X-RAY MIRROR POINT SPREAD FUNCTION COMPUTATION: IMPACT OF DIFFERENT SPATIAL WAVELENGTHS

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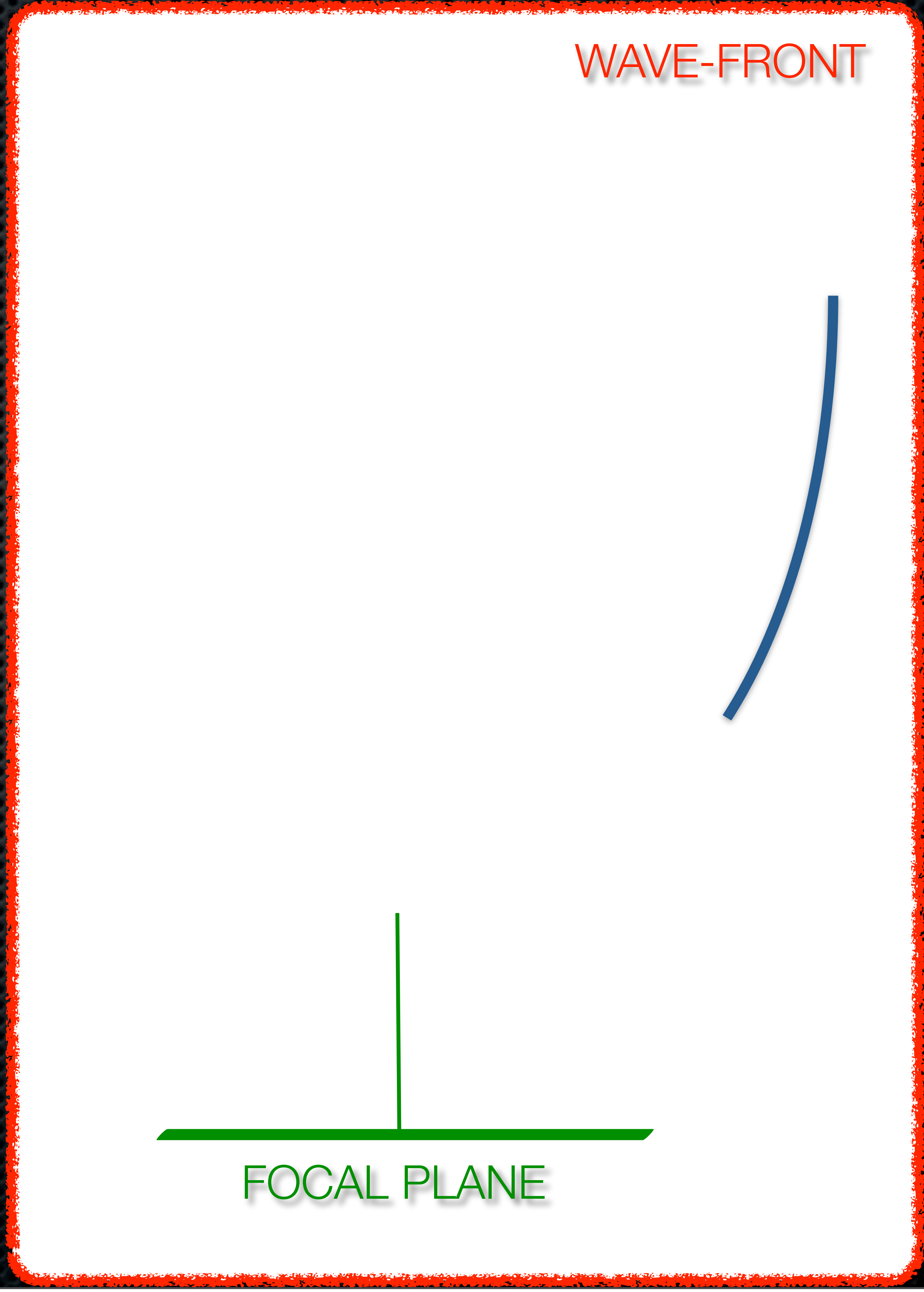
PSF WITH FRESNEL DIFFRACTION

- PSF computation from surface metrology (not only HEW)
- At any energy
- Without any separation between figure errors and microroughness



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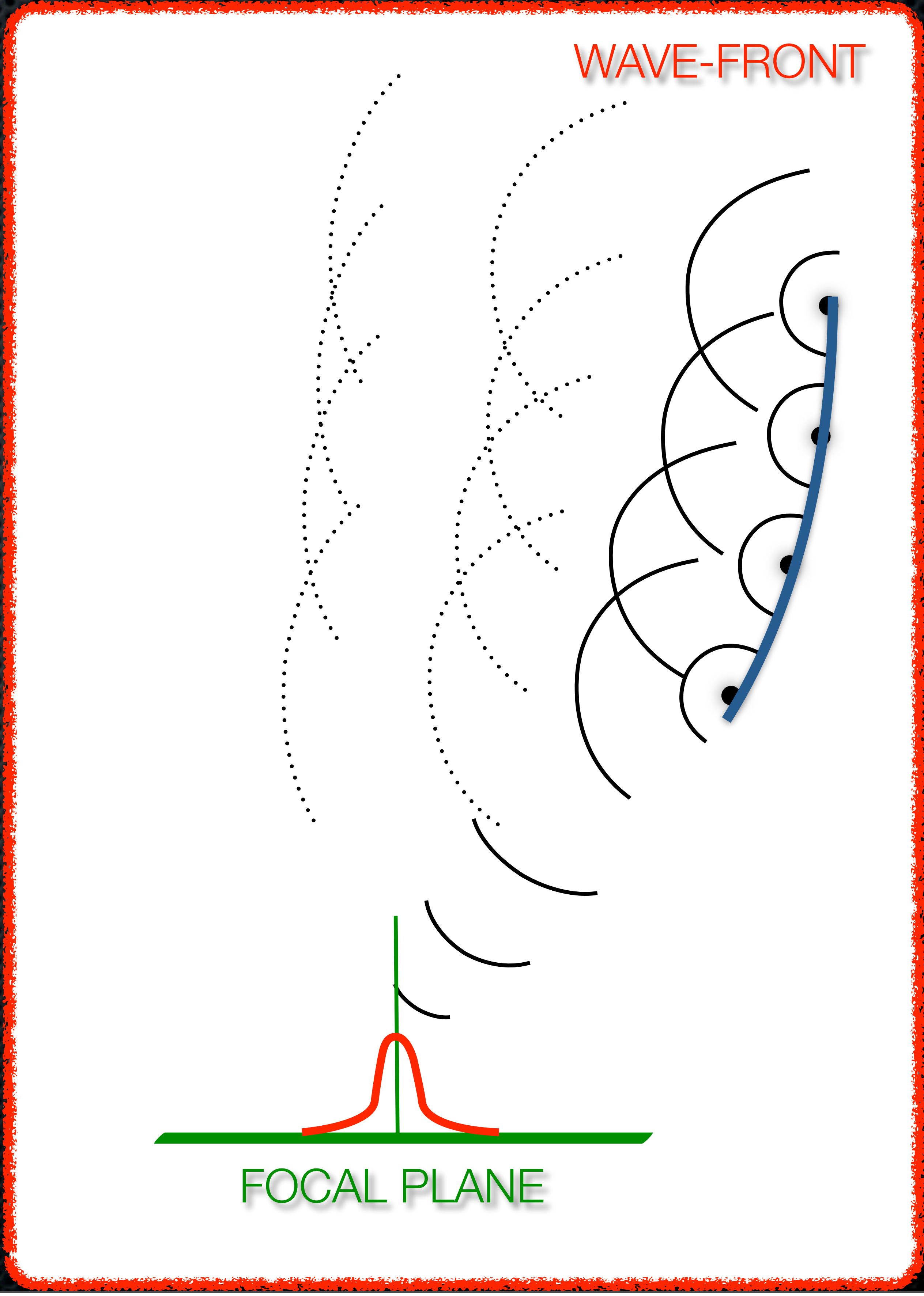
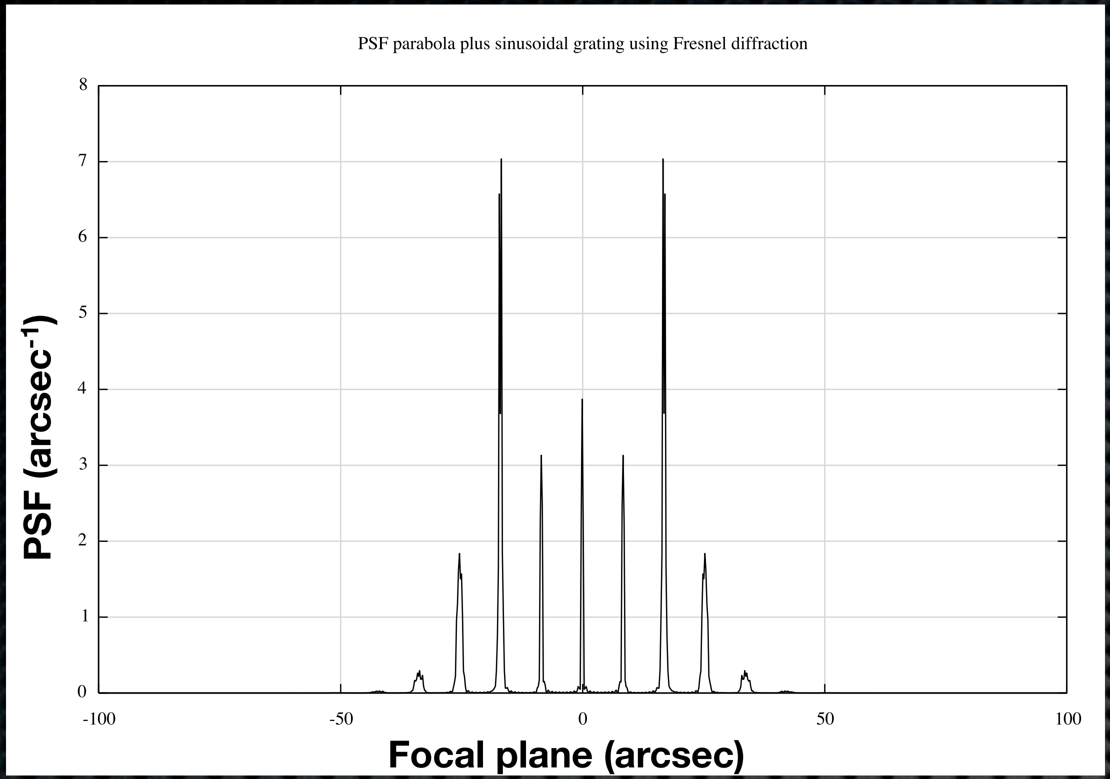
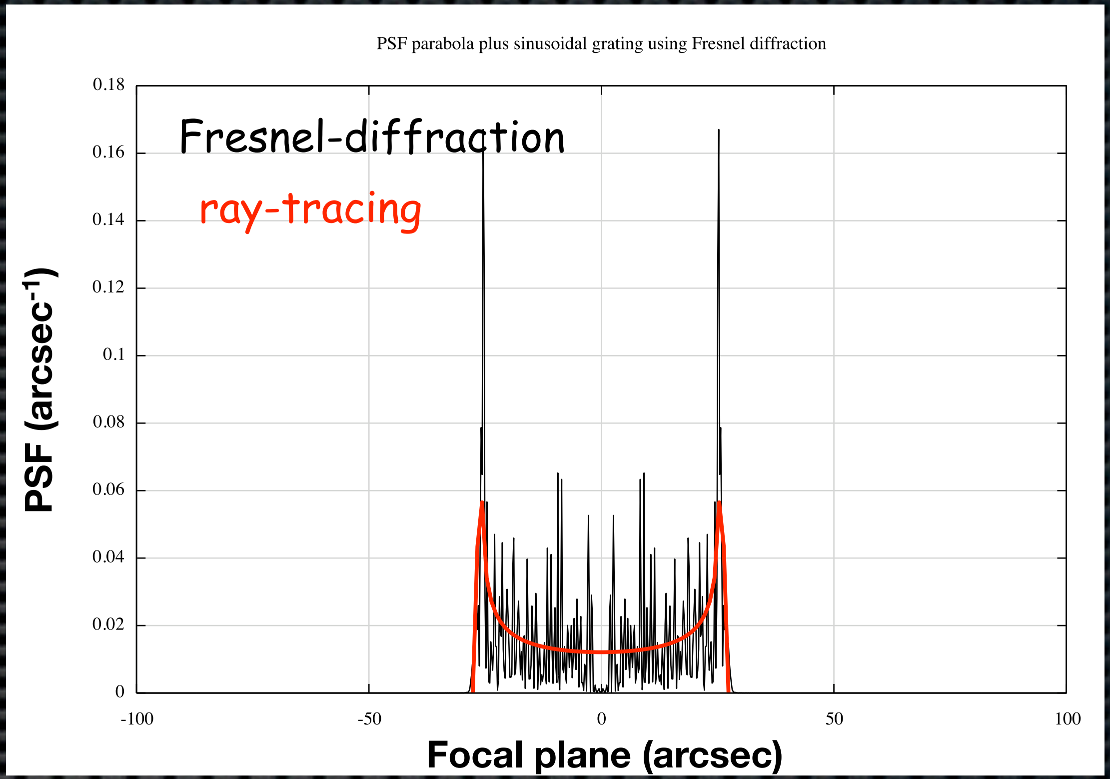


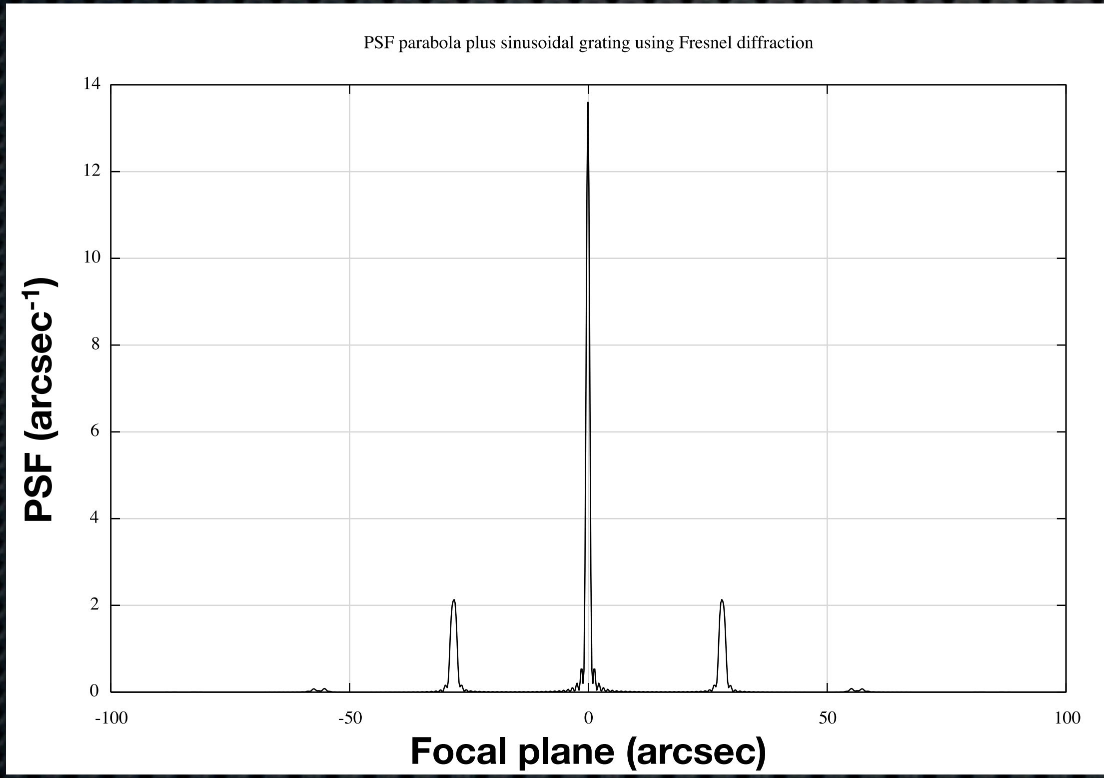
SCATTERING: SINUSOIDAL GRATING



λ = 30 A



λ = 1A Vs. ray-tracing



λ = 100 A

- SINUSOIDAL GRATING:

  $I = A \sin(2\pi X/\Phi)$ where $A = 0.1\ \mu m$ $\Phi = 1cm$

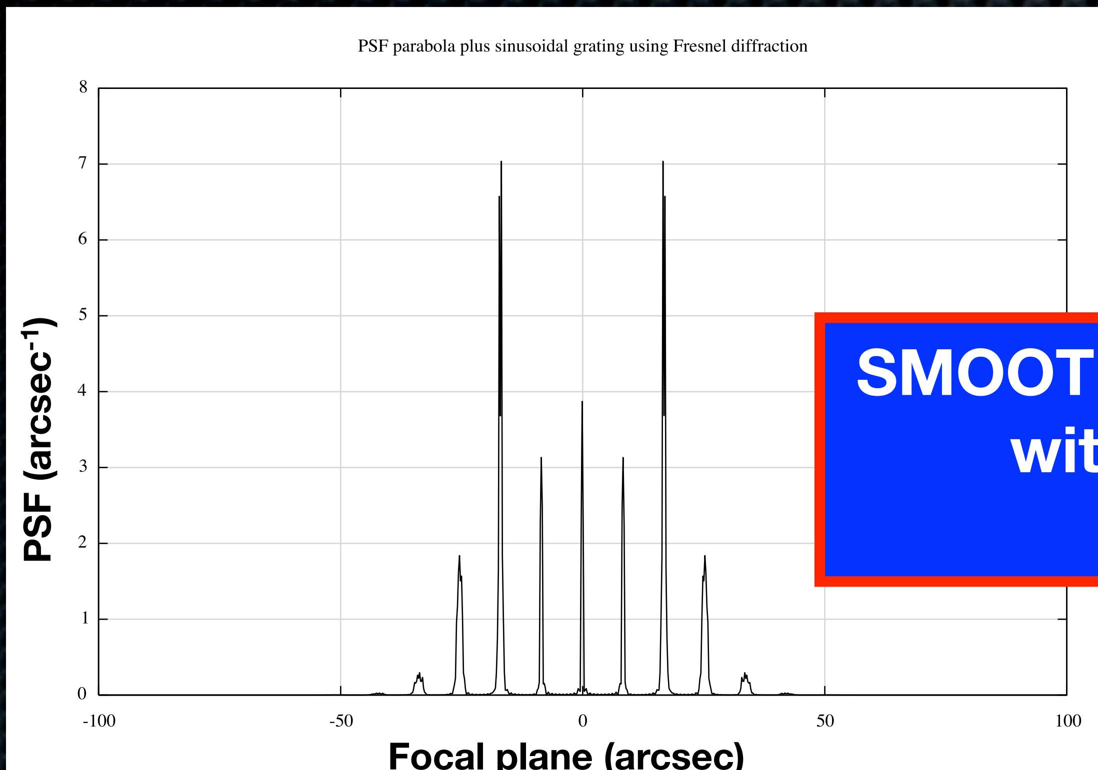
- PREDICTED PEAK POSITIONS:

  $\Phi = N\ \lambda/(\cos\theta_i - \cos\theta_s)$

- PREDICTED PEAK HEIGHTS:

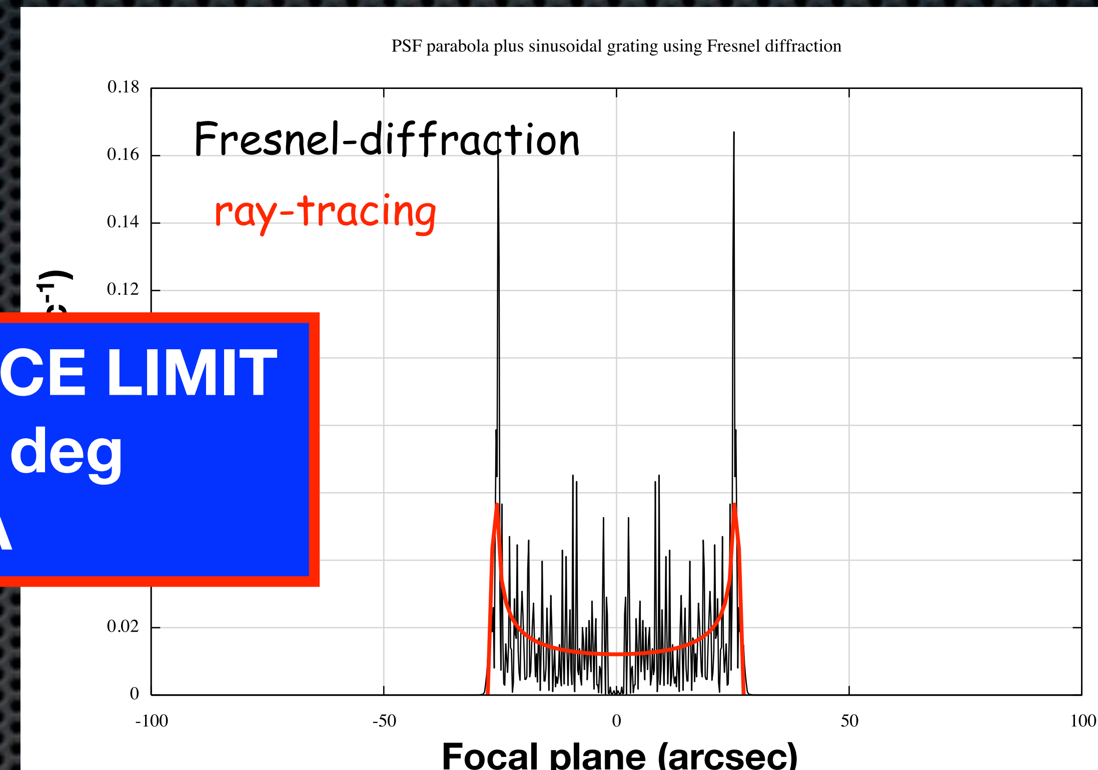
  $I = J_N^2[(2\pi A/\lambda)(\sin\theta_i + \sin\theta_s)]$

SCATTERING: SINUSOIDAL GRATING



λ = 30 A

SMOOTH SURFACE LIMIT
with α = 0.4 deg
λ > 62 A



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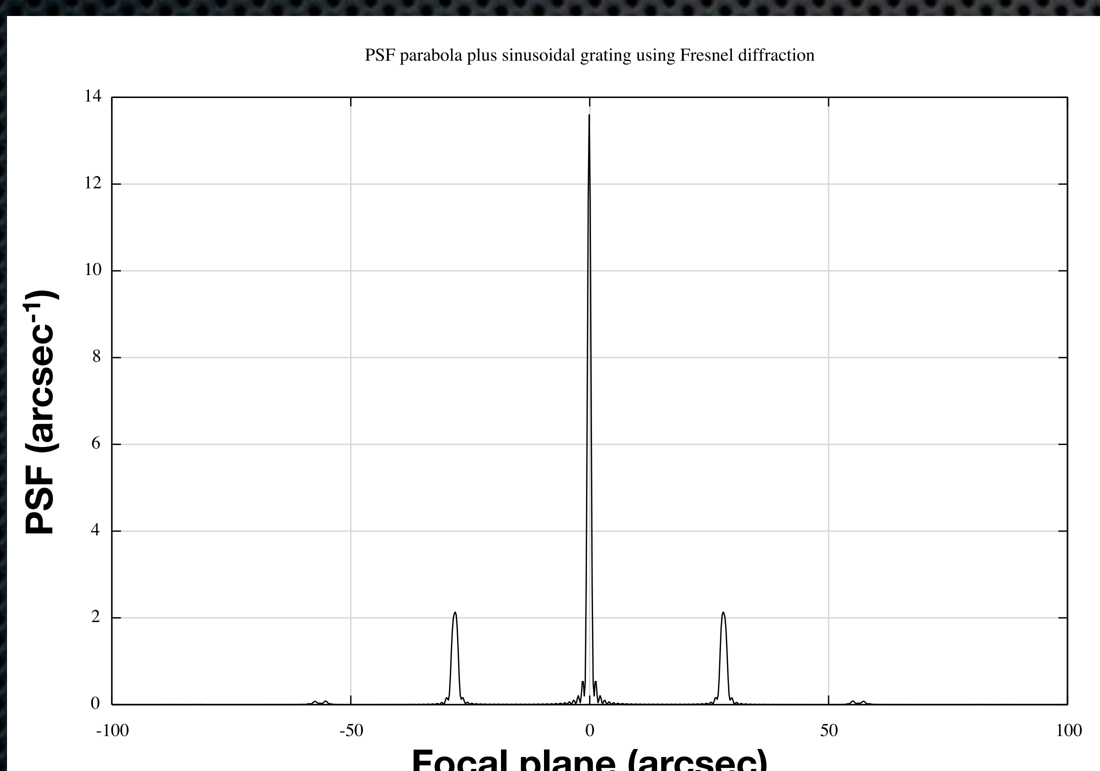

