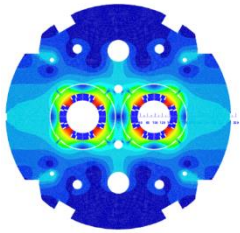


MQYYM INSTRUMENTATION TECHNICAL REVIEW

Damien Simon for the MQYYM team

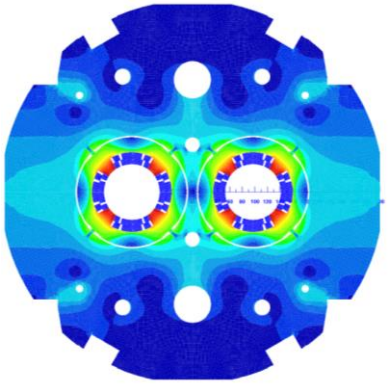
CEA: H. Felice, D. Simon, M. Segreti, J.M. Rifflet, S. Somsom, R. Machado-Correia, R. Godon

CERN: M. Guinchard, P. Grosclaude, J.C. Perez, N. Bourcey, A Foussat, E. Todesco

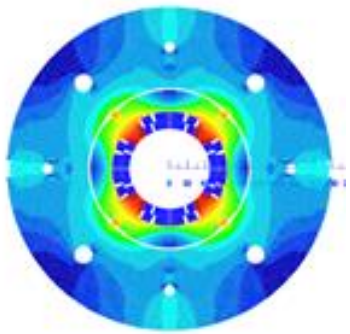
INTRODUCTION

The MQYY project:

- Collaboration CERN-CEA for the HL-LHC
- Design of the MQYY a double aperture cos(2θ) Nb-Ti matching section magnet
- Fabrication and test of the MQYYM single aperture magnet short model of the MQYY magnet
- Fabrication of the MQYYM coils at CEA
- Assembly, instrumentation and warm magnetic measurements at CERN
- Cold magnetic measurements at CEA



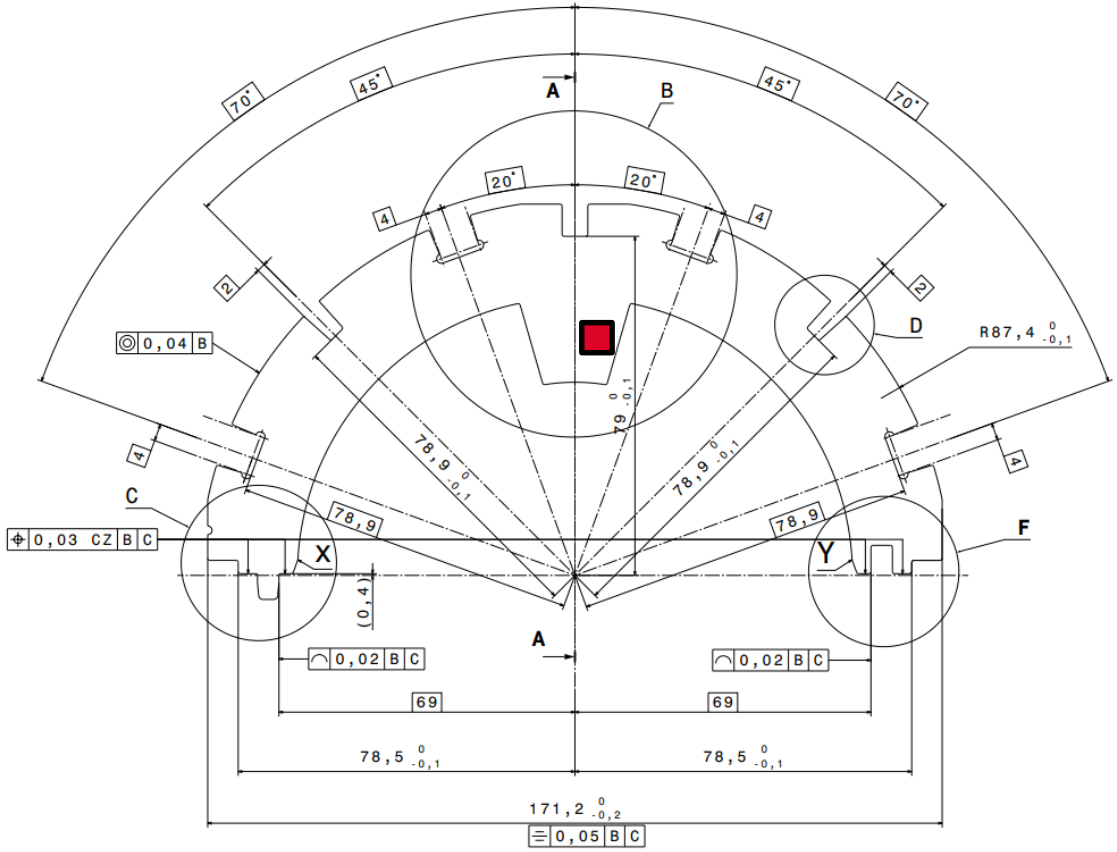
The MQYY

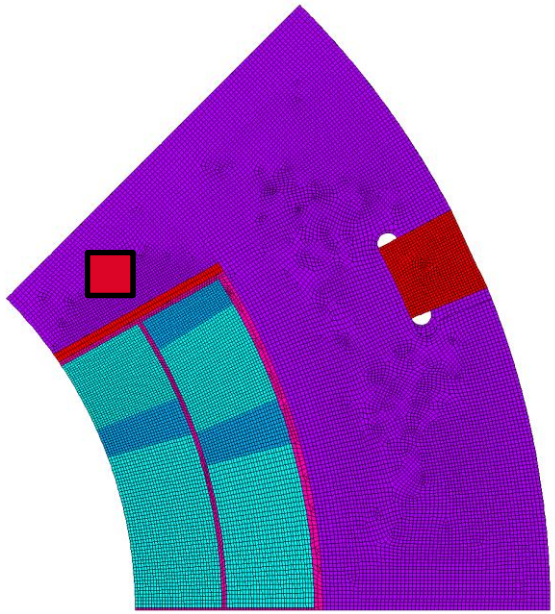


The MQYYM

STRAIN GAUGES POSITION

Collars instrumentation:



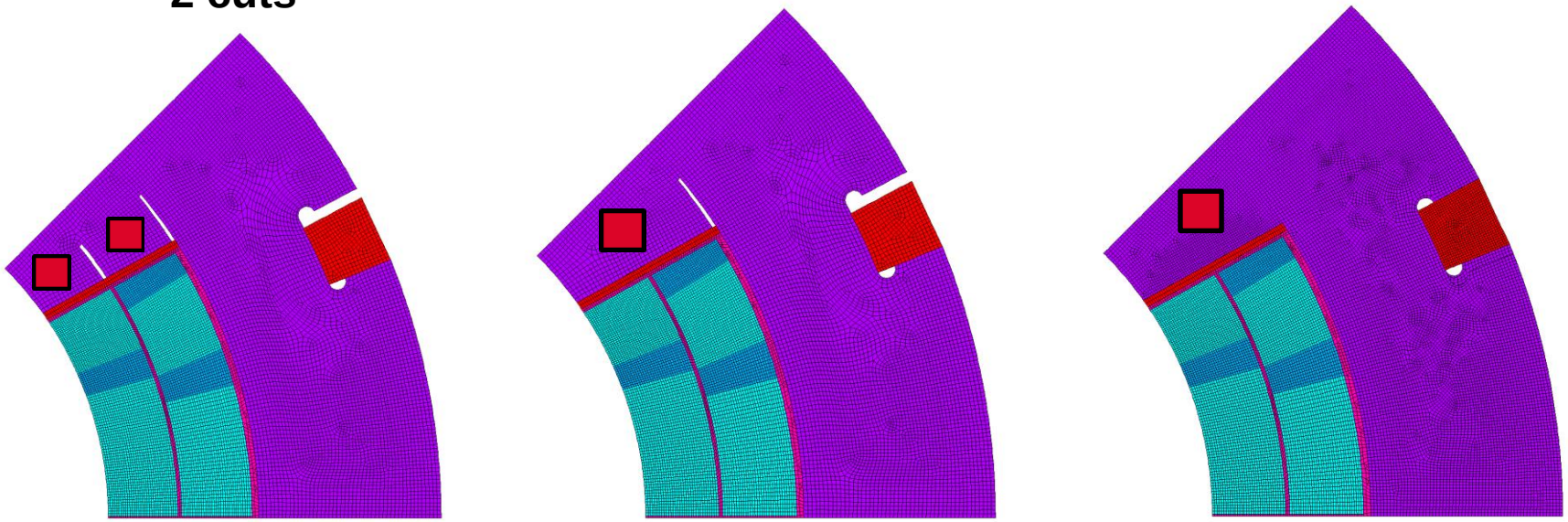


Strain gages

SCENARII

Collars instrumentation:

- **The goal is to measure the azimtal stress on the pole**
- **The radial stress should be low to measure only the azimutal stress**
- **3 possibilities:**
  - **0 cut**
  - **1 cut**
  - **2 cuts**

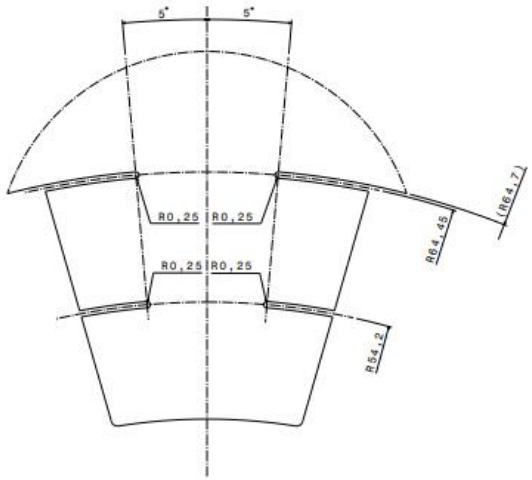


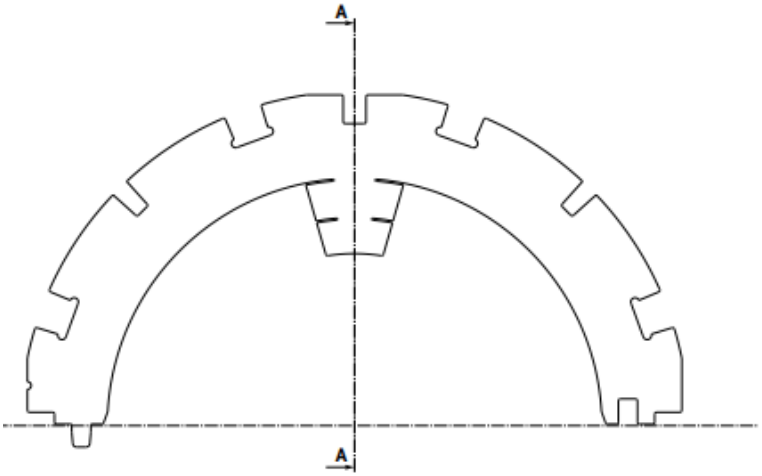
Strain gages

DRAWINGS

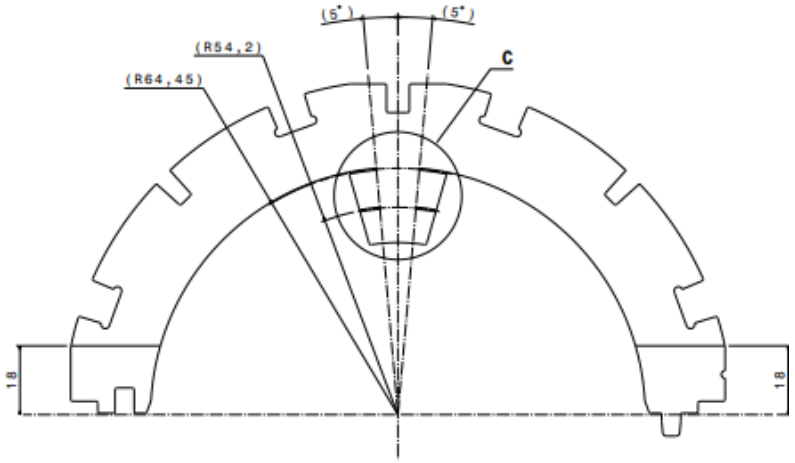
Collars instrumentation:

- **The goal is to measure the azimtal stress on the pole**





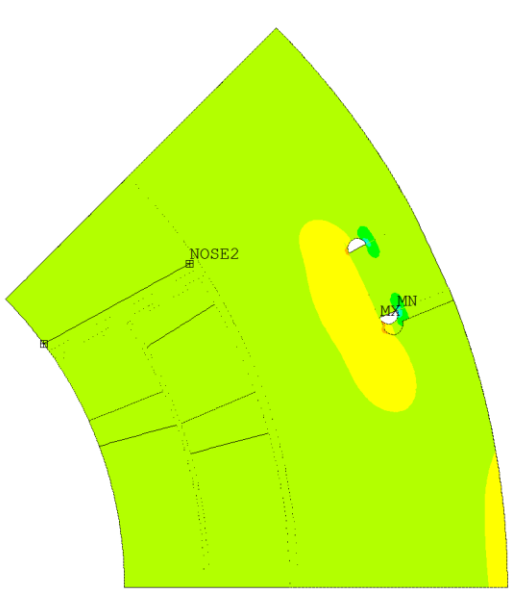
A-A

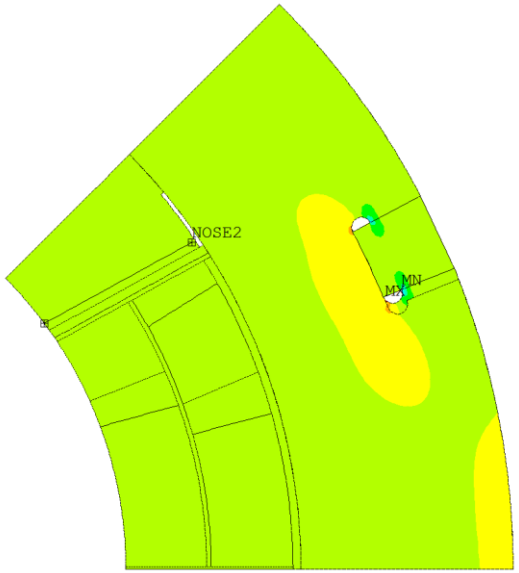


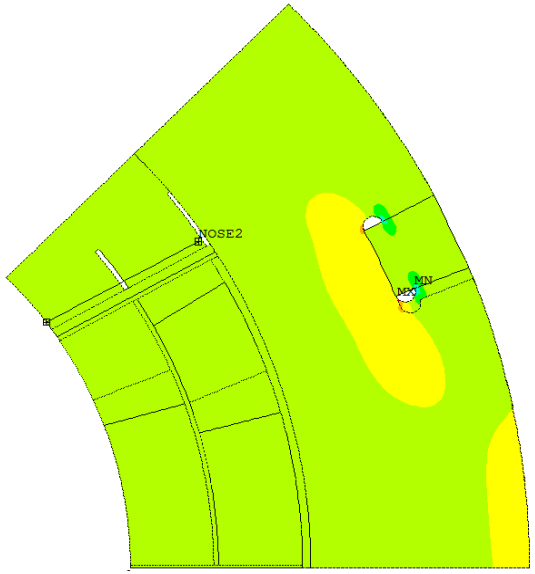
INTRODUCTION TO THE SIMULATION

Collars instrumentation:

- **PATH: 1 path**
  - **NOSE2**
- **Notation: e(x/y)StepYZCuts**
  - **X Radial strain & Y azimuthal strain**
  - **Y number of the load step (1 collaring, 2 cooling, 3 enregization)**
  - **Z number of cuts (0 cut, 1 cut, 2 cuts)**



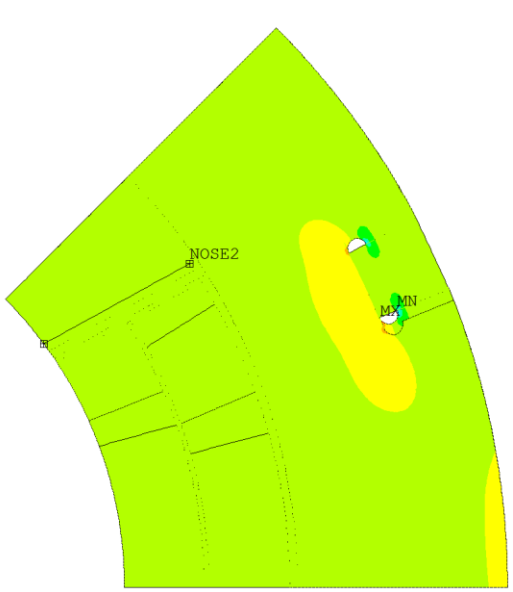


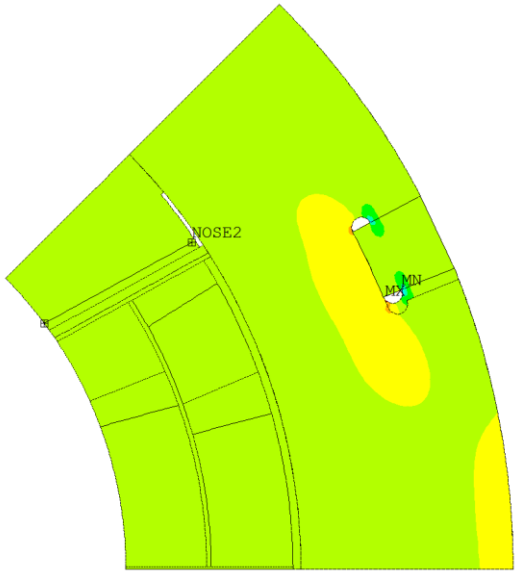


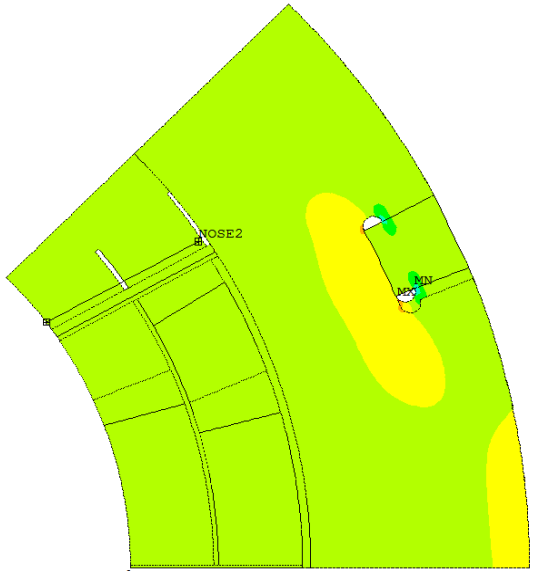
INTRODUCTION TO THE SIMULATION

Collars instrumentation:

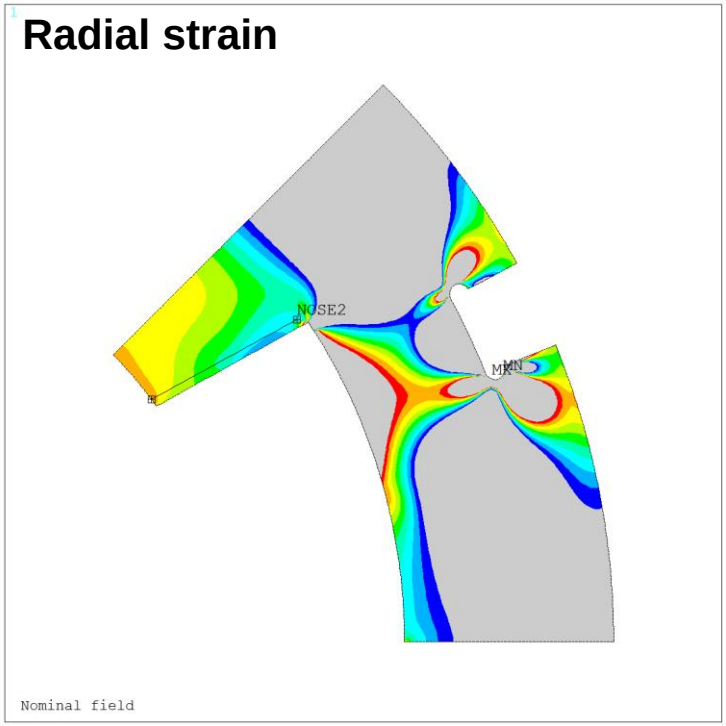
- **The idea is to canceled the azimuthal stress**
- **The poisson ratio of the stainless steel is 0,3**
- **To canceled the azimuthal stress we need a ratio between the radial strain and the azimuthal strain of -0,3.**







RESULTS 0 CUT



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Build 18.2
NODAL SOLUTION
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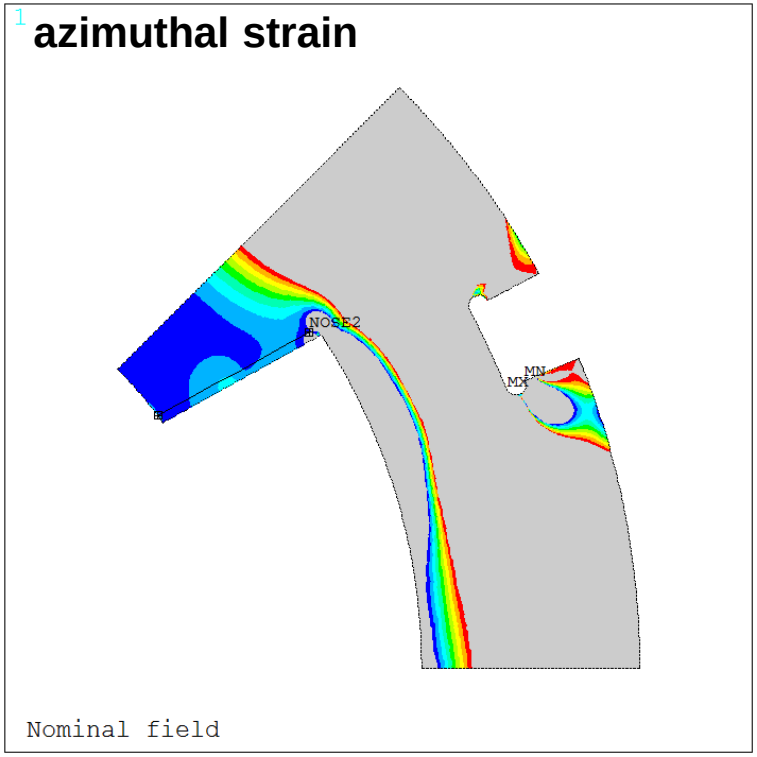
SUB =1
TIME=3
EPELX (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.593E-03
SMN =-.001069
SMX =.001753
PATH

-.592E-04
-.476E-04
-.360E-04
-.243E-04
-.127E-04
-.109E-05
.105E-04
.222E-04
.338E-04
.454E-04

Radial and azimuthal strain in the collar nose for 0 cut (Step 3)



ANSYS Release 18.
Build 18.2
NODAL SOLUTION
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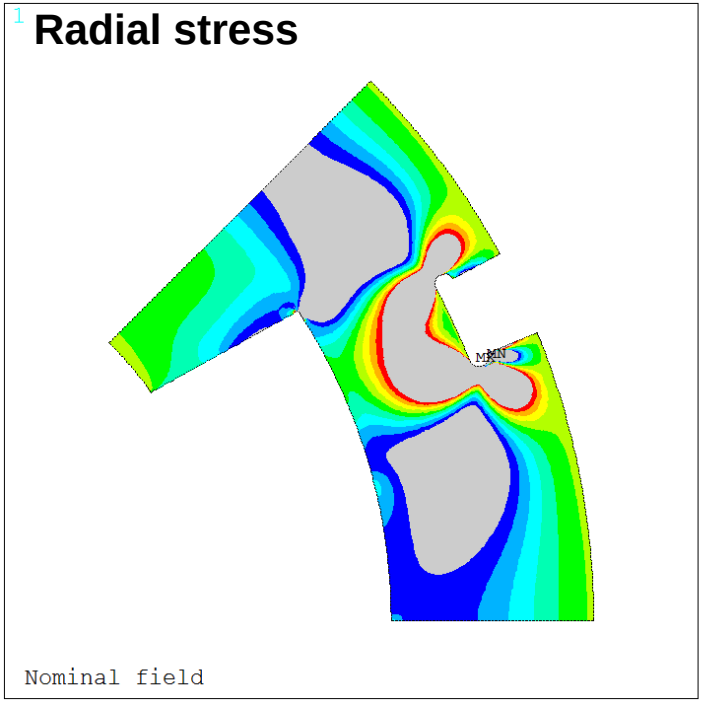
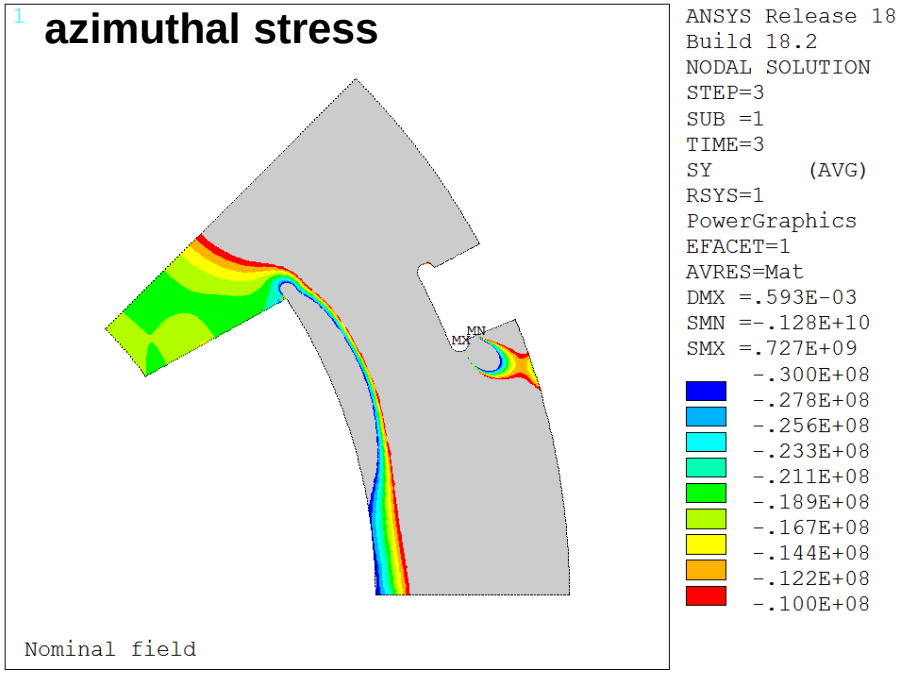
SUB =1
TIME=3
EPELY (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.593E-03
SMN =-.006066
SMX =.003356
PATH

