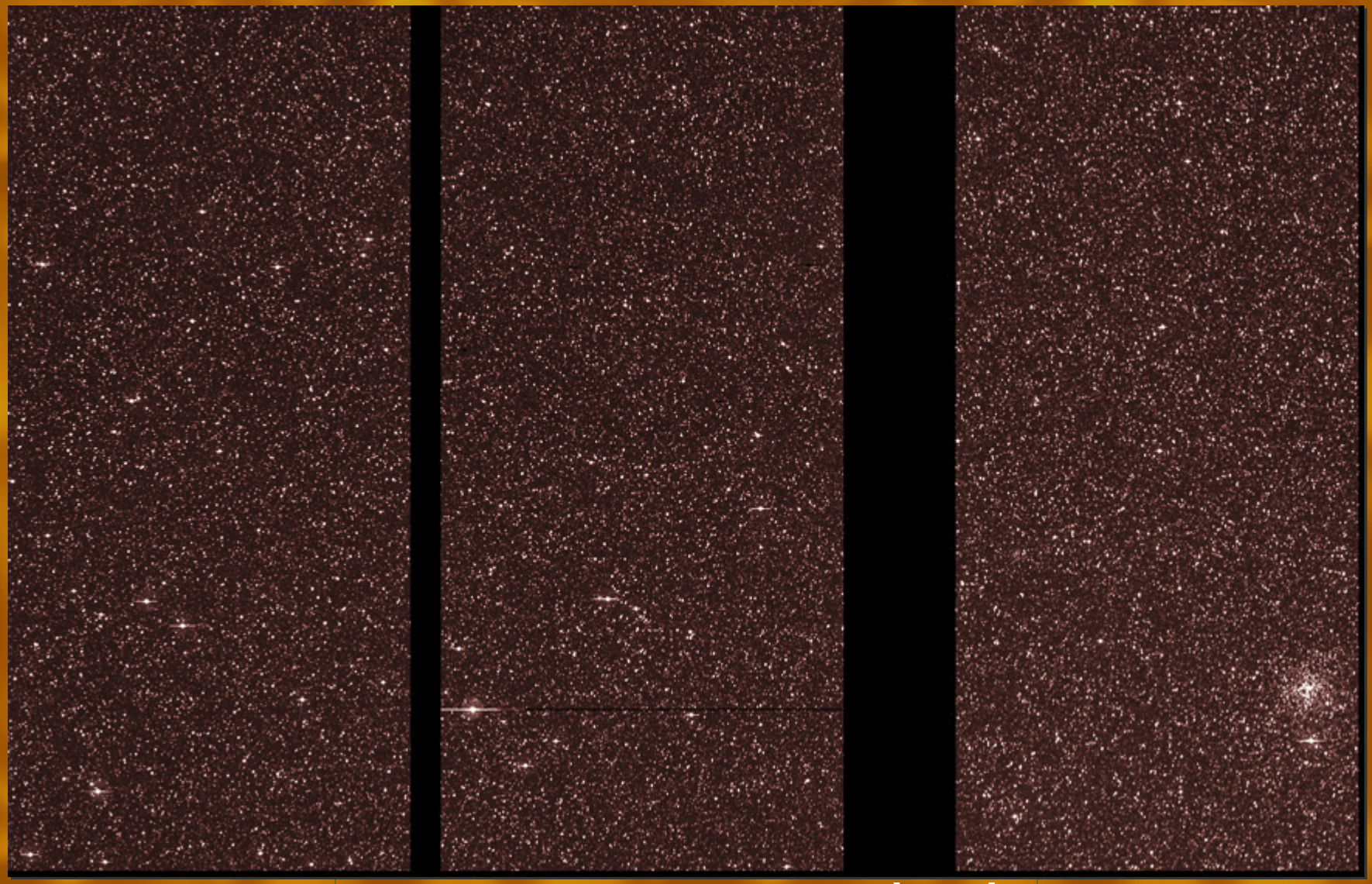
The Shape of Granulation Spectra: Simulations, Observations and Models



Regner Trampedach

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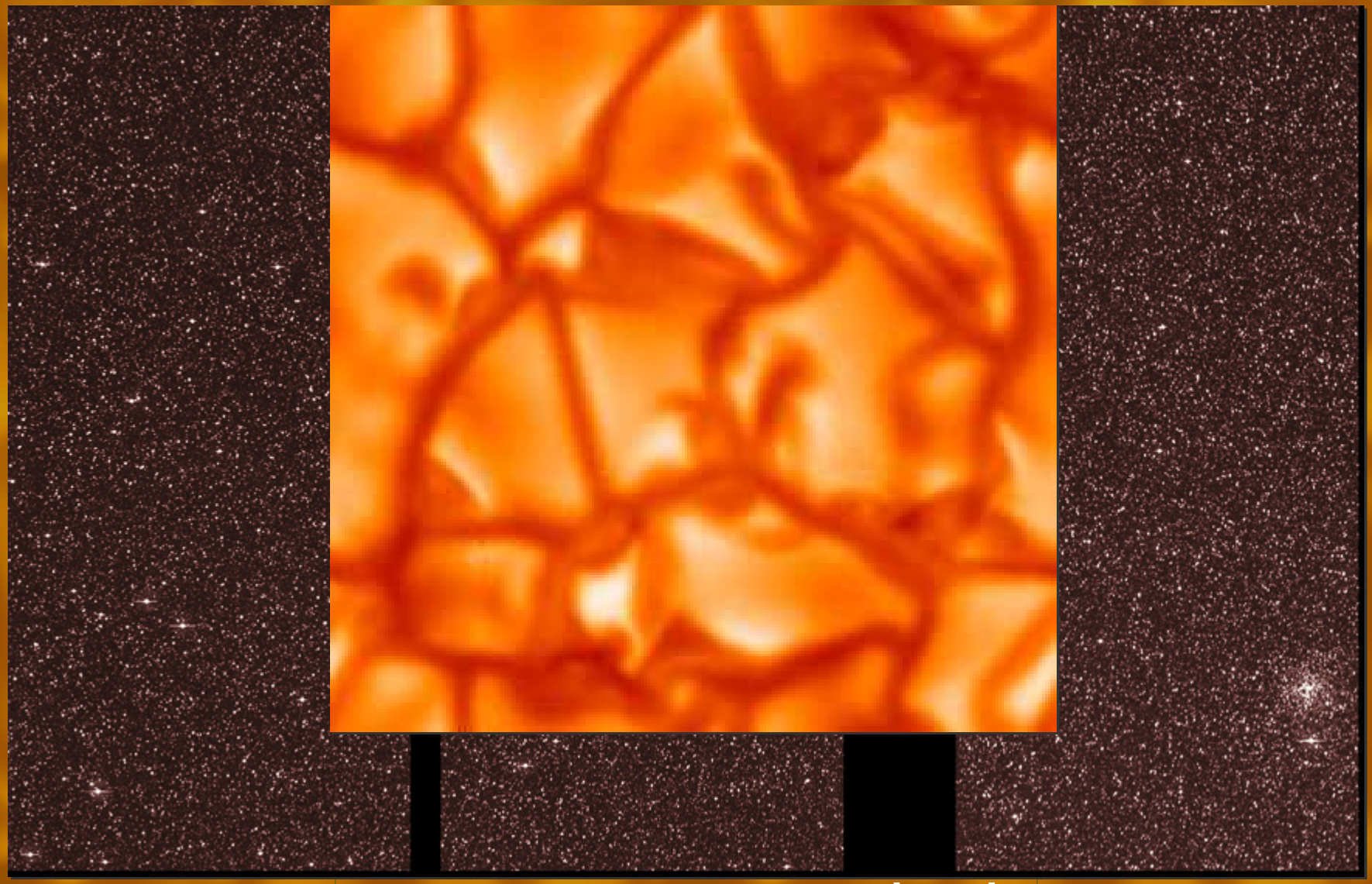


Regner Trampedach

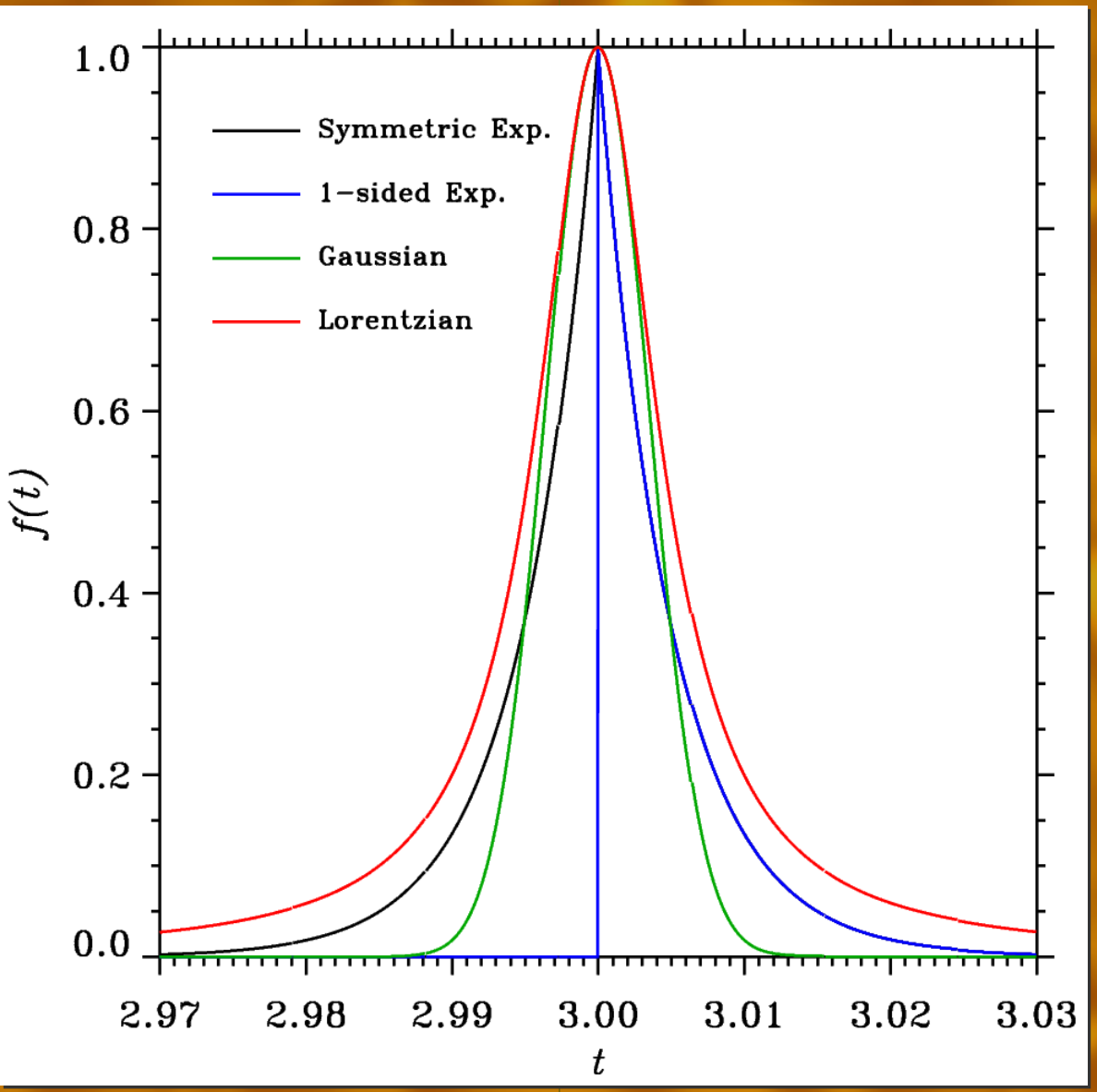
Why care about granulation “noise”?

- We can actually observe something unresolvable on other stars than Sun
- The fit, for p modes and background is more stable with good fitting functions. ...and fewer parameters.
- Something seems fishy with the Harvey law...

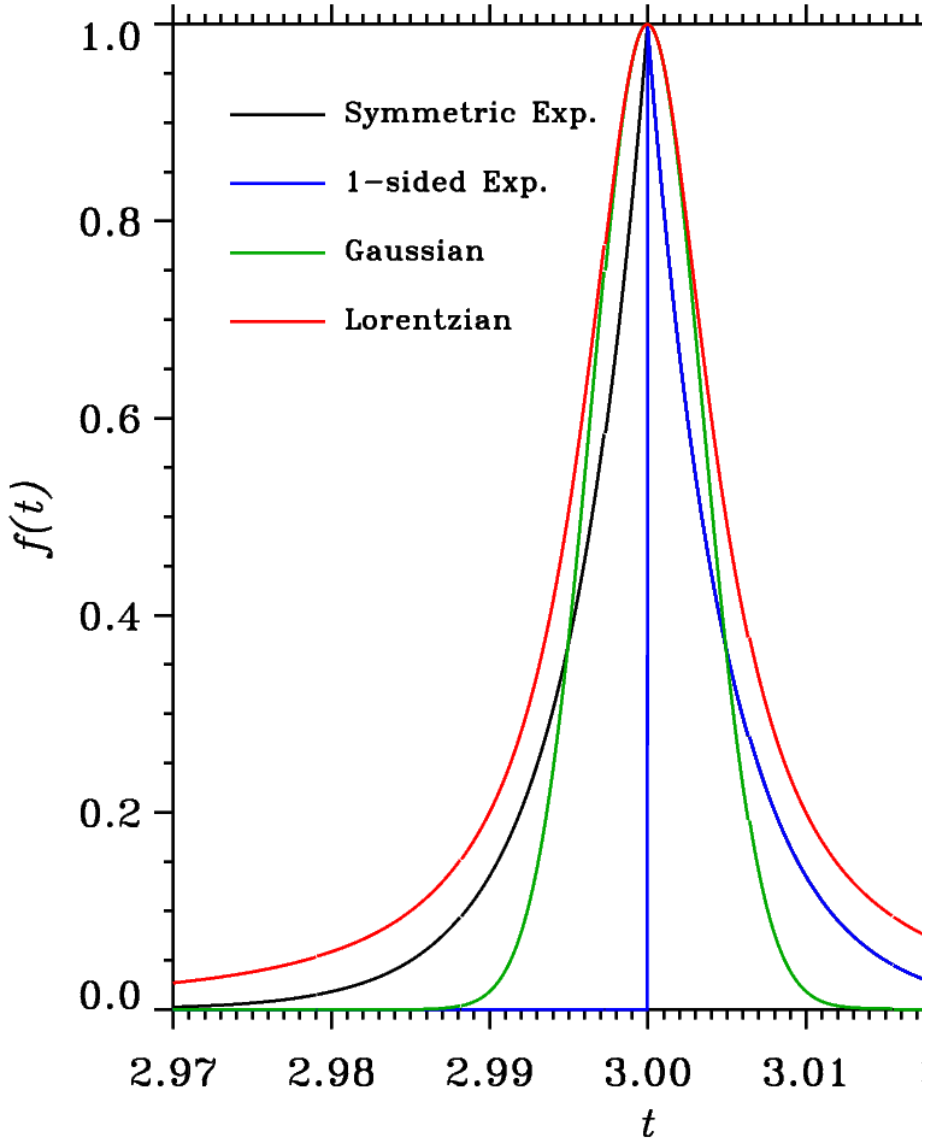
Some Fourier Transforms

Time series		Power spectrum
1-sided Exp.	$e^{-t/\tau}$ for $t>0$	$\frac{1}{1+(2\pi\nu\tau)^2}$
Symmetric Exp.	$e^{-\lvert t/\tau\rvert}$	$\frac{1}{[1+(2\pi\nu\tau)^2]^2}$
Gaussian	$e^{-(t/\tau)^2}$	$e^{-(2\pi\nu\tau)^2}$
Lorentzian	$\frac{1}{1+(t/\tau)^2}$	$e^{-2\pi\nu\tau}$