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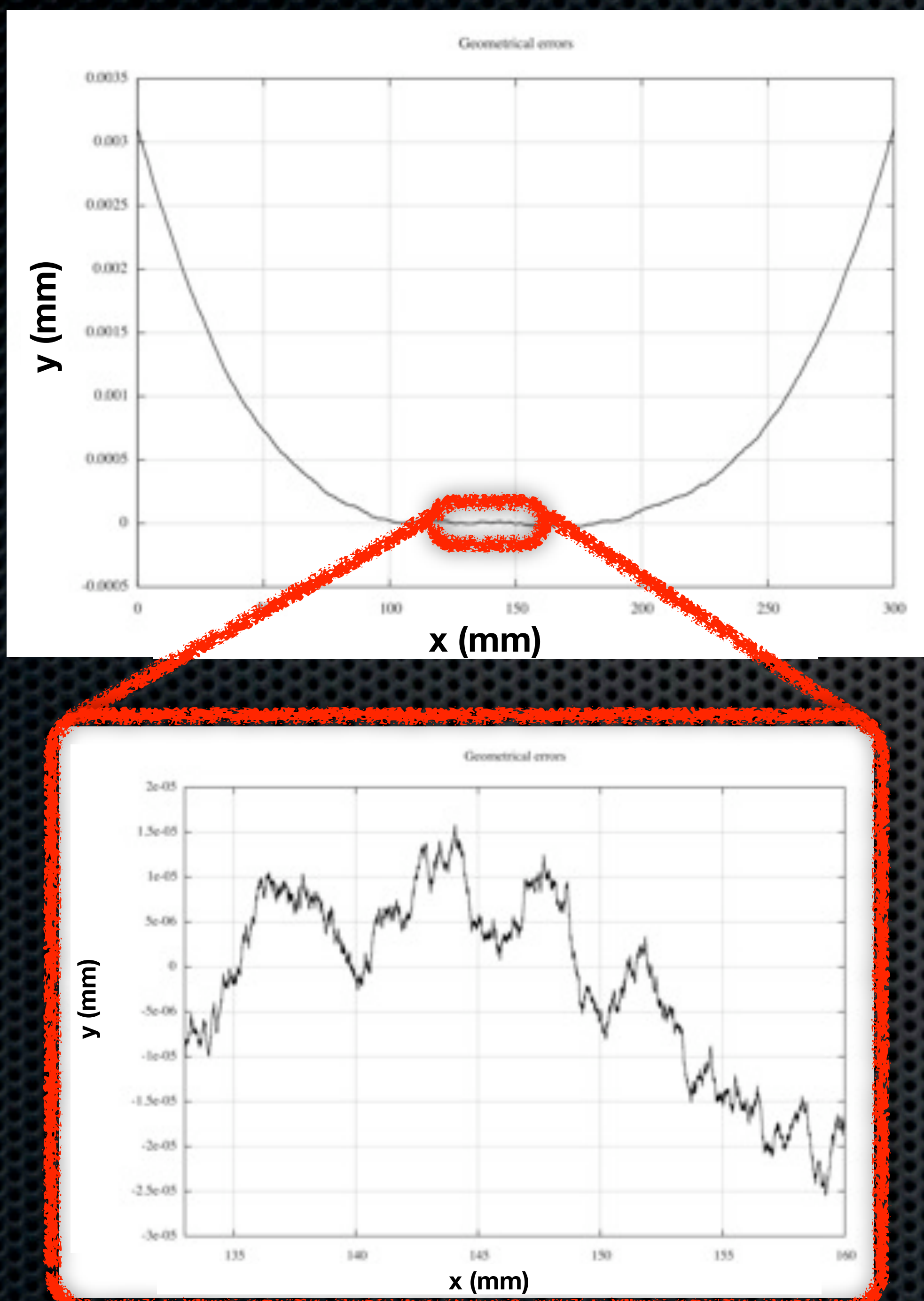
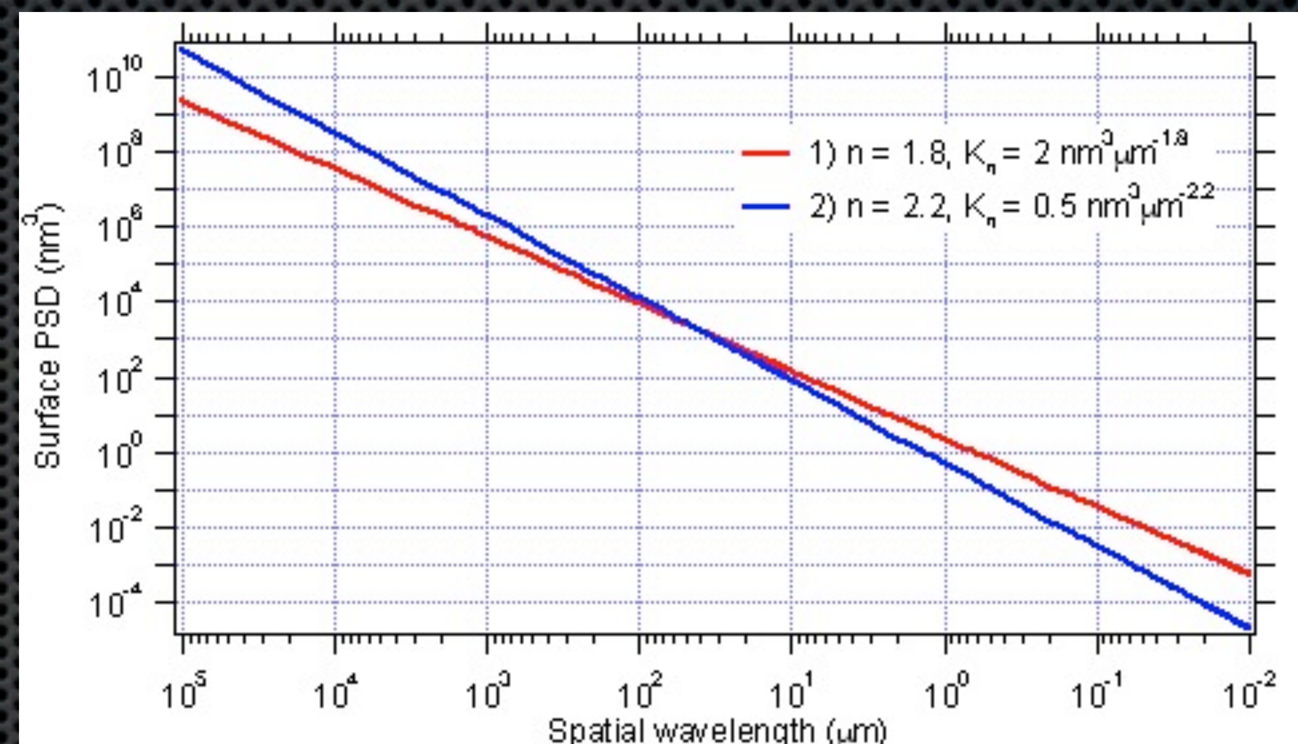
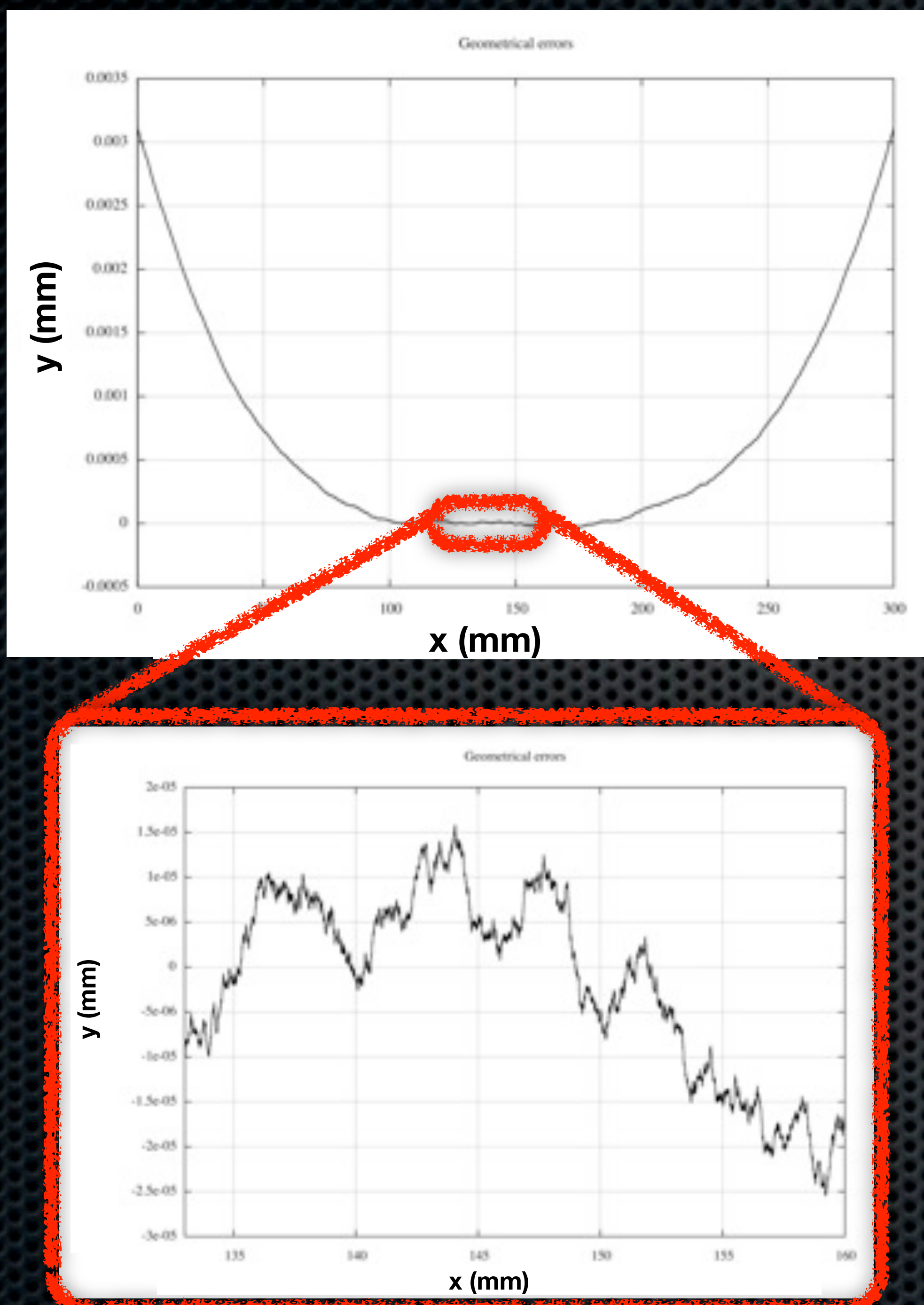
PSF COMPUTATION FOR A TYPICAL MIRROR PROFILE

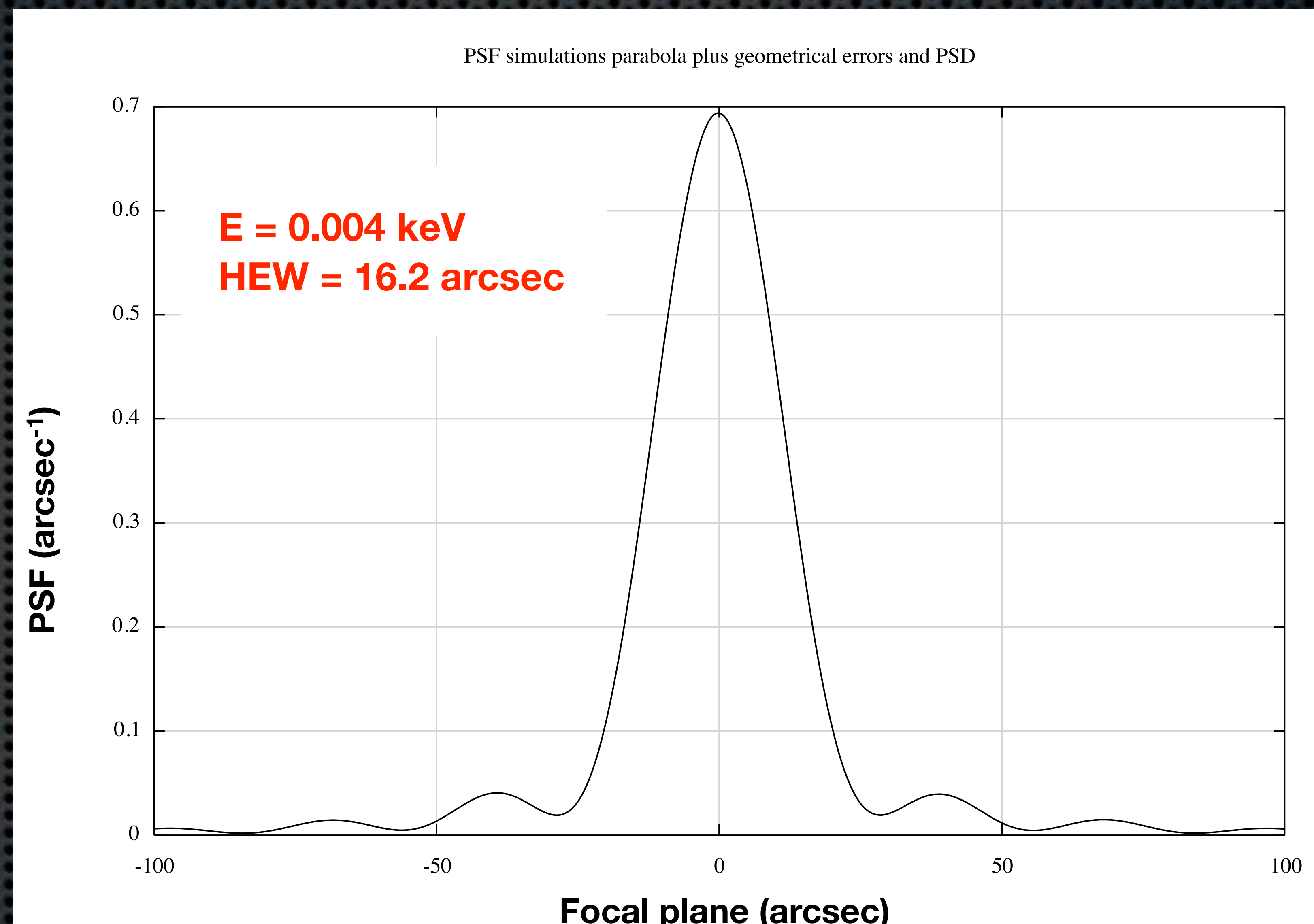




$$PSD = K_n/f^n$$

PSF COMPUTATION FOR A TYPICAL MIRROR PROFILE





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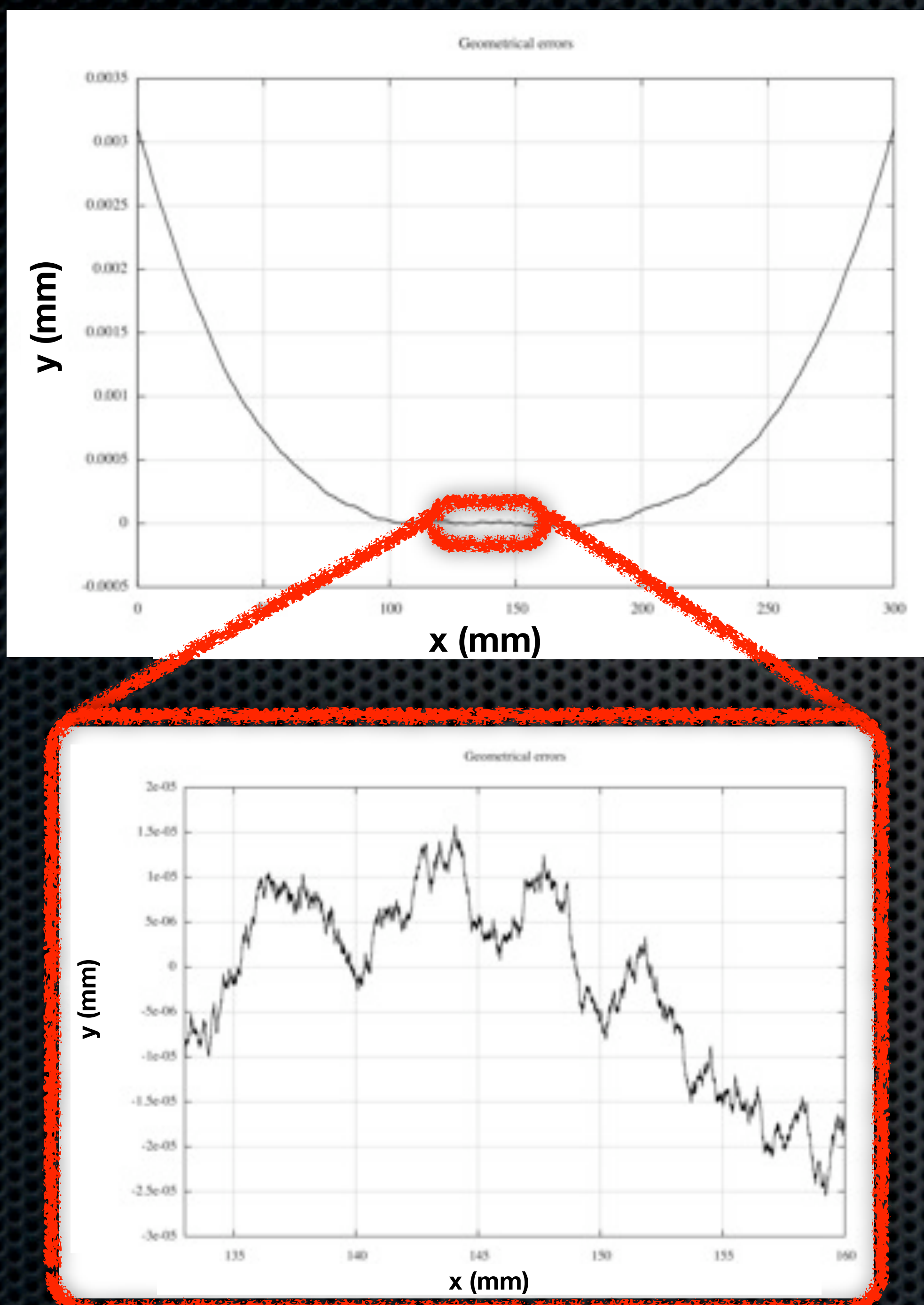

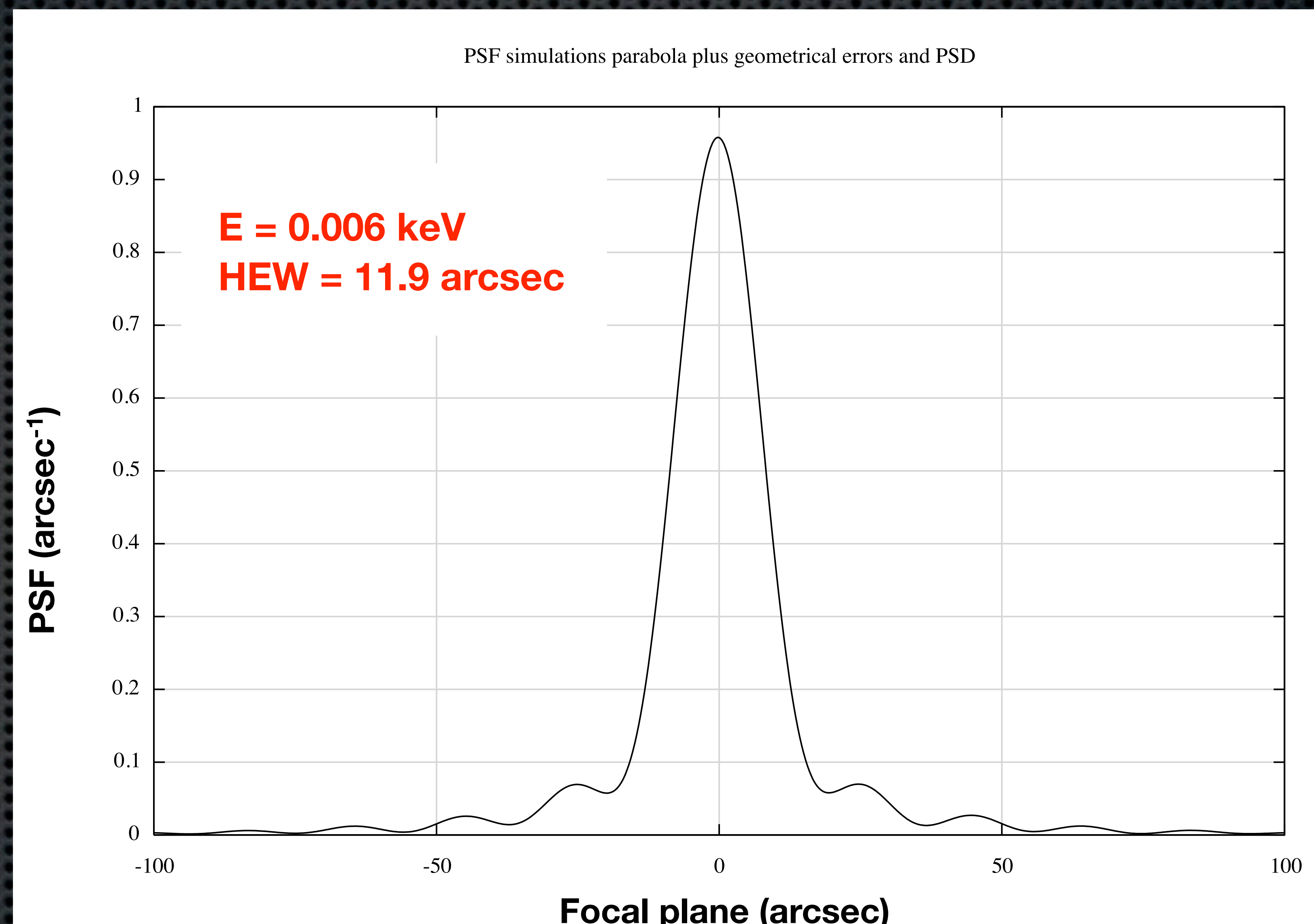

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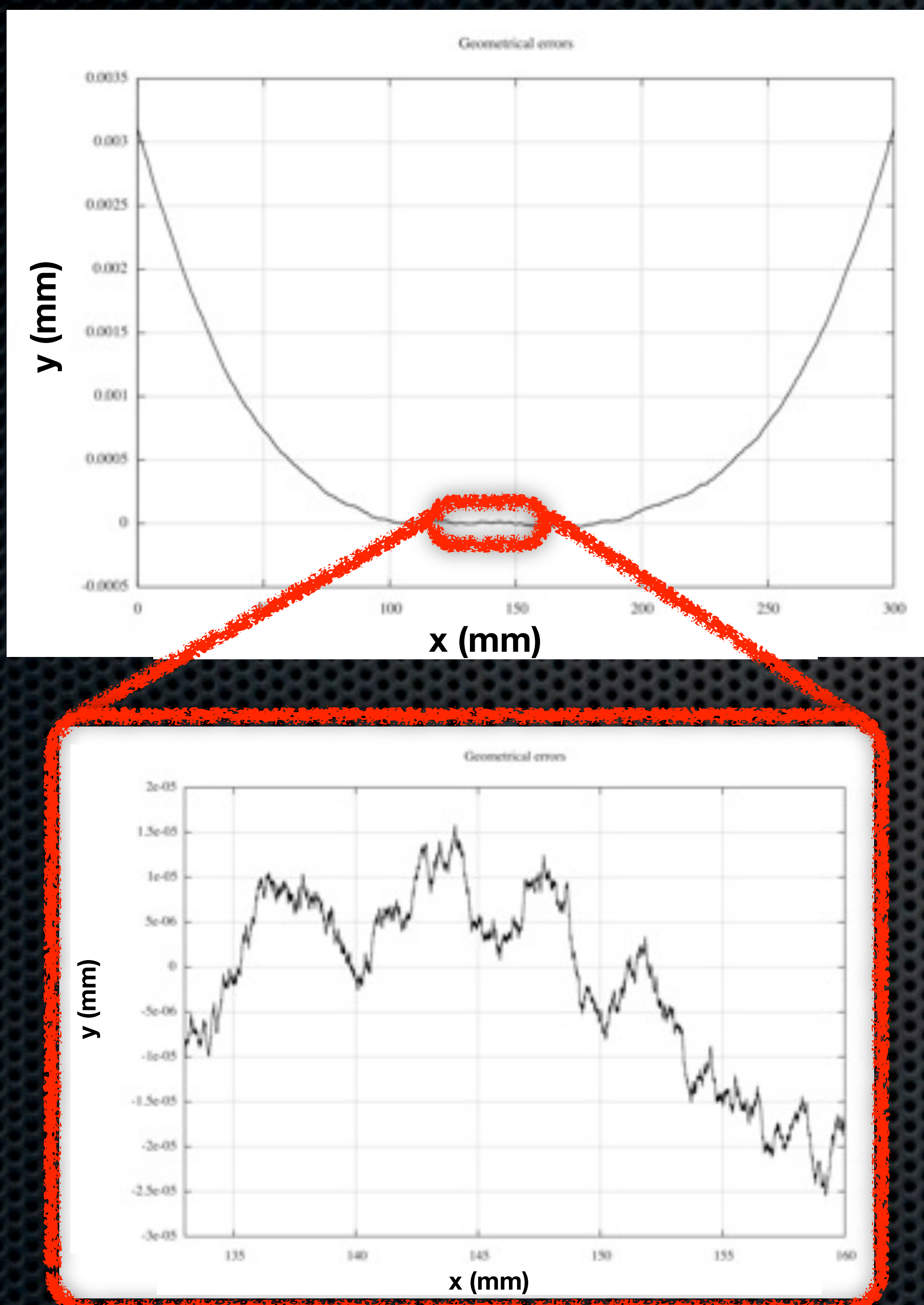

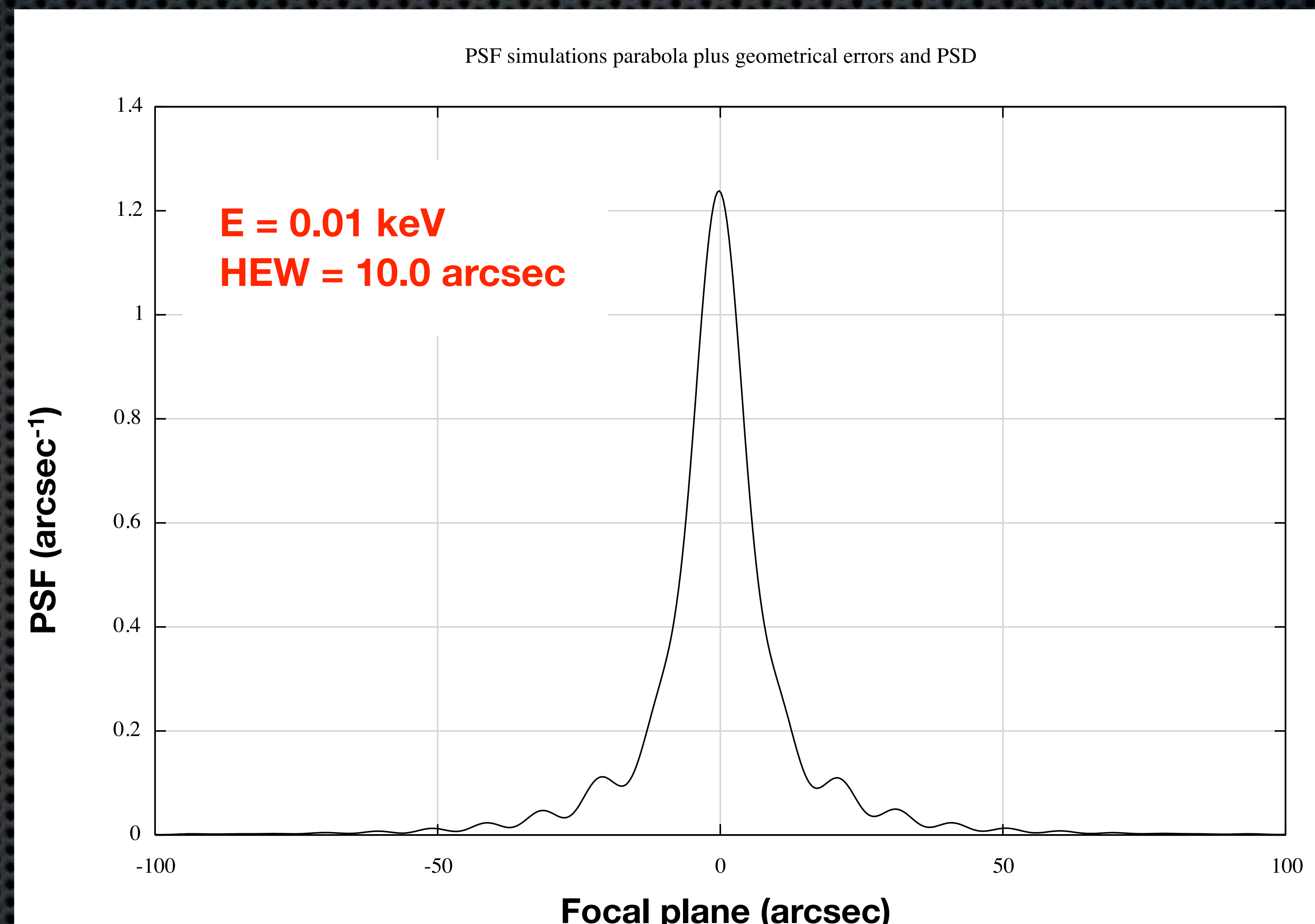

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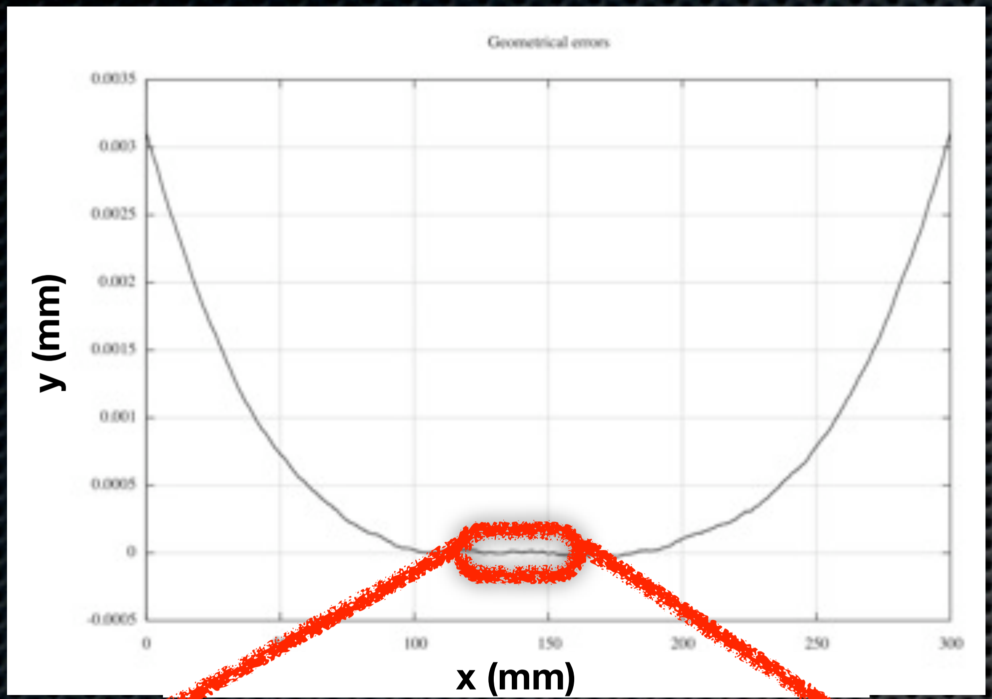