-.923E-04
-.820E-04
-.718E-04
-.615E-04
-.513E-04
-.410E-04
-.308E-04
-.205E-04
-.103E-04
0

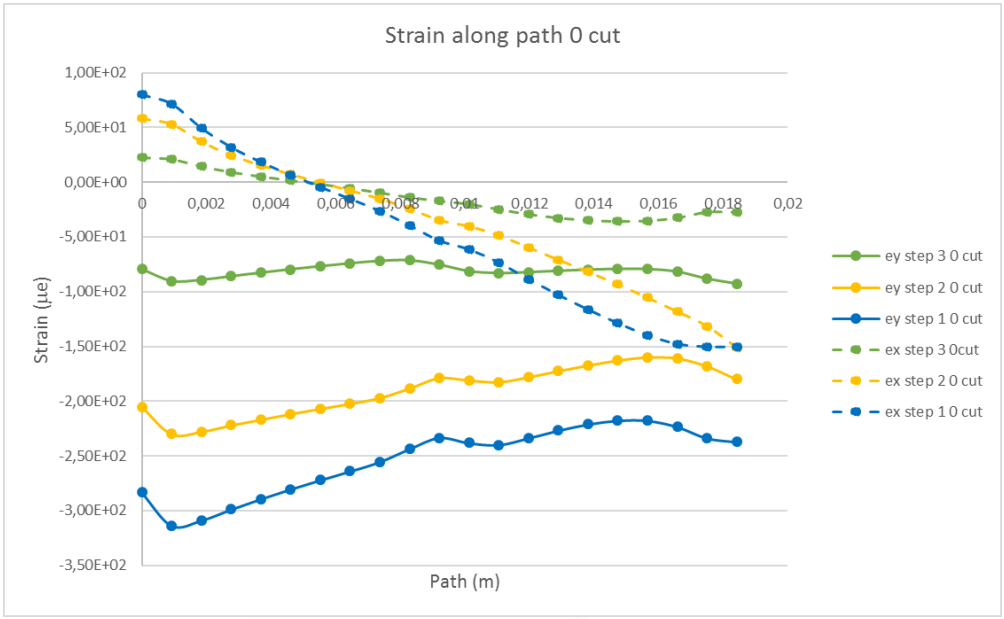
RESULTS 0 CUT



Radial and azimuthal stress in the collar nose for 0 cut (Step 3)

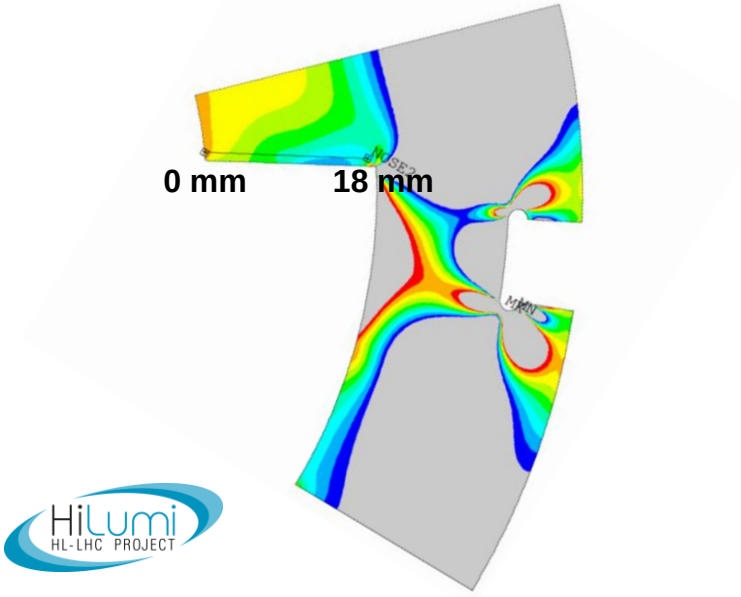


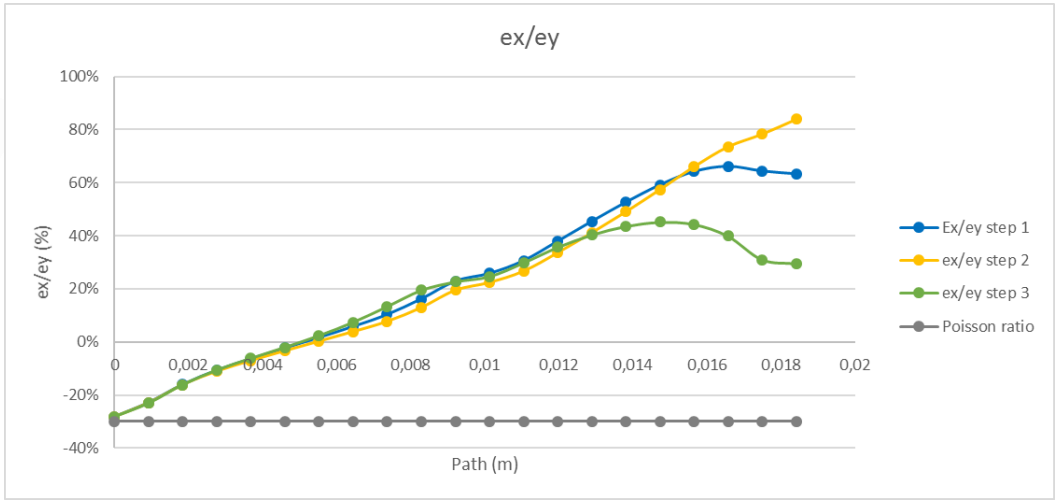
RESULTS 0 CUT



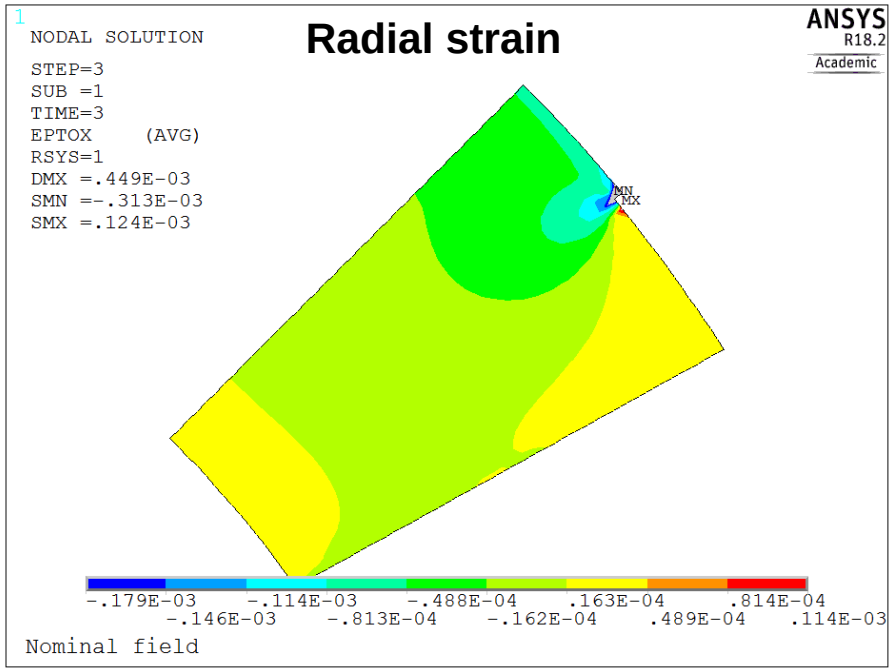
The radial strain along the « nose 2 » path is huge and not constant especialy at the end of the nose (x = 18 mm)

The radial stress is not canceled

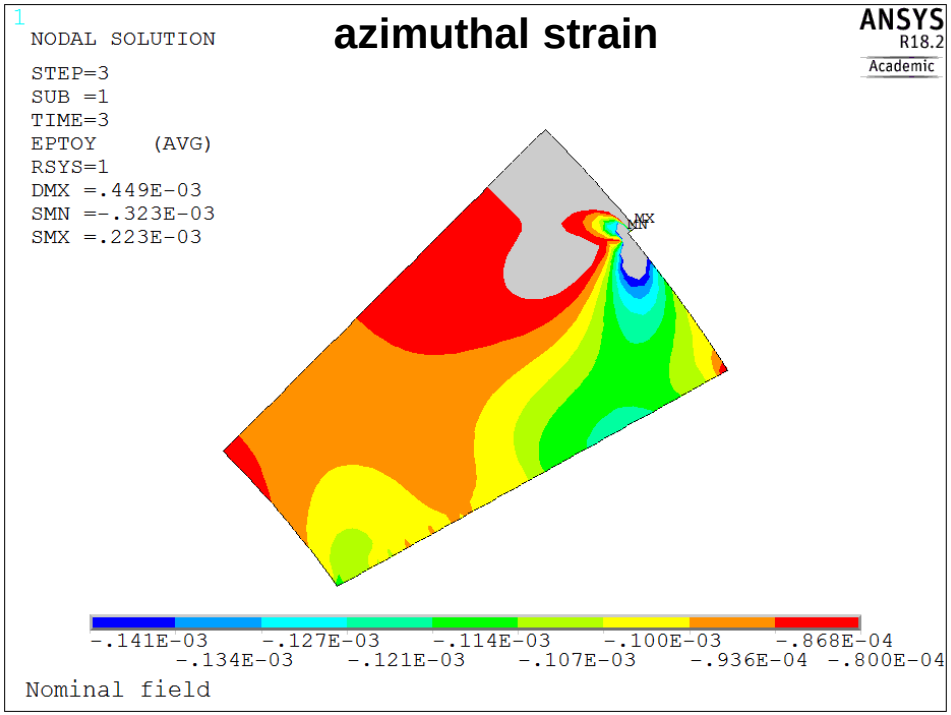




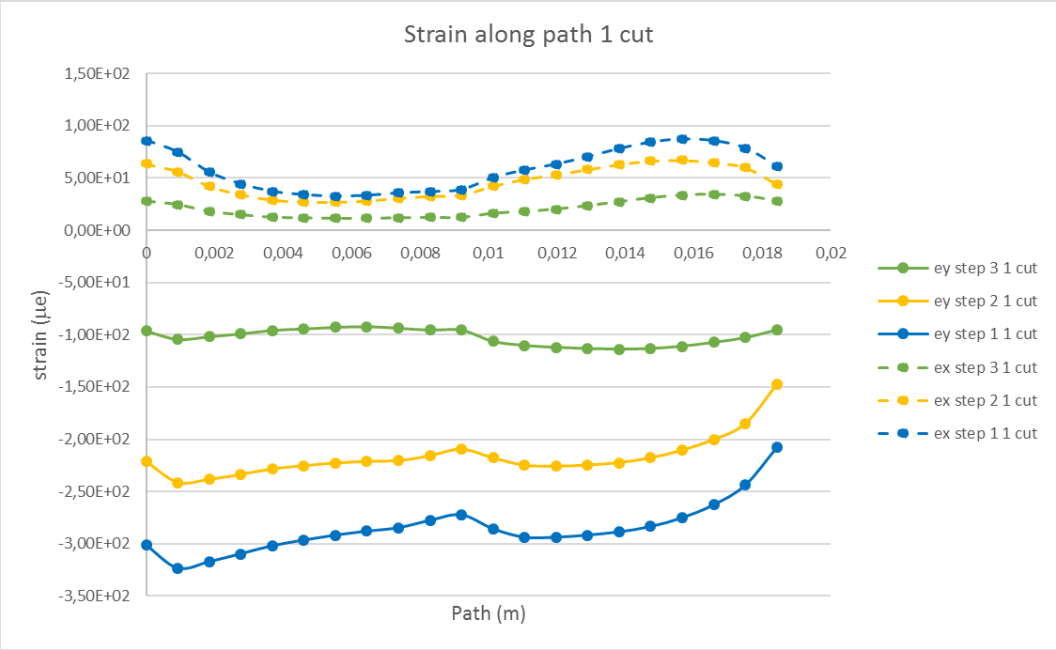
RESULTS 1 CUT



Radial and azimuthal strain in the collar nose for 1 cut (Step 3)

