A cover to protect the KOTO CsI calorimeter from earthquakes

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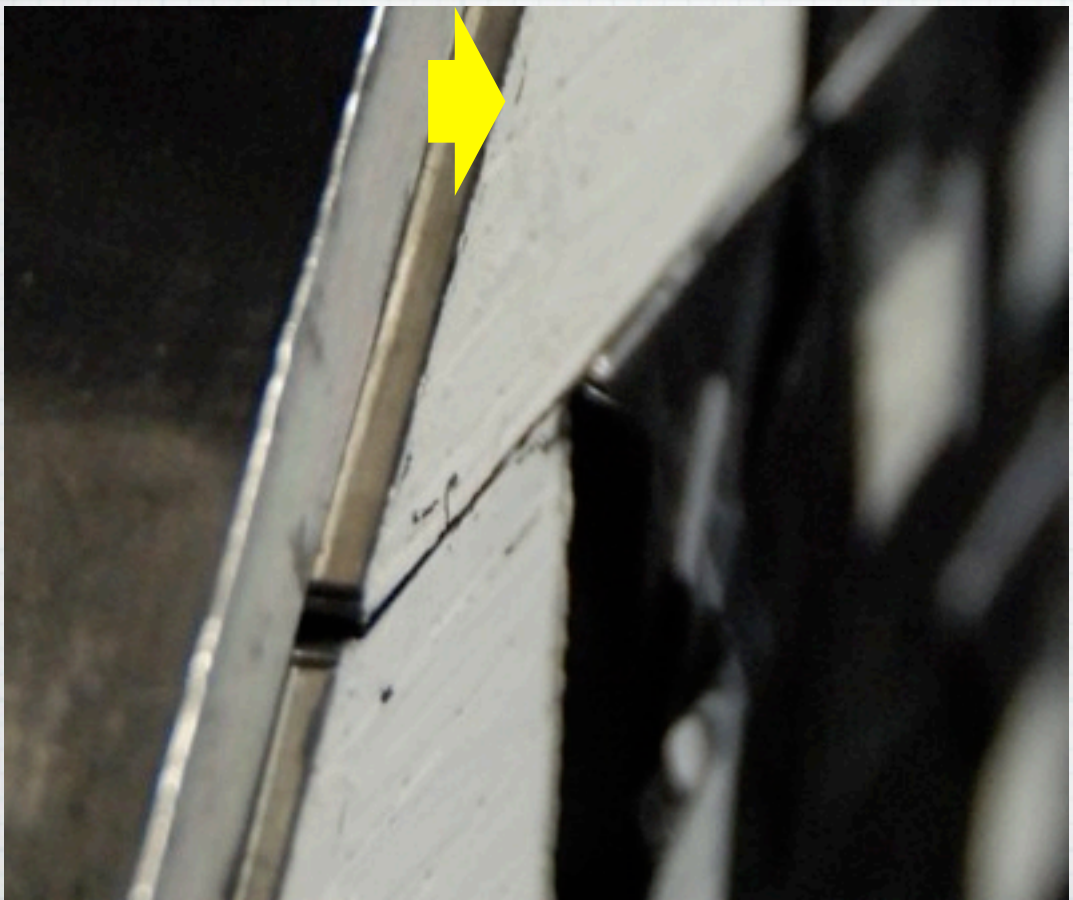
Kuno-Yamanaka Group Year-end Meeting

KOTO CsI Calorimeter

* 2240 2.5cm x 2.5cm
* 476 5cm x 5cm
* 50cm long CsI crystals
* Finished stacking on Feb. 10, 2011

The Earthquake

* moved the CsI crystals out by ~5mm

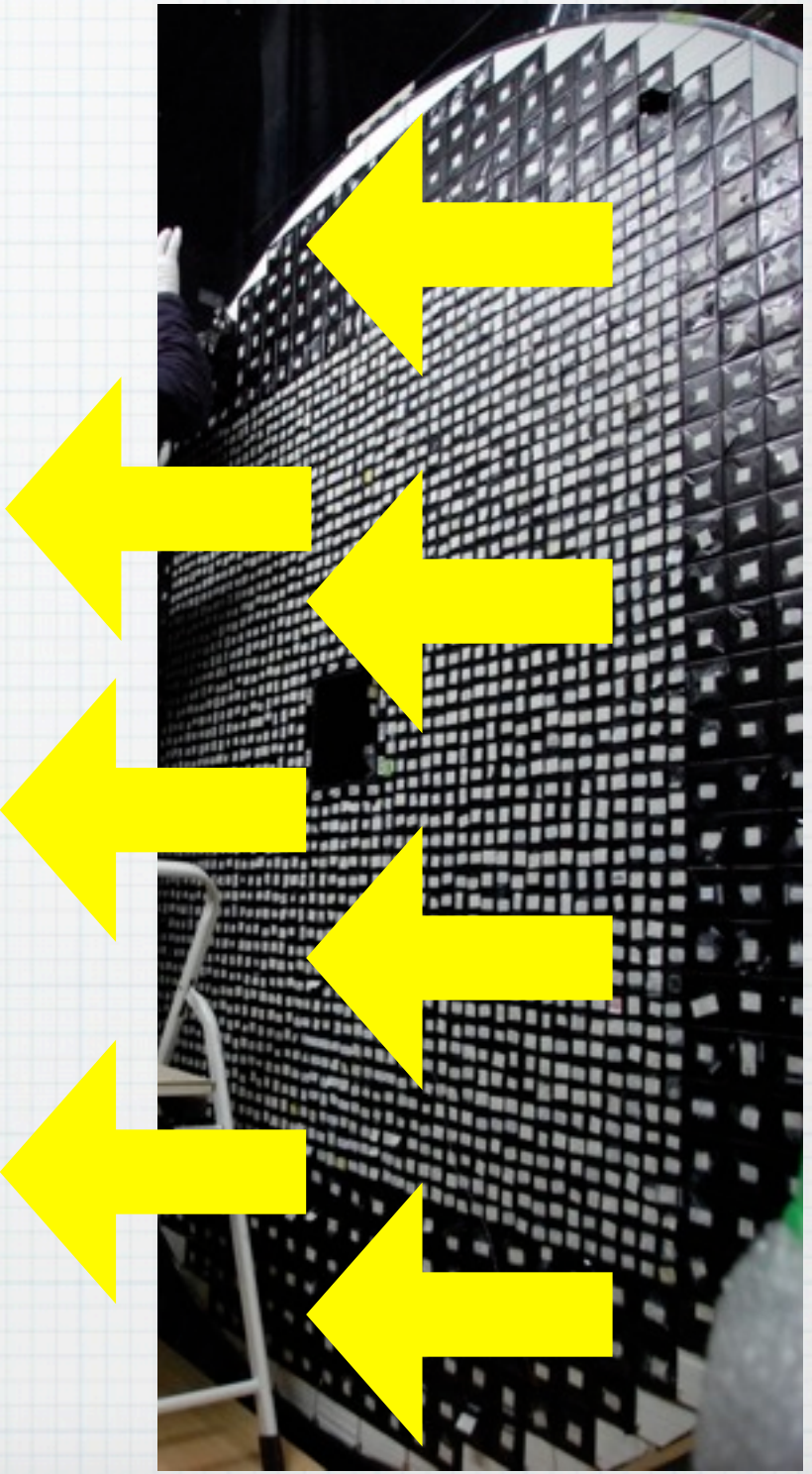


How do we prevent the crystals from *flying out* when the next large earthquake comes?

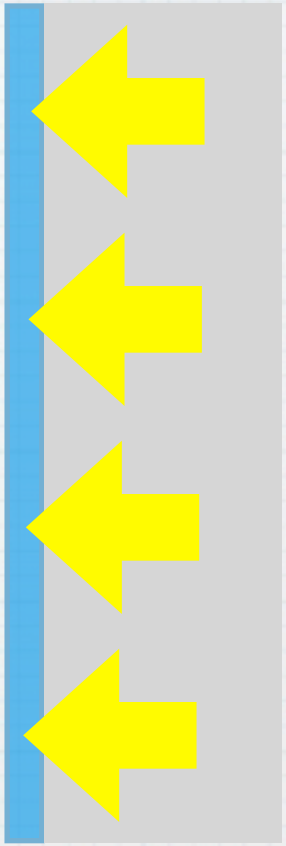
Assumptions

* 1G horizontal acceleration
* $4.5g/cm^3$ x 50cm x $9.8m/s^2$ = 22kPa side pressure
* x3 safety factor = 66kPa

  (20t on 2m-diameter surface)



Bending-force of a hard plate?



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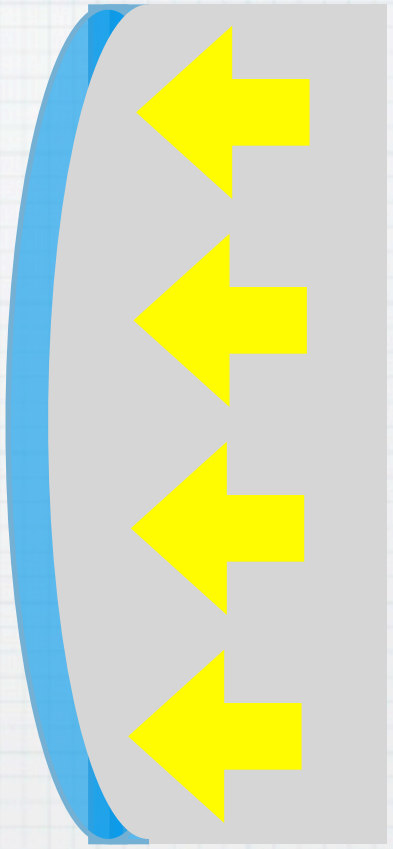
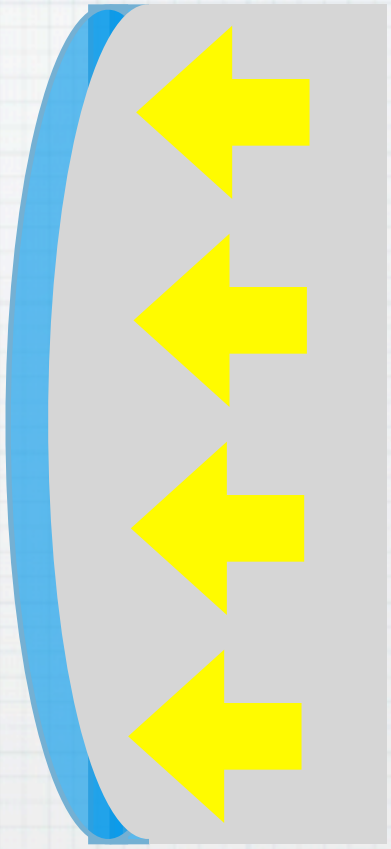


Bending-force of a hard plate?

* Needs 2cm thick steel plate
* ~500 kg!



Tension of a soft cloth?

