The PANDA Barrel DIRC

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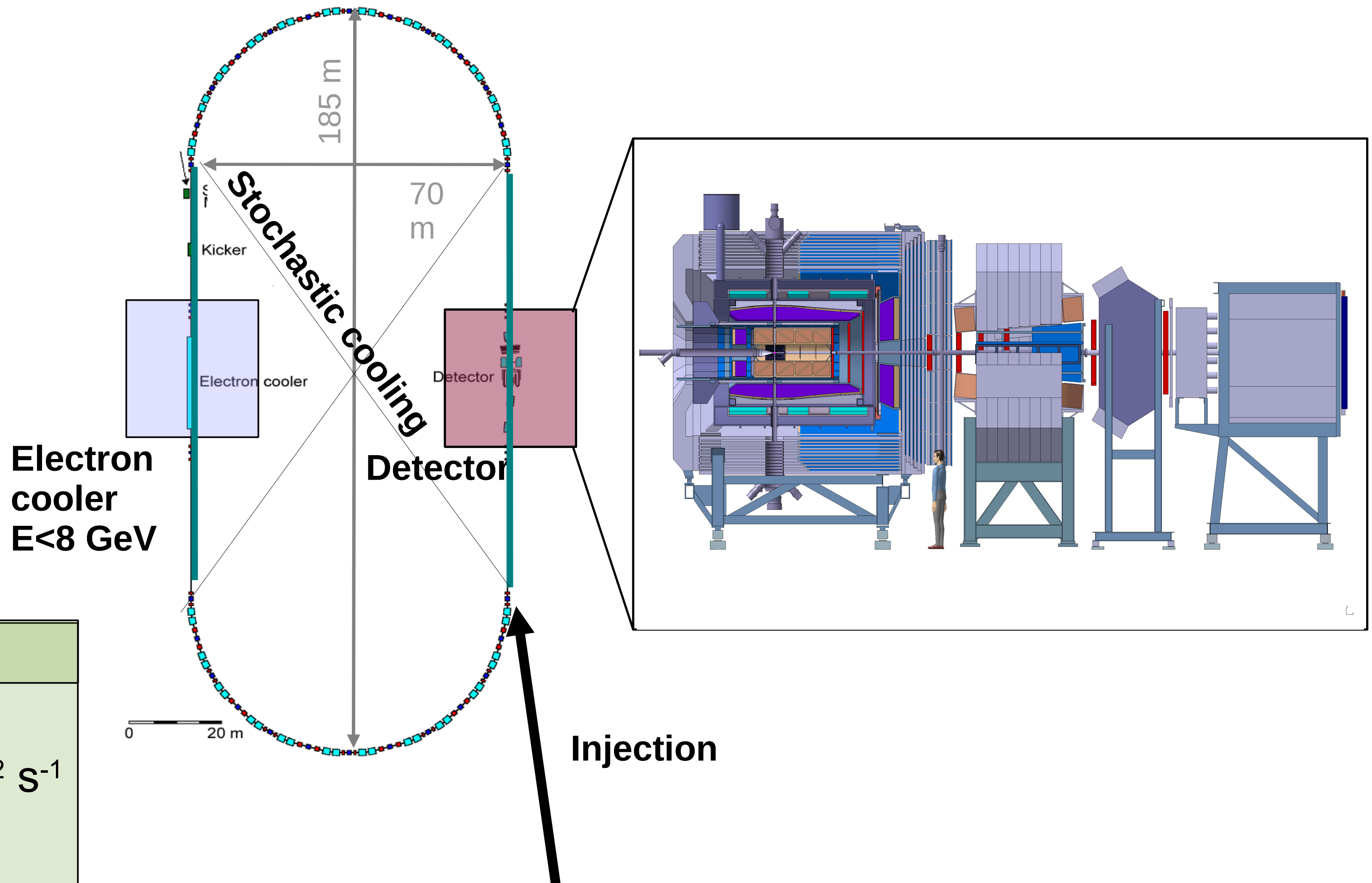
- Introduction
  - HESR
  - PID
  - The PANDA DIRCs
  - DIRC principle
- Photon detector
  - Mirrors
  - Lenses
- Photon detection
  - MCP-PMT
- Radiator quality
- Read out chain

HESR@FAIR

Cooling: electron/stochastic

High resol. mode: $\mathcal{L}$ = 10^{31} cm^{-2} s^{-1} δp/p ~ 10^{-5}

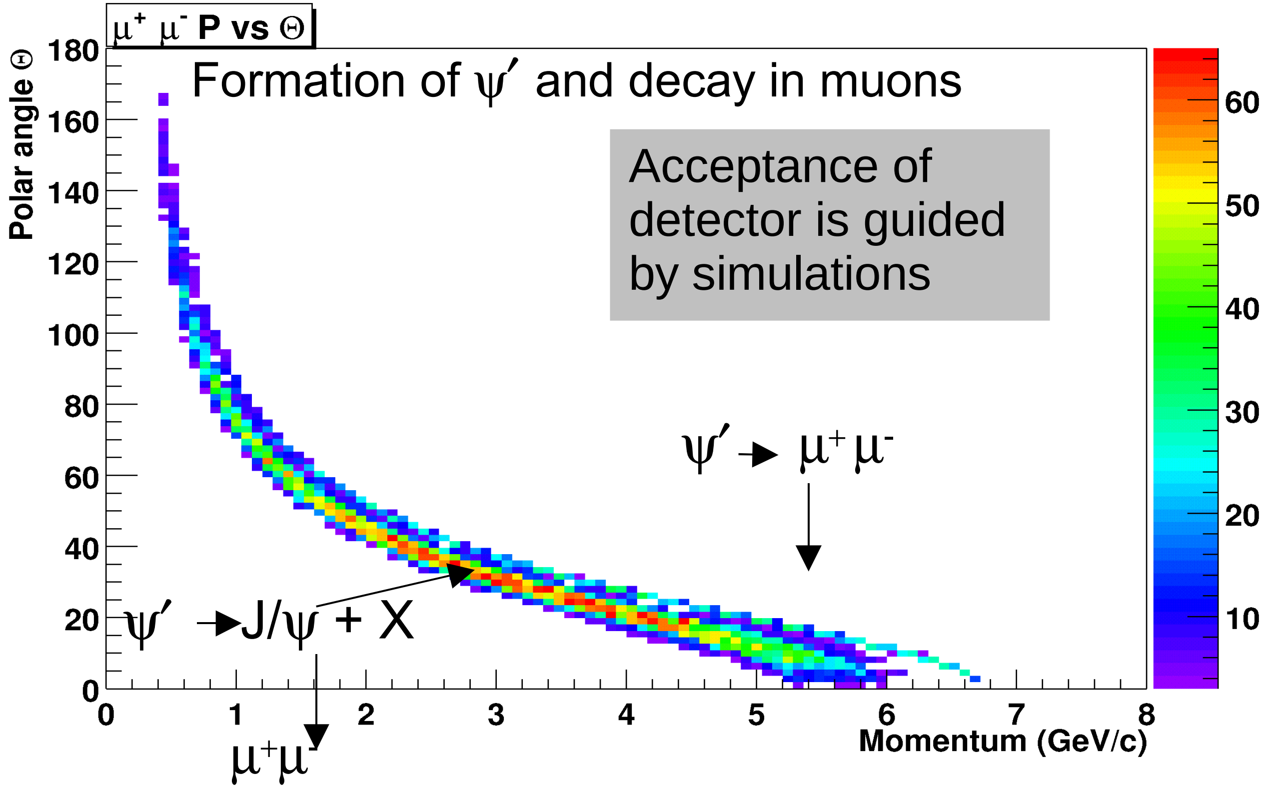
High lum. mode: $\mathcal{L}$ = $2 \cdot 10^{32}$ cm^{-2} s^{-1} δp/p < 10^{-4}



Characteristics
P_{max} = 15 GeV/c
$\mathcal{L}_{max}$ = $2 \cdot 10^{32}$ cm^{-2} s^{-1}
Ø < 100 μm
δp/p < 10^{-5}
internal target

Detector requirements:

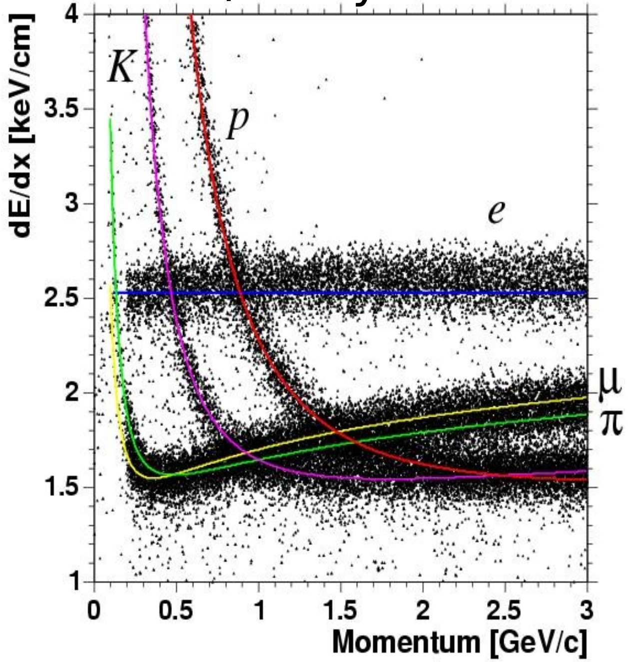
- nearly 4π solid angle for PWA
- high rate capability: $2x10^7\ s^{-1}$ interactions
- efficient event selection
- momentum resolution ~1%
- vertex info for D, $K^0{}_S$, Λ (cτ = 317 μm for $D^\pm$)
- good PID (γ, e, μ, π, K, p)
- photon detection 1 MeV – 10 GeV



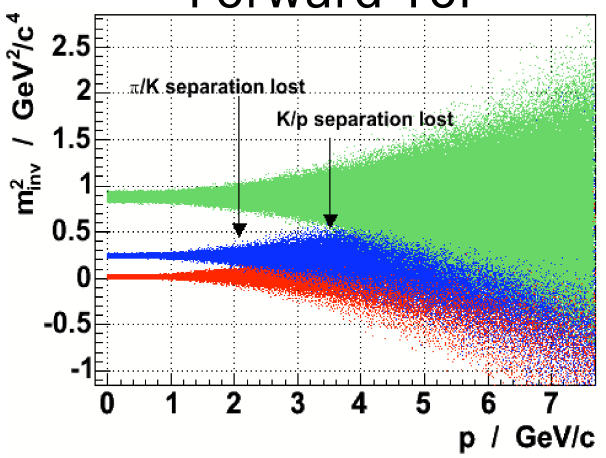
PANDA PID Requirements:

- Particle identification essential for PANDA
- Momentum range 200 MeV/c – 10 GeV/c
- Different process for PID needed

dE/dX by TPC



Forward ToF



PID Processes:

- Cherenkov radiation: above 1 GeV

  Radiators: quartz, aerogel, C4F10

- Energy loss: below 1 GeV

  Best accuracy with TPC

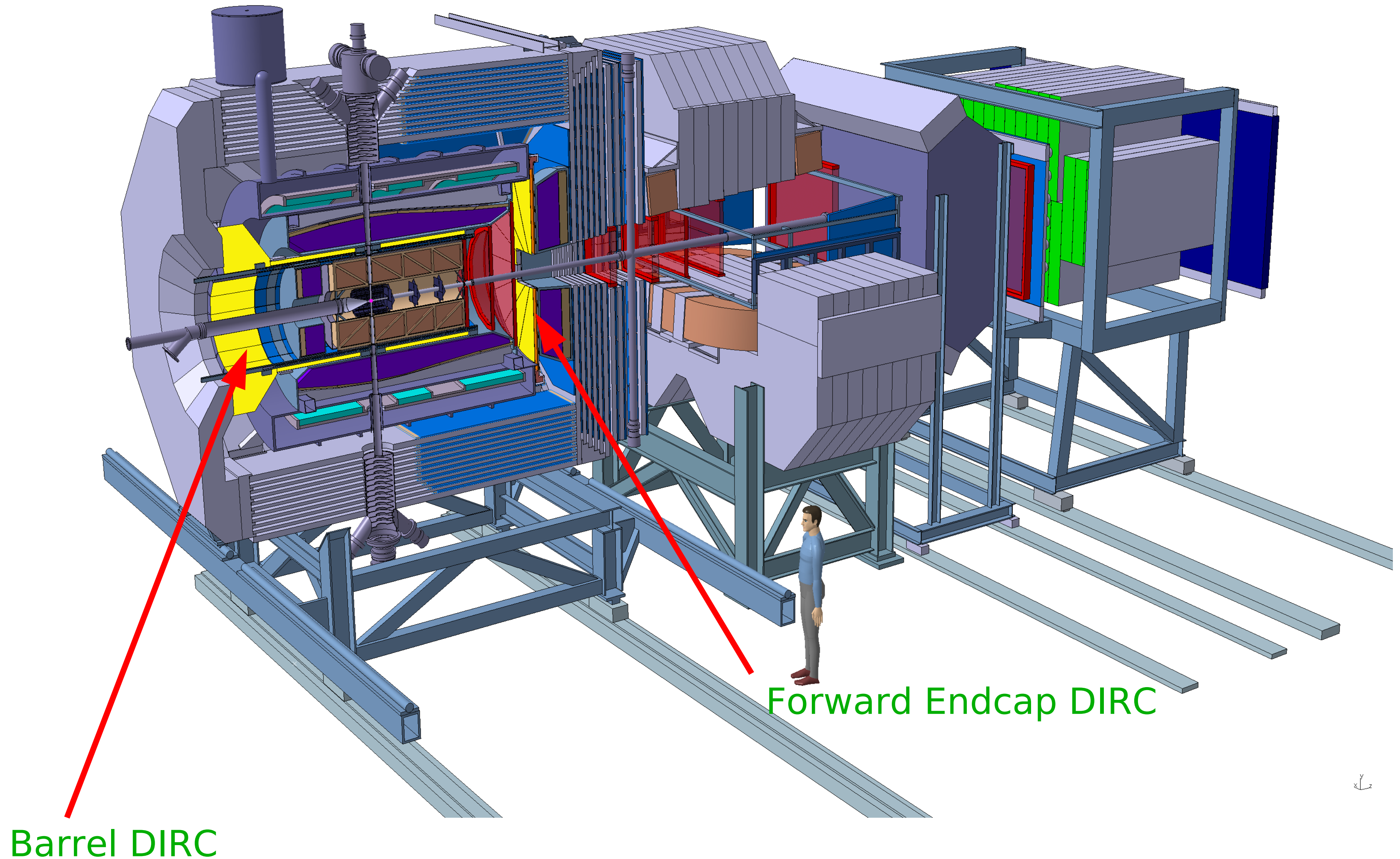
- Time of flight

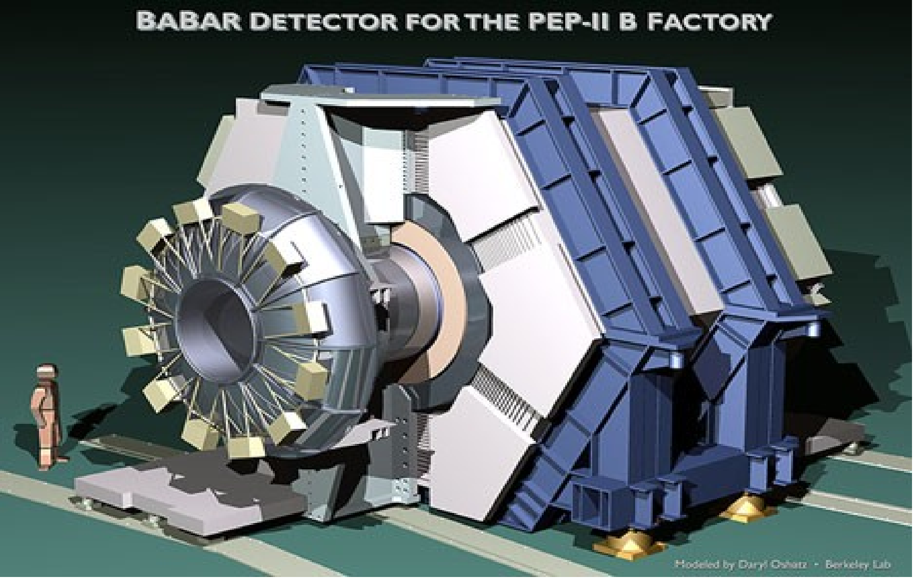
  Problem: no start detector

- Electromagnetic showers: EMC for e and γ
- Muon detection system

The PANDA DIRCs

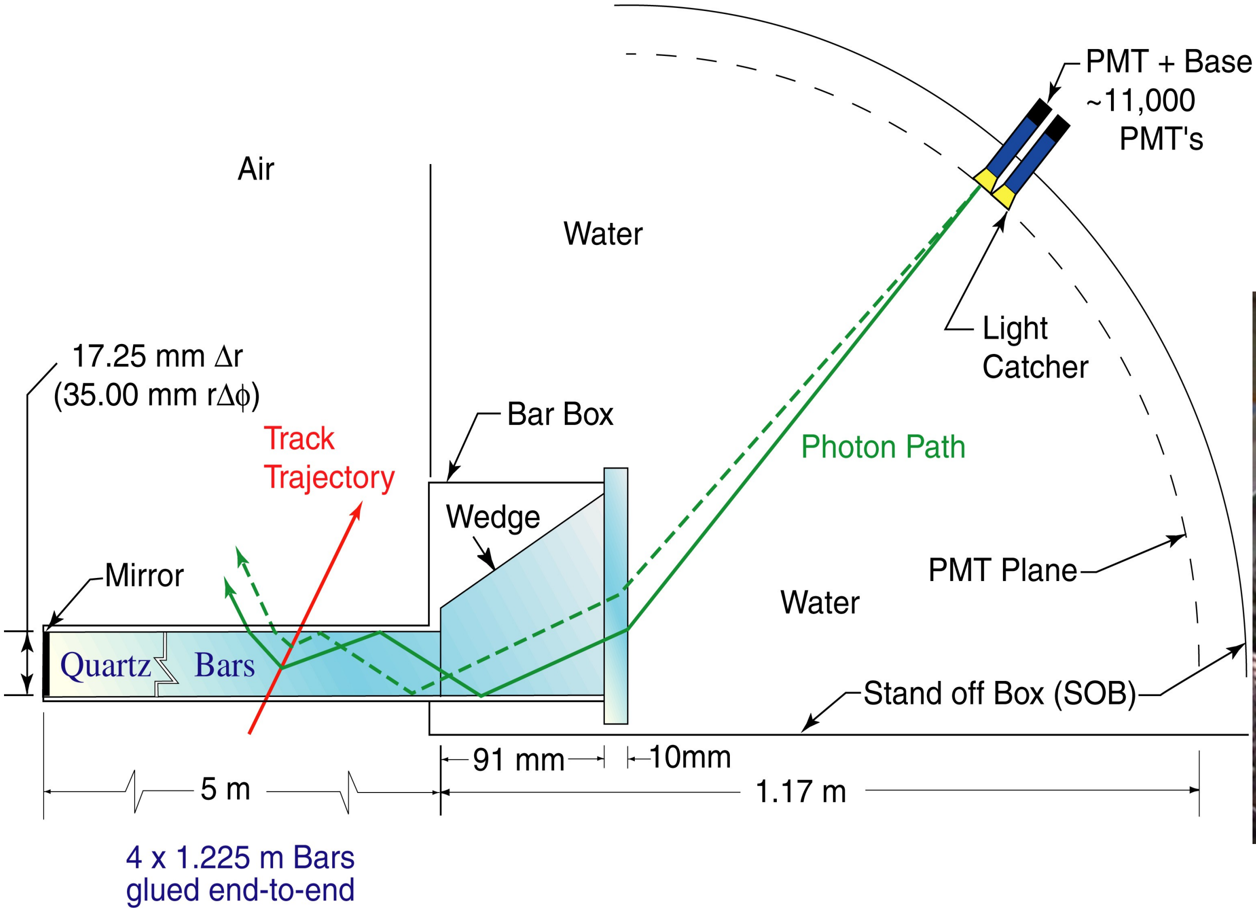
DIRC principle to minimize space





DIRC principle

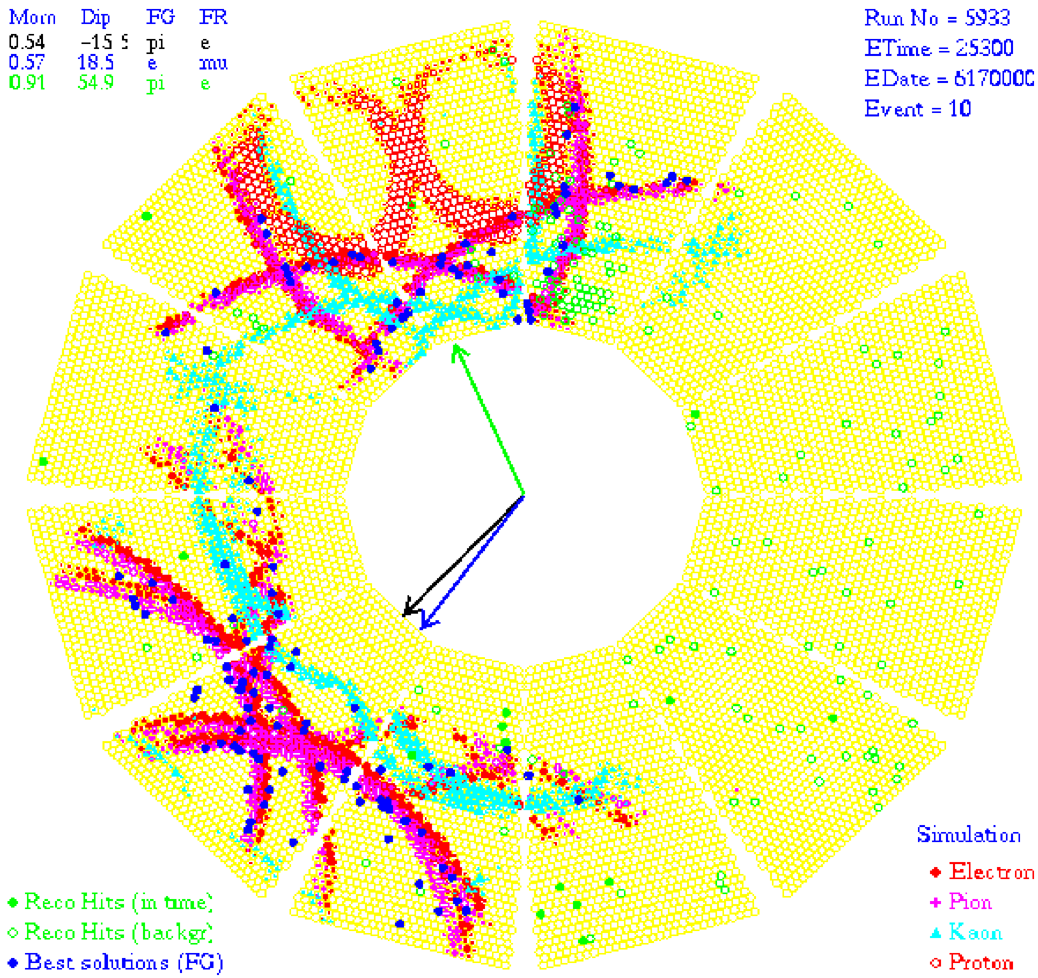
Detection of
Internally
Reflected
Cherenkov light



BaBar 11000 PMT
Panda 7000 PMT
(for the BaBar readout)

Ring Imaging

BaBar event

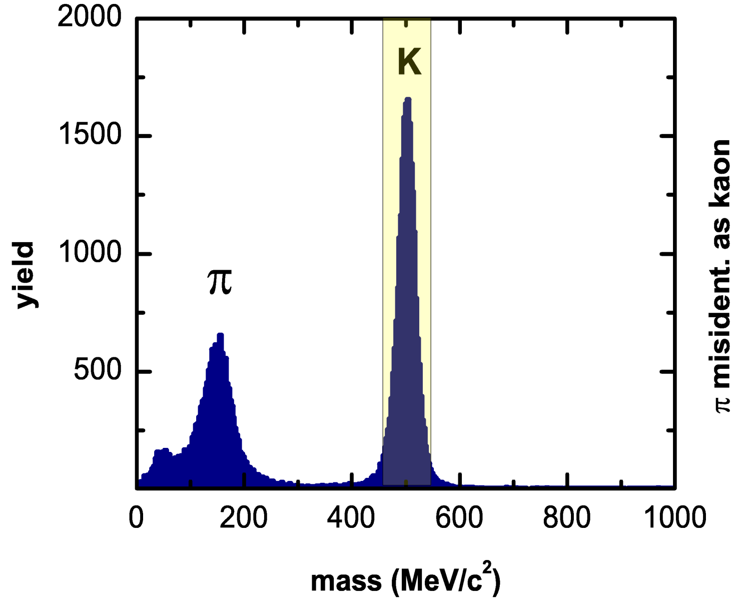


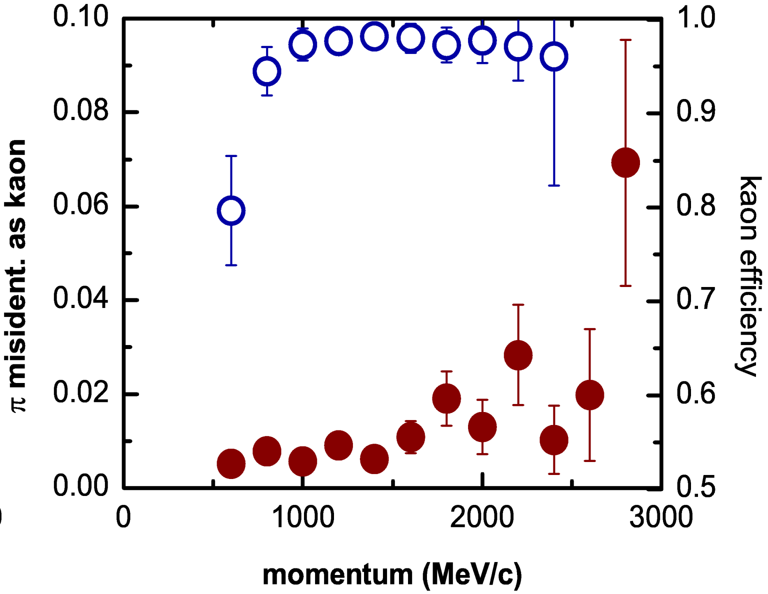
BaBar pinhole focus

for smaller photon detector
focussing needed
- mirror
- lens

Performance of the PANDA barrel DIRC

reduced BaBar version (7000 PMT, pinhole focus)



