



Mechanical Design of BOC cavity

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CERN-SL/CT

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The Team (SL/CT Group)



■ Raymond Hanni

- ◆ Responsible for the definition of the fabrication procedures and follow-up

■ Sebastien Marque

- ◆ Numerical simulations, cooling design

■ Sylvain Gyrod

- ◆ draughtsman

■ Myself

- ◆ RF stuff....



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 - ◆ (Igor, Igor...)
- Design, Simulations & Solutions
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Specs



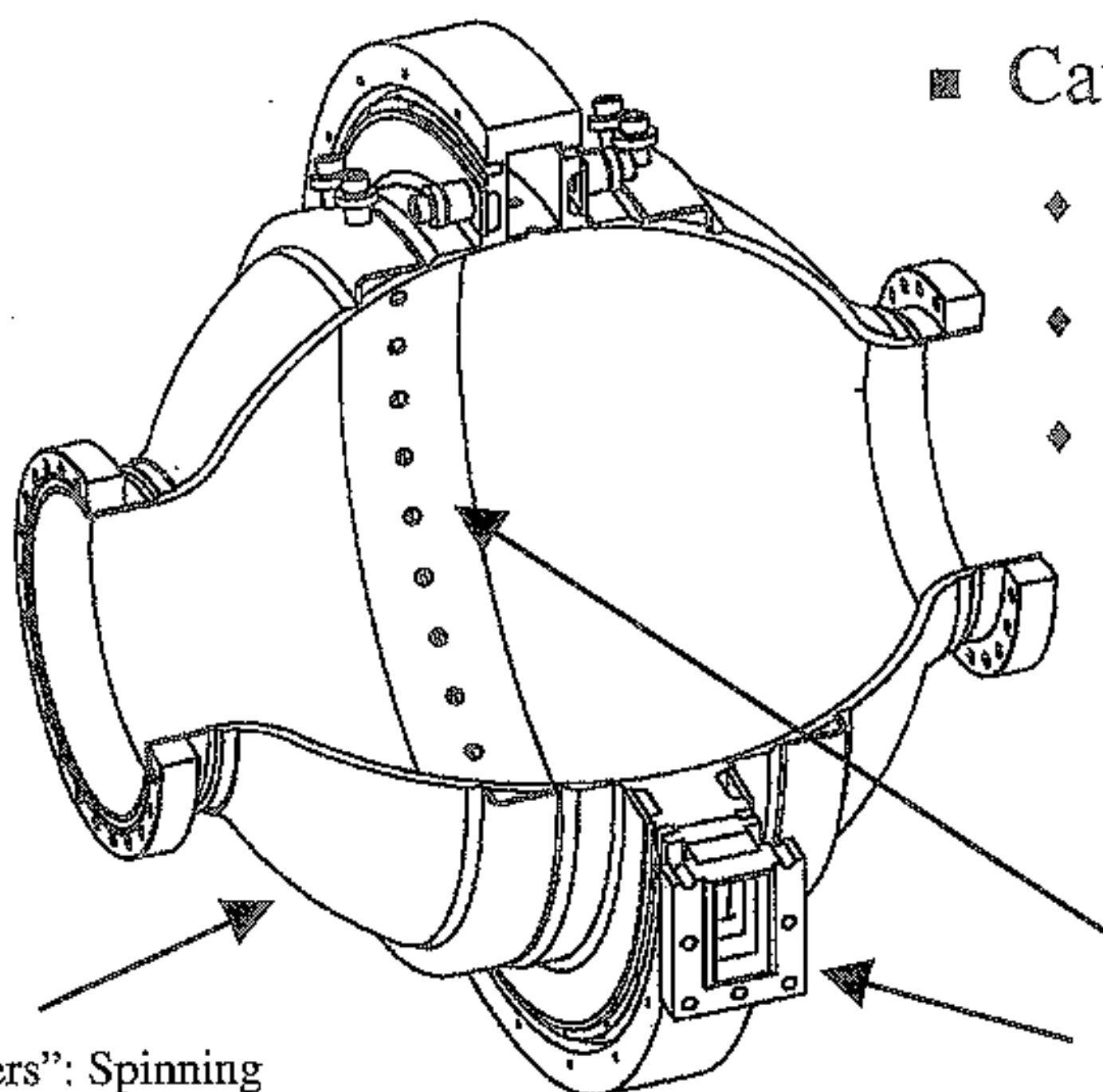
- Frequency: 2998.550 MHz
- Pulse shape:
 - ◆ $4.5 \div 6 \mu\text{s}$, $5 \div 25 \text{ Hz}$ rep. rate
- Power:
 - ◆ 40 MW from source
 - ◆ 1750 W average loss on walls ($6 \mu\text{s}$, 25 Hz)



- Tuning Strategy: by water cooling.
 - ◆ Range: ± 250 kHz ($\pm 0.0085\%$!!!)
- Consequences:
 - ◆ must be insensible to pressure variations $\Rightarrow$
 - ◆ cavity must be very stiff $\Rightarrow$
 - ◆ good precision for manufacturing.



- How to get the ideal frequency???
 - ◆ Cut & try: sensitivity is few MHz/mm at the equator.
- Proposed final fine tuning is through electrolytic etching
 - ◆ (but we would like to avoid it).



- Cavity Material : OFE Copper
 - ◆ Thermal Conductivity: 400 W/m/K
 - ◆ Specific Heat: 385 J/Kg/K
 - ◆ Yield stress: 200 MPa

"Shoulders": Spinning

Equator + Waveguide:
Machined then EB welded

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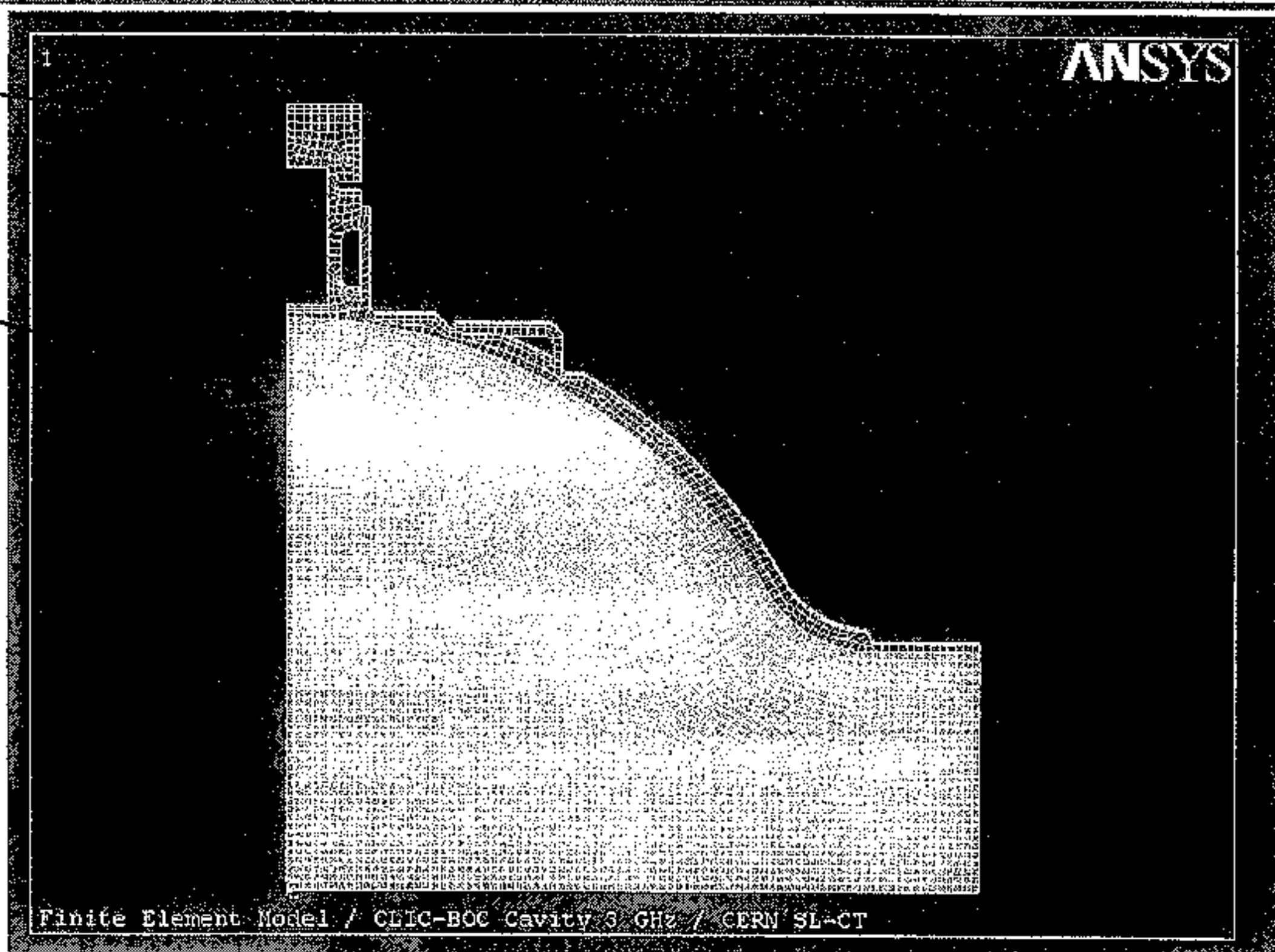
Simulations



