

Analysing FLASH data at PITZ - tomography

Data structure

Image treatment

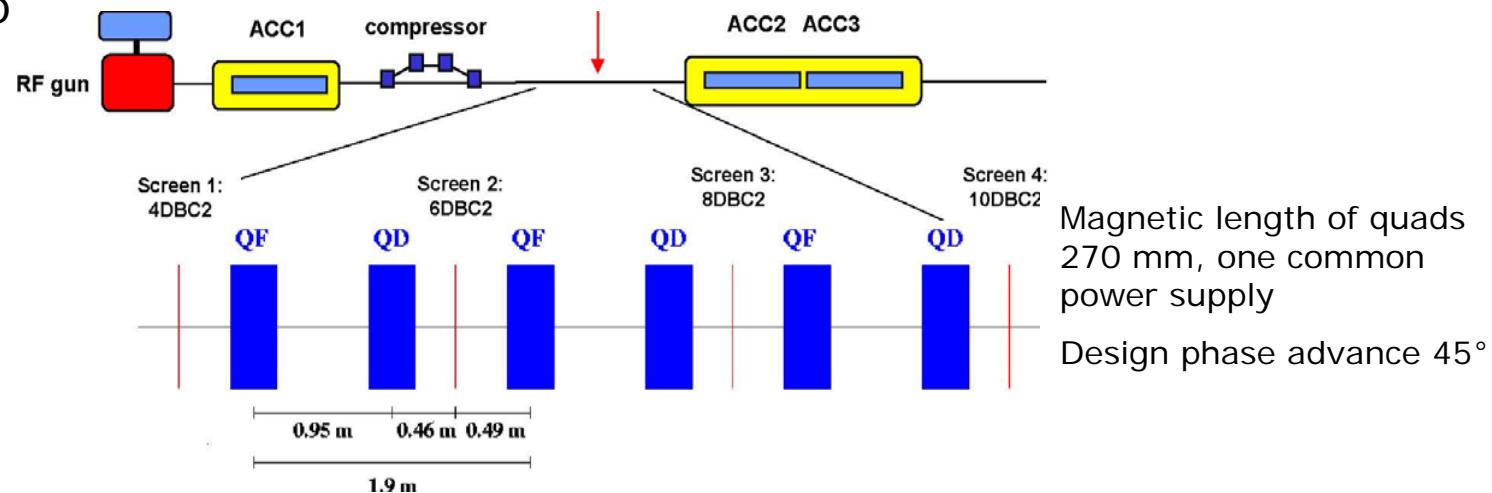
Reconstruction

Summary

G. Asova

Data provided

- Setup



- Images on 4 screens

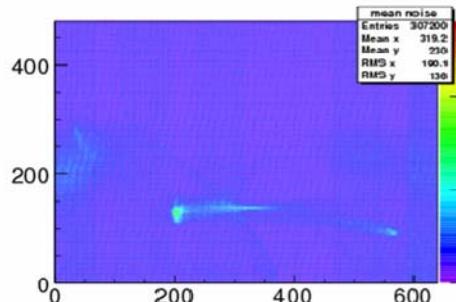
- Each frame is a tiff file
- 10 frames noise taken @ first
- 10 frames (signal + noise) " signal

- Transfer matrices from screen #1 to each following screen for both transverse planes
- Calibration factors for Ox & Oy for each screen
- Beam momentum of 127.62 MeV/c

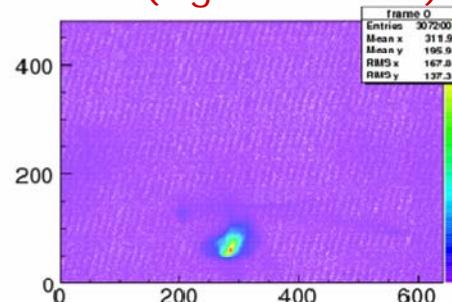
Image treatment

- Mean and rms of a pixel over the **noise** frames
- Each **(signal+noise)** frame treated separately:
 - mean noise subtracted from each frame

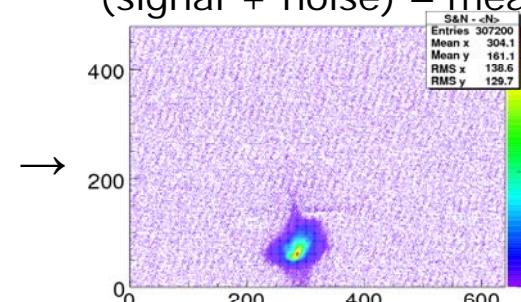
mean noise



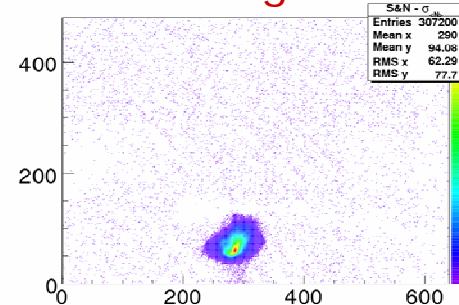
frame (signal + noise)



