# Drift chamber R&D progress in Novosibirsk

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for DC working group

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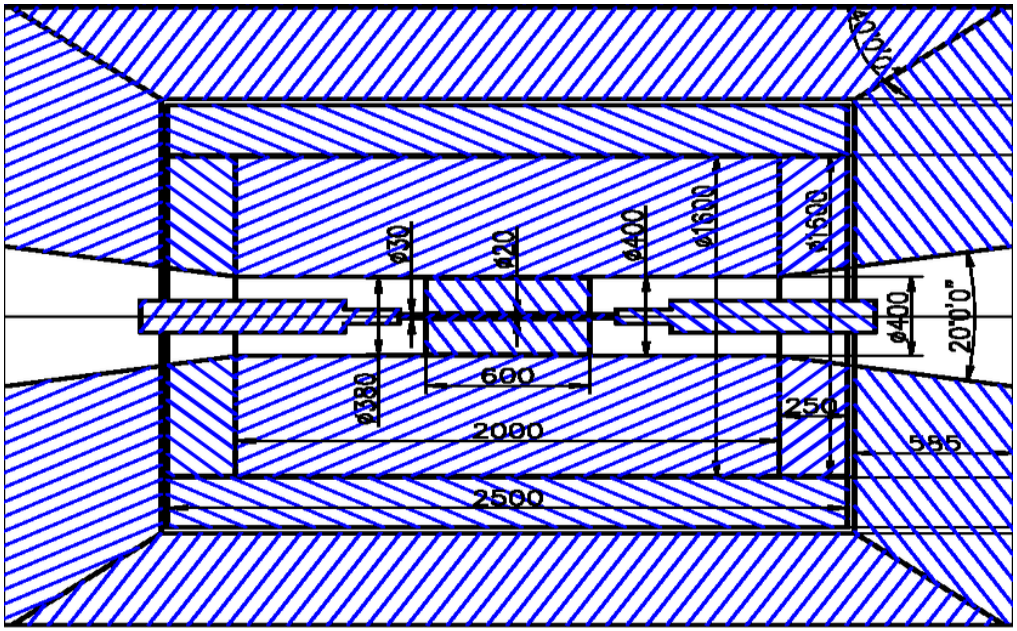
2019 Joint Workshop on Future charm-tau Factory

# OUTLINE

- General description.
- Parametric simulation.
- ANSYS calculation.
- Wire quality study and etc.




SCTF Detector central part

DC provides:

- Precise momentum resolution and maximum solid angle coverage.
- Good dE/dx resolution for PID.

# Drift Chamber project

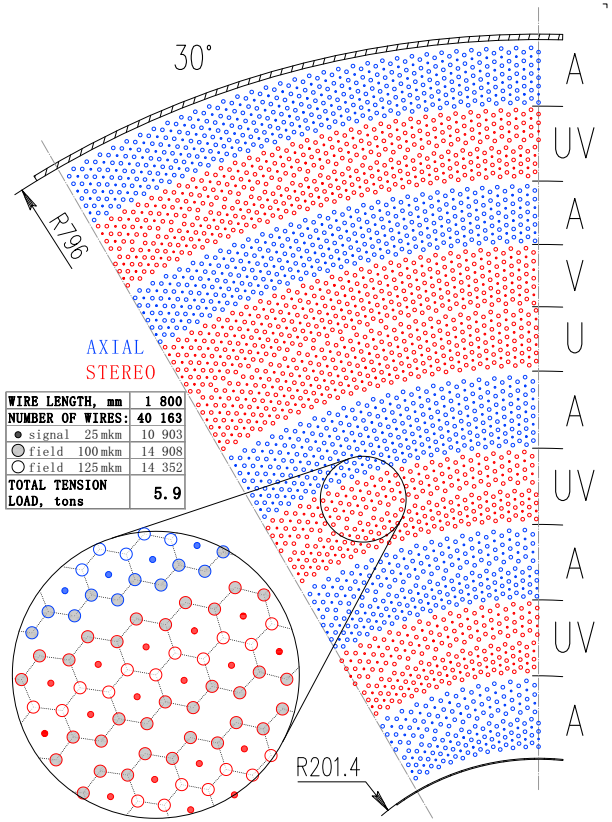
- Hexagonal cell
- 41 layers: 10 SL

  5 stereo/ 5 axial
- Gas $He/C_3H_8$ (60%/40%)

