Next generation of QCD global analysis tools

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Current paradigm

- Global analysis uses Bayesian regression
- It is done via posterior sampling

$$\rho(\boldsymbol{a}|\mathrm{data}) = \mathcal{L}(\boldsymbol{a}, \mathrm{data})\pi(\boldsymbol{a})$$

- $\boldsymbol{a}$ are the "shape" parameters for QCF

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- We **DON'T** have the inverse function to go from cross sections to $\boldsymbol{a}$

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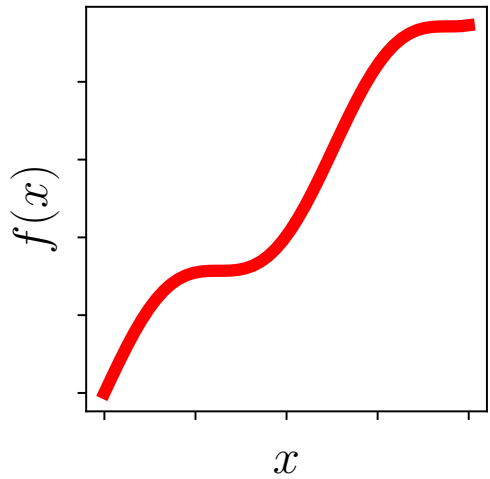
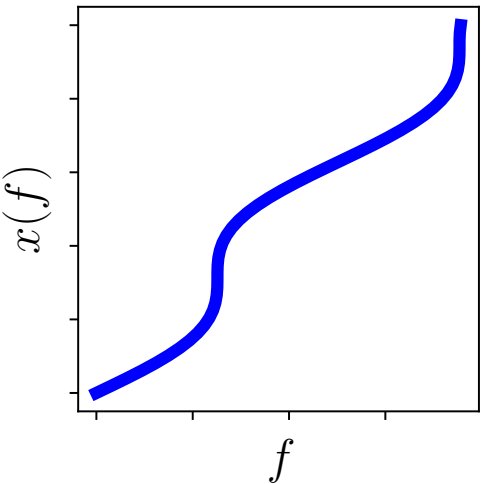
- Suppose we know $f(x)$ but not its inverse

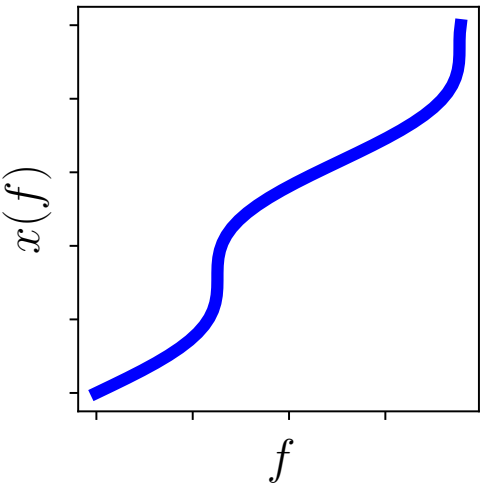


Consider a simple scenario in 1D

- Suppose we know $f(x)$ but not its inverse
- We can flip the graph to get the inverse



The key idea



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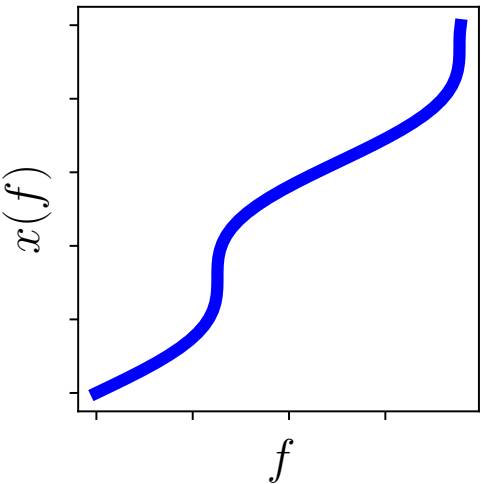
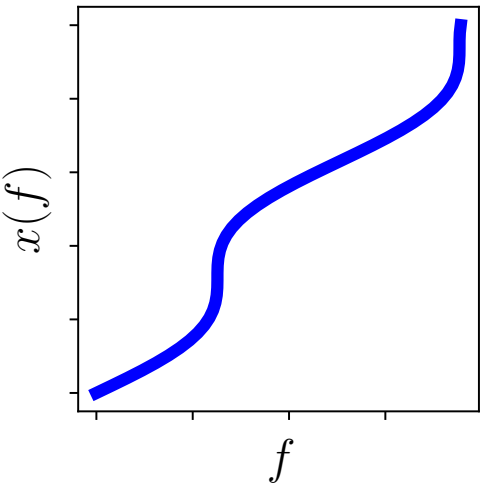
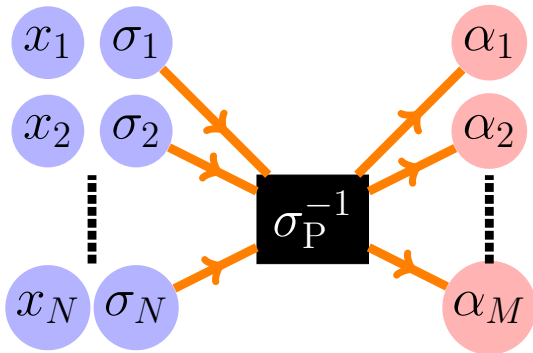


