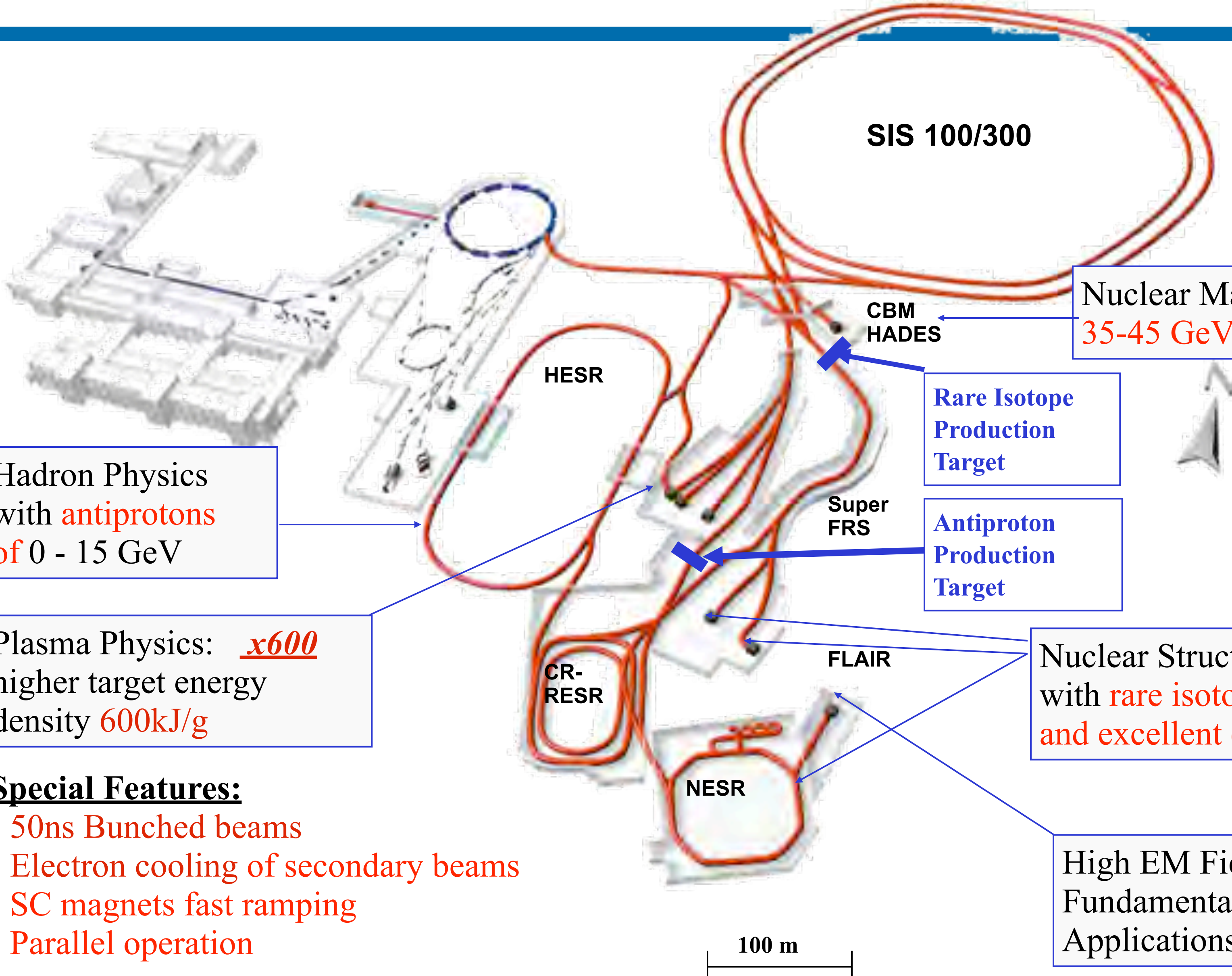
The FAIR facility

Ulrich Wiedner
Ruhr-Universität Bochum

Williamsburg, 4-June-2010

Research Communities at FAIR



Nuclear Matter Physics with
35-45 GeV/u HI beams, ***x1000***

Rare Isotope Production Target

Antiproton Production Target

Hadron Physics
with antiprotons
of 0 - 15 GeV

Plasma Physics: ***x600***
higher target energy
density 600kJ/g

Nuclear Structure & Astrophysics
with rare isotope beams, ***x10 000***
and excellent cooling

High EM Field (HI)
Fundamental Studies (HI & $\bar{p}$)
Applications (HI)

Special Features:

- 50ns Bunched beams
- Electron cooling of secondary beams
- SC magnets fast ramping
- Parallel operation

Development of Project Staging

2003	**Recommendation by WissenschaftsRat – FAIR Realisation in three stages**						
2005	**Entire Facility** **Baseline Technical Report**						
2007	**Phase A**						**Phase B** SIS300
2009	**Module 0** SIS100	**Module 1** expt areas CBM/HADES and APPA	**Module 2** Super-FRS fixed target area NuSTAR	**Module 3** pbar facility, incl. CR for PANDA, options for NuSTAR	**Module 4** LEB for NuSTAR, NESR for NuSTAR and APPA, FLAIR for	**Module 5** RESR nominal intensity for PANDA & parallel operation with	**Module 6** SIS300 HESR **Cooler** ER

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Modularized Start Version

Cost Estimate Modules 0-3 (Price Basis 2005)

Total accelerator and personnel Modules 0 - 3	**502**
Total civil construction Modules 0 - 3	**400**
Experiment funding	**78**
FAIR GmbH personnel and running costs	**47**
Grand Total Modules 0 - 3	**1027**

all values in M€

Firm Commitments

FAIR Countries	Total declared Contribution (k€)
Austria	5.000
China	12.000
Finland	5.000
France	27.000
Germany	705.000
Great Britain	8.000
Greece	4.000
India	36.000
Italy	42.000
Poland	23.740
Romania	11.870
Russia	178.050
Slovenia	12.000
Slovakia	6.000
Spain	19.000
Sweden	10.000
Total	**1.104.660**
Firm Commitments	**1.038.660**

not firm for the first batch

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Primeminister Putin signed. Officially publicized last week.

not firm for the first batch

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ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ

РАСПОРЯЖЕНИЕ

от 27 февраля 2010 г. № 245-р

МОСКВА

1. В соответствии со статьей 11 Федерального закона "О международных договорах Российской Федерации" одобрить представленные Государственной корпорацией по атомной энергии "Росатом" согласованные с МИДом России и другими заинтересованными федеральными органами исполнительной власти и предварительно проработанные с государствами - участниками проекта по сооружению и эксплуатации Европейского центра по исследованию ионов и антипротонов (ФАИР) в г. Дармштадте (ФРГ) проекты Конвенции о сооружении и эксплуатации Европейского центра по исследованию ионов и антипротонов (ФАИР) и Заключительного акта конференции полномочных представителей по сооружению и эксплуатации Европейского центра по исследованию ионов и антипротонов (ФАИР) (прилагаются).

2. Поручить Государственной корпорации по атомной энергии "Росатом" провести при участии МИДа России переговоры и по достижении договоренности подписать от имени Правительства Российской Федерации документы, указанные в пункте 1 настоящего распоряжения, разрешив в случае необходимости вносить в проекты этих документов изменения, не имеющие принципиального характера.

3. Назначить Государственную корпорацию по атомной энергии "Росатом" участником компании с ограниченной ответственностью "Европейский центр по исследованию ионов и антипротонов (ФАИР)".

4. Государственной корпорации по атомной энергии "Росатом":

после подписания документов, указанных в пункте 1 настоящего распоряжения, уведомить в установленном порядке государства - участники Конвенции о сооружении и эксплуатации Европейского центра

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по исследованию ионов и антипротонов (ФАИР) о том, что участником компании с ограниченной ответственностью "Европейский центр по исследованию ионов и антипротонов (ФАИР)" от Российской Федерации выступит Государственная корпорация по атомной энергии "Росатом";

обеспечить выполнение обязательств Российской Федерации, вытекающих из Конвенции о сооружении и эксплуатации Европейского центра по исследованию ионов и антипротонов (ФАИР).

5. Государственной корпорации по атомной энергии "Росатом" и Минфину России при формировании проекта федерального бюджета на очередной финансовый год и плановый период предусматривать бюджетные ассигнования на выполнение обязательств Российской Федерации, вытекающих из Конвенции о сооружении и эксплуатации Европейского центра по исследованию ионов и антипротонов (ФАИР), в том числе в отношении обязательств по взносам в сооружение и эксплуатацию Европейского центра по исследованию ионов и антипротонов (ФАИР).

Председатель Правительства
Российской Федерации — В.Путин

ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ

РАСПОРЯЖЕНИЕ

от 27 февраля 2010 г. № 245-р

Dear Colleagues,
We are happy to inform you that the Decree of the Russian Government on Russian participation in FAIR project was issued and published. Its number is 245-p of February 27, 2010.
By this decision Russian Government approved the project of FAIR Convention with Russian contribution to FAIR construction in the amount of 178,05 MEuro (prices of January 2005) and authorized the State Corporation "Rosatom" to be Russian Shareholder of FAIR Company.

Sincerely, O.Patarakin, P.Bogdanov.

документов изменения, не имеющие принципиального характера.

3. Назначить Государственную корпорацию по атомной энергии "Росатом" участником компании с ограниченной ответственностью "Европейский центр по исследованию ионов и антипротонов (ФАИР)".

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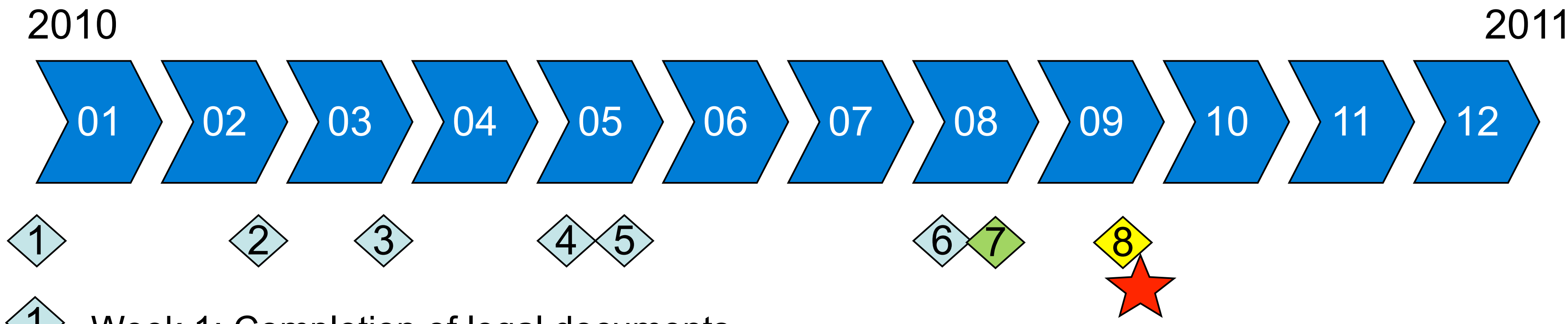
после подписания документов, указанных в пункте 1 настоящего распоряжения, уведомить в установленном порядке государства - участники Конвенции о сооружении и эксплуатации Европейского центра

антипротонов (ФАИР)".

Председатель Правительства Российской Федерации В.Путин

№ 1

Roadmap to foundation the FAIR company



1 Week 1: Completion of legal documents

2 Week 8: Documents sent out by Foreign Office to other countries

3 Week 13: Translated documents back in Foreign Office

4 Week 19: Bilateral agreements on open problems

5 Week 22: Legal documents available in 5 official languages

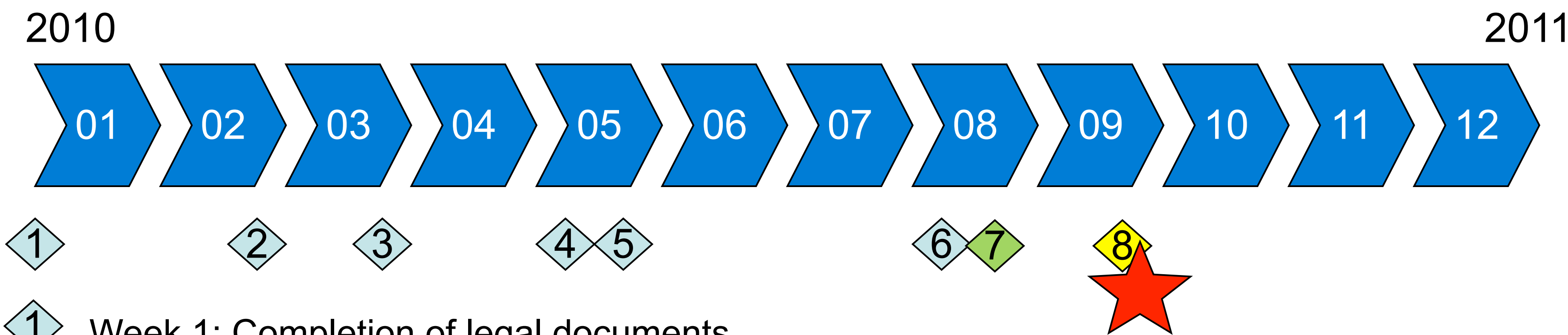
6 Week 32: Formal agreement of all partner countries

7 Week 33: Translation conference

8 Week 37: Formal signing of the FAIR convention

★ Week 38: Founding of FAIR GmbH

Roadmap to foundation the FAIR company



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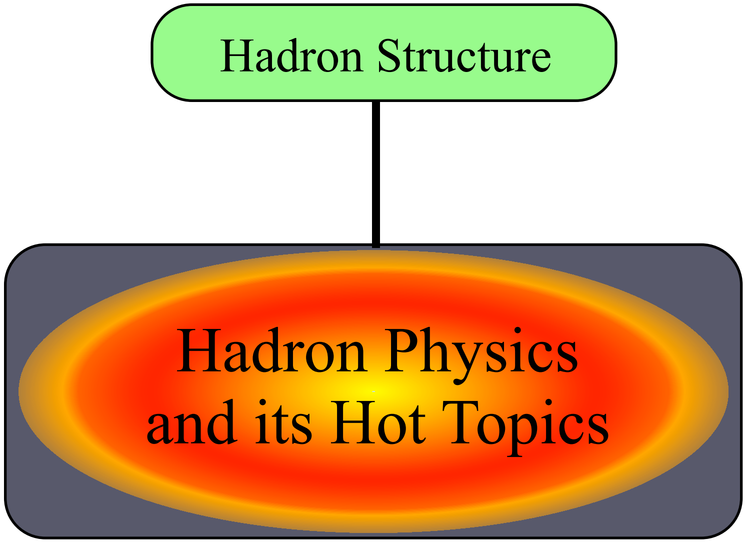
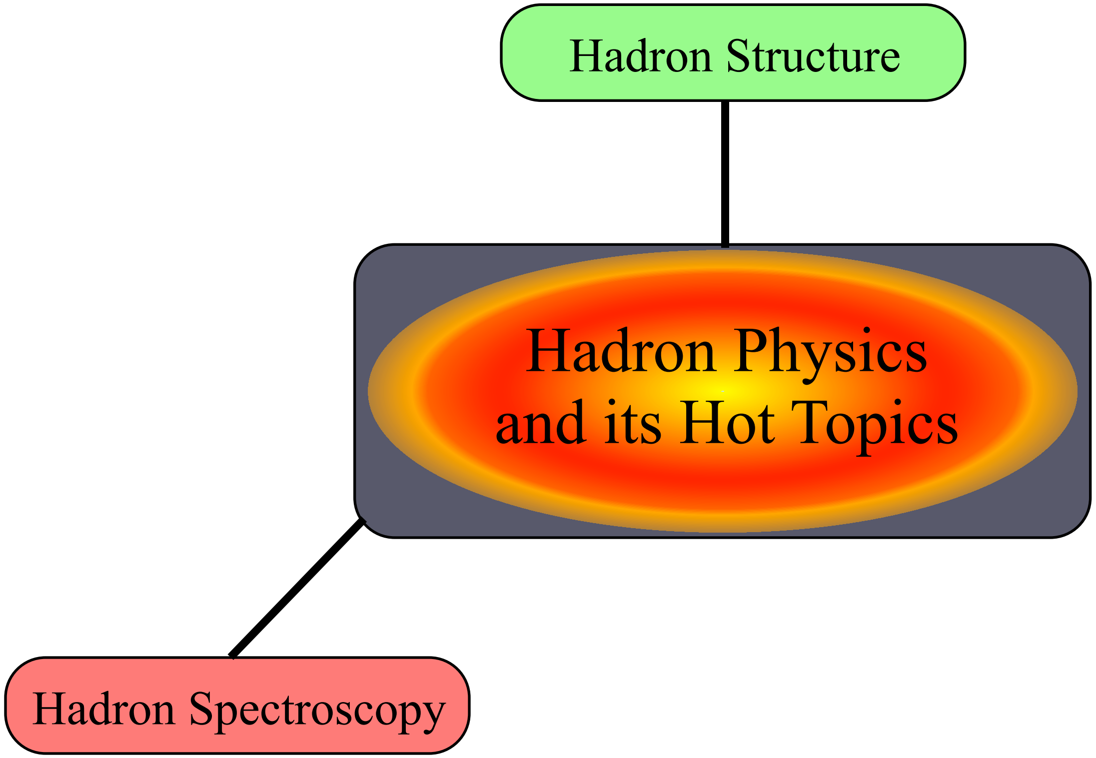
Roadmap

- Start of construction activities 2010/11 +1 year
- Schedule is driven by **civil construction**
- Aim for earliest commissioning of accelerators and respective experiments

Module	Construction time (months)	Ready for installation	
0	72	2015 / 16	+1 year
1	28	2015 / 16	+1 year
2	60	2016	
3	60	2016	+1 year

Hadron Physics and its Hot Topics


Hadron Structure
Hadron Physics
and its Hot Topics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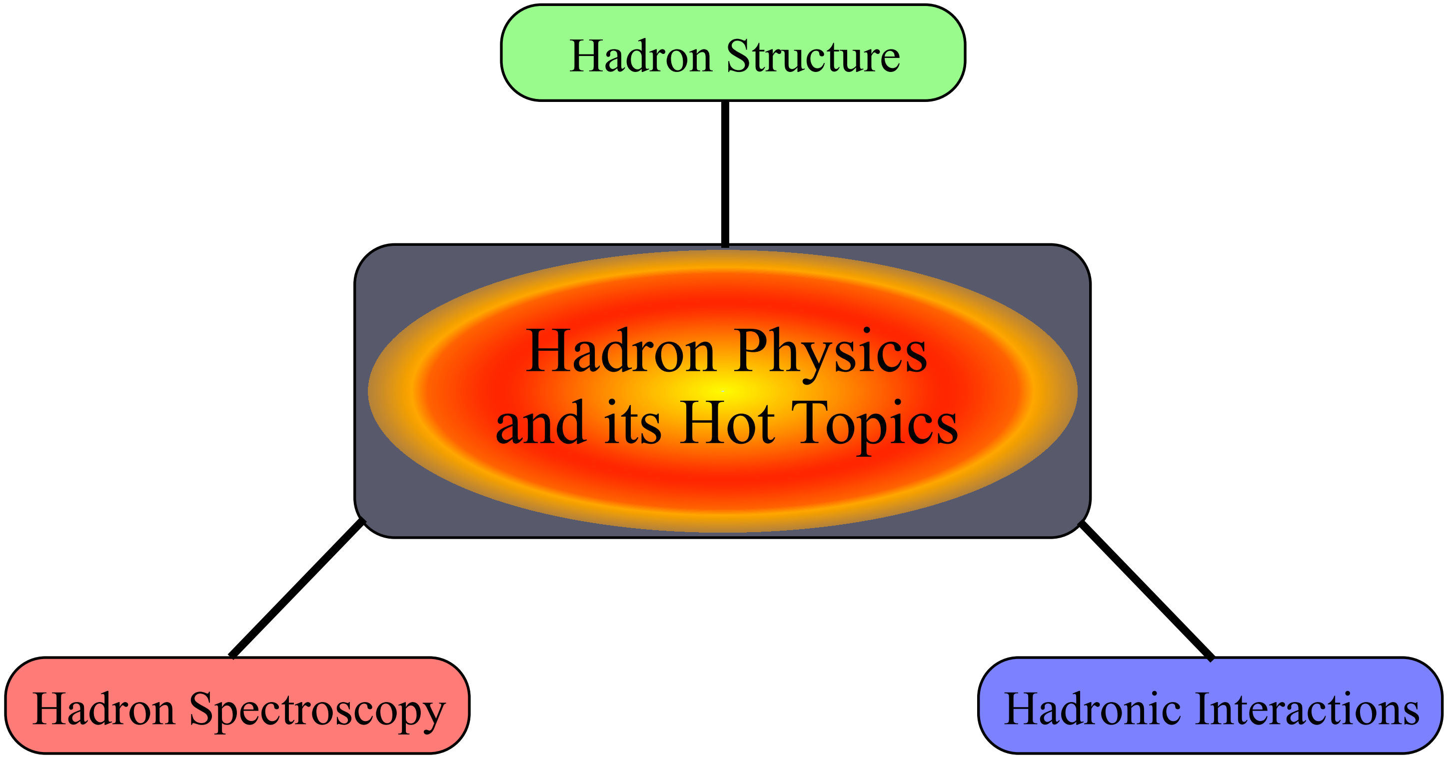


Hadron Structure
Hadron Physics and its Hot Topics
Hadron Spectroscopy
Hadronic Interactions

Standard Model of

FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model summarizes the current knowledge in Particle Physics. It is the quantum theory that includes the theory of strong interactions (quantum chromodynamics or QCD) and the unified theory of weak and electromagnetic interactions (electroweak). Gravity is included on this chart because it is one of the fundamental interactions even though not part of the "Standard Model."

