Simulation of FDC wire and cathode deformation

Using ansys program

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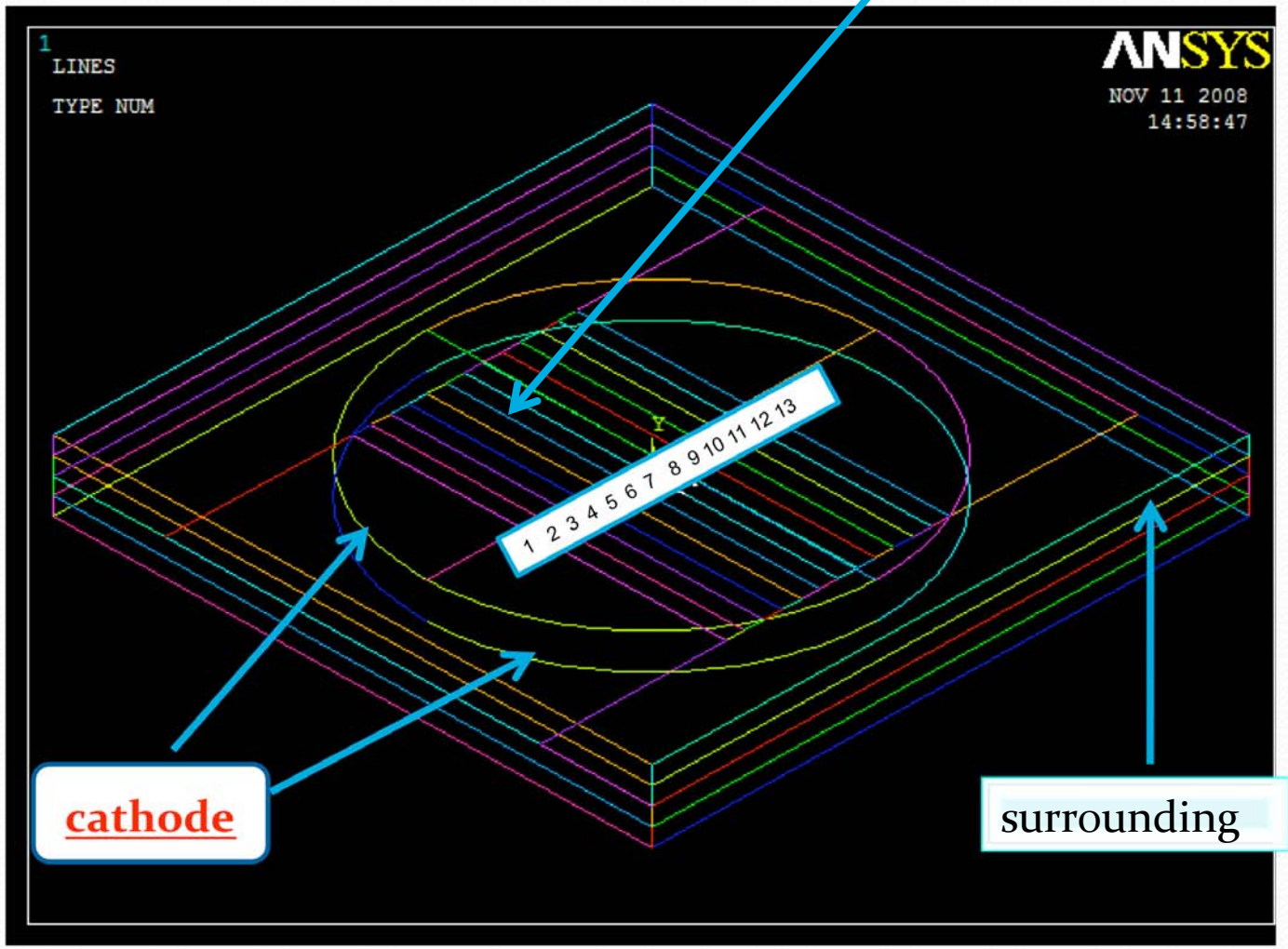
Outline

- Model of FDC
- Material properties
- Result of simulation
- 1. capacitance of wires and strips
- 2.wire deformed due to self weight
- 3.wire and cathode deformed due to electrostatic forces

Model of FDC

wire
- 1,3,5,7,9,11,13 field wire
- 2,4,6,8,10,12 sense sire



Model of FDC

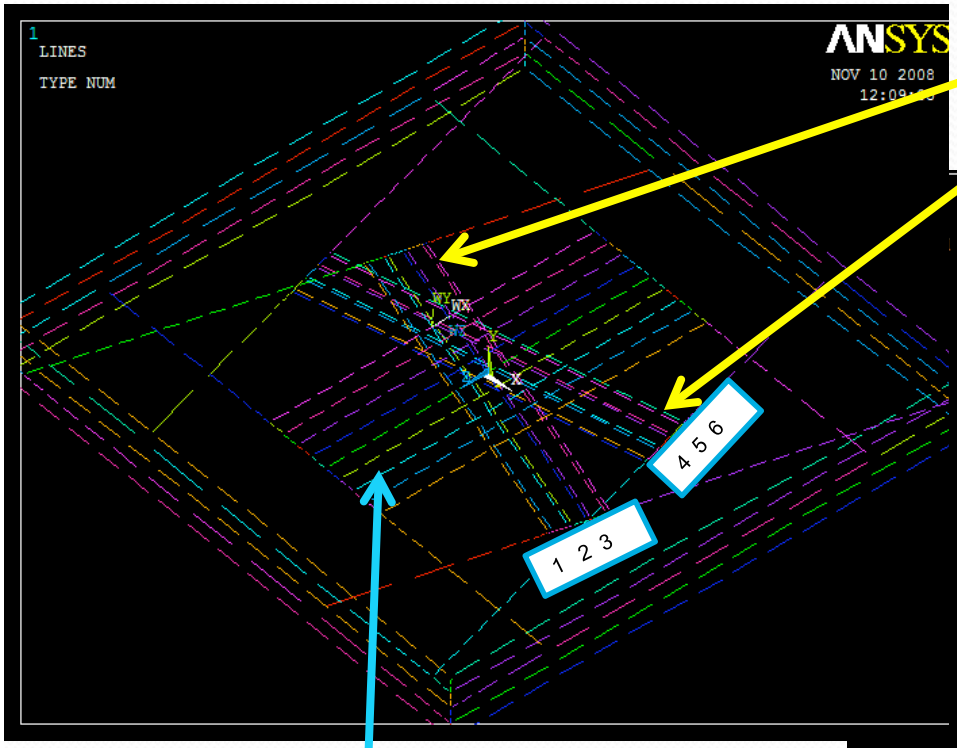
- Wire: length=100mm distance between=5 mm
  radius1=0.01 mm(sense wire)
  radius2=0.04 mm(field wire)
- Cathode radius=60 mm, thickness=5 micron or 2 micron
- Distance between wire and cathode=5 mm

Material properties

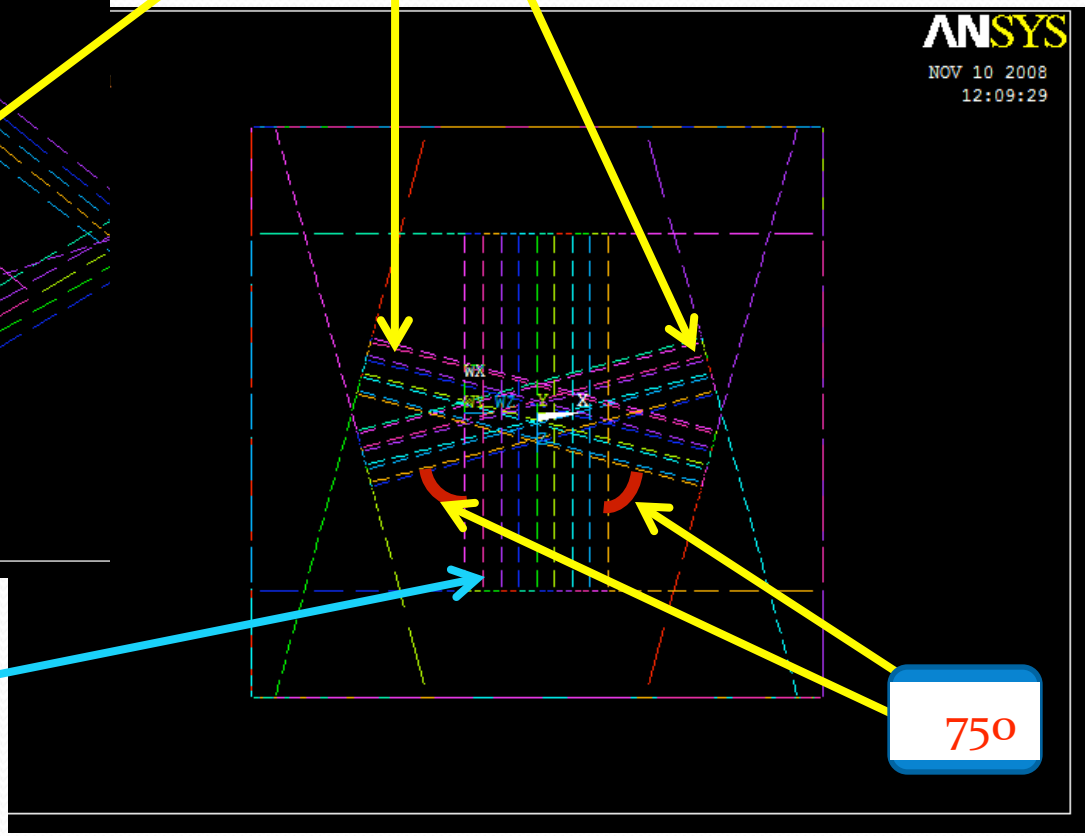
- Wire: tungsten
  - Young's modulus 411 GPa
  - Poisson ratio 0.28
- Cathode :copper
  - Young's modulus 128 GPa
  - Poisson ration 0.34
- relative permittivity $\varepsilon_r = 1$

Result of simulation

capacitance



Cathode



Wire

7,8,9,10 ,11,12,13,14,15

Capacitance

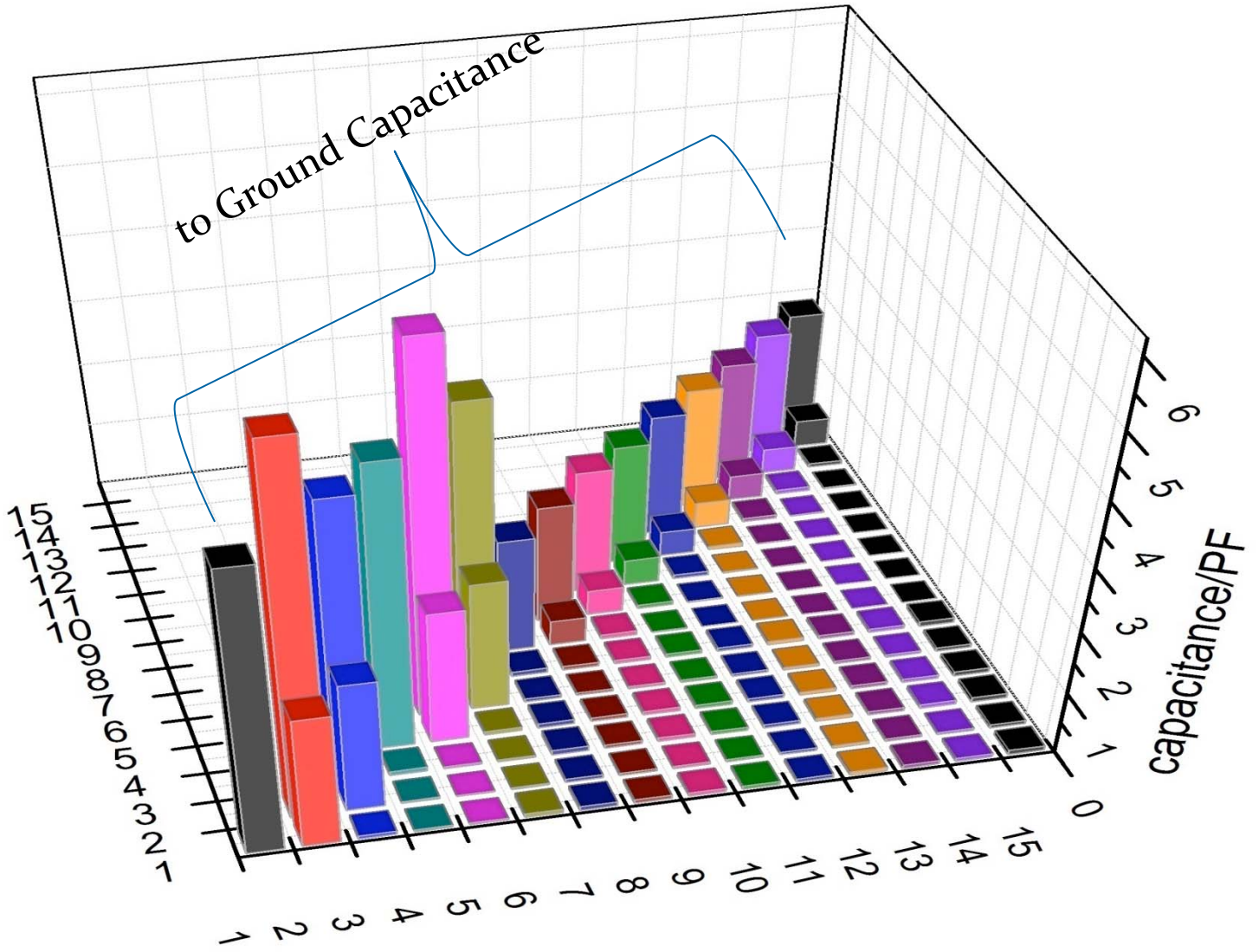
- Mutual Capacitance between conductors

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	4.4779	2.0964	0.052203	0.032451	0.026524	0.063505	0.066314	0.057266	0.053846	0.055205	0.05289	0.055494	0.055629	0.056885	0.072002
2		5.7634	2.0788	0.027286	0.013845	0.02758	0.050836	0.037623	0.037246	0.034318	0.039686	0.036563	0.037378	0.036238	0.05136
3			4.4546	0.064335	0.027338	0.031104	0.07347	0.055463	0.058306	0.055141	0.053664	0.051264	0.052454	0.056279	0.067345
4				4.4945	2.117	0.050285	0.07163	0.057735	0.05624	0.055191	0.054425	0.052401	0.054648	0.053032	0.067722
5					5.7702	2.0631	0.050947	0.037825	0.036747	0.03683	0.03817	0.035531	0.036921	0.038406	0.051401
6						4.4407	0.066826	0.056571	0.055426	0.052898	0.054005	0.055247	0.054858	0.059076	0.074344
7							1.8325	0.40009	0.06634	0.012366	0.003079	0.00074	0.000198	5.27E-05	1.33E-05
8								1.8794	0.39831	0.049126	0.012525	0.002722	0.00066	0.000171	4.3E-05
9									1.9654	0.40789	0.059638	0.011865	0.002727	0.000707	0.000185
10										1.9072	0.39631	0.053678	0.012136	0.002955	0.000698
11											1.9413	0.4111	0.054	0.012116	0.002644
12												1.9276	0.3929	0.062169	0.012419
13													1.8984	0.39421	0.057675
14														1.95	0.42906
15															1.8634

