

Research Highlights

- Ankita Budhraja



- Saad el Morabit



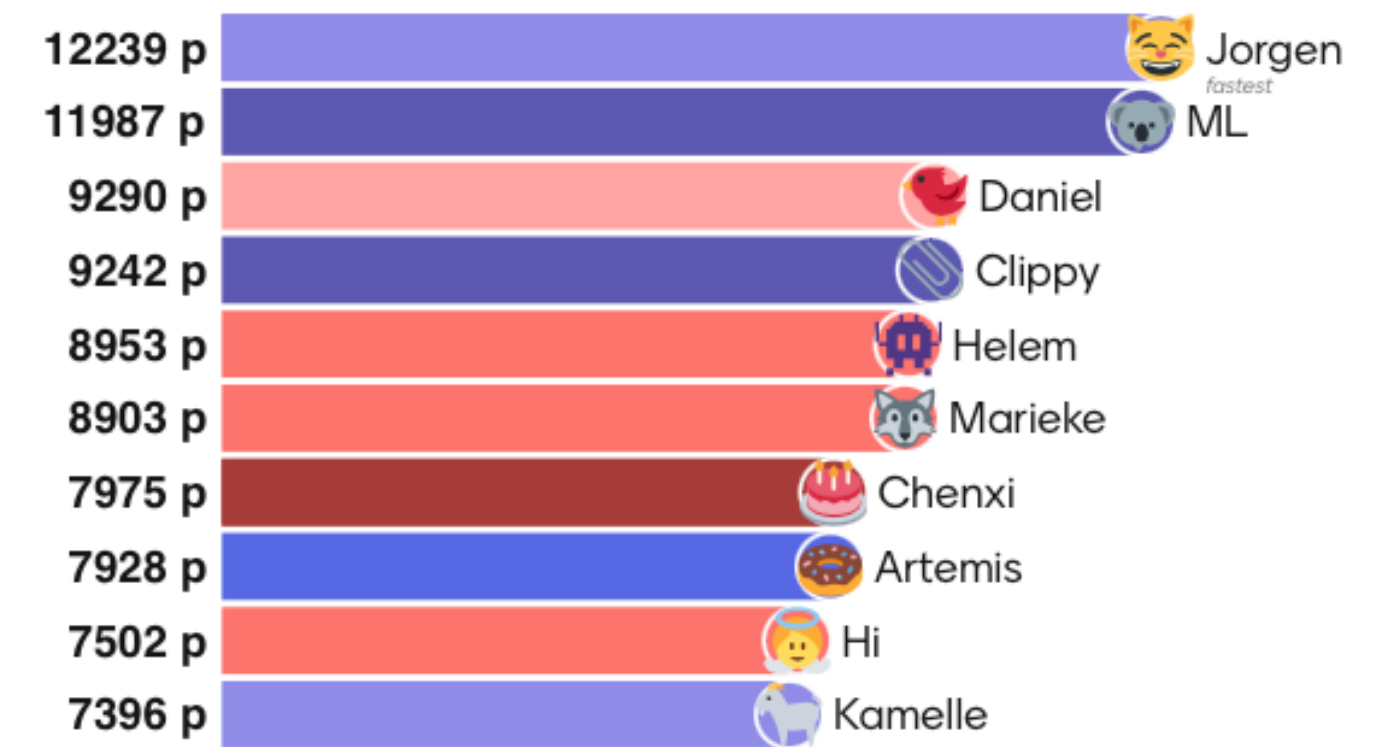
Toast to Robert



What happened when Robert took Eric and Marcel out for dinner in Geneva?



Quiz leaderboard



New FORM 5 Release

[J. Davies, T. Kaneko, Coenraad Marinissen, T. Ueda, Jos Vermaseren, 2601.19982]



- What's new
 - Built-in Feynman Graph generator
 - Improved polynomial arithmetic performance
 - Floating point coefficients as opposed to rational numbers



COMPUTING | FEATURE

The most important tool you've never heard of

6 March 2026

Commercial software can't keep pace with experimental precision when it comes to large-scale computer-algebra calculations in quantum field theory. Maintained by a single theorist for decades, FORM is often the only option, underpinning a remarkable fraction of papers in high-energy physics. The *Courier* interviewed key figures from its past, present and future.



The inventor Jos Vermaseren, Nikhef. Credit: J Vermaseren

Jos, FORM has been at the heart of precision calculations for decades. But the story starts earlier, with Martinus Veltman (see "The pioneer" image). What was he trying to do?

Jos Vermaseren In 1963, Veltman was interested in the renormalisation of Yang–Mills theories. He wanted to check whether certain models produced unphysical infinities that could not be removed. These calculations are a lot of work: you don't do that by hand. So he built himself a program, which he called Schoonschip, to do

that calculation.

Theses



Money

- ERC-C

Dr. Jordy de Vries (Institute of Physics) -
The Common, the Rare, and the Unseen:
Precision Theory fo Precision Experiments

Deeltjesfysica staat voor grote vragen, zoals het gebrek aan antimaterie en de oorsprong van neutrino-massa's. Laag-energetische precisie-experimenten kunnen daarbij



New: Theory Coffee Hour

Have a question you have always wanted to ask a theorist?
Working on the theory chapter of your thesis?
Curious about the theoretical implications of (recent) measurements?
Interested in setting up a shared theory/experiment initiative?

Come to the **theory coffee hour!**

Every last Wednesday of the month
3pm in the coffee area downstairs.



FCC @ Nikhef

- Monthly meetings & discussions on FCC topics
- Driven by current interests:
informal, exploratory, low commitment
- Indico page and mailing list: fcc@nikhef.nl

June 2026

17 Jun [SMEFT for FCC - Elie Hammou](#) **NEW**

May 2026

06 May [Summary of the first FCC-ee TDAQ workshop - Mengqing Wu](#)

April 2026

08 Apr [A TPC as a central tracker in a FCCee experiment - Peter Kluit](#)

March 2026

11 Mar [Kick off meeting - Wouter Waalewijn](#)



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- **Recycling frontier:** New theory enables new measurements from old LEP data!



Regions inaccessible before!

June 2026

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May 2026

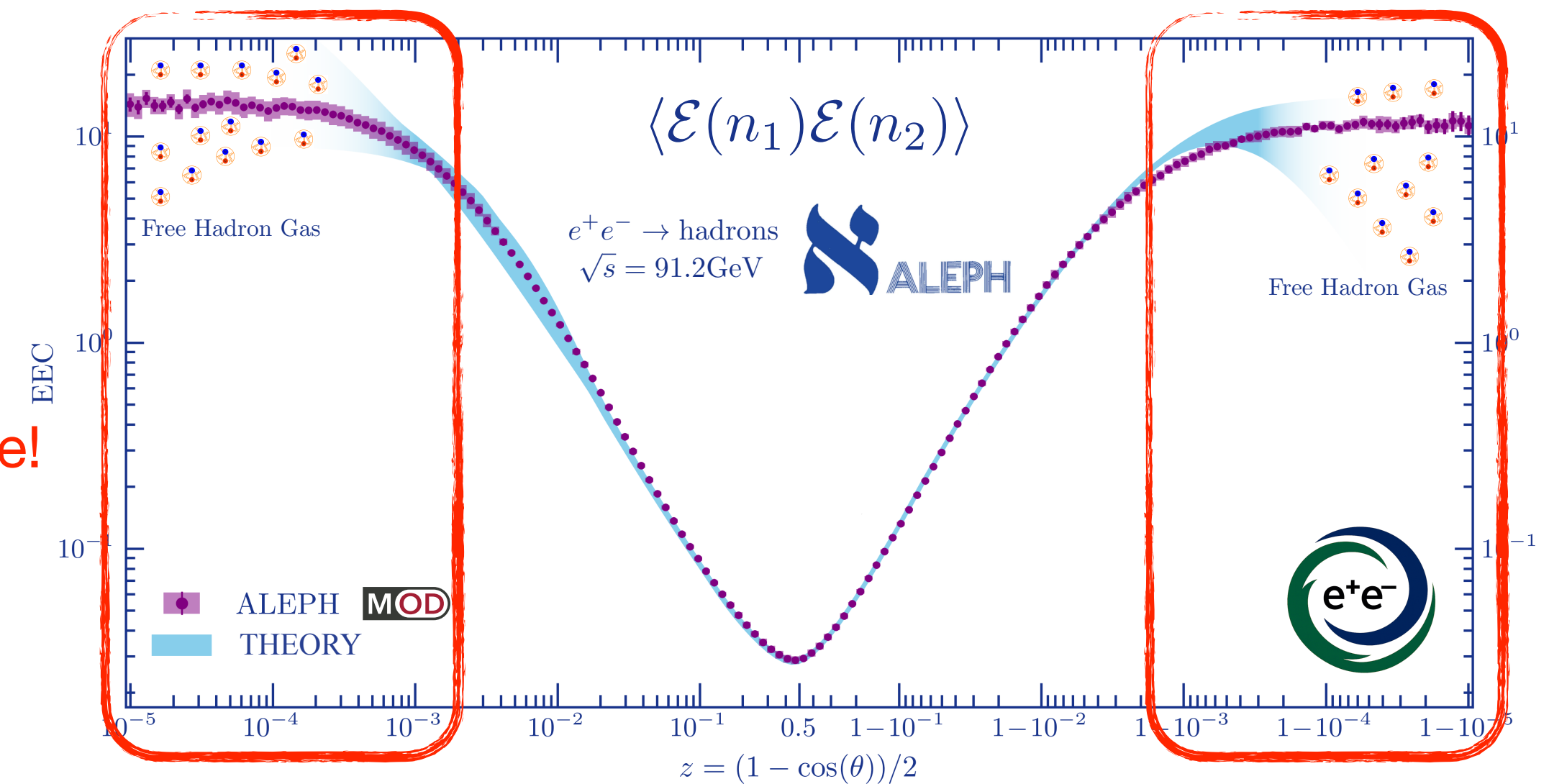
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Healthy Together



running @ QCD journal club

Polarized training model

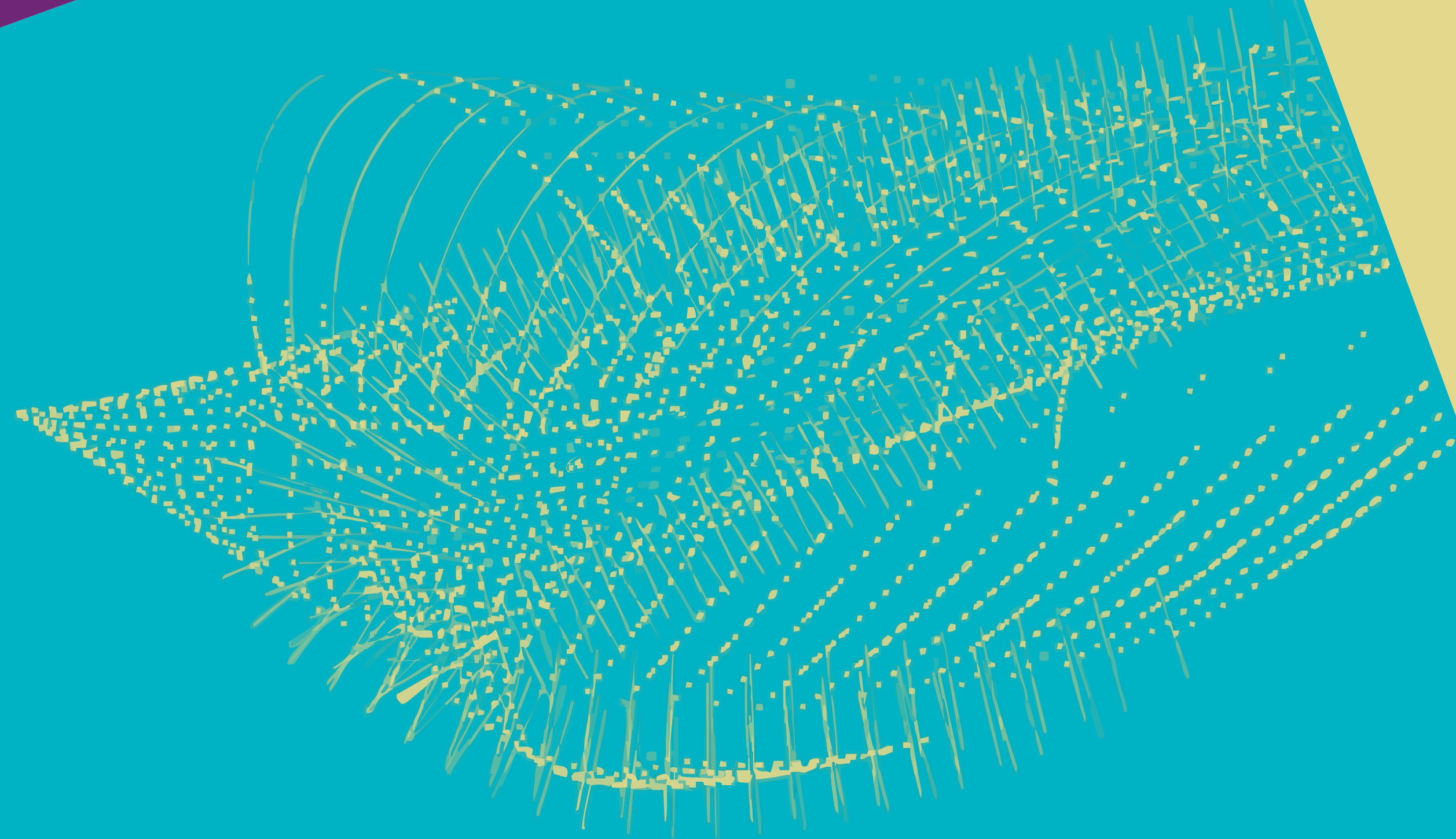
80% effort in low zones 1 + 2 with only 20% in zones 4 + 5
"Go slow to go fast"



