Heavy Jet Observables within the JetScape Framework

Wenkai Fan, Weiyao Ke and Steffen Bass

13th International Workshop on High-pT Physics
in the RHIC/LHC era

University of Tennessee, Knoxville

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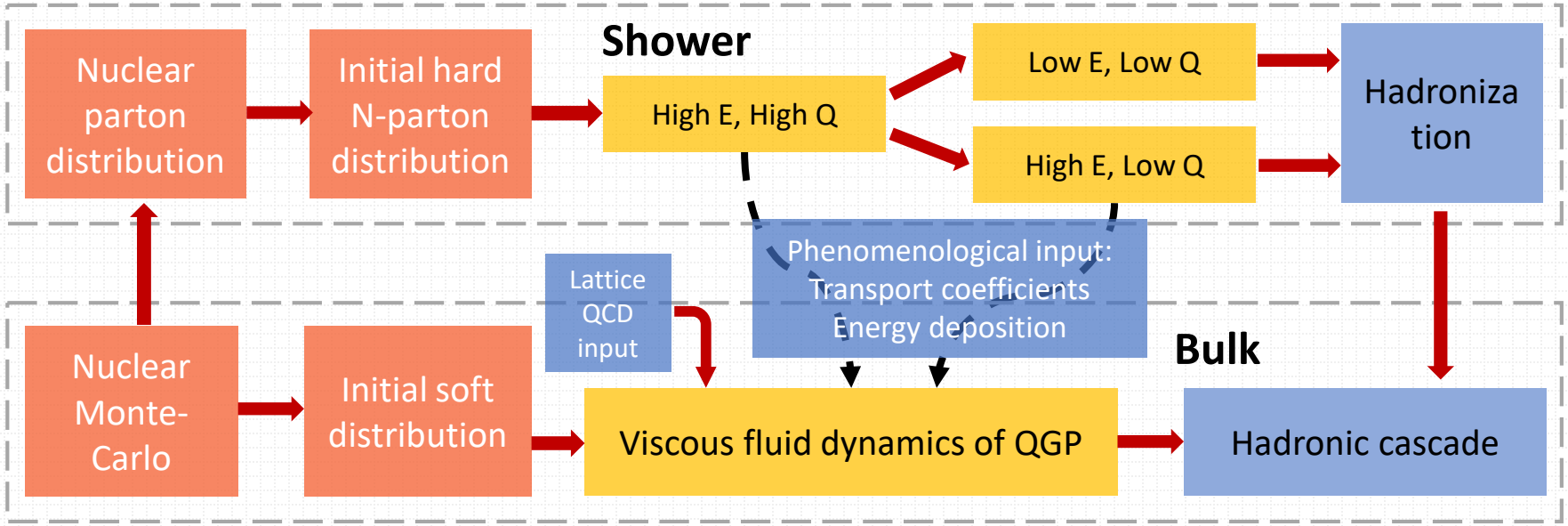
OUTLINE

- **The JetScape Framework**
- Validation of heavy jet production in p+p collisions
- The Lido transport model in the JetScape framework

PART ONE

The JetScape FrameWork

Jet Energy Loss Tomography
with a Statistically and Computationally Advanced Program Envelope



Kauder, Kolja, and JETSCAPE Collaboration. "Jetscape v1. 0 quickstart guide." *Nuclear Physics A* 982 (2019): 615-618.

Public version: https://github.com/JETSCAPE/JETSCAPE

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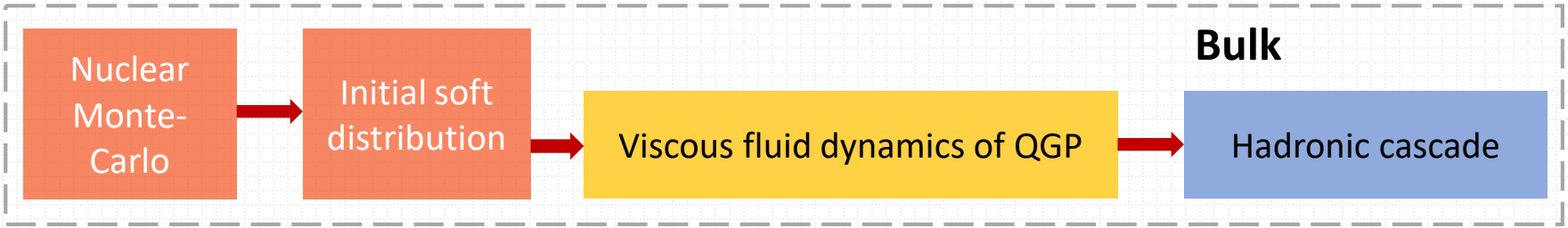

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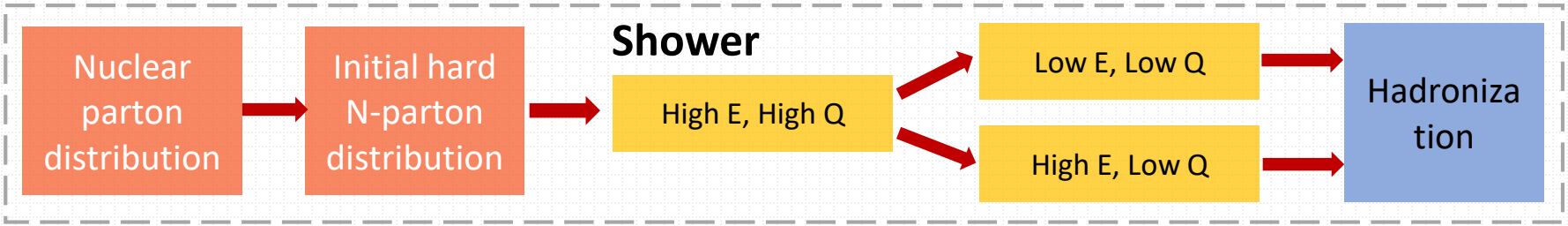

