Status of PANDA

L. Schmitt, GSI/FAIR

FAIR RRB PANDA Breakout Session
Online Meeting, February 22, 2022

General News on PANDA

System Highlights and Updates

Infrastructure Updates

Antiproton Production at FAIR

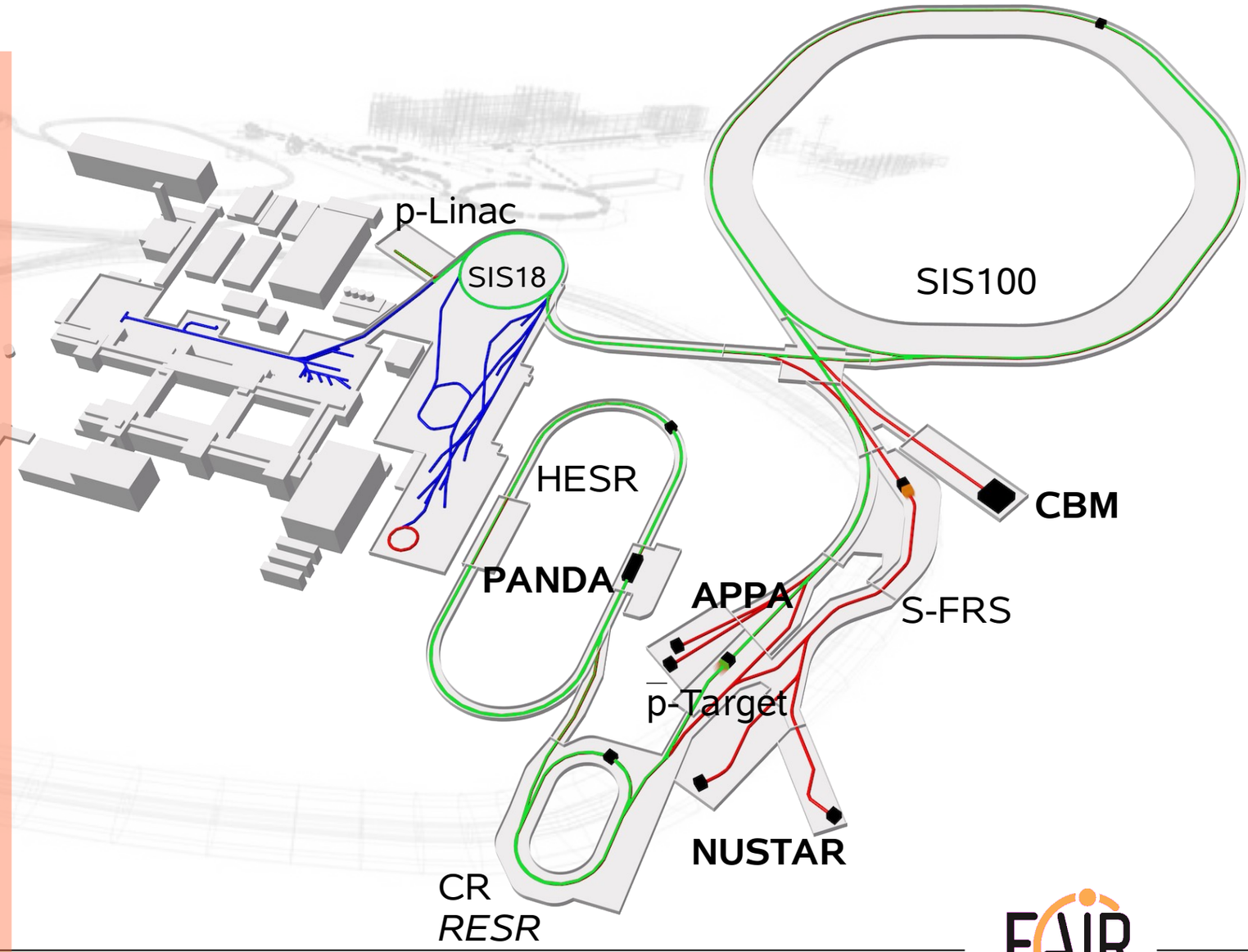
Antiproton production

- Proton Linac 68 MeV
- Accelerate p in SIS18 / 100
- Produce $\bar{p}$ on Ni/Cu target
- Collection in CR, fast cooling
- *Full FAIR*:
  - Accumulation in RESR, slow cooling
  - Storage in HESR
  - $\bar{P}$ANDA luminosity < 2×10^{32} $cm^{-2}s^{-1}$
- *FAIR MSV:*
  - Accumulation in HESR
  - Luminosity 10^{31} $cm^{-2}s^{-1}$

FAIR Intermediate Objective

- North site plus S-FRS, NUSTAR, APPA hall, pBar target
- Work on all accelerators & exp

Buildings for CR, pLinac, HESR and PANDA in construction phase 2



News from PANDA

- **Contracting**
  - STT-FT-FEE in-kind contract at work: ASICs delivered, mass testing
  - FT contract at work: procurement started
  - Preparations for Barrel Muon Detectors CC with Dubna
  - Assignment of Czech funds for more EMC PWO crystals
- **Reports**
  - DAQT TDR approved
  - Infrastructure and Installation report approved
  - GEM Tracker TDR draft reviewed, testbeam with RD51 at CERN
- **Progress highlights**
  - Solenoid magnet: production of SC strands, first samples exceed specs
  - Barrel DIRC: production of PMTs started
  - PANDA@HADES Straw Trackers currently in HADES physics run
- PANDA schedule was updated w.r.t. new building schedule in Q1 2021, architectural planning resumes in 2022

PANDA Schedule

Current status

- Construction of many Phase 1 systems has started
- Integration and infrastructure planning progressing
- Delays in several parts due to delayed funding or contracting
- Covid-19 still has effects on the schedule

Installation periods according to present plans:

- Installation period 1: solenoid, dipole, supports etc.
  in parallel with installation of technical building infrastructure
- Installation period 2: all other systems after building completed

Commissioning strategy:

- Device commissioning synchronised with installation
- Experiment commissioning without beam: dry runs, cosmics
- First beam commissioning with protons from SIS18

→ Ready for physics when first antiprotons arrive

PANDA Progress Scorecard

	PANDA	TDR / Specs	Cost [k€ 2005]	% Funding (Sec / RUS / EoI / TBA)	Construction	Construction complete	Test/ Commissioning
Day-1	Cluster Jet Target		771,00			10/2025	
	Micro Vertex Detector (MVD) - Str		2.550,00			01/2025	
	Straw Tube Tracker (STT) (1)		2.603,00			09/2025	
	Planar GEM Tracker - 50%		555,00			03/2025	
	Barrel DIRC		2.782,00			10/2024	
	Barrel Time of Flight (TOF)		310,00			10/2024	
	Forward Tracking (w/o FT 5/6) (1)		1.145,00			08/2025	
	Forward TOF (2)		362,00			12/2024	
	Barrel EMC System		8.258,00			12/2025	
	Barrel EMC Crystals - 75% (2)		8.712,00			12/2025	
	Backward Endcap EMC		1.267,00			06/2025	
	Forward Endcap EMC		5.714,00			12/2023	
	Forward Shashlyk Calorimeter (2)		1.447,00			12/2025	
	Luminosity Detector		666,00			03/2025	
	Muon Detectors (2)		2.318,00			06/2024	
	Solenoid		5.800,00			04/2024	
	Interaction Region		151,00			12/2024	
	Infrastructure		2.441,00			06/2024	
	DAQ Hardware (3)		609,00			06/2025	
		99% *value weighted*	48.461,00	75% 17% 6% 2%	44% *value weighted*		1% *value weighted*
	Changes since RRB #10	+7%	-7.7%	+5.6% +1.3% -7.1% -2.0%	+5%		

(1) if synergies between STT and Fw. Tracking realise
(2) if German-Russian Roadmap realised
(3) DAQ computing via operation funds

2022-02-04

PANDA TDR Schedule

System	Submission *Expected*	M3 (Approval) *Expected M3*
PANDA PHASE 1		
Target Spectrometer EMC		18/08/2008
Update Report		17/06/2021
Solenoid		21/05/2009
Dipole		
Micro Vertex Detector (MVD)		26/02/2013
Straw Tube Tracker (STT)		29/01/2013
Cluster Jet Target		28/08/2013
Muon System		22/09/2014
Forward Shashlyk Calorimeter		03/03/2016
Barrel DIRC		20/08/2017
Barrel Time of Flight (TOF)		14/02/2018
Forward TOF		16/10/2018
Forward Tracking		16/10/2018
Luminosity Detector		04/04/2019
Controls		12/10/2020
DAQ		25/08/2021
Infrastructure		17/11/2021
Planar GEM Trackers	*3/2022*	*9/2022*
PANDA PHASE 2		
Endcap Disc DIRC		08/11/2011
Forward RICH	*6/2022*	*12/2022*
Pellet Target	*6/2023*	*12/2023*
Hypernuclear Setup	*7/2022*	*1/2023*
		Status 17/11/2021

For the item “Interaction Region” no TDR is planned, only a specification document. Computing TDR together with FAIR Computing TDR.

Phase 1: 15 TDRs approved

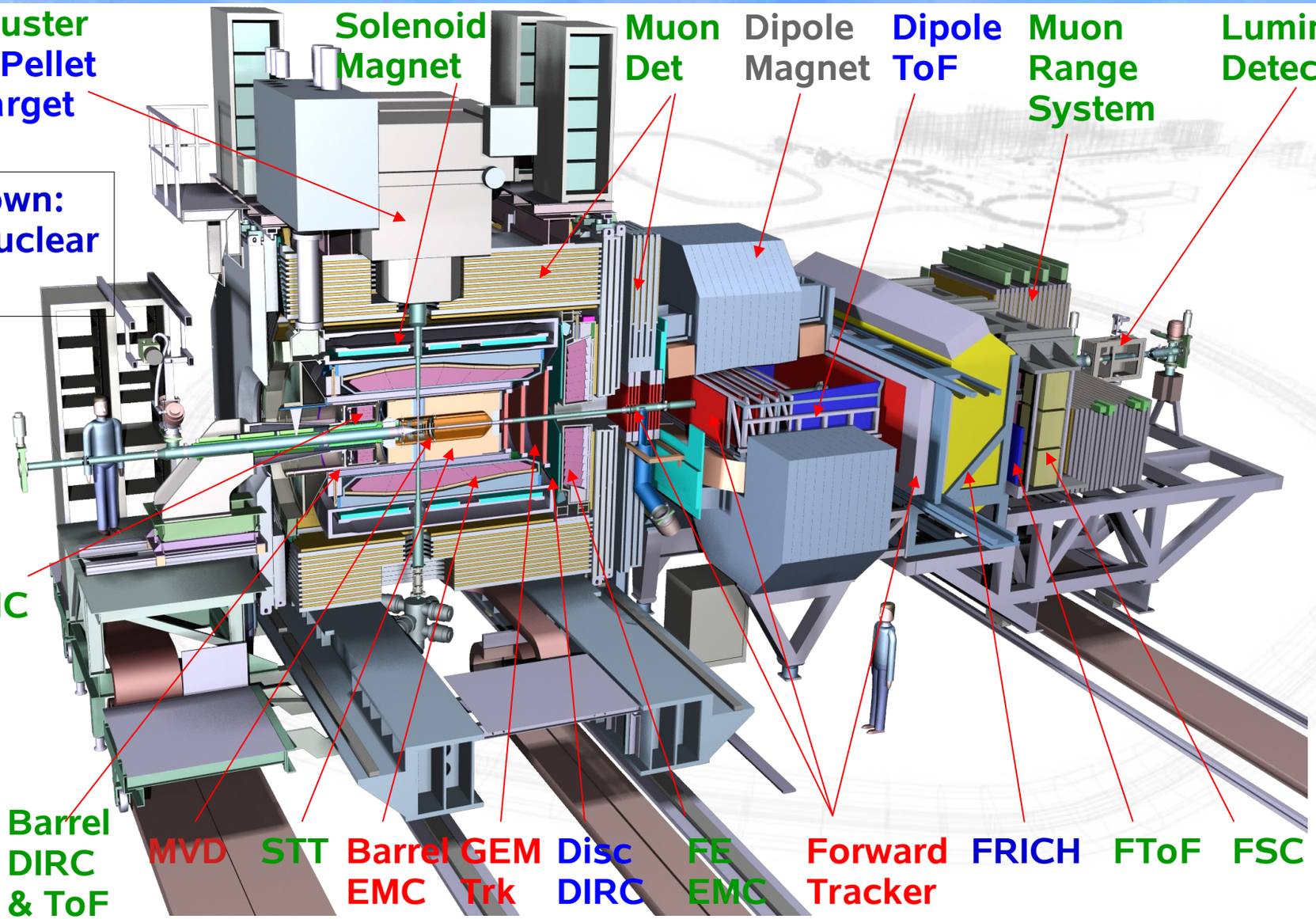
- EMC TDR Update Report approved June 17, 2021
- DAQT TDR approved August 25, 2021
- Infrastructure report submitted, in review

