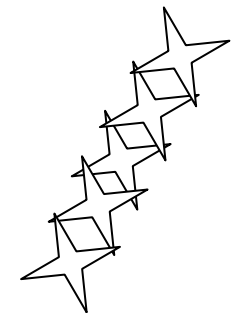
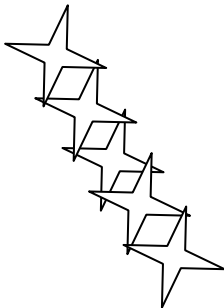


# SpotOptics 5STAR

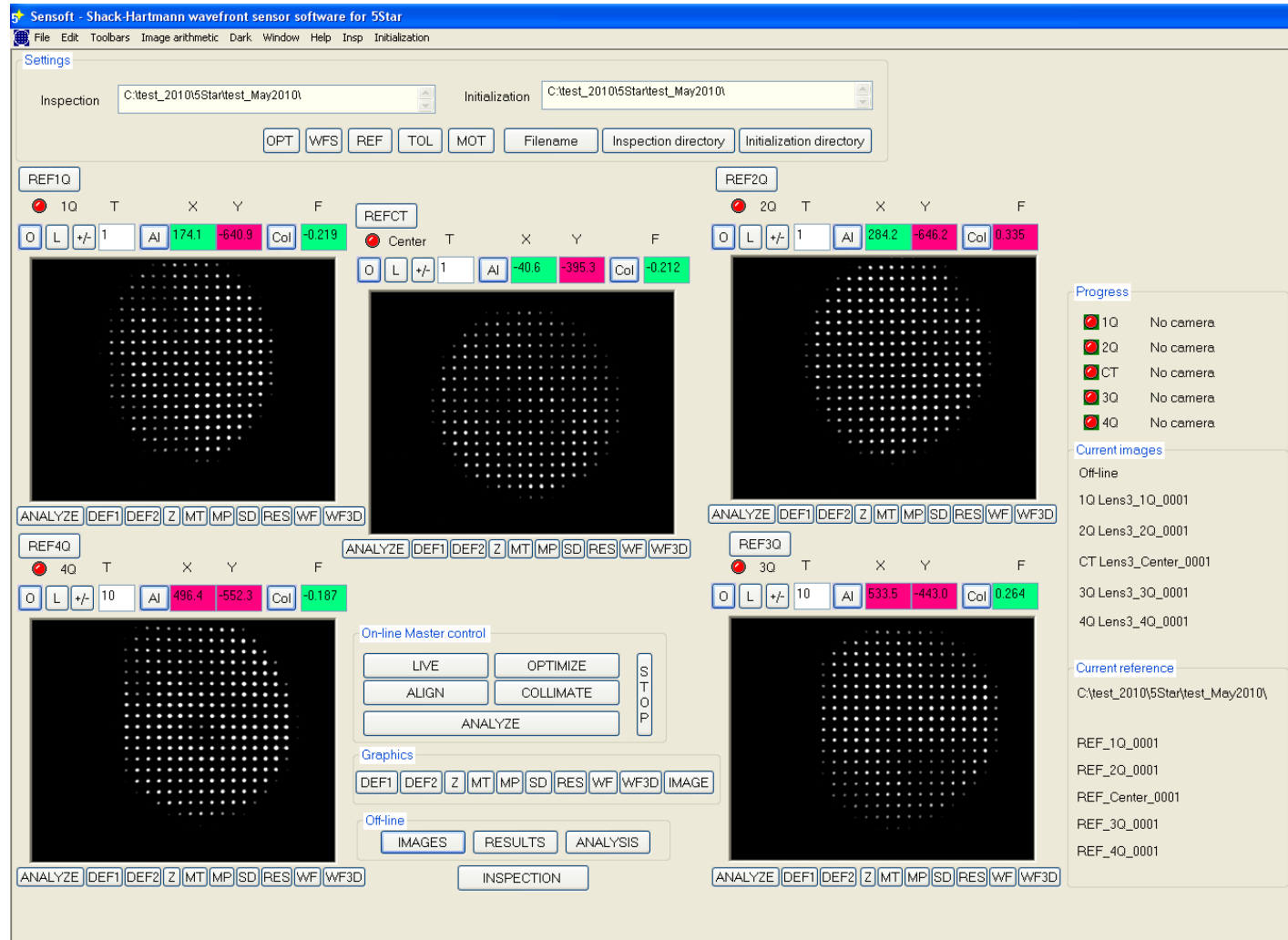
The superior class  
instrument and software



