Issues with Theoretical Uncertainties

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I. What are theory errors/uncertainties?
II. Correlated errors
III. Strategies for expressing correlated uncertainties
IV. Challenges

I. What are theory errors/uncertainties?

Type 1: Statistical uncertainty
e.g. finite # of SMASH events

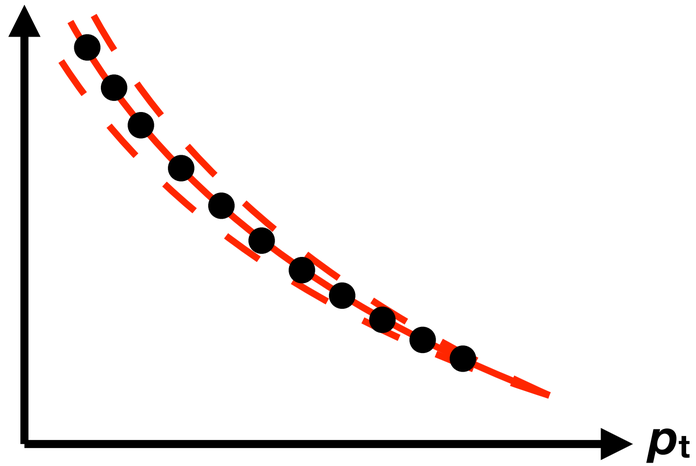
Type 2: Numerical accuracy
e.g. finite mesh sizes

Type 3: Missing physics / Theoretical *systematic* errors
If all parameters are set to their
a) true values (e.g. viscosity)
or
b) to the values that best capture desired physics (e.g. TRENTO best reproduces initial state)
By what amount do you expect to miss a perfectly measured observable?

CAN BE DIFFICULT TO ESTIMATE !!!
Examples:
- **finite DeBroglie wavelengths for cascade**
- **unequal flow of quarks and gluons**
- **chemical equilibrium at hydro/cascade interface**

