

# Jetscape/X-scape Collaboration Goals

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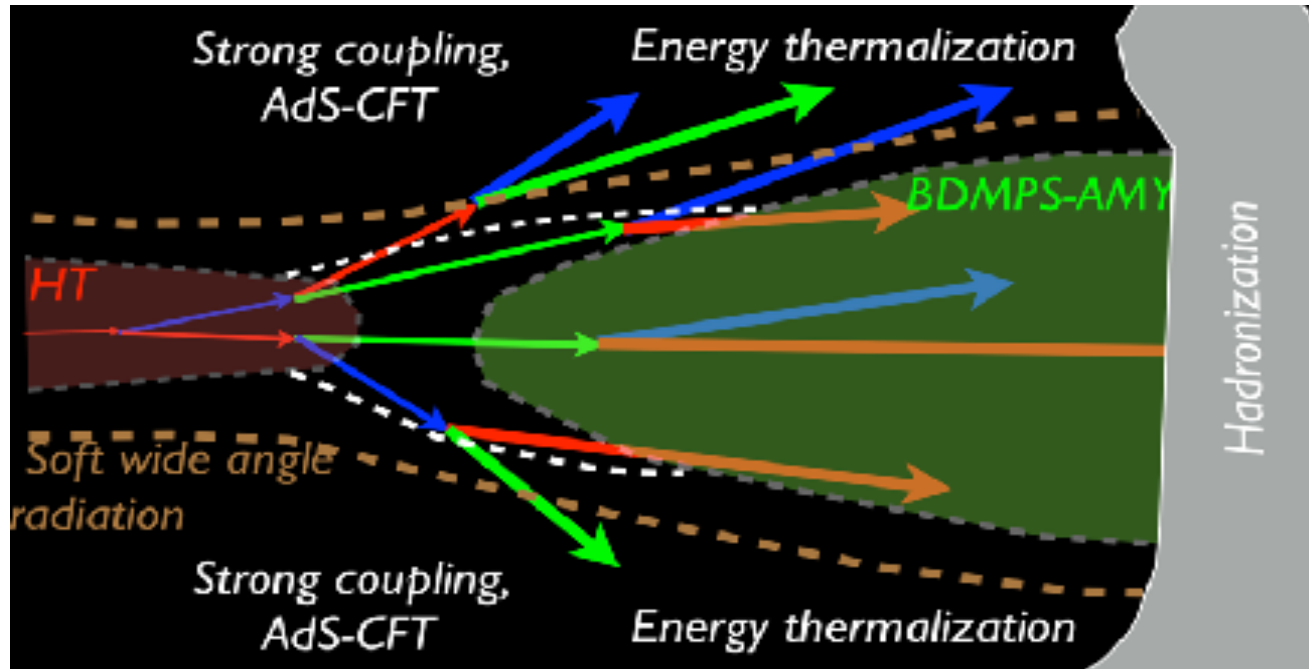
LBL - MIT - McGill OSU - TAMU

LLNL - UT<sup>2</sup> - Vanderbilt - WSU



# Jetscape: Motivation

Jet Energy Loss Tomography with a **S**tatistically and **C**omputationally **A**dvanced **P**rogram **E**nvelope



- provide a tool to study the physics of energy-loss
- large area of research, many different approaches exist, no single group or PI has the capability to do them all
- Collaboration of theoretical and experimental physicists, computer scientists and statisticians

- Goal is to develop a state-of-the-art extensive, extensible and modular event generator
- The code as deliverable is as important as the physics that the collaboration produces
- Note: Framework is agnostic to “multi-stage”, “energy loss”
- Annual schools: educate the community on usage and capabilities of the Jetscape package

# The Road to Jetscape



**TECHQM (2008):** Theory-Experiment Collaboration for Hot QCD Matter

(Cole, Gyulassy, Heinz, Jacobs, Majumder, Mueller, Nagle, Wang, Wiedemann - unfunded)

**MADAI (2009):** Models and Data Analysis Initiative

(Pratt, O'Shea, Dougherty, Zhong, Bass & Wolpert: NSF-CDI)

