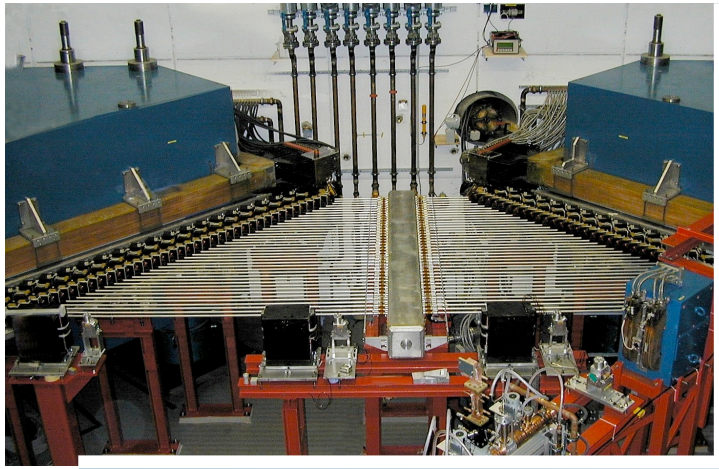
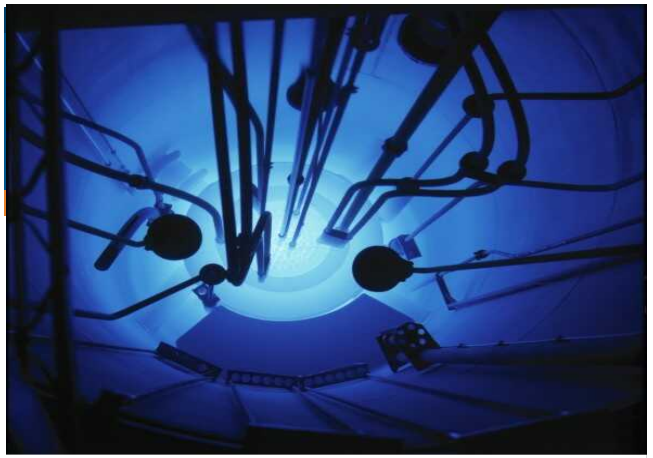




Research Area SPECF

Hadron Spectroscopy and Flavour

Status Report

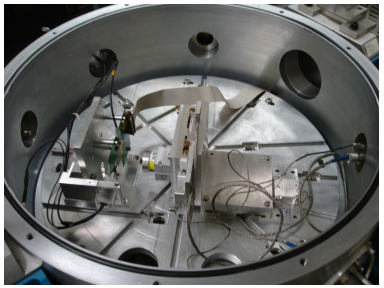
Achim G. Denig

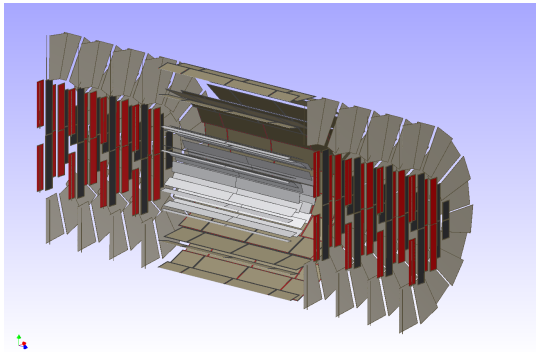
Second Session of the HIM Scientific Council

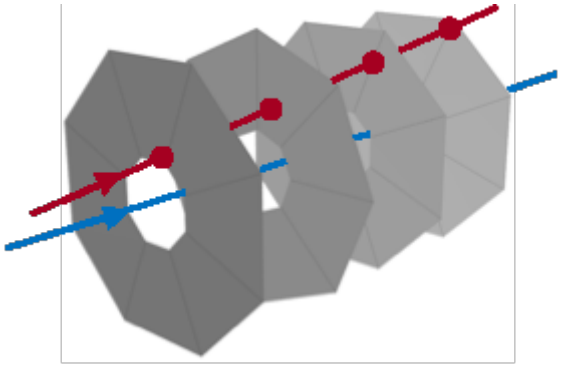
2010, November 8

HELMHOLTZ GEMEINSCHAFT GSI
Helmholtz-Institut Mainz
JGU JOHANNES GUTENBERG UNIVERSITÄT MAINZ

