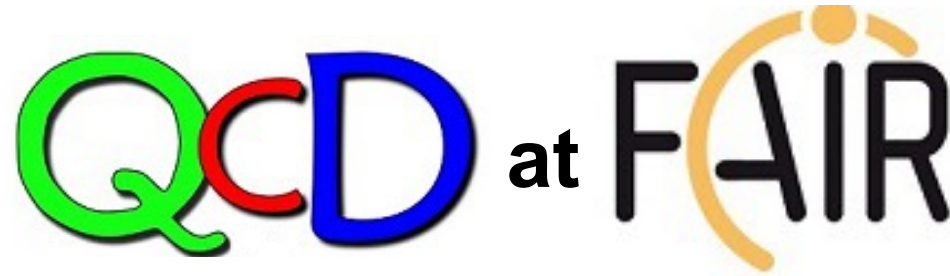


“QCD at FAIR” Workshop 2024

Frank Nerling
HFHF, GU Frankfurt & GSI Darmstadt
&

Johan Messchendorp
FFN, GSI Darmstadt

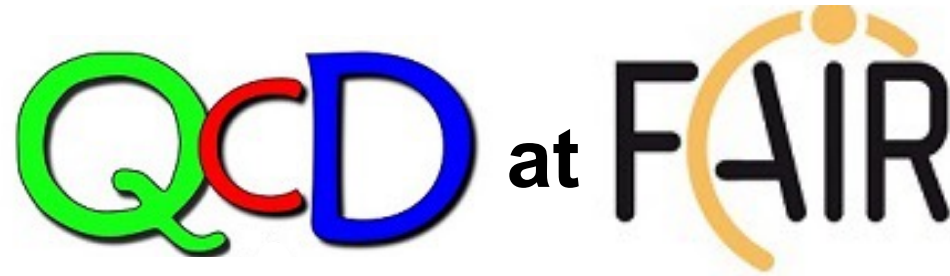


“QCD at FAIR” Workshop 2024

Opening & introduction

Frank Nerling

HFHF, GU Frankfurt & GSI Darmstadt



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

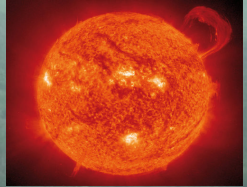
Facility for Antiproton and Ion Research – „The Universe in the Laboratory“

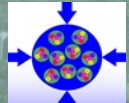
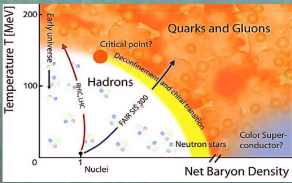


**Hadron Physics
Facilities at FAIR**

Facility for Antiproton and Ion Research – „The Universe in the Laboratory“



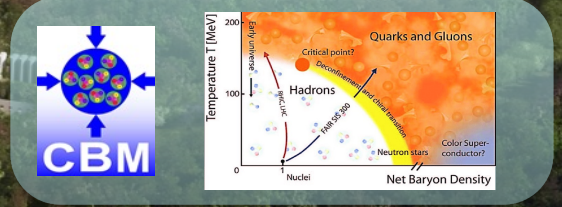
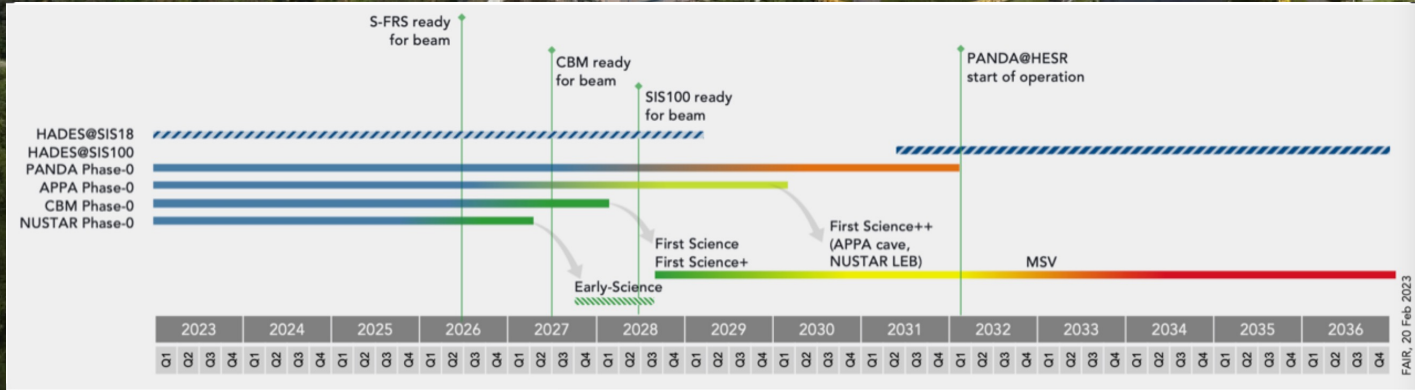
APPA 

CBM  

pANDA 

NUSTAR 

Hadron Physics Facilities at FAIR

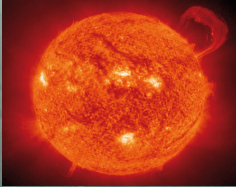


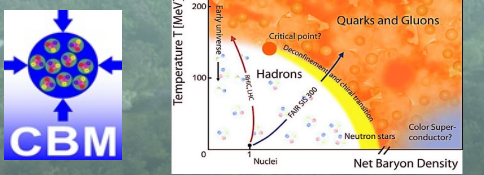
Hadron Physics Facilities at FAIR

FAIR, 20 Feb. 2023

Facility for Antiproton and Ion Research – „The Universe in the Laboratory“



APPA 

CBM 
Temperature T (MeV) vs. Net Baryon Density. The diagram shows a phase transition from Nuclei to Quarks and Gluons, with labels for Critical point?, Hadrons, Neutron stars, and Color Superconductor?.

