A DIRC detector for WASA-at-COSY[*]

where we are – where we go

Wolfgang Eyrich

`Wolfgang.eyrich@physik.uni-erlangen.de`

Physikalisches Institut der Friedrich-Alexander Universität
Erlangen / Nürnberg

Friedrich-Alexander-Universität Erlangen-Nürnberg

WASA-at-COSY

A DIRC detector for WASA-at-COSY

where we are – where we go

- Introduction and Motivation

- DIRC Concept

- MonteCarlo Studies

- Studies on Components

  – Radiators

  – Optics

  – Sensors and Electronics

- Prototype Measurements and Results

- Road Map to an Operating Detector

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R.Siudak, K.Ulbrich (Bonn), A.Pricking (Tübingen)

Ch. Adolph, A. Schmidt, A. Teufel, Ch. Vogel, C. Pizzolotto (Erlangen)

A DIRC detector for WASA-at-COSY

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Bonn – Erlangen – Gießen – Jülich – Tübingen

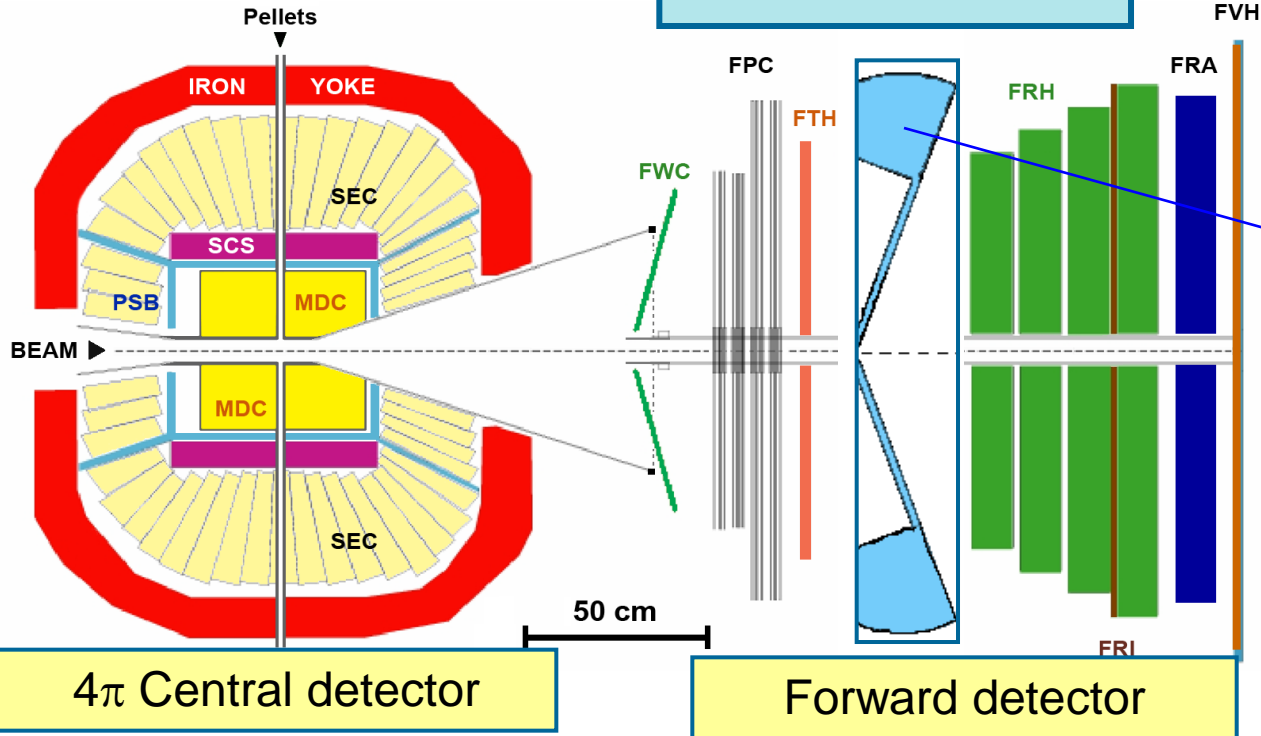WASA – PANDA

WASA-at-COSY
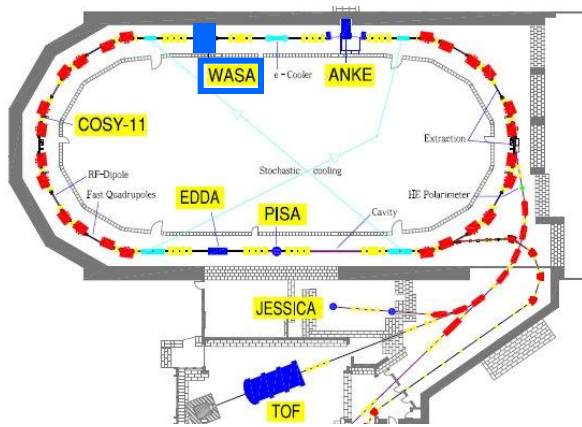
Key experiment:
- decay of η, η' mesons

huge background !!! →
Particle ID is very important

DIRC detector

Actually: PID by FRH energy loss information

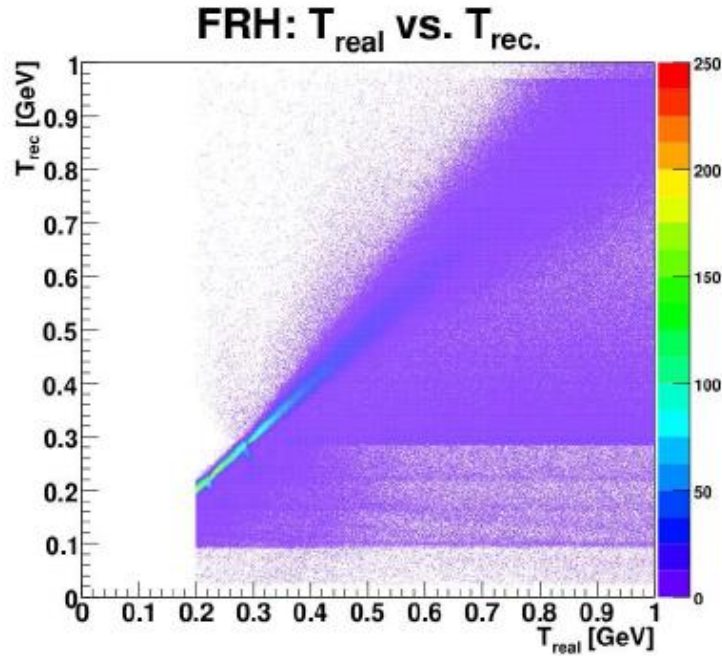Strong improvement expected by DIRC:

Limited space → focussing lightguide

Pellets

IRON   **YOKE**

SEC

SCS

PSB   **MDC**

BEAM ▶

MDC

SEC

FWC

FPC

FTH

FRH

FRA

FVH

FRI

50 cm

4π Central detector

Forward detector

MDC – Main drift chamber
PSB – Plastic scintillator barrel
SCS – Super conducting solenoid
SEC – Scintillator em calorimeter

FWC – Forward window counter
FPC – Forward proportional chamber
FTH – Forward trigger hodoscope
FRH – Forward range hodoscope
FRH – Forward range absorber
FVH – Forward veto hodoscope

detection of photons, electrons, charged pions

detection of scattered projectiles and charged recoil particles

WASA   ANKE
COSY-11
e - Cooler
Extraction
RF-Dipole   Stochastic   cooling
Fast Quadrupoles   ³He Polarimeter
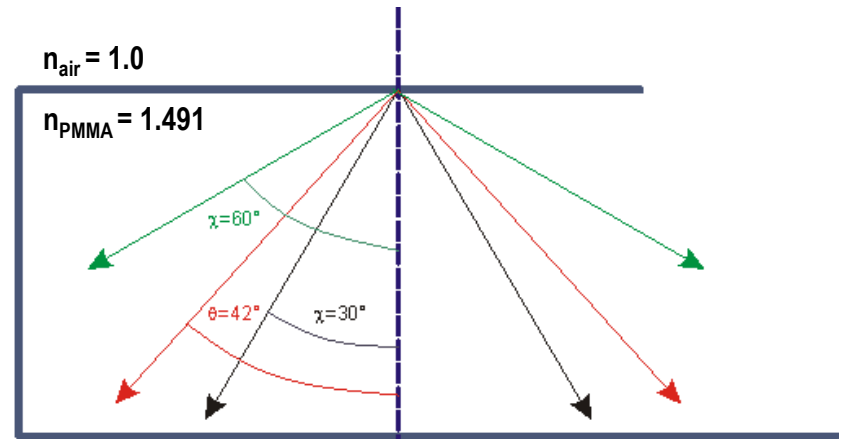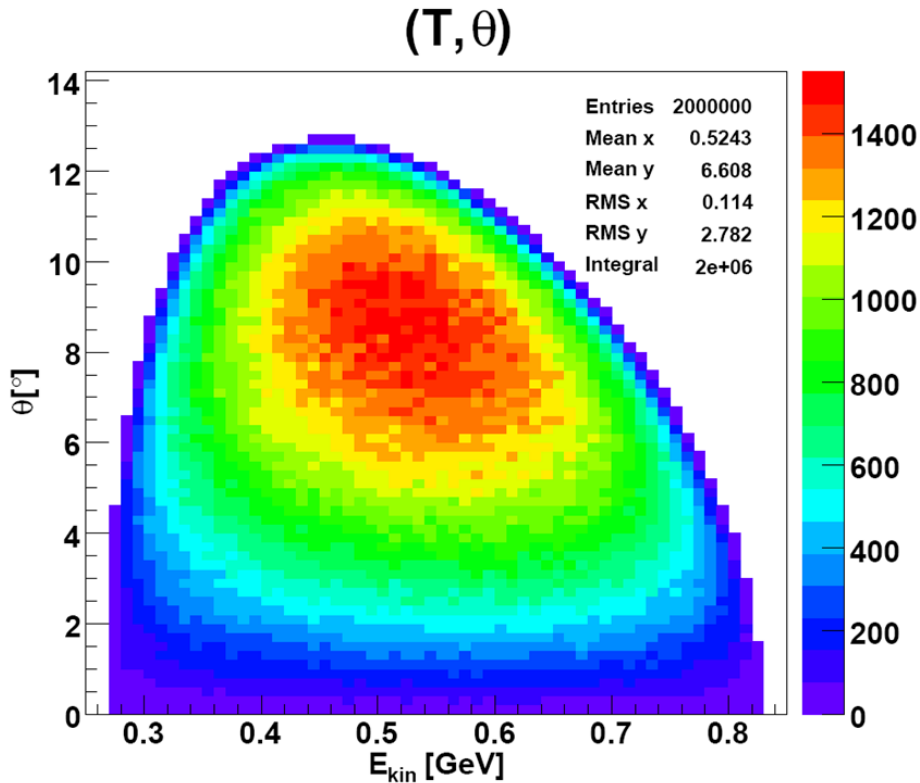EDDA   Cavity
PISA
JESSICA
TOF