"What is best practice for training intensity and duration distribution in endurance athletes?" [S Seiler (2010)]

zone training by Maximillian @ group meeting

Nikhil

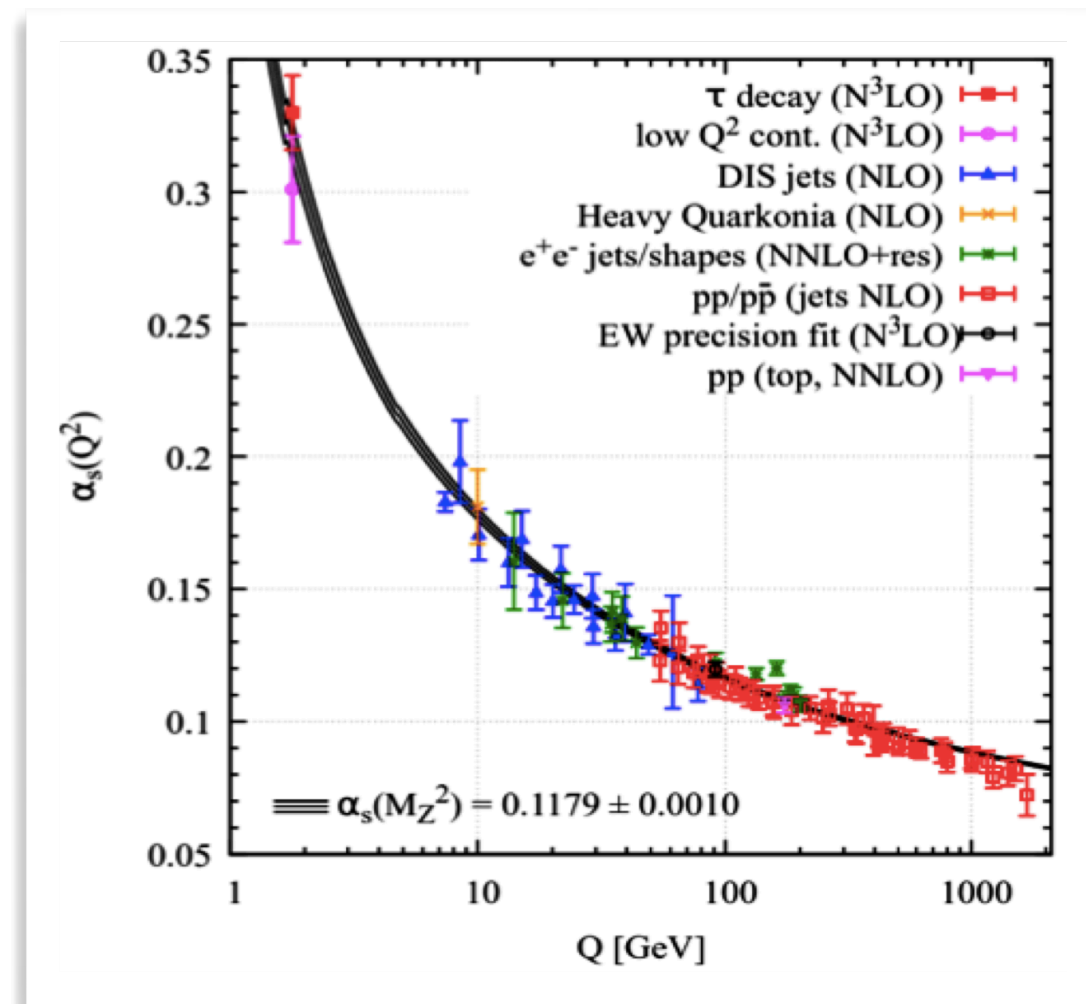
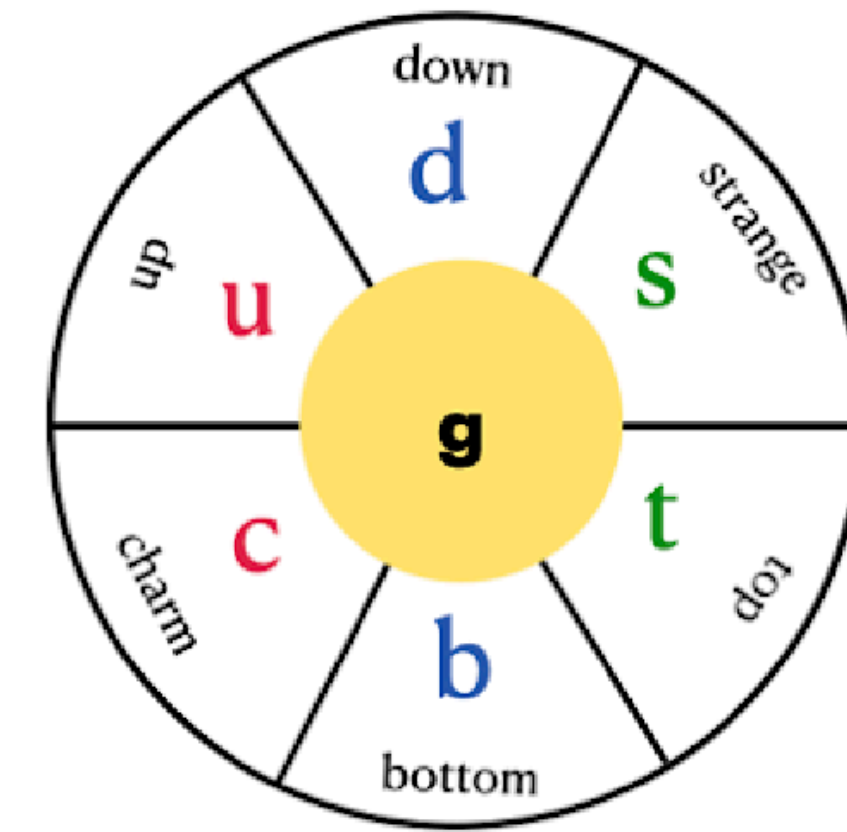


Jet Substructure with Energy Correlators

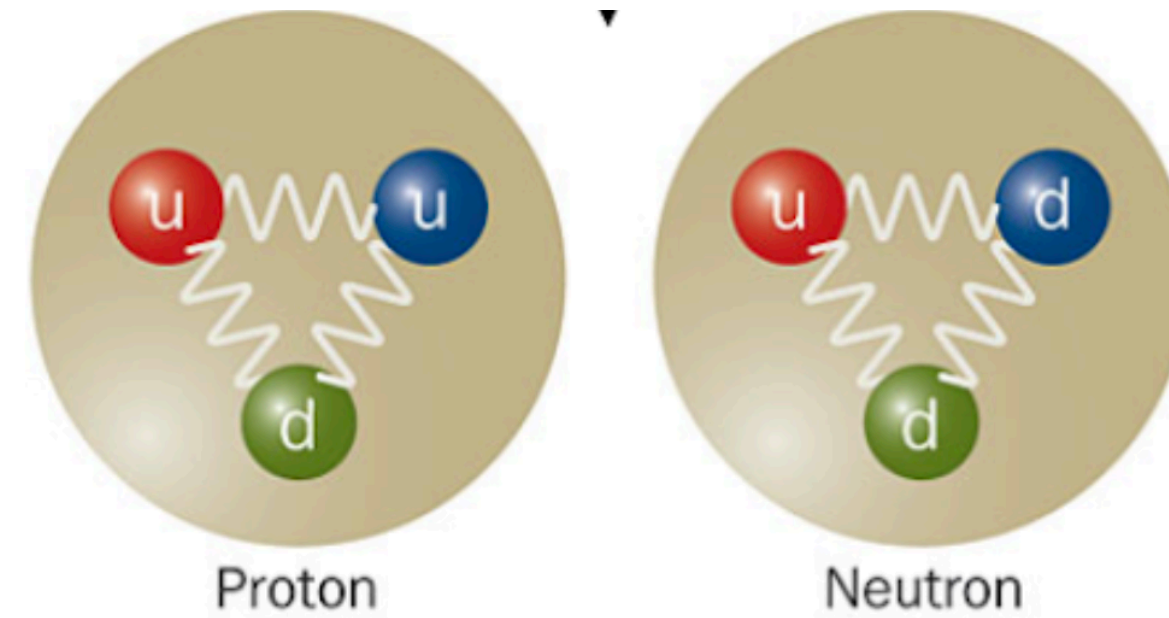
Ankita Budhraja

QCD AT PARTICLE COLLIDERS

- **QCD** is the fundamental theory of strong interactions.

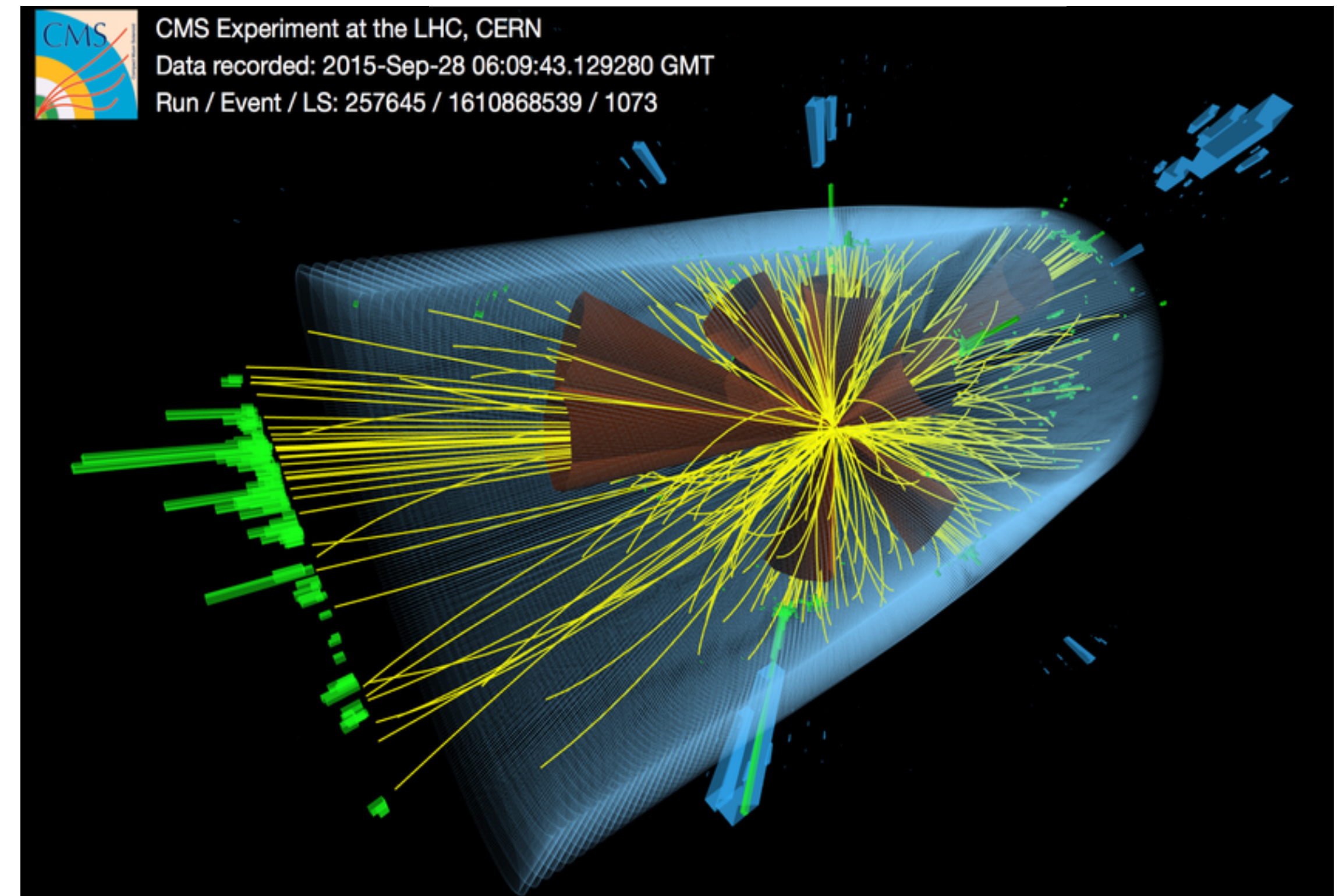


asymptotic
freedom

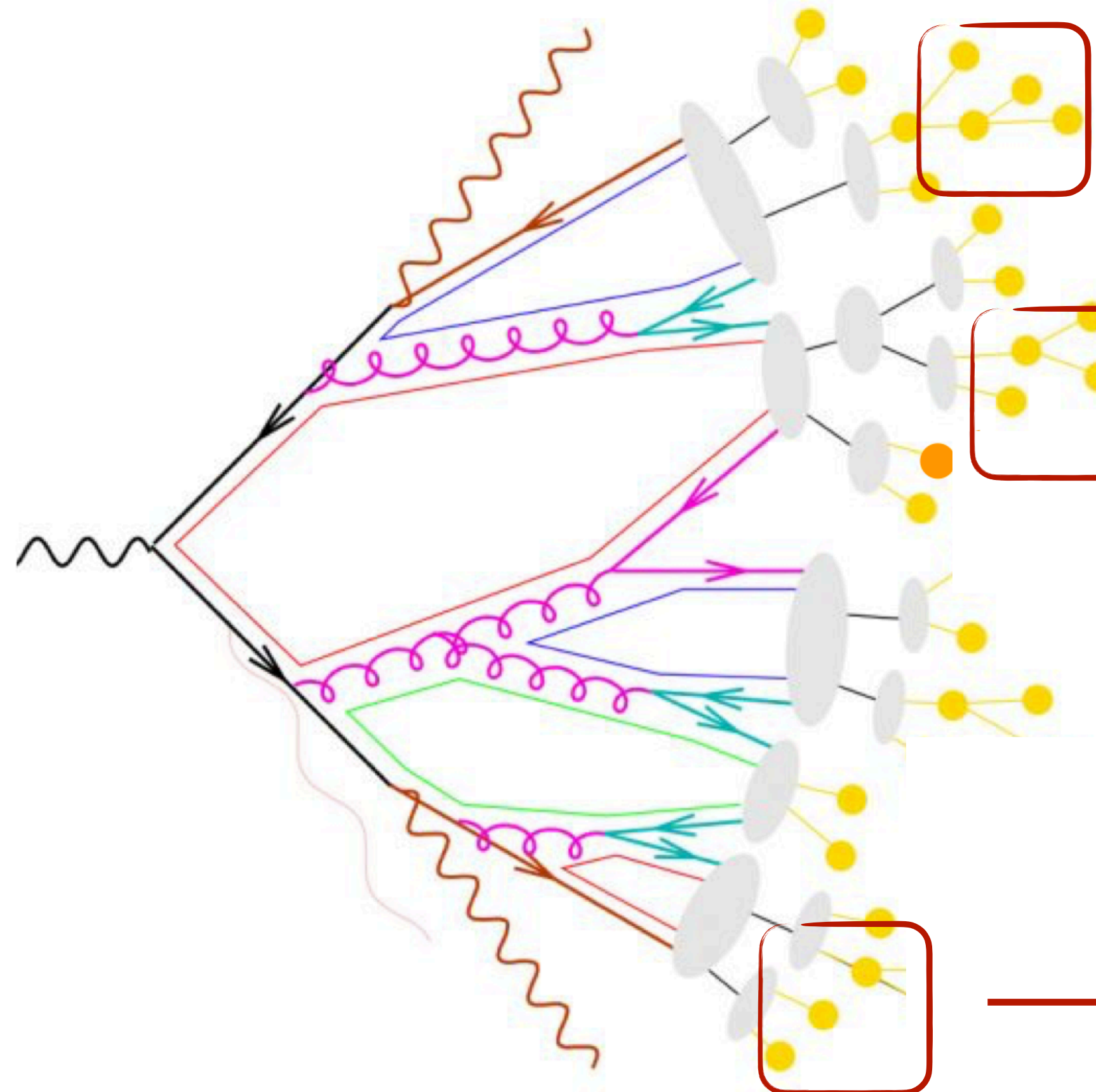


confinement

- Jets are manifestation of **QCD** in real-world particle colliders.