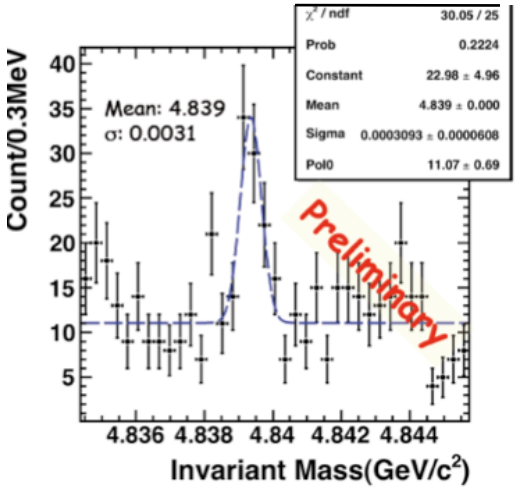
Outline







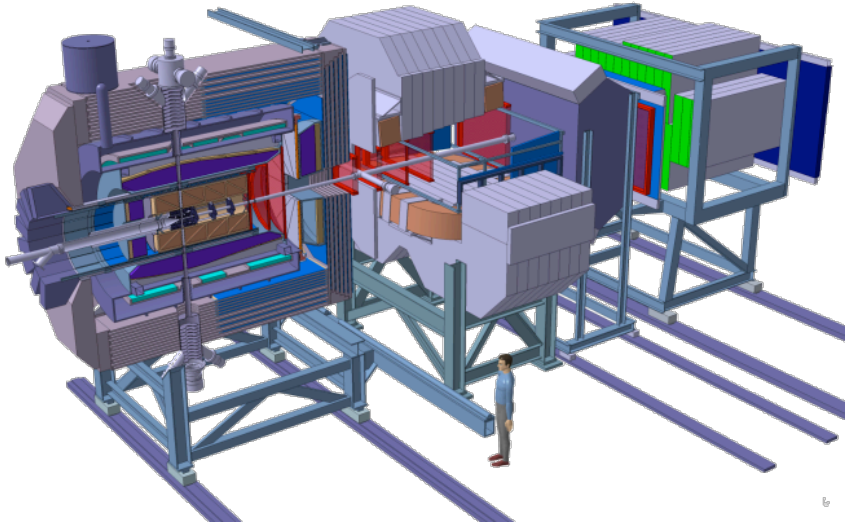
- *Section SPECF within HIM and PANDA*
- *Status Report Working Packages*
  - *Luminosity Monitor*
  - *Open Charm*
  - *Hypernuclear Physics*
  - *ENC @ FAIR*
- *Conclusions*

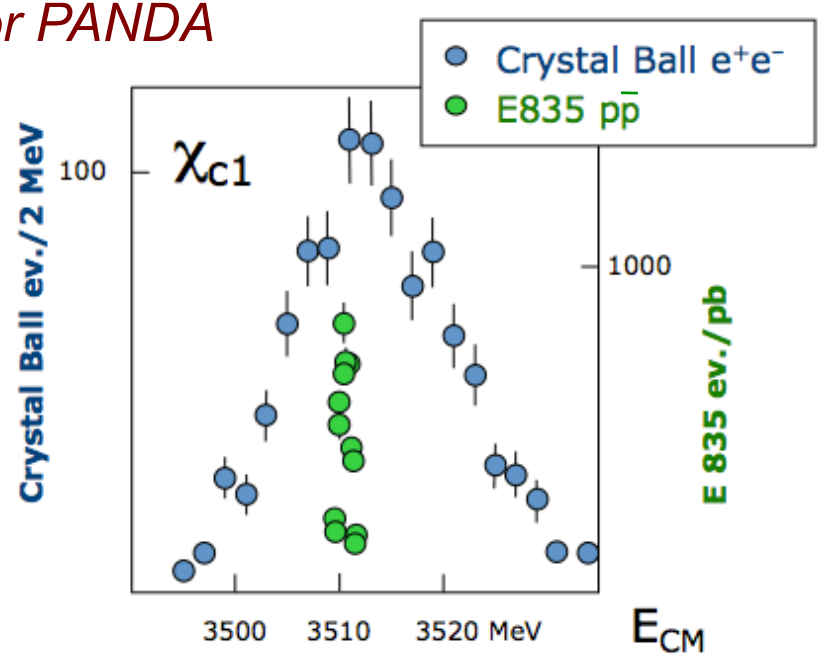


Opportunities SPECF

Antiproton proton collisions at HESR offer unique opportunities

- *High-rate hadron production with valence CHARM QUARK(S)*
- *Nuclei containing STRANGE BARYONS*
- *High-resolution ANTIPROTON BEAM*
- *State-of-the-art multiple purpose detector PANDA*





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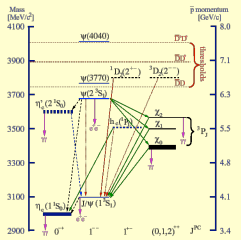
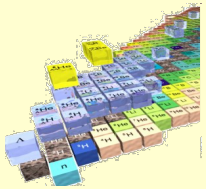
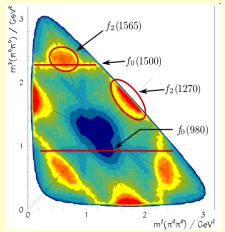
PANDA Physics Programme



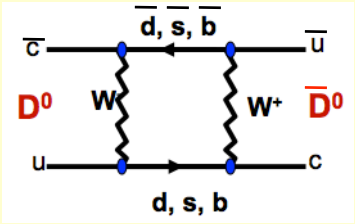
Charmonium Spectroscopy



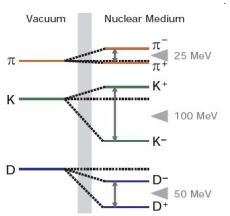
S=2 Hypernuclei



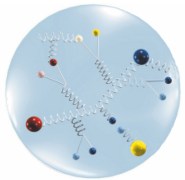
Search for Exotics



Electroweak physics



Charm in Medium



Nucleon Structure

FAIR/PANDA/Physics Book i

Physics Performance Report for:

PANDA

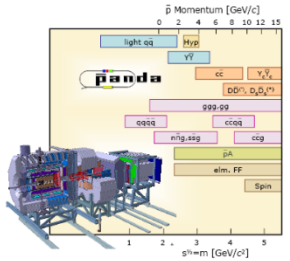
(AntiProton Annihilations at Darmstadt)