to Ground Capacitance

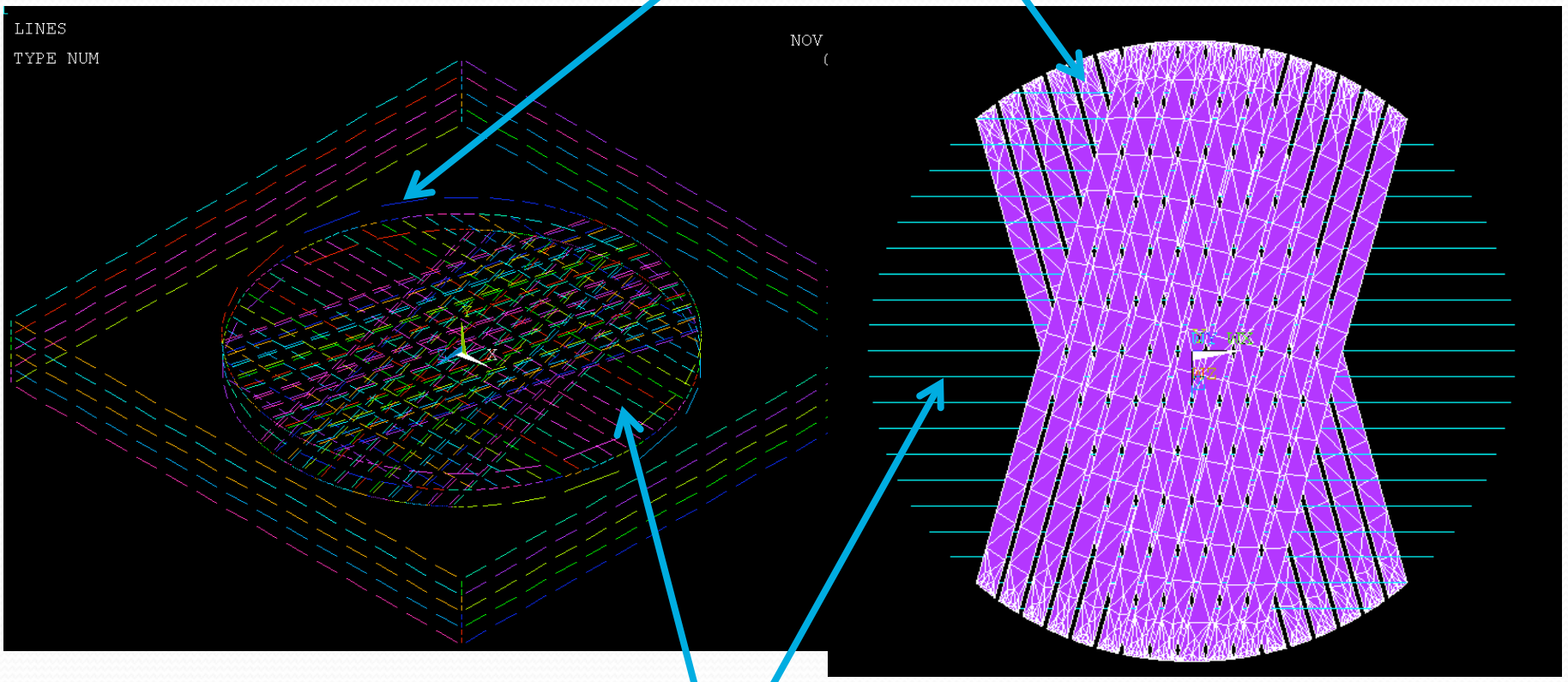
Unit pF

Capacitance



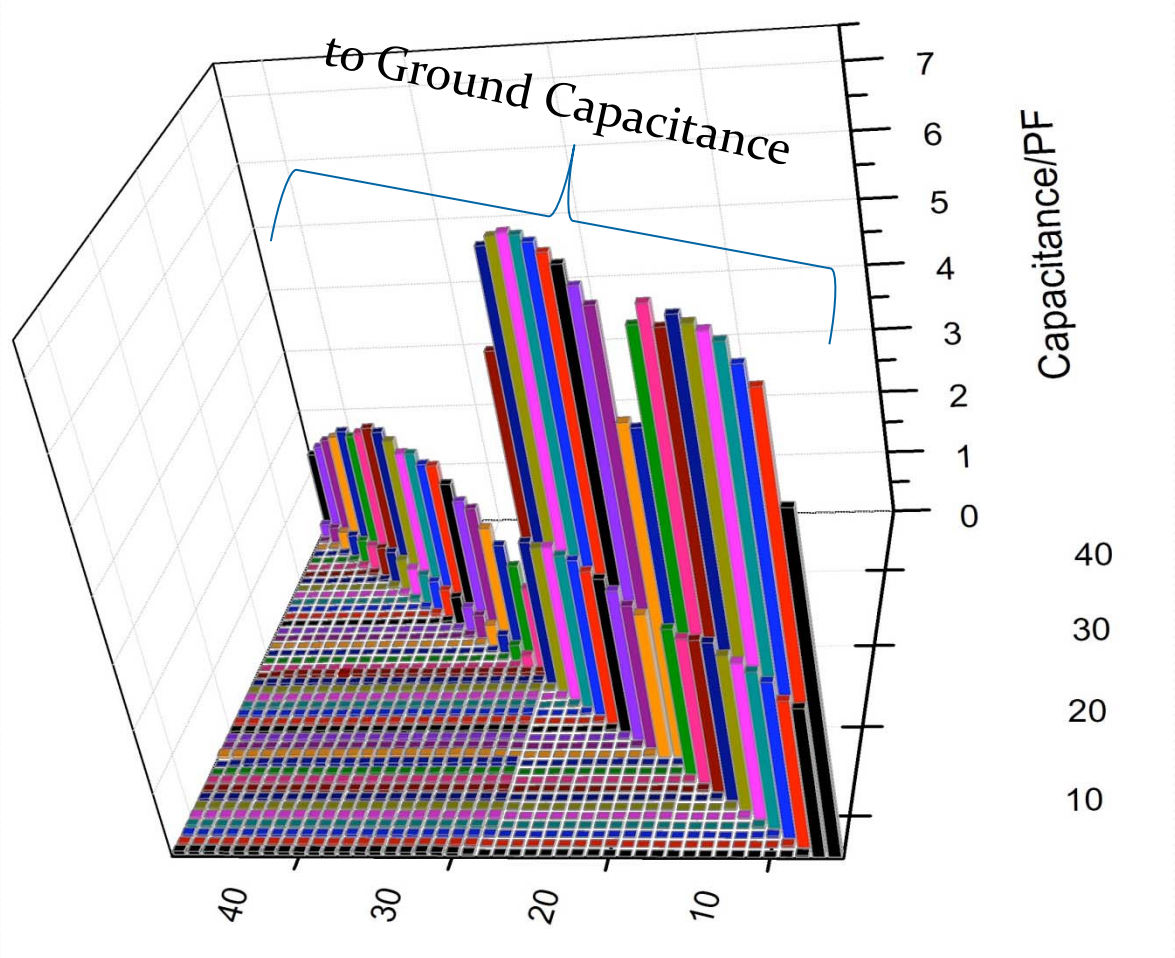
capacitance

Strips
No.: from 1 to 22



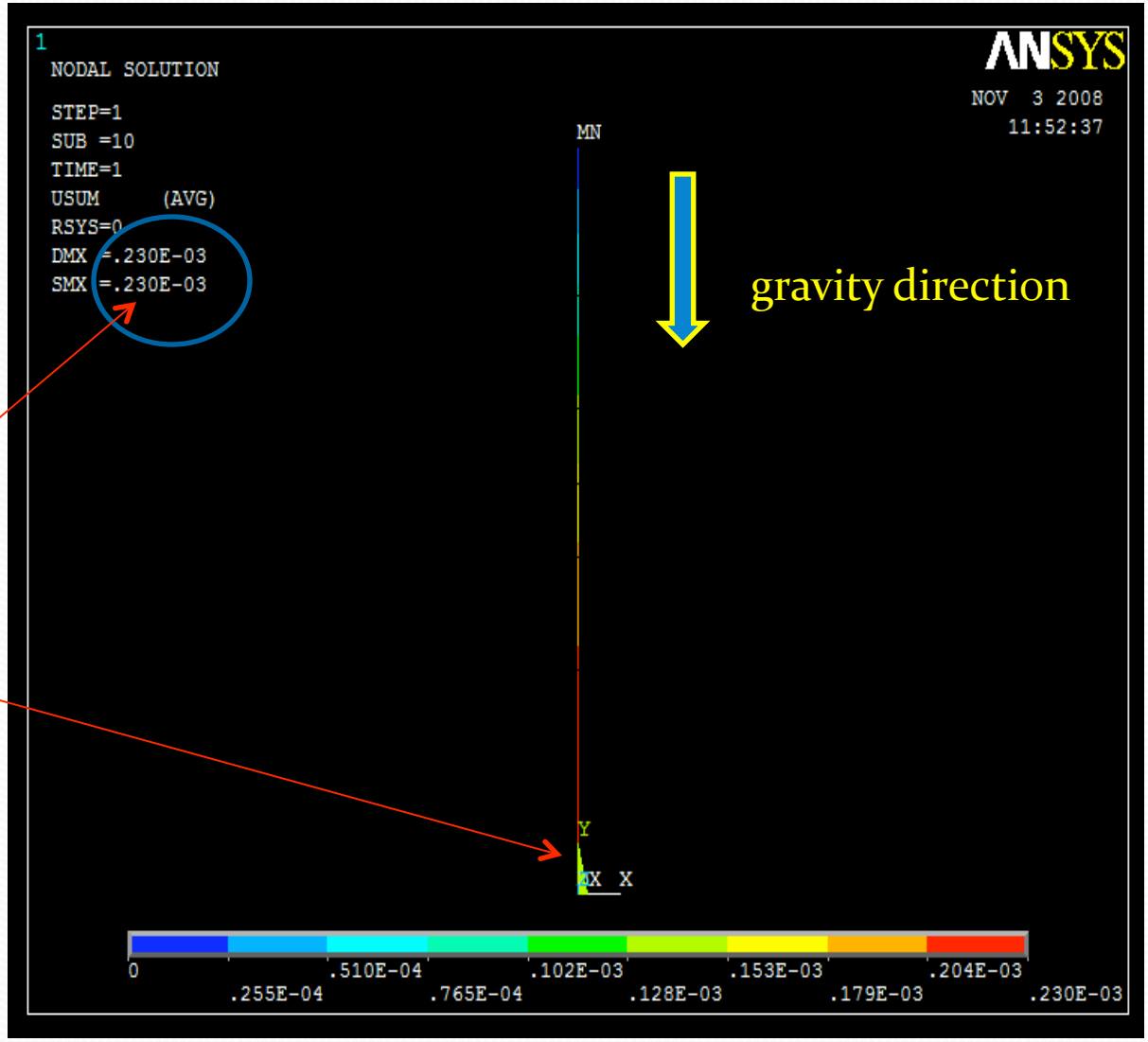
Wire
No.: from 23 to 43

Mutual Capacitance between conductors



wire deformed by its own weight

Material: tungsten
Length=1000mm
Radius=0.01mm
Density=19.25g.cm^{-3}



Max. =0.23e-3mm

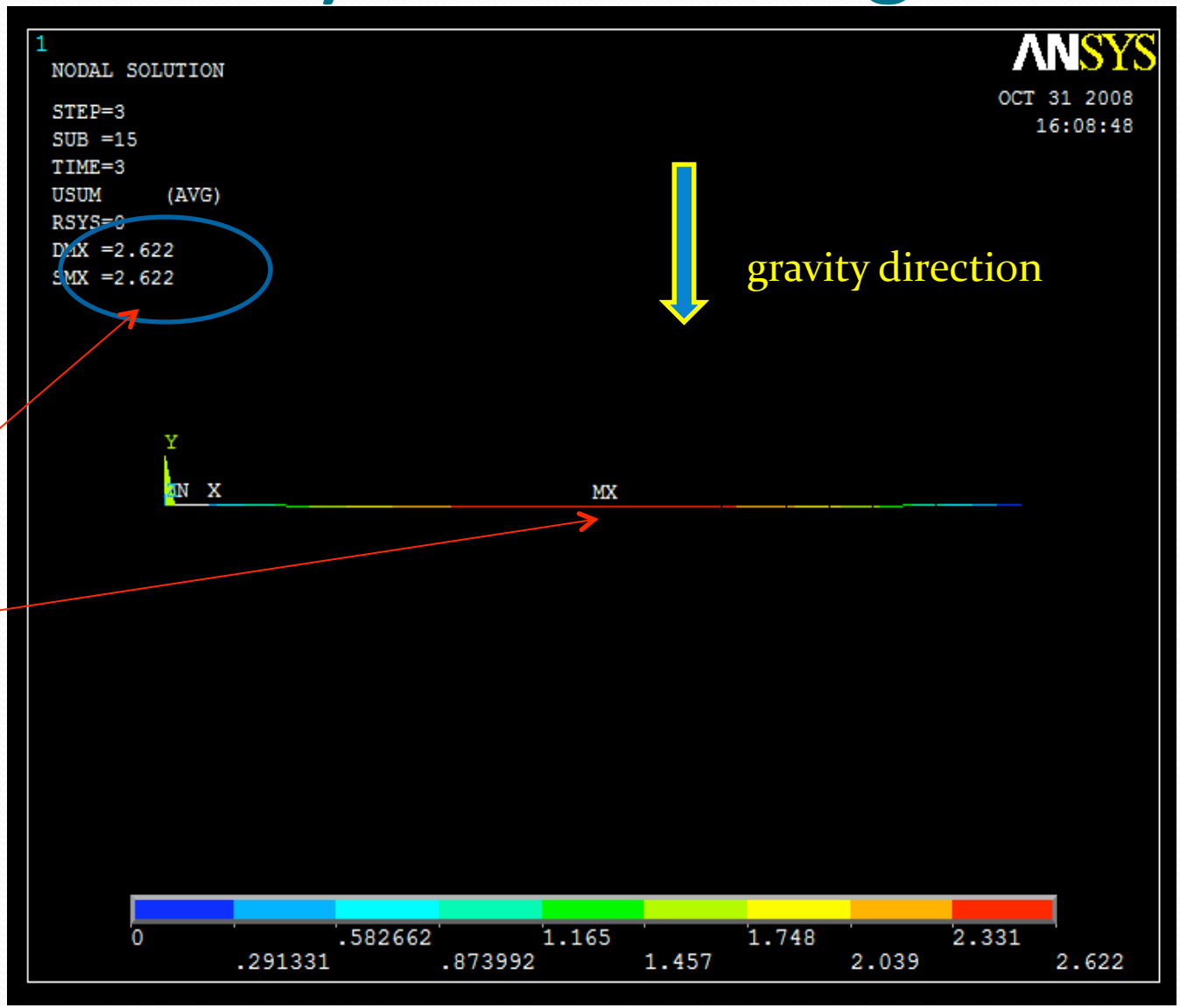
wire deformed by its own weight

Material: tungsten

Length=1000mm

Radius=0.01mm

Density=19.25g.cm^{-3}

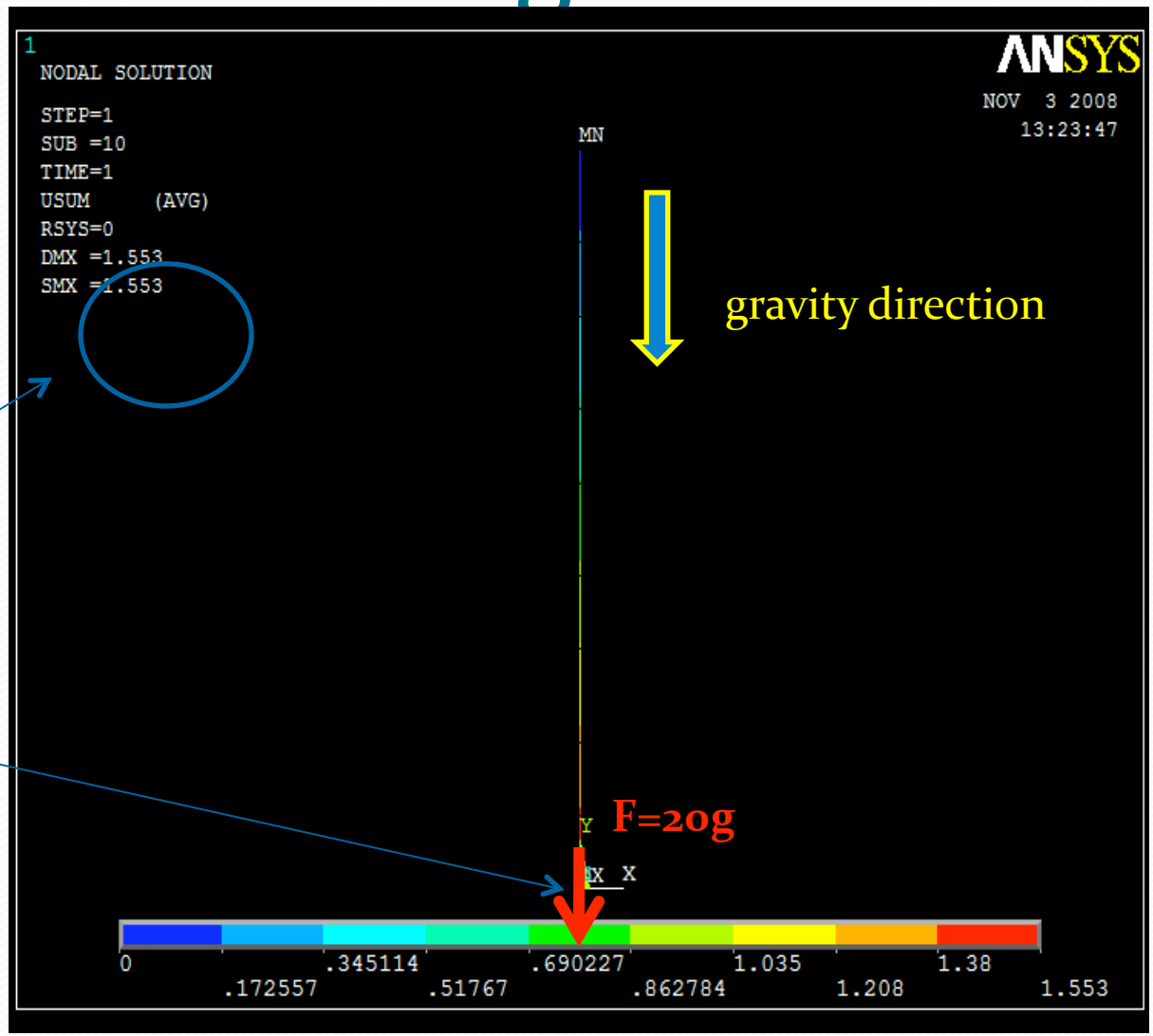


Max.=2.6mm

wire deformed at20g tension

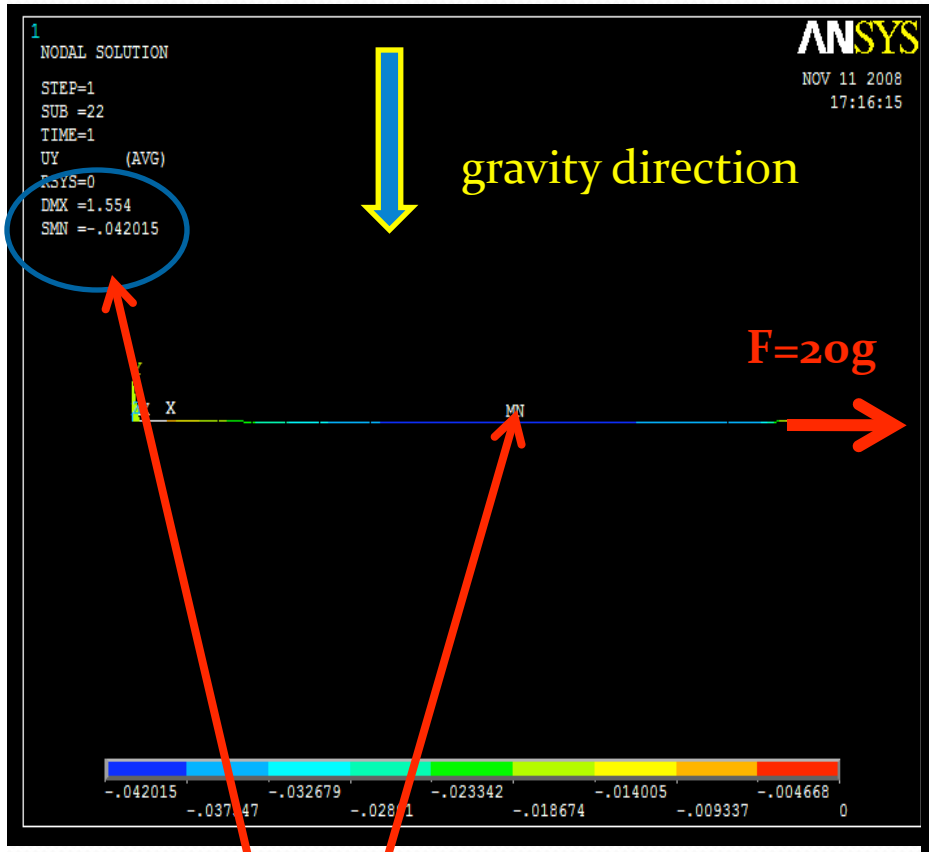
Material: tungsten
Length=1000mm
Radius=0.01mm
Density=19.25g.cm^{-3}

