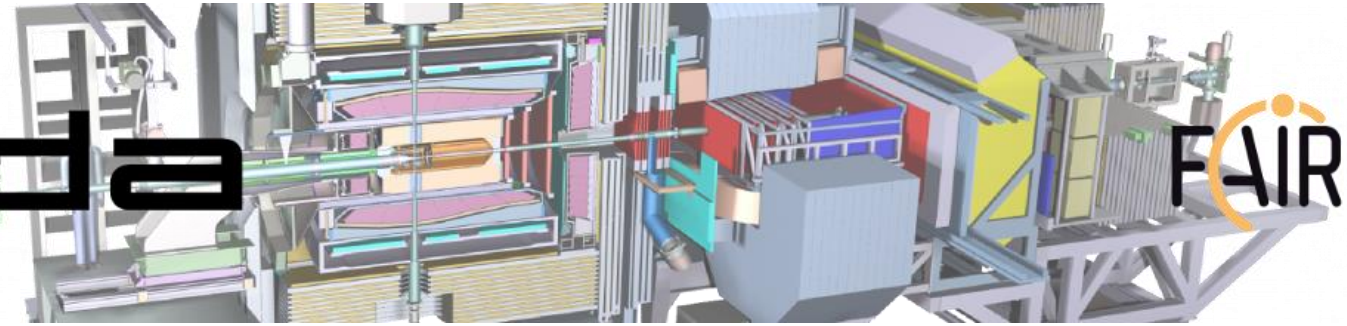
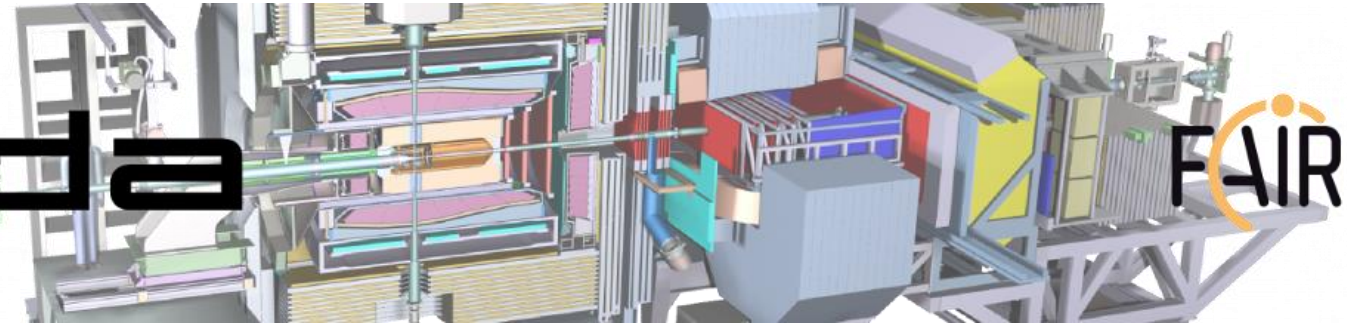


PANDA Detector at FAIR Status and Challenges

Anastasios Belias
GSI Helmholtzzentrum für Schwerionenforschung GmbH

The 6th International Workshop on Future Tau Charm Facilities
Guangzhou, China – November 17-21, 2024



PANDA Detector at FAIR
Status and Challenges

Antiprotons at FAIR

PANDA Detectors

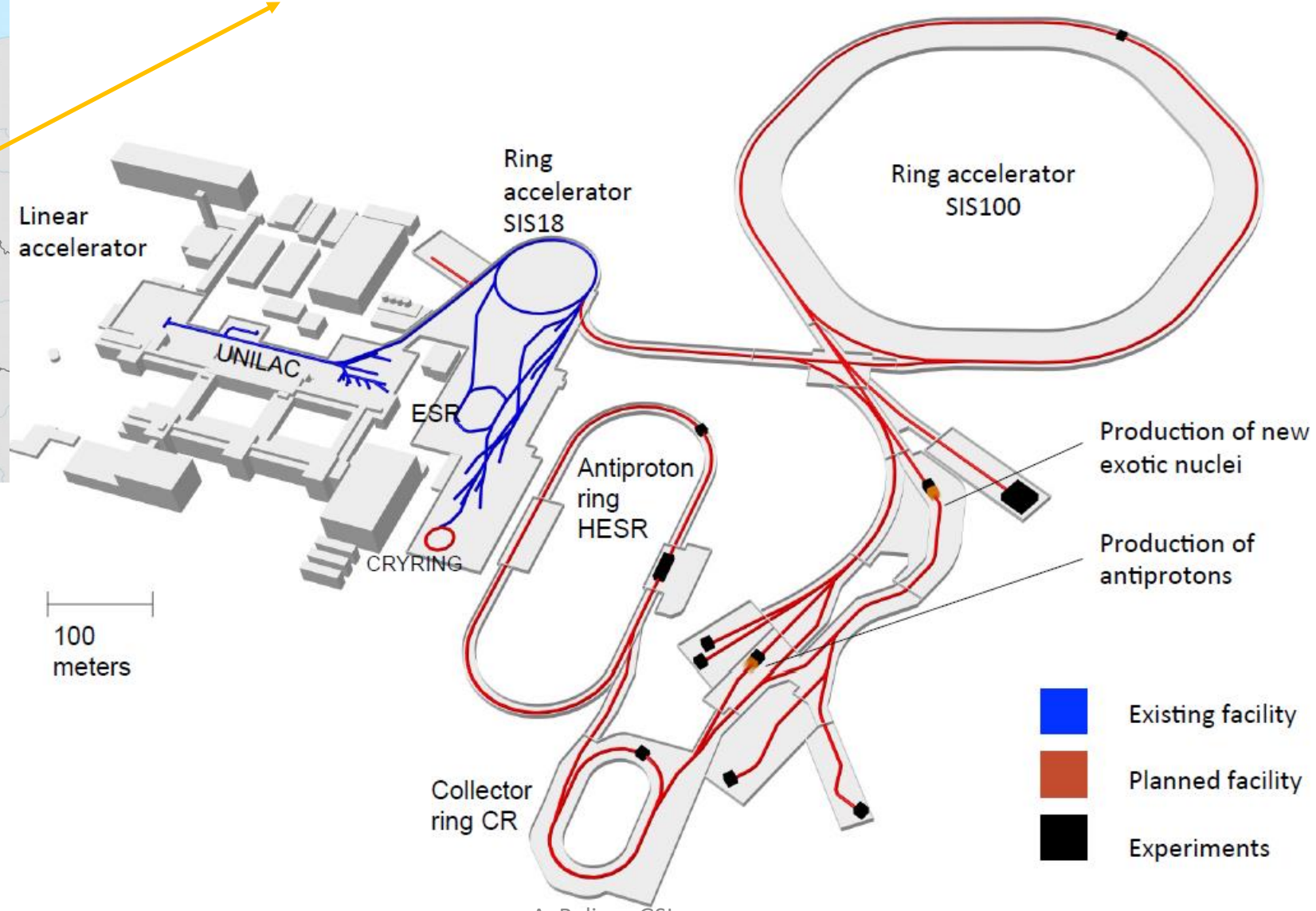
Targets
Magnets
Particle Tracking
Calorimetry
Particle Identification
DAQ & Detector Control

Status and Challenges

Outlook

Facility for Antiproton and Ion Research

@ GSI, near Darmstadt, Germany



FAIR – The Facility

FAIR

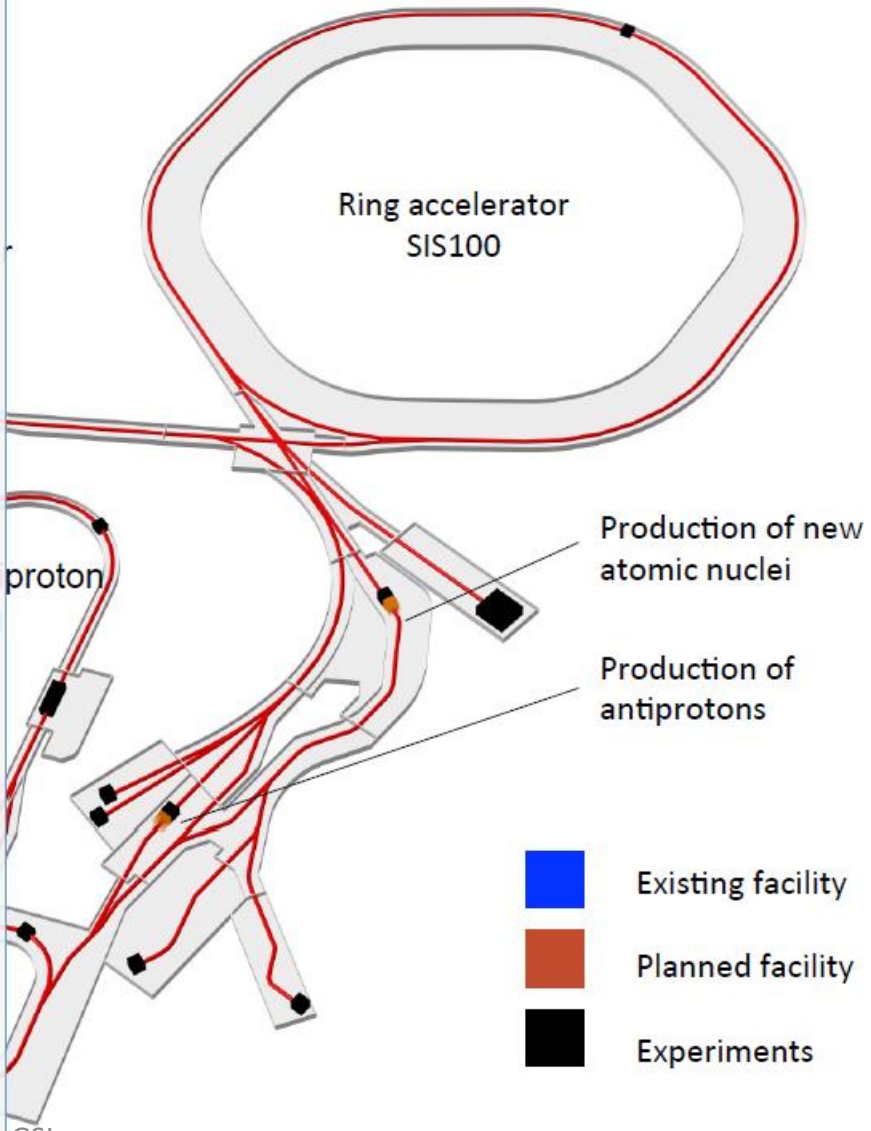
... accelerates particle beams from (anti)protons up to uranium ions with

- very high intensities
  - up to a factor of ~100 increase for primary Uranium beams (~ 5 x 10^{11} U^{28+} ions /s),
  - up to a factor of ~10.000 increase for secondary rare isotope beams
- high pulse power (up to ~ 50 kJ / 50 ns)
- suite of storage cooler rings equipped with stochastic and electron cooling for brilliant beam quality

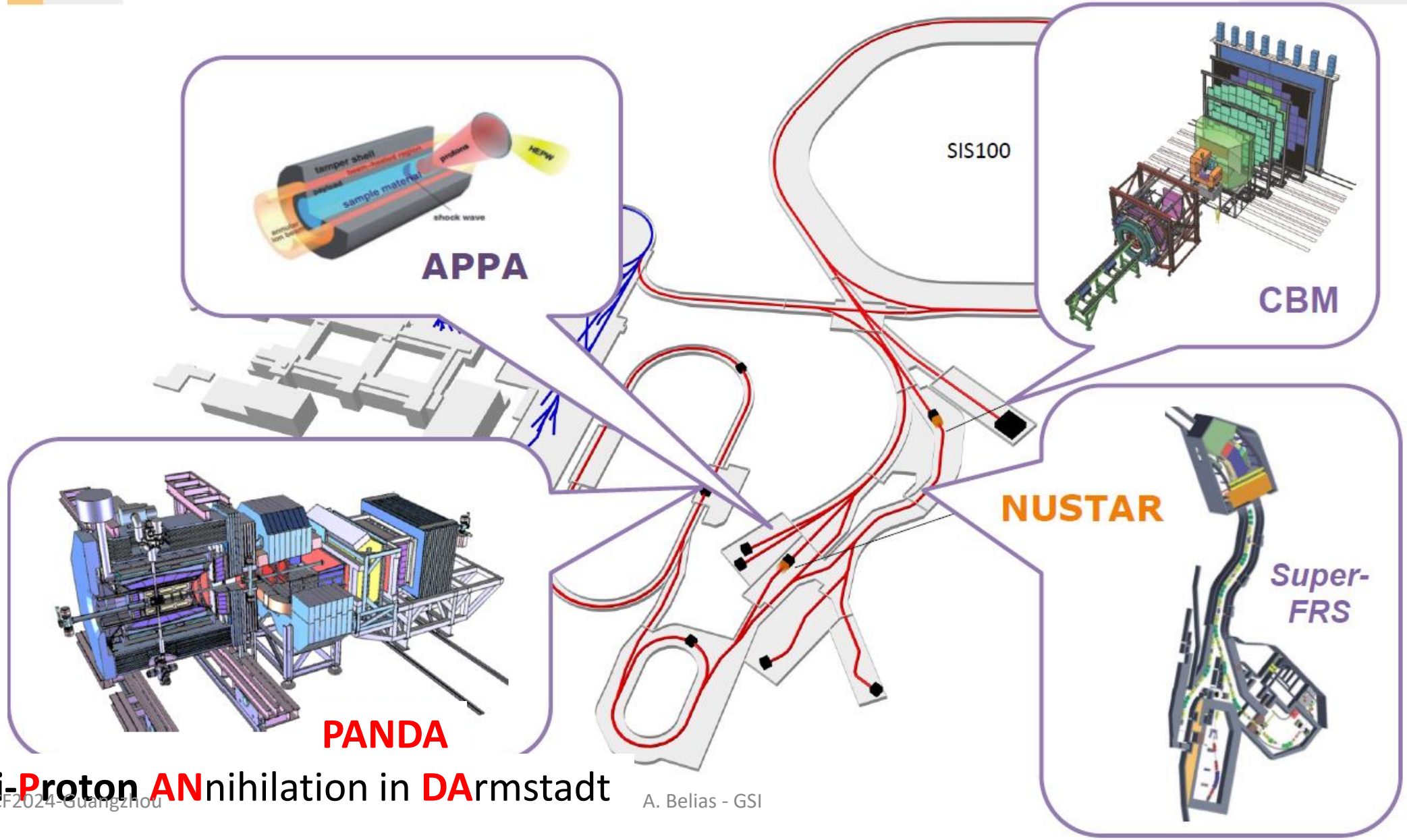
... develops and exploits innovative particle separation and detection methods, as well as novel computing techniques

... to perform forefront experiments towards the production and investigation of

New Extreme States of Matter.

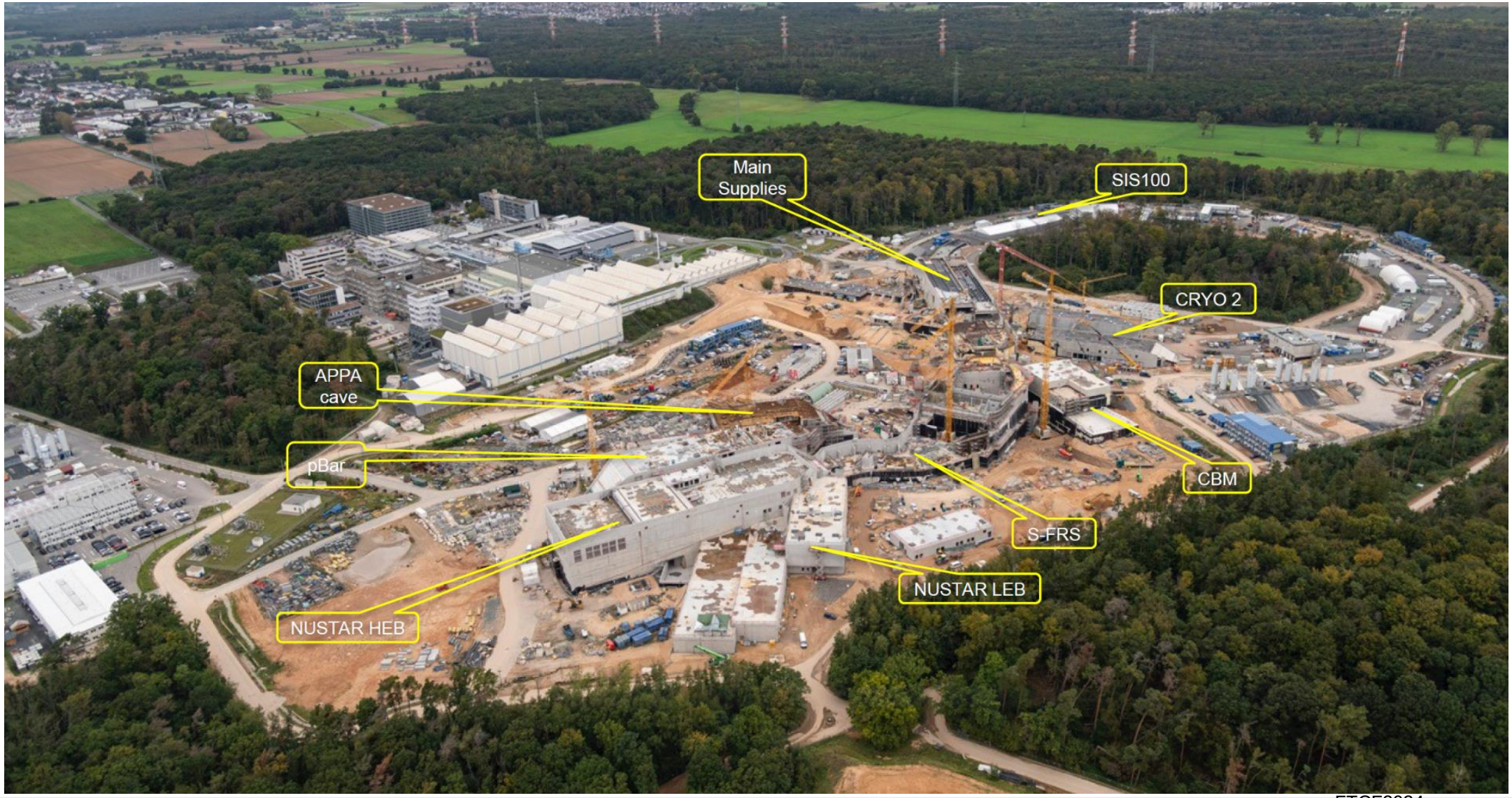


FAIR – four research pillars



anti-Proton ANnihilation in DArmstadt

FAIR - Construction update



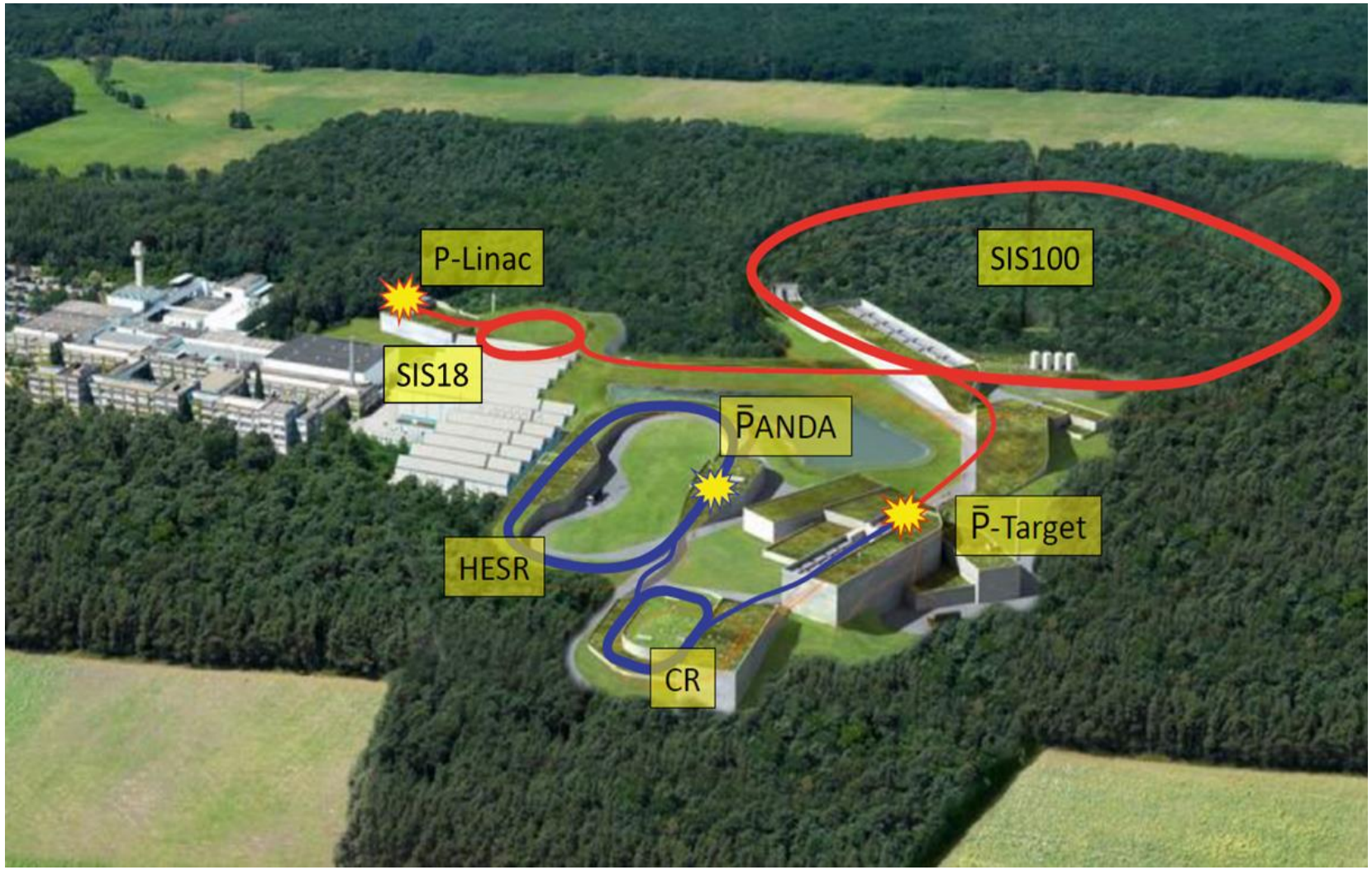
Antiprotons at FAIR

Antiproton production

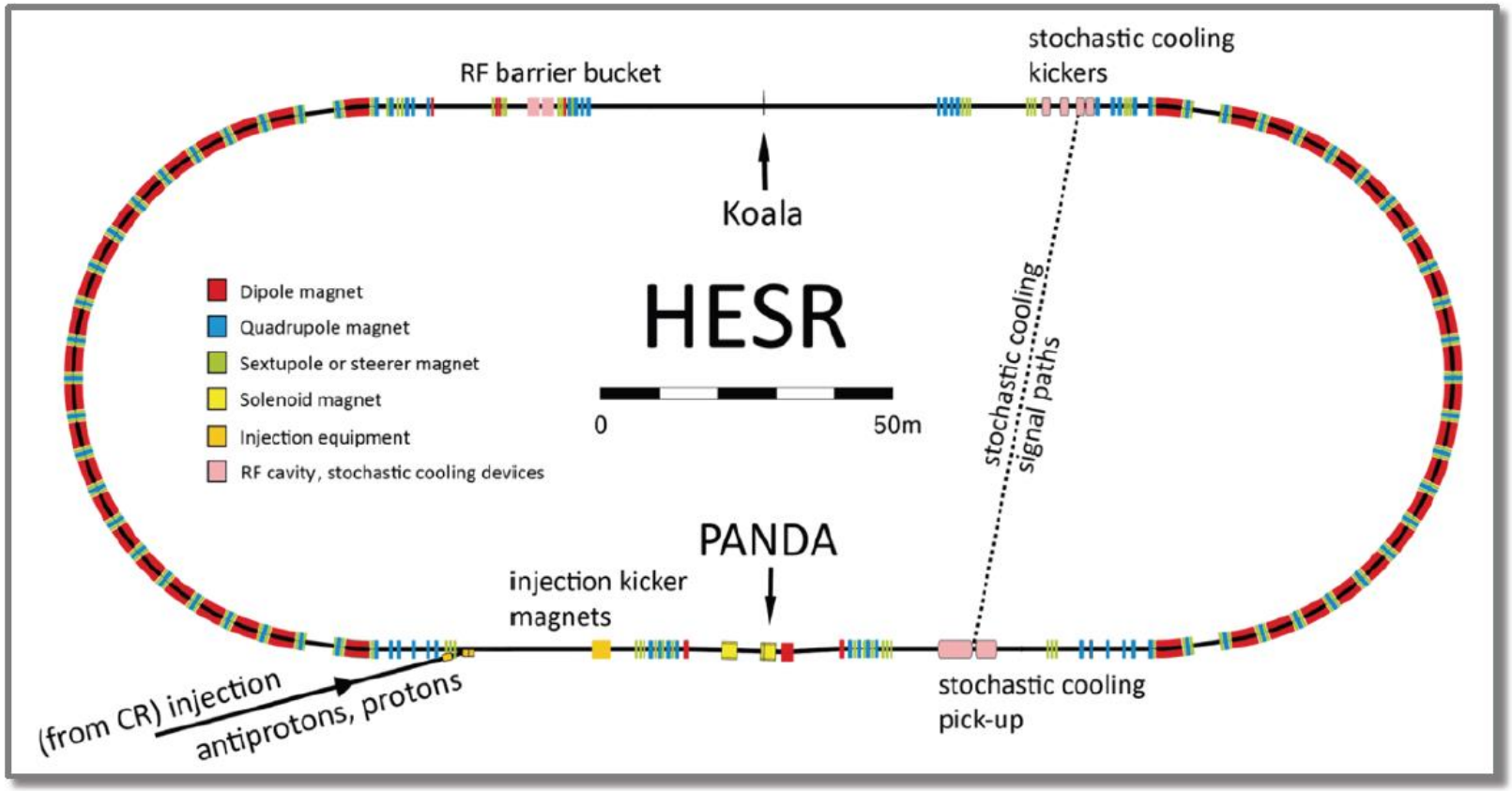
- Proton Linac *(70 MeV)*
- Accelerate p in SIS18/100 *(4/29 GeV)*
- Produce p̄ on Ni/Cu target *(3 GeV)*
- Collection in CR, fast cooling
- Accumulation in HESR
- PANDA luminosity ≤ $2x10^{31}cm^{-2}s^{-1}$
- p̄ momentum: 1.5 – 15 GeV/c
- Fixed target: cluster jet/pellet