On-axis and off-axis test  
in one single shot



- 5 cameras: 1 on-axis and 4 off-axis, 5 Live Shack-Hartmann images
- On-line optimization of exposure time for 1 to 5 images
- Simultaneous on-line alignment and collimation



# On-line and off-line analysis for 1 to 5 images (simultaneously)

## Sensoft output results: Zernike coefficients

Sensoft - Shack-Hartmann wavefront sensor software for 5Star

File Edit Toolbars Image arithmetic Dark Window Help Insp Initialization

Settings

Inspection: C:\test\_2010\5Star\test\_May2010\ Initialization: C:\test\_2010\5Star\test\_May2010\

OPT WFS REF TOL MOT Filename Inspection directory Initialization directory

**REF1Q**

1Q T X Y F

O L +/- 1 AI 174.1 -640.9 Col -0.219

Aber	C(nm)	Angle	Aber	C(nm)	Angle
Def	-282.4		Tilt	4207.1	-141.1
Coma	58.1	-126.3	SA3	16.2	
Ast3	297.2	-82.1	TCom	66.3	-3.1
QAst	5.7	16.7			
D50	D80	PV	Rms		
98.7	163.3	1289.2	322.8		

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

**REF2Q**

2Q T X Y F

O L +/- 1 AI 284.2 -646.2 Col 0.335

Aber	C(nm)	Angle	Aber	C(nm)	Angle
Def	-125.0		Tilt	4870.6	-14.8
Coma	13.8	22.7	SA3	8.2	
Ast3	150.9	-65.7	TCom	80.3	5.5
QAst	7.2	-2.6			
D50	D80	PV	Rms		
53.3	92.2	805.6	174.5		

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

**REF4Q**

4Q T X Y F

O L +/- 10 AI 496.4 -552.3 Col -0.187

Aber	C(nm)	Angle	Aber	C(nm)	Angle
Def	-279.5		Tilt	2569.3	86.7
Coma	70.7	142.6	SA3	20.9	
Ast3	214.3	78.8	TCom	64.8	-1.3
QAst	7.5	-35.2			
D50	D80	PV	Rms		
98.6	146.3	1241.0	291.3		

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

**REF3Q**

3Q T X Y F

O L +/- 10 AI 533.5 -443.0 Col 0.264

Aber	C(nm)	Angle	Aber	C(nm)	Angle
Def	-108.6		Tilt	1039.3	126.9
Coma	62.2	119.2	SA3	8.4	
Ast3	26.6	18.0	TCom	75.4	-6.9
QAst	2.5	-11.2			
D50	D80	PV	Rms		
46.3	82.6	581.2	129.1		

