FDIRC optics with Mathematica

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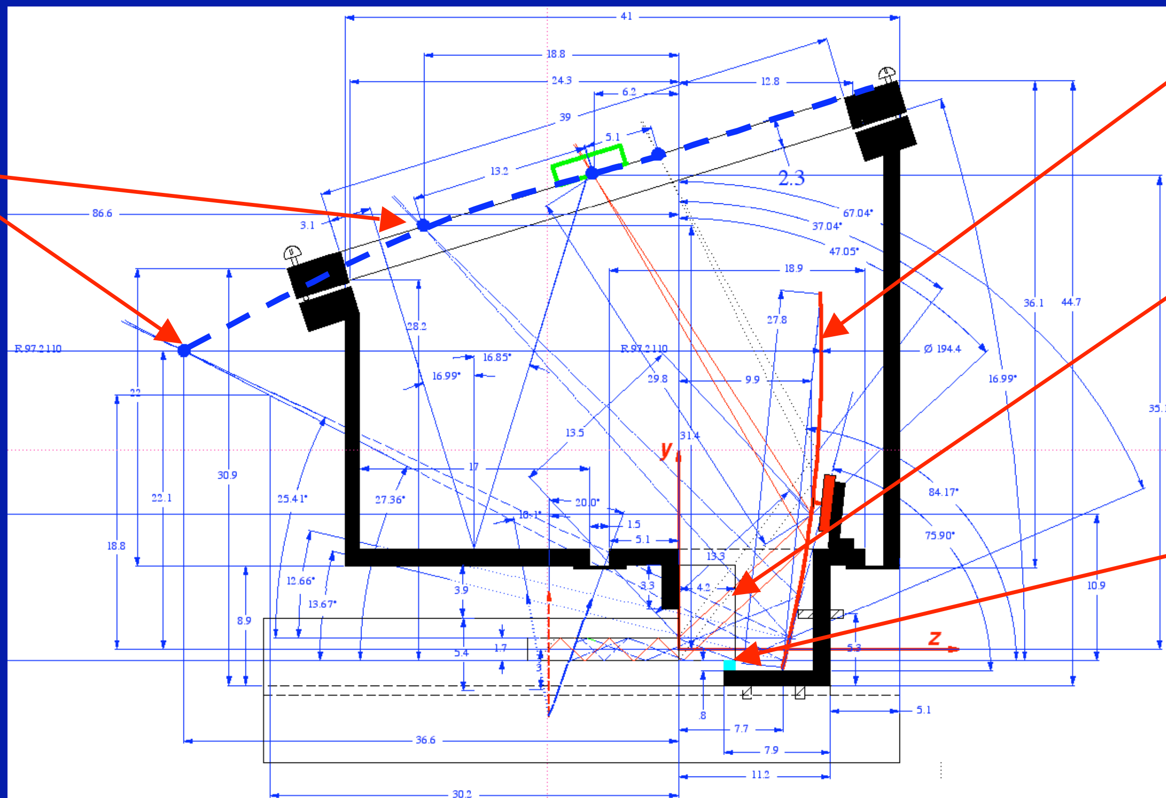
Content

- The ray-tracing simulation with the Mathematica is employing a geometry similar to the FDIRC prototype, which was originally designed with the Vellum drafting program by a manual ray-tracing.
- Ray-tracing done in Mathematica in 3D (without Optica).
- FDIRC prototype - with spherical mirror, no wedge.
- FDIRC with a wedge and cylindrical mirror.
- Non-focusing DIRC with & without a wedge.

Focusing DIRC Prototype optics

Focal plane is not flat !!



Spherical mirror

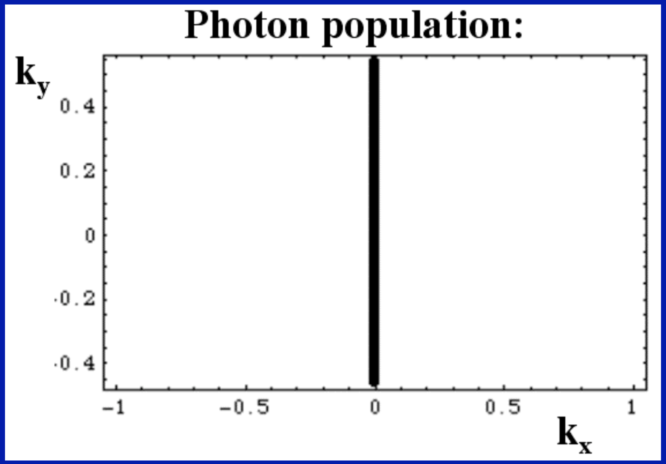
Bar ends with a quartz block which reflects a downward aiming image up

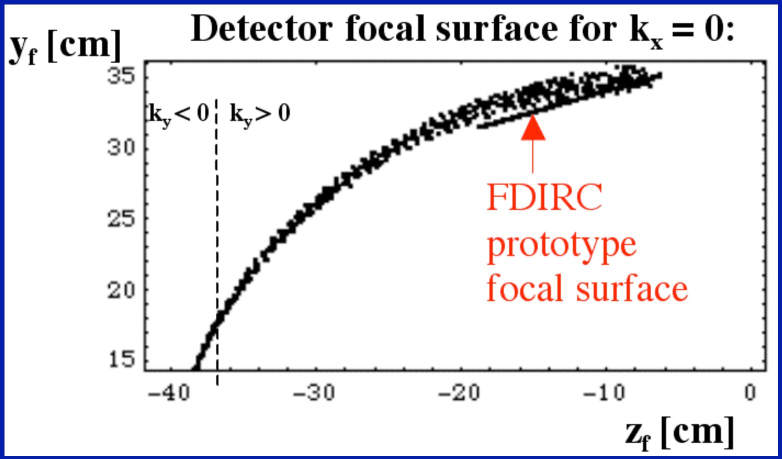
This blue support block is mirrorized on one side

