

Fifth Lisbon mini-school on Particle and Astroparticle Physics – 7 Feb 2020

Phenomenology@LIP

Guilherme Milhano, LIP & IST
[on behalf of the group]

what is phenomenology?



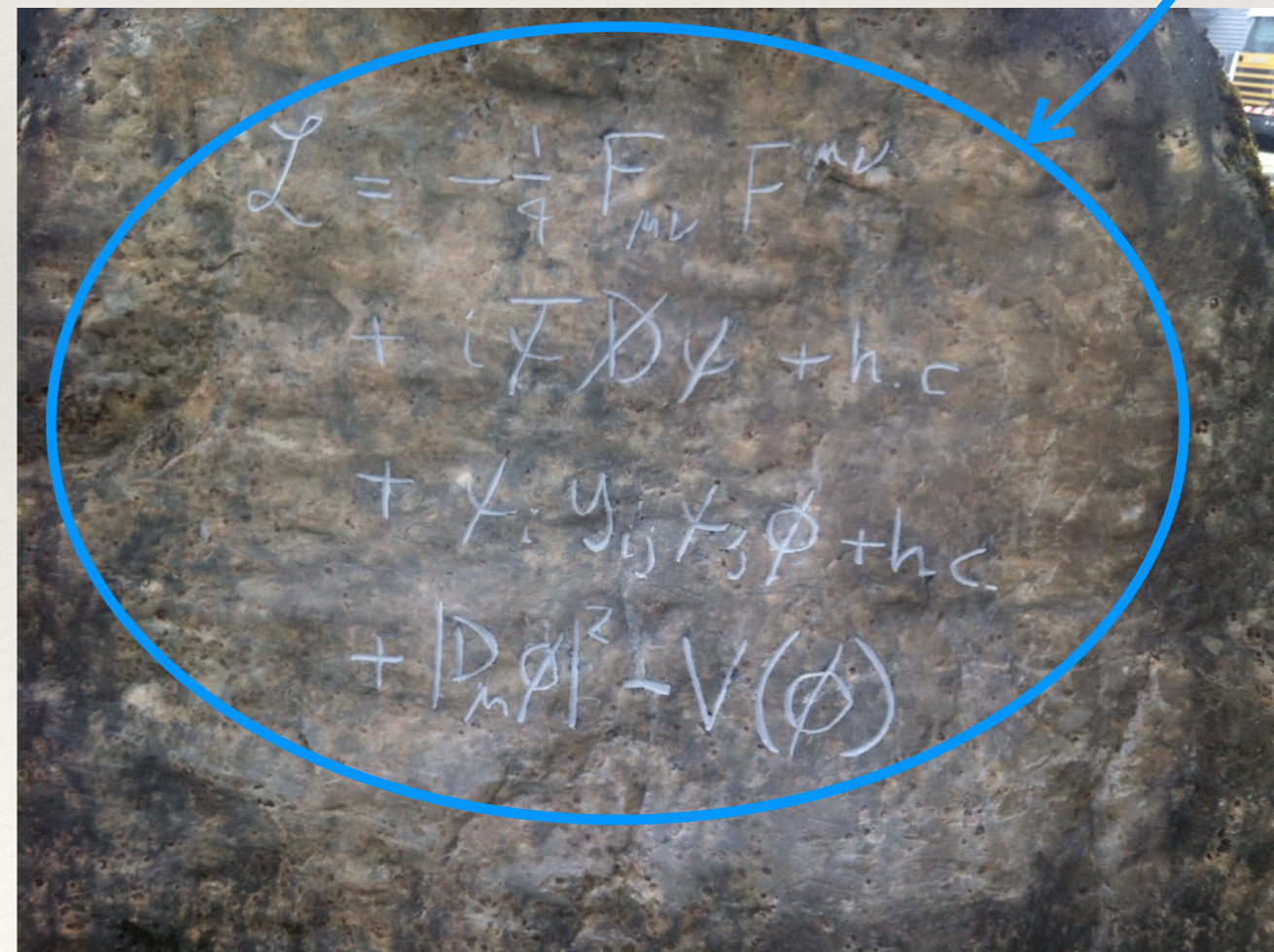
STONE INSCRIPTIONS

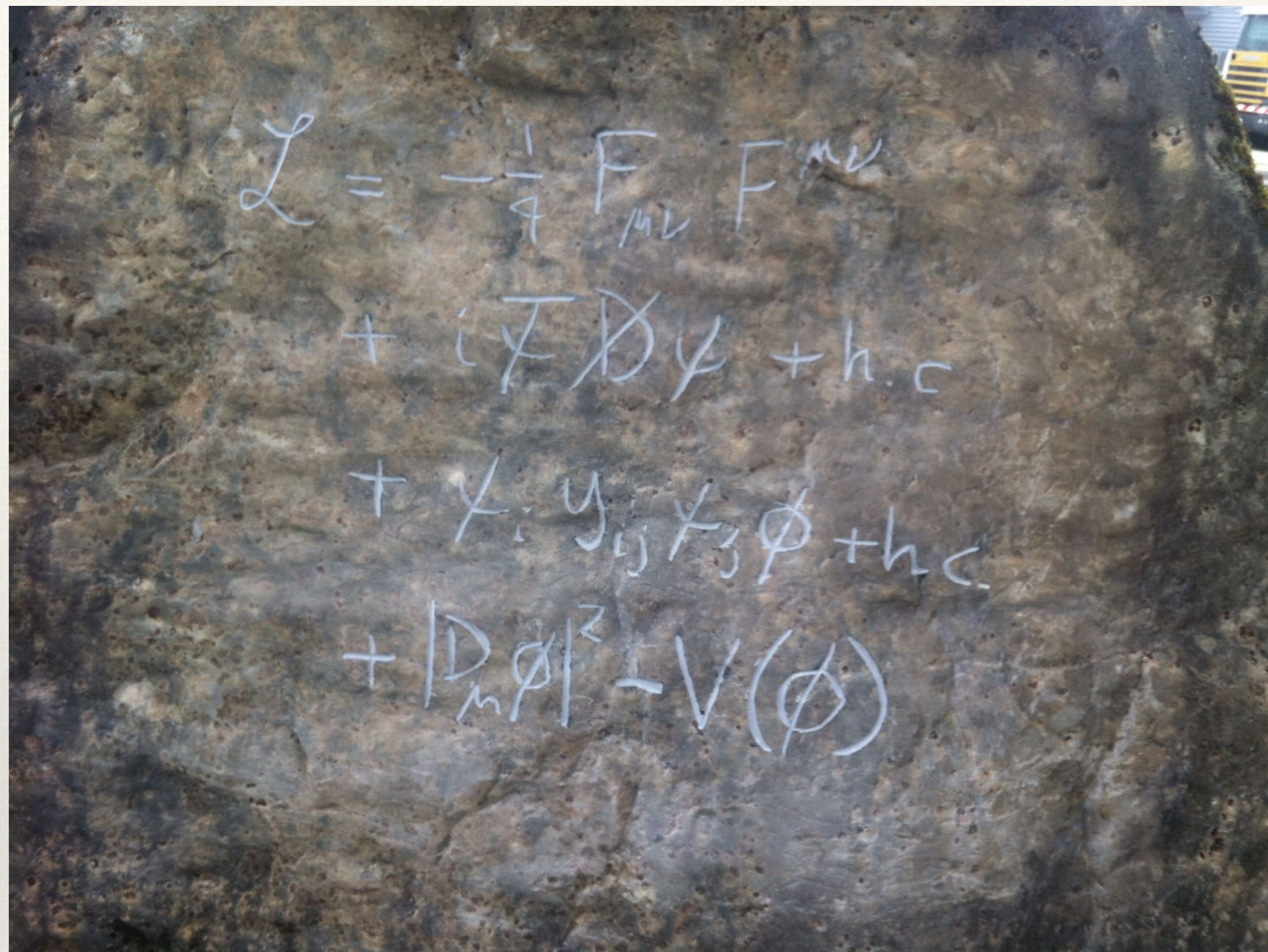
PREVESSIN (SWISS-FRENCH BORDER), EARLY XXI CENTURY A.D.



