

Laser viewport investigations – Status Report

Measurement of laser viewports at PITZ (Nov. 2015 – Feb. 2016)

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Zeuthen, 01.06.2016,

Motivation

- > Viewport laser windows installed at DDC in accelerator beam line
 - windows exposed to nuclear radiation

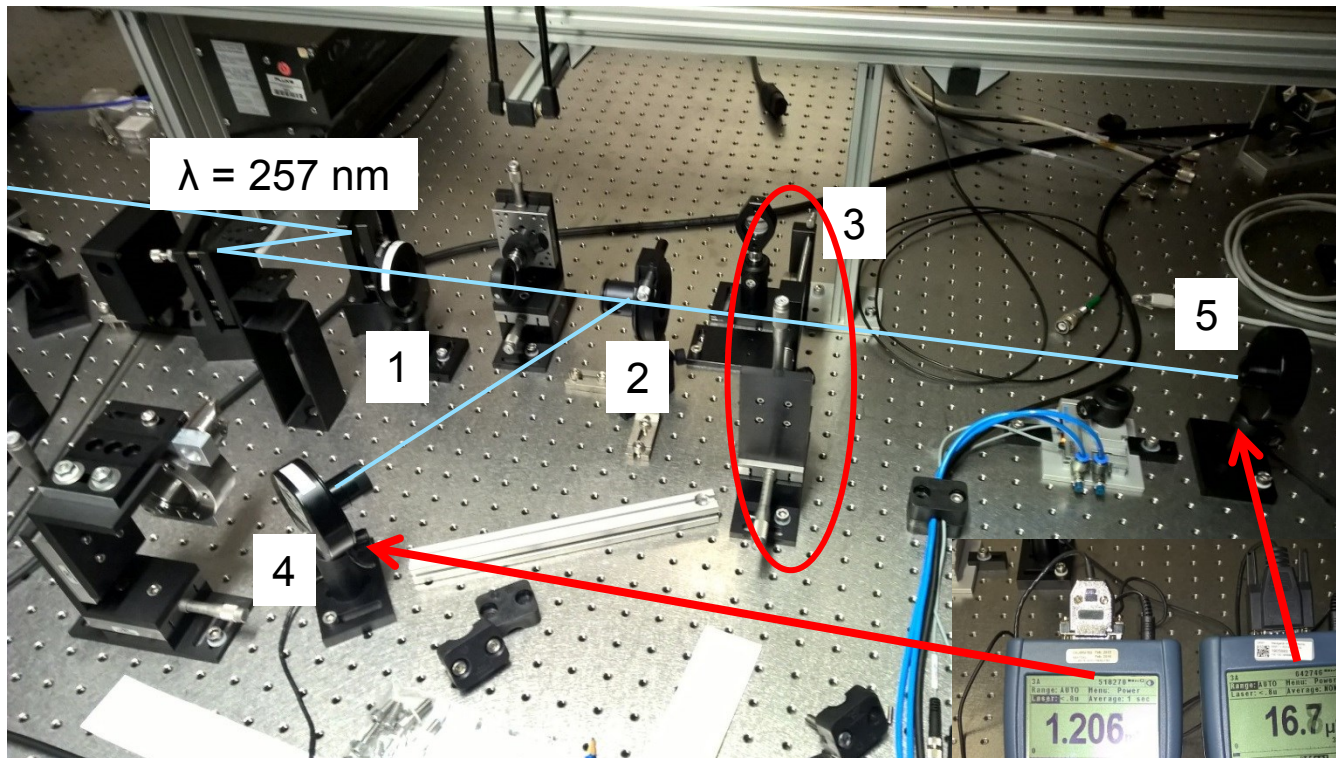
- > Different kinds of viewport windows used / bought at PITZ

- > No information about radiation hardness (in terms of laser light transmission behavior)

BUT: last dismantled viewport showed color centers and lower transmission values than expected!!!

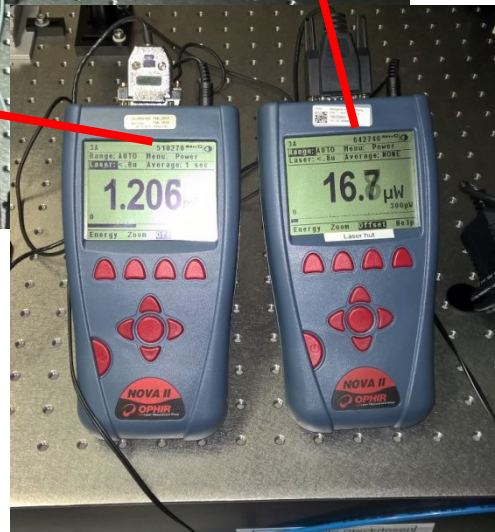


Measurement set-up



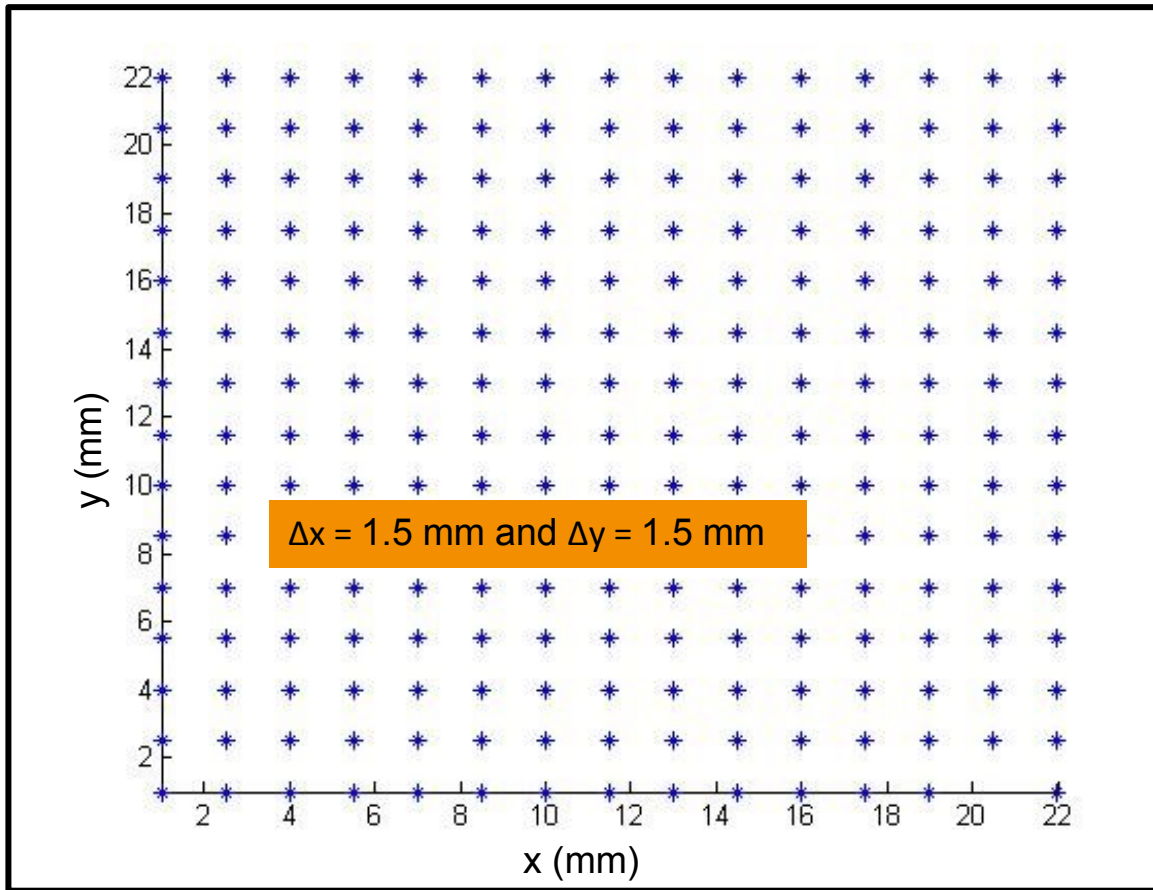
At Glen-Taylor-prism 50% of pulse energy (adjusted by $\lambda/2$ wave plate) is reflected for reference measurement and 50 % is transmitted to laser window. Therefore simultaneous laser energy measurement of initial and transmitted laser pulses is possible!!!

- 1 - $\lambda/2$ wave plate
- 2 - Glen-Taylor-prism
- 3 - „window-holder“ mounted on movable x-y-table
- 4 - power meter head (reference measurement)
- 5 - power meter head (transmission measurement)



Laser beam diameter: ~ 1 mm (FWHM)

Measure grid as used during characterization



Measurements were done using a **measure grid**. The **distance** of each measure point had been **1.5 mm in each direction**.

Displacement was done by use of translation stage with precision of $50 \mu\text{m}$.

Measured transmission **data** had been **analyzed using Matlab**. Thereby, reading points at the edge of the window had been rejected.

Calculated values: average, homogeneity, minimal and maximal transmission value of all reading points (x_i, y_i)

Measured transmission values (all windows listed)

viewport	average	homogeneity	minValue	maxValue
102015_1	0,8827	0,0135	0,8233	0,9089
102015_2	0,7698	0,0132	0,7427	0,8407
102015_3	0,7705	0,0488	0,6830	0,8743
112015_1	0,9271	0,0056	0,8994	0,9381
112015_2	0,6749	0,0119	0,6103	0,7383
1210850_3	0,5800	0,0138	0,5626	0,6624
1210850_6	0,91634	0,0042	0,8979	0,9439
2004283_1	0,7384	0,0053	0,7088	0,7767
2004283_2	0,9177	0,0099	0,8450	0,9577
2004283_3	0,9057	0,0026	0,8962	0,9398
2004283_4	0,9127	0,0058	0,8683	0,9645
2004283_5	0,9297	0,0045	0,9197	0,9397
2004283_6	0,9048	0,0054	0,8875	0,9230
2004283_7	0,8633	0,0099	0,8182	0,8885
2004283_8	0,9334	0,0059	0,9230	0,9609
9722005_10	0,9173	0,0057	0,8981	0,9305
102015_Test	0,9074	0,0052	0,8843	0,9219
022016_1	0,9191	0,0147	0,8661	0,9610
022016_2	0,9079	0,0124	0,8541	0,9394



Preselection of acceptable laser viewports according to the different measured transmission values

1st criteria: standard deviation (Stddev) < 0.01 (value arbitrary chosen)

viewport	average	homogeneity	minValue	maxValue
112015_1	0,9271	0,0056	0,8994	0,9381
1210850_6	0,91634	0,0042	0,8979	0,9439
2004283_1	0,7384	0,0053	0,7088	0,7767
2004283_2	0,9177	0,0099	0,8450	0,9577
2004283_3	0,9057	0,0026	0,8962	0,9398
2004283_4	0,9127	0,0058	0,8683	0,9645
2004283_5	0,9297	0,0045	0,9197	0,9397
2004283_6	0,9048	0,0054	0,8875	0,9230
2004283_7	0,8633	0,0099	0,8182	0,8885
2004283_8	0,9334	0,0059	0,9230	0,9609
9722005_10	0,9173	0,0057	0,8981	0,9305
102015_Test	0,9074	0,0052	0,8843	0,9219



Preselection of acceptable laser viewports according to the different measured transmission values

2nd criteria: average transmission (Average) > 0,85 (value arbitrary chosen)

viewport	average	homogeneity	minValue	maxValue
112015_1	0,9271	0,0056	0,8994	0,9381
1210850_6	0,91634	0,0042	0,8979	0,9439
2004283_2	0,9177	0,0099	0,8450	0,9577
2004283_3	0,9057	0,0026	0,8962	0,9398
2004283_4	0,9127	0,0058	0,8683	0,9645
2004283_5	0,9297	0,0045	0,9197	0,9397
2004283_6	0,9048	0,0054	0,8875	0,9230
2004283_7	0,8633	0,0099	0,8182	0,8885
2004283_8	0,9334	0,0059	0,9230	0,9609
9722005_10	0,9173	0,0057	0,8981	0,9305
102015_Test	0,9074	0,0052	0,8843	0,9219






The table above shows all viewports, which are chosen for a more detailed analysis!!!



