

HEPDipo

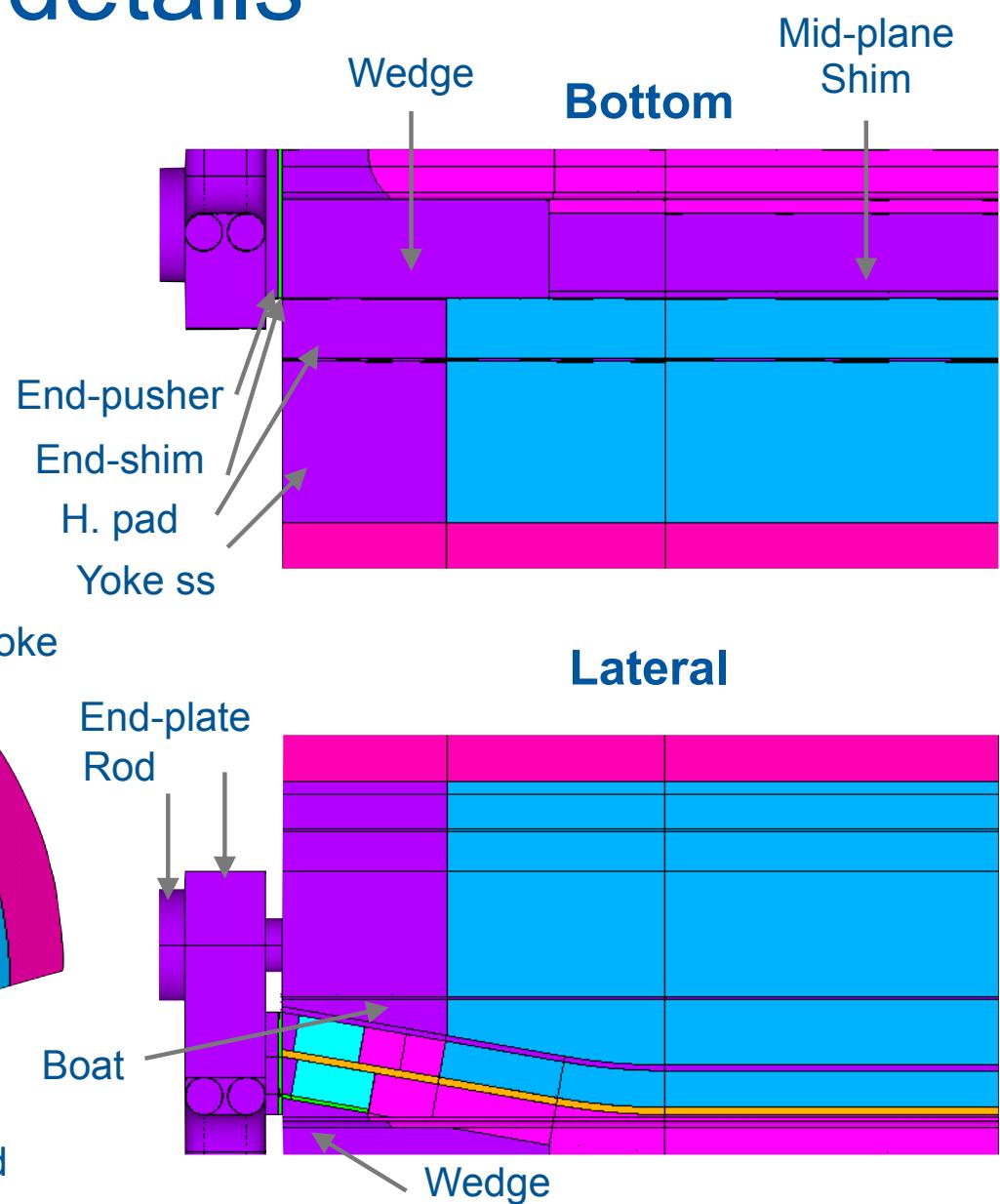
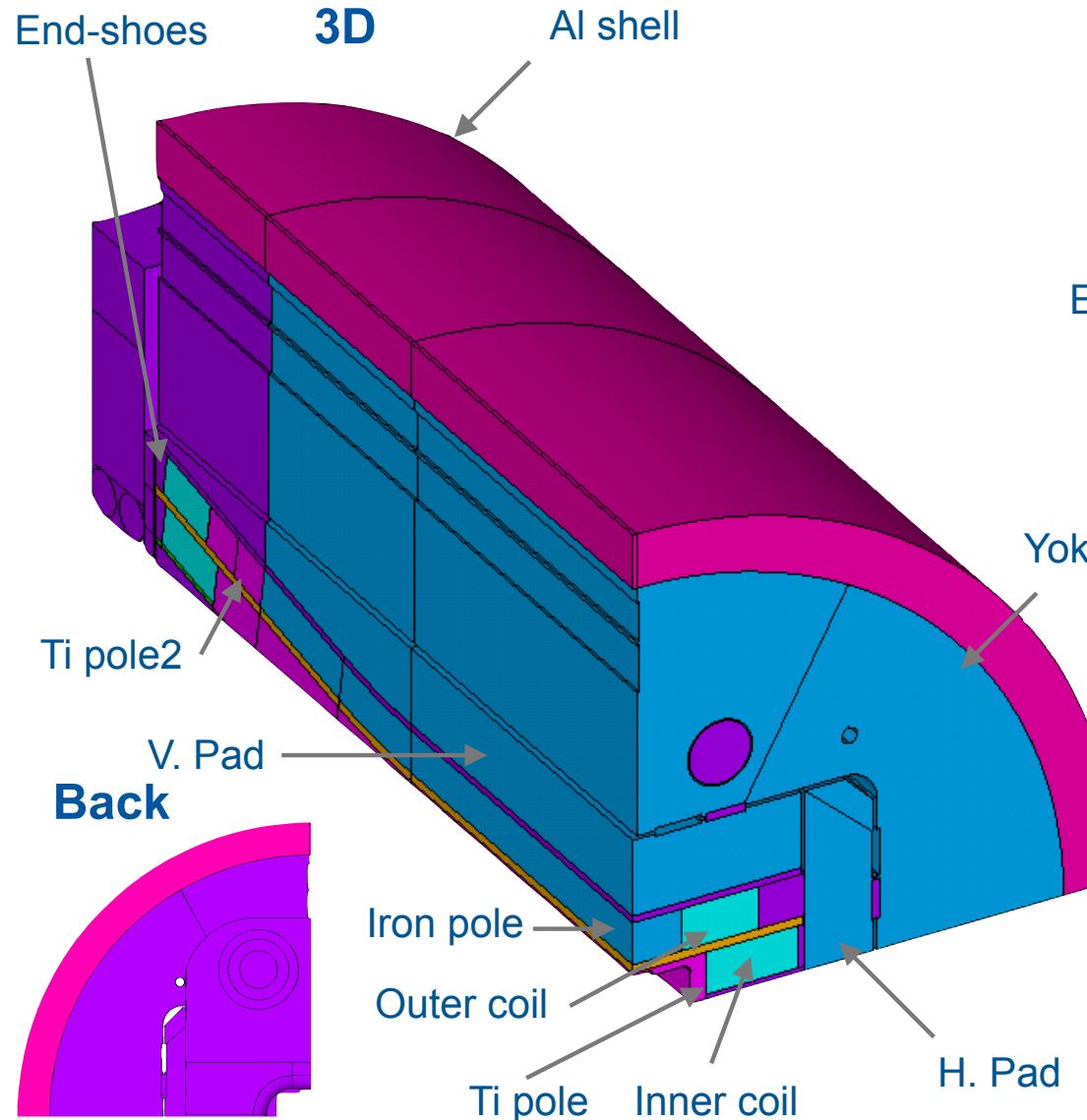
Summary of 3D mechanical results