WASA - MonteCarlo Simulation wo / w additional PID
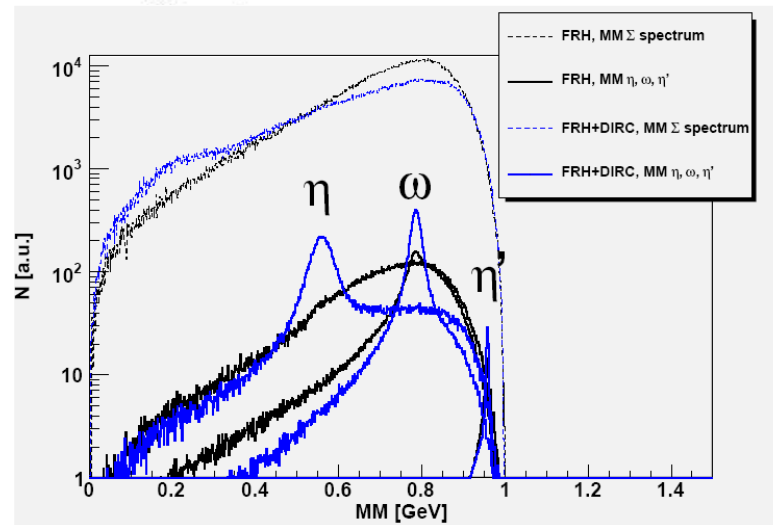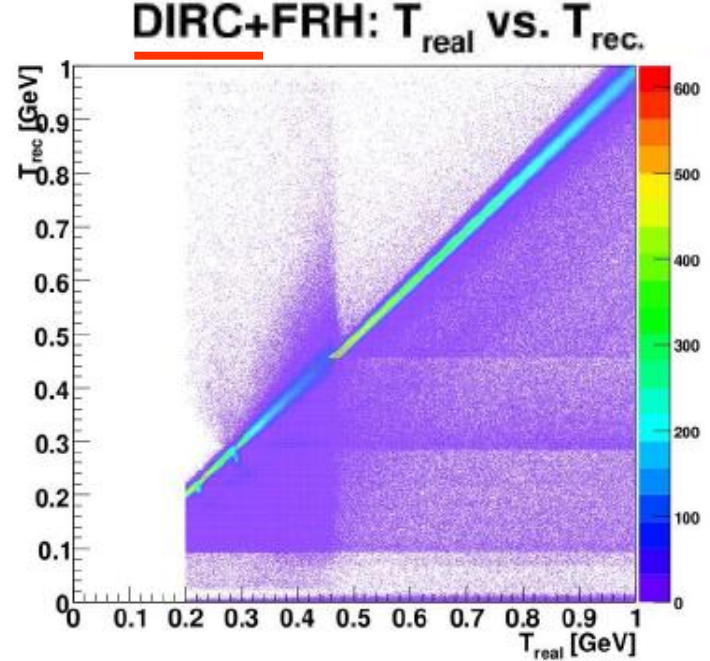
Kay Ulbrich
HISKP Uni Bonn

DIRC for WASA - Kinematic Conditions

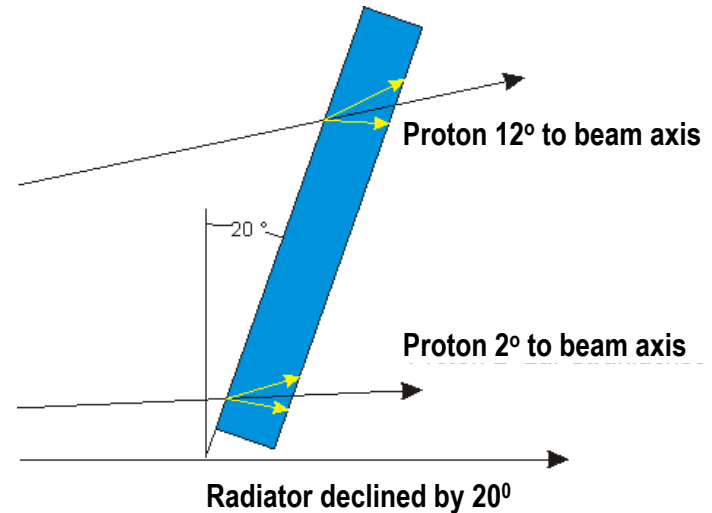**Proton distribution @ eta´ channel**

angle vs kinetic energy

(T, θ)

Entries	2000000
Mean x	0.5243
Mean y	6.608
RMS x	0.114
RMS y	2.782
Integral	2e+06

$n_{air} = 1.0$

$n_{PMMA} = 1.491$

$\chi = 60°$

$\theta = 42°$ $\chi = 30°$

Total reflection angle: $\theta_{tot} = 42^0$

$\cos(\chi) = 1/\beta^* n_{PMMA} = 0.86429$

$\chi = 30.19°$

Proton
$E_{kin} = 550 MeV$
$\beta = 0.776$

Proton 12º to beam axis

20°

Proton 2º to beam axis

Radiator declined by 20^0

DIRC for WASA: Possible solution – focussing technique

reflective surface

photon sensor + electronics

PlexiGlas® (PMMA)

4 cm

focussing element

radiator bar

H 50 cm
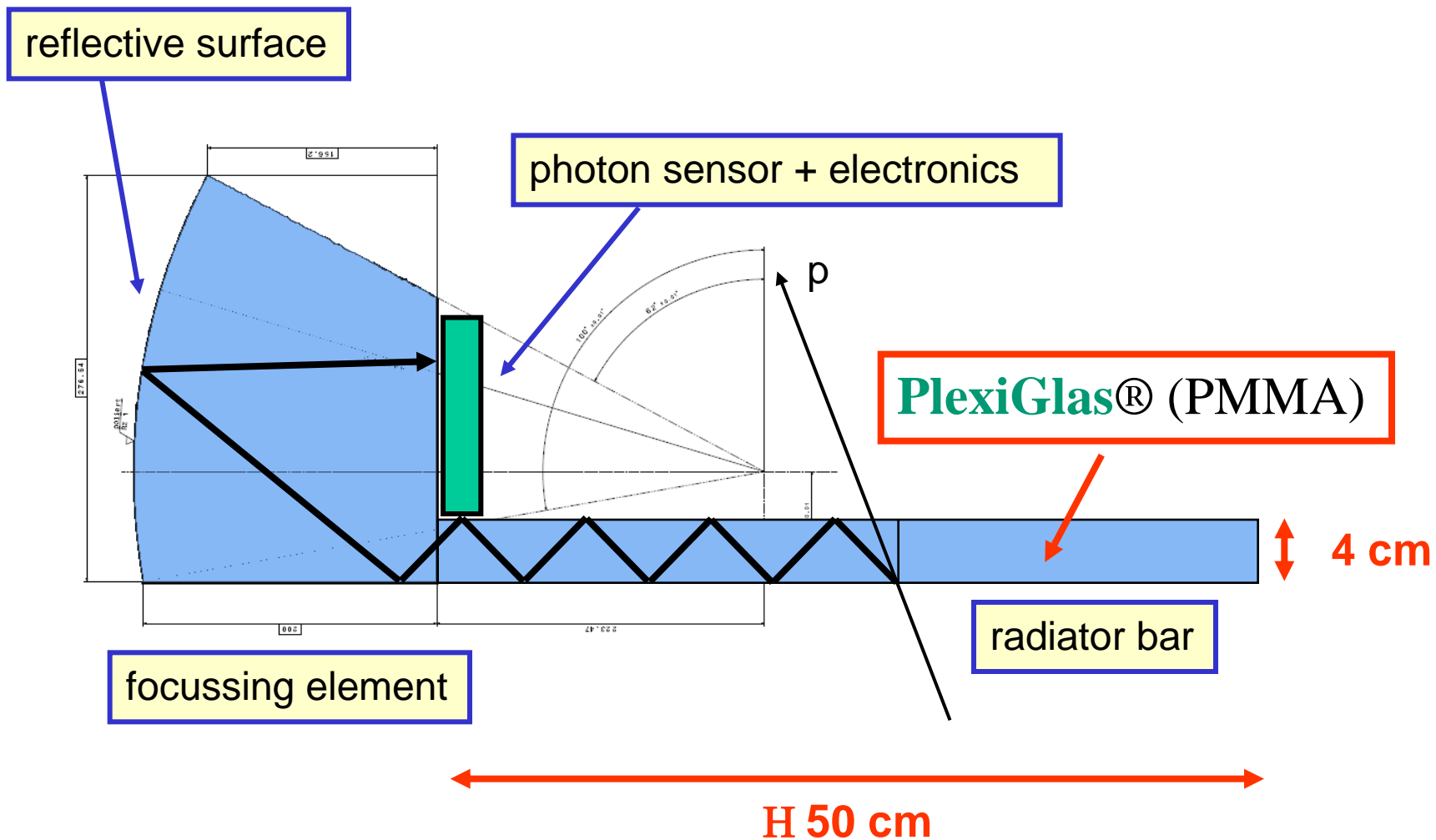
Component Studies - Radiators

- **PlexiGlas**® (PMMA) ➜ Röhm GS233 n=1.491 / 700x40x40 mm³
  wavelength range : 400nm – 750nm transparent

- Surface quality
  - casted / diamond cut / diamond cut + polished (PMMA)
    - Transmission
    - Absorption
    - **Reflectance** (transmission per reflection)
    - **Image quality** ➜ angle conservation

    _____

- **Fused Silica** ➜ Schott Lithosil Q_0 n=1.47 / 800x35x17 mm³
  (Panda PID Group sample – C.Schwarz / GSI)
  wavelength range : 200nm – 750nm transparent

Radiators: Reflectance and Image Quality
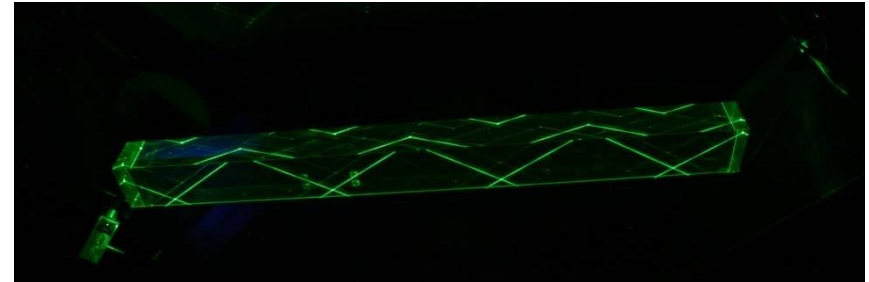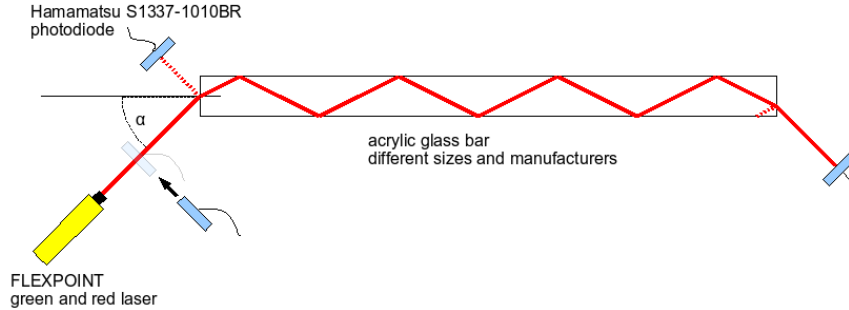
- **casted surface**: effective reflectance: **99.0%**

  compact spot
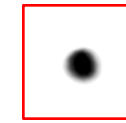
  diode size 10x10mm²

- **diamond cut + polished surface**: **98.4%**

  diffuse spot
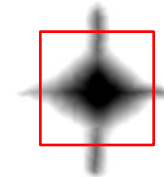
- diamond cut surface: from 98% down to 91%

  grid like spot
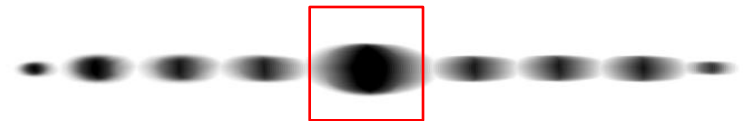
- (fused silica: 99.5%)

Focussing elements

Reflector: aluminum foil

Photosensor

p

Radiator
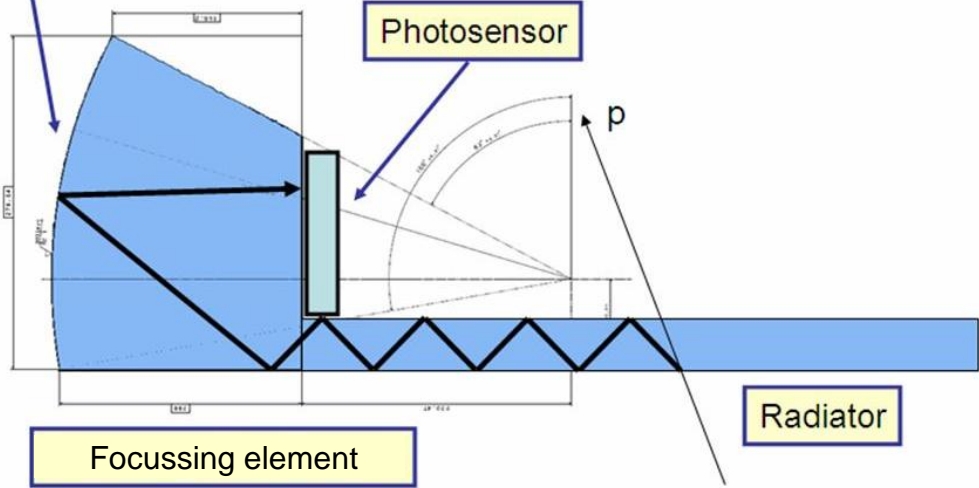
Focussing element

Parabolic type with aluminum coating (Design R.Siudak)

