BWP Modeling

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AMS Users' Meeting

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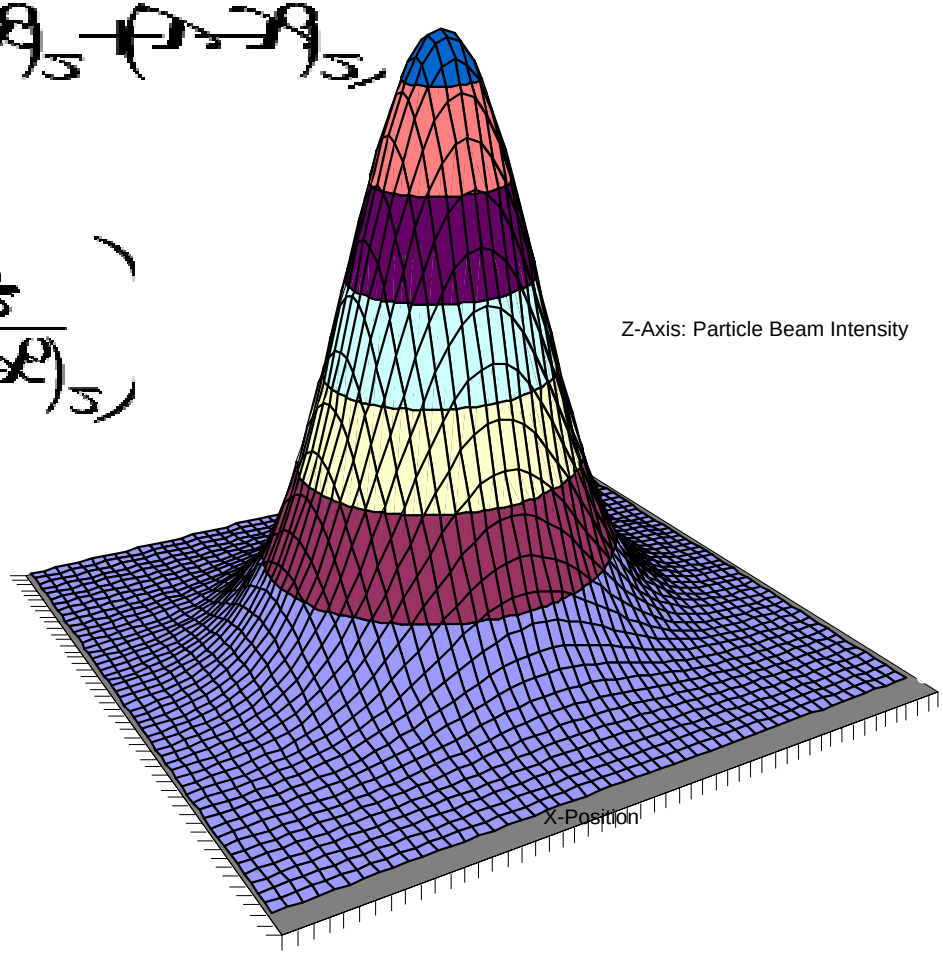
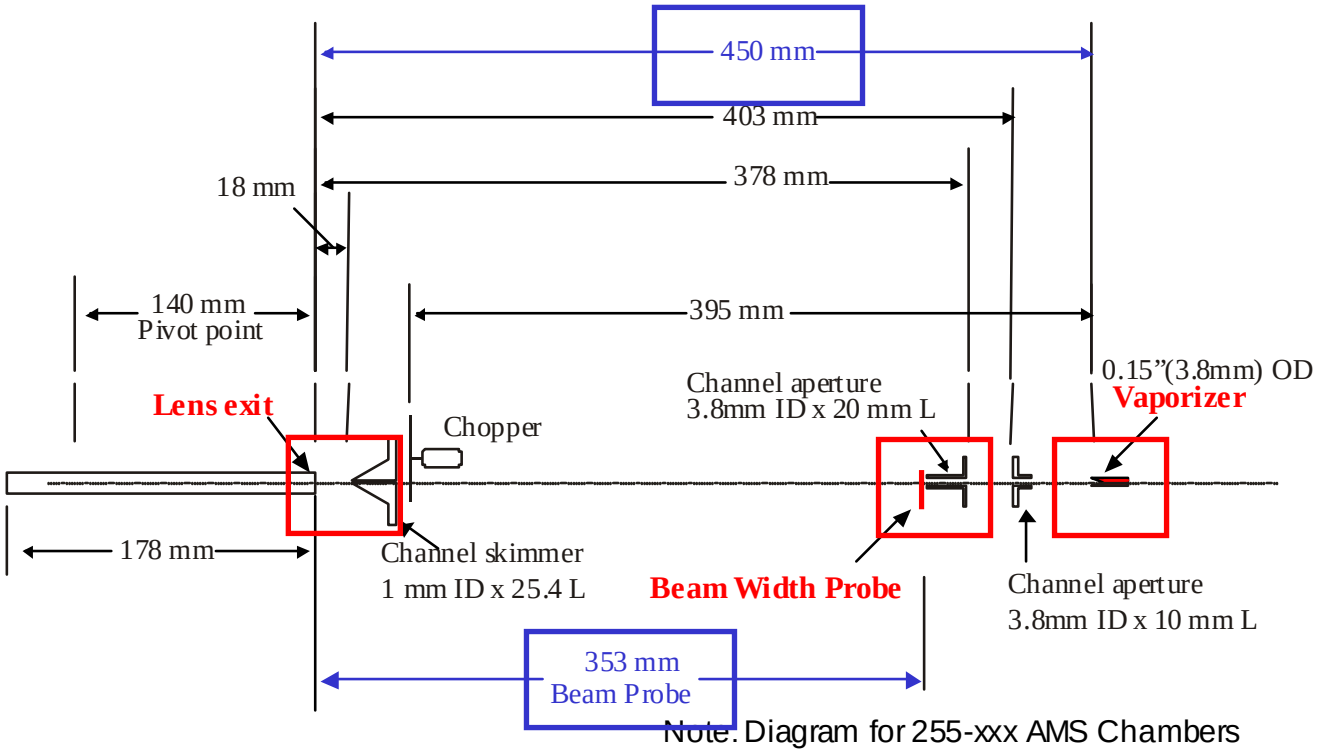
Gaussian Assumption

