WP13.4.3
Control of foil/micromesh mechanical tensioning by optical techniques

report 19 October

Laboratori Nazionali di Frascati dell'INFN

INFN Bari

INFN Bologna

- Flatness of MPGD foils/meshes must be assured within about 100microns and monitored over long term detector lifetime (10-20 years)
  - Flatness QC during assembly
  - Continuous monitoring during operation

From AIDA2020 proposal

- ***Control of foil/micromesh mechanical tensioning by optical techniques***
  - engineering an optical system for quality assessment of mechanical tensioning and flatness of MPGD films and meshes.
  - prototyping integrated Fiber Bragg Grating sensors for monitoring the mechanical tension of MPGD films (GEMs) and meshes (MICROMEGAS).

Sharing of activities among partners (from AIDA2020 proposal)

- Laboratori Nazionali di Frascati
  - Engineering, Fiber Bragg Grating sensors deployment, tests in clean room
- INFN Bari
  - Film stretching mechanics
- INFN Bologna
  - Tests of stretched foils

AIDA2020 Milestones

MS Number	MS Description	Task	Due by	Result type
MS13.8	Optical system for the quality assessment of MPGD foil/mesh mechanical tensioning	13.4.3	M12	Demonstrator
MS13.9	Integrated FBG sensors for monitoring the mechanical tension of MPGD films and meshes	13.4.3	M24	Prototype

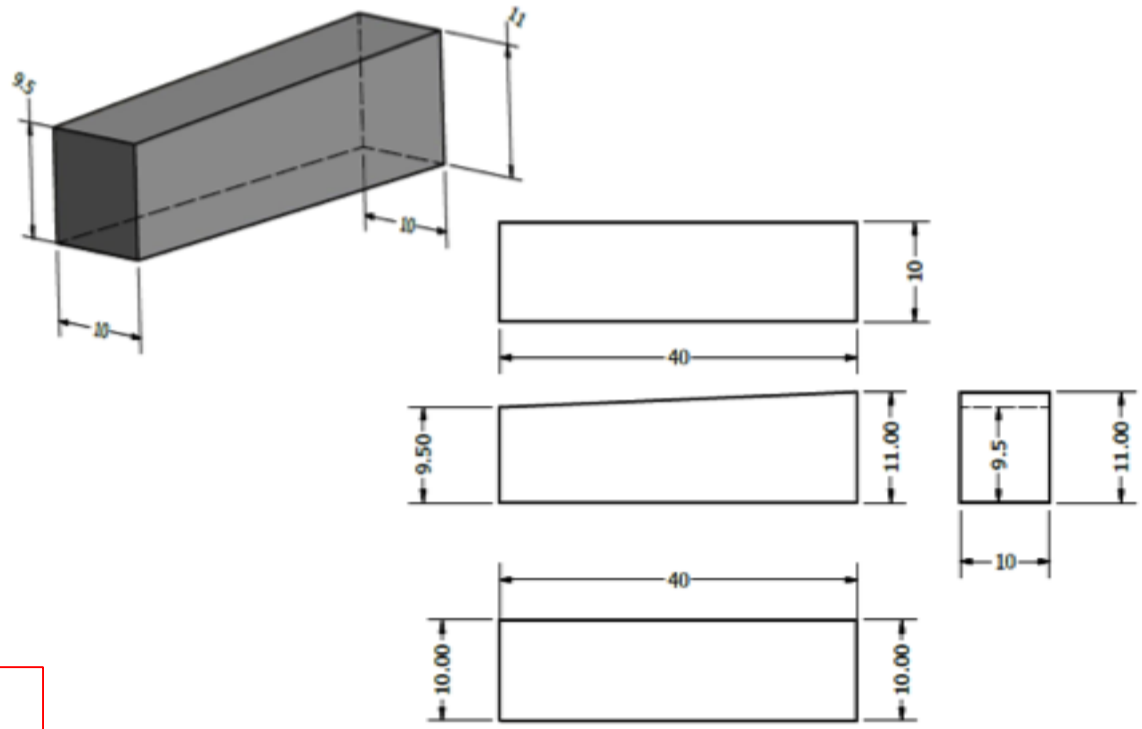
Internal and official MS

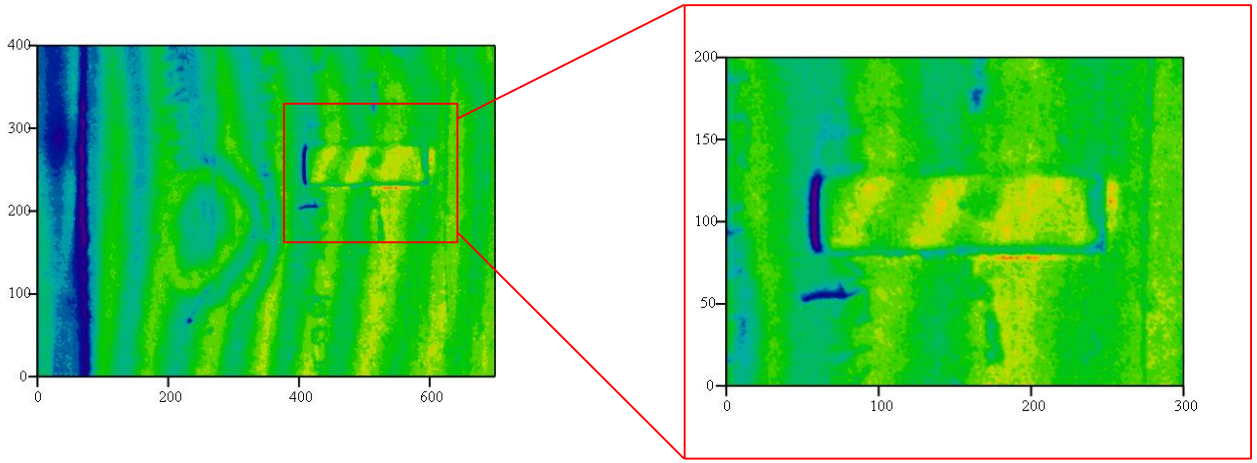
Milestones	Year 1	Year 2	Year 3	Year 4
Design/qualify an optical interferometric system				
Engineering interferometric system MS13.8				
Qualify FBG sensors				
Proof of concept integration of FBG MS13.9				
Long term characterization of FBG				
Qualification at test beams				

Wedged specimen is used for resolution calibration

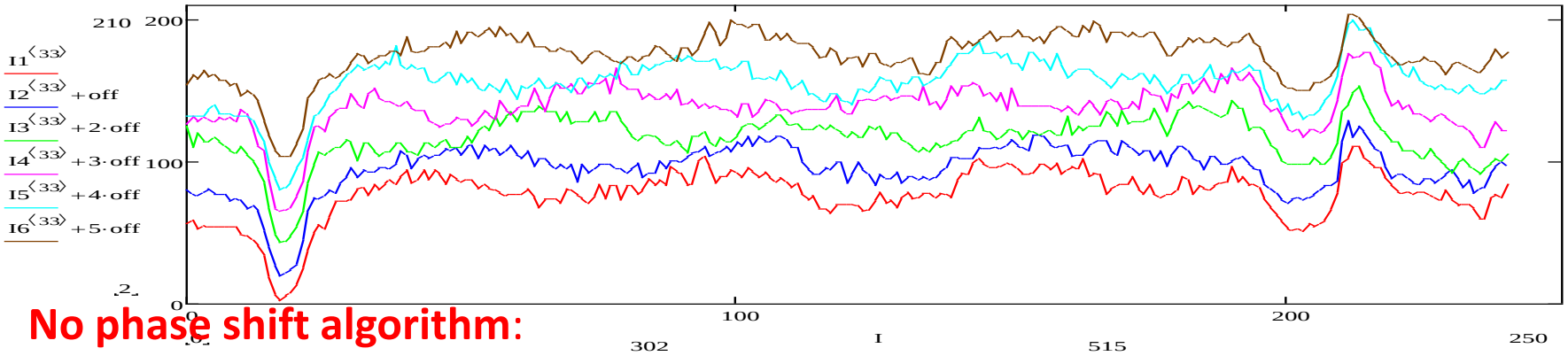
Counting N fringes between points with known Δh provides resolution R (points are chosen at center of dark fringe for best precision)

$R = \Delta h / N$





Fhase shift algorithm double n. of fringes, lowers noise enhances contrast: fraction of fringe can be appreciated



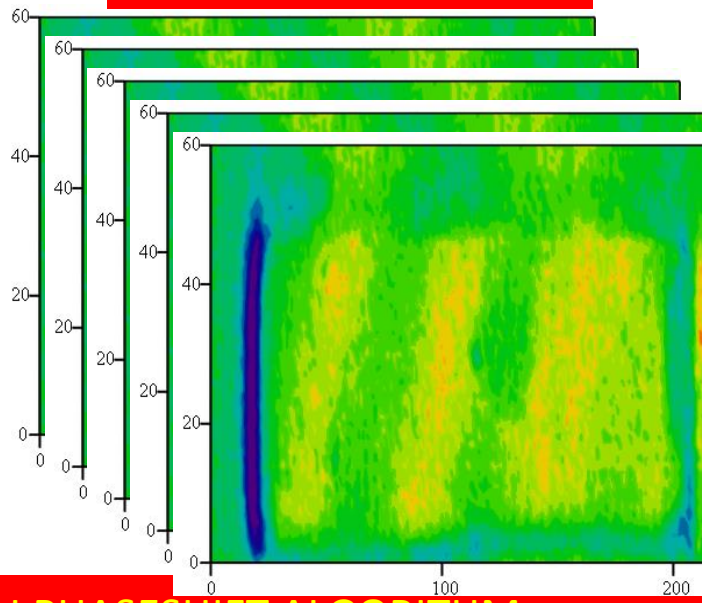
No phase shift algorithm:

Noise and low contrast: even center of fringe can be appreciated with difficulty

Phase shift algorithm:

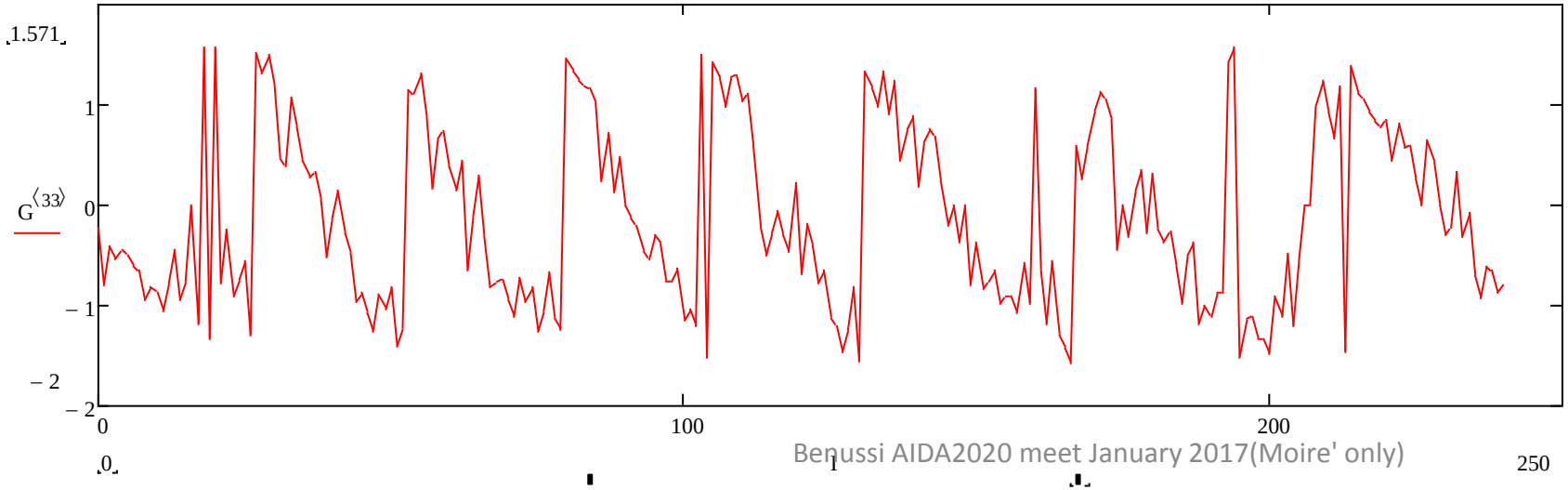
Low noise, good contrast, number of fringe doubled: <1/3 of (narrower) fringe can be nicely appreciated, much better by fitting each slope (cont'd)

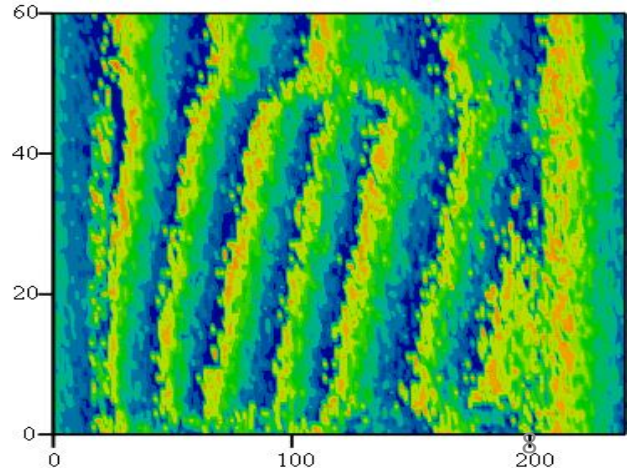
WITHOUT PHASESHIFT



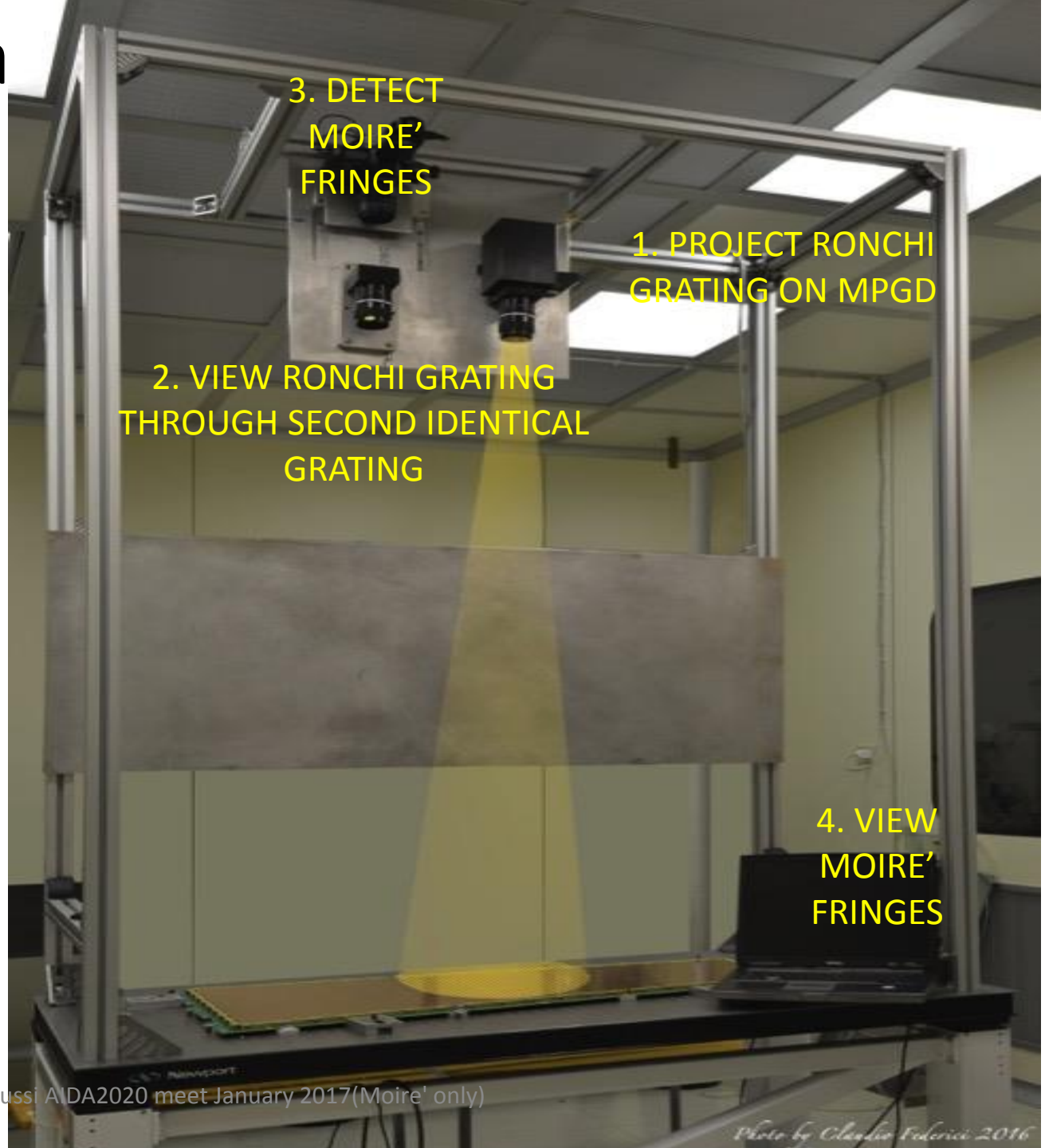
WITH PHASESHIFT ALGORITHM

Yi-Bae Choi, Yusong-Gu, "Phase shifting grating projection mo topography", Optical Engineering, Vol. 37, No. 3, March 1998



