

# CFD MODEL OF A SPINNING PIPE GAS LENS

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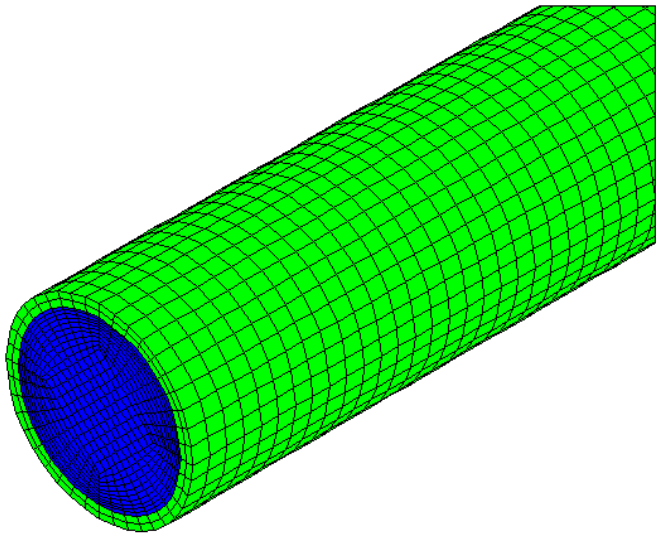
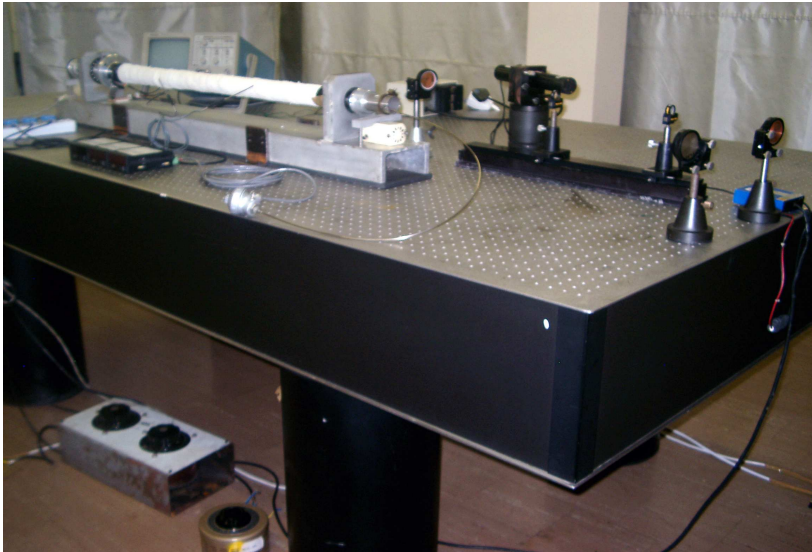
**SAIP**