Preselection of acceptable laser viewports according to the different measured transmission values

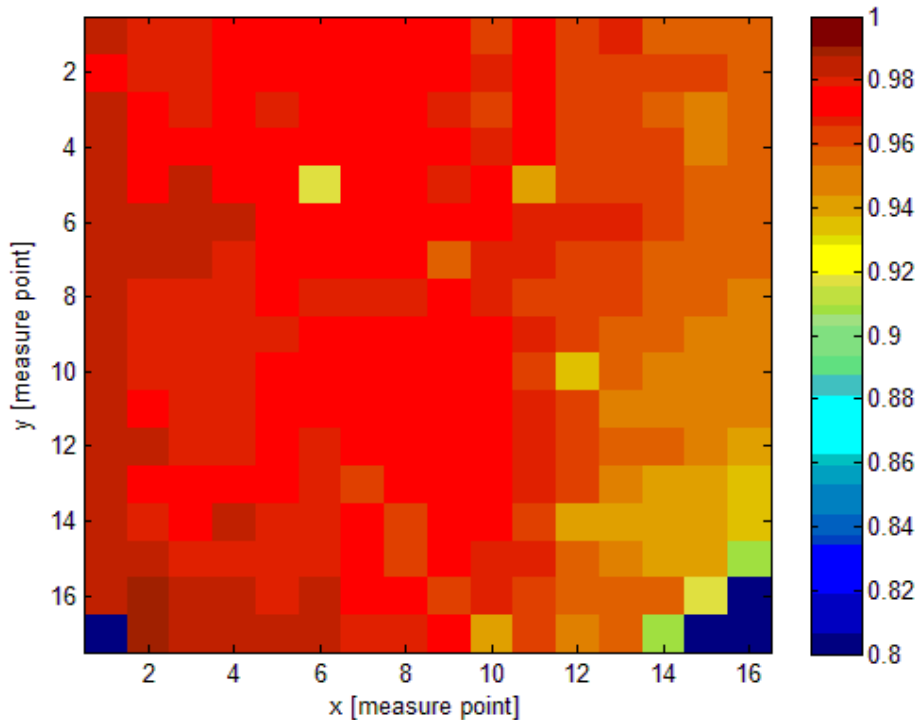
Viewport types:

viewport	average	homogeneity	minValue	maxValue
112015_1	0,9271	0,0056	0,8994	0,9381
1210850_6	0,91634	0,0042	0,8979	0,9439
2004283_2	0,9177	0,0099	0,8450	0,9577
2004283_3	0,9057	0,0026	0,8962	0,9398
2004283_4	0,9127	0,0058	0,8683	0,9645
2004283_5	0,9297	0,0045	0,9197	0,9397
2004283_6	0,9048	0,0054	0,8875	0,9230
2004283_7	0,8633	0,0099	0,8182	0,8885
2004283_8	0,9334	0,0059	0,9230	0,9609
9722005_10	0,9173	0,0057	0,8981	0,9305
102015_Test	0,9074	0,0052	0,8843	0,9219

	Corning 8655 Grade AA
	VPZ38QVAR-NM
	ZVP-DUV-C40-QZ
	VP-DUV-200-C40
	unknown



Viewport 112015_1 (Corning 8655 Grade AA)



Distributor: Corning

Model: Corning 8655 Grade AA

Code:

Batch no.: no information

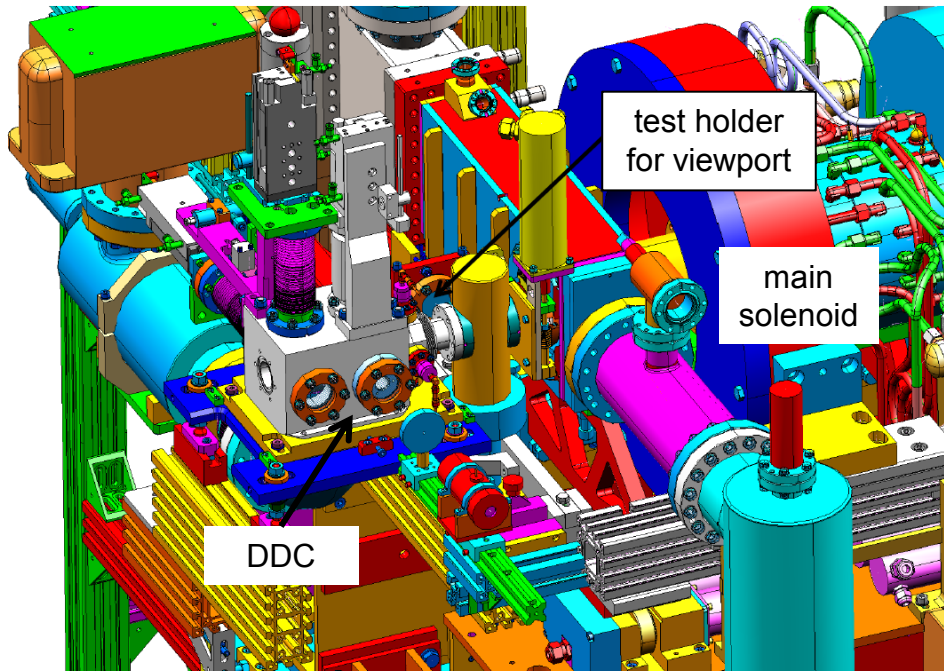
Coated: yes (air side)

Delivery: no information

Used: **no**

- > Specs (manufacturer): $R < 0.25\%$ air side @ 257.5nm (standard)
- > Measurement (before installation): 96 % transmission (back side reflection of about 4 % expected) ✓

Viewport 112015_1 (Corning 8655 Grade AA)



Distributor: Corning

Model: Corning 8655 Grade AA

Code:

Batch no.: no information

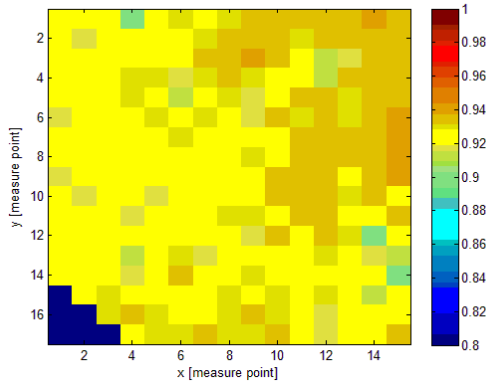
Coated: yes (air side)

Delivery: no information

Used: **Yes (no laser)**

- > **For test purposes:** installation close to electron beam line
- > Position of viewport installation in a test holder next to LOW.V1 (25.05.2015 - 09.11.2015)

Viewport 112015_1 (Corning 8655 Grade AA)

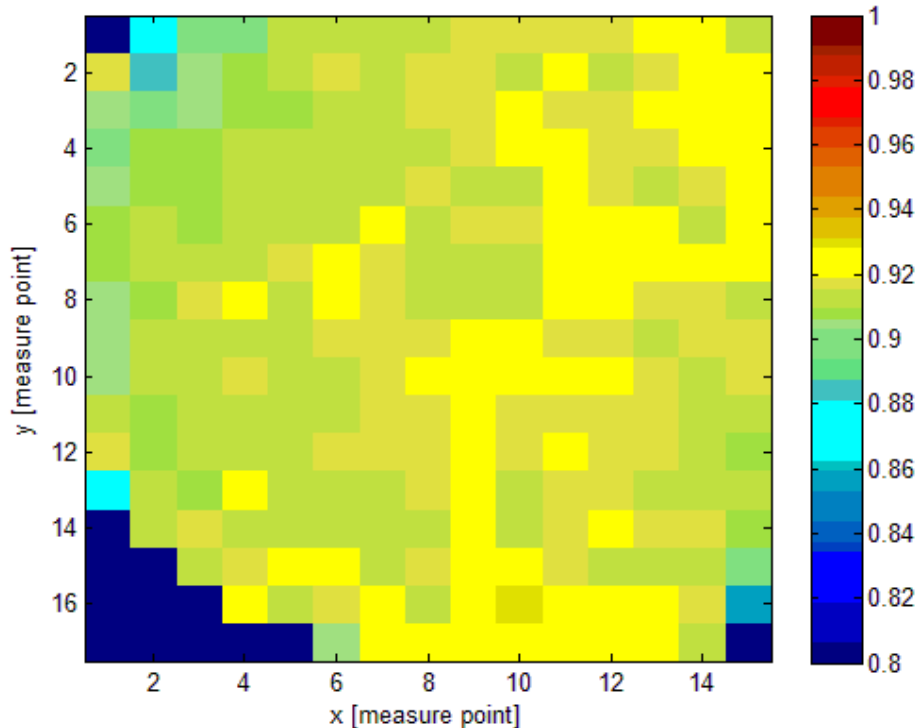


Model: Corning 8655 Grade AA

Integrated irradiation value: $\gg 5$ kGy

- > Measurement after installation: decrease of transmission ~ 3 % (homogeneity still ~ 0.56 %); BUT:
 - Uncertainty of each measurement about 3 % due to power meter and detector head
 - Different measurement set-ups (1st measurement done at XFEL injector laser)
 - 2nd measurement improved -> simultaneous measurement of laser pulse intensity before and after viewport via software script
 - > **Currently:** 2nd installation of viewport at PITZ injector for ~ 6 month at **DDC laser port** and afterwards full characterization again
- ONGOING at PITZ since January 2016!!!

