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# The PANDA Barrel Time-of-Flight Detector

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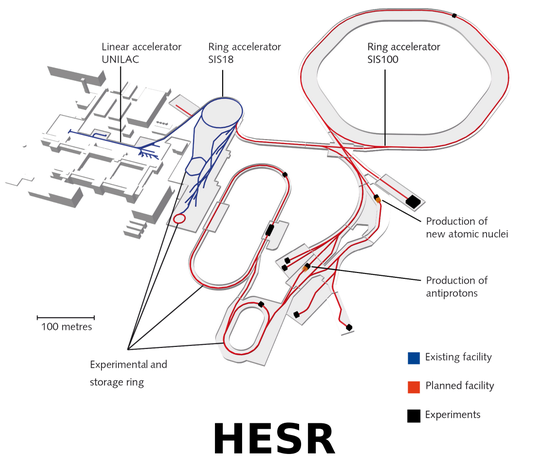
## FAIR

- **F**acility for **A**ntiproton and **I**on **R**esearch[1]
- Under construction at Darmstadt, Germany
- FAIR will host multiple experiments with the four major experiments:
  **APPA, CBM, NUSTAR and PANDA**

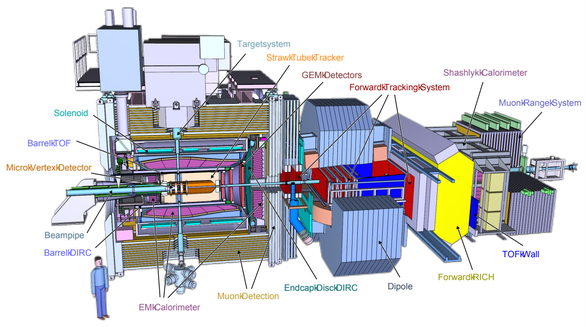



## HESR

- **H**igh **E**nergy **S**torage **R**ing
- Beam momentum p = 1.5 - 15 GeV/c
- Employs electron and stochastic cooling
- Excellent momentum resolution:
  $dp/p = 5 \times 10^{-5}$
- High luminosity $L = 2 \times 10^{32}\ cm^{-2}s^{-1}$

## PANDA

- Anti**p**roton **An**ihilation at **Da**rmstadt[2,3]
- Fixed target (cluster-jet or pellet)
- Detector with almost $4\pi$ coverage
- Colission rate of $N_{avg}$ = 20 MHz
- Free flowing DAQ with continuous redout

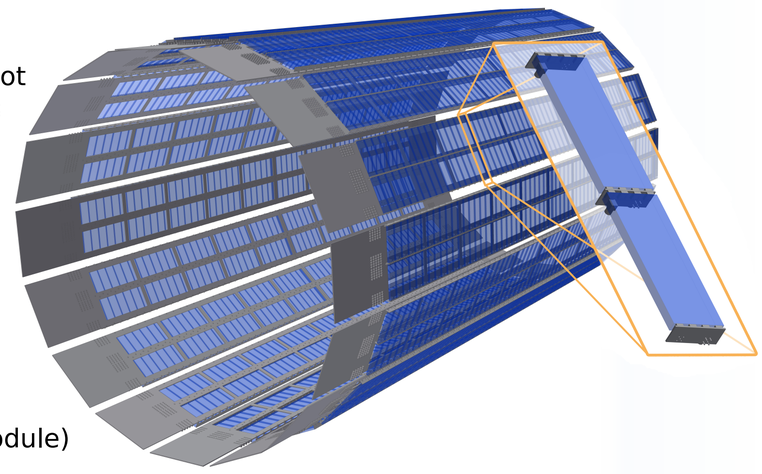



## Scientific Progam:

- Charmonium and open-charm spectroscopy
- Exotic hadrons, hybrids and glueballs
- Hadrons in nuclear matter
- Hyperon physics

## The Barrel Time of Flight Detector[4,5]

For an average rate of 20 MHz the time resolution of most PANDA subdetectors is not sufficient to ensure that hits from different event do not overlap. For this reason the barrel shaped scintillating-tile hodoscope was designed.
In addition to helping with the event sorting the detector will be able to deliver particle identification information using the time of flight of each particle, calculated from a single time stamp per particle with no dedicated start counter.

