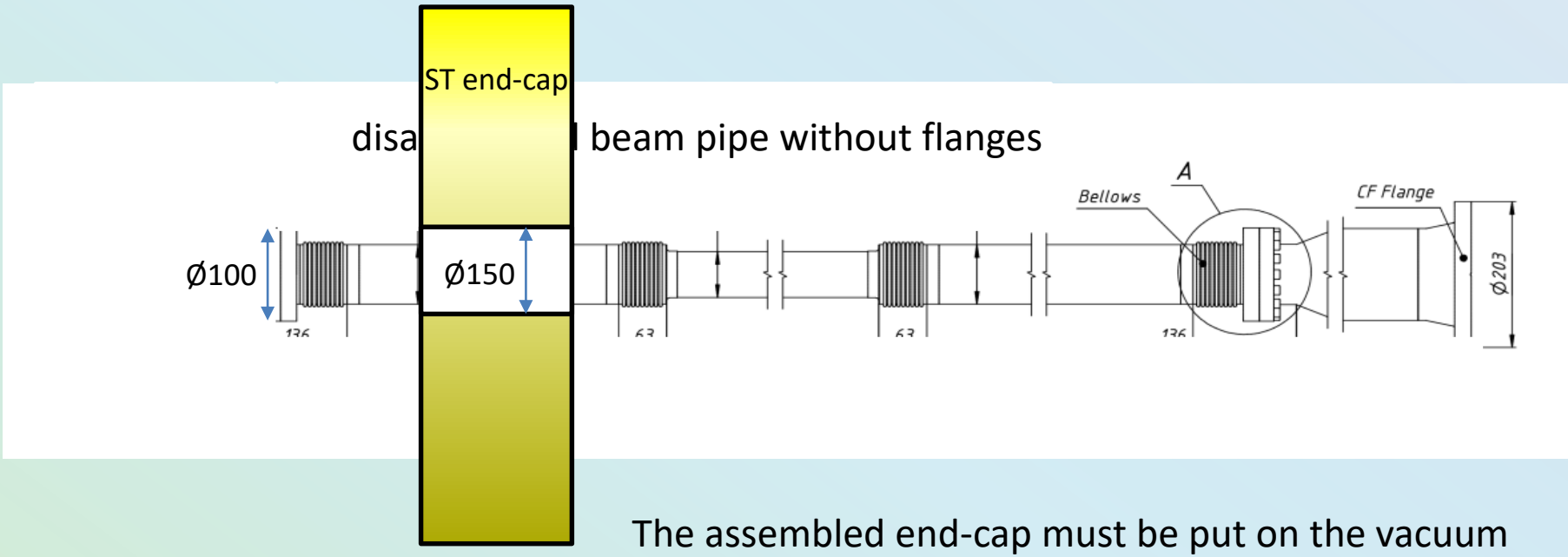
- *Straw Tubes end-cap*



The dimensions of the end-cap space are limited to R=847 mm and a thickness of 286 mm



