CBM-XYTER Family Planning Workshop
GSI
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Frontend electronics specifications for the silicon strip detectors of the PANDA MVD

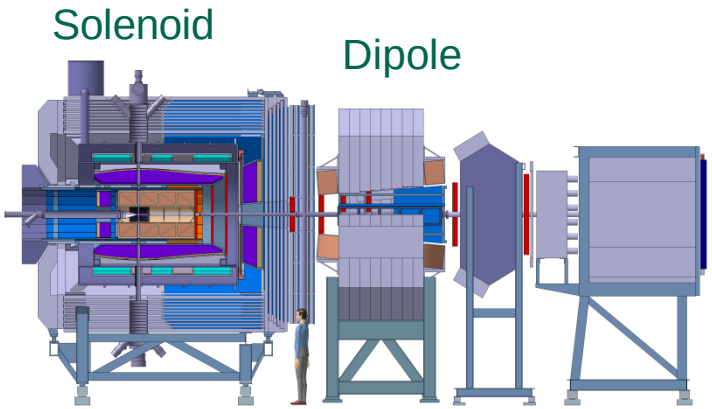
HISKP universitätbonn

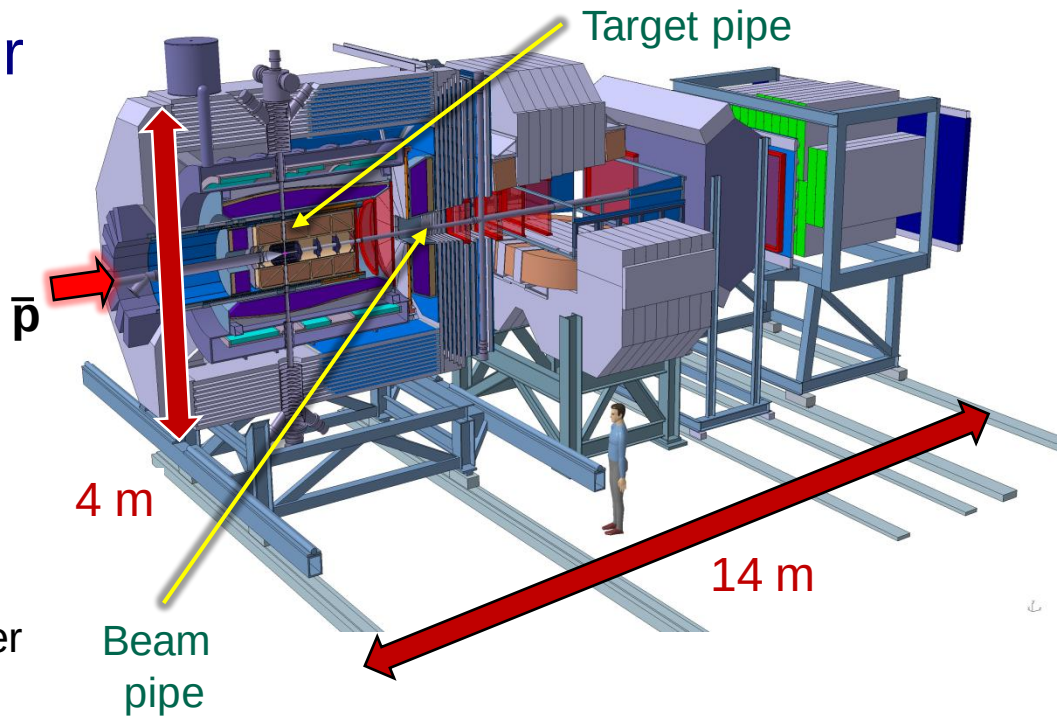
Introduction

- *PANDA*-Experiment

Luminosity: $\leq 2 \cdot 10^{32}$ / cm^2 s
Event rate: $\leq 10^7$ / s
Momentum range: (2 ...15) GeV/c

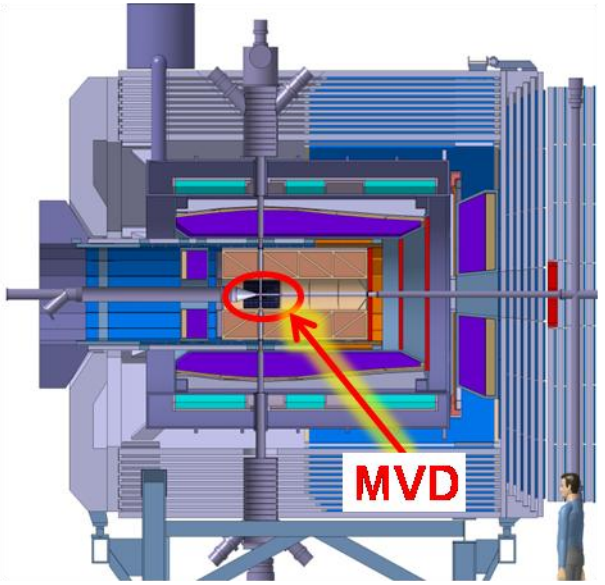
- Fixed-Target-Experiment
  - Beam: Antiprotons ($\bar{p}$)
  - Target: Helium or heavier nuclear targets



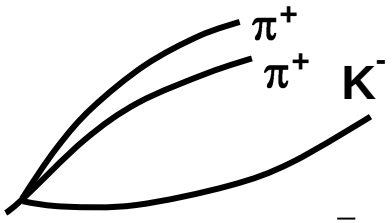


Introduction

- Micro-Vertex-Detector (MVD)
  - a Tracking detector
  - b Innermost detector in PANDA
  - c High vertex resolution for primary interaction vertex as well as for secondary vertices of short living particles (e.g. mesons with charm and strange content) and delayed decay products
  - d Should provide additionally some dE/dx information for PID