- FDIRC prototype designed with a Vellum drafting program by ray-tracing.
- Keep similar dimension in the following simulation with the Mathematica.
- To find a true focal plane, throw a pair of two photons for each dip angle and find their intersect in 2D.
- Focal plane chosen so that 6mmx6mm pixels yield the same resolution as BaBar DIRC

What is a detector surface with a spherical mirror & no wedge ?

zbarstart = - barl; zbarend = 0;
Theta = (60 + Random[]*2*30 - 40)/(180/Pi); Phi = 90/(180/Pi);
Thetac = 47.3/(180/Pi); Phic = 180/(180/Pi); Vary Phic
xm0 = 0; ym0 = 23.0; zm0 = -86.6; r = 2*(48.6); **Choose r as one has in the FDIRC prototype Vellum study**
a11 = 1; a22 = 1; a33 = 1; a12 = 0; a13 = 0; a23 = 0.0; a14 = - xm0; a24 = -ym0; a34 = - zm0; a44 = xm0*xm0 + ym0*ym0 + zm0*zm0 - r*r;





- In the region, where the FDIRC prototype works (z ~ -6 cm), the calculated focal plane is close to a straight line. So a flat window solution for the FDIRC prototype was OK.

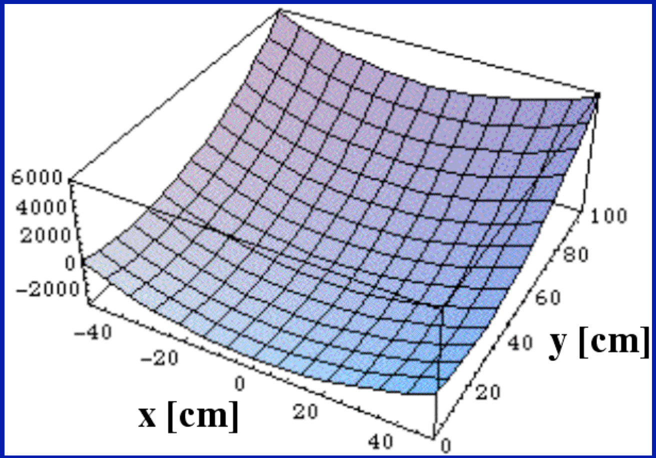
FDIRC prototype: no wedge, spherical mirror, flat detector plane, $\theta_{dip} = 90^o$

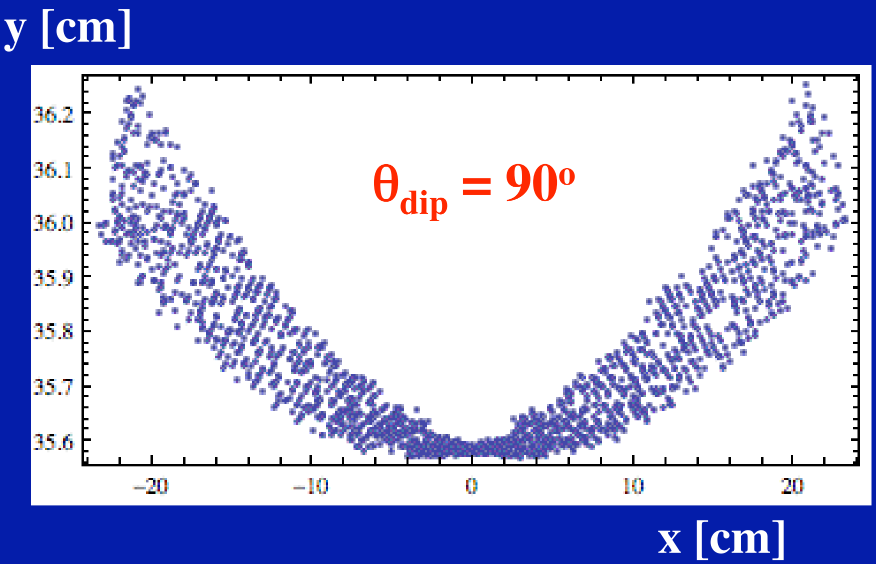
Mirror equation: $(x - xm_0)^2 + (y - ym_0)^2 + (z - zm_0)^2 - r^2 = 0$

$a_{11} x^2 + a_{22} y^2 + a_{33} z^2 + 2a_{12} x y + 2a_{13} x z + 2a_{23} y z + 2a_{14} x + 2a_{24} y + 2a_{34} z + a_{44} = 0$

xm0 = 0; ym0 = 23.0; zm0 = -86.6; r = 2*(49.5); ← CRID mirror parameters

a11 = 1; a22 = 1; a33 = 1; a12 = 0; a13 = 0; a23 = 0.0; a14 = - xm0; a24 = - ym0; a34 = - zm0; a44 = xm0*xm0 + ym0*ym0 + zm0*zm0 - r*r;

