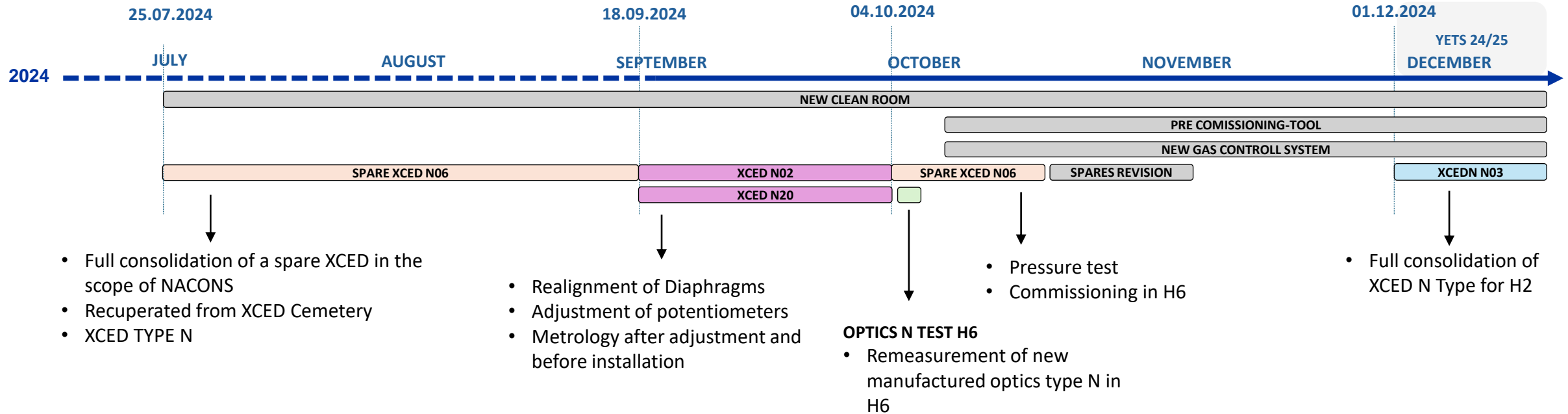
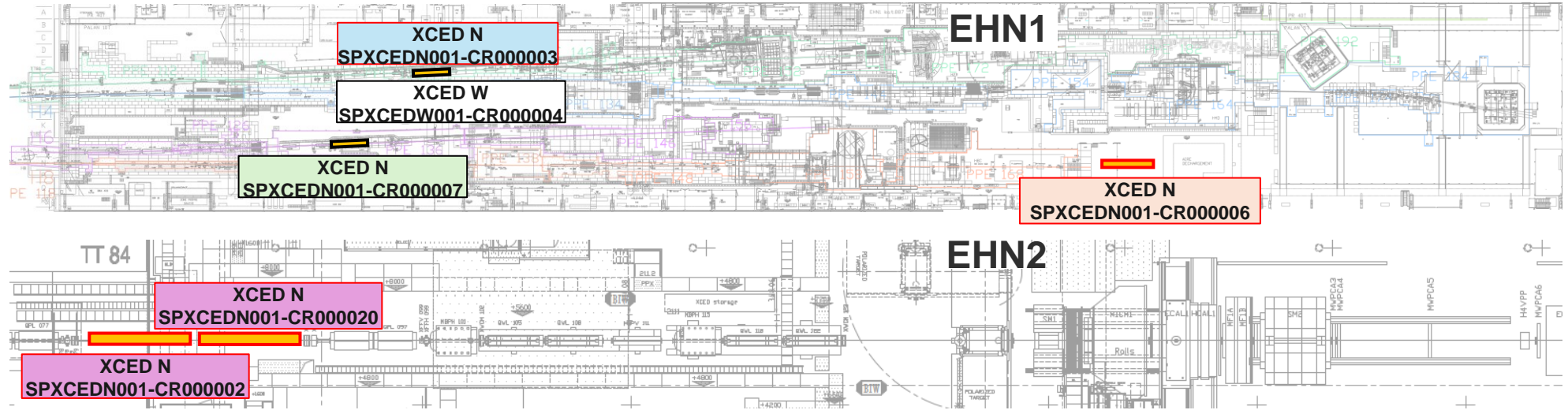


2024 ACTIVITIES SUMMARY & XCED DIAPHRAGM ALIGNMENT

M. Santos et. all - BE-EA

CEDAR

ACTIVITIES 2024



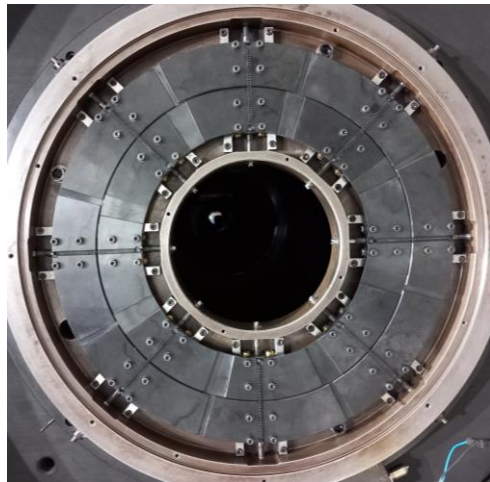
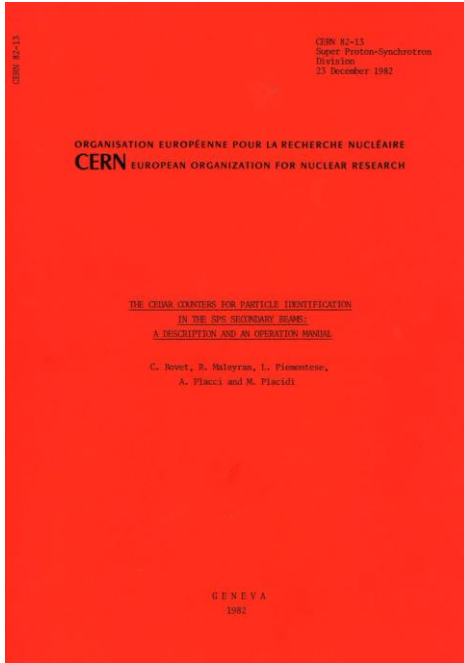
CEDAR DIAPHRAGM

DIAPHRAGM 1980s SPECIFICATIONS

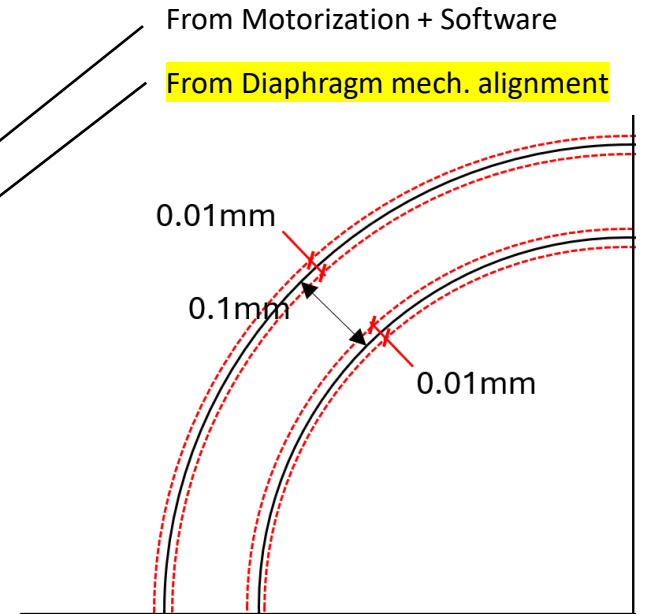
According to 1982 operation manual for the Cedars

“In practice the variable annular opening can be set as small as 0.1+/-0.01mm but it is a difficult optical problem to focus the light into such a sharp ring image”

“The opening can be varied between 0.03mm and 20 mm, in steps of 0.01mm, with a motor located externally to the vessel. A final check of the circularity of the aperture performed on an optical turntable shows radial deviations of less than 0.02mm.”