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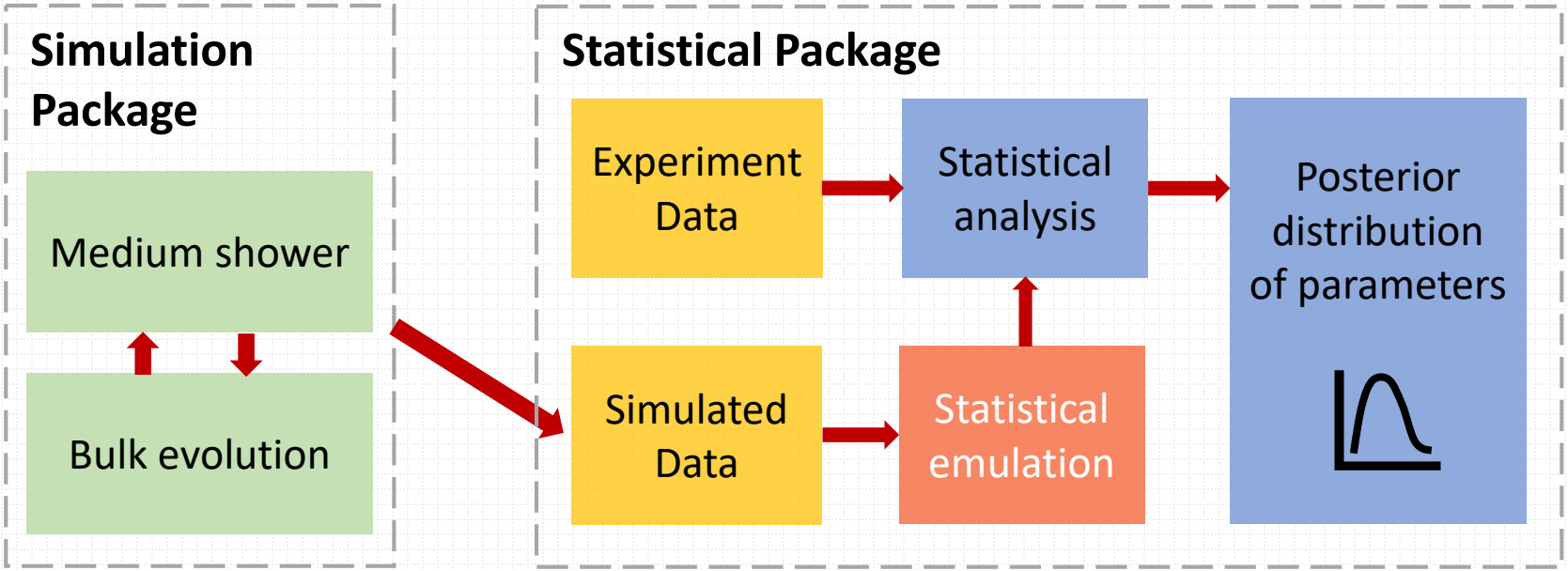
The JetScape FrameWork

Jet Energy Loss Tomography
with a **S**tatistically and Computationally Advanced Program Envelope



