3D PDF Extraction and VAlidation framework (EVA)

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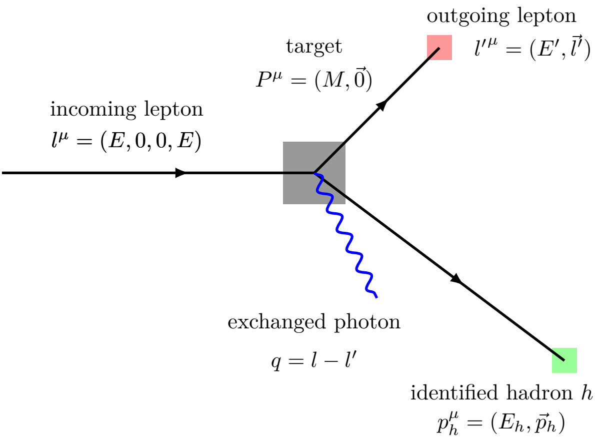
Short theory review

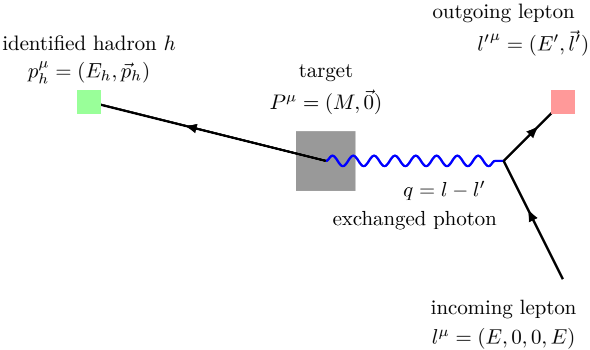
Semi inclusive deep inelastic scattering (SIDIS)

Lab frame

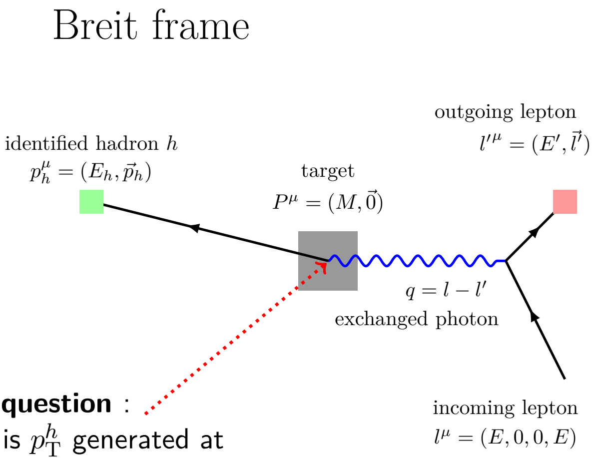


Semi inclusive deep inelastic scattering (SIDIS)

Breit frame



Semi inclusive deep inelastic scattering (SIDIS)



- **Key question** :
  How is p_{T}^h generated at short distances?

