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Transverse Phase Space Distribution of an RFQ-Generated Bunch at the SNS BTF

Kiersten Ruisard, Oak Ridge National Laboratory

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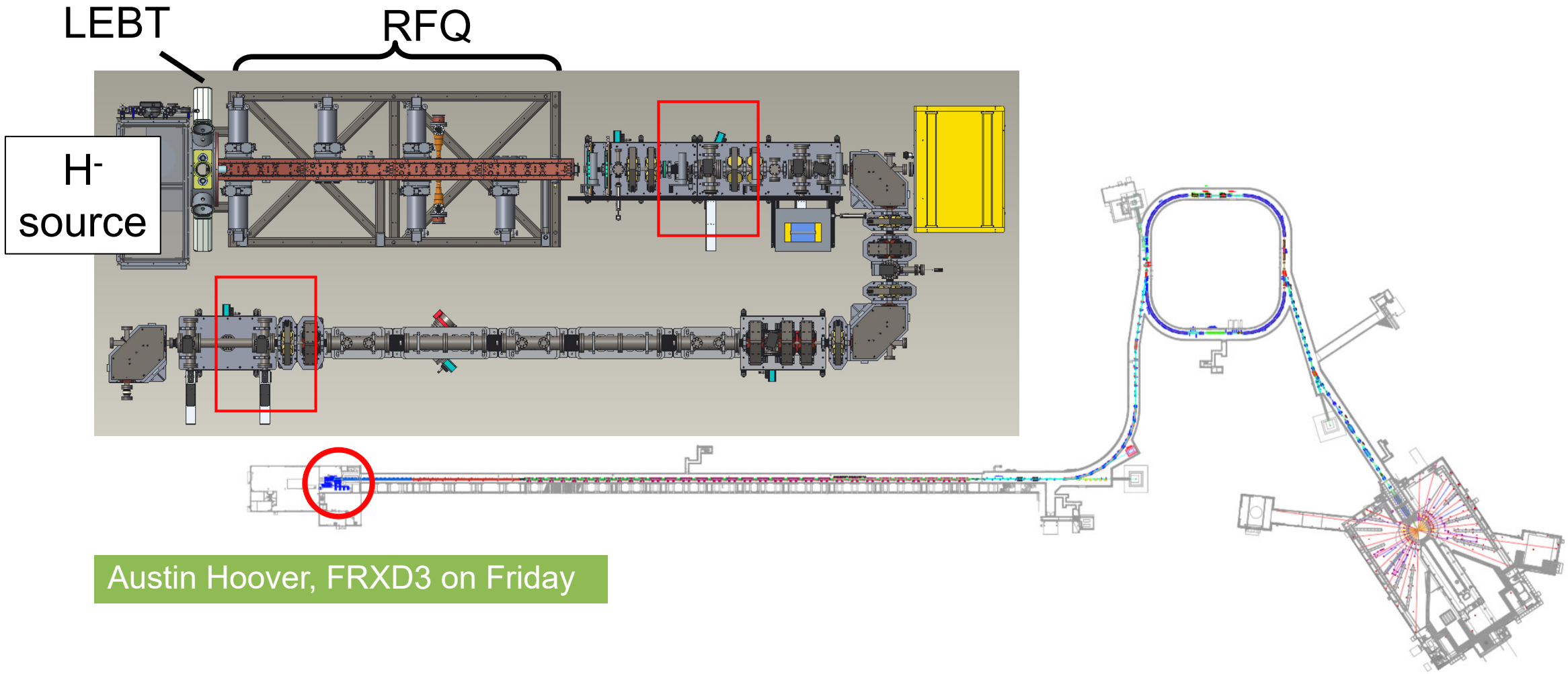
U.S. DEPARTMENT OF ENERGY