FERMIONS
matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c²	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	–1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	–1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	–1

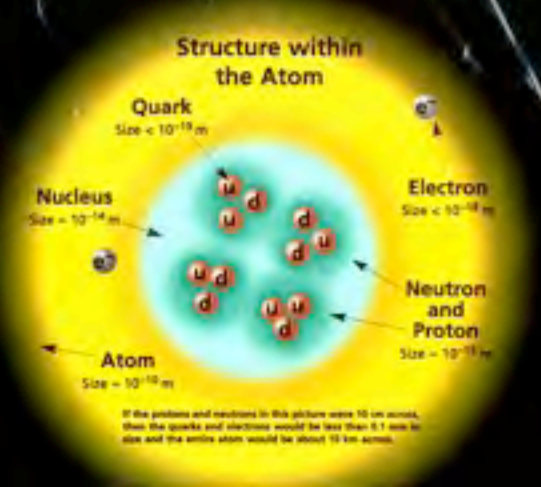
Quarks spin = 1/2

Flavor	Approx. Mass GeV/c²	Electric charge
u up	0.003	2/3
d down	0.006	–1/3
c charm	1.3	2/3
s strange	0.1	–1/3
t top	175	2/3
b bottom	4.3	–1/3

Spin is the intrinsic angular momentum of particles. Spin is given in units of $\hbar$, which is the quantum unit of angular momentum, where $\hbar = h/2\pi = 6.58\times10^{-25}$ GeV s $= 1.05\times10^{-34}$ J s.

Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10^{-19} coulombs.

The **energy** unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. **Masses** are given in GeV/c² (remember $E = mc^2$), where 1 GeV = 10^9 eV = 1.60×10^{-10} joule. The mass of the proton is 0.938 GeV/c² $= 1.67\times10^{-27}$ kg.



If the protons and neutrons in this picture were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

BOSONS
force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c²	Electric charge
γ photon	0	0
W^-	80.4	–1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

Name	Mass GeV/c²	Electric charge
g gluon	0	0

Color Charge
Each quark carries one of three types of "strong charge," also called "color charge." These charges have nothing to do with the colors of visible light. There are eight possible types of color charge for gluons. Just as electrically-charged particles interact by exchanging photons, in strong interactions color-charged particles interact by exchanging gluons. Leptons, photons, and W and Z bosons have no strong interactions and hence no color charge.

Quarks Confined in Mesons and Baryons
One cannot isolate quarks and gluons; they are confined in color-neutral particles called **hadrons**. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs (see figure below). The quarks and antiquarks then combine into hadrons; these are the particles seen to emerge. Two types of hadrons have been observed in nature: **mesons** $q\bar{q}$ and **baryons** qqq.

Residual Strong Interaction
The strong binding of color-neutral protons and neutrons to form nuclei is due to residual strong interactions between their color-charged constituents. It is similar to the residual electrical interaction that binds electrically neutral atoms to form molecules. It can also be viewed as the exchange of mesons between the hadrons.

PROPERTIES OF THE INTERACTIONS

Property \ Interaction	Gravitational	Weak (Electroweak)	Electromagnetic	Strong: Fundamental	Strong: Residual
Acts on:	Mass – Energy	Flavor	Electric Charge	Color Charge	See Residual Strong Interaction Note
Particles experiencing:	All	Quarks, Leptons	Electrically charged	Quarks, Gluons	Hadrons
Particles mediating:	Graviton (not yet observed)	W^+ W^- Z^0	γ	Gluons	Mesons
Strength relative to electromag for two u quarks at: 10^{-18} m	10^{-41}	0.8	1	25	Not applicable to quarks
Strength relative to electromag for two u quarks at: 3×10^{-17} m	10^{-41}	10^{-4}	1	60	Not applicable to quarks
Strength relative to electromag for two protons in nucleus	10^{-36}	10^{-7}	1	Not applicable to hadrons	20

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$
Baryons are fermionic hadrons.
There are about 120 types of baryons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c²	Spin
p	proton	uud	1	0.938	1/2
$\bar{p}$	anti-proton	$\bar{u}\bar{u}\bar{d}$	–1	0.938	1/2
n	neutron	udd	0	0.940	1/2
Λ	lambda	uds	0	1.116	1/2
Ω^-	omega	sss	–1	1.672	3/2

Mesons $q\bar{q}$
Mesons are bosonic hadrons.
There are about 140 types of mesons.

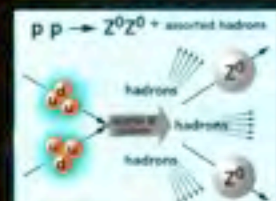
Symbol	Name	Quark content	Electric charge	Mass GeV/c²	Spin
π^+	pion	$u\bar{d}$	+1	0.140	0
K^-	kaon	$s\bar{u}$	–1	0.494	0
ρ^+	rho	$u\bar{d}$	+1	0.770	1
B^0	B-zero	$d\bar{b}$	0	5.279	0
η_c	eta-c	$c\bar{c}$	0	2.980	0

Matter and Antimatter
For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or – charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z^0, γ, and $\eta_c = c\bar{c}$, but not $K^0 = d\bar{s}$) are their own antiparticles.

Figures
These diagrams are an artist's conception of physical processes. They are not exact and have no meaningful scale. Green shaded areas represent the cloud of gluons or the gluon field, and red lines the quark paths.

A neutron decays to a proton, an electron, and an antineutrino via a virtual (mediating) W boson. This is neutron β decay.

An electron and positron (antielectron) colliding at high energy can annihilate to produce B^0 and $\bar{B}^0$ mesons via a virtual Z boson or a virtual photon.



Two protons colliding at high energy can produce various hadrons plus very high mass particles such as Z bosons. Events such as this one are rare but can yield vital clues to the structure of matter.

The Particle Adventure
Visit the award-winning web feature The Particle Adventure at
http://ParticleAdventure.org

This chart has been made possible by the generous support of:
U.S. Department of Energy
U.S. National Science Foundation
Lawrence Berkeley National Laboratory
Stanford Linear Accelerator Center
American Physical Society, Division of Particles and Fields
BURLE INDUSTRIES, INC.

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… but

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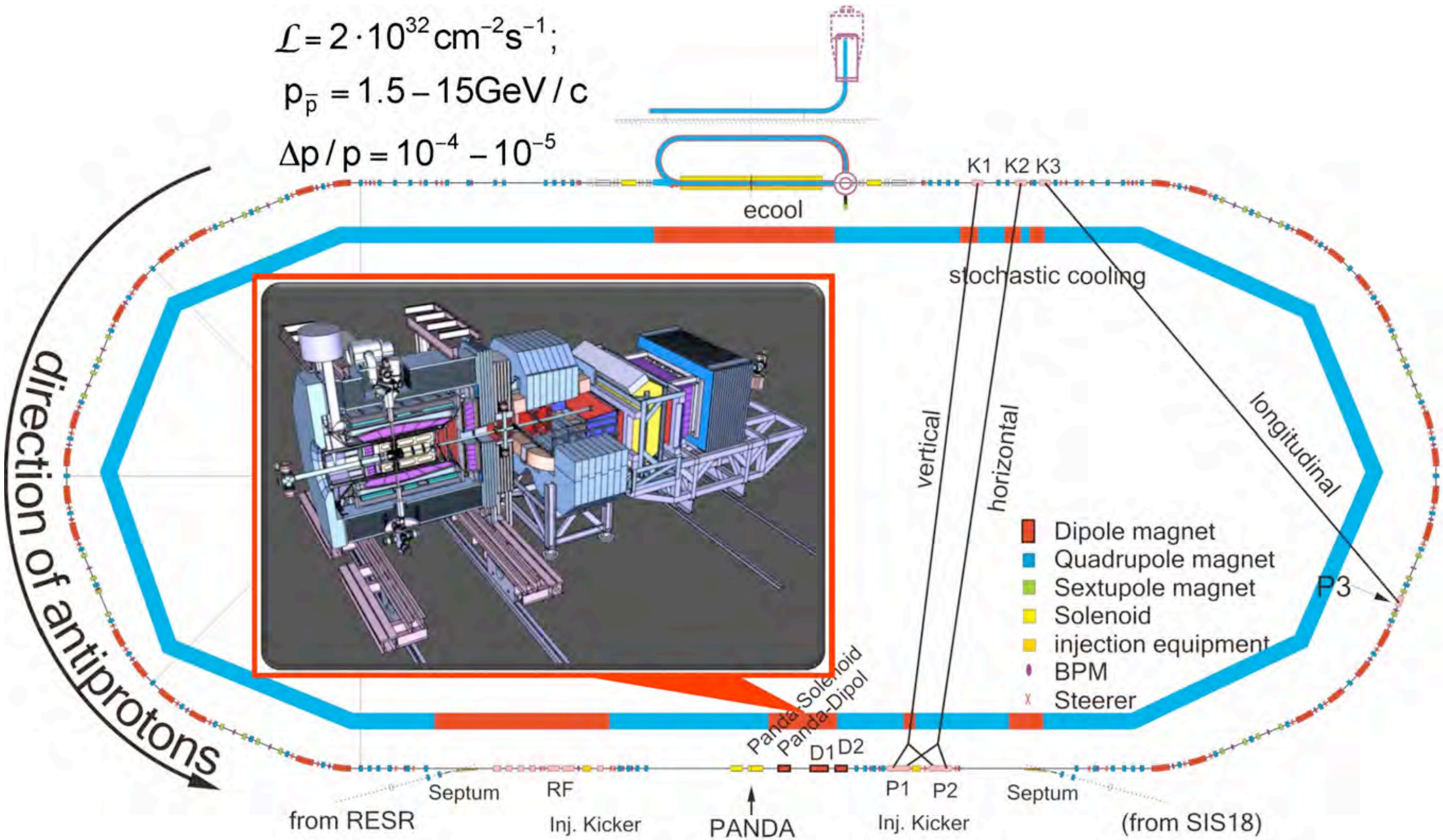
Hadron Physics at FAIR with PANDA

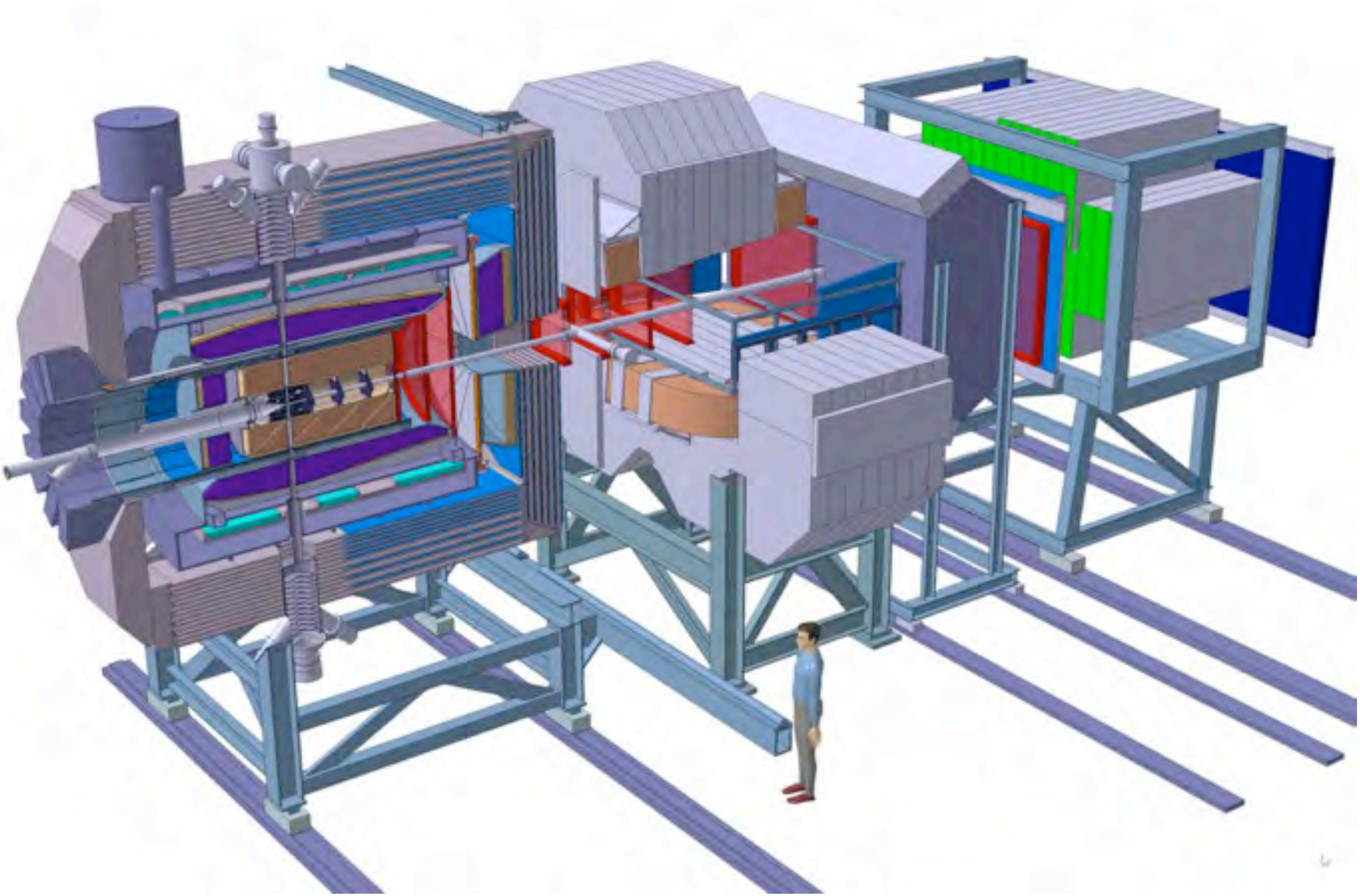
$\mathcal{L} = 2 \cdot 10^{32} cm^{-2}s^{-1}$;

$p_{\bar{p}} = 1.5 - 15 GeV/c$

$\Delta p / p = 10^{-4} - 10^{-5}$



The PANDA Detector



PANDA Collaboration

- At present a group of **420 physicists** from 54 institutions and 16 countries

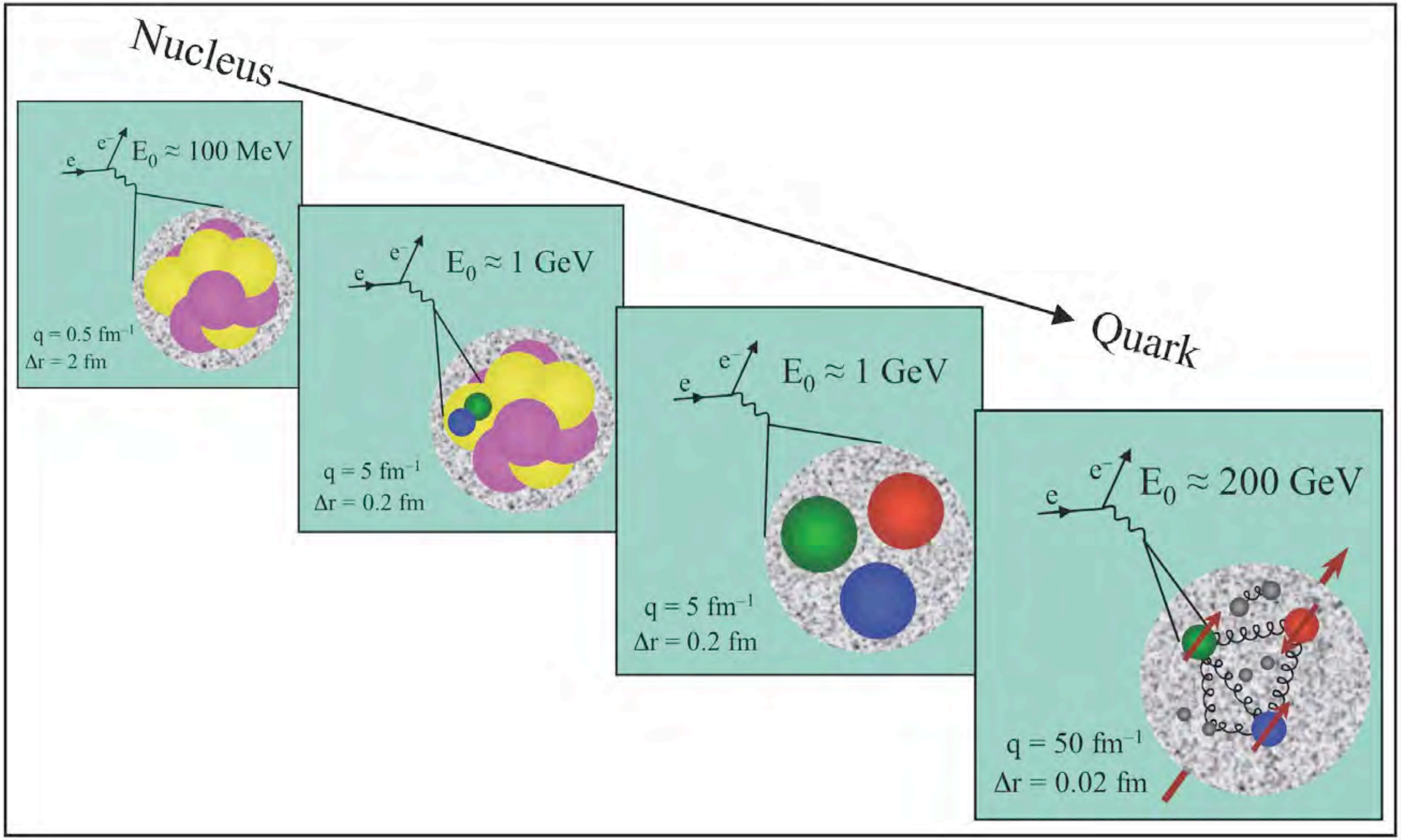
Austria – Belaruz – China – France – Germany – India – Italy – The Netherlands – Poland – Romania – Russia – Spain – Sweden – Switzerland – U.K. – U.S.A.

