“QCD at FAIR” Workshop 2024

Frank Nerling
HFHF, GU Frankfurt & GSI Darmstadt
&
Johan Messchendorp
FFN, GSI Darmstadt

“QCD at FAIR” Workshop 2024

Opening & introduction

Frank Nerling
HFHF, GU Frankfurt & GSI Darmstadt

QCD at FAIR

On behalf of the LOC: Johan Messchendorp, FN, Anja Meergans and Belma Hadzimehmedovic

HFHF
Helmholtz Forschungsakademie Hessen für FAIR

Facilitiy for Antiproton and Ion Research –

„The Universe in the Laboratory“

GSI
JOHANN WOLFGANG GOETHE
UNIVERSITÄT
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Hadron Physics Facilities at FAIR

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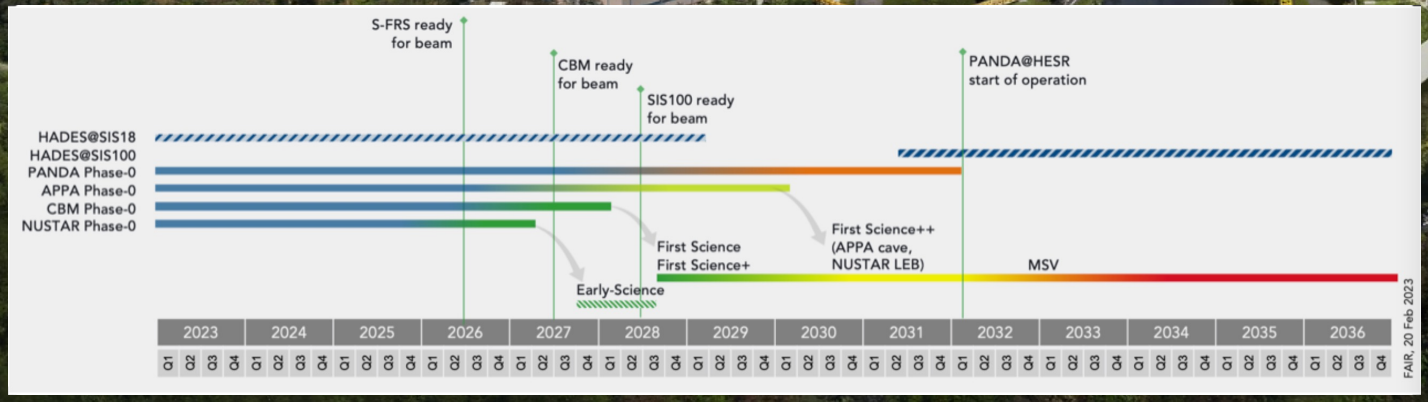

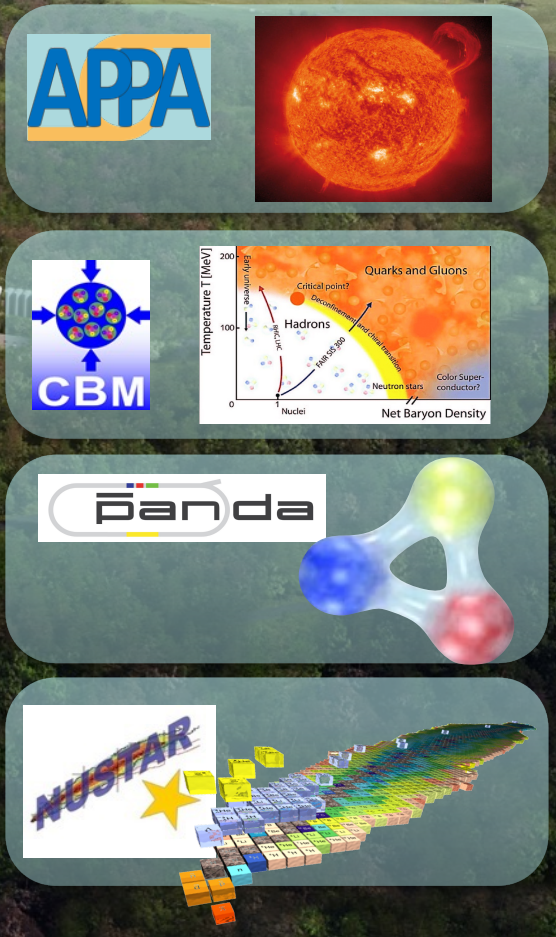

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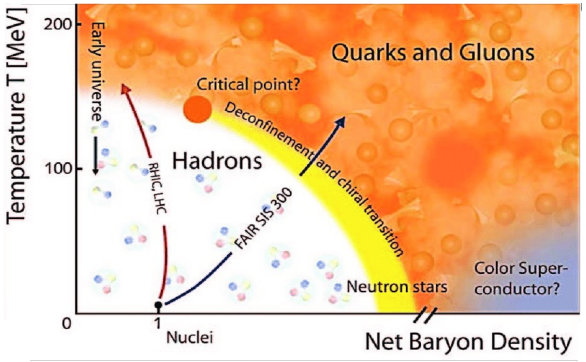
Hadron Physics Facilities at FAIR

Methodologies at FAIR – QCD matter at extremes

Heavy-ion physics:

- Exploring dense QCD matter
- Probe strongly-interacting many-body systems
- Hadrons as probes of the medium
- Properties of hadrons in a dense environment



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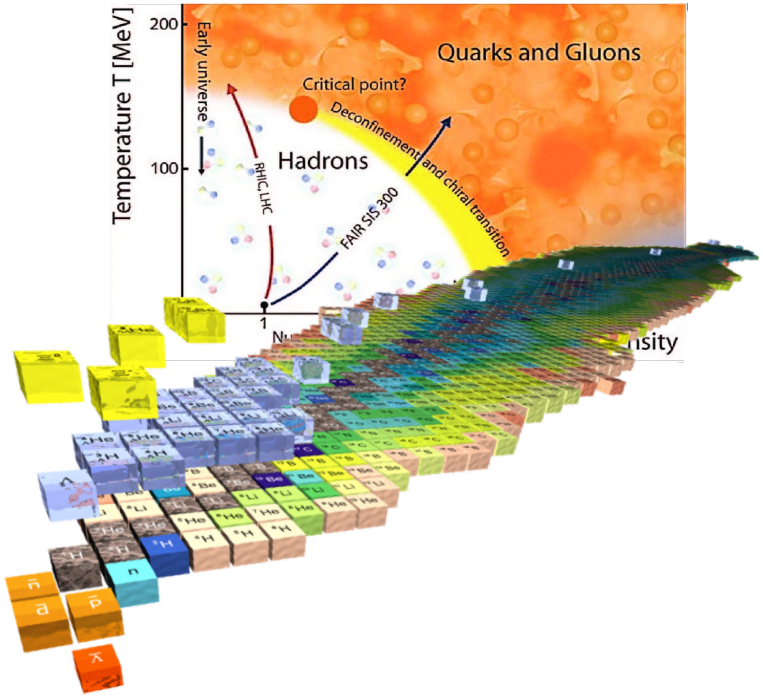
Nuclear physics:

- Map out the nuclear spectrum in isospin and strangeness
- Properties of nuclei at the edge of stability, *e.g. neutron-rich*
- Probe baryon/meson degrees-of-freedom in many-body systems



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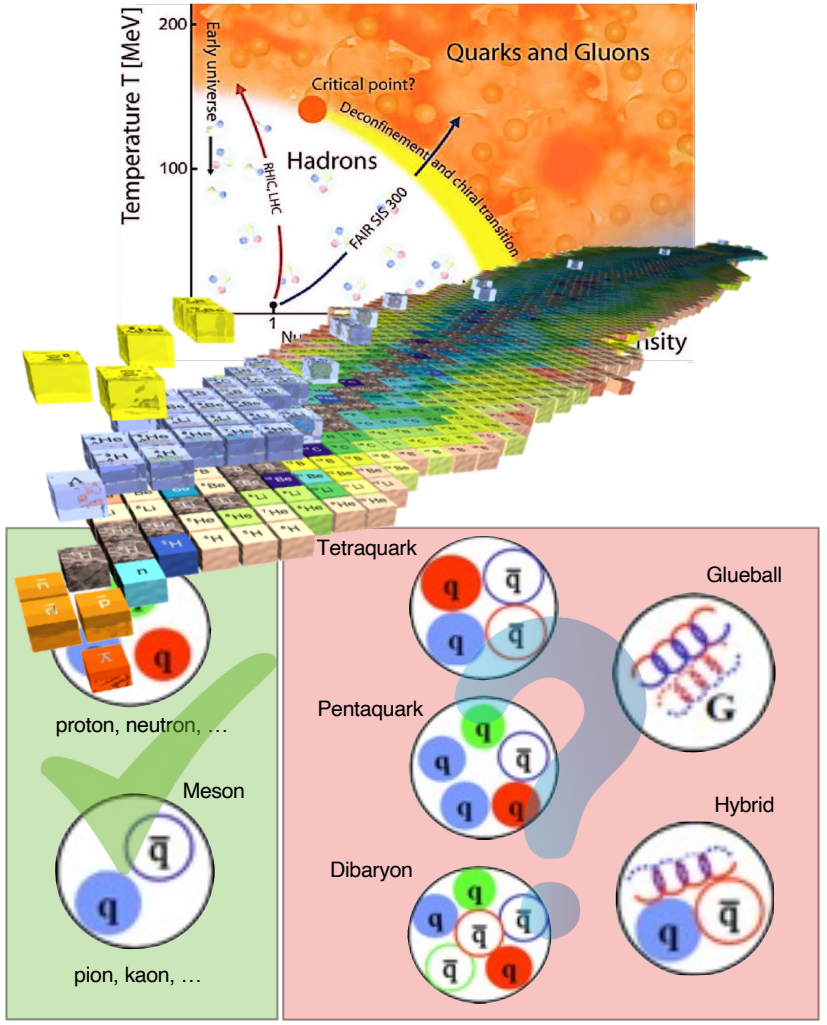
Hadron physics:
- Map out the hadron spectrum
- Search for "exotic" forms of hadrons
- "Microscopic" study of hadron-hadron interactions



