RNA structuredness of viral genomes

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Computational Approaches to RNA Structure and Function
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- Many examples of structured, functional RNAs in untranslated regions
- Some known examples of (conserved) RNA structures in coding regions
- Different evolutionary pressures on RNA structure in coding/non-coding regions

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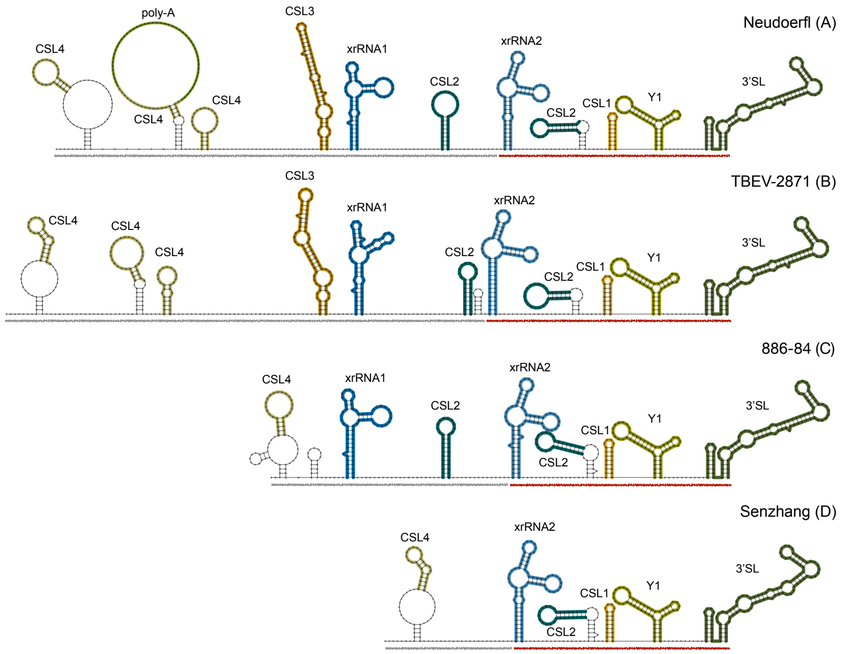

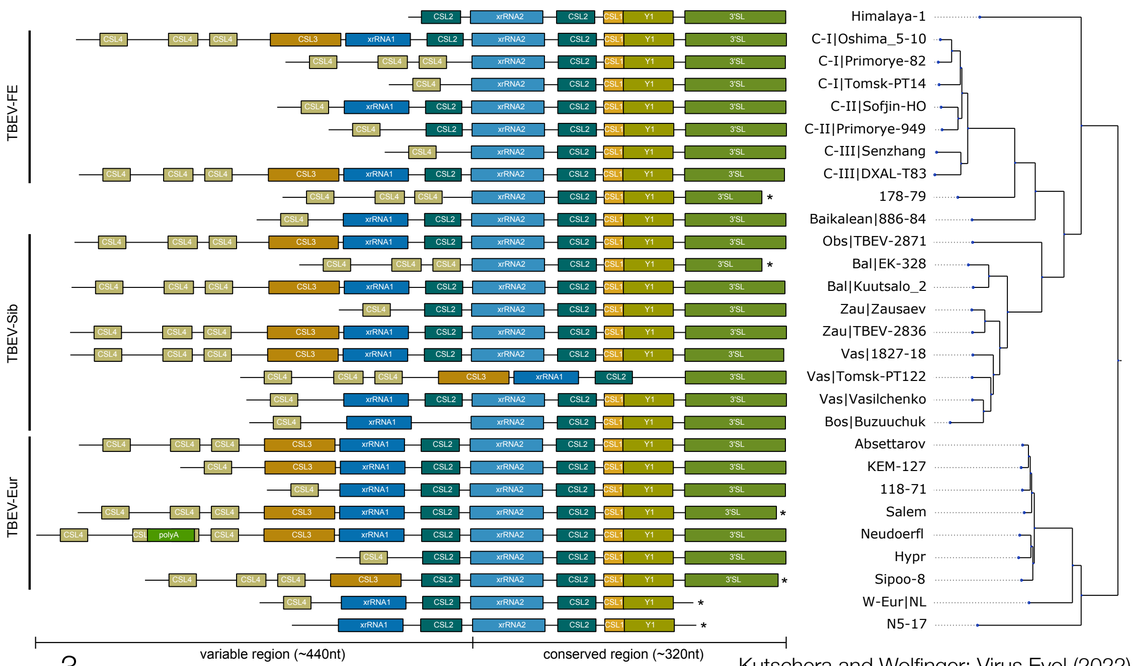

Kutschera and Wolfinger; Virus Evol (2022)

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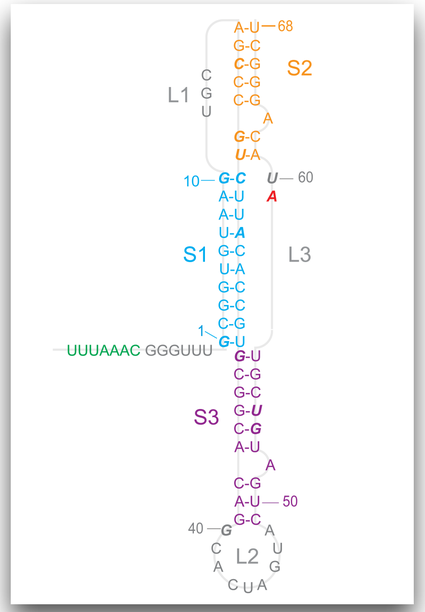
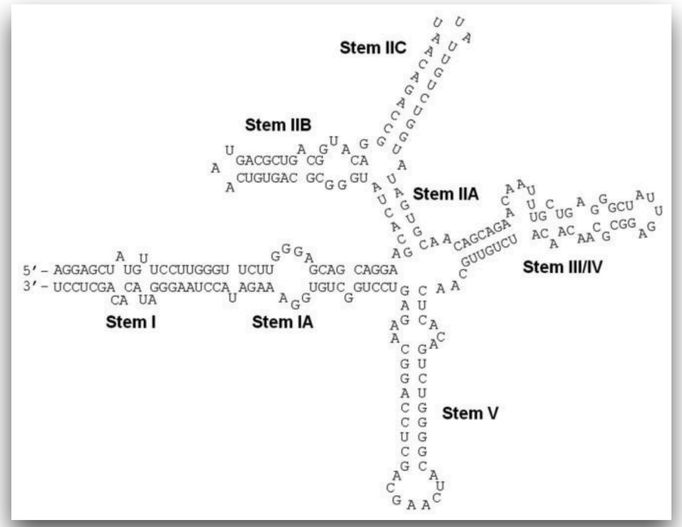
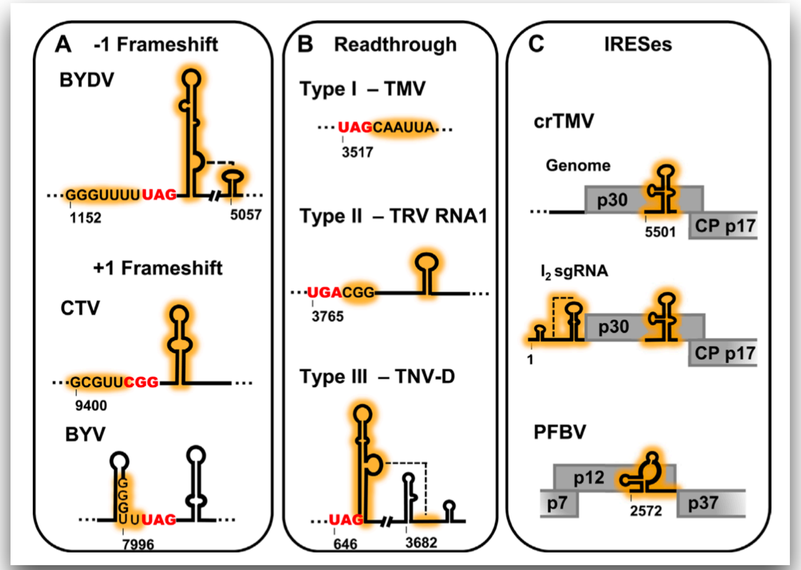


Omar et al.; PLoS Comput Biol (2021)



Fernandes et al.; RNA Biol (2012)



Newborn and White; Virology (2015)

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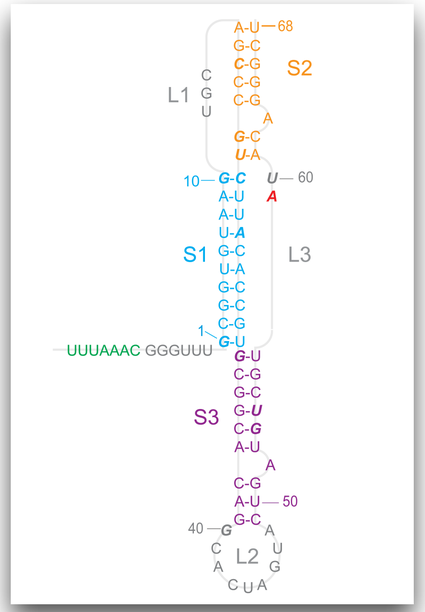

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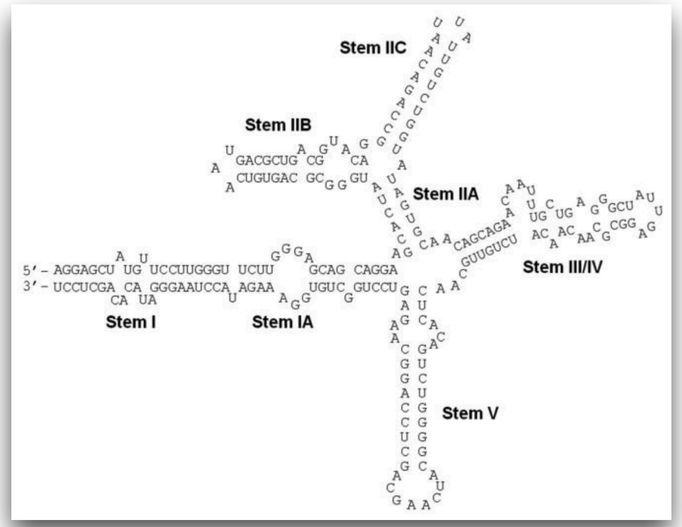

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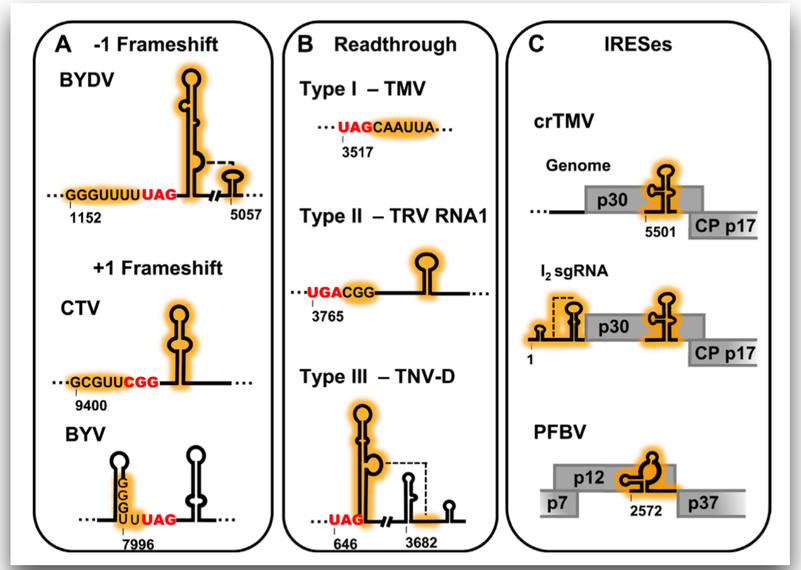

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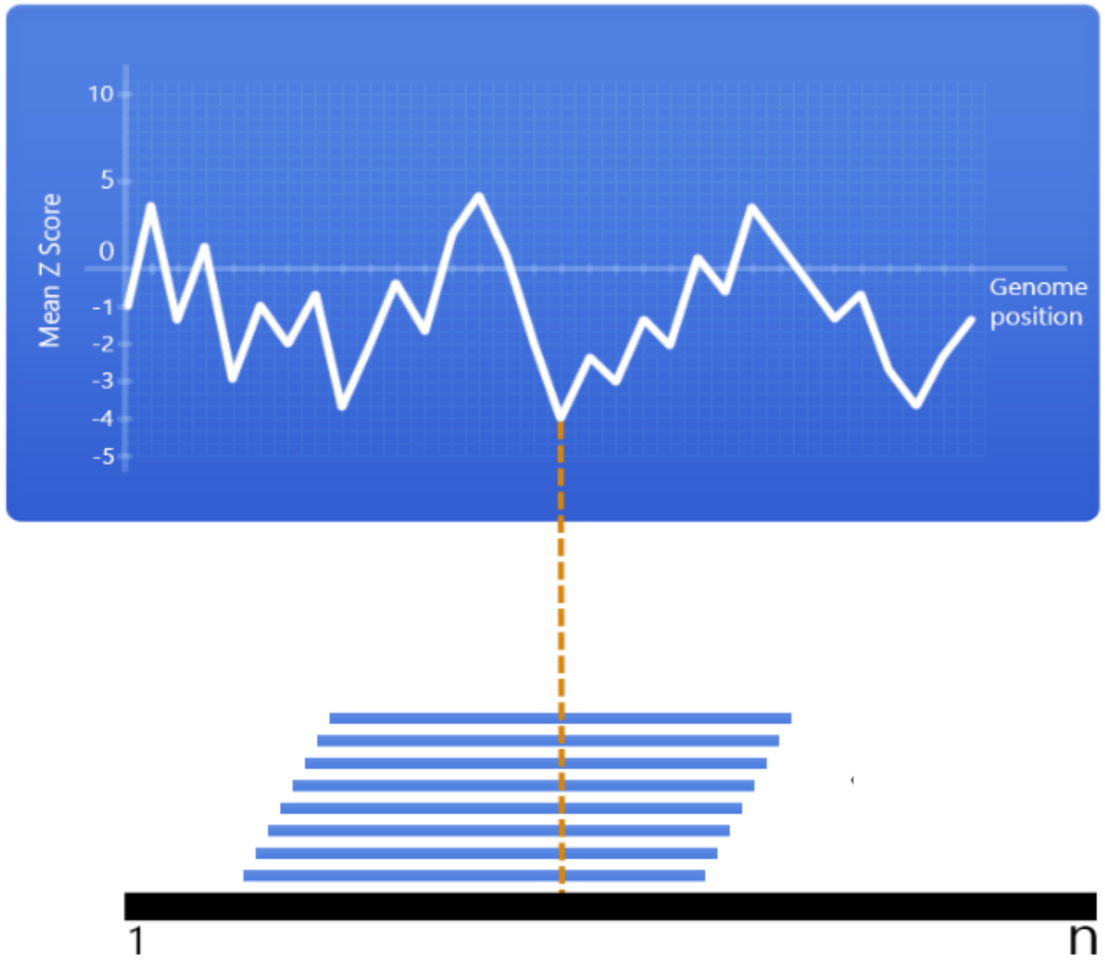
How to assess global RNA structuredness?

- MFE Z scores as a proxy for RNA structuredness

$$z = \frac{m - \mu}{\sigma}$$



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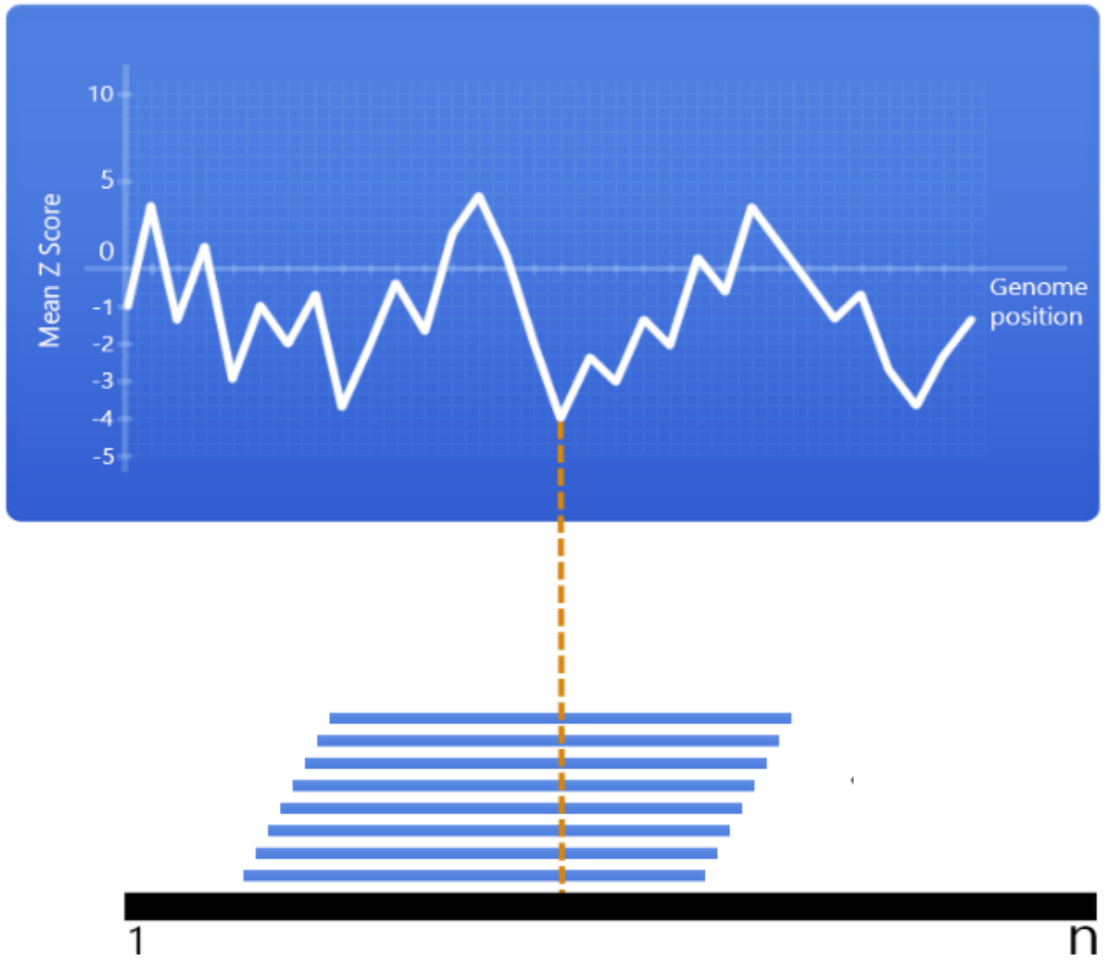
- MFE Z scores as a proxy for RNA structuredness

$$z = \frac{m - \mu}{\sigma}$$

- Opening energy

$$\Delta G_{\text{open}} = -RT \ln P(\text{unpaired})$$

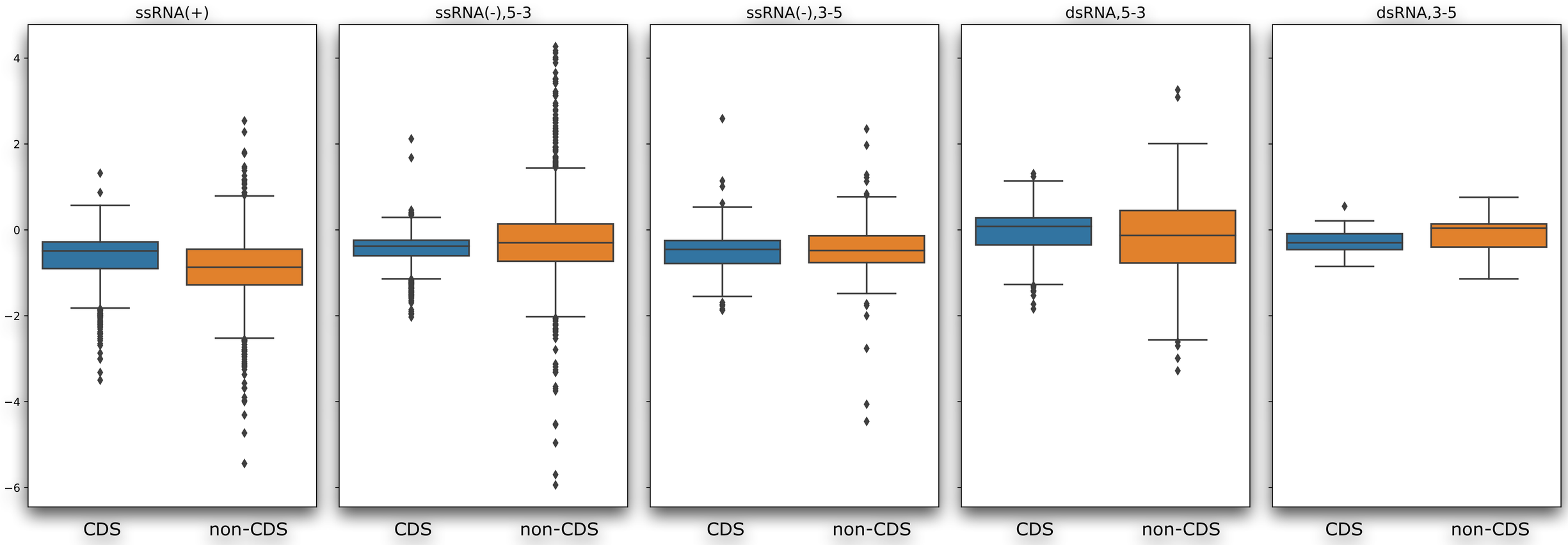
- GC content



Data Set

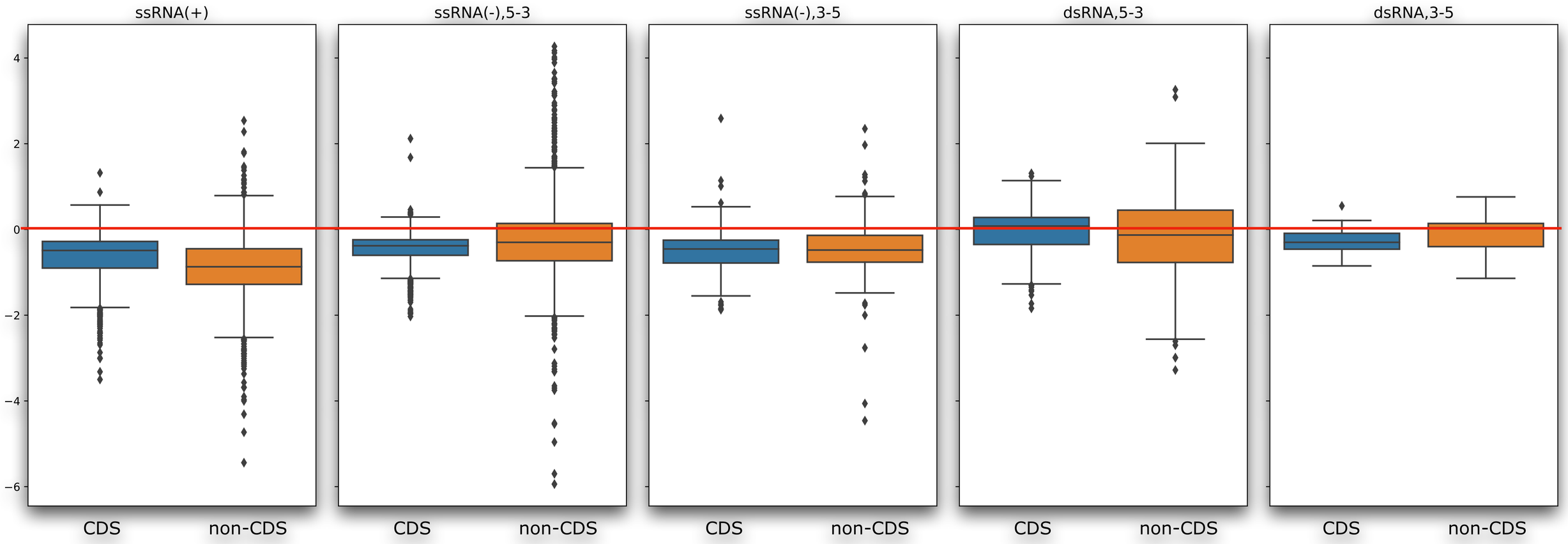
Baltimore classification	Unsegmented	Segmented	Total
ssRNA(+)	1333	373	1706
ssRNA(-)	355	1118	1473
dsRNA	73	890	963
dsDNA	714	0	714
	2475	2381	4856

Structuredness coding/non-coding regions



MFE Z scores

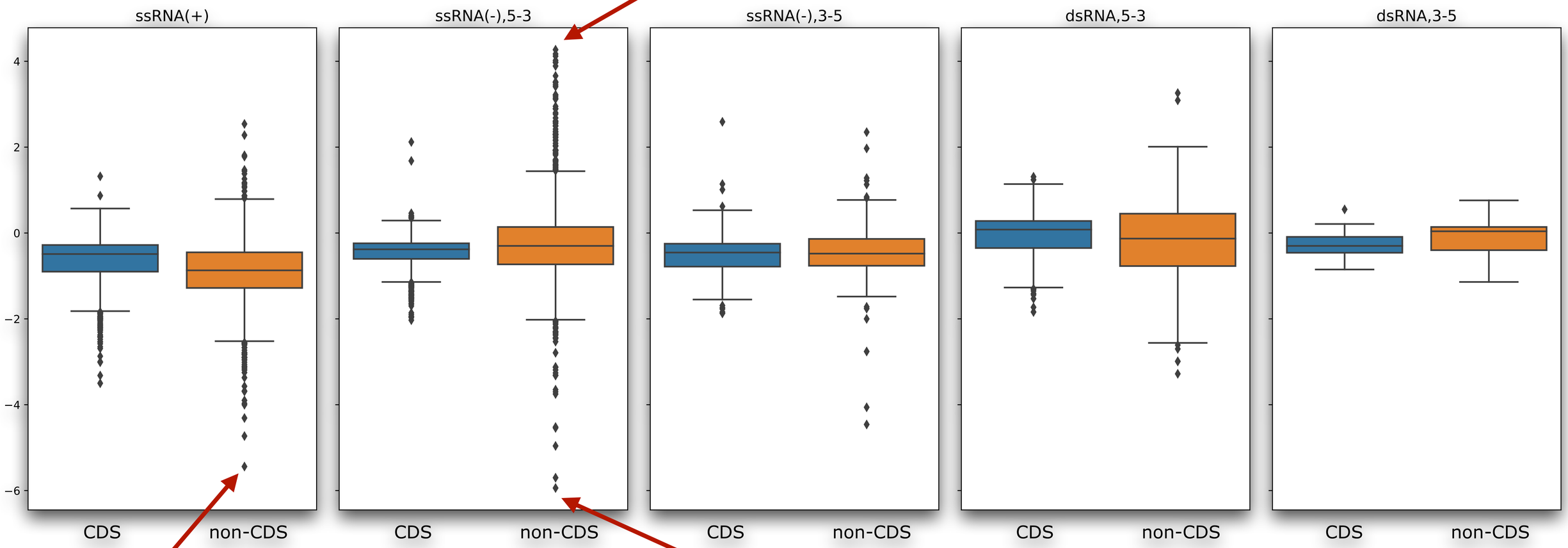
Structuredness coding/non-coding regions



MFE Z scores

Structuredness coding/non-coding regions

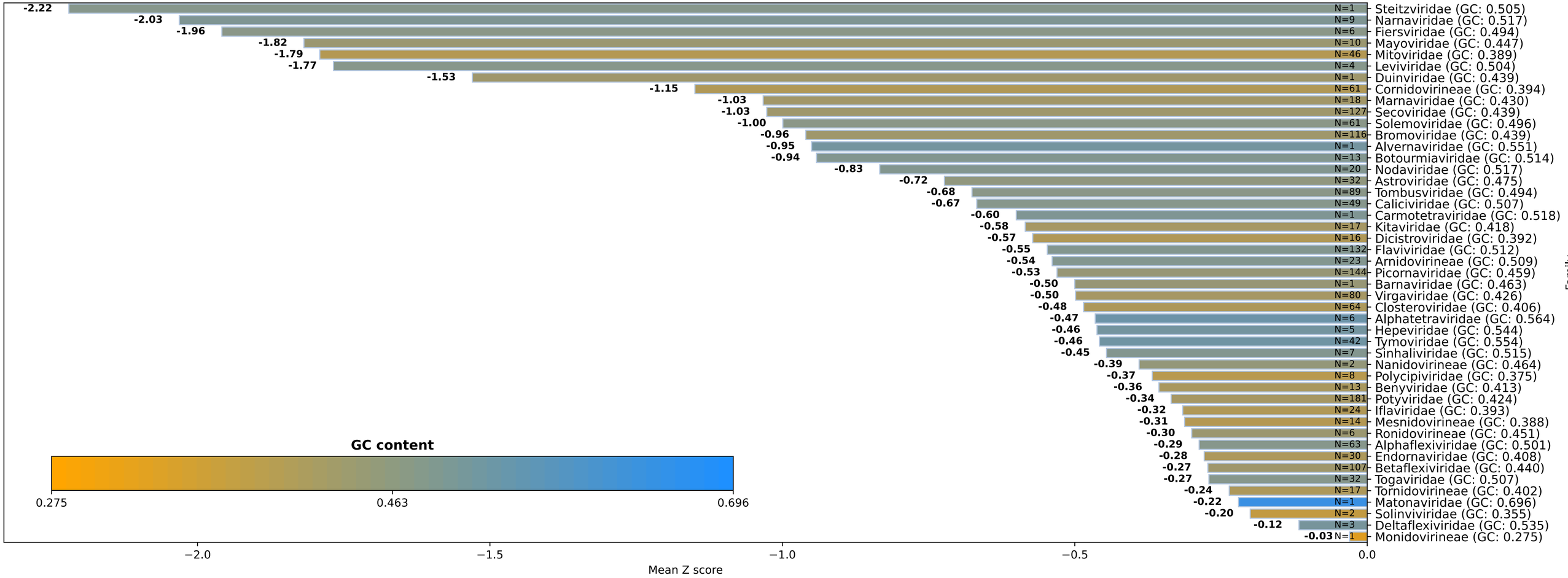
Anhembi virus, segment L (Bunyavirus)



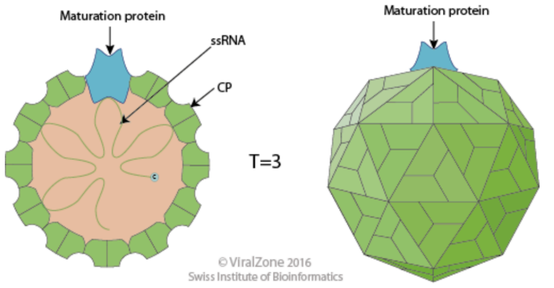
Blechmonas luni narnavirus 1

Uukuvirus (Bunyavirus)

Mean Z score of ssRNA(+) families



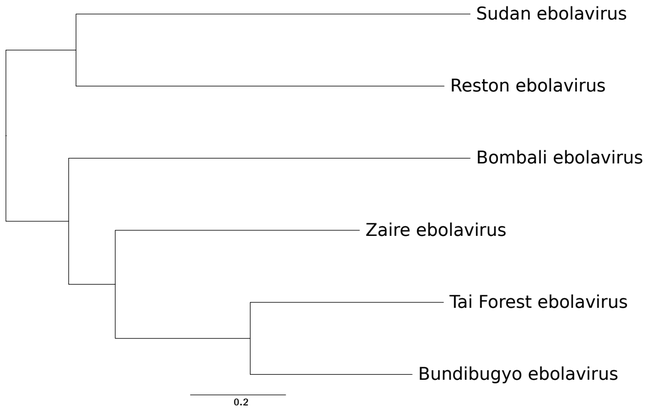
Phage example [ssRNA(+)]



https://viralzone.expasy.org/163

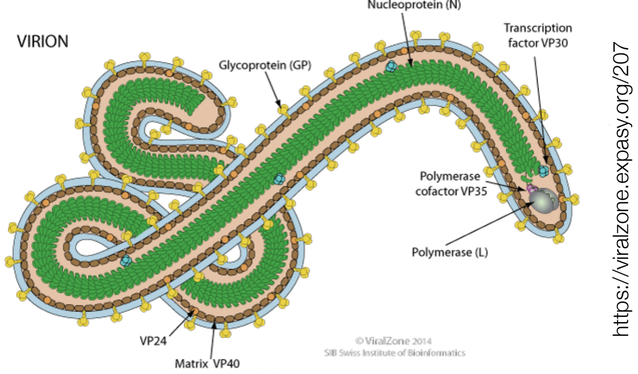
Viruses|Orthornavirae|Lenarviricota|Leviviricetes|Norzivirales|Fiersviridae|Enterobacteria phage M

Ebolavirus example [ssRNA(-)]



	BDBV	BOMV	EBOV	RESTV	SUDV	TAFV
TAFV	0.678	0.603	0.634	0.598	0.596	1
SUDV	0.597	0.578	0.6	0.594	1	
RESTV	0.597	0.582	0.602	1		
EBOV	0.633	0.605	1			
BOMV	0.602	1				
BDBV	1					

nucleotide identity
0.6 0.7 0.8 0.9 1.0



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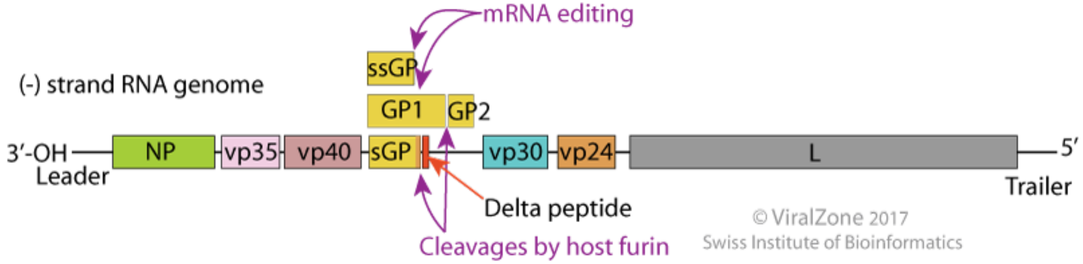

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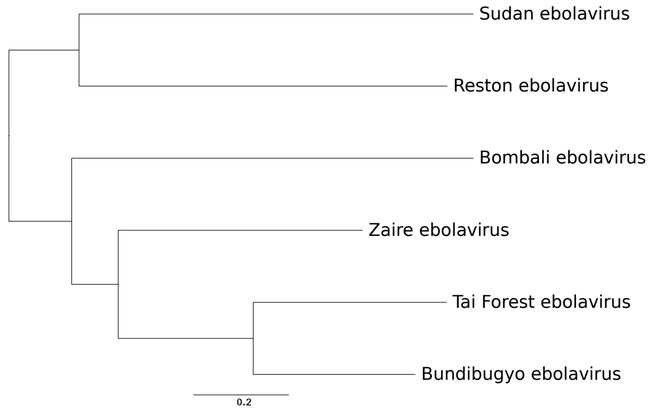

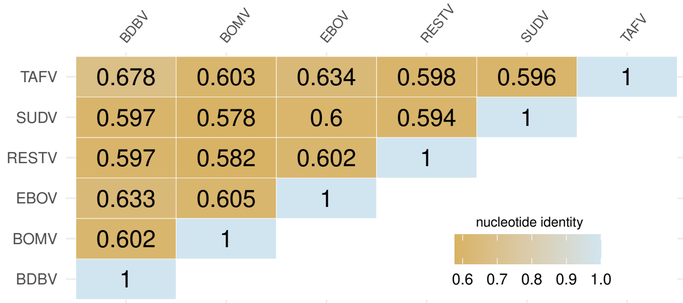

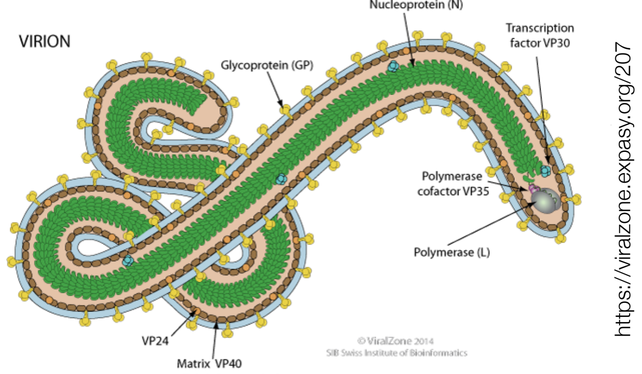

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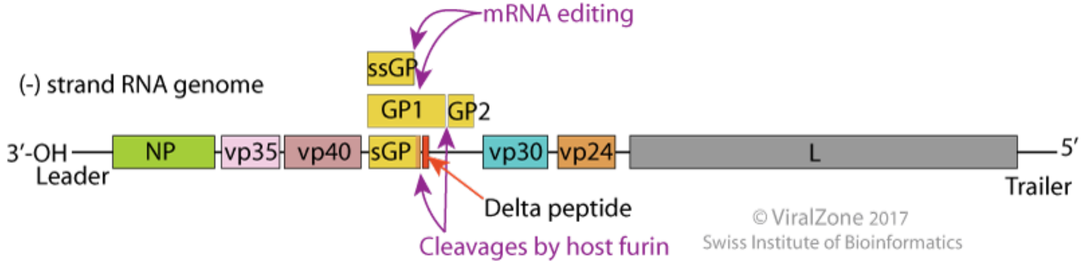

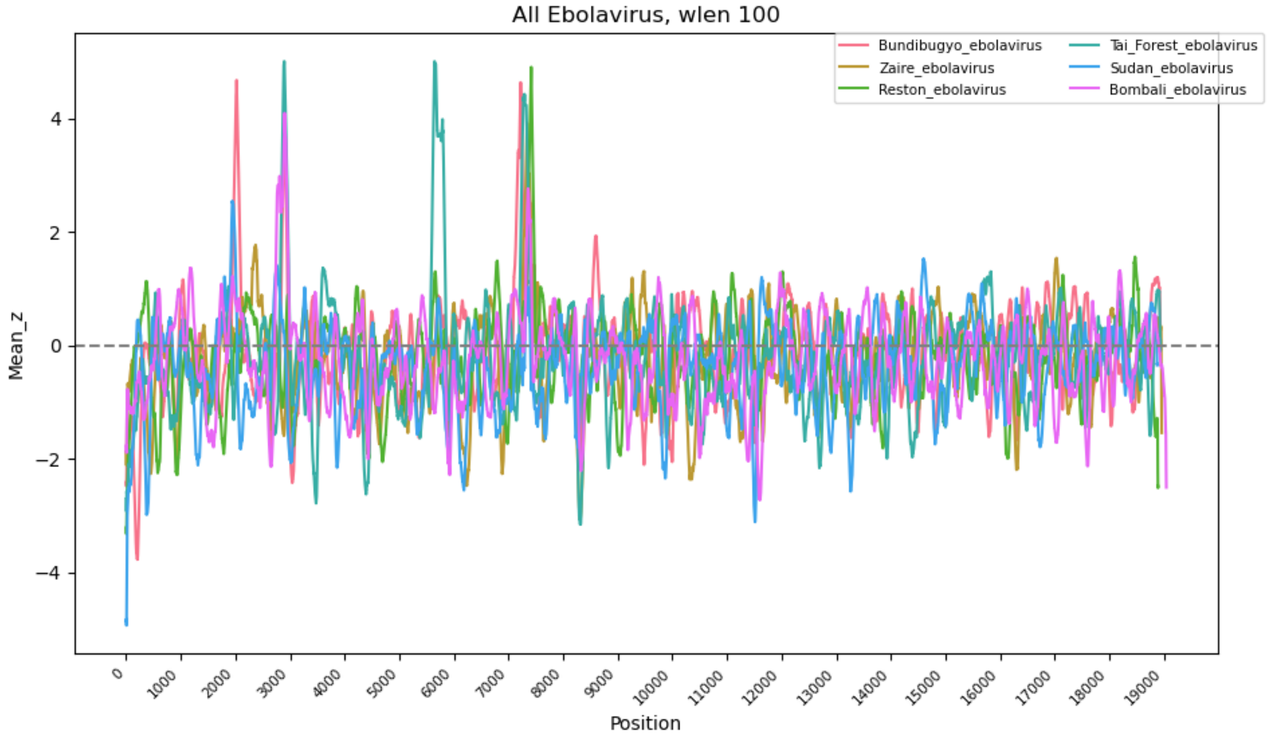

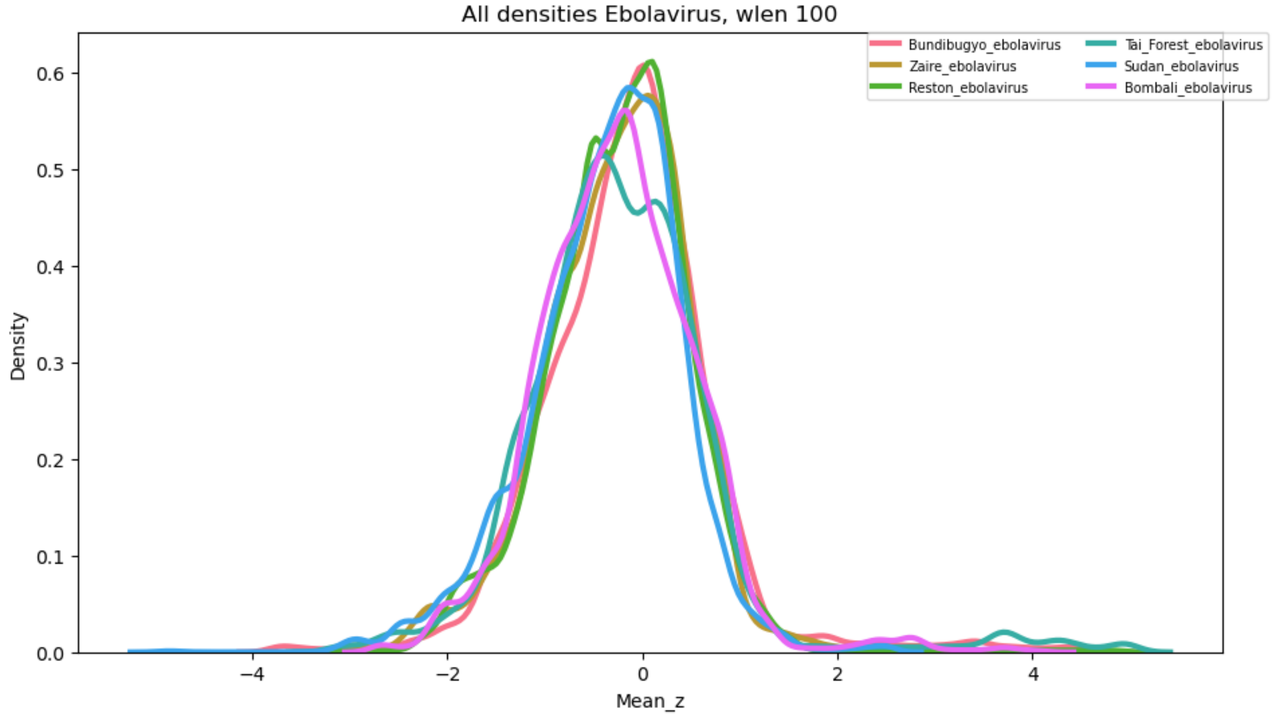

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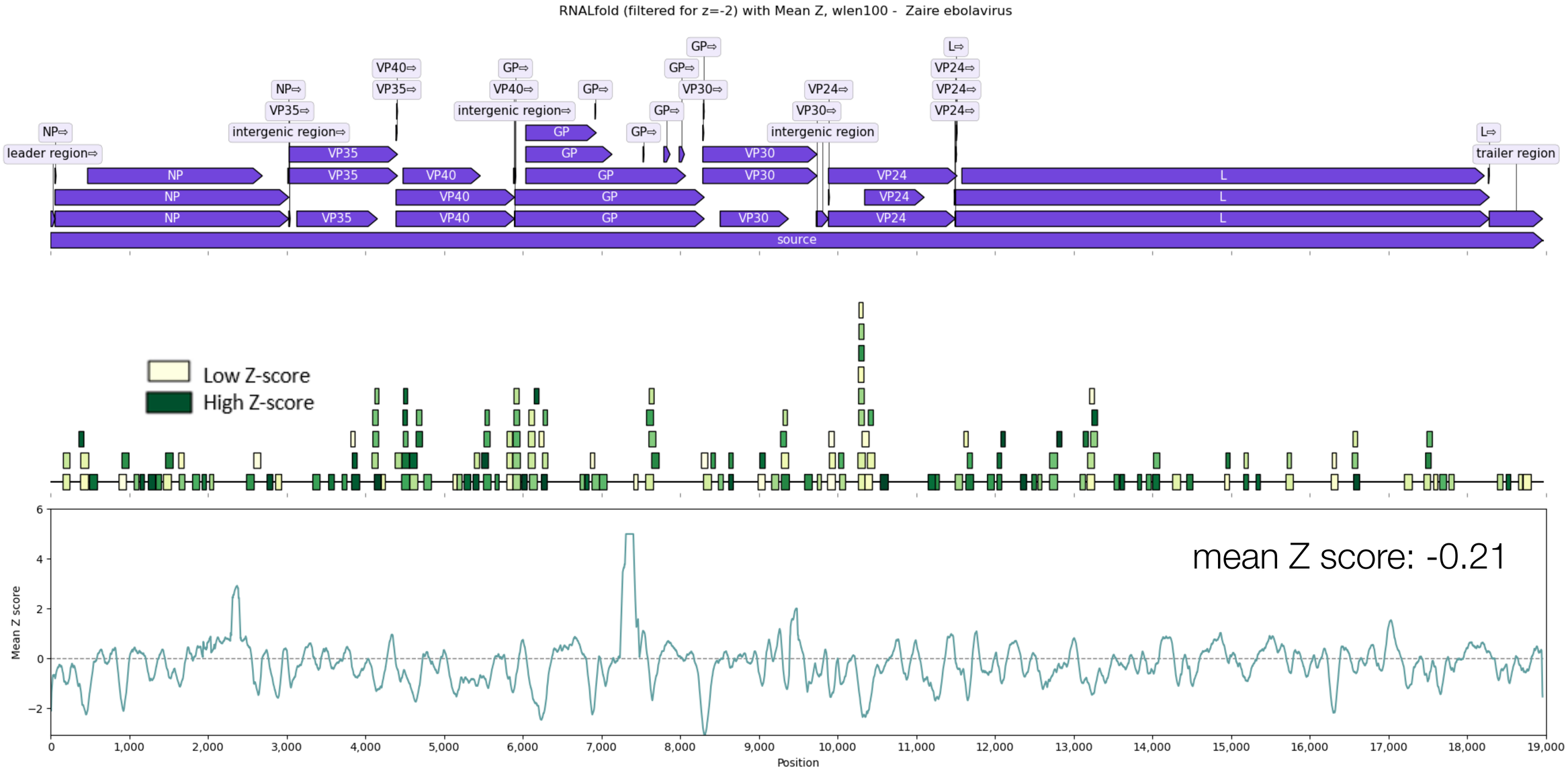
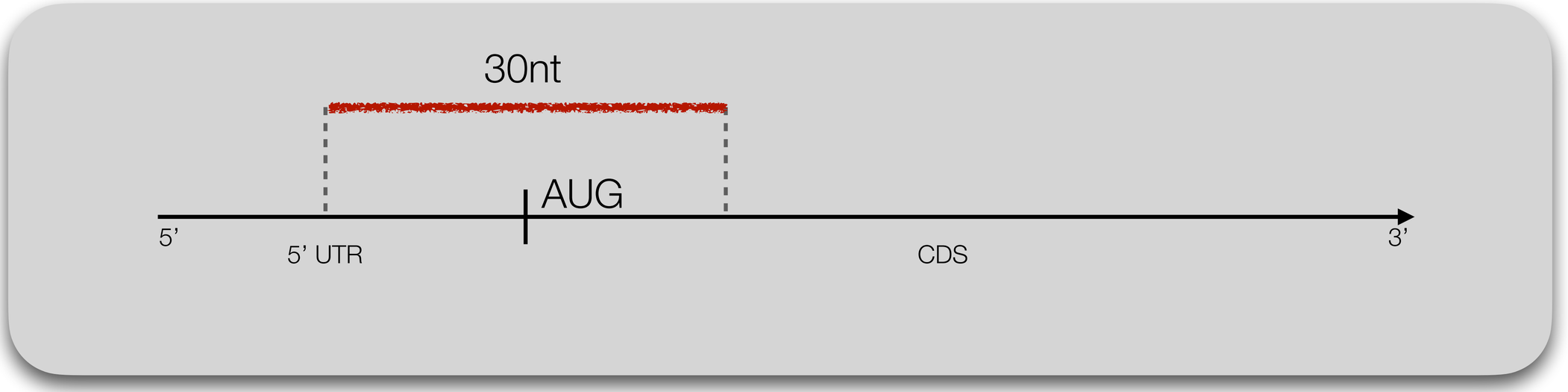


Structuredness of gene start regions

Are they accessible?



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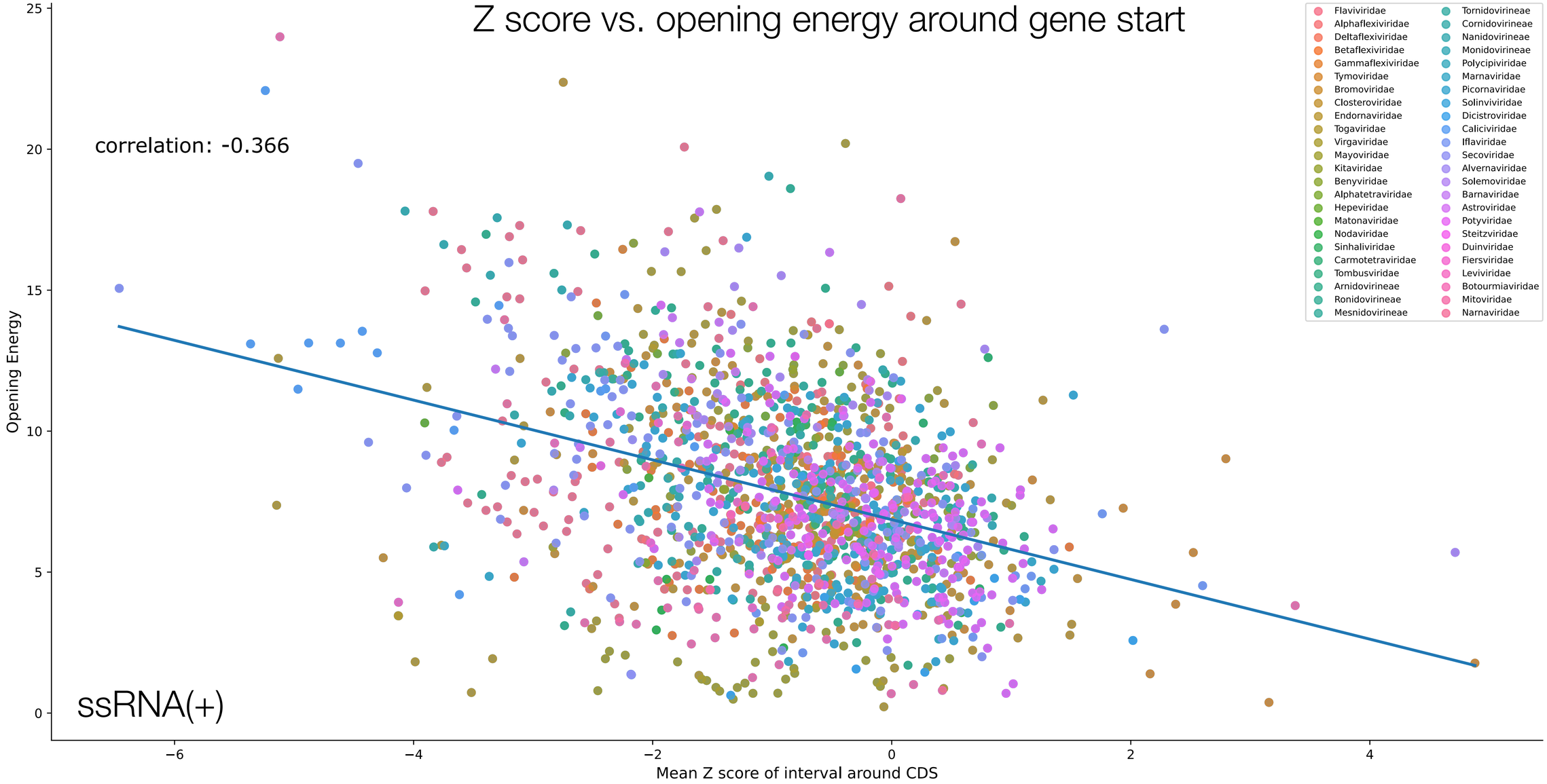

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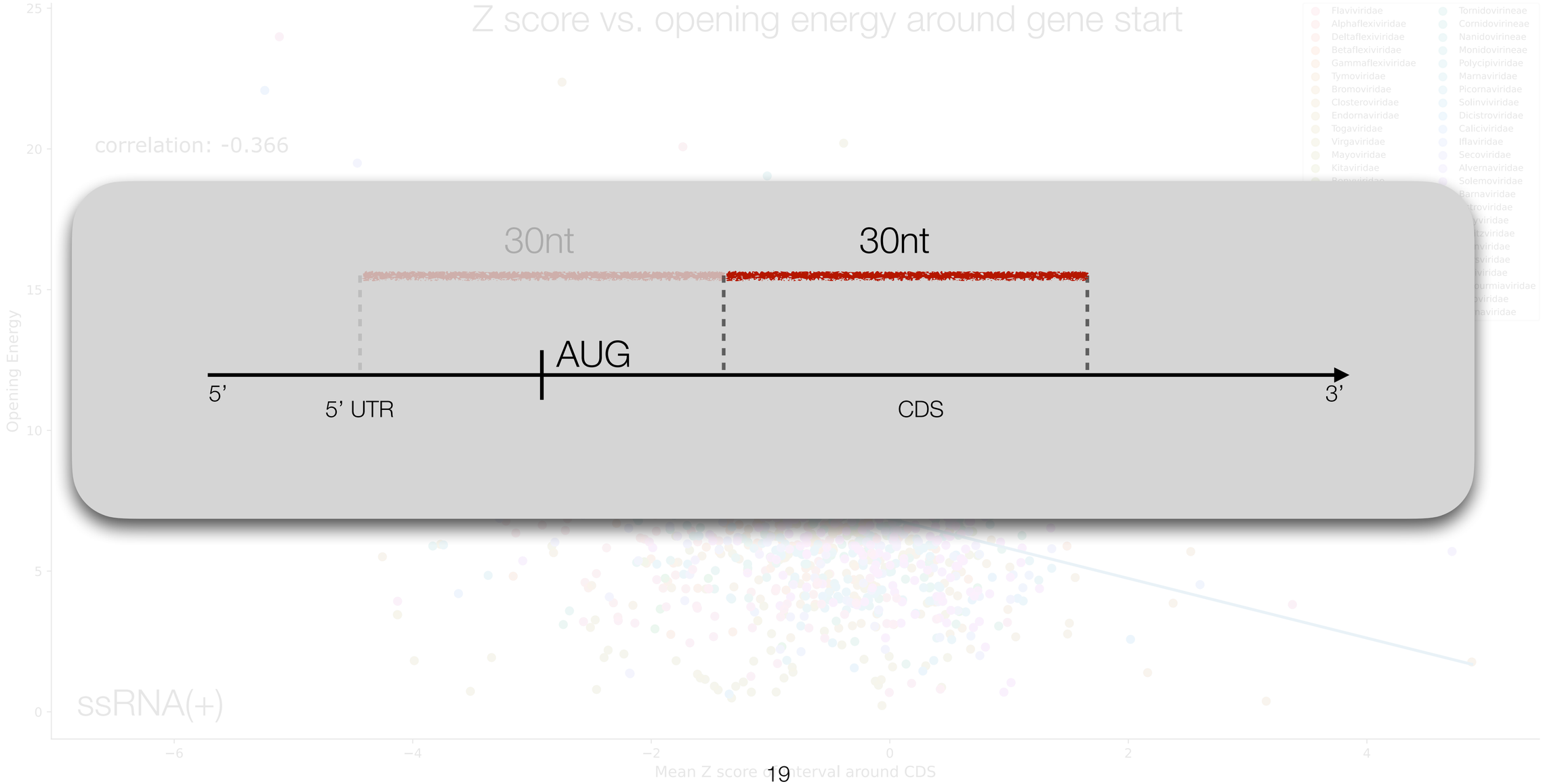

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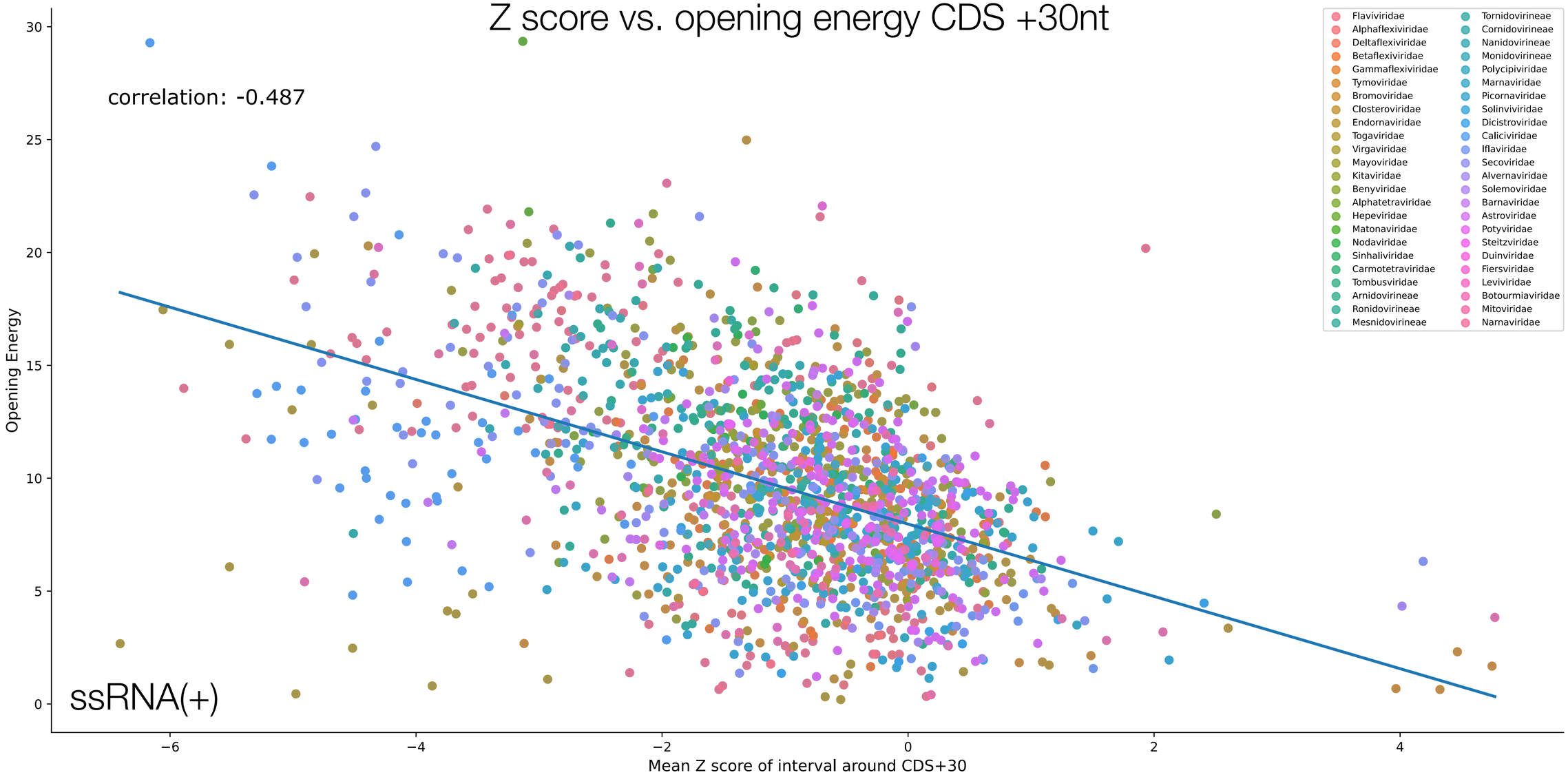

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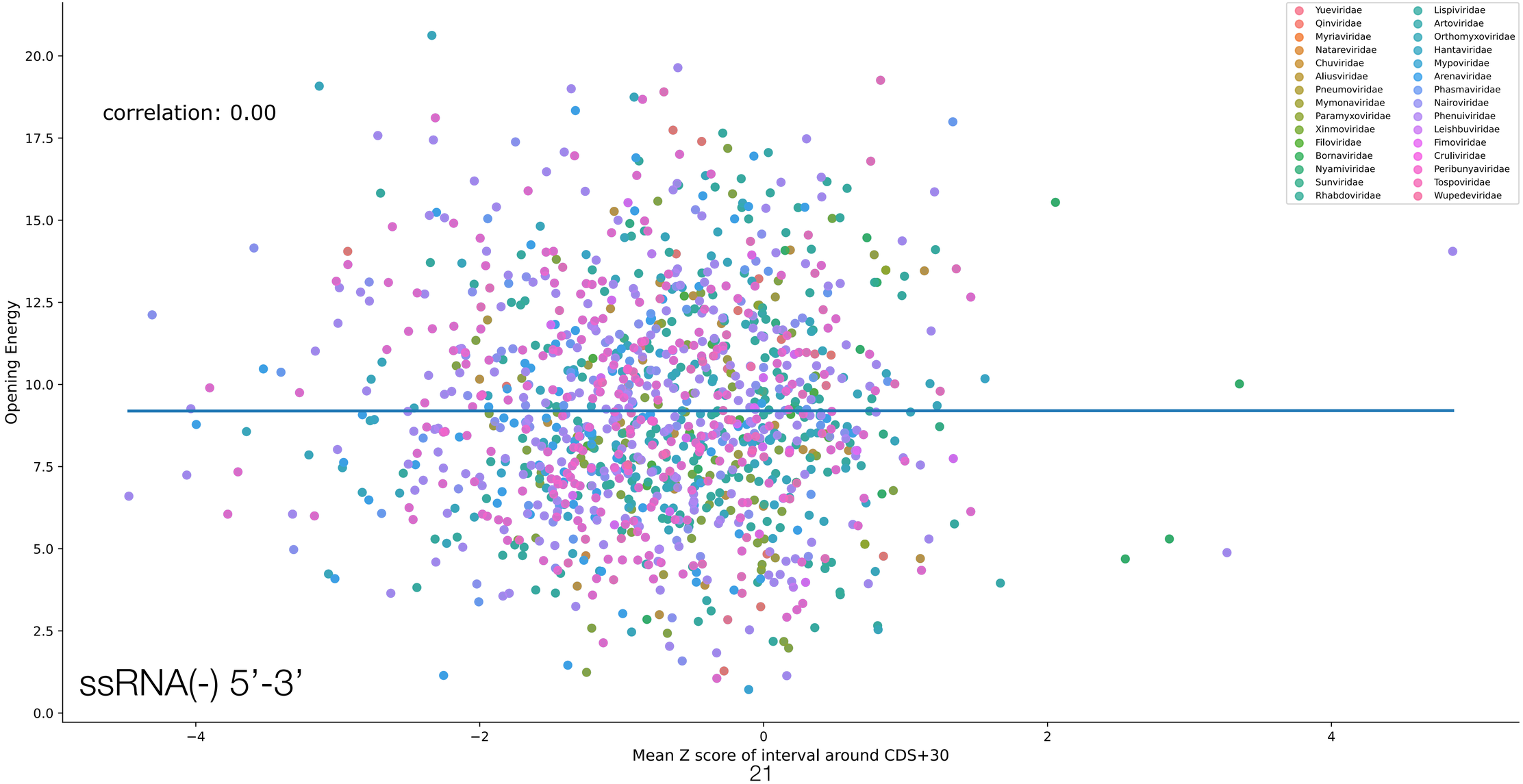

Where we are

- Viruses differ in their RNA structuredness; many viruses are more structured than expected
- GC content is not always a proxy for RNA structuredness
- Some viruses achieve high structuredness despite low GC content

The next steps

- Analyse structuredness of human mRNAs
- Assess the impact of codon usage bias on RNA structuredness
- Synbio: Study the impact of alternative genetic codes on RNA structuredness

Acknowledgements

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Mario Mörl

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