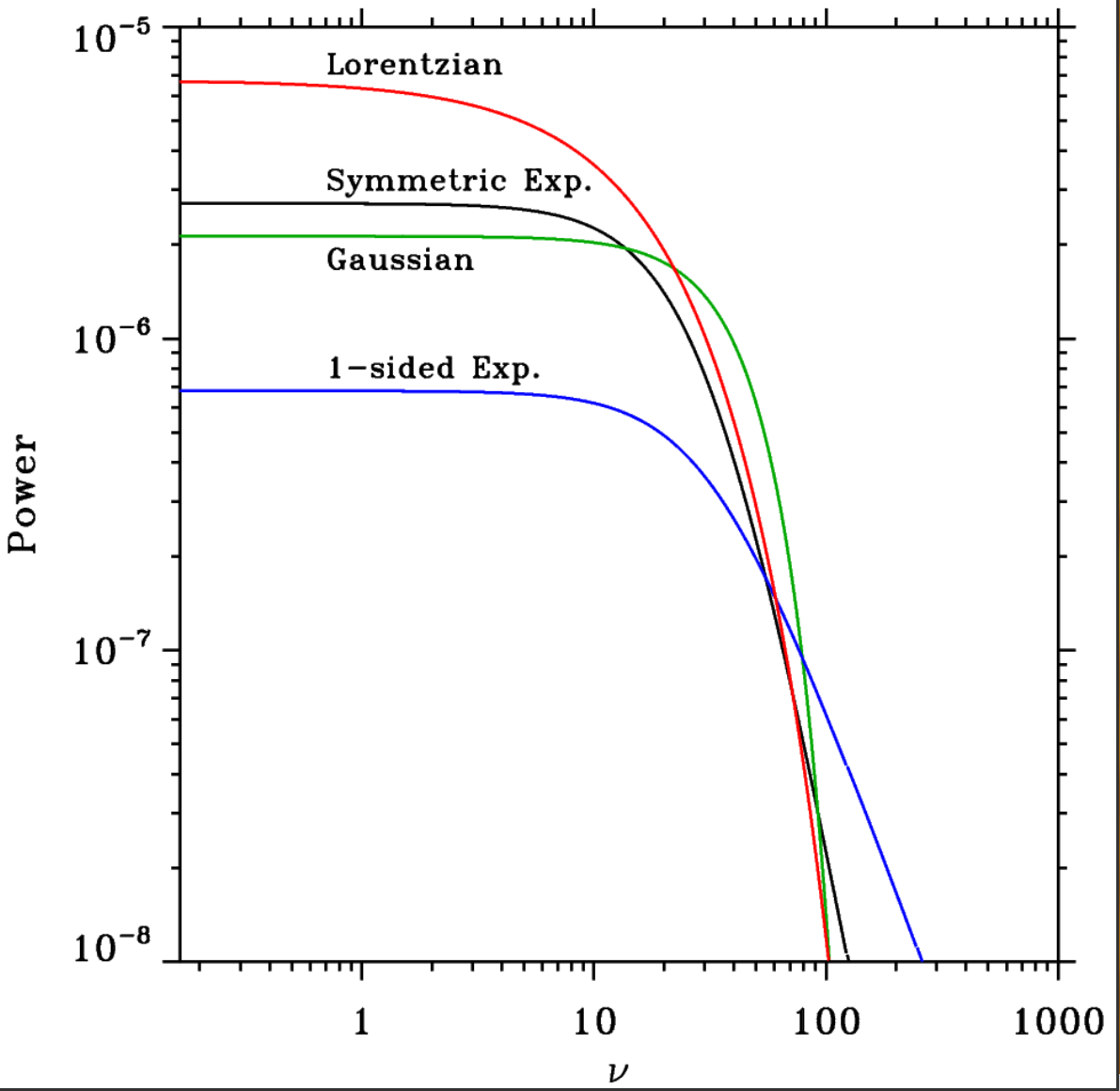
Pulse in time



Pulse in time



Power Spectra



The Harvey Law – Generalized

- Harvey (1985):

$$P(\nu) = 1/[1 + (2\pi\nu\tau)^2]$$

- Generalized to:

$$P(\nu) = 1/[1 + (2\pi\nu\tau)^\alpha]$$

- Different slopes: $\alpha \sim [1.5; 5]$
  $\Rightarrow$ different pulse width
- τ_{eff} Measure actual width (Jérôme Ballot, priv. comm.)

The Ha

- Harvey (19

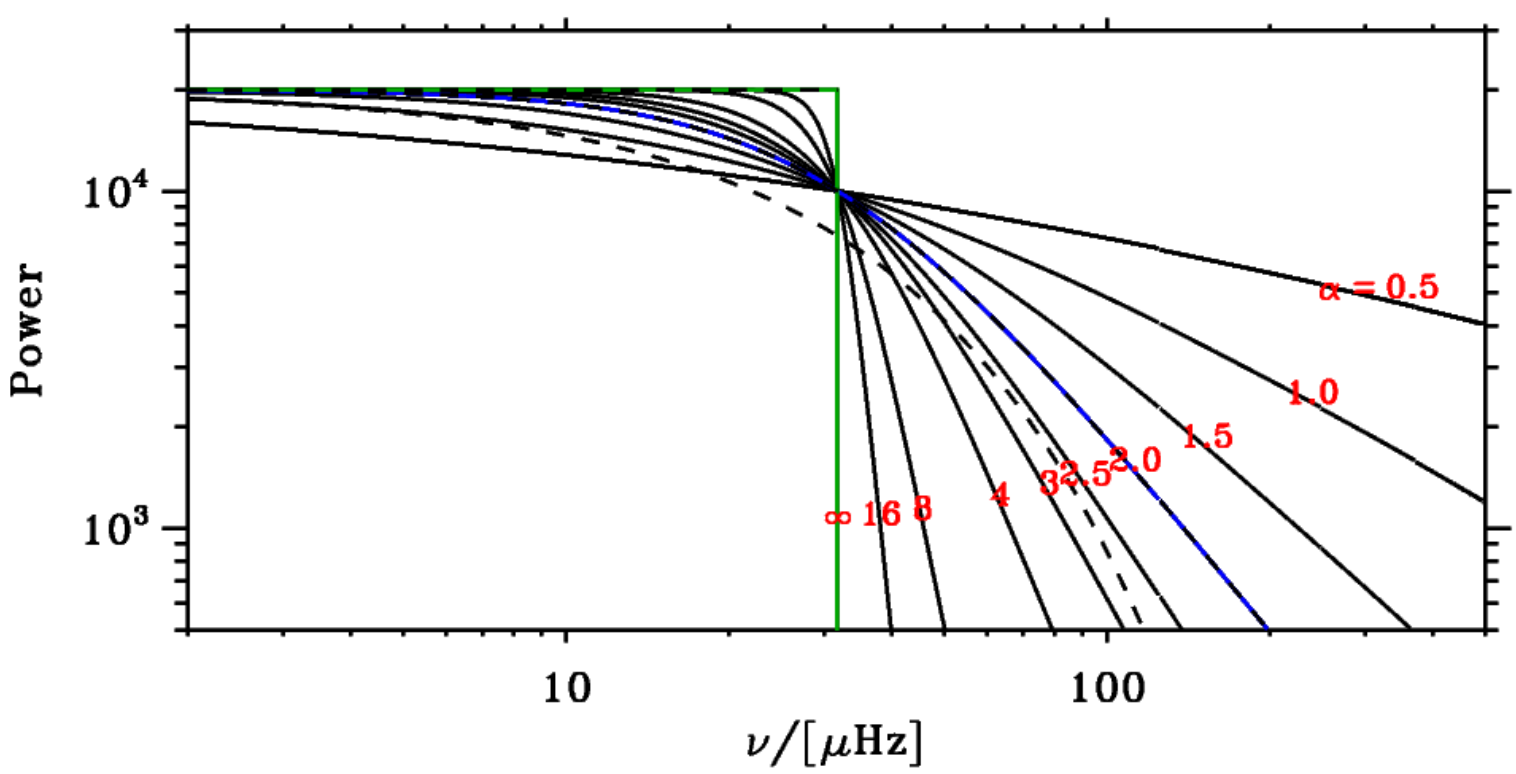
  $P(\nu) = 1/$

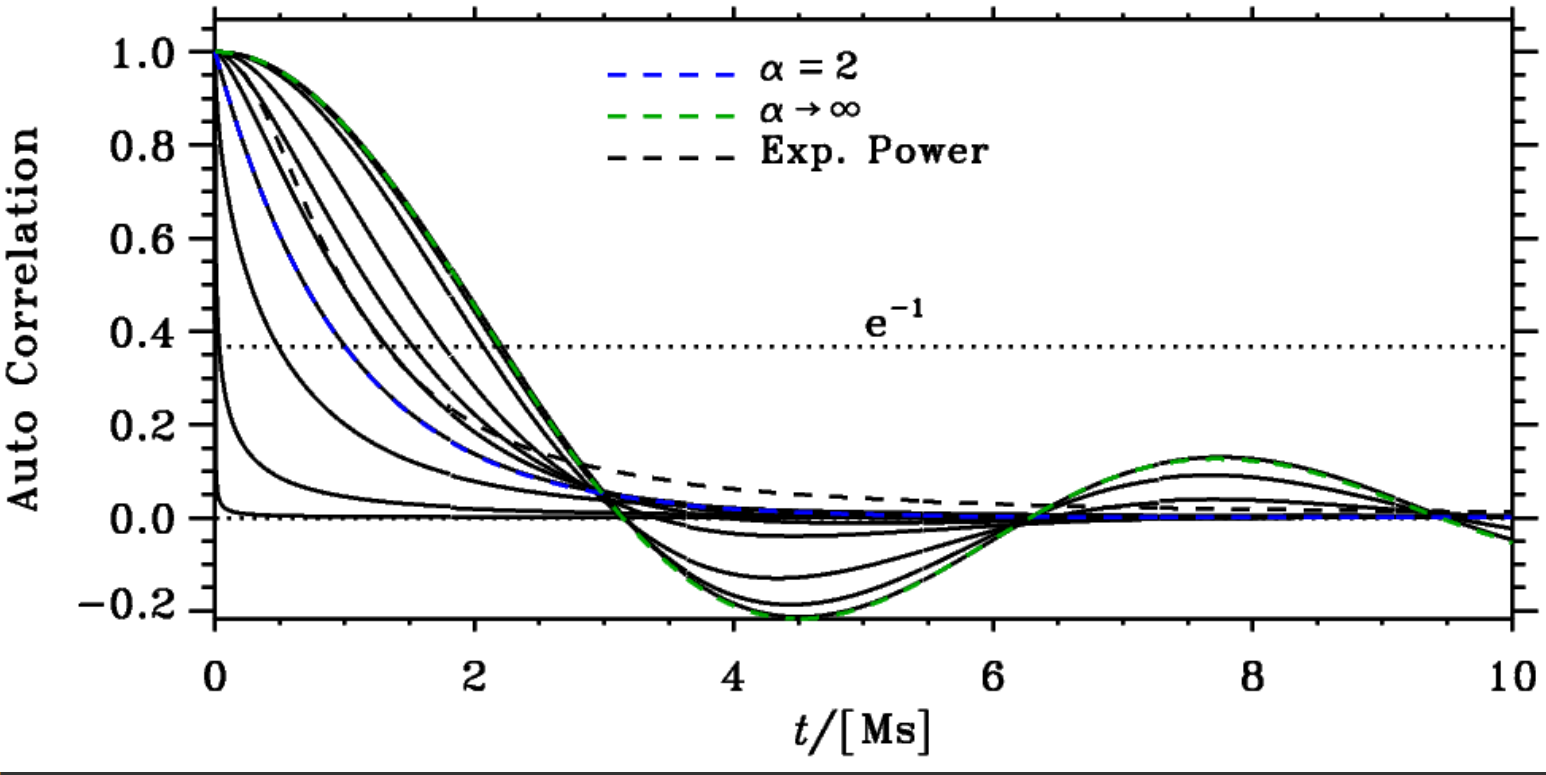
- Generalize

  $P(\nu) = 1/$

- Different s
  ⇒ differen

- τ_{eff} Measu
  (Jérôme B
  comm.)





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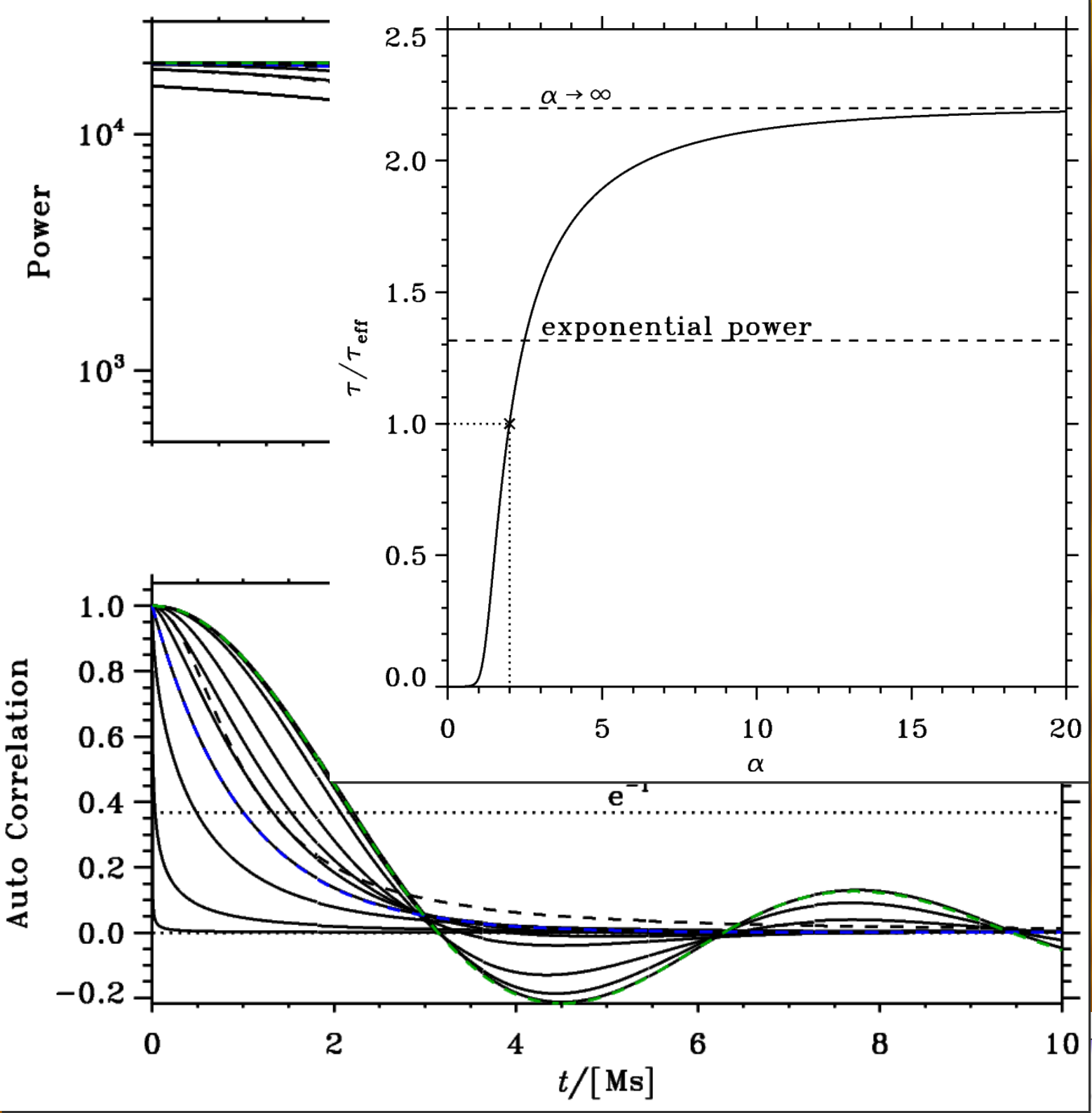
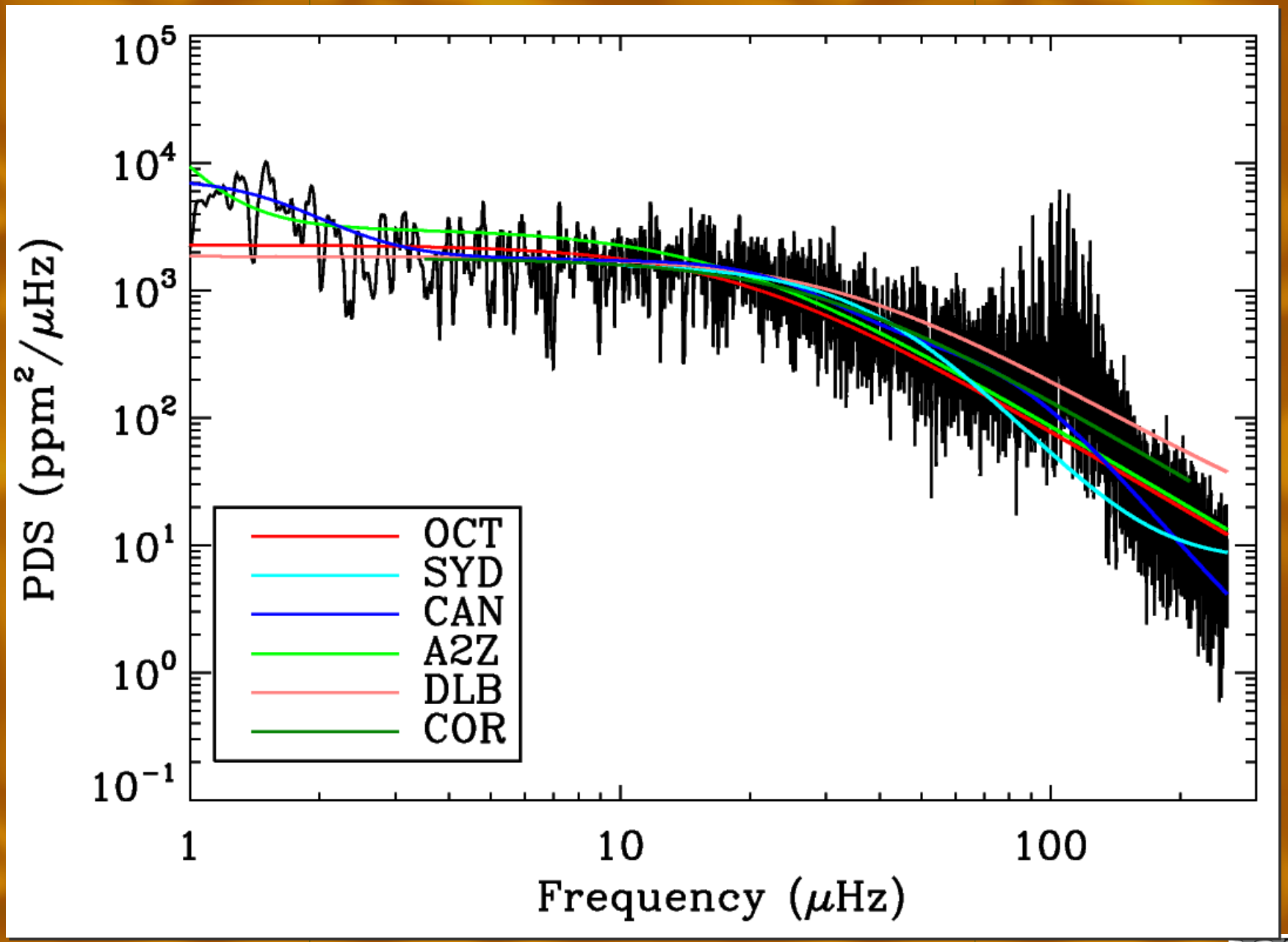
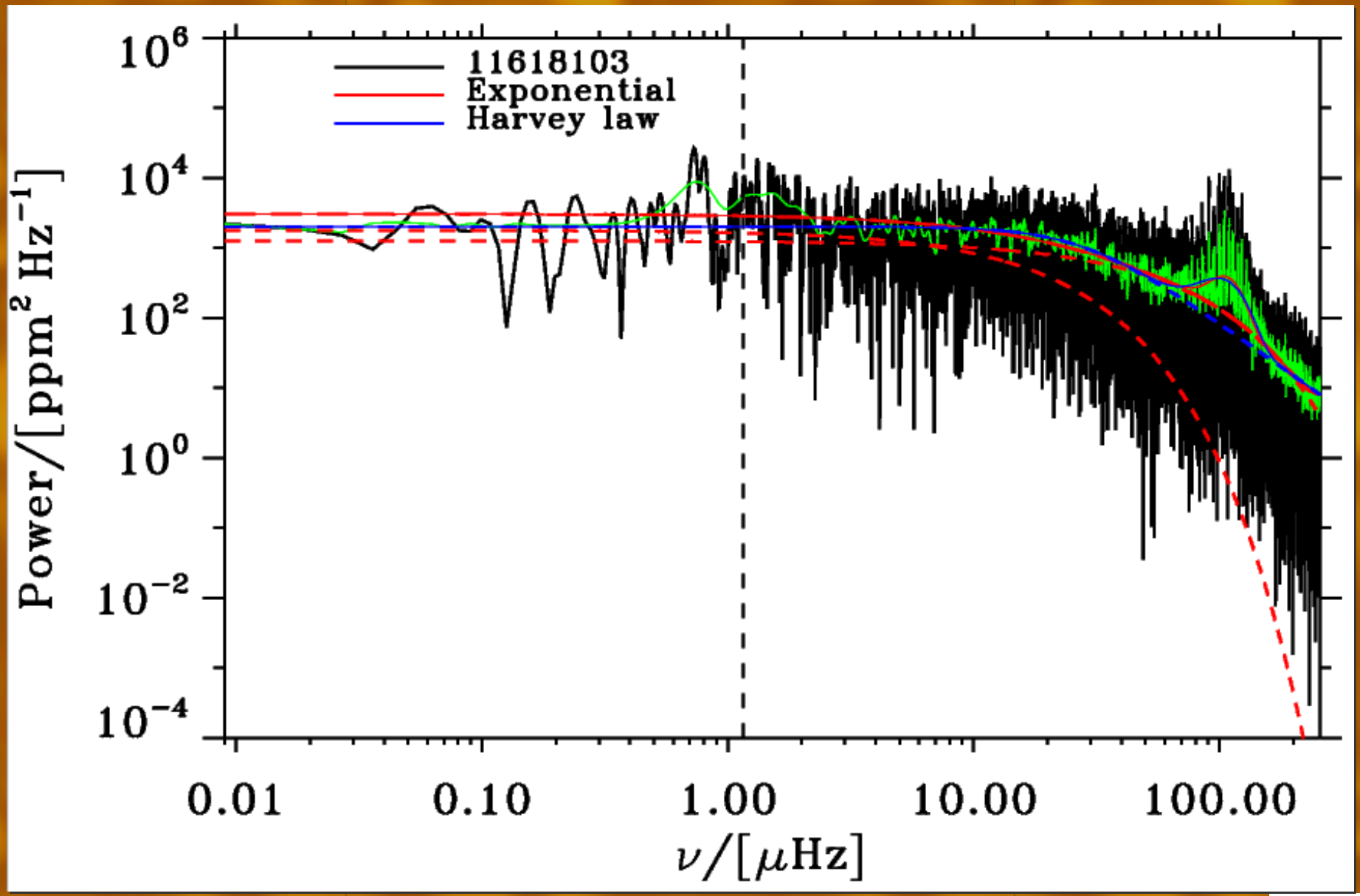


