Status of PANDA Experiment

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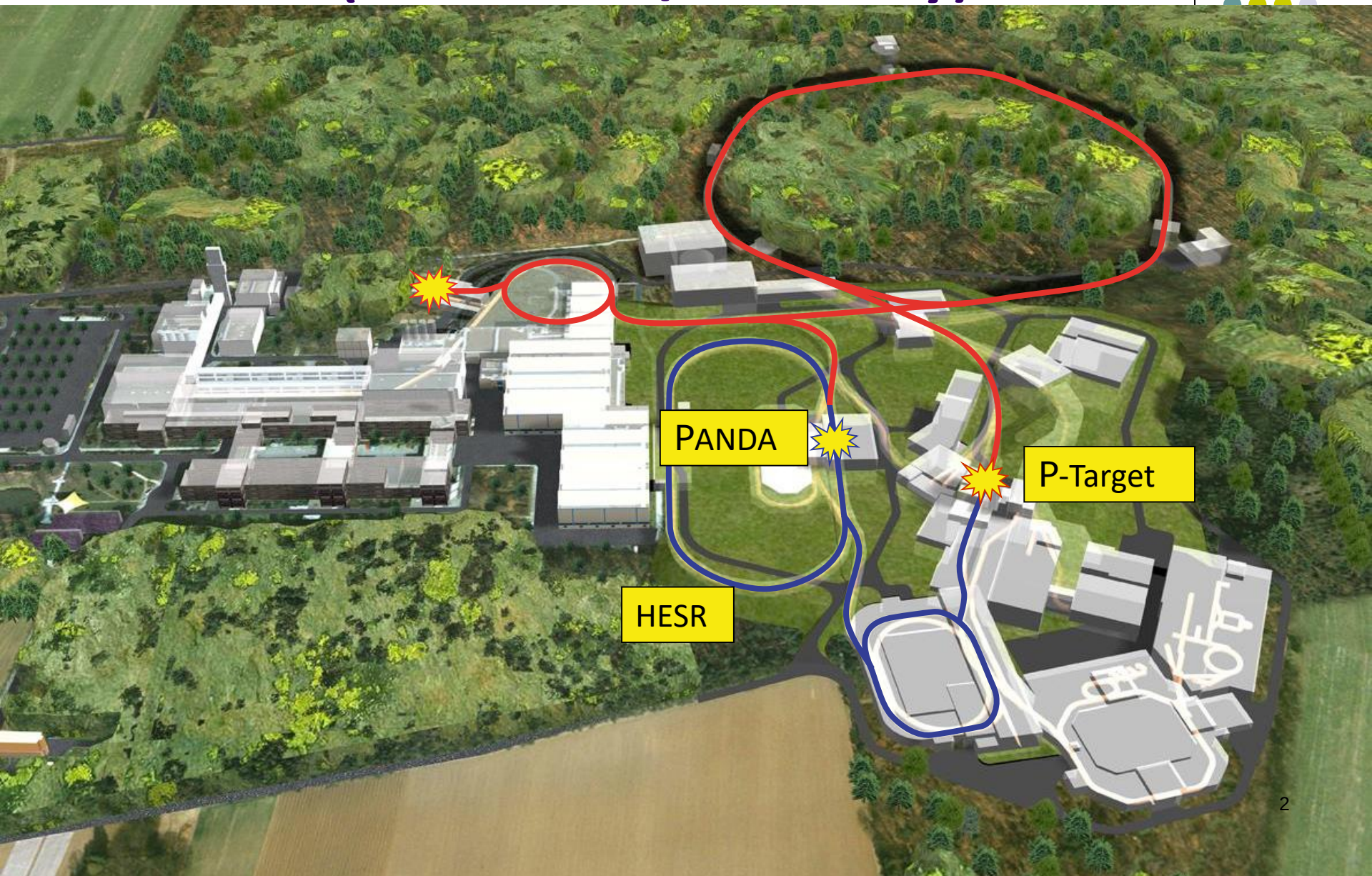
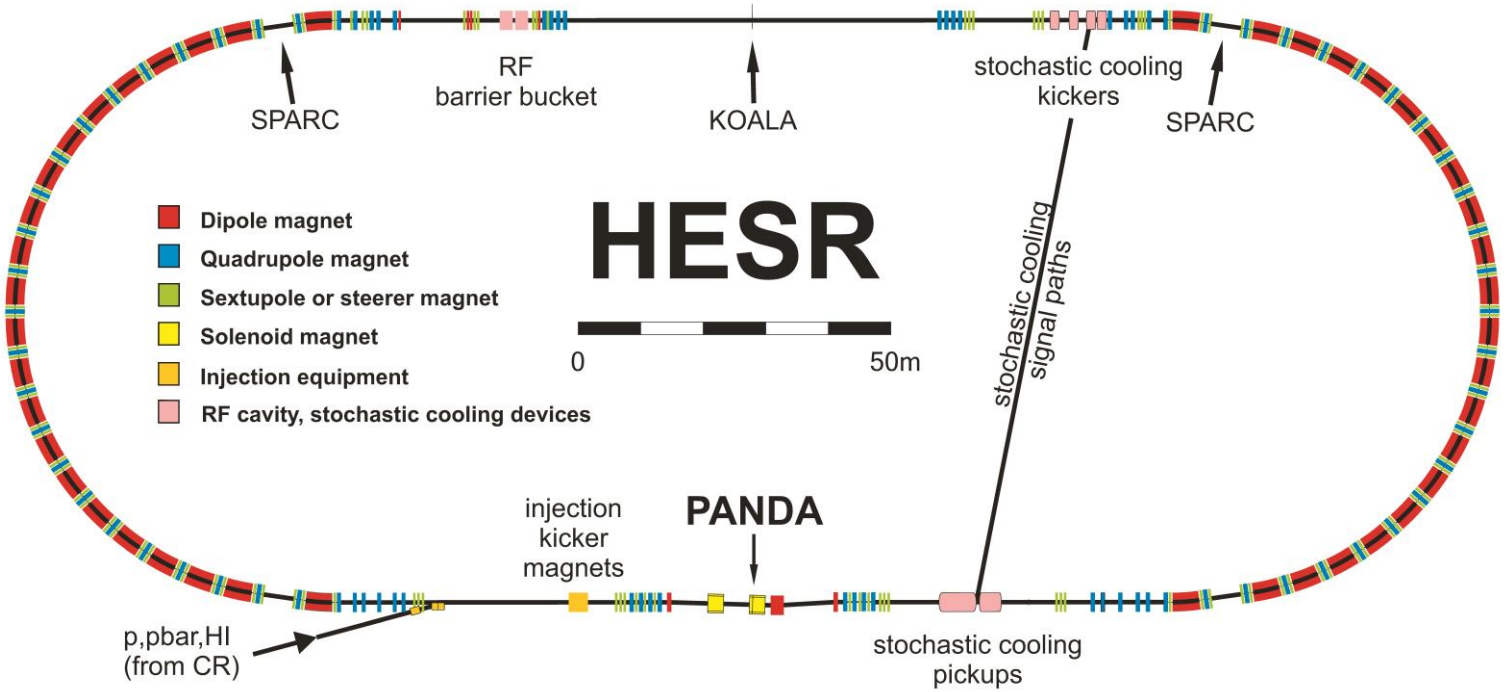
Facility for Antiproton and Ion Research (Darmstadt/Germany)



HESR — High Energy Storage Ring



Injection momentum 3.8GeV/c

Storage ring with internal target

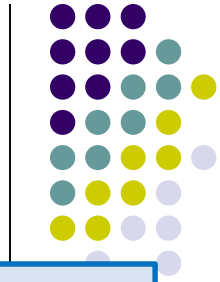
Mode	High Resolution	High Luminosity
Momentum range	1.5 – 15 GeV/c	1.5 – 15 GeV/c
Energy range	2.3 – 5.5 GeV	2.3 – 5.5 GeV
Stored antiprotons	10^{10}	10^{11}
Peak luminosity	10^{31} cm^{-2}s^{-1}	$2 \cdot 10^{32}$ cm^{-2}s^{-1}
$\Delta p/p$	$5 \cdot 10^{-5}$	$1 \cdot 10^{-4}$

Construction Site

September 3, 2017

https://fair-center.eu/construction/webcam.html

PANDA — Physics Program



HEP underlying elementary processes

Spectroscopy

New narrow XYZ:
Search for partner states

Production of exotic QCD states:
Glueballs & hybrids

HEP interference of coupled channels

Astrophysics strange n-stars

Nucleon Structure

Generalized parton distributions:
Orbital angular momentum

Drell Yan process:
Transverse structure, valence anti-quarks

Time-like form factors:
Low and high E, e and μ pairs

Bound States of Strong Interaction

Strangeness

Strange baryons:
Spectroscopy
Polarization

Nuclear physics hypernuclear spectroscopy

Nuclear Physics

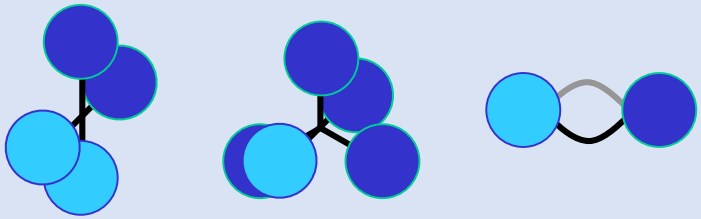
Hypernuclear physics:
Double Λ hypernuclei
Hyperon interaction

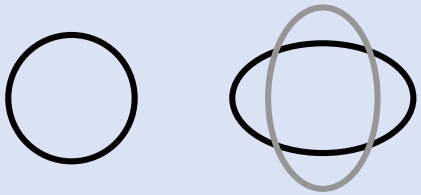
Hadrons in nuclei:
Charm and strangeness in the medium

HI collisions comparing QGP to elementary reactions

XYZ States

What is the nature of these states ?