(signal + noise) – mean noise



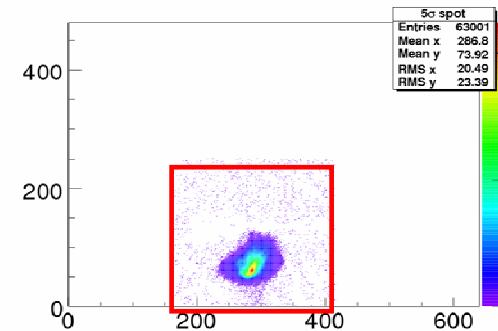
filtered signal



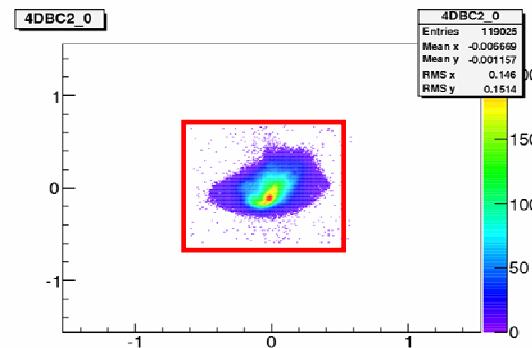
- pixel is noise if it is within one sigma of the oscillations of the mean noise

... specific for the reconstruction

- The reconstruction procedure needs data with identical binning and center
 - 5-sigma spot cut → ROI

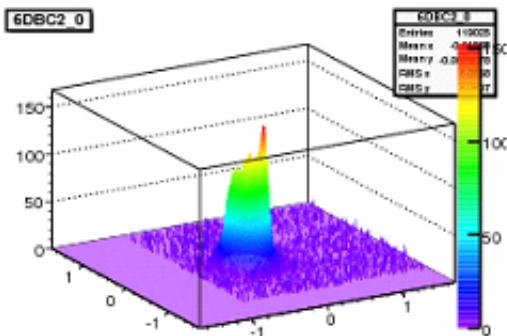


- define common boundaries for all of the projections
 - fill with 0-s the ones which are smaller than the biggest 5-sigma spot
 - spot sizes aren't changed
- Center the spots
- Calculate projections & beam sizes



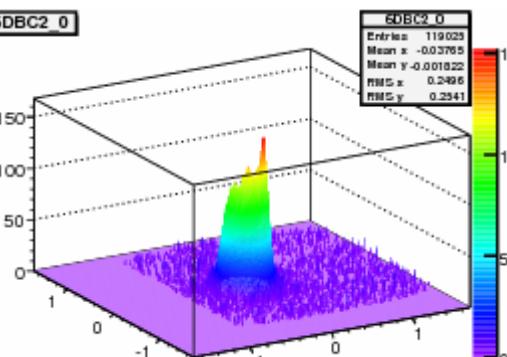
Different ROIs

6DBC2 0



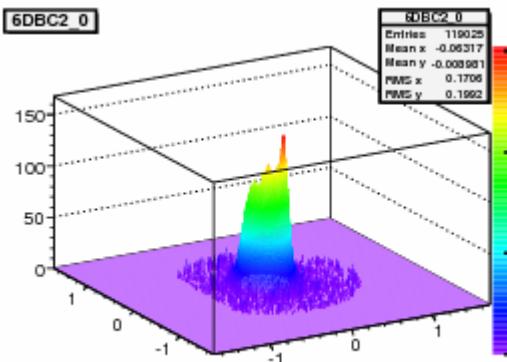
Non-symmetric quadratic ROI of $\max\{5_{\diamond_x}, 5_{\diamond_y}\}$

6DBC2 0



Non-symmetric elliptical ROI of $\max\{5_{\diamond_x}, 5_{\diamond_y}\}$

6DBC2 0



Circular ROI of $\max\{5_{\diamond_x}, 5_{\diamond_y}\}$

Reconstruction feed

- 10 frames on each screen

- create 10 sets of input projections → statistics
 - minimise blurring effects related to jitter

$S_{1,1}$	$S_{1,2}$	$S_{1,3}$	$S_{1,4}$
...
$S_{10,1}$	$S_{10,2}$	$S_{10,3}$	$S_{10,4}$

- Filter the data as shown

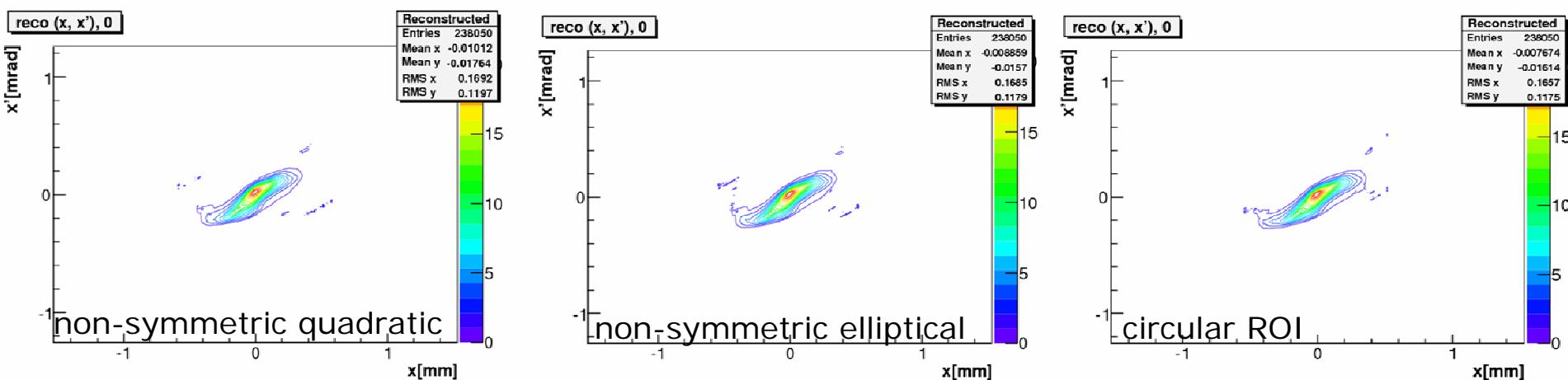
- Centred, rescaled with calibration factor & extended to the size of the spot with $\max\{5\Delta_x, 5\Delta_y\}$