Polynomic type based on internal reflection ➔ no coating needed (Design K.Föhl)

Polynomic shape

Radiator

Focussing element
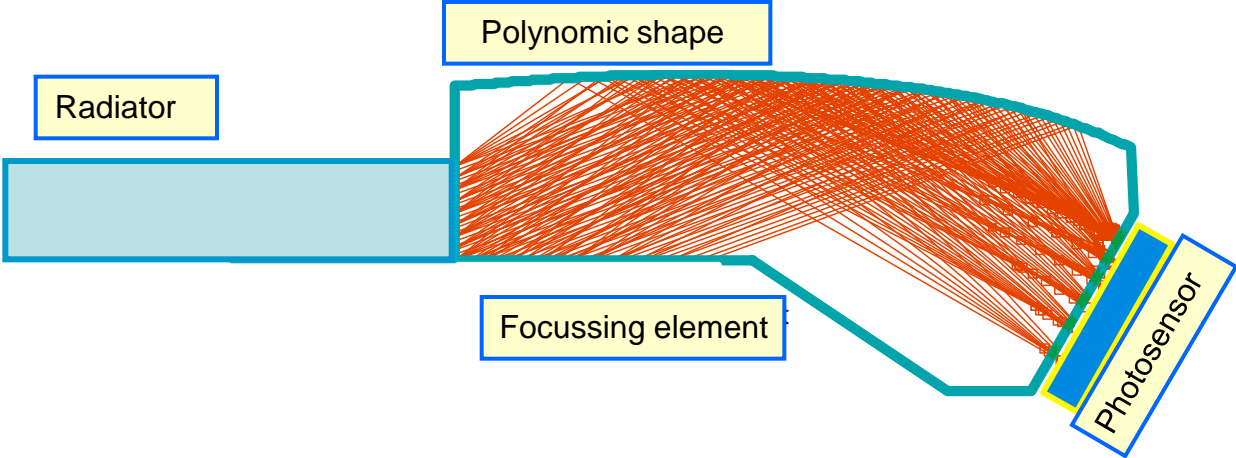
Photosensor

Focussing Elements
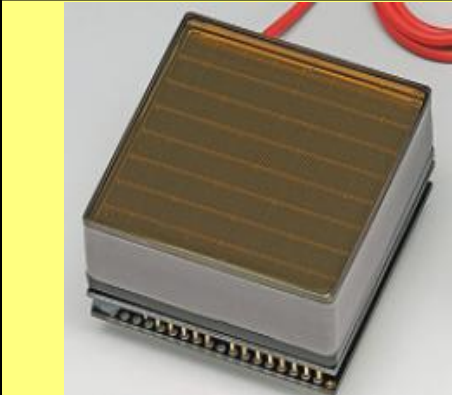
Parabolic type – Mylar coated

Green LaserSpot

Spotsize	
Entries	8038836
Mean x	1821
Mean y	998.6
RMS x	121.1
RMS y	119.6

Sigma_X for Y-Slices

$\sigma = 0.25\text{-}0.75\text{mm}$

Spotsize_2	
Entries	290
Mean	1008
RMS	79.95

sigma * 6.4 um

Y-axis <6.4 um>

Polynomic type

Green Laserspot internally reflected

foo	
Entries	8038836
Mean x	1747
Mean y	1067
RMS x	93.09
RMS y	176.7

Sigma_X for Y-Slices internally reflected

$\sigma = 0.13 \text{ mm}$

Spotsize	
Entries	290
Mean	1012
RMS	16.62

sigma *6.4 um

Y-axis <6.4 um>

Photon Sensors

Type	Hamamatsu MAPMT R7600-03-M16	Hamamatsu MAPMT H8500C	Hamamatsu MAPMT H9500
Dimensions	45x30x30 mm^3	52x52x28 mm^3	52x52x33.3 mm^3
Weight	55 g	117 g	177 g
No. channel	16 (4x4)	64 (8x8)	256 (16x16)
Active area	18.1 x 18.1 mm^2 (36%)	49 x 49 mm^2 (89%)	49 x 49 mm^2 (89%)
Pixel size	4 x 4 mm^2	5.8 x 5.8 mm^2	3.04 x 3.04 /3.22 mm^2
Peak λ	400 nm	400 nm	400 nm
Multiplication	metalchannel dynode 12step	metalchannel dynode 12step	metalchannel dynode 12step

Photon Sensor H6568

QDC single photon response

H6568 ADC Kanal 0

adc0	
Entries	300231
Mean	13.98
RMS	23.56
c^2 / ndf	395.1 / 258
Prob	3.003e-08
p0	119.8 ± 2.2
p1	8.521 ± 0.230
p2	6.171 ± 0.351
p3	176.3 ± 2.1
p4	28.87 ± 0.16
p5	7.192 ± 0.108

UV transparent glass window !!!
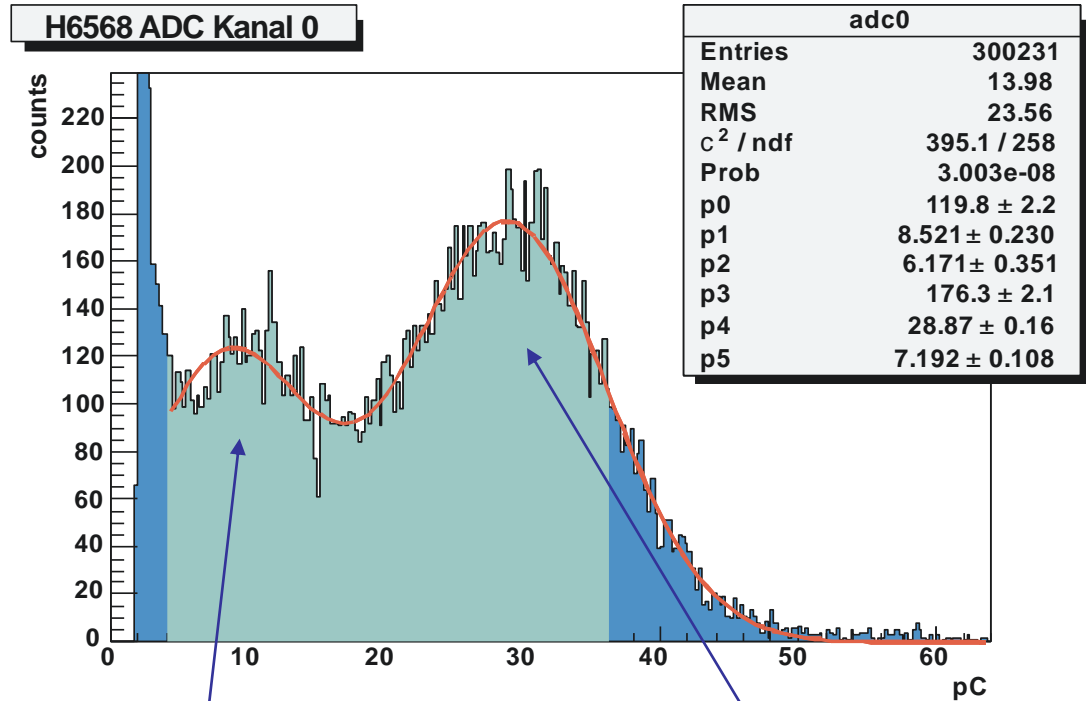
full step amplification

one amplification stage less

Photon Sensor H6568

Uniformity of ADC SER Distribution

Gain of PMT channel 2

measured @ 360 nm

c^2 / ndf	0.01876 / 3
Constant	-5.986± 0.3789
Slope	0.007774± 0.0004047
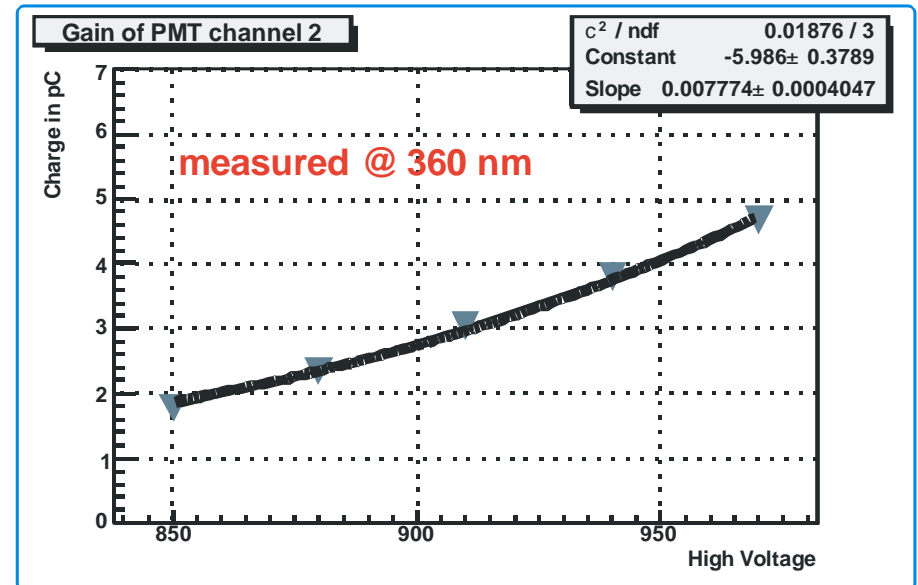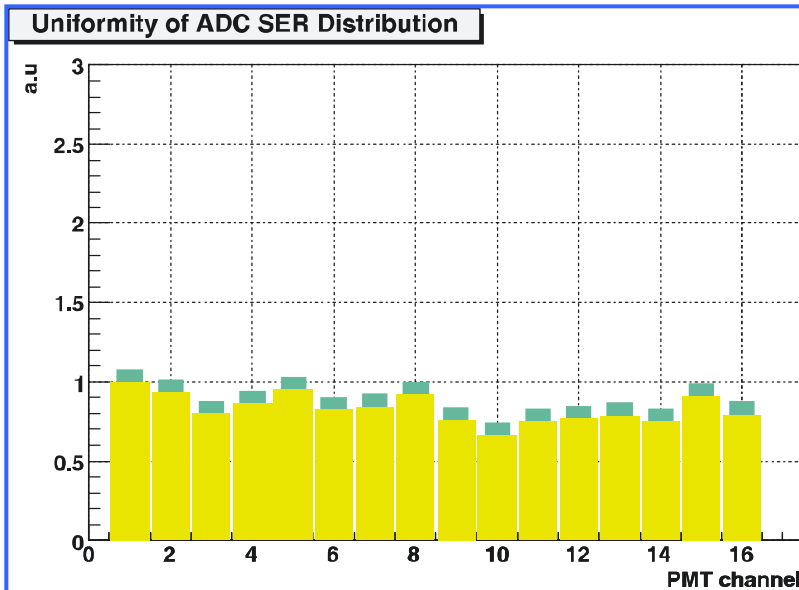
Max variation: 20-40%