Mechanical/Thermal
elements

RF elements

- Coupled Rf
and
Mechanical
simulations
made with
ANSYS™



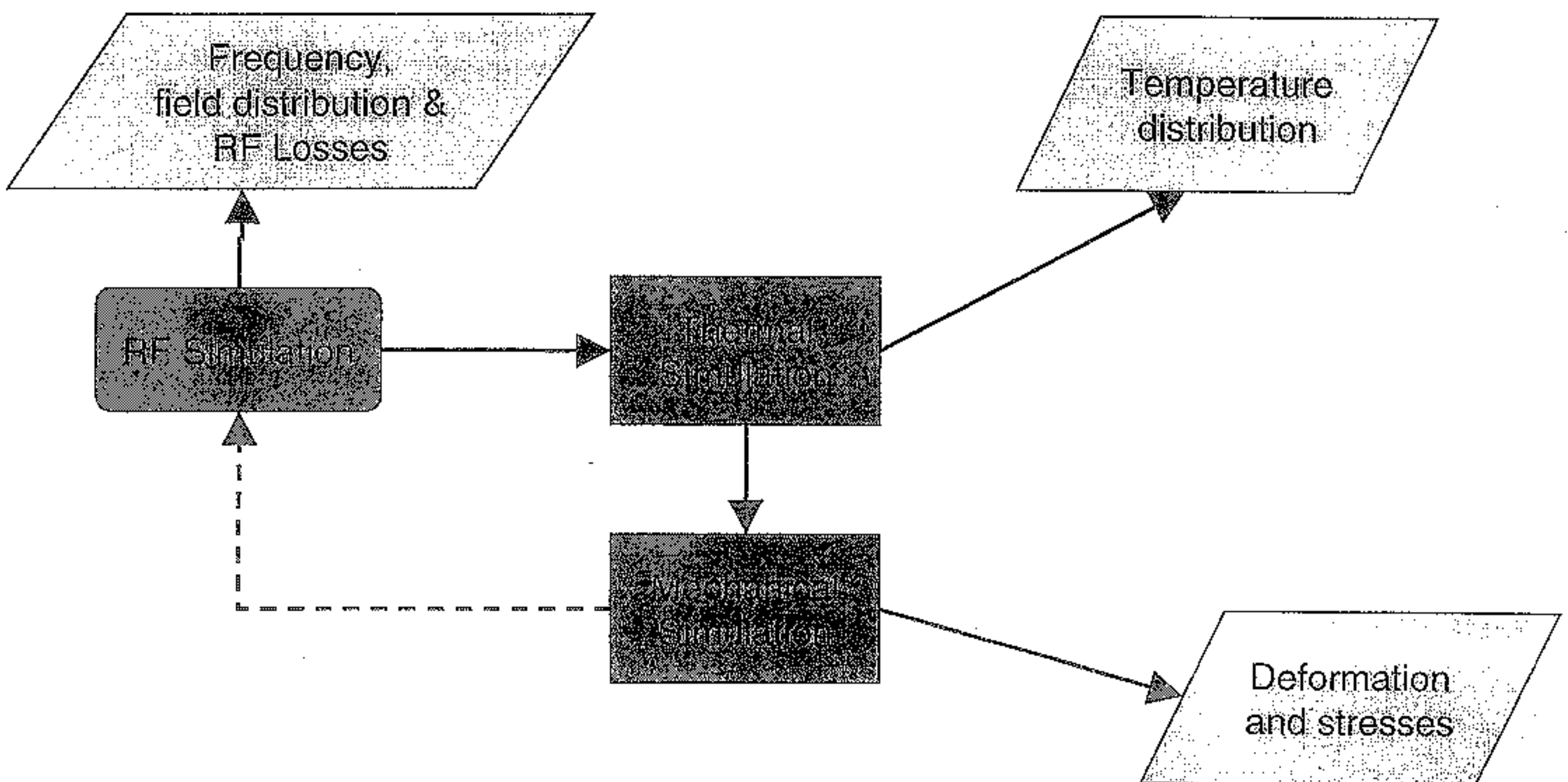
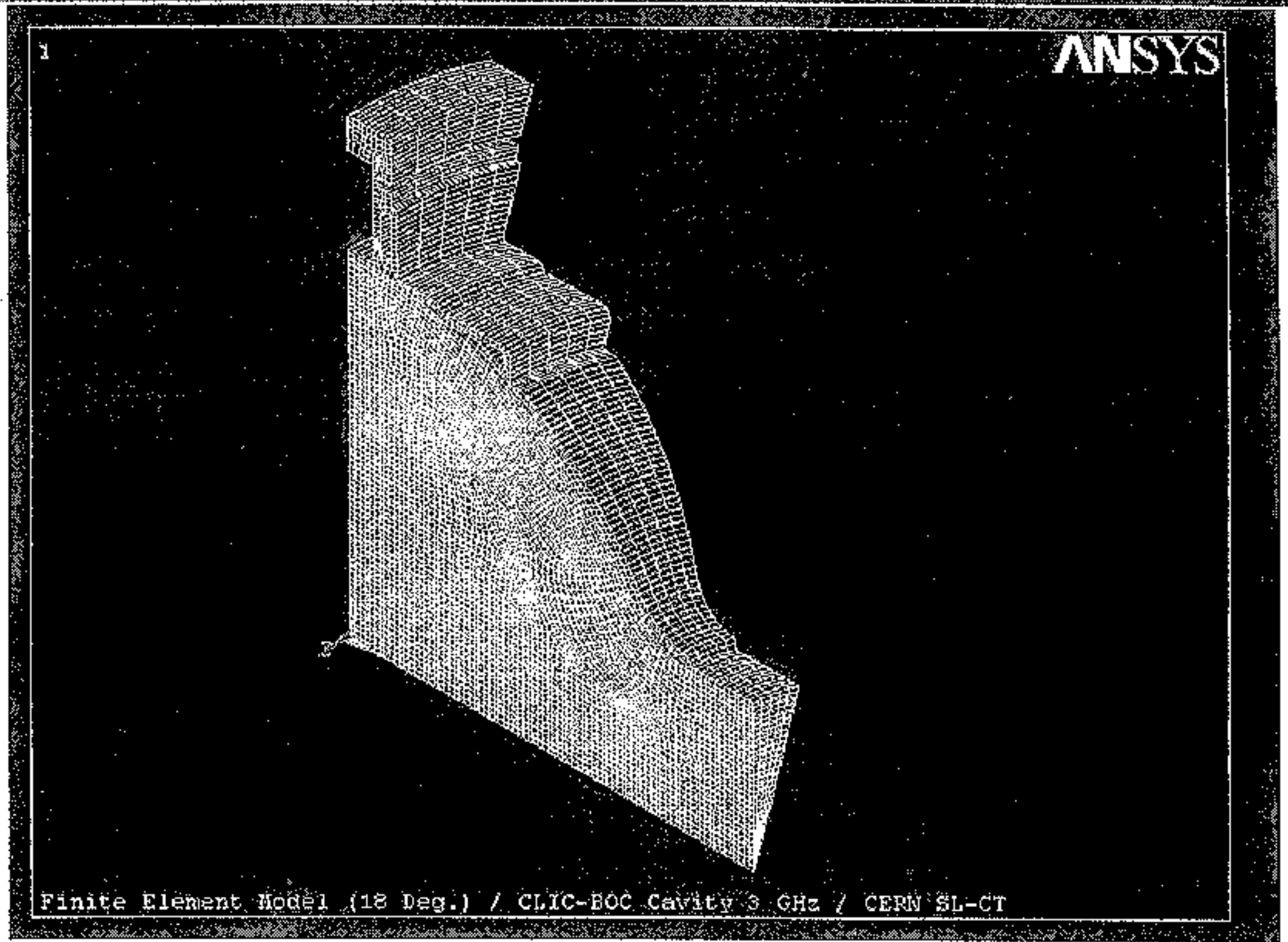
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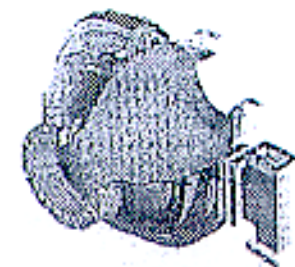
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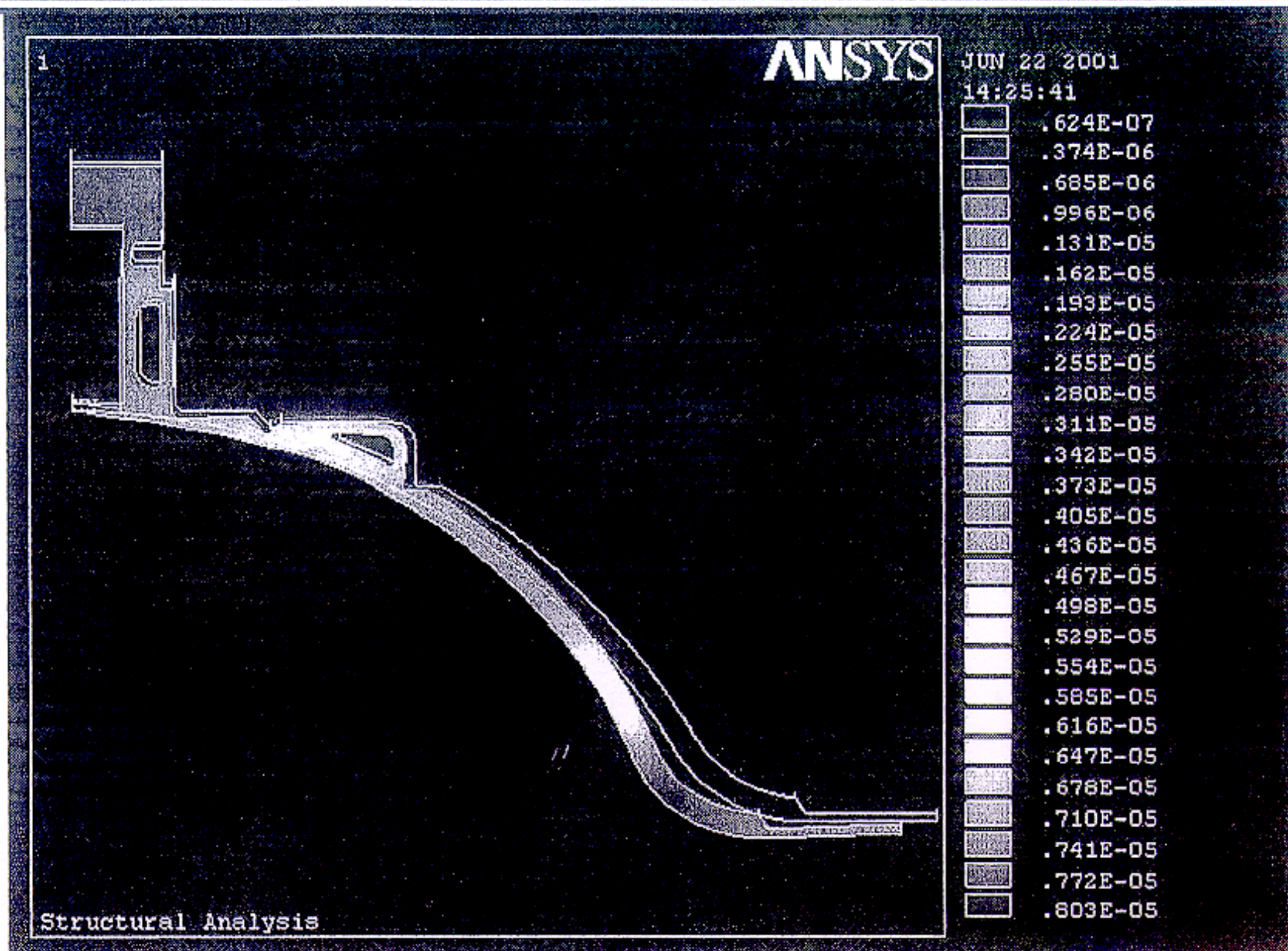