Target spectrometer



$D^{\pm}_S \rightarrow \bar{K}^0 x + K^0 y$

$c\tau = 147\ \mu m$

$D^{\pm} \rightarrow \bar{K}^0 x + K^0 y$

$c\tau = 312\ \mu m$

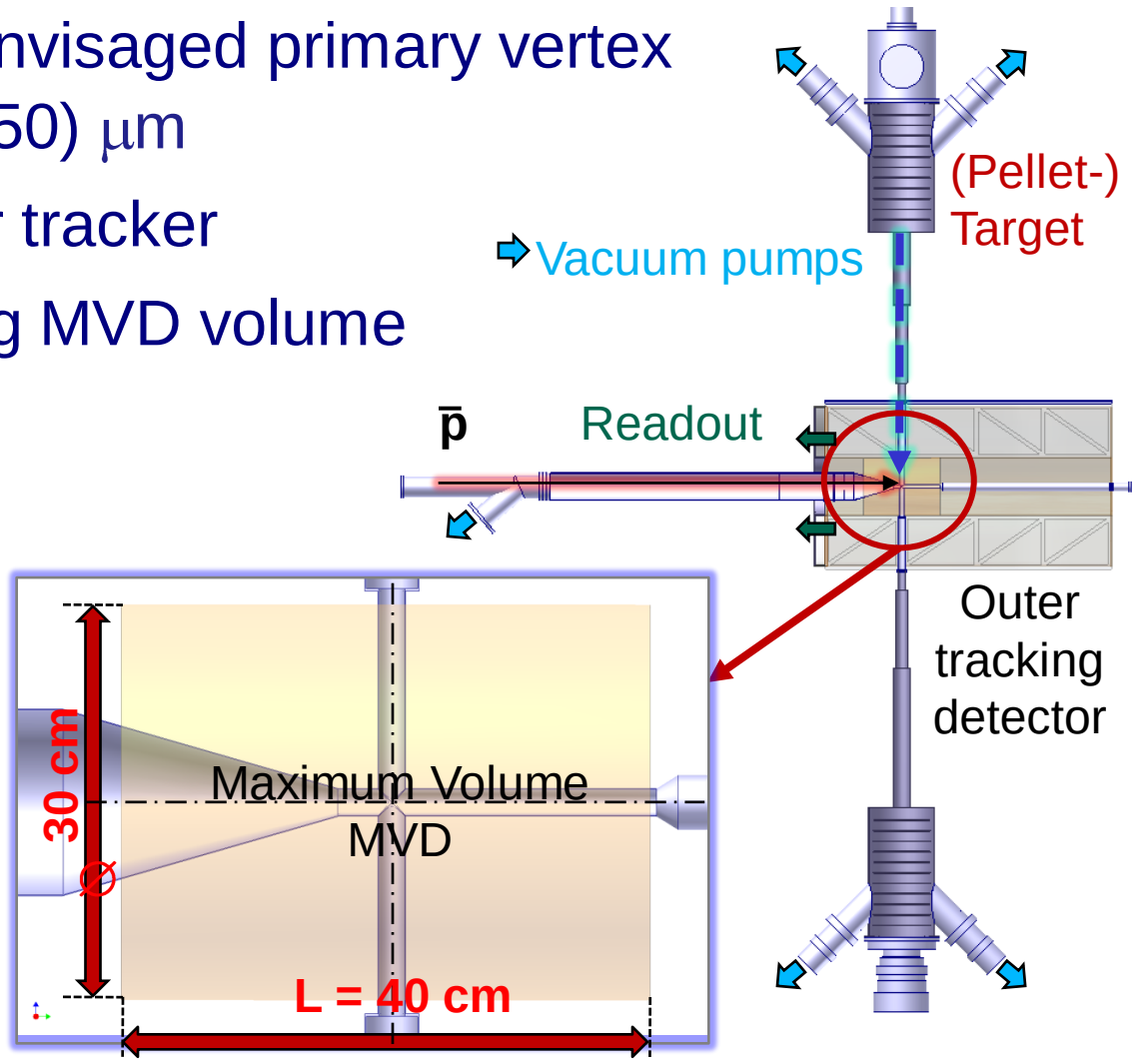
Vertex-Geometry

- Pellet-Target with envisaged primary vertex resolution of (25 ... 50) μm
- MVD inside of outer tracker
- Target pipe crossing MVD volume

➢ Consequences:

→ Broken radial symmetry

→ Sharp restrictions for MVD-volume



MVD Geometry

- 4 barrel layers along beam axis

1. / 2. layer: Pixel detectors

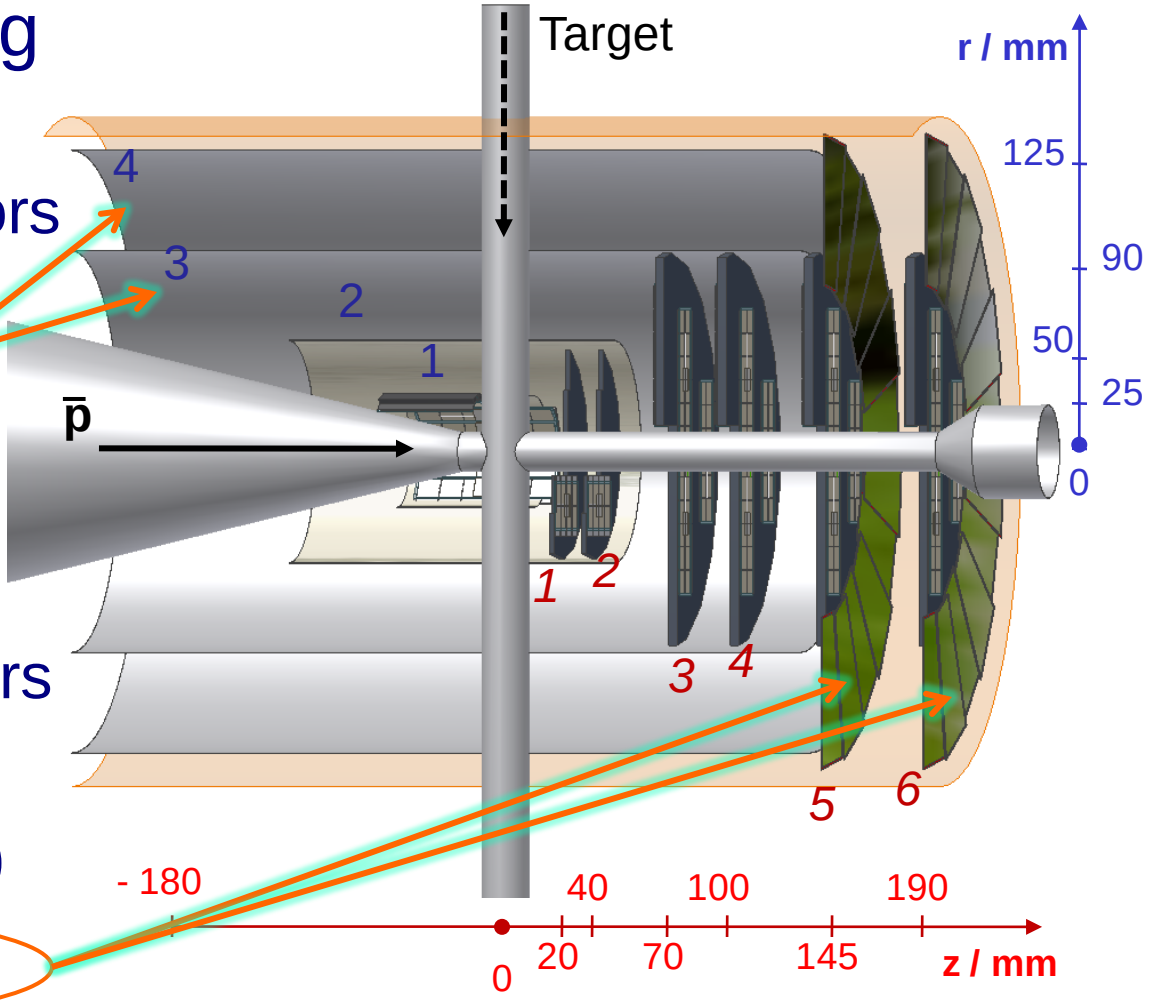
3. / 4. layer: Strip detectors

- Forward part: 6 disks

1. – 4. disk: Pixel detectors

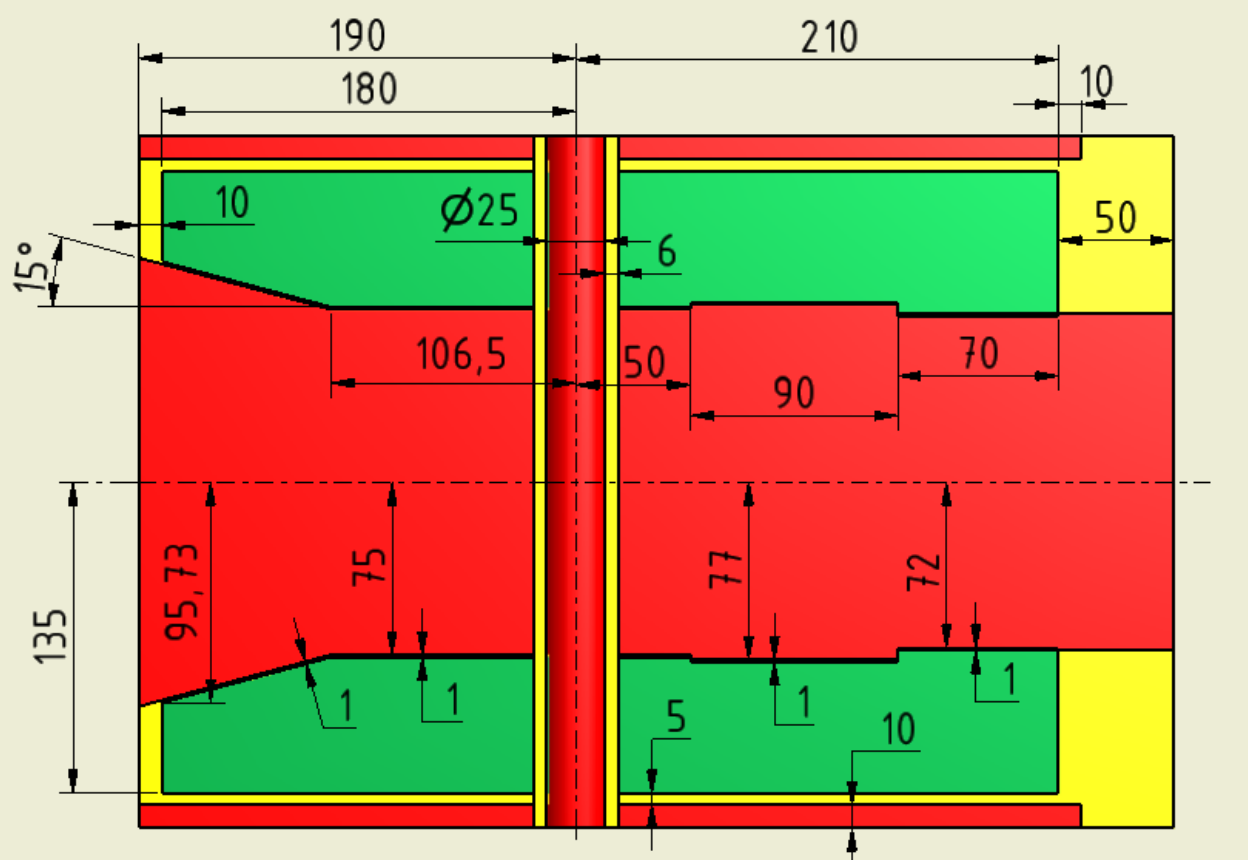
5. – 6. disk: Pixel detectors (inner)

