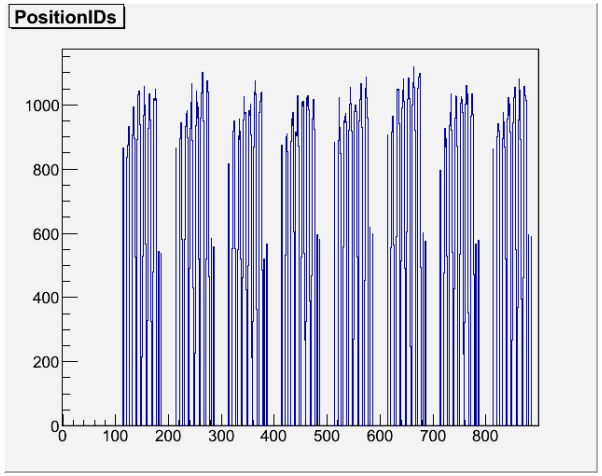
Update on KTAG Alignment studies

Bozydar Wrona

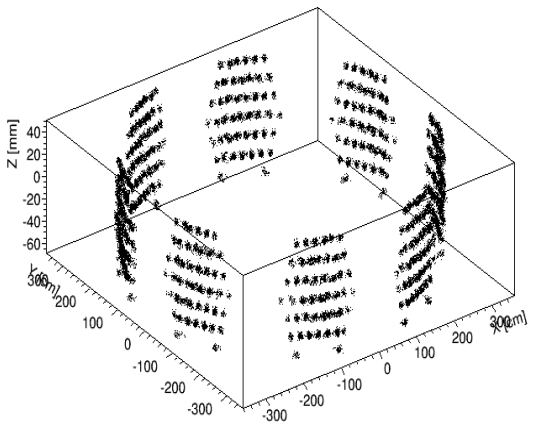
3/9/24

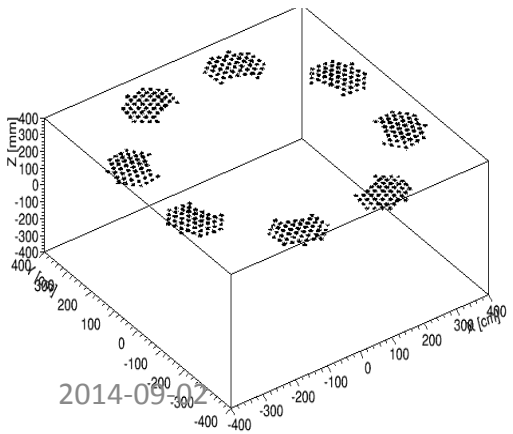
UNIVERSITY OF LIVERPOOL

CEDAR vessel misalignment: geometrical fit approach



- Agreed input (with B'ham): reconstructed (photoelectons) per PMT (position ID),
- Conversion from ID to (XYZ) of the PMT centres (taken from MC)
- Rotation of the octants to XY plane to exploit circular symmetry of the detector
- Best circle fit performed, minimising (weighted) sum of squares of the distances between PMT centres and the corresponding nearest point on the fitted circle, to extract (X', Y') position of the circle centre
- Repeated in each of 1600 (simulated) misaligned bins i.e. for shifts of CEDAR vessel in range of (-4,4)mm in (XY), step 0.2mm
- done for 4 proposed diaphragm openings : 1mm, 1.5mm, 2mm, 2,5mm i.e 6400 fits