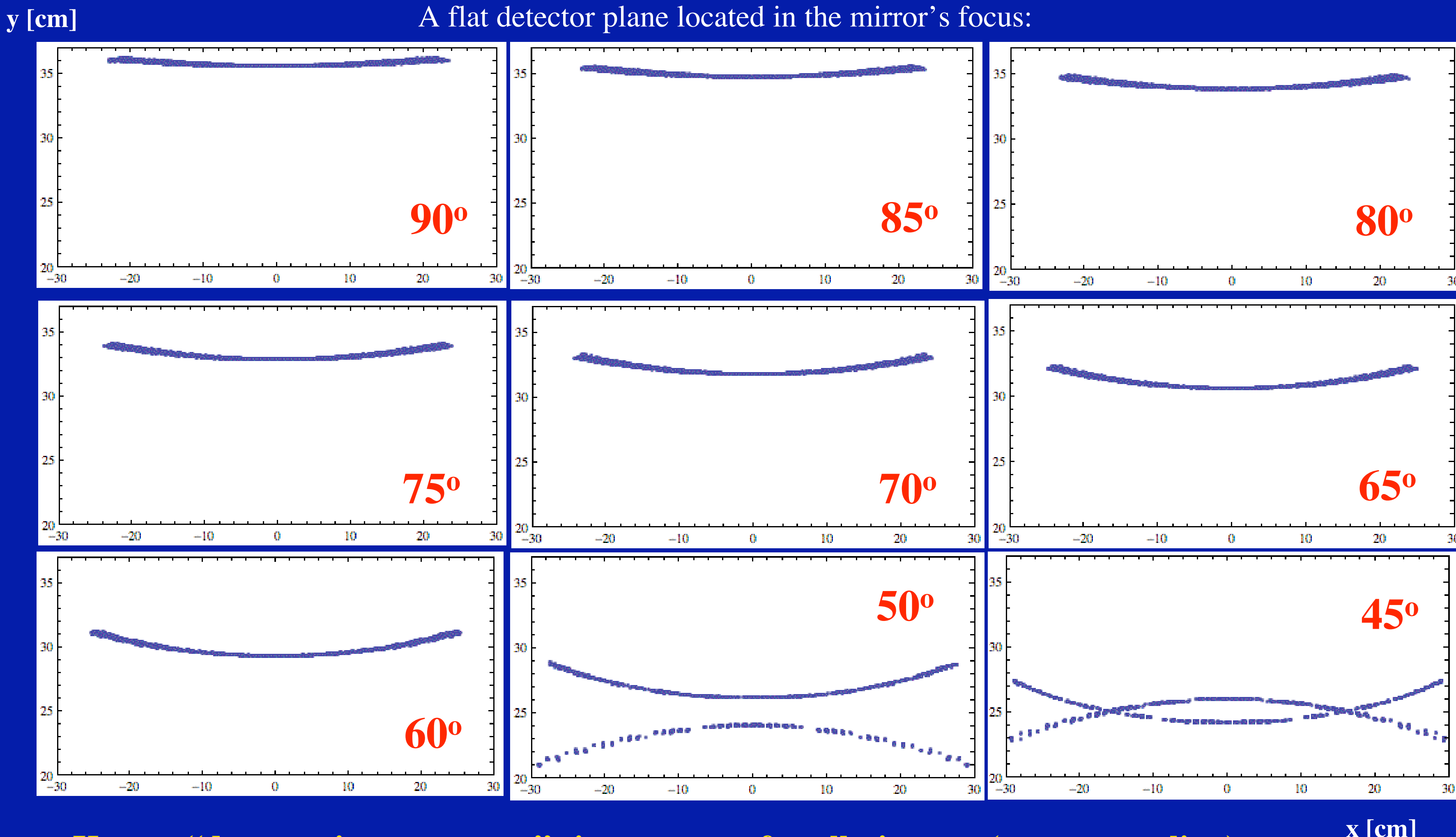




- Detector plane in the bar coordinate system
- Because of the quartz rectangular block at the end of bar, we have only one Cherenkov image for this dip angle.
- Kaleidoscopic wiggles in image come from the bar rectangular structure.

FDIRC prototype: no wedge, spherical mirror, flat detector plane, vary θ_{dip}

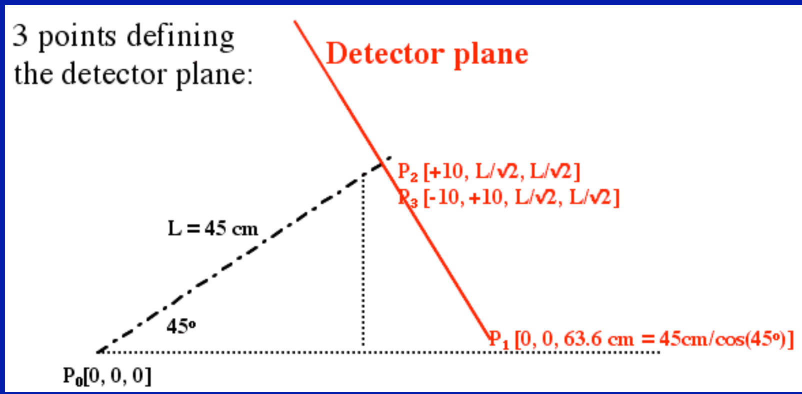
A flat detector plane located in the mirror's focus:



- **Keep a "detector image canvas" size constant for all pictures (no auto-scaling)**

Non-focusing DIRC: no wedge, no mirror, flat detector plane

A flat detector plane:



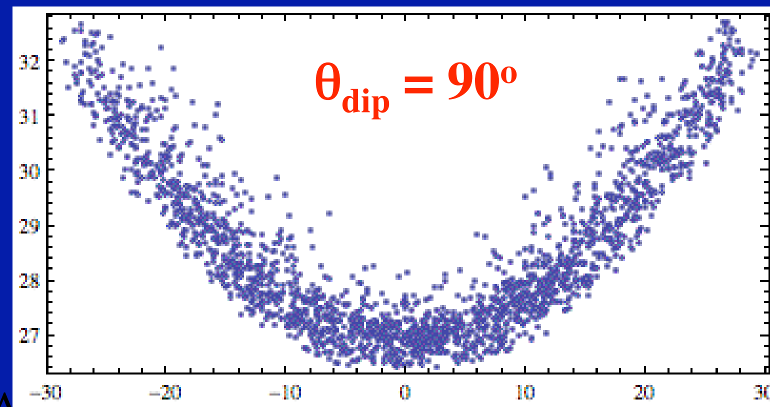


Image without a mirror:

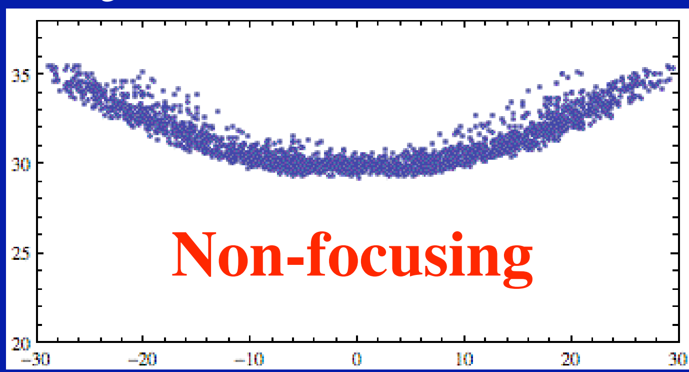
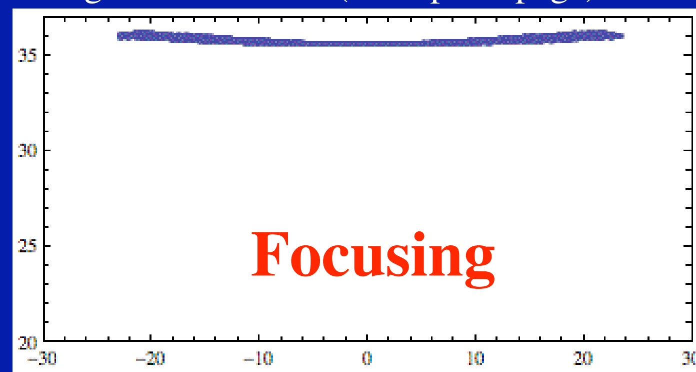
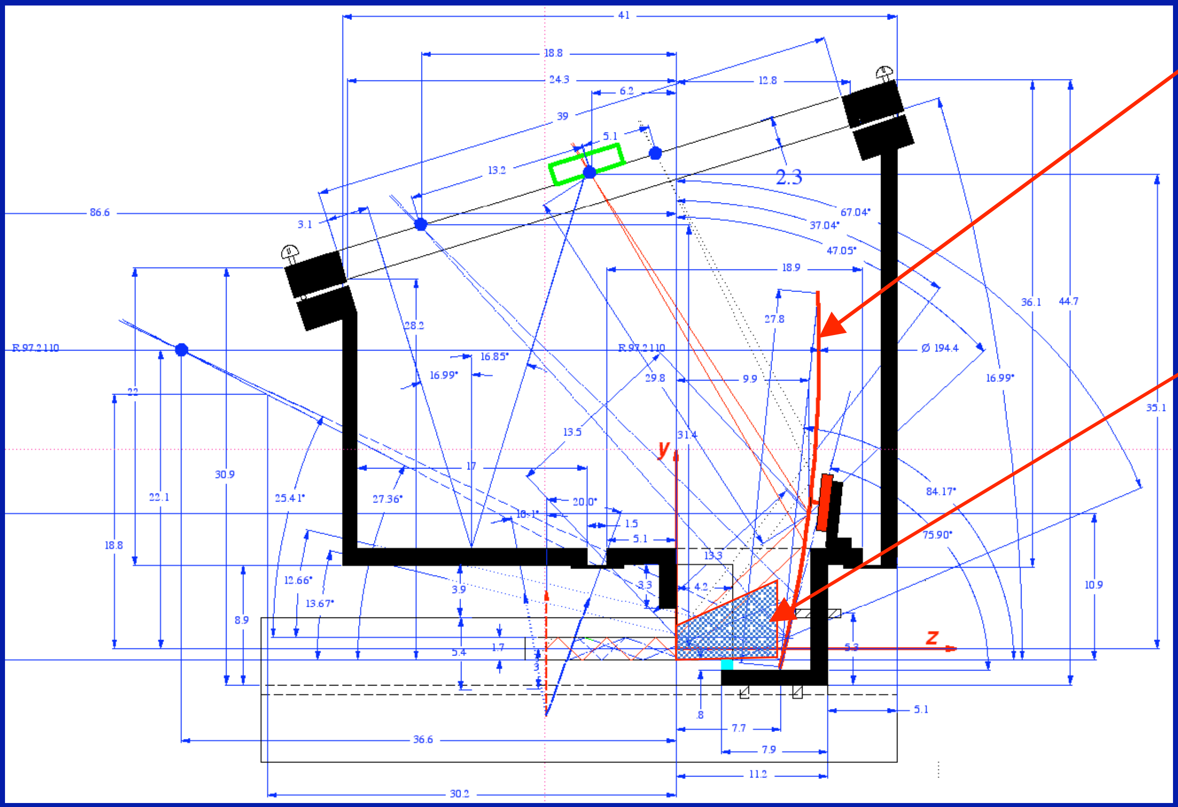


Image with a mirror (from prev. page):



- Focal plane chosen so that 6mmx6mm pixels yield the same resolution as BaBar DIRC
- Image is wider without a mirror.