- Full FAIR version

Accumulation in RESR, slow cooling
Storage in HESR
PANDA luminosity ≤ $2x10^{32}cm^{-2}s^{-1}$



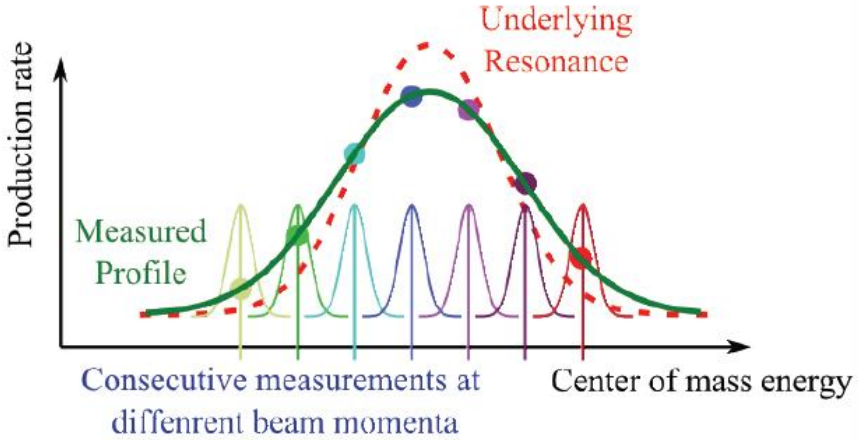
HESR - High Energy Storage Ring



Circumference	575 m
Momentum	1.5 – 15 GeV/c

Stochastic cooling
over full momentum range
$\longrightarrow \Delta E \approx 50$ keV

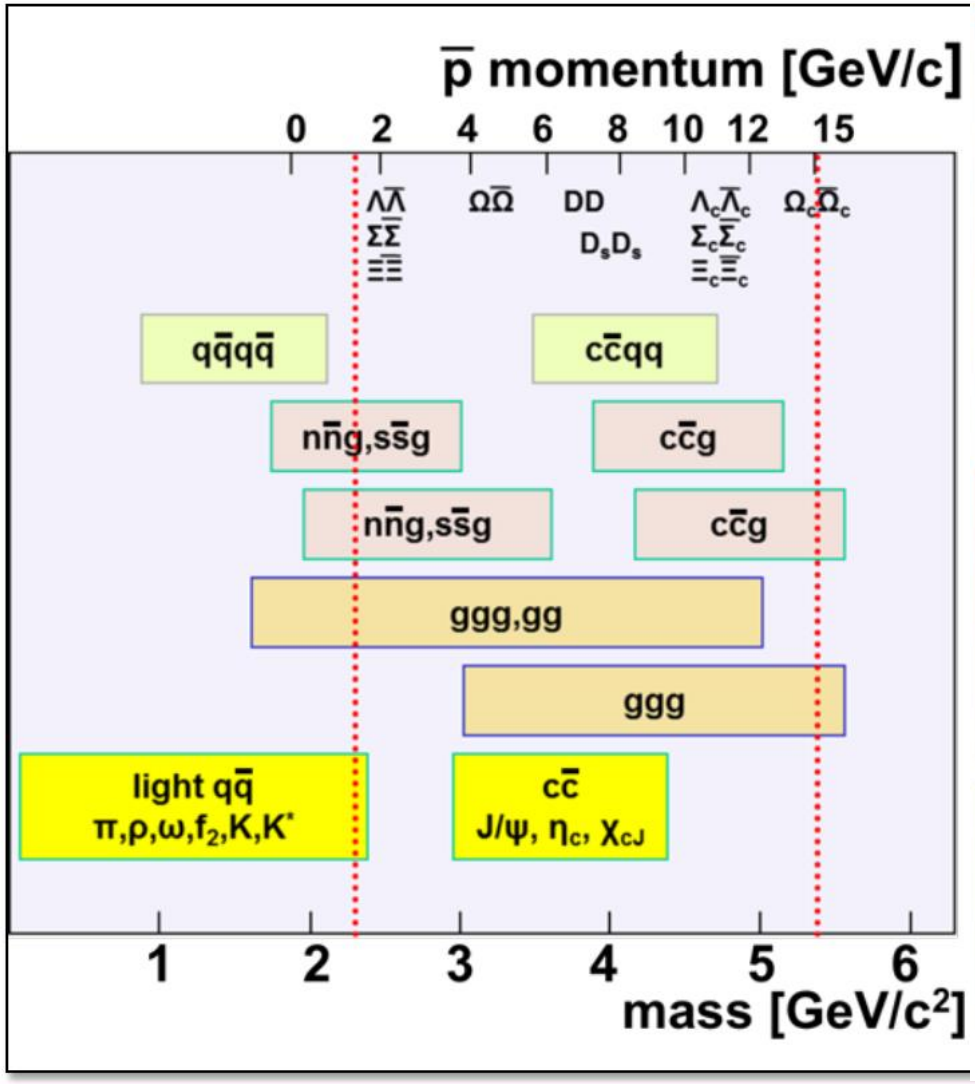
Production experiments
with high-precision beam energy



Mode	High luminosity (HL)	High resolution (HR)
$\Delta p/p$	$\sim 10^{-4}$	$\sim 4\times10^{-5}$
L ($cm^{-2}s^{-1}$)	2×10^{32}	2×10^{31}
Stored $\bar{p}$	10^{11}	10^{10}

PANDA Physics Objectives

Antiprotons – Unique Probes for Discoveries and Precision Physics



Hadron Spectroscopy

Experimental Goals: *mass, width & quantum numbers J^{PC} of resonances*

Charm Hadrons: *charmonia, D-mesons, charm baryons*

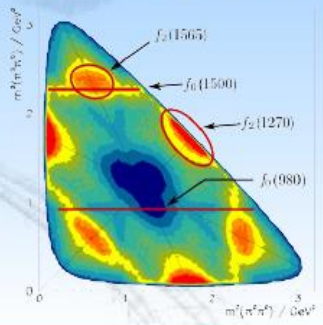
➔ Understand new XYZ states, $D_s(2317)$ and others

Exotic QCD States: *glueballs, hybrids, multi-quarks*

Spectroscopy with Antiprotons:

Production of states of all quantum numbers

Resonance scanning with high resolution



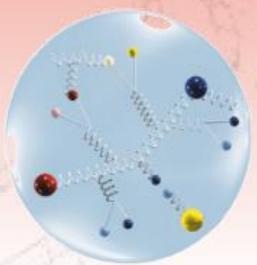
Hadron Structure

Time-like Nucleon Formfactors

➔ Measurable in annihilation, discrepancy with space-like

Generalized Parton Distributions

Drell-Yan Process

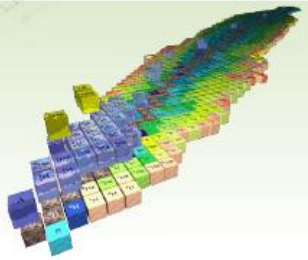


Nuclear Physics

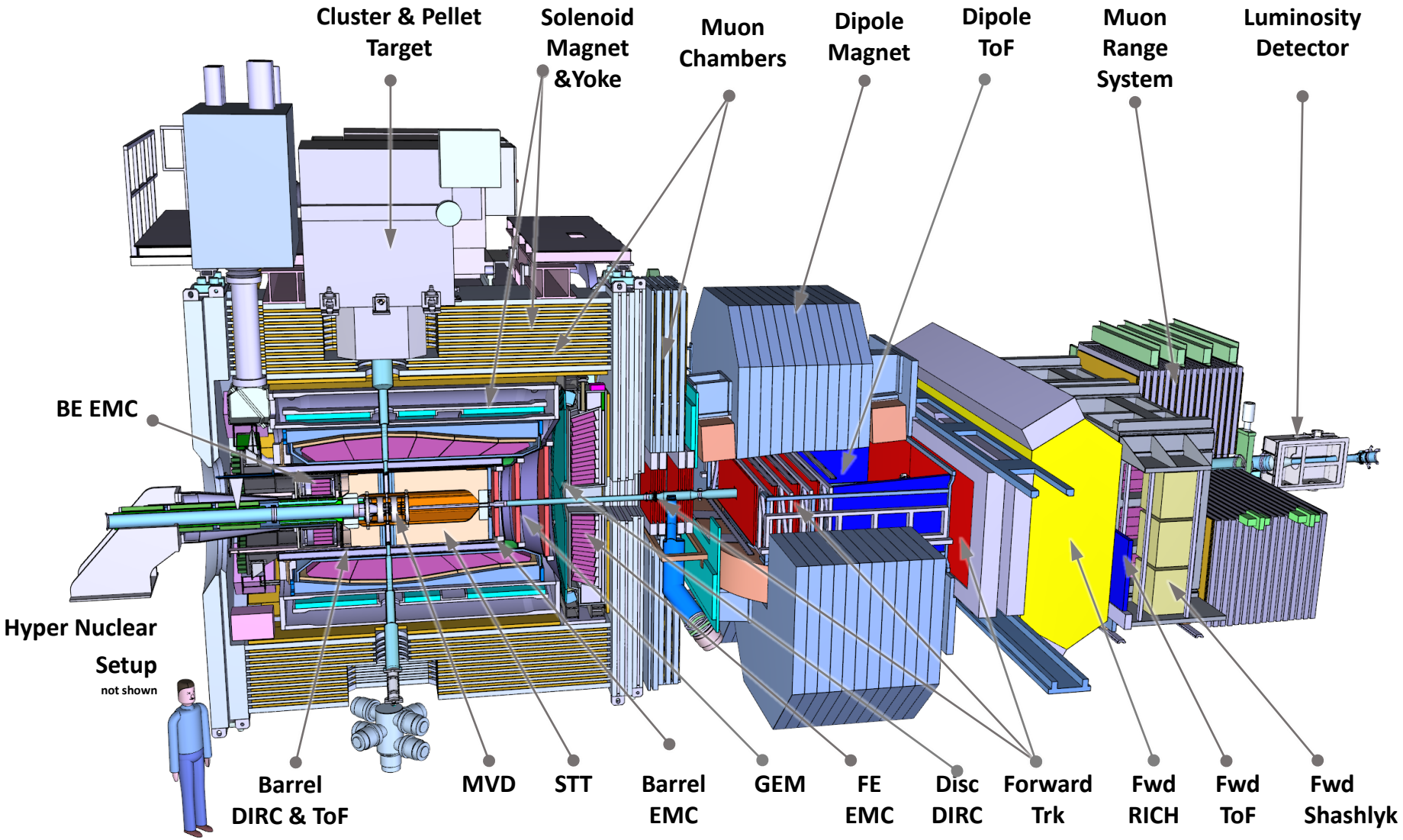
Hypernuclei: Production of double Λ-hypernuclei

➔ γ-spectroscopy of hypernuclei, YY interaction

Hadrons in Nuclear Medium

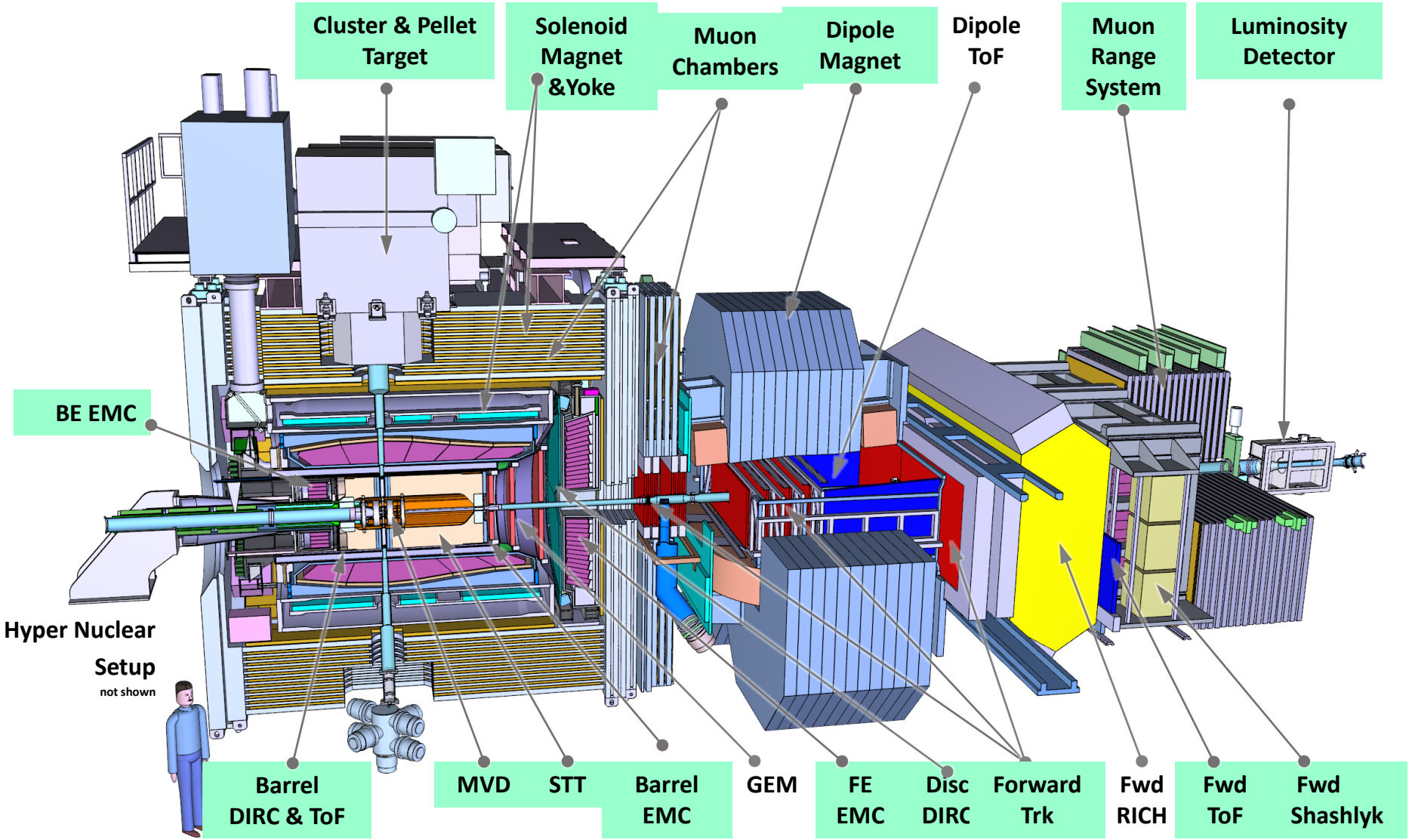


PANDA Detectors

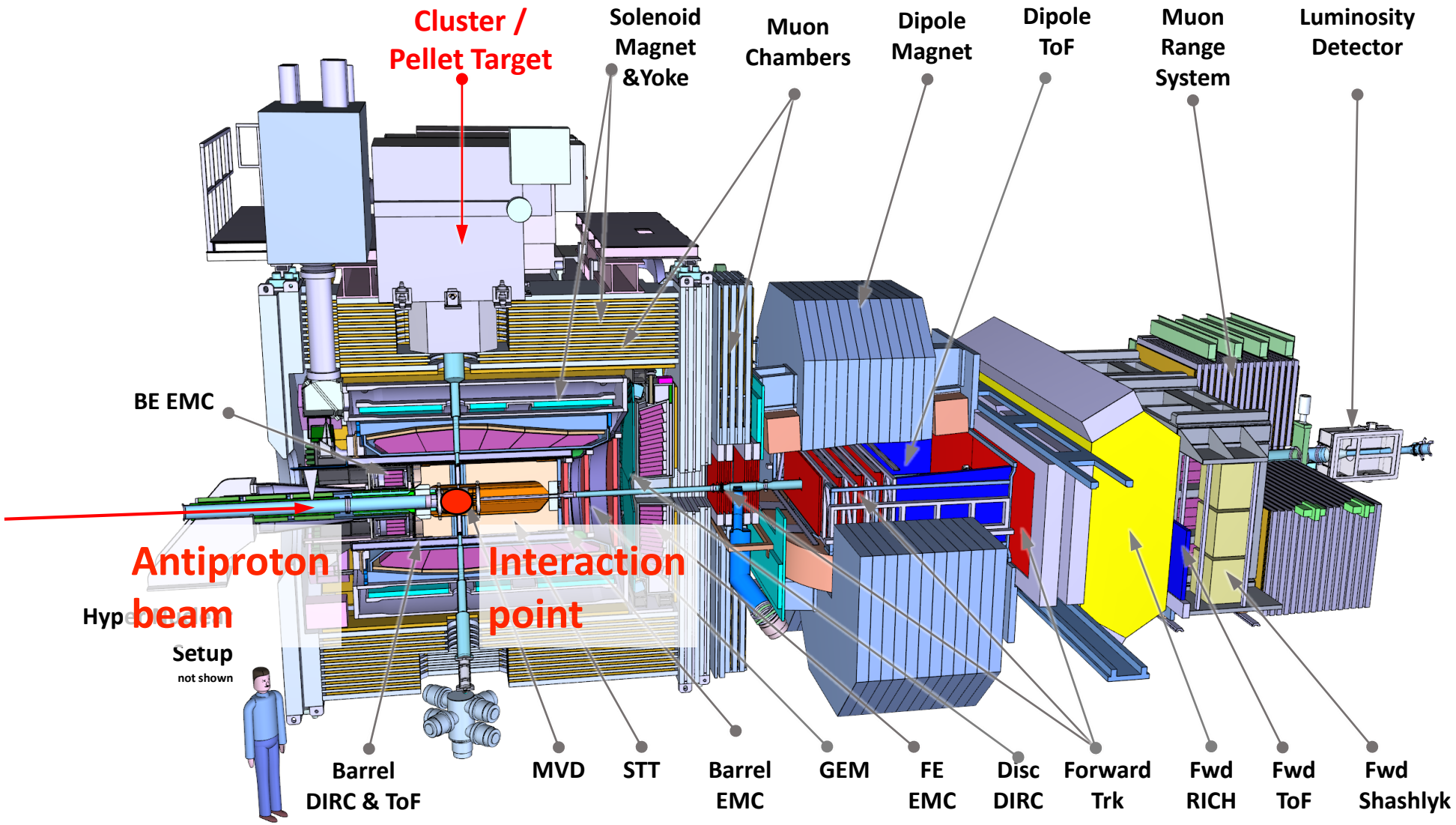


PANDA Detectors

Technical **D**esign **R**eports approved by experts review



PANDA Detectors



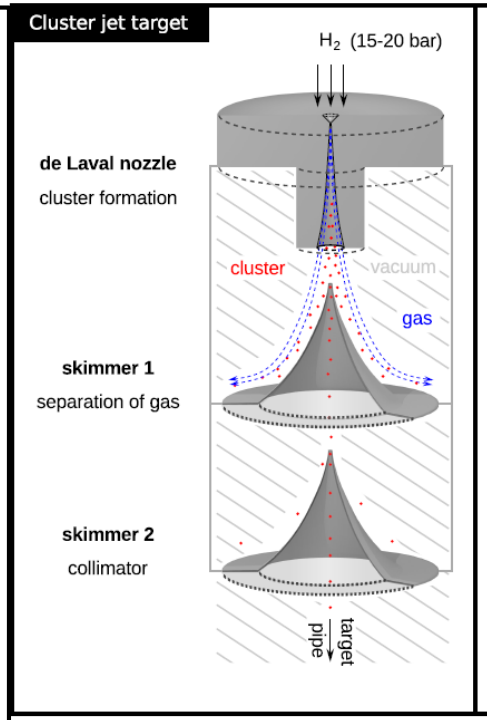
PANDA Targets

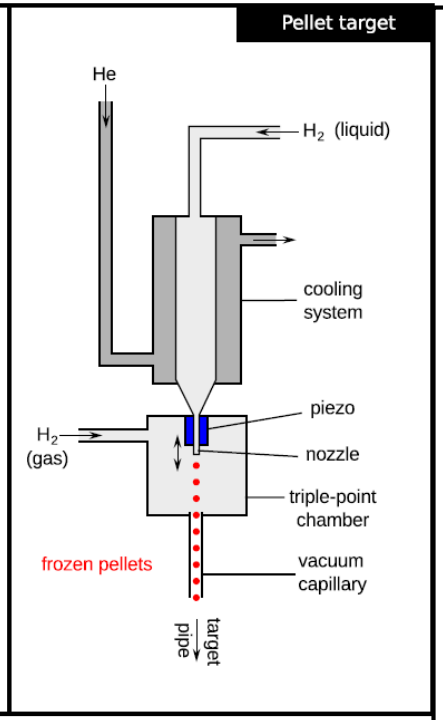
Cluster Jet Target

- Expansion of pre-cooled and compressed hydrogen gas into beam pipe
- Cluster jets move with supersonic speed during condensation
- Size: 10^3-10^5atoms/cluster

Project status:

- TDR approved
- Continuous development
- Nozzle improvement
- Better alignment by control device tilting
- Goal: $4 \times 10^{15} cm^{-2}$ target density already achieved
- Continuous improvements





Pellet Target

- Small droplets of frozen hydrogen created in triple point chamber
- Pellet diameter: 10 – 30 µm
- Vertical injection into target tube
- Falling speed: ~60 m/s
- Flow rate: 100,000 pellets/s
- $> 4 \times 10^{15} cm^{-2}$ feasible

Project status:

- TDR approved &Prototype in progress

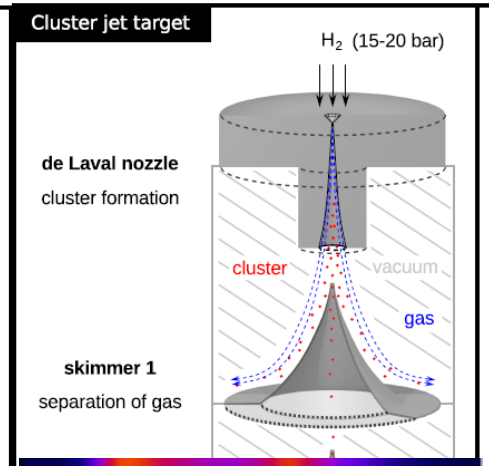
Project freeze!