SNS Beam Test Facility is measuring full 6D distribution of SNS H- bunch

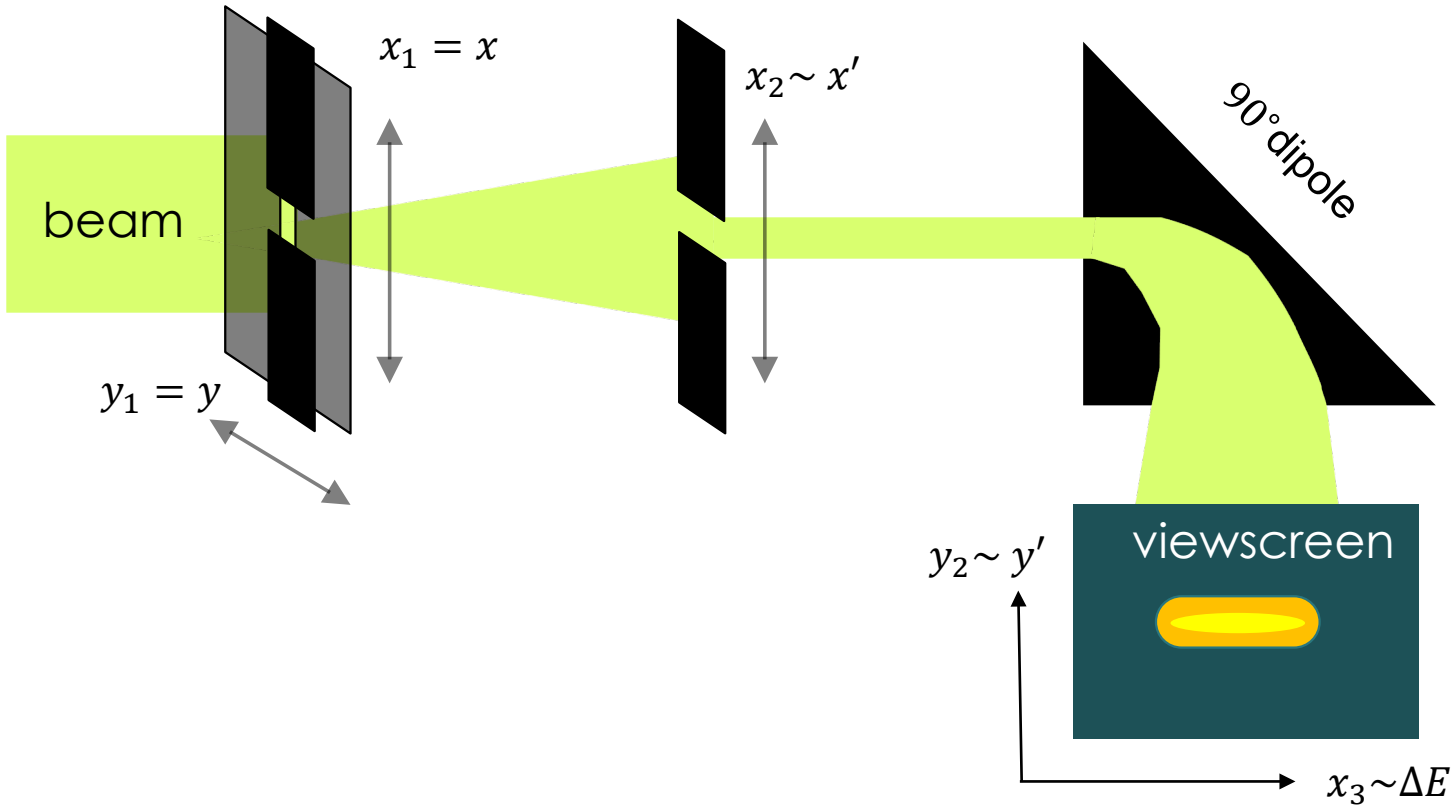


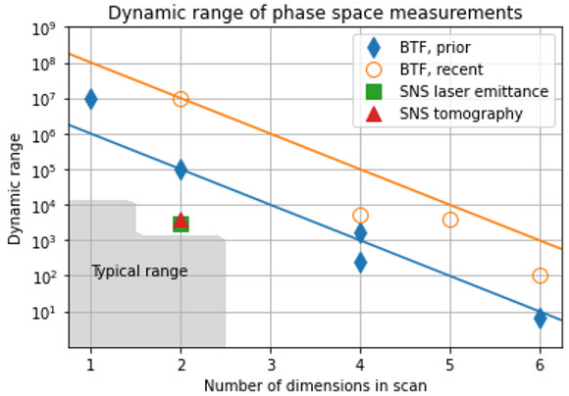
Austin Hoover, FRXD3 on Friday

In this presentation

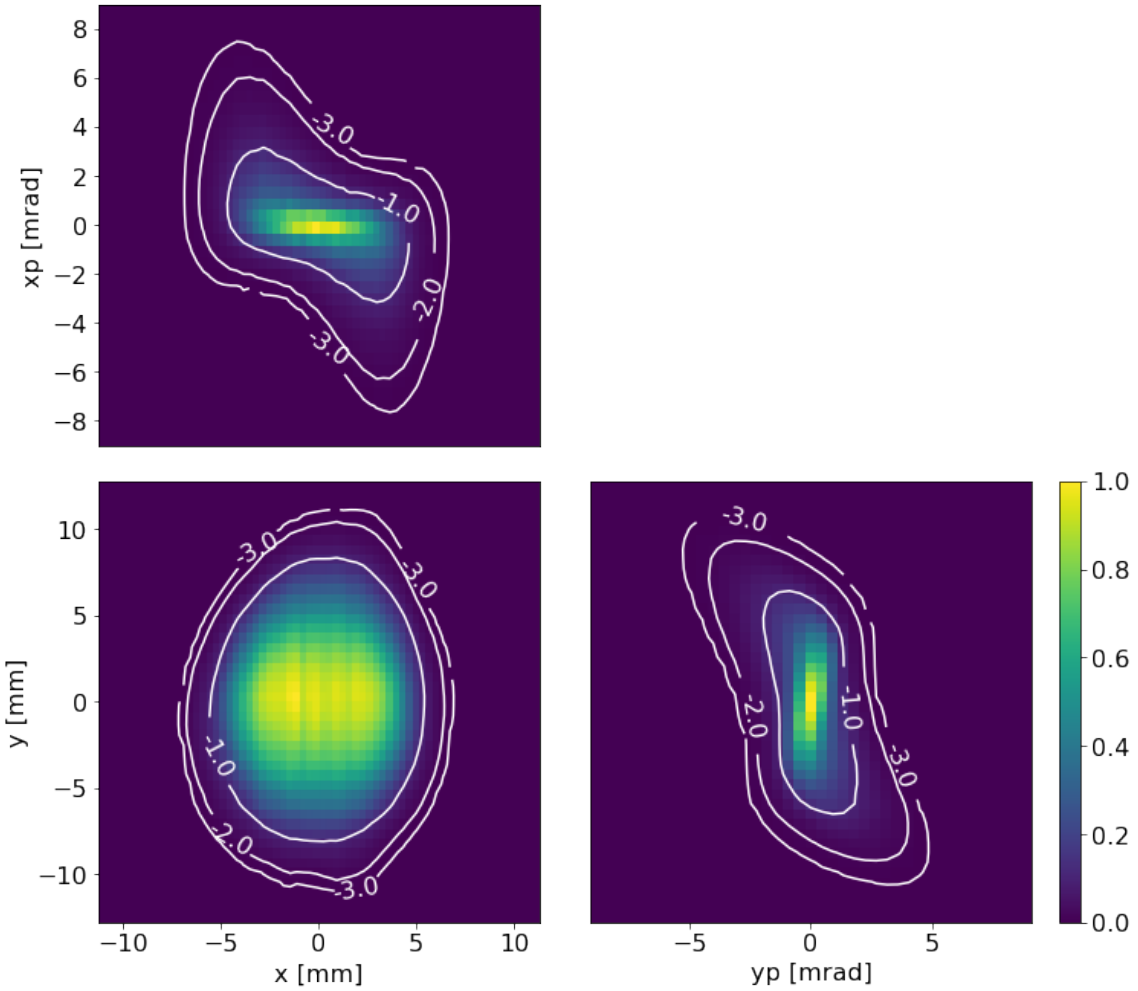
- What does the transverse (4D) beam distribution look like at RFQ output?
  - High-dimensional view shows space charge driven correlation
  - High-dynamic range view covered elsewhere, e.g. Aleksandrov, A., 2021, NIM-A
- How does the transverse distribution compare to predicted distribution?
  - PARMTEQ/PyOrbit model of BTF front-end

