

**BERGISCHE
UNIVERSITÄT
WUPPERTAL**



**Introduction to the
workshop:
Background, purpose, and
workshop objectives**



Johan Messchendorp (GSI & FAIR)
Physics opportunities with proton beams at SIS100, Feb 6-9, 2024, Wuppertal

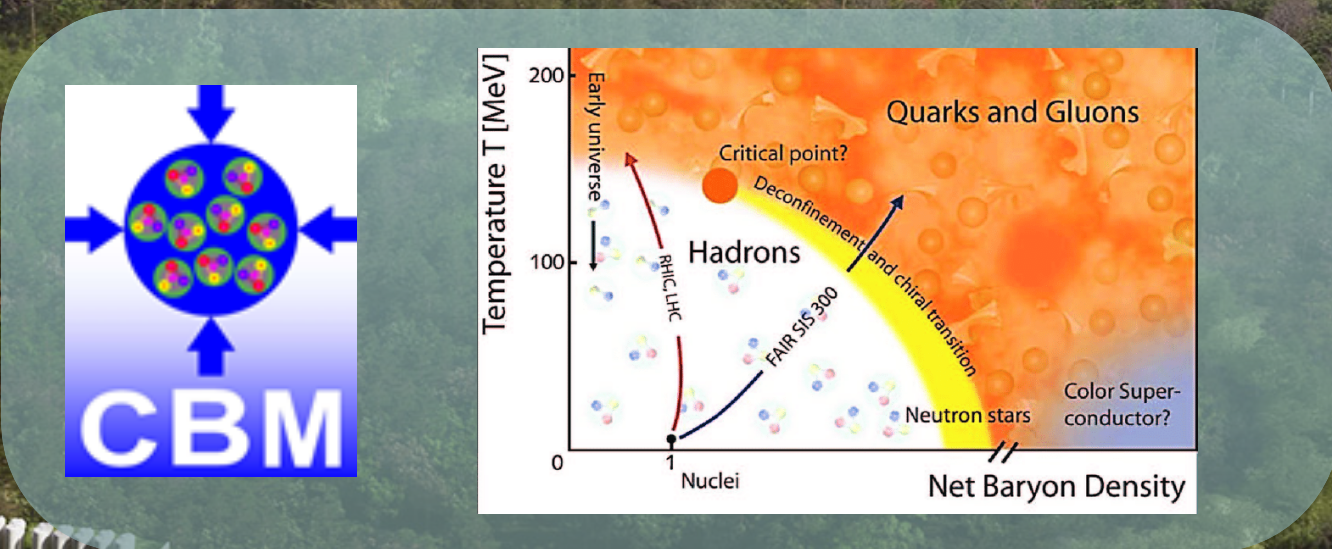








APPA

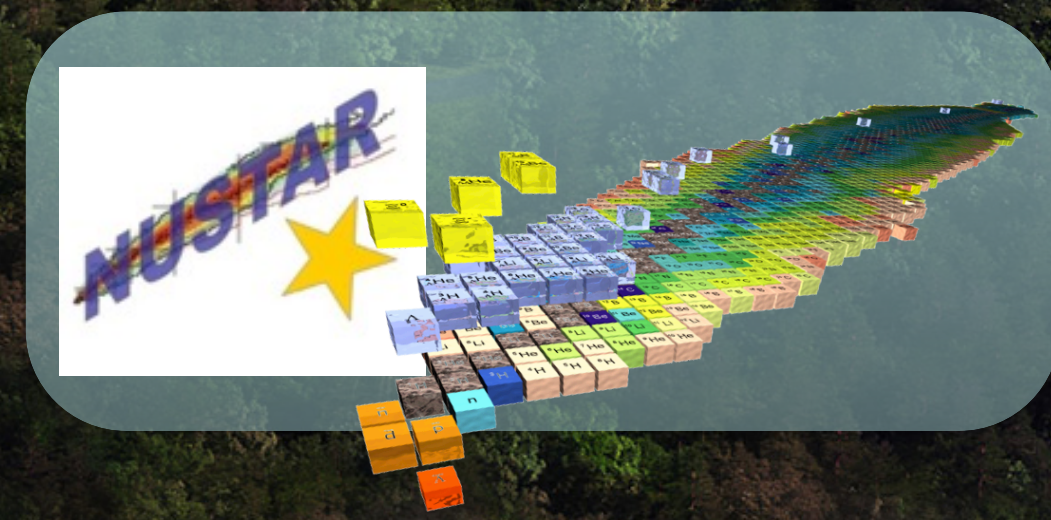
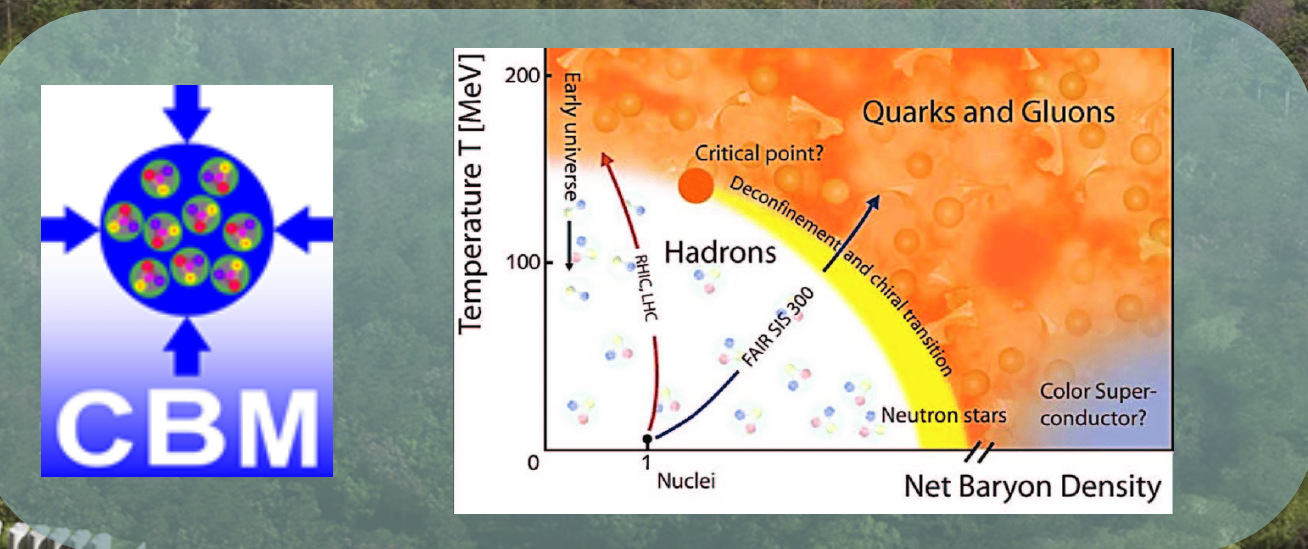


panda

NUSTAR

Facility for Antiproton and Ion Research -
"The Universe in the Laboratory"

$$\mathcal{L}_{\text{QCD}} = \sum_{q=u,d,s,c,b} \bar{q} (i\gamma_{\mu} D^{\mu} - m_q) q - \frac{1}{4} G^{\mu\nu} G_{\mu\nu}$$



Properties of strongly interacting matter

Formation of hadronic matter

Underlying symmetries

Degrees of freedom: from quarks/gluons to baryons/mesons

Origin of mass

Purpose

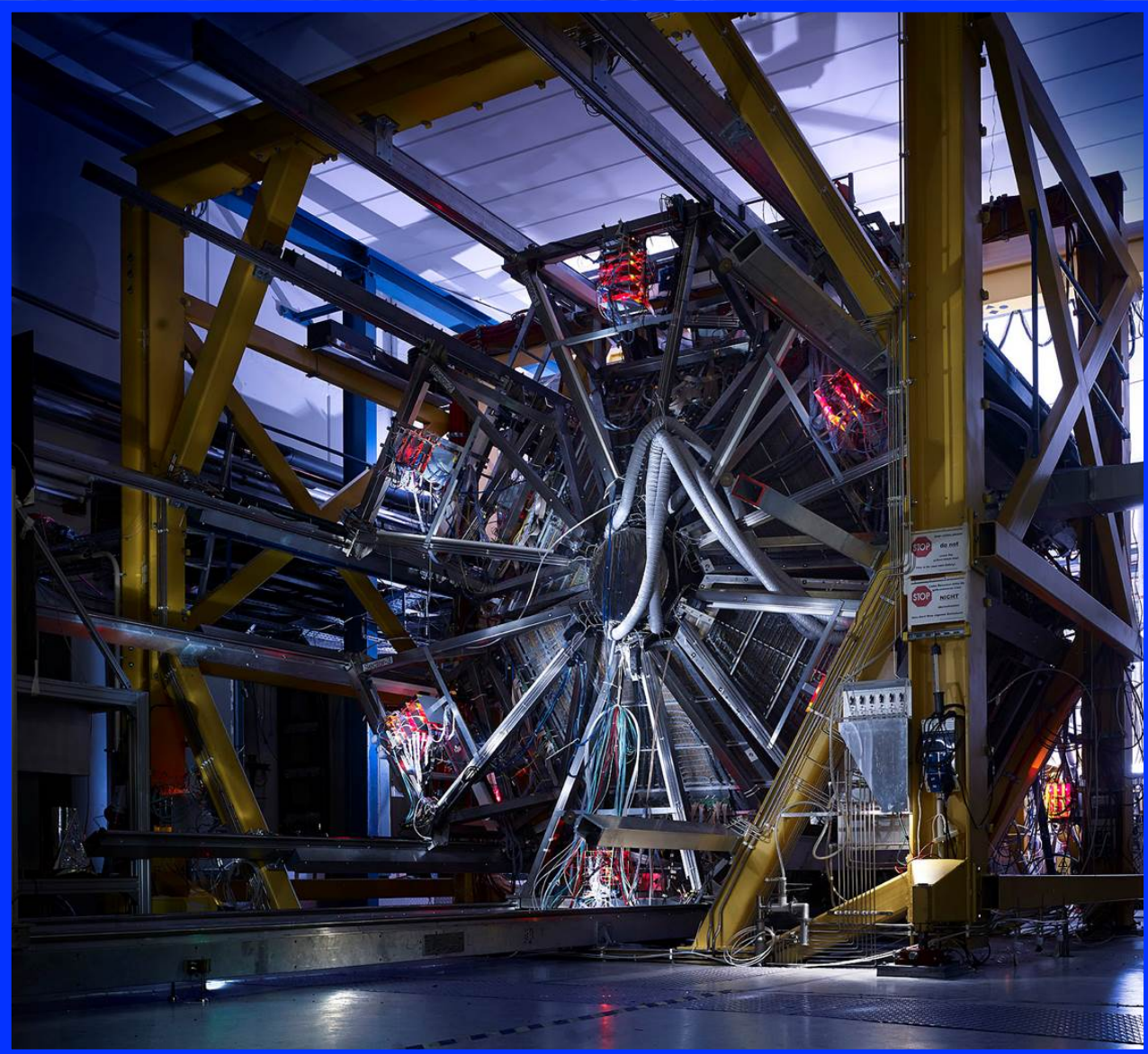
...the context

- **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**
- **Strengthen collaborations** among hadron and heavy-ion communities
- Reach out for **new collaborators** from both experiment and theory!