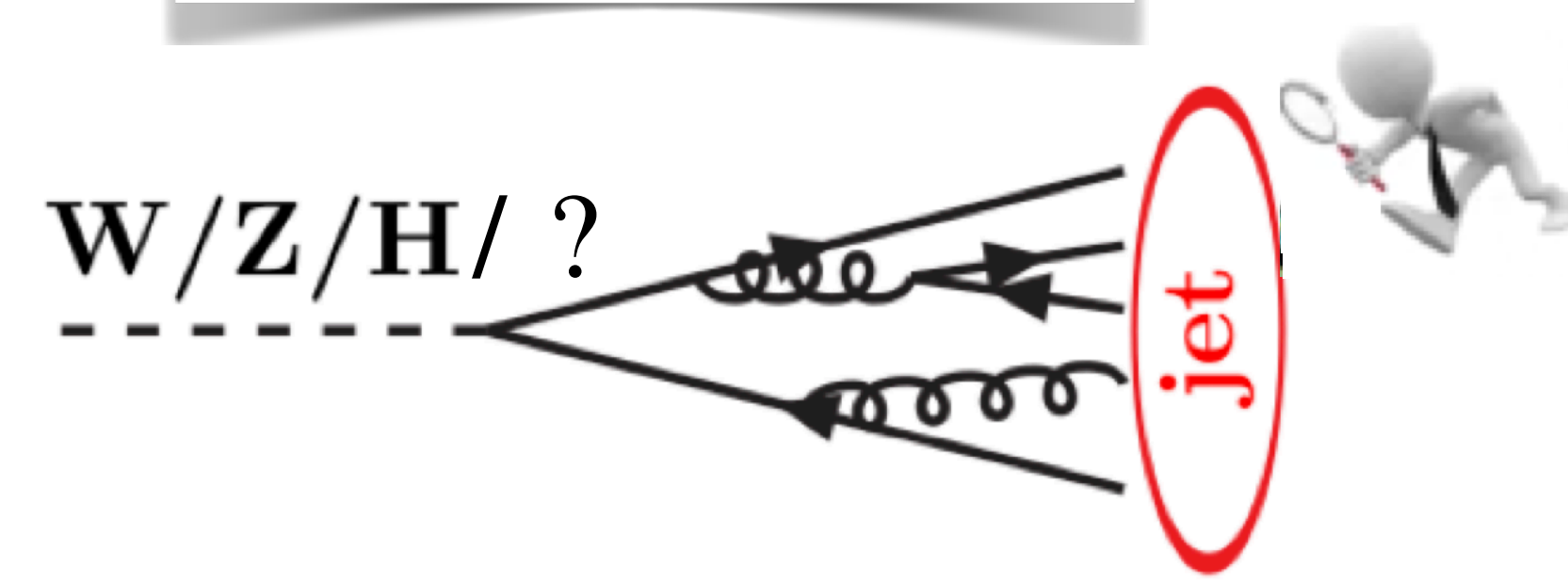
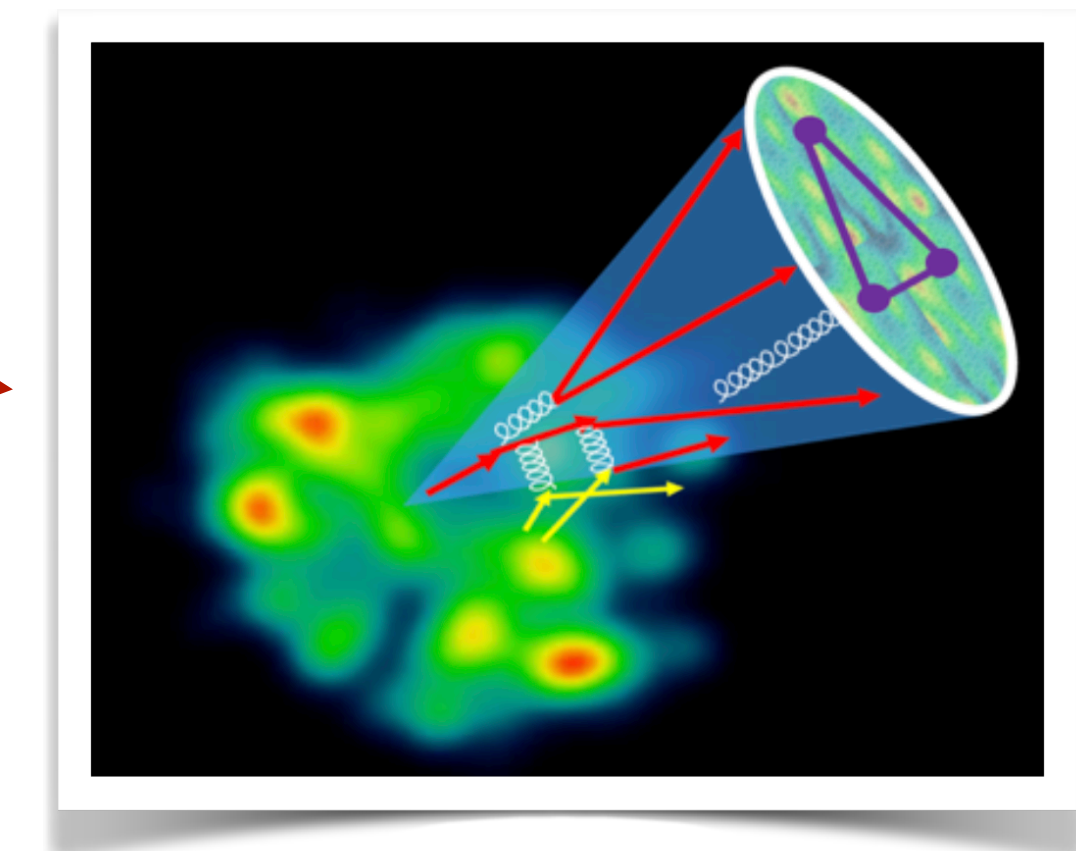
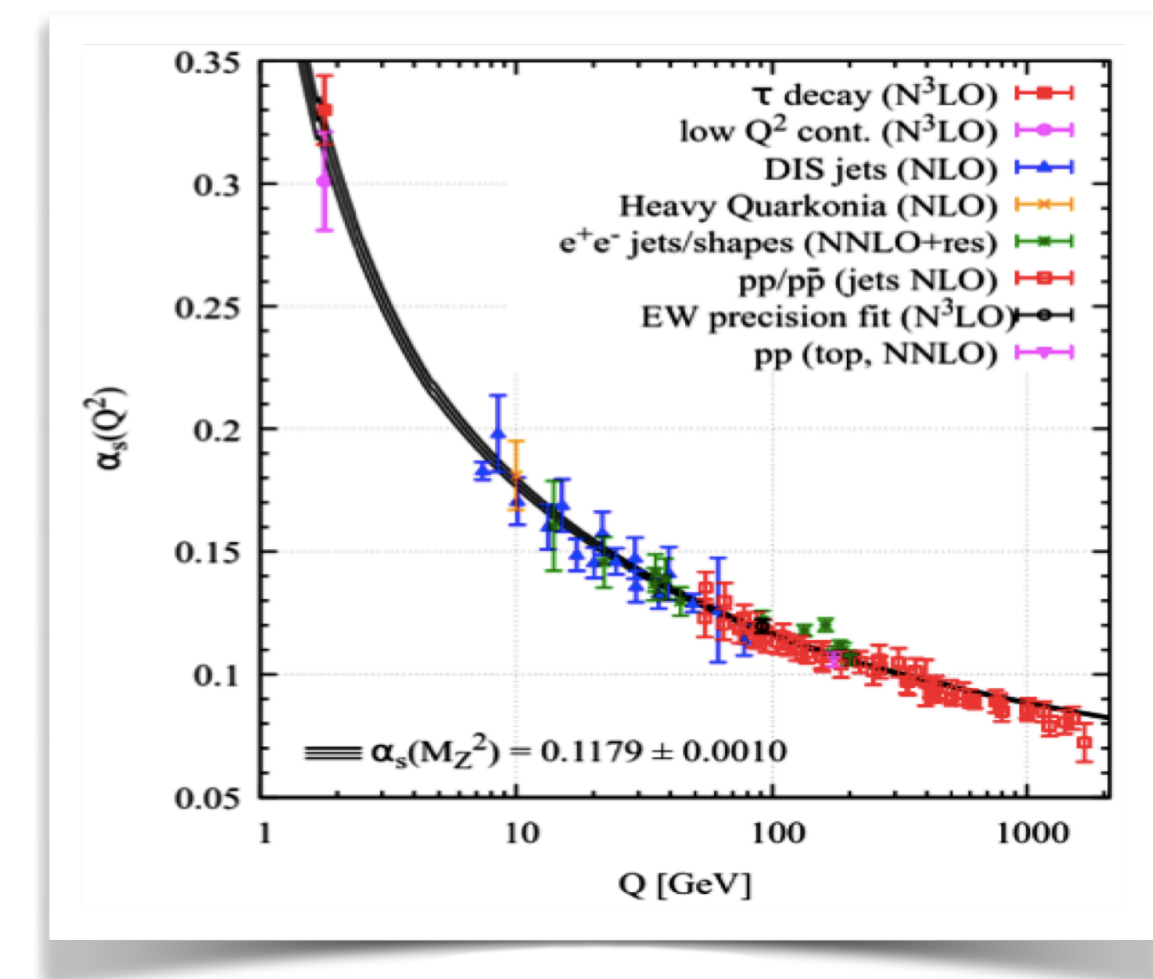
QCD AT PARTICLE COLLIDERS