PANDA 

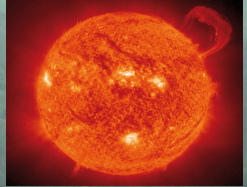
NUSTAR 


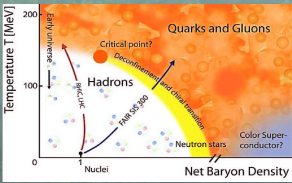
FAIR

**Hadron Physics
Facilities at FAIR**



QCD
at
FAIR

APPA 

CBM  

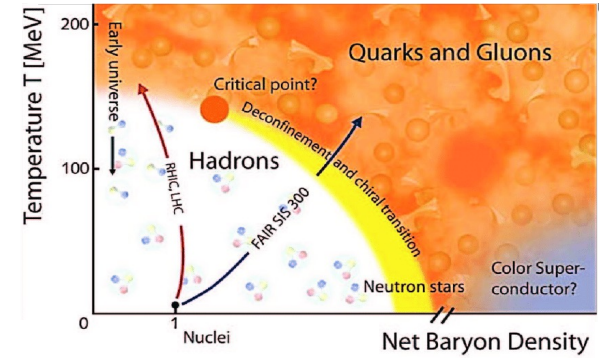
PANDA 

NUSTAR 

**Hadron Physics
Facilities at FAIR**

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**

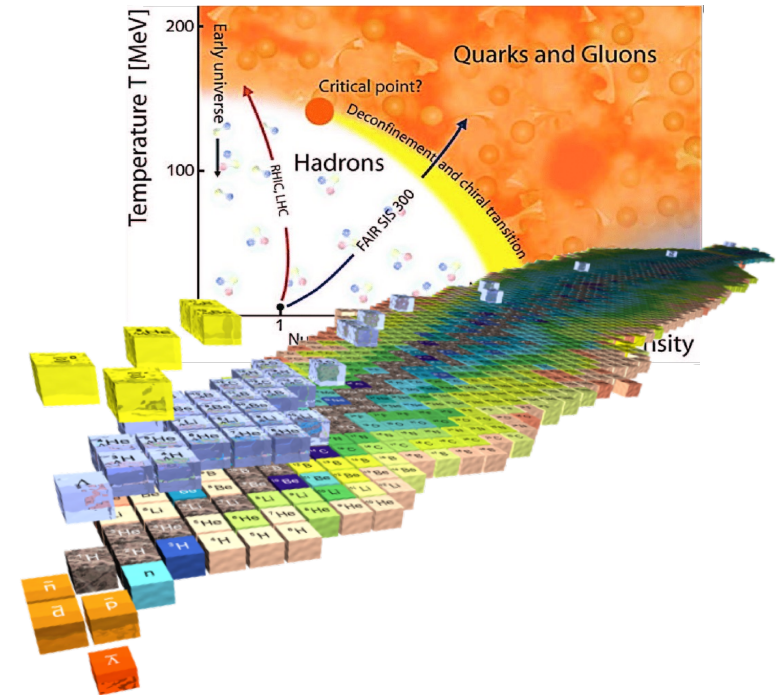


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Nuclear physics:

- 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**



Heavy-ion physics:

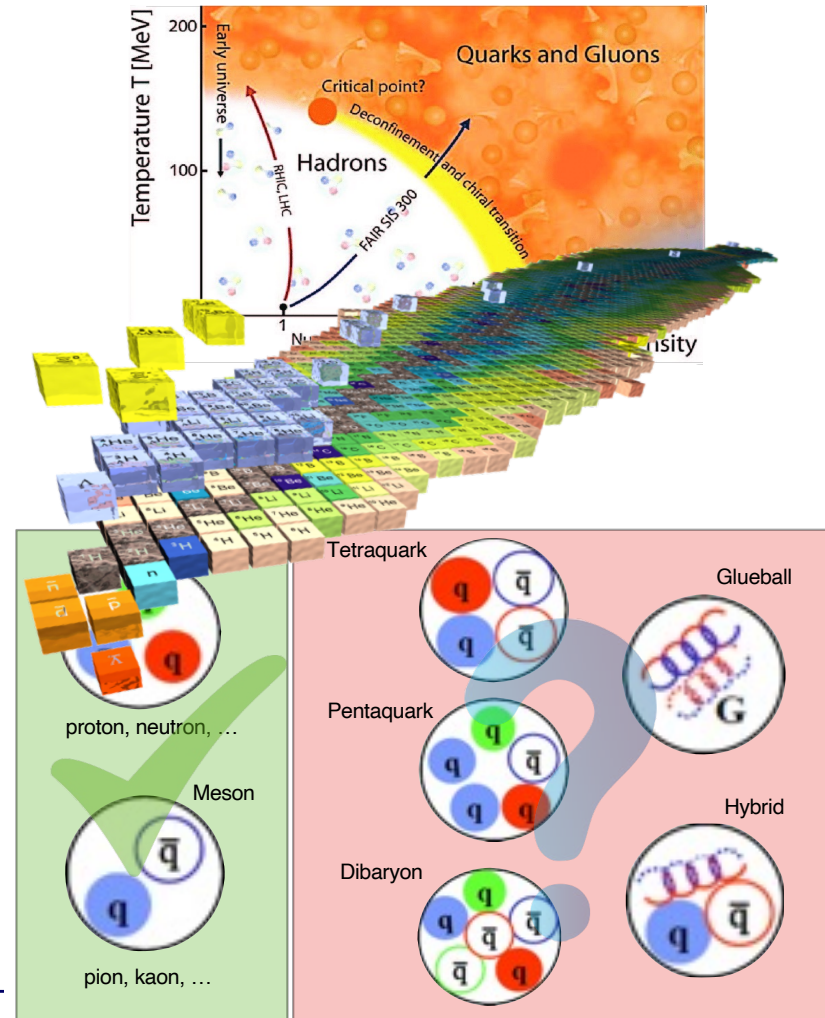
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Hadron physics:

- Map out the **hadron spectrum**
- Search for “**exotic**” forms of **hadrons**
- “**Microscopic**” study of **hadron-hadron** interactions



Heavy-ion physics:

- Exploring **dense QCD** matter
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- Properties of **hadrons in a dense environment**

Hadron interactions:
Reference for understanding medium effects

Nuclear physics:

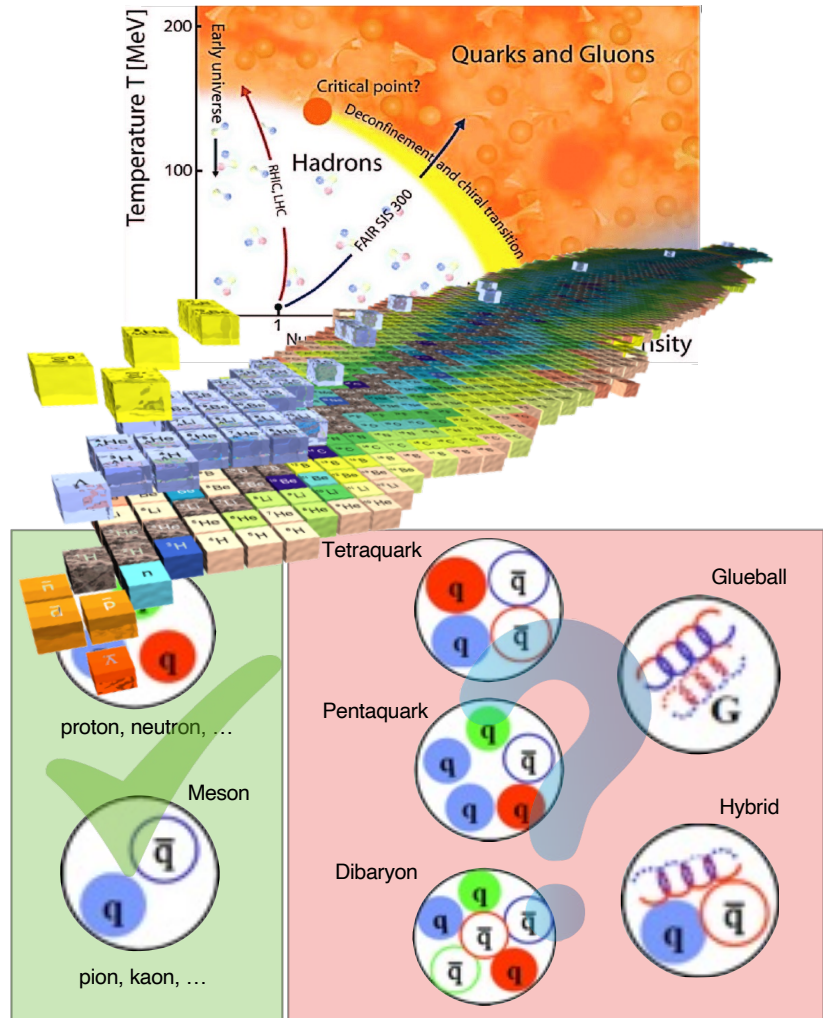
- Map out the **nuclear spectrum** in isospin and strangeness
- Properties of **nuclei at the edge of stability**, e.g. *neutron-rich*
- Probe **baryon/meson** degrees-of-freedom

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 interactions**

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?