STONE INSCRIPTIONS

PREVESSIN (SWISS-FRENCH BORDER), EARLY XXI CENTURY A.D.





THEORY OF FUNDAMENTAL INTERACTIONS [EARLY XXI CENTURY A.D]
[LITERALLY] SET IN STONE



CMS Experiment at the LHC, CERN

Data recorded: 2018-Nov-11 23:57:04.330752 GMT

Run / Event / LS: 326580 / 14140126 / 52

Electron

b jet

b jet

Muon

RECONSTRUCTION OF OUTCOME OF Pb-Pb COLLISION
SWISS-FRENCH BORDER, EARLY XXI CENTURY A.D

what is phenomenology?

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not the same as theory nor the same as experiment :: in between?

what is phenomenology?

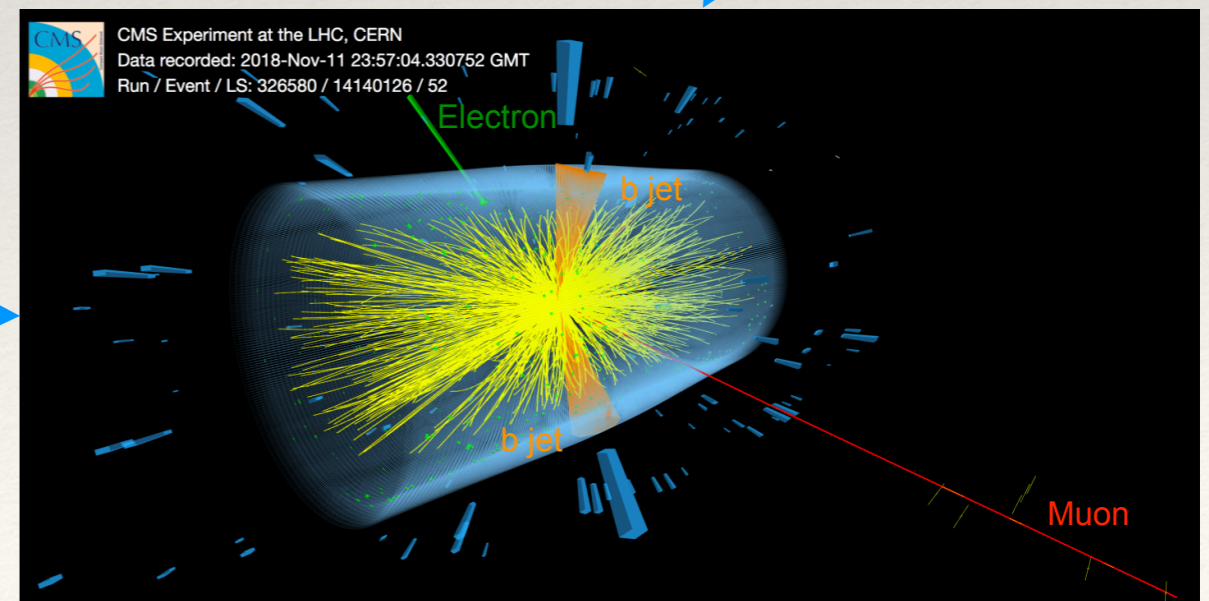


THEORY

PHENOMENOLOGY

EXPERIMENT

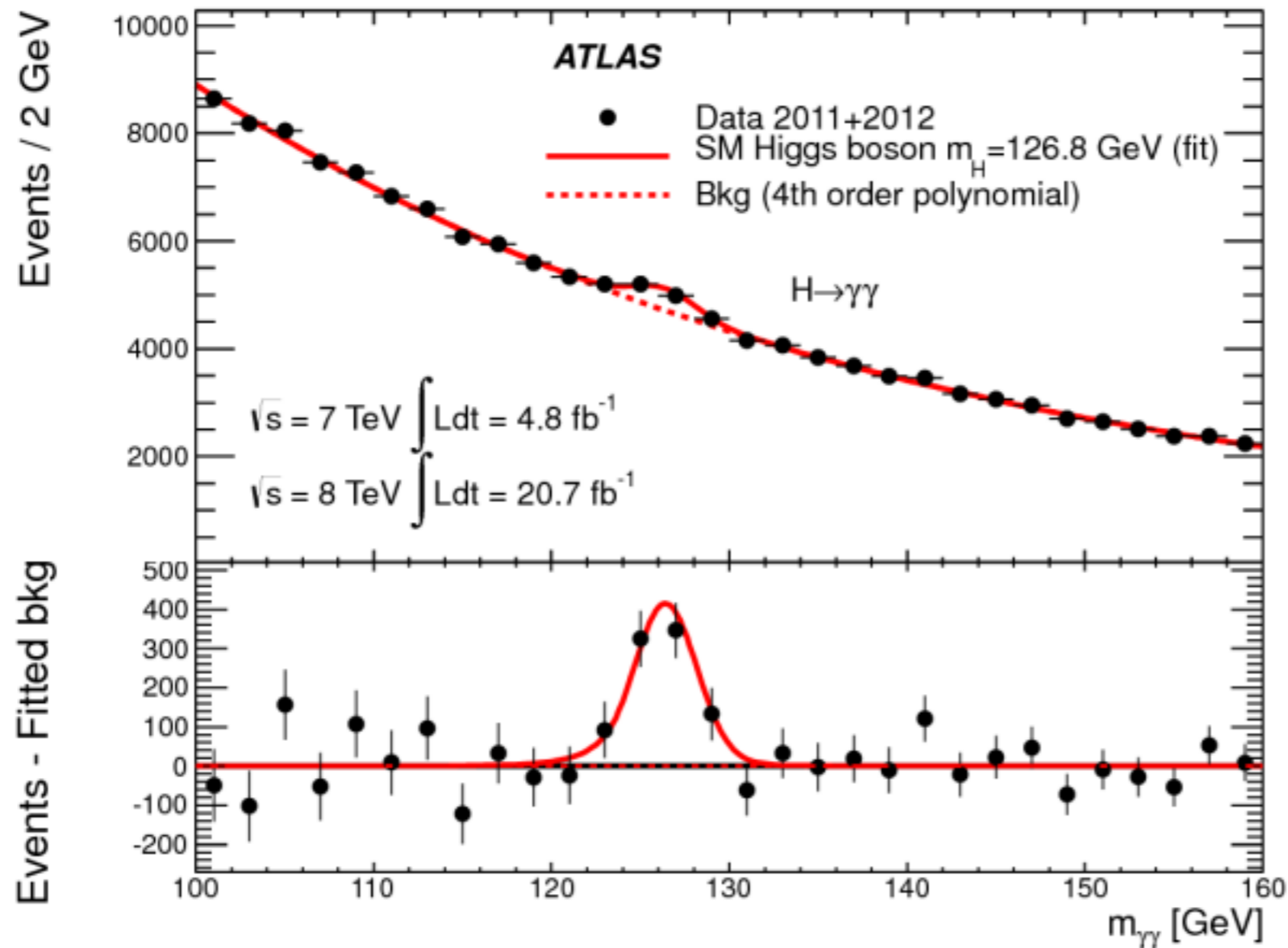
Phenomenology
bridges between
Theory and Experiment