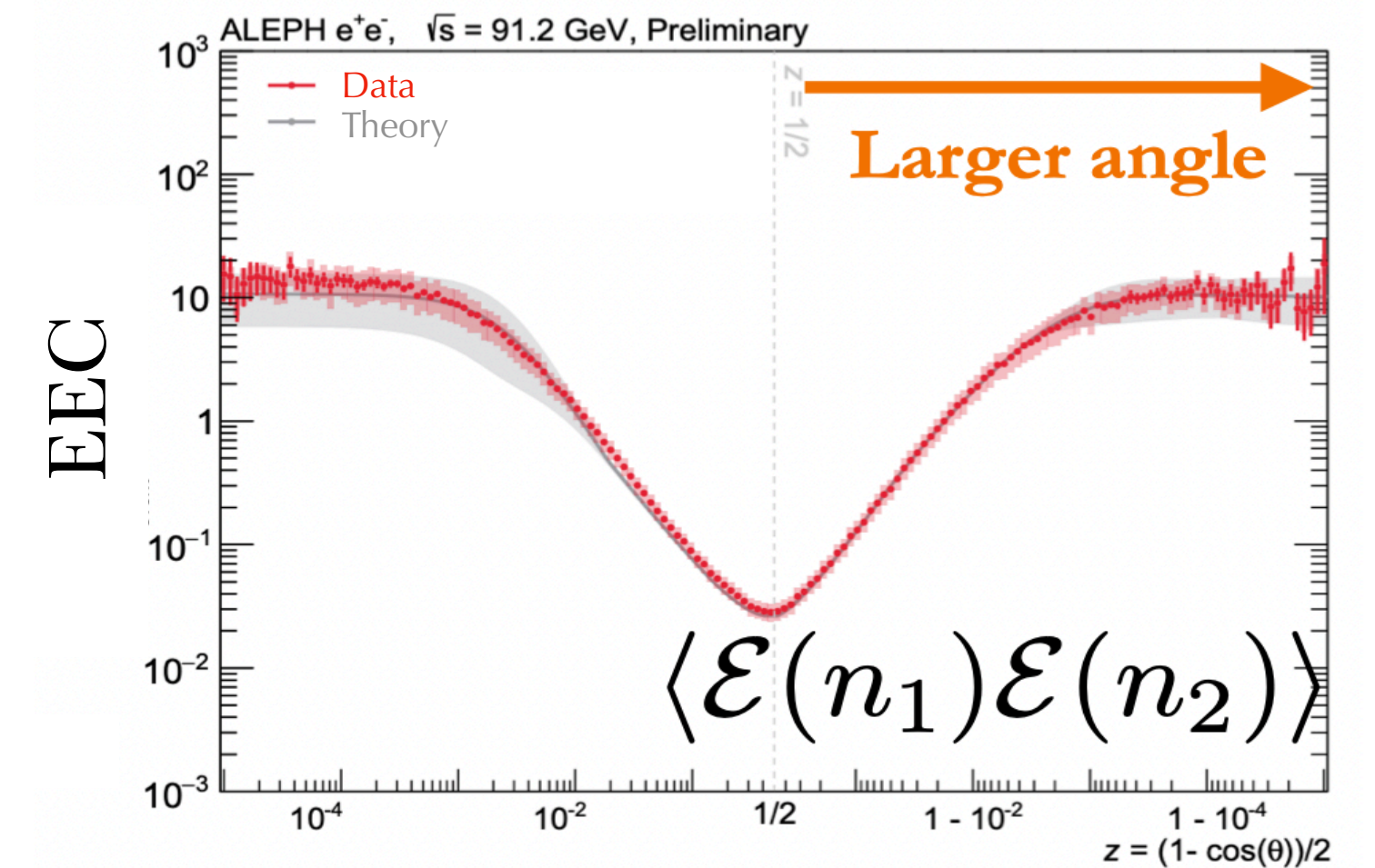
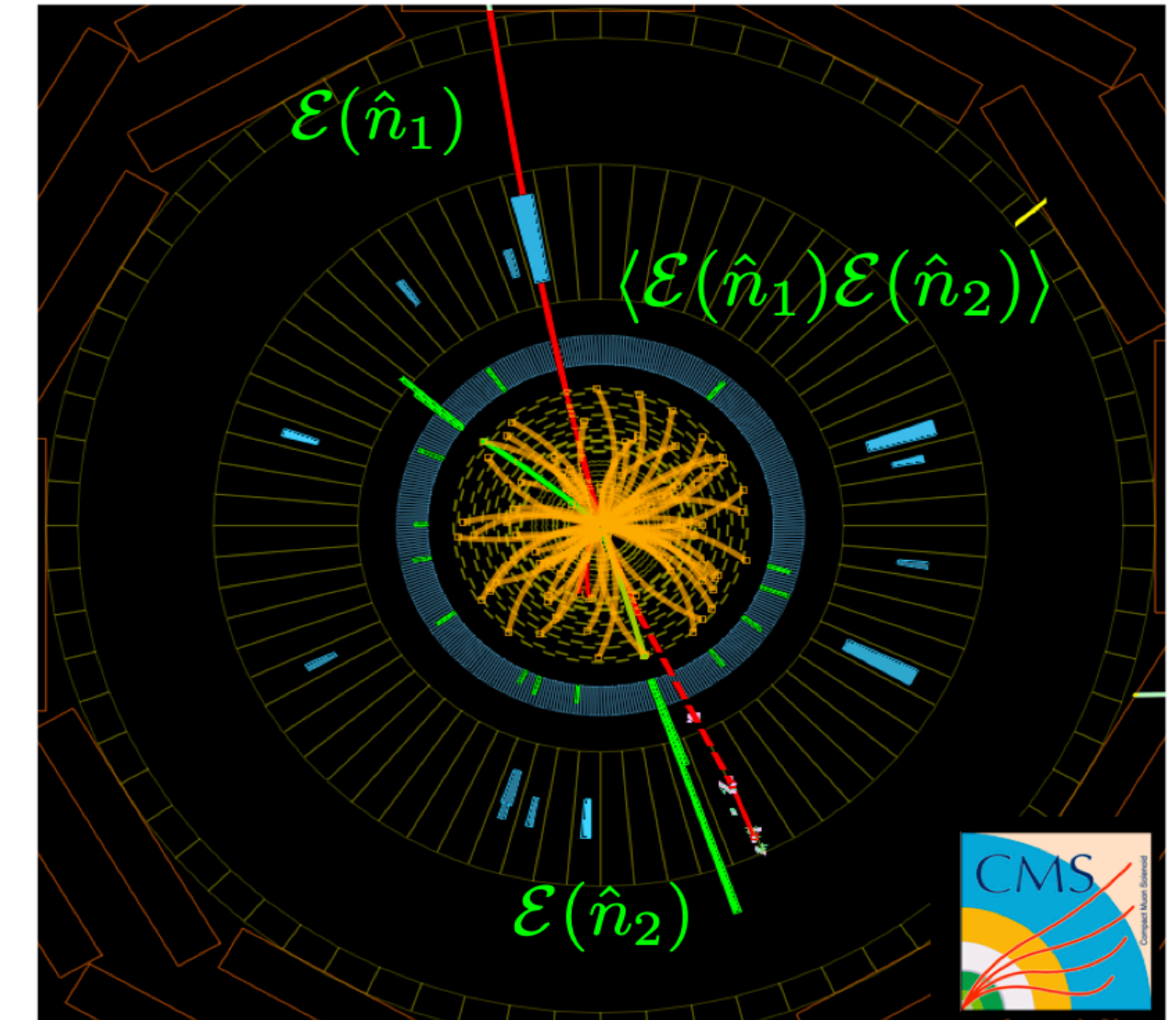
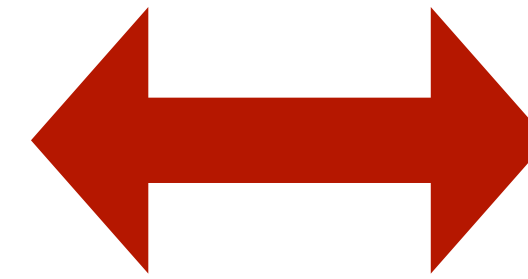
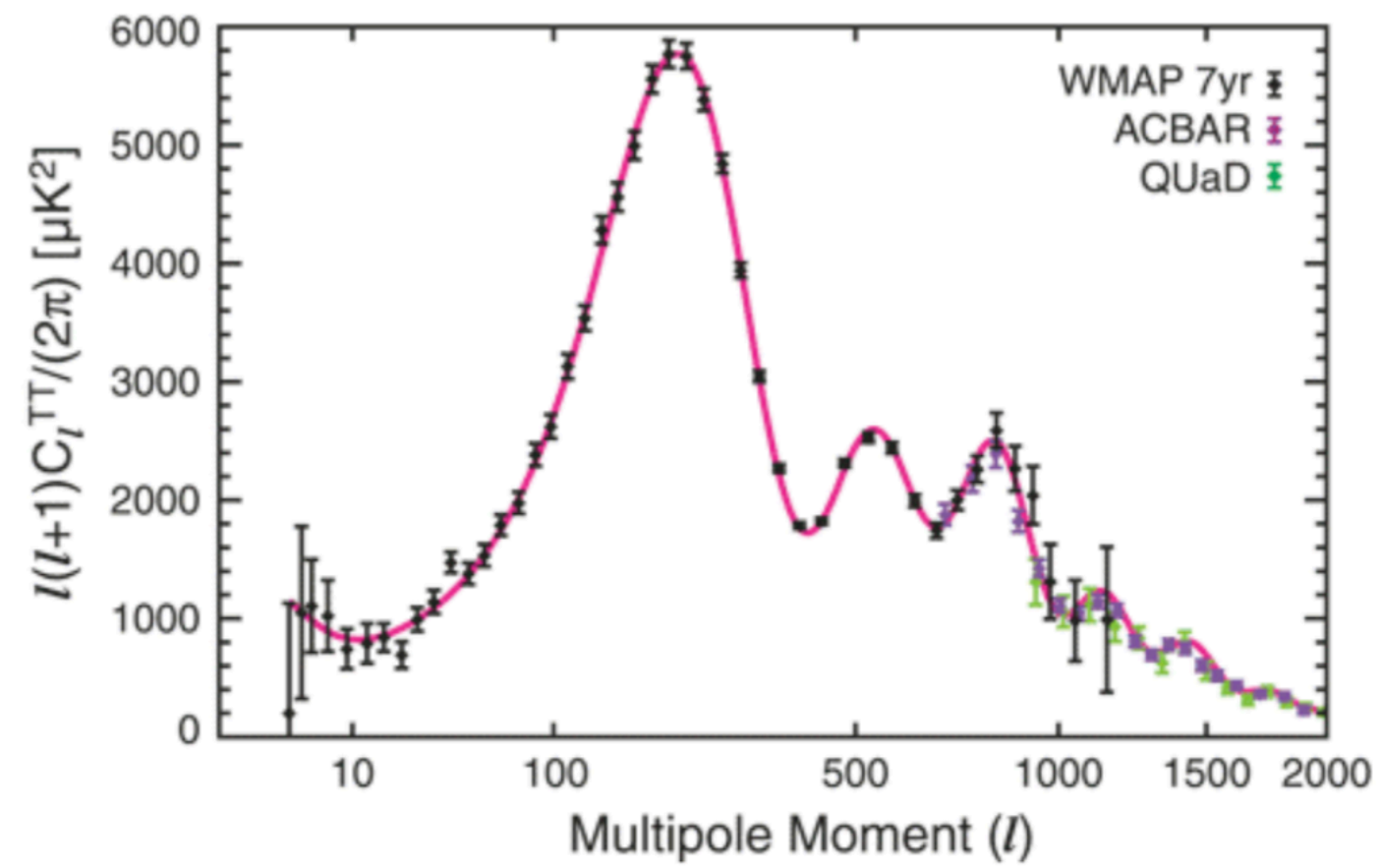
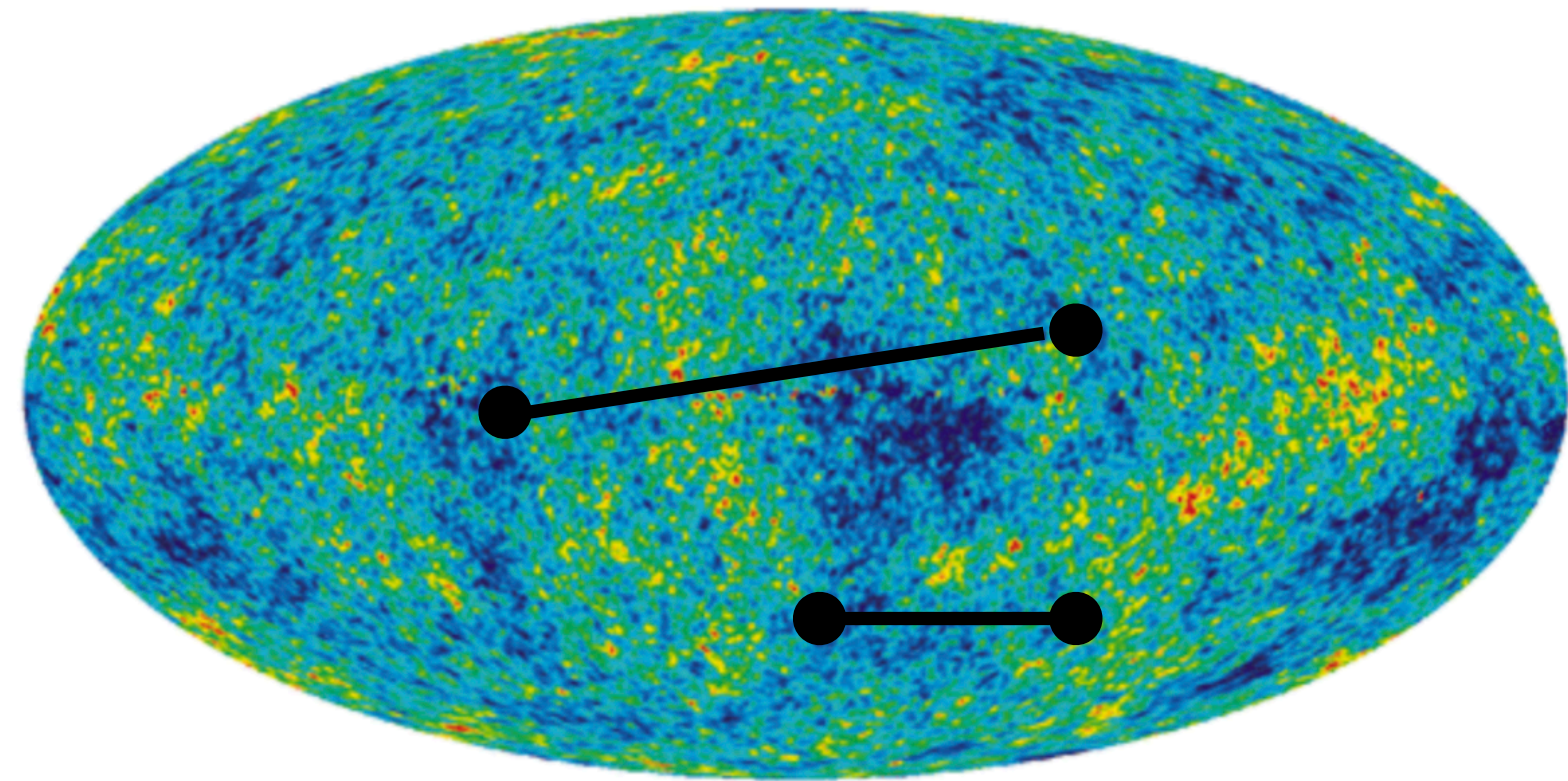
QCD precision studies

Probe quark-gluon plasma

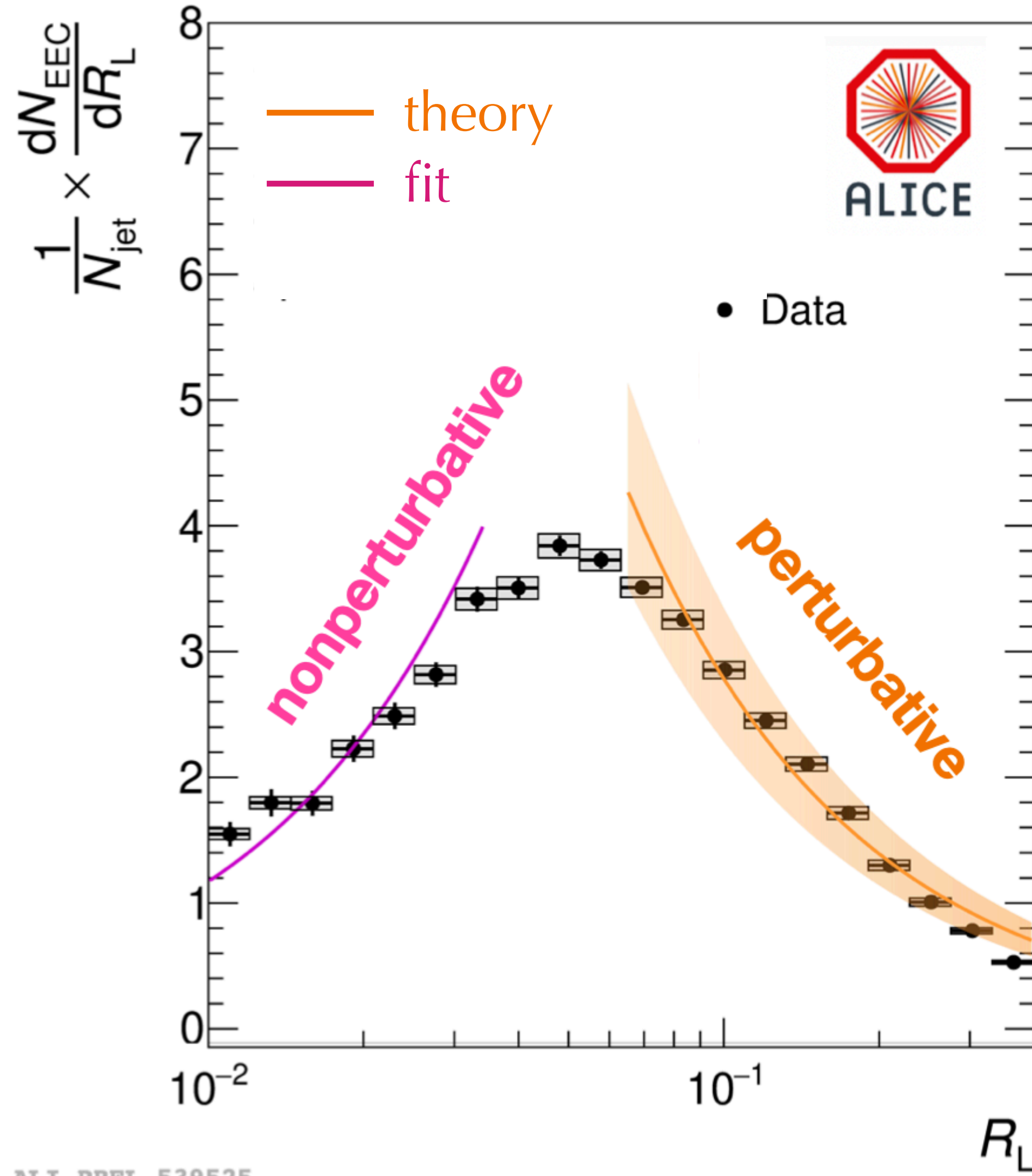
New physics searches



ENERGY CORRELATORS IN JETS



WHY ENERGY CORRELATORS ?