Strip detectors (outer)



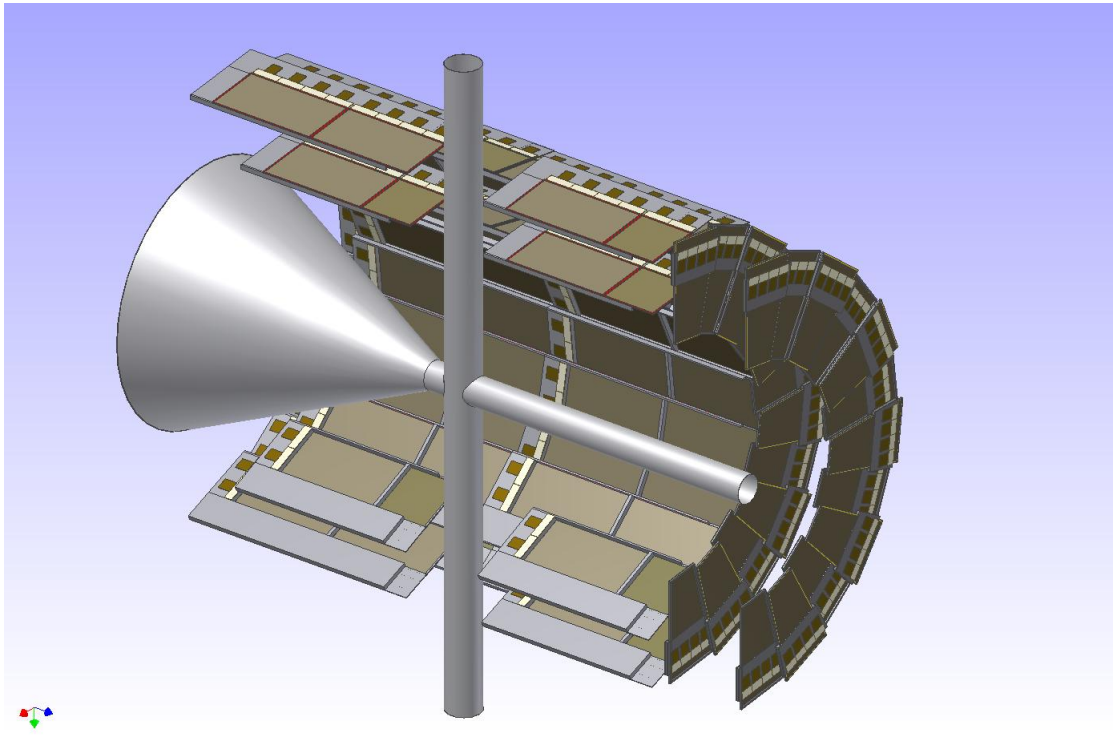
MVD-Geometry

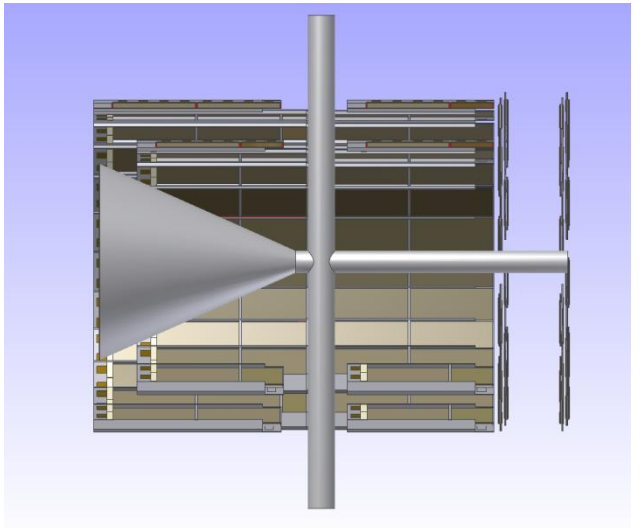
- Restricted volumes: Red (beam-target + pixel part) / Green (strip part) / Yellow (regions of interference)

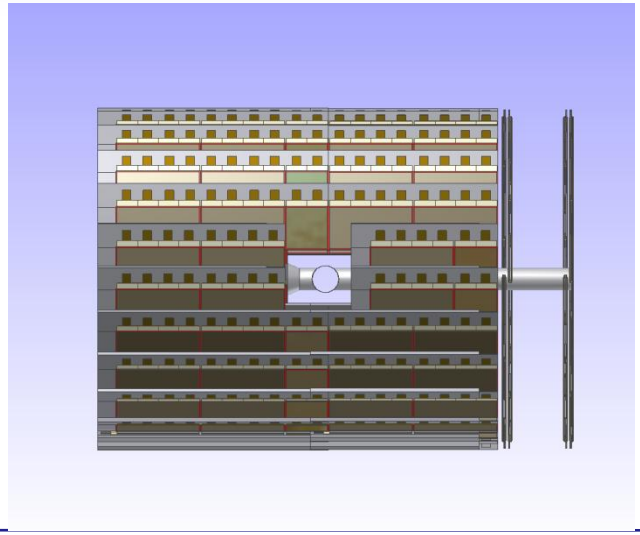


Strip part implementation

- Geometrical input
- Simulations of physics performance
- Feasibility for engineering process

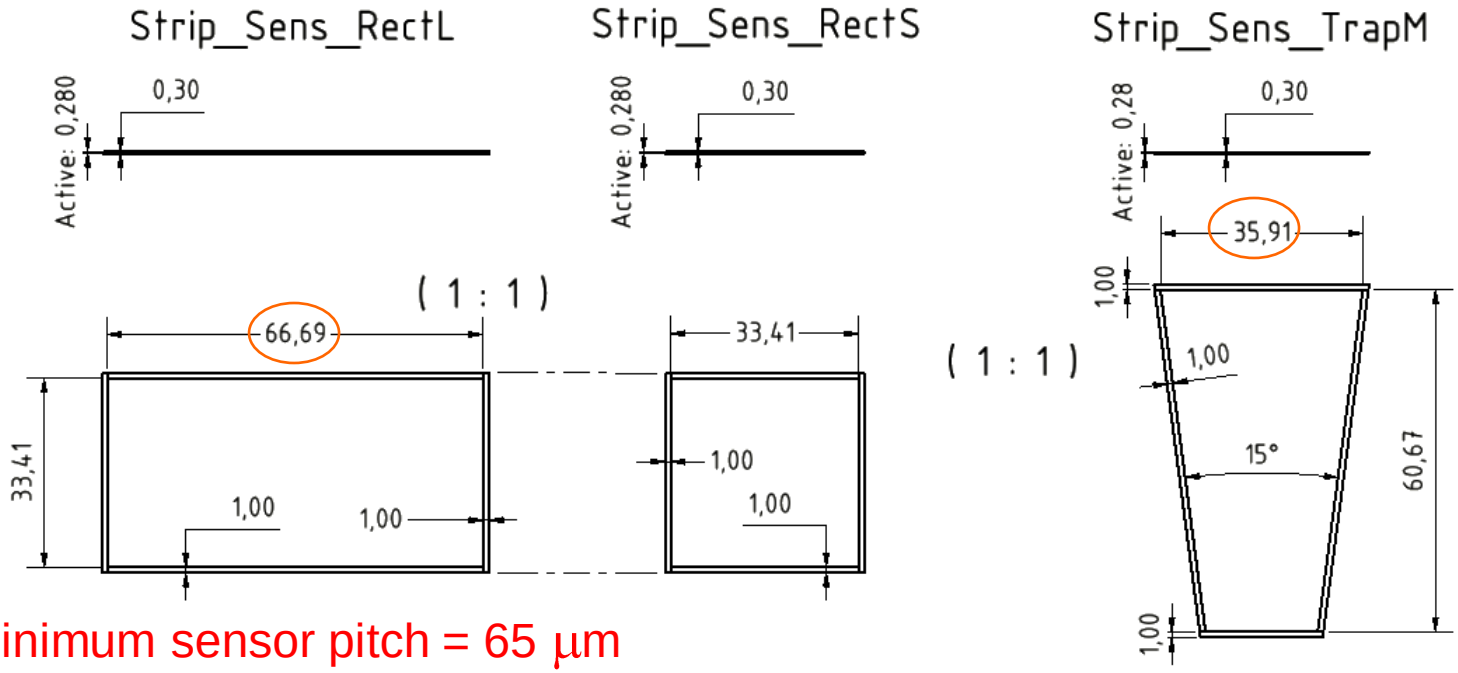






Strip part implementation

- Sensor layout



FE pitch **<** minimum sensor pitch = 65 μm

Stereo angle:	90°	90°	15°
Pitch	0.130 (altern. 0.065)	0.130 (altern. 0.065)	0.070
No. of channels:	512 (1024)	256 (512) long side	512
	256 (512)	256 (512) short side	(both sides)
No. of FE:	4 (8)	2 (4)	4