D. Martins Araujo

MSC-MDT

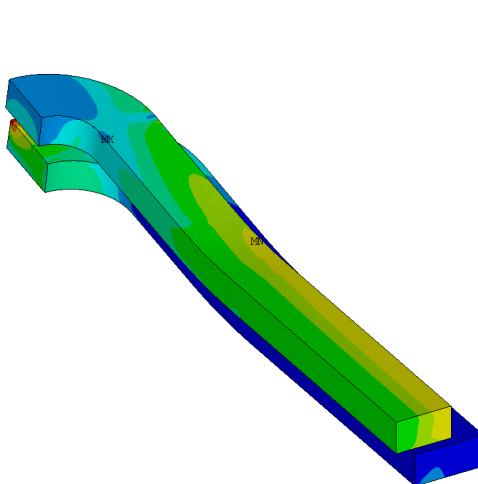


3D structure - some details



Coils - mech. analysis - S,EQV

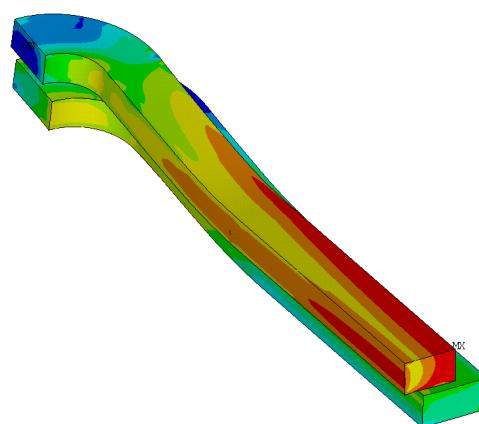
Room temperature



Keys,rod

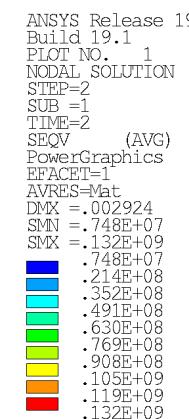
S,EQV at RT
74 MPa

At cold



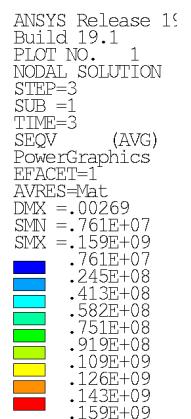
S,EQV at CD
132 MPa

15 T



Nominal field

S,EQV at NF
159 MPa

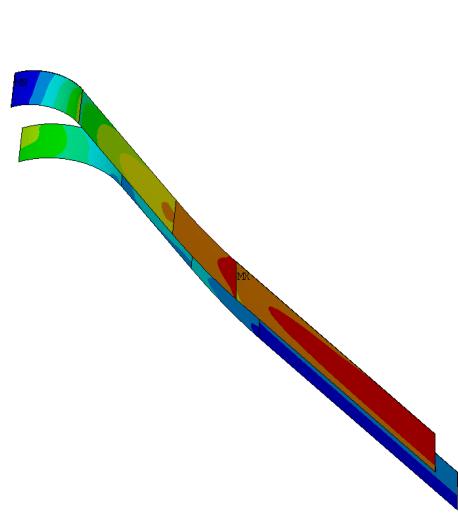


Bonded contact assumption between coils and poles



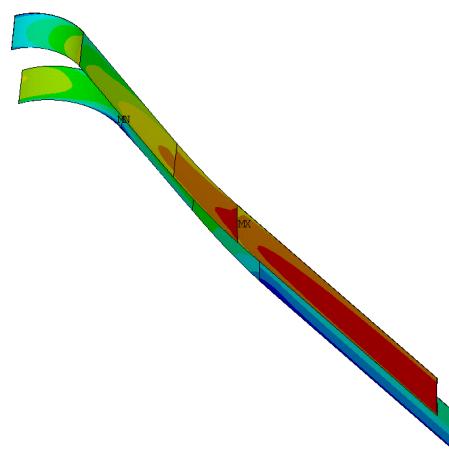
Contact pressure - mech. analysis

Room temperature



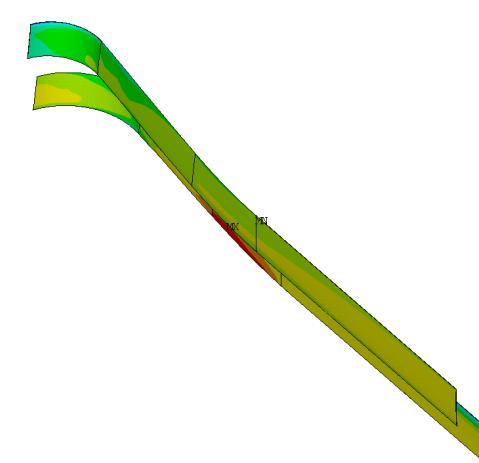
Keys, rod

At cold



Cool-down to 4.5 K

15 T



Nominal field

Straight section

$-10.6 / -4.1 \text{ MPa}$

Hard-way bend

$-7.6 / -11.5 \text{ MPa}$

Ramp

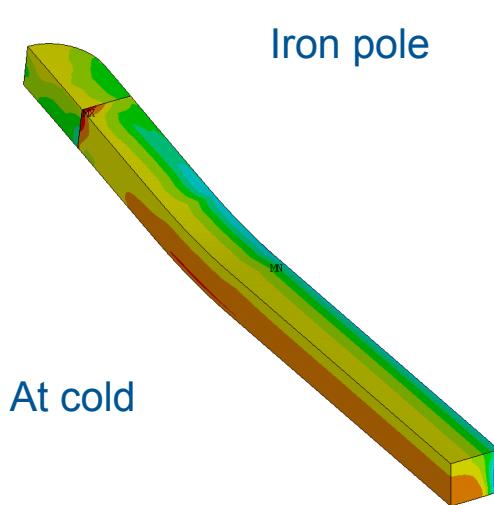
$-19.7 / -19.2 \text{ MPa}$

Easy-way bend

$-18.5 / -16.3 \text{ MPa}$

Respecting the criterium of a maximum of 20 MPa on average 15 T *inner / outer coils*

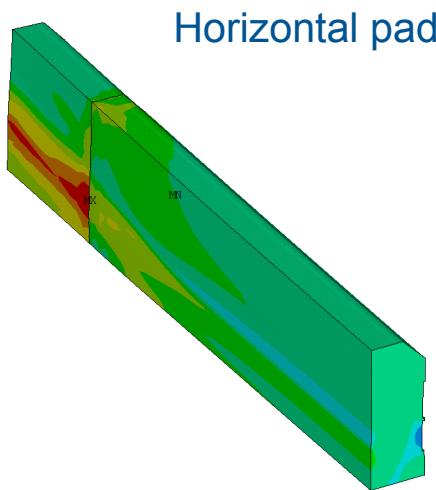
Iron pole and pads - mech. analysis - S,1



```

ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002101