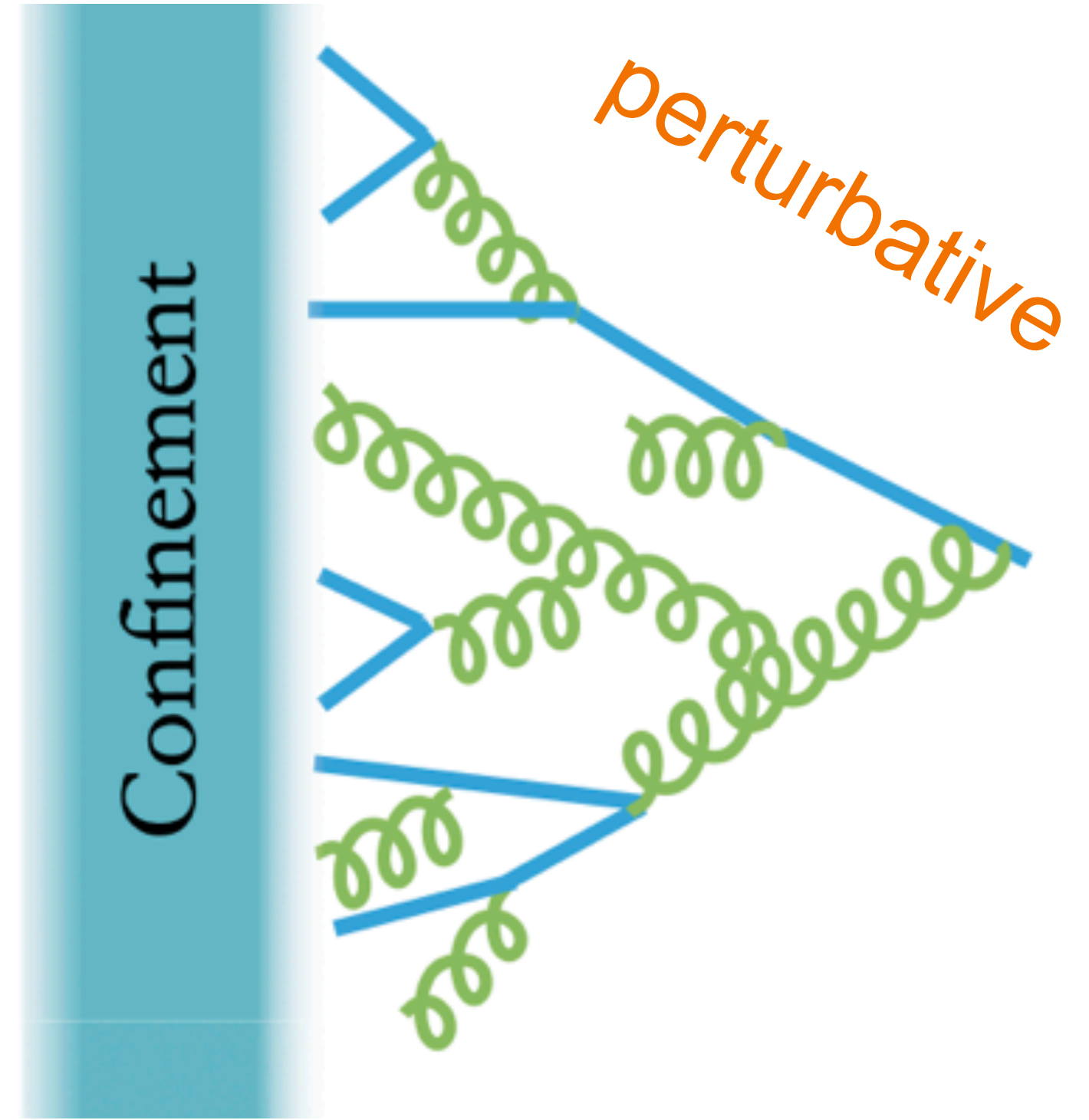


ALI-PREL-539525

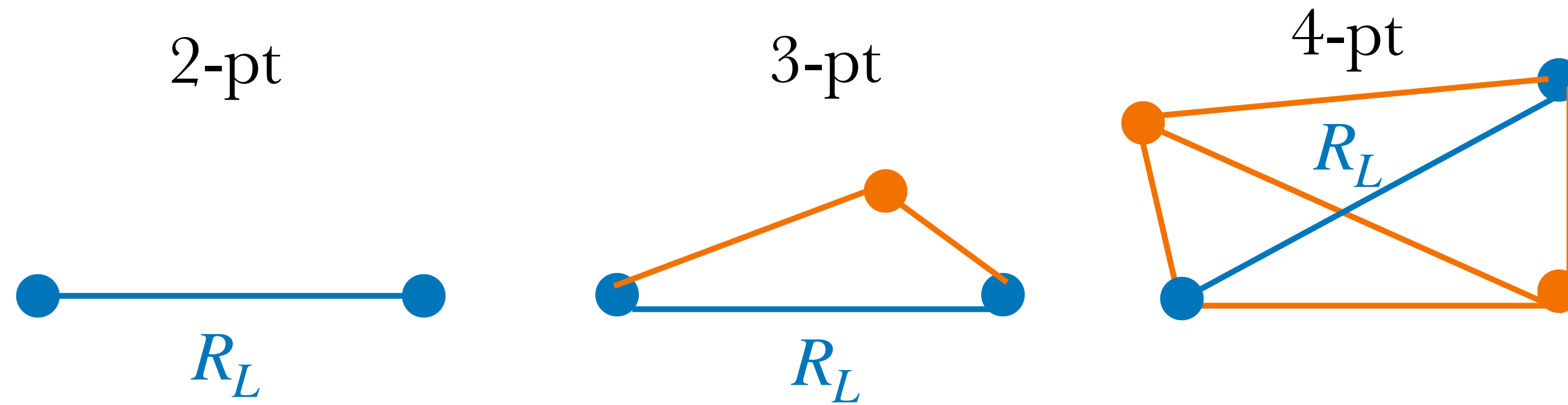
nonperturbative



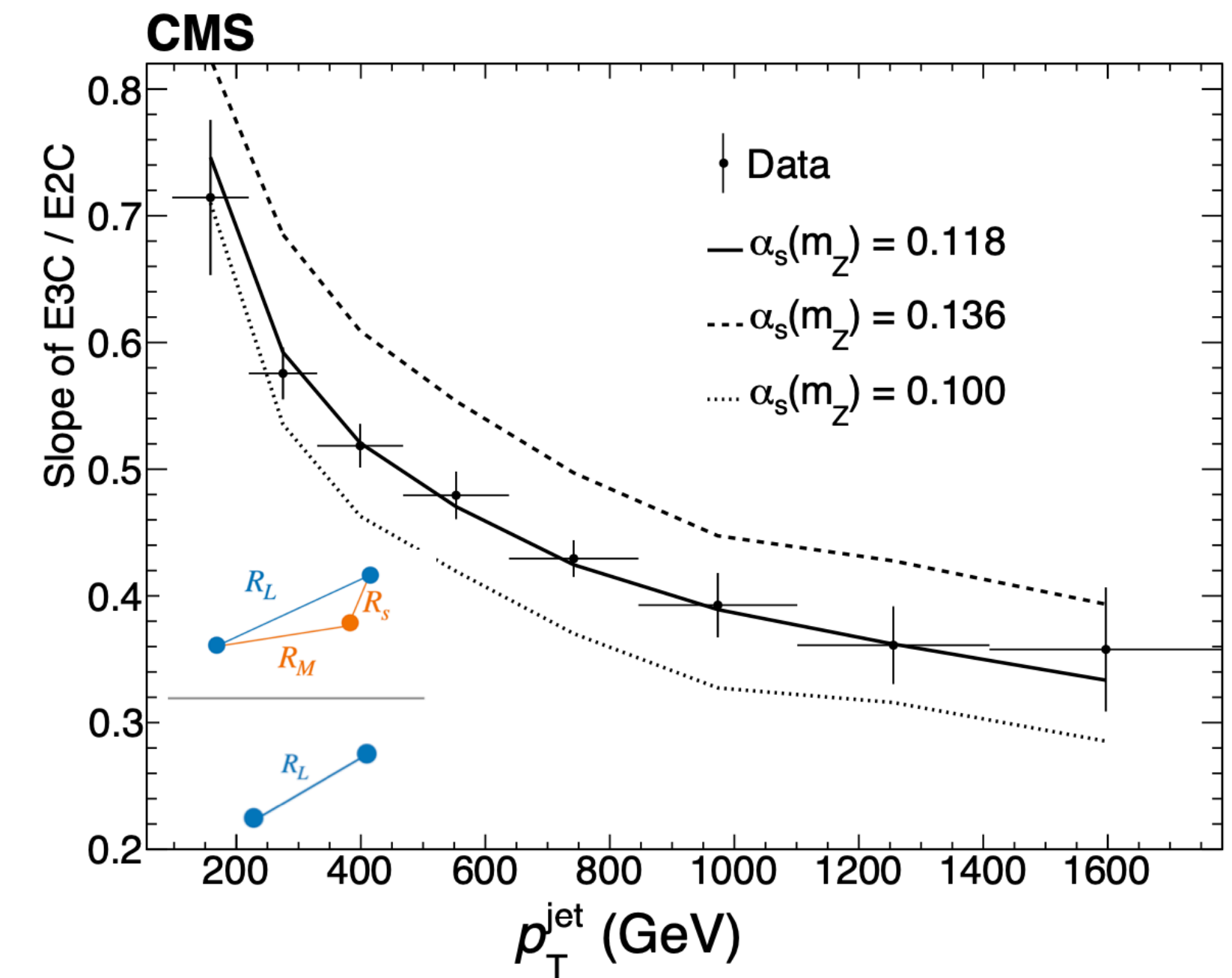
Λ_{QCD}



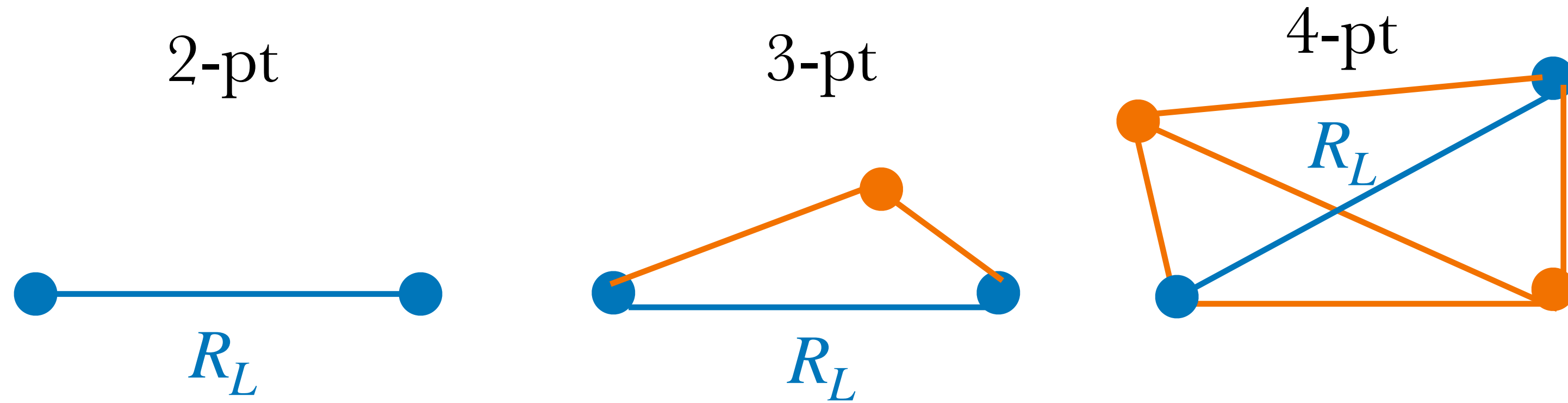
HIGHER-POINT CORRELATORS : COMPUTATIONALLY EXPENSIVE