$$I(x,y) = \frac{I_0}{2\pi\sigma_x\sigma_y}\exp\left(-\frac{(x-x_0)^2}{2\sigma_x^2} - \frac{(y-y_0)^2}{2\sigma_y^2}\right)$$

$$I(x) = \frac{\sqrt{2\pi}}{\sigma}\exp\left(-\frac{(x-x_0)^2}{2\sigma^2}\right)$$

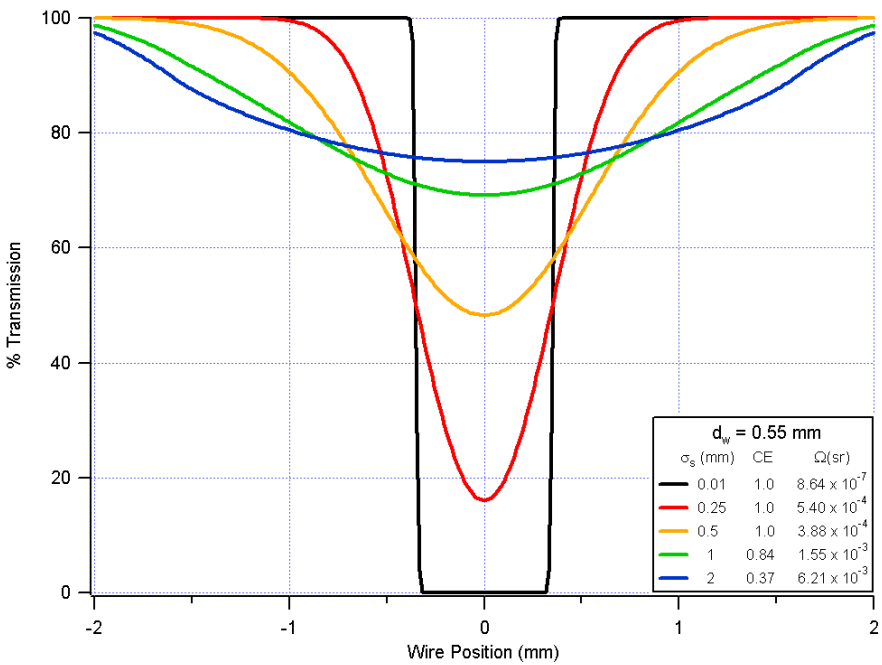


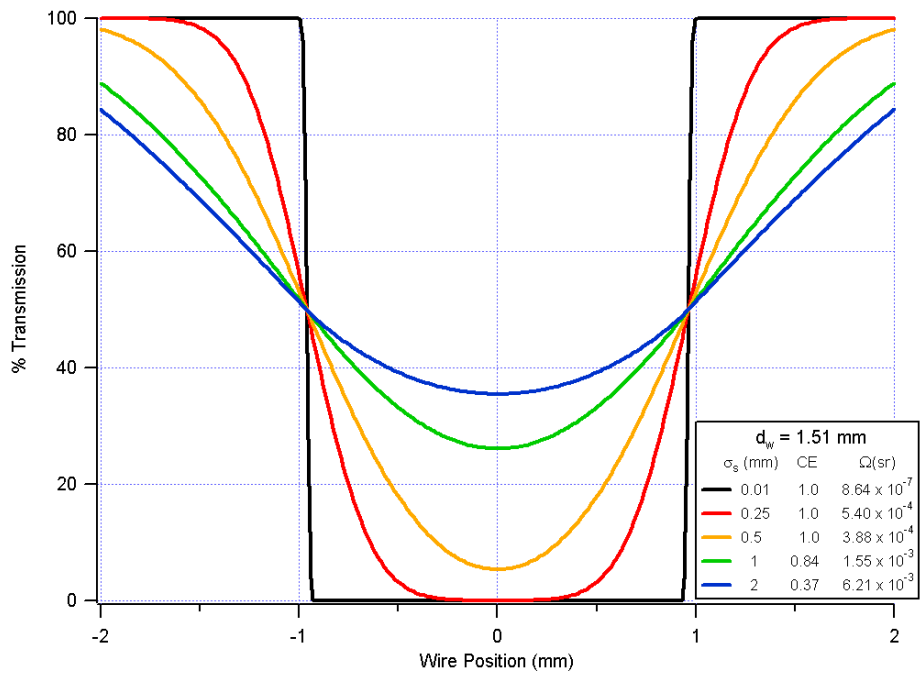
Chamber Diagram



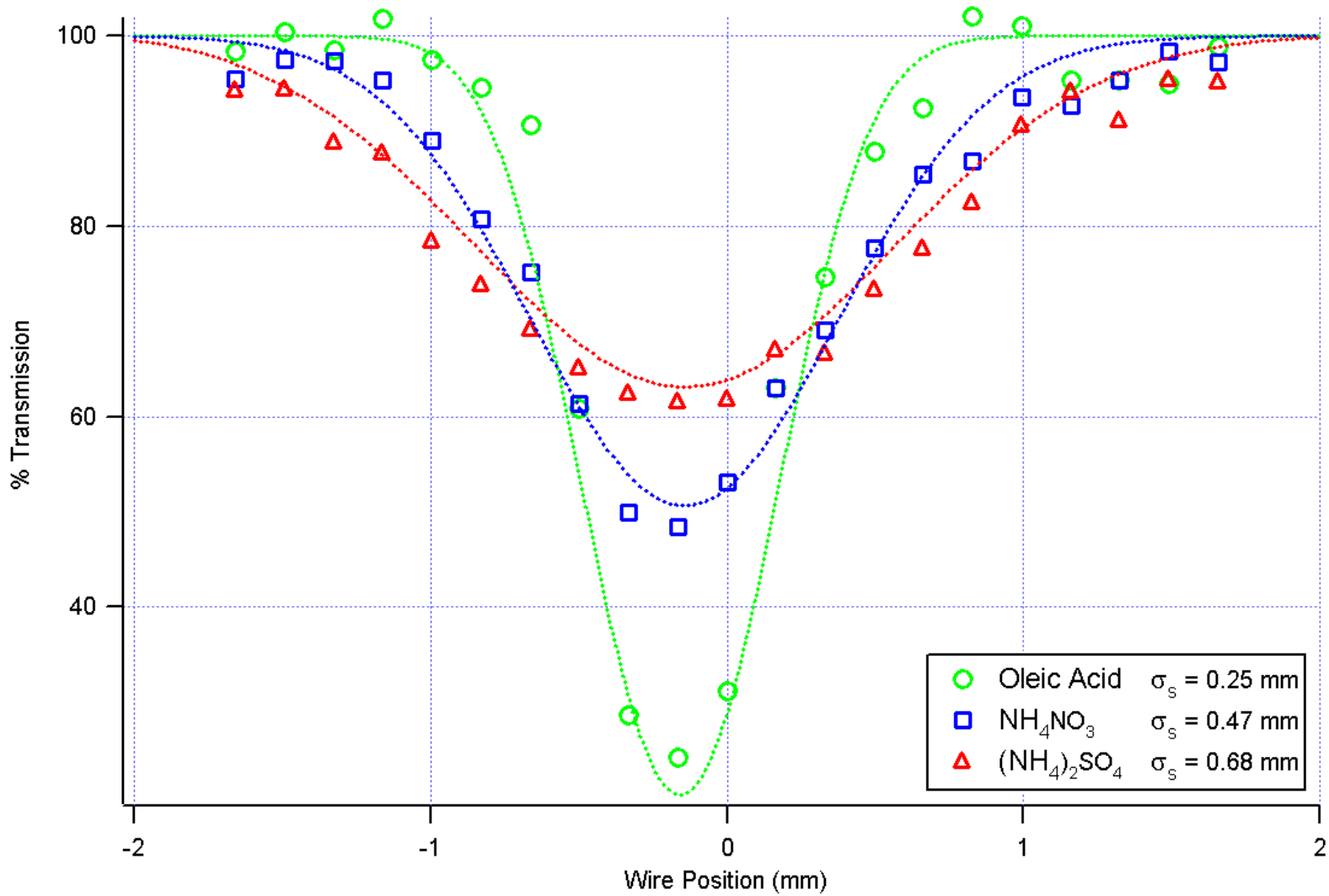
- Beam Width Probe (BWP):
  - Collection Efficiency (CE)
  - Surrogate particle non-sphericity