Beam pipe and End-cap installation

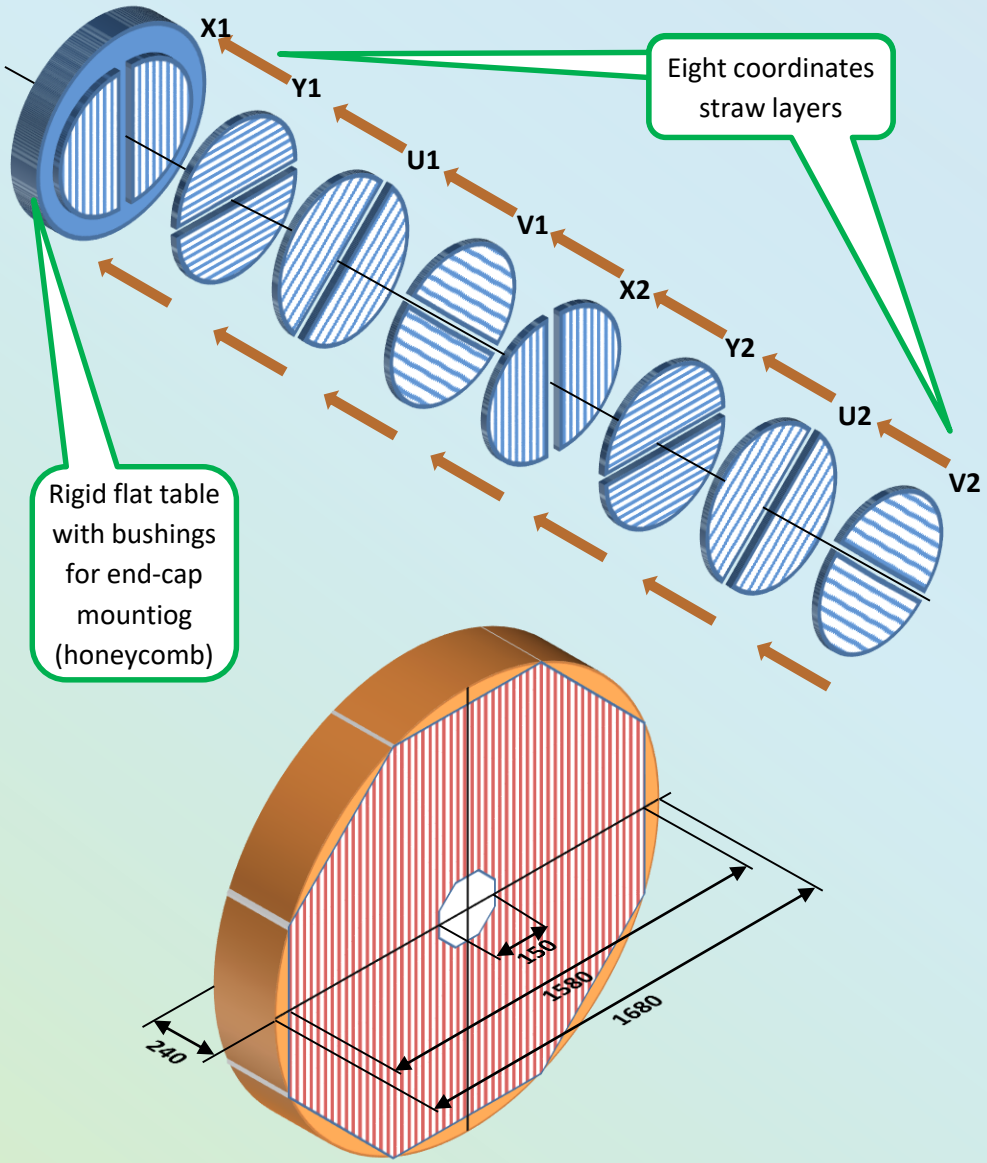


The outer diameter of the beam pipe is 100 mm without flanges.
Central hole in end-cap is 150 mm and defined by a beam pipe

The assembled end-cap must be put on the vacuum beam pipe, together with the rest of the internal detectors
The installation of the ST end-cap will be carried out on a disassembled beam pipe without flanges.

- The detector must have the shape of a disk,
- have a relatively small central hole, which is defined by a beam pipe,
- have a small amount of matter in the sensitive region of the detector.
- The detection layers should be thin,
- the number of layers should be sufficient to identify particles via dE/dx measurement.