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The JetScape FrameWork

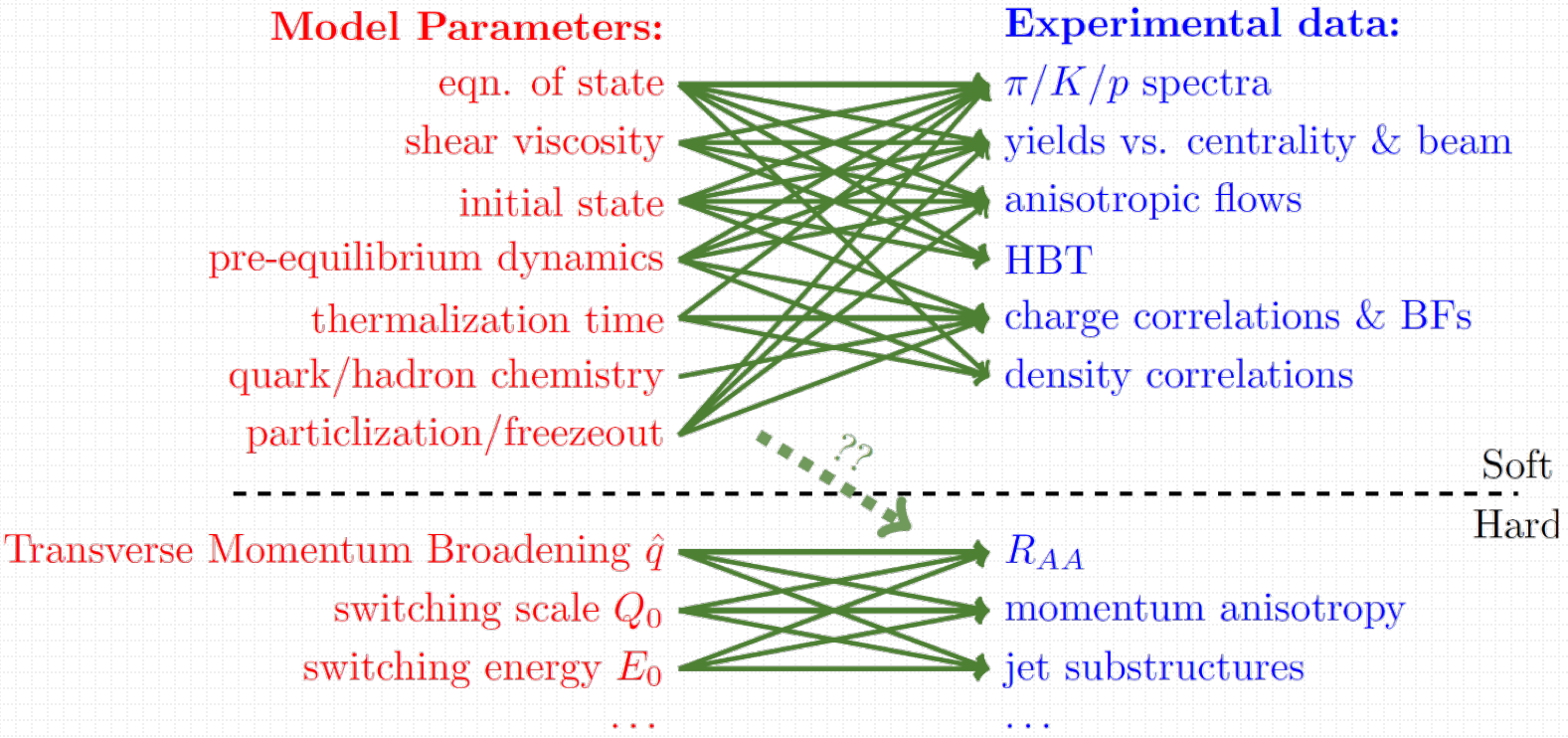

Figure from Steffen Bass &Weiyao Ke

PART ONE

The JetScape FrameWork

- Large number of parameters and observables
- Complex correlations

Use JetScape for:

- Study single model systematics.
- Study model-to-model comparison in a more controlled manor
- Study model-to-data comparison using the statistical package.

OUTLINE

- The JetScape Framework
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- The Lido transport model in the JetScape framework

PART TWO

Validation of heavy jet production in p+p collisions

Inclusive b-jet production in p+p collisions.

Pythia (ISR + MPI) — initial hard parton

↓

MATTER — MC event generator that produces virtuality-ordered shower with large virtuality ($Q^2 \geq \sqrt{\hat{q}E}$ in medium and $Q^2 > 1GeV^2$ in vacuum). (no mass in the splitting function for now)