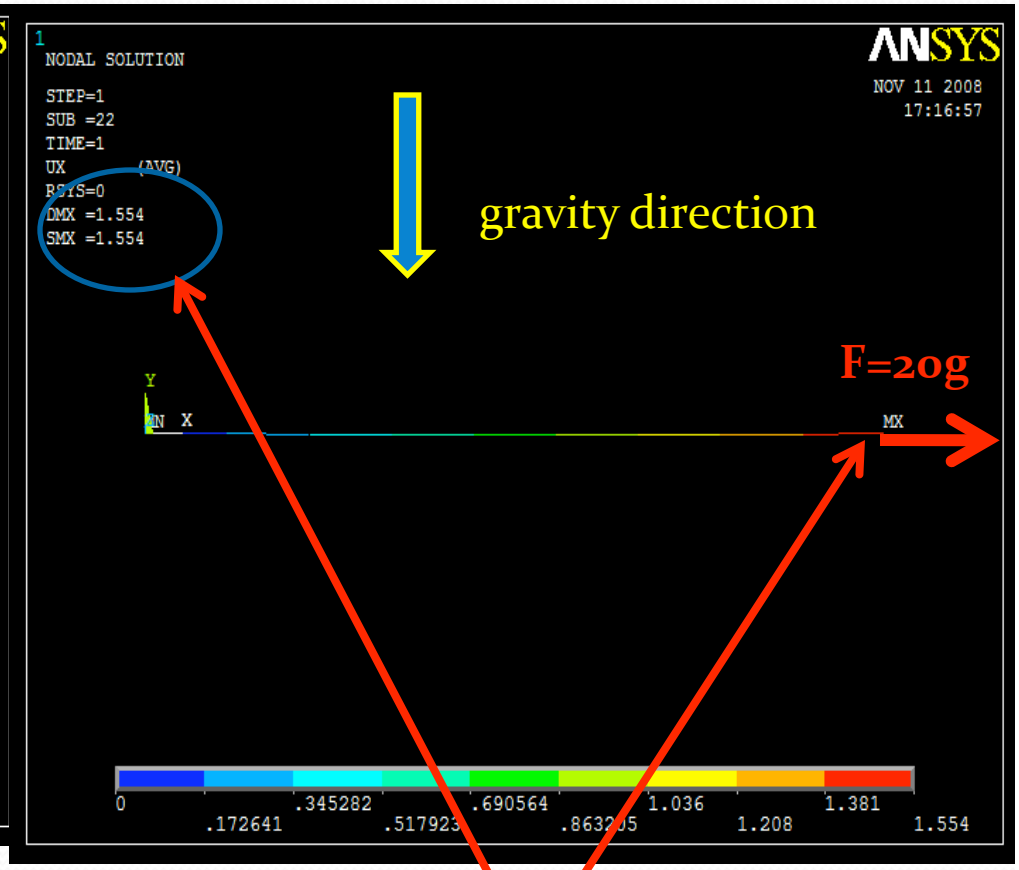
Max.=1.5mm



wire deformed at 20g tension

- Material: tungsten Length=1000mm Radius=0.01mm Density=19.25g.cm^{-3}

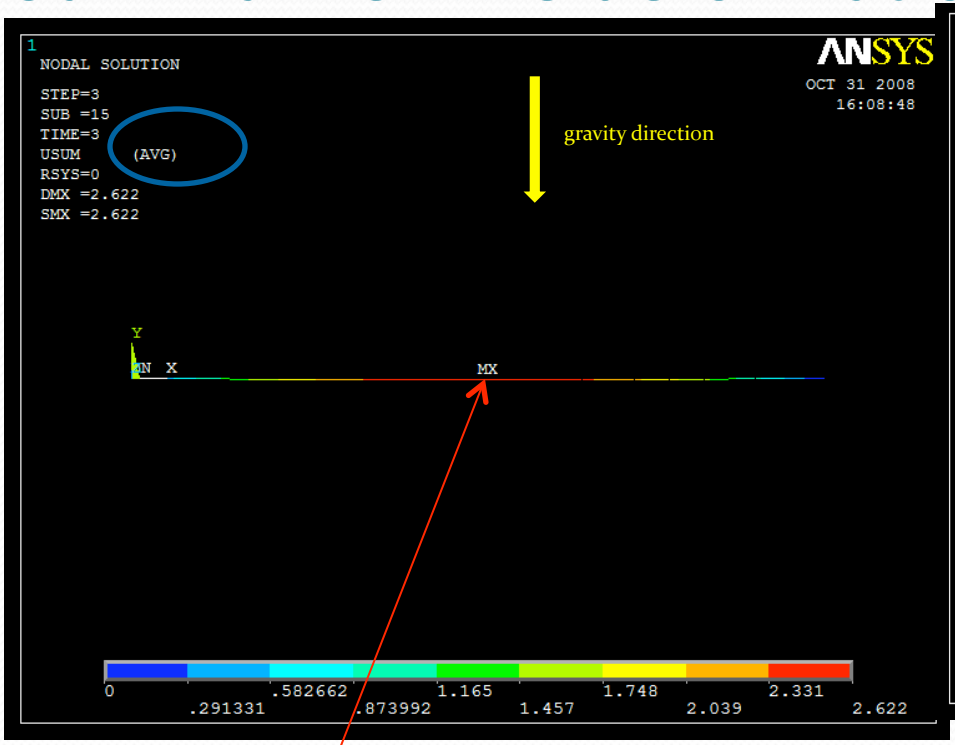


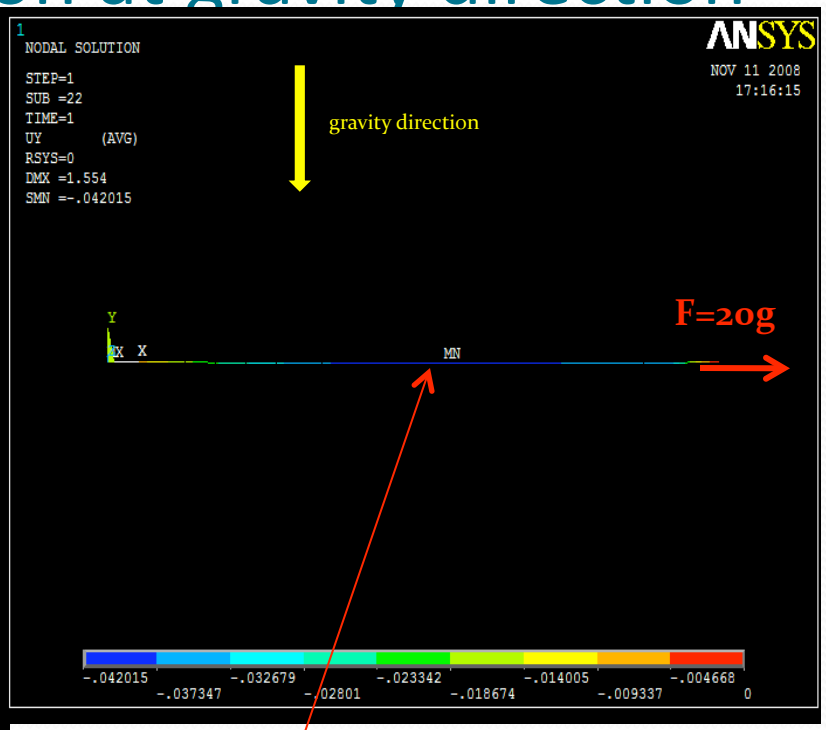


Deformation in Y direction
max.=0.04mm

Deformation in X direction
max.=1.554mm

Summarize wire deformation at gravity direction





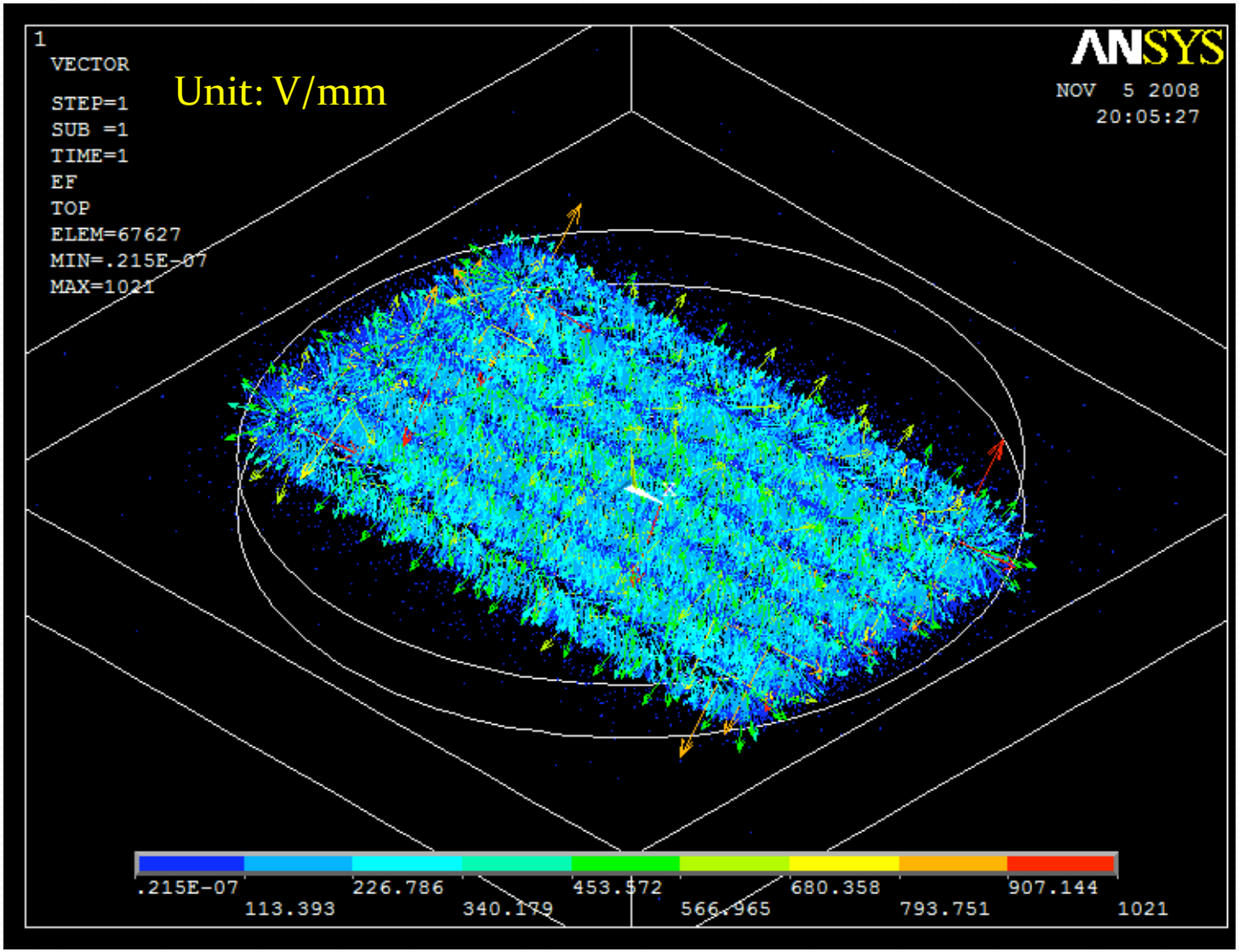
Max.=2.6mm

Max.=0.04 mm

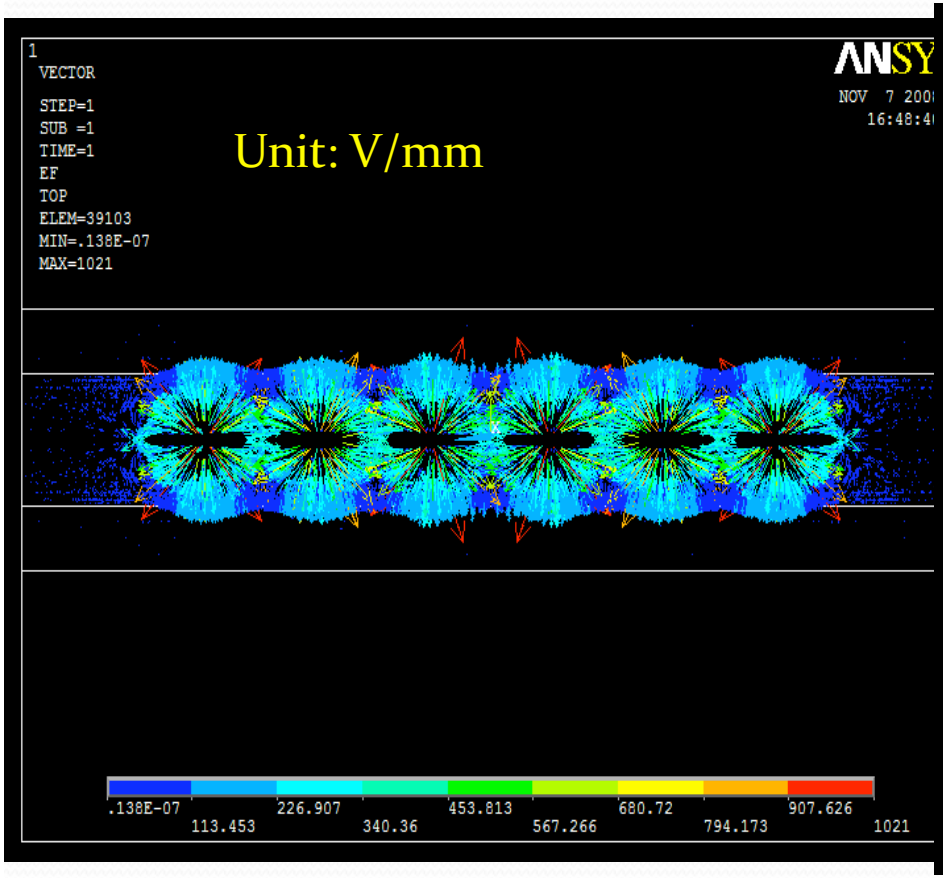
model for wire and cathode deformed in the electric field(A)

- The voltage
  - 0 v cathode
  - 2420 V sense wire
  - -500 V field wire
- Surrounding
  - Material air
  - Style: block
    - Length=160 mm
    - Thickness=20 mm
    - Width=160 mm

