PANDA

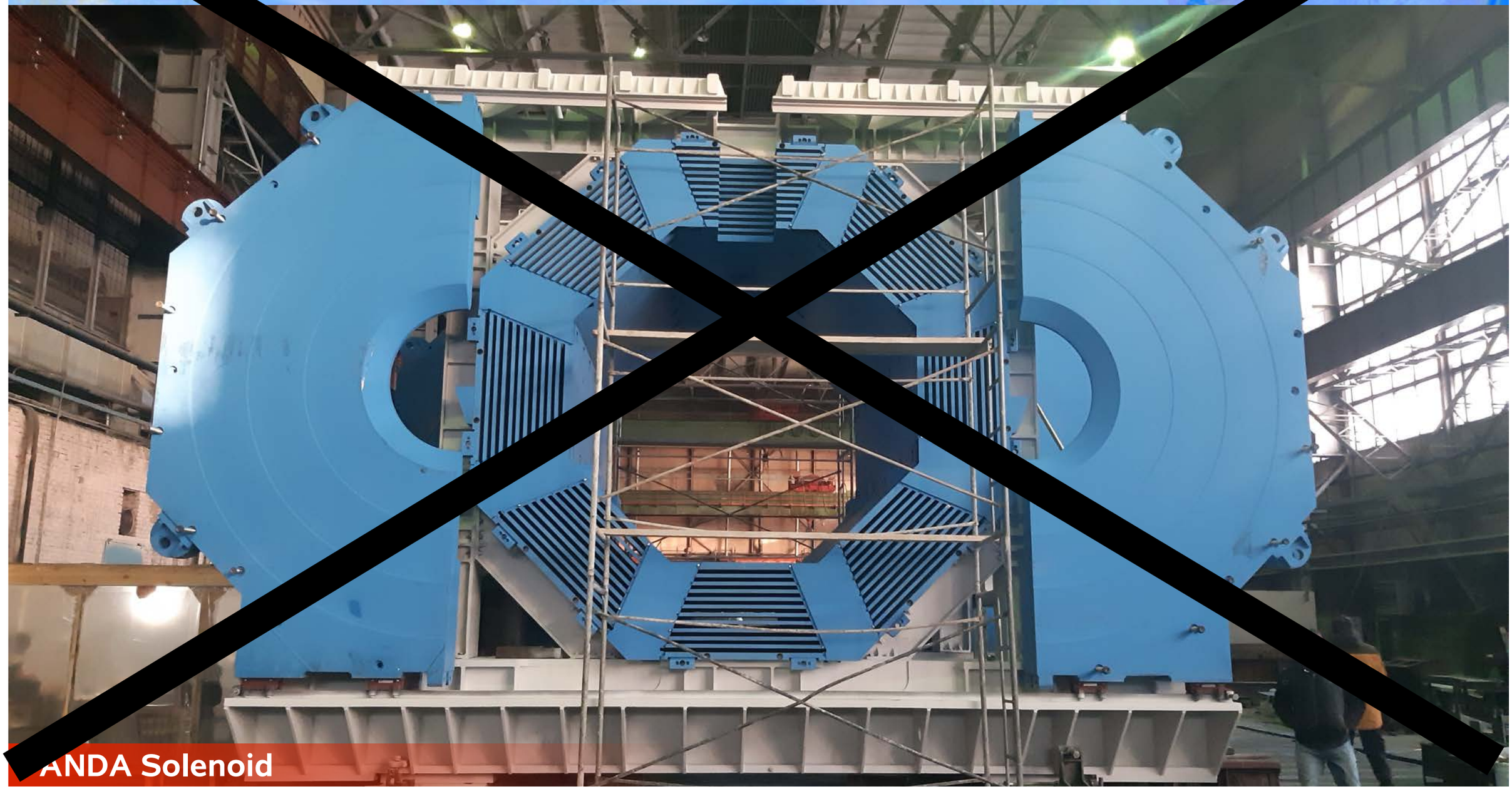
Ulrich Wiedner
(Ruhr-University Bochum)

“With its use of a stored anti-proton beam, PANDA is unique and is the only experiment in the world that can definitely answer the question as to whether or not the states under study are new, ‘exotic’, forms of hadronic matter. PANDA’s unique glueball discovery program will provide the critical tests of strong interaction theory that predict masses of the only particles with mass generated entirely through the strong interaction.

Yifang Wang (Director, Institute of High Energy Physics, Beijing):

“It is clear to us that PANDA is the killer of the field. Without PANDA, this field will remain to be open with many questions unanswered, and someone else will come up with a new facility in the future.”

Solenoid Magnet: Russian Contribution



Detector Status: Magnet

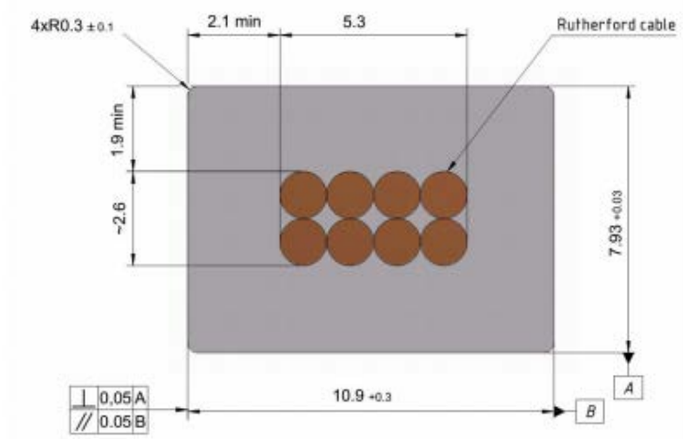
Conductors for Detector Magnets

- Al stabilised conductors are still state-of-art for safe operation
- Currently no commercial producer

Workshop on Superconducting Detector Magnets
CERN, September 12-14, 2022

Superconductor Layout

- Nb/Ti in Cu strands
- Rutherford cable 2x8
- Co-extrusion in pure Al



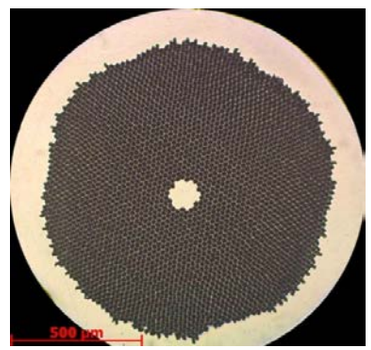
PANDA SC Cable LAyout

Status of Production:

- Joint venture with 4 partners in Russia
- Consulting by ATLAS/CERN
- Production was to be completed in 2022

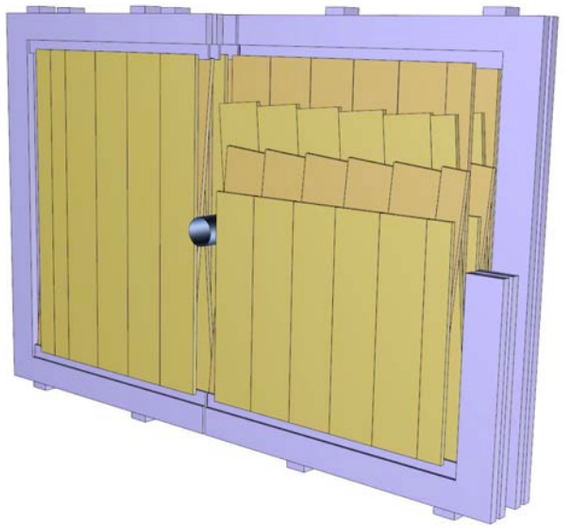
Strategy on Aluminum Extrusion

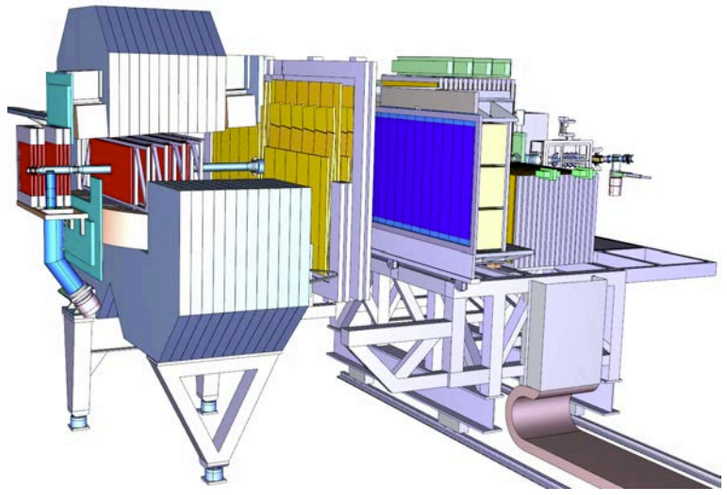
- Contact to producer of machinery
- Establish knowhow at extrusion lab
- Cooperation for nearest projects (PANDA, EIC, BabyIAXO)