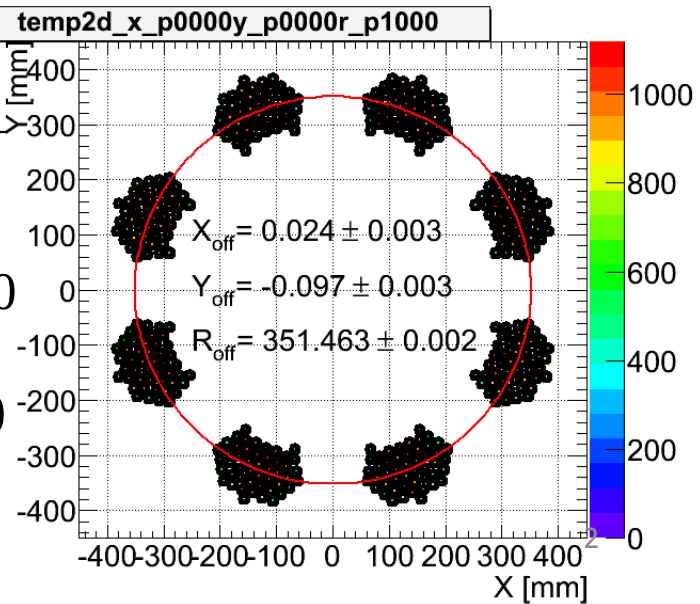
x,y- PMT centre coords

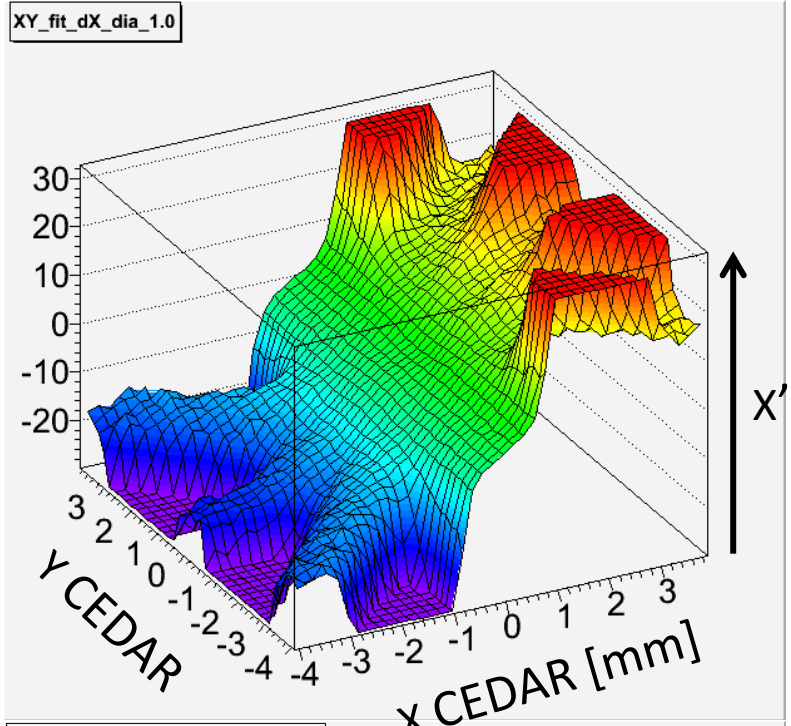
a,b-best circle centre coords

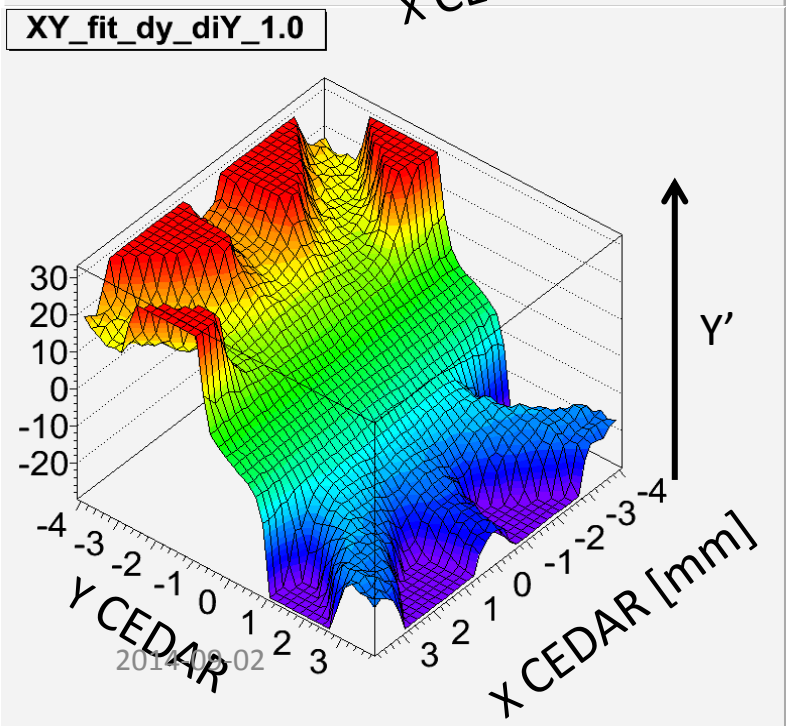
$$dR = R - \sqrt{(x-a)^2 + (y-b)^2}$$

$$f = \sum_{i=1}^{384} weight \cdot dR^2 \rightarrow \partial f = 0$$

done in TMinuit (MIGRAD)







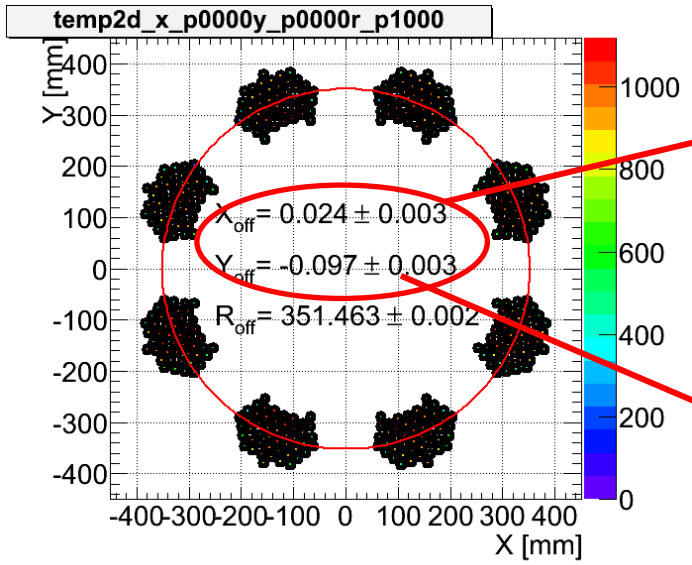
MC Template

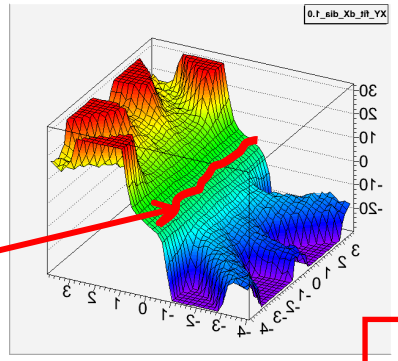
- Fit results summarized in maps (MC templates) i.e. relation between (X,Y) position of the CEDAR vessel with (X', Y') shift in centre position of fitted circle
- Extracted for both pure Kaon and Kaon + Pion samples
- To be used for the alignment procedure