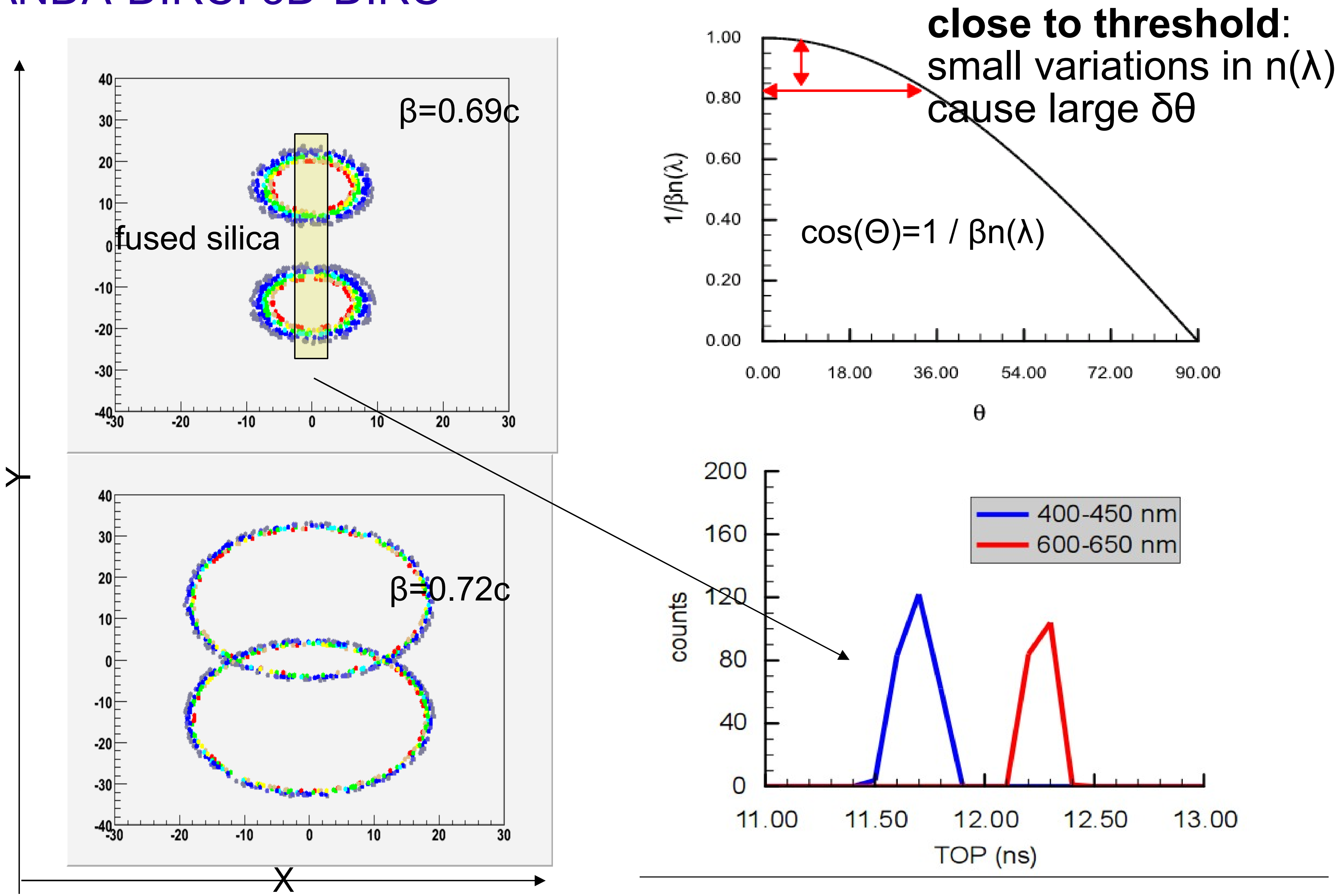


Geant4 simulation with own photon propagation
reconstruction was done with Root-fit of image

status of Conceptional Design Report 2001
Technical Progress Report 2005

recent developments: timing information, lens focusing
--> **focusing 3-D DIRC**

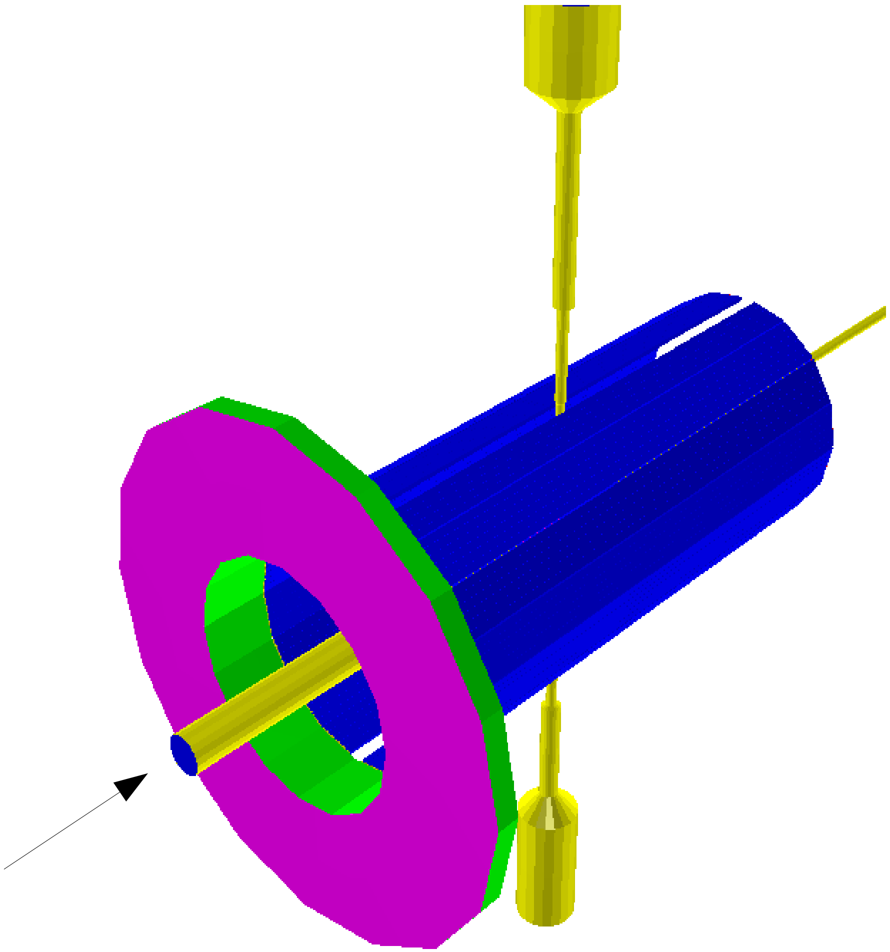
PANDA-DIRC: 3D-DIRC



Time of Propagation measurement better 0.5ns allows to correct dispersion for high and low momenta→x,y,t→3D-DIRC

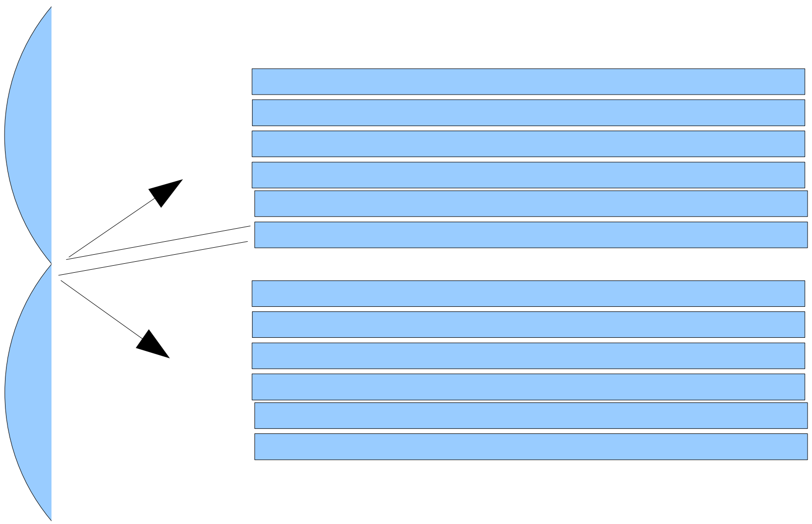
Photon detector, Mirrors

Towards a smaller photon detector:
pinhole focus -->
optical element: mirror, lenses



Visualization by PandaRoot simulation framework

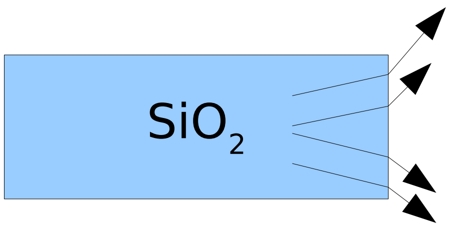
mirror: problem with “split rings”

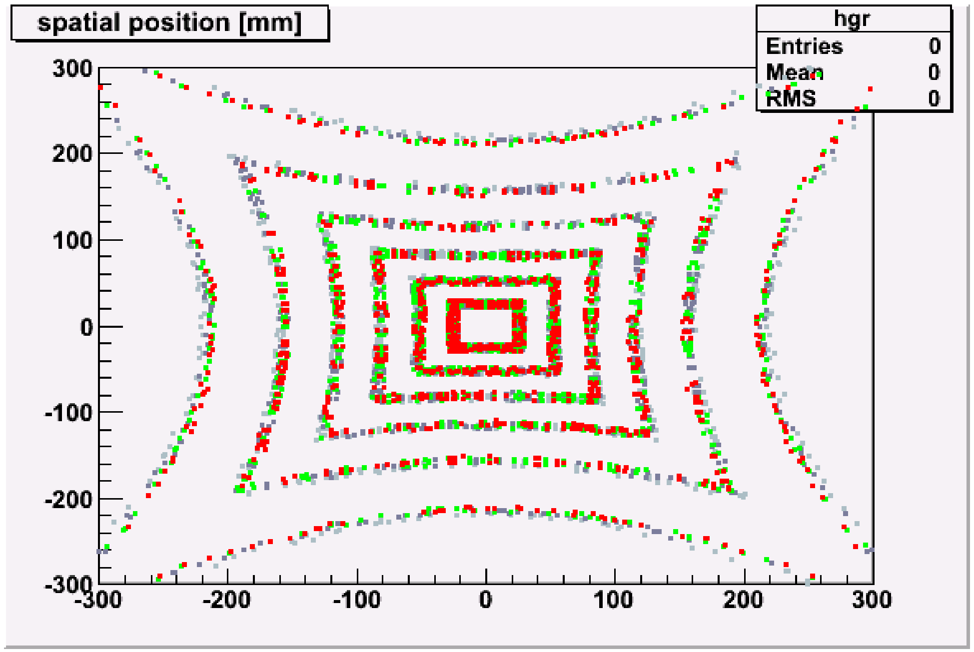


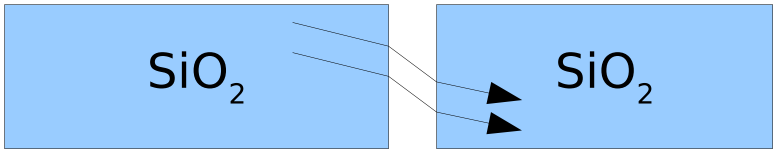
using one or two single mirror
(toroidal section)
needs huge radius