Add the wedge into FDIRC prototype simulation

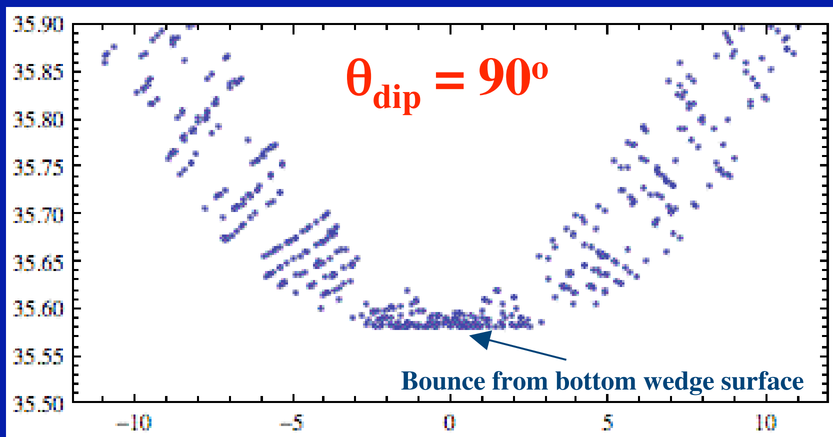


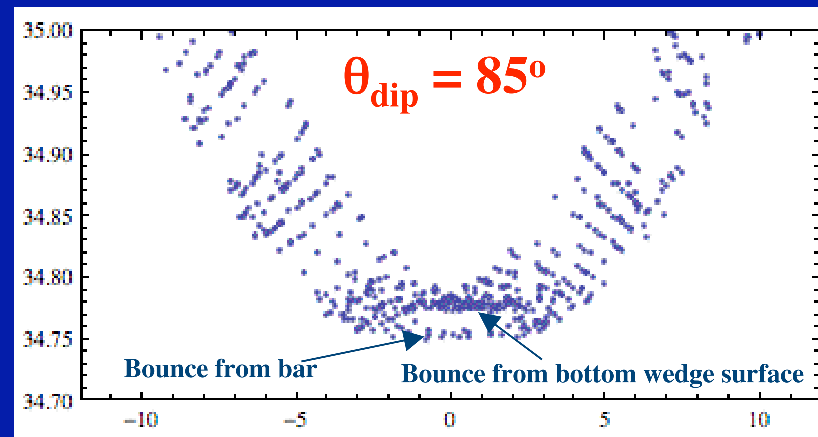
- Add the wedge, while keeping other dimensions the same => getting crowded. Intended only for this particular study.
- The reason for adding the wedge: the real DIRC bar boxes have them presently.

FDIRC: with wedge, cylindrical mirror, flat detector plane, $\theta_{dip} = 90$ & 85^o

A flat detector plane located in the mirror's focus:

y [cm]

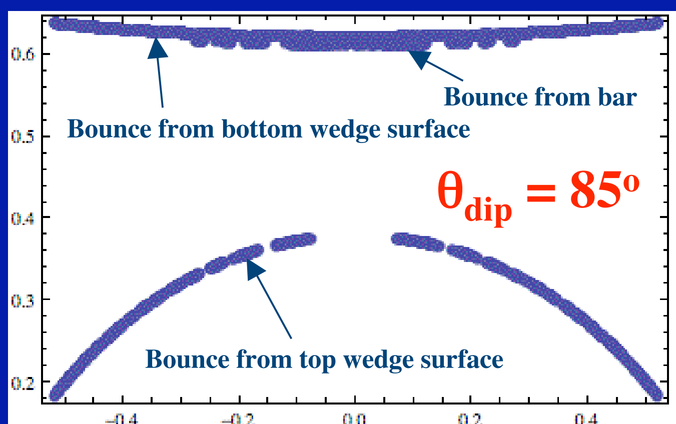




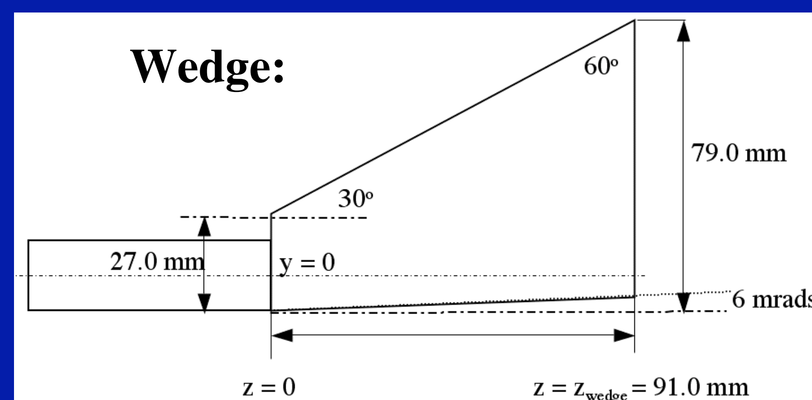
x [cm]

x [cm]