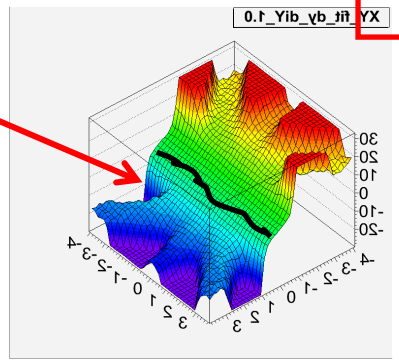
CEDAR Alignment Procedure

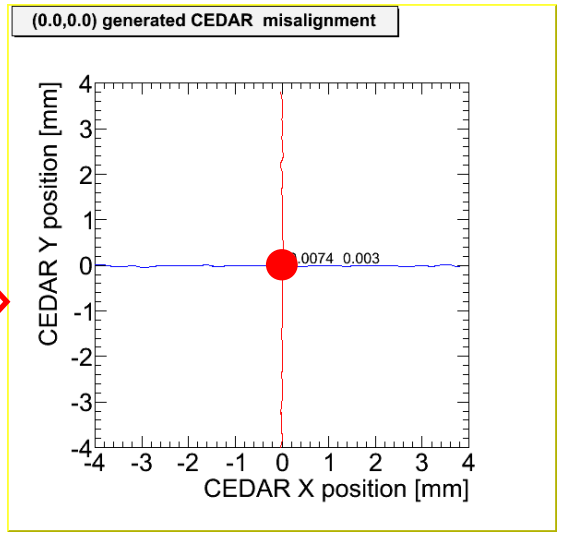
- Best Circle Fit performed on the block of data (e.g. burst) to obtain (X',Y') with errors
- $X' \pm \Delta X'$
- $Y' \pm \Delta Y'$

  defines (up/down) boundaries for the contours on the MC templates
- Intersection between contours mark the CEDAR vessel actual position
- Straight forward e.g.





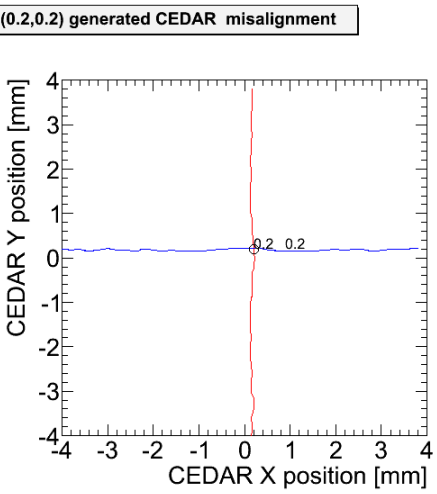




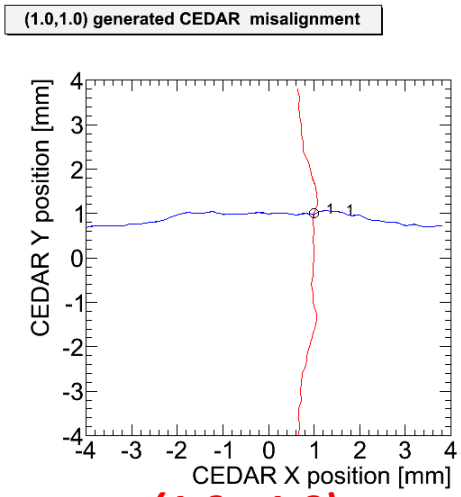
- Contour's intersection plot visible to shifter

Shifter panel examples for pure Kaon

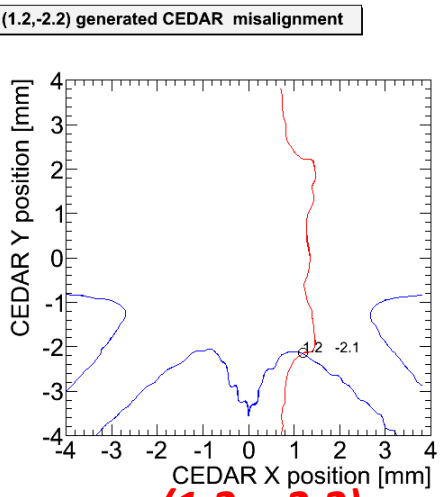
- For pure Kaon sample fit performs well, up to large values of misalignment i.e no degenerate solutions



