TECHNISCHE UNIVERSITÄT DRESDEN

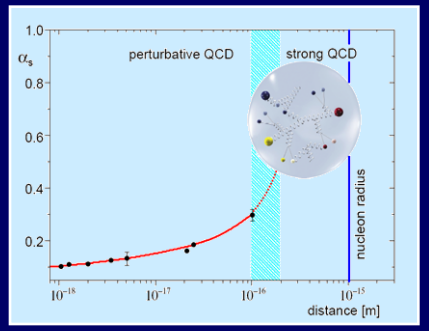
Fakultät Mat/Nat Fachrichtung Physik Institut für Kern- und Teilchenphysik

The P̄ANDA MVD

- Introduction: P̄ANDA physics program
- Layout of the P̄ANDA MVD
  - Simulations
  - Mechanics
- Sensors and electronics
  - Pixel and strip layers

Kai-Thomas Brinkmann, CBM silicon workshop, GSI April 18, 2007

The P̄ANDA Physics



- Many open questions in strong (non-perturbative) QCD

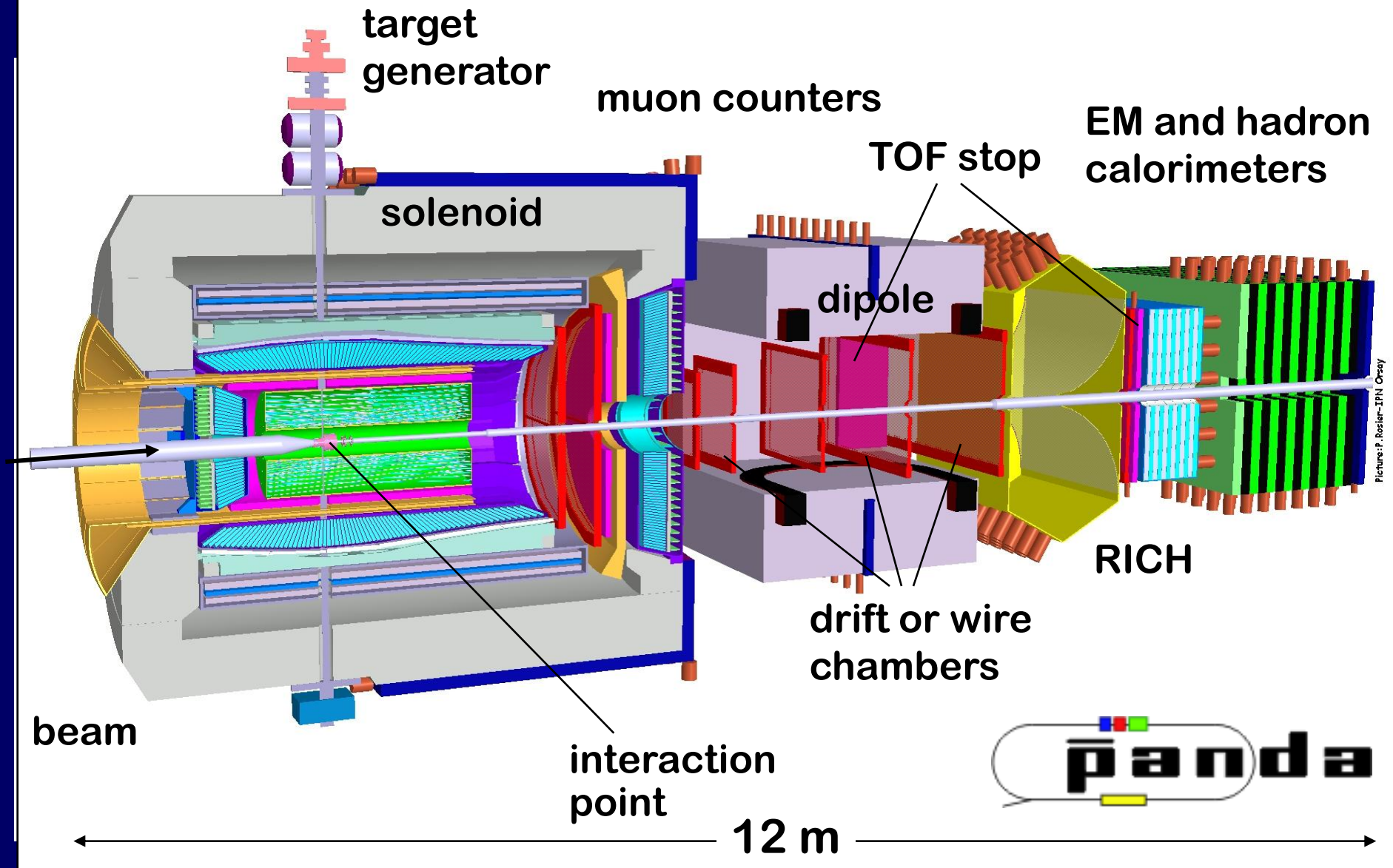
- charmonium - hybrids, glueballs and exotics - open charm

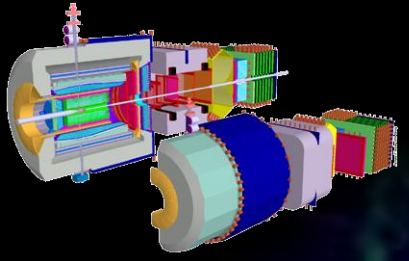
- Chiral symmetry in SU(3) and SU(4)

  - hadrons in the nuclear medium

- Hypernuclei: "3rd dimension" of the chart of nuclides

rare decays, baryon spectroscopy, CP violation in the charm sector, electromagnetic channels and processes (virtual Compton scattering, generalized parton distributions, Drell-Yan, e-m formfactor of the proton in the time-like regime), antiproton physics at low energies


target
generator
muon counters
TOF stop
EM and hadron
calorimeters
solenoid
dipole
RICH
drift or wire
chambers
beam
interaction
point
12 m
Picture: P. Rosier - IPN Orsay



The P̄ANDA Detector

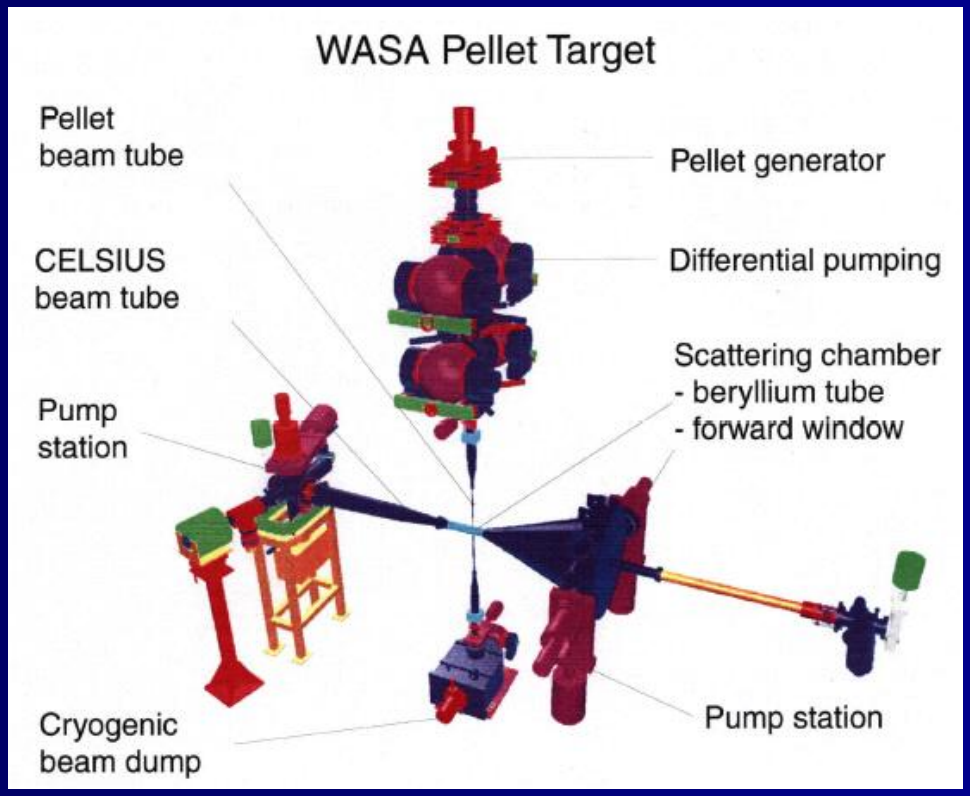
P̄ANDA Technical Status Report, http://www.ep1.rub.de/~panda/