Measurements of 5D beam distribution: balancing resolution with measurement time





Observations of 4D distribution



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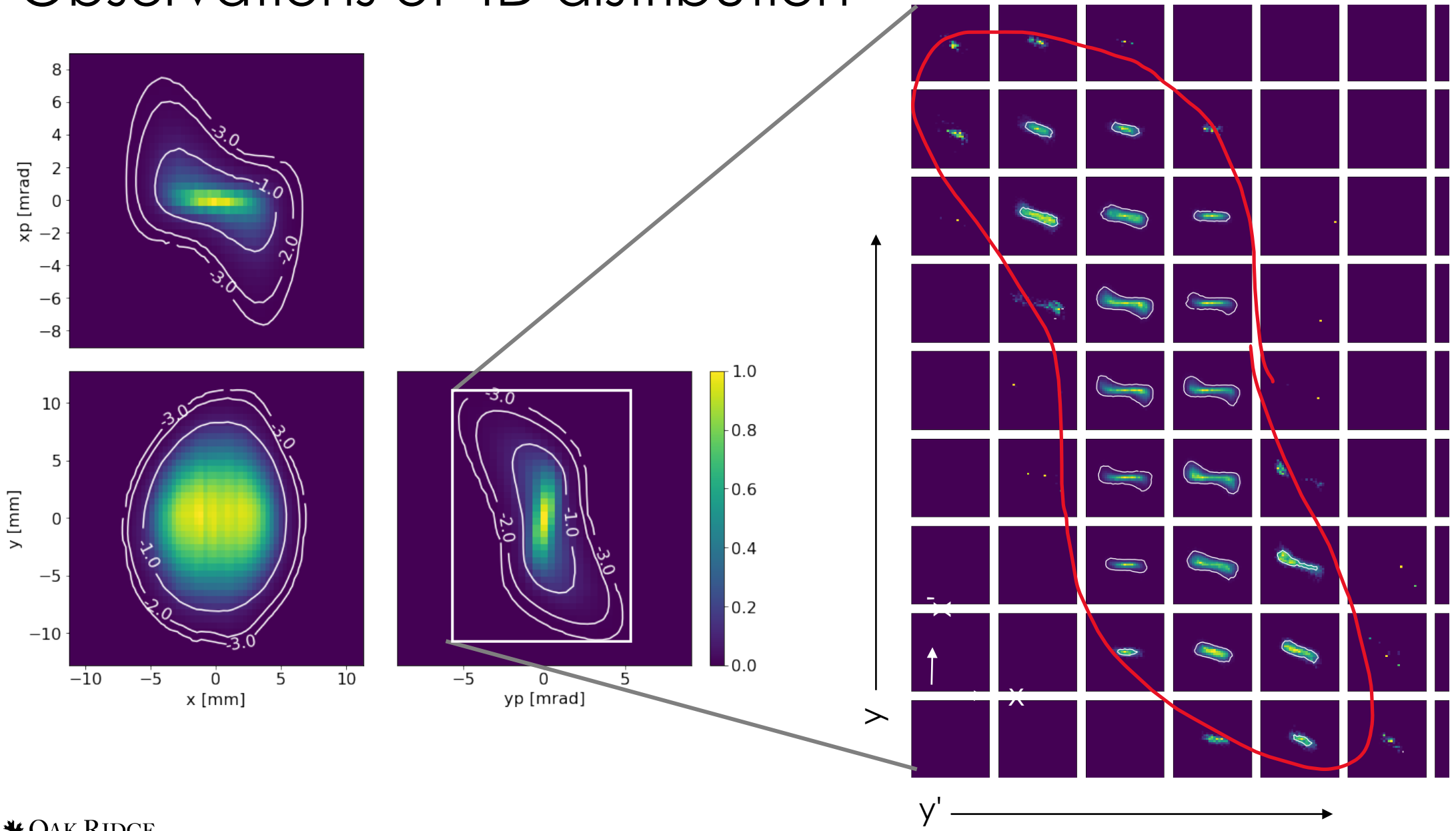

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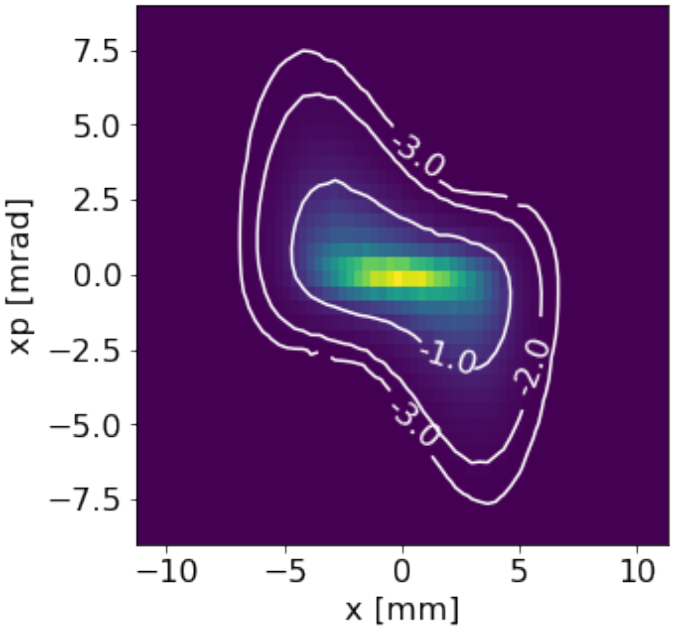