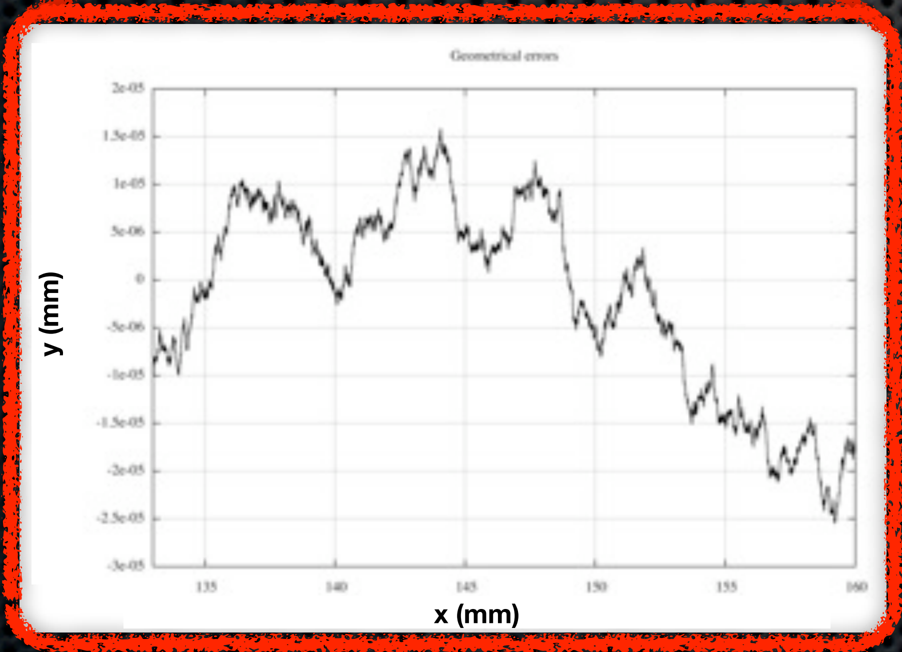

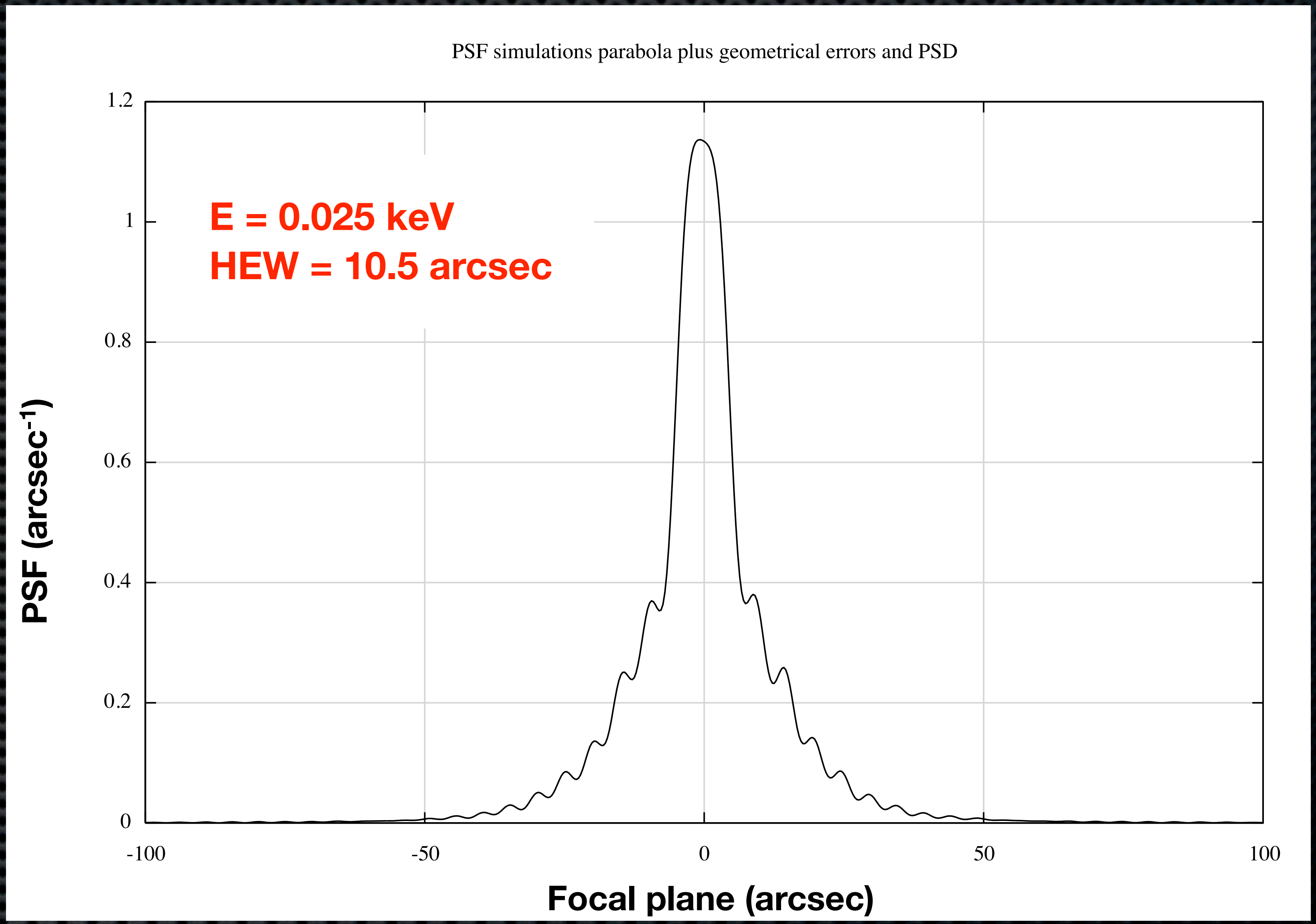

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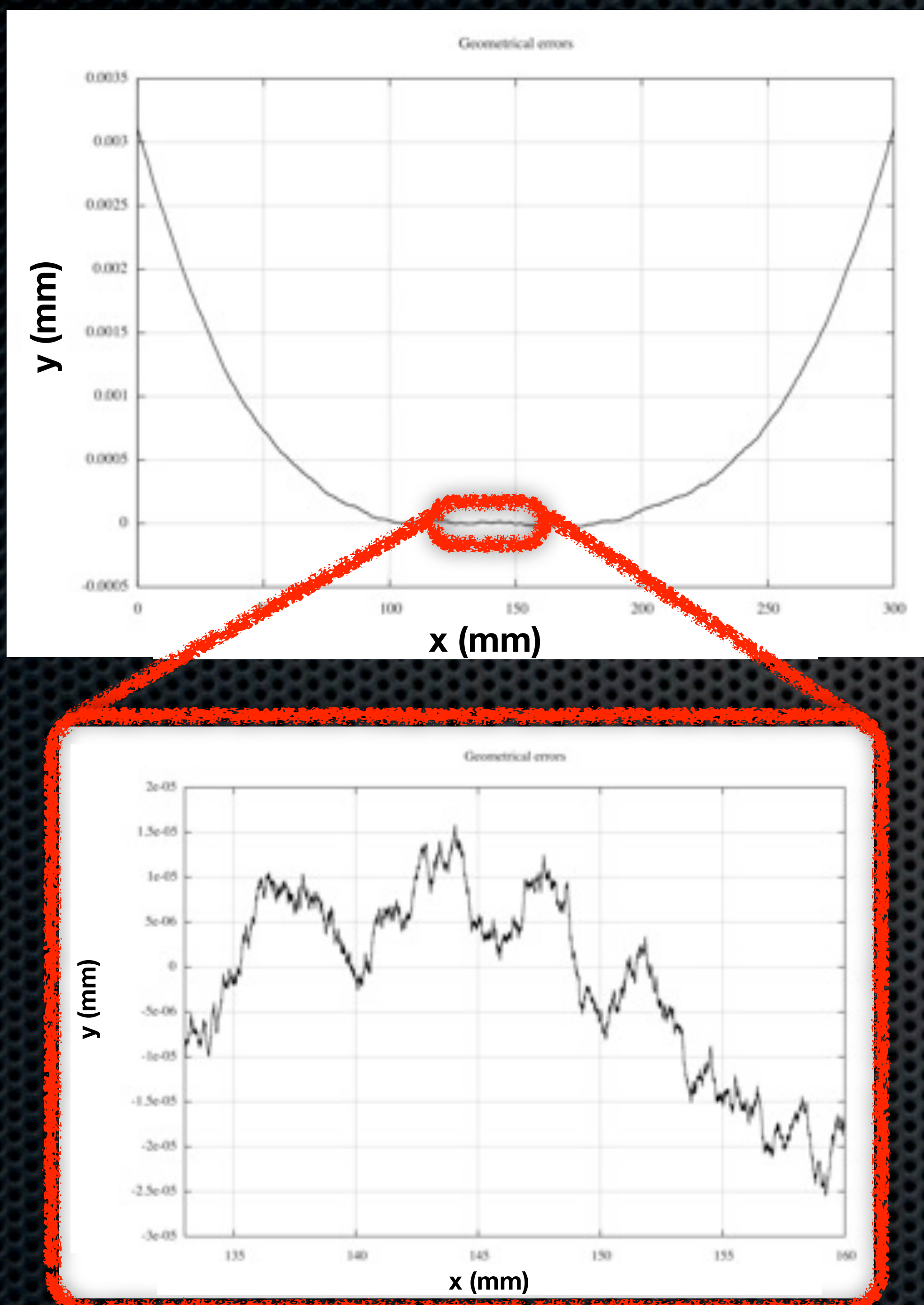

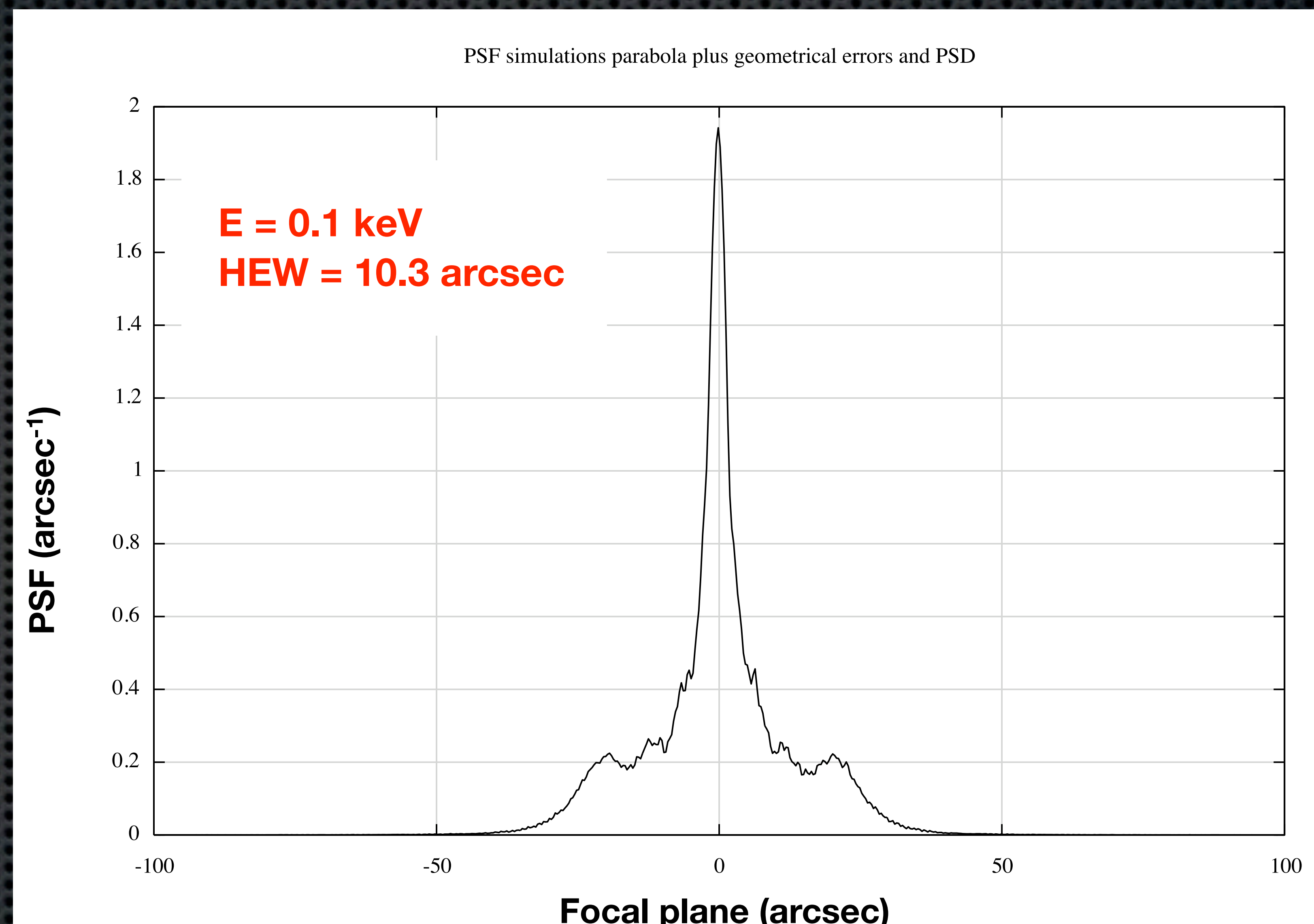

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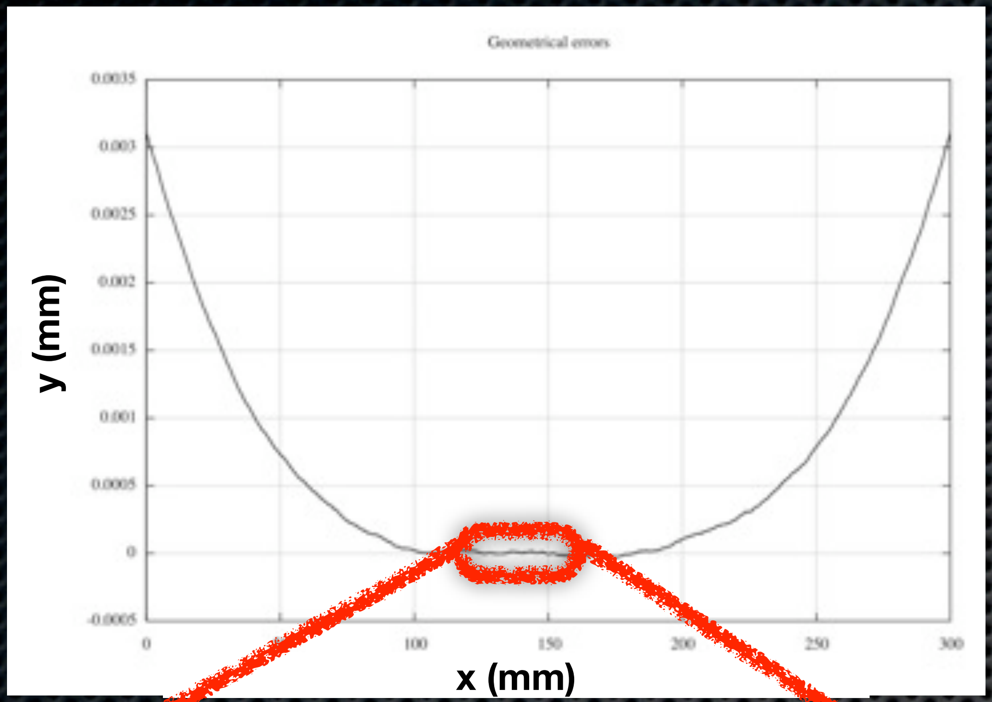

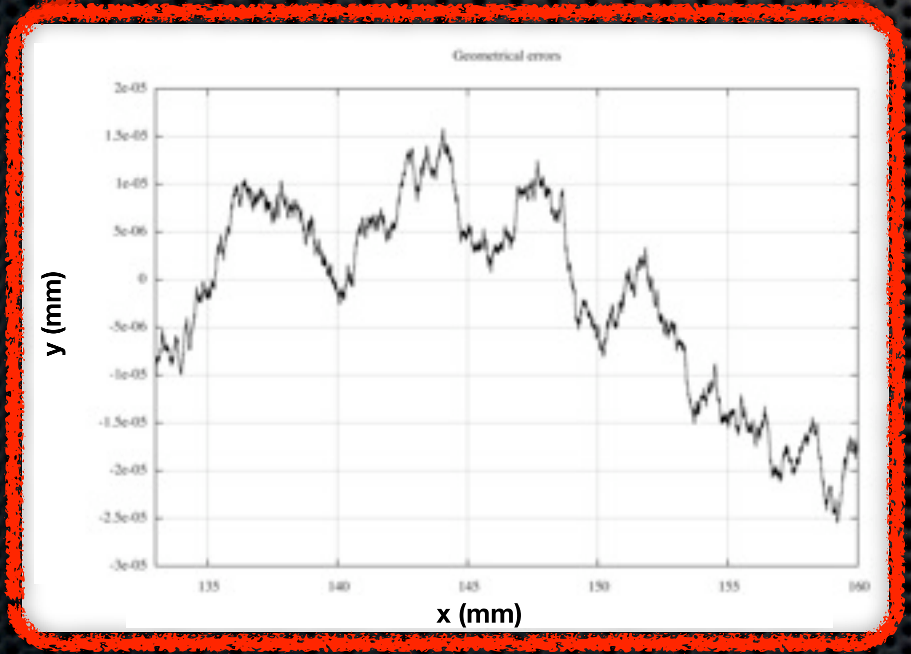

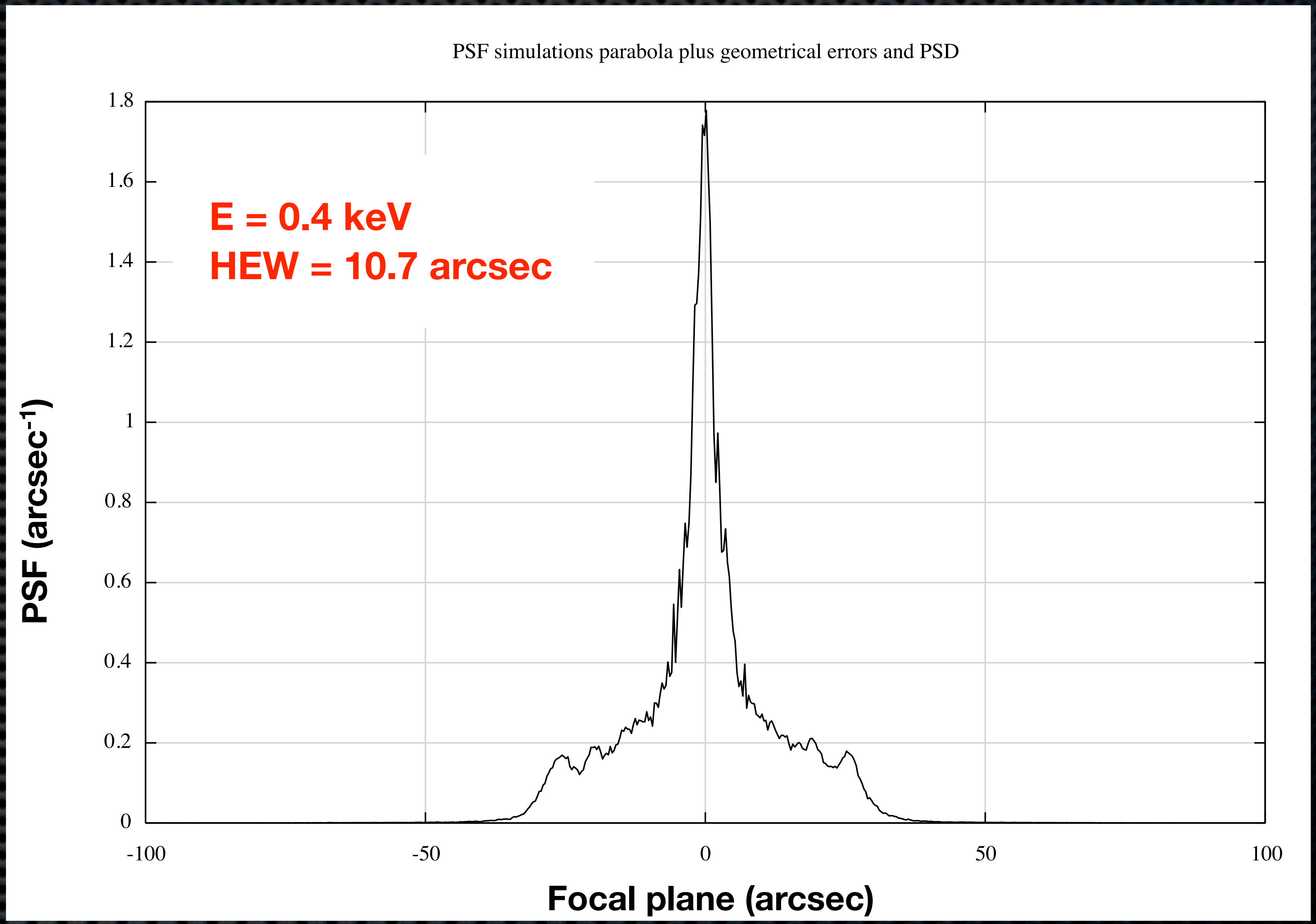

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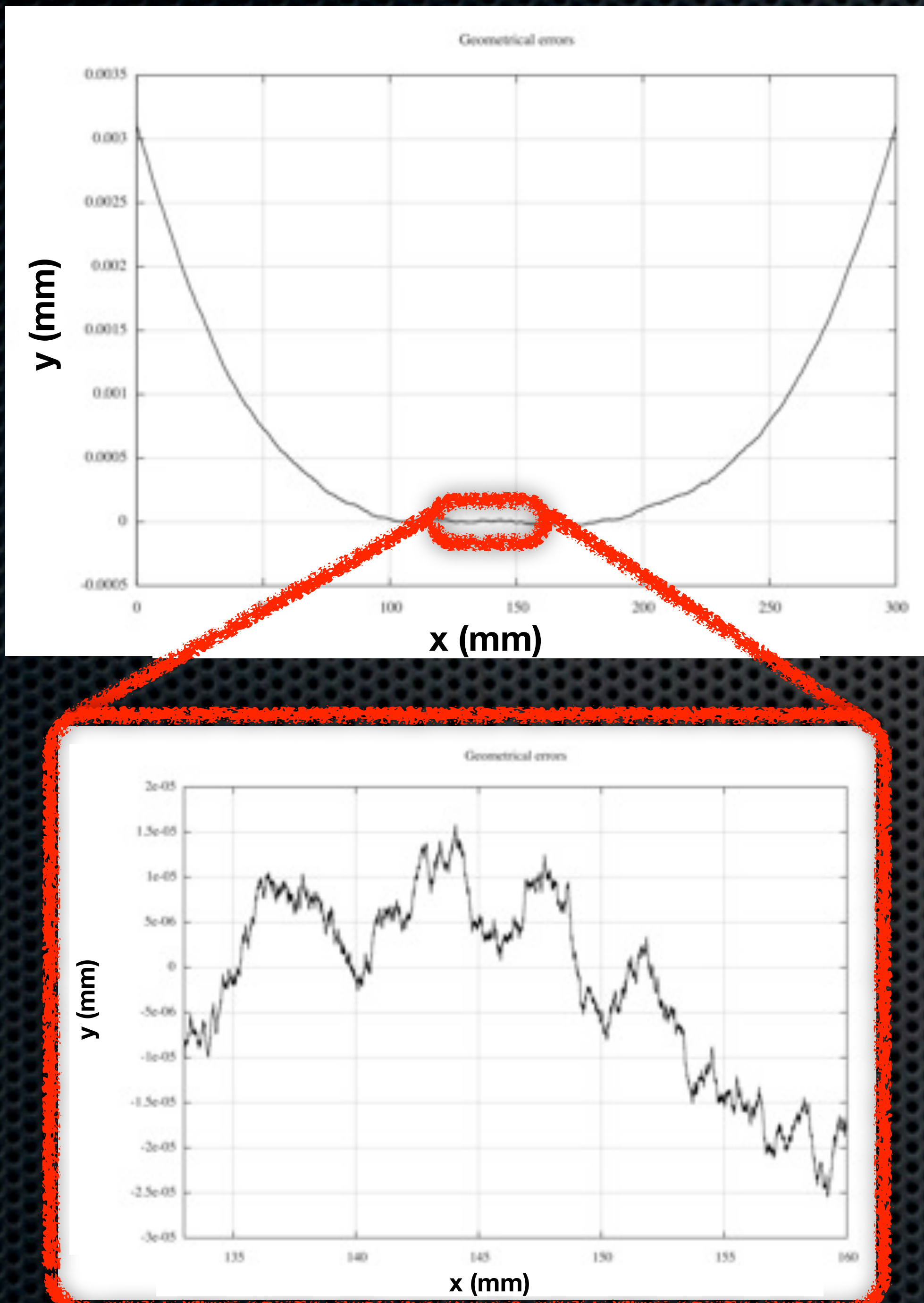

