Theory oriented program: motivations and goals

Cédric Mezrag

Irfu, CEA, Université Paris-Saclay

October 28st, 2024

On behalf of the organizing committee
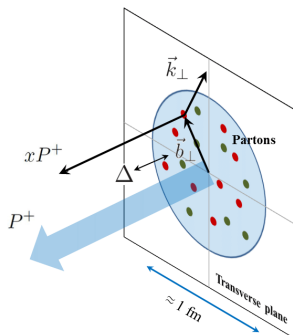
Welcome !

Hadron Physics 2030

Hadron Physics 2030 is the result of the merge of two projects:

- Multidimensional Hadron Structure (MDHS) whose goal was to kick start the reflexion about the theoretical and phenomenological tools we need to develop in order to exploit at full potentiality EIC data.

- JPhys++ whose goal was to refined the physics case for extending the current facility, toward both a positron beam and then an energy upgrade.

Hadron Physics 2030 is the result of the merge of two projects:

- Multidimensional Hadron Structure (MDHS) whose goal was to kick start the reflexion about the theoretical and phenomenological tools we need to develop in order to exploit at full potentiality EIC data.
- JPhys++ whose goal was to refined the physics case for extending the current facility, toward both a positron beam and then an energy upgrade.

As IPa is a multidisciplinary institute, the scientific council accepted to support our application, but requiring the two projects to be merged in a single one: Hadron Physics 2030

3D structure of the nucleon

- 3D picture in Coordinate space
  - Access to Generalized Parton Distributions (GPDs)
  - Average position of quarks and gluons
  - Connection with the energy momentum tensor
  - Exclusive processes
- 3D picture in Momentum space
  - Access to Transverse Momentum Dependent Distributions (TMDs)
  - Average momentum of quarks and gluons
  - Inclusive processes

3D structure of the nucleon
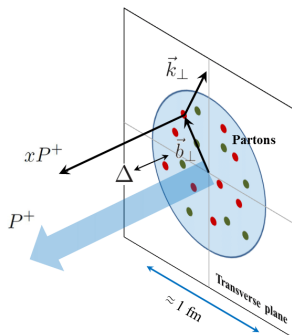
- 3D picture in Coordinate space
  - ▶ Access to Generalized Parton Distributions (GPDs)
  - ▶ Average position of quarks and gluons
  - ▶ Connection with the energy momentum tensor
  - ▶ Exclusive processes
- 3D picture in Momentum space
  - ▶ Access to Transverse Momentum Dependent Distributions (TMDs)
  - ▶ Average momentum of quarks and gluons
  - ▶ Inclusive processes

Connecting experimental data with hadron structures requires many theoretical and numerical developments (choice and description of observables, ill-posed inverse problems, statistical data analysis, etc)
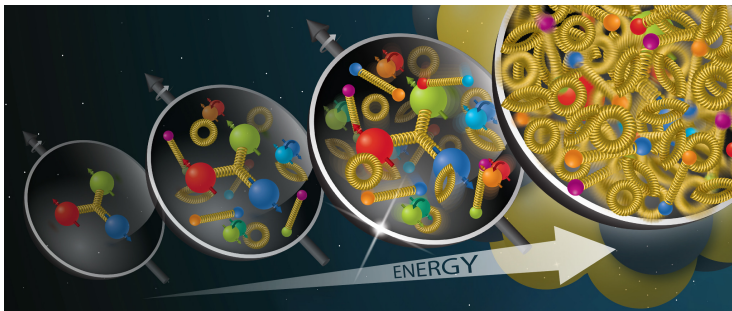
Current Fixed Target
Jefferson Laboratory

Future Electron-Ion collider
Brookhaven Laboratory
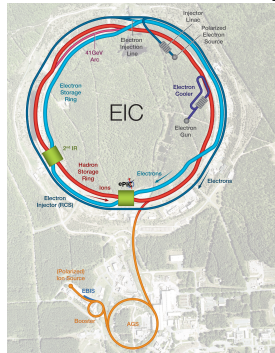
- 2020s : High precision/Low energy measurement at Jefferson Lab
- 2030s : High precision/ High energy measurement at EIC
- UPSaclay is deeply involved in both facilities

- When the energy of the probe grows, the sensitivity to quantum fluctuations with a large number of gluons strongly increases.
- At the EIC, we expect to reach a regime where the nucleon is saturated by gluons.
- This is a real challenge for building 3D maps.
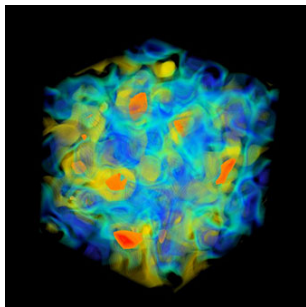
- Computer and algorithmic progress now allows realistic simulation of QCD
- Simulated data can be bound to hadron structure
- **Direct computation remains impossible today!**
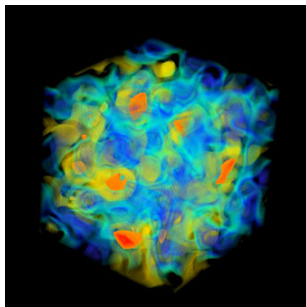
QCD simulations

- Computer and algorithmic progress now allows realistic simulation of QCD
- Simulated data can be bound to hadron structure
- **Direct computation remains impossible today!**

Connecting the simulation data to hadron structure requires the same effort as for experimental data (perturbative expansion, ill-posed inverse problem, etc).