- dependant on the selected ROI

- Snap projections

Reconstruction result

- MENT algorithm used over each set, 20 iterations
- Mean value and standard uncertainty calculated



$$\mathfrak{M}_{x, N} = 3.51 \pm 0.17 \text{ mm mrad}$$
$$\mathfrak{M}_{y, N} = 3.48 \pm 0.24 \text{ mm mrad}$$

$$3.33 \pm 0.16 \text{ mm mrad}$$
$$3.37 \pm 0.23 \text{ mm mrad}$$

$$2.61 \pm 0.05 \text{ mm mrad}$$
$$2.67 \pm 0.09 \text{ mm mrad}$$

Basic phase space shape is very similar, peculiarities differ.

The effects of the ROI should be studied.

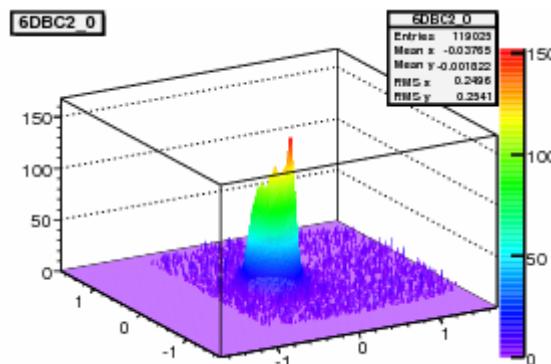
Summary

- Reconstruction was performed with
 - different steps of background subtraction
 - different criteria for ROI
 - the result in terms of artifacts, emittance and uncertainty strongly depends on the ROI
- The spot steered at nearly the same screen area
 - during analysis but depends on left over noise level

Thanks for the attention!

Effects of calibration

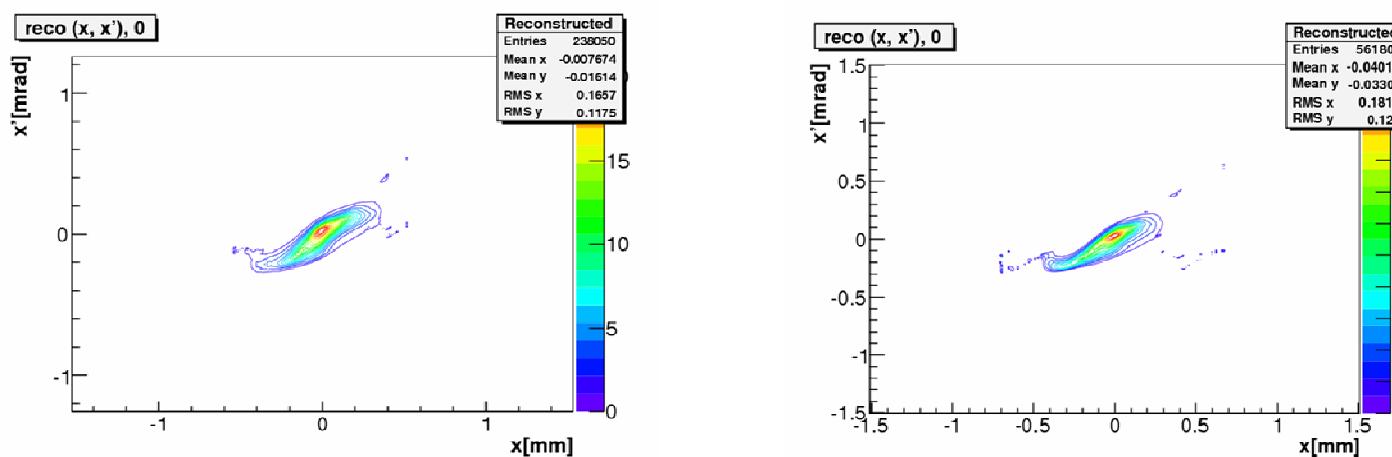
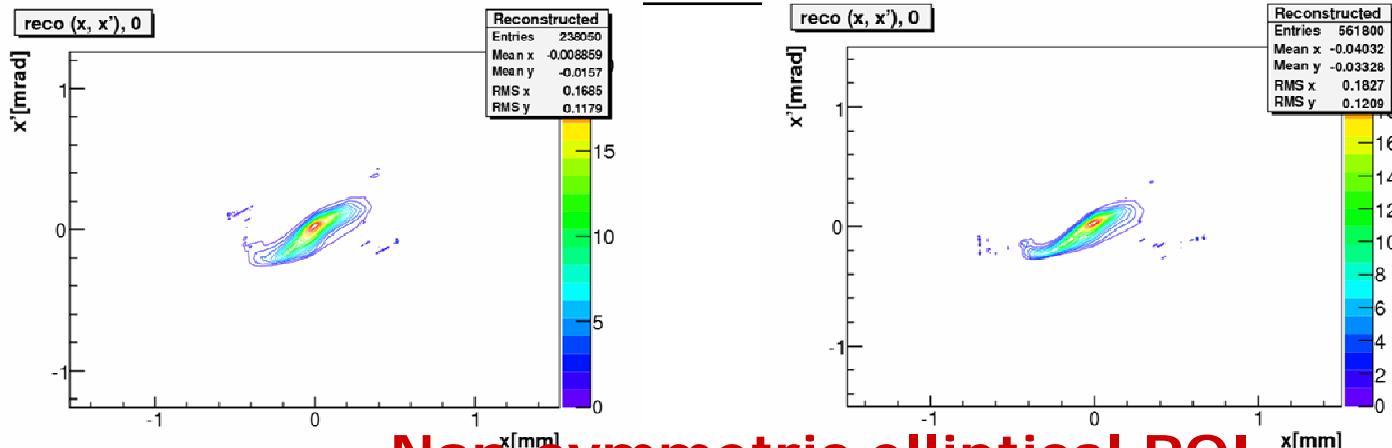
- Define ROIs
 - by the matrix CCD dimensions