Superconducting strand

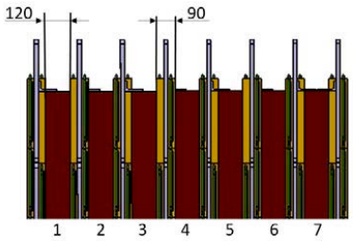
Detector Status: LHCb Outer Tracker

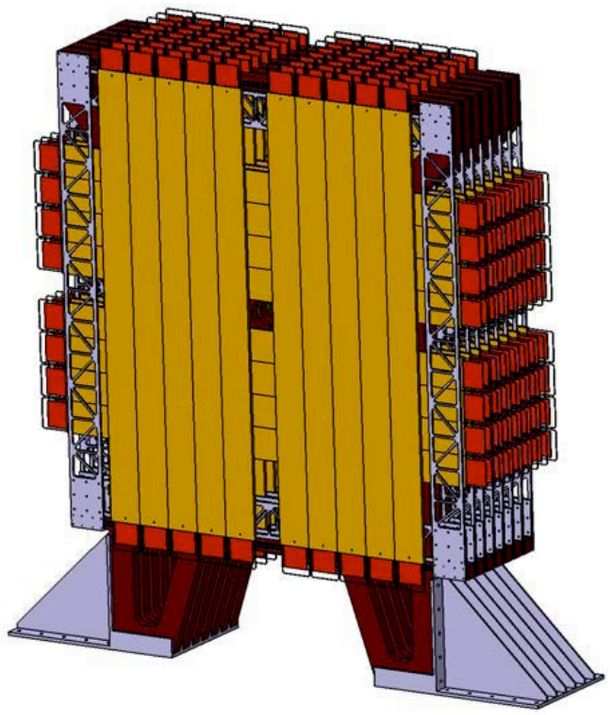


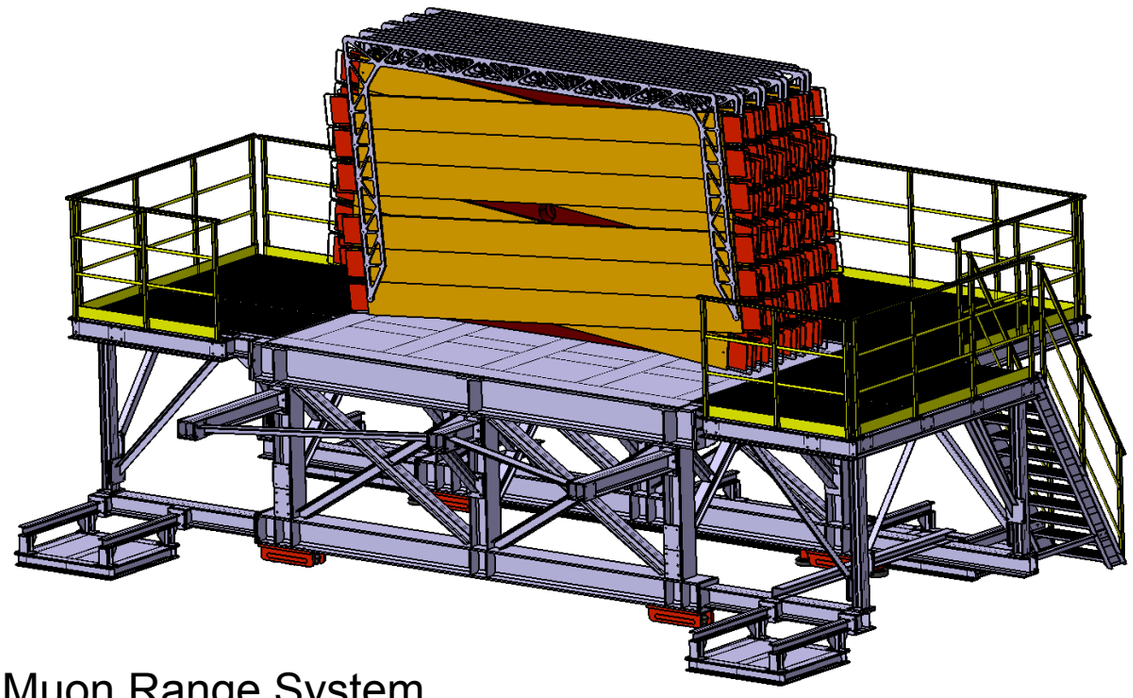


LHCB OT half modules for PANDA Forward Tracker

H x W x L: 4.9m x 3.5m x 7m, weight: 22t

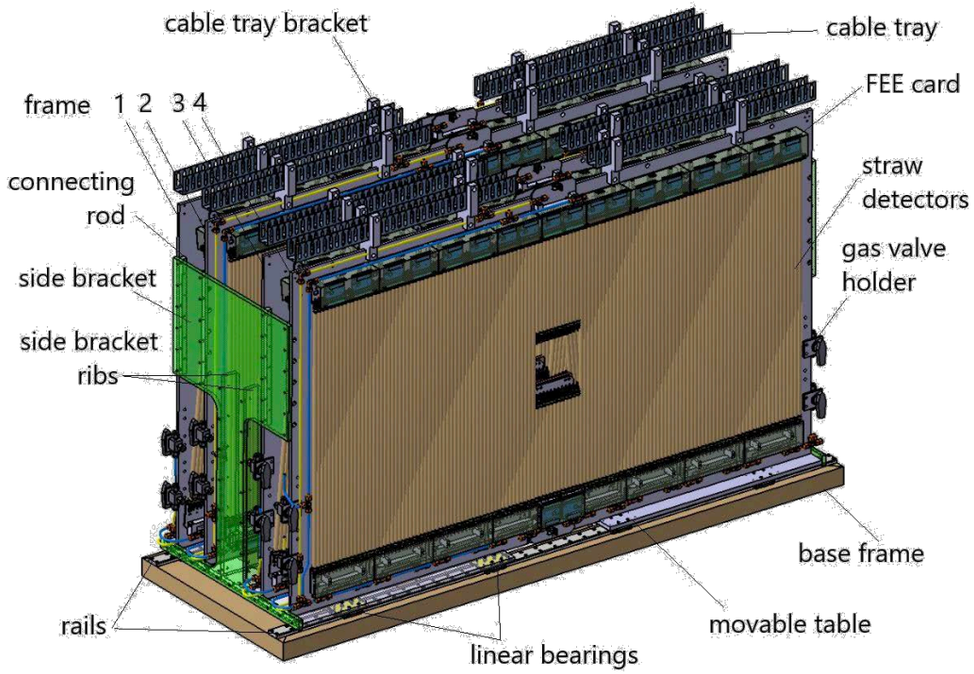




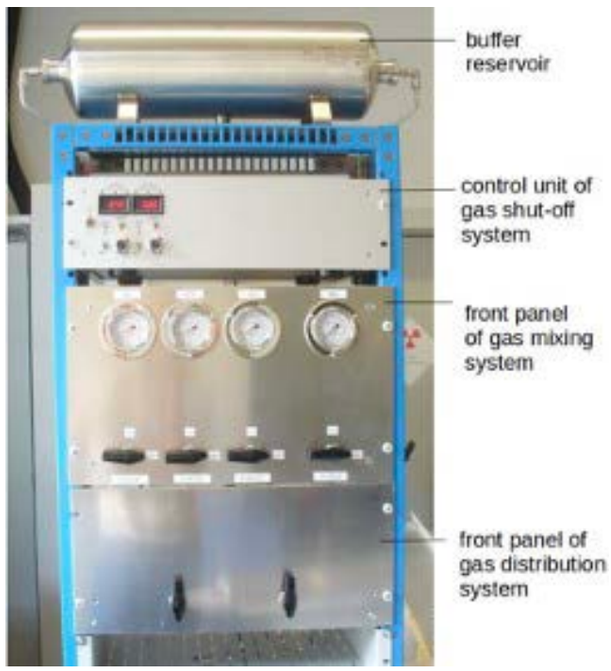


LHCB OT long modules for PANDA Muon Range System

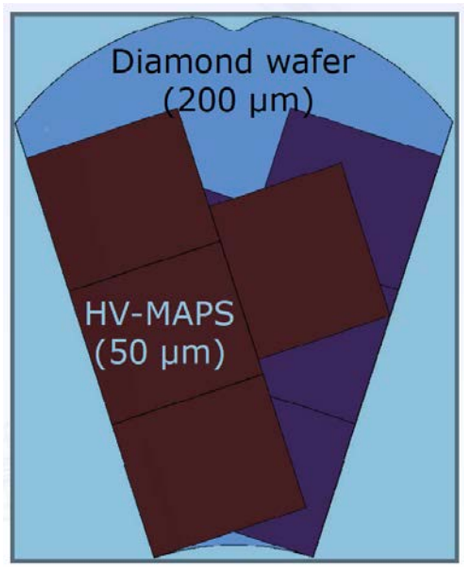
Detector Status: Tracker and Luminosity Detector

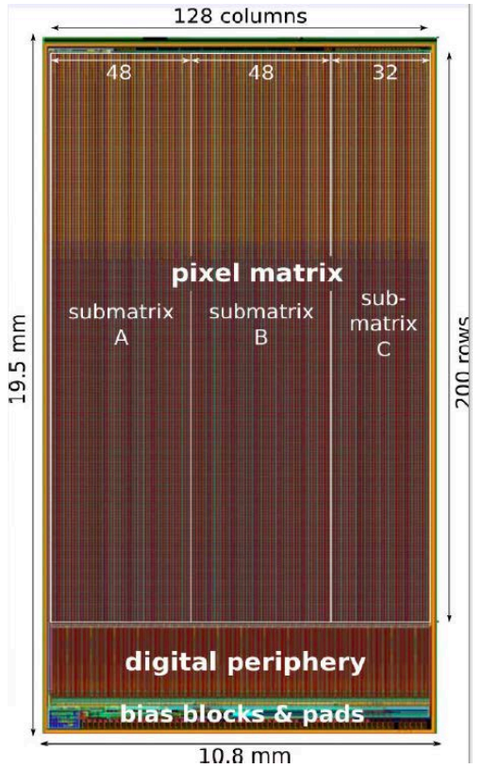


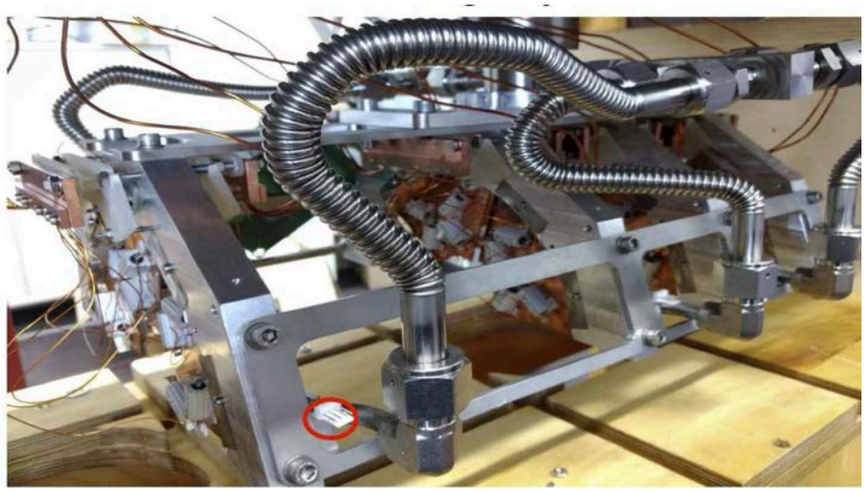
Forward tracker (in-kind JU Krakow)



