UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Trackless Jet Vertexing and Timing using ML

Wen Han Chiu

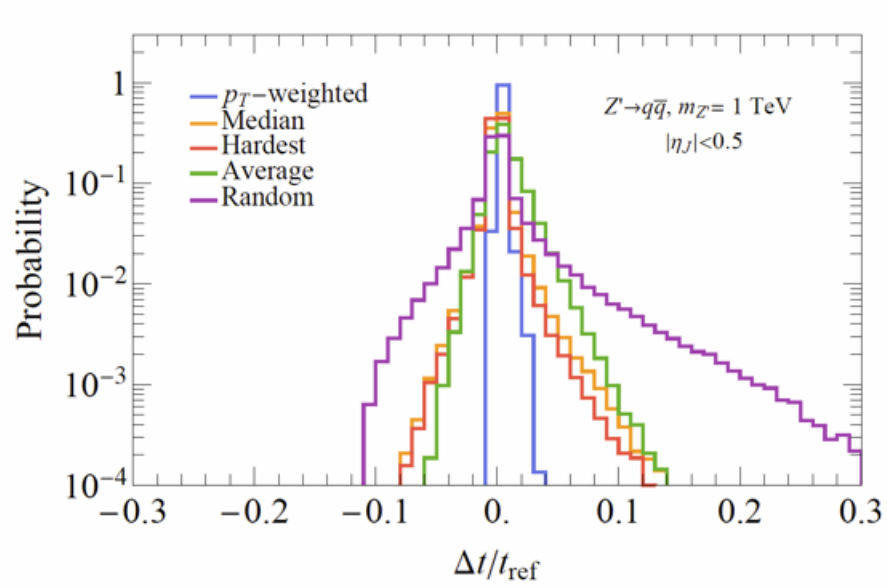
Joint DPF - Phenomenology Symposium 2024

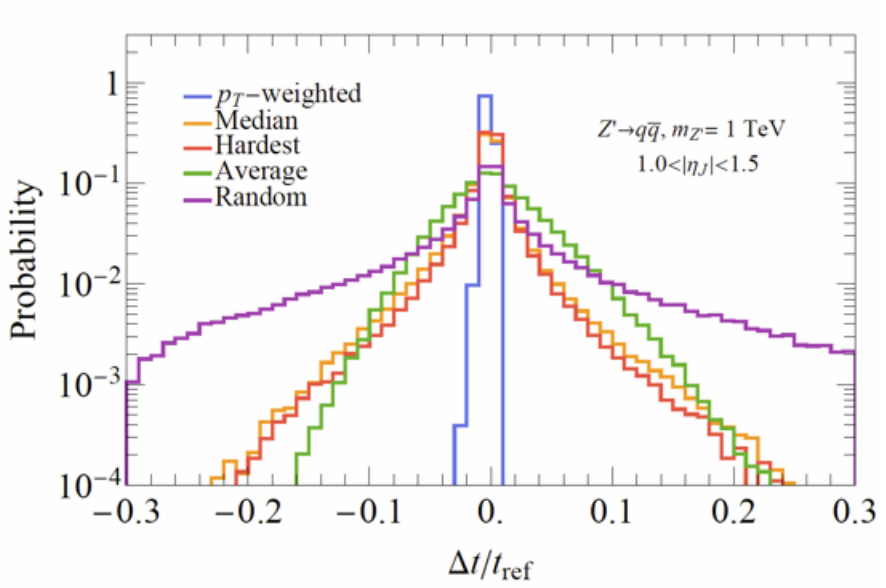
Based on:
Ongoing work – *WHC, Zhen Liu, Tong Shen*
2109.01682 – *WHC, Zhen Liu, Matthew Low, Lian Tao Wang*

Why timing (for BSM)?

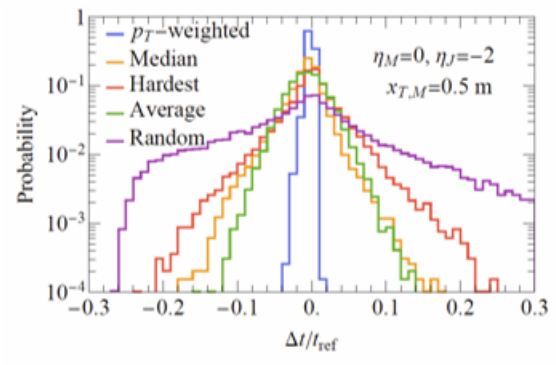
Why timing (for BSM)?