↓

Hadronization — heavy baryon decay channels are turned off

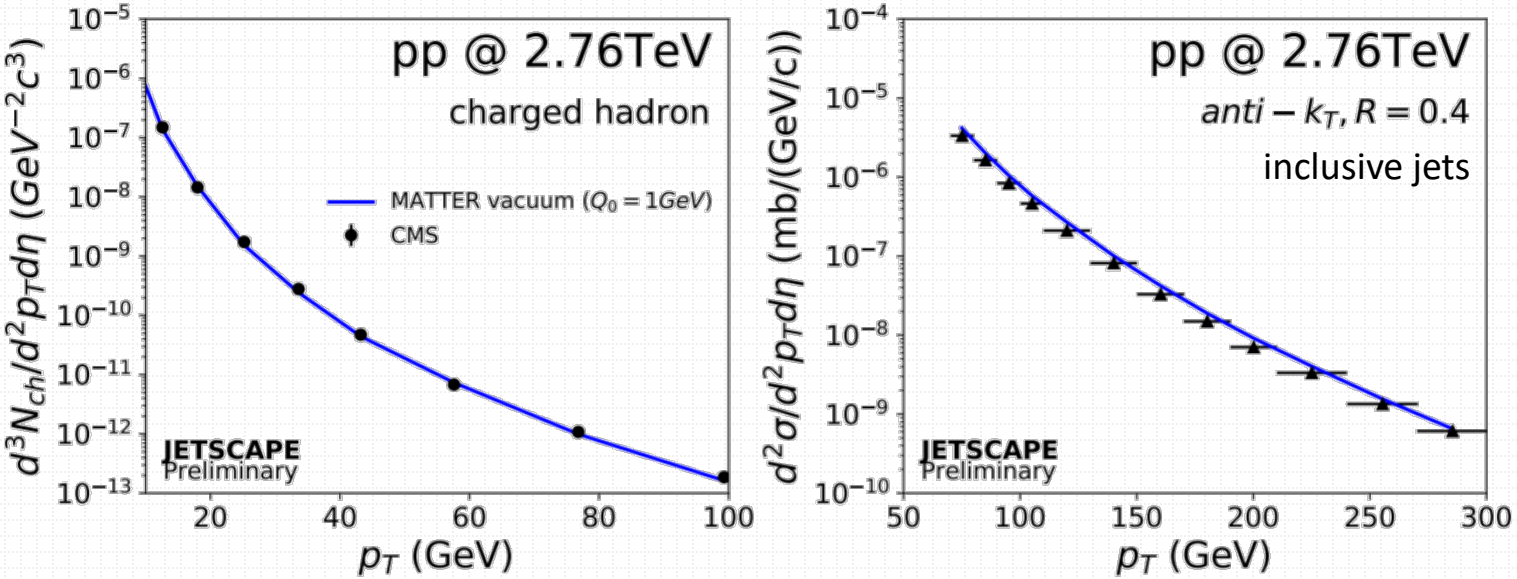
↓

Jet finding — anti-kT, $R = 0.4$

PART TWO

Validation of heavy jet production in p+p collisions

p+p baseline data: inclusive charged hadrons and jets:

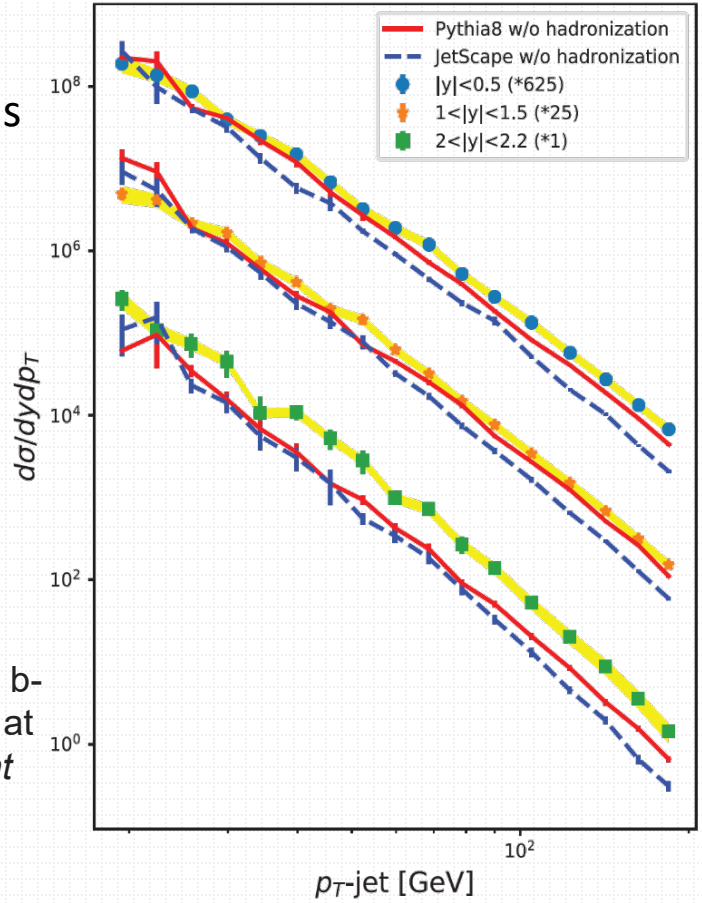


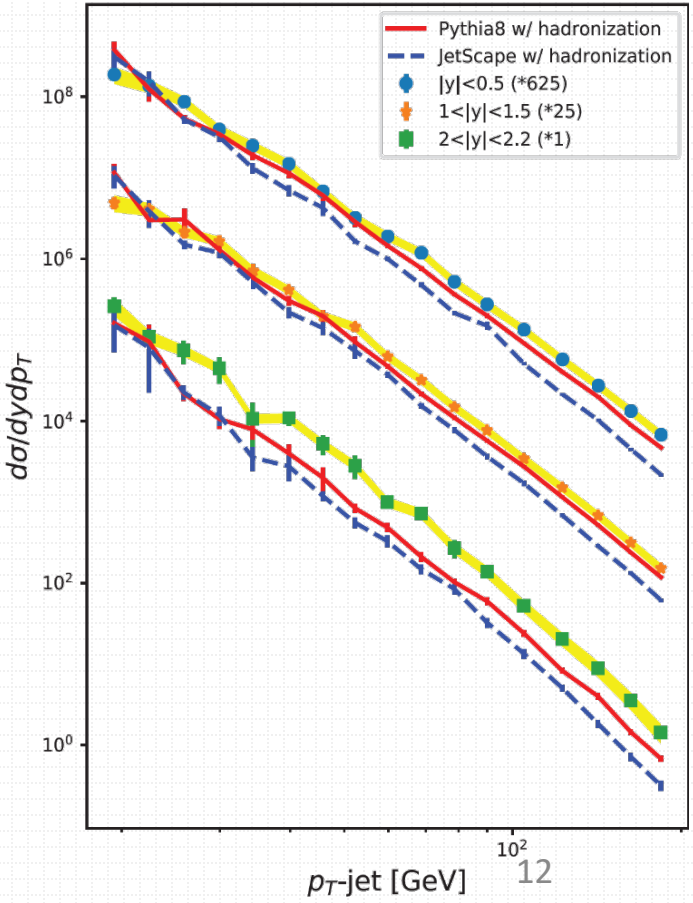
Park, C., et al. "Multi-stage jet evolution through QGP using the JETSCAPE framework: inclusive jets, correlations and leading hadrons." *arXiv preprint arXiv:1902.05934* (2019).