Azimuthal opening	8 x 42.6°
Radial opening	0 to 20 mm
Opening accuracy	0.1 (+/-0.01) mm
Aperture / radial deviations	< 0.02 mm
Min./Max. usable aperture	0.1 mm to 20 mm



Min. Aperture scheme
Not to scale

Note: Errors can be non symmetric but in total always bellow 0.02 mm

	TOLERANCE mm
	BASELINE VALUES
Outer Circle Circularity	0.01
Inner Circle Circularity	0.01
Gap Profile	0.02

CEDAR DIAPHRAGM

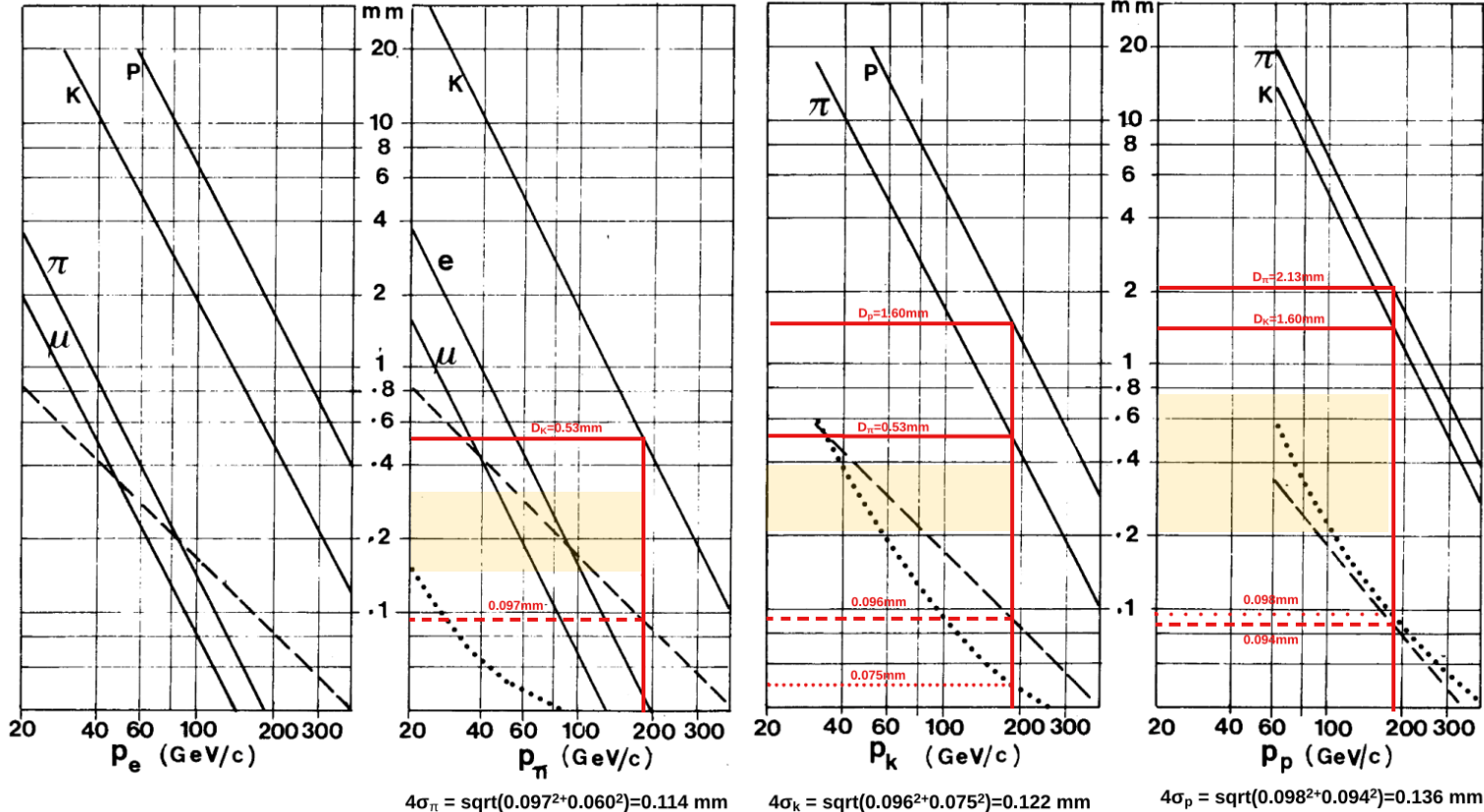
AMBER DIAPHRAGM APPERTURE REQUIREMENTS

For the current and future experiments AMBER requires to tag kaons at 190 GeV/c that the diaphragm is set more than the light ring and multiple scattering and less than the pion ring, so **between 200 μm and 400 μm** .

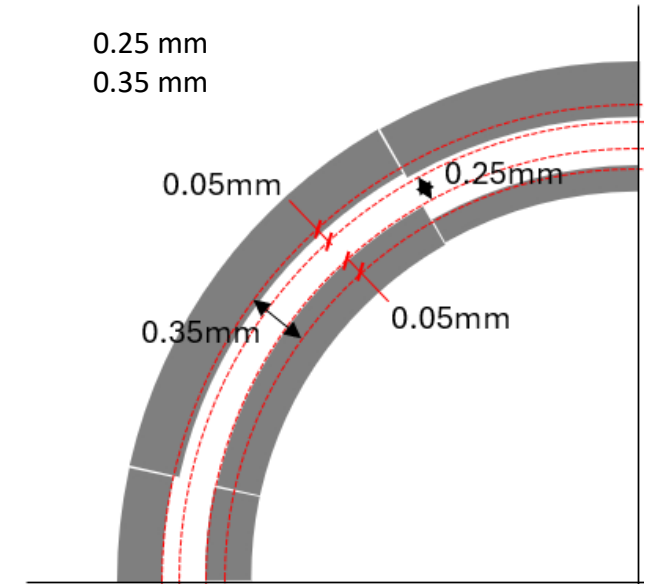
Courtesy B. Moritz

From CERN CEDAR Yellow Report page 26 , Figure 21

Radial distance of rings of wanted and unwanted particles vs. beam momentum, dotted line = width of the light spot (4σ), dashed line contributin multiple scattering (4σ)



- Considering the error margins from the Diaphragm specifications: $\sim 0.3 \text{ mm} \pm 0.05 \text{ mm}$ the aperture can vary between:



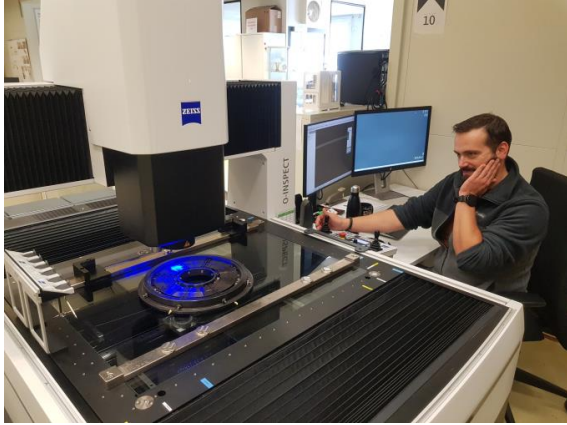
	TOLERANCE mm	
	BASELINE VALUES	PROPOSED REQ.
Outer Circle Circularity	0.01	0.05
Inner Circle Circularity	0.01	0.05
Gap Profile	0.02	0.1

Outer Circle Circularity	0.01	0.05
Inner Circle Circularity	0.01	0.05
Gap Profile	0.02	0.1