Methodologies at FAIR – QCD matter at extremes

Heavy-ion physics:
- Exploring dense QCD matter
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- Properties of hadrons in a dense envi

Hadron interactions:
Reference for understanding medium effects

Nuclear physics:
- Map out the nuclear spectrum in isospin and strangeness
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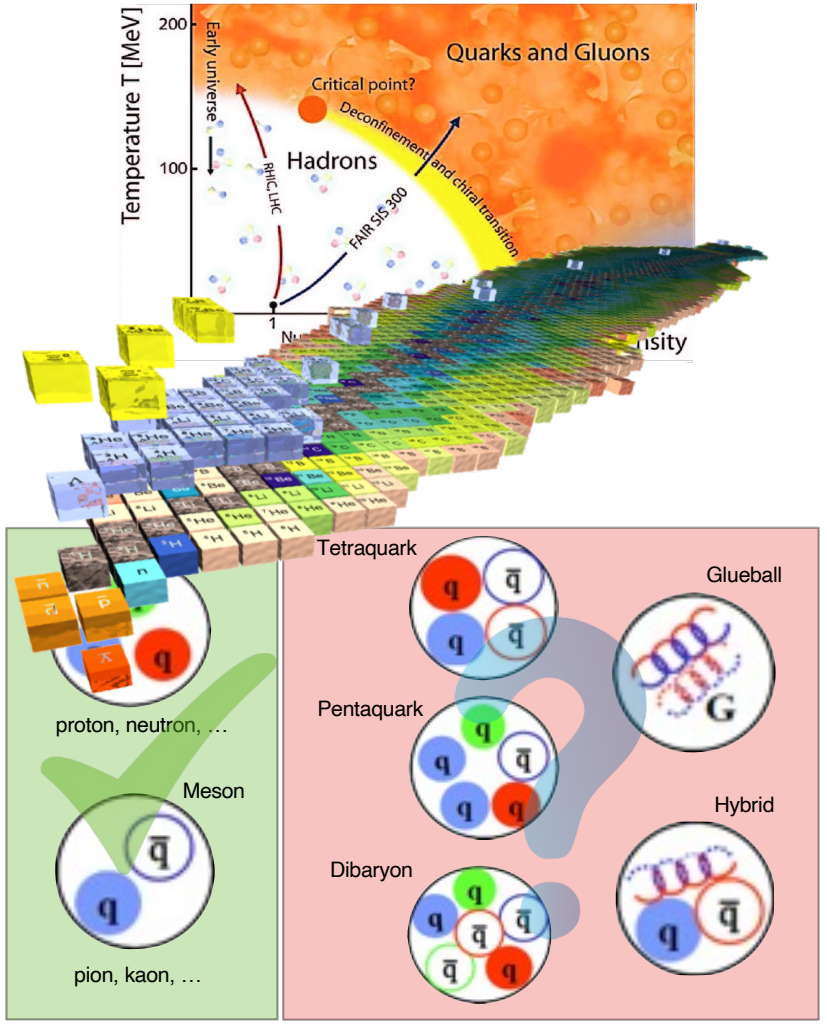
- Probe baryon/meson degrees-of-freed

Hadron interactions:
Provide baryon-baryon data in flavour SU(3)

Hadron physics:
- Map out the hadron spectrum
- Search for "exotic" forms of hadrons
- "Microscopic" study of hadron-hadron

Hadron interactions:
Enable spectroscopy of (new) hadronic matter



Purpose of our white paper – how it all started

What can be achieved for hadron physics with proton and pion beams?

- Initiative from FAIR-motivated group from within various collaborations, such as CBM, HADES, PANDA
- Promote the realisation of First Science+ (FS+) at FAIR
- Identify a QCD-inspired physics program with proton beams

From SIS18 to SIS100 – Context

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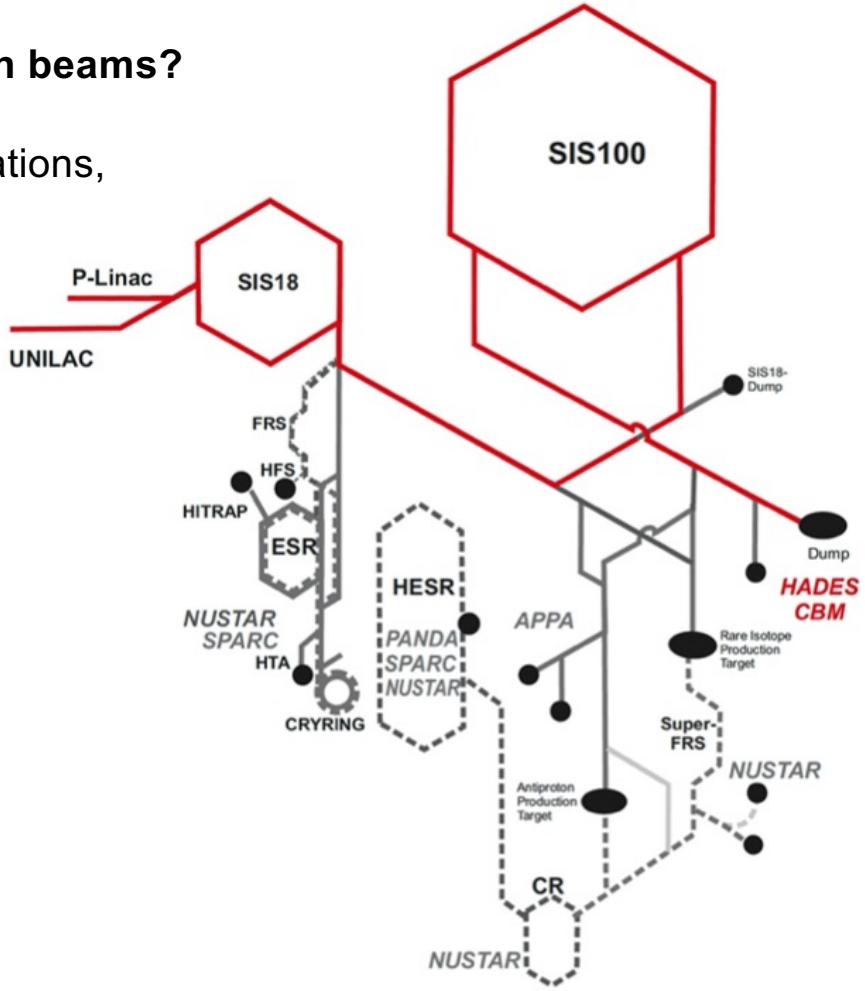
  - Heavy-ion physics communities: Enrich program with “elementary” component, strengthen political impact at FAIR
  - Nuclear physics communities: Large overlap in physics topics: nuclear astrophyiscs, hypernuclei, EoS, ...
  - Hadron physics communities: Probe terra incognita regime, keep “flame” alive at FAIR



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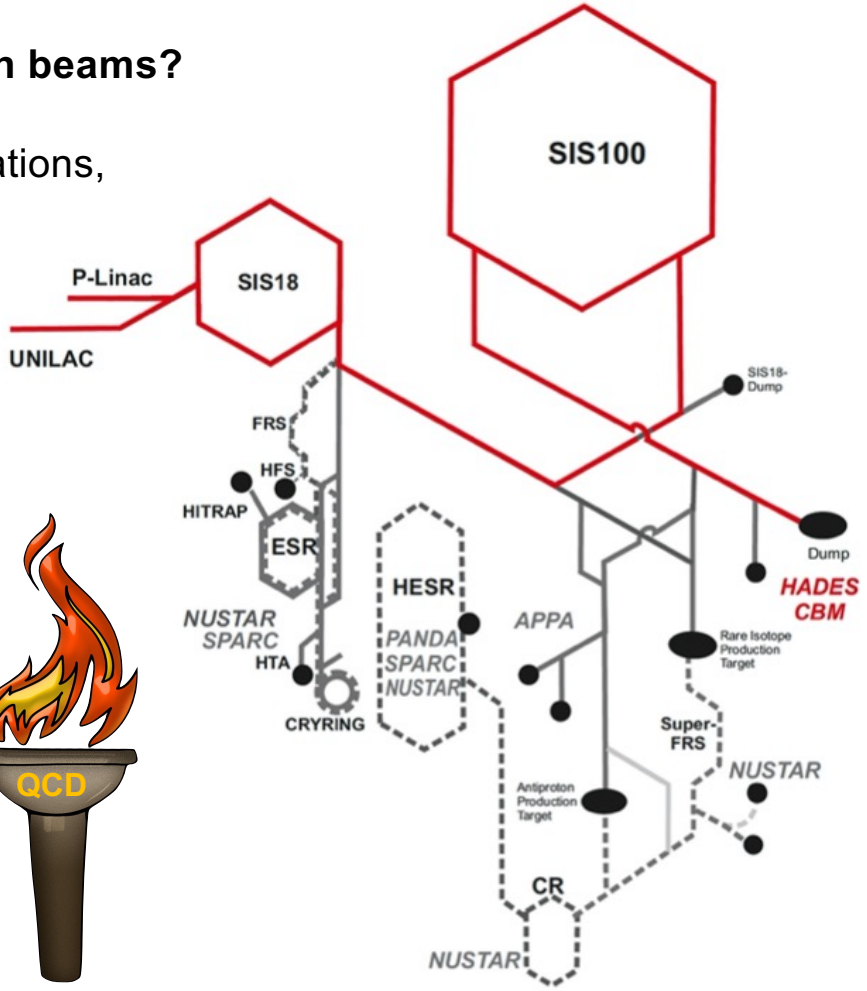