The key idea

- We can parametrize the inverse
- Given measurements of f we can infer x with the inverse



The inverse mapper for global analysis



$$R^N \to R^M$$

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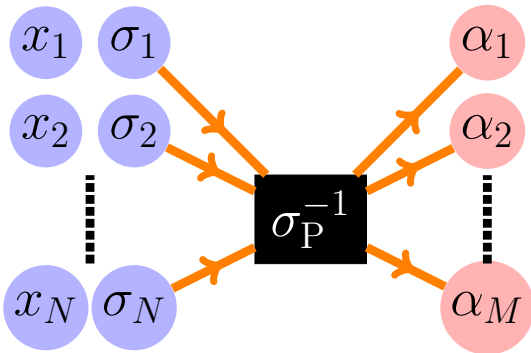

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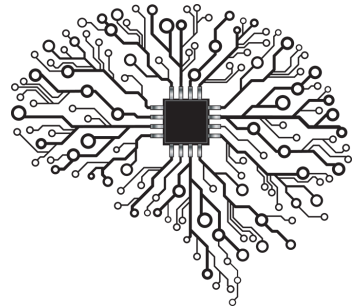
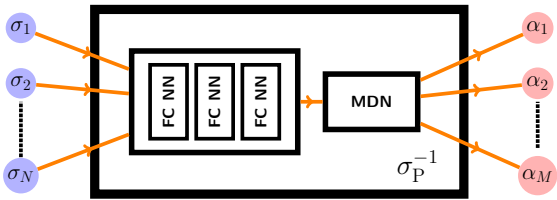


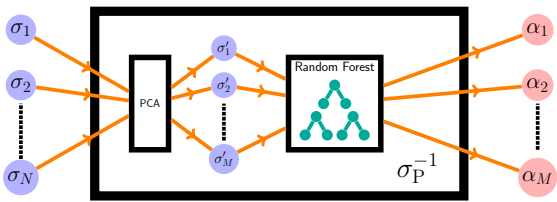
Can we use Machine Learning?

Partnership with computer scientists

- M. Almaeen (ODU)
- Y. Awadh Alanazi (ODU)
- M. Houck (Davidson College)
- M. P. Kuchera (Davidson College)
- Y. Li (ODU)
- W. Melnitchouk (JLab)
- R. Ramanujan (Davidson College)
- NS (JLab)
- E. Tsitinidi (Davidson College)

ML prototypes





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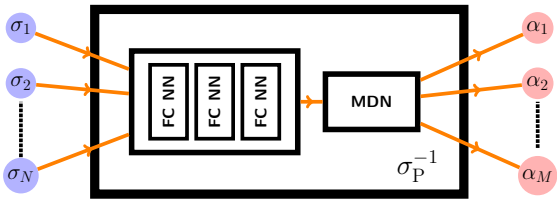

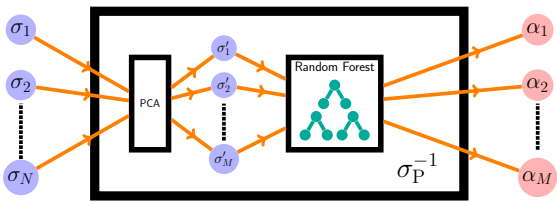

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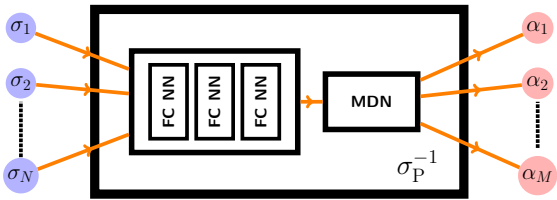

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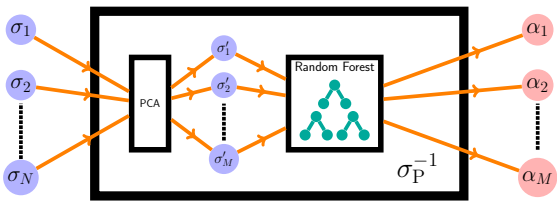
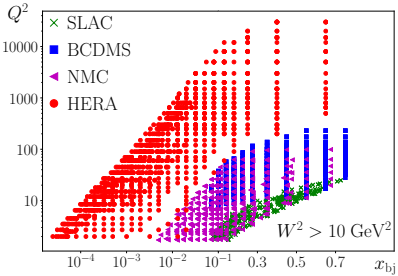


- How about real QCD analysis?