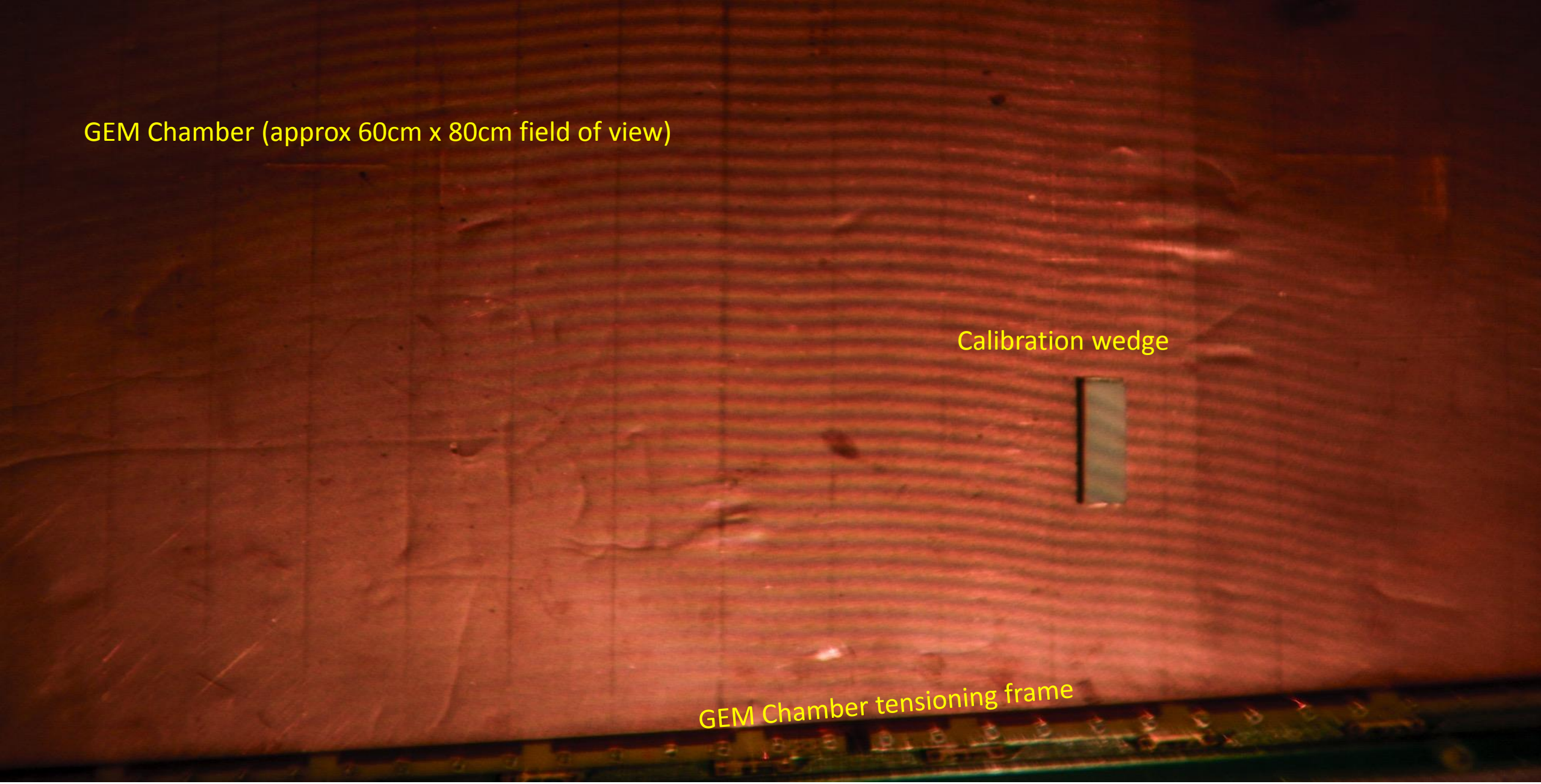


Engineered setup for la foils MPGD flatness monitoring

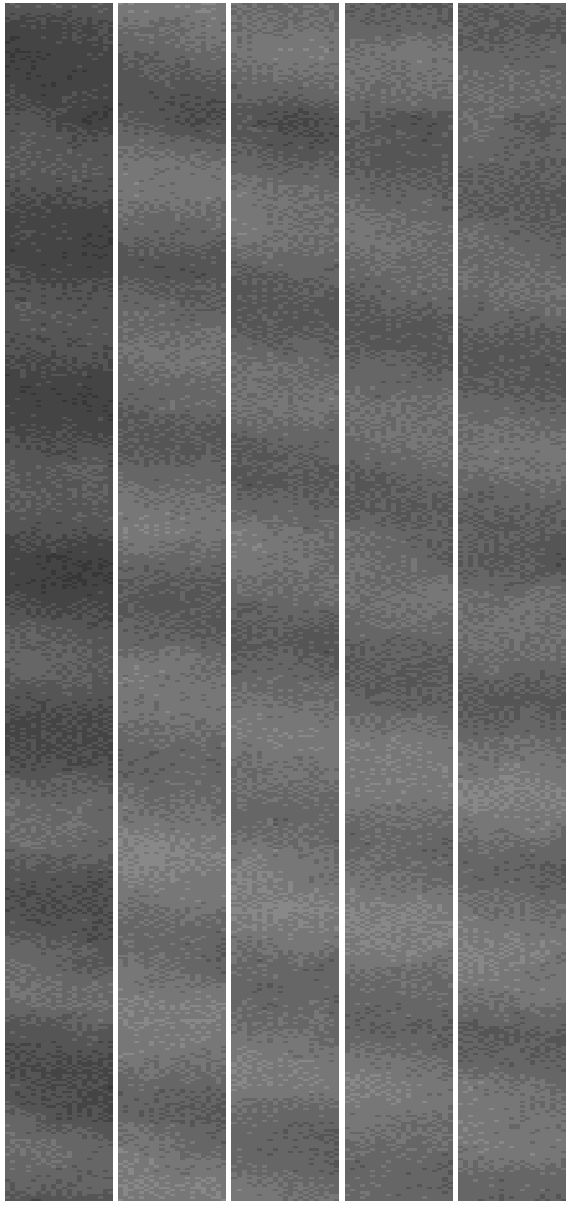


- After completing the system engineerization, focus of work
  on solving light reflex on full GEM chamber surface making
  the fringes non optimally clear
- Also analyzing the calibration wedge

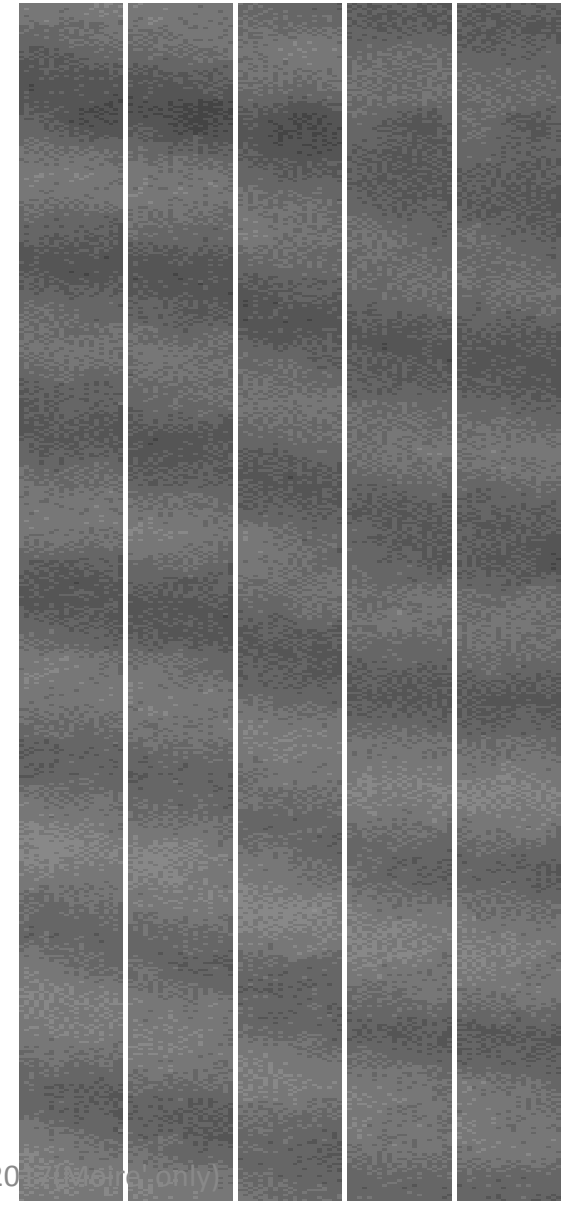
Light reflection solved by tilting the GEM chamber (about 10deg) This introduce an global fringes shift known and easy to be corrected.

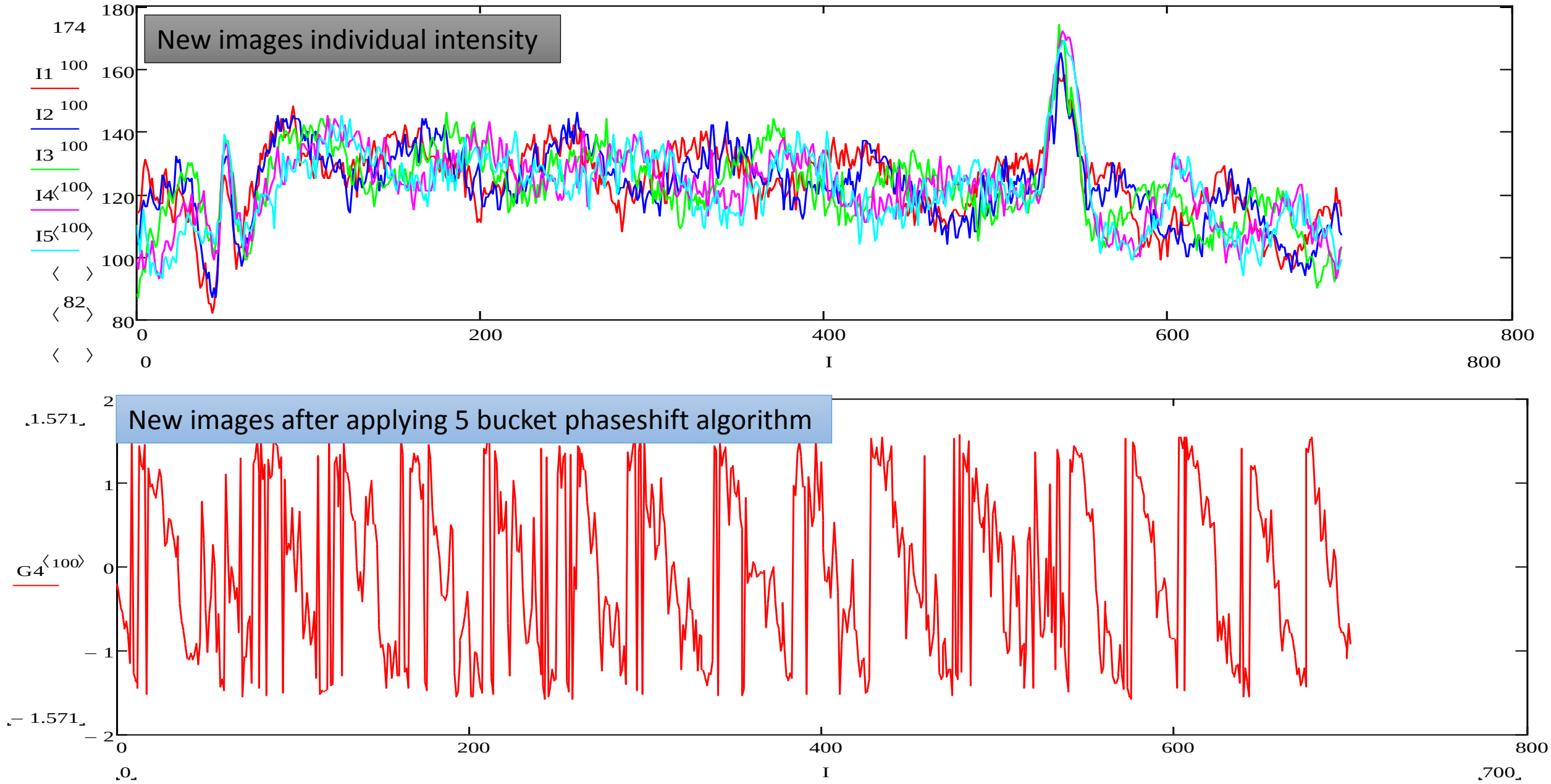

GEM Chamber (approx 60cm x 80cm field of view)
Calibration wedge
GEM Chamber tensioning frame

Previously selected images phase shift (images 2,5,9,13,17)

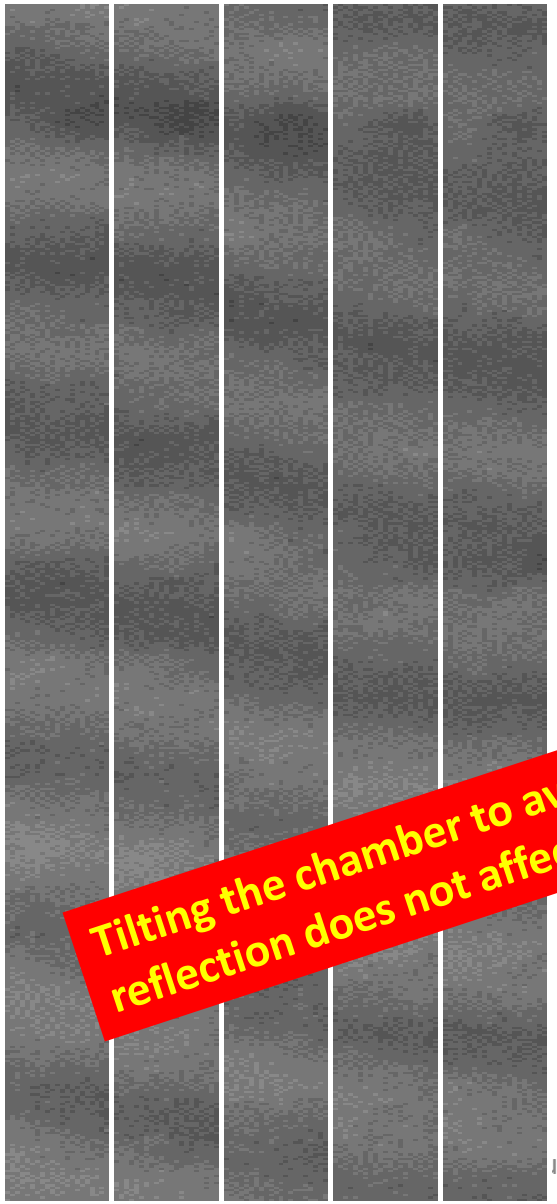


New selected images phase shift (images 3,6,10,14,17)



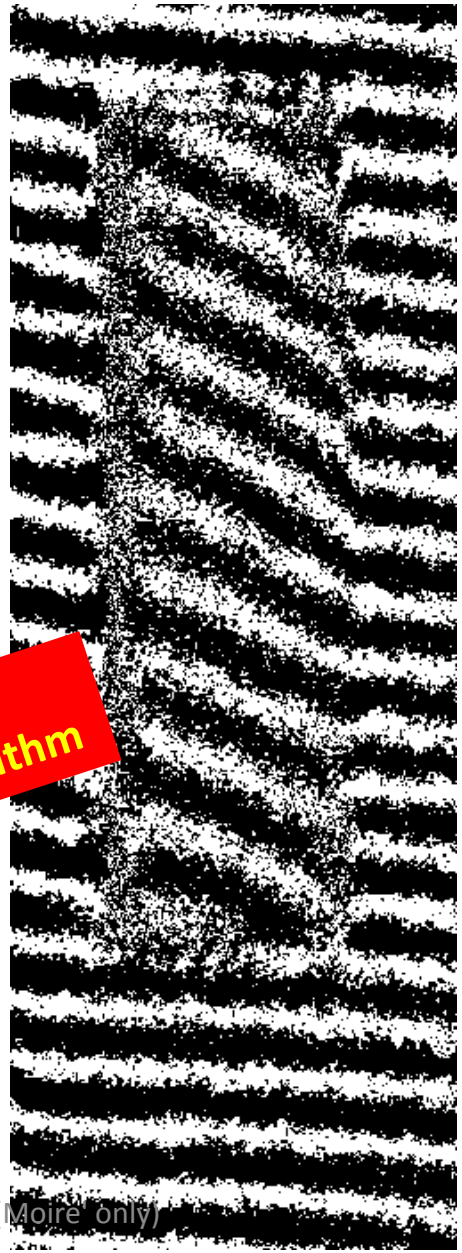

New images individual intensity
I1 100
I2 100
I3 100
I4 100
I5 100
82
174
180
160
140
120
100
80
0
200
400
600
800
I
New images after applying 5 bucket phaseshift algorithm
G4 100
1.571
2
1
0
− 1
− 1.571
− 2
0
200
400
600
800
I
700

New selected images phase shift (images 3,6,10,14,17)



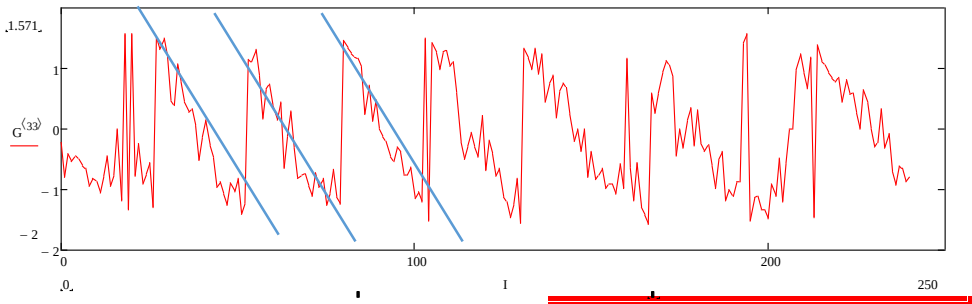
Tilting the chamber to avoid light reflection does not affect the phase shift algorithm