**Dr Andrew Forbes**

**July 2006**

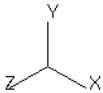


# Spinning Pipe Gas Lens

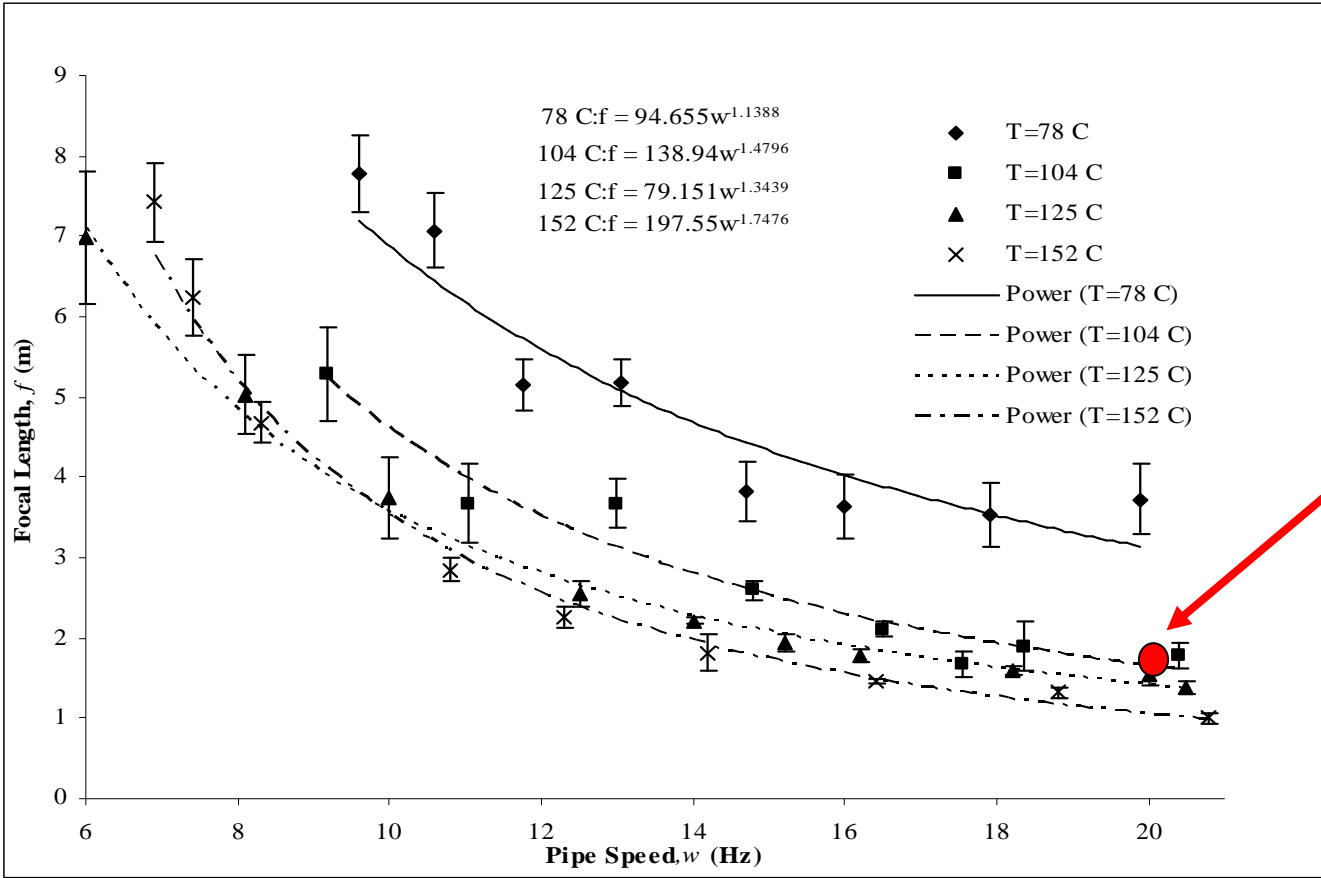


STAR  
D  
pro-STAR 3.2  
VIEW  
1.000  
1.000  
1.000  
ANGLE  
0.000  
DISTANCE  
0.057  
CENTER  
-0.222  
-0.227  
1.564  
EHIDDEN PLOT

