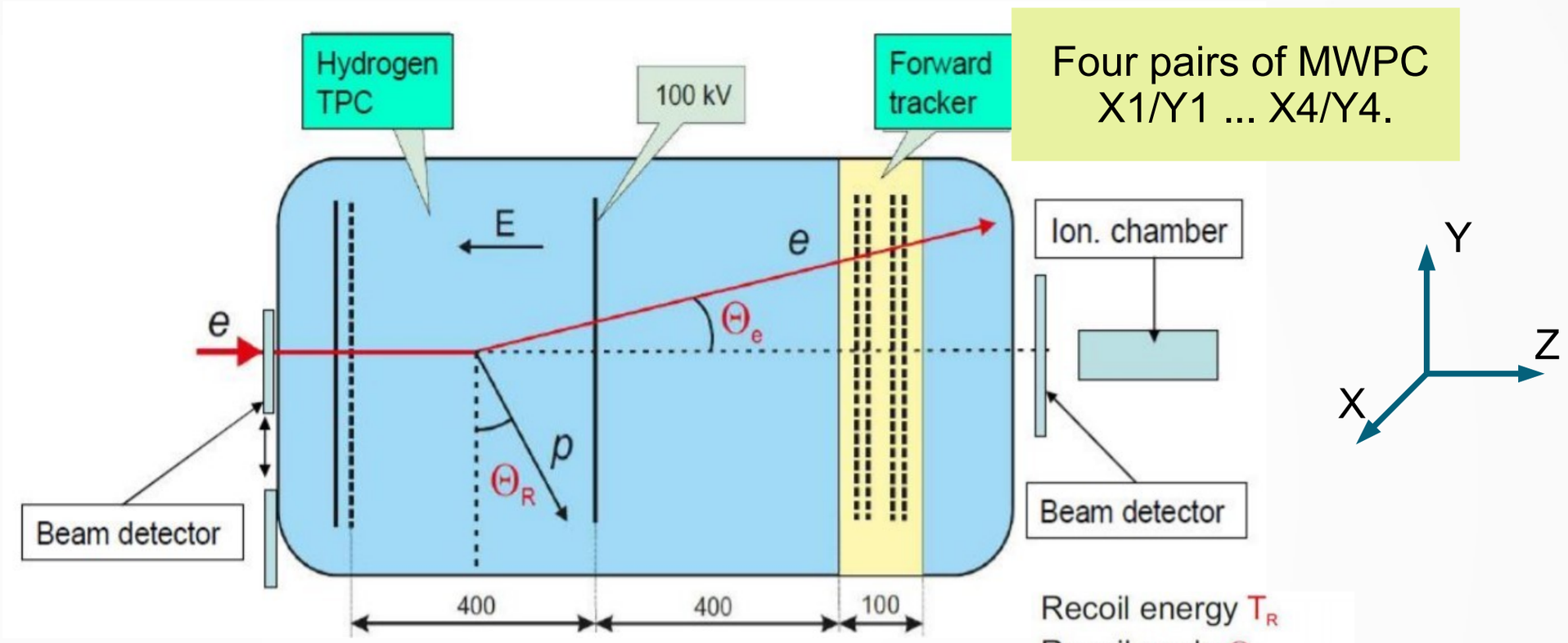
Forward Tracker of the PRESS experiment

Design and construction of the MWPCs

S.Mikirtychyants, PNPI

PRES experiment setup



Aim is high precision measurement of the differential ep elastic cross sections dσ/dt in the region of low momentum transfer: $0.002 \le Q2 \le 0.04$ GeV^2 with 0.2% absolute precision in dσ/dt.

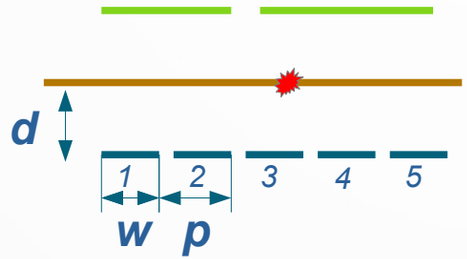
scattered electrons angle Θ_e : Acccuracy better 0.02%

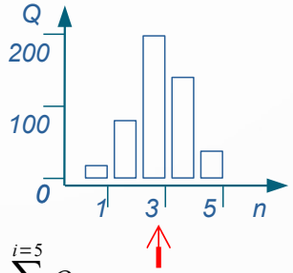
Design requirements for the MWPCs of the Forward Tracker (1-4)

1. MWPCs operate @ 20 bar gas mixture pressure →
   share the same high pressure volume with TPC, wich
   has to cover needed range R_p of the scattered protons;
2. Sensitive area 600x600 mm (octagone) → to don“t cut acceptance

3. Wire cathodes (∅ 50 micron, step 0.5 mm) →
   Minimum of Material to reduce small angle scattering of electrons;

4. Space resolution ~ 50 micron →
   The key element of the MWPC is the cathode plane
   with orthogonal cathode/anode wires (CathodeStripChamber: CSC).
   Cathode Strip Readout with the center of gravity algorithm
   for the charge distribution over the active strips





$$n_x = \frac{\sum_{i=5} Q_i * n_i}{\sum_{i=5} n_i} = 2.87$$

Design requirements for the MWPCs of the Forward Tracker (5)