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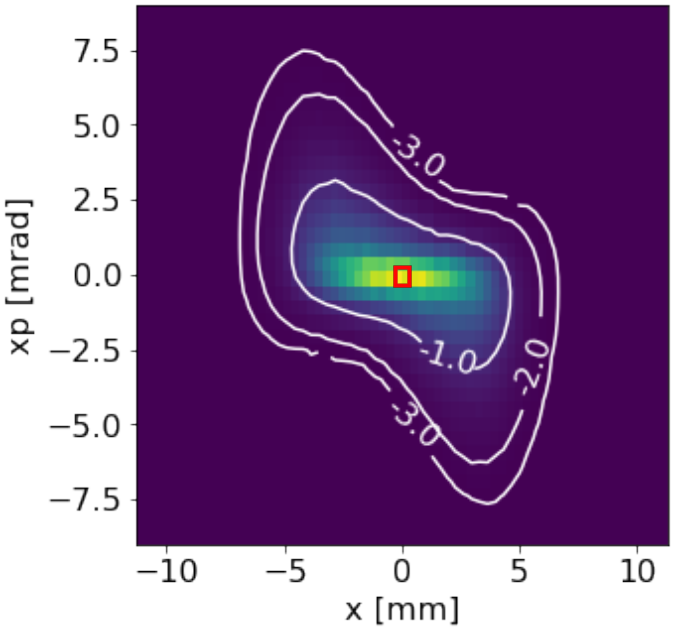
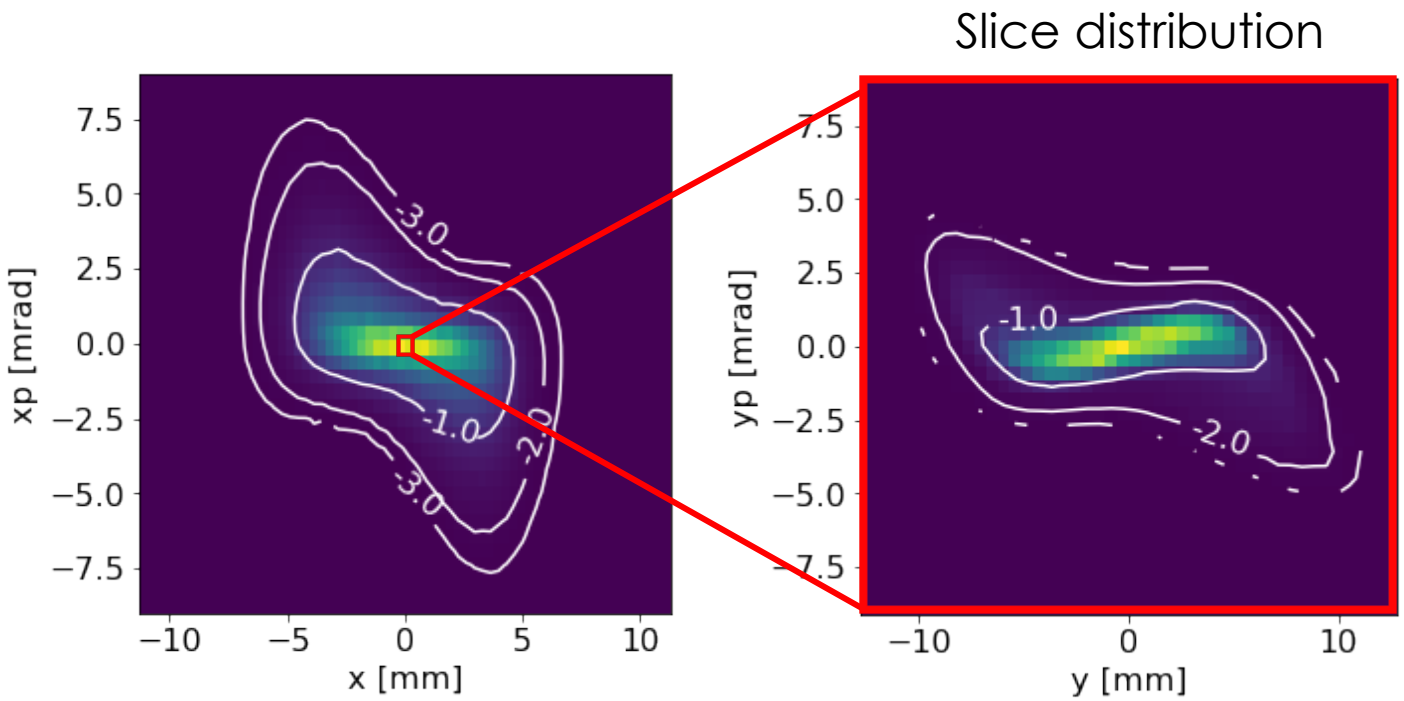