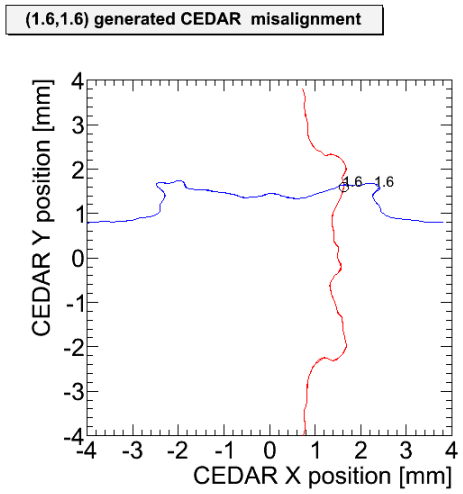
(0.2 , 0.2) mm



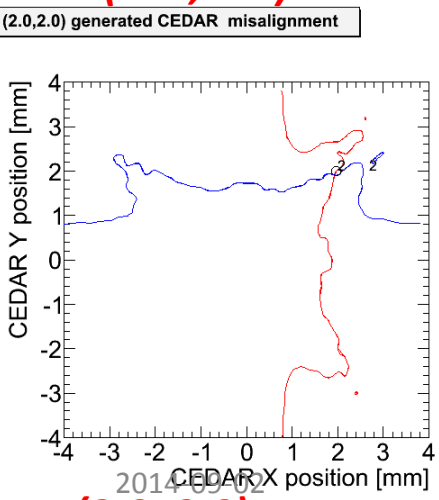
(1.0. ,1.0) mm



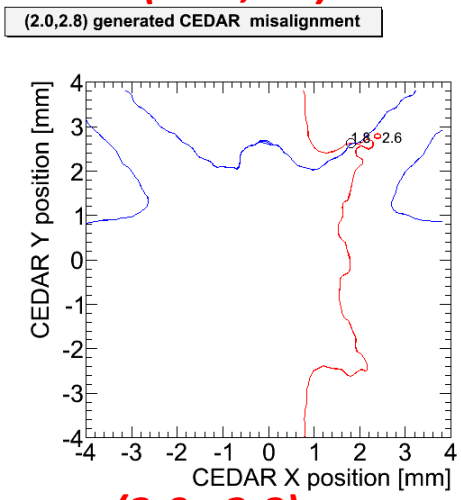
(1.2 , -2.2) mm



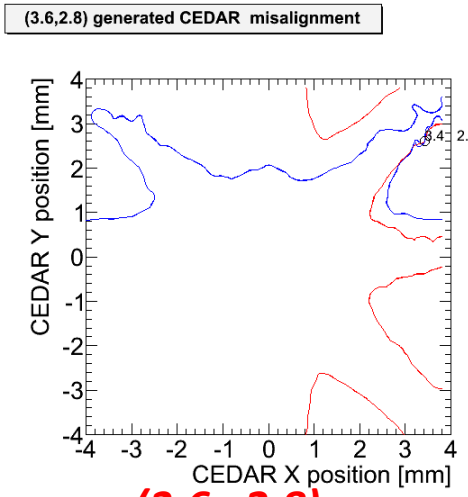
(1.6 , 1.6) mm



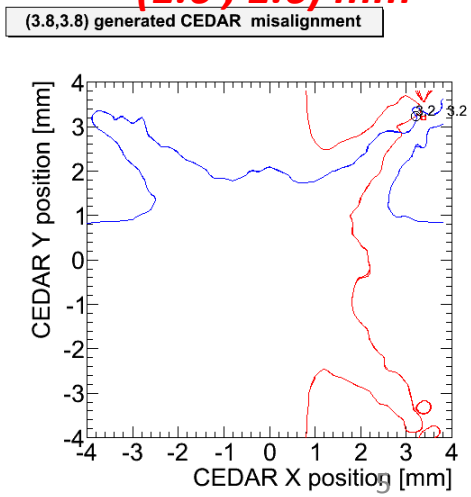
(2.0, 2.0) mm



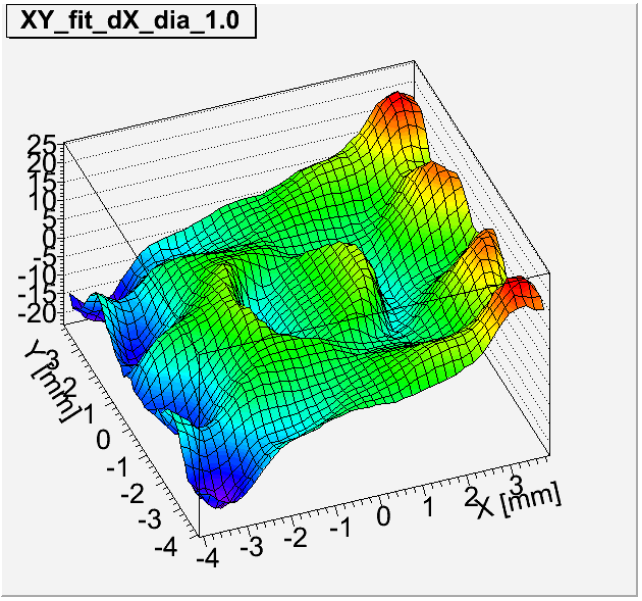
(2.0 , 2.8) mm



(3.6 , 2.8) mm

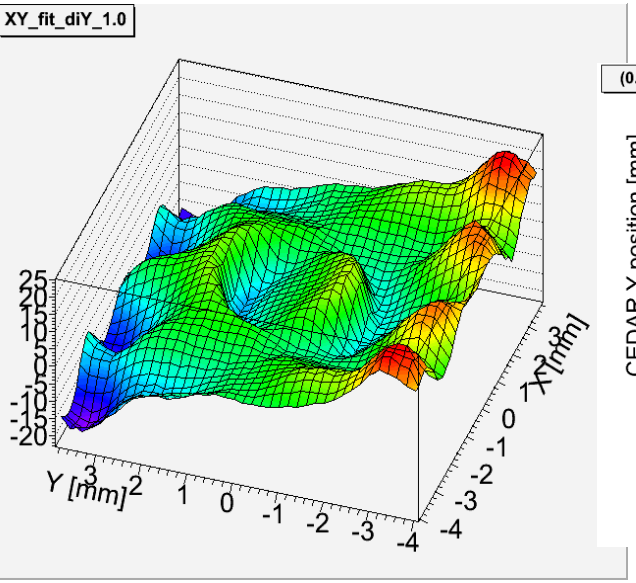


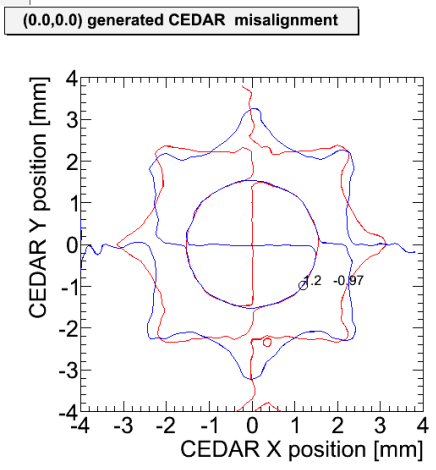
(1.0 , 1.0) mm



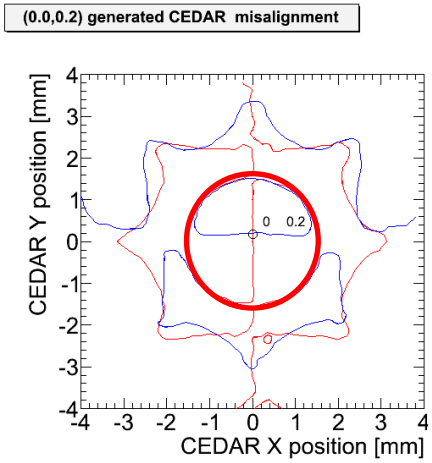
More examples
Kaon + pion

- Kaon and pion beam mixture forces complex topology of the MC template i.e. degeneracy
- Usable within 1 mm radius from the CEDAR central position
- Monitoring of CEDAR drift during run