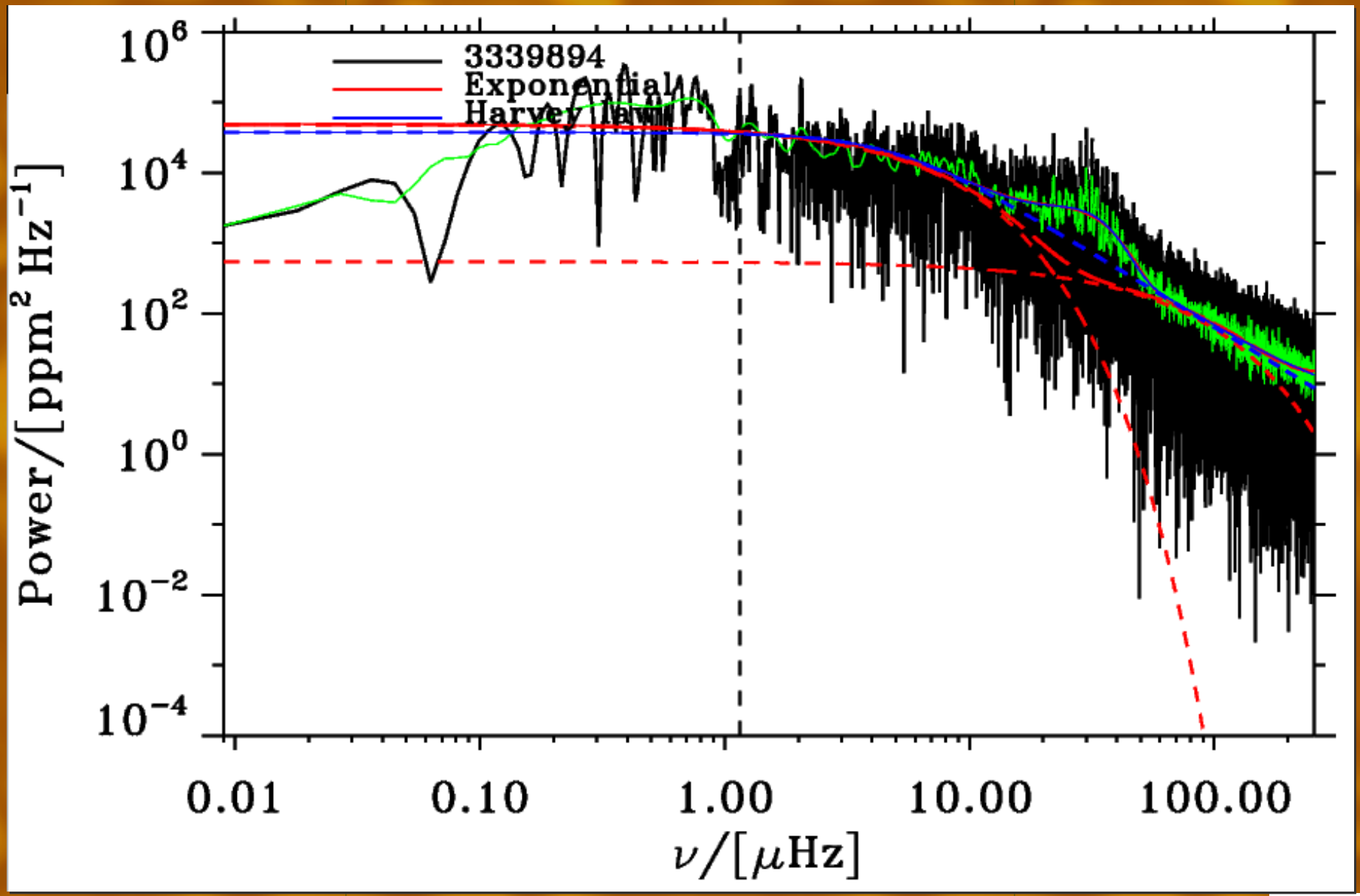
One star, 6 fits, 6 realities!



Fits to 6 Kepler Red Giants



Fits to 6 Kepler Red Giants



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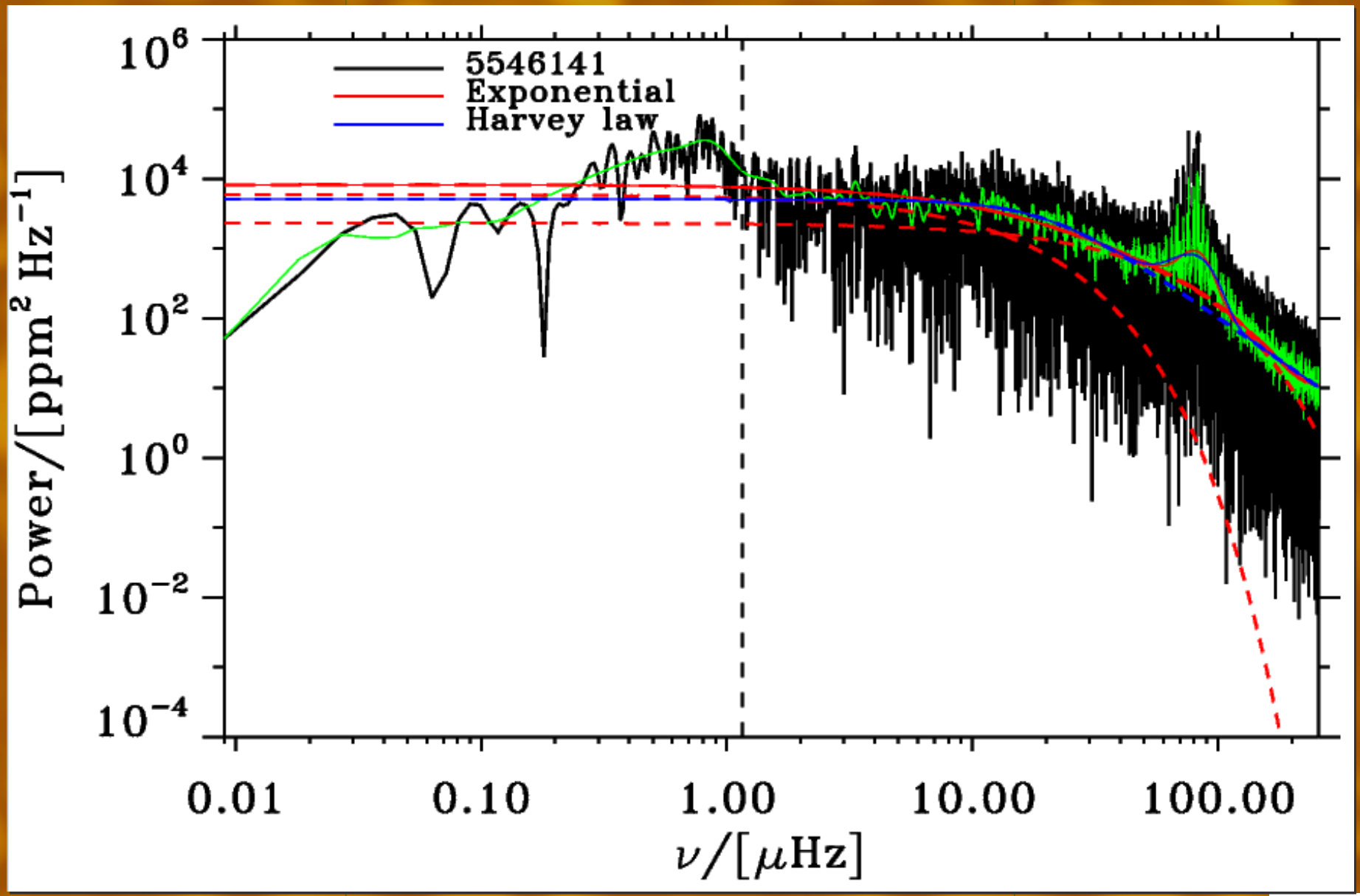

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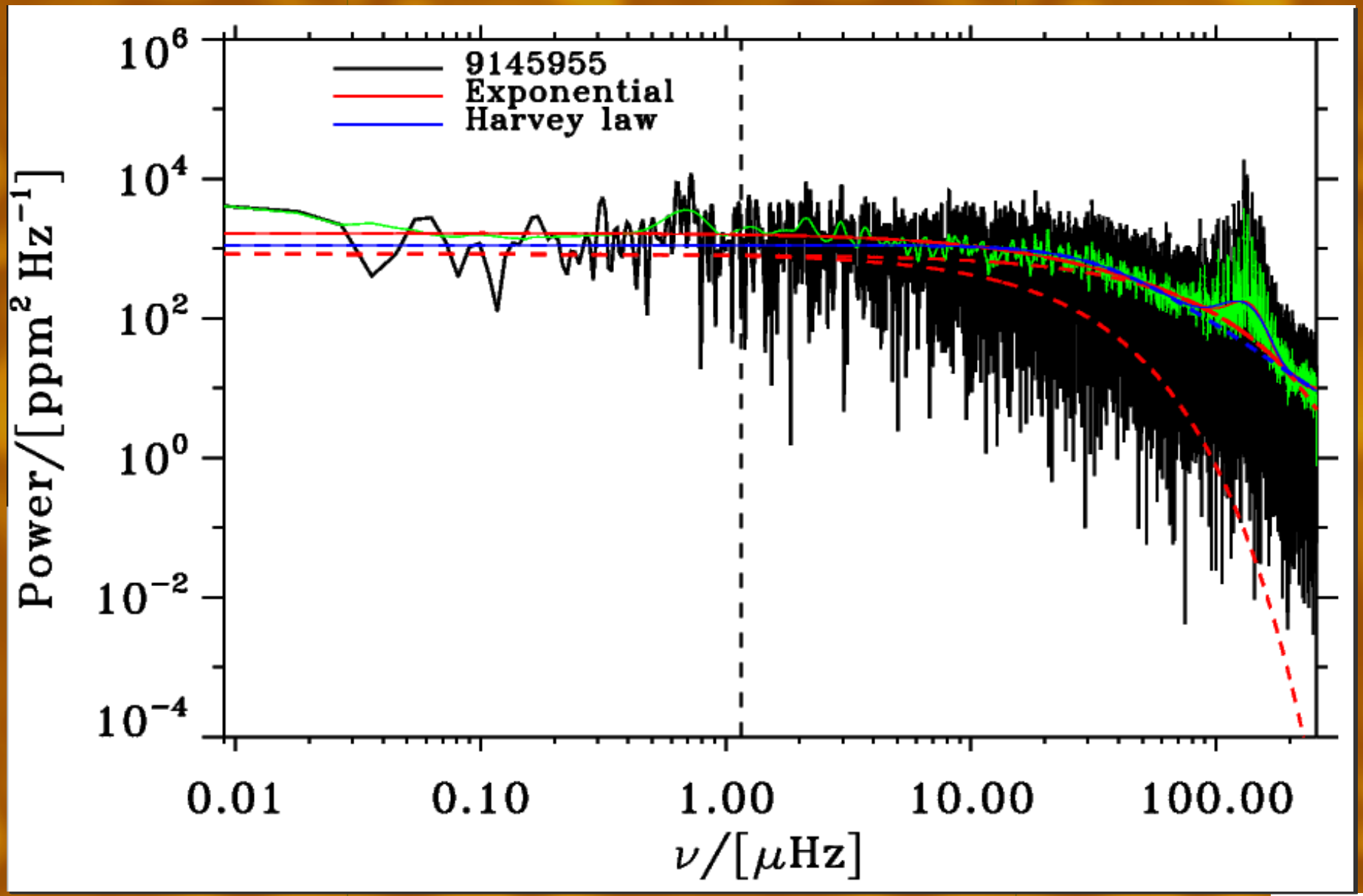