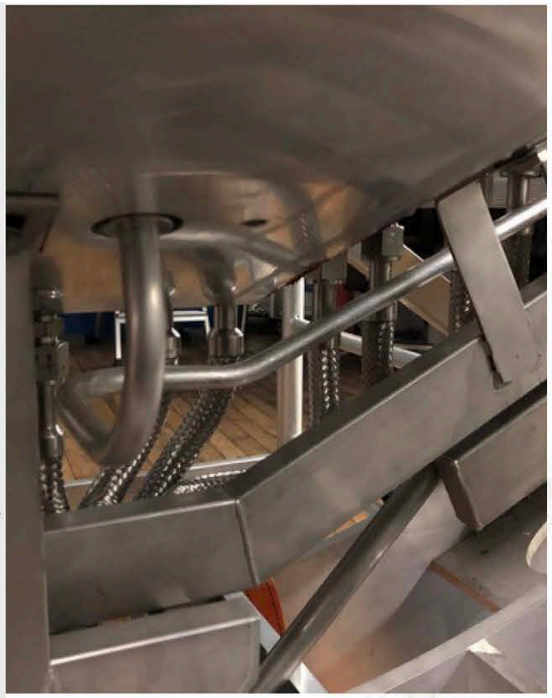
Luminosity detector

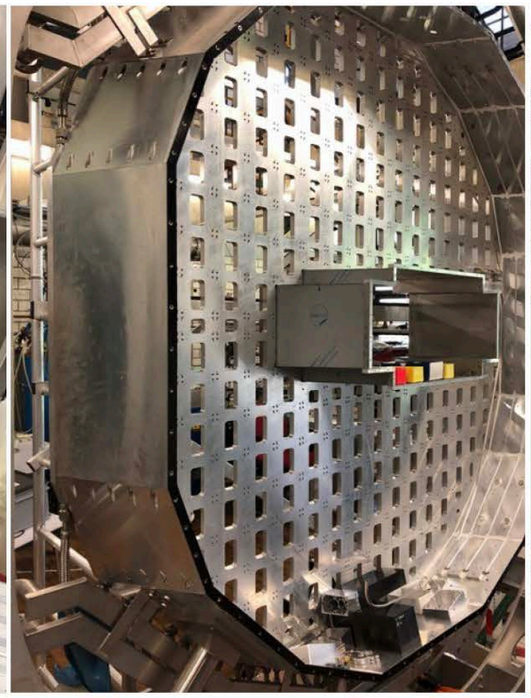




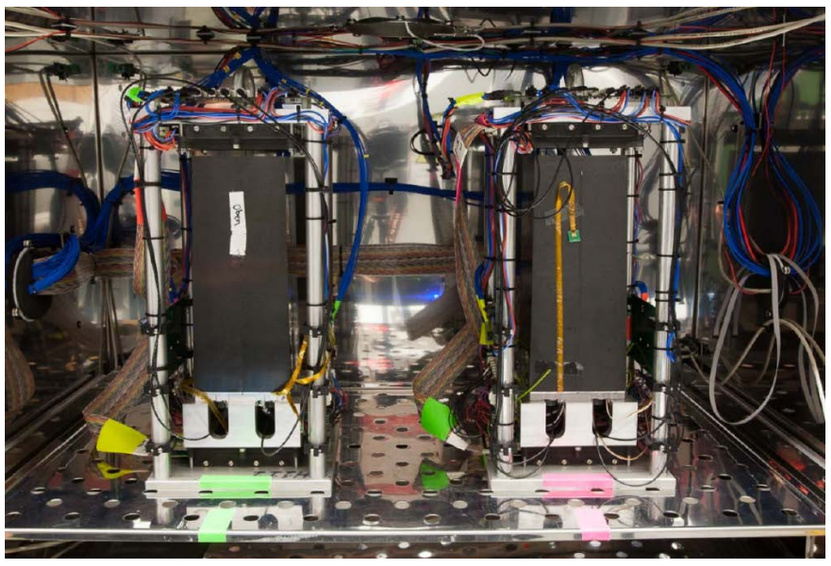


Detector Status: The Electromagnetic Calorimeter





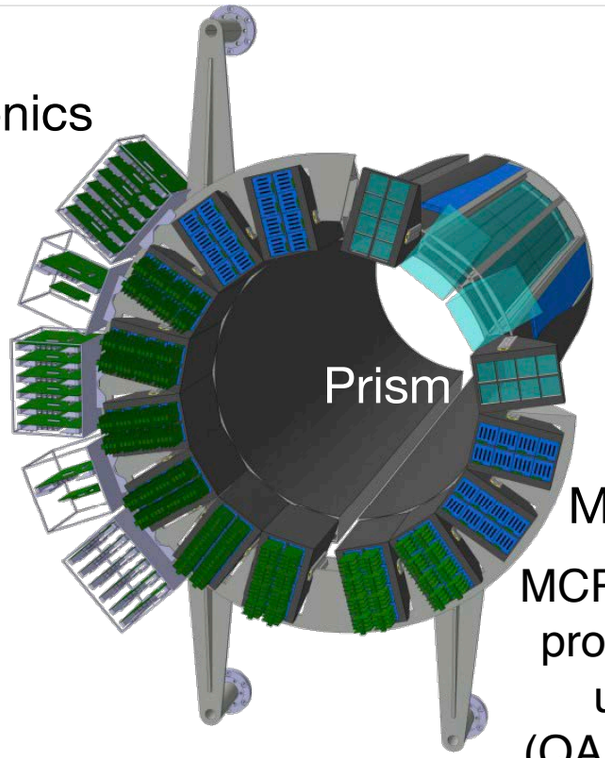
Mechanics of the cooling system at the forward endplate is finished → this week transport to Jülich




Pre-calibration of modules with cosmics ongoing

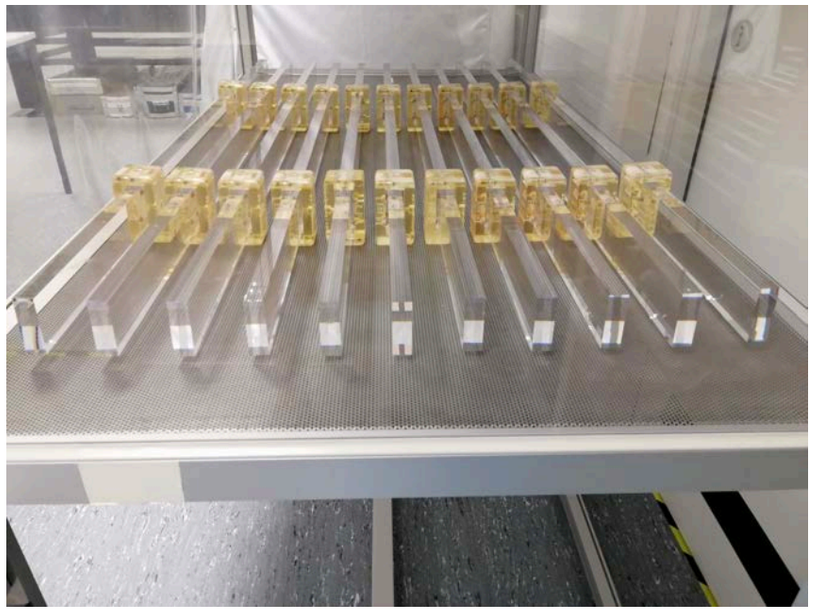
Preparation for mounting at Jülich

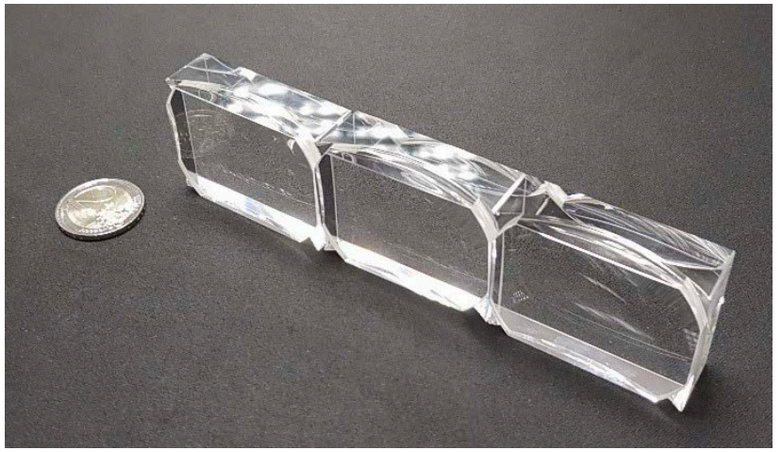
Detector Status: The DIRC

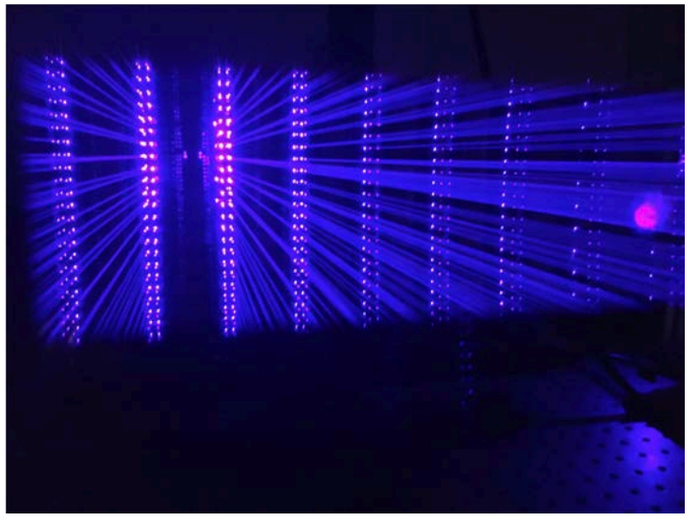


MCP-PMT series production well underway (QA at Erlangen)

Fused silica bars (2.5 m) → all 112 bars delivered to GSI







Lens/prism/electronics procurement postponed

Current R&D focus on mechanical design and readout

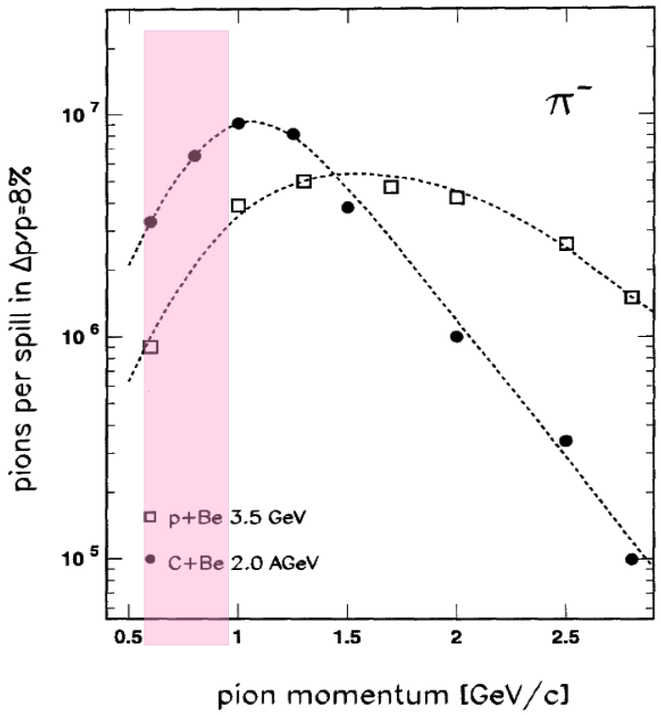
PANDA – short and midterm plans

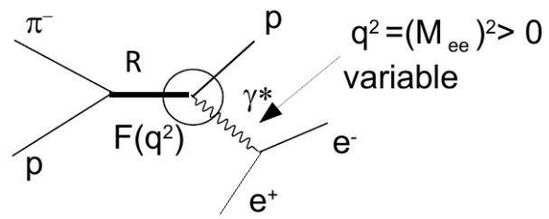
Short- and midterm plans:

- *various opportunities*
- *many unknowns*

Build up, tests and **physics**

Pion Beam @ GSI



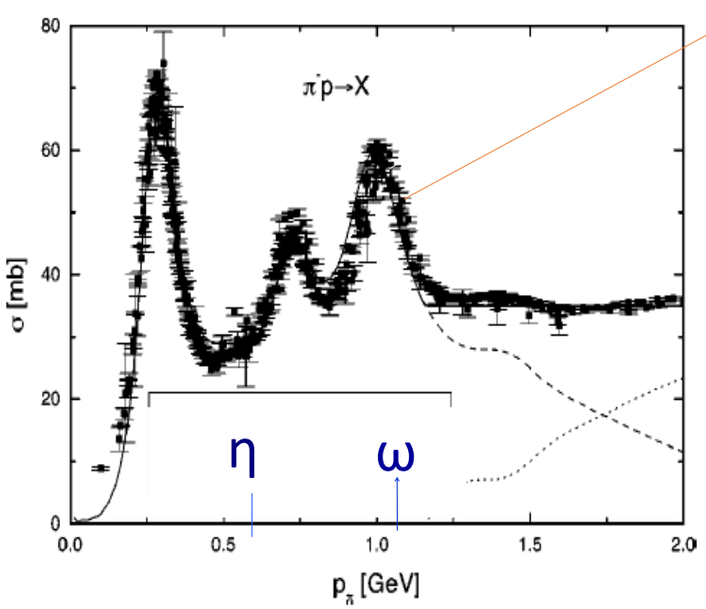


Eur. Phys. J. A (2017) 53: 188

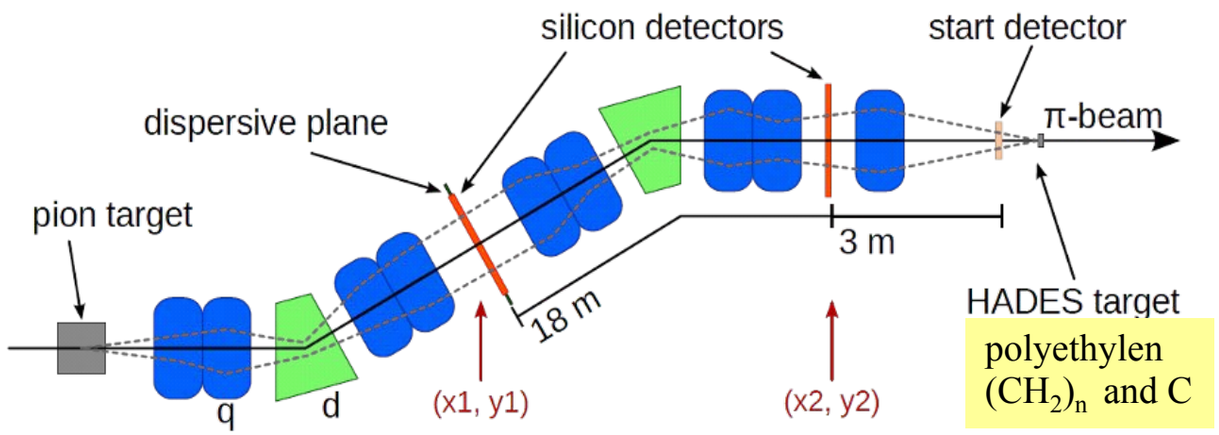
- reaction **N+Be,** 6×10^{10} N_2 ions/spill (4s)
- secondary π^- with **I ~ 2-3 10^5/s**
- pion momentum $\Delta p/p = 2.2\%$ (σ)
- 50% acceptance of pion beam line