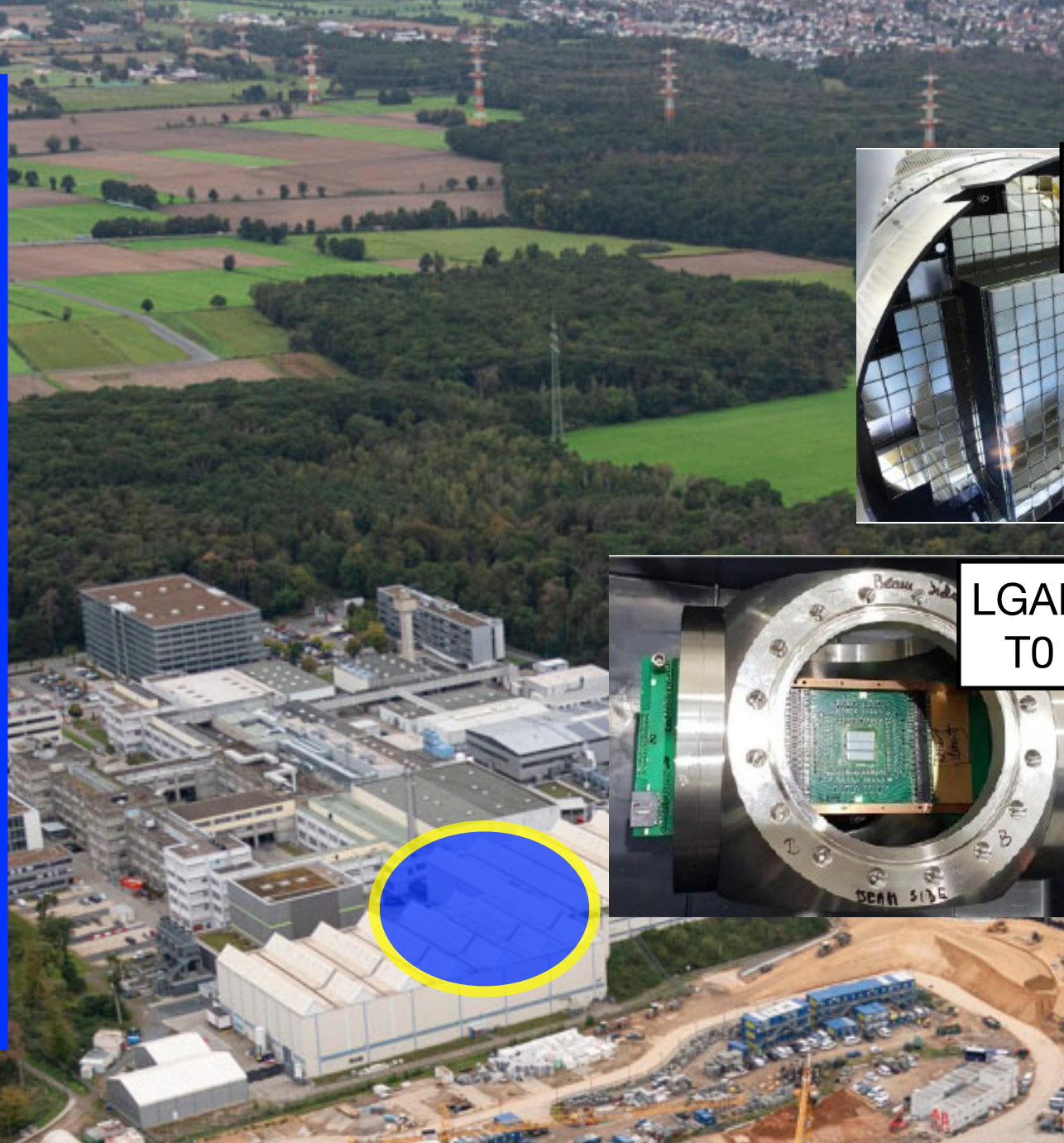
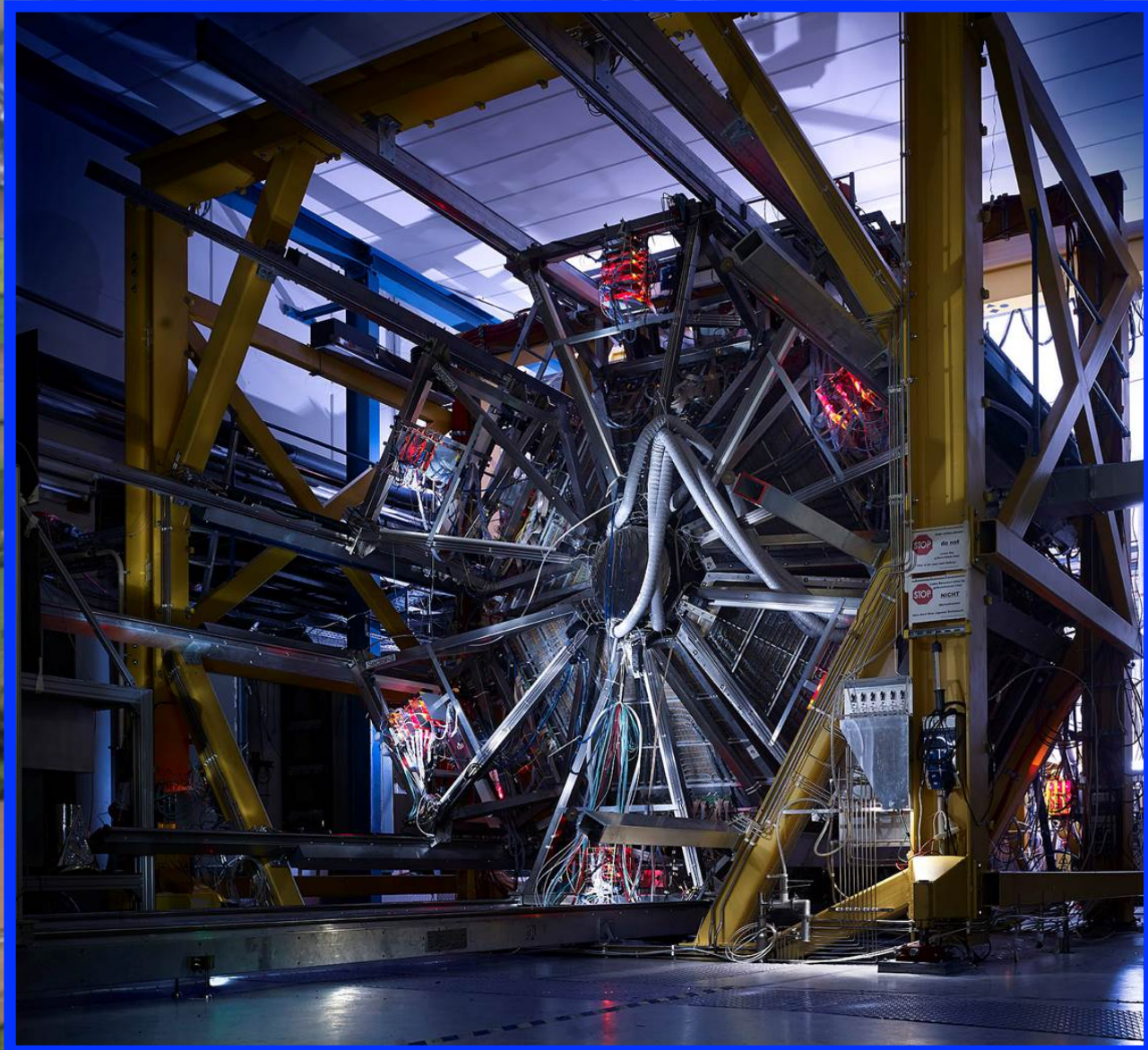




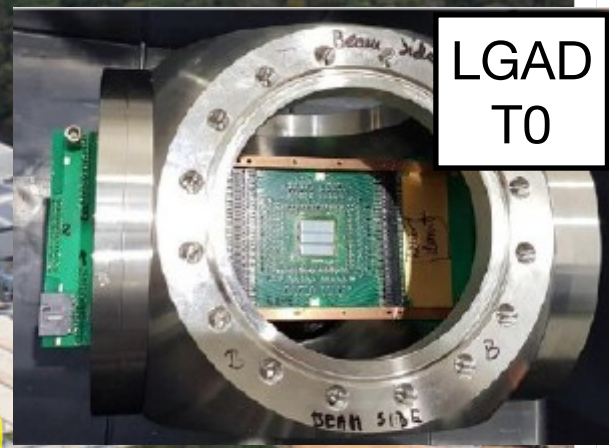




HADES/PANDA@FAIR-Phase-0:
“Hadron physics meets heavy-ion physics”



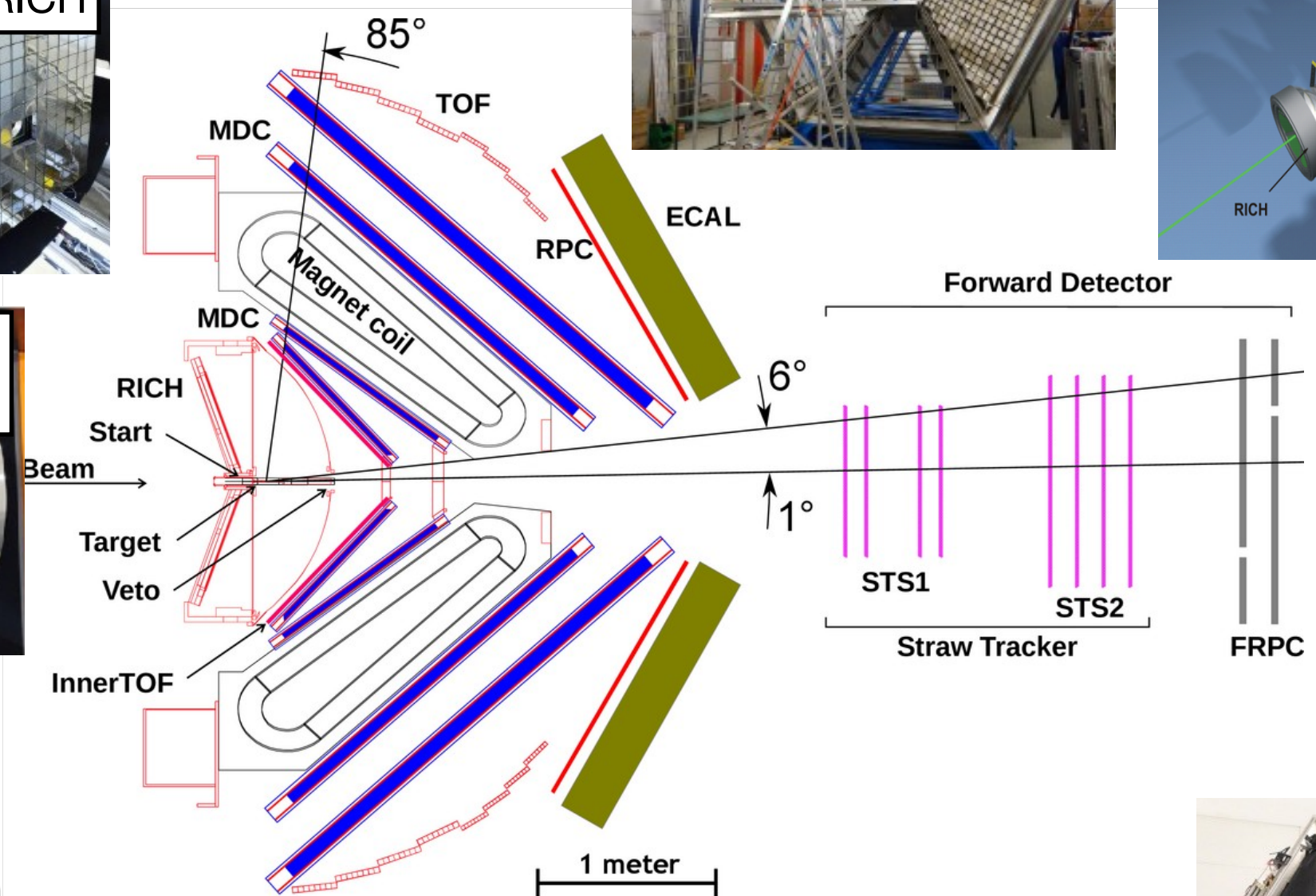
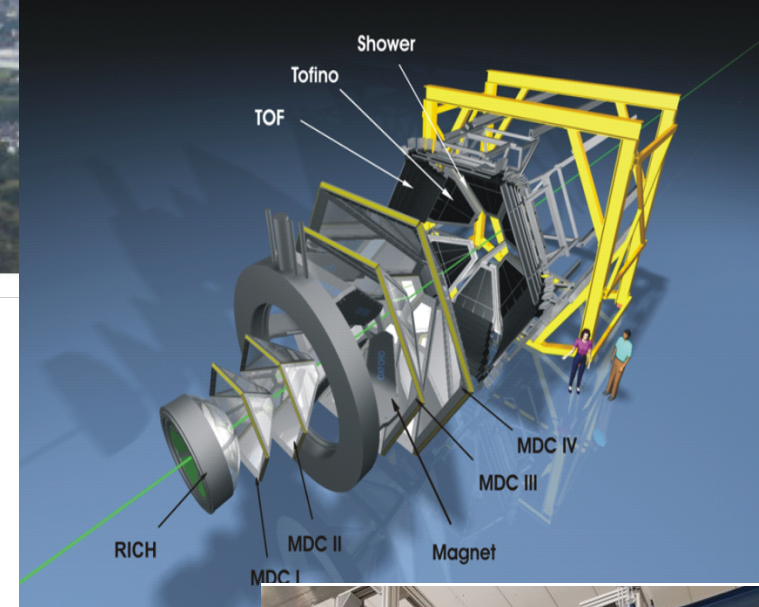
CBM RICH