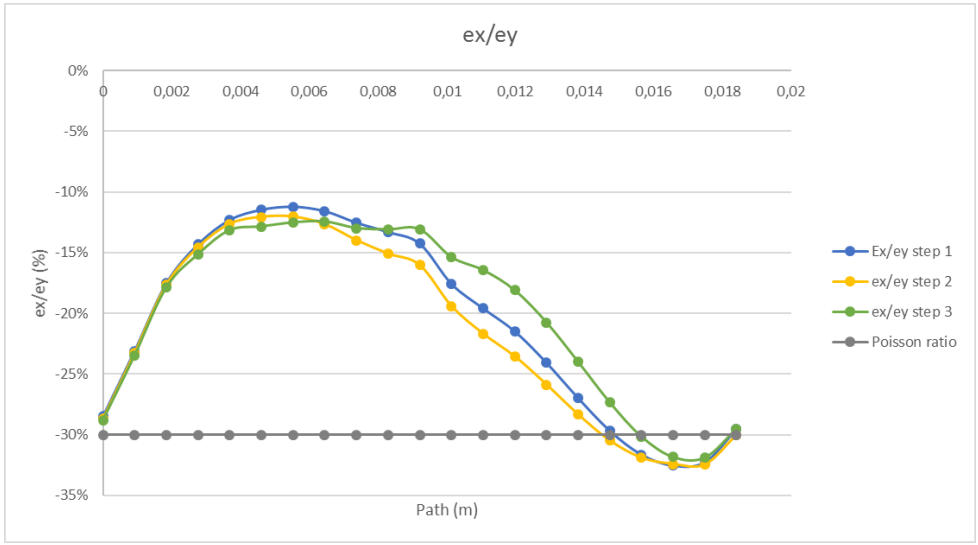


RESULTS 1 CUT

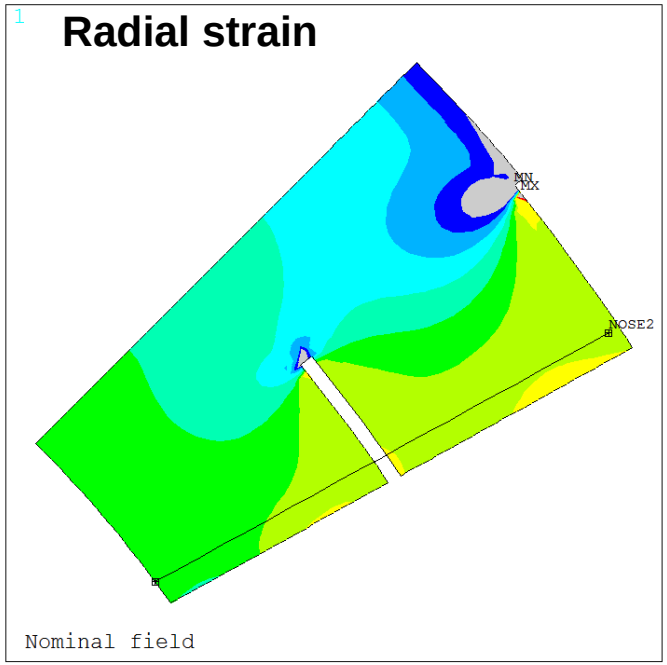


The radial and azimuthal strain along the « nose 2 » path is almost contant.

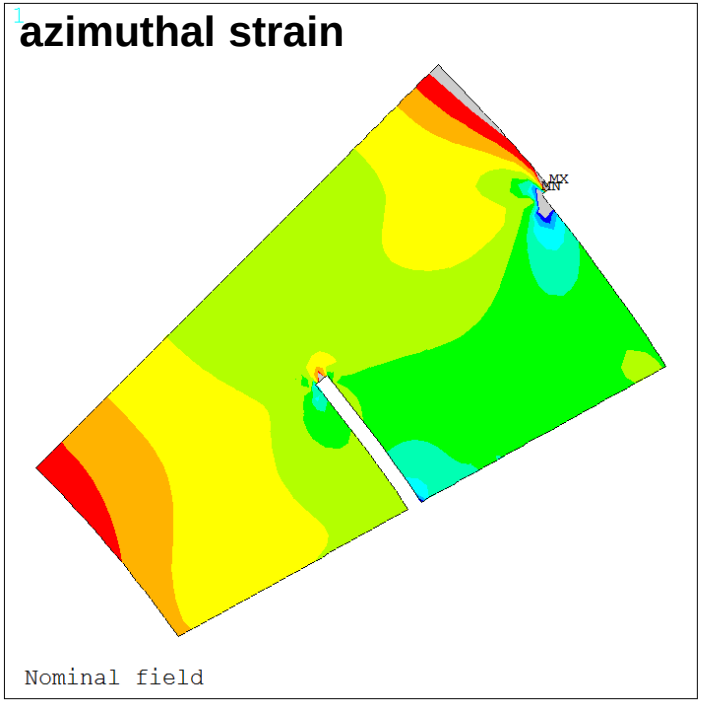
The radial stress is not canceled at the middle of the path.



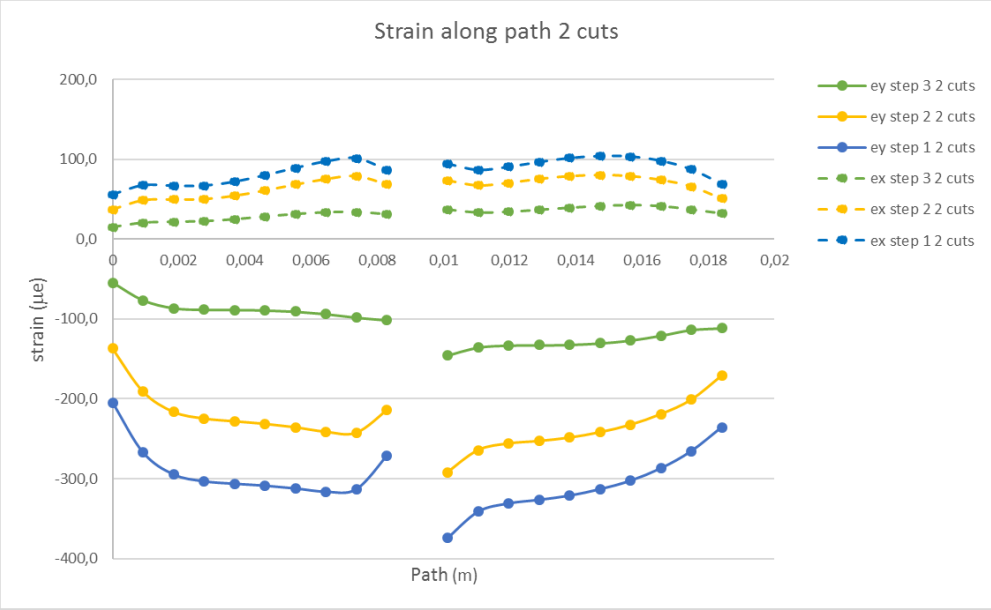
RESULTS 2 CUTS



Radial and azimuthal strain in the collar nose for 2 cut (Step 3)



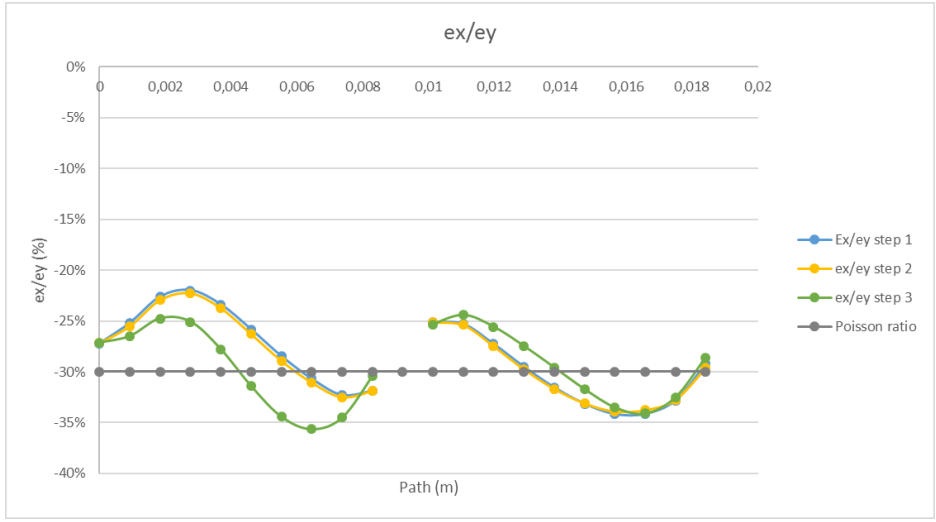
RESULTS 2 CUTS



The radial and azimuthal strain along the « nose 2 » path is almost contant.

The radial stress is almost canceled all along the path

2 CUTS: BEST OPTION



RESULTS 2 CUTS

Stress

Path (m)	Step 1			Step 2			Step 3		
	sy (MPa)	sx (MPa)	sx/sy	sy (MPa)	sx (MPa)	sx/sy	sy (MPa)	sx (MPa)	sx/sy
0	-41,9	-1,3	3%	-28,1	-0,9	3%	-11,1	-0,3	3%
9,21E-04	-55,0	-2,9	5%	-39,3	-1,9	5%	-15,7	-0,6	4%
1,84E-03	-61,2	-4,9	8%	-44,9	-3,4	8%	-17,8	-1,0	6%
2,76E-03	-63,2	-5,4	9%	-46,8	-3,9	8%	-18,2	-1,0	5%
3,68E-03	-63,5	-4,5	7%	-47,3	-3,2	7%	-18,1	-0,4	2%
4,60E-03	-63,5	-2,9	5%	-47,5	-1,9	4%	-18,0	0,3	-2%
5,52E-03	-63,7	-1,1	2%	-48,0	-0,6	1%	-18,2	0,9	-5%
6,45E-03	-64,0	0,5	-1%	-48,8	0,6	-1%	-18,7	1,2	-6%
7,37E-03	-63,1	1,6	-3%	-48,8	1,4	-3%	-19,6	1,0	-5%
8,29E-03	-54,7	1,1	-2%	-43,2	0,9	-2%	-20,6	0,1	0%
9,21E-03									
1,01E-02	-77,2	-4,1	5%	-60,2	-3,2	5%	-30,0	-1,5	5%
1,10E-02	-70,3	-3,6	5%	-54,4	-2,7	5%	-28,0	-1,7	6%
1,20E-02	-67,8	-2,0	3%	-52,4	-1,4	3%	-27,4	-1,3	5%
1,29E-02	-66,3	-0,4	1%	-51,3	-0,1	0%	-27,2	-0,7	3%
1,38E-02	-64,8	1,1	-2%	-50,2	0,9	-2%	-26,8	-0,1	0%
1,47E-02	-62,9	2,2	-3%	-48,6	1,7	-3%	-26,3	0,5	-2%
1,57E-02	-60,5	2,8	-5%	-46,6	2,0	-4%	-25,4	1,0	-4%
1,66E-02	-57,4	2,7	-5%	-43,9	1,9	-4%	-24,2	1,1	-5%
1,75E-02	-53,4	1,7	-3%	-40,4	1,2	-3%	-22,9	0,6	-3%
1,84E-02	-47,9	-0,4	1%	-34,7	-0,1	0%	-22,7	-0,4	2%
	-61,1	**-1,0**	**1%**	**-46,3**	**-0,6**	**1%**	**-21,8**	**-0,1**	**0%**