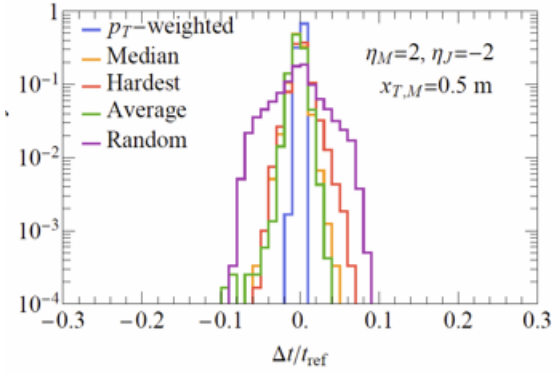
Timing prompt jets

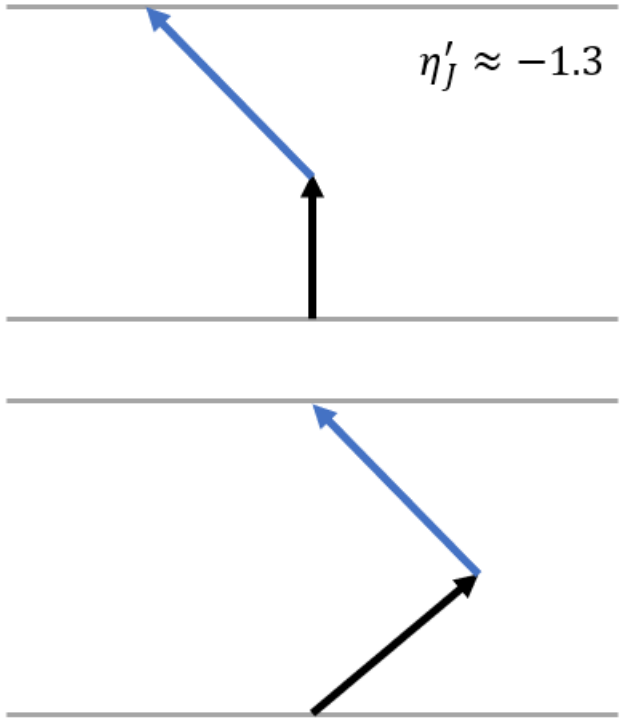




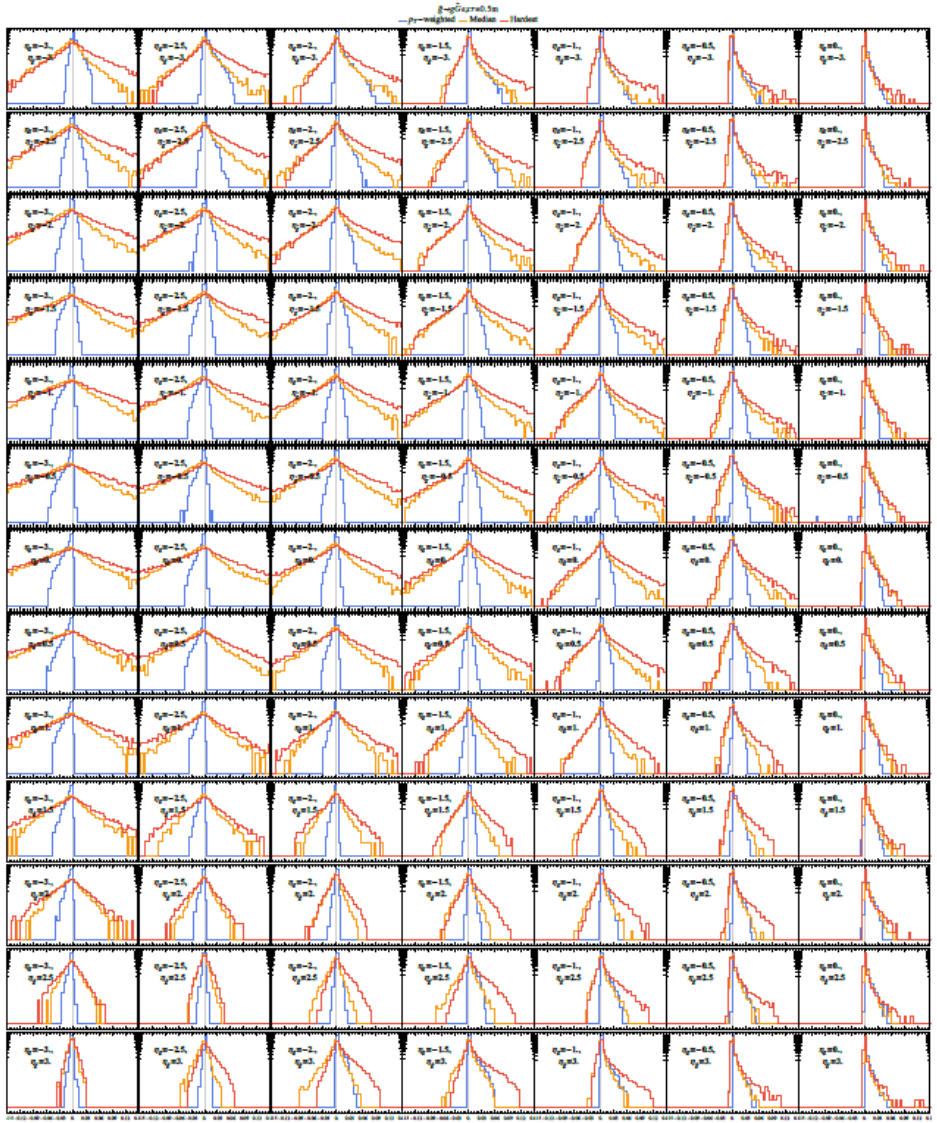
Timing delayed jets







Timing delayed jets (cont.)



Questions

Questions