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

**On-line Master control**

LIVE OPTIMIZE STOP

ALIGN COLLIMATE

ANALYZE

**Graphics**

DEF1 DEF2 Z MT MP SD RES WF WF3D IMAGE

**Off-line**

IMAGES RESULTS ANALYSIS

INSPECTION

**Progress**

- 1Q No camera
- 2Q No camera
- CT No camera
- 3Q No camera
- 4Q No camera

**Current images**

Off-line

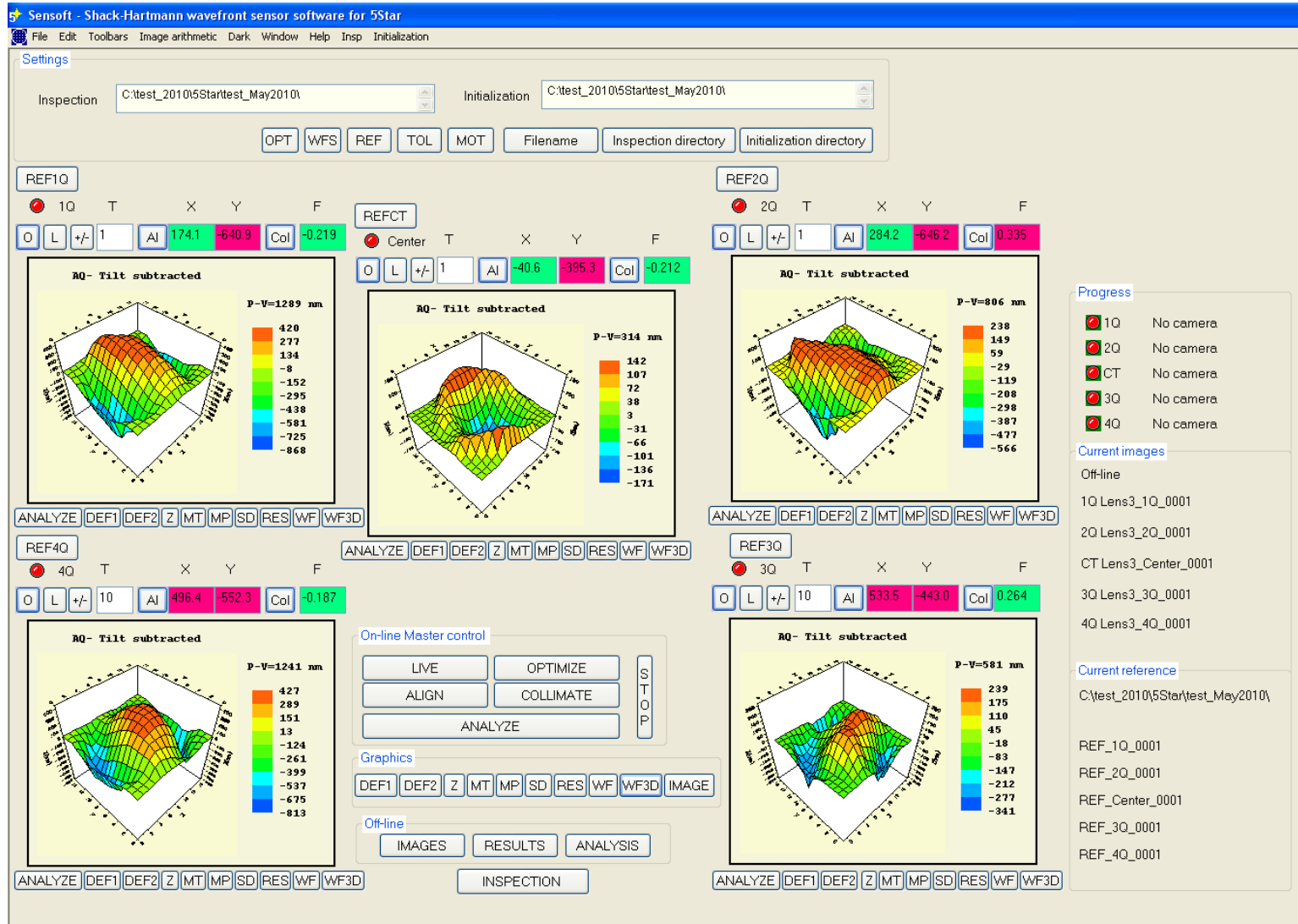
- 1Q Lens3\_1Q\_0001
- 2Q Lens3\_2Q\_0001
- CT Lens3\_Center\_0001
- 3Q Lens3\_3Q\_0001
- 4Q Lens3\_4Q\_0001

