Strong Interactions

Jorgen D’Hondt and Krzysztof Redlich
Version 12th of April 2019
Zoom into the Strong Interaction session
(email list for convenors, speakers, scientific secretaries: PPG2020-QCD@cern.ch)
Copied from the input submission page:

- perturbative and non-perturbative QCD
- DIS
- Heavy Ions

Link to the input files: [https://indico.cern.ch/event/765096/contributions/](https://indico.cern.ch/event/765096/contributions/)

By using the “export to PDF” option on this website you can obtain an overview of the submitted input ordered by ID-number (i.e. relevant for the next page).
Input to be considered

Category: Facilities and experiments with strong interactions as key topic
(Id13) NA61++ (SPS)
(Id42) PBC@CERN, COMPASS++, MUSE@PSI, MUonE, DIRAC++, NA61++
(Id46) Heavy flavour in HI
(Id47 and Id67 and Id110) LHC-FT: ALICE and LHCb (LHCSpin)
(Id90) NA60+ (SPS)
(Id110) ALICE upgrade for HL-LHC
(Id135) QCD/HI at FCC-hh and FCC-eh
(Id143) COMPASS++/AMBER (SPS)
(Id152) QCD/HI at HL-LHC
(Id159) LHeC/PERLE
(Id160) QCD/HI at HE-LHC

Category: Synergies on a global scale
(Id76) J-PARC
(Id93) NICA
(Id99) US-based EIC

Category: Facilities & experiments with strong interactions as a topic
(Id13 and Id50) AWAKE
(Id49) Super Charm-Tau Factory

Category: QCD results in support for other programs
(Id117) Auger experiment
(Id131) LBNF/DUNE
(Id151) New physics with HI collisions

Category: QCD theory in support
(Id100 and Id101) Precise calculations @ colliders
(Id114) MC generators
(Id163) QCD theory

Category: QCD and nuclear physics
(Id39) ISOLDE/EPIC

Category: National roadmaps
(Id21) INFN Hadron
(Id37) Germany ALICE
(Id56) INFN HI
(Id115) Germany Hadron

Category: Individual and community thoughts
(Id48) Town meeting on Heavy Ions
(Id103) DIS
(Id140) personal input
(Id148) NuPECC

Theme: Strong Interactions
Charge of each presentation in the Strong Interaction session
(as communicated to speakers)

Taking into account the input to the process and discussions within the PPG
Aspirations

Scientific aspirations of the community in strong interactions, i.e. what do we want to know about the strong interaction and what are the challenges ahead? This will be the first presentation to kick-off the QCD sessions, followed with presentations on how to address these challenges on the experimental (ep/ee/pp collisions) and on the theoretical side. There will be a separate session on Heavy Ion physics, hence this would not be a focus for your talk.
“Facility oriented”

QCD@HL-LHC
How to address the current and future challenges in experimental QCD physics in high-energy beams with a focus on LHC/HL-LHC and future pp/ee colliders (ep collision physics would have a separate talk, and Heavy Ion physics would have a separate session); as well the need of research in QCD physics to support other research areas of particle physics. The session would start with a presentation on the scientific aspirations of the community in strong interactions, and in the same session your talk would be complemented with a similar presentation from the theory side.

HI theory
Theoretical concepts and challenges for Future Heavy Ion Physics in high-energy beams at the LHC and perspectives at HL-LHC and beyond

Heavy Ion physics in high-energy beams (AA and pA)
Prospects and Challenges for Future Experiments in Heavy Ion Collisions in high-energy beams at the LHC and perspectives at HL-LHC and beyond
“Facility oriented”

Fix Target experiments @HL-LHC
   Fix target experiments in high-energy beams (ALICE and LHCb)

eA collisions
   Prospects and Challenges for Electron-Ion Collider, also from the perspectives of the US-EIC, to trigger our understanding of the rich variety of structures at the subatomic scale.

ep collisions at high energies
   Opportunities and challenges for QCD physics in high-energy ep collisions at future facilities (including as well PERLE).

Pre-Acc@HL-LHC
   Opportunities (and challenges) for strong interaction physics with the current CERN pre-accelerator complex in the era of LHC/HL-LHC (incl COMPASS++, MUonE, DIRAC++, ISOLDE, ...). In the same session there will be a presentation as well related to these opportunities with the potential future CERN pre-accelerator complex, i.e. beyond LHC/HL-LHC.

Pre-Acc@Future
   Opportunities (and challenges) for strong interaction physics with the (potential) future CERN pre-accelerator complex in the era of HE-LHC, FCC, LHeC, CLIC, AWAKE, etc. In the same session there will be a presentation as well related to these opportunities with the current CERN pre-accelerator complex.
“Synergy oriented”

Synergies with physics in astroparticle, nuclear and neutrino

*What needs to be known from the strong interactions in order to make progress in other areas of astroparticle, neutrino and nuclear physics?*

Theory challenges

*How to address the current and future challenges in theoretical QCD physics research, especially that revolving around $ep/ee/pp$ collisions (Heavy Ion physics would have a separate session). The session would start with a presentation on the scientific aspirations of the community in strong interactions, and in the same session your talk would be complemented with a similar presentation from the experimental side.*

Precision physics at low energies

*Opportunities and challenges for precision QCD physics at low energies (e.g. CERN, PSI, J-PARC, ...).*

Overview around the world

*Experimental Prospects and strategic Challenges for Heavy Ion Experiments that include: HADES, FAIR, NICA, NA60++, NA61++*)
Lattice QCD

Recent results and challenges of lattice QCD relevant for particle and nuclear physics, that include e.g. determination of the fundamental parameters of QCD and the equation of state, quantitative understanding of hadronic properties and QCD corrections to precision tests of the Standard Model.
• Each speaker will be asked to end the presentation with a comprehensive summary of 1-2 slides, including open questions, challenges, opportunities and objectives. This will facilitate the discussion with the audience.