New images after applying 5 bucket

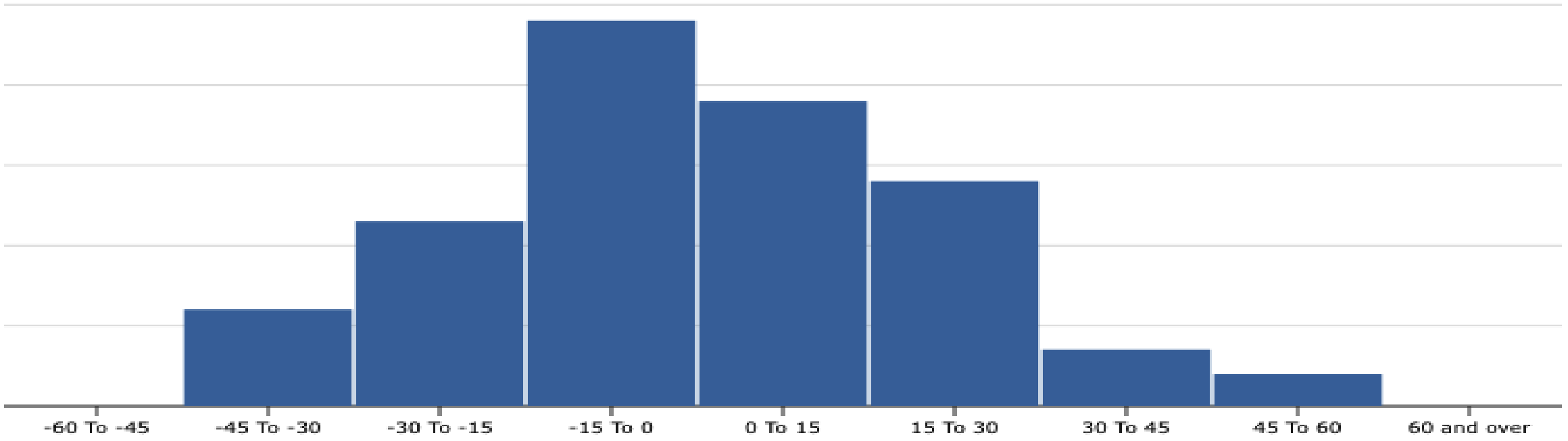


Number of fringes doubles as expected

Frequency distribution of residuals (data-fit) transverse displacements [um]



Standard Deviation = R transverse resolution = 20 um



Conclusions

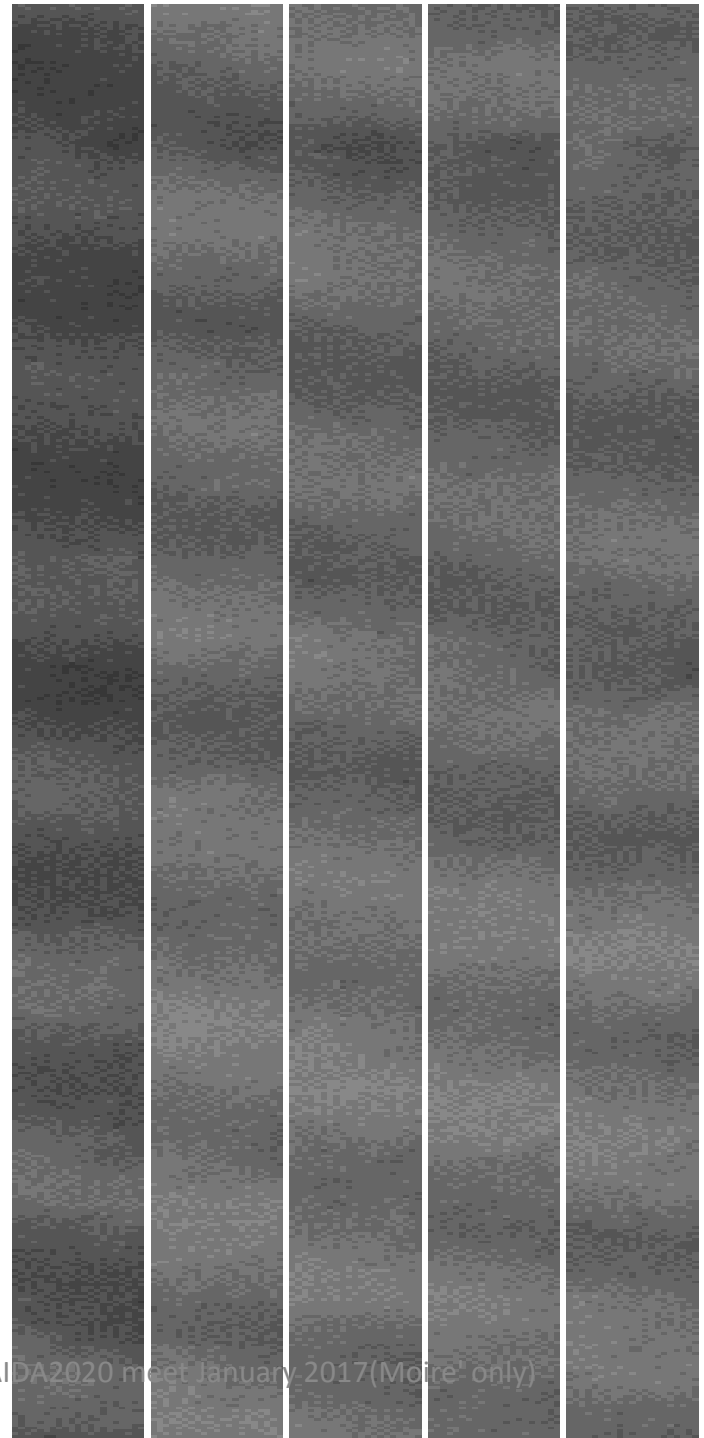
- Fringes and phase-shift algorithm demonstrated to work on full GEM chamber
- Better than 30um resolution confirmed
- Full report published

SPARES

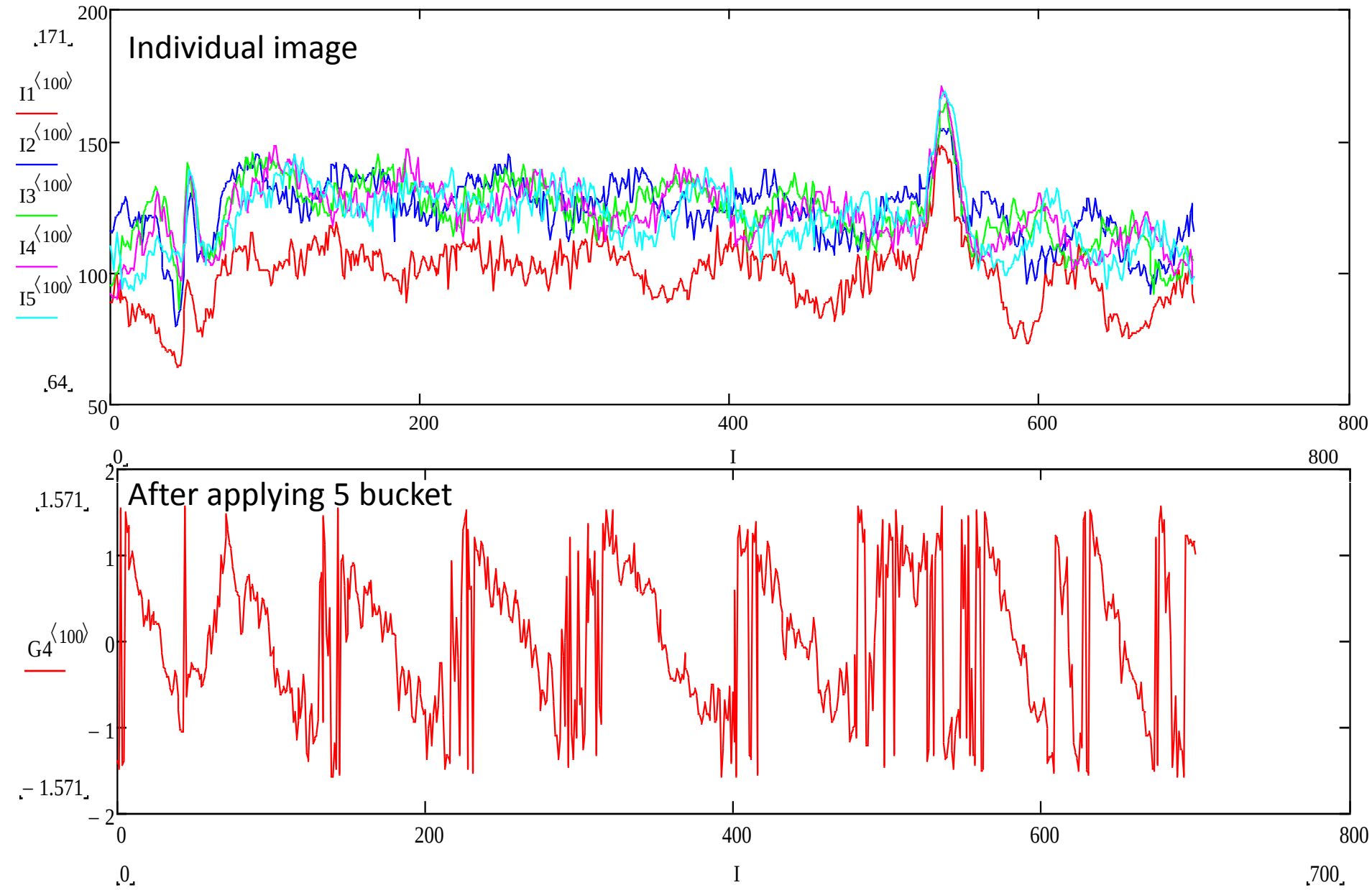
Moiré updates

Sept. 20, 2016

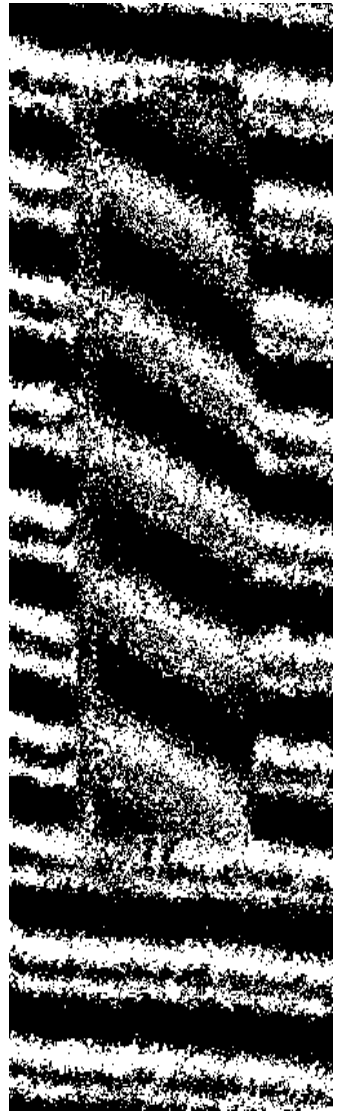
New Five images phase shift (images 2,5,13,17)