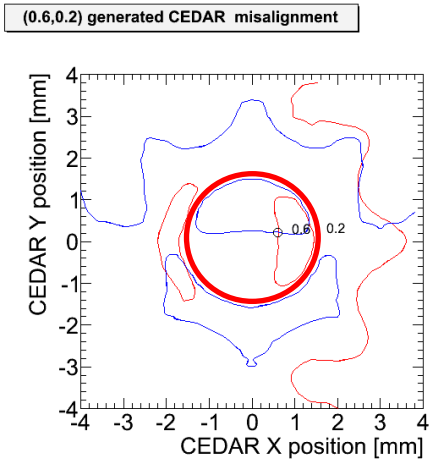




(0.0 , 0.0) mm



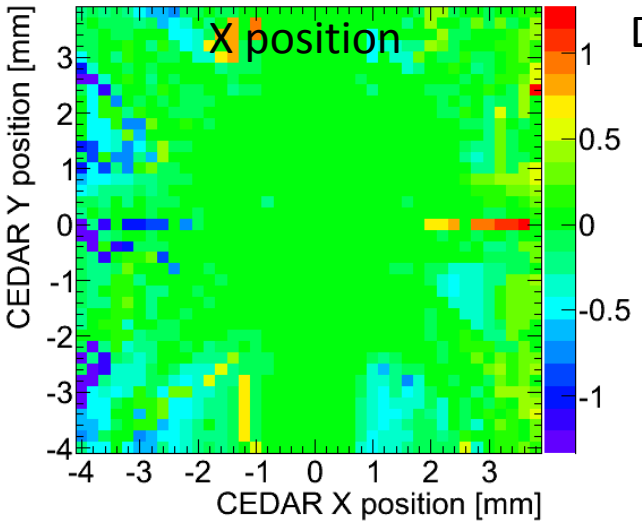
(0.0. ,0.2) mm



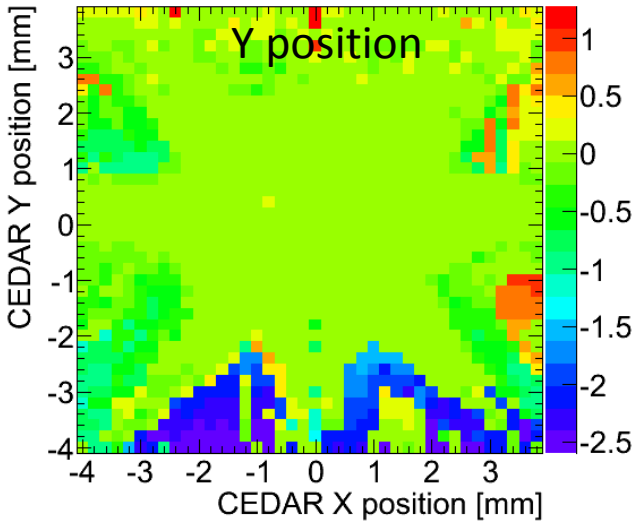
(0.6 , 0.2) mm

How Stable the method is?

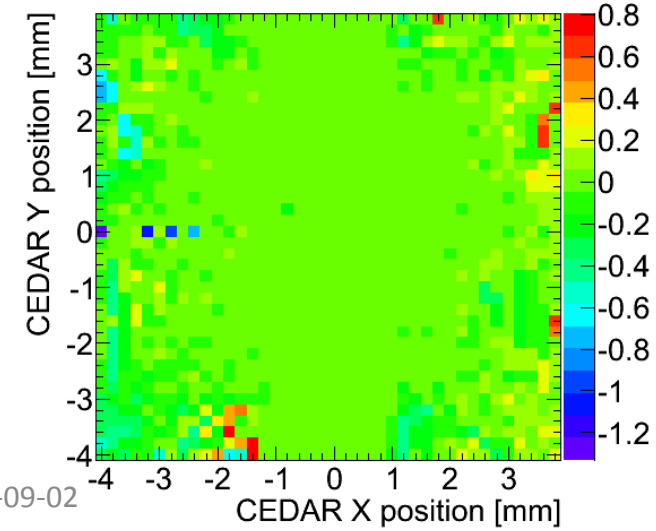
- Stability, difference in [mm] between CEDAR position derived from the fit , contours intersection on template MC, and the “true” position of the CEDAR (i.e. bin centre) at which the fit was generated



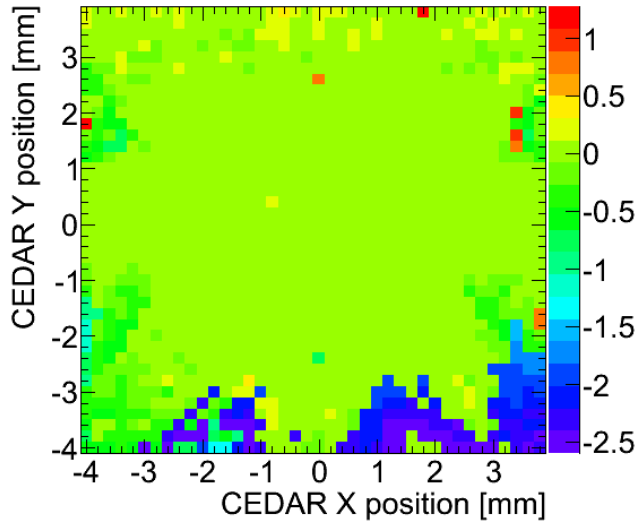
Dia. 1.0mm



- Plots for pure Kaon sample at 2 diaphragm openings (stability for Kaon+pion in Backup)