Transmission Curves

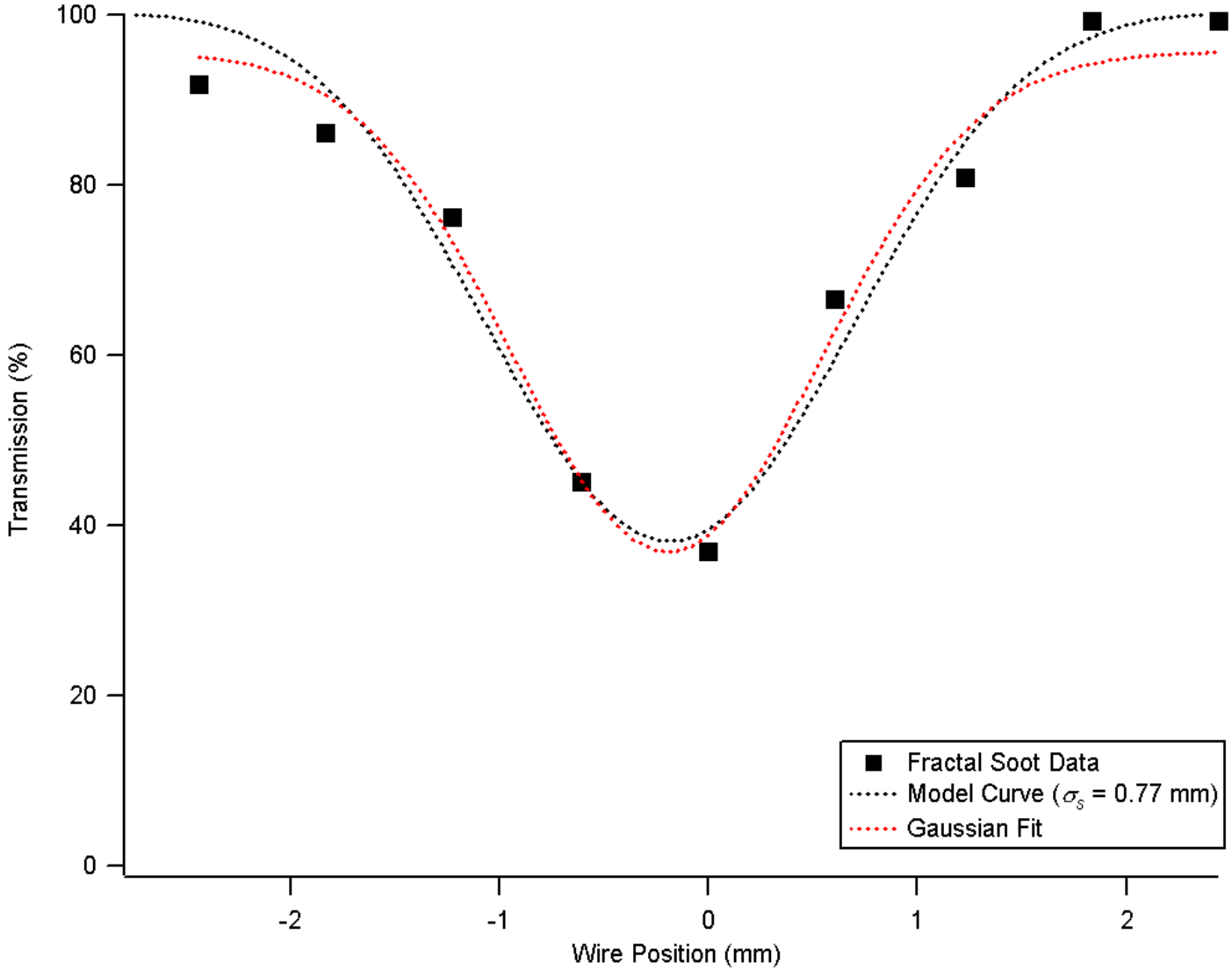




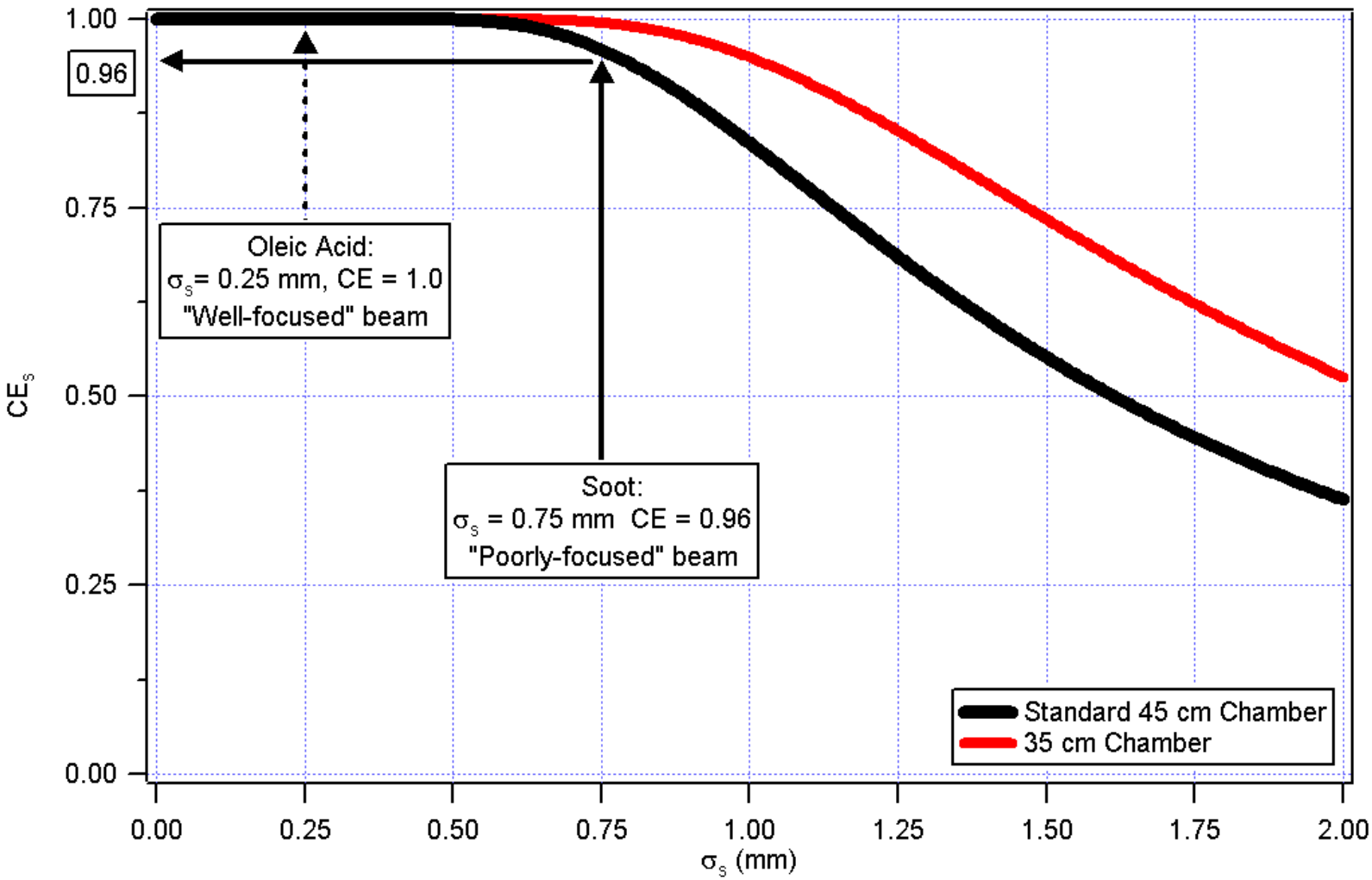
Lab Data


100
80
60
40
% Transmission
-2
-1
0
1
2
Wire Position (mm)
Oleic Acid σ_s = 0.25 mm
NH_4NO_3 σ_s = 0.47 mm
$(NH_4)_2SO_4$ σ_s = 0.68 mm

Soot Data


100
80
60
40
20
0
Transmission (%)
-2
-1
0
1
2
Wire Position (mm)
Fractal Soot Data
Model Curve (σ_s = 0.77 mm)
Gaussian Fit