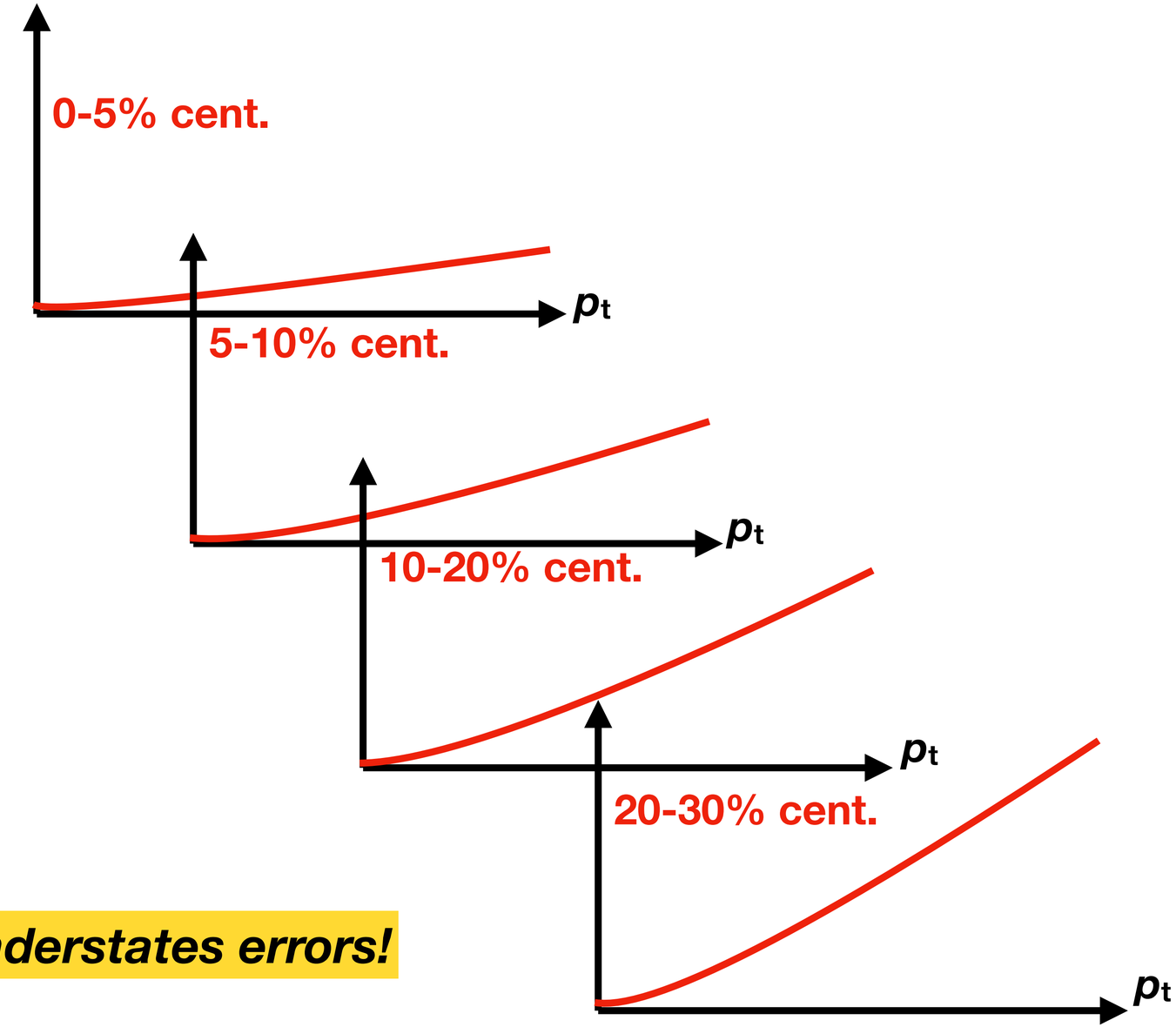
II. Correlated errors

1. Intra-plot
Example: Pion Spectra



Errors in accounting for resonances or symmetrization affect low pt points but not high pt points

2. Inter-plot
Example: v_2 vs p_t



Treating points independently understates errors!