1. MWPCs operate @ 20 bar gas mixture pressure
2. Sensitive area 600x600 mm (octagone)
3. Wire cathodes (∅ 50 micron, step 0.5 mm)
4. Space resolution ~ 50 micron

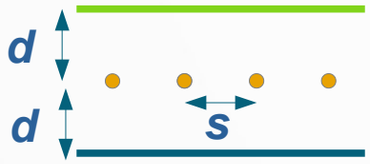
5. a. Gas gain > 300 → SNR ≥ 100 to reach p.4 (noise);
   b. At High Voltage < 6 kV → to don"t exeed anode wire tension limit;

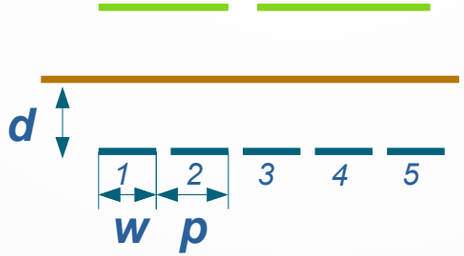
a & b → gas mixture: Ar + 4%CH_4 ,

→ anode wire: golden W(Re) ∅ 20 micron

→ CSC geometry

s - AW step: 3.0 mm; *d* - A-C gap: 3.0 mm; *p* / *w* - C strip pitch/width: 2.5/2.0 mm.





Coarse Cathode ∠ 45° to Anode

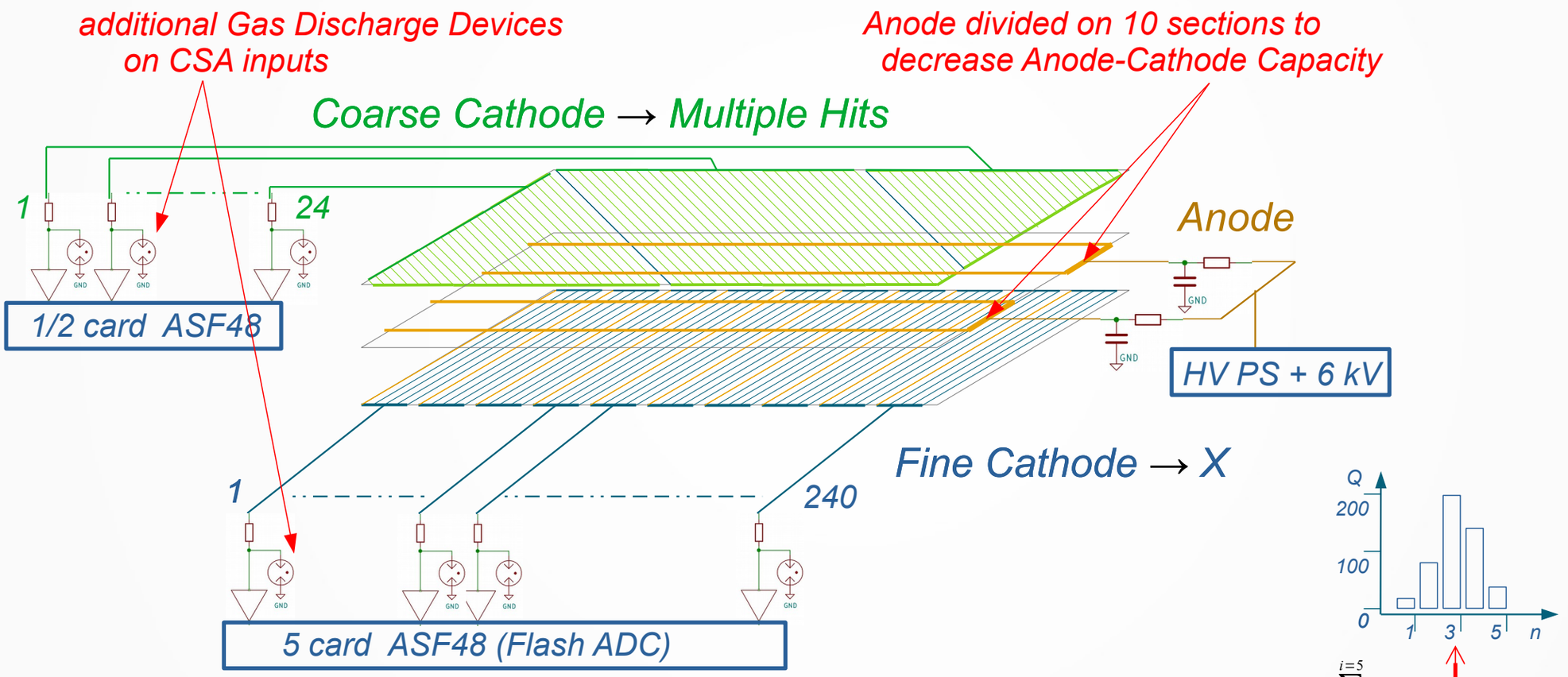
Anode T = 12 N

Fine Cathode ⊥ to Anode

Design requirements for the MWPCs of the Forward Tracker (5b)

5. b: High Voltage ~ 6 kV

$W(HV) \sim C*V^2 \rightarrow$ Surge Protection



$$n_x = \frac{\sum_{i=5} Q_i * n_i}{\sum_{i=5} n_i} = 2.87$$

Design requirements for the MWPCs of the Forward Tracker (6)