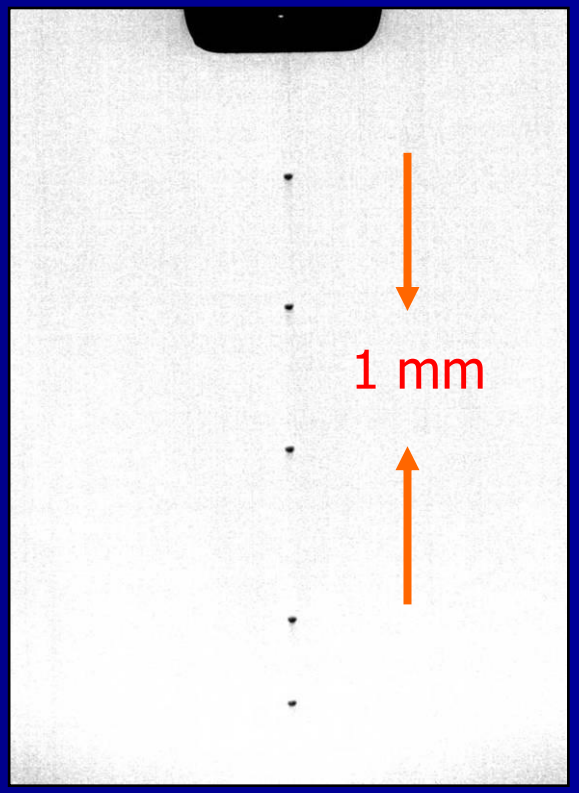
P̄ANDA is a modular multi-purpose device:

- Excellent forward acceptance and resolution
- (Moderate) backward acceptance
- Wide dynamic range: particle momenta 0.1 - 8 GeV/c
- Momentum measurements in magnetic fields ($\Delta p/p \approx 1\%$)
- Particle ID in wide momentum range $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, $K^{\pm}$, p, …
- Electromagnetic calorimeter: γ, π^0, η ... $(e^{\pm})$
- High-resolution vertex detection: $D^{\pm}$, D^0 / K_s, Λ, Σ, Ω ...
- High interaction rate up to $2 \cdot 10^7\ s^{-1}$
- Intelligent trigger design for parallel data acquisition at high rates and small branching fractions

The P̄ANDA Targets

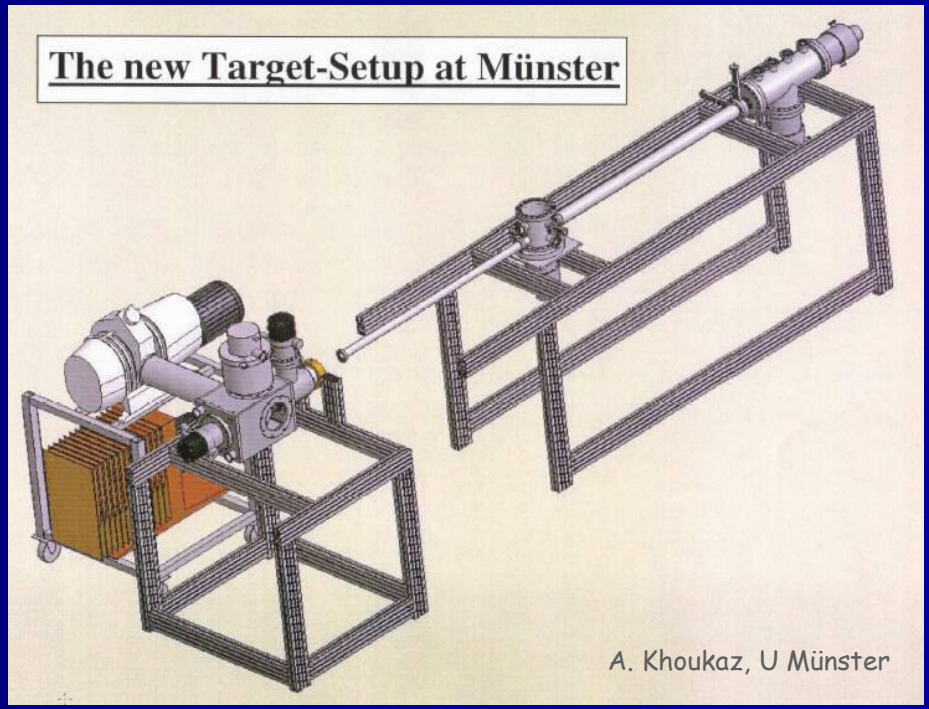
Pellet target: 10^{16} atoms/cm^2 , pellets of 20-40 µm diameter





The P̄ANDA Targets

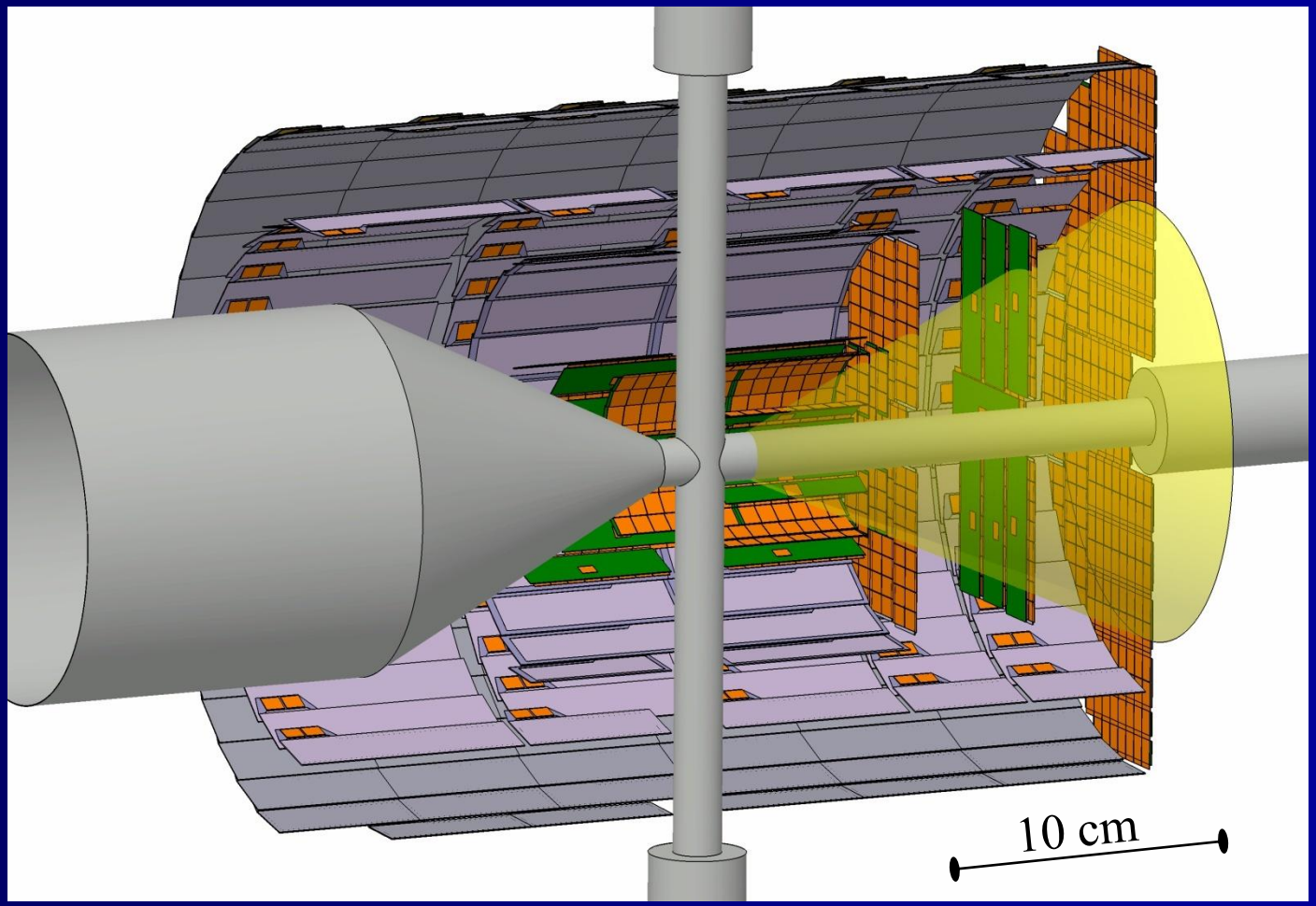
Cluster jet target:
Up to 10^{15} atoms/cm^2
a few mm long in
interaction region