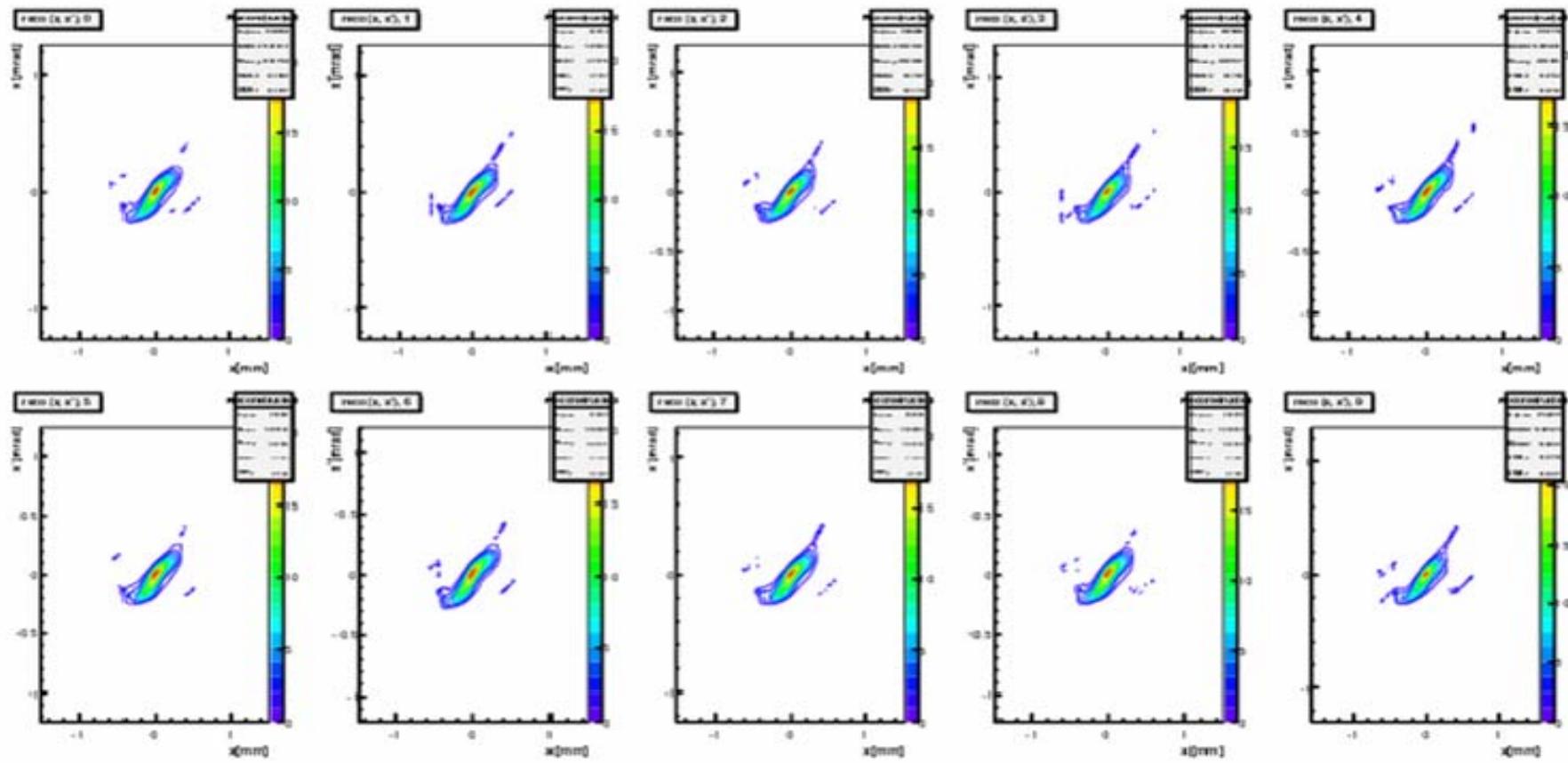
Non-symmetric elliptical ROI of $\max\{5\Delta_x, 5\Delta_y\}$