- Drawback:
only 3D
elements are
available for
RF

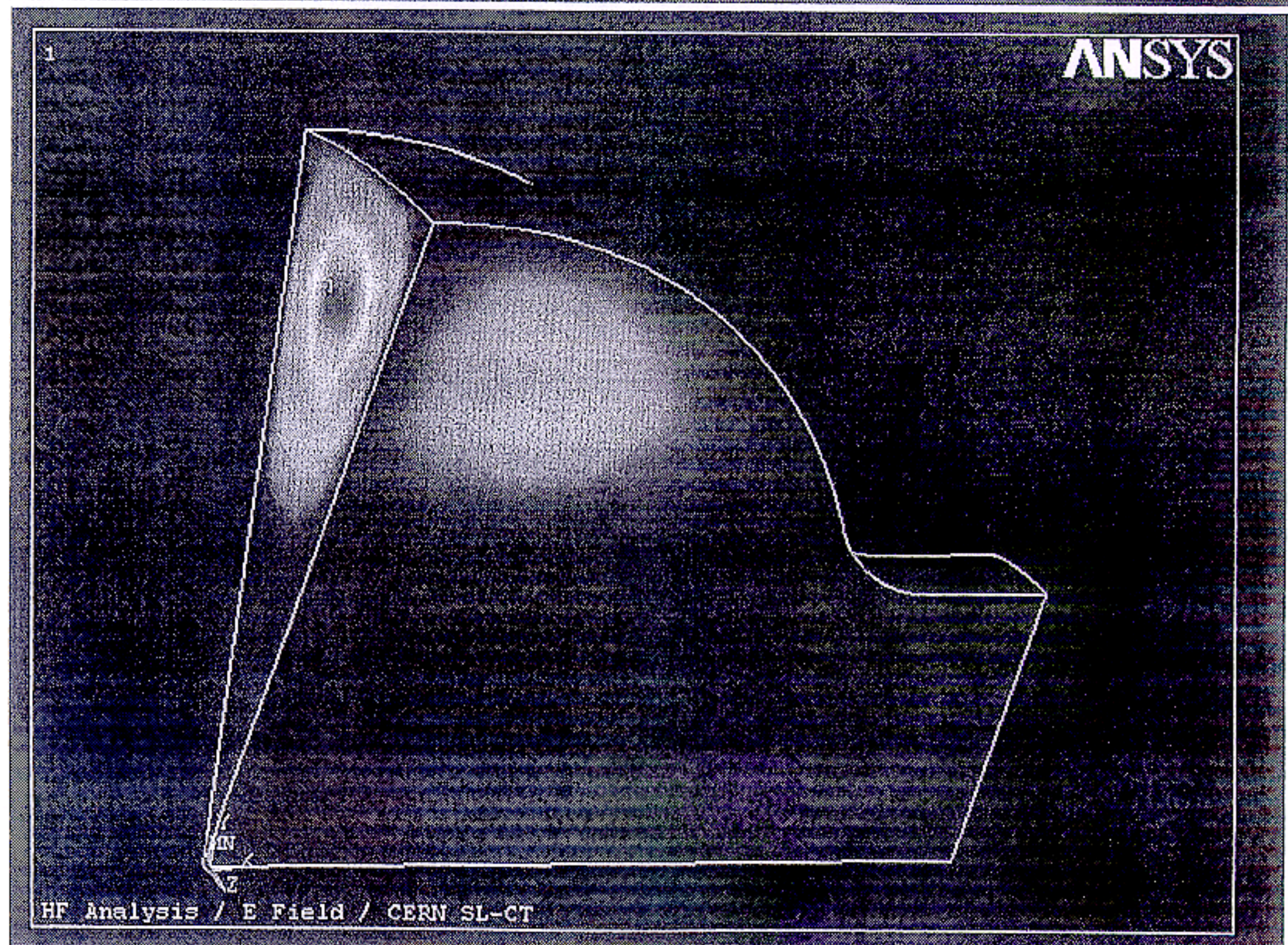




- Deformation due to $\Delta p = 1 \text{ Bar}$
- Max $|\Delta x| = 8 \mu\text{m}$
- $\Delta f = 8 \text{ KHz}$



- Mode $E_{10,1,1}$:
- E-Field

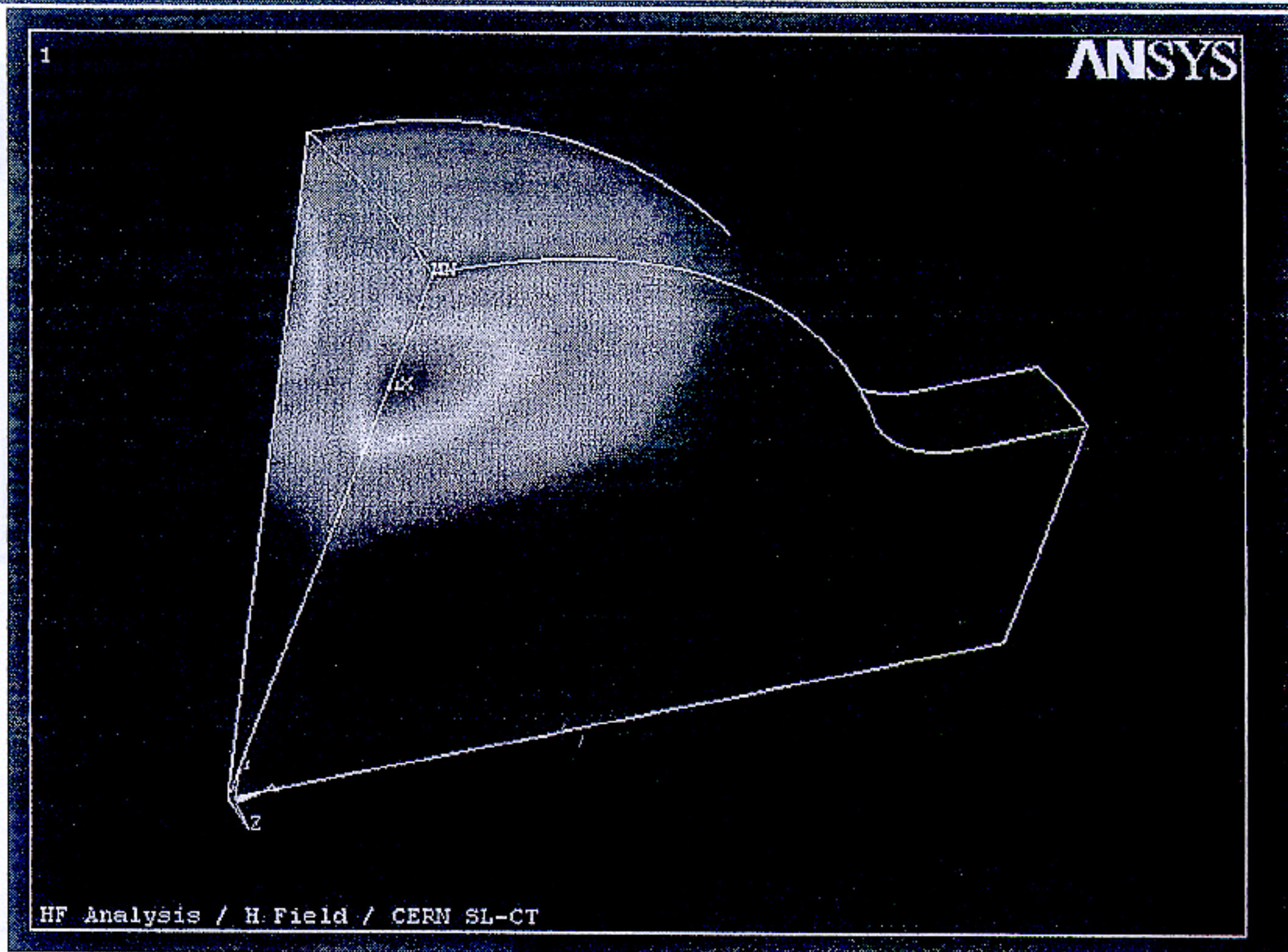


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■ Mode $E_{10,1,1}$:

H-Field



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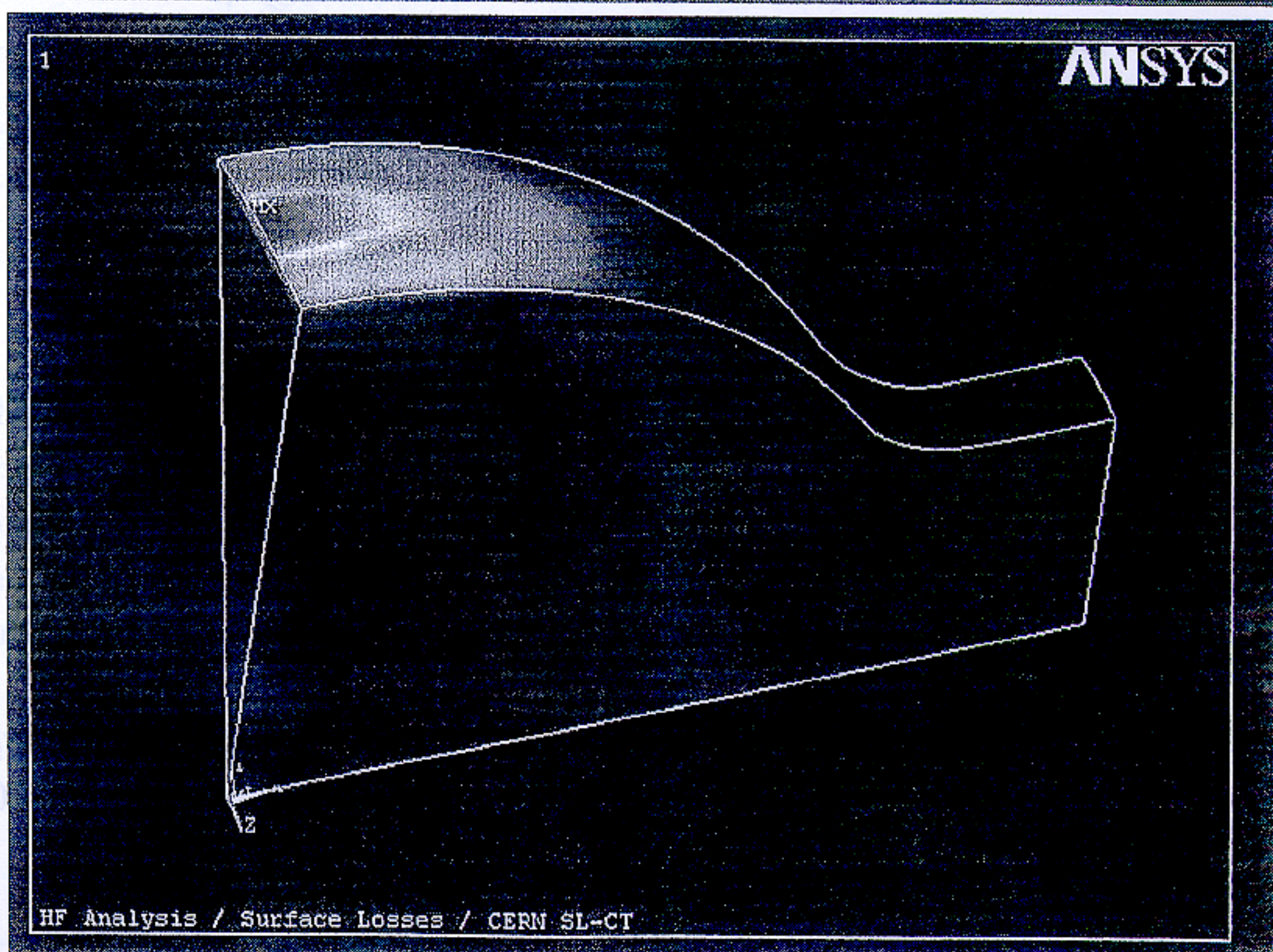
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■ Mode $E_{10,1,1}$:

Losses

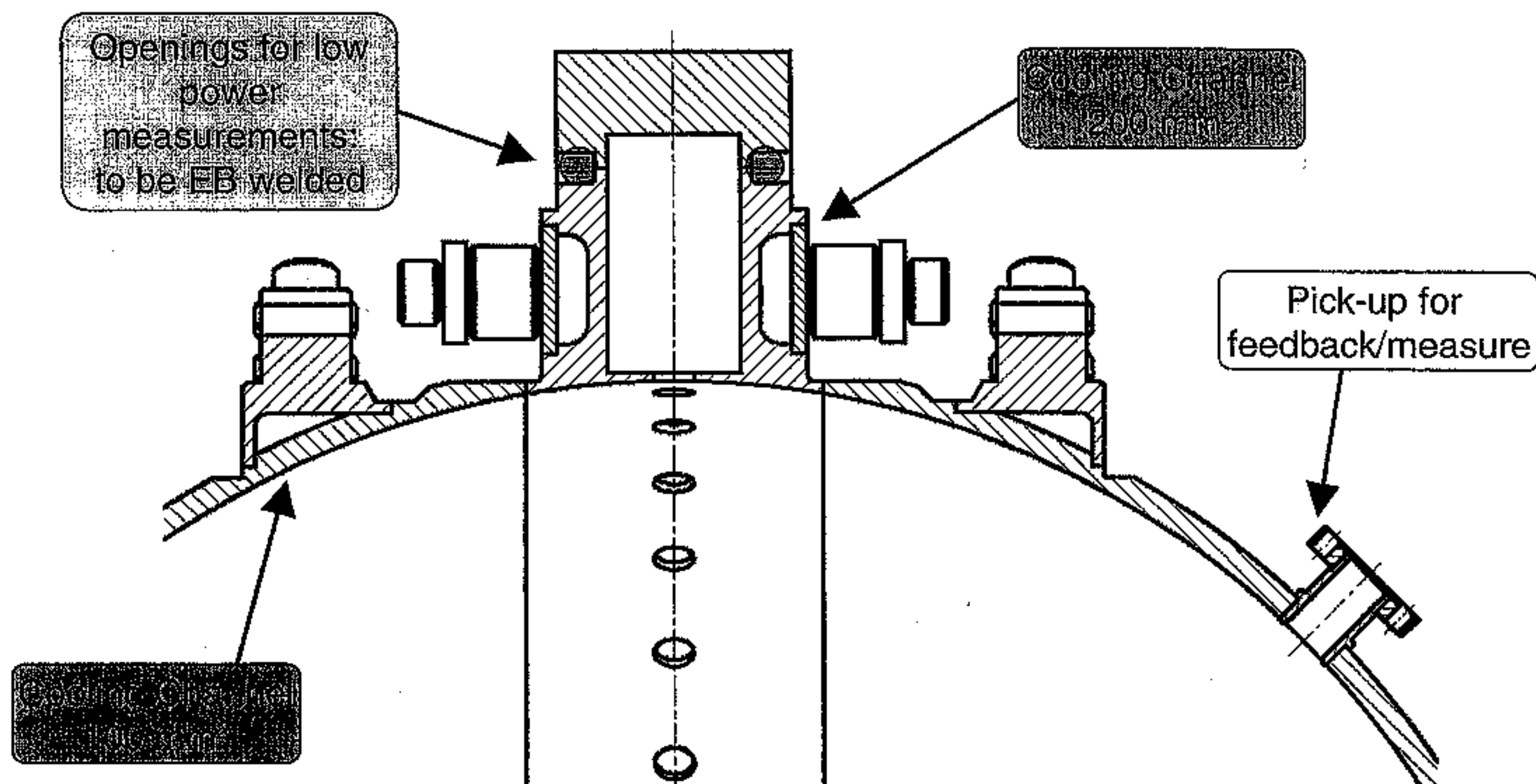


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- ◆ Demineralised Water
- ◆ Power to be dissipated : 1750 Watts
- ◆ Temperature rise for water: 1 K
- ◆ Coolant velocity < 2.5 m/s
- ◆ Turbulent regime

Water cooling Specs



- ◆ Water Flow:
 - ▣ 1 m³/h for the waveguide cooling channels
 - ▣ 0.5 m³/h for the shoulders' cooling channels
- ◆ Global Exchange coefficient :
 - ▣ 4700 W/m²/K for the waveguide cooling channels;
 - ▣ 7800 W/m²/K for the shoulders' cooling channels;
- ◆ Total Pressure Drop : 0.2 Bar
- ◆ Coolant Velocity : 1.3 m/s;
Reynolds Number : 18000;



Simulations



$$f = 2998.550 \text{ MHz}; \quad Q = 180000; \quad P_f = 40 \text{ MW};$$

$$\beta = 6; \quad \alpha = \frac{2\beta}{\beta+1}; \quad \tau = \frac{2Q}{\omega(\beta+1)};$$

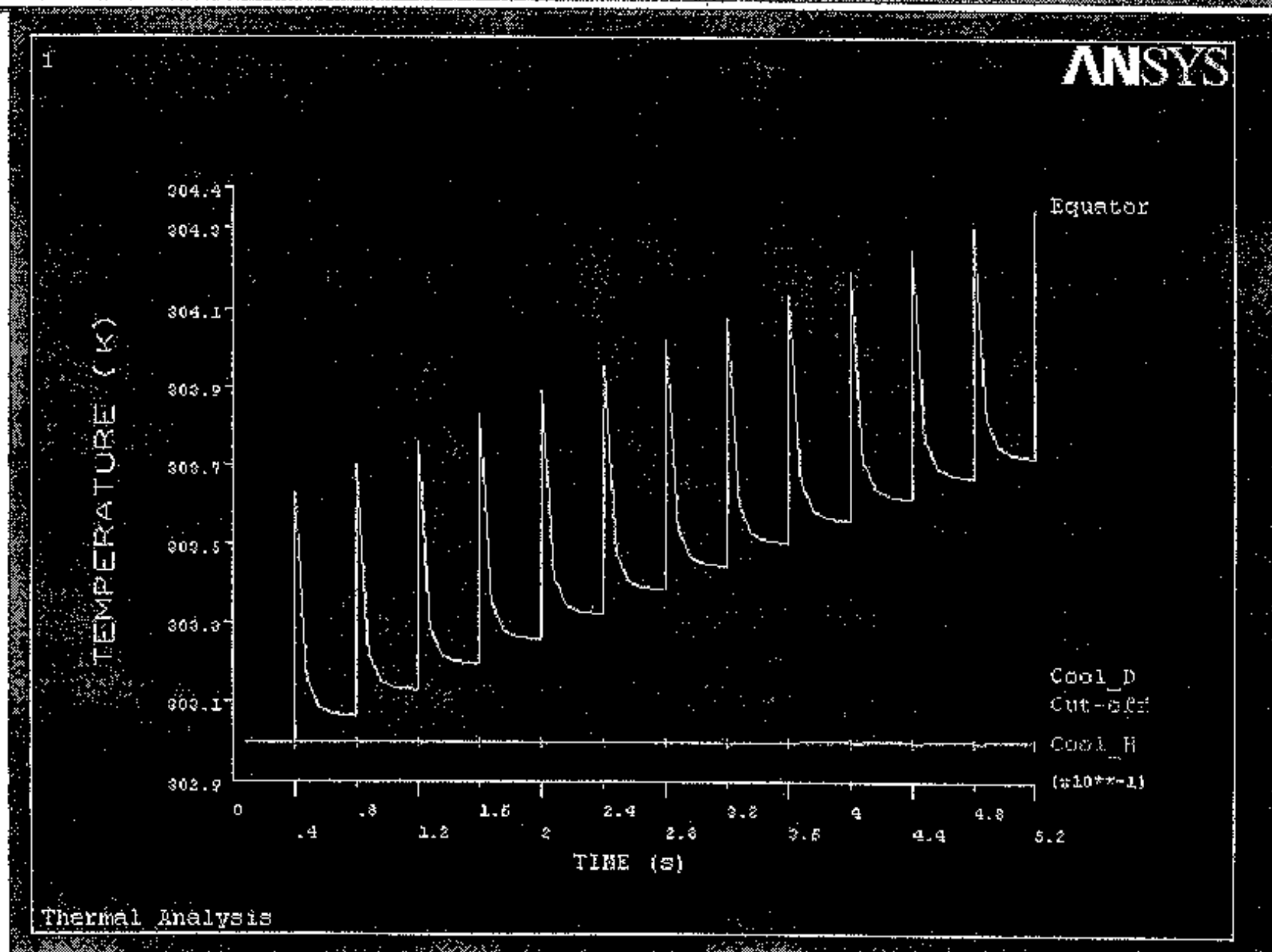
$$W = \tau \alpha \left(1 - e^{-\frac{t}{\tau}}\right) P_f; \quad P_{diss} = \frac{\omega W}{Q}$$