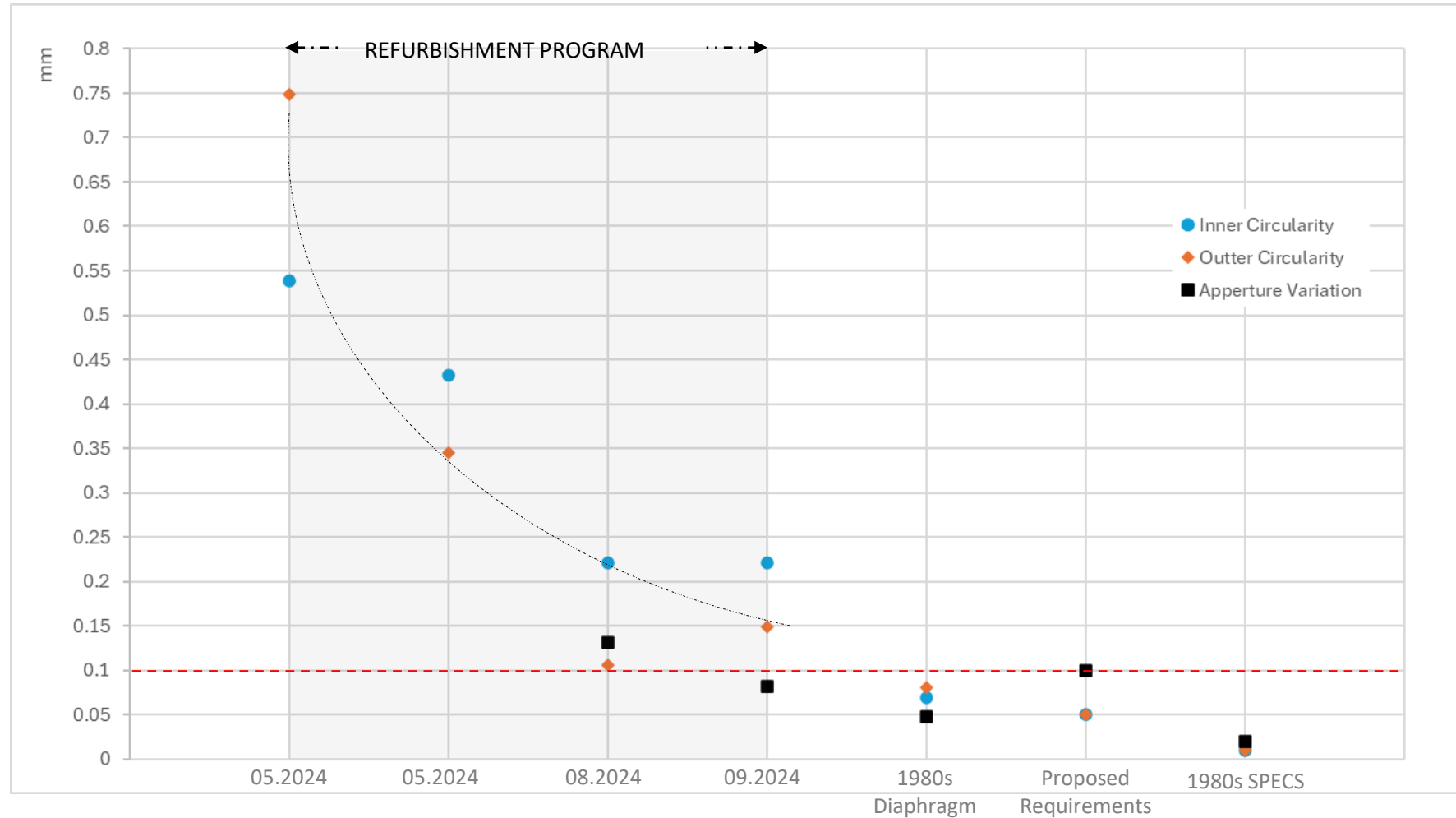
CEDAR DIAPHRAGM

DIAPHRAGM METROLOGY ANALYSIS

From 5 different measurements to 4 different diaphragms during 2024

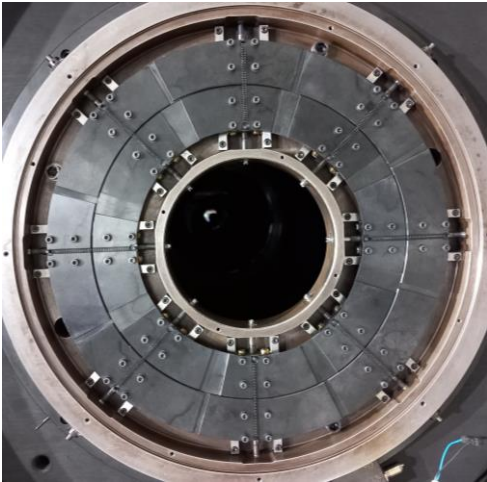


- Progressive improvement since the beginning of 2024 → Learning Curve
- Reaching a limit? More data needed however current aperture variation ~ values of 1980s
- Current method suitable for AMBER?: Aperture variation > 0.1 mm
- Inner and outer circularity are limiting min. aperture. → Not a direct indicator of the aperture variation
- Relative position between gaps was not evaluated **yet** → **new reports will include it in any case is correlated with inner/outer circularity**



CEDAR DIAPHRAGM

CONCLUSIONS



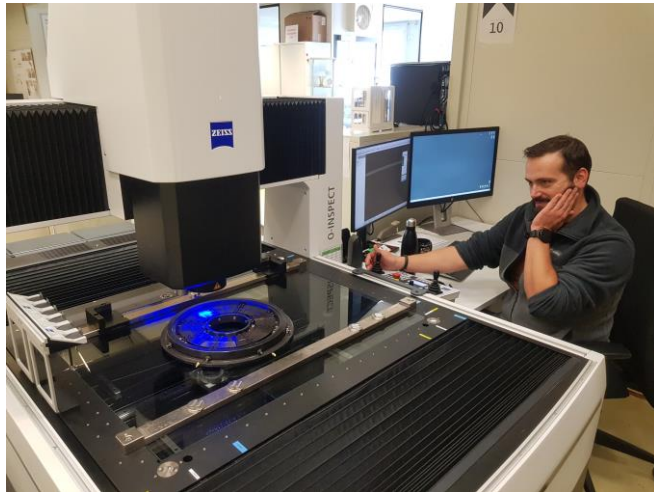
1. Measurements of an untouched diaphragm from the 80s seem to indicate that spec. were not met. → lack of statistics (possibility to measure other untouched diaphragms to confirm – Long term activity)
2. A progressive learning is in course aiming to define the best procedure for the Diaphragms maintenance → With each refurbishment there is an improvement with the clear objective to reach 1980 specs, more studies/trials are needed...
3. Currently the precision achieved seems approaching AMBER future requirements → pending relative position between flaps to confirm
4. Diaphragms are 40 Yrs old! They need urgent maintenance motivated by many fault reports of malfunctioning and misalignments → We need to understand them!
5. Higher precisions than 1980s measured diaphragm will most likely require an upgrade and or new tooling or completely new diaphragm design

THANK YOU !

CEDAR DIAPHRAGM

According to Metrology - 1980s procedure

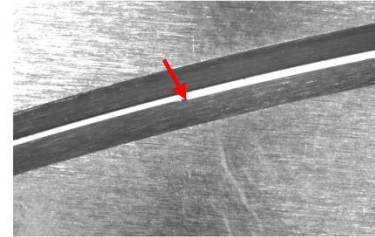
Contrôleur BURKOWSKI Maciej
Machine ZEISS O-INSPECT
Précision des mesures 2,2 µm + L/150mm
Température 20°C ±1°C



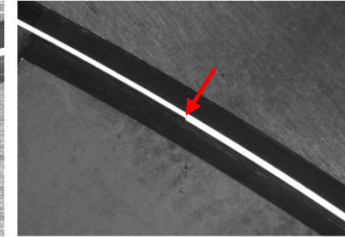
[EDMS3152574](#) - J3094591 CEDAR N06 diaphragm

- A diaphragm was recuperated from the XCED spare pool (cemetery)
- It is assumed that its untouched from the early 80's set up.
- It is assumed that the assembly method used was the same used for all XCEDs diaphragms at the time. We cannot be certain as there are no records
- It was measured without any refurbishment or intervention directly out of the spare SPXCEDN001-CR000006

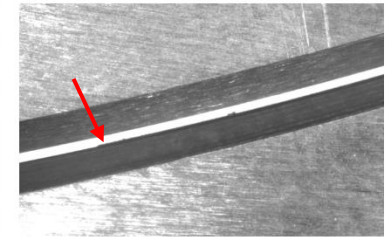
The objective is to understand if with the methods used in the 80's, the specifications mentioned in the *1982 operation manual for the Cedars*, are respected.



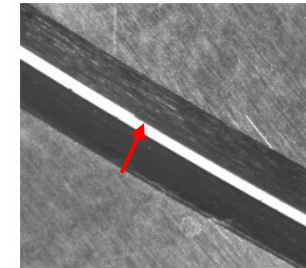
Segment No. 9



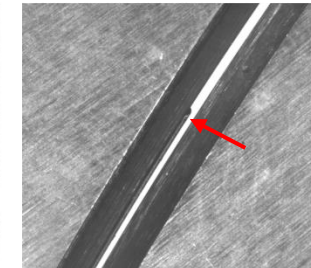
Segment No. 10



Segment No. 13



Segment No. 14



Segment No. 13

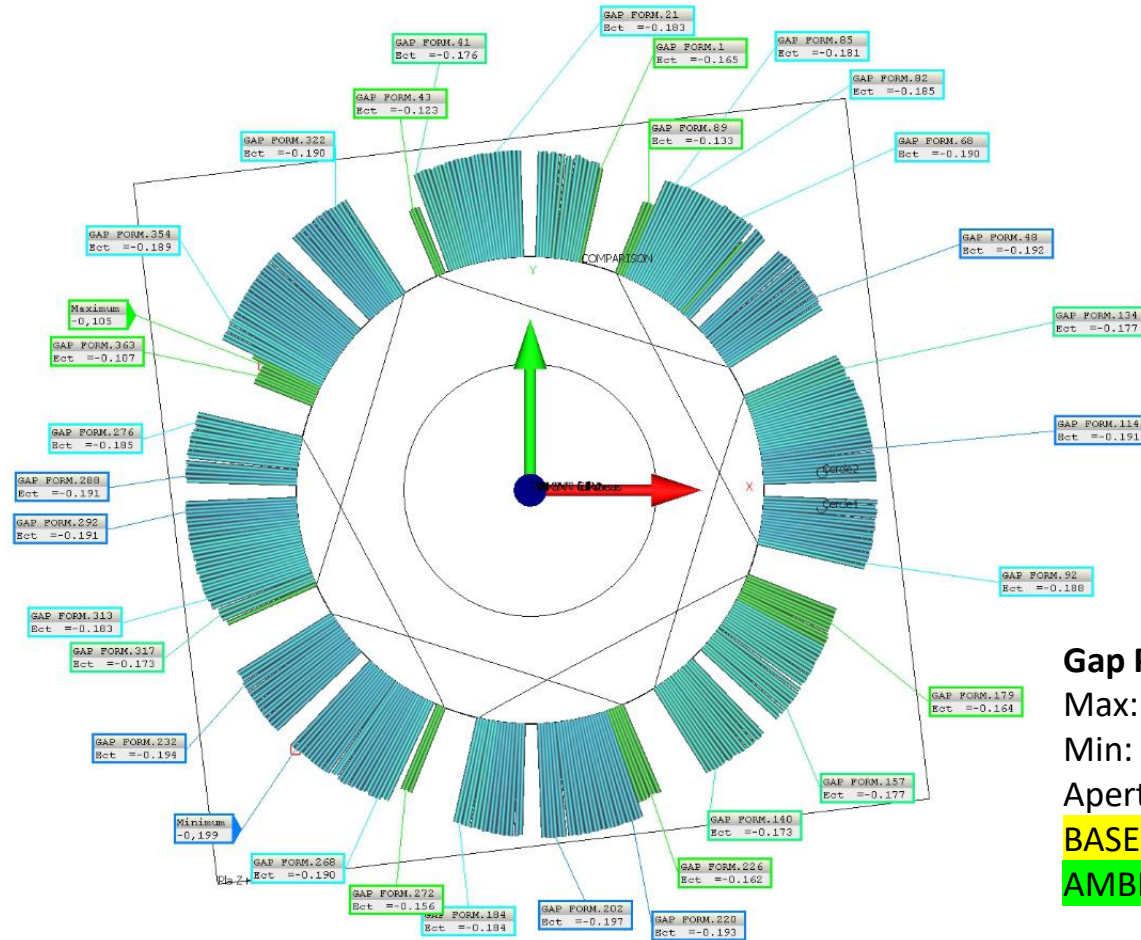
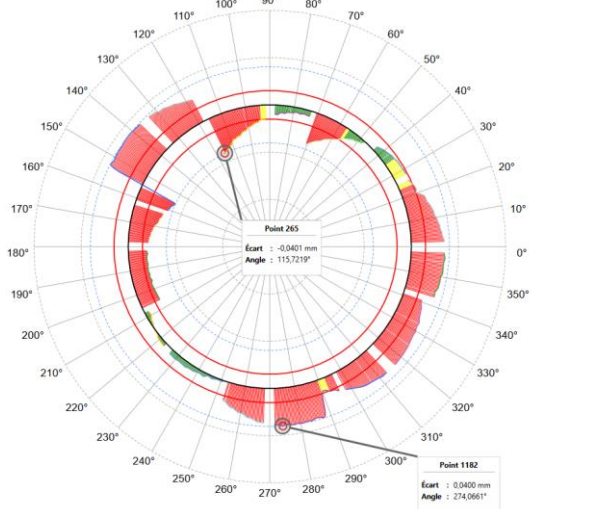
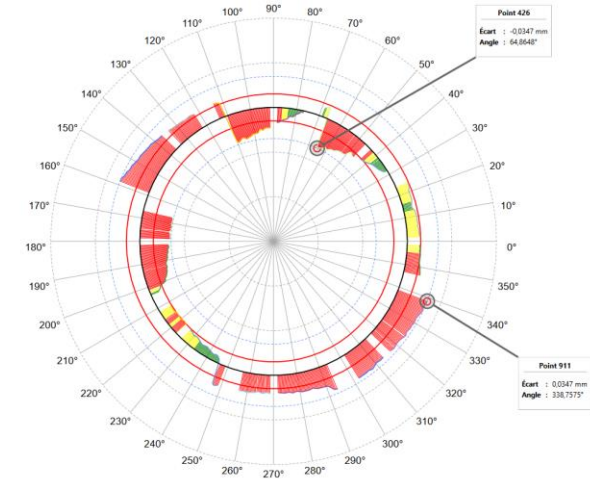
Comment upon visual inspection