typical gain : $1*10^7$ up to $4*10^7$

Time resolution: 300ps

Rate capable up to 5 MHz per channel

Photon Sensor H8500C

Uniformity

QDC single photon response

Uniformity of H8500C subsample

Mean Gauss

Gain = 9.87E6

Gain = 5.20E6

Channel

8500C HV = 1100V

h	
Entries	1000051
Mean	47.9
RMS	6.366
Underflow	0
Overflow	0
Integral	1e+06
χ^2 / ndf	226.7 / 142
Constant	171.3 ± 1.9
Mean	93.94 ± 0.42
Sigma	30.23 ± 0.30
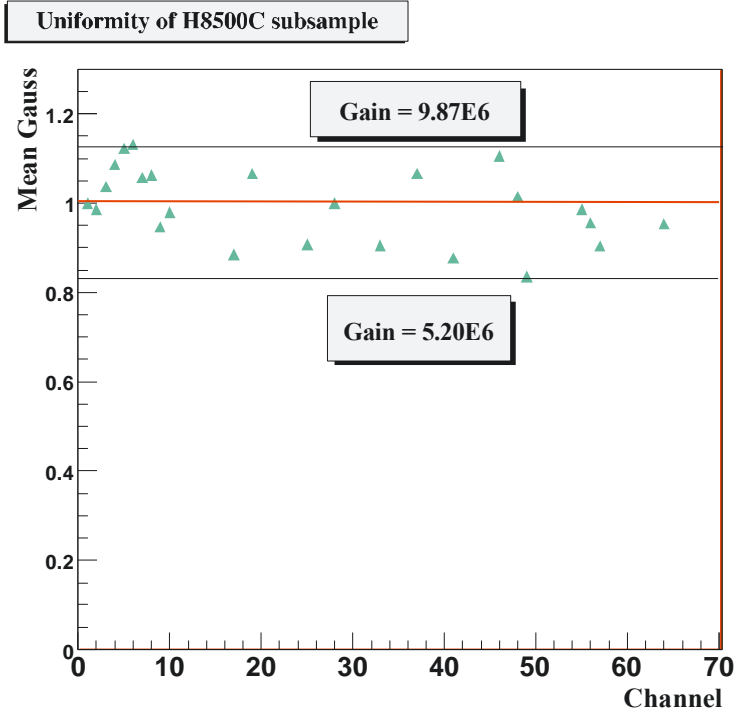
Max variation: 20-40%
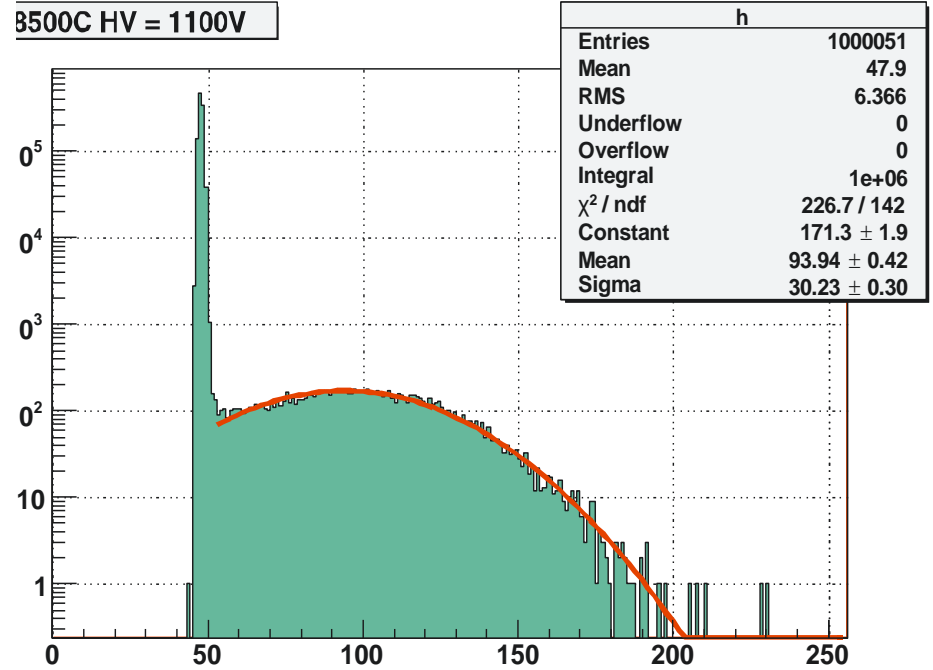
gain : ~ 7*10^6

Photon Sensor H8500C

Wolfgang Eyrich - Universität Erlangen-Nürnberg
Gießen, May 12th, 2009
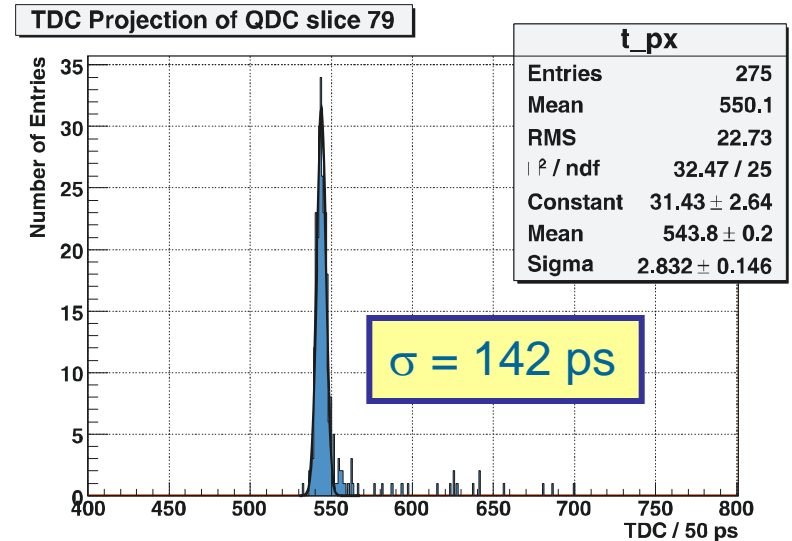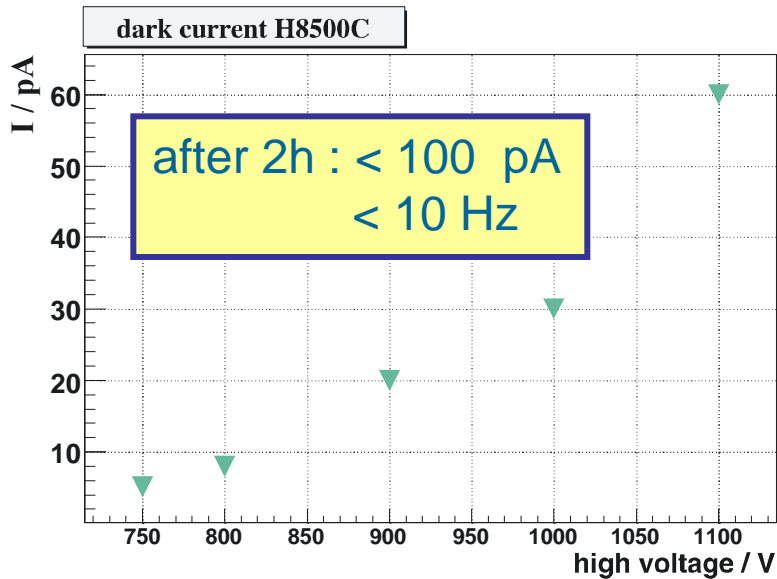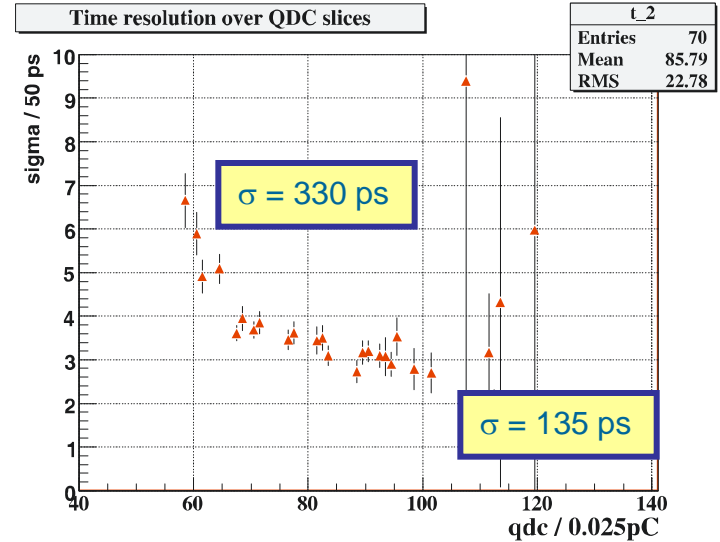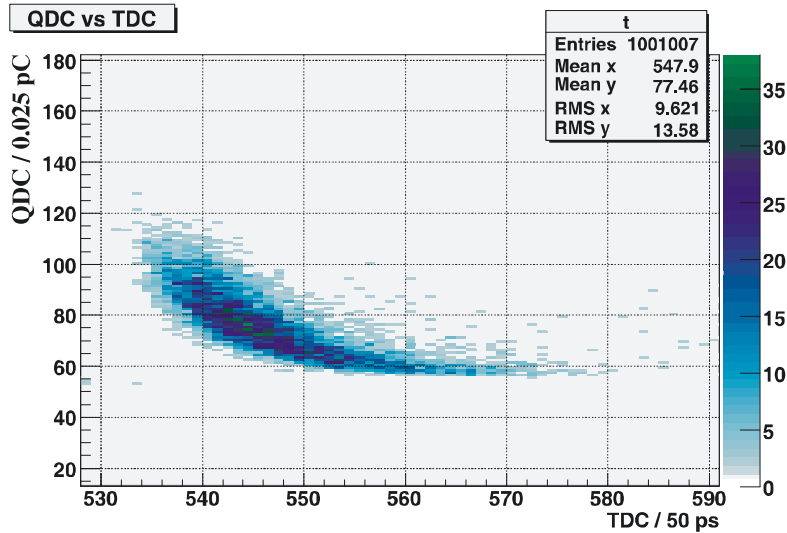
Prototype Measurements

COSY-TOF external experimental area

- Protons at **1155 MeV/c** and **3050 MeV/c** momentum
  - position sensitive **beam hodoscope** as trigger

- **Various measurements** done:
  - Cherenkov photon output of radiator bars themselve
  - photon left – right asymmetry as function of x and ϕ (**8 x H6568**)
  - two fully equipped DIRC submodules
    - **Tübingen radiator** (40x40x600mm3) + **parabolic optic** + **H8500C**
    - **Jülich radiator** (40x40x600mm3) + **polynomic optic** + **H8500C**
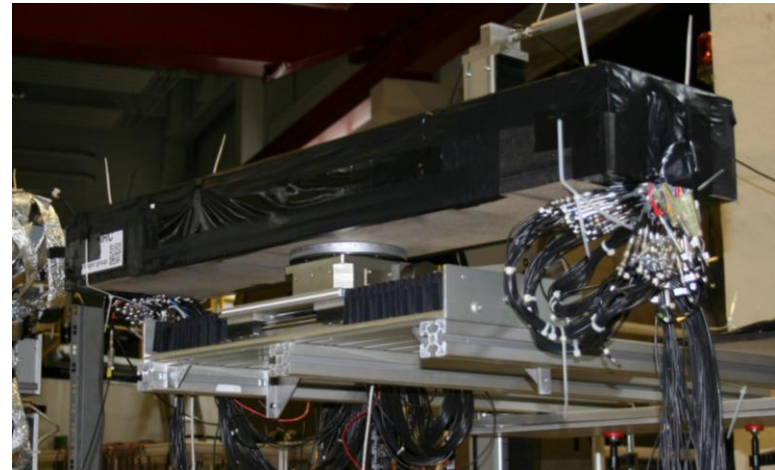
Prototype Measurements w/o Focussing
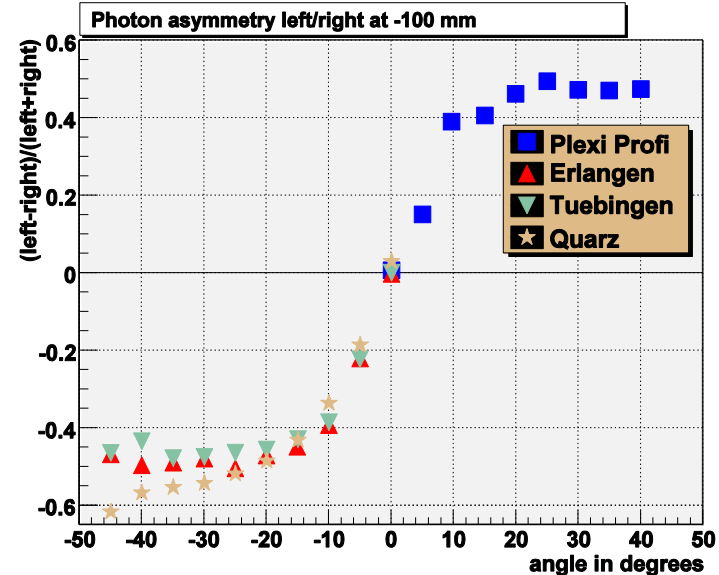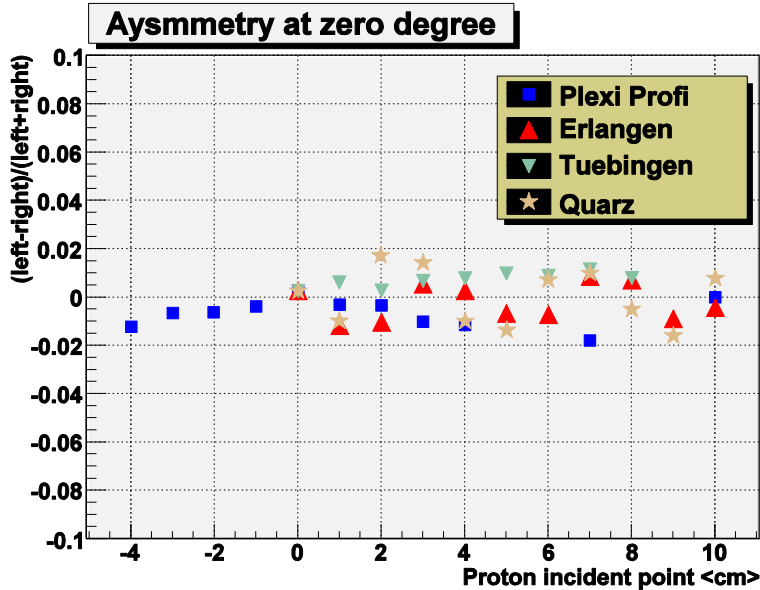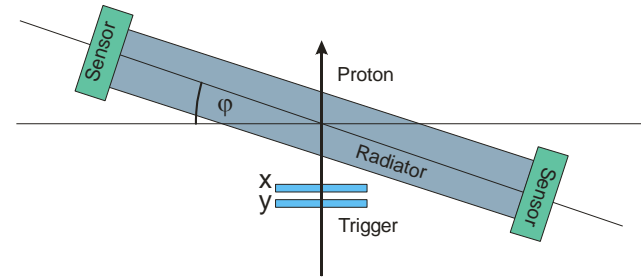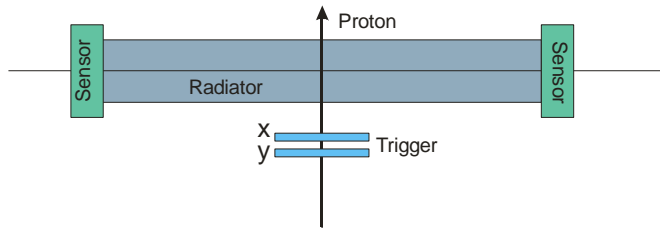
Proton momentum 3050 MeV / c

