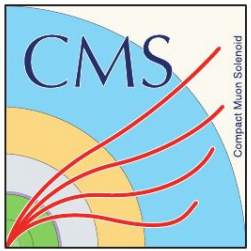
ETH zürich

Computing the **Matrix Element Method** with generative machine learning

Davide Valsecchi for the CMS collaboration



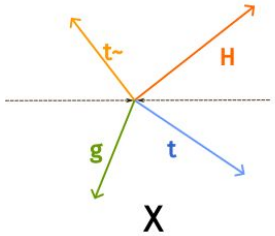
Matrix Element Method: powerful summary statistics combining theoretical and experimental knowledge

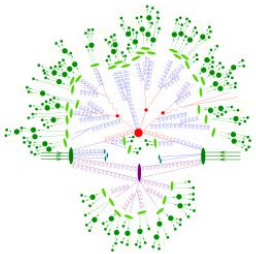
single-event likelihood — hard-scattering — transfer function

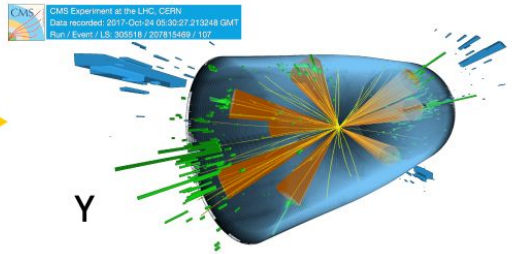
$$\mathcal{P}(\vec{Y} \mid \vec{\theta}) = \int_{\phi} d\vec{X} \cdot |\mathcal{M}(\vec{X} \mid \vec{\theta})|^2 \cdot Pdf \cdot \mathcal{W}(\vec{Y} \mid \vec{X})$$

parton-level events

per-event high-dim integral → too expensive to compute in most of the cases!







ETH zürich

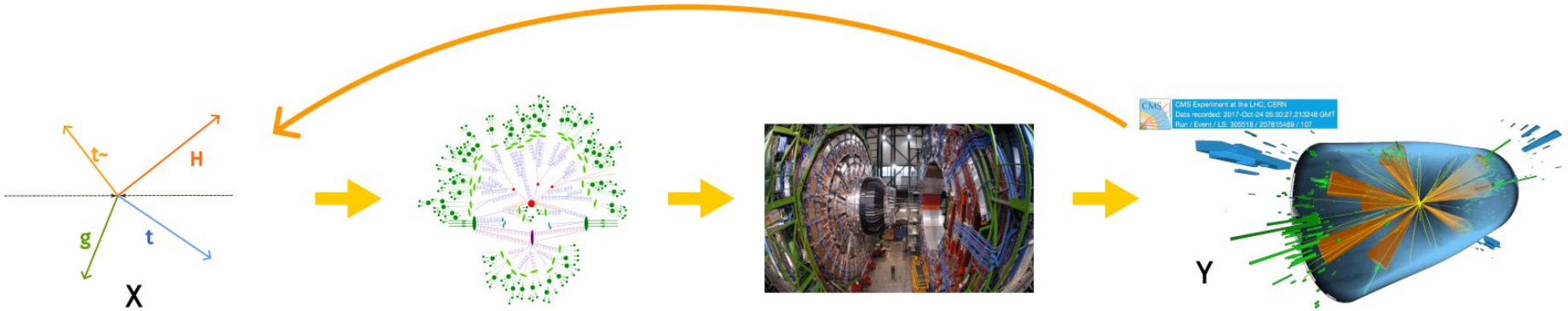
single-event likelihood

hard-scattering

transfer function

$$\mathcal{P}(\vec{Y} \mid \vec{\theta}) = \int_{\phi} d\vec{X} \cdot |\mathcal{M}(\vec{X} \mid \vec{\theta})|^2 \cdot Pdf \cdot \mathcal{W}(\vec{Y} \mid \vec{X})$$

