

Hadron Physics with PANDA: From FAIR Phase 0 to Phase 1

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Outline

- Overview of PANDA
- Phase 1 program
- Phase 0 activities
 - a) Trackers at HADES
 - b) Backward PWO Calorimeter at MAMI
 - c) PWA developments applied to other experiments
- Summary



Overview of PANDA

PANDA Objectives

HEP: interference of coupled channels

Spectroscopy

New narrow XYZ:
Search for partner states

Production of exotic QCD states:
Glueballs & hybrids

Bound States of Strong Interaction

HEP: underlying elementary processes

Nucleon Structure

Generalized parton distributions:
Orbital angular momentum

Drell Yan process:
Transverse structure, valence anti-quarks

Timelike formfactors:
Low and high E, e and μ pairs

Astro physics: Strange n-stars

Strangeness

Strange baryons:
Spectroscopy
Polarisation

HI collisions: comparing QGP to elementary reactions

Nuclear physics: Hypernuclear spectroscopy

Nuclear Physics

Hypernuclear physics:
Double Λ hypernuclei
Hyperon interaction

Hadrons in nuclei:
Charm and strangeness in the medium

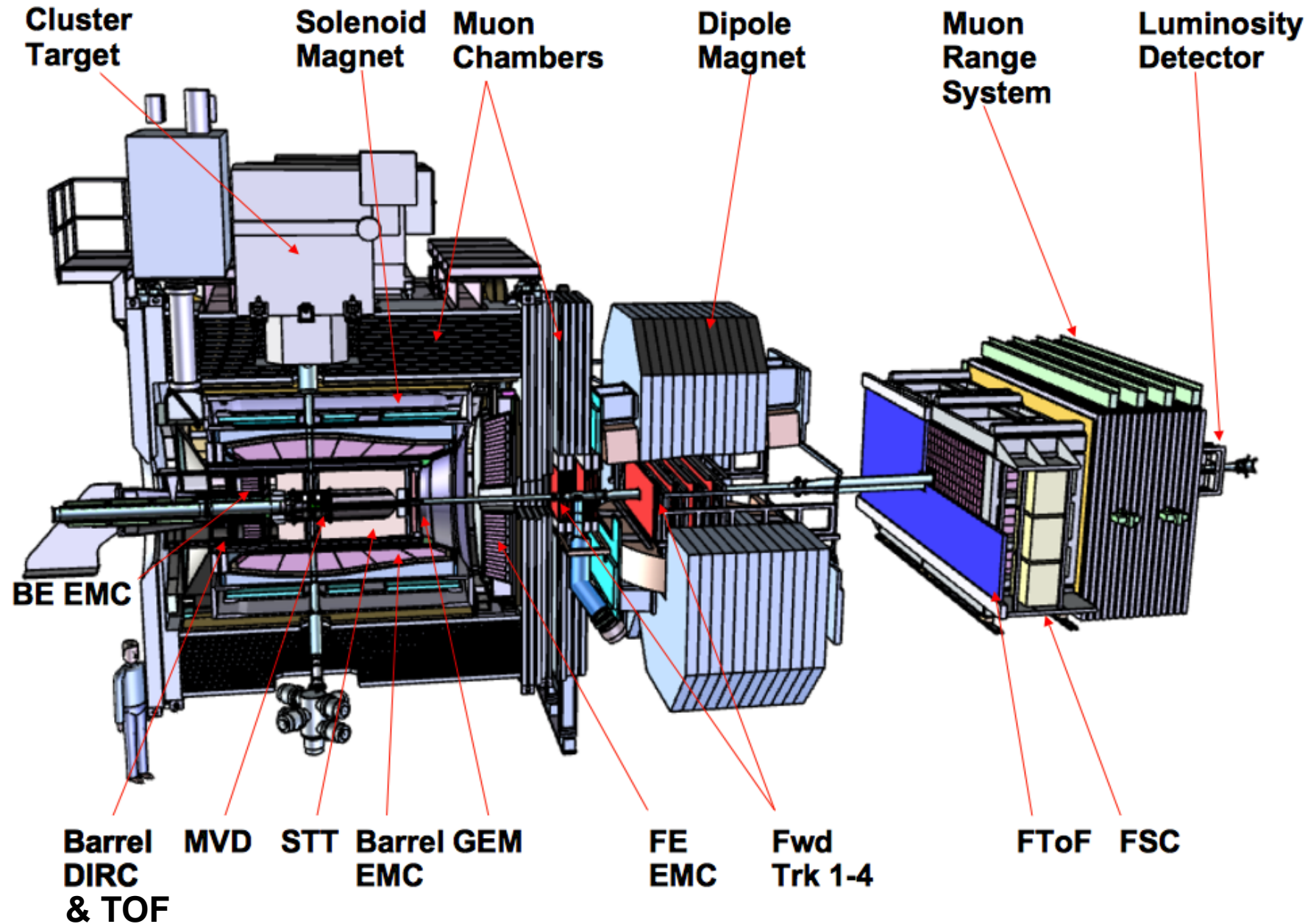
Actions by PANDA Since the 2015 Heuer Review