Strong Interaction Studies with Antiprotons

PANDA Collaboration

February 13, 2009 - Revision: 810

To study fundamental questions of hadron and nuclear physics in interactions of antiprotons with nucleons and nuclei, the universal PANDA detector will be build. Gluonic excitations, the physics of strange and charm quarks and nucleon structure studies will be performed with unprecedented accuracy thereby allowing high-precision tests of the strong interaction. The proposed PANDA detector is a state-of-the-art internal target detector at the HESR at FAIR allowing the detection and identification of neutral and charged particles generated within the relevant angular and energy range.
This report presents a summary of the physics accessible at PANDA and what performance can be expected.



arXiv:0903.3905v1

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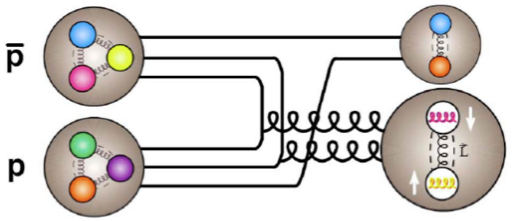
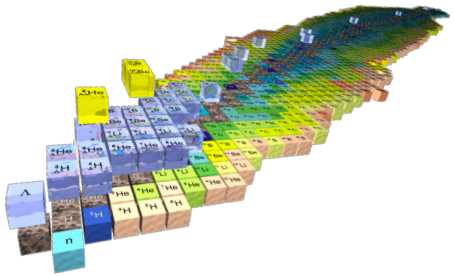
Proposal: Working Packages

➔ *WP 1: Charmonium and Open Charm Spectroscopy*



➔ *WP 2: Open Charm Physics; Search for CP Violation and Charm Oscillation*



➔ *WP 3: Hypernuclear Physics: Nature of the Baryon-Baryon Forces*

➔ *Design of the PANDA Luminosity Monitor*
Design of detectors for PANDA hypernuclear physics runs

➔ *Common working package : Electron Nucleon Collider (ACID, EMP, SPECF, THFL)*

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SPECF PIs and Personnel

Principal Investigators

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

GSI

Achim Denig (Section Leader)
Miriam Fritsch
Lutz Köpke
Joseph Pochodzalla
Take Saito
Concettina Sfienti

Klaus Götzen
Klaus Peters
Lars Schmitt

SPECF Personnel (with HIM contract in 2010):

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Helmholtz Institute Mainz

Alexander Gerhard (Engineer)
Donghee Kang (Postdoc)
Mathias Michel (Ph.D.)
Alicia Sanchez (Postdoc)
Tobias Weber (HiWi → Diplomand)
.... + non-HIM paid staff

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Helmholtz Nachwuchsgruppe from 01/2011

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Status Report
Working Packages

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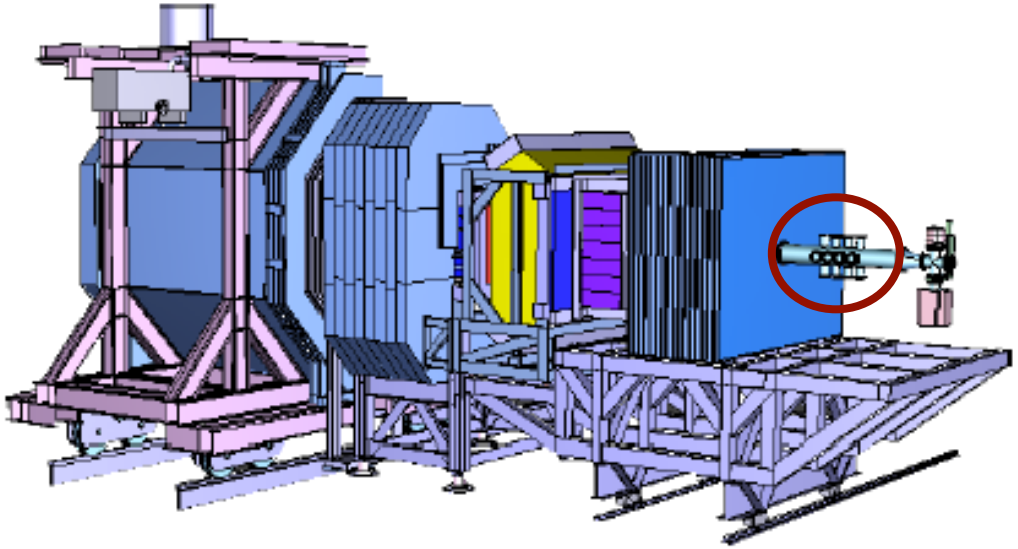
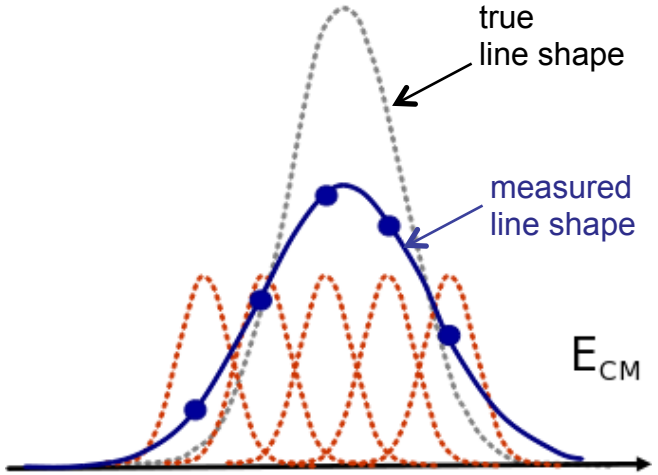
Luminosity Monitor