Superfluid Helium targets: 10^{15} atoms/cm^2, droplets, 0.5-100 µm Ø
with little divergence only (<0.1°)

Heavy ion targets: heavy gases, wires, and foils

Micro-Vertex Detector

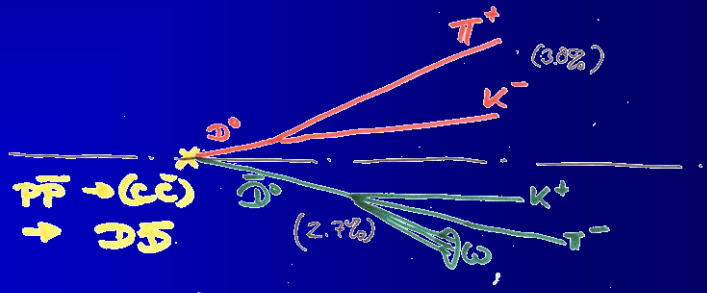


Micro-Vertex Detector

Charm: resolution and triggering of D decays needs spatial resolution of better than 100 µm

$$D^0:\ c\tau = 123.7\,\mu\text{m} \qquad (56\pm5)\%\ \text{K}^{\pm} + anything \qquad (42\pm5)\%\ \text{K}^0/\overline{\text{K}}^0 + anything$$

$$D^{\pm}:\ c\tau = 315\,\mu\text{m} \qquad (30\pm4)\%\ \text{K}^{\pm} + anything \qquad (59\pm7)\%\ \text{K}^0/\overline{\text{K}}^0 + anything$$

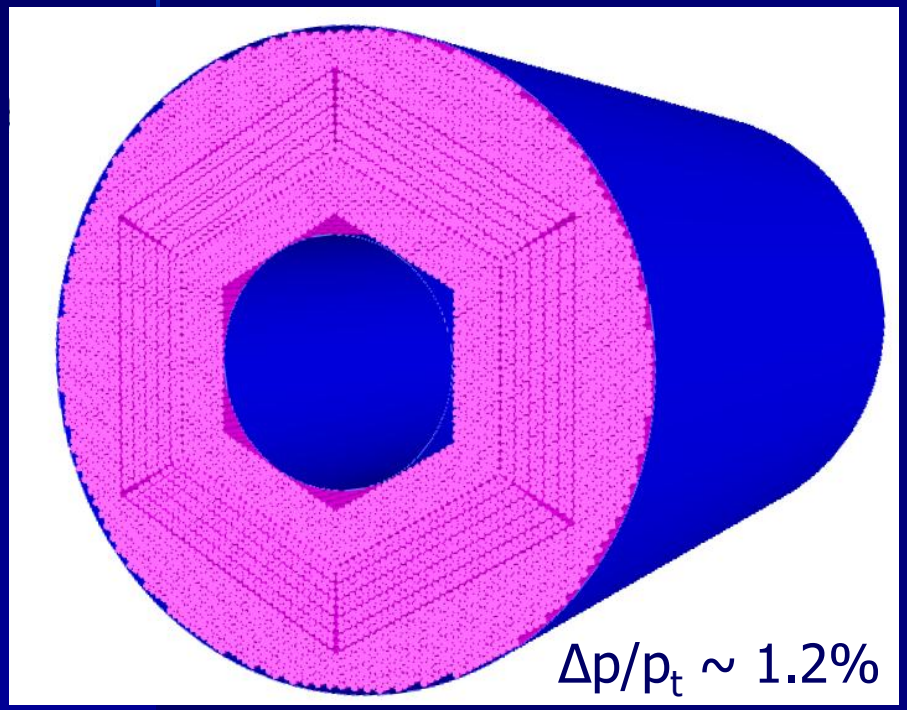


(c$\bar{c}$) also have considerable branching ratios involving K$\overline{\text{K}}$

"**Charm tagging**" usually refers to offline identification of displaced decay vertex – can we do better, i.e. faster?

Tracking

Straw tubes



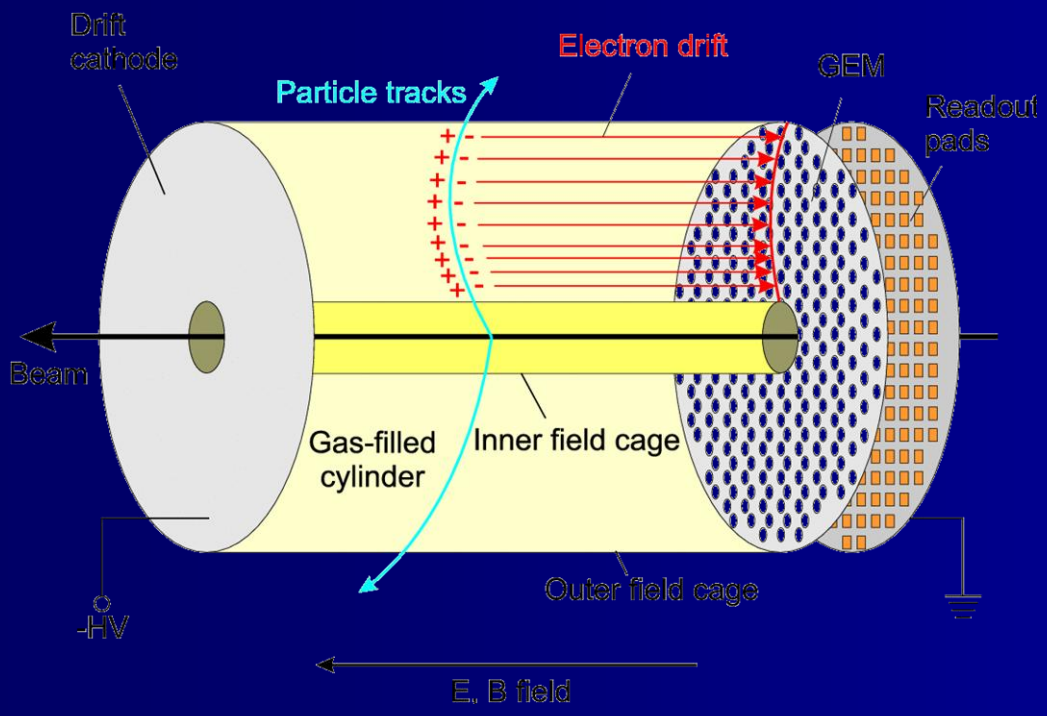
Straight and tilted layers

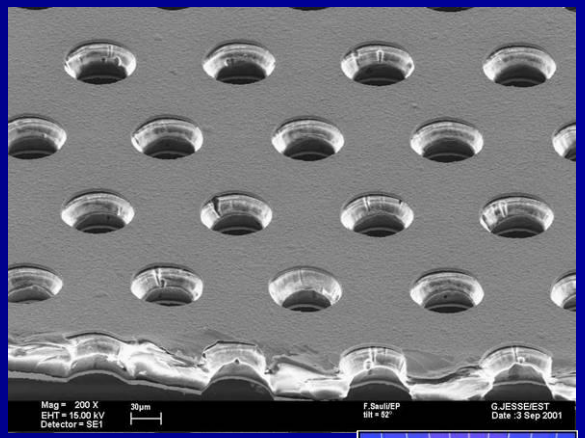
- 5340 straws in 21-27 layers
- Tube length 1.5 m
- Tube diameter 10.1 mm
- Al-mylar film tube,
  10 x 0.03 x 1500 mm
- Ar/CO_2, 2 bar
- $X/X_0 \sim 1 – 1.3\%$