LGAD TO

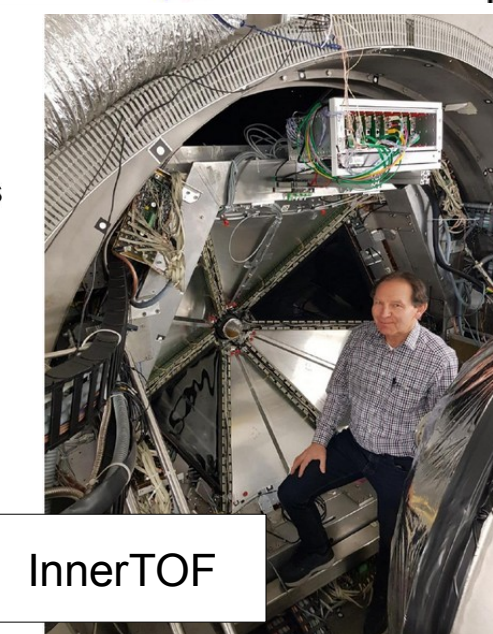
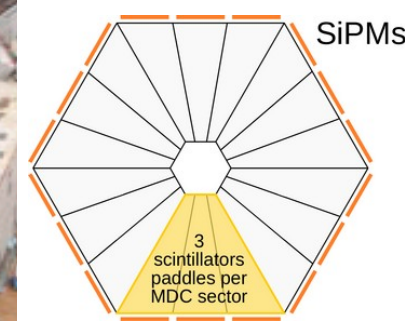


ECAL



fRPC

HADES/PANDA@FAIR-Phase-0:
“Hadron physics meets heavy-ion physics”



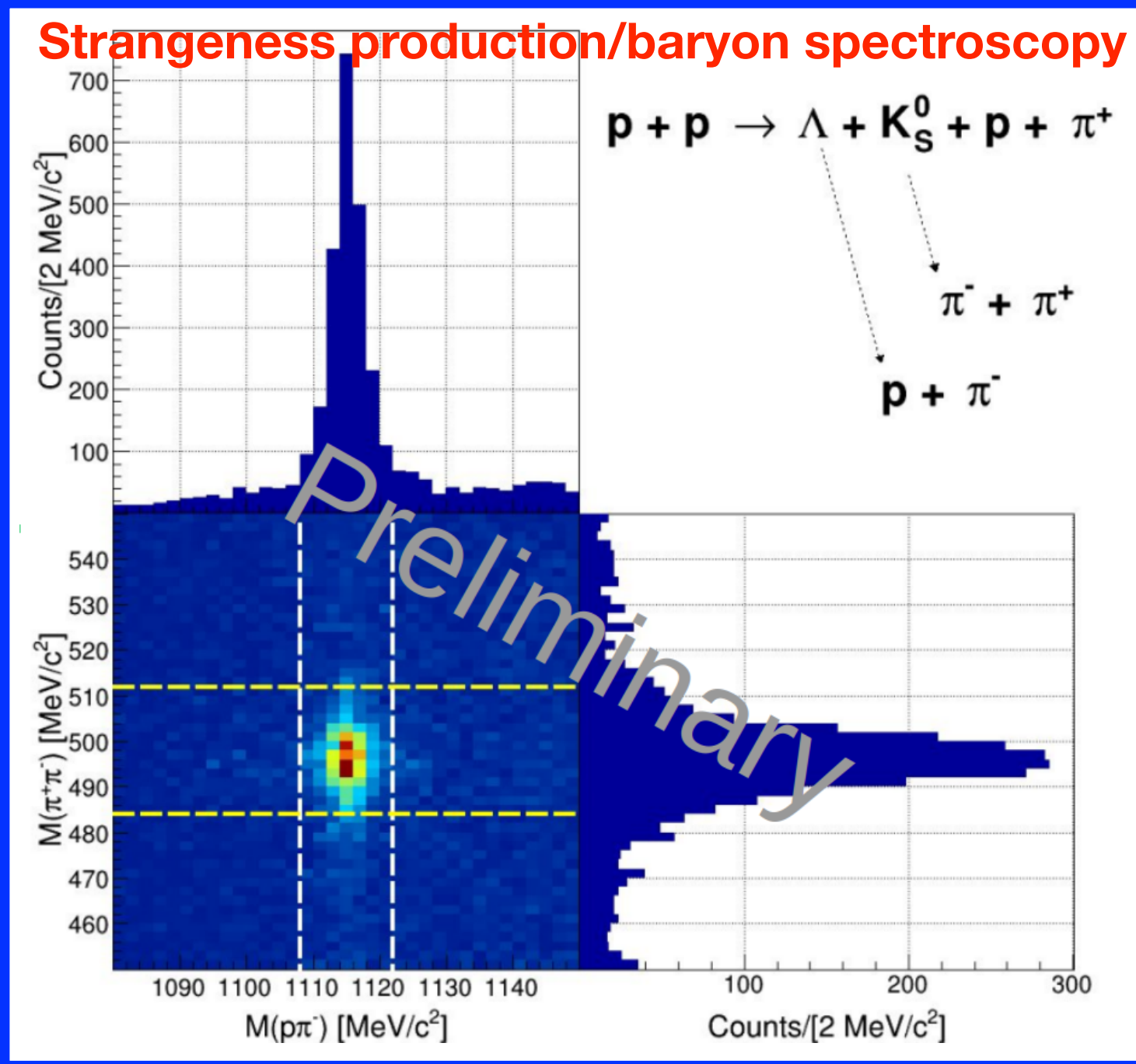
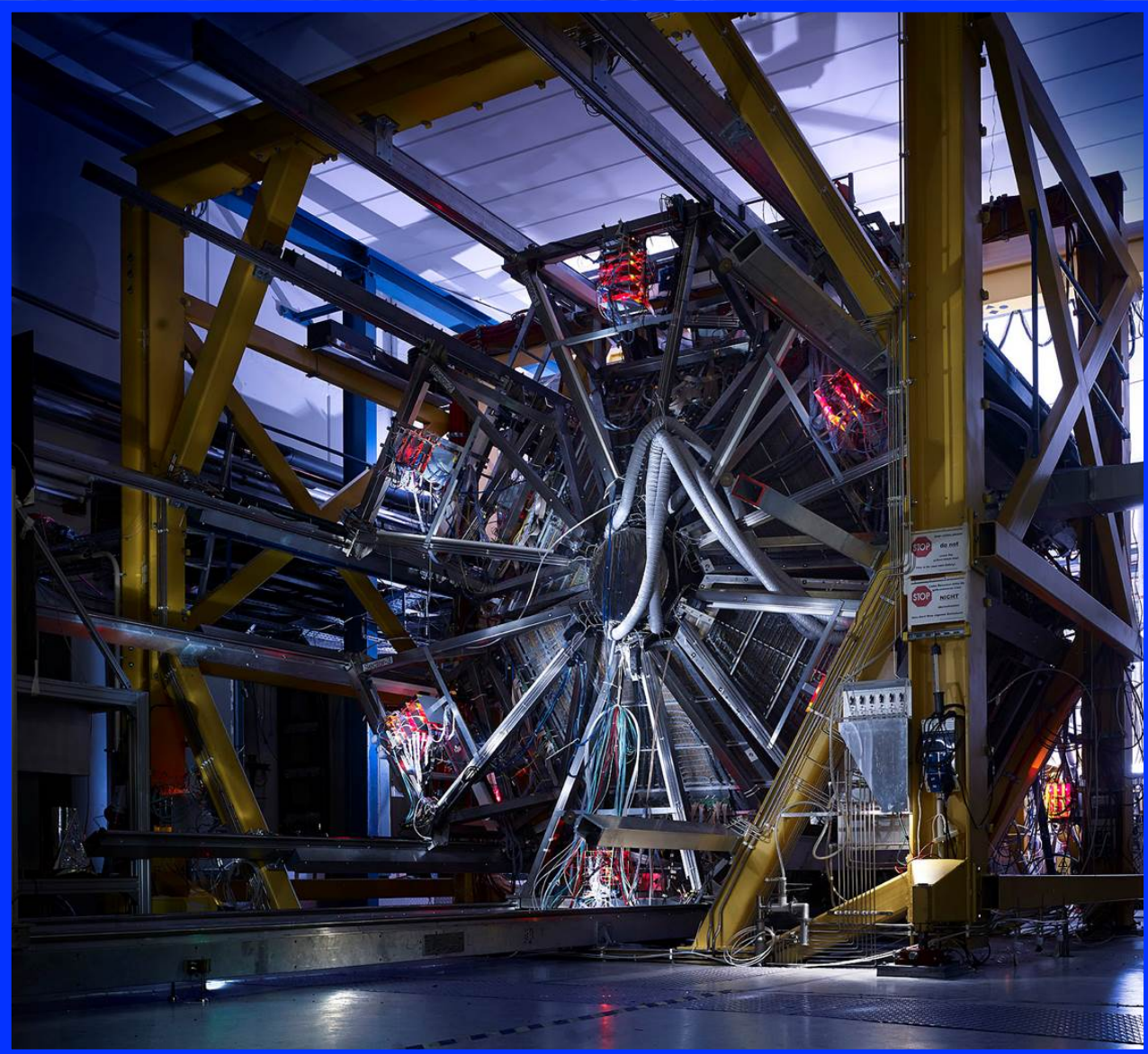
InnerTOF



