Higher Order PT

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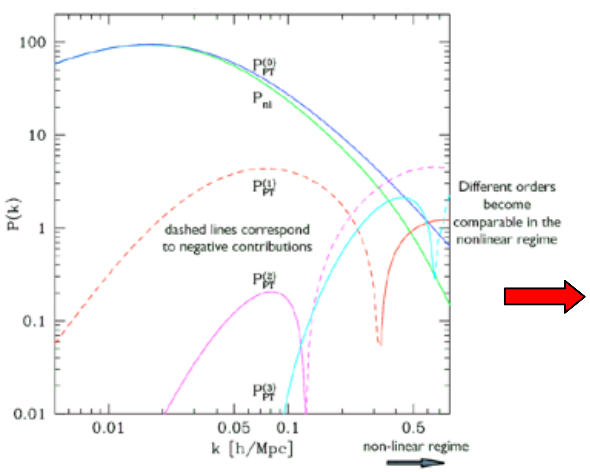
+ Roman Scoccimarro, Francis Bernardeau, Rob Smith, ..

Reconstruction of P(k) from Multi-point propagators

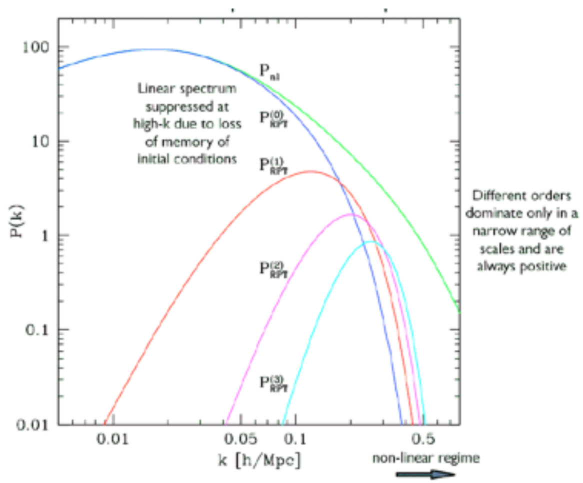
$$P_{ab}(\mathbf{k},\eta) = \sum_t t! \int \mathrm{d}^3\mathbf{q}_1 \ldots \mathrm{d}^3\mathbf{q}_t\, \delta_{\mathrm{D}}(\mathbf{k}-\mathbf{q}_{1\ldots t})\, \Gamma_a^{(t)}(\mathbf{q}_1,\ldots,\mathbf{q}_t;\eta)\, \Gamma_b^{(t)}(\mathbf{q}_1,\ldots,\mathbf{q}_t;\eta)\, P_0(q_1)\ldots P_0(q_t),$$

$$P(k) = [\Gamma^{(1)}(k)]^2 P_0(k) + 2\int d^3q\, [\Gamma^{(2)}(\mathbf{k}-\mathbf{q},\mathbf{q})]^2 P_0(|\mathbf{k}-\mathbf{q}|) P_0(q) + \ldots$$

- Sum of positive contributions



ZA power spectrum in standard PT



ZA power spectrum in multi-point expansion

Ansatze for MP propagators :

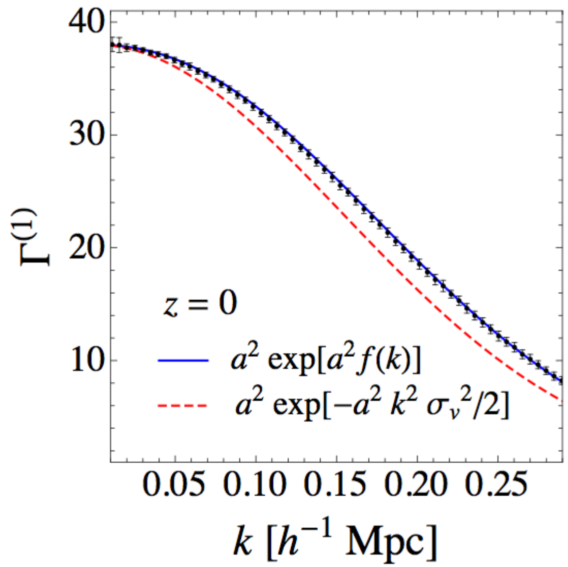
✓ $\Gamma^{(1)}(k,z) = G(k,z) \times D(z)$