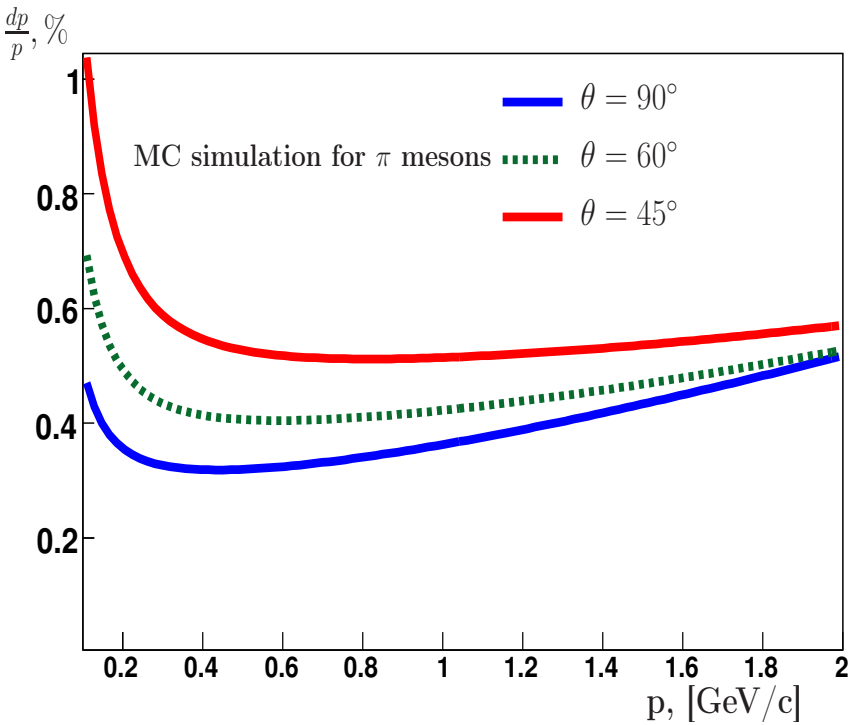
  Operate at $\sim 2.0$ **kV**

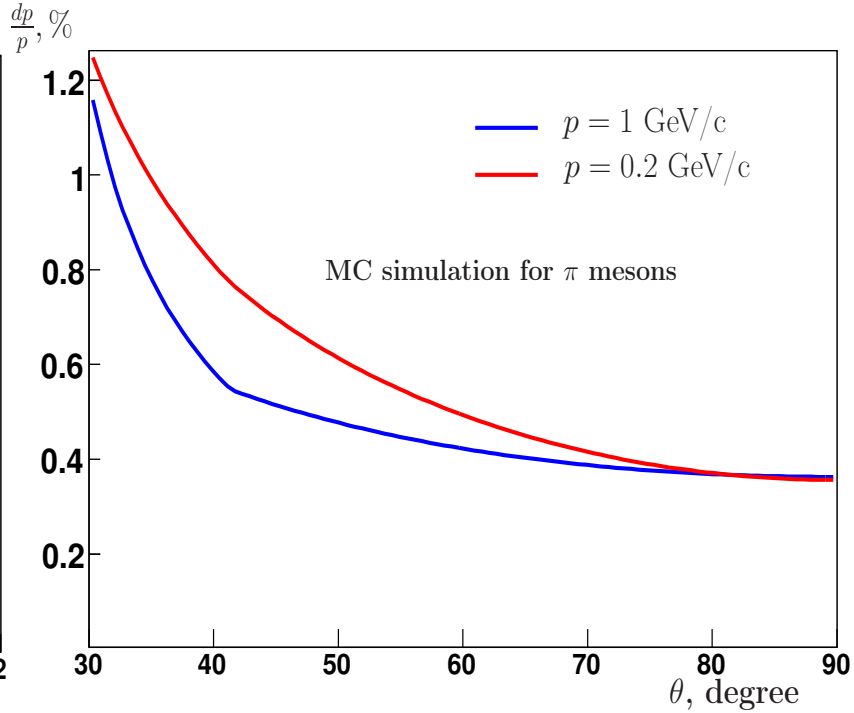
  Gas gain $\sim 4 \cdot 10^4$
  - $T_{drift}^{max} \sim 400$ **ns** ($B = 1.5$ **T**)
  - $\sigma \lesssim 90$ $\mu$**m**
  - $\frac{\sigma_{\frac{dE}{dx}}}{\frac{dE}{dx}} \lesssim 6.9\%$

| SUPER LAYER NUMBER | NUMBER OF MONO-LAYERS | NUMBER OF CELLS IN MONOLAYER | NUMBER OF CELLS | STEREO ANGLE, mrad | CELL SIZE r ± Δr, mm | | RADIUS OF ANODE WIRE LAYER, mm |
|---|---|---|---|---|---|---|---|
| 1 | 4 | 125 | 500 | 0 | 6.306 | 0.034 | 217.306 |
| | | | | | 6.644 | 0.007 | 227.100 |
| | | | | | 7.165 | 0.039 | 246.906 |
| | | | | | 7.549 | 0.009 | 258.035 |
| 2 | 4 | 157 | 628 | + 33.8 | 6.473 | 0.028 | 280.154 |
| | | | | | 6.747 | 0.006 | 290.136 |
| | | | | − 34.2 | 7.182 | 0.031 | 310.863 |
| | | | | | 7.486 | 0.007 | 321.938 |
| 3 | 4 | 189 | 756 | 0 | 6.564 | 0.024 | 341.986 |
| | | | | | 6.794 | 0.005 | 352.060 |
| | | | | | 7.140 | 0.026 | 371.992 |
| | | | | | 7.388 | 0.005 | 382.950 |
| 4 | 4 | 223 | 892 | + 48.9 | 6.603 | 0.020 | 405.941 |
| | | | | | 6.799 | 0.004 | 416.040 |
| | | | | − 49.3 | 7.104 | 0.021 | 436.741 |
| | | | | | 7.314 | 0.005 | 447.606 |
| 5 | 5 | 255 | 1275 | 0 | 6.651 | 0.018 | 467.570 |
| | | | | | 6.823 | 0.003 | 477.718 |
| | | | | | 6.968 | 0.001 | 488.097 |
| | | | | | 7.120 | 0.001 | 498.701 |
| | | | | | 7.274 | 0.001 | 509.535 |
| 6 | 4 | 287 | 1148 | + 63.1 | 6.741 | 0.016 | 533.350 |
| | | | | | 6.895 | 0.004 | 543.615 |
| | | | | | 7.026 | 0.001 | 554.088 |
| | | | | | 7.161 | 0.001 | 564.762 |
| 7 | 4 | 313 | 1252 | − 63.4 | 6.778 | 0.015 | 584.801 |
| | | | | | 6.919 | 0.003 | 595.108 |
| | | | | | 7.039 | 0.001 | 605.606 |
| | | | | | 7.163 | 0.001 | 616.289 |
| 8 | 4 | 341 | 1364 | 0 | 6.768 | 0.014 | 636.220 |
| | | | | | 6.898 | 0.003 | 646.501 |
| | | | | | 7.007 | 0.001 | 656.957 |
| | | | | | 7.121 | 0.001 | 667.581 |
| 9 | 4 | 371 | 1484 | + 64.7 | 6.746 | 0.013 | 689.948 |
| | | | | | 6.865 | 0.003 | 700.185 |
| | | | | − 65.0 | 7.041 | 0.013 | 720.090 |
| | | | | | 7.165 | 0.002 | 730.775 |
| 10 | 4 | 401 | 1604 | 0 | 6.791 | 0.012 | 750.730 |
| | | | | | 6.902 | 0.003 | 761.027 |
| | | | | | 6.995 | 0.001 | 771.472 |
| | | | | | 7.091 | 0.001 | 782.061 |
| TOTAL | 41 | | 10903 | | | | |