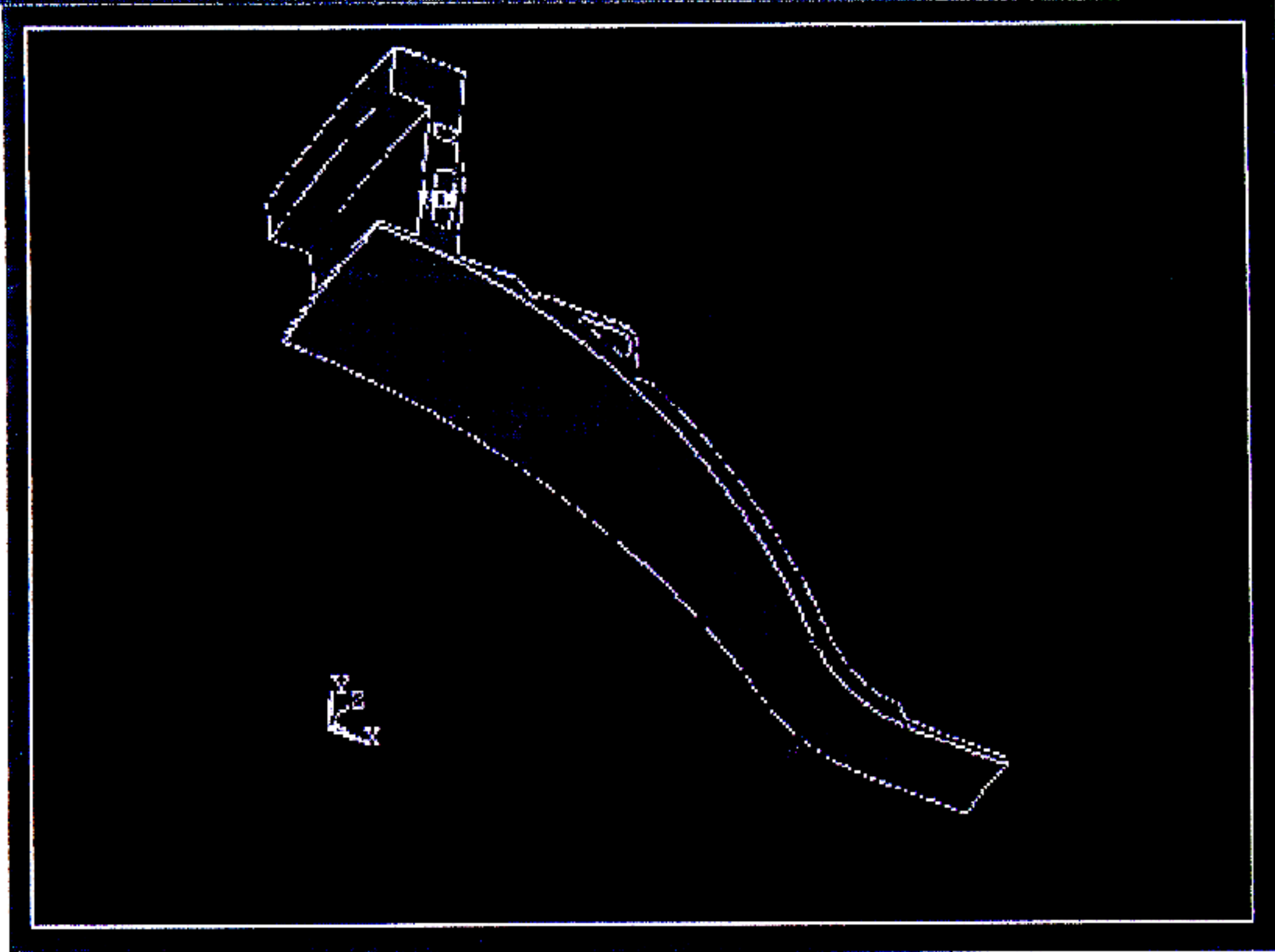
Simulations



- 12 cycles,
25 Hz
(0.52 sec)
- Max stored
Energy:
148 J
- Coolant
temperature:
303K



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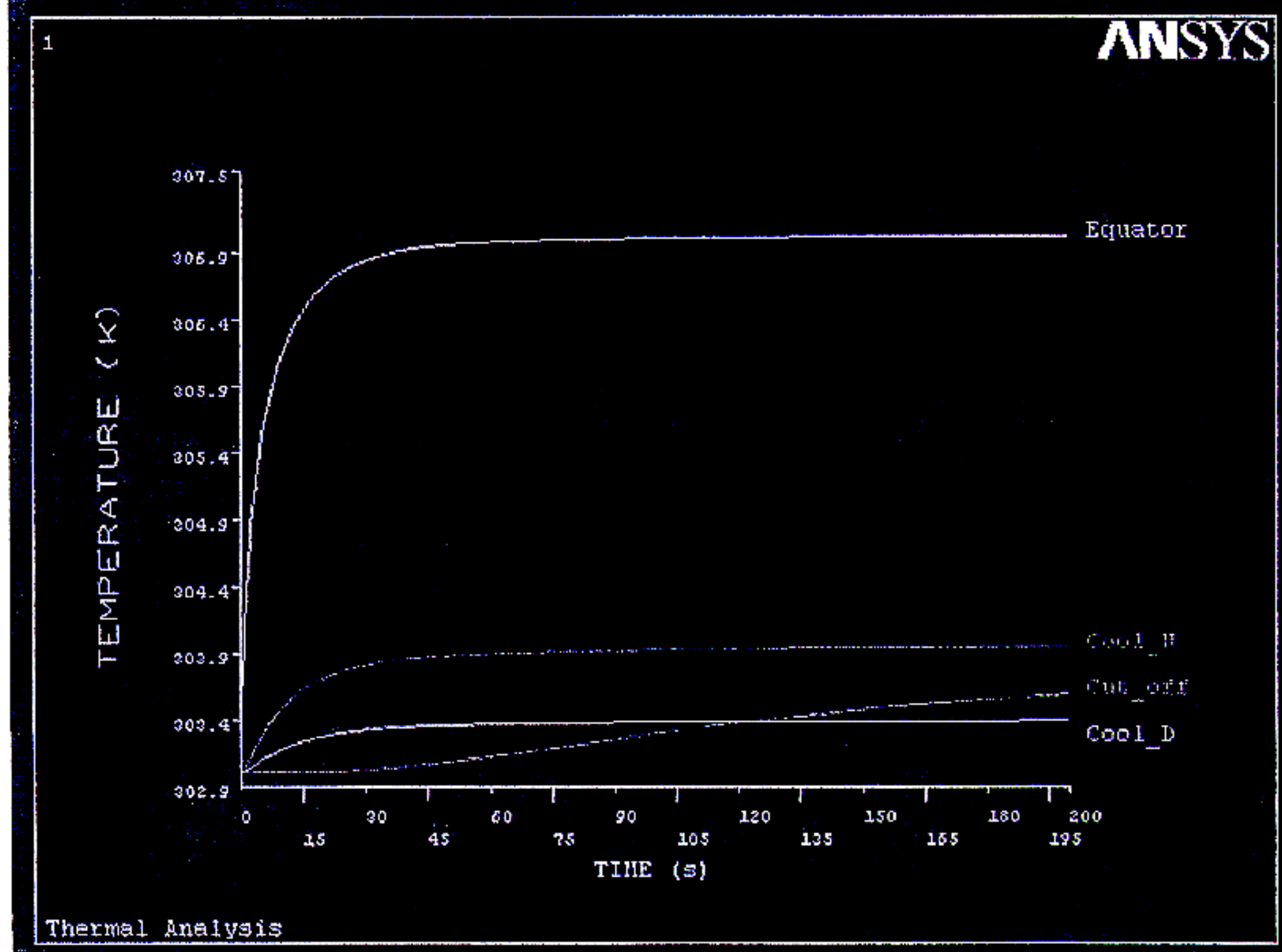


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- Response to step with average power: 1750 W
- Max $\Delta t = 4\text{K}$
- Max $|\Delta x| = 6\mu\text{m}$



