Thoughts on analysing photon hit patterns from Disc DIRC detectors

Klaus Föhl

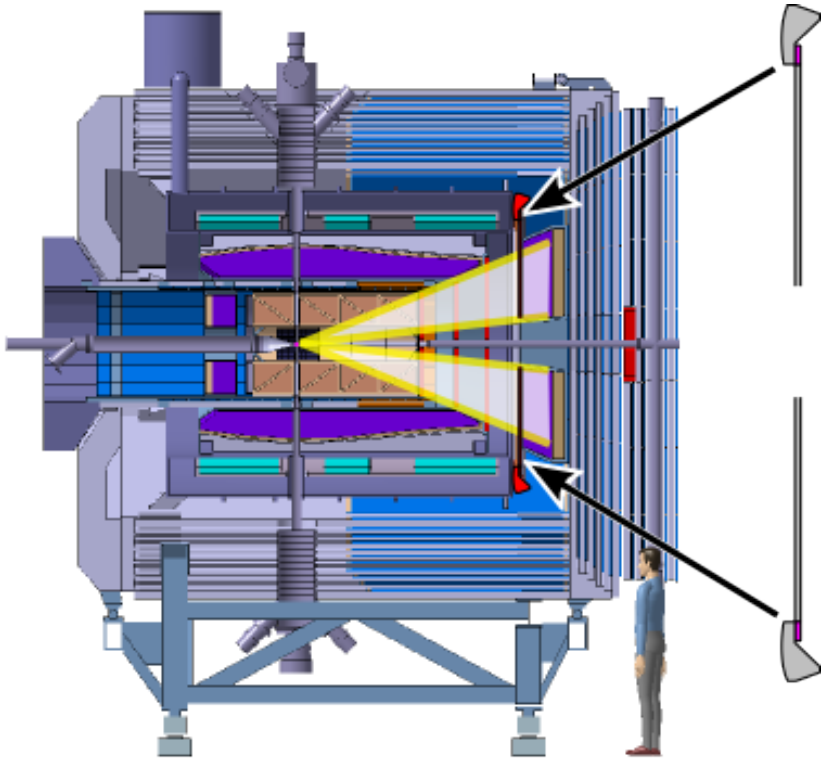
panda DAQT&FEE Workshop

Rauischholzhausen

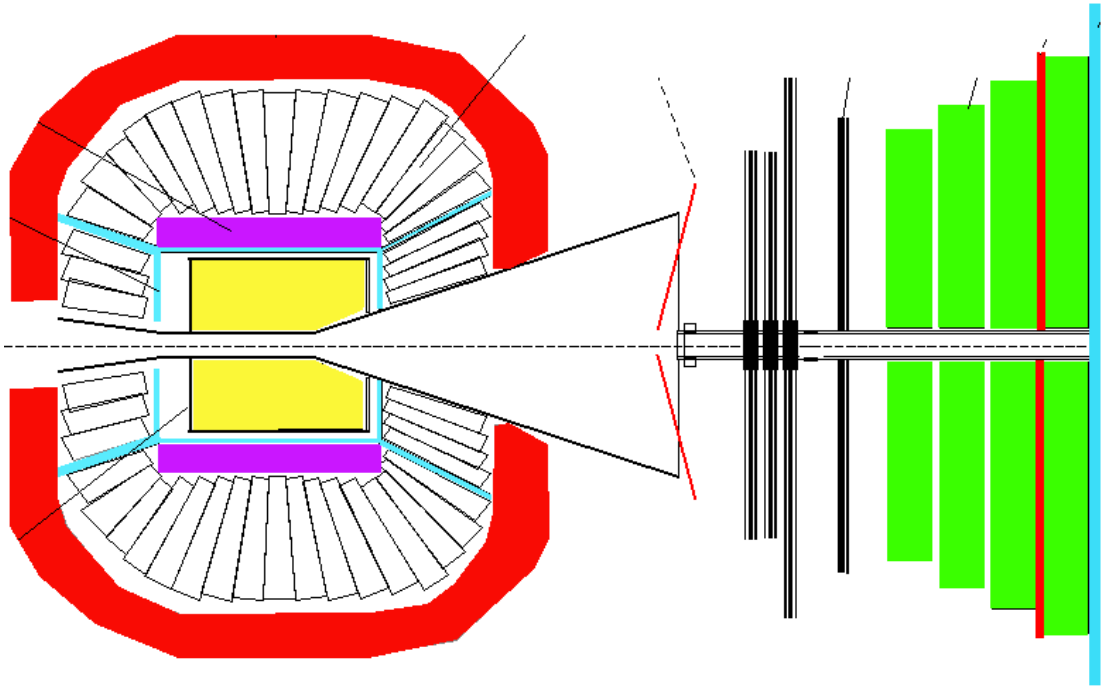
16 April 2010

JUSTUS-LIEBIG-
UNIVERSITÄT
GIESSEN

Experiments longing for “new” DIRC



PANDA Target Spectrometer



WASA experiment at COSY

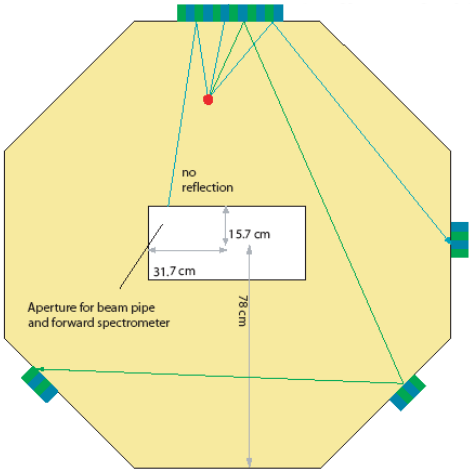
measure beta for PID

measure beta for energy determination

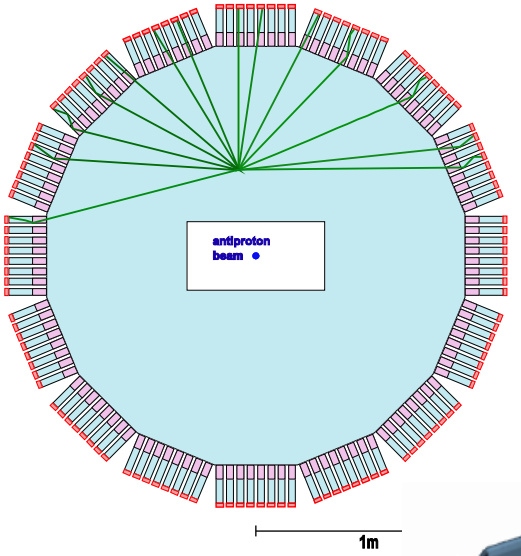
forward phase space to cover: theta=5-23deg for PANDA, theta=3-17deg for WASA