k_y

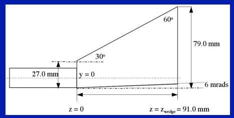


k_x

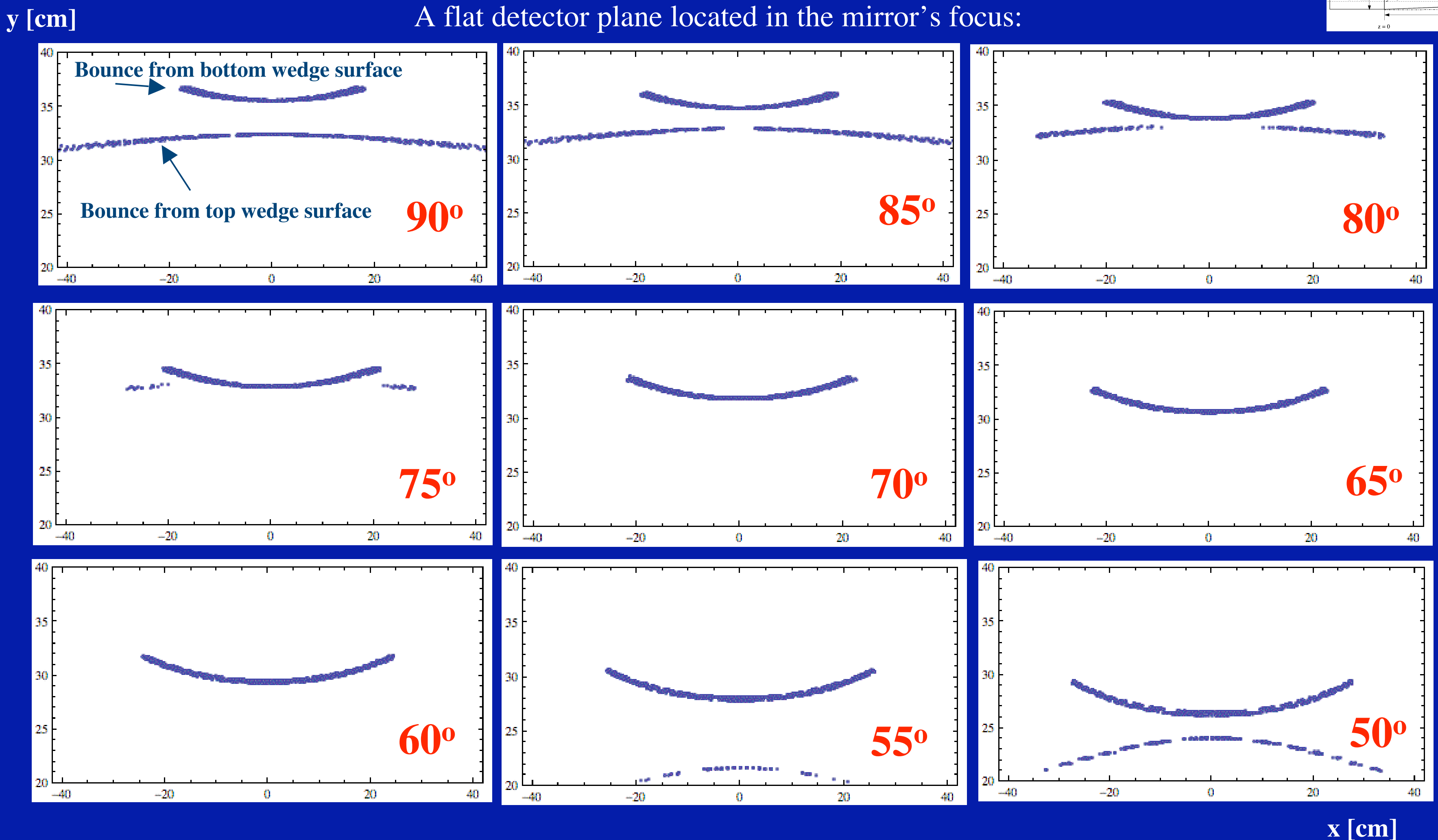


FDIRC: with wedge, cylindrical mirror, flat detector plane, vary θ_{dip}

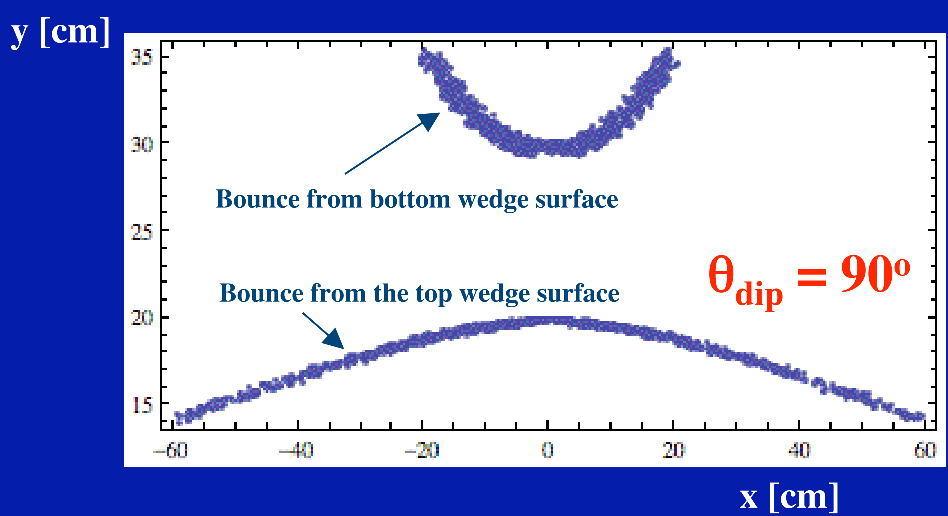
Wedge:

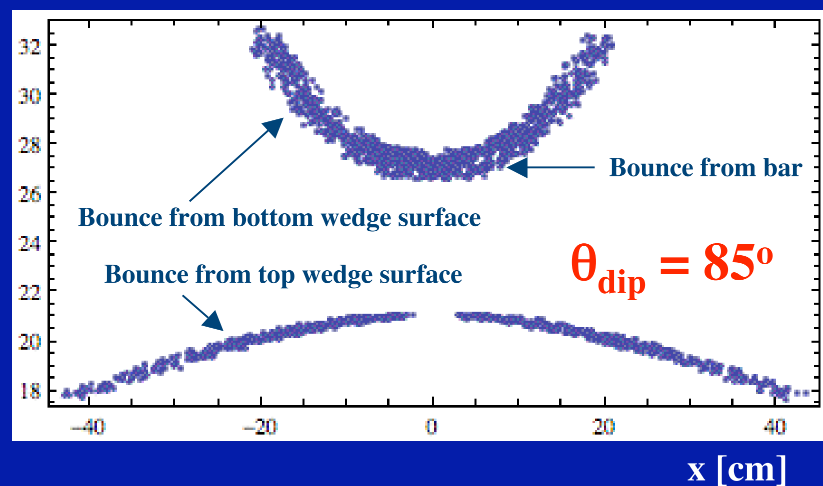


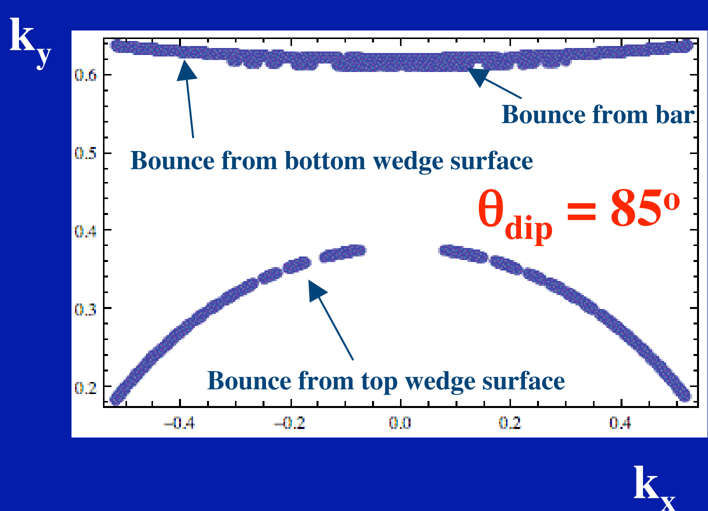
A flat detector plane located in the mirror's focus:

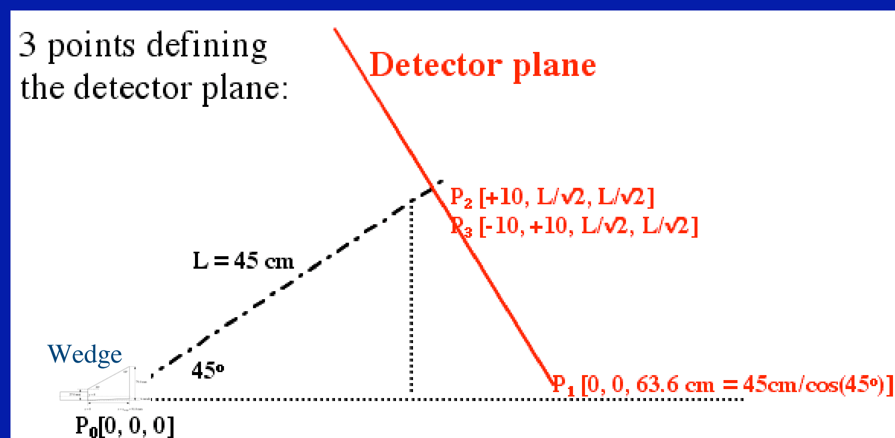


Non-focusing DIRC: with wedge, no mirror, flat detector plane, $\theta_{dip} = 90$ & 85^o



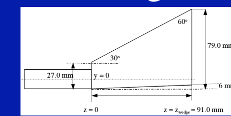




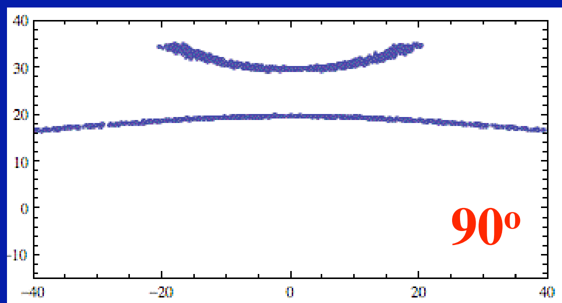


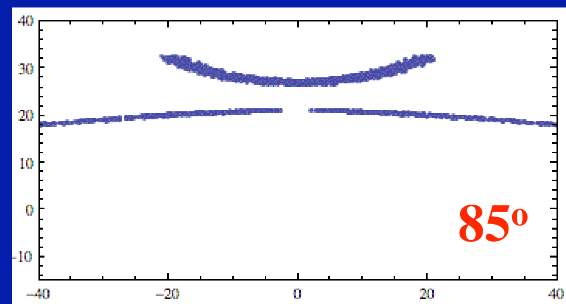
Non-focusing DIRC: with wedge, no mirror, flat detector plane, vary θ_{dip}

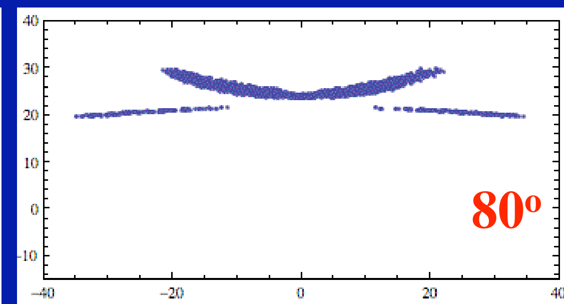
Wedge:

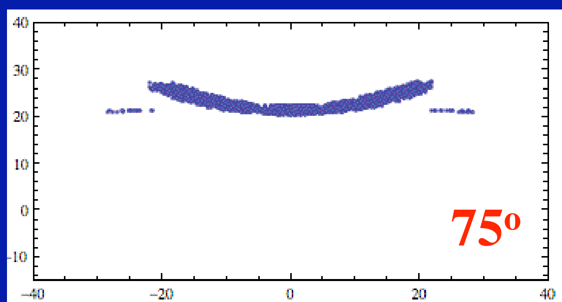


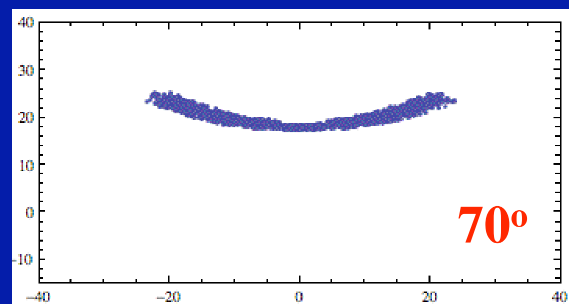
y [cm]