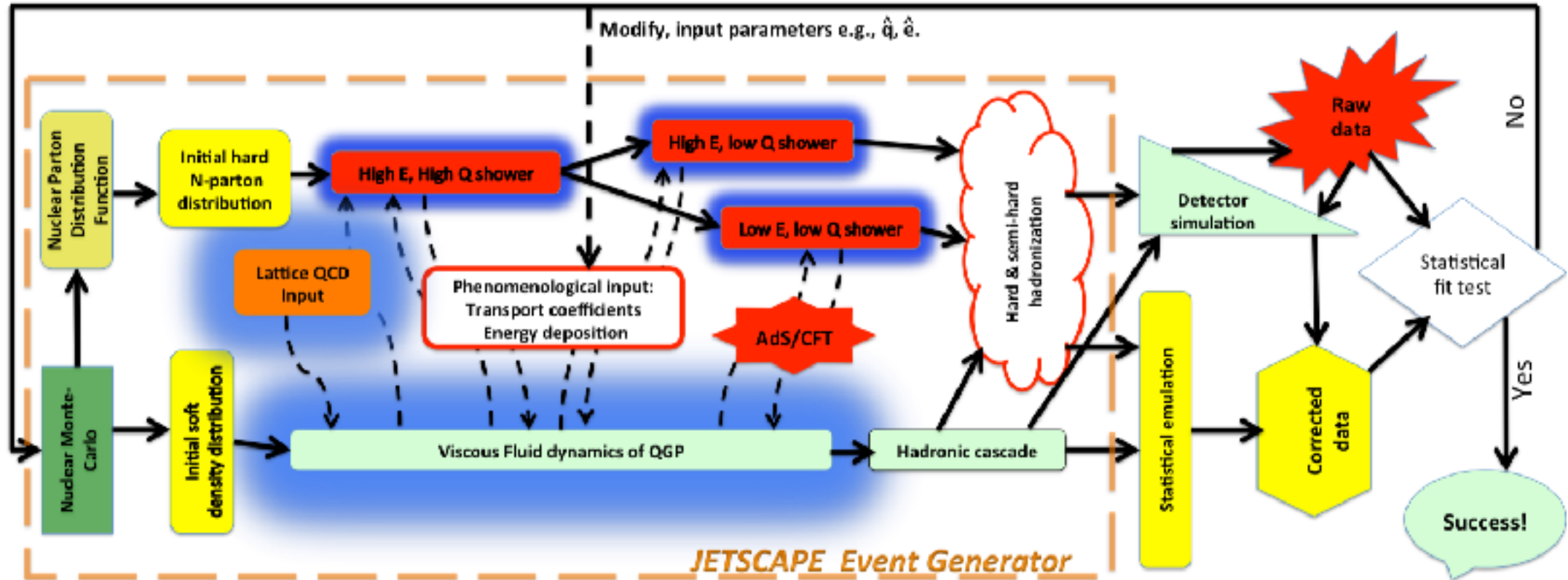
**JET (2010):** Topical Collaboration on the Quantitative Study of Properties of the QGP through Jet-Emission Tomography

(Wang, Gyulassy, Romatschke, Bass, Mueller, Strickland, Vogt, Vitev, Gale, Jeon, Heinz, Molnar, Fries, Ko & Majumder: DOE-TC)

**JETSCAPE (2016):** Jet Energy-loss Tomography with a Statistically and Computationally Advanced Program Envelope

(Majumder, Schwiebert, Gale, Bass, Wolpert, Roland, Heinz, Fries, Jacak, Jacobs, Wang, Putschke: NSF SI2-SSI)

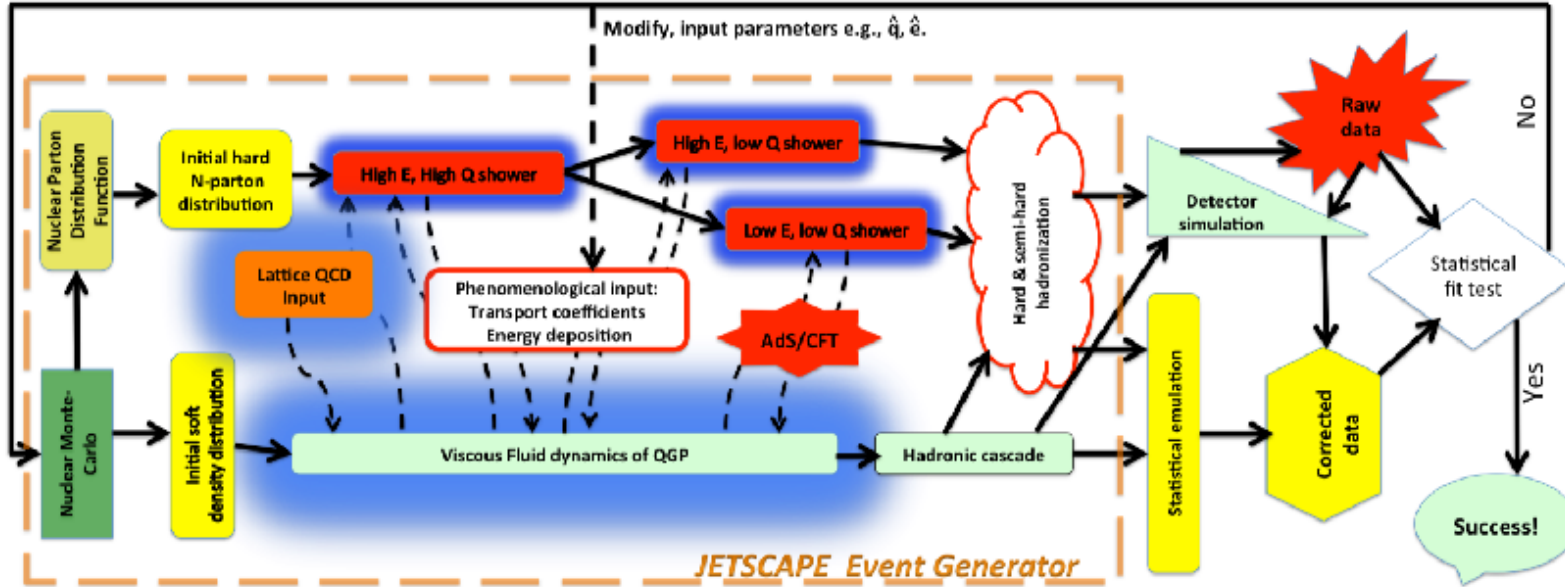
# Jetscape: Overview



Advanced programming concepts:

- C++ 11.0, smart pointers, encapsulation
- XML reader, thread-safe logger
- Code-internal communication via signals and slots
- GitHub actions: automated testing on any code change
- Docker: allows code to run in a pre-tested environment
- GitHub repository of Bayesian statistical analysis tools

# Jetscape: Interfacing with established codes



- Jetscape package interfaces with leading community tools that are publicly available and well-tested
- Additional functions and codes can be linked as external modules (e.g. Lido) or utilize the framework for their own energy-loss kernel (e.g. Tequila)

- Trento (2+1) + free Streaming
- Medium evolution:
  - MUSIC (2+1, 3+1),
  - external reader
  - brick
  - Gubser
- Pythia8 (parton gun, string fragmentation)
- MATTER
- Martini
- AdS/CFT
- LBT
- Cooper Frye
- SMASH
- Custom and HepMC output

# Jetscape: advancing Bayesian Statistics for Relativistic Heavy-Ion Collisions

Jacob Coleman PhD thesis:

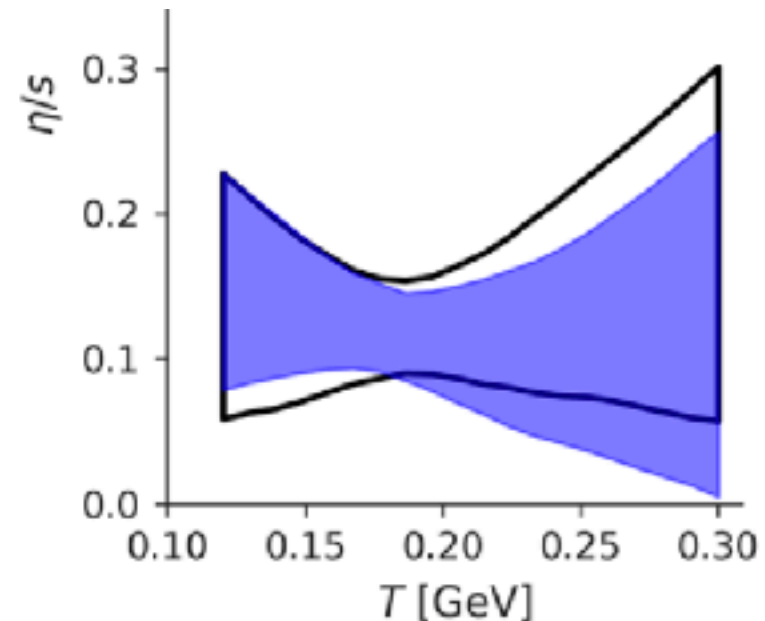
- Model emulation and calibration with multivariate output using GPEs
- Comparing multiple models:
  - Bayes Factor
  - Model Mixing
  - Model Discrepancy

Improved treatment of experimental uncertainties in Bayesian parameter estimation:

- treatment of correlated uncertainties
- use of the covariance matrix

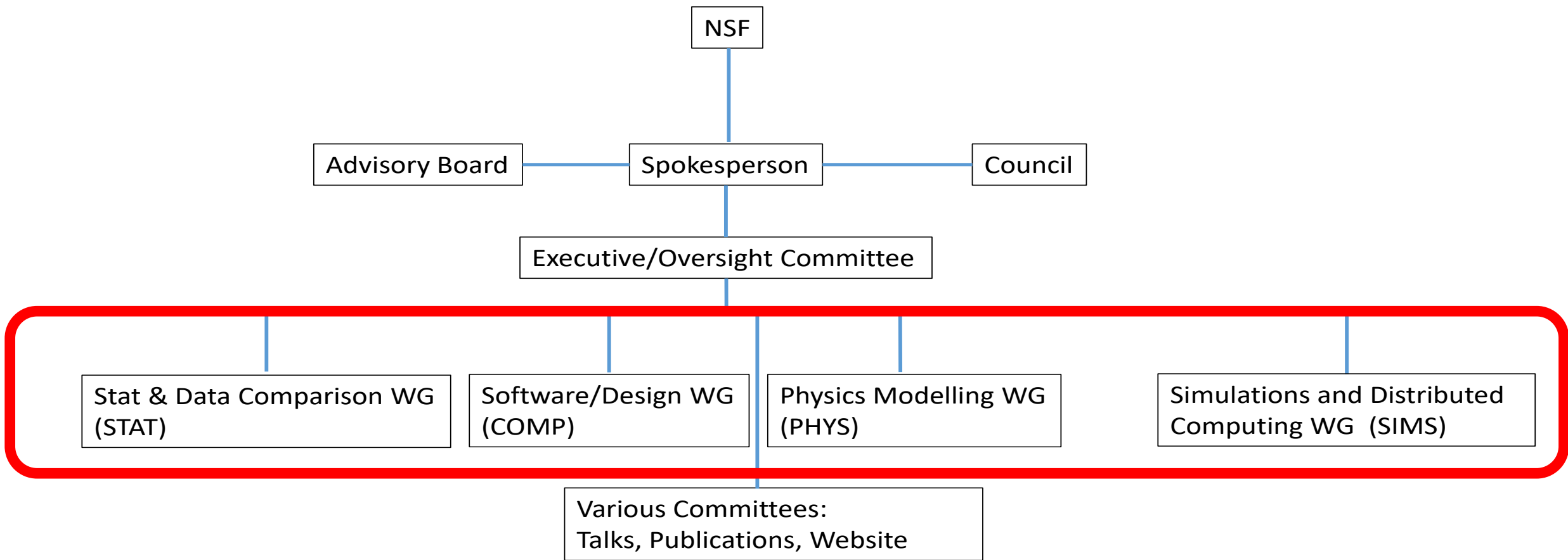
Improved extraction of QGP transport coefficients:

- Uncertainty budget
- better understanding of the role of the prior
- combining RHIC + LHC data

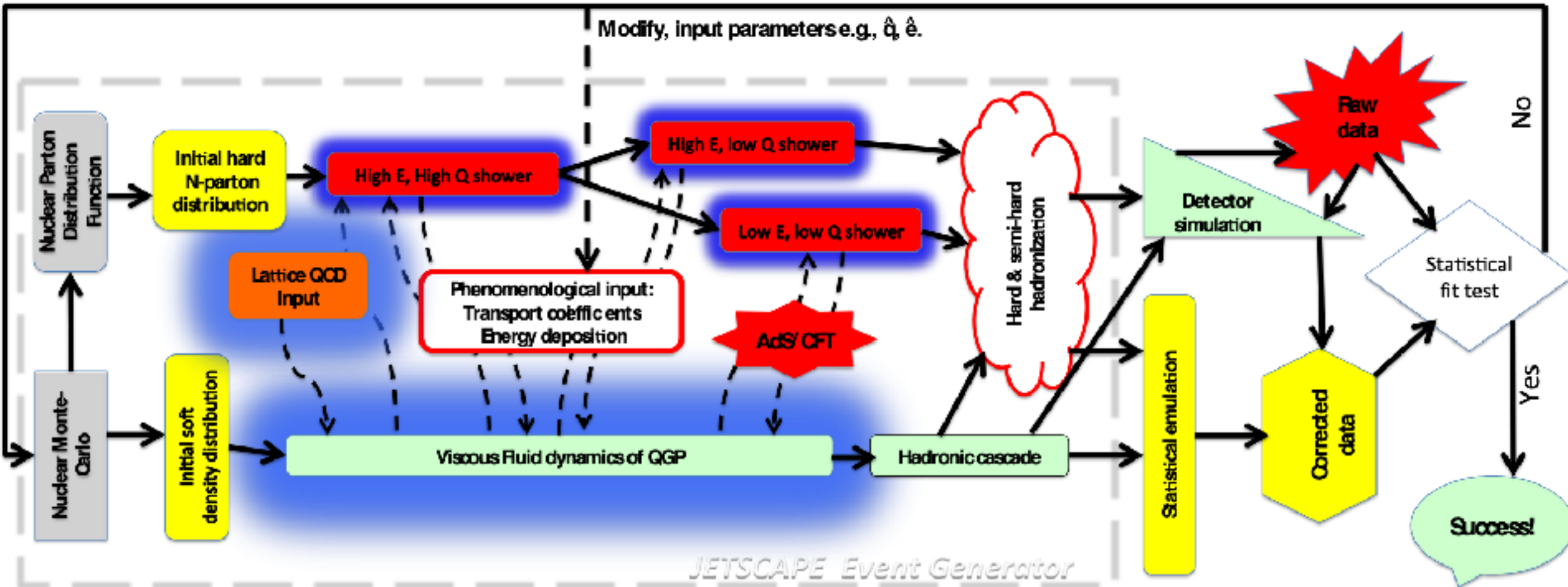




# Organization

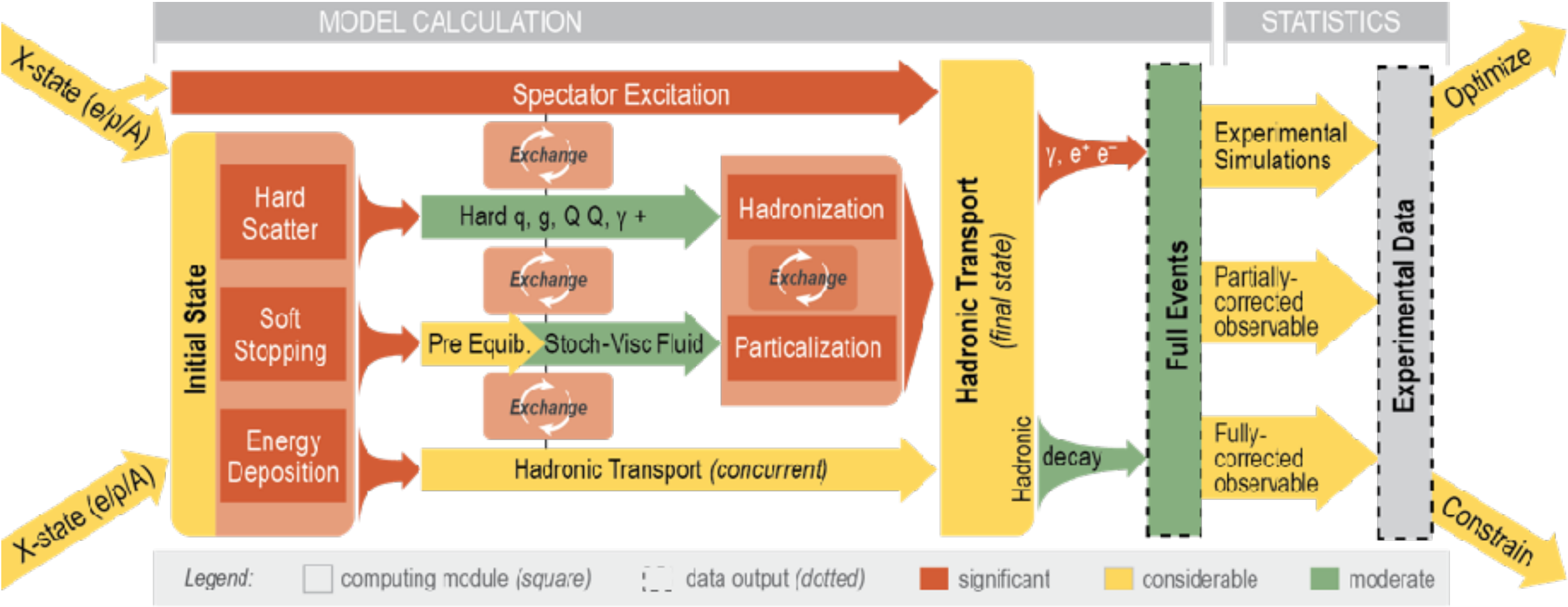