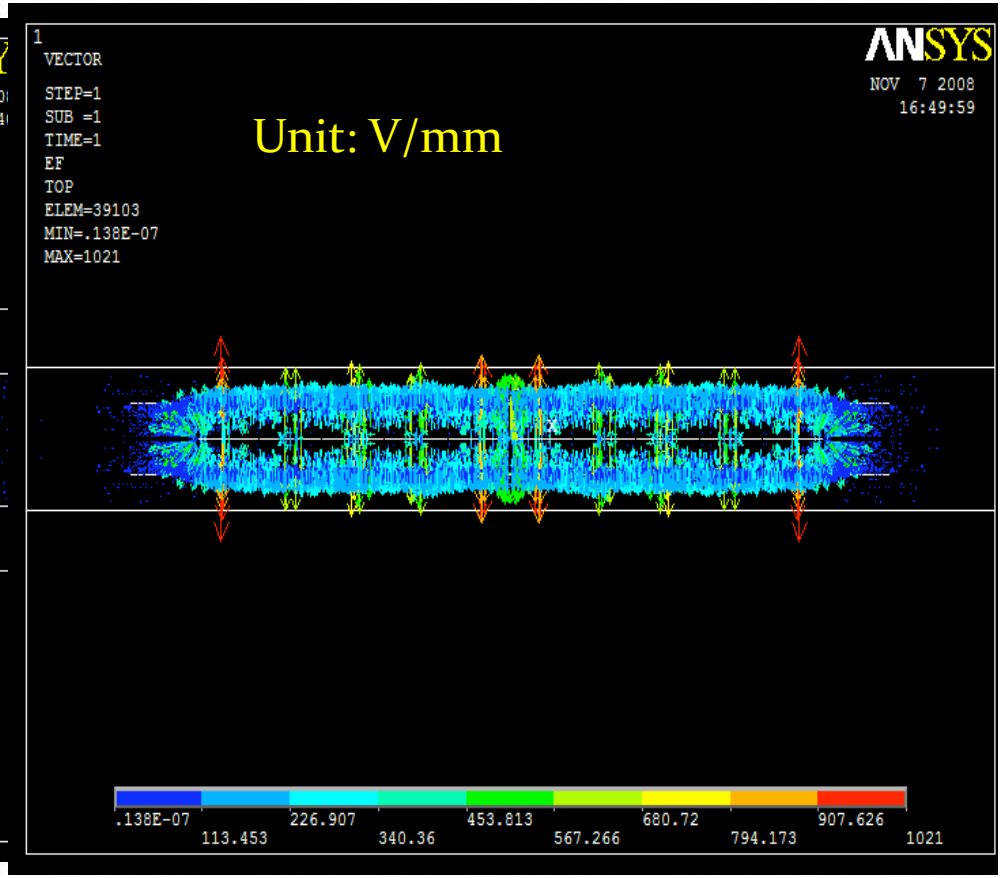
FDC electric field



FDC electric field

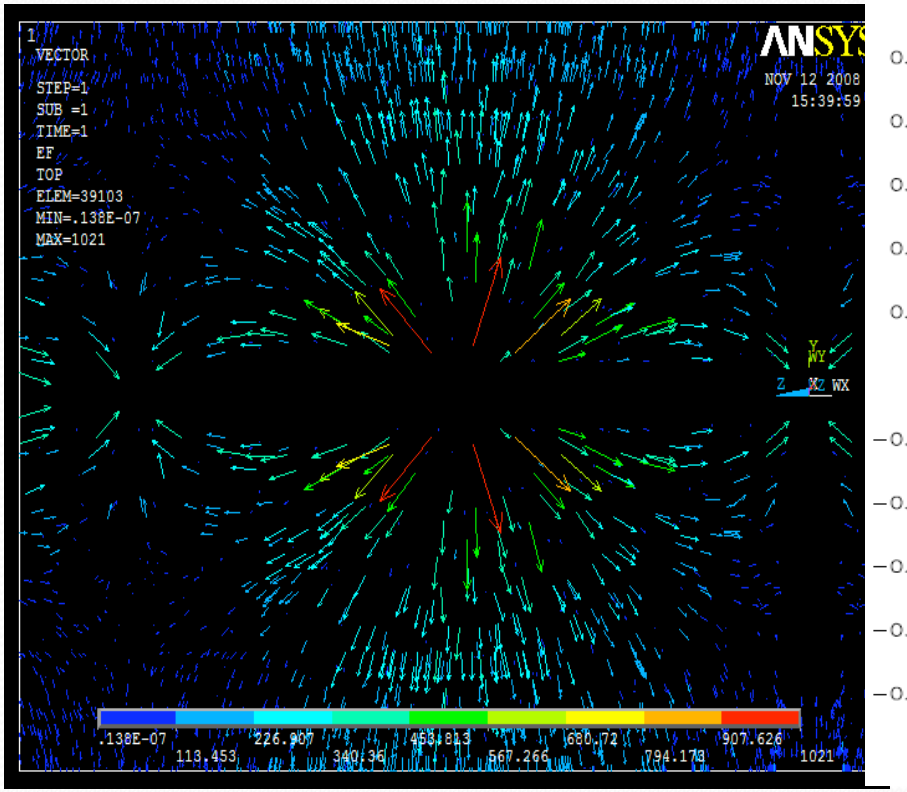


X direction view

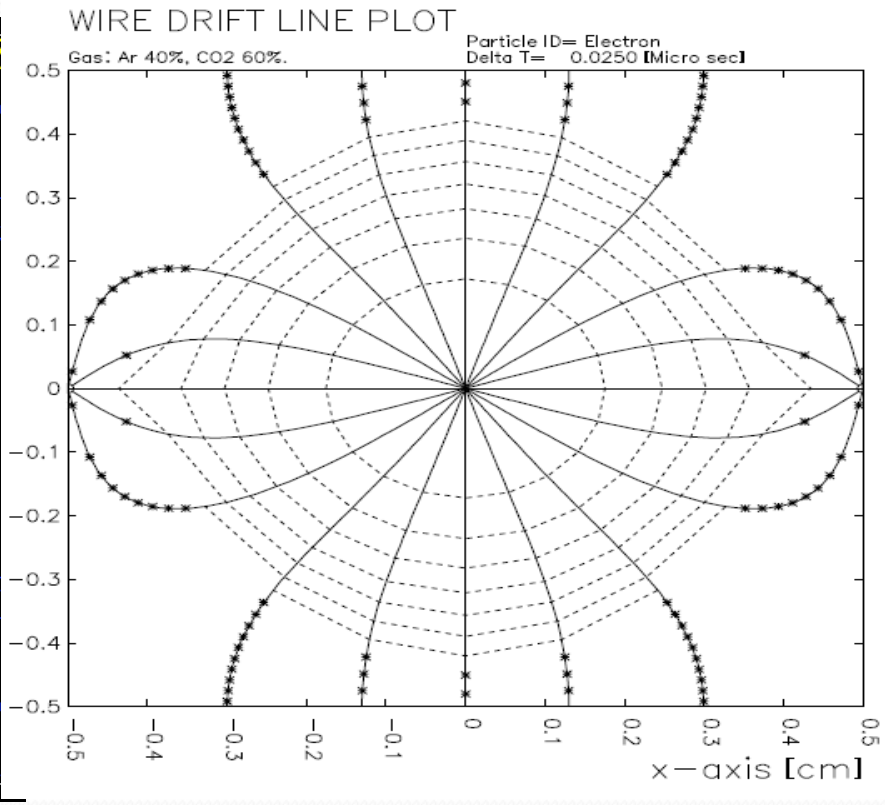


Z direction view

FDC electric field

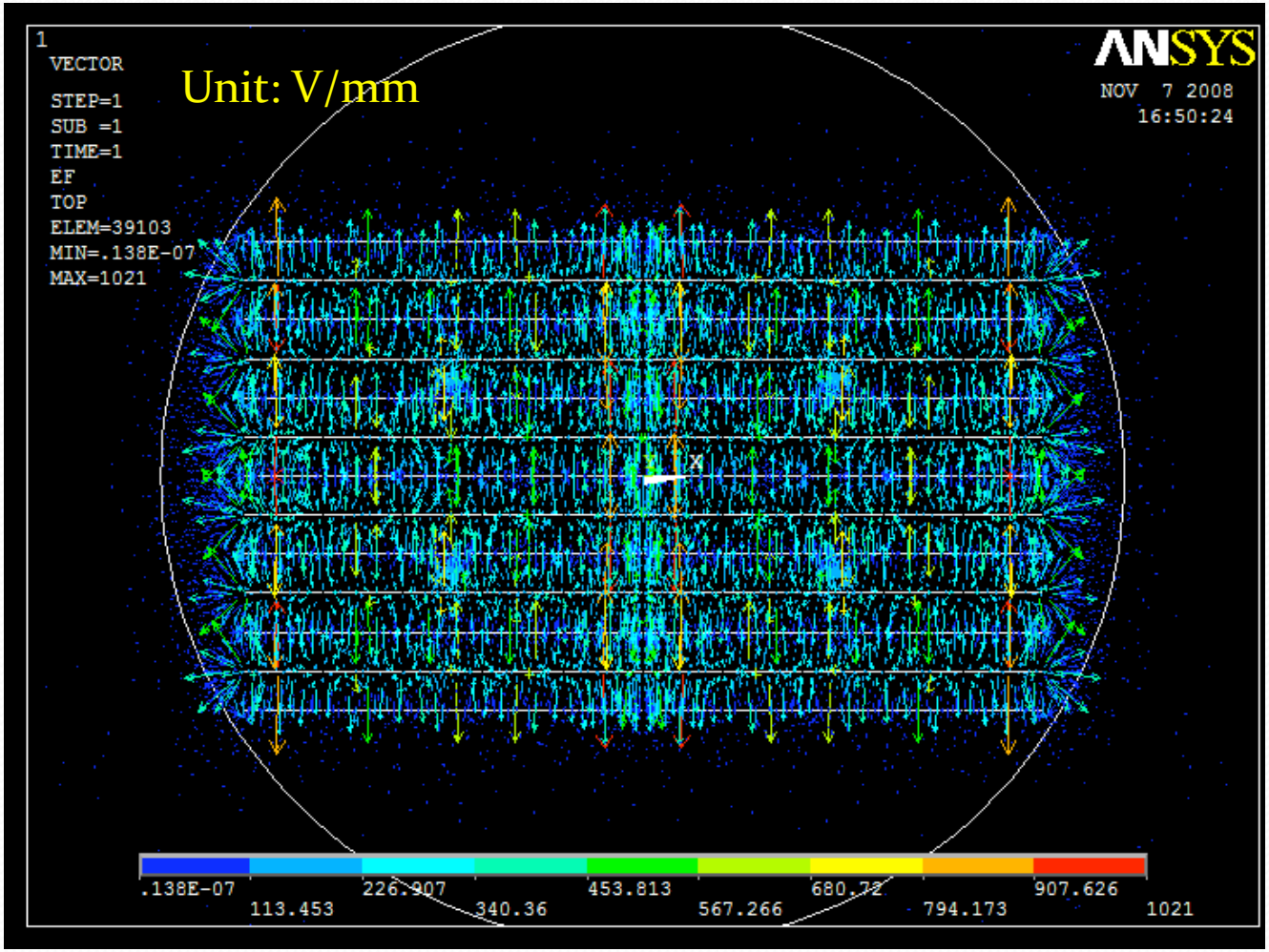


Using ansys program simulation

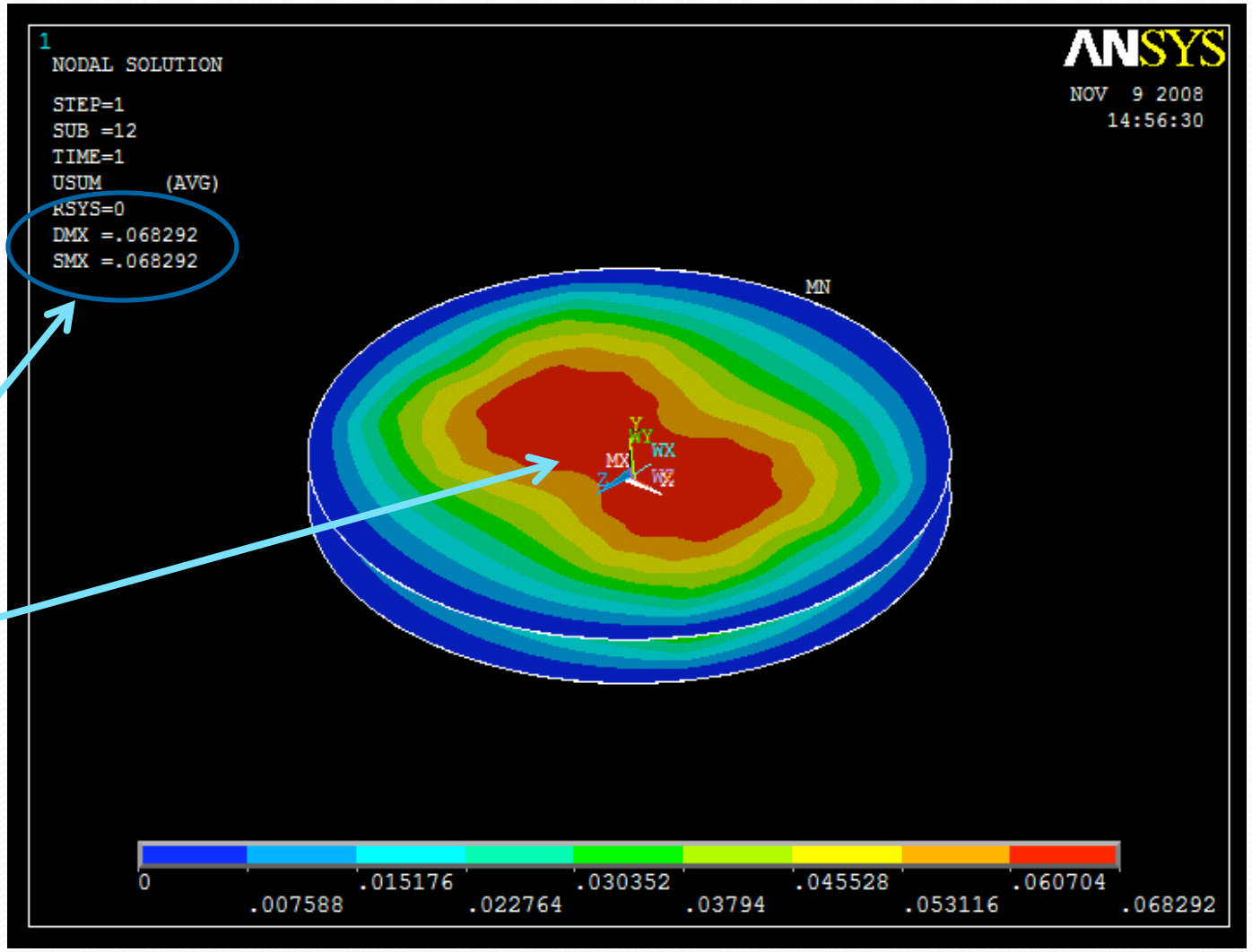


Using Garfield simulation

FDC electric field



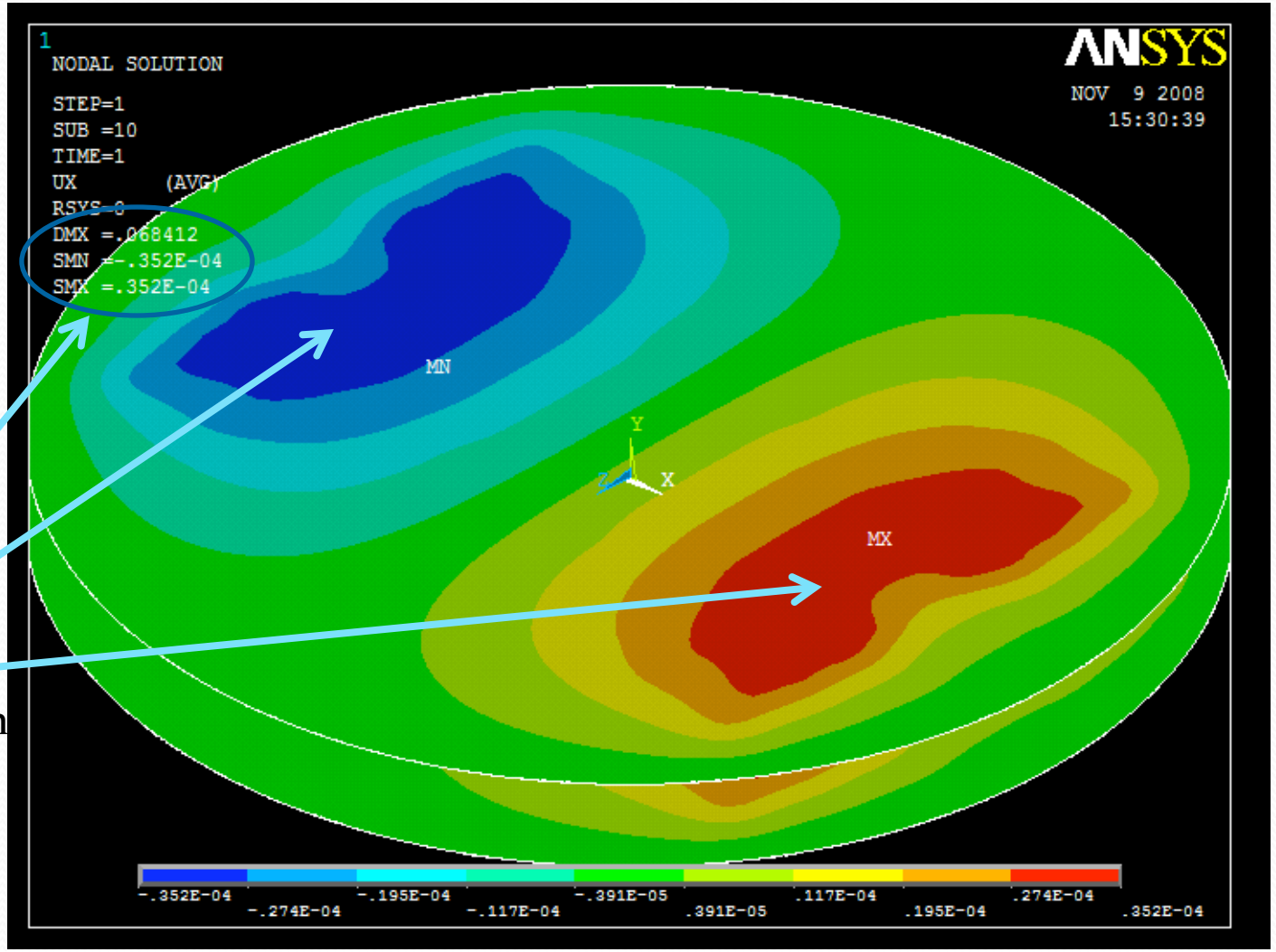
Deformed cathode



Max.=0.068 mm

Summary deformation

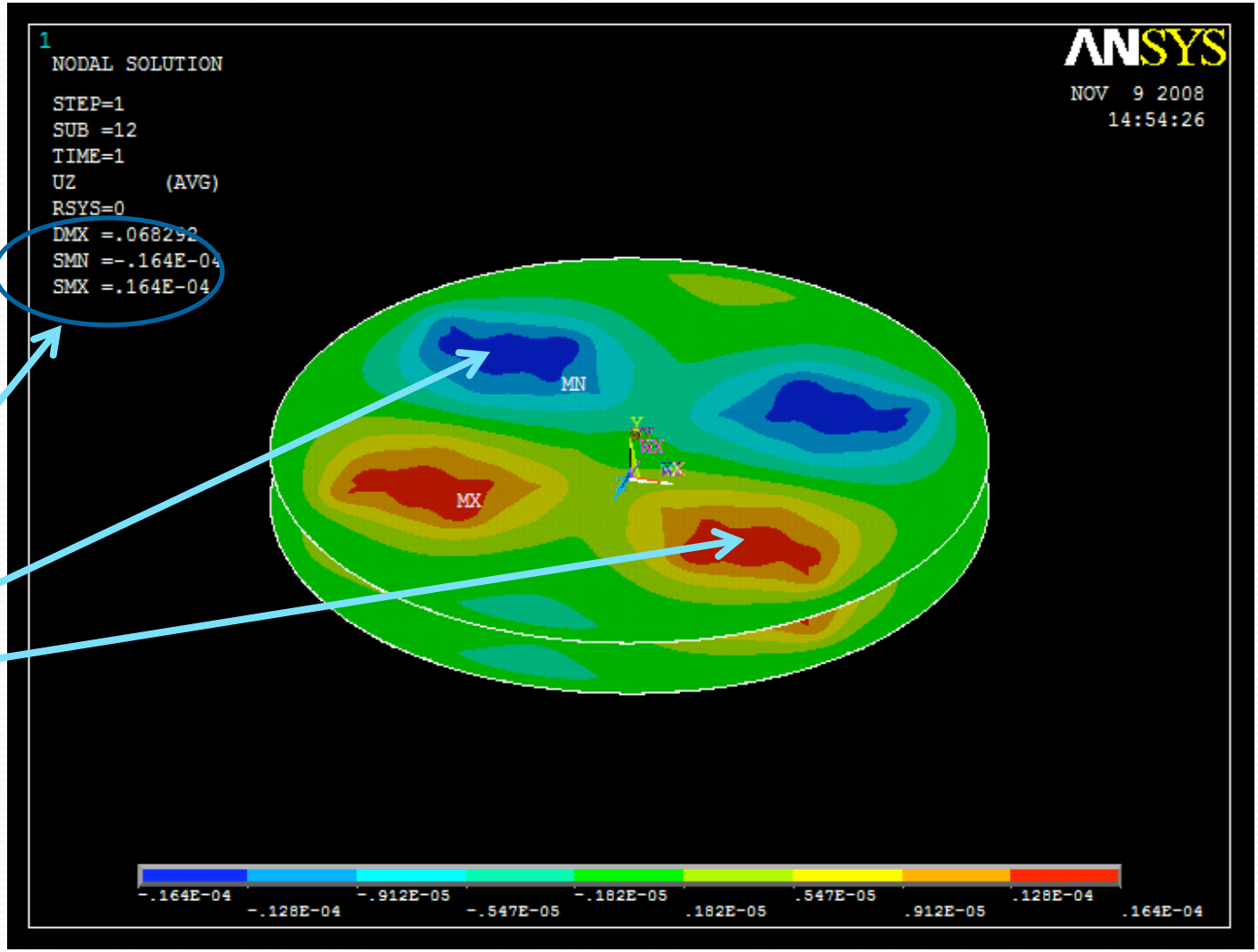
Deformed cathode



Max.=0.35e-4 mm

X direction deformation

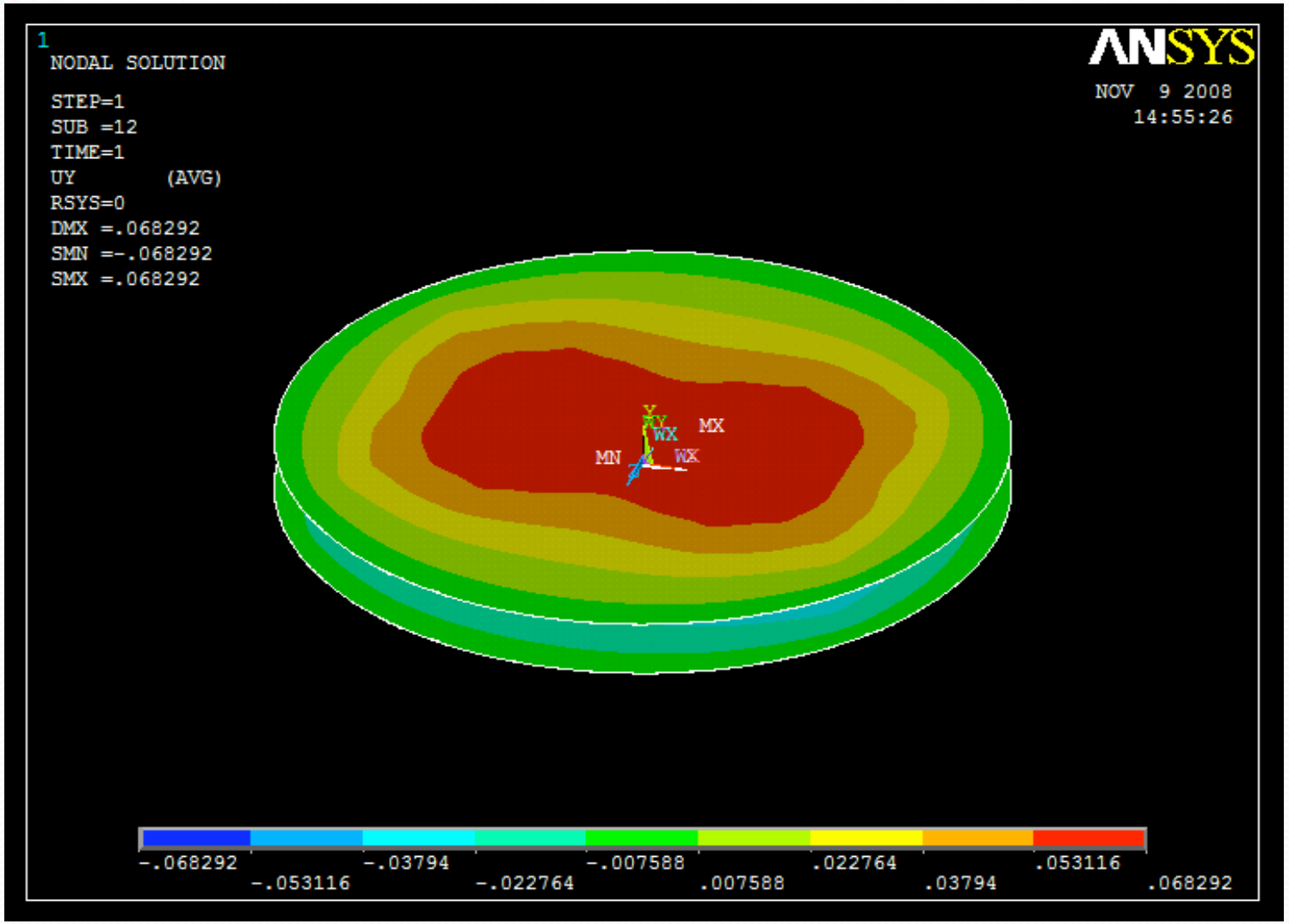
Deformed cathode



Max.=0.16e-4 mm

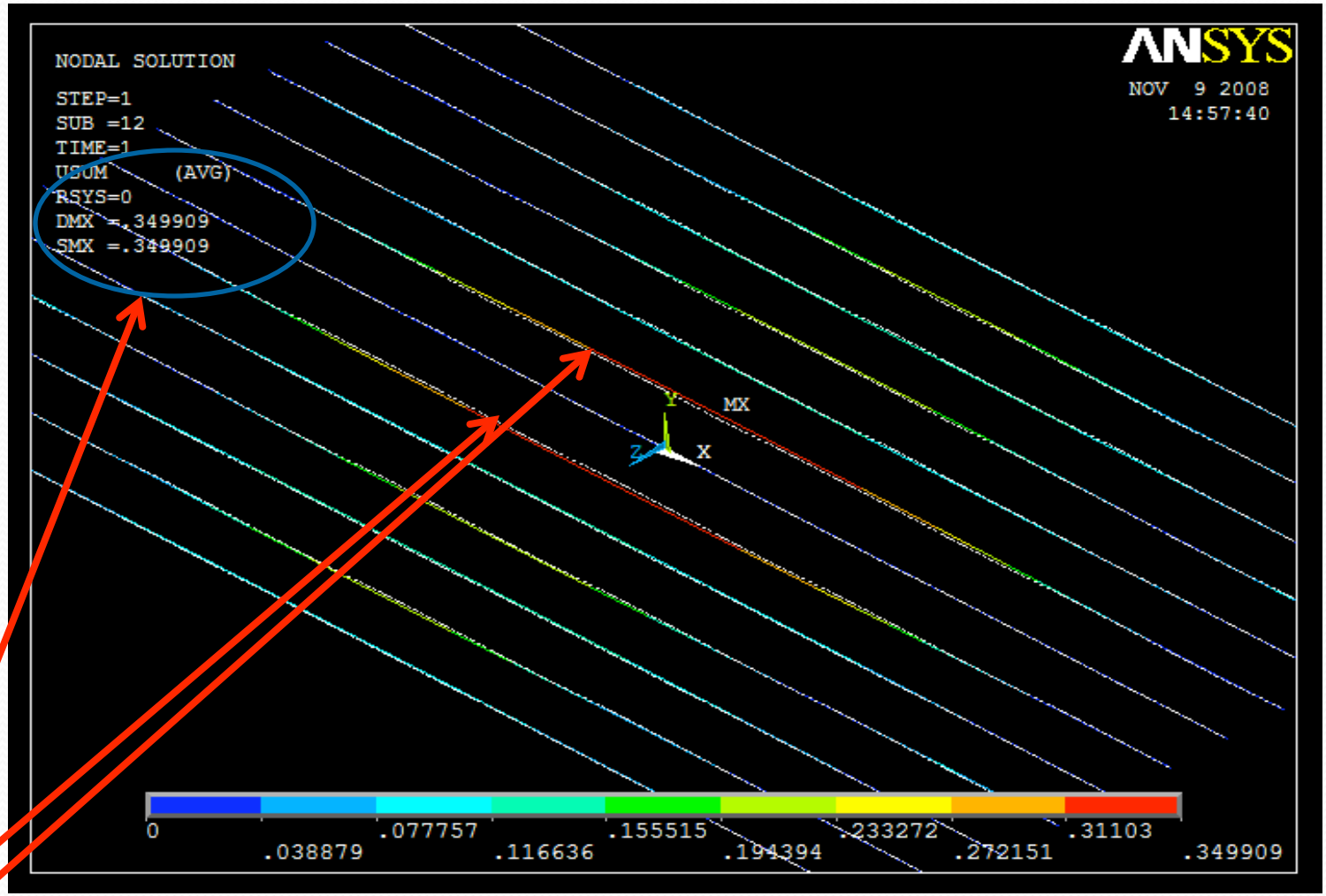
