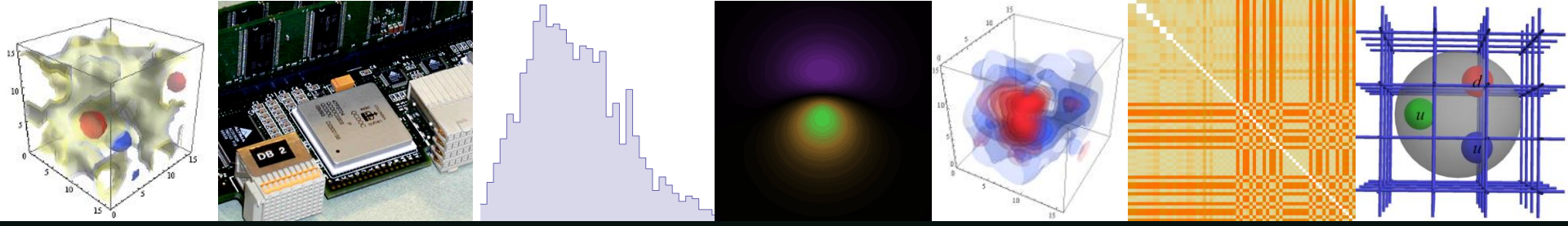
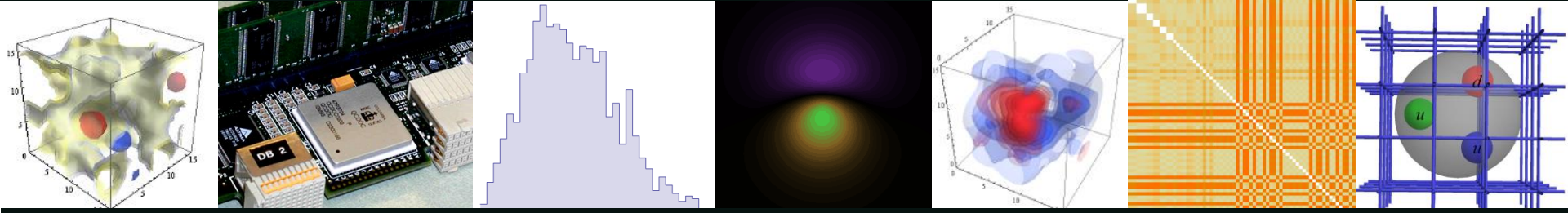


Hadron tomography at EIC and HEP

Huey-Wen Lin



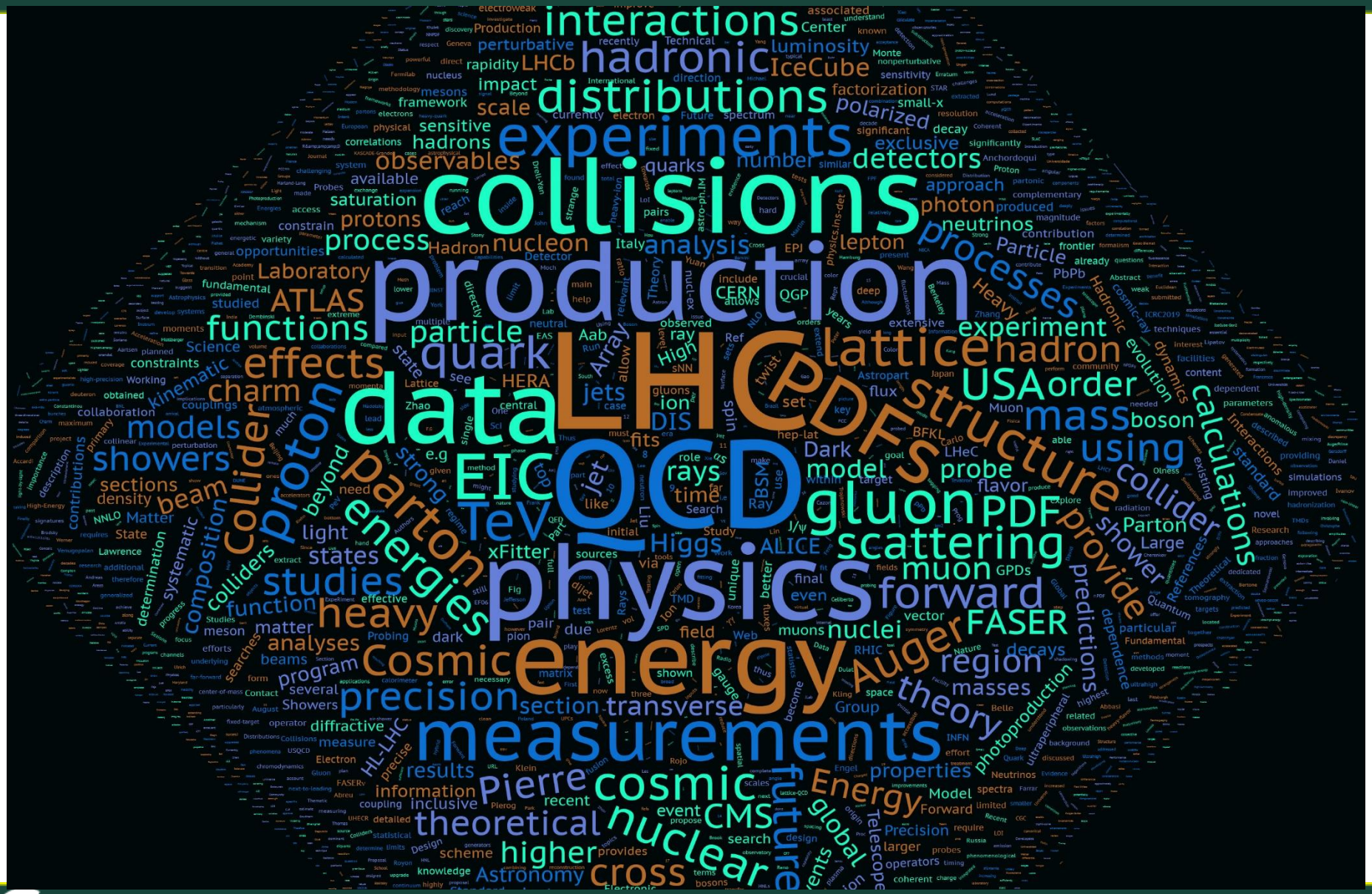
Snowmass EF06: Hadronic structure and forward QCD