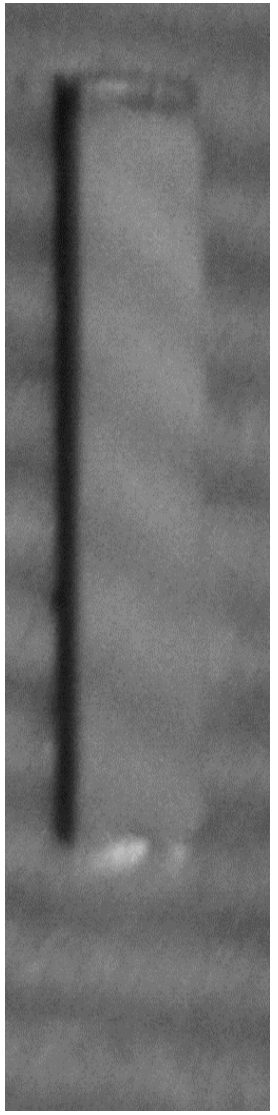
New images



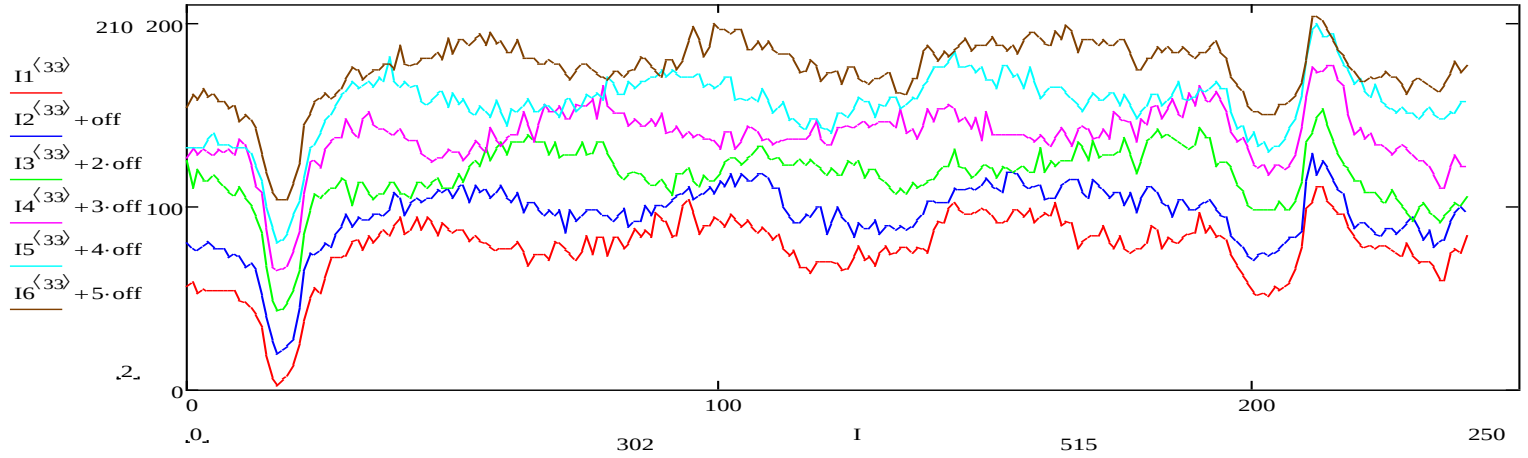
After

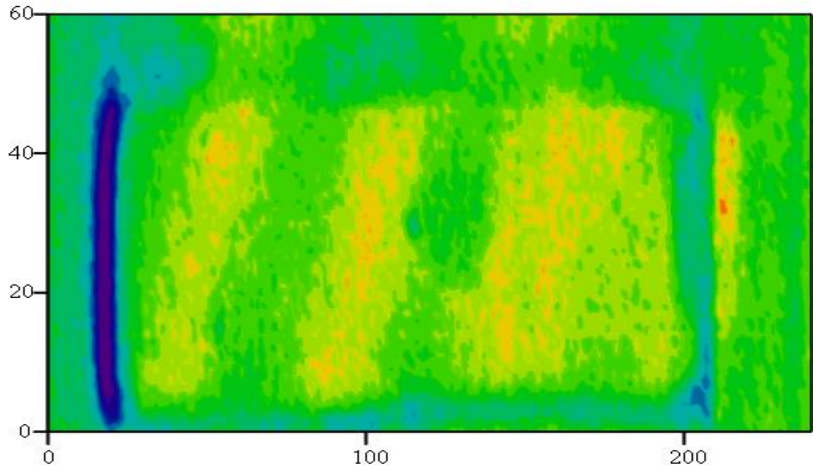


Before



Old images





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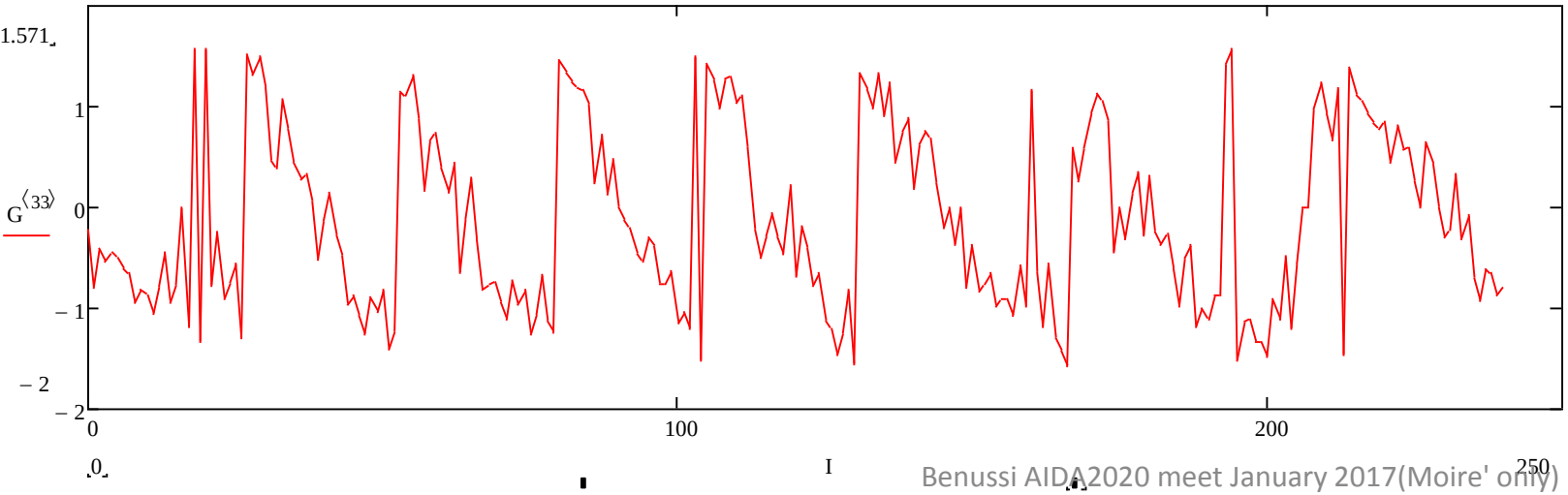
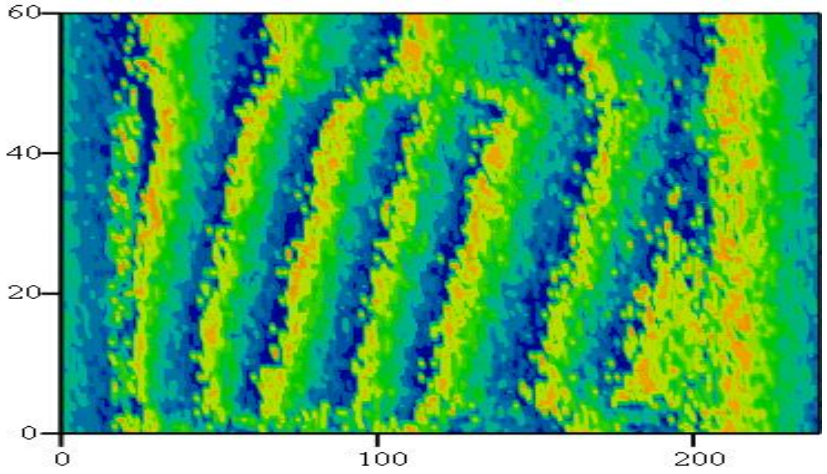
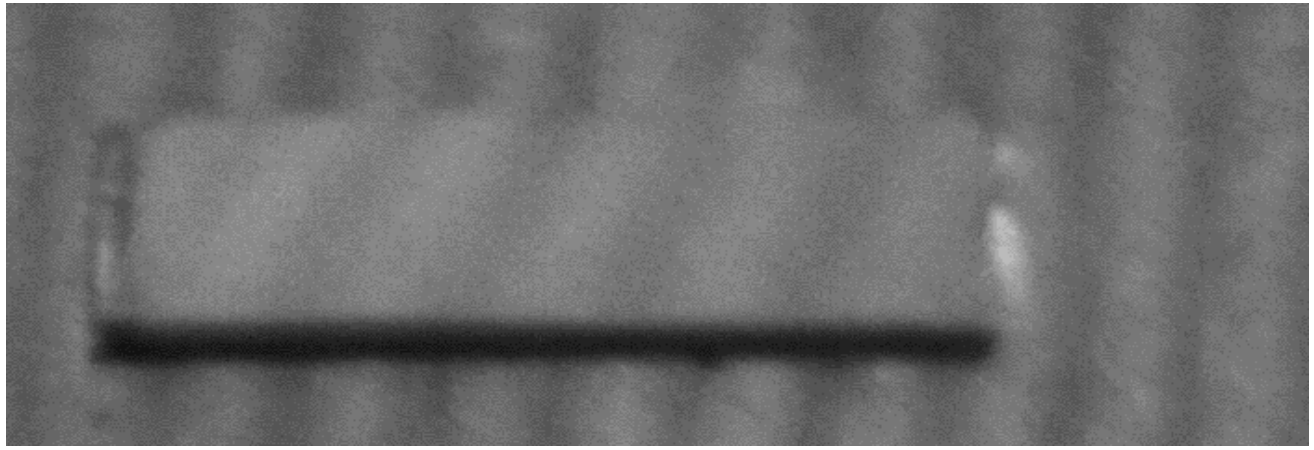
Noise and low contrast: even center of fringe can be appreciated with difficulty
Phase shift algorithm:
Low noise, good contrast, number of fringe doubled: <1/3 of (narrower) fringe can be nicely appreciated

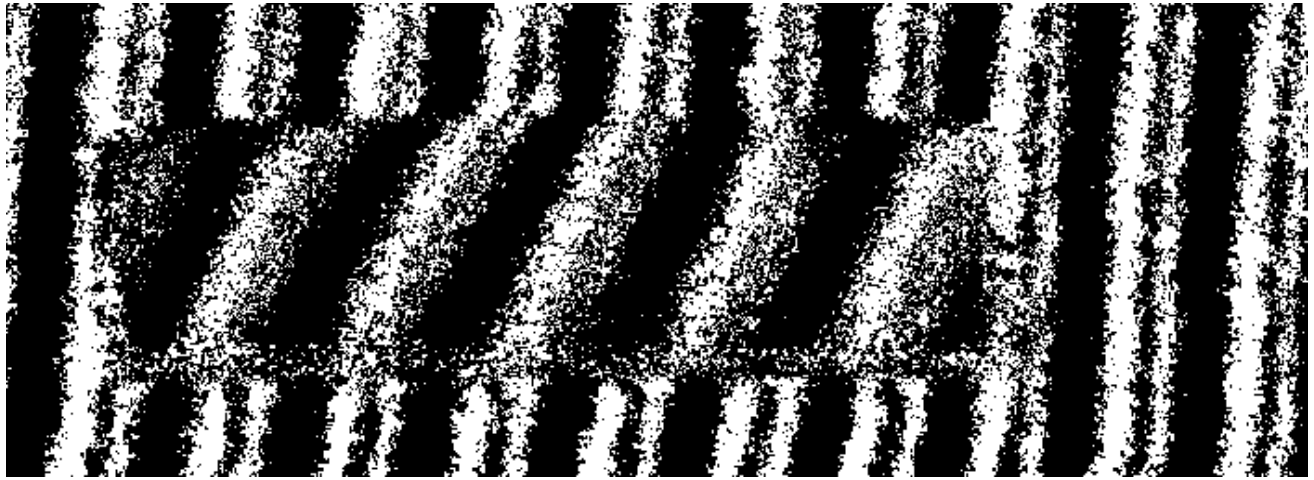


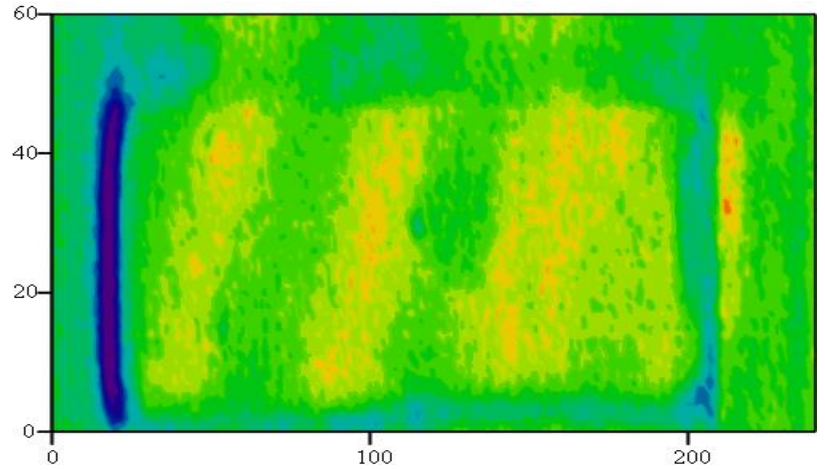


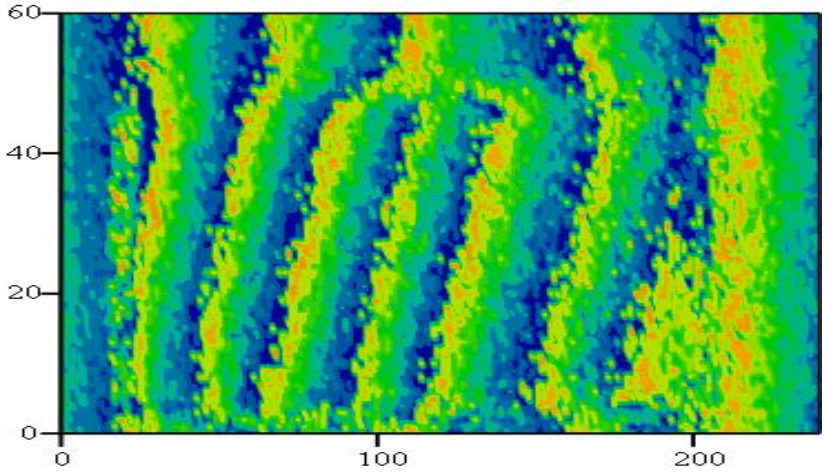
Problem

Difference in new and old images after applying the 5 Bucket algorithm









It looks

the NUMBER of fringes become double in case of OLD images

but for new images the NUMBER of fringes does not changes after applying the 5 bucket algorithm

Although in both cases Fringes become more clear and noise is suppressed

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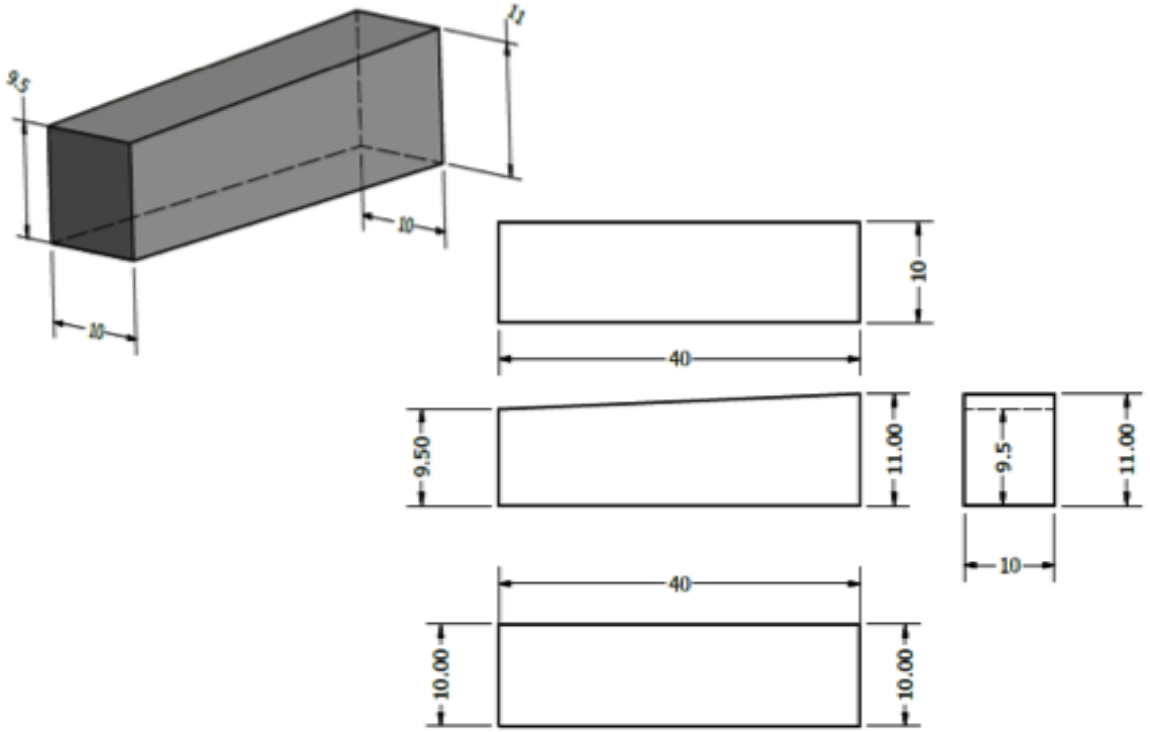
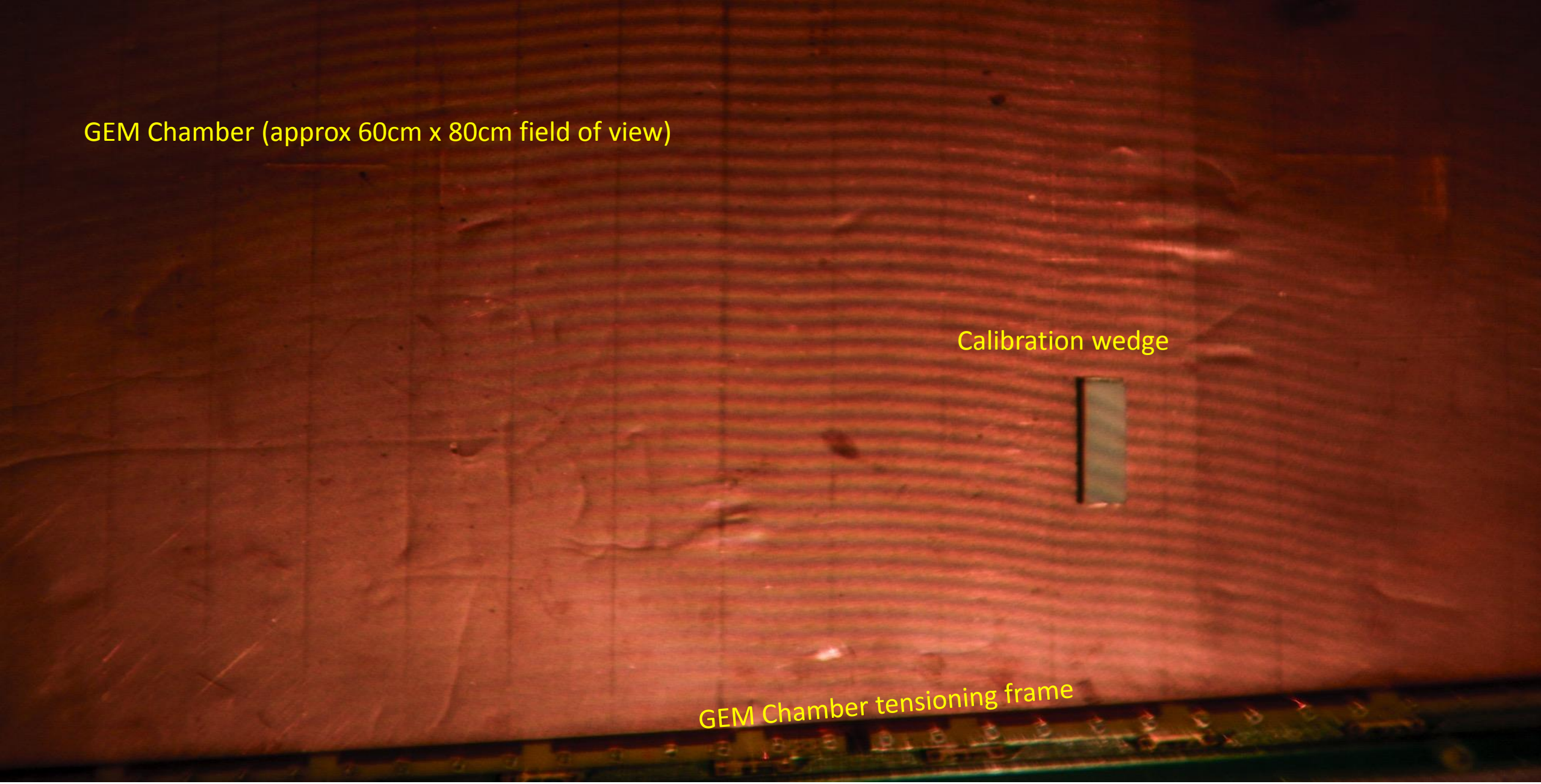
STUDYING THE MISSING PUZZLE PIECE

- Resolution on Z displacement proved matching design requirements
- System engineerization now completed to illuminate and analyze a full GEM chamber
  - Solved several problems such as light reflex, etc
- Next page:
  - GEM chamber
  - calibration wedge

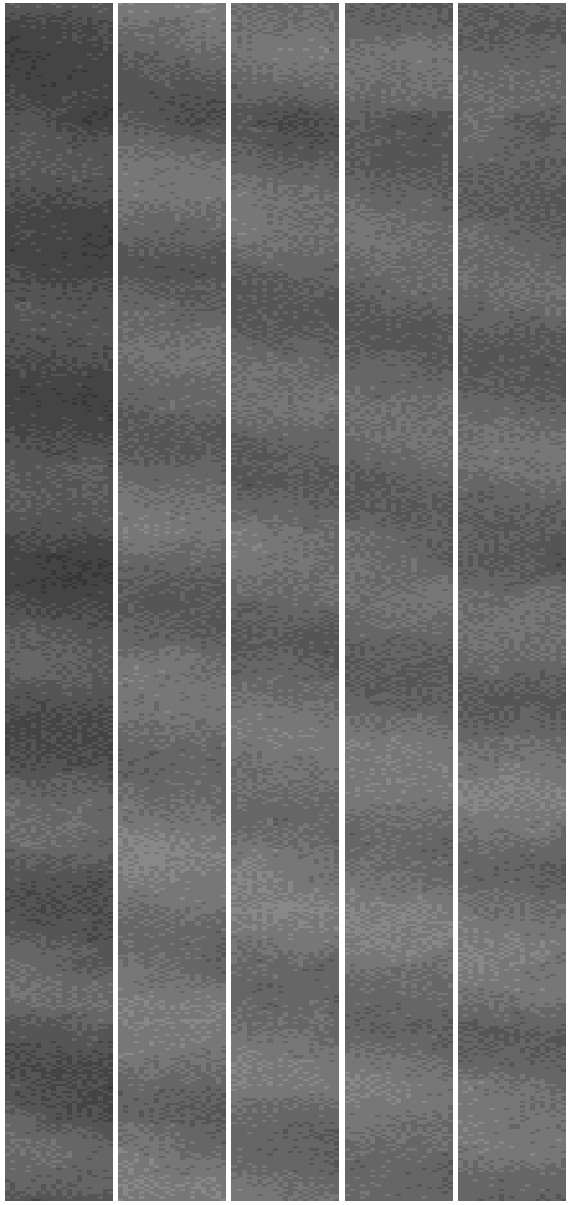



GEM Chamber (approx 60cm x 80cm field of view)
Calibration wedge
GEM Chamber tensioning frame

Moiré updates

Sept. 27, 2016

Previously selected images phase shift (images 2,5,9,13,17)