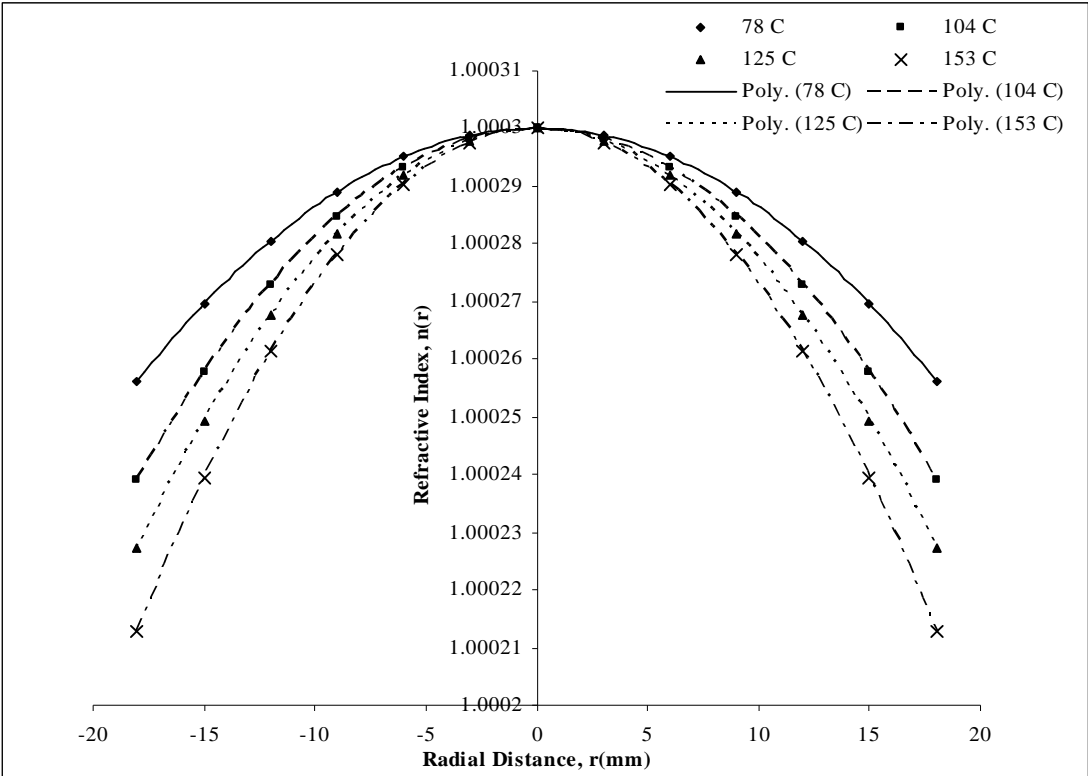
Gas Lens



# Focal Length

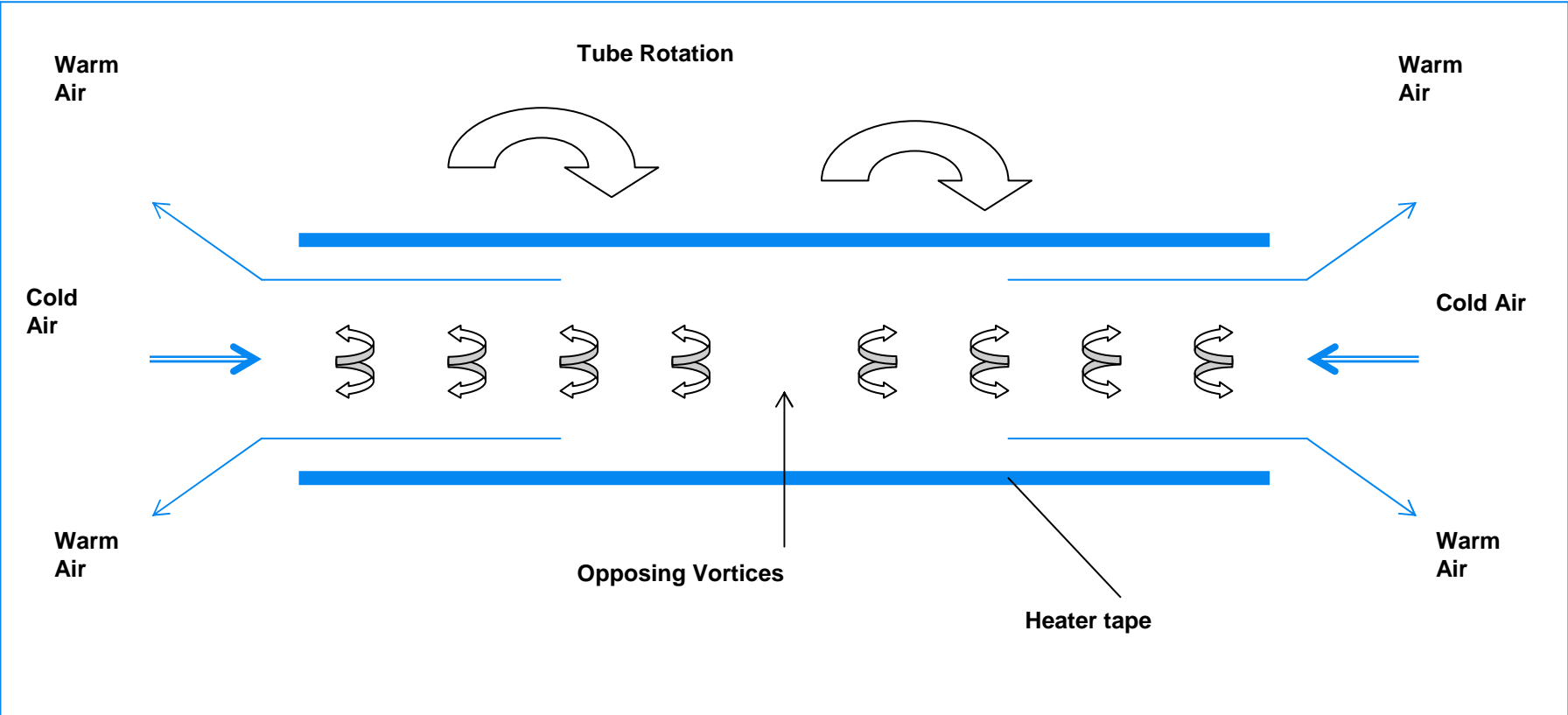


# Refractive Index

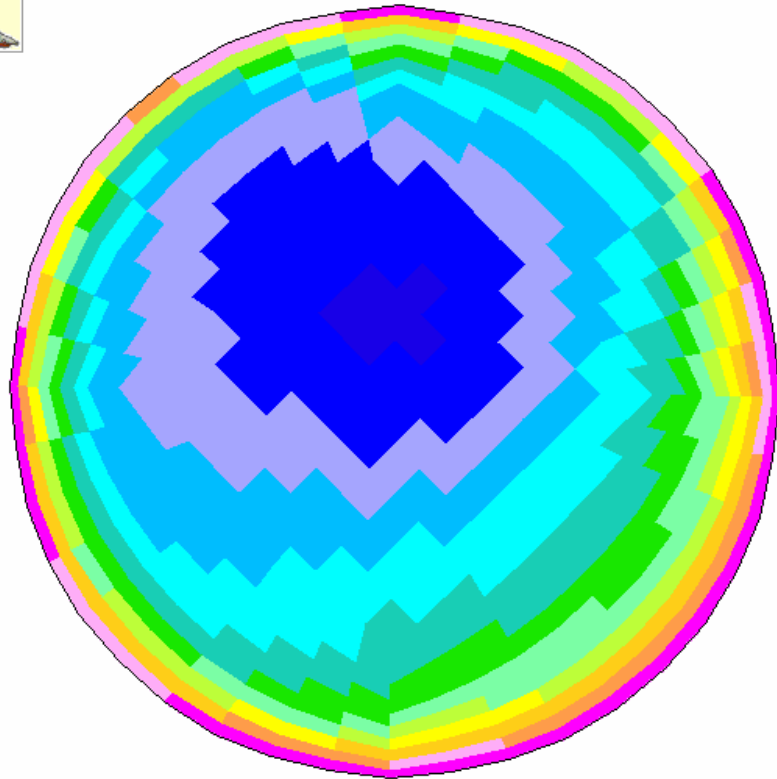


# Gas Dynamics

# Guess at the gas dynamics



# Density Profile



Gas Lens  
0Hz, 373K

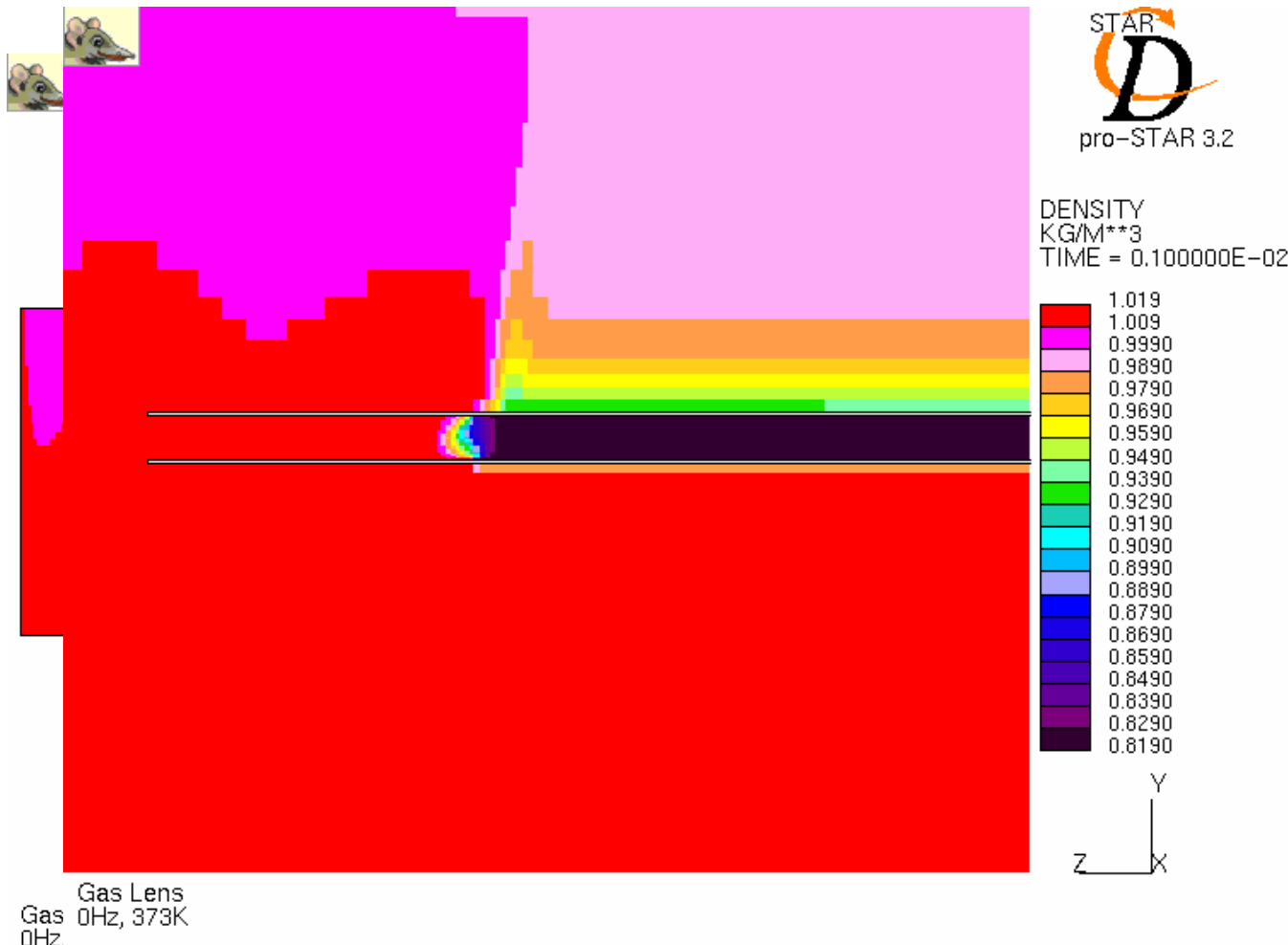


DENSITY  
KG/M\*\*3  