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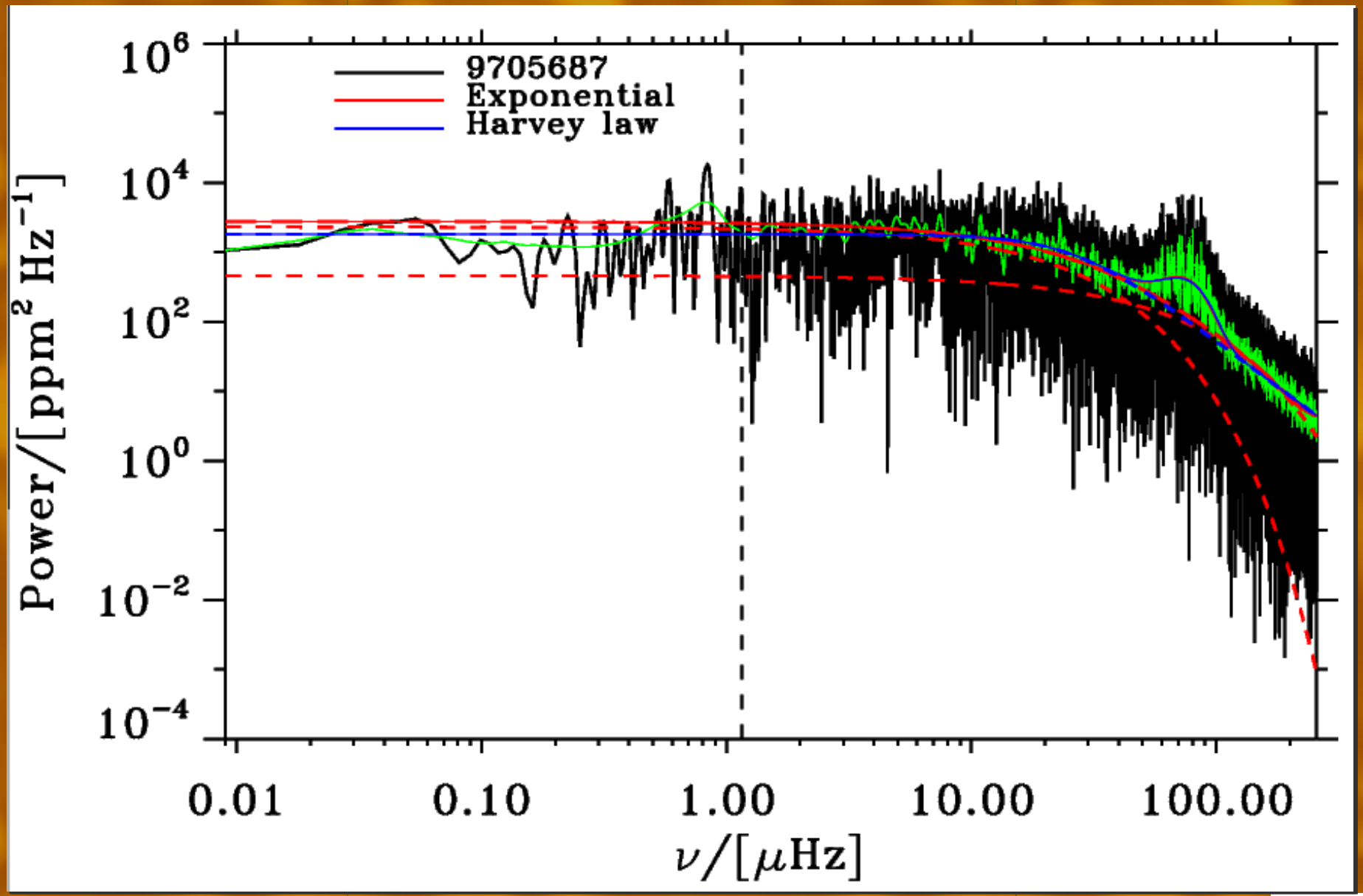

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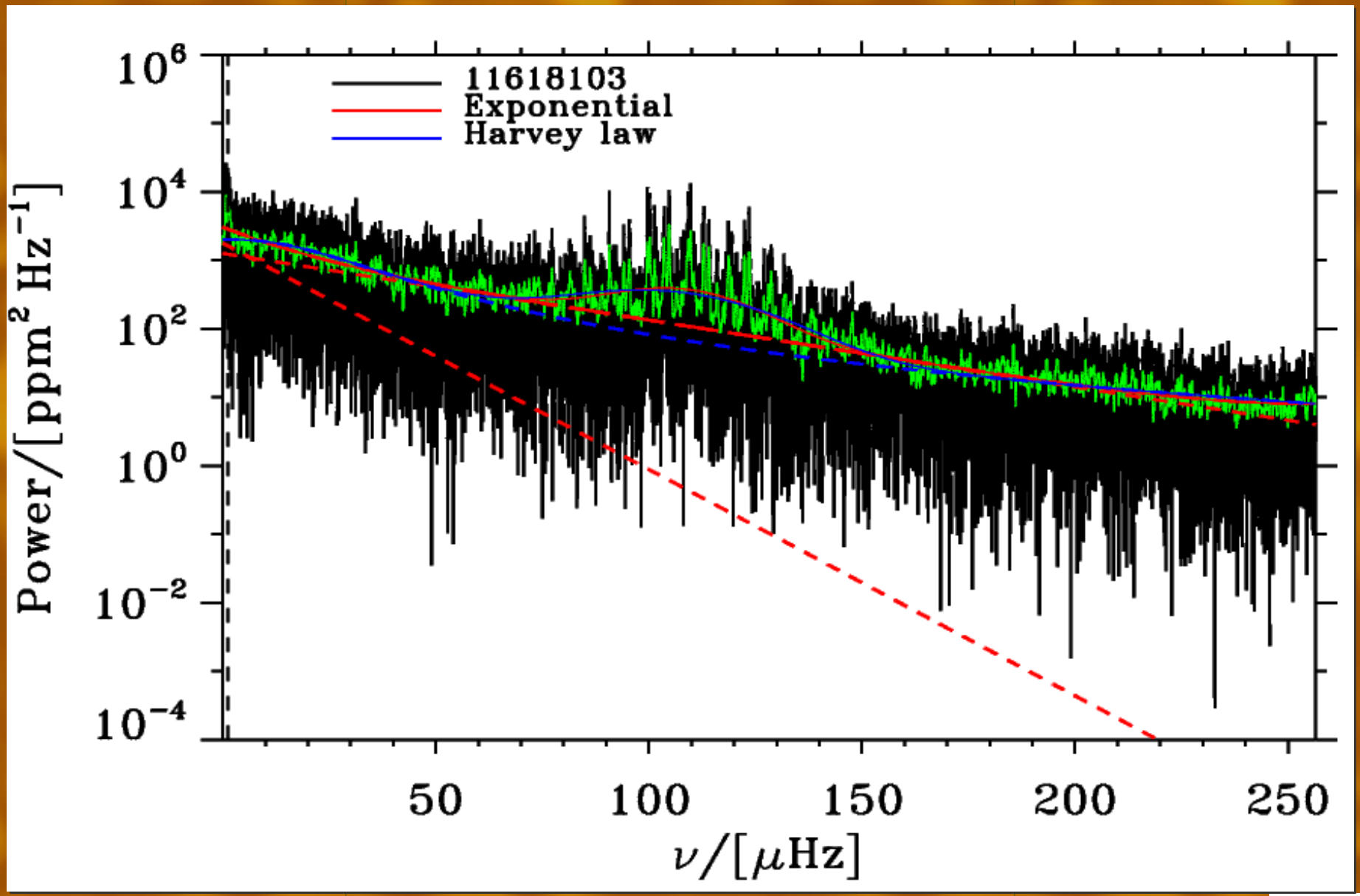

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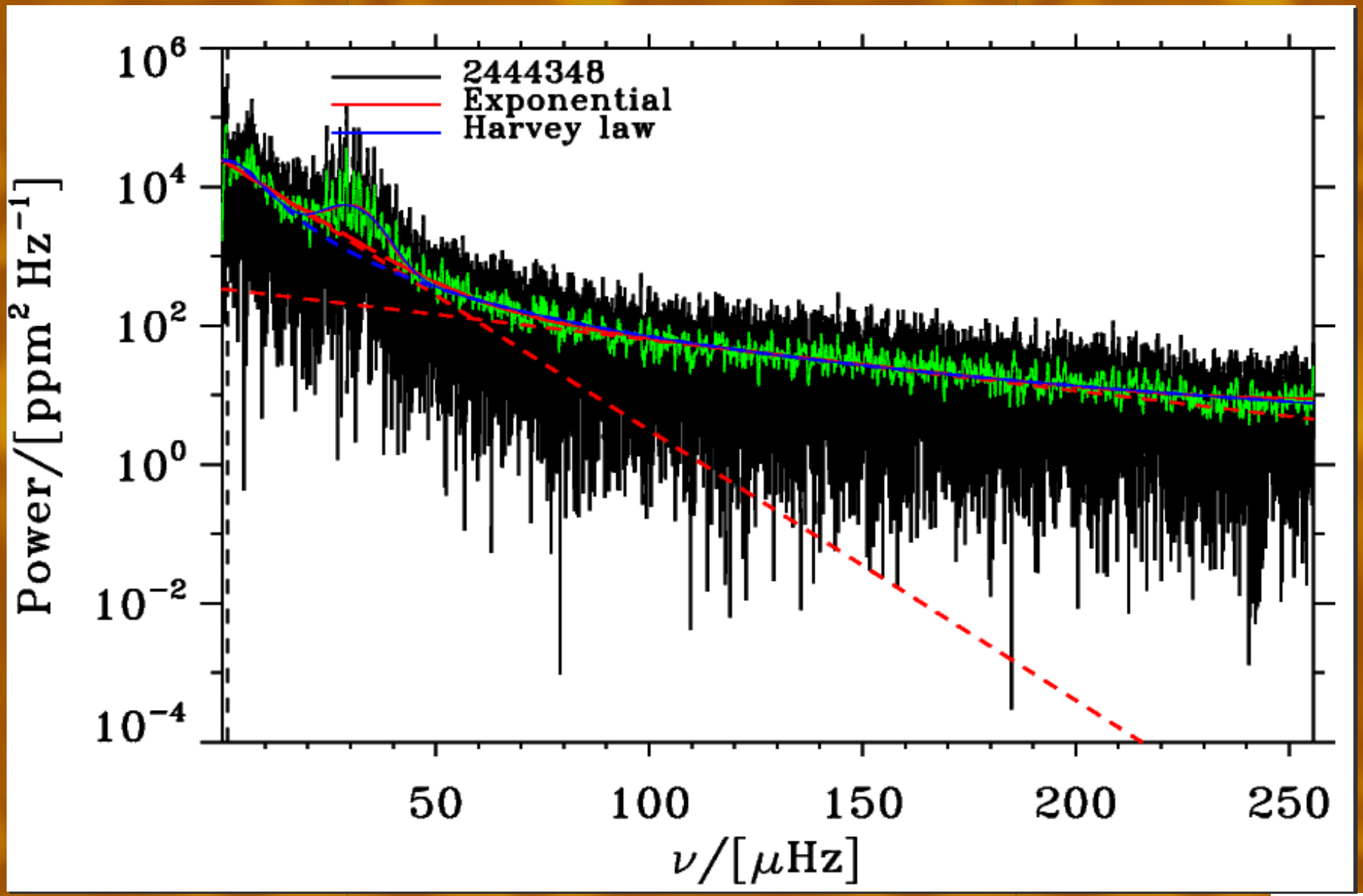

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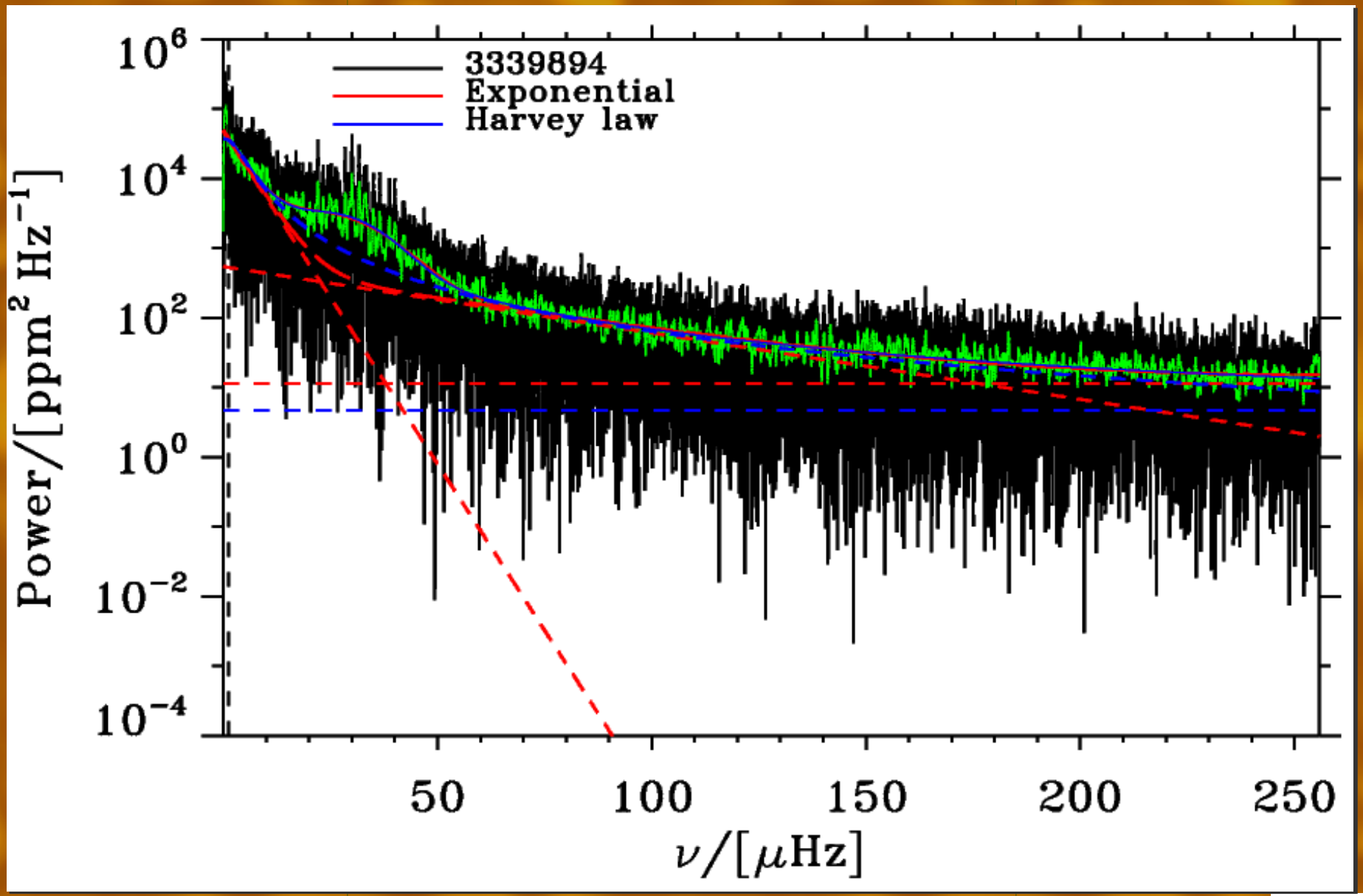