1. Sensitive area 600x600 mm (octagone)
2. MWPCs operate @ 20 bar gas mixture pressure
3. Wire cathodes (∅ 50 micron, step 0.5 mm)
4. Space resolution ~ 50 micron
5. a. Gas gain > 300
   b. At High Voltage < 6 kV

6. High efficiency (~100%) in whole sensitive area, BUT low (~1%) in the central area (∅ ~20 mm) to avoid DAQ overloads by intense e-beam → central part of anode wires increased up to ∅ 80 micron by chemical deposition of gold («golden spot»)

Design requirements for the MWPCs of the Forward Tracker (7a)

7. The most important requirement for the cathode strip plane:

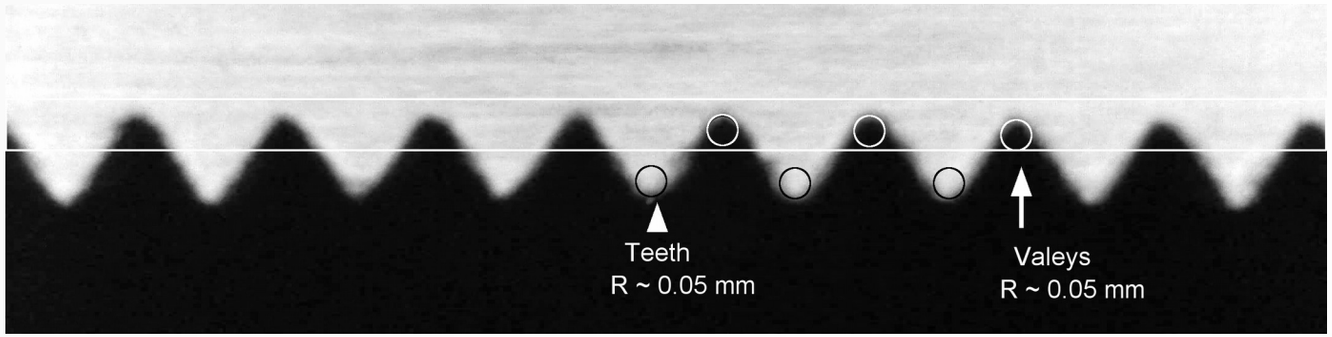
Space homogeneous of the cathode strip positions →

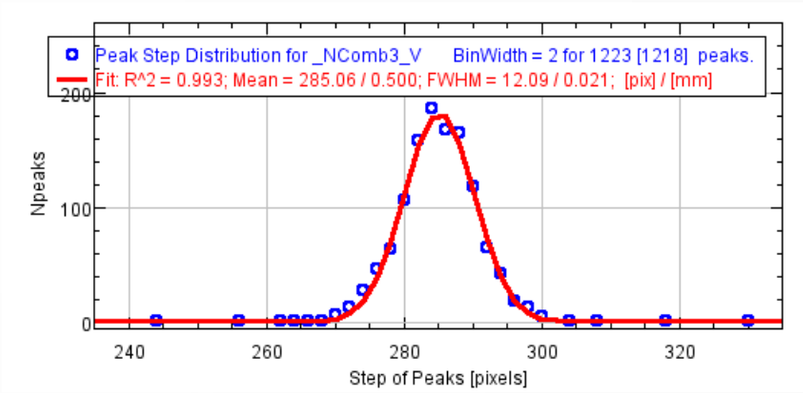
scale linearity of the coordinate system better ~ 0.02% in whole sensitive area
for the right definition Θ_e (scattered electrons angle)

How to reach it ?

1. Production: positioning of wires in to a valleys of the precise comb (pressed to wires) followed gluing the wires to support frame.

Comb L = 610 mm; step = 0.5 mm; FWHM = 0.02 mm





Design requirements for the MWPCs of the Forward Tracker (7a)

