# First results on phase space tomography for ELENA

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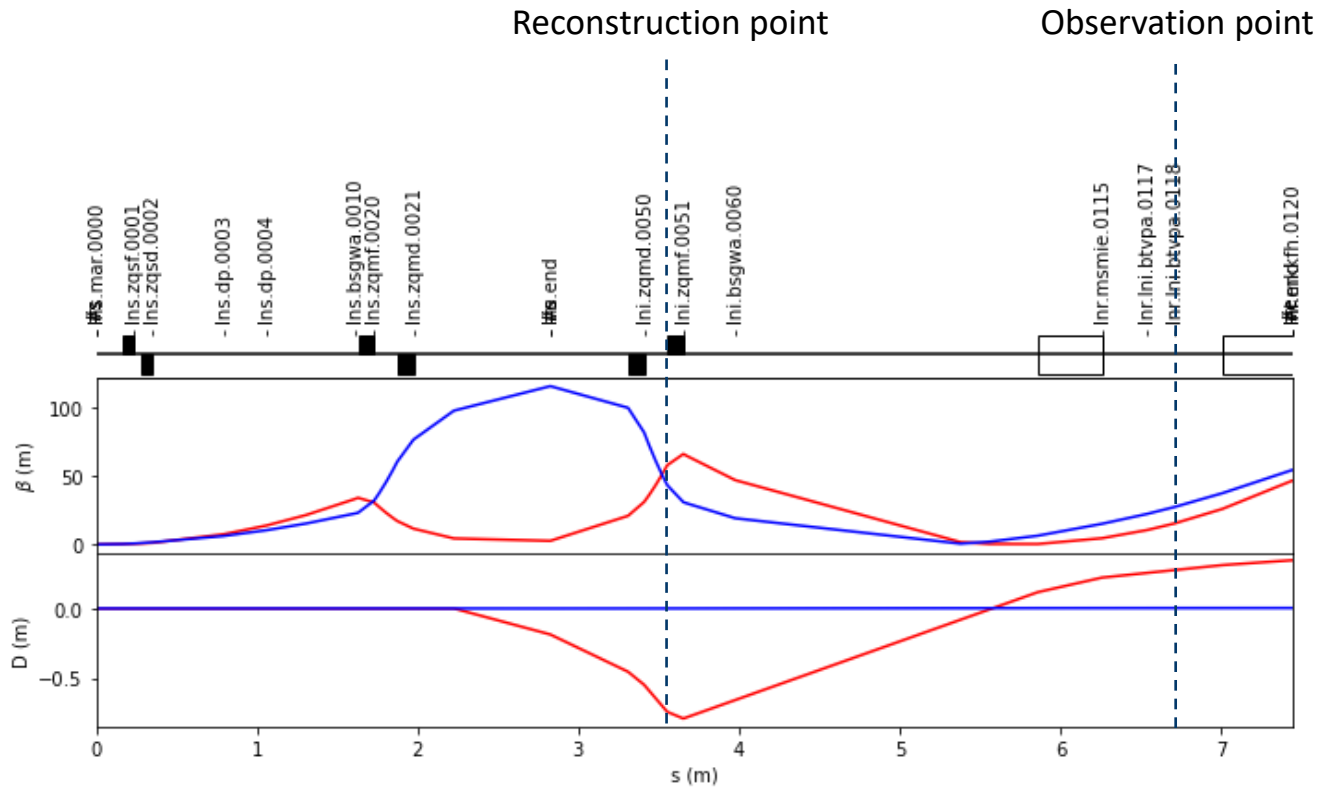
# Reconstruction setup

- Input for reconstructions are measurements contained in Lajos folder.
- Quad strengths: 1.649383 - 1.899588 kV (20.04 – 23.08 1/m2)