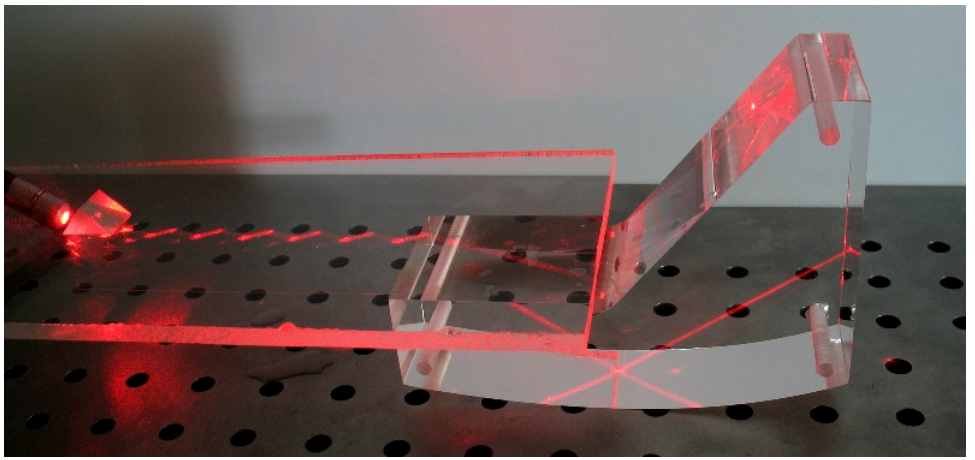
Disc DIRCs for PANDA and WASA

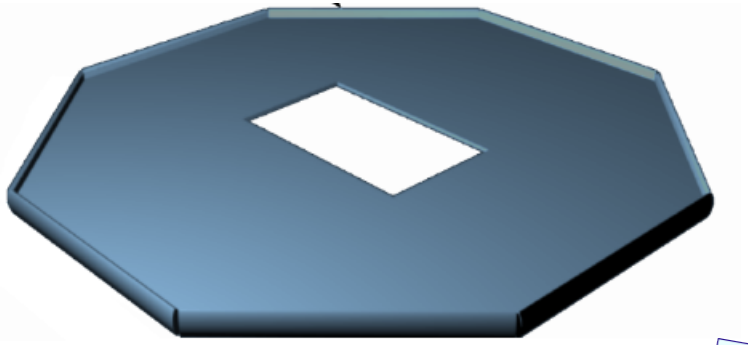
Time-of-Propagation

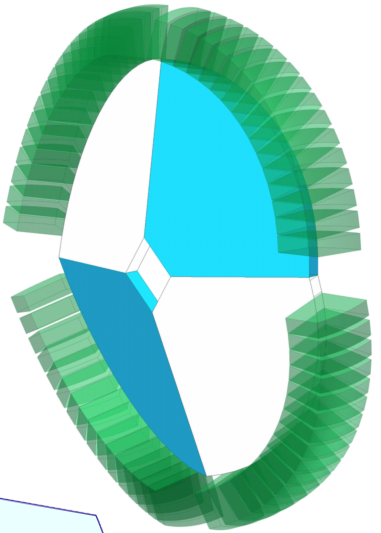


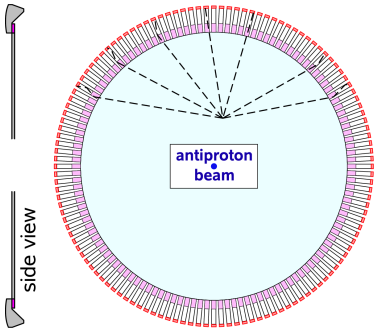
Focussing Lightguide



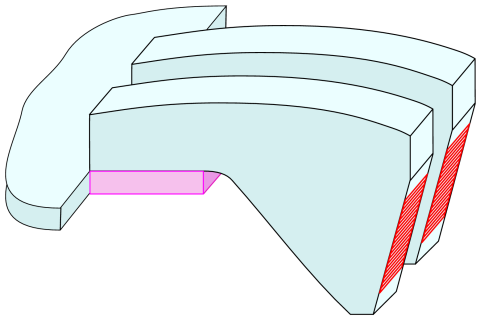




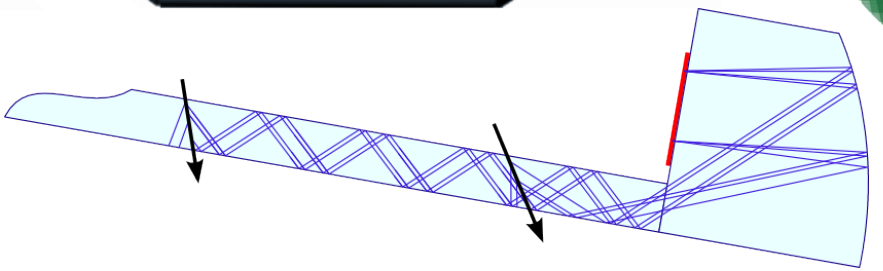




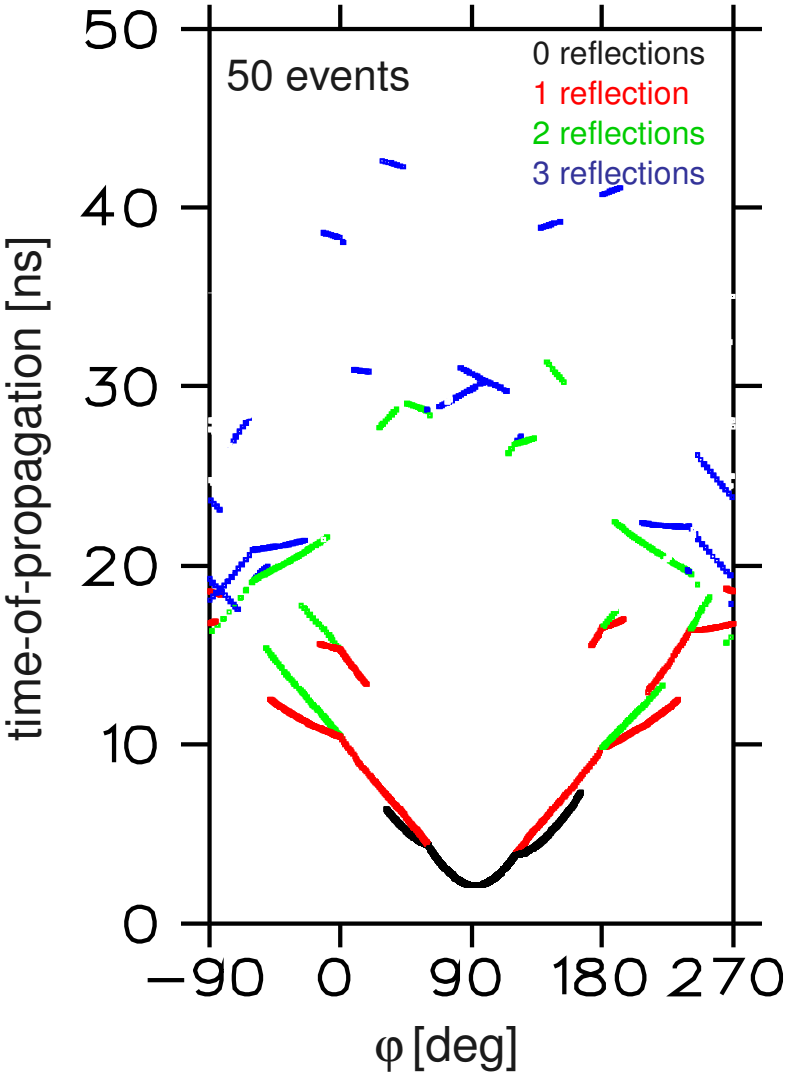
Disc DIRC seen from target

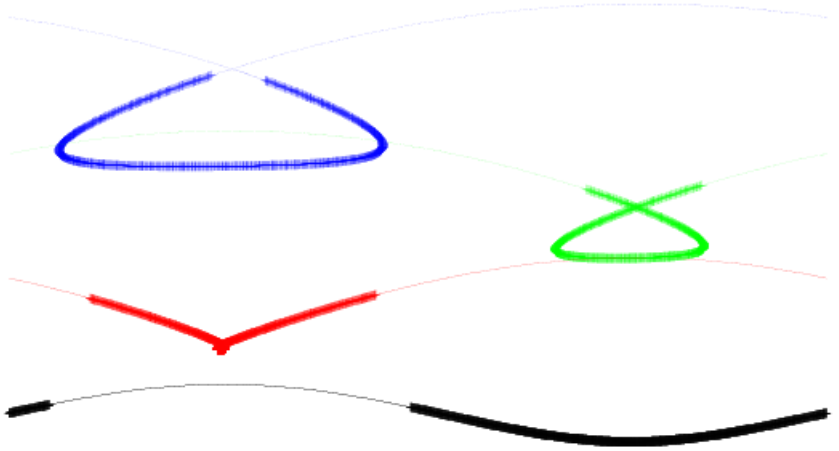


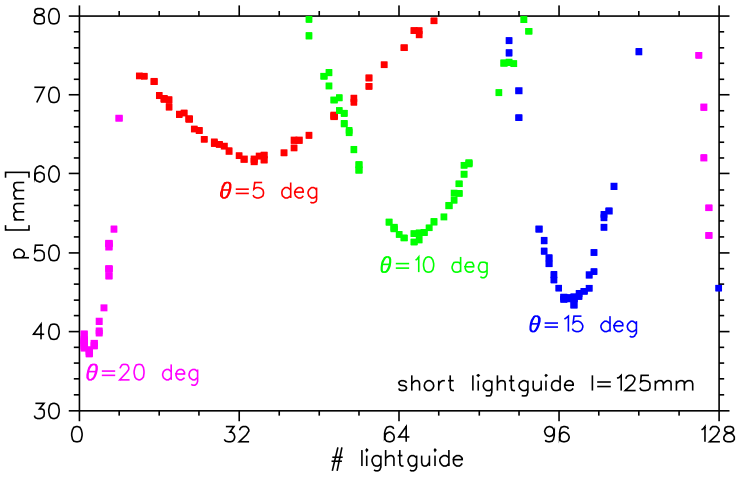
Lightguides with LiF - 3D visualisation

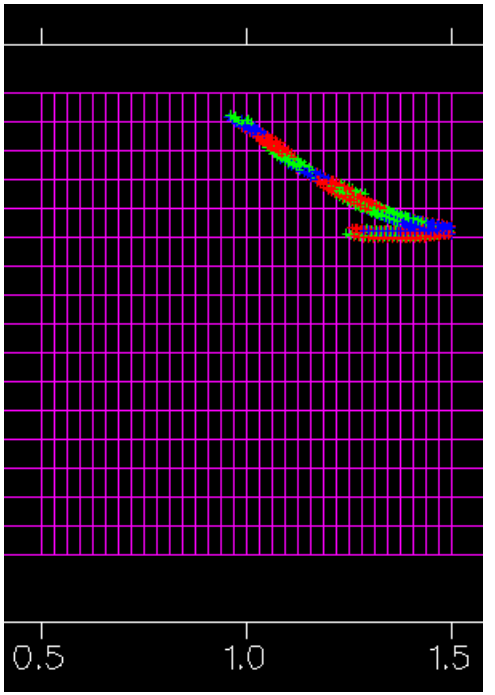


Photon Hit Patterns

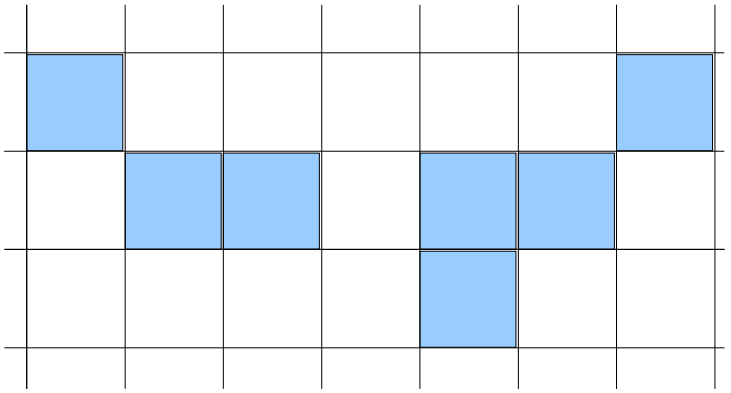


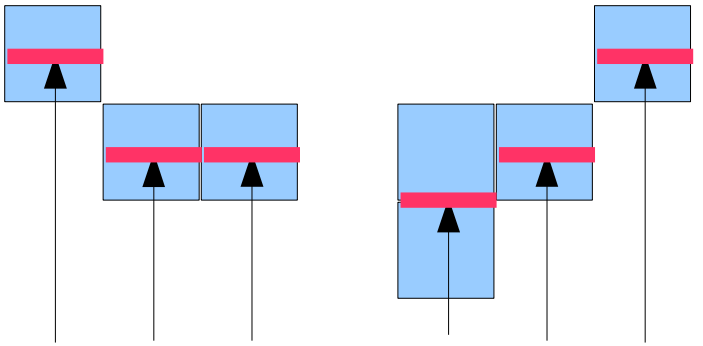






2D versus Vector Description





vector (3 , 2 , 2 , - , 1.5 , 2 , 3)