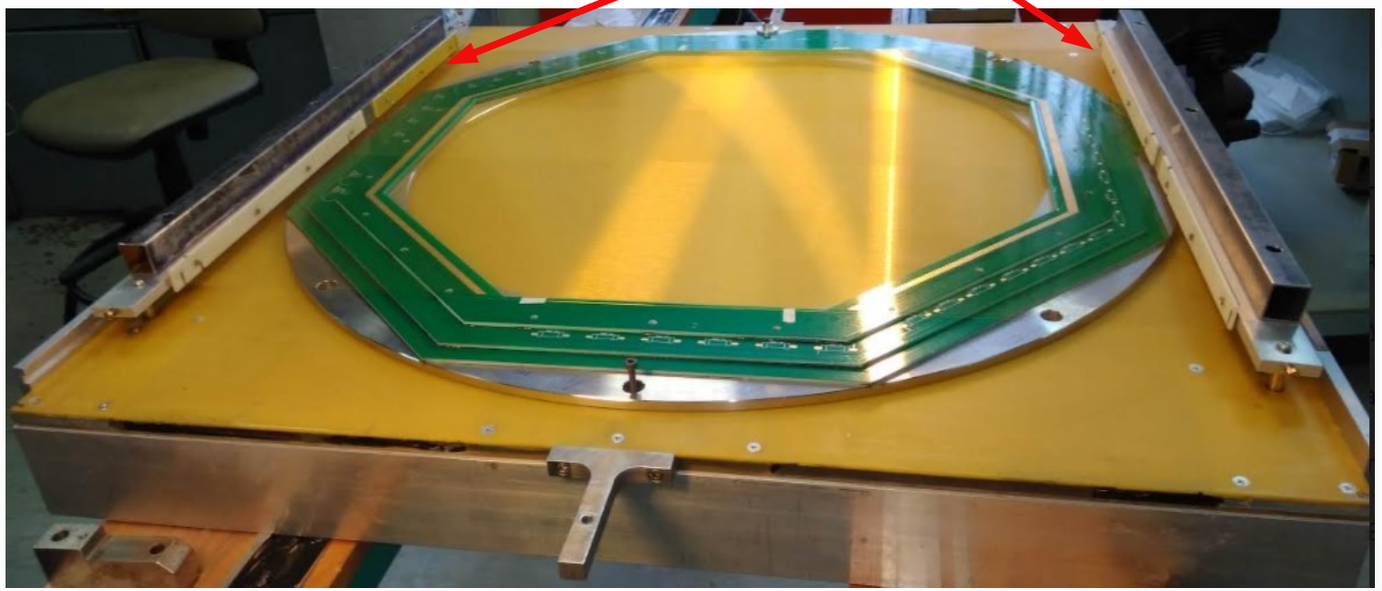
7. The most important requirement for the cathode strip plane:

Space homogeneous of the cathode strip positions →

scale linearity of the coordinate system better ~ 0.02% in whole sensitive area
for the right definition Θ_e (scattered electrons angle)

How to reach it ?

a. Production: positioning of wires in to a valleys of the precise combs (pressed to wires) followed gluing the wires to support frame.



Design requirements for the MWPCs of the Forward Tracker (7b)

7. The most important requirement for the cathode strip plane:

Space homogeneous of the cathode strip positions

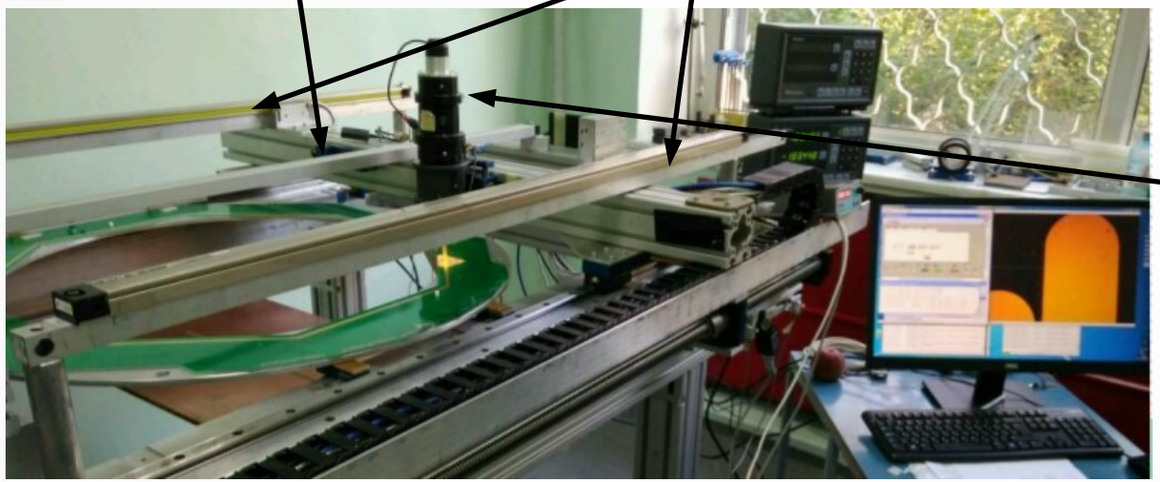
How to reach it ?

a. Production with precise combs

b. Position measurement of each wire of the cathode strip plane by movable Microscope.

Space homogenius defined by linearity of Linear Scale Mitytoyo A715,

±2μ/1m *certified by the second Etanlon of the State Standart of length*



MuScope setup

Design requirements for the MWPCs of the Forward Tracker (7b)

7. The most important requirement for the cathode strip plane:

Space homogeneous of the cathode strip positions

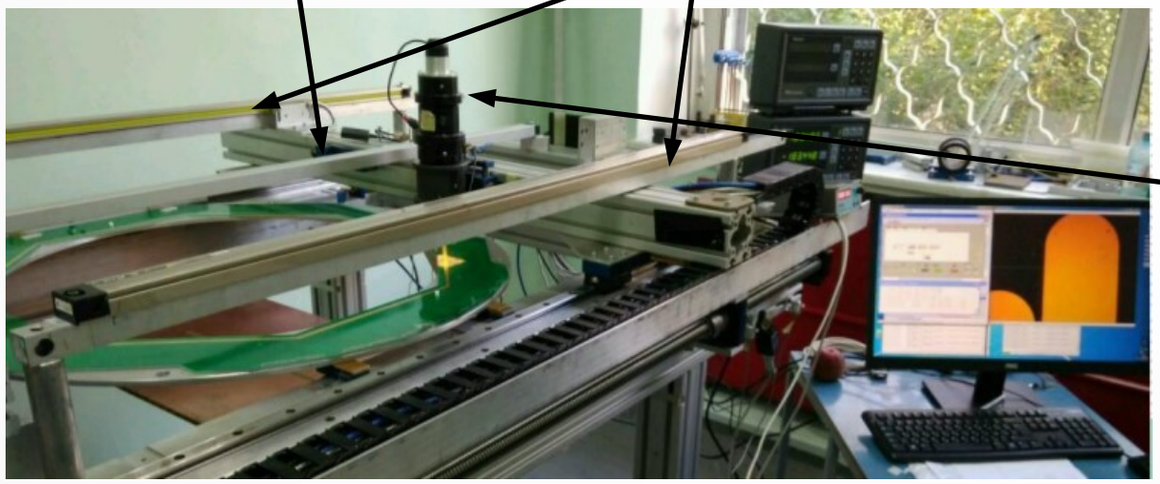
How to reach it ?