STS1

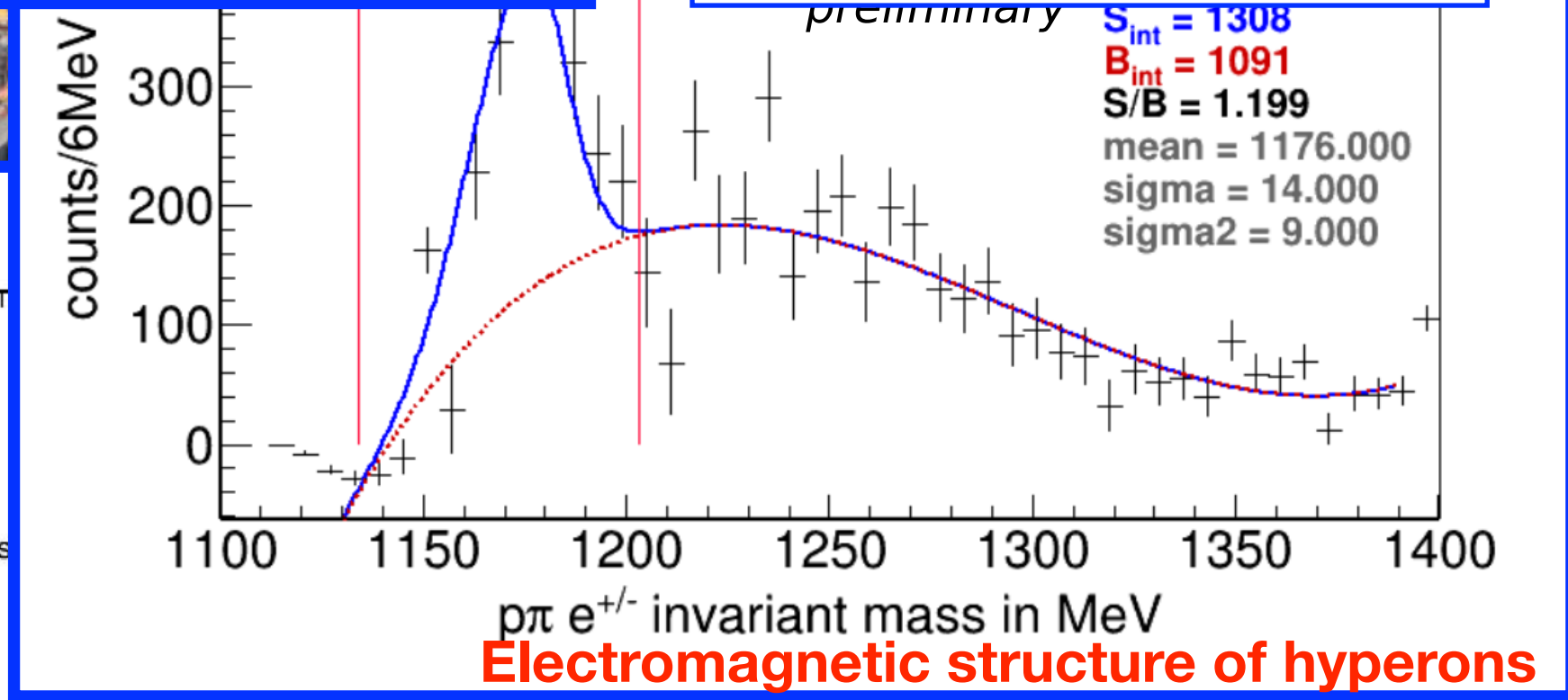


STS2

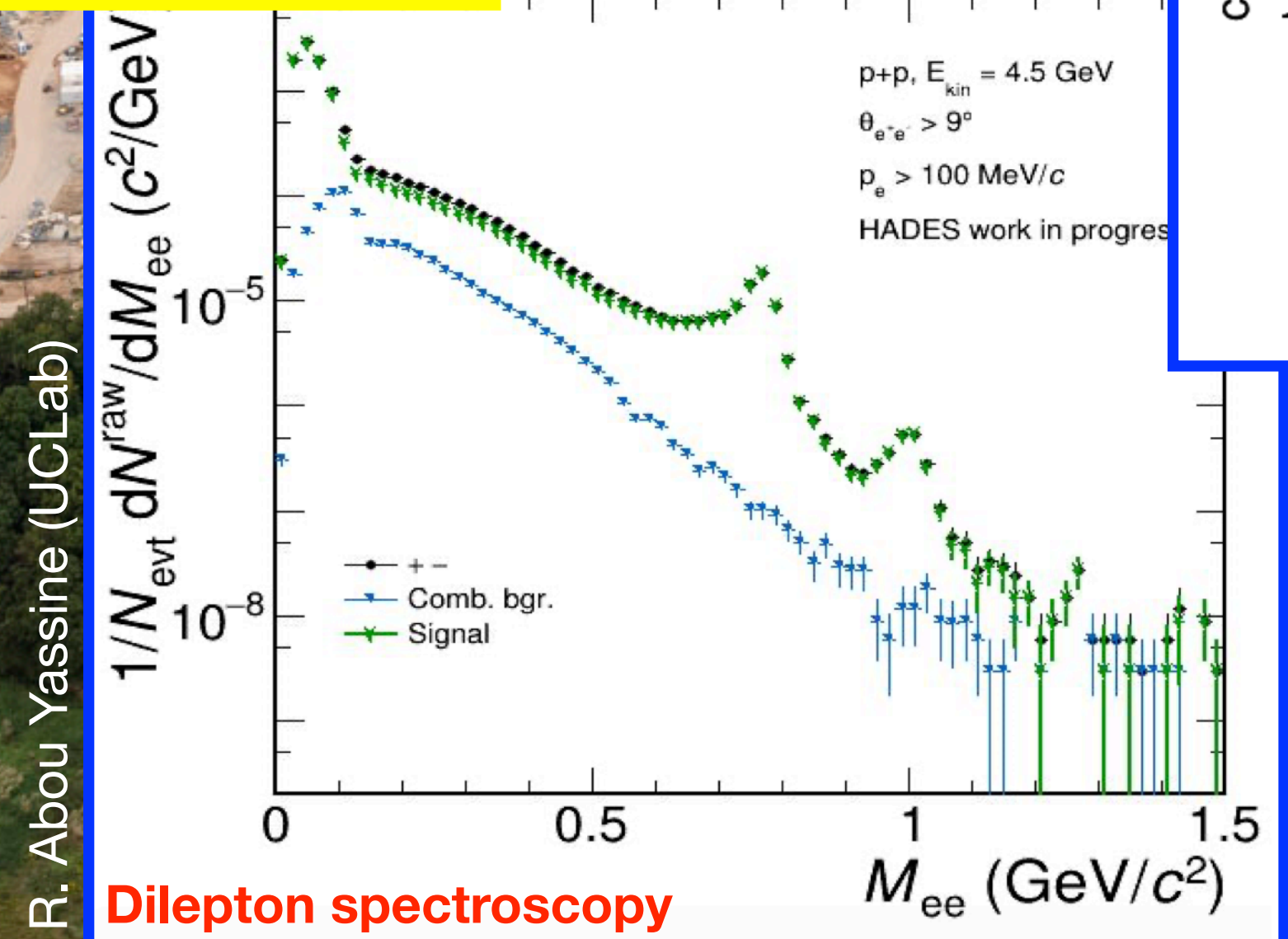


S. Pattnaik (GSI)

HADES/PANDA@FAIR-Phase-0: “Hadron physics meets heavy-ion physics”



J. Rieger (Uppsala)

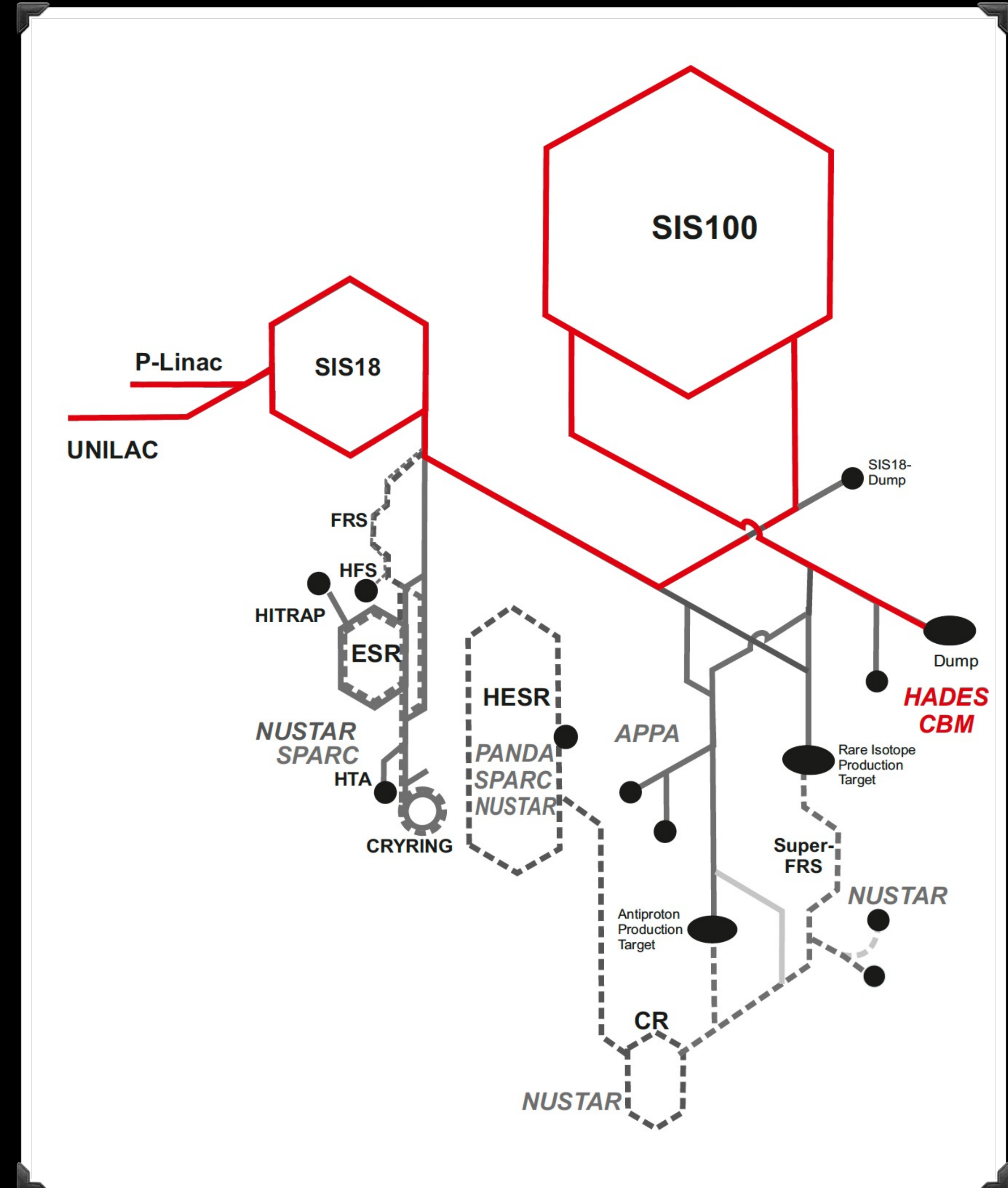


R. Abou Yassine (UCLab)

Recent p+p studies at T=4.5 GeV

From SIS18 to SIS100

...what could that add in proton physics?