- Light materials
- Self-supporting structure
- High rate capability due to single-straw readout

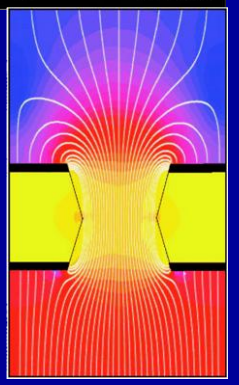
Tracking

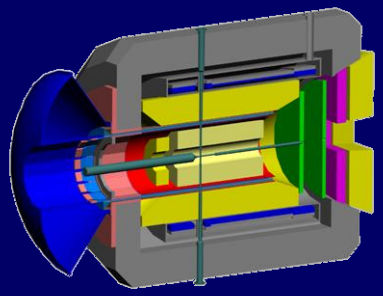
TPC option



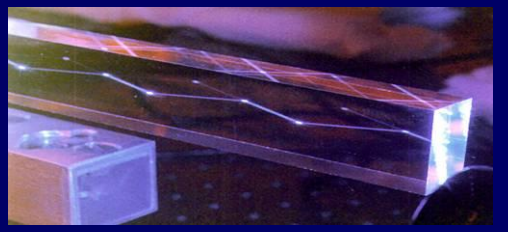


GEM readout





Particle ID

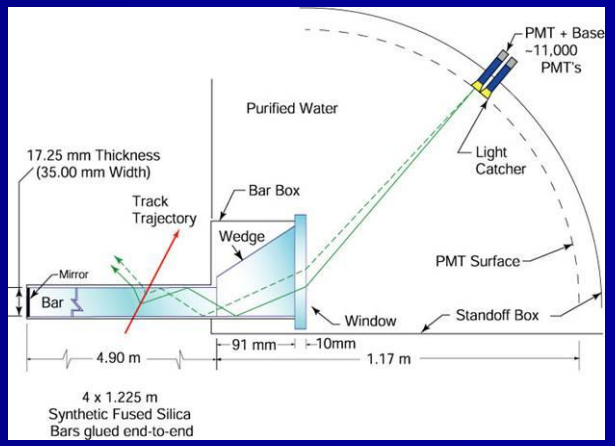


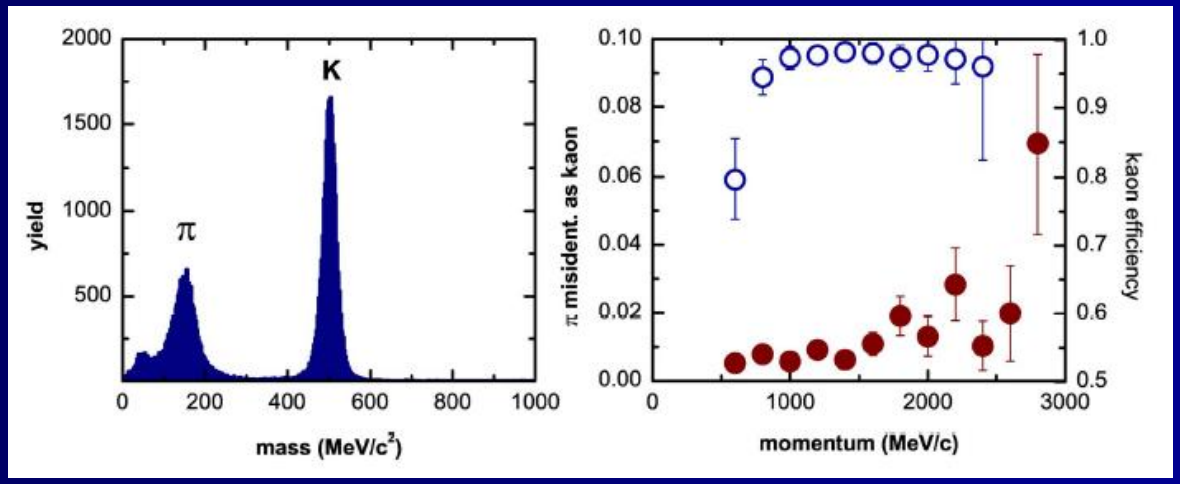
PID (e, μ, π, K, p):

below 5^0 hadronic calorimeter

$5^0<\theta<22^0$ aerogel Cherenkov counter or forward RICH

$22^0<\theta<140^0$ DIRC (BABAR@SLAC)





Simulated DIRC response:

π / K sep.

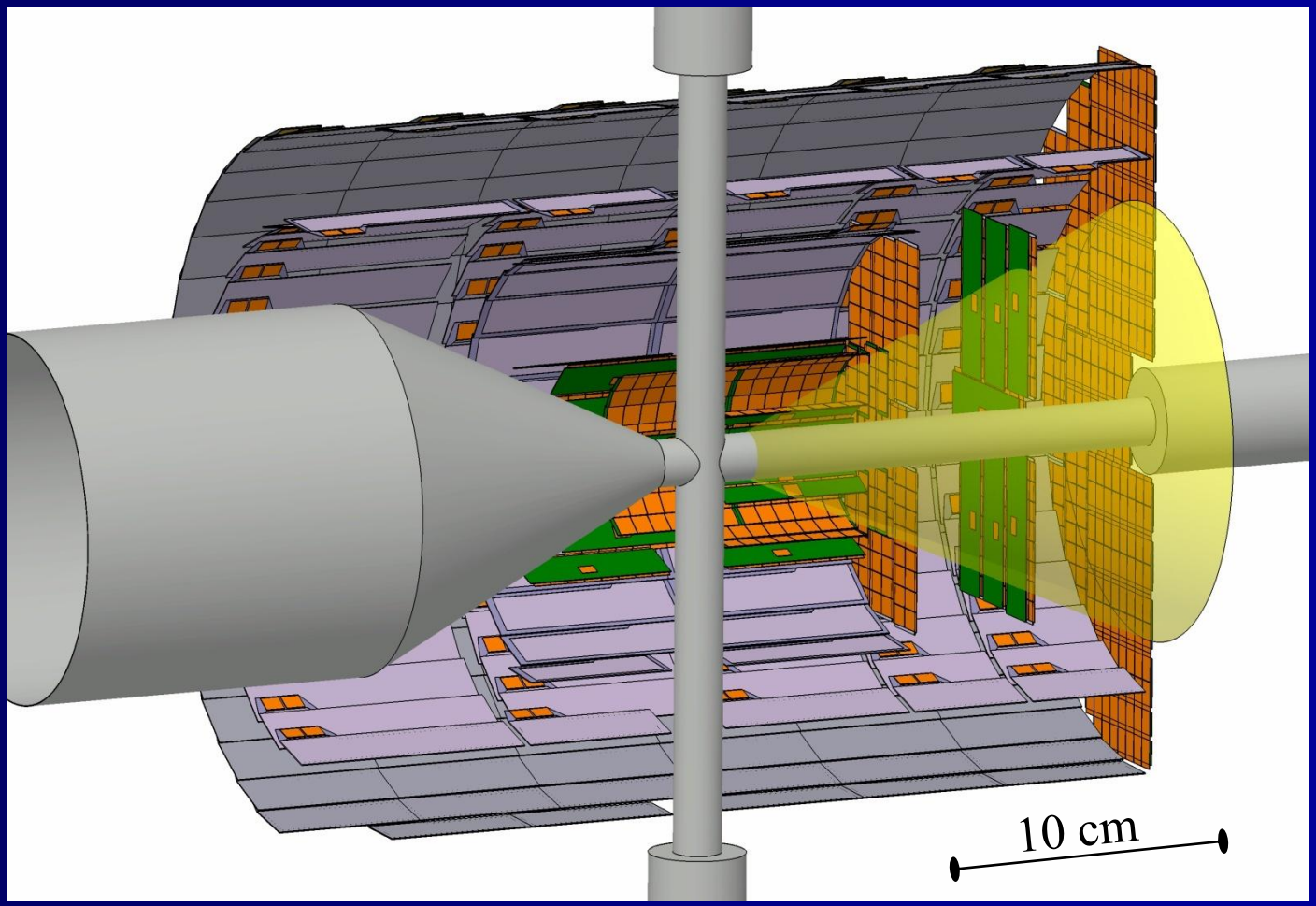
Micro-Vertex Detector

Conceptual design adopts state-of-the-art silicon sensor techniques (ATLAS/CMS/ALICE inner tracker layers, BaBar tracking of B mesons)