Visible "steps" on the profile of the segments, which affect the gap of the diaphragm. Defects can be seen on segments number: 9,10,13,14,16. Photos on the last page

CEDAR DIAPHRAGM

According to Metrology - 1980s procedure

EDMS3152574 - J3094591 CEDAR N06 diaphragm



Gap Profile
 Max: 0.105 mm
 Min: 0.199 mm
 Aperture variation: +/-0.047 mm
BASELINE: OUT OF TOLERANCE
AMBER: OK

Repeatability

A repeatability test was conducted
 2x setting the diameter by narrowing aperture
 2x setting the diameter by enlarging the aperture

Very good repeatability measured between ~3-4 μm , (metrology error is $2.2+L/250 \rightarrow \sim 3.5 \mu\text{m}$)

Outer Circle Circularity Tolerance 0.08 mm
Inner Circle Circularity Tolerance 0.069 mm

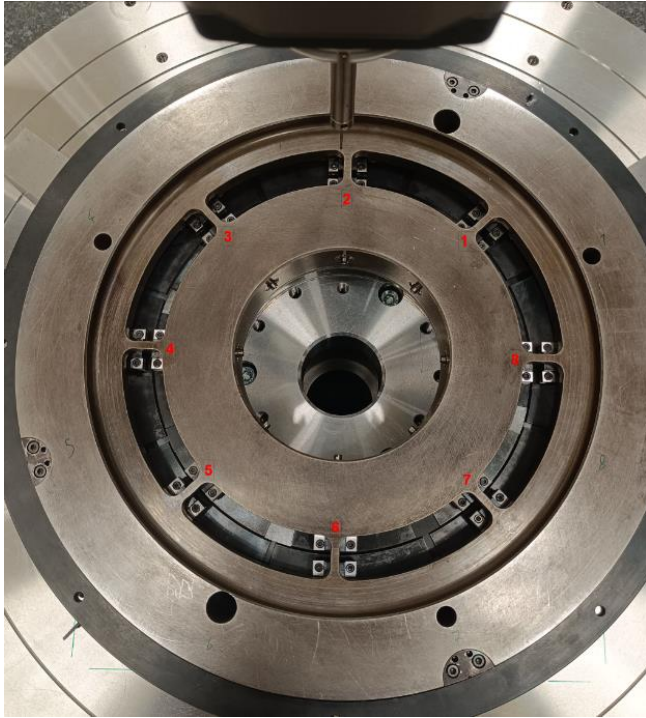
CEDAR DIAPHRAGM

According to Metrology – 05.2024 Procedure

DIAPHRAGM 1 - SPXCEDN001-CR000020 before refurbishment

DIAPHRAGM 2 - SPXCEDN001-CR000020 after refurbishment

Contrôleur	DEQUIDT Mike
Machine	ZEISS Prismo Ultra 12-18-10
Précision des mesures	1,2 μm + L/500mm
Température	20°C \pm 1°C

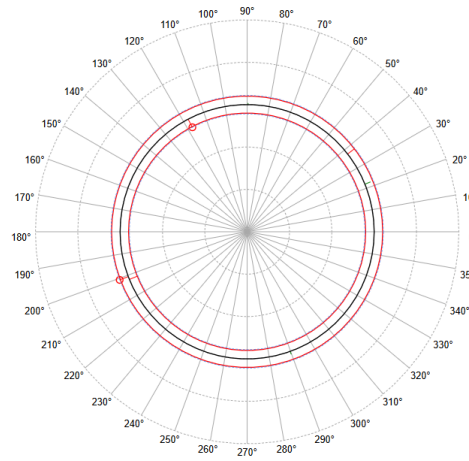
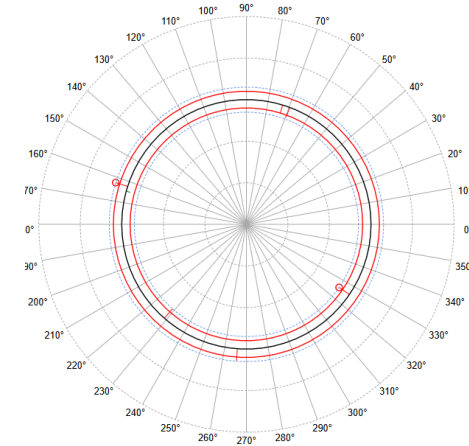


No gap profile was measured.
Not possible to tell actual aperture tolerance

[EDMS3085596](#) - J3092453.CEDAR SPXCEDN001-CR000020

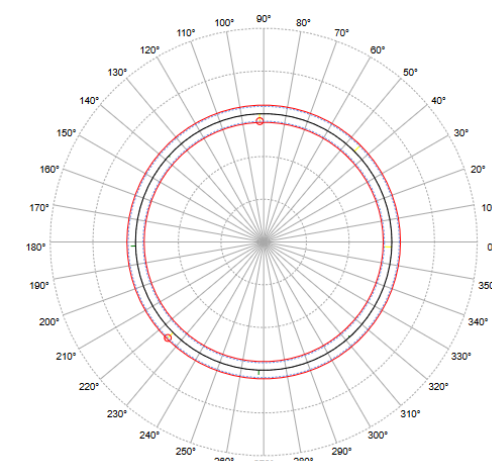
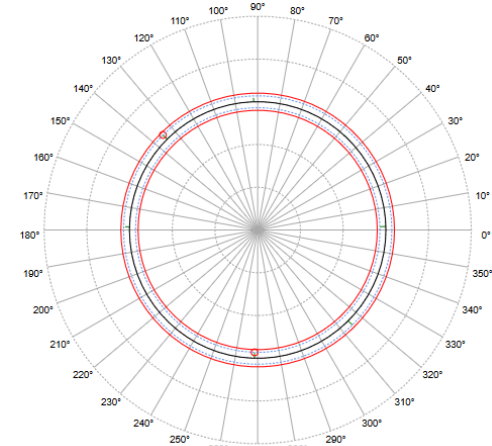
[EDMS.3085596-J3092453-CEDAR-DIAPHRAGME OUVERT 10MM PART 1 PRISMO.pdf](#)

[EDMS.3085596-J3092453-CEDAR-DIAPHRAGME OUVERT 10MM PART 2 PRISMO.pdf](#)



DIAPHRAGM 1

Inner Circle Circularity Tolerance 0.539 mm
Outer Circle Circularity Tolerance 0.749 mm
Without alignment tooling
Out of tolerance