CE_s Plot


1.00
0.96
0.75
0.50
0.25
0.00
CE_S
Oleic Acid:
σ_S= 0.25 mm, CE = 1.0
"Well-focused" beam
Soot:
σ_S = 0.75 mm CE = 0.96
"Poorly-focused" beam
Standard 45 cm Chamber
35 cm Chamber
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
σ_S (mm)

Definition of ψ

- Lift shape factor (surrogate non-sphericity parameter):

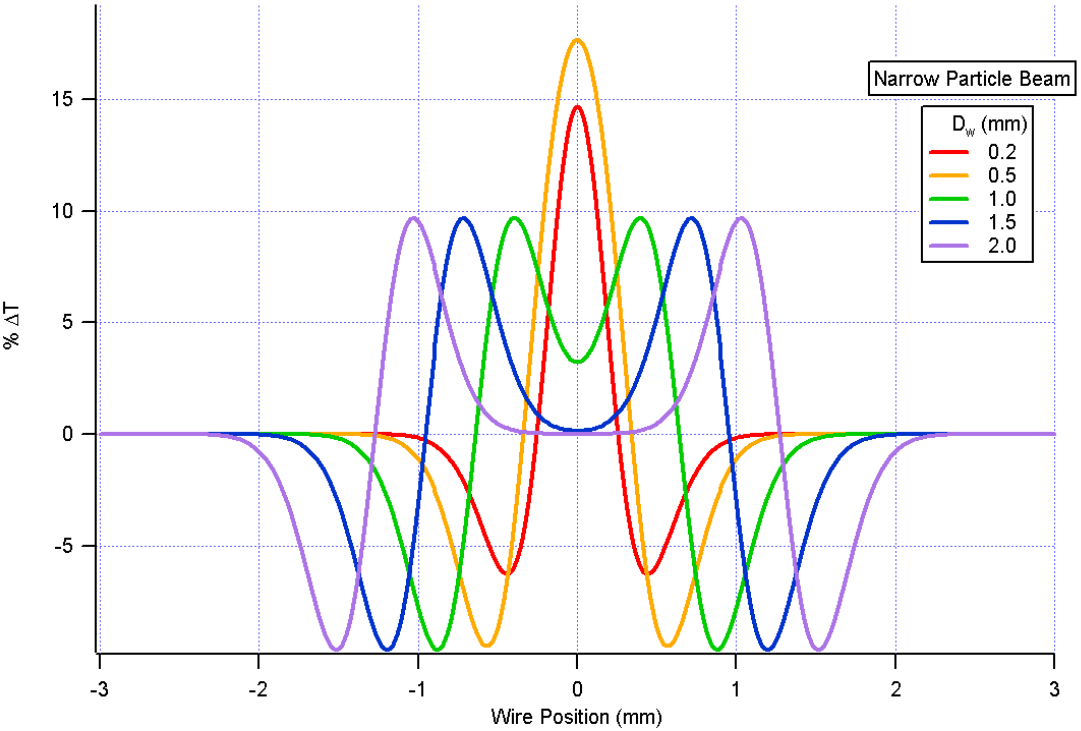
$$\psi = \frac{\sigma_p^{d_{va}}}{\sigma_{sph}^{d_{va}}}$$

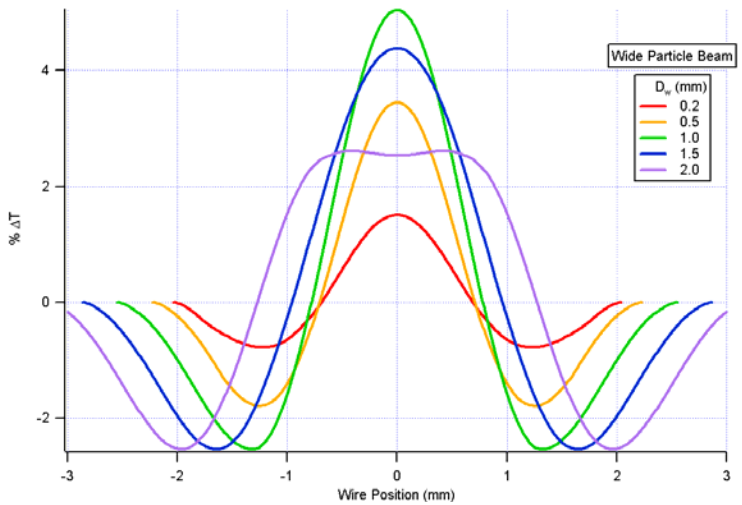
- σ is the standard deviation of Gaussian
- Beam width for sphere of given d_{va} : $\sigma_{sph}^{d_{va}}$
- Beam width of particle of same d_{va} : $\sigma_p^{d_{va}}$