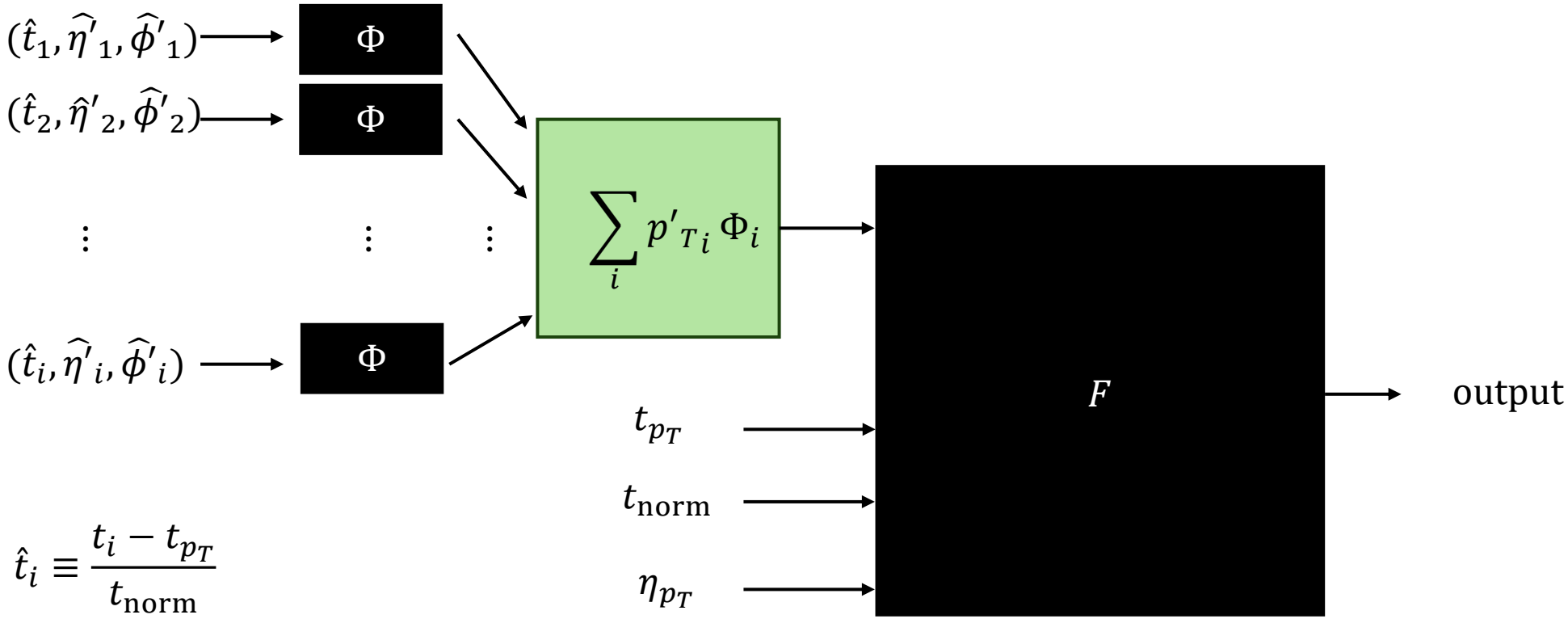
- Can we do even better?

Questions

- Can we do even better?
- If the location of the decay affects timing distributions, can we infer the decay location from timing distributions?

