From Charles^X to IC^3: from Finite Volume to Spectral Difference LES

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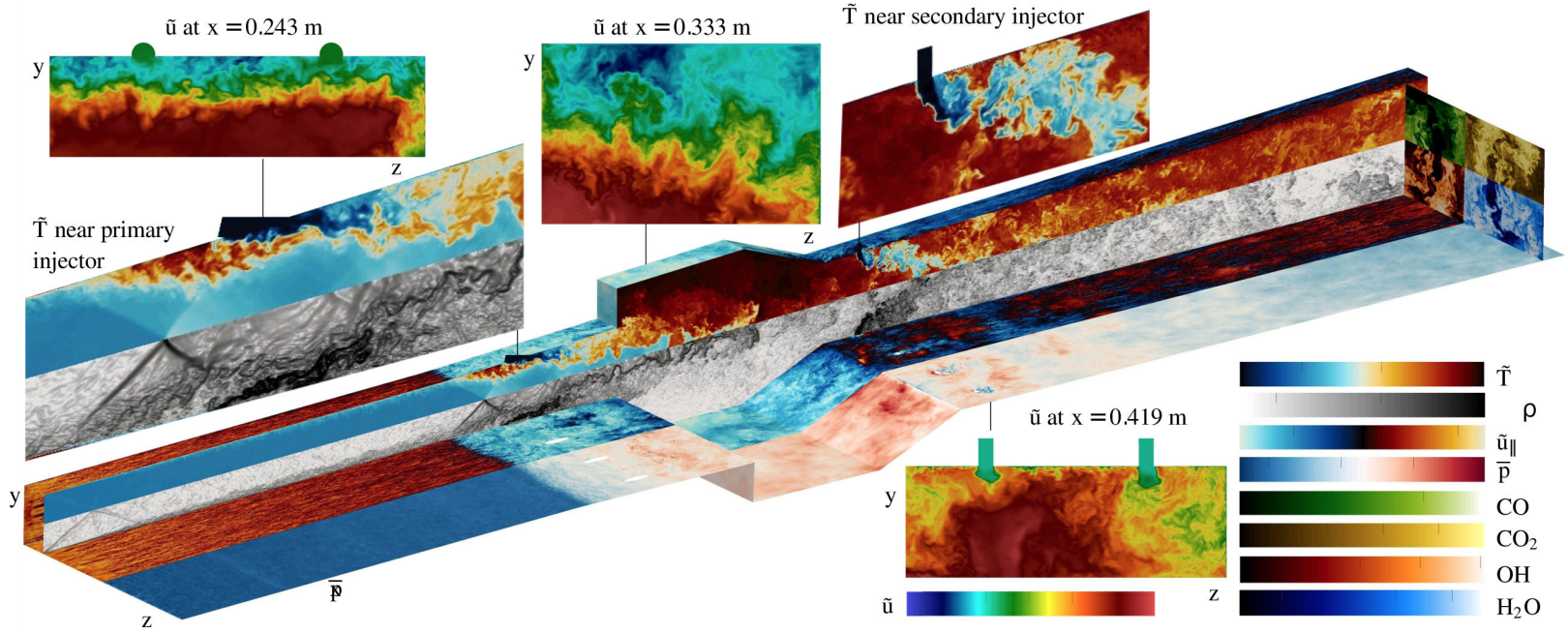
DAEP/ISAE-SUPAERO

Past applications (FV solver Charles^X)

I. Bermejo Moreno (2013) et al.

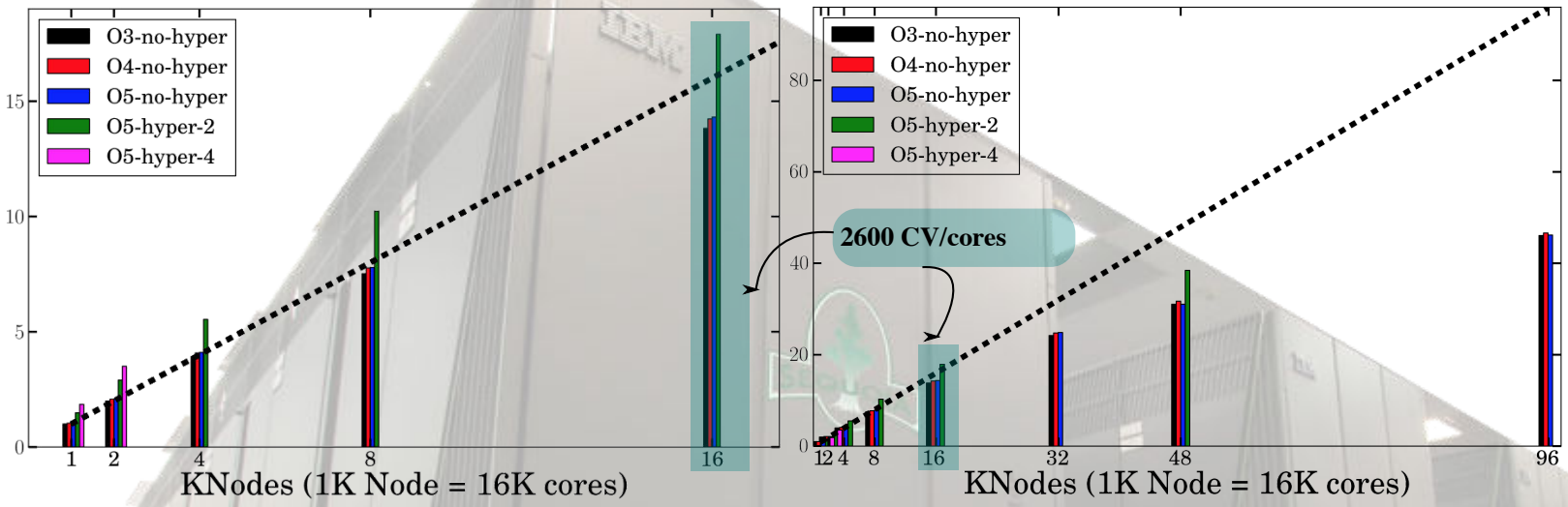


Hifire Scramjet(PSAAP program)

Uncertainty quantifications applied on scramjet unstart at Stanford

Performance of the finite volume solver

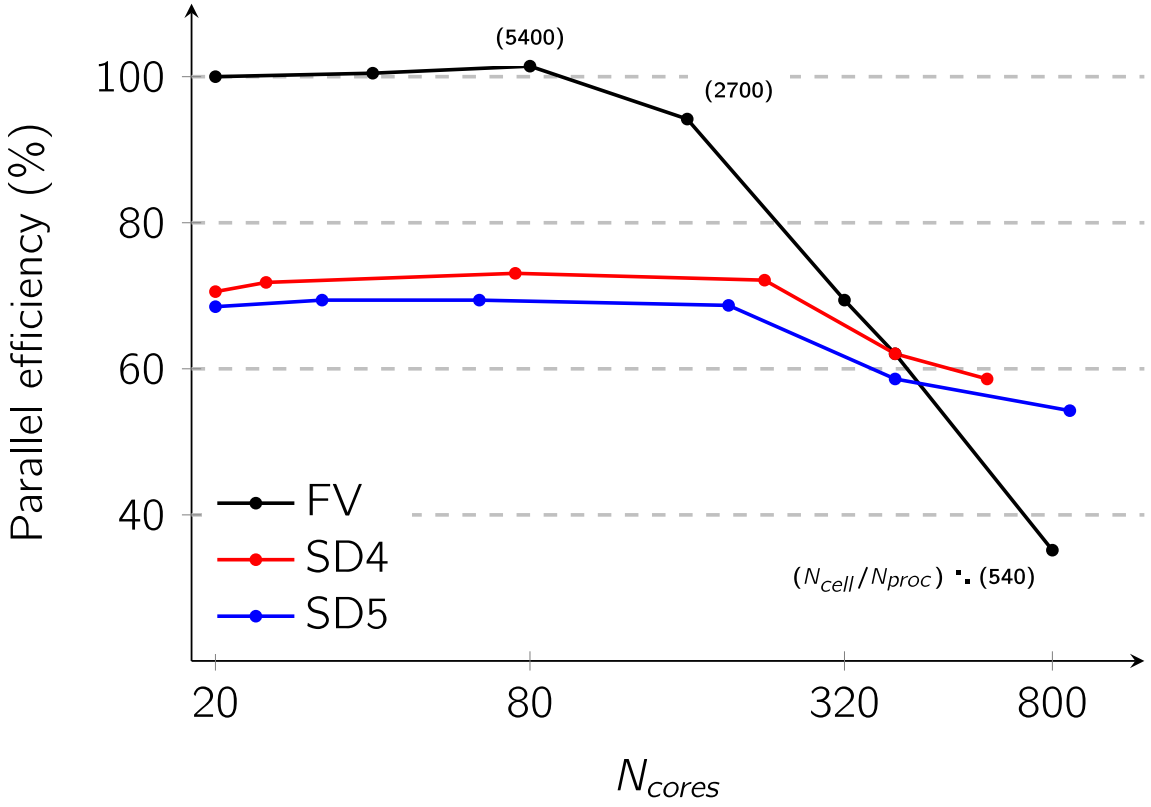
(2013) Pushing the strong scaling as far as we could...