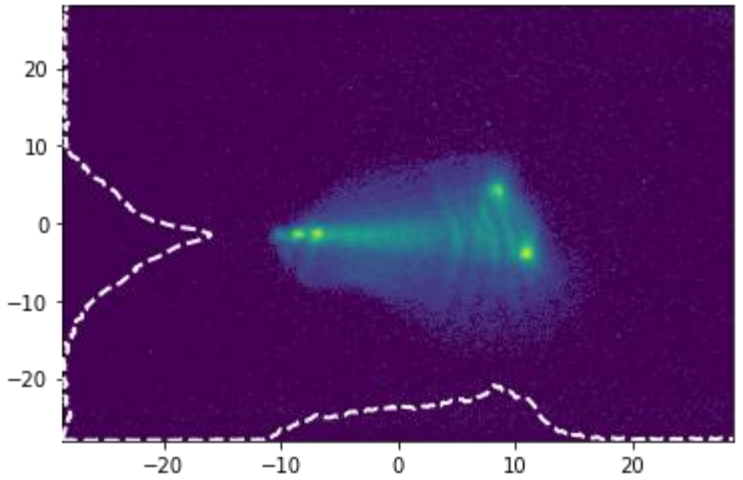
# Images preprocessing

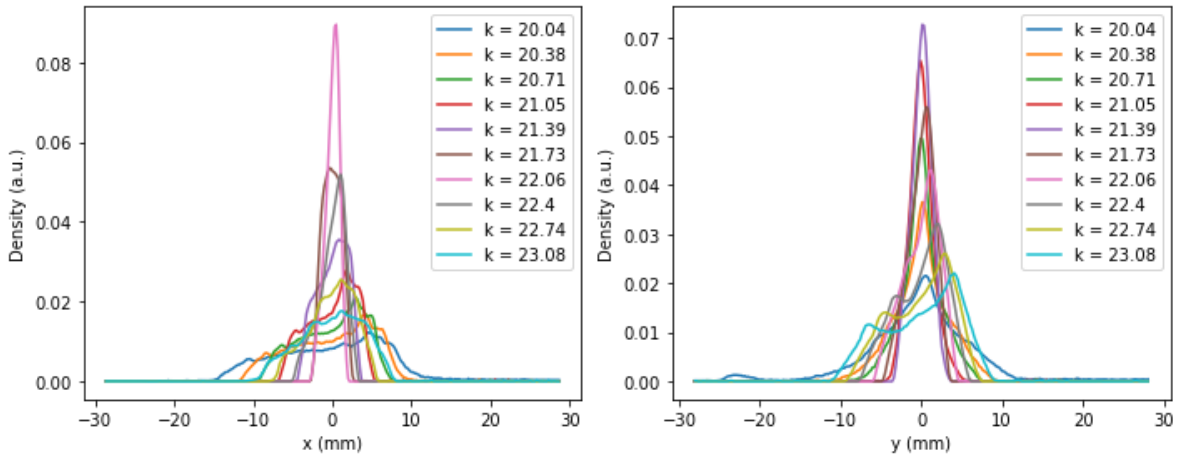
- 10 quad strength considered
- For each strengths 10 images saved

For each strength:

- Apply a threshold to each image (10 % of max)
- Extract x and y projections
- Center projections w.r.t mean value and normalize by sum (intensity)
- Take the average of projections