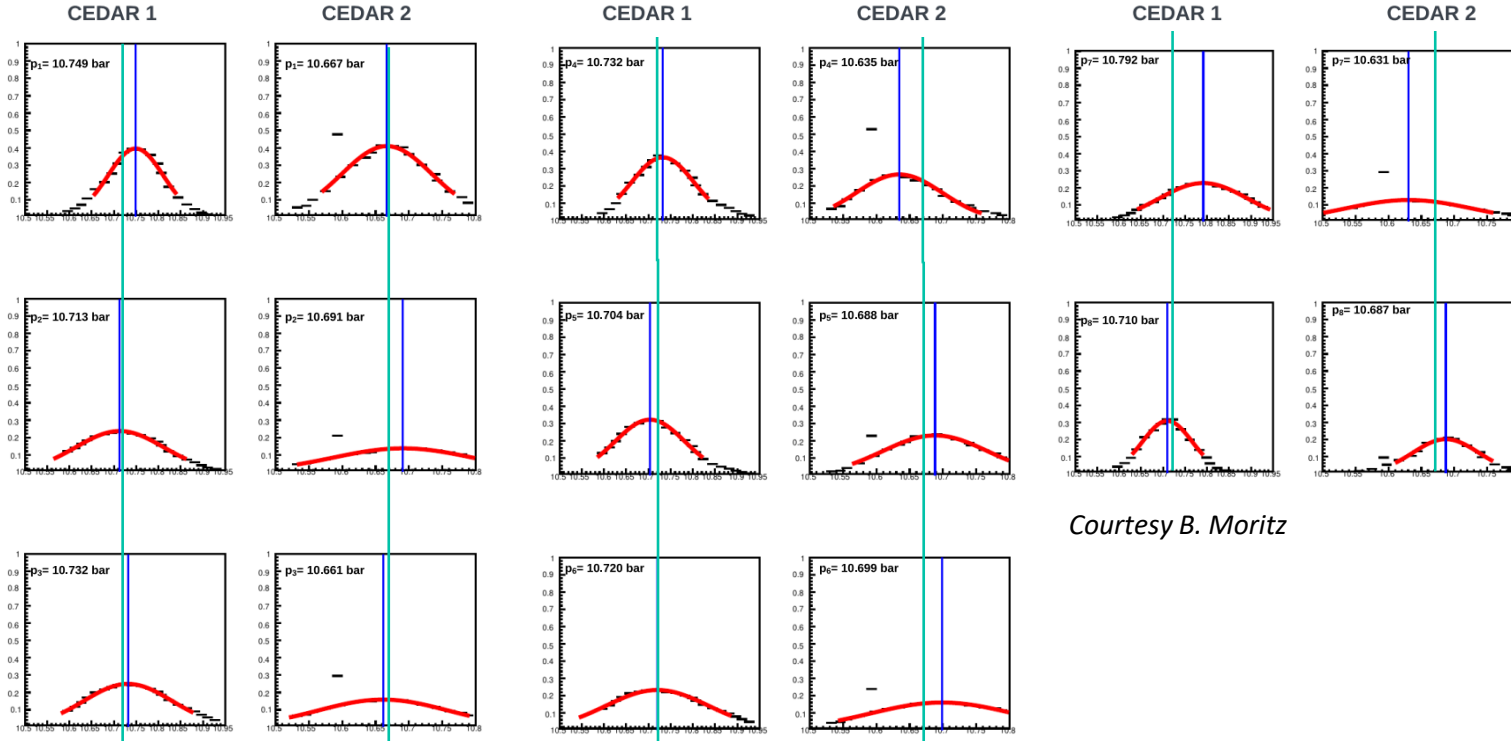


DIAPHRAGM 2

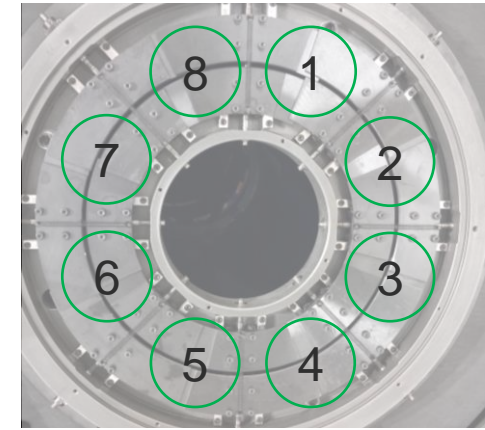
Inner Circle Circularity Tolerance 0.432 mm
Outer Circle Circularity Tolerance 0.345 mm
With alignment tooling
Out of tolerance

CEDAR DIAPHRAGM

According to pressure scans – 05.2024 Procedure



Courtesy B. Moritz



CEDAR1 - SPXCEDN001-CR000002
CEDAR2 - SPXCEDN001-CR000020

PMT	CEDAR1 [μm]	CEDAR2 [μm]
1	290	30
2	70	210
3	110	90
4	120	360
5	170	180
6	0	280
7	710	390
8	100	170

Confirmed by AMBER (B.Moritz) 10 mbar pressure translates to about 100 μm offset

The largest deviation between shutters translates then: 0.071 bar = **710 μm** for the **CEDAR1** - SPXCEDN001-CR000002 7 PMT position

The deviations are off tolerance by at least 1.5 x order of magnitude for most shutters !!

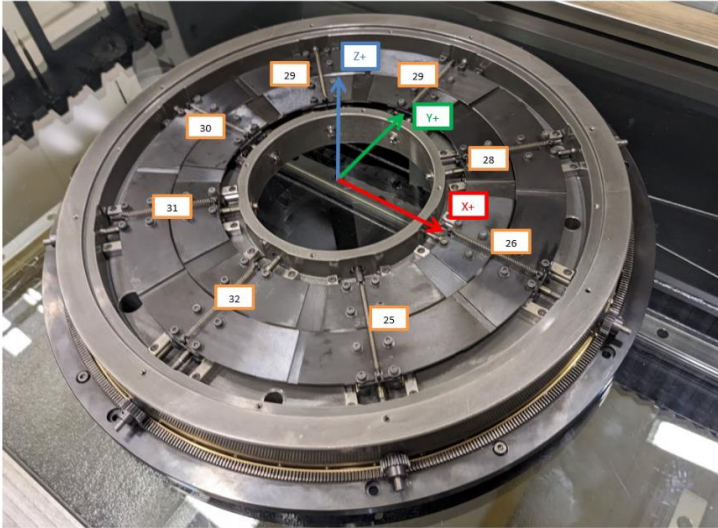
The largest deviation is bigger than the min aperture requirements

NOTE this CEDAR1 Diaphragm was aligned without tooling - CEDAR2 was aligned with tooling

CEDAR DIAPHRAGM

According to Metrology – 08.2024 Procedure
1st ESSAY

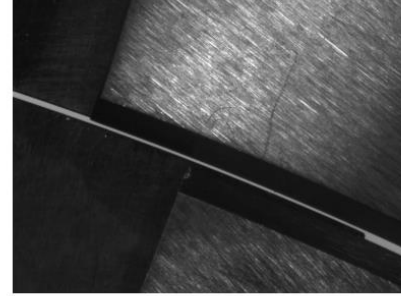
Contrôleur BURKOWSKI Maciej
Machine ZEISS O-INSPECT
Précision des mesures 2,2 µm + L/150mm
Température 20°C ±1°C



[EDMSJ3094591](#) - J3094591 CEDAR N01 diaphragm
[EDMS.3152574_J3094591_CEDAR_No1.pdf](#)