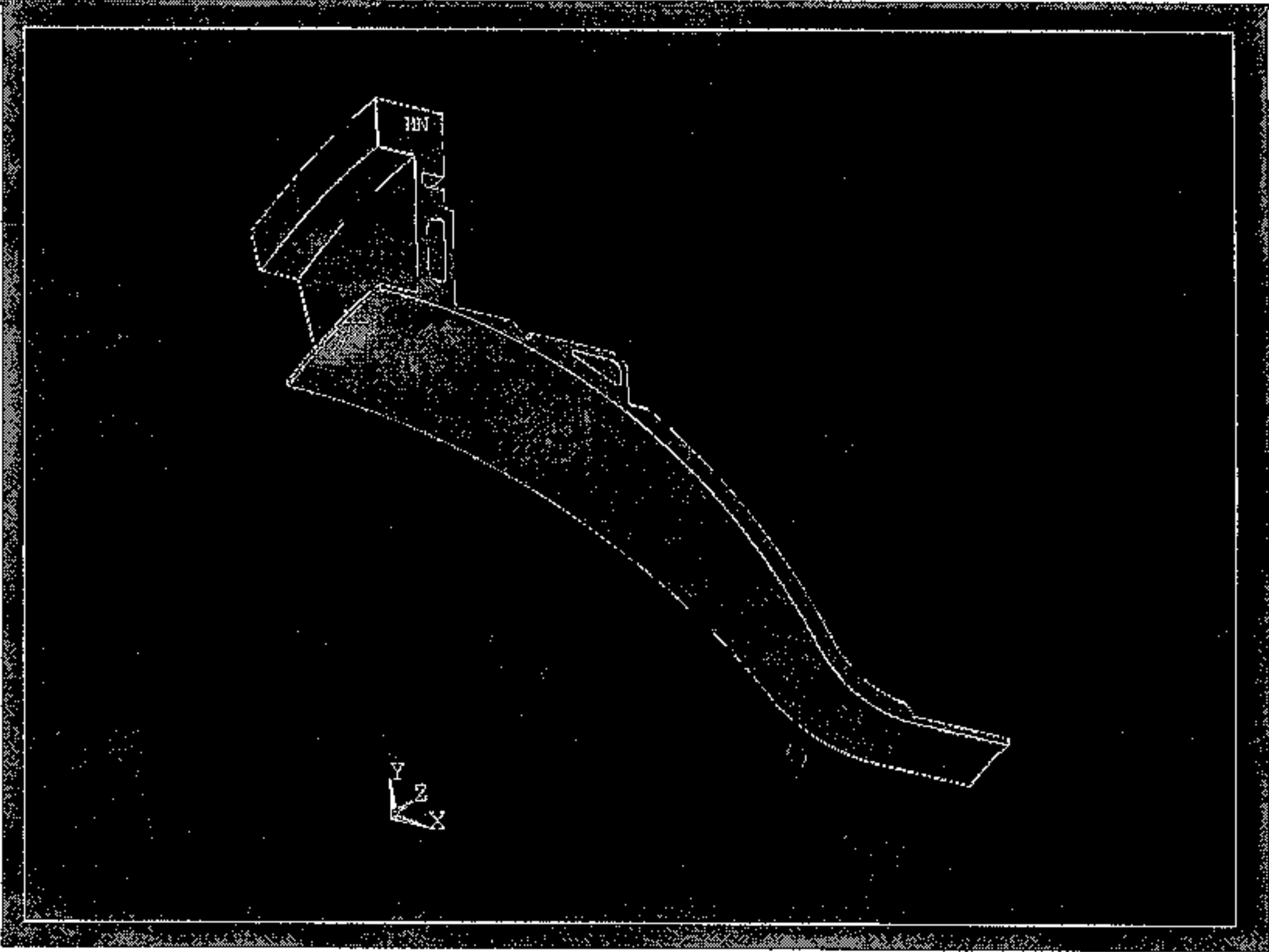
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Simulations



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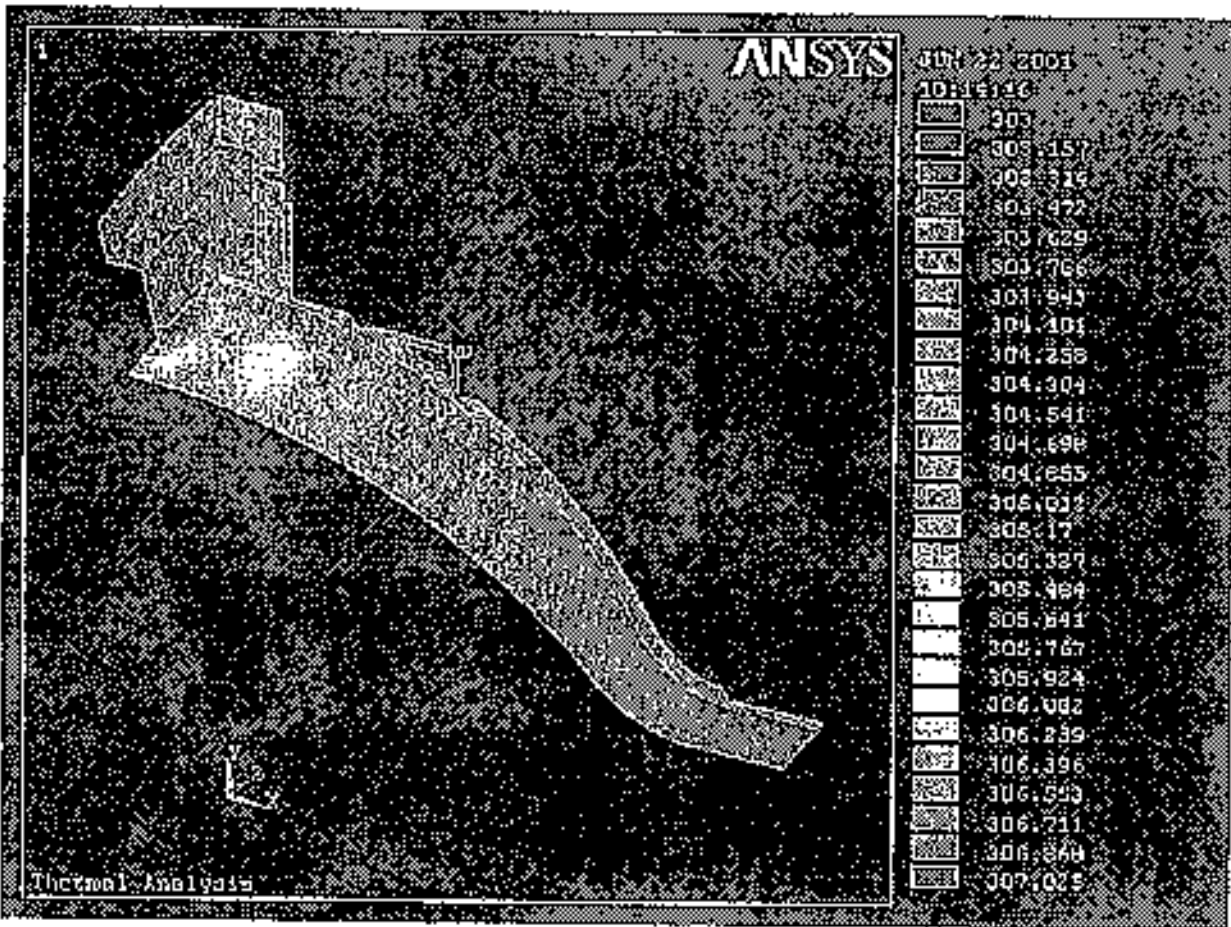
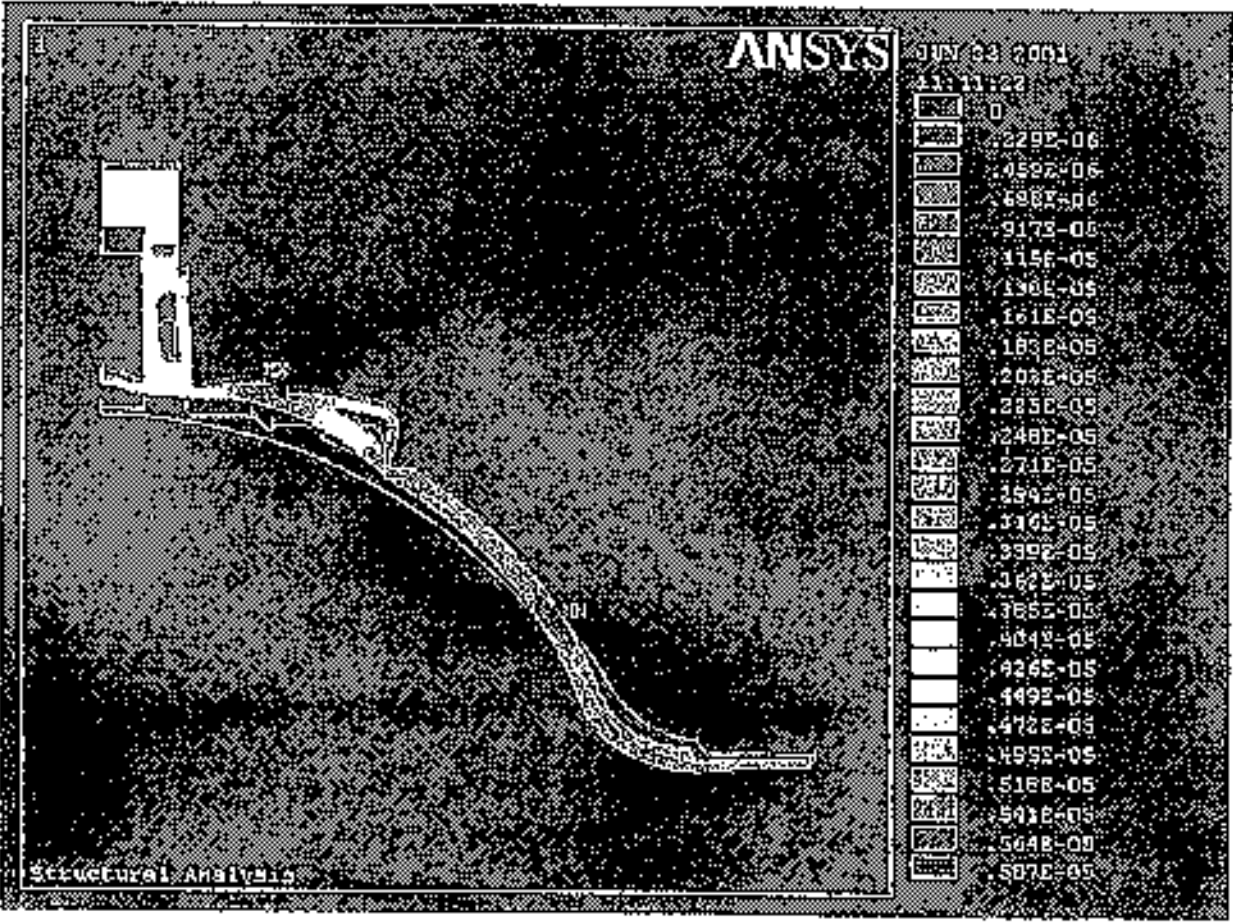
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Simulations