SMN =-.104E+09
SMX =.130E+08
SMX =-.104E+09
-.906E+08
-.776E+08
-.647E+08
-.517E+08
-.388E+08
-.258E+08
-.129E+08
67931.6
.130E+08

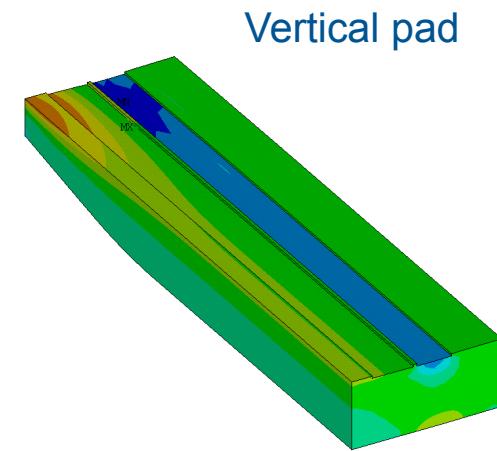
```



```

ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002815
SMN =-.161E+09
SMX =.268E+09
SMX =-.161E+09
-.114E+09
-.659E+08
-.517E+08
-.386E+08
-.258E+08
-.129E+08
.220E+09
.268E+09

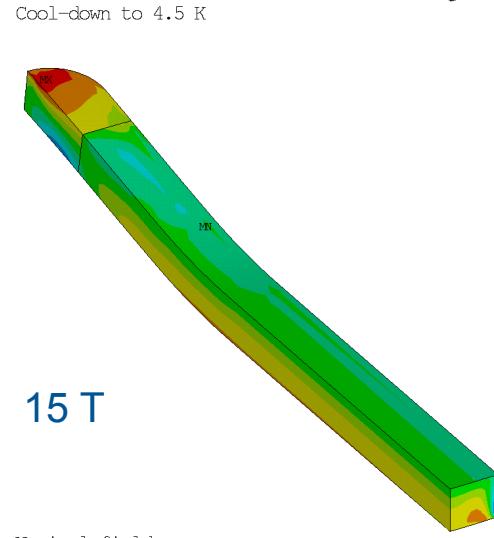
```



```

ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .001972
SMN =-.141E+09
SMX =.168E+09
-.141E+09
-.107E+09
-.725E+08
-.381E+08
-.365E+07
.308E+08
.652E+08
.996E+08
.134E+09
.168E+09

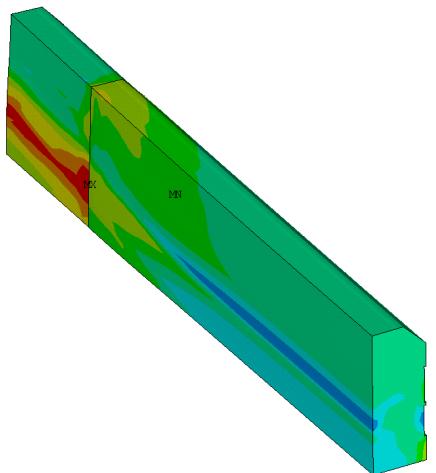
```



```

ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002028
SMN =-.481E+08
SMX =.128E+09
SMX =-.481E+08
-.285E+08
-.888E+07
.107E+08
.304E+08
.300E+08
.696E+08
.892E+08
.109E+09
.128E+09

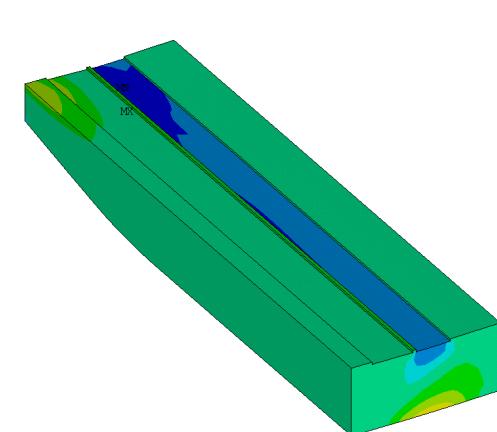
```



```

ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002668
SMN =-.126E+09
SMX =.233E+09
SMX =-.126E+09
-.858E+08
-.460E+08
-.611E+07
.337E+08
.736E+08
.113E+09
.152E+09
.193E+09
.233E+09