- by spots rescaled with the calibration factors

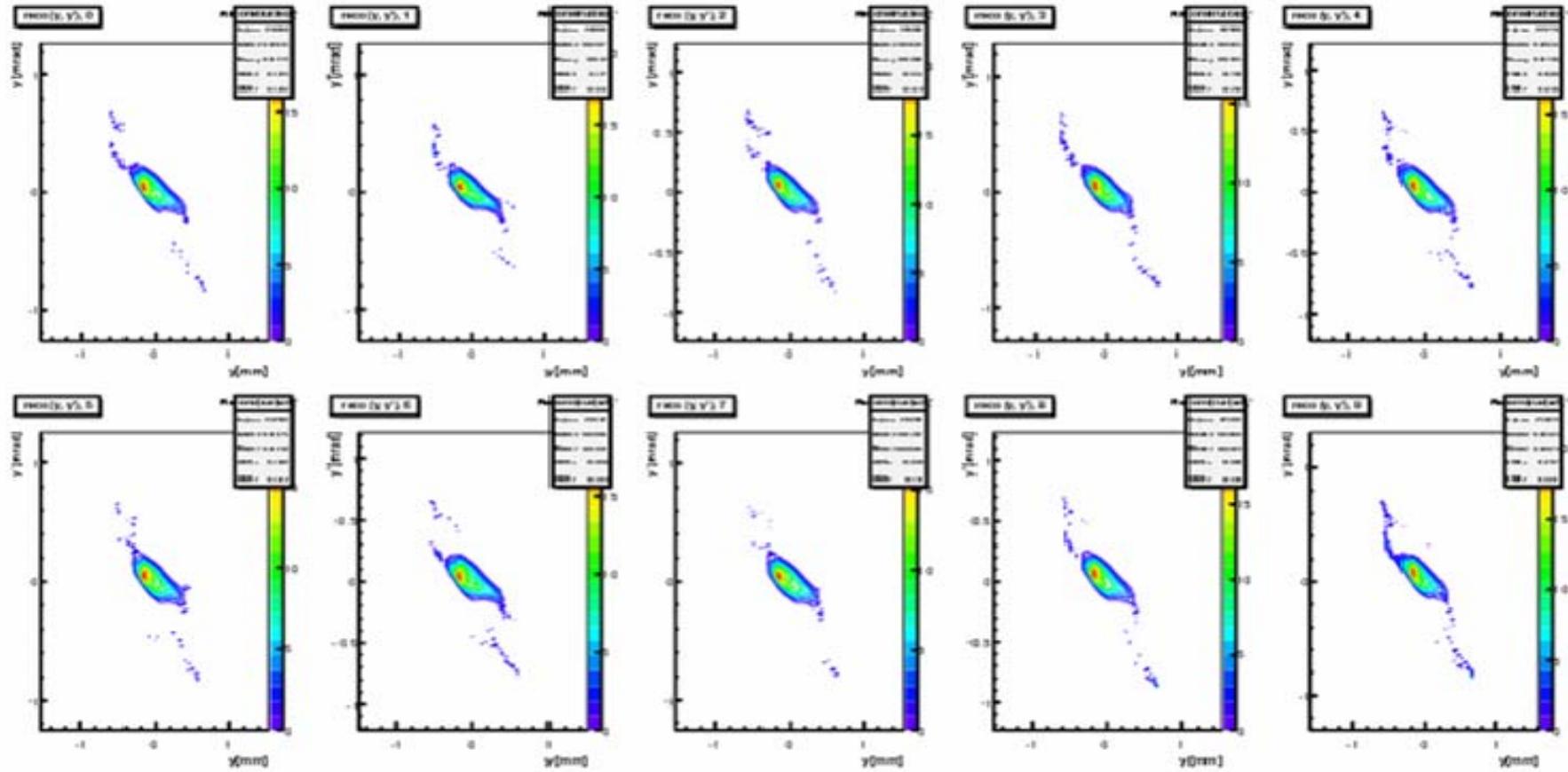
Effects of calibration, reconstruction



Circular ROI

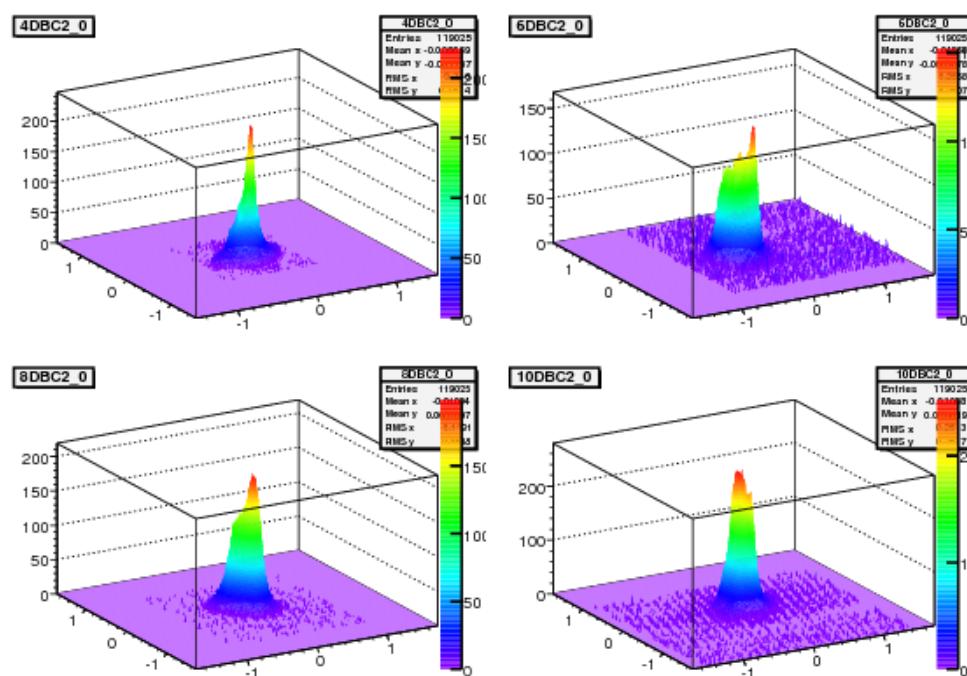
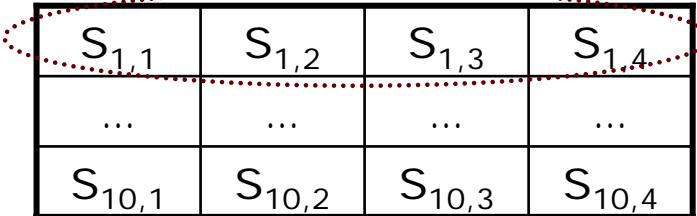