$n \cdot width_{FE} = width_{SENSOR}$ **+ safety** (minimum distance between 2 FE)

Strip part implementation

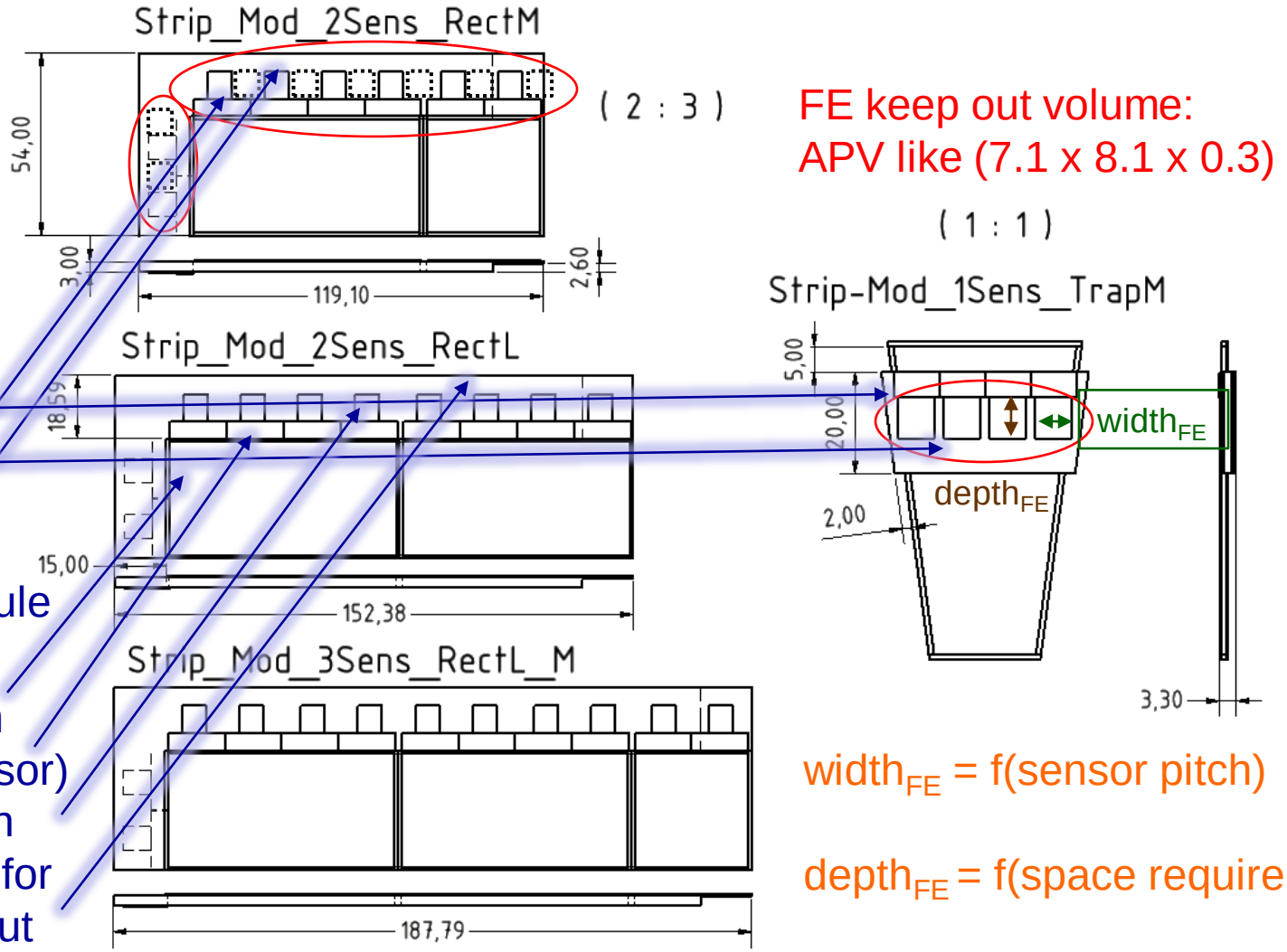
- Module layout

→ FE connections

>> Frontend
>> Backend

→ Total module depth:

sensor depth
+ d (FE-sensor)
+ FE depth
+ space for readout



FE keep out volume:
APV like (7.1 x 8.1 x 0.3) mm^3

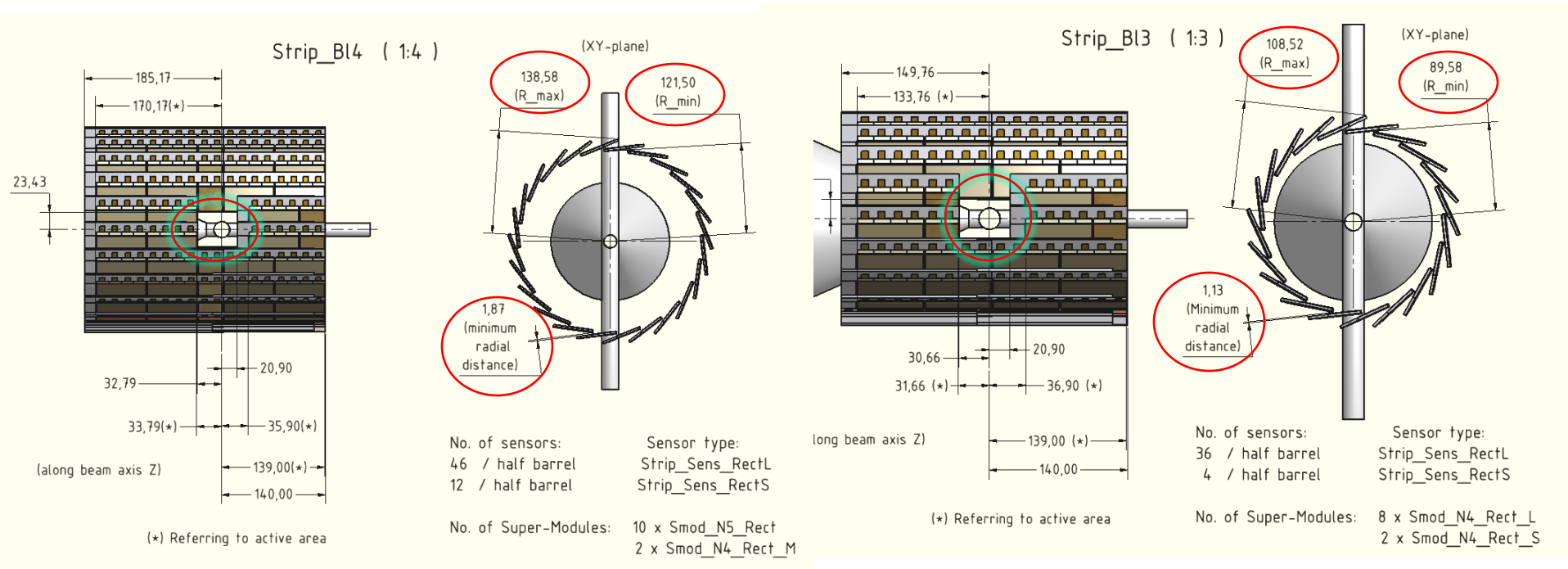
width$_{FE}$ = f(sensor pitch)

depth$_{FE}$ = f(space requirement)