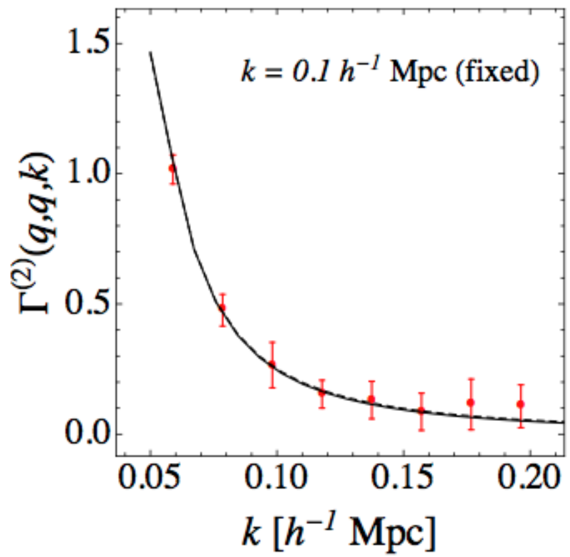
✓ $\Gamma^{(2)} = G(k,z) \times F_2$

✓ $\Gamma^{(3)} = G(k,z) \times F_3$

$$G = \exp\left[f(k) D^2(z)\right]$$

Testing the propagators





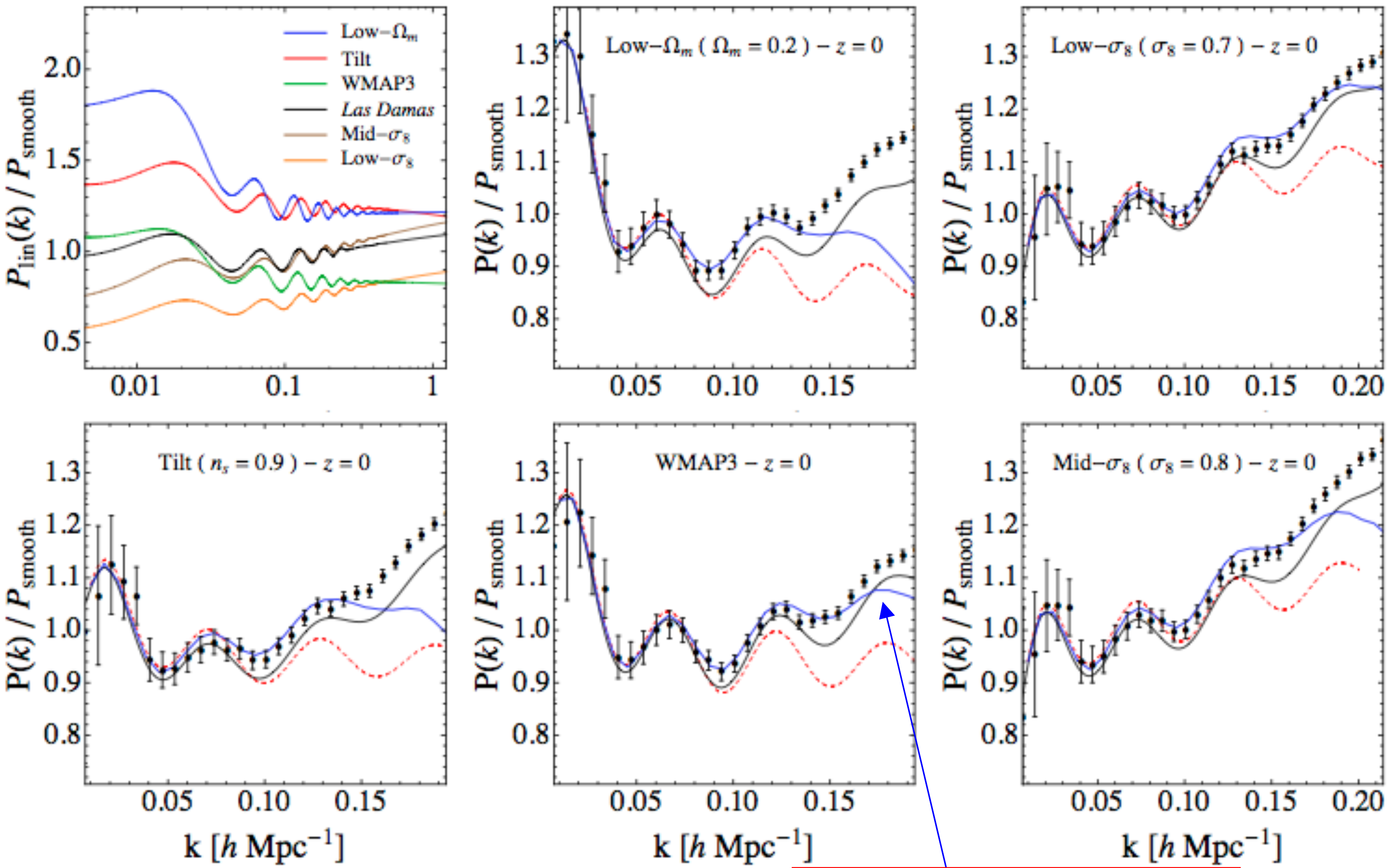
✓ Provided with the propagators we compute the expansion to two-loops