Strain

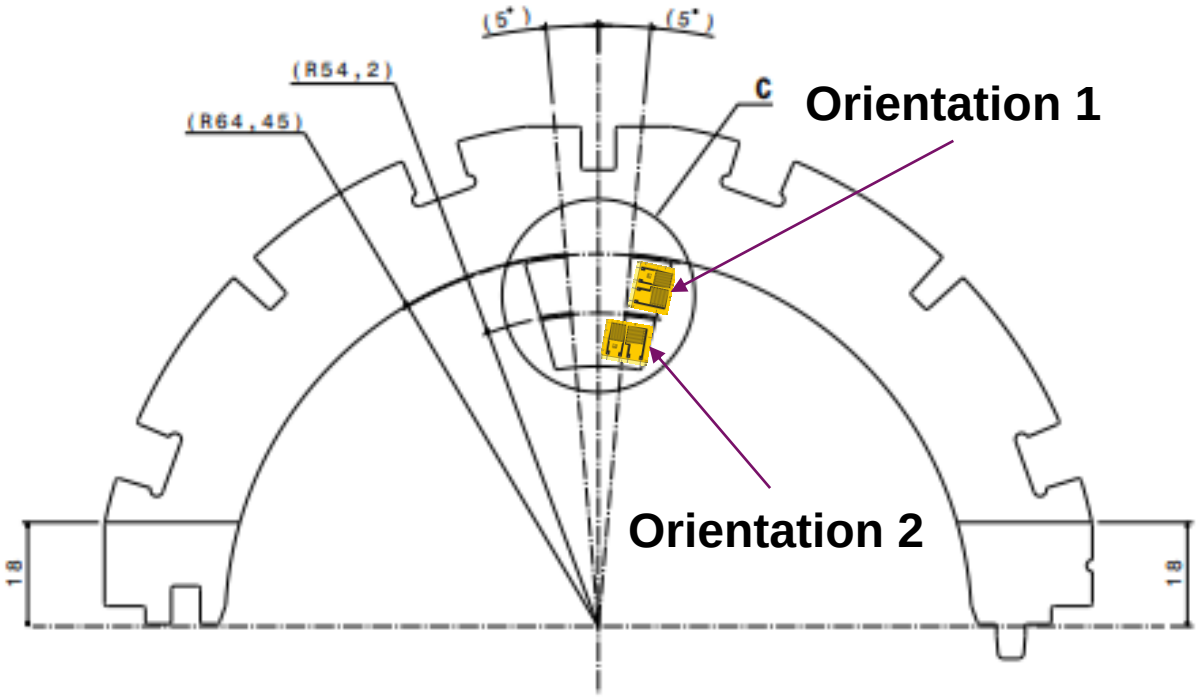
Path (m)	Step 1			Step 2			Step 3		
	ey (με)	ex (με)	ex/ey	ey (με)	ex (με)	ex/ey	ey (με)	ex (με)	ex/ey
0	-204,6	55,7	-27%	-137,0	37,2	-27%	-54,4	14,8	-27%
9,21E-04	-266,9	67,2	-25%	-190,8	48,7	-26%	-76,5	20,3	-26%
1,84E-03	-294,5	66,6	-23%	-216,3	49,6	-23%	-86,4	21,4	-25%
2,76E-03	-303,1	66,6	-22%	-224,6	50,0	-22%	-88,4	22,2	-25%
3,68E-03	-306,2	71,6	-23%	-228,1	54,2	-24%	-88,6	24,6	-28%
4,60E-03	-308,6	79,7	-26%	-231,3	60,8	-26%	-89,1	28,0	-31%
5,52E-03	-312,0	88,8	-28%	-235,6	68,2	-29%	-90,8	31,2	-34%
6,45E-03	-316,1	97,0	-31%	-241,2	74,9	-31%	-93,7	33,4	-36%
7,37E-03	-313,2	101,1	-32%	-242,5	78,9	-33%	-98,1	33,9	-35%
8,29E-03	-271,3	86,4	-32%	-214,1	68,2	-32%	-101,5	30,9	-30%
9,21E-03									
1,01E-02	-374,3	94,1	-25%	-291,9	73,4	-25%	-145,4	36,9	-25%
1,10E-02	-341,1	86,4	-25%	-264,1	67,1	-25%	-135,5	33,1	-24%
1,20E-02	-330,8	90,2	-27%	-255,8	70,3	-27%	-132,9	34,0	-26%
1,29E-02	-326,3	96,3	-30%	-252,7	75,2	-30%	-132,7	36,4	-27%
1,38E-02	-321,0	101,3	-32%	-248,5	78,7	-32%	-132,1	39,1	-30%
1,47E-02	-313,0	103,8	-33%	-241,8	80,1	-33%	-130,3	41,3	-32%
1,57E-02	-302,4	103,3	-34%	-232,4	78,8	-34%	-126,7	42,5	-34%
1,66E-02	-286,8	97,9	-34%	-219,0	74,0	-34%	-120,7	41,2	-34%
1,75E-02	-265,3	87,1	-33%	-200,9	65,8	-33%	-113,7	36,9	-32%
1,84E-02	-235,4	68,8	-29%	-170,7	50,6	-30%	-111,5	31,9	-29%
	-299,6	**85,5**	**-29%**	**-227,0**	**65,2**	**-29%**	**-107,4**	**31,7**	**-30%**

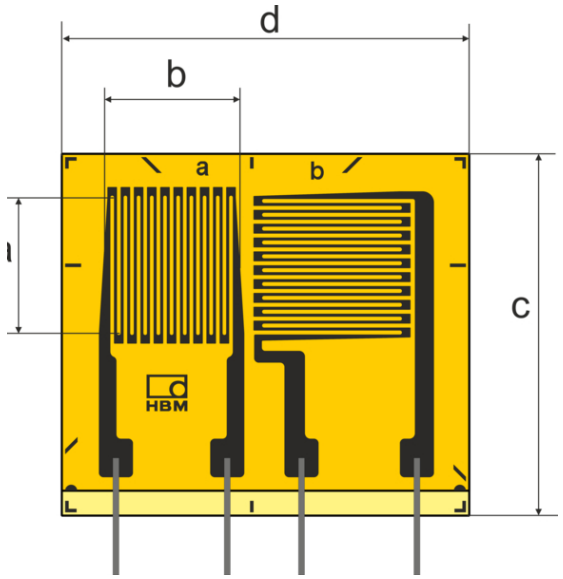
$$\sigma x=(E/(1-\nu^2))*(\varepsilon_x+\nu\varepsilon_y)$$

E	2,03E+11
ν	0,3

STRAIN GAGES

Orientation of the gages:



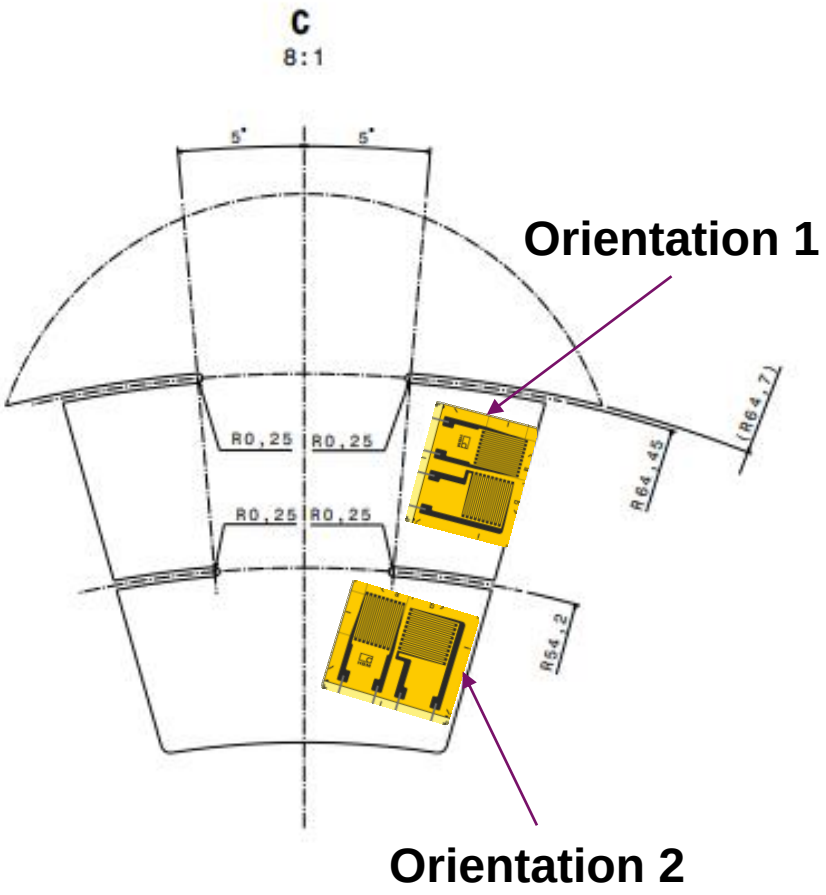


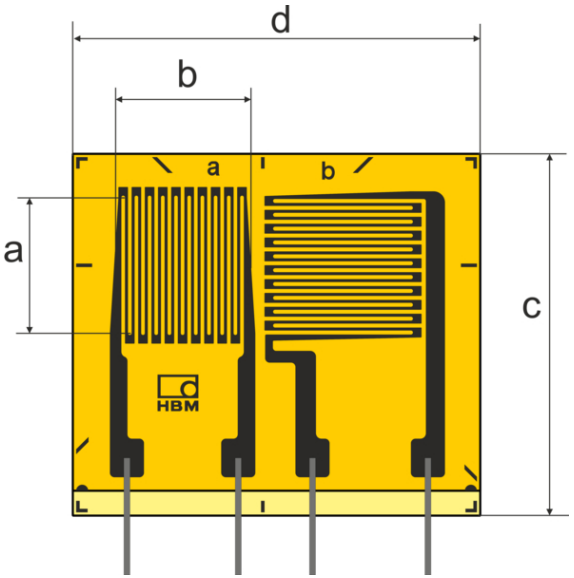
a	b	c
1,5 mm	1,5 mm	6 mm

1-XC11-1.5/350

STRAIN GAGES ORIENTATION

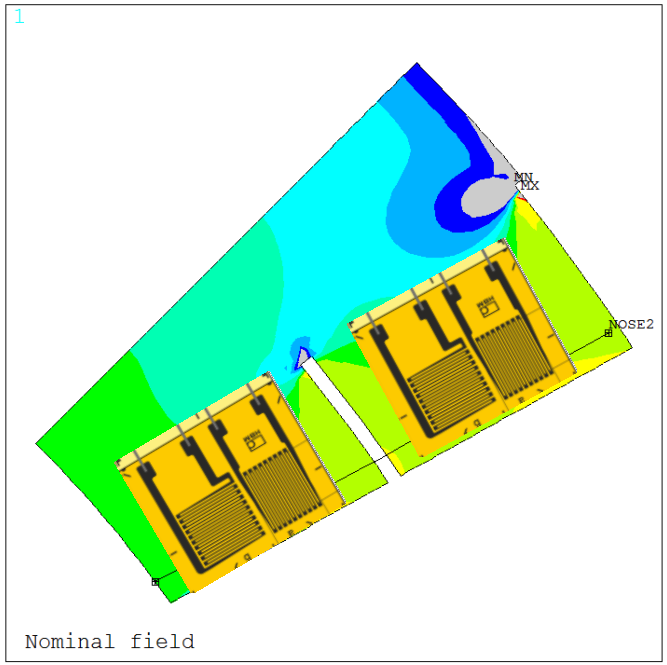
1-XC11-1.5/350





a	b	c
1,5 mm	1,5 mm	6 mm

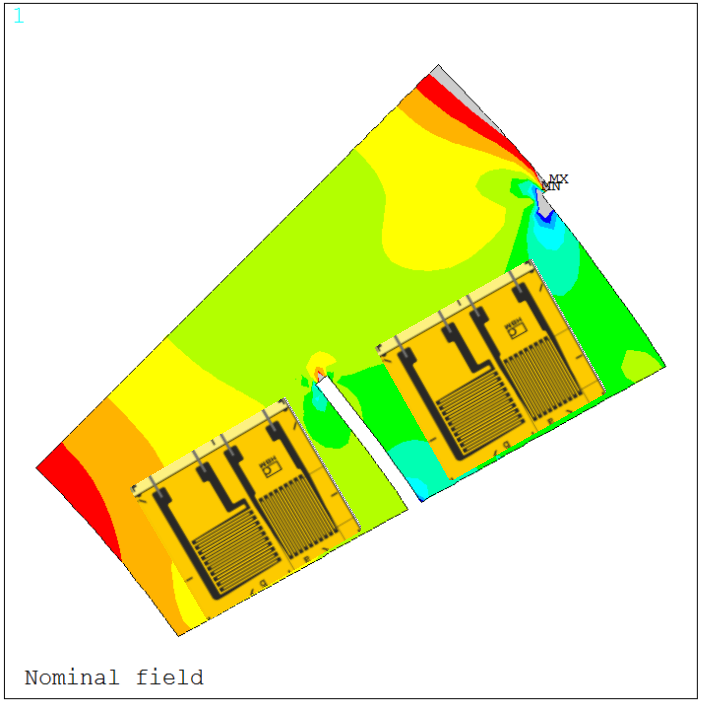
STRAIN GAGES ORIENTATION



ANSYS Release 18
Build 18.2
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
EPTOX (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.449E-03
SMN =-.323E-03
SMX =.146E-03
PATH