- GEM TDR draft passed internal review, work on revision along recommendations

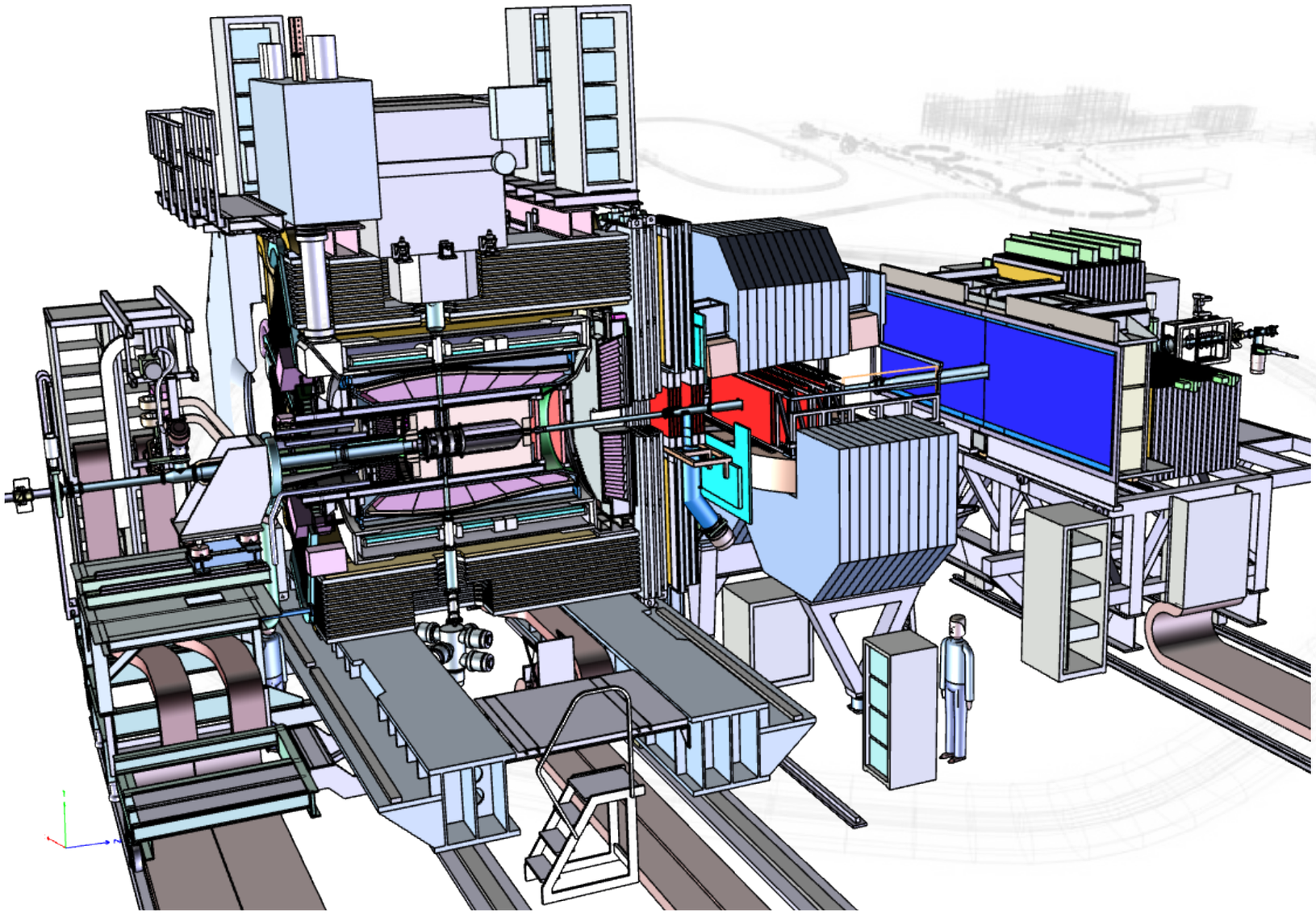
Phase 2: 1 TDR approved

- Disc DIRC: approved Nov 2019
- Pellet Target: in preparation
- Forward RICH
- Hypernuclear Setup

PANDA Day-1 / Phase 1 / Phase 2



PANDA System News



Solenoid Magnet

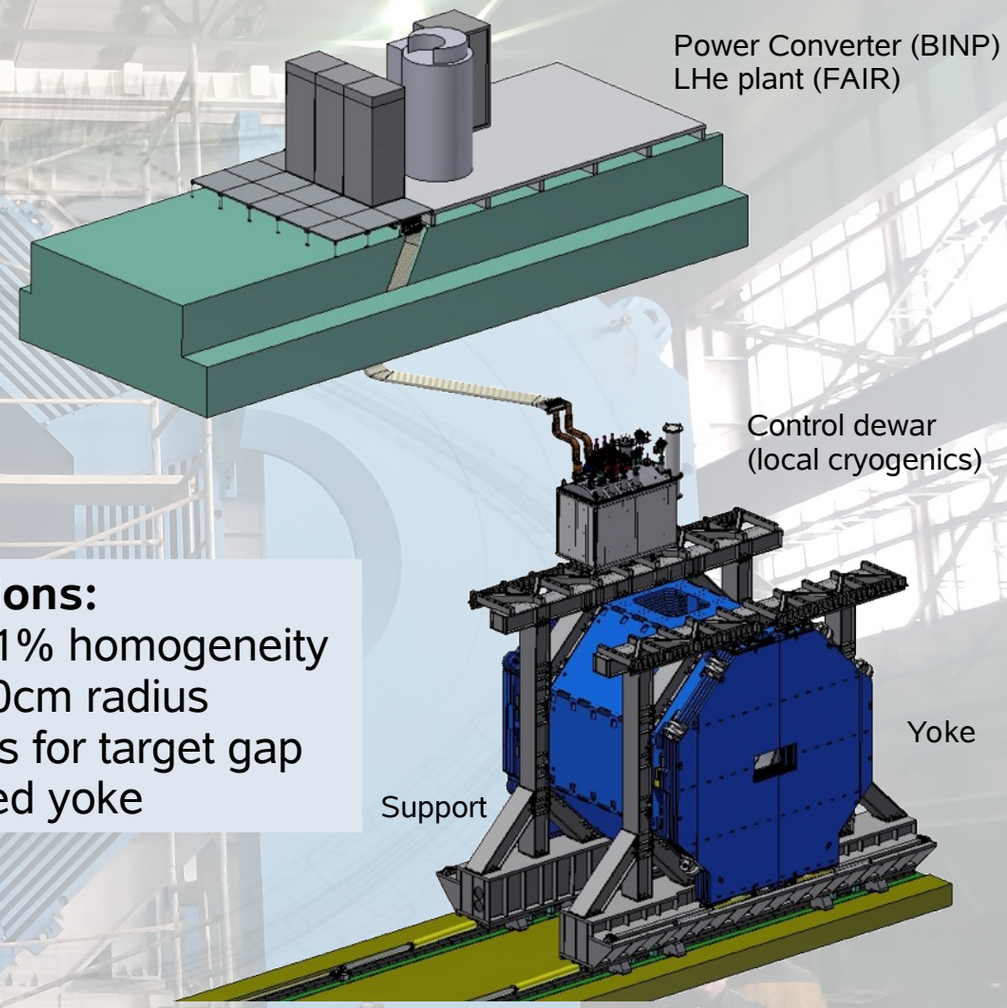
Project Status:

- Contract with BINP since March 2017
- Yoke complete, test assembly done
- Cryostat component procurement ongoing
- Local cryogenics design close to FDR

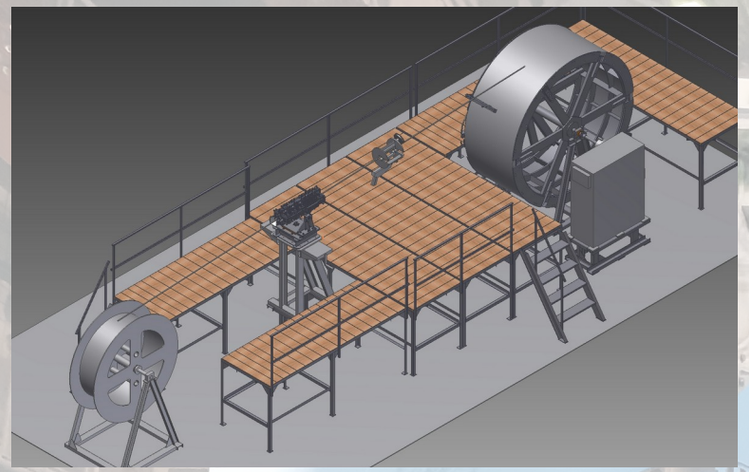
Critical Items:

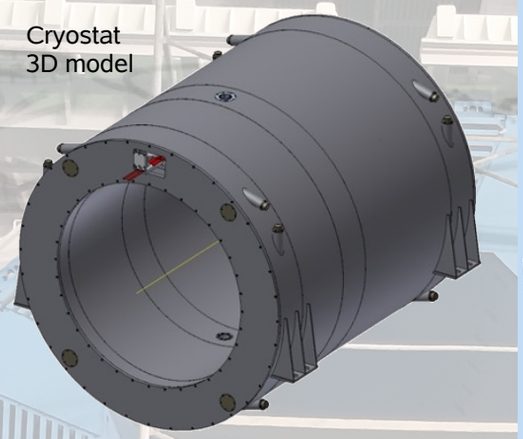
- Superconductor procurement
  - Contracts signed, purchasing in process
  - First SC strands tested within specs
- Schedule:
  - Coordination of installation at FAIR
  - Field-mapping to be done before at BINP
  - Insertion of muon detectors

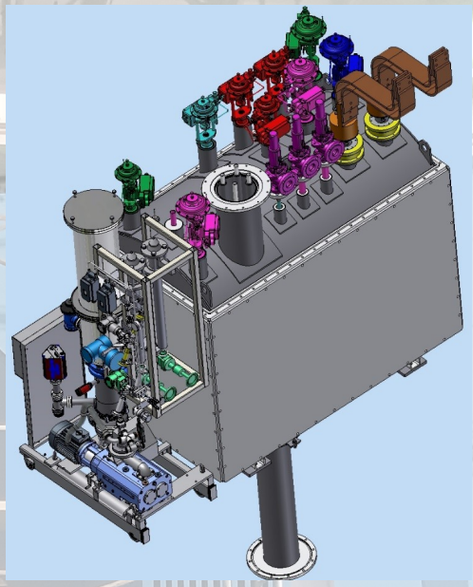
Specifications:
- 2 T field, 1% homogeneity
- Bore of 90cm radius
- 3 sub-coils for target gap
- Segmented yoke

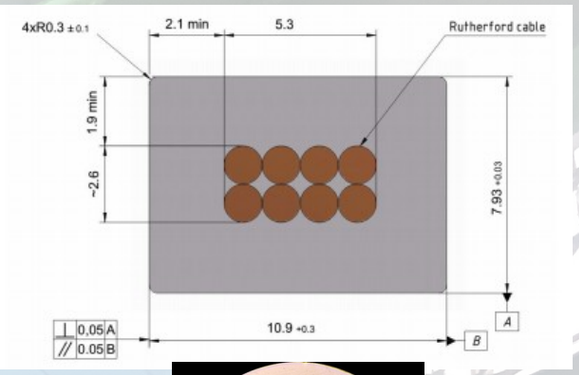


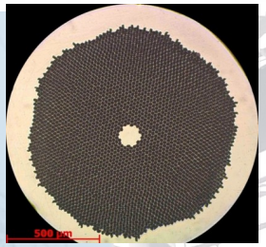
Solenoid: Progress











Coil Winding Device

- Design completed
- Tools in production, delivery in December ‘21

Electrical Systems

- Dump resistor ready
- Power supply units TDK Lambda
- Racks in production
- Bus bars with ATLAS conductor

Cryostat and Cold Mass

- Production at Votkinsk ZA
- QC of welds by BINP controls dept. done
- Delivery Q2/22

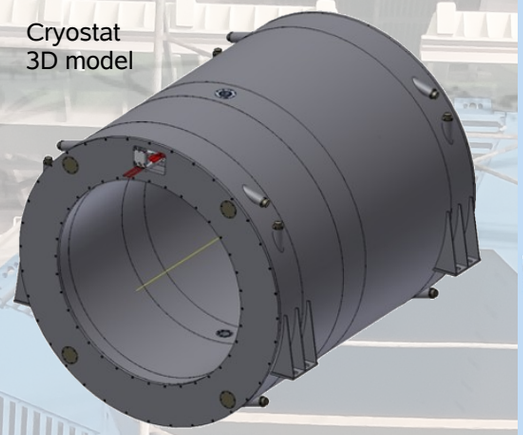
Control Dewar: FDR Q2/22

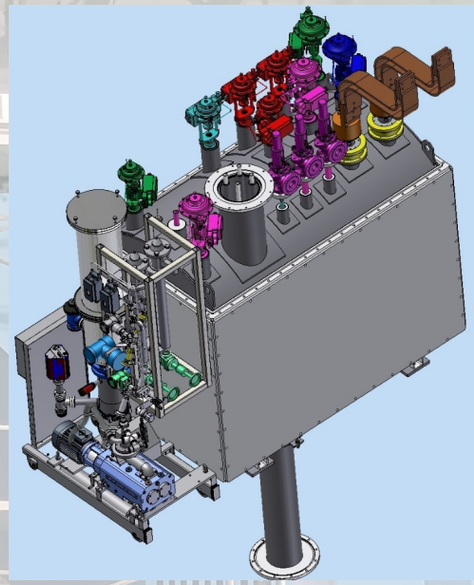
- Drawings in preparation for FDR and TÜV