TIME = 0.100000E-02

Red	1.019
Magenta	1.009
Pink	0.9990
Light Pink	0.9890
Orange	0.9790
Yellow-Orange	0.9690
Yellow	0.9590
Light Green	0.9490
Green	0.9390
Light Blue	0.9290
Cyan	0.9190
Blue-Cyan	0.9090
Blue	0.8990
Dark Blue	0.8890
Very Dark Blue	0.8790
Dark Purple	0.8690
Medium Purple	0.8590
Light Purple	0.8490
Dark Purple	0.8390
Very Dark Purple	0.8290
Black	0.8190



# Density Profile



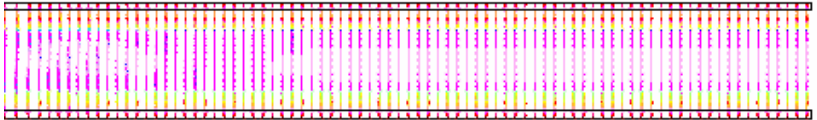


# Flow Profile

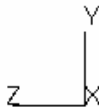


pro-STAR 3.2

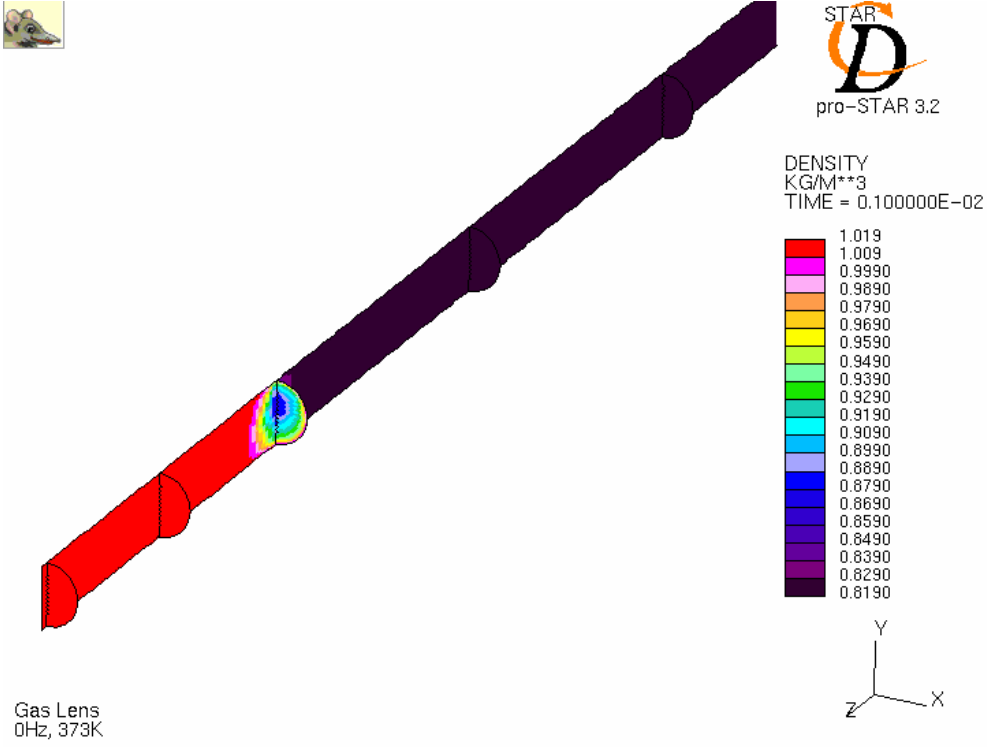
5-APR-06  
 VEL. COMP V W  
 M/S  
 TIME = 0.100000E-02  
 LOCAL MX= 0.1798  
 LOCAL MN= 0.3315E-04