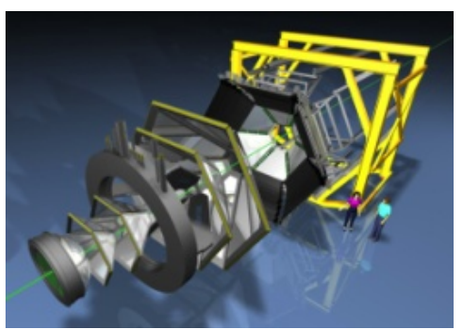
First run:

- **$\sqrt{s}$ =1.46-1.55 GeV (4 points)**
- **PE $(CH_2)_n$** and **C** targets : 2-pion and e+e- production

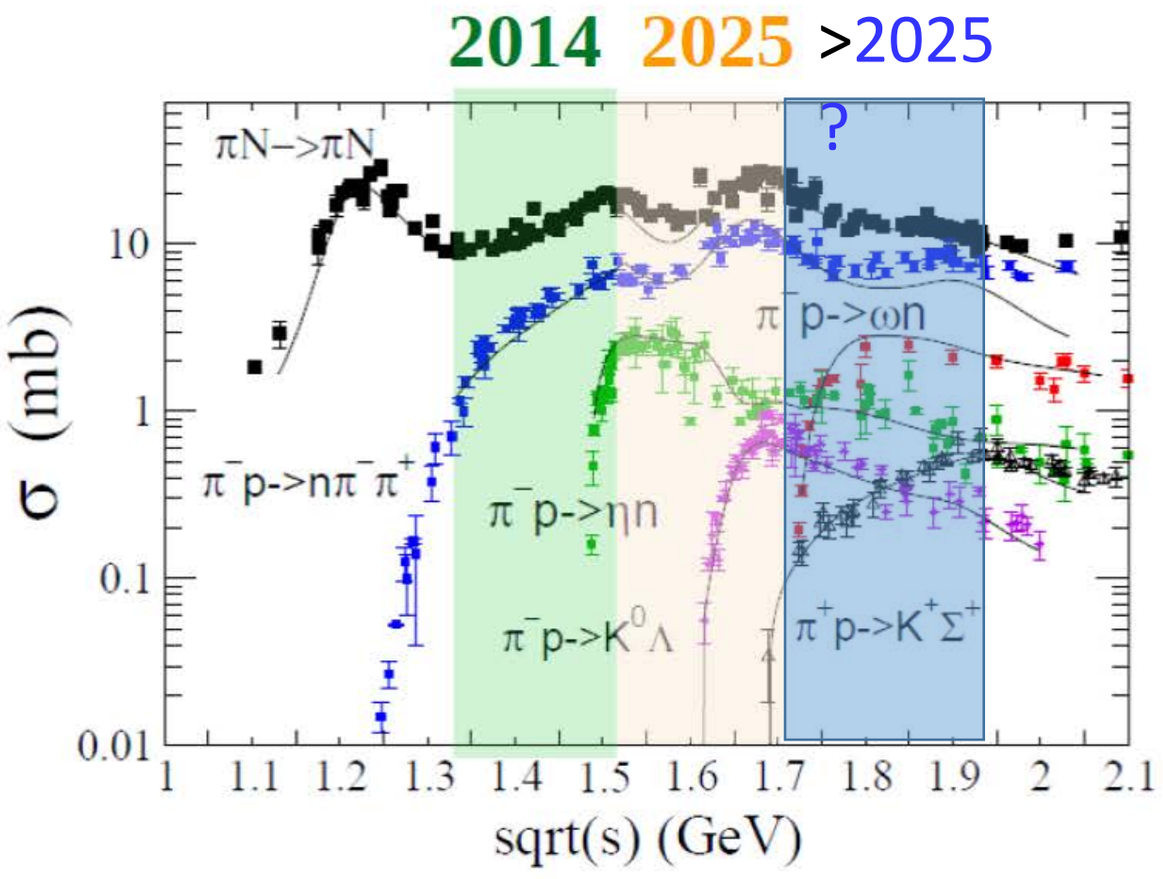


pion beam tracker **diamond detector**





HADES pion beam program – past and future



High statistics beam energy scan: continuation and extension to 3rd resonance region

1) Baryon-meson couplings:

- ρ/ω/ϕ-N, η-N, $K^0\Lambda$, $K^0\Sigma^0$
- two, three pion final states (sequential resonance decays: Δπ, N*π

2) Time-like em. baryon transitions

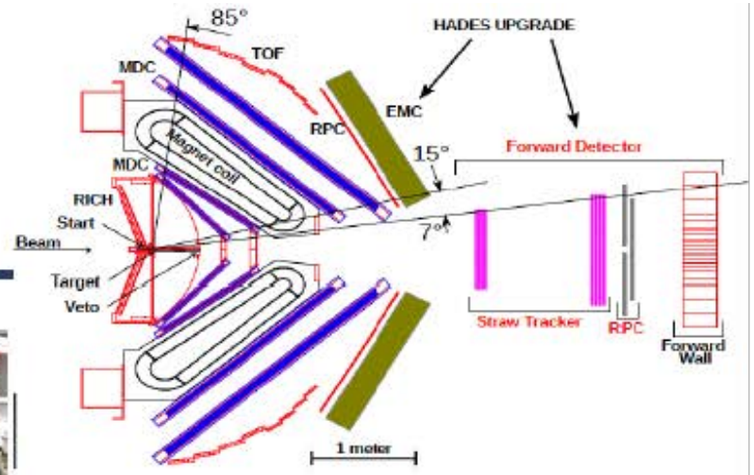
$\pi^-p \rightarrow ne^+e^-$,
test of VMD for ρ and ω,
spin-density matrix elements,

3) Cold nuclear matter studies:

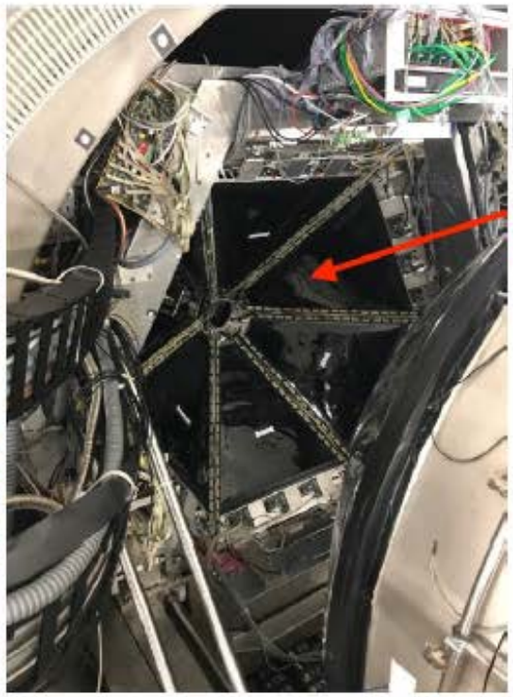
→ ω absorption
→ ρ spectral function
→ strangeness production

Build up, tests and **physics**

HADES Spectrometer UPGRADE

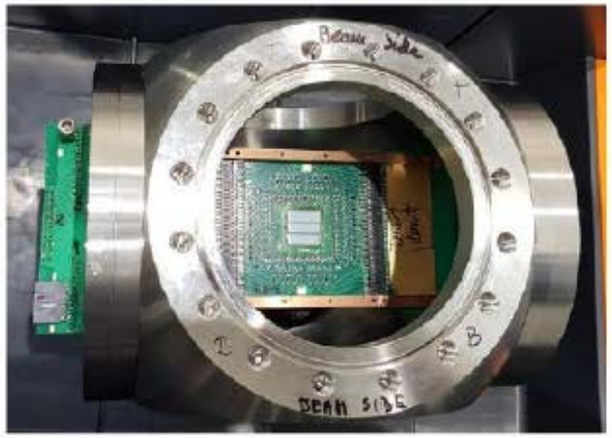


HODO, fRPC, STS2, STS1



innerTOF (fast trigger)

- **START T0 detector**

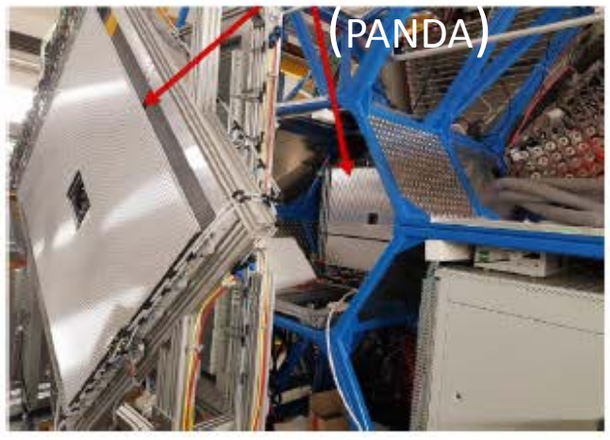


Low Gain Avalanche Detectors for the HADES reaction time (T) detector upgrade (Eur. Phys. J. A (2020) 56: 183)

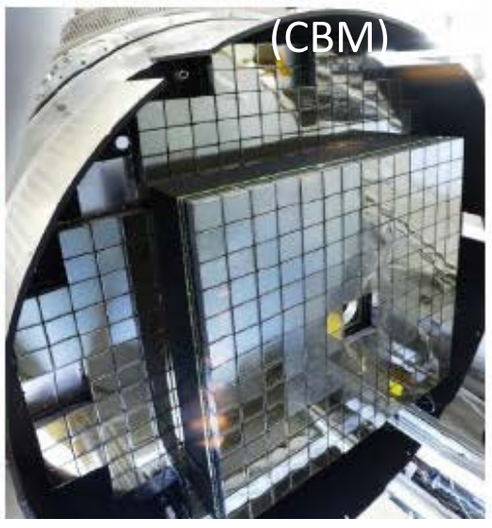
- timing < 100 ps

- **ECAL (lead glass)**

STS2 STS1 (PANDA)