-.624E-04
-.450E-04
-.276E-04
-.103E-04
.711E-05
.245E-04
.419E-04
.592E-04
.766E-04
.940E-04

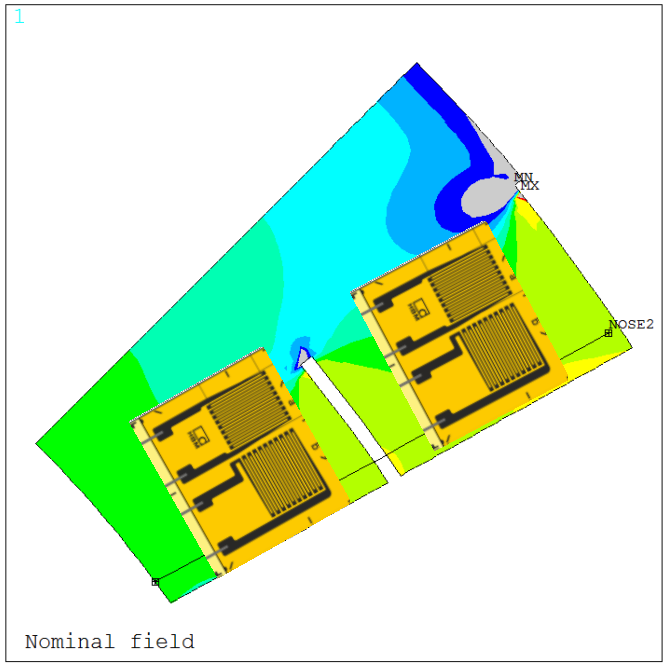
Strain Gages parallel to the pole



ANSYS Release 18
Build 18.2
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
EPTOY (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.449E-03
SMN =-.345E-03
SMX =.227E-03

-.218E-03
-.197E-03
-.176E-03
-.154E-03
-.133E-03
-.112E-03
-.909E-04
-.697E-04
-.485E-04
-.273E-04

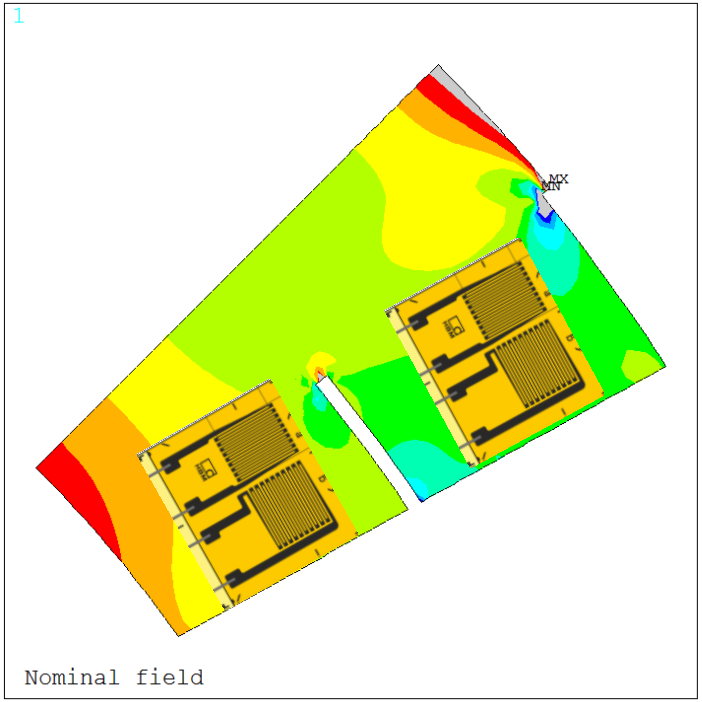
STRAIN GAGES ORIENTATION



ANSYS Release 18
Build 18.2
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
EPTOX (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.449E-03
SMN =-.323E-03
SMX =.146E-03
PATH

-.624E-04
-.450E-04
-.276E-04
-.103E-04
.711E-05
.245E-04
.419E-04
.592E-04
.766E-04
.940E-04

Strain Gages perpendicular to the pole

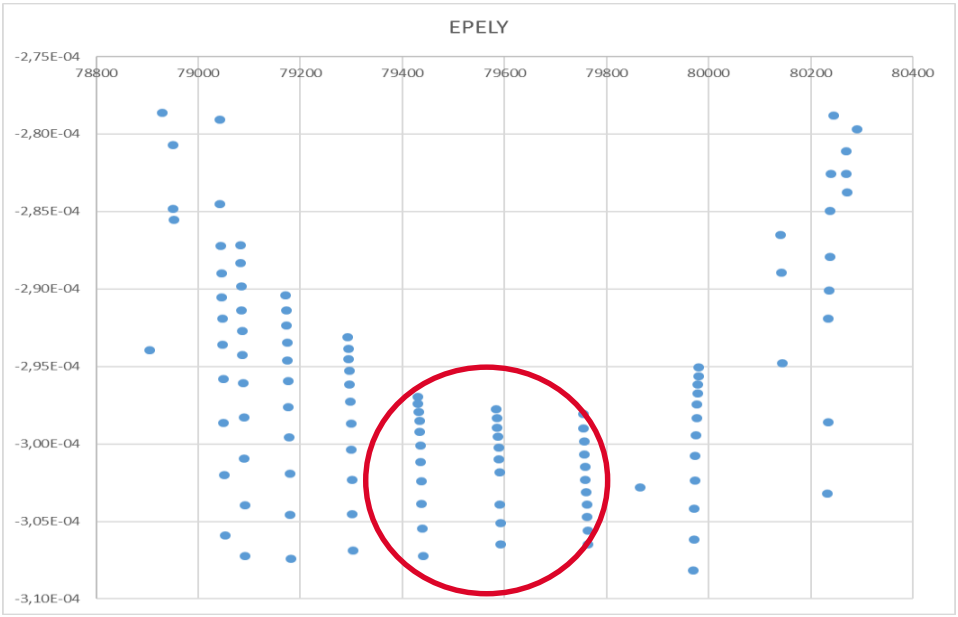


ANSYS Release 18
Build 18.2
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
EPTOY (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX =.449E-03
SMN =-.345E-03
SMX =.227E-03

-.218E-03
-.197E-03
-.176E-03
-.154E-03
-.133E-03
-.112E-03
-.909E-04
-.697E-04
-.485E-04
-.273E-04

STRAIN GAGES ORIENTATION

Time 1 (layer 1)

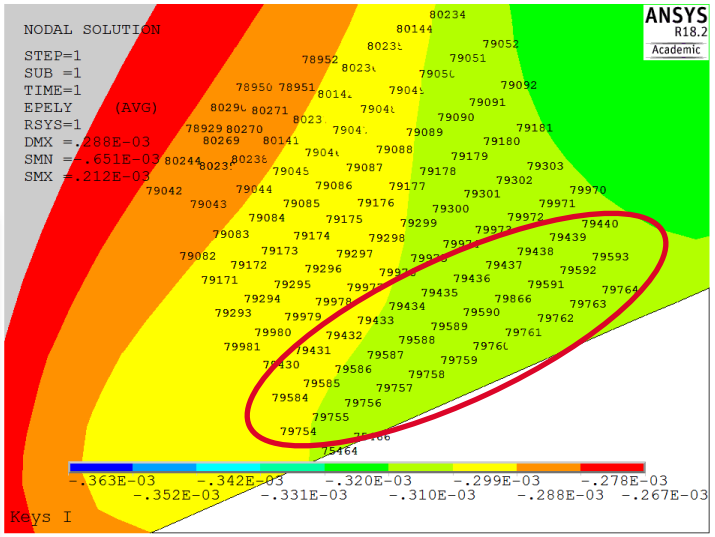


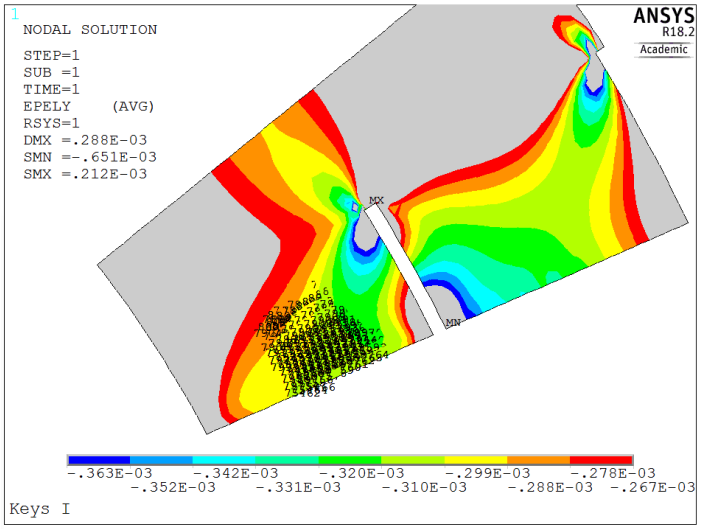
Nodes

Strain max: - 297 με

Strain min: - 307 με

Strain mean: - 302 με





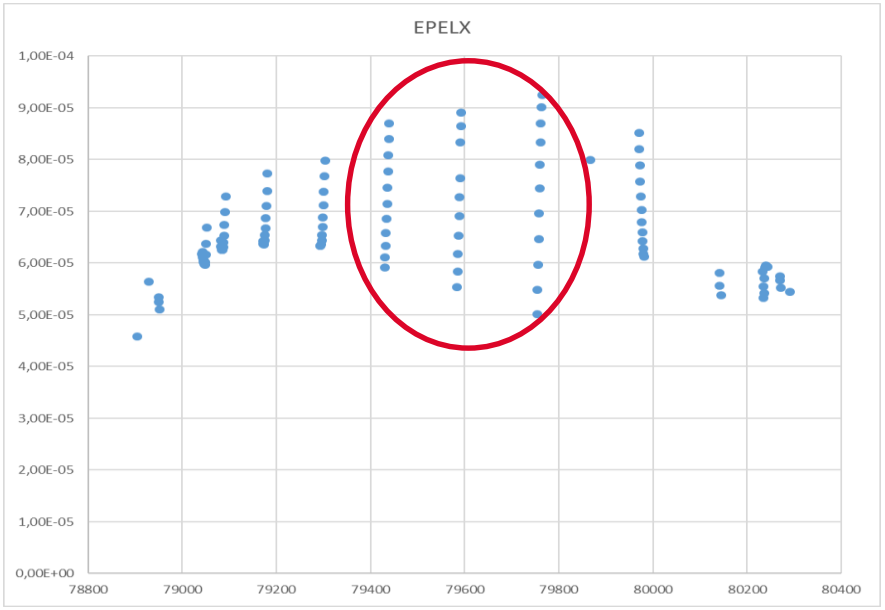
STRAIN GAGES ORIENTATION

Time 1 (layer 1)