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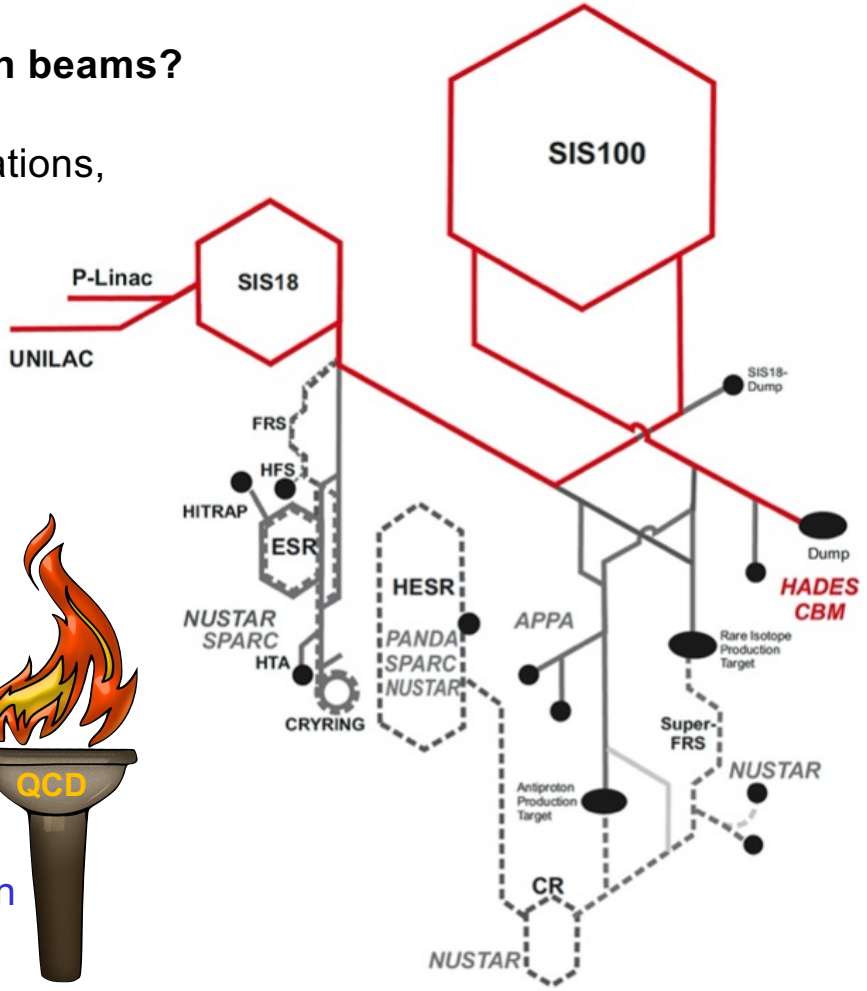
- Strengthen collaborations among hadron-, nuclear- and heavy-ion communities from both, experiment and theory!



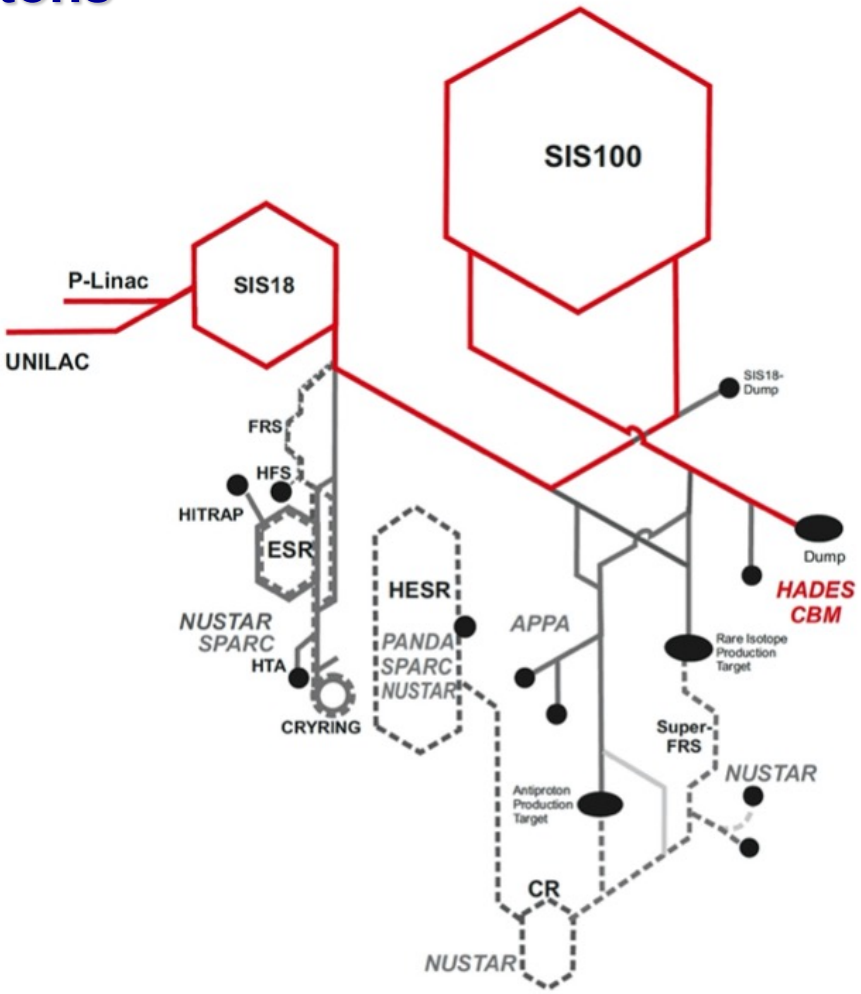
From SIS18 to SIS100 – Hadron physics
with pions and protons

Energy upgrade:

- From max 4.7 GeV (SIS18) to 29 GeV (SIS100) proton energy: $\sqrt{(s_{NN})} \approx 3.5$ GeV → 7.6 GeV
- Opening new realm: double & triple strangeness and even charm baryons and mesons!
- Significant increase in production yield of hyperons

Intensity upgrade:

- From max protons/cycle of 10^{12} (SIS18) to 2×10^{13} (SIS100)
- Even during "commissioning" (10^{10} protons/cycle) and 5 cm LH2 target: ~10 pb^{-1} day^{-1}



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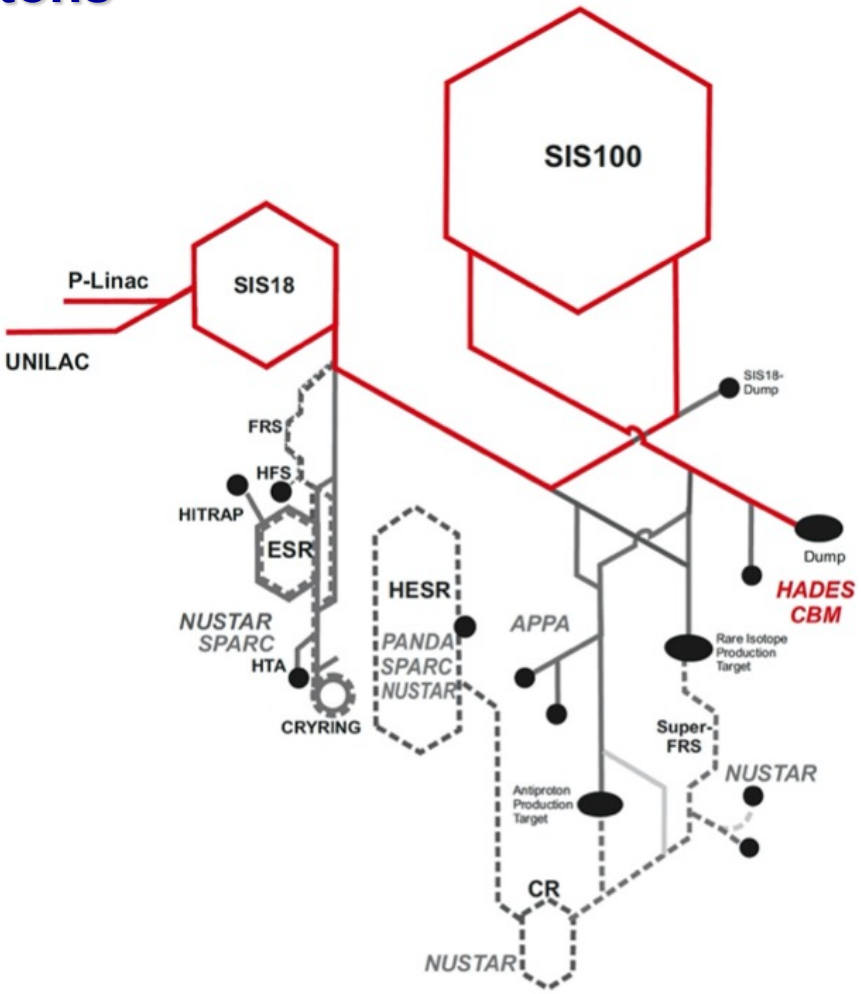
Detector enrichment:

- Towards high-rate capabilities and free-streaming DAQ's etc.