Application to unpolarized DIS



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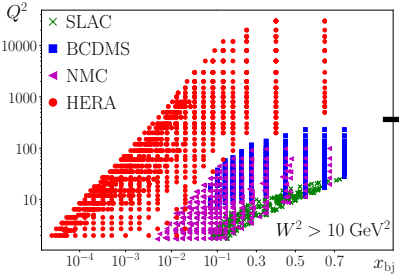

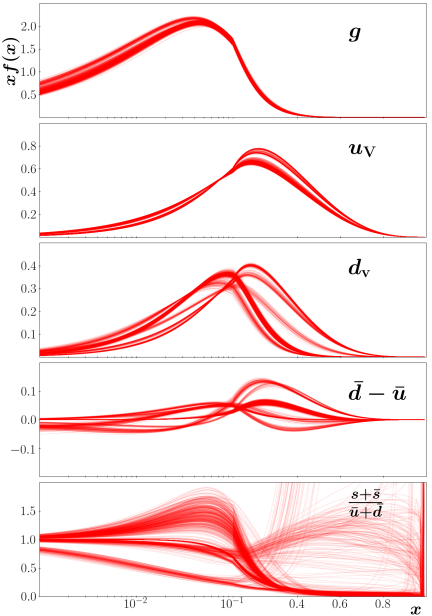

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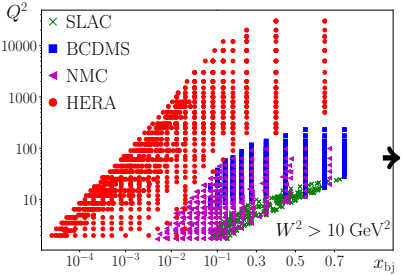

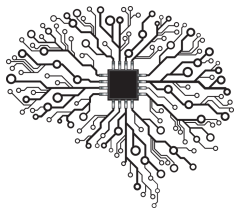

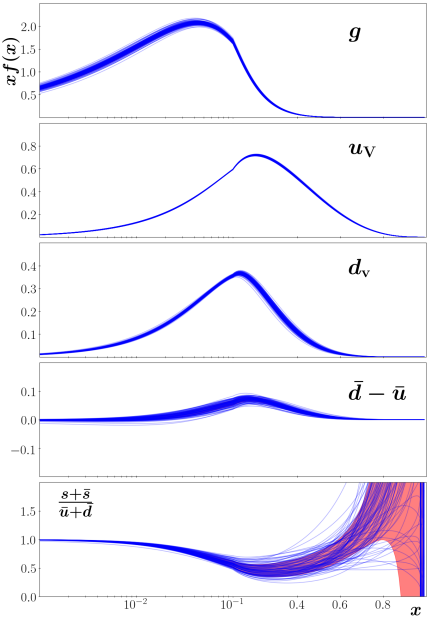

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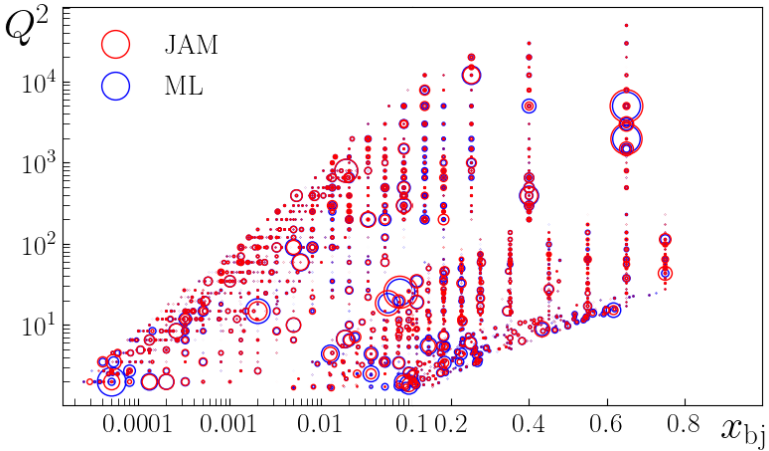

- Proton DIS kinematics
- Blobs $\propto \chi^2$
- $\frac{\chi^2_{\mathrm{JAM}}}{N_{\mathrm{pts}}} = 1.25$
- $\frac{\chi^2_{\mathrm{ML}}}{N_{\mathrm{pts}}} = 1.36$

Summary and outlook

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- A new paradigm for QCD
  - + simultaneous extraction of PDFs and FFs
  - + boosts the SIDIS program to study hadron structure
  - + the ultimate strategy for TMD and GPD physics
  - + ripe for Machine Learning techniques