➡ 1 projections per strength in x and y

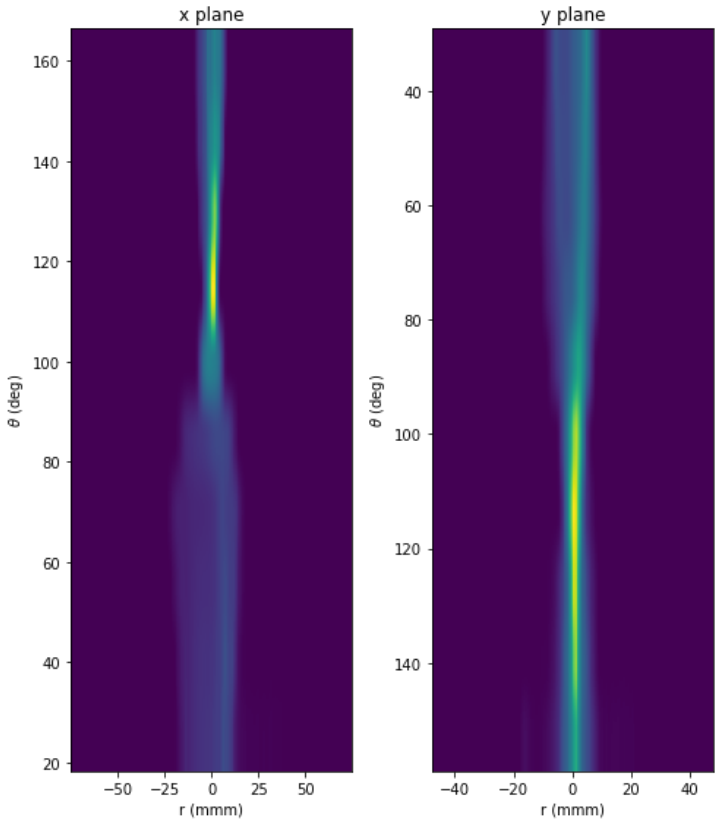


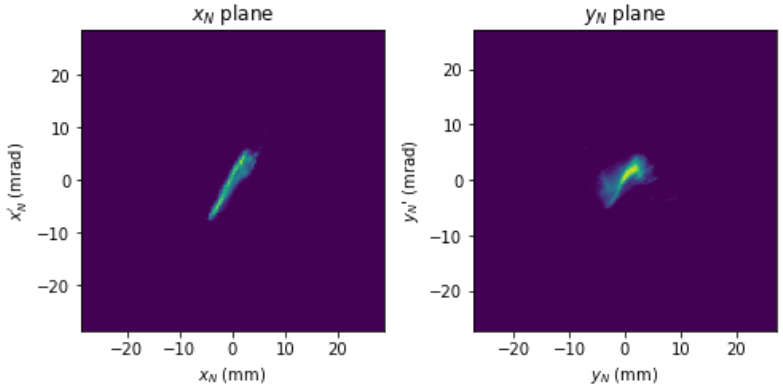
# Tomographic reconstruction

- Assume normalization Twiss parameters (used to optimize the angular range of the reconstruction)
- Calculate scaling factors and angles from transport matrix and generate sinograms for reconstruction
- Use ML-EM algorithm for reconstruction in normalized coordinates

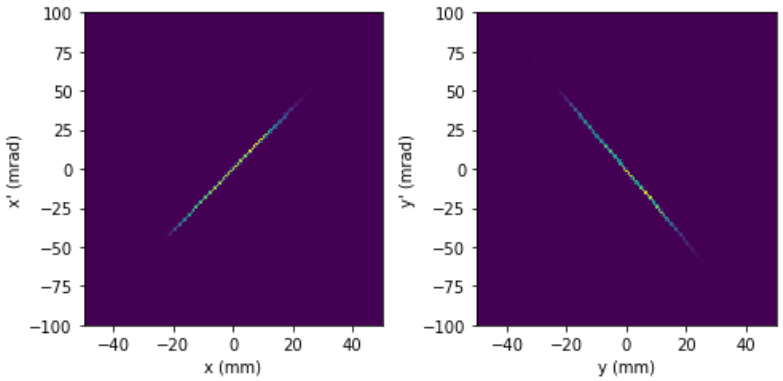
Scaled sinograms




Reconstructed distribution




Unnormalized



# Quad scan reconstruction

- Instead of the classical approach of fitting a parabolic function to the square of the beam size, we use a different approach that allows for thick lens approximation.
- By matrix inversion we can calculate the beam matrix at reconstruction point

Squared measured sigmas

Elements of transport matrix

Beam matrix elements at rec. point

K1

K2

.

.

.

kn

$$\begin{bmatrix} \sigma_{11_s}^{(a)} \\ \sigma_{11_s}^{(b)} \\ \vdots \\ \sigma_{11_s}^{(n)} \end{bmatrix} = \begin{bmatrix} R_{11}^{2(a)} & 2R_{11}^{2(a)}R_{12}^{2(a)} & R_{12}^{2(a)} \\ R_{11}^{2(b)} & 2R_{11}^{2(b)}R_{12}^{2(b)} & R_{12}^{2(b)} \\ \vdots & \vdots & \vdots \\ R_{11}^{2(n)} & 2R_{11}^{2(n)}R_{12}^{2(n)} & R_{12}^{2(n)} \end{bmatrix} \cdot \begin{bmatrix} \sigma_{11_q} \\ \sigma_{12_q} \\ \sigma_{22_q} \end{bmatrix}$$