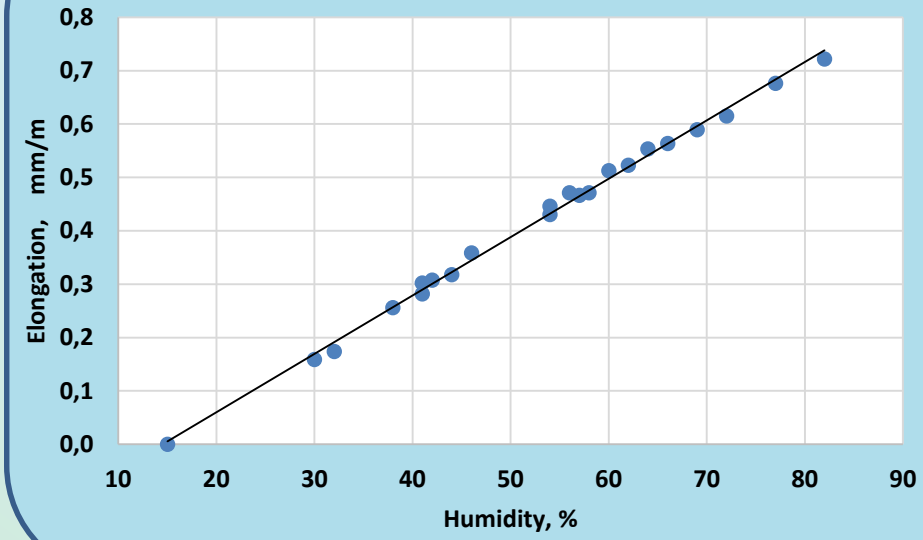
Principle design of ST end-cap



- Detector arranged so - that they form an X, Y, U, V coordinate system at an angle of 45 degrees.
- Each coordinate plane consists of two halves separated by a distance for installation on a vacuum tube - the gap.
- The thickness of one coordinate plane is 30 mm
- Eight coordinate planes are mounted together on the rigid flat table, forming a rigid block, 240 mm thick.

- After assembling all eight planes, the flat table is removed

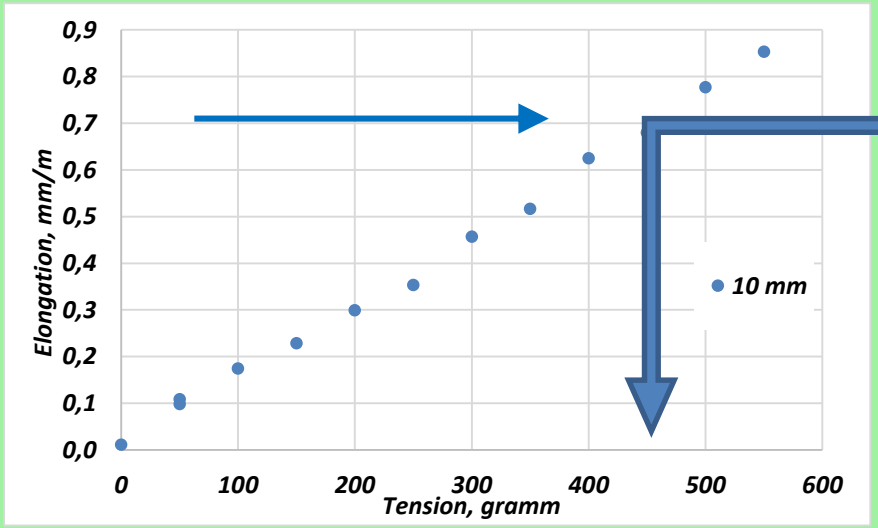
The effect of humidity



It is known that twisted straw tubes change their sizes under the influence of atmospheric humidity

The elongation value of the straw tubes was found to be ***0.7±0.2 mm/m*** for copper-coated tubes with diameters of 6 mm and 10 mm for a change in relative humidity from 50% to 80%.

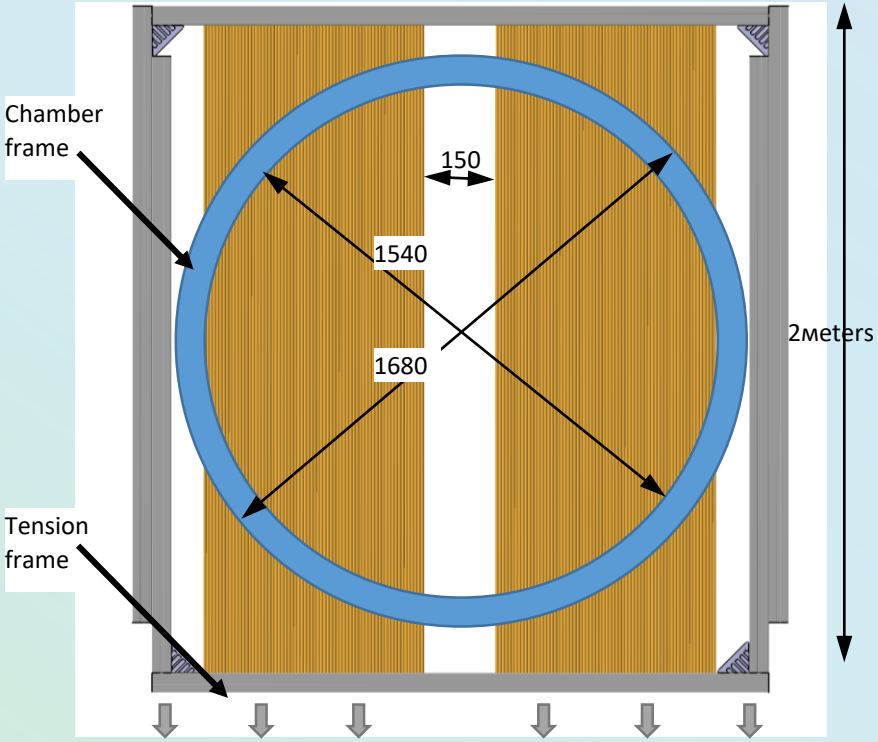
The test showed that the elongation has a range of elastic deformation. Straw size is returned after drying. That is, the tubes have a range of elastic deformation. On the figure shows the elongation of straw tubes depending on humidity.