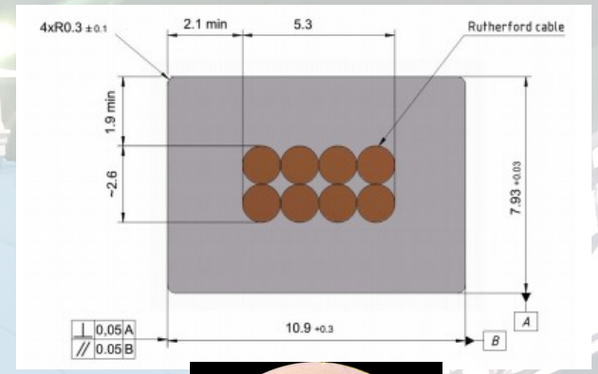
Superconductor Production

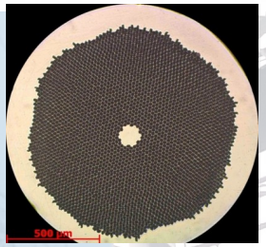
- SC strand production started, first samples better than specs
- Extrusion of pure Al at SARKO, contract for 1km test piece
- Conditioning Al gives good RRR
- Delivery till 12/22

Solenoid: Progress









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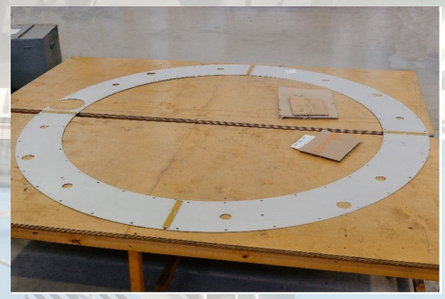
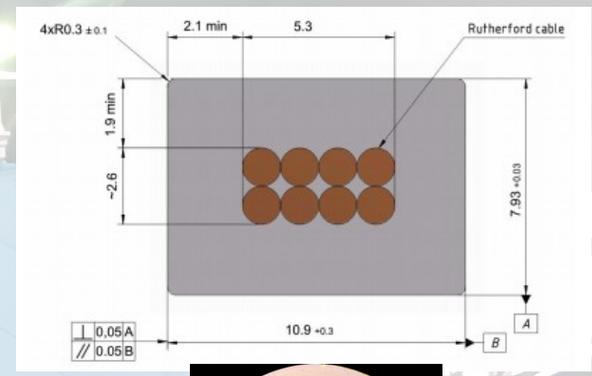
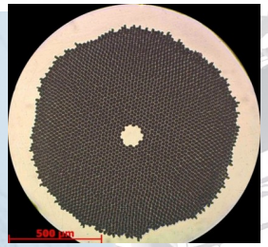
Solenoid: Progress

1) Coil Shell
2) Shield end-face
3) Cryostat flange







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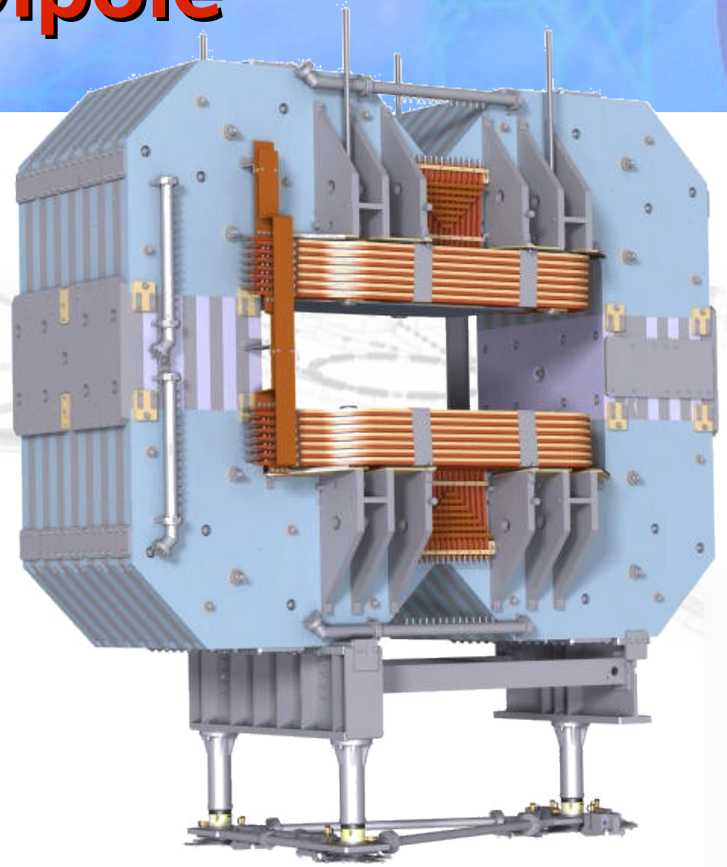
HESR PANDA Chicane Dipole

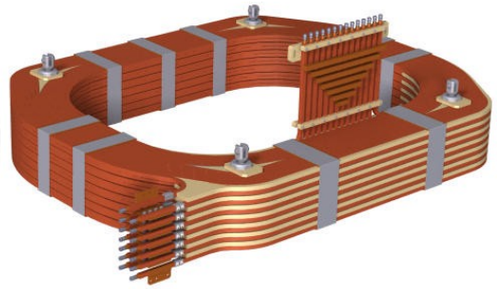
Specifications:

- Normal conducting Spectrometer Dipole
- Integral component of the HESR
- Beam deflection angle 40 mrad (2.29°)
- Dynamic range 0.2 T·m … 2.0 T·m
- Ramping speed from 25% to 100% in 60s

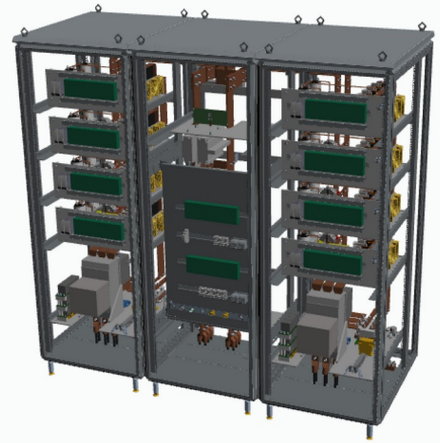
Project Status:

- Final report of magnet design received
- Preliminary design of Power Converter started
- Construction contract signed with BINP
- Material procurement and production preparation:
  - Steel order from Magnetogorsk delivered
  - Yoke production contract signed
  - Copper material ordered at Luvata
  - Tooling design for coil winding in progress

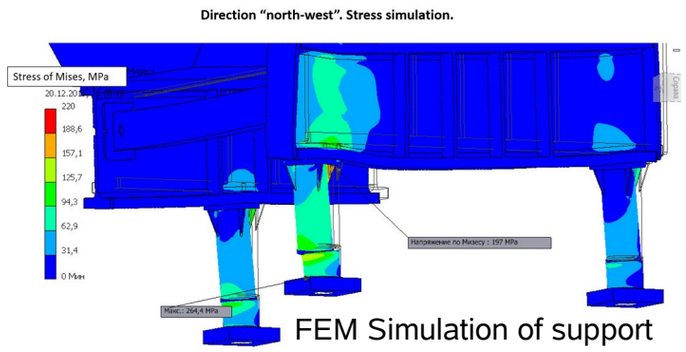




Detailed design of coil



3D CAD of Power Converter

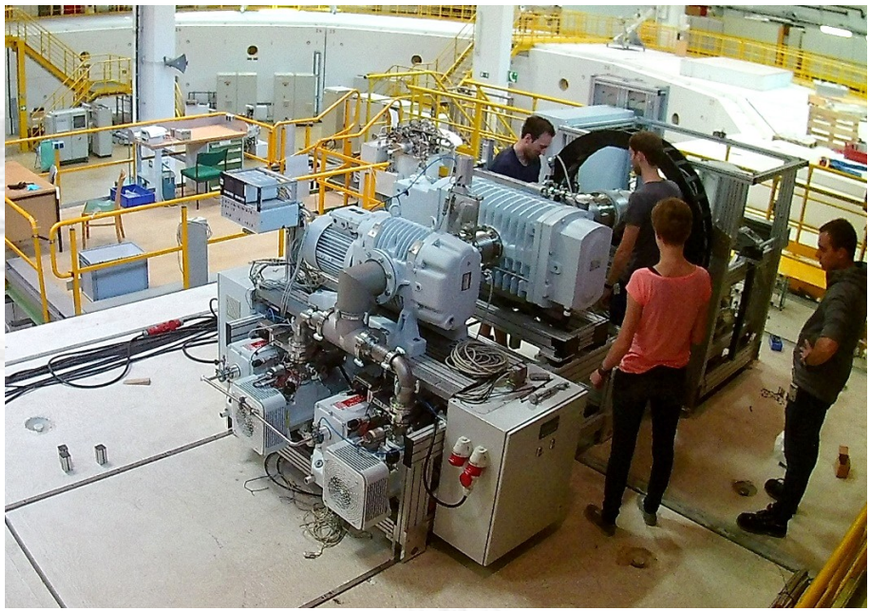


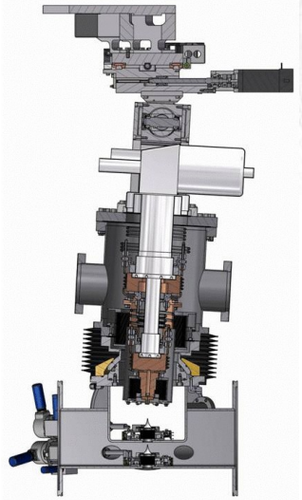
FEM Simulation of support

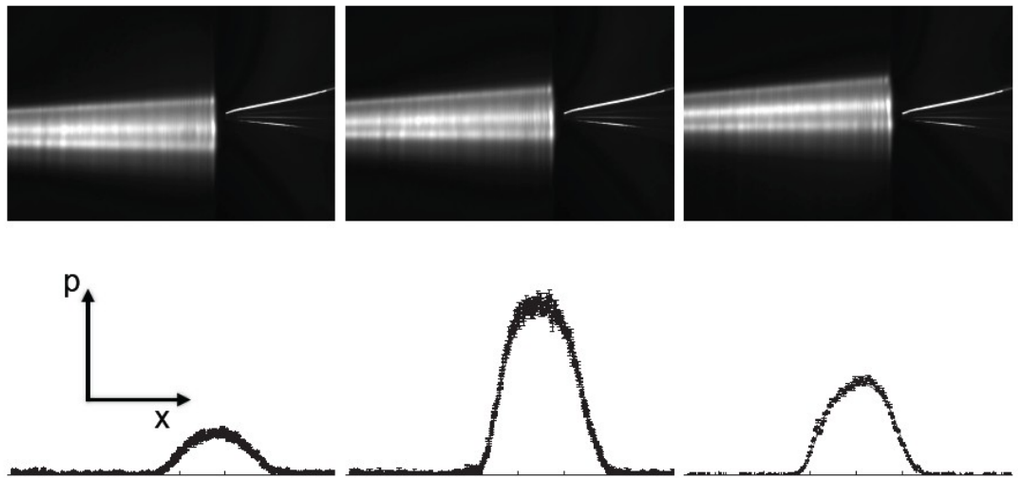
Cluster Jet Target Developments

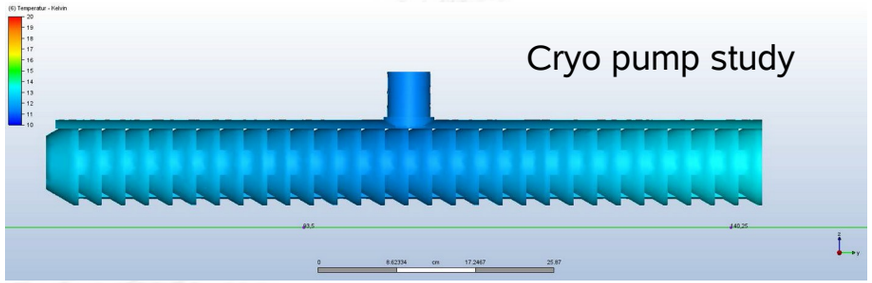
Experiments at COSY:

- Studies of beam-target interaction till 2024
- Performance of beam cooling in presence of the cluster jet
- Vacuum situation at IP and improvements
- Latest campaign took place May 2021:
  - 3.0 GeV/c p beam, 2×10^{9} – 5×10^{9} s^{-1}, target 1×10^{13} - 2×10^{15} atoms/cm^{2}
  - HESR stoch. cooling & barrier bucket cavity: $\Delta p/p = 10^{-4}$ after 100 s
  - MAD-X simulation of beam-target interaction
- Design study for cryo pump prototype
- Automatic nozzle adjustment in development: steady luminosity