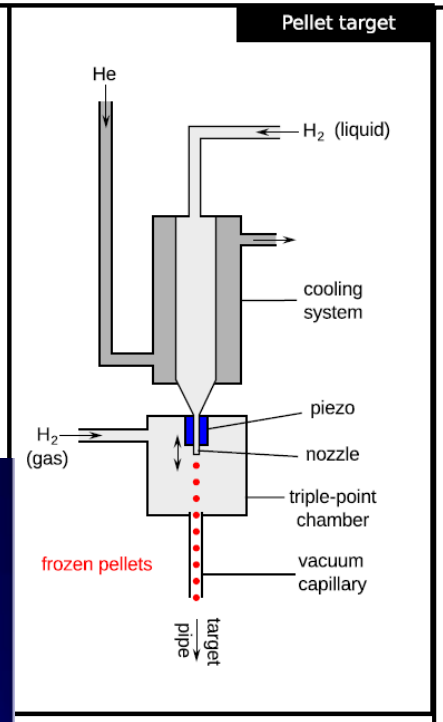
- Some developments by other group

PANDA Targets

Cluster Jet Target

- Expansion of pre-cooled and compressed hydrogen gas into beam pipe
- Cluster jets move with supersonic speed during condensation
- Size: 10^3-10^5atoms/cluster





Pellet Target

- Small droplets of frozen hydrogen created in triple point chamber
- Pellet diameter: 10 – 30 µm
- Vertical injection into target tube
- Falling speed: ≈60 m/s

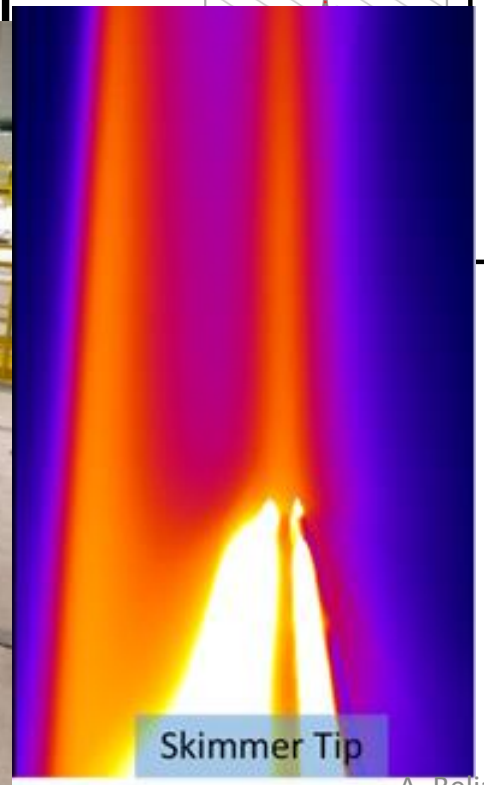
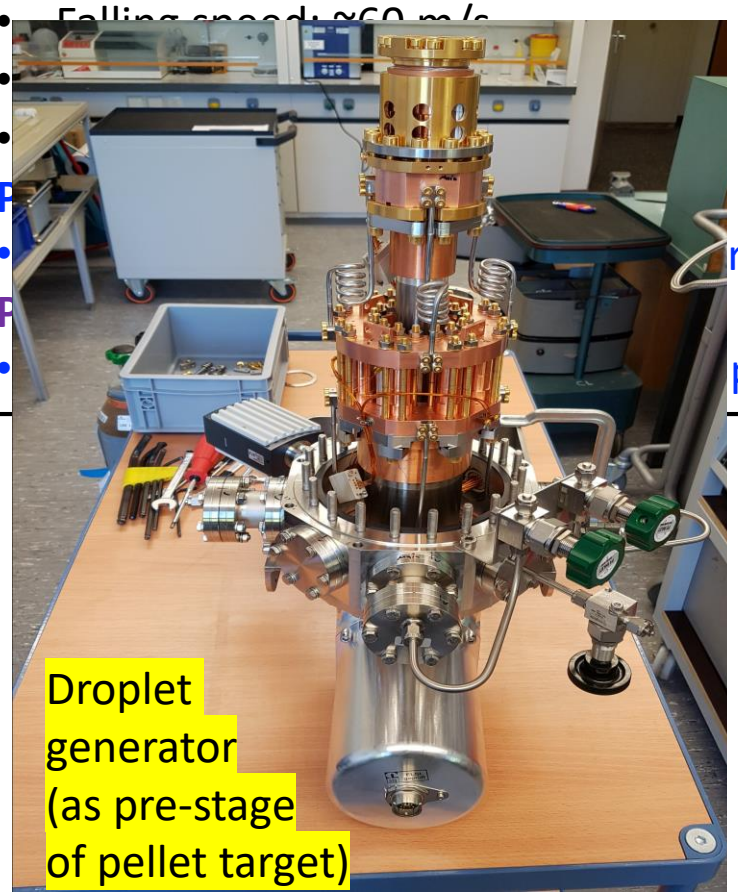
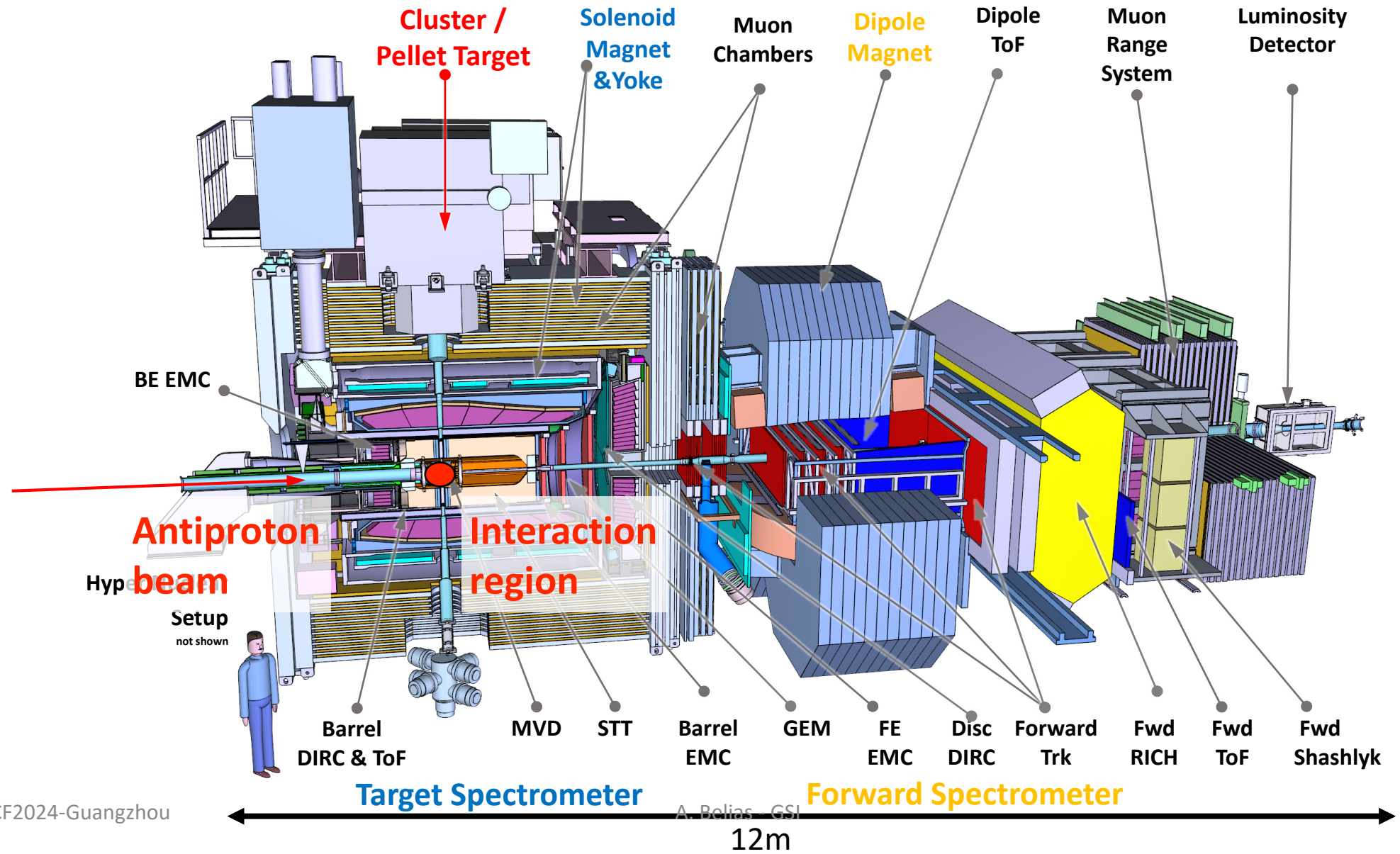


Photo of the cluster-jet beam (false colour). Visible are the two highly intense core beams.



PANDA Detectors



PANDA - Magnets

Solenoid Magnet

- Super conducting coil, 2 T central field (B_z)
- Segmented coil for target
- Instrumented iron yoke – muon chambers
- Doors laminated, instrumented, retractable

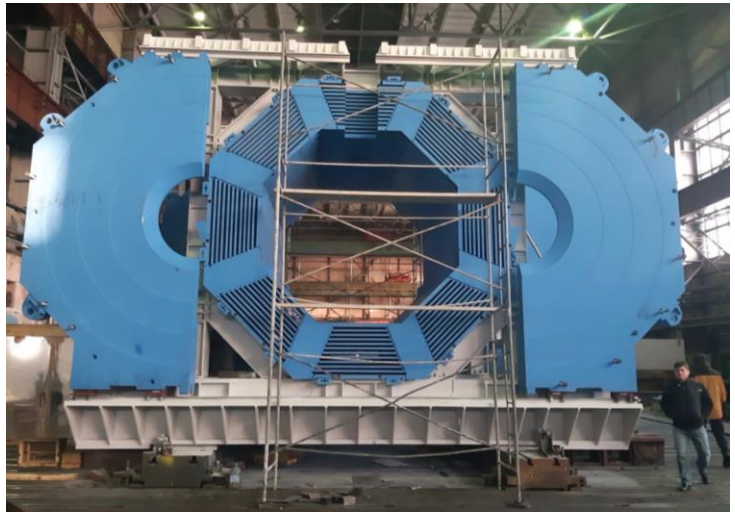
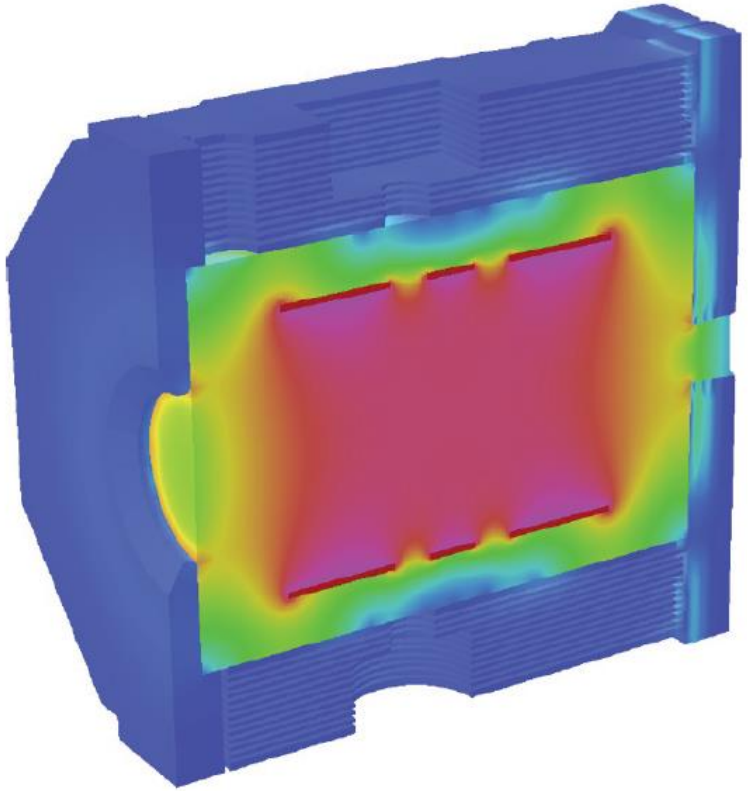


Photo : PANDA Yoke manufactured at BINP, BINP 2021.



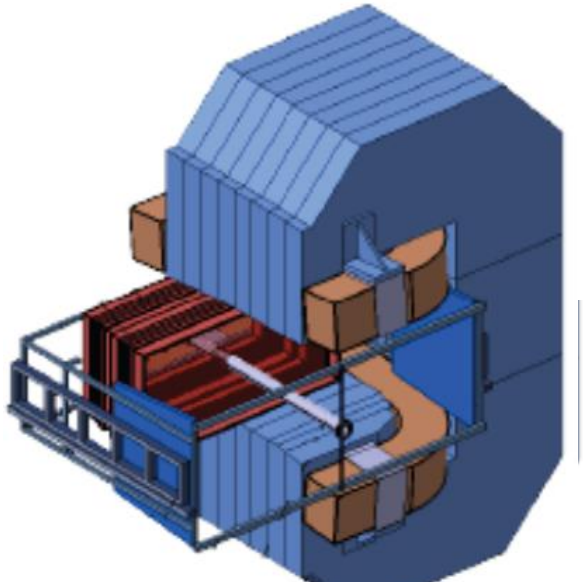
Inner bore: ∅ 1.9 m /L: 2.7 m

Outer yoke: ∅ 2.3 m /L: 4.9 m

Total weight: 300 t

Dipole Magnet

- Normal conducting racetrack design, 2 Tm
- Forward tracking detectors partly integrated
- Dipole also bends the beam
- HESR component



Vertical acceptance: ± 5°

Horizontal acceptance: ± 10°

Total weight: 200 t

PANDA - Magnets

Solenoid Magnet

- Super conducting coil, 2 T central field (B_z)
- Segmented coil for target
- Instrumented iron yoke – muon chambers
- Doors laminated, instrumented, retractable

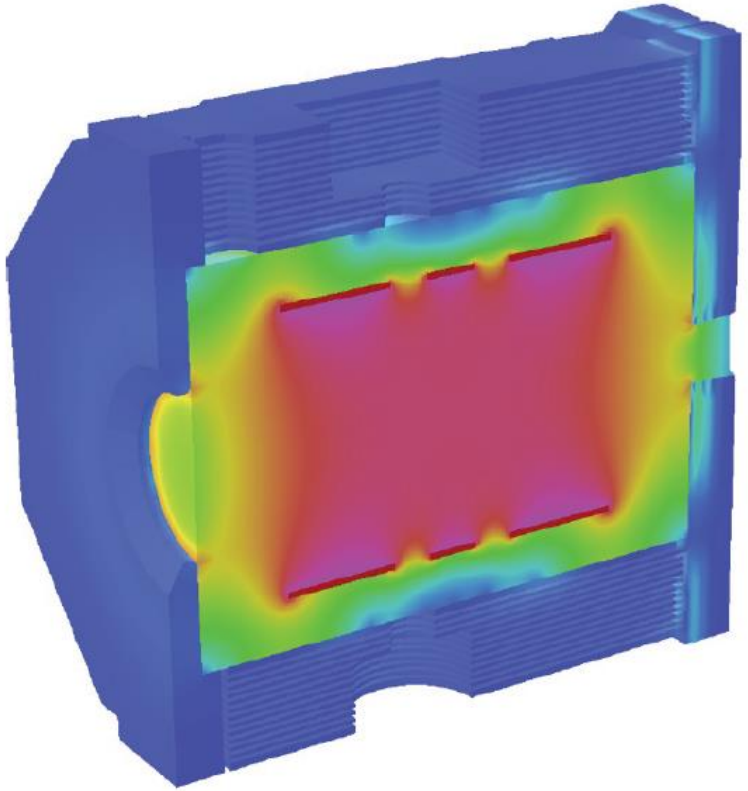
Project status:

- TDR approved
- Yoke build & SC cable prototype started

Project freeze!

Challenges:

- Review the use of other existing solenoids
- Impact studies
  - Different geometry parameters
- New magnet design considerations
  - SC cable – new production and QA
  - Yoke design & instrumentation



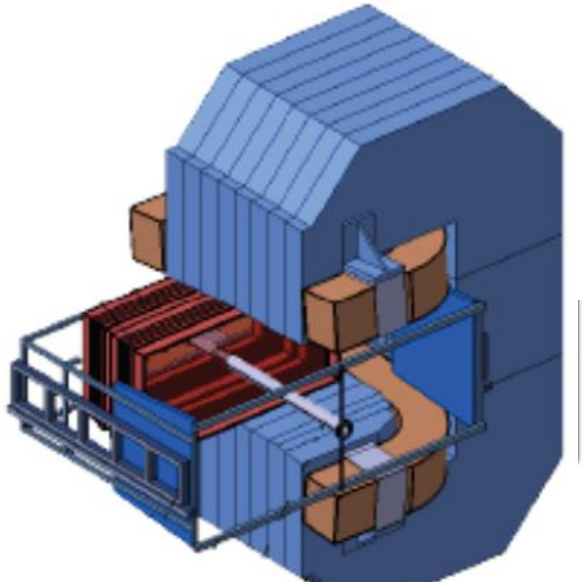
Inner bore: ∅ 1.9 m /L: 2.7 m

Outer yoke: ∅ 2.3 m /L: 4.9 m

Total weight: 300 t

Dipole

- Nor
- Forward tracking detectors partly integrated
- Dipole also bends the beam
- HESR component

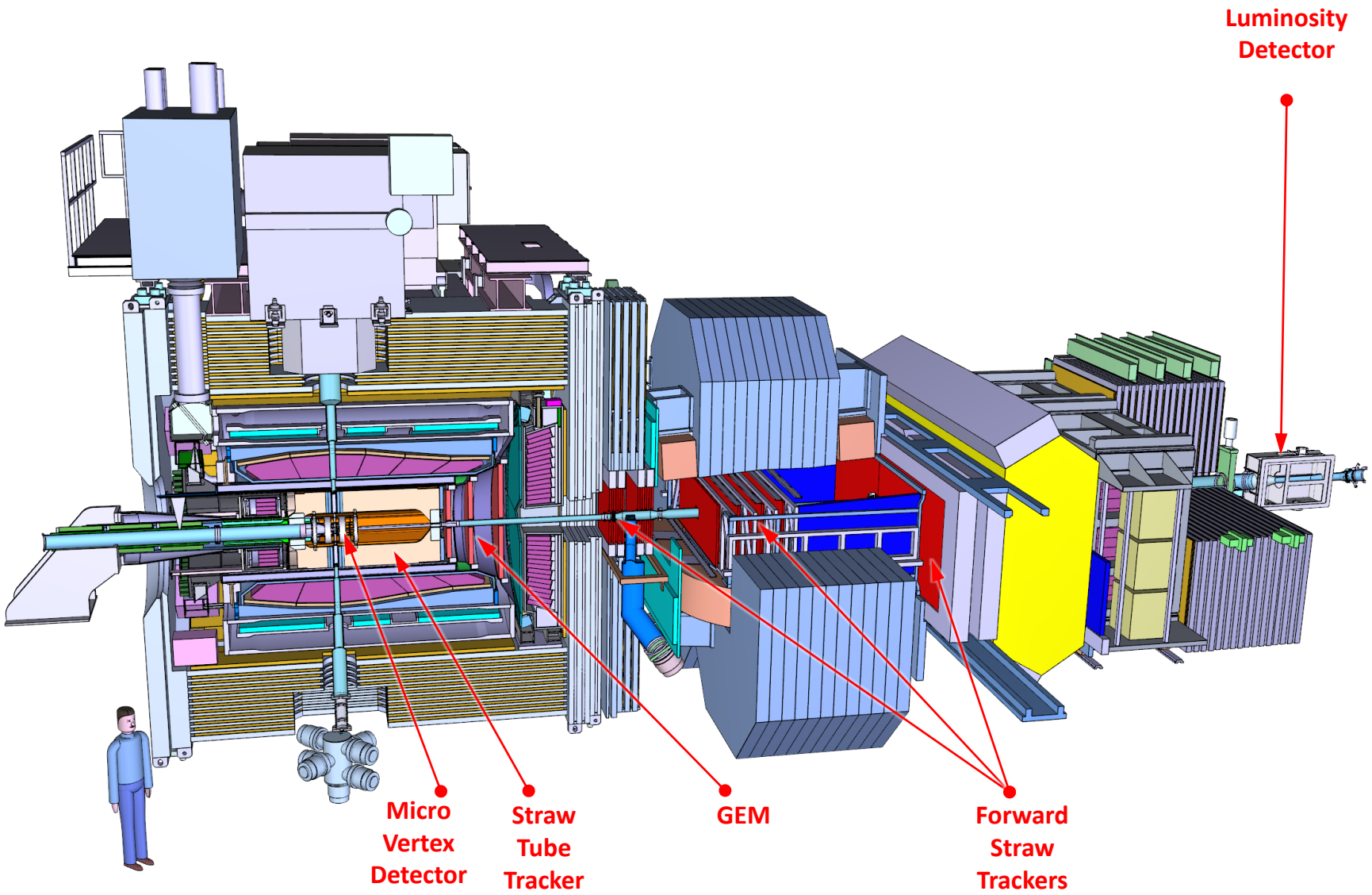


Vertical acceptance: ± 5°

Horizontal acceptance: ± 10°

Total weight: 200 t

PANDA Detectors - Particle Tracking



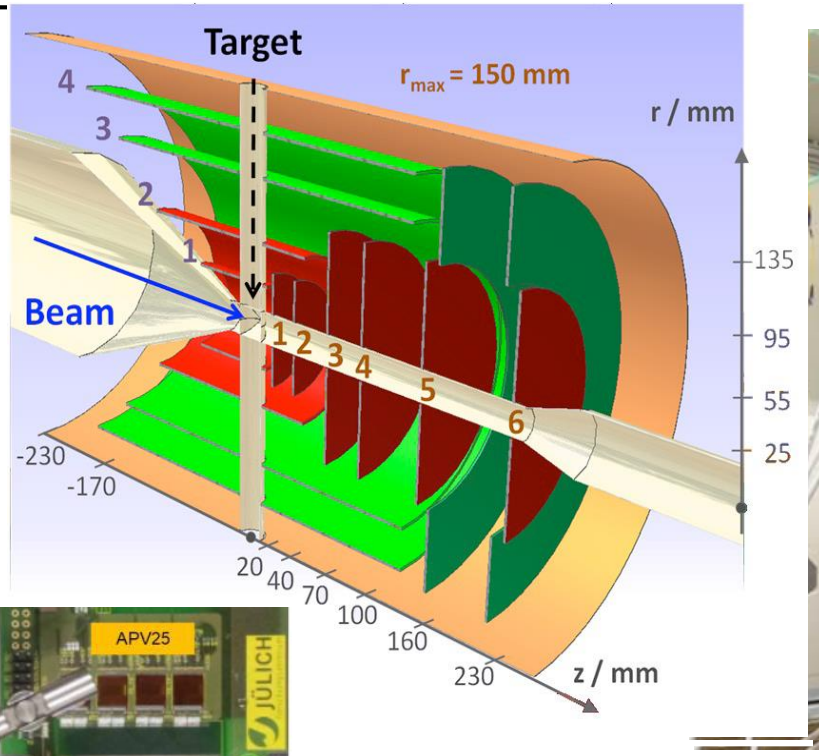
PANDA – Micro Vertex Detector

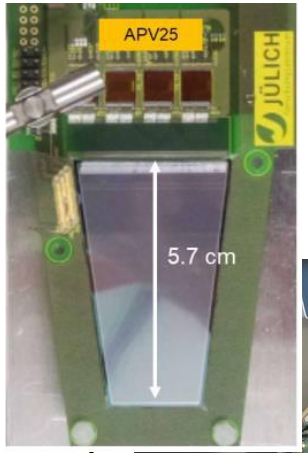
MVD Design

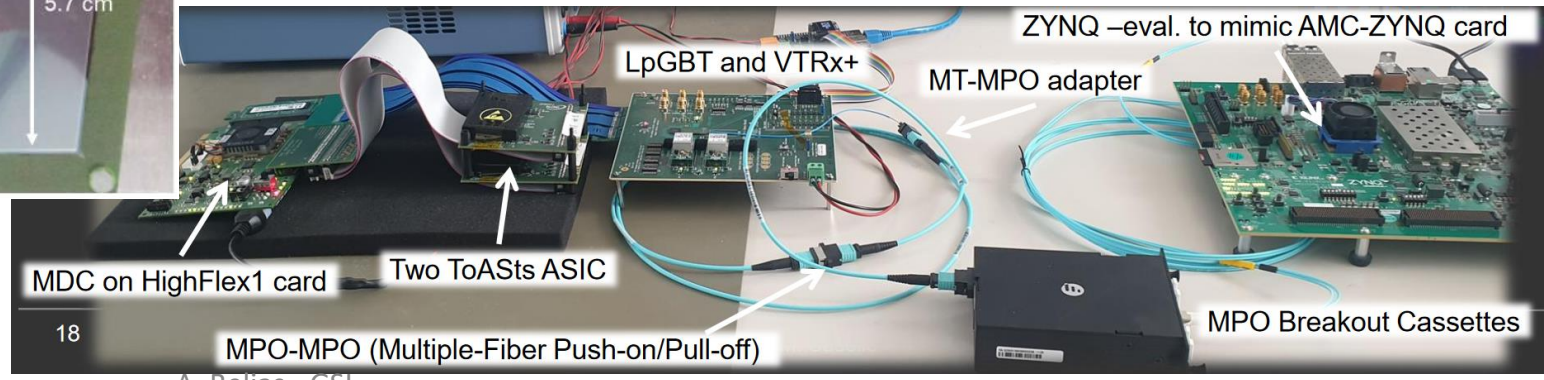
- Si-Pixels – inner layers
  - hybrid pixels with thinned sensors (100×100 µm^2) TDR design
  - ToPiX ASIC, 0.13 µm CMOS
- Si-Strips – outer layers
  - Rectangles and trapezoids
  - 130 (70) µm pitch 90 (15) stereo angle
  - ToASt ASIC, 110 nm CMOS
- 6 ns timing resolution
- 50 µm vertex resolution, $\delta p/p \sim 1\%$
- Low material budget X/Xo ≤ 1 % / layer
- Radiation tolerance < $10^{14} n_{1MeV\ eq}$ cm^{-2}
- Total Dose: 10 MRad
- Continuous readout 10^7 ch @160 MHz