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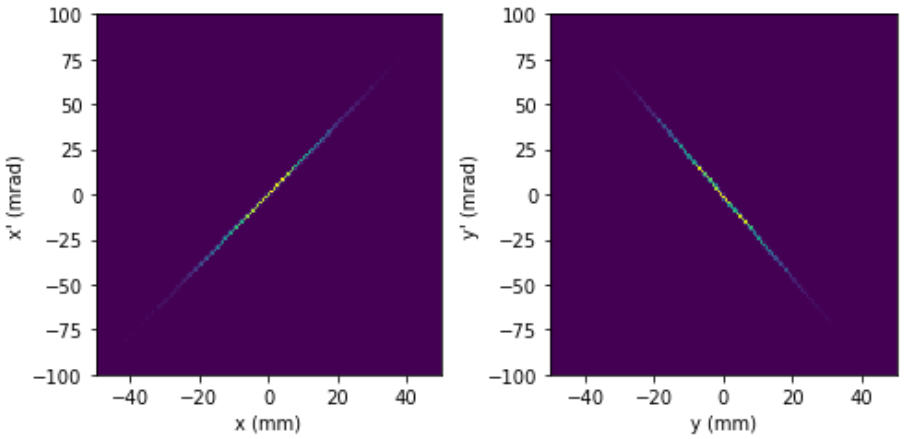
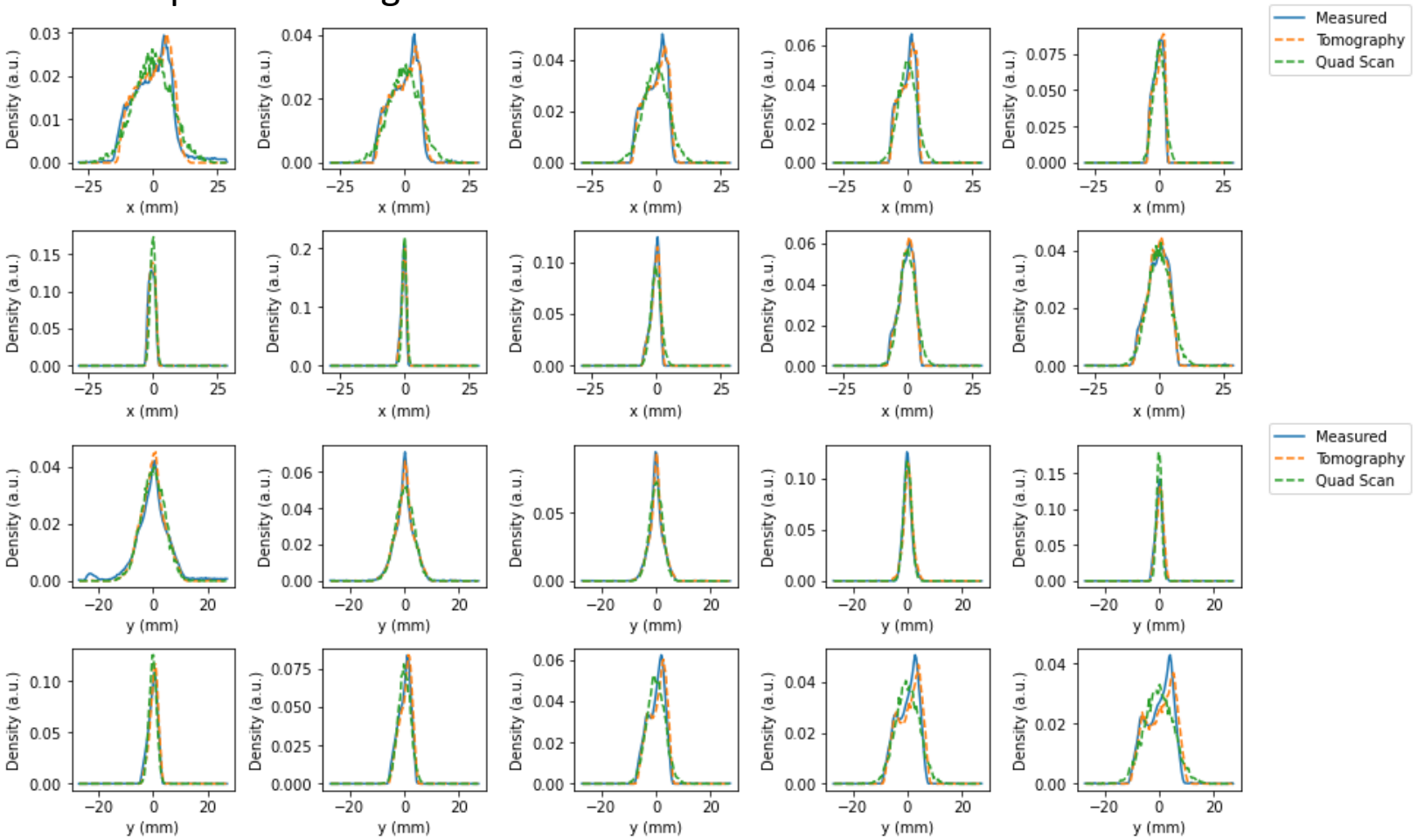