?

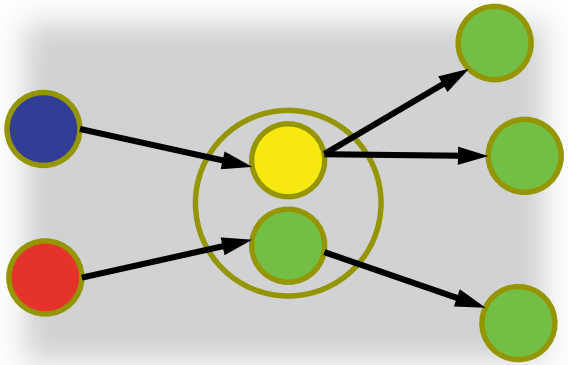
→ Search for partners and additional states

→ Lineshape measurements

→ Amplitude analysis

pp-Annihilations: Gluon Rich Environment

Production

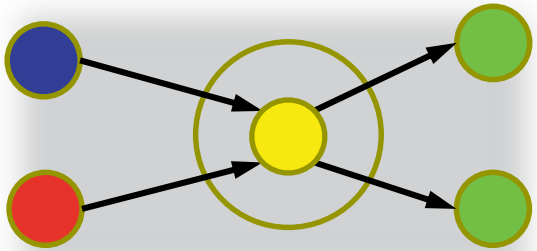


High Discovery Potential

associated production
→ access to all quantum numbers (exotic and non-exotic)

limited by detector resolution

Formation

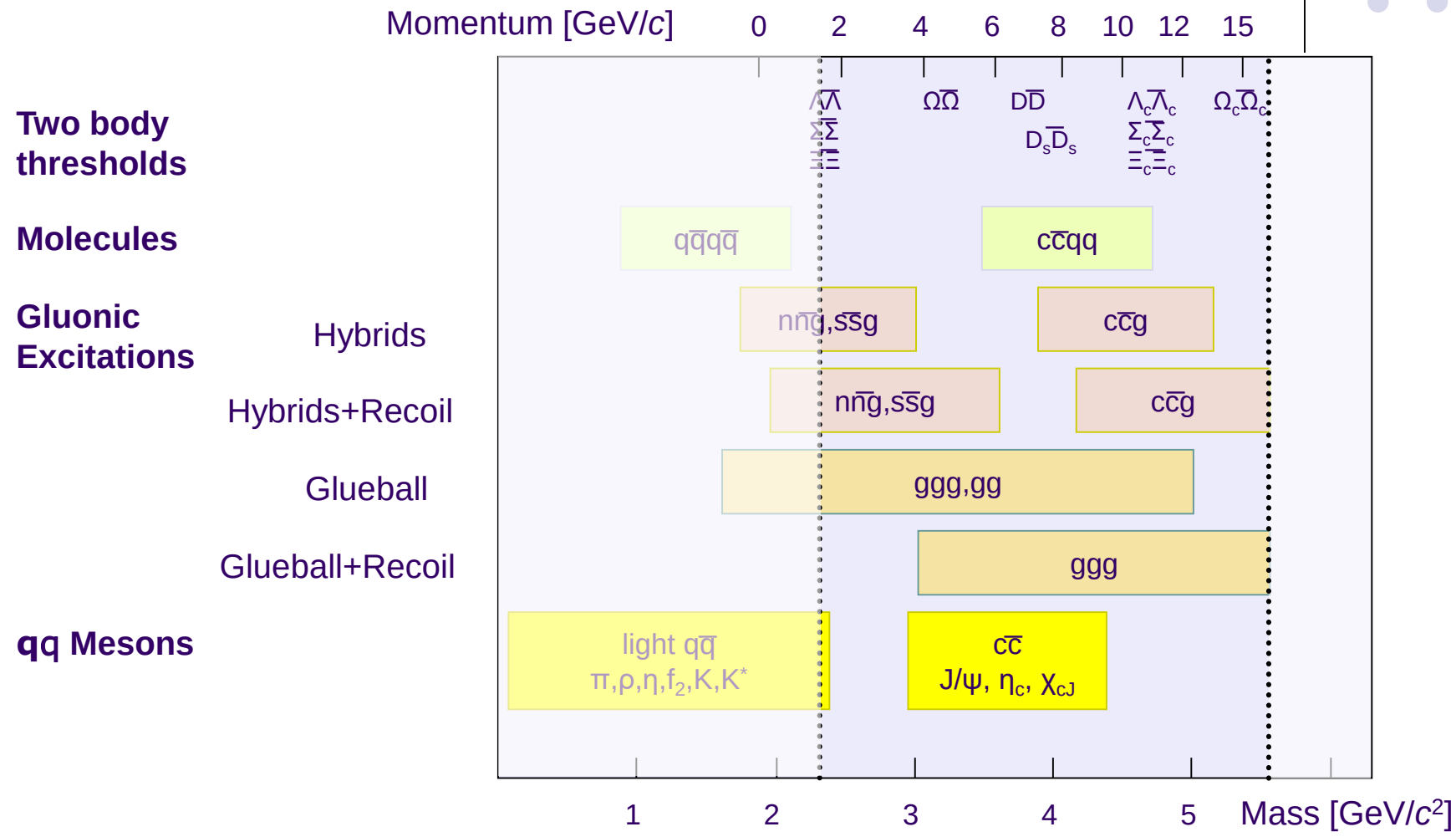


Precision Physics of Known States

not limited to $J^{PC} = 1^{--}$ as e^+e^- colliders
direct formation of resonance
→ access to qq quantum numbers high statistic

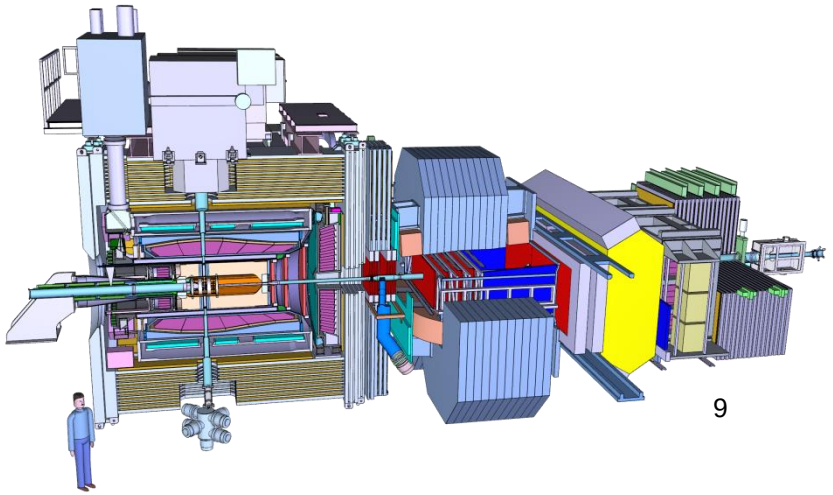
limited by momentum resolution
→ precise measurement of mass and width

Accessible Hadrons at PANDA



PANDA Detector

- Target Spectrometer + Forward Spectrometer
- PANDA Detector:
  - Tracking System: MVD + STT + GEM + FT
  - Electromagnetic Calorimeter: Barrel + Forward + Backward + Shashilik type sampling
  - Particle Identification: DIRC + TOF + MUD + RICH
  - Magnet: Solenoid + Dipole
  - Target: Cluster-jet