Network architecture

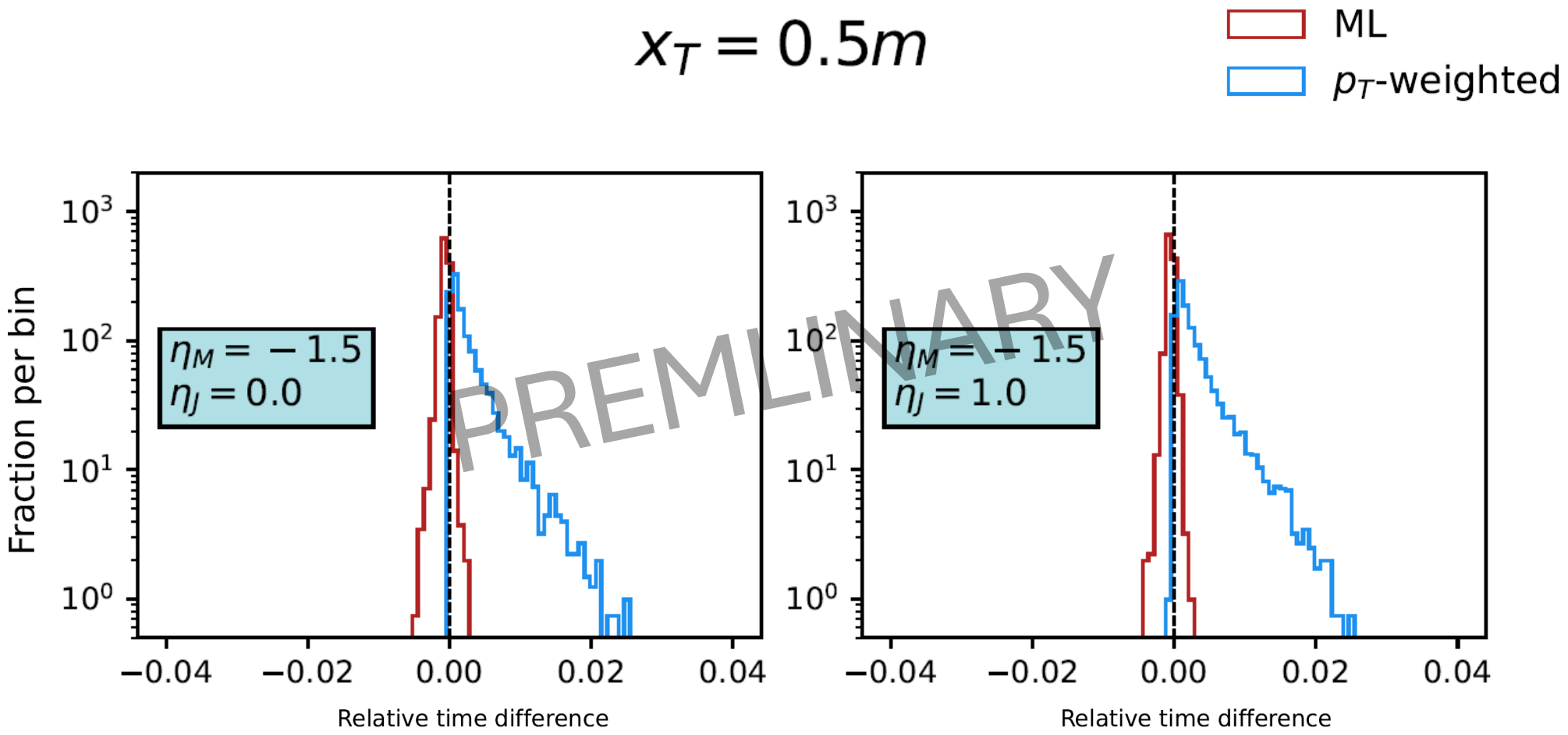
- Adapted from Energy Flow Network (EFN)



Training sample (timing)

- 2000 idealized mono-jet events with an idealized $1\ \mathrm{m}$ radius cylindrical detector per configuration
  - x_T varied from $100\ \mathrm{mm}$ to $1\ \mathrm{m}$ with $100\ \mathrm{mm}$ steps
  - η_M and η_J independently varied from -2 to 2 with 0.2 steps
  - β_M held fixed at 0.38