Viewport 1210850_6 (VPZ38QVAR-NM) - unused



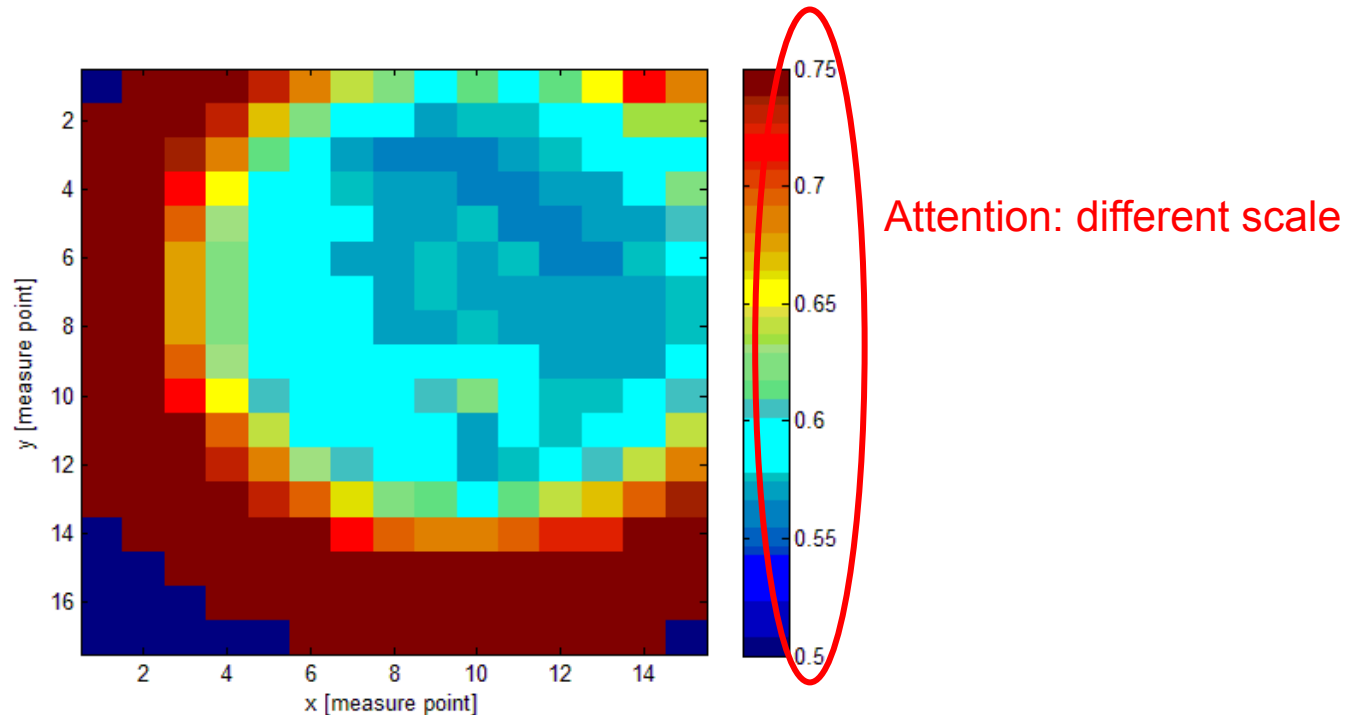
Distributor: MDC vacuum Ltd.
Model: **DN40CF Spectrosil
Quartz VP 316LN /
Tantalum**
Code: **VPZ38QVAR-NM**
Batch no.: 120918/6
Coated: yes
Delivery: no information
Used: **no**

- > Currently: tested at DDC X-flange
- > Example of used type → next slide (1210850_3)

1210850_3 (VPZ38QVAR-NM) – used

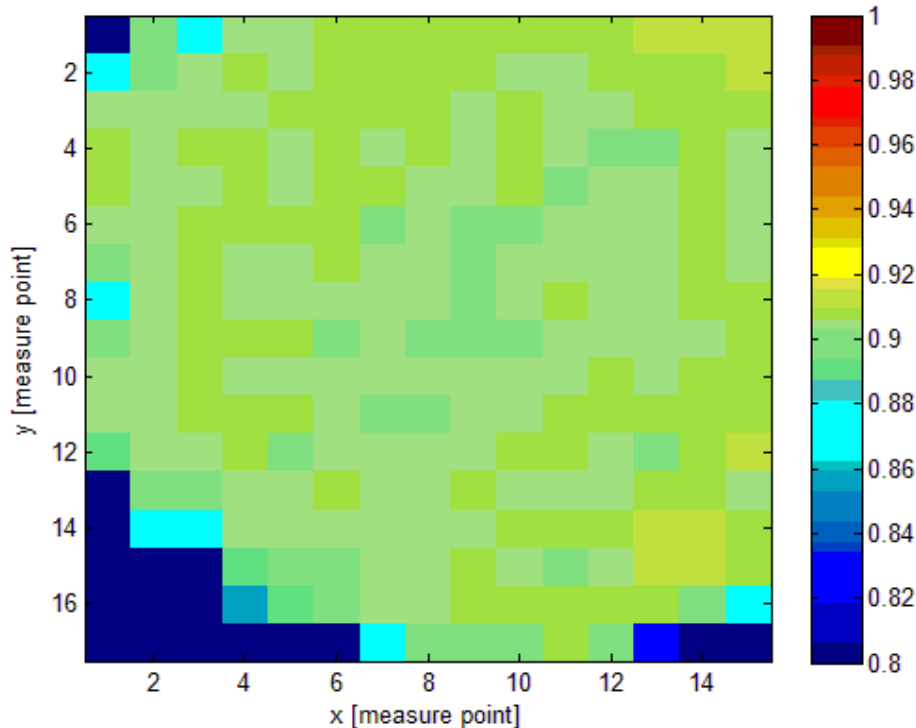
Transmission values:

window	average	homogeneity	minValue	maxValue
1210850_3	0,5800	0,0138	0,5626	0,6624



➤ Installed at DDC laser port (11.2014 – 11.2015)

Viewport 2004283_3 (ZVP-DUV-C40-QZ) - unused



Distributor: Caburn MDC

Model: **DN40CF Quartz V/P**
(standard fused silica?)

Code: **ZVP-DUV-C40-QZ**

Batch no.: 74972/1

Coated: yes

Delivery: no information

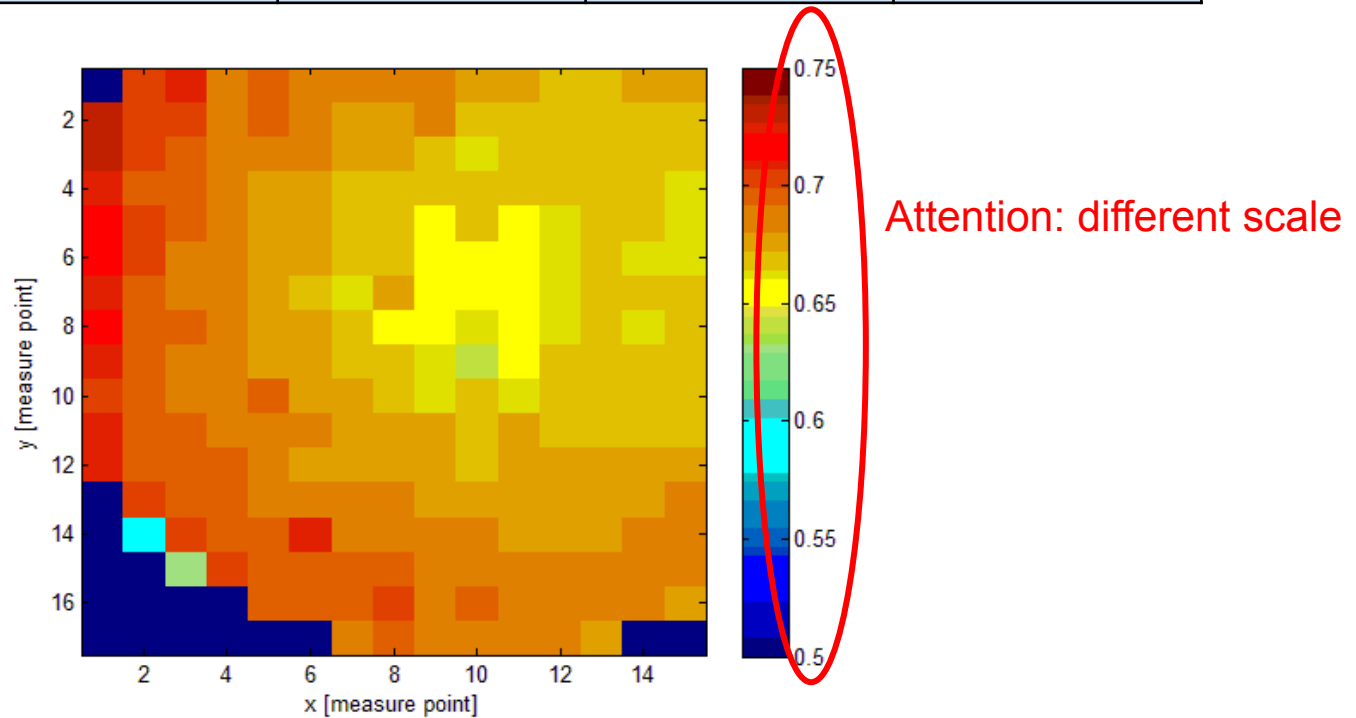
Used: no information / most likely **not**

- Currently: other new window of this type tested at test holder near Low.V1
- Example of used type → next slide (112015_2)

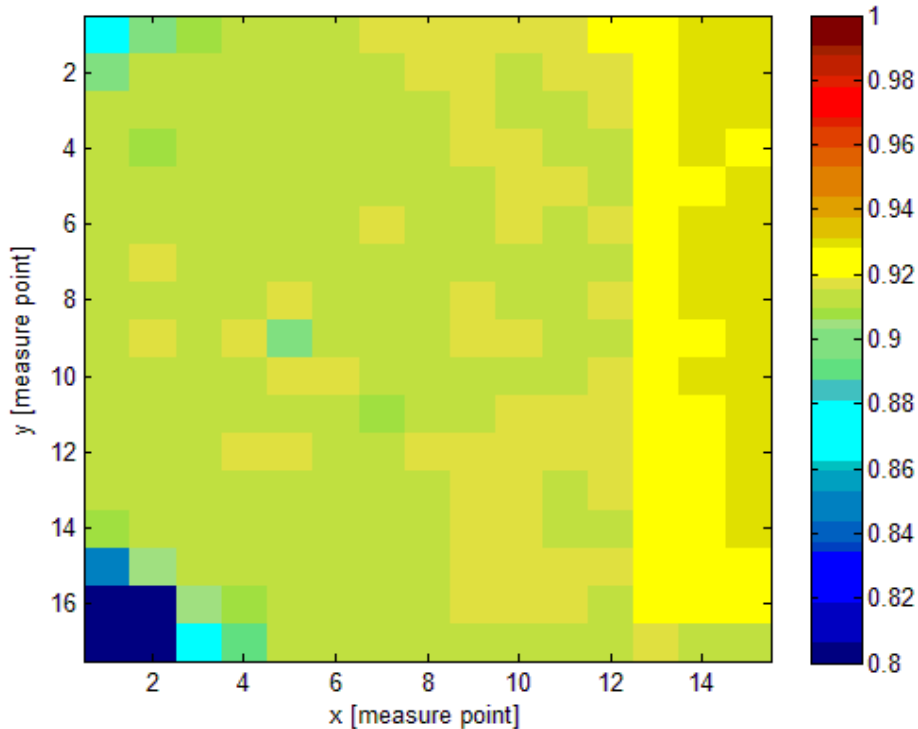
Viewport 112015_2 (ZVP-DUV-C40-QZ) - used

Transmission values:

window	average	homogeneity	minValue	maxValue
112015_2	0,6749	0,0119	0,6103	0,7383



- > Viewport w/o AR coating
- > Was installed at DDC backside (**not laser port**) (11.2014 – 11.2015)



Distributor: MDC vacuum Ltd.
Model: **DN40CF DUV V/P**
(equivalent Suprasil 1)
Code: **VP-DUV-200-C40**
Batch no.: 111362/0
Coated: no
Delivery: no information
Used: probably **not**

> Currently: tested at DDC Z+flange

Summary

- > All available laser windows at PITZ had been analyzed
- > History of most of the 19 windows is unknown
- > 4 of the “bad” windows had been installed in the PITZ injector beam line at different positions for sure (documented);
2 others show signature that indicates use as laser port windows
- > Only 1 window known to be “installed” beforehand shows promising (uniform) transmission: **“Corning 8655 Grade AA”**

Attention: window was only fixed on the top of the injector close to the DDC but not used as laser port!!!