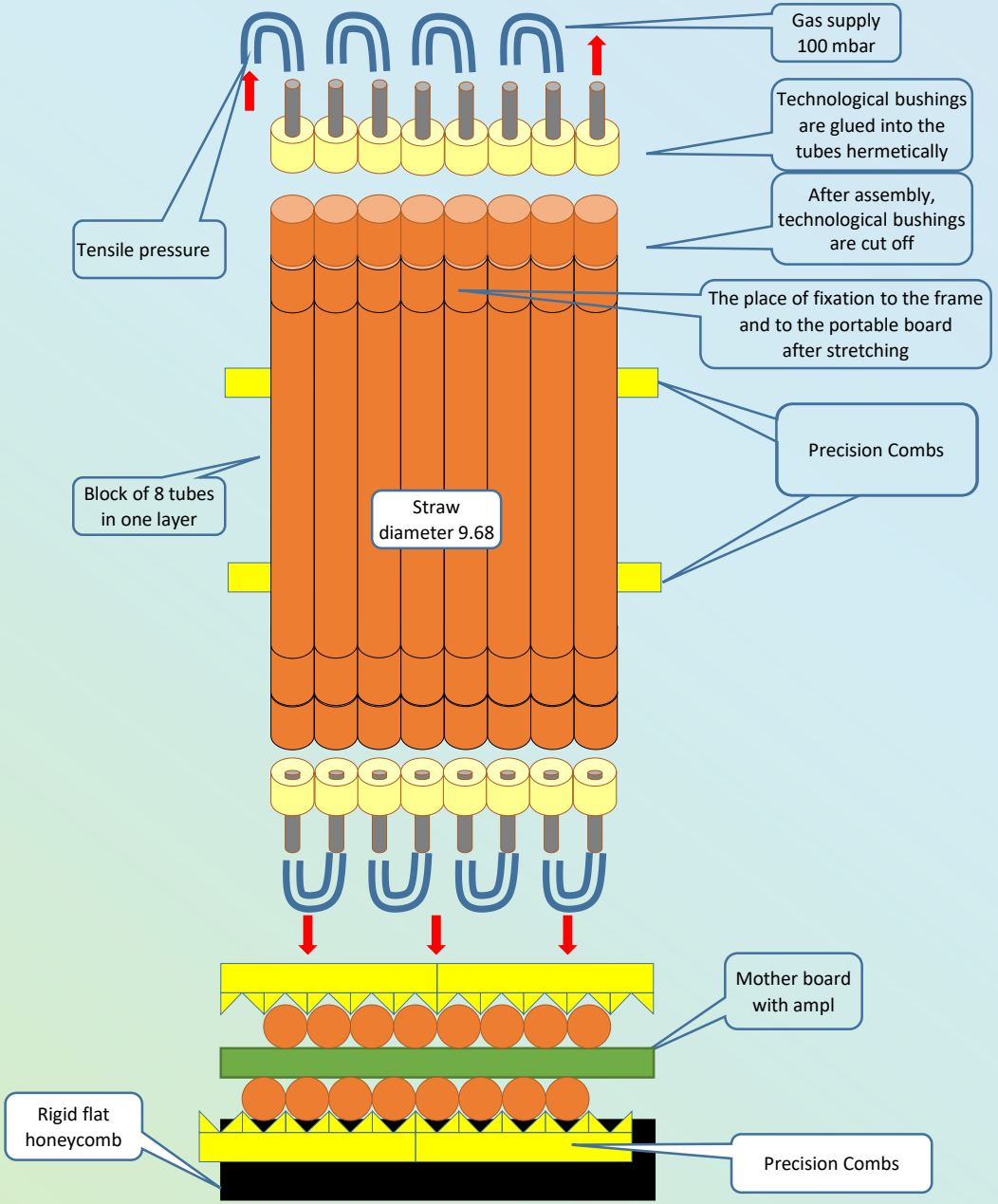


0.6 atm inside the straw is equivalent to 450 g of power

Straw Ø9.68 mm

Special technological frame for stretching straw arrays.