- PANDA physics workshop in Uppsala, 8. - 12. June 2015
- PANDA internal scrutiny process (Final report September 2015)
- EMMI rapid reaction task force, 12.-14. October 2015
- Results:
 - Definition of key experiments with high impact in Phase 1
 - Definition of reduced detector setup for Phase 1
 - Proposals for PANDA Phase 0
- Present activities on the way to FAIR
 - Development of dedicated analysis methods at ELSA, MAMI, BESIII, Jlab, COMPASS to ensure a quick start of PANDA.
 - Cutting edge physics results, education of young scientists
 - Application of modern PANDA technologies at present and future facilities Cherenkov (DIRC), EMC, Photon readout, Readout electronics

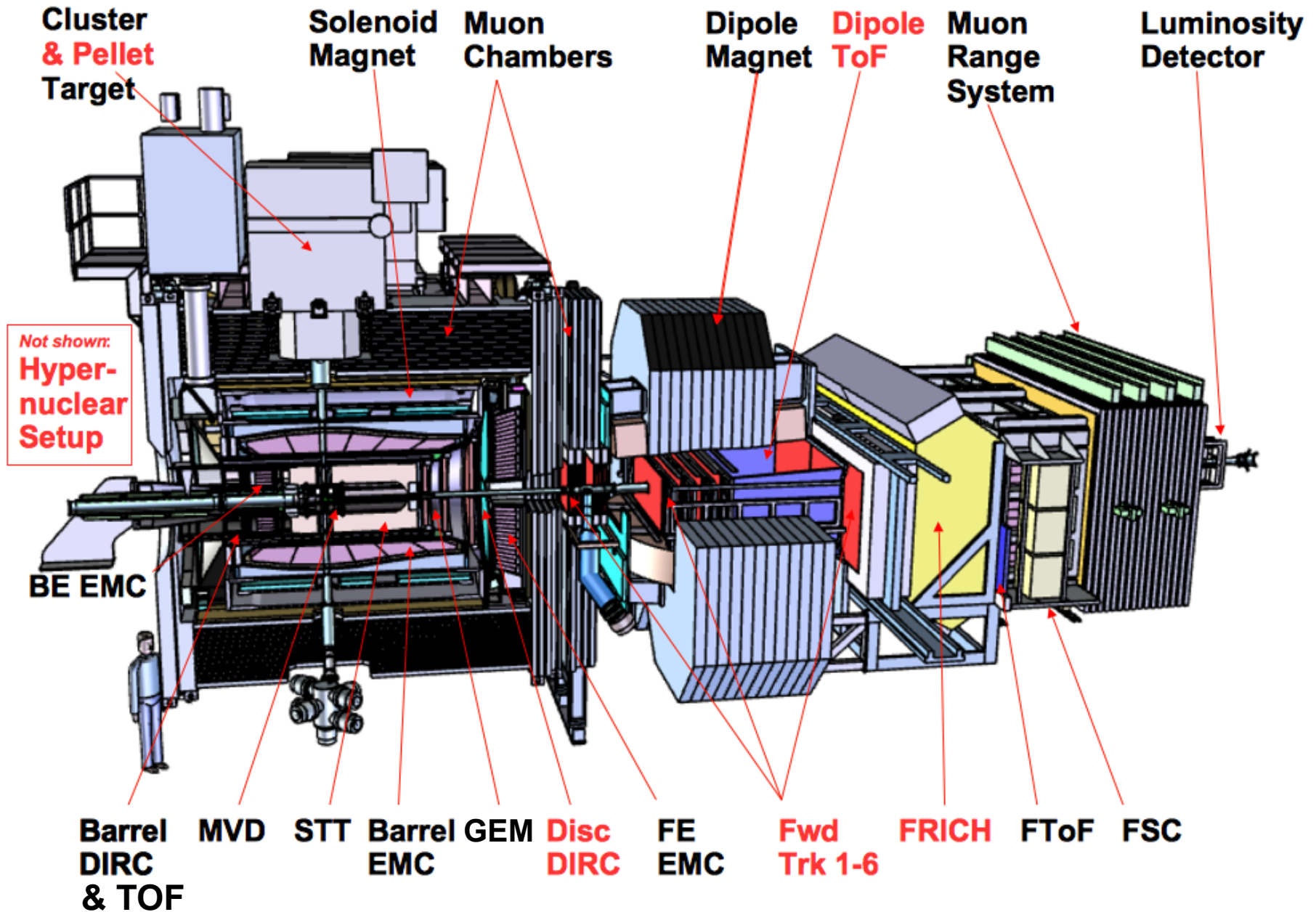
Phase of PANDA

- Phase 0
Currently PANDA detectors are being built. They will be used in other excellent experiments until the experimental hall is available.
- Phase 1
First physics experiments with the PANDA *start setup* using antiprotons
- Phase 2
Experiments using the *full setup* (MSV)
- Phase 3
Experiments beyond MSV (RESR)

Start Setup



Full Setup





PANDA Phase 1 Program

Key-Experiments of the Start Phase