Strip part implementation

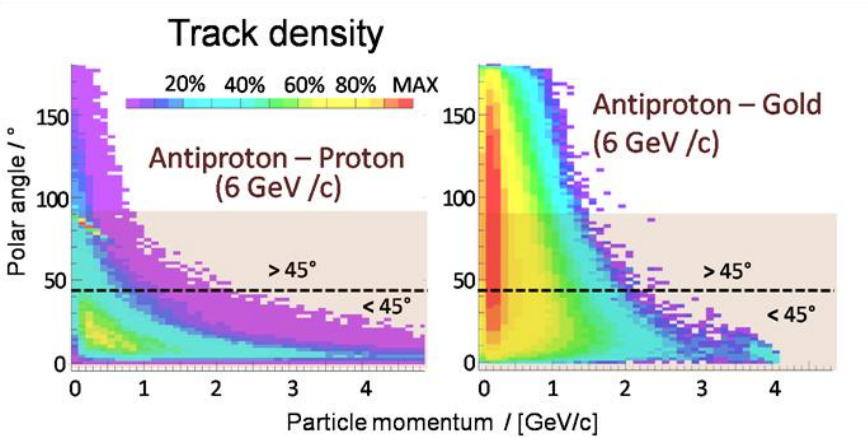
- Barrel layout

Impact of module sizes = f(sensor size; FE size)

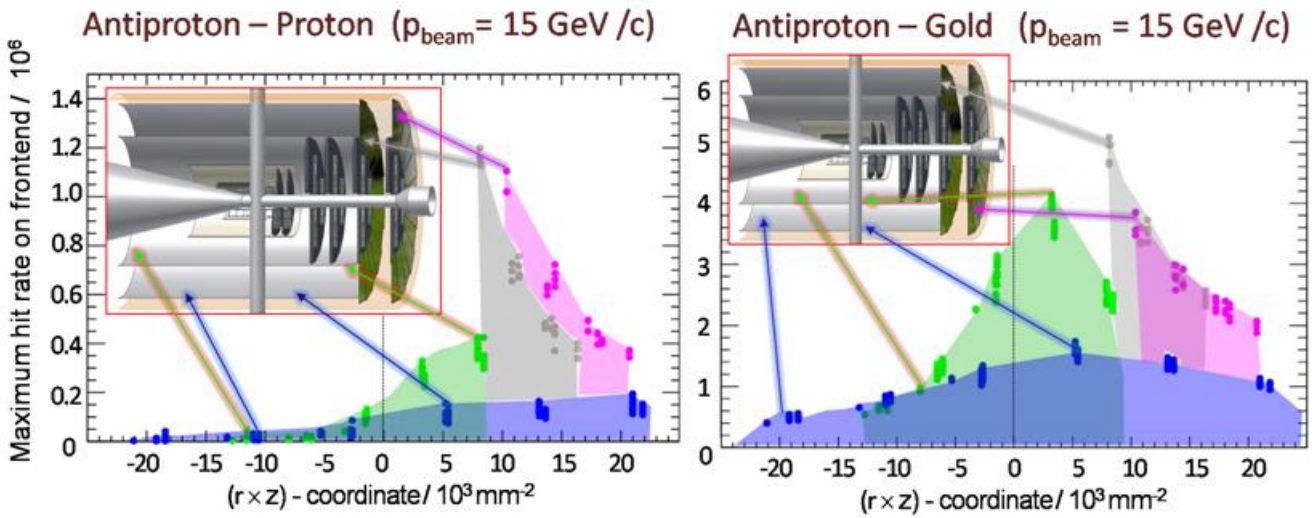


Module depth <> space requirement: Inner + outer barrel radii /
Minimum distances of super-modules / Keep out for target pipe

Count rate studies



- Maximum hit rates at highest beam momenta assuming an interaction rate of 10^7 / sec:
  - → (1 ... 5) Mevts / sec / frontend
  - → Several 10k evts / sec / single channel



- → Peaking in forward direction
- → Spatial non-uniformity
  - → values differ by one order of magnitude

Cooling

STRIPS GEOMETRY FOR THERMAL SIMULATION

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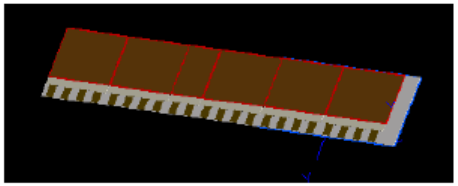


STRIPS SUPER MODULE LAYER 4

22 FEE on one side (along the barrel)

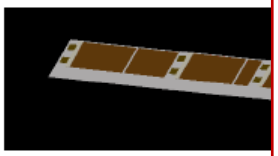
6 FEE on the other side

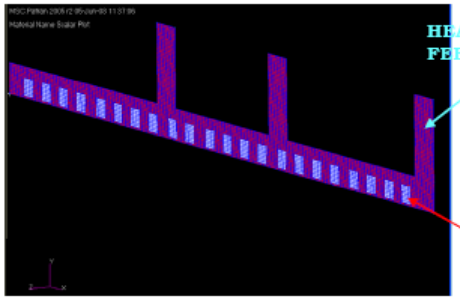
POWER: 28 W

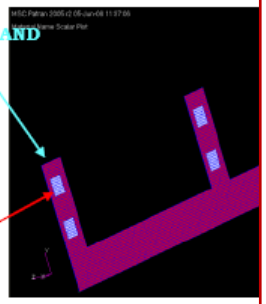
Tube at 20°C only along the barrel

HEAT BRIDGE THICKNESS: 0,2-0,4mm

FEE THICKNESS: 0,3 mm







- Water cooling
- Pipe diameter ~ 2 mm

THERMAL RESULTS

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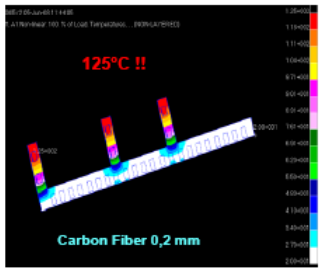
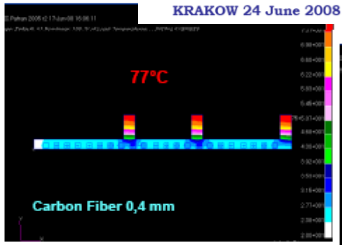
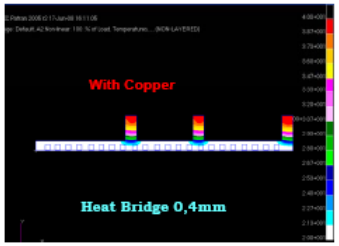
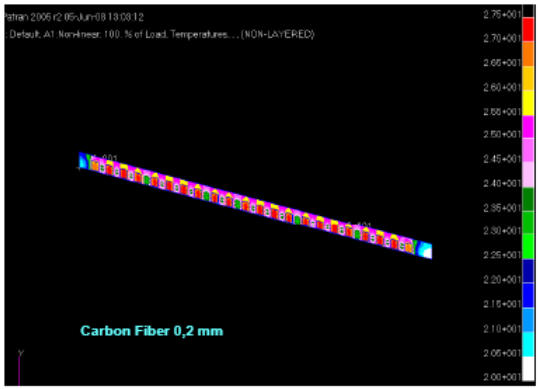








22 FEE (22W)

HEAT BRIDGE in CARBON FIBER

COOLING TUBE AT 20°C

Which means (for ex. with WATER cooling fluid):

Diam. cooling tube: 2mm (80 micron thickness)