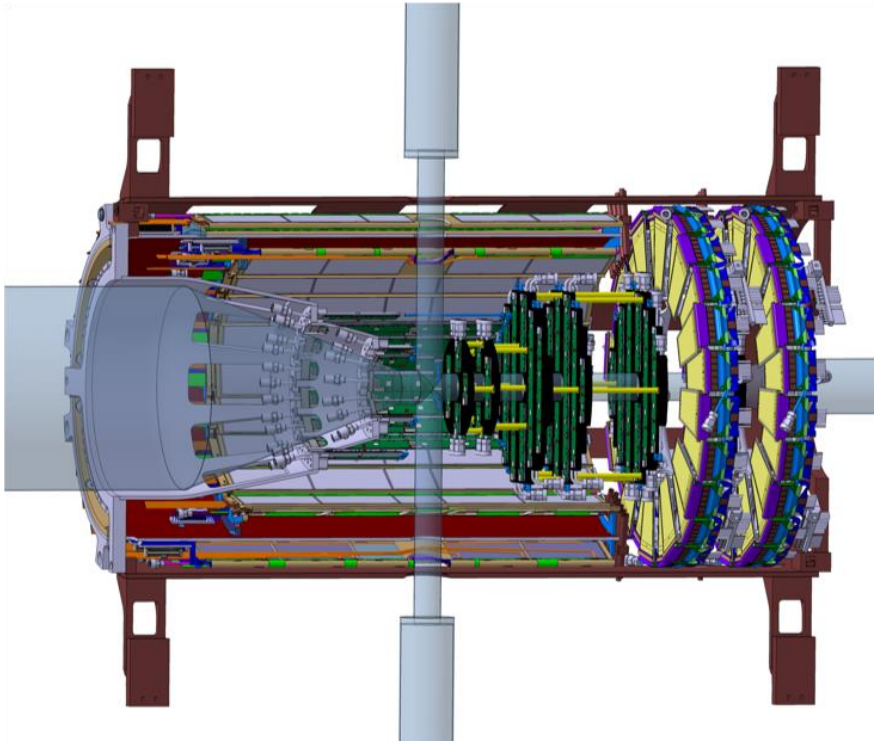


Tracking Detectors: Micro Vertex Detector

Innermost detector, closest to primary interaction vertices
Essential for precise determination of secondary decay vertices
Barrel shell structure (4 layers), disk structure (6 pieces) in forward direction

Double sided silicon strip detectors, pixel detectors

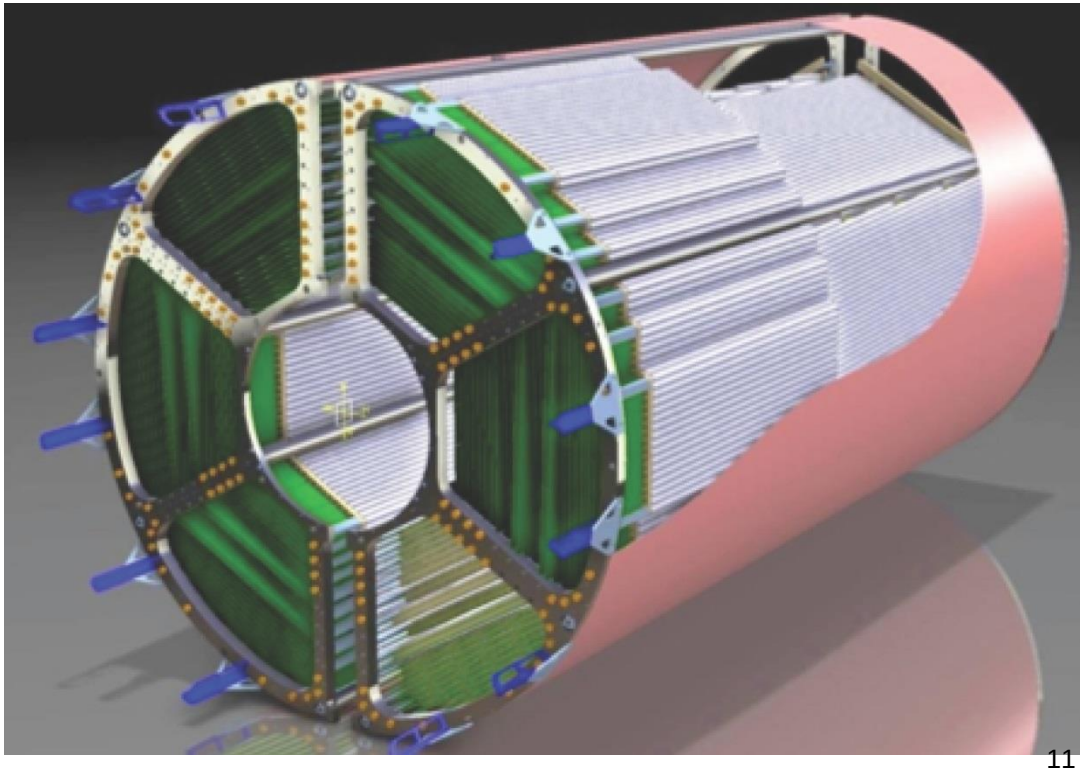
time resolution	< 10 ns
pixel	28 μm pos. res.
strips	14 μm pos. res.
vertex resolution	< 100 μm



Tracking Detectors: Straw Tube Tracker

4200 Ar/CO_2 (90/10) filled Al-mylar drift tubes
Arranged in cylindrical volume around MVD
Avalanche multiplication: gain≈100

Inner radius	15 cm
Outer radius	42 cm
Tube diameter	10 mm
Tube length	150 cm
ρ/ϕ plane resolution	150 μm
z resolution	1 mm



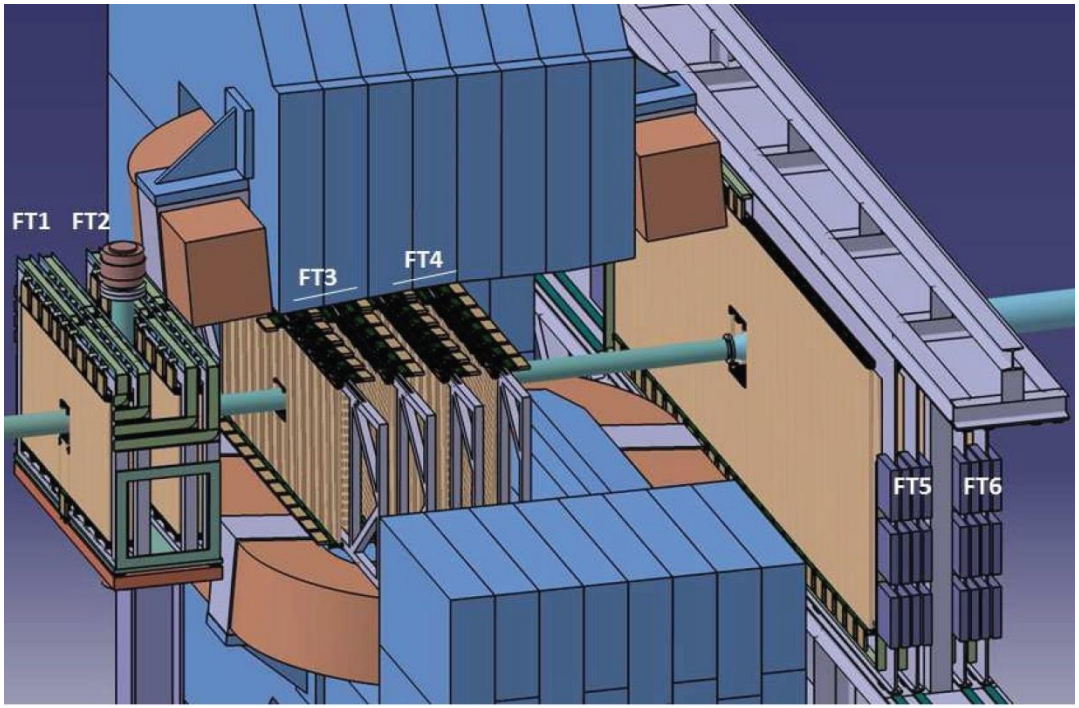
Forward Spectrometer: Forward Tracker

Based on 10 mm diameter straw tubes as in central tracker

Momentum acceptance better than $0.03 \times \bar{p}_{beam}$

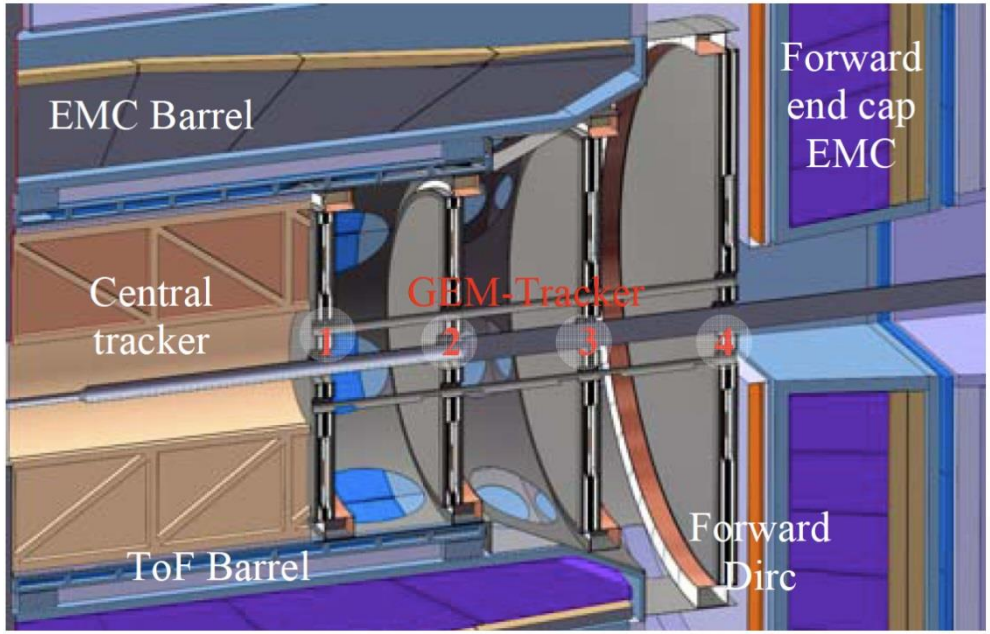
(B_{dipole} scaled according to $\bar{p}_{beam}$)