Basel, Beijing, Bochum, IIT Bombay, Bonn, Brescia, IFIN Bucharest, Catania, IIT Chicago, AGH-UST Cracow, JGU Cracow, IFJ PAN Cracow, Cracow UT, Edinburgh, Erlangen, Ferrara, Frankfurt, Genova, Giessen, Glasgow, GSI, FZ Jülich, JINR Dubna, Katowice, KVI Groningen, Lanzhou, LNF, Lund, Mainz, Minsk, ITEP Moscow, MPEI Moscow,TU München, Münster, Northwestern, BINP Novosibirsk, IPN Orsay, Pavia, IHEP Protvino, PNPI St.Petersburg, KTH Stockholm, Stockholm, Dep. A. Avogadro Torino, Dep. Fis. Sperimentale Torino, Torino Politecnico, Trieste, TSL Uppsala, Tübingen, Uppsala, Valencia, SINS Warsaw, TU Warsaw, AAS Wien

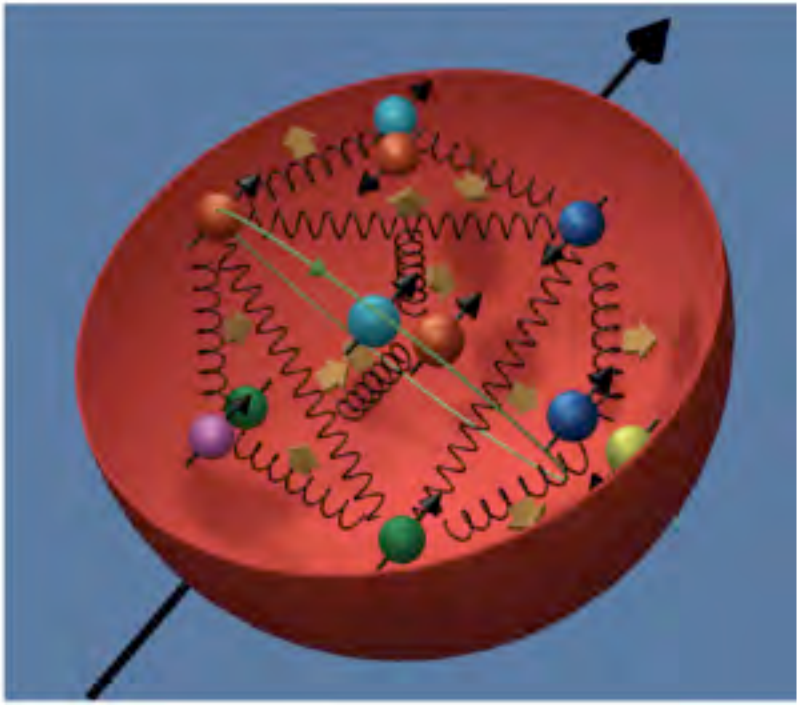
Spokesperson: Ulrich Wiedner (Bochum)

http://www.gsi.de/panda

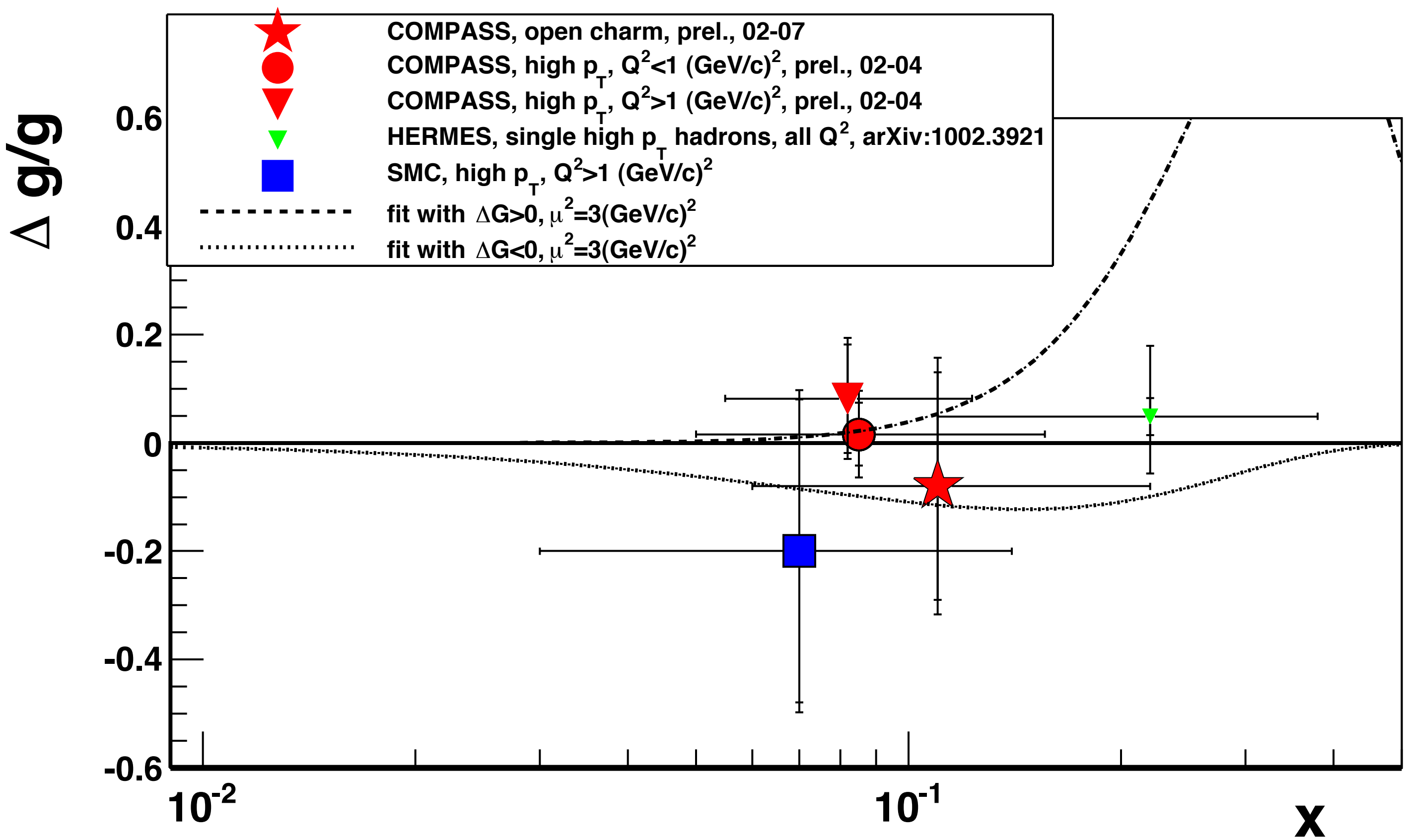
Hadron Structure



The Nucleon (as composed by fundamental particles)



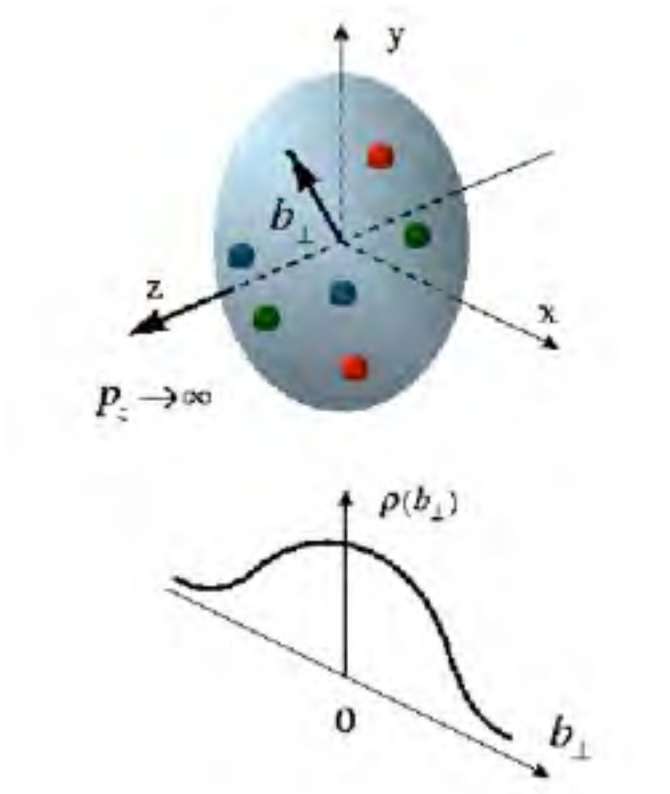
Gluon polarization results from SMC, HERMES, and COMPASS, in comparison with theoretical fits



Ulrich Wiedner

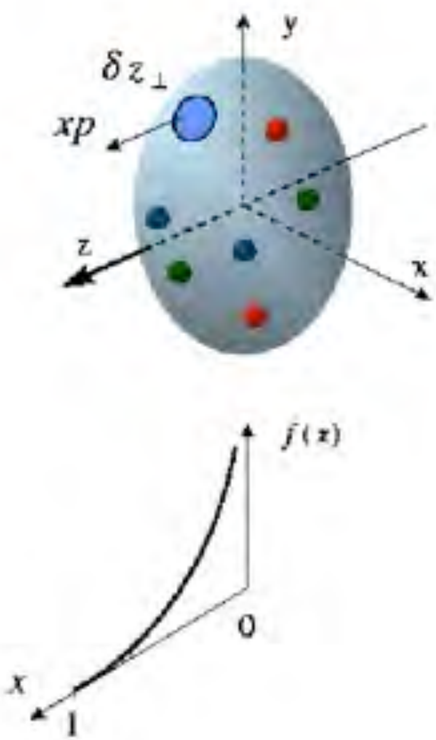
Elastic scattering

... reveals transverse quark distribution in coordinate space



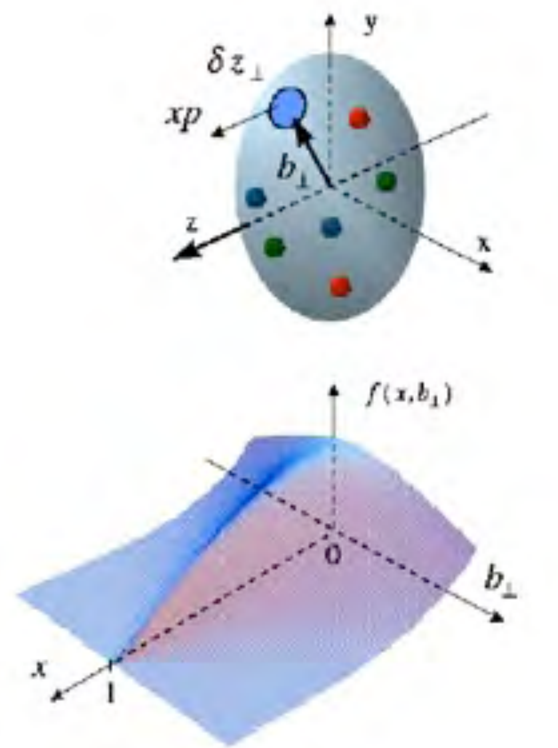
Deep inelastic scattering

... reveals longitudinal quark distribution in momentum space

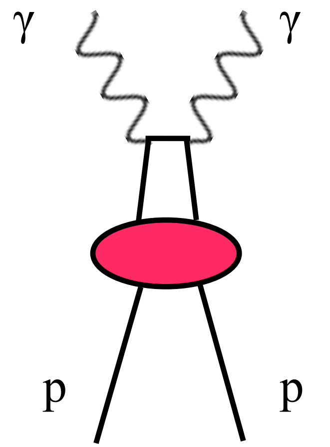


Common description:

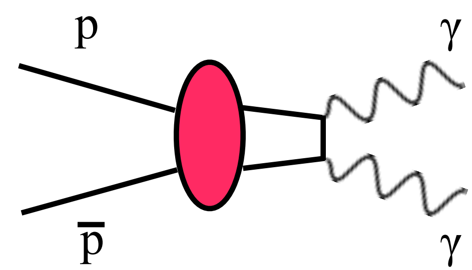
Generalized Parton Distributions (GPDs)

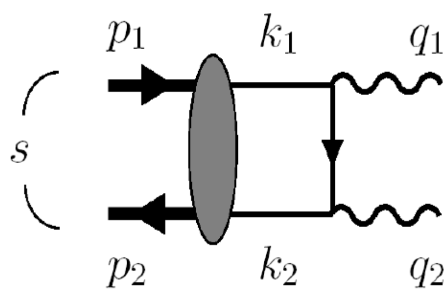


Electromagnetic Processes: $\bar{p}p \rightarrow \gamma\gamma$



crossed-channel
Compton scattering





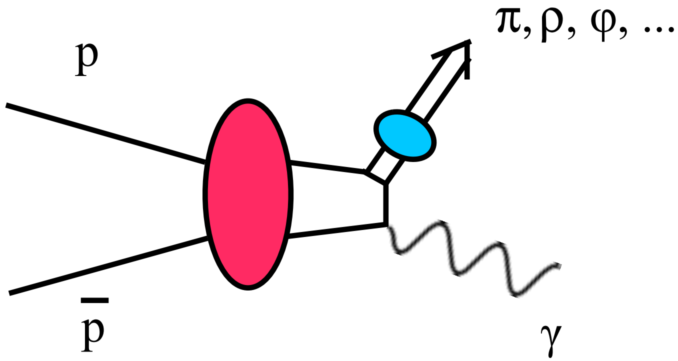
Handbag diagram separates a soft part described by GPDs from a hard $q\bar{q}$ annihilation process

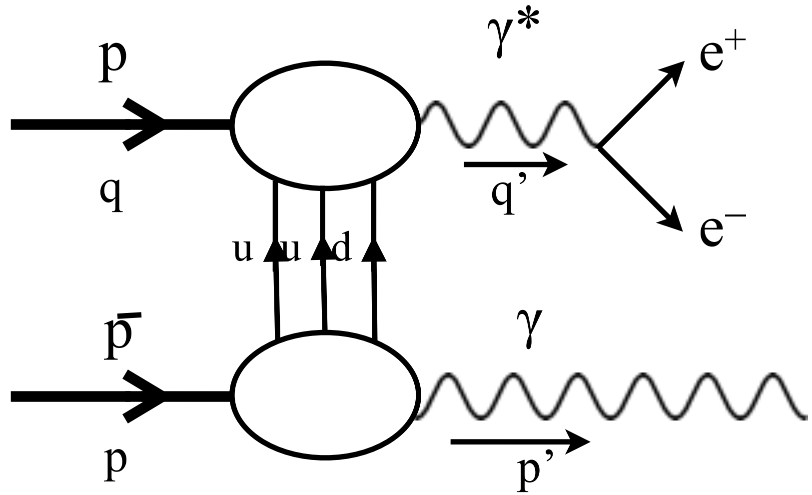
Predicted rates*: several thousand / month or above

Exp. problem: Background channels like $\pi^0\gamma$ or $\pi^0\pi^0$ 5× - 100× stronger.

*A. Freund, A. Radyushkin, A. Schäfer, and C. Weiss, Phys. Rev. Lett. 90, 092001 (2003).

Related exclusive annihilation processes studies:





➥ check of factorization.

Electromagnetic form factors of the proton

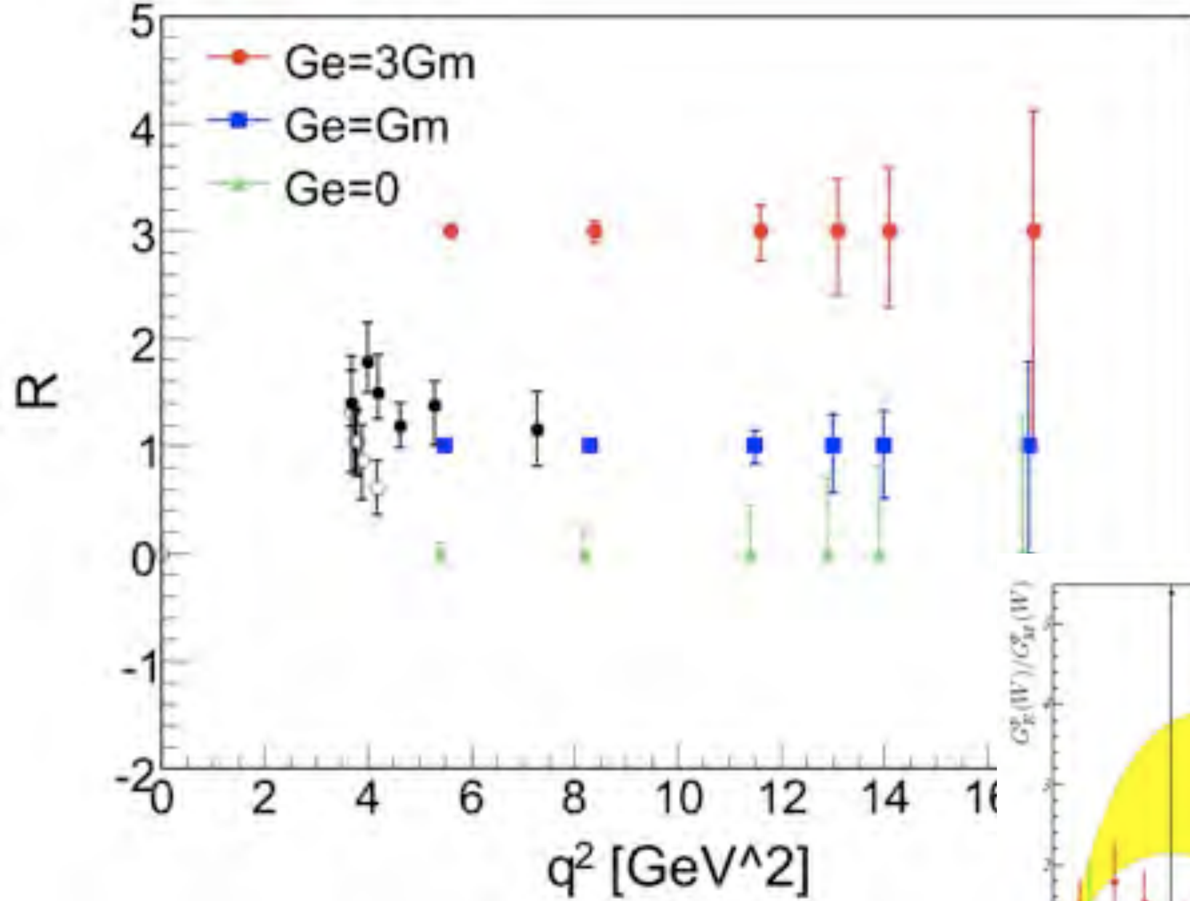
... can be extracted from the cross section: $\bar{p} + p \rightarrow e^+ + e^-$

$$\frac{d\sigma}{d(\cos\theta^*)} = \frac{\pi\alpha^2\hbar^2c^2}{2xs}\left[|G_M|^2(1+\cos^2\theta^*) + \frac{4m_p^2}{s}|G_E|^2(1-\cos^2\theta^*)\right]$$

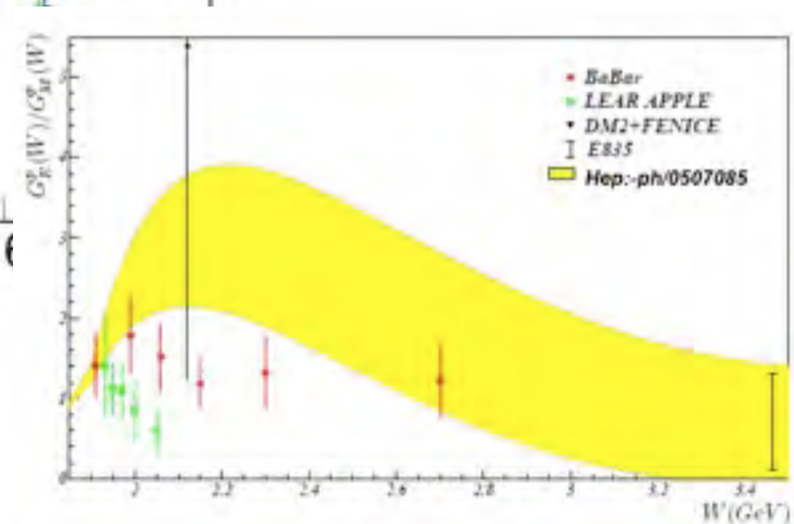
(first order QED prediction)

Data at high Q^2 test QCD predictions for the asymptotic behavior of the form factors and spacelike-timelike equality at corresponding Q^2.