Project status

- TDR approved
- Si-Strips ready, ASIC v2 progress
- Radiation hard links GBTx & DC/DC (CERN)
- Module Data Concentrator ASIC progress



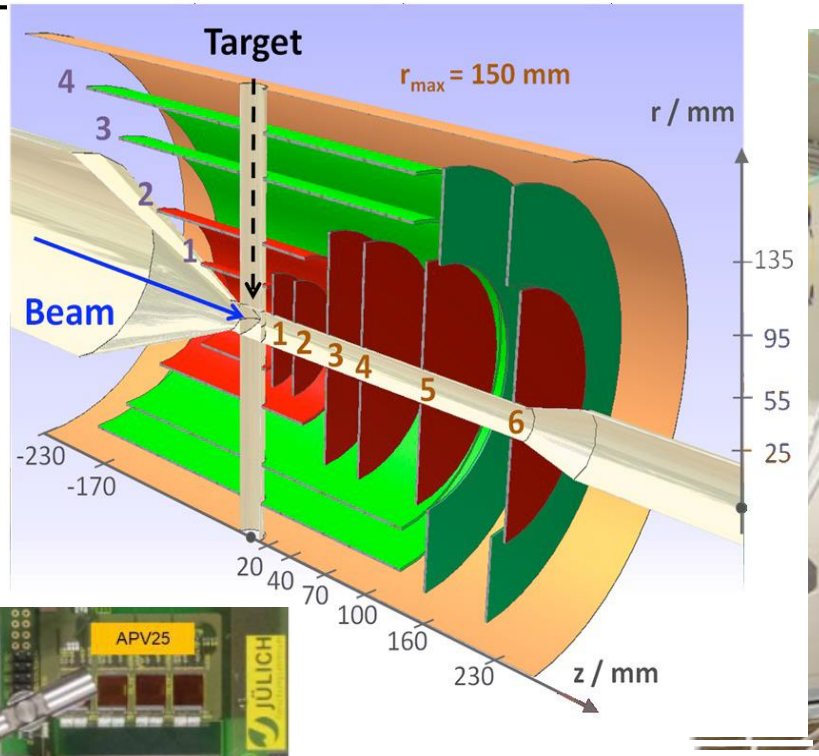


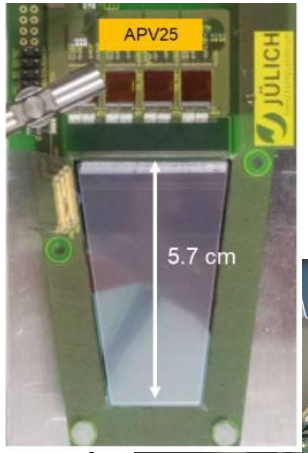


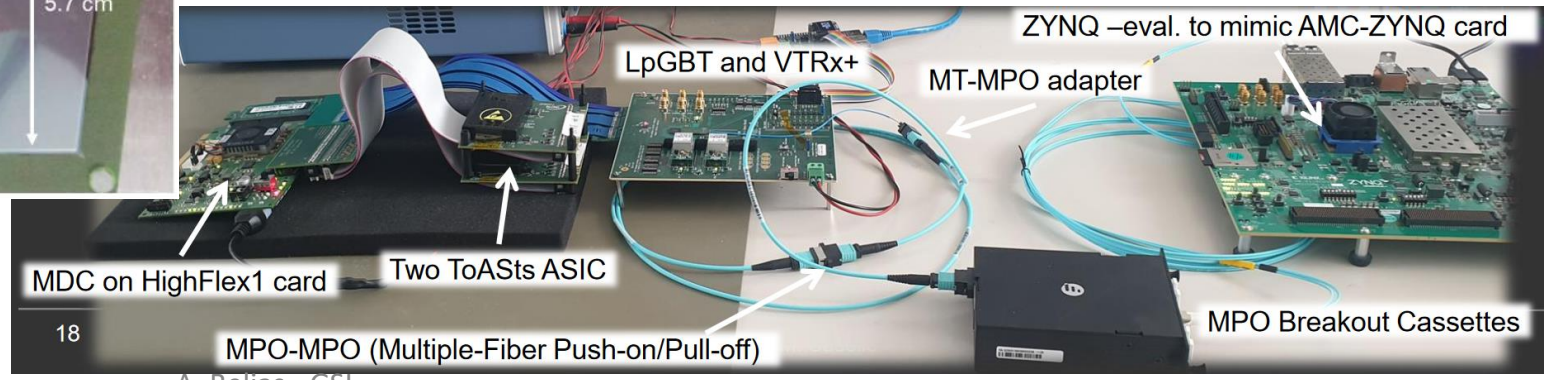
PANDA – Micro Vertex Detector

MVD Design

- **Challenges:**
  Revise Si-Pixels with new options:
  ALICE ITS / HV MAPS / MIMOSIS(CBM)
- Si-Strips – outer layers
  - Rectangles and trapezoids
  - 130 (70) µm pitch 90 (15) stereo angle
  - ToASt ASIC, 110 nm CMOS
- 6 ns timing resolution
- 50 µm vertex resolution, δp/p~1%
- Low material budget X/Xo ≤ 1 % / layer
- Radiation tolerance < $10^{14} n_{1MeV\ eq}\ cm^{-2}$
- Total Dose: 10 MRad
- Continuous readout 10^7 ch @160 MHz







Project status

- TDR approved
- Si-Strips ready, ASIC v2 progress
- Radiation hard links GBTx & DC/DC (CERN)
- Module Data Concentrator ASIC progress

PANDA - Straw Trackers

Central Tracker STT

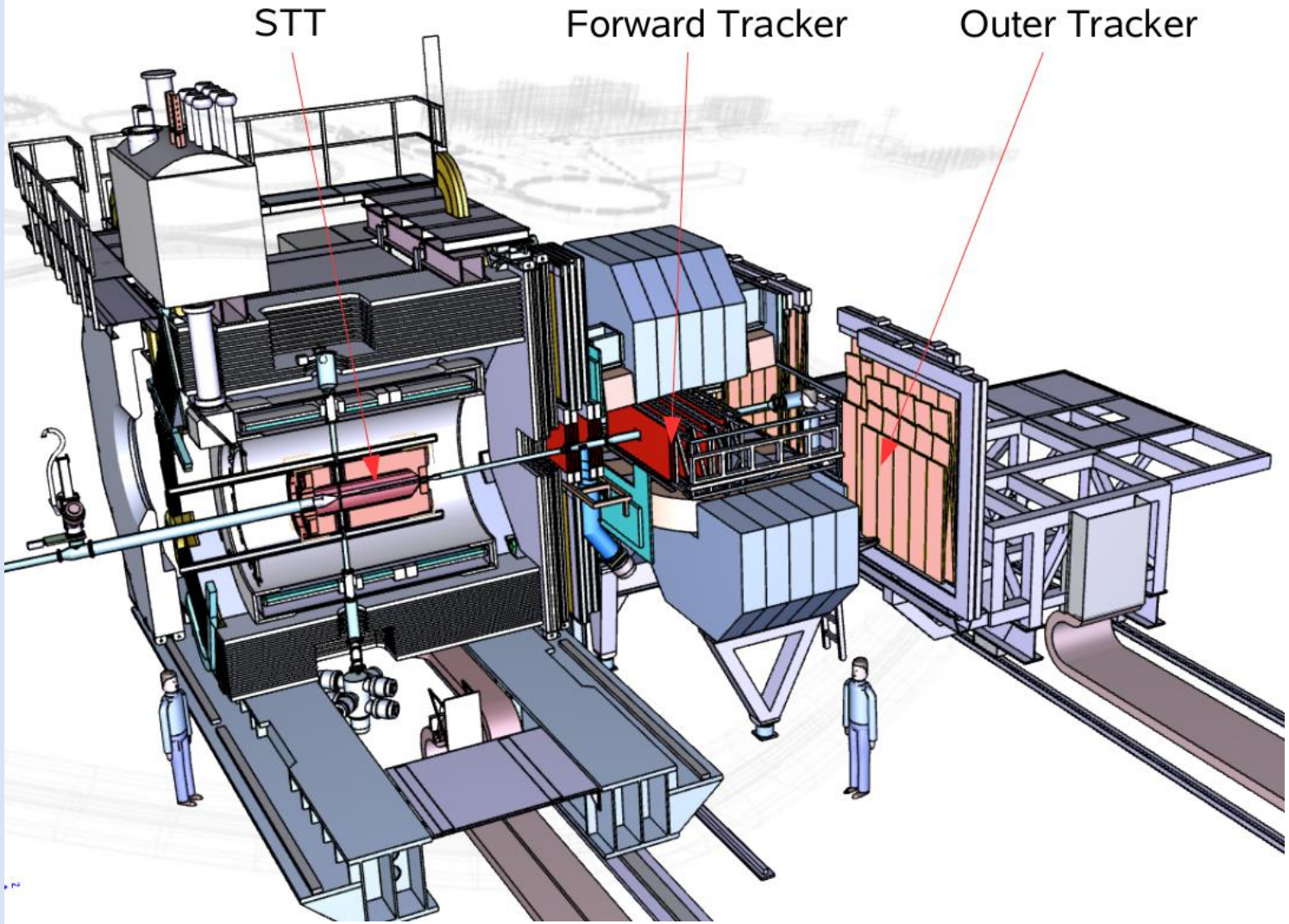
- 4224 straws, Ø 1cm
- Ar CO_2 at 2 bar (absolute)
- 19 axial layers, 8 skewed
- 0.04% X_0/layer
- ASIC readout

Forward Tracker 1-4

- 2+2 planar stations,
- 5600 straws, 1 cm diameter
- Ar CO2 at 2 bar (absolute)
- 4 DL/station (x,u,v,x)
- ASIC readout

OuterTracker (LHCb straws)

- Inner half length modules 2.4m
- 10800 straws, Ø 0.5cm
- 4 DL/station (x,u,v,x)
- 0.1% X_0/layer
- LHCb ASIC readout + interface



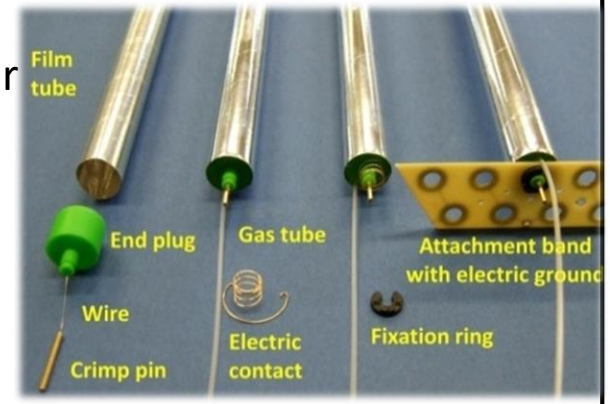
PANDA - Straw Tube Tracker - Barrel

Tracking in Target Spectrometer

- Layers of drift tubes
- R_{in}= 150 mm, R_{out}= 420 mm, l=1500 mm
- Tube made of 27 µm thin Al-Mylar, O=1cm
- **Self-supporting straw double layers at ~1 bar overpressure (Ar/CO_2) developed at FZ Jülich**
- 4224 straws in 19 /8 Axial /stereo layers at ~3°
- **Resolution: σ(r) ~150µm, σ(z) ~2-3mm**

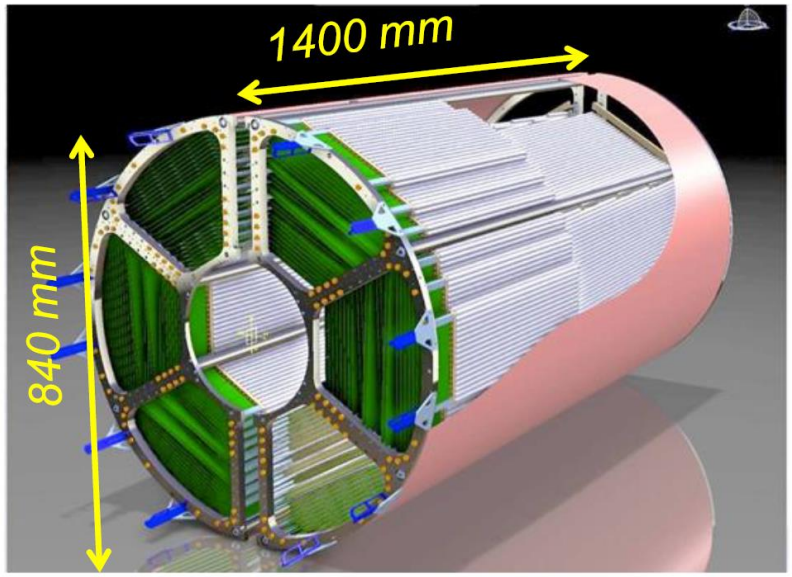
Material Budget

- 0.05 % X/X_0 per layer
- **Total 1.3% X/X_0**

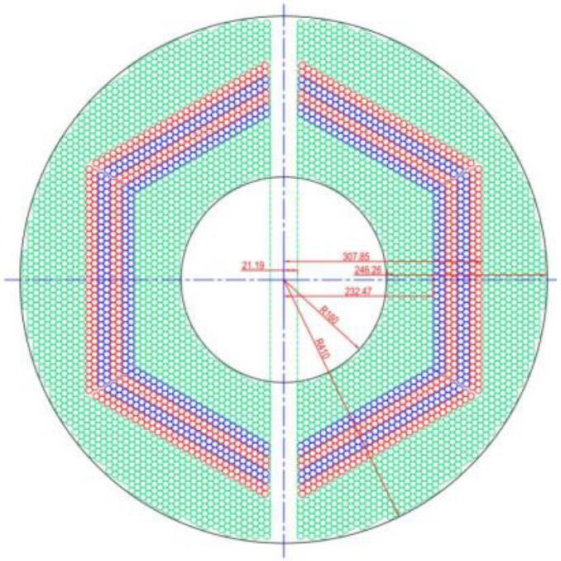


Project Status

- TDR Approved
- **ASIC (PASTTREC) &TDC FPGA**
  AMS 0.35µm CMOS
  - time and ToT, PID capability
- Extensive beam tests at COSY and QA done
- Ageing tests: up to 1.2 C/cm²
- Module production starting

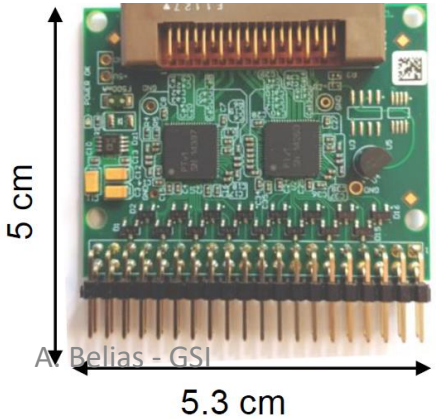


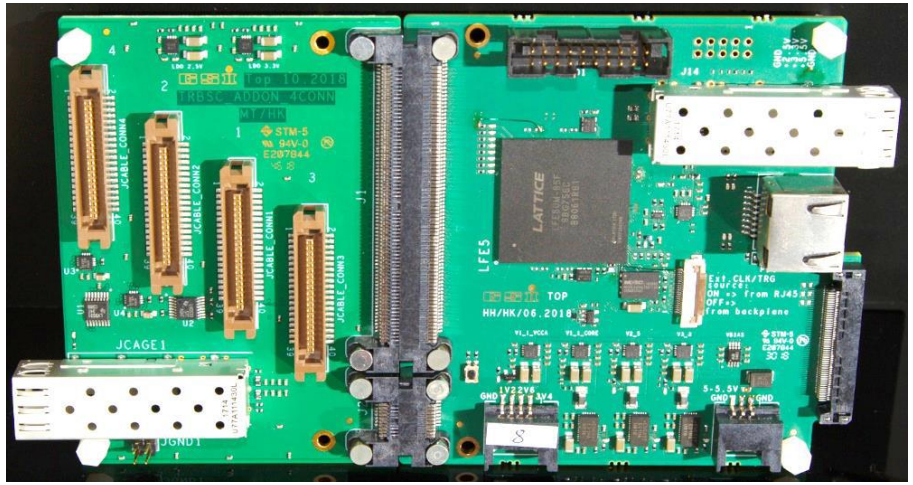
PANDA-STT (3D-view)



Straw layout (cross-view), stereo layers in red/blue.

New FEBv4 (with temperature sensor & chip e-ID)





PANDA - Forward Straw Tube Tracker

Tracking in Forward Spectrometer

Stations 3 with 2 chambers each

- FT1&2 : in front of dipole
- FT3&4 : inside the dipole gap
- FT5&6 : behind the dipole

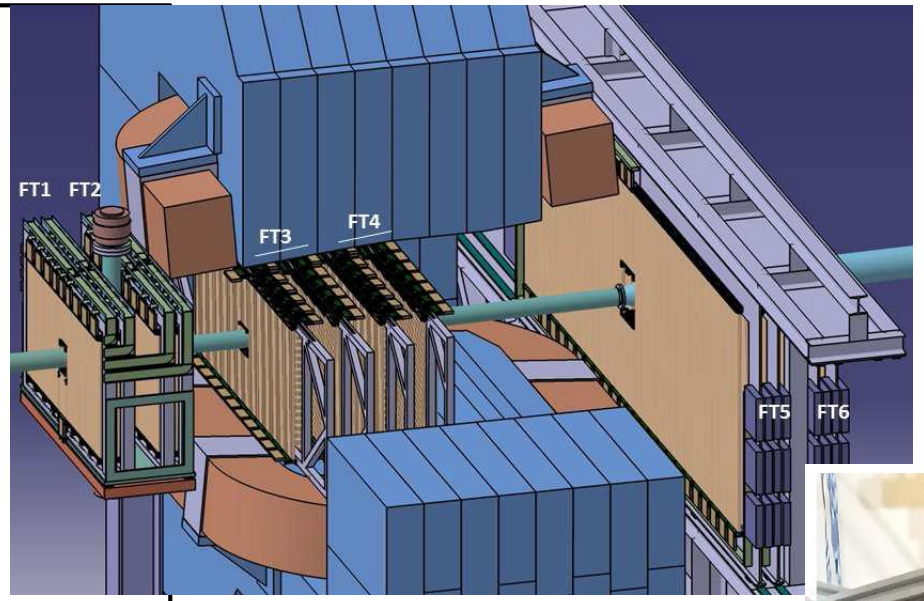
Straw tubes arranged in double layers

- Same technology as for STT Barrel
- 27 µm thin Al-mylar, O=1cm tubes
- Stability by 1 bar overpressure

- 4 projections 0°/+ -5°/0° per chamber
- Readout ASIC (PASTREC) & TDC FPGA (same as STT Barrel)

Project status

- TDR approved
- Straw and module production ongoing
- Ageing tests: up to 1.2 C/cm^2
- Frames for FT1/2 ready, for FT3/4 in production
- Module production started
- Tender for HV system and gas flow regulators
- Prototype purified gas system used for tests



PANDA - Straw Tube Tracker in FAIR Phase 0

Detector Layout

- Layers of drift tubes
- R_{in}= 150 mm, R_{out}= 420 mm, l=1500 mm
- Tube made of 27 µm thin Al-Mylar, O=1cm
- **Self-supporting straw double layers at ~1 bar overpressure (Ar/CO2) developed at FZ Jülich**
- 4224 straws in 19 /8 Axial /stereo layers at ~3°
- **Resolution: σ(r) ~150µm, σ(z) ~2-3mm**

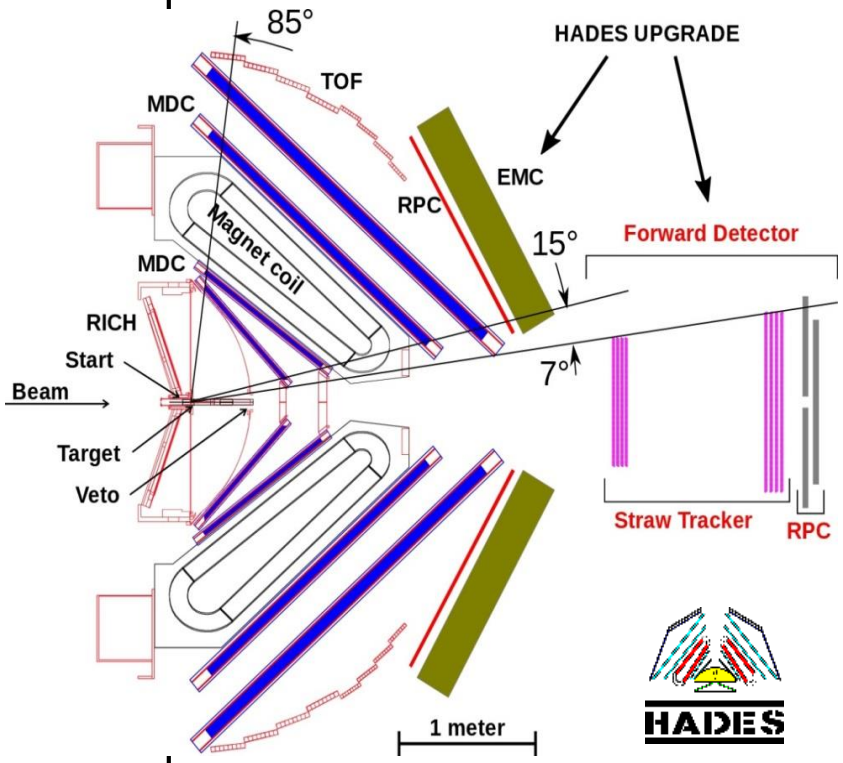
Material Budget

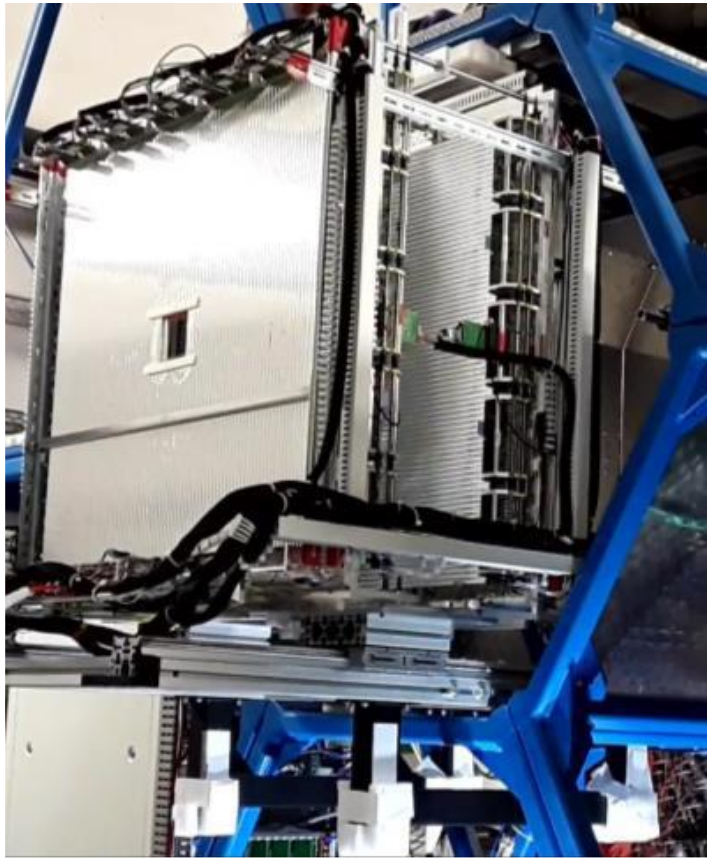
- 0.05 % X/X_0 per layer
- **Total 1.3% X/X_0**