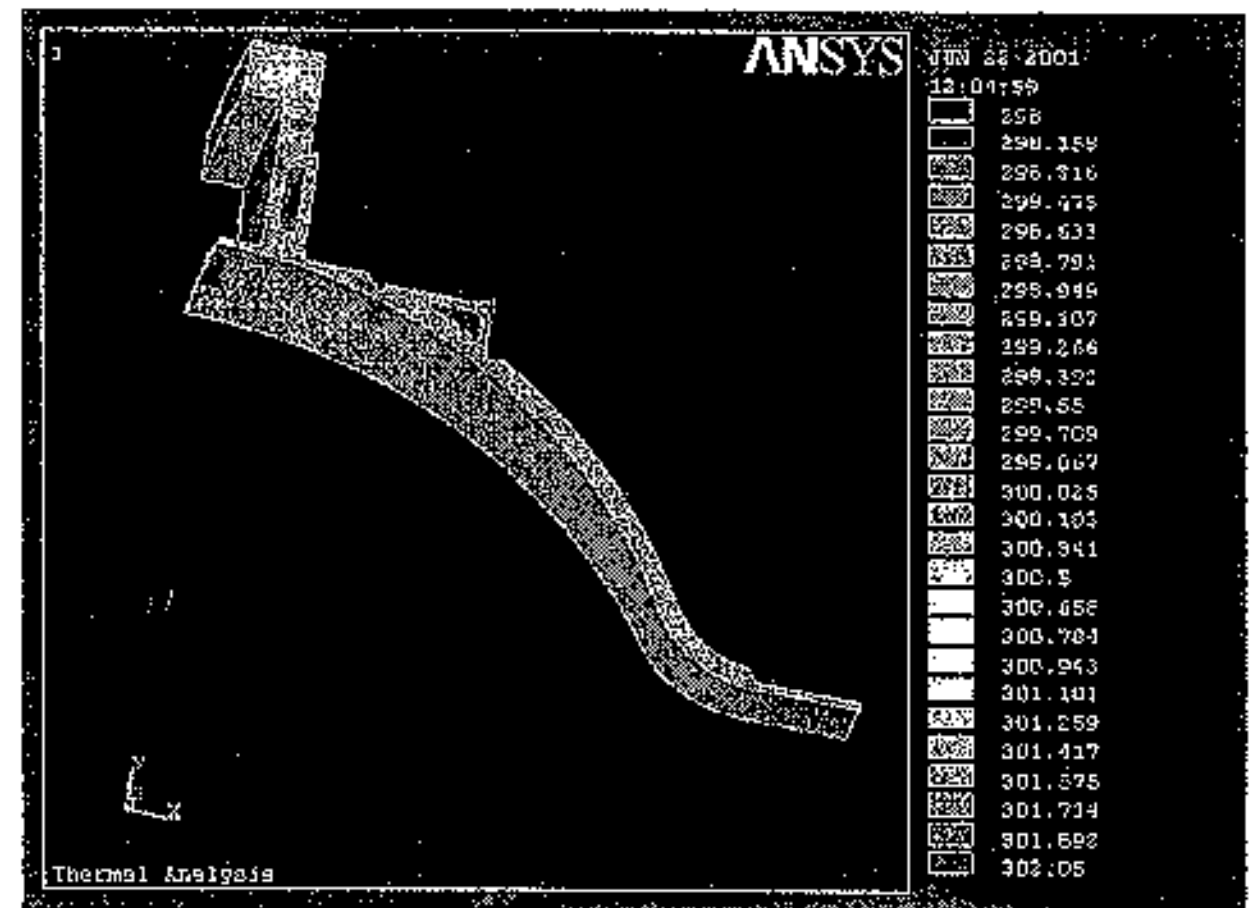
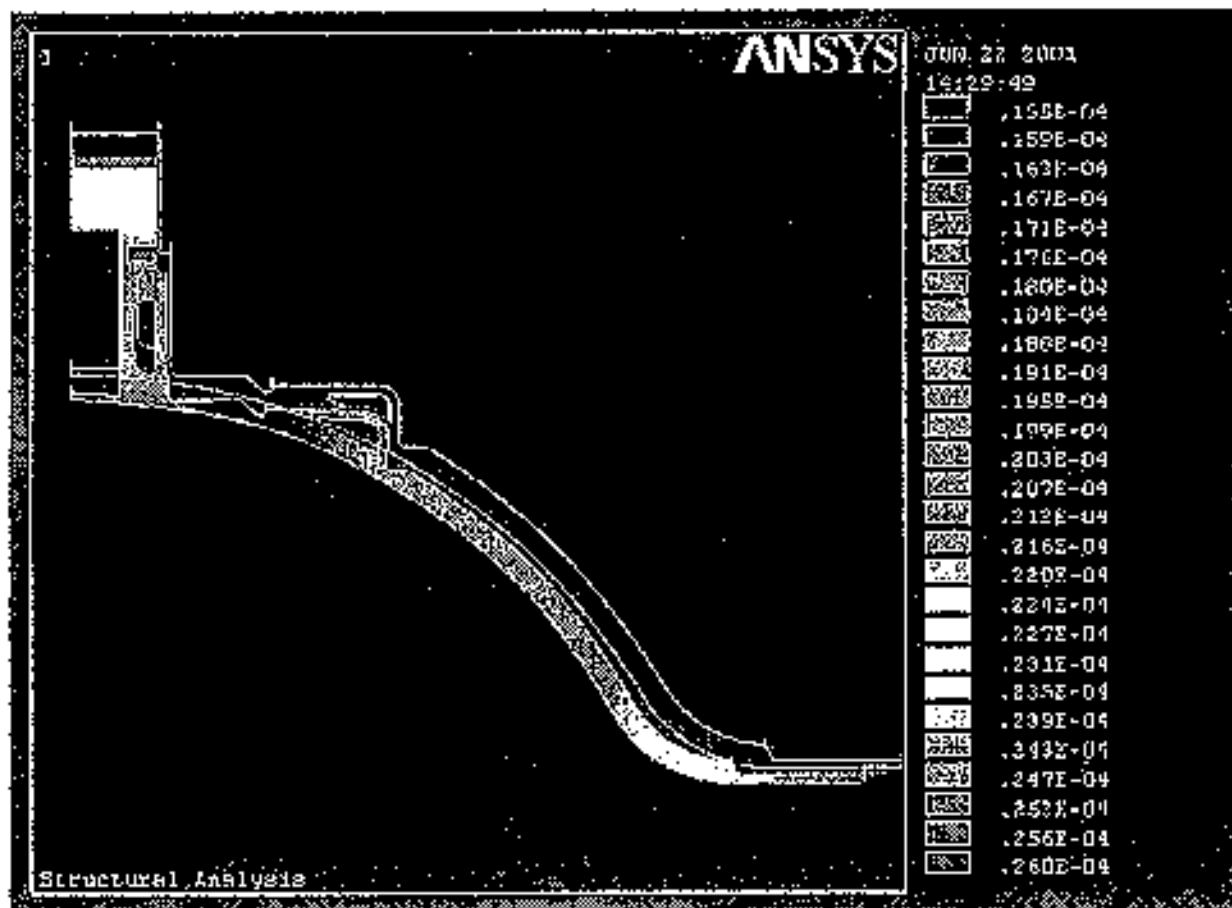
- $f_0 = 2998.550 \text{ MHz}$ @ ($\langle P_{RF} \rangle = 1750 \text{ W} + \text{Water@303 K}$)
 - ◆ Max $\Delta T = 4.02 \text{ K}$
 - ◆ Max $|\Delta x| = 6 \mu\text{m}$,
 - ◆ Max Von Mises eq. Stress: 11 MPa
- $\Delta f_{RFOFF} = -110 \text{ KHz}$