panda MC studies

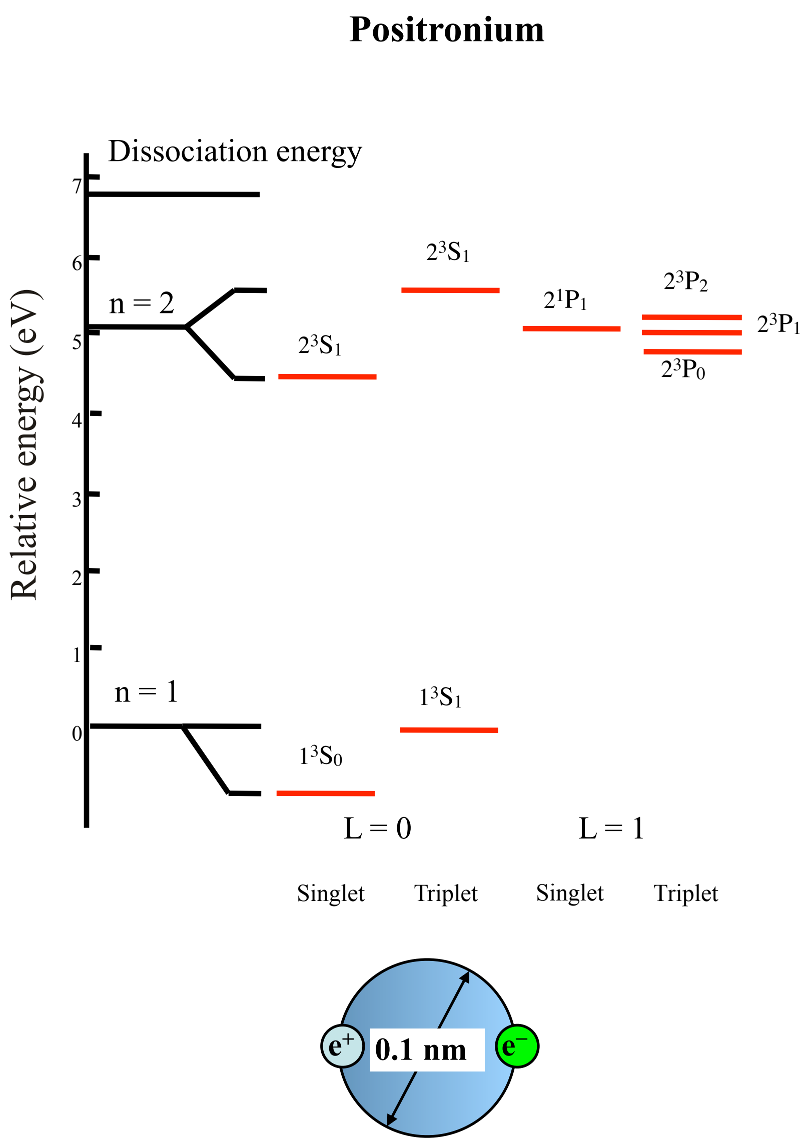


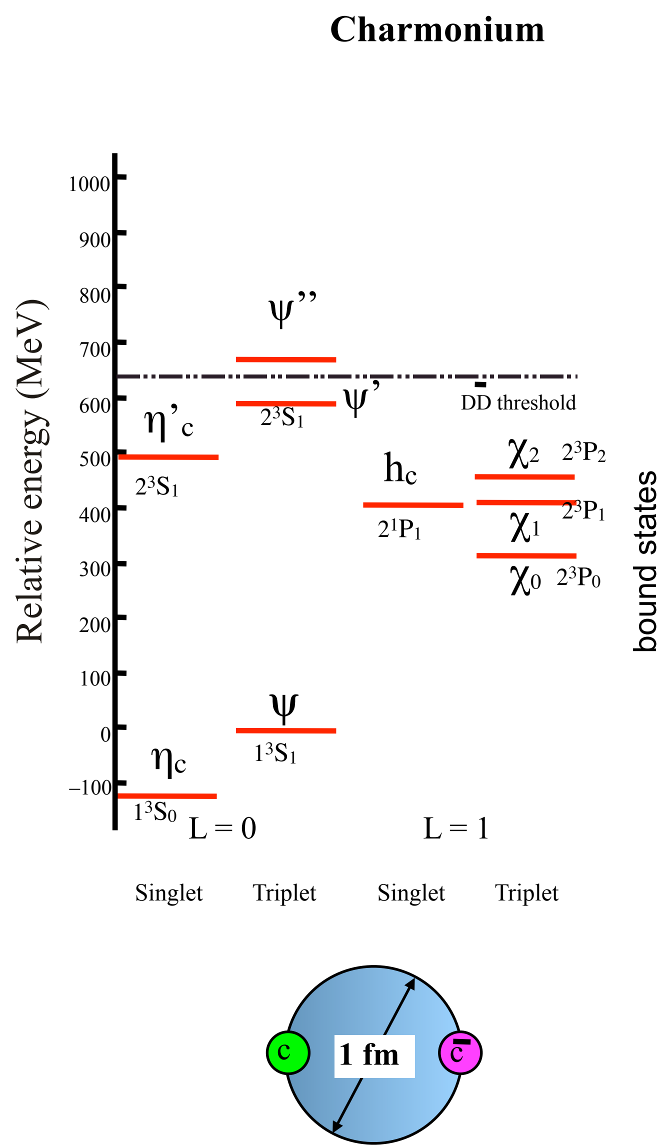
$$R = \frac{G_E}{G_M}$$



PANDA will measure the form factors in the biggest Q^2 range for a single experiment up to values of ~20 GeV^2/c^4 (beam time dependent).

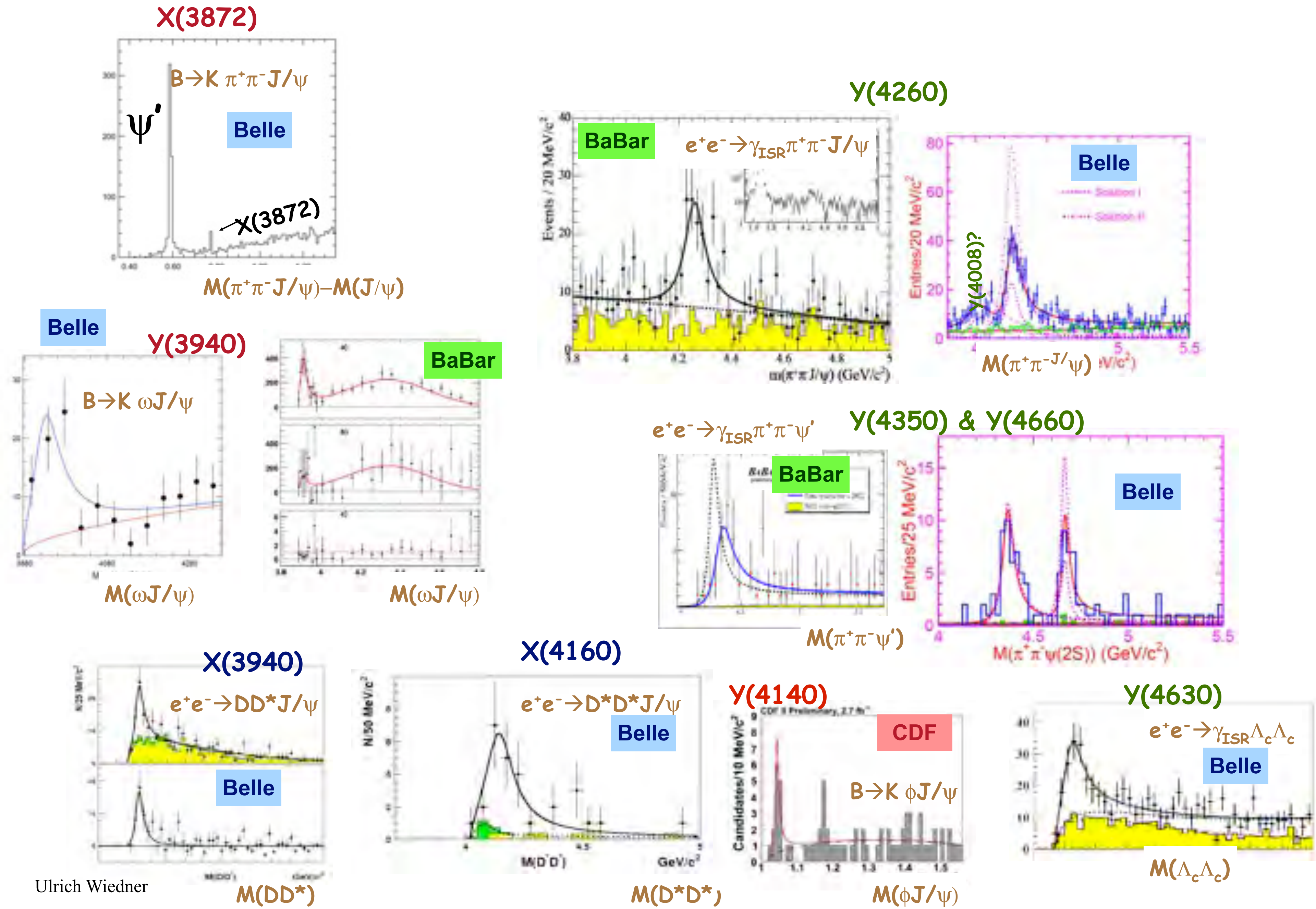
Hadron Spectroscopy

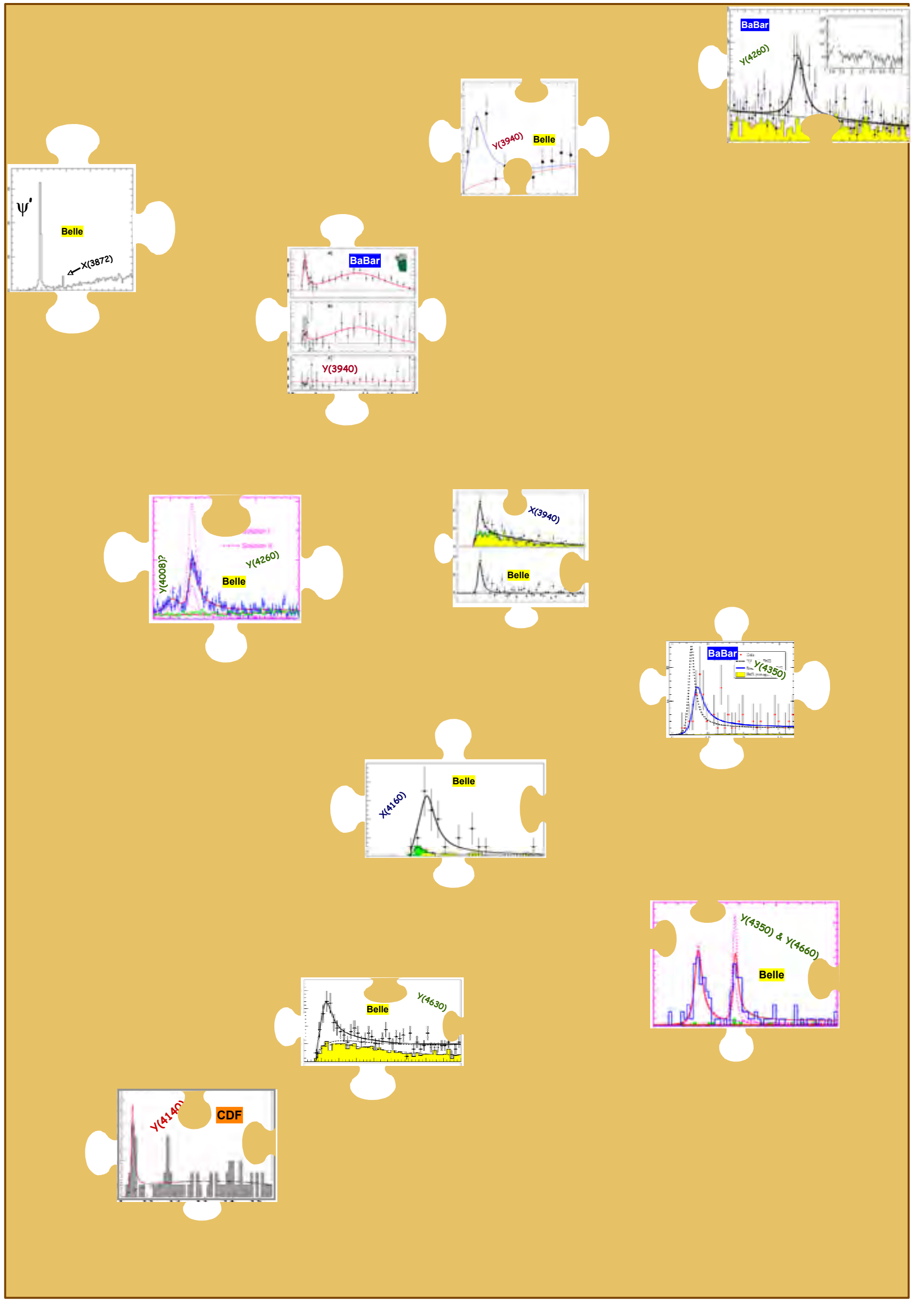




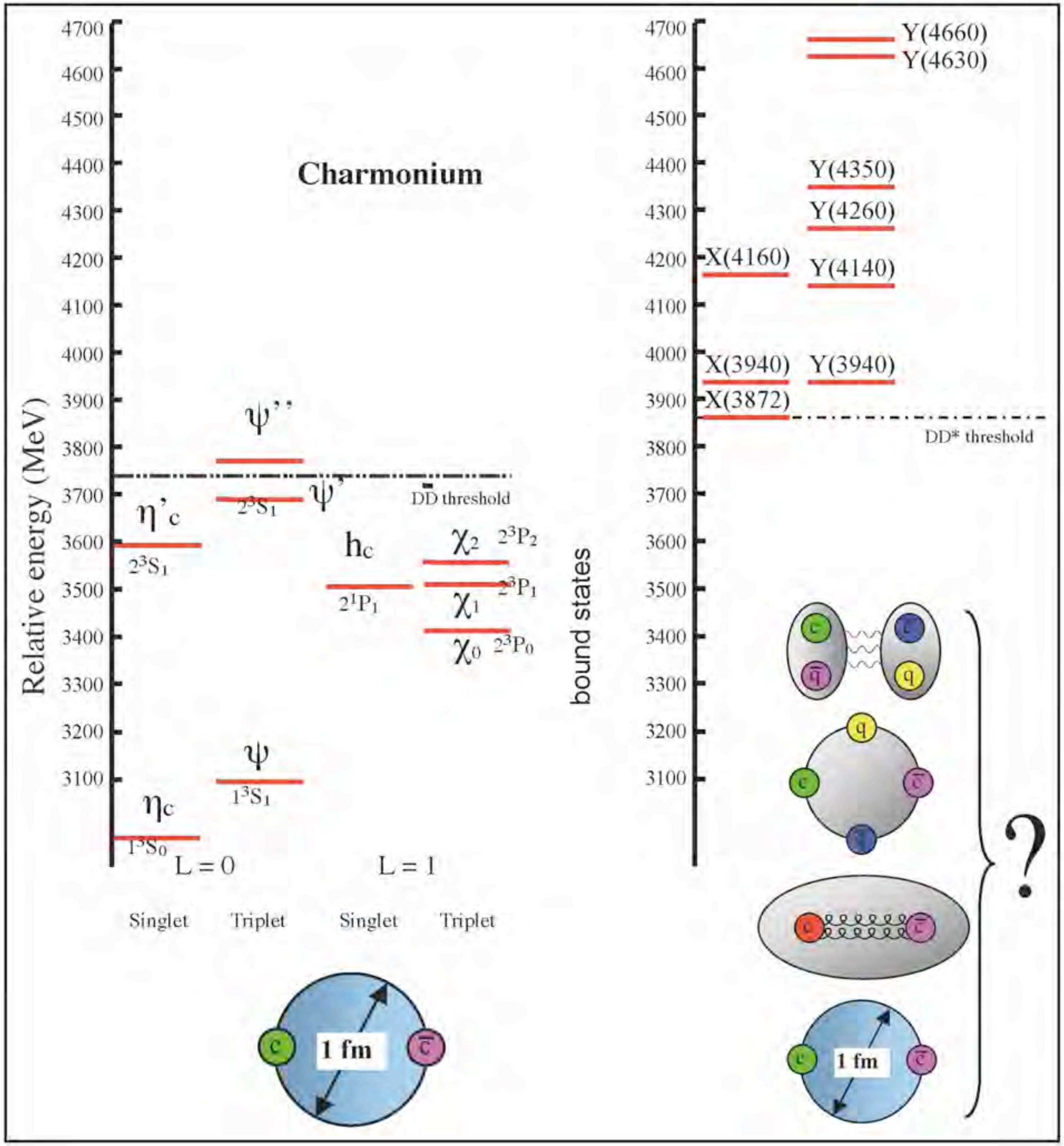
Ulrich Wiedner

X and Y mesons



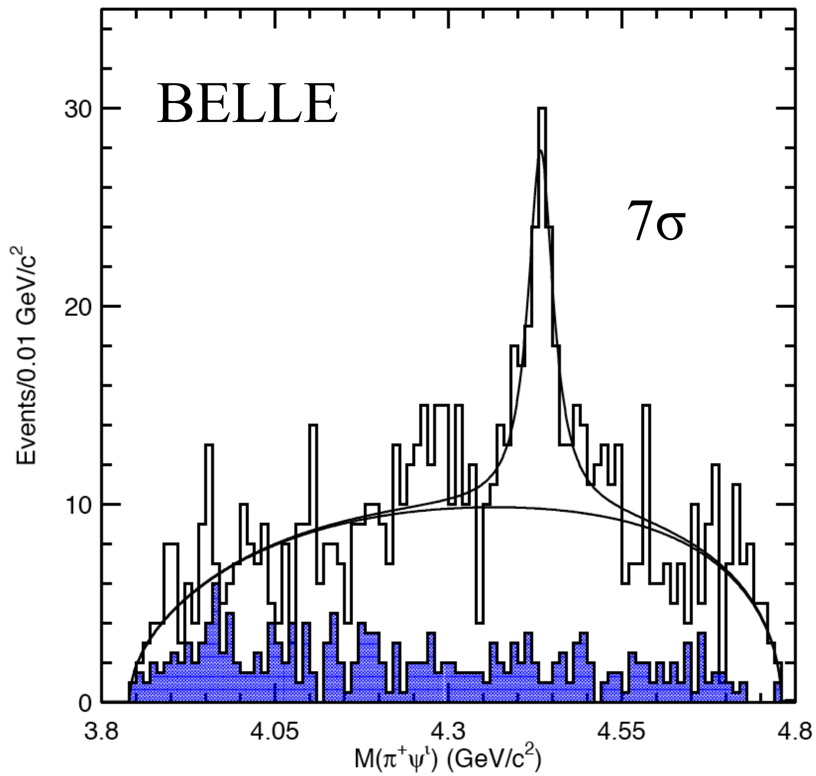

BaBar
Y(4260)
Y(3940)
Belle
ψ'
Belle
X(3872)
BaBar
Y(3940)
Y(4008)?
Y(4260)
Belle
X(3940)
Belle
BaBar
Y(4350)
Belle
X(4160)
Y(4350) & Y(4660)
Belle
Belle
Y(4630)
Y(4140)
CDF

Ulrich Wiedner



Ulrich Wiedner

Z^+ (4430) - a new state of matter (tetraquark?) decaying into $\pi^+\psi'$



$$M = (4.433 \pm 0.004\ (stat) \pm 0.001\ (syst))\ GeV$$

$$\Gamma = (0.044^{+0.017}_{-0.011}\ (stat)^{+0.030}_{-0.011}\ (syst))\ GeV$$

$$\mathcal{B}(B \to KZ(4430) \times \mathcal{B}(Z \to \pi^+\psi') = (4.1 \pm 1.0\ (stat) \pm 1.3\ (syst)) \times 10^{-5}$$

PRL 100, 142001 (2008)
arXiv:0708.1790 [hep-ex]

Like social elephants, quarks only exist in groups with other quarks and are never found alone. Composite particles made of quarks are called

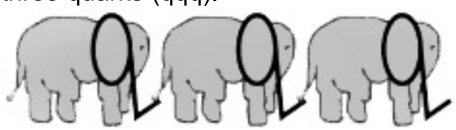
HADRONS

Although individual quarks have fractional electrical charges, they combine such that hadrons have a net integer electric charge. Another property of hadrons is that they have no net color charge even though the quarks themselves carry color charge (we will talk more about this later).