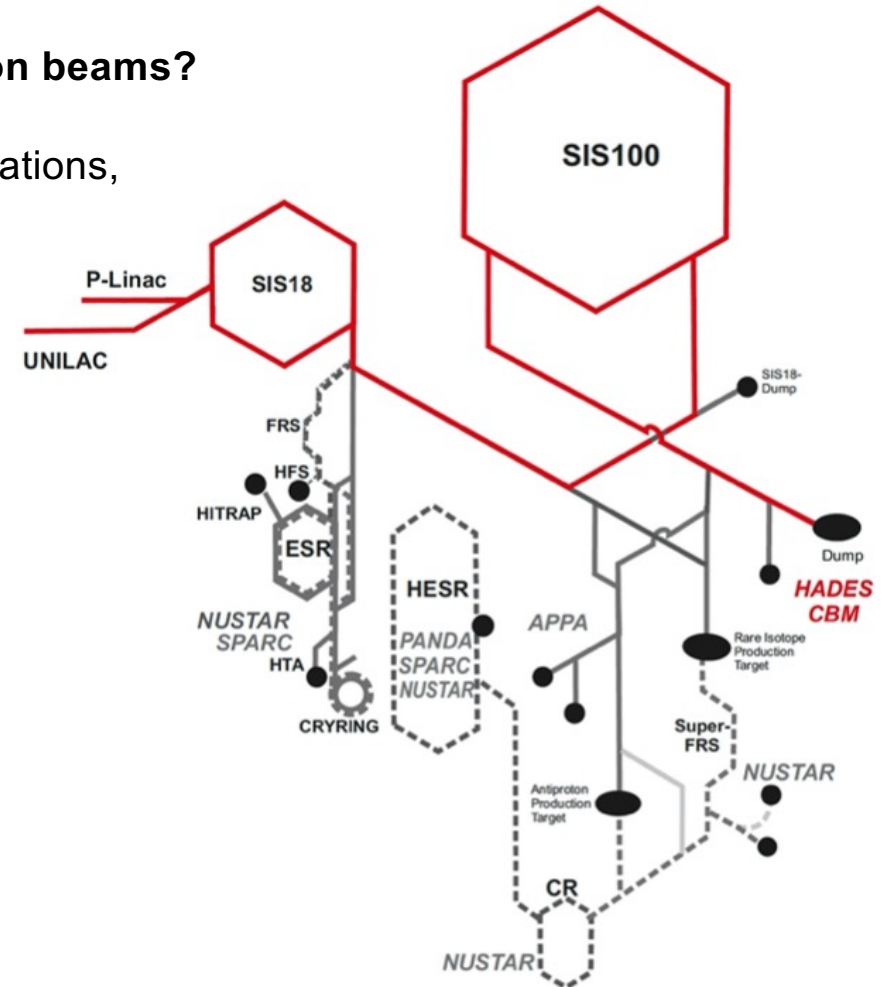
- Initiative from [FAIR-motivated group](#) from within various collaborations, such as CBM, HADES, PANDA
- Promote the realisation of [First Science+ \(FS+\)](#) at FAIR
- Identify a [QCD-inspired physics program](#) with proton beams



From SIS18 to SIS100 – Context

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

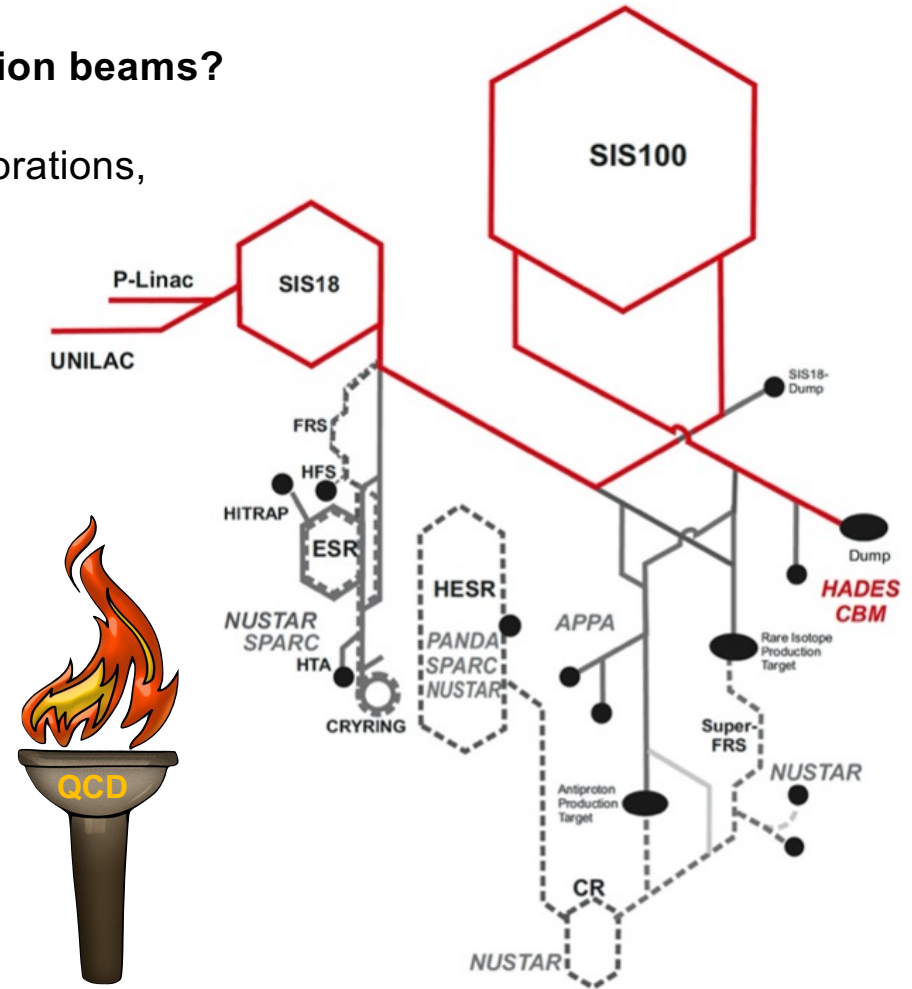
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 - **Heavy-ion physics communities:** Enrich program with “elementary” component, strengthen political impact at FAIR
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From SIS18 to SIS100 – Context