a. Production with precise combs

b. Position measurement of each wire of the cathode strip plane by movable Microscope.

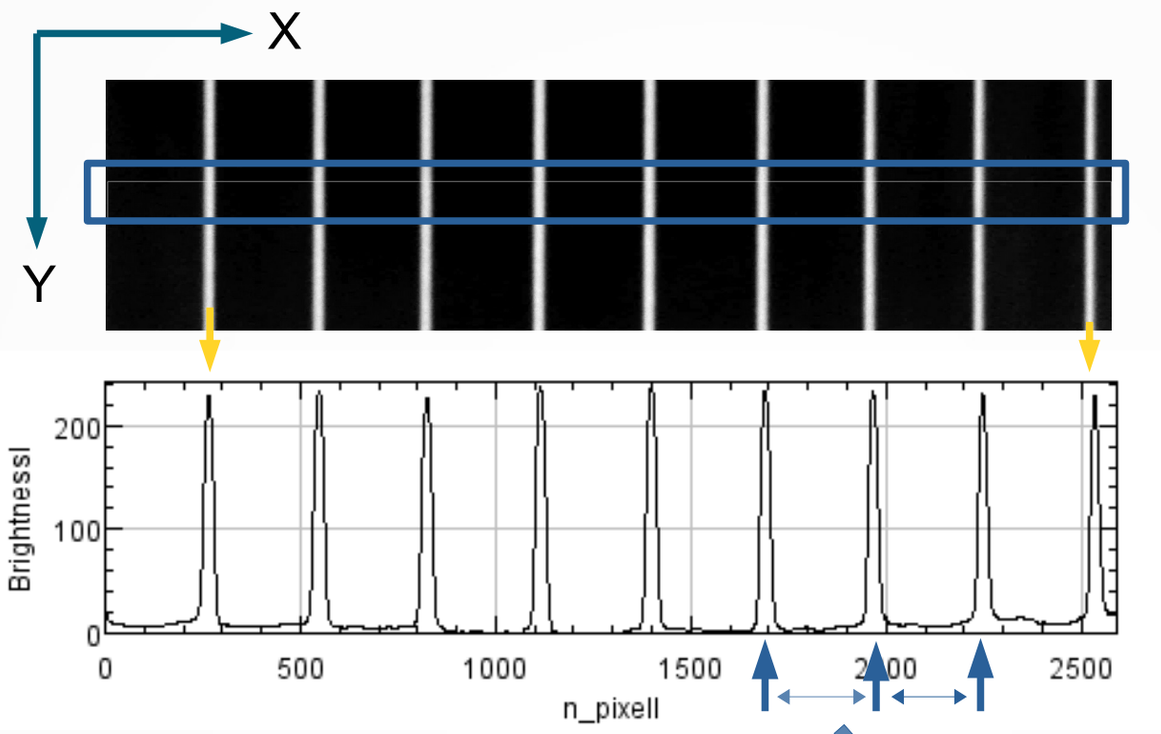
Space homogeneous defined by linearity of Linear Scale Mitytoyo A715,