Scaling on Sequoia Supercomputer(Livermore National Lab):

- up to 96K nodes = 1.5 million cores
- **as low as 450 CV/core**
- Good scaling up to 2600 CV/core

Scalability limits FV vs SD



Spatially weighted projections for discontinuities treatment adapted to compact high-order schemes.

Monday, CS 930, 4.30pm

A fair performance comparison between HO and classical FV schemes for unstructured grids and complex turbulent flows *Tuesday, CS 500, 4.30pm*

Channel flow test case

Charles^X - Compressible NS LES *unstructured*

- 2nd to 4th order/ skew-symmetric form of the advective term
- Left/Right states uses(n_{faces}+1) points stencil
- Convective flux: Blending between fully centered and approximate Riemann solver *based on mesh quality* (Structured mesh: **>99%** centered)
- Vreman model

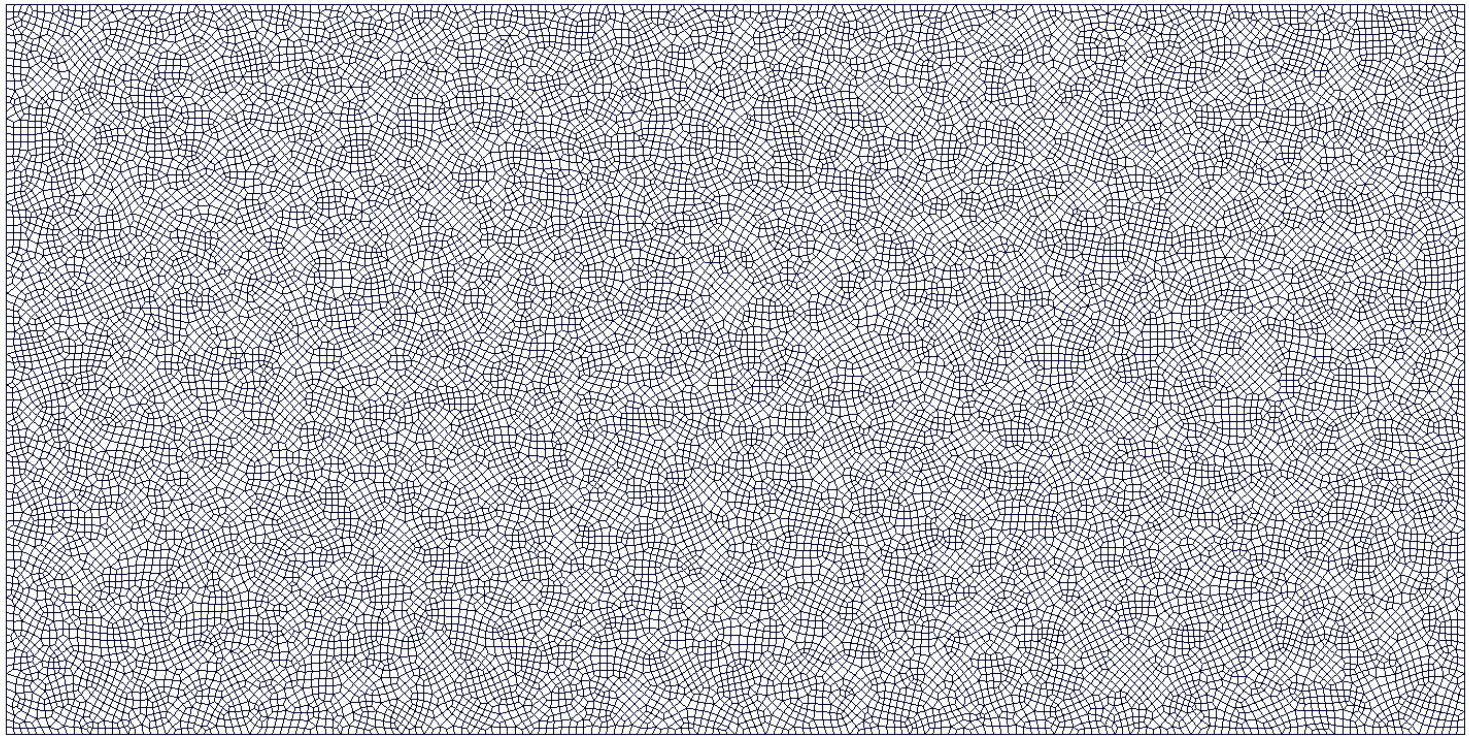
Hybrid - Compressible NS DNS/LES *structured*

- Order 6 centered derivatives for diffusion and advection operators.
- Dynamic Smagorinsky LES model
- *Disclaimer:* not expert user

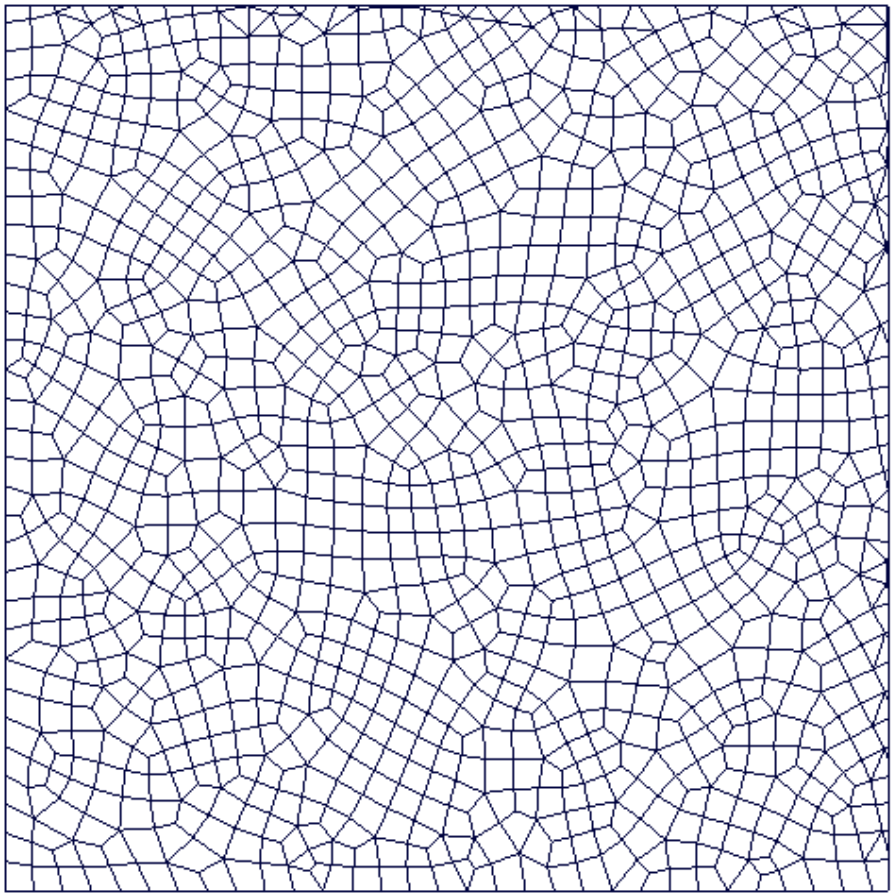
Grid resolutions

Type	Resolution	ID	Number of dof	$\Delta x^+ \times x \Delta y^+ \times \Delta z^+$	Solver
Struct.	Fine	MS1	256x96x128	14.5x0.7x14.5	FD6,FV2
Struct.	Baseline	MS2	192x96x96	19.3x0.7x19.3	FD6,FV2
Struct.	Coarse	MS3	128x96x64	29x0.7x29	FD6,FV2
Unstruct.	Fine	MU1	-x96x-	14.5x0.7x14.5	FV2
Unstruct.	Baseline	MU2	-x96x-	19.3x0.7x19.3	FV2
Unstruct.	Coarse	MU3	-x96x-	29x0.7x29	FV2

Unstructured grid(x/z direction)