There are two classes of hadrons (try putting your mouse on the elephants):

BARYONS

...are any hadron which is made of three quarks (qqq).



Because they are made of two up quarks and one down quark (uud), **protons** are baryons. So are **neutrons** (udd).

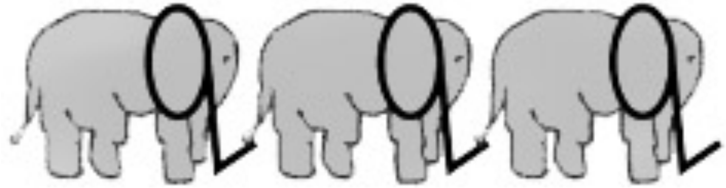
MESONS

...contain one quark (q) and one antiquark ($\bar{q}$).

One example of a meson is a pion (π^+), which is made of an up quark and a down anitiquark. The antiparticle of a meson just has its quark and antiquark switched, so an antipion (π^-) is made up a down quark and an up antiquark.

Because a meson consists of a particle and an antiparticle, it is very unstable. The kaon (K^-) meson lives much longer than most mesons, which is why it was called "strange" and gave this name to the strange quark, one of its components.

A weird thing about hadrons is that only a very very very **small part of the mass of a hadron** is due to the quarks in it.



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Glueballs

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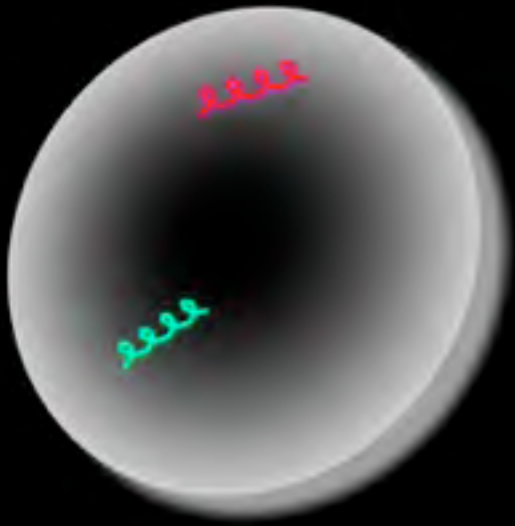
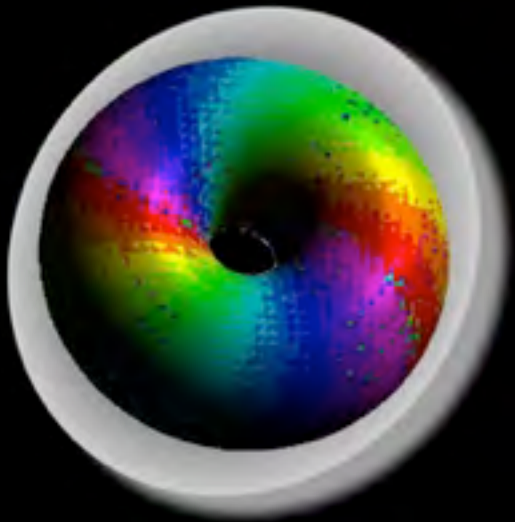


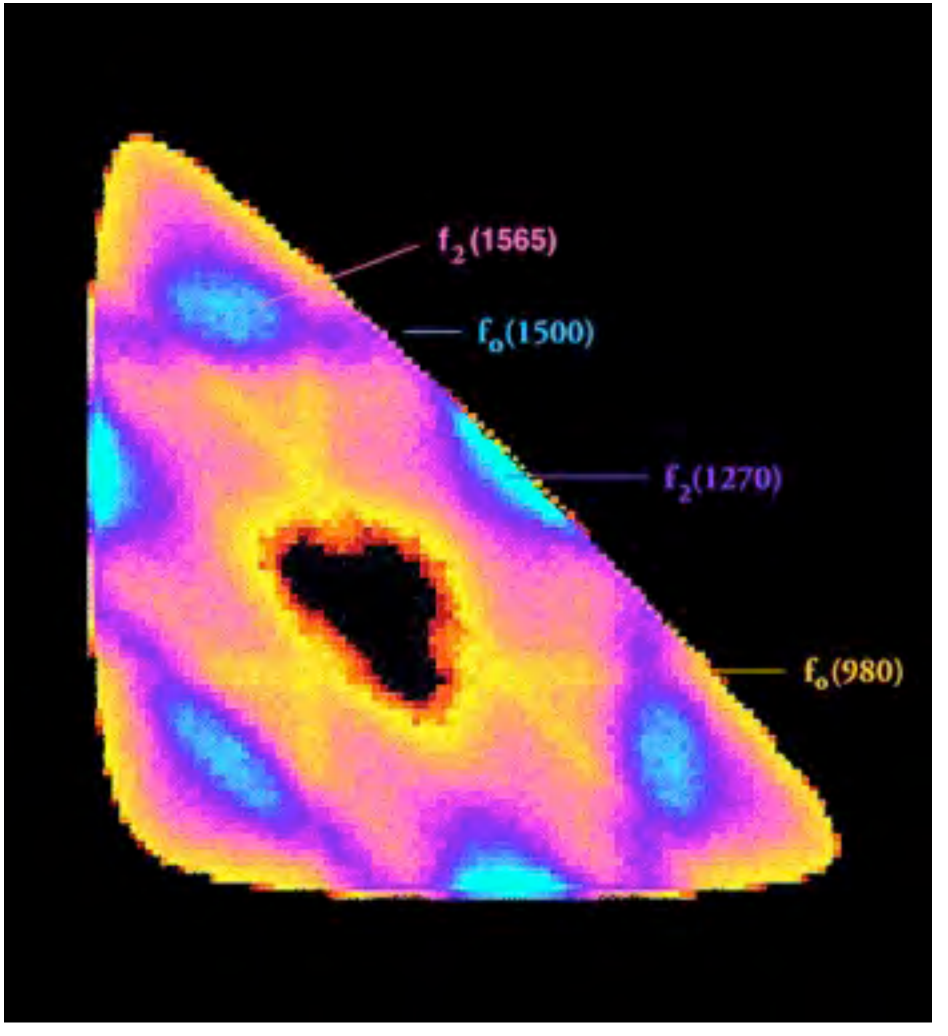


Glueballs, closed fluxtubes and η(1440)

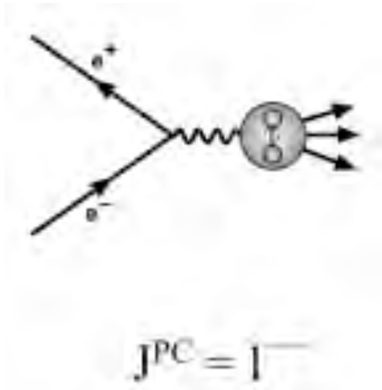
Ludvig Faddeev, Antti Niemi and Ulrich Wiedner

Phys.Rev.D70:114033, 2004

Crystal Barrel $p\bar{p} \to \pi^0\pi^0\pi^0$ Dalitz plot



700000 events = 6×700000 entries



Production of $\chi_{1,2}$

$e^+e^- \rightarrow \psi'$

$\searrow \gamma\chi_{1,2}$

$\searrow \gamma\,(\gamma J/\psi)$

$\searrow \gamma\gamma\,(e^+e^-)$

Reconstruction of invariant mass:
detector resolution dependent

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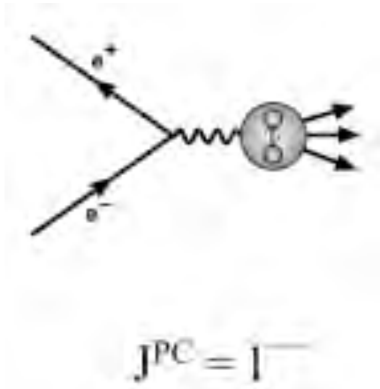

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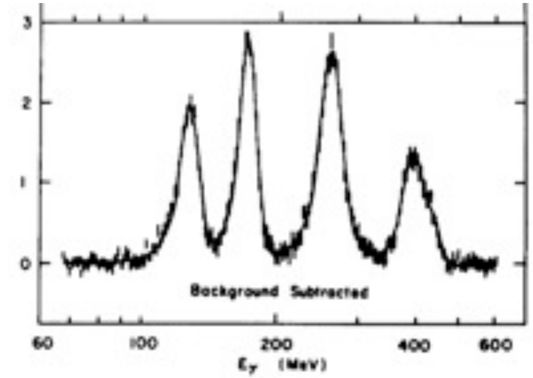

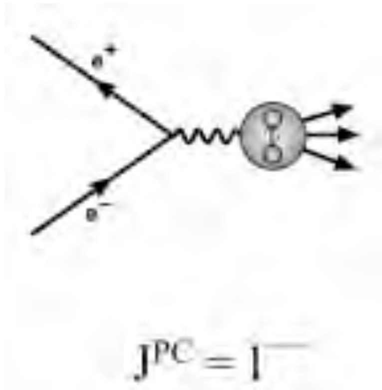

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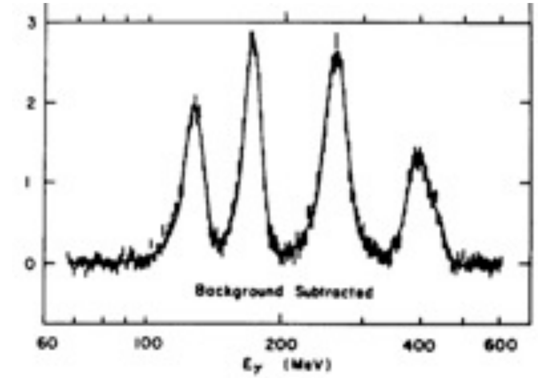

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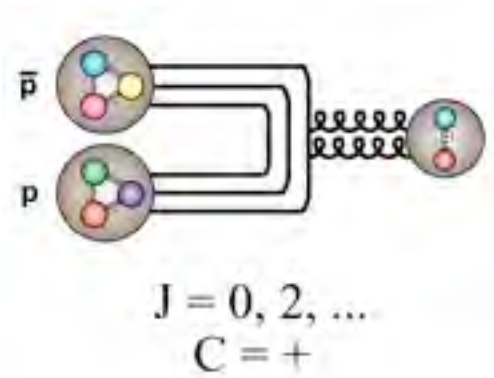

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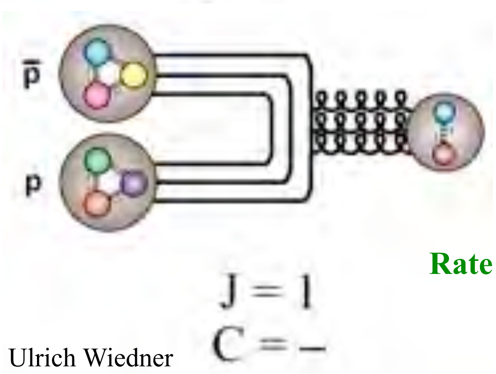
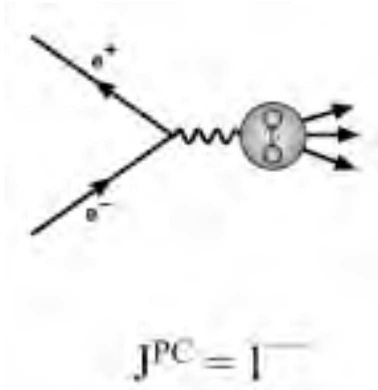


Rate measurement (beam energy dependent):
detector resolution "independent"



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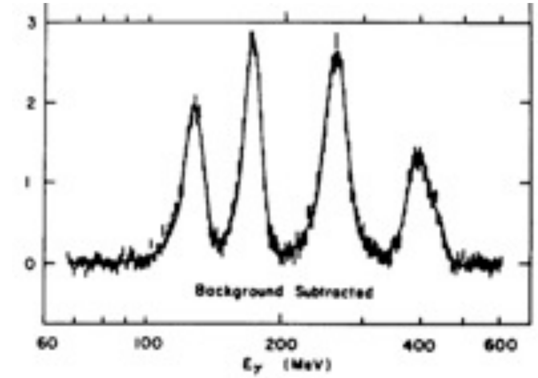

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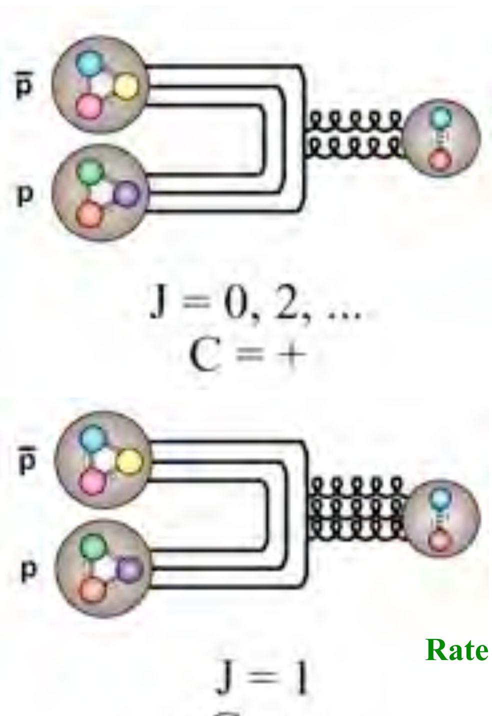

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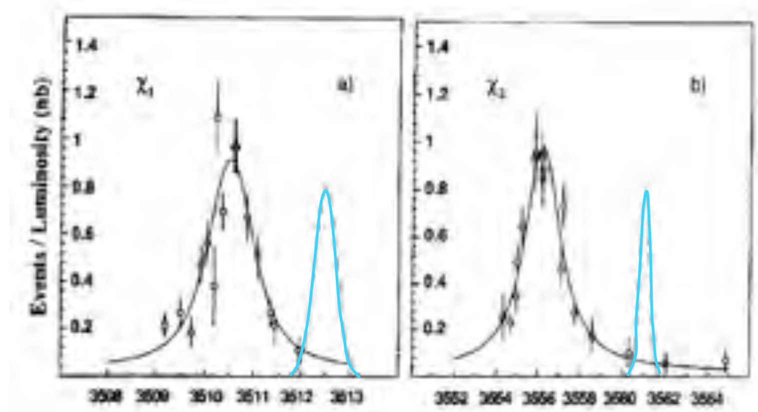
E 760 (Fermilab)



Rate measurement (beam energy dependent):
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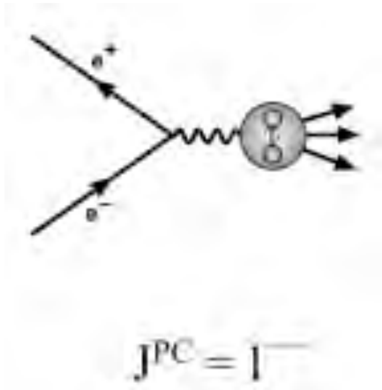
σ_m (beam) = 0.5 MeV

Ulrich Wiedner



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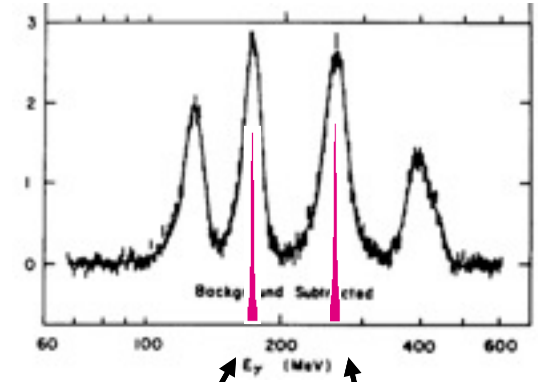

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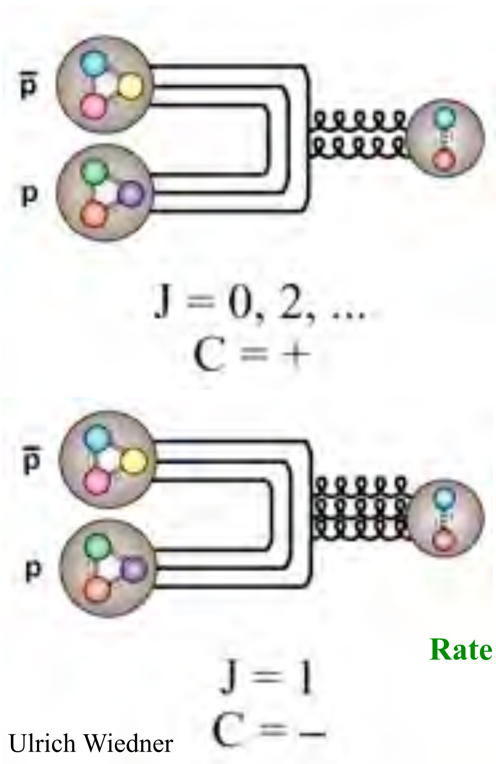

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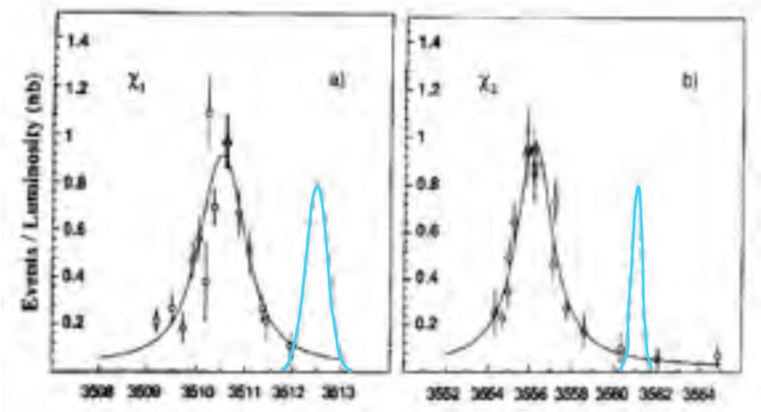