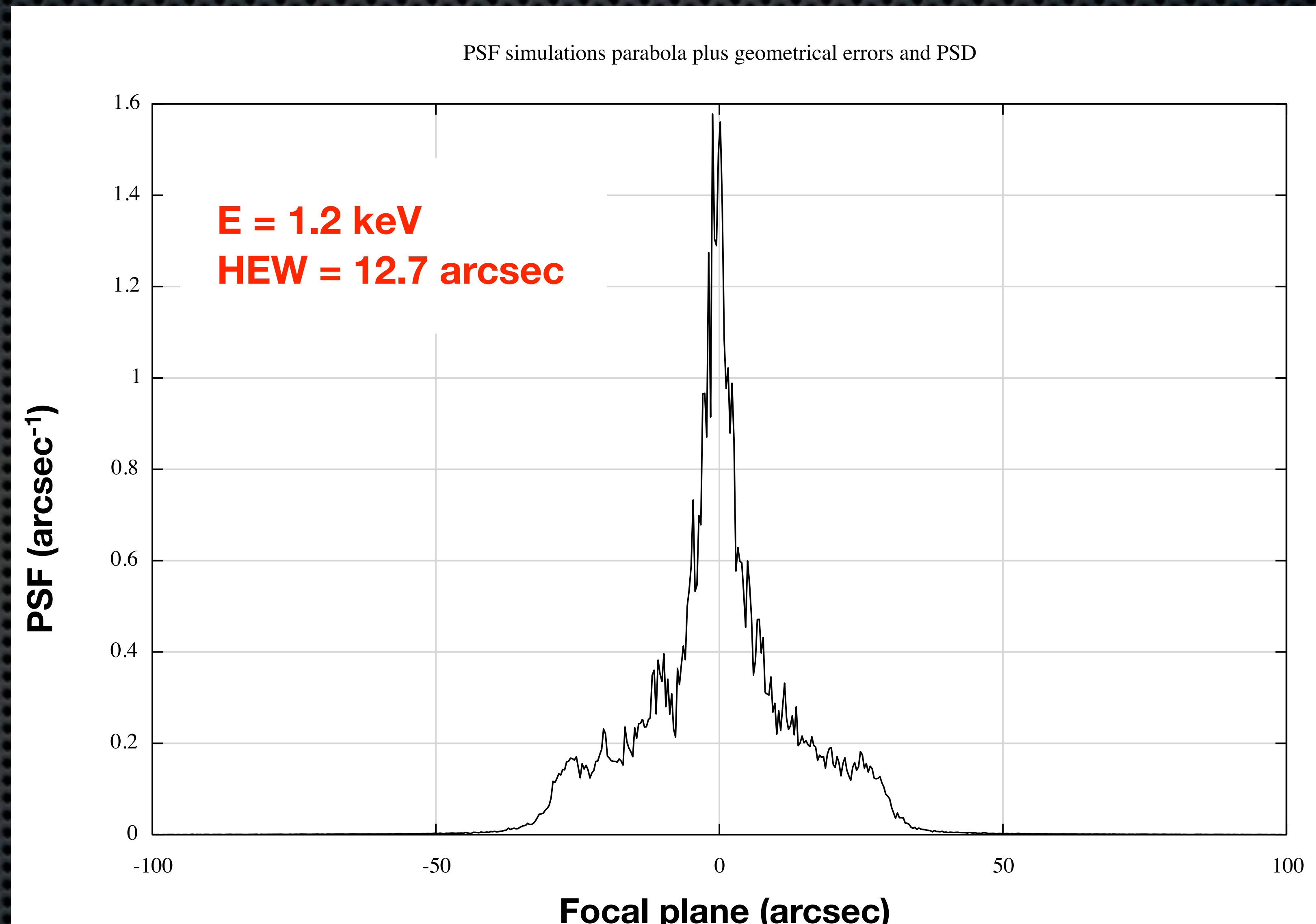

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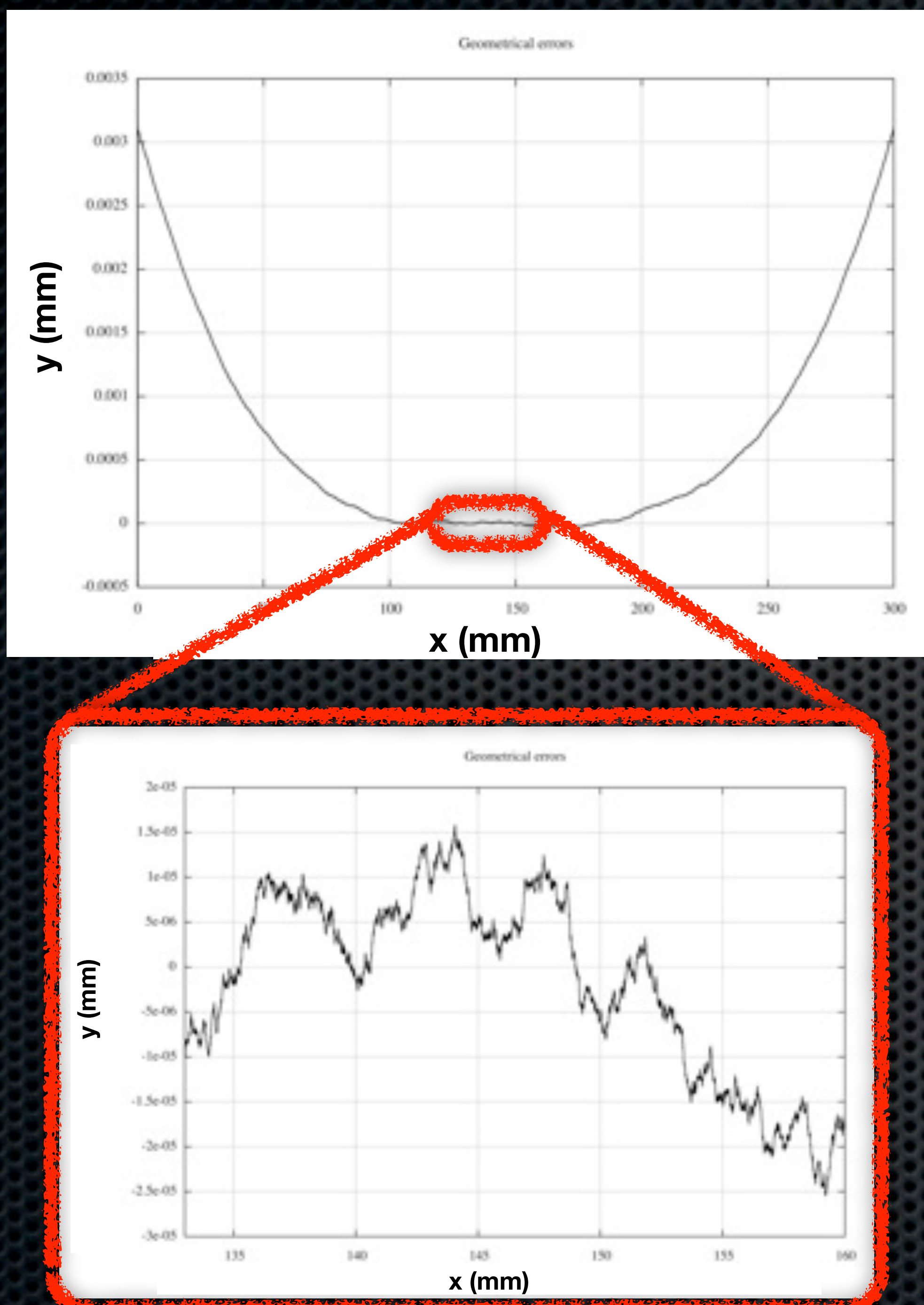

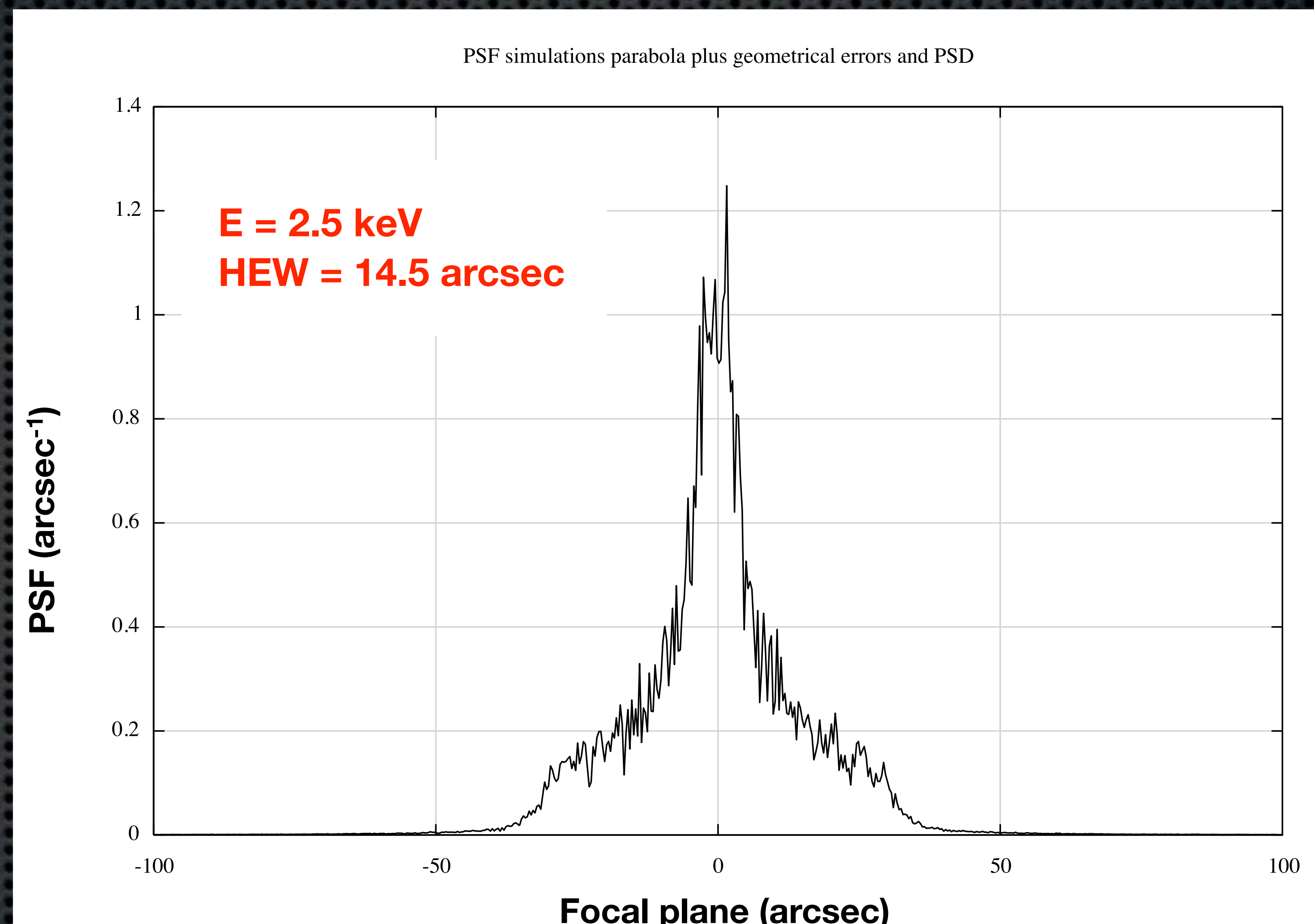

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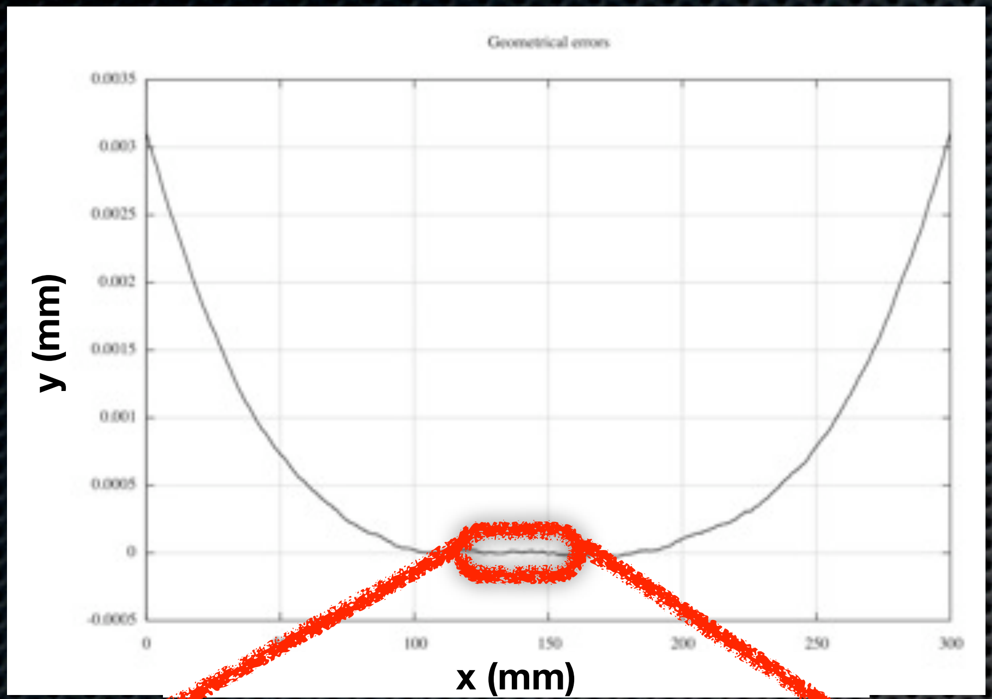

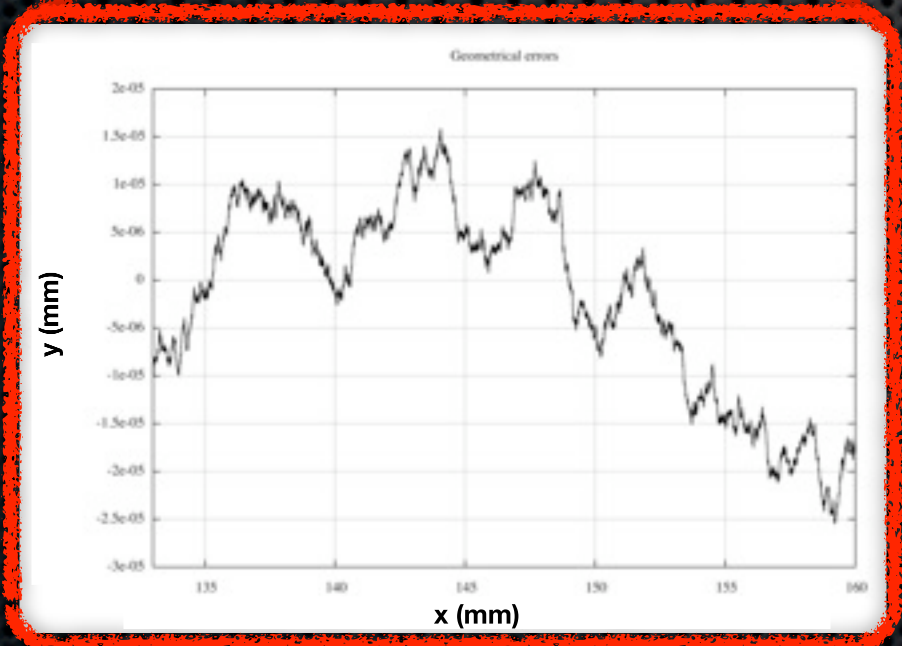

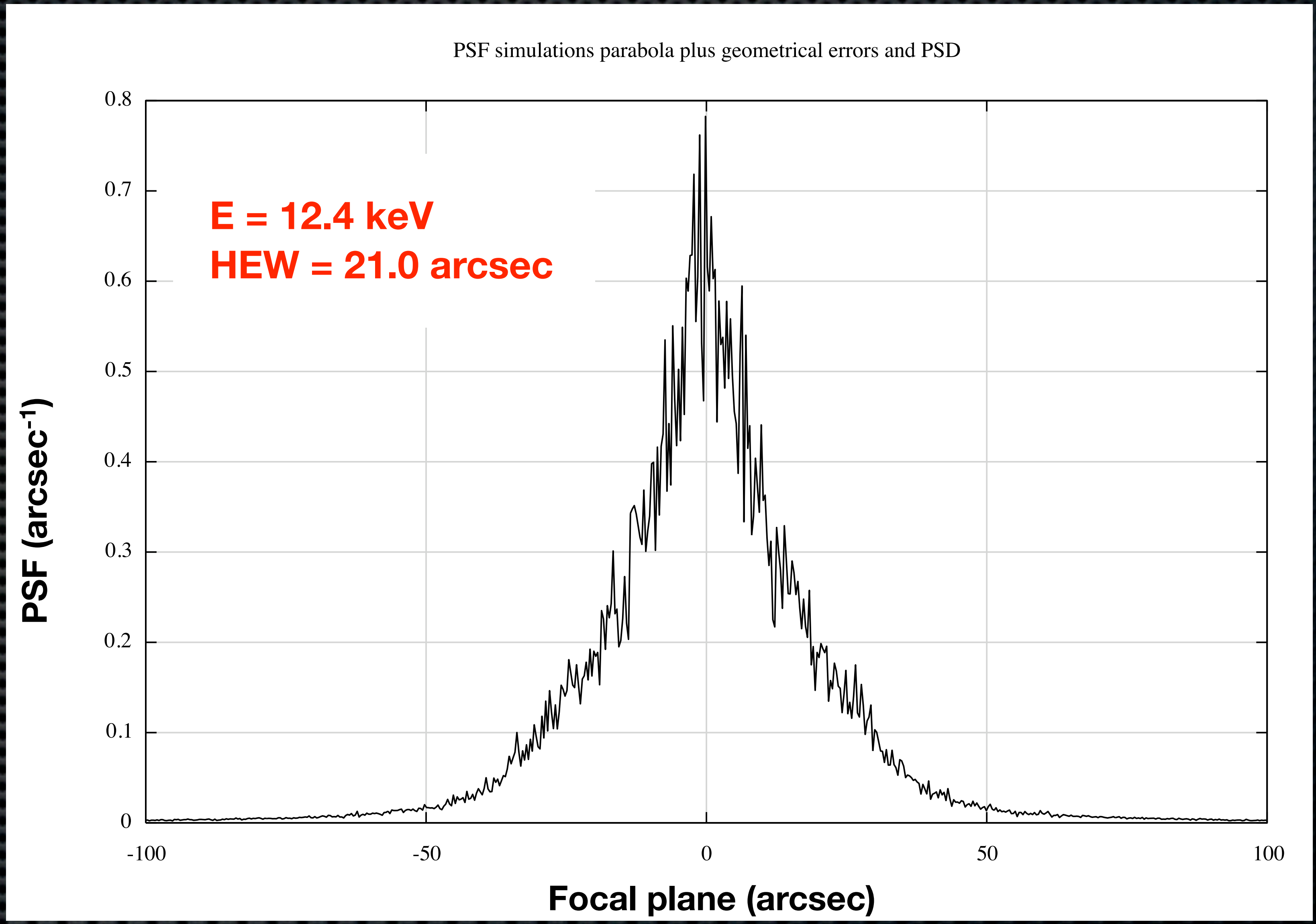

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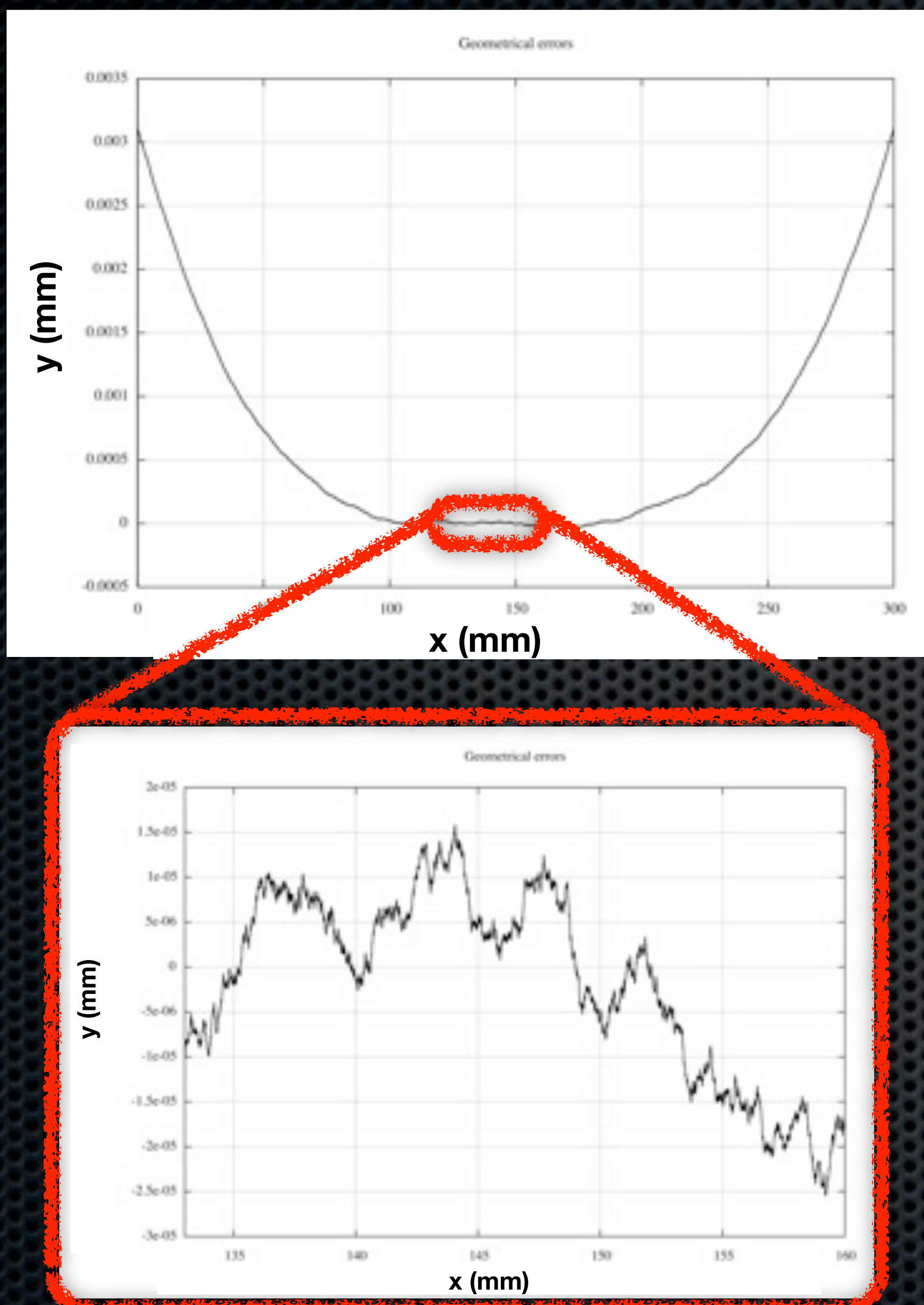