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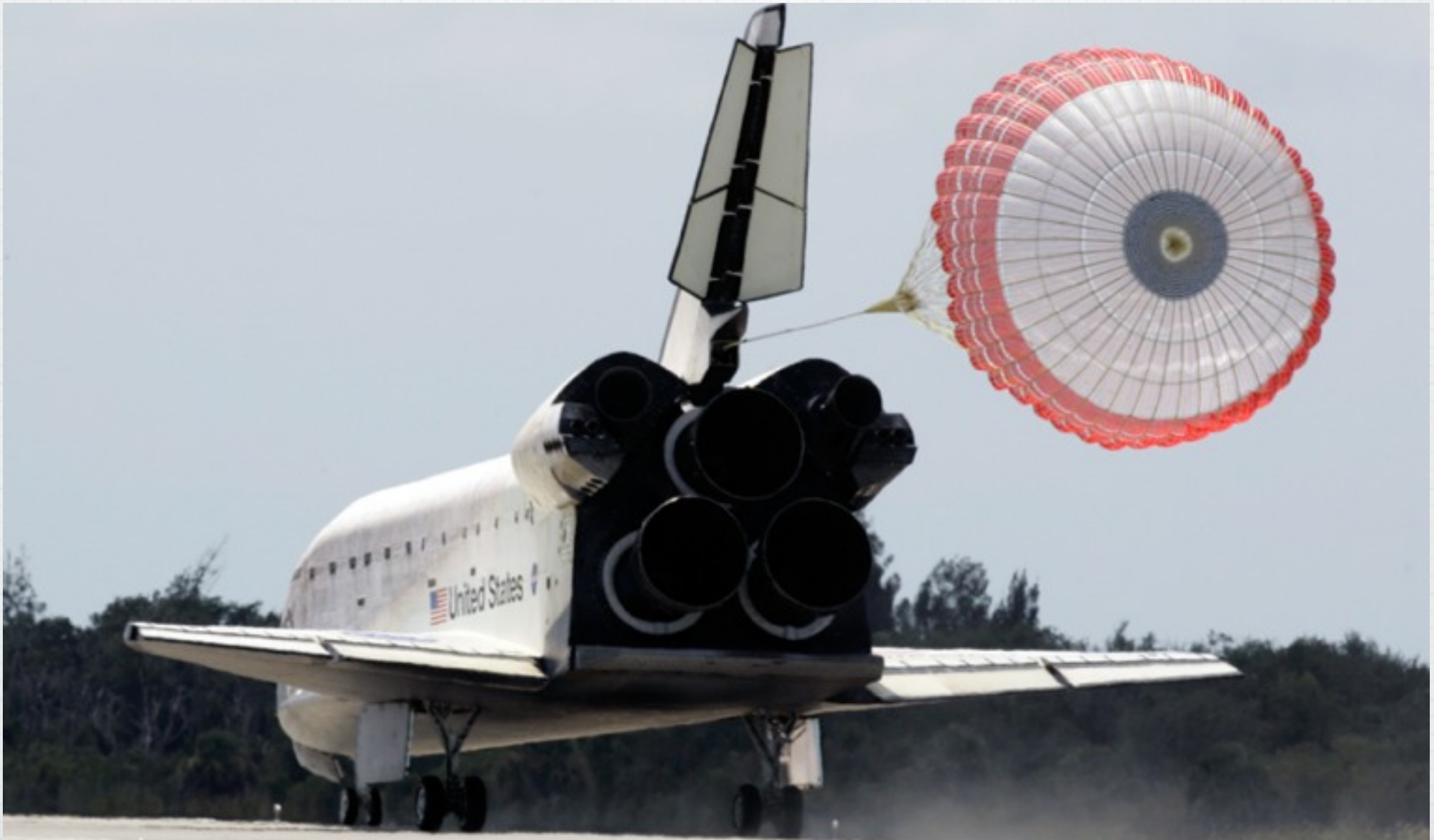
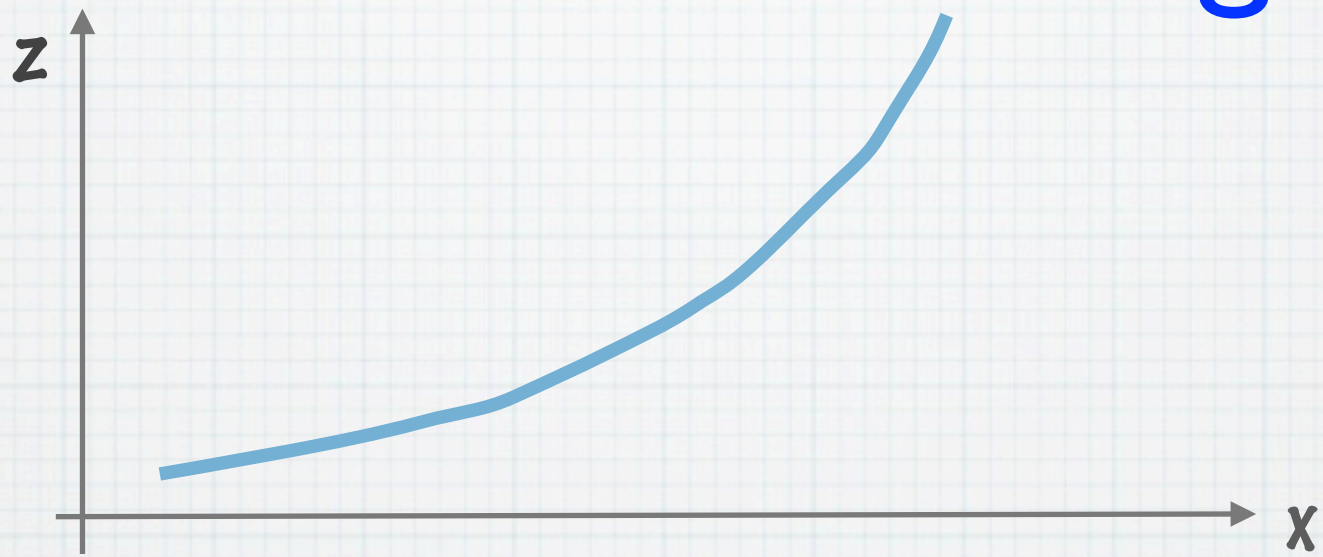


Tension and curvature
- in case of a string -



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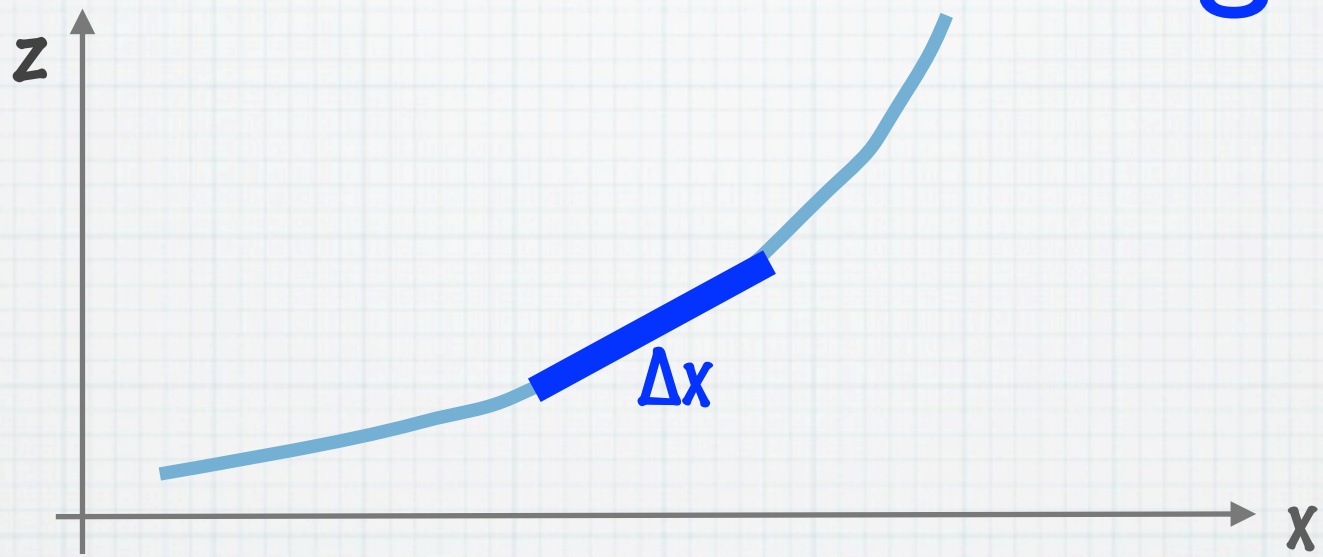

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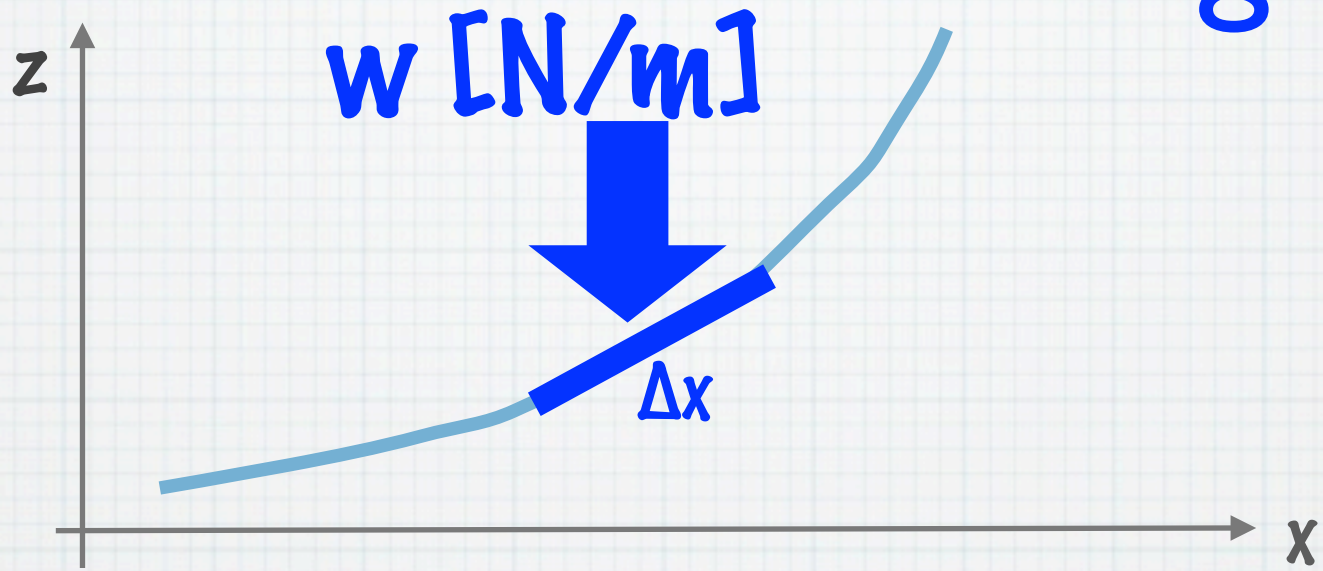

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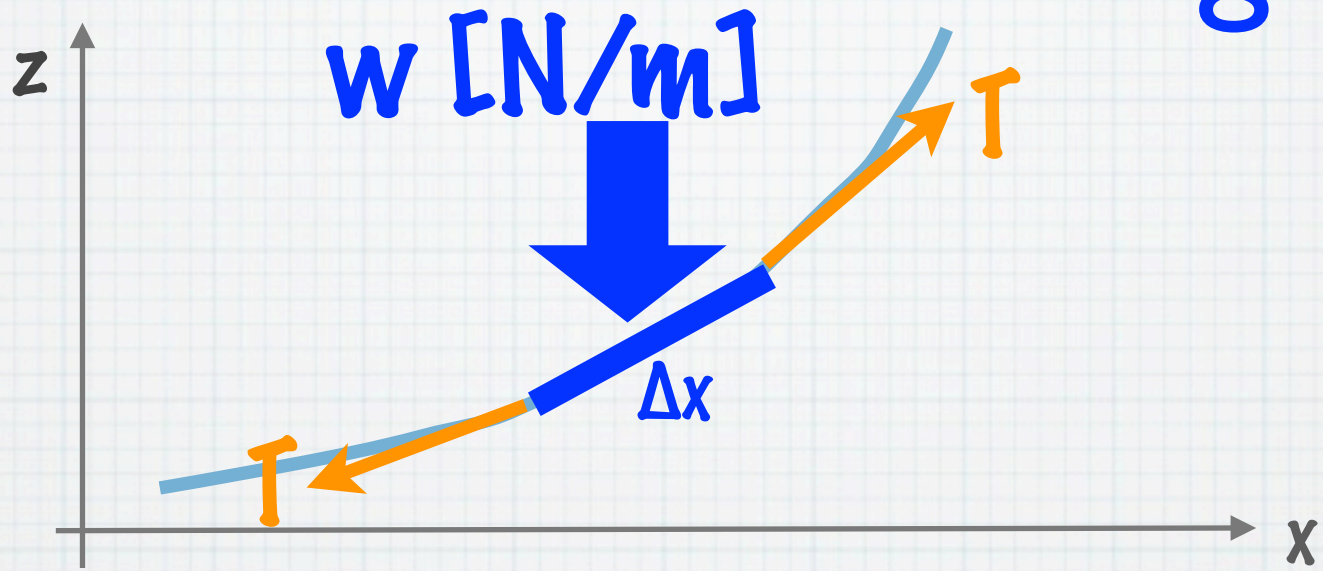