Design features:

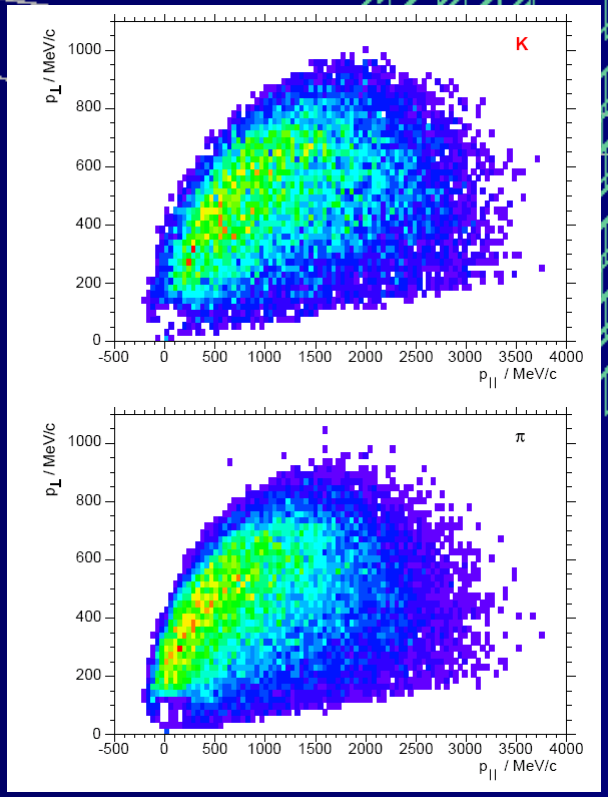
- Minimum of 4 space points forward of 90°
- Barrel and forward disk structures
- Pixels and double-sided strips
- Smallest possible inner radius
- Fast readout

Micro-Vertex Detector

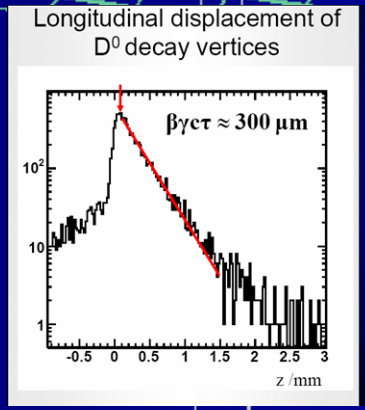


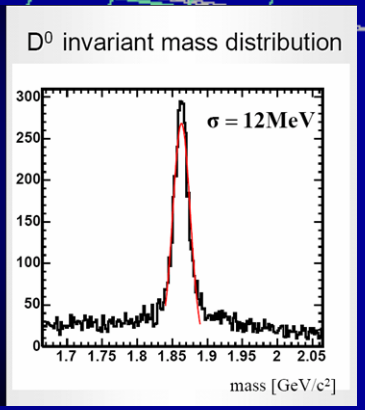
Micro-Vertex Detector

$$\bar{p}(6.7\,GeV)\,p \rightarrow \bar{D}D$$
$$(D \rightarrow K\pi\pi)$$



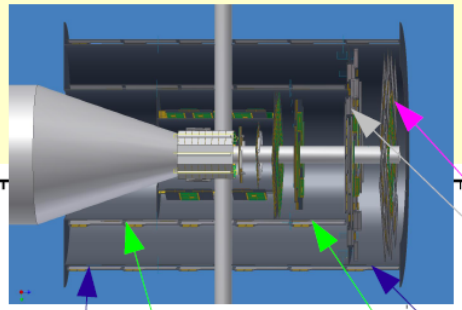
- $\bar{P}$ANDA will have to cope with an extended interaction region
- Primary vertex often unknown, wires and (perhaps) pellets define z with ~20 µm accuracy, displacement observable
- $2 \cdot 10^7$ interactions per second have to be handled and efficiently searched for events of desired shape