Inlet water temperature: 15°C

Water flow: about 0,25-0,3 lit/min

Pressure drop along each tube: about 200 mbar

Water ΔT along the tube: about 1,5°C

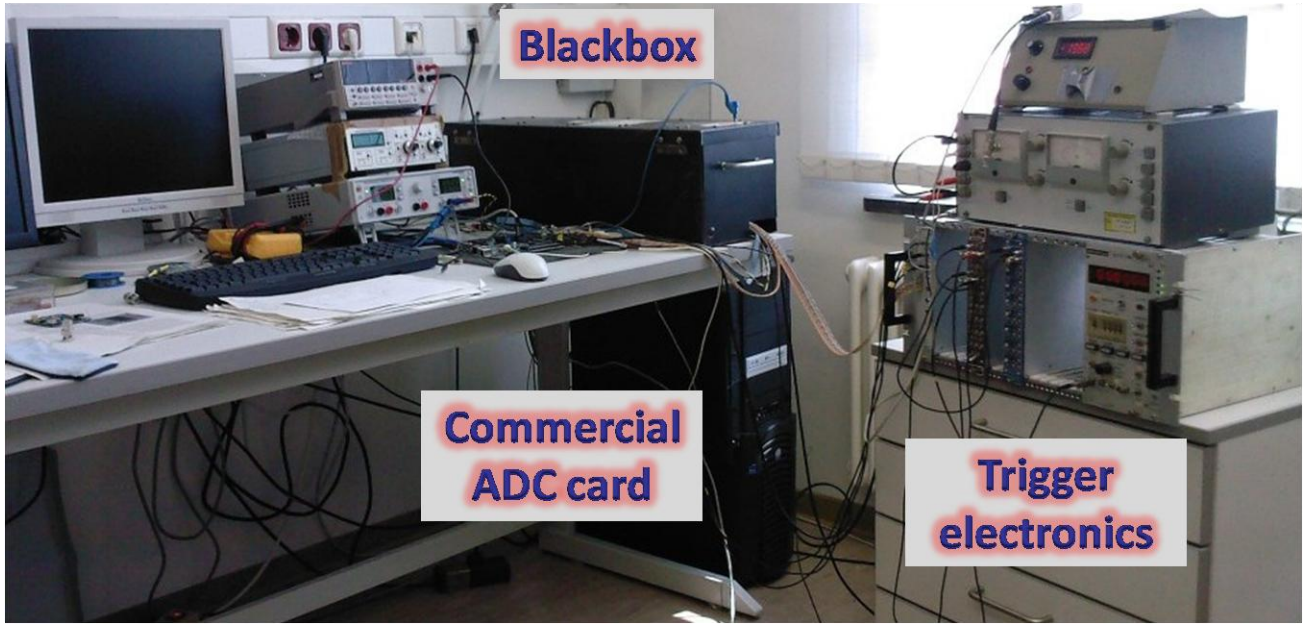
Re about 2300

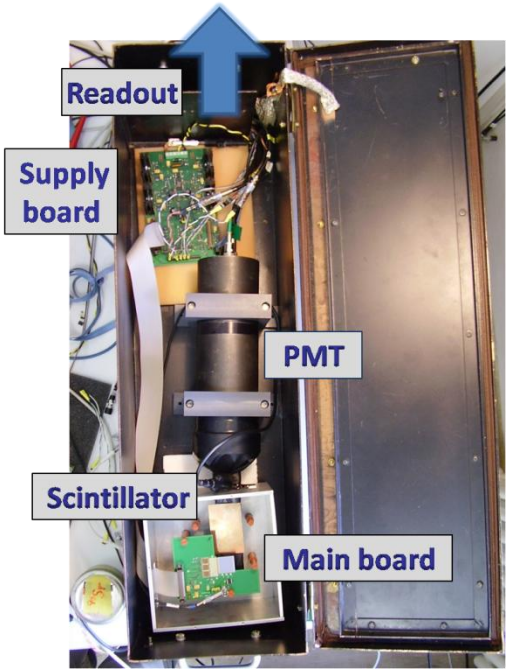
Cooling power very crucial design criterion!!!

Critical: barrel part, readout of short strips, and for forward disks

Hardware development

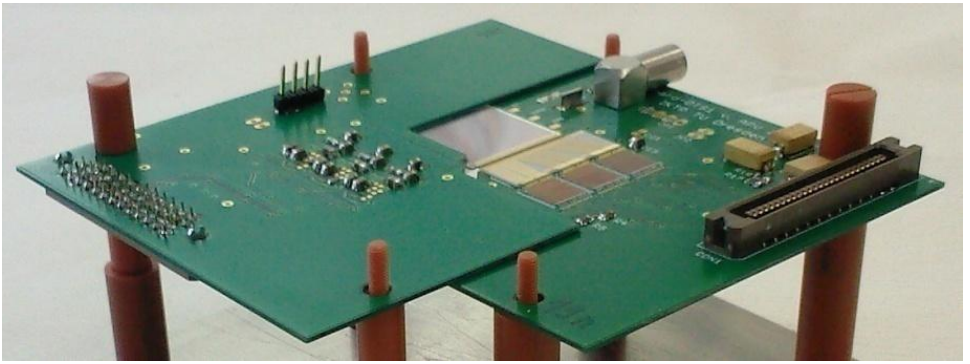
- Test station: DTS1 (Lab setup)
  - Evaluation of silicon strip sensors
  - Modular setup allowing further prototype testing