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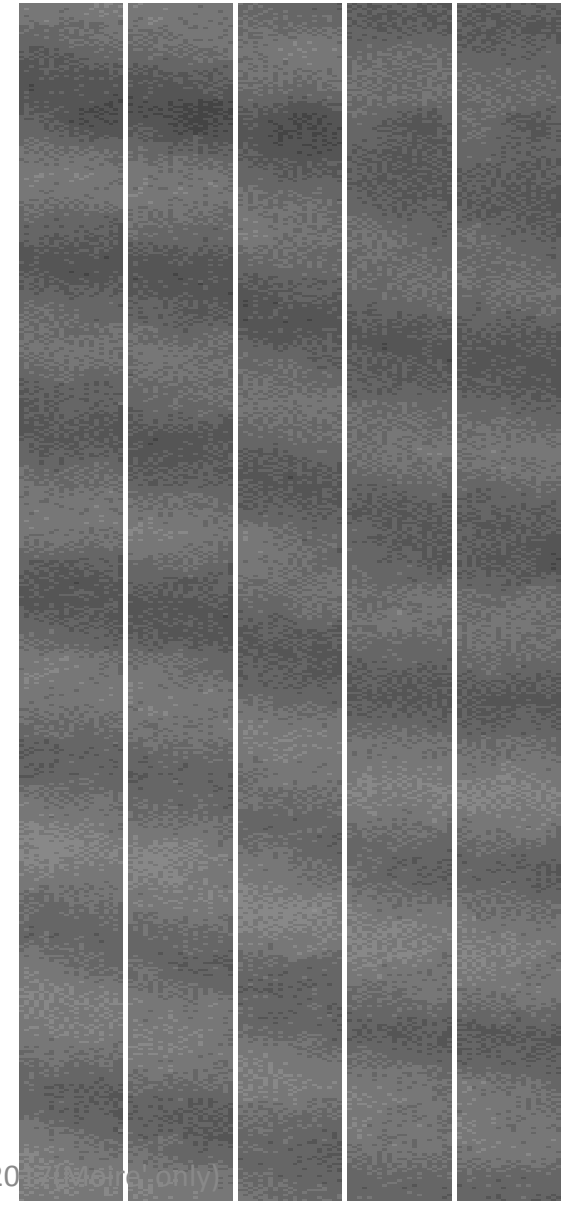

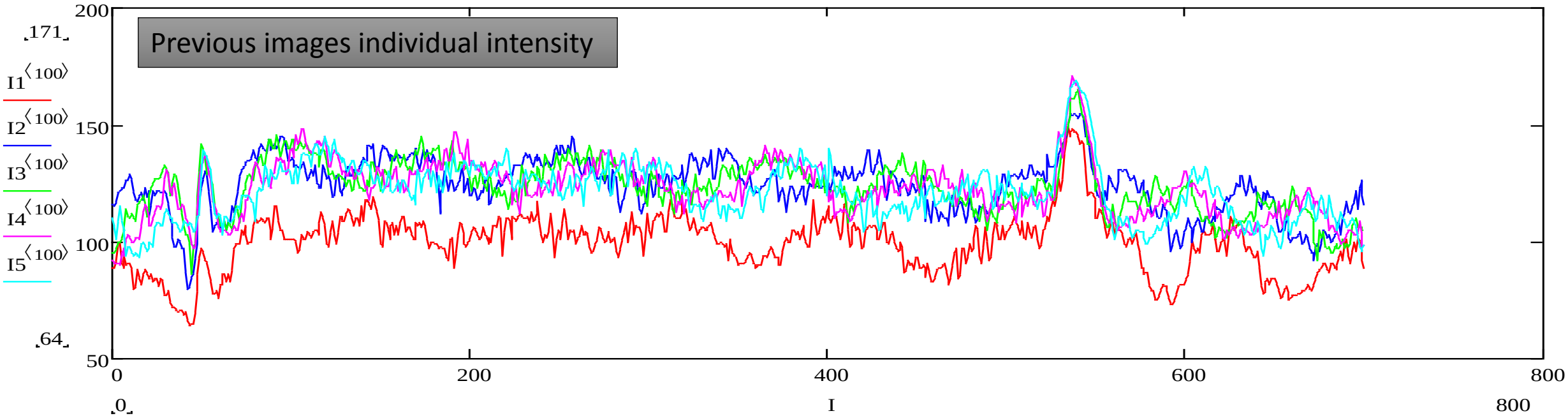
Previous images individual intensity
I1⟨100⟩
I2⟨100⟩
I3⟨100⟩
I4⟨100⟩
I5⟨100⟩
171
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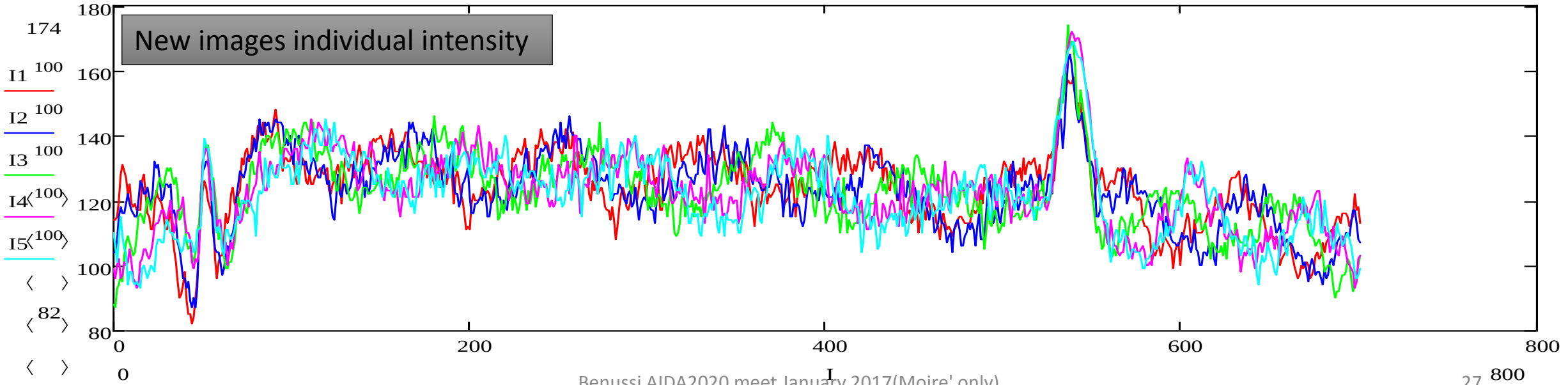
New images individual intensity
I1 100
I2 100
I3 100
I4⟨100⟩
I5⟨100⟩
174
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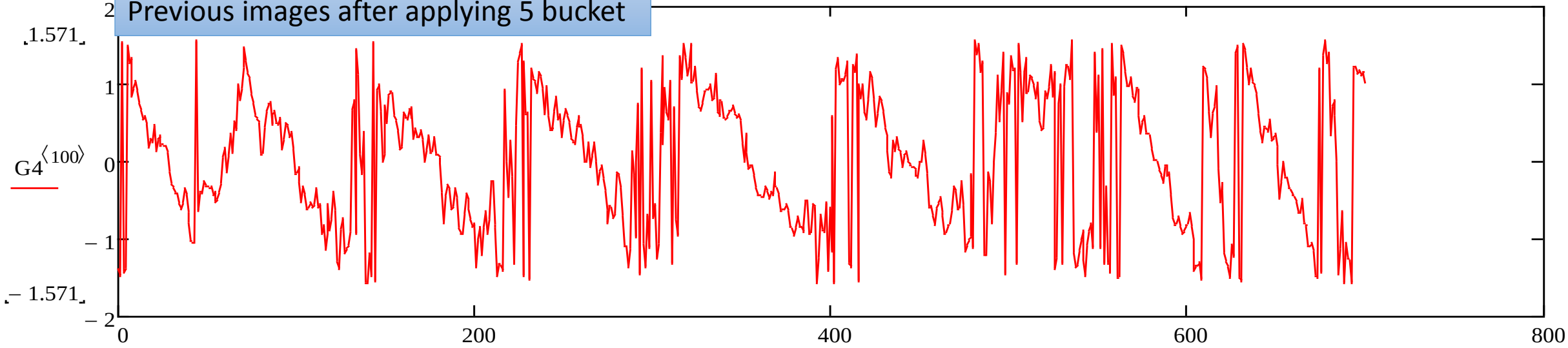
Previous images after applying 5 bucket



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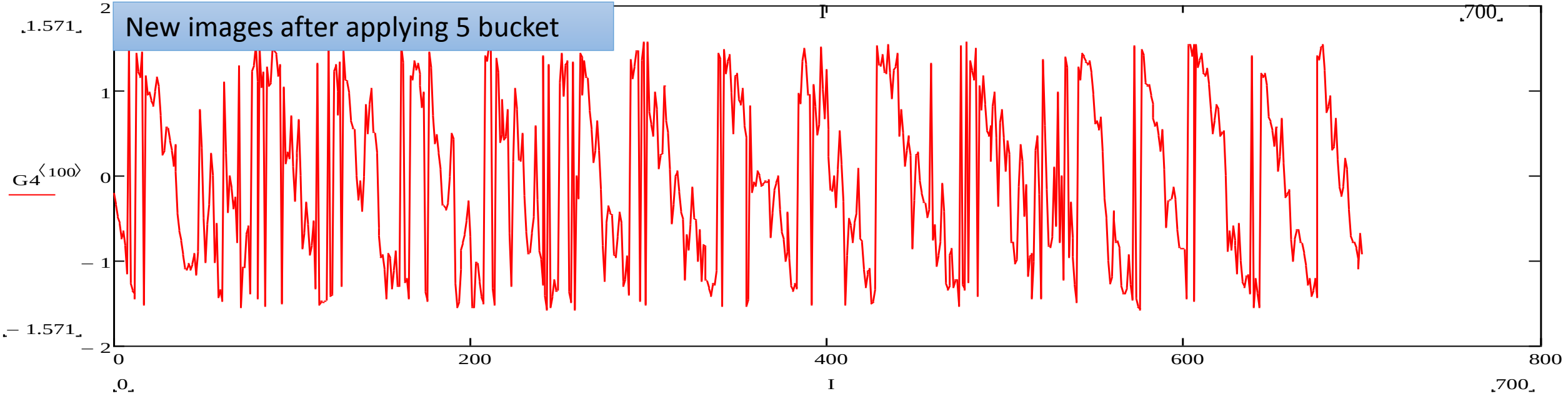

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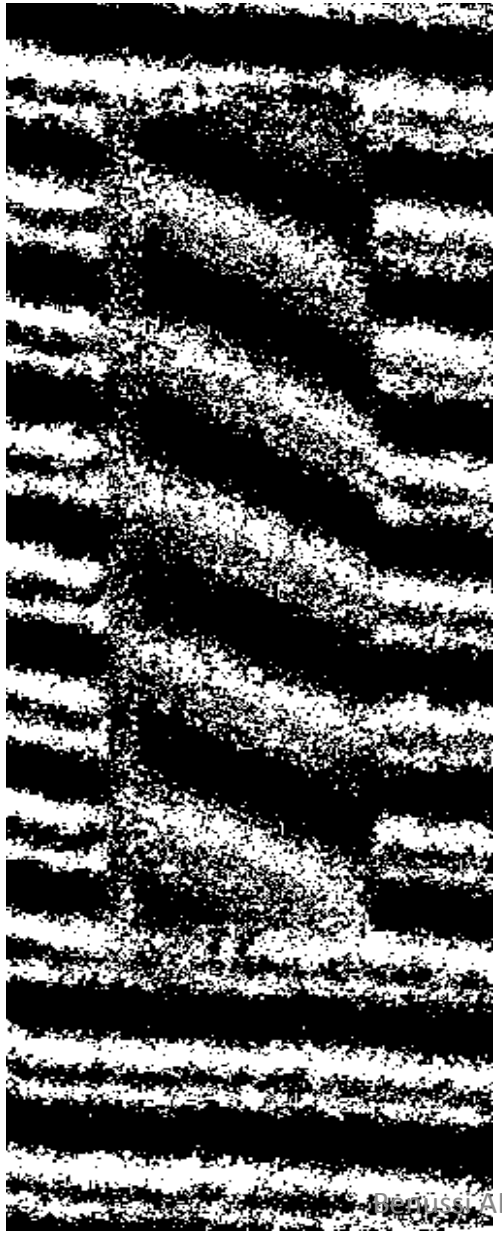
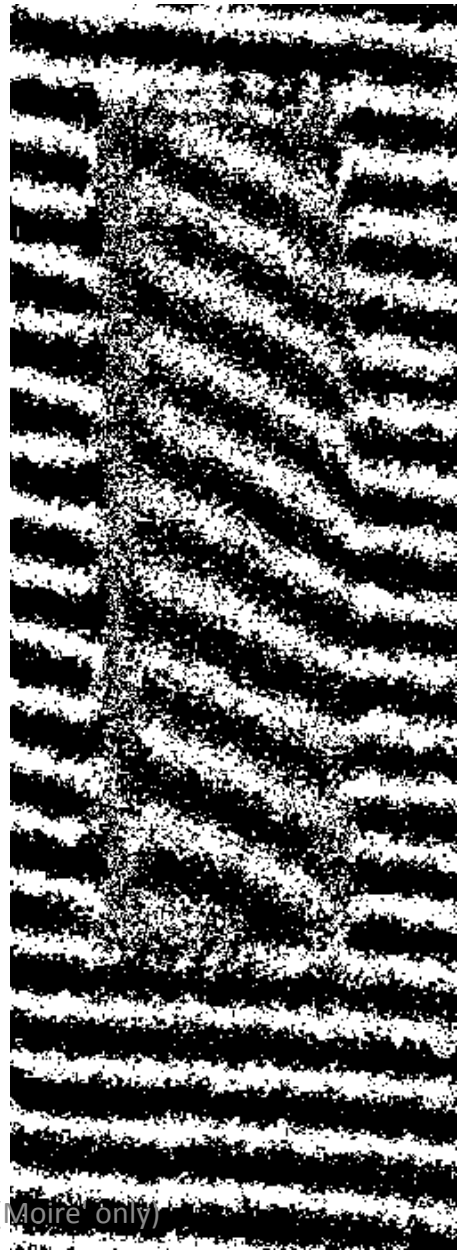


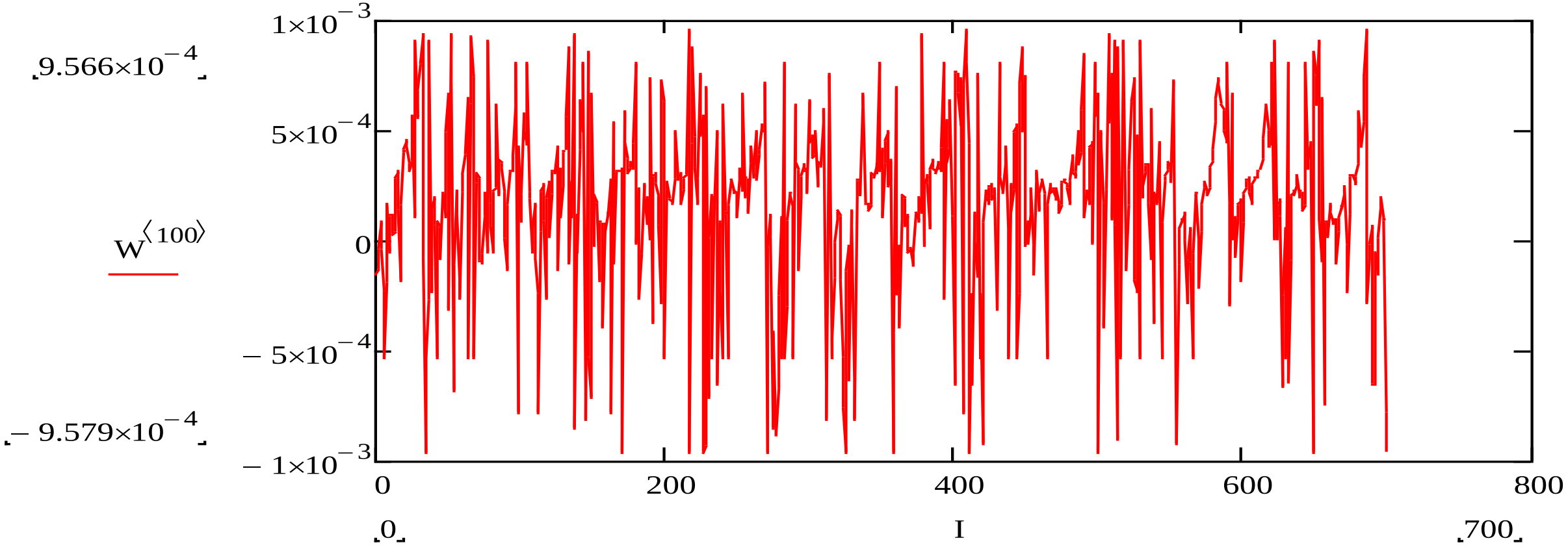
Number of fringes are not increased but spreade, we were not expected like that.