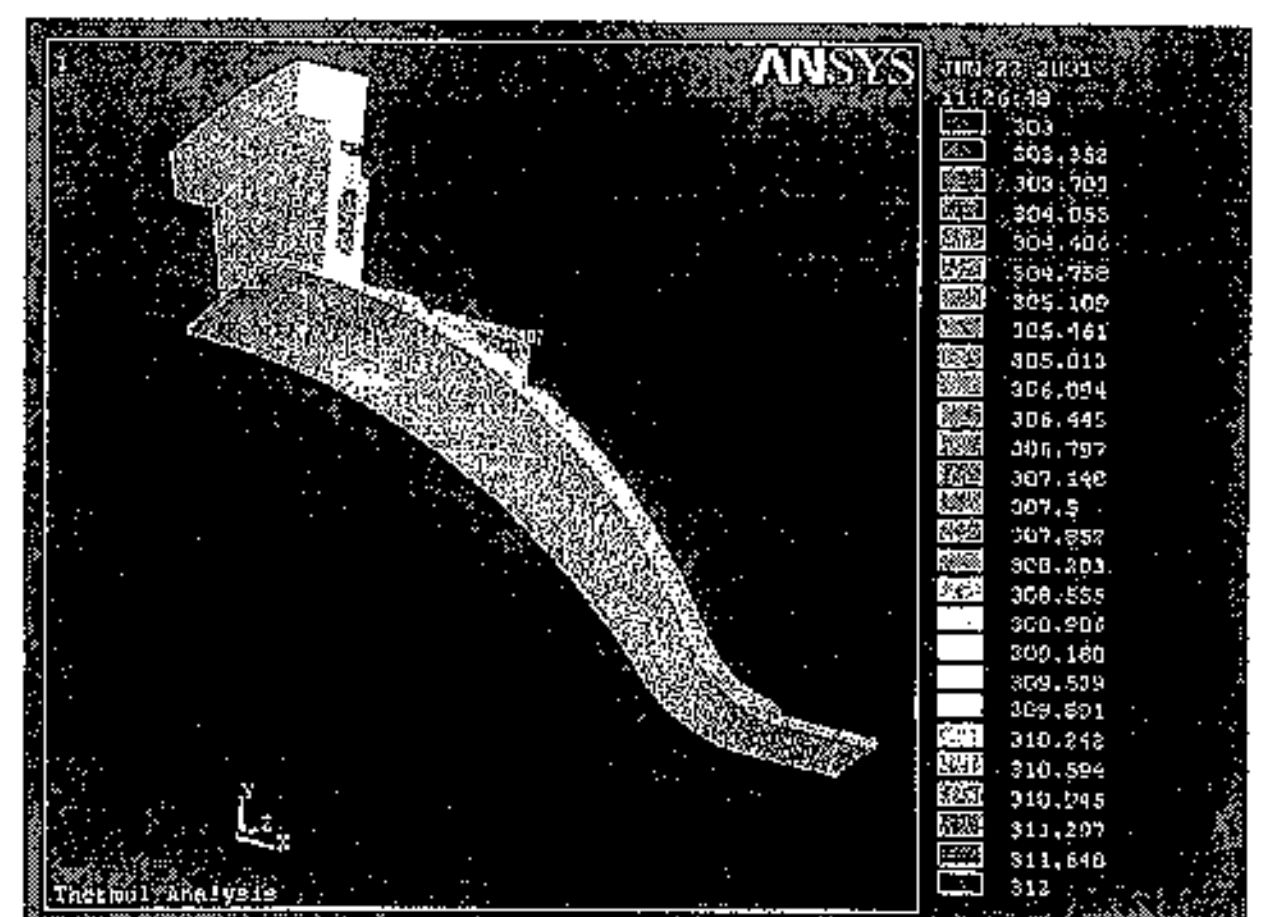
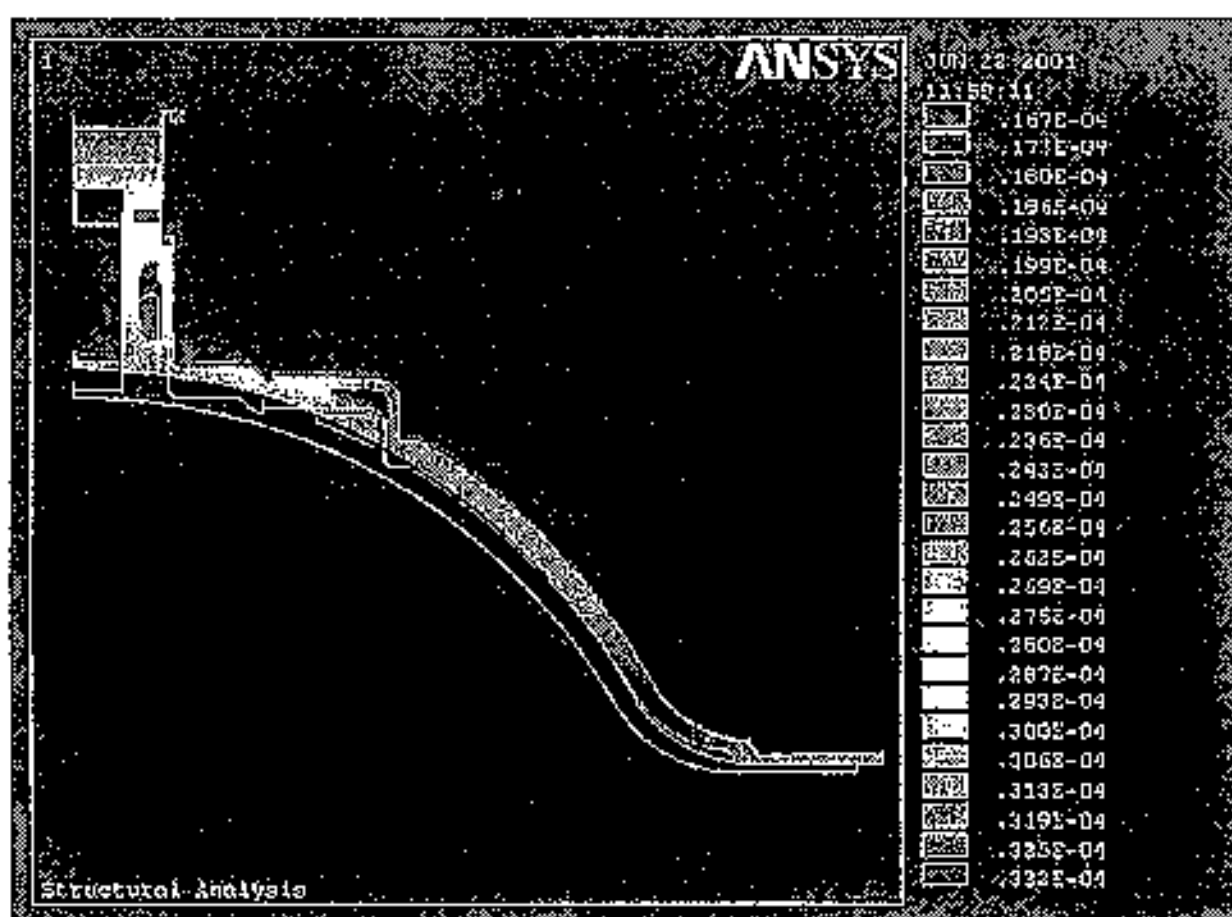
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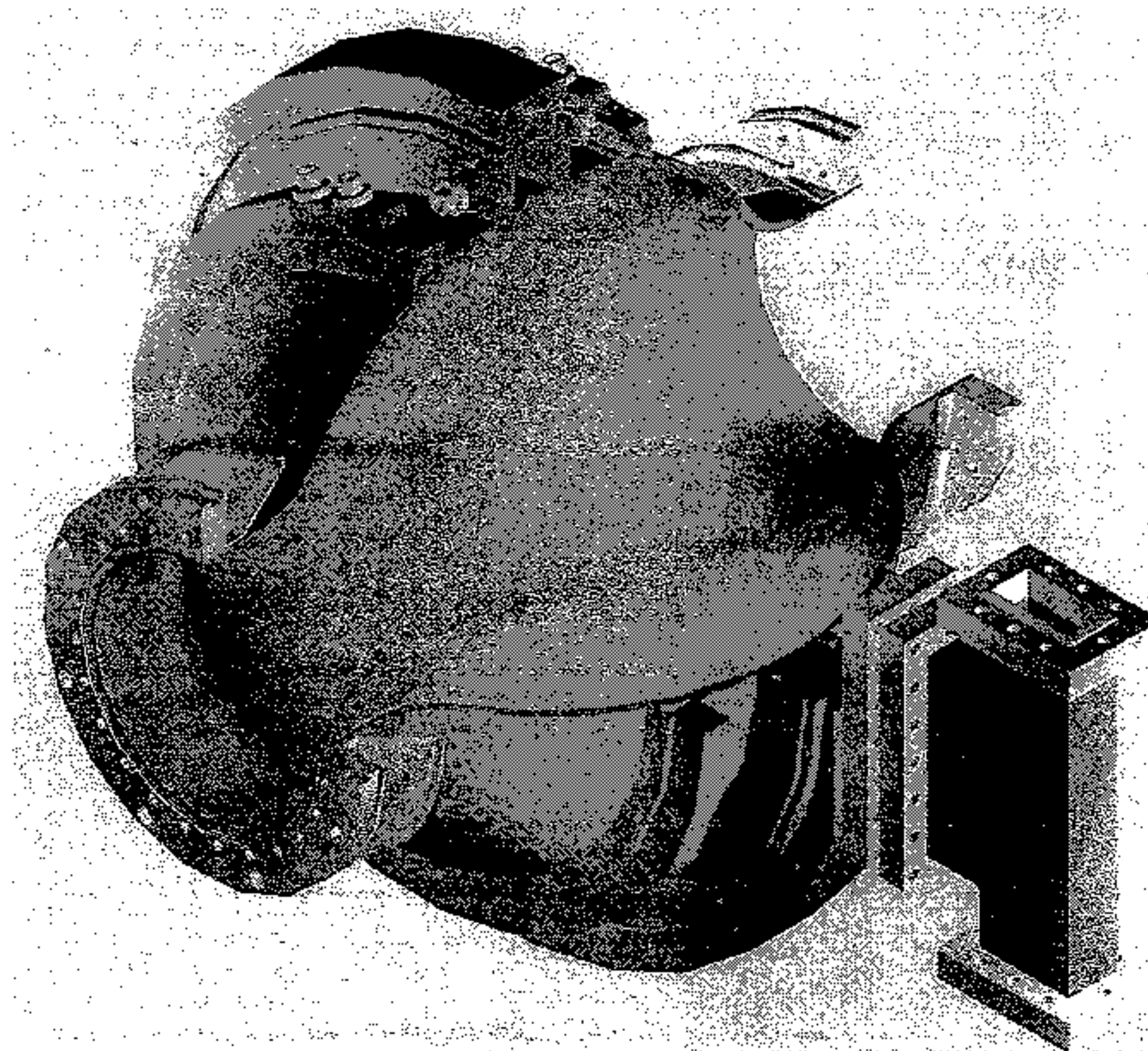
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- Δf ($\langle P_{RF} \rangle = 1750 \text{ W} + \text{Water@298 K}$) = +210 KHz
 - ◆ Max $\Delta T = 4.05 \text{ K}$
 - ◆ Max $|\Delta x| = 26 \mu\text{m}$,
 - ◆ Max Von Mises eq. Stress: 11 MPa



- Δf ($\langle P_{RF} \rangle = 1750 \text{ W} + \text{Water@308 K}$) = -210 KHz
 - ◆ Max $\Delta T = 4.0 \text{ K}$
 - ◆ Max $|\Delta x| = 33 \mu\text{m}$,
 - ◆ Max Von Mises eq. Stress: 11 MPa





- Simulations confirm that the specs are fulfilled
 - ◆ (and all parameters are consistent with Igor's experience)
- Production has already started, cavity available by February 2002.