*Energy slice $\Delta E = 0$ keV

Observations of 4D distribution



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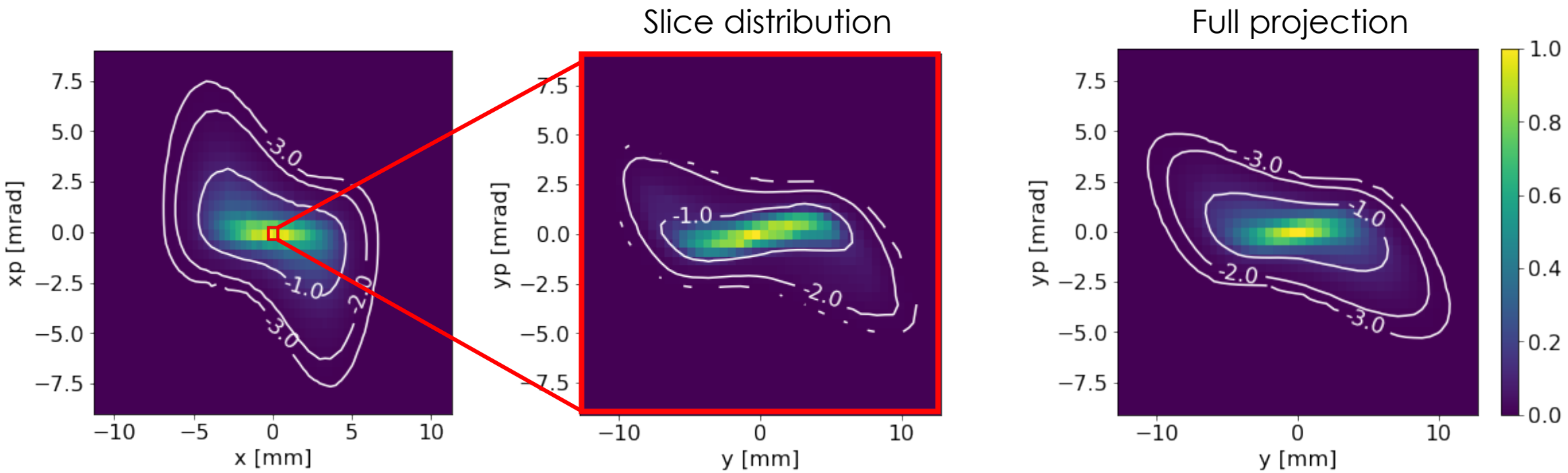

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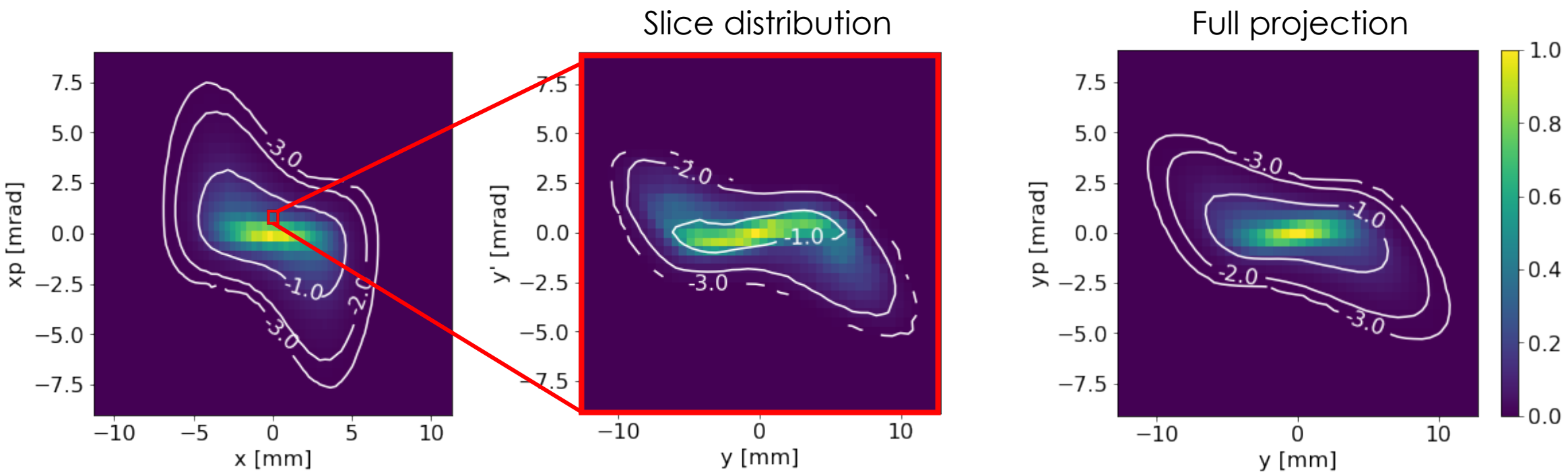

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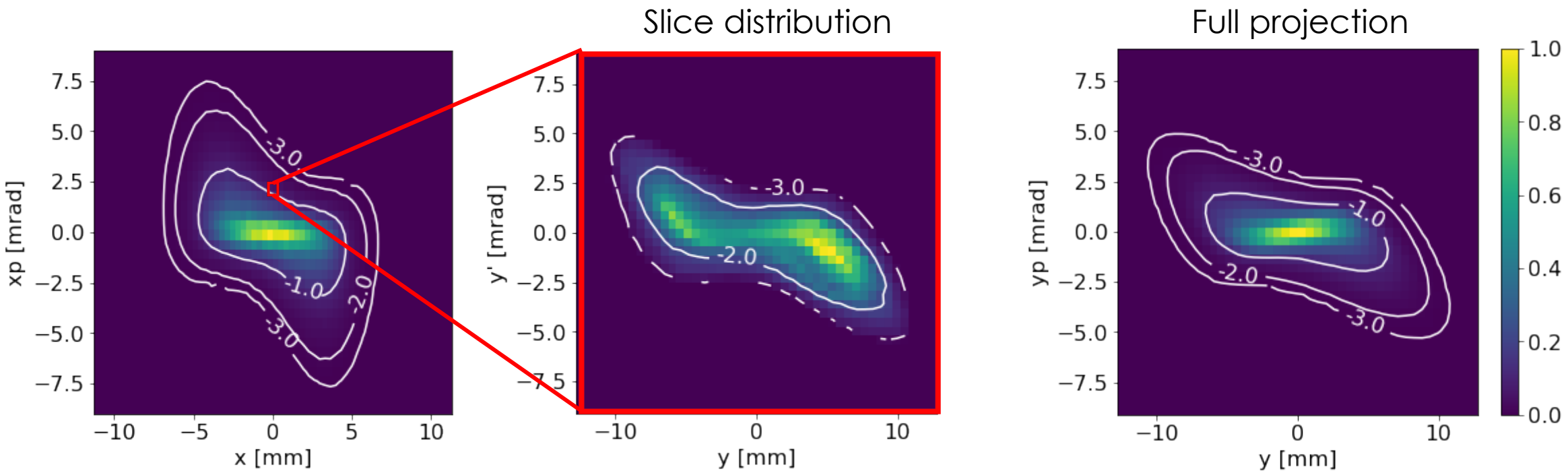