New images after applying 5 bucket



Number of fringes become double as we were expected

3 bucket
(Following are the initial results I am working on it)



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Control of foil/micromesh mechanical tensioning by optical techniques

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Additional Funding

- Additional funding was provided by INFN in the framework of GEM upgrade Phase 2 R&D.
- AIDA2020 WP13.4.3 activity has benefitted wi from existing equipment, infrastructure and consumables funded by INFN

Optical setup for Moiré fringes

- White light projector and viewing TV camera equipped with identical objectives and grating
- Grating: 120 lines/mm
- Viewing TV camera on step-motor translation stage to implement precise Phase Shift
- Setup optical geometry: reference plane perpendicular to bisectrix of angle between projection and viewing direction

  Procedure: Optimize intensity and contrast of Moiré fringes with live visual inspection of unprocessed image; Define required translation of TV-camera to produce 360° degree Phase Shift; Grab n.5 images with precise phase shift and PC-processing according to 5-bucket algorithm

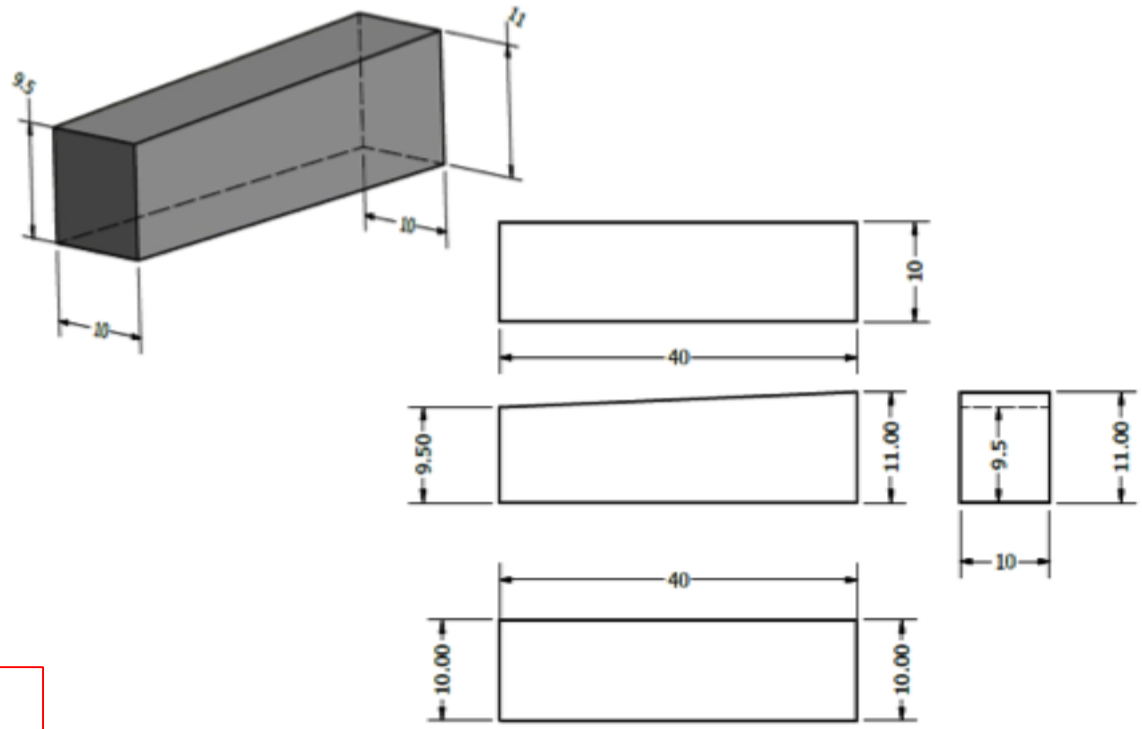
AIDA 2 - WP Name - Task 12.4.3: preparation for large series production: control of foil/micromesh mechanical tensioning by optical inspection

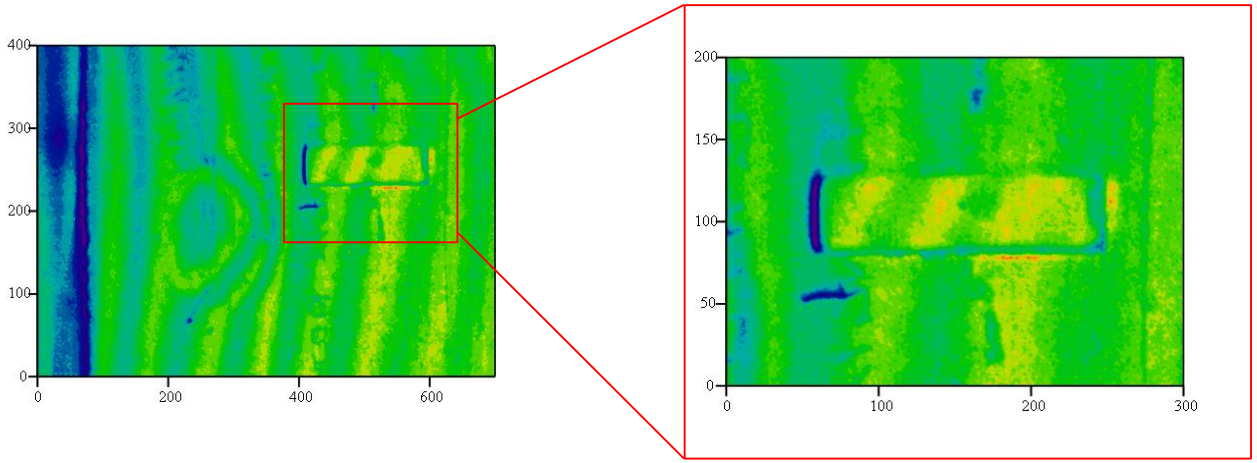
1. Moire' interferometry for large area surfaces
   - Phase shift algorithm greatly improves resolution on transverse displacement
     - **R=+-30um reached over small areas**
     - **Engineering over large areas in progress**
       - **Milestone JUNE 2016**
2. FBG sensors embedded in MPGD detectors
   - Lots of preliminary results
3. For both tasks, 5 conference presentations in 2015

Wedged specimen is used for resolution calibration

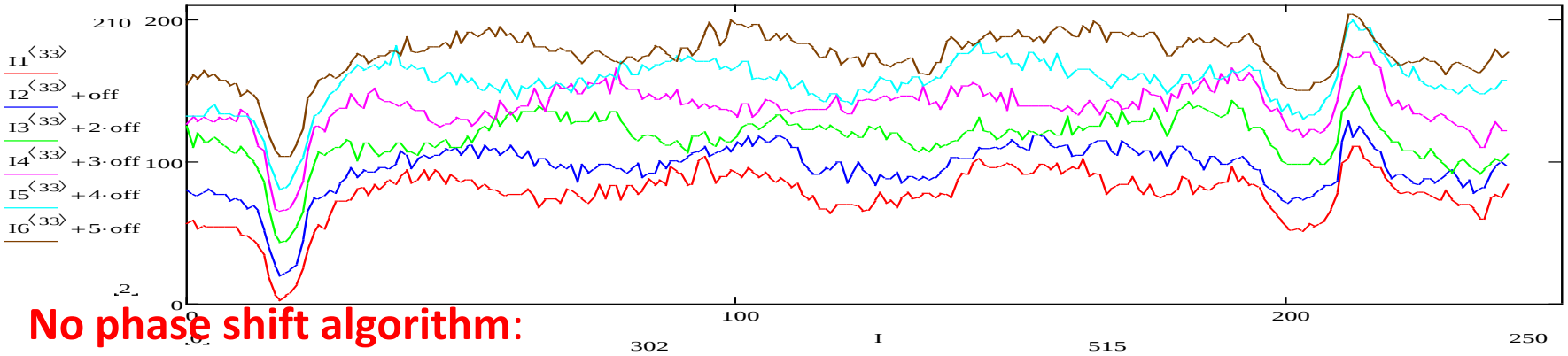
Counting N fringes between points with known Δh provides resolution R (points are chosen at center of dark fringe for best precision)

$R = \Delta h / N$





Fhase shift algorithm double n. of fringes, lowers noise enhances contrast: fraction of fringe can be appreciated



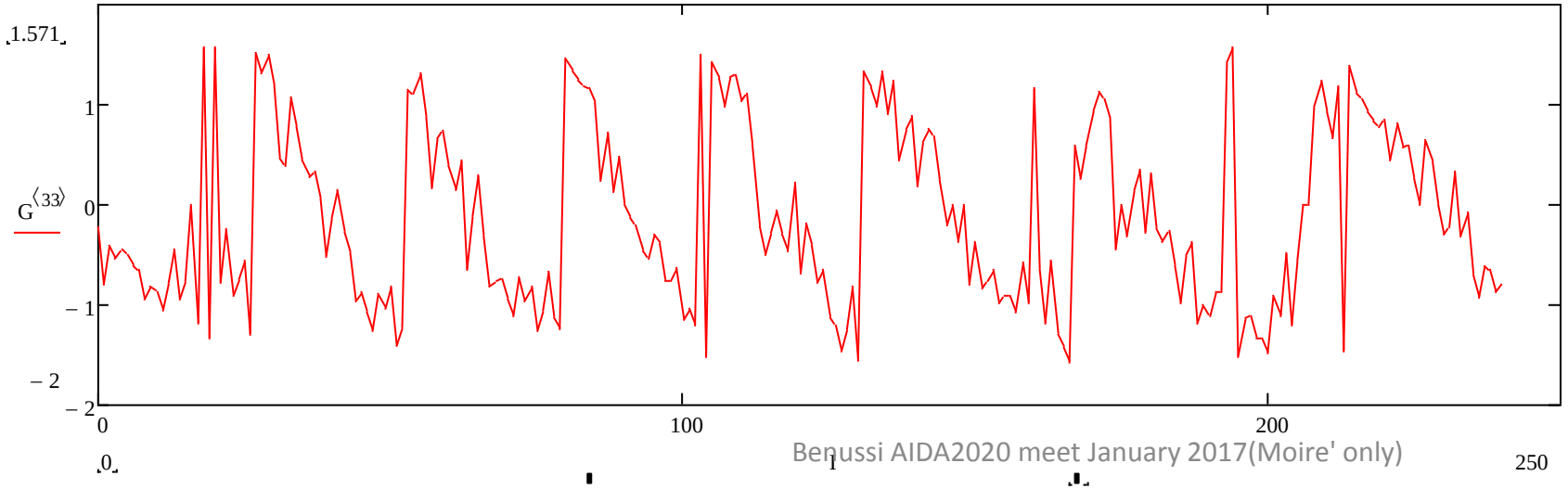
No phase shift algorithm:

Noise and low contrast: even center of fringe can be appreciated with difficulty

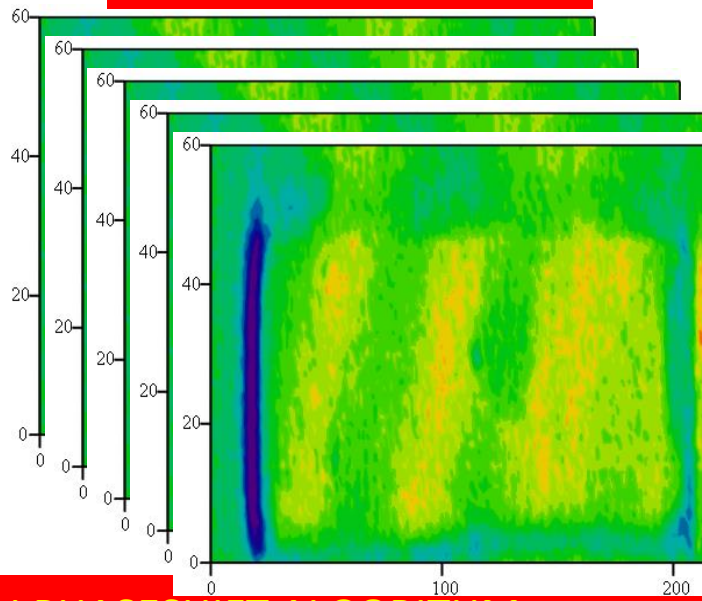
Phase shift algorithm:

Low noise, good contrast, number of fringe doubled: <1/3 of (narrower) fringe c

much better by fitting each slope (cont'd)

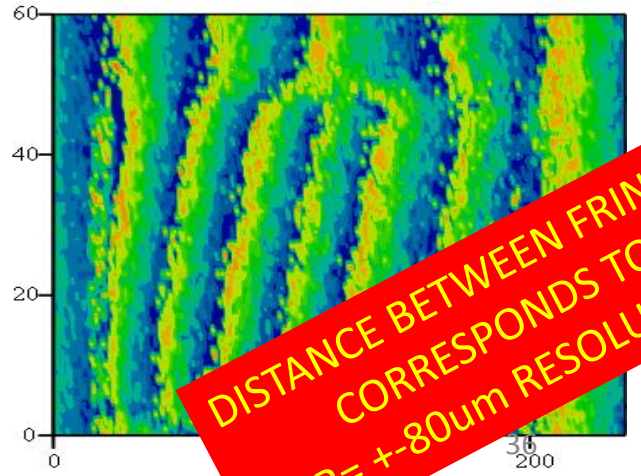


WITHOUT PHASESHIFT



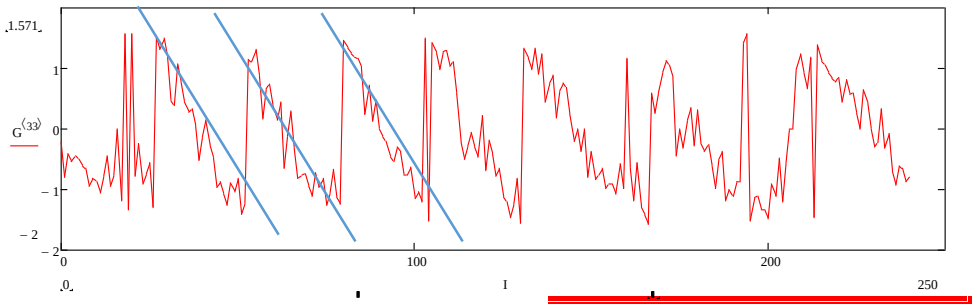
WITH PHASESHIFT ALGORITHM

Yi-Bae Choi, Yusong-Gu, "Phase shifting grating projection mo topography", Optical Engineering, Vol. 37, No. 3, March 1998

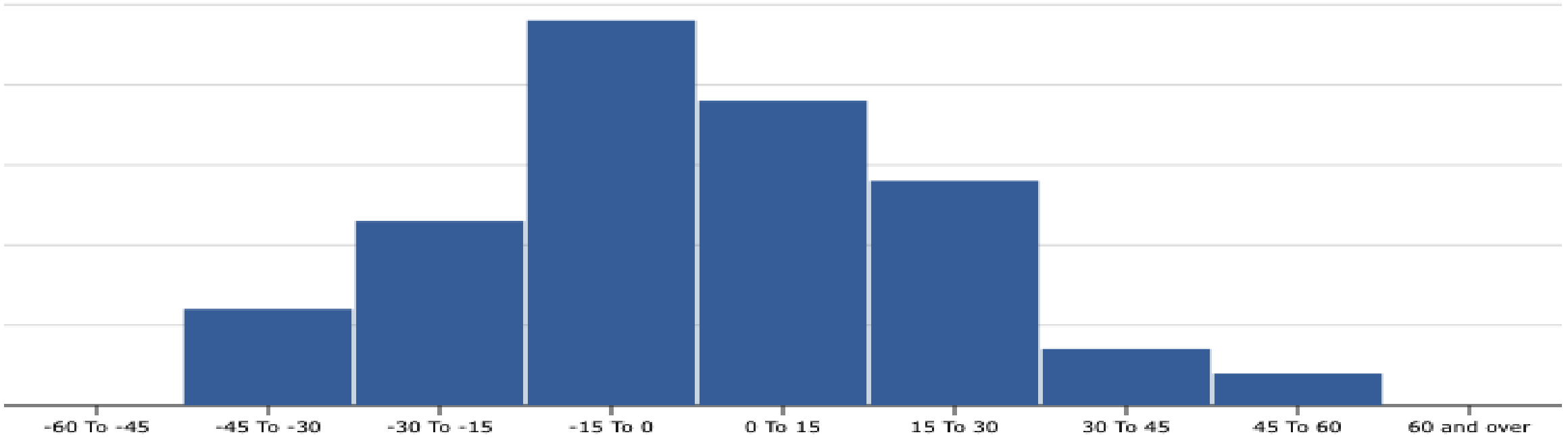


DISTANCE BETWEEN FRINGES CORRESPONDS TO R= +-80um RESOLUTION

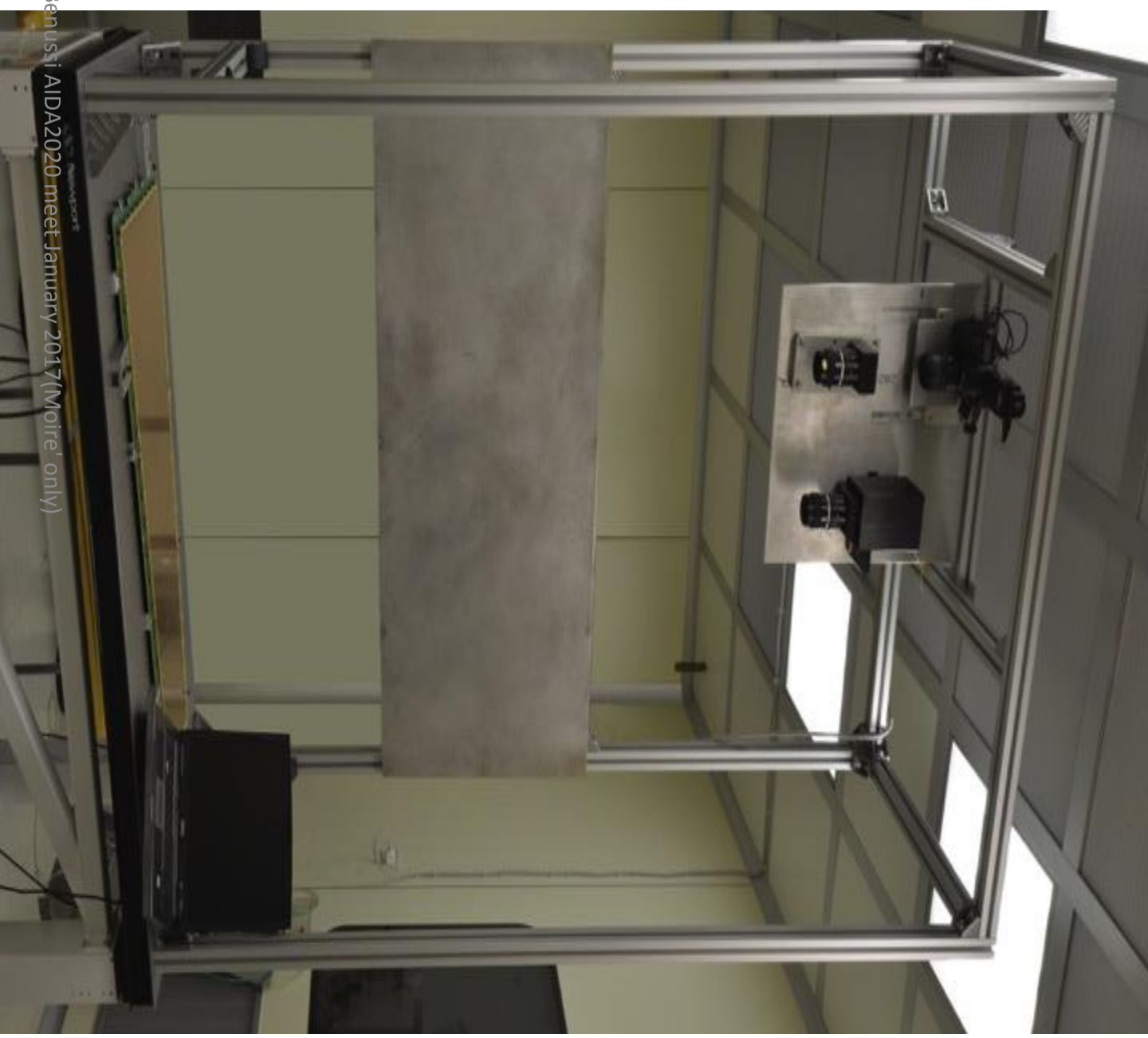
Frequency distribution of residuals (data-fit) transverse displacements [um]