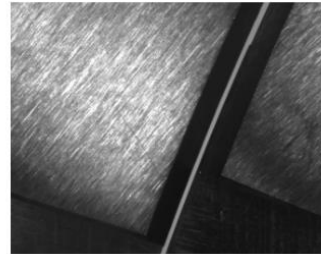
Section No 26 - GAP CLOSED



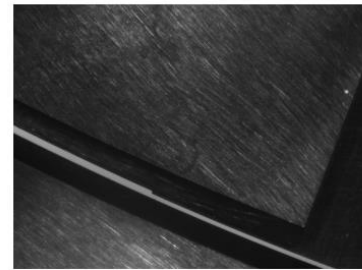
Section No 27



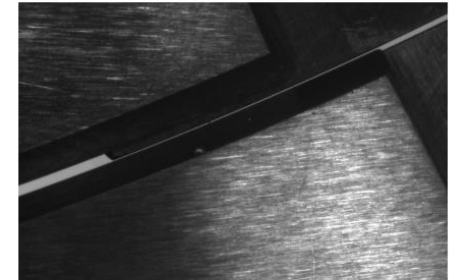
Section No 28



Section No 29



Section No 31



Section No 32

Comment upon visual inspection

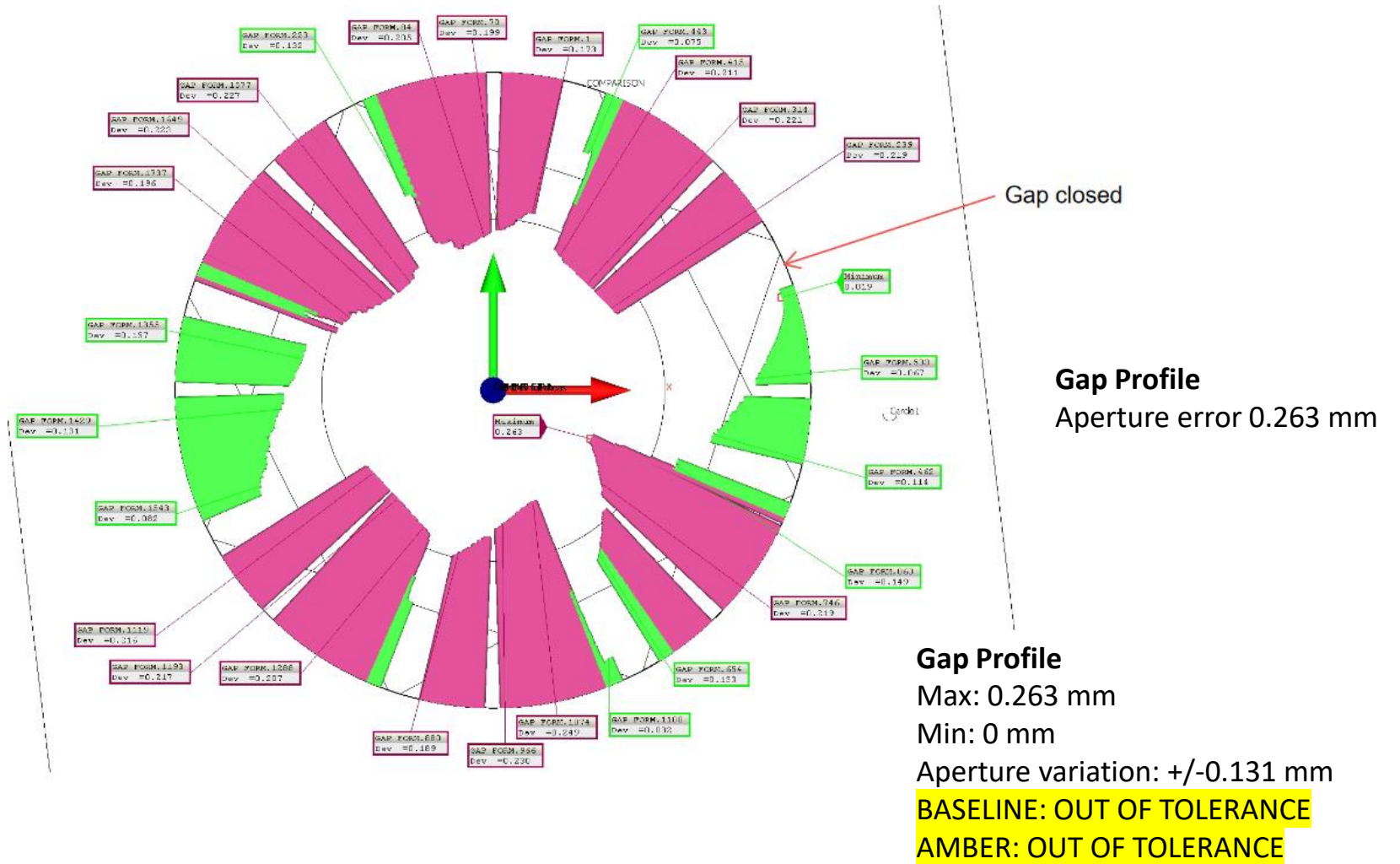
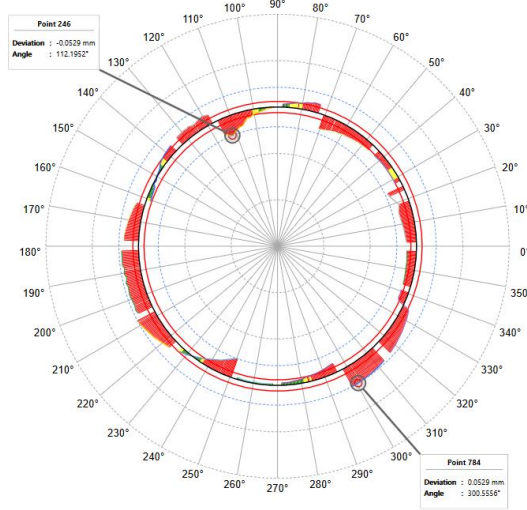
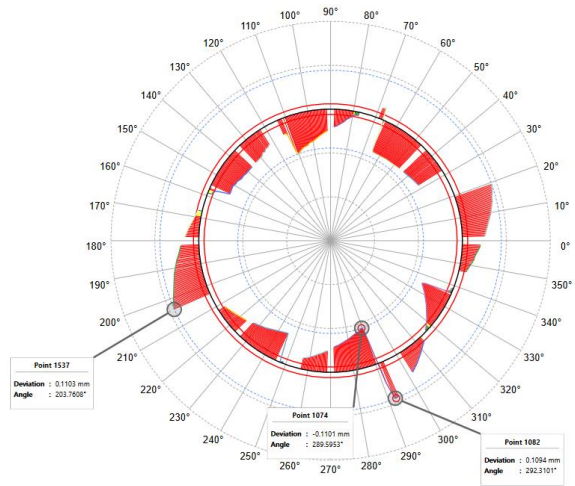
Visible "steps" on the profile of the segments, which affect the gap of the diaphragm.

Section 26 completely closed

CEDAR DIAPHRAGM

According to Metrology – 08.2024 Procedure
1st ESSAY

[EDMSJ3094591](#) - J3094591 CEDAR N01 diaphragm
[EDMS.3152574](#) J3094591 CEDAR No1.pdf



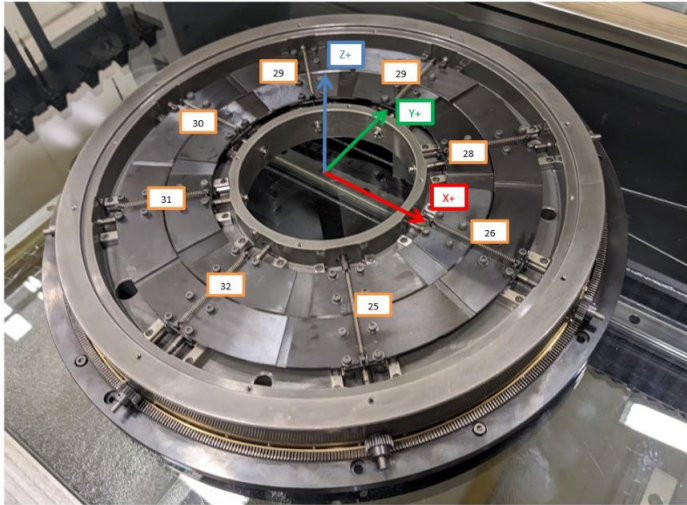
Gap Profile
Max: 0.263 mm
Min: 0 mm
Aperture variation: +/-0.131 mm
BASELINE: OUT OF TOLERANCE
AMBER: OUT OF TOLERANCE

Outer Circle Circularity Tolerance 0.106 mm
Inner Circle Circularity Tolerance 0.221 mm

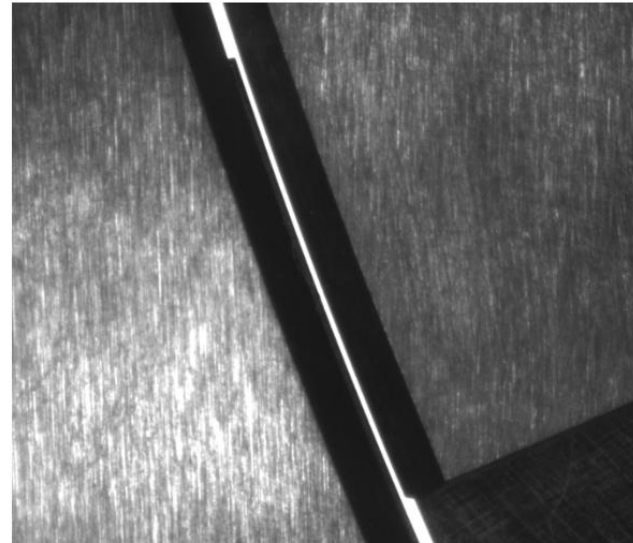
CEDAR DIAPHRAGM

According to Metrology – 09.2024 Procedure
2nd ESSAY

Contrôleur BURKOWSKI Maciej
Machine ZEISS O-INSPECT
Précision des mesures 2,2 µm + L/150mm
Température 20°C ±1°C



[EDMSJ3094591](#) - J3094591 CEDAR N01 diaphragm
[EDMS.3152574 J3094591 CEDAR No1 after repair.pdf](#)



minimum gap size

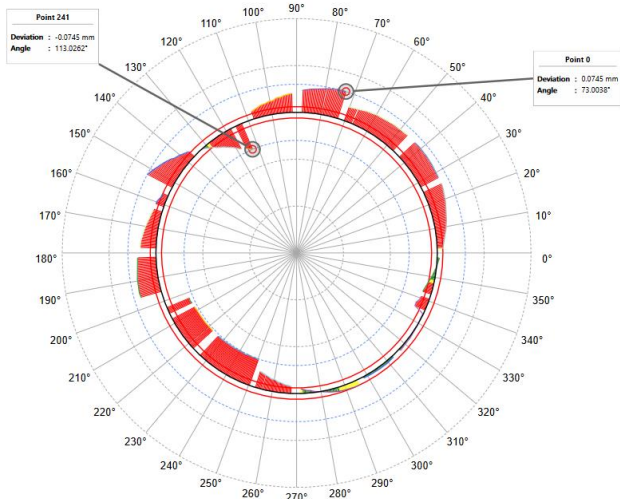
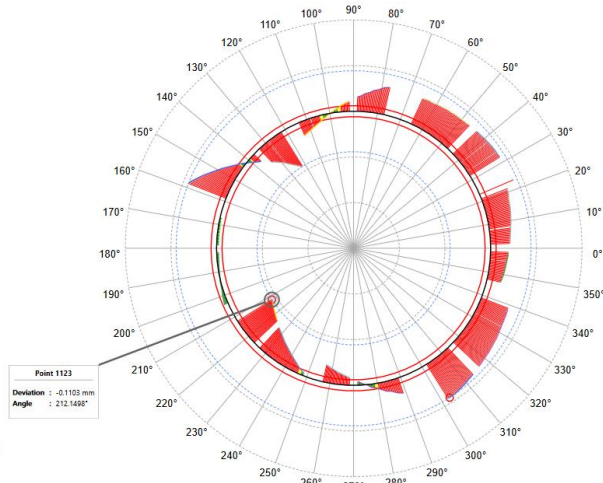
Comment upon visual inspection

Visible "steps" on the profile of the segments,
which affect the gap of the diaphragm.