Prototype Measurements
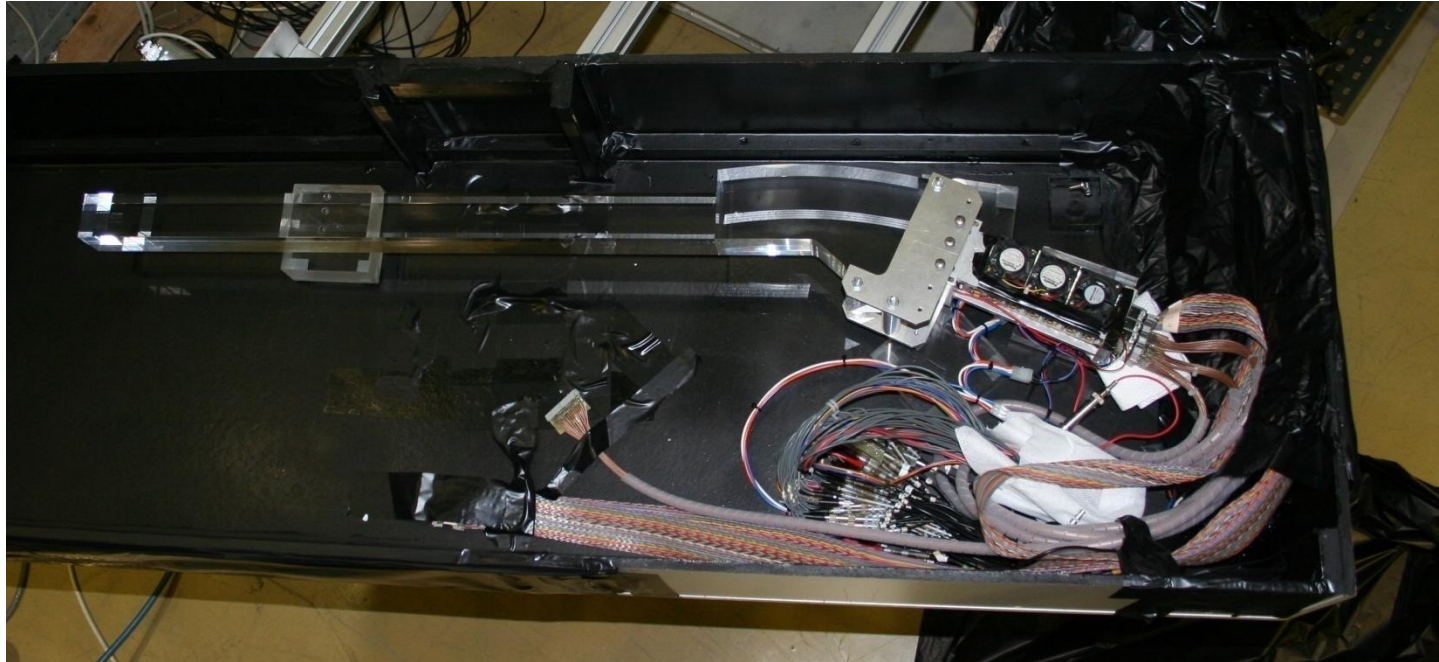
Polynomic type

Prototype Measurements

7μ Mμlar coating
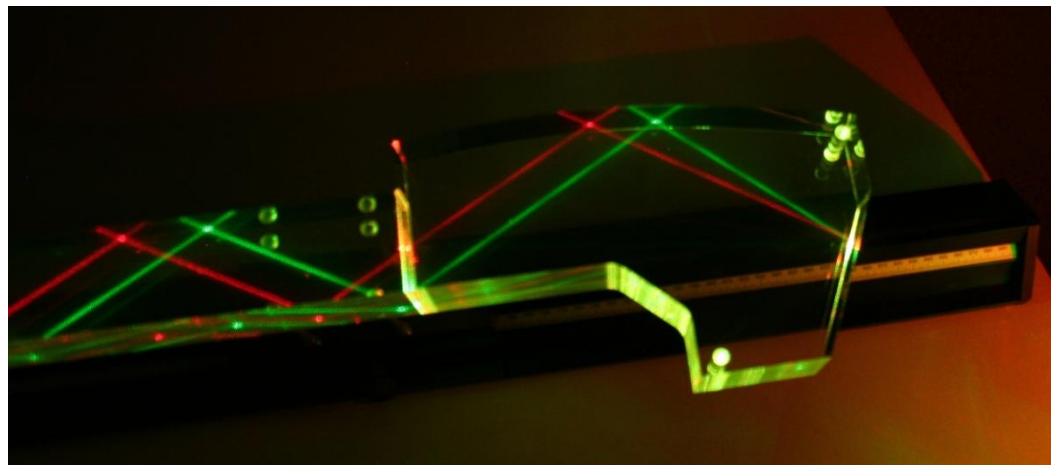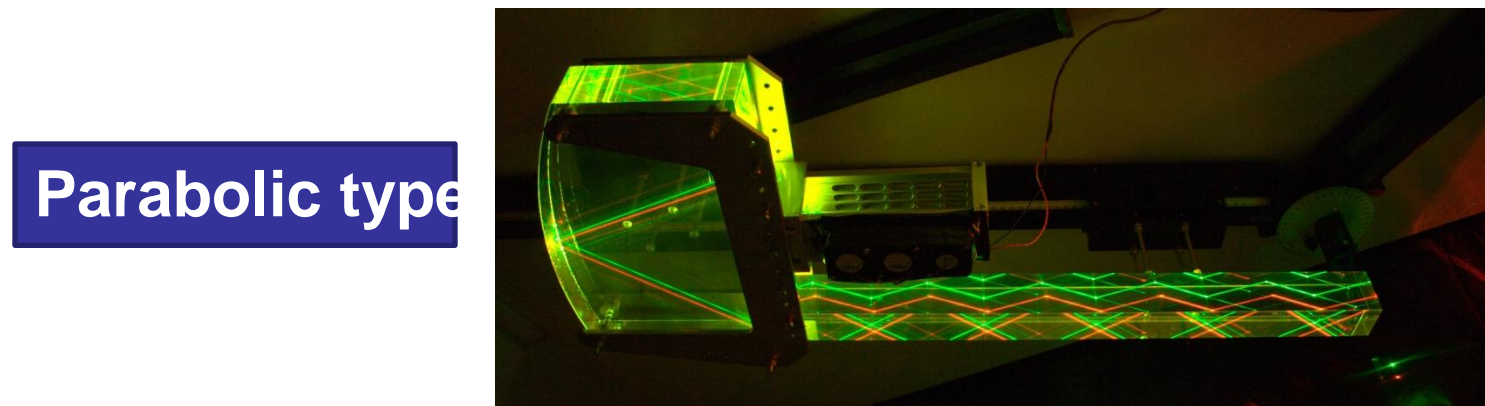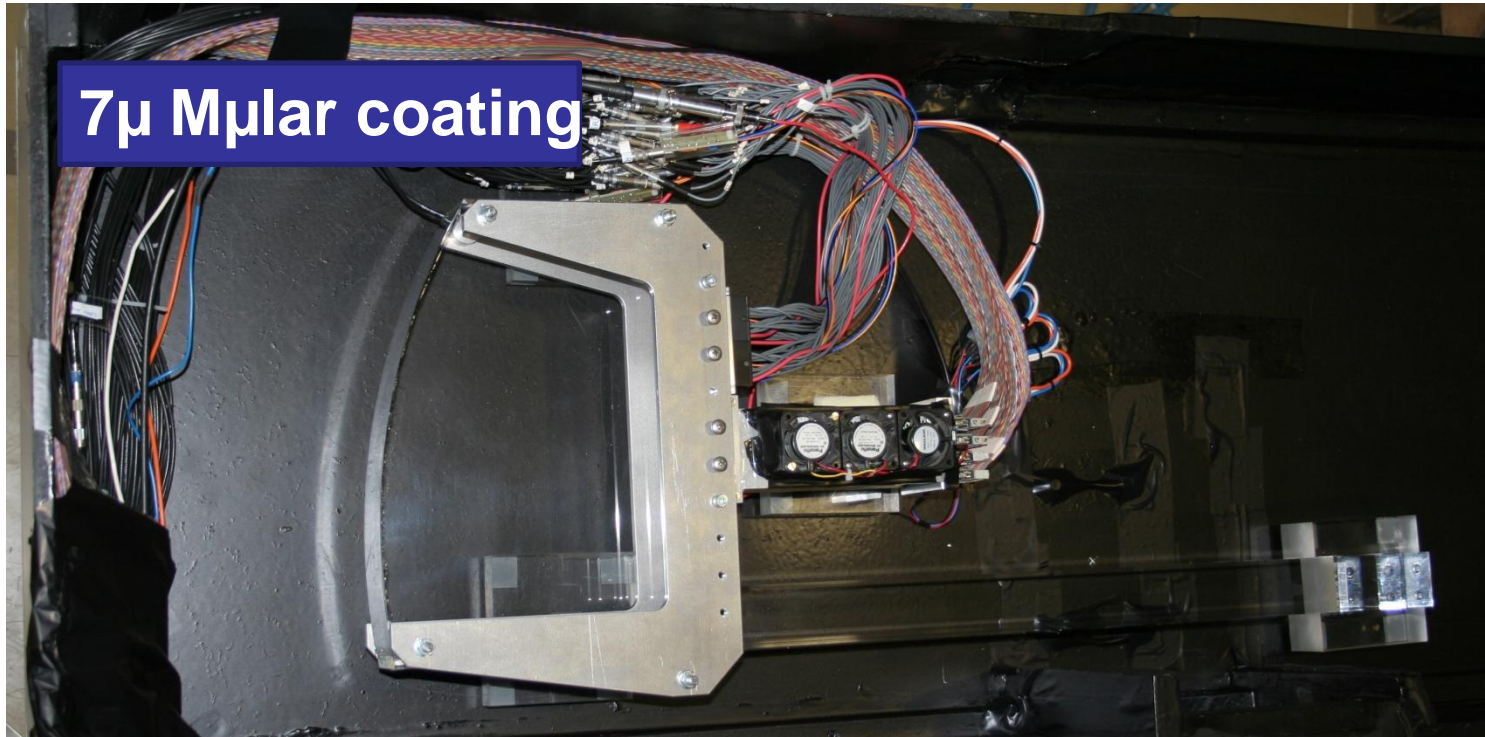
Parabolic type