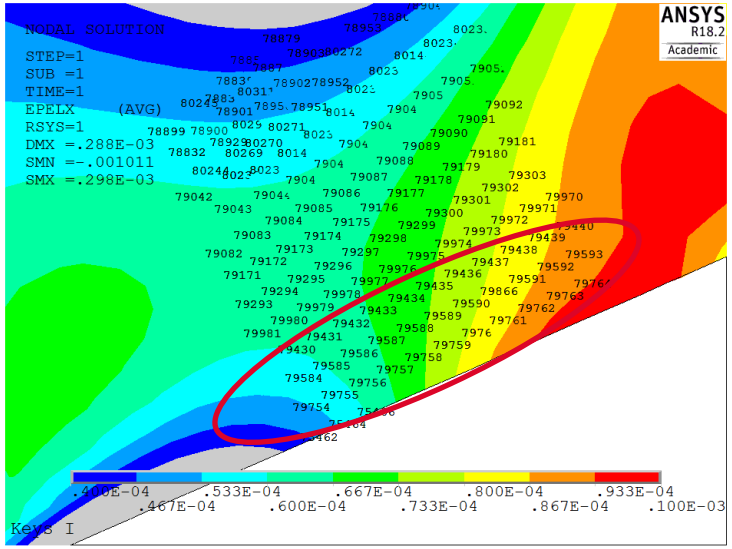
Strain max: 92 με

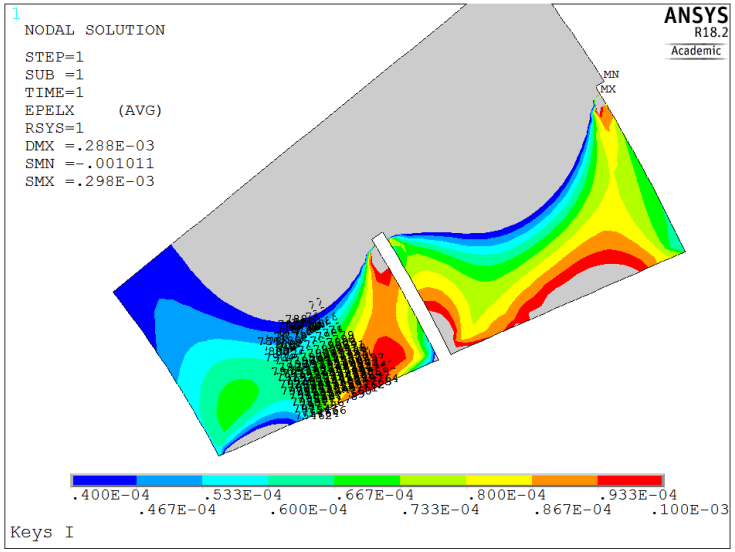
Strain min: 48 με

Strain mean: 70 με



Nodes





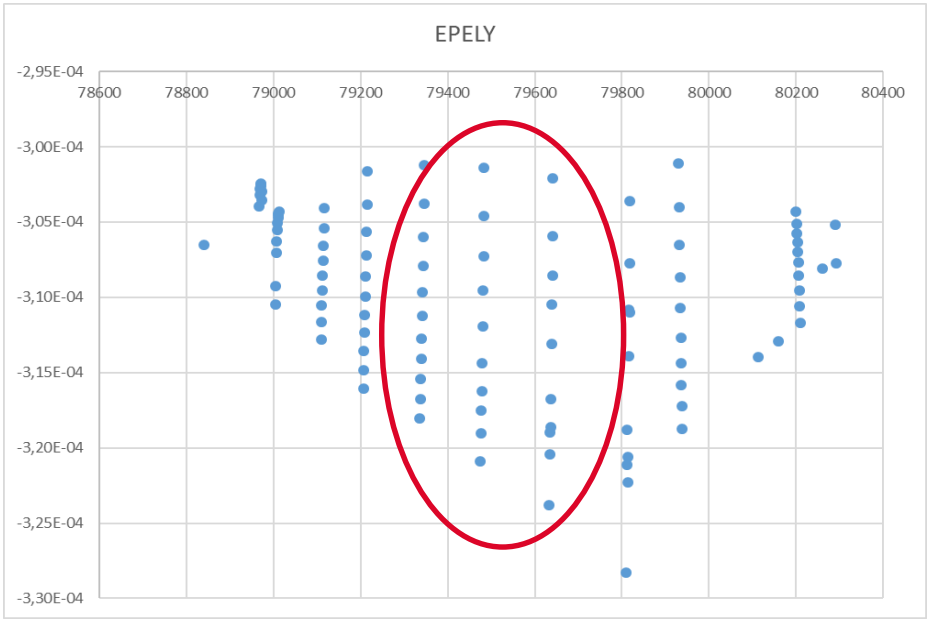
STRAIN GAGES ORIENTATION

Time 1 (layer 2)

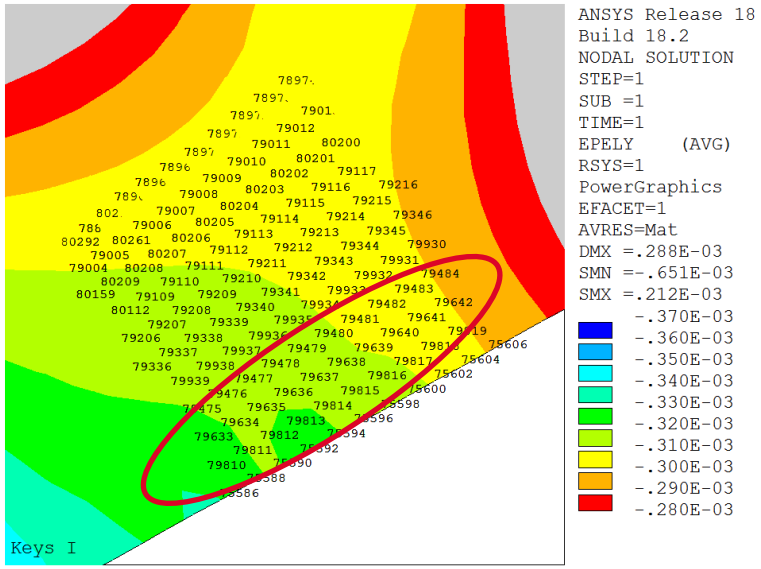
Strain max: - 300 με

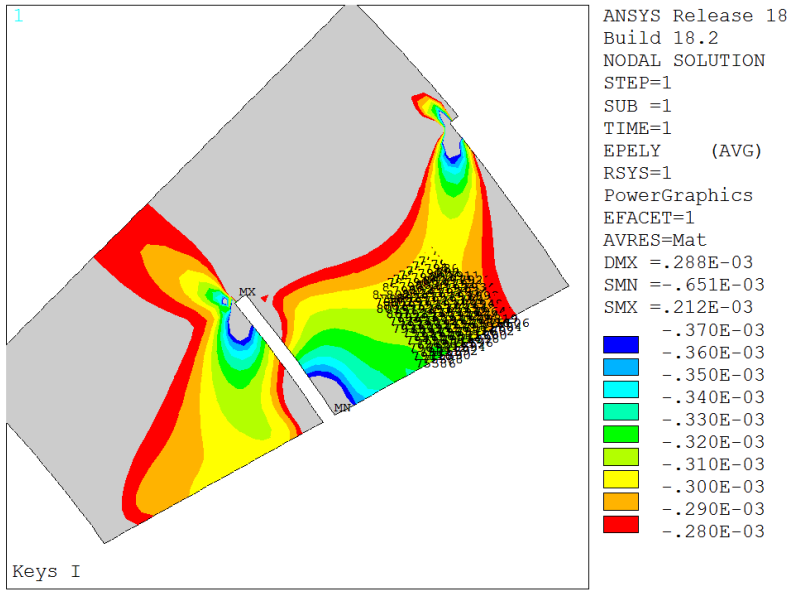
Strain min: - 320 με

Strain mean: - 310 με



Nodes





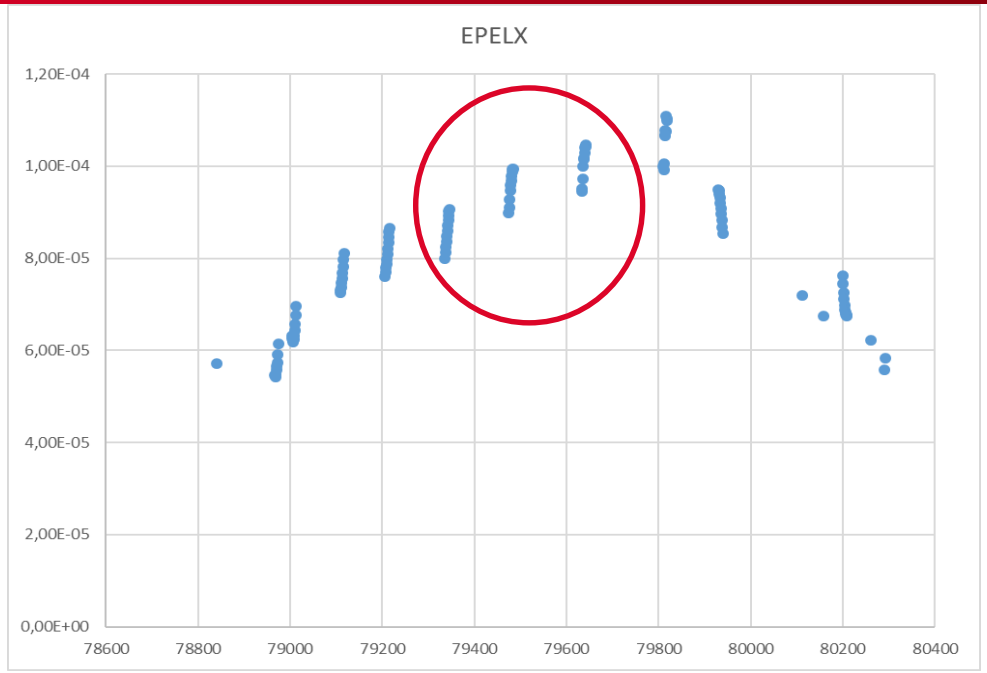
STRAIN GAGES ORIENTATION

Time 1 (layer 2)

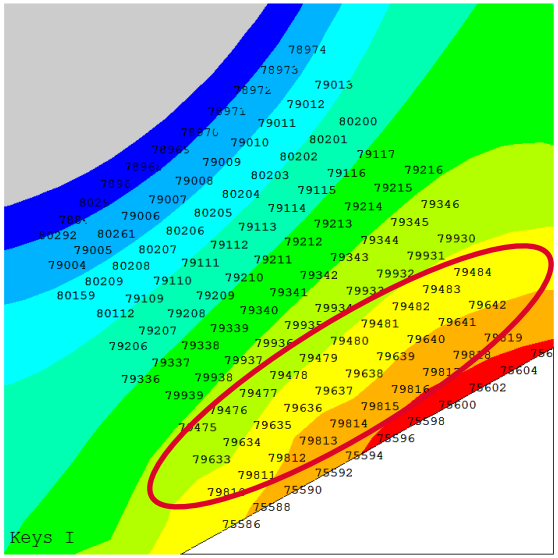
Strain max: 105 με

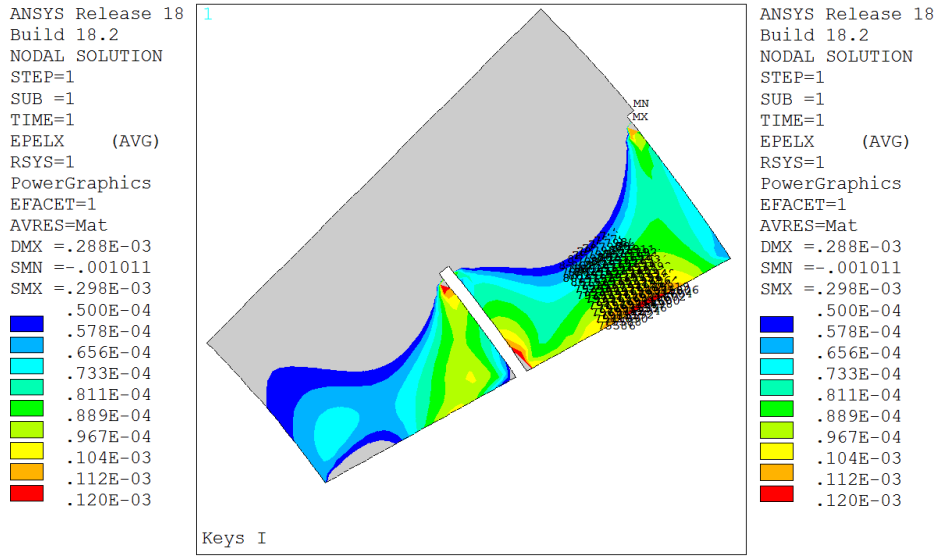
Strain min: 80 με

Strain mean: 92 με



Nodes





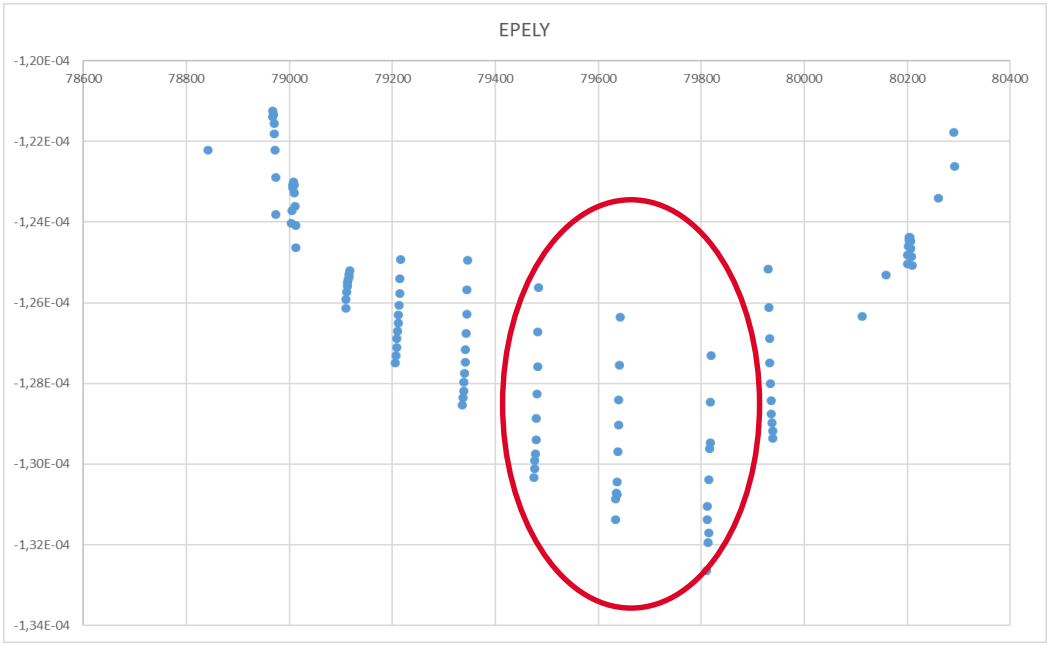
STRAIN GAGES ORIENTATION

Time 3 (layer 2)

