Towards GPD evolution at NLO in PARTONS with APFEL++

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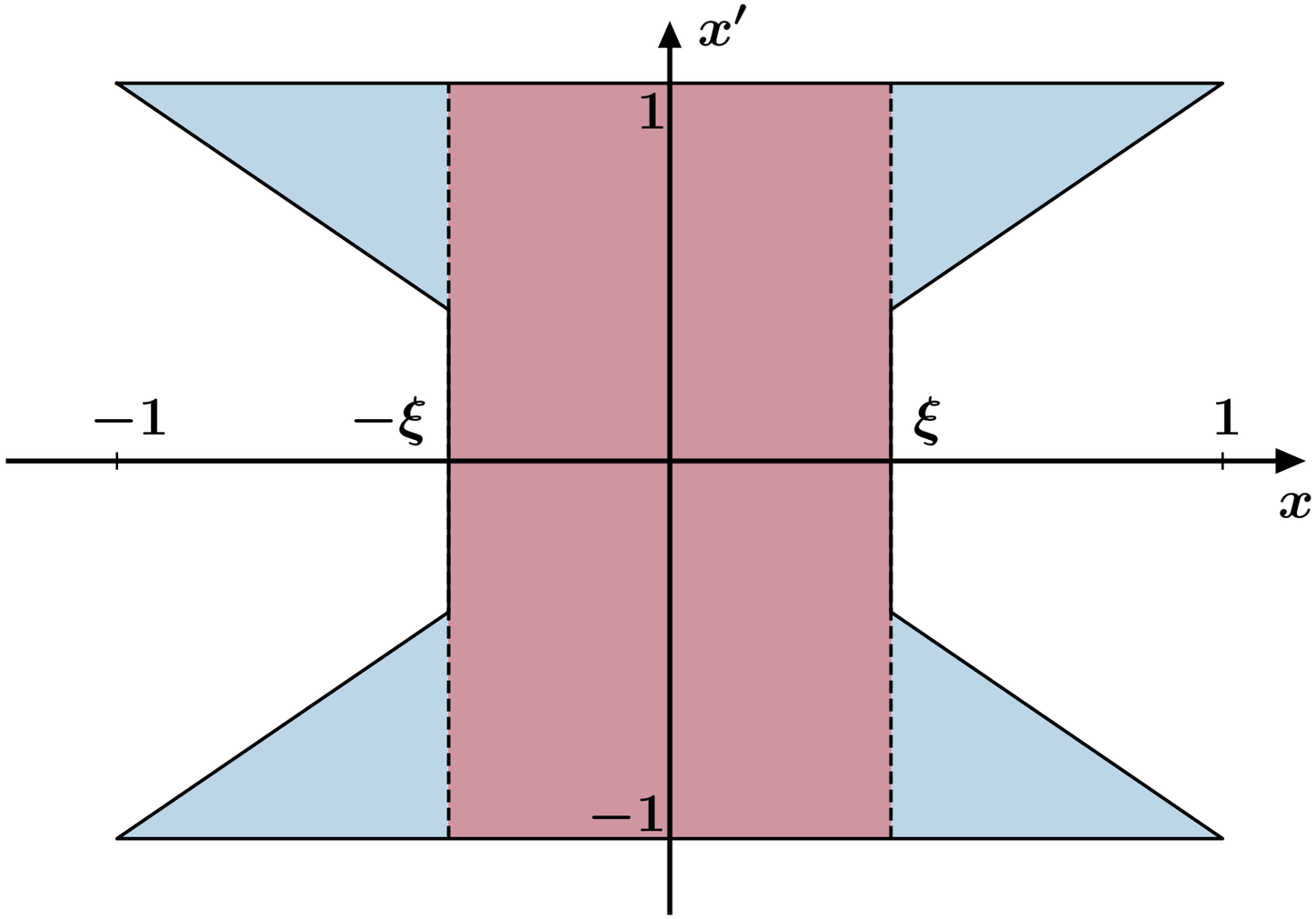
GPD evolution equations

- The operator definition of (collinear) GPDs gives rise to UV divergencies.
- The RGE deriving from the renormalisation is:

$$\mu^2 \frac{d}{d\mu^2} f(x,\xi,t,\mu) = \int_{-\infty}^{+\infty} \frac{dx'}{|2\xi|} P\left(\alpha_s(\mu), \frac{x}{\xi}, \frac{x'}{\xi}\right) f(x',\xi,t,\mu)$$