Prototype Measurements

- ## Setup scheme
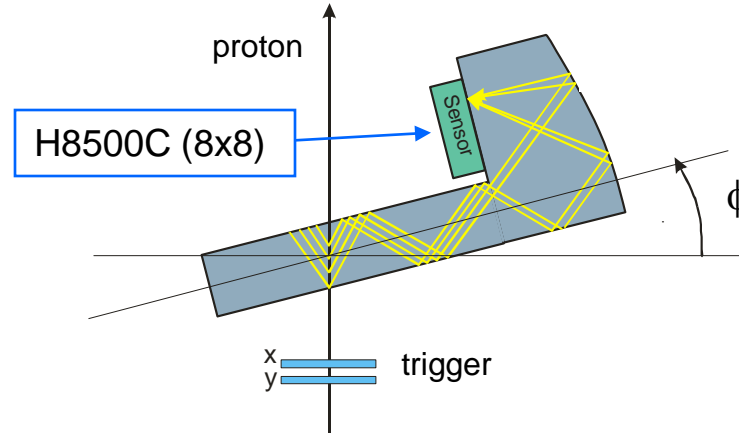
- ## Some MC
  - Geant3 software package – R.Siudak (Jülich/Bonn)
  - **Geant4 software package – K.Ulbrich** (Bonn)
  - Photon tracking package – A.Pricking (Tübingen)
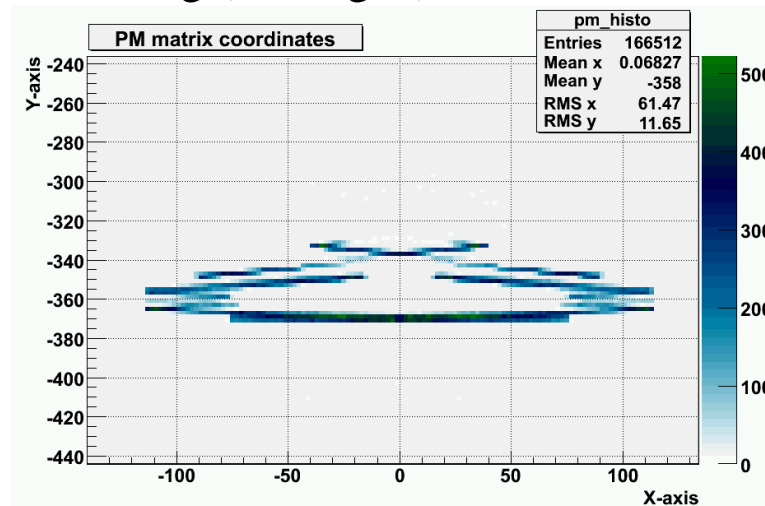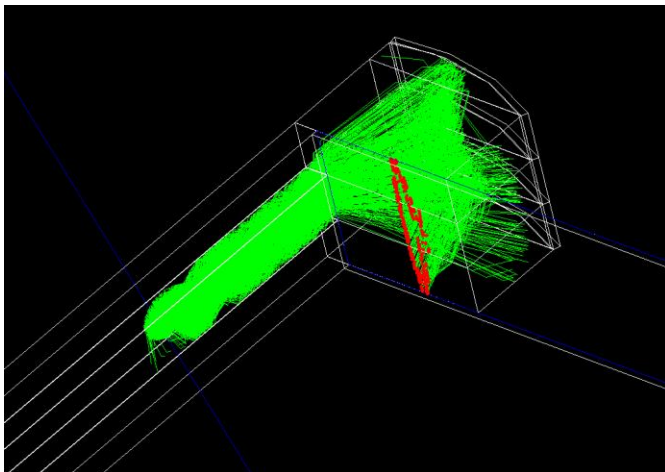
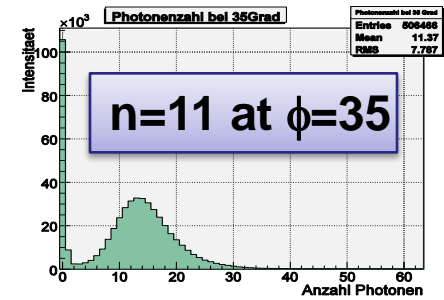# Prototype Measurements

Parabolic type – number of photons and image

n=3

n=5

n=7

parabolic 20⁰   parabolic 25⁰   parabolic 30⁰
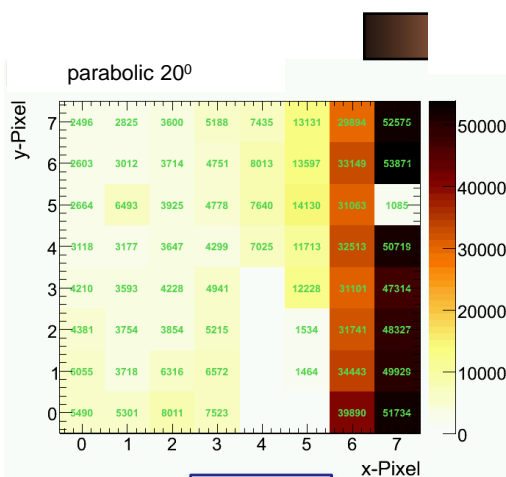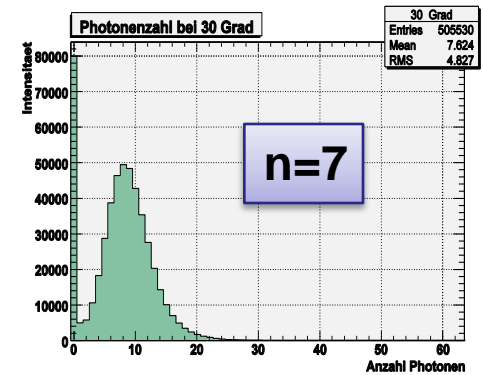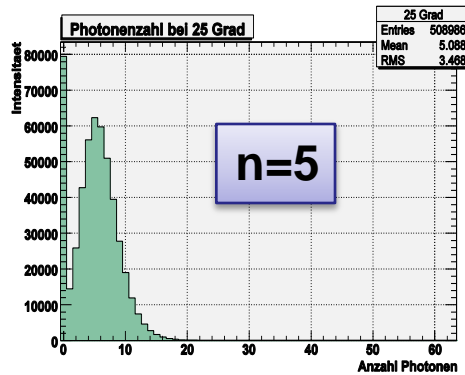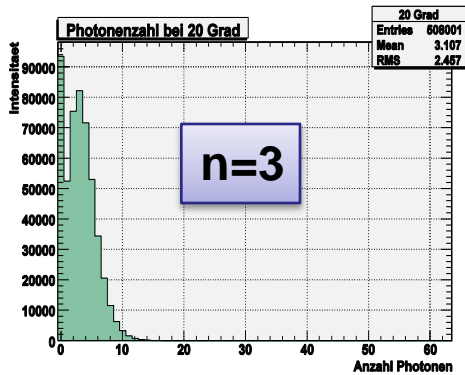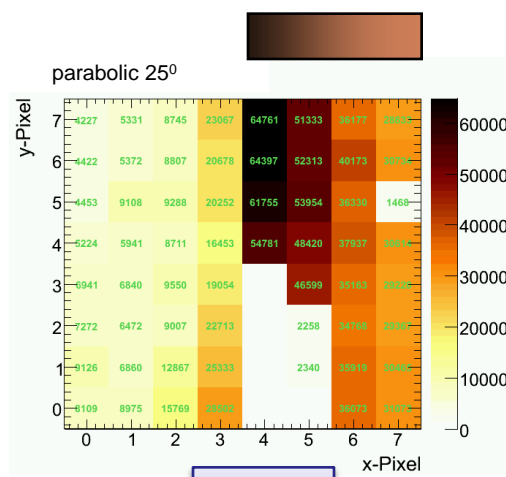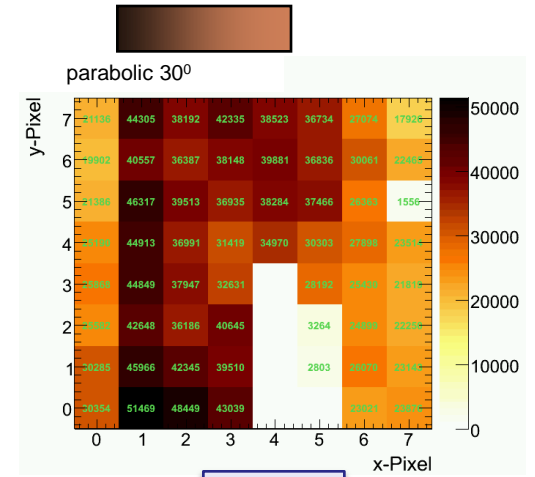
φ=20   φ=25   φ=30

pixel resolution ~ 25 mrad

Prototype Measurements

Parabolic type – number of photons and image
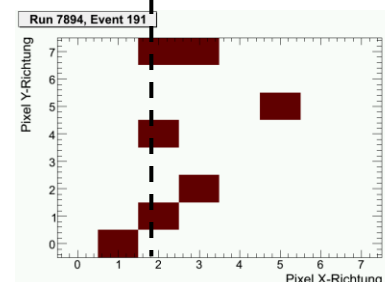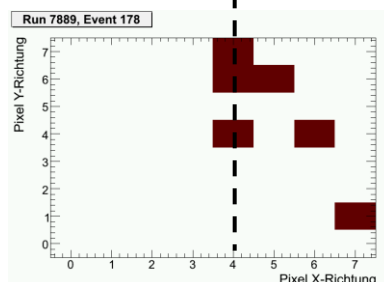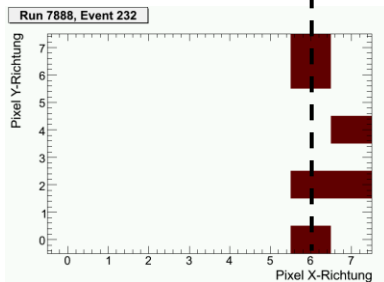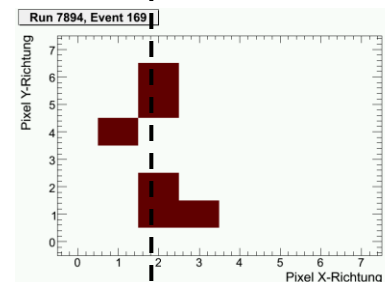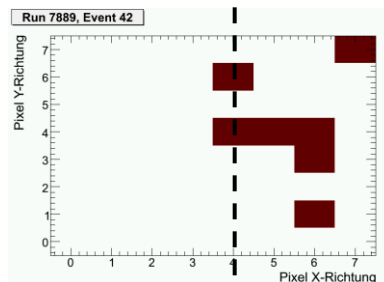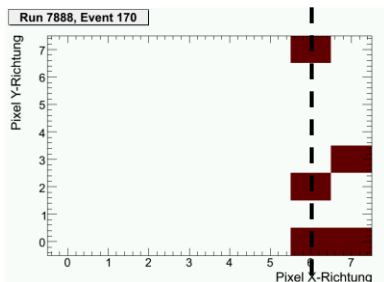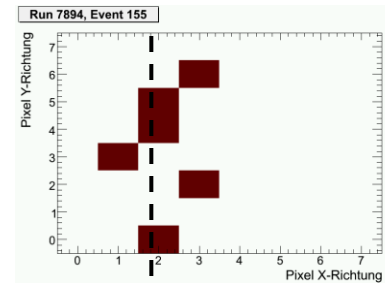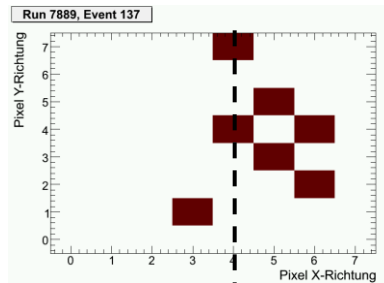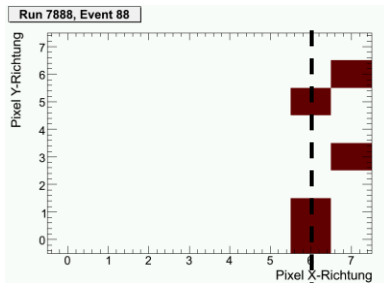
φ=20   φ=25   φ=30