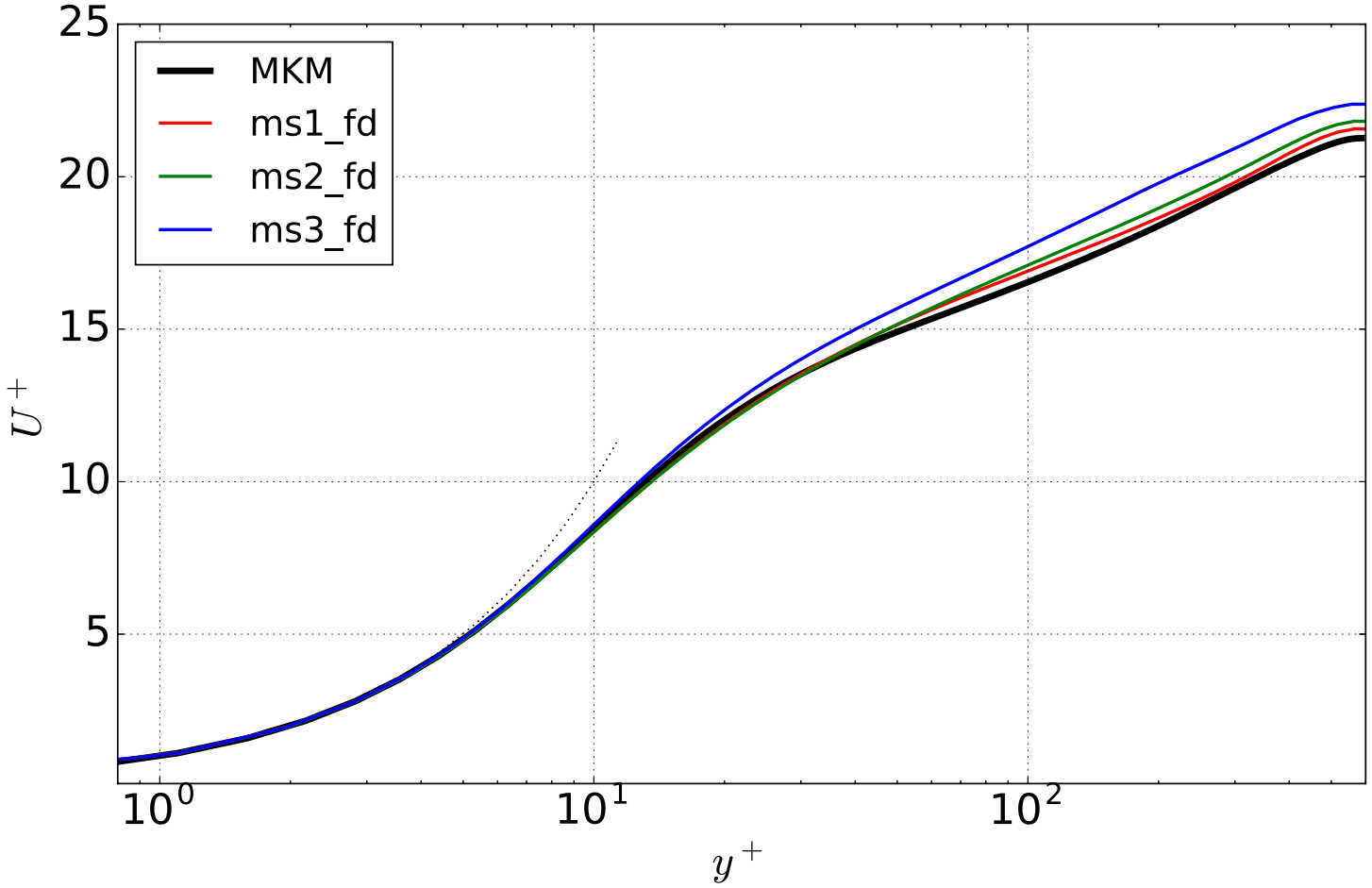


Unstructured grid(x/z direction)

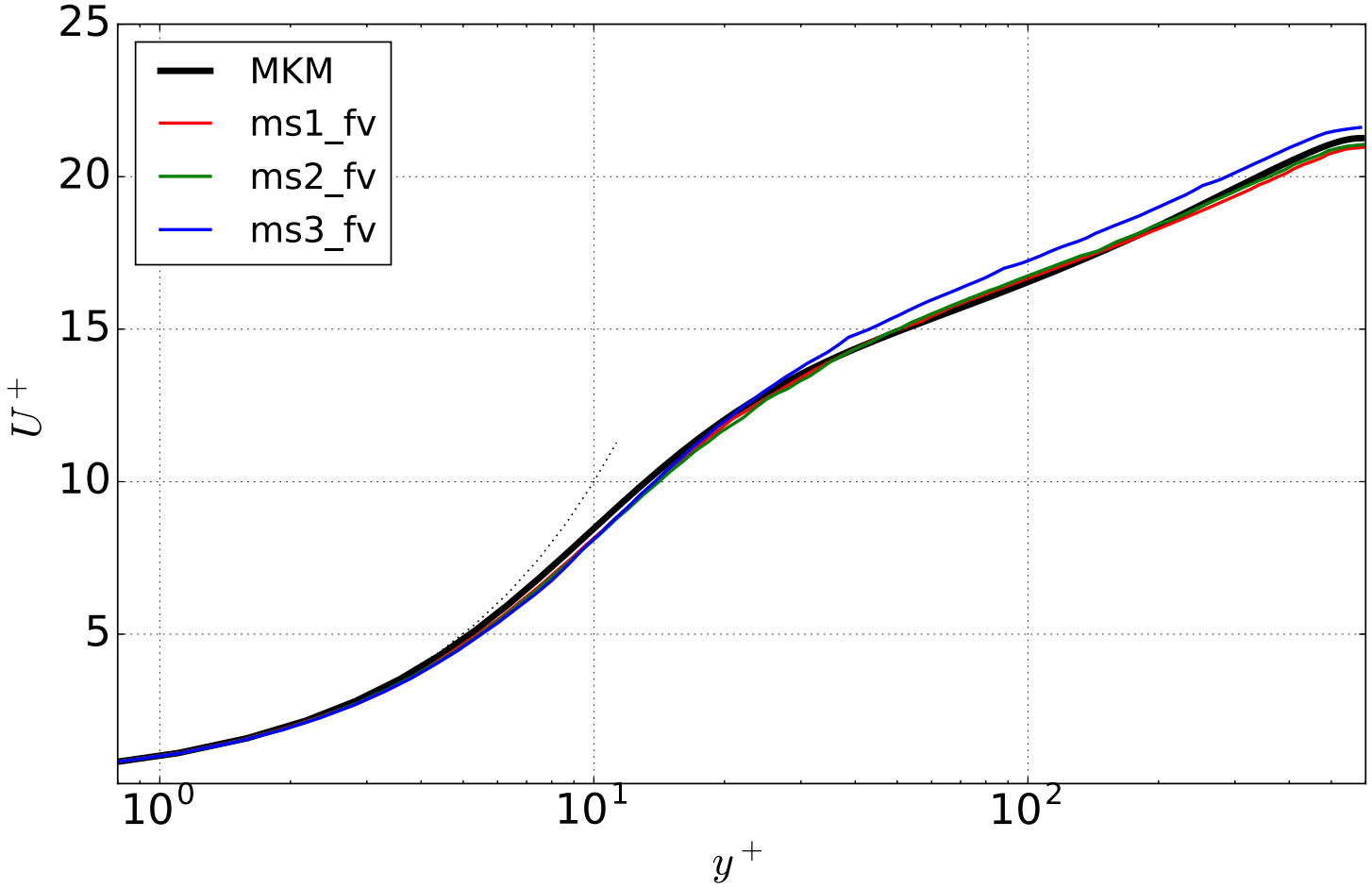


1x1 Zoom

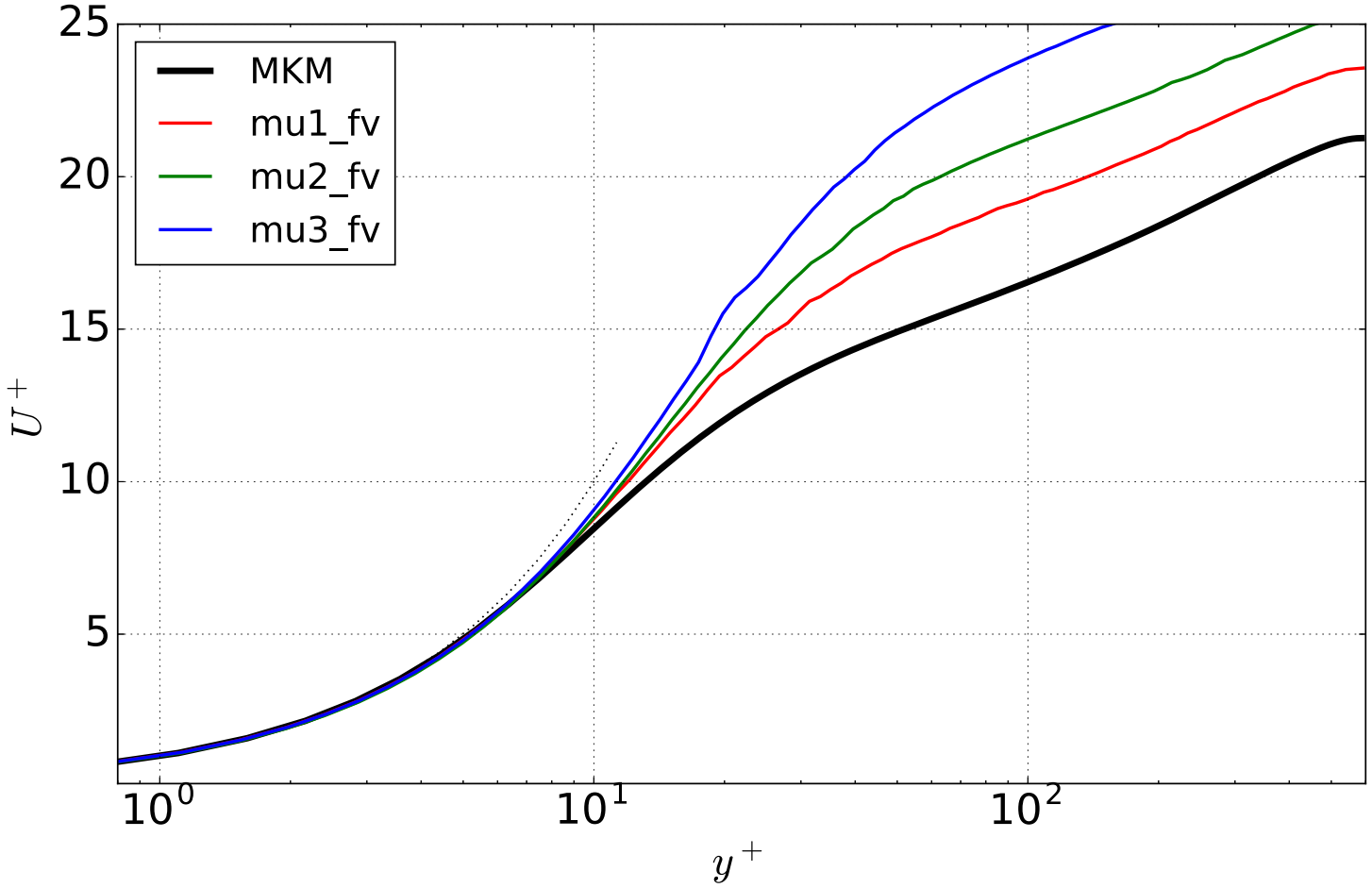
Results (Velocity, FD, MS)



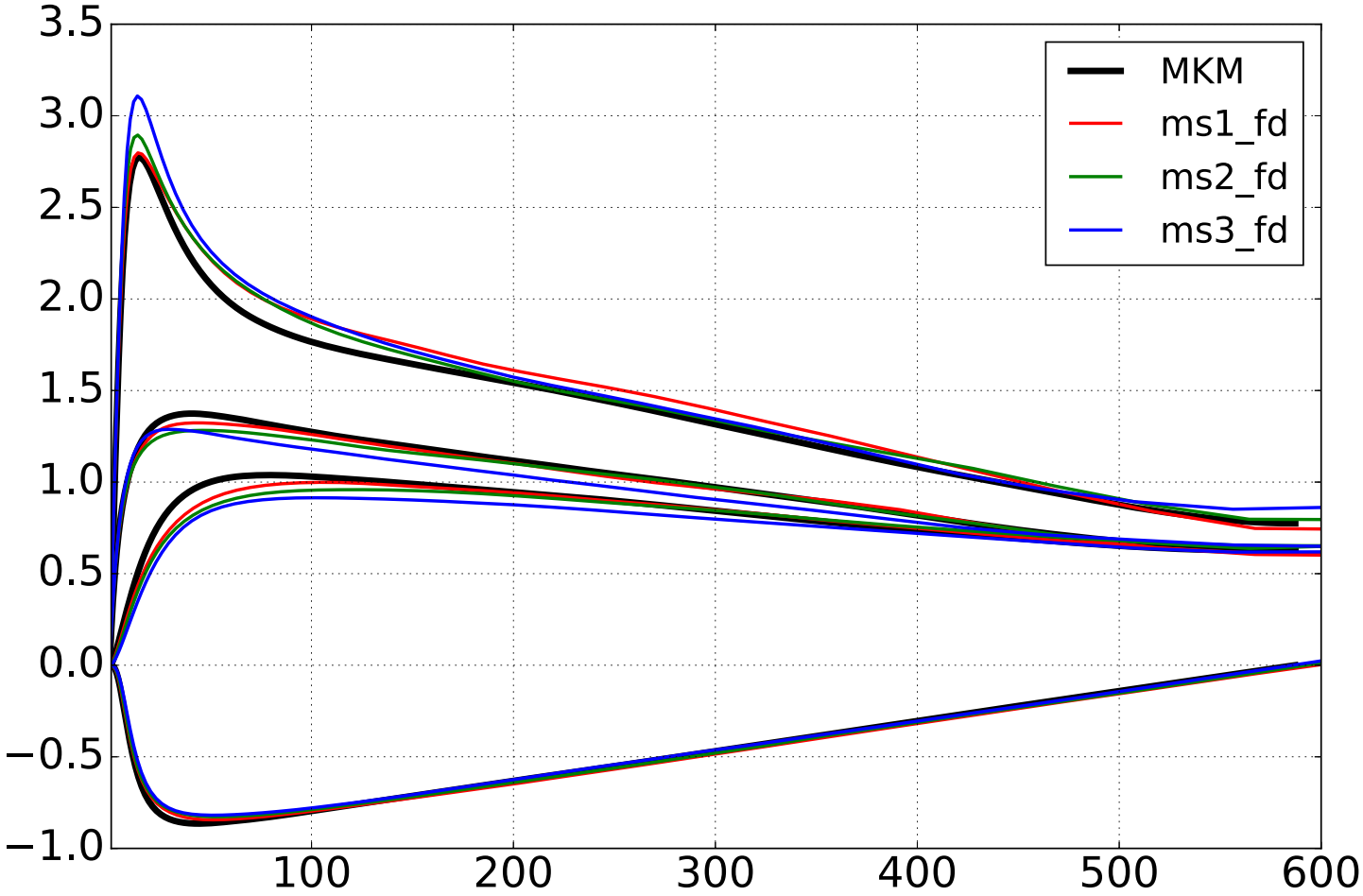
Results (Velocity, FV, MS)



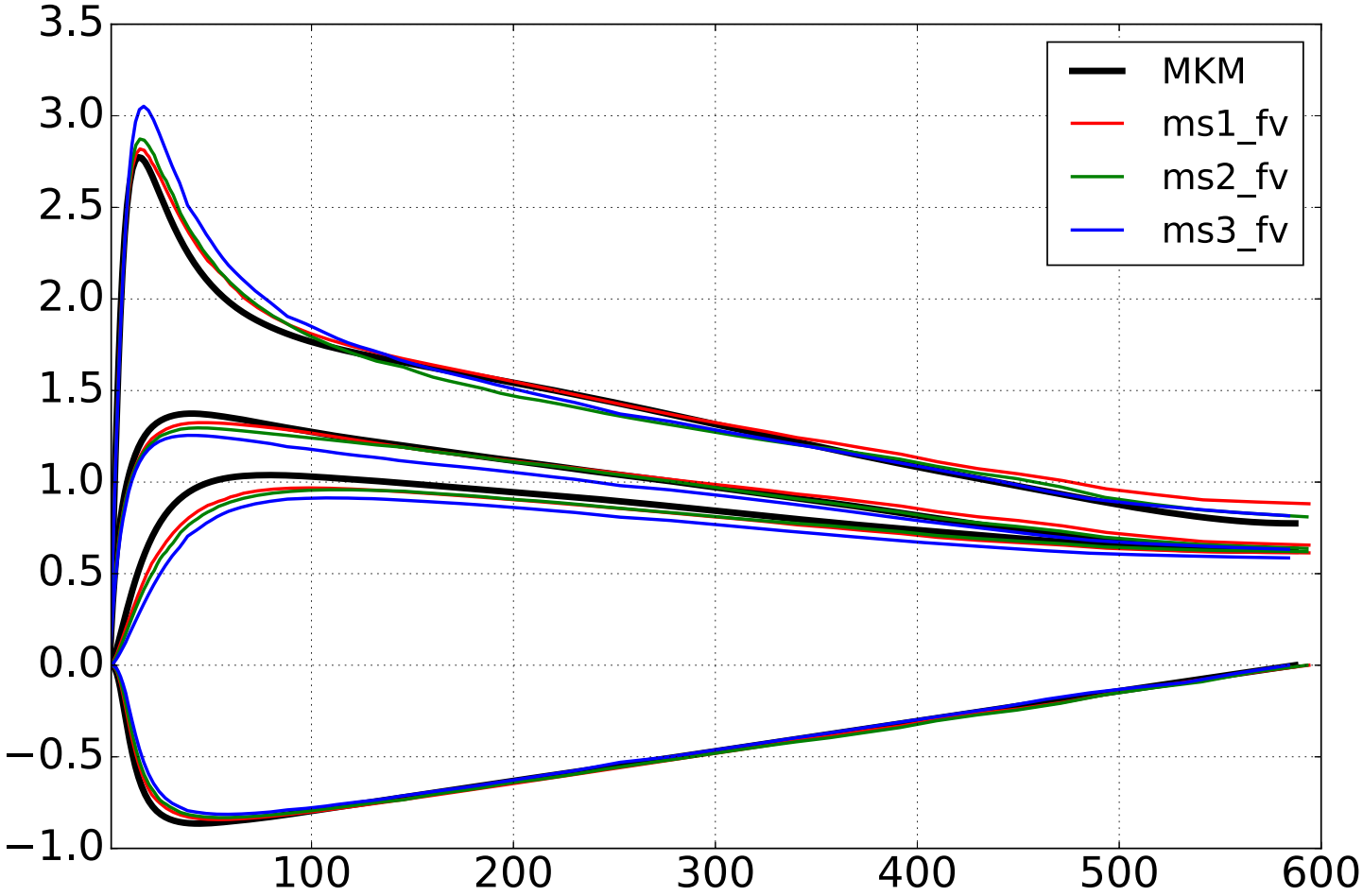
Results (Velocity, FV, MU)



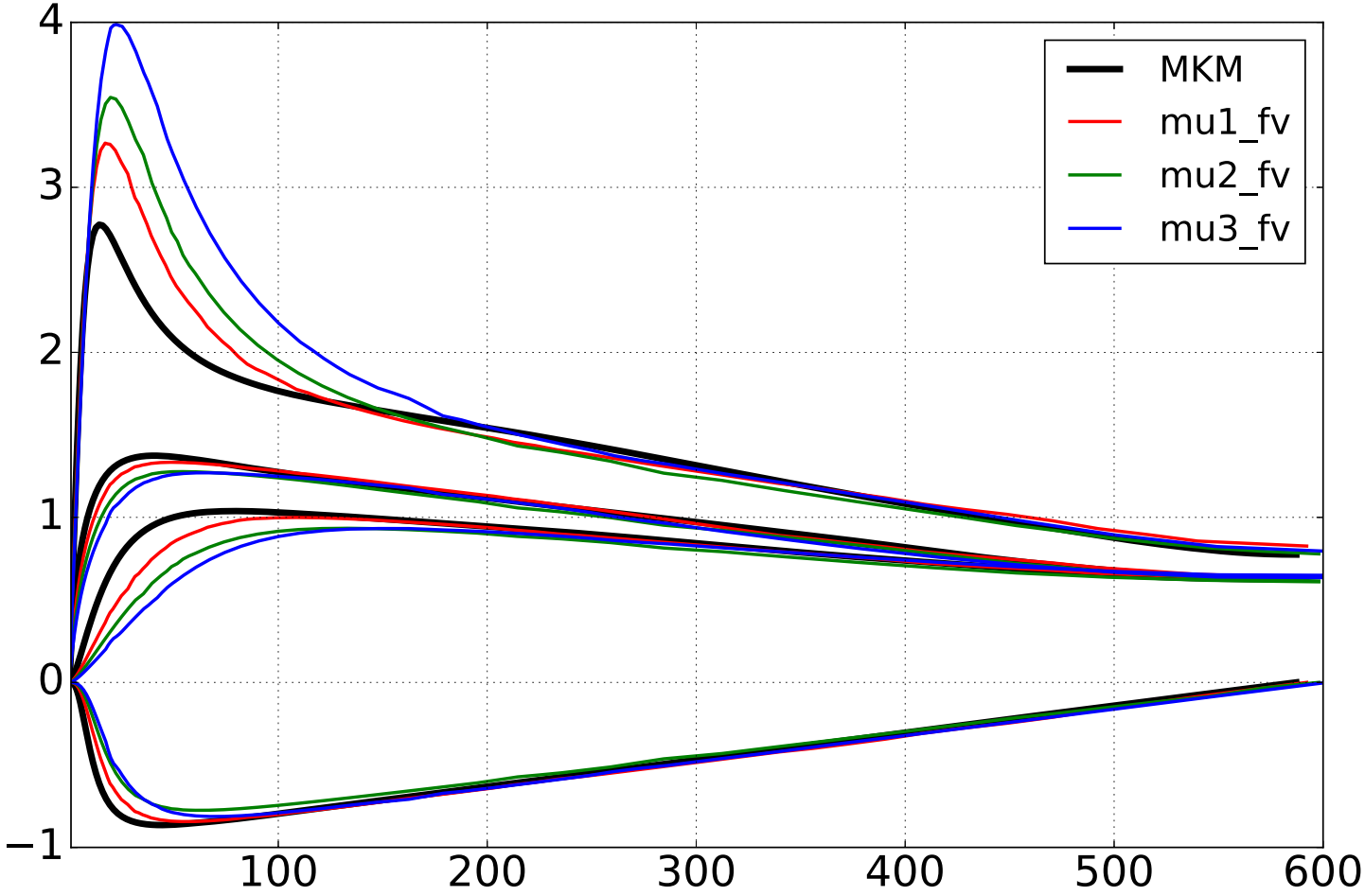
Results (Reynolds stress, FD, MS)



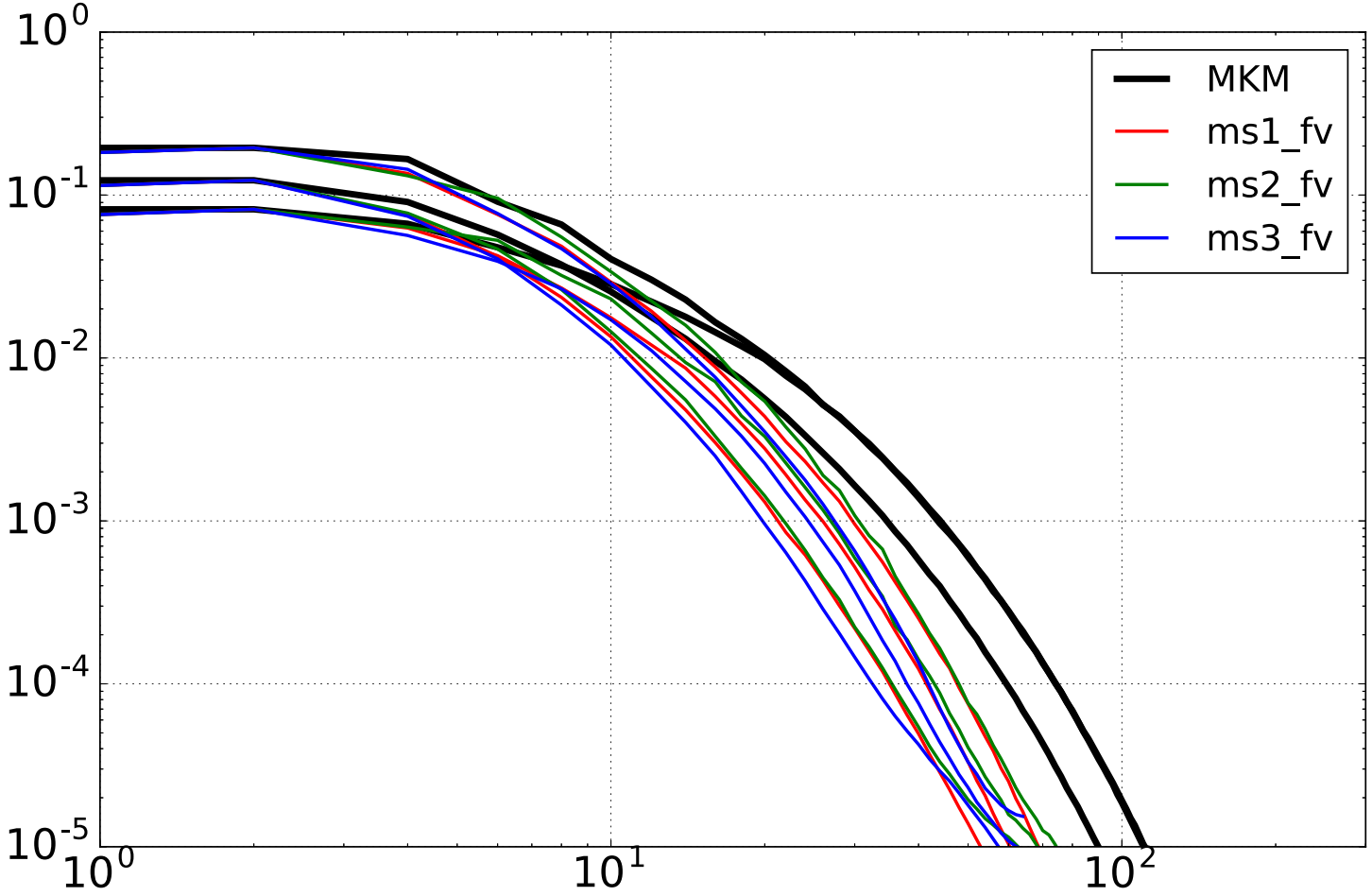
Results (Reynolds stress, FV, MS)



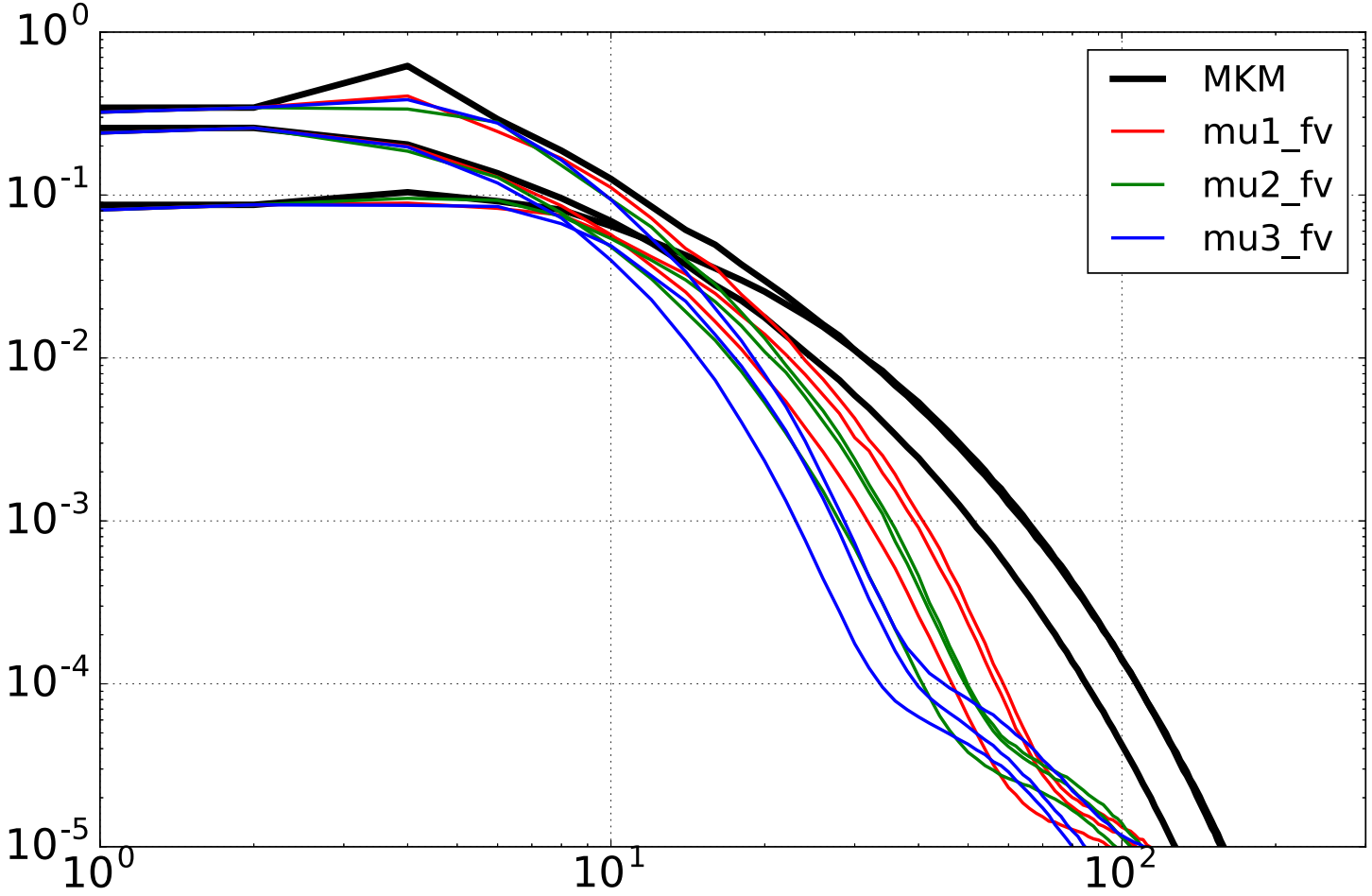
Results (Reynolds stress, FV, MU)



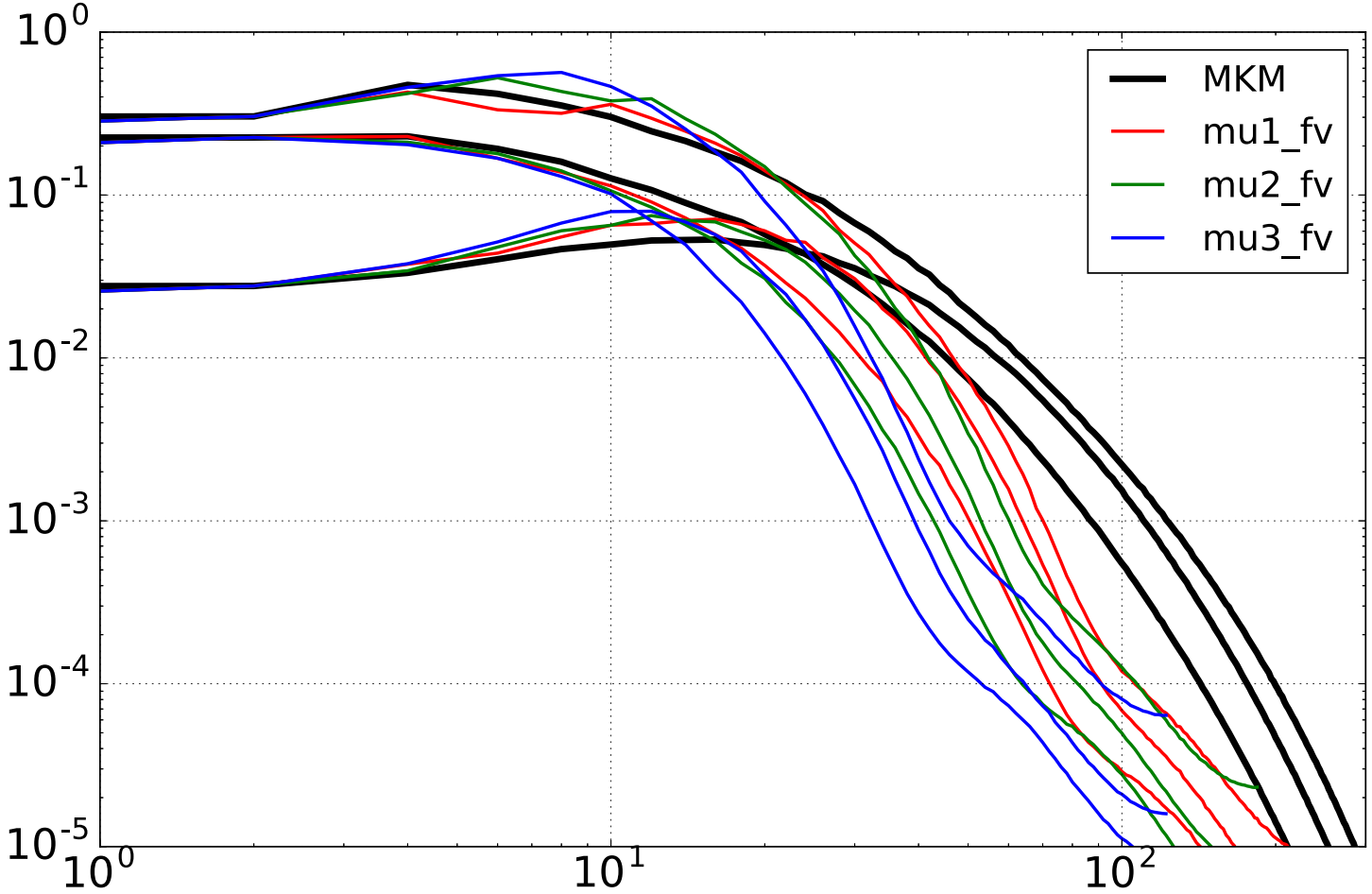
Results (Spectra-z, FV, MS) y^+=501



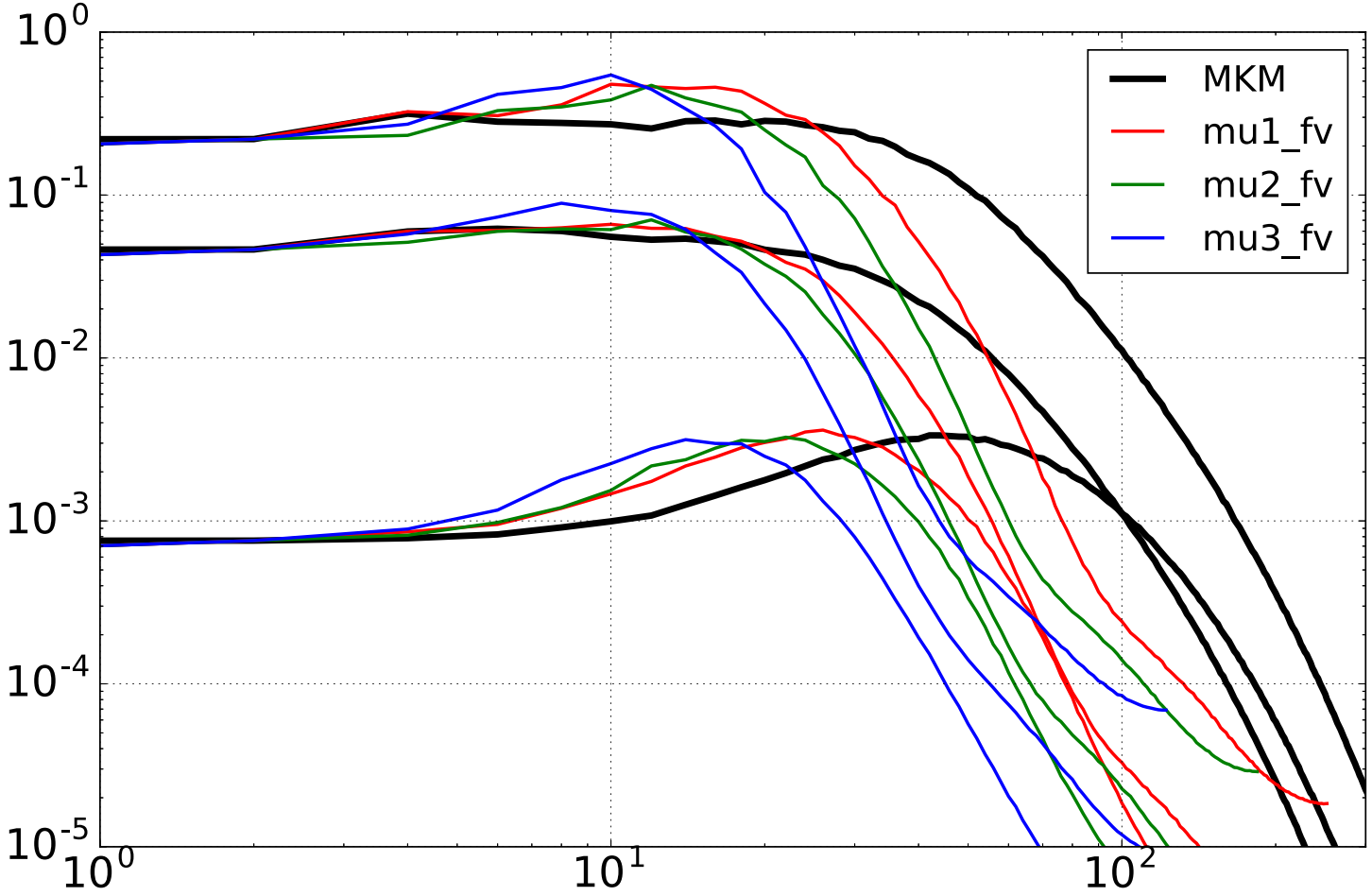
Results (Spectra-z, FV, MS) y^+=249



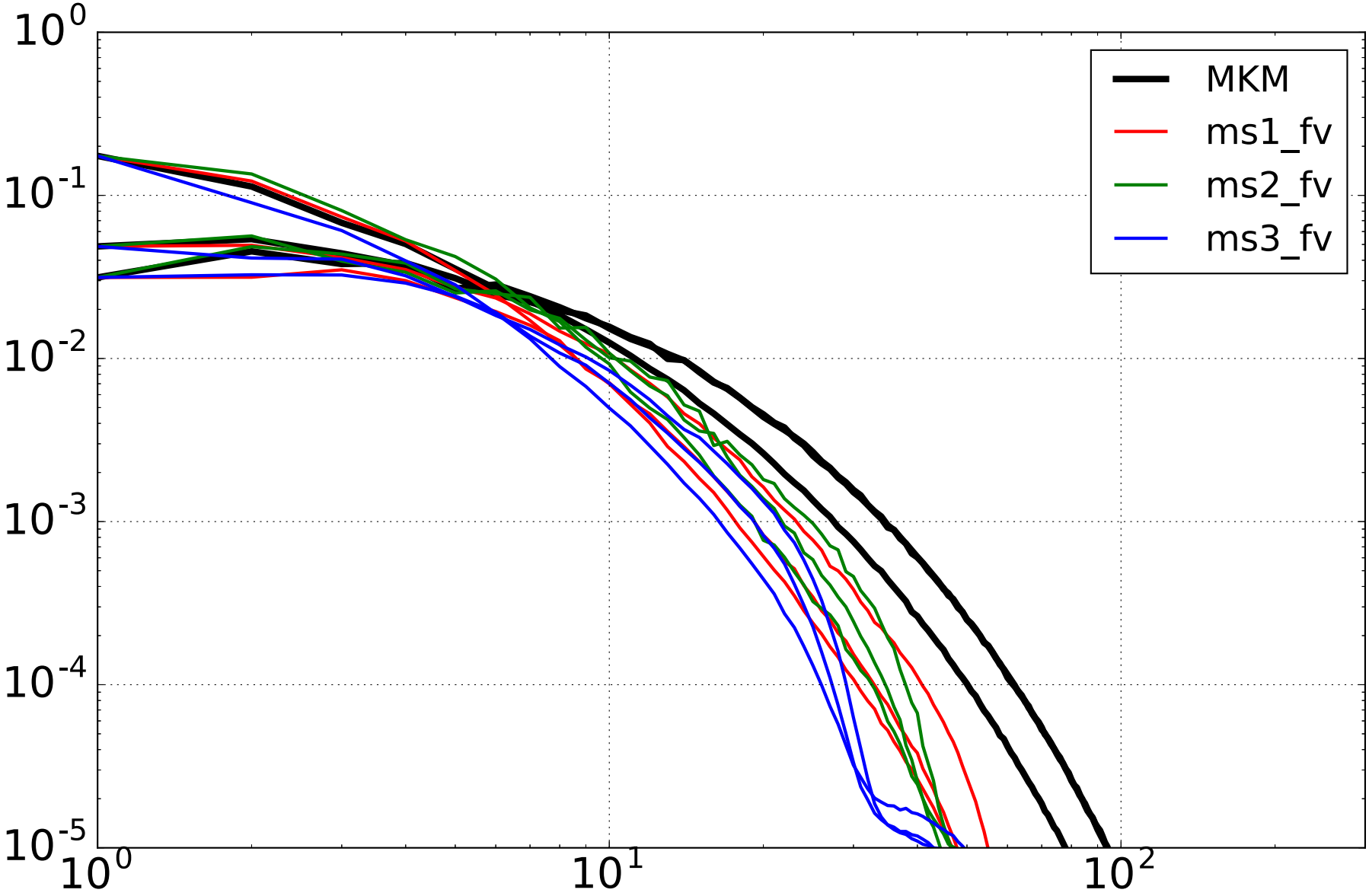
Results (Spectra-z, FV, MS) y^+=59



Results (Spectra-z, FV, MS), y^+=10



Results (Spectra-x, FV, MS) y+=501



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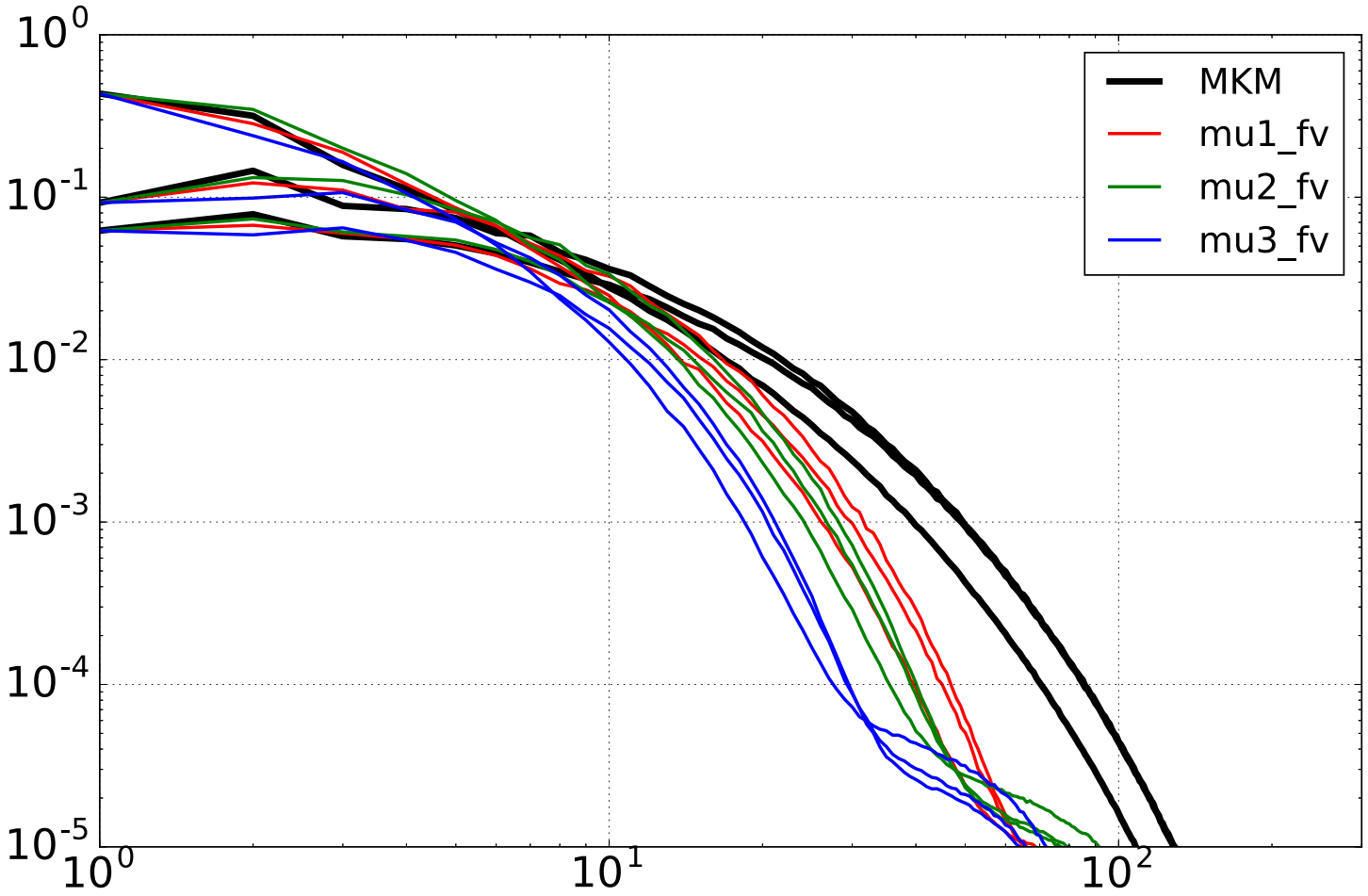
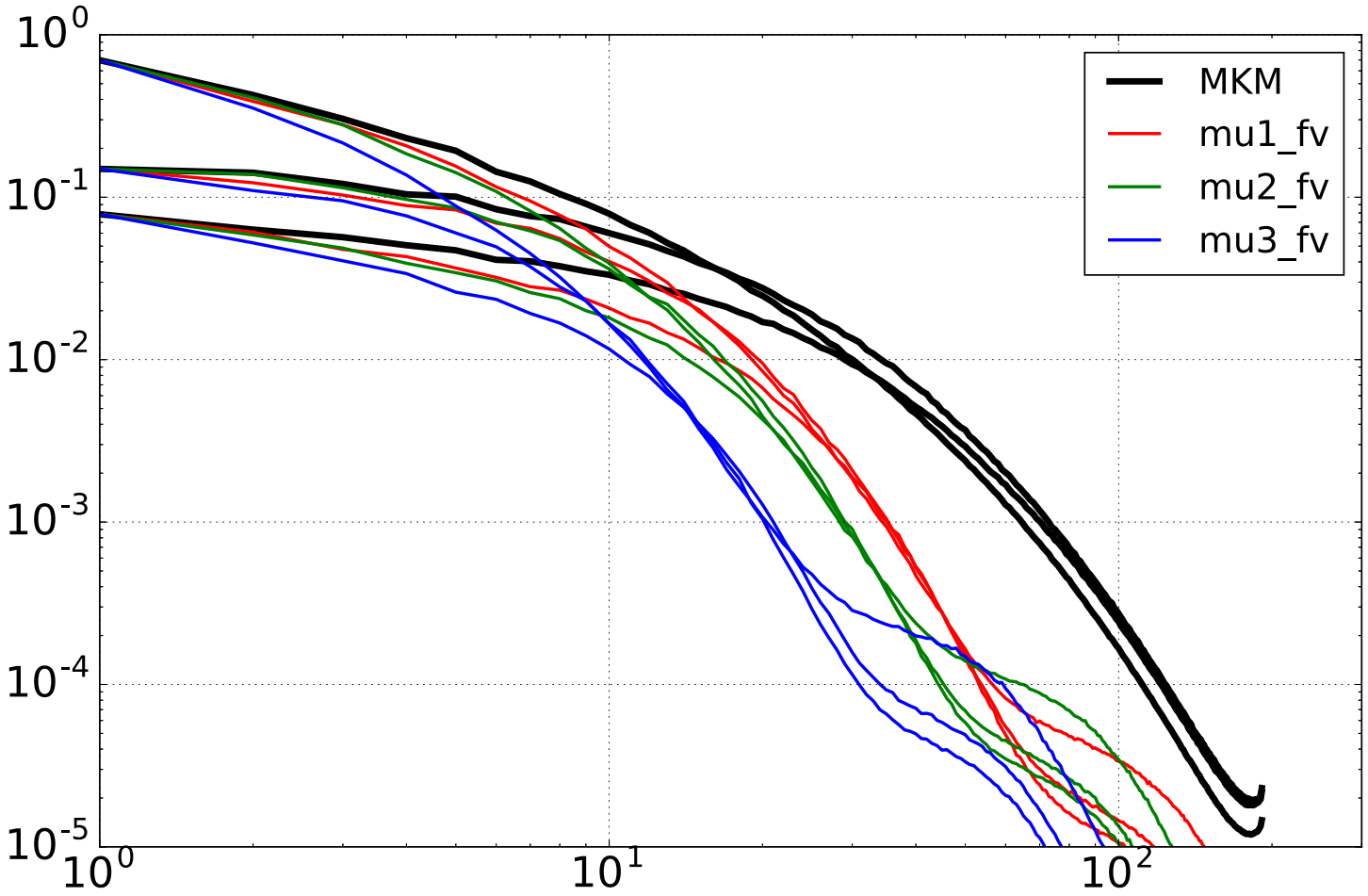
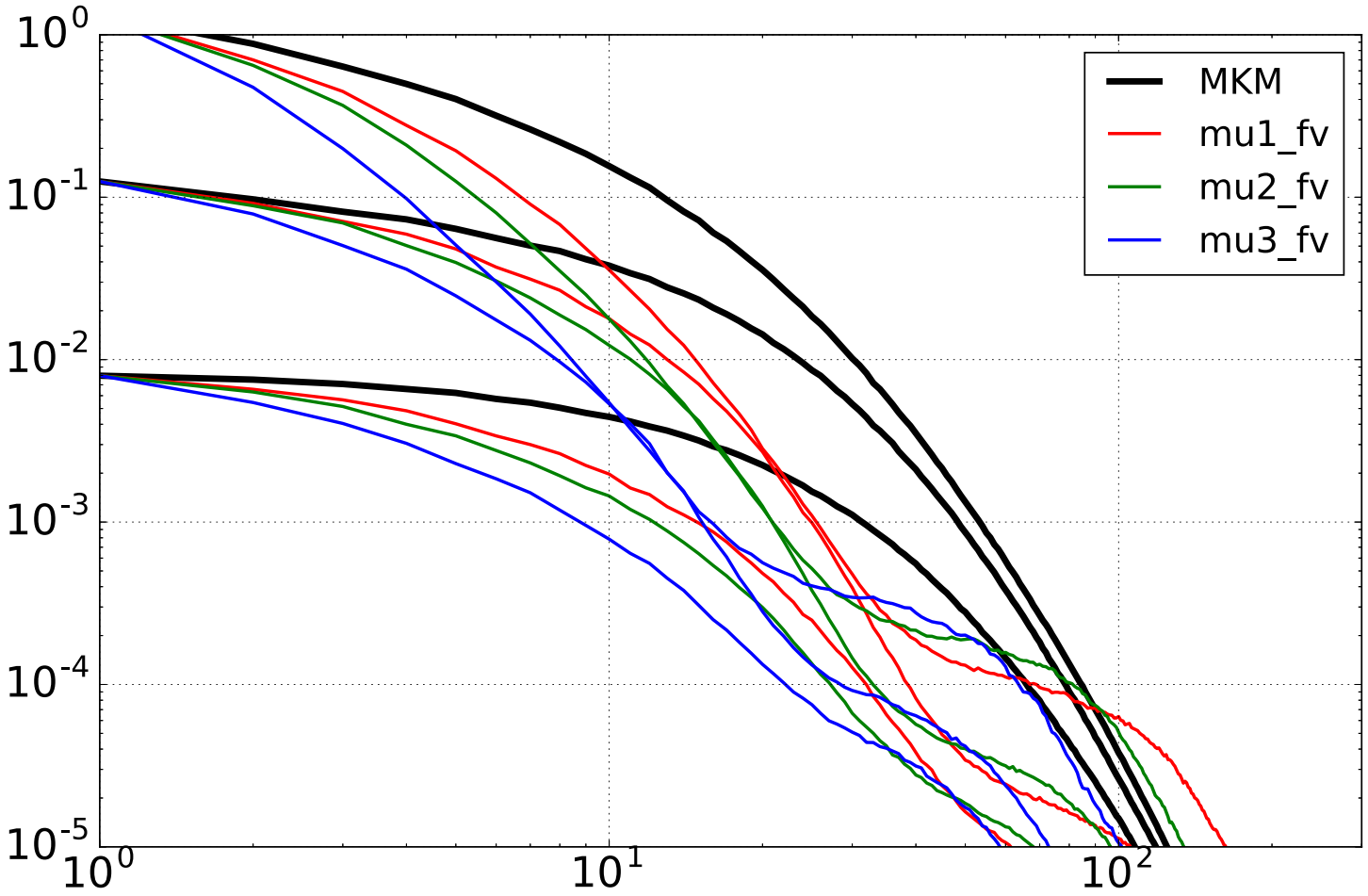
Results (Spectra-x, FV, MS) y^+=249



Results (Spectra-x, FV, MS) y^+=59



Results (Spectra-x, FV, MS) $y^+=10$



Summary

1. Fundamental test case for wall-bounded turbulent flows
2. Does not need to be driven by constant pressure gradient
3. Constant flow rate is much faster
4. Grid is not well suited to FV schemes
5. Maybe not challenging enough for LES with HO