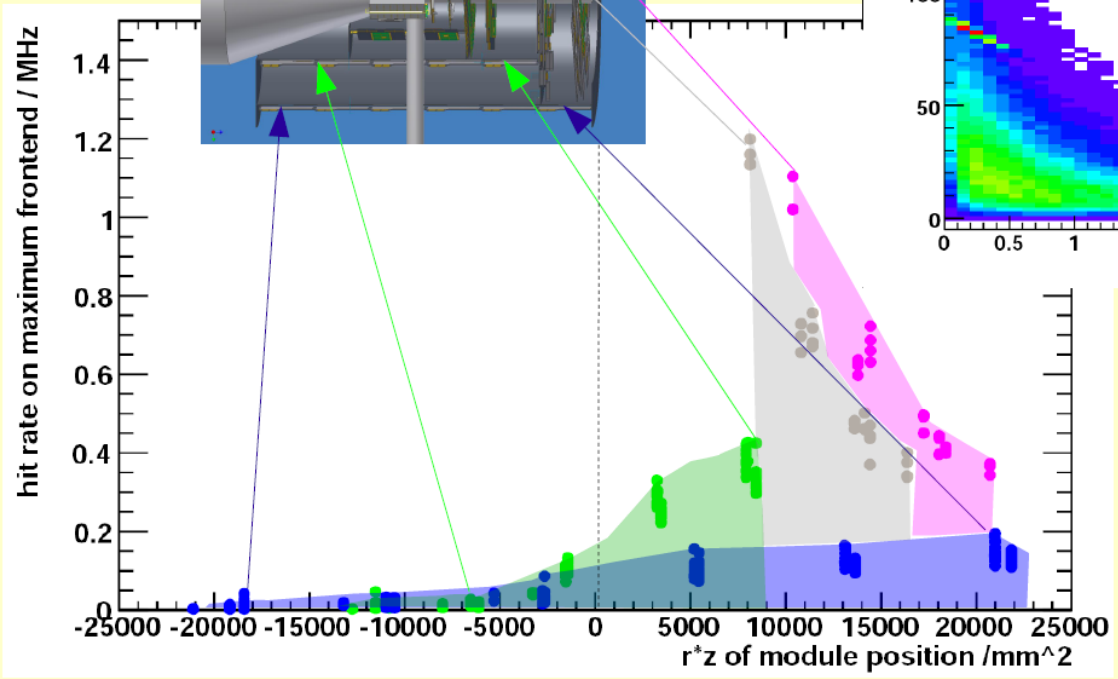


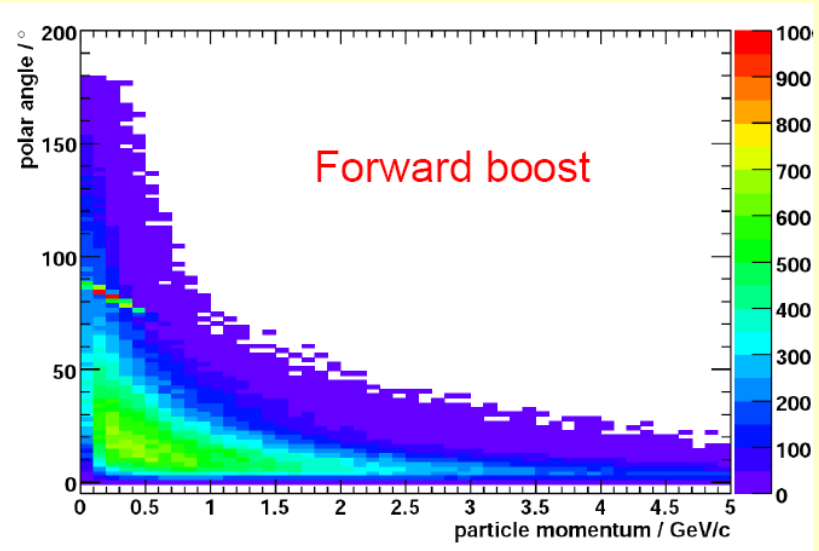


Micro-Vertex Detector - Simulations

- Antiproton - proton





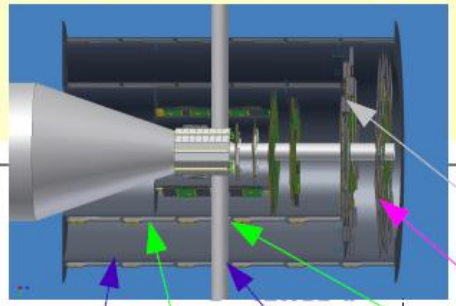


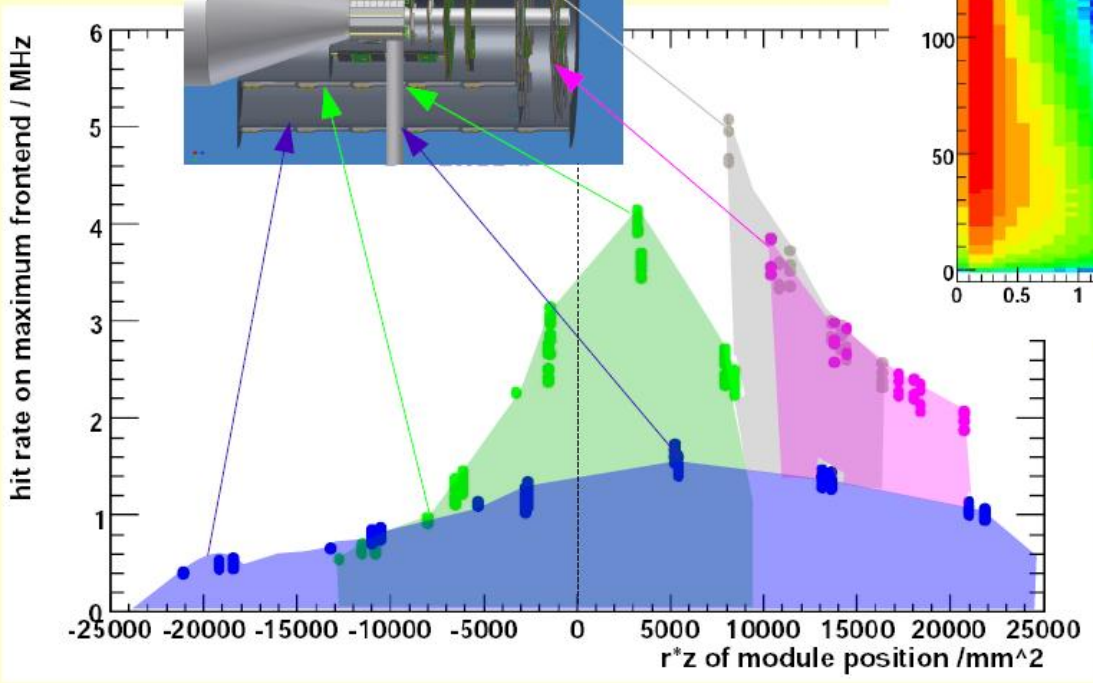
Highest rate:

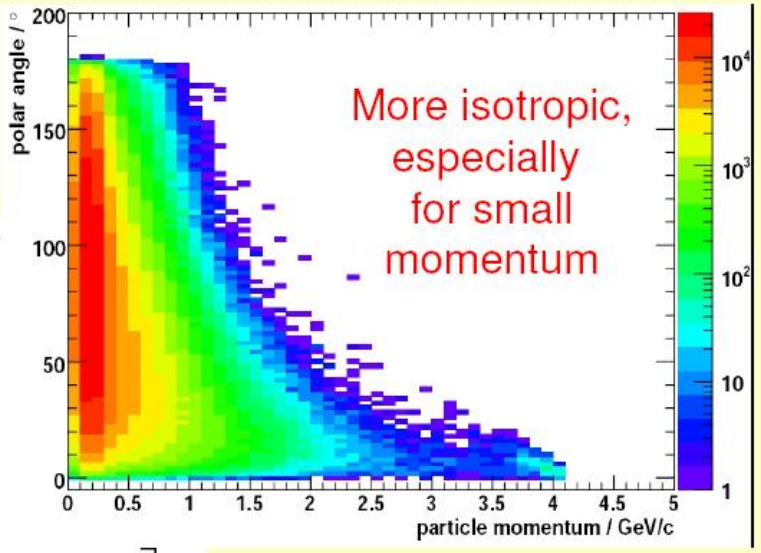
$1{,}2 \cdot 10^6$ / s / FE

Micro-Vertex Detector - Simulations

- Antiproton - gold





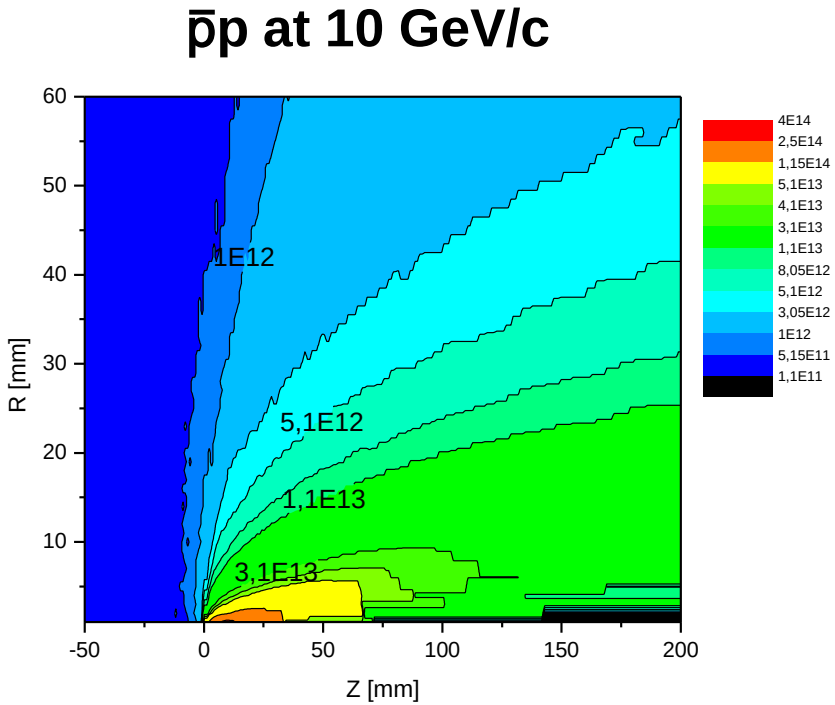


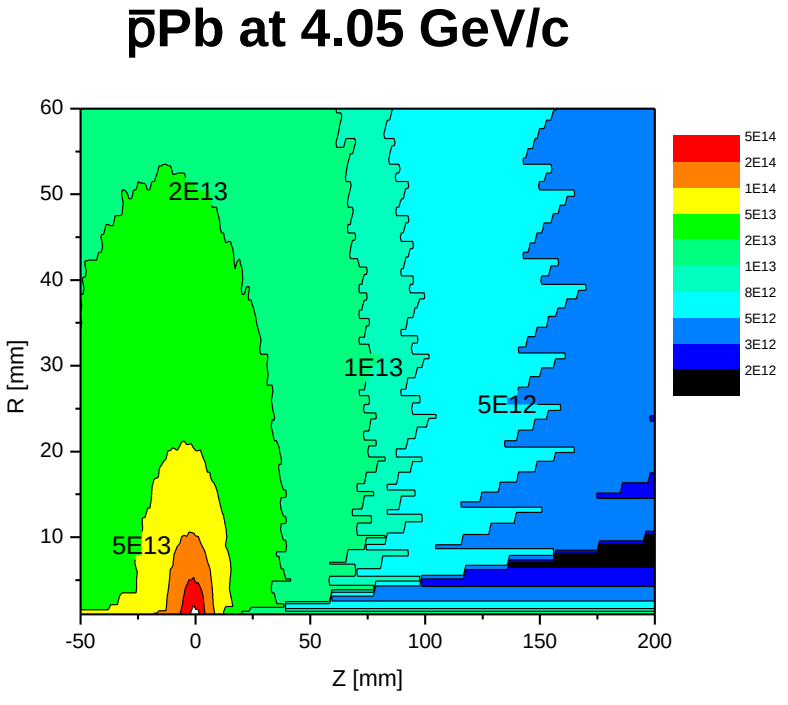
Highest rate:

$5{,}1 \cdot 10^6$ / s / FE

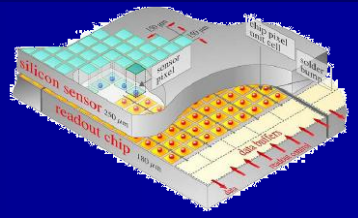
Micro-Vertex Detector - Simulations

Radiation load maps





Micro-Vertex Detector - Pixels

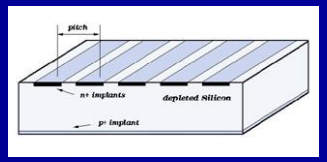


PANDA optimized pixel layout:

- Small pixel cells – 100 x 100 μm^2
- Need specialized custom hybrid ☞ talk by Angelo Rivetti

features:
- .13 µ technology
- ToT to retain (some) energy information
- fast handling for high data rates
- “untriggered” readout of data
- rad hard within “typical” limits
- minimum material load ⇔ sensor technology

Micro-Vertex Detector - Strips



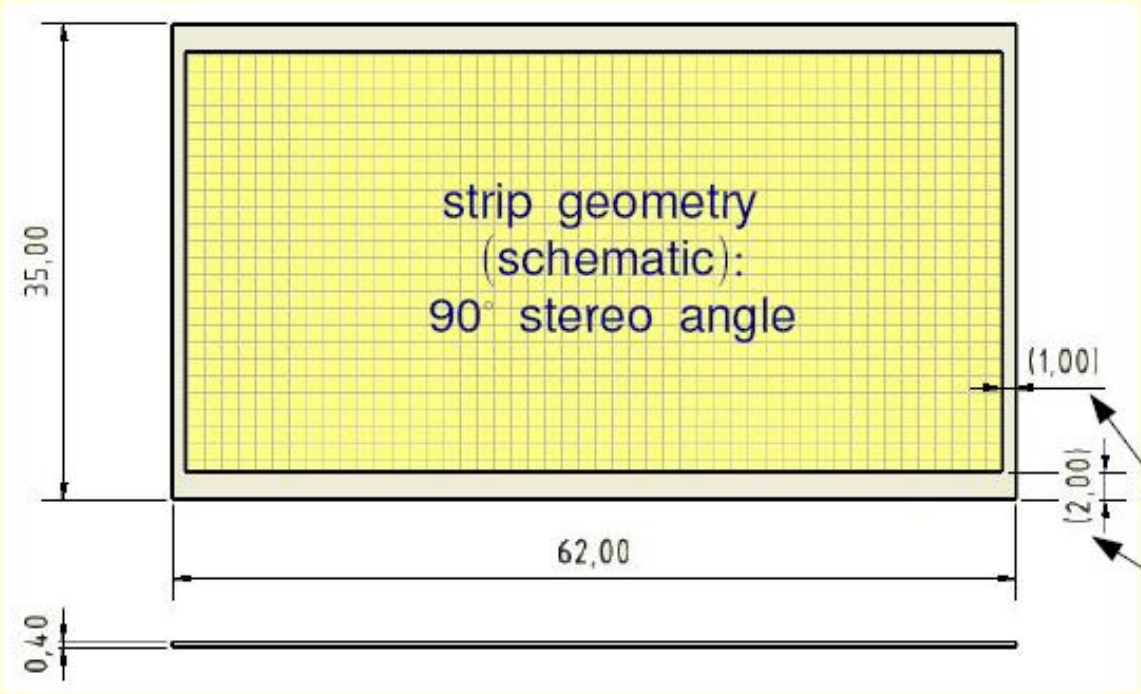
P̄ANDA strip layers:

- Substitute strips for pixels to keep number of space points with less traversed material where possible
- Use standard solutions where possible

features:
- pitch of 50 – 100 µm
- double-sided sensors, 200 µm thick
- need specialized solution for front-end to achieve untriggered readout
  - ☞ synergy CBM / P̄ANDA on n-XYTER
- minimum possible thermal load

Micro-Vertex Detector - Strips

- Barrel: Sensor

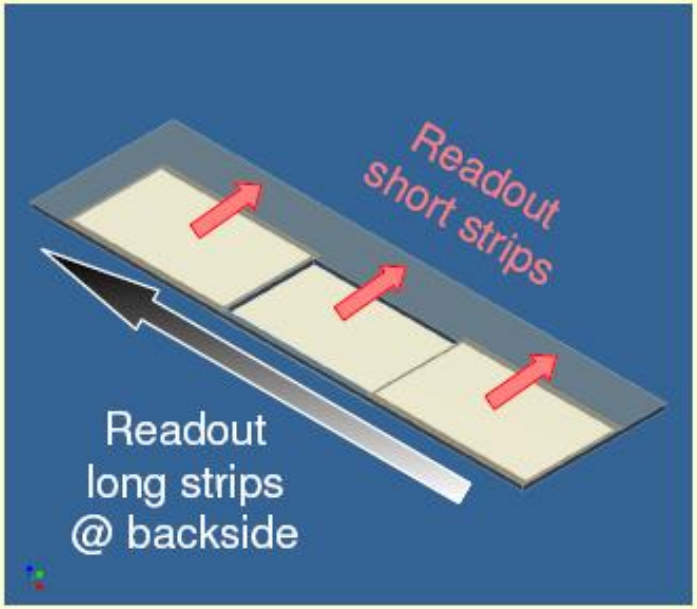


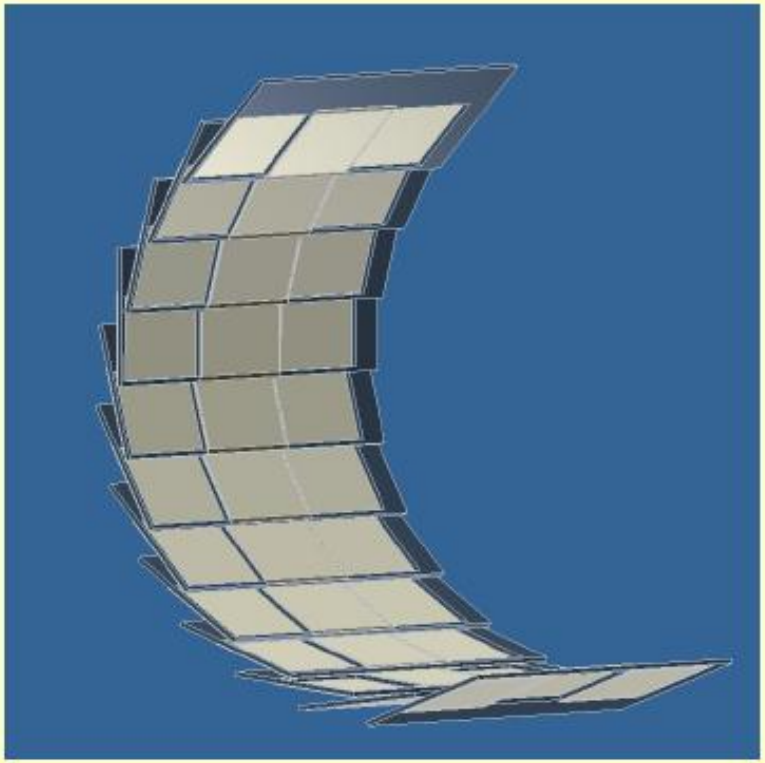
#FE	#ch	Pitch
	long side	
5	640	90 µm
6	768	78 µm
7	896	67 µm
	short side	
2	256	121 µm
3	384	81 µm
4	512	61 µm