Tomo FLASH data, CHHB



Reconstruction feed

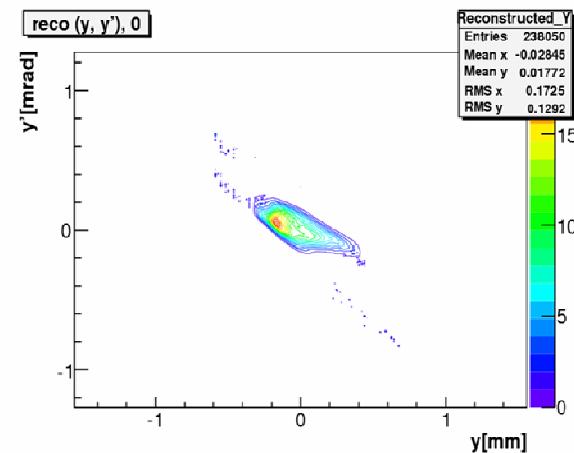
- 10 frames on each screen
 - create 10 sets of input projections
 - minimise jitter effects
 - statistics
- Filter the data as shown
- Centred, rescaled & rebinned to the binning of the spot with $\max\{5\Delta_x, 5\Delta_y\}$



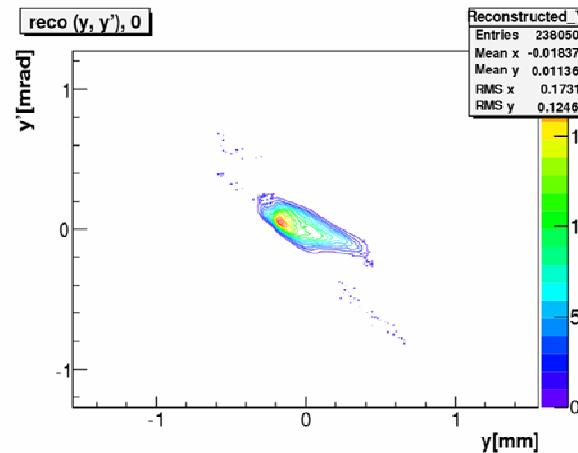
Reconstruction result, (y, y')

- MENT algorithm used, 20 iterations

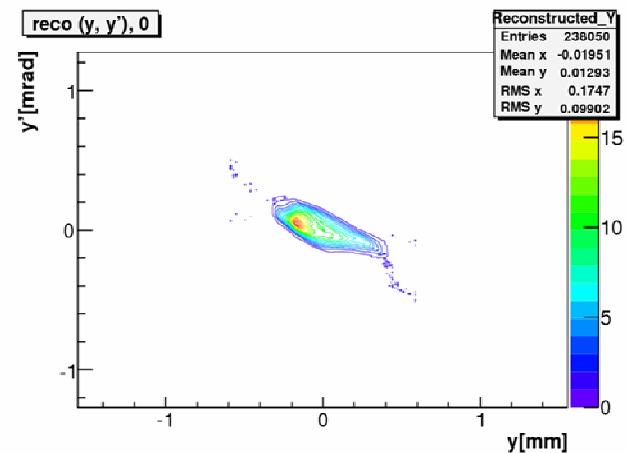
Non-symmetric quadratic



Non-symmetric elliptical



Circular ROI



$$\begin{aligned}\mathfrak{M}_{x, N} &= 3.51 \pm 0.17 \text{ mm mrad} \\ \mathfrak{M}_{y, N} &= 3.48 \pm 0.24 \text{ mm mrad}\end{aligned}$$

$$\begin{aligned}&3.33 \pm 0.16 \text{ mm mrad} \\ &3.37 \pm 0.23 \text{ mm mrad}\end{aligned}$$