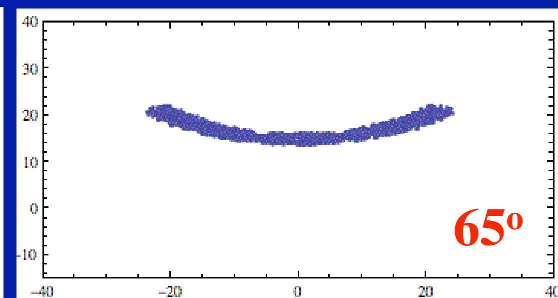


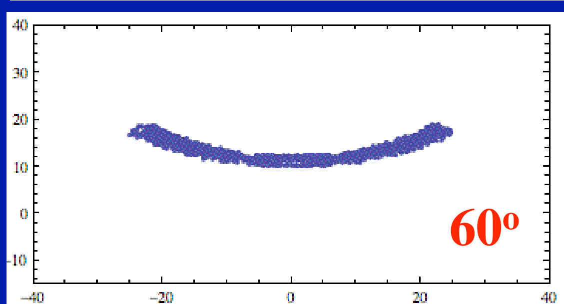


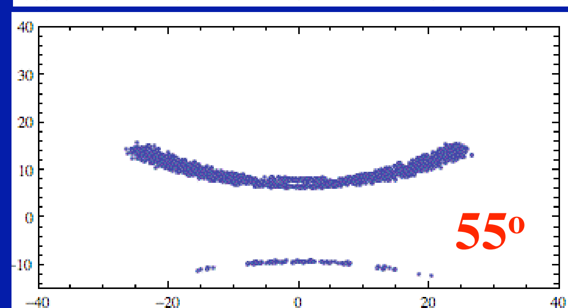












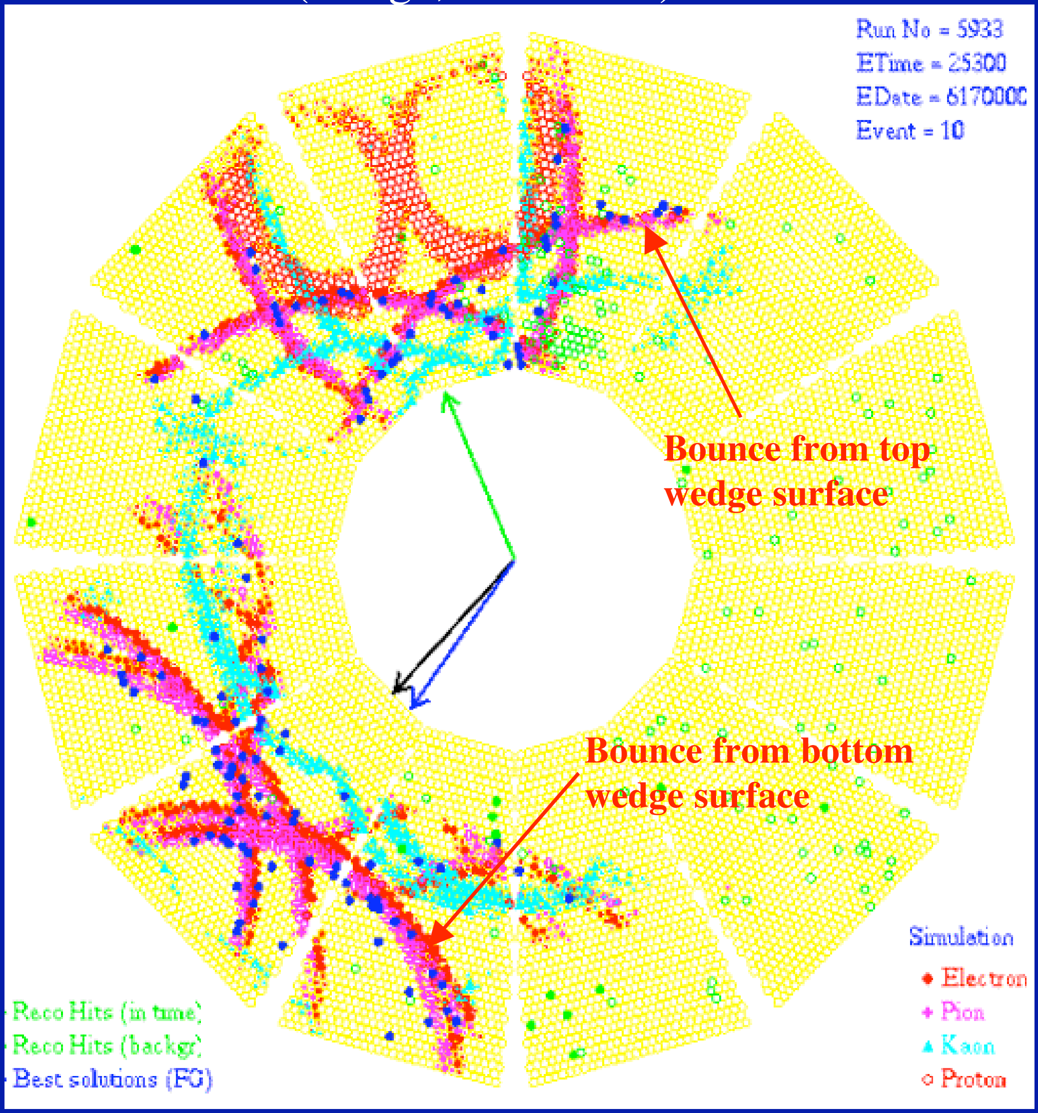
x [cm]

- Non-focusing DIRC with no mirror has a wider image, and a larger overall detector canvas size (~ 2x)

=> <u>need more pixels to cover the area</u>

Images in BaBar DIRC

(wedge, no mirrors)



Conclusion

- We have developed a useful tool to study the optics.
- Cylindrical mirror requires a non-flat detector focal plane in principle,although a flat detector plane may be good enough approximation. One needs to quantify this.
- Non-focusing DIRC requires ~2x larger pixel area to cover compared to the FDIRC with a cylindrical mirror.
- The wedge does not seem to be too big obstacle even for the FDIRC.