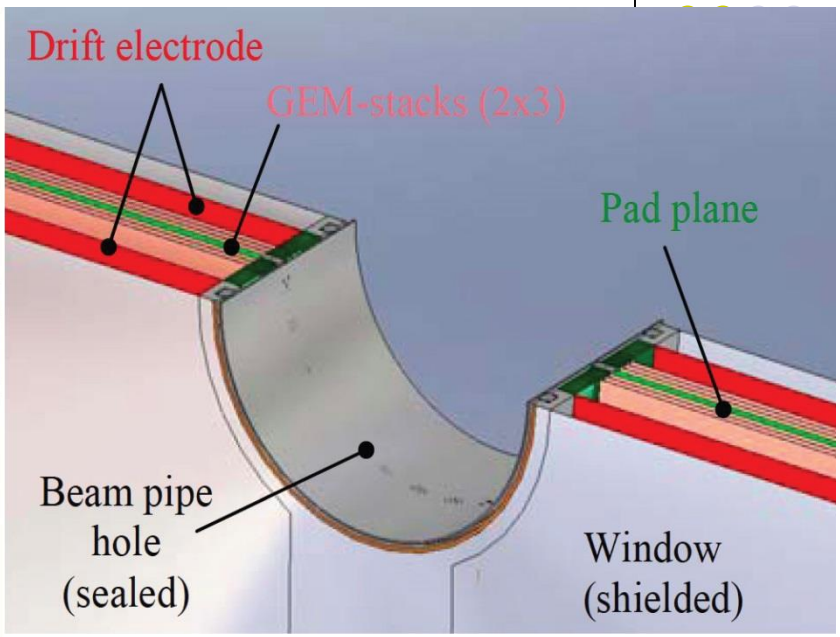
Three pairs of planer tracking stations in front, behind and inside (for low momentum particles) magnet yoke



Coverage	$\pm$ 10° horizontally $\pm$ 5° vertically
Position resolution	0.1 mm / layer
$\Delta p/p$	< 1 %

Tracking Detectors: GEMs





Station No.	1	2	3	4
Weight [kg]	20	20	30	40
Distance to target [cm]	81	117	153	189
Outer diameter [cm]	90	90	112	148
Resolution trajectory position	$< 100\ \mu$m			

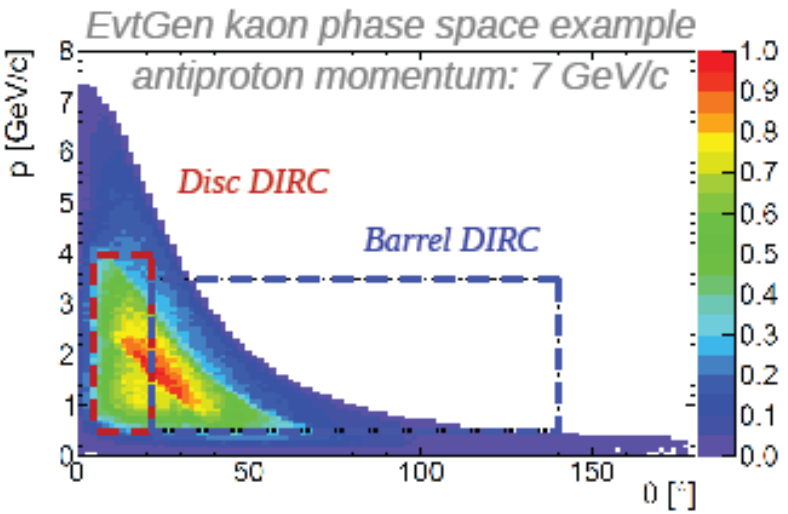
Particle Identification

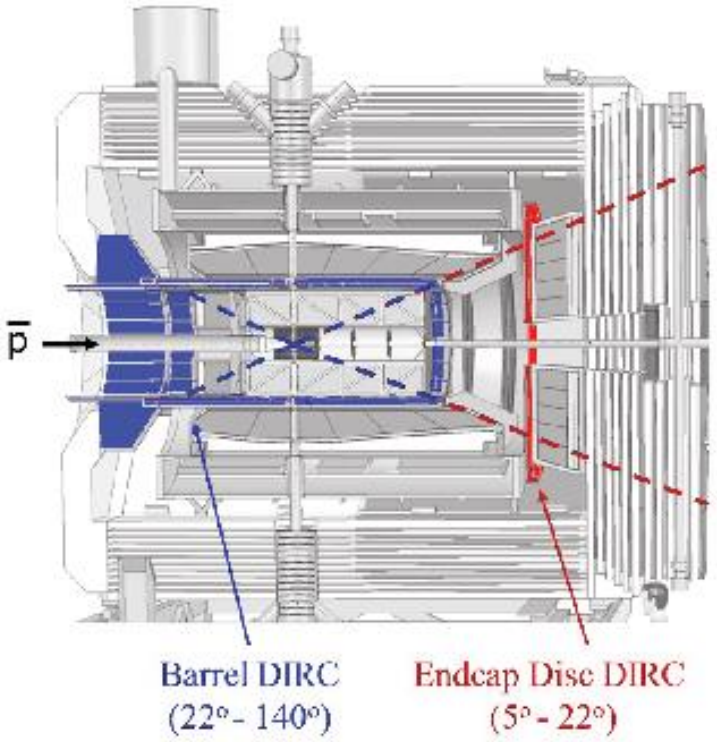
- Accurate PID key requirement to unveal many aspects of PANDA physics program
- Various dedicated high developed PID systems are able to classify particle species over whole kinematic range:

  Cherenkov detectors: DIRCs, RICH

  Time of Flight system

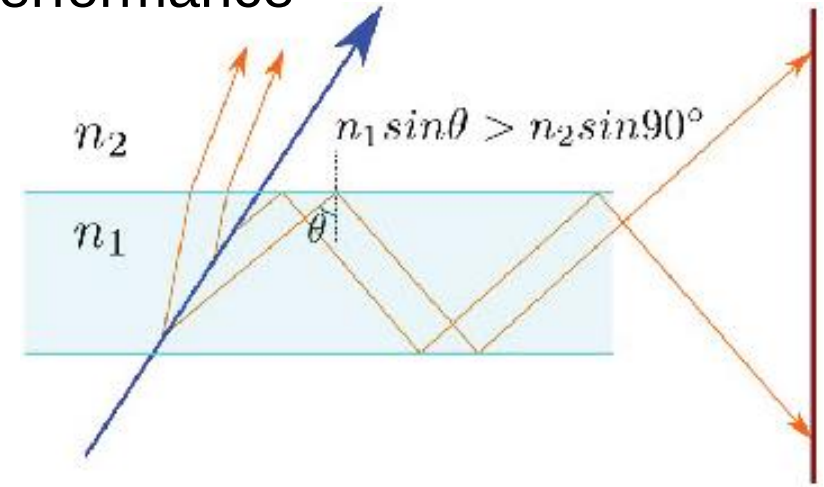
  Moun detection system



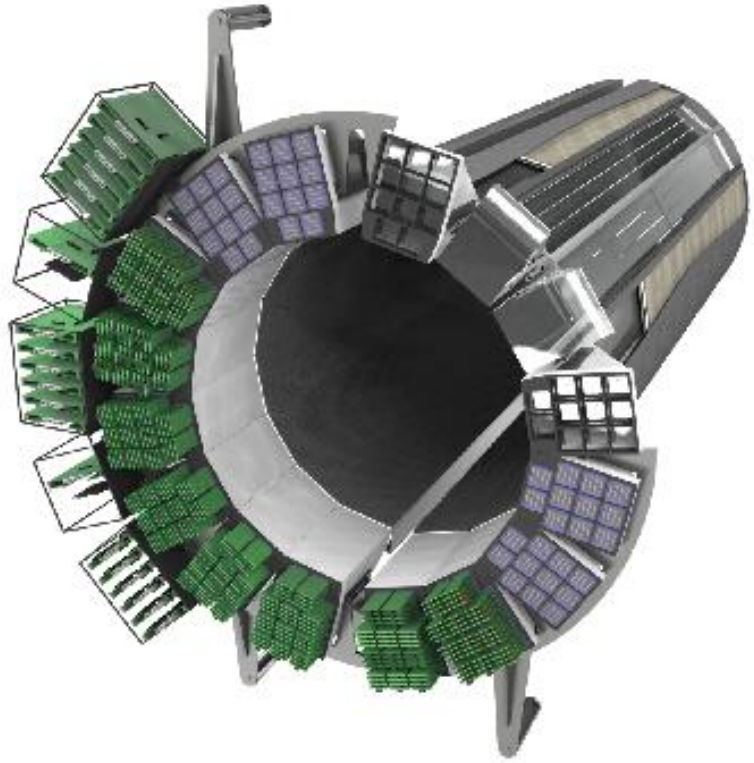


Particle Identification: Barrel DIRC

DIRC: Detection of Internally Reflected Cherenkov light
Compact fused silica (quartz) bars, spherical lenses, prisms MCP-PMT read out: excellent timing, B-field performance



$\beta > 1/n$	$\cos\Theta_C = 1/\beta$ n(λ)
n radiator	1.47
π/K separation	3 σ (up tp 3.5 GeV/c)
γ time res.	100 ps
PMT channels	10000



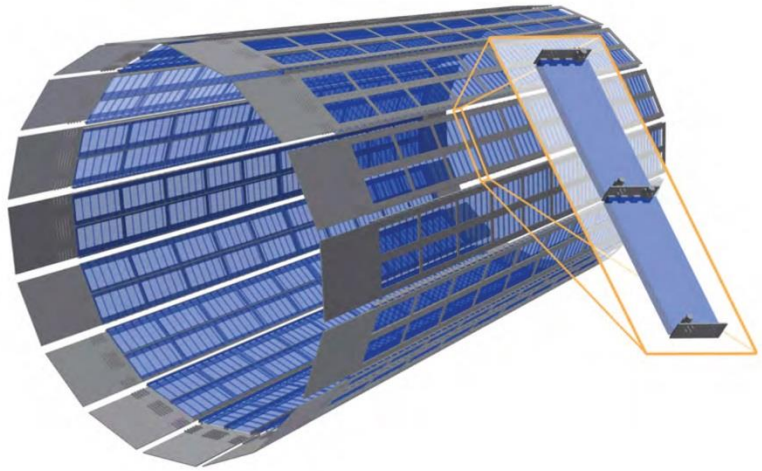
Particle Identification: Barrel TOF

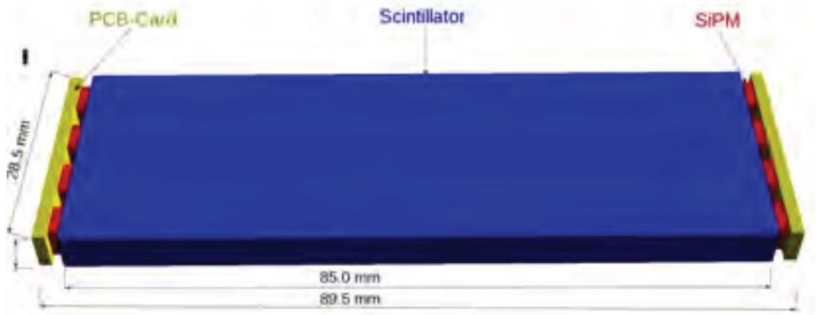
Low momentum particle PID (<1GeV)

Excellent time resolution of about 100 ps

System of scintillator tiles read out by SiPMs (two sides)

Light weight construction





Scintillator	plastic (EJ-228 or EJ-232)
Read out	SiPM (Hamamatsu)
FEE	TOF PET ASIC (PETsys electronics)

Electromagnetic Calorimetry

PANDA physics: Complete reconstruction of multi-photon and lepton-pair channels of importance

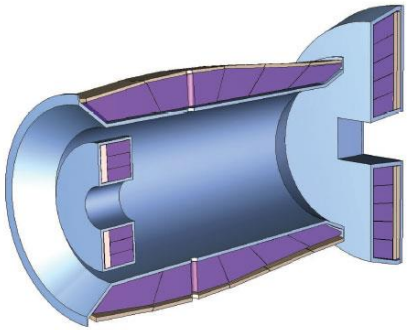
Good energy and spatial resolution for photons up to 15 GeV

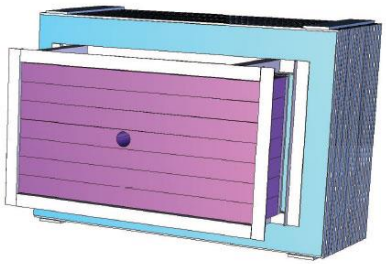
High yield and background rejection

Target spectrometer: Homogenius barrel part plus two endcaps

Forward spectrometer: Sample calorimeter

Energy threshold	10 MeV
Spacial coverage	98 % of 4π
Single crystal rate	up to 1 MHz

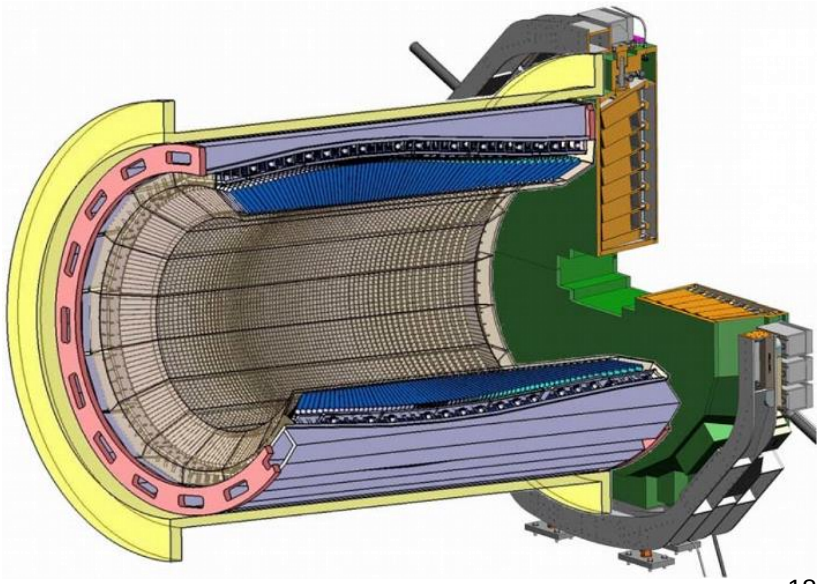




Electromagnetic Calorimeter: Target calorimeter

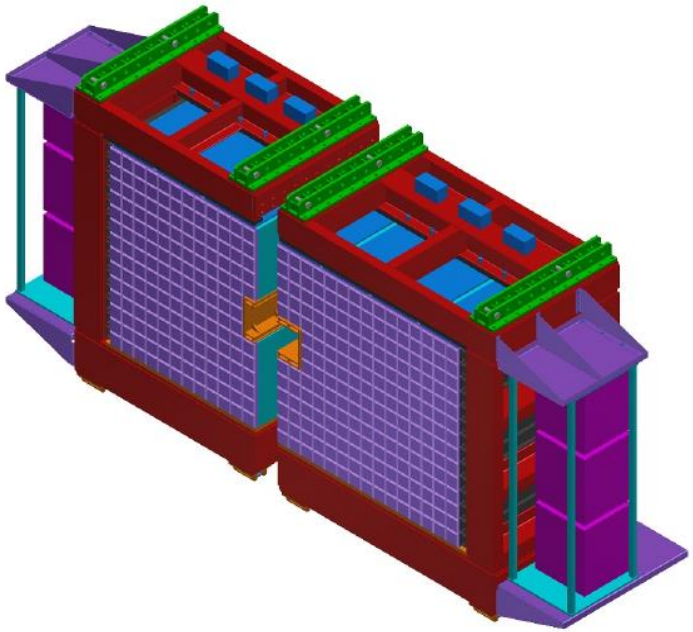
- 2^{nd} generation $PbWO_4$ (PWO-II), improved light yield, radiation hardness, 15744 crystals
- Operating at -25℃ (×4 light yield)
- Read out: Large area APDs (2 per crystal), vaccum photo tetrodes (inner forward endcap)