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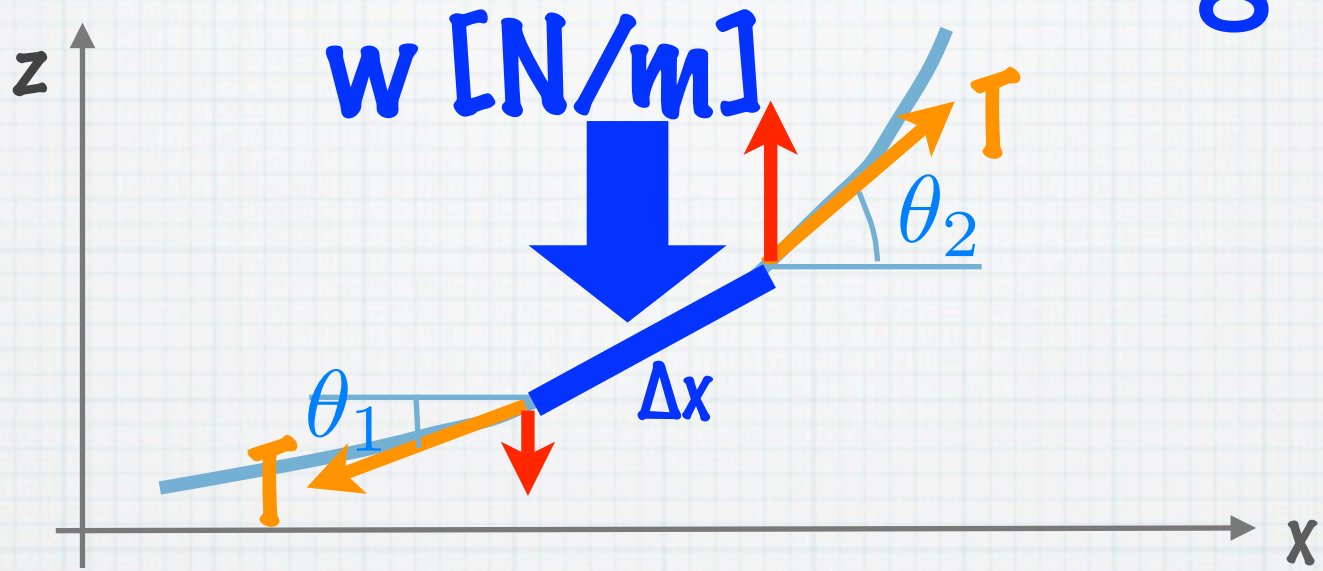

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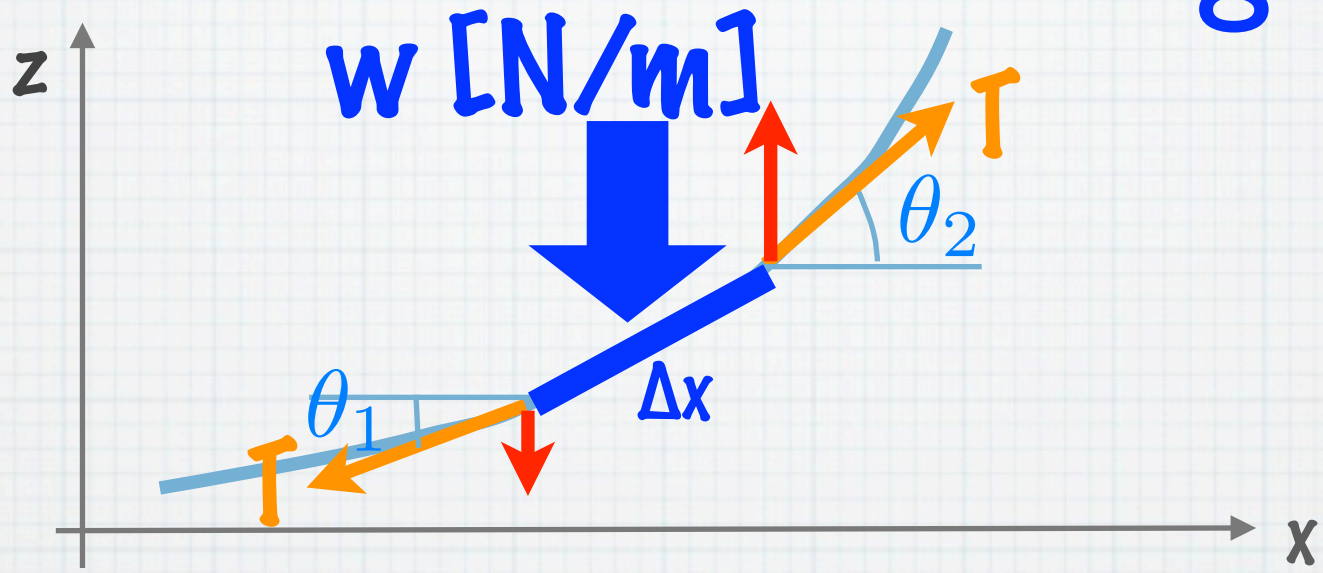


$$w\Delta x = T(\sin\theta_2 - \sin\theta_1)$$

$$\simeq T(\frac{dz}{dx}(x+\Delta x) - \frac{dz}{dx}(x))$$

$$w \simeq T\frac{d^2z}{dx^2}$$

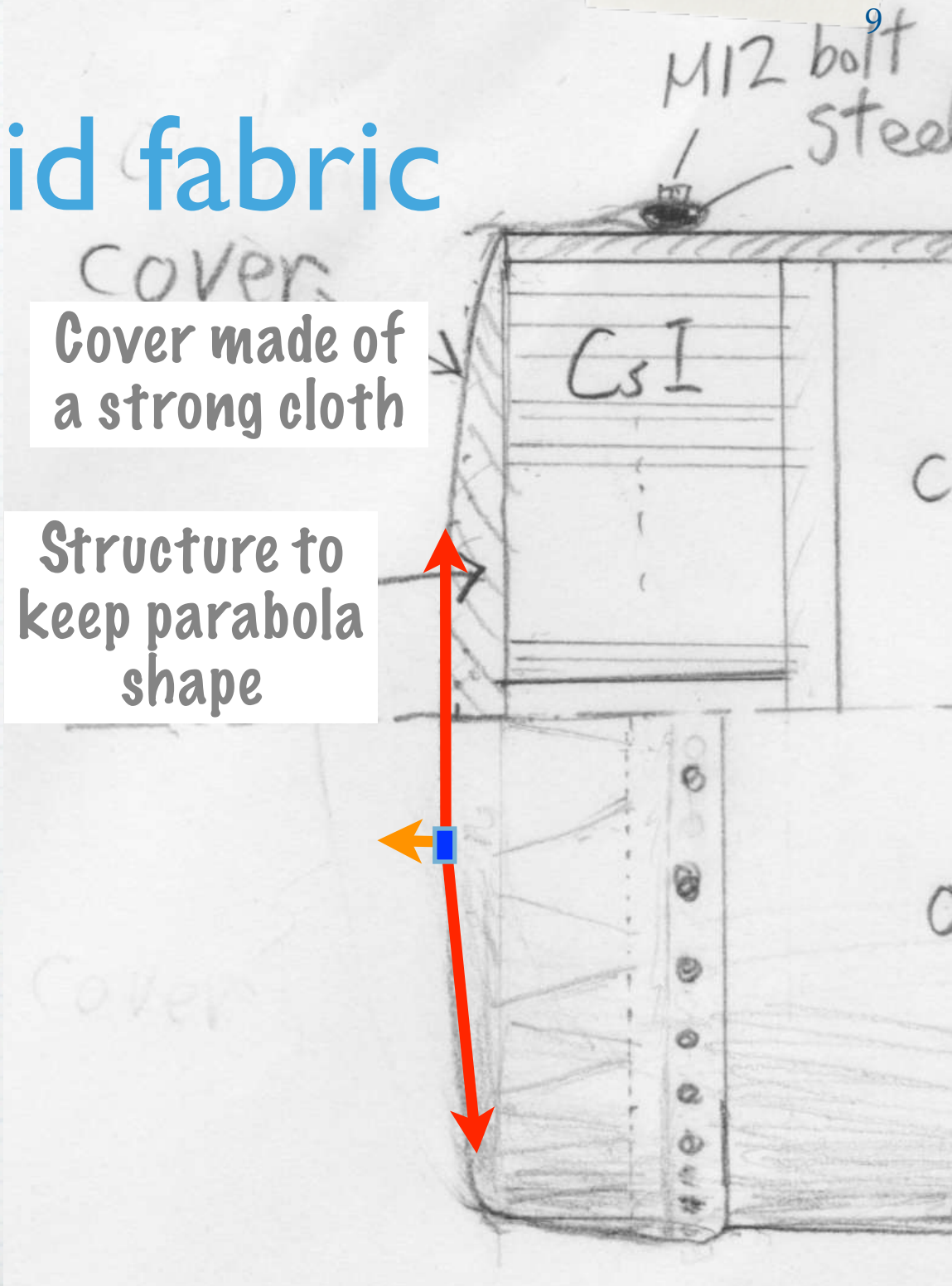
Aramid fabric

- Teijin Technora:

  T < 170kN/m

- Curvature with 10cm bulging can hold the weight

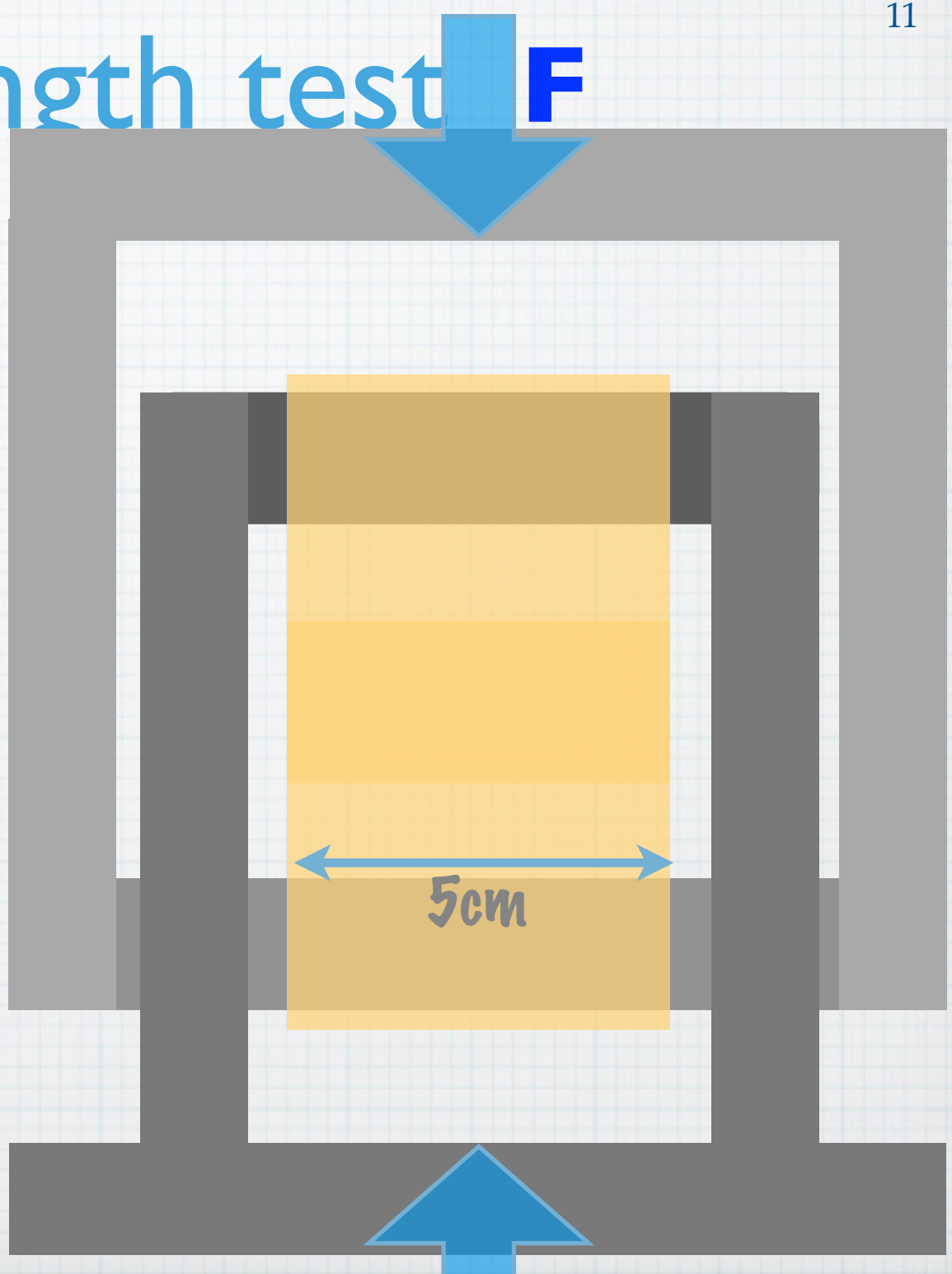
- ... but only 1m wide



How to sew fabrics together

Strength test

- Make a fabric loop with sewing
- Insert two bars inside the loop
- Press the two bars apart with force F
- Tension = **F**/2



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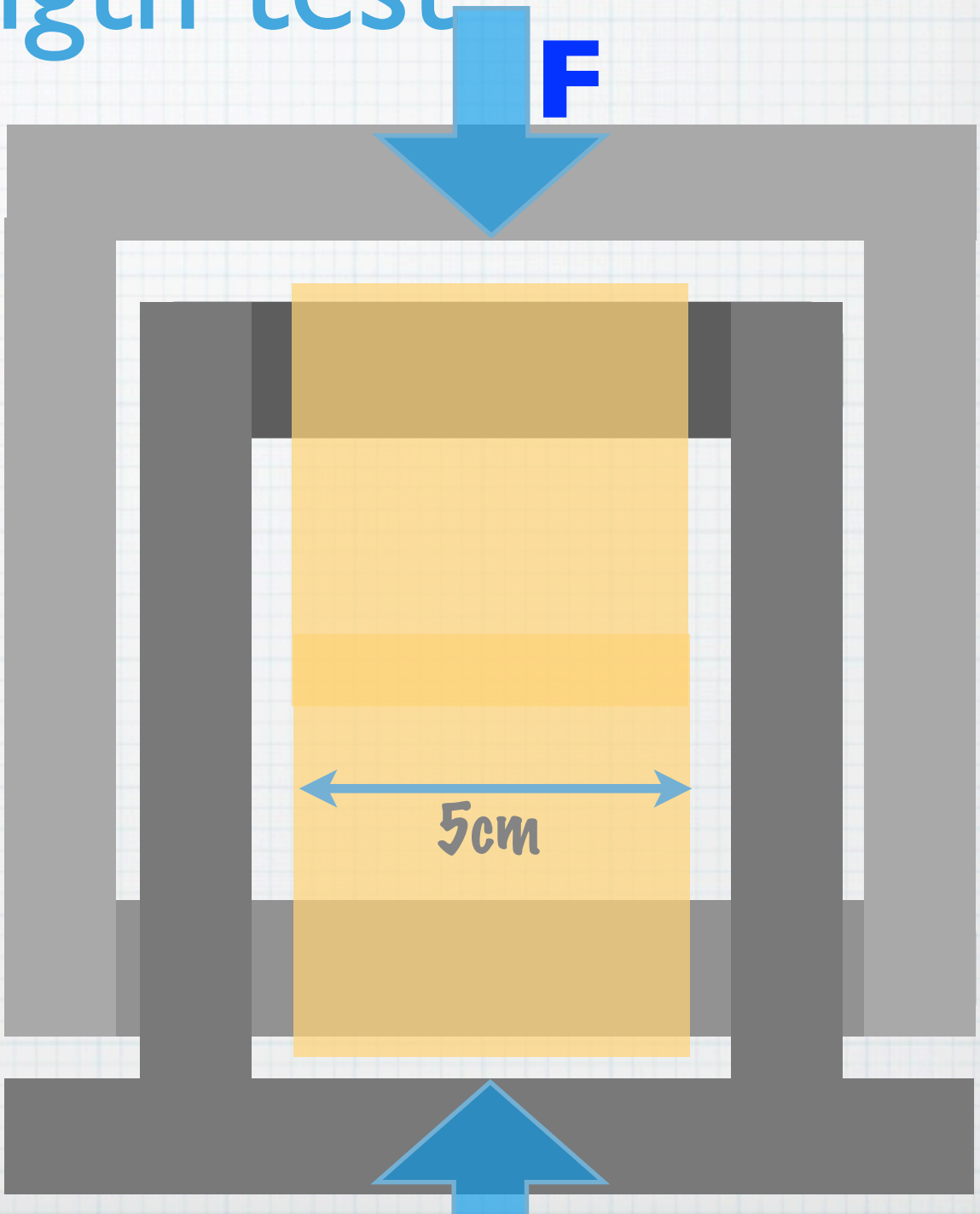