Concentration on unique and forefront physics topics

- Production of **multi-strangeness baryons**
(unexplored, new territory, „Strangeness-Factory“)
- Precise measurement of the **line shape of narrow XYZ-states**, e.g. X(3872)
(only possible in proton–antiproton, counting experiment, clarification of the nature of the states)
- Resonant formation of the **negative and uncharged partners of the Z-States**
(only possible in proton–antiproton, clarification of the nature of the states)
- Measurement of **the electromagnetic form factors of the proton** in the time-like domain with electrons and muons in the final state
- Production of **high spin charmonia** (only possible in proton–antiproton)
light mesons, baryons and production of hybrids und glueballs

XYZ-, hyperon factory

PANDA Phase 0 Projects

Already 2018++

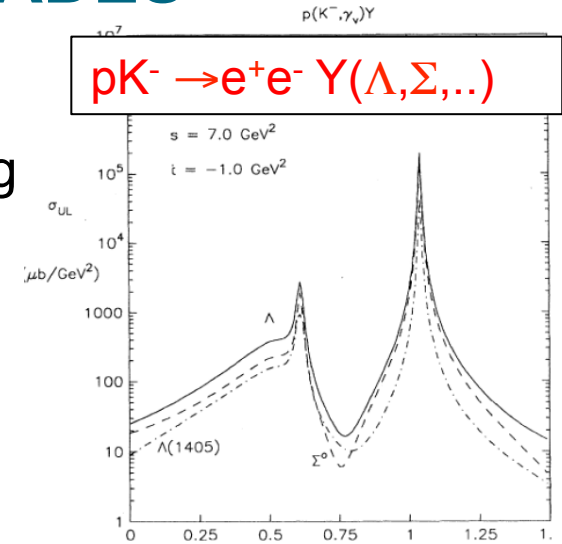
PANDA detector components will be used for physics

PANDA Phase 0 Experiments with HADES

Physics Motivation

Goal: Hyperon structure, extend our understanding of the nucleon

How: Hyperon Dalitz decay Transition FF well connected to PANDA physics program



Role of ρ -baryon coupling (VMD?)