Summary Table

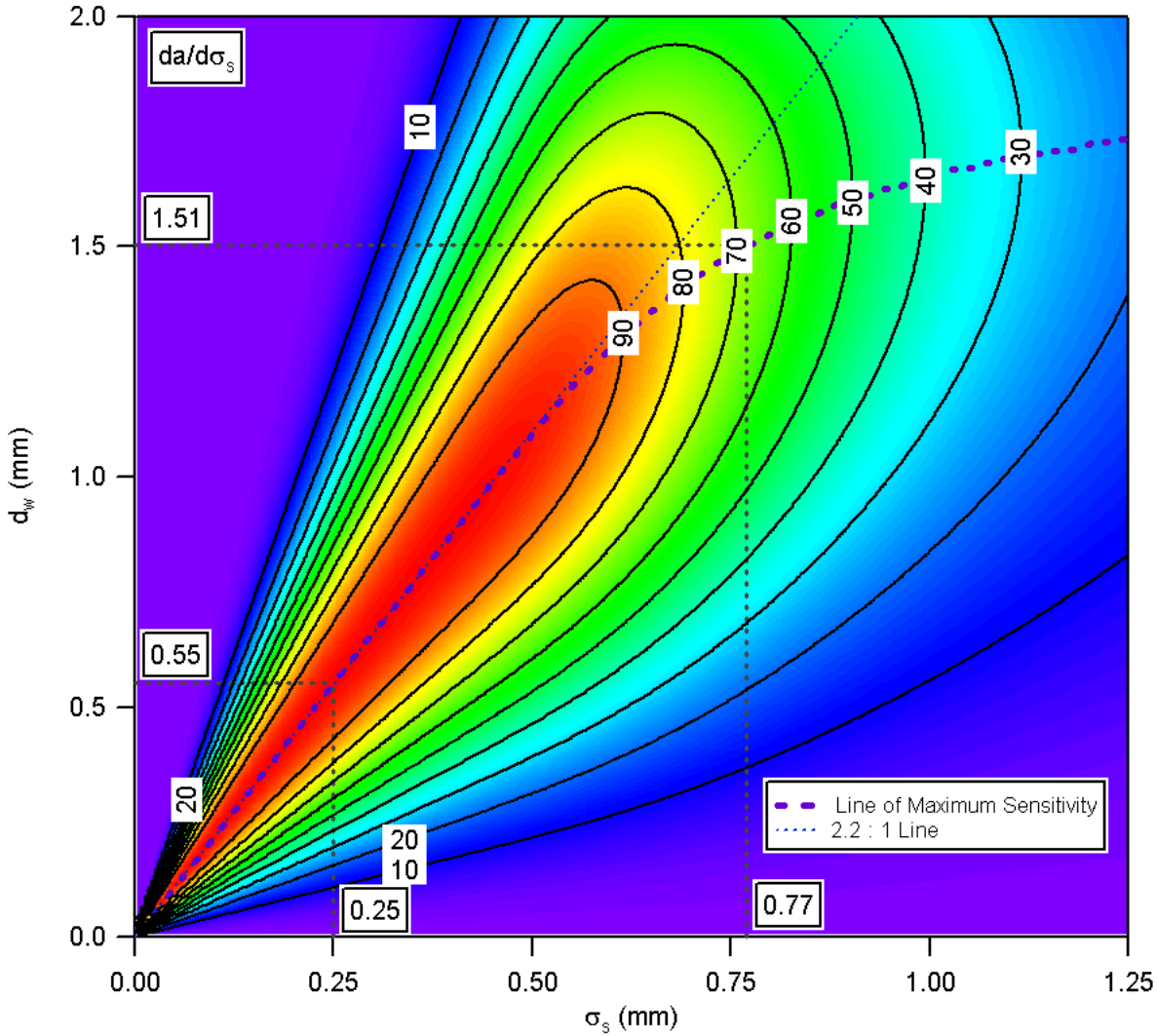
	Beam Width (mm)	CEs	Lift Shape Factor
Oleic Acid	0.25	1	1
Ammonium Nitrate	0.47	1	1.88
Ammonium Sulfate	0.68	0.98	2.72
Fractal Soot (Jay)	0.77	0.95	3.08