Conclusion

- > **“Corning 8655 Grade AA”** window solution for laser port is promising – further **investigations at DDC as laser viewport** ongoing
- > Earlier installed windows of type **VPZ38QVAR-NM** and **ZVP-DUV-C40-QZ** showed (inhomogeneous) reduction in transmission



they seem to be **not radiation hard**

- > **New test series** ongoing for the three window types:

VPZ38QVAR-NM:	1210850_6 (DDC X- flange),
ZVP-DUV-C40-QZ:	2004283_8 (test holder near Low.V1)
VP-DUV-200-C40:	9722005_10 (DDC Z+ flange)



Thank you for your attention!!!



Measured transmission values (all windows listed)

viewport	average	homogeneity	minValue	maxValue	laser port
102015_1	0,8827	0,0135	0,8233	0,9089	no
102015_2	0,7698	0,0132	0,7427	0,8407	no
102015_3	0,7705	0,0488	0,6830	0,8743	no
112015_1	0,9271	0,0056	0,8994	0,9381	yes
112015_2	0,6749	0,0119	0,6103	0,7383	no
1210850_3	0,5800	0,0138	0,5626	0,6624	no
1210850_6	0,91634	0,0042	0,8979	0,9439	yes
2004283_1	0,7384	0,0053	0,7088	0,7767	no
2004283_2	0,9177	0,0099	0,8450	0,9577	no
2004283_3	0,9057	0,0026	0,8962	0,9398	yes
2004283_4	0,9127	0,0058	0,8683	0,9645	yes
2004283_5	0,9297	0,0045	0,9197	0,9397	yes
2004283_6	0,9048	0,0054	0,8875	0,9230	yes
2004283_7	0,8633	0,0099	0,8182	0,8885	no
2004283_8	0,9334	0,0059	0,9230	0,9609	yes
9722005_10	0,9173	0,0057	0,8981	0,9305	yes
102015_Test	0,9074	0,0052	0,8843	0,9219	yes
022016_1	0,9191	0,0147	0,8661	0,9610	no
022016_2	0,9079	0,0124	0,8541	0,9394	no

**Corning 8655
Grade AA**



VPZ38QVAR-NM



ZVP-DUV-C40-QZ



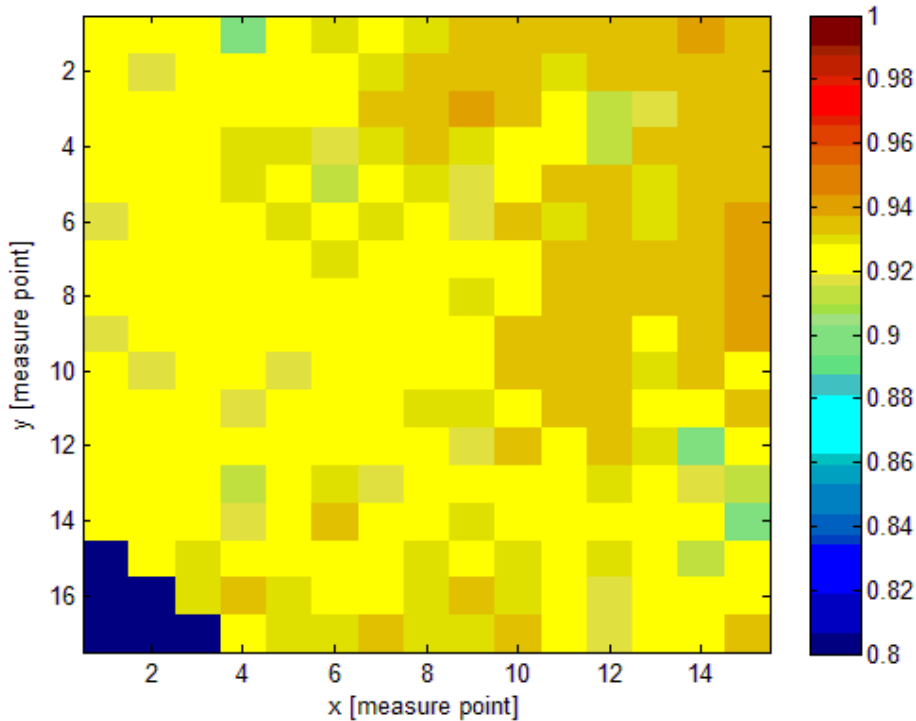
VP-DUV-200-C40



unknown



Viewport 112015_1



Distributor: Corning

Model: Corning 8655 Grade AA

Code:

Batch no.: no information

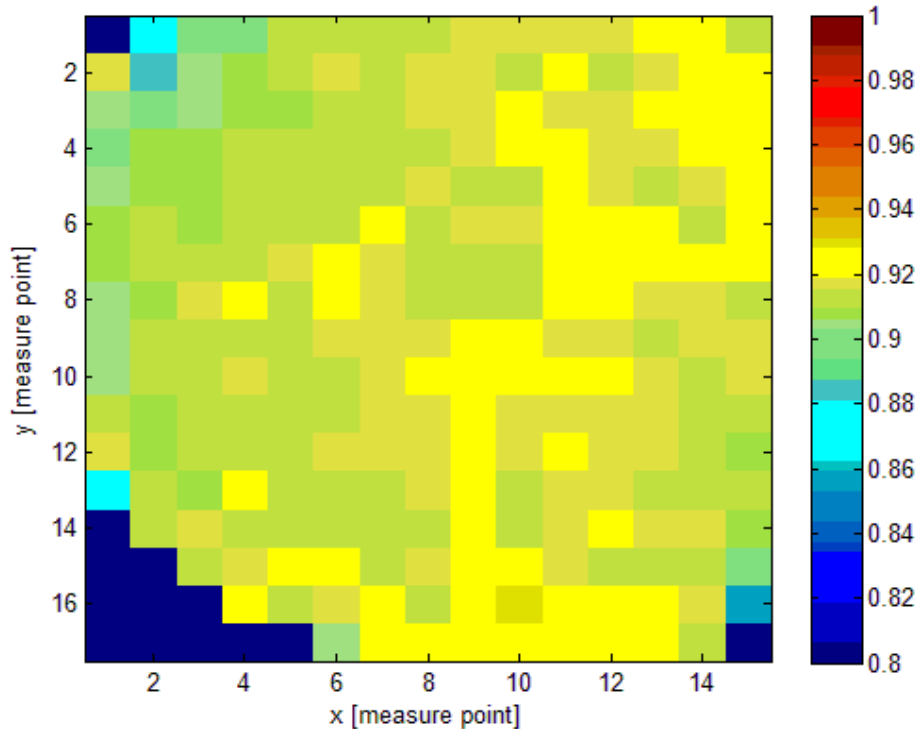
Coated: yes (air side)

Delivery: no information

Used: **see comments below**

Tag: usable as laser window

Viewport 1210850_6



Distributor: MDC vacuum Ltd.

Model: DN40CF Spektrosil
Quartz VP 316LN /
Tantalum

Code: VPZ38QVAR-NM

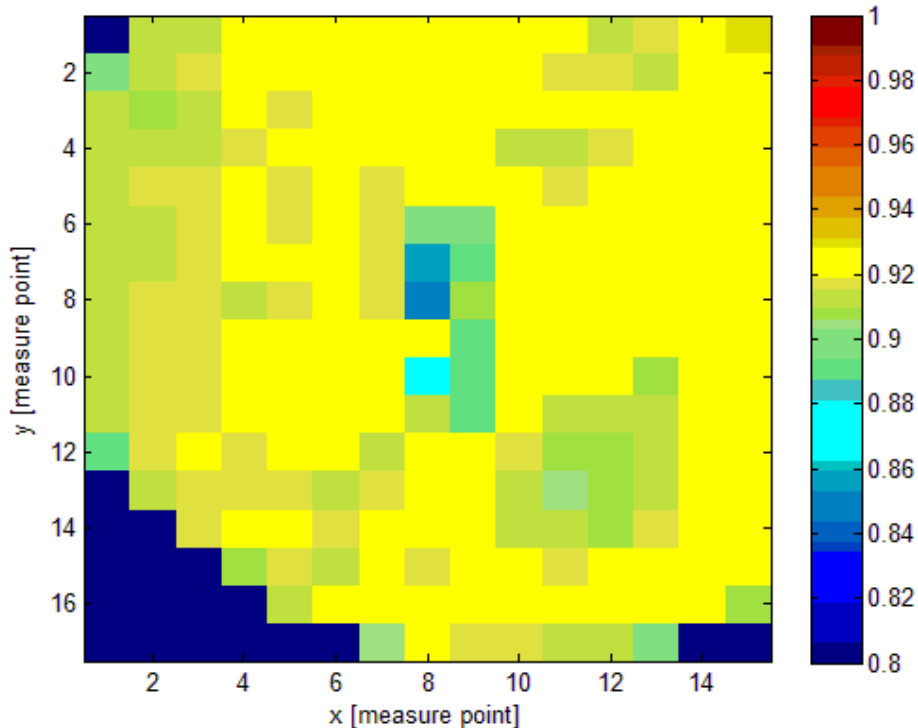
Batch no.: 120918/6

Coated: yes

Delivery: no information

Used: no

Tag: usable as laser window



Distributor: (Caburn?) MDC

Model: DN40CF Quartz V/P

Code: ZVP-DUV-C40-QZ

Batch no.: 74972/1

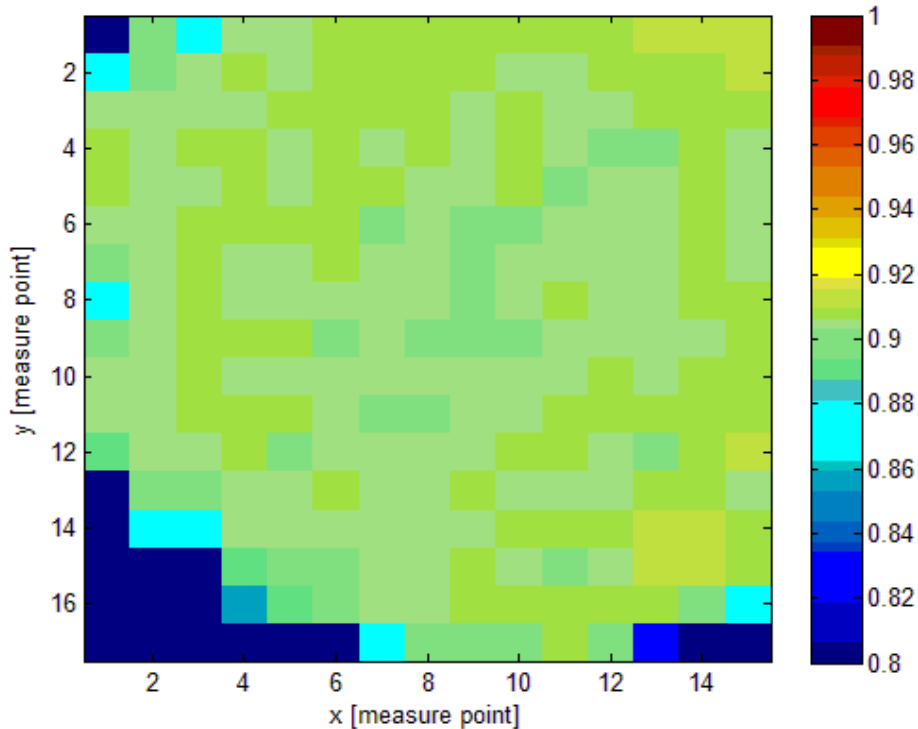
Coated: Yes

Delivery: no information

Used: yes

Tag: no laser window

- > Was installed in former diamond station (~ 2010)
- > Spot in the middle could be due to earlier installation as laser port (lack of information) -> **don't use it as laser port again !!!**