- Only few measurements of radiative decays:



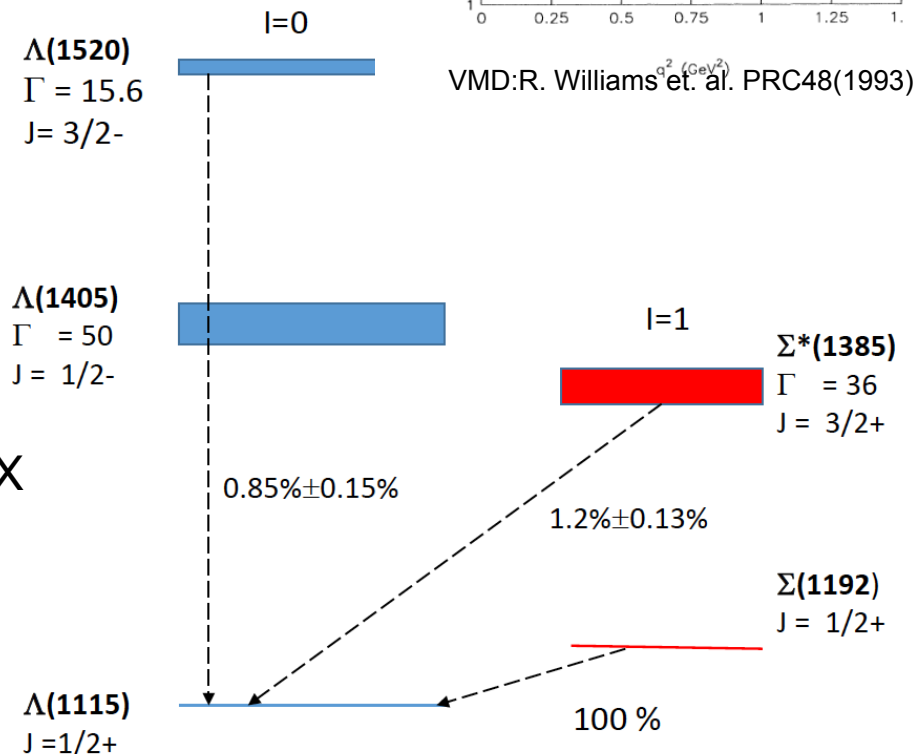
- $Y \rightarrow \Lambda e^+ e^-$ never measured !

- Proposed reaction:



tag with $\Lambda \rightarrow \pi^- p$

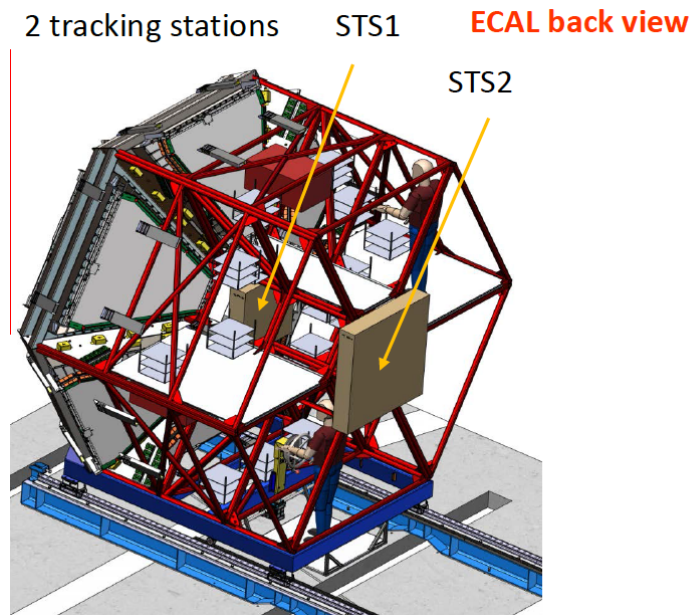
BR $\sim 10^{-5}$



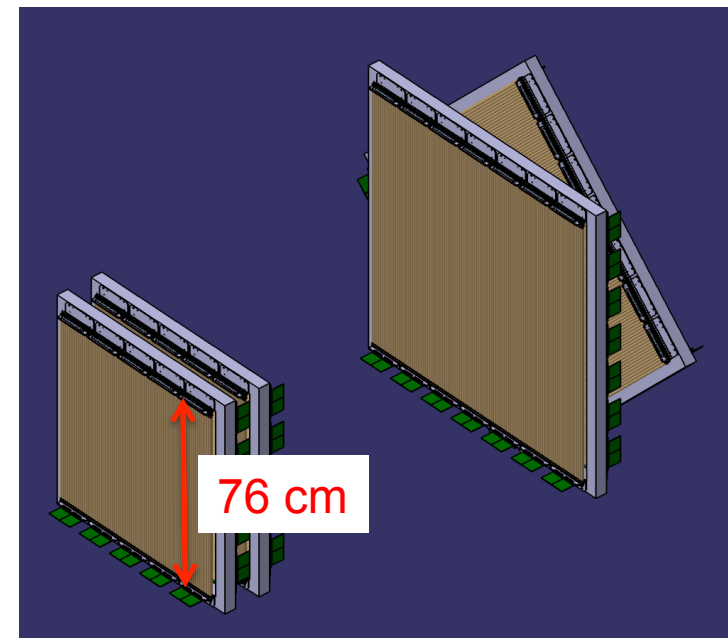
PANDA Phase 0 Experiments with HADES Detectors

PANDA pre-series and prototype detectors for STS1/2

- **HADES** measures the dileptons & mesons
- **PANDA** Straw Trackers for the baryon ($\Theta < 7^\circ$)
 STS1: 640 tubes (use later as FT3/4)
 STS2: 900 tubes (use later as FT5/6)
 (4 double layers each)



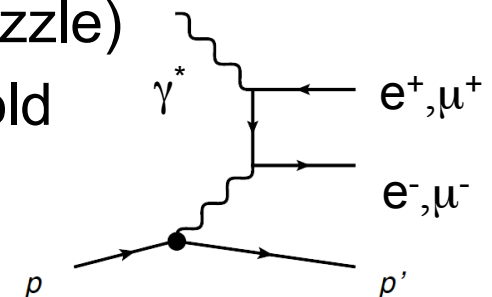
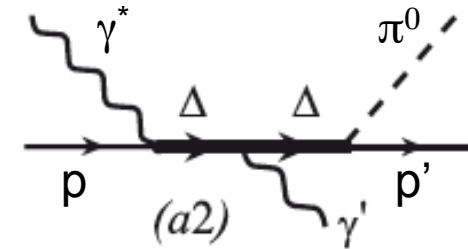
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Phase 0: BEMC@MAMI

Physics Motivation

- Magnetic Moment of $\Delta(1232)$ -Resonance by
 - $e p \rightarrow e p \pi^0 \gamma$
 - Additional calorimeter for π^0 and γ detect.
 - Virtual photon flux higher in e-production
 - S_{11} -Resonance
- Electron-Muon-Universality (Proton Radius Puzzle)
 - $e p \rightarrow e p l^+ l^-$ below/above $\mu^+ \mu^-$ pair threshold
 - Additional calorimeter for forward angles
- Multi- π^0 -Production
 - $e p \rightarrow e p \pi^0 \pi^0$ etc.
 - Unknown transition amplitudes, calibration and commissioning of calorimeter