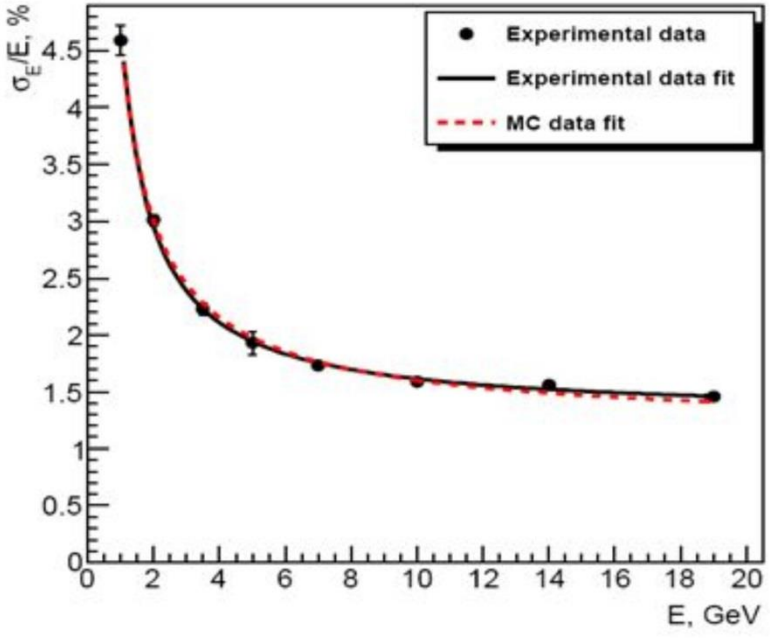
Radiation length	0.9 cm
Molière radius	2.1 cm
Crystal dimensions	$20 \times 2.5 \times 2.5$ cm^3
Time resolution	≤ 1 ns (> 100 MeV)
Energy res. $\frac{\sigma_E}{E}$	$1\% \oplus \frac{2\%}{\sqrt{E[GeV]}}$
Spacial resolution	≤ 1.5 mm



Electromagnetic Calorimetry: Forward Calorimeter

Shashlik type sampling calorimeter:
Lead absorbers, plastic scintillators, light collection by wavelength shifting fibers, PMT readout

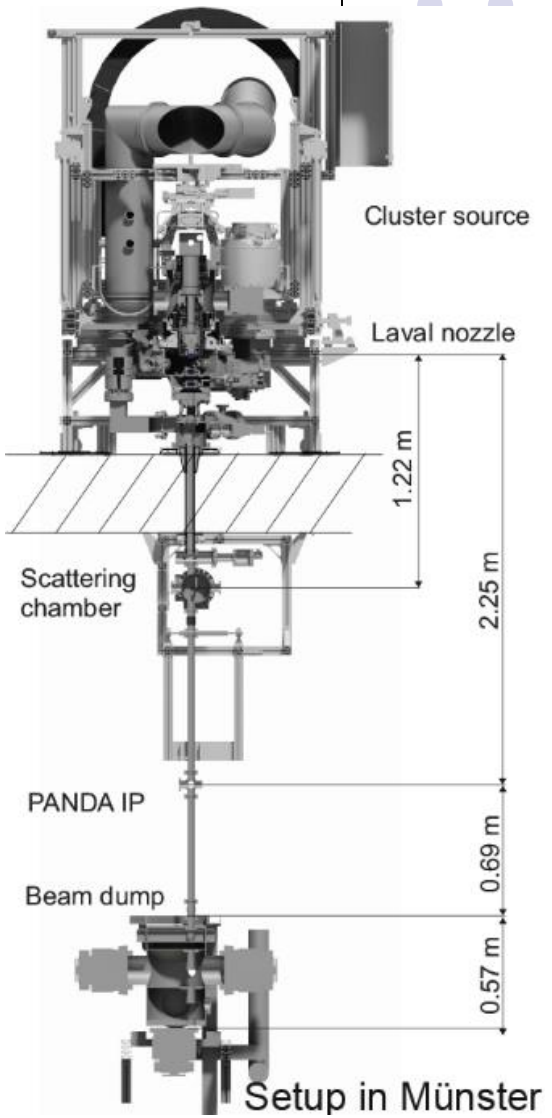




$$\frac{\sigma_E}{E} \leq 1.3\% \oplus \frac{2.8\%}{\sqrt{E[GeV]}} \oplus \frac{3.5\%}{E[GeV]}$$

Cluster-Jet Target

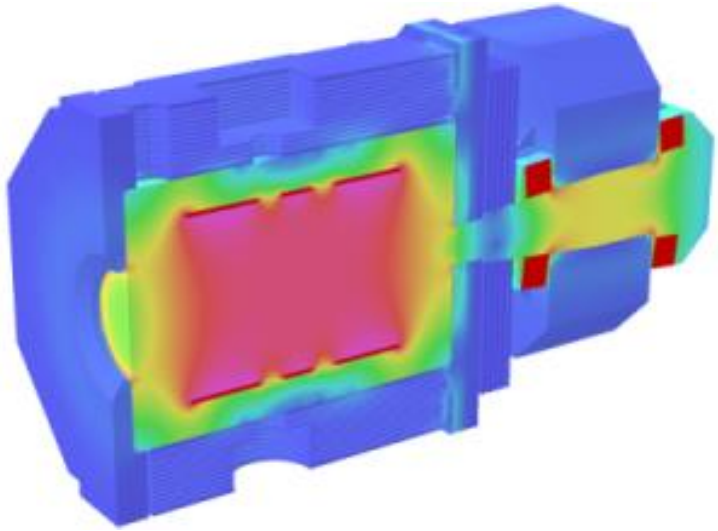
- Target thickness $\rho > 2 \times 10^{15}$ hydrogen atoms/cm^2 at PANDA IP
- Well defined vertex point
- Cluster size on nanometer scale
  - homogeneous target beam with no time structure
- Target thickness continuously adjustable over magnitudes
- Non-destructive target thickness monitor system for online thickness analysis



Magnets

Ideal combination of superconducting solenoid (target region) and dipole (forward spectrometer, below $5^{\circ}/10^{\circ}$)

	Solenoid	Dipole
Field	2 T	1 T
Diameter	inner/outer 1.9/2.3 m	1 m × 3 m opening
Length	4.9 m	2.5 m
Weight	300 t	220 t



Solenoid:

Instrumented flux return

Field inhomogeneity $\leq 2\%$

Dipole ramping operation fully synchronous with storage ring, ramp speed 1.25%/s

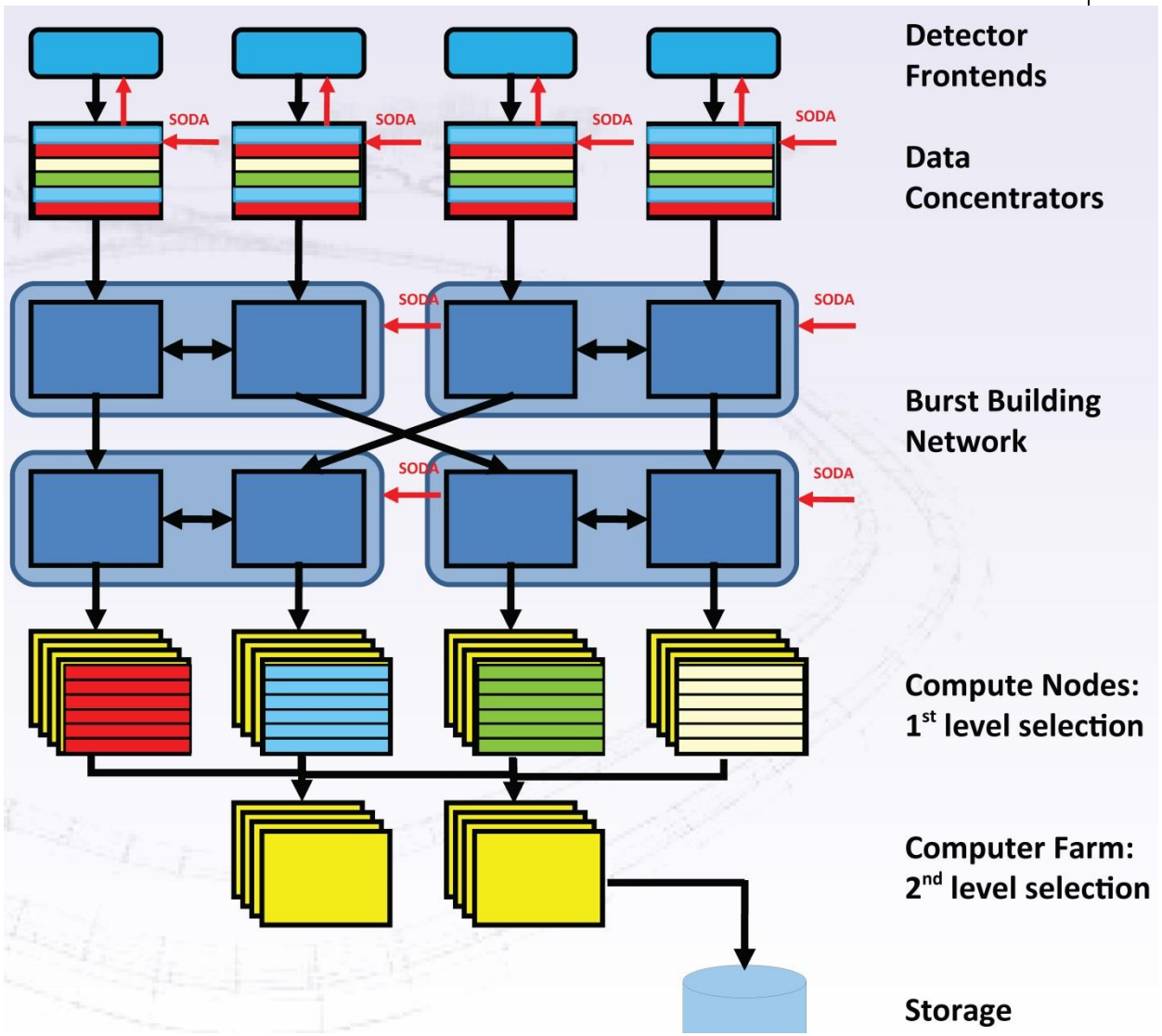
Data Aquisition

High interaction rate, wide physics objectives: triggerless DAQ

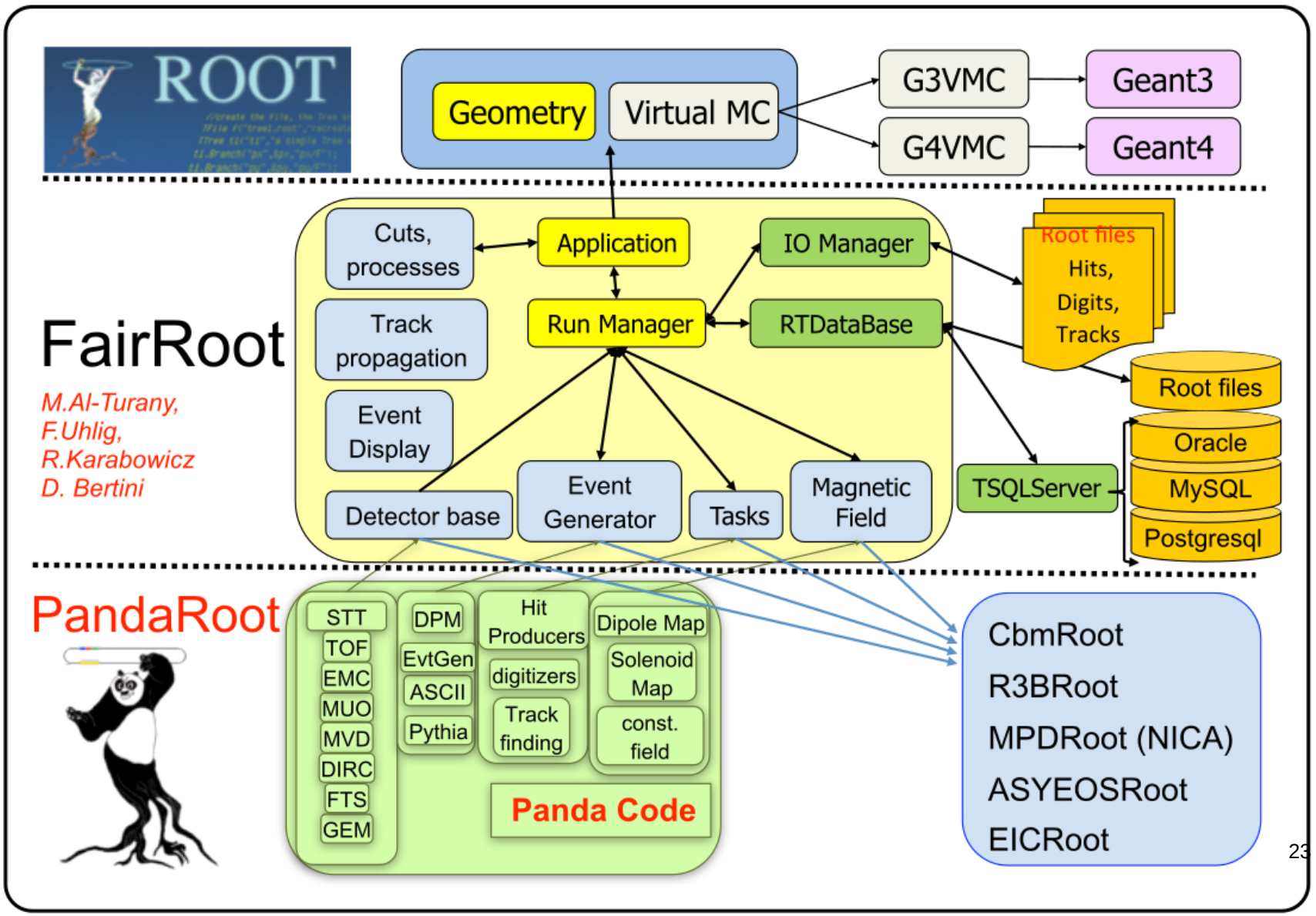
Time distribution: SODA

Time tag / hit

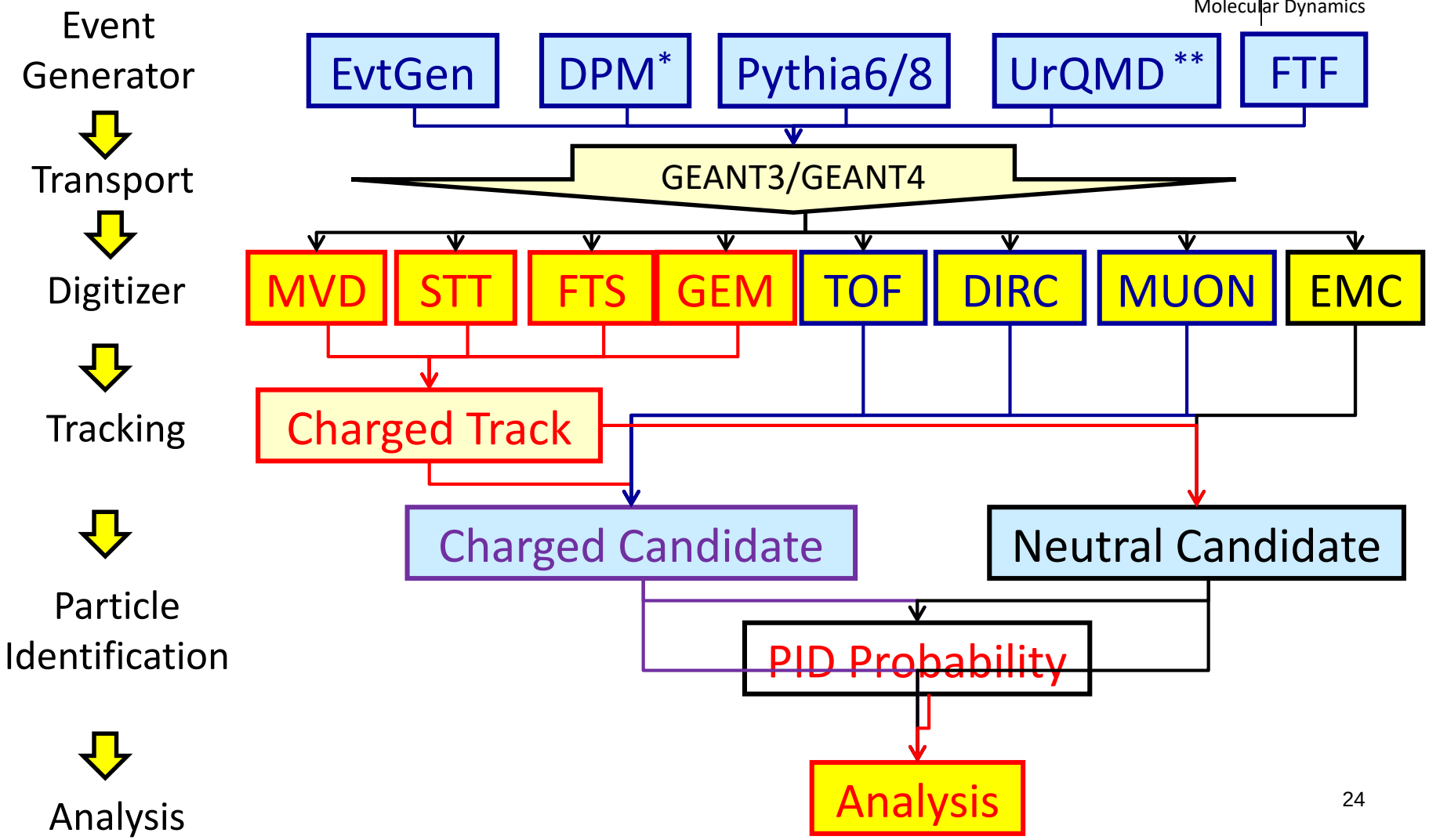
Selection after event building



Structure of Code

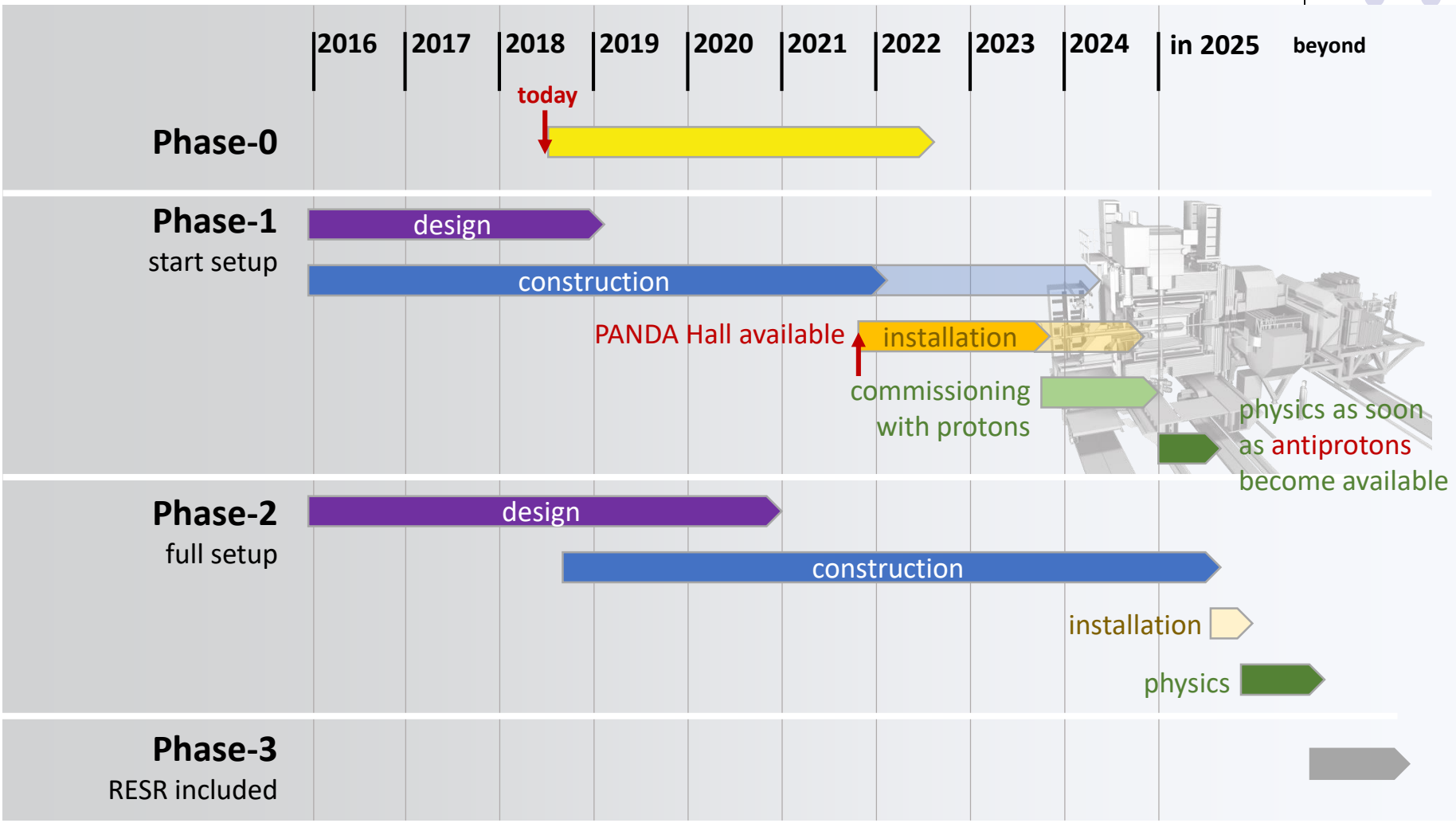


PANDA Data Flow



* Dual parton Model
** Ultra Relativistic Quantum Molecular Dynamics

PANDA Schedule



PANDA Phases

Phase 0

Currently PANDA detectors are being built.