**Current reference**

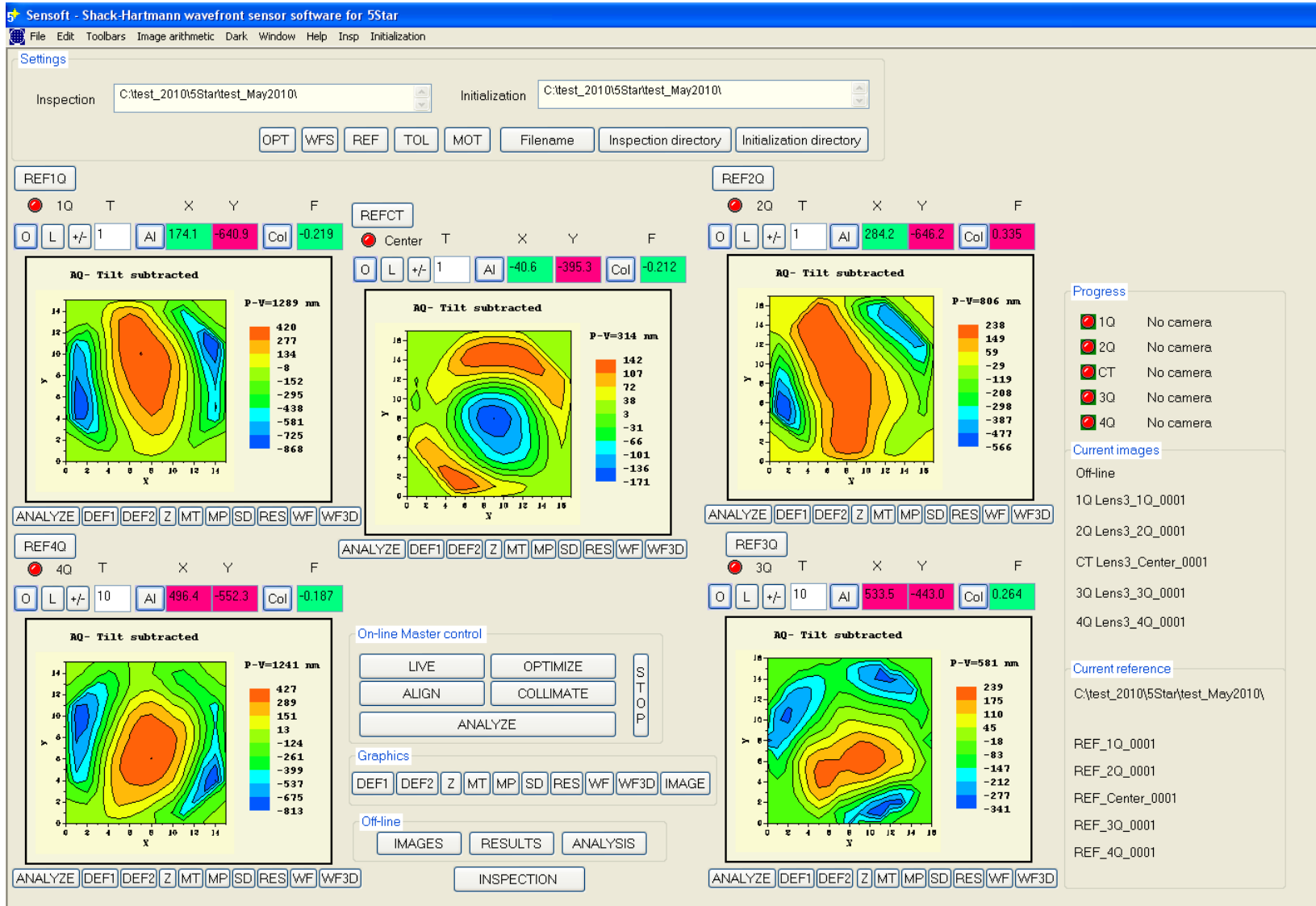
C:\test\_2010\5Star\test\_May2010\

- REF\_1Q\_0001
- REF\_2Q\_0001
- REF\_Center\_0001
- REF\_3Q\_0001
- REF\_4Q\_0001

# Sensoft output results: 3D of wavefront



# Sensoft output results: contour of wavefront



# Sensoft output results: spot diagram

Sensoft - Shack-Hartmann wavefront sensor software for 5Star

File Edit Toolbars Image arithmetic Dark Window Help Insp Initialization

Settings

Inspection: C:\test\_2010\5Star\test\_May2010\ Initialization: C:\test\_2010\5Star\test\_May2010\