useful for α_s determination

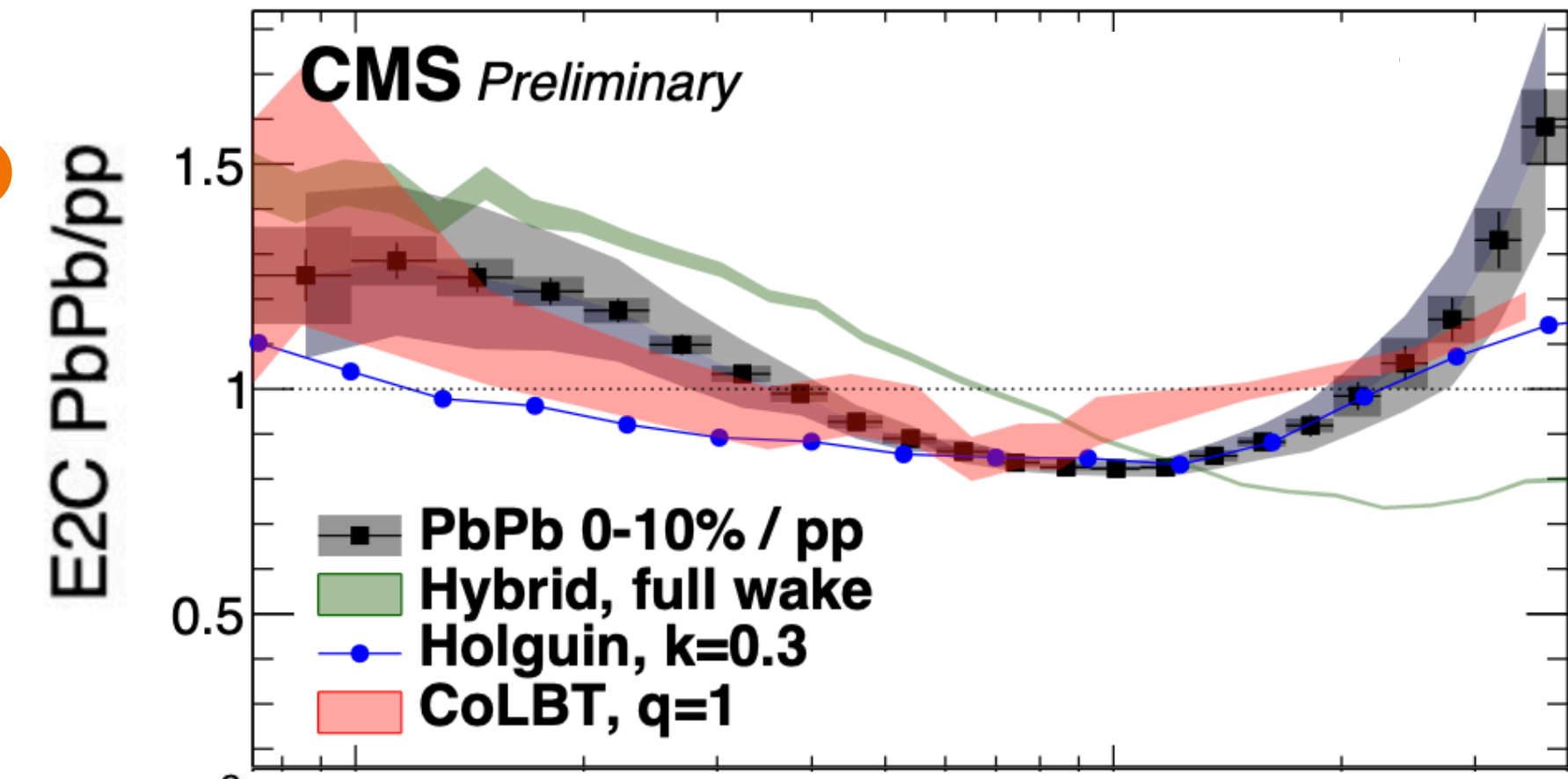


HIGHER-POINT CORRELATORS : COMPUTATIONALLY EXPENSIVE

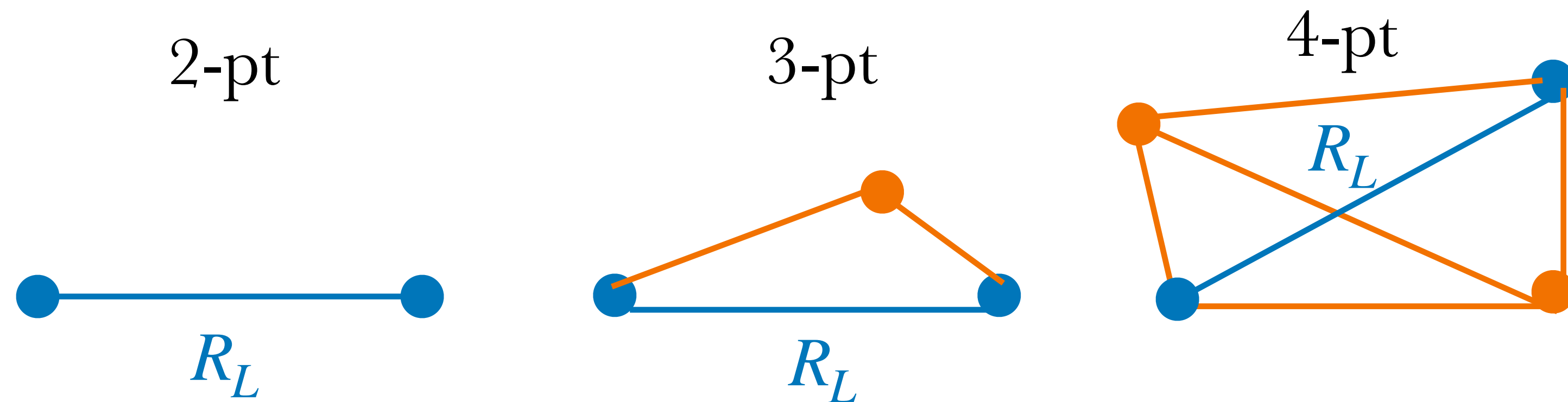


takes $\mathcal{O}(M^N)$ computational time.

medium modifications

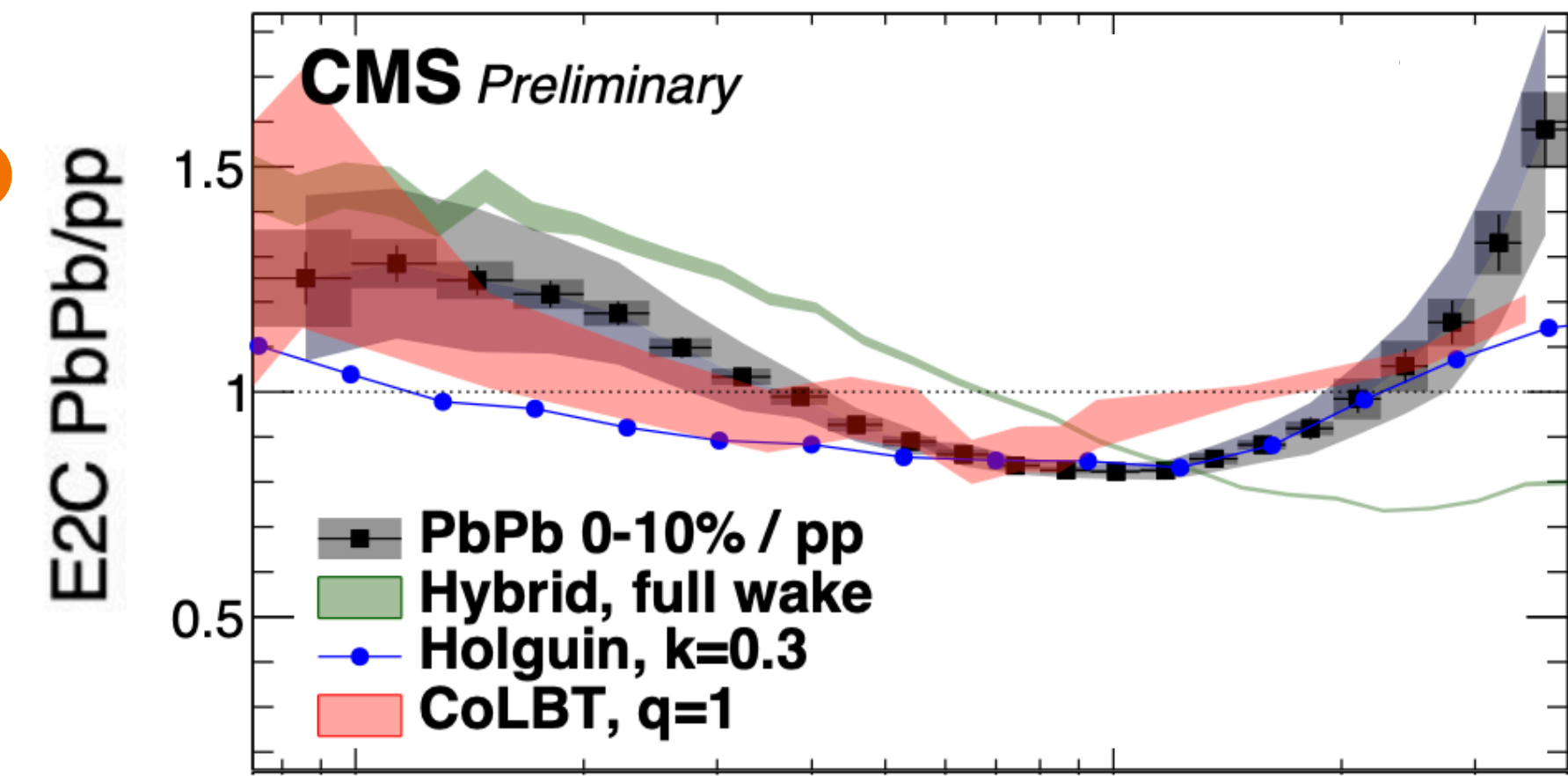


HIGHER-POINT CORRELATORS : COMPUTATIONALLY EXPENSIVE



takes $\mathcal{O}(M^N)$ computational time.

medium modifications



FastEEC 0.1

This code implements the fast evaluation method for N-point energy correlators, by reclustering with C/A or kT jet algorithm and using a dynamical

FastEEC 0.3 Latest

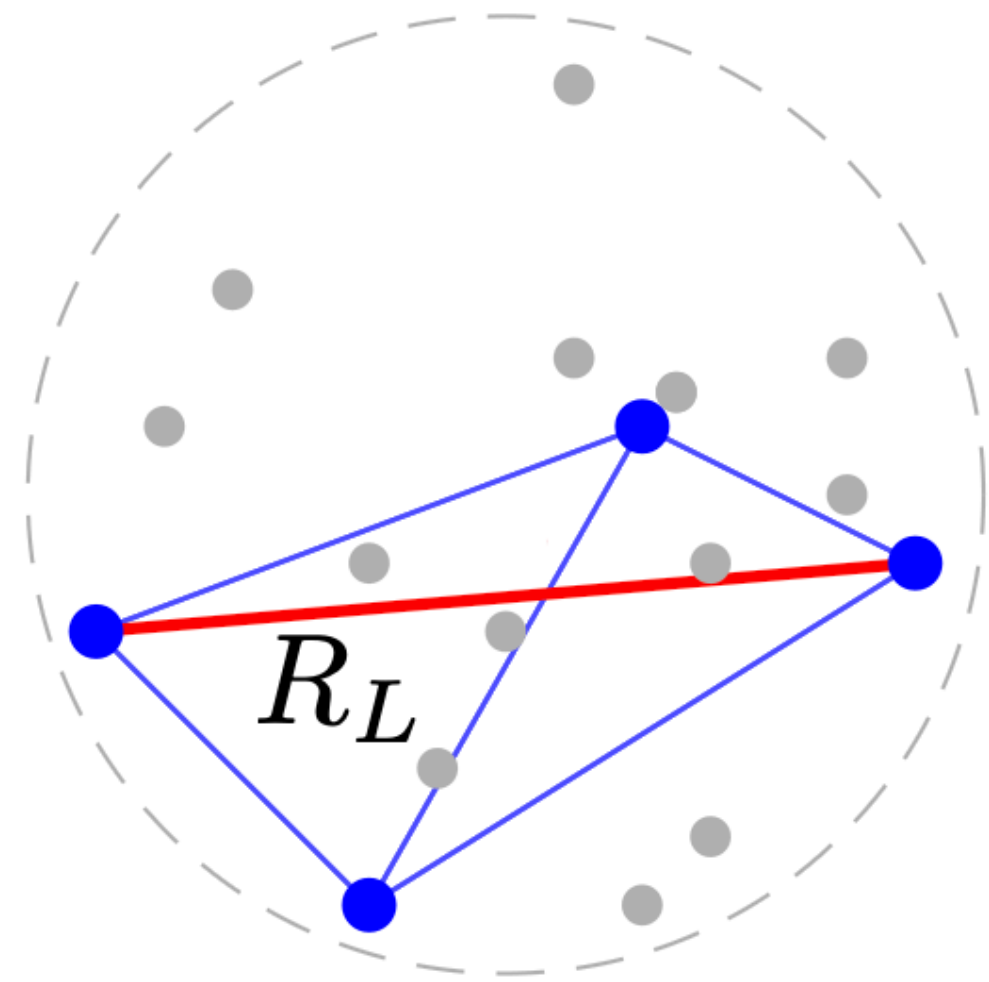
Provides a new implementation of N-point energy correlators that can be used for any (integer or non-integer) N values. The new algorithm relies on a new parametrization of N-point projected energy correlators recently proposed and achieves a computational scaling of $M^2 \log(M)$, without approximations.

FastEEC-0.2

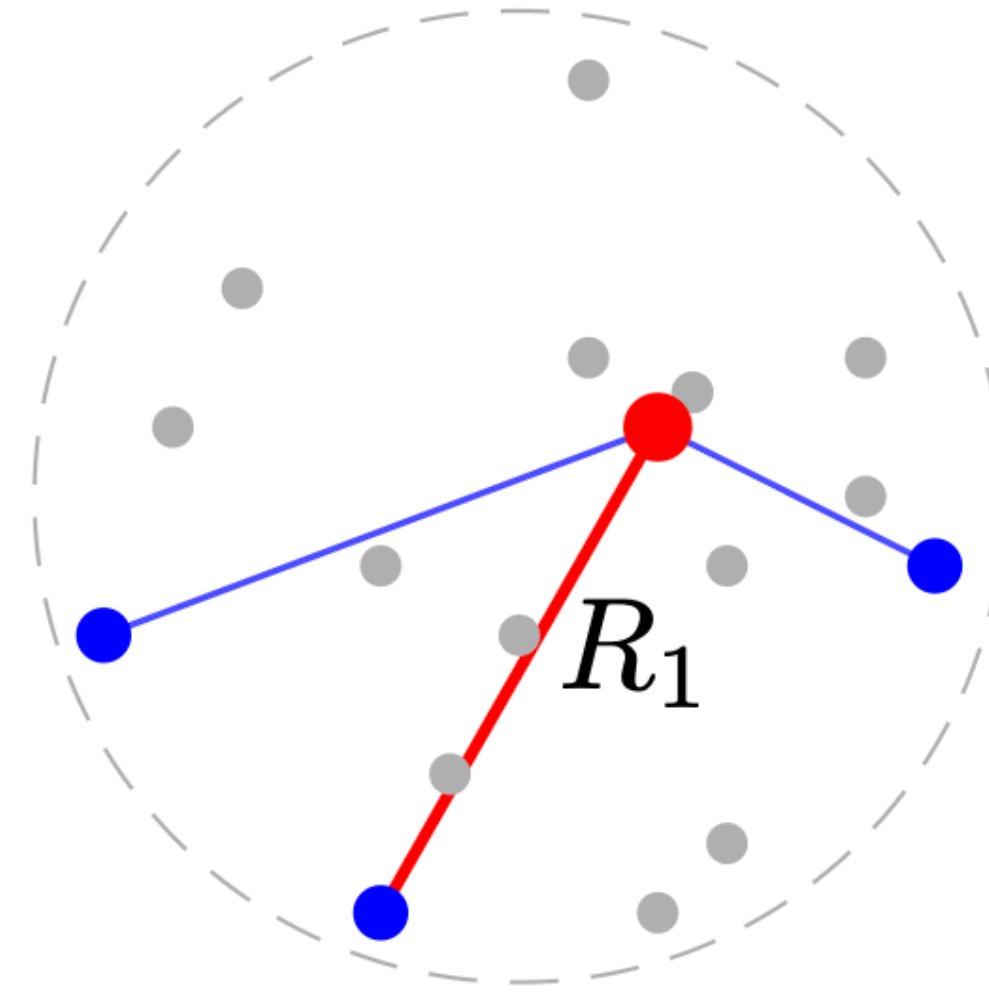
Extends the implementation of the

I will focus on this !