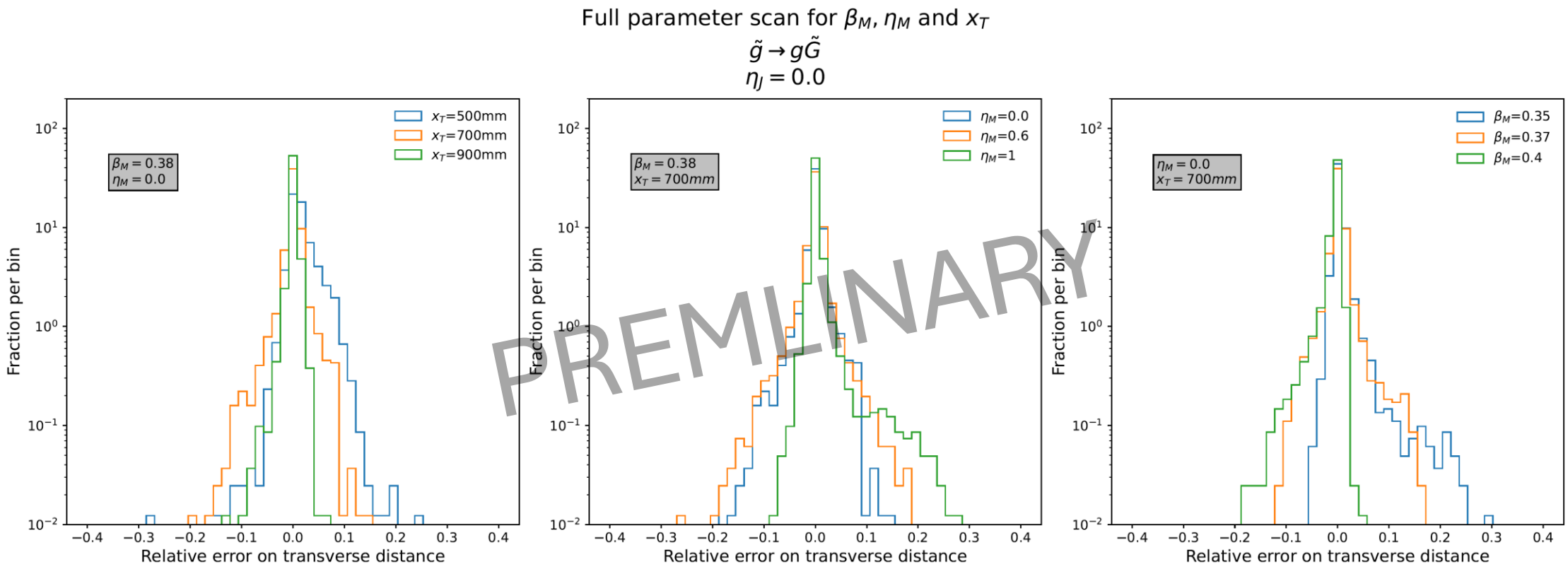
ML timed jets



Training sample (vertexing)

- Idealized jets with an idealized cylindrical detector
  - x_T varied from $500\ \mathrm{mm}$ to $950\ \mathrm{mm}$ with $10\ \mathrm{mm}$ steps
  - η_M varied from -1 to 1 with 0.1 steps
  - β_M varied from 0.35 to 0.4 with 0.01 steps
  - η_J held fixed at 0

Vertexing


Full parameter scan for β_M, η_M and x_T
$\tilde{g} \to g\tilde{G}$
$\eta_J = 0.0$
$\beta_M = 0.38$
$\eta_M = 0.0$
x_T=500mm
x_T=700mm
x_T=900mm
$\beta_M = 0.38$
$x_T = 700mm$
η_M=0.0
η_M=0.6
η_M=1
$\eta_M = 0.0$
$x_T = 700mm$
β_M=0.35
β_M=0.37
β_M=0.4
Fraction per bin
Relative error on transverse distance
PRELIMINARY