```



```

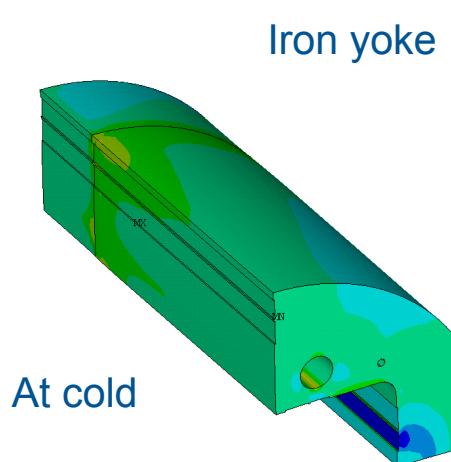
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002033
SMN =-.146E+09
SMX =.257E+09
-.146E+09
-.101E+09
-.564E+08
-.116E+08
.332E+08
.780E+08
.123E+09
.168E+09
.212E+09
.257E+09

```

Maximum principal stress at cold of 257 MPa

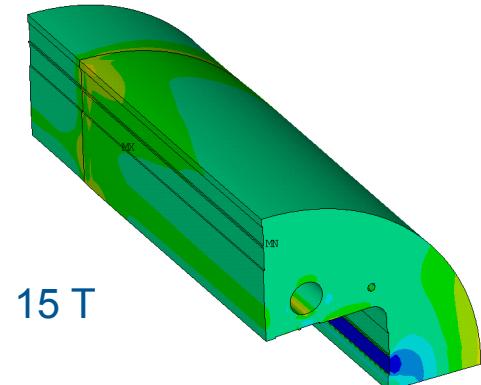


Iron yoke and Ti pole - mech. analysis



```
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002991
SMN = -.152E+09
SMX = .299E+09
SMX = -.152E+09
-.101E+09
-.514E+08
-.140E+07
.486E+08
.387E+08
.149E+09
.199E+09
.249E+09
.299E+09
.299E+09
```

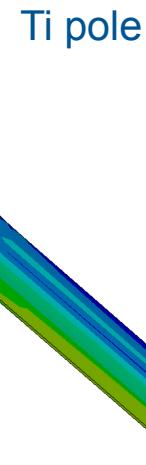
Cool-down to 4.5 K



```
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .003133
SMN = -.163E+09
SMX = .278E+09
SMX = -.163E+09
-.114E+09
-.654E+08
-.164E+08
.326E+08
.816E+08
.131E+09
.180E+09
.229E+09
.278E+09
```

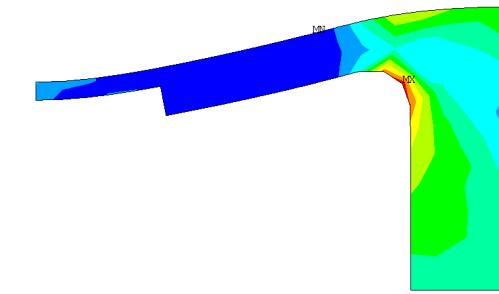
Nominal field

Yoke maximum principal stress at cold of 300 MPa



```
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
SEQV (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002109
SMN = .954E+07
SMX = .862E+09
.954E+07
.104E+09
.199E+09
.294E+09
.388E+09
.483E+09
.578E+09
.672E+09
.767E+09
.862E+09
```