Prototype Measurements

Polynomic type – number of photons and image

n=0 at φ=0

n=3 at φ=20

n=11 at φ=35

φ=20

φ=27

φ=35
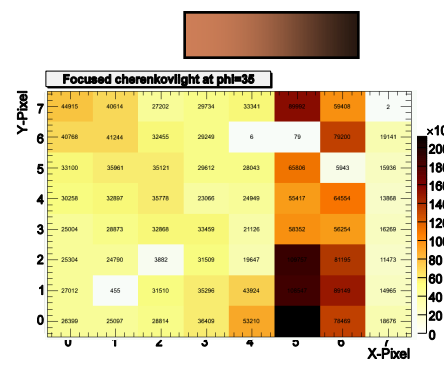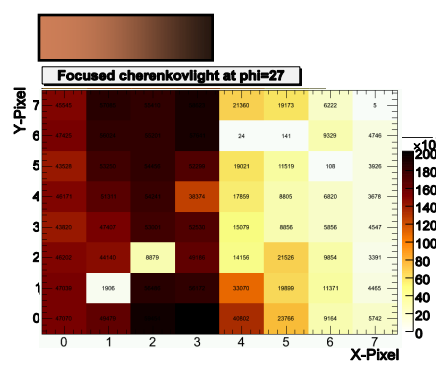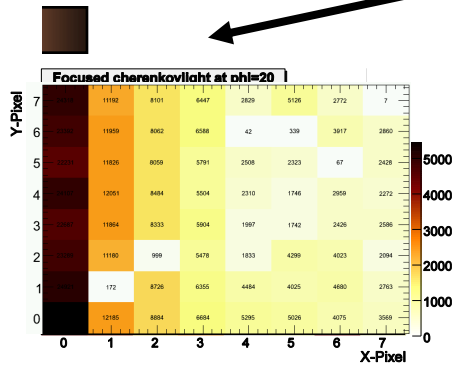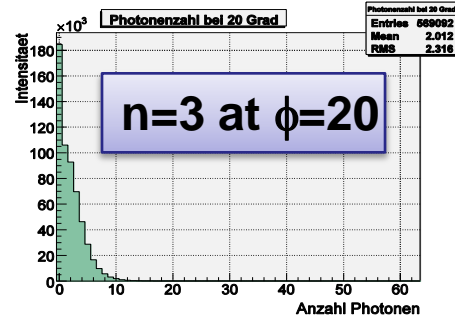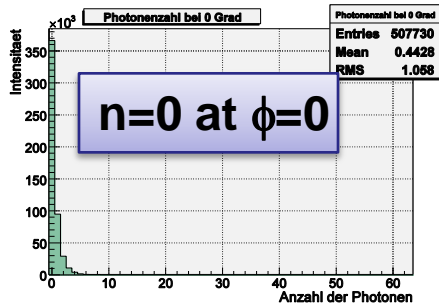
pixel resolution ~ 35 mrad

Prototype Measurements

Polynomic type – single event pattern
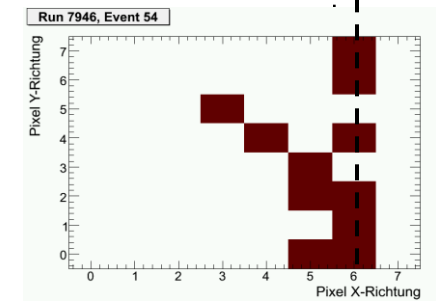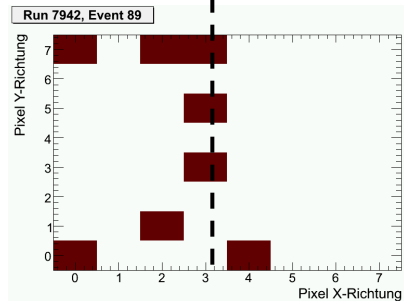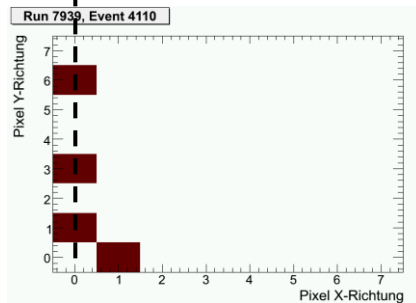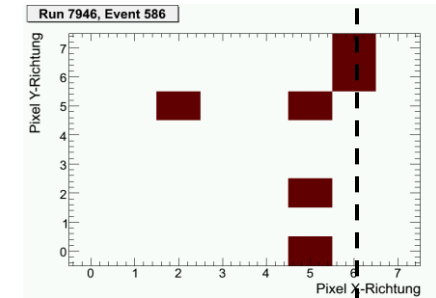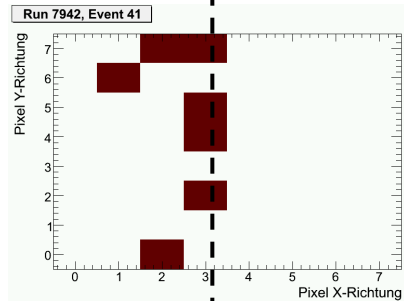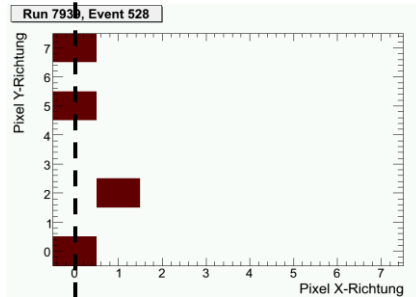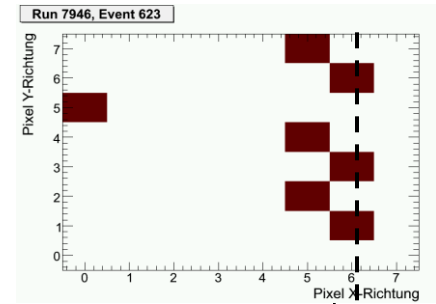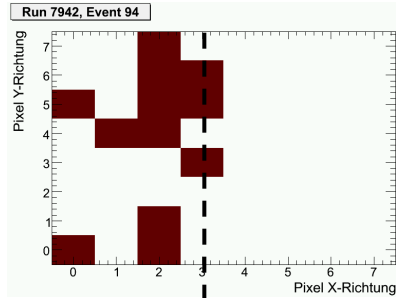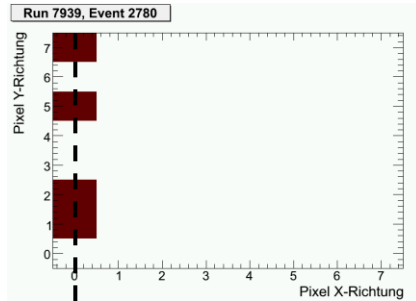
- Extended Prototypes
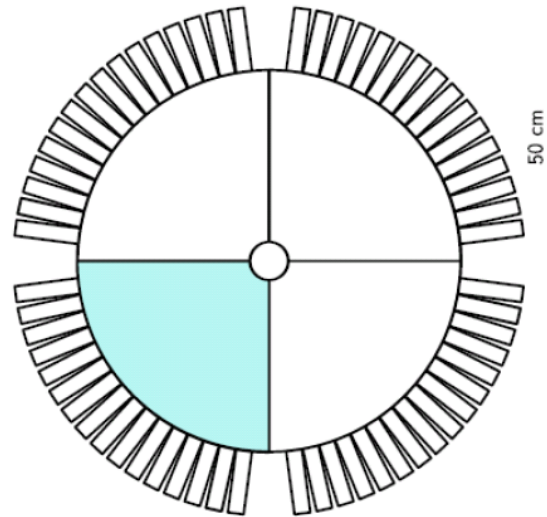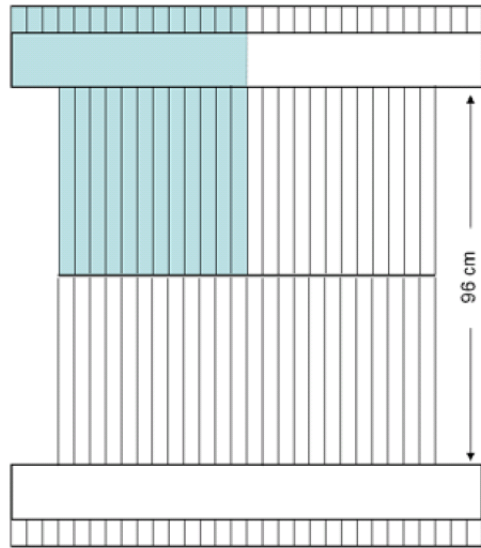
- Photon Sensors: Hamamatsu Super/Ultra Cathodes

- Readout Electronics – Software – MC

- Detector for WASA → Experience for PANDA

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- **H. Hadamek** et. al. – IKP FZ Jülich
- **N. Paul** , **J. Uehlemann, Th. Sefzick** – IKP FZ Jülich
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- **Th. Spona, K. Streeb, K. Kärcher** – Workshop PI Erlangen