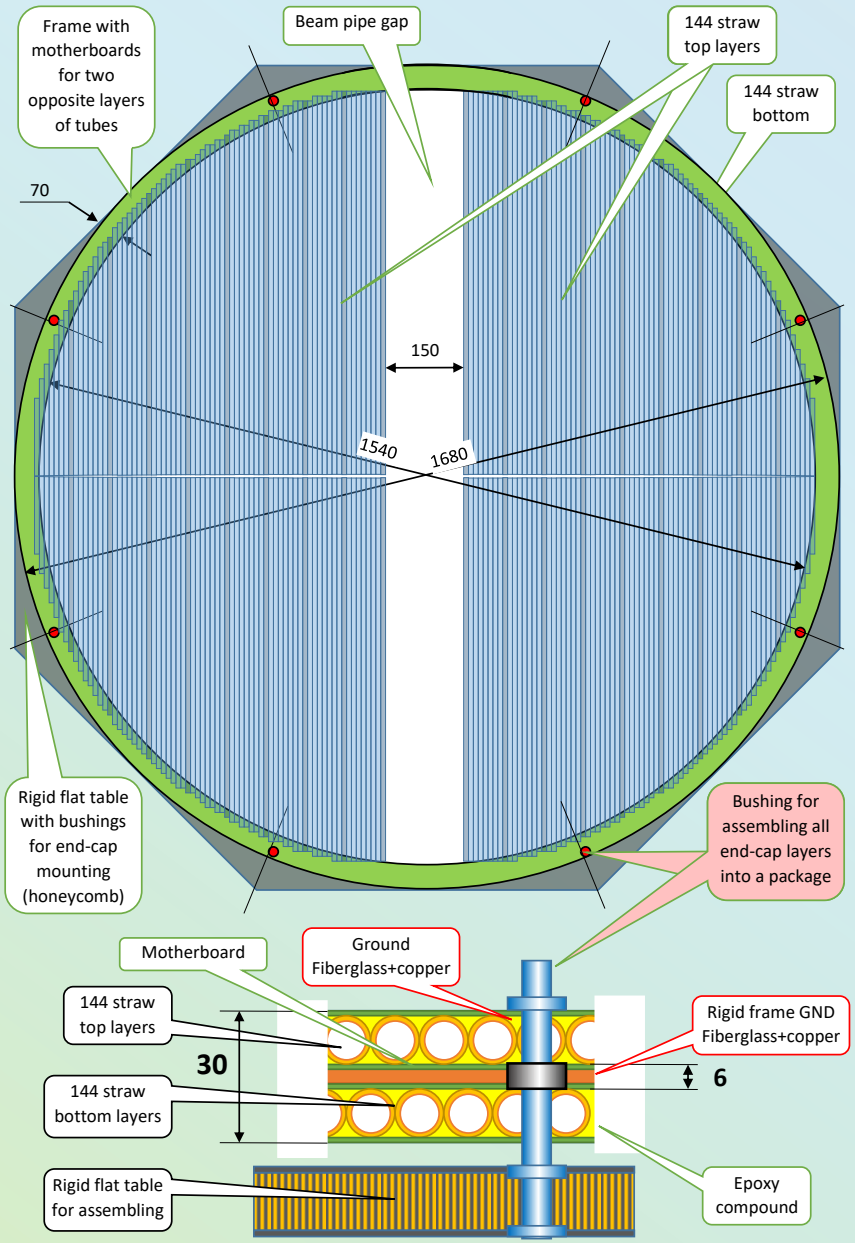
Principle design of ST end-cap

We proposed to use the pre-tension of straw tubes to compensate for climatic changes of lengths in the tubes.

Illustration of technological procedures during detector assembly.

- A block of several, 8 tubes is glued to the frame. The tubes are under pressure, which stretches the tubes, The gas supply is carried out by flexible PVC tubes through straw tubes sequentially.
- We proposed to use the force acting on the end of the tube at an excess pressure of 0,6 bar – (490 g/straw).
- Such a force causes the length 0.7 mm for 1 m tube.