OPT WFS REF TOL MOT Filename Inspection directory Initialization directory

REF1Q

1Q T X Y F

O L +/- 1 AI 174.1 -640.9 Col -0.219

REFCT

Center T X Y F

O L +/- 1 AI -40.6 -395.3 Col -0.212

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

REF2Q

2Q T X Y F

O L +/- 1 AI 284.2 -646.2 Col 0.335

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

REF4Q

4Q T X Y F

O L +/- 10 AI 496.4 -552.3 Col -0.187

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

REF3Q

3Q T X Y F

O L +/- 10 AI 533.5 -443.0 Col 0.264

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

On-line Master control

LIVE OPTIMIZE STOP

ALIGN COLLIMATE

ANALYZE

Graphics

DEF1 DEF2 Z MT MP SD RES WF WF3D IMAGE

Off-line

IMAGES RESULTS ANALYSIS

INSPECTION

Progress

- 1Q No camera
- 2Q No camera
- CT No camera
- 3Q No camera
- 4Q No camera

Current images

Off-line

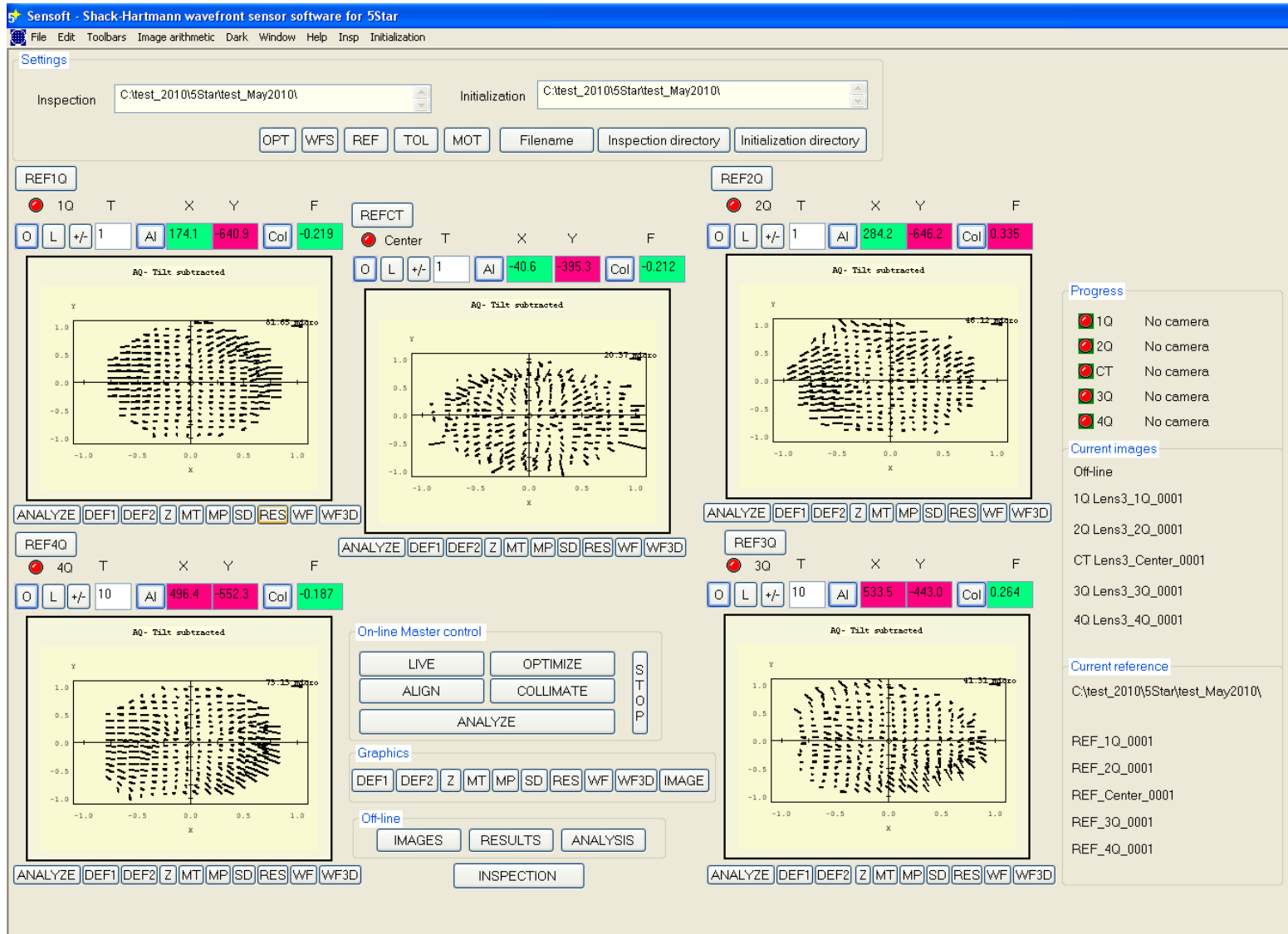
- 1Q Lens3\_1Q\_0001
- 2Q Lens3\_2Q\_0001
- CT Lens3\_Center\_0001
- 3Q Lens3\_3Q\_0001
- 4Q Lens3\_4Q\_0001