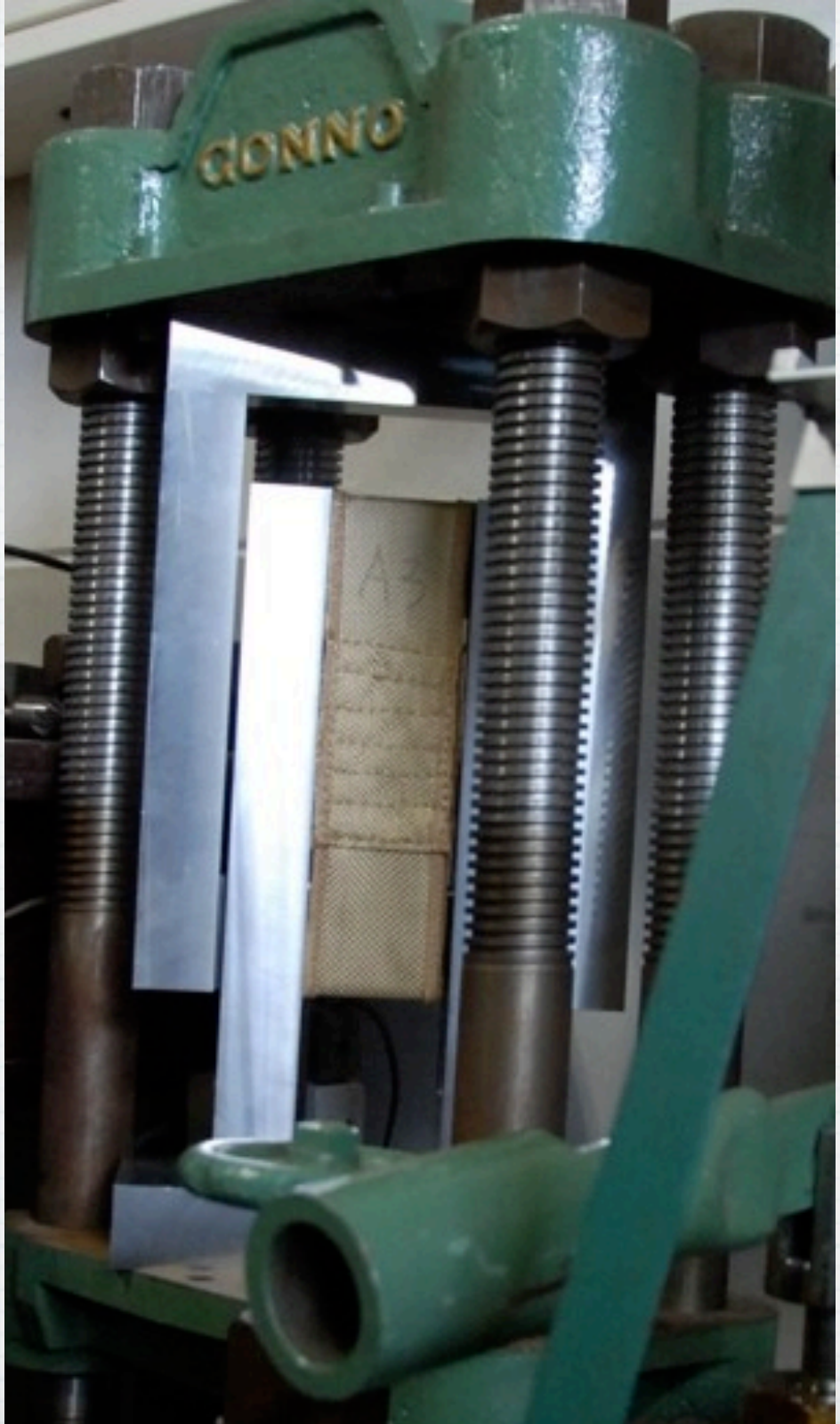
GONNO

Sample made by company

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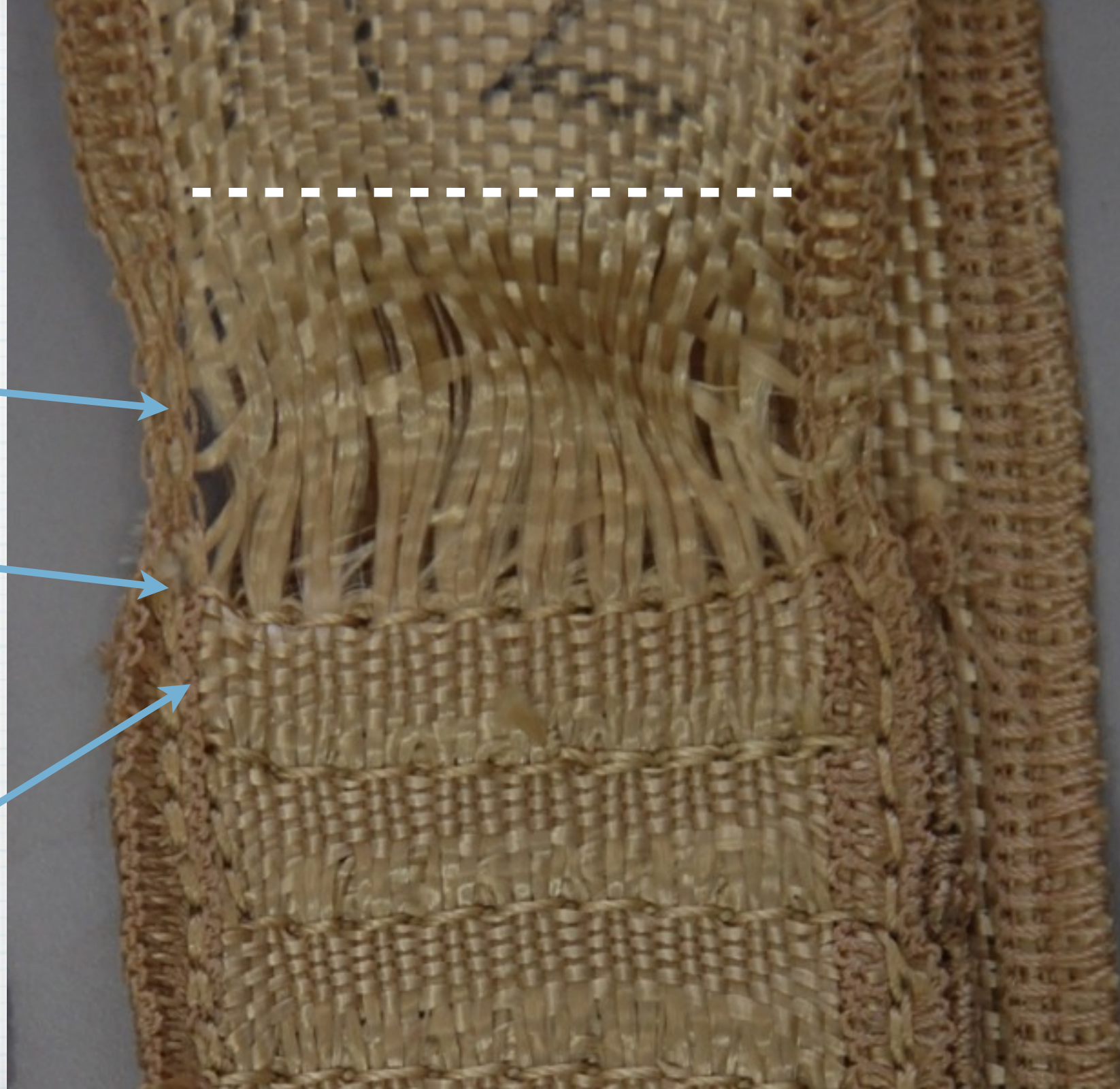
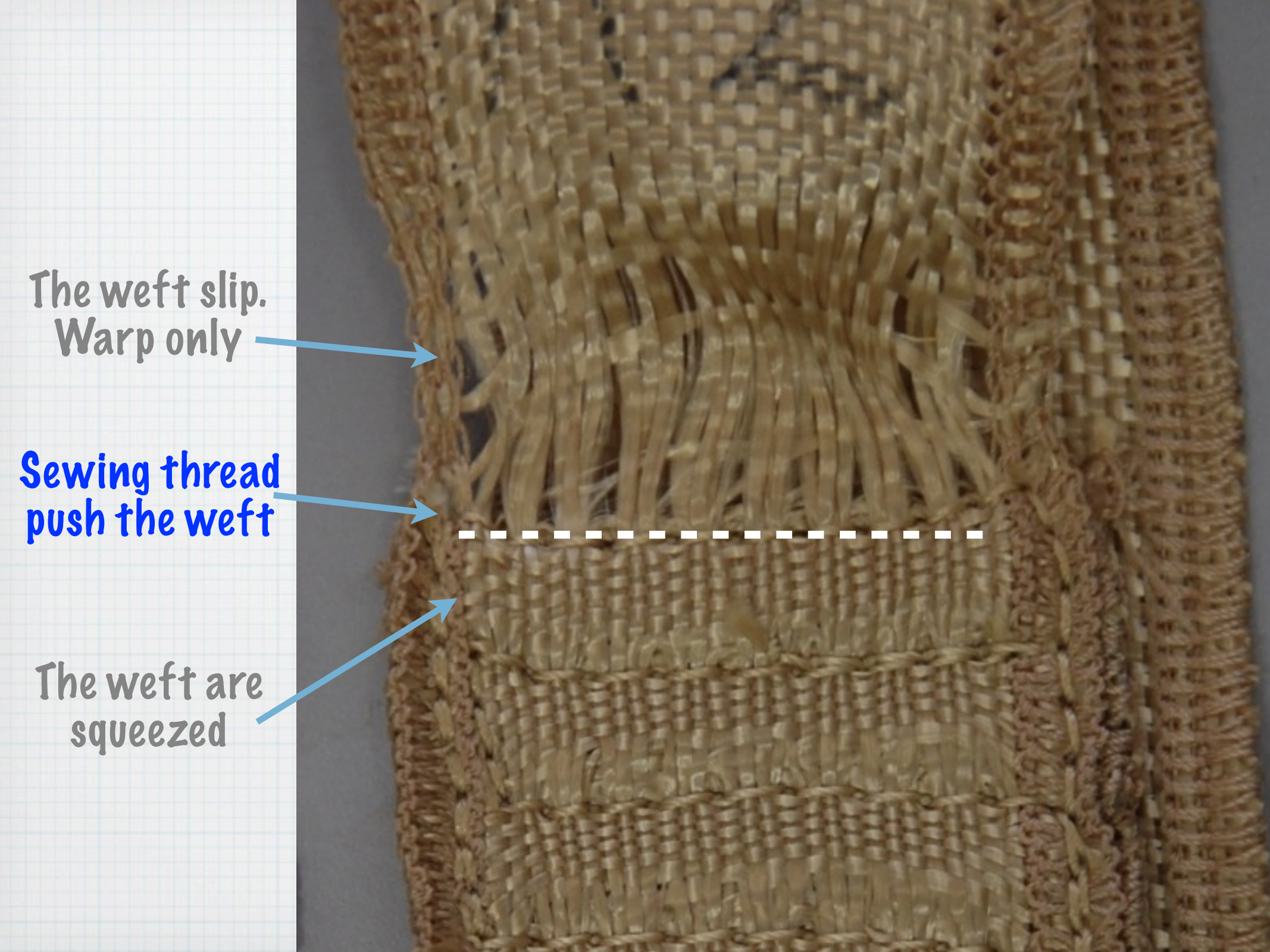
* Tension

  ~3kN/5cm

  = 60kN/m

  < 170kN/m
  (fabric strength)


The weft slip.
Warp only
Sewing thread
push the weft
The weft are
squeezed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I tried many sewing methods











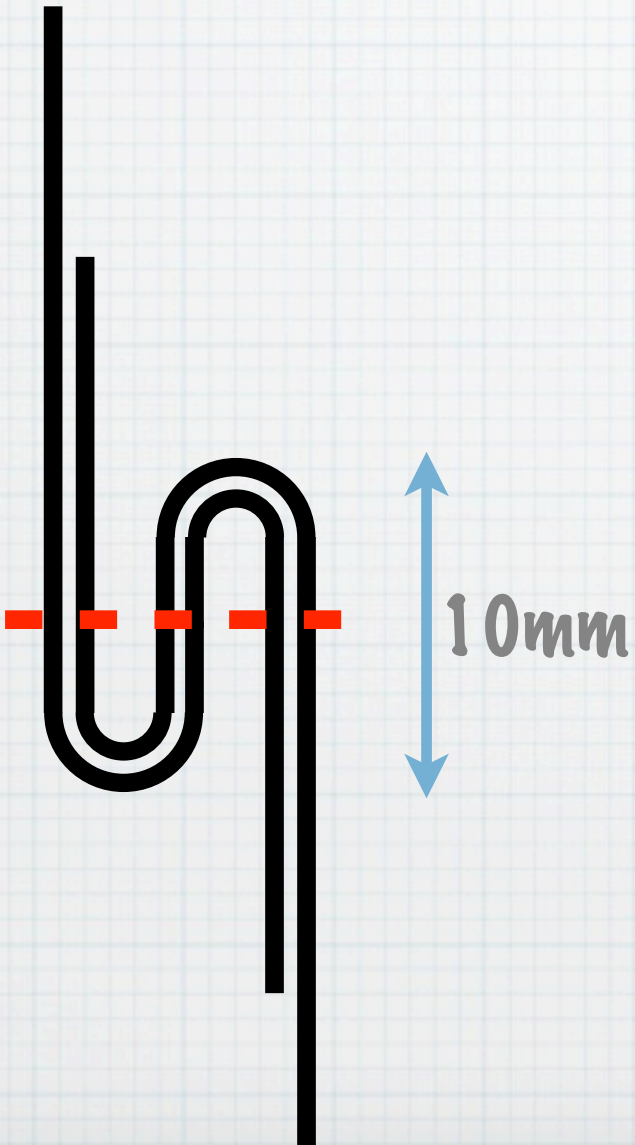






Solution

* Make dead ends for weft



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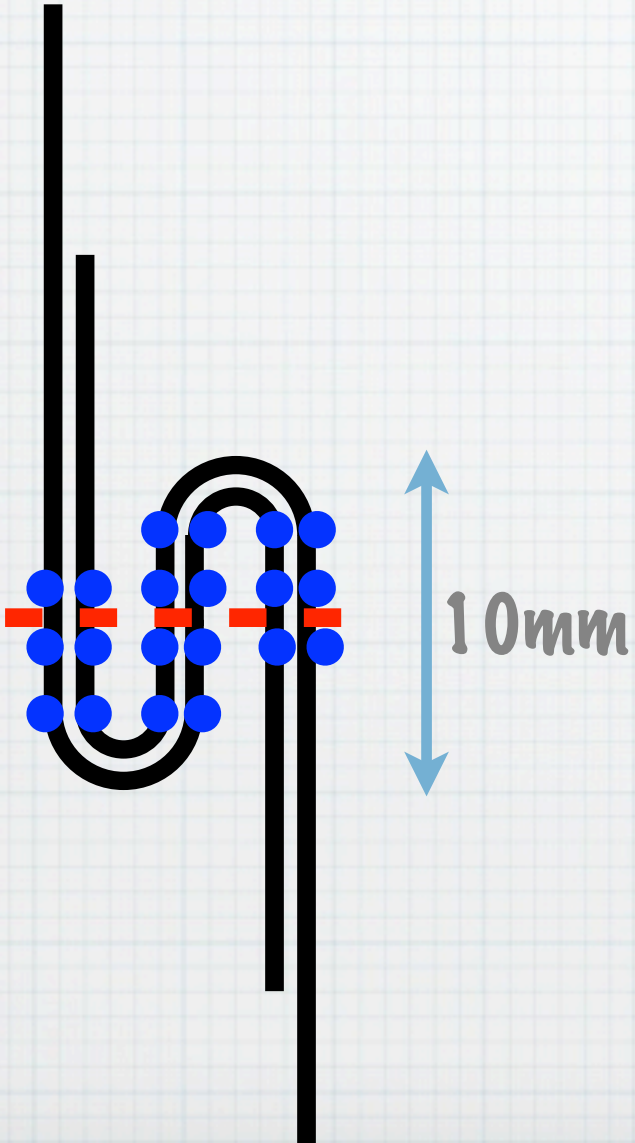