PART TWO

Validation of heavy jet production in p+p collisions

B jet cross-section versus jet p_T at $\sqrt{s} = 7TeV$

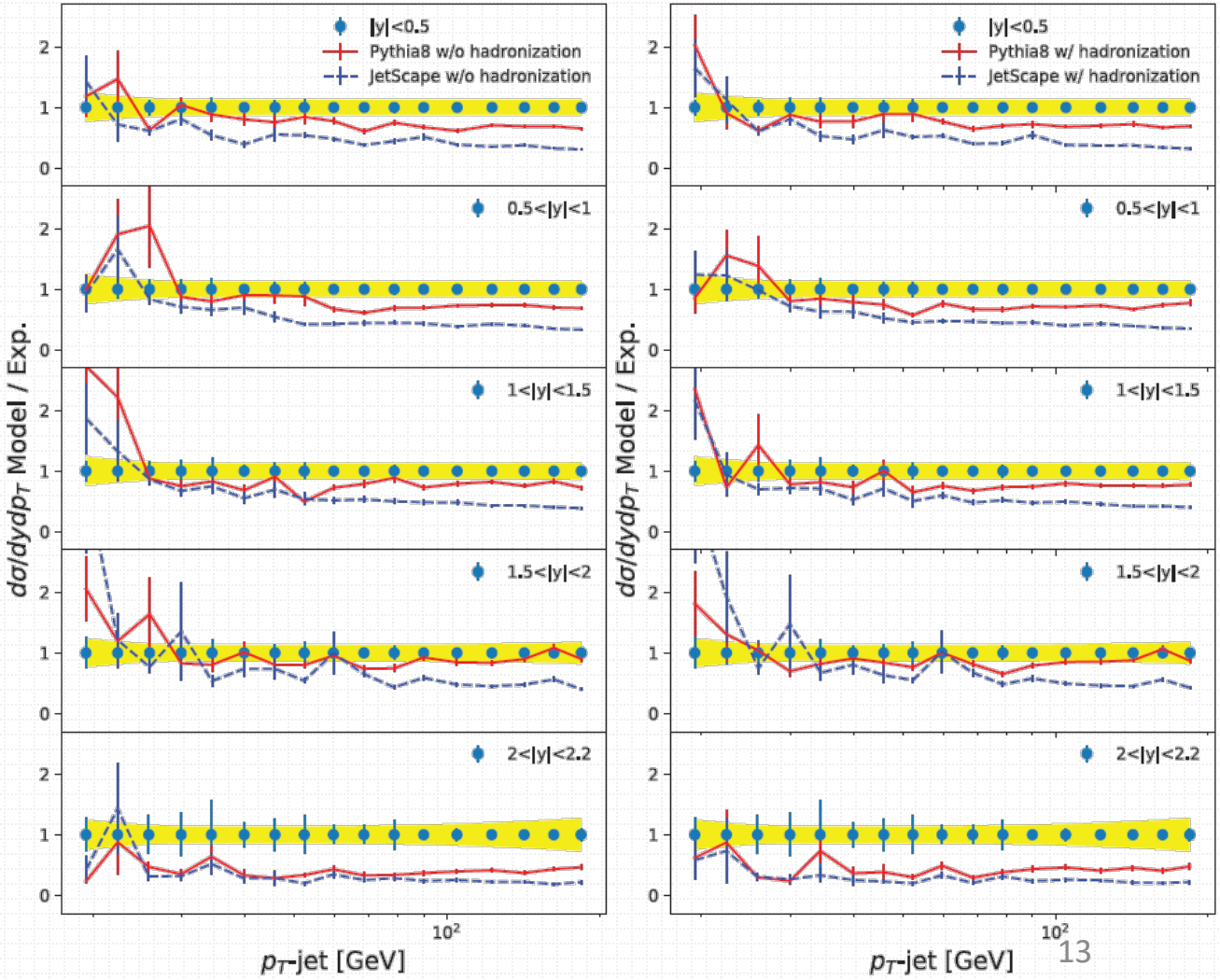




Data from:
CMS collaboration. "Inclusive b-jet production in pp collisions at sqrt (s)= 7 TeV." *arXiv preprint arXiv:1202.4617* (2012).