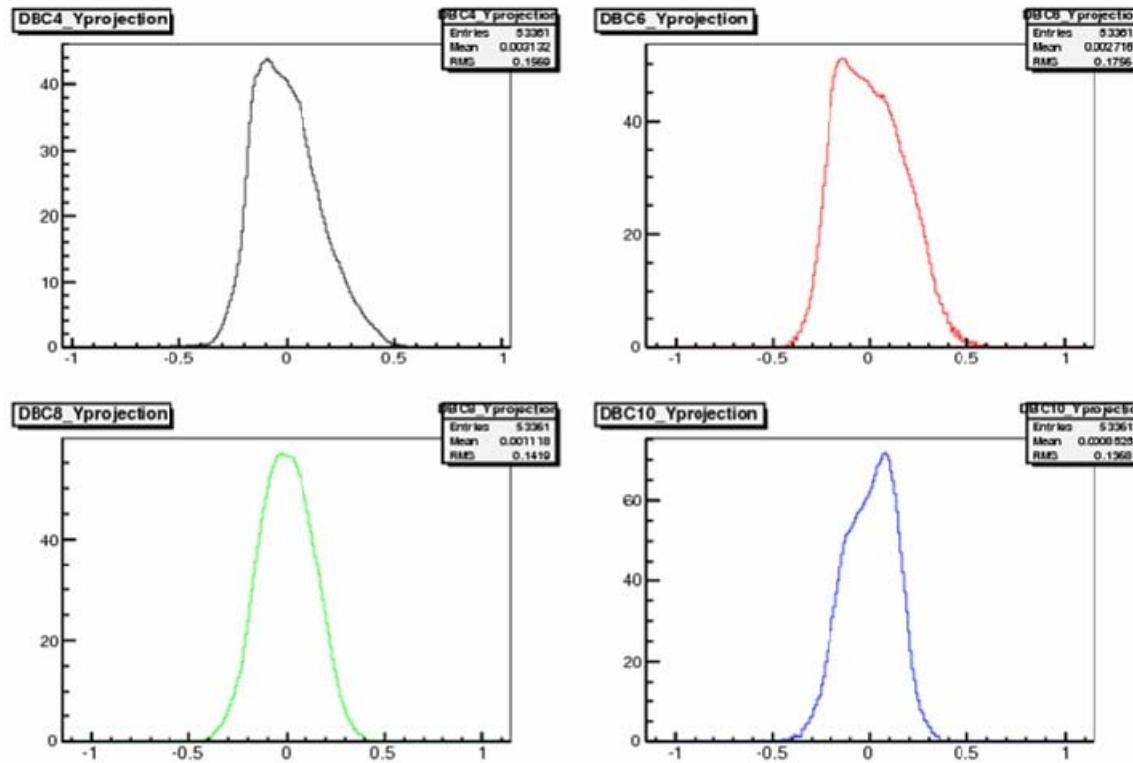
$$\begin{aligned}&2.61 \pm 0.05 \text{ mm mrad} \\ &2.67 \pm 0.09 \text{ mm mrad}\end{aligned}$$

Summarised

	PITZ	FLASH
◆ x, y' , 4DBC2	0.154, 0.157	0.161, 0.178
◆ x, y' , 6DBC2	0.150, 0.176	0.176, 0.223
◆ x, y' , 8DBC2	0.14, 0.141	0.181, 0.181
◆ x, y' , 10DBC2	0.146, 0.137	0.237, 0.199
ℳ x, y' , 4DBC2	2.417, 2.594	3.69, 3.74
(?)	50%, 44%	

TODO

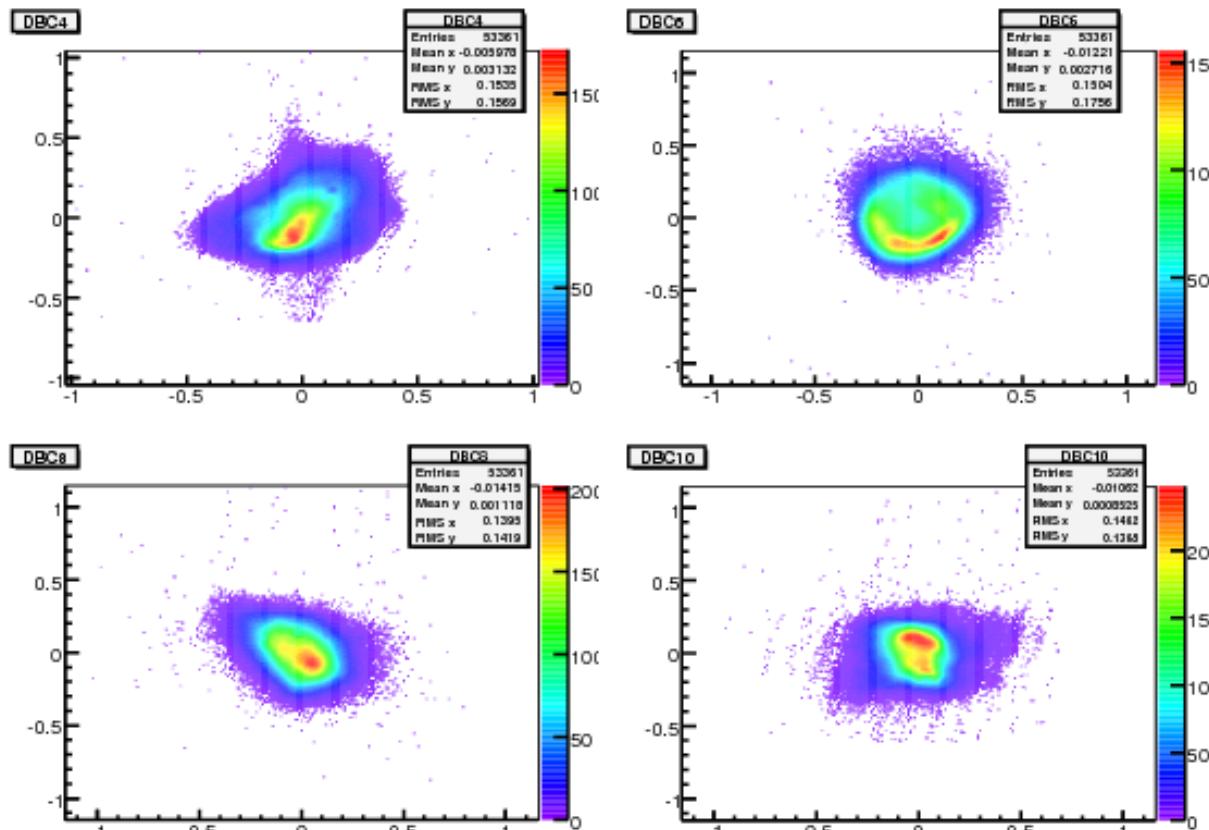
- Center each frame after the 6-sigma spot cut to avoid blurring of the profile due to jitter
- It's not clear if the transfer matrices are from scr1 -> scr2, scr2 -> scr3 or scr1->scr2, scr1->scr3
- Use a number of short hard edge quads instead of a long hard edge one if k-value is provided