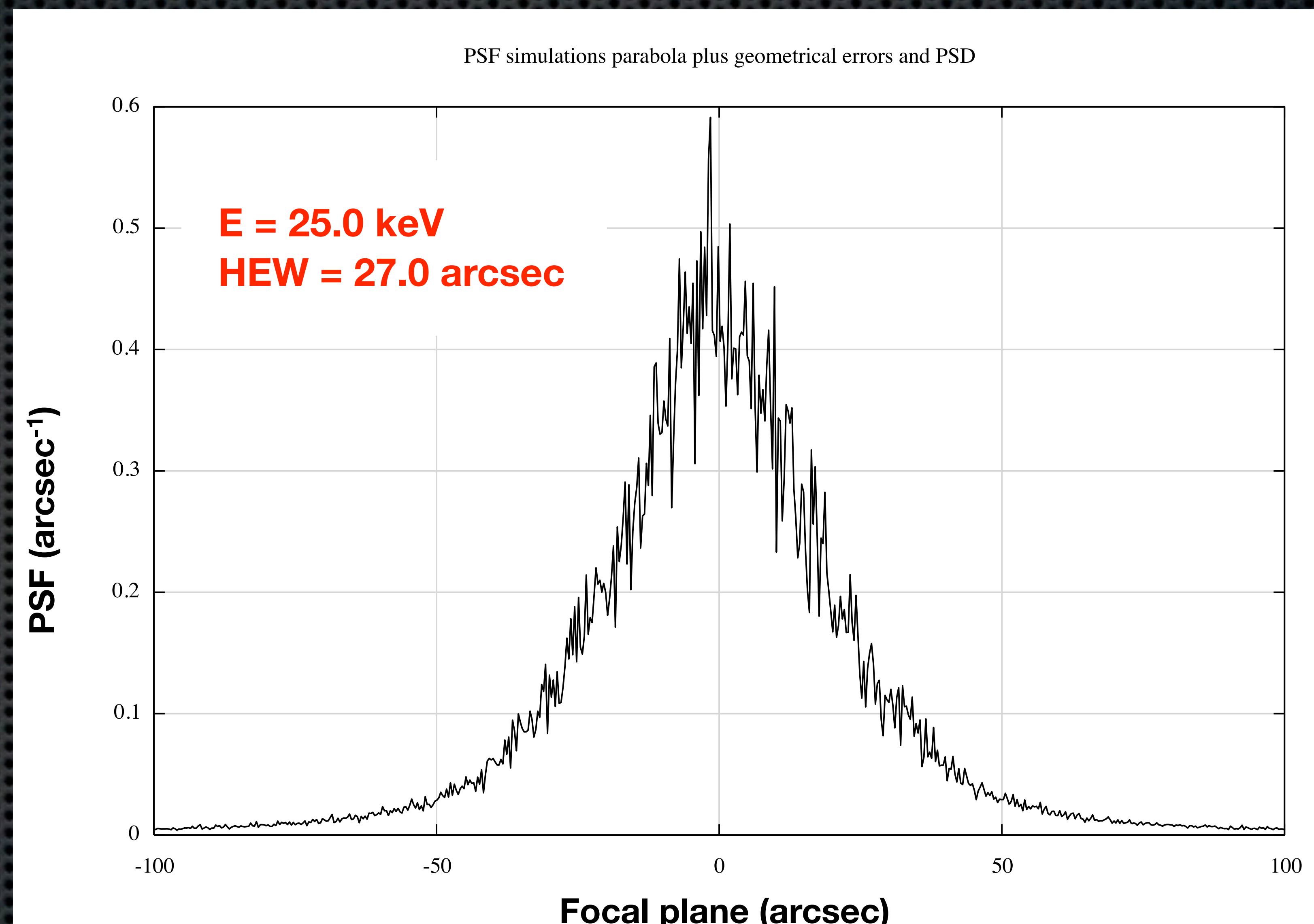

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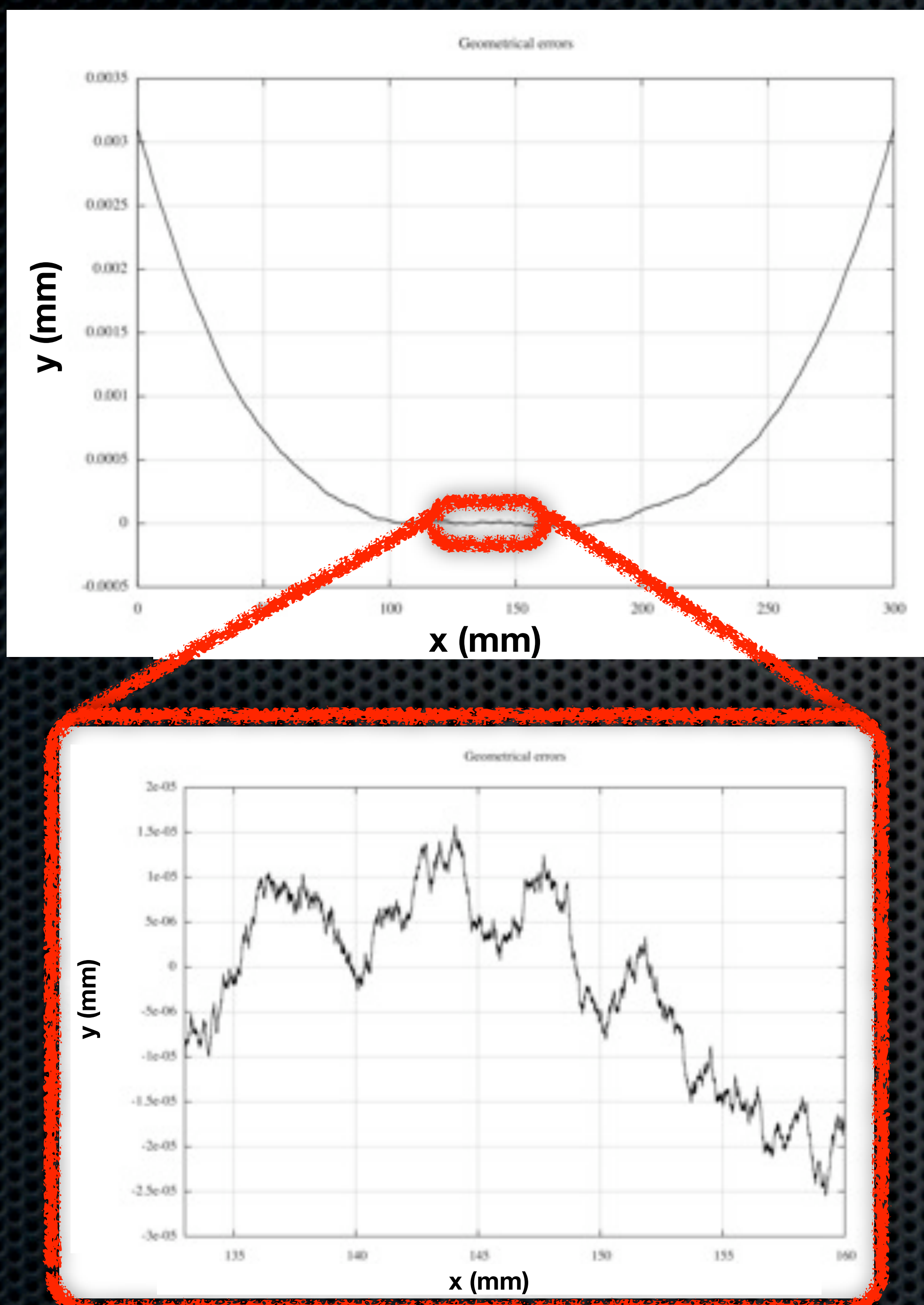
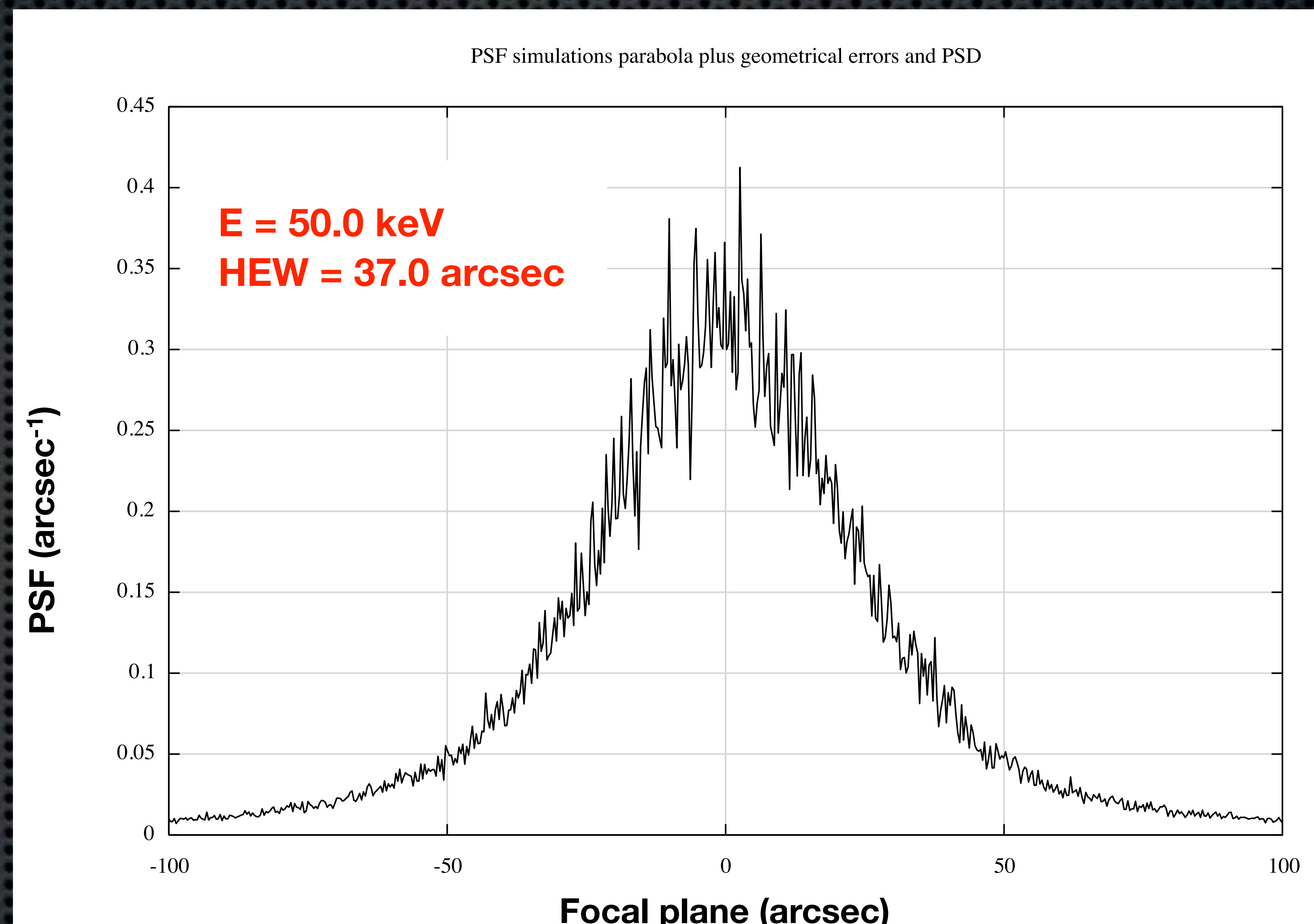
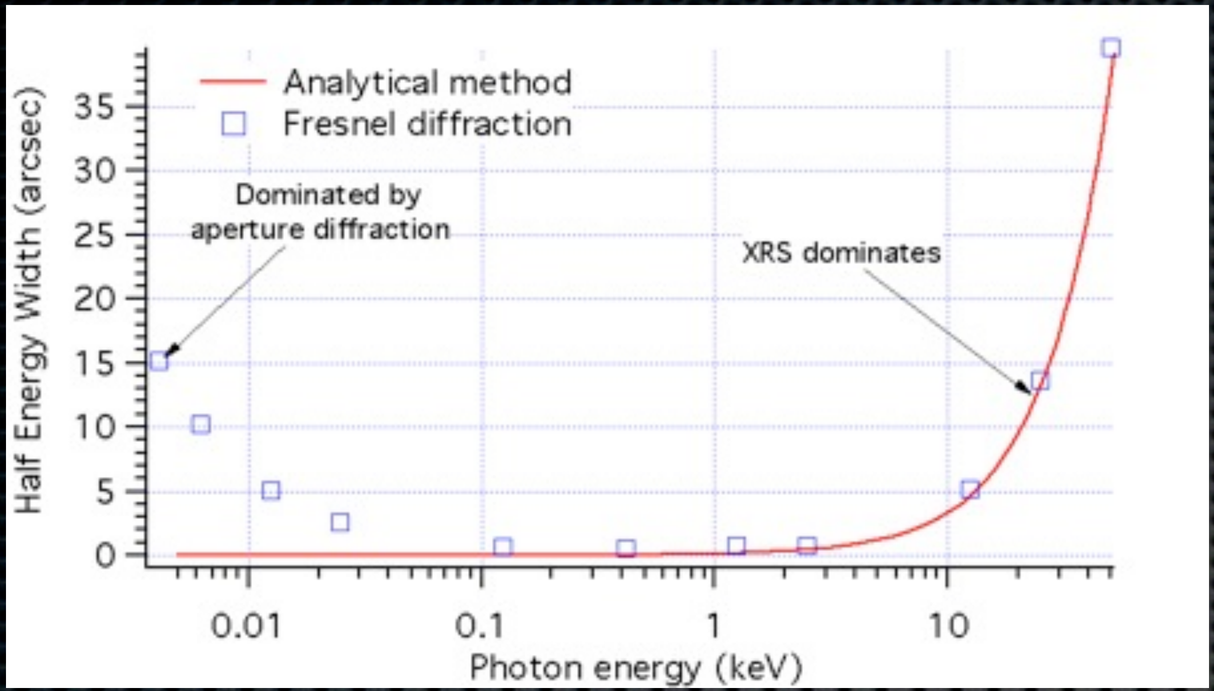


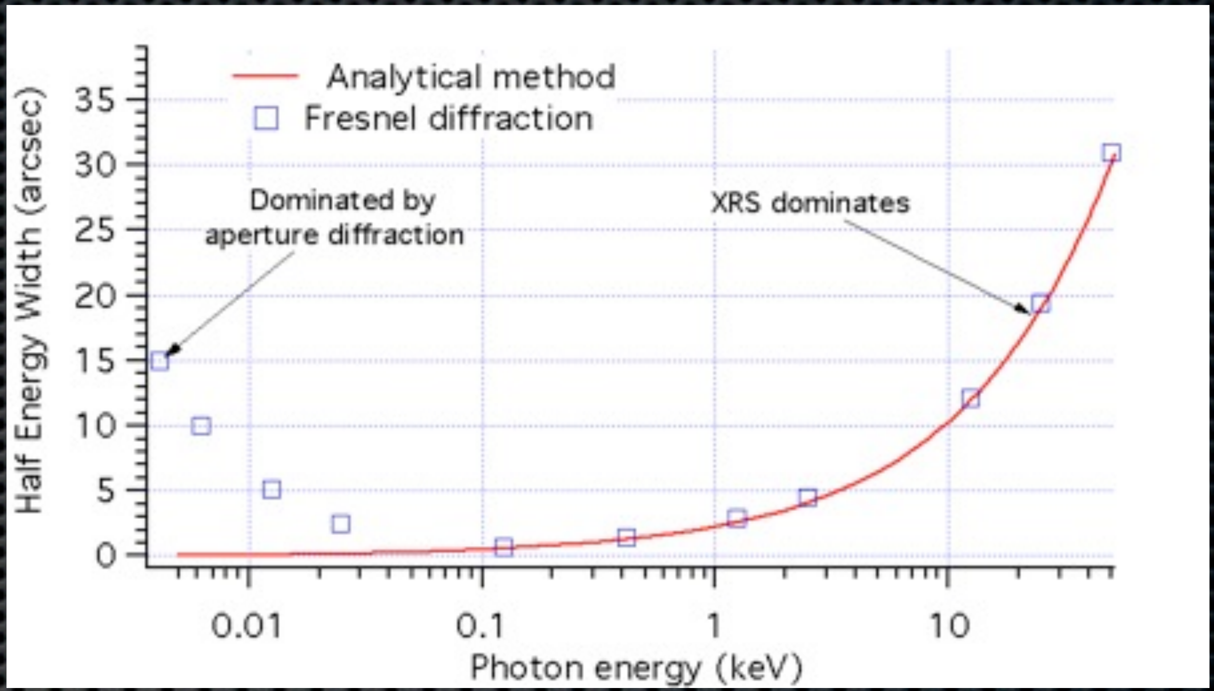


HEW VARIATION WITH ENERGY

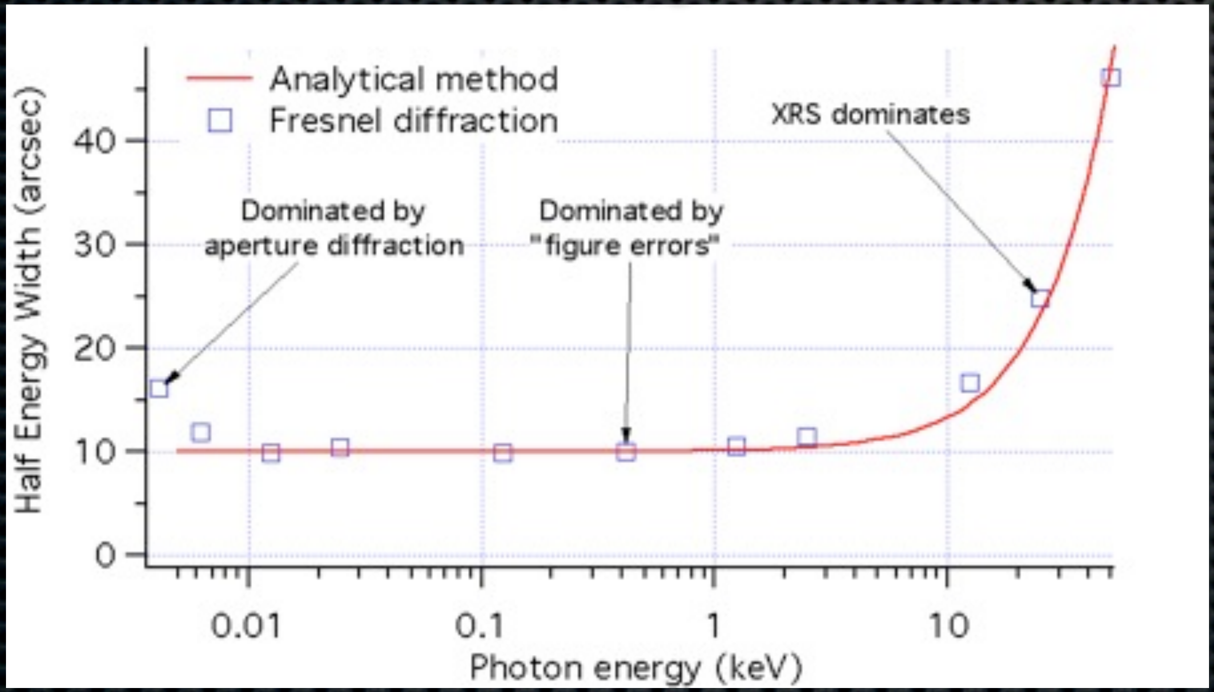
comparison with analytical method (Spiga 2007)



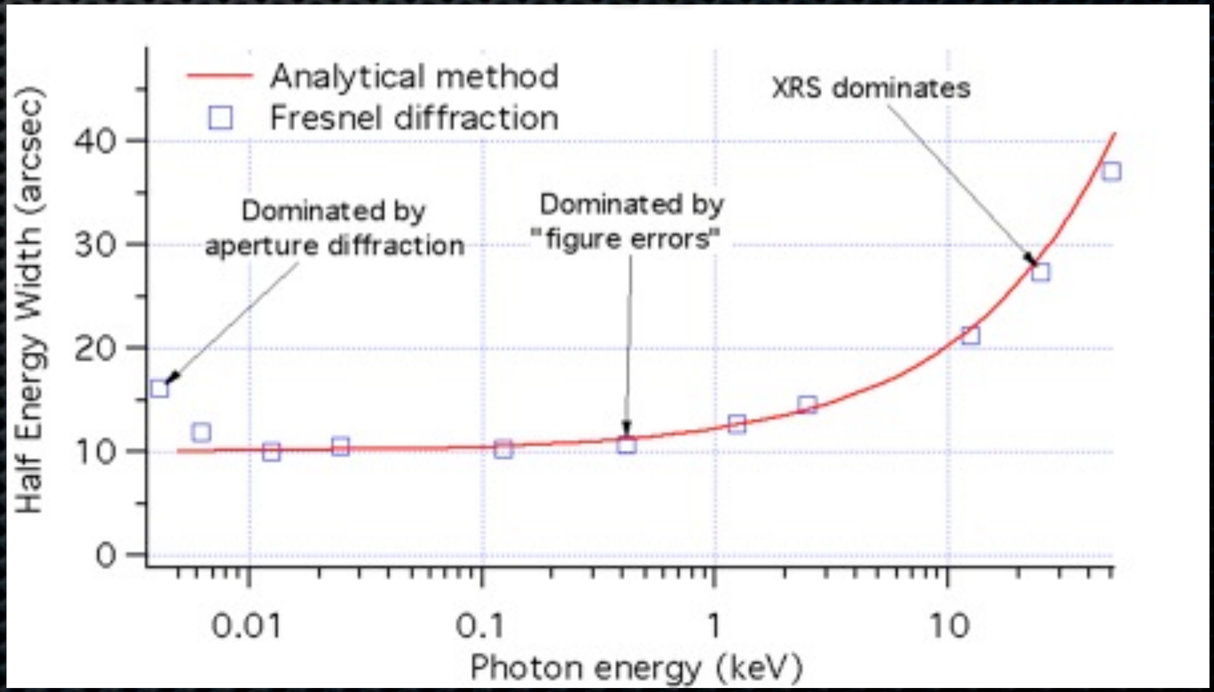
Perfect shape parabola plus PSD Kn=2.2 n=1.8



Perfect shape parabola plus PSD Kn=0.5 n=2.2



Parabola plus geometrical errors and PSD Kn=2.2 n=1.8



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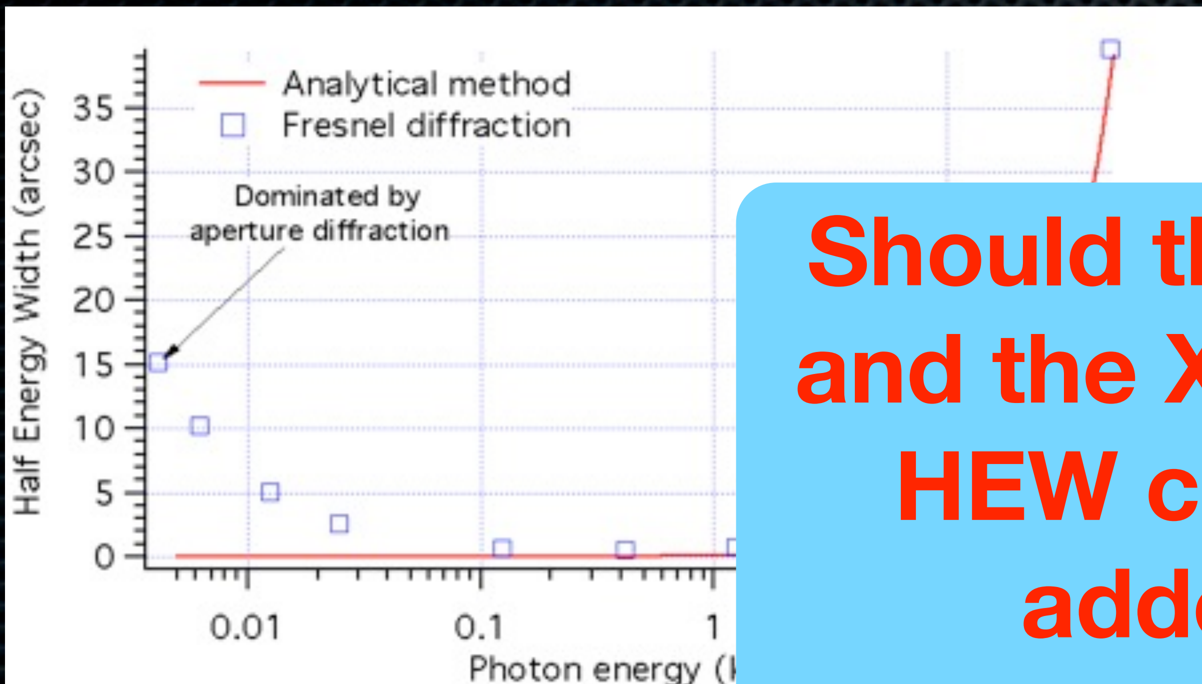

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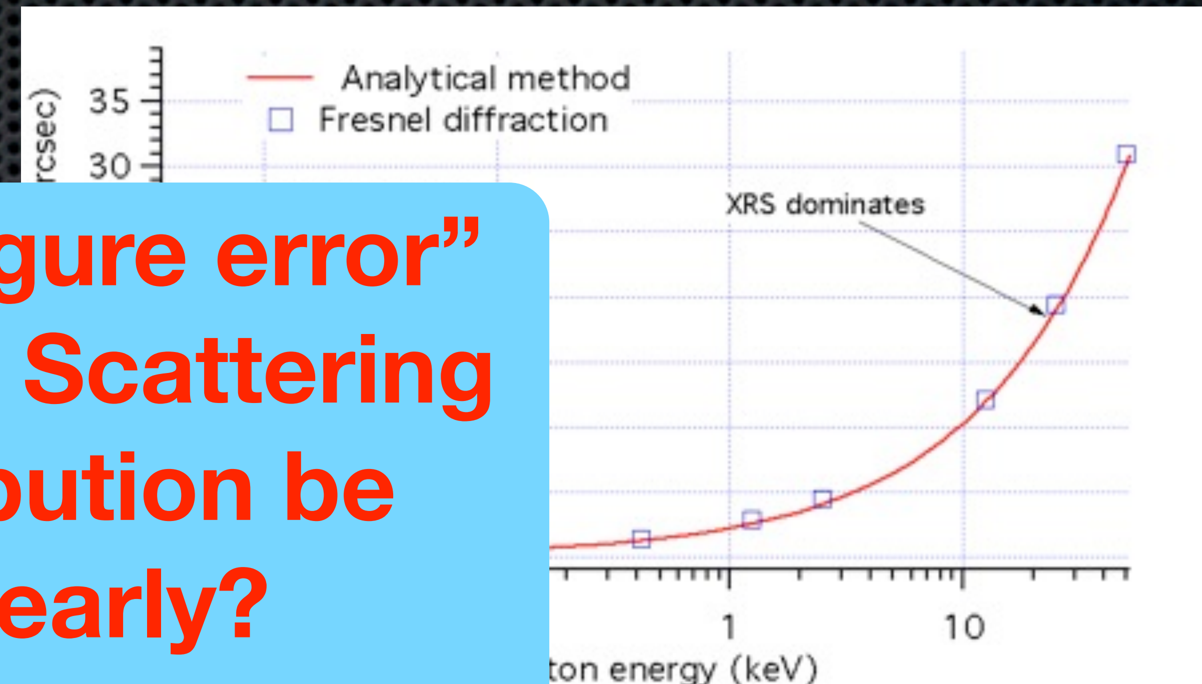
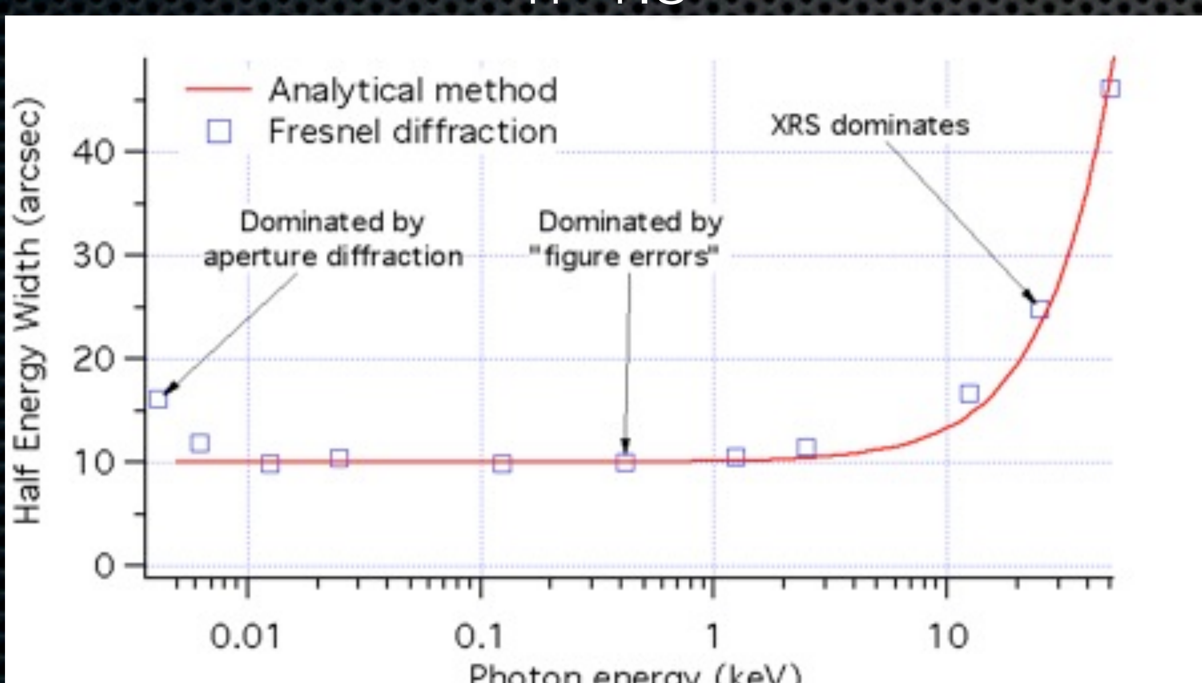


Perfect shape parabola plus PSD Kn=0.5 n=2.2

Should the "figure error" and the X-Ray Scattering HEW contribution be added linearly?