Project Status

- TDR Approved
- **ASIC (PASTTREC) &TDC FPGA**
  AMS 0.35µm CMOS
  - time and ToT, PID capability
- Extensive beam tests at COSY & QA
- Module production starting
- **FEE Calibration & Readout fully validated**

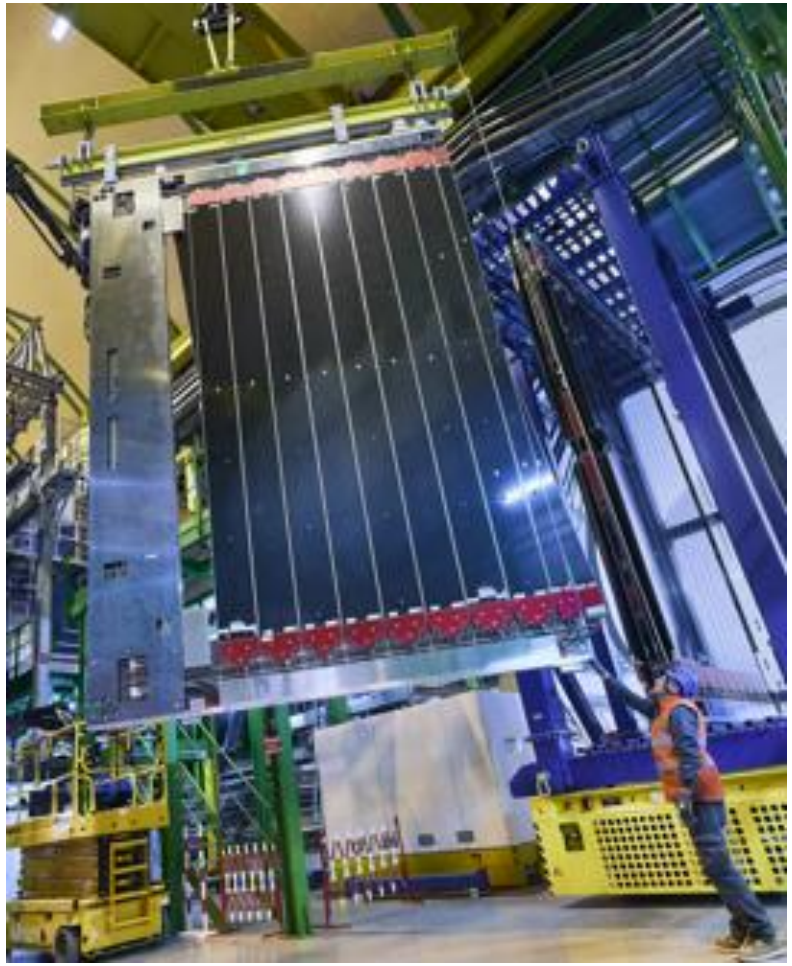
PANDA Straw Tube Tracker in HADES (GSI)
Hyperon Physics @GSI





LHCb Outer Tracker Straw Tubes in PANDA

LHCb/CERN donated the formidable Outer Tracker straw tube detector to PANDA at GSI/FAIR.



One of 12 frames, 5x6 m^2, with 4352 straws in 18 modules. (Photo courtesy: LHCb)

Outer Tracker brief specs

Straw tube

- Diameter, length: 5 mm, 2.4 m
- Anode wire: 25µm at 1550 V
- Gas mix: $Ar/CO_2/O_2$

Module

- Two staggered layers of 64 straw tubes
- One module: $X/X_0 = 0.37\%$
- Independent upper and lower sides
- Front-end electronics (FEE) each side

Whole Detector

- 53,760 straw tubes, 216 modules, 432 FEE
- Area coverage: 5 x 6 m^2 x12 planes

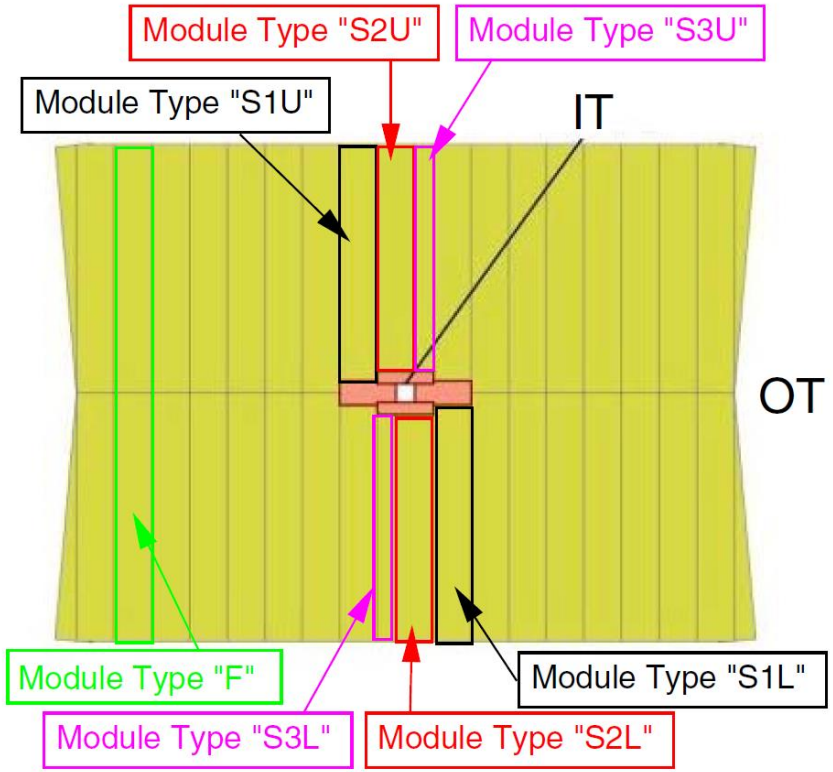
Performance (LHCb operations, Run 1&2)

- $\varepsilon \approx 98\%$, $\sigma \approx 170$ µm
- $\delta p/p \approx 0.4\%$ (2-100 GeV tracks)
- No significant ageing or gain loss

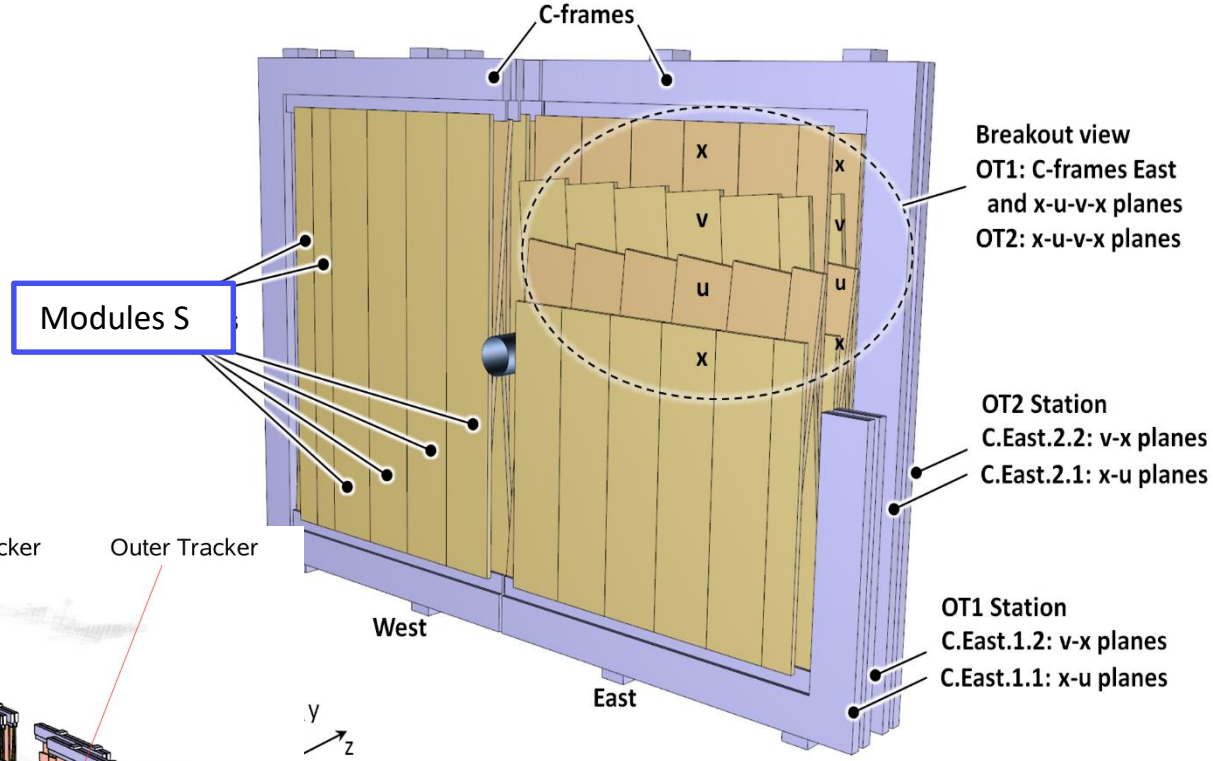
Whole OT in transport frame, 7x5.5x3.5 m^3, 24t, arrival at GSI, Aug. 25, '23. (Photo courtesy: GSI)

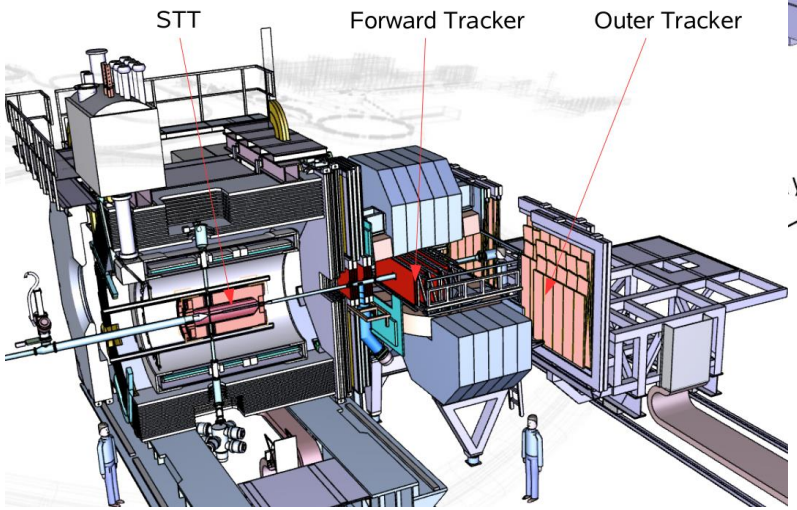
OT use case I: PANDA Forward Tracking

LHCb: Modules S separable in “U” and “L” parts



PANDA: Split & pair “U” and “L” parts of S Modules





PANDA - Gaseous Electron Multiplier Tracker

Forward Tracking inside Solenoid

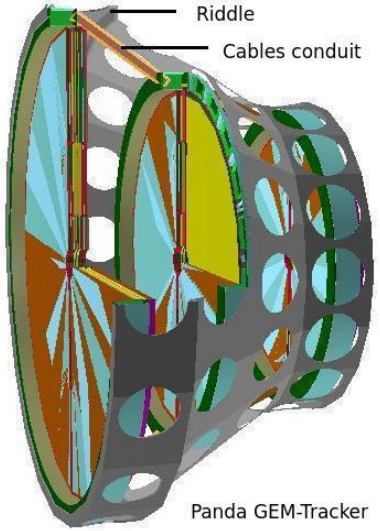
- Tracking in high occupancy region
- Important for large parts of physics

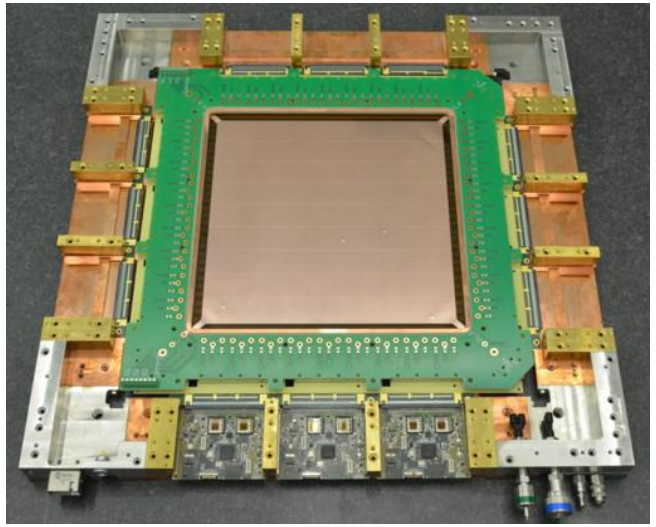
Detector design

- 3 stations with 4 projections each
  - ➔ Radial, concentric, x, y
- Central readout plane for 2 GEM stacks
- Large area GEM foils developed at CERN (50µm Kapton, 2-5µm copper coating)
- Outer diameter (mm): 900, 1120,1480
- ADC readout for cluster centroids
  - ➔ Approx. 35000 channels total
- Challenge to minimize material

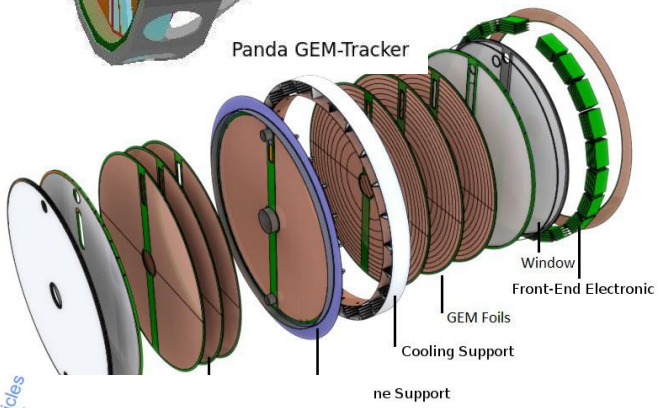
Project status

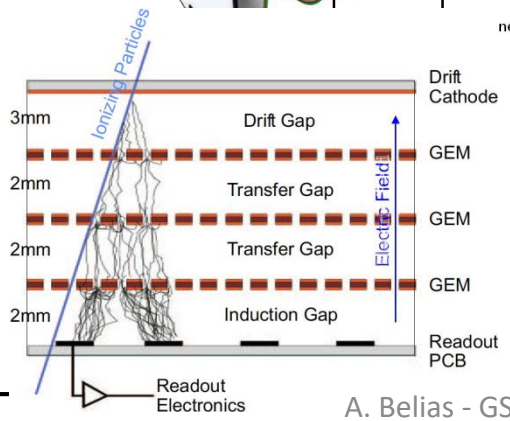
- Advanced mechanical concept
- Demonstrator construction started
- Readout electronics (VMM by CERN)

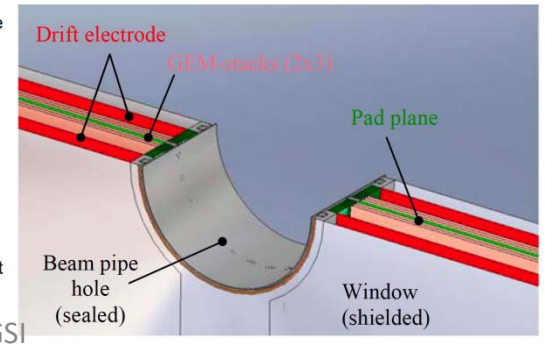




2D Demonstrator at GSI







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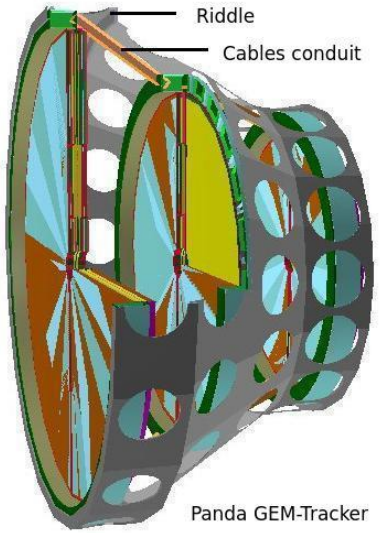
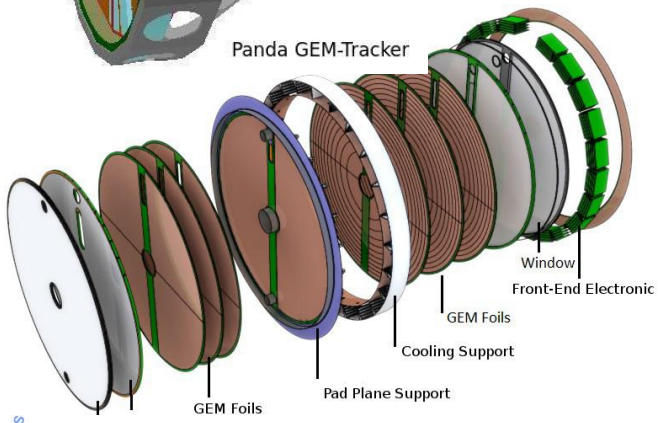
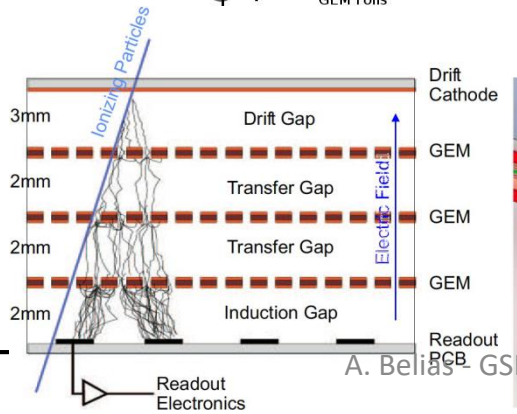
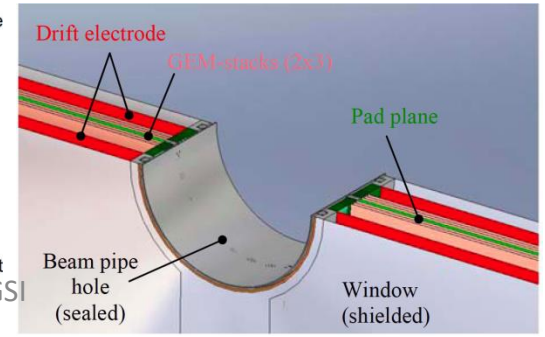
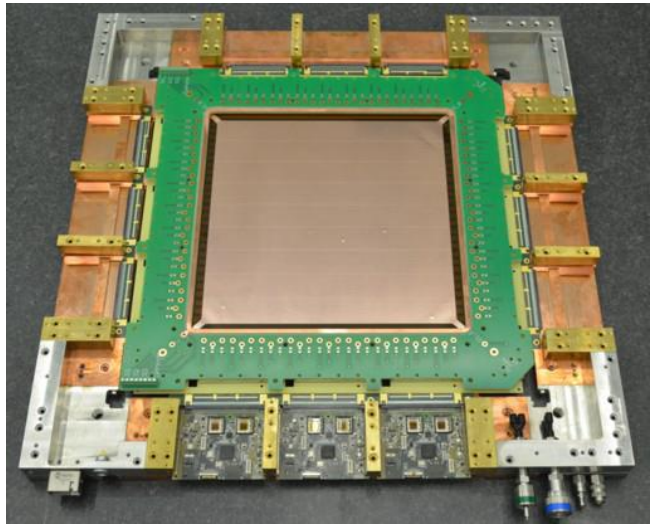










2D Demonstrator at GSI

Challenges:

- Large Area coverage
- Segmentation issues
- Reconsider design & other MPGD

PANDA - Luminosity Detector

Elastic scattering:

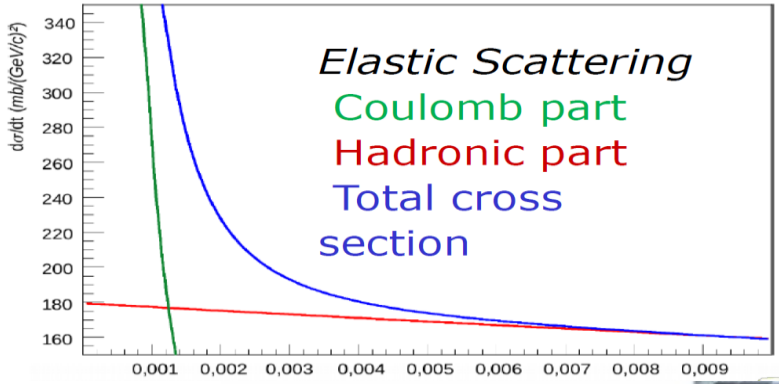
- Coulomb part calculable
- Tracking scattered p̄

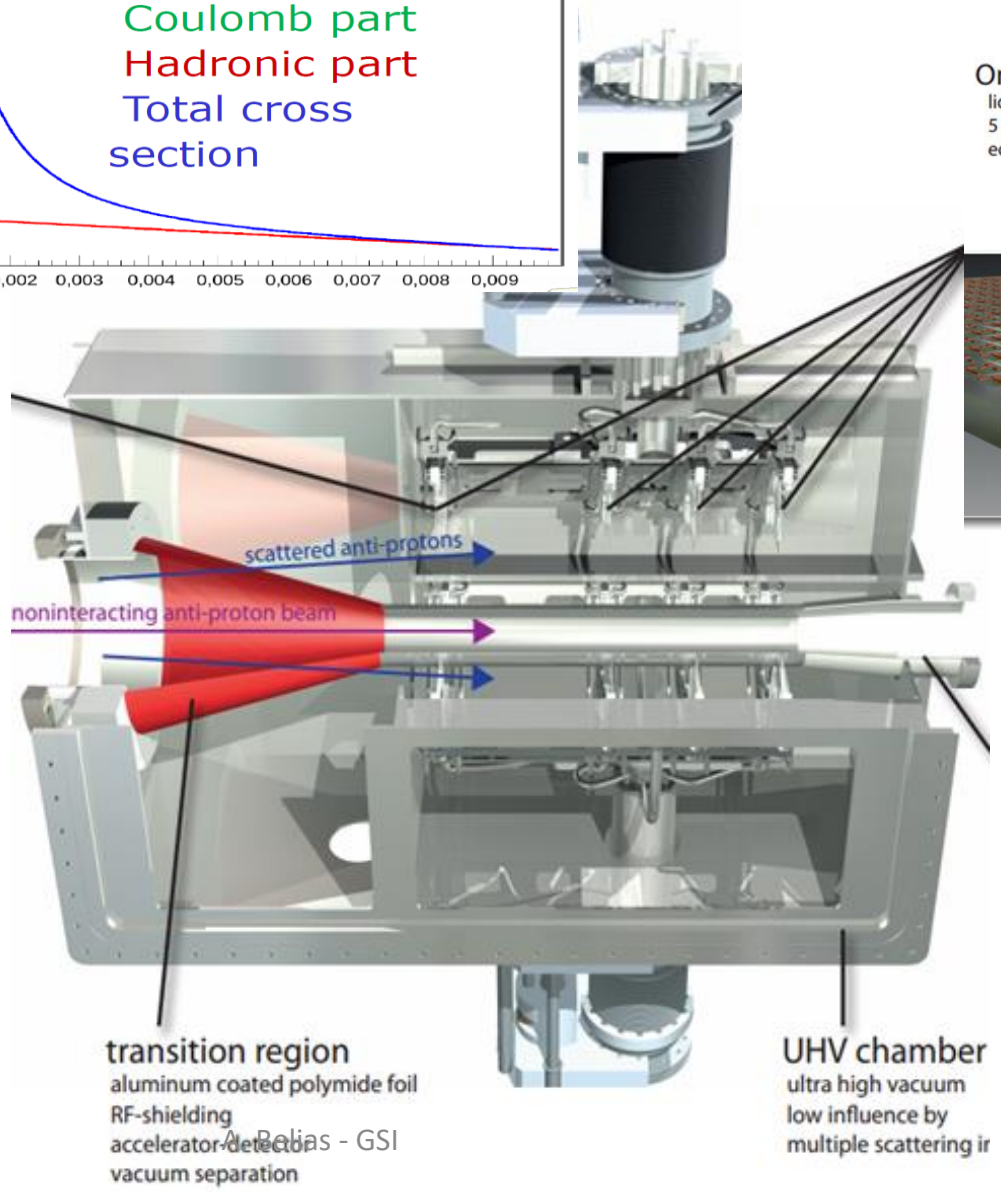
Detector layout:

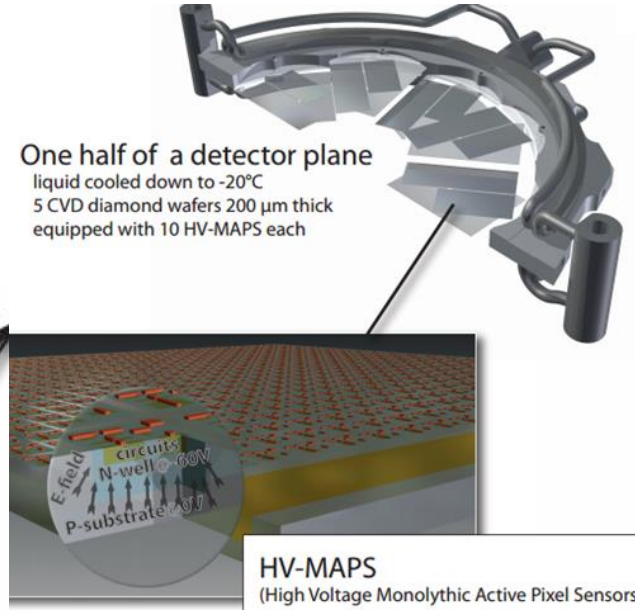
- Roman pot system at z=11 m
- Acceptance 3-8 mrad
- Silicon pixels (80x80 μm²):
  4 planes of HV MAPS (50 μm thick)
  - Active pixel sensor HV CMOS (Mu3e)
  - Digital processing on chip
  - Faster and more rad. hard
  - Testbeams: S/N ~ 20
    Efficiency ~99,5 %
- CVD diamond supports (200 μm)
- Retractable half planes in sec. vacuum

Project status:

- TDR approved
- Mechanical vessel, vacuum, cooling ready
- CVD diamond supports available
- Large sensors MuPix 11 sensors available
- In beam tests luminosity determined to 2%
- Detector completion progressing well

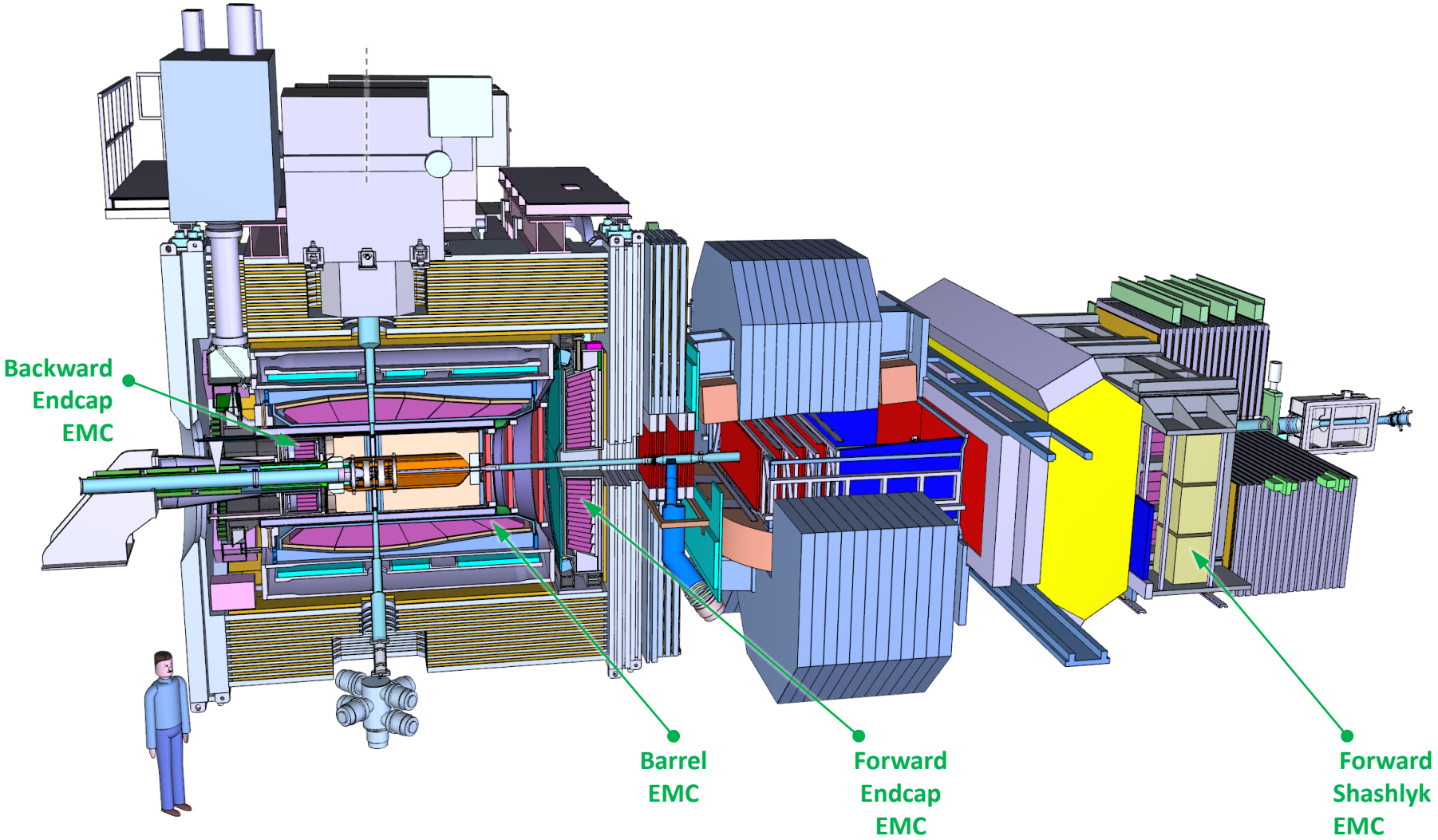






KOALA @ COSY (FZ Jülich)
PANDA Lumi Detector
Prototype & Target testing

PANDA Detectors - Calorimetry



PANDA - Crystal Calorimeter: Barrel and Endcaps

Crystal Calorimeter based on ~15,500 high quality second-generation PWO II ($PbWO_4$) crystals (Lead Tungsted)

- Radiation length X_0 = 0.89 cm (20cm ≈ 22 X_0)
- Short decay time τ=6.5 ns
- Increased light yield, at -25°C
- Time resolution <2ns

Project Status

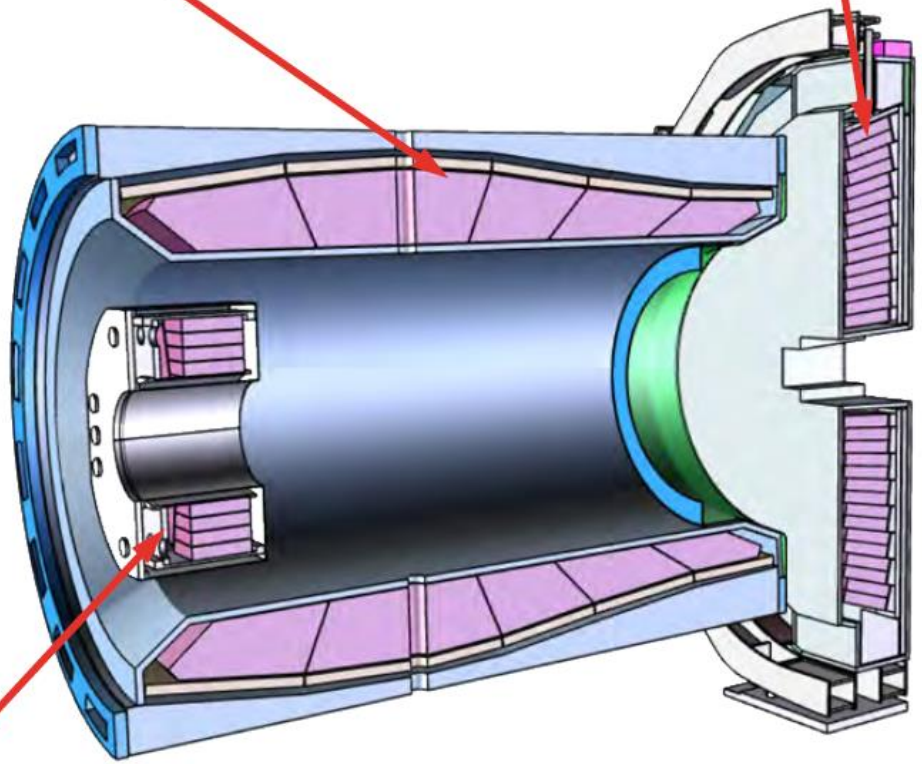
- TDR approved
- EMC Endcaps ready to completion
- Barrel EMC in progress
- Crystal production continued effort

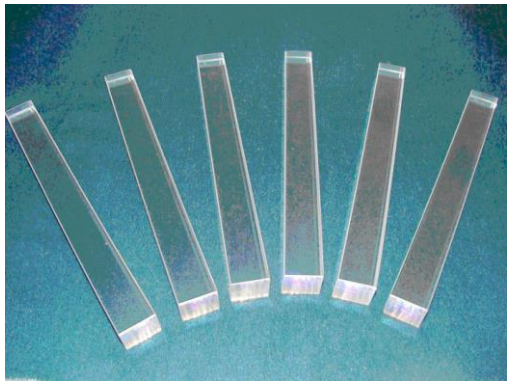
Barrel Calorimeter

11000 crystals PWO II
LAAPD readout, 2x1cm^2
σ(E)/E~1.5%/√E + const.

Forward Endcap

4000 crystals PWO II
High occupancy in center
LA APD and VPTT





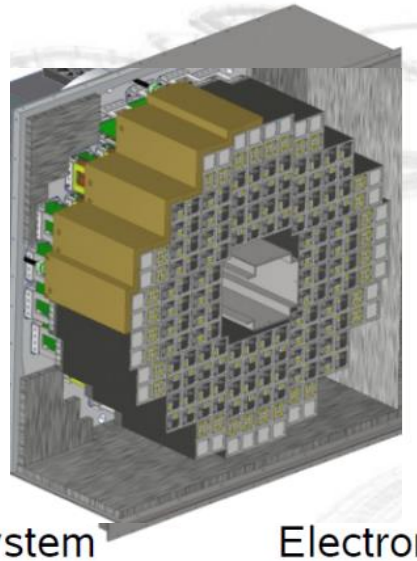
Large Area APDs

Backward Endcap for hermeticity, 530 crystals PWO II

PANDA – Backward Endcap EMC

Project status

- TDR approved
- Detector construction towards completion
- PANDA BWE EMC in use at Mainz Microtron (MAMI)



Assembly of Phase 0 system
(640 ch instead of 524 for PANDA)

- All modules assembled and calibrated
- Pre-tests done
- Calibration in Coldbox starting
- Beamtimes at MAMI in 2024 ff

Electronics

- HV boards series production, calibration in progress
- Lightpulser system: fibrebundles produced, PCB boards in production
- Arduino Apfel&HV control: tested and working

PANDA – Backward Endcap EMC in FAIR Phase 0

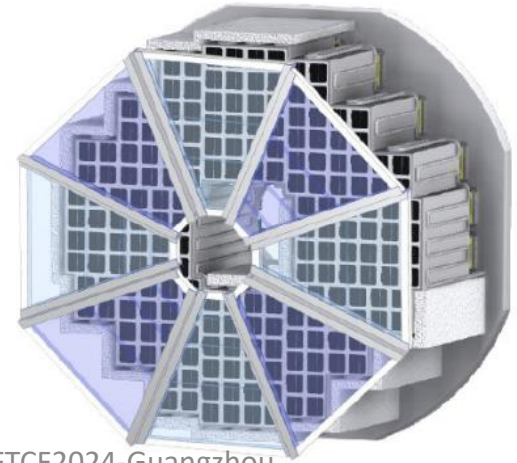
PANDA BWE EMC at Mainz Microtron (MAMI) part of experiments for high-resolution electron scattering in coincidence with hadrons (FAIR Phase 0)

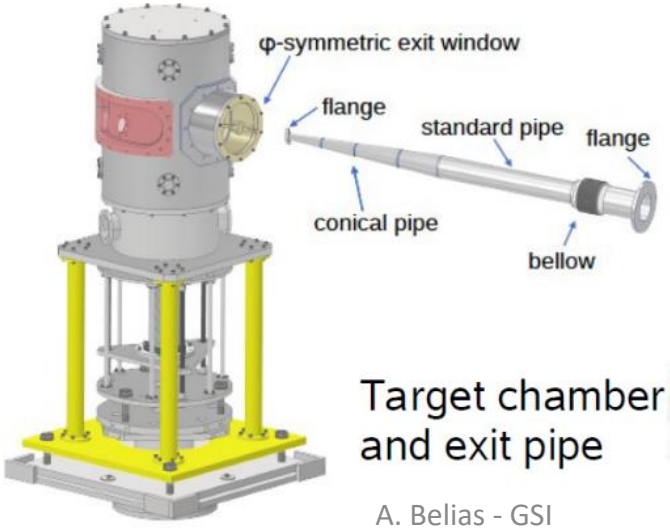
Physics program with PANDA Endcap at MAMI

- π^0 to $\gamma\gamma$ transition form factor (TFF)
- Primakoff π^0 electroproduction
- Setup: endcap calorimeter around beam pipe
- Measurement at MAMI: CW e-beam, up to 1.5 GeV

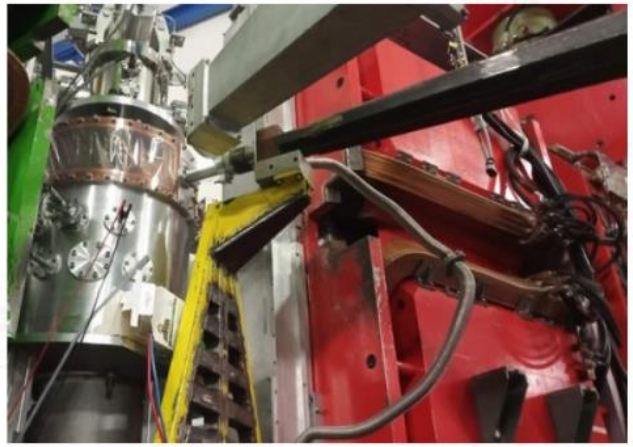
MAMI A1
3 spectrometer setup

PANDA Endcap with Scintillator for e-detection

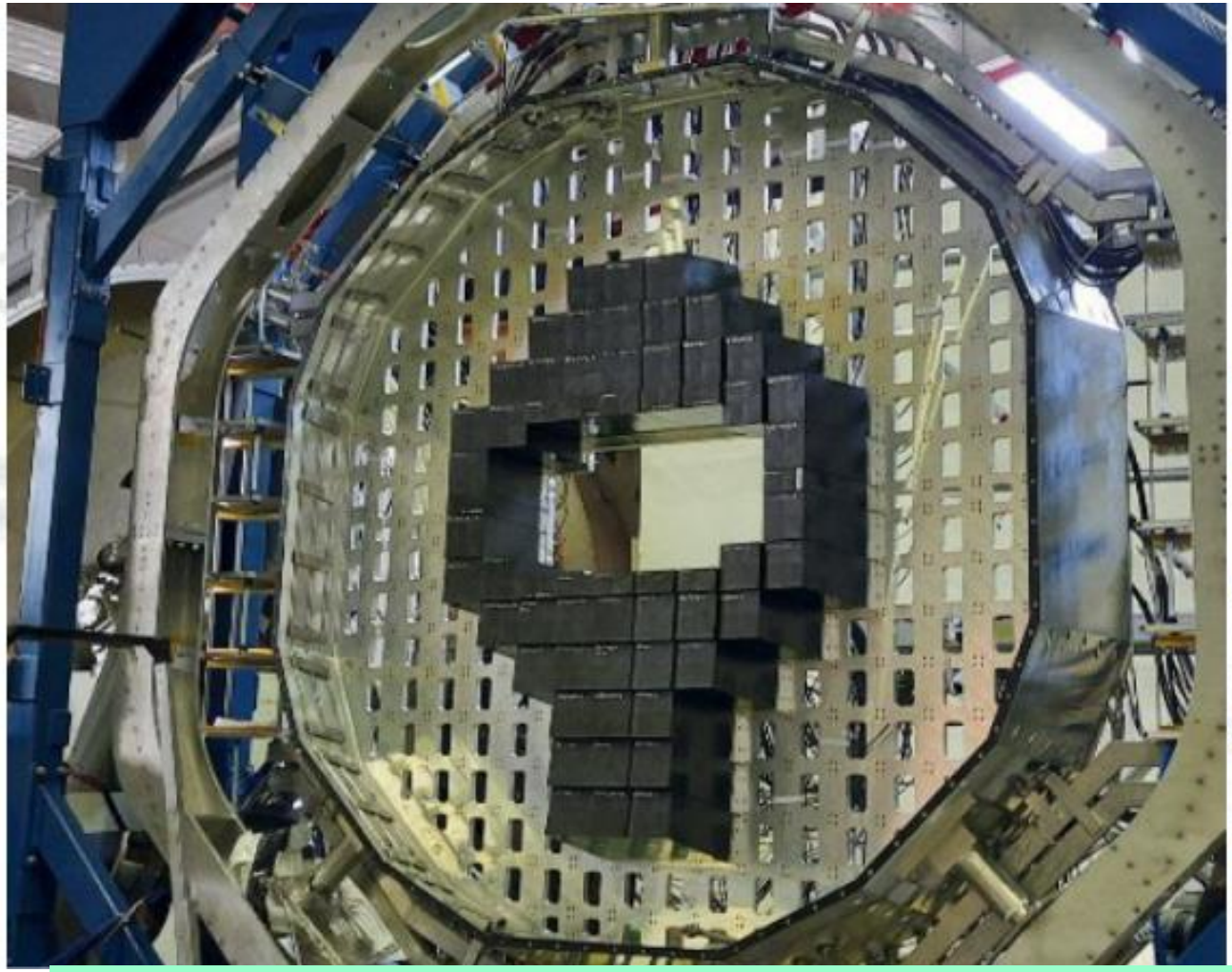




Target chamber and exit pipe

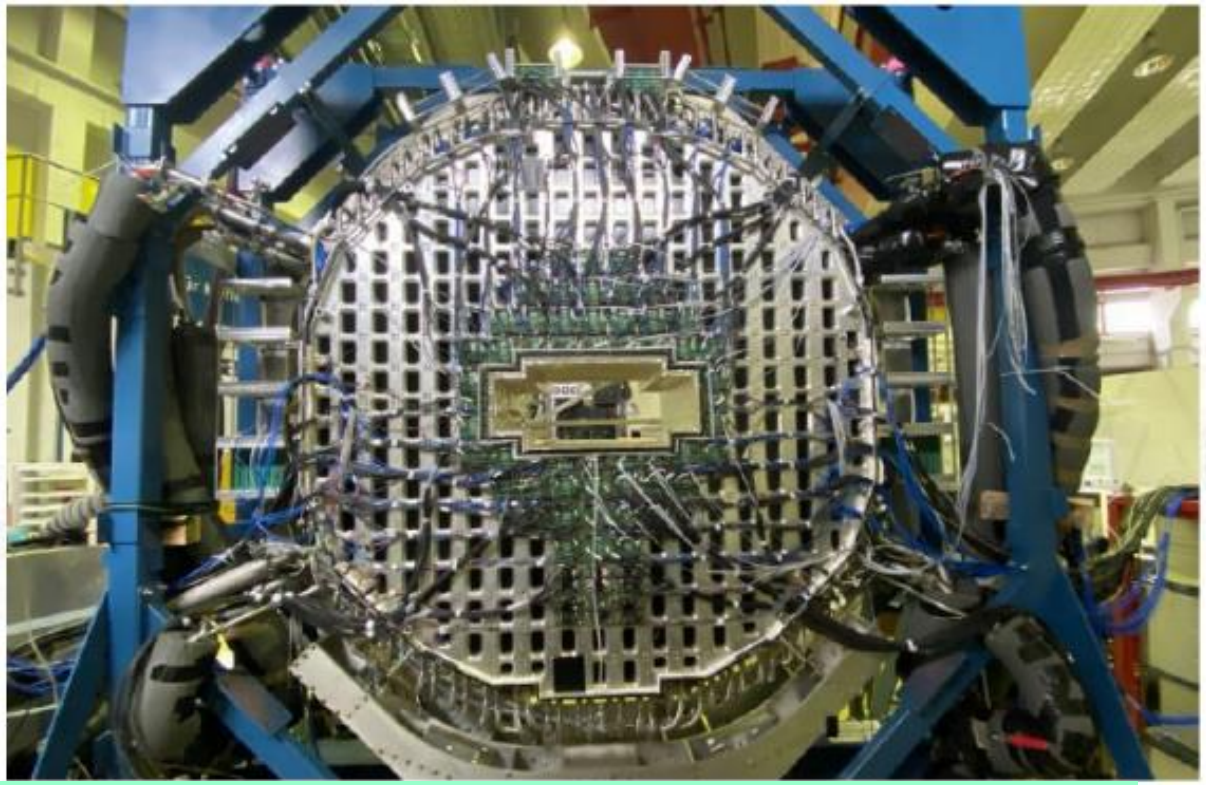


PANDA – Forward Endcap EMC



Project status

- TDR approved
- Detector construction towards completion
- PANDA FWE EMC in experiments at ELSA



Talk by Meike Kuessner,
"Performance of the new PANDA Forward-Endcap PbWOII-EMC measuring neutral pions produced by the COSY beam "

PANDA - Barrel EMC

Mechanics

- All alveoles produced
- First slice fully assembled, cooling implemented
- Production of next slice in preparation

Crystals

- Producer Crytur in Czech Republic
- 6100 crystals for complete setup needed, 129 needed for 3rd slice, 402 for 4th slice
- All raw material available

Readout

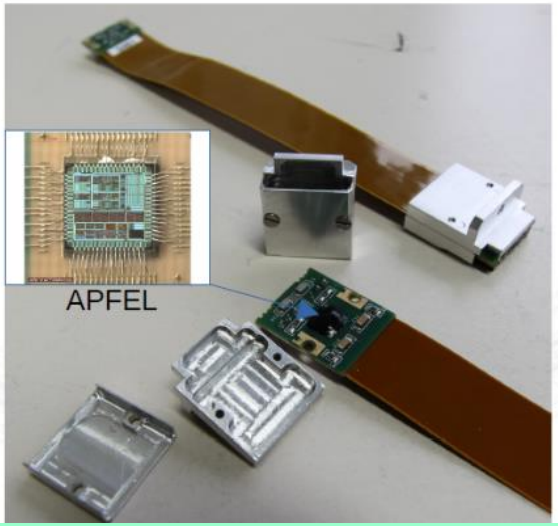
- APFEL ASIC, all available, flex PCBs delivered
- Hit Detection ASIC: ATR16 prototype delivered
- Backplane stack with HV regulation board, design verified, preparing series production

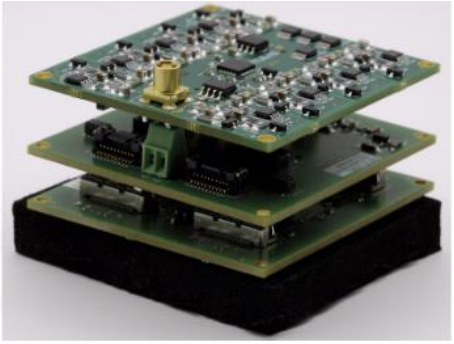
Services

- Light pulser monitoring
- Stimulated recovery with blue LED

Project status

- TDR approved
- Crystal production ongoing
- Slices construction continue





Talk by Holger Flemming,
"Design of Analogue Transient Recorder and Digitiser for Particle Detector Readout - ATR16 and CTR16"