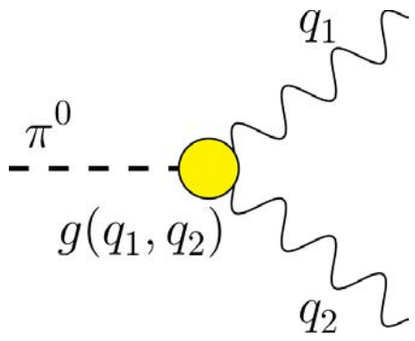
- **new RICH** (CBM)



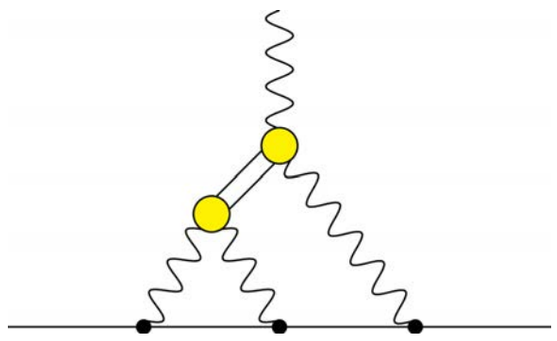
Build up, tests and **physics**

MAMI: Measurement of π^0 Transition Form Factor

Parametrises the $\pi^0 \to \gamma^*\gamma^*$ transition

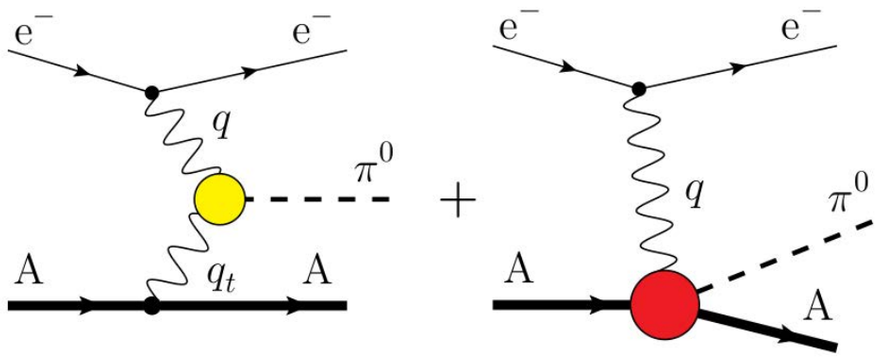


Enters the hadronic corrections to $g_\mu - 2$ through the HLbL scattering diagram (Hadronic Light-by-Light-scattering)



Can be accessed in single pion electroproduction on a nucleus: $e^- + A(Z,N) \to e^- + \pi^0 + A(Z,N)$

Dominant contributions:



"Virtual Primakoff" contribution (negative momentum transfer) :

- proportional to the transition form factor
- enhanced at small $t = q_t^2$
- enhanced for high Z targets

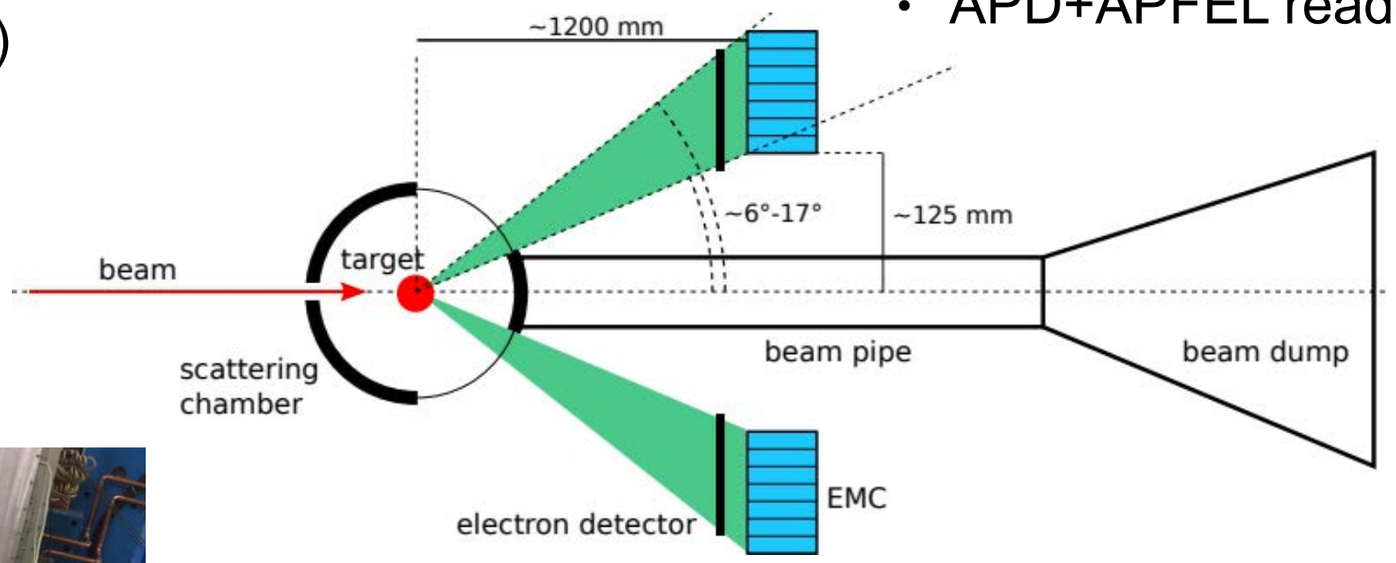
Build up, tests and **physics**

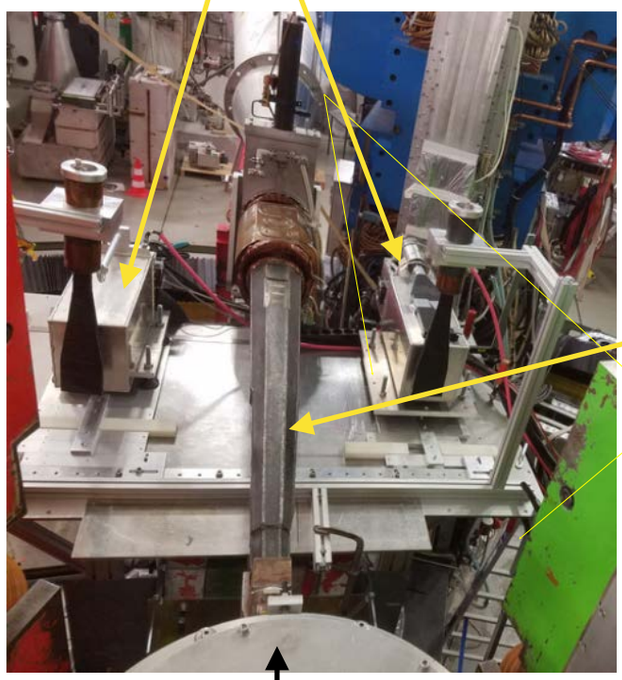
The experimental setup at MAMI

- at A1 electron scattering facility
- beam energy: 1.5 GeV
- Ta target (Z=73)

Modified version of PANDA backward EMC

- 640 $PbWO_4$ crystals
- APD+APFEL readout





Test measurements with prototypes

- real experimental condition
- measurement of total detector rates
- ⇒ determination of feasible luminosity
- measurement of energy spectra

Build up, tests and **physics**

Time plans for the MAMI experiment

Experiment construction
- PANDA backward endcap calorimeter setup finished: first half of 2023
- MAMI A1 hall infrastructure (target chamber, beam pipe, EMC support): end of 2023
- Experiment installation in MAMI A1 hall: first 2024

Last test with prototypes
- test of final readout electronics
- second half of 2023

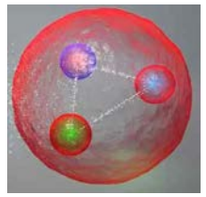
Commissioning and production beam times
(subject to MAMI beam schedule)
- commissioning run (1 week) and pilot run, small Q^2 values (2 weeks): second half of 2024
- Analysis of pilot run
- full statistics run (4 extra weeks): 2025
- Analysis of data: 2026/2027

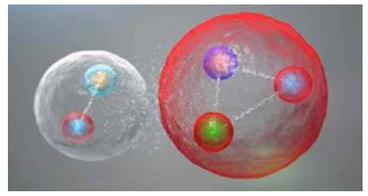
Build up, **tests** and **physics**

Baryon spectroscopy @ ELSA

Investigating the spectrum and properties of baryons ⇔ complex bound states of QCD

- **Effective degrees of freedom**
- **Forces between them**

e.g.  qqq

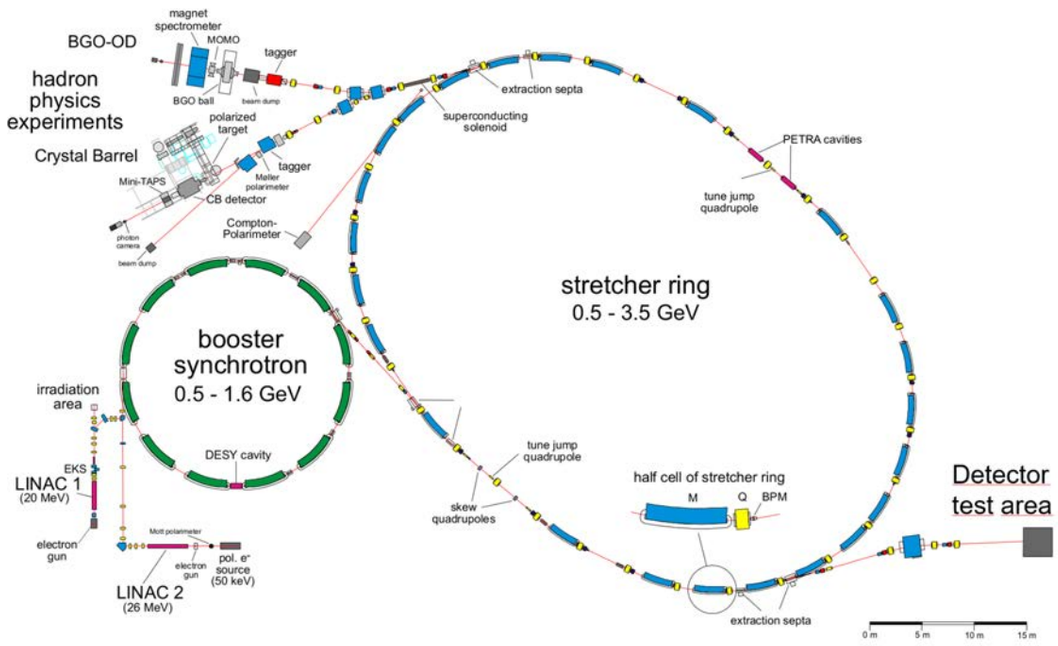
or  ?