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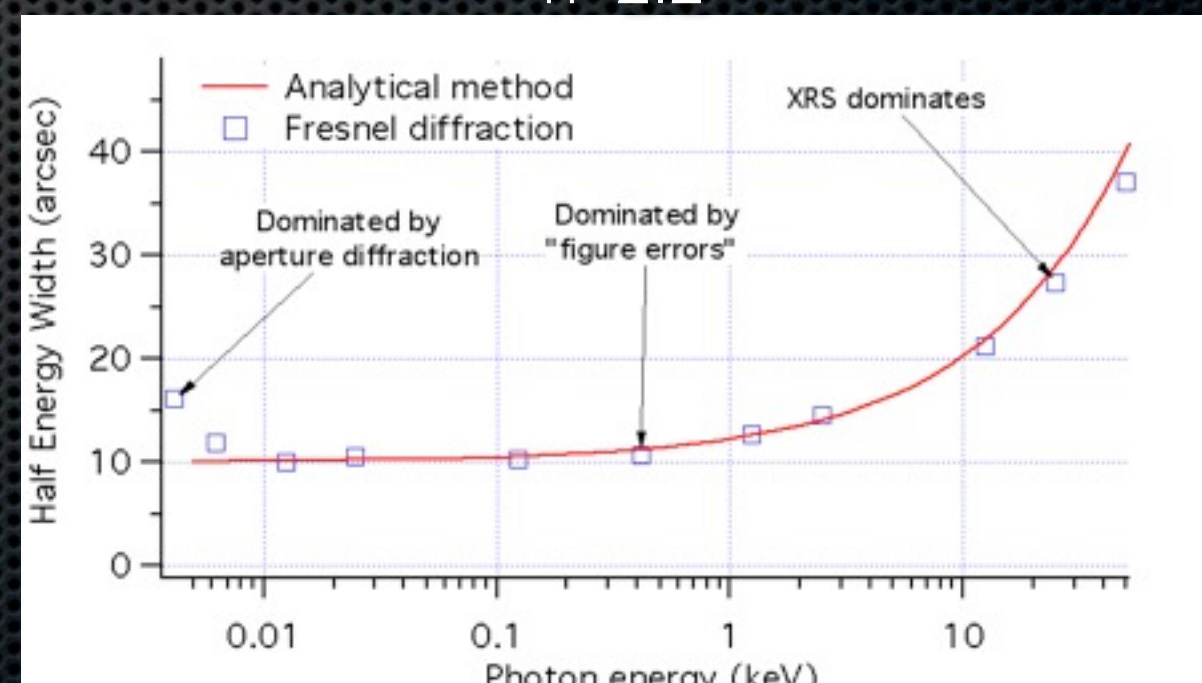
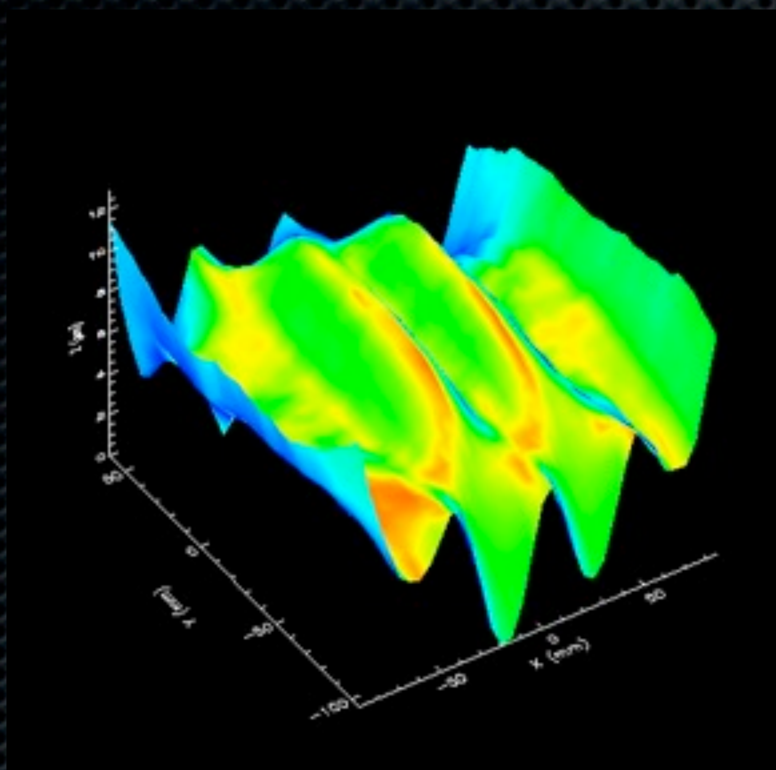


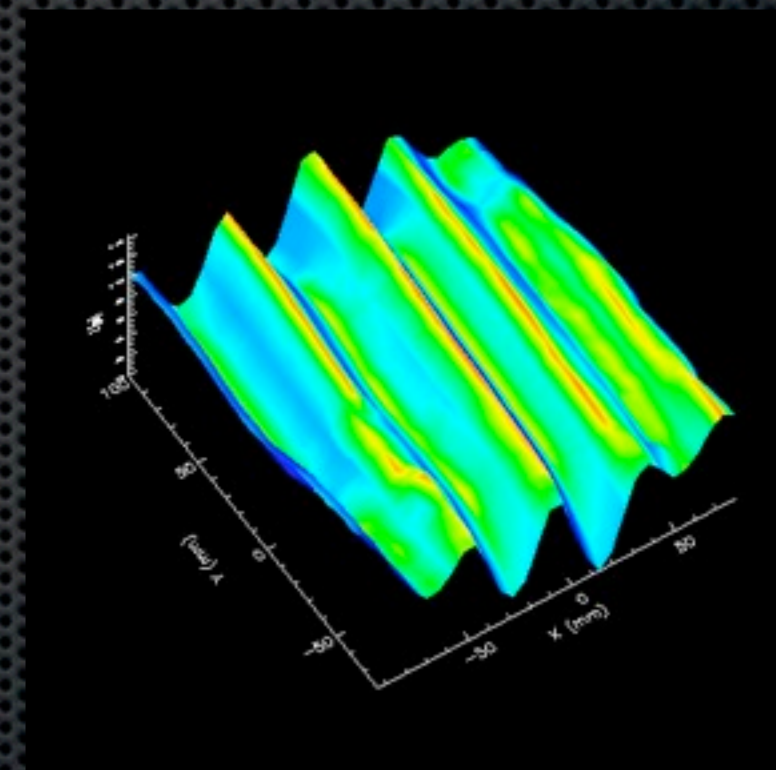
Parabola plus geometrical errors and PSD Kn=0.5 n=2.2

SLUMPED GLASSES PSF ANALYSIS
SURFACE METROLOGY

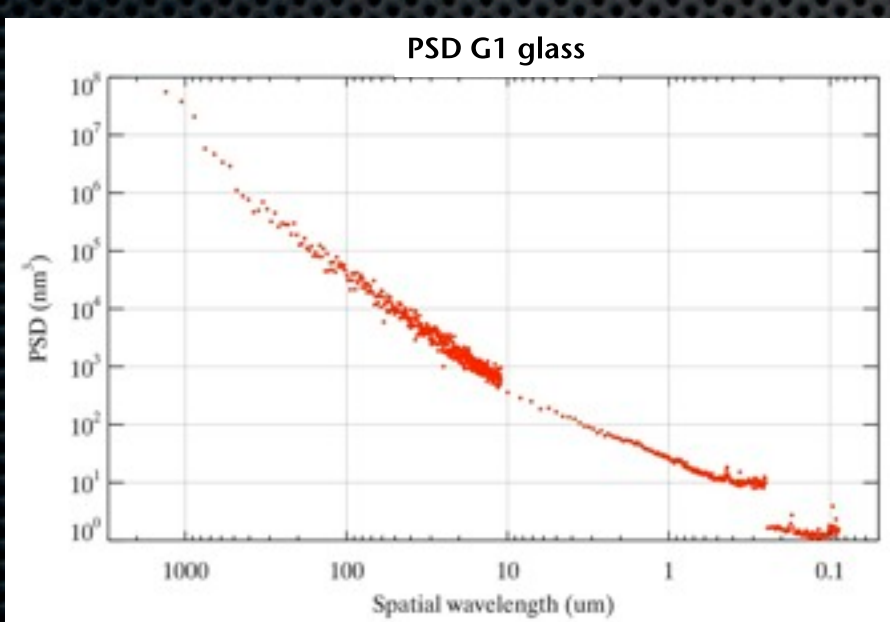
G1 glass



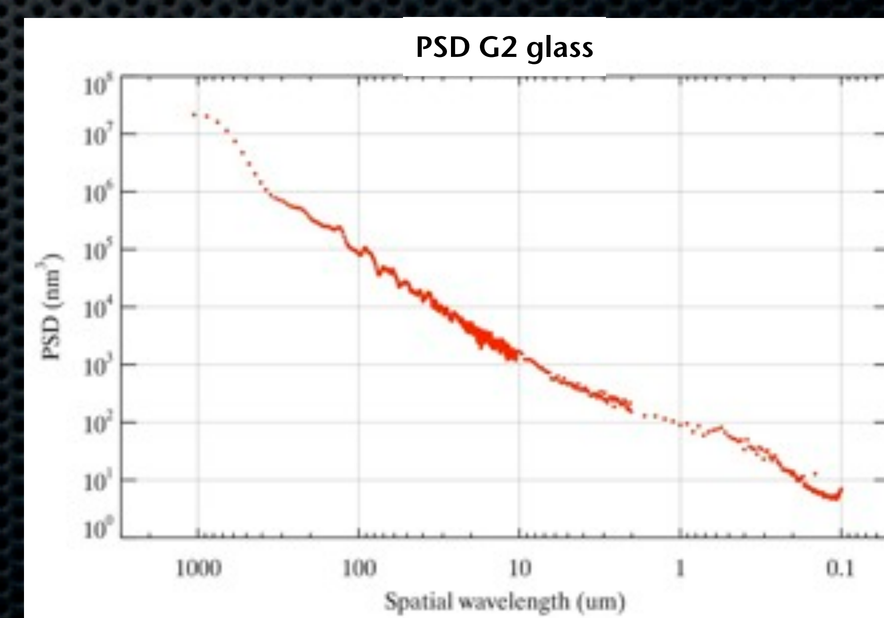
G2 glass



- PROFILES MEASURED WITH 3D PROFILOMETER 5-200 mm



- PSD ACHIEVED FROM AFM, OPTICAL INTERFEROMETER AND X-RAY DIFFRACTOMETER MEASURE 1 mm - 0.1 um



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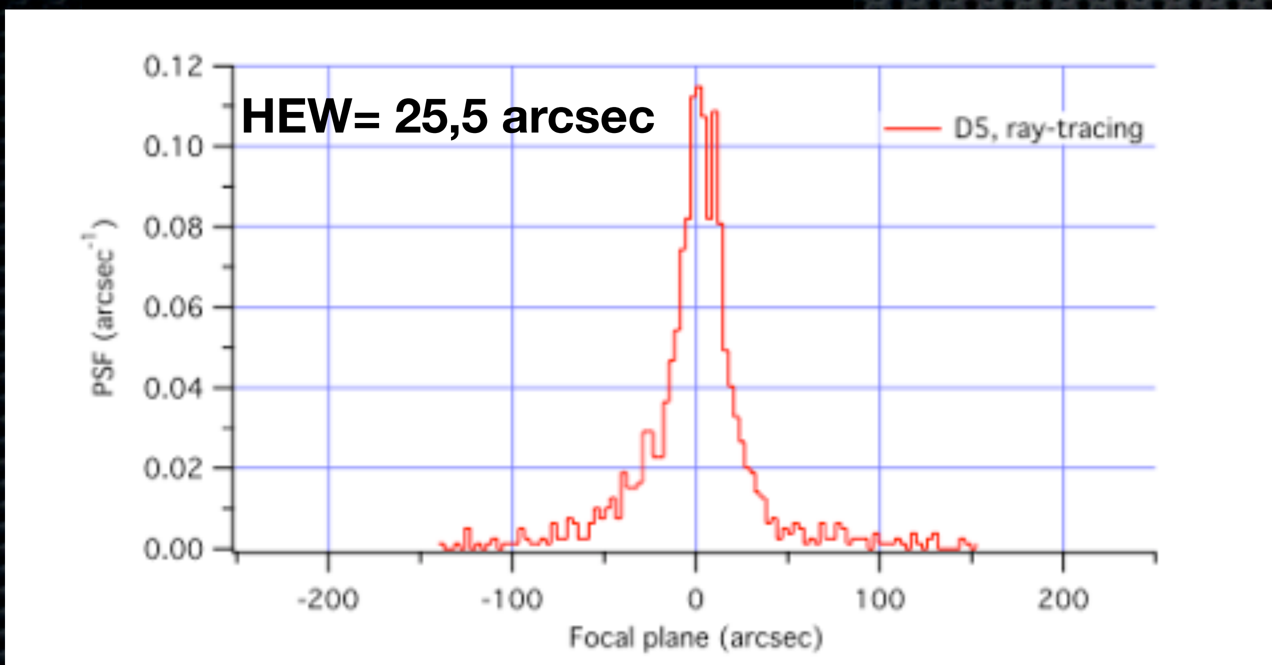
G2 glass



ES MEASUR

PROFILOM

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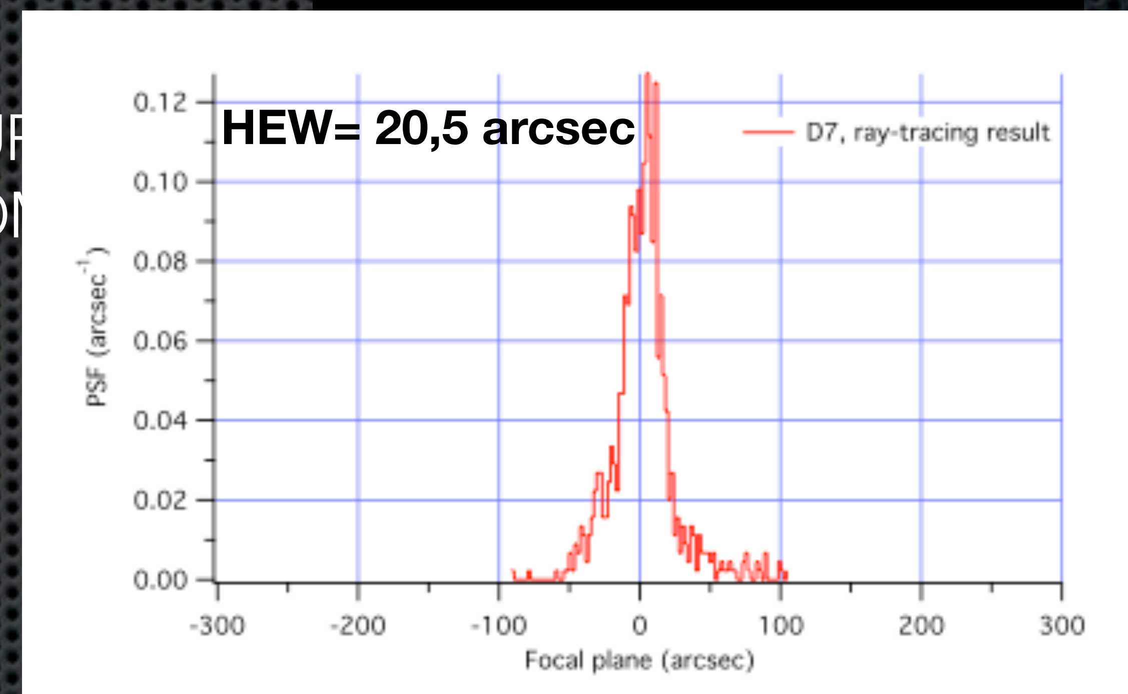

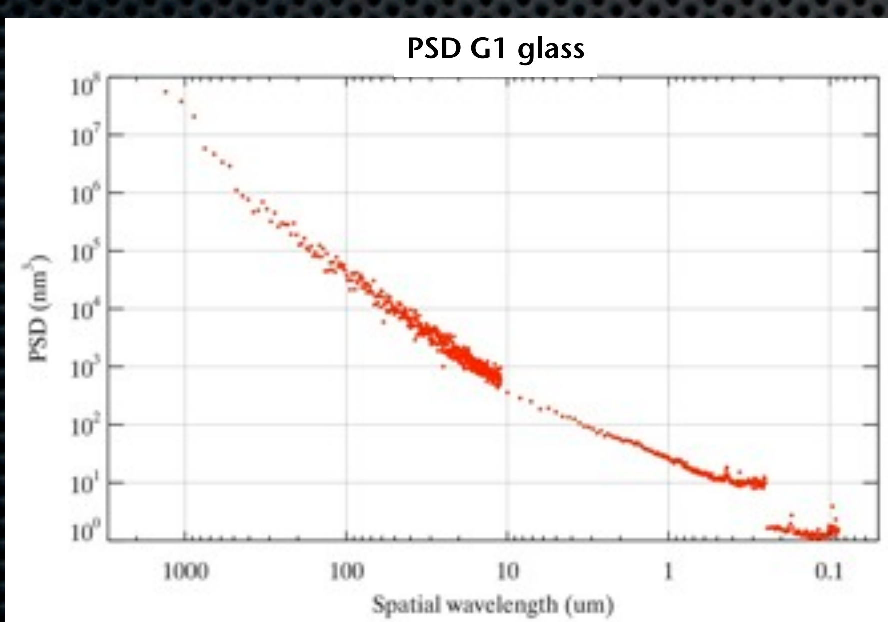

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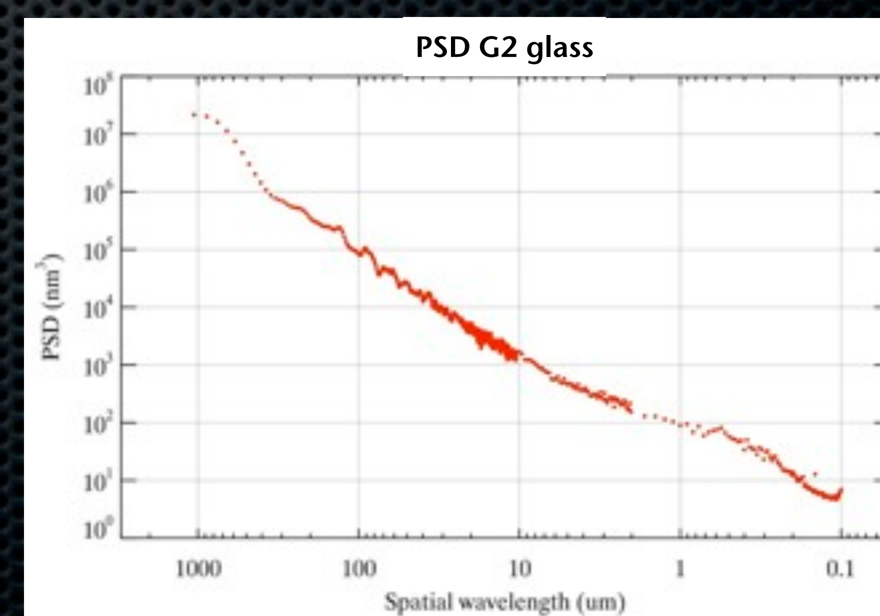
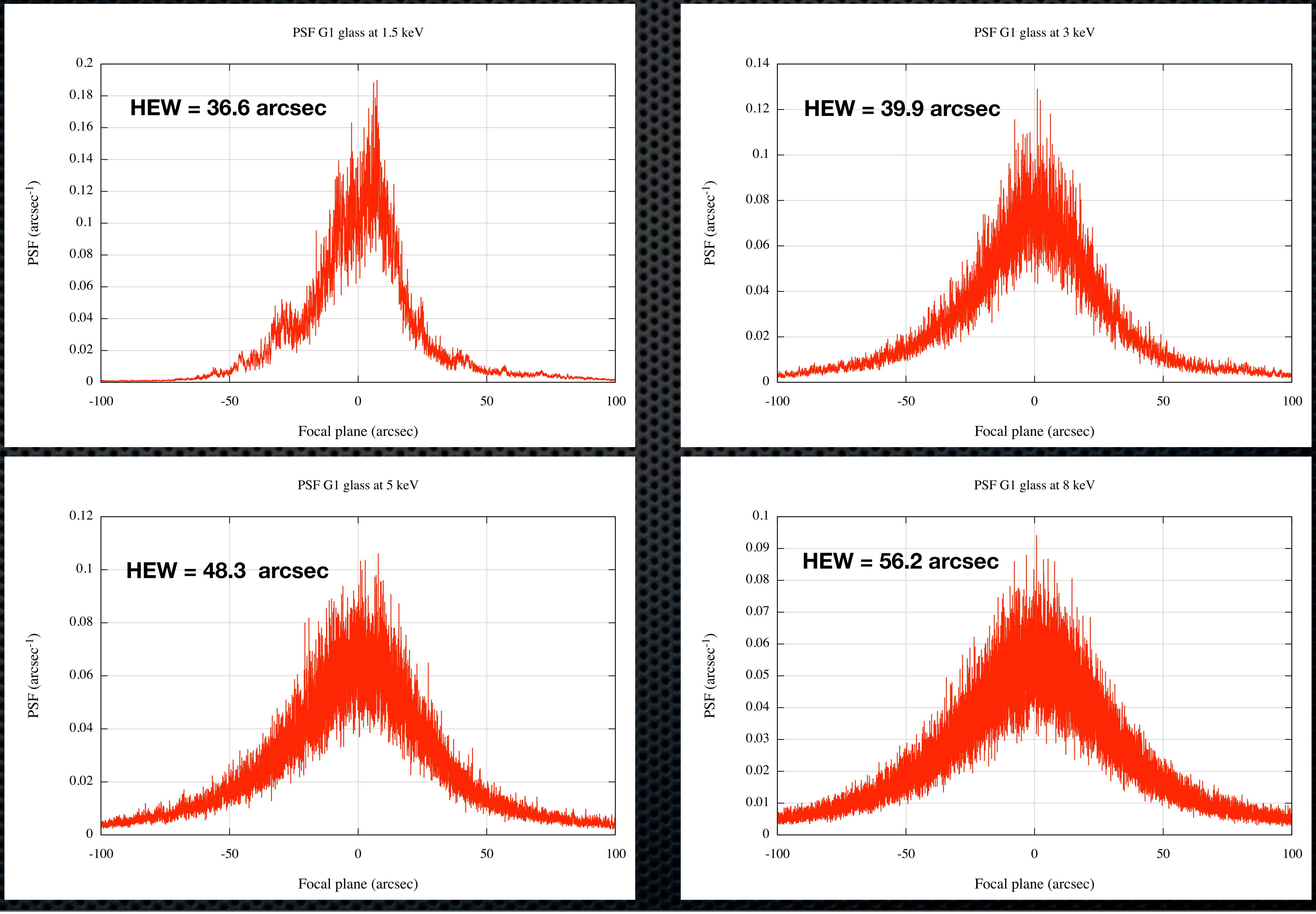


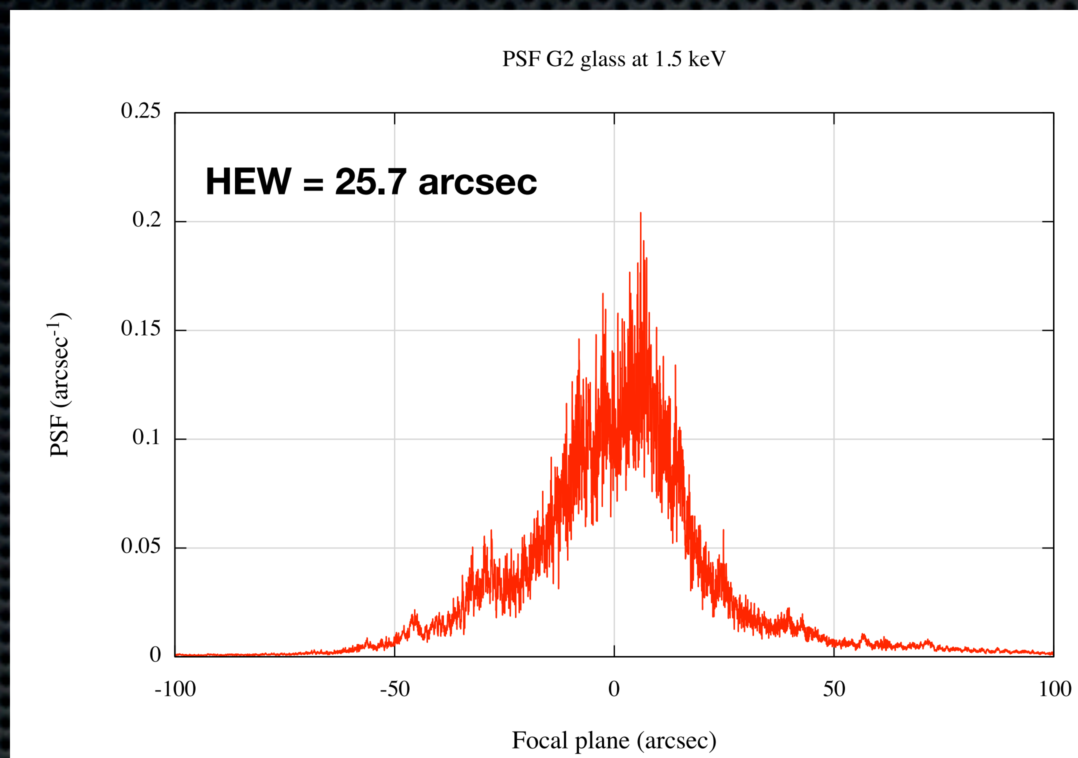
SLUMPED GLASSES PSF ANALYSIS
PSF COMPUTATION

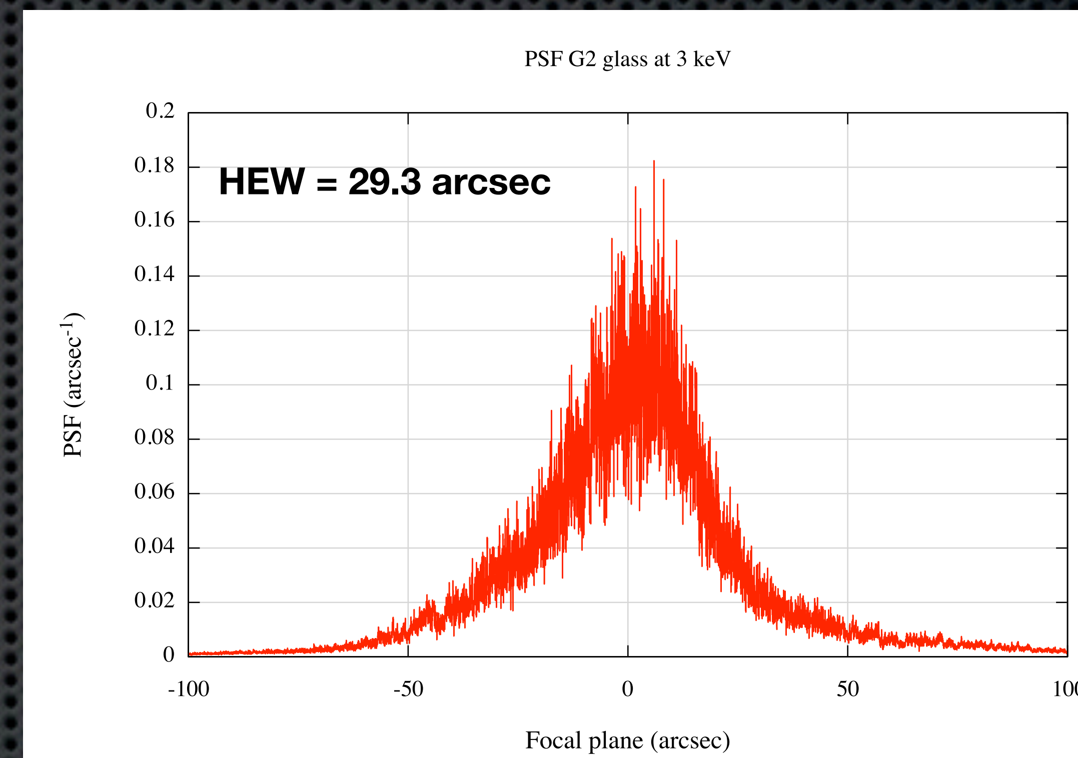
G1

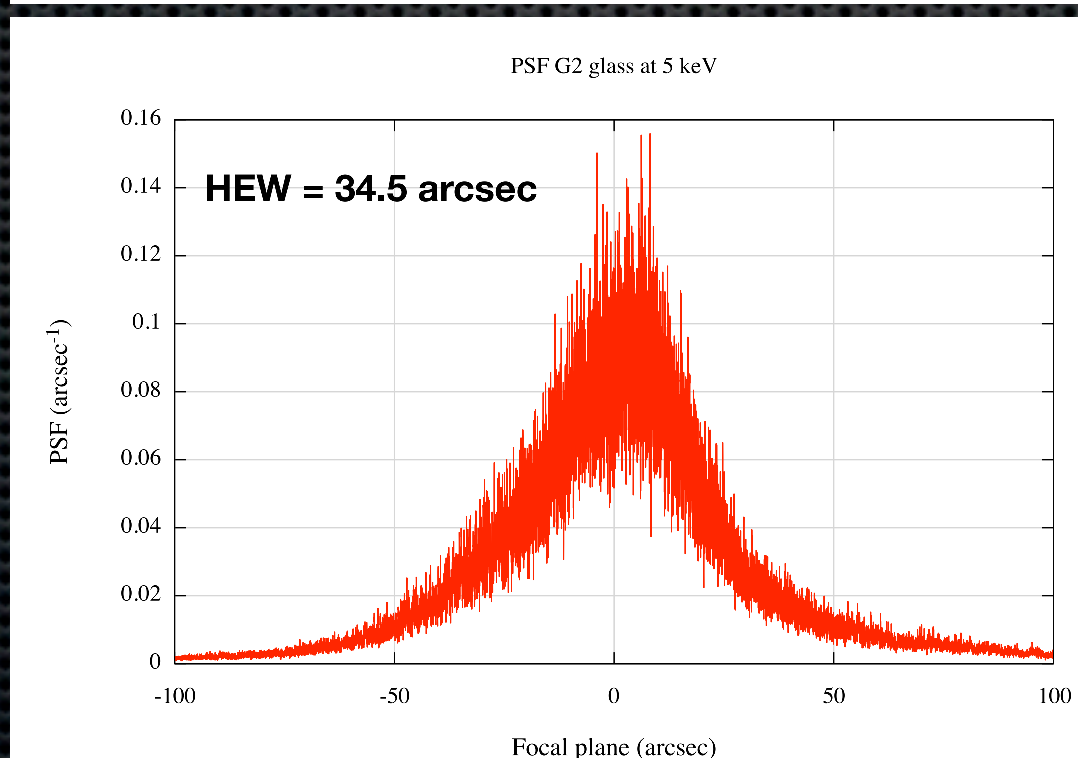


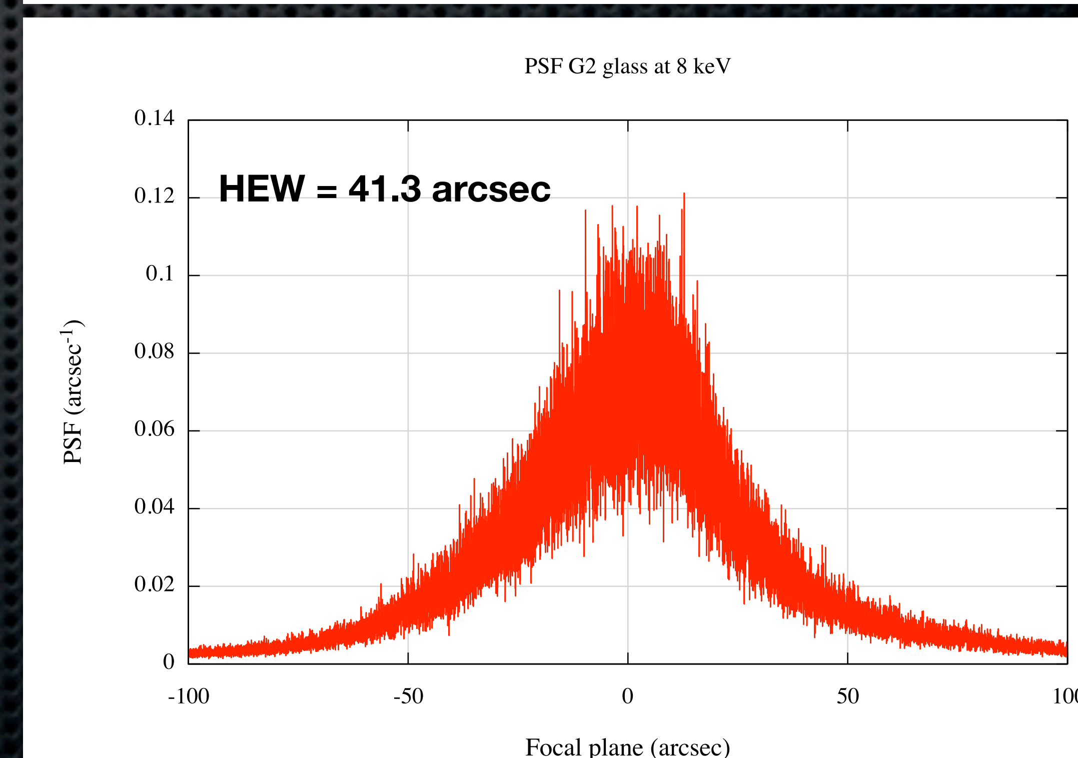
SLUMPED GLASSES PSF ANALYSIS
PSF COMPUTATION