- The support domain of the evolution kernel $P(\alpha_s, x/\xi, x'/\xi)$ is:



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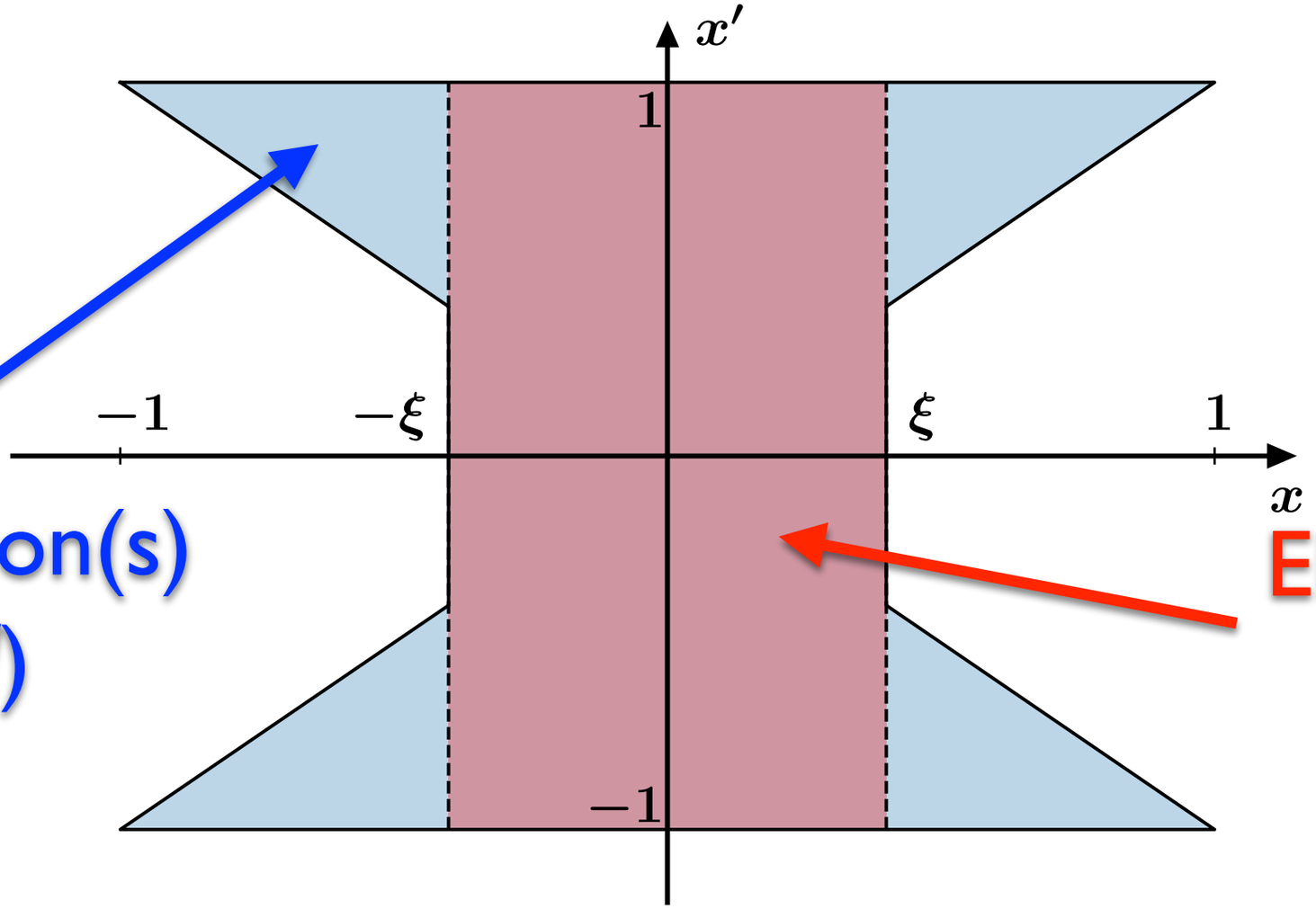


DGLAL region(s)
(*|x| > |ξ|*)

ERBL region
(*|x| < |ξ|*)