meson-baryon (e.g. Λ(1405))

u, d — **u, d, s** — **u/d, s, s** — **s, s, s** — **charm**

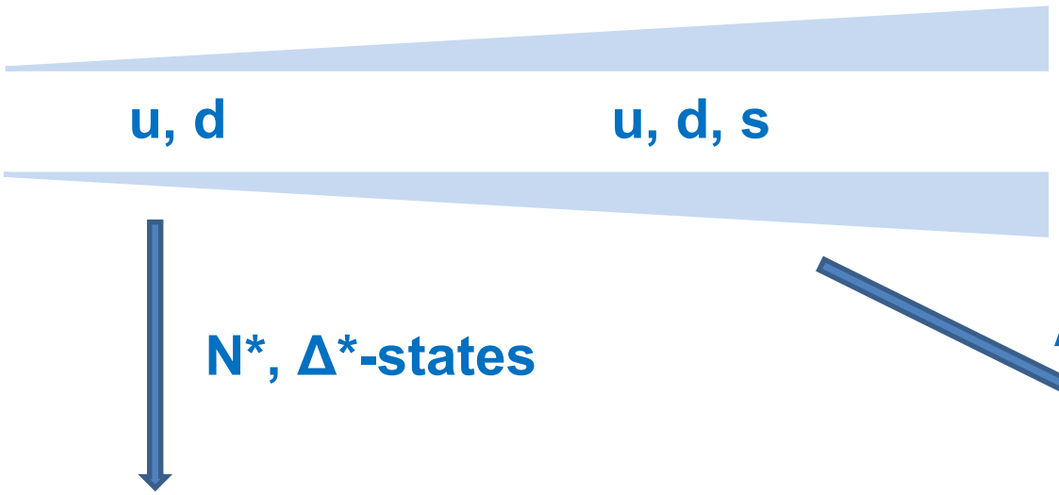
decreasing knowledge

@ELSA — **@HESR**



Build up, **tests** and **physics**

Baryon spectroscopy @ ELSA



Existing states and properties

To gain a complete picture of the light-quark baryon spectrum:

- **Polarized photoproduction off the polarized proton and neutron!**

⇔ unambiguous PWA not possible without the measurement of polarization observables

- **Multi-meson photoproduction**

Existing states and properties

More states expected than in the u,d-sector but much less states found so far!

⇔ **Do they exist ?**

⇔ **Are they consistent with SU(6)xO(3)-symmetry?**

⇔ **Nature of the observed states=?**

e.g. Λ(1405)

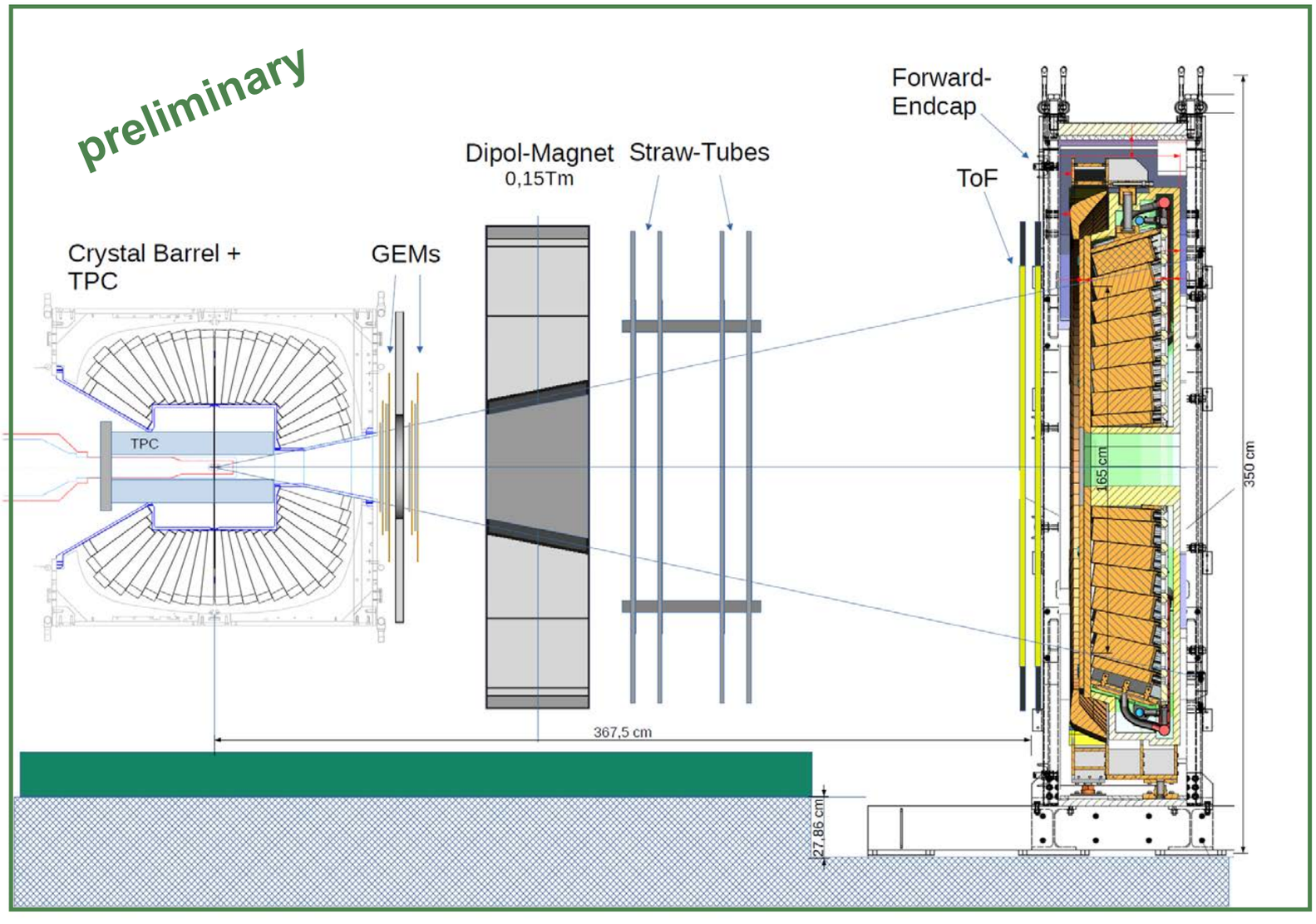
The problem:

PDG'2022: **"., the field is starved for data"**

<=> ELSA

Future: Hadron spectroscopy perspectives @ ELSA

Upgrade of the detector system (new detectors for charged particles (TPC, GEM, Straws, TOF)



+
FWEC @ELSA
Scientifically a win-win-situation
(funding still needs clarification)

4π for photons and for charged particles + polarized target

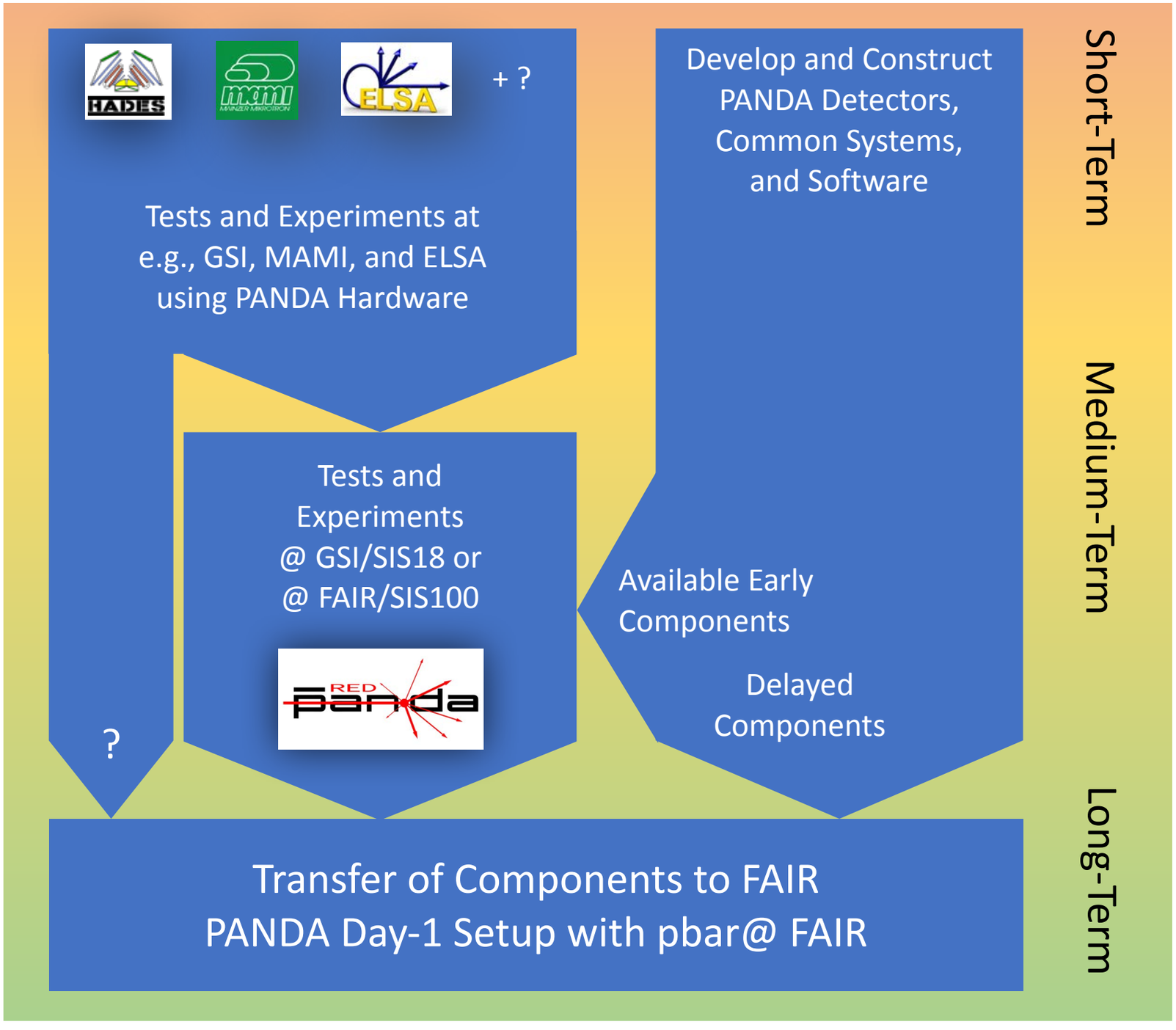
⇔ **Polarized photoproduction off proton and neutron in the non-strange and strange baryon sector**
- spectrum / properties of baryons, search for multi-quark states

Build up, **tests** and physics

Red PANDA Context

This simplified graphic shows the general idea.
Concrete plans will have to consider more details.