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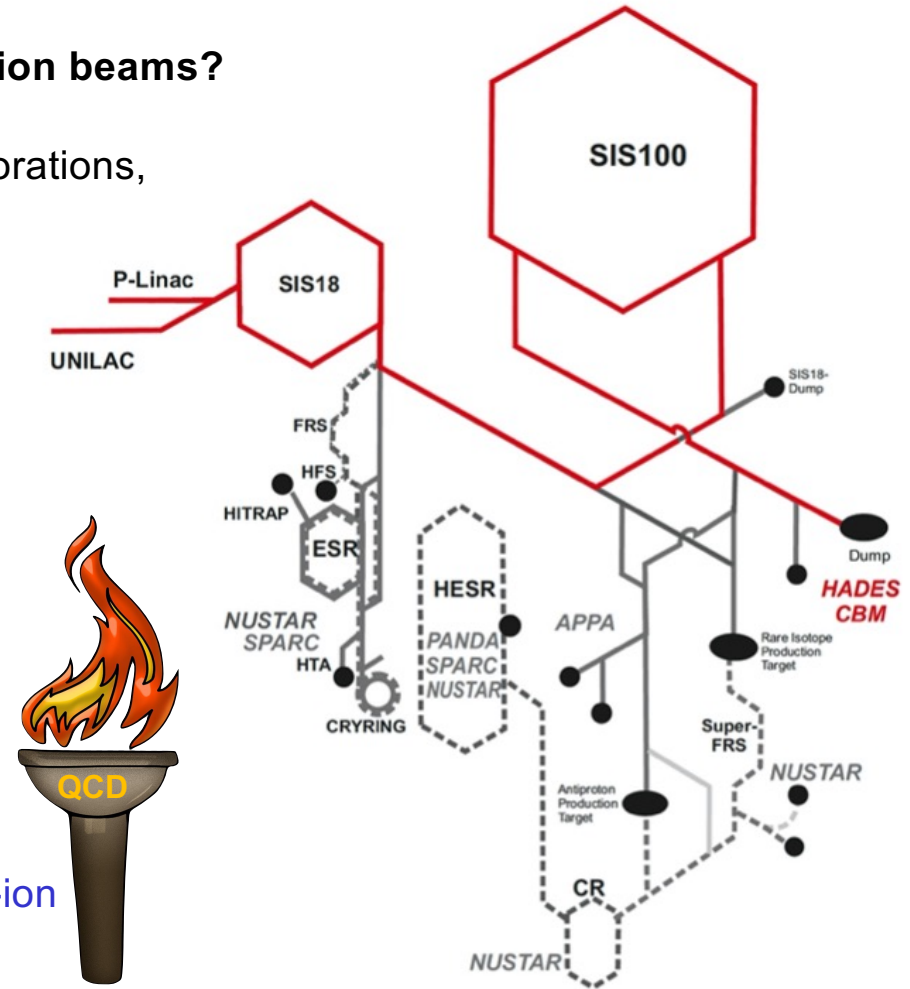
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- Strengthen **collaborations** among **hadron-, nuclear- and heavy-ion** communities from both, **experiment** and **theory**!



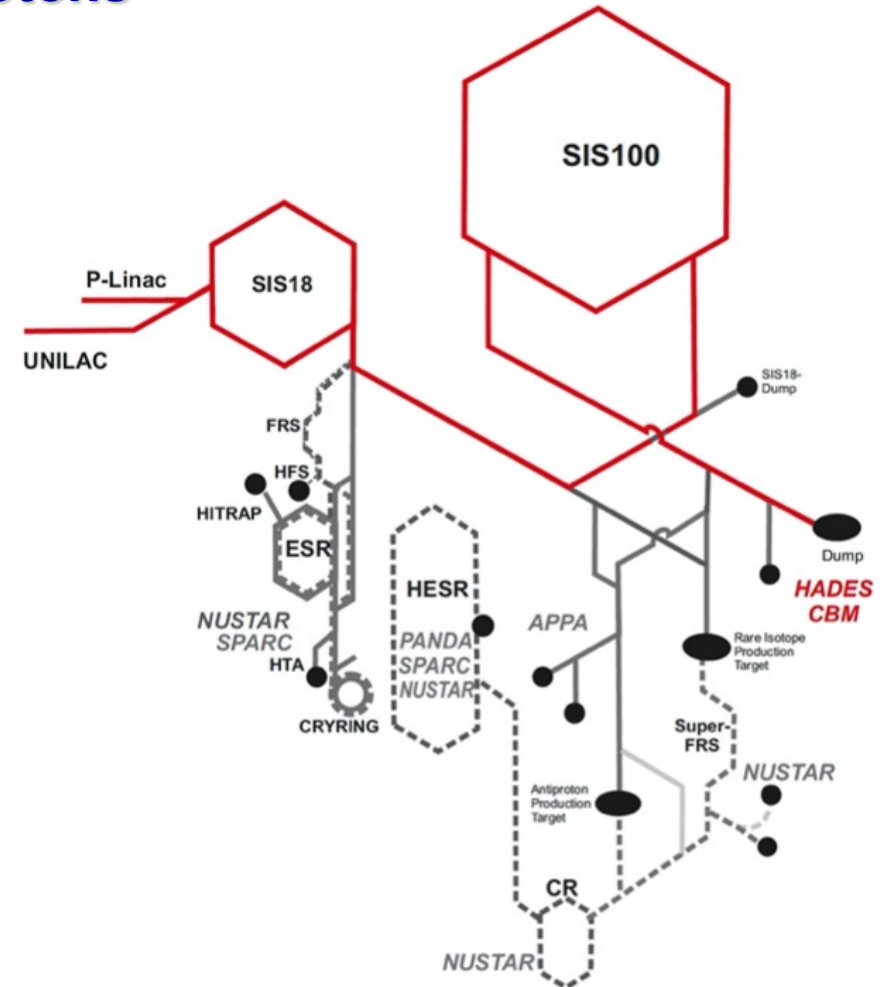
From SIS18 to SIS100 – Hadron physics with pions and protons

Energy upgrade:

- From max 4.7 GeV (SIS18) to 29 GeV (SIS100)
proton energy: $\sqrt{s_{NN}} \approx 3.5 \text{ GeV} \rightarrow 7.6 \text{ GeV}$
- 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: $\sim 10 \text{ pb}^{-1} \text{ day}^{-1}$



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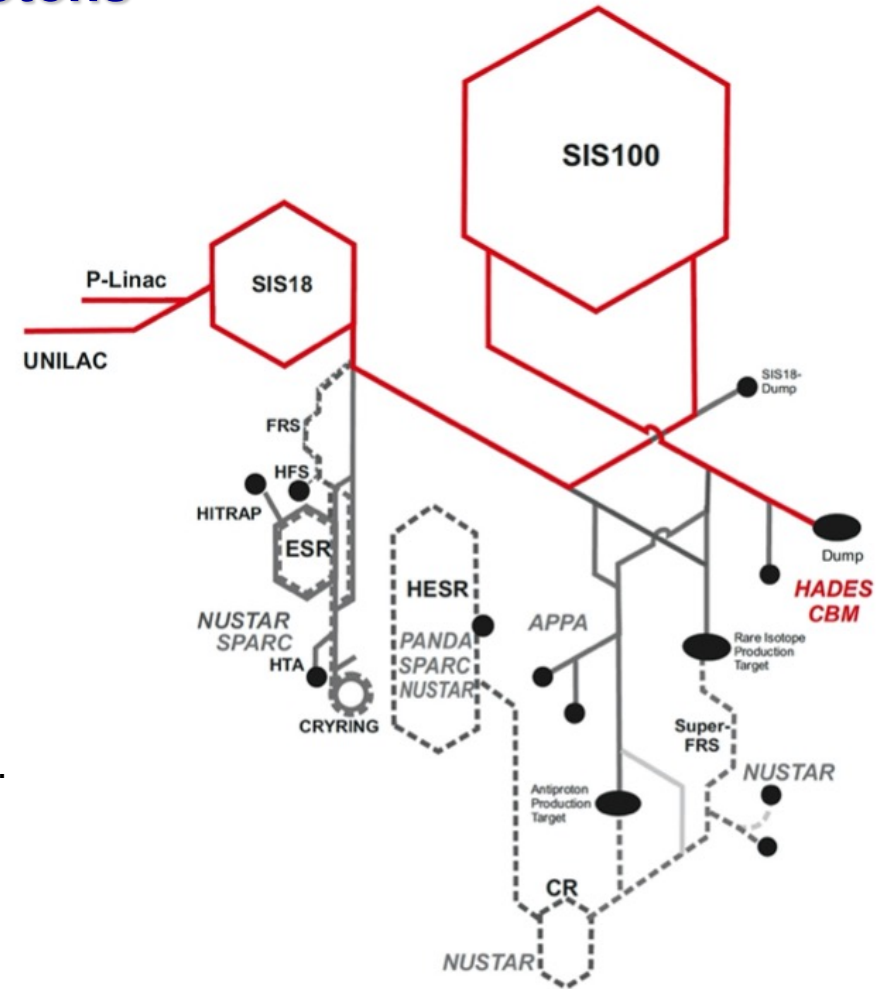
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Detector enrichment:

- 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.