Distributor: Caburn MDC

Model: DN40CF Quartz V/P

Code: ZVP-DUV-C40-QZ

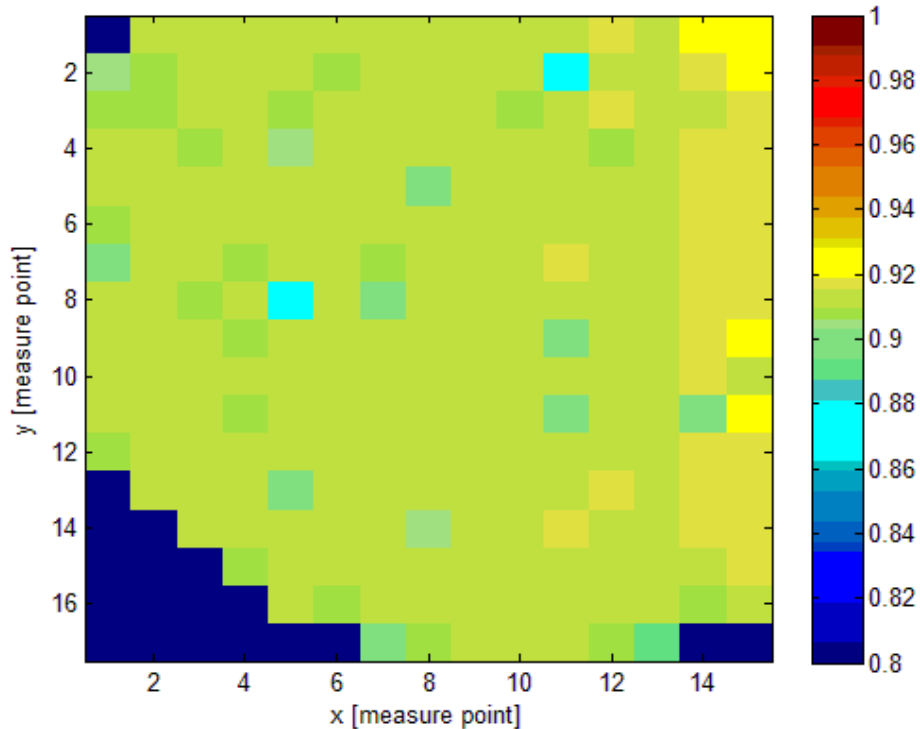
Batch no.: 74972/1

Coated: yes

Delivery: no information

Used: no information

Tag: usable as laser window



Distributor: Caburn MDC

Model: DN40CF Quartz V/P

Code: ZVP-DUV-C40-QZ

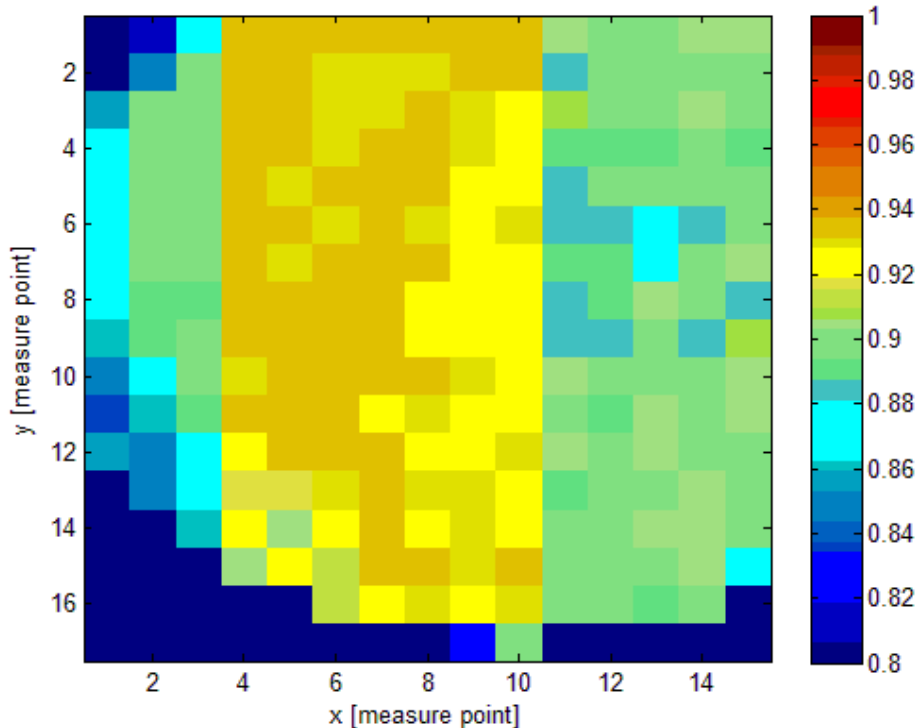
Batch no.: 74972/1

Coated: yes

Delivery: no information

Used: no information

Tag: usable as laser window



Distributor: Caburn MDC

Model: DN40CF Quartz V/P

Code: ZVP-DUV-C40-QZ

Batch no.: 75076/1

Coated: yes

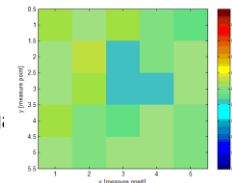
Delivery: no information

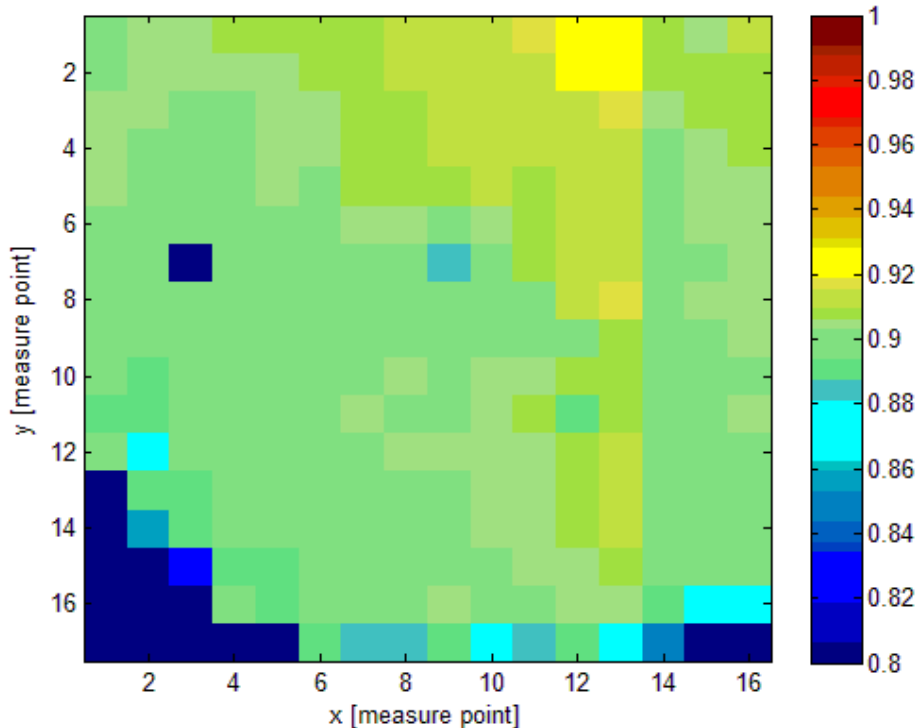
Used: no information

Tag: usable as laser window

Attention: different measure procedure without instantaneous calibration

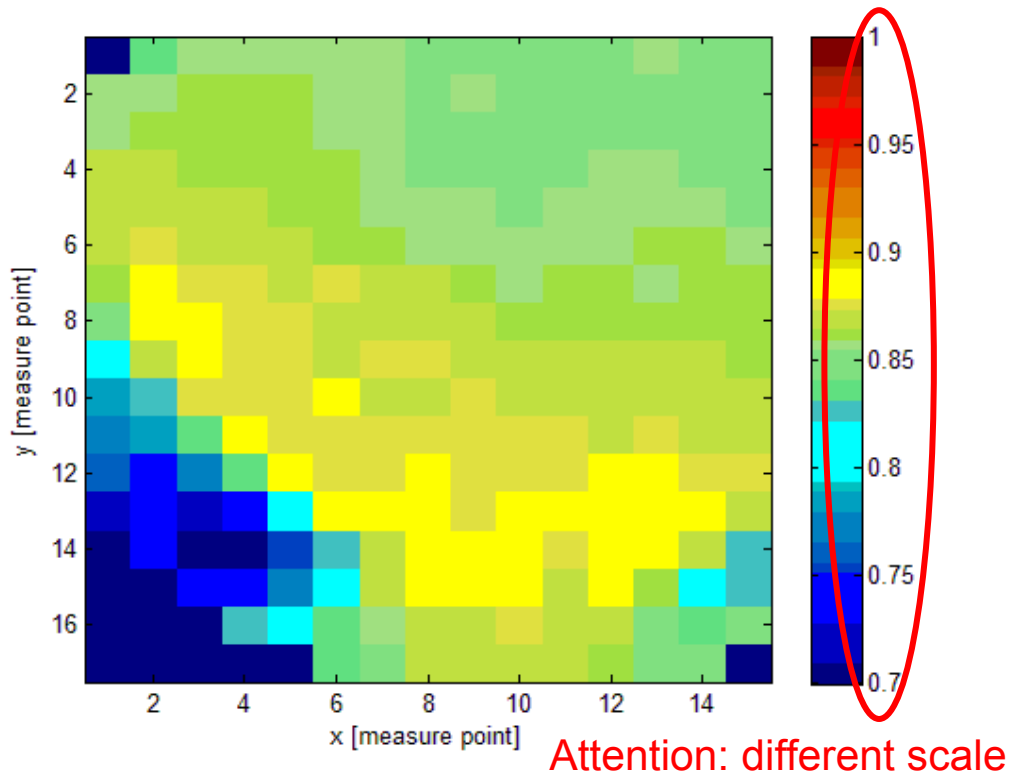
- > at ~15 mm (y-axis) the transmission changes significantly by ~ 3 %
=> there had been a break during the measurement (PITZ seminar)
- > check of transmission (25 points in step of 4 mm in x and y) showed homogeneity of about **90.1 % +/- 0.8 %**