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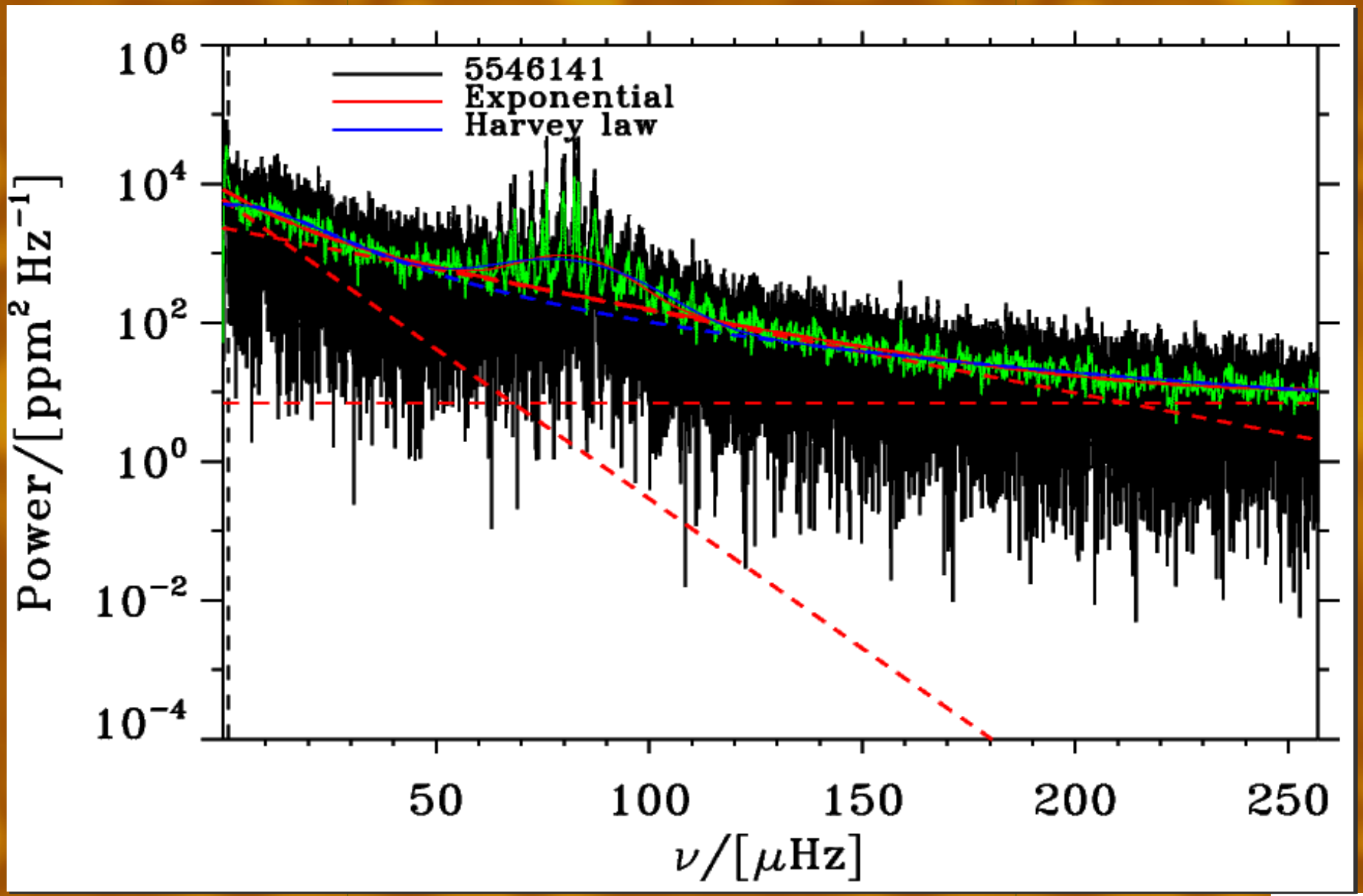

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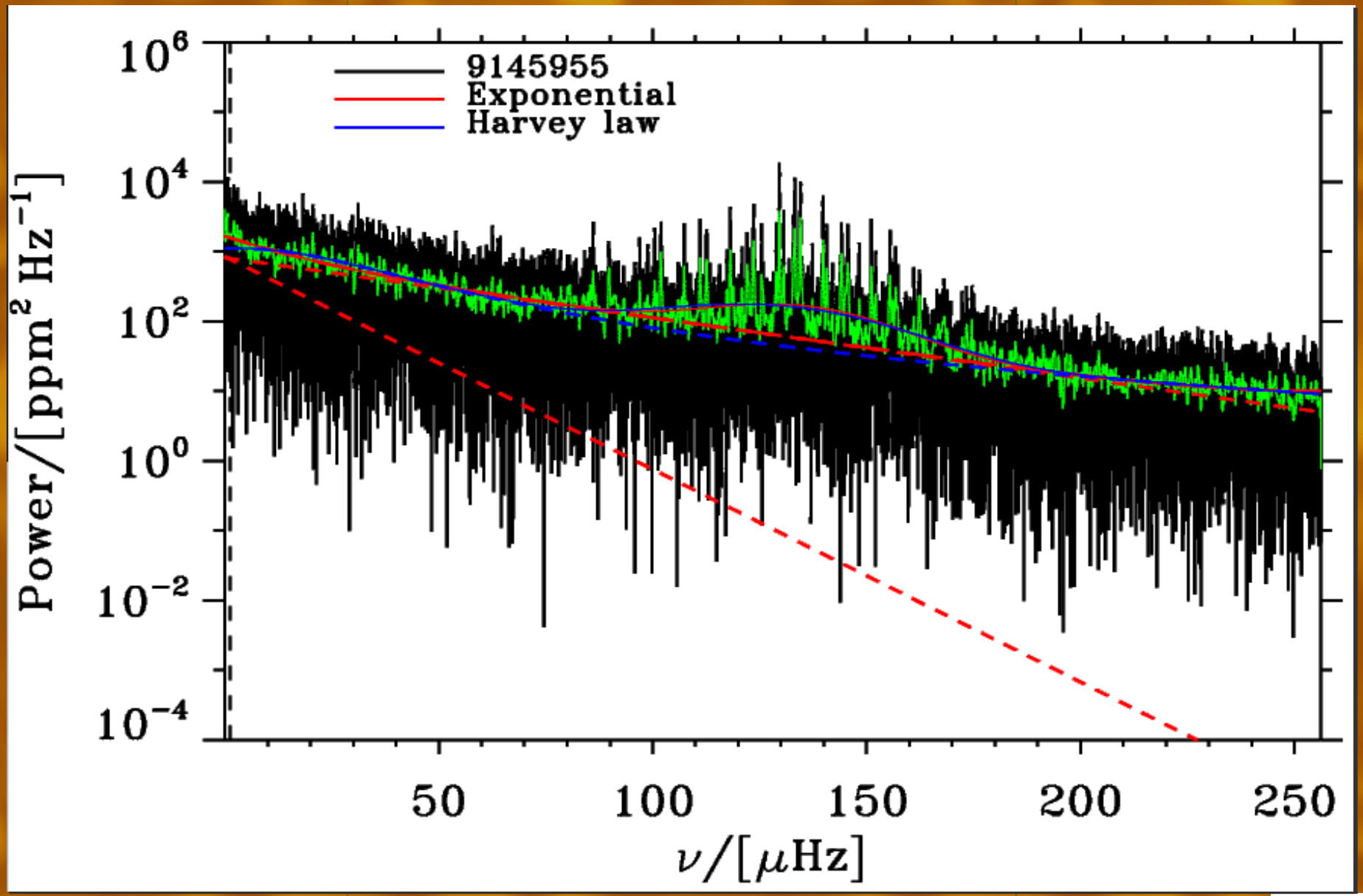

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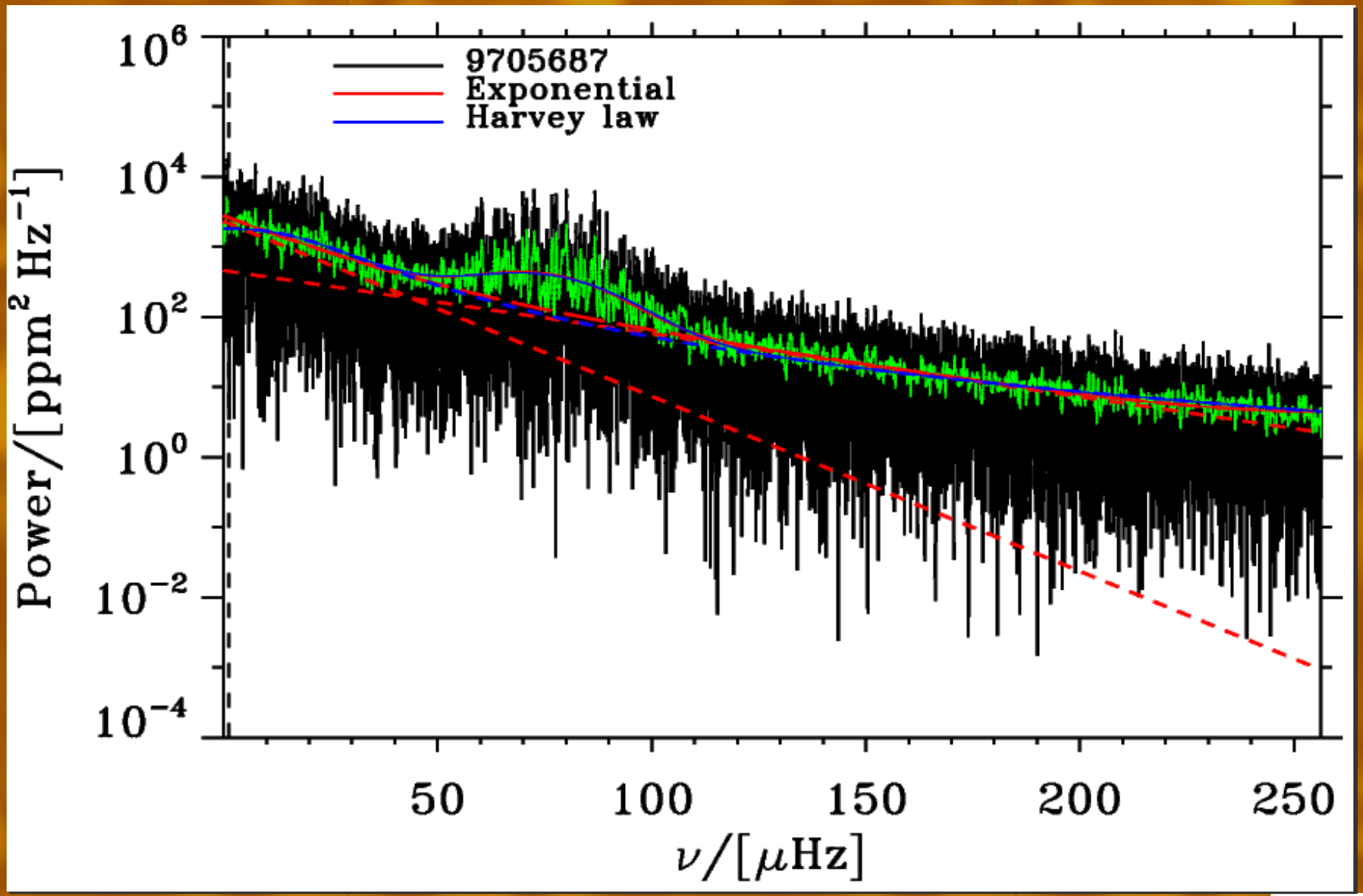
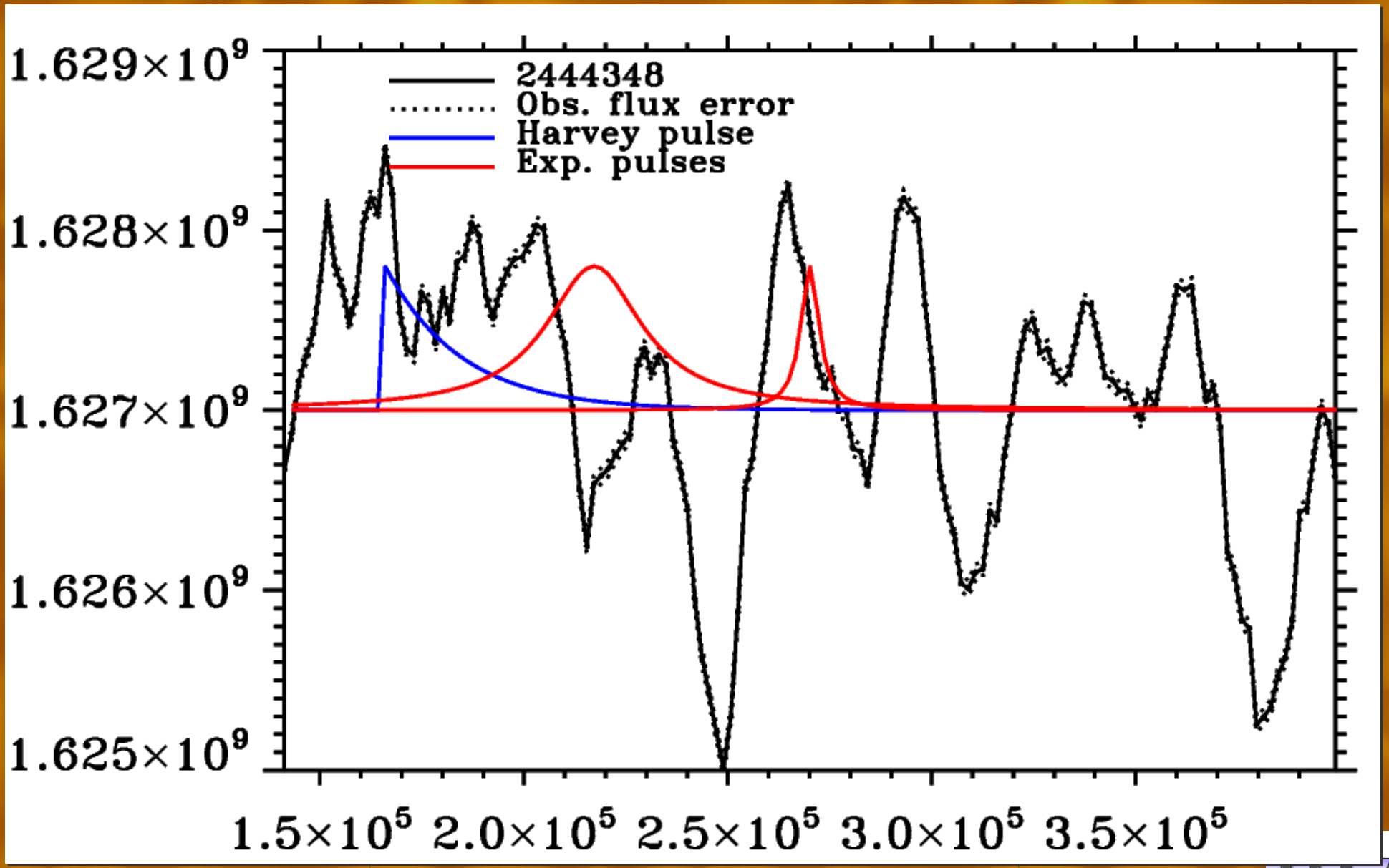


Fitting the time-series: The Good



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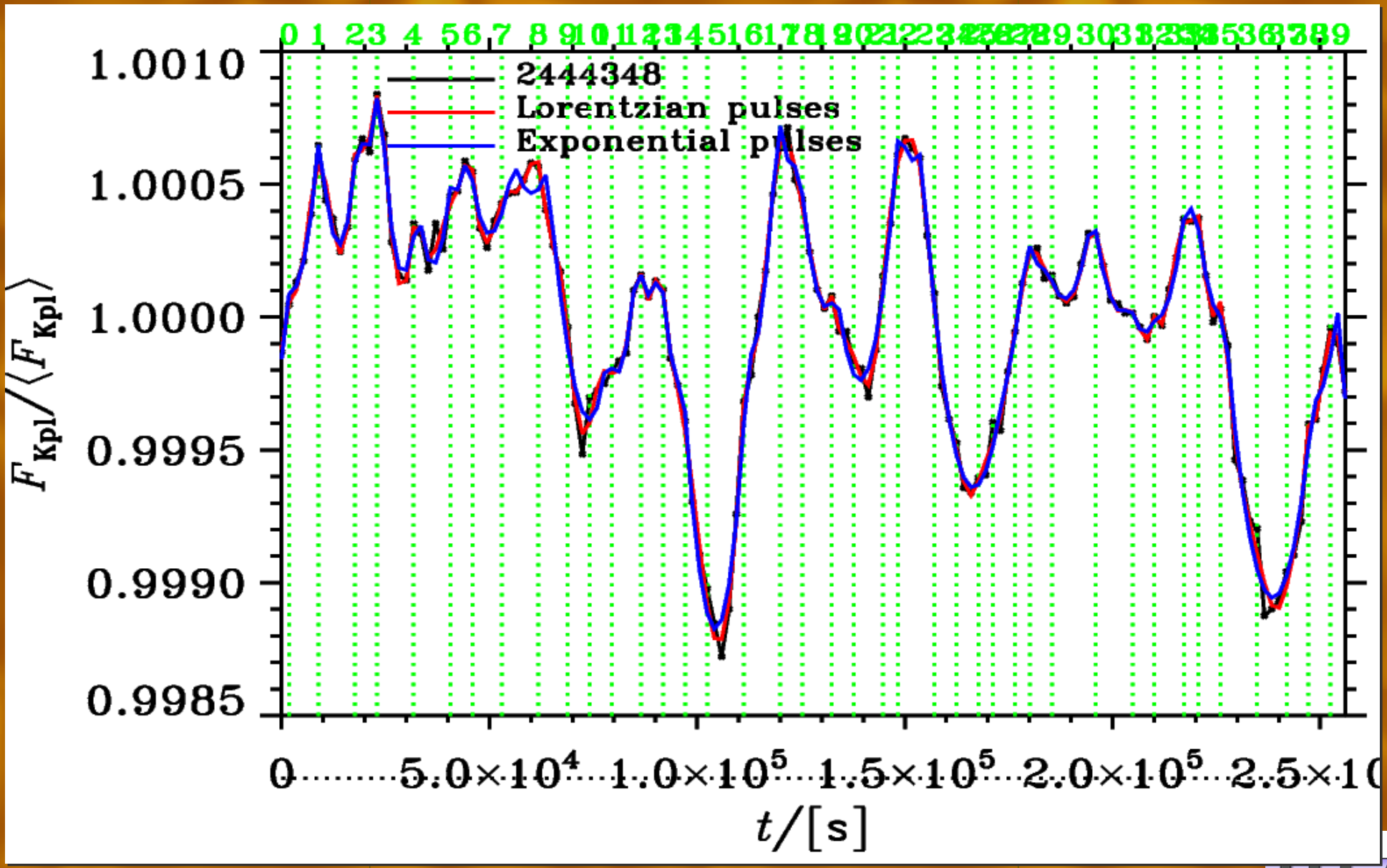