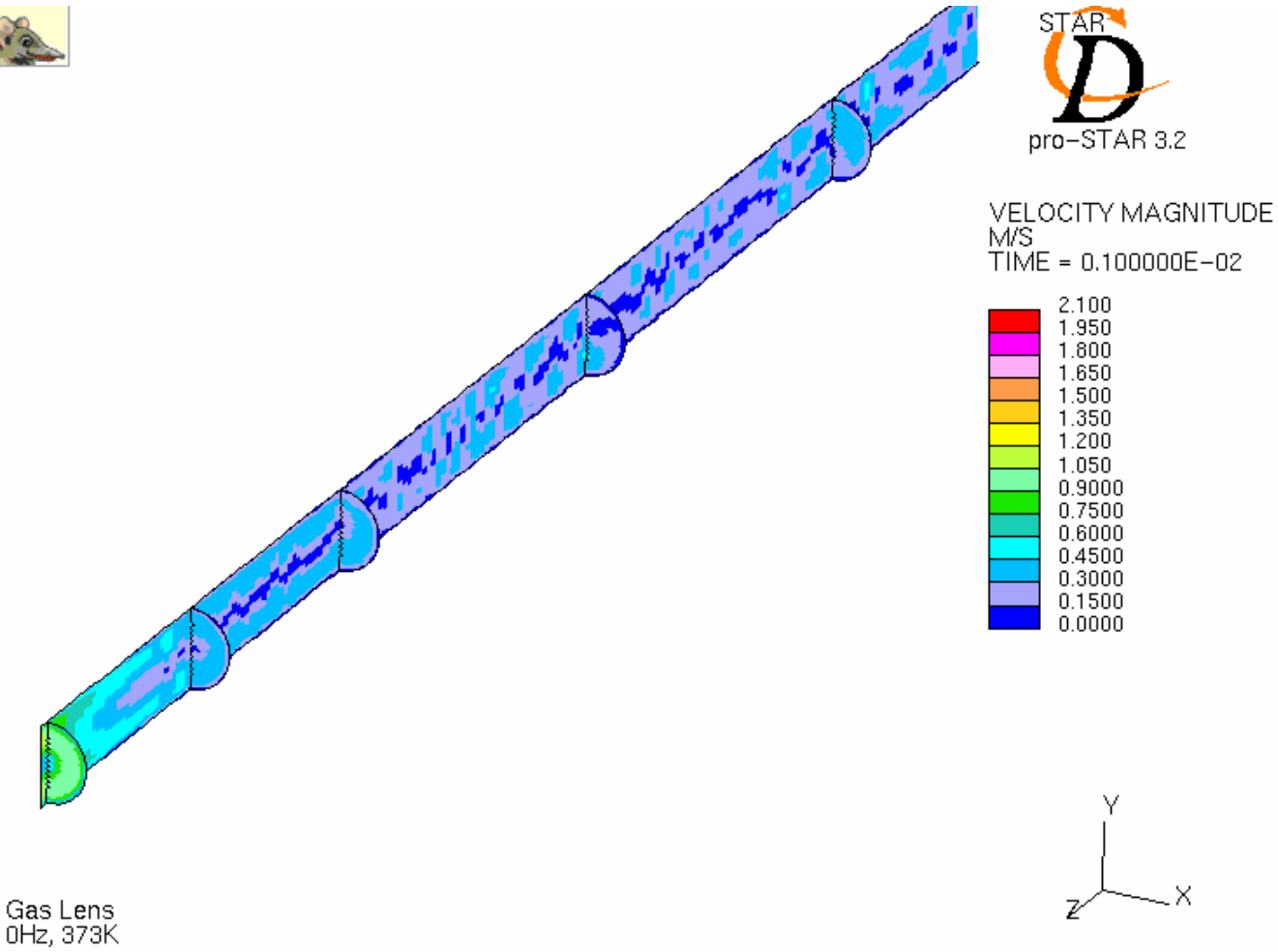
- 0.1798
- 0.1670
- 0.1541
- 0.1413
- 0.1285
- 0.1156
- 0.1028
- 0.8993E-01
- 0.7709E-01
- 0.6425E-01
- 0.5140E-01
- 0.3856E-01
- 0.2572E-01
- 0.1288E-01
- 0.3315E-04