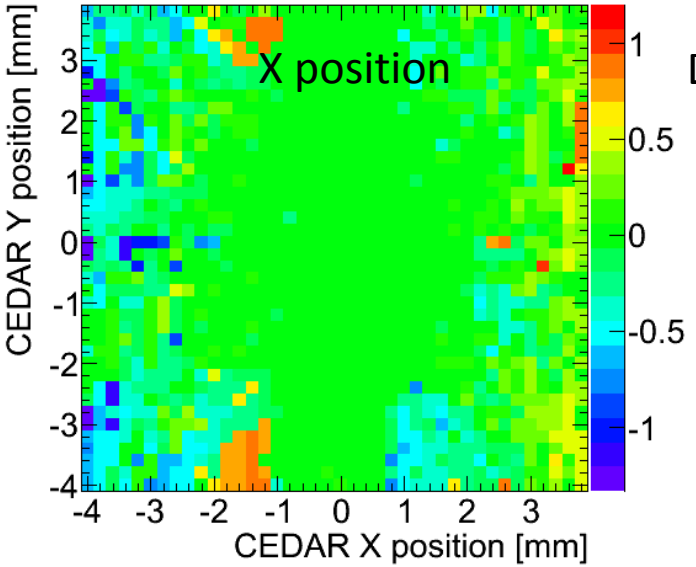


Dia. 1.5mm

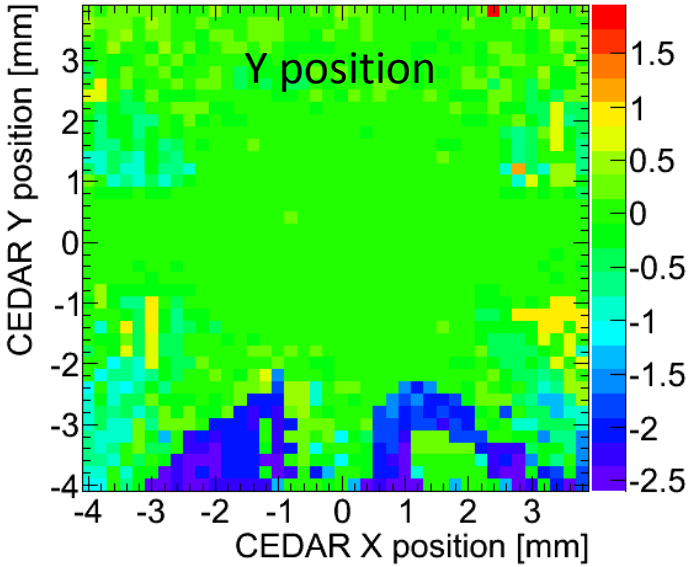


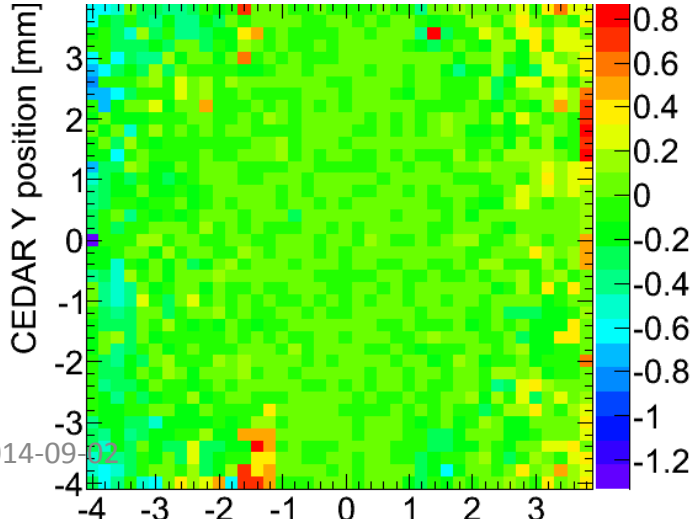
Systematic effects on Resolution

- Plethora of factors to consider, but assuming geometry correct, QW transmittance etc. PMT QE fluctuation impact on the method accuracy is of interest
- Individual PMT efficiencies smeared according to Gaussian with 15% sigma, concluded from the spread of the PMTs blue indices (shown for Kaons only)