Reconstruction steps

Input data

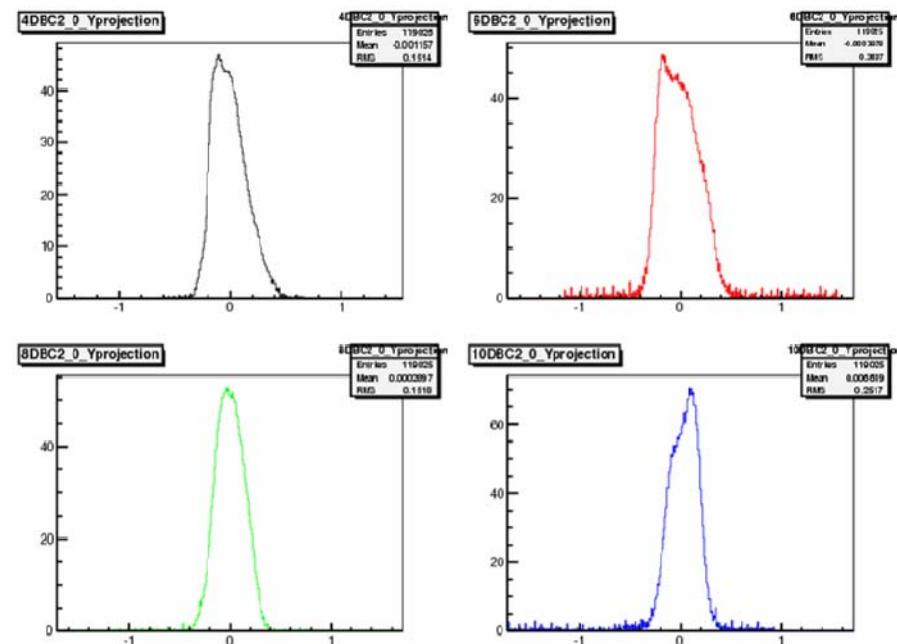
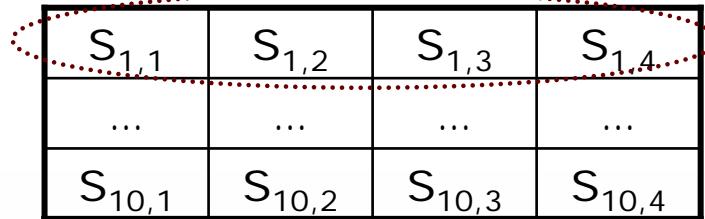
- ✓ filtered as shown until now
- ✓ rescaled & rebinned to the binning of the spot with $\max\{6\cdot x, 6\cdot y\}$



Something wrong
since...

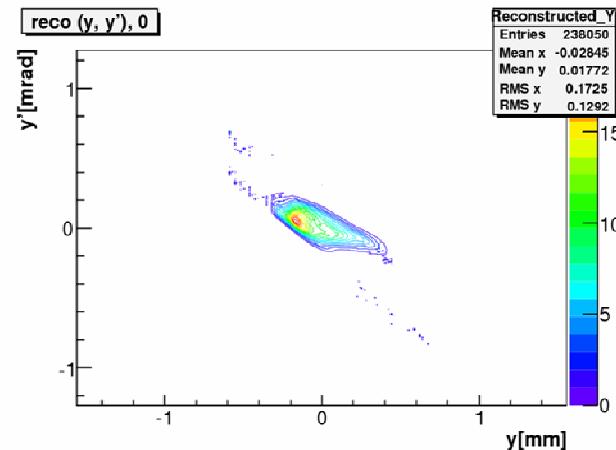
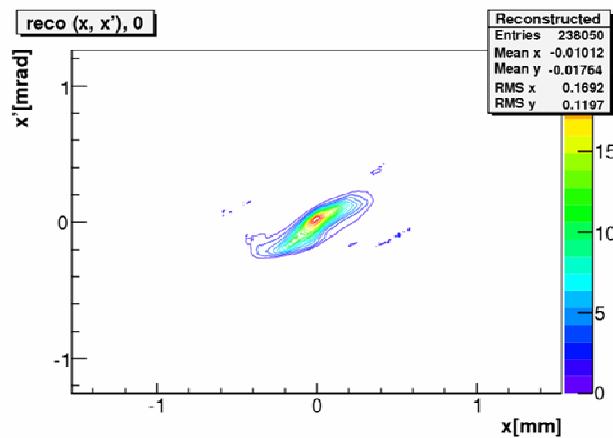
Reconstruction feed

- 10 frames on each screen
 - create 10 sets of input projections
 - minimise jitter effects
 - statistics
- Filter the data as shown
- Centred, rescaled & rebinned to the binning of the spot with $\max\{5_{\diamond_x}, 5_{\diamond_y}\}$



Reconstruction result

- MENT algorithm used, 20 iterations



$$\mathfrak{M}_{x, N} = 3.51 \pm 0.17^* \text{ mm mrad} \quad \mathfrak{M}_{y, N} = 3.48 \pm 0.24^* \text{ mm mrad}$$

- Spots around the core might be artefacts due to the non-symmetric ROI
 - the spot steered at nearly the same screen area
 - define symmetric common ROI

* standard uncertainty