Current reference

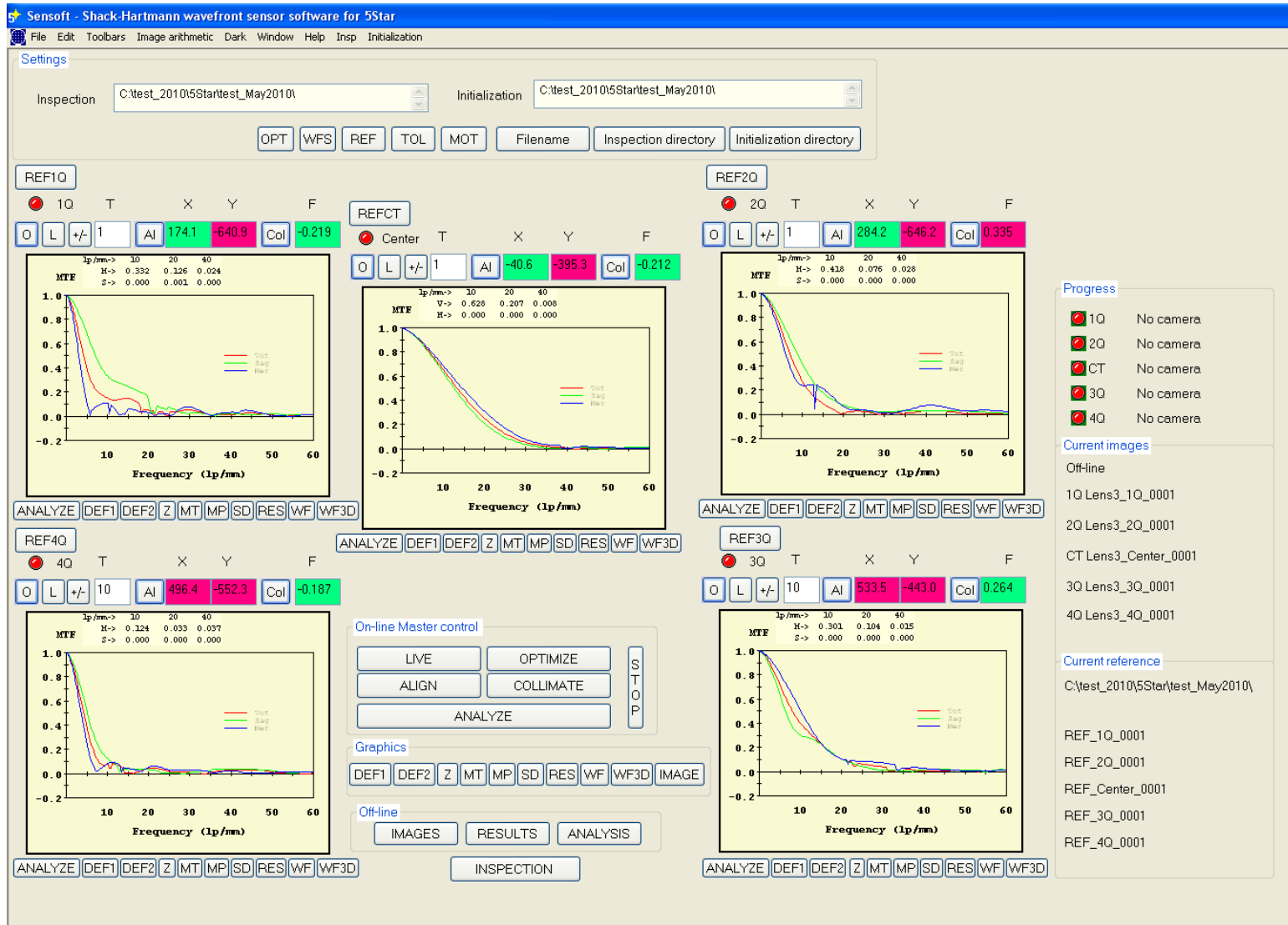
C:\test\_2010\5Star\test\_May2010\

- REF\_1Q\_0001
- REF\_2Q\_0001
- REF\_Center\_0001
- REF\_3Q\_0001
- REF\_4Q\_0001