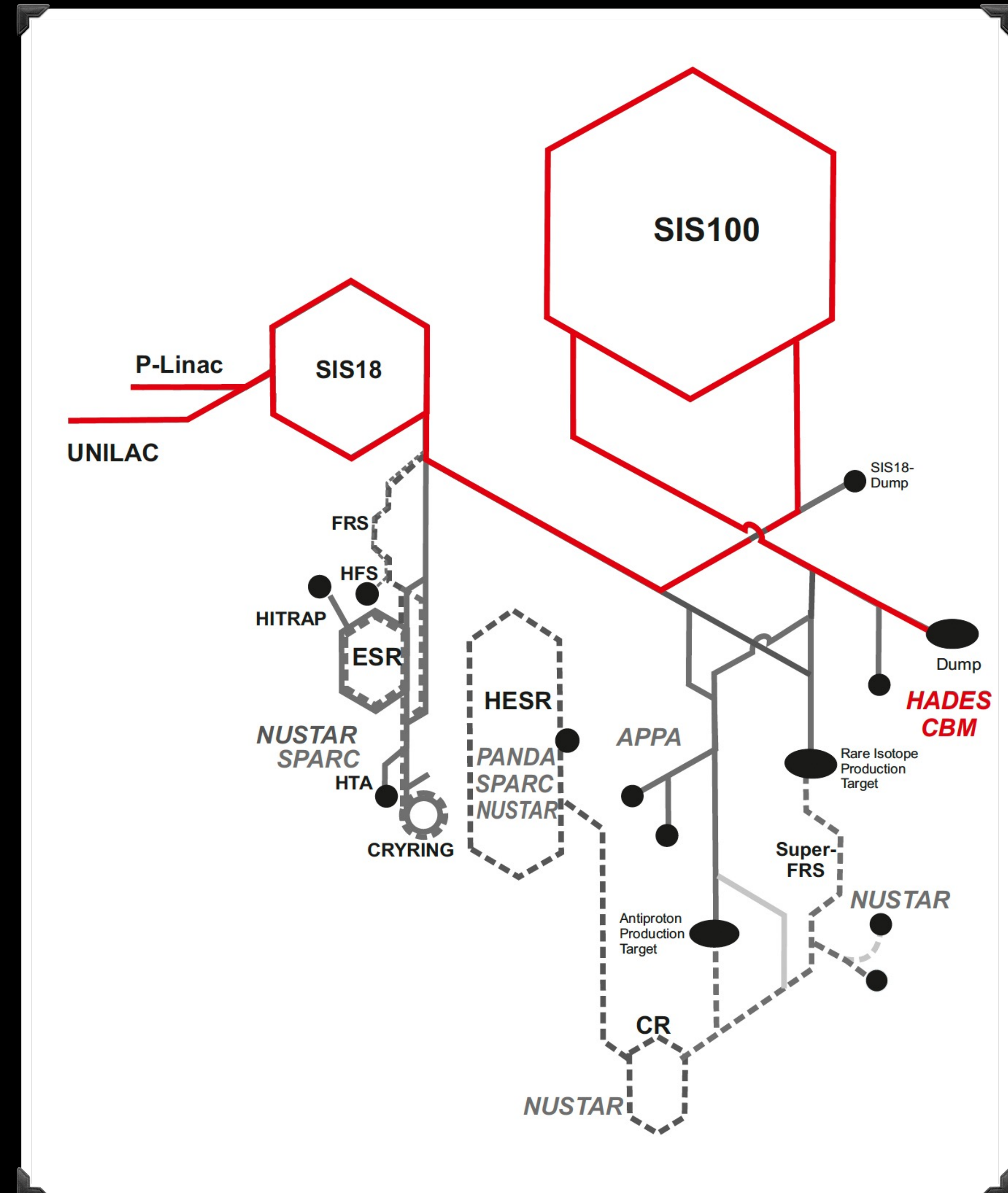


From SIS18 to SIS100

...what could that add in proton physics?

- **Energy upgrade:**

- From max 4.7 GeV (SIS18) to 29 GeV (SIS100) proton energy
- Opening **new realm**: double+triple strangeness and even charm baryons and mesons!
- Significant **increase in production yield** of hyperons



From SIS18 to SIS100

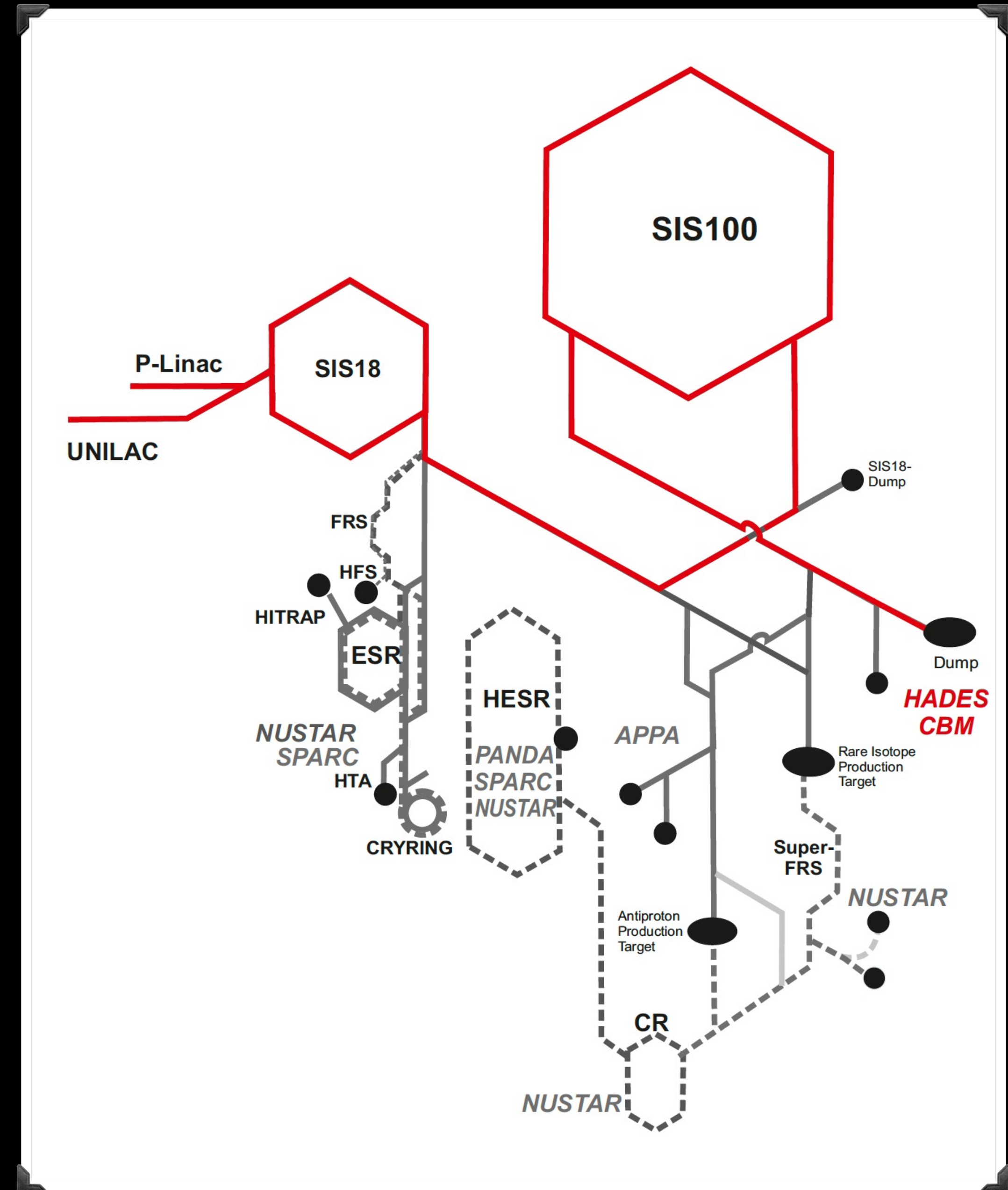
...what could that add in proton physics?

- **Energy upgrade:**

- From max 4.7 GeV (SIS18) to 29 GeV (SIS100) proton energy
- 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: **$\sim 10 \text{ pb}^{-1} \text{ day}^{-1}$**



From SIS18 to SIS100

...what could that add in proton physics?

- **Energy upgrade:**

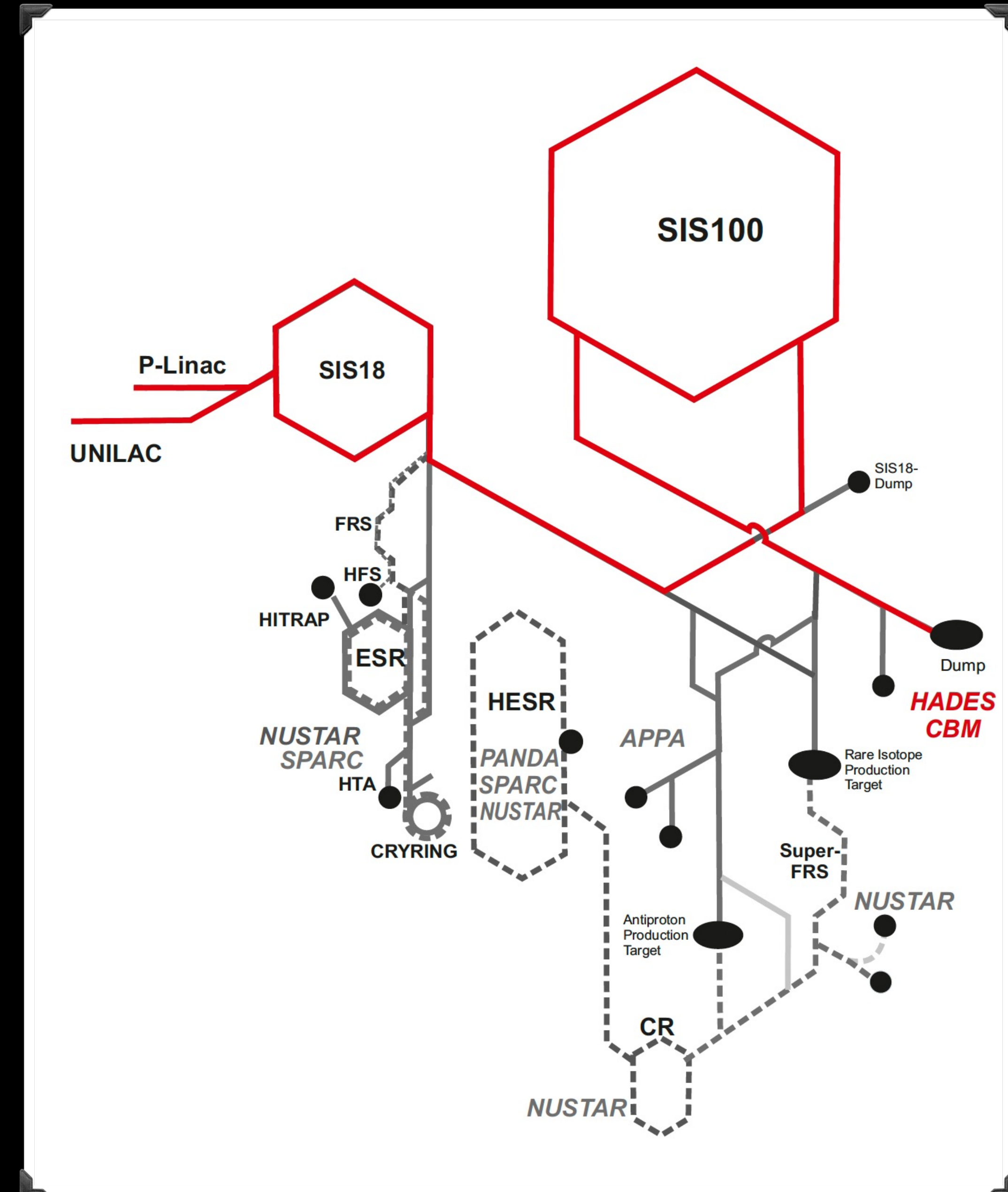
- From max 4.7 GeV (SIS18) to 29 GeV (SIS100) proton energy
- Opening **new realm**: double+triple strangeness and even charm baryons and mesons!
- Significant **increase in production yield** of hyperons

- **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: **$\sim 10 \text{ pb}^{-1} \text{ day}^{-1}$**

- **Detector enrichment:**

- Towards **high-rate capabilities** and free-streaming DAQ's



From SIS18 to SIS100

...what could that add in proton physics?