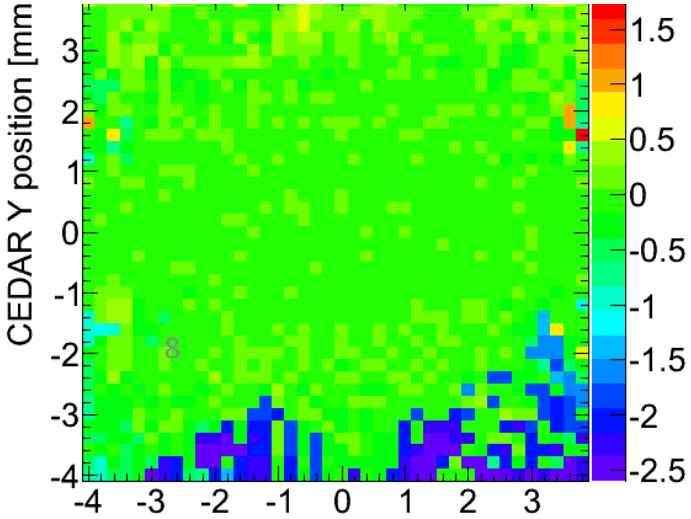


Dia. 1.0mm





Dia. 1.5mm



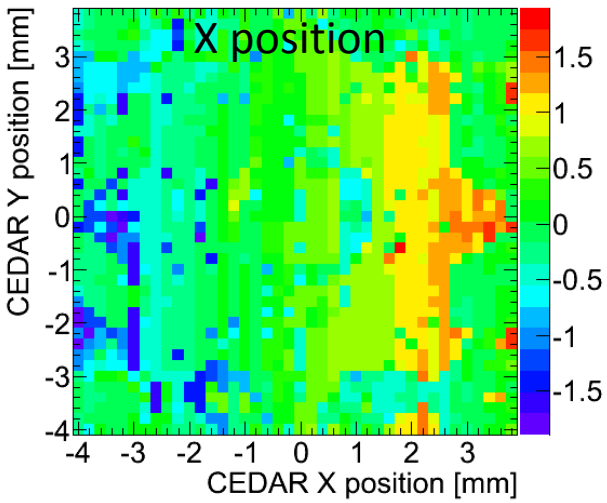
Conclusion

- Choose simplicity and align with protons , far from Kaons/Pions interference
- To be tested but in principle mimics pure Kaons, robust
- Pressure setting prerequisite for any studies, so lets start from 1.91 bar instead of 1.71 bar 
- Add balancing of the PMT array in case of a channel failure
- Solution for the monitoring of the CEDAR drift during the run, since clearly within 1mm
- Integration within Online Monitor Framework

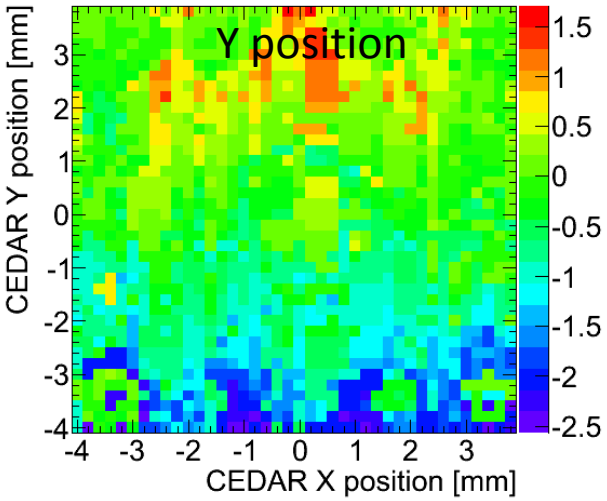
(to be discussed)