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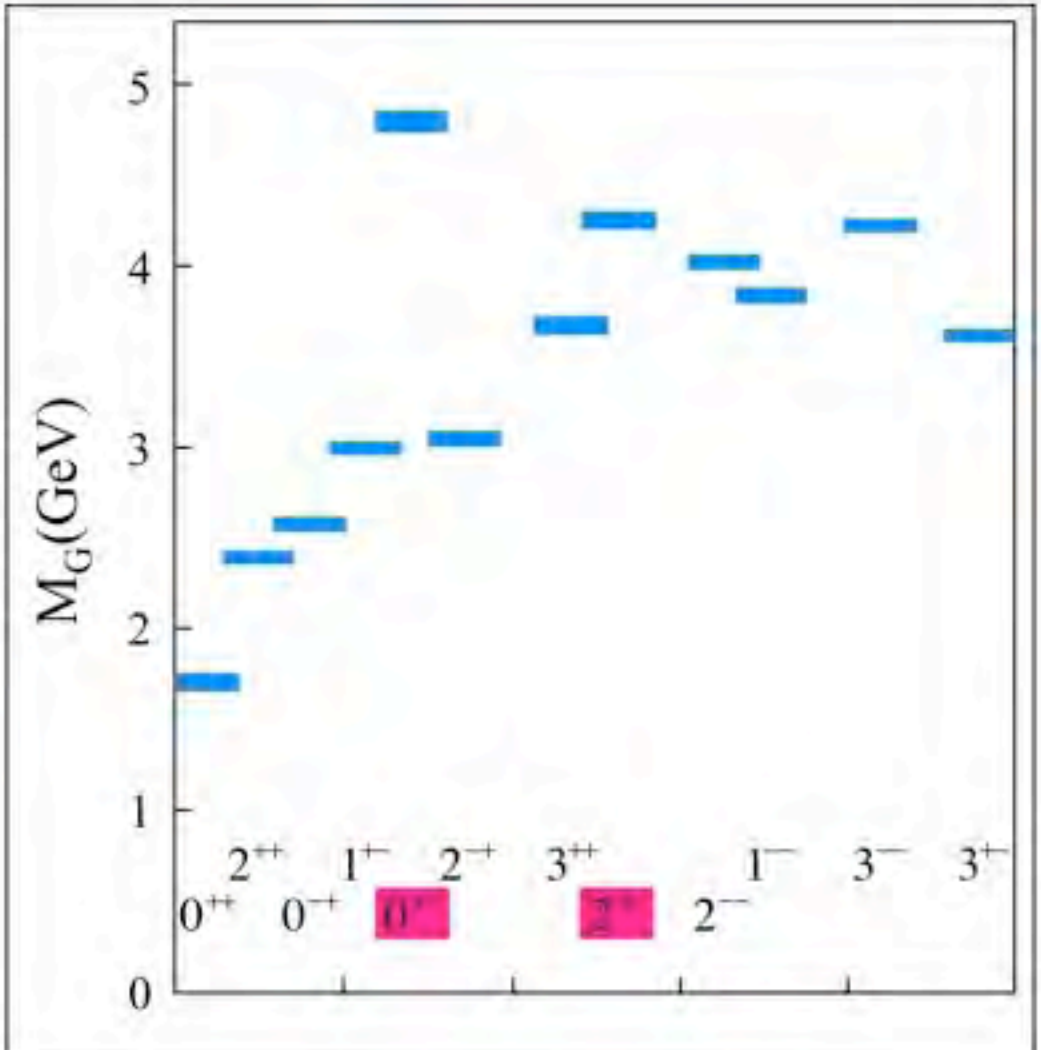
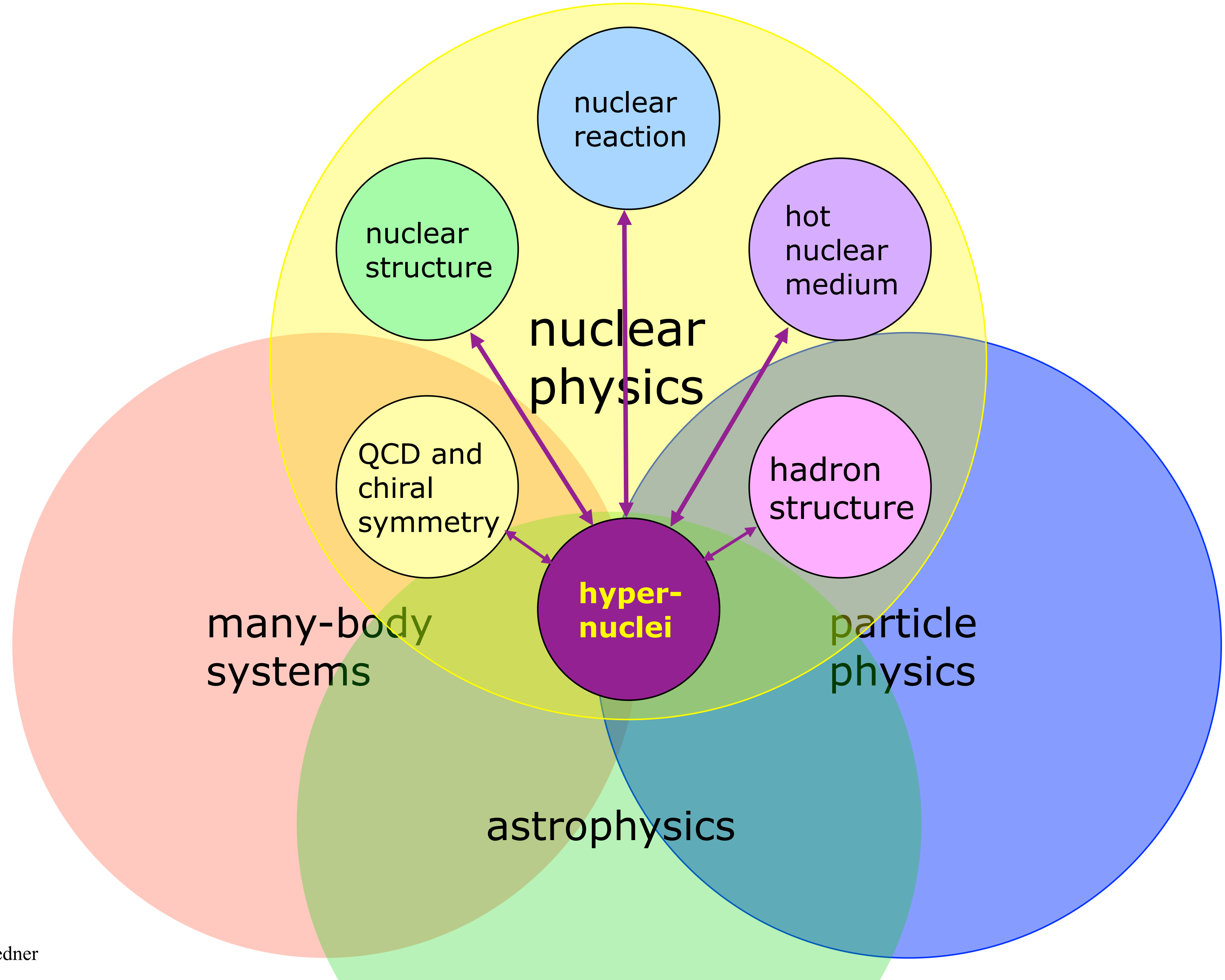
Ulrich Wiedner

The glueball spectrum



Hadron Interactions

Hypernuclear physics: a multicultural activity



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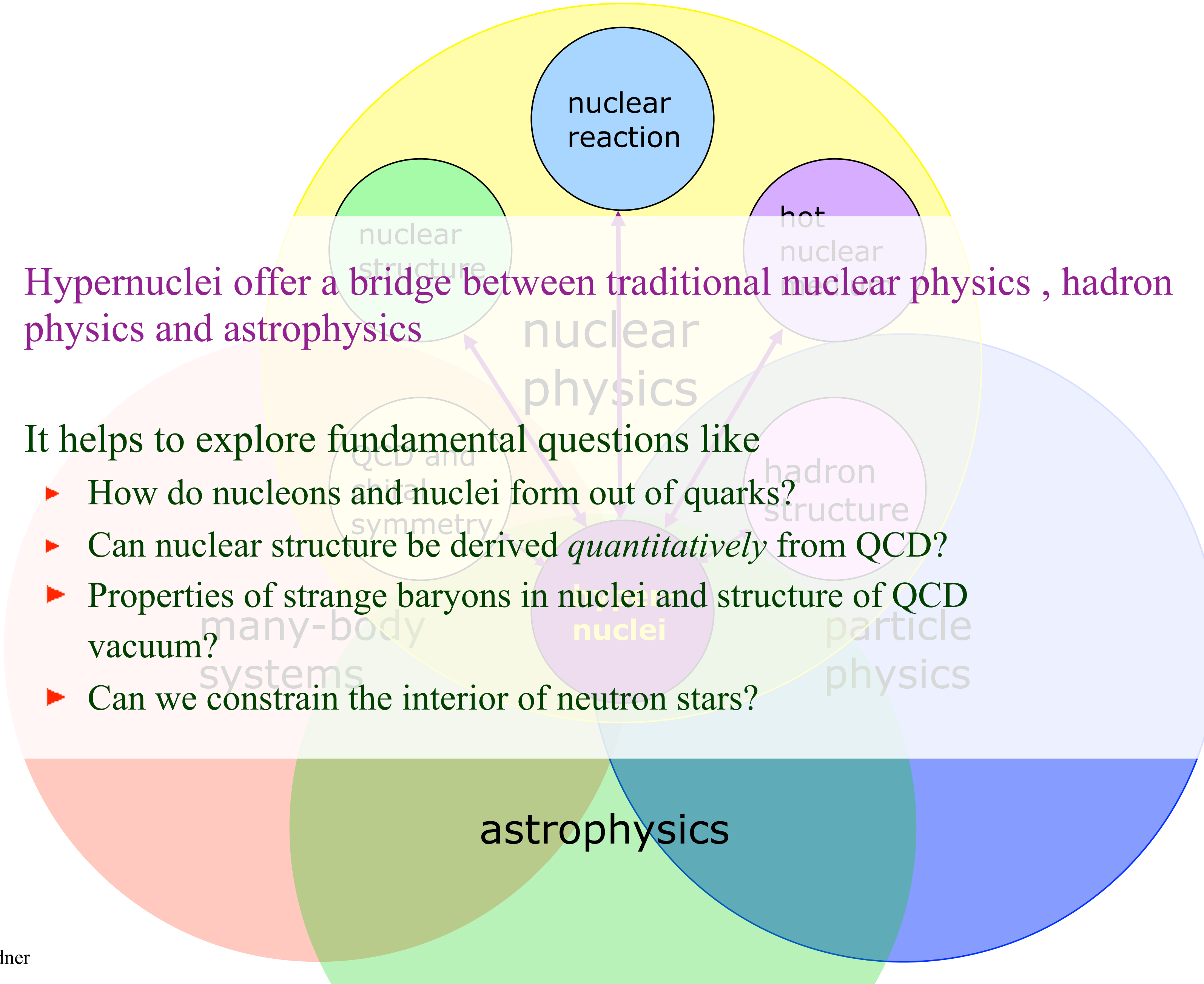
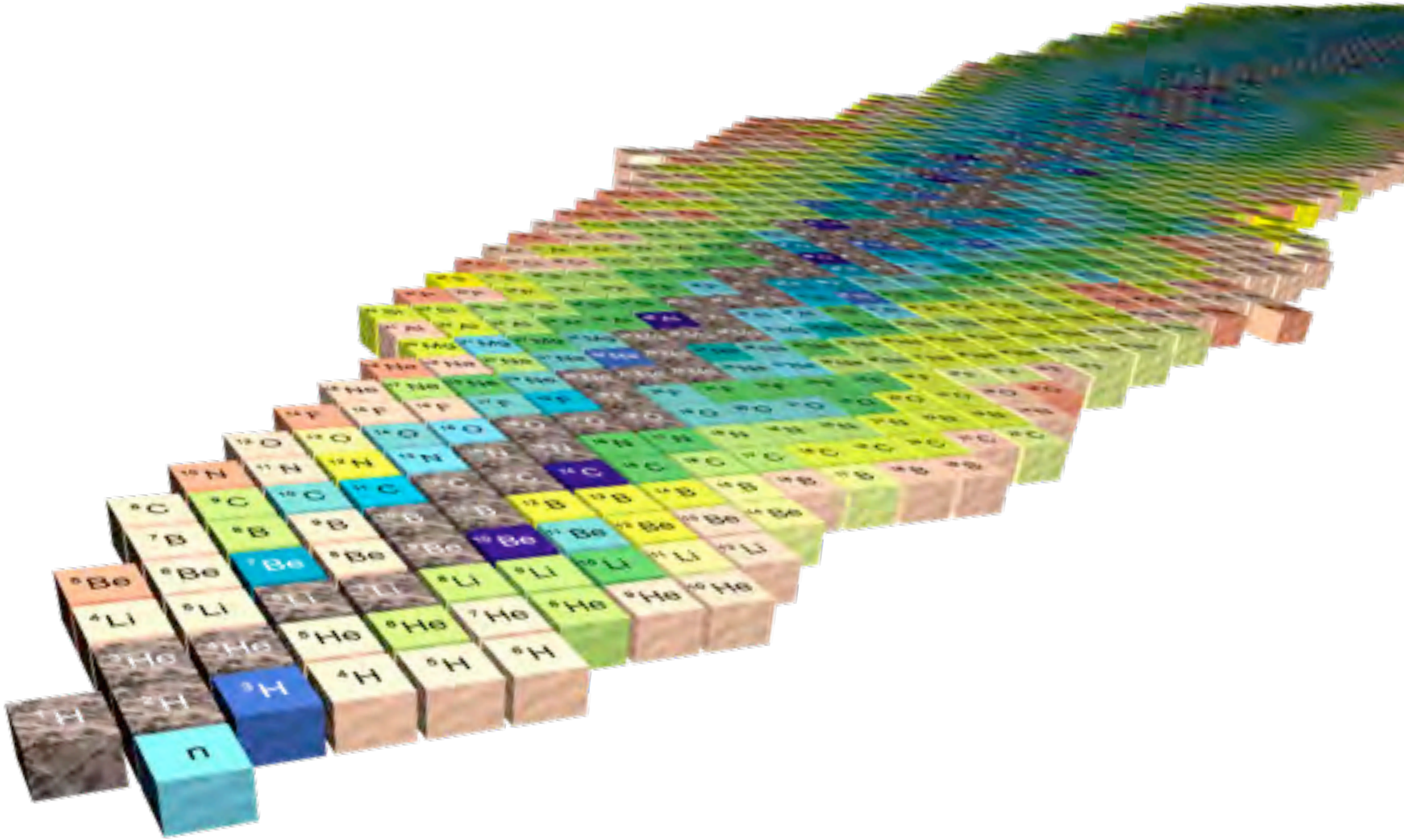


- Hypernuclei offer a bridge between traditional nuclear physics , hadron physics and astrophysics

- It helps to explore fundamental questions like
  - How do nucleons and nuclei form out of quarks?
  - Can nuclear structure be derived *quantitatively* from QCD?
  - Properties of strange baryons in nuclei and structure of QCD vacuum?
  - Can we constrain the interior of neutron stars?

Adding the third dimension to the nuclear chart

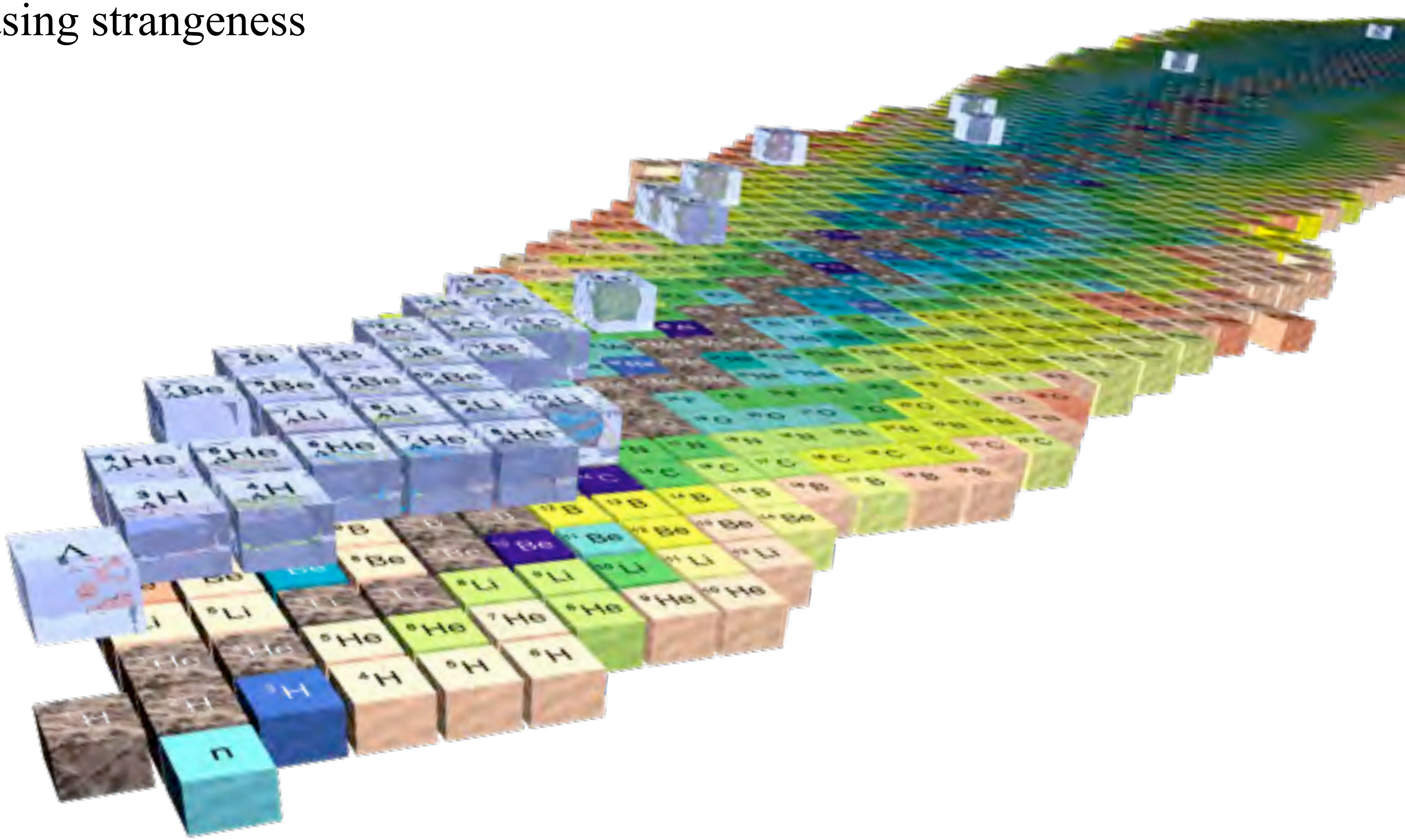
Adding the third dimension to the nuclear chart



Adding the third dimension to the nuclear chart

Increasing strangeness

$^{B}_{Y}X$



- Present limitations
  - only single Λ-hypernuclei close to valley of stability
  - only very few ΛΛ-hypernuclei events
  - no information on antihyperons in nuclei

Ulrich Wiedner

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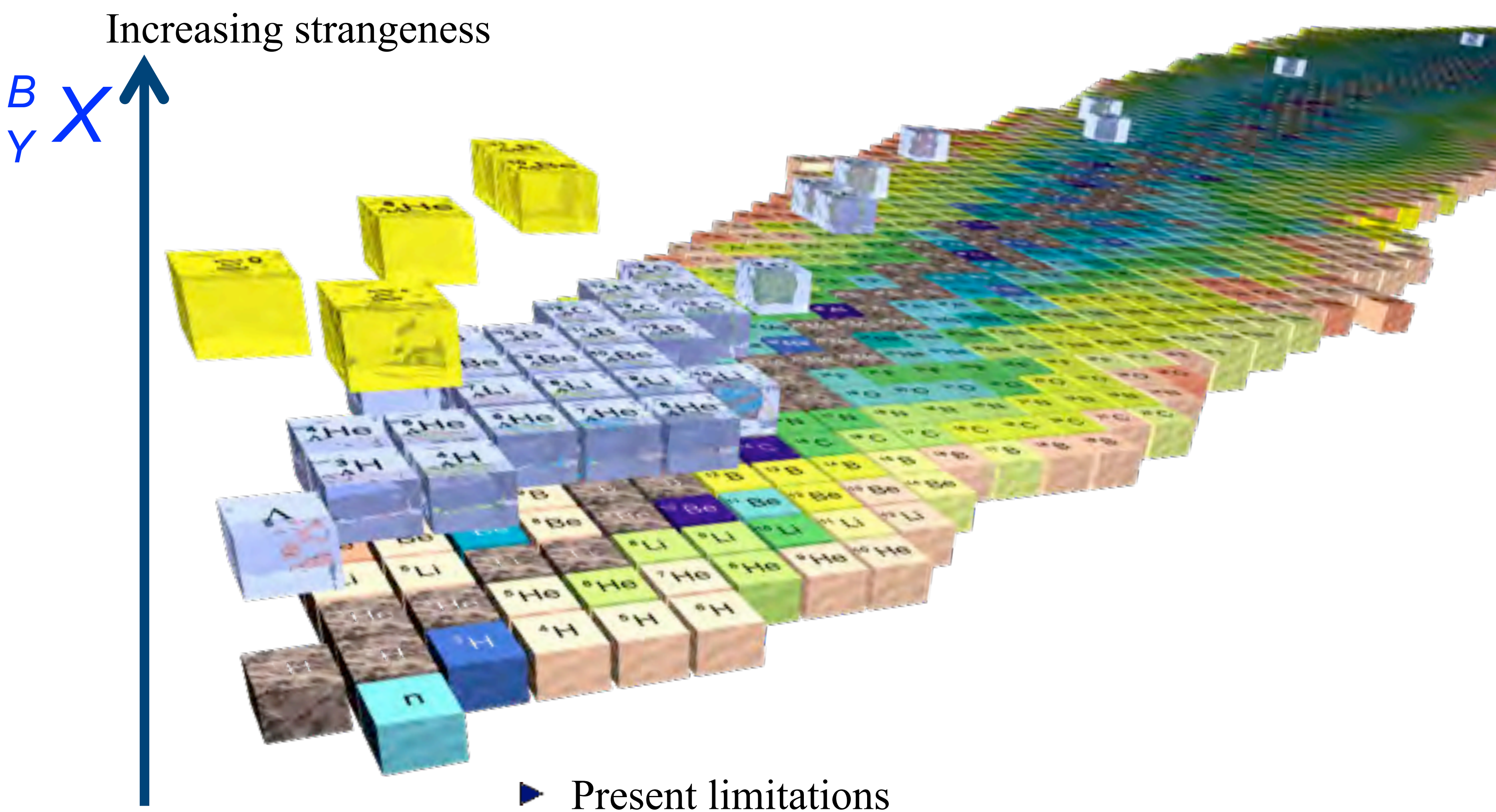