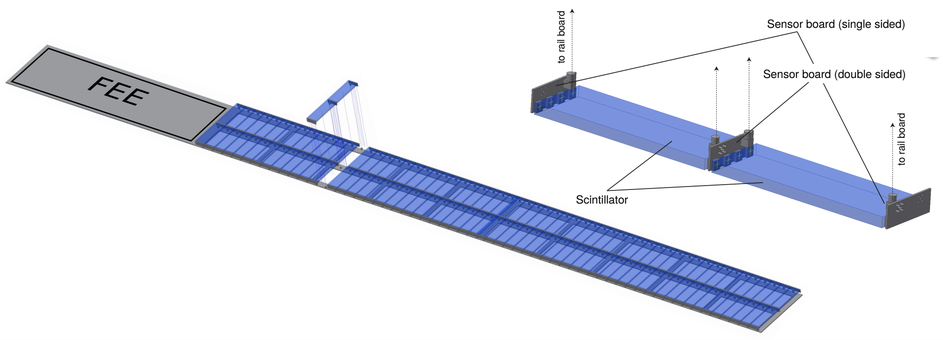


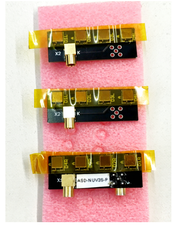
**Detector requirements:**

- Time resolution < 100 ps
- 1.6 cm radial thickness
- Minimal material budget
- Large angular acceptance
  ($22° \leq \theta \leq 140°$)

**Detector Setup:**

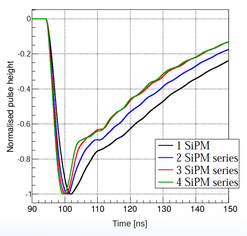
- 16 independant detector modules
- Radius of 0.5 m and length of 2 m
- 1920 scintillating tiles (60x2 per module)
  - Dimensions: 87 x 29.4 x 5 $mm^3$
- 15360 SiPMs (4 per scintillator side)
- 3840 channels



- The SiPMs are connected in series
- Decreases effective capacitance
  → faster signal

- Larger sensitive area
- Small number of channels
- Bias voltage adds up

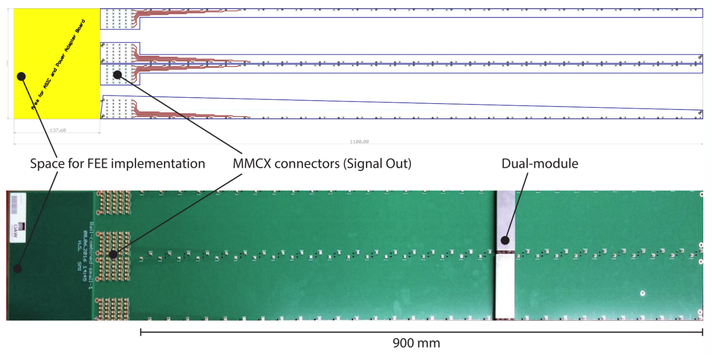


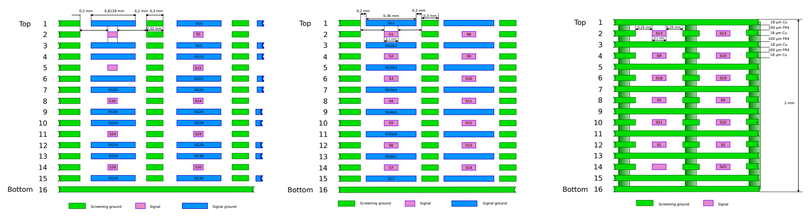

## Signal Transmission

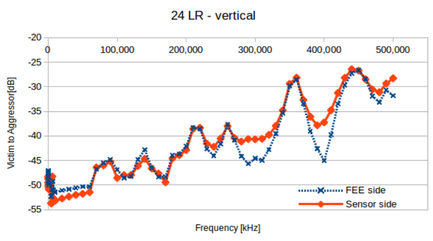
The electric signals are generated at the SiPMs along the detector modules. These signals are transmitted to the Front-End Electronics (FEE) via a large Printed Circuit Board (PCB), where they will be digitized.