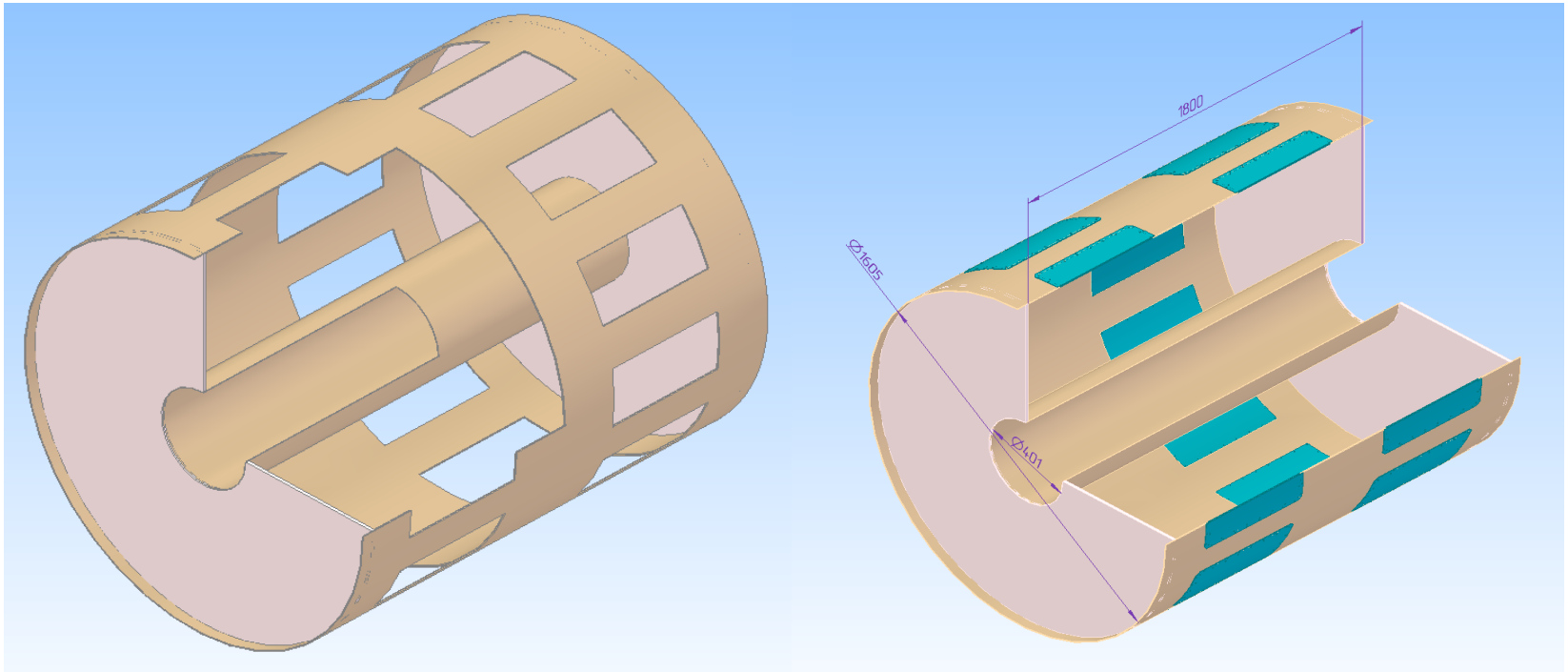
# MC simulation




- The parametric simulation of the momentum resolution is available in CTD software.