±2μ/1m *certified by the second Etanlon of the State Standart of length*



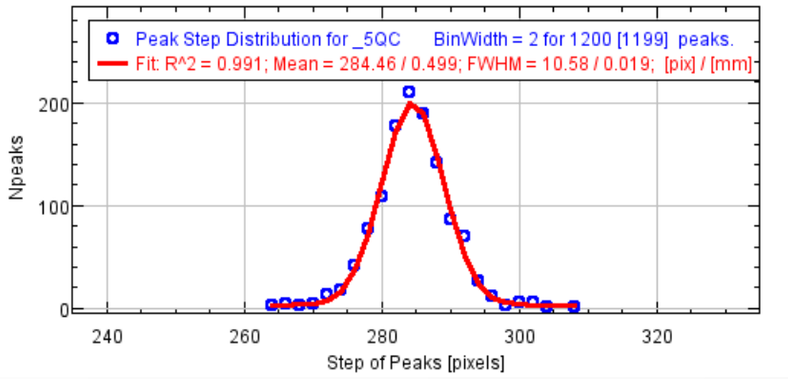
MuScope setup

Handling with Images of cathode wires

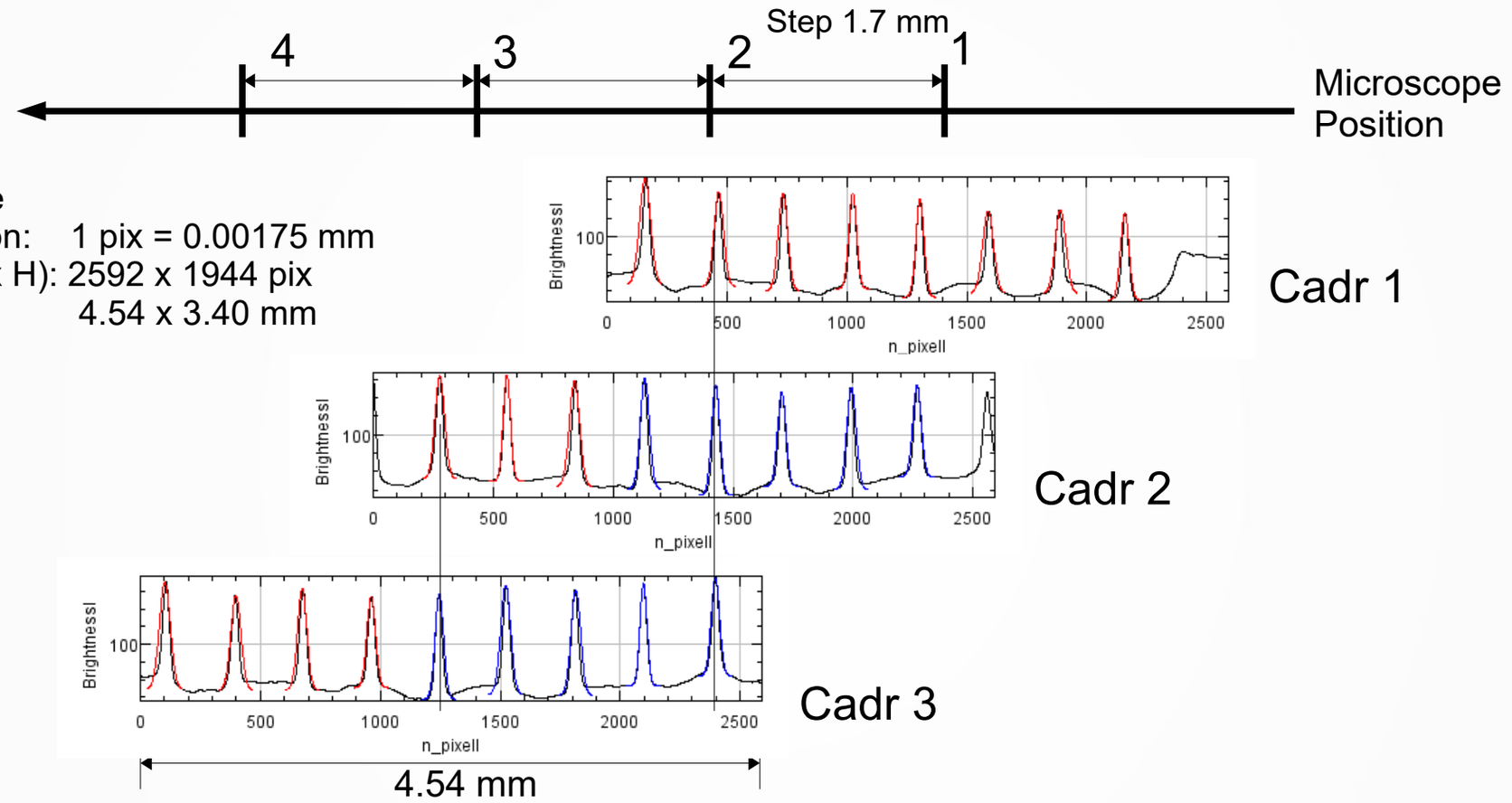


Horisontal (X) Brightness profile

Step distribution over 354 cadrs
Mean = 0.499 mm
FWHM = 0.019 mm



Peak Numbering



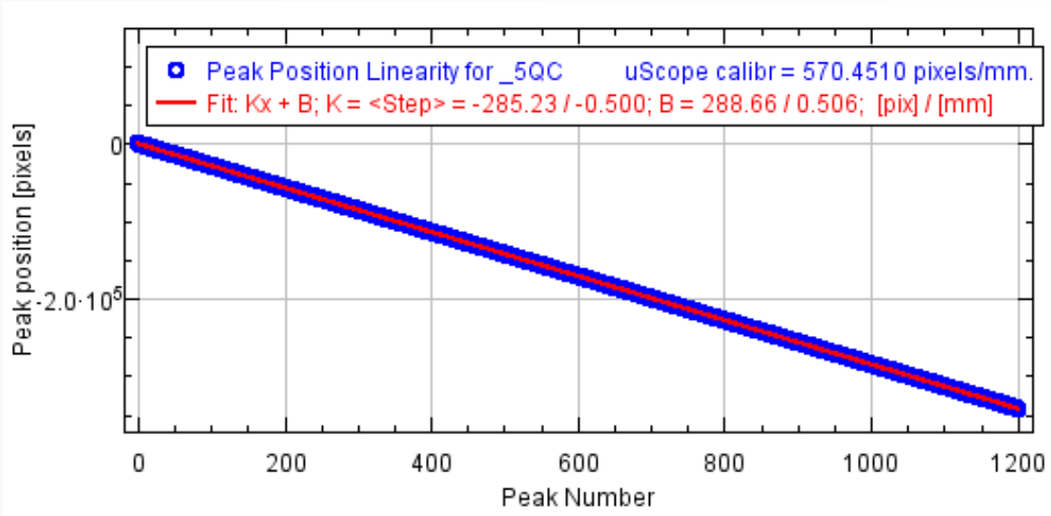
Horisontal Brightness Profiles for adjacent cadrs of cathode wires