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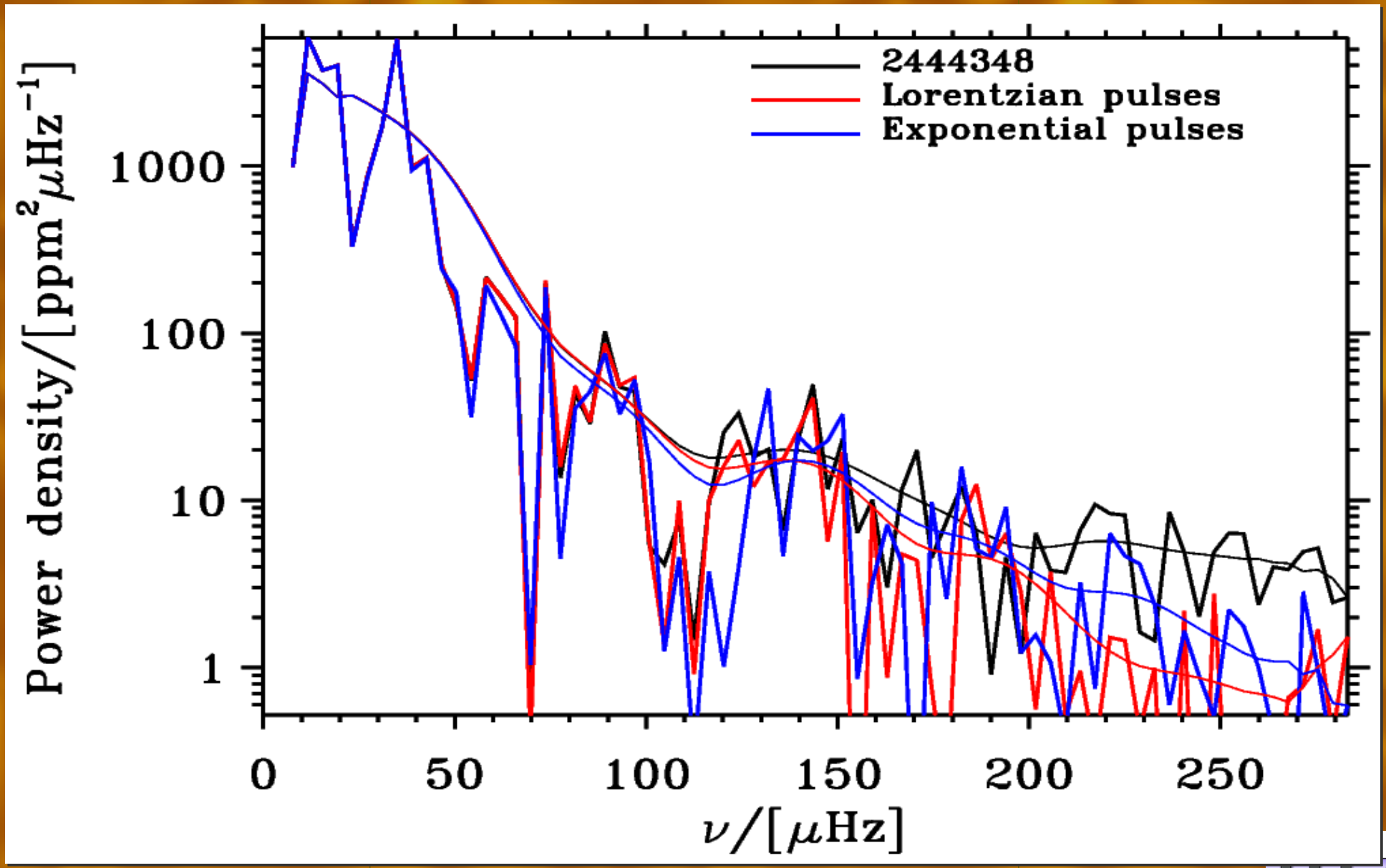
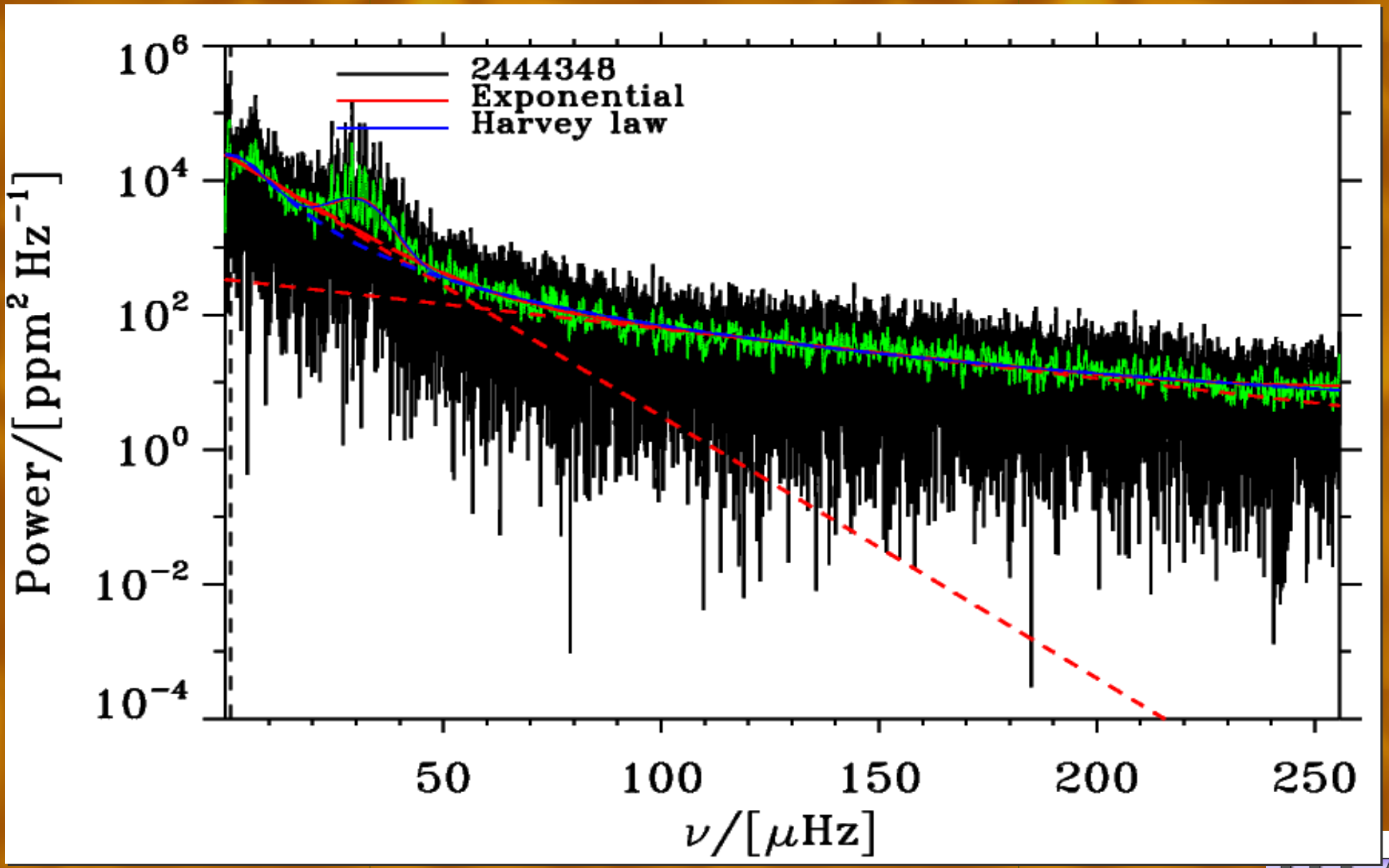
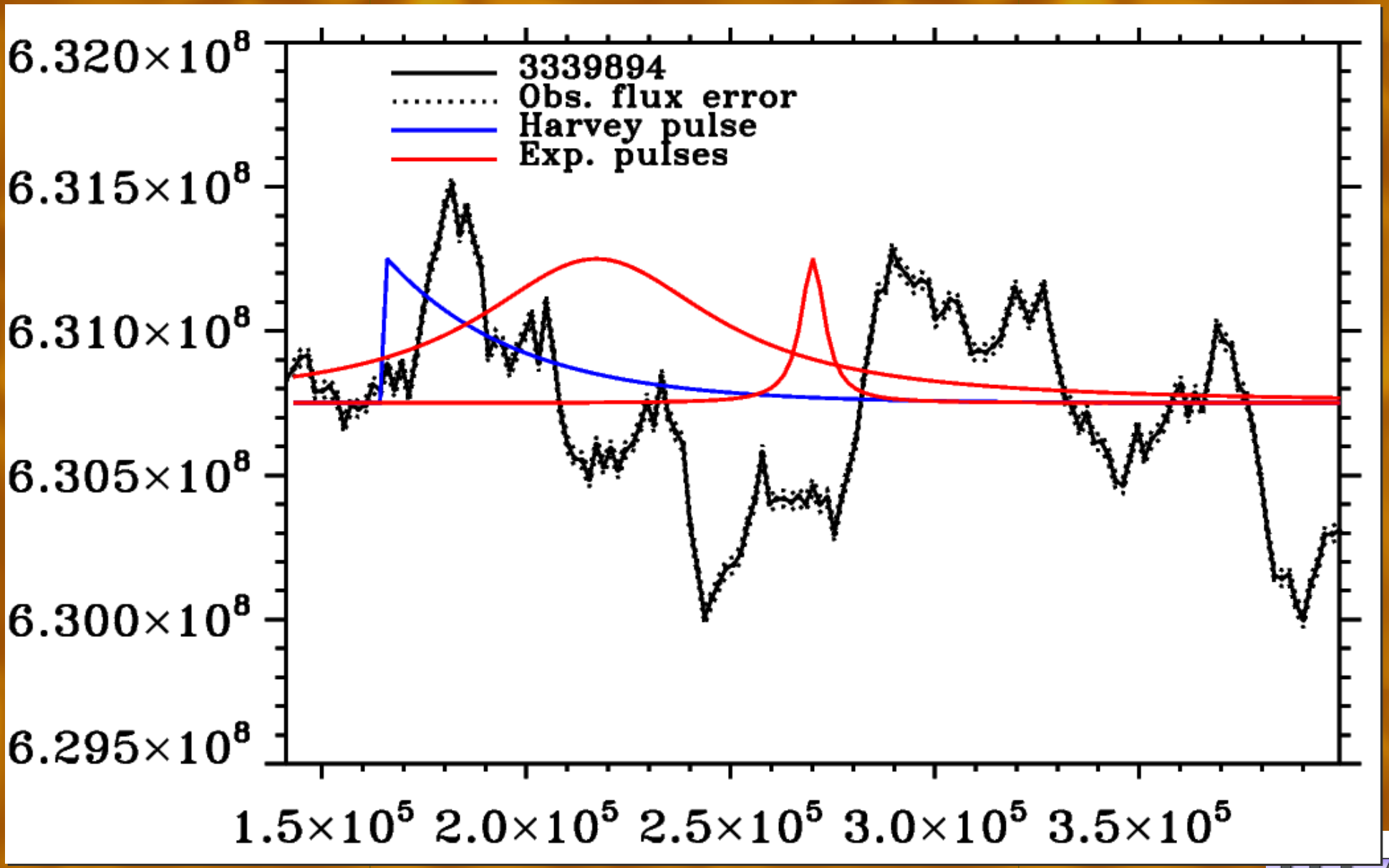


Remember the global fit?



And the bad and ugly one



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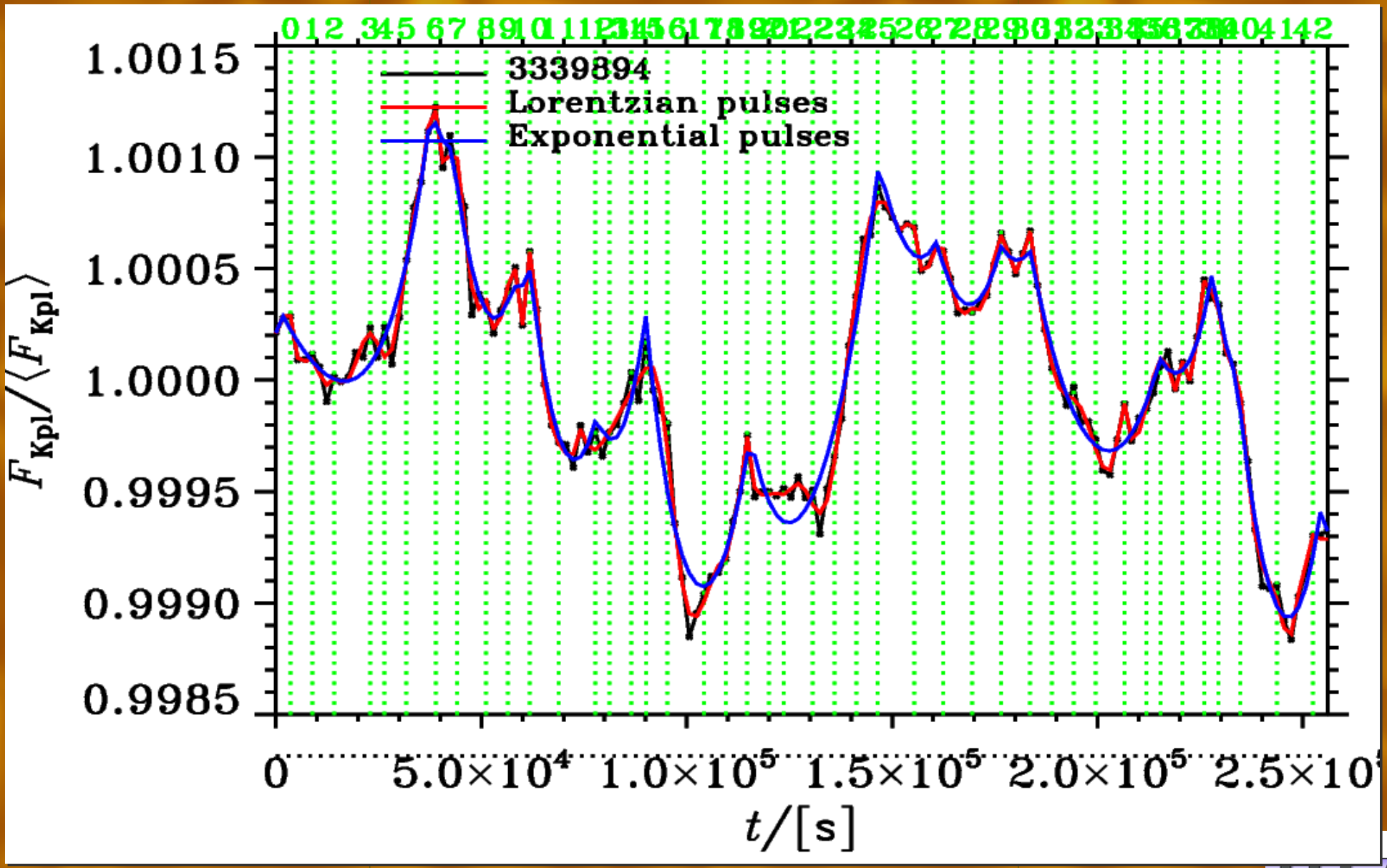