what is phenomenology?

- *application of theoretical physics to experimental data by making quantitative predictions based upon known theories*
- *bridge between mathematical models and physical reality*
- *essential go-between to validate known physical theories, to understand new phenomena through novel physical theories*

how to find something?

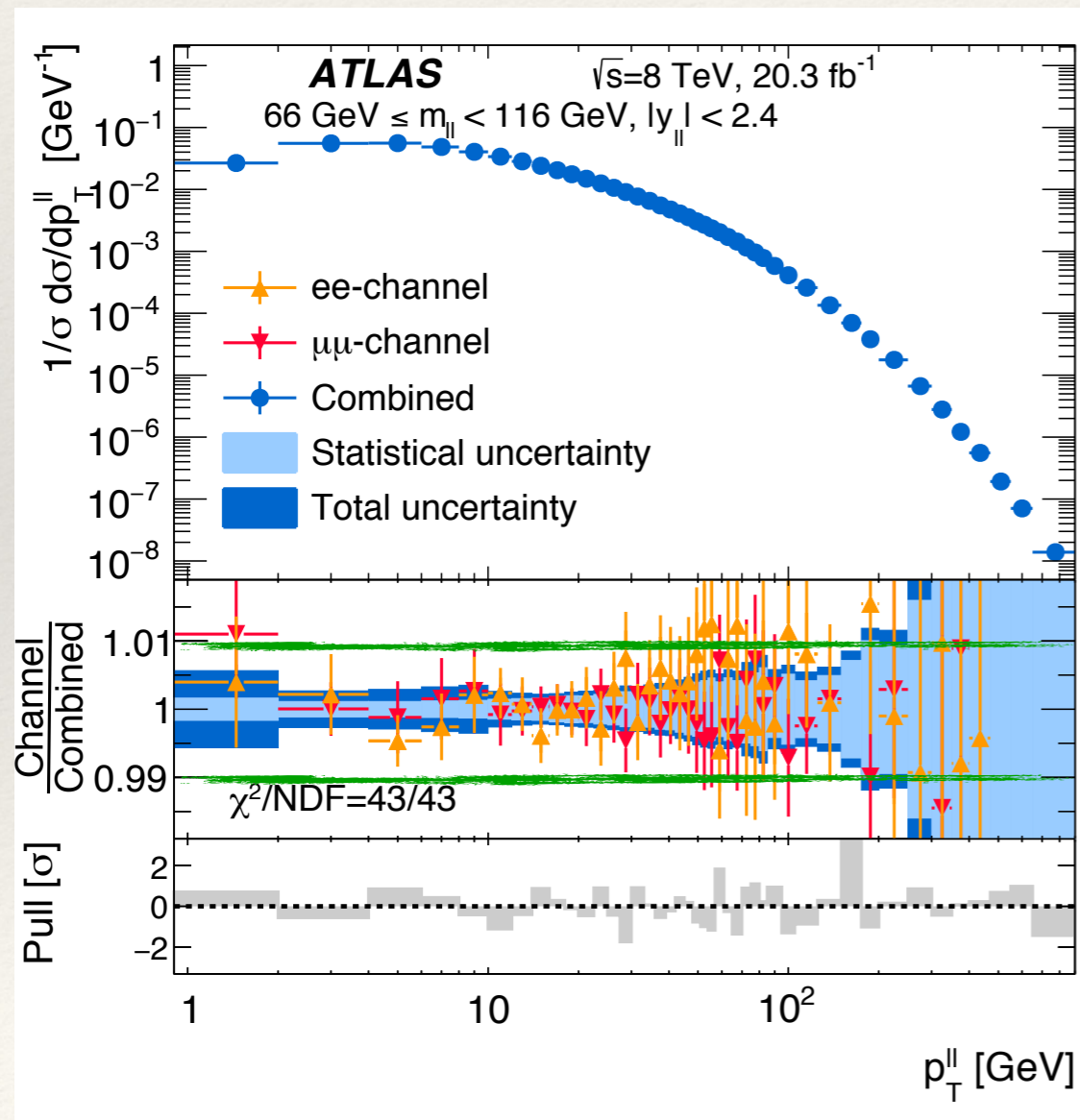


the Higgs boson was discovered as a tiny excess above a known 'background' (all the known Physics producing a similar outcome)
:: precision in both theory and experiment is crucial to make a discovery