# Validate reconstruction

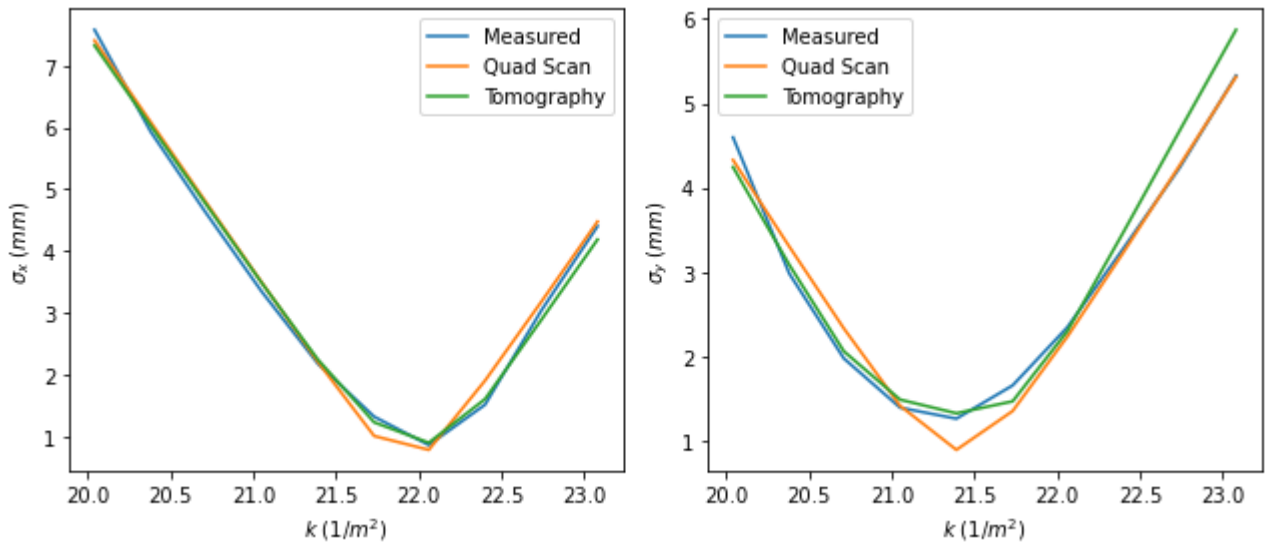
- To validate the reconstruction:
  - Simulate the quadrupole scan with the reconstructed distribution
  - Compare with measured profiles and gaussian beam

x plane

y plane



# Compare with quad scan




| | Quad scan | Tomography | Model |
|---|---|---|---|
| $\alpha_{x,y}$ | -110.42/92.63 | -68.1/61.64 | -107.88/112.56 |
| $\beta_{x,y}$ $(mm)$ | 23.6/55.98 | 34.53/27.24 | 58.01/43.44 |
| $\varepsilon_{x,y}$ $(mm\ mrad)$ | 2.72/2.72 | 3.05/3.67 | 6/6 |

# x-y plane reconstruction (preliminary)

- To reconstruct the x-y plane:
  - Forward track reconstructed distribution
  - Use measured distribution to add x-y correlation
  - Backtrack to have x-y distribution at reconstruction plane