G2

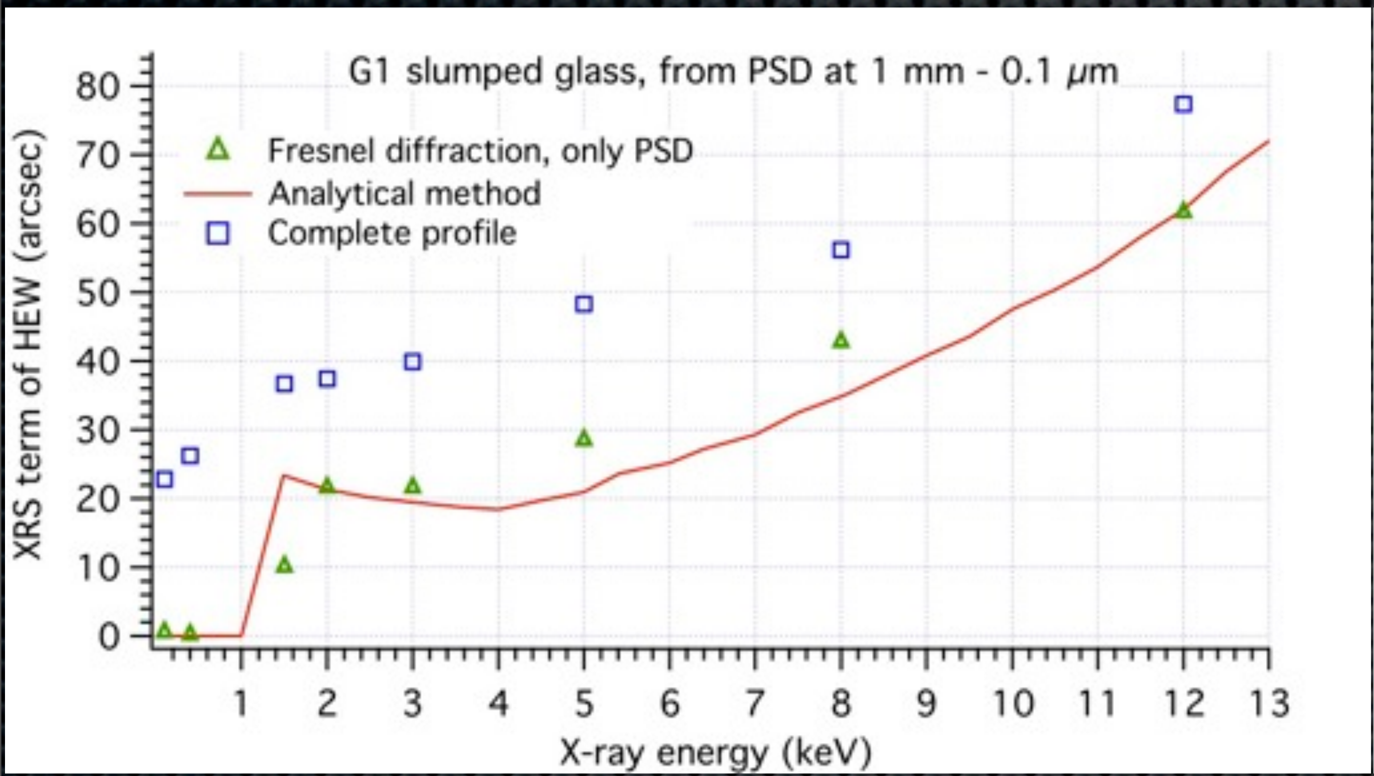


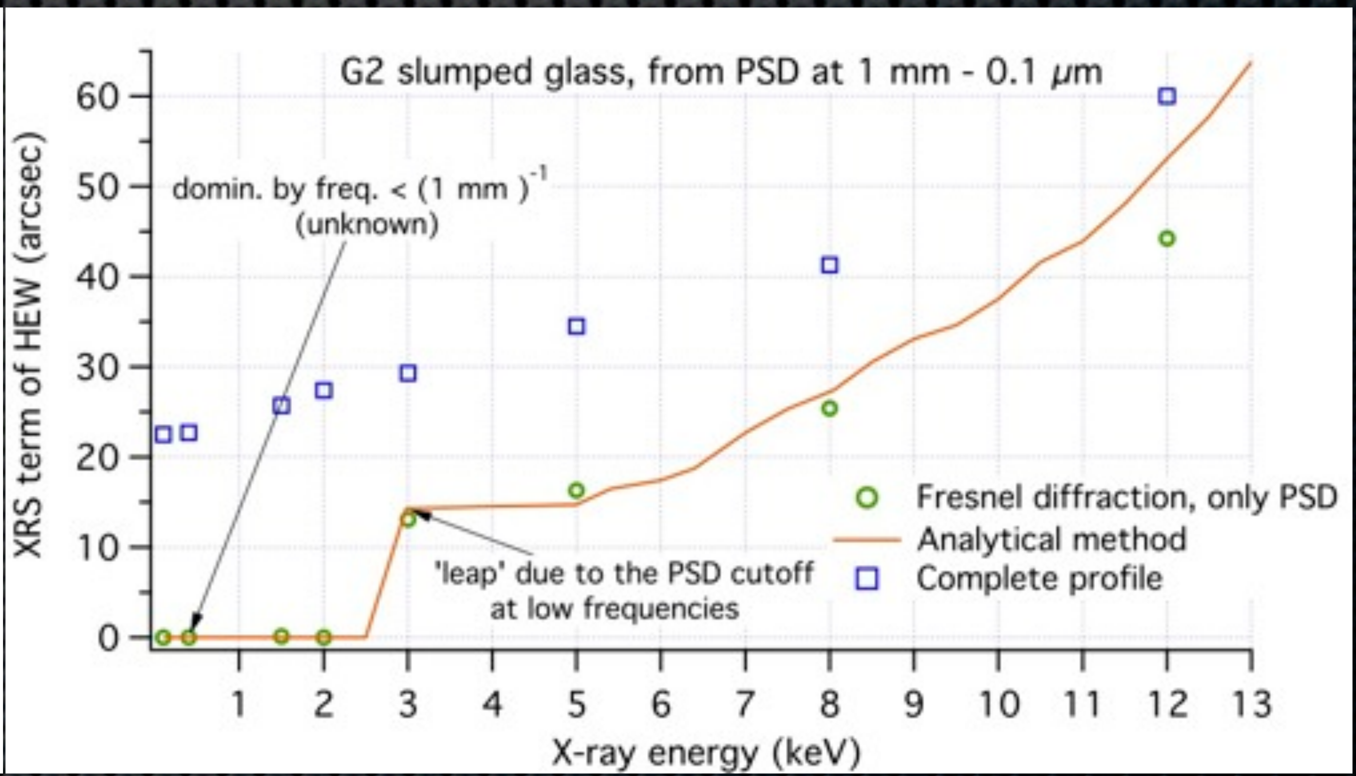






SLUMPED GLASSES PSF ANALYSIS
HEW BEHAVIOR WITH ENERGY





Behavior of HEW with Energy of G1-G2 mirrors:

comparison between the analytical method and the Fresnel diffraction simulations.

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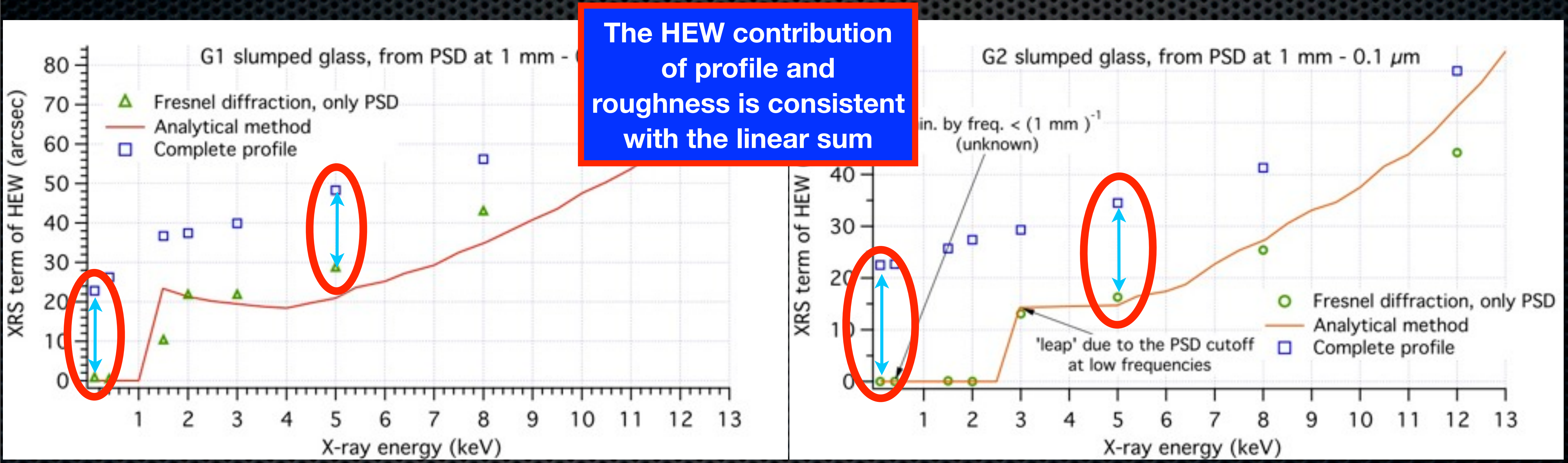
HEW BEHAVIOR WITH ENERGY



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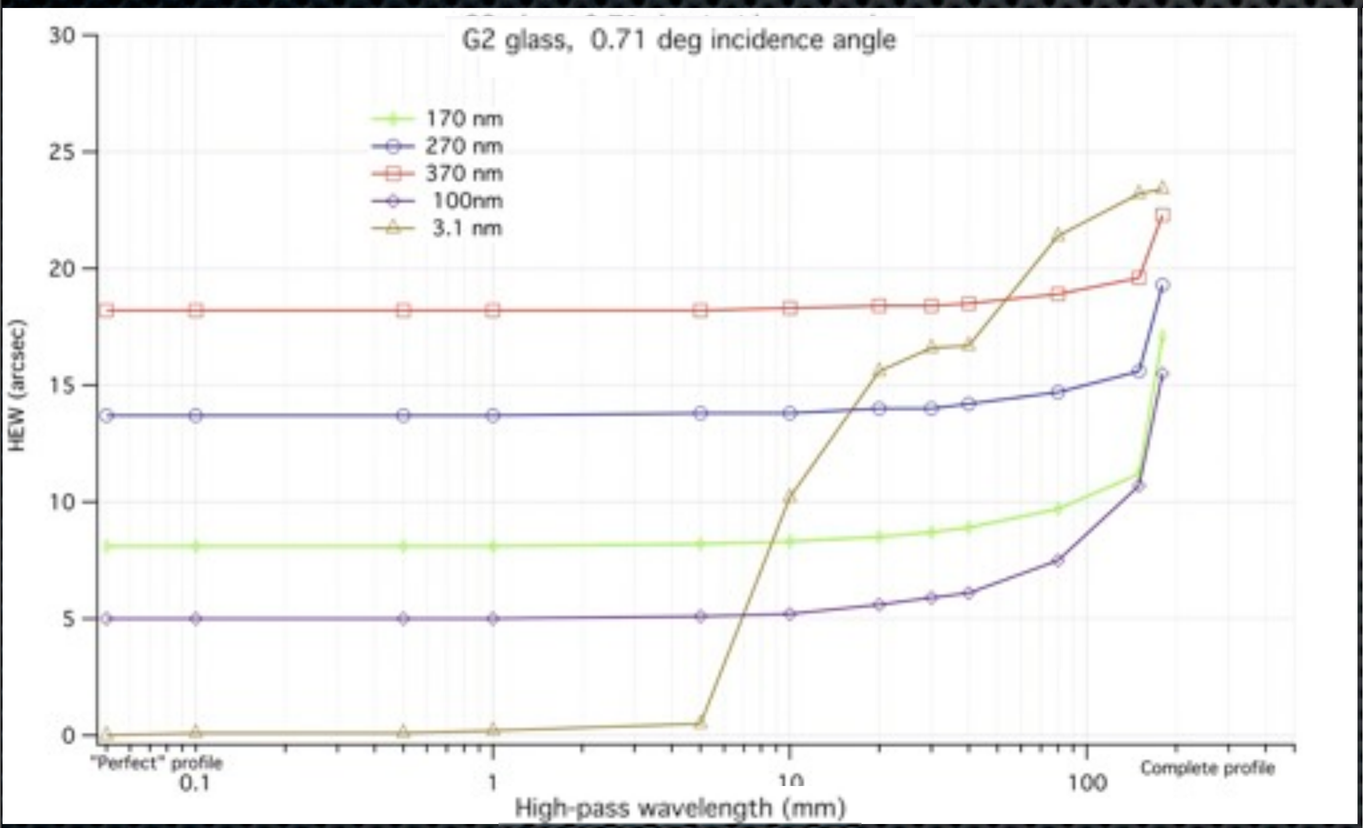
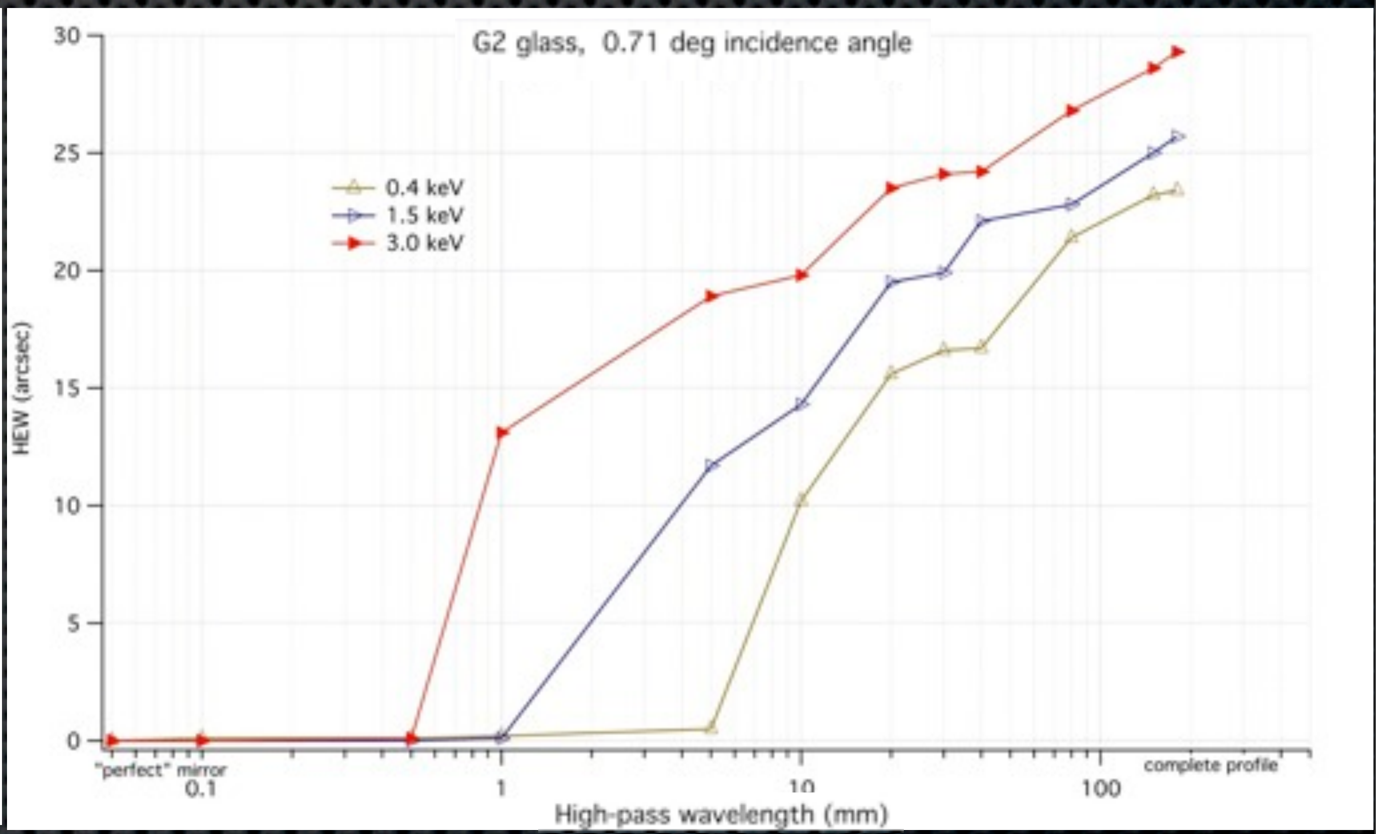
HEW BEHAVIOR WITH ENERGY

Analysis of different spatial wavelength ranges impact on PSF degradation





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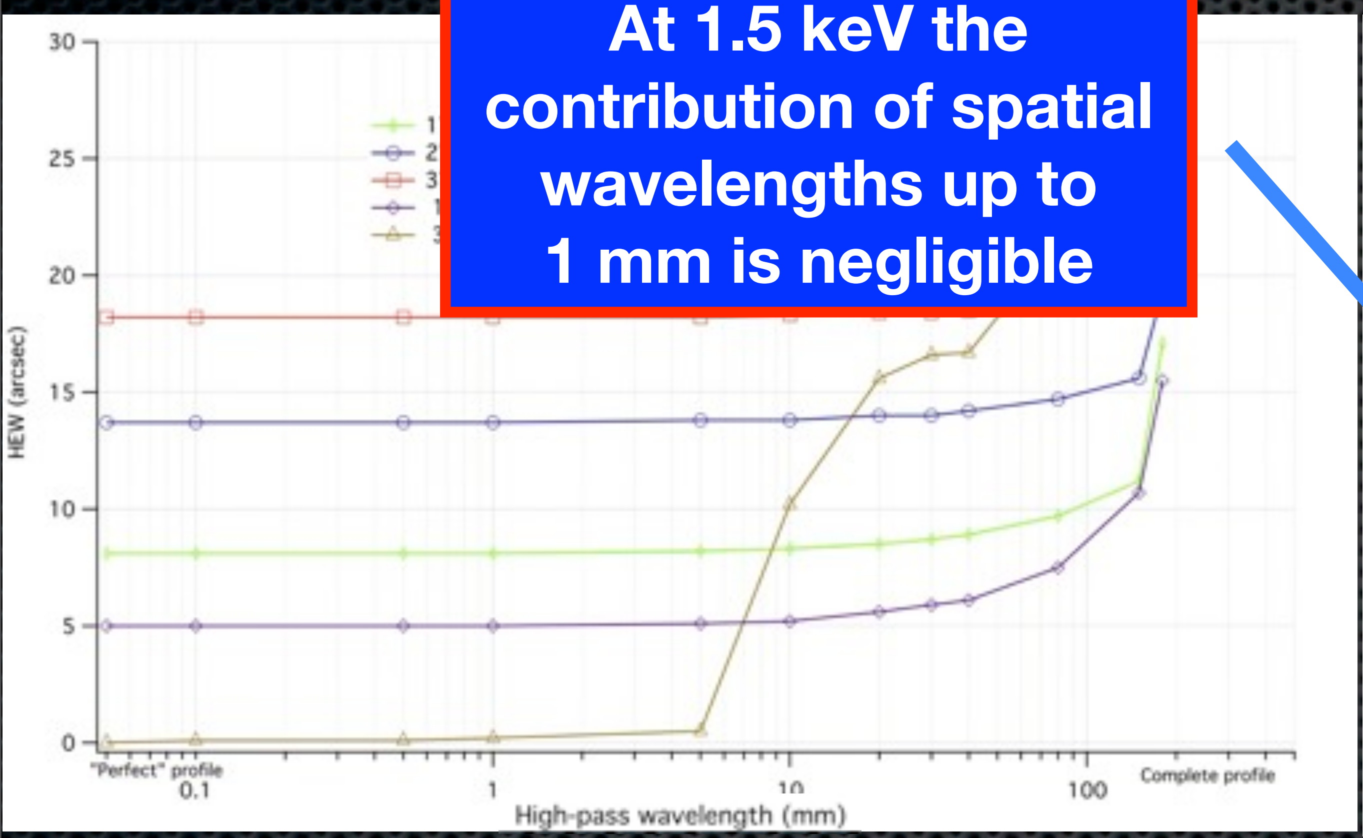
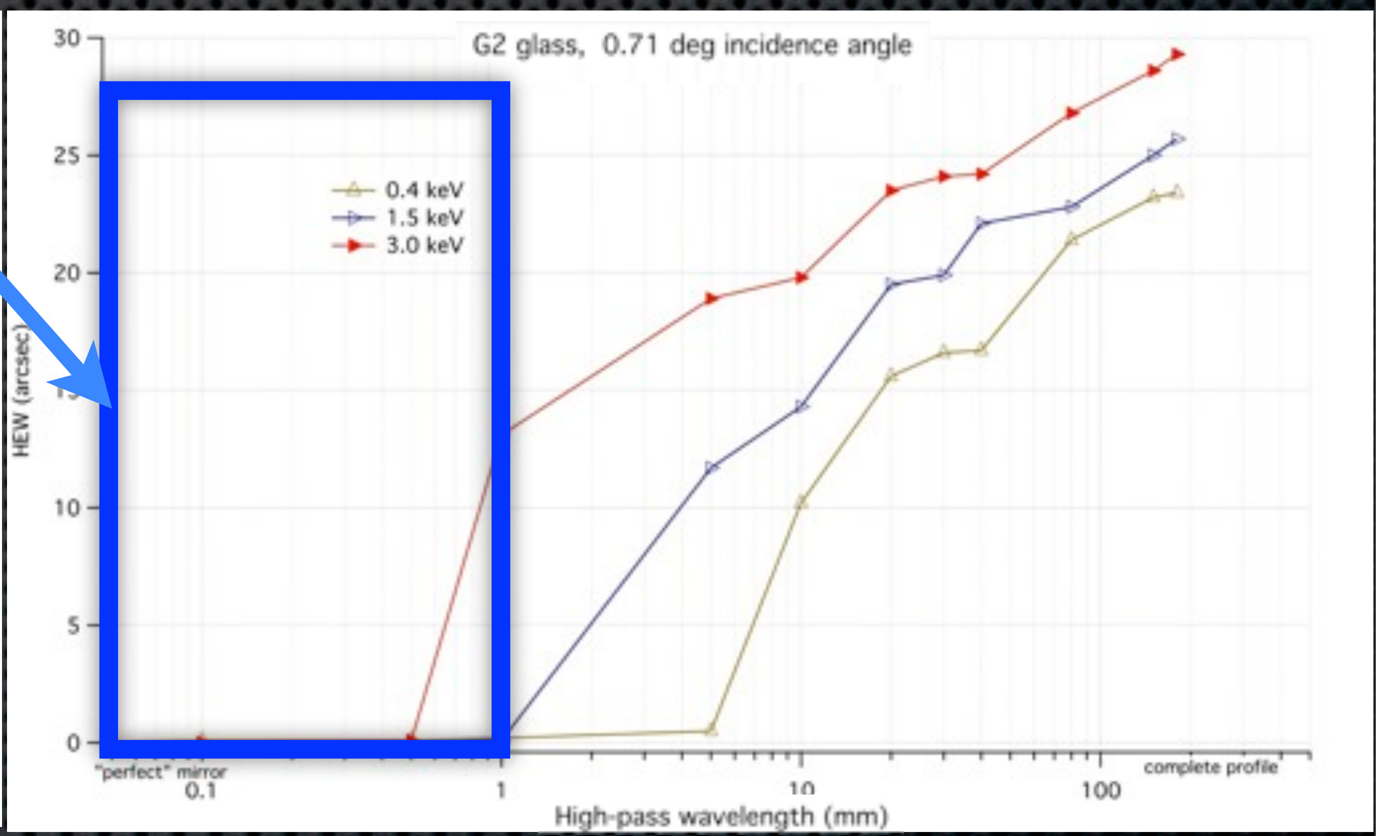
At 1.5 keV the contribution of spatial wavelengths up to 1 mm is negligible