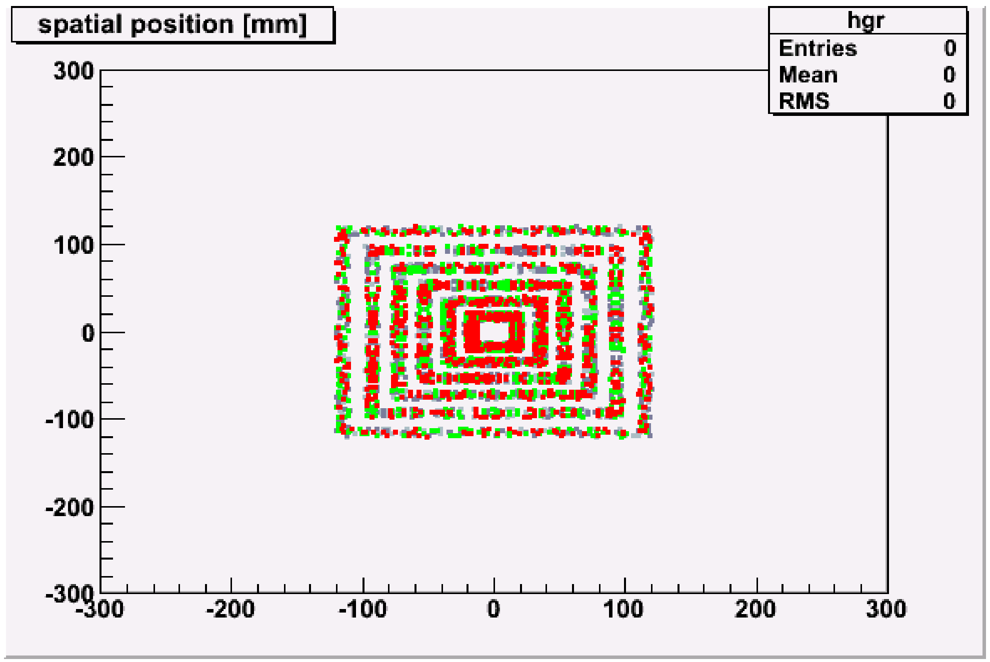
DRCPROP routines

Lenses

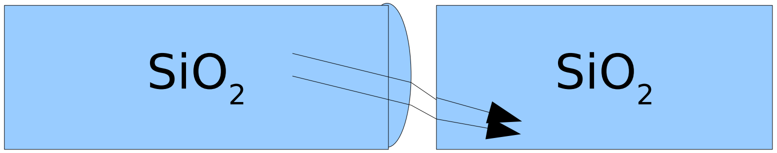

SiO2

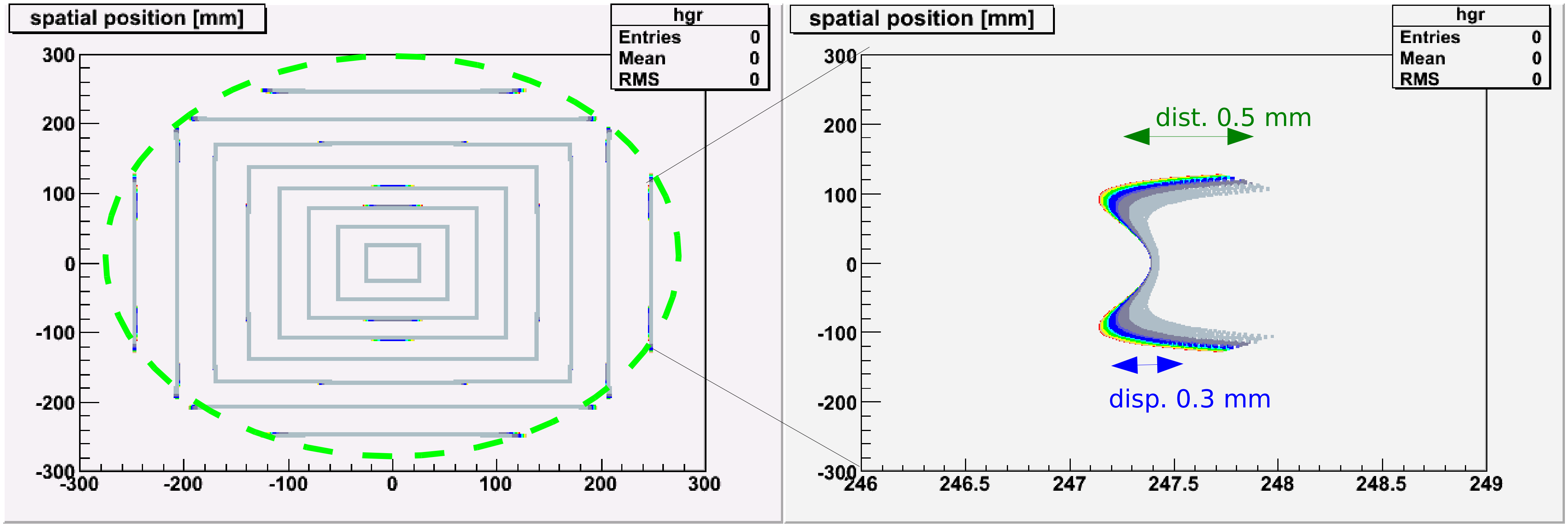

spatial position [mm]
hgr
Entries 0
Mean 0
RMS 0

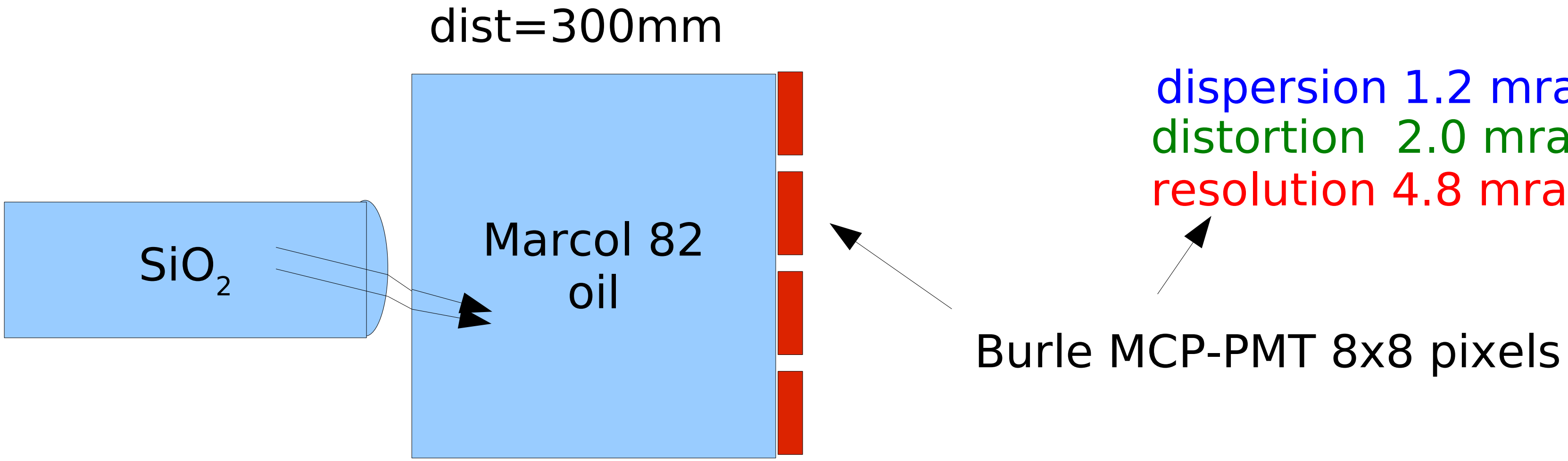

SiO2
SiO2


spatial position [mm]
hgr
Entries 0
Mean 0
RMS 0

Lens



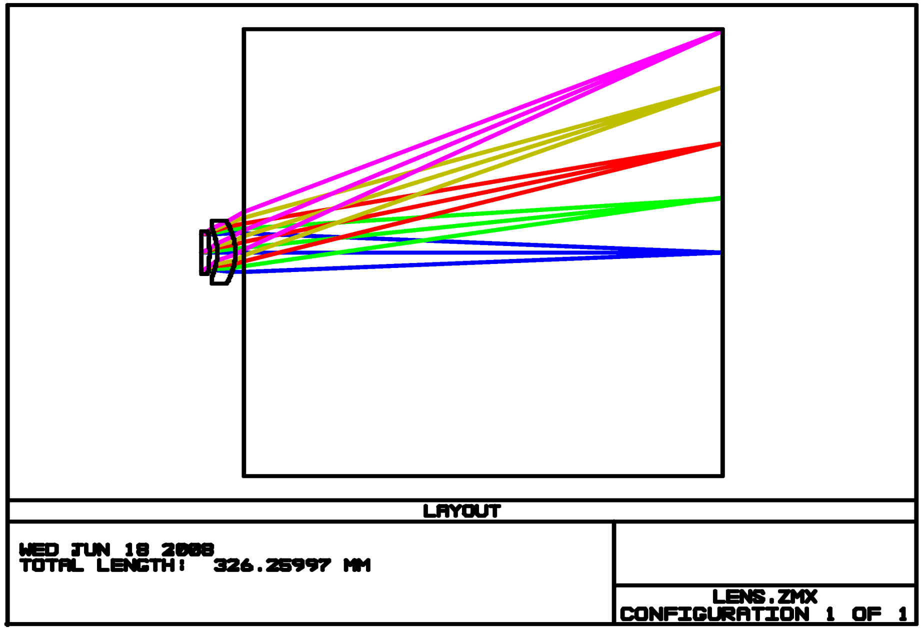




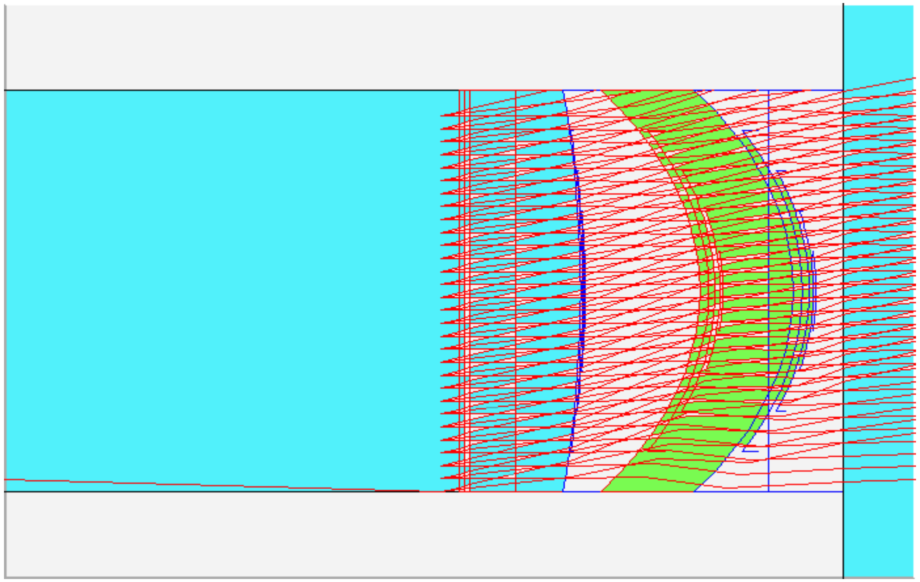
dispersion 1.2 mrad
distortion 2.0 mrad
resolution 4.8 mrad

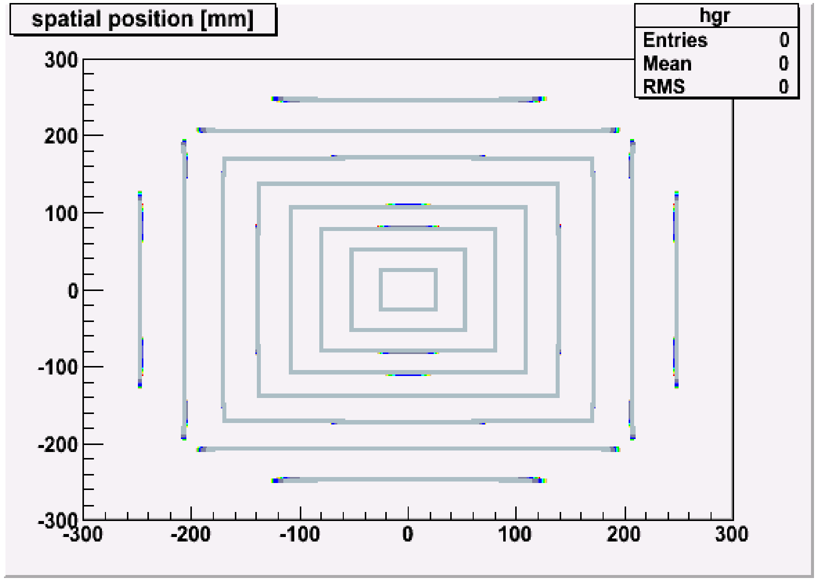
Lens doublett

flat focal plane computed
with ZEMAX optical software

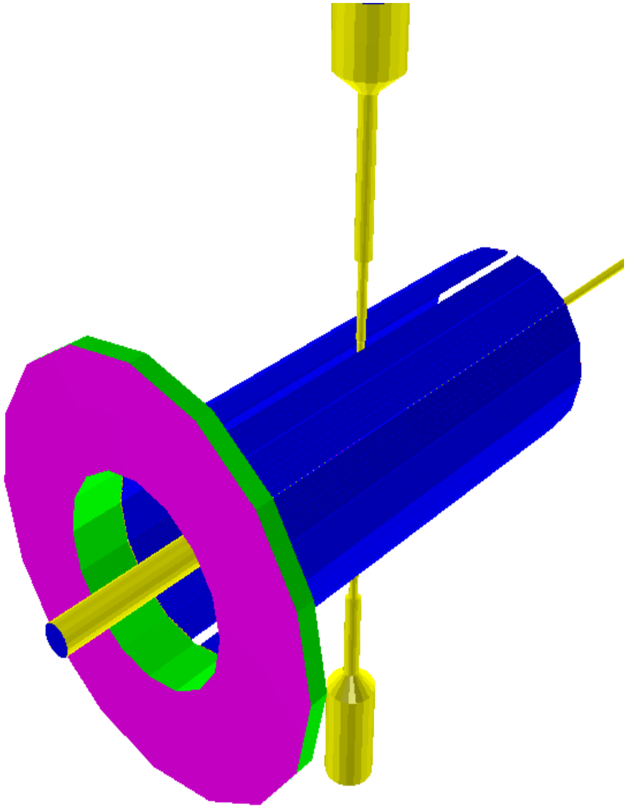


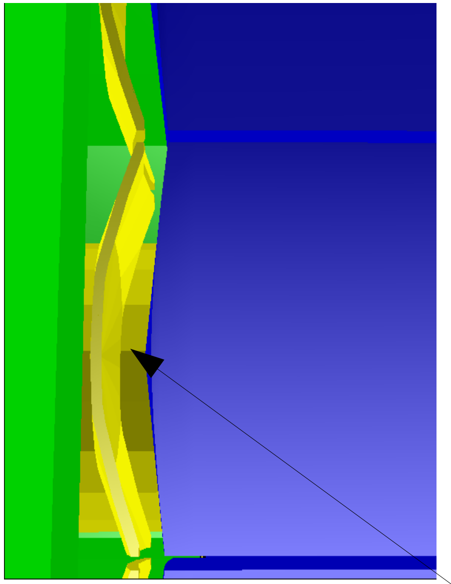
DRCPROP routines (no Fesnel reflections)



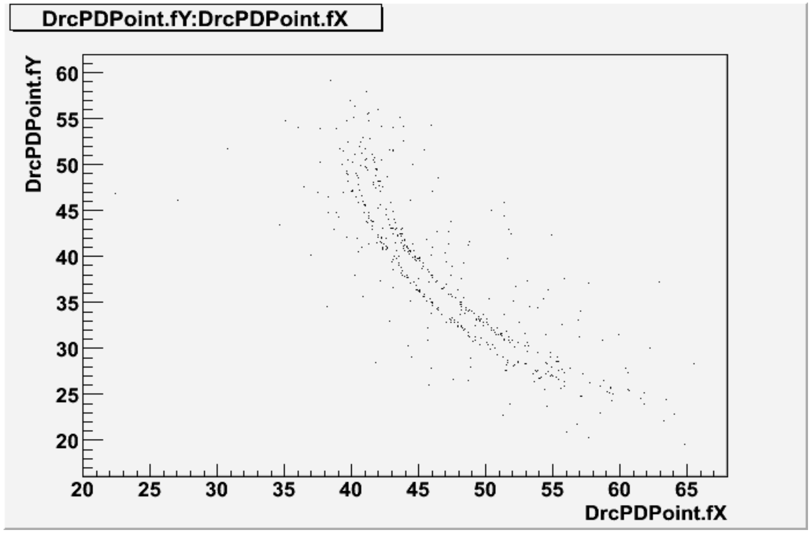


Lens doublett



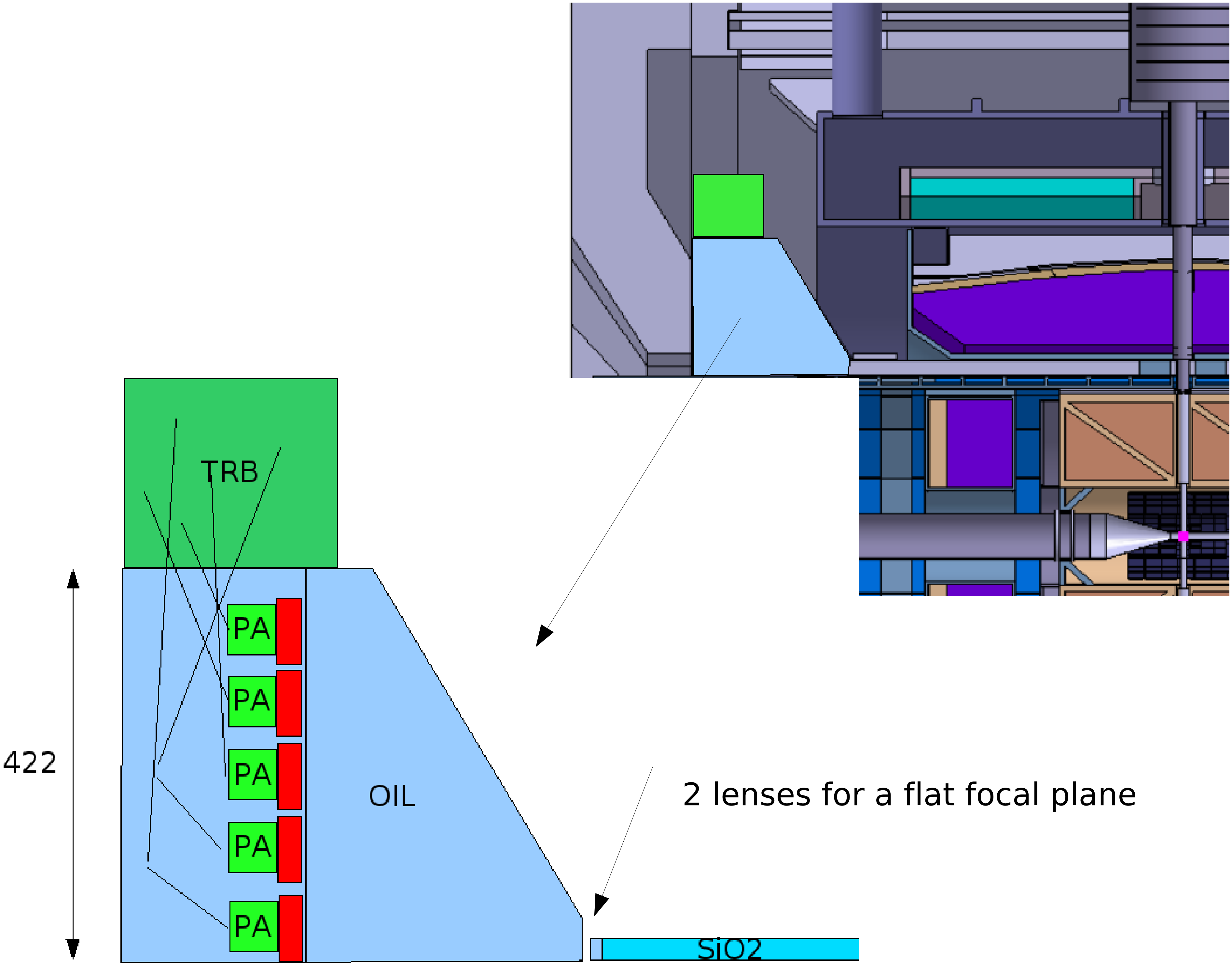


in PandaRoot framework
(with Fresnel reflections)