Cool-down to 4.5 K



```
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
SEQV (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .001845
SMN = .153E+08
SMX = .820E+09
.153E+08
.105E+09
.194E+09
.284E+09
.373E+09
.462E+09
.552E+09
.641E+09
.731E+09
.820E+09
```

Nominal field

Ti pole maximum eqv stress: 862 MPa

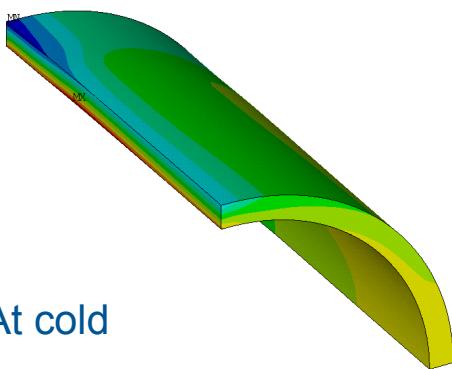
```
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
SEQV (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .454E-03
SMN = .266E+08
SMX = .634E+09
.266E+08
.941E+08
.162E+09
.229E+09
.297E+09
.364E+09
.432E+09
.499E+09
.567E+09
.634E+09
```

```
ANSYS Release 19
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
SEQV (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .968E-03
SMN = .345E+08
SMX = .698E+09
.345E+08
.108E+09
.182E+09
.256E+09
.329E+09
.403E+09
.477E+09
.551E+09
.624E+09
.698E+09
```



Shell and wedge - mech. analysis

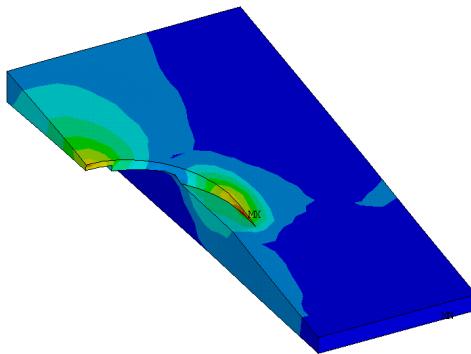
Shell



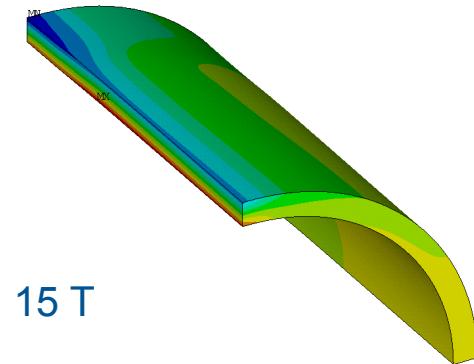
At cold

```
ANSYS Release 19.1
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
SY (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .005271
SMN = .753E+08
SMX = .241E+09
[Color Scale]
.937E+08
.112E+09
.131E+09
.149E+09
.168E+09
.186E+09
.204E+09
.223E+09
.241E+09
```

Wedge



Cool-down to 4.5 K



15 T

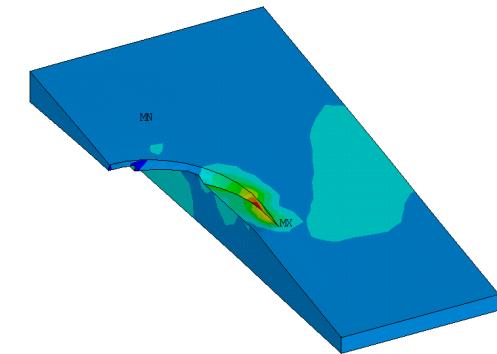
```
ANSYS Release 19.1
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
SY (AVG)
RSYS=1
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .0054
SMN = .582E+08
SMX = .248E+09
[Color Scale]
.582E+08
.793E+08
.100E+09
.122E+09
.143E+09
.164E+09
.185E+09
.206E+09
.227E+09
.248E+09
```