Suite of Cosmological Simulations

Run	Ω_m	Ω_b	h	σ_8	n_s	$L_{box}(h^{-1}\,\mathrm{Mpc})$	N_{runs}
FID	0.27	0.04	0.7	0.9	1	1280	50
tilt					0.9	1250	4
WMAP3	0.2383	0.0418	0.73	0.74	0.95	1250	4
Low-Ω_m	0.20					1250	4
Mid-σ_8				0.8		1250	4
Low-σ_8				0.7		1250	4
Las Damas	0.25	0.044	0.7	0.8	1	2400	4

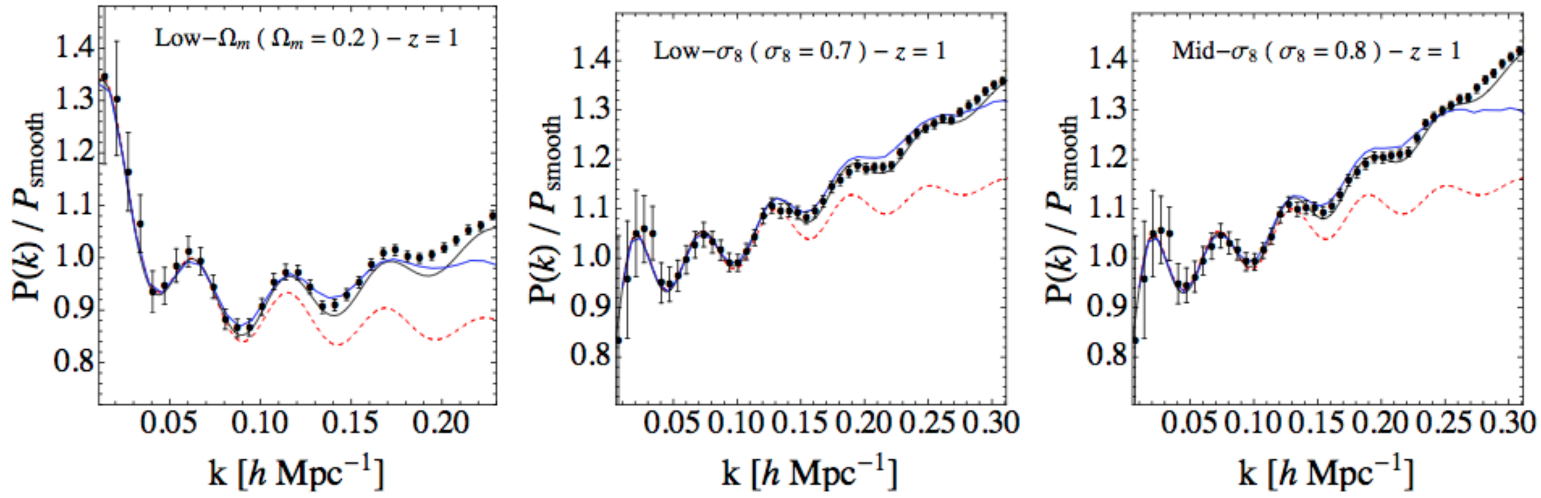
+ *w*CDM

Performance for different LCDM models - z = 0

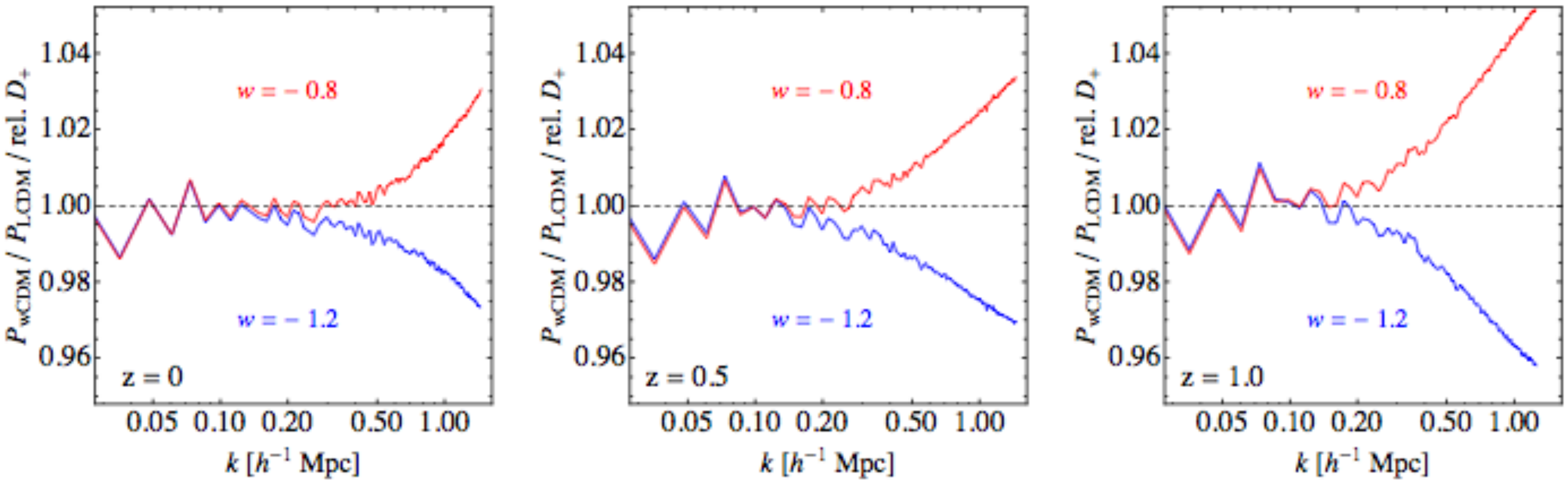


Few secs evaluation time

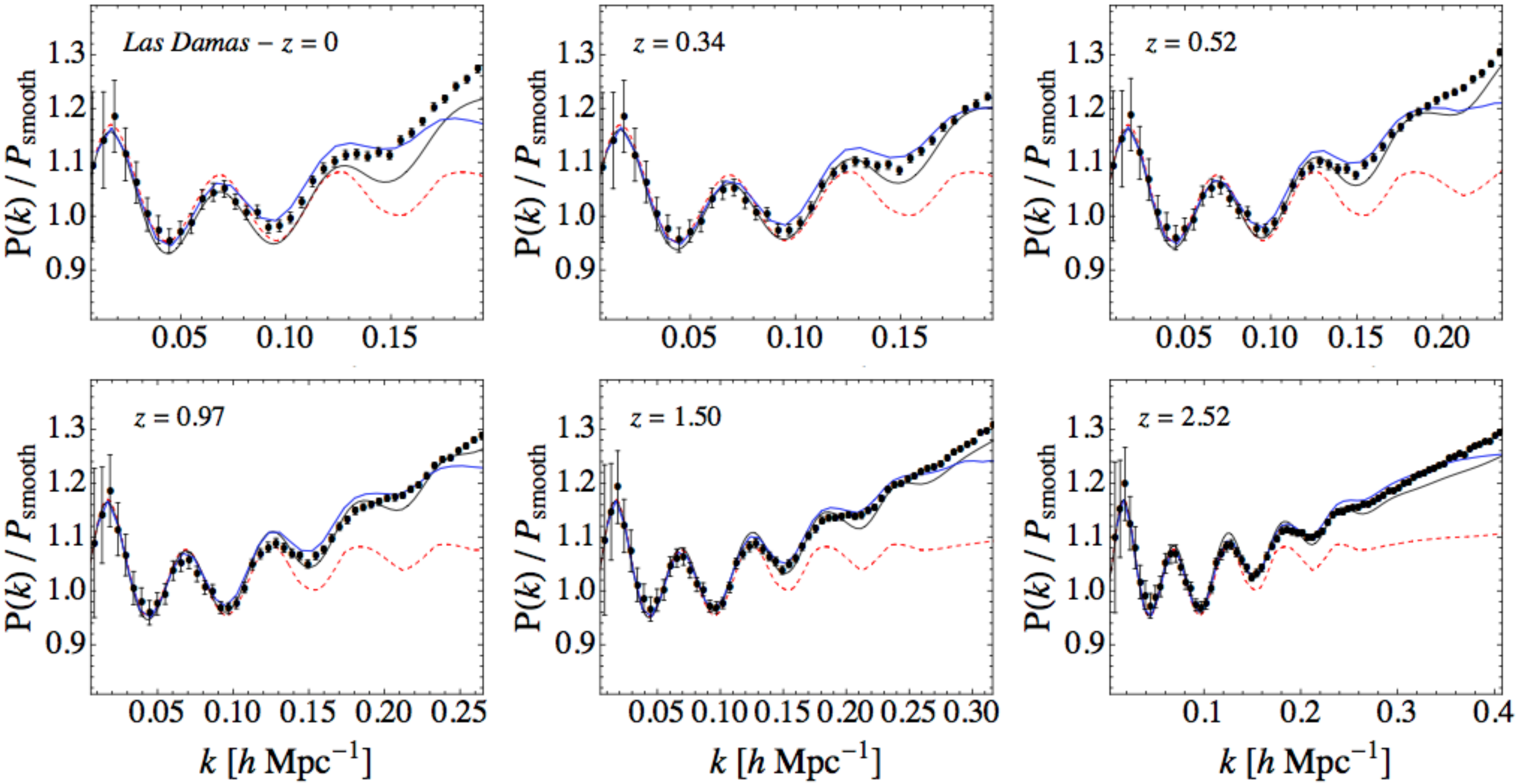
Performance for different LCDM models - z = 1