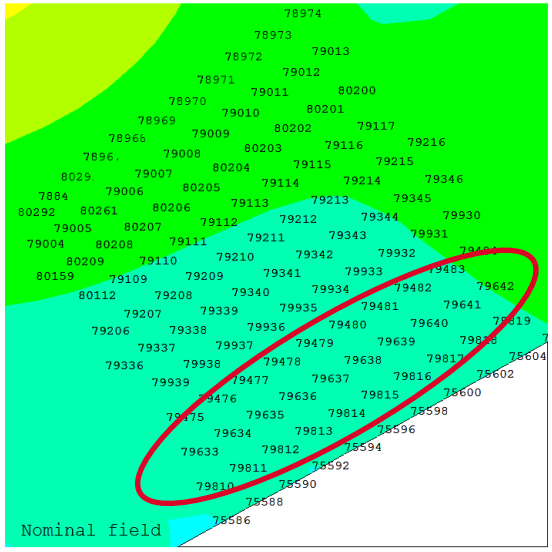
Strain max: - 125 με

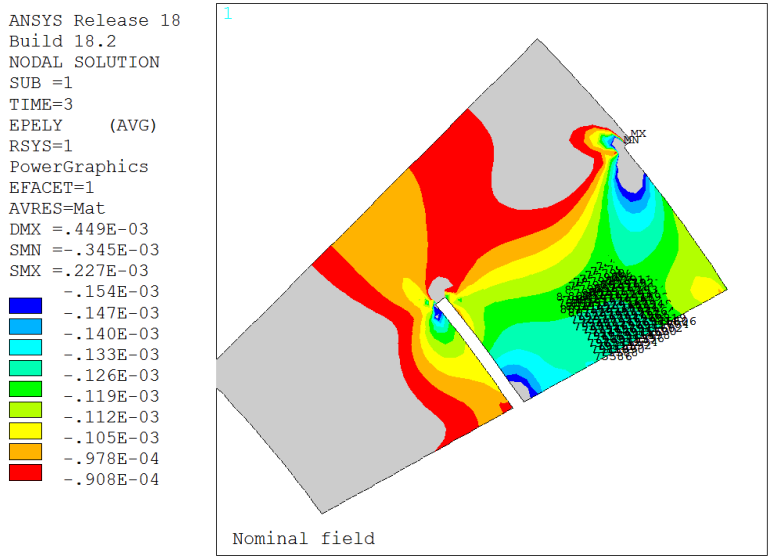
Strain min: - 133 με

Strain mean: - 129 με



Nodes





STRAIN GAGES ORIENTATION

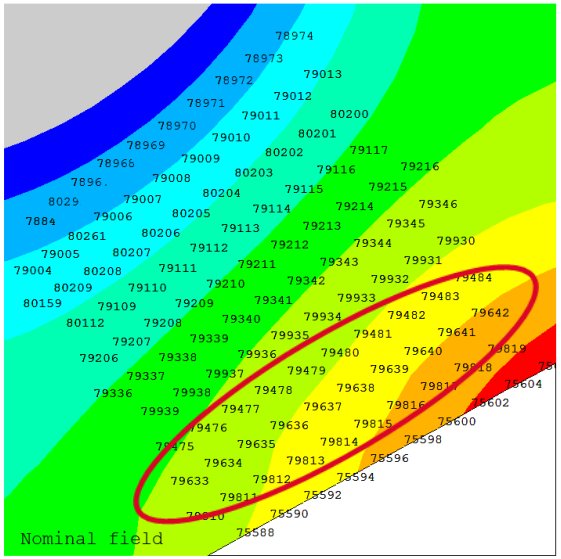
Time 3 (layer 2)

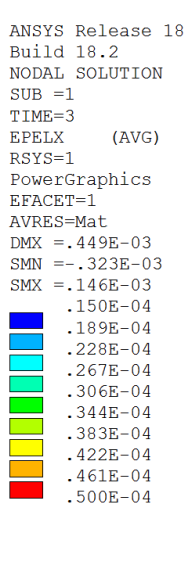
Strain max: 45 με

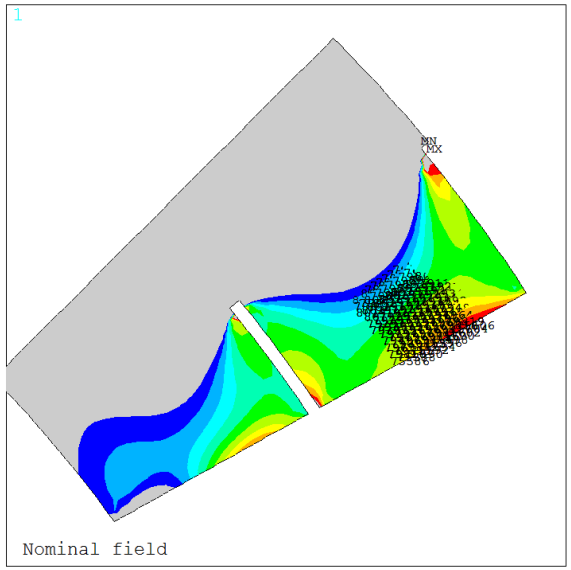
Strain min: 35 με

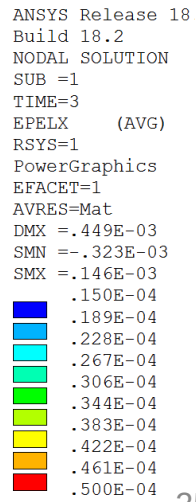
Strain mean: 40 με

Nodes



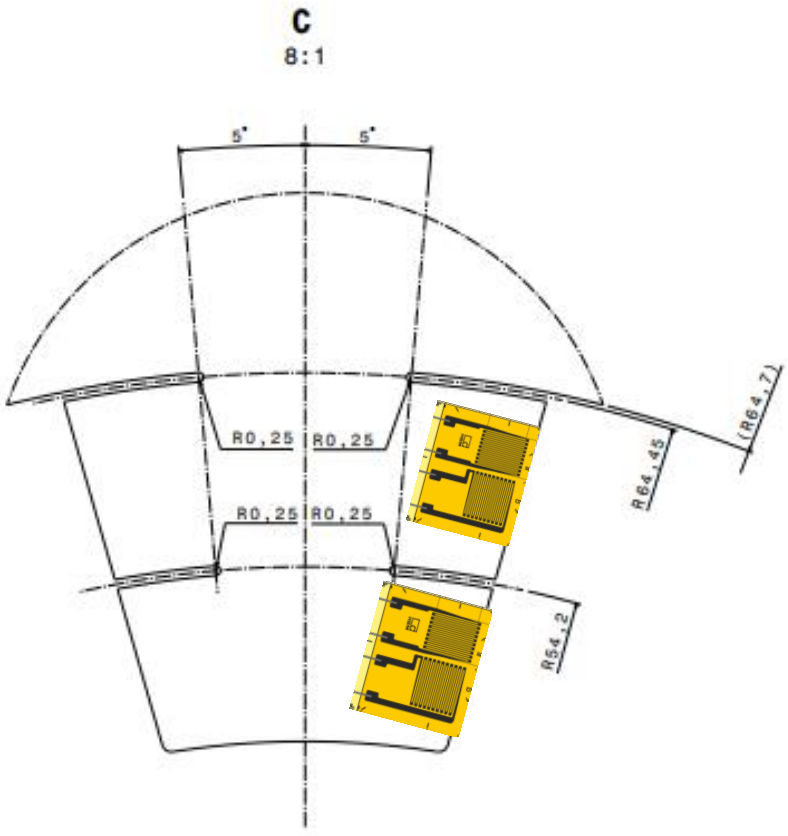






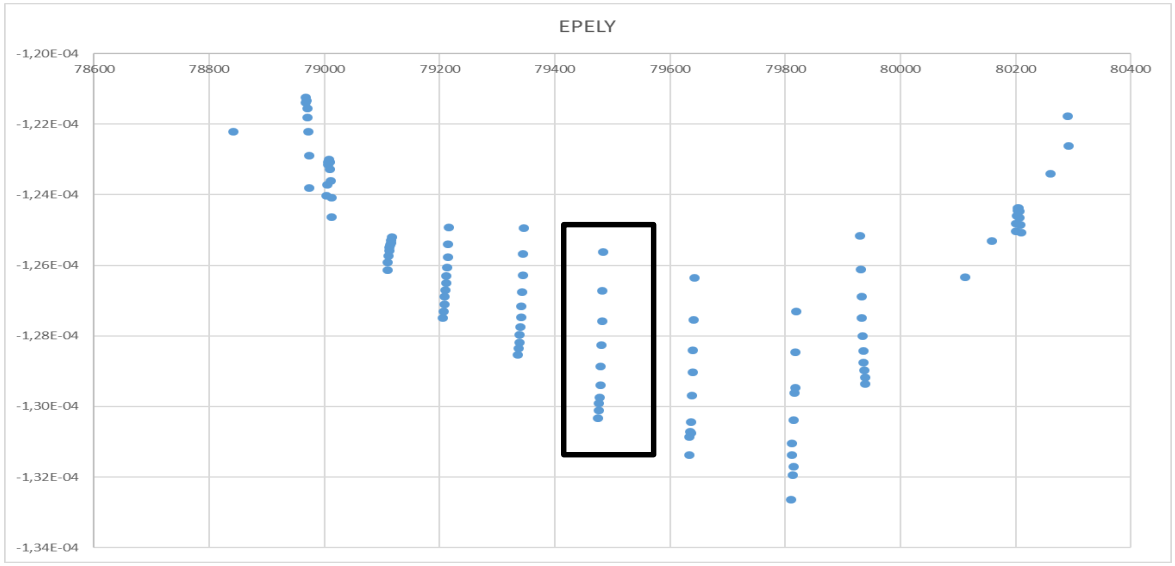
STRAIN GAGES ORIENTATION

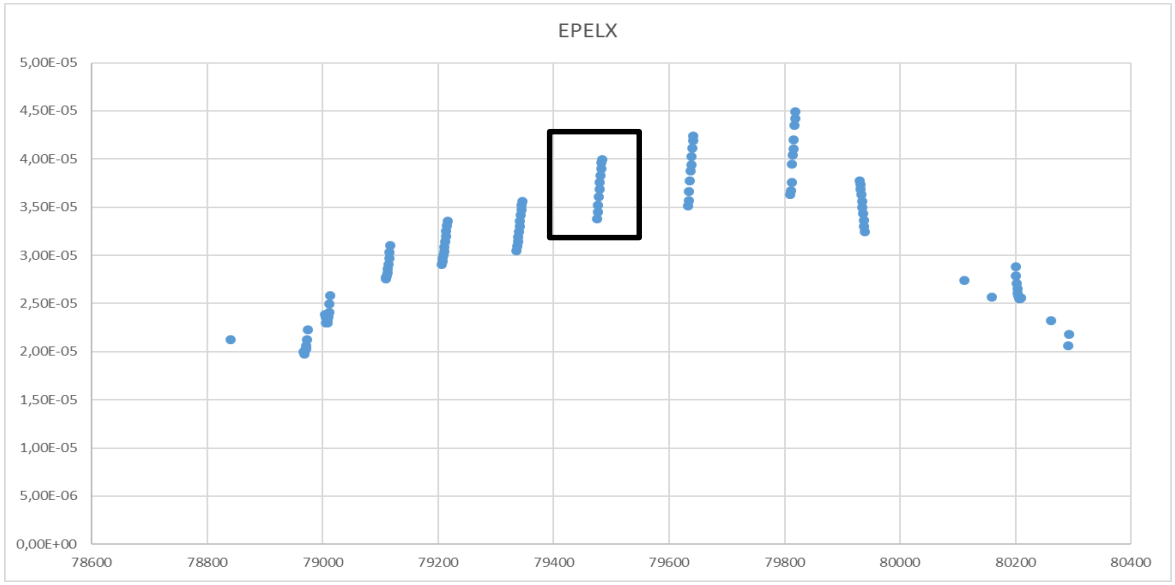
BEST SOLUTION:
Solution 1

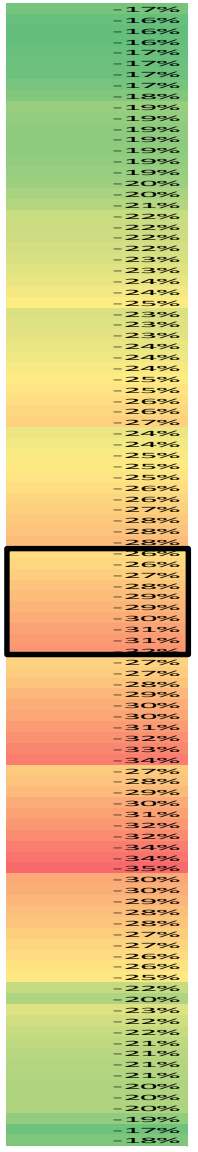


STRAIN GAGES ORIENTATION

Time 3 (layer 2)







30%