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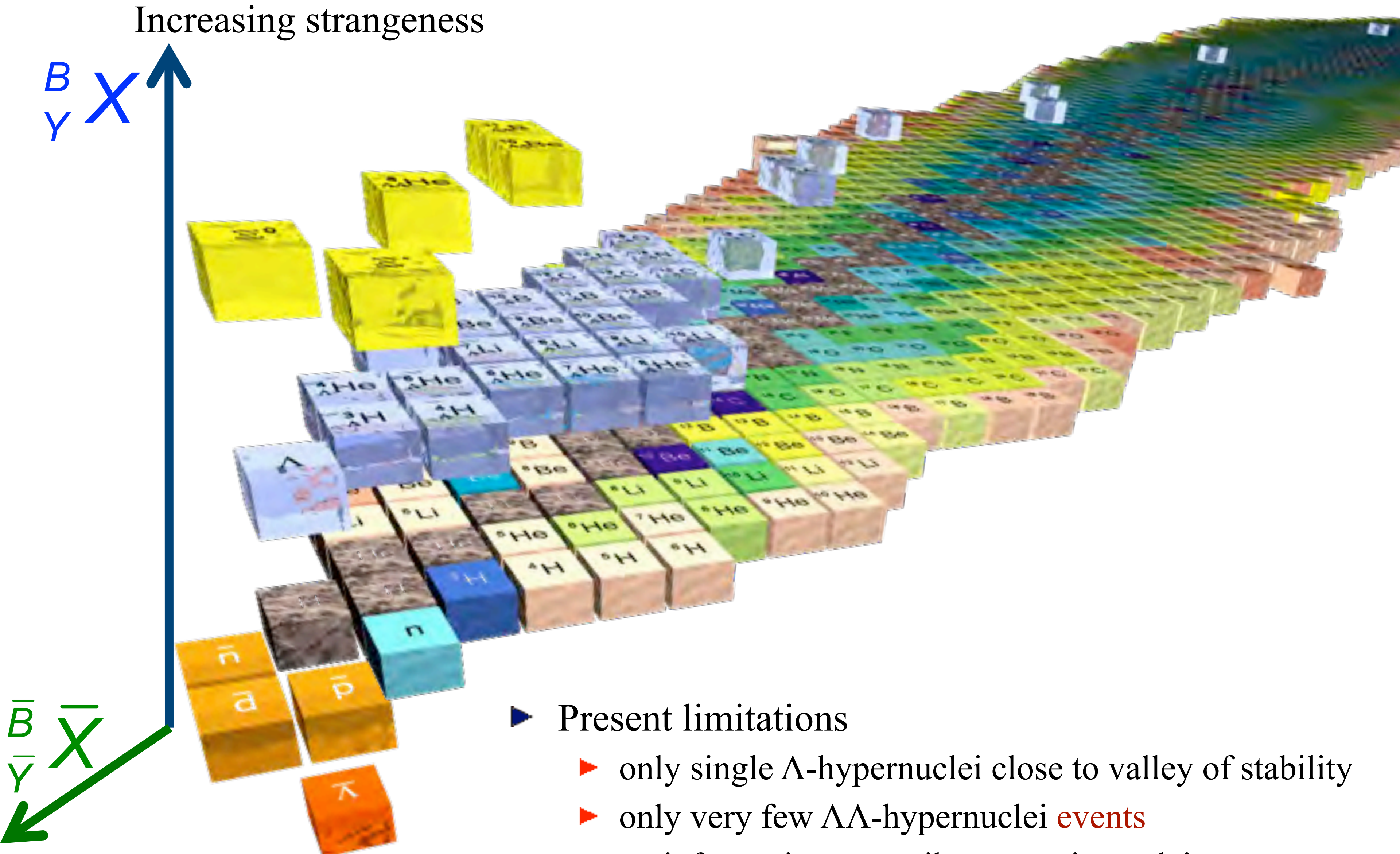

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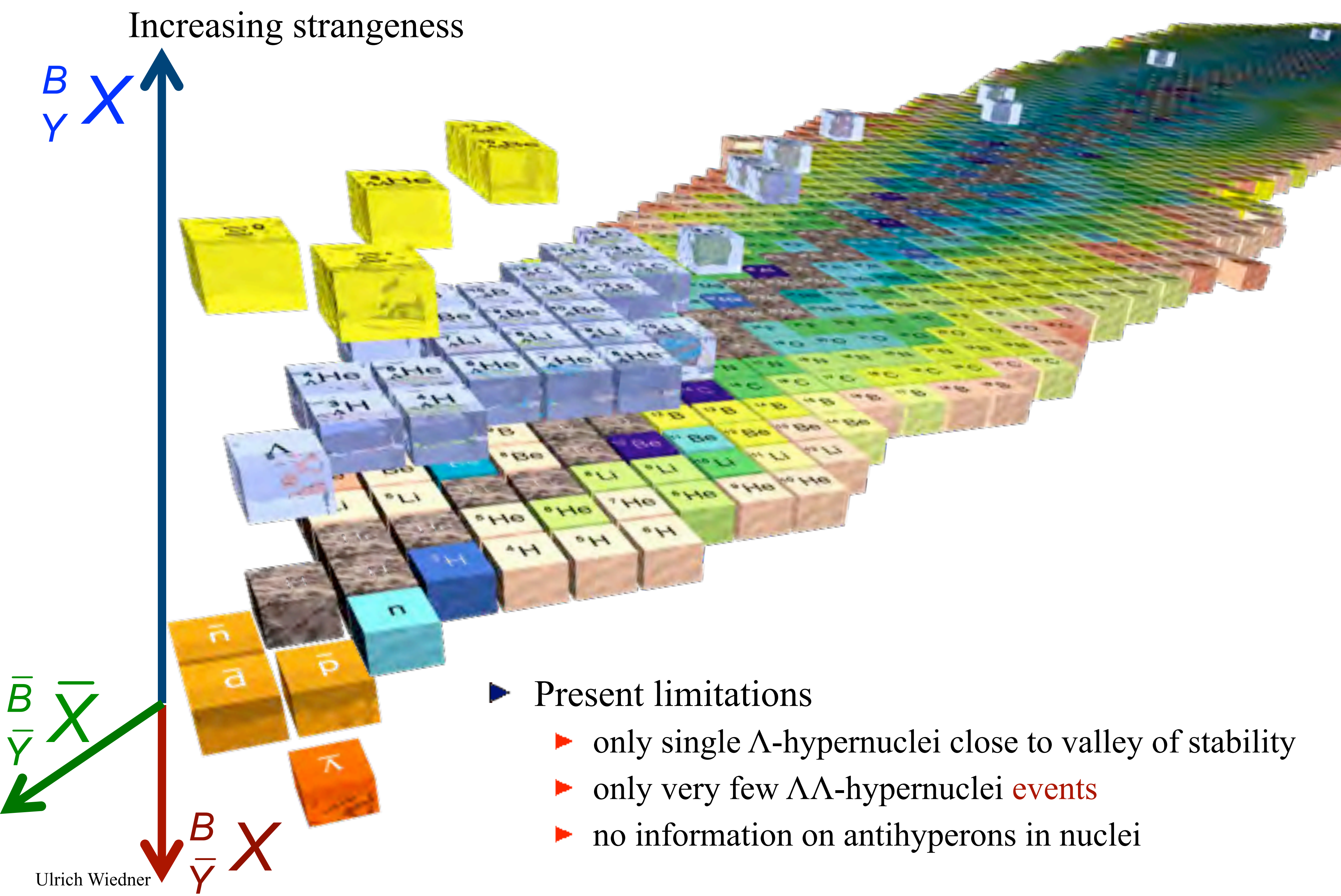

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Production of Hypernuclei at PANDA

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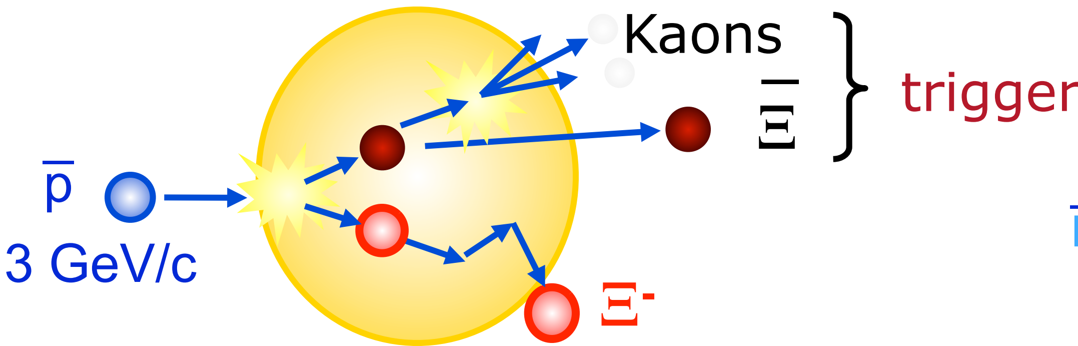

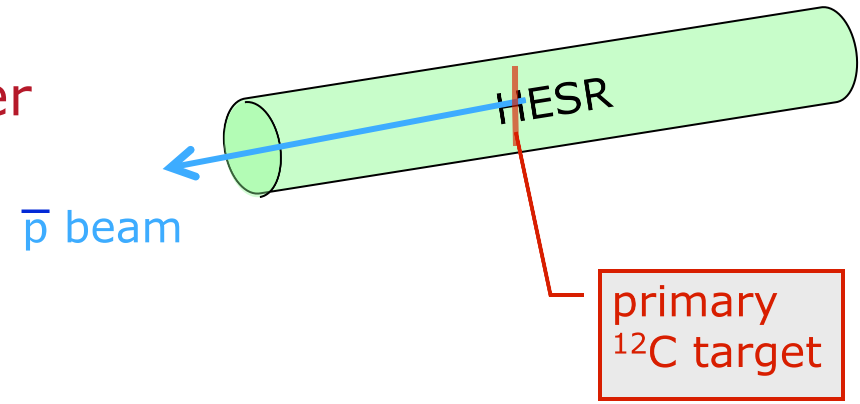

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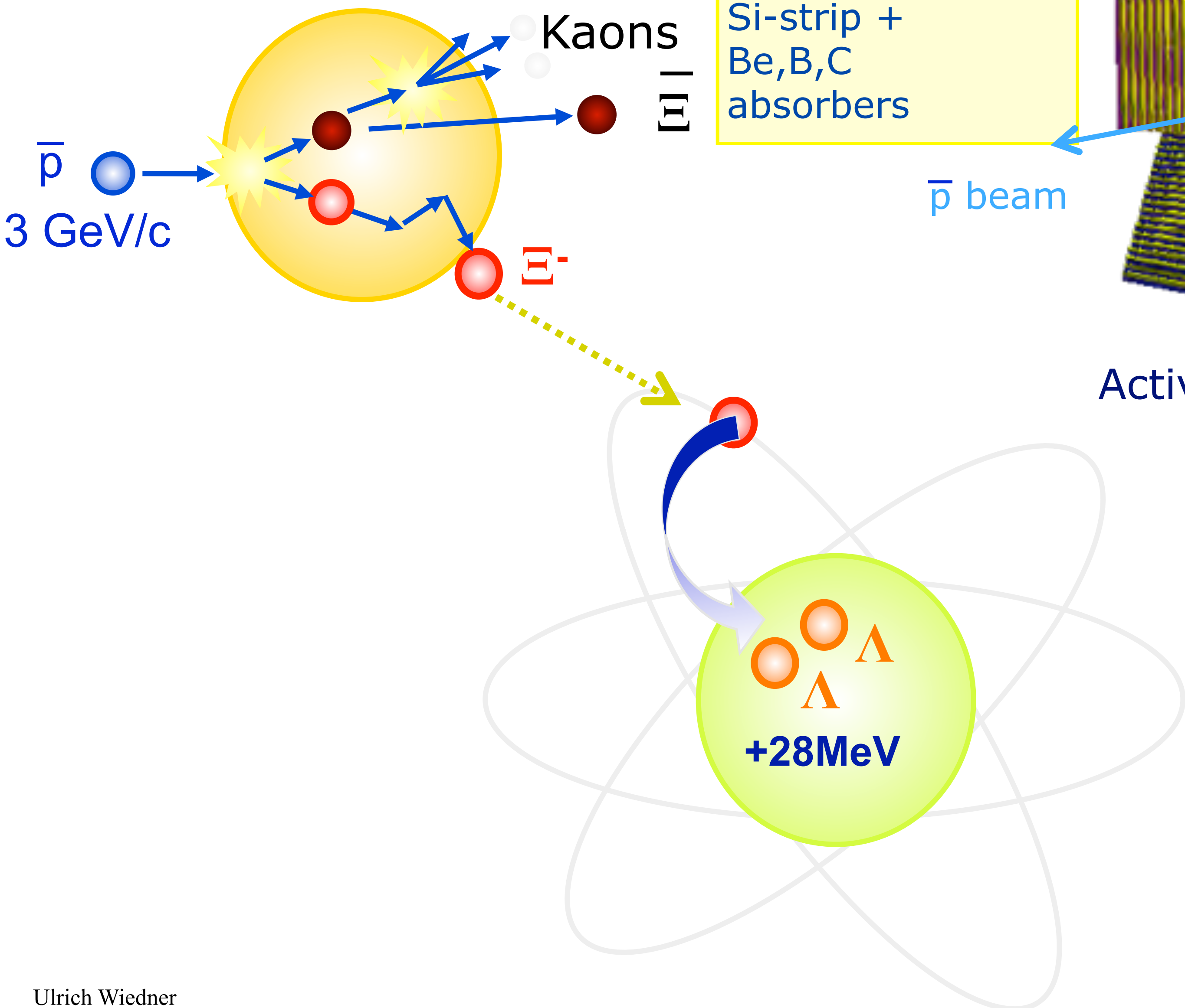

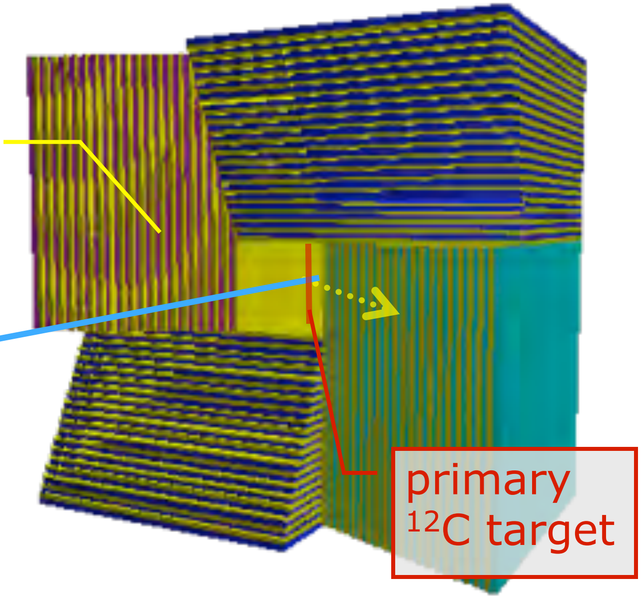

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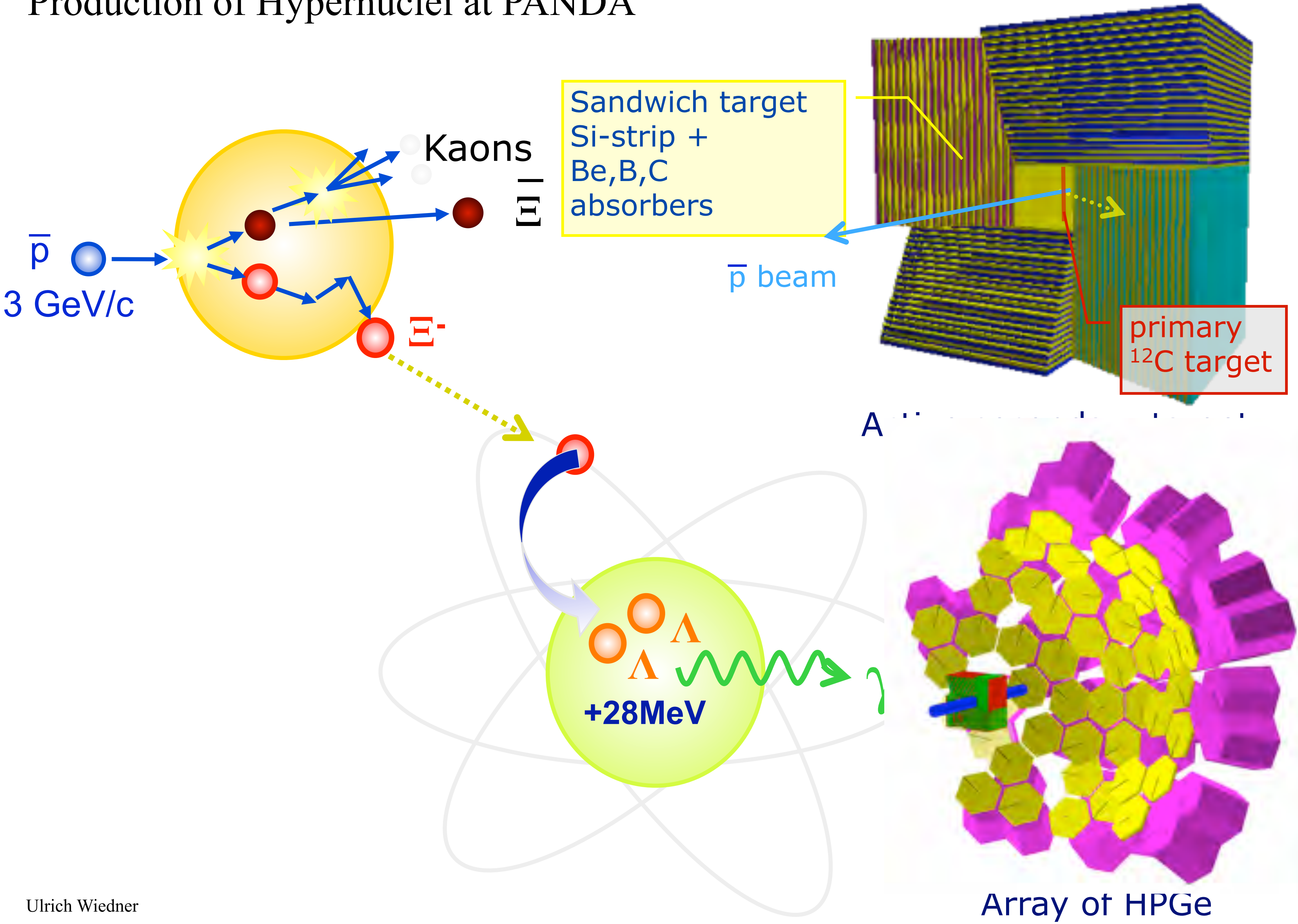
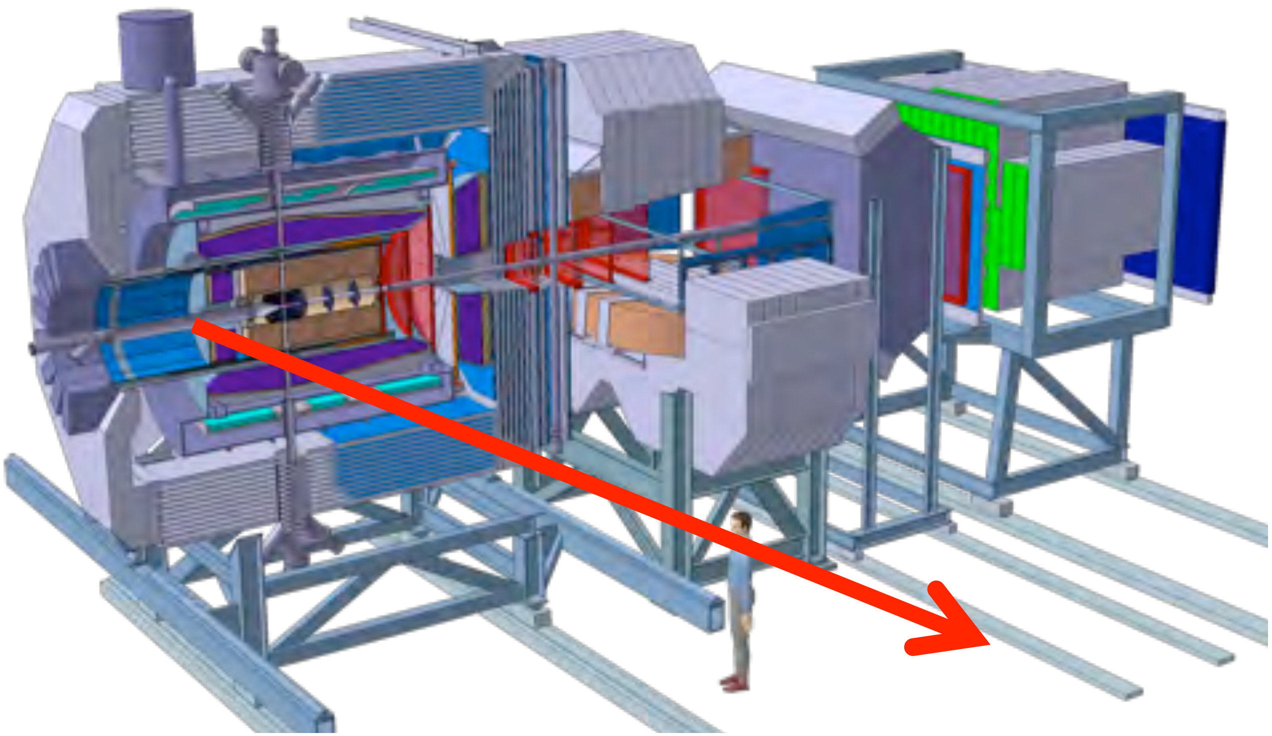