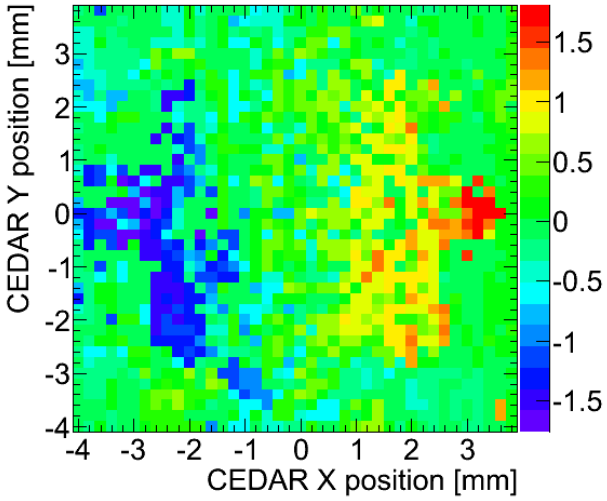
BACKUP

Stability Kaon + Pion

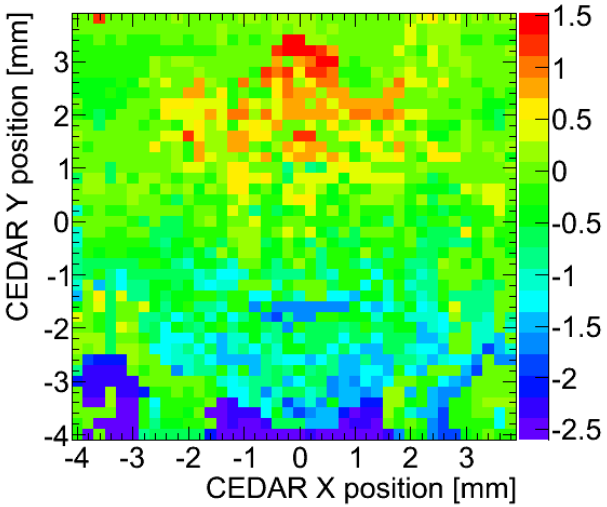


Dia 1.0mm

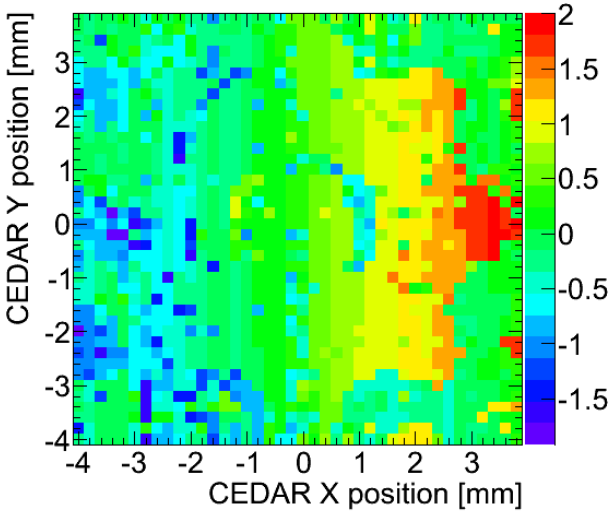




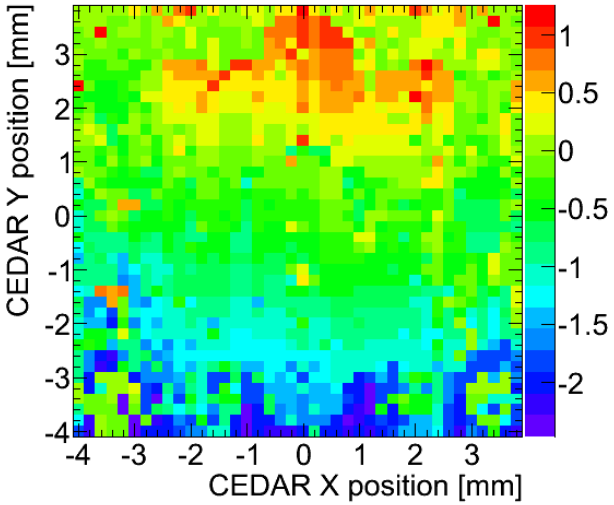
Dia 1.5 mm

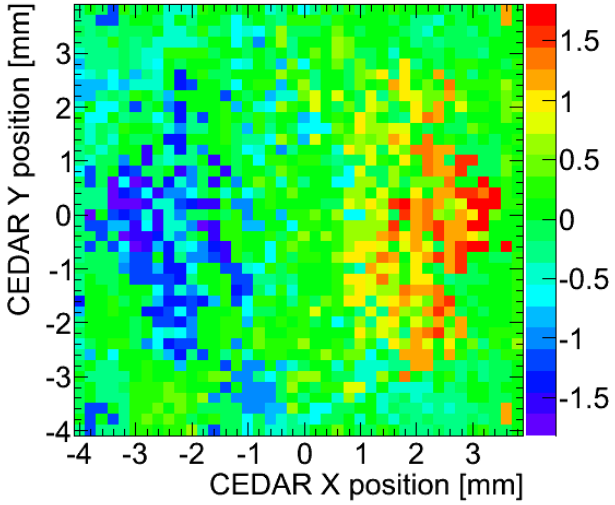


Resolution Kaon + Pion

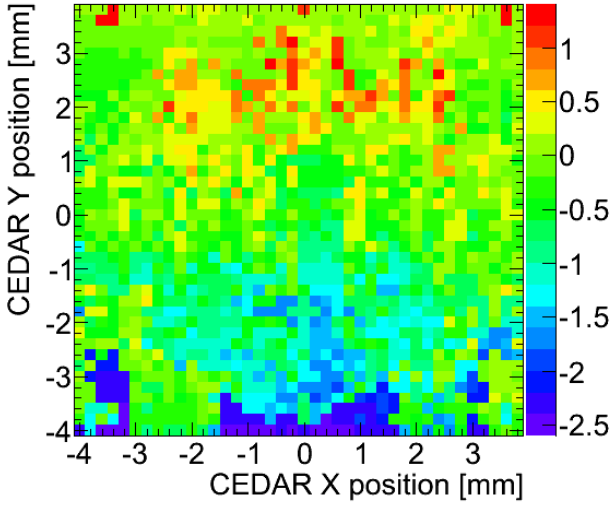


Dia 1.0mm

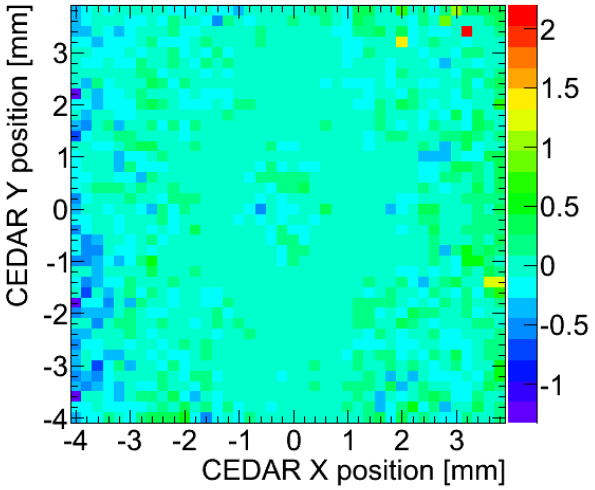




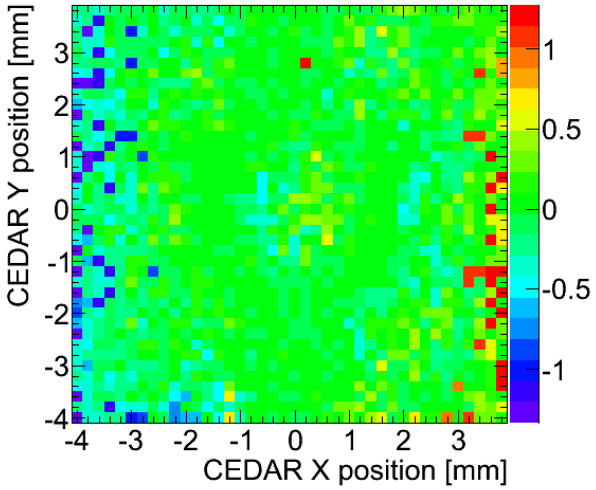
Dia 1.5 mm

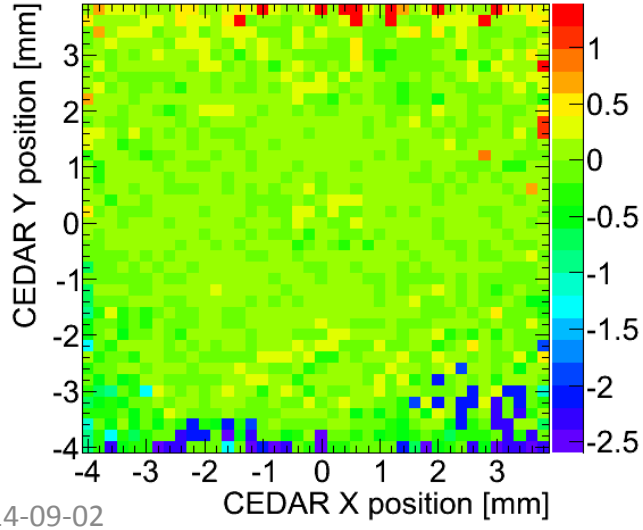


Resolution after QE for larger diaphragm openings (pure Kaon)



Dia 2.0mm





Dia 2.5 mm