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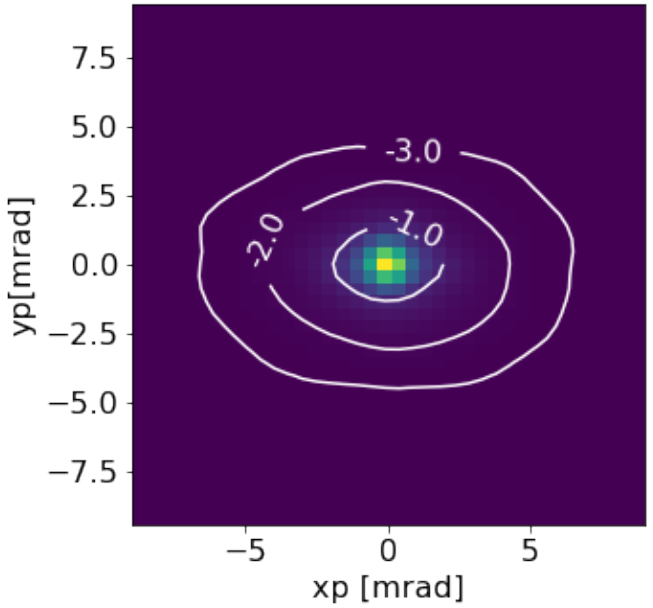

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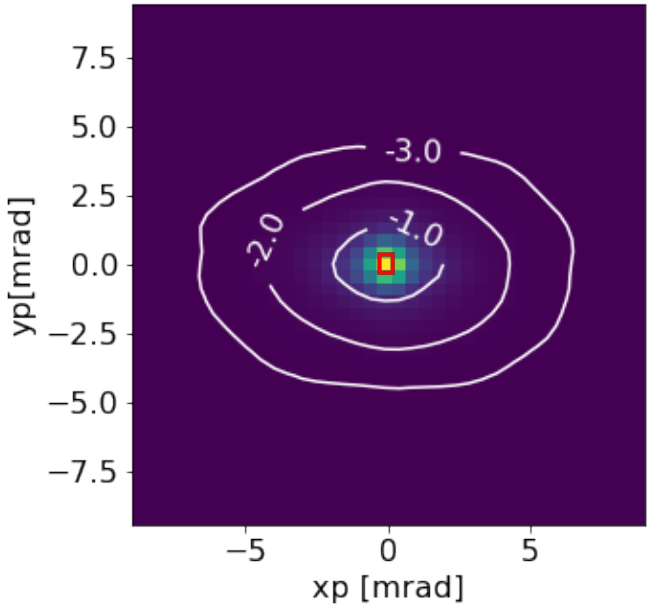

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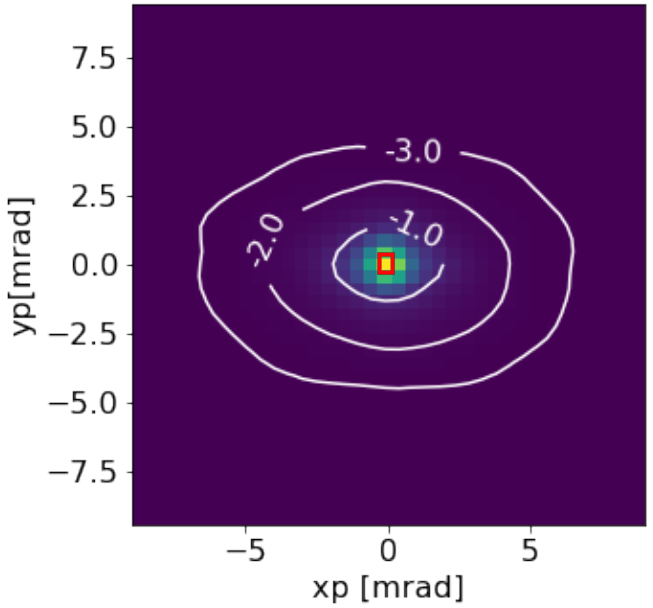