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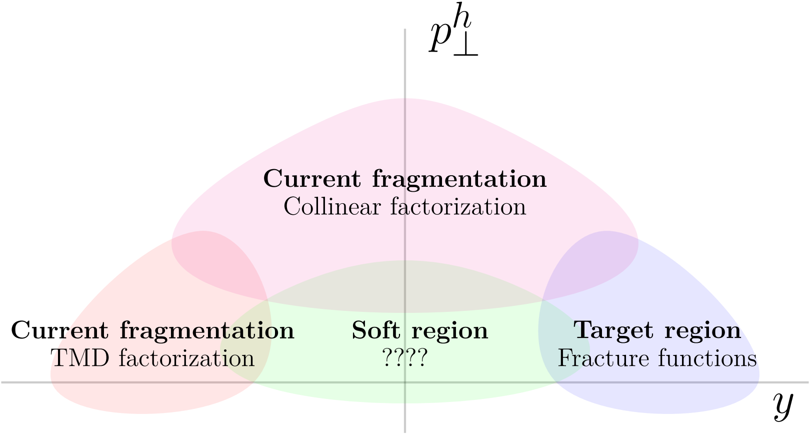
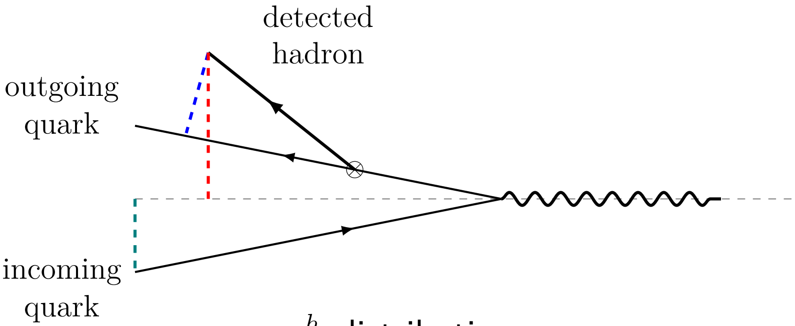


How is p_{T}^{h} generated at short distances?

Current fragmentation:

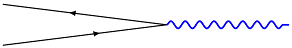


p_{T}^{h} distribution:

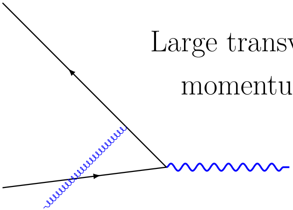
$$\mathcal{P}(p_{\mathrm{T}}^{h}) \propto \mathcal{F}(k_{\perp}) \otimes \mathcal{D}(k'_{\perp})$$

How is p_{T}^{h} generated at short distances?

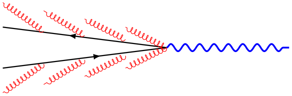
Small transverse momentum

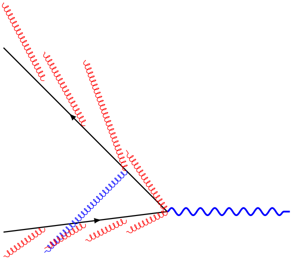


Large transverse momentum



+parton shower (Evolution)





SIDIS differential cross section

$$
\begin{aligned}
\frac{d\sigma}{dx\; dy\; d\Psi\; dz\; d\phi_h\; dP_{h\perp}^2} = \frac{\alpha^2}{xyQ^2}\,\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Bigg\{ & F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\varepsilon(1+\varepsilon)}\;\cos\phi_h\; F_{UU}^{\cos\phi_h} \\
& + \varepsilon\;\cos(2\phi_h) F_{UU}^{\cos 2\phi_h} + \lambda_e \sqrt{2\varepsilon(1-\varepsilon)}\sin\phi_h\; F_{LU}^{\sin\phi_h} \\
& + S_{||}\bigg[\sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_h\; F_{UL}^{\sin\phi_h} + \varepsilon\sin(2\phi_h)\; F_{UL}^{\sin\;2\phi_h}\bigg] \\
& + S_{||}\lambda_e\bigg[\sqrt{1-\varepsilon^2}\; F_{LL} + \sqrt{2\varepsilon(1-\varepsilon)}\;\cos\phi_h F_{LL}^{\cos\phi_h}\bigg] \\
& + |\vec{S}_\perp|\bigg[\sin(\phi_h-\phi_S)\;\left(F_{UT,T}^{\sin(\phi_h-\phi_S)} + \varepsilon\; F_{UT,L}^{\sin(\phi_h-\phi_S)}\right) + \varepsilon\;\sin(\phi_h+\phi_S)\; F_{UT}^{\sin(\phi_h+\phi_S)} \\
& \qquad + \varepsilon\;\sin(3\phi_h-\phi_S) F_{UT}^{\sin(3\phi_h-\psi_S)} + \sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_S\; F_{UT}^{\sin\phi_S} \\
& \qquad + \sqrt{2\varepsilon(1+\varepsilon)}\sin(2\phi_h-\phi_S)\; F_{UT}^{\sin(2\phi_h-\phi_S)}\bigg] \\
& + |\vec{S}_\perp|\lambda_e\bigg[\sqrt{1-\varepsilon^2}\cos(\phi_h-\phi_S) F_{LT}^{\cos(\phi_h-\phi_S)} + \sqrt{2\varepsilon(1-\varepsilon)}\cos\phi_S\; F_{LT}^{\cos\phi_S} \\
& \qquad + \sqrt{2\varepsilon(1-\varepsilon)}\cos(2\phi_h-\phi_S)\; F_{LT}^{\cos(2\phi_h-\phi_S)}\bigg]\Bigg\}
\end{aligned}
$$