precision

LHC has taught us that new physics will be manifest as very small effects

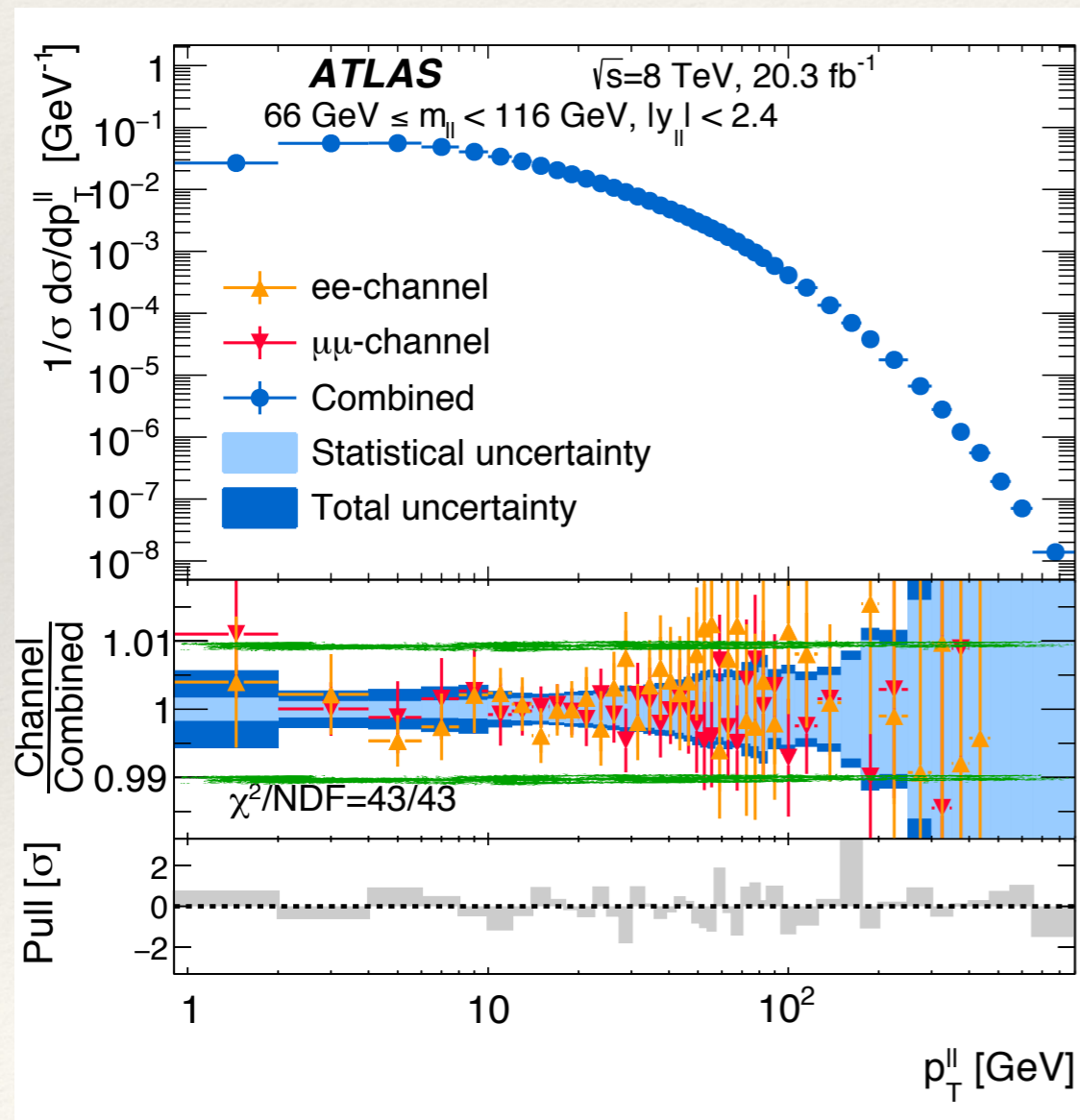
LHC measurements have [or will have soon] uncertainties $\sim 1\%$



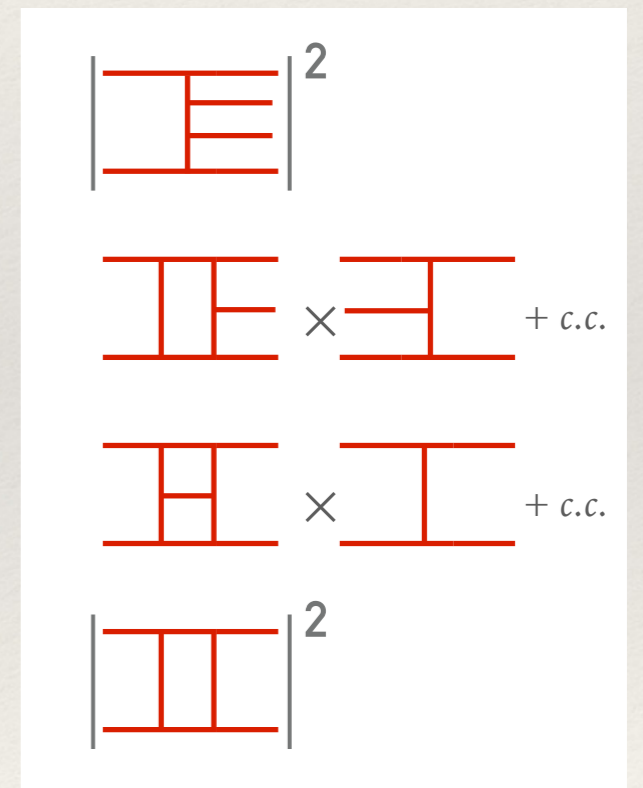
precision

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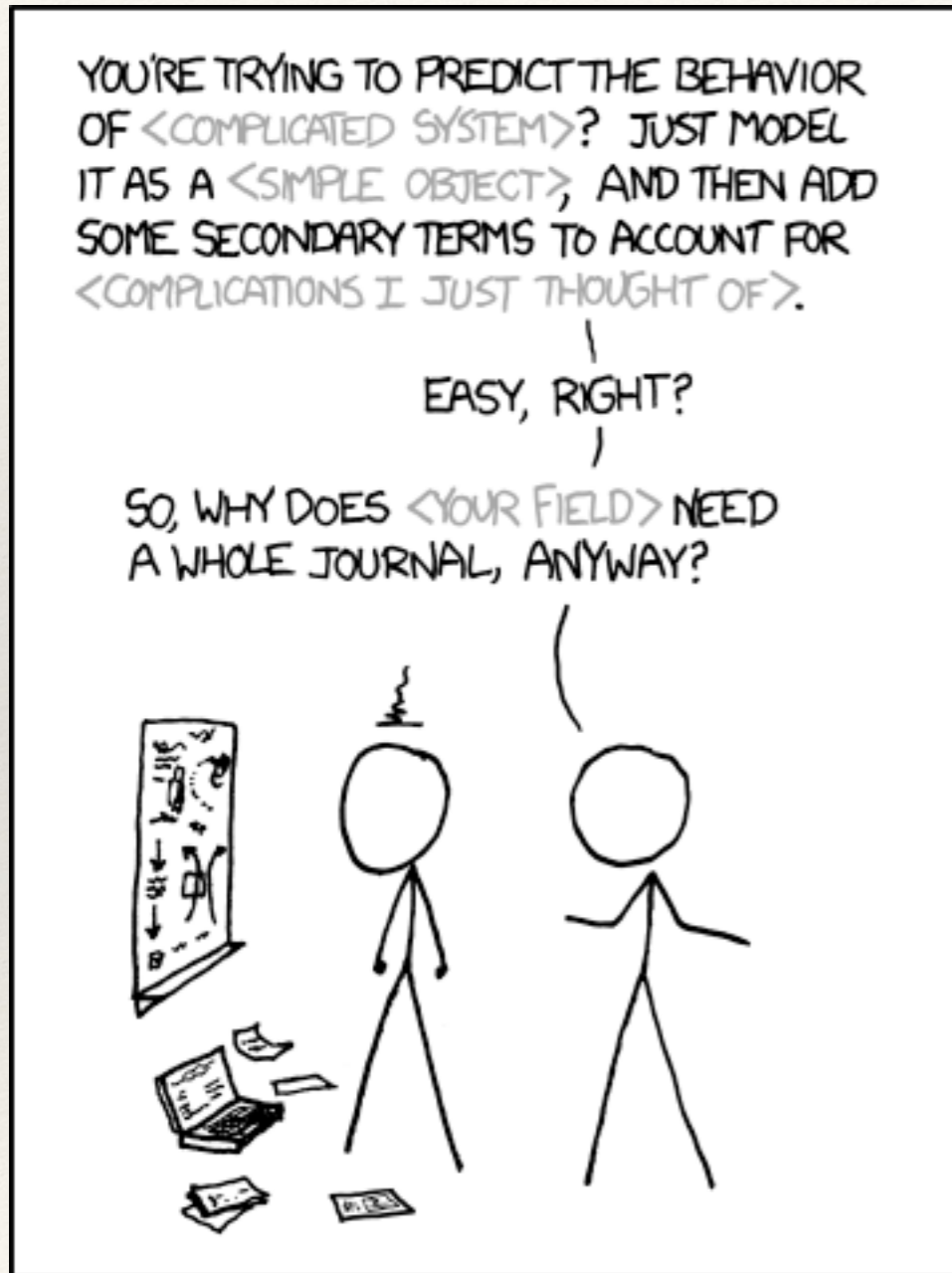