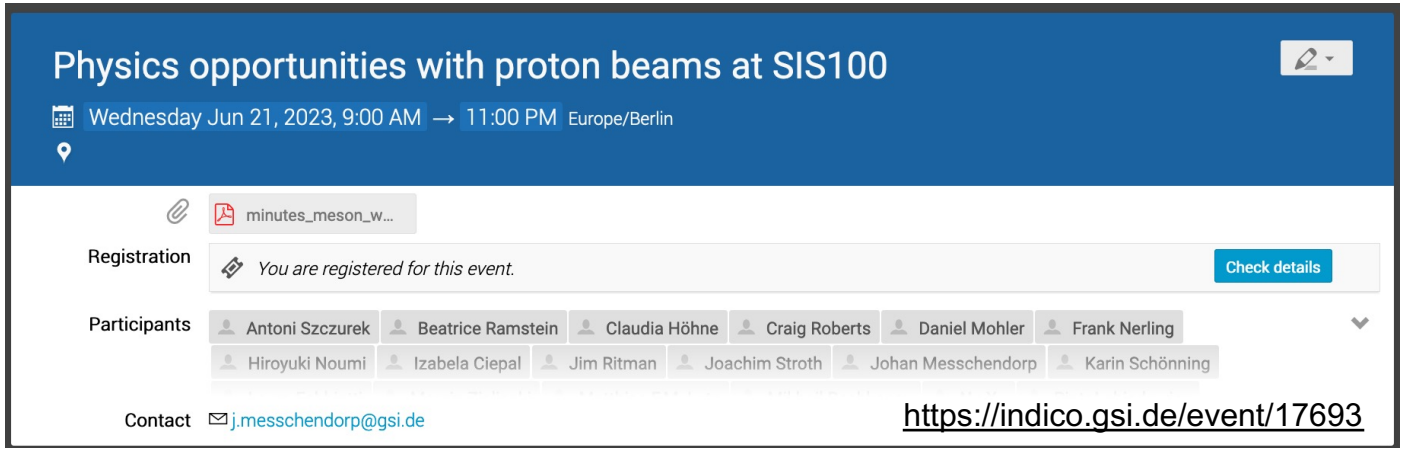
Theory enrichment:

- Terra incognita: intellectual challenges in this energy regime!



After a series of workshops ...

One-day satellite workshop prior to the MESON2023 conference in Cracow, June 21th, 2023.



https://indico.gsi.de/event/17693

After a series of workshops ...

One-day satellite workshop prior to the MESON2023 conference in Cracow, June 21th, 2023.

Physics opportunities with proton beams at SIS100

Wednesday Jun 21, 2023, 9:00 AM → 11:00 PM Europe/Berlin

Four-days workshop in Wuppertal, Feb 6-9th, 2024

Physics opportunities with proton beams at SIS100

6-9 February 2024
Wuppertal University
Europe/Berlin timezone

https://indico.gsi.de/event/18475

- Overview
- Timetable
- Registration
- Participant List
- Venue details
- Accomodation
- Workshop fee
- Payment details

Purpose of this workshop is to bring together experts working in the field of proton induced interactions, and to explore possibilities for exciting physics at the SIS100 accelerator at FAIR.

This workshop is a follow-up of a kick-off event that was held in June 2023 connected to the MESON2023 conference. For further details including an executive summary and slides that were presented, we refer to https://indico.gsi.de/event/17693.

Frank Nerling
James Ritman
Johan Messchendorp
Karl-Heinz Kampert
Piotr Salabura
Tetyana Galatyuk

Physics opportunities with proton beams at SIS100

6-9 February 2024
Wuppertal University
Europe/Berlin timezone

Physics opportunities with ~~proton~~ p, d, π beams at ~~SIS100~~ GSI/FAIR

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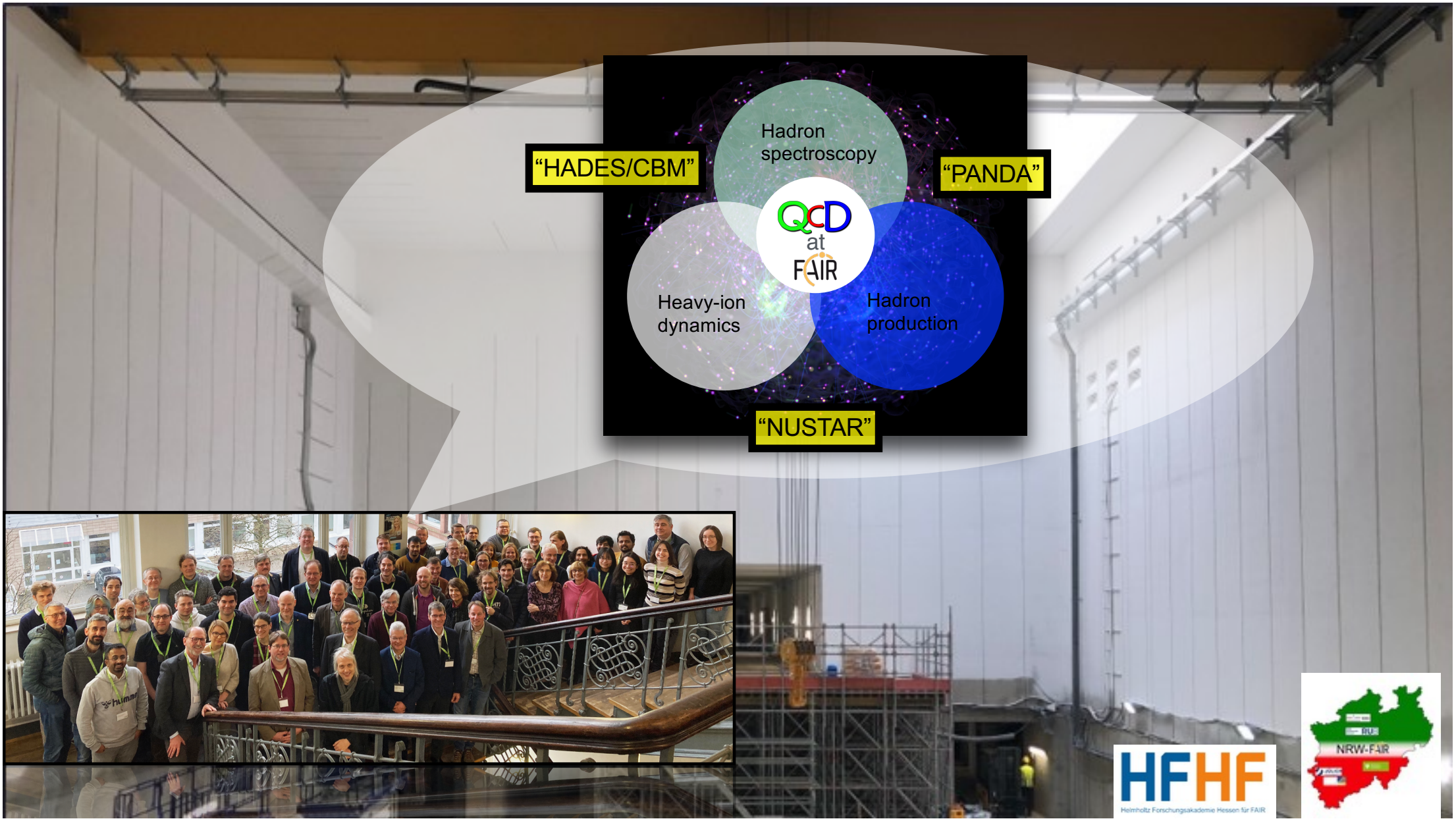
“HADES/CBM”
Hadron spectroscopy
“PANDA”
QCD at FAIR
Heavy-ion dynamics
Hadron production
“NUSTAR”
HFHF
Helmholtz Forschungsakademie Hessen für FAIR
NRW-FAIR

QCD at FAIR

Contact
A.Meergans@gsi.de
B.Hadzimehmedovic@g...