# From JETSCAPE to X-SCAPE



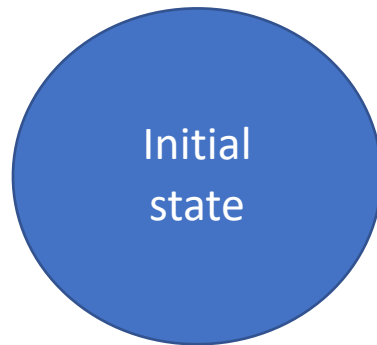
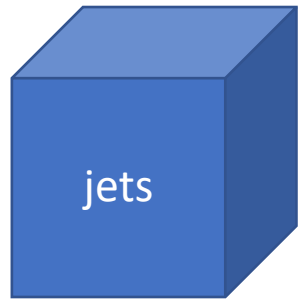


# From JETSCAPE to X-SCAPE



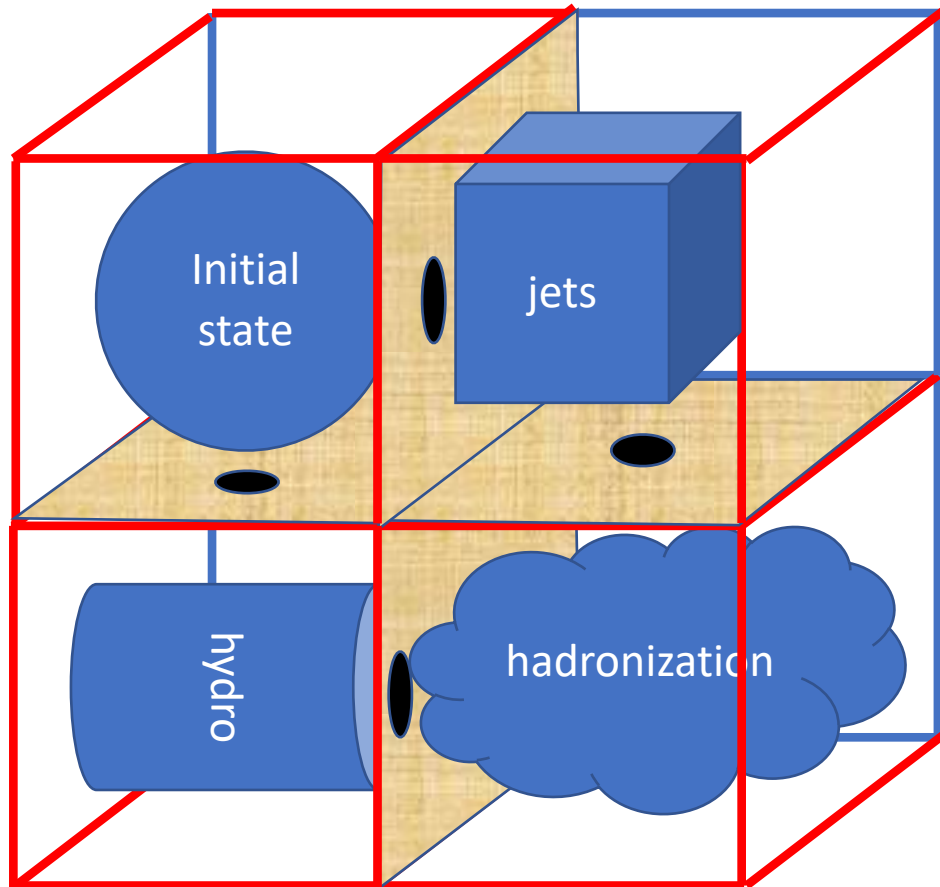
# From JETSCAPE to X-SCAPE

- From 2016 to 2020:



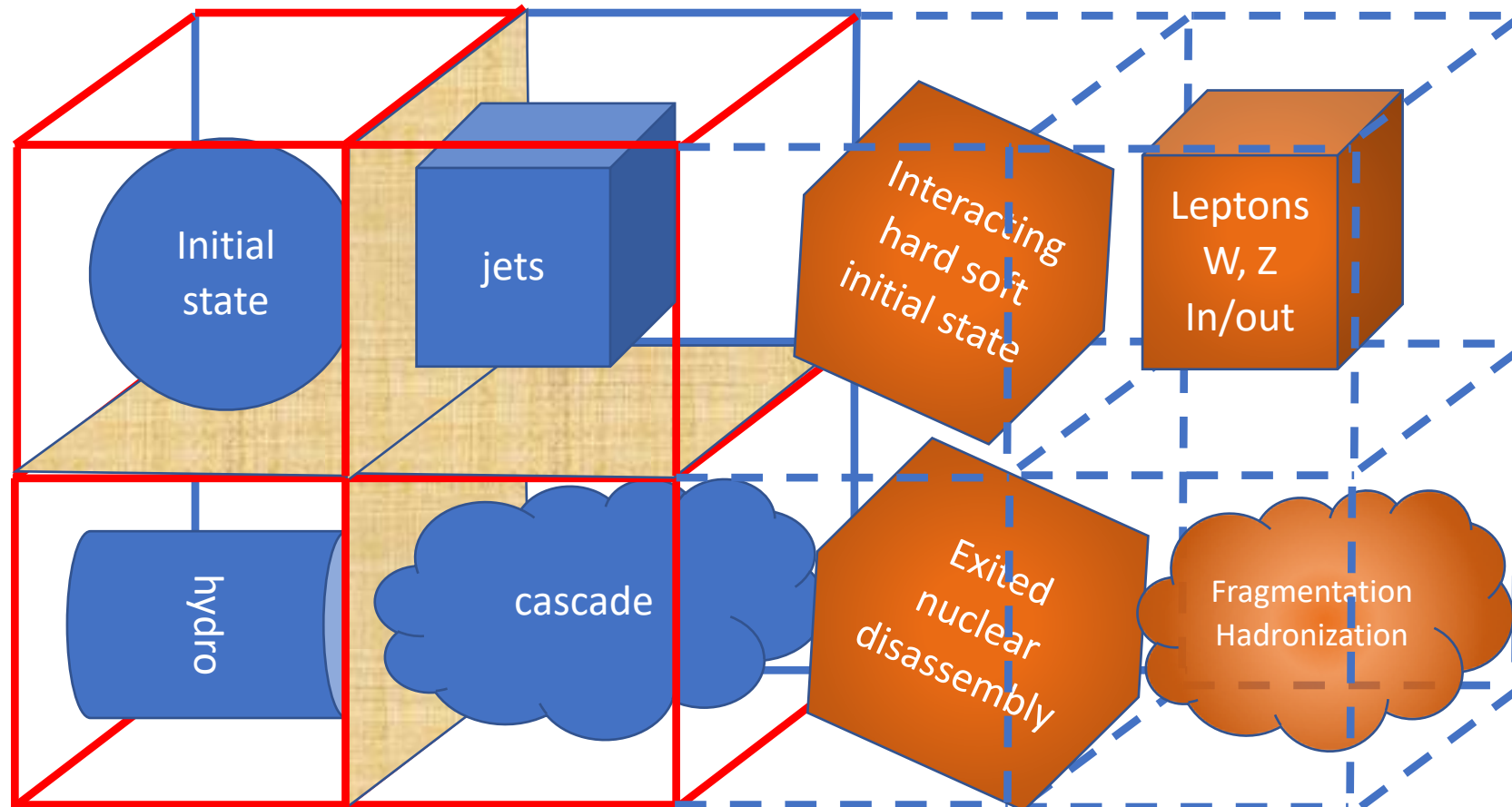
# From JETSCAPE to X-SCAPE

- From 2016 to 2020



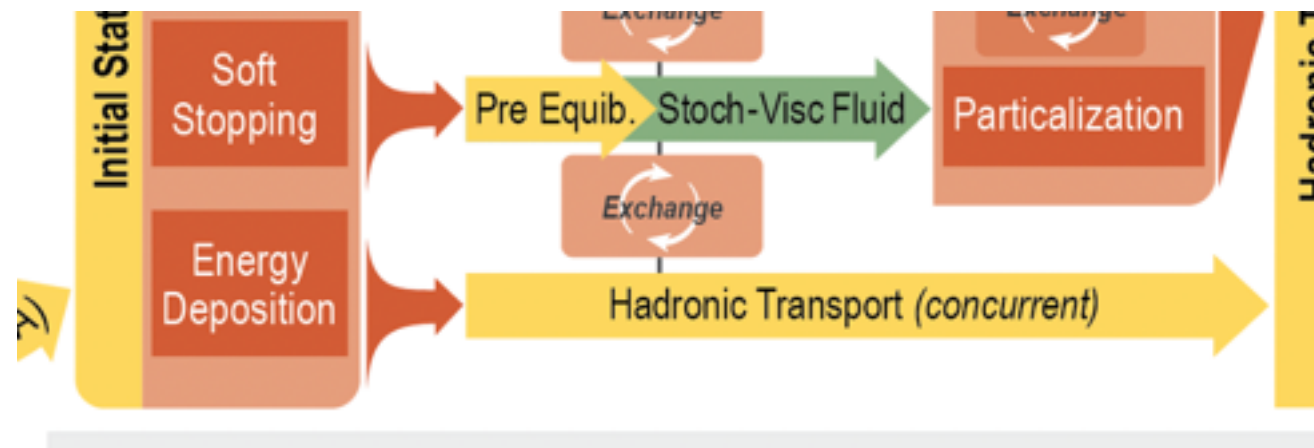
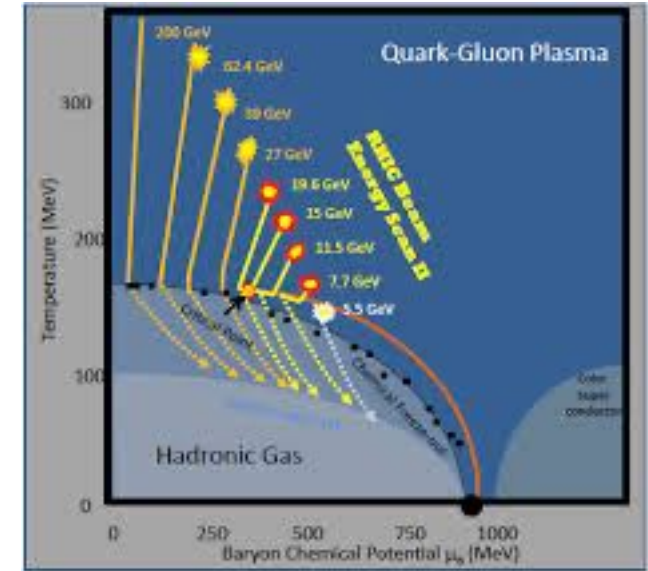