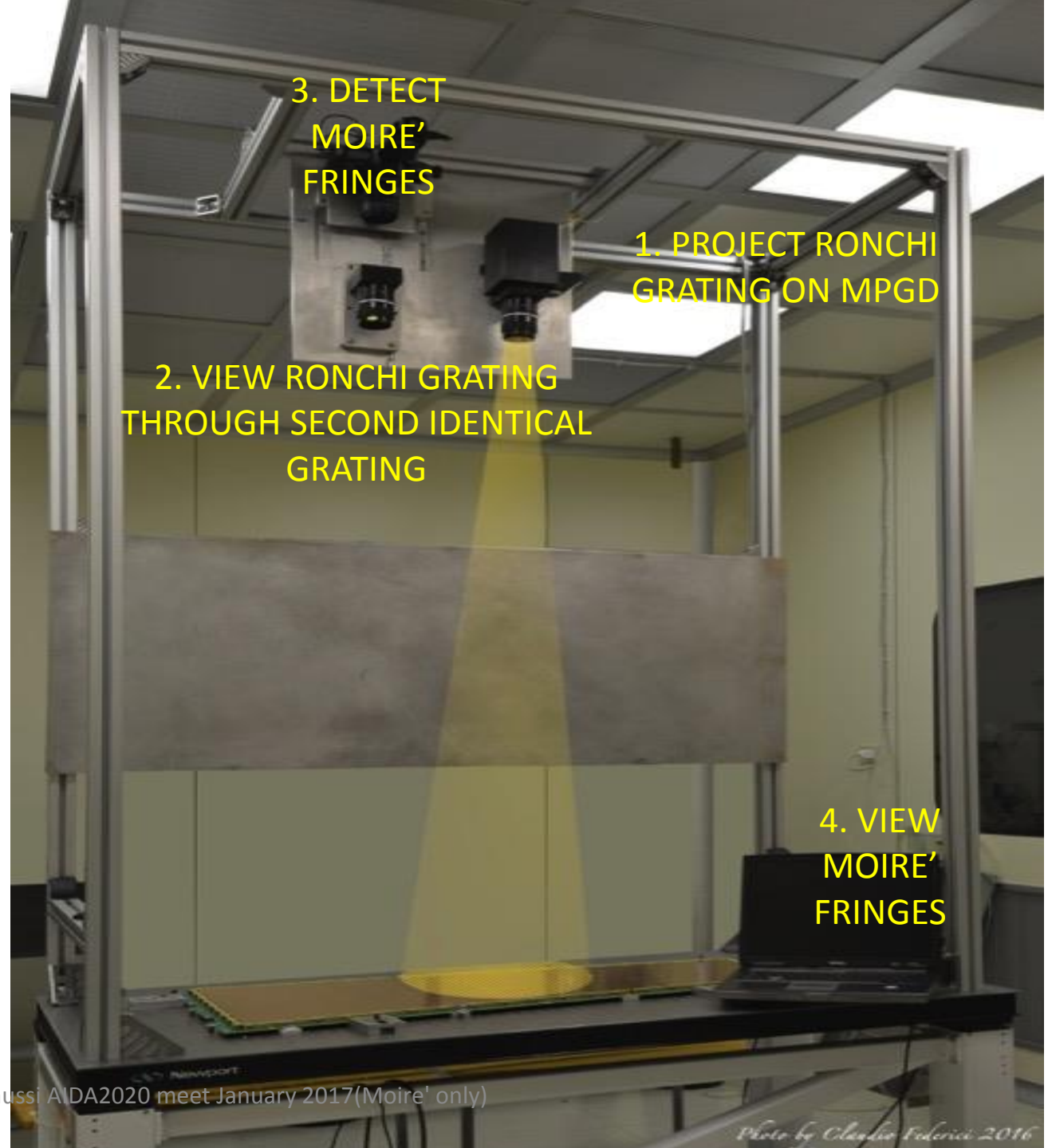
Standard Deviation = R transverse resolution = 20 um



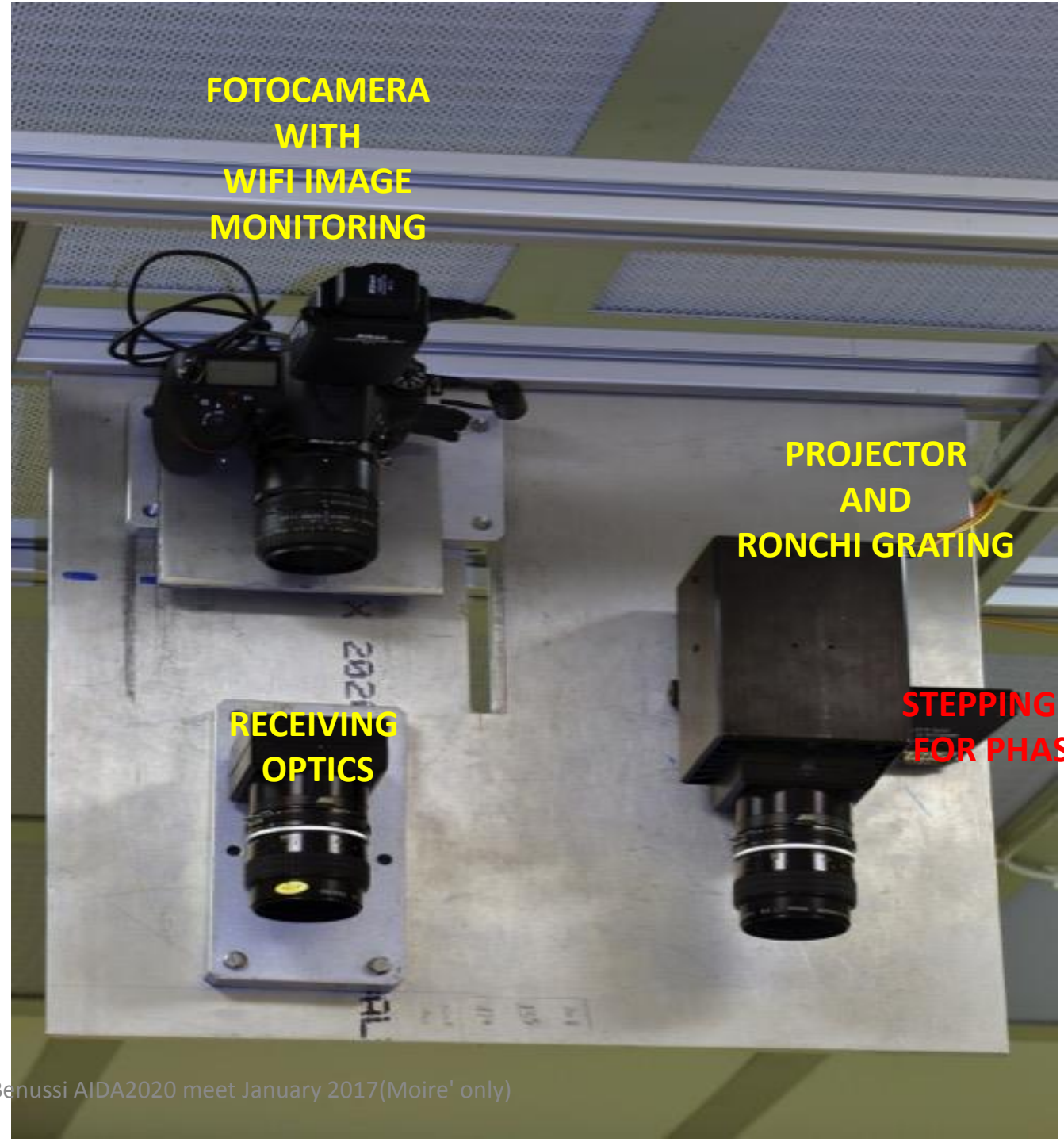
Engineered setup for large foils MPGD flatness monitoring



Engineered setup for large foils MPGD flatness monitoring



Engineered setup for large foils MPGD flatness monitoring



CONCLUSIONS

- Target resolution better than 30um reached with Moire’ setup
- Moire’ Engineering demostrator ready (milestone M12)
- Preparing full report with images of fringes over the whole MPGD chamber
- Several presentations of FBG sensors shown at conference in 2015-2016
- Prepare conference talk and publications

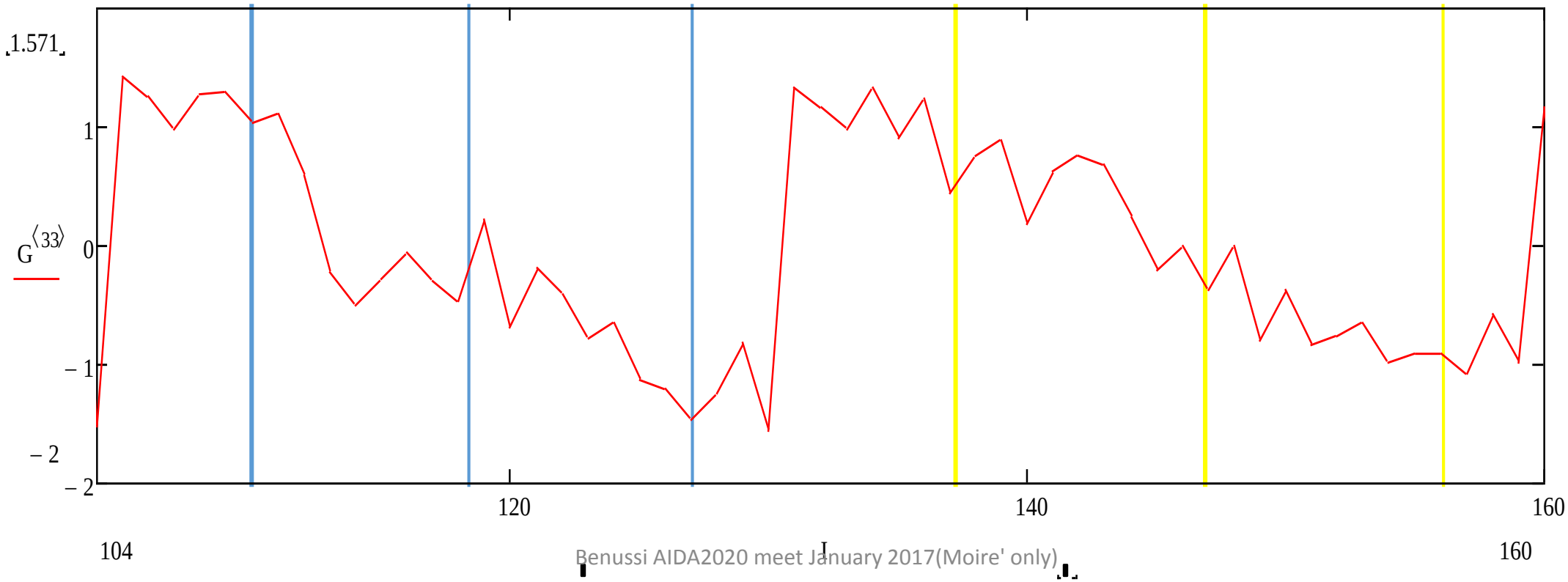
SPARES

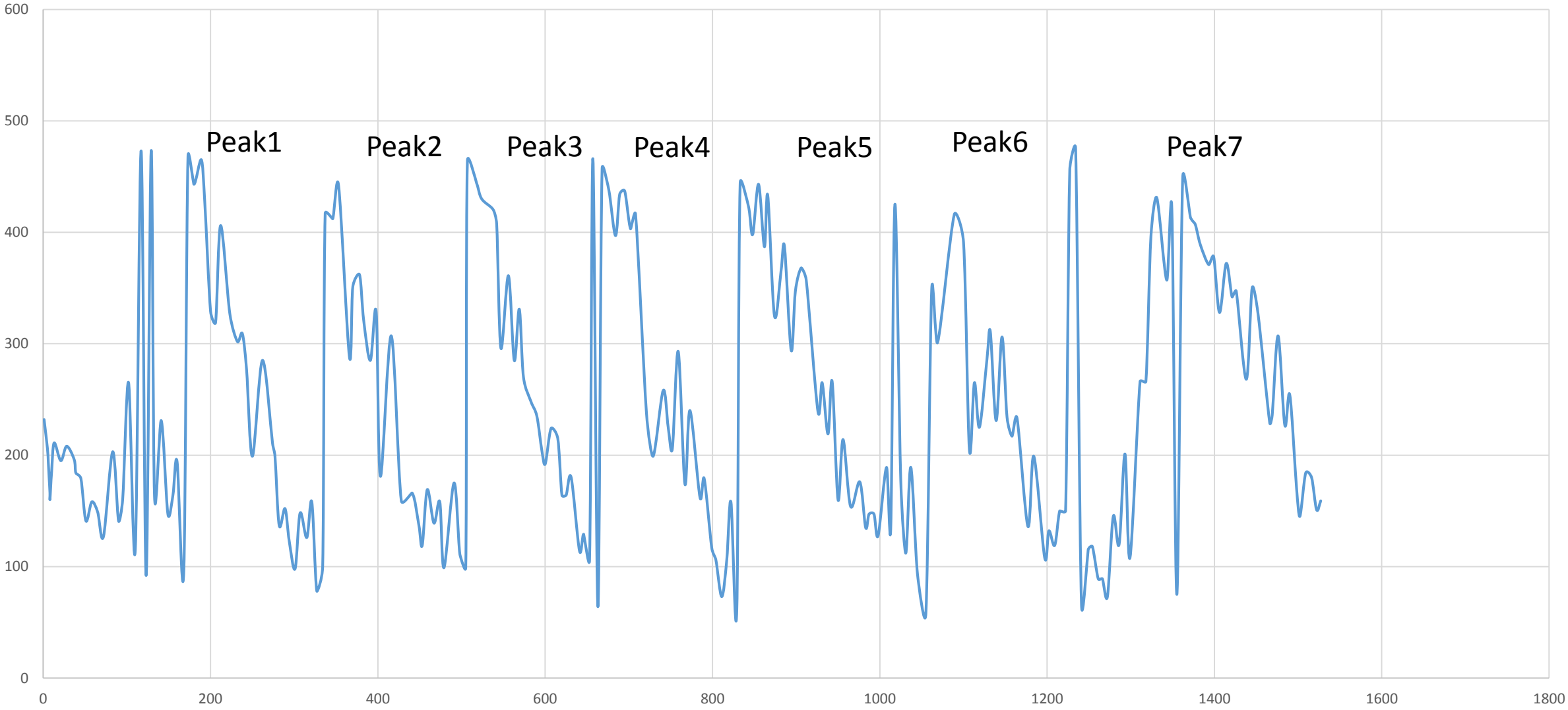
Actual optical Moirè set up in Astra

No Phase Shift Moiré fringes: resolution = 0.5 mm (from centre-of-fringe to centre-of fringe)