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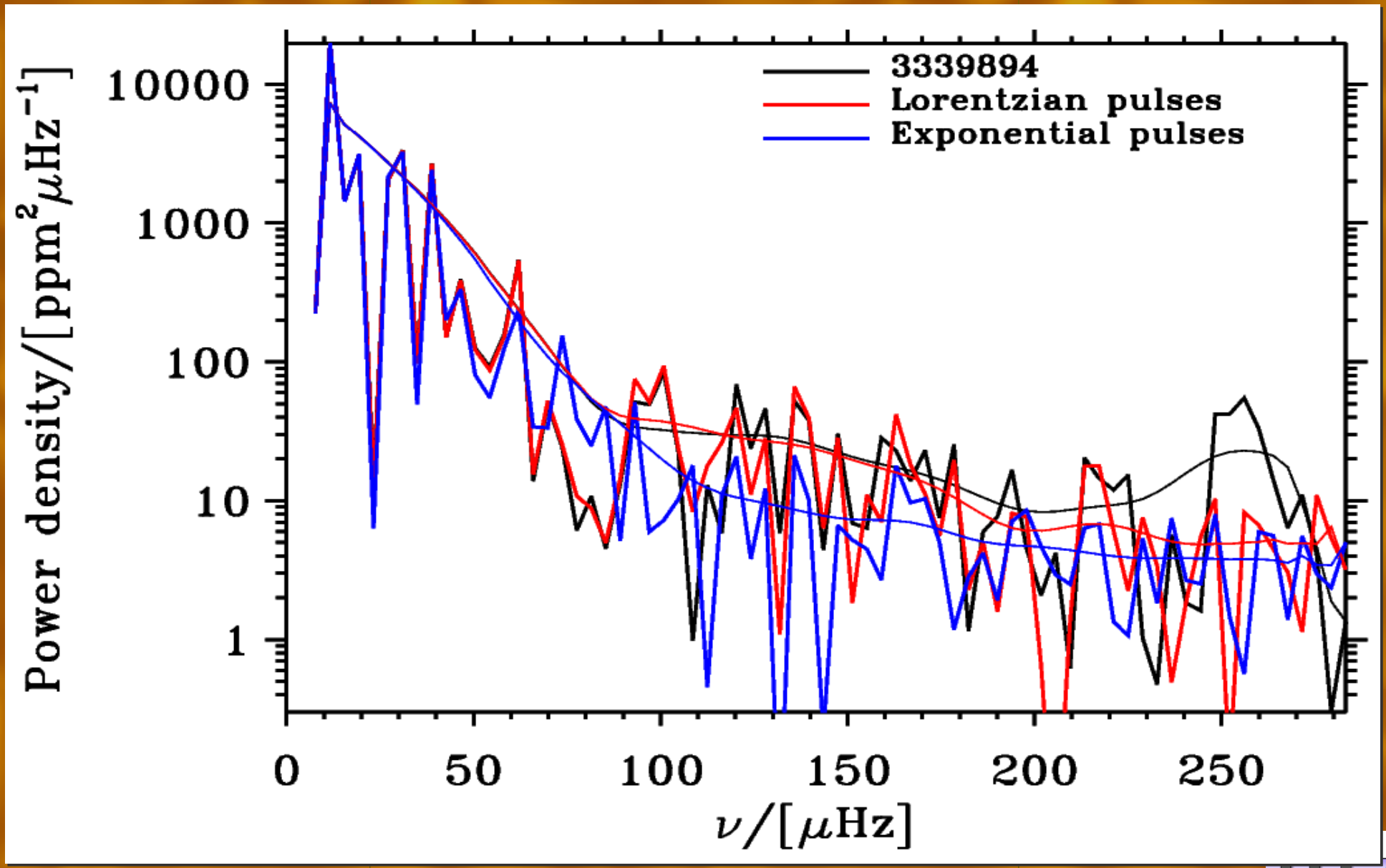
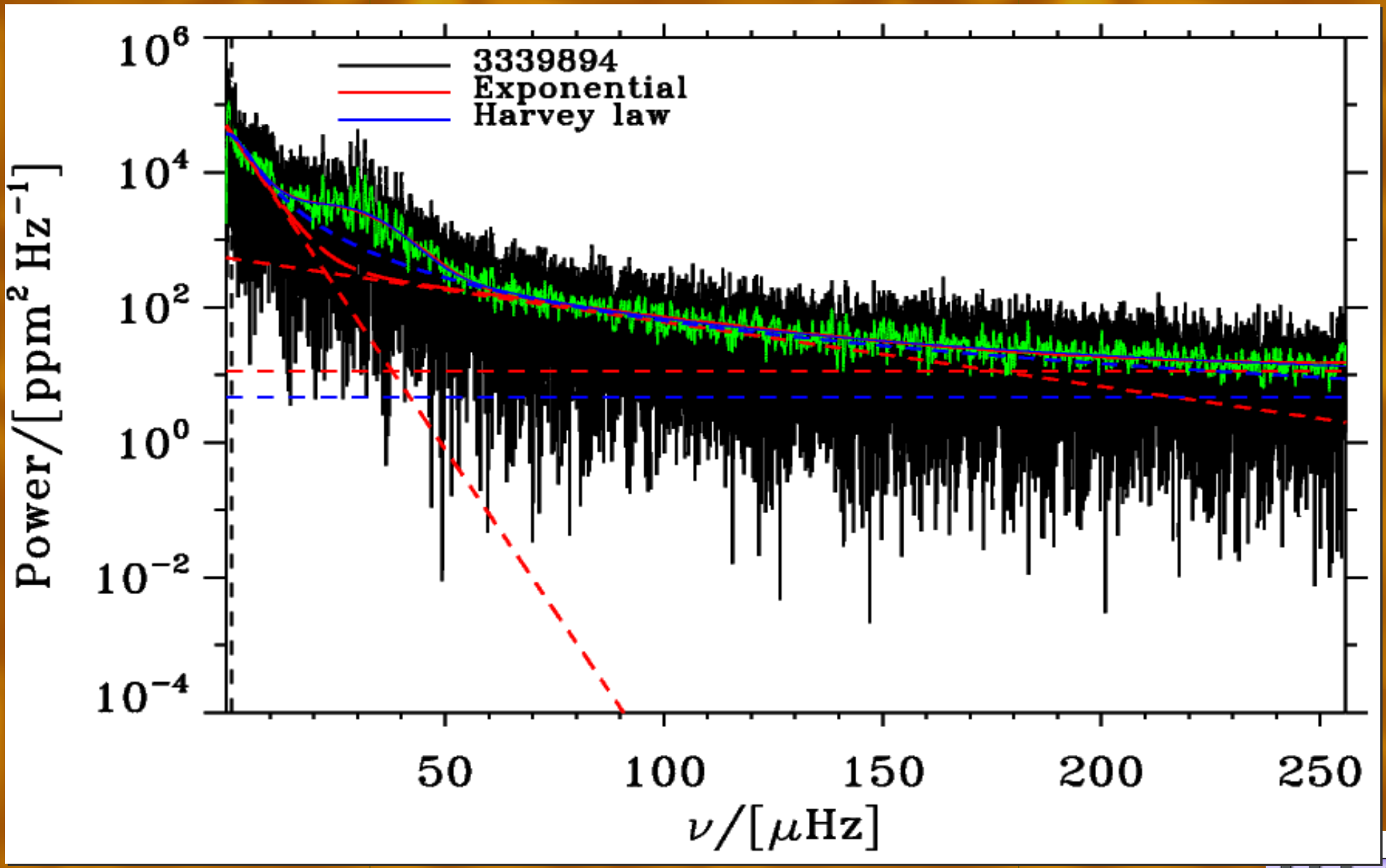
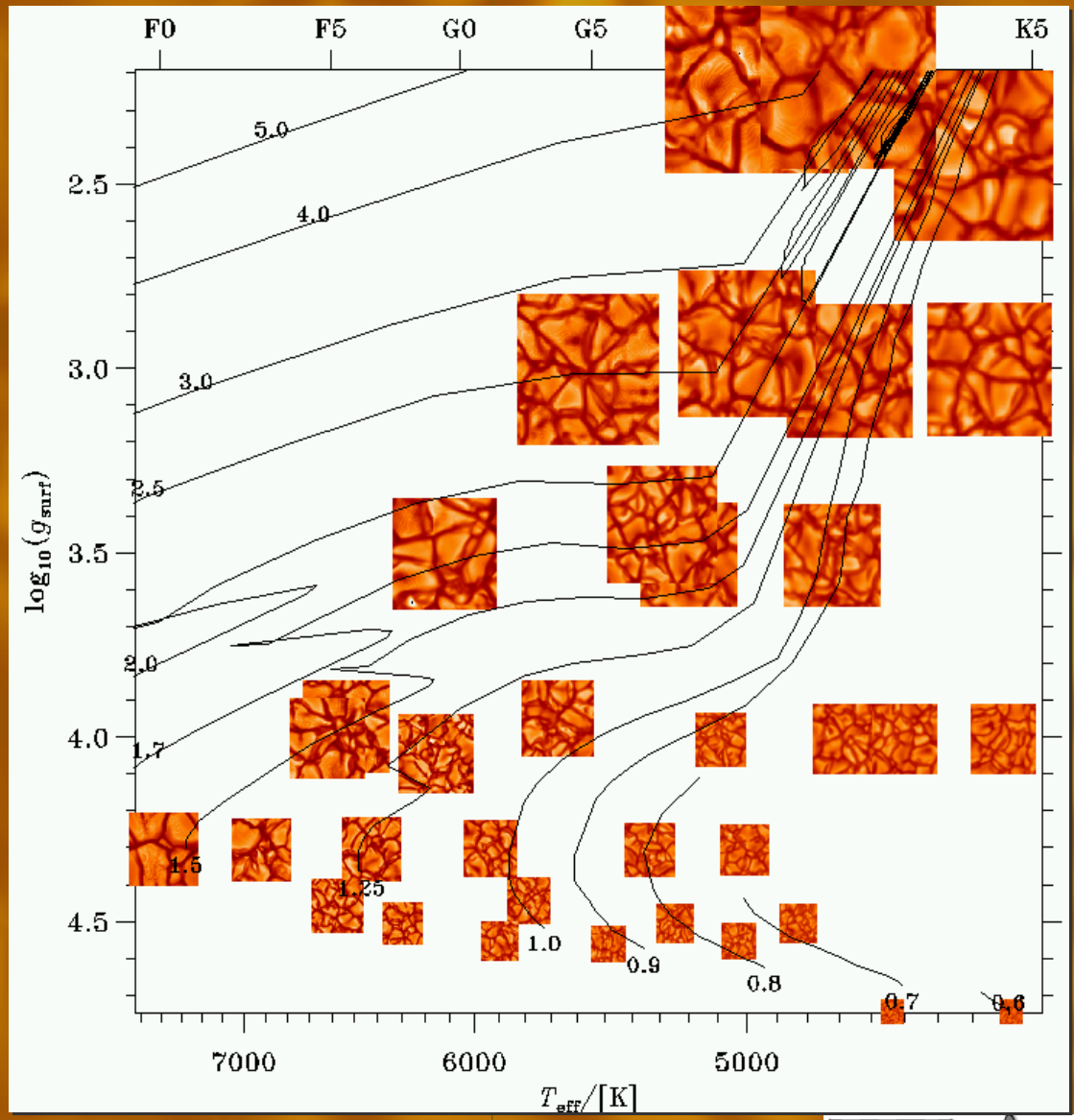


And the global fit:



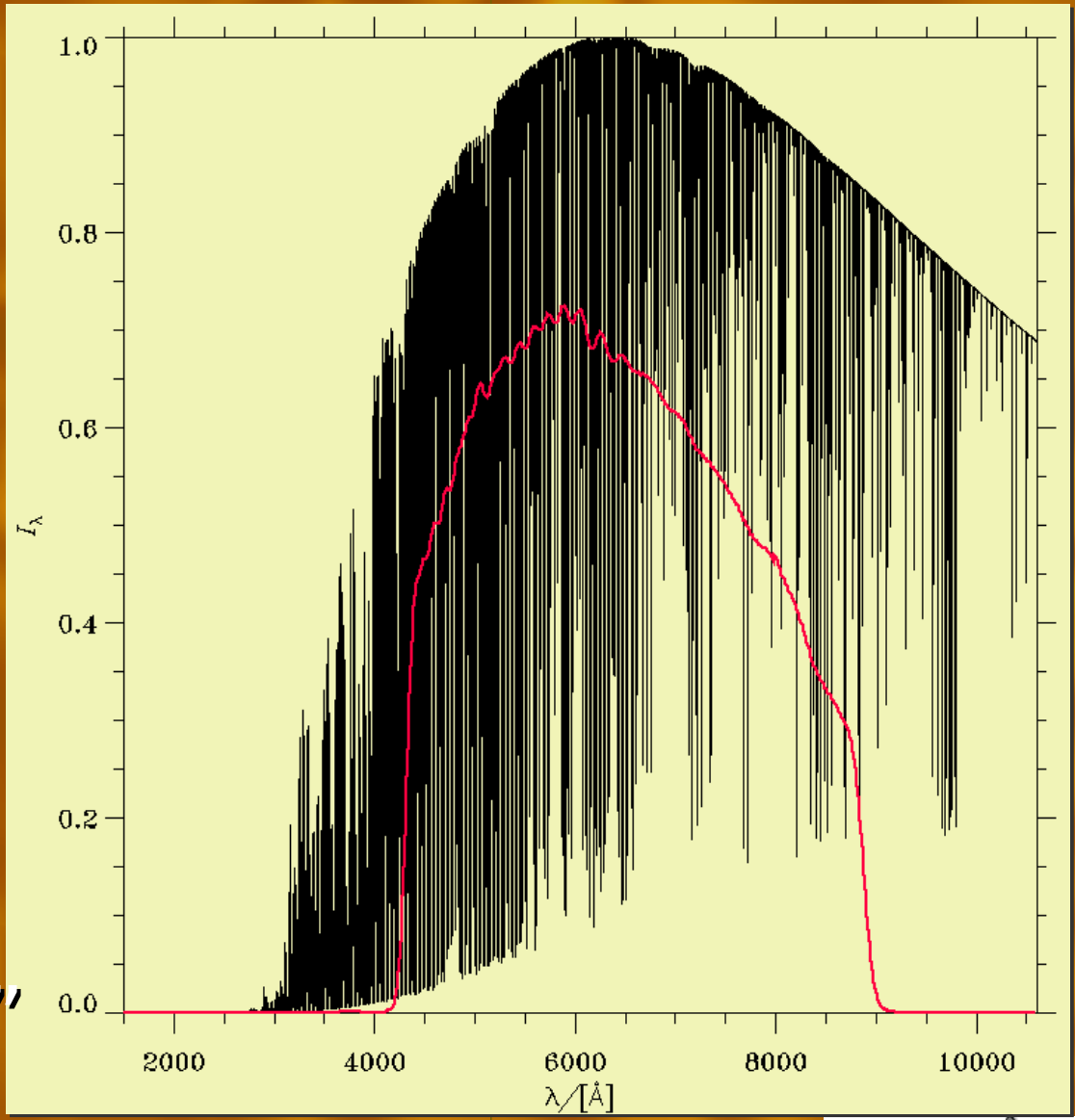
And the 3D convection simulations?

- Grid of 37 sims.
- Realistic EOS, opacities and radiative transf.
- [Fe/H]=0.0 ~GN93



And the 3D convection simulations?

- Grid of 37 sims.
- Realistic EOS, opacities and radiative transf.
- [Fe/H]=0.0 ~GN93
- Monochromatic intens.*Kepler filter
- ⇒“obs. Time-series
- Fitted gran. “noise”



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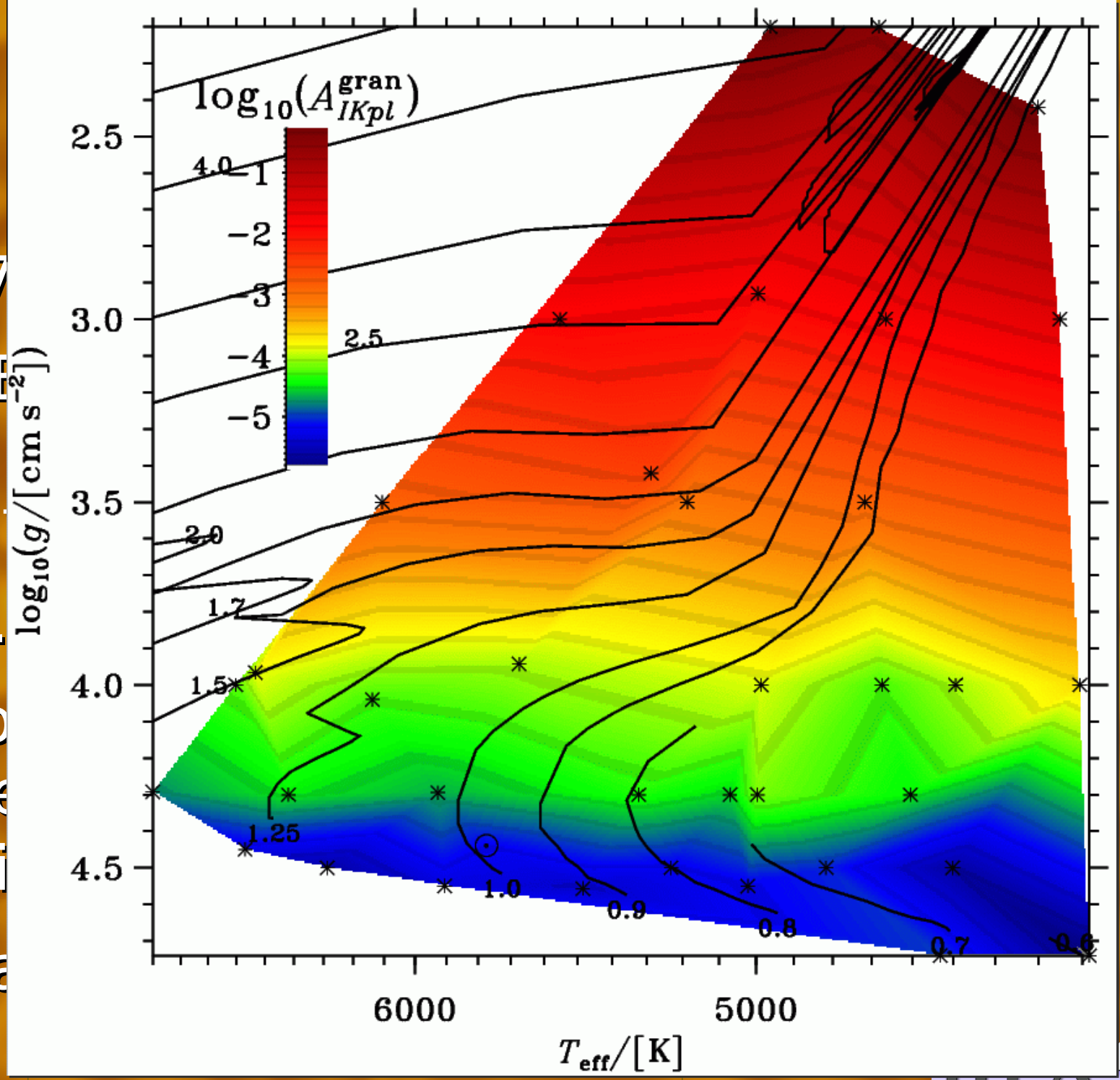