EVA framework

K. Tezgin (UConn)

D. Riser (UConn)

EVA framework

Objectives

- Computational tools for TMD studies
- General purpose structure functions interface
- MCEG for detector simulation studies
- Extraction of TMDs via likelihood analysis

EVA framework

Details

- Main programming language: Python
  - Easy to integrate with existing Fortran codes
  - Extensive libraries for state-of-the-art data analysis kits
  - Interface with ROOT (pyROOT)
  - Extensive libraries for parallel computing

1) Structure functions (SFs) library

- Generic interface to SFs
- Implementation of the 18 SIDIS SFs
- SFs to neural nets for SFs with slow performance

2) MCEG

- Sampling methods:
  - Vegas integrator
  - MCMC sampling
  - Nested sampling (nestle)
- Radiative corrections
- JSON format as ouput

3) Detector simulation

- Not part of this project
- JSON files as input
- JSON files as output

4) TMD extraction

- JSON format as input
- Likelihood analysis
  - Least squares minimization
  - Iterative Monte Carlo (IMC)
  - MCMC sampling (HMC)
  - Nested sampling (nestle)

Progress

SIDIS in WW-approx. (Prokudin et al., in prep.)

- The 18 STFs are described in terms of "known" TMDs
- TMDs are computed using the Gaussian model
- No treatment for gluon ration
- Dedicated numerical library for SIDIS in WW-approx.

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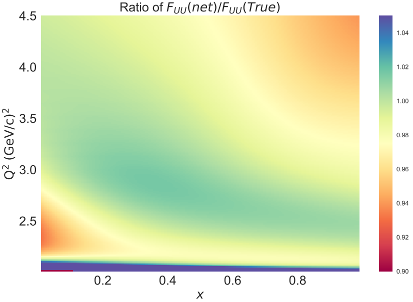
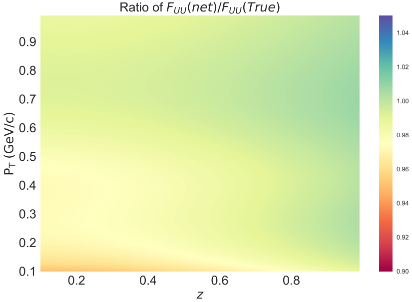
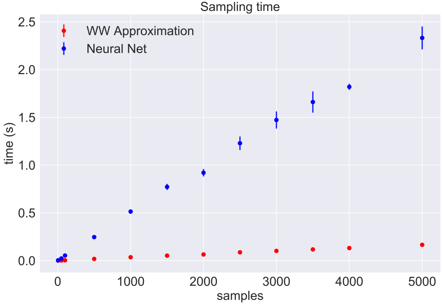
Neural Net representation of SFs







D. Riser (UConn)

Summary and outlook

- **New analsys framework for TMDs**
  - Implementation of all 18 SFs using WW-approx
  - Neural Nets representation of SFs
  - TMD extraction package

- **TO DO**
  - Perform a new global analysis for TMDs within the WW-approx
  - Implementation of MCEG
  - Validation of input and output TMDs