Z direction deformation

Deformed cathode



Y direction deformed

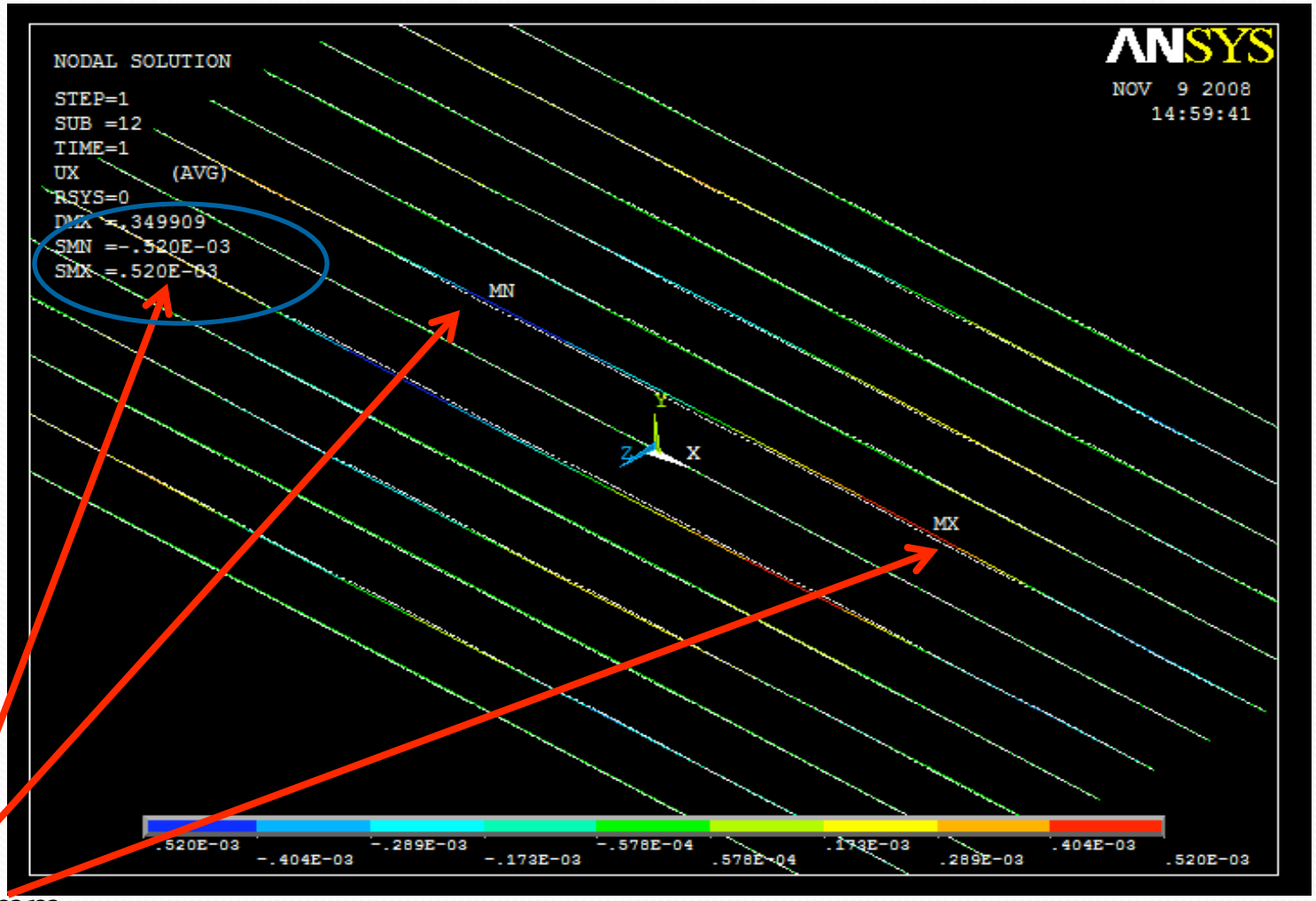
Deformed wire with **both ends fixed**



Max.=0.35mm

Summary deformation

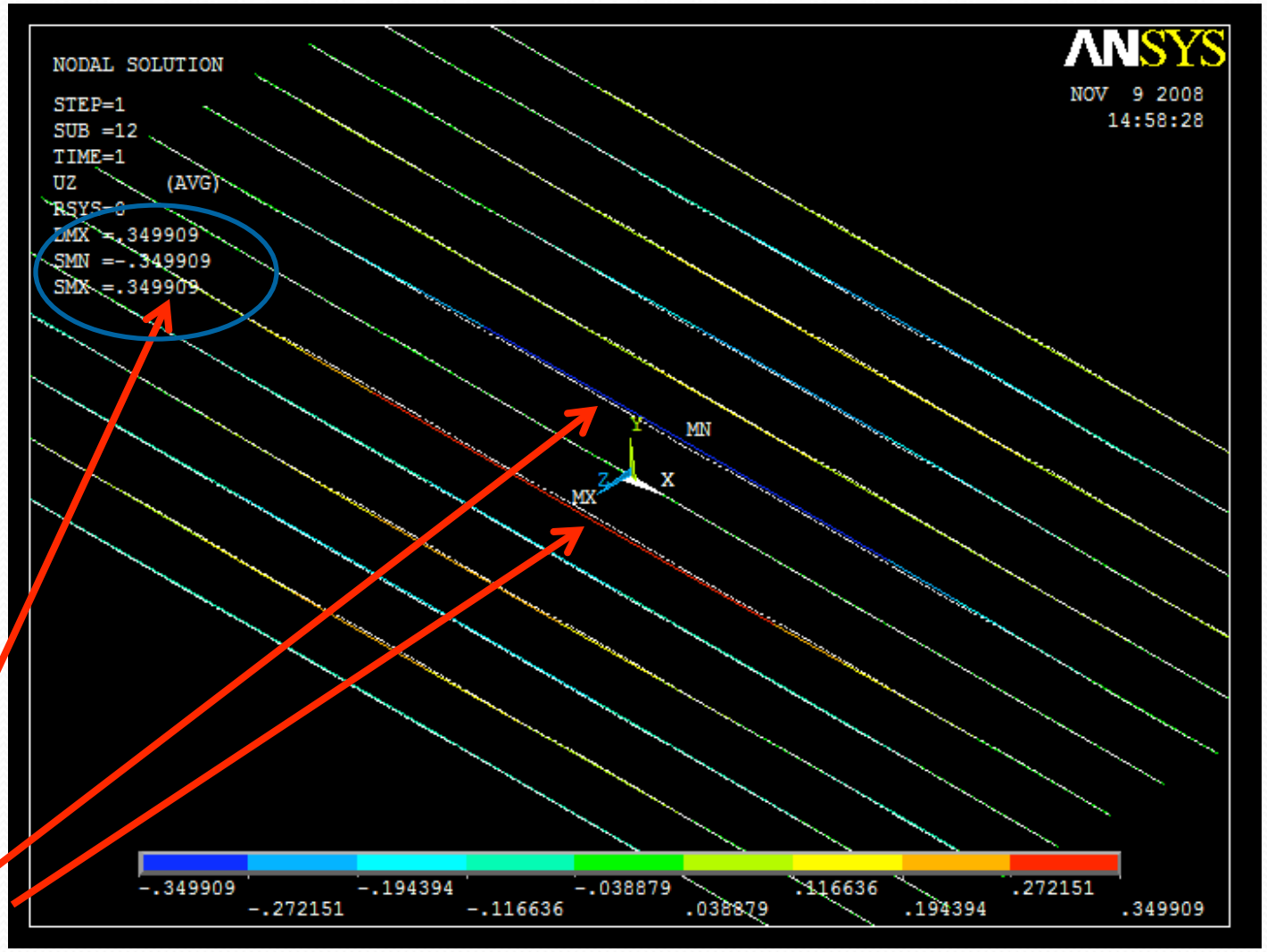
Deformed wire with **both ends fixed**



Max.=0.52e-3mm

X direction deformation

Deformed wire with **both ends fixed**



Max.=0.35mm

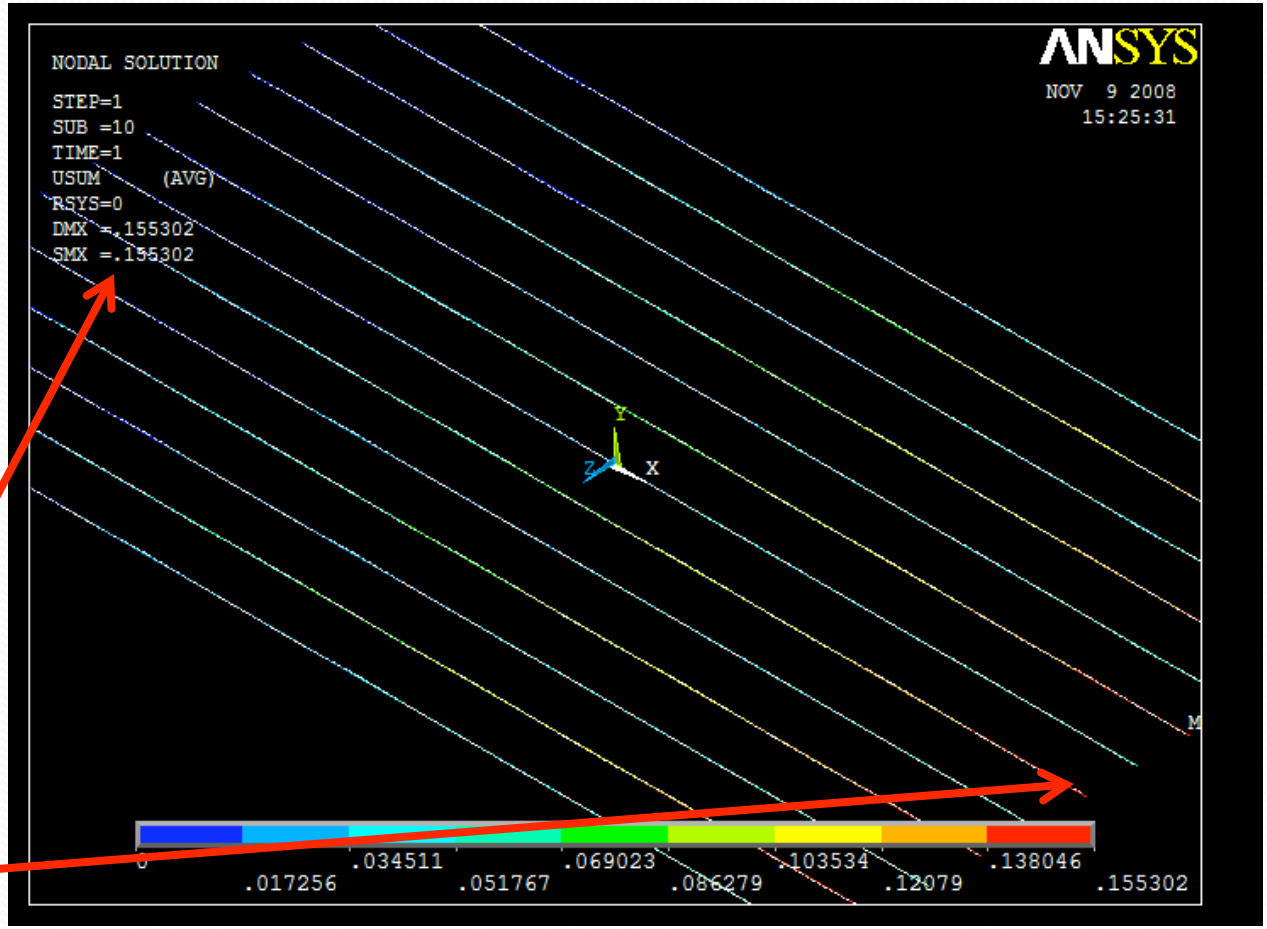
Z direction deformation

Deformed wire at the tension

at the Tension

130g field wire

20g sense wire



Max.=0.155mm

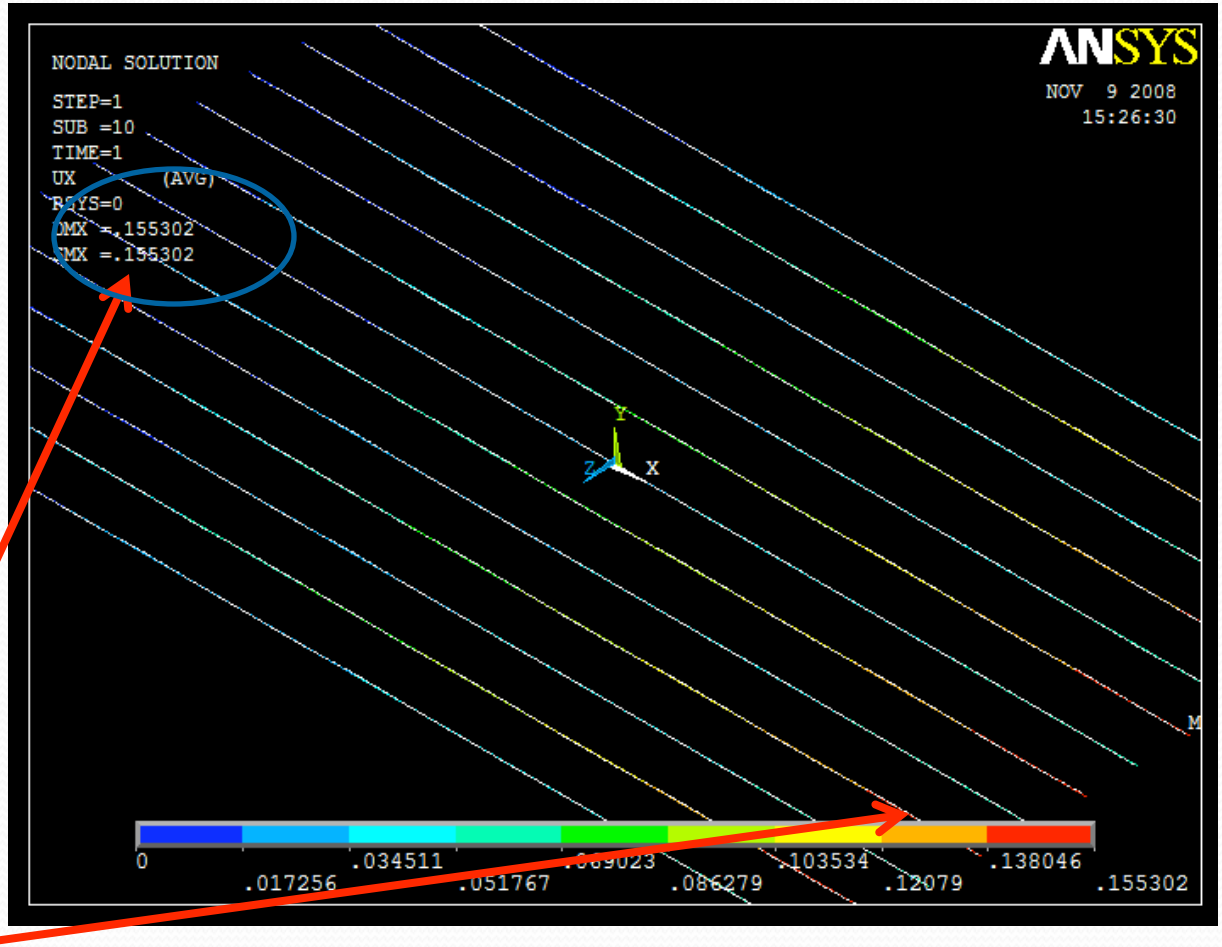
Summary deformation

Deformed wire at the tension

at the Tension

130g field wire

20g sense wire



Max.=0.155mm