Denig, Fritsch, Karavdina, Panzenböck, Peters, Michel, Weber



Motivation

- *Normalization for cross section measurements*
- *High resolution energy scan*



Concept

- *Measure elastic scattering* $p\bar{p} \rightarrow p\bar{p}$
- *Small polar angles 3-8 mrad*

  → *Maximizes Coulomb scattering contribution*
- *4 layers of double-sided Si-microstrip detectors*

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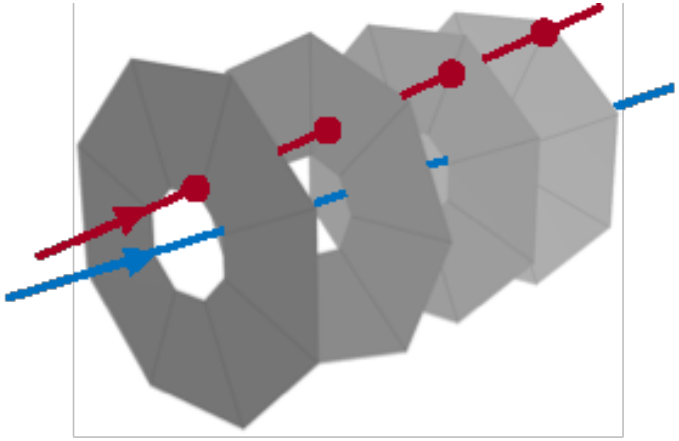
Luminosity Monitor: Software

Design optimization using MonteCarlo Simulations

Influence of

- Thickness of the silicon sensors
- Pitch
- Target size and beam emittance
- Solenoid and Dipole magnet



Only one official package for all Silicon Detector Software

Reconstruction Software

- Backtracking to the IP region with GEANE
- Track Finder: suppression of ghost tracks
- Track Fitter: quality checks
- Efficiency estimation, track finding + CPU-time optimization

Next steps

Geometrical acceptance optimization

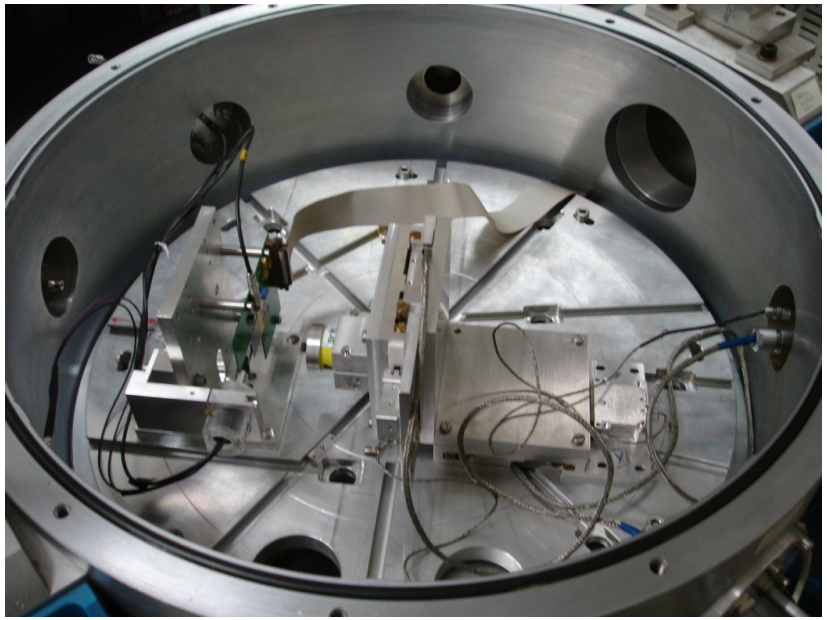
Background models and background suppression

Precision requirement studies

Luminosity Monitor: Hardware

Test setup ready

- Vacuum chamber
  - Sensorboard single sided (ATLAS detector)
  - Scintillation detector for triggering
  - Strontium source
- Cooling system prepared
- Electronics ready
  - APV 25 (CMS)
  - FPGA
  - Support electronics
- Readout with oscilloscope and via VME

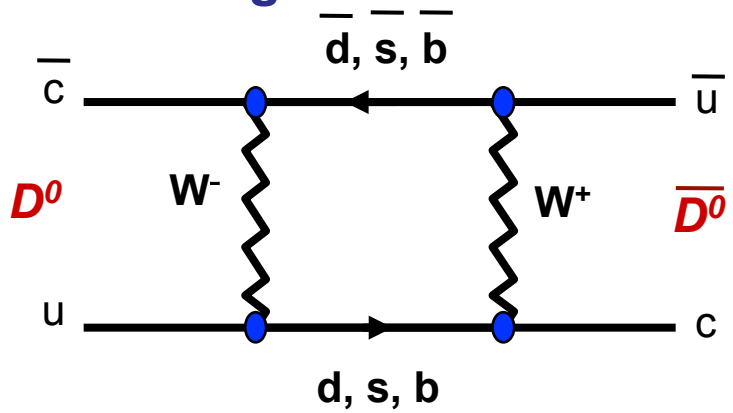


Next steps

- Sensor tests and development (cooperation D0/FNAL)
- Frontend tests
- Mechanical Design (e.g. sensors, cooling, roman pots)

Open Charm Physics

Charm Mixing



D^0 - $\overline{D^0}$ mixing observed in 2007:

- very sensitive to **New Physics**

but:

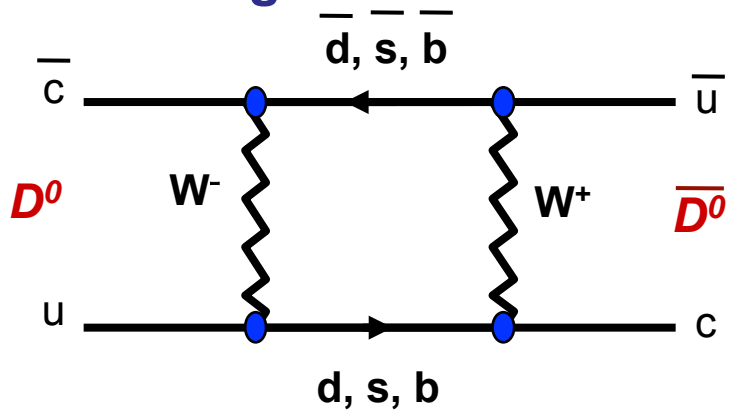
- amplitude was believed to be small
- issue: hadronic uncertainties

CP Violation

- No indication for CP violating asymmetries so-far found in charm decays
- Positive signal would clearly indicate New Physics

Open Charm Physics

Charm Mixing



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PANDA at the HESR?

- **huge production rate of open charm in high luminosity (?)**
- **feasible in modularized starting version of FAIR (?)**
- **what about experimental systematics (?)**

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Open Charm Workshops

Denig, Michel, Peters, Götzen, Schmitt

- More than 50 intl. participants
- Organized by JGU, HIM, Siegen (A.D. & Thomas Mannel)
- 20 plenary talks
- Lively discussion atmosphere

Next steps:

- Charm production cross section calculations
  → impact for entire PANDA programme
- Interplay with partial wave analyses
  → follow-up workshop: *Les Nabis*
  March 2010, Kloster Eberbach (K. Peters, GSI)
- Experimental systematics (background subtraction)
  → Open Charm spectrocopy

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Hypernuclear Physics

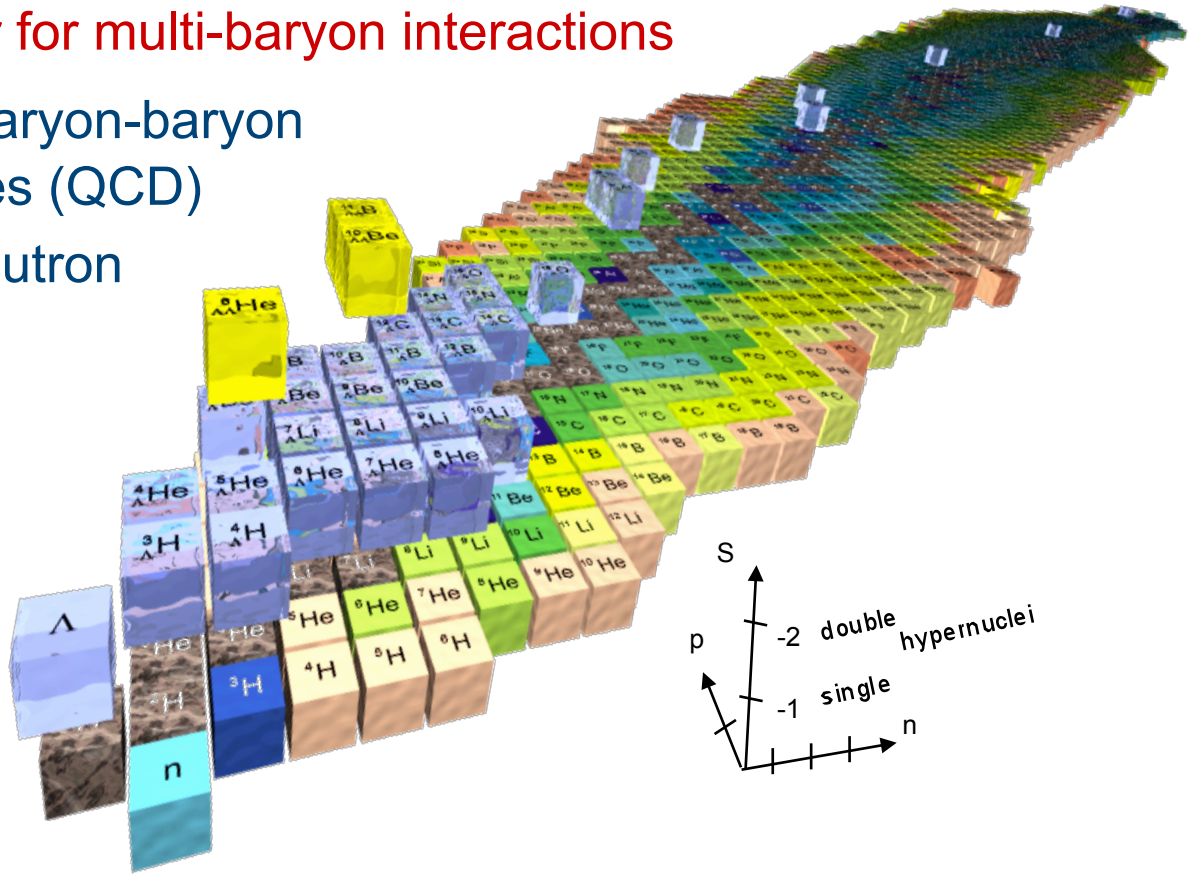
Hypernuclei are a sensitive tracer for multi-baryon interactions