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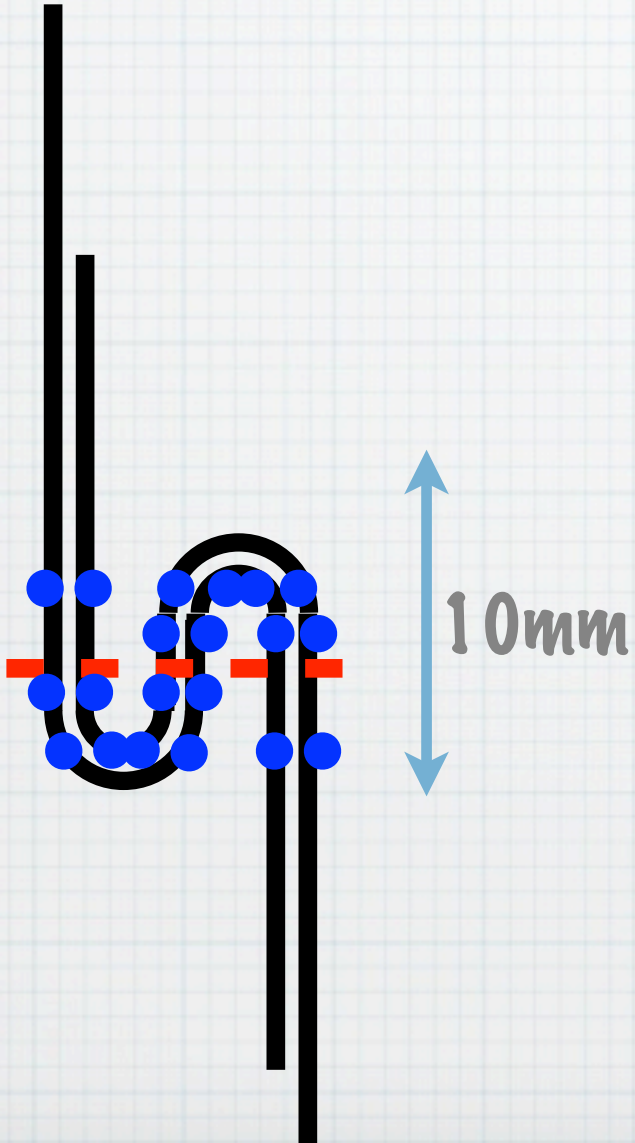
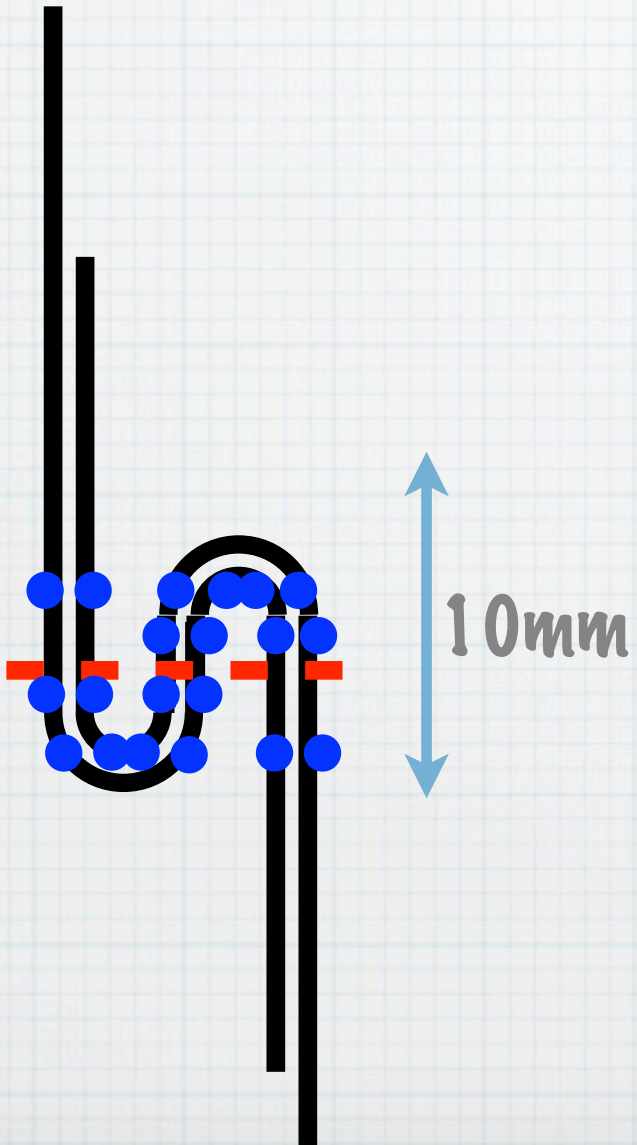


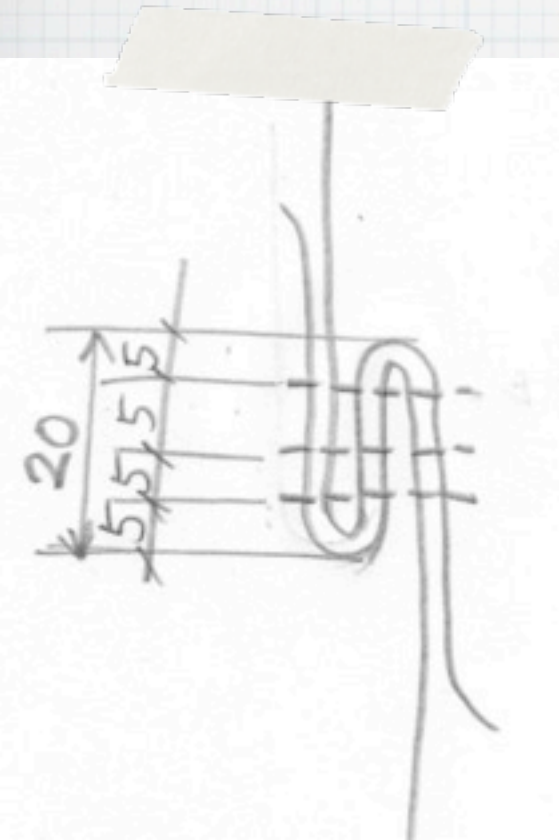
Solution

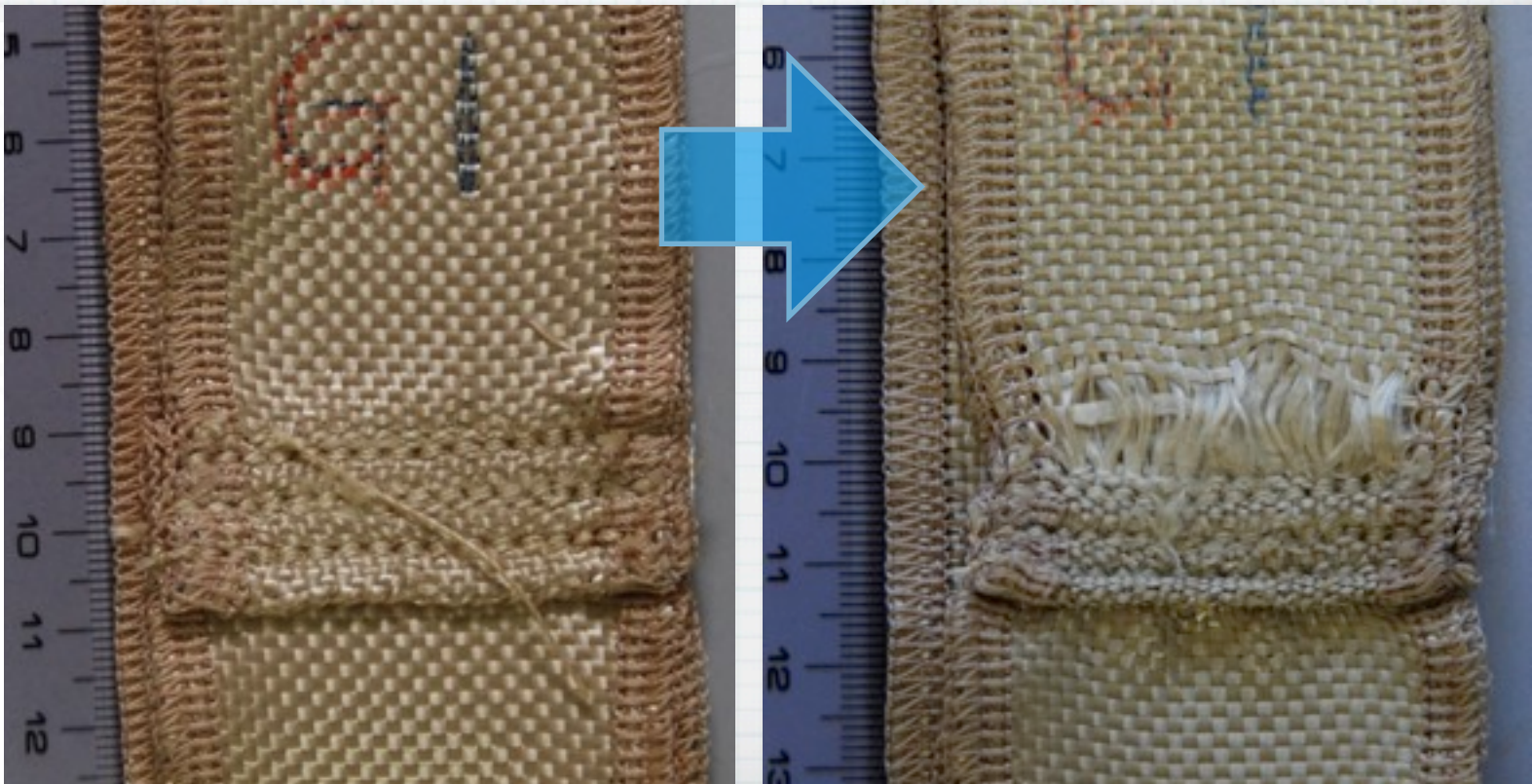
* Make dead ends for weft
* Tension ~ 100 kN/m



Final sewing method for Ver. I

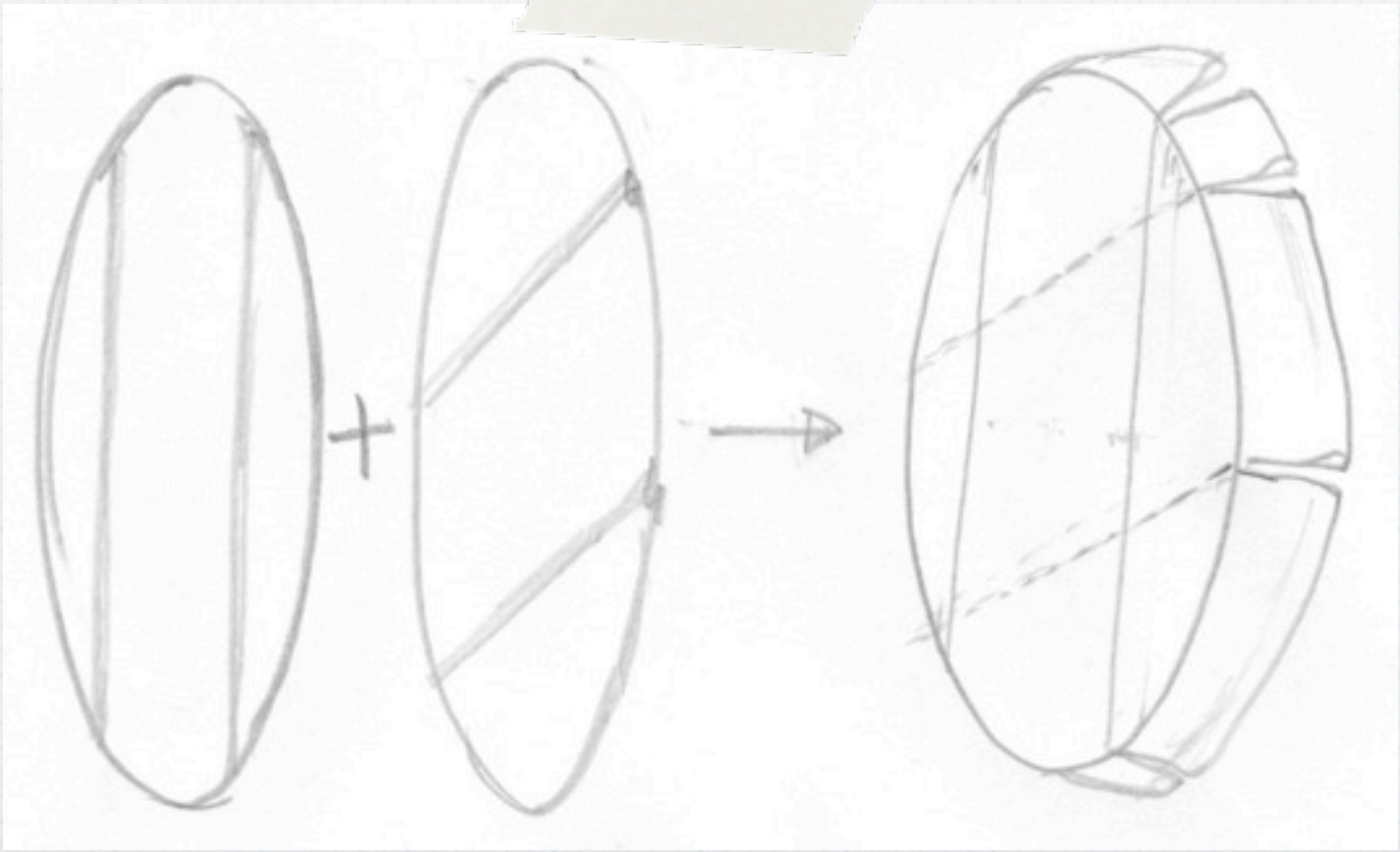
* Bend two fabrics together in Z-shape
* Sew 3 locations x 3 times w/ 3mm pitch
* Tension = 100 kN/m = 0.6 x 170kN (fabric)