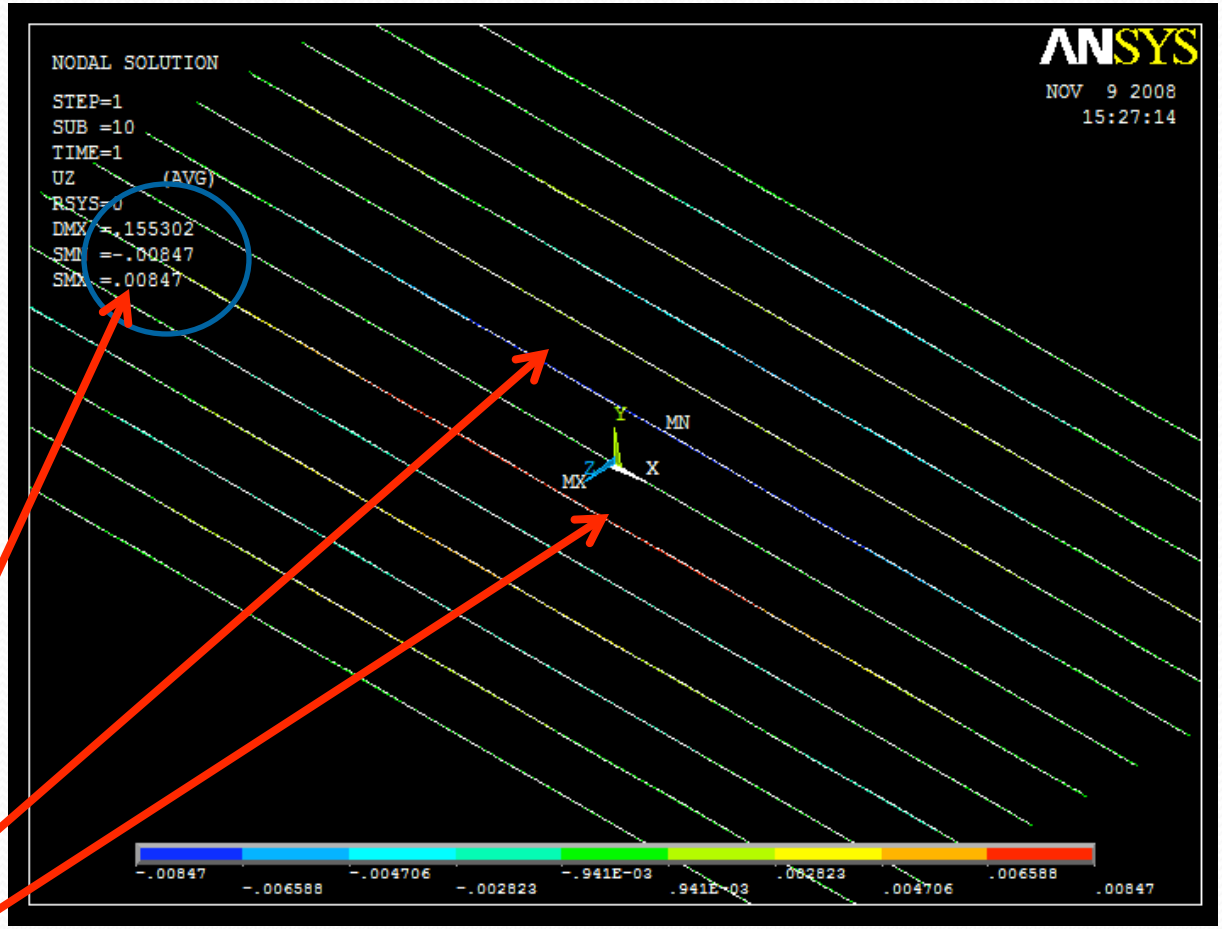
X direction deformation

Deformed wire at the tension

at the Tension

130g field wire

20g sense wire



Max.=0.008mm

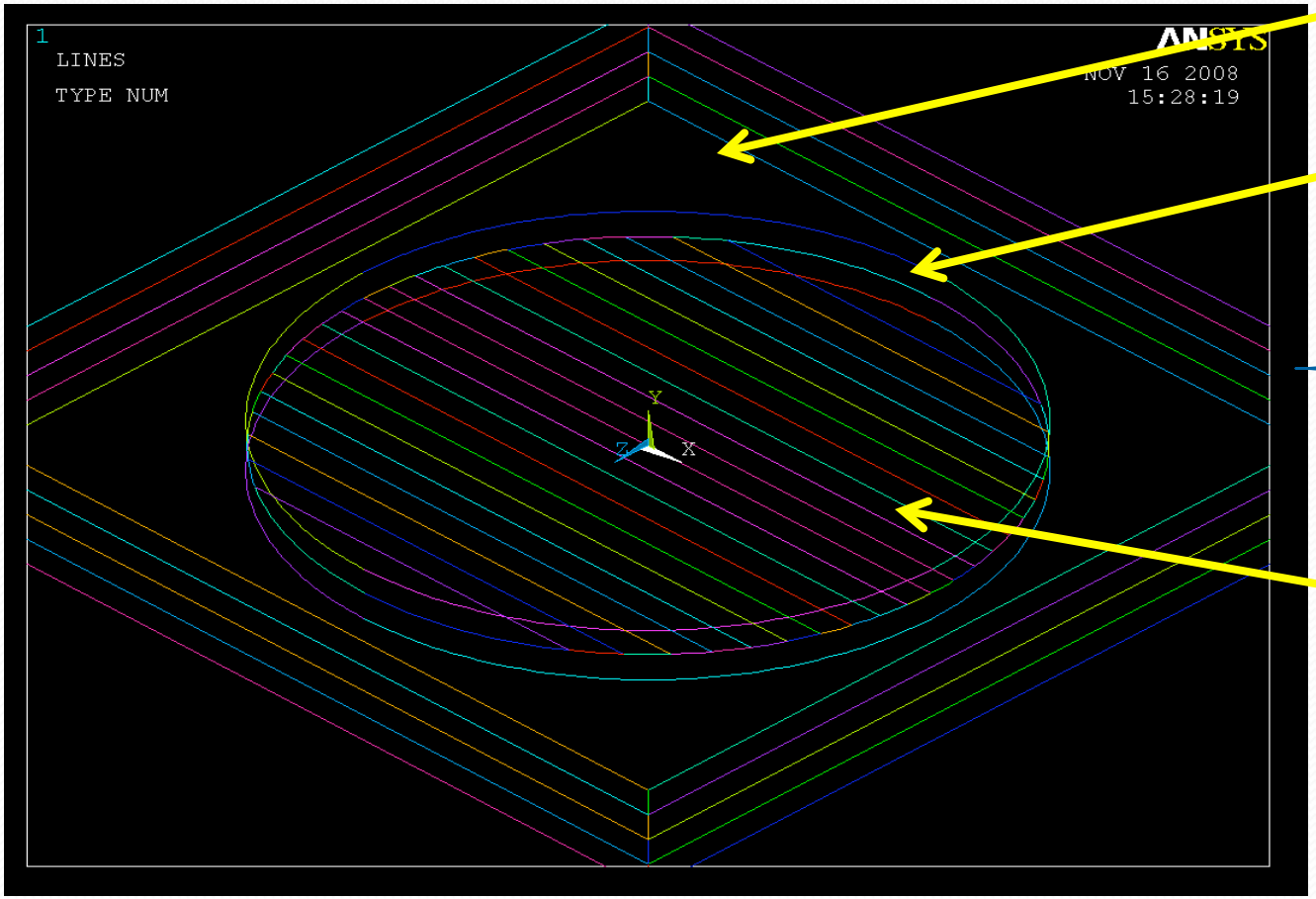
Z direction deformation

Summarize deformation

Wire deformation	Total		X direction		Z direction	
	5 micron	2 micron	5 micron	2 micron	5 micron	2 micron
Fixed ends, no tension	0.35 mm	0.54 mm	0.52e-3 mm	0.0013 mm	0.35 mm	0.54 mm
At tension	0.155 mm	0.155 mm	0.155 mm	0.155 mm	0.008 mm	0.02 mm

Cathode deformation	Y direction	X direction	Z direction
5 micron	0.68 mm	0.35e-4 mm	0.16e-4 mm
2 micron	0.78 mm	0.71e-4 mm	0.37e-4 mm

model for wire and cathode deformed in the electric field(B)