# Rosby Waves



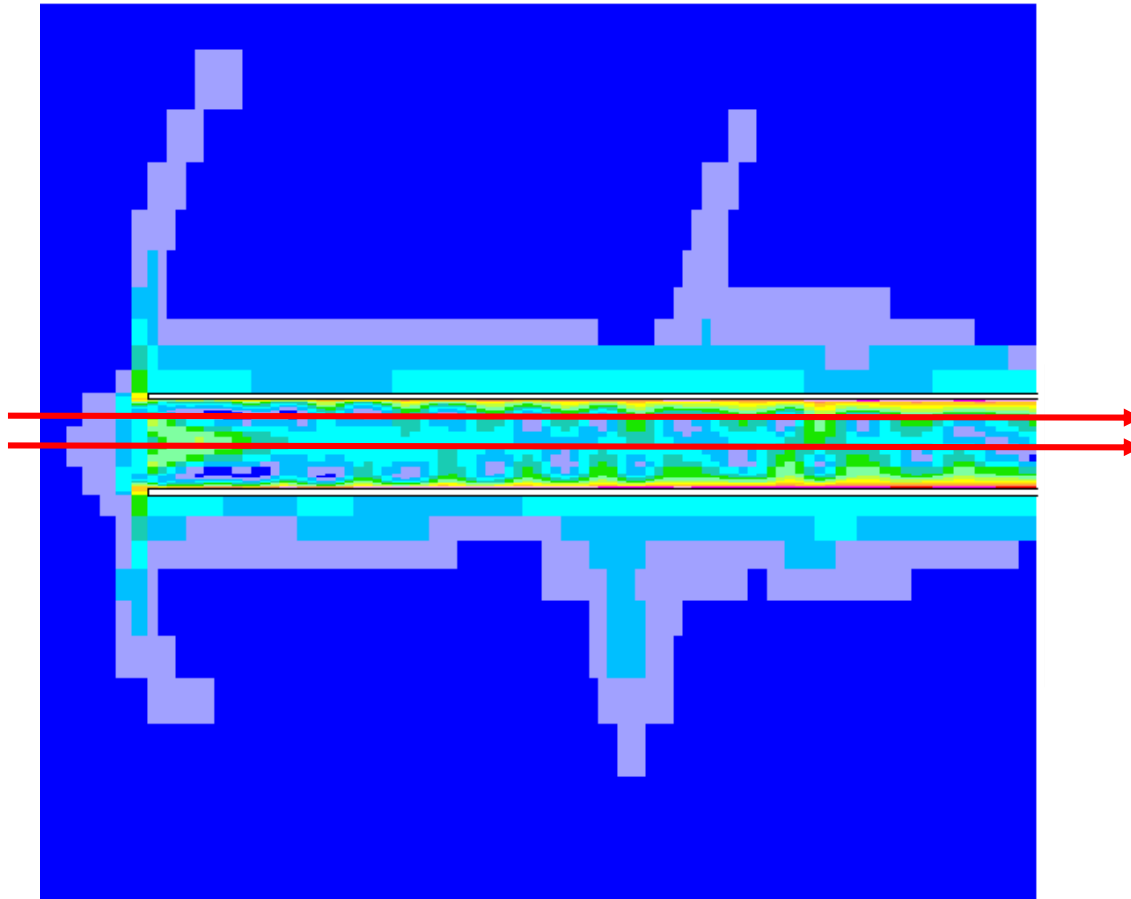
# Rayleigh–Taylor Instabilities



# Future Work



# Instabilities near the boundary



# Wavefront Measurement & Control

$$\Phi(\rho, \theta) = \sum_{n=0}^{\infty} \sum_{m=0}^n [A_n^m U_n^m(\rho, \theta) + B_n^m V_n^m(\rho, \theta)]$$



$$R_n^m(\rho) = \sum_{k=0}^{\frac{n-m}{2}} \frac{(-1)^k (n-k)!}{k! (\frac{n+m}{2} - k)! (\frac{n-m}{2} - k)!} \rho^{n-2k}$$