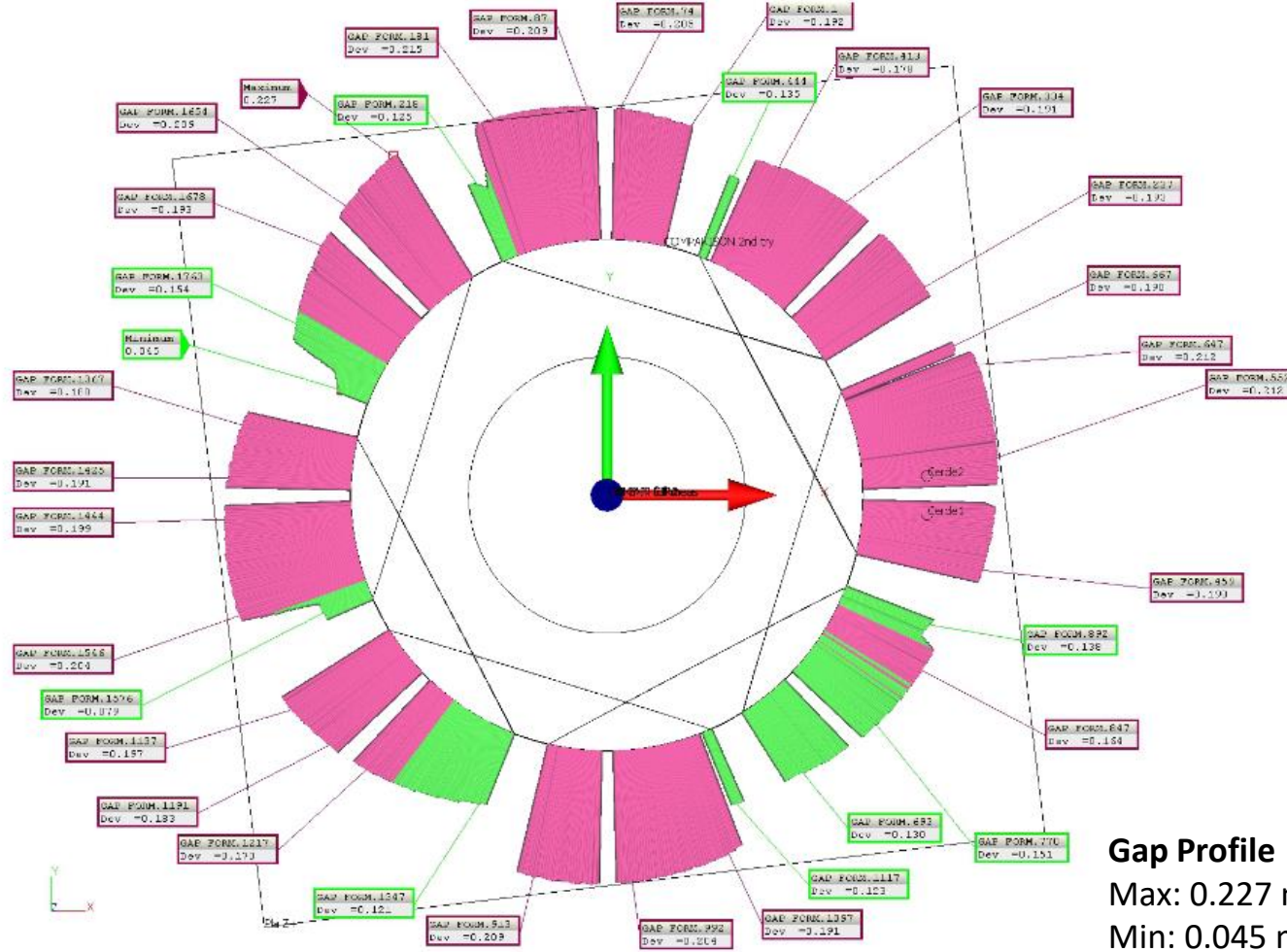
CEDAR DIAPHRAGM

DIAPHRAGM 2024s SPECIFICATIONS
According to Metrology – 08.2024 Procedure
2nd ESSAY

[EDMSJ3094591](#) - J3094591 CEDAR N01 diaphragm
[EDMS.3152574](#) J3094591 CEDAR No1 after repair.pdf



Outer Circle Circularity Tolerance 0.149 mm
Inner Circle Circularity Tolerance 0.221 mm

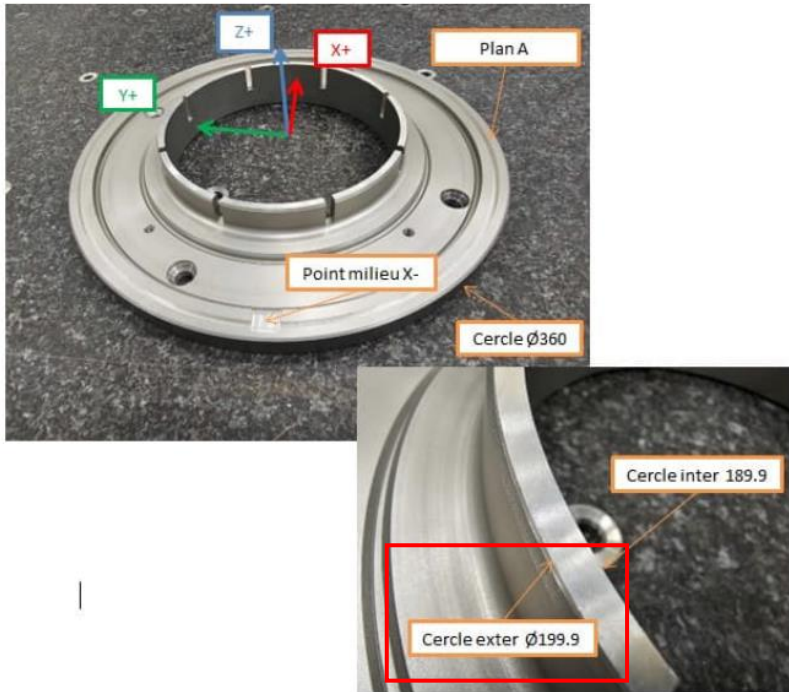


Gap Profile
Max: 0.227 mm
Min: 0.045 mm
Aperture variation: +/-0.082 mm
BASELINE: OUT OF TOLERANCE
AMBER: OK

CEDAR DIAPHRAGM

DIAPHRAGM ALIGNMENT TOOL – 1980s
Metrology

Contrôleur PUGNAT Dominique
Machine ZEISS Prismo Ultra 12-24-10
Précision des mesures 1,2 µm + L/500mm
Température 20°C ±1°C