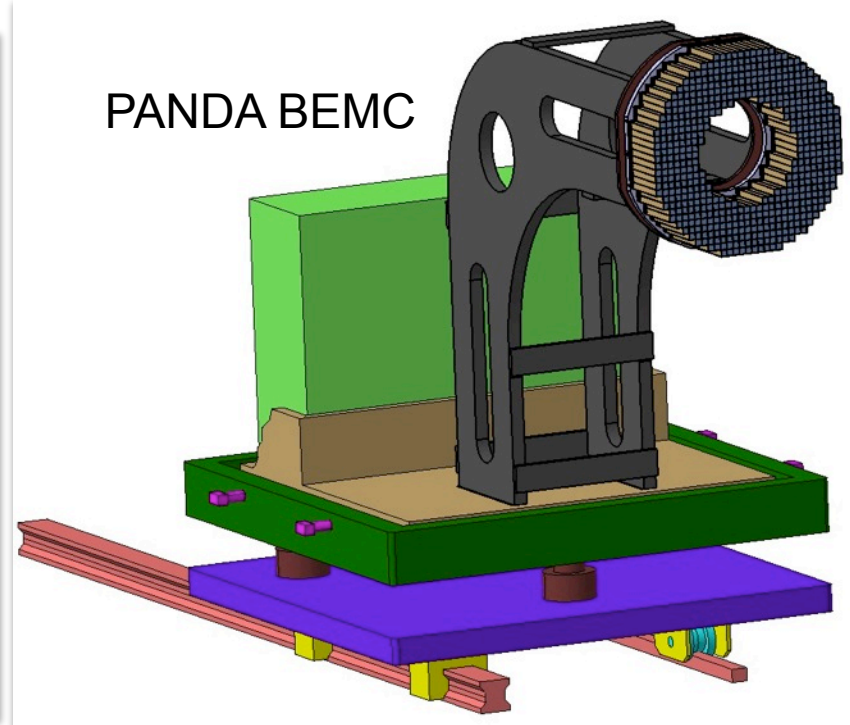
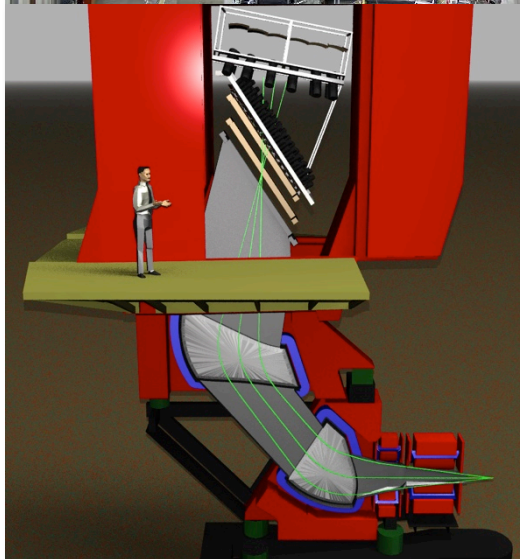


Phase 0: BEMC@MAMI

Detectors



A1-3 Spectrometer Setup



PANDA BEMC

- A1: 3 Magnetic Spectrometer setup
- Momentum Resolution: $\Delta p/p < 10^{-4}$ in each spectrometer
- Coincident detection of three charged particles.
- MAMI: 180 MeV – 1.6 GeV electron accelerator
- Enough crystals to close acceptance in the middle

Summary

Excellent Physics from the Start

- Clear strategy for a strong PANDA physics case with high impact for the start phase
- PANDA detector for the start phase defined in line with FAIR high level time schedule
- Good progress with the production of the detectors
- **Start of Physics from 2018** with the Phase 0 measurements :
 - i. Hyperon Dalitz decays together with HADES
 - ii. Delta magnetic moment together with MAMI
 - iii. Use PANDA PWA tools in other experiments GlueX, BESIII
- Phase 1 Experiments on track