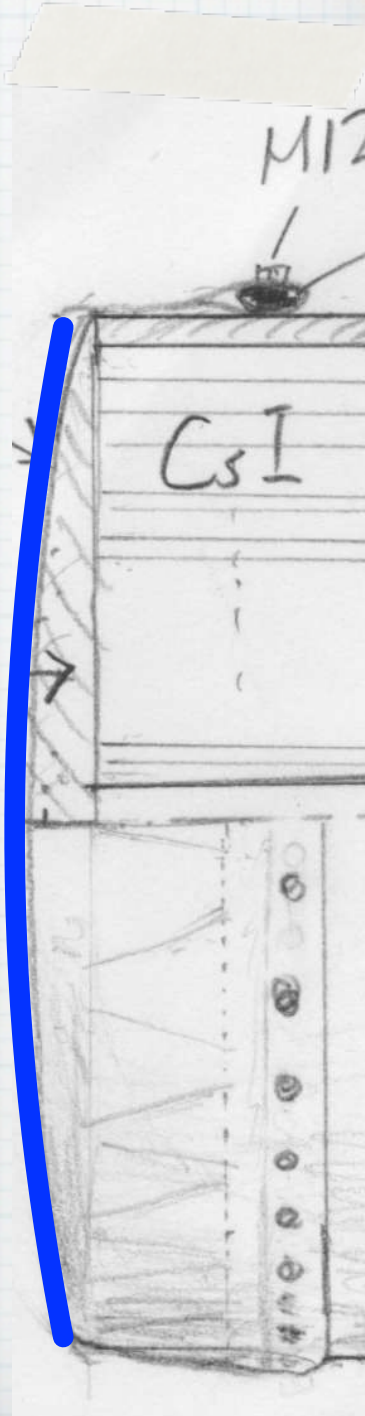
Design

- Sew three 1m wide fabrics => 1 sheet
- 2 sheets at 45deg
- Add sides for securing down to the cylinder