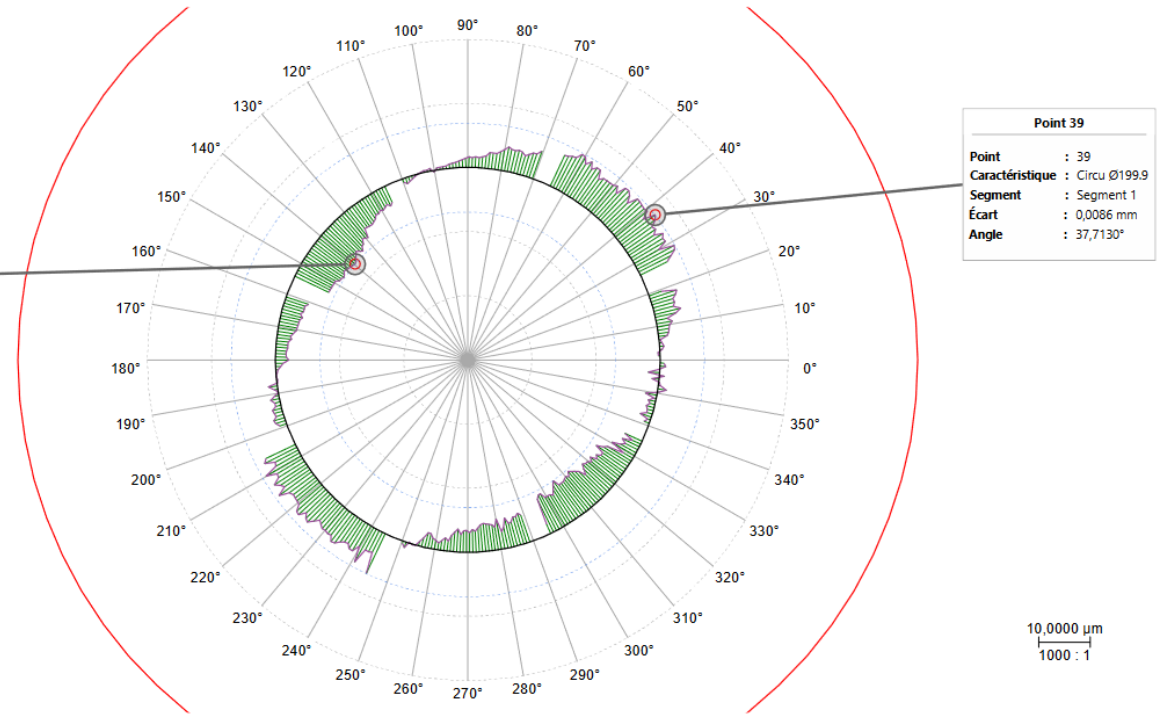
- Orientation primaire Z: Normale au plan A
- Orientation secondaire X: Droite passant par le point milieu et le centre du cercle Ø360
L'origine en X et Y est le centre du cercle Ø360
L'origine en Z est le plan A

[EDMS3085596](#) - J3092453.CEDAR SPXCEDN001-CR000020
[EDMS.3085596-J3092453-CEDAR_TOOL-metrologie.pdf](#)

— Dans la tolérance
— Tolérances
— Valeur nominale
--- Cercles extrêmes
--- Limite de la zone d'évaluation
— Segment 1
○ Points extrêmes

Point 145
Point : 145
Caractéristique : Circu Ø199.9
Segment : Segment 1
Écart : -0,0086 mm
Angle : 139,6899°

Y
X



Point 39
Point : 39
Caractéristique : Circu Ø199.9
Segment : Segment 1
Écart : 0,0086 mm
Angle : 37,7130°

Nom	Valeur mesurée	Limite supérieure	Points	Filter type	Lc	upr	Probe radius	Vmess[mm/sec]	Evaluation method
○ Circu Ø199.9	0,017	0,100	329	Pas de filtre	-	-	0,502	5,000	Élément minimum

DIAPHRAGM ALIGNMENT TOOLING

Tolerance 0.017 µm

Tolerance required < 0.01µm

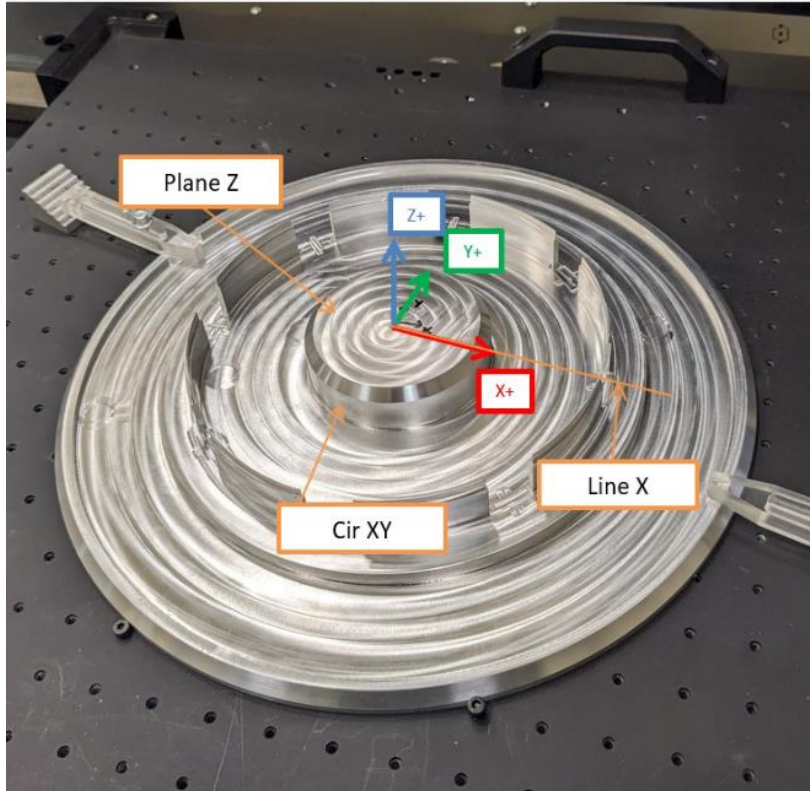
Out of tolerance

CEDAR DIAPHRAGM

DIAPHRAGM ALIGNMENT TOOLING

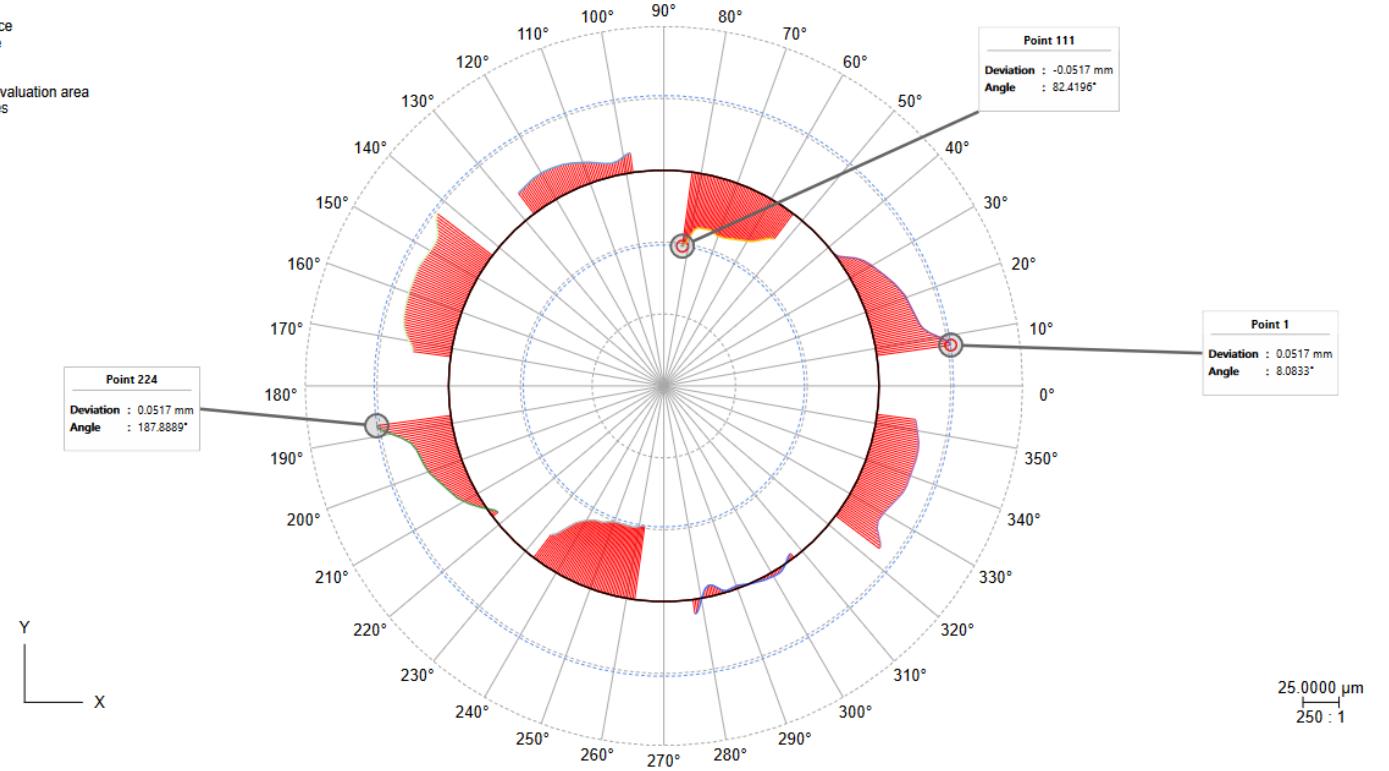
Metrology
New Tooling
1st ESSAY

Contrôleur BURKOWSKI Maciej
Machine ZEISS O-Inspect
Précision des mesures 2.2 μm + L/150mm
Température 20°C \pm 1°C



EDMS3160745 - J3094591 CEDAR adjustment tool

- In tolerance
- Out of tolerance
- Nominal value
- Tolerances
- - - Boundary of evaluation area
- - - Extreme circles
- Segment 1
- Segment 2
- Segment 3
- Segment 4
- Segment 5
- Segment 6
- Segment 7



Name	Measured value	Upper limit	Points	Filter type	Lc	upr	Probe radius	Vmess[mm/sec]	Evaluation method
○ Roundness External	0.103	0.000	439	Low-pass Spline	-	50 -	2.500		Minimum Feature

DIAPHRAGM ALIGNMENT TOOLING

Tolerance 0.103 μm

Tolerance required < 0.01 μm

Out of tolerance – Still allowed to understand the old tool