PART TWO

B jet cross-section (Model/Exp.) versus jet p_T



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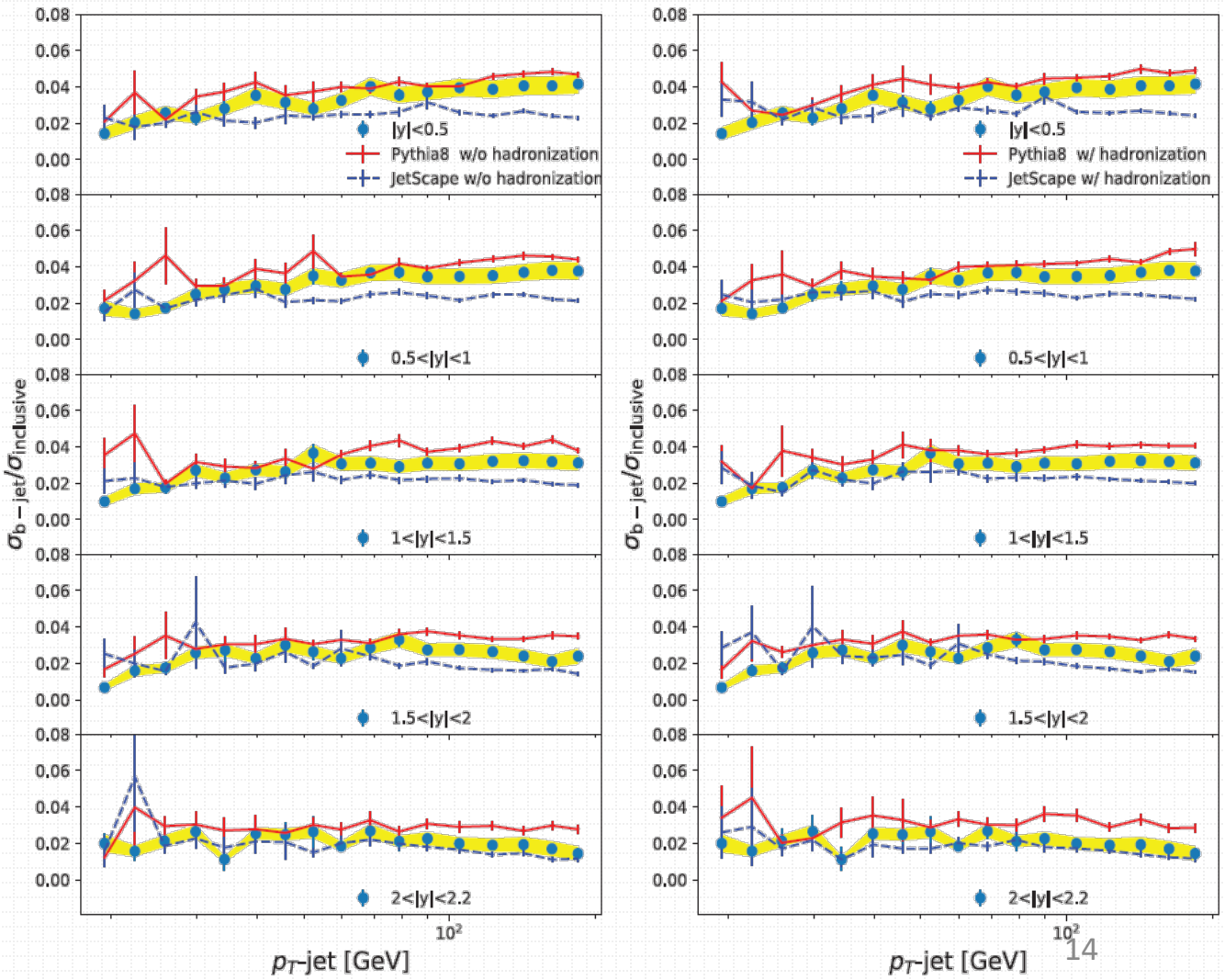
PART TWO

$\sigma_{b_{jet}}/\sigma_{inclusive}$ versus jet p_T



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OUTLINE

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- **The Lido transport model in the JetScape framework**

PART THREE

The Lido transport model in the JetScape framework

- A separation of momentum transfer between:
  Small-q ($q < Q_{cut}$): diffusion
  Large-q ($q > Q_{cut}$): scattering

- An MC implementation of the Landau-Pomeranchuk-Migdal (LPM) effect

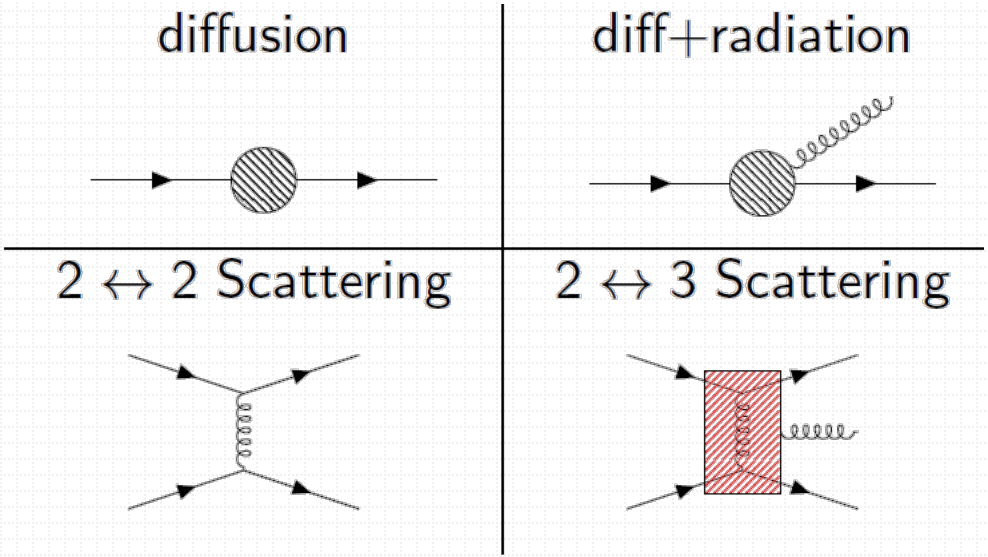


Figure from Weiyao Ke

PART THREE

The Lido transport model in the JetScape framework

$$\frac{df}{dt} = \mathcal{D}[f] + \mathcal{C}^{1\leftrightarrow 2}[f] + \mathcal{C}^{2\leftrightarrow 2}[f] + \mathcal{C}^{2\leftrightarrow 3}[f]$$