Physics opportunities with proton beams at SIS100

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

📎 minutes_meson_w...

Registration You are registered for this event. [Check details](#)

Participants

- Antoni Szczurek
- Beatrice Ramstein
- Claudia Höhne
- Craig Roberts
- Daniel Mohler
- Frank Nerling
- Hiroyuki Noumi
- Izabela Ciepal
- Jim Ritman
- Joachim Stroth
- Johan Messchendorf
- Karin Schönning

Contact ✉ j.meschendorf@gsi.de <https://indico.gsi.de/event/17693>



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Physics opportunities with proton beams at SIS100

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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	<p>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.</p> <p>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.</p>
Timetable	
Registration	
Participant List	
Venue details	
Accommodation	
Workshop fee	
Payment details	



CBM / HADES cave 2023



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



Physics opportunities with proton beams at SIS100

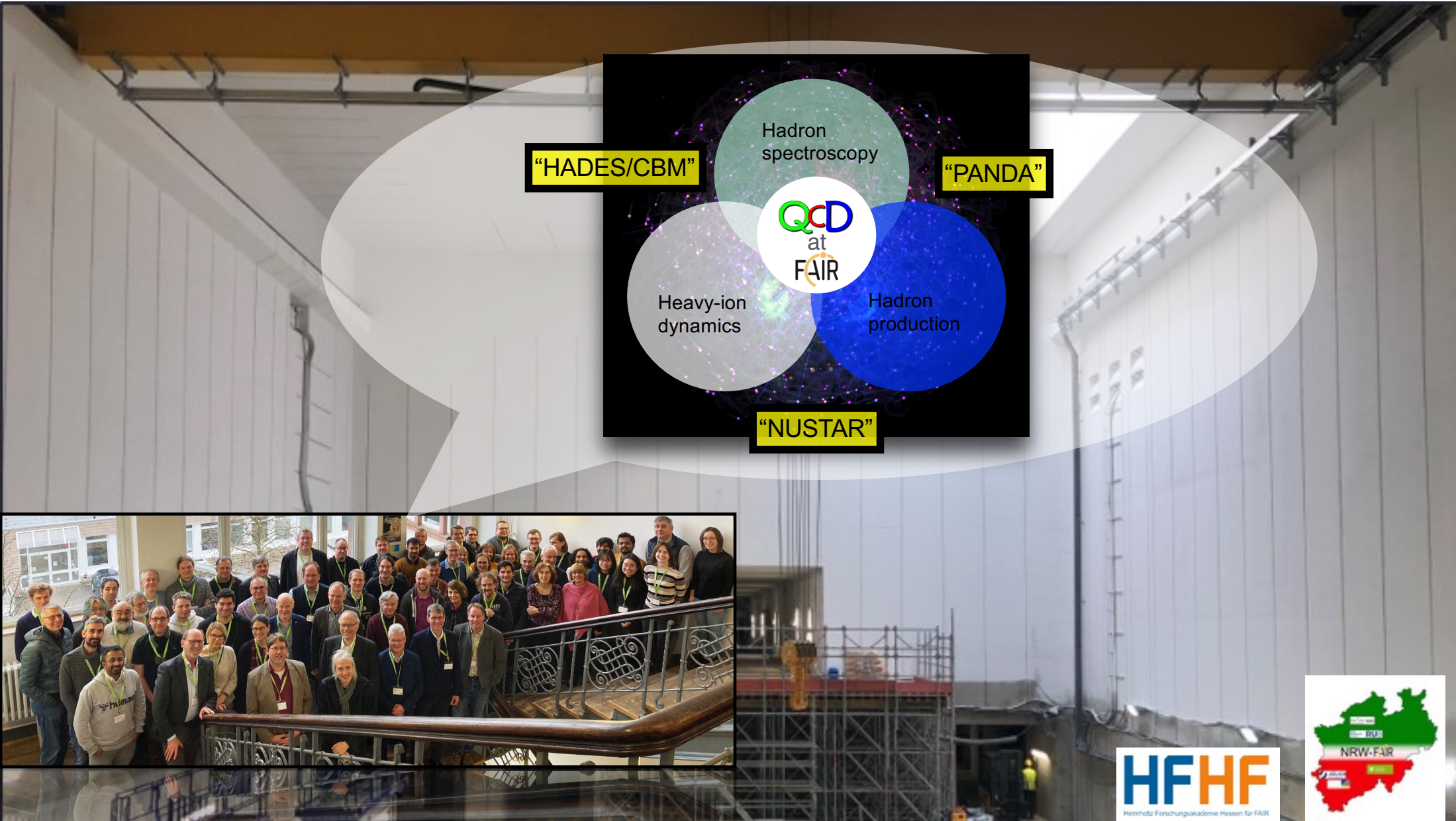
6-9 February 2024
Wuppertal University
Europe/Berlin timezone



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

6-9 February 2024
Wuppertal University
Europe/Berlin timezone





“HADES/CBM”

“PANDA”

Hadron spectroscopy

Heavy-ion dynamics

Hadron production

“NUSTAR”

QCD at FAIR



HFHF
Heinrich-Fischer-Forschungsinstitut für 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