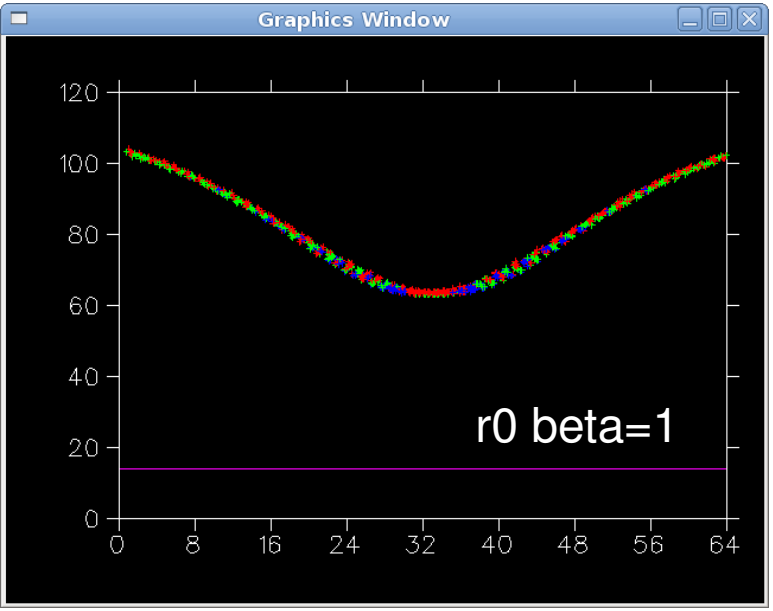
weight (1 , 1 , 1 , 0 , 2 , 1 , 1)

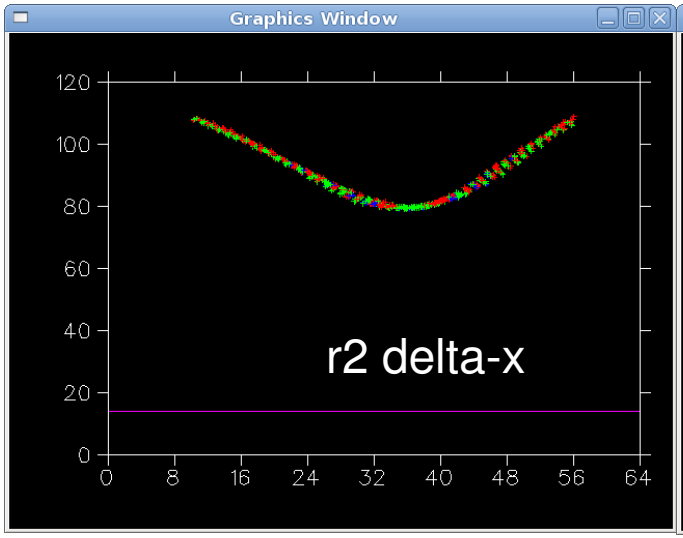
Reference Pattern Generation 1

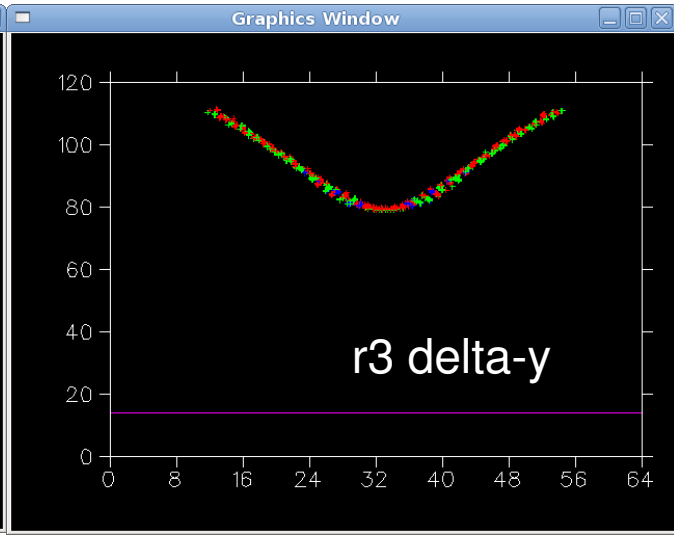
- currently computed on the fly
- x100 / x40 photon statistics
- random numbers not used to get error ~1/n
- no pixel discretisation – true position used

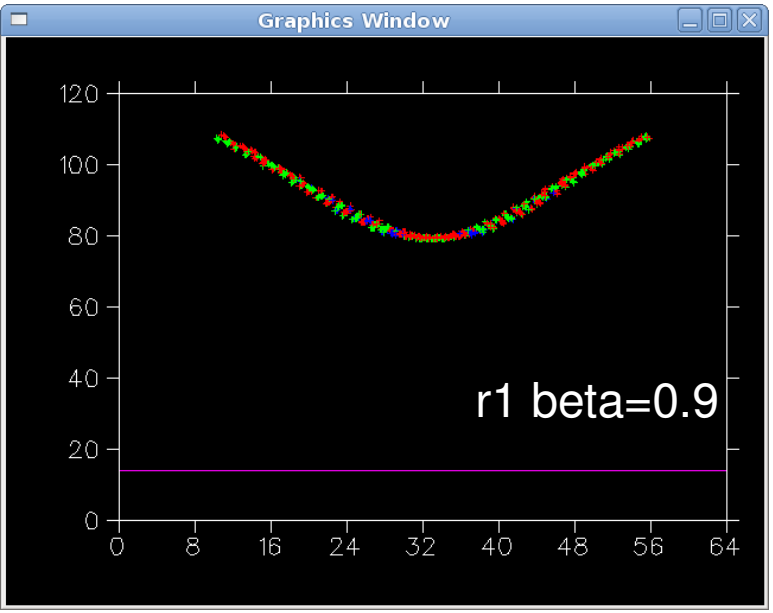
- photon selection (from pattern width)
- position analysis (average position)

Reference patterns

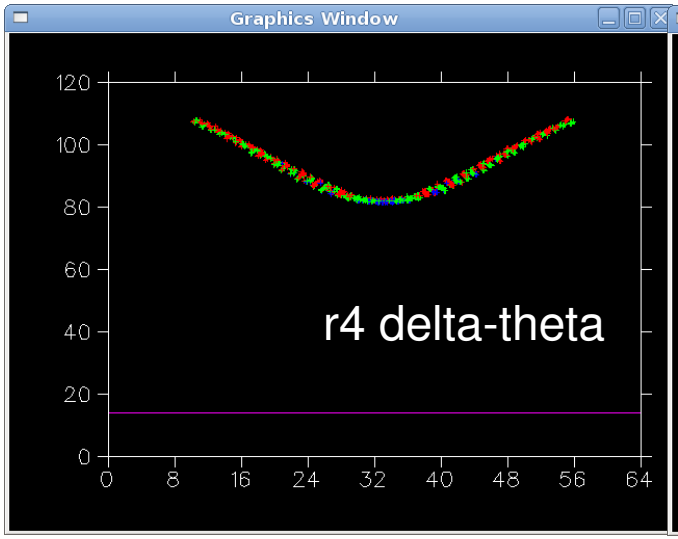


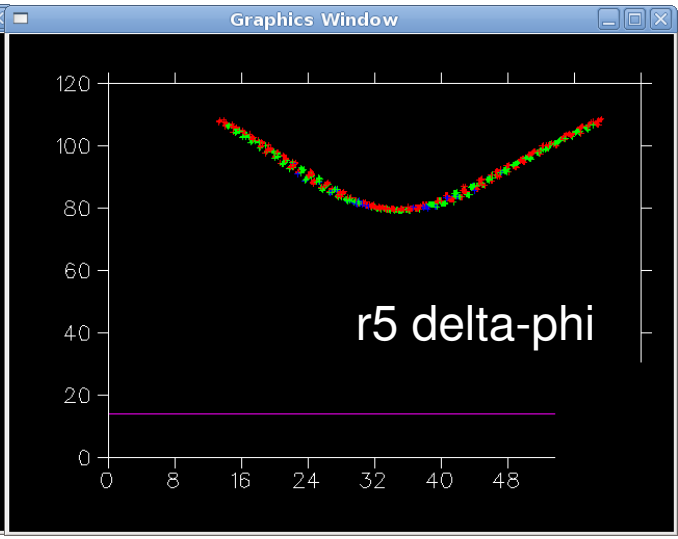




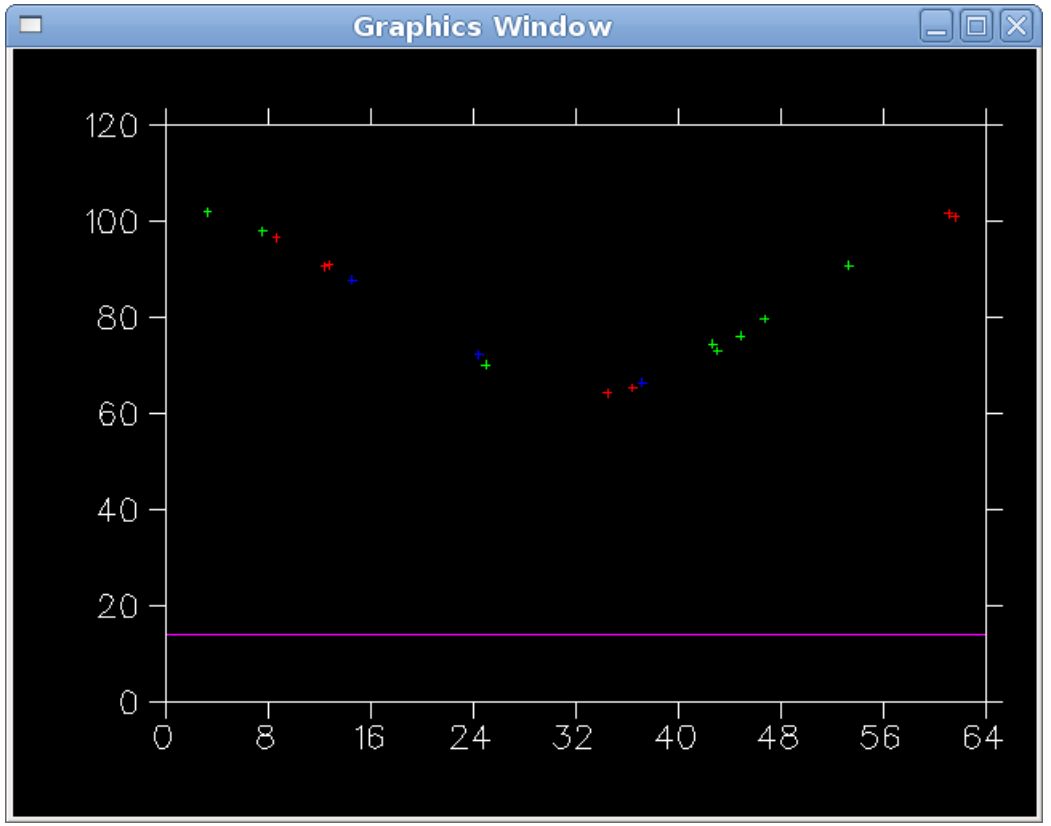


4 additional degrees of freedom





Solve Linear Equation for Event

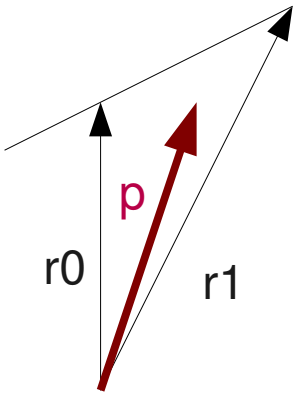


- with tracking --> beta
- without tracking:

(beta,x,y,theta,phi)

Error Matrix:

bb	bx	by	bt	bp
xb	xx	xy	xt	xp
yb	yx	yy	yt	yp
tb	tx	ty	tt	tp
pb	px	py	pt	pp



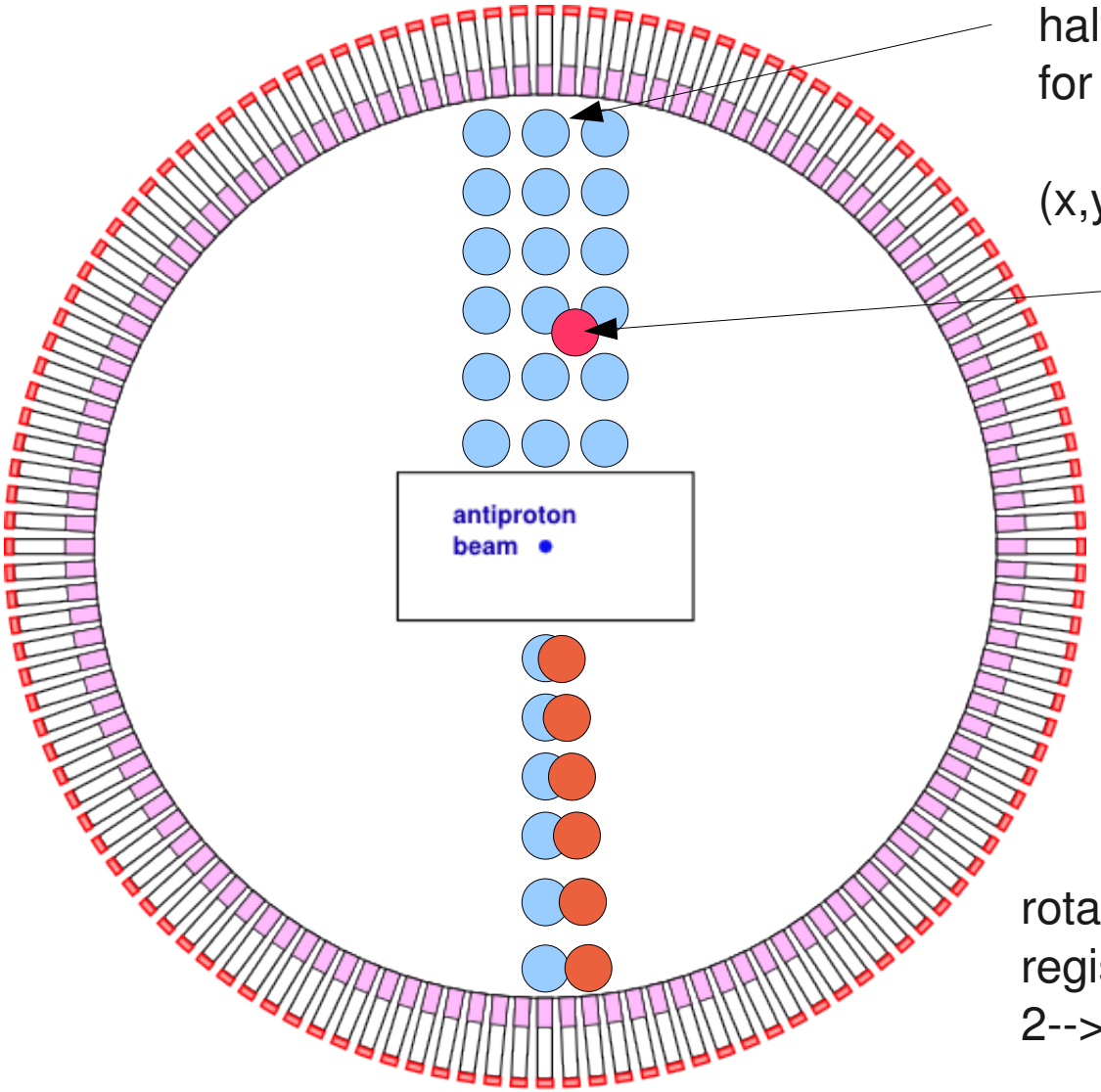
$p = chi + r0 + \sum ci*(ri-r0)$

general case: Chi^2 fit – this case solving a linear regression with 5 unknowns

Reference Pattern Generation 2

- currently computed on the fly
- x100 / x40 photon statistics
- random numbers not used to get error ~1/n
- no pixel discretisation – true position used

- For FPGA implementation precompute patterns
- How many patterns?
- Preferably keep them in FPGA and not in RAM
- 5 (five) dimensions to cover (10^5? 100^5??)



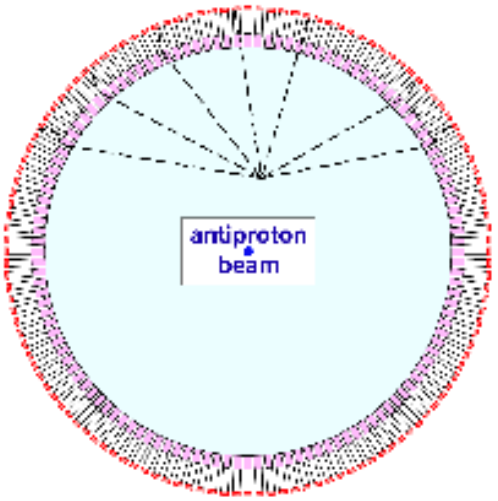
full set of theta
half set of phi
for each position

(x,y,1) for direction?

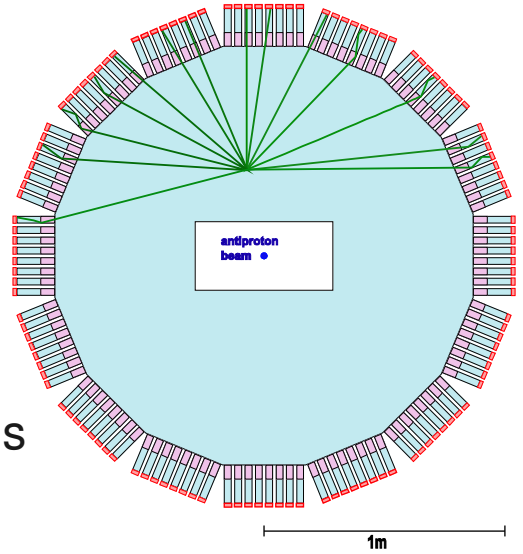
interpolation
linear or to
higher order
(wider spacing,
more coefficients)

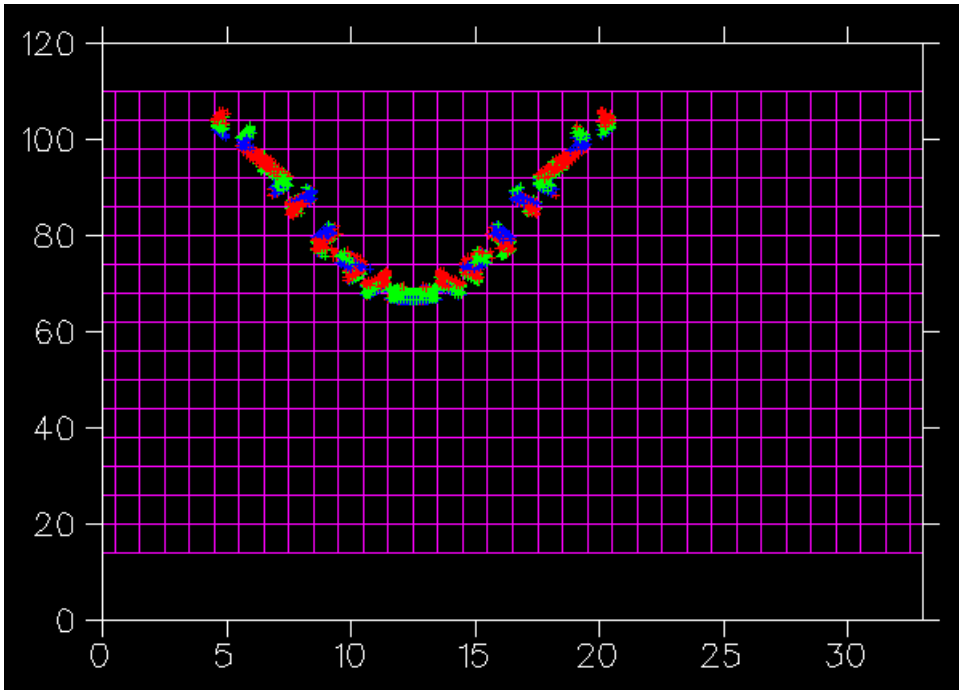
rotational symmetry:
register shifting:
2-->1 dim location