Nominal field

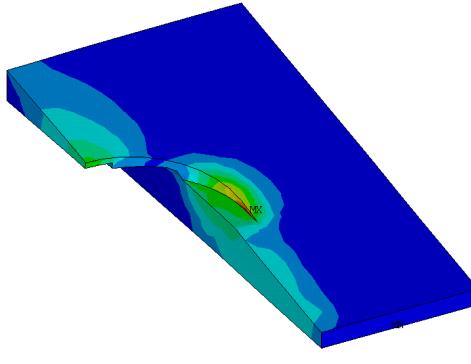
Shell max azimuthal stress of 248 MPa



Wedge



Cool-down to 4.5 K



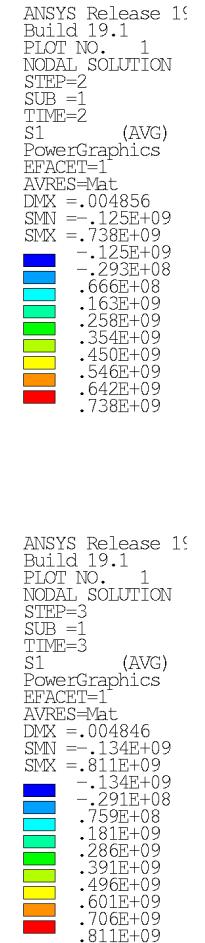
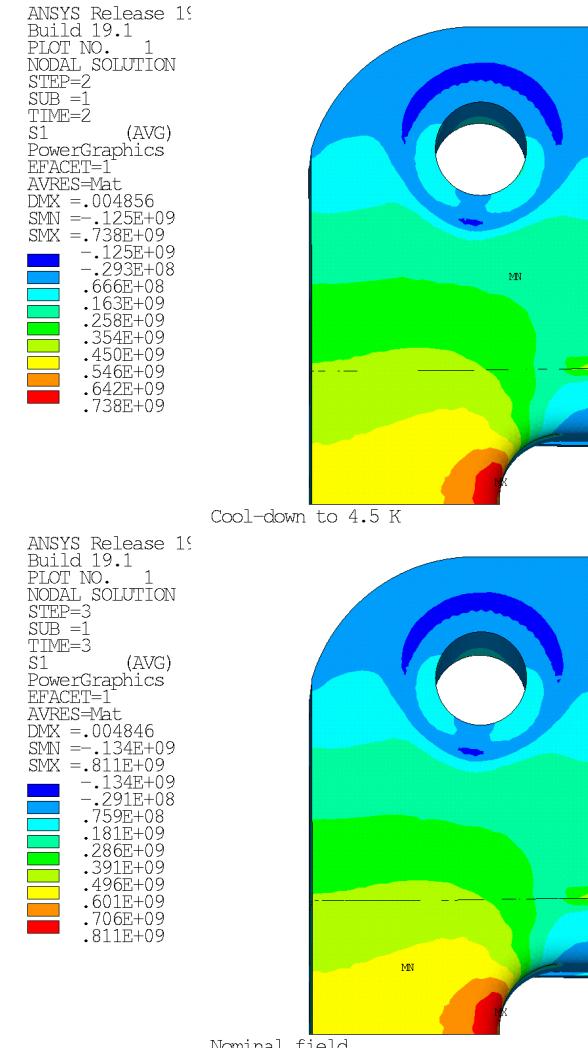
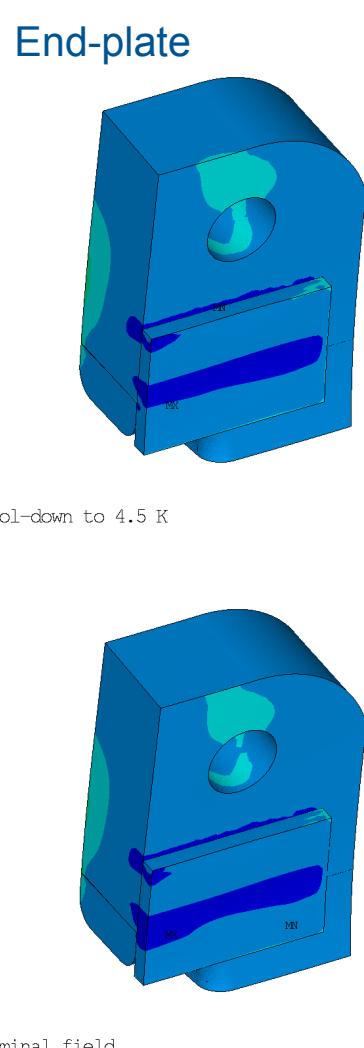
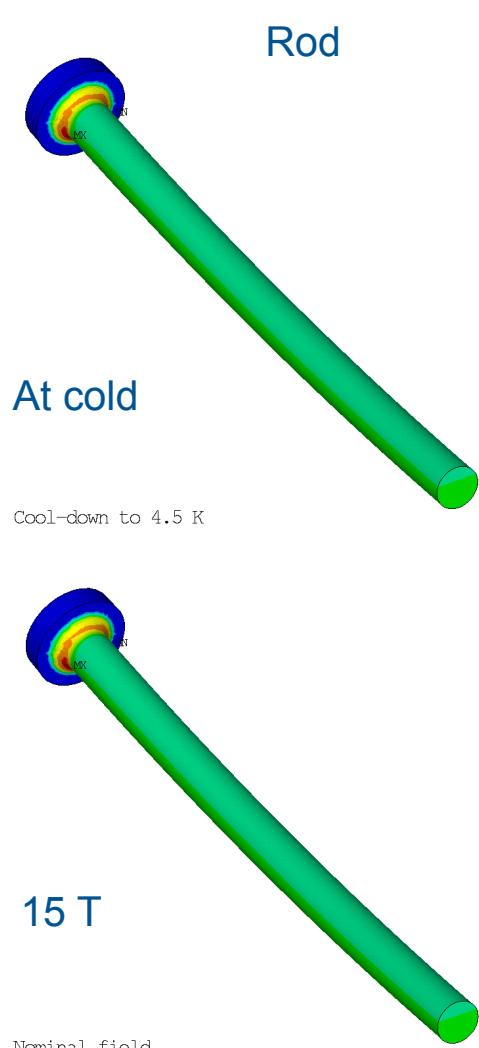
Nominal field

Wedge maximum principal stress of 381 MPa

```
ANSYS Release 19.1
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002511
SMN = -.809E+08
SMX = .364E+09
-.809E+08
-.315E+08
.179E+08
.673E+08
.117E+09
.166E+09
.216E+09
.265E+09
.314E+09
.364E+09
```

```
ANSYS Release 19.1
Build 19.1
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
S1 (AVG)
PowerGraphics
EFACET=1
AVRES=Mat
DMX = .002264
SMN = .148E+08
SMX = .985E+09
.148E+08
.123E+09
.230E+09
.338E+09
.446E+09
.554E+09
.661E+09
.769E+09
.877E+09
.985E+09
```

