

# FASER Nikhef meeting

## **NSBI PDF measurements at FASER**

04 February 2026

# NSBI in a nutshell

## Event-by-event measurement

### Neural Simulation-Based Inference (NSBI)

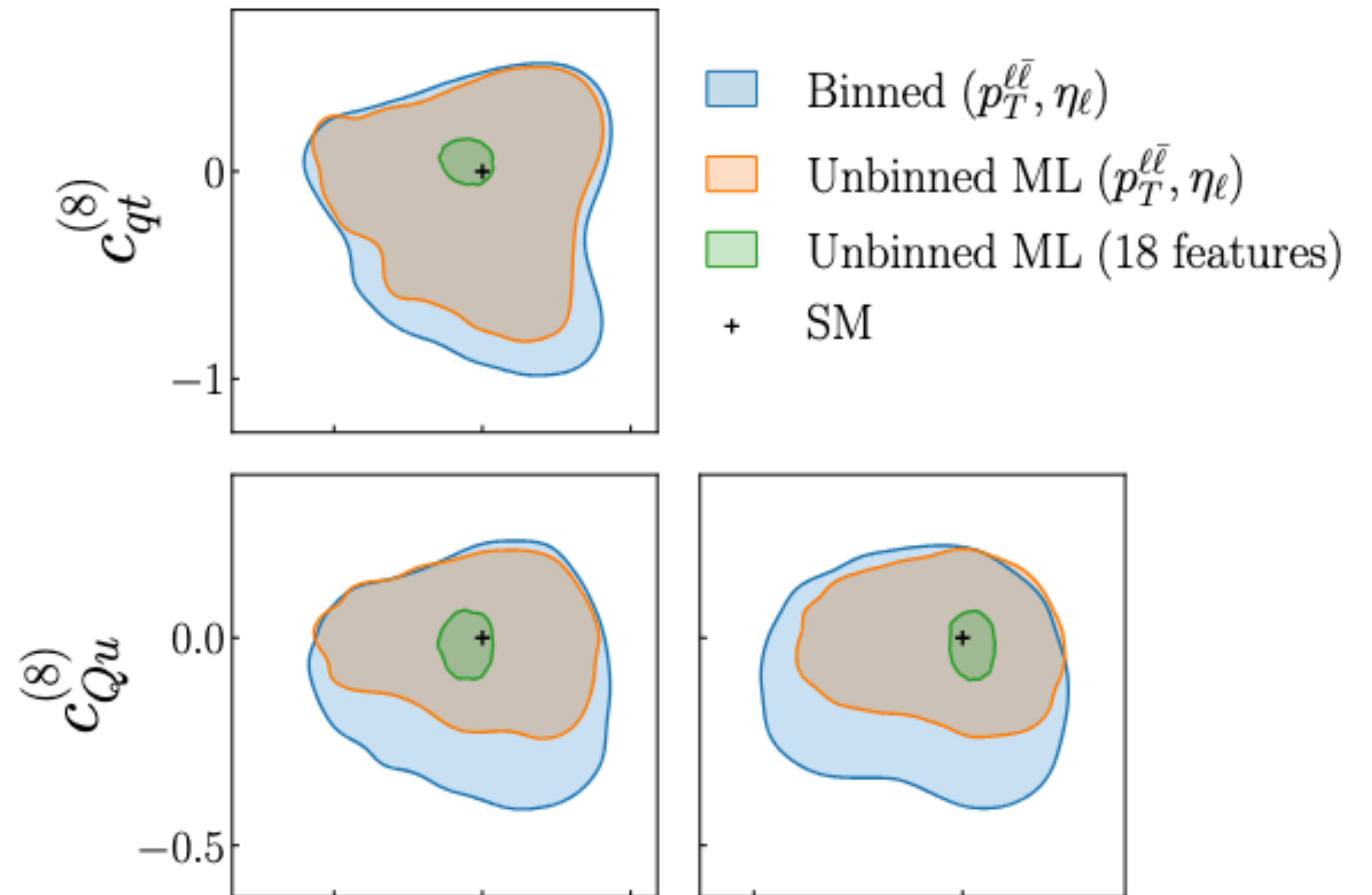
- Generate (many) event-level observables  $x \sim p(x | \theta, \nu)$ 
  - $x$ : events,  $\theta$  parameters of interest (POI),  $\nu$  nuisance params
- Train NN on simulated events to learn likelihood or posterior
  - e.g.  $p(\theta | x)$
- Evaluate NN on each real measured event
  - able to constrain  $\theta$

# Motivation

Big uncertainty reduction

Example of SMEFT NSBI  
measurements

Juan + Jaco



# Choosing PDF model

## A linear PDF parametrisation

$$f_{\mathbf{w}}(x) = \mathbf{w}^T \boldsymbol{\varphi}(x) = \varphi_0(x) + \sum_{k=1}^N w_k \varphi_k(x),$$

Construct a basis of functions  $\phi_i$

Fit the weights  $w_i$

-> they appear linearly + quadratically in observables (like SMEFT)

# Proper Orthogonal Decomposition

## Constructing function basis (ongoing work)

Steps:

- generate ~ 20K random functions using NNPDF

$$xg_m^j(x, Q_0; \boldsymbol{\theta}) = A_m^j x^{1-\alpha_m^j} (1-x)^{\beta_m^j} \text{NN}_m(x; \boldsymbol{\theta}),$$

- Identify optimal orthogonal basis (2507.16913) of 5 - 10 elements (not trivial)
- potentially restrict to charm PDF only with other flavours fixed
- Measure weights  $w_i$  with NSBI

# Implementing NSBI framework

## Integration in the FASER pipeline (future work)

Currently relying on Gollum (proprietary CMS...)

-> need our own tool for FASER

What we already have:

- SMEFT framework from Juan + Jaco
- colibri: flexible PDF fitting framework

Options:

- build tool from scratch (difficult)
- implement NSBI procedure in colibri