# Sensoft output results: distribution of residuals over the pupil



# Sensoft output results: Mtf from Shack-Hartmann analysis





# Sensoft output results: any combination of graphics is allowed

Sensoft - Shack-Hartmann wavefront sensor software for 5Star

File Edit Toolbars Image arithmetic Dark Window Help Insp Initialization

Settings

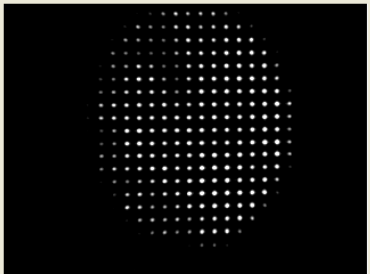
Inspection: C:\test\_2010\5Star\test\_May2010\ Initialization: C:\test\_2010\5Star\test\_May2010\

OPT WFS REF TOL MOT Filename Inspection directory Initialization directory

REF1Q

1Q T X Y F

O L +/- 1 AI 174.1 -640.9 Col -0.219



REFCT

Center T X Y F

O L +/- 1 AI -40.6 -395.3 Col -0.212

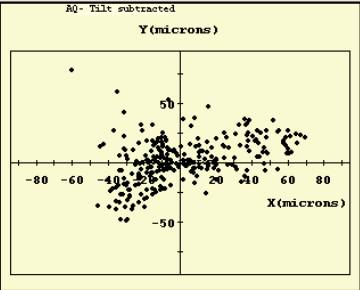
Aber	C(nm)	Angle	Aber	C(nm)	Angle
Def	48.3		Tilt	4151.7	168.6
Coma	42.1	-73.6	SA3	-29.2	
Ast3	28.2	53.4	TCom	9.5	0.6
QAst	3.6	6.9			
D50	D80	PV	Rms		
28.1	40.7	314.2	74.4		

ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

REF2Q

2Q T X Y F

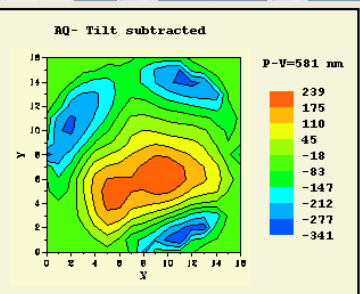
O L +/- 1 AI 284.2 -646.2 Col 0.335



REF3Q

3Q T X Y F

O L +/- 10 AI 533.5 -443.0 Col 0.264

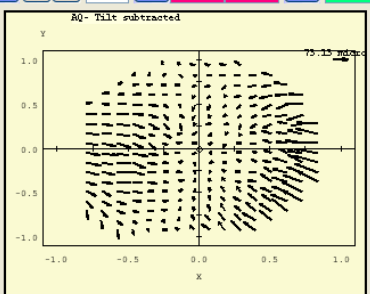


ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

REF4Q

4Q T X Y F

O L +/- 10 AI 496.4 -552.3 Col -0.187



ANALYZE DEF1 DEF2 Z MT MP SD RES WF WF3D

On-line Master control

LIVE OPTIMIZE

ALIGN COLLIMATE

ANALYZE

Graphics

DEF1 DEF2 Z MT MP SD RES WF WF3D IMAGE

Off-line

IMAGES RESULTS ANALYSIS

INSPECTION

Progress

- 1Q No camera
- 2Q No camera
- CT No camera
- 3Q No camera
- 4Q No camera

Current images

Off-line

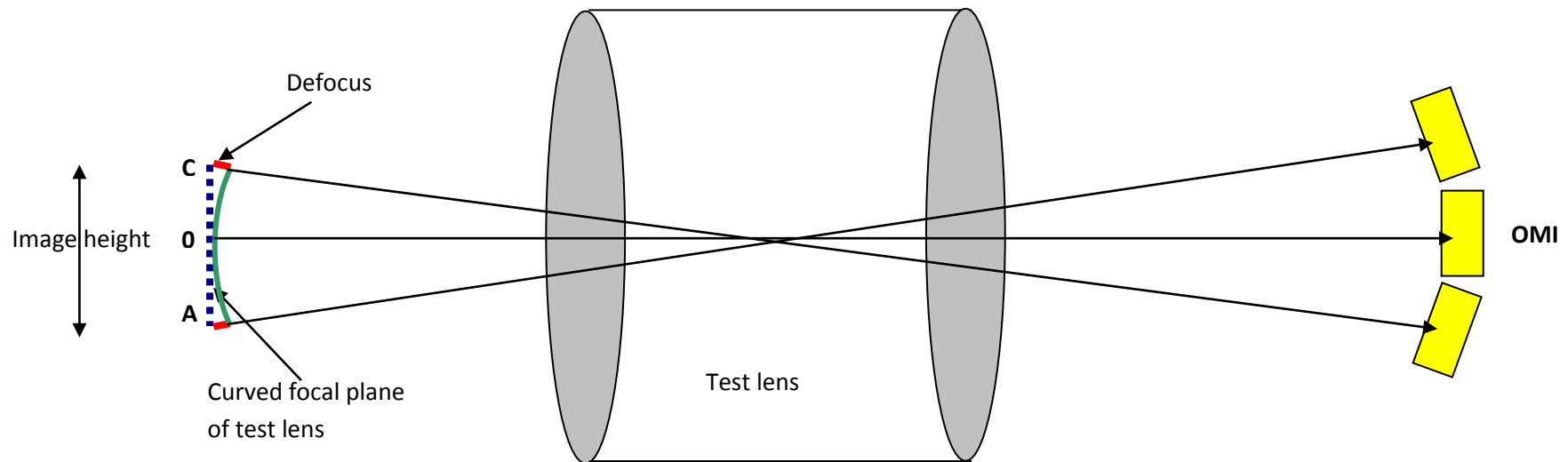
- 1Q Lens3\_1Q\_0001
- 2Q Lens3\_2Q\_0001
- CT Lens3\_Center\_0001
- 3Q Lens3\_3Q\_0001
- 4Q Lens3\_4Q\_0001

Current reference

C:\test\_2010\5Star\test\_May2010\

- REF\_1Q\_0001
- REF\_2Q\_0001
- REF\_Center\_0001
- REF\_3Q\_0001
- REF\_4Q\_0001

## Measurement of image plane curvature without scanning



The ideal image plane of the test lens is flat (shown by dotted blue line), while the real image plane is shown by the green line.

The real image plane is defined as the locus of points that have the best focus at that off-axis angle.

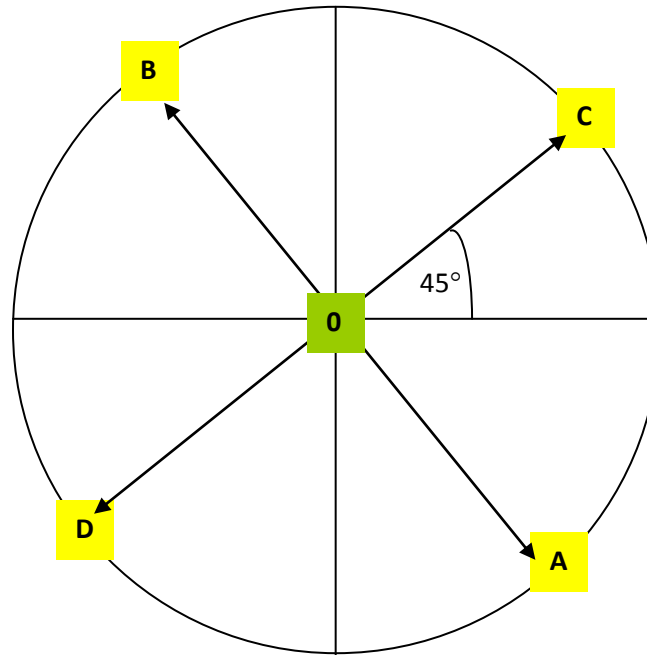
The deviation of the green line from the red blue line at off-axis points A and C is a measure of optical quality,. It is shown by the short red lines.

In the standard method, the best focus is found by mechanical scanning to measure the MTF. However, this takes time. Moreover, the MTF measurement system occupies considerable space, which is expensive in the production line.

5\* is very compact. A compact instrument means more production units can be mounted.

In 5Star, pinholes are placed at 5 (or more) positions in the focal plane: thus the light emerging from the lens is parallel and falls on the OMI wavefront sensor. The figure above shows 3 of the positions (A, O, C) while the figure below shows all 5. The software makes a full Zernike analysis and mathematically computes the best focus. No scanning is involved.

The measurement time is less than 1 second, thereby increasing productivity.



The 5 pinhole positions in the focal plane of the test lens where the measurements are made. More positions can be used if required

# Comparison with real measurements