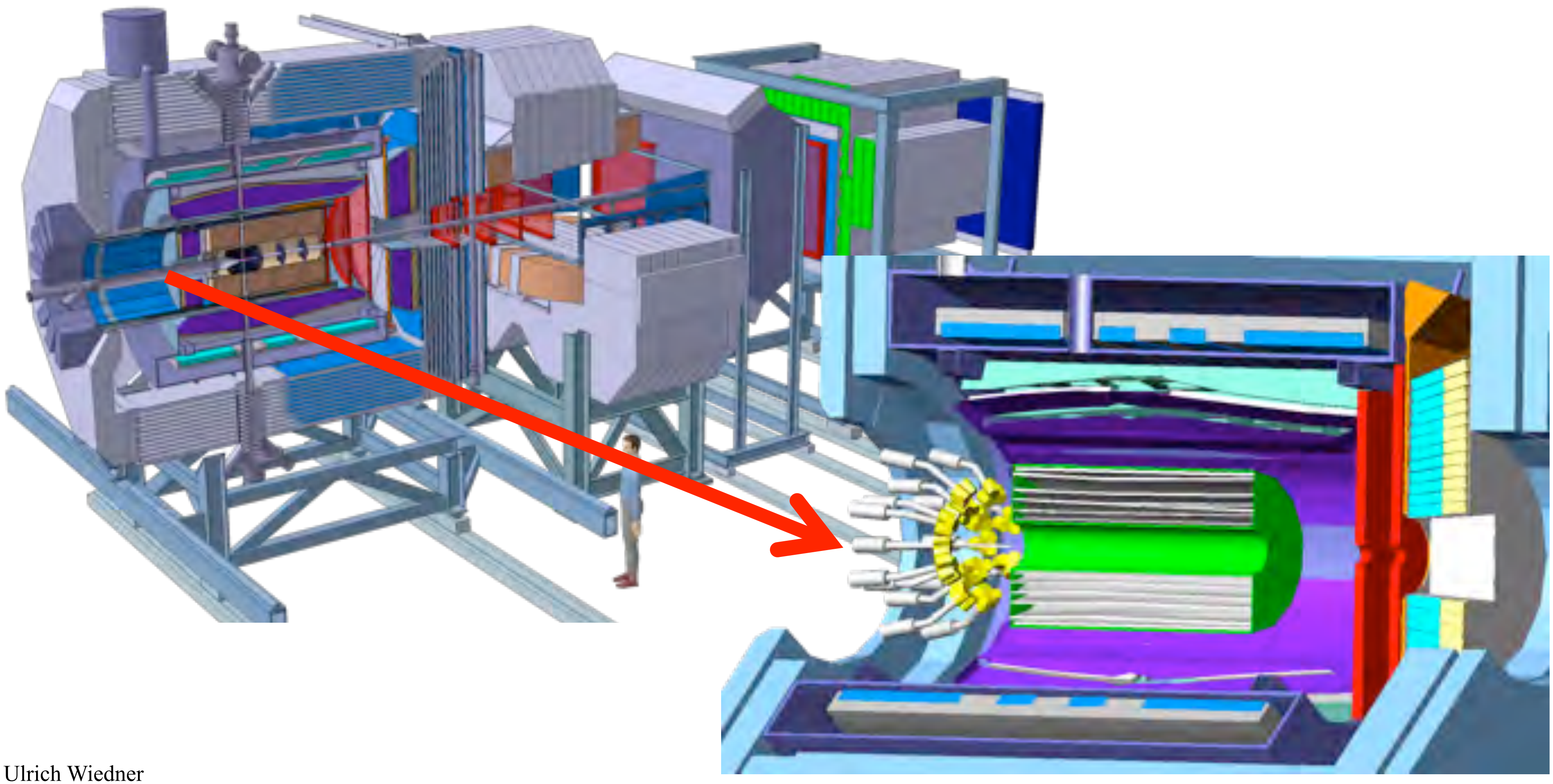
PANDA Detector set-up for hypernuclei physics

- $\theta_{lab} < 45°$: $\overline{\Xi}$, K^- trigger (PANDA)
- $\theta_{lab} = 45°$-$90°$: Ξ-capture, hypernucleus formation
- $\theta_{lab} > 90°$: γ-detection Euroball at backward angles

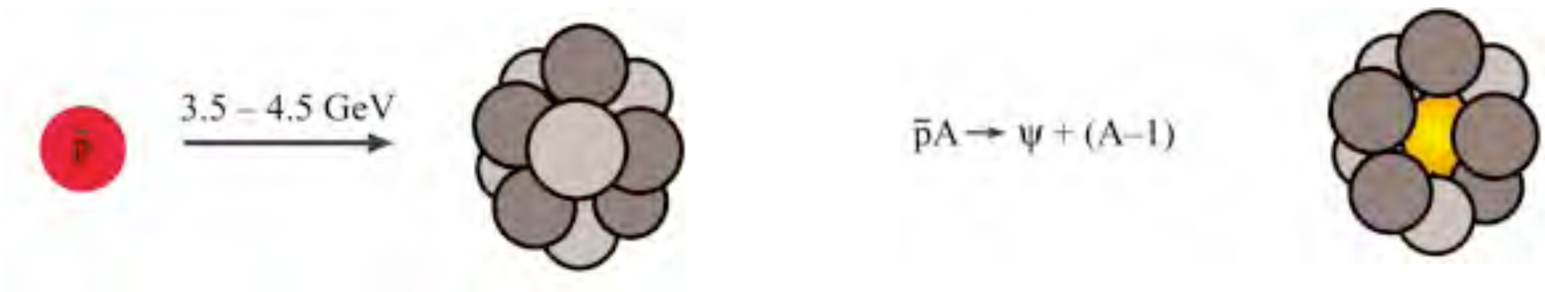


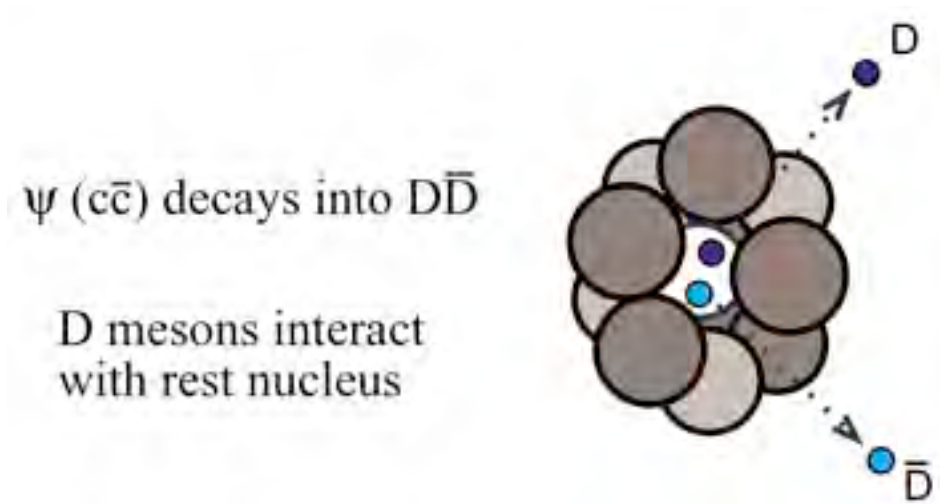
PANDA Detector set-up for hypernuclei physics

- $\theta_{lab} < 45°$: $\overline{\Xi}$, K^- trigger (PANDA)
- $\theta_{lab} = 45°\text{-}90°$: Ξ-capture, hypernucleus formation
- $\theta_{lab} > 90°$: γ-detection Euroball at backward angles

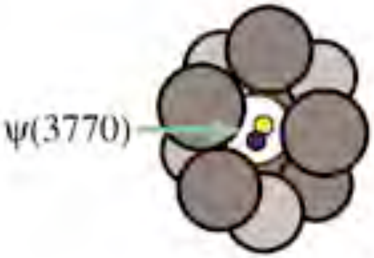


Antiproton-Nucleus Interaction





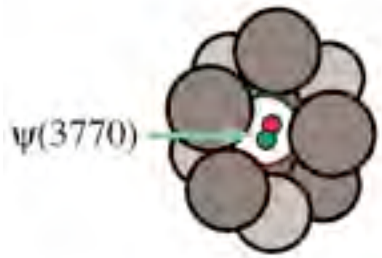
$D^- = d\bar{c}$



quark – nucleus interaction = d (or $\bar{d}$) – nucleus interaction*

$D^+ = \bar{d}c$

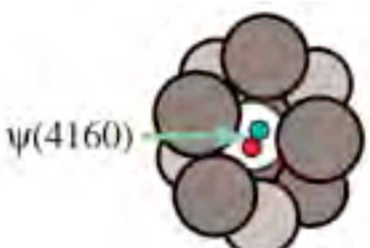
$\bar{D}^0 = u\bar{c}$



quark – nucleus interaction = u (or $\bar{u}$) – nucleus interaction*

$D^0 = \bar{u}c$

$D_s^- = s\bar{c}$



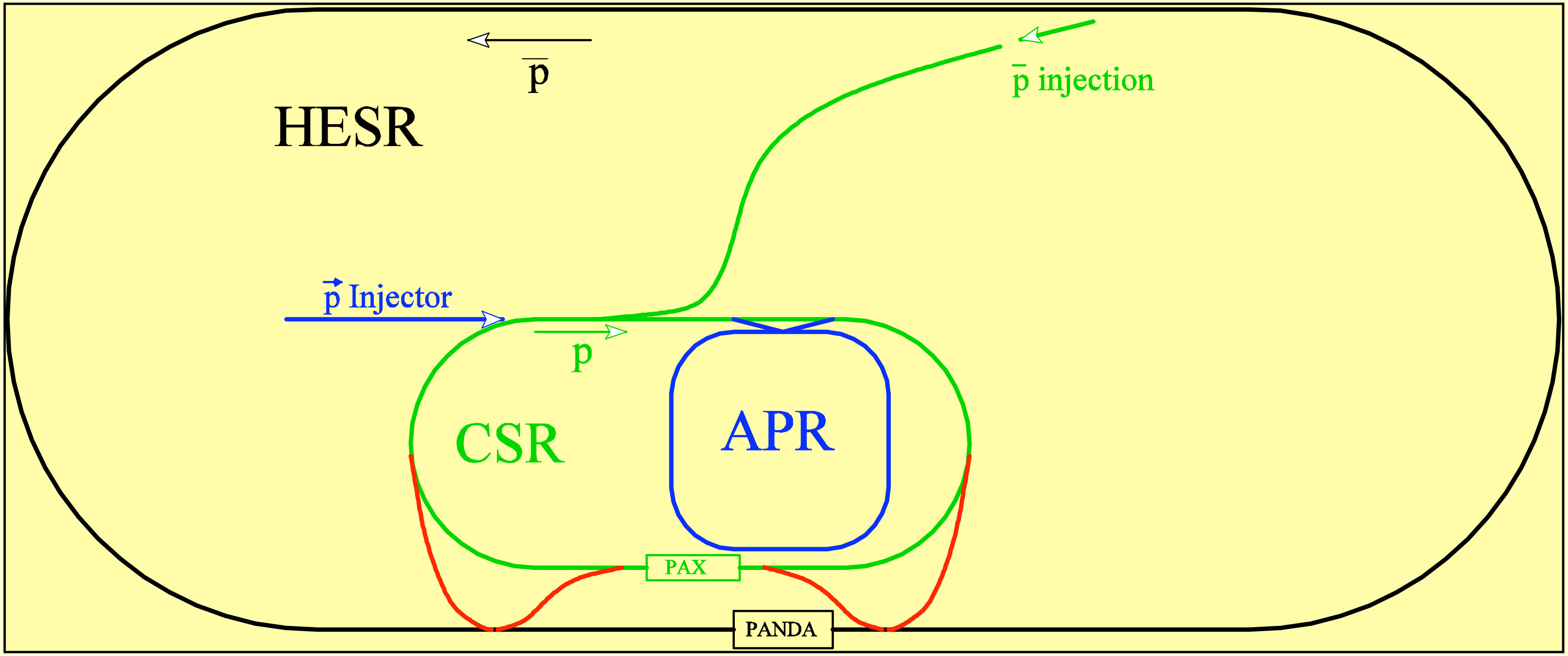
quark – nucleus interaction = s (or $\bar{s}$) – nucleus interaction*

$D_s^+ = \bar{s}c$

* ignoring c (or $\bar{c}$) – nucleus interaction

The long-term future at FAIR

Accelerator Setup

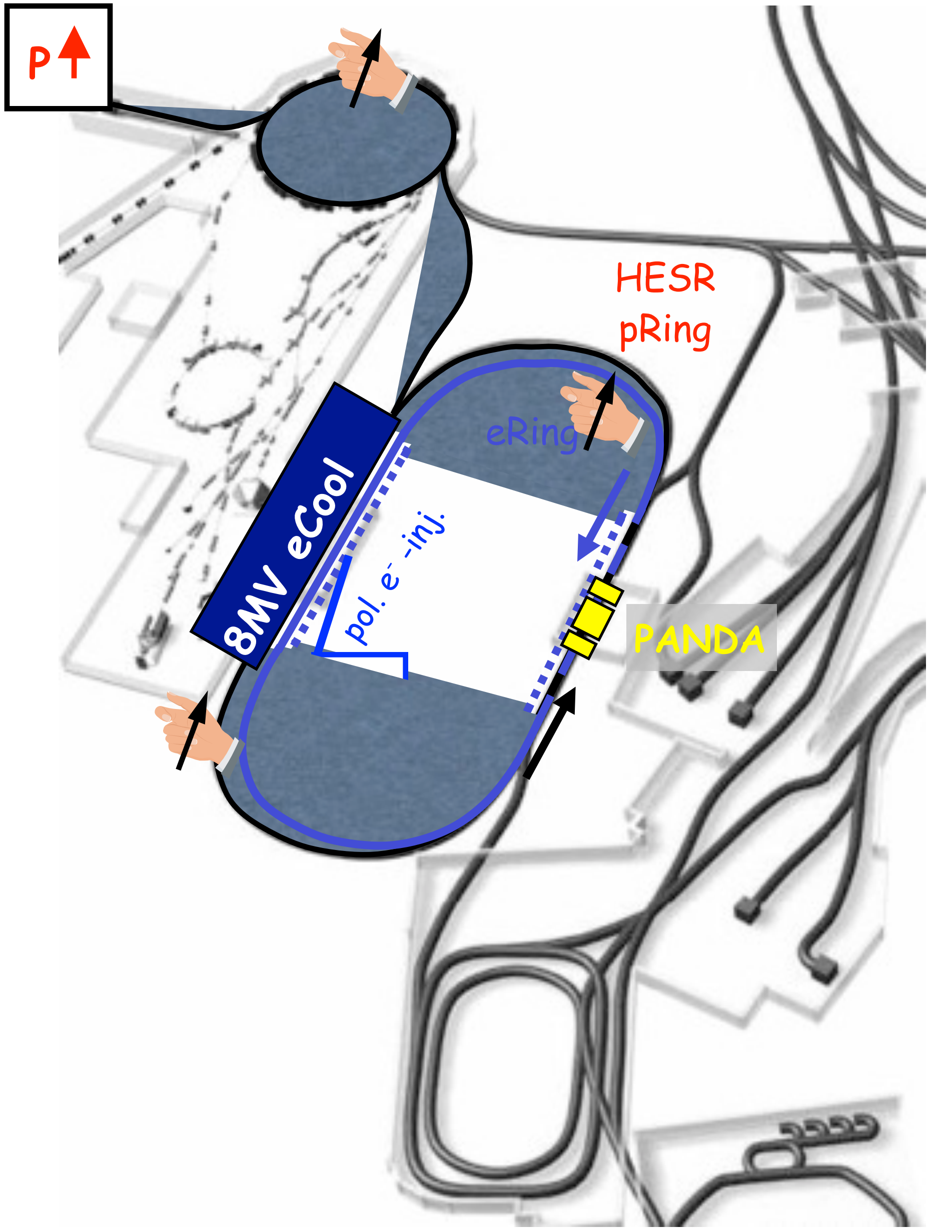


- Antiproton Polarizer Ring (APR)
- Cooler Storage Ring (CSR)
- High Energy Synchrotron Ring (HESR)

Phase I: Polarized Internal Target

Phase II: Asymmetric Antiproton-Proton Collider

idea: ENC@FAIR



$L > 10^{32}\ 1/cm^2s$

$s^{1/2} > 10GeV$

(3.3GeV e^- ↔ 15GeV p)

polarised e^- (> 80%)

↔

polarised p / d (> 80%)

(transversal + longitudinal)

using the PANDA detector

Common effort of
German Universities
(Bonn, Mainz, Dortmund)
plus collaboration with
Research Centres
FZJ, DESY, GSI, ...

Thank you for your attention!