3rd order (NNLO) in perturbation theory



these measurement are only physically useful if theoretical predictions have compatible uncertainties

novel theory and modelling



oftentimes, theory consistency leads to theory developments

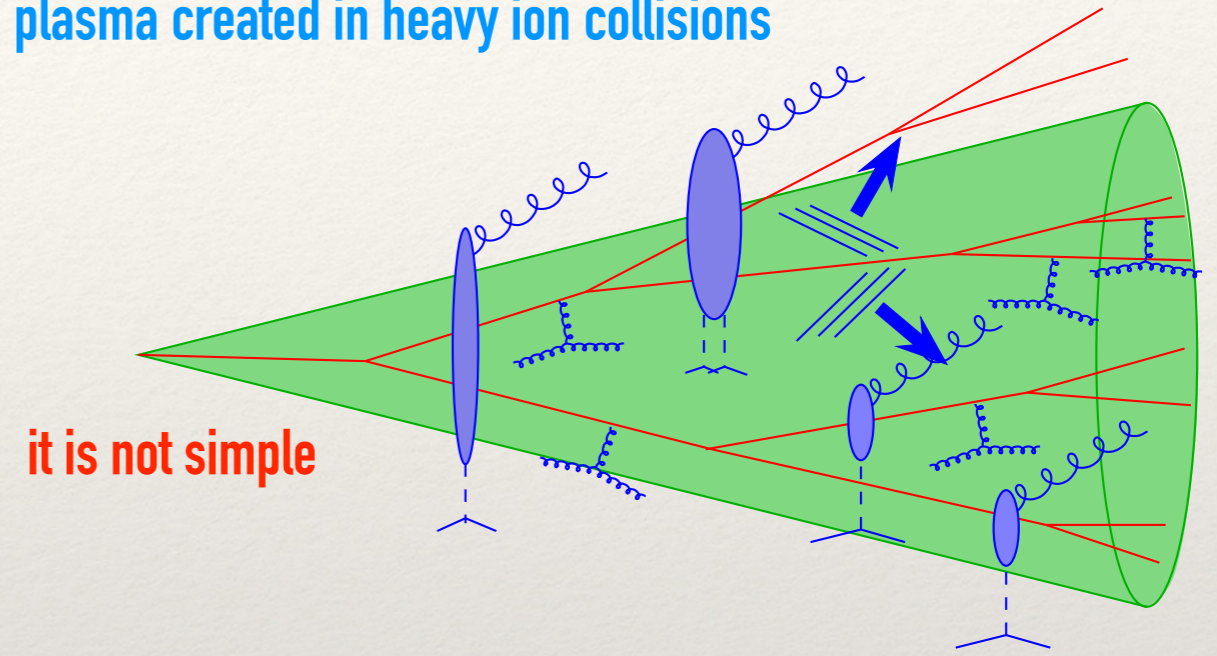
confrontation of theory predictions with experimental reality constrains [by excluding many] possible theory extensions
:: this is the case with all theories beyond the SM (BSM)

oftentimes, phenomena description beyond scope of first principle theory thus requiring modelling [including event simulation]

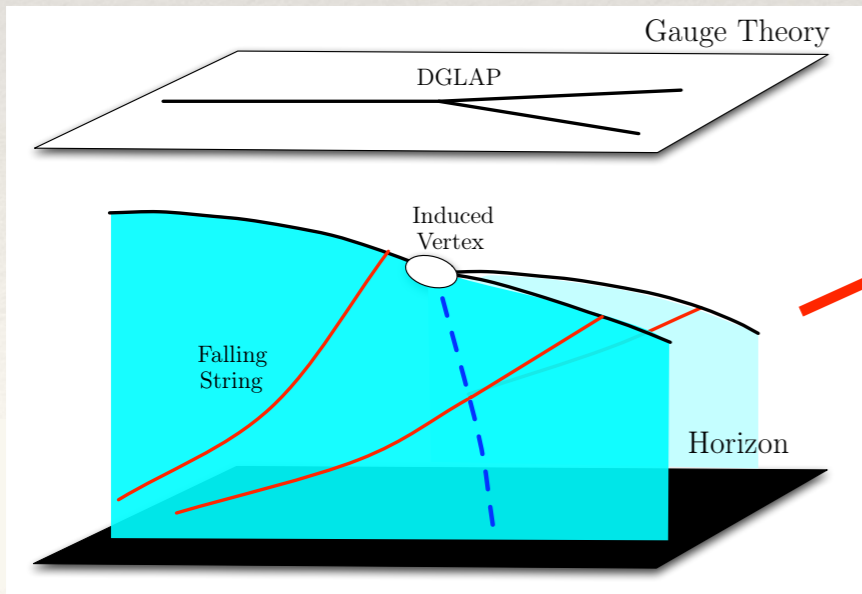
confrontation of model predictions with experimental reality constrains model assumptions