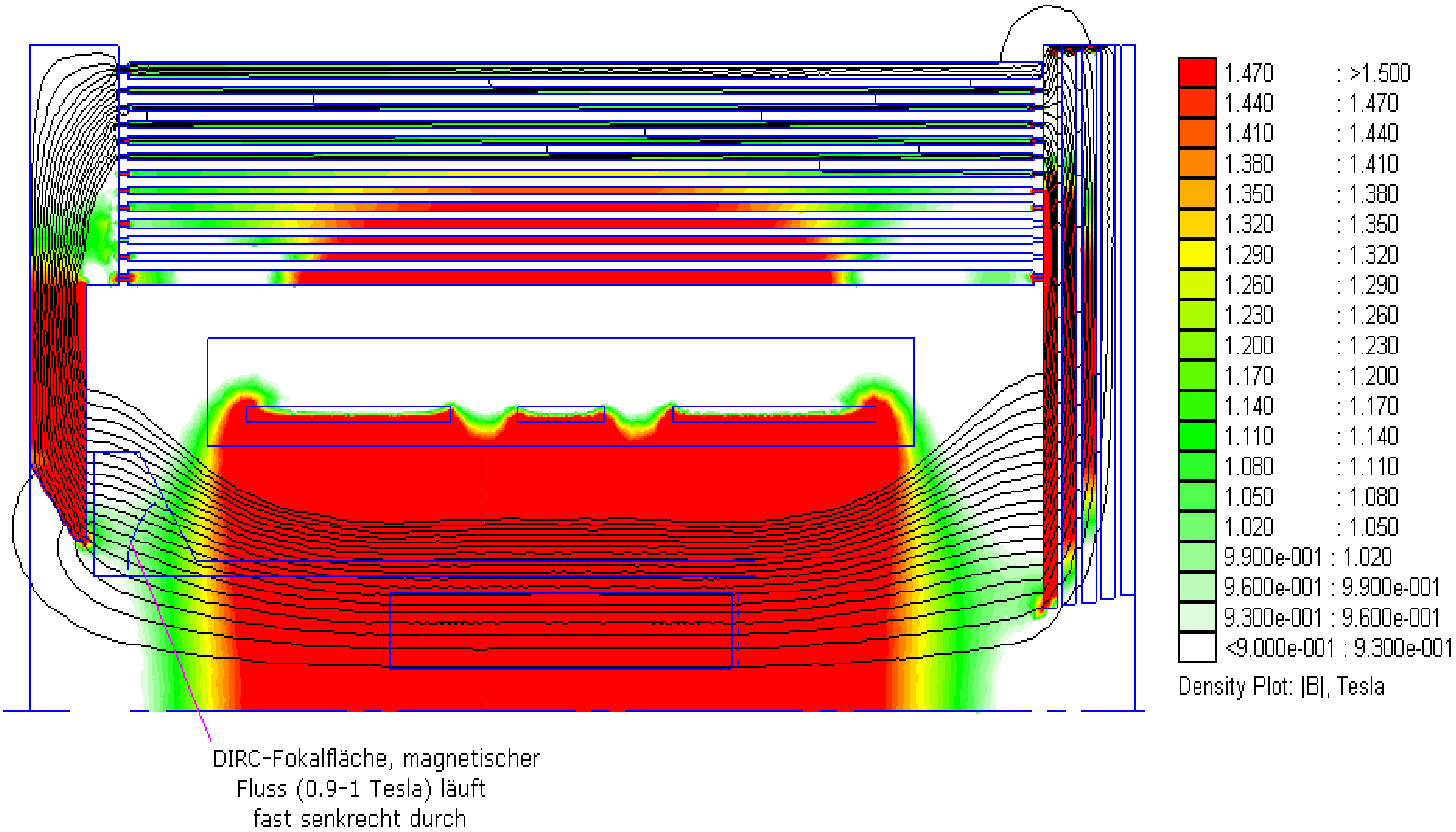
double structure comes from 1st air gap

to do: close this air gap (ZEMAX)


TRB
PA
PA
PA
PA
PA
422
OIL
SiO2
2 lenses for a flat focal plane

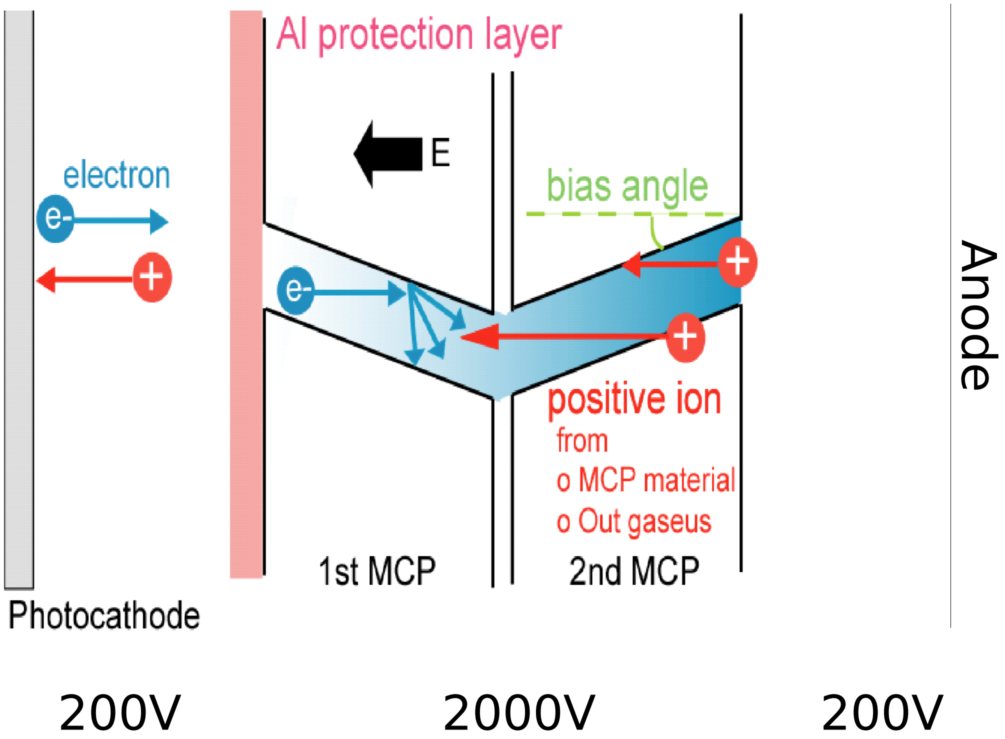
The photon detection device

needs to work in magnetic field of ~ 1 Tesla --> channel plate PMT, Si-PMT



The photon detection device

Multi Channel Plate - PMT



on anode!
gain ~ 10^6

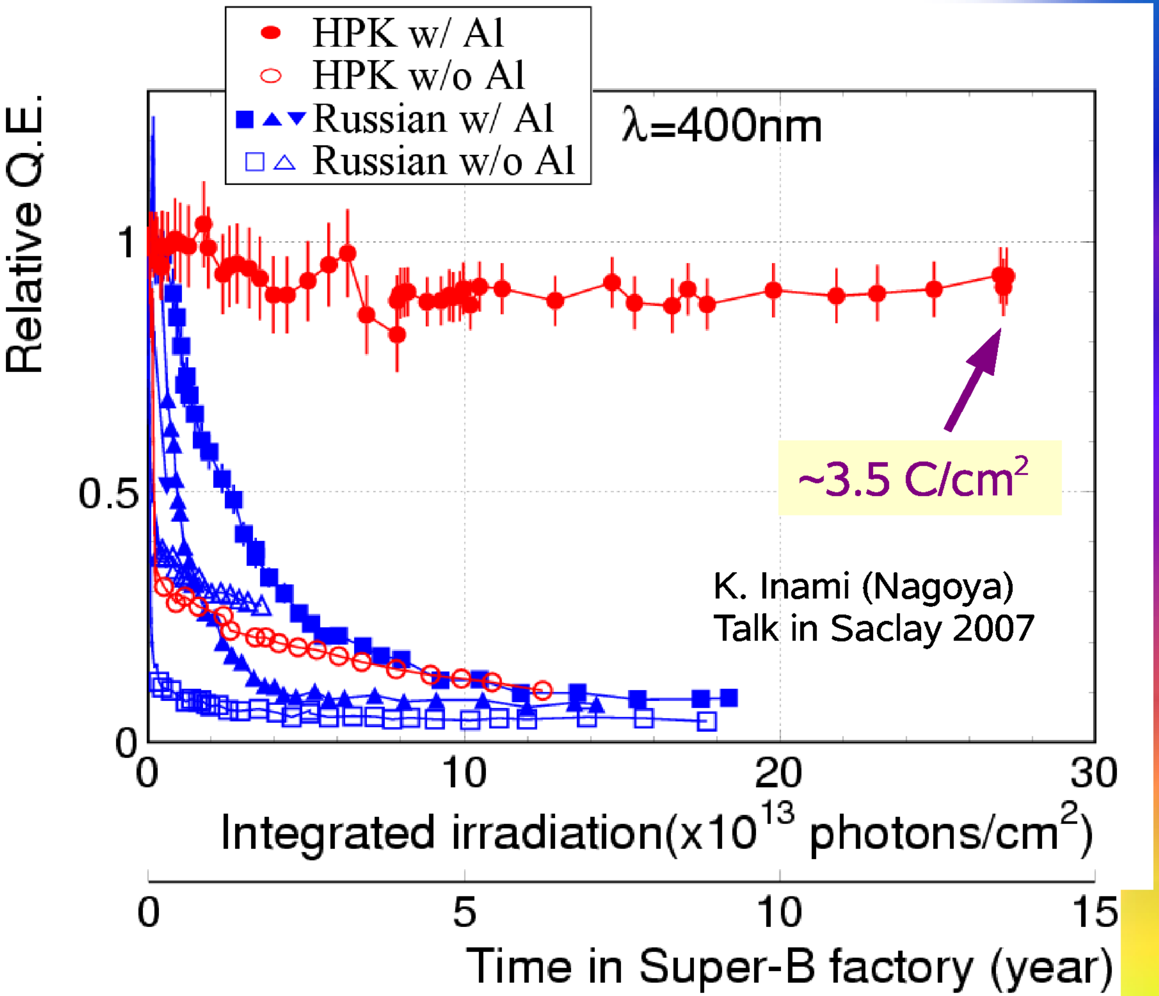
Aging: typically 1C/cm^2 -> 30% loss of QE

Barrel DIRC: 0.8 C/(cm^2*year)

for 10-15 years we need 8-12 C/cm^2

Lifetime – Quantum Efficiency

- Q.E. of Russian MCP-PMTs drops very fast
  - better with Al-layer but lifetime still much too short for PANDA
- Q.E. of HPK MCP-PMT wo Al-layer drops fast as well
- Q.E. of HPK MCP-PMT with Al-layer remains almost constant



only 10% Q.E. drop of HPK MCP with Al-layer after ~3.5 C/cm^2

The photon detection device

Further developments:

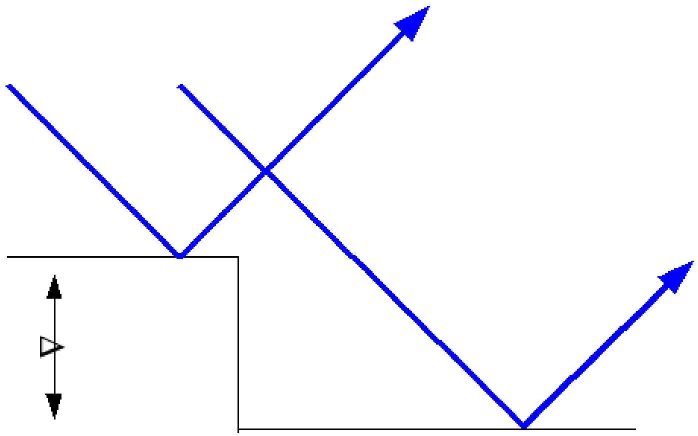
diamond dynode PMTs working in 1 Tesla
with CsTe photo cathode (UV)

--> Uni Erlangen group, Photek talk Monday

Radiator quality

polishing of synthetic fused silica
no problem for industry

question of machine time and money



20Å

$T=0.999^{100}=0.9$
$T=0.99^{100}=0.37$

costs: 25% bulk, 75% polishing
--> looking into extruded bars
& surface melted bars