Diffusion is solved by Langevin equations with "soft" transport coefficients $\hat{q}$, $\hat{q}_L$

$$\mathcal{D}: \begin{cases} \frac{\Delta\vec{x}}{\Delta t} = \frac{\vec{p}}{E} \\ \frac{\Delta\vec{p}}{\Delta t} = -\eta_D\vec{p} + \vec{\xi}(t) \end{cases}, \quad \left\langle \vec{\xi}(t)\vec{\xi}(t') \right\rangle = \delta(t-t')\left(\hat{P}_L\hat{q}_L + \hat{P}_T\frac{\hat{q}}{2}\right)$$

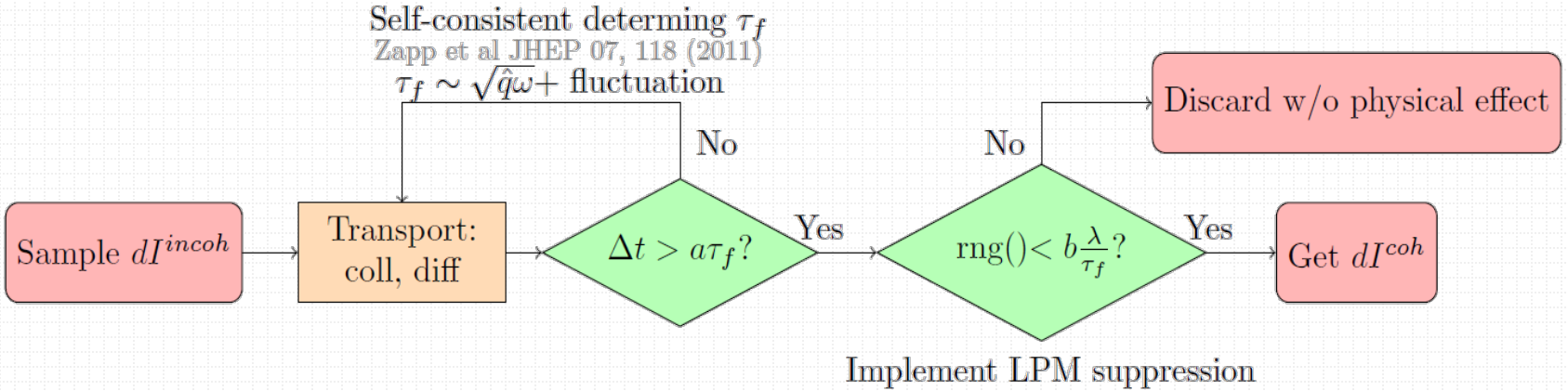
Large-q scatterings are solved by sampling the final states from the collision rate.

$\mathcal{C}$: sample $\vec{p}_1, \vec{p}_2$ from $\frac{\Delta t dR}{d^3p_1 d^3p_2 \ldots}$

PART THREE

The Lido transport model in the JetScape framework

Modifying the transport simulation to include the LPM effect:

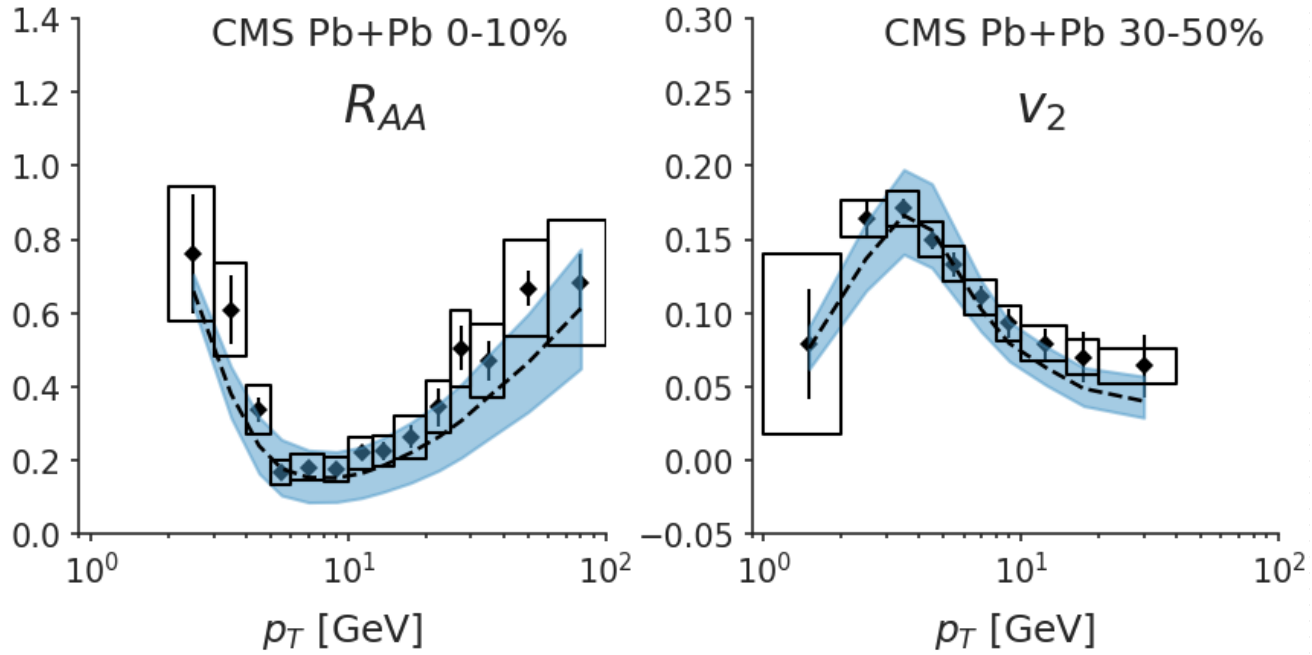


Operate on particle level, easy to couple to event-by-event hydrodynamic simulation.