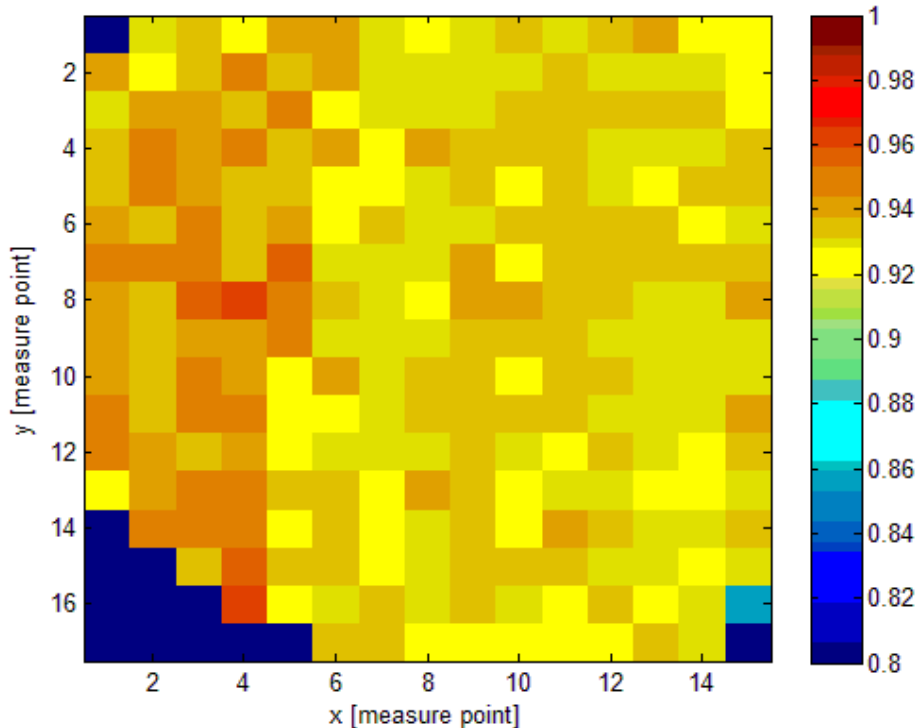
Distributor: MDC vacuum Ltd.
Model: DN40CF Quartz V/P
Code: ZVP-DUV-C40-QZ
Batch no.: 13098/1
Coated: yes
Delivery: no information
Used: no information
Tag: pot. laser window

- > Engraving: “4679”;”316LN M8475R”
- > no measure data for $x=3, y=7$



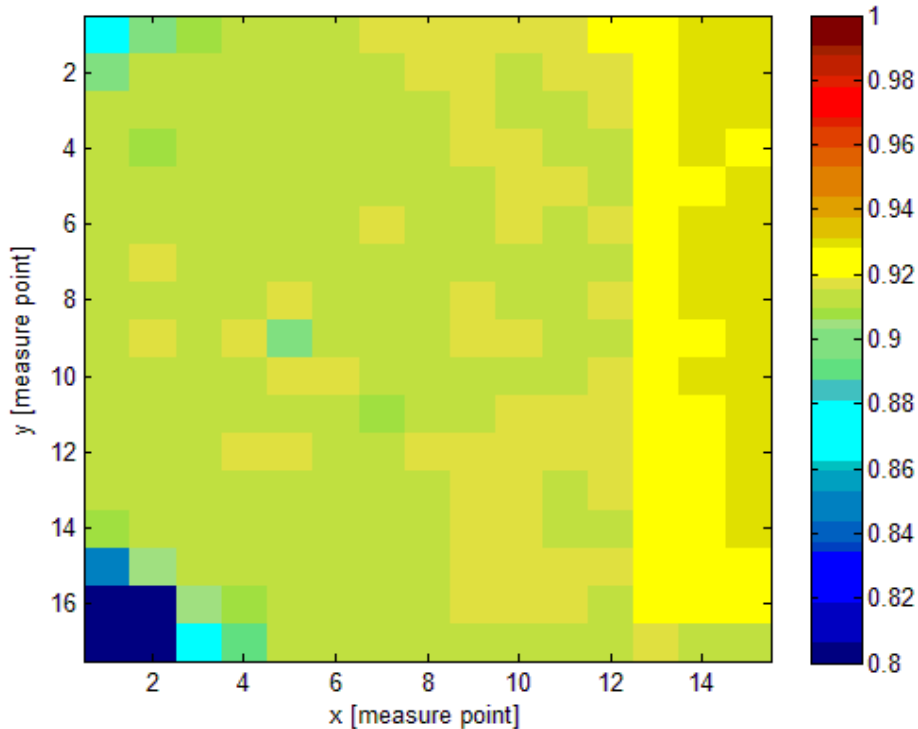
Distributor: MDC vacuum Ltd.
Model: DN40CF Quartz V/P
Code: ZVP-DUV-C40-QZ
Batch no.: 13098/1
Coated: yes
Delivery: no information
Used: most likely (due to transmission behavior)
Tag: no laser window

- > Engraving: “4681”;”316LN M8475R”
- > Measured transmission values in lower left region is real behavior performance



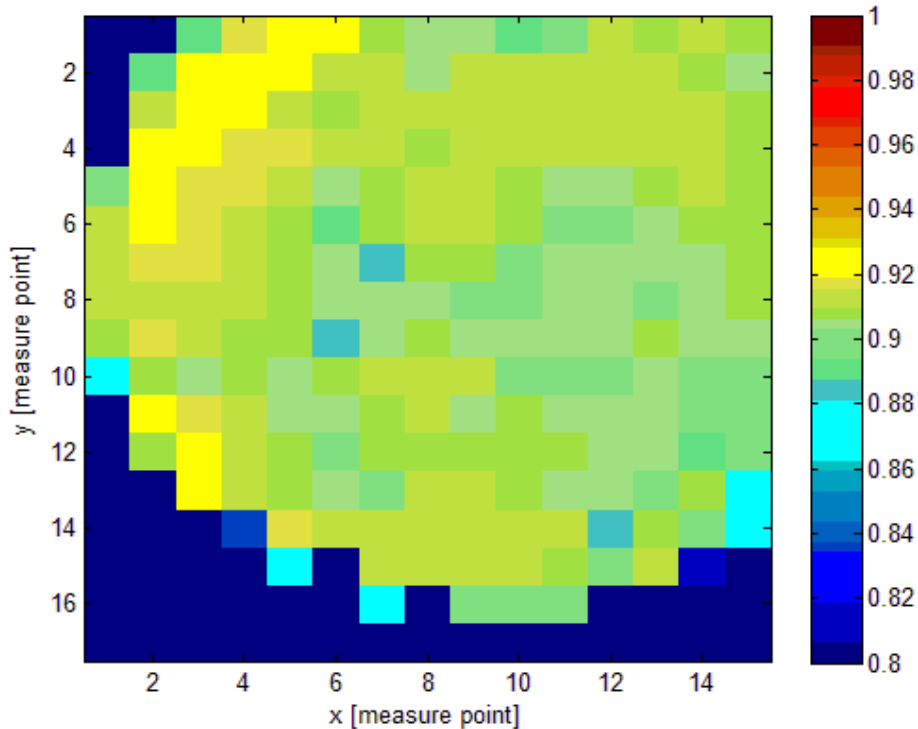
Distributor: MDC vacuum Ltd.
Model: DN40CF Quartz V/P
Code: ZVP-DUV-C40-QZ
Batch no.: 13098/1
Coated: yes
Delivery: no information
Used: no information
Tag: no laser window

> Engraving: “4674”;”316LN M8475R”



Distributor: MDC vacuum Ltd.
Model: DN40CF DUV V/P
Code: VP-DUV-200-C40
Batch no.: 111362/0
Coated: no
Delivery: no information
Used: no information
Tag: usable as laser window

Viewport 102015_Test

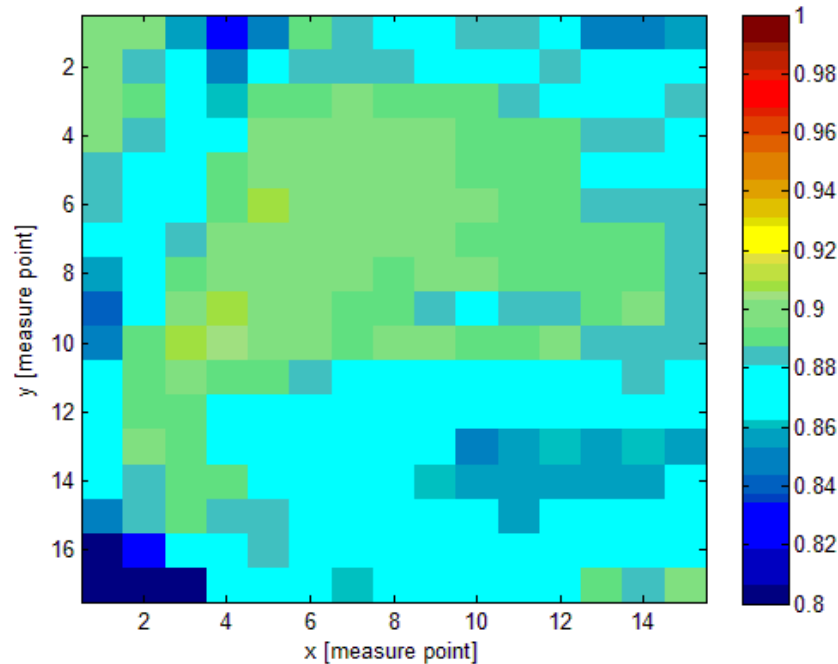


Distributor: MDC vacuum Ltd.
Model: no information
Code: no information
Batch no.: no information
Coated: no
Delivery: no information
Used: no information
Tag: usable as laser window



Transmission of preselected rejected windows

window	average	homogeneity	minValue	maxValue
102015_1	0,8827	0,0135	0,8233	0,9089