Principle design of one coordinate plane ST end-cap

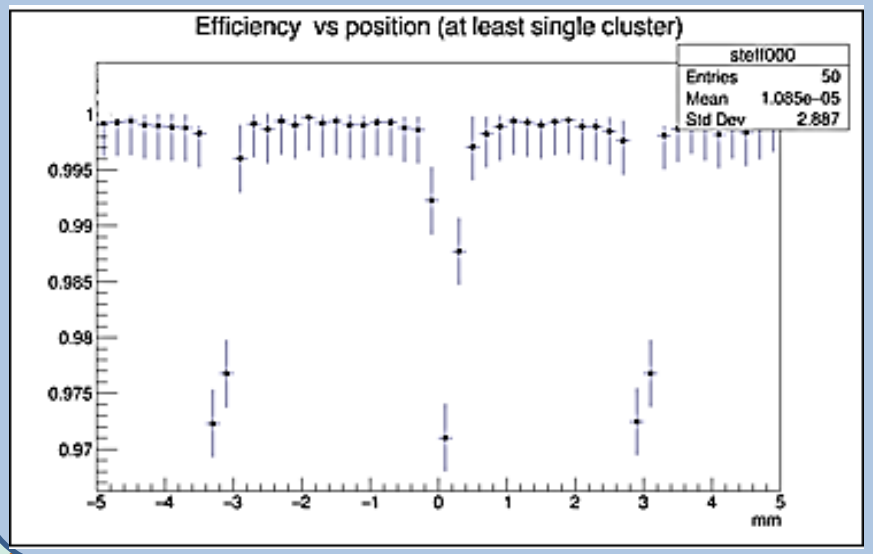


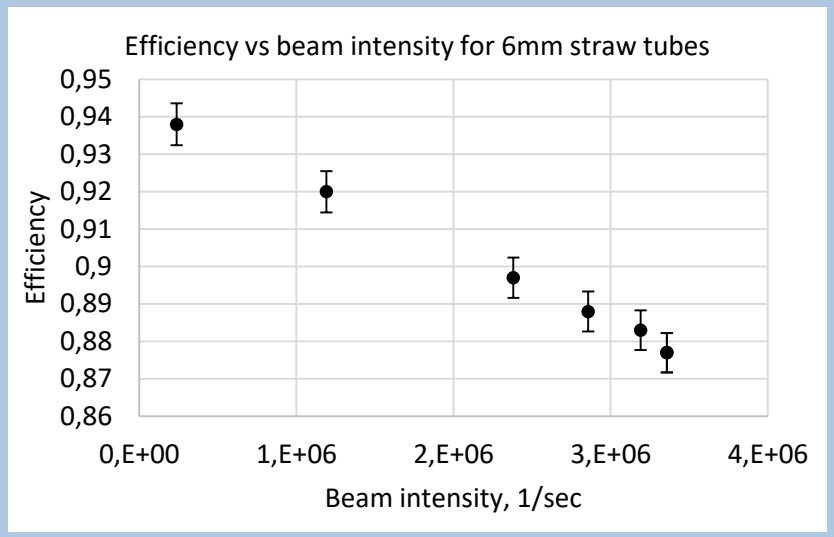
One coordinate layer consists of a frame on which 288 individual straw tubes are glued on both sides

The straw planes are assembled on a rigid portable honeycomb board on a rotatable octagonal frame

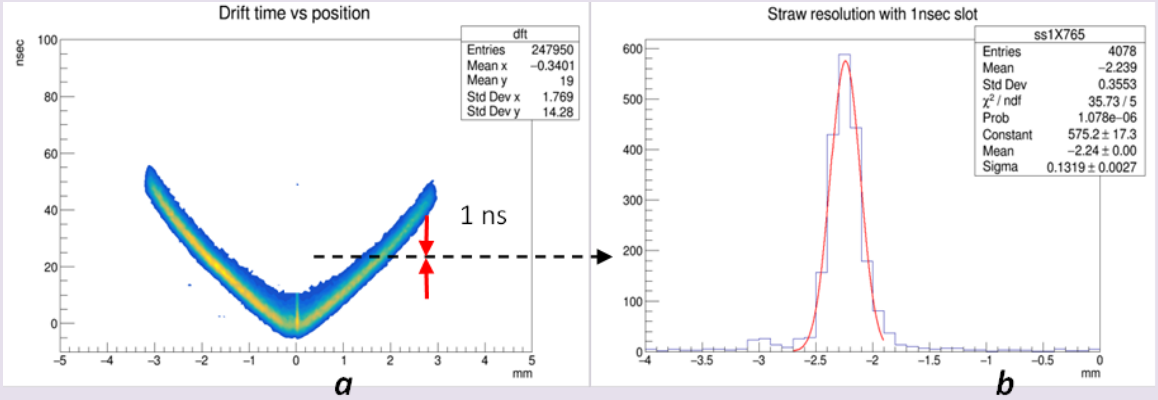
In total , 4608 strings are contained in two end-caps with a diameter of tubes 9,68 mm.