- Quantitative understanding of baryon-baryon interactions from basic principles (QCD)
- What are the constituents of neutron stars?

number of baryons N+Z+Y

(number of) hyperons Y

$${}^{B}_{Y}X$$



Projects

- *HypHI:* properties of hypernuclei with extreme isospin
- *PANDA:* hyperon-hyperon interaction from double hypernuclei

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Hypernuclear Physics: PANDA

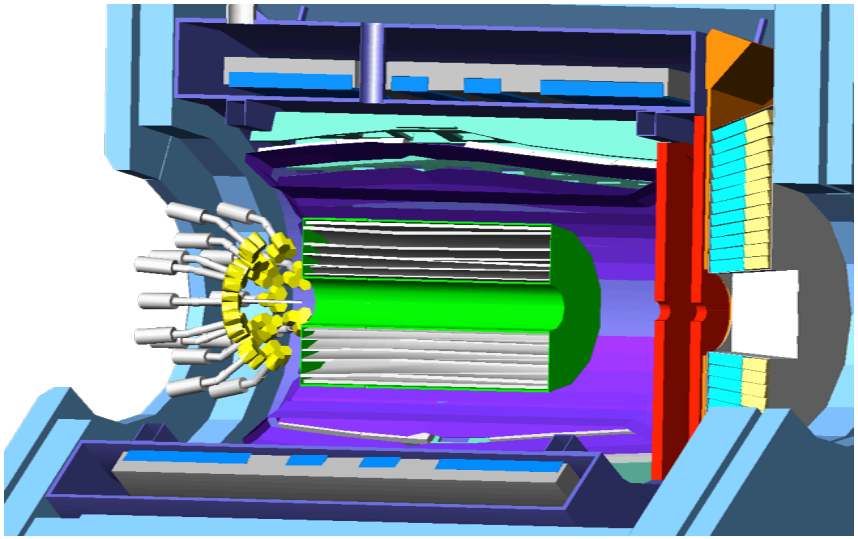
Achenbach, Bleser, Pochodzalla, Saito, Sanche, Sfienti, Steinen

Dedicated runs for hypernuclear physics require:

→ High resolution Ge array inside PANDA

- technical design
- cooling calculated
- Ge crystal delivered
- further components ordered