Mission:

- Bring together experts from both theory & experiment
- Form community connecting common interest among different QCD-driven scientists
- Identify promising topics for a long-term pion- and proton -driven physics program
- Evaluate complementarity to programs at other facilities
- Prepare towards a white-paper

Frank Nerling
Johan Messchendorp

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A comprehensive QCD program at GSI/FAIR

GSI
JOHANN WOLFGANG GOETHE
UNIVERSITÄT
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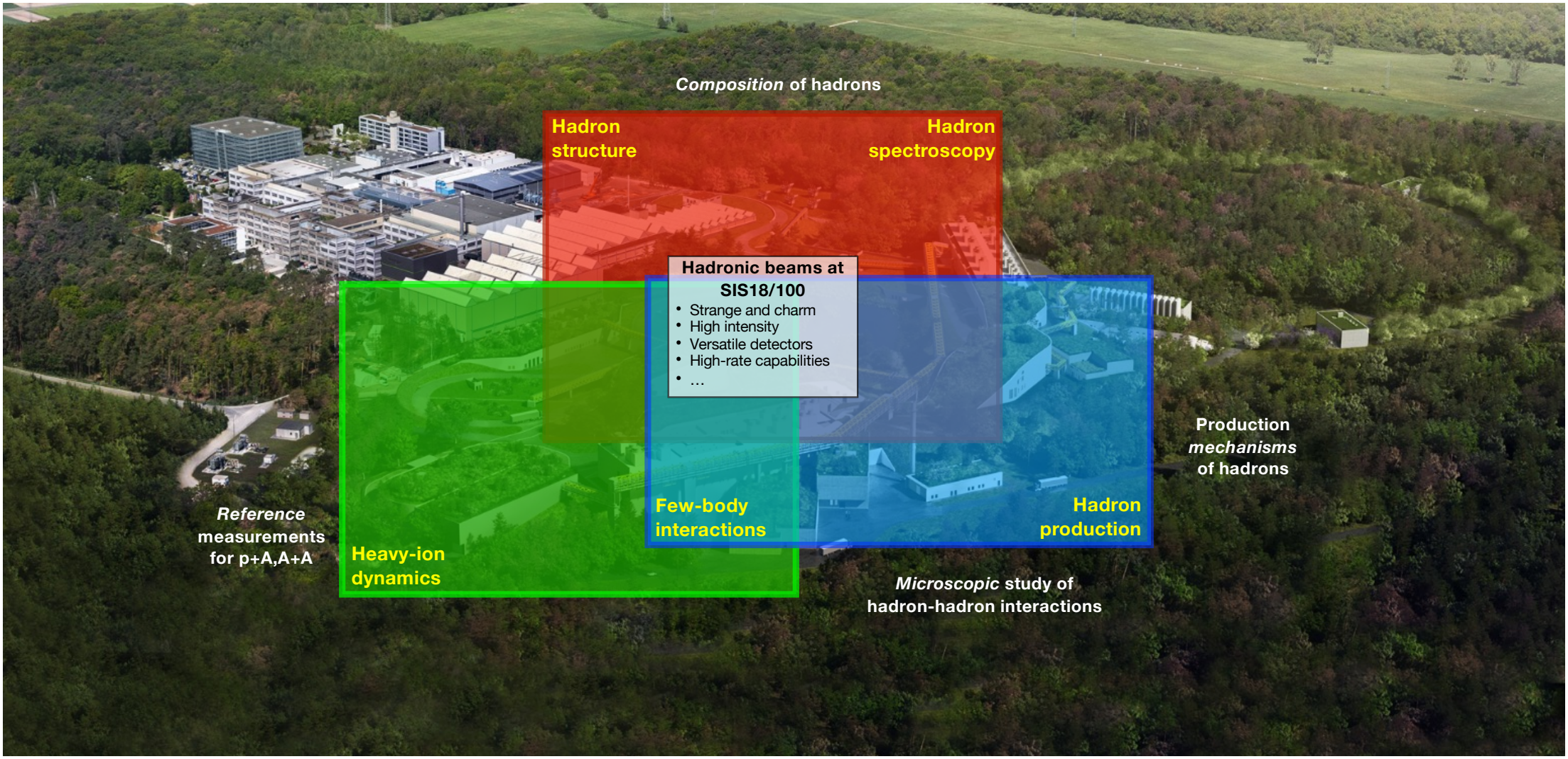

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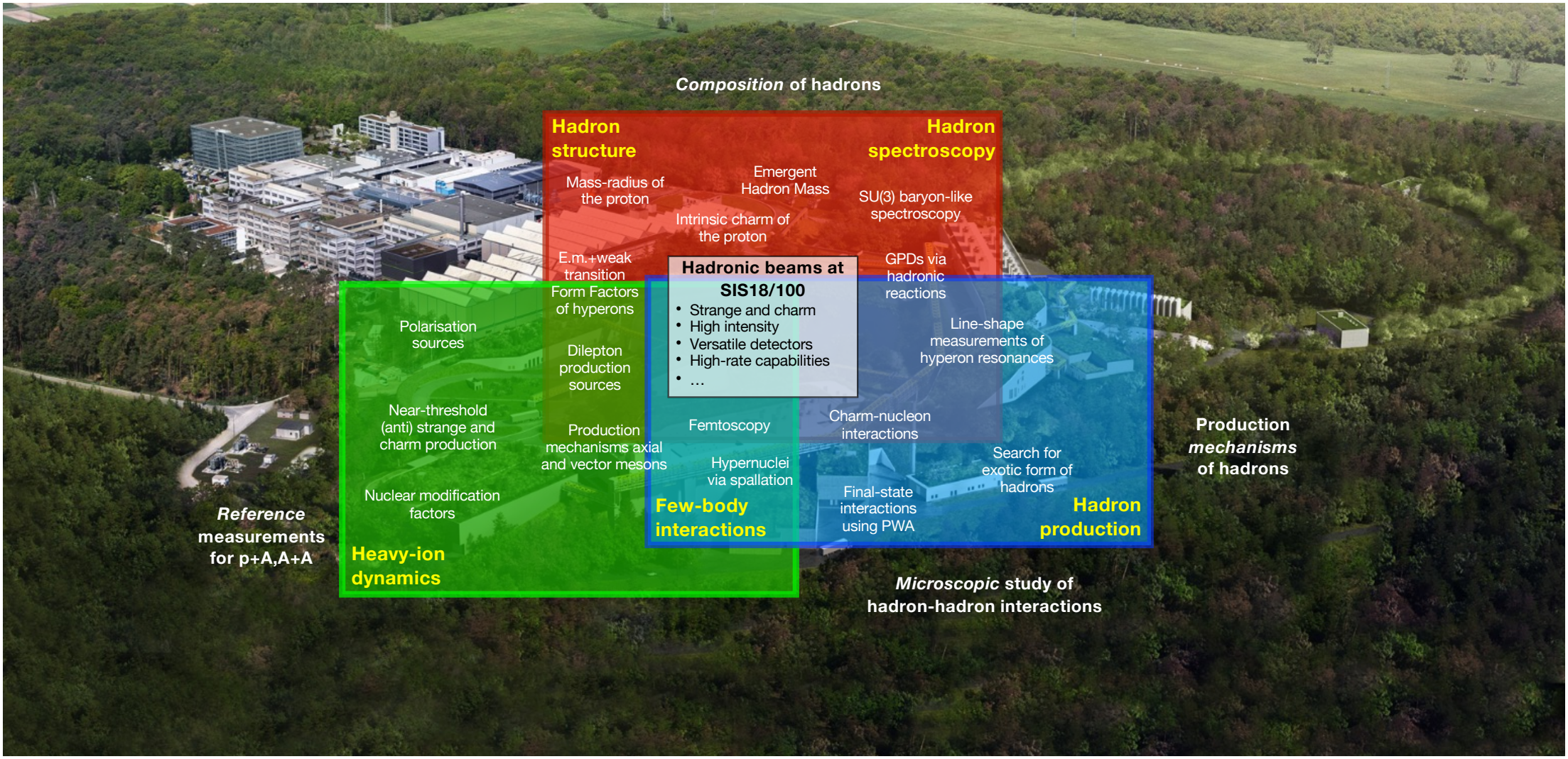

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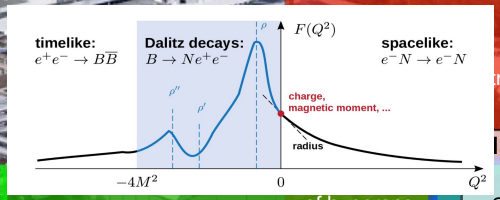
Composition **of hadrons**

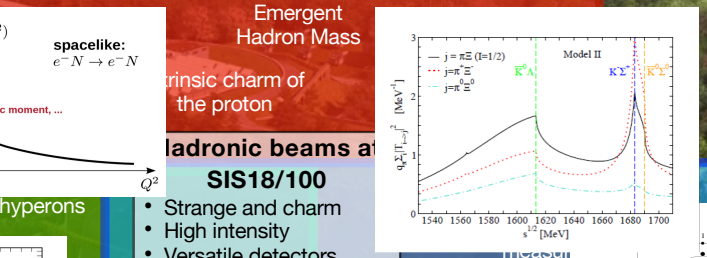
Hadron structure

Hadron spectroscopy



Emergent Hadron Mass

rinsic charm of the proton



adronic beams at

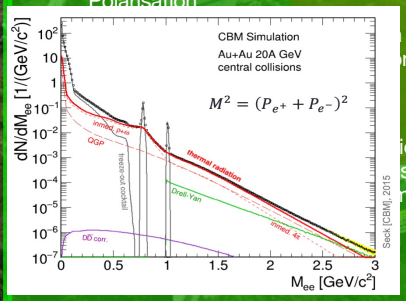
SIS18/100

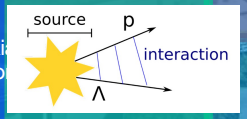
- Strange and charm
- High intensity
- Versatile detectors
- High-rate capabilities
- …