III. Strategies for expressing correlated uncertainties

1. Error matrices
   Yuck!

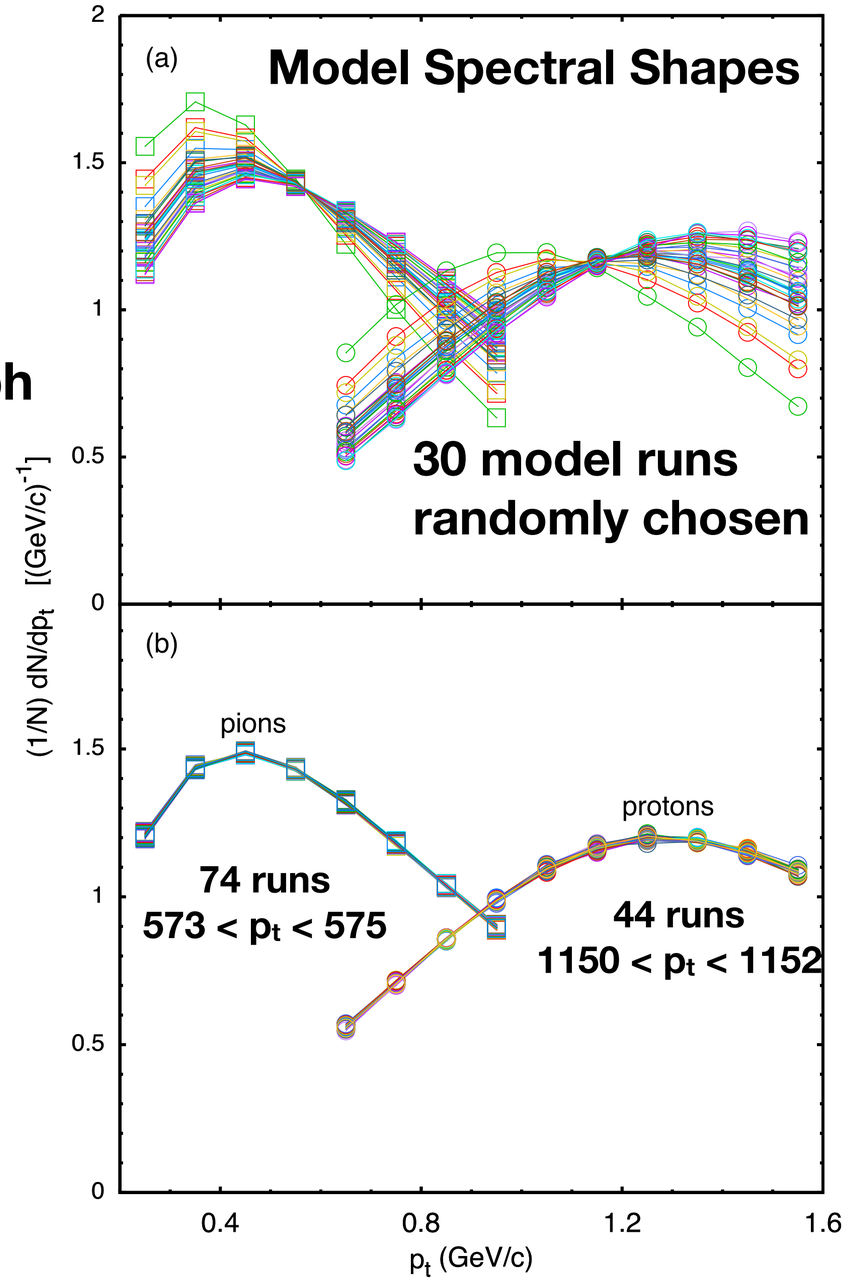
2. “Nuisance” parameters

$$\frac{dN}{dyd^2p_t} = \frac{dN^{(\mathrm{model})}}{dyd^2p_t}\left(A + Be^{-p_t/C}\right),$$

$$A \approx 1, B \approx 0, C \approx 200\ \mathrm{MeV}/c$$

A,B,C **treated as model parameters**
(assign priors…)

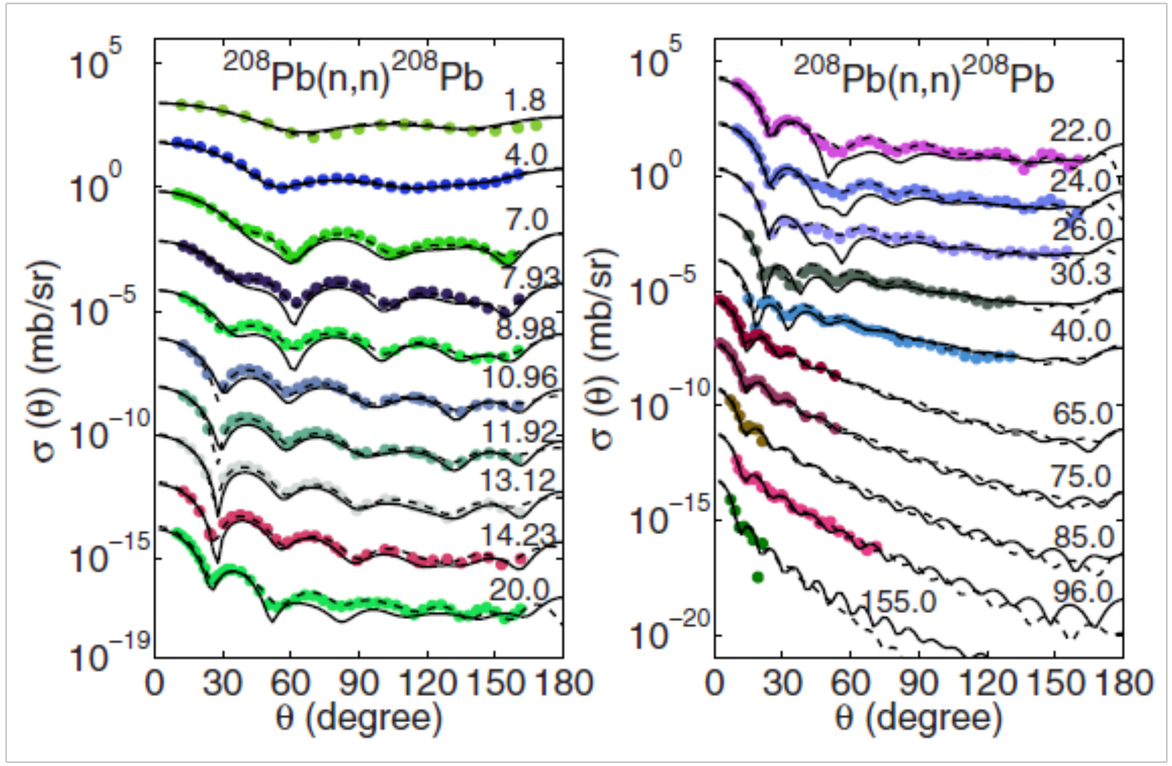
3. Data distillation
   Few centralities
   Few points/graph
   (can use PCA)



Only one “observable” -> no correlated errors

IV. Challenges

1. Complicated structures



2. Who assigns systematic error?

Experimental collaborations have forums for extensive discussions and debate,
but what about theoretical systematic uncertainties?