- **A. Teufel, Ch. Adolph A. Schmidt, Ch. Vogel,, C. Pizzolotto** – Erlangen
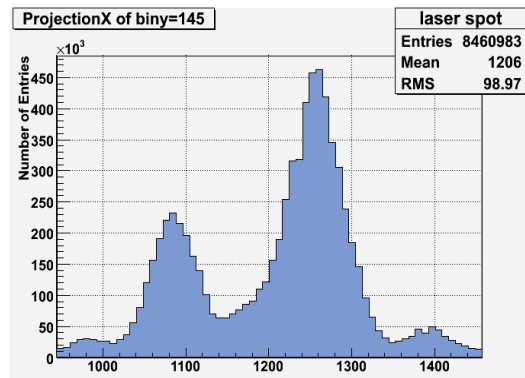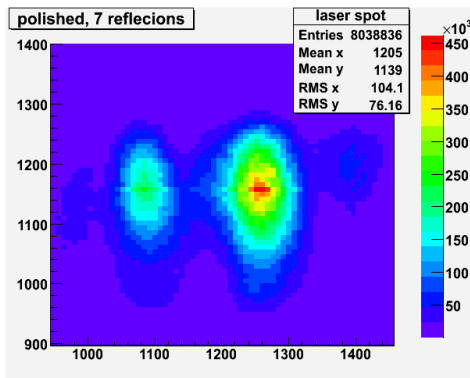
Supported by BMBF, FZ-Jülich
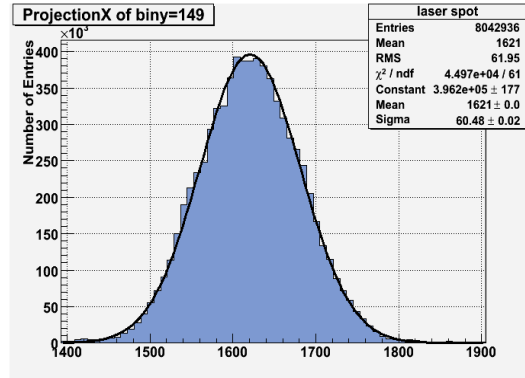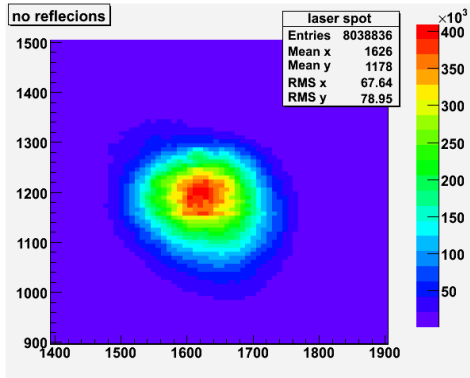
Spot without reflections
σ=0.387 mm
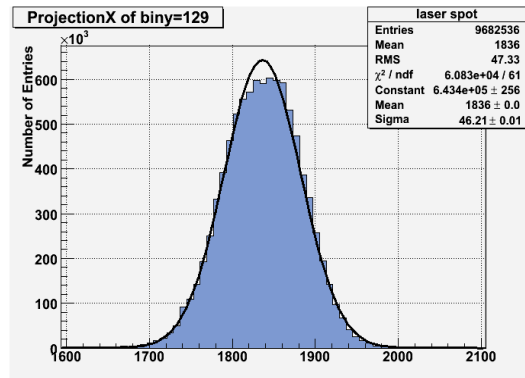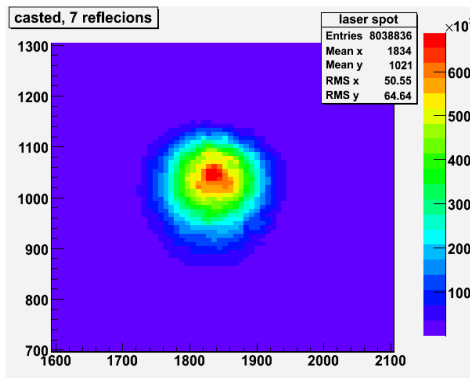
Spot after 7 reflections
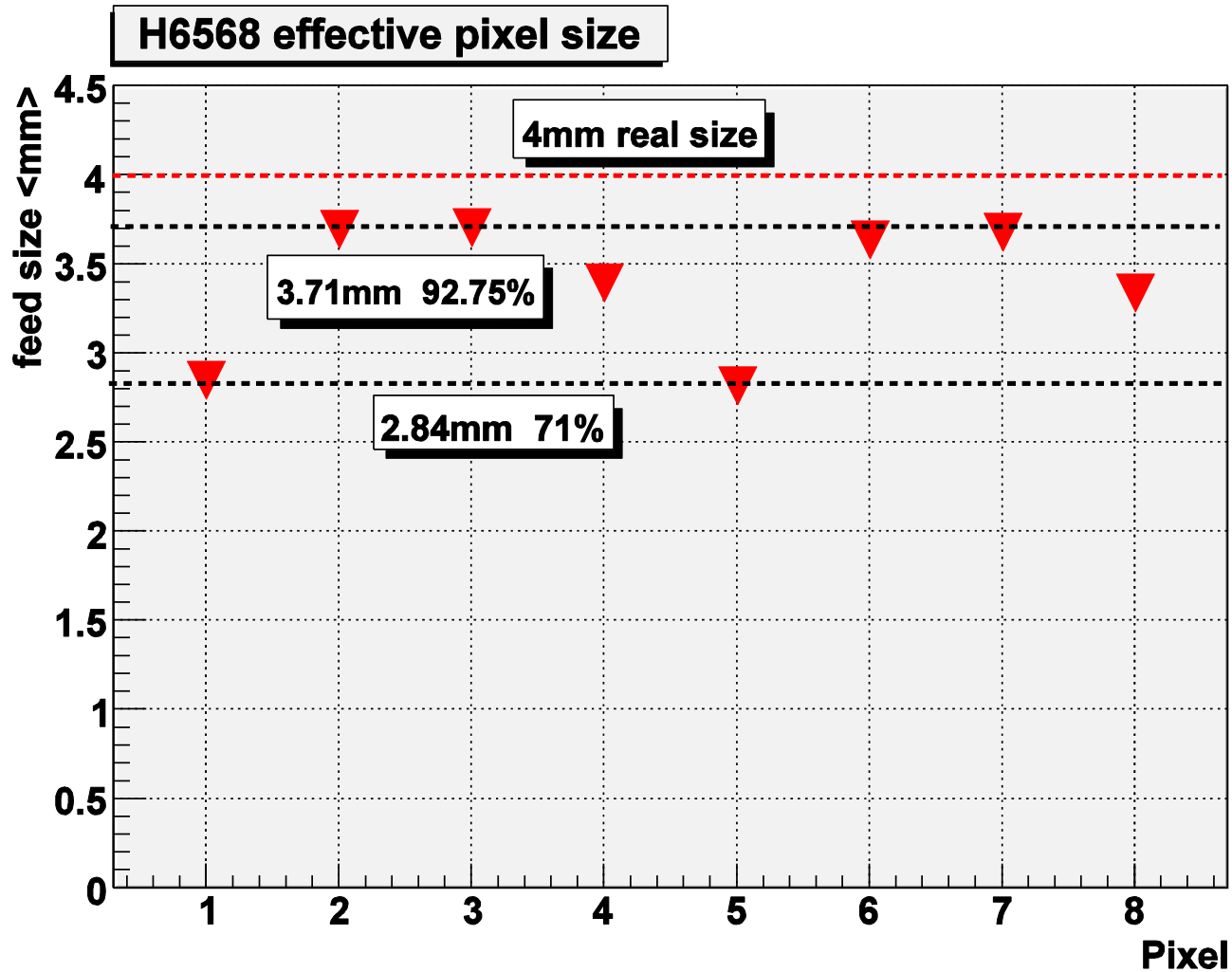**casted surface**
s=0.295 mm

Spot after 7 reflections
cut and polished surface
double peak structure

Δx=1.28 mm

Photon Sensors H6568

Crosstalk and effective Pixelsize ➔ scan with 0.5 mm step

H6568 effective pixel size

4mm real size

3.71mm 92.75%

2.84mm 71%

feed size <mm>

Pixel

Photon Sensors – H8500C

Crosstalk and effective Pixelsize ➔ scan with 0.5 mm step

H8500C effective pixelsize

6.08mm real size

5.94mm 97.7%

5.04mm 82,9%

Proton 12° zur Strahlachse

20 °

Proton 2° zur Strahlachse

Detektor um 20° geneigt

Proton

φ

χ
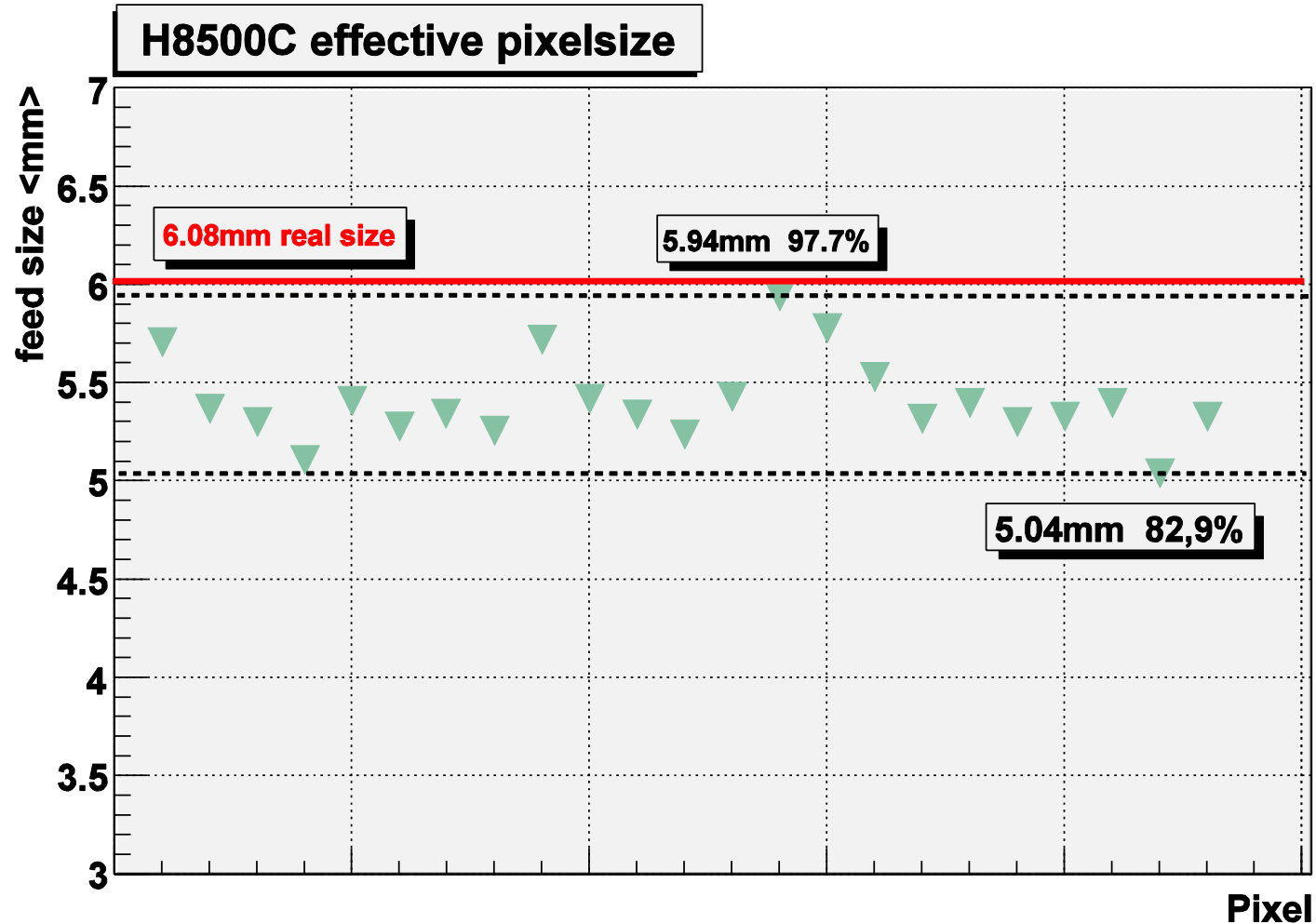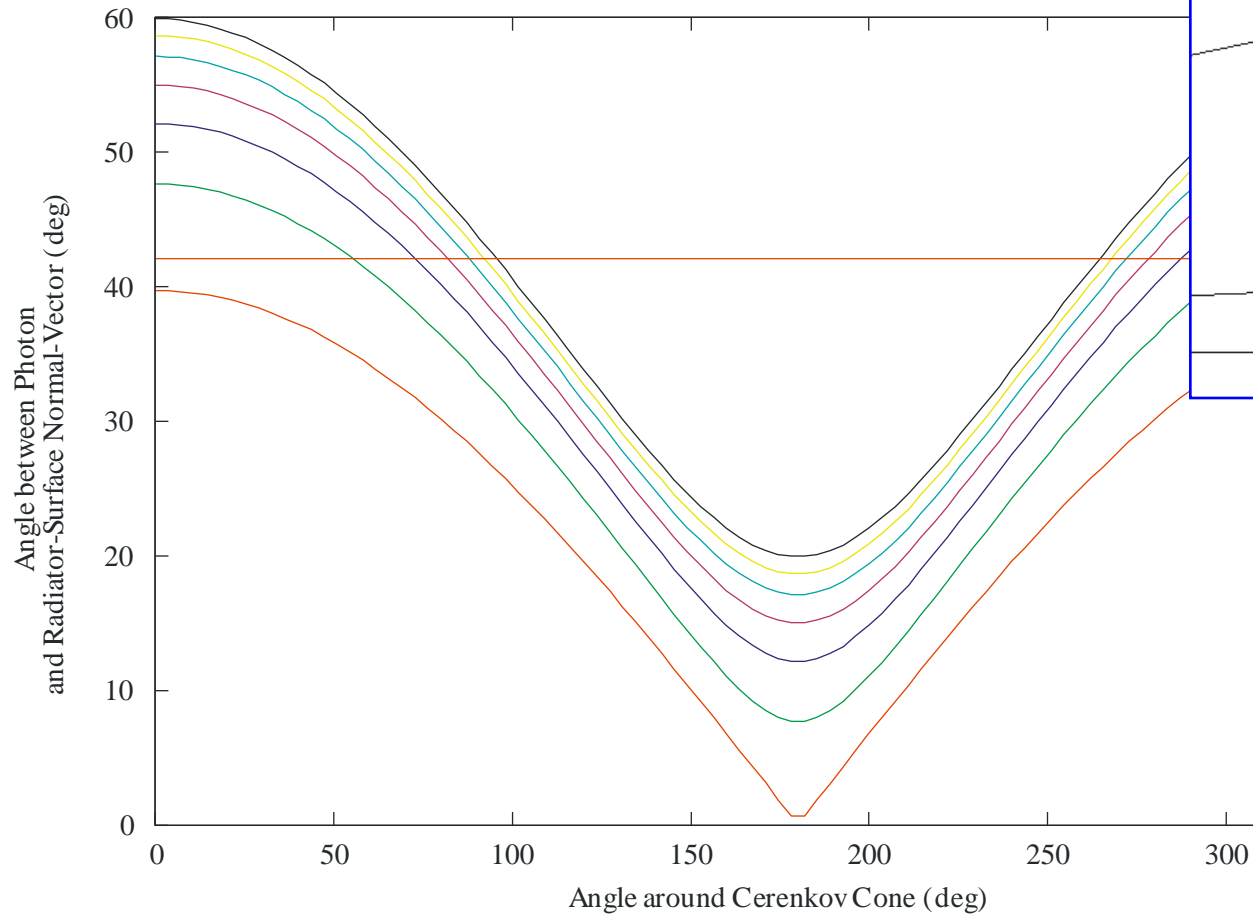
400 MeV (19deg)	700 MeV (35deg)	1 GeV (40deg)
500 MeV (27deg)	800 MeV (37deg)	42.1 deg
600 MeV (32deg)	900 MeV (39deg)	

Y-axis: Angle between Photon and Radiator-Surface Normal-Vector (deg)

X-axis: Angle around Cerenkov Cone (deg)