of hyperons

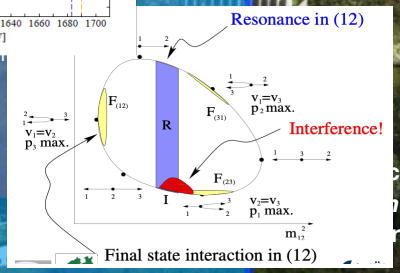
Polarisation

hyperon





Charm-nucleon interactions



Reference **measurements for p+A,A+A**

Heavy-ion dynamics

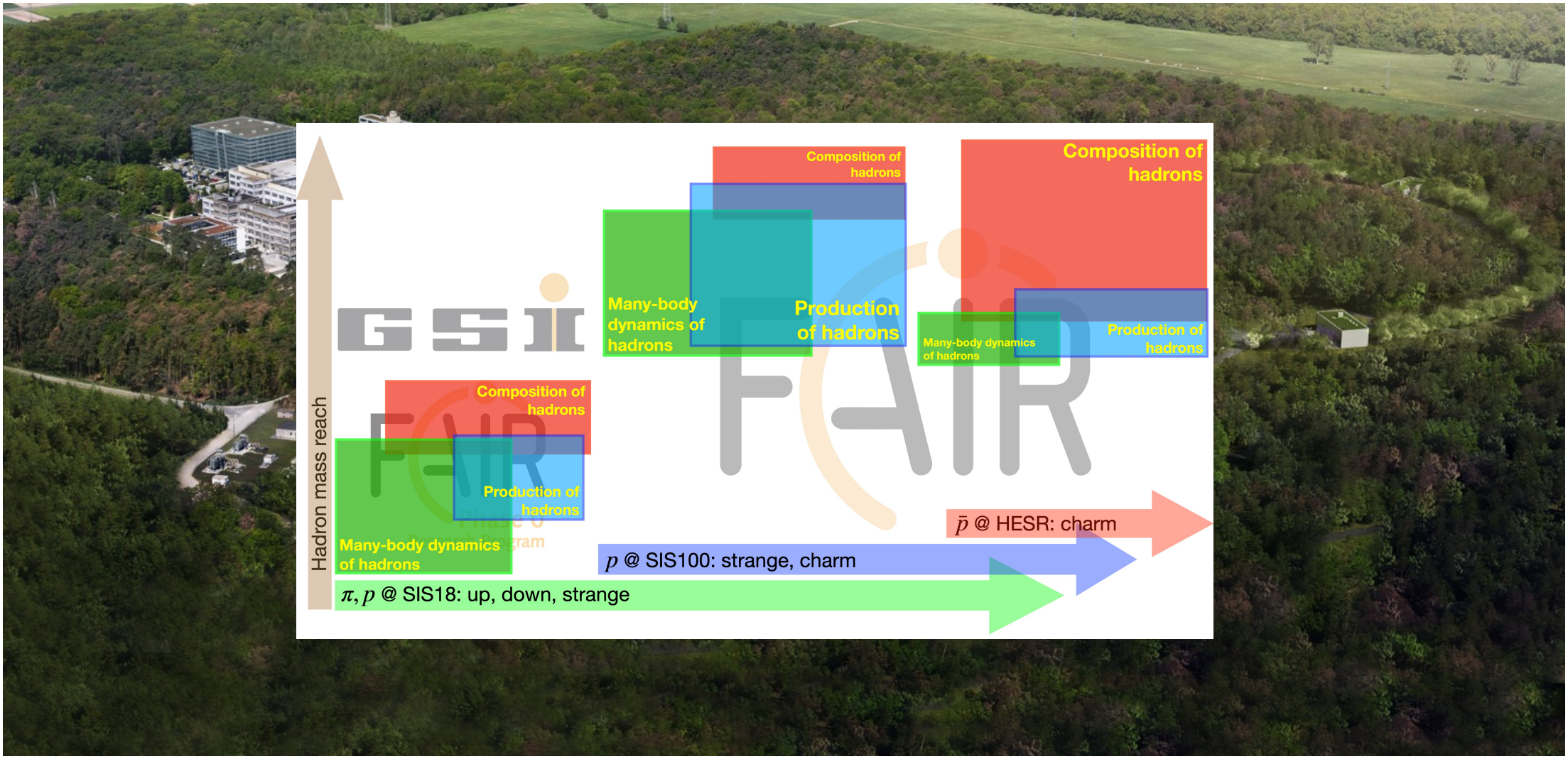
Few-body interactions

Final-state interactions using PWA

Hadron production

Microscopic **study of hadron-hadron interactions**

A comprehensive QCD program at GSI/FAIR



A comprehensive QCD program at GSI/FAIR!

(from SIS18 to SIS100)

White Paper:

- Paper is under production!
- ~70 contributors
- Including leading theorists & experimentalist from strong-QCD communities
- Publication ~spring 2025

Hadron Physics at GSI/FAIR:
=> Prospects for next decade

Contents — Convenors:

Editors: Frank Nerling, Johan Messchendorp

QCD at FAIR, 2024 – Agenda

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Arrival | Open Plenary session

GSI Helmholtzzentrum für Schwerionenforschung GmbH 09:00 - 13:00

13:00 **Lunch break**
GSI Helmholtzzentrum für Schwerionenforschung GmbH 13:00 - 14:00

14:00 **Opening** — Frank Nerling — SB1.1.201 (Audit), GSI — 14:00 - 14:10
Welcome by GSI Management — Yvonne Leifels — SB1.1.201 (Audit), GSI — 14:10 - 14:25
"On the origin of hadron mass and structure" — Craig Roberts — SB1.1.201 (Audit), GSI — 14:25 - 14:55
15:00 **Employing Hadron beams** — Joachim Stroth — SB1.1.201 (Audit), GSI — 14:55 - 15:25
„Opportunities with hadron beams for light baryon spectroscopy" — Deborah Rönchen — SB1.1.201 (Audit), GSI — 15:25 - 15:55

16:00 **Coffee break**
SB1 Foyer, GSI 16:00 - 16:30

"Femtoscopy / Corre. Fctns" — Miguel Albaladejo Serrano — SB1.1.201 (Audit), GSI — 16:30 - 17:00
17:00 **"Quark-diquark correlations in baryons"** — Gernot Eichmann — SB1.1.201 (Audit), GSI — 17:00 - 17:30
Highlight talk Chapter 4, „Probing final state interactions with femtoscopy" — Hanna Zbroszczyk — SB1.1.201 (Audit), GSI — 17:30 - 18:00
18:00 **"QCD, EOS and neutron star mergers"** — Andreas Bauswein — SB1.1.201 (Audit), GSI — 18:00 - 18:30

Welcome Reception

Closed Plenary session | Open Plenary session | Parallel working group meetings I

09:00 **Highlight talk Chapter 3, (title tbd)** — Daniel Winney — KBW.1.017 (Lecture Hall+Sideroom), GSI — 09:00 - 09:30
"Flavour-exotic pentaquarks and where to find them" — Nils Hüsken — KBW.1.017 (Lecture Hall+Sideroom), GSI — 09:30 - 10:00
10:00 **Highlight talk Chapter 5, "Nucleon Structure: Internal charm and trace anomaly"** — Stefan Diehl — KBW.1.017 (Lecture Hall+Sideroom), GSI — 10:00 - 10:30
Coffee break — KBW Foyer, GSI — 10:30 - 11:00
11:00 **Chapter 1 + 2** — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:00 - 11:15
Chapter 3 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:15 - 11:30
Chapter 4 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:30 - 11:45
Chapter 5 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:45 - 12:00
12:00 **Chapter 6** — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 12:00 - 12:15
Chapter 7 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 12:15 - 12:30
Chapter 8 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 12:30 - 12:45
Chapter 9 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 12:45 - 13:00
13:00 **Lunch break**
GSI Helmholtzzentrum für Schwerionenforschung GmbH 13:00 - 14:00

14:00 **Parallel working group meetings I: Experimen… facilities & requireme… (Chapter 9)** — KBW.5.029, GSI — 14:00 - 16:00
Parallel working group meetings I: Tools and techniques (Chapter 3) — KBW.2.028, GSI — 14:00 - 16:00
Parallel working group meetings I: Hadron-hadron interactions (Chapter 4) — Lecture Hall KBW.1.017, GSI — 14:00 - 16:00
Parallel working group meetings I: Composition of hadrons (Chapter 5) — KBW.1.017 (Sideroom), GSI — 14:00 - 16:00
Parallel working group meetings I: Exotic hadrons (Chapter 6) — KBW.2.027, GSI — 14:00 - 16:00
Parallel working group meetings I: Hadrons and dileptons as probes to study cold nuclear matter (Chapter 7) — SB3.2.283, … — 14:00 - 16…
Parallel working group meetings I: Connection and input to astro(parti… physics (Chapter 8) — C27.3.010, GSI — 14:00 - 16:00
15:00 **Parallel wo…** — SB1.4.101, … — 15:00 - 16:…
16:00 **Coffee break**
KBW Foyer, GSI 16:00 - 16:30

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Parallel working group meetings I: Exploiting hadronic beams (Chapter 2) — SB1.4.101, GSI — 16:30 - 18:30

HPS Seminar | Open Plenary session | Open Plenary session | Parallel working group meetings II