2023
now/soon



MSV 0-3

Build up, **tests** and physics

Red PANDA Context

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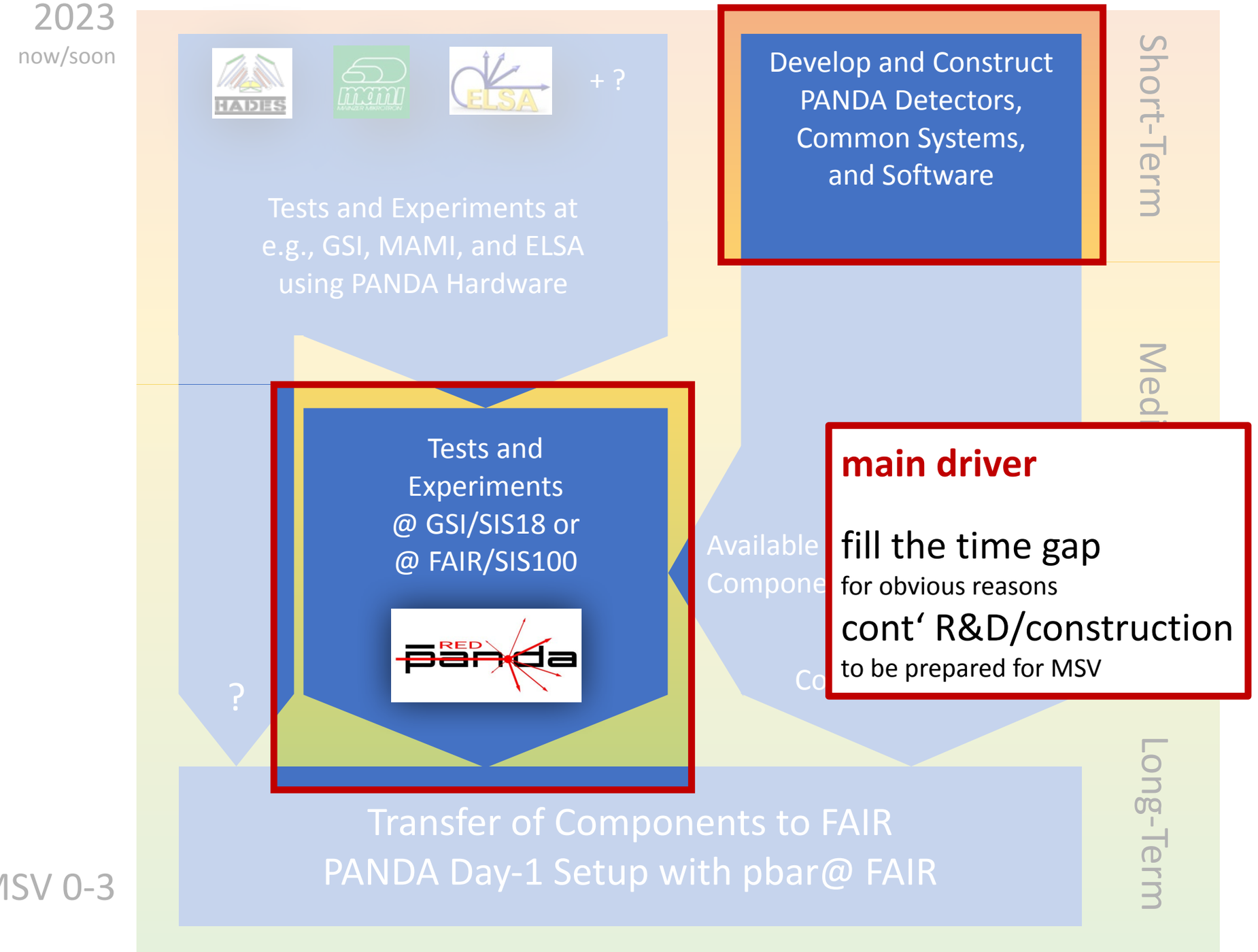


Red PANDA Tasks

Long ToDo list

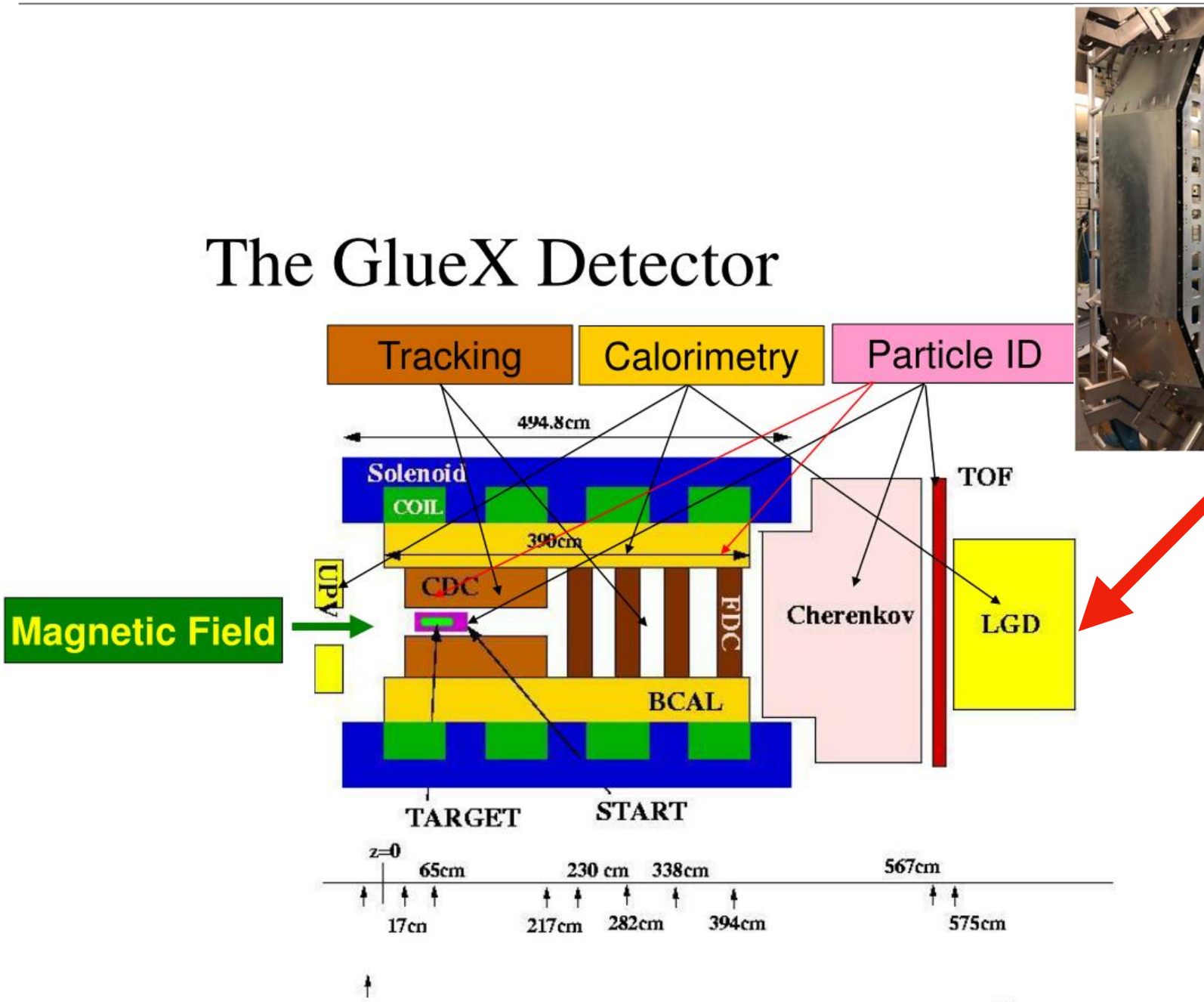
- Investigation of physics cases for proton/ion-physics @SIS-18/100
- Investigation of availability/schedule of PANDA components
- Investigation of alternative detector(-elements) and magnets
- Investigation of possible locations and beam properties
- Simulation of most promosing reactions w/ a likely setup
- LoI drafting etc …

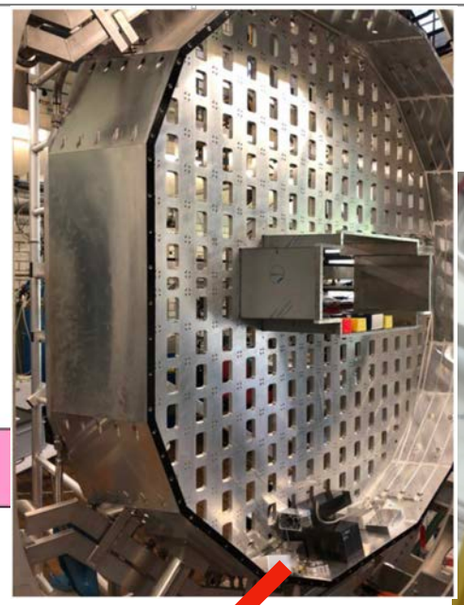
RedPANDA Retreat in 2 weeks

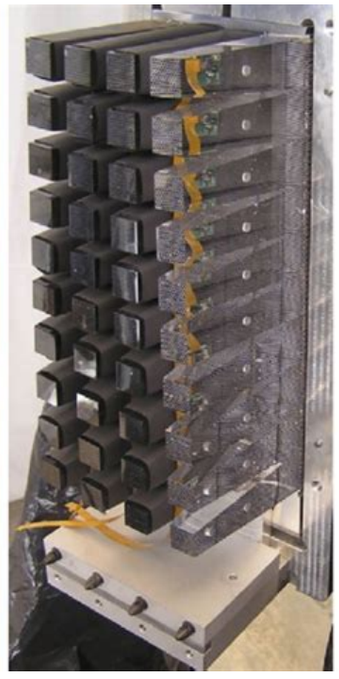
- for a first assessment to see where we are and how we can move forward

Build up, tests and **physics @ GlueX** (JLab)

Build up, tests and **physics @ GlueX** (JLab)

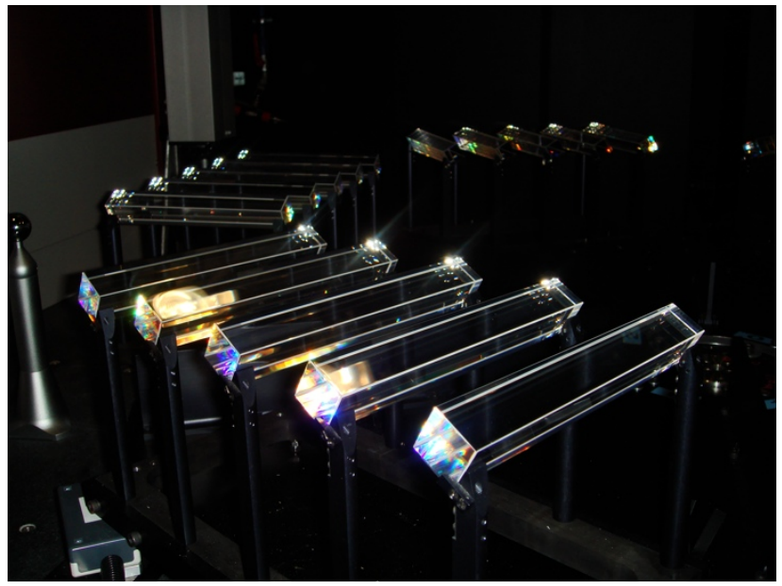




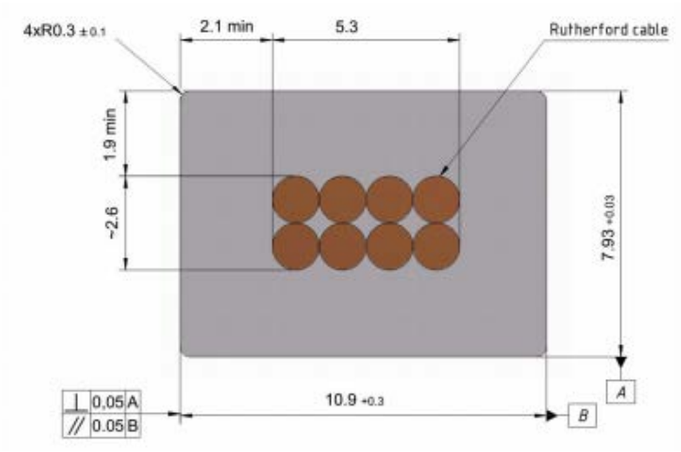


Possible PANDA timelines?