Difference Curves





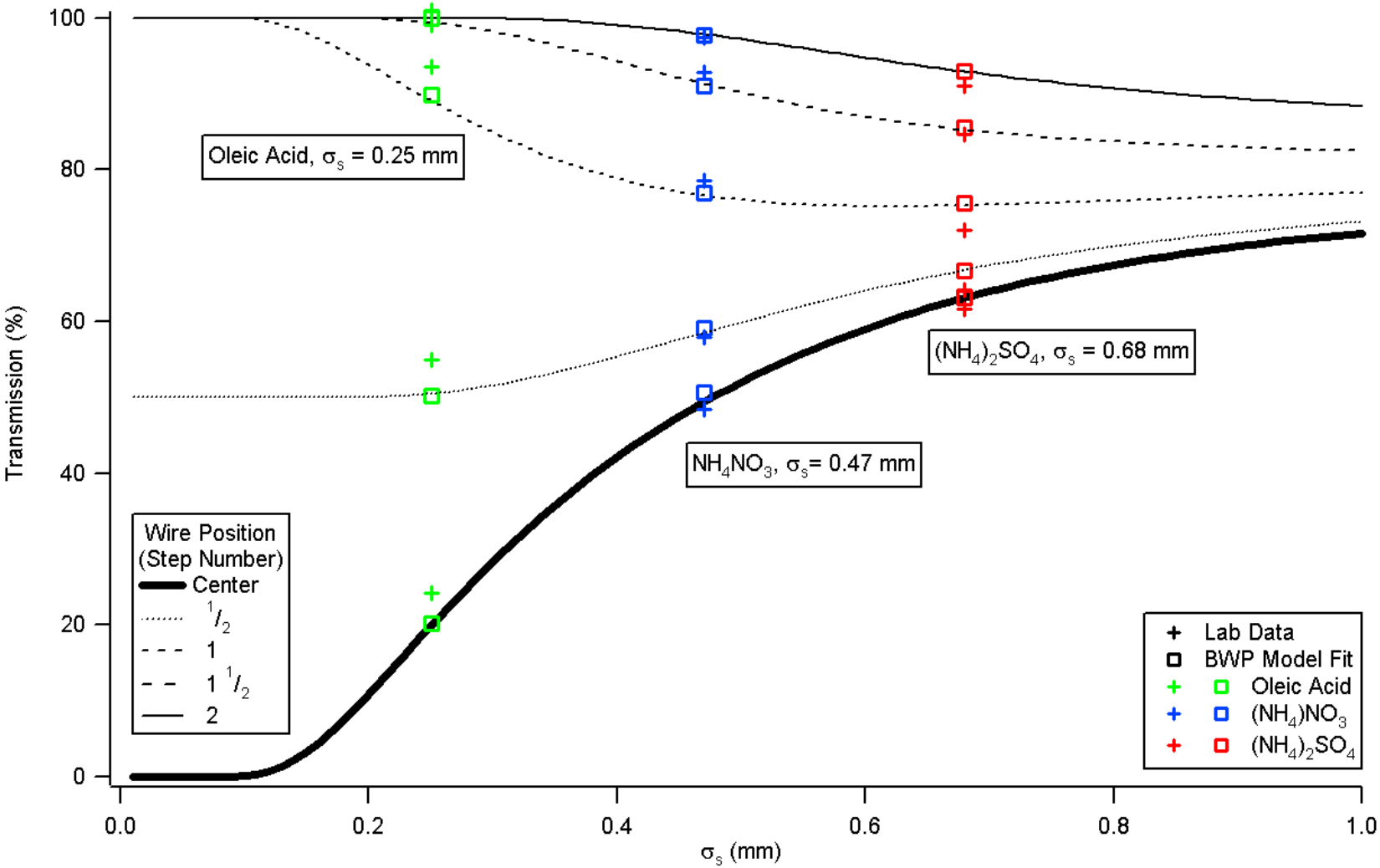
BWP Optimization



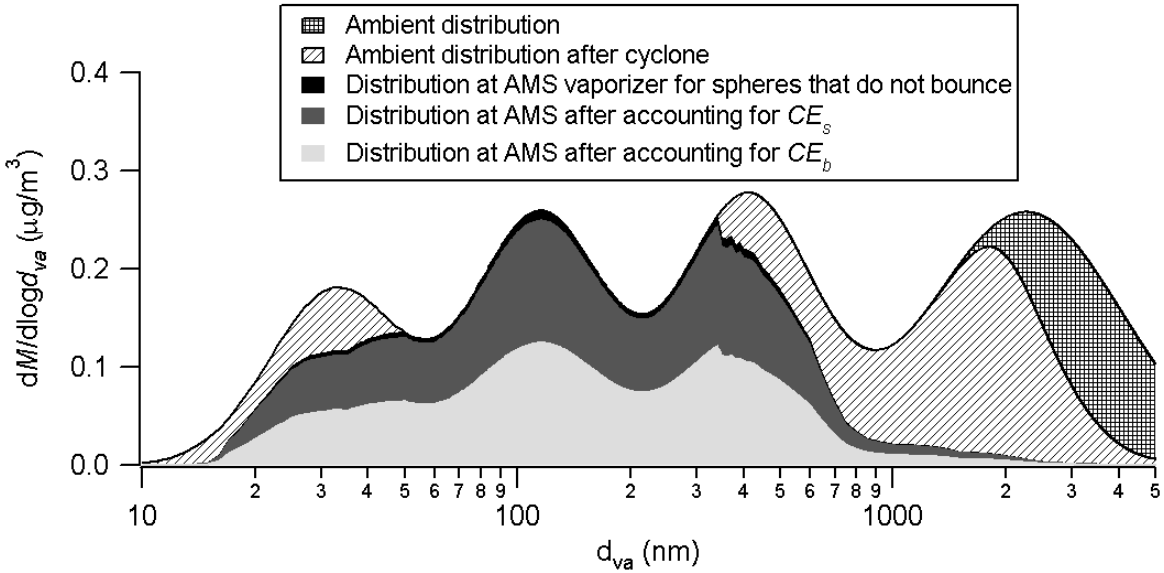
BWP Current Conclusions

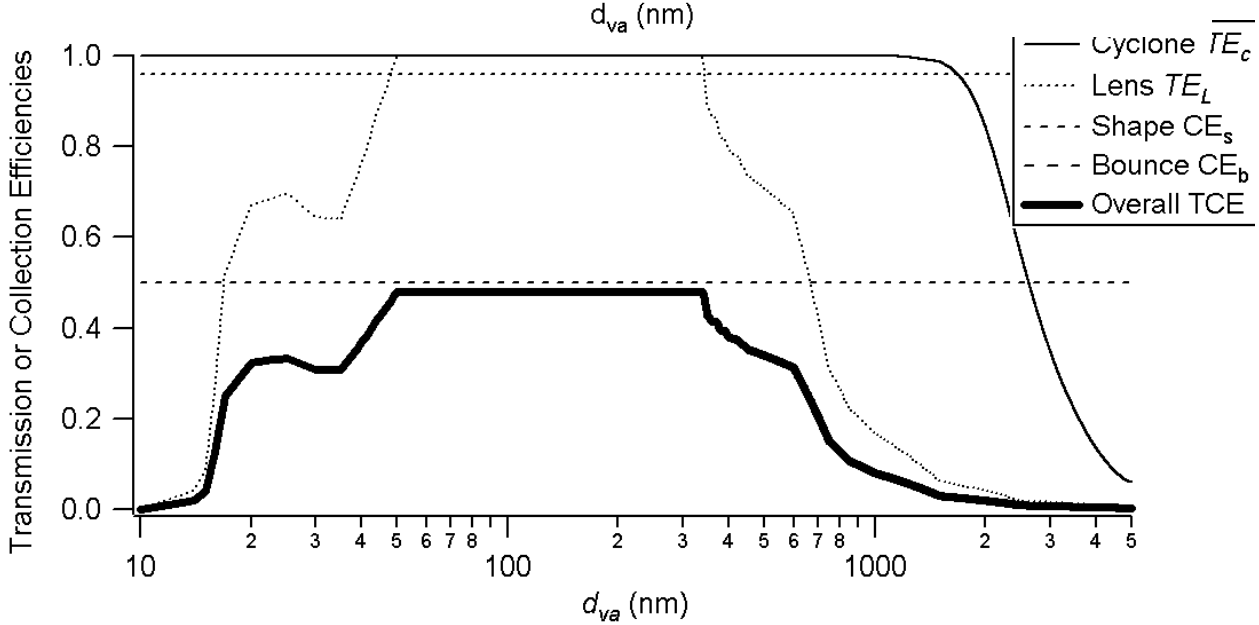
- CE_s (due to shape) is 1.0 in most cases
  - Bounce is much more important for CE (Tim)
- BWP still provides information about:
  - CE_s when important (fractal, etc.)
  - Surrogate shape factor (Ψ) achieved easily (to be tested in lab for what it means)
  - Phase related to focusing (Yasmine)
- Optimal BWP ~ 1.0 mm