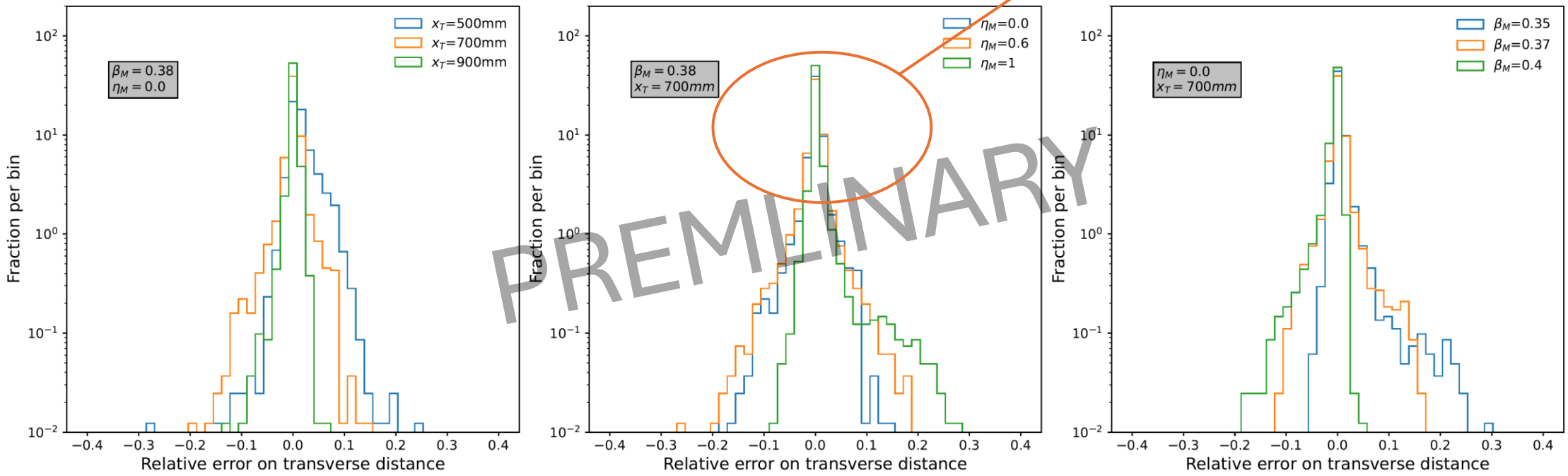
Vertexing

Full parameter scan for β_M, η_M and x_T

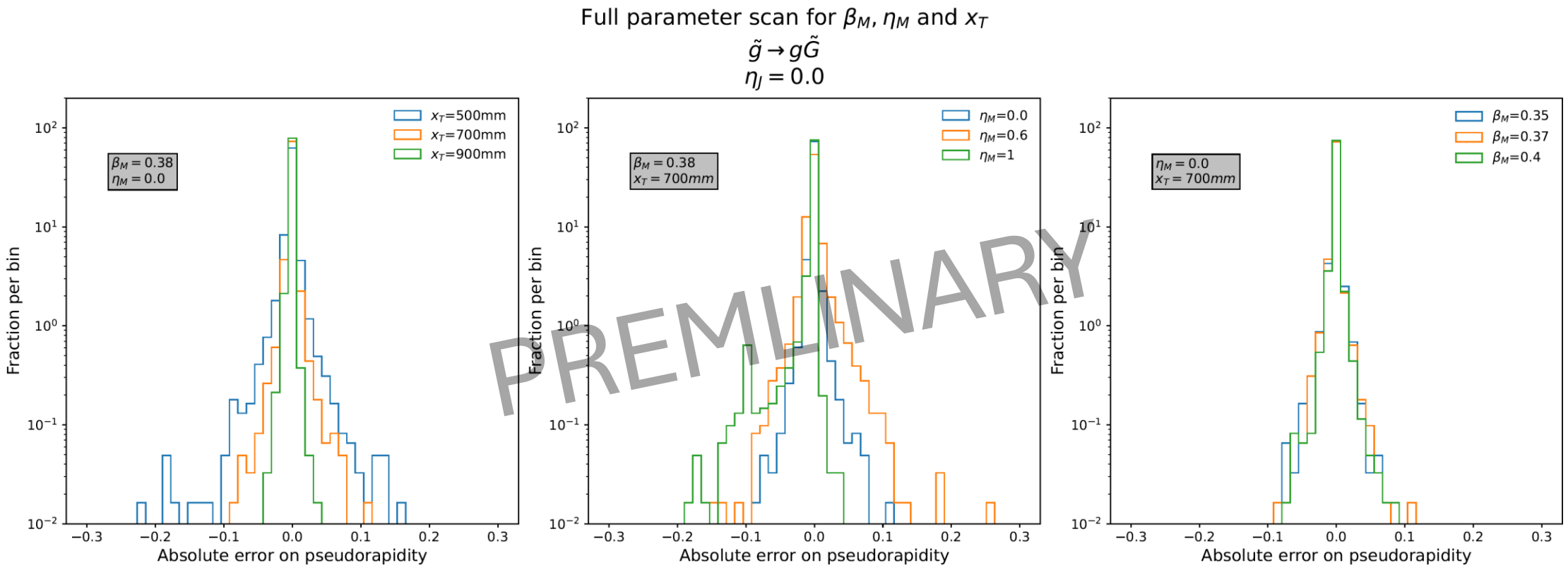
$\tilde{g} \to g\tilde{G}$