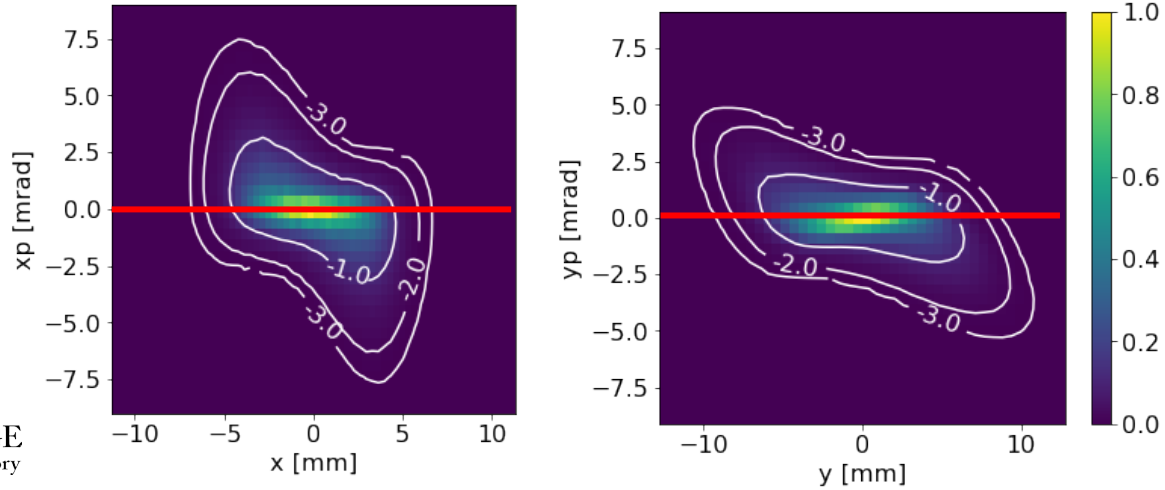

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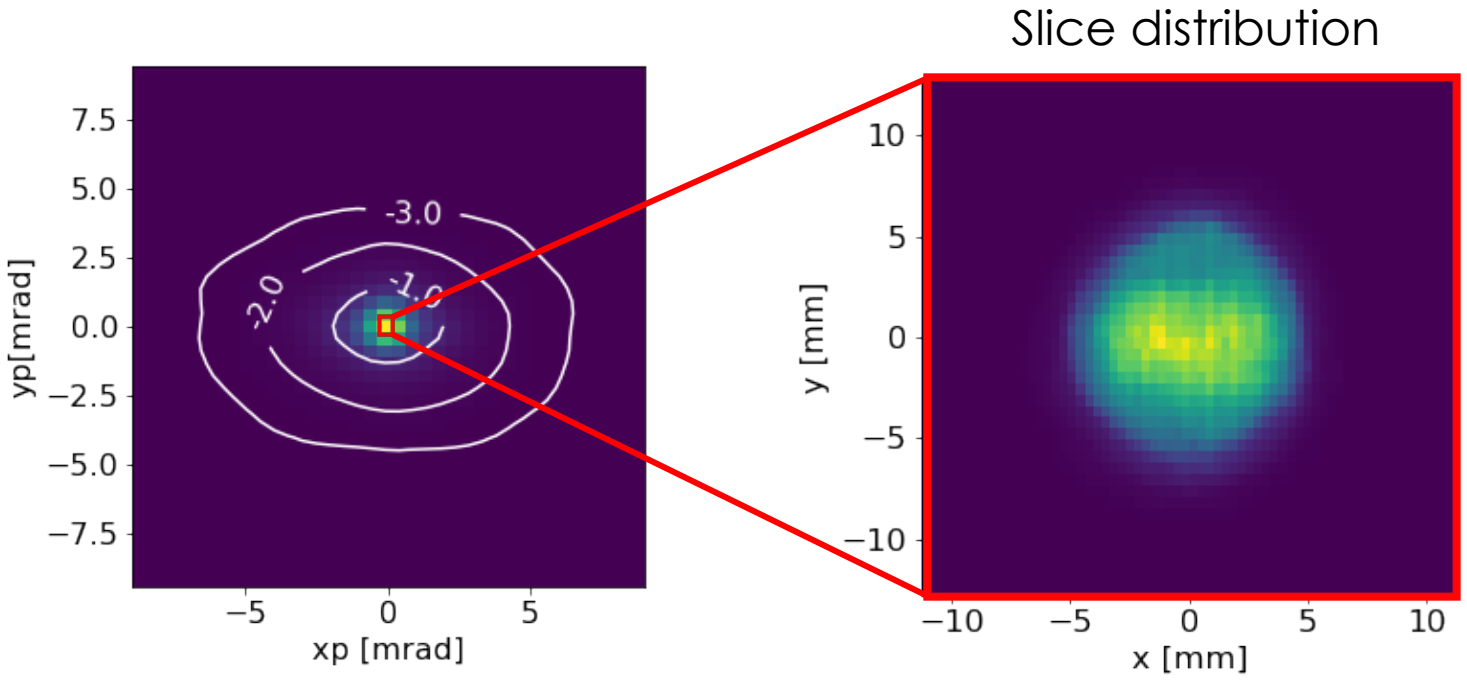