Trans. vs sigma



TCE Summary

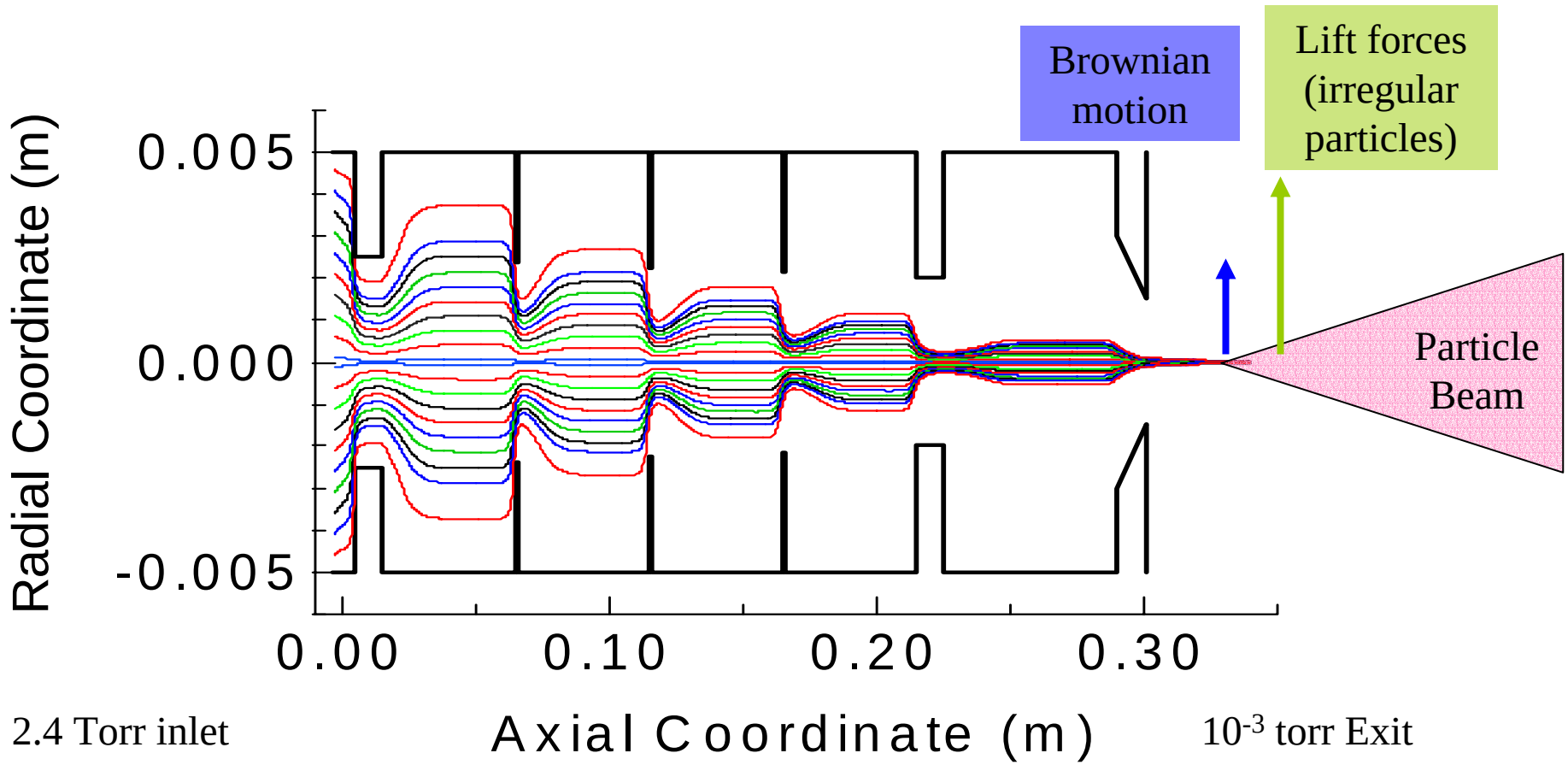

Ambient distribution
Ambient distribution after cyclone
Distribution at AMS vaporizer for spheres that do not bounce
Distribution at AMS after accounting for CE_s
Distribution at AMS after accounting for CE_b
$dM/d\log d_{va}$ ($\mu g/m^3$)
0.0
0.1
0.2
0.3
0.4
10
100
1000
d_{va} (nm)


Cyclone $\overline{TE_c}$
Lens TE_L
Shape CE_s
Bounce CE_b
Overall TCE
Transmission or Collection Efficiencies
0.0
0.2
0.4
0.6
0.8
1.0
10
100
1000
d_{va} (nm)

Gaussian Volume Integration Table

	1-D	**2-D**
1σ	68.2	**60.7**
2σ	95.5	**88.3**
2.36σ	-	**93.8**
3σ	99.7	**95.6**

Aerodynamic Lens



•Forces act to broaden beam only during nozzle expansion

Beam Width Probe Diagram