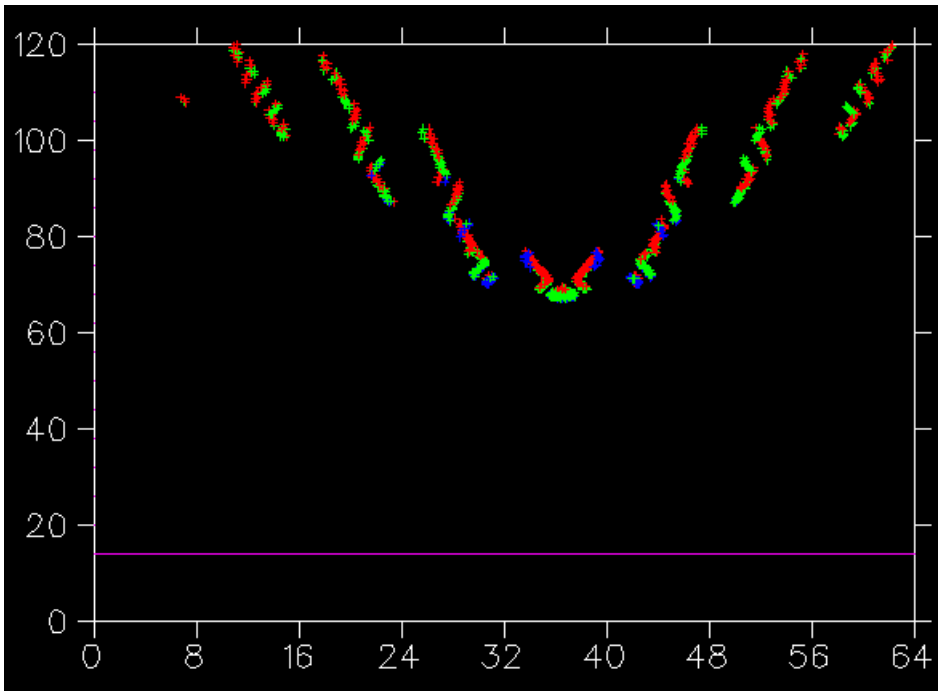
Symmetry effect on pattern



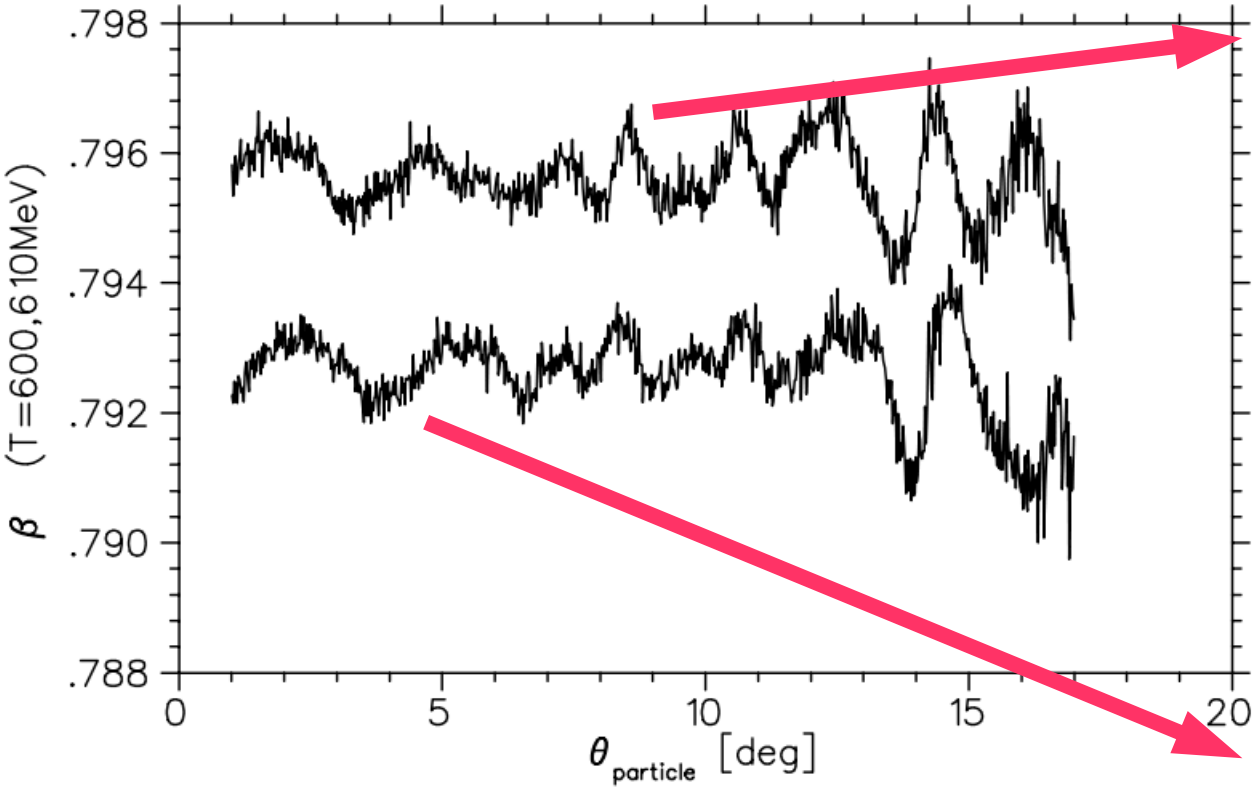
similar physical performance, reduced symmetry means more patterns to store

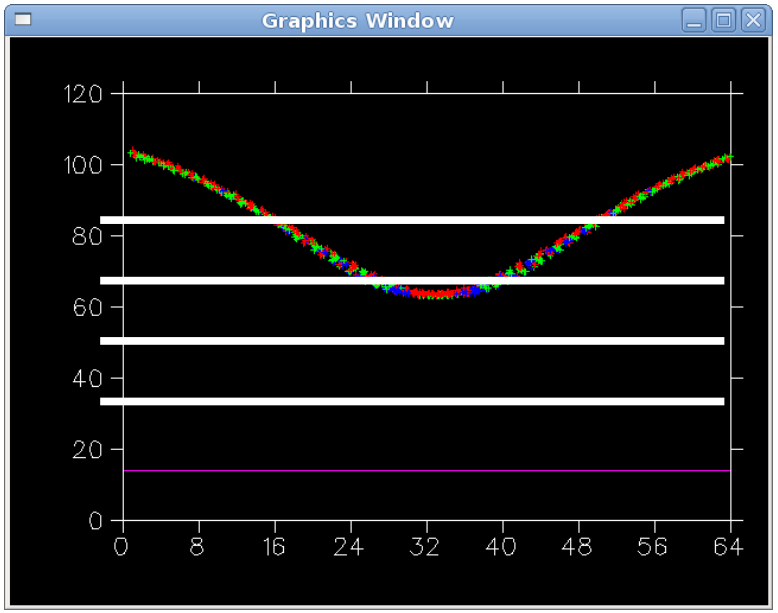


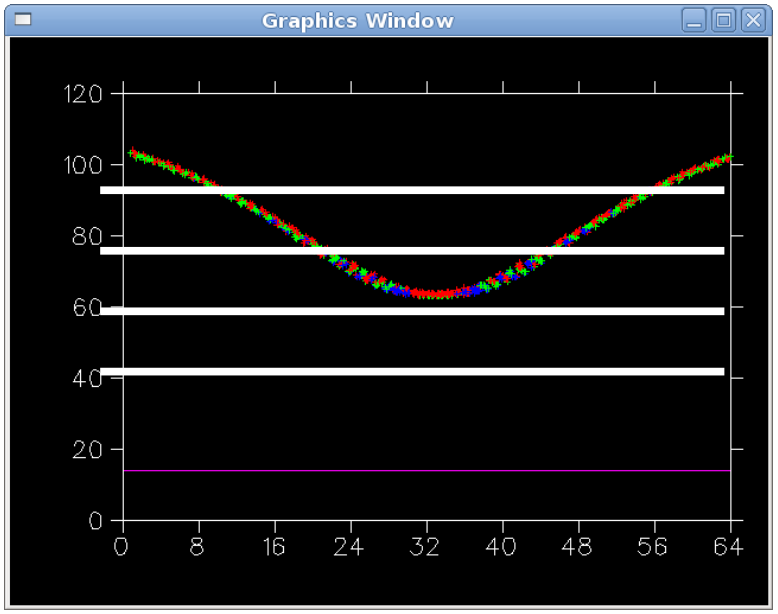




Finite Pixel Size Corrections







to be studied and also implemented on FPGA

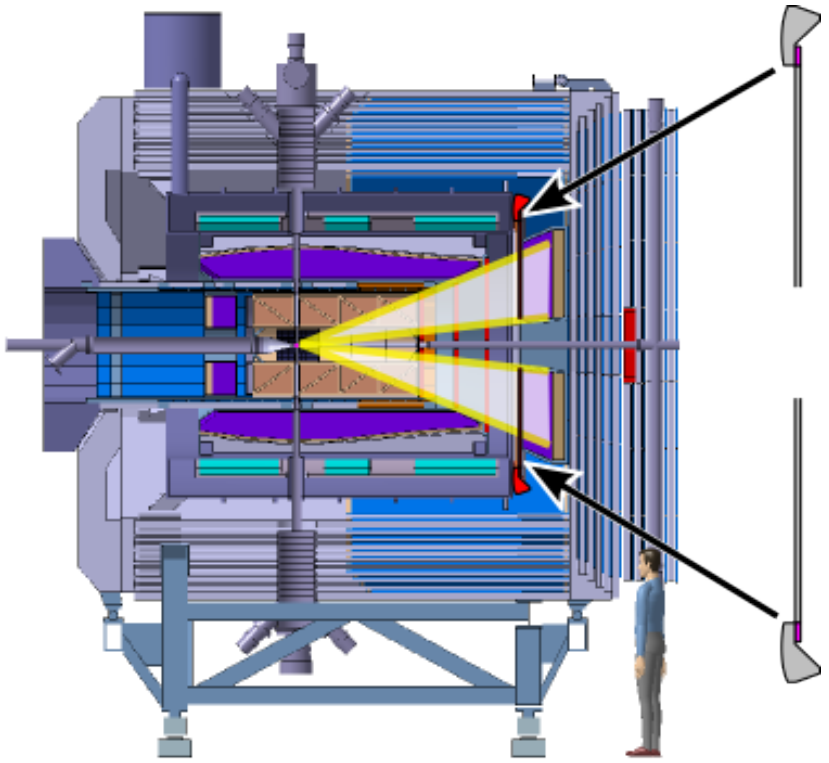
Summary

- variety of photon hit patterns
- description in R^n vector space
- minimise distance to hyperplane – linear problem
- #patterns stored and (linear, 2^{nd} order interpolation) versus accuracy required and FPGA RAM memory
- make detector geometry analysis friendly
- ==> high symmetry advantageous
- understand and correct systematic effects