novel theory and modelling

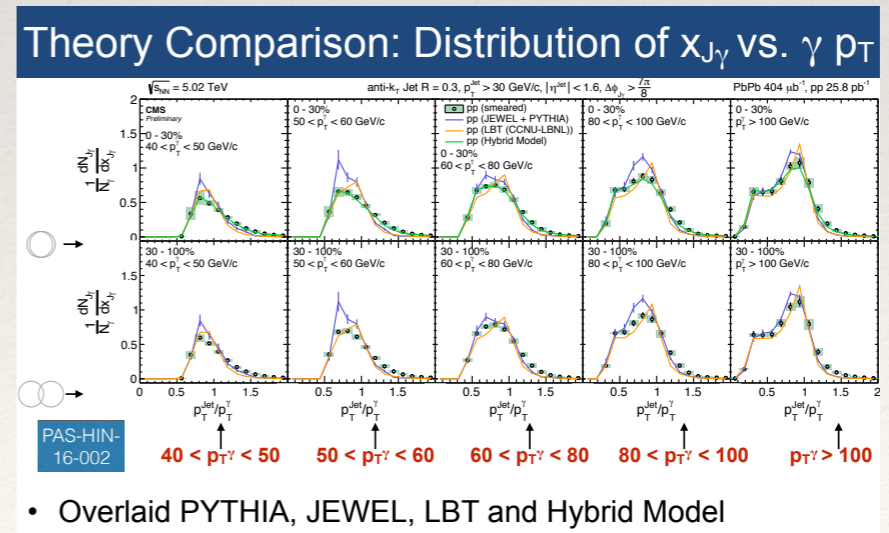
jet development while traversing and interacting with quark gluon plasma created in heavy ion collisions



model as blend of known jet development in vacuum with jet-QGP interaction as propagation of particles in 5d AdS space with BH in 5th dimension [this all somehow makes sense but IS NOT first principles theory]