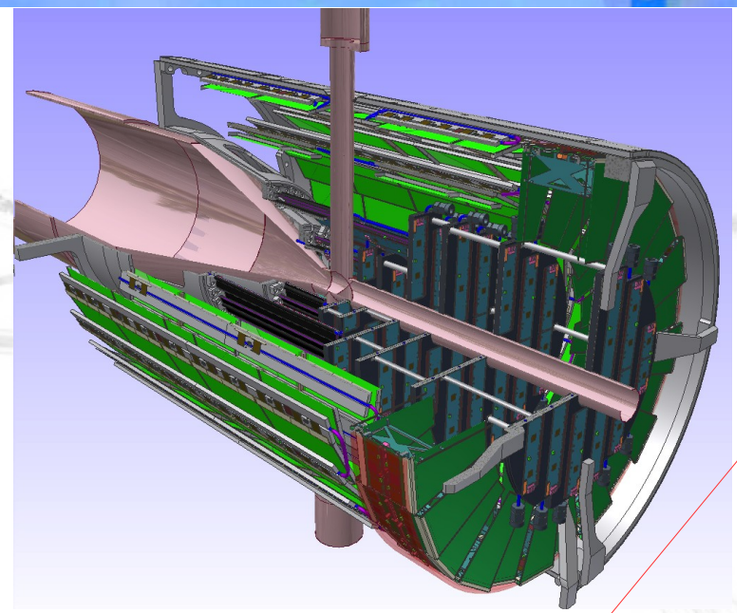
Micro Vertex Detector

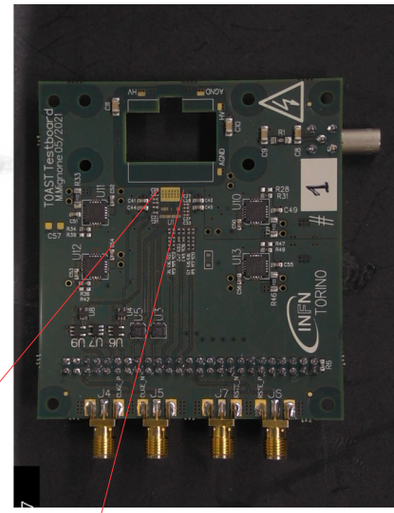
- **MVD Layout**
  - Barrel: 2 pixel layers, 2 strip layers
  - Forward: 6 disks, 2 mixed strips and pixels
  - Advanced mechanical engineering
  - ToPix ASIC prototype with full functionality

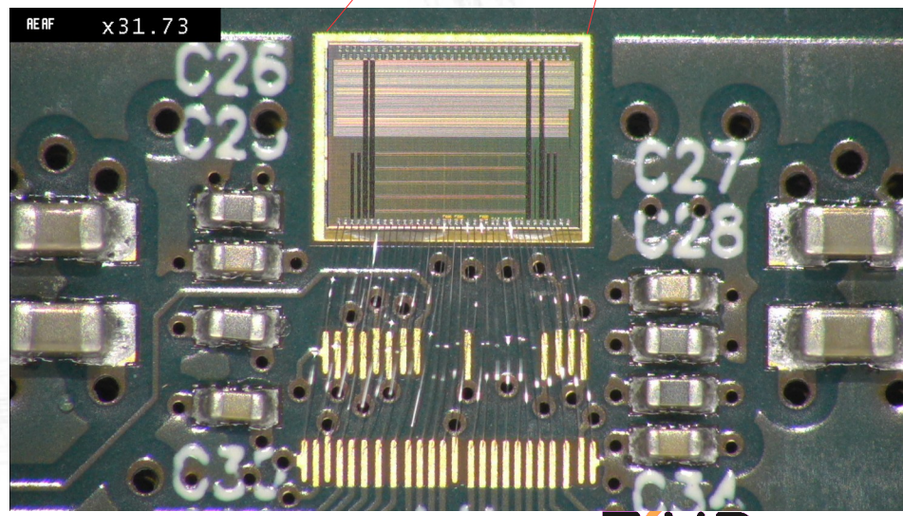
  Pixel part currently on hold

- **First priority: strip barrel**
  - New 64 ch ASIC ToASt for strips:
    - 60 Chips delivered in October
    - Successful chip tests
    - Preparation of SEU tests
  - Mechanical design progress at FZ Jülich: stave prototypes produced in autoclave
  - Further barrel strip sensors ordered in Gießen

- **Further progress:**
  - FE board design at KIT
  - MDC ASIC design at KIT







ToASt ASIC wire bonded to test PCB

Straw Trackers in PANDA

Central Tracker STT

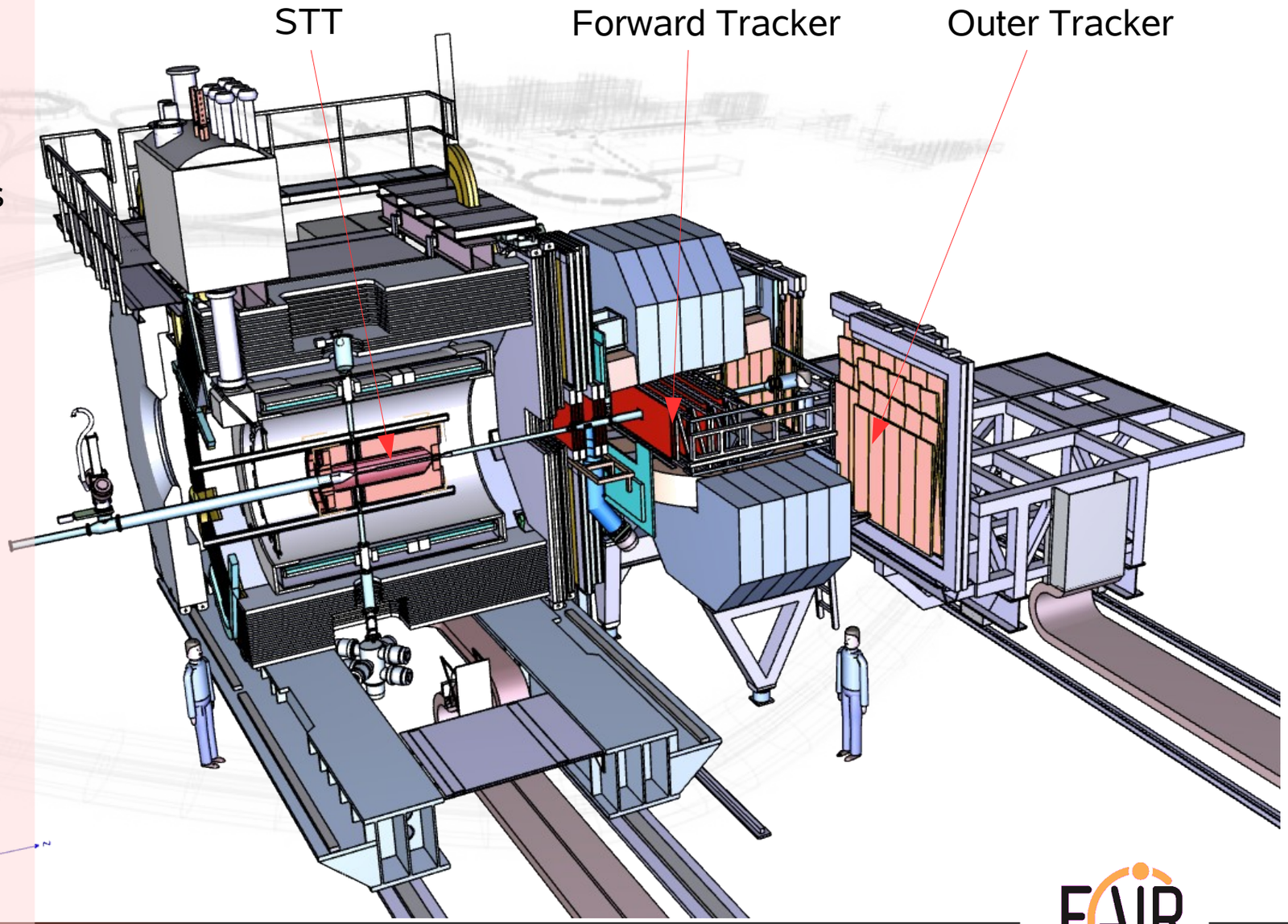
- 4600 straws, Ø 1 cm
- Ar CO_2 at +1 bar
- 20 parallel layers, 8 skewed layers
- 0.05% X_0 / layer
- ASIC readout

Forward Tracker 1-4

- 2+2 planar stations, 5600 straws, Ø 1 cm
- Ar CO_2 at +1 bar
- 4 DL/station (x,u,v,x)
- ASIC readout

Outer Tracker (LHCb straws)

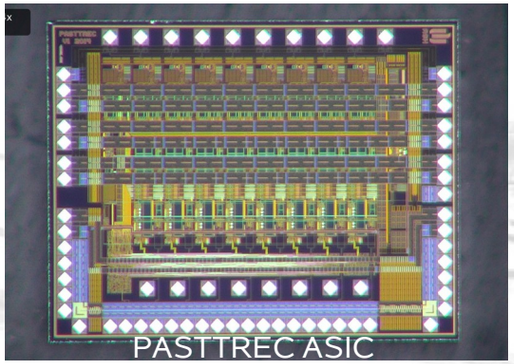
- Inner half length modules 2.4m
- 10800 straws, Ø 0.5 cm
- 0.1% X_0 / layer
- Readout from LHCb + interface

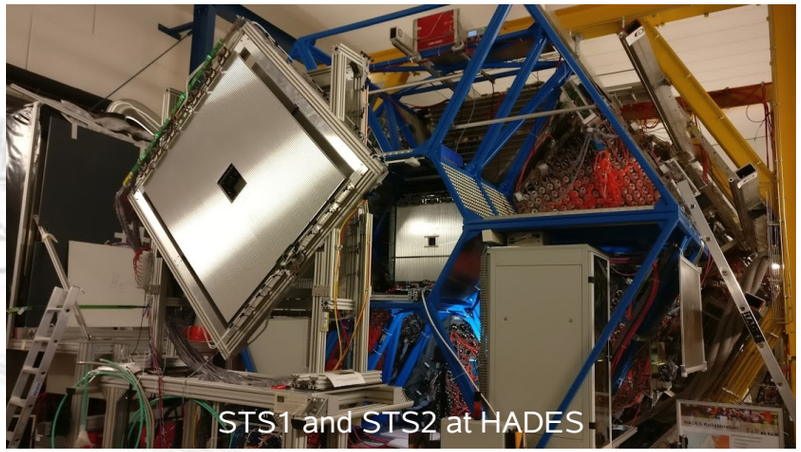


Progress of PANDA Straws

Status of electronic readout (AGH):

- All PASTTREC ASICs delivered
- Mass testing of FEBs
- Est'd FEB yield >94% (PASTTRECs>97%)


PASTTREC ASIC

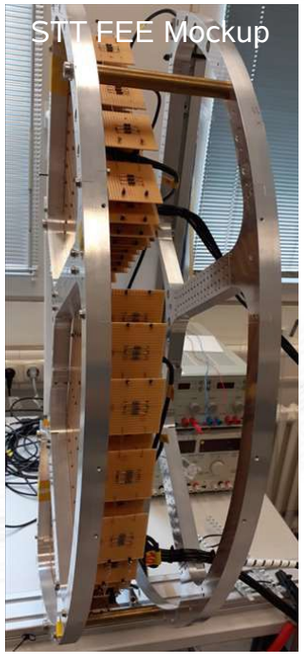

STS1 and STS2 at HADES

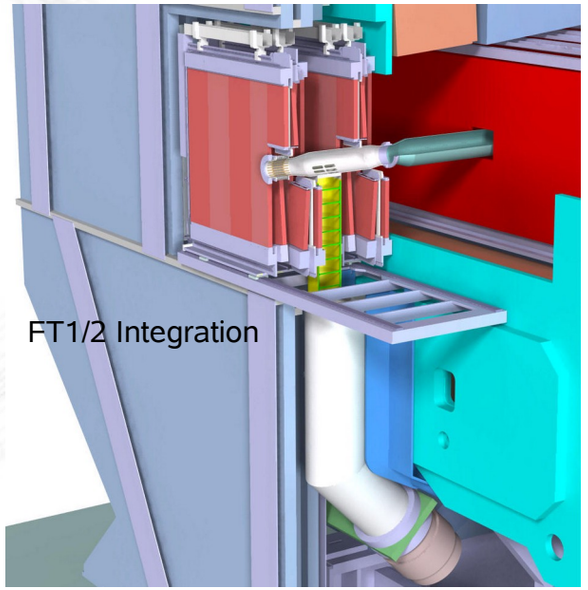
PANDA@HADES STS:

- Successful start of physics beam time: online tracking

Central STT design work:

- FEE air cooling design studies
- Preparation of frame assembly


STT FEE Mockup

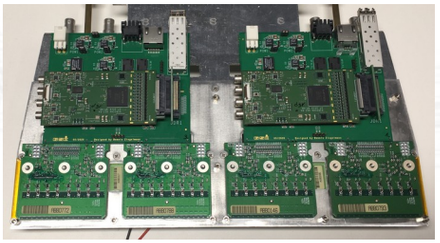

FT1/2 Integration

Forward Tracker FT1-4

- In-kind contract with JU Krakow, procurement of material started
- Aging studies with varied CO2 and 4 glues
- Detailed mechanical production design in progress

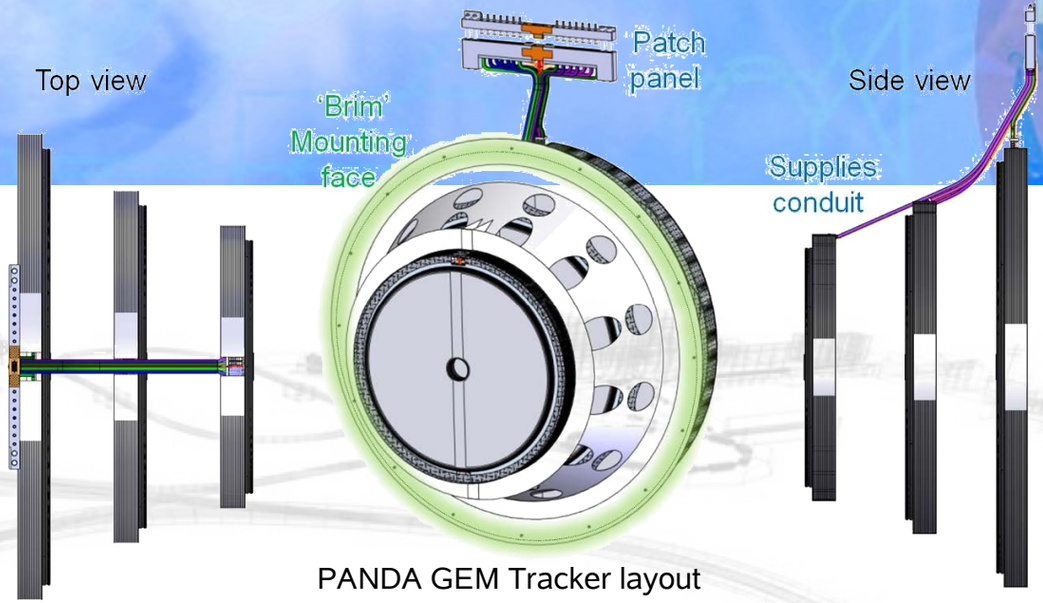
Outer Tracker

- Interface board to connect LHCb FEE ready
- Preparation of system test
- Mechanics design with SLRI, Thailand



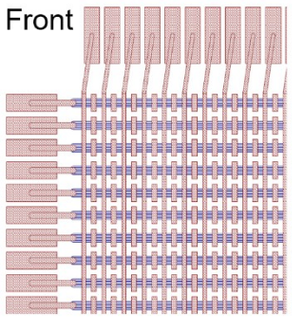
GEM Tracker

- GEM-Production
  - QA, classification & selection
  - Considering available suppliers
- Laboratory tests of framed foils
- GEM-TPC beamtime at FRS 12/19
- Readout design
  - CTR16 prototype ASIC submitted: CSA and analog Transient Recorder
  - VMM3 readout from CERN for tests
- TDR draft reviewed by PANDA, recommendations from review

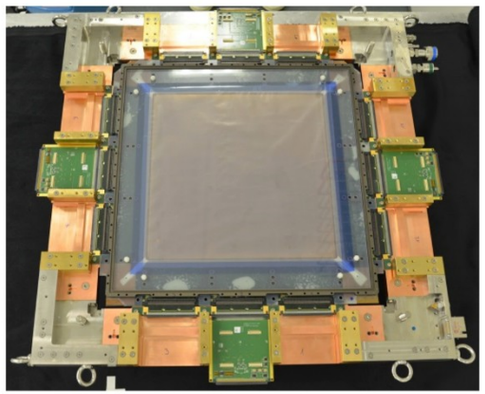


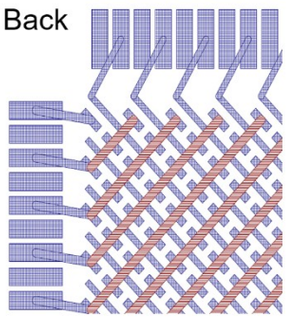
PANDA GEM Tracker layout

GEM2D Demonstrator

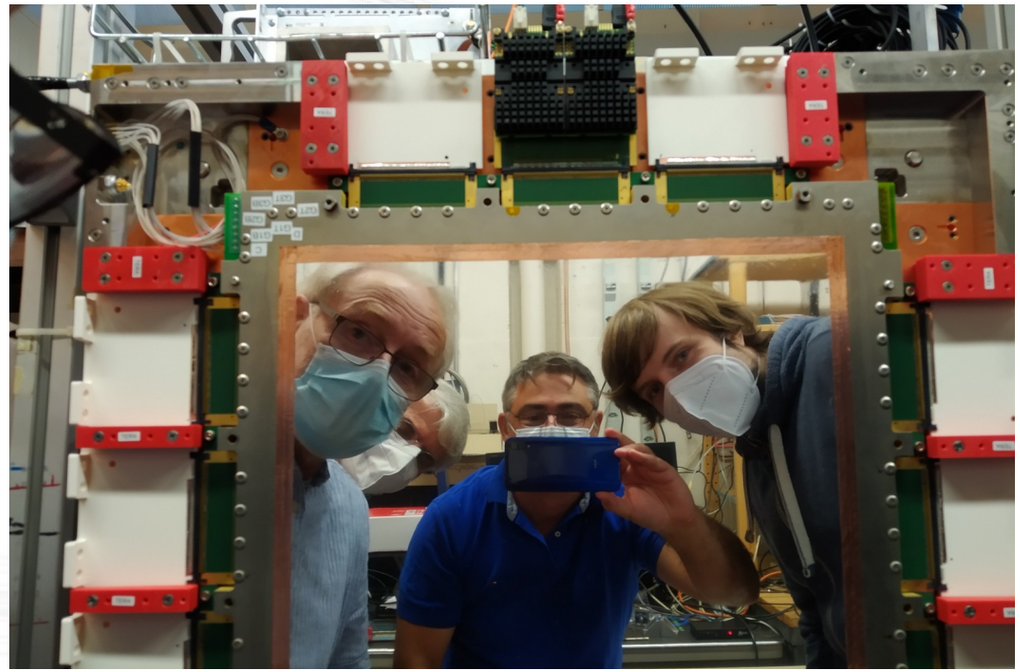


Cartesian
Δ 400µm





Tilted Cartesian
Δ 566µm


GEM2D in RD51 Lab at CERN

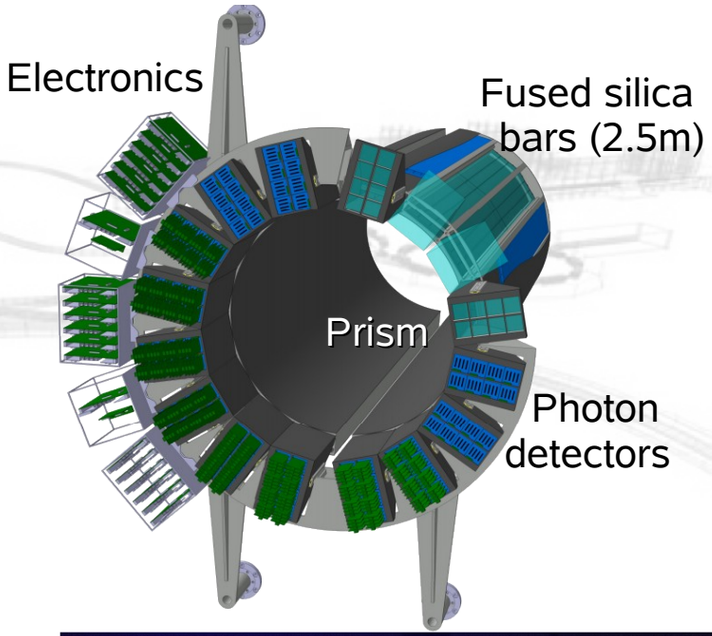
Barrel DIRC

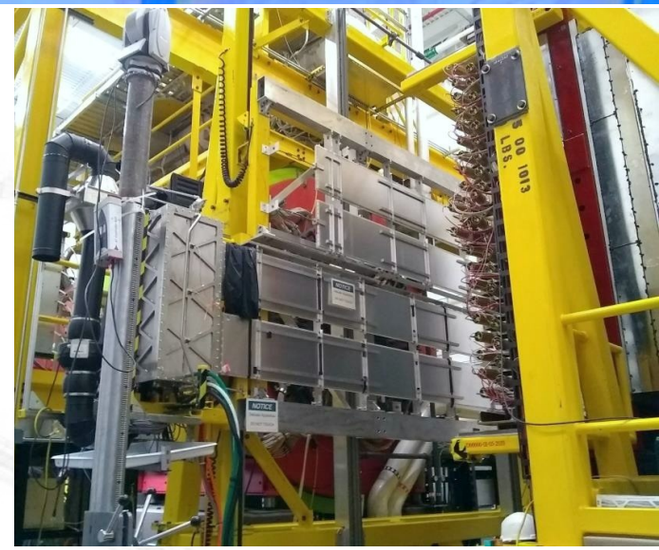
Baseline design

- Fused silica (SiO_2) radiator bars and prisms
- MCP PMT for readout
- Focusing by 3-layer spherical lenses
- Fast readout to suppress BG

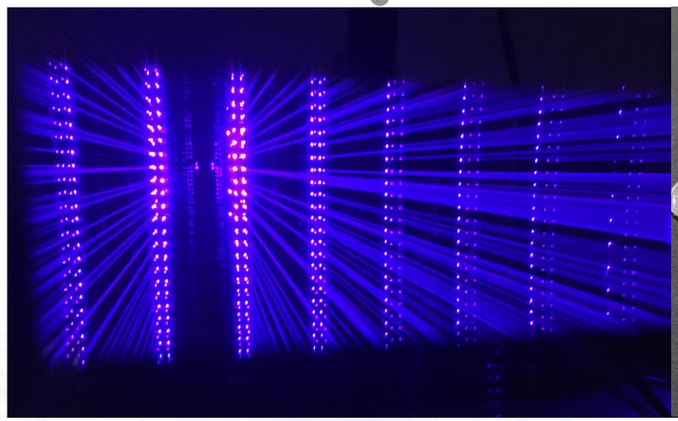
Project status

- Series production of DIRC bars at Nikon
- All 112 bars delivered to GSI
  - detailed evaluation ongoing
  - preparation of order for spares
- MCP PMT procurement:
  - evaluation of samples completed
  - order placed 22/12/2020
  - delay due to problems with ALD device
- Prototype lenses received,
  laser tests at CUA (USA) ongoing
- Phase 0: Participation at GlueX DIRC





GlueX DIRC



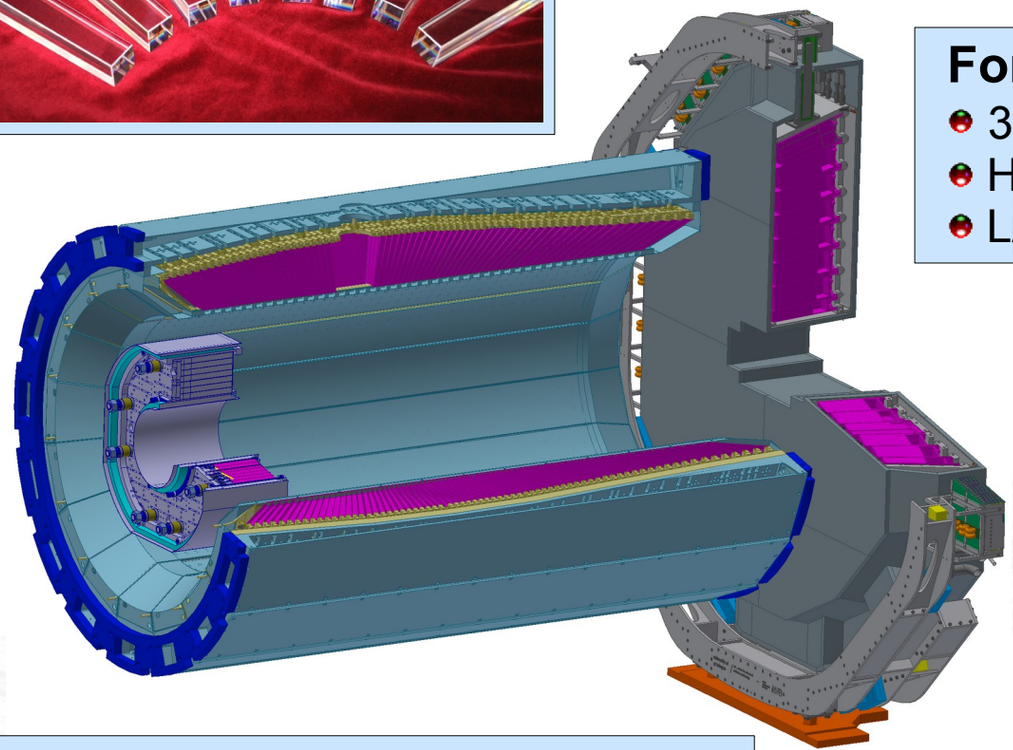
Kaleidoscopic image of a HeCd laser beam a DIRC bar on test bench

3-layer lens prototypes

PANDA EMC

$\bar{P}$ANDA PWO Crystals

- PWO is dense and fast
- Low energy threshold
- Increase light yield:
  - improved PWO II (2xCMS)
  - operation at -25°C (4xCMS)
- Challenges:
  - temperature stable to 0.1°C
  - control radiation damage
  - low noise electronics
- New producer CRYTUR



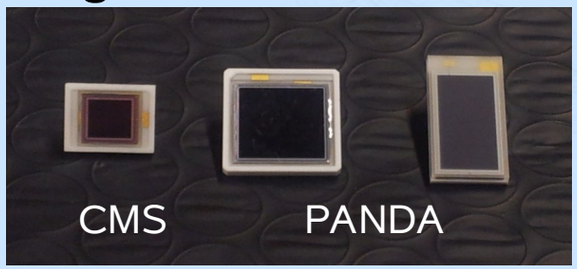
Barrel Calorimeter

- 11360 PWO Crystals
- LAAPD readout, 2x1cm²
- σ(E)/E~1.5%/√E + const.