→ Secondary sandwich target inside PANDA

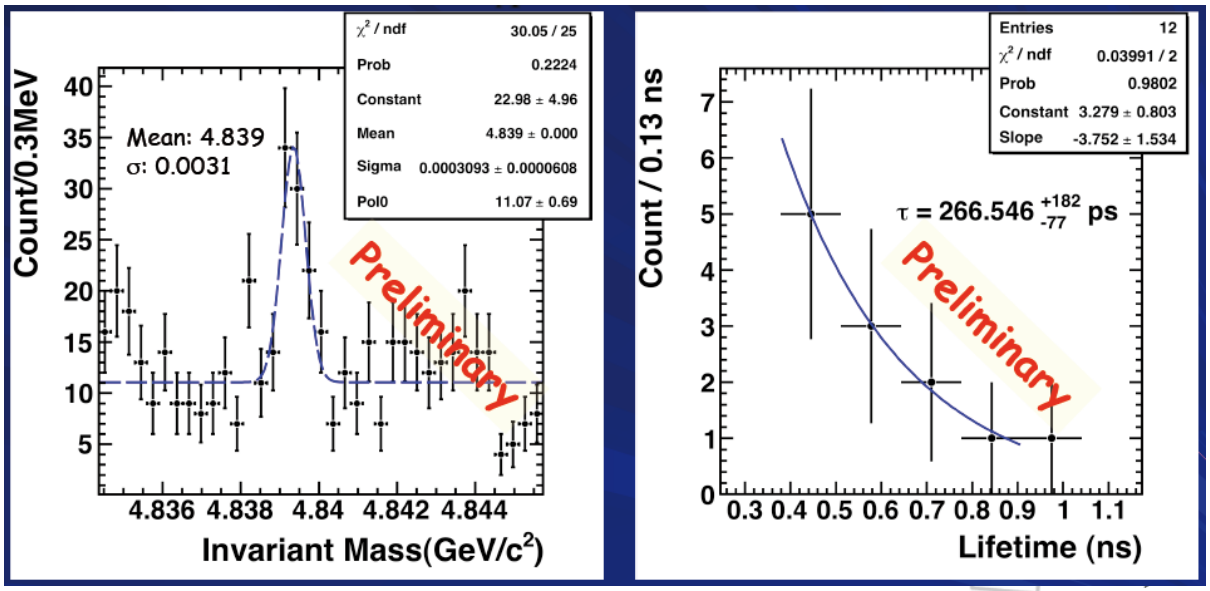


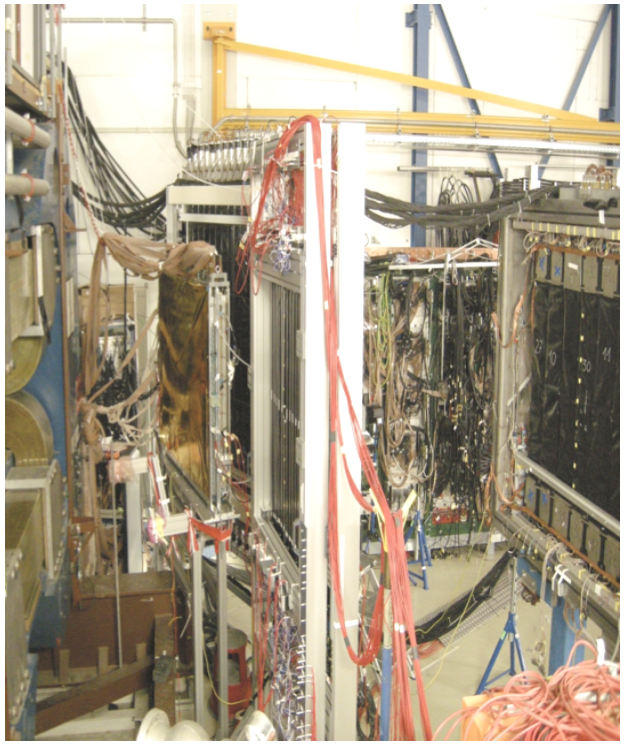
Next steps:

- Resolution tests, cooling,..
- Raditation damage (e.g. at COSY)
- annealing procedures

Hypernuclear Physics: HyPhi

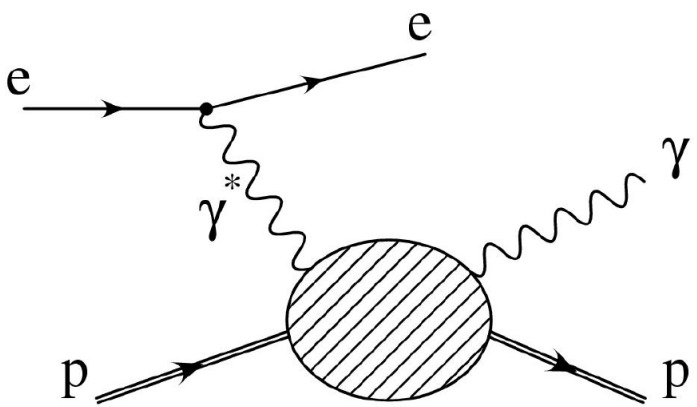
First succesful runs of HyPhi with 2AGeV ^{6}Li+^{12}C and 2AGeV ^{20}Ne+^{12}C





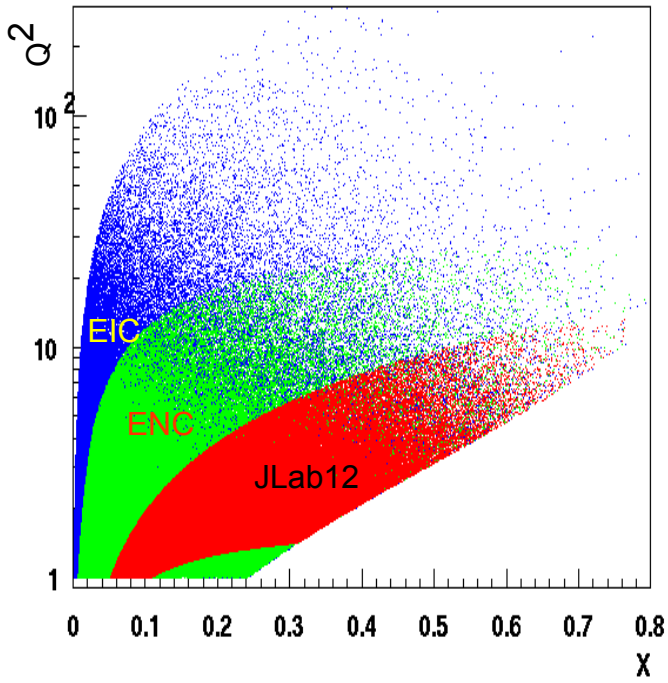
First decays of Λ-hyperons and a first indication of $^{5}_{\Lambda}$He are found which are compatible with a known mass of 4.840 GeV and a lifetime of 256 (20) ps