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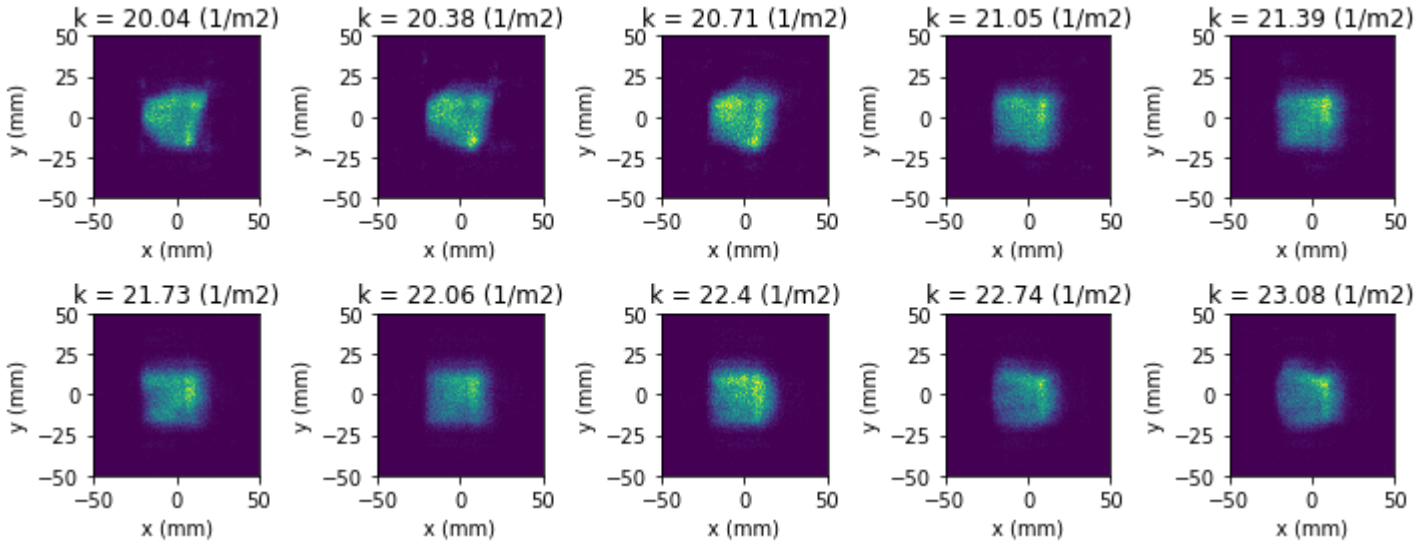