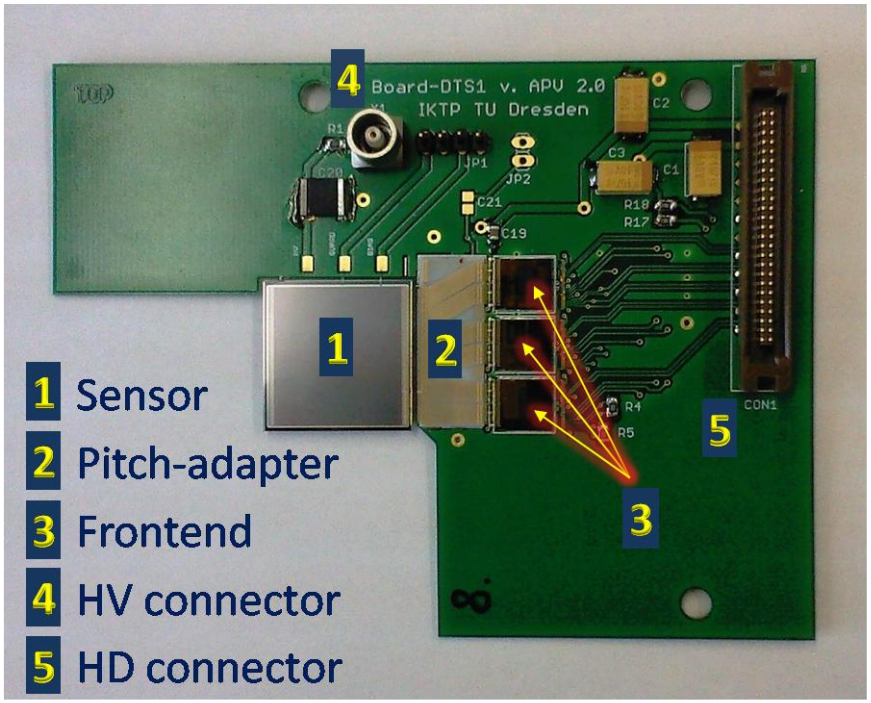


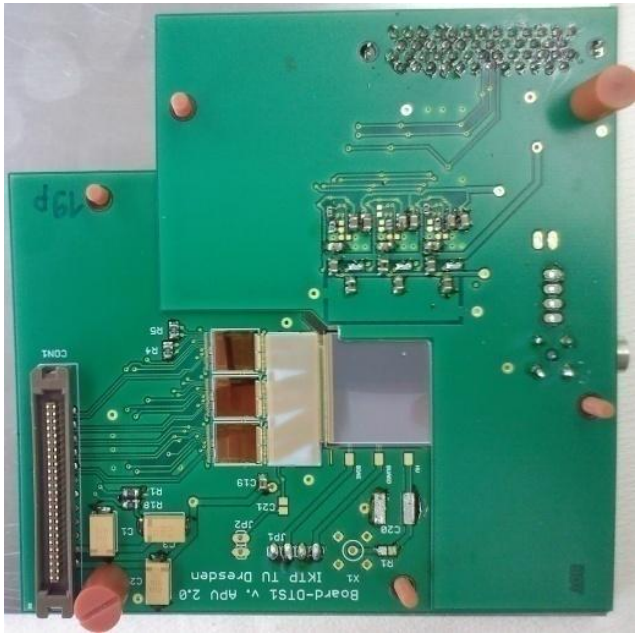


Hardware development

- Main sensor boards for double-sided readout

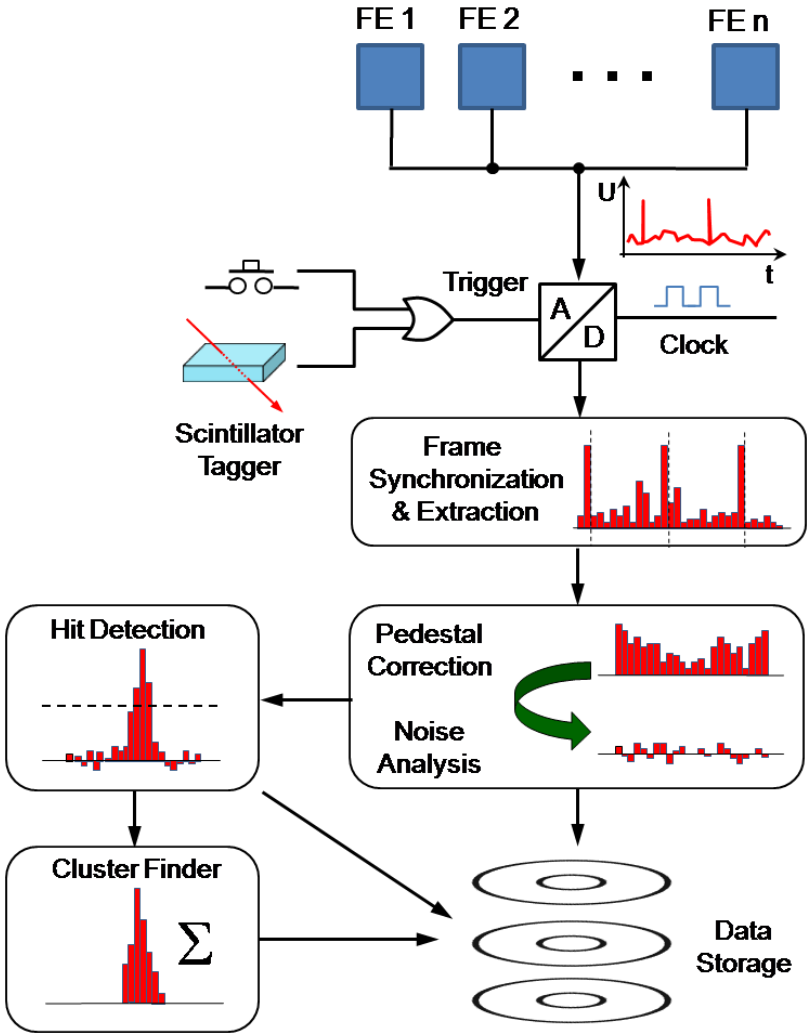






Hardware development

- Data acquisition (Lab-setup)
  - Used FE: APV25
  - Scintillation trigger
  - Feature extraction in software
  - Numerous tools to characterize module performance