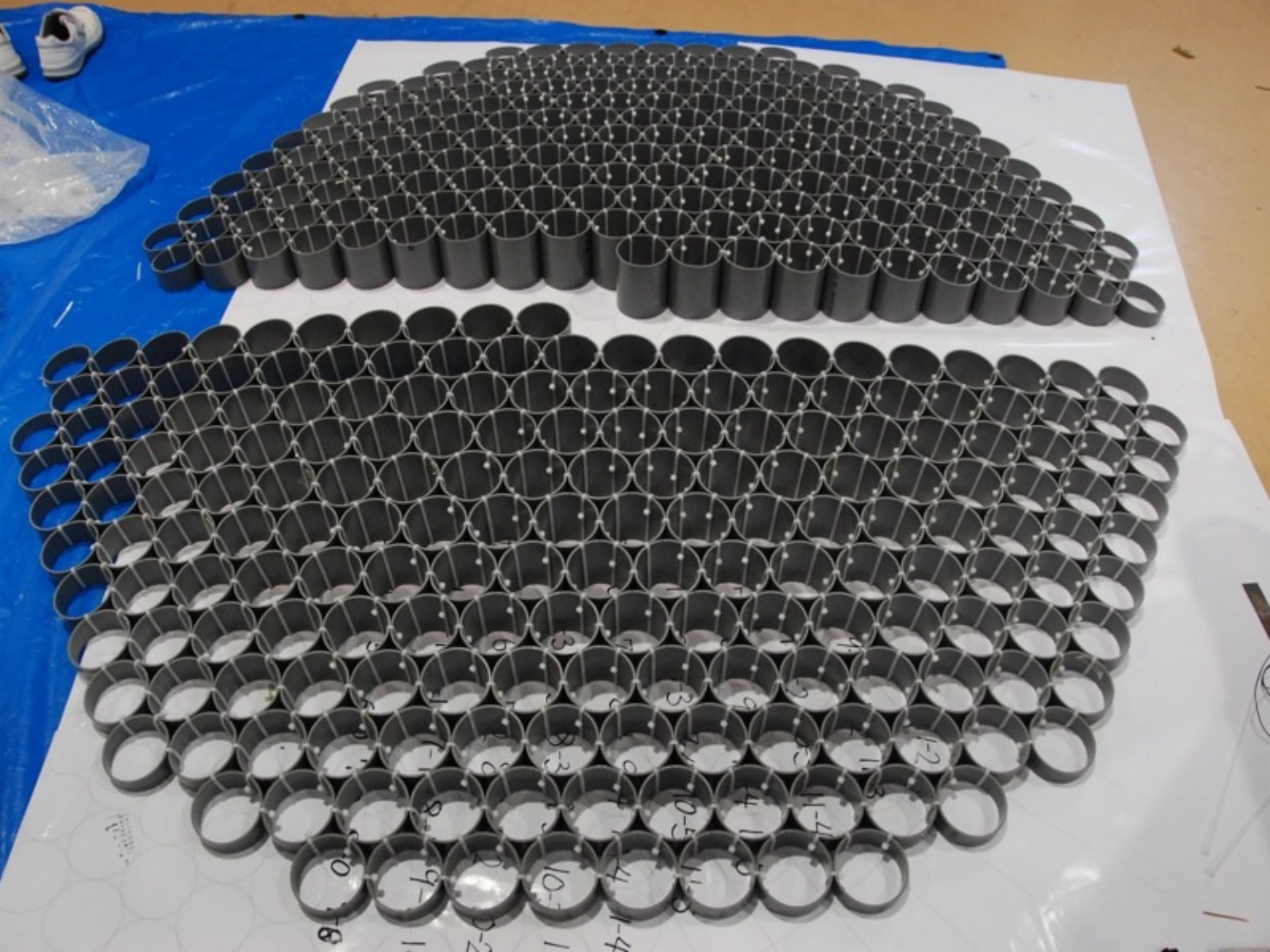
The cover

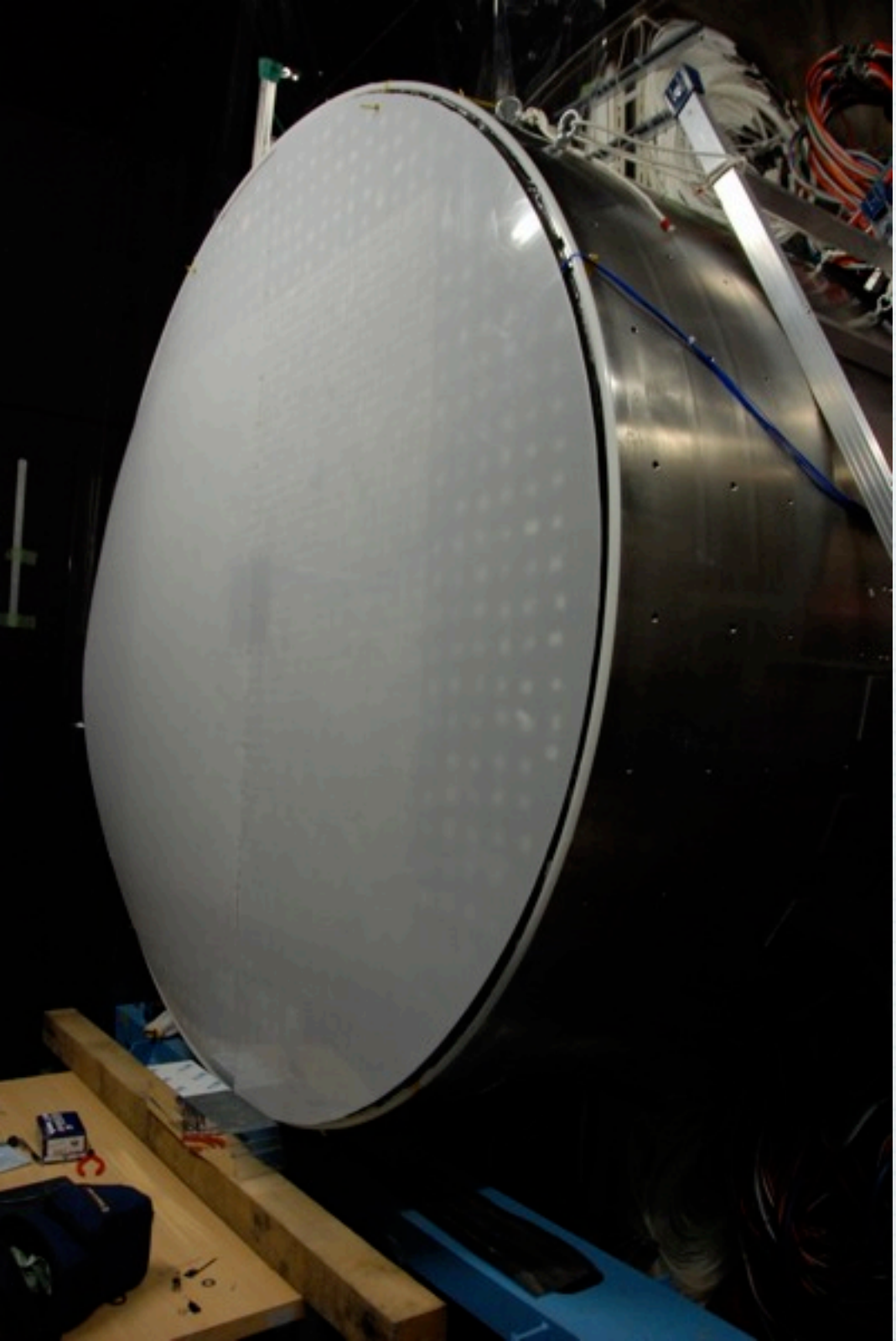
How to keep the parabola shape

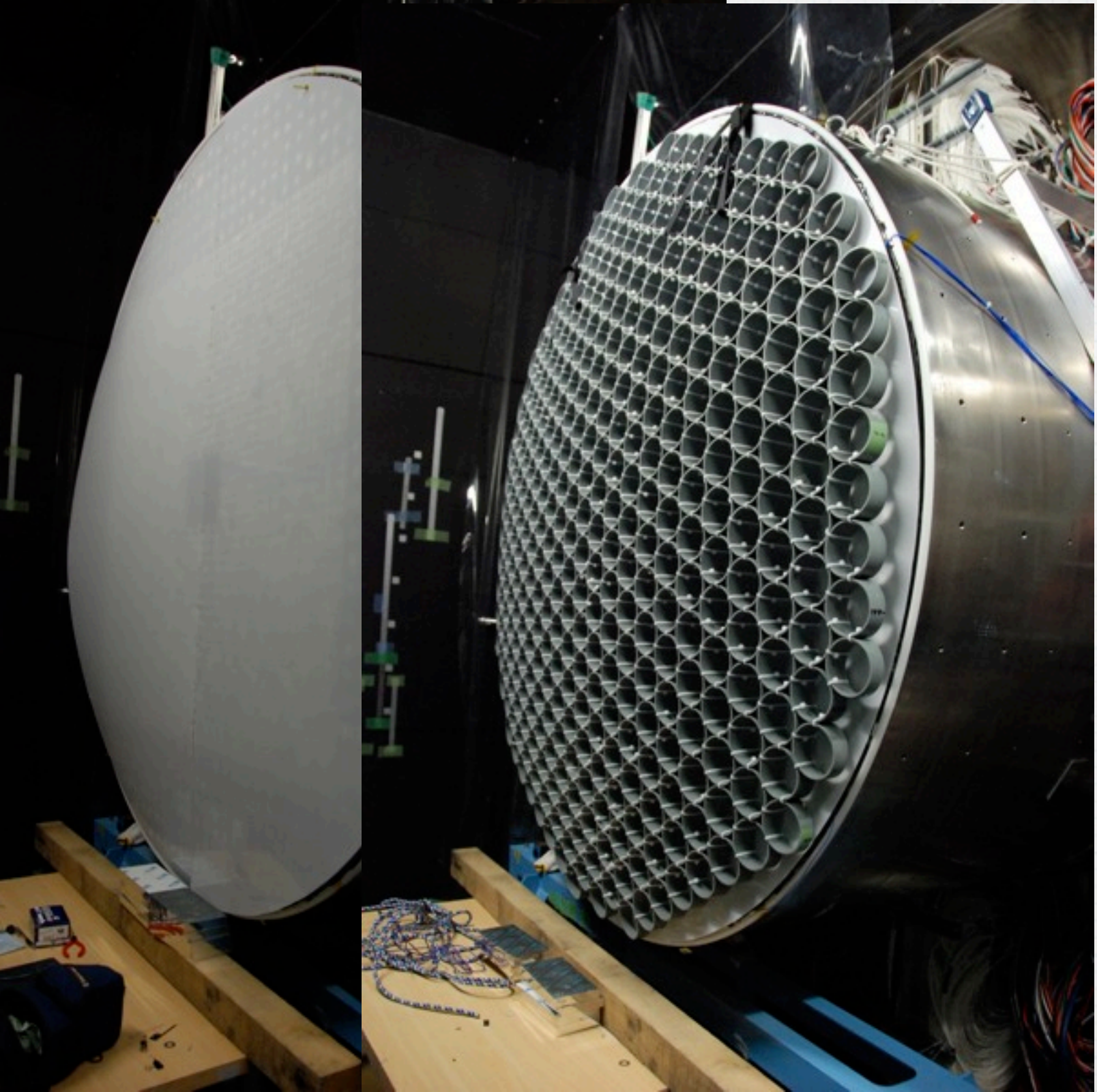


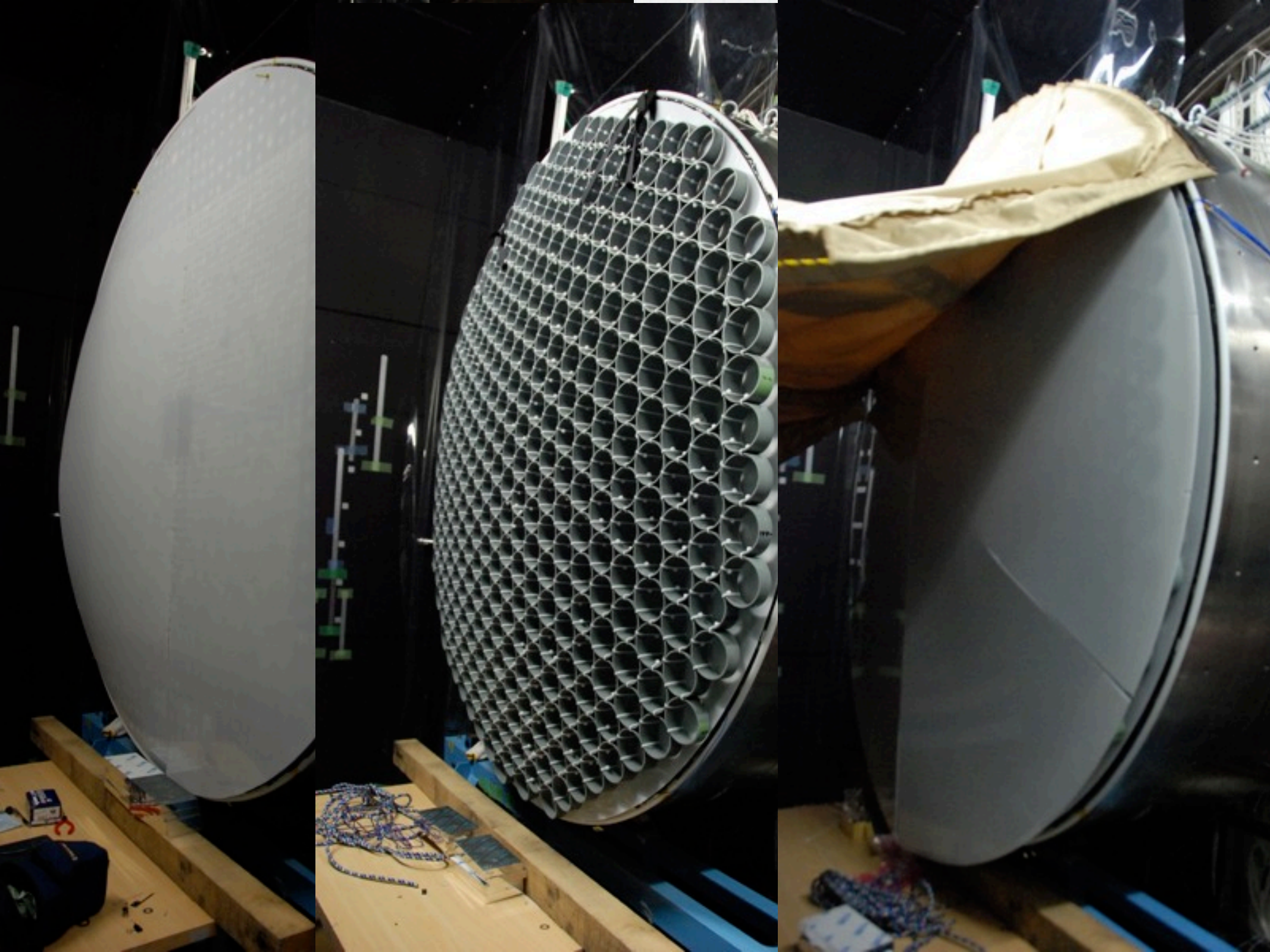
PVC pipes

* 40 different types
* 379 pieces

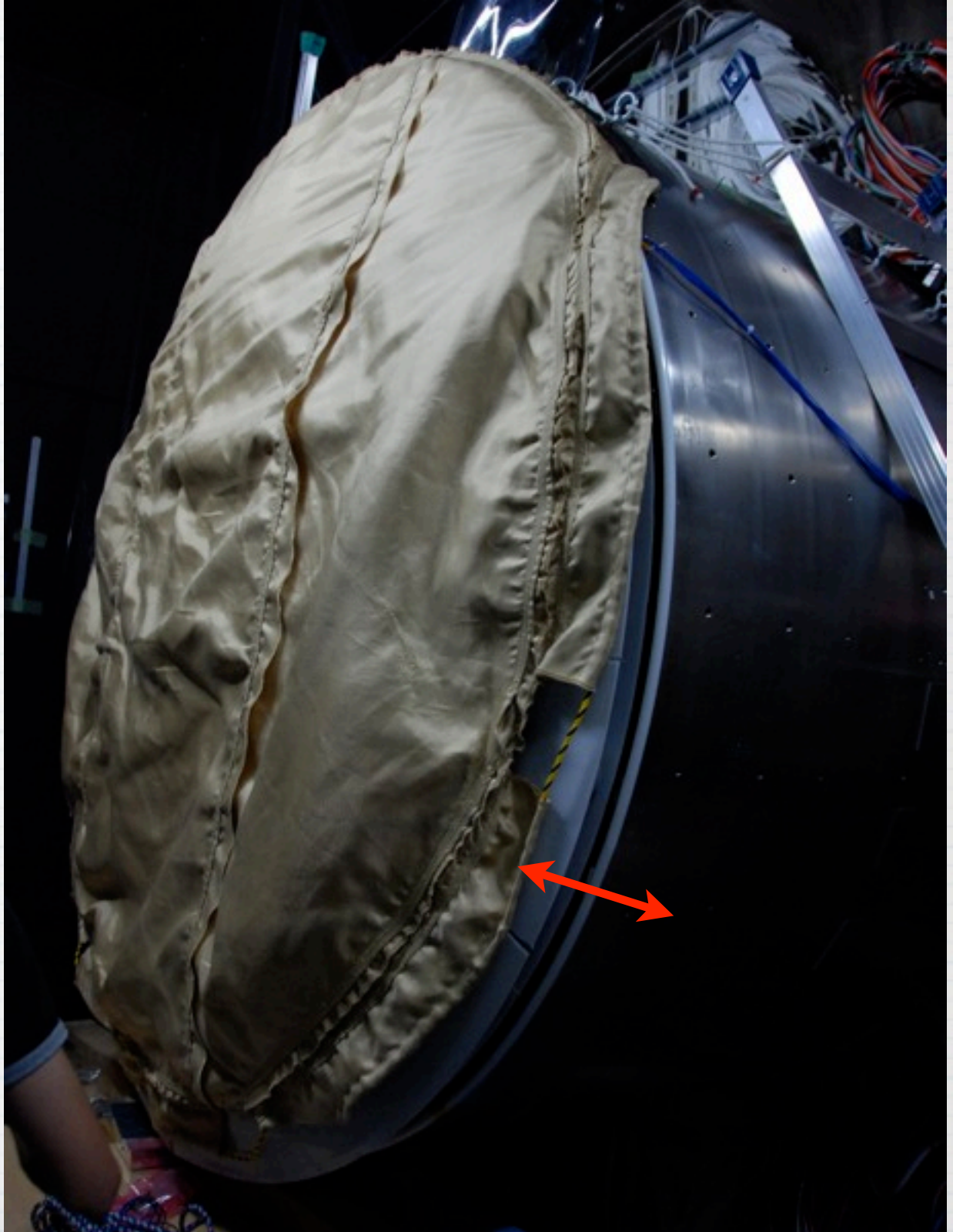








5cm short!



* So we removed strings for half a circle, extended the side sheet by 7cm, and hand-sewed it.


Aug. 19, 2011 3AM
= T - 6h

What we learned

- Aramid cloths are strong
- They can be sewed together w/ 60% strength
- Prepare an length-adjustment mechanism for fabrics