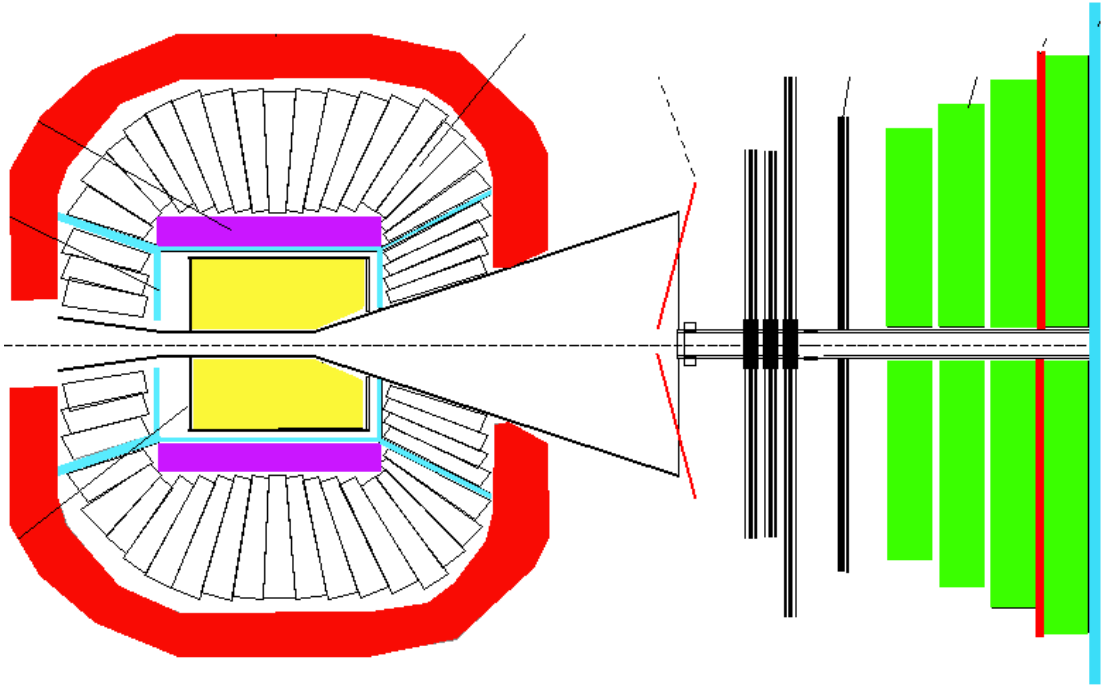
Thank you for your attention

backup slides

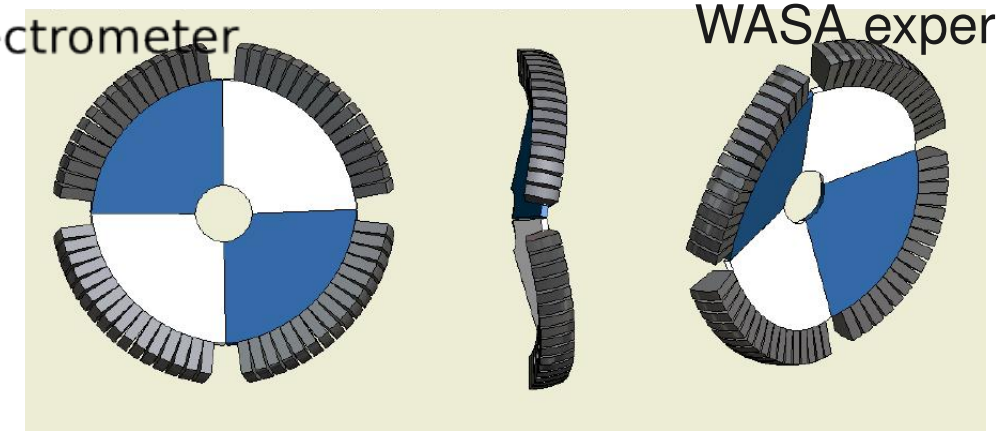
Disc DIRCs for PANDA and WASA



PANDA Target Spectrometer

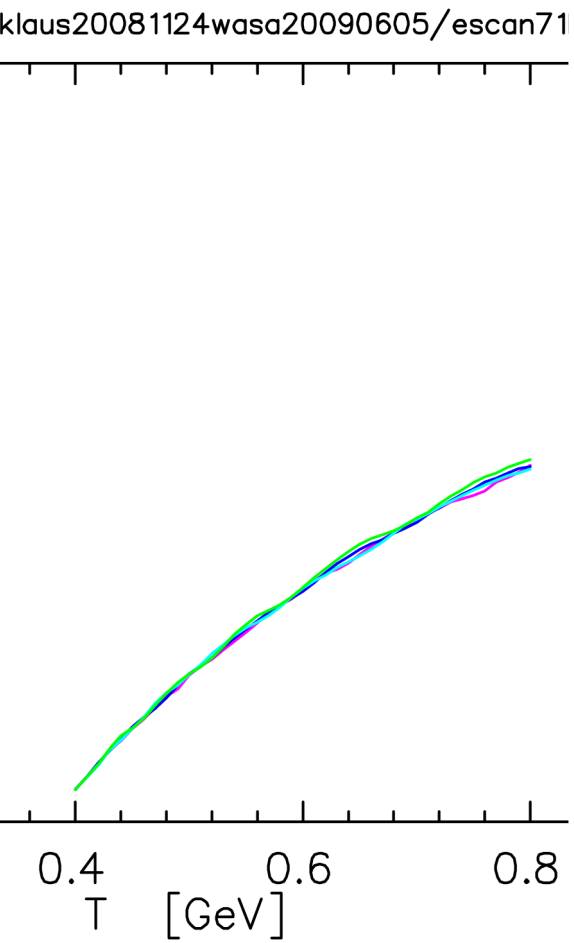


WASA experiment at COSY

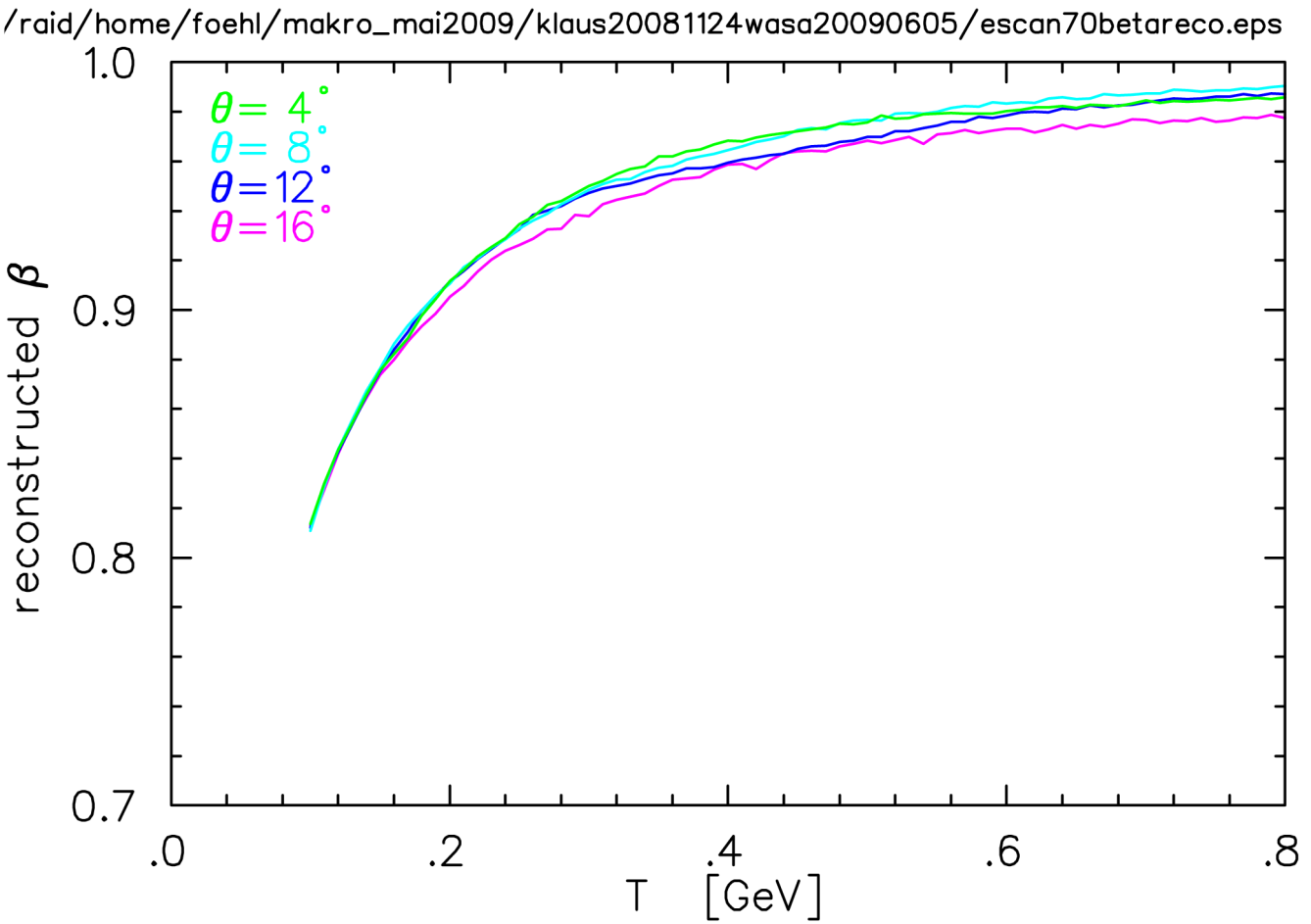


Reconstructed β values

protons, VM2000 foil

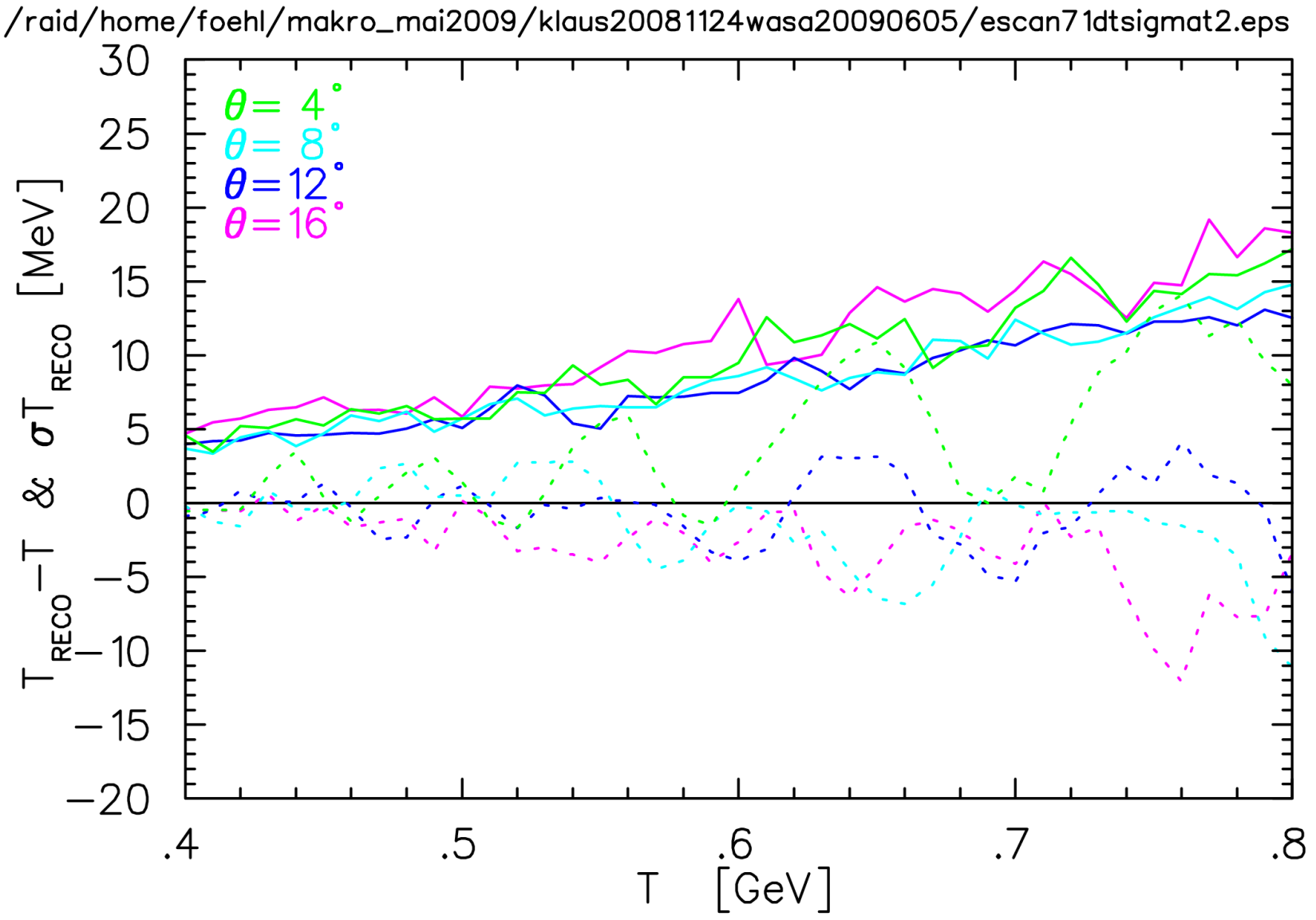


pions, VM2000 foil



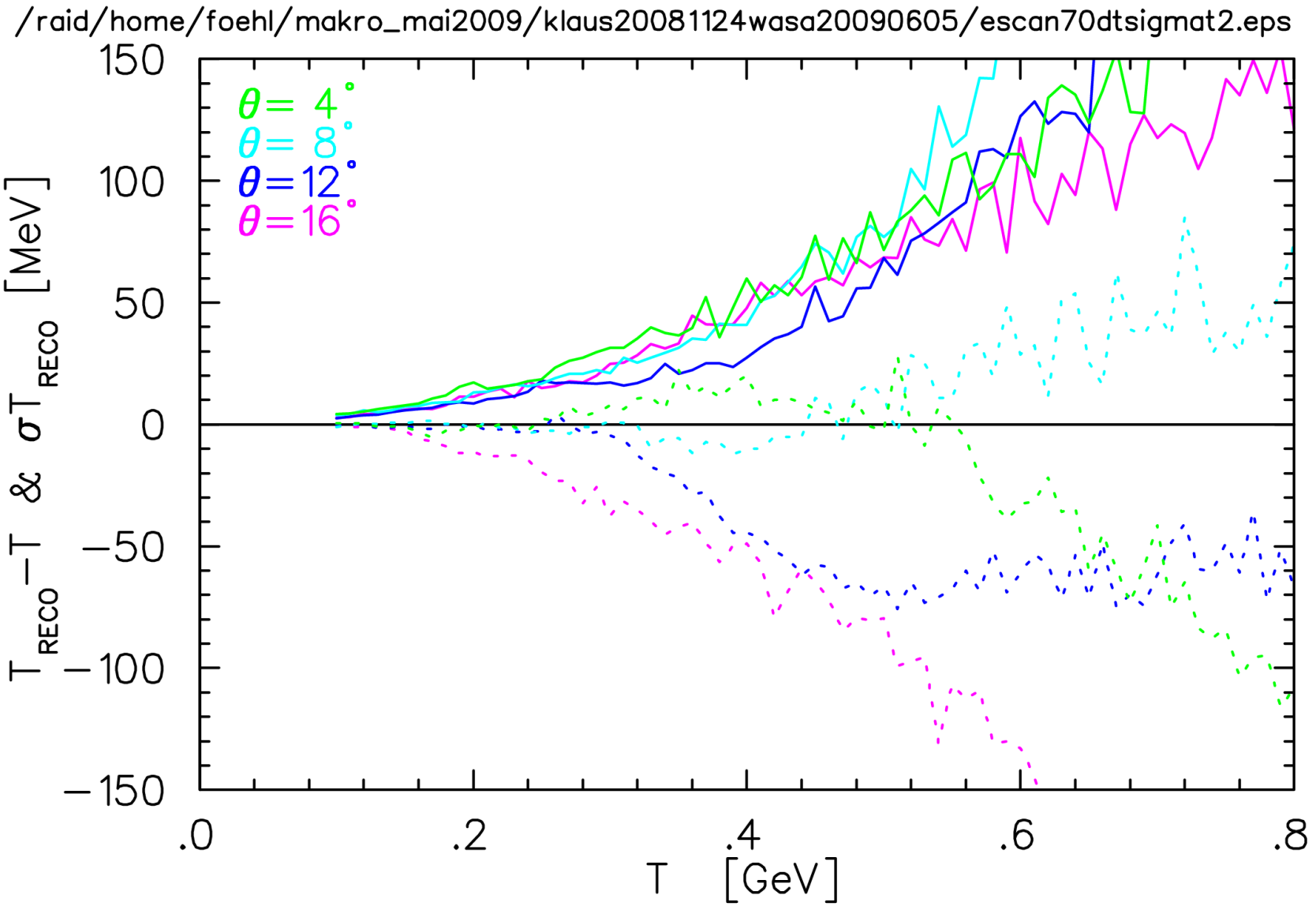