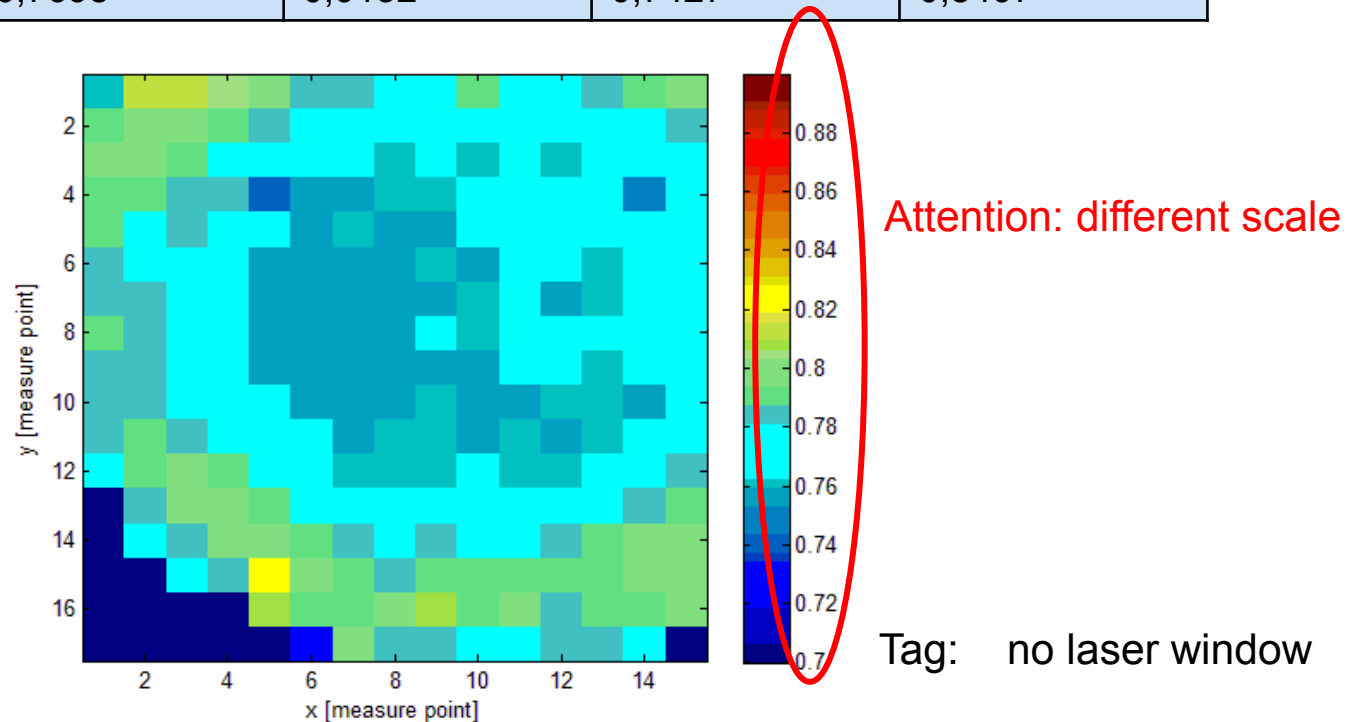


Tag: no laser window

> Distributor: ?, window type unknown, AR coating: no

Transmission of preselected rejected windows

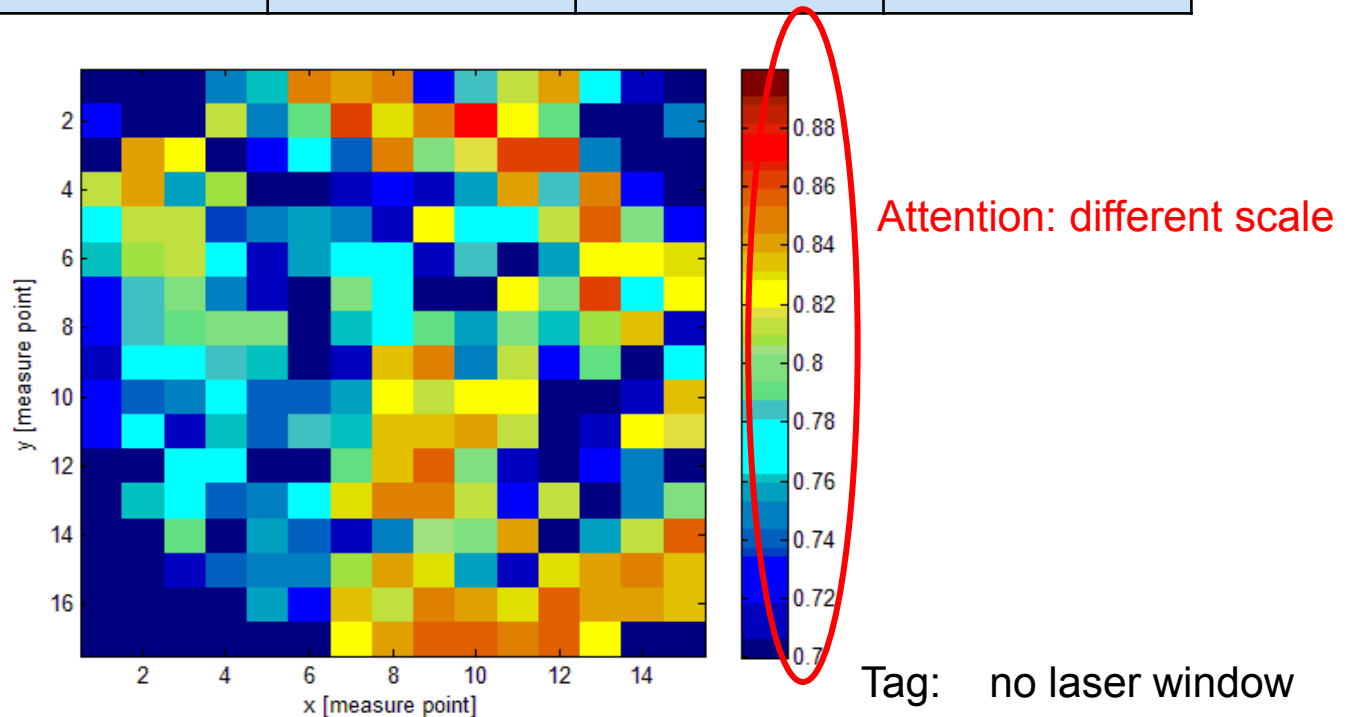
window	average	homogeneity	minValue	maxValue
102015_2	0,7698	0,0132	0,7427	0,8407



- > Distributor: allectra, window type unknown, AR coating: yes
- > Installed at DDC Laserport (11.2011 – 08.2013)

Transmission of preselected rejected windows

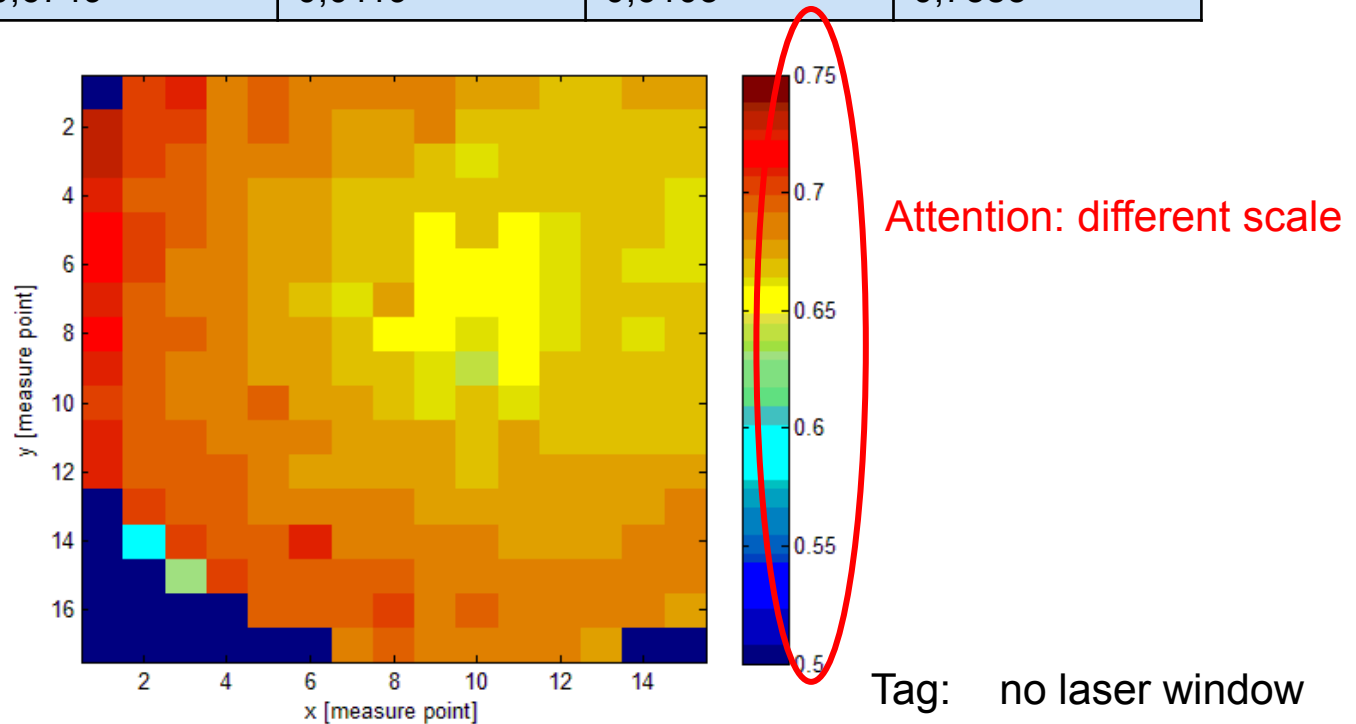
window	average	homogeneity	minValue	maxValue
102015_3	0,7705	0,0488	0,6830	0,8743



- > Distributor: allectra, window type unknown, AR coating: yes
- > Entire surface scratched mechanically