-->talk of Roland Hohler, Wednesday

Radiator quality

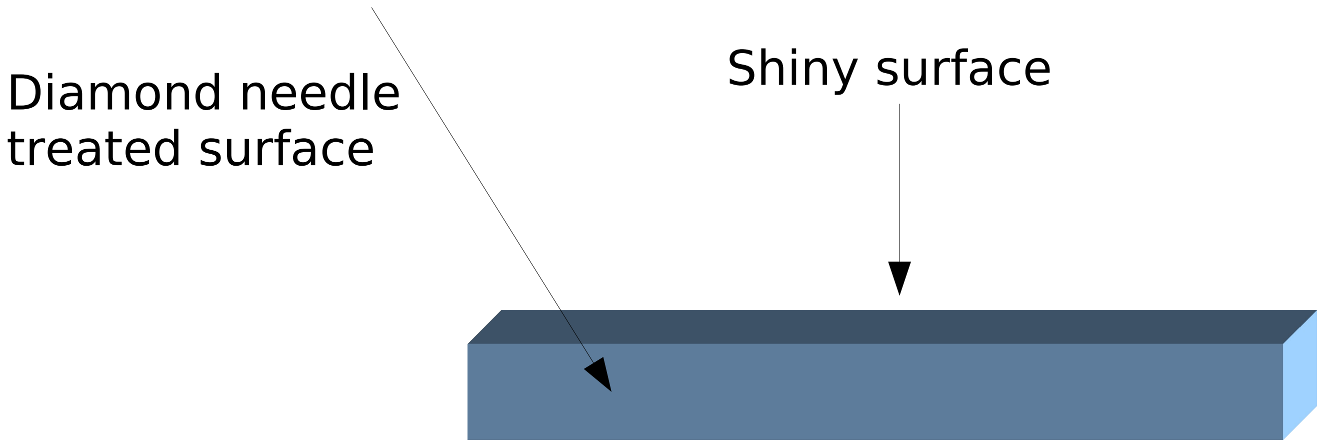
LithotecQ0 bar with σ=20 Å specified by Schott-Lithotec

R = 0.99918 ± 0.00031 σ = 21.6 ± 4.1 Å

Plexiglas GS233 bar

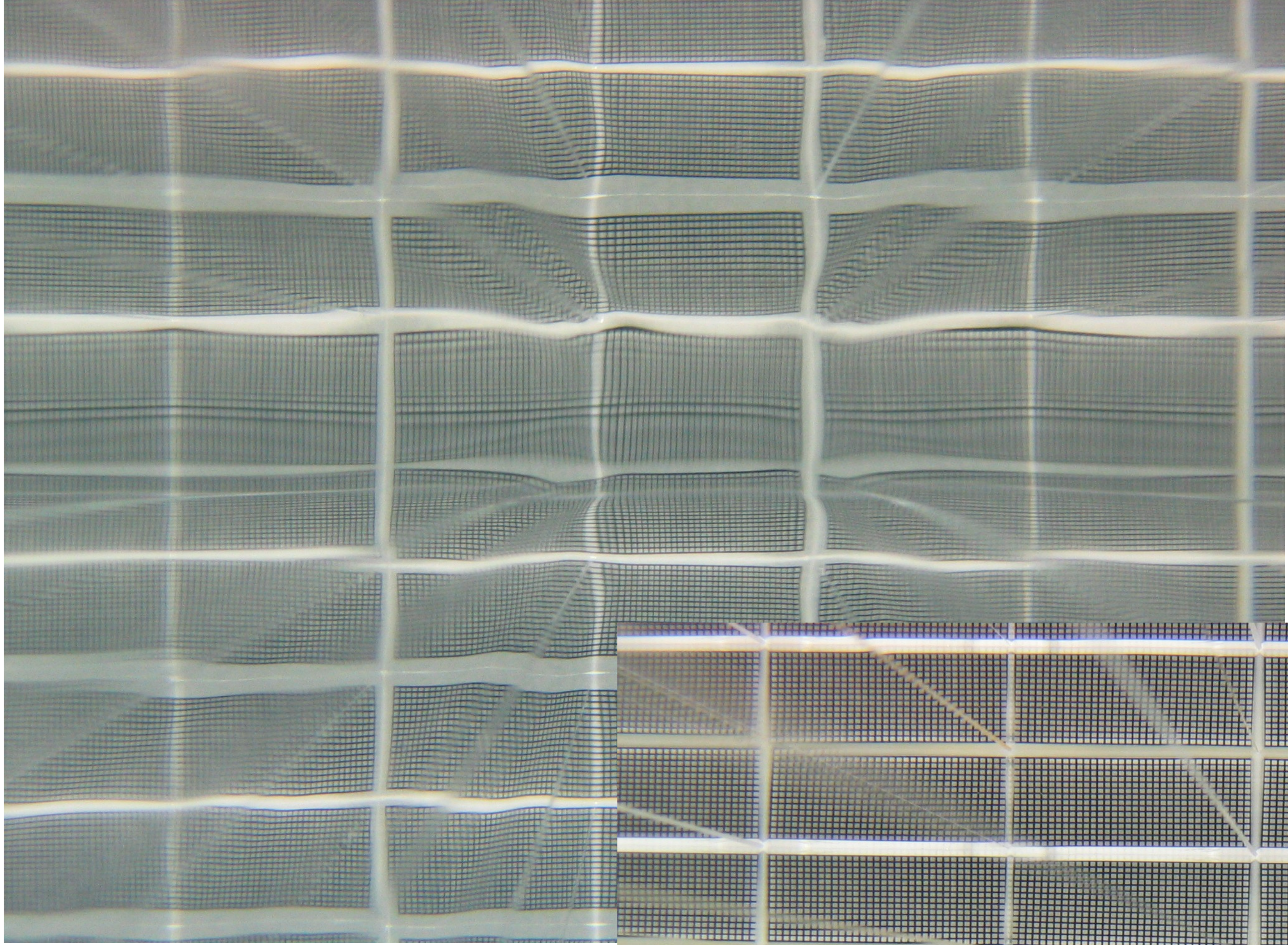
R=0.8866 ± 0.0003 0.9922 ± 0.0003

σ = 256.4 ± 0.3 Å 67.2 ± 1.3 Å

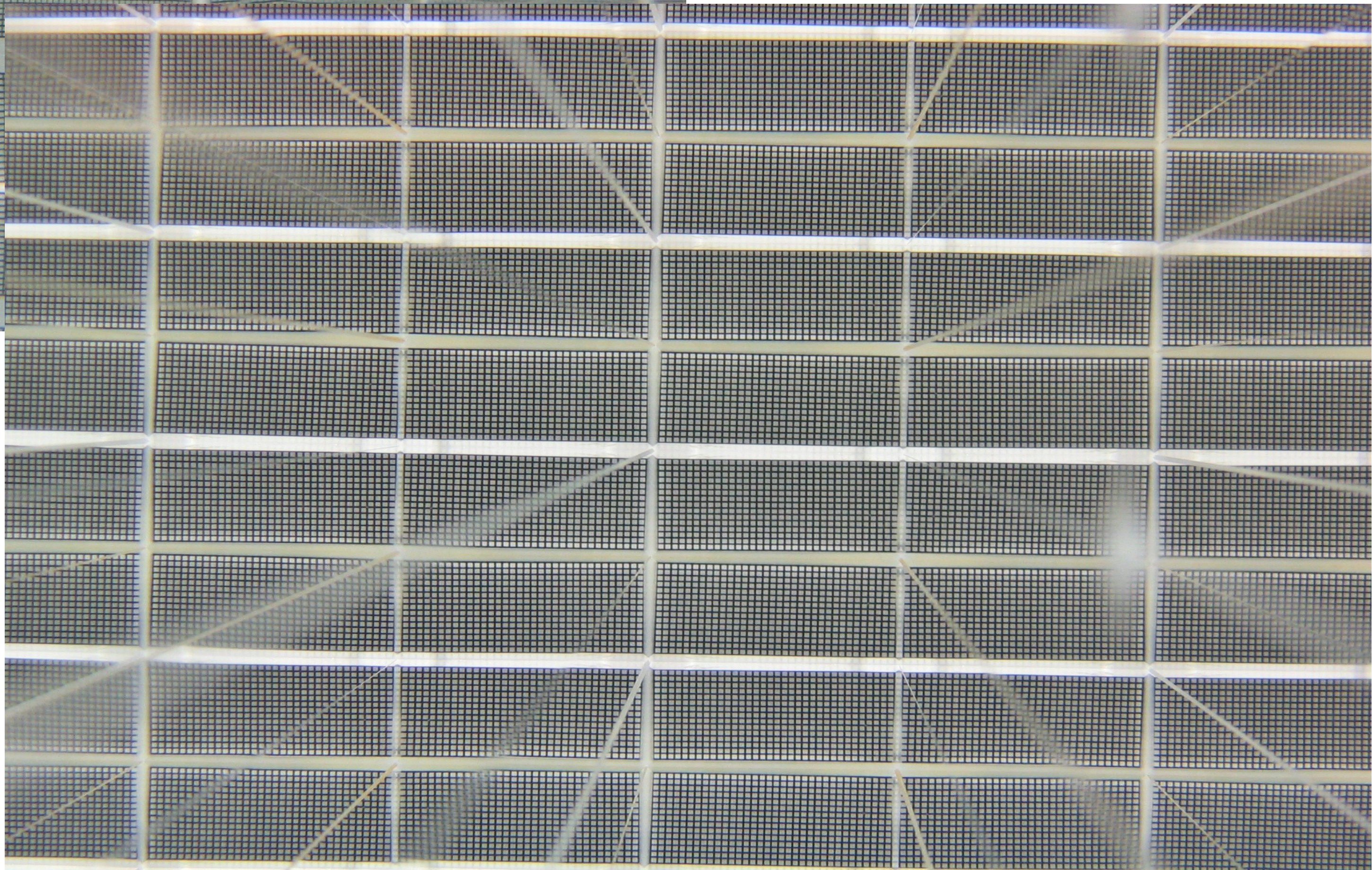


For 100 reflections: 45% transport efficiency (shiny side reflections only)