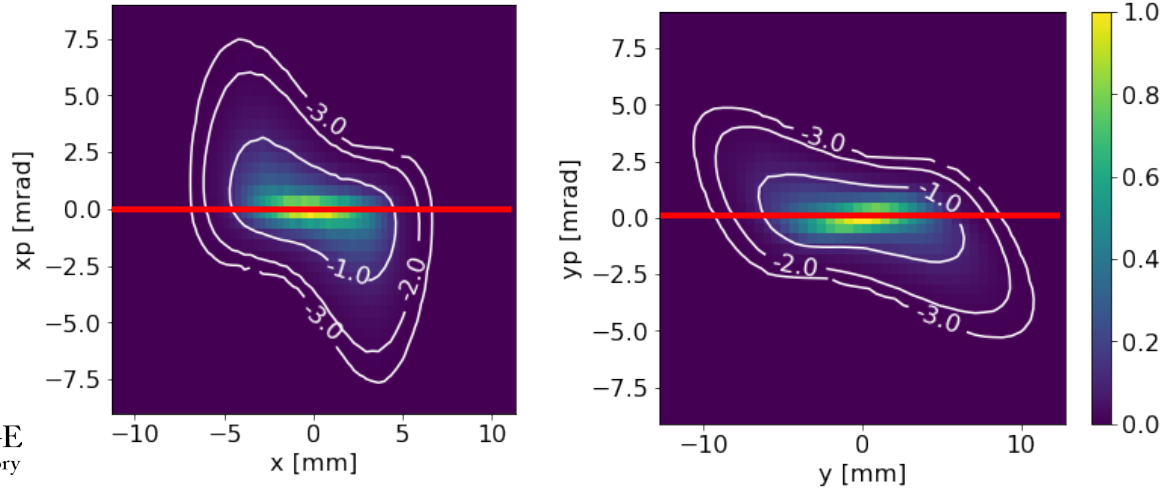

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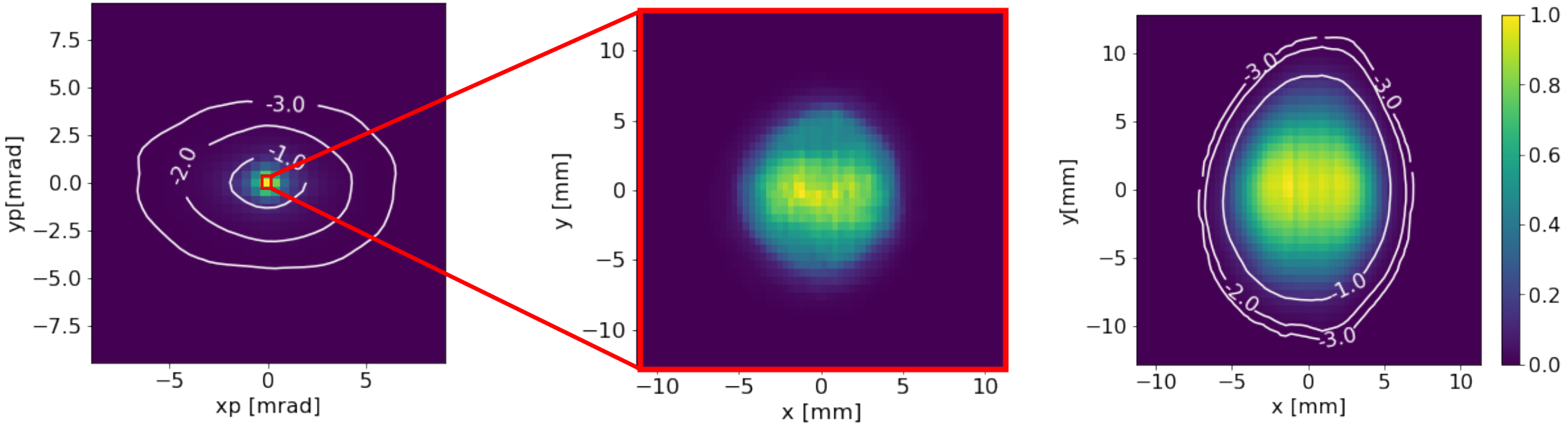
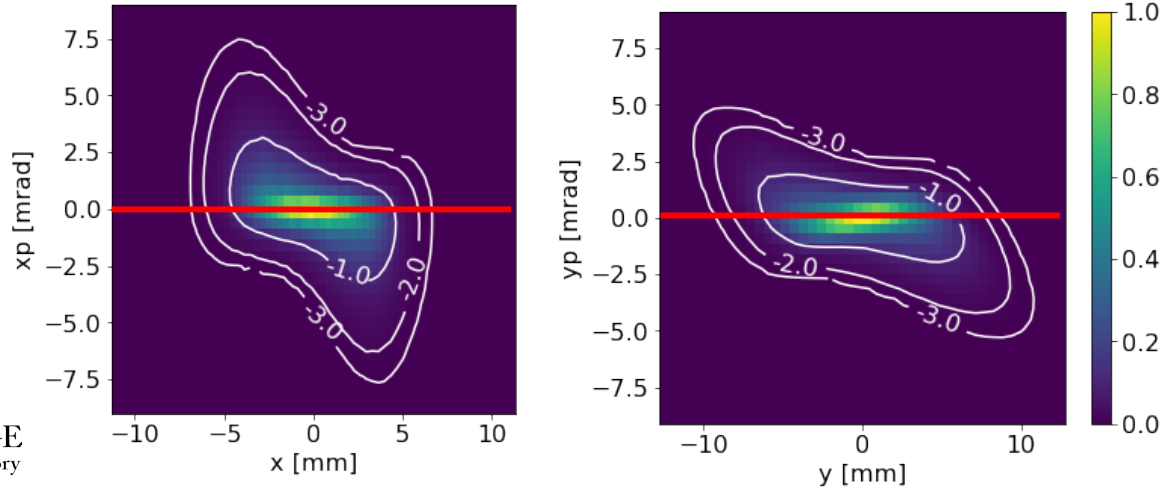
Observations of 4D distribution

Slice distribution

Full projection





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Observations of 4D distribution

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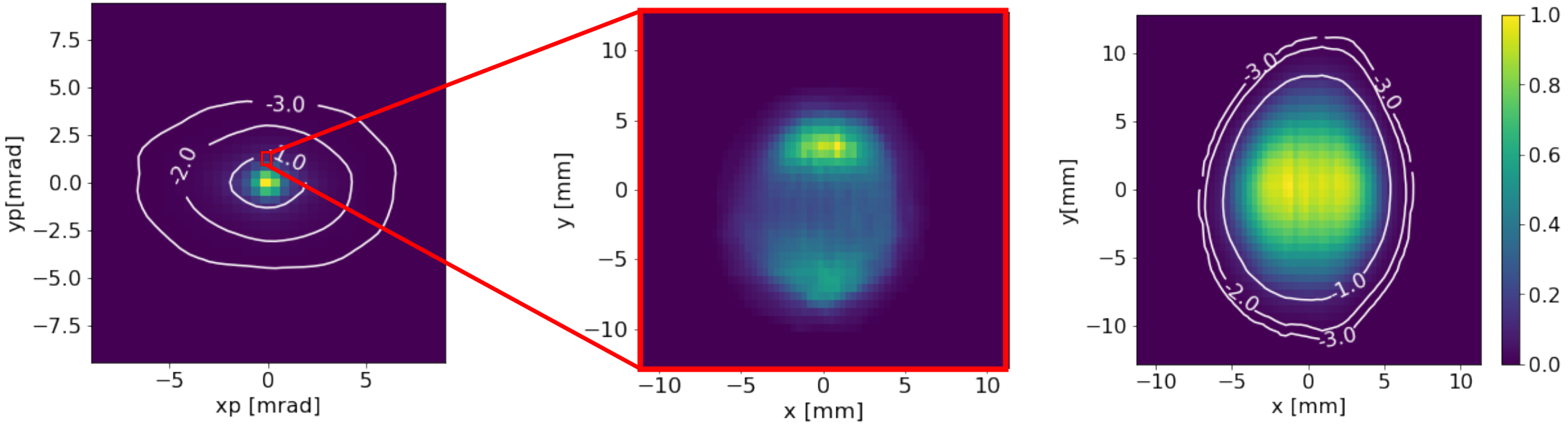