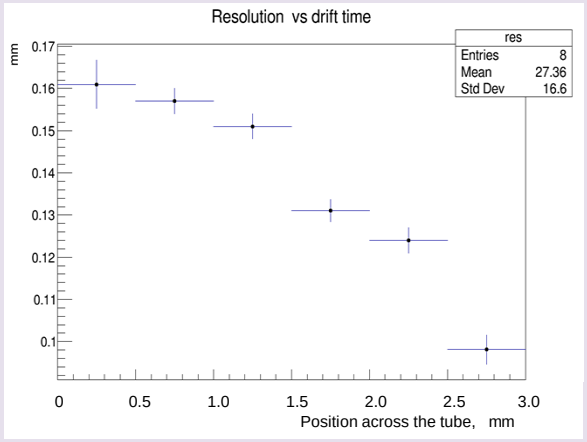
Efficiency and dependence of beam intensity





Coordinate accuracy

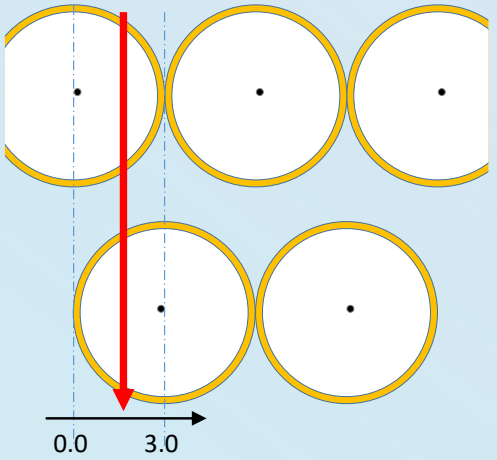


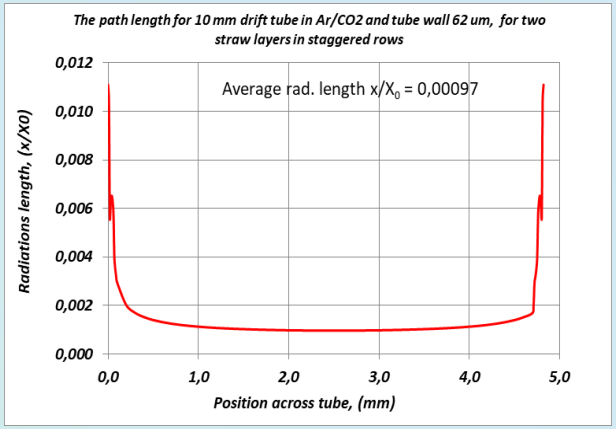


Coulomb scattering in the straw material

$$\theta_0 = \frac{13.6\ MeV}{p\beta c} z \sqrt{\frac{x}{X_0}} \left[1 + 0.038\, ln\left(\frac{x}{X_0}\right)\right]$$

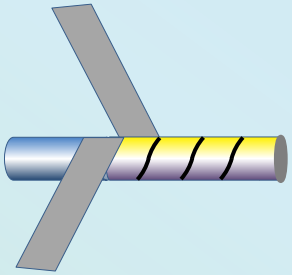
Coulomb multiple scattering angle ϑ_0 for two straw layers (x/X_0) = 0,0009, (diameter 10mm) and for single-charged particle with a momentum p = 1 GeV/c is 9.4×10^{-5}, that corresponds to a deviation at ***1 m base line of 0.094 mm***.