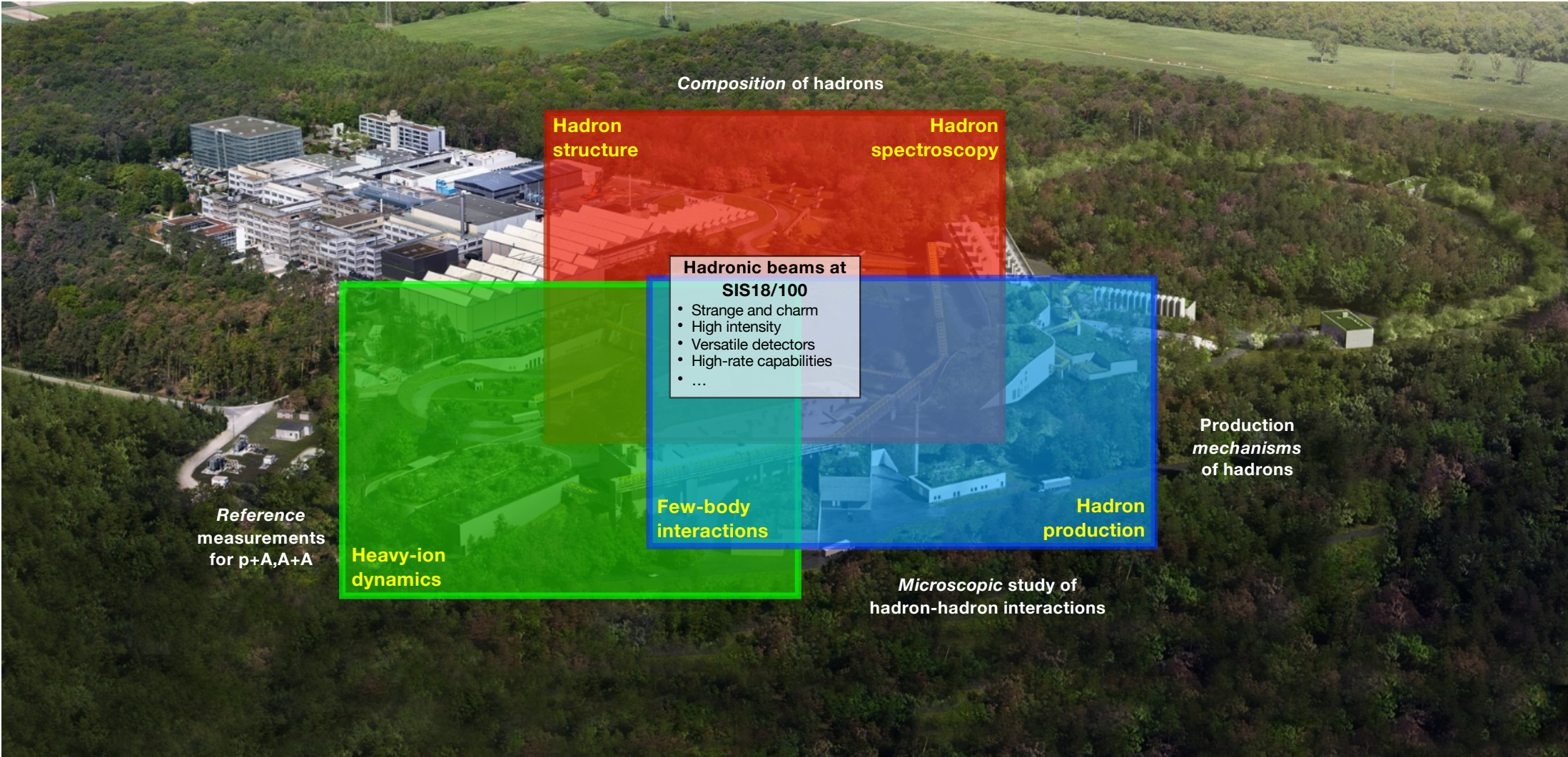


 Frank Nerling
Johan Messchendorp

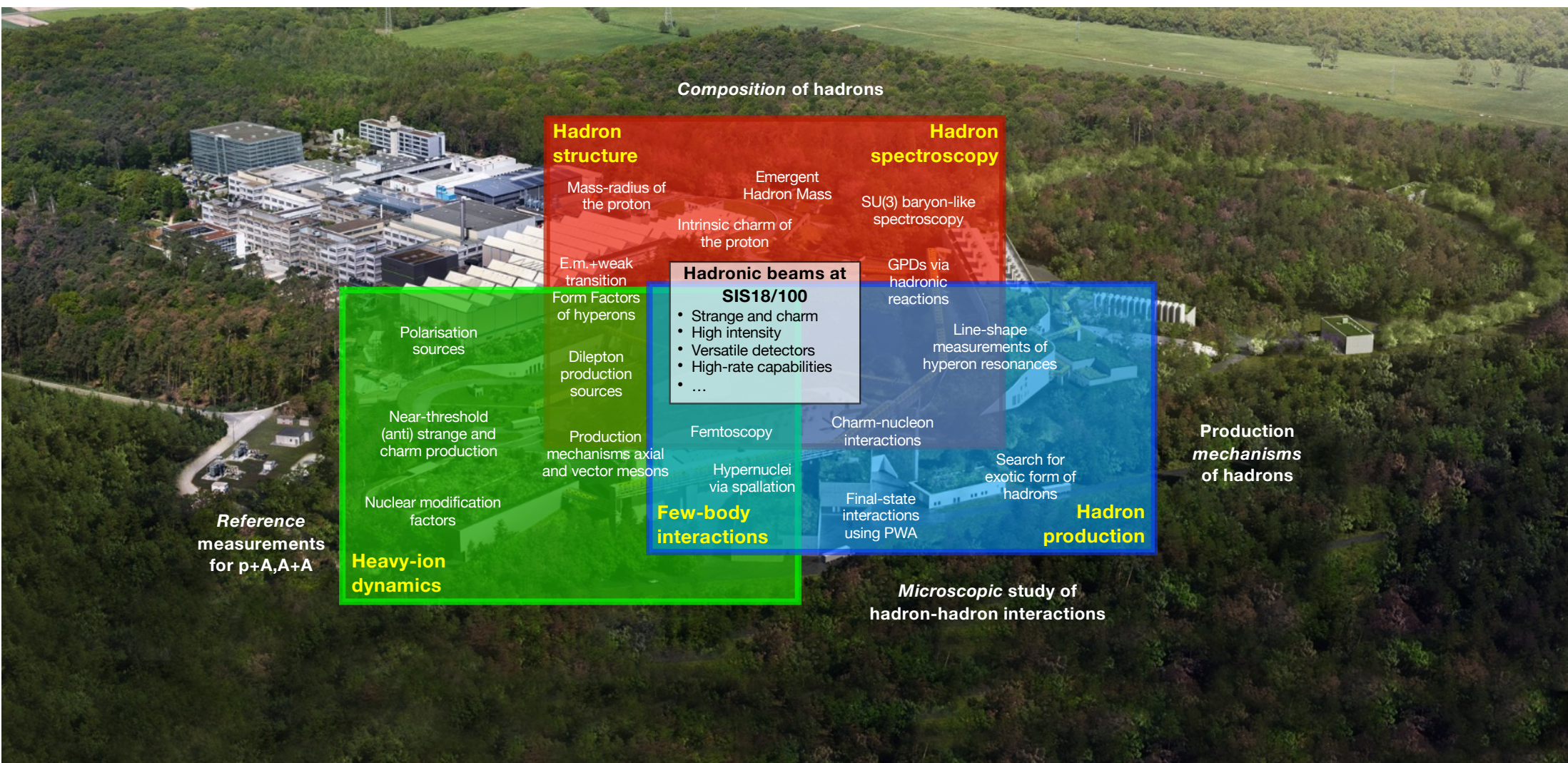
HFHF
Heinrich-Forschungsakademie Hessen für FAIR



A comprehensive QCD program at GSI/FAIR

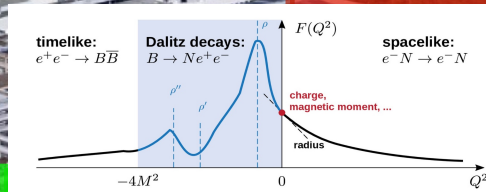


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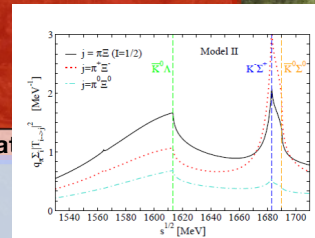