$\eta_J = 0.0$

99.7% of events have $\frac{\Delta x_T}{x_{T,\text{truth}}} \in [-0.16, 0.16]$

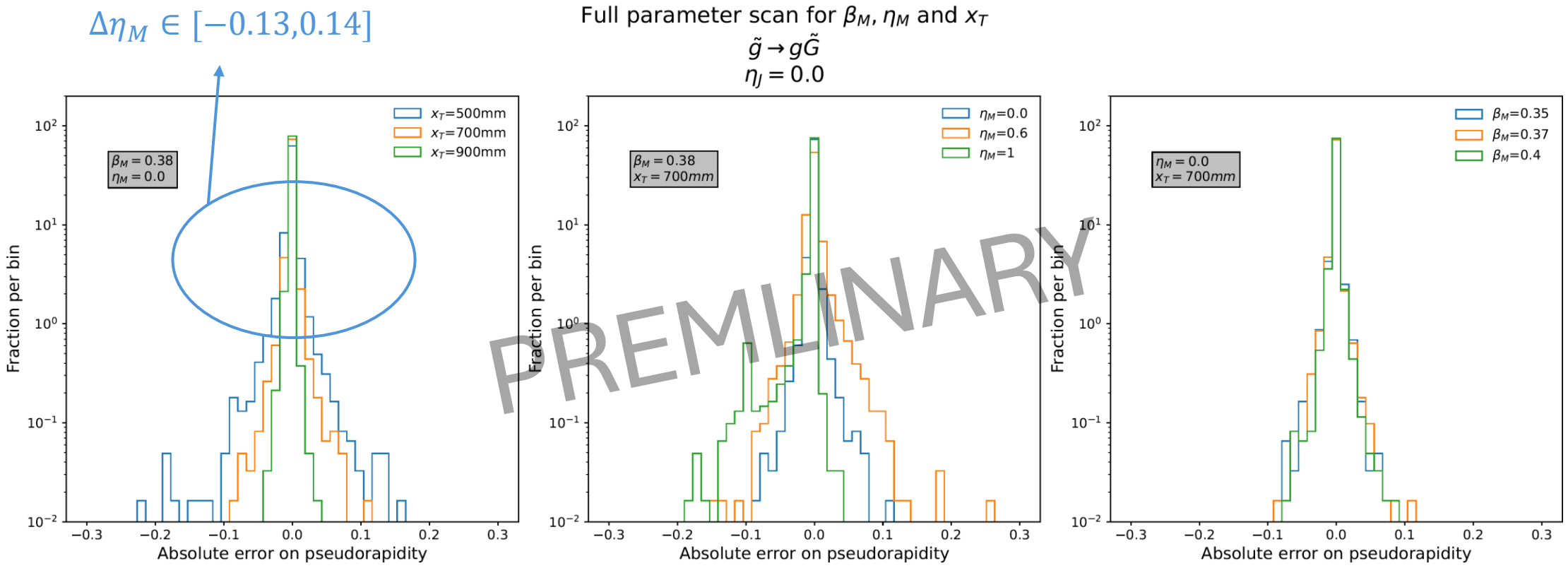


Vertexing (cont.)



Vertexing (cont.)