**Transmission PCB:**

- 2460 x 180 x 20 $mm^3$
- 16 layer design
- Micro stripline design
- 3 basic layouts tested
- Shilding ground layout changed
- Via density tested
- Signal crosstalk and attenuation measured



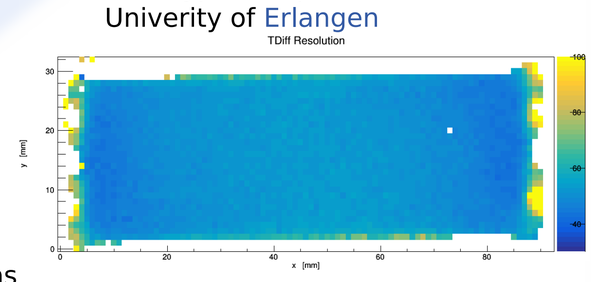




- crosstalk measured with sinusoidal periodic signal
- exected signal at ~350 MHz

## Performance

Prototype test performed at the Univerity of Erlangen

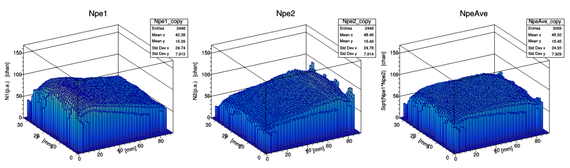


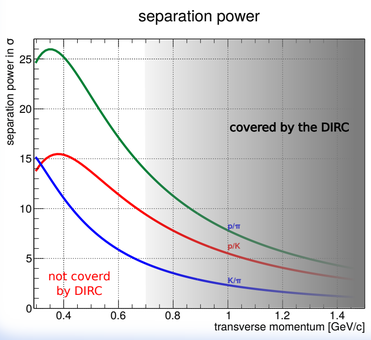

- Time resolution
- Detected photons
- Time difference left/right

... were scanned

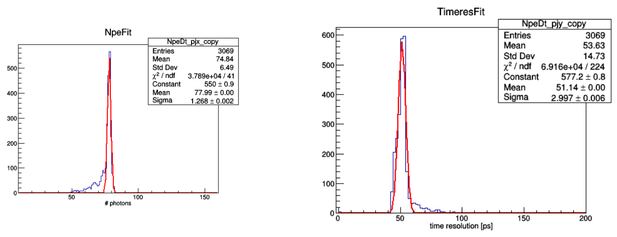
- Different scintillator materials (EJ-232, EJ-228) and thicknesses were tested
- An average time resolution of 51 ps was measured for the detectoracross the tile
- Derived position resolution of 10 mm

## PID Performance




- Separation power of p/K/π below the cherenkov threshold is important
- We can use a relative TOF method to determine event start time ($t_0$)
- Simulation done with ideal $t_0$




## References

[1] FAIR website (May 2018): *https://www.gsi.de/en/researchaccelerators/fair.htm*

[2] PANDA website (May 2018): *https://panda.gsi.de*

[3] PANDA Collaboration. Physics Performance Report for PANDA: Strong Interaction Studies with Antiprotons. *arxiv:0903.3905*, 2009.

[4] K. Suzuki et al. Technical Design Report for the: PANDA Barrel Time-of-Flight Detector, 2017

[5] Zimmermann, Sebastian, et al. "The P̄ANDA Barrel-TOF Detector at FAIR." Journal of Instrumentation 12.08 (2017): C08017.

links: [1] [2] [3] [5]

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HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

HIC for FAIR
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