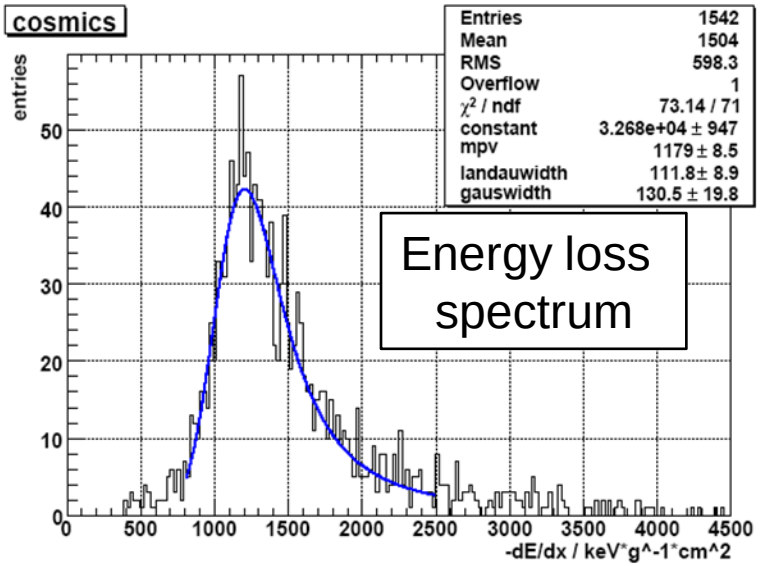


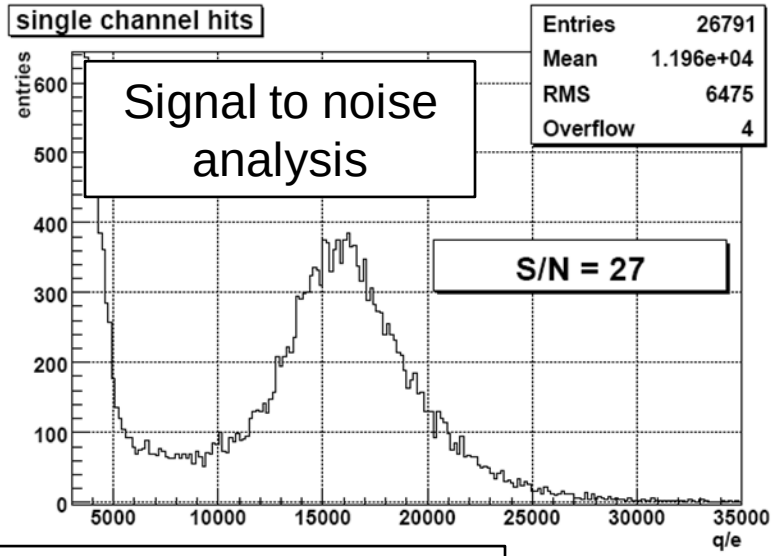
Hardware development

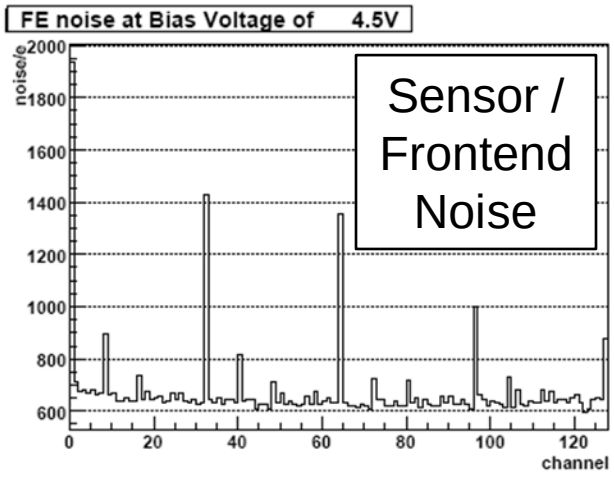
- Test-beam setup in Bonn

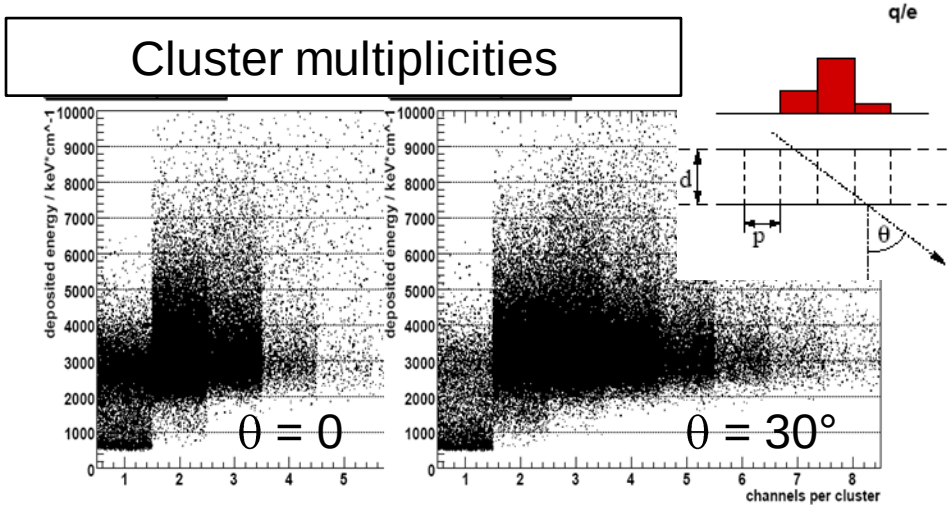
ELSA

Measurements

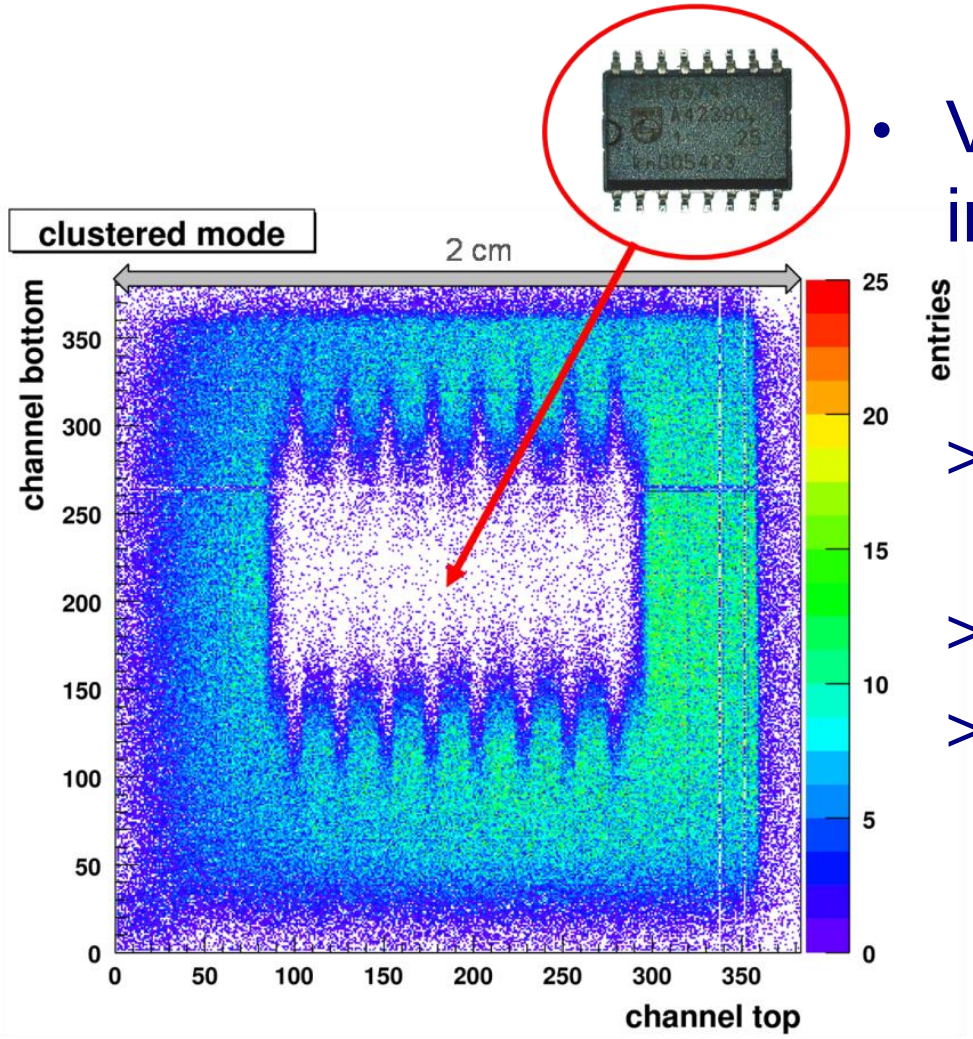








Measurements



- Visualisation of 2D-imaging capability

>> Measurement with ^{90}Sr source at lab-setup

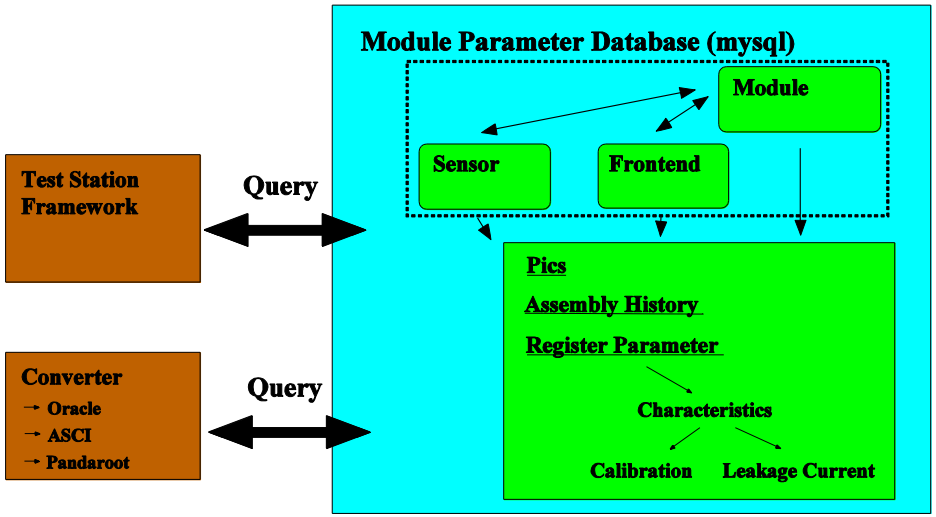
>> SMD device as absorber

>> 2 sensors with single-sided readout

- 90° stereo angle

- distance: 3 mm

Database



File Edit View History Bookmarks Tools Help

http://localhost/~felix/calib.php?mod=16

openSUSE Getting Started Latest Headlines LAstFM

Calibration Module: 16

FeID	Channel	Parameter	Error	Chi2	
0	0	5.328376	0.04956	29.995182	Graph
0	1	6.113114	0.008866	1.090123	Graph
0	2	6.167943	0.005545	0.418843	Graph
0	3	6.199384	0.005166	0.359924	Graph
0	4	6.160224	0.004283	0.250523	Graph
0	5	6.146802	0.004647	0.285985	Graph
0	6	6.126975	0.005177	0.370097	Graph
0	7	6.021127	0.00481	0.290785	Graph
0	8	5.176104	0.021612	3.882887	Graph
0	9	5.40176	0.004009	0.165988	Graph
0	10	5.436323	0.005163	0.27171	Graph
0	11	5.475609	0.005491	0.302987	Graph
0	12	5.439868	0.005059	0.260585	Graph
0	13	5.434856	0.005206	0.276417	Graph
0	14	5.409358	0.006049	0.376762	Graph

File Edit View History Bookmarks Tools Help

http://localhost/~felix/module_detail.php?mod=

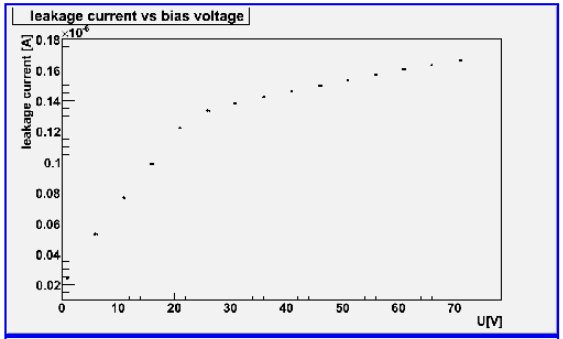
openSUSE Getting Started Latest Headlines LAstFM

Module: 16

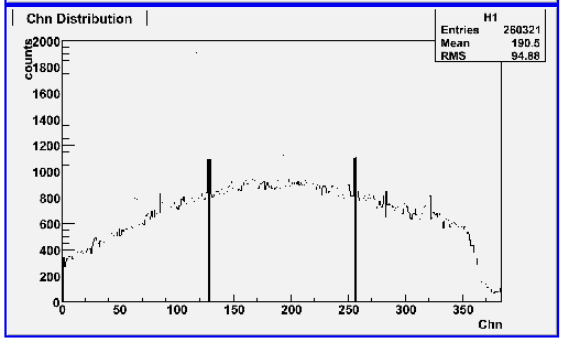
Location: Dresden

I2C Adresses: FE1: 0110011
FE2: 0110100
FE3: 0110101

Leakage Current



Channel Distribution



Done

FE requirements

- Updated specifications based on:
  - Experimental setup
  - Physics requirements
  - Input of detailed implementation
    - Mechanics
    - Cooling
    - Support
    - Design optimisation:
      technical feasibility <> detector simulations
  - Input of measurements with test station

FE requirements

Parameter	Value	Remarks
Geometry		
width	$\leq$ 8 mm	
depth	$\leq$ 8 mm	
input pad pitch	$\leq$50 μm	
pad configuration		lateral pads occupied only for diagnostic functions, must be left unconnected for final setup
FE channels	$2^6 \ldots 2^8$	default: 128 channels
Input Compliance		
sensor capacitances, full depletion		
	<10 pF	rect. short strips
	<50 pF	rect. long strips + ganging
	<20 pF	fw. disc strips
charge polarity	either	selectable via slow control
input ENC	$< 800\,e^-$	C_{Sensor} =10 pF
	$< 1100\,e^-$	C_{Sensor} =25 pF
Signal		
dynamic range	160 ke^-	
min. SNR for MIPs	12	24.000 e^- MIPs in 300 μm Silicon, guaranteed within lifetime
peaking time	$\approx$ 10...25 ns	typical Si drift times
digitization resolution	$\geq$8bit	

FE requirements

Parameter	Value	Remarks
Power		
overall power dissipation	$<1W$	assuming 128 channels/FE
Dynamical		
trigger	internally generated	when charge pulse exceeds adjustable threshold level
time stamp resolution	$<20\,ns$	
dead time / ch	$<6\,\mu s$	baseline restored to within 1% of equilibrium
overshoot recovery time / ch	$<25\,\mu s$	
average hit rates / ch (poissonian mean)		simulations @ 15 GeV beam mom.
hot spots	$9.000\ s^{-1}$	$\overline{p}p$
	$40.000\ s^{-1}$	$\overline{p}\,Au$
average occupancy	$6.000\ s^{-1}$	$\overline{p}p$
	$30.000\ s^{-1}$	$\overline{p}\,Au$
Interface		
slow control	any	
data	sparsified digital	

Radiation Hardness: ~ 1Mrad (TID)

http://panda-wiki.gsi.de/cgi-bin/view/Mvd/FEspecs