99.7% of events of
$\Delta\eta_M \in [-0.13, 0.14]$

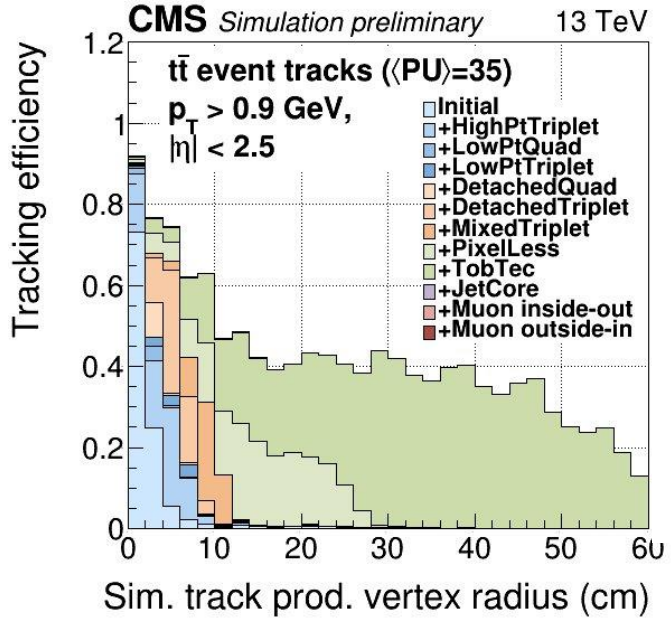


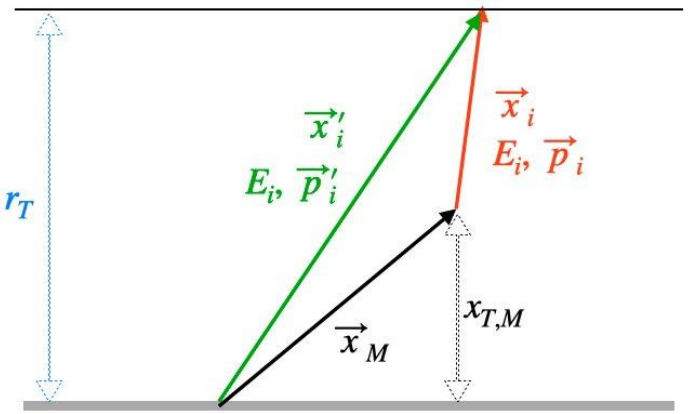
Summary

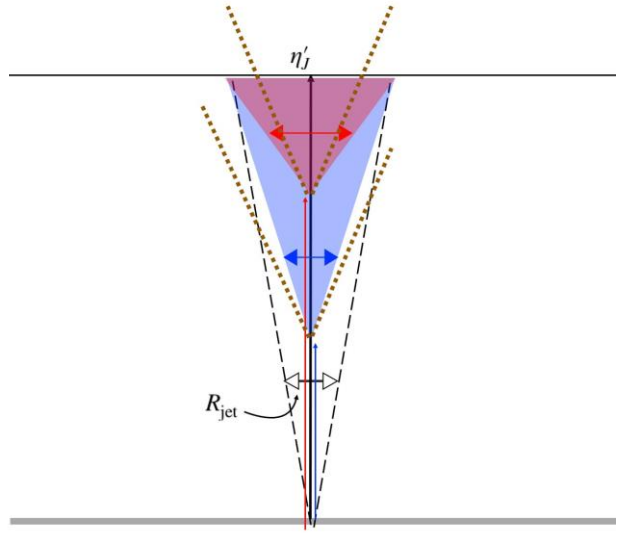
- Timing is a valuable observable when searching for decays of LLPs
- The notion of timing can be extended to jets – with many subtleties related to the kinematic configuration of the parent particle-jet system
- These details can be learned by a machine, giving both an improved notion of jet time and information of the production vertex

Backup Slides

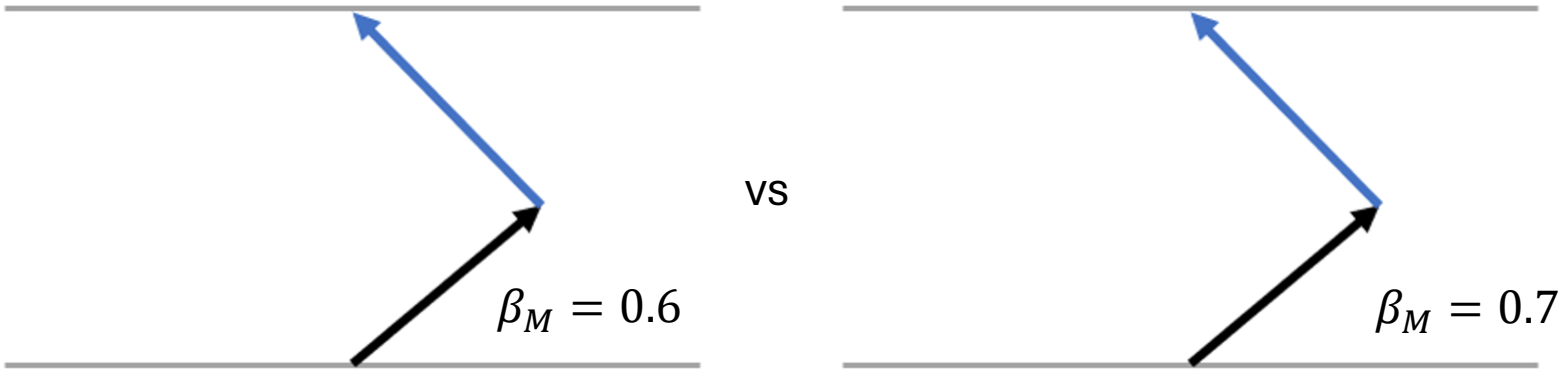
Timing delayed jets (cont.)







Time-preprocessing



- Goal: Tell the machine that only β_M has changed without penalizing certain configurations
- $t_i - t_{p_T}$ is the same for both configurations
- Needs t_{norm} to NOT be an actual measured time