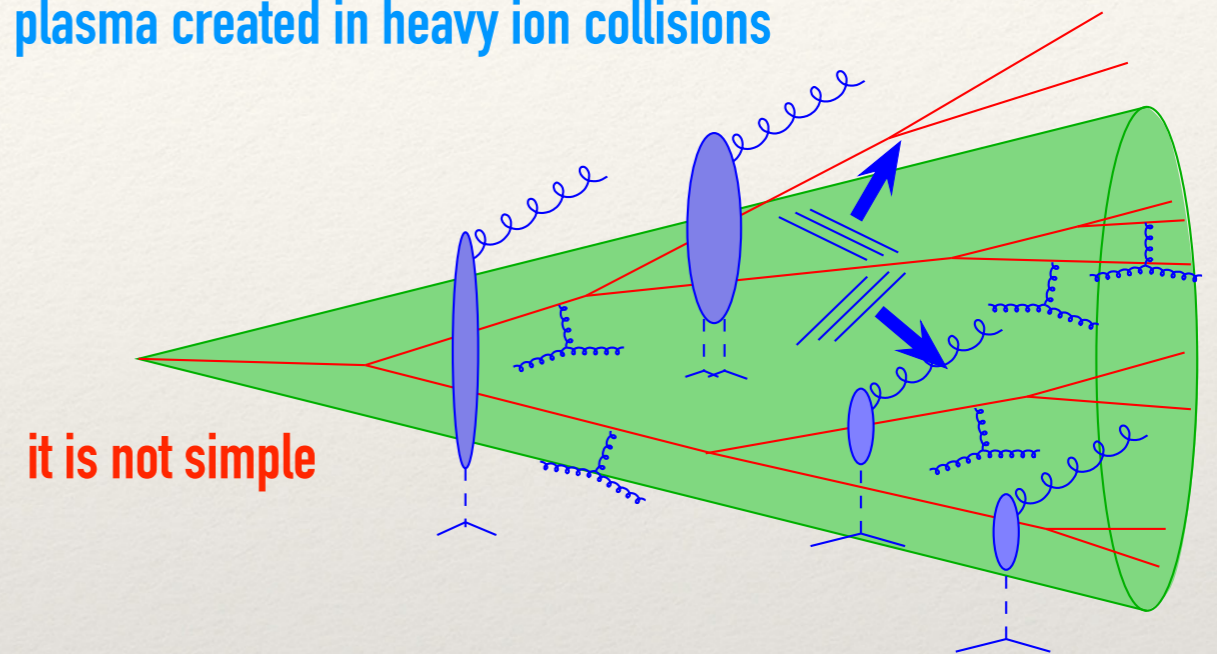


confront with data

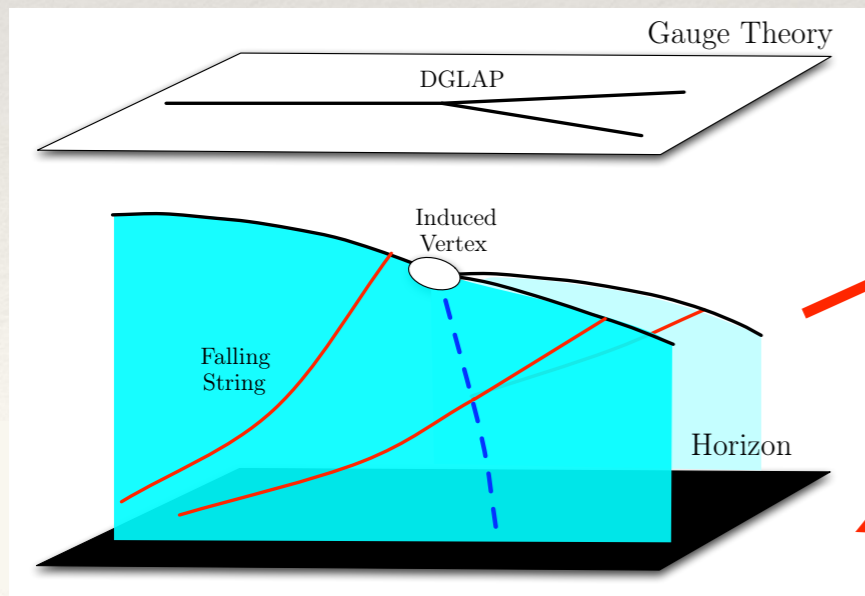


novel theory and modelling

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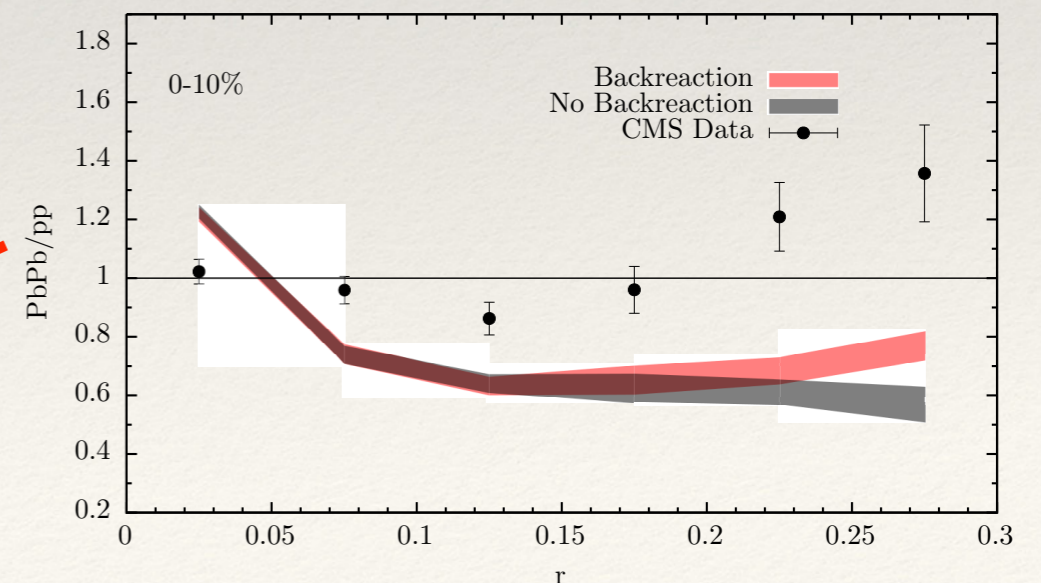


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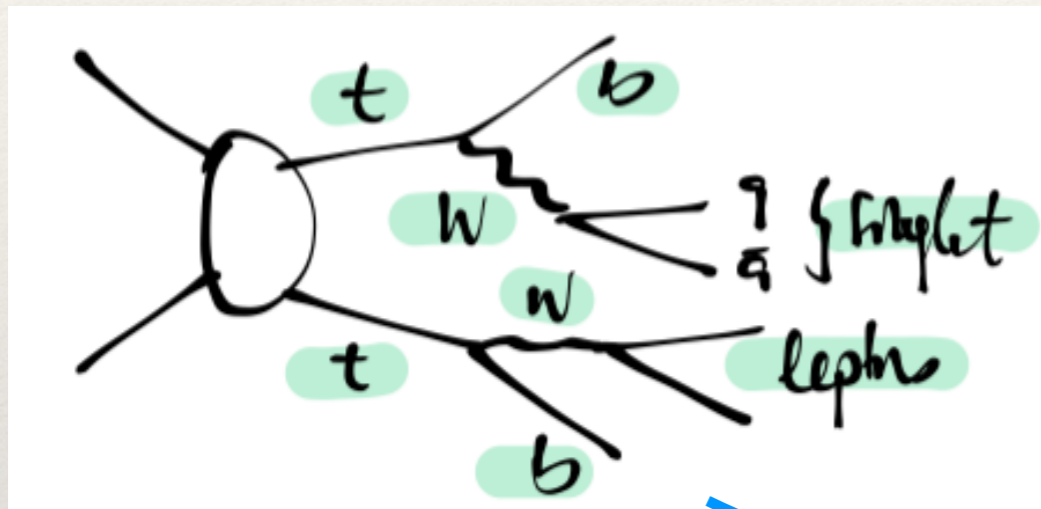
confront with data

improve !!!!!

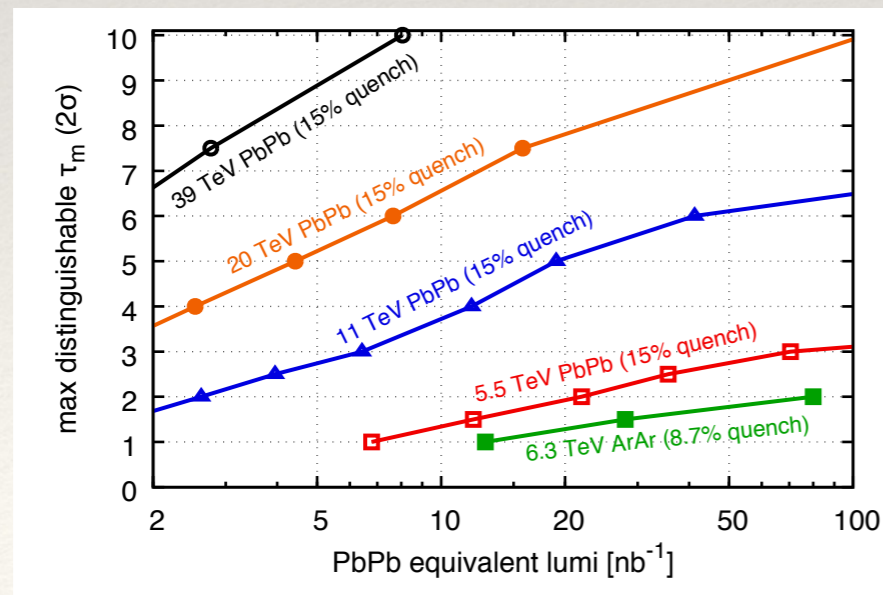


new observables

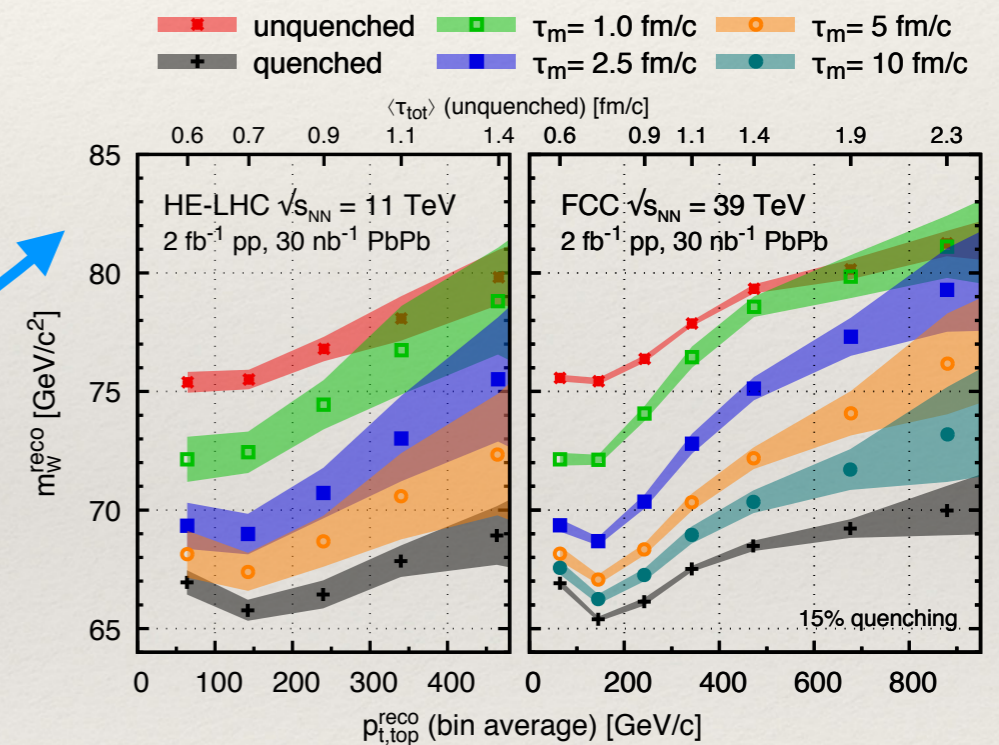
define measurable and calculable quantities that are sensitive to whatever properties you want to access
 :: to measure time evolution of properties of the QGP need objects that start interacting with it at different times