Forward Endcap

- 3856 PWO crystals
- High occupancy in center
- LA APD and VPTT

Large Area APDs



5x5 mm² 10x10 mm² and 7x14 mm²

Backward Endcap for hermeticity,
524 PWO crystals

Barrel EMC Status

Mechanics

- All alveoles produced
- First slice fully assembled, cooling implemented
- Installation with annealing LEDs
- Mechanics FDR in preparation

Crystals

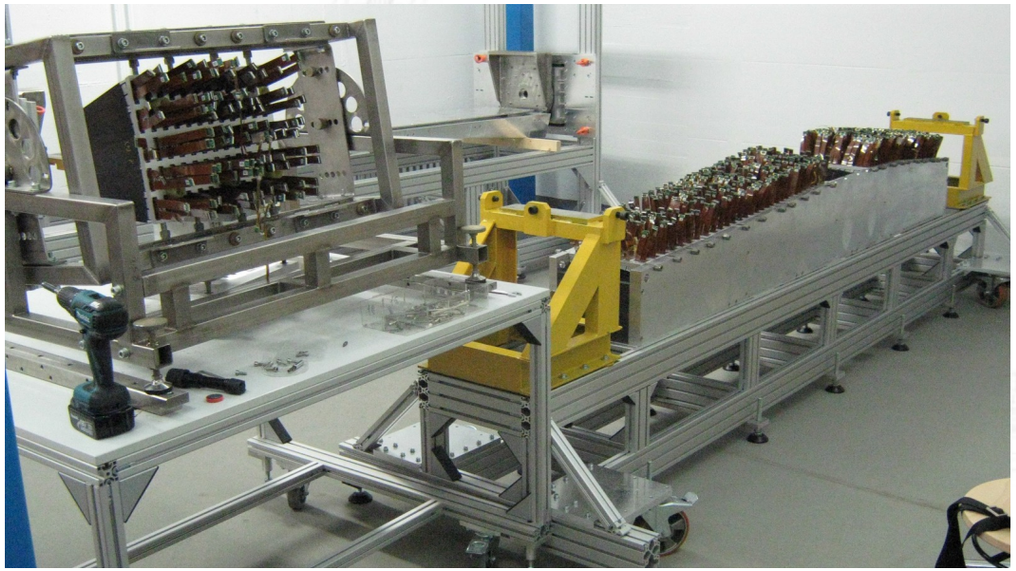
- New producer Crytur
- 4000 crystals for Day-1 needed

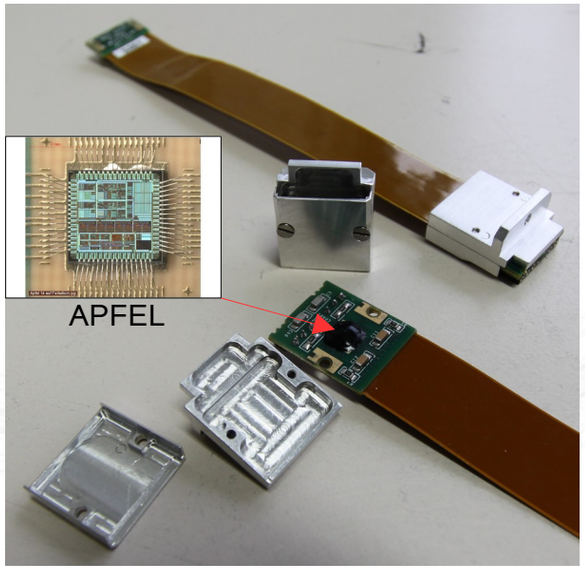
Readout

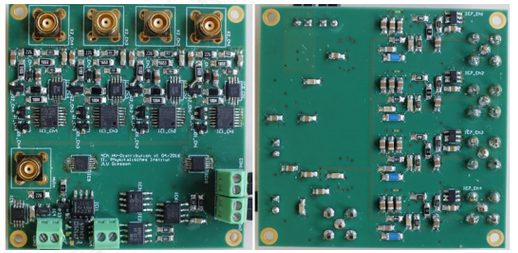
- APFEL ASIC, all available, flex PCBs ordered
- Hit Detection ASIC: ATR16 prototype delivered
- Protocol ASIC for control
- HV regulation board

Services

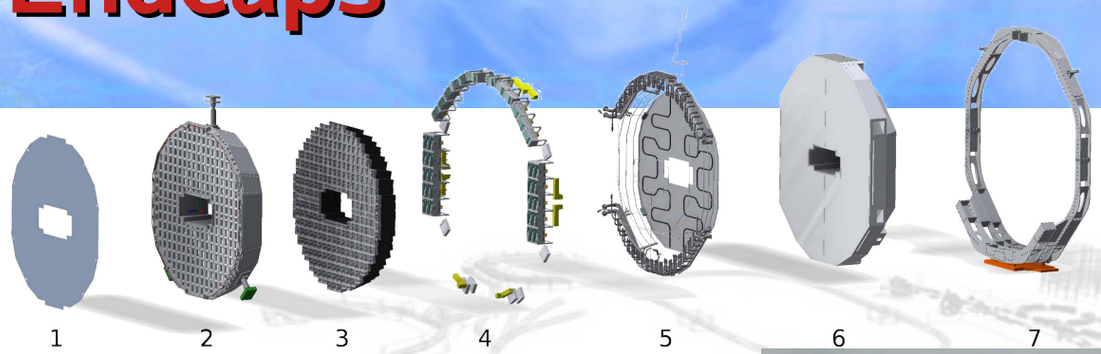
- Light pulser monitoring
- Stimulated recovery with LED

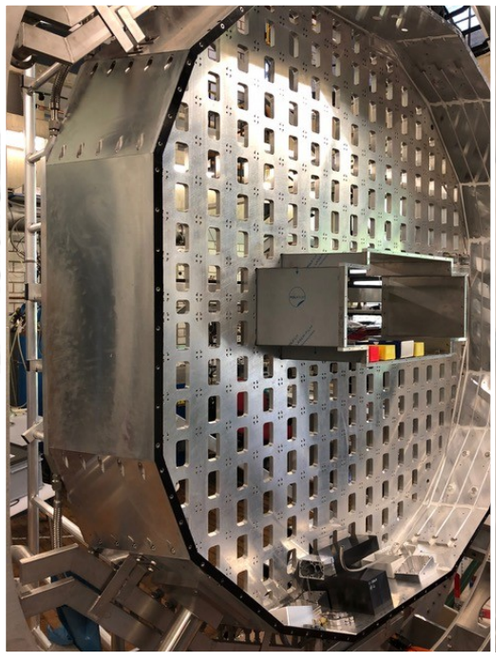






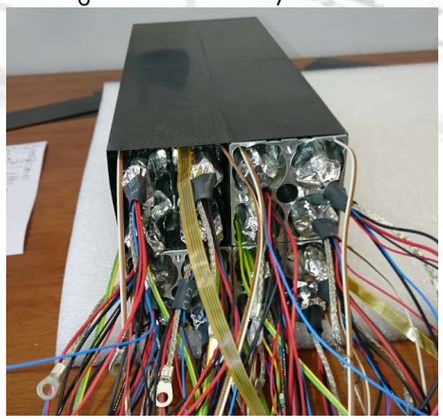
EMC Endcaps





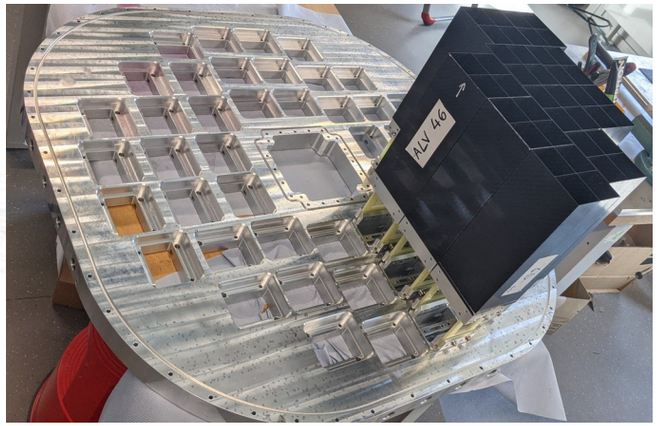
Forward Endcap

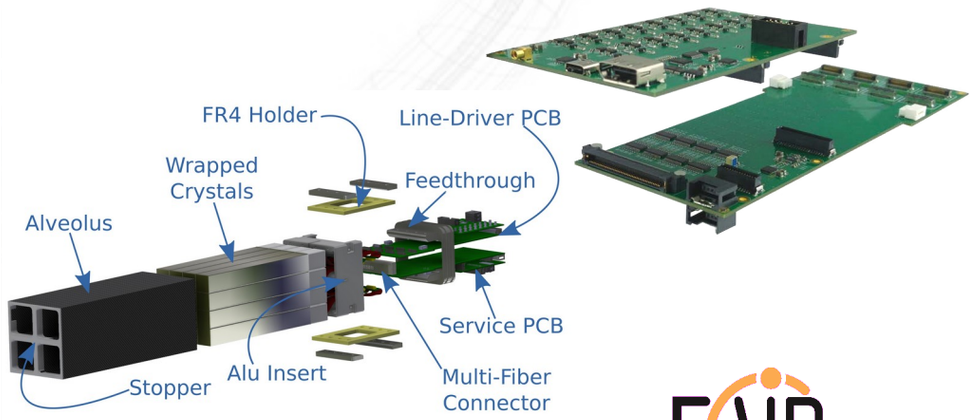
- Assembly of VPTT modules done
- APD modules: ~160/214 done, 3/wk
- 1500 new APDs delivered
- Cosmics calibration at U Bonn
- Front lid, cooling pipes, SADC crates
- Pre-assembly planned at FZJ in ‘22



Backward Endcap

- Assembly of Phase 0 system
  (640 ch instead of 524 for PANDA)
  - All alveoles produced
  - Delays in assembly process
  - Beamtime at MAMI in 2023
  - HV distribution board done
  - Al support plane delivered