09:00 **Amber overview** — Kai-Thomas Brinkmann — Lecture Hall KBW.1.017, GSI — 09:00 - 09:30
WASA overview — Lecture Hall KBW.1.017, GSI — 09:30 - 10:00
10:00 **"Opportunities for Antiproton Physics with COSY at FAIR"** — Klaus Peters — Lecture Hall KBW.1.017, GSI — 10:00 - 10:30
Coffe break — KBW Foyer, GSI — 10:30 - 11:00
11:00 **Highlight talk Chapter 6 (tbd)** — Lecture Hall KBW.1.017, GSI — 11:00 - 11:30
Highlight talk Chapter 7, "Matter" — Manuel Lorenz — Lecture Hall KBW.1.017, GSI — 11:30 - 12:00
12:00 **Highlight talk Chapter 8, "High energy fragmentation reaction and its importance for the galaxy's structure"** — Prof. Takehiko Saito
Lunch break
GSI Helmholtzzentrum für Schwerionenforschung GmbH 12:30 - 13:15
13:00 **HPS Seminar: "Scattering parameters from Production Reactions"** — Christoph Hanhart — SB3.3.170a, GSI — 13:15 - 14:15

14:00 **Parallel working group meetings II: Exploiting hadronic beams (Chapter 2)** — 14:15 - 16:00
Parallel working group meetings II: Hadron-hadron interactions (Chapter 4) — KBW.1.017 (Audit), GSI — 14:15 - 16:00
Parallel working group meetings II: Composition of hadrons (Chapter 5) — KBW.1.017 (Sideroom), GSI — 14:15 - 16:00
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15:00 **Parallel wo…** — BK1 (4.019… — 15:00 - 16…
Parallel wo… — SB3.2.283, … — 15:00 - 16:…
16:00 **Coffee break**
KBW Foyer, GSI 16:00 - 16:30

17:00 **Parallel working group meetings II: Tools and techniques (Chapter 3)** — BK1 (4.019+4.024), GSI — 16:30 - 18:30
Parallel working group meetings II: Hadron-hadron interactions (Chapter 4) — KBW.1.017 (Audit), GSI — 16:30 - 18:30
Parallel working group meetings II: Composition of hadrons (Chapter 5) — KBW.1.017 (Sideroom), GSI — 16:30 - 18:30
Parallel working group meetings II: Exotic hadrons (Chapter 6) — KBW.5.029, GSI — 16:30 - 18:30
18:00 **Parallel working group meetings II: Hadrons and dileptons as probes to study cold nuclear matter (Chapter 7)** — SB3.2.283, GSI — 16:30 - 18:30
Parallel working group meetings II: Connection and input to astro(particle) physics (Chapter 8) — C27.3.010, GSI — 16:30 - 18:30
Parallel working group meetings II: Experimental facilities & requirements (Chapter 9) — SB1.4.101, GSI — 16:30 - 18:30

19:00 **Dinner at GSI**

09:00 **"Charm @ FAIR"** — Antoni Szczurek — Lecture Hall KBW.1.017, GSI — 09:30 - 10:00
Highlight talk Chapter 9 / Simulation — Shreya Roy — Lecture Hall KBW.1.017, GSI — 10:00 - 10:30
Coffee break — KBW Foyer, GSI — 10:30 - 11:00
11:00 **Chapter 1 + 2** — KBW.1.017 (Audit), GSI — 11:00 - 11:15
Chapter 3 — KBW.1.017 (Audit), GSI — 11:15 - 11:30
Chapter 4 — KBW.1.017 (Audit), GSI — 11:30 - 11:45
Chapter 5 — KBW.1.017 (Audit), GSI — 11:45 - 12:00
12:00 **Chapter 6** — KBW.1.017 (Audit), GSI — 12:00 - 12:15
Chapter 7 — KBW.1.017 (Audit), GSI — 12:15 - 12:30
Chapter 8 — KBW.1.017 (Audit), GSI — 12:30 - 12:45
Chapter 9 — KBW.1.017 (Audit), GSI — 12:45 - 12:55
13:00 **Concluding remarks and summary** — Johan Messchendorp — KBW.1.017 (Audit), GSI — 12:55 - 13:05
Lunch break
GSI Helmholtzzentrum für Schwerionenforschung GmbH 13:05 - 14:00
14:00 **Visit FAIR-site**

QCD at FAIR, 2024 – Agenda

HFHF
Helmholtz Forschungsakademie Hessen für FAIR

GSI
JOHANN WOLFGANG GOETHE
UNIVERSITÄT
FRANKFURT AM MAIN

QCD at FAIR


Arrival | Open Plenary session

GSI Helmholtzzentrum für Schwerionenforschung GmbH 09:00 - 13:00

13:00 Lunch break — GSI Helmholtzzentrum für Schwerionenforschung GmbH 13:00 - 14:00

14:00 Opening — Frank Nerling — SB1.1.201 (Audit), GSI — 14:00 - 14:10
Welcome by GSI Management — Yvonne Leifels — SB1.1.201 (Audit), GSI — 14:10 - 14:25
"On the origin of hadron mass and structure" — Craig Roberts — SB1.1.201 (Audit), GSI — 14:25 - 14:55

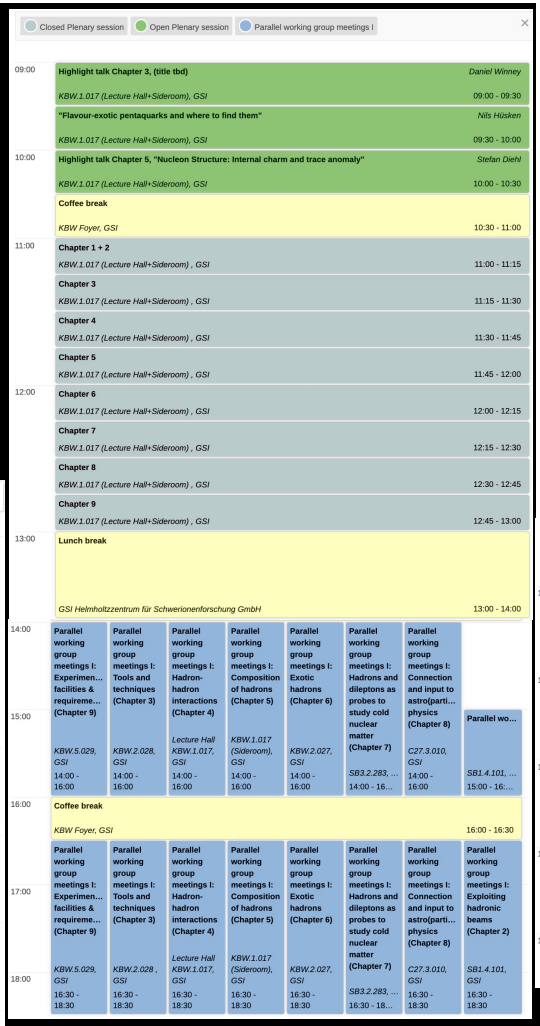
15:00 Employing Hadron beams — Joachim Stroth — SB1.1.201 (Audit), GSI — 14:55 - 15:25
„Opportunities with hadron beams for light baryon spectroscopy" — Deborah Rönchen — SB1.1.201 (Audit), GSI — 15:25 - 15:55

16:00 Coffee break — SB1 Foyer, GSI — 16:00 - 16:30

"Femtoscopy / Corre. Fctns" — Miguel Albaladejo Serrano — SB1.1.201 (Audit), GSI — 16:30 - 17:00

17:00 "Quark-diquark correlations in baryons" — Gernot Eichmann — SB1.1.201 (Audit), GSI — 17:00 - 17:30
Highlight talk Chapter 4, „Probing final state interactions with femtoscopy" — Hanna Zbroszczyk — SB1.1.201 (Audit), GSI — 17:30 - 18:00

18:00 "QCD, EOS and neutron star mergers" — Andreas Bauswein — SB1.1.201 (Audit), GSI — 18:00 - 18:30
Welcome Reception


Closed Plenary session | Open Plenary session | Parallel working group meetings I

09:00 Highlight talk Chapter 3, (title tbd) — Daniel Winney — KBW.1.017 (Lecture Hall+Sideroom), GSI — 09:00 - 09:30
"Flavour-exotic pentaquarks and where to find them" — Nils Hüsken — KBW.1.017 (Lecture Hall+Sideroom), GSI — 09:30 - 10:00

10:00 Highlight talk Chapter 5, "Nucleon Structure: Internal charm and trace anomaly" — Stefan Diehl — KBW.1.017 (Lecture Hall+Sideroom), GSI — 10:00 - 10:30
Coffee break — KBW Foyer, GSI — 10:30 - 11:00

11:00 Chapter 1 + 2 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:00 - 11:15
Chapter 3 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:15 - 11:30
Chapter 4 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:30 - 11:45
Chapter 5 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 11:45 - 12:00

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Chapter 9 — KBW.1.017 (Lecture Hall+Sideroom) , GSI — 12:45 - 13:00

13:00 Lunch break — GSI Helmholtzzentrum für Schwerionenforschung GmbH — 13:00 - 14:00