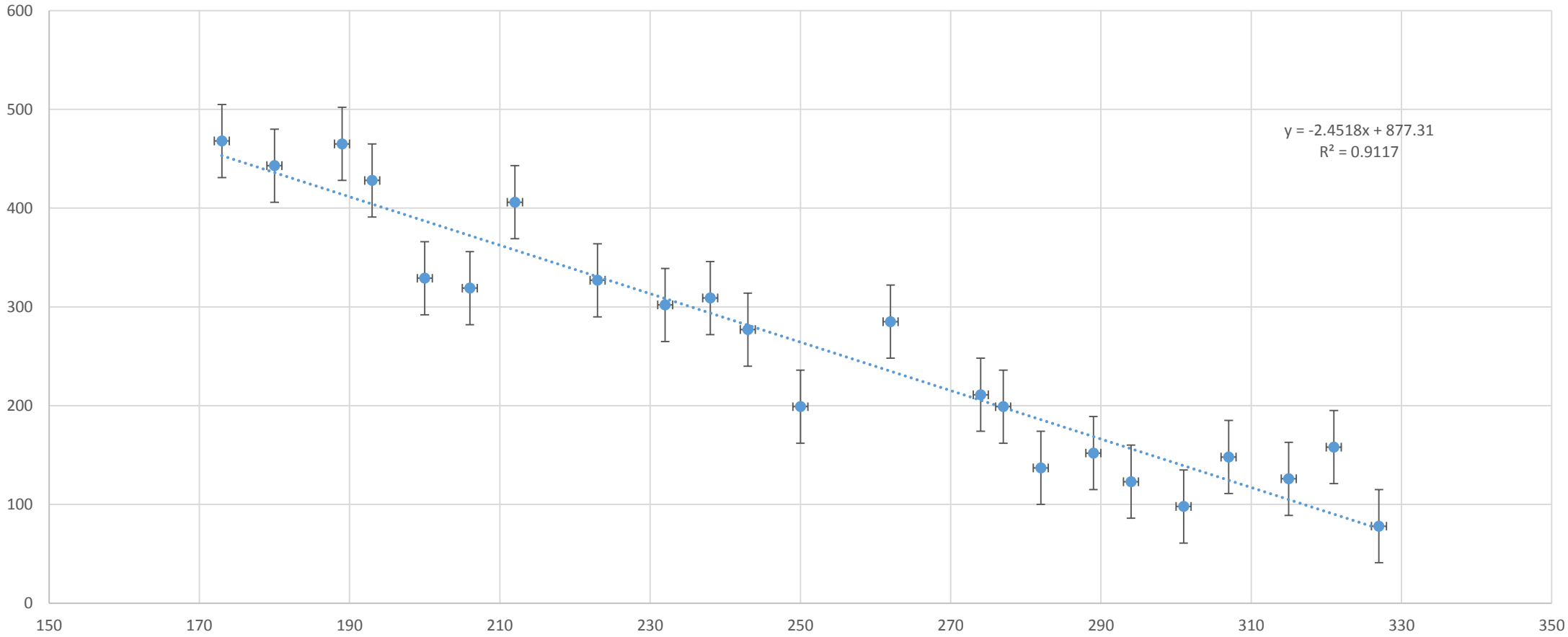
Phase Shift

- doubles N. of fringes: resolution = 0.25 mm (from centre-of-fringe to centre-of fringe)
- **Enhances contrast and lowers noise: resolution better tnab 0.08 mm (<1/3 of fringe can be appreciated)**

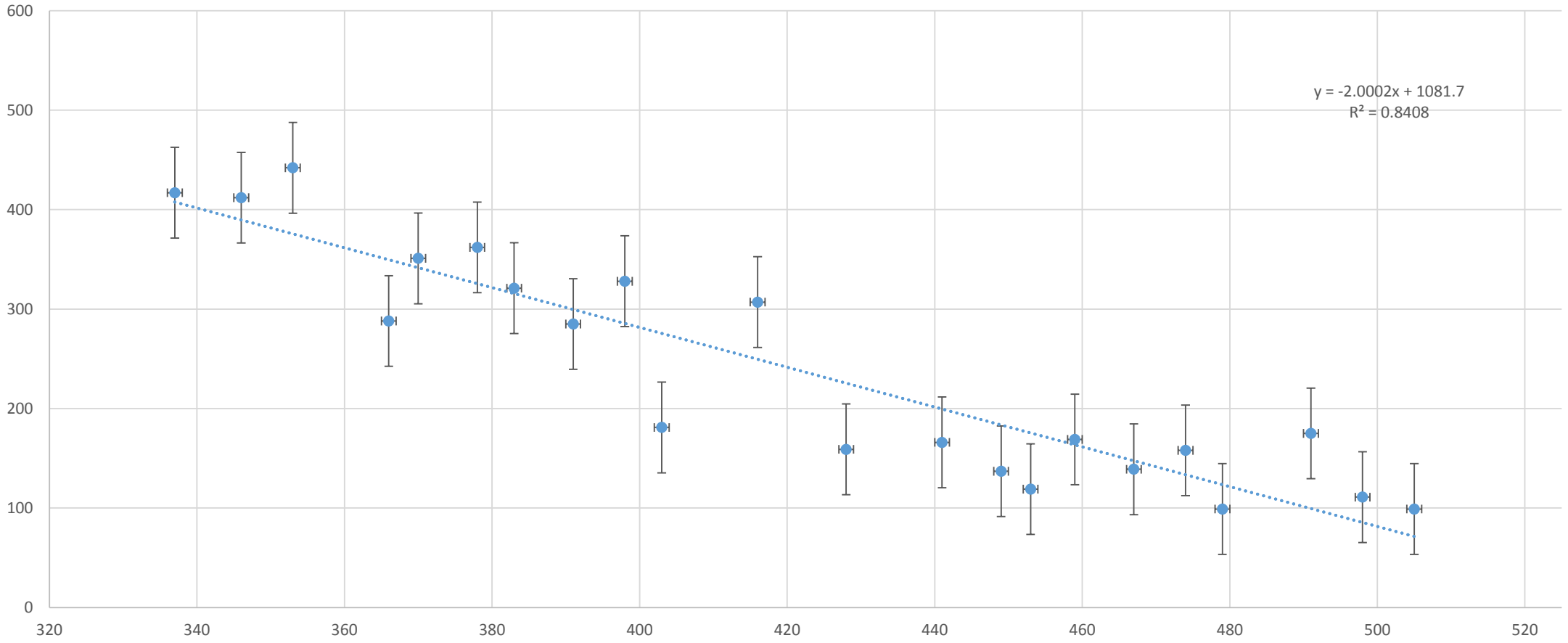



Peak1
Peak2
Peak3
Peak4
Peak5
Peak6
Peak7
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
1800

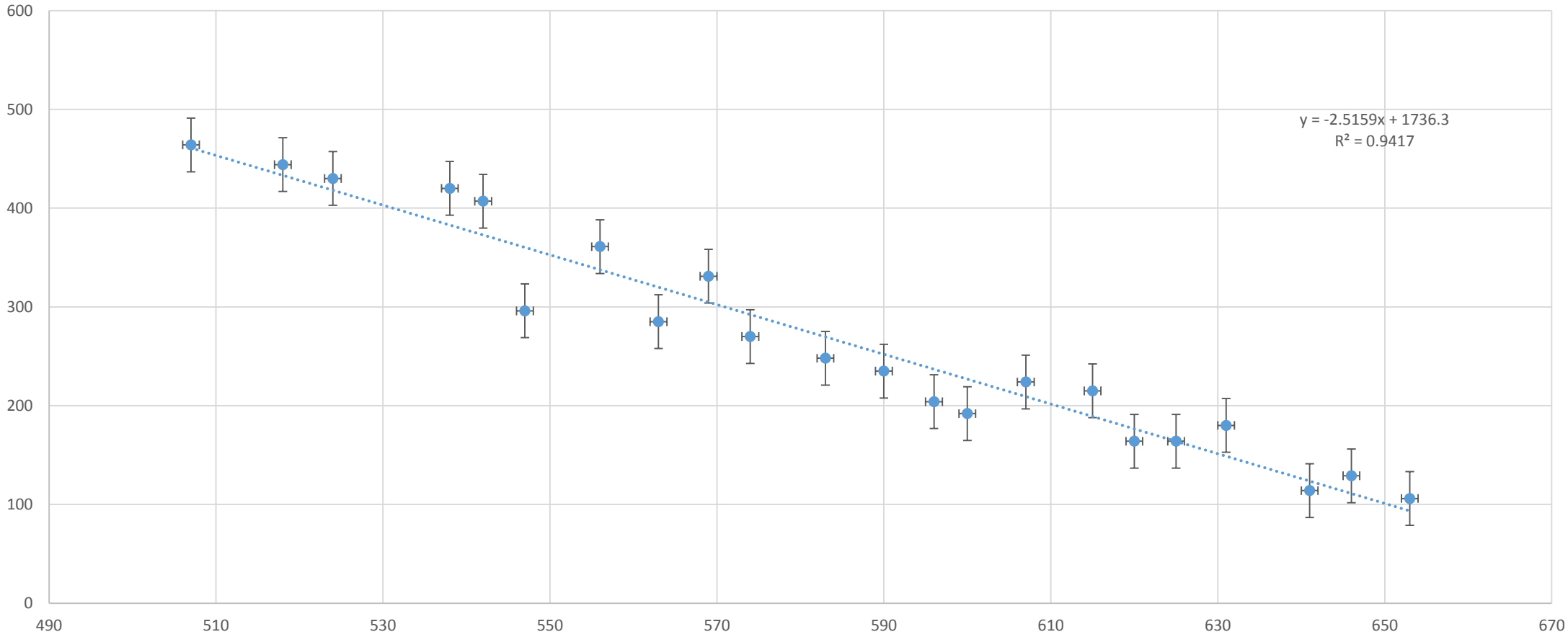
Peak 1- (standard deviation 37)



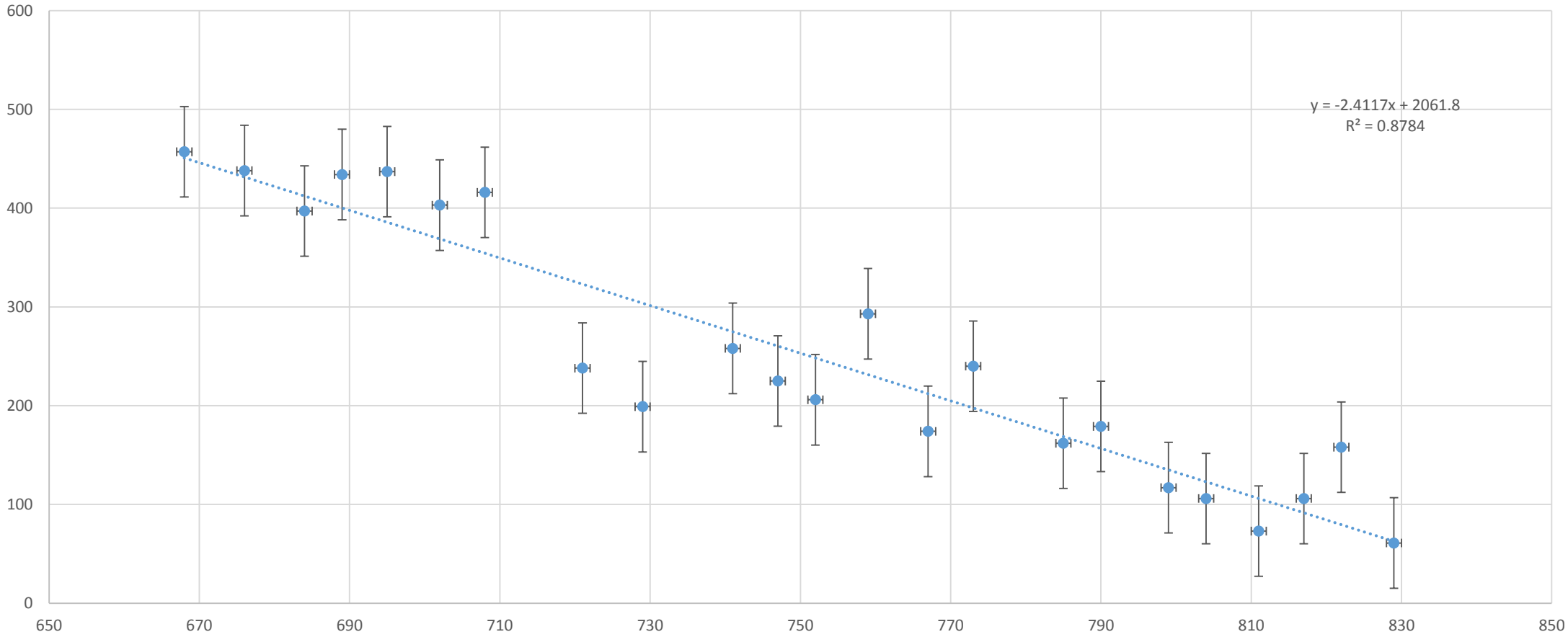
Peak 2- (standard deviation 45.6)



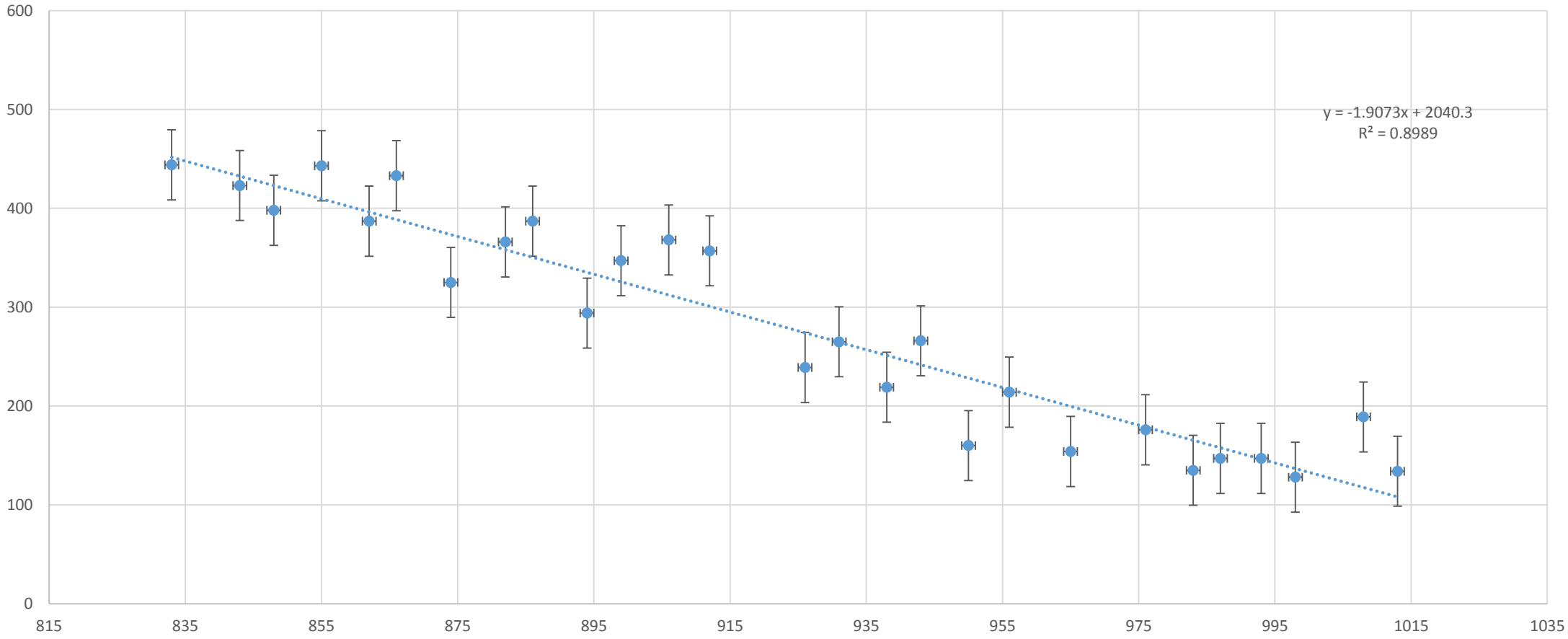
Peak 3- (standard deviation 27)



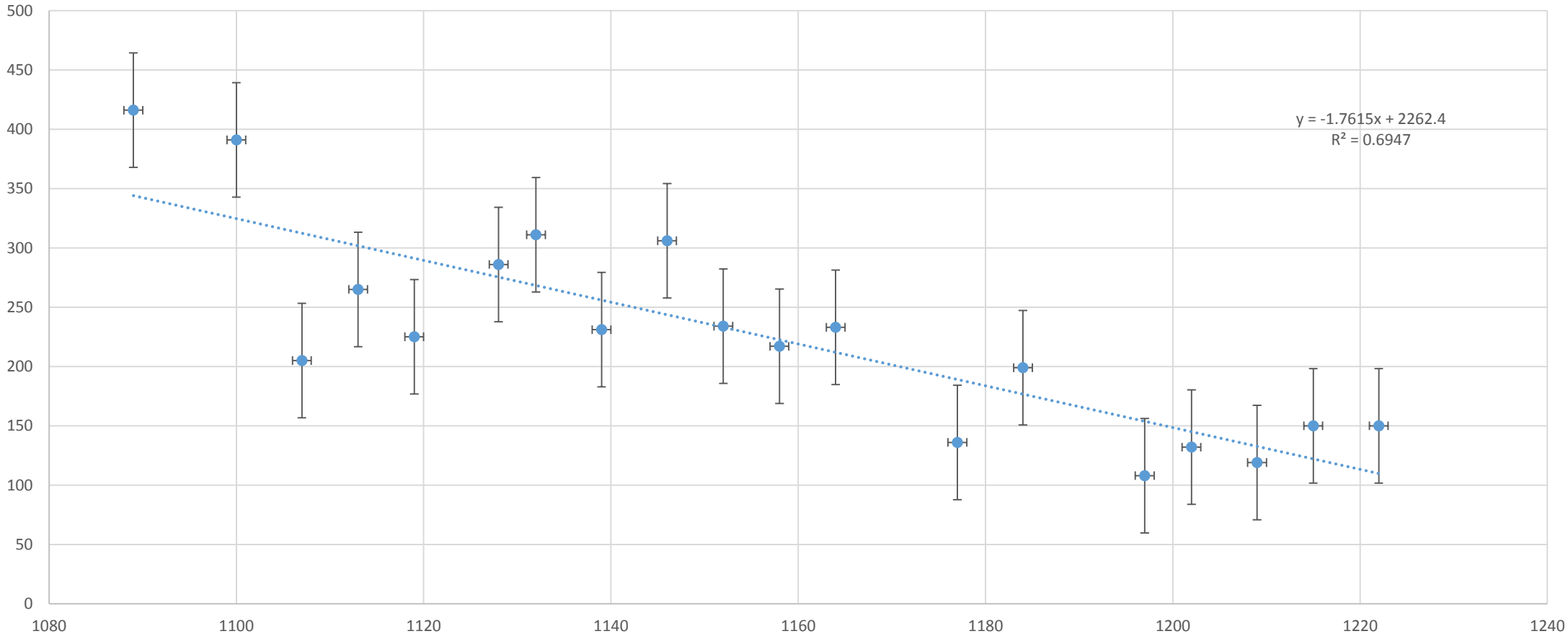
Peak 4- (standard deviation 45.8)



Peak 5- (standard deviation 35.4)



Peak 6- (standard deviation 48.2)



Peak 7- (standard deviation 29.4)