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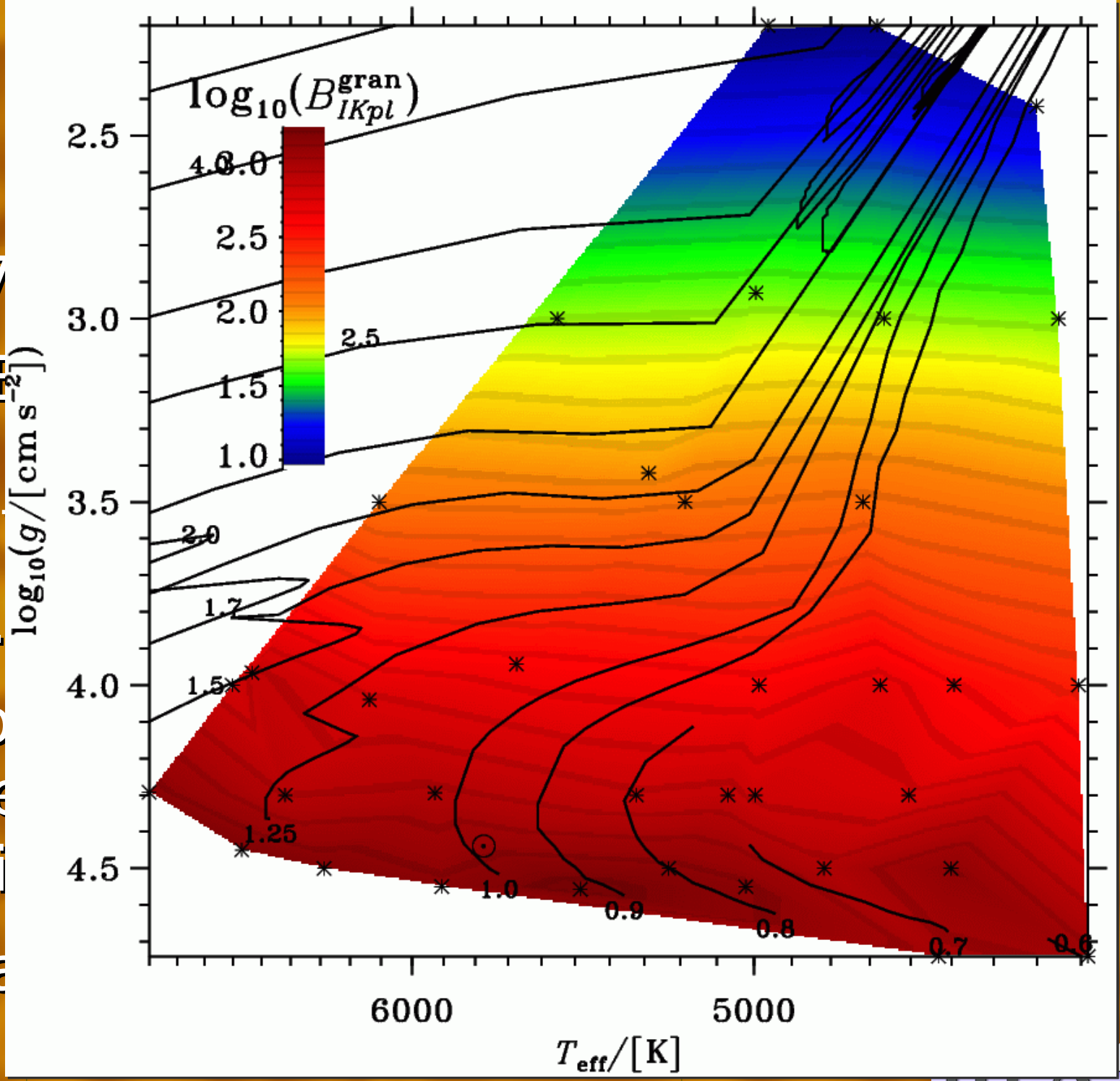
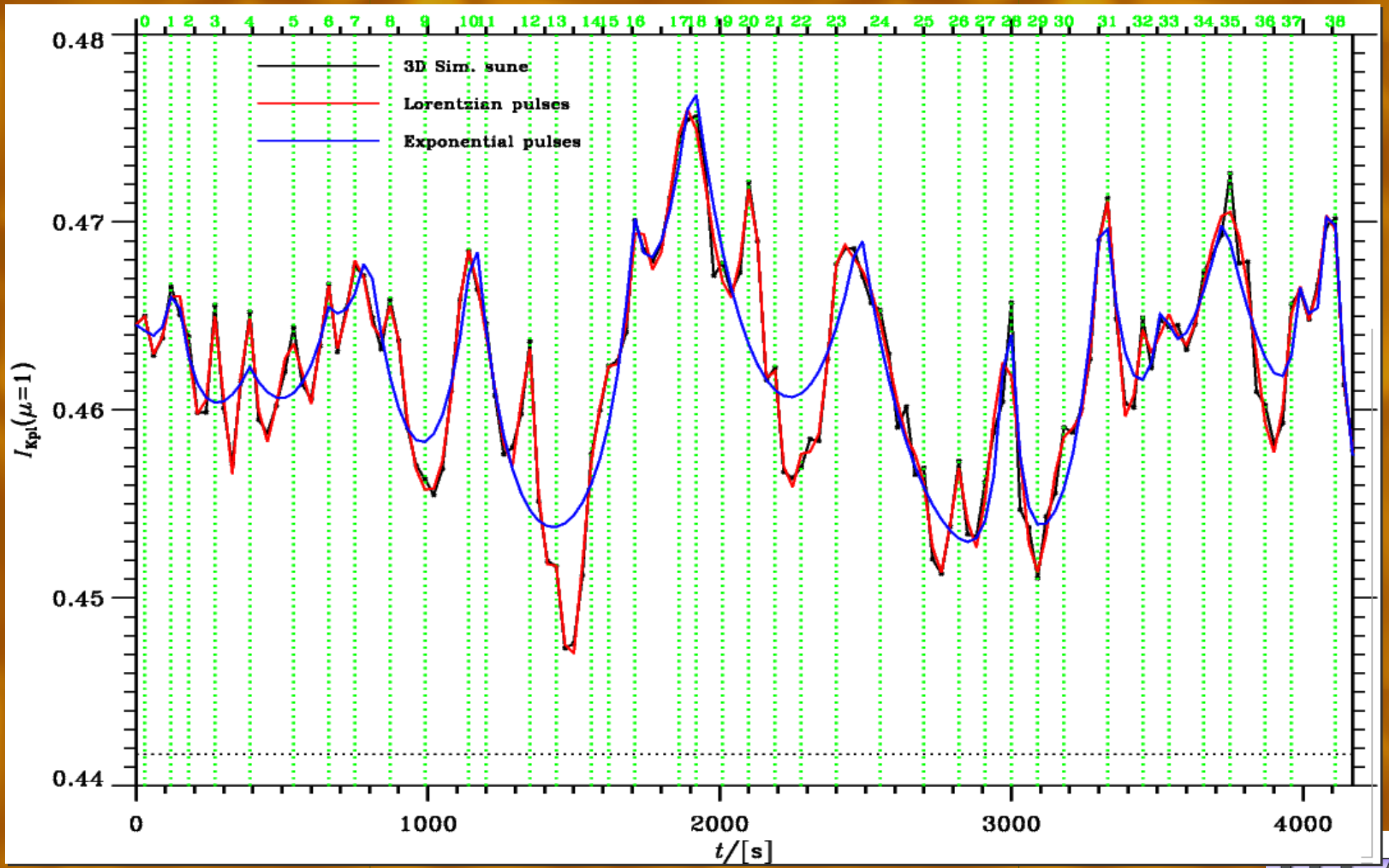


Time-series of solar simulation



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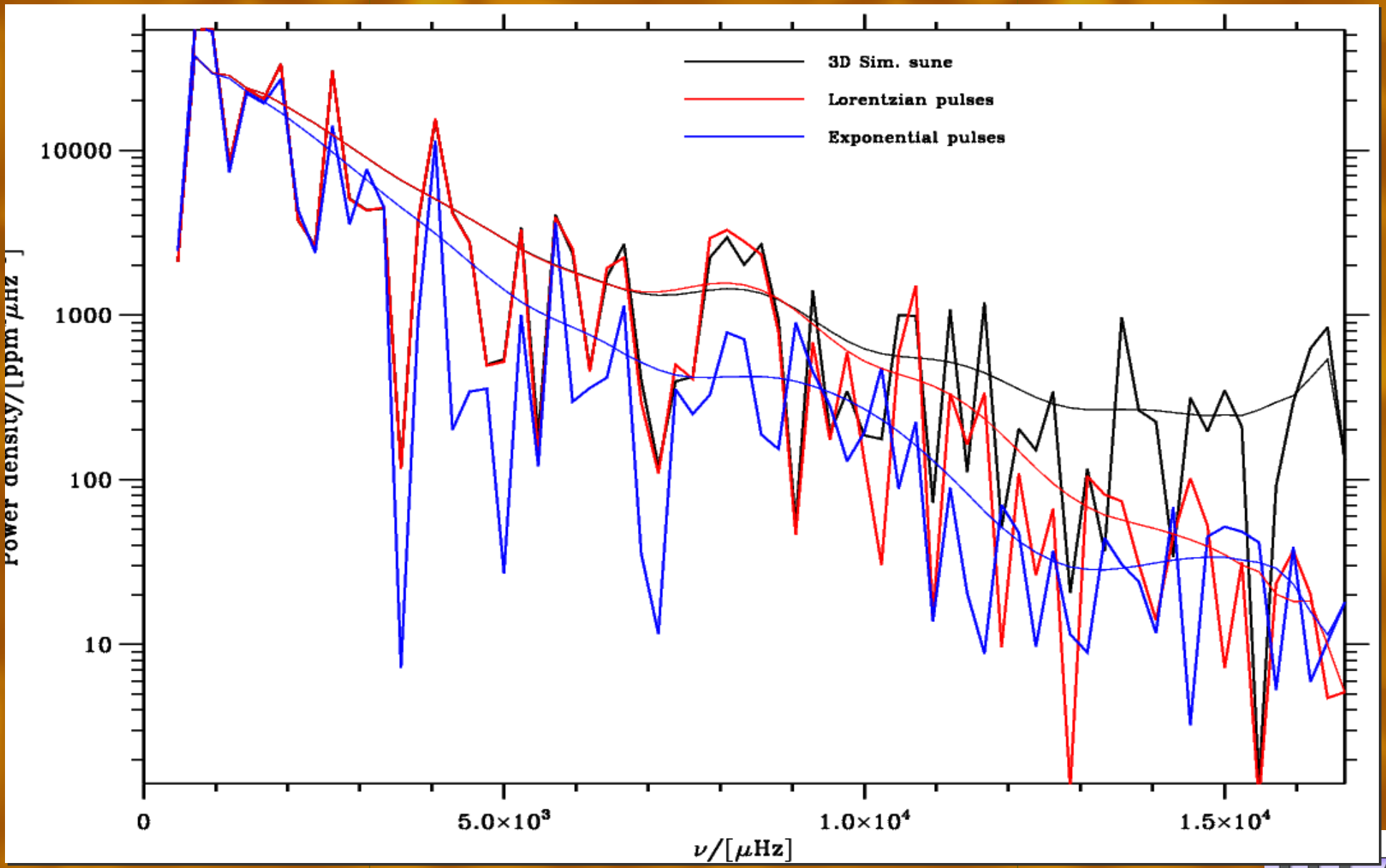
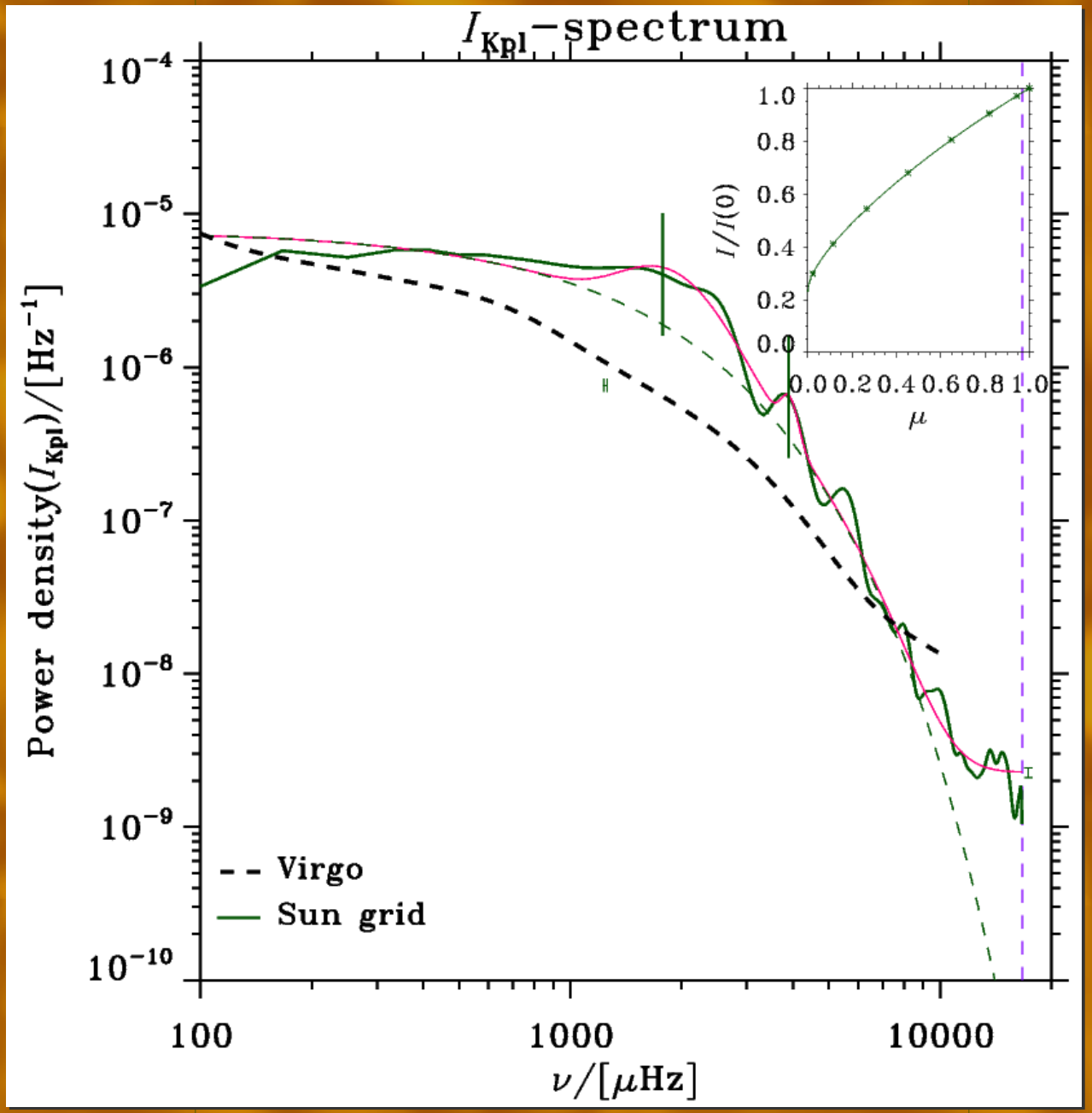


Global spectrum of solar sim.



Conclusions

- Harvey law results from 1-sided Exp. Pulse
- Original Harvey (1985) α=2-law rarely fit
- Time-series of Kepler stars and 3D conv. simulations show symmetric pulses.
- Well fit by Lorentzian pulses ⇒ Exponential power spectrum ⇒ 2 params.
- To fit spectrum well, need:
  - 2 granulation-like components
  - Gaussian envelope of p modes
  - White noise ⇒ 8 parameters