# From JETSCAPE to X-SCAPE

- From 2020 to 2024



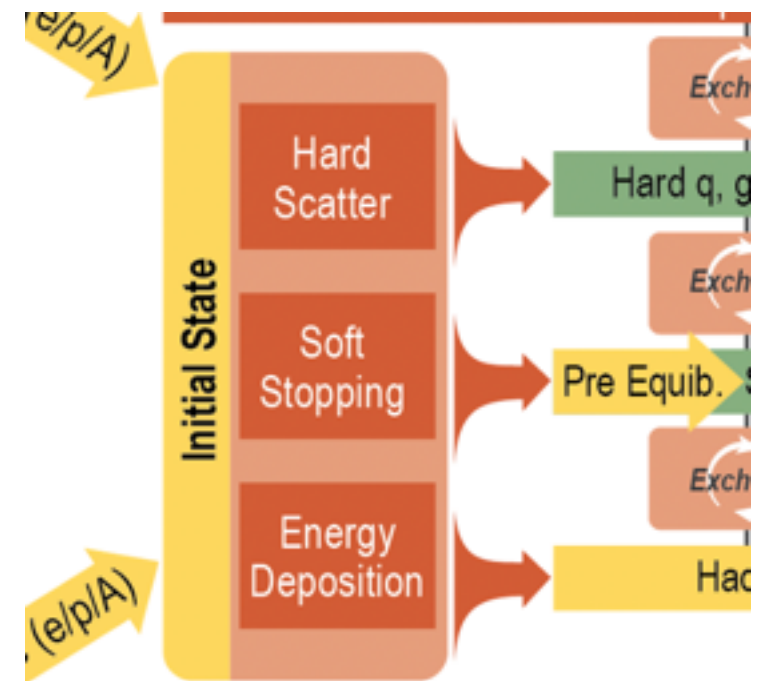
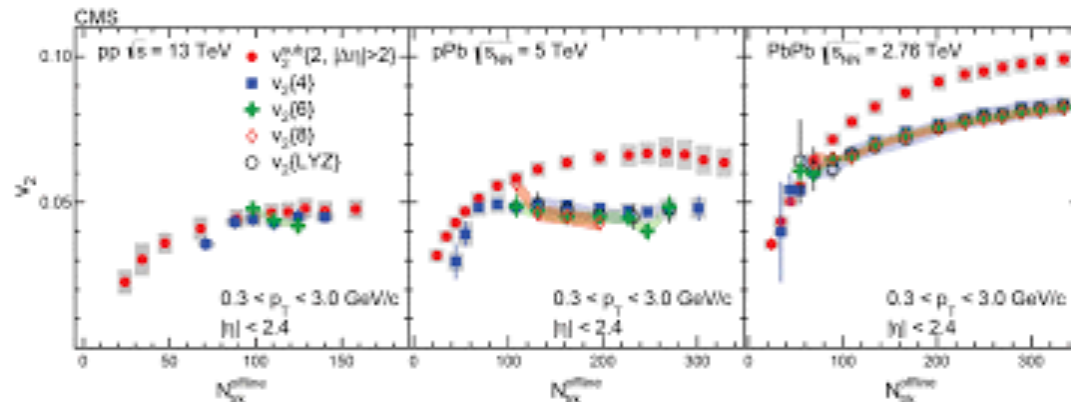
# Lower Energy Heavy-ion collisions