Edge:
Overlap for
mounting

Micro-Vertex Detector - Strips

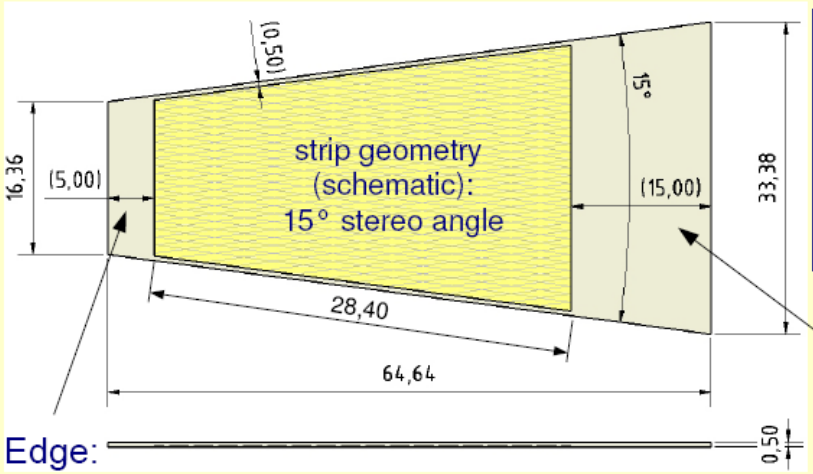
- Barrel: Stave arrangement





Micro-Vertex Detector - Strips

- Disk: Sensor

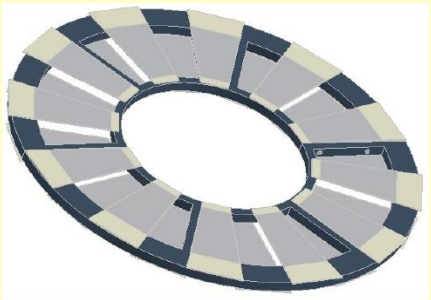


#FE	#ch	Pitch
3	384	74 µm
4	512	55 µm
5	640	44 µm

Edge:
Overlap for mounting and connection to inner disk part

Edge:
Overlap for mounting and area for readout

- Disk: Support and sensor arrangement

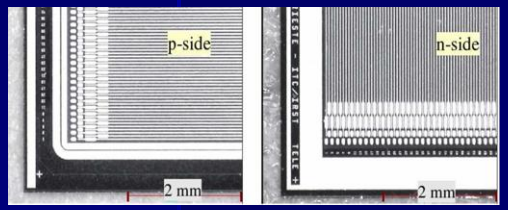


Strip Sensors – Test Station

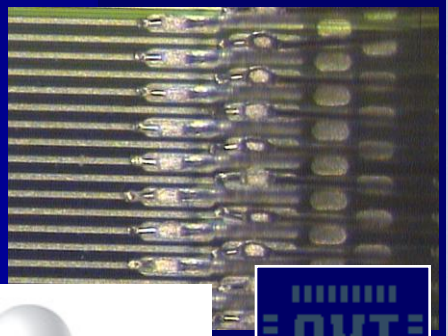
sensor “telescope”

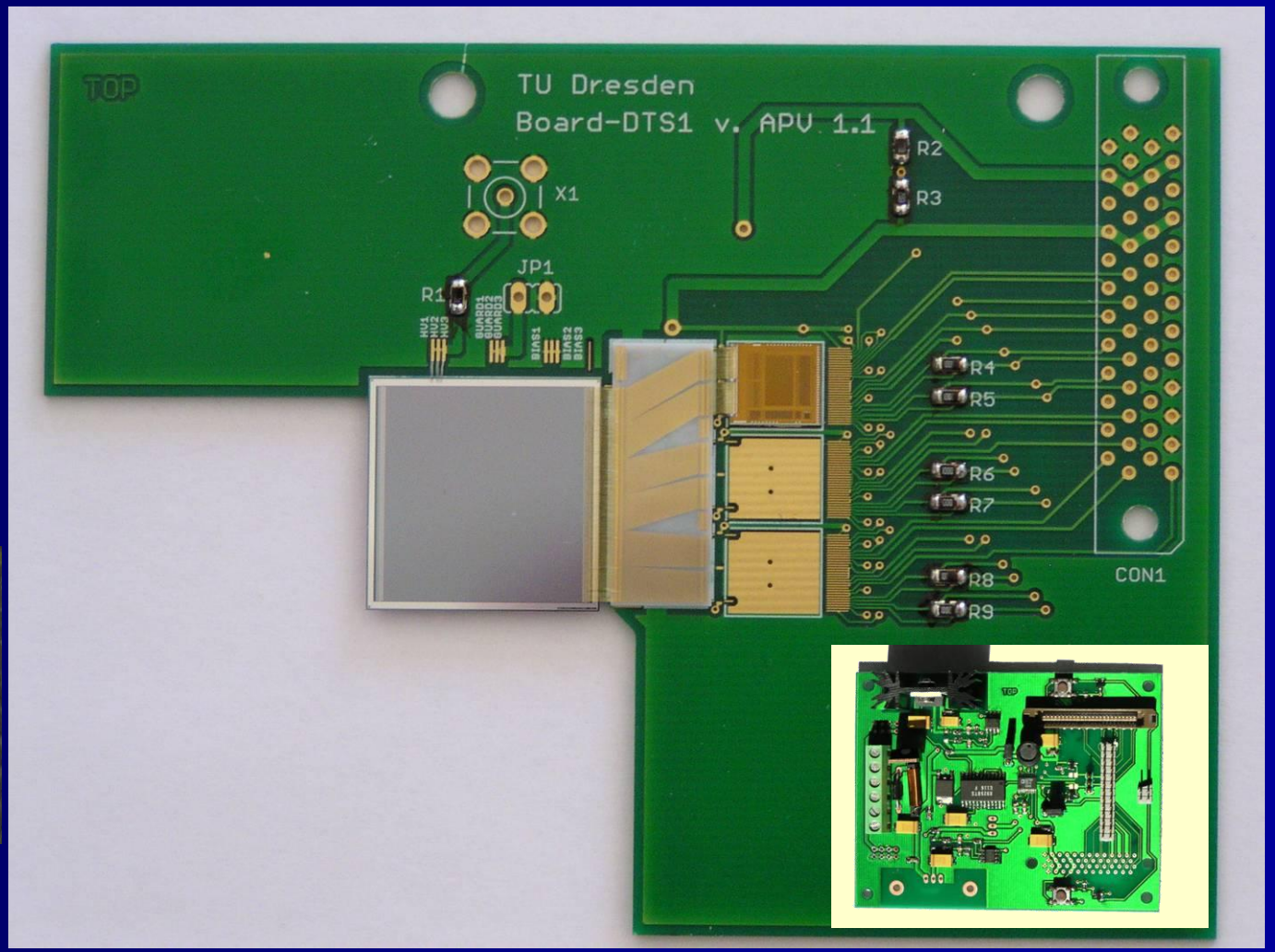
20x20 mm^2

50 µm pitch



front end APV25 S1





$\bar{P}$ANDA MVD Summary

- $\bar{P}$ANDA will greatly benefit from a state-of-the-art silicon tracking device.
- $\bar{P}$ANDA-specific challenges: very compact design, high and anisotropic data rates, free-running DAQ concept (untriggered readout), material budget.
- $\bar{P}$ANDA-specific solutions needed:

  pixel readout, strip front-end, compact arrangement around fixed target.