wCDM models



Comparison to Las Damas for several redshifts

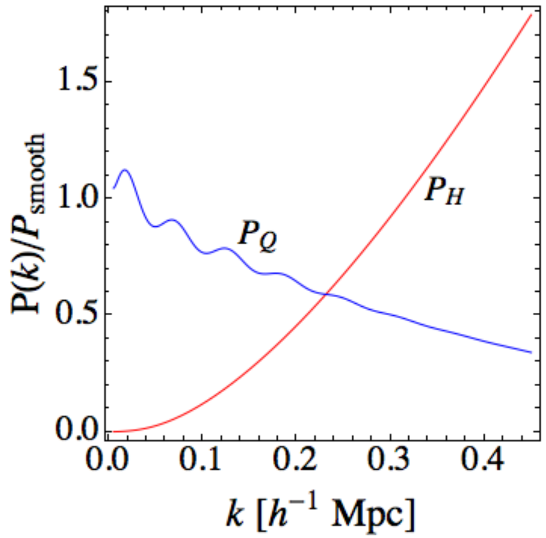


Beyond BAO - Coupling to Halofit

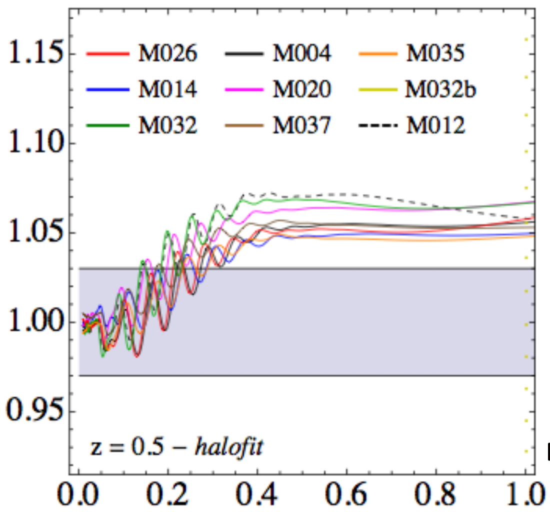
$$P_{NL}(k) = P_Q(k) + P_H(k)$$

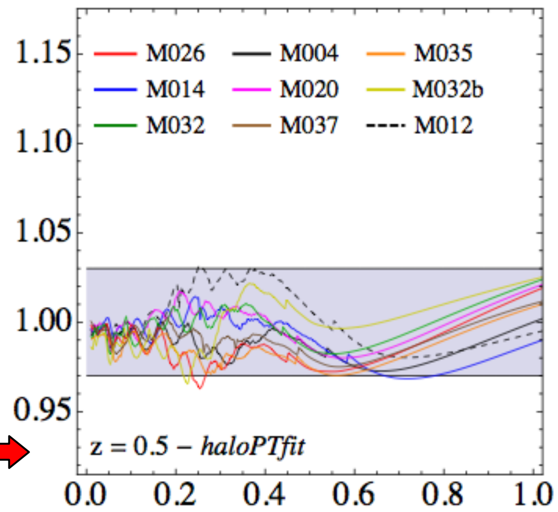
$$P_H(k) = \frac{P'_H(k)}{1 + \mu_n y^{-1} + \nu_n y^{-2}}$$

Replace quasilinear term with multi-point expansion and recalibrate the transition to the 1-halo part



Performance against Coyote Universe emulator





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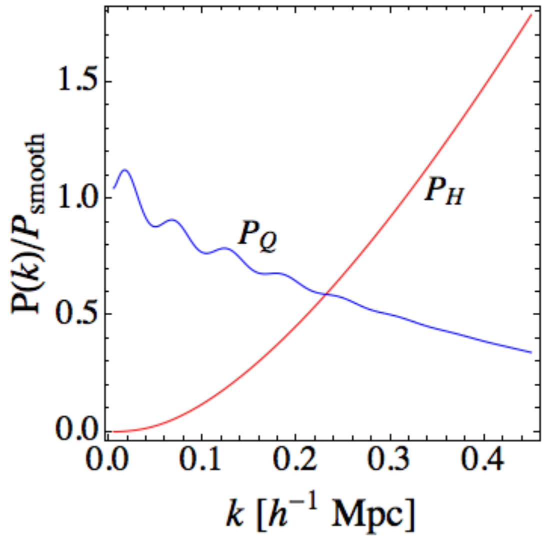
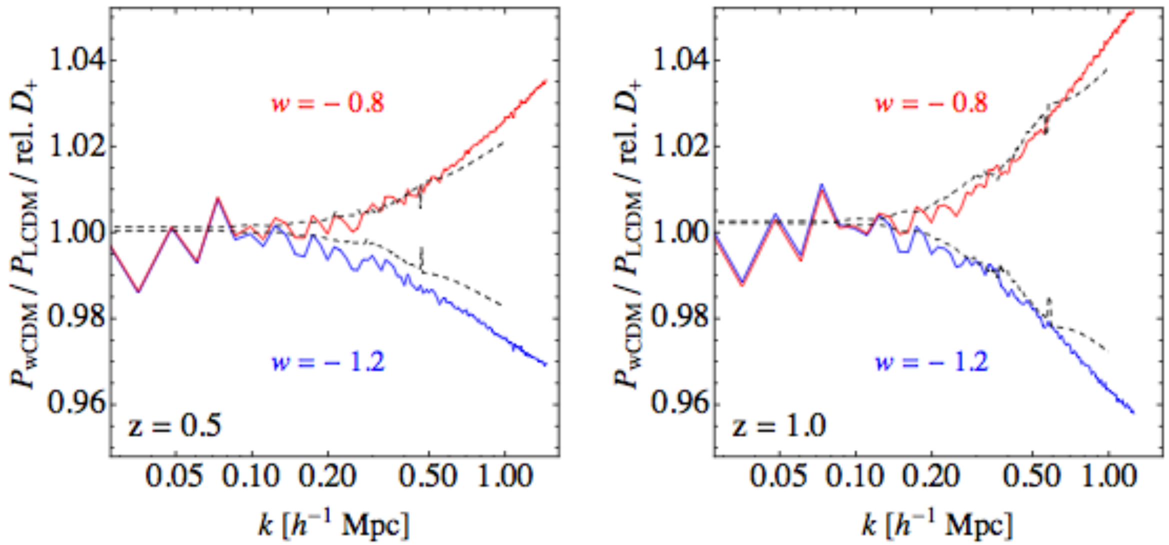