- Energy and Baryon number deposition
- 3-D systematics (lack of boost invariance)
- Increasing chemical potential/baryon density
- Sections will be in QGP phase
- Sections in hadronic phase
- Concurrent hydro + Cascade

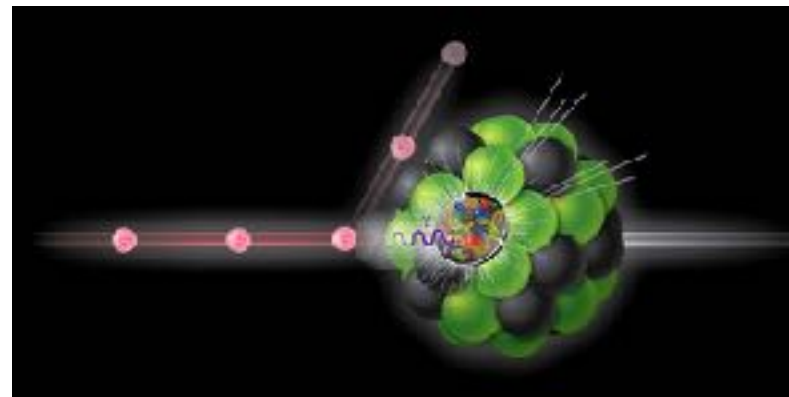


# Small systems

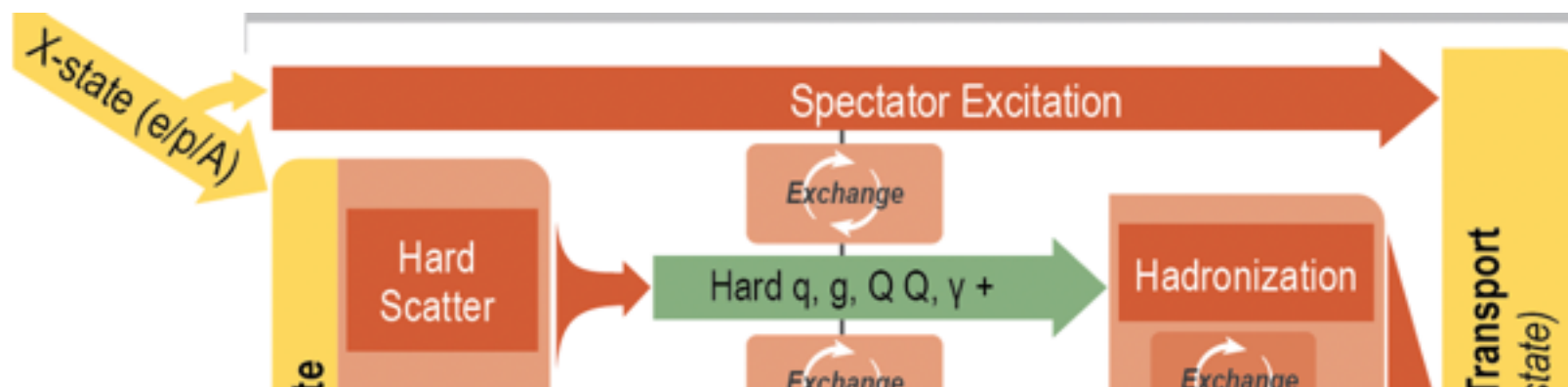
- Initial state + pre-equilibrium + hadronization + cascade
- Initial state + pre-eq + hydro + hadronization + cascade
- Initial state hard and soft correlation
- Jet quenching in small systems ?



# E I C



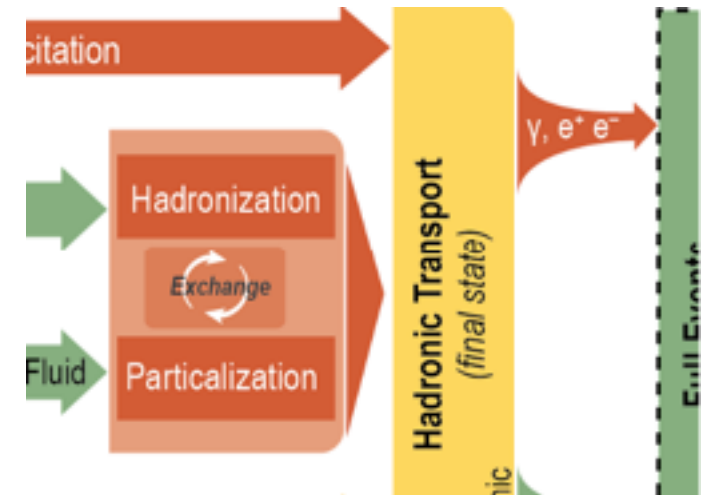
- Initial state (CGC)
- Jets propagation and hadronization in a nuclear environment
- Nuclear excitation and disassembly
- Hadronic/partonic jets interacting with hadronic matter.



See talk by Chun Shen

# Other topics

- $e^+e^-$ ,  $\mu^+\mu^-$  production in pA and AA collisions
- Z, W production, and correlation with jets
- $e^+e^-$  annihilation, jets in vacuum



- Hadronization in vacuum, cold nuclear environment, hot hadronic environment, edge of QGP
- Get serious about GPU parallelization!



# X-SCAPE: a one stop shop event generator w/ Bayesian Estimation