Rod and end-plate - mech. analysis

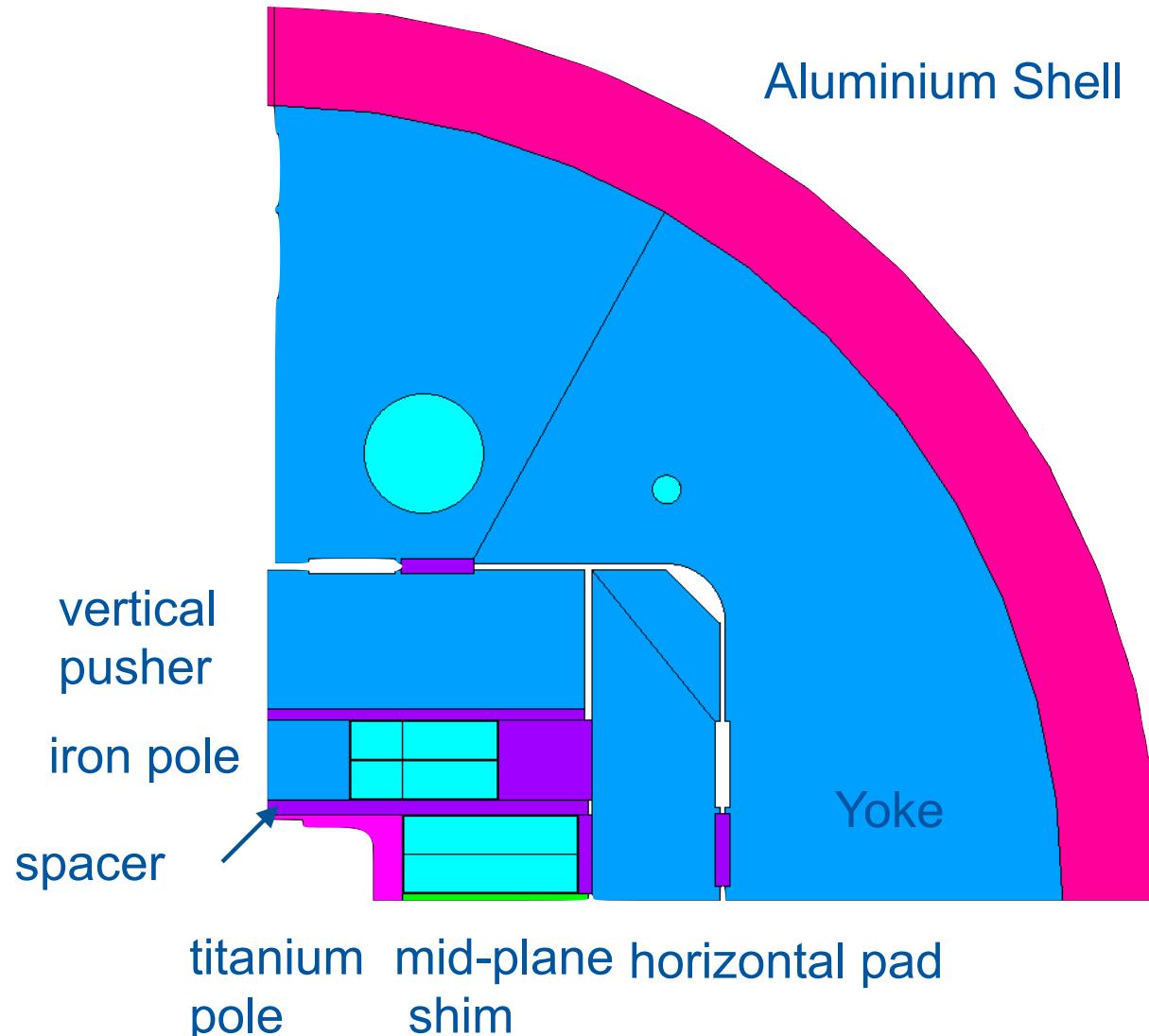


Rod max principal stress of 667 MPa

End-plate maximum principal stress of 811 MPa

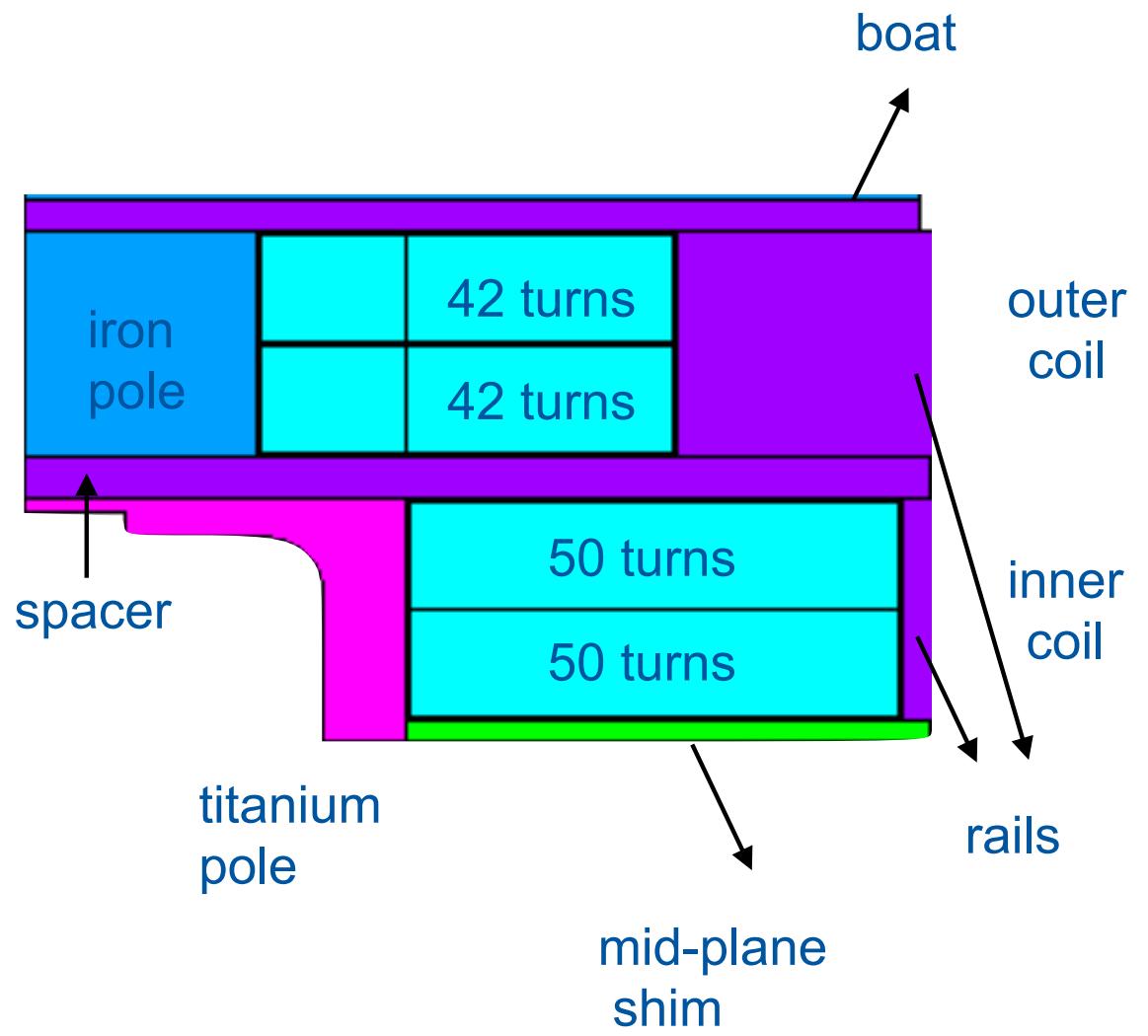
Specification and 4 coils option cross-section