PANDA - Forward Spectrometer Shashlyk Calorimeter

Forward electromagnetic calorimeter

- Interleaved scintillator and absorber layers
  - 380 layers of 0.3 mm lead and 1.5 mm scintillator, total length 680 mm
  - Transverse size 55x55 mm^2
- WLS fibers for light collection
- Active area size 297x154 cm^2
- PMTs for photon readout & FADCs for digitization

Project Status

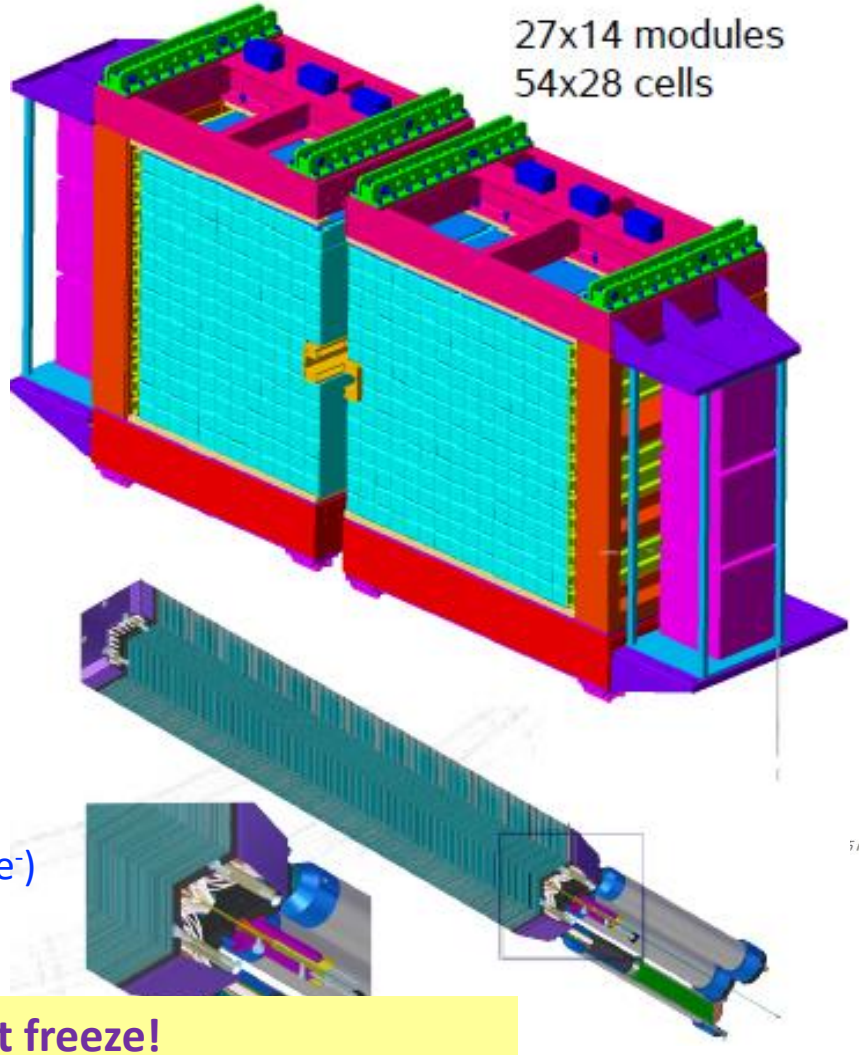
- TDR approved
- Prototype 2 x 2 cells of 5.5 x 5.5 cm^2 verified
- FADC systems ready, QA in progress
- Tests with electrons and tagged photons:

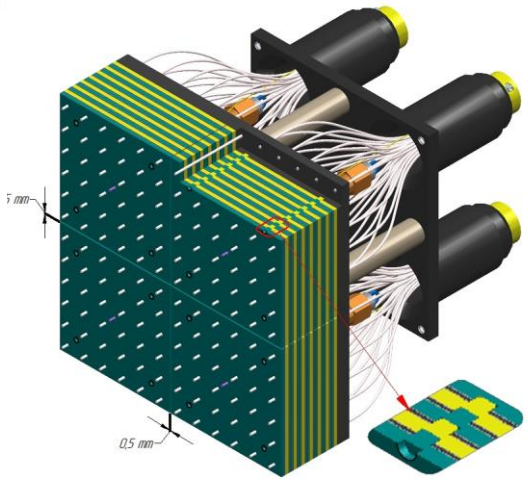
→ **Energy resolution**

- $\frac{\sigma_E}{E} = 5.6/E \oplus 2.4/\sqrt{\mathrm{E[GeV]}} \oplus$ 1.3 [%] (1-19 GeV e^-)
- $\frac{\sigma_E}{E} = 3.7/\sqrt{\mathrm{E[GeV]}} \oplus$ 4.3 [%] (50-400 MeV γ)

→ **Time resolution**

- 100 $\mathrm{ps}/\sqrt{\mathrm{E[GeV]}}$



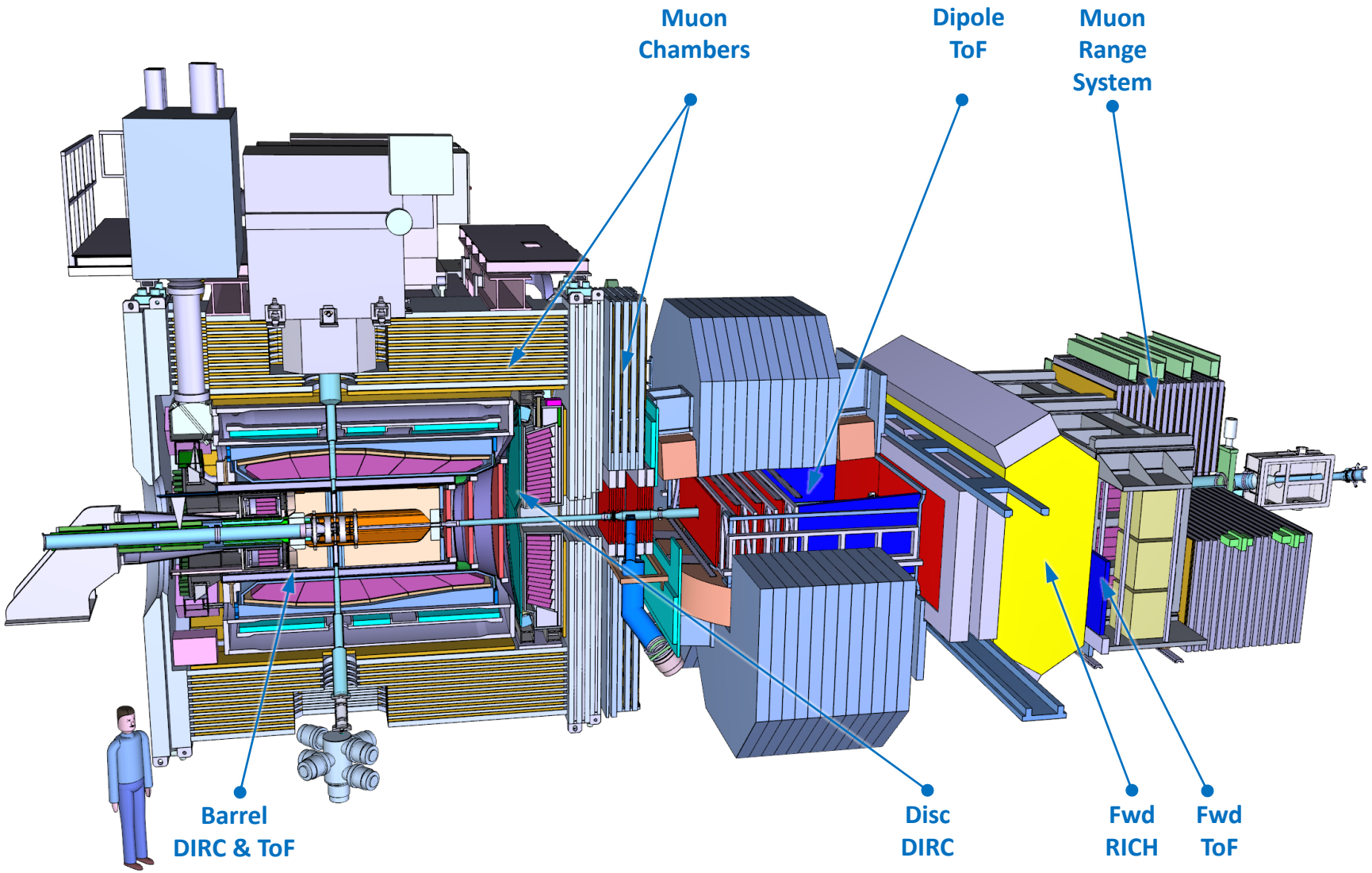


Project freeze!

Challenges:

- Detector design & continuity

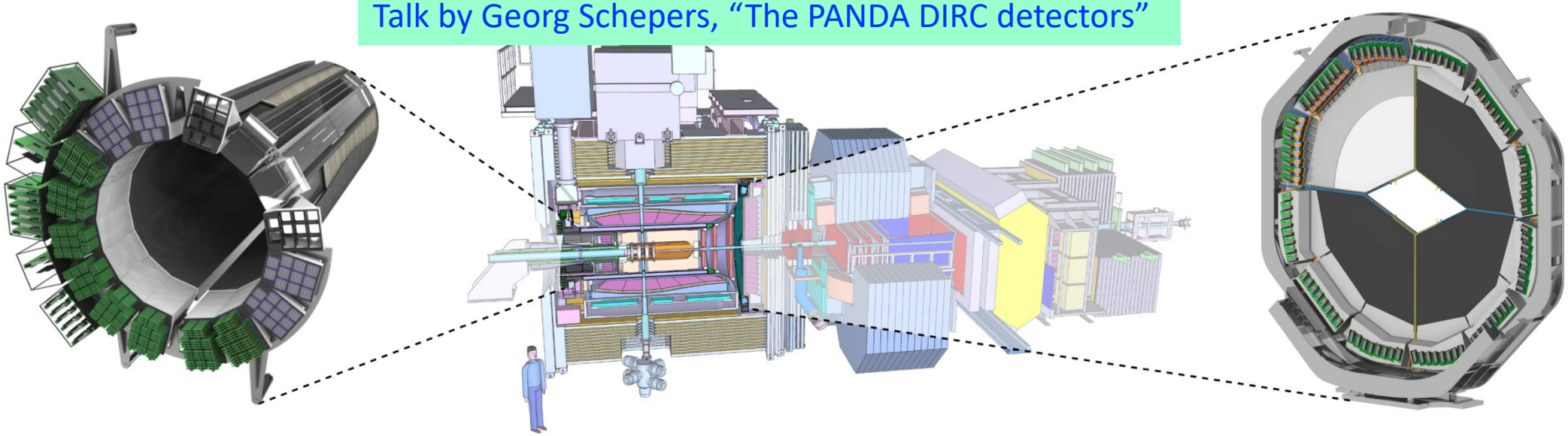
PANDA Detectors - Partcile ID



PANDA – DIRC Counters

Detection of Internally Reflected Cherenkov light pioneered bv BaBar
- Cherenkov detector with SiO_2 radiator
- Detected patterns give β of particles

Talk by Georg Schepers, “The PANDA DIRC detectors”



Barrel DIRC

- Design similar to BaBar DIRC
- Polar angle coverage:
  $22° < \theta < 140°$
- PID goal:
  3σ π/K separation up to 3.5 GeV/c

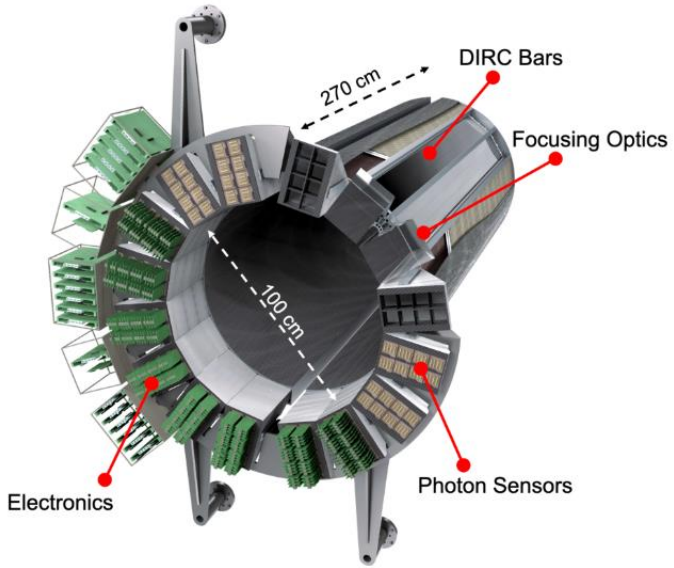
Key technologies:

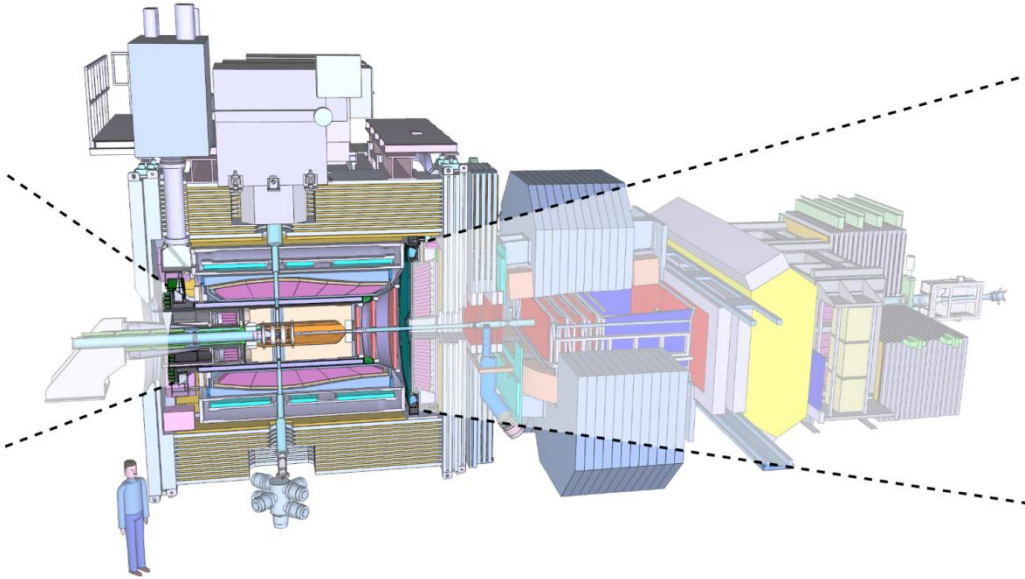
- Fast single photon timing in high B-fields with small pixels and long lifetime
- MicroChannelPlate (MCP) PMT
- High-quality fused silica radiators – Bars and Discs

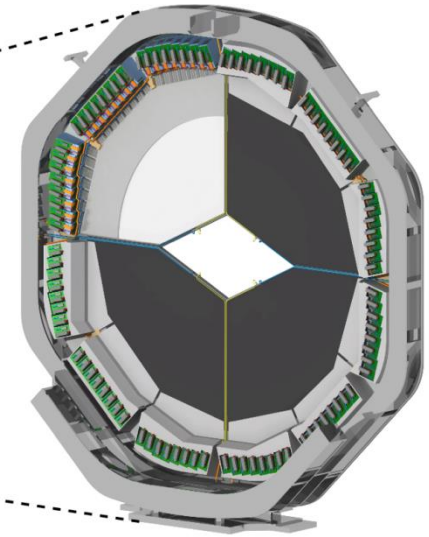
Endcap Disc DIRC

- Novel type of DIRC
- Polar angle coverage:
  $5° < \theta < 22°$
- PID goal:
  3σ π/K separation up to 4 GeV/c

PANDA – Barrel DIRC







Barrel DIRC

- Coverage: 22° < θ < 140°

Project Status

- TDR approved
- All radiators received at GSI
- MCP-PMTs deliveries to GSI
- MCP-PMT tests ongoing at FAU-Erlangen
- Bar box (radiator's enclosure) material tests
- Long-term outgassing measurements at GSI
- Procedure for bar gluing started
- Readout design progressing
- Development of ANNs for DIRC PID

Key technologies:

- Fused silica radiators
- Fast single photon timing in B-field with small pixels and long lifetime

Endcap Disc DIRC

- Coverage: 5° < θ < 22°

Project Status

- TDR approved
- One quadrant available
- Prototype readout started

Project freeze!

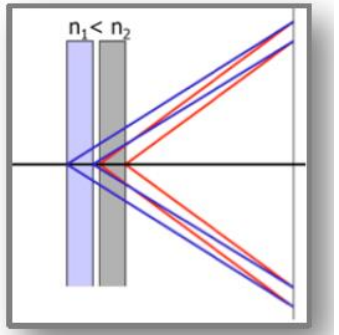
Challenges:

- Detector construction & completion

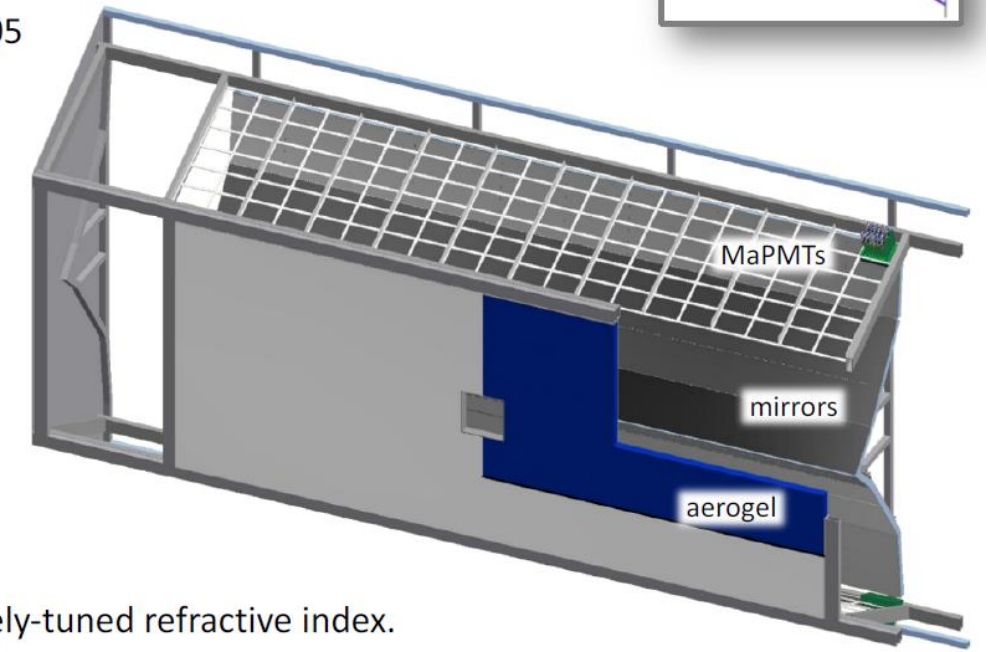
PANDA - Forward RICH

Design based on "Focusing Aerogel"

Increase light yield without deterioration of photon resolution by combining multiple tiles with different refractive index



- Coverage: $\theta_x<10°$, $\theta_y<5°$
- 40mm thickness focusing aerogel tiles (2 or 3 layers), n≈1.05
- Focusing mirrors direct Cherenkov photons to sensor array above/below beam
- Mirrors: 2mm float glass, Al+SiO_2 coating
- Sensors: ~240 Hamamatsu H12700 MaPMTs
- Fast FPGA-based readout electronics: DiRICH (same as PANDA Barrel DIRC, HADES/CBM RICH)
- Expected performance: ≥ 3 s.d. π/K separation for 2 – 10 GeV/c



Key technology: high-quality transparent aerogel tiles with finely-tuned refractive index.

Project status

- Small scale system tests
- Beam tests with electrons at BINP in 2019

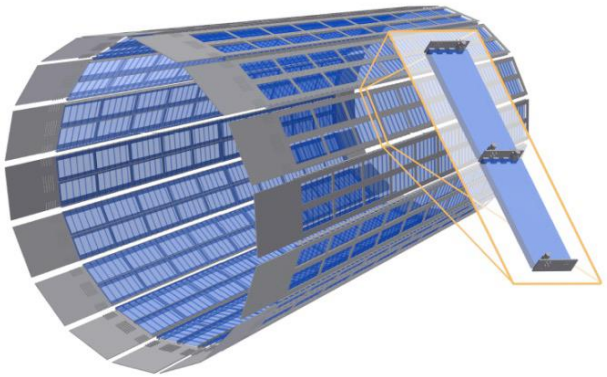
Project freeze!

Challenges:

- Technical Design
- Detector construction

PANDA - ToF Systems

Barrel ToF



- Scintillator tiles 5 mm thick
- Photon readout with SiPMs (3x3 mm^2)
  - High PDE, time resolution, rate capability
  - Work in B-fields, small, robust, low bias
- System time resolution: <100 ps achieved
- ToFPET ASIC for SiPM readout
- Layout: long multilayer PCB for transmission ("railboard")

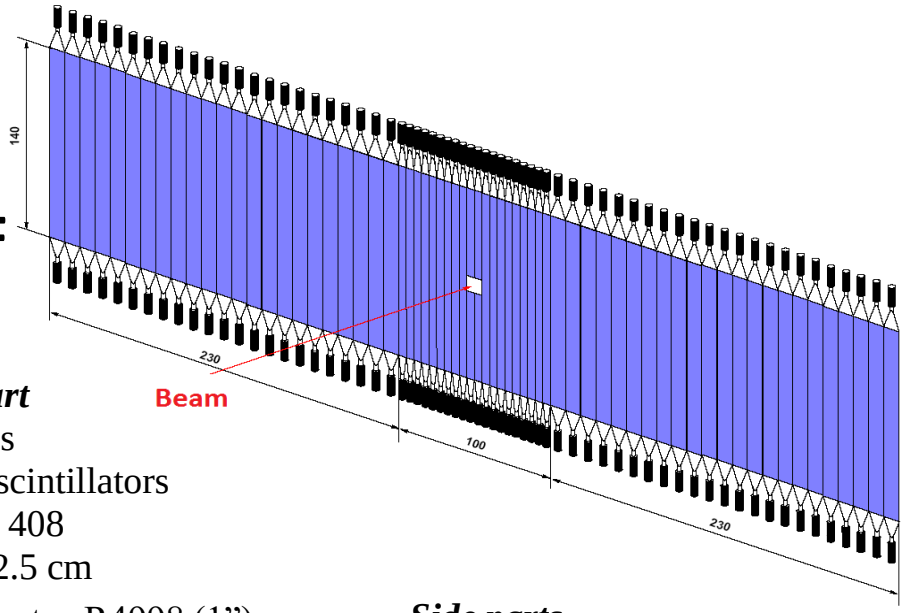
Project Status

- TDR Approved
- Studies on scintillator thickness
- Long PCB module produced, FoS (1/16)
- Optimizations and performance validation

Projects freeze!
Challenges:

- Detector construction & completion

Forward ToF



Central part
20 counters
20 plastic scintillators
Bicron 408
140x5x2.5 cm
40 Hamamatsu R4998 (1")

Side parts
2x23 counters
46 plastic scintillators
Bicron 408
140x10x2.5 cm
92 Hamamatsu R2083 (2")