• Speakers should mention as well relevant EU programs on the topic(s), and the evolution thereof.

• Scientific secretaries: Anton Andronic (Munster, ALICE; QCD/nucl Think Tank) and Ferenc Sikler (Wigner, CMS; QCD/part Think Tank). Their role would be to take notes of the discussions during the sessions such this can be incorporated in the Physics Briefing Book.
To prepare the Open Symposium we are working with two groups of speakers ("Think Tanks") to enhance the coherence of the sessions and to produce a summary report of the session (TTs = QCD/part and QCD/nucl)

1. 1\textsuperscript{st} meeting (March 29): kick-off the discussion on the agenda and process
2. 2\textsuperscript{nd} meeting (April 15): exchange first thoughts among speakers about the content of the presentations, avoid overlap, and seek coverage
3. 3\textsuperscript{rd} meeting (TBD): on the basis of draft presentations the Think Tanks will serve well as a reflection group towards finalizing the presentations

All speakers and Scientific Secretaries are invited for dinner during the Open Symposium to discuss the outcome of the meeting, and get first impressions towards the Physics Briefing Book (dinner time Wednesday)

Meetings with the Think Tanks will be planned as well beyond the Open Symposium towards a concrete summary in the Physics Briefing Book, together with the Scientific Secretaries
### Schedule

**Tuesday morning**

**Session 1** (1.5 hours) – QCD oriented
- Talk 1: Aspirations
  - T. Gehrmann (Zurich)
- Talk 2: QCD@HL-LHC
  - D. d’Enterria (CERN)
- Talk 3: Theory challenges
  - G. Salam (Oxford)
- Reserve 15 min

**Session 2** (2 hours) – Target oriented
- Talk 4: Pre-Acc@HL-LHC
  - G. Schnell (Bilbao)
- Talk 5: Pre-Acc@Future
  - D. Boer (Groningen)
- Talk 6: Lattice QCD
  - TBC
- Talk 7: FT@HL-LHC
  - J-P. Lansberg (IPN-Orsay)

**Session 3** (1.5 hours) – HI oriented
- Talk 8: HI Theory
  - U. Wiedemann (CERN)
- Talk 9: HI@(HL-)LHC
  - J. Stachel (Heidelberg)
- Talk 10: eA
  - N. Armesto (Santiago de Compostella)
- Reserve 15 min

**Session 4** (2 hours) – Topical
- Talk 11: Around the world
  - T. Galatyuk (Darmstadt)
- Talk 12: ep
  - U. Klein (Liverpool)
- Talk 13: Synergies ApPEC/NuPECC/Neutrino
  - T. Pierog (KIT)
- Talk 14: Precision at low energies
  - K. Kirch (PSI)
- Reserve 15 min

**Wednesday morning**

- "Think Tank QCD/part"
- "Think Tank QCD/nucl"

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Theme: Strong Interactions
Agenda

*(will appear now any moment on the Open Symposiums website)*
<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Time</th>
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<tbody>
<tr>
<td>Scientific aspirations of the community in strong interactions</td>
<td>Thomas Gehrmann</td>
<td>09:00 - 09:20</td>
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<td>Granada Conference Center</td>
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<td>Discussion</td>
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<td>09:20 - 09:30</td>
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<td>Granada Conference Center</td>
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<td>Experimental path for QCD physics in high-energy beams</td>
<td>David d’Enterria</td>
<td>09:30 - 09:50</td>
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<td>Theoretical path for QCD physics</td>
<td>Gavin Salam</td>
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<tr>
<td>11:15 - 11:45</td>
<td>Strong Interaction physics with the (HL-)LHC pre-accelerator complex</td>
<td>Gunar Schnell</td>
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<td>11:45 - 12:00</td>
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<td>12:00 - 12:20</td>
<td>Strong Interaction physics with a future CERN pre-accelerator complex</td>
<td>Daniel Boer</td>
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<td>12:30 - 12:50</td>
<td>Lattice QCD: challenges and opportunities</td>
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<td>Fixed Target opportunities at the (HL-)LHC</td>
<td>Jean-Philippe Lansberg</td>
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<td>Theory challenges for Heavy Ion physics</td>
<td>Urs Wiedemann</td>
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<td>Heavy Ion collisions at (HL-)LHC</td>
<td>Johanna Stachels</td>
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<td>Strong interaction physics at future eA colliders</td>
<td>Nestor Arrieto Perez</td>
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<td><strong>Precision QCD physics at low energies</strong></td>
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Big Questions – now on Granada website

• What are the experimental and theoretical pre-requisites to reach an adequate precision of perturbative and non-perturbative QCD predictions at the highest energies?
• What can be learned from beams-on-target experiments at current and potential future (pre-)accelerators to test strong interactions?
• How to probe the QGP equation of state and to establish whether there is a 1st order phase transition at high baryon density?
• What is known about the make-up of the proton (mass, radius, spin, etc.) and how to extract it?
• What is the role of strong interactions at very low and very high (up to astrophysical) energies?