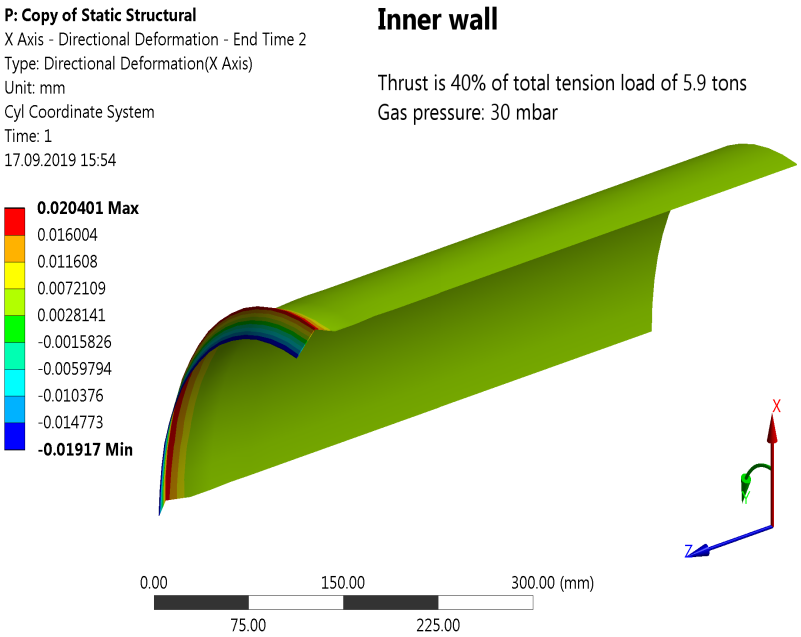
# DC project development in progress

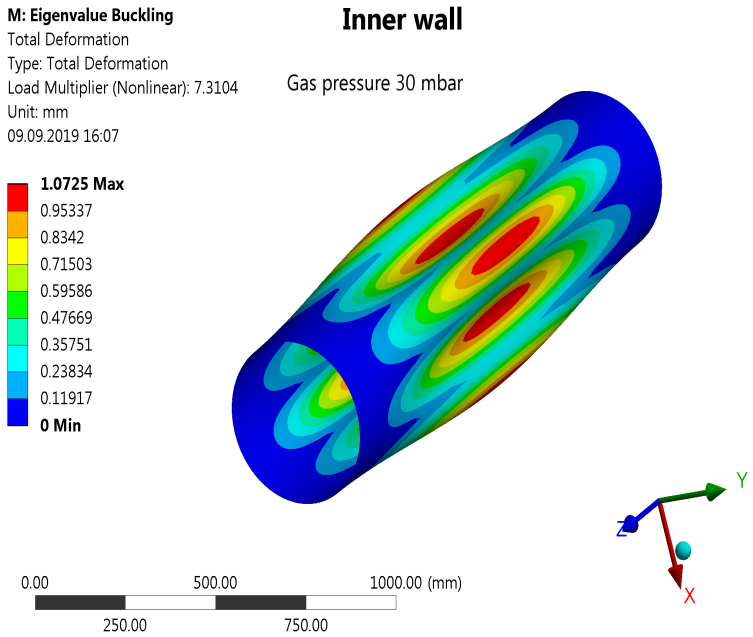



DC Project. Cutaway view.

- To facilitate the wiring, the DCH is provided with 24 windows.
- Window covers are designed to withstand overpressure.
- The ANSYS program is used to simulate structural stability.

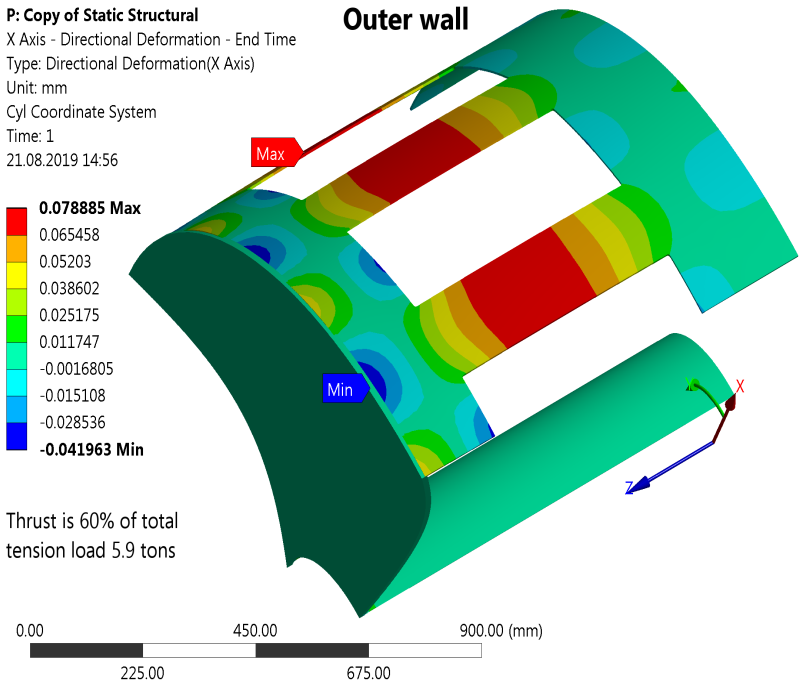
# An inner tube simulation in ANSYS

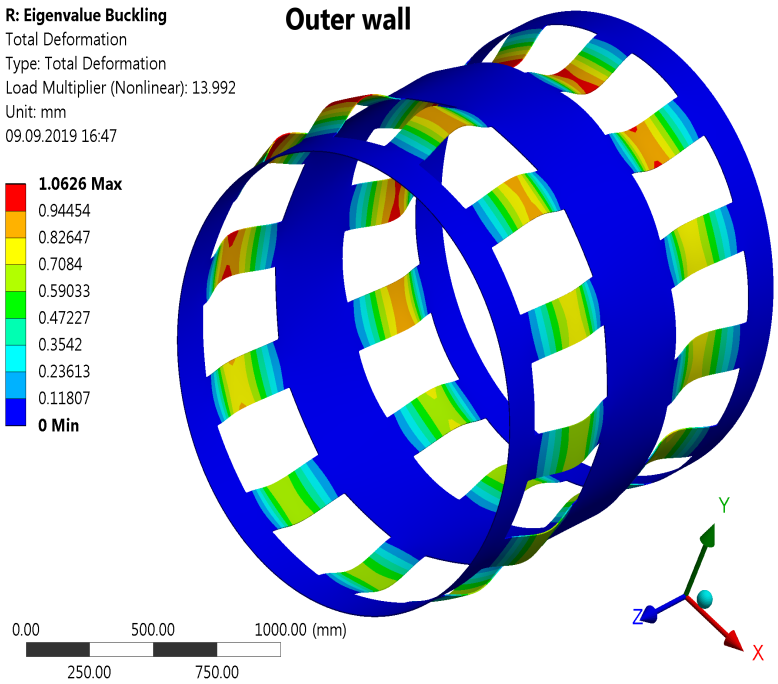



- The inner tube of carbon fibre reinforced polymer (CFRP) has a cylindrical shape. The wall thickness is 0.9 mm.
- The load of wire tension is about 2.36 tons (max deformation is less than 21 $\mu$m).
- Stability safety factor is 7.3