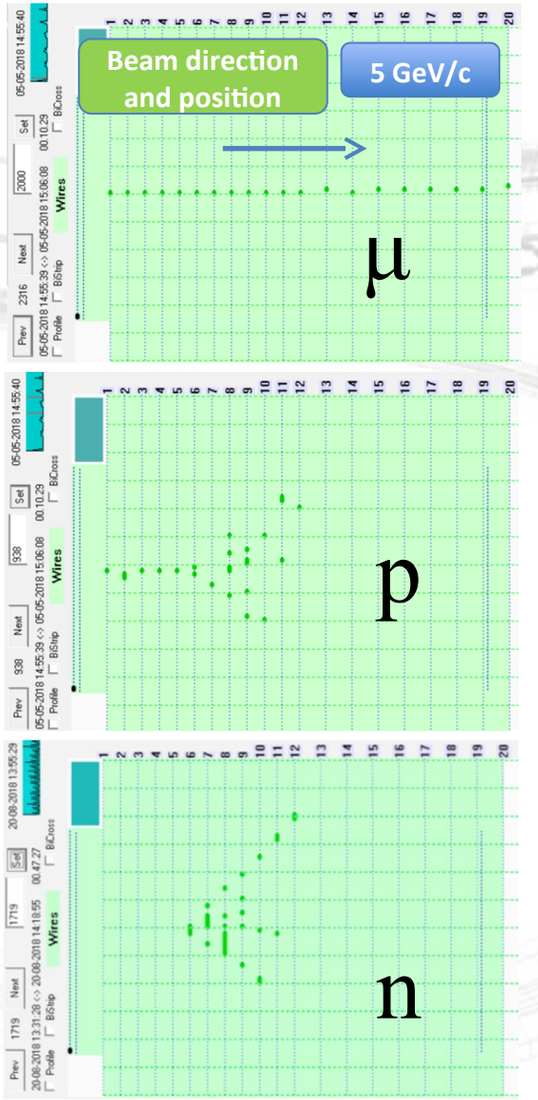
Muon Detectors

Status

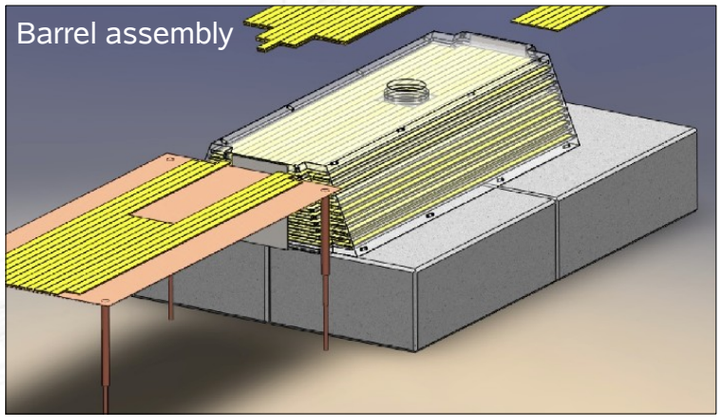
- TDR approved in 2015
- Baseline design ready
- Prototype (10t) test results at CERN:
  μ, p and n easily resolved
- Prototype setup (1.5t) at Nuclotron/JINR

Ongoing activities

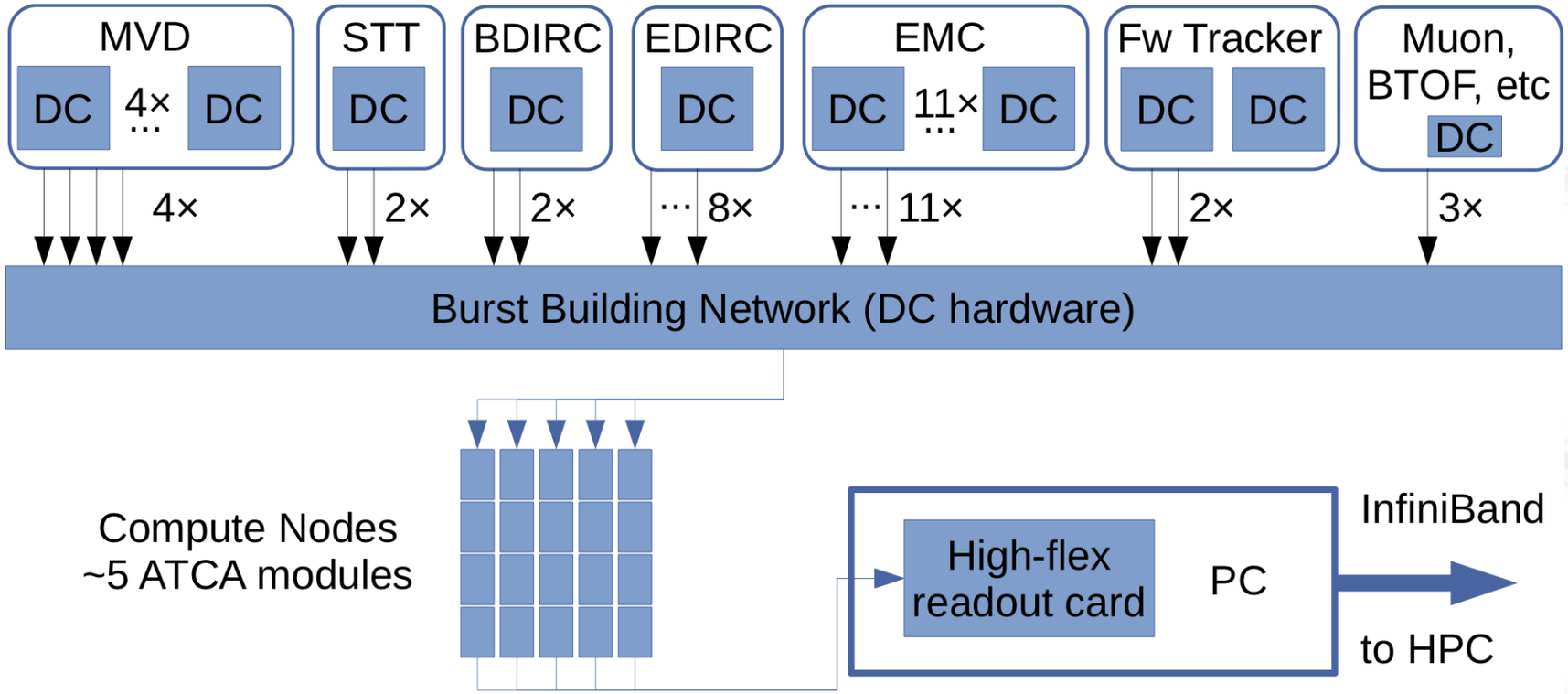
- Detailed simulation, PID software
- Digital FEE: Artix FPGA board ready
  Synergy with NICA SPD
- **FAIR Council:** first funds for barrel chambers
- Preparation of specs
- JINR PAC approves work
- Renew supplier contacts for components:
  - Al profile extrusion
  - Readout ASICs (Integral, Minsk)
  - Plastic furnishings from Yerevan
- Next step: Collaboration Contract



Range System Prototype at CERN mounted for cosmic tests



PANDA DAQT

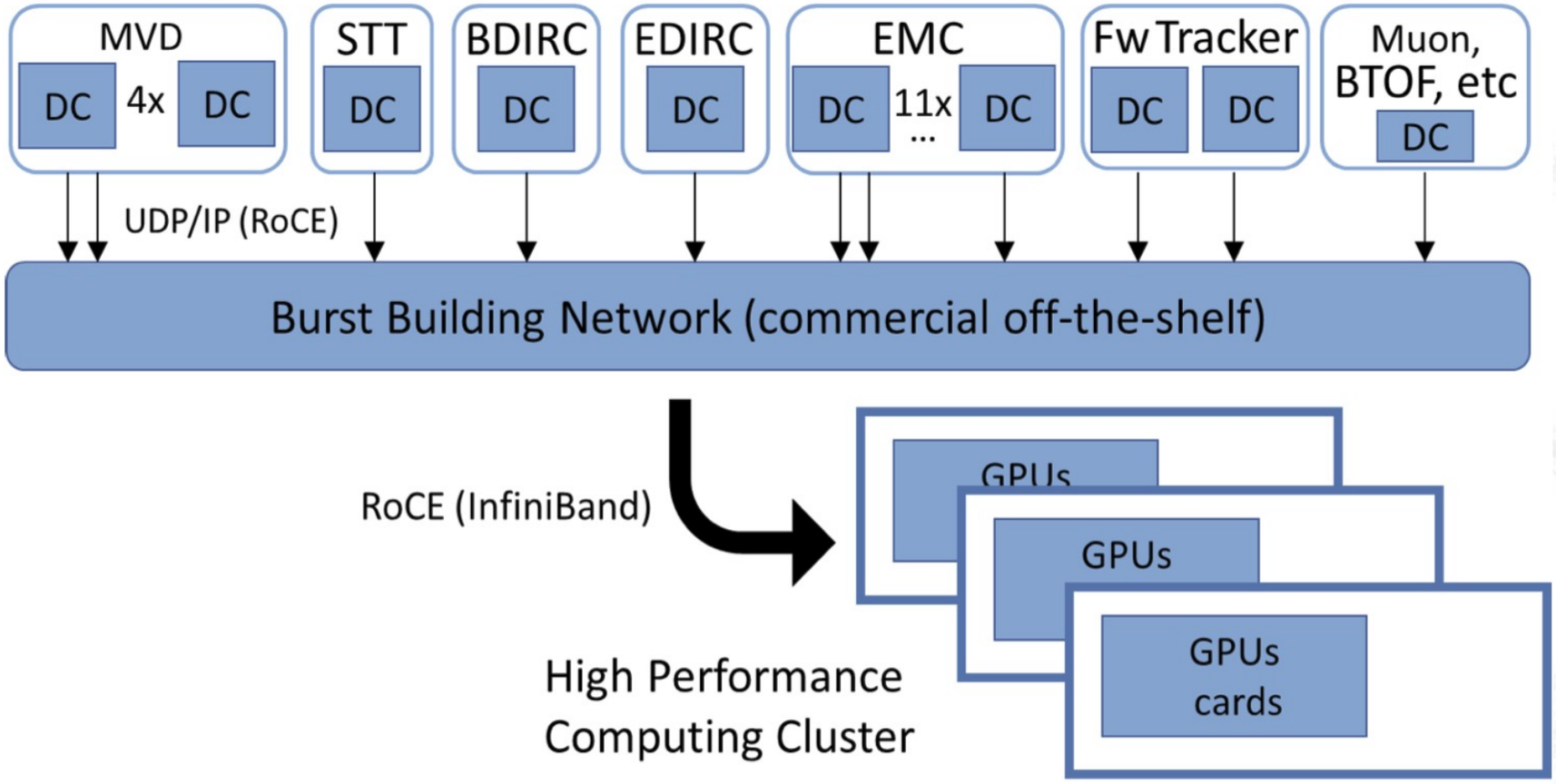


Full DAQT Scheme
for Phase 1/2

- Prototypes for all required hardware available
- Data rate 10 GB/s at Phase 1&2 (<2 MHz rate)

- TDR approved by FAIR August 2021, work by M. Kavatsyuk, RU Groningen
- From 2022 DAQT coordination taken over by G. Korcyl, JU Krakow

PANDA DAQT

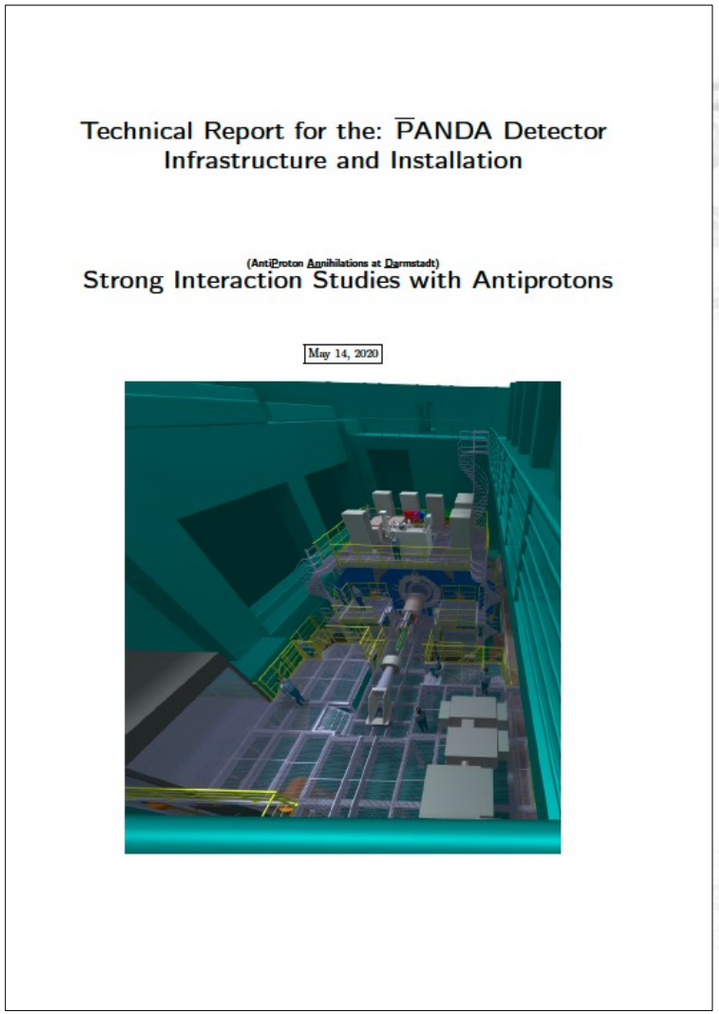


Initial DAQT Scheme
for Day-1 and Tests

- Prototypes for all required hardware available
- Data rate 10 GB/s at Phase 1&2 (<2 MHz rate)

- TDR approved by FAIR August 2021, work by M. Kavatsyuk, RU Groningen
- From 2022 DAQT coordination taken over by G. Korcyl, JU Krakow

Updates on Infrastructure


Technical Report for the: $\overline{\text{P}}$ANDA Detector
Infrastructure and Installation

(AntiProton Annihilations at Darmstadt)
Strong Interaction Studies with Antiprotons

May 14, 2020

Continuing work since Infra Report:

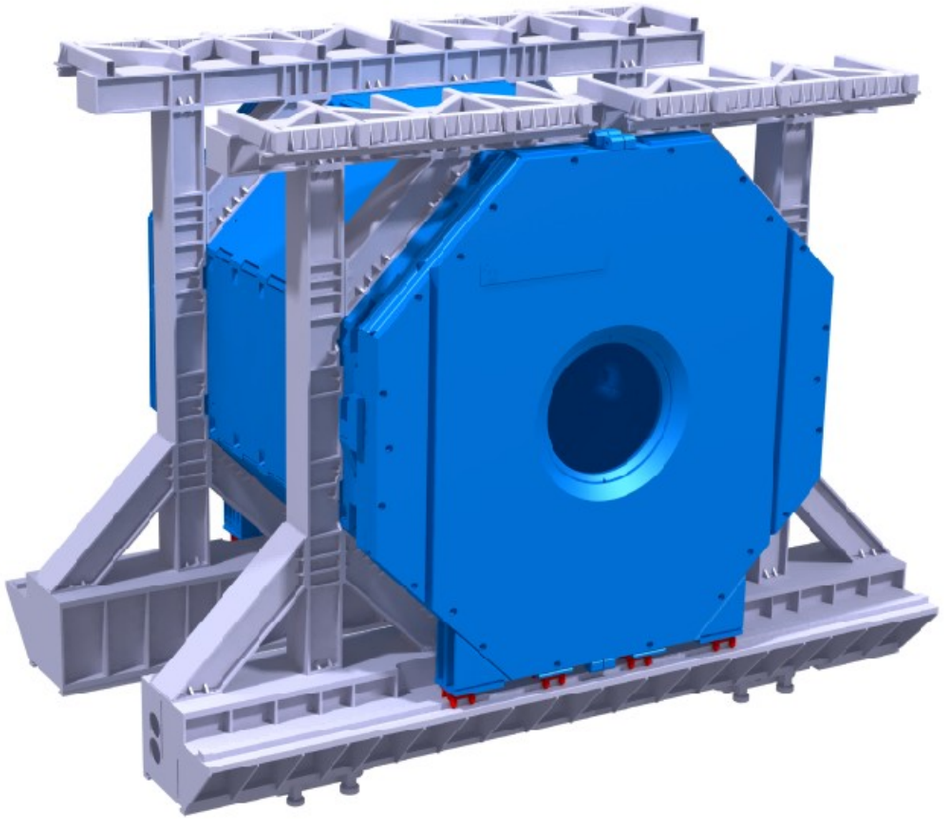
Project topics
- Safety risk assessment
- Alignment strategy
- Commissioning strategy

Support structures
- Solenoid Platforms
- Installation procedures
- Rack placement

Supply infrastructure
- Leakless rack cooling
- Technical gases

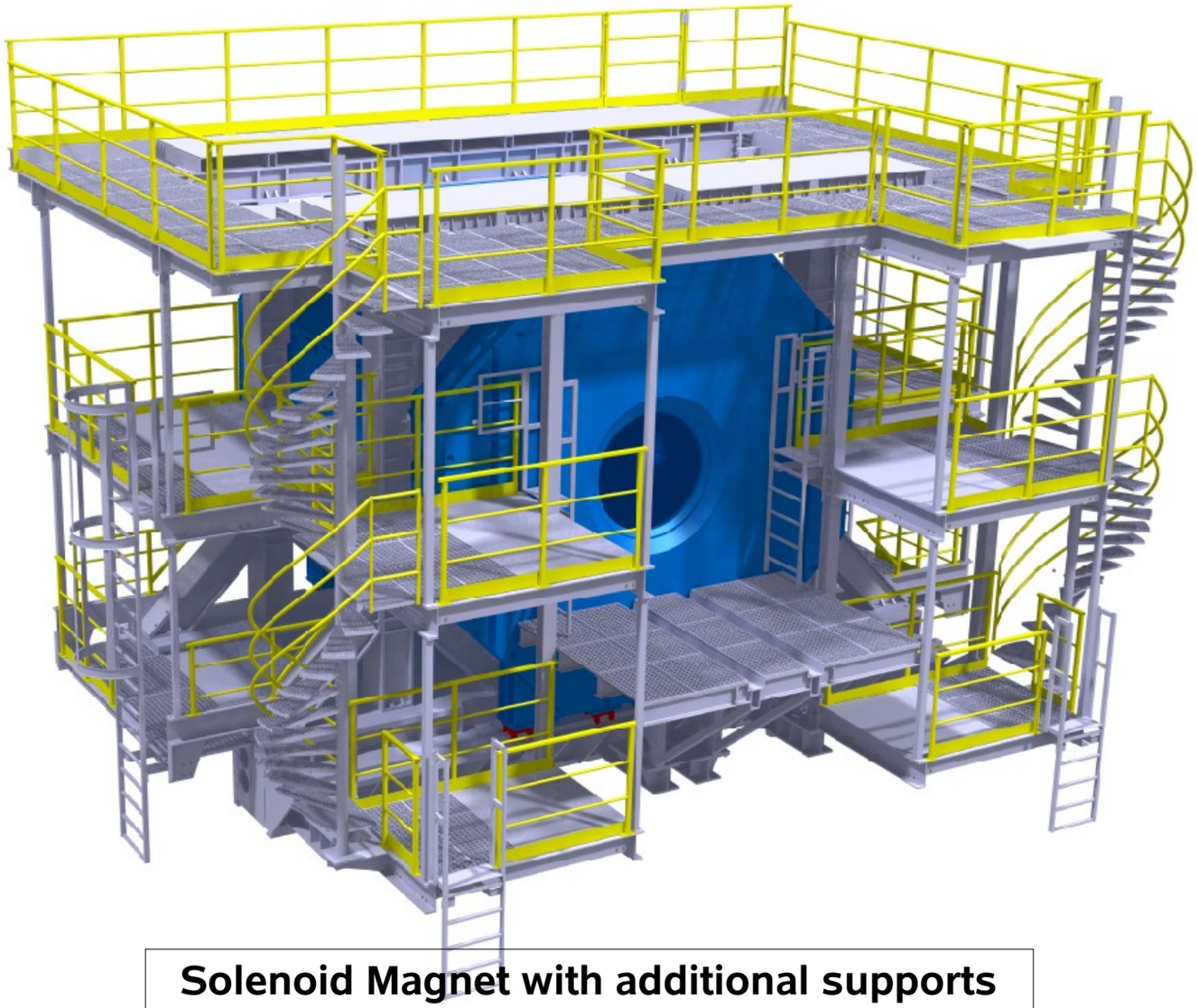
Recommendations by ECE/ECSG:
- Approval of report by FAIR
- Consider as living document to update regularly
- Technical personnel for safety and infrastructure

Solenoid Platforms



Solenoid Magnet Yoke

Solenoid Platforms



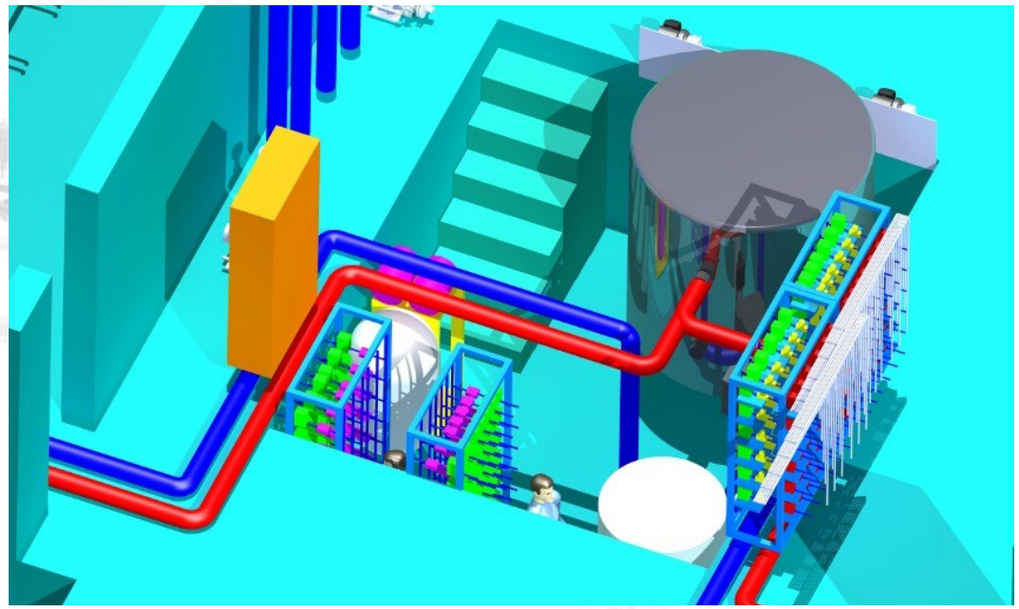
Solenoid Magnet with additional supports

Proposal for an add-on contract for BINP:
- Production of yoke and platforms unified
- Early implementation of interfaces
- Certification of stability in one hand

Supplies: Rack Cooling, LN2 Supply

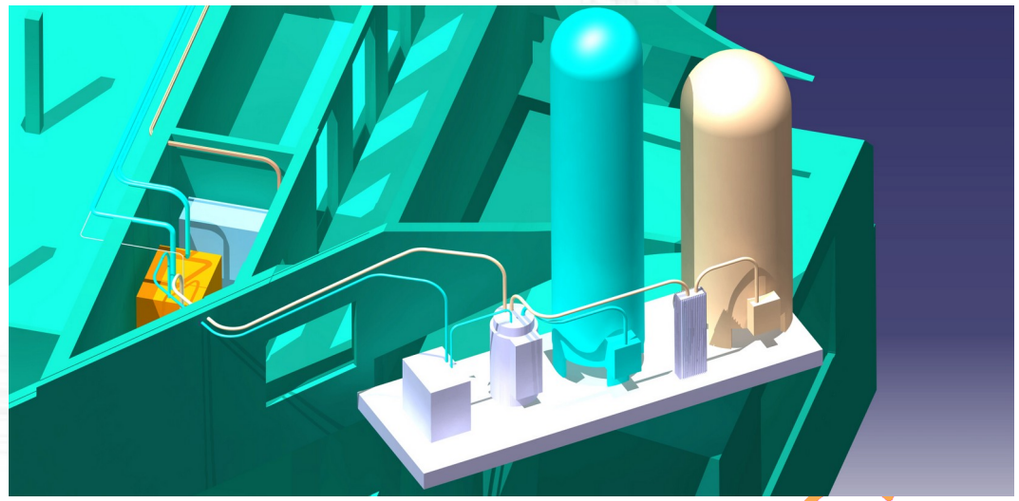
Planning of under-pressure rack cooling

- Distribution circuits planning and seizing
- Pumps and reservoir below floor level
- Under-pressure systems:
  - MVD and EMC detector cooling
  - Rack cooling
- Current layout of pit to small: enlarge 2x
- Pressure drop calculations



LN2 Supply

- LN2 to cool GHe of Solenoid shield in parking position
- LN2 to produce GN2 to flush detectors
- Combine circuits to save LN2 consumption
- Better long cool GHe line than long LN2 line
- (in consultation with FAIR Cryo Dept.)



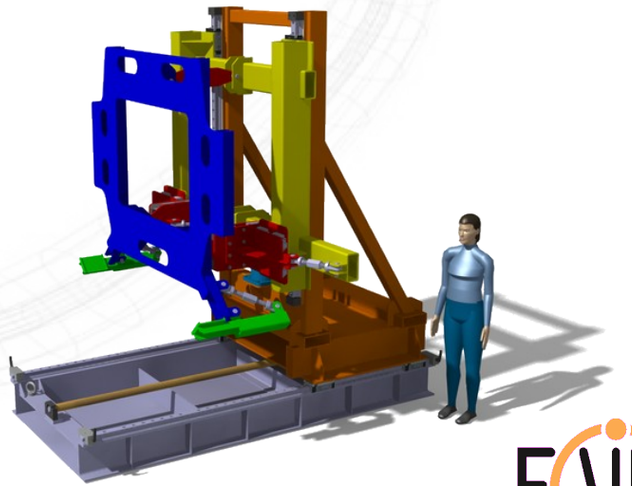
Supports: CSF and FWE Mounting

Central Space Frame (CSF)

- Interfaces with beam target pipe, MVD, STT, and Barrel DIRC
- Modular construction
- Mix of CFC frame and Al pieces
  Prototype assembled end of 2021
- Load tests in preparation

Forward Endcap Mounting Device

- Common tool to insert into forward endcap of solenoid:
  - Forward Endcap EMC (with and w/o Disc DIRC)
  - GEM Tracker
- Insertion movement on precision rail
- Raising and lowering
- Adjustment of all angles



Conclusion

PANDA Achievements:

- Solenoid construction in full swing, first SC strands, cryostat production
- Barrel DIRC procurement progressing, PMT delivery starting
- Barrel EMC first slice assembled, finalisation of cooling, readout PCBs
- Cluster Jet Target: Tests at COSY with HESR beam cooling successful
- TDRs approved by FAIR: **DAQT**, **Infrastructure**
- Forward Tracker component procurement

Upcoming milestones:

- Solenoid:
  - Delivery of cryostat and cold mass spring 2022
  - Super-conductor production to finish by 12/2022
- GEM Tracker TDR 2022
- Barrel Muon Chamber IKC
- Construction MoU and Common Fund

PANDA on track for Day-1, turning risks into opportunities