14:00 Parallel working group meetings I: Experimen… facilities & requireme… (Chapter 9) — KBW.5.029, GSI — 14:00 - 16:00
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Parallel working group meetings I: Composition of hadrons (Chapter 5) — KBW.1.017 (Sideroom), GSI — 14:00 - 16:00
Parallel working group meetings I: Exotic hadrons (Chapter 6) — KBW.2.027, GSI — 14:00 - 16:00
Parallel working group meetings I: Hadrons and dileptons as probes to study cold nuclear matter (Chapter 7) — SB3.2.283, … — 14:00 - 16:…
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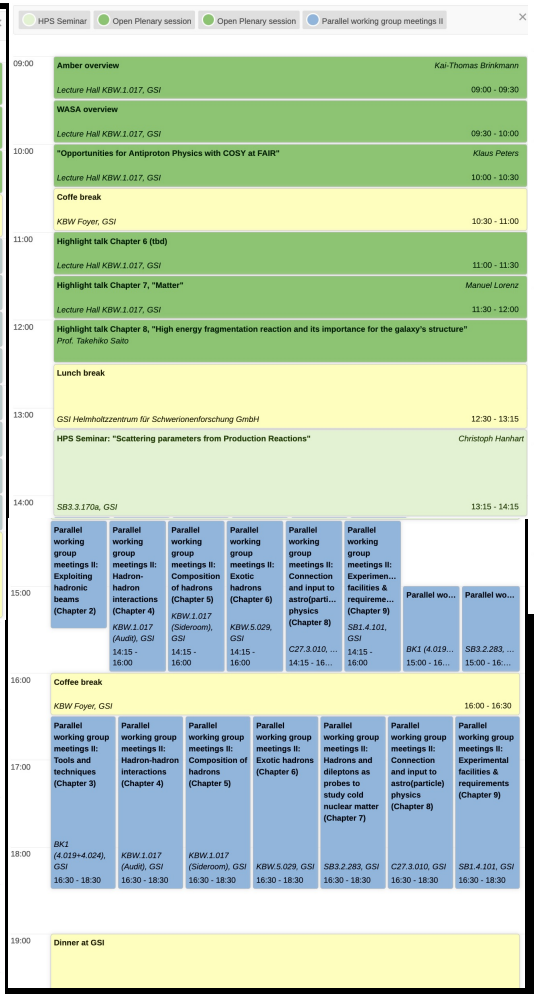
Parallel working group meetings I: Exploiting hadronic beams (Chapter 2) — SB1.4.101, GSI — 16:30 - 18:30


HPS Seminar | Open Plenary session | Open Plenary session | Parallel working group meetings II

09:00 Amber overview — Kai-Thomas Brinkmann — Lecture Hall KBW.1.017, GSI — 09:00 - 09:30
WASA overview — Lecture Hall KBW.1.017, GSI — 09:30 - 10:00

10:00 "Opportunities for Antiproton Physics with COSY at FAIR" — Klaus Peters — Lecture Hall KBW.1.017, GSI — 10:00 - 10:30
Coffe break — KBW Foyer, GSI — 10:30 - 11:00

11:00 Highlight talk Chapter 6 (tbd) — Lecture Hall KBW.1.017, GSI — 11:00 - 11:30
Highlight talk Chapter 7, "Matter" — Manuel Lorenz — Lecture Hall KBW.1.017, GSI — 11:30 - 12:00

12:00 Highlight talk Chapter 8, "High energy fragmentation reaction and its importance for the galaxy's structure" — Prof. Takehiko Saito
Lunch break — GSI Helmholtzzentrum für Schwerionenforschung GmbH — 12:30 - 13:15

13:00 HPS Seminar: "Scattering parameters from Production Reactions" — Christoph Hanhart — SB3.3.170a, GSI — 13:15 - 14:15

14:00 Parallel working group meetings II: Exploiting hadronic beams (Chapter 2)
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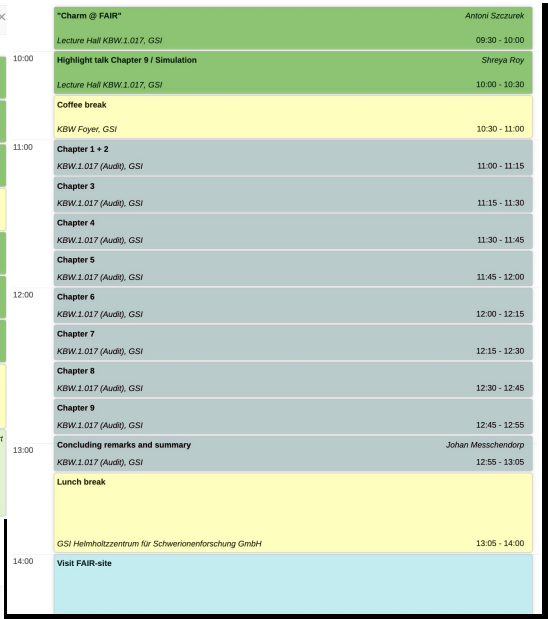
19:00 Dinner at GSI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14:00 Visit FAIR-site

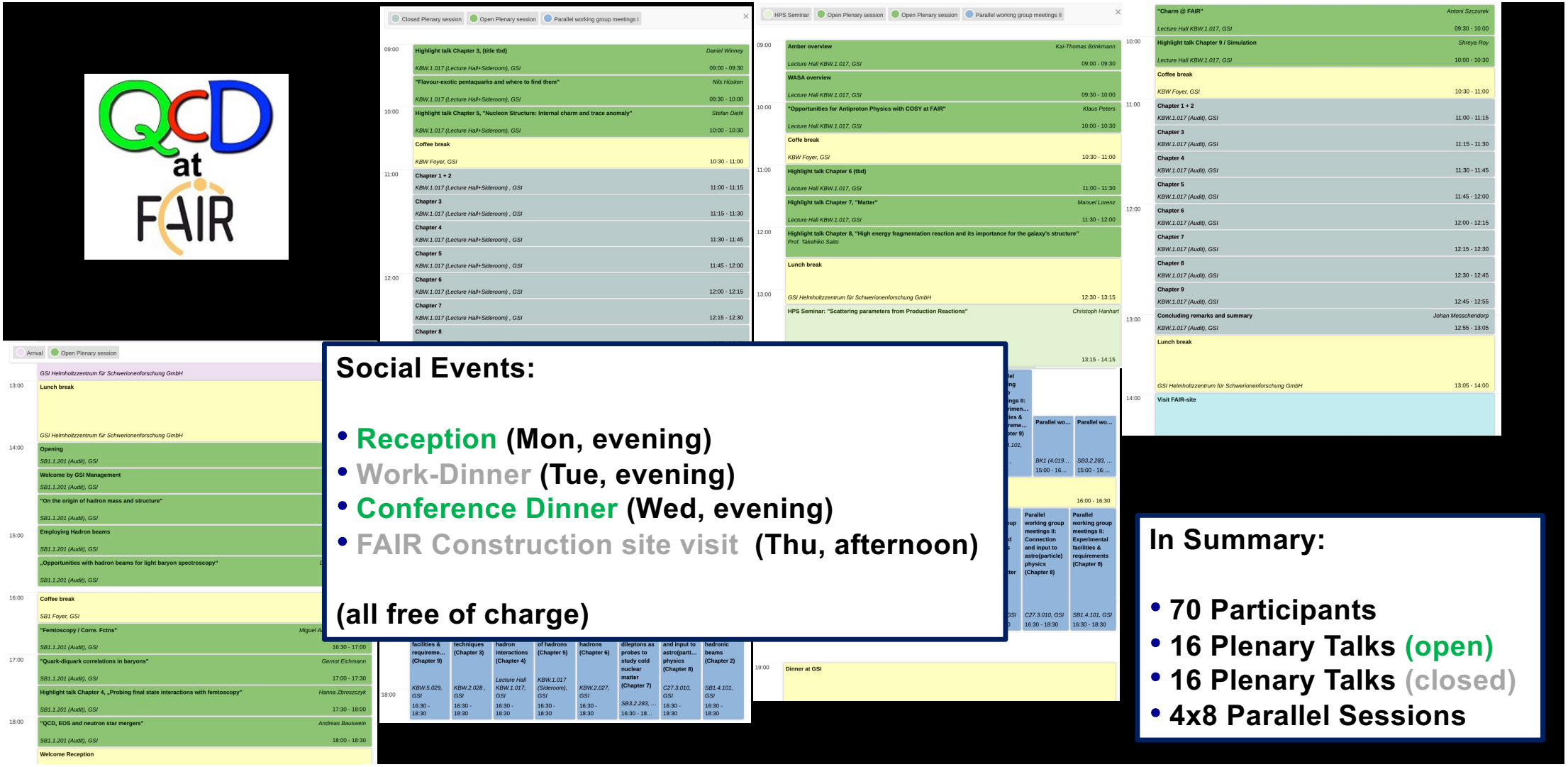
In Summary:

- 70 Participants
- 16 Plenary Talks (open)
- 16 Plenary Talks (closed)
- 4x8 Parallel Sessions

QCD at FAIR, 2024 – Agenda

HFHF
Helmholtz Forschungsakademie Hessen für FAIR

GSI
JOHANN WOLFGANG GOETHE
UNIVERSITÄT
FRANKFURT AM MAIN



Social Events:

- **Reception** (Mon, evening)
- **Work-Dinner** (Tue, evening)
- **Conference Dinner** (Wed, evening)
- **FAIR Construction site visit** (Thu, afternoon)

(all free of charge)

In Summary:

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- 4x8 Parallel Sessions

QCD at FAIR Workshop, November 2024

This series of workshops is organised for:

- Hadron-driven "QCD" physics at FAIR – a win-win-win situation!
- Heavy-ion physics perspectives:
  - Crucial reference to heavy-ion reactions
  - Detailed information on baryons and meson-baryon couplings
- Nuclear physics perspectives:
  - (Ab-initio) baryon-baryon data in flavour SU(3)
- Hadron physics perspectives:
  - Controllable tool for hadron spectroscopy & structure studies in u,d,s,c sectors
  - Intermediate physics program with pions & protons towards antiprotons

Let me wish us a very interesting workshop with constructive discussions and progress – thank you very much for your participation!

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