Composition of hadrons

Hadron structure

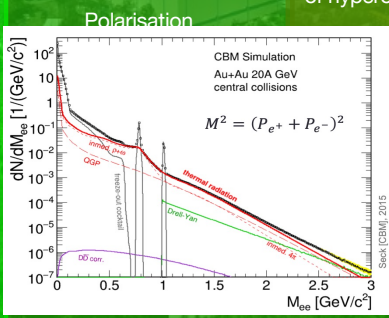


Hadron spectroscopy



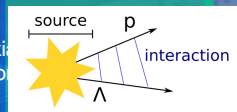
Hadronic beams at SIS18/100

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



Reference measurements for p+A, A+A

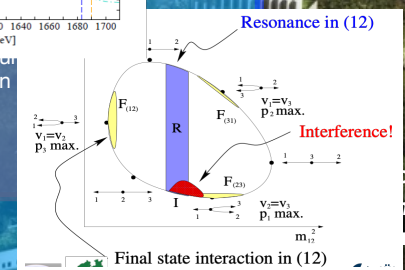
Heavy-ion dynamics



Few-body interactions

Charm-nucleon interactions

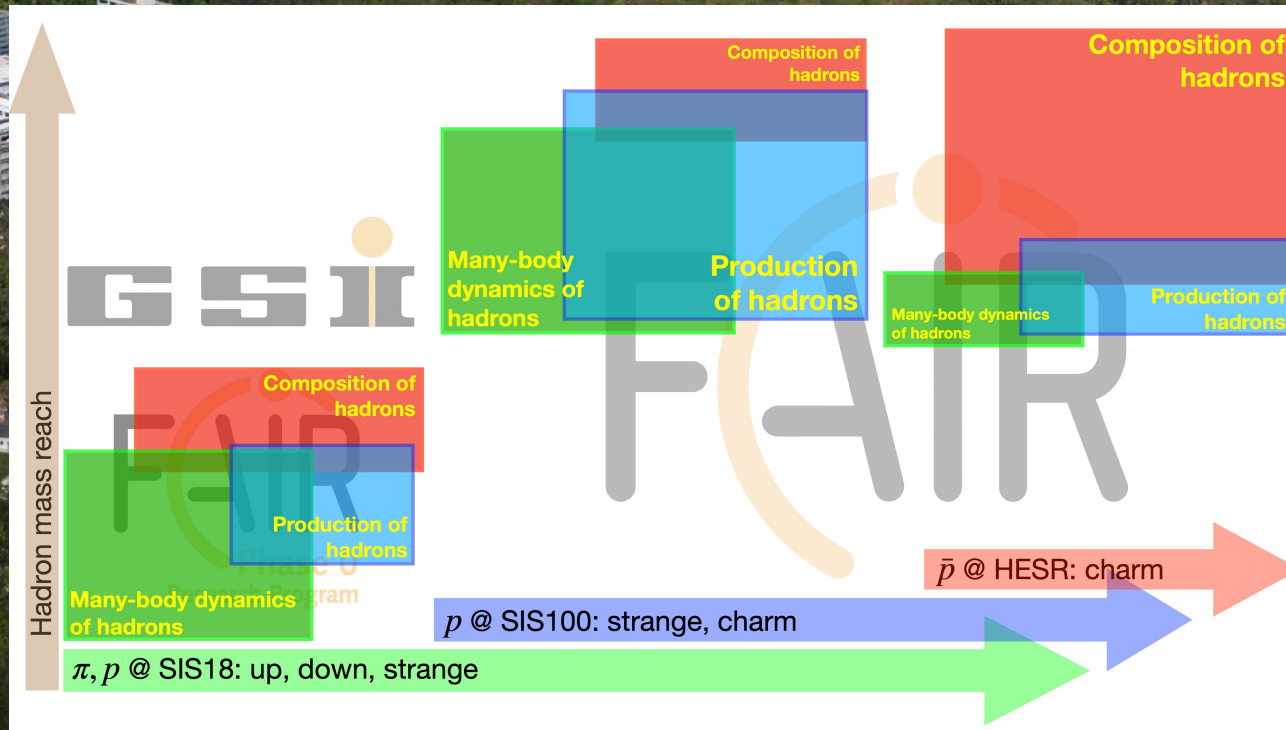
Final-state interactions using PWA



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

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Editors: Frank Nerling, Johan Messchendorp

QCD at FAIR, 2024 – Agenda



Time	Event	Speaker
09:00	Highlight talk Chapter 3, (title tbd)	Daniel Winney
09:00 - 09:30	KBW.1.017 (Lecture Hall+Sideroom), GSI	
09:30 - 10:00	"Flavour-exotic pentaquarks and where to find them"	Nils Husken
10:00	KBW.1.017 (Lecture Hall+Sideroom), GSI	
10:00 - 10:30	Highlight talk Chapter 5, "Nucleon Structure: Internal charm and trace anomaly"	Stefan Diehl
10:30 - 11:00	KBW.1.017 (Lecture Hall+Sideroom), GSI	
11:00	Chapter 1 + 2	
11:00 - 11:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
11:15 - 11:30	Chapter 3	
11:30 - 11:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
11:45 - 12:00	Chapter 4	
12:00 - 12:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
12:15 - 12:30	Chapter 5	
12:30 - 12:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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13:00 - 13:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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13:30 - 13:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
13:45 - 14:00	Chapter 8	
14:00 - 14:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
14:15 - 14:30	Chapter 9	
14:30 - 14:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
14:45 - 15:00	Chapter 10	
15:00 - 15:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
15:15 - 15:30	Chapter 11	
15:30 - 15:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
15:45 - 16:00	Chapter 12	
16:00 - 16:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
16:15 - 16:30	Chapter 13	
16:30 - 16:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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17:00 - 17:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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18:15 - 18:30	Chapter 17	
18:30 - 18:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
18:45 - 19:00	Chapter 18	
19:00 - 19:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
19:15 - 19:30	Chapter 19	
19:30 - 19:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
19:45 - 20:00	Chapter 20	
20:00 - 20:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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20:30 - 20:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
20:45 - 21:00	Chapter 22	
21:00 - 21:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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22:00 - 22:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
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23:00 - 23:15	KBW.1.017 (Lecture Hall+Sideroom), GSI	
23:15 - 23:30	Chapter 27	
23:30 - 23:45	KBW.1.017 (Lecture Hall+Sideroom), GSI	
23:45 - 00:00	Chapter 28	