Performance against wCDM models



Velocity Divergence Power Spectrum

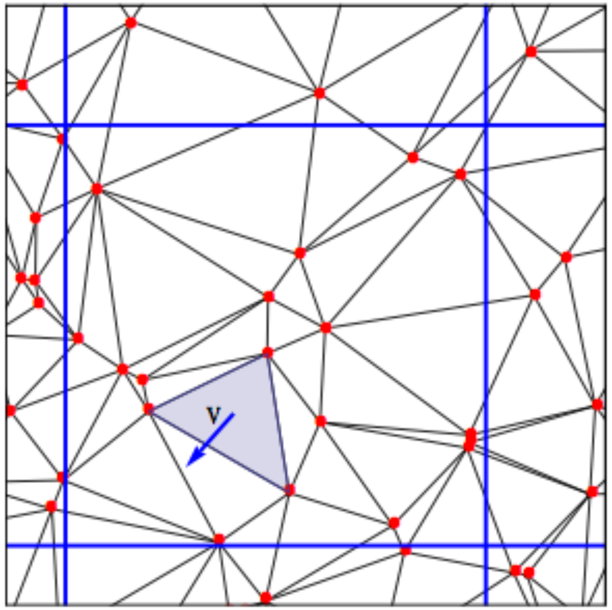
- Velocity divergence statistics is can be important to model RSD, e.g.

$$P_s(\mathbf{k}) = \left[P_{\delta\delta}(k) + 2f\mu^2 P_{\delta\theta}(k) + f^2\mu^4 P_{\theta\theta}(k)\right] \times \exp(-f^2 k_z^2 \sigma_v^2)$$

- Sensitivity of DE models to velocity spectra (see E. Jennings talk)

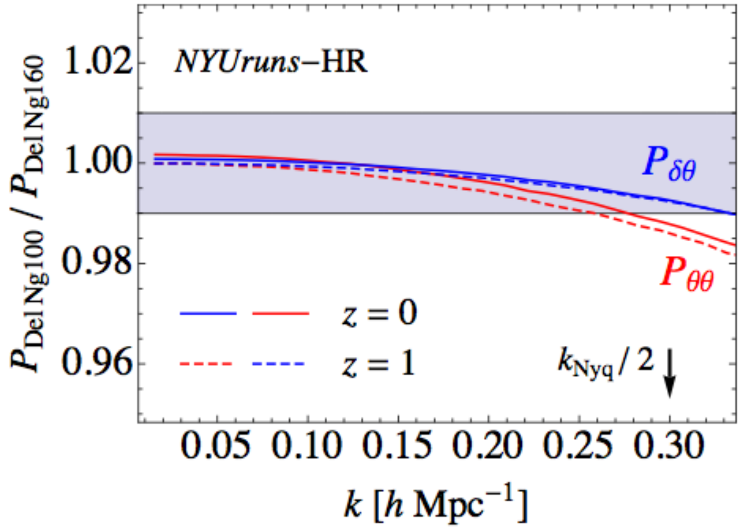
- Velocity divergence is a volume weighted quantity, it's hard to estimate because a priori we only know the velocity wherever there is a particle, what leads to a mass weighting scheme (i.e. momentum).