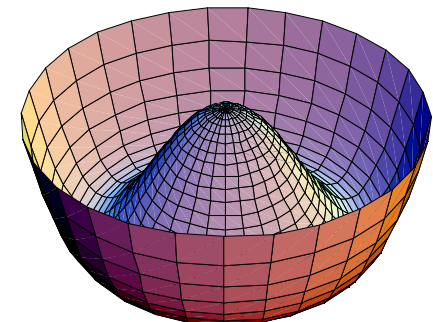
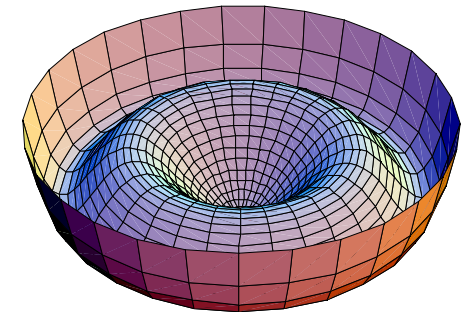
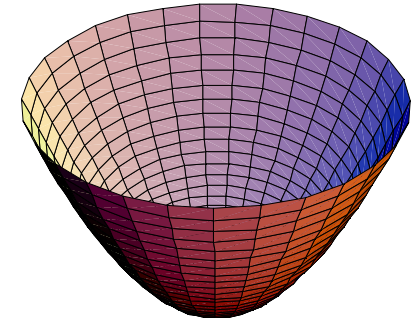
$$A_n^m = K(m) \frac{n+1}{\pi} \int_0^{2\pi} \int_0^1 \Phi(\rho, \theta) U_n^m(\rho, \theta) \rho d\rho d\theta$$

$$\sigma_{nm}^2 = N_{nm} \left( \frac{D}{r_0} \right)^{5/3} \quad r_0 = \left[ 0.423 k^2 \int_{h_{\min}}^{h_{\max}} C_n^2(h) dh \right]^{-5/3}$$

$$N_{nm} = \frac{0.15337 (-1)^{n-m} (n+1) \Gamma(14/3) \Gamma(n-5/6)}{\Gamma(17/6)^2 \Gamma(n+23/6)}$$

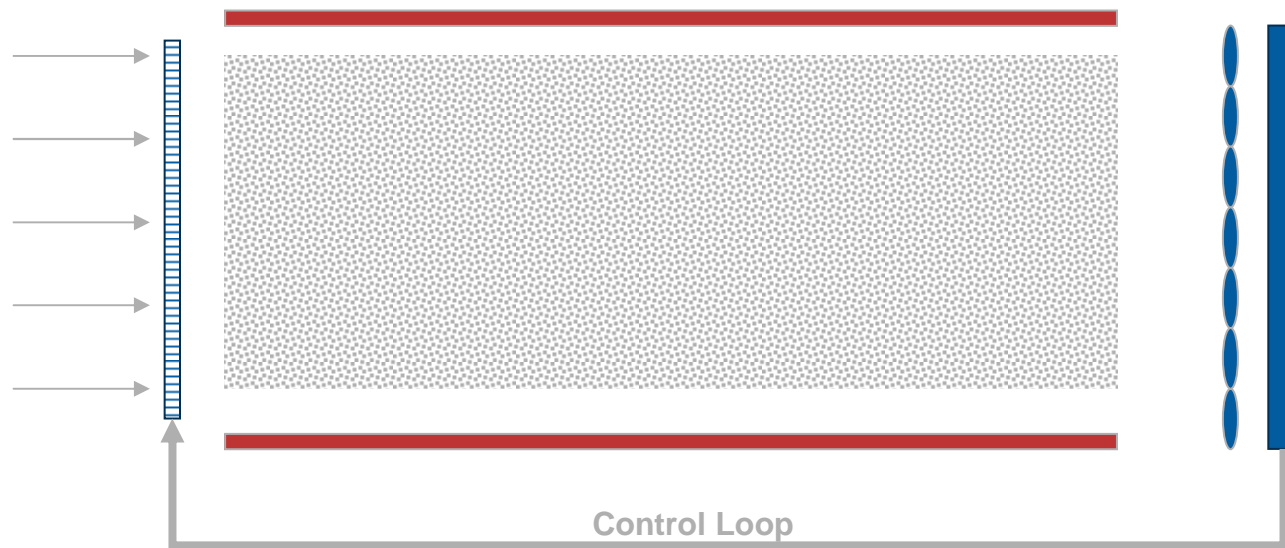


$$\phi(\kappa) = 0.033 C_n^2 \kappa^{-11/3}$$



# Adaptive optics for turbulence correction

- SLM acts as an adaptive optic
  - Measure wavefront distortion,
  - Feed result back into SLM to create conjugate phase,
  - Propagate conjugate phased beam through medium.



# Conclusion

- CFD model of gas lens
  - Shows Rosby waves and Rayleigh–Taylor instabilities
- Propagation model in preparation
  - Full Fresnel propagation through GRIN system
- Future work
  - Adaptive optics theory and experiment



# Questions