They will be used in other excellent experiments until the experimental hall is available.

3 Experiments
Software-Development

Phase 1

First physics experiments with the PANDA start setup using antiprotons

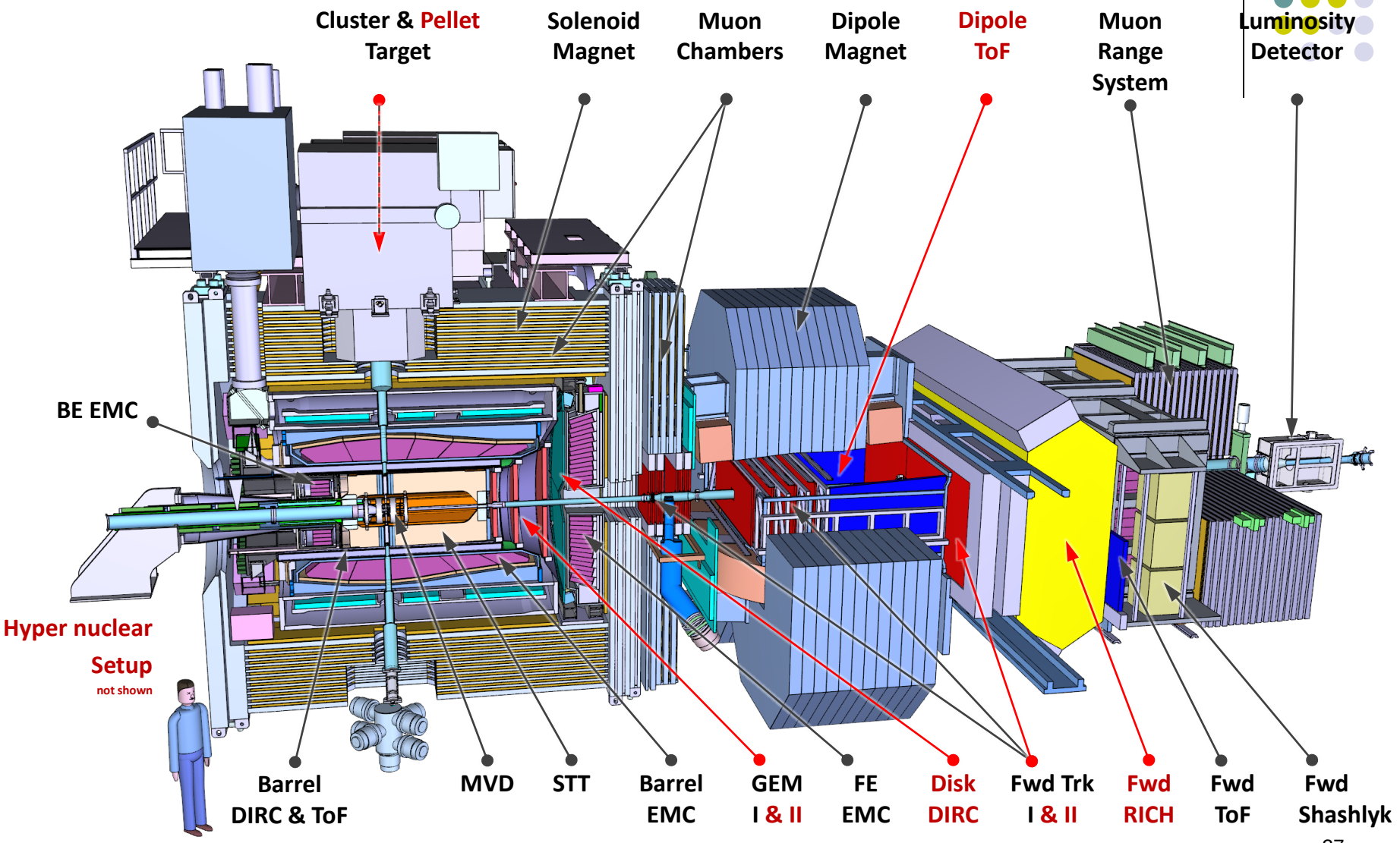
Phase 2

Experiments using the full setup

Phase 3

Experiments beyond MSV (needs RESR)

Start / Full Setup (Phase 1 & 2)



Summary

- The civil construction advances well, and HESR is also well in time line
- Installation window will be in 2022
- Detector design of PANDA experiment is presented
- The full setup of PANDA covers the broadest physics case in hadron physics.

Thank you for your attention!