Surrounding : air

Cathode

R=60mm

Material: copper

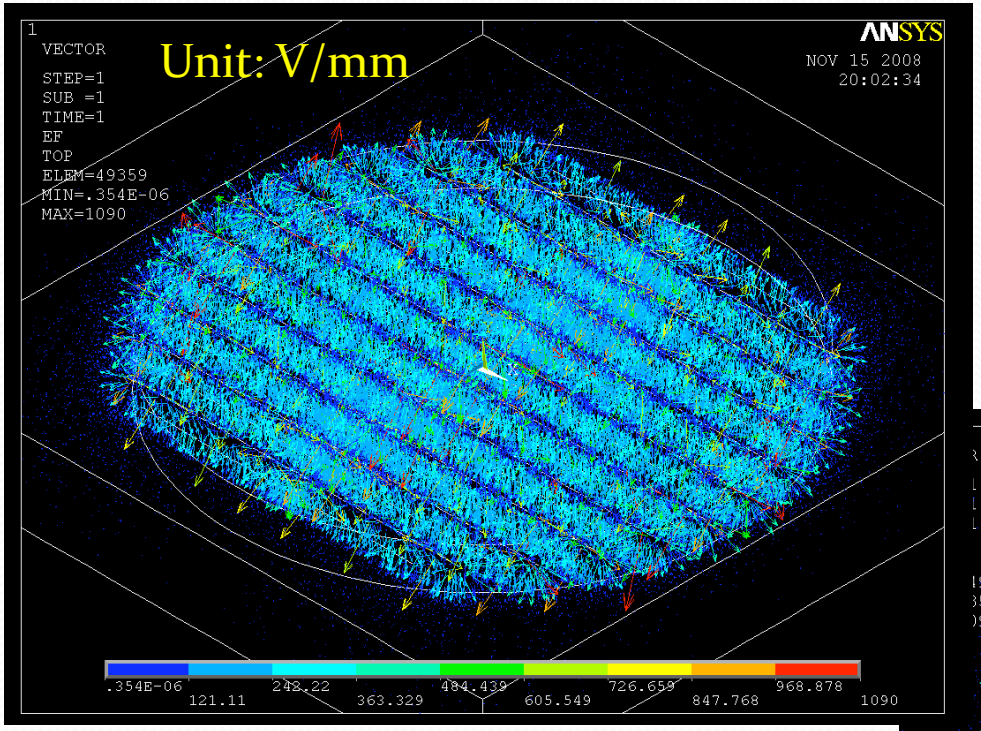
Voltage: 0 V

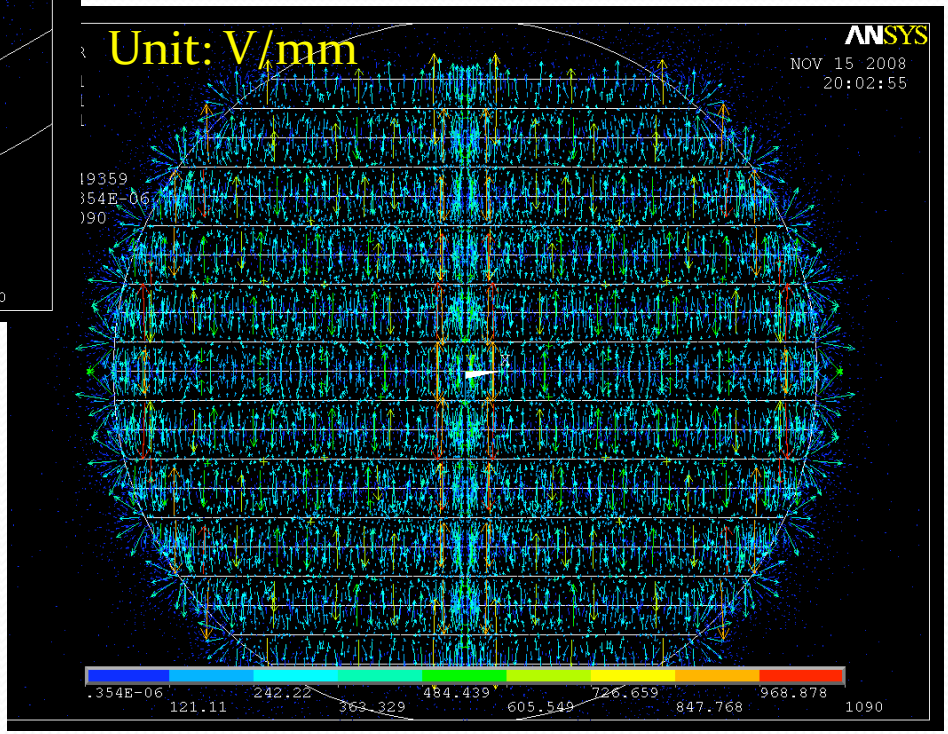
wire

Sense wire:
R=0.01 mm
tungsten; 2420 V

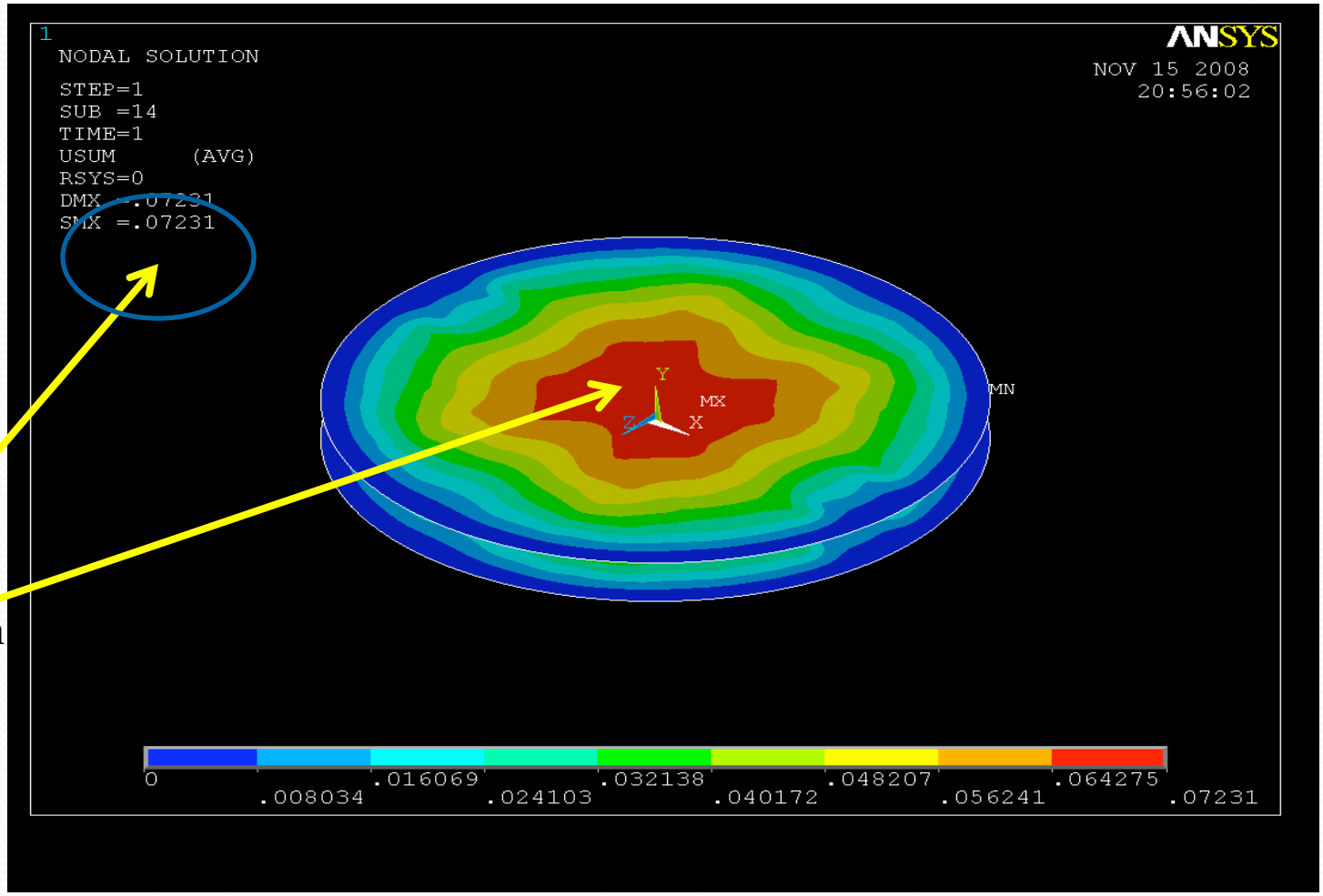
Field wire:
R=0.04 mm
Copper; -500 v

FDC electric field





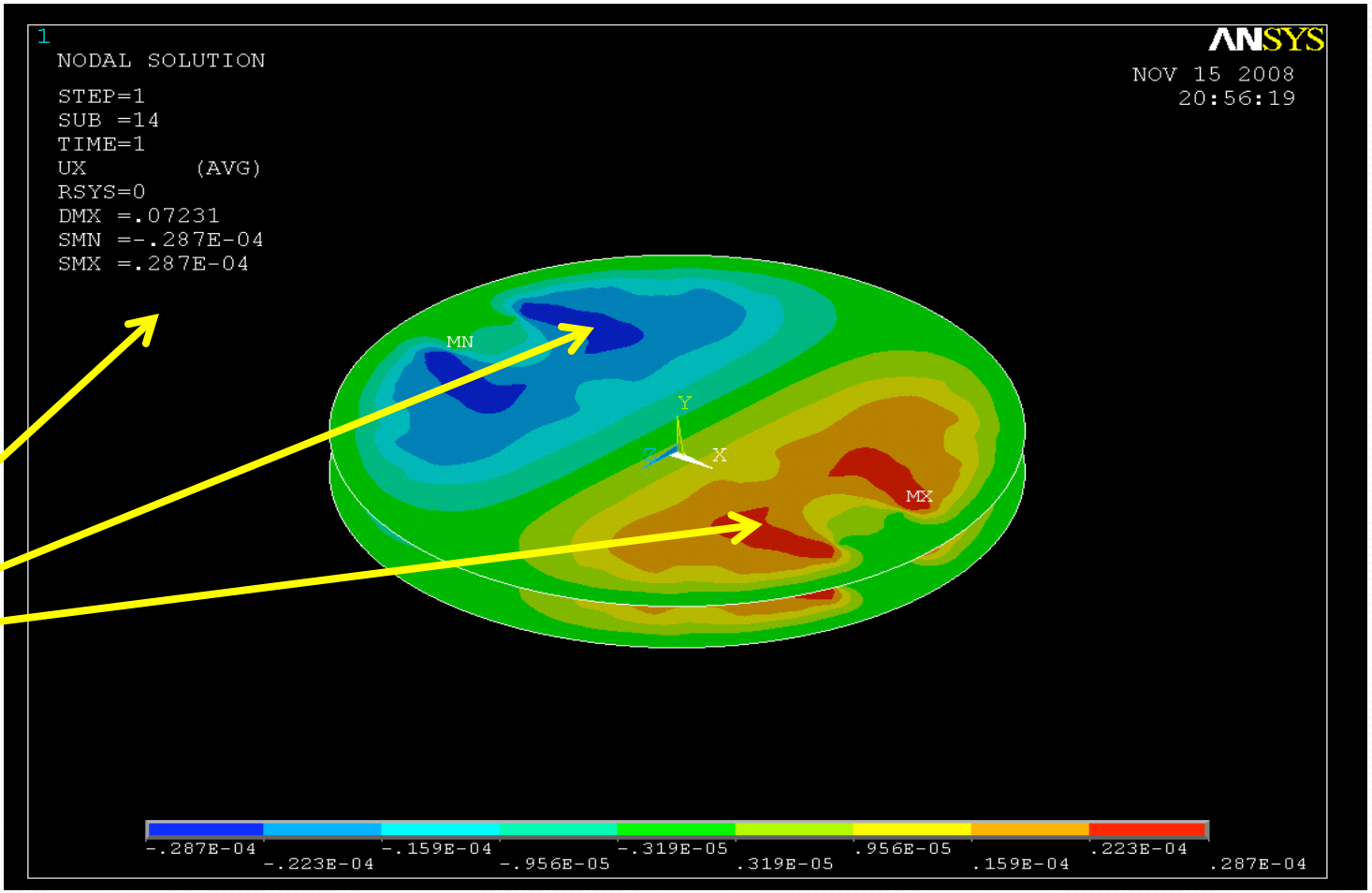
Deformed cathode



Max.=0.72 mm

Total direction deformation

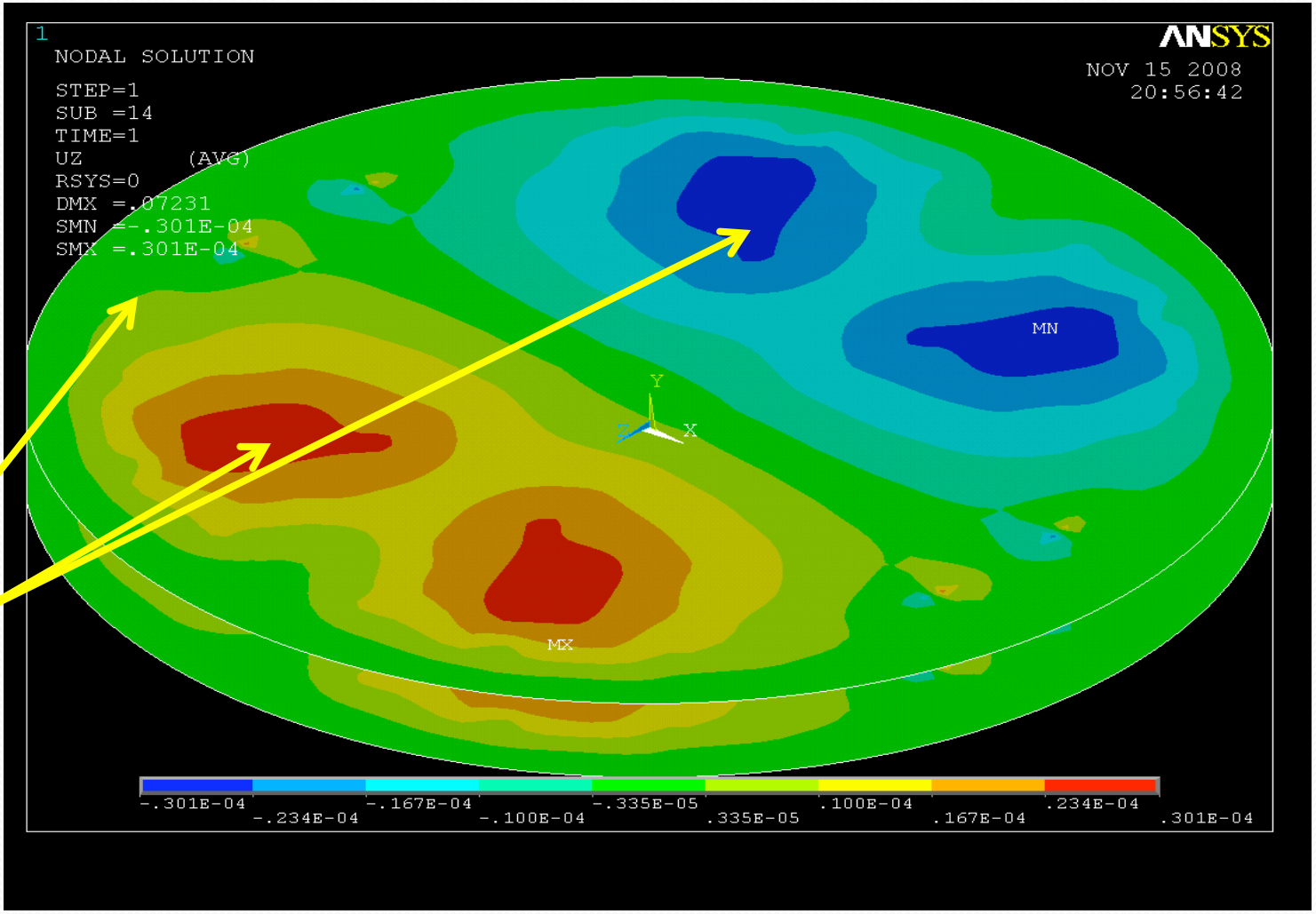
Deformed cathode



Max.=0.29e-4 mm

X direction deformation

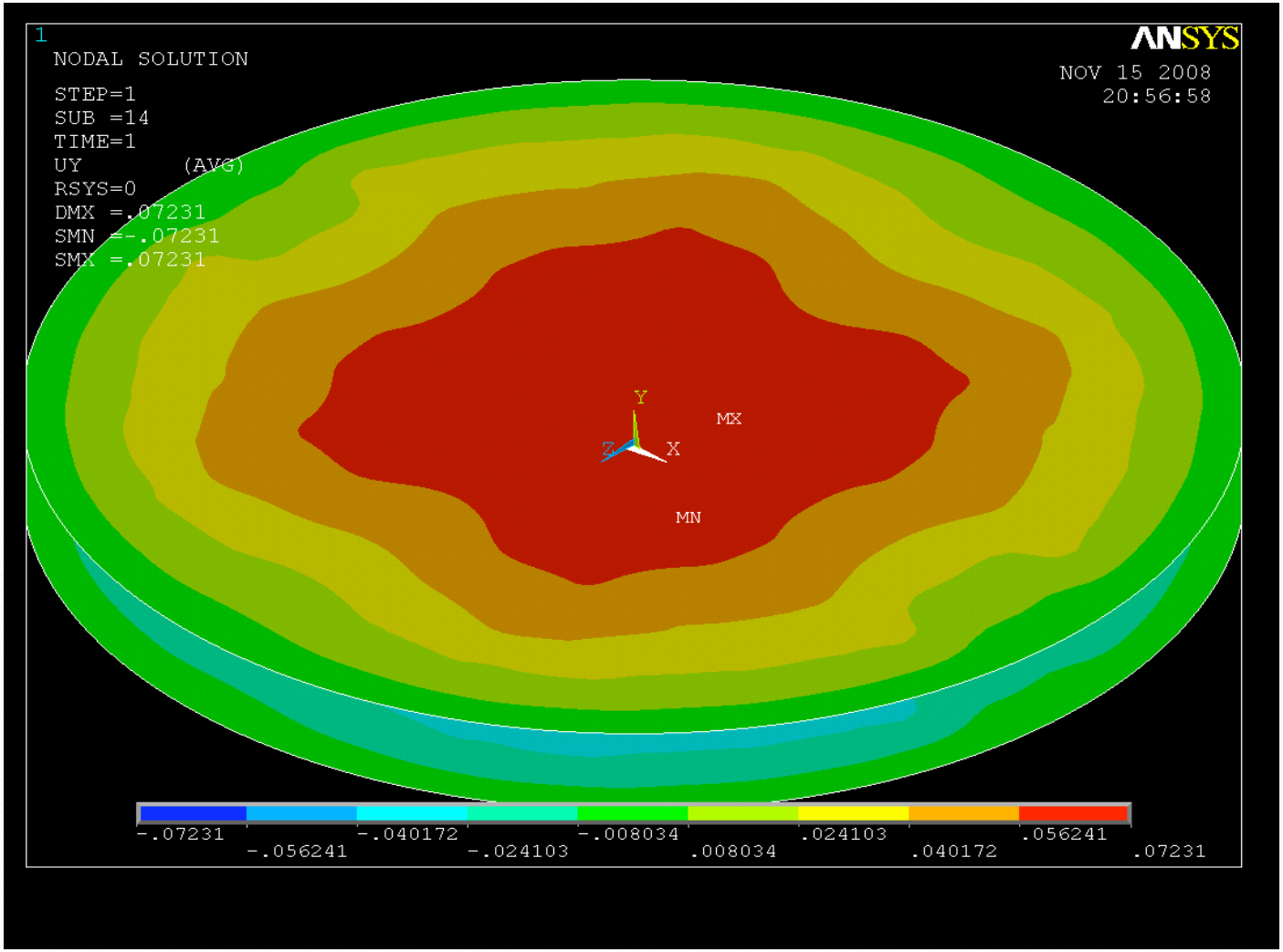
Deformed cathode



Max.=0.3e-4 mm

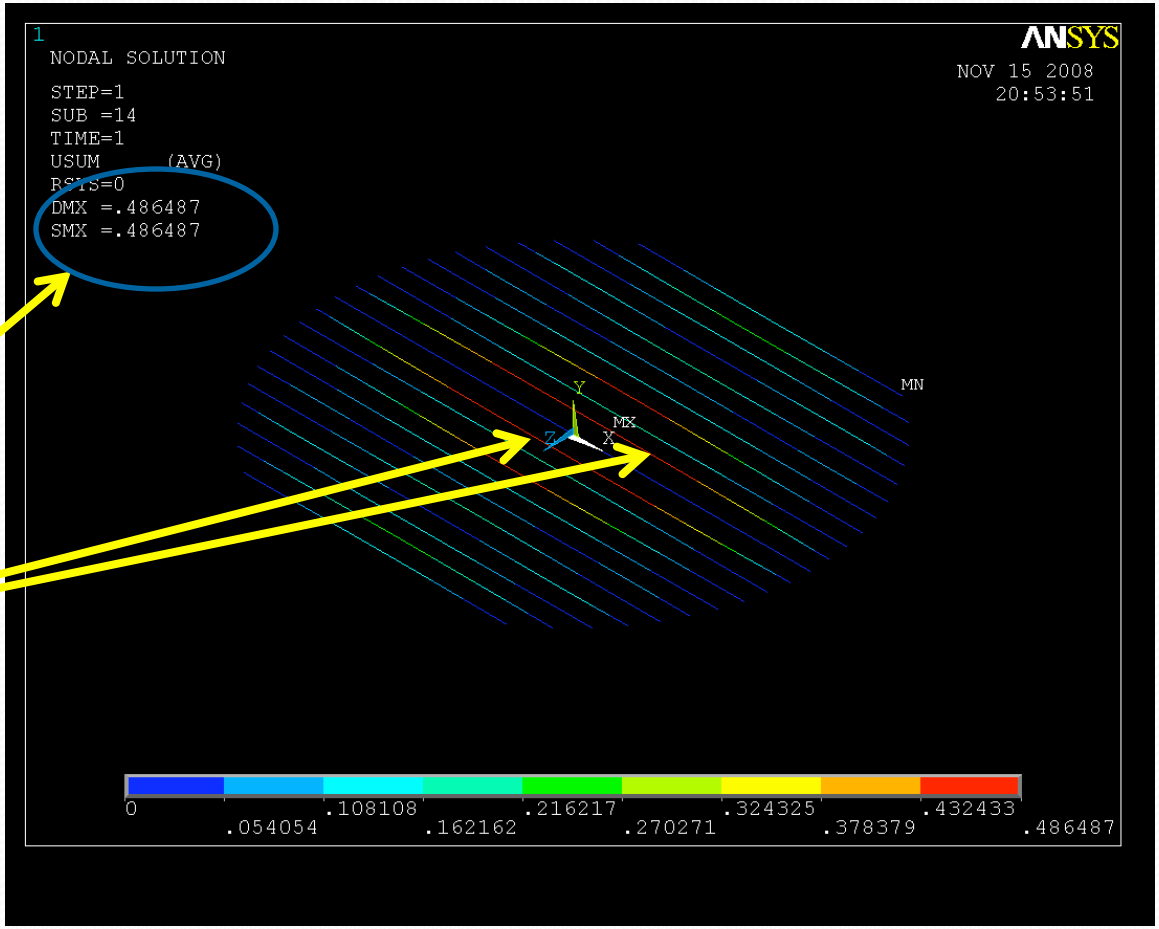
Z direction deformation

Deformed cathode



Y direction deformation

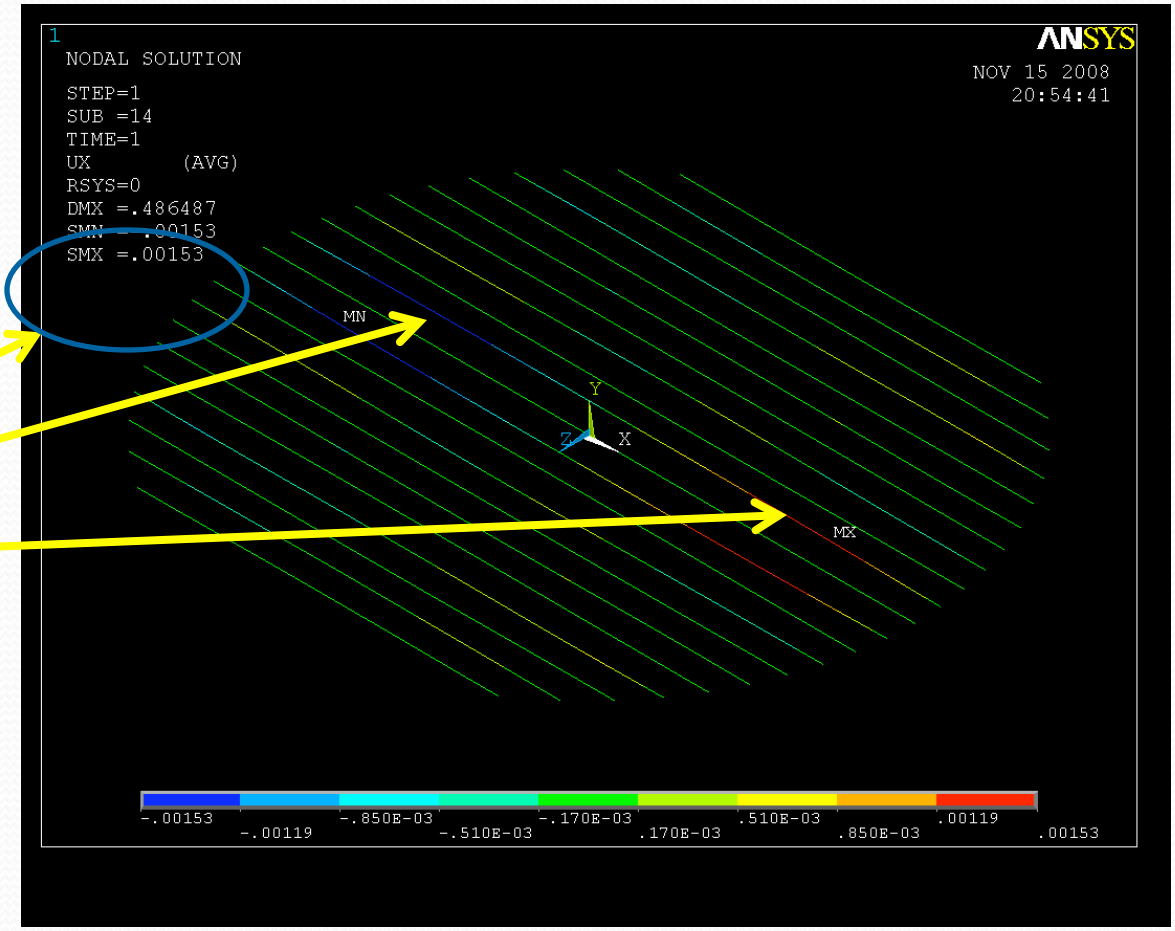
Deformed wire with **both ends fixed**



Max.=0.486 mm

Total direction deformation

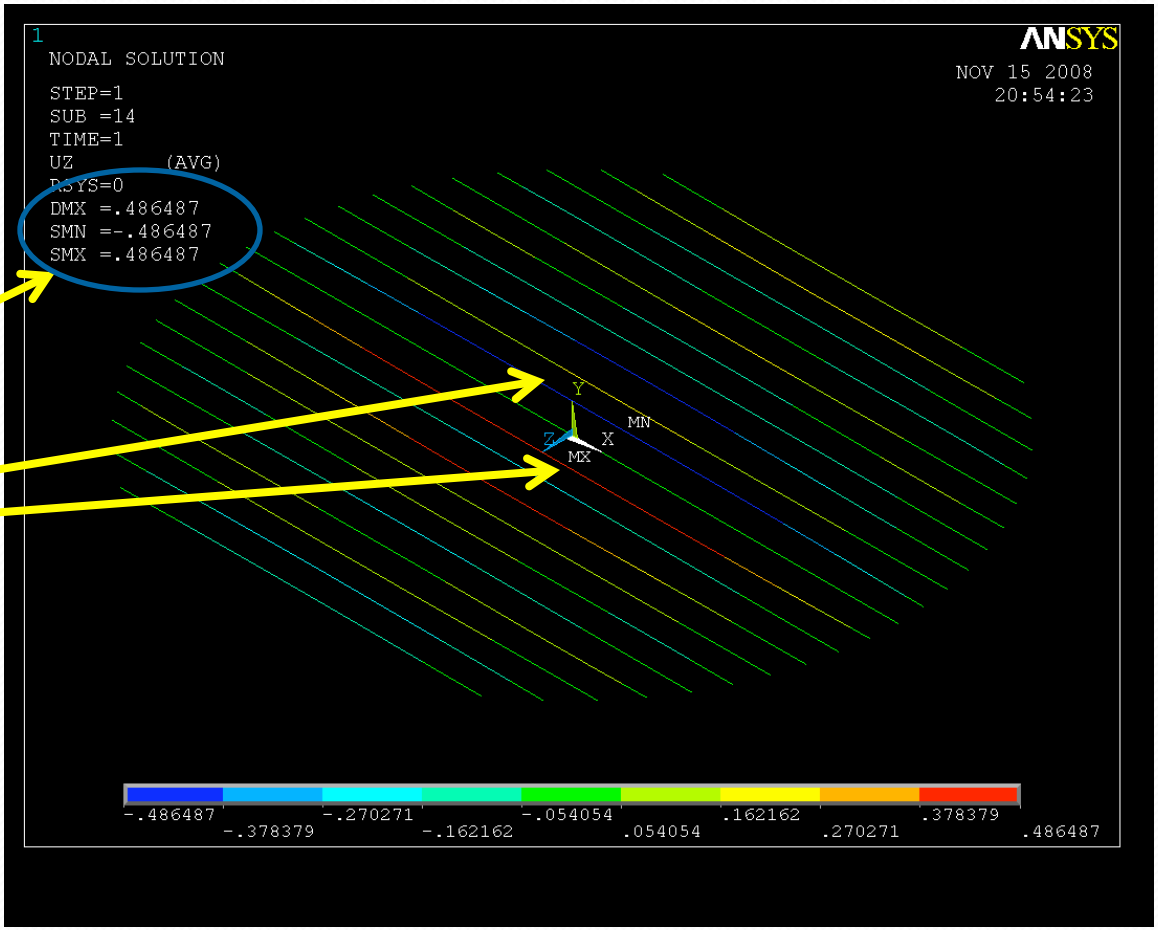