process



feasibility

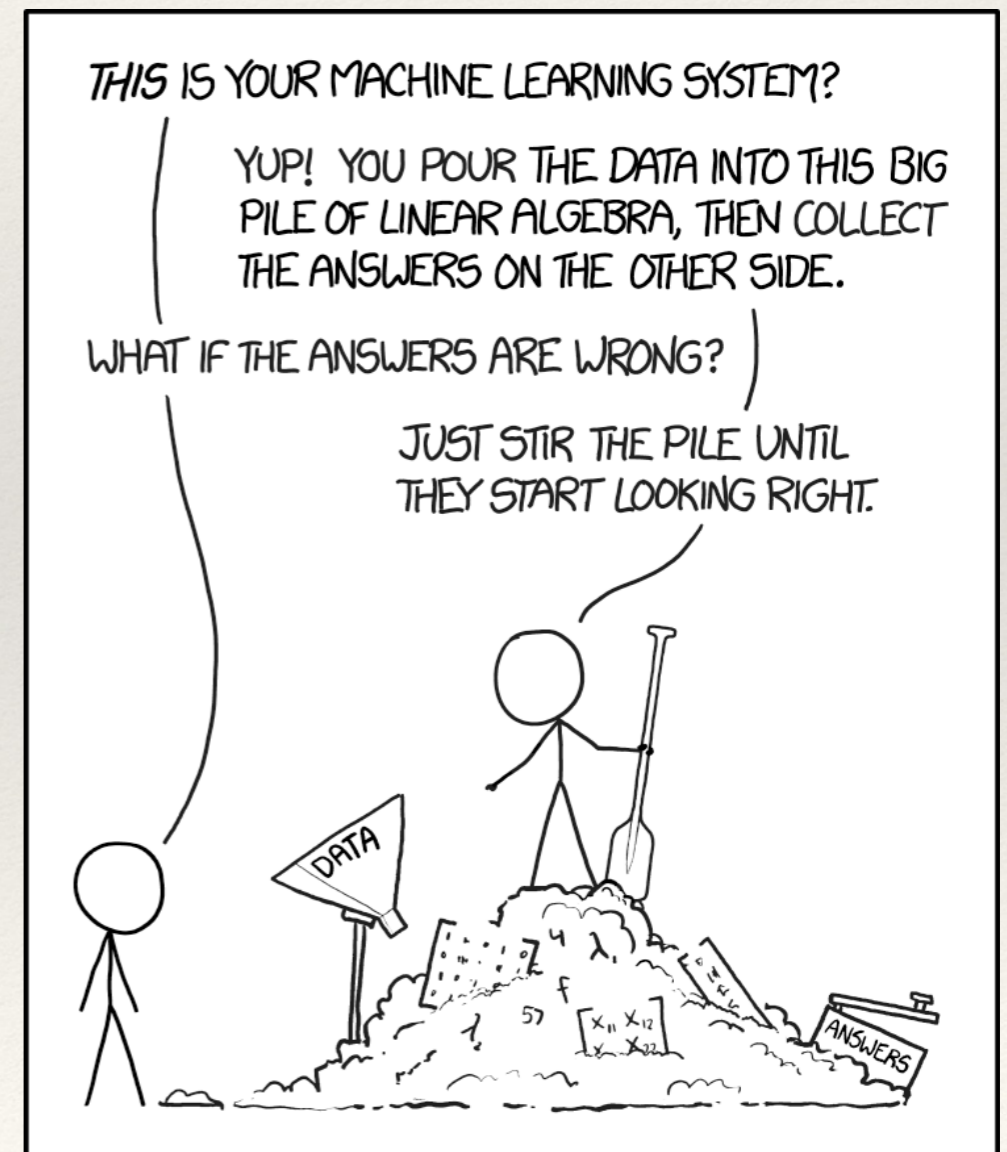


observable

new techniques

Machine Learning techniques have proved very helpful for phenomenological studies

:: let the Machine learn from data [real or simulated] and then learn Physics from the Machine



pheno@LIP :: what we do

- SM/BSM :: observables for new Physics searches [Minho/Coimbra]
- QCD precision and automation [Lisboa]
- Quark Gluon Plasma [mostly its characterisation with jets] :: theory :: Monte Carlo simulation :: observables
- in all the above Machine Learning techniques are increasingly being used

pheno@LIP :: a few of us



Guilherme Milhano [LIP-Lisboa]
Jet Physics, QGP

Liliana Apolinário [LIP-Lisboa]
Jet Physics, QGP



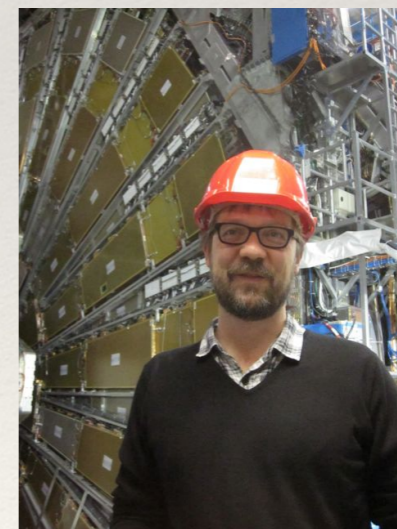
João Pires [LIP-Lisboa]
QCD precision

Grigorios Chachamis [LIP-Lisboa]
QCD precision



Nuno Castro [LIP-Minho]
SM/BSM [also ATLAS]

Nuno Castro [LIP-Minho/Lisboa]
Machine Learning, SM/BSM



Ricardo Gonçalo [LIP-Coimbra/Lisboa]
SM/BSM [also ATLAS]

pheno@LIP :: most important



Maria Ramos [LIP-Minho]
PhD :: BSM/DM



Guilherme Guedes [LIP-Minho]
PhD :: BSM/DM



João Silva [LIP-Lisboa]
MSc :: Jets in HI // ML

2019 vintage



João Gonçalves [LIP-Lisboa]
MSc :: Jets in HI // ML



Bruno Silva [LIP-Lisboa]
MSc :: Jets in small nuclei



Filipa Peres [LIP-Minho]
MSc :: Jets in HI // ML