parton-level events



ETH zürich

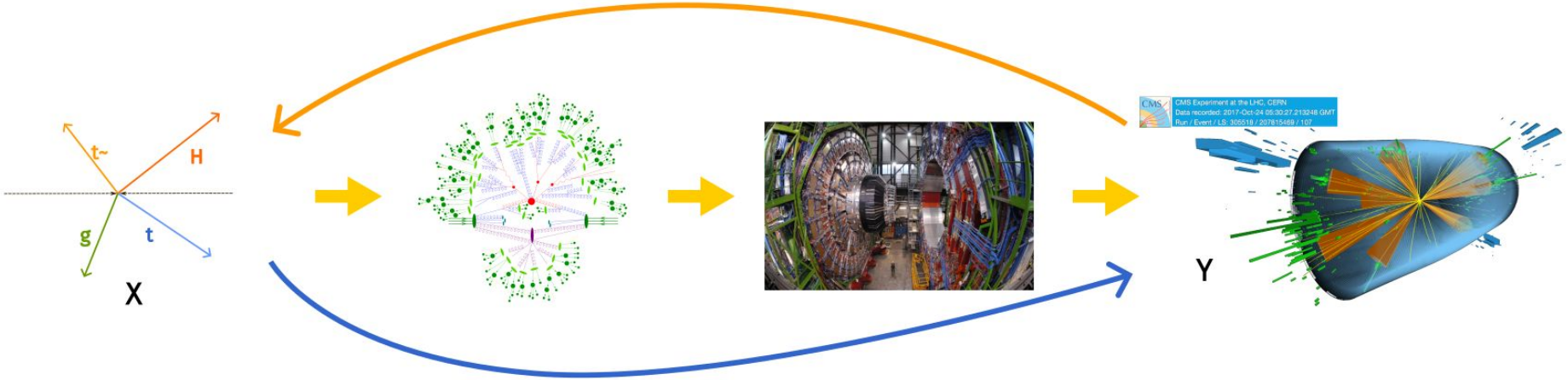
single-event likelihood

hard-scattering

transfer function

$$\mathcal{P}(\vec{Y} \mid \vec{\theta}) = \int_{\phi} d\vec{X} \cdot |\mathcal{M}(\vec{X} \mid \vec{\theta})|^2 \cdot Pdf \cdot \mathcal{W}(\vec{Y} \mid \vec{X})$$

parton-level events



transfer function

$$\mathcal{W}(\vec{Y} \mid \vec{X})$$

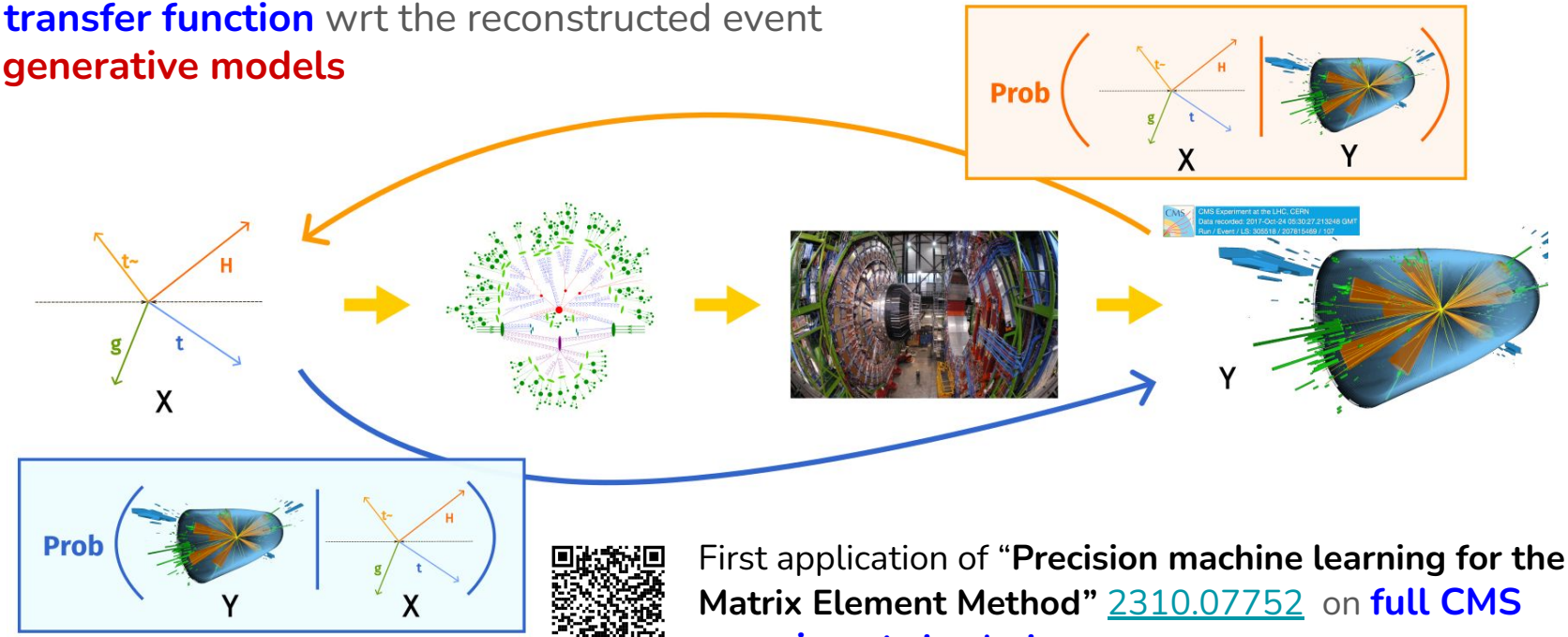
single-event likelihood

hard-scattering

transfer function

$$\mathcal{P}(\vec{Y} \mid \vec{\theta}) = \int_{\phi \text{ parton-level events}} d\vec{X} \cdot |\mathcal{M}(\vec{X} \mid \vec{\theta})|^2 \cdot Pdf \cdot \mathcal{W}(\vec{Y} \mid \vec{X})$$

Sampling parton-level candidates and evaluating their **transfer function** wrt the reconstructed event with **generative models**



First application of "**Precision machine learning for the Matrix Element Method**" 2310.07752 on **full CMS experiment simulation**