- **Energy upgrade:**

- From max 4.7 GeV (SIS18) to 29 GeV (SIS100) proton energy
- Opening **new realm**: double+triple strangeness and even charm baryons and mesons!
- Significant **increase in production yield** of hyperons

- **Intensity upgrade:**

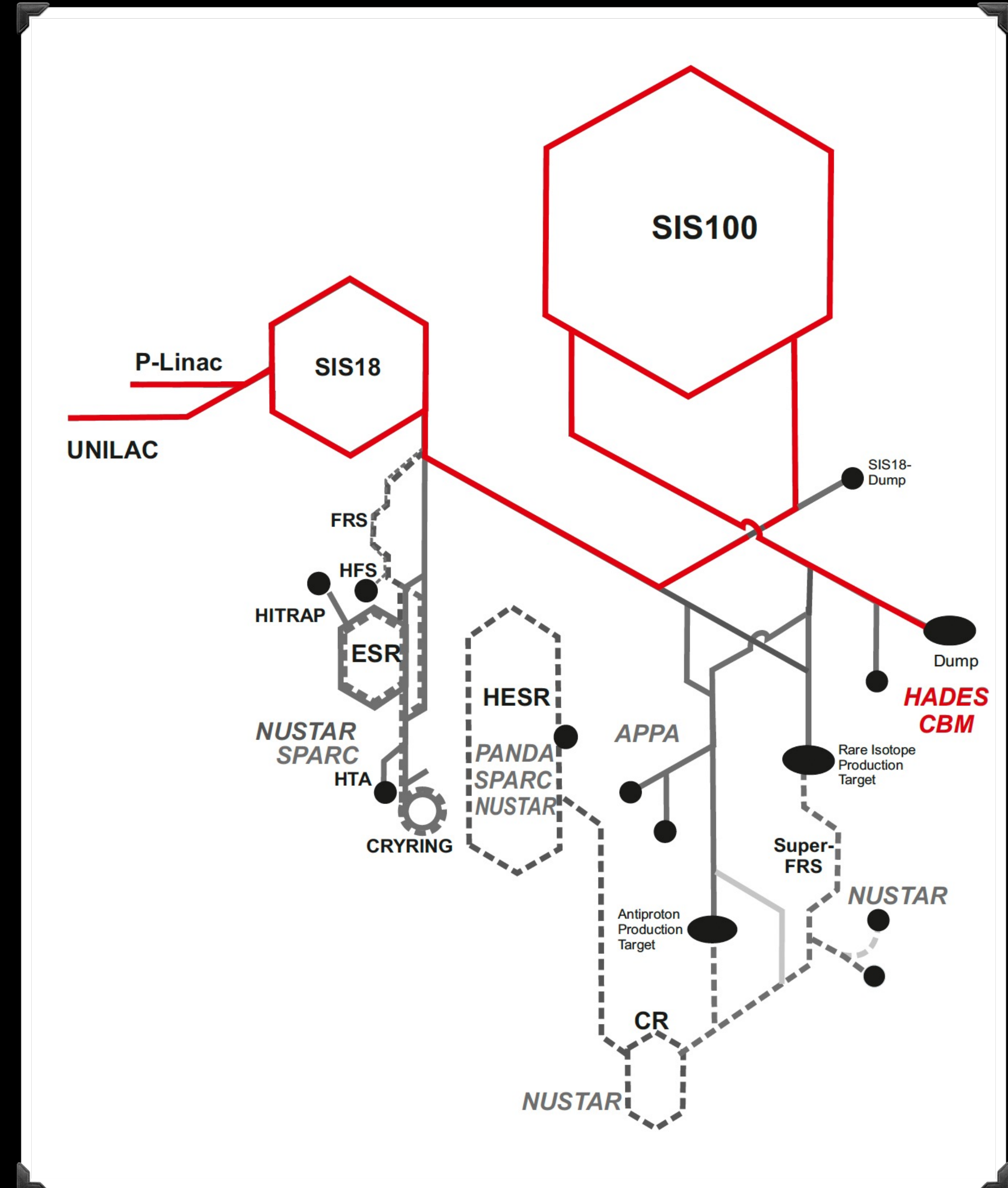
- From max #protons/cycle of 10^{12} (SIS18) to 2×10^{13} (SIS100)
- Even during “commissioning” (10^{10} protons/cycle) and 5 cm LH₂ target: **$\sim 10 \text{ pb}^{-1} \text{ day}^{-1}$**

- **Detector enrichment:**

- Towards **high-rate capabilities** and free-streaming DAQ's

- **Theory enrichment:**

- **Terra incognita**: intellectual challenges in this energy regime!



The process

...activities of last year

- Many preparatory **activities** ongoing since 2023
- **Discussions** among physicists from various FAIR **collaborations**
- **Kick-off satellite event** at MESON2023 in June 2023
- **Feasibility studies** using Monte Carlo simulations
- Presentations at **FAIR advisory boards** ECE/ECSG and JSC
- This **workshop** “*physics opportunities with proton beams at SIS100*”



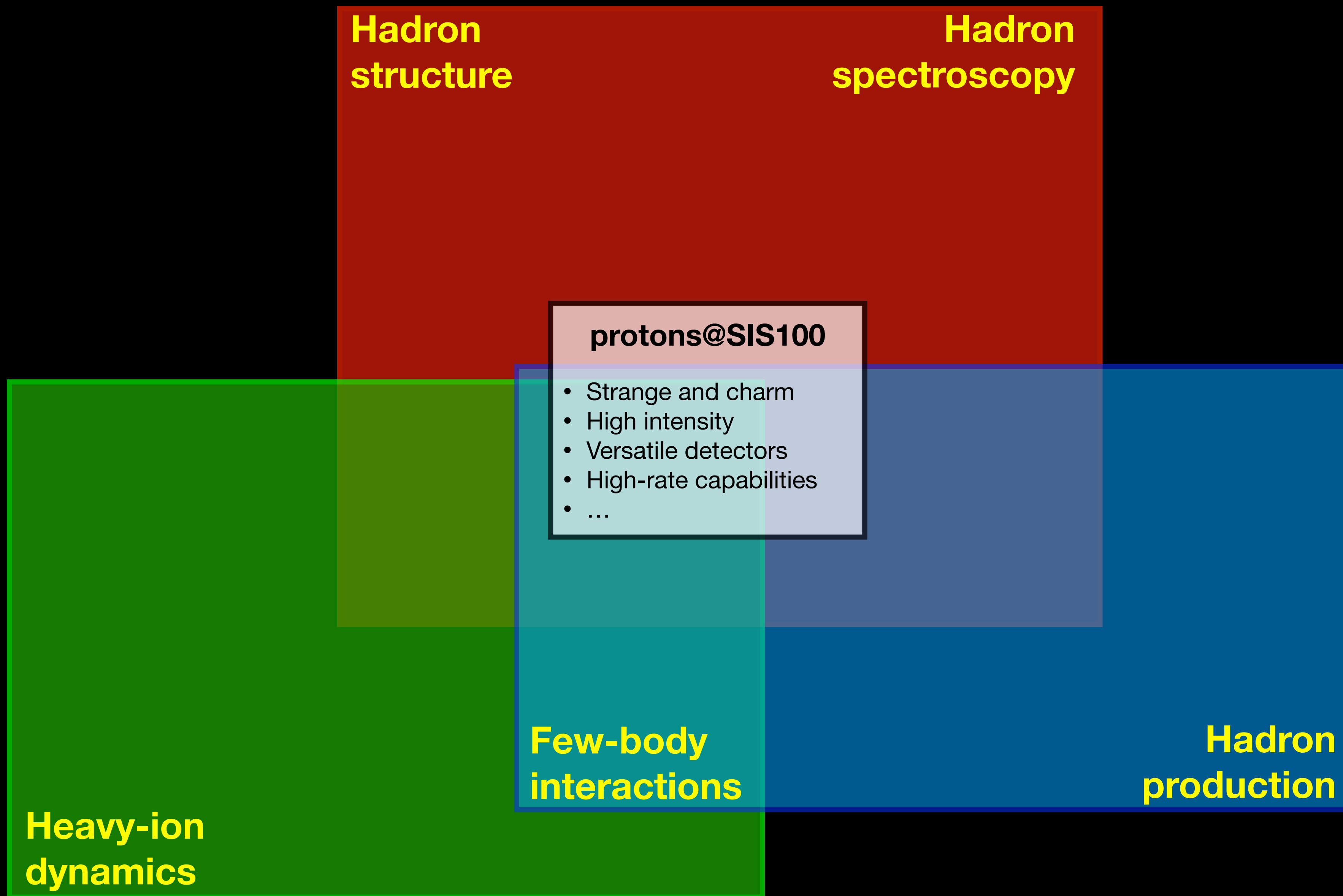
A comprehensive QCD program!

A comprehensive QCD program!

protons@SIS100

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

A comprehensive QCD program!



A comprehensive QCD program!

QCD dynamics within baryons

**Hadron
structure**

**Hadron
spectroscopy**

protons@SIS100

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

*Reference
measurements
for A+A*

*Production
mechanisms
of hadrons*

**Few-body
interactions**

**Hadron
production**

**Heavy-ion
dynamics**

*Microscopic study of
hadron-hadron interactions*

A comprehensive QCD program!