FAST COMPUTATION



traditional



new

$\mathcal{O}(M^2 \log M)$ computational time for any N !

New definition, same physics !



Samuel Alipour-fard

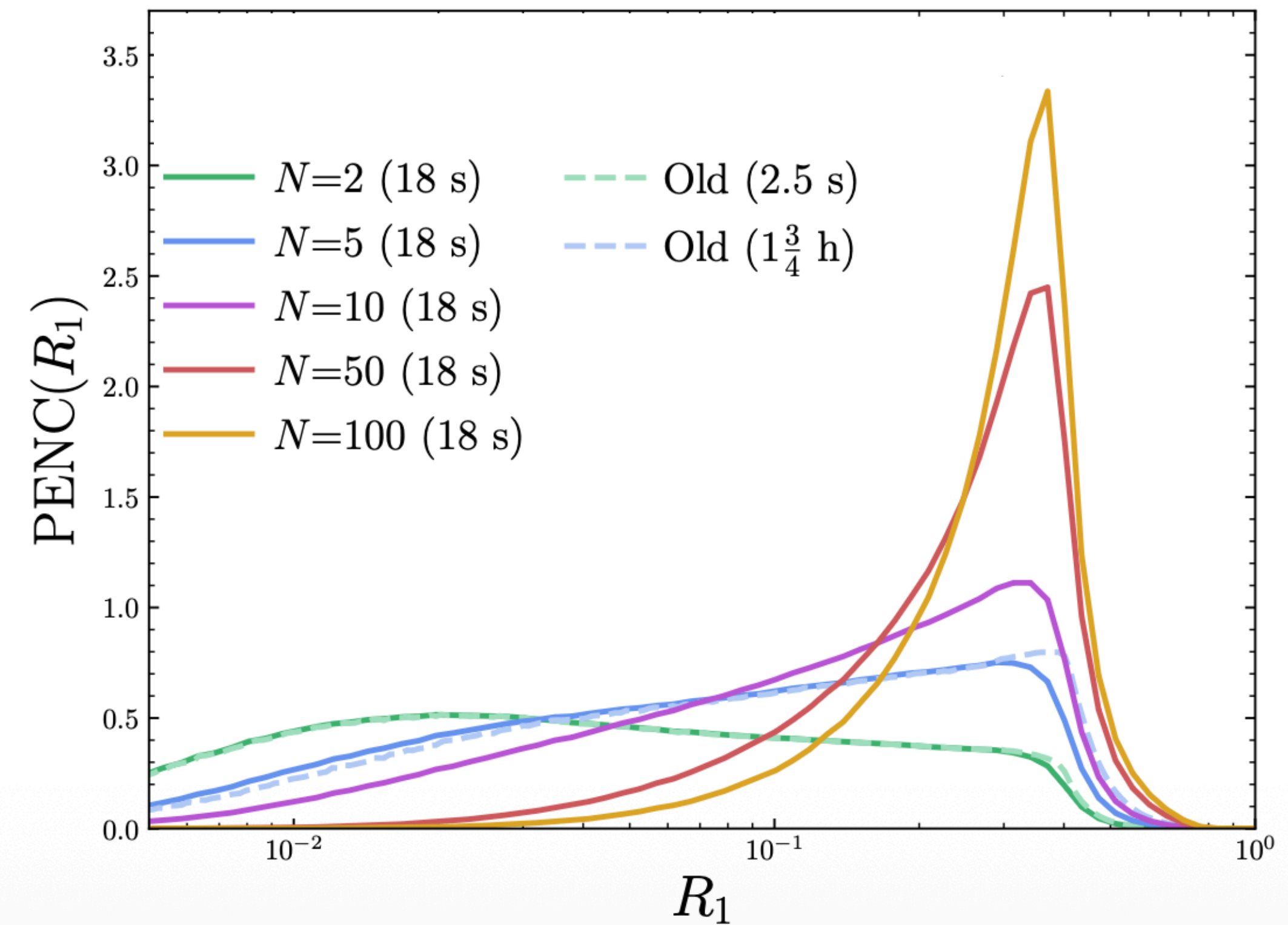


Jesse Thaler

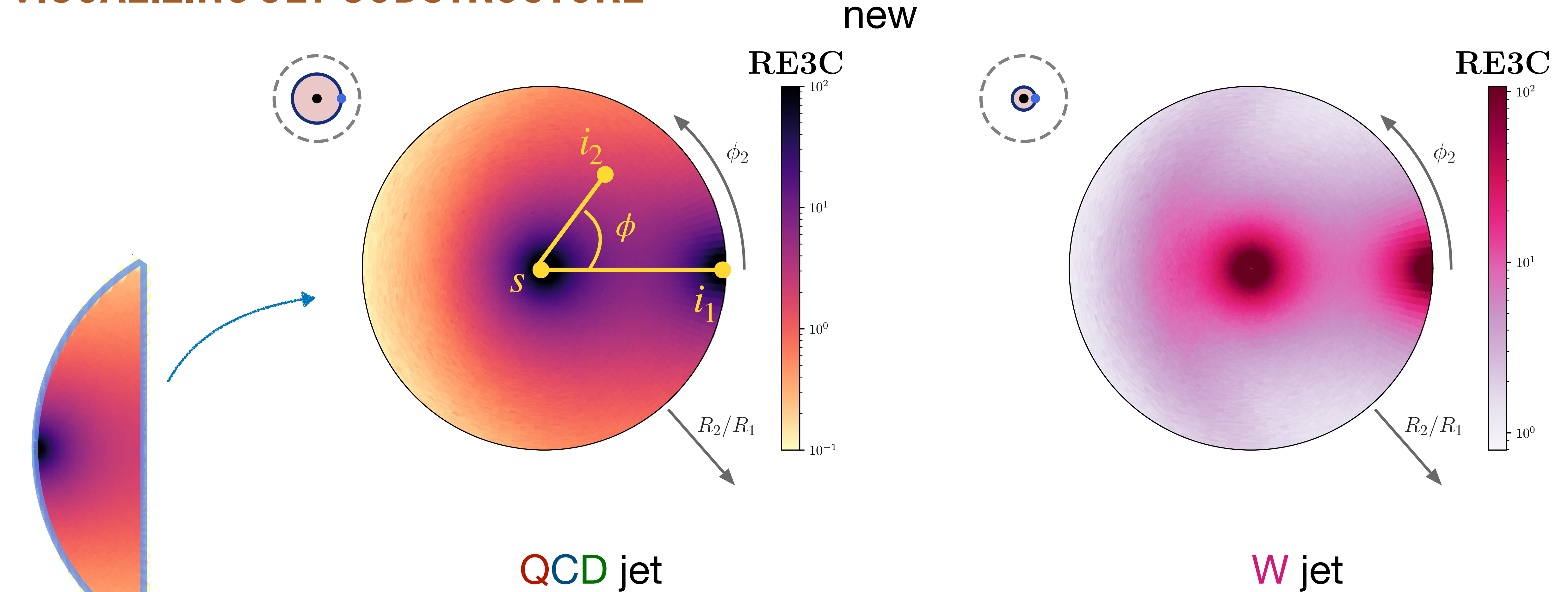


Wouter Waalewijn

measure distances relative to a special particle s



VISUALIZING JET SUBSTRUCTURE

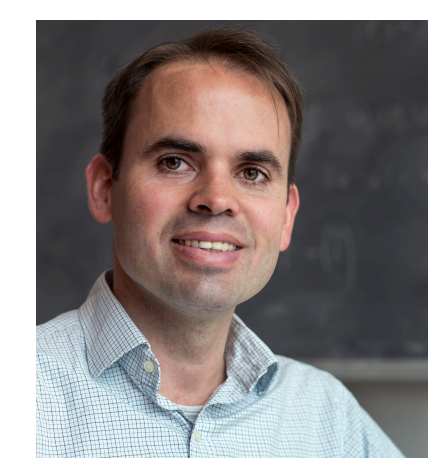


- Qualitative differences between QCD jets and W boson jets.

GAINS : UNDERSTANDING THE NON-PERTURBATIVE EFFECTS



Isabelle Pels



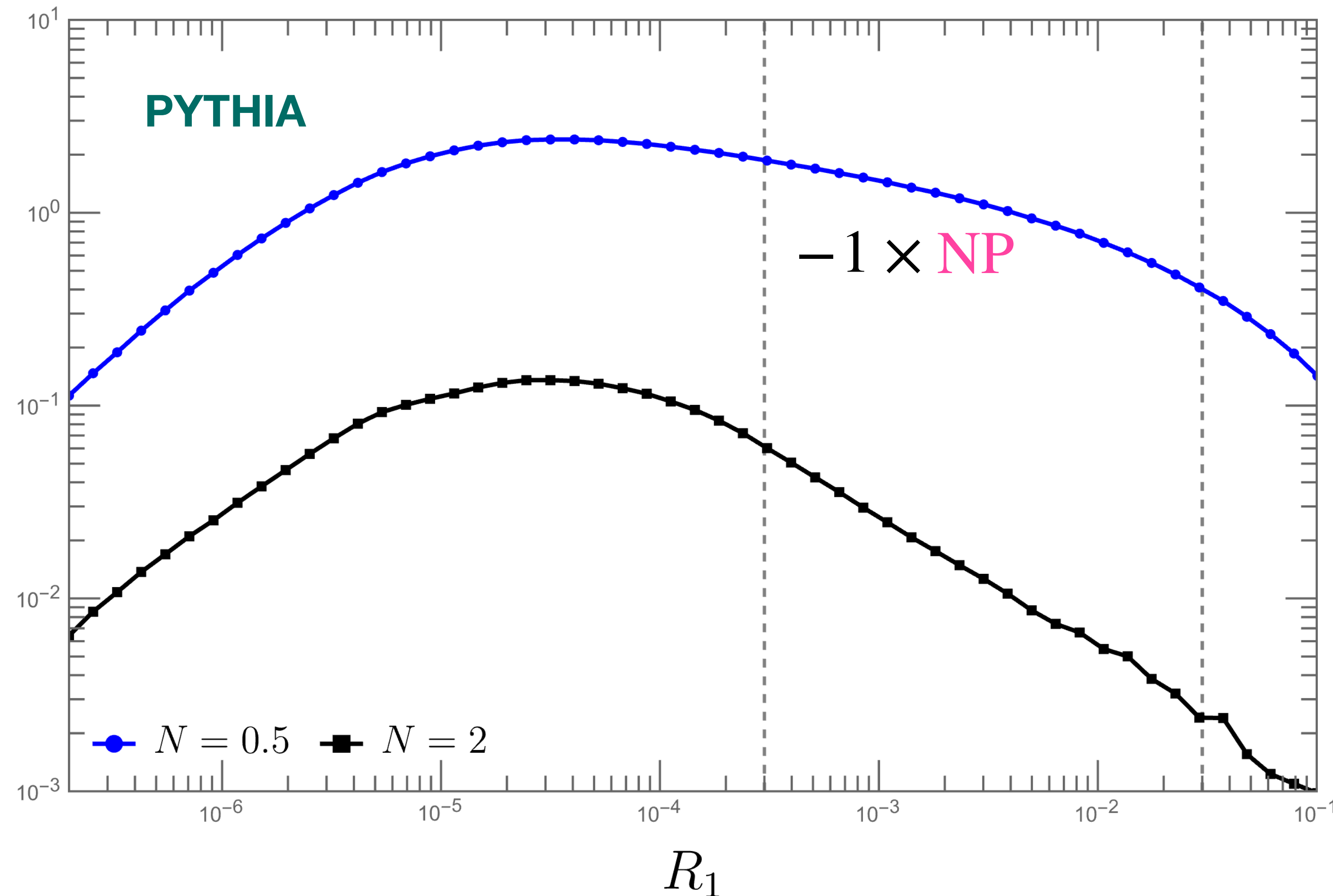
Wouter Waalewijn

$$\text{NP} = \frac{N \Lambda_{\text{QCD}}}{Q R_1^{3/2}} - \left(\frac{\Lambda_{\text{QCD}}}{Q} \right)^N \frac{1}{R_1^{1+N/2}}$$

our prediction !