Overlap of cadrs with the same peaks allows to apply selfcalibtration Algorithm for Microscope

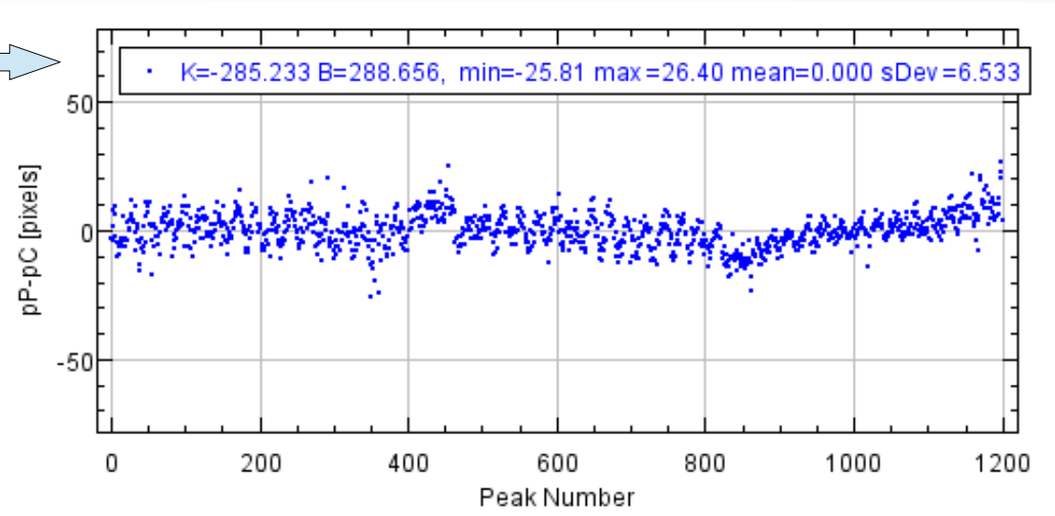
Linearity: Ppos vs Pnum

*Ppos = K * Pnum + B*

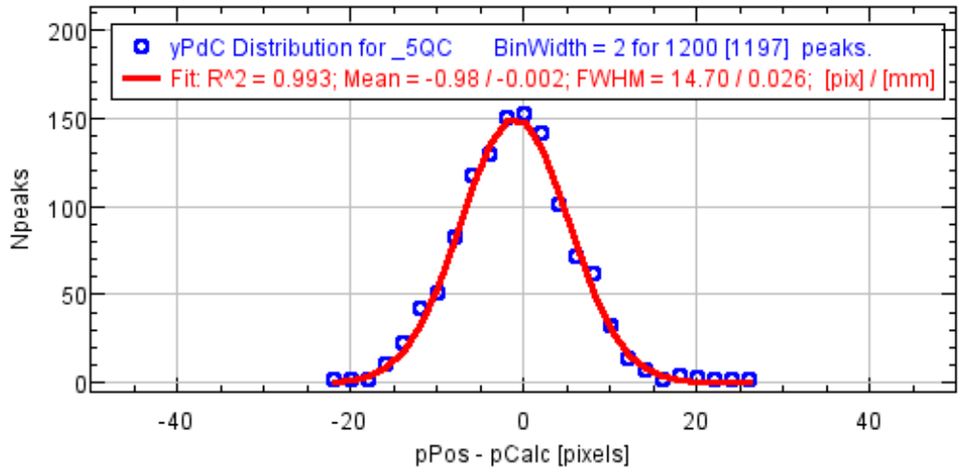
K = 285.233 -> 0.49915 mm



Peak position vs Peak number



Difference between Measured Peak position and Calculated Peak position pP - pC vs Pnum



Distribution of (pP - pC)

<pP - pC> = - 0.002 mm
FWHM = 0.026 mm

Design requirements for the MWPCs of the Forward Tracker (7)

7. The most important requirement for the cathode strip plane:

Space homogeneous of the cathode strip positions →

Reachable by
a. Production with precise combs

b. Position measurement of each wire of the cathode strip plane by movable Microscope

shows wire position accuracy on level 0.026/600 = $4.5*10^{-5}$ or 0.0045% !!!