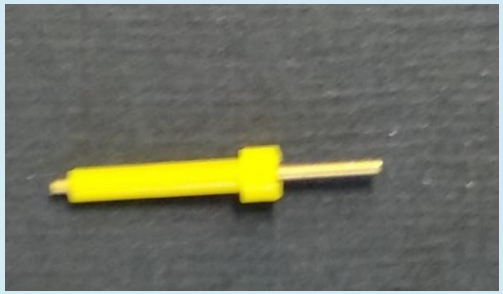


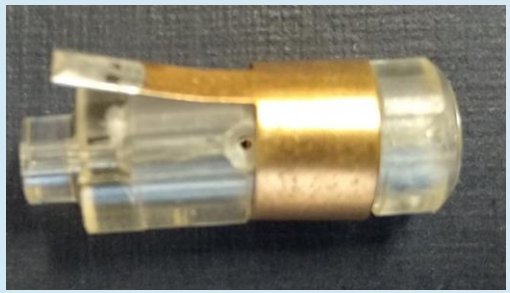


Elements of technology for straw assembling

- *Straw Tubes end-cap*





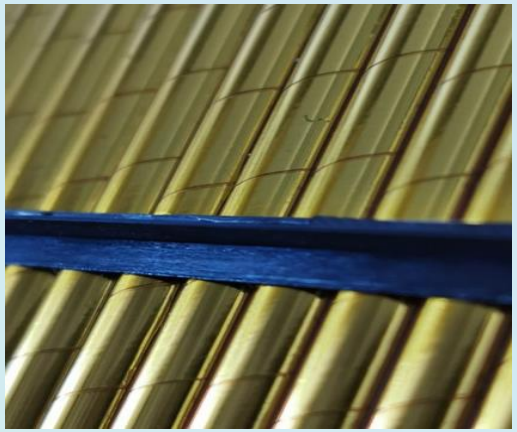


Twisted structure of the straw tube. The picture illustrates a winding on a precision rod. The end-plug and the crimping pin are used to fix the anode signal wire

The outer layer of the straw tube consists of a polyimide tape with a thickness of 25 microns. A copper coating with a thickness of 100 nm on one side is applied. On the other side Polyurethane hot-glue coating with a thickness of 4 ± 1 μm is applied. The surface resistance is 1 ± 0.1 Ω/square.

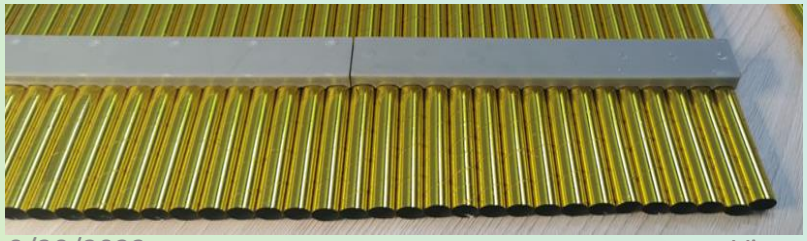
The inner layer of the straw tube consists of a similar polyimide tape. The layer of hot glue is applied to one side, and on the other side – a layer of aluminum 0.2 μm thick. Graphite with a thickness of 6 μm and 2 μm of aluminum. The resistivity of this surface is about 10 Ω/square.

The outer and inner tapes are glued together on a calibrated rod. The rod heated to 170 ºC. The outer diameter of the tubes is 9.68 mm.



Carbon fiber strips used as external support for the straw tubes.

External precision combs to fix the position of the tube in the plane



Action plan for 2022 - 2024

Action plan for 2022 – 2024

1. Production of an experimental batch of straw with a diameter of 9.54 mm. Length 2 m 100 pcs.	Sept 2022
2. Investigation of mechanical and humidity properties of straw tubes.	Dec 2022
3. Development and manufacture of end-plugs and pins.	Nov 2023
4. Development of drawings of a full-size prototype.	Febr 2023
5. Calculation of prototype deformations.	Mar 2023
6. Purchase of materials for the manufacture of all End-caps elements: Kapton, Tungsten wire, pins, end-plugs, frames, precision combos.	May 2023
7. Development and manufacture of technological equipment: Tube cutting, straw stretching device, honeycomb plate for assembly.	Nov 2023
8. Development and manufacture main frame for prototype.	Nov 2023
8. Development and manufacture of mother board with amplifiers.	Nov 2023
8. Production of a small prototype.	Nov 2023
9. Production of a full-size prototype.	May 2024