QCD dynamics within baryons

Hadron structure

Mass-radius of the proton

Intrinsic charm of the proton

E.m. transition
Form Factors of hyperons

Hadron spectroscopy

Emergent Hadron Mass

SU(3) baryon-like spectroscopy

protons@SIS100

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

Heavy-ion dynamics

Polarisation sources

Near-threshold (anti) strange and charm production

Nuclear modification factors

Dilepton production sources

Production mechanisms axial and vector mesons

Few-body interactions

Charm-nucleon interactions, SU(4) dynamics

Femtoscopy

Final-state interactions using PWA

Line-shape measurements of hyperon resonances

Search for exotic form of hadrons

Hadron production

Reference measurements for A+A

Production mechanisms of hadrons

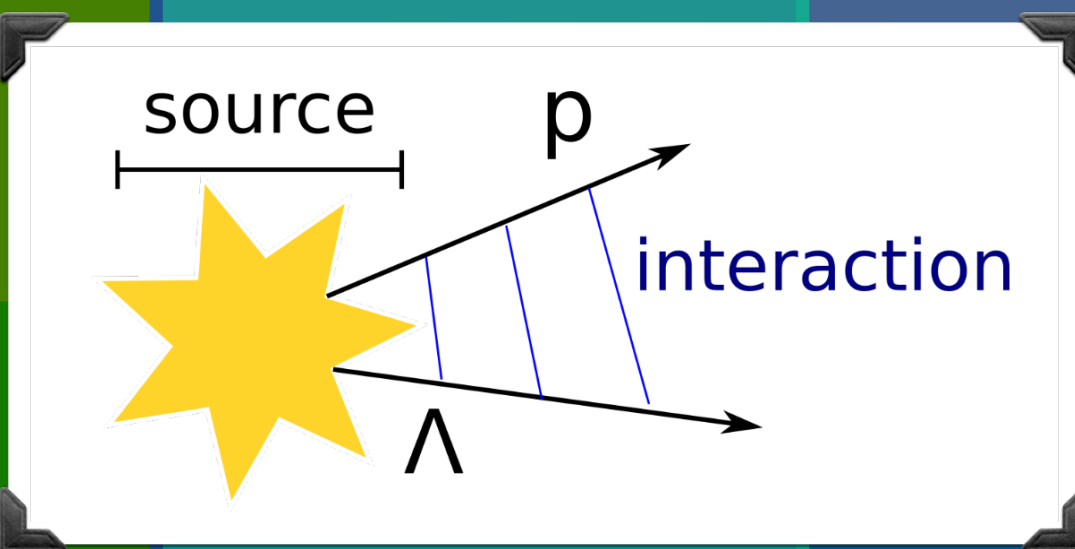
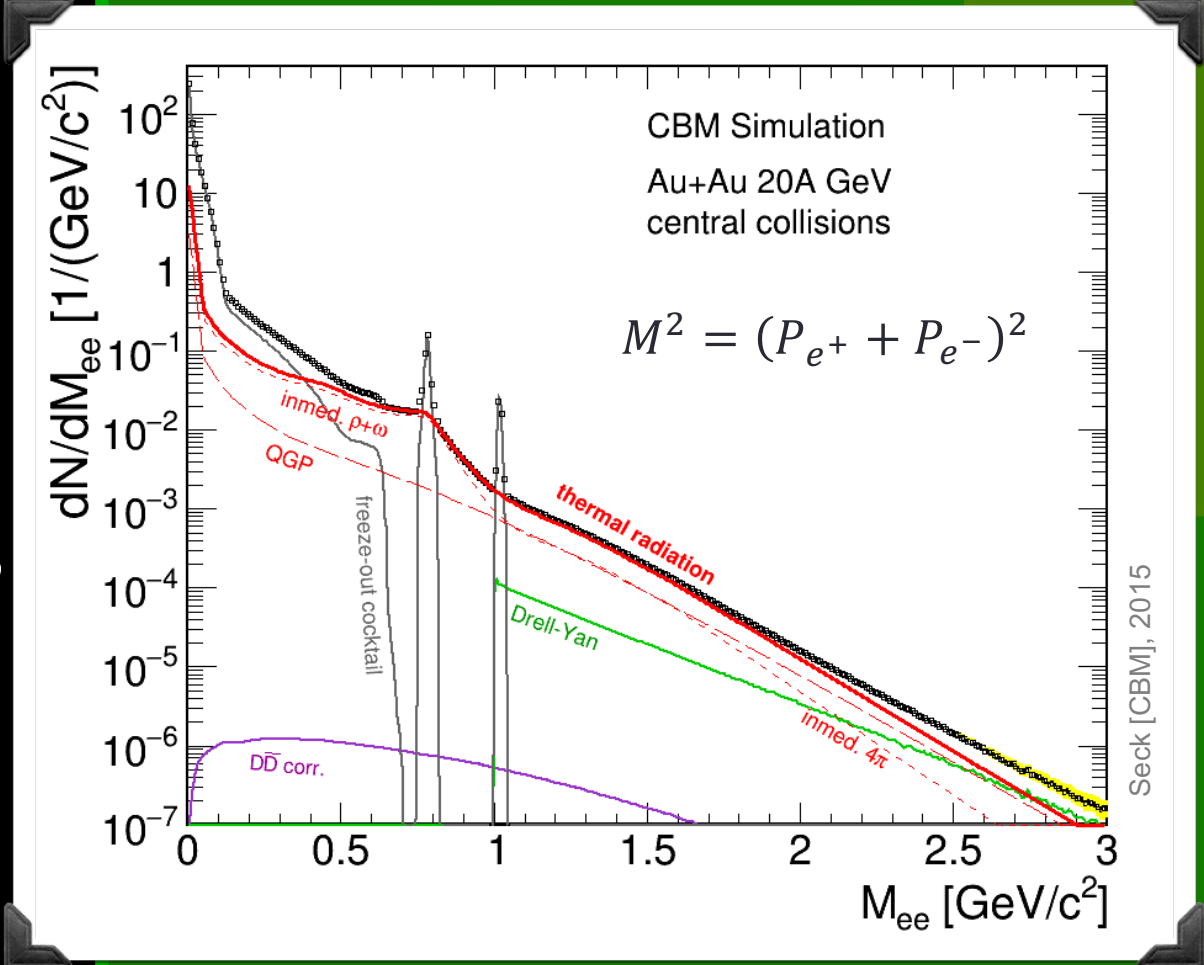
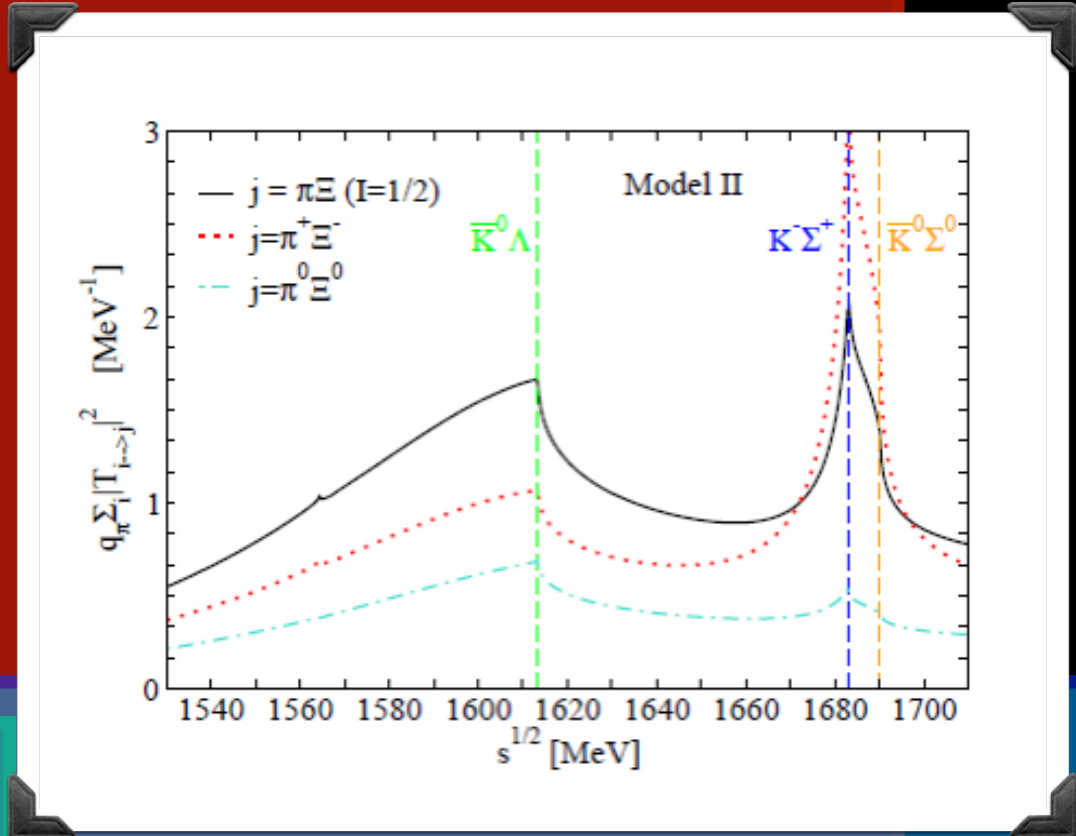
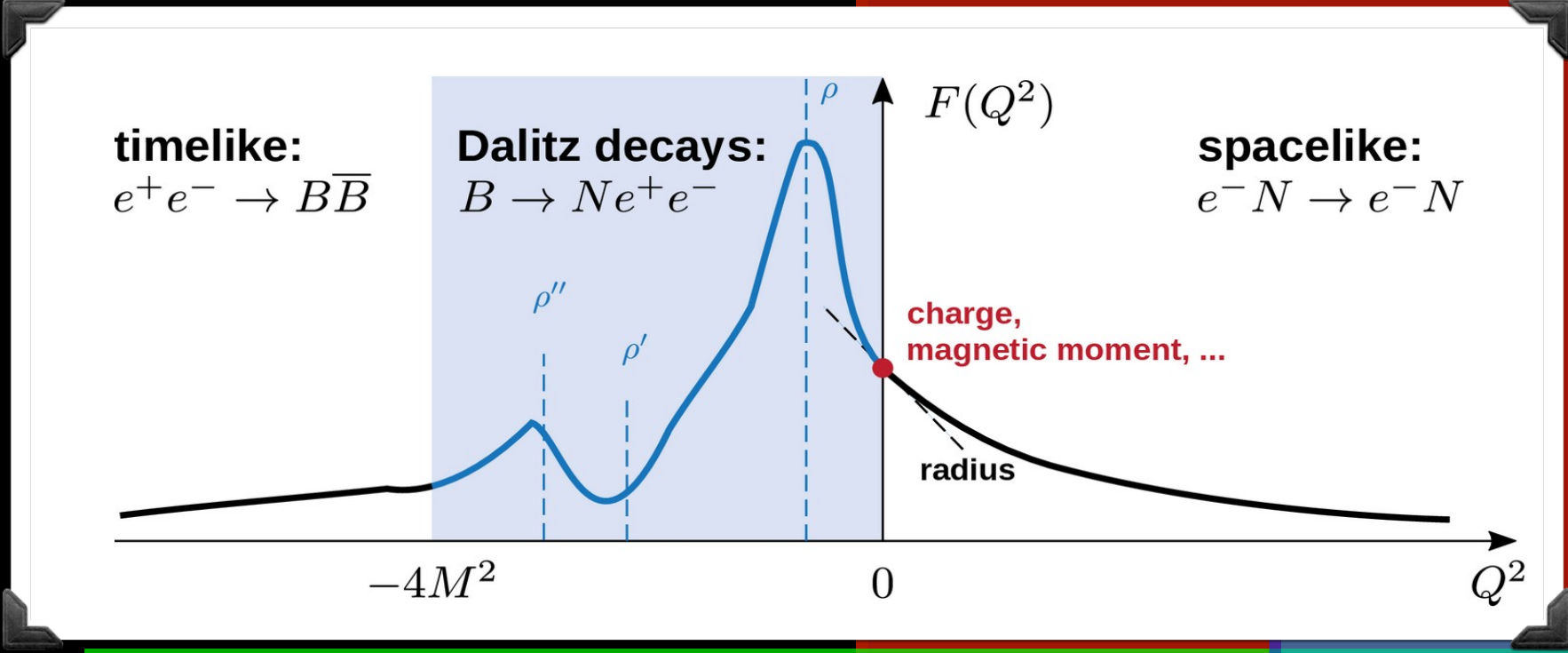
Microscopic study of hadron-hadron interactions

A comprehensive QCD program!