PART THREE

The Lido transport model in the JetScape framework

Recent calibration on D meson observables:
(outside of JetScape framework, see Weiyao's talk for more details)



PART THREE

The Lido transport model in the JetScape framework

Incorporate model into JetScape:

- Compile Lido as an external package.
- Use a wrapper class to let Lido communicate with JetScape.
- Produce same result as Lido standalone.
- More realistic observables (jet R_{AA}, v_2, …) calculation coming up…

PART FOUR

Summary and Future Plan

- JetScape is a versatile and easy-to-use framework.
- Current heavy jet validation result is acceptable, with some physics (mass effect for the splitting function) to be implemented within the next few months.

- Improve MATTER to include mass effect for heavy quarks.
- Use Lido to do heavy jet analysis within the JetScape framework.
- Perform Bayesian analysis on heavy jet observables.

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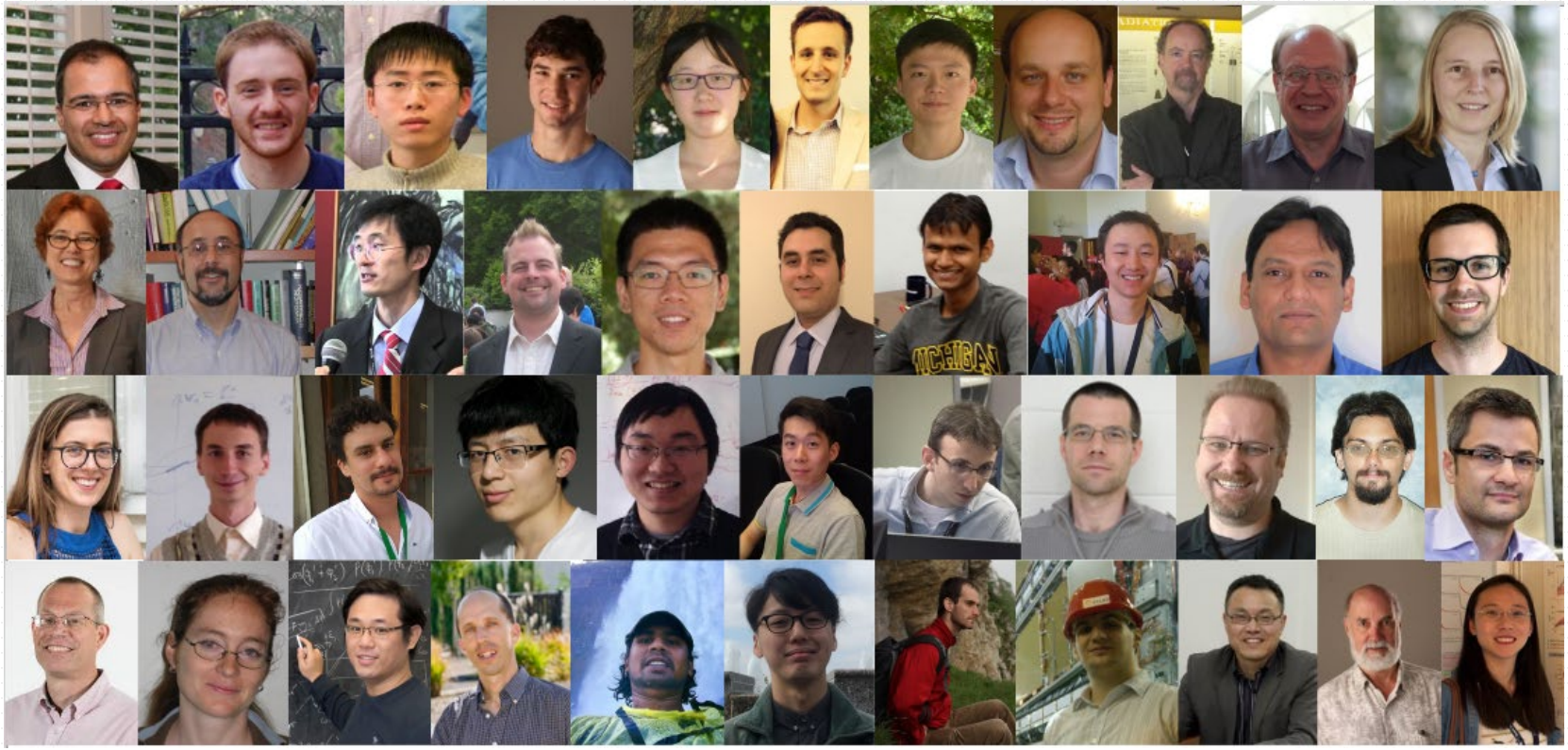
Summary and Future Plan



JetScape Collaboration members

THANK YOU

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Duke University