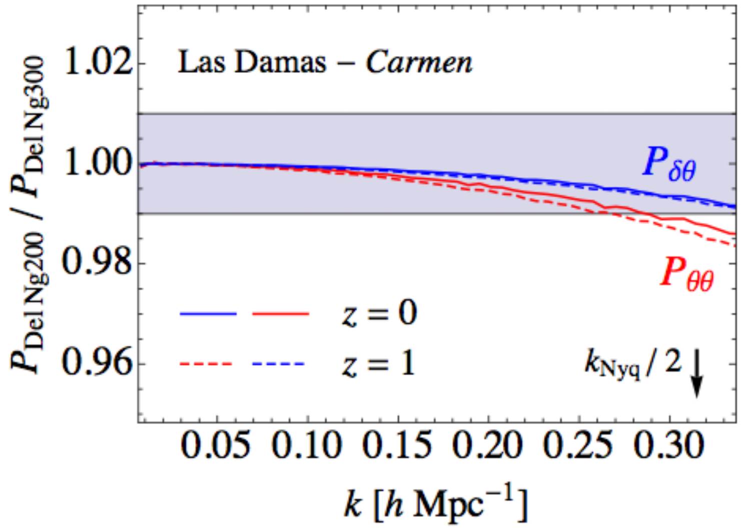
Use of Delaunay Tesselation



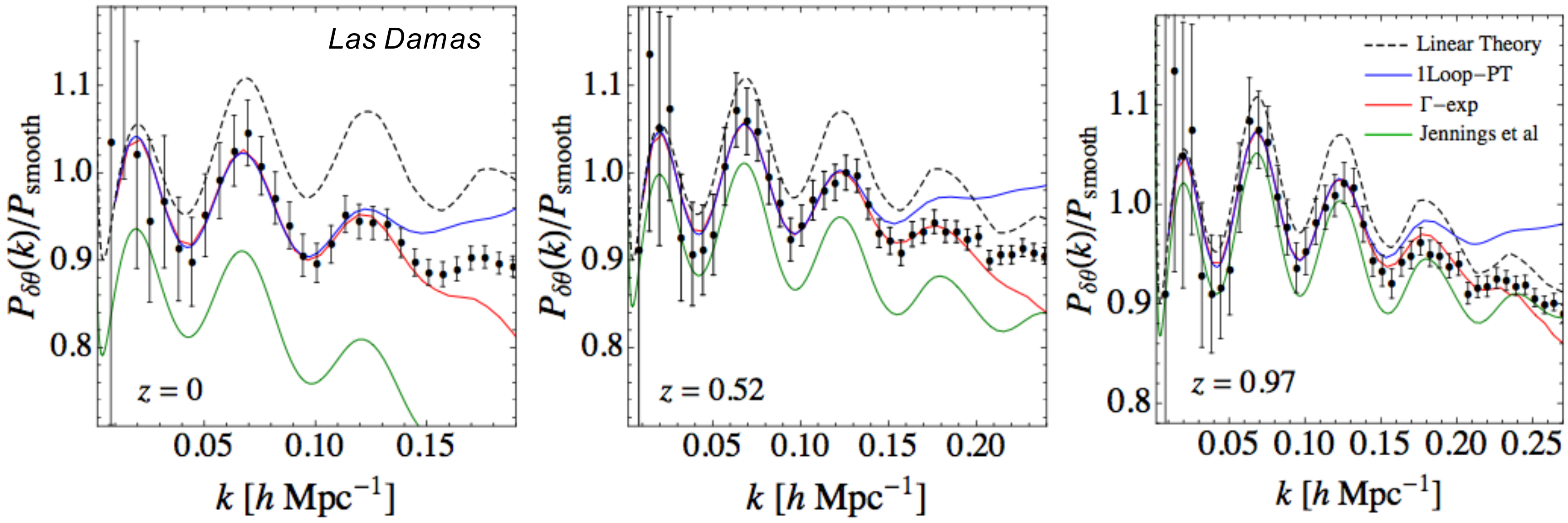
$$\mathbf{v}_i = \frac{\sum_{j=1}^{N_{Del}} \mathbf{v}_j vol_j}{\sum_{j=1}^{N_{Del}} vol_j}$$

Once the Tesselation is done the velocity field is computed in each Delaunay volume by linear combination of the velocity at the vertices, Then interpolated onto a grid (in blue) weigh... by the volume