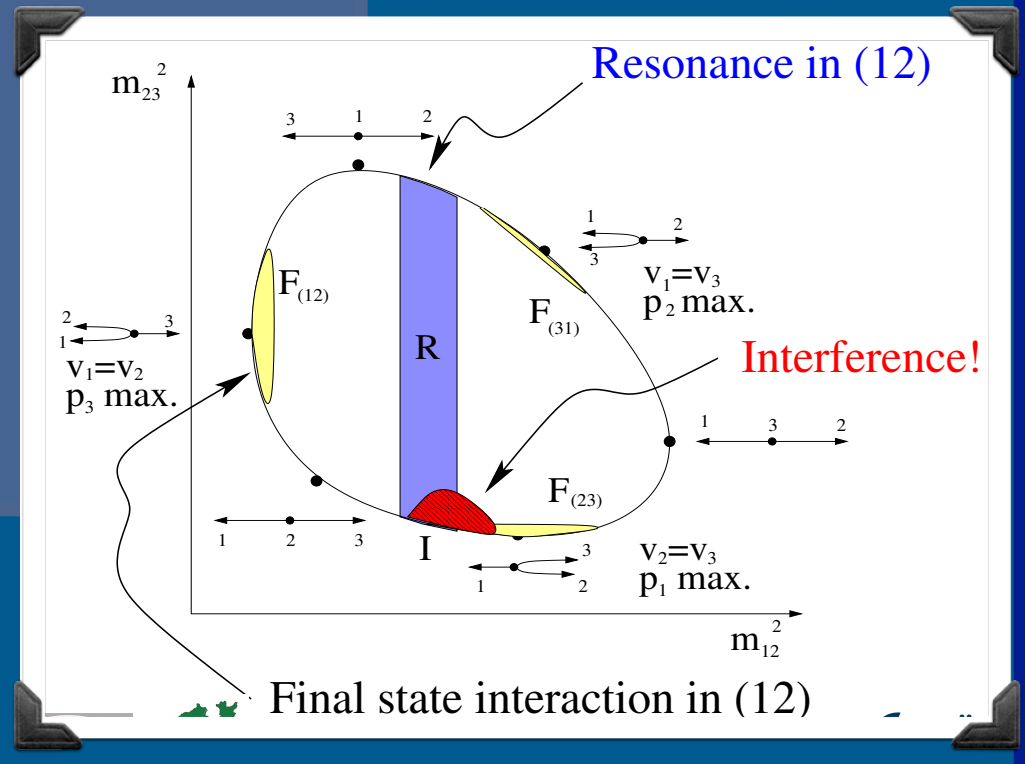
QCD dynamics within baryons

Hadron structure

Hadron spectroscopy



Few-body interactions



Hadron production

Production mechanisms of hadrons

Reference measurements for A+A

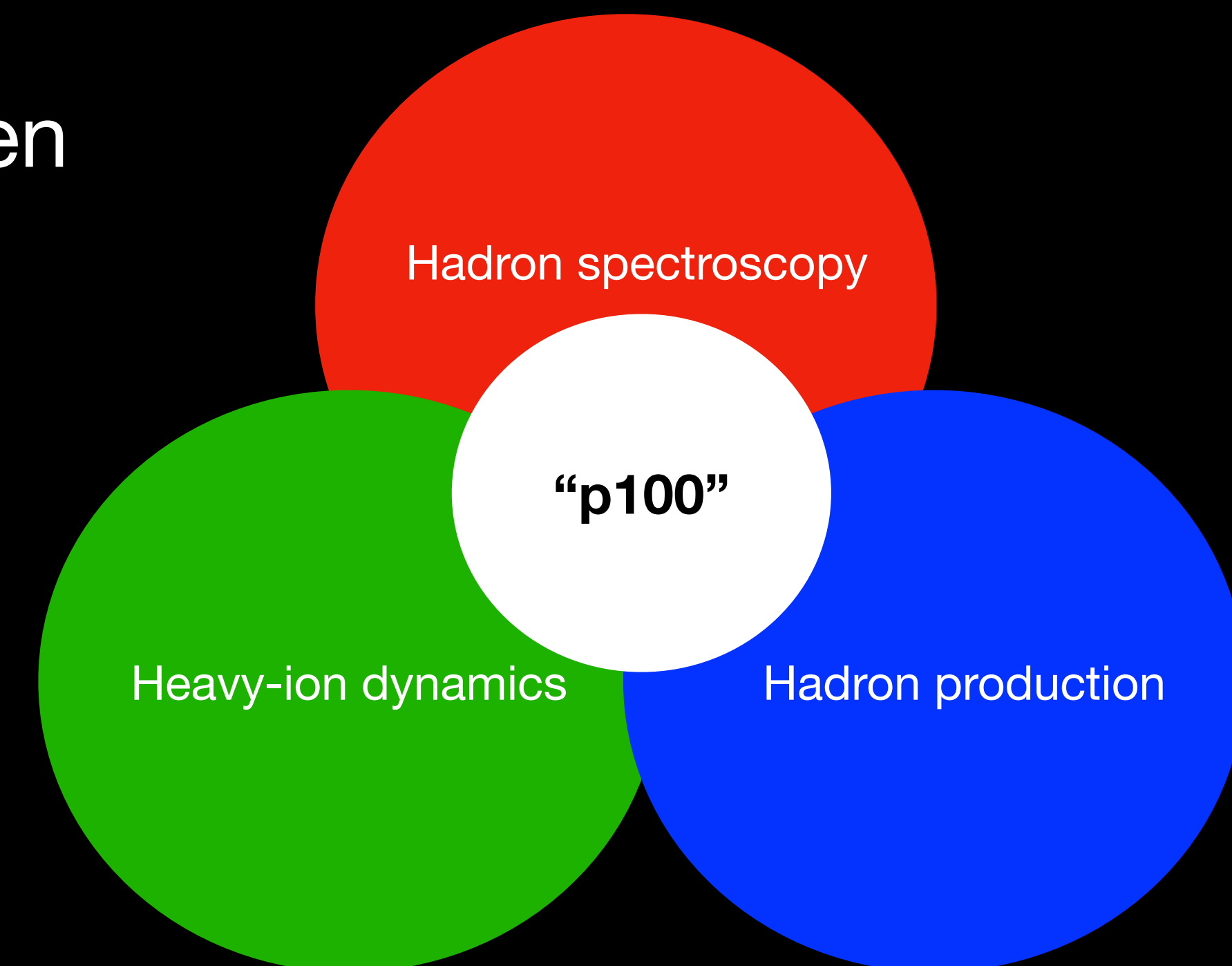
Heavy-ion dynamics

Microscopic study of hadron-hadron interactions

Objectives

...of this workshop

- **Bring together experts** from both theory and experiment
- Form a **community** connecting the common interest among theory and experiment!
- Identify **promising topics** as a basis for a proton-driven physics program
- Evaluate its **complementarity** with programs at other facilities
- Prepare towards a **white-paper**



Physics opportunities with proton beams at SIS100

... the workshop program

Tuesday

Wednesday

Thursday

Friday

12:00	Registration	
13:00	Campus Haspel, Wuppertal University	12:00 - 13:30
14:00	Welcome: Opening	James Ritman
14:00	Campus Haspel, Wuppertal University	13:30 - 14:30
15:00	session 1: Dense medium I	James Ritman
15:00	Campus Haspel, Wuppertal University	14:30 - 15:30
16:00	Coffee break	
16:00	Campus Haspel, Wuppertal University	15:30 - 16:00
17:00	session 2: Dense medium II	Karl-Heinz Kampert
17:00	Campus Haspel, Wuppertal University	16:00 - 18:00
18:00	Welcome reception	
18:00	Campus Haspel, Wuppertal University	18:00 - 19:00
19:00		

09:00	session 3: Few-body systems I	Tetyana Galatyuk
10:00	Campus Haspel, Wuppertal University	09:00 - 10:30
10:00	coffee break	
10:00	Campus Haspel, Wuppertal University	10:30 - 11:00
11:00	session 4: Few-body systems II	Christoph Hanhart
12:00	Campus Haspel, Wuppertal University	11:00 - 12:30
13:00	Lunch break	
13:00	Campus Haspel, Wuppertal University	12:30 - 14:00
14:00	session 5: Reaction dynamics I	Christian Sturm
15:00	Campus Haspel, Wuppertal University	14:00 - 15:30
15:00	Coffee break	
15:00	Campus Haspel, Wuppertal University	15:30 - 16:00
16:00	session 6: Reaction dynamics II	Piotr Salabura
17:00	Campus Haspel, Wuppertal University	16:00 - 17:30

09:00	session 7: Hadron spectroscopy I	Christian Fischer
10:00	Campus Haspel, Wuppertal University	09:00 - 10:30
10:00	coffee break	
10:00	Campus Haspel, Wuppertal University	10:30 - 11:00
11:00	session 8: Hadron spectroscopy II	Stefan Leupold
12:00	Campus Haspel, Wuppertal University	11:00 - 12:30
13:00	Lunch break	
13:00	Campus Haspel, Wuppertal University	12:30 - 14:00
14:00	session 9: Hadron structure	Beatrice Ramstein
15:00	Campus Haspel, Wuppertal University	14:00 - 15:30
15:00	coffee break	
15:00	Campus Haspel, Wuppertal University	15:30 - 16:00
16:00	session 10: Proton-charm	Frank Nerling
17:00	Campus Haspel, Wuppertal University	16:00 - 18:00
18:00	Brezel & Beer	
18:00	Campus Haspel, Wuppertal University	18:00 - 19:00
19:00	Evening lecture	Prof. Klaus Helbing
20:00	Campus Haspel, Wuppertal University	19:00 - 20:00

09:00	session 11: Facilities I	Anastasios Belias
10:00	Campus Haspel, Wuppertal University	09:00 - 10:40
10:00	coffee break	
10:00	Campus Haspel, Wuppertal University	10:40 - 11:00
11:00	session 12: Facilities II	Piotr Gasik
12:00	Campus Haspel, Wuppertal University	11:00 - 12:40
13:00	Closing remarks	
13:00	Campus Haspel, Wuppertal University	12:40 - 13:00

Physics opportunities with proton beams at SIS100

... the workshop program

Speakers (37)

- Jorg Aichelin - Paris
- Vadim Baru - Bochum
- Mikhail Bashkanov - York
- Markus Bleicher - Frankfurt
- Elena Bratkovskaya - Frankfurt
- Nora Brambilla - Munich
- Izabela Ciepal - Cracow
- Sean Dobbs - Tallahassee
- Raffaele Del Grande - Munich
- Oleg Denisov - Torino
- Gernot Eichmann - Graz
- Evgeny Epelbaum - Bochum
- Christian Fischer - Giessen
- Piotr Gasik - Darmstadt
- Felix Hekhorn - Jyvaskyla
- Christoph Hanhart - Julich
- Peter Hurck - Glasgow
- Robert Kaminski - Kraków
- Stefan Leupold - Uppsala
- Rafal Maciula - Rzeszow
- Maxim Mai - Bonn
- Bryan McKinnon - Glasgow
- Mikhail Mikhasenko - Bochum
- Yuhei Morino - KEK, Tsukuba
- Andreas Nogga - Julich
- Maria Pena - Lisbon
- Allesandro Pilloni - Catania
- Szymon Puławski - Chorzów
- Takehiko Saito - Wako/RIKEN
- Joachim Stroth - Frankfurt/GSI
- Antoni Szczurek - Cracow
- Jenny Taylor - Darmstadt
- Laura Tolos - Barcelona
- Richard Tyson - Newport News
- Daniel Winney - Bonn
- Gyuri Wolf - Budapest
- Hanna Zbroszczyk - Warsaw

Physics opportunities with proton beams at SIS100

... the workshop program

Speakers (37)

- Jorg Aichelin - Paris
- Vadim Baru - Bochum
- Mikhail Bashkanov - York
- Markus Bleicher - Frankfurt
- Elena Bratkovskaya - Frankfurt
- Nora Brambilla - Munich
- Izabela Ciepal - Cracow
- Sean Dobbs - Tallahassee
- Raffaele Del Grande - Munich
- Oleg Denisov - Torino
- Gernot Eichmann - Graz
- Evgeny Epelbaum - Bochum
- Christian Fischer - Giessen
- Piotr Gasik - Darmstadt
- Felix Hekhorn - Jyvaskyla
- Christoph Hanhart - Julich
- Peter Hurck - Glasgow
- Robert Kaminski - Kraków
- Stefan Leupold - Uppsala

- Rafal Maciula - Rzeszow
- Maxim Mai - Bonn
- Bryan McKinnon - Glasgow
- Mikhail Mikhasenko - B...
- Yuhei Morino - KEK, T...
- Andreas Nogga - Jul...
- Maria Pena - Lisbon
- Allesandro Pilloni - ...
- Szymon Puławski
- Takehiko Saito - W...
- Joachim Stroth - F...
- Antoni Szczurek - C...
- Jenny Taylor - Darm...
- Laura Tolos - Barcelo...
- Richard Tyson - Newpo...
- Daniel Winney - Bonn
- Gyuri Wolf - Budapest
- Hanna Zbrozczyk - Warsaw

Participants (87)