GPD evolution equations

- A general solution of the GPD evolution equations is tricky:
  - evolution kernels are discontinuous,
  - non-trivial support domain.
- Analytic approaches exist based of conformal moments:
  - complicated beyond LO,
  - problem of reconstructing GPDs in x space.
- A fully numerical treatment seems to be more flexible and general:
  - not restricted to LO,
  - no approximations needed,
  - (no functional constraint on the initial-scale GPDs).
- Going to NLO requires the knowledge of the second term of the series:

$$P\left(\alpha_s(\mu), x, x'\right) = \sum_{n=0}^{\infty} \left(\frac{\alpha_s(\mu)}{4\pi}\right)^{n+1} P^{(n)}\left(x, x'\right)$$

GPD evolution equations

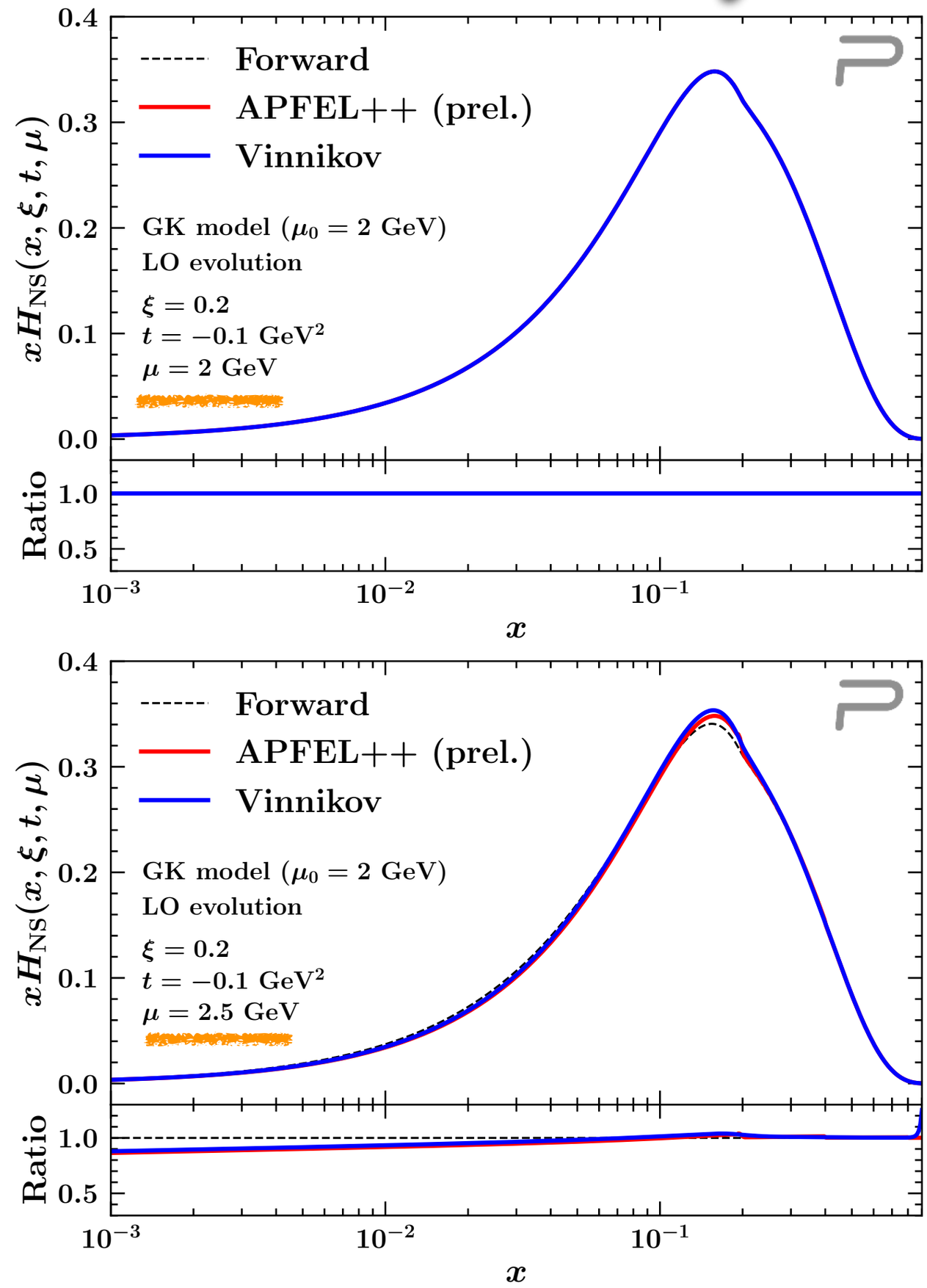
- LO evolution kernels are known and well-established since long:
  - reasonably simple,
  - computed in different ways (*e.g.* Feynman diagrams, analytic continuation).
- NLO evolution kernels have been computed only once:
  - non-singlet [hep-ph/9812448] and singlet [hep-ph/9912379],
  - computations based on analytic continuation on the ERBL kernels.
  - explicit proof that they reduce to the DGLAP kernels for $\xi \to 0$.
- So far, only one numerical implementation of the NLO evolution exists:
  - not entirely public,
  - convoluted expressions hard to decode and implement.