The avenue to Generalized Parton Distributions: hard exclusive processes



$ep \rightarrow e'p'\gamma$: **DVCS**

Deeply Virtual Compton Scattering



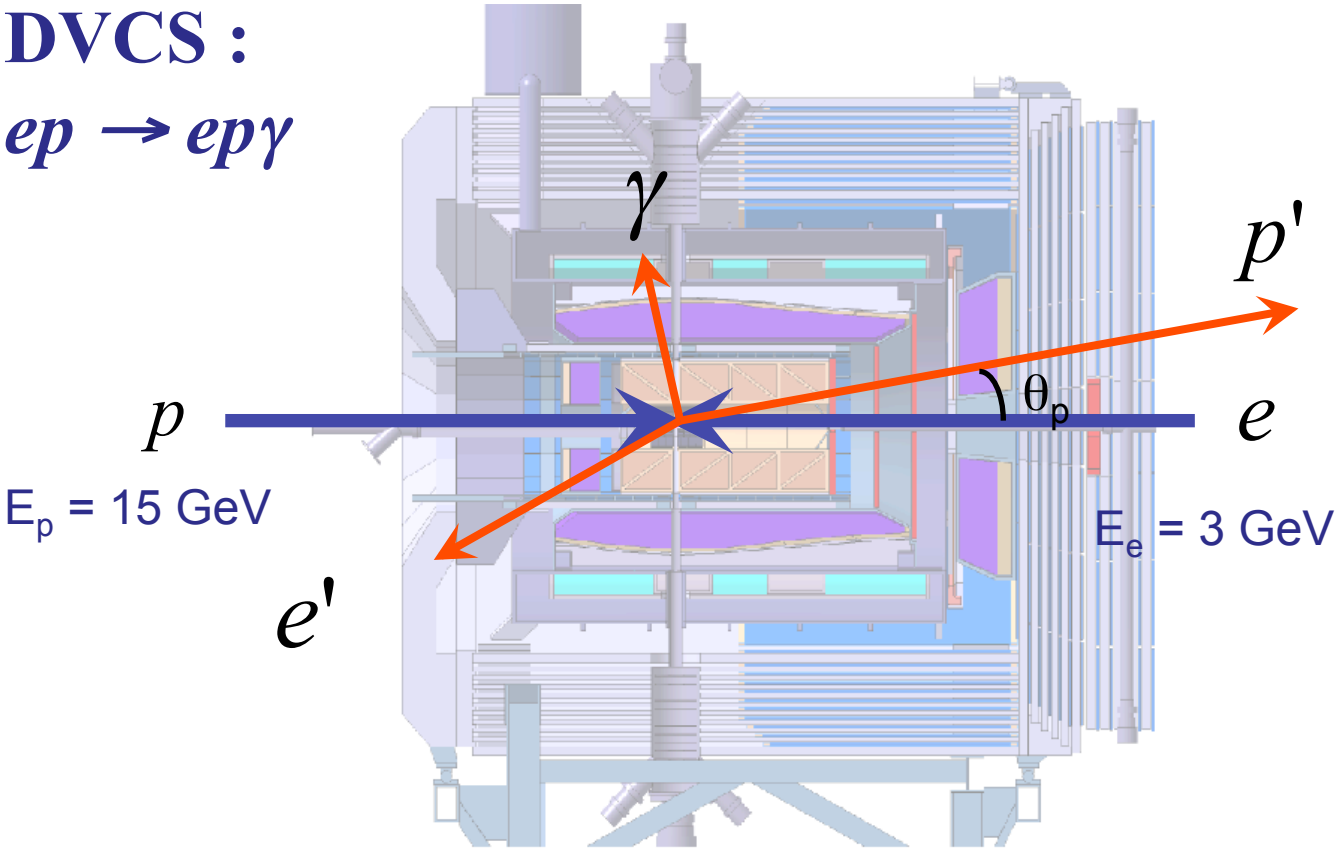
QCD Facilities to study GPDs:

- HERMES, JLAB 12 GeV, COMPASS-II, EIC
- ENC has a great potential in GPD physics:
  - → better kinematic coverage compared to fixed target
  - → very high beam polarization
  - → comparable to staged EIC - projects at JLAB, BNL

ENC @ FAIR: PANDA Integration

DVCS :

$ep \rightarrow ep\gamma$



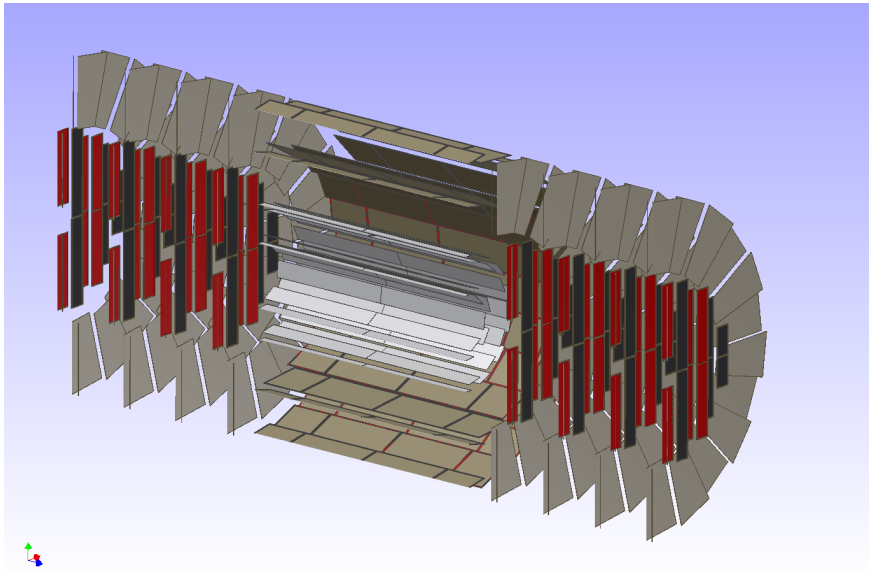
PANDA detector well suited for collider kinematics

Issues: - interaction region
- backward calorimeter

ENC @ FAIR: Simulation Studies

particle	efficiency	resolution δp / p	resolution δθ / θ
e	83%	< 2.0%	< 2.0 %
γ	93%	< 2.0%	< 5.0 %
p	64%	< 1.0%	< 10.0 %

Combined efficiency: ca. 50%, high resolution



Prelimenary ENC – MVD design

Next steps:

- Improved tracking
- Influence of dipoles on tracking
- Simulation of additional physics channels

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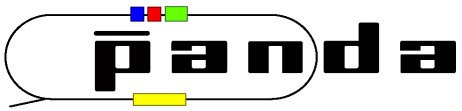
Conclusions

- ➔ *New PANDA activities established and strenghened at Mainz (physics, software, hardware)*
- ➔ *ENC design and physics simulation making further progress*
- ➔ *Successful cooperations btw. Mainz and GSI*
  - *will further be strenghened by C. Sfienti's DIRC activities*
  - *new personnel in 2011 for PANDA physics simulations*
  - *close cooperation btw. experiment and theory*
  - *BES-III analyses as preparation for PANDA*



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