Huey-Wen Lin (MSU)
Pavel Nadolsky (SMU)
Christophe Royon (Kansas)

QCD and Strong Interactions @Snowmass

EF05:Precision QCD	Michael Begel (BNL), Stefan Hoeche (FNAL), Michael Schmitt (Northwestern)
EF06: Hadronic structure and forward QCD	Huey-Wen Lin (MSU), Pavel Nadolsky (SMU), Christophe Royon (Kansas)
EF07: Heavy Ions	Yen-Jie Lee (MIT), Swagato Mukherjee (BNL)

LOIs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EF06 Focus Questions

1. What is the best approach to reduce systematic uncertainties in LHC measurements to achieve the accuracy of PDFs envisioned by electroweak precision studies at the high-luminosity LHC?
2. What is the feasible strategy for obtaining accurate PDFs for N3LO QCD computations? Which theoretical advances and computational tools will be necessary?
3. What is the potential of new deep inelastic scattering facilities (**EIC** and LHeC) for probing the hadronic and nuclear structure in the regions relevant for HEP experiments? How can the experience of the HEP community be transferred to enhance the potential of the **EIC** and LHeC studies?
4. How does the knowledge of hadron structure affect measurements of the QCD coupling constant in various processes?
5. When do power-suppressed contributions to the hadron structure become important in NXLO QCD calculations? What are the best approaches to predict or measure them?
6. What are the best observables to look for low-x resummation effects predicted by the Balitsky-Fadin-Kuraev-Lipatov resummations? Define less inclusive variables compared to pure Mueller-Naveletjets, and compute predictions on jet gap jet observables at NLO.
7. What are the prospects of running forward proton detectors at the LHC at high luminosity? What will be their sensitivity to anomalous couplings between photon, W, Z bosons, top quarks…
8. How to observe saturation effects or high-gluon density regimes at the LHC and the **EIC**?
9. Which diffractive measurements can be performed at the LHC and the **EIC** in order to understand better the structure of the Pomeron?
10. Which detectors (including acceptance/resolution) will be needed at the LHC and the **EIC** in order to perform the best possible measurements of energy, particle production in the very forward region?
11. How can the LHC, LHeC, and FCC improve our knowledge of the 3-dimensional structure of nucleons and nuclei?
12. How do excited hadronic states with two or more heavy quarks form and decay?
13. What are the BSM connections for hadron spectroscopy at future facilities?
14. How will artificial intelligence methods advance extraction of nonperturbative hadronic functions from experimental measurements?

Connection with EIC

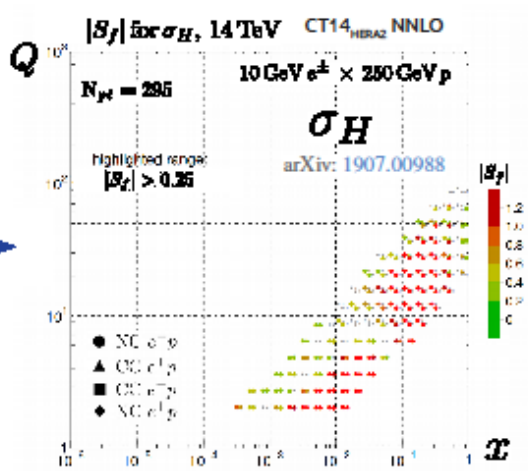
EIC@Snowmass21 LOI: Hadronic Tomography at the EIC and the Energy Frontier

October 2020 **Editors: Salvatore Fazio, Tim Hobbs, Alexei Prokudin, Alessandro Vicini** **160+ coauthors/signers**

- tomography encompasses a wide range of EIC ↔ HEP topics
- EIC determinations of partonic distributions (PDFs, TMDs, GPDs)

- high-energy QCD (DIS measurements; heavy quarks/masses, jets, α_s)
- gluonic structure/Higgs (gluon PDF/GPD; improvements to gg→ h production)
- QED effects (photon PDF; improved EW corrections)
- TMD measurements, precision EW physics (TMDs and M_W extractions)
- nuclear structure (nuclear PDFs; connections to heavy-ion UPCs)

select topics



EIC pseudodata sensitivity

- progress will depend on various methods
  - → phenomenological studies; global analyses
  - → continuum QCD approaches
  - → lattice QCD input
  - → AI/machine-learning and MCEGs

Slide by Tim Hobbs at Snowmass CMP #92

- completed LoI available here