tracking resolution 0.2deg

Protons



tracking resolution 0.2deg

Pions

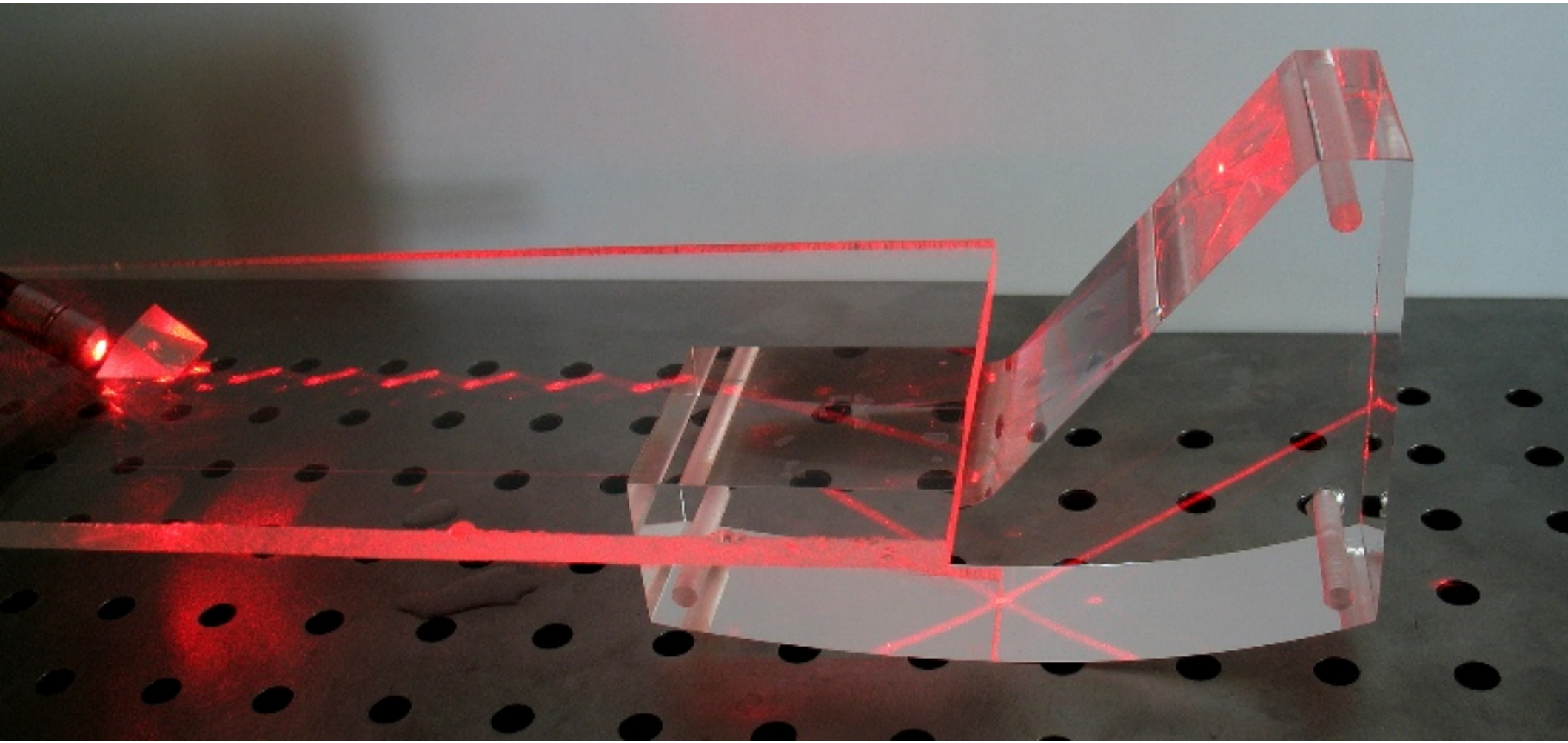


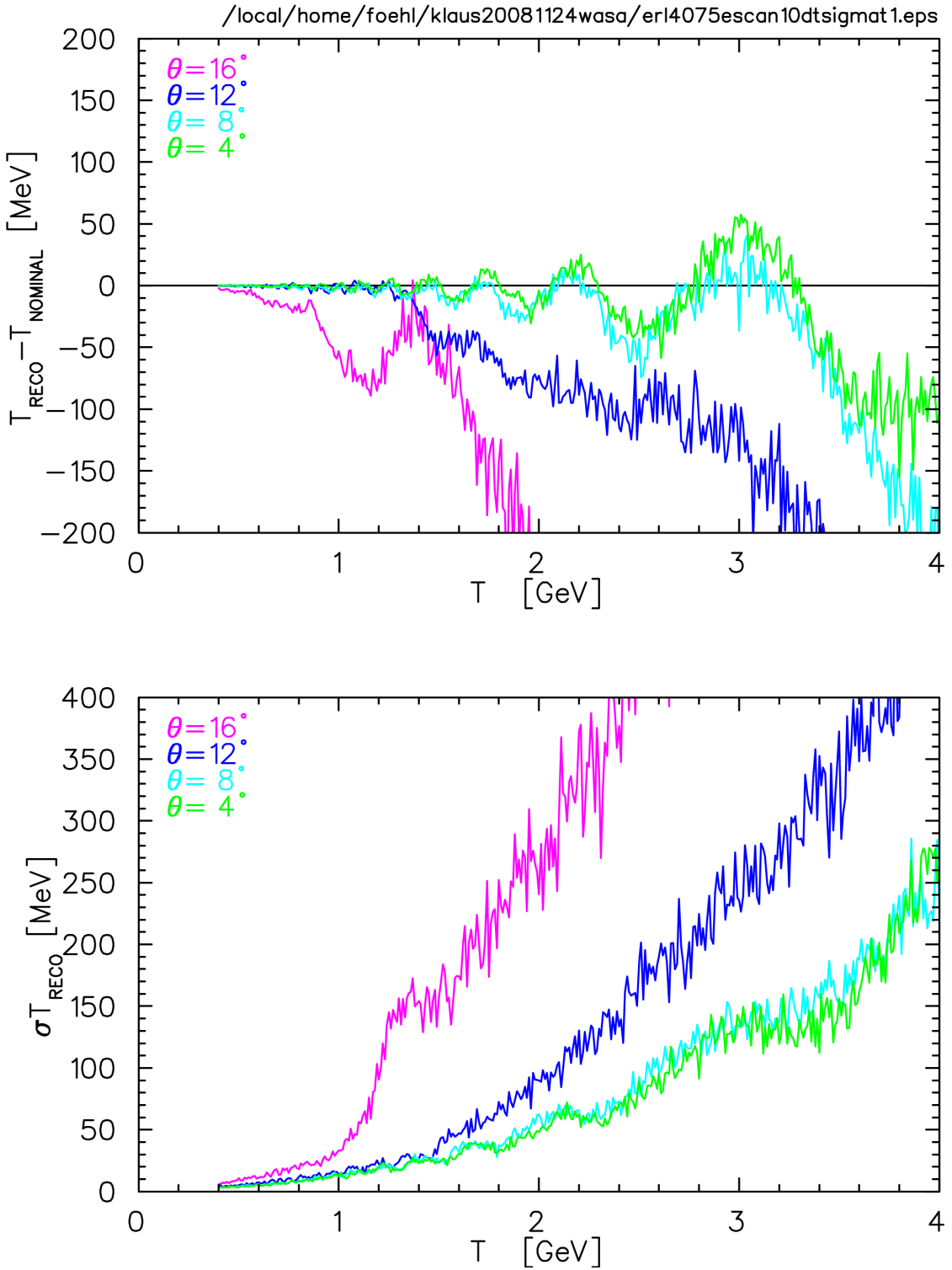
tracking resolution 0.2deg

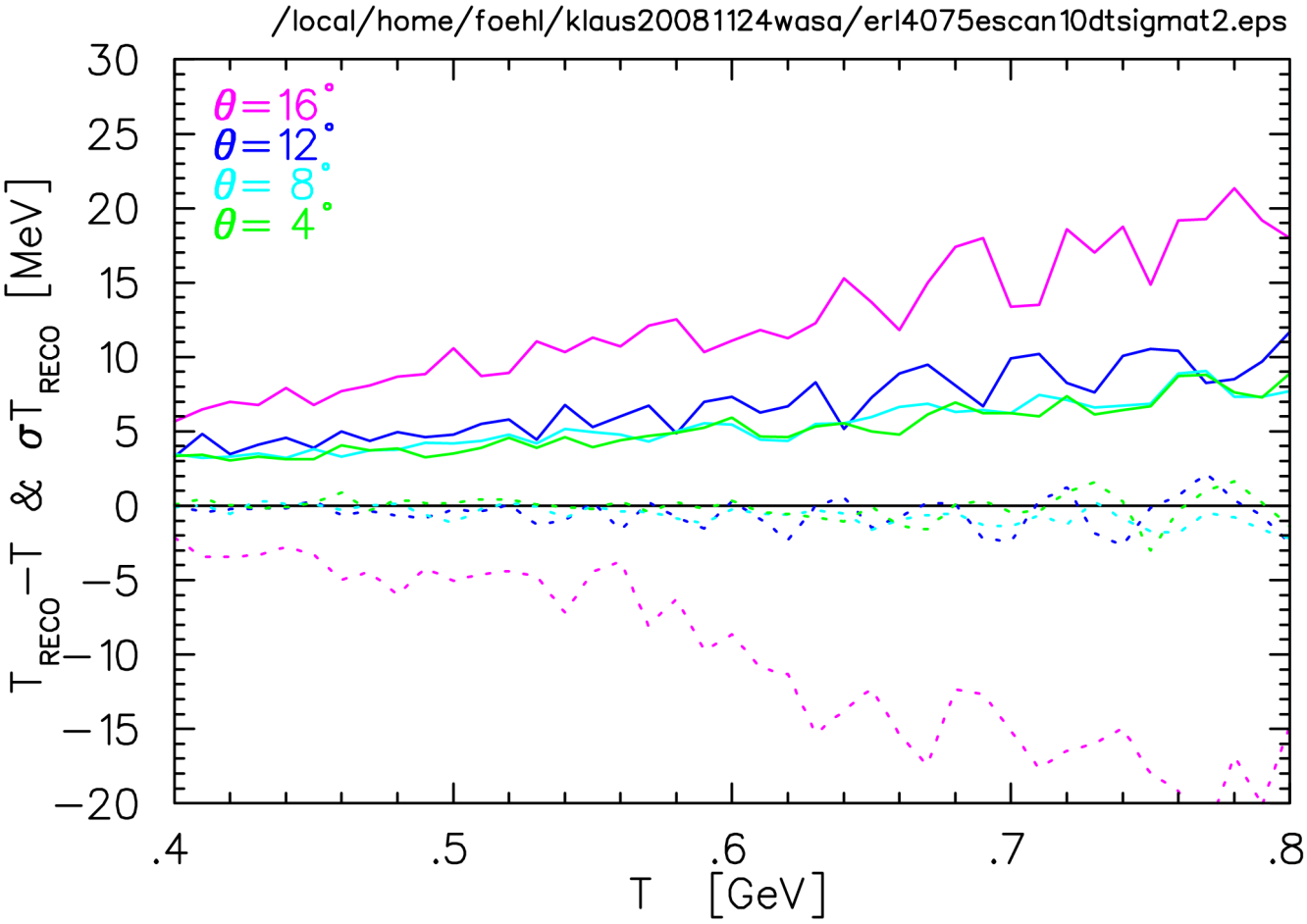
Summary

- Update since Dec 2008 CANU meeting
  - 130mm slice thickness
  - DIRC radiator with bent
  - lenses in imaging system
- NEW: aspect of reflecting foil
- pion and proton performance
  - p: T measurement ok
  - π: PID contribution - rough T available
- *lots of things need to be validated experimentally*

Thank you for your attention




/local/home/foehl/klaus20081124wasa/erl4075escan10dtsigmat1.eps
θ=16°
θ=12°
θ= 8°
θ= 4°
T_RECO−T_NOMINAL [MeV]
T [GeV]
σT_RECO [MeV]
T [GeV]


/local/home/foehl/klaus20081124wasa/erl4075escan10dtsigmat2.eps
θ=16°
θ=12°
θ= 8°
θ= 4°
T_RECO−T & σT_RECO [MeV]
T [GeV]
30
25
20
15
10
5
0
−5
−10
−15
−20
.4
.5
.6
.7
.8