Time	Event	Speaker
09:00	Amber overview	Kai-Thomas Brinkmann
09:00 - 09:30	Lecture Hall KBW.1.017, GSI	
09:30 - 10:00	WASA overview	
10:00	Lecture Hall KBW.1.017, GSI	
10:00 - 10:30	"Opportunities for Antiproton Physics with COSY at FAIR"	Klaus Peters
10:30 - 11:00	Lecture Hall KBW.1.017, GSI	
11:00	Highlight talk Chapter 6 (tbd)	
11:00 - 11:30	Lecture Hall KBW.1.017, GSI	
11:30 - 12:00	Highlight talk Chapter 7, "Matter"	Manuel Lorenz
12:00	Lecture Hall KBW.1.017, GSI	
12:00 - 12:30	Highlight talk Chapter 8, "High energy fragmentation reaction and its importance for the galaxy's structure"	Prof. Takehiko Saito
12:30 - 13:15	Lunch break	
13:00	GSI Helmholtzzentrum für Schwerionenforschung GmbH	
13:15 - 13:30	HPS Seminar: "Scattering parameters from Production Reactions"	Christoph Hanhart
13:30 - 14:15	SB3.3.170a, GSI	
14:00	Parallel working group meetings II: Exploiting hadronic beams (Chapter 2)	
14:15 - 15:00	Parallel working group meetings II: Hadron-hadron interactions (Chapter 3)	
15:00	Parallel working group meetings II: Tools and facilities & requirements (Chapter 4)	
15:15 - 16:00	Parallel working group meetings II: Composition of hadrons (Chapter 5)	
16:00	Parallel working group meetings II: Exotic hadrons (Chapter 6)	
16:15 - 17:00	Parallel working group meetings II: Hadrons and dileptons as probes to study cold nuclear matter (Chapter 7)	
17:00	Parallel working group meetings II: Connection and input to astrophysics (Chapter 8)	
17:15 - 18:00	Parallel working group meetings II: Experimental facilities & requirements (Chapter 9)	
18:00	Parallel working group meetings II: Concluding remarks and summary	
18:15 - 19:00	Parallel working group meetings II: Lunch break	
19:00	Parallel working group meetings II: Visit FAIR-site	

Time	Event	Speaker
09:30 - 10:00	"Charm @ FAIR"	Antoni Szczurek
10:00 - 10:30	Lecture Hall KBW.1.017, GSI	
10:30 - 11:00	Highlight talk Chapter 9 / Simulation	Shreya Roy
11:00 - 11:15	Lecture Hall KBW.1.017, GSI	
11:15 - 11:30	Coffee break	
11:30 - 11:45	KBW Foyer, GSI	
11:45 - 12:00	Chapter 1 + 2	
12:00 - 12:15	KBW.1.017 (AudIt), GSI	
12:15 - 12:30	Chapter 3	
12:30 - 12:45	KBW.1.017 (AudIt), GSI	
12:45 - 13:00	Chapter 4	
13:00 - 13:15	KBW.1.017 (AudIt), GSI	
13:15 - 13:30	Chapter 5	
13:30 - 13:45	KBW.1.017 (AudIt), GSI	
13:45 - 14:00	Chapter 6	
14:00 - 14:15	KBW.1.017 (AudIt), GSI	
14:15 - 14:30	Chapter 7	
14:30 - 14:45	KBW.1.017 (AudIt), GSI	
14:45 - 15:00	Chapter 8	
15:00 - 15:15	KBW.1.017 (AudIt), GSI	
15:15 - 15:30	Chapter 9	
15:30 - 15:45	KBW.1.017 (AudIt), GSI	
15:45 - 16:00	Concluding remarks and summary	Johan Messchendorp
16:00 - 16:15	KBW.1.017 (AudIt), GSI	
16:15 - 16:30	Lunch break	
16:30 - 16:45	GSI Helmholtzzentrum für Schwerionenforschung GmbH	
16:45 - 17:00	Visit FAIR-site	

In Summary:

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

Time	Event	Speaker
09:00 - 13:00	GSI Helmholtzzentrum für Schwerionenforschung GmbH	
13:00 - 14:00	Lunch break	
14:00	GSI Helmholtzzentrum für Schwerionenforschung GmbH	
14:00 - 14:15	Opening	Frank Niering
14:15 - 14:30	SB1.1.201 (AudIt), GSI	
14:30 - 14:45	Welcome by GSI Management	Yvonne Leifels
14:45 - 15:00	SB1.1.201 (AudIt), GSI	
15:00 - 15:15	"On the origin of hadron mass and structure"	Craig Roberts
15:15 - 15:30	SB1.1.201 (AudIt), GSI	
15:30 - 15:45	Employing Hadron beams	Joachim Stroth
15:45 - 16:00	SB1.1.201 (AudIt), GSI	
16:00 - 16:15	"Opportunities with hadron beams for light baryon spectroscopy"	Deborah Röschner
16:15 - 16:30	SB1.1.201 (AudIt), GSI	
16:30 - 16:45	Coffee break	
16:45 - 17:00	SB1 Foyer, GSI	
17:00 - 17:15	"Femtoscopy / Corre. FCns"	Miguel Albaladejo Serrano
17:15 - 17:30	SB1.1.201 (AudIt), GSI	
17:30 - 17:45	"Quark-diquark correlations in baryons"	Gernot Eichmann
17:45 - 18:00	SB1.1.201 (AudIt), GSI	
18:00 - 18:15	Highlight talk Chapter 4, "Probing final state interactions with femtoscopy"	Hanna Zdrozarczyk
18:15 - 18:30	SB1.1.201 (AudIt), GSI	
18:30 - 18:45	"QCD, EOS and neutron star mergers"	Andreas Bauswein
18:45 - 19:00	SB1.1.201 (AudIt), GSI	
19:00 - 19:15	Welcome Reception	



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

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

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11:15 - 11:30	Coffee break	
11:30 - 11:45	KBW Foyer, GSI	
11:45 - 12:00	Chapter 1 + 2	
12:00 - 12:15	KBW.1.017 (AudIt), GSI	
12:15 - 12:30	Chapter 3	
12:30 - 12:45	KBW.1.017 (AudIt), GSI	
12:45 - 13:00	Chapter 4	
13:00 - 13:15	KBW.1.017 (AudIt), GSI	
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15:45 - 16:00	Concluding remarks and summary	Johan Messchendorp
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16:30 - 16:45	GSI Helmholtzzentrum für Schwerionenforschung GmbH	
16:45 - 17:00	Visit FAIR-site	

Time	Topic	Speaker
13:00	Lunch break	
14:00	Opening	
14:00 - 14:15	SBI.1.201 (AudIt), GSI	
14:15 - 14:30	Welcome by GSI Management	
14:30 - 14:45	SBI.1.201 (AudIt), GSI	
14:45 - 15:00	"On the origin of hadron mass and structure"	
15:00 - 15:15	SBI.1.201 (AudIt), GSI	
15:15 - 15:30	Employing Hadron beams	
15:30 - 15:45	SBI.1.201 (AudIt), GSI	
15:45 - 16:00	"Opportunities with hadron beams for light baryon spectroscopy"	
16:00 - 16:15	SBI.1.201 (AudIt), GSI	
16:15 - 16:30	Coffee break	
16:30 - 16:45	SBI Foyer, GSI	
16:45 - 17:00	"Femtoscopy / Corre. Fctns"	Miguel A...
17:00 - 17:15	SBI.1.201 (AudIt), GSI	
17:15 - 17:30	"Quark-diquark correlations in baryons"	Gernot Eichmann
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18:15 - 18:30	"QCD, EOS and neutron star mergers"	Andreas Bauswein
18:30 - 18:45	SBI.1.201 (AudIt), GSI	
18:45 - 19:00	Welcome Reception	

Social Events:

- Reception (Mon, evening)
 - Work-Dinner (Tue, evening)
 - Conference Dinner (Wed, evening)
 - FAIR Construction site visit (Thu, afternoon)
- (all free of charge)

Time	Topic	Speaker
18:00	Dinner at GSI	

Time	Topic	Speaker
16:00 - 16:30	Parallel working group meetings II: Experimental facilities & requirements (Chapter 9)	
16:30 - 18:30	Parallel working group meetings II: Connection and input to astro(particle) physics (Chapter 8)	
16:30 - 18:30	Parallel working group meetings II: Experimental facilities & requirements (Chapter 9)	

In Summary:

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

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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Thank you for your participation!



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