Radiator quality



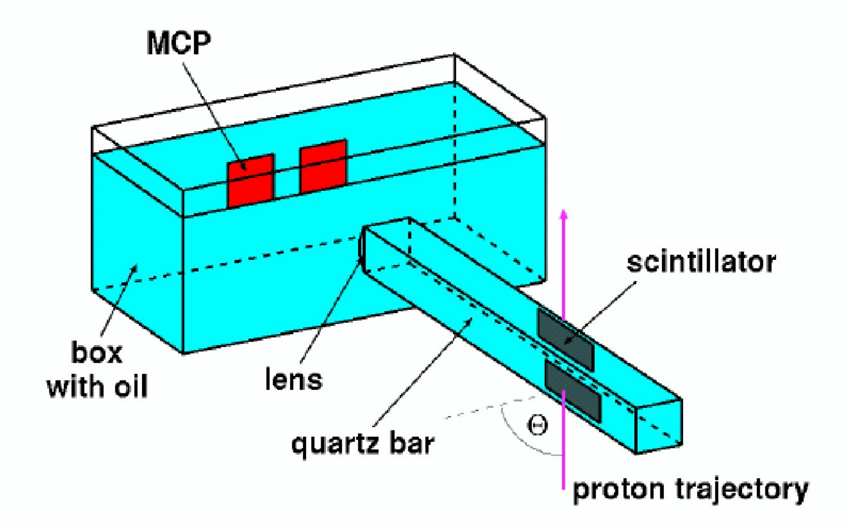
Plexiglas
GS213

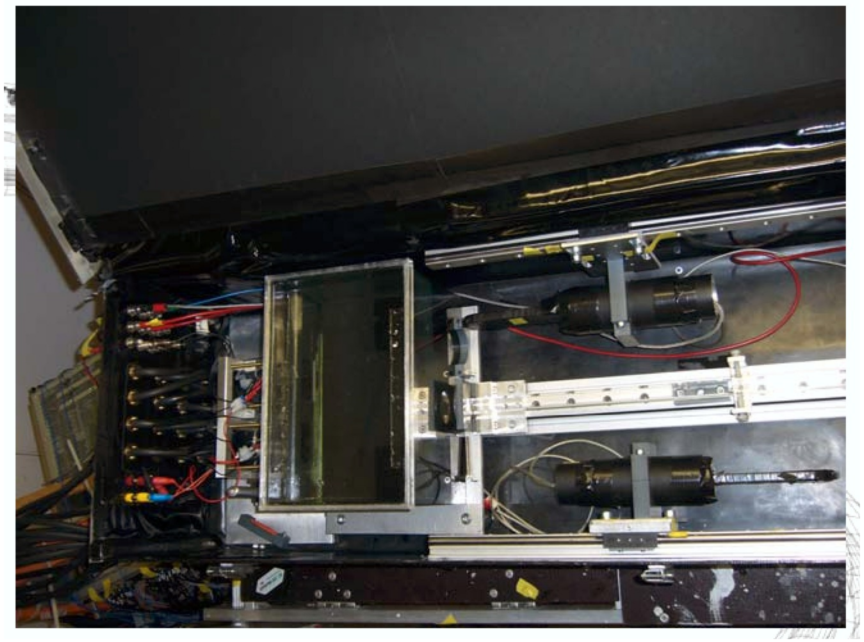


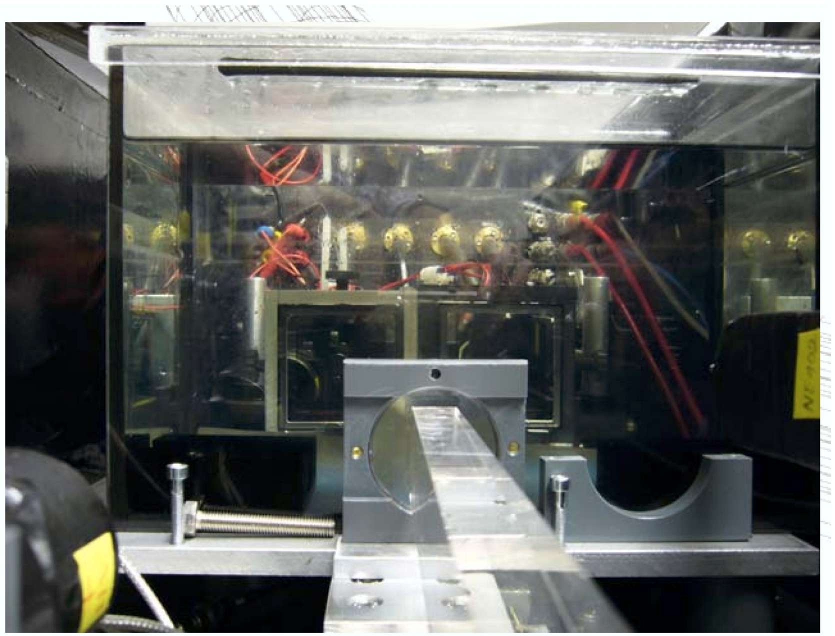
LithotekQ0

May 11-13, 2009

Read out chain



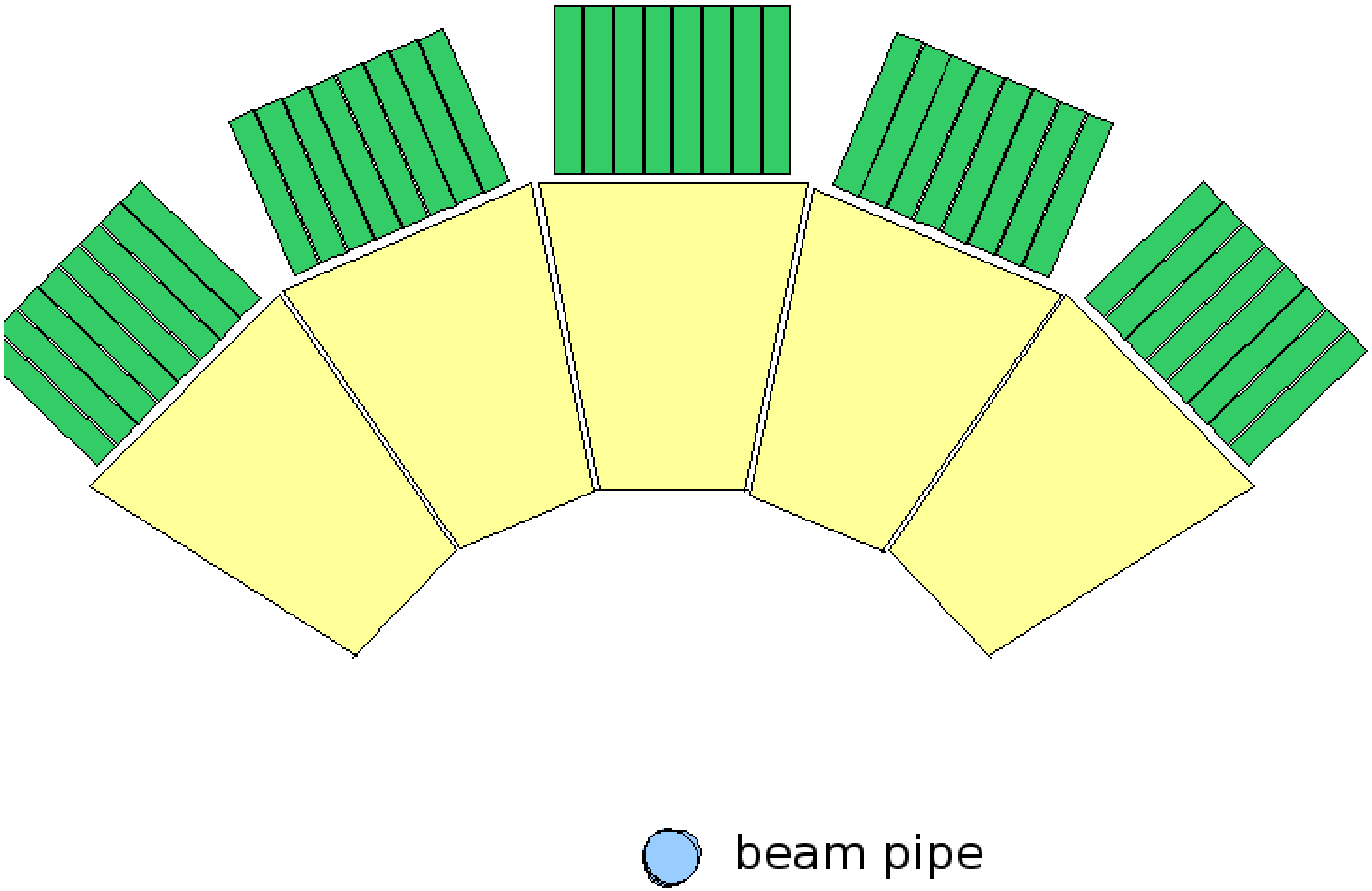




Test beam September 2008
with 2.3 GeV protons

2 Burle MCPPMTs
as photon detector (2x64 channels)

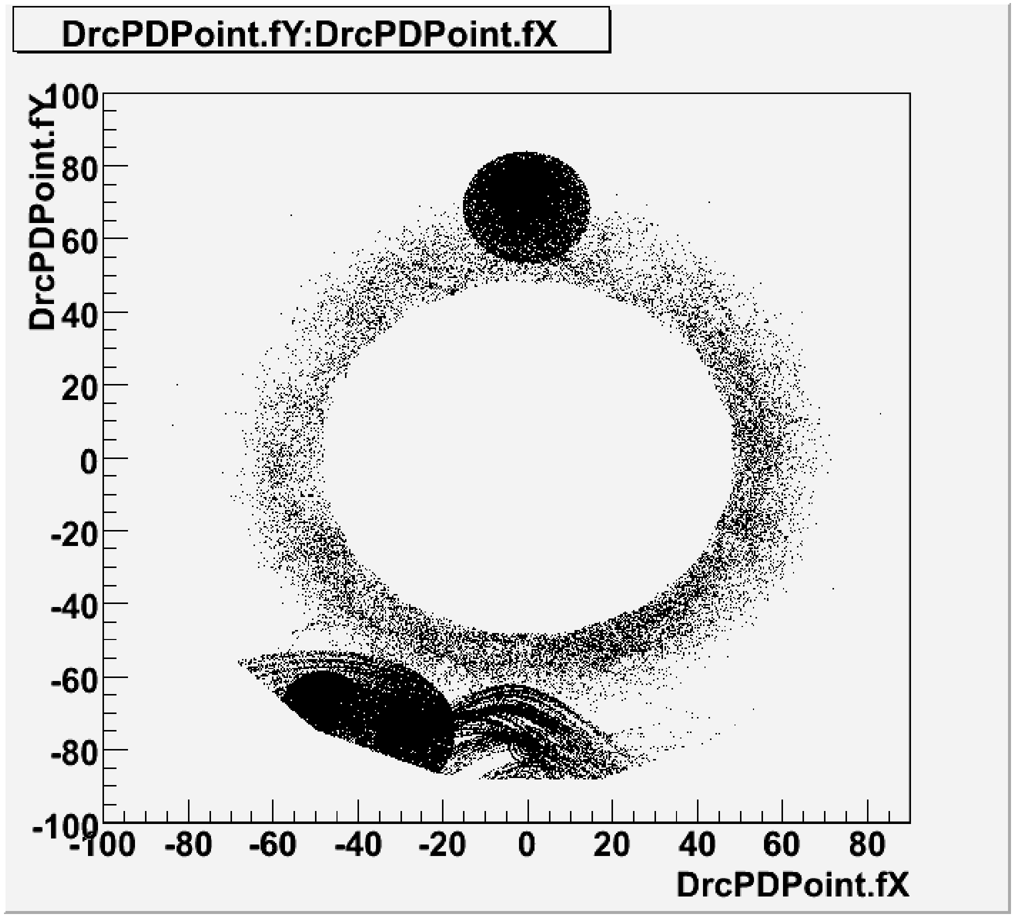
Read out chain



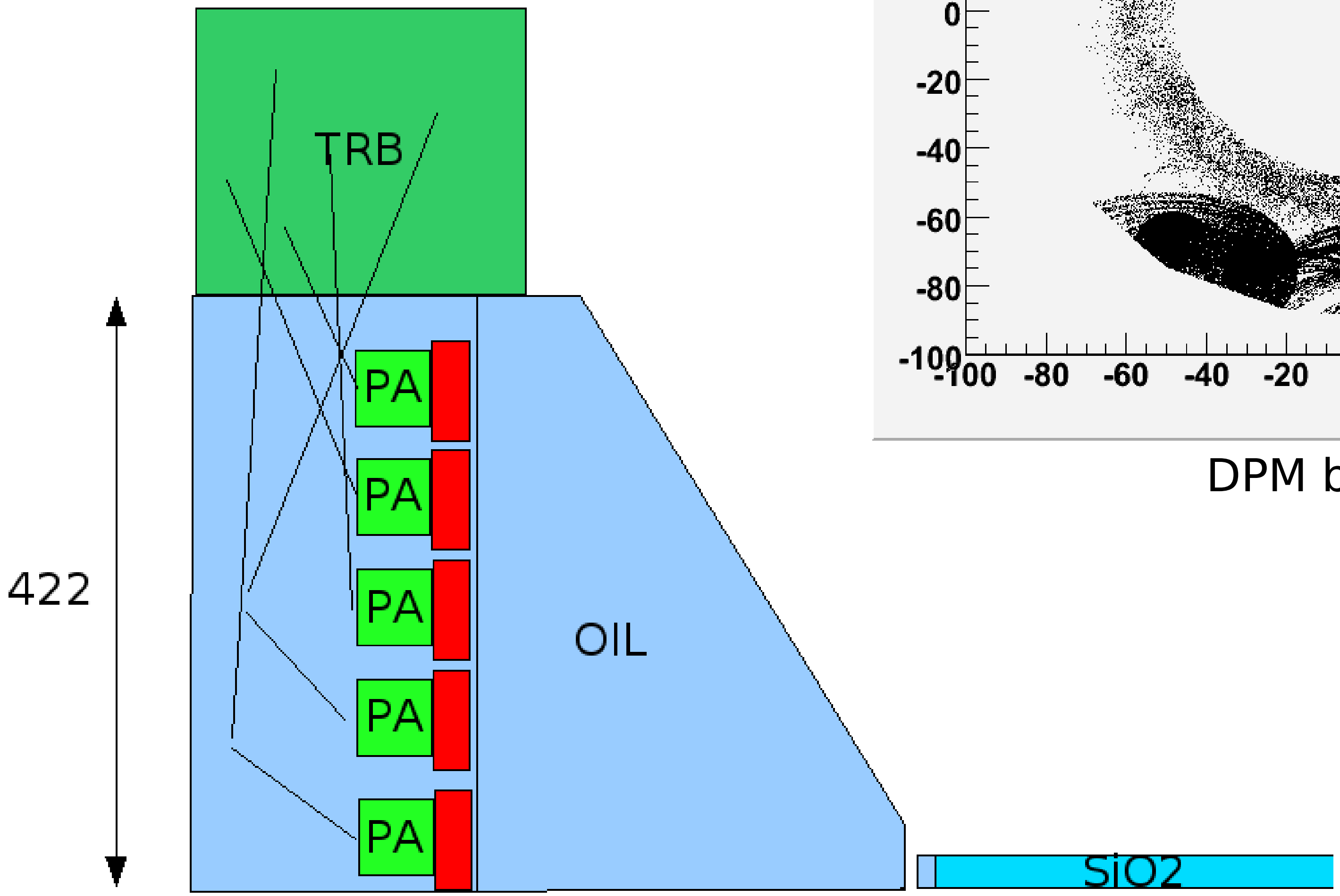
FEE boards are on top of photon detector boxes

20 MHz interaction rate
barrel multiplicity 2
20 photons per ring
~ 5000 channels (inside region)

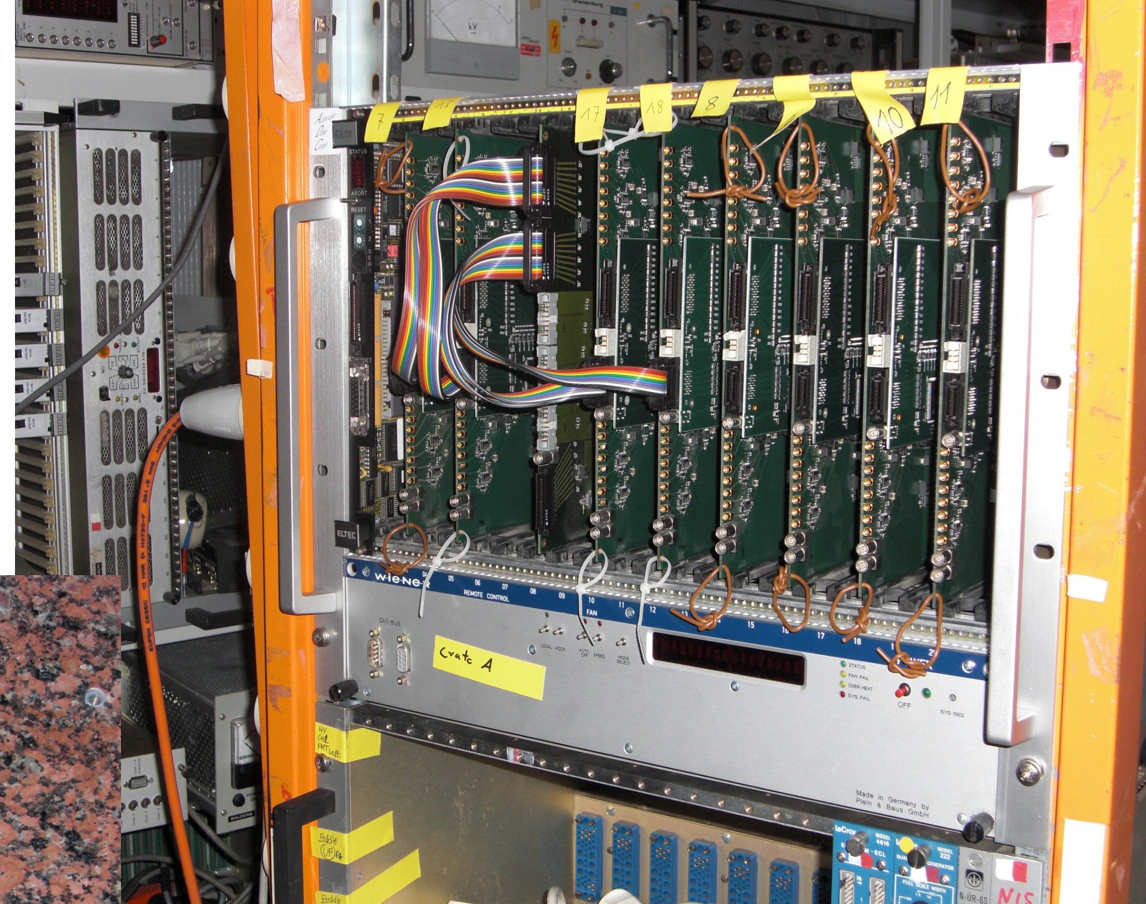
Rate: 160kHz (inside region)