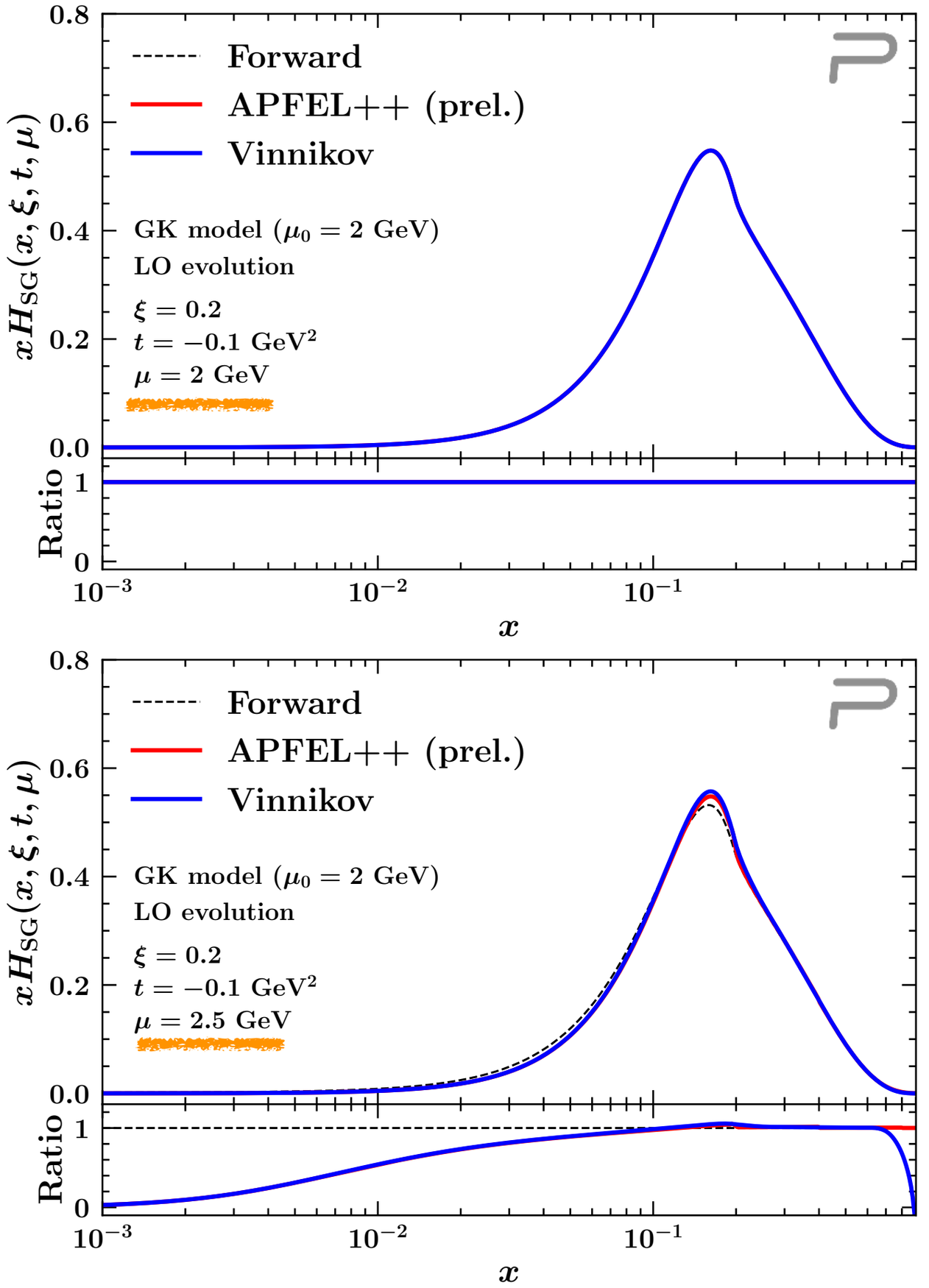
Preliminary results

Benchmark setup

- Benchmark completely implemented in the **PARTONS** framework:
  - built-in version of **Vinnikov**'s code for LO evolution [hep-ph/0604248],
  - newly interfaced to **APFEL++** (in which we are implementing GPD evolution).
- We use the Goloskokov-Kroll (**GK**) model for the initial-scale GPDs:
  - we start the evolution at $\mu_0 = 2$ GeV,
  - skewness and momentum transfer are set to $\xi = 0.2$ and $t = -0.1$ GeV^2.
  - GPDs are evolved with Vinnikov's code and APFEL++ to different energies μ.
  - Also **forward** LO evolution (as implemented in APFEL++) is considered.
- We looked at the parity-even unpolarised distributions H:
  - presented as functions of x, both **DGLAP** and **ERBL** regions are probed,
  - both **singlet** and **non-singlet** behaviours are checked.