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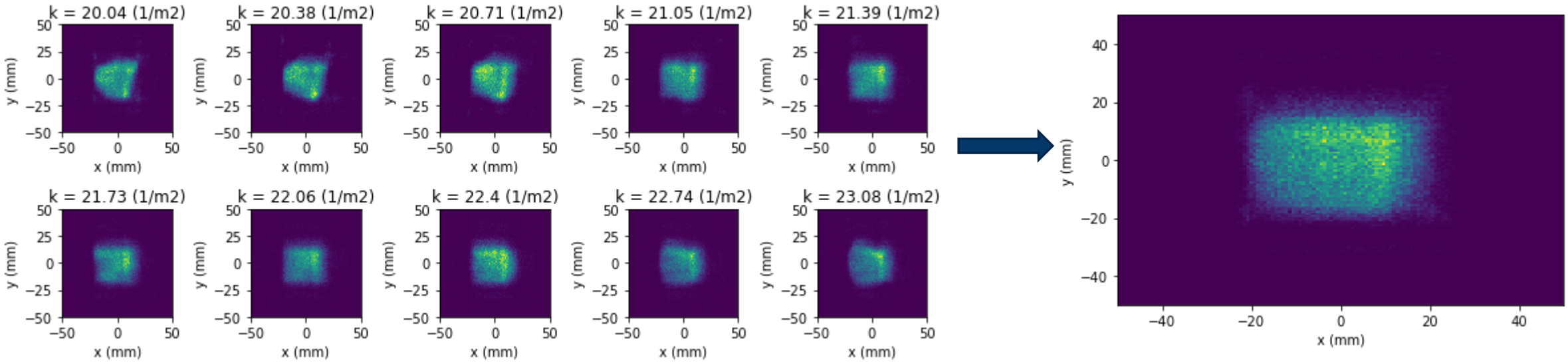
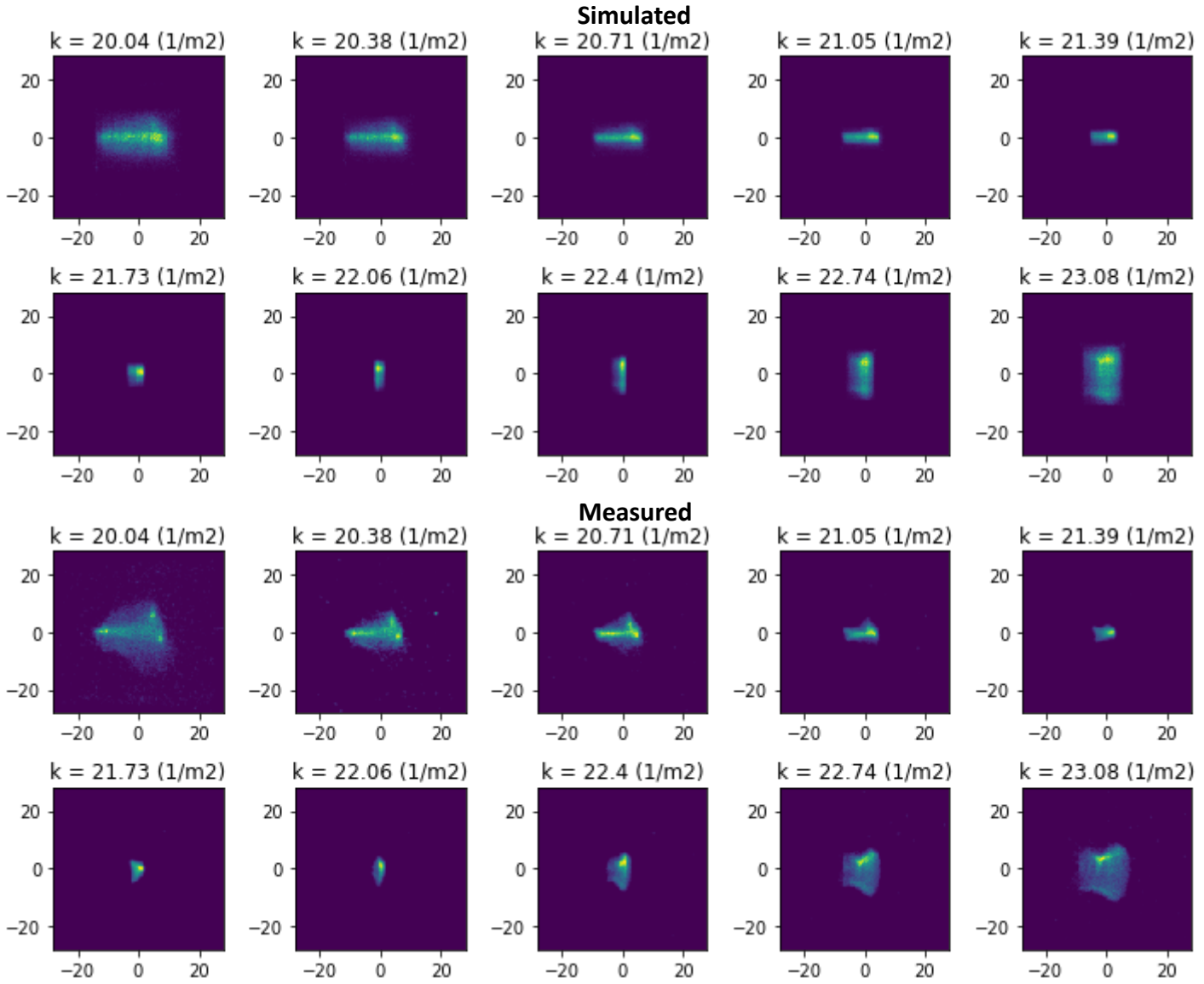


# x-y plane reconstruction (preliminary)

- Let's see what happens if we forward track it and compare with measurements.
- Manage to get some features, but still not satisfactory.
- It needs more investigation



# Conclusions and next steps

- Tomographic reconstruction allows to extract more information about the distribution than quadrupole scan.

- The results can be compared with the acceptance of the transfer line at the same point to check for losses.

Next steps

- Further investigation needed to better reconstruct xy distribution

- Explore possibility of including dispersion in the model (neglected here), by scaling projections by their dispersive contribution

- Do further measurements using also second quadrupole for larger angular range.