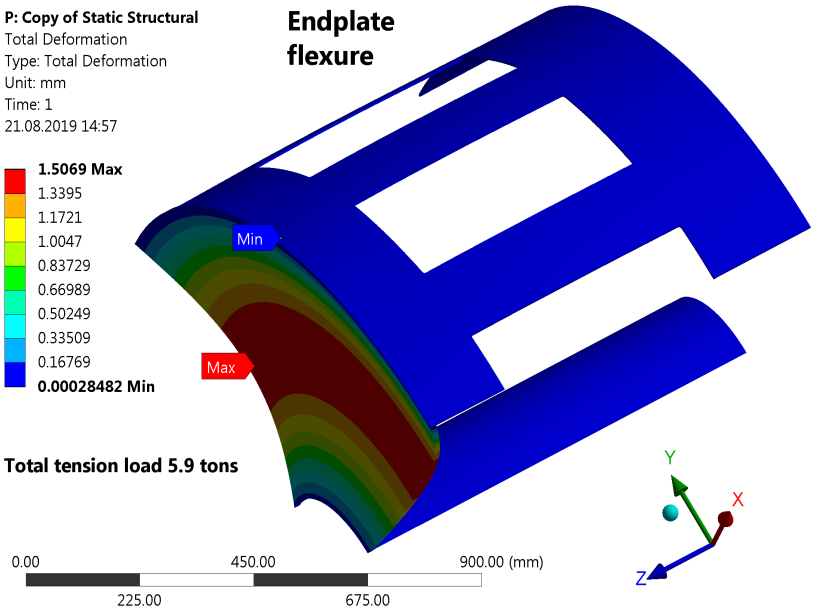
# An outer tube simulation in ANSYS

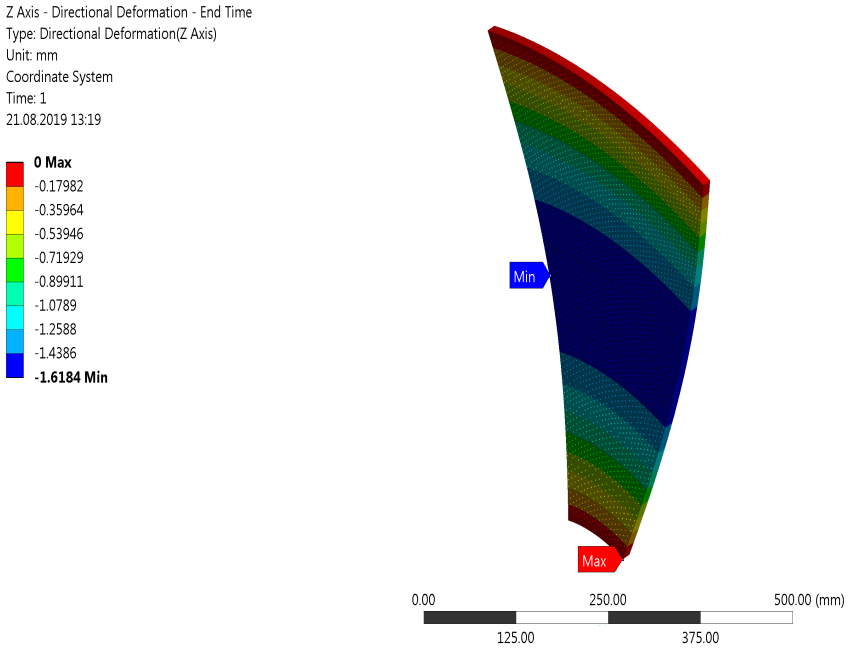


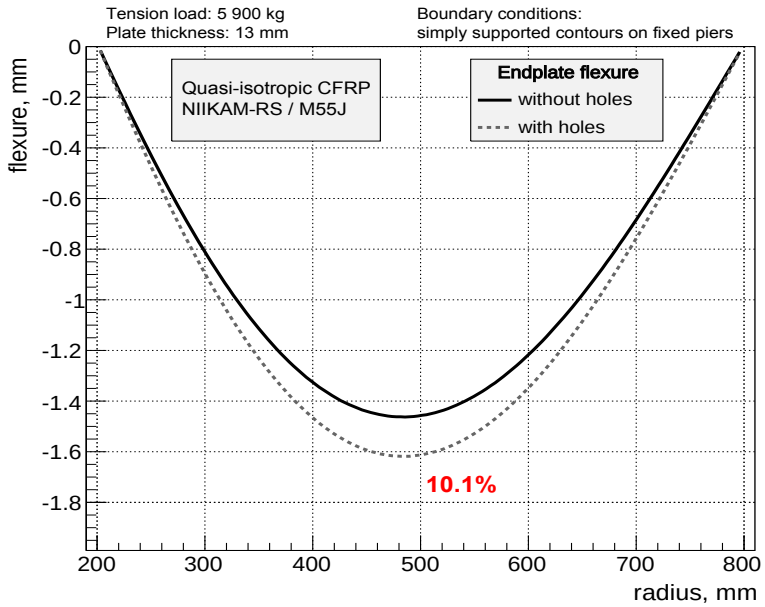

- The outer tube has a cylindrical shape (CFRP material). The wall thickness is 4.5 mm.
- The load of wire tension 3.54 tons (maximal deformation is less than 80 $\mu$m).
- Stability safety factor is about 14.