	Goal
B center	15 T
% SS	85%
temperature	4.2 K
apperture	'rectangular' 150x100
length	~ 2 m
I_nom	14.74 kA

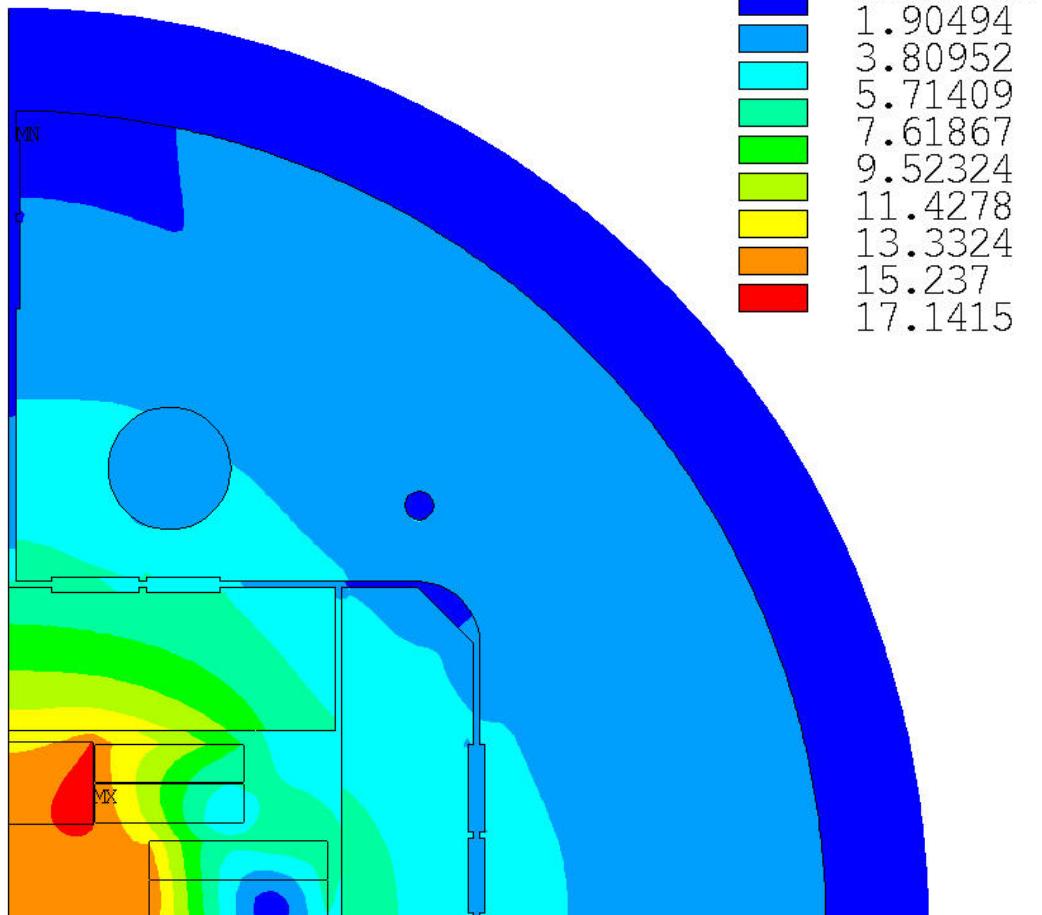


Cable specification

Cable data	
d_strand	1.1 mm
number of strands	44
thickness	1.95 mm
width	26.2 mm
turn insulation thickness	0.15 / 0.20 mm
min coil insulation thickness	0.5 mm
Inter-layer insulation	0.5 mm
SC:Cu	1:1



4.2 K - 85% of the load line



Bore field (B): 14.92 T

Max coil field (B): 15.19 T