Cross Velocity-Density power spectrum



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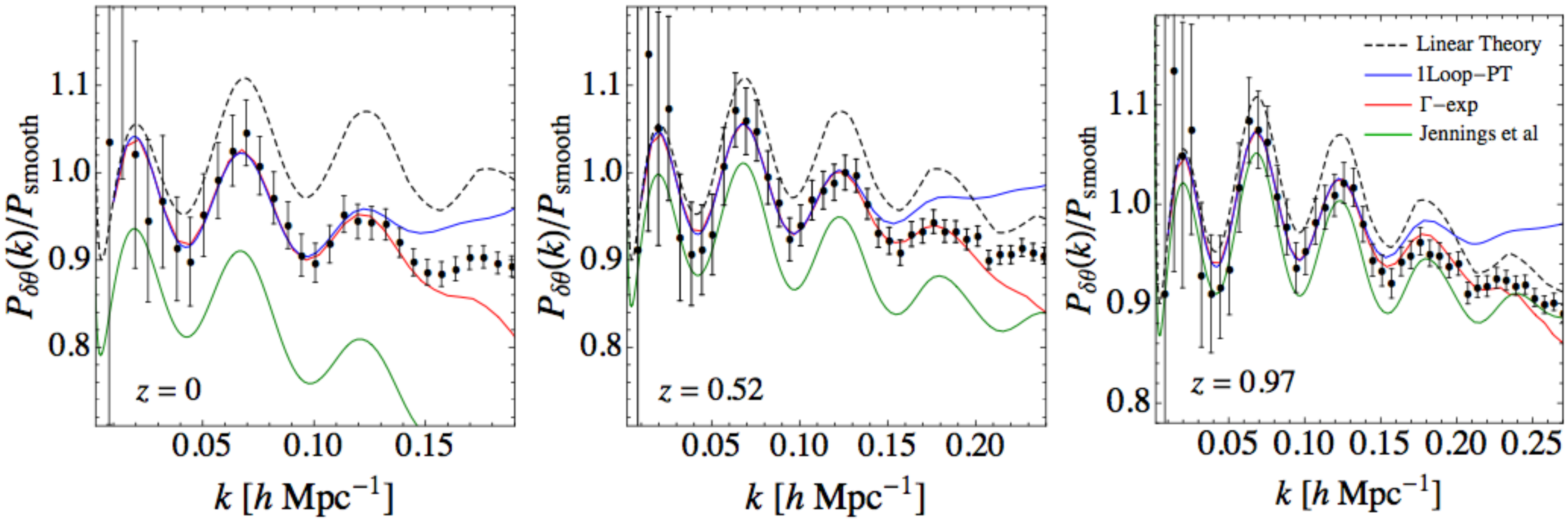
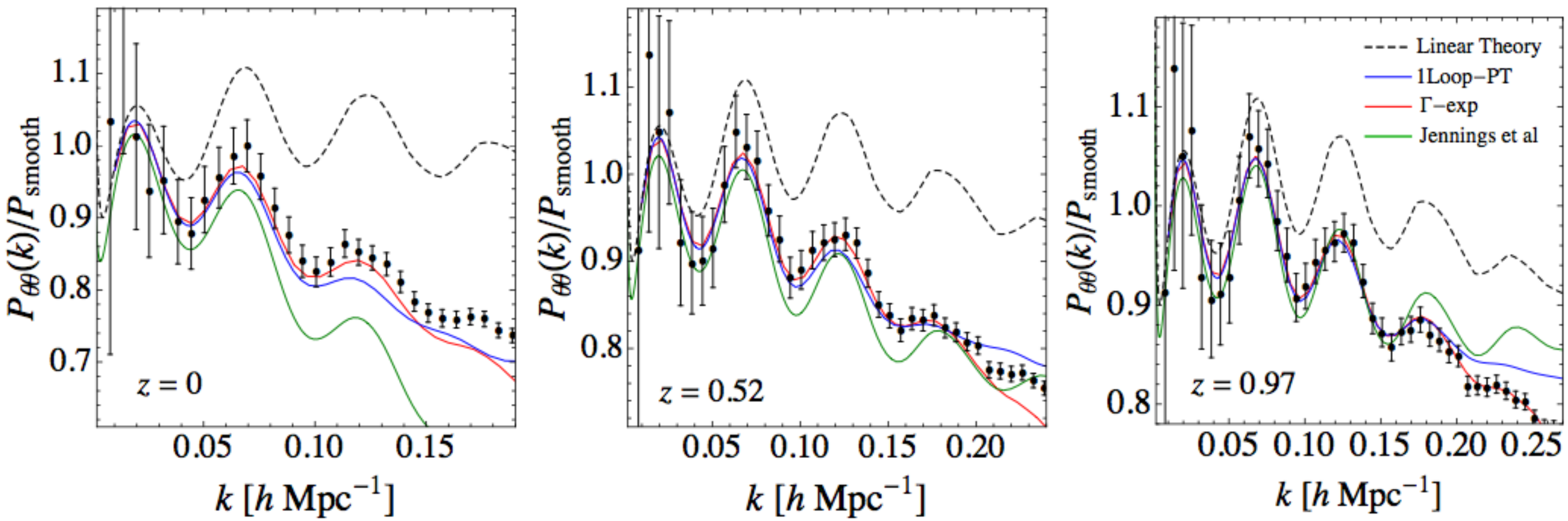


Velocity-Velocity power spectrum



Conclusions

- ✓ The multi-point expansion can be executed in few seconds, fast enough for typical parameter sampling. Accurate at ~ 2% on BAO scales.
  Code publicly available http://maia.ice.cat/crocce
- ✓ Description of smaller scales could be done by coupling multi-point exp with Halofit
- ✓ Tested with dedicated simulations of different cosmological models, including wCDM
- ✓ Quite robust of velocity divergence statistics, multi-point expansion can also be used here .. Impact on RSD ?