Theoretical Challenges

Challenges

- What are the best strategies to extract GPDs and TMDs from experimental data with a good control on theoretical systematic uncertainties?
- How can large scale simulation improve our understanding of the multidimensional hadron structure?
- With the forthcoming high energy facilities, how to bridge the gap between two distinct regimes of the strong interaction?

Objectives

- Break the walls between the GPDs/TMDs/Lattice/High Energy communities
- Identify common needs between the four different communities
- Trigger the development of common tools and standards
- Define research priorities in view of the construction of the EIC

How does it work ?

This week schedule is much lighter than last one, allowing for more collaboration time. We will have a single session per day.

This week schedule is much lighter than last one, allowing for more collaboration time. We will have a single session per day.

- Monday : F. De Soto on QCD gauge sector on the lattice
- Tuesday : J.M. Morgado Chavez and A. Castro on Sullivan DVCS
- Wednesday : C. Mezrag on extraction of pressure forces from DVCS data
- Thursday : C. Flett on J/Psi photoproduction

Collaboration/ Working time

- Office space is available for everyone
- Meeting rooms with zoom connections can be booked for collaborative and remote works
- Amphitheater available if a large number of people wants to discuss (except Thursday)
- If you want a passcard opening doors, ask Vesna

Collaboration/ Working time

- Office space is available for everyone
- Meeting rooms with zoom connections can be booked for collaborative and remote works
- Amphitheater available if a large number of people wants to discuss (except Thursday)
- If you want a passcard opening doors, ask Vesna

Advice from IPa

Put trust in your participants.
Once you'll have chose them wisely, they'll know how to do good physics.

Collaboration/ Working time

- Office space is available for everyone
- Meeting rooms with zoom connections can be booked for collaborative and remote works
- Amphitheater available if a large number of people wants to discuss (except Thursday)
- If you want a passcard opening doors, ask Vesna

Advice from IPa

Put trust in your participants.
Once you'll have chose them wisely, they'll know how to do good physics.

My advice

Take this opportunity to start discussing with people you usually don't (especially if you're a student/postdoc).

Social events

IPa has organised for us some social events:

- Monday: buffet at lunch
- Tuesday: Happy hours (cocktail) in the cathedral
- Wednesday: Workshop diner at restaurant le Gramophone (Orsay)
  - You need to register, a registration list will be available in the cathedral
  - If you need to go back to Paris, be careful of RER schedule (works)

If you have any questions regarding the events, please ask Vesna !

Two main actions need to be performed:

1. Participants have to answer a survey (hopefully not too difficult)
2. Organisers have to write two reports

Follow up

Two main actions need to be performed:

1. Participants have to answer a survey (hopefully not too difficult)
2. Organisers have to write two reports
   - A "organisational report" (hopefully easy)
   - A scientific and impact report, within a year after the end of the workshop

Two main actions need to be performed:

1. Participants have to answer a survey (hopefully not too difficult)
2. Organisers have to write two reports
   - A "organisational report" (hopefully easy)
   - A scientific and impact report, within a year after the end of the workshop

This second report has of course some consequences:

- We will probably contact you again before summer 2025 to ask you what will have been the scientific impact for you
- We *may* ask *some of* you to write a few pages document
- The final report will be published in "Les cahiers de l'Institut Pascal".

Impact of IPa

We hope that this workshop will trigger new ideas, or allow you to improve existing ones. If it ends up in a publication, please mention IPa through in the acknowledgement:

This allows IPa to justify its scientific impact through the programs it supports, and will allow us to organise other meeting in the future.

Impact of IPa

We hope that this workshop will trigger new ideas, or allow you to improve existing ones. If it ends up in a publication, please mention IPa through in the acknowledgement:

This work was made possible by Institut Pascal at Université Paris-Saclay with the support of the program "Investissements d'avenir" ANR-11-IDEX-0003-01

This allows IPa to justify its scientific impact through the programs it supports, and will allow us to organise other meeting in the future.

Bottom line
If you want a sequel, make sure to mention IPa !

Acknowledgements

I would like to stress that I/we are thanksfull to

- My co-organisers who helped me to build this project

Acknowledgements

I would like to stress that I/we are thanksfull to

- My co-organisers who helped me to build this project
- The scientific committee of IPa for supporting our workshop

Acknowledgements

I would like to stress that I/we are thanksfull to

- My co-organisers who helped me to build this project
- The scientific committee of IPa for supporting our workshop
- Yves Balkanski for his support and advice while we try to merge our two projects

I would like to stress that I/we are thanksfull to

- My co-organisers who helped me to build this project
- The scientific committee of IPa for supporting our workshop
- Yves Balkanski for his support and advice while we try to merge our two projects
- Vesna Cupic, our workshop manager, for her tremendous work, allowing this three weeks workshop to take place

Acknowledgements

I would like to stress that I/we are thanksfull to

- My co-organisers who helped me to build this project
- The scientific committee of IPa for supporting our workshop
- Yves Balkanski for his support and advice while we try to merge our two projects
- Vesna Cupic, our workshop manager, for her tremendous work, allowing this three weeks workshop to take place

Thank you very much !

Thank you
and enjoy our workshop

Back up slides