Design requirements for the MWPCs of the Forward Tracker (7)

7. The most important requirement for the cathode strip plane:

Space homogeneous of the cathode strip positions →

Reachable by
a. Production with precise combs

b. Position measurement of each wire of the cathode strip plane by movable Microscope

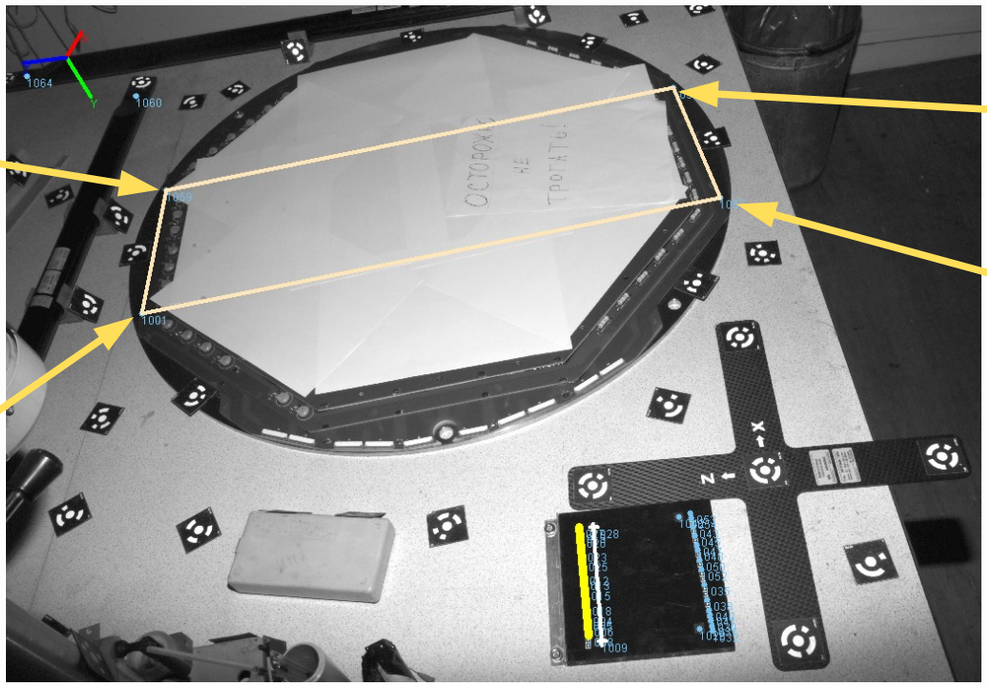
shows wire position accuracy on level 0.026/600 = $4.5*10^{-5}$ or 0.0045% !!!

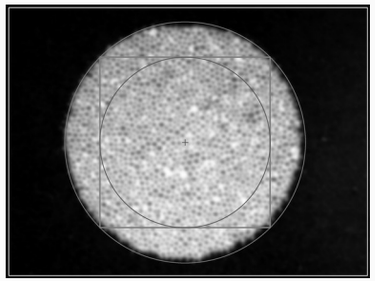
That is accuracy inside one CSC plane.
BUT what is distance accuracy between Planes???
How to measure with requested precision?

Answer: Use PHOTOGRAMMETRY metod (FGM) and GEODESY

FGM system **AICON DPA Pro** and **MuScope**

CSC plane prepared for FGM measurement





FGM light reflection label ∅ 3 мм

Results of neasurement by FGM **AICON DPA Pro** / **MuScope:**

distance 1-2	Расстояние между 1 и 2 меткой	247.80 / ------- мм`
2-3	Расстояние между 2 и 3 меткой	758.37 / 758.411 мм
3-4	Расстояние между 3 и 4 меткой	246.90 / ------- мм
4-1	Расстояние между 4 и 1 меткой	758.73 / 758.766 мм

Δ = + 0.04 mm

By such way labels attached to wires and not visible after assembling could be joined to additional labels reachable on assembled device

How to measure relative position FT and TPC ?

Inside one CSC plane accuracy on level 0.0045% or 0.045 mm / 1 m

BUT what is distance accuracy between CSC Planes and relative to TPC (internal geometry)?
Detector position relative to accelerator beam (external geometry)?
How to measure with requested precision?

	FGM	*GEODESY*
Accuracy:	*0.030 mm / 1 m*	*0.010 mm / 1 m*
Label:	*Flat film*	*Corner Reflector (CRef)*
	Glued on surface	*∅10 mm Ball on fixed neste*

Short distances ~ 1 m

Labels attached to wires of CSC
are supplemented with labels
visible during assembly
and labels on external flange sufrace
+ fixed nestes for CRef

Long distances > 1 m

1. Check Detector deformation at 20 bar

2. Detector positioning relative to beam
using the Accelerator Geodesy System

Conclusions

The construction of MWPC for Forward Tracker of PRES experiment fully satisfies requirements 1 – 7

1. MWPCs operate @ 20 bar pressure of gas mixture
2. Sensitive area 600x600 mm (octagone)
3. Wire cathodes (∅ 50 micron, step 0.5 mm)
4. Space resolution ~ 50 micron
5. Gas gain ~ 300 at High Voltage < 6 kV gas mixture: Ar + 4%CH_4
6. High efficiency (~100%) in whole sensitive area,
   BUT low one (~1%) in the central area (∅ ~20 mm) («golden spot»)
7. *Space homogeneous of the cathode strip positions:* Measured Linearity is *0.0045%*
   Relative positions FT, TPC and whole detector to beam will be measured by FGM and GEODESY with accuracy ~ 0.003%

   Expected accuracy of scattered electrons angle Θ_e better 0.02%

Done: Produced 5 CSC planes, 4 planes tested on air @ 2.5 kV, linearity was measured for 2 planes
CSC small and full size prototypes was succesfully tested @ 20 bar Ar + 4%CH_4

Plans: Continue production of CSC planes and linearity measurements
Test @ 20 bar 3 planes.