- PANDA long lead procurement start: barrel crystals 2024, solenoid 2025
- 2028: start of civil construction
- 2030: start of PANDA installation
- 2032: antiprotons at FAIR



Stop the only company in the world for PWO crystal production from discontinuing production line.

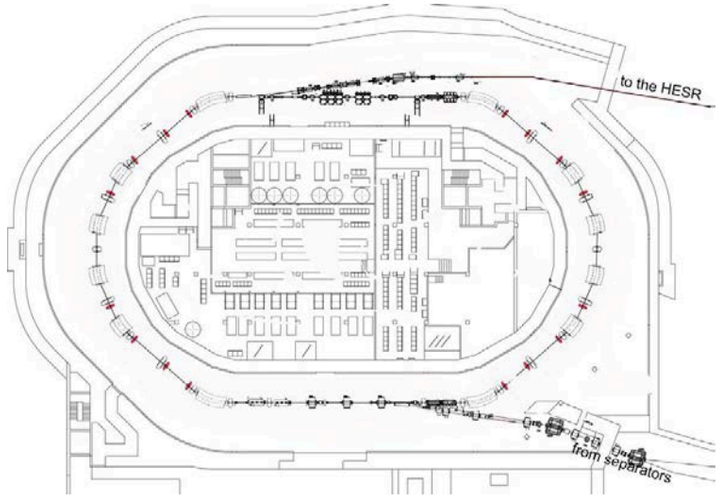


Long production time and technology for SC Solenoid cable unavailable. Mitigation: cooperation with CERN and other experiments.

Options for Antiproton collection at FAIR (MAC)

Option 1: AA

Components of CERN AA used for a new collector ring (CR)



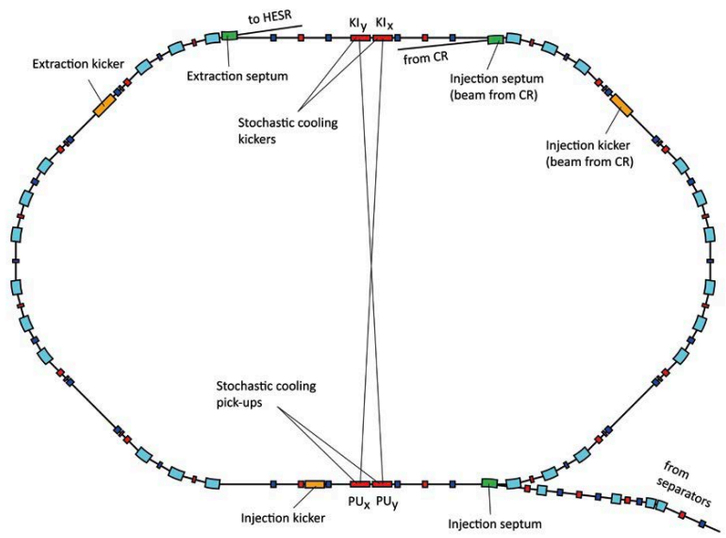
Option 2: COSY

- Refurbishing vacuum system for new geometry
- All other COSY components ready
- Serve as collector for commissioning
- Later COSY can be used as accumulator (“RESR”)

⇒ Having both rings allows 8× previous Phase 1 luminosity

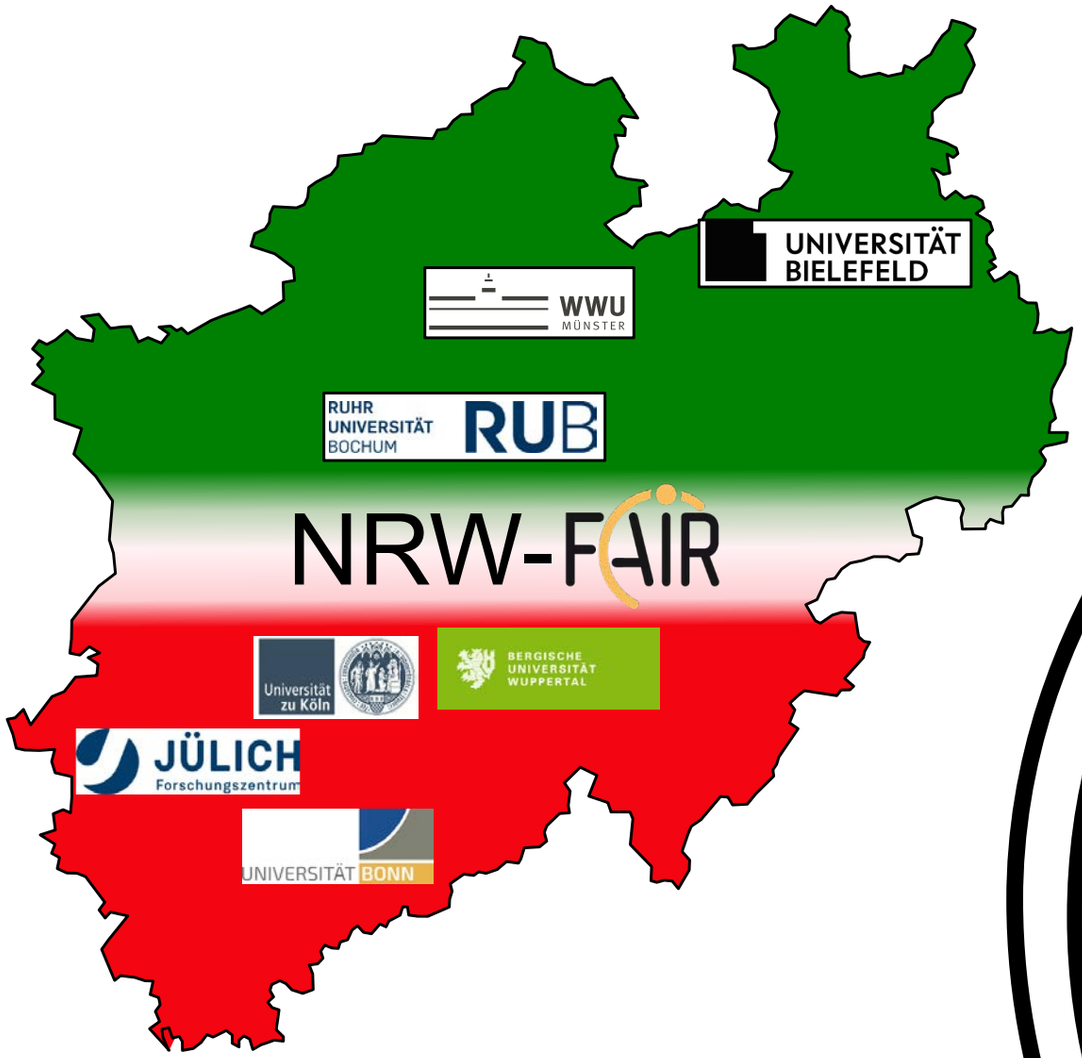
Option 3: New Superferric CR

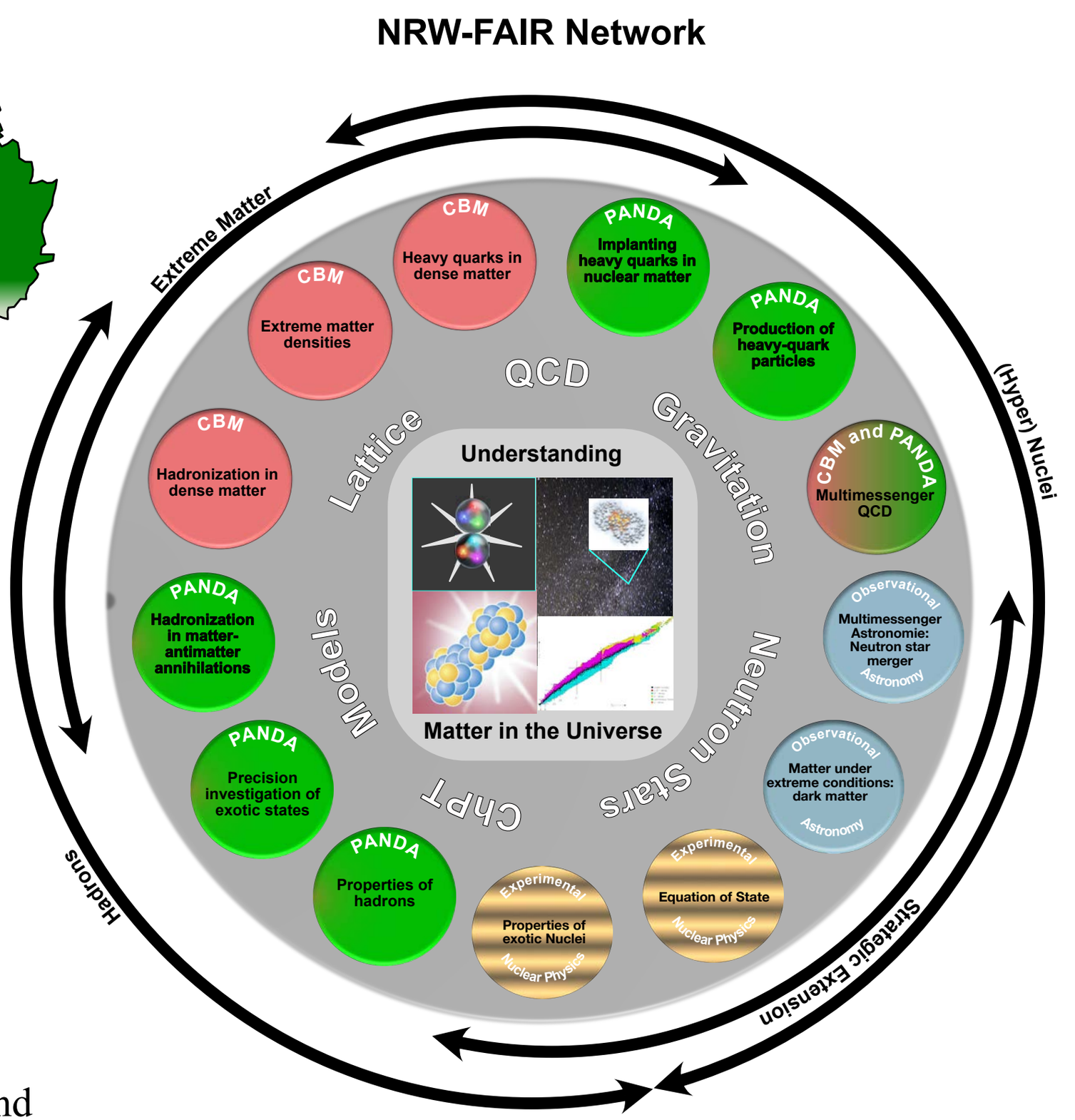
- Superferric CR derived from Super-FRS design
- Higher investment costs, long-term lower operation cost



MAC Recommendations:

Baseline CR with AA magnets followed by COSY as RESR





Fokus auf Synergien zwischen

PANDA (Bochum, Bonn, Jülich, Wuppertal, Münster)

und

CBM (Jülich, Wuppertal, Münster)

sowie die Einbindung von Bielefeld and Köln (NUSTAR)

FAIR, GSI and Council

Build trust in FAIR MSV by concrete plans

and actions to keep the

PANDA collaboration strong!

The physics is worth it.

Thank you for your attention!

and many thanks to

Piotr Salabura

Ulrike Thoma

Frank Maas

Lars Schmitt

Klaus Peters

for helping with transparencies