Transmission of preselected rejected windows

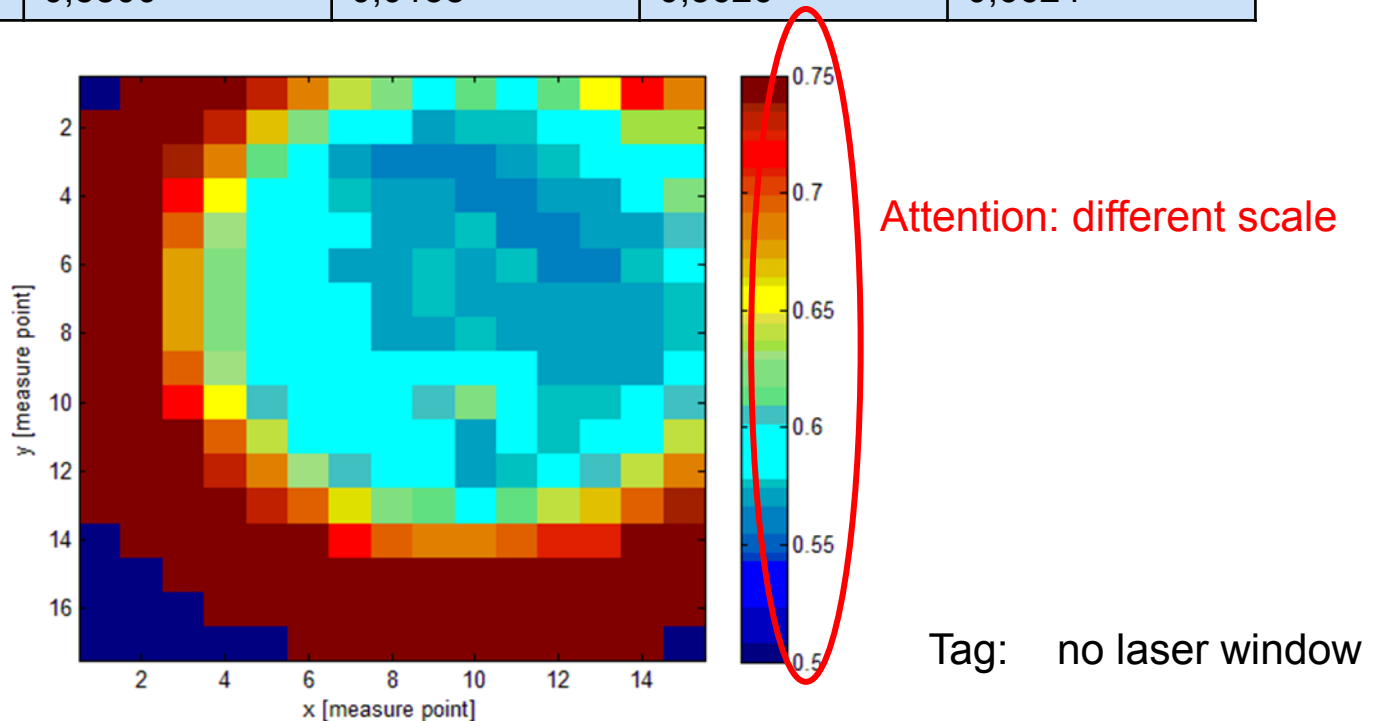
window	average	homogeneity	minValue	maxValue
112015_2	0,6749	0,0119	0,6103	0,7383



- > Distributor: MDC, ZVP-DUV-C40-QZ V/P w/o AR coating
- > 112015_2 installed at DDC backside (not Laserport) (11.2014 – 11.2015)

Transmission of preselected rejected windows

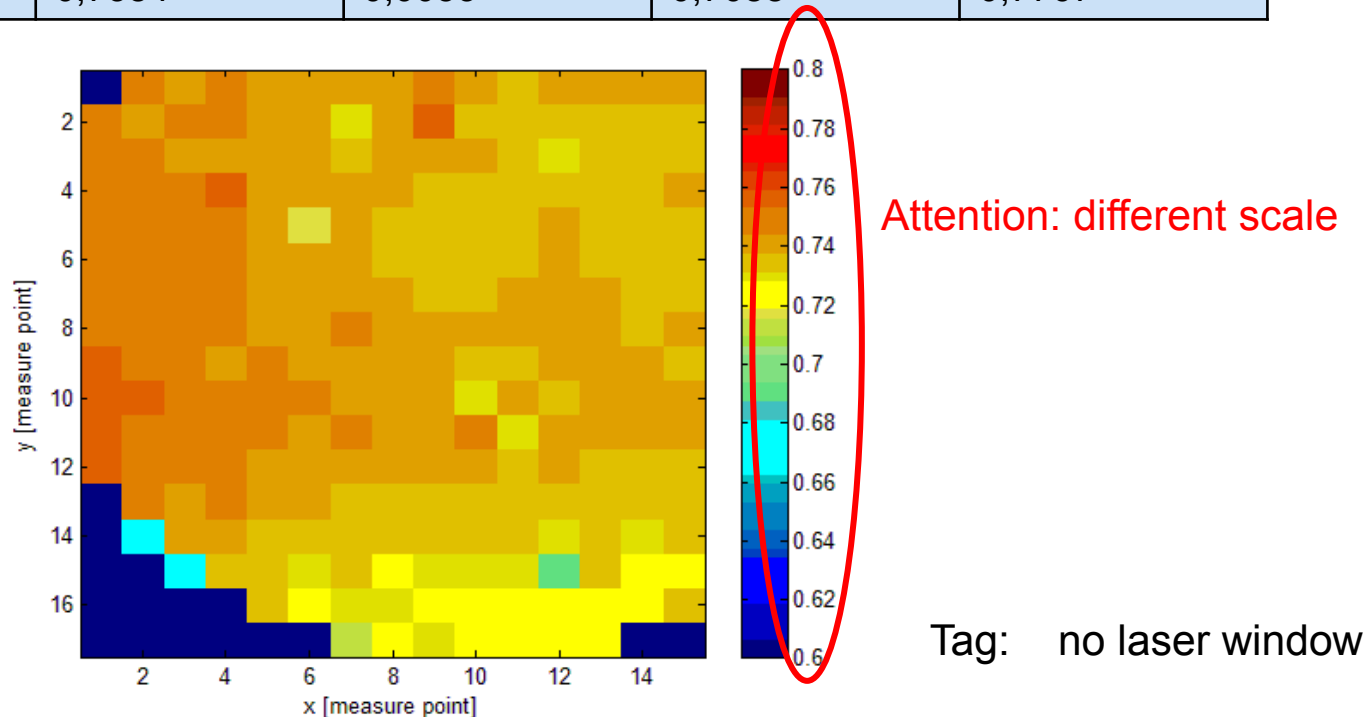
window	average	homogeneity	minValue	maxValue
1210850_3	0,5800	0,0138	0,5626	0,6624



- > Distributor: MDC, VPZ38QVAR-NM with AR coating
- > Installed at DDC laser port (11.2014 – 11.2015)

Transmission of preselected rejected windows

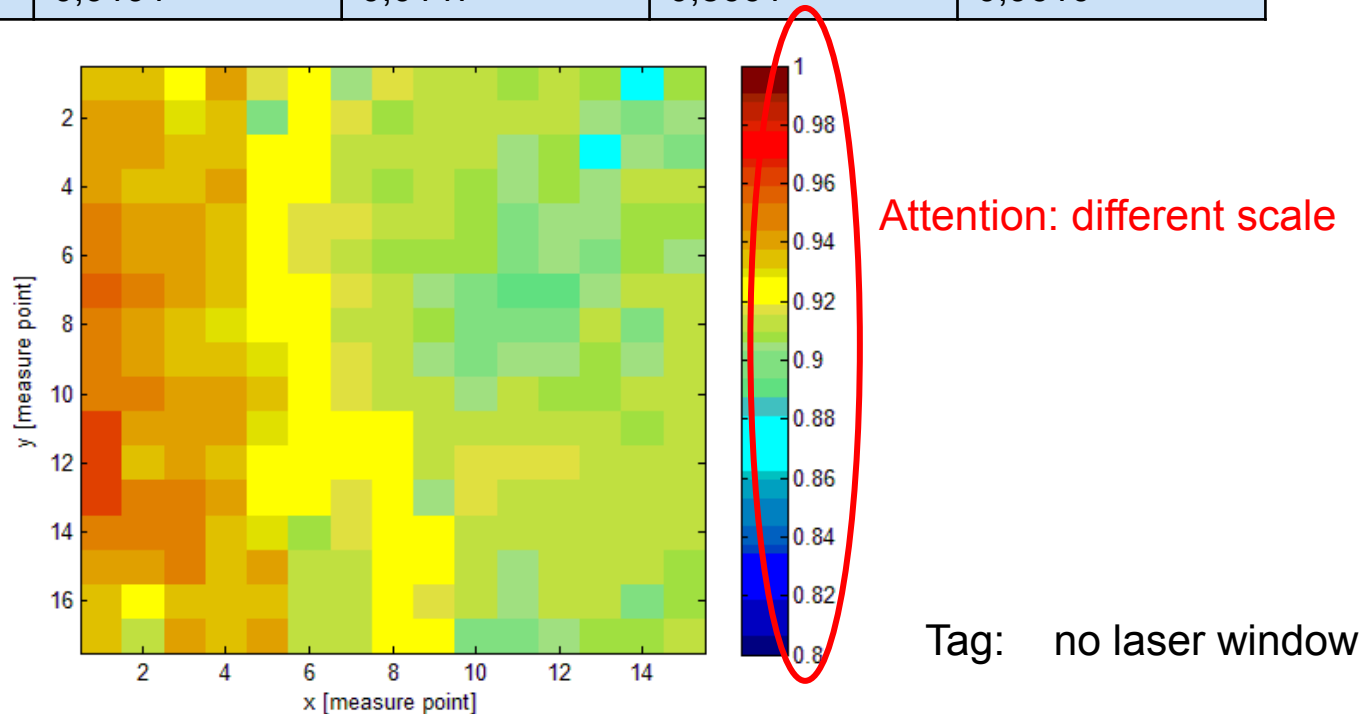
window	average	homogeneity	minValue	maxValue
2004283_1	0,7384	0,0053	0,7088	0,7767



- > Distributor: MDC, ZVP-DUV-C40-QZ V/P w/o AR coating
- > Installed at DDC (not Laserport): 18.06.2008 - 18.11.2011

Transmission of preselected rejected windows

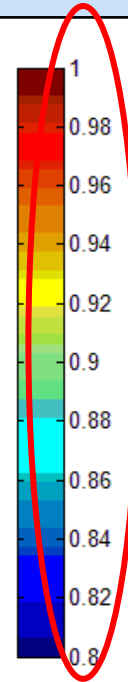
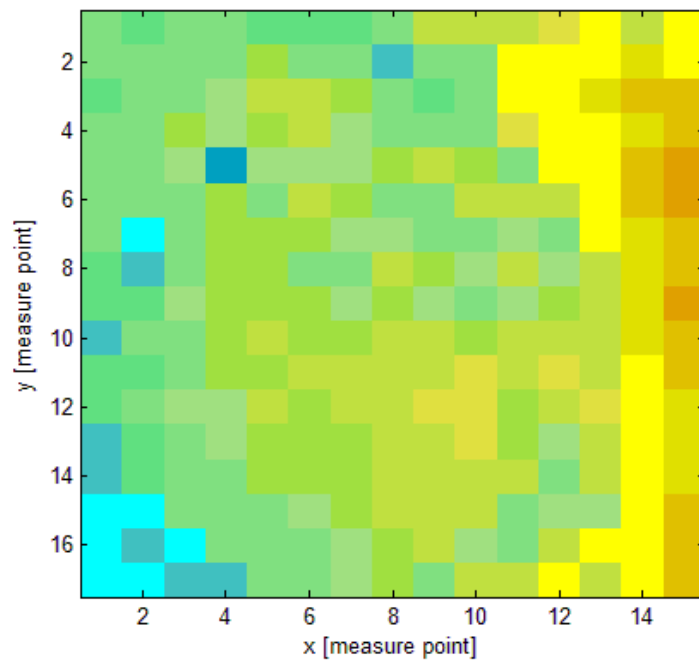
window	average	homogeneity	minValue	maxValue
022016_1	0,9191	0,0147	0,8661	0,9610



- > Distributor: MDC, Model: unknown, AR coating: most likely
- > No information about installation

Transmission of preselected rejected windows

window	average	homogeneity	minValue	maxValue
022016_2	0,9079	0,0124	0,8541	0,9394



Attention: scale equal to 022016_1

Tag: no laser window

- > Distributor: MDC, Model: unknown, AR coating: most likely
- > No information about installation