# Endplate simulation in ANSYS

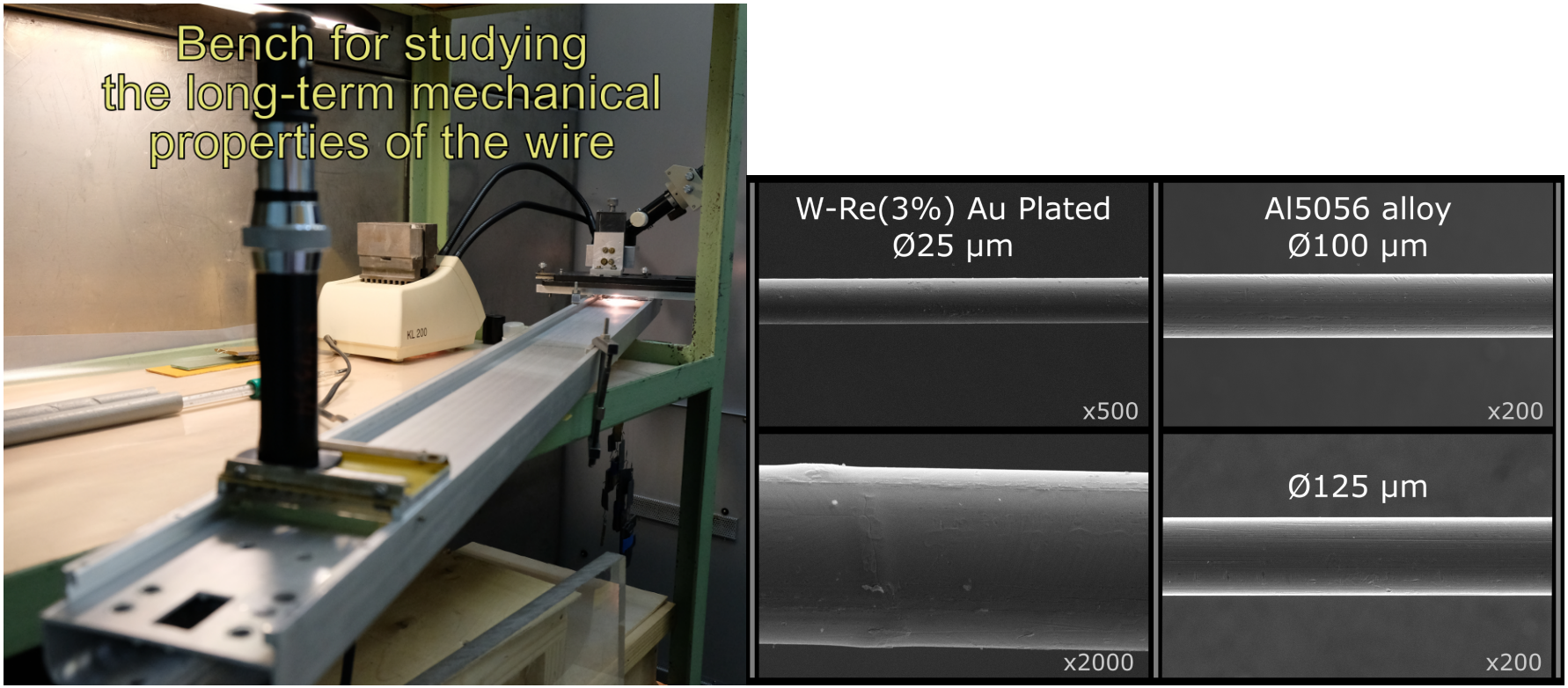



- Endplate is flat, the thickness is 13 mm (material CFRP).
- The full load is about 5.9 tons (max deformation is about 1.6 mm).