Project Status

- TDR Approved
- Readout optimization
- Design laser calibration system

PANDA - Muon Detector System

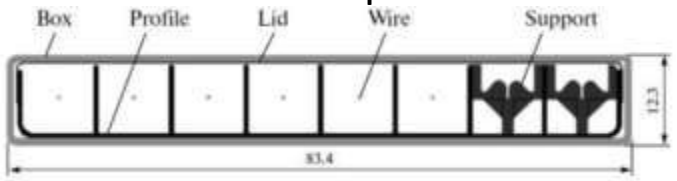
Muon system rationale

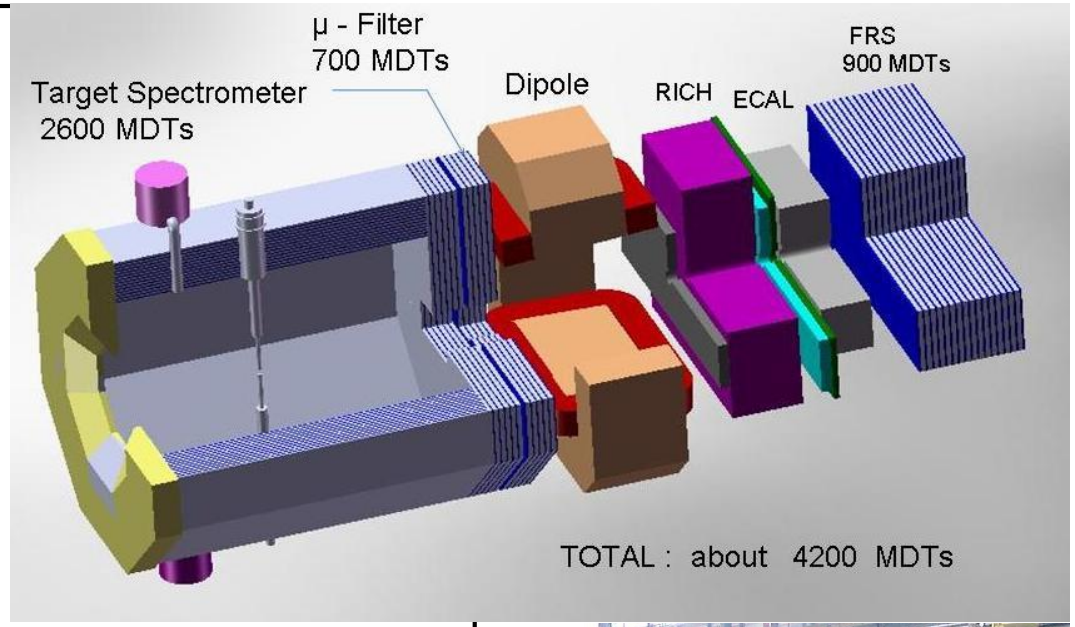
- Low momenta, high BG of pions

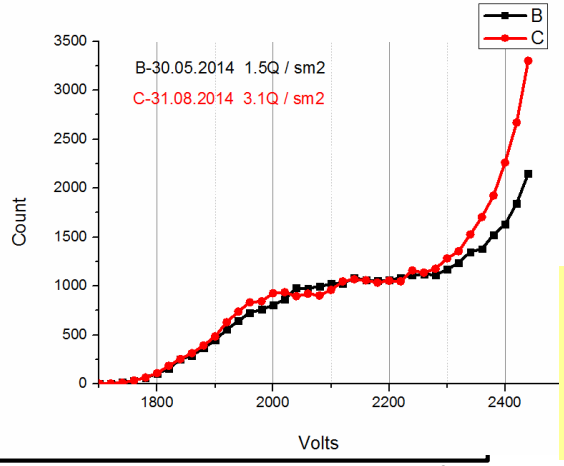
➔ Multi-layer range system

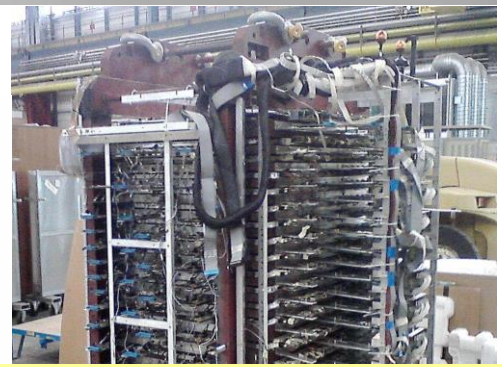
Muon system layout

- *Barrel*: 12+2 layers in yoke
- *Endcap*: 5+2 layers
- *Muon Filter*: 4 layers
- *Fw Range System*: 16+2 layers
- *Detectors:* Mini Drift Tubes (MDT) wire & cathode strip readout









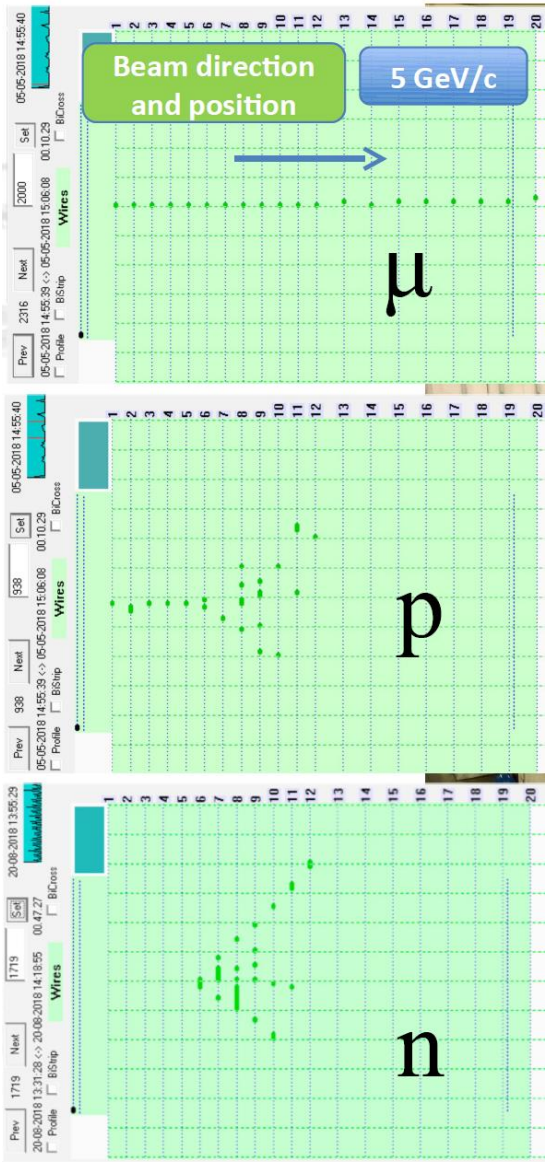
Project freeze!

Challenges:

- Consider alternatives

Testbeam results:

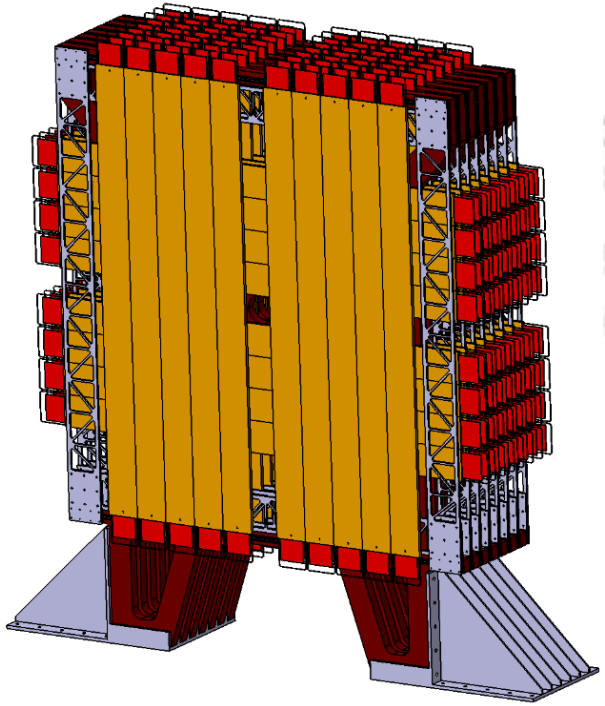
- μ, p and n easily resolved

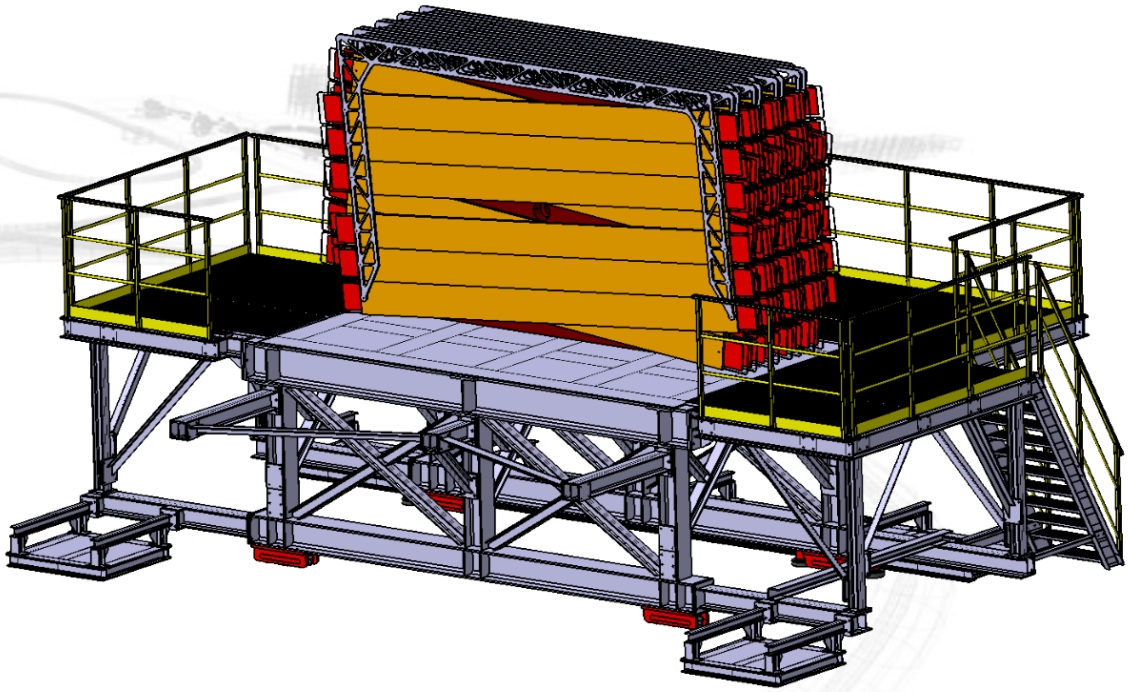


Project status

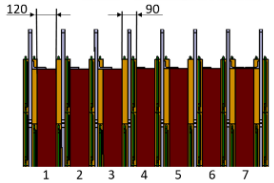
- TDR approved
- Testbeams at CERN, aging, cosmics
- Digital FEE developments

PANDA – Muon Range System with LHCb OT Straw Planes





- LHCb Outer Tracker long modules for PANDA Muon Range System,
- Option 1 (right): +-5° angle, same size as original FRS
- Option 2 (left): 90° angle, fixed absorber planes



Less layers,
thicker absorber

PANDA - Detector Control System (DCS)

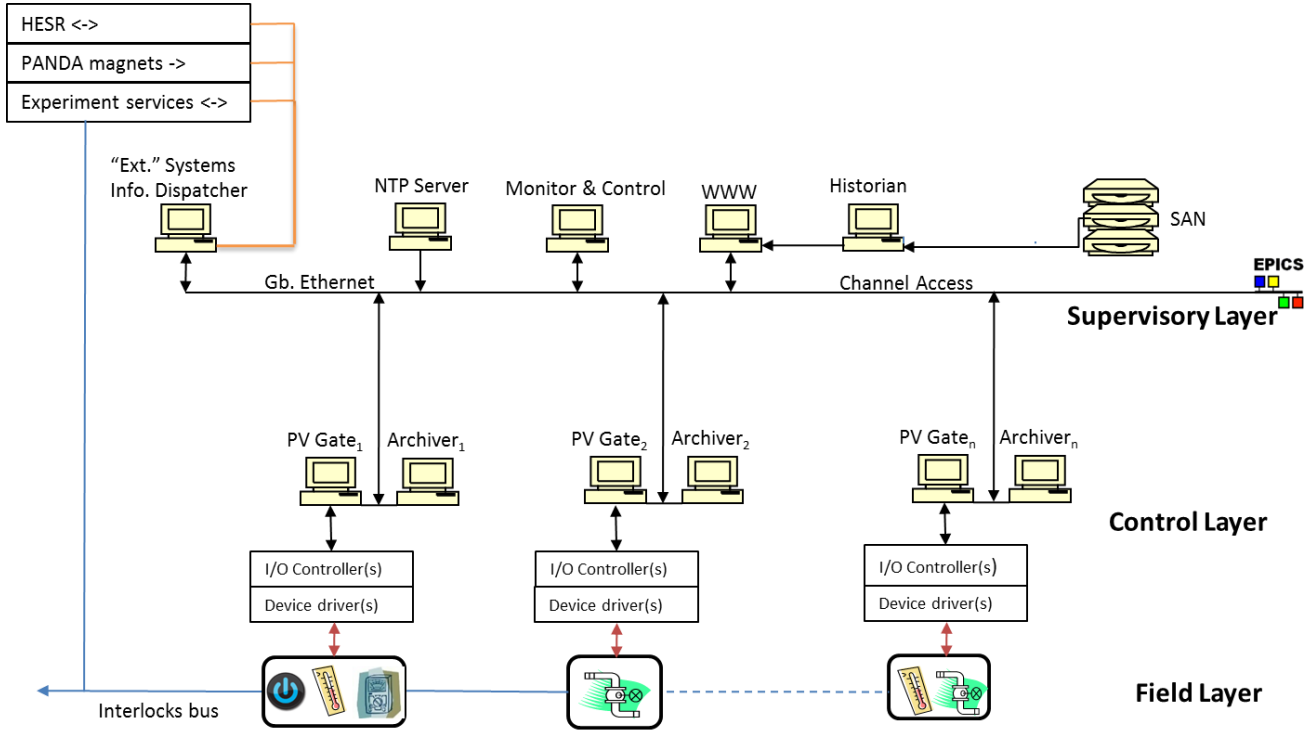
Control, Monitor and Archive for all detectors and sub-systems

Operations parameters:
- HV, LV, currents,
- gas-flows, cooling

Environmental parameters:
- Temp., Hum.

Interface to HESR, Magnets
Detector Safety

DCS TDR review ongoing



Supervisory Layer
Controls GUI interface
Databases & configurations
Interface: HESR, DAQ

Control Layer
I/O controllers
Device Drivers
Archiving sub-system

Field Layer
PANDA sub-systems specific
Interface: Detector Safety System

EPICS - Experimental Physics and Industrial Control System

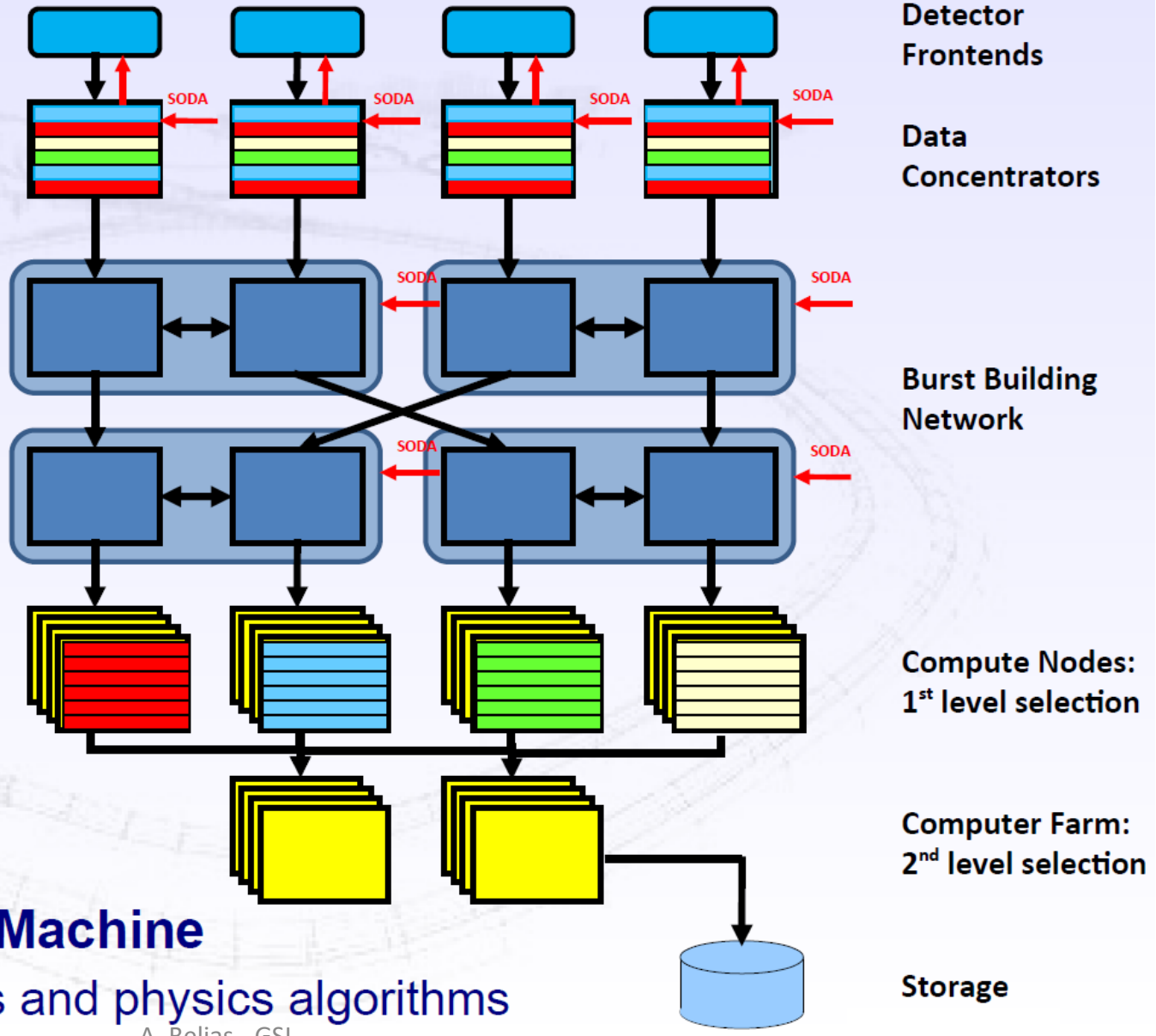
- ❑ Decentralized architecture
- ❑ Freely scalable
- ❑ Allows "partitioning") each subdetector has its own DCS

PANDA - Data Acquisition (DAQ)

PANDA FEE/DAQ Workshop, Jun.2024
https://indico.gsi.de/event/19628/

Self triggered readout

- Components:
  - Time distribution: SODA
  - Intelligent frontends
  - Powerful compute nodes
  - High speed network
- Data Flow:
  - Data reduction
  - Local feature extraction
  - Data burst building
  - Event selection
  - Data logging after online reconstruction



→ **Programmable Physics Machine**

Online selection schemes and physics algorithms are a key for successful measurements

PANDA Detectors - Visualization

PANDA Detectors - Visualization

Detector construction /system completion

Cluster-Jet Target

Dipole Magnet

Si-Strip Detector

Straw Tracking

- Barrel and planar

Luminosity Detector

EMC Forward Endcap

EMC Backward Endcap

Barrel EMC

Barrel DIRC

PANDA Detectors - Visualization

Detector construction /system completion

- Cluster-Jet Target
- Dipole Magnet
- Si-Strip Detector
- Straw Tracking
- - Barrel and planar
- Luminosity Detector
- EMC Forward Endcap
- EMC Backward Endcap
- Barrel EMC
- Barrel DIRC

Detector New Design

- MVD Si-Pixel
- GEM (MPGD)
- Muon ID (Sci. Til.)

PANDA Detectors - Visualization

Detector construction /system completion

Cluster-Jet Target

Dipole Magnet

Si-Strip Detector

Straw Tracking

- Barrel and planar

Luminosity Detector

EMC Forward Endcap

EMC Backward Endcap

Barrel EMC

Barrel DIRC

Major Challenge

Solenoid Magnet

Challenges Detectors

Shashlyk Calorimeter

Muon detection

Forward RICH

TOF Systems

Disc DIRC

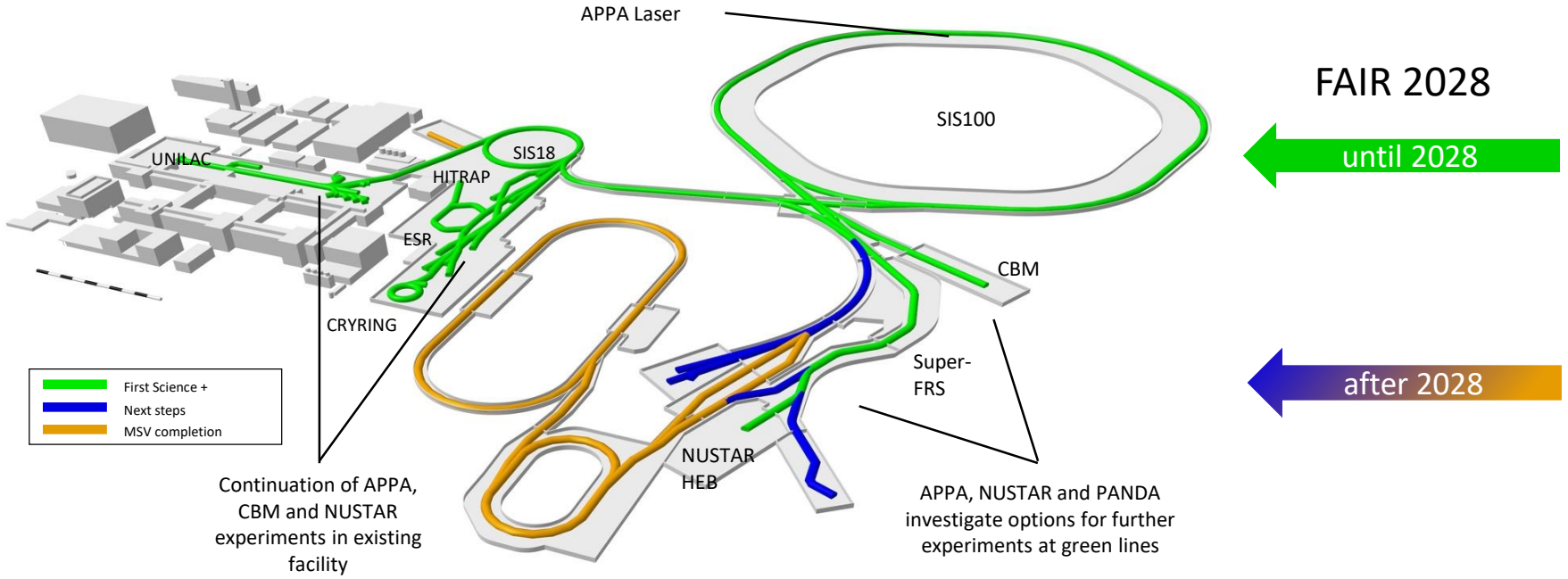
Detector New Design

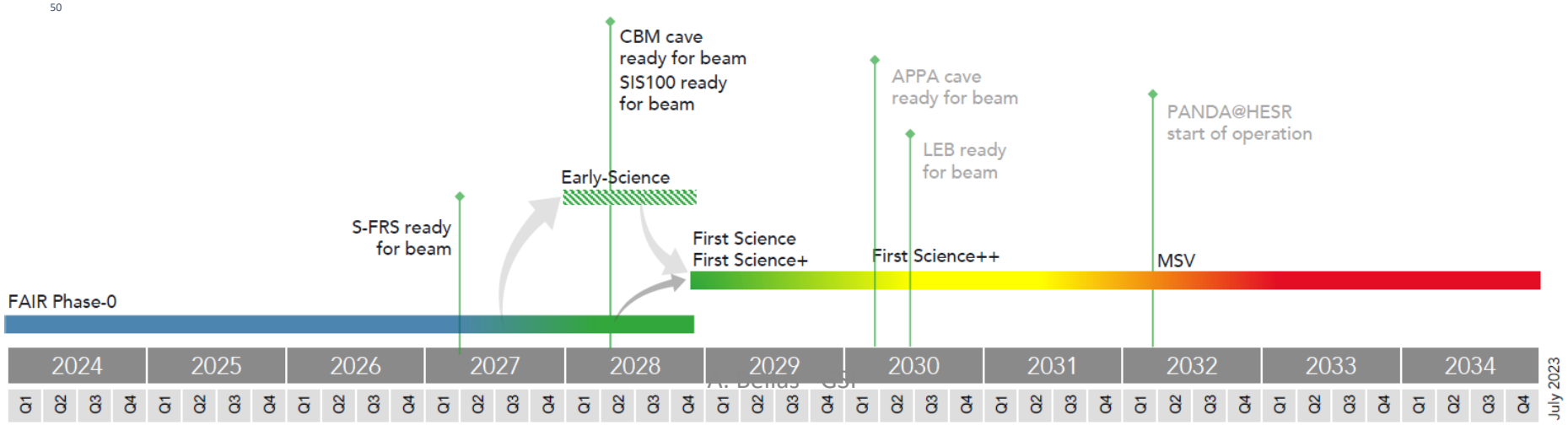
MVD Si-Pixel

GEM (MPGD)

Muon ID (Sci. Til.)

Current prospects and timeline





p̄anda @FAIR with antiproton beams in HESR by 2032