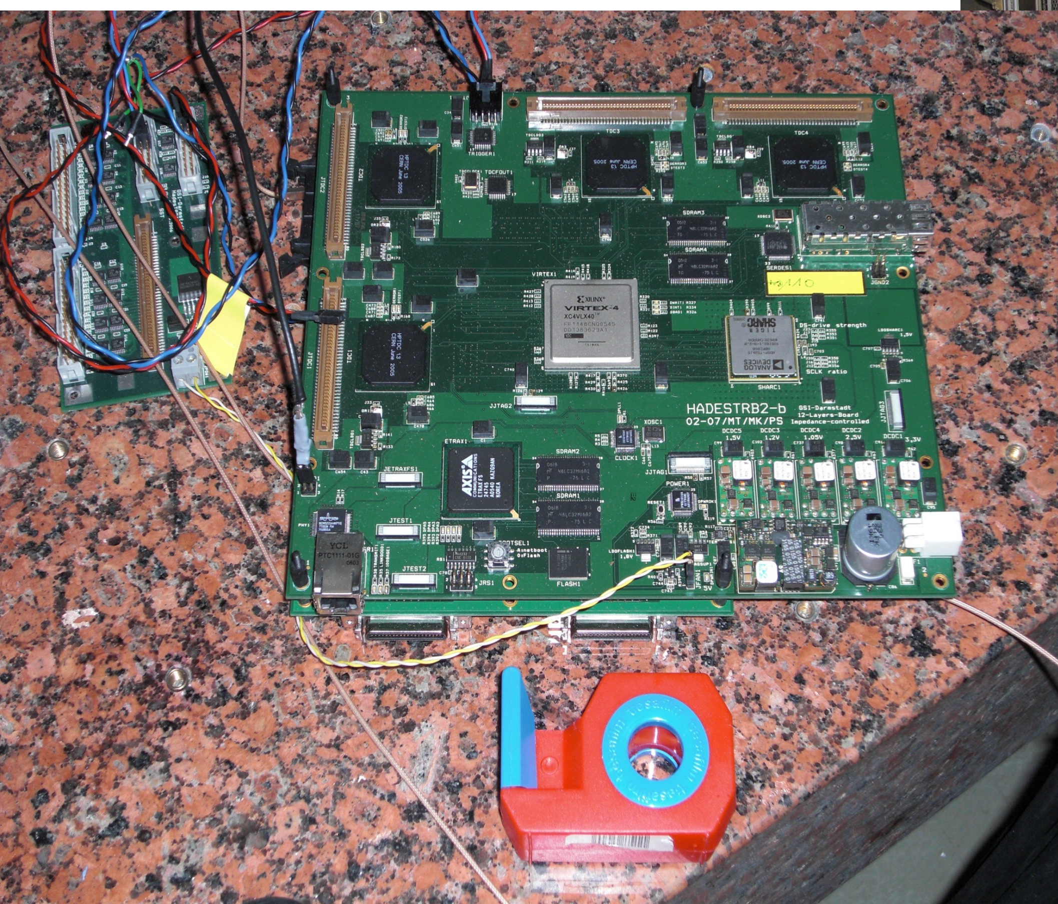


DPM background generator



Read out chain

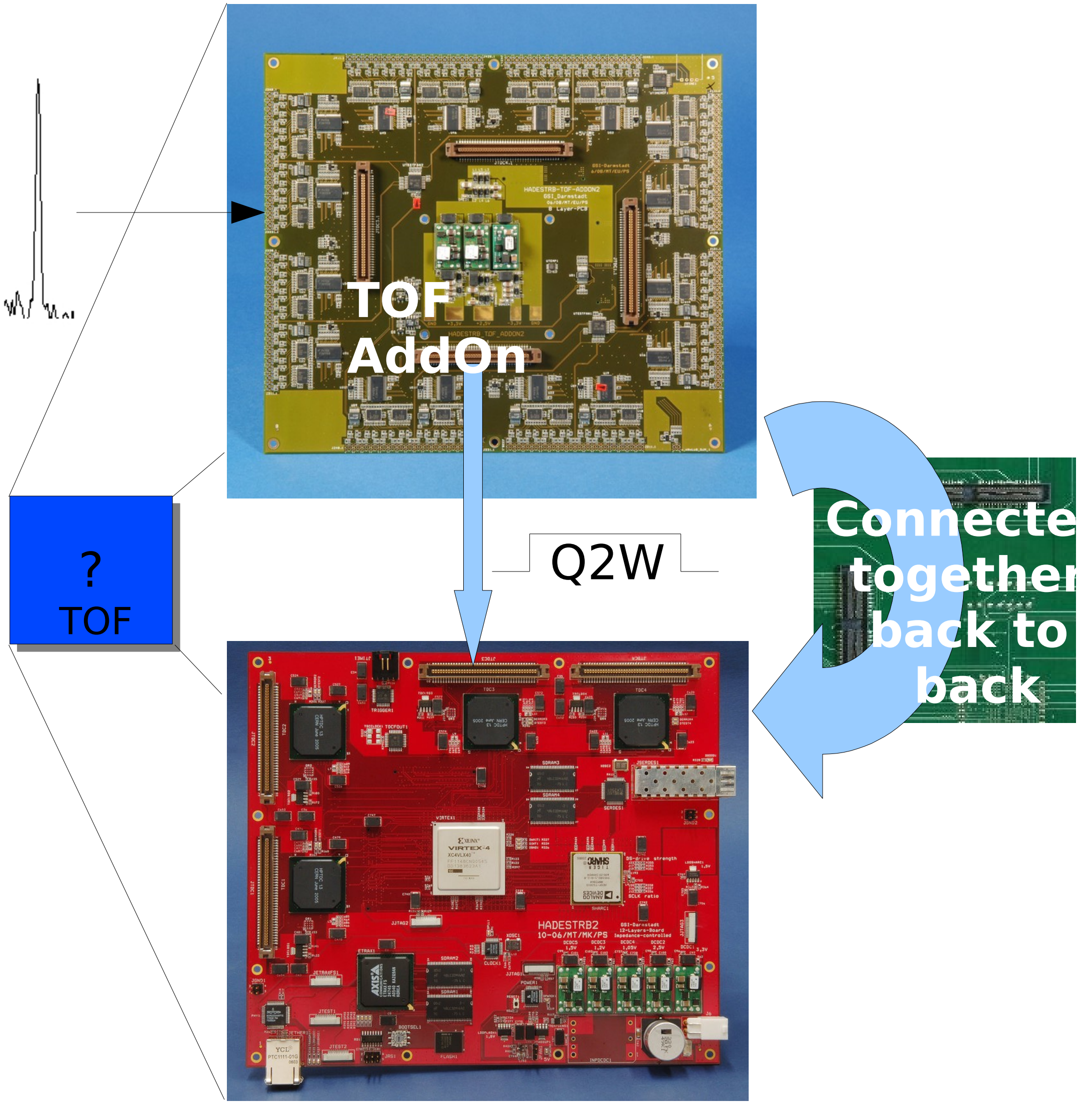




TRB
+ discriminator board
(HADES)

Read out chain

NINO discriminators --> time over threshold



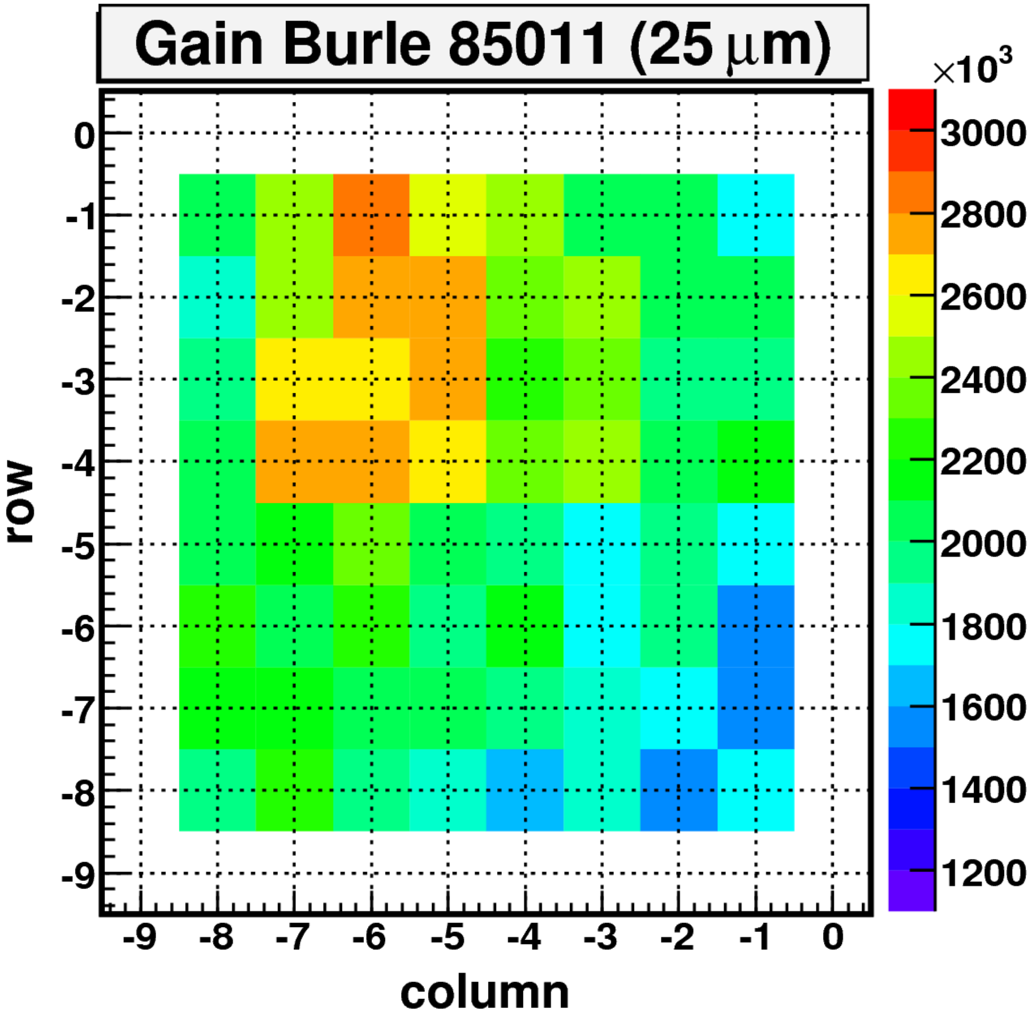
The TRB gives a power supply and a slow control

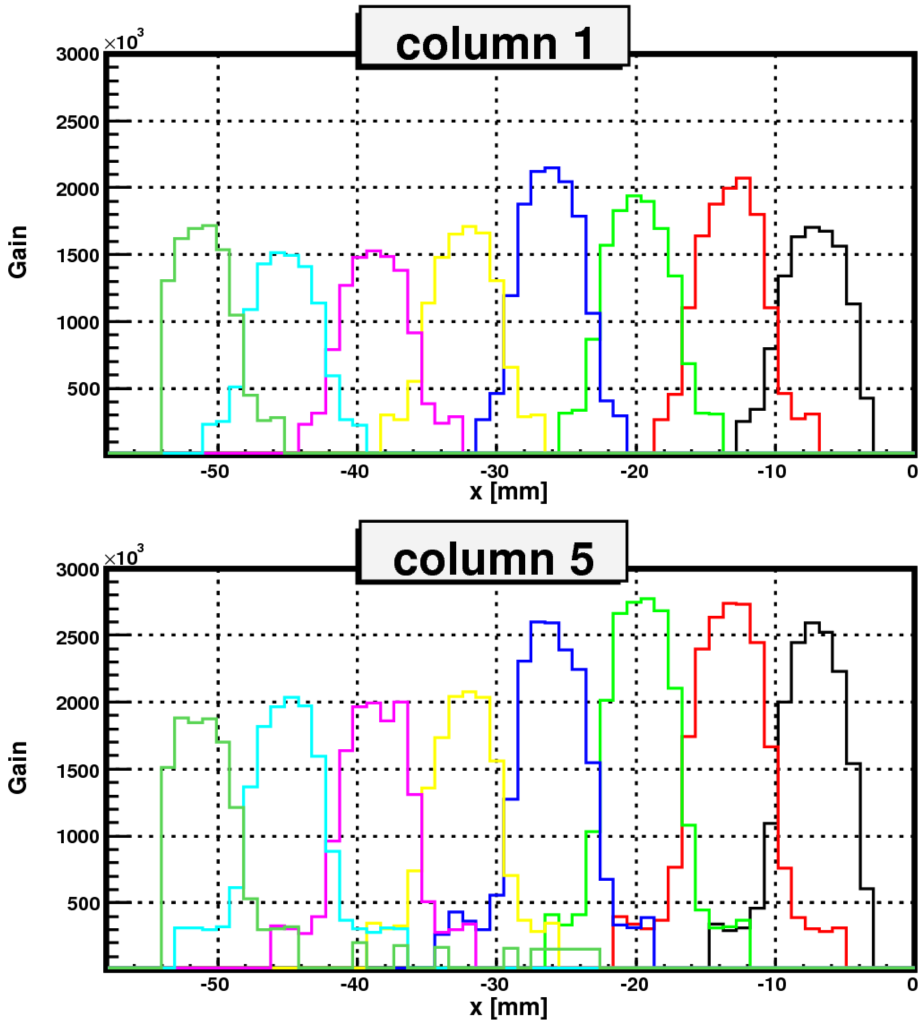
128 Q2W channels

Marek Palka IEEE Dresden

Read out chain

Albert Lehmann, Coll. Meeting March 2009, GSI





Caveat: NINO chip: 16 channels, 1 threshold,
Burle 85011 have gain variations of factor 2
Adjustable preamplifiers, patch panels?

Read out chain

- Read out for test experiments need existing electronics
  - HADES read out
- Possible future solution
  - GET4 TDC development of GSI

--> tomorrows FEE and DAQ session

Summary

- Barrel DIRC uses improved DIRC principle
  - using timing information
  - smaller photon detection box (focusing)
- Progress on
  - photon detection device characterization
  - radiator bar quality
  - read out chain
  - software development