Deformed wire with **both ends fixed**



Max.=0.0015 mm

X direction deformation

Deformed wire with **both ends fixed**



Max.=0.486 mm

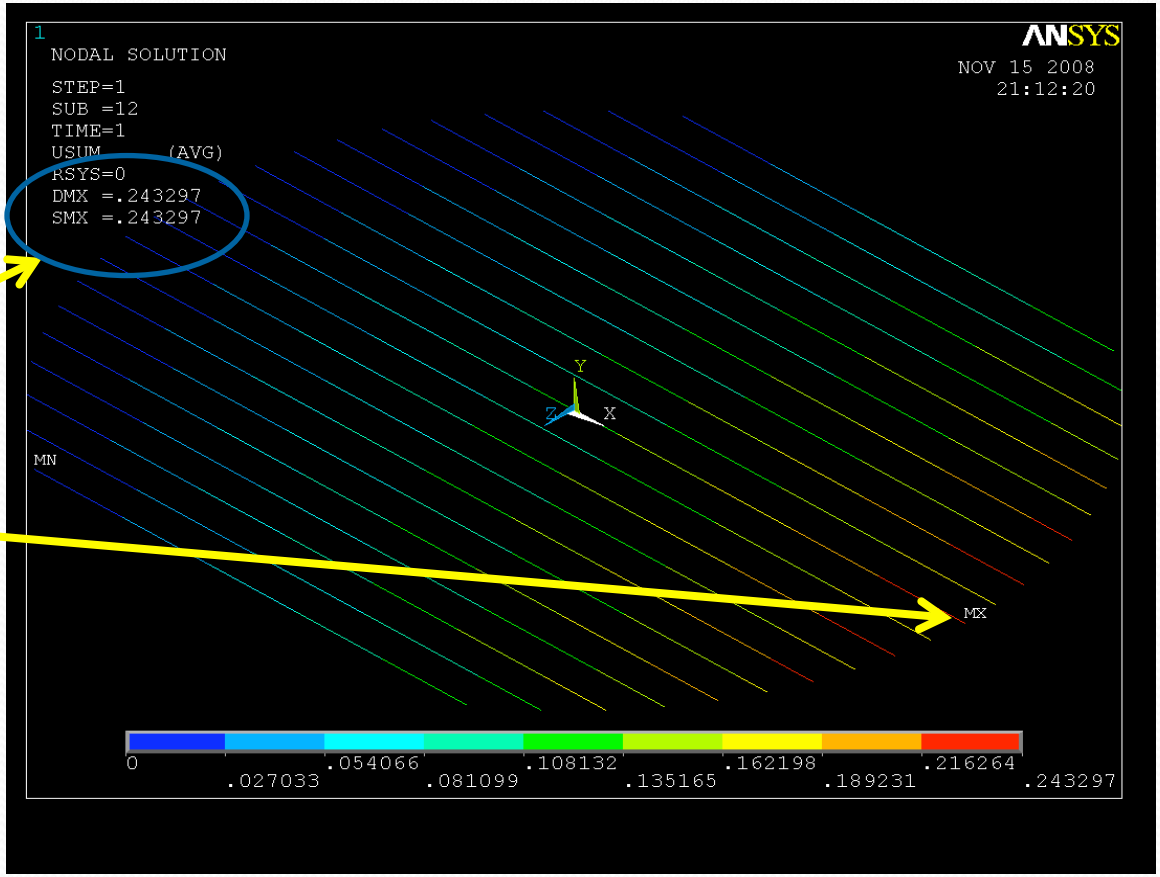
Z direction deformation

Deformed wire at the tension

at the Tension

- 130g field wire
- 20g sense wire

Max.=0.24 mm



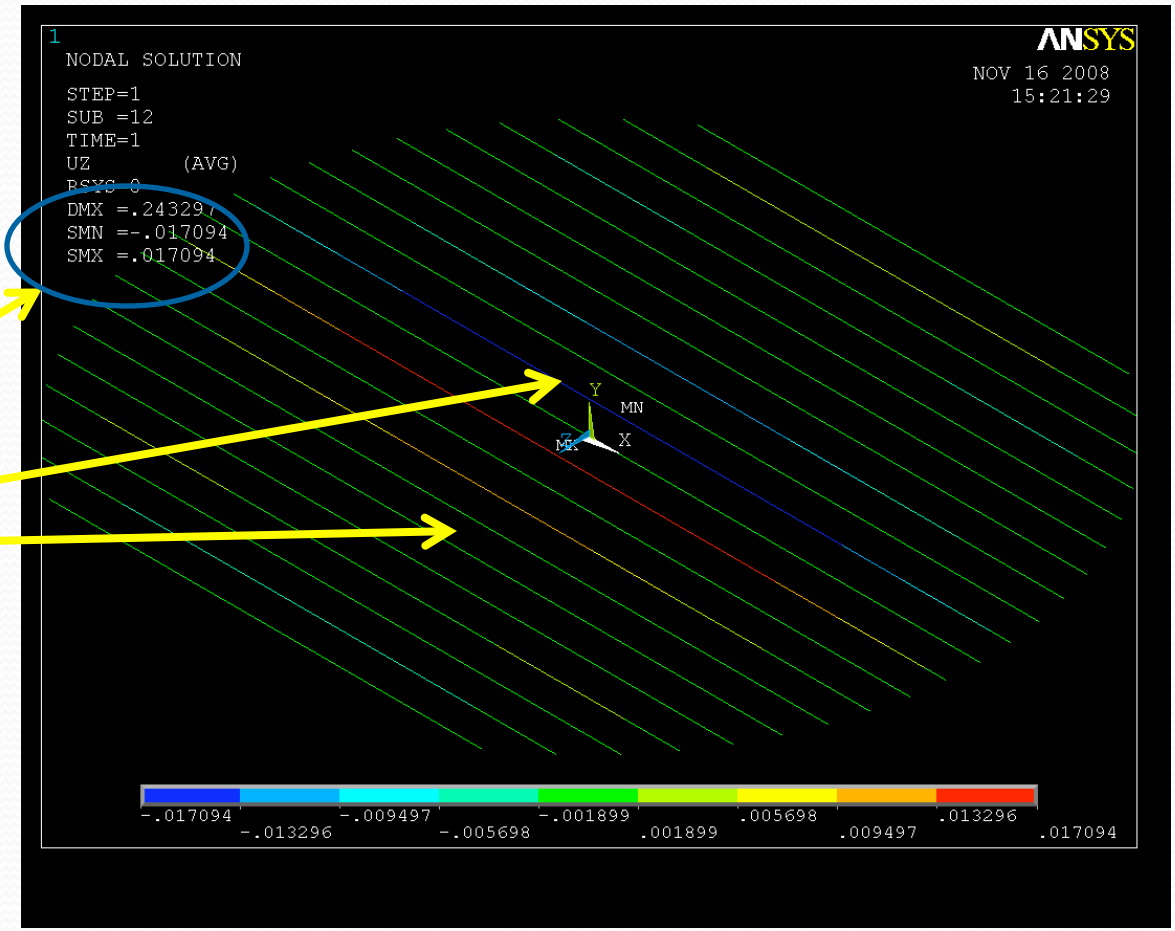
Total direction deformation

Deformed wire at the tension

at the Tension

- 130g field wire
- 20g sense wire

Max.=0.017 mm



Z direction deformation

Summarize deformation

Wire deformation	Total		X direction		Z direction	
	5 micron	2 micron	5 micron	2 micron	5 micron	2 micron
Fixed ends, no tension	0.48 mm	0.408 mm	0.0015 mm	0.0014 mm	0.48 mm	0.408 mm
At tension	0.24 mm	0.24 mm	0.24 mm	0.24 mm	0.017 mm	0.01 mm

Cathode deformation	Y direction	X direction	Z direction
5 micron	0.072 mm	0.28e-4 mm	0.3e-4 mm
2 micron	0.96 mm	0.11e-4 mm	0.86e-4 mm