- For $N < 1$, nonperturbative large and negative.

nonperturbative



GAINS : NEW OBSERVABLES TO PROBE MEDIUM EFFECTS



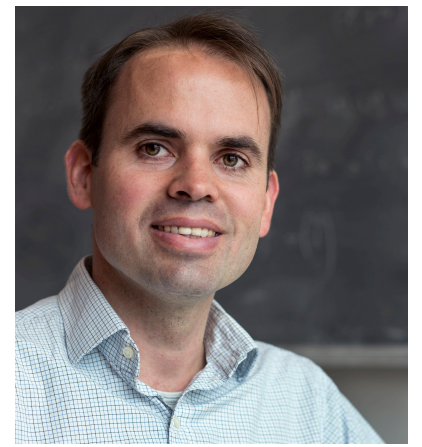
Samuel Alipour-fard



Arjun Kudinoor



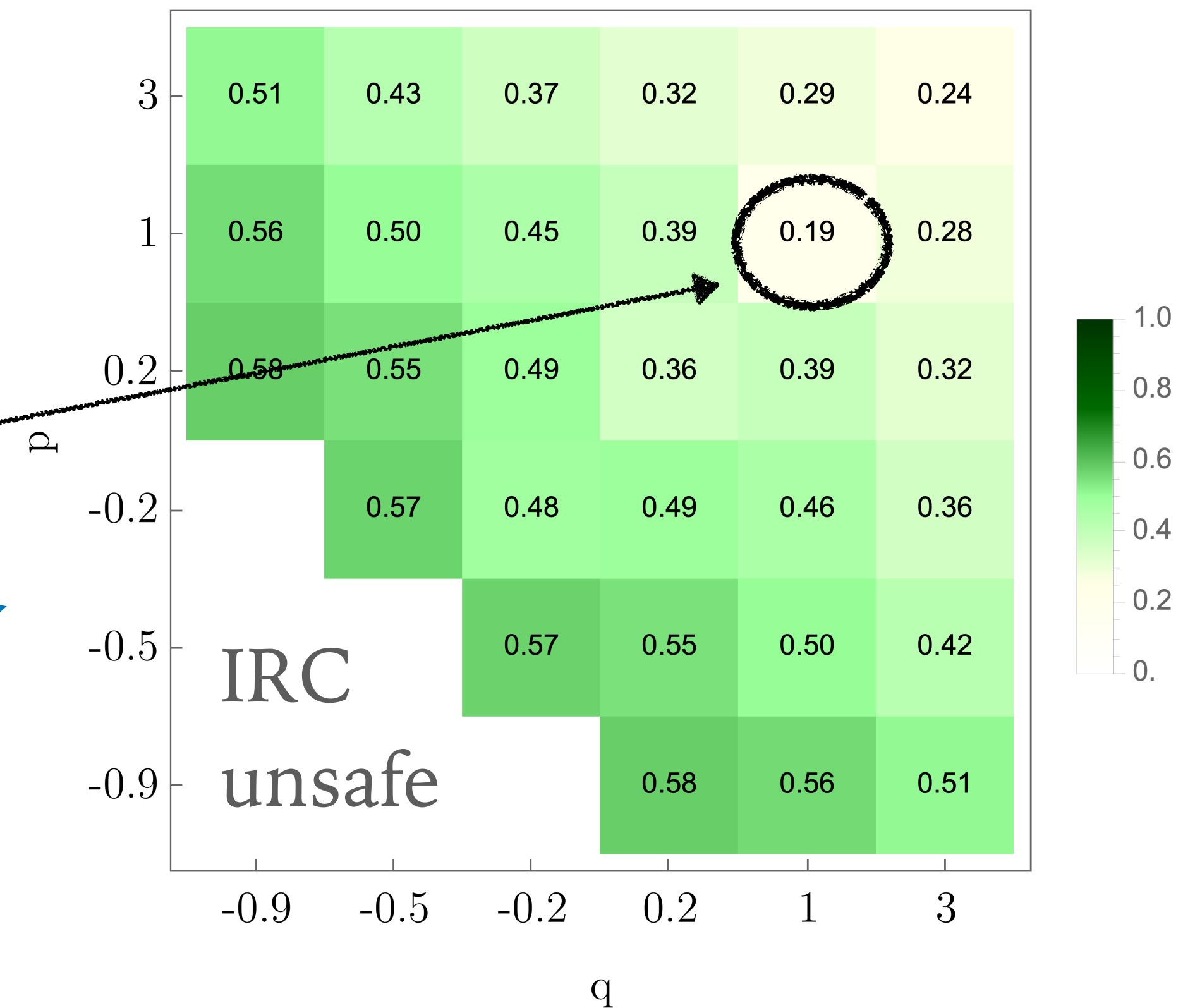
Jesse Thaler



Wouter Waalewijn

- A new generalization of 3-point correlator
- Stats is hard for energy correlators.
- We define a new discriminant D .
 $D = 0$ no discrimination $D = 1$ perfect discrimination
- Standard choice $p = q = 1$ is the least discriminating

Scanning observables to discriminate pp and PbPb jets





Physicists

Ads/CFT,
Lattice, Models
Holography,
Hydro

QGP



QGP

Physicists

Energy
Correlators

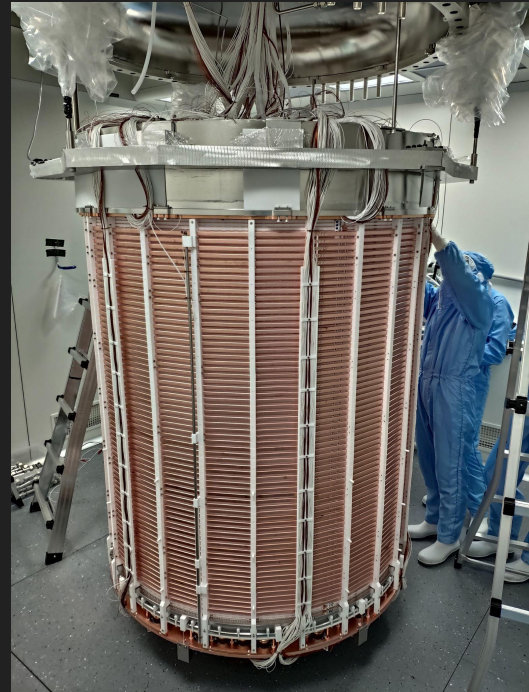
Ads/CFT,
Lattice, Models
Holography,
Hydro

Old Problems, New Solutions

Saad el Morabit: Dark Matter and Theory Group

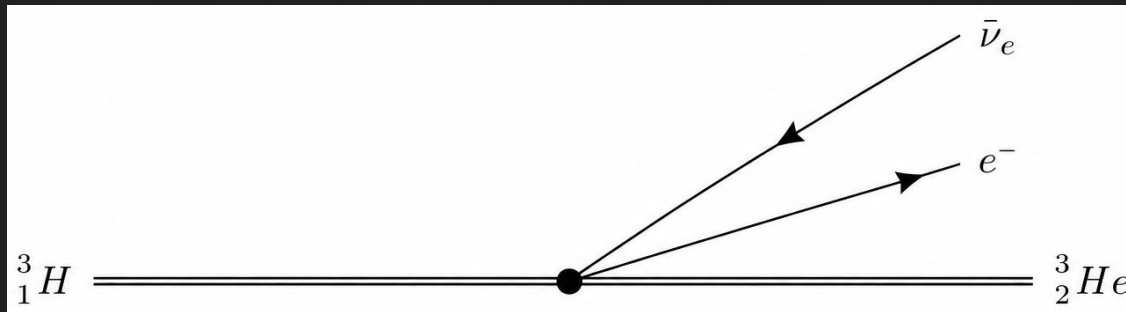
- What is beta-decay?
- What is *double* beta-decay?
- My theory and experimental work.

<https://xenonexperiment.org/photos>

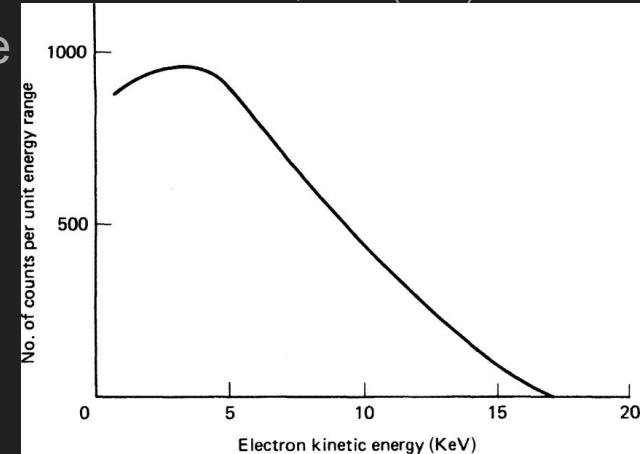


The ABC of Radioactivity, over a 100 years of decay

- Fact of life: Things Fall Apart. Some large particles decay into smaller ones
- Why? Daughter particle is more energetically favourable than mother
- Many ways to do this, important one is beta decay: $n \rightarrow p + e^- + \bar{\nu}_e$
- Alternatively: positron emission and electron capture

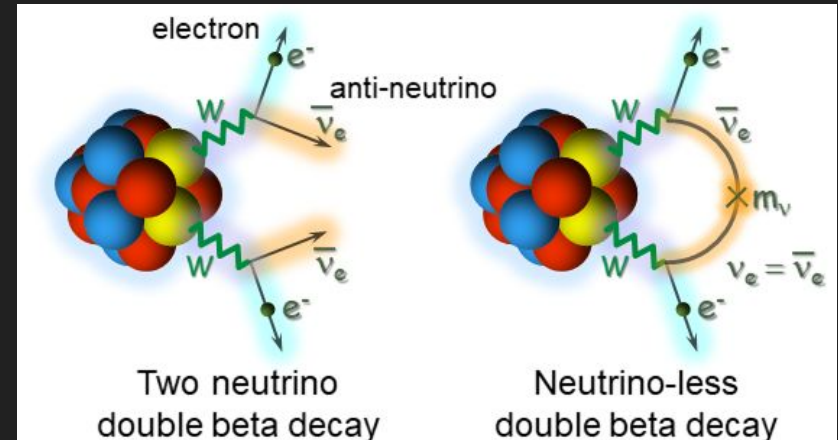


Lewis, G. M. (1970) Neutrinos



Double Beta Decay. What is it?

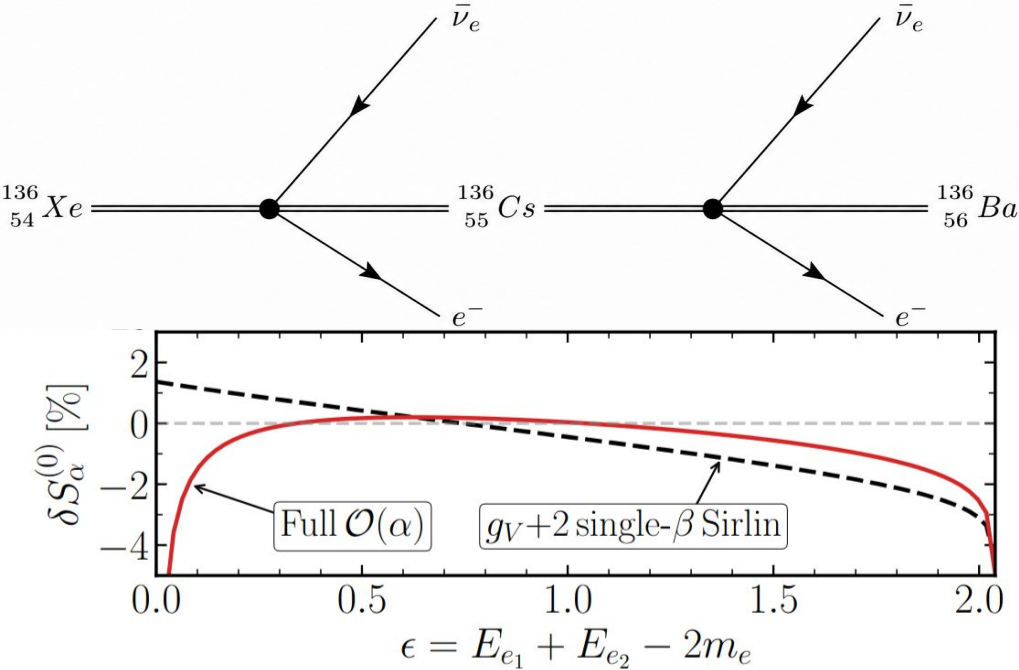
- Now two neutrons decay $2n \rightarrow 2p + 2e^- + 2\bar{\nu}_e$ (Xe136, maybe Xe134)
- Also has positron and electron capture cousin (Xe124, even rarer 10^{22} yr)
- Rarest events on the record: Xe136 $\sim 10^{21}$ yr. Universe's age $1 \cdot 10^{10}$ yr
- Neutrinoless variety, implies neutrino is its own antiparticle (nobel prize)
- Respected nuclear models disagree by whole integers (really hard physics)



New paper: “Radiative corrections to two-neutrino double-beta decay”

- Electric Field near nucleus is enormous ($\sim 10^{21}$ V/m), electron is scattering
- Only partially solved: Electron feels whole nucleus through Coulomb’s law
- What we did: allowed the electron to radiate photons
- Status quo: Just combined single beta decay corrections
- Result 1: status quo is far off because of electron-electron repulsion (% diff)
- Result 2: insensitive to nuclear details

Black: status quo and Red: what we did



This is for Ge76 but also applies to Xe136

Fraction of events generating a photon

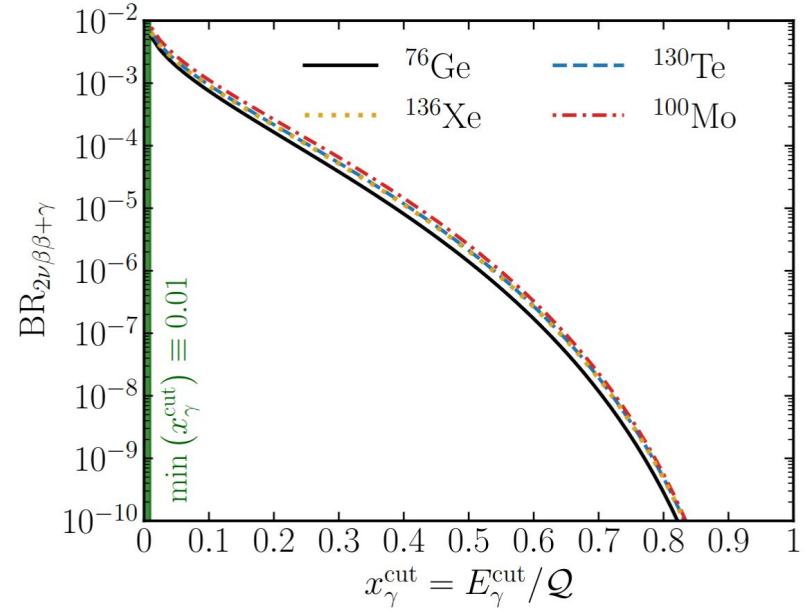


FIG. 5. Branching ratio of $2\nu\beta\beta + \gamma$ as a function of the photon energy cut $x_\gamma^{\text{cut}} = E_\gamma^{\text{cut}}/Q$.

Photons mess up event reconstruction

Current Experimental Work

Saad chiseling
off some ice



- Use own theory work in measurement of $\text{Xe}136$ in XENONnT
- Simulate various backgrounds ($\text{U}235$, $\text{K}40$, $\text{Cs}137$, $\text{Co}60$, solar neutrinos, ...)
- Match data-simulation matching, binned-inference, cut analysis, etc.
- BBKING: program to allow experimentalists to generate spectra themselves