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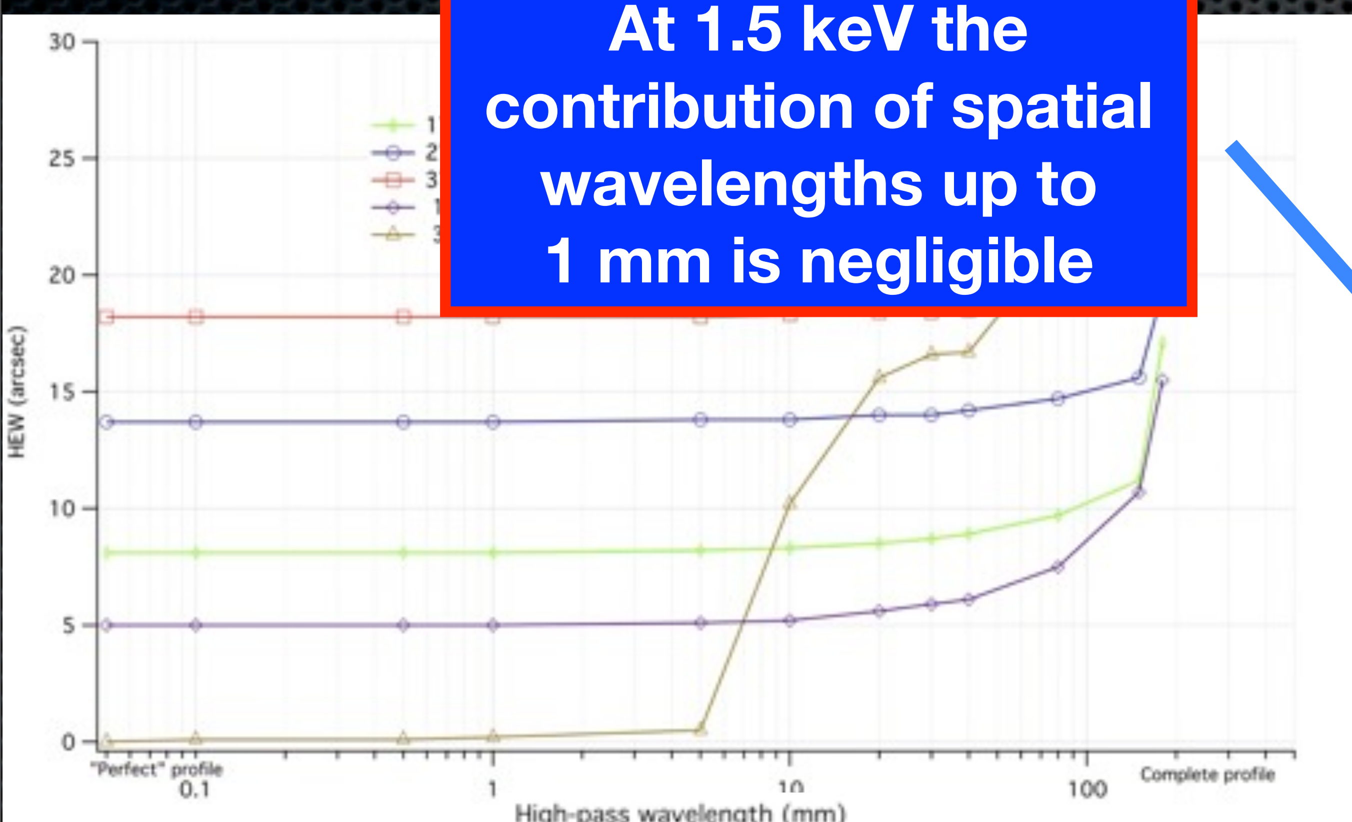
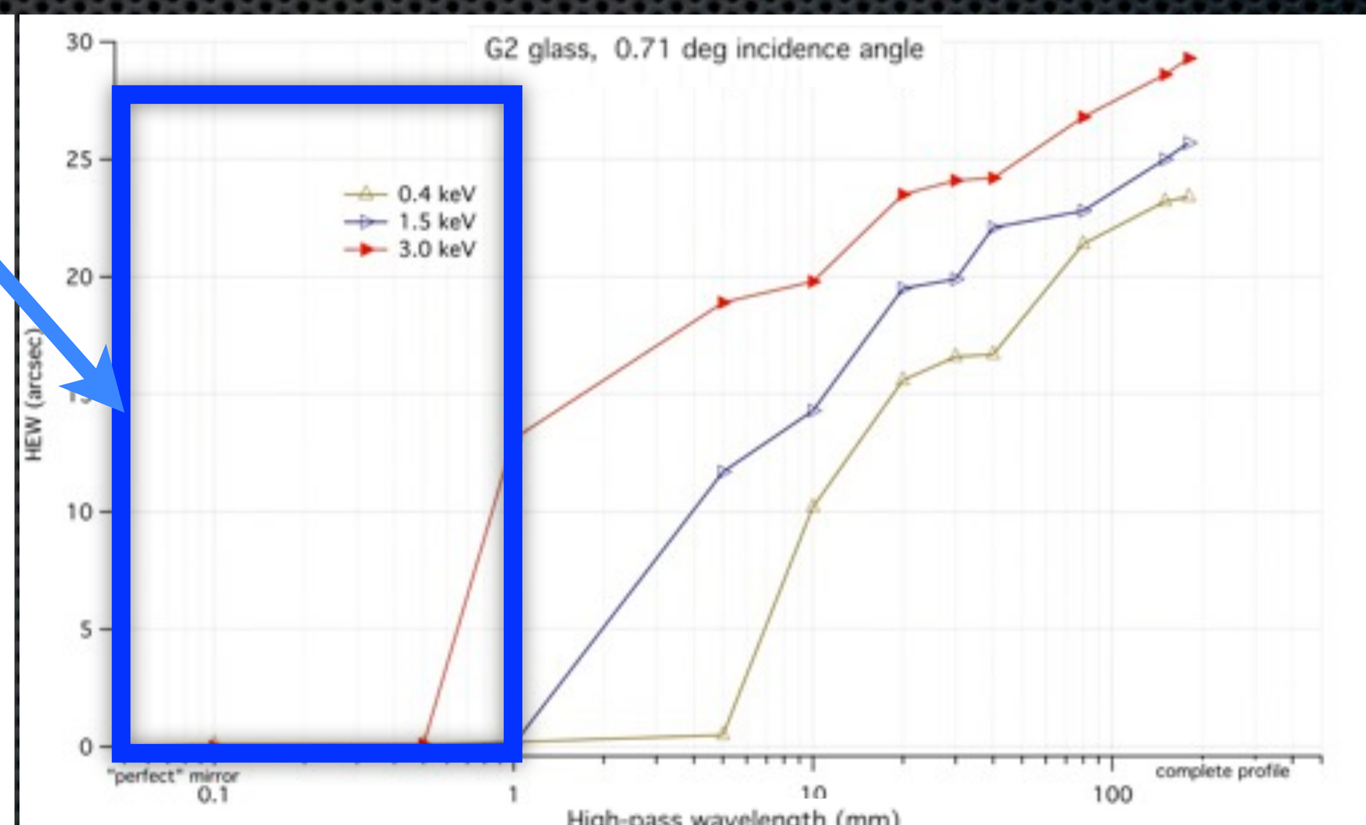
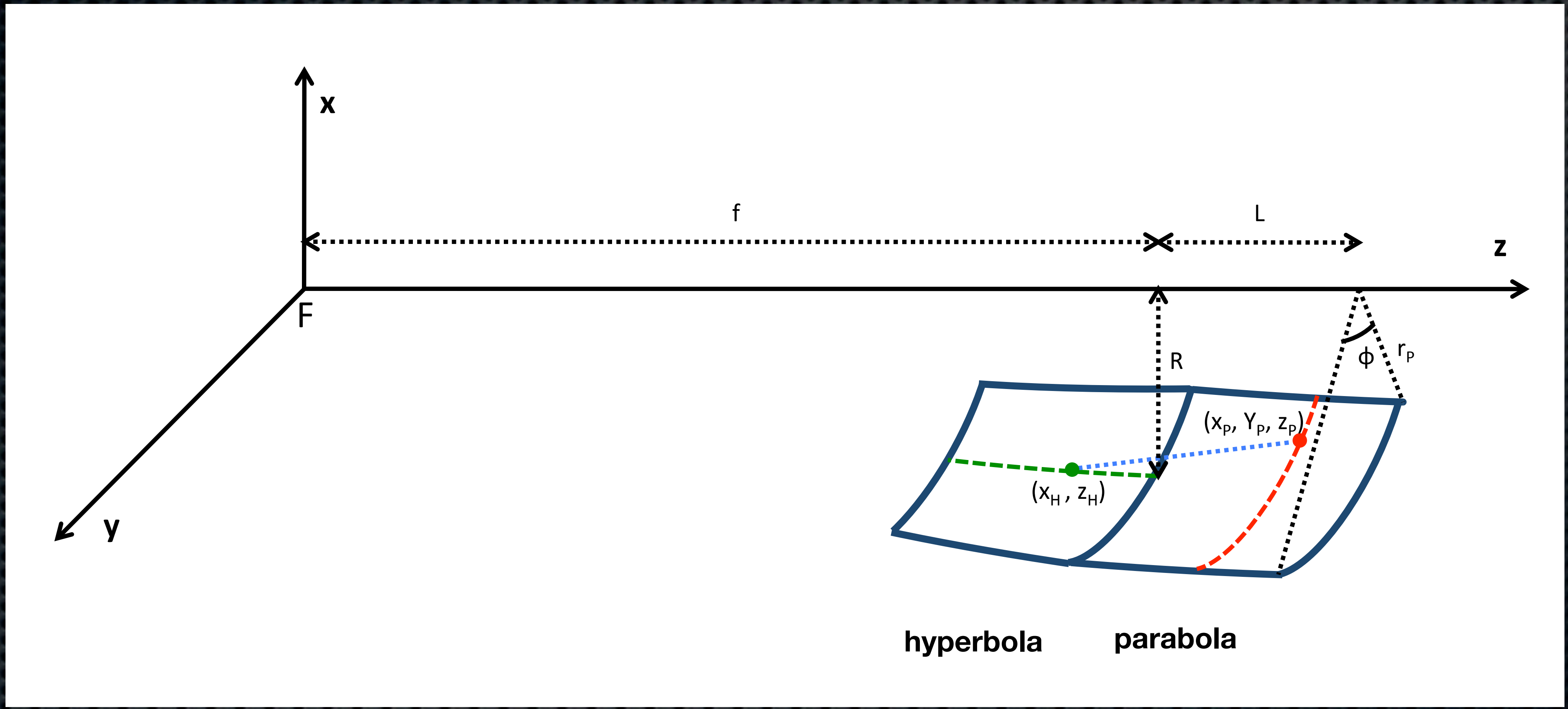
At 1.5 keV the contribution of spatial wavelengths up to 1 mm is negligible





This analysis should allow us to understand at which spatial wavelength scale an active X-ray optic system should operate to obtain the best efficiency

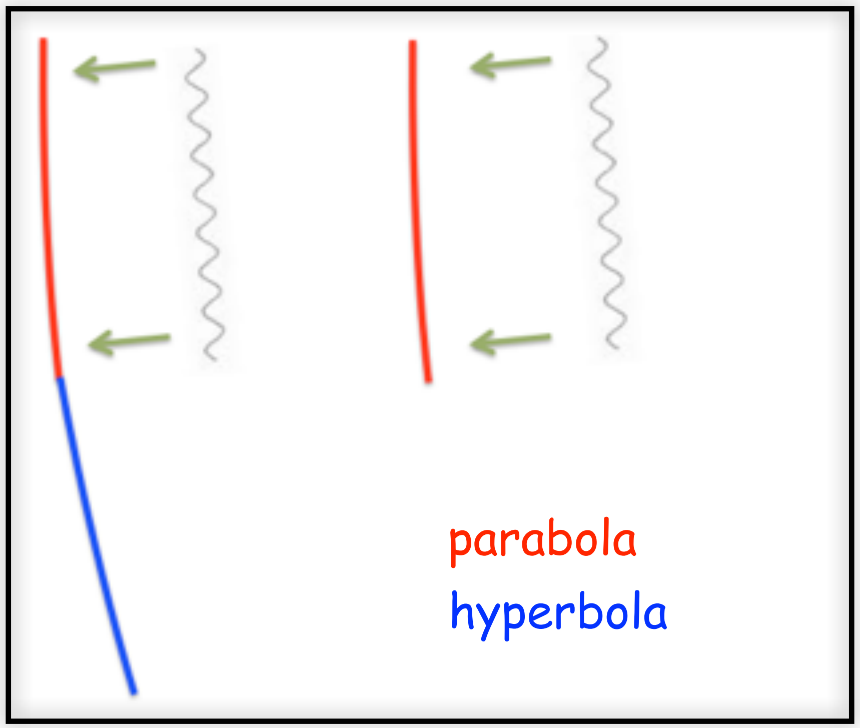
DOUBLE REFLECTION PSF COMPUTATION: WOLTER-I CONFIGURATION

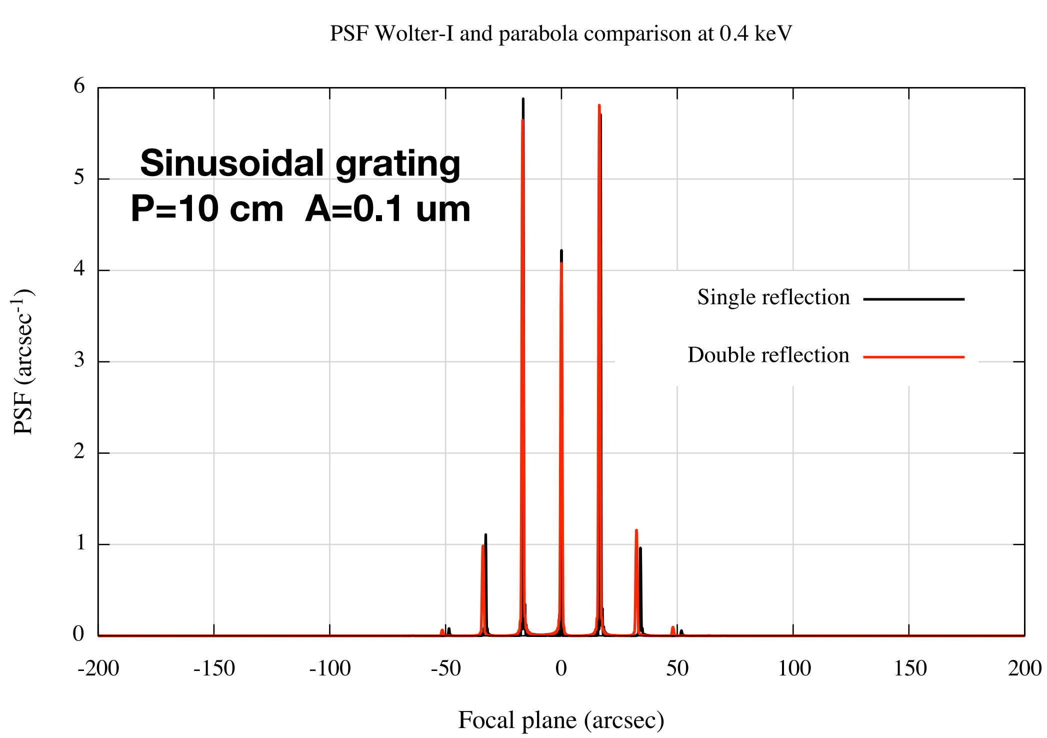


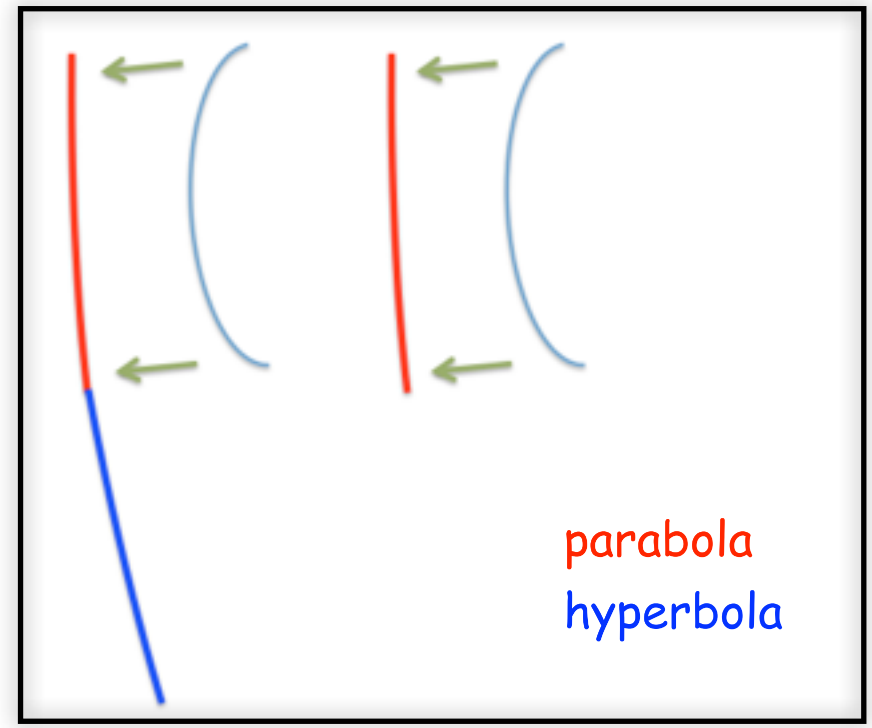
Wolter-I configuration

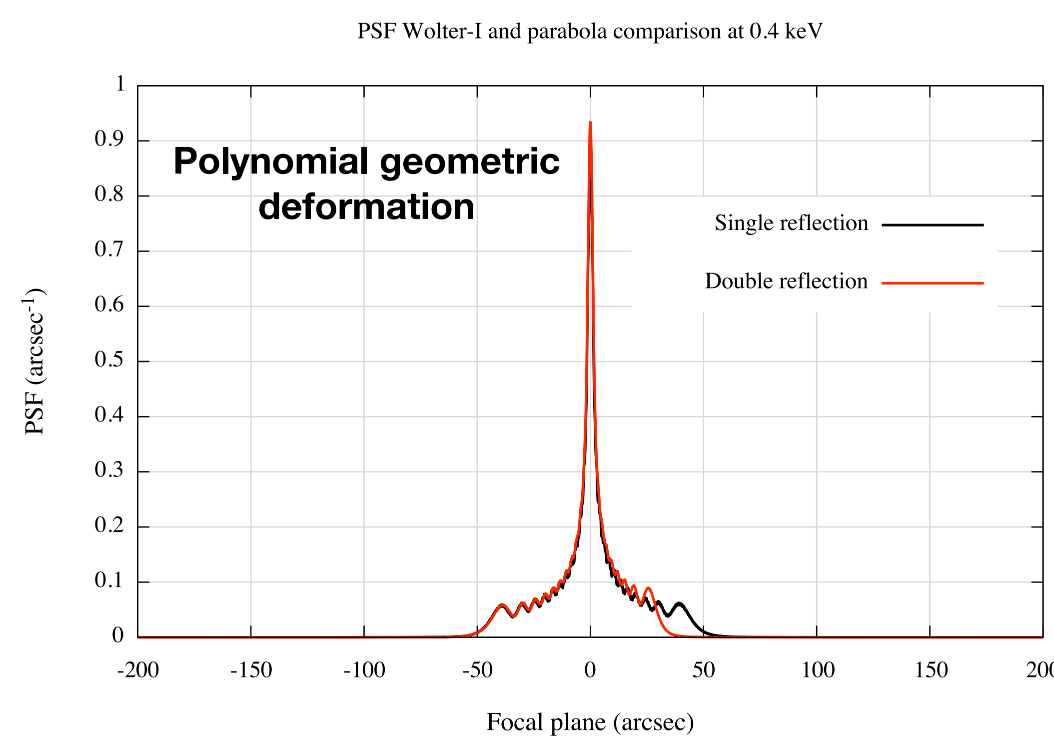
- reduction of the coma aberration
- to shorten the focal length

DOUBLE REFLECTION PSF COMPUTATION: WOLTER-I CONFIGURATION

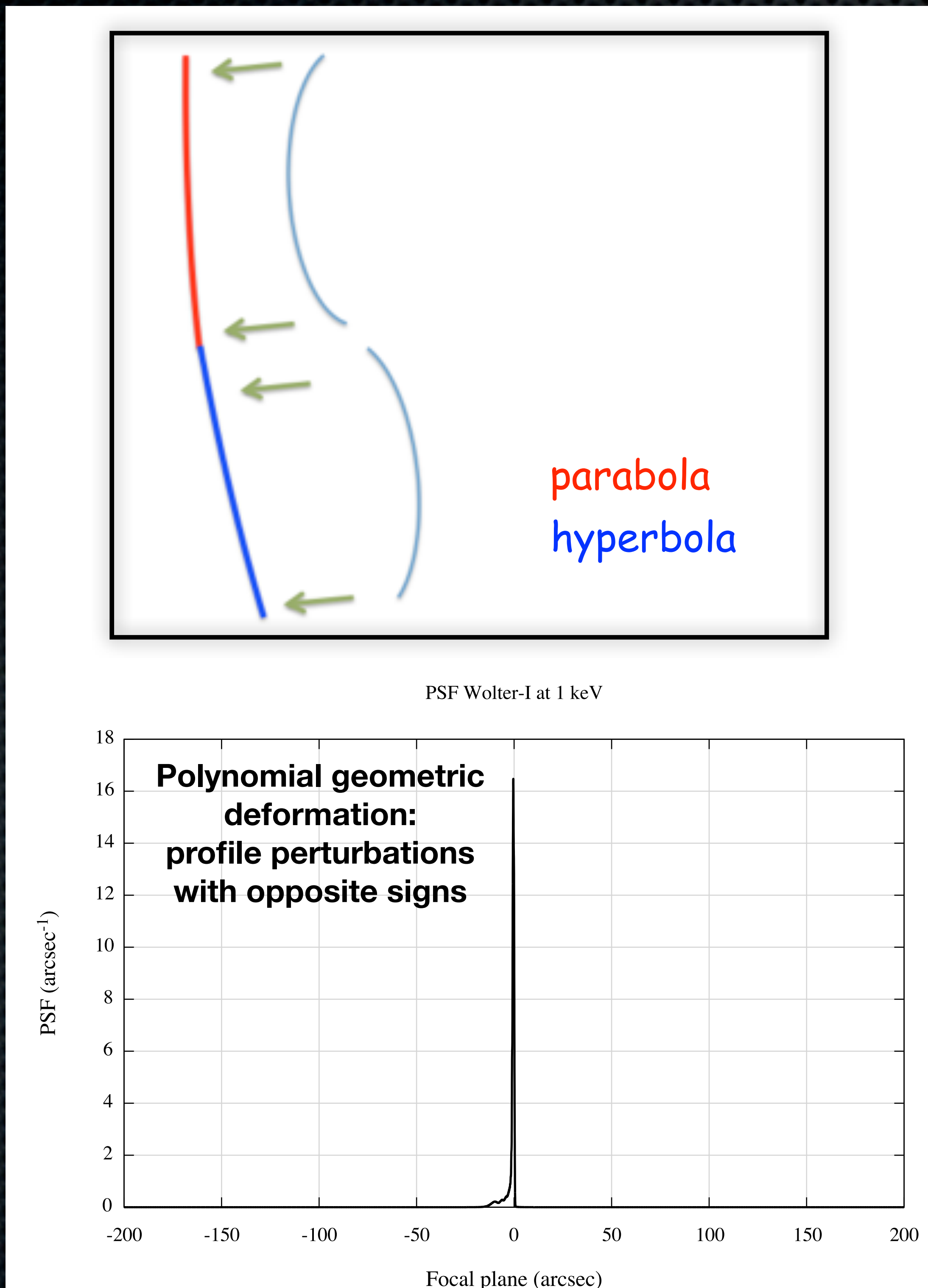


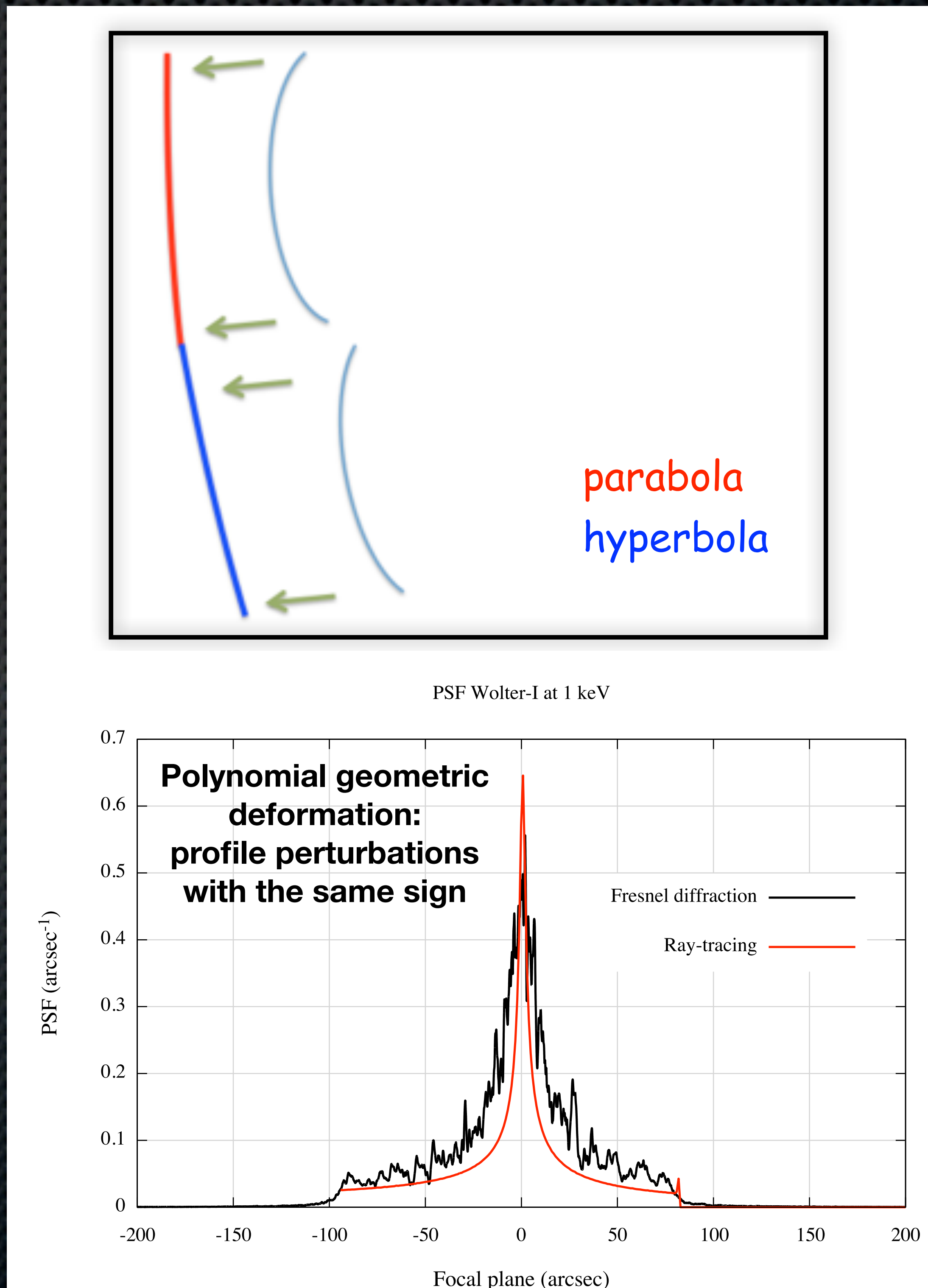






DOUBLE REFLECTION PSF COMPUTATION:
WOLTER-I CONFIGURATION





CONCLUSIONS

- We have applied a self-consistent method to obtain the PSF from the X-ray mirror metrology data, at ANY energy, without setting any geometrical optics/roughness boundary
  - The method is consistent with the ray-tracing (at energies, where a posteriori, the geometrical optics can be applied) and with the behavior of the HEW increase obtained from the X-ray scattering analytical approach
  - The separate contributions to the HEW from the geometrical profile and from the microroughness, when summed, are close to the total HEW (TBC)
  - This approach allows to assess the impact of different spatial wavelengths on the mirror PSF and to understand at which spatial scale an active X-ray optic system should operate for the best efficiency, depending on λ.
  - This method is easily extendable to the double reflection case, widespread in X-ray telescopes.

THANKS