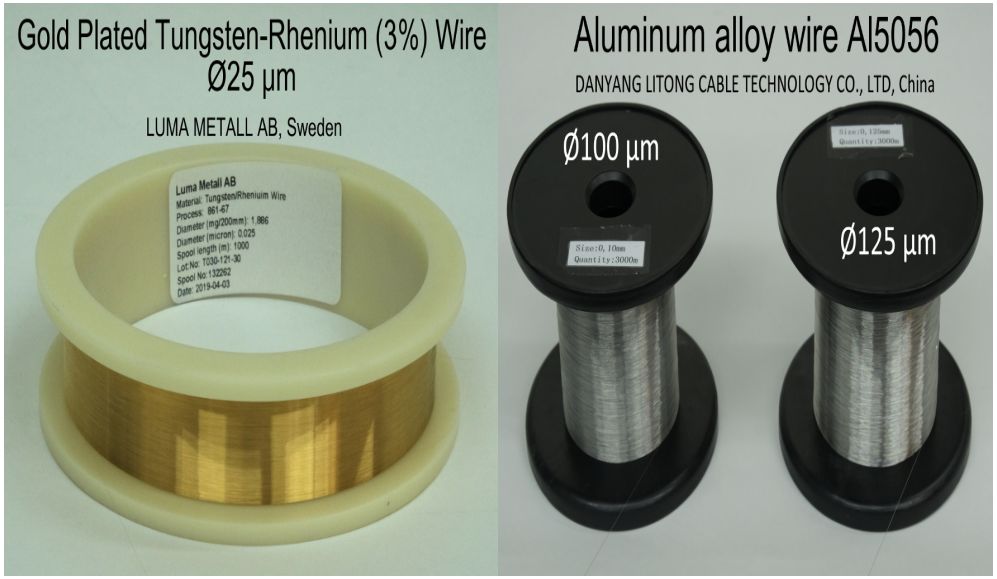
# Wire quality study

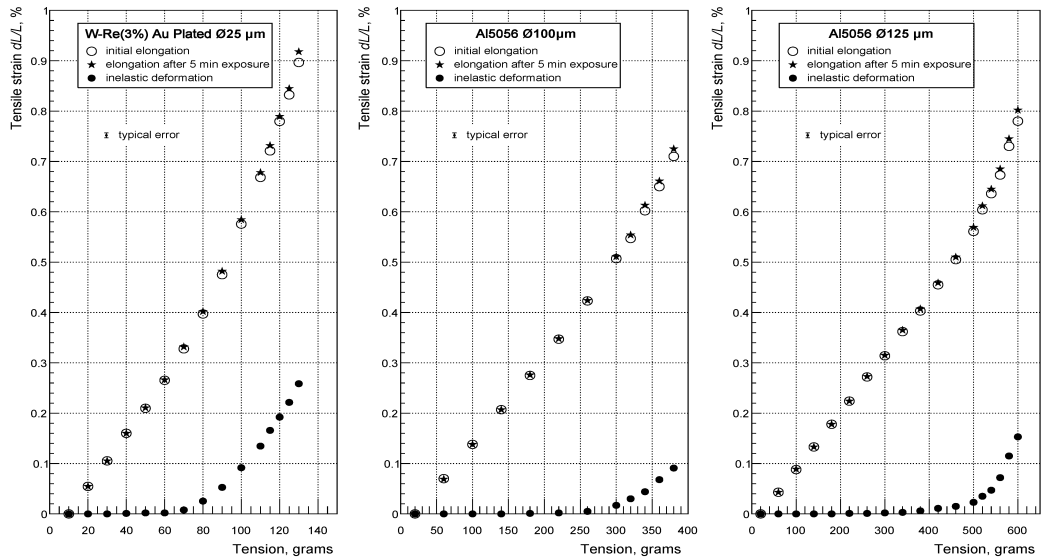



- We study surface quality and carry out mechanical tests.

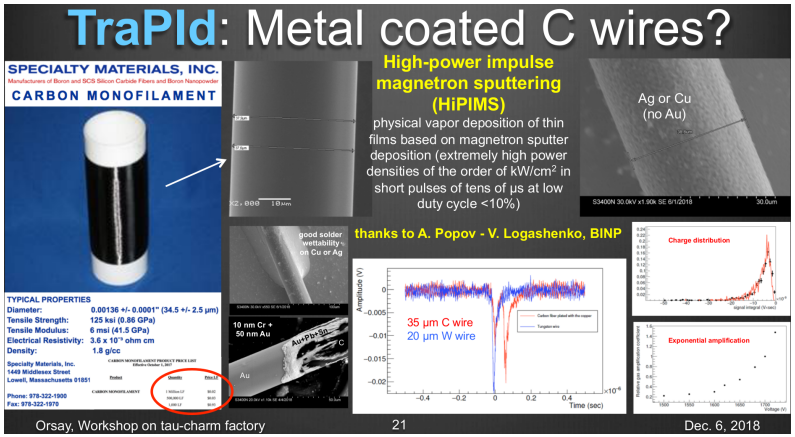
# Results of the mechanical tests

| | W-Re(3%) Au Plated 25 μm in dia. | Al5056 alloy 100 μm in dia. | Al5056 alloy 125 μm in dia. |
|---|---|---|---|
| Manufacture Date | 2019-04-03 | 2019-06 | 2019-06 |
| Wire Type | 861/67 | - | - |
| Diameter (rating) | 25 microns | 100 microns | 125 microns |
| Diameter Tolerance (±) | 2% | 2 microns | 2 microns |
| Straightness grade | 1 | - | - |
| Ovality | 2% | - | - |
| | | | |
| Measured Properties*: | | | |
| Diameter, microns | 25.0 ± 0.2 | 102 ± 1 | 126 ± 1 |
| Linear Density**, mg/m | 9.4 | 21.6 | 32.9 |
| Yield Strength, g | 65 ± 5 | 240 ± 20 | 360 ± 20 |
| Young's Modulus, GPa | 381 ± 1 | 70 ± 2 | 70 ± 2 |
| Tensile Strength, g | 140 ± 5 | 400 ± 20 | 600 ± 20 |
| Elongation (before breaking), % | > 0.92 | > 0.72 | > 0.8 |
| *Based on samples taken from the first 10 meters of wire length on the spool. | | | |
| **Calculated mean value using the material density from the specification. | | | |

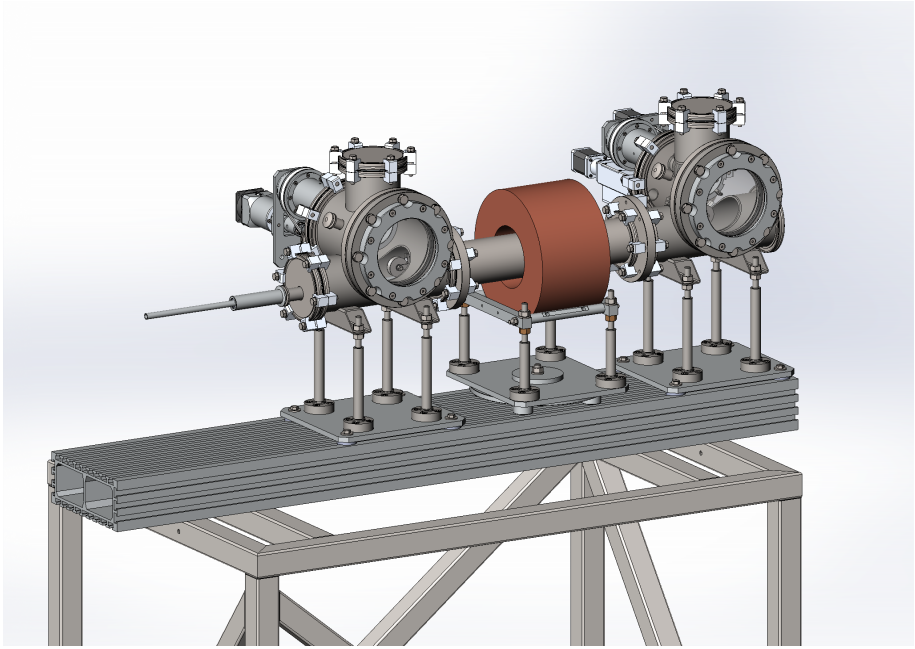


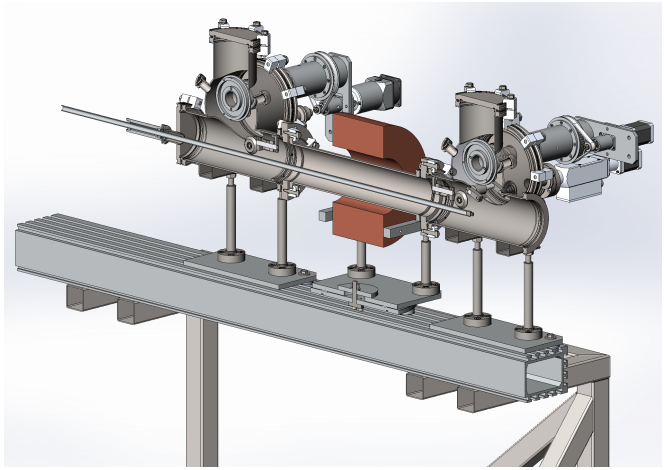
# Cylindrical magnetron sputtering apparatus




Orsay, 2018. F.Grancagnolo



Project of cylindrical magnetron sputtering apparatus.



Sectional view.

- Project is ready.
- Cylindrical magnetron is made. Stable discharge is obtained.
- The system of wire moving is in production process.

# Conclusions

- There is a some progress in MC simulation.
- Preliminary calculation of the DC construction is completed in ANSYS.
- Wire quality study is in progress.

Plans

- To perform aging tests with wire samples.
- To study the properties of gas mixtures using small prototypes.
- ...
- ...
- Drift chamber prototype creation.

# Thanks for your time and attention!

# BACKUP

# DC material

- 10903 sense wires 25 $\mu m$ W-Rh plated 0.5 $\mu m$ Au (tension 60 g)
  Thickness: 0.05%(0.004%)
- 29260 field wires (two types field wires to reduce M.S.)
  - **14908** ($D = 100$ $\mu m$, **tension 140 g**)
  - **14352** ($D = 125$ $\mu m$, **tension 220 g**)

  Al plated 0.5 $\mu m$ Au
  Thickness in X0: $0.105\% + 0.049\% \sim 0.15\%$
- 40163 wires give 5.9 tons on endplate

# General description

| DC Design | |
|---|---|
| $R_{in}/R_{out}$, mm | $\simeq$ 200/800 |
| $L_{in}/L_{out}$, mm | $\simeq$ 1800/1800 |
| Construction inner tube | |
| Material | CF 0.9 mm<br>+ Al foil 0.05 mm |
| X/X0,% | 0.46 |
| Construction outer cylinder | |
| Material | CF 2.5 mm<br>+ Al foil 0.05 mm |
| X/X0,% | 2.1 |
| Endplate | |
| Shape | Flat |
| Material | CF 13 mm<br>or Al 15.5 mm<br>sag $\sim$ 1.6 mm |
| X/X0,% | 5.9 or 17.4 |

| Cell | |
|---|---|
| Shape | hexagonal |
| Size | $6.306 \div 7.549$ mm |
| Layers configuration | |
| 10 superlayers<br>of 4(5) layers each | |
| $N^{layers}$ | 41 |
| Axial and stereo | |
| Odd $N^{cells}$ | $125 \div 401$ |
| $\alpha_{stereo}$ | $1.9^\circ \div 3.7^\circ$ |
| $N^{wires}_{sense}$ | 10903 ($D = 25\mu m$) |
| $N^{wires}_{field}$ | 29260<br>14908 ($D = 100\mu m$)<br>14352 ($D = 125\mu m$) |

# Expected momentum resolution

$$\frac{\sigma_{p_t}}{p_t} = \sqrt{a^2 p_t^2 + b^2}$$

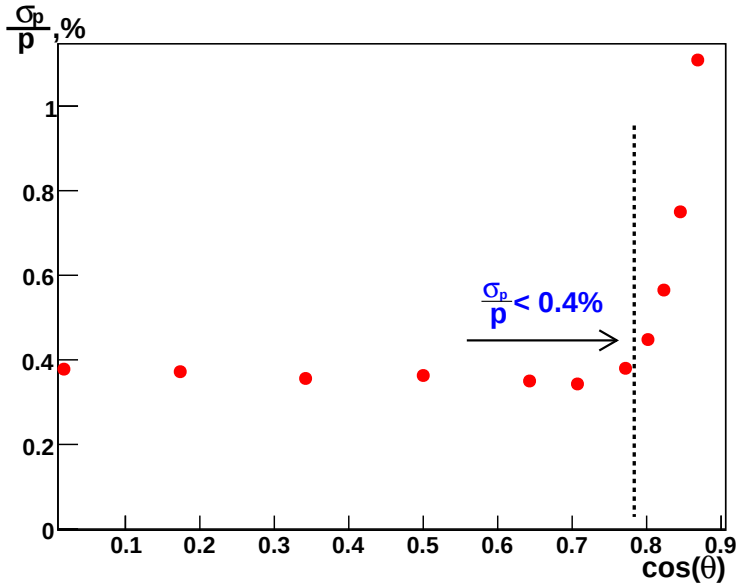
$a \simeq 0.21\%$ (BELLE CDC only
$a = 0.28\%$, Belle II CDC only (test)
$a = 0.2\%$ )

$$b \simeq \frac{0.06}{LB}\sqrt{\frac{X}{X_0}}\left(1 + 0.038 \ln \frac{X}{X_0}\right)$$

$L = 0.565$ м, $B = 1.5$ T,
$X/X_0 = \cancel{0.0046\ (\text{inner tube})} +$
Calculation for DC only
$0.0021\ (\text{wires}) + 0.0011(\text{gas}) = 0.0032$

$b \simeq 0.31\%$ (BELLE CDC only
$b = 0.35\%$, Belle II $b = 0.29\%$)

$$\frac{\sigma_{p_t}}{P_t}(1GeV) \sim 0.38\% \qquad \text{preliminary}$$




Expected momentum resolution vs cosine of polar angle ($p_t = 1$ GeV)

$dE/dx$ resolution $\sigma_{\frac{dE}{dx}} \lesssim 6.9\%$ is estimated from CLEO $dE/dx$ resolution and comparable with Belle(6.9%) and BaBar(7.5%)