Preliminary results





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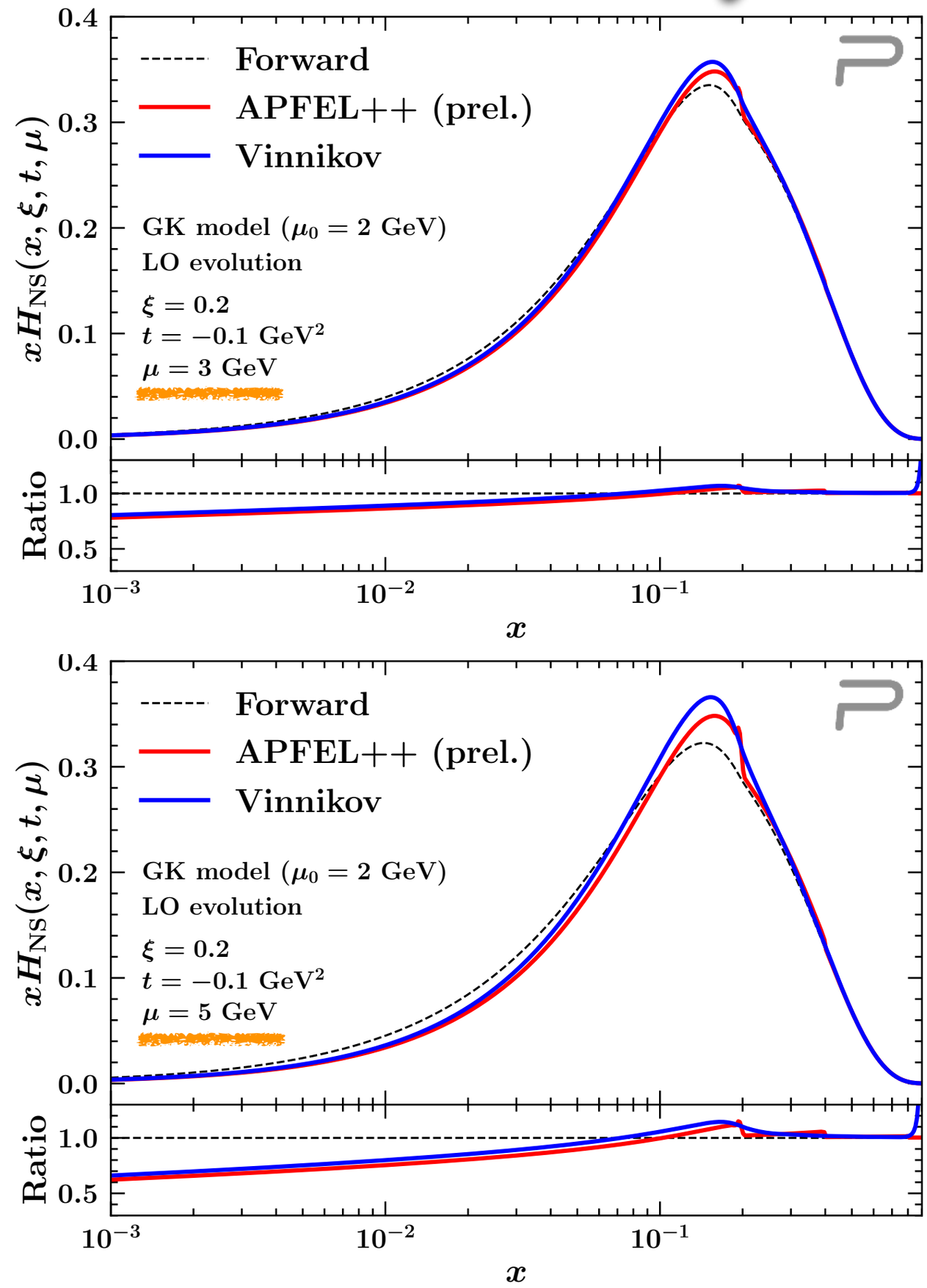
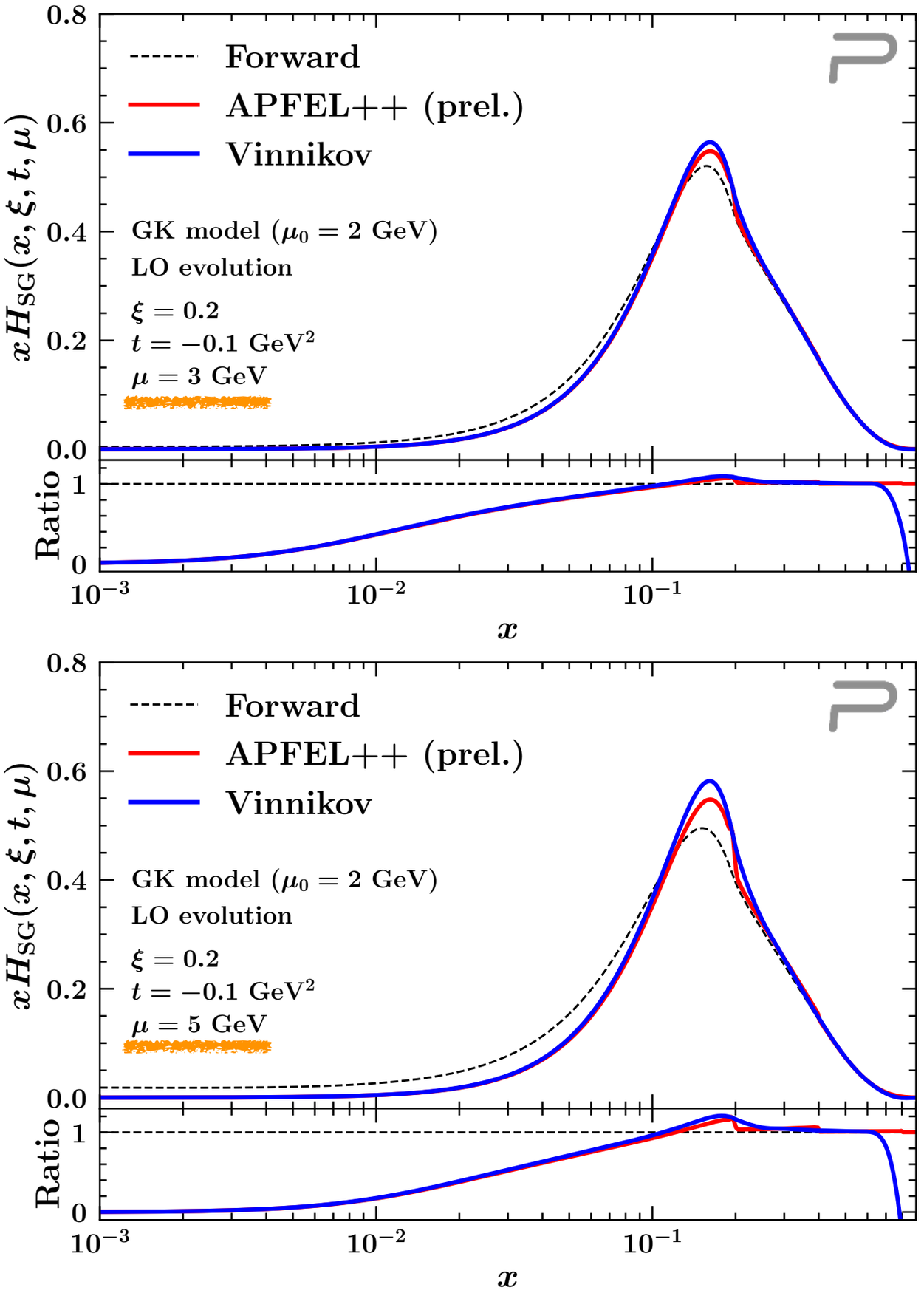
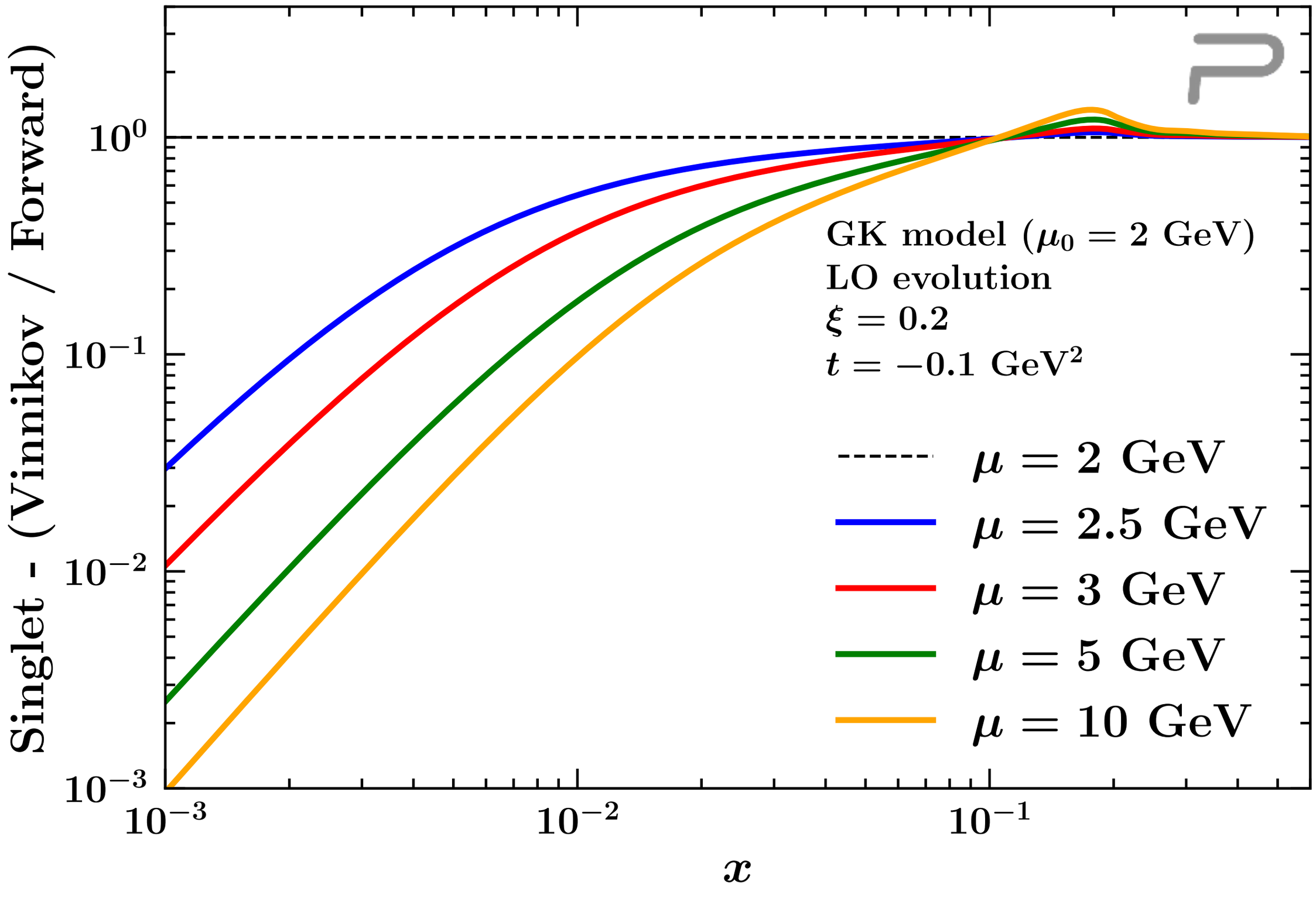
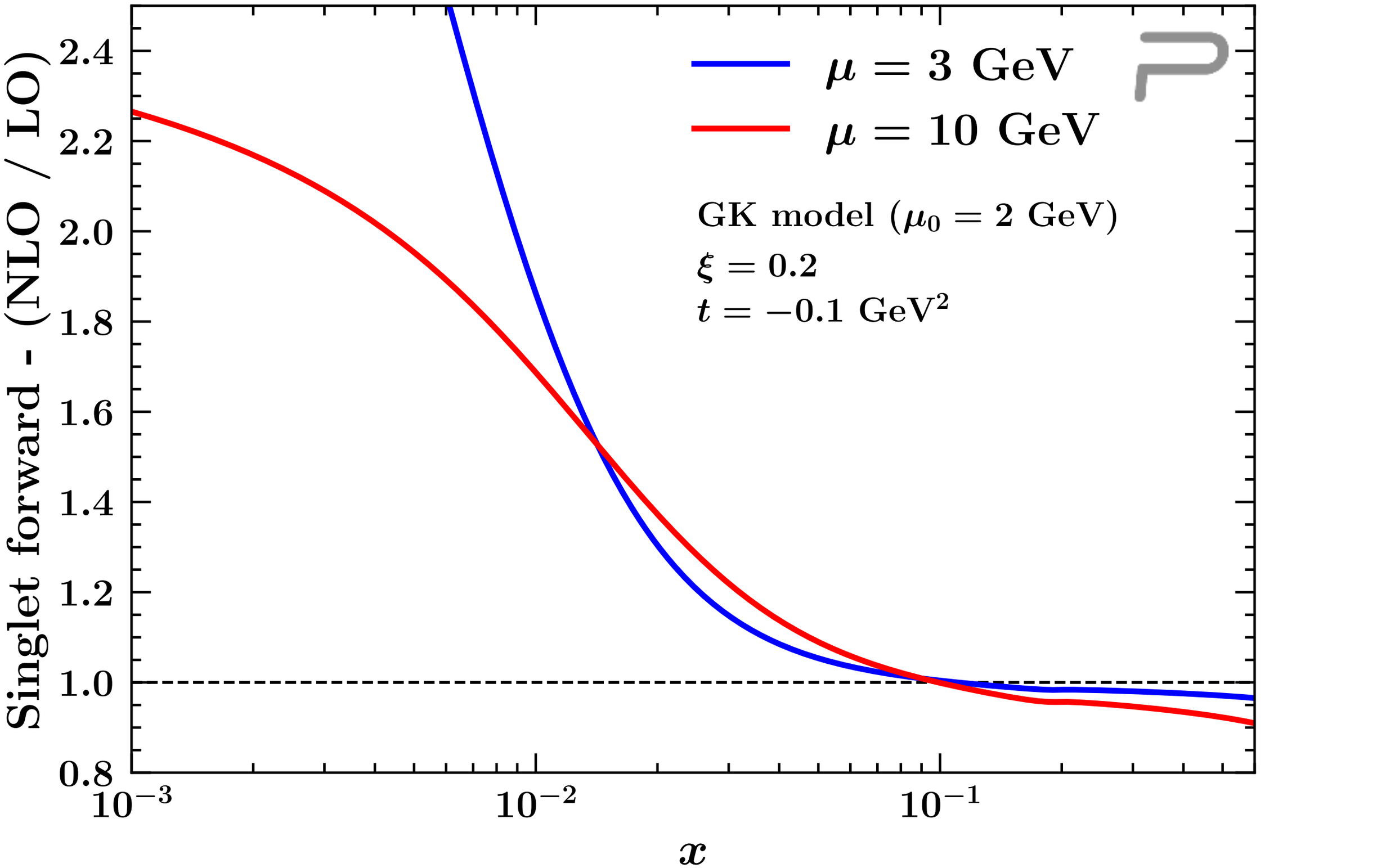




GPD vs. forward evolution



Estimate of NLO corrections



Concluding remarks

- **PARTONS** is getting in good shape to face the challenges of the EIC:
  - preparing to include GPD evolution effects in a fully-fledged fashion,
  - interfaced to **APFEL++**.
- We are currently working on APFEL++ to implement **GPD evolution**:
  - first encouraging results: reasonable agreement with Vinnikov's code,
  - plan to go beyond LO as soon as the benchmark is successful.
- GPD evolution effects appear to be **phenomenologically** relevant:
  - large deviations from the forward evolution is some particular regions,
  - singlet distribution, relevant *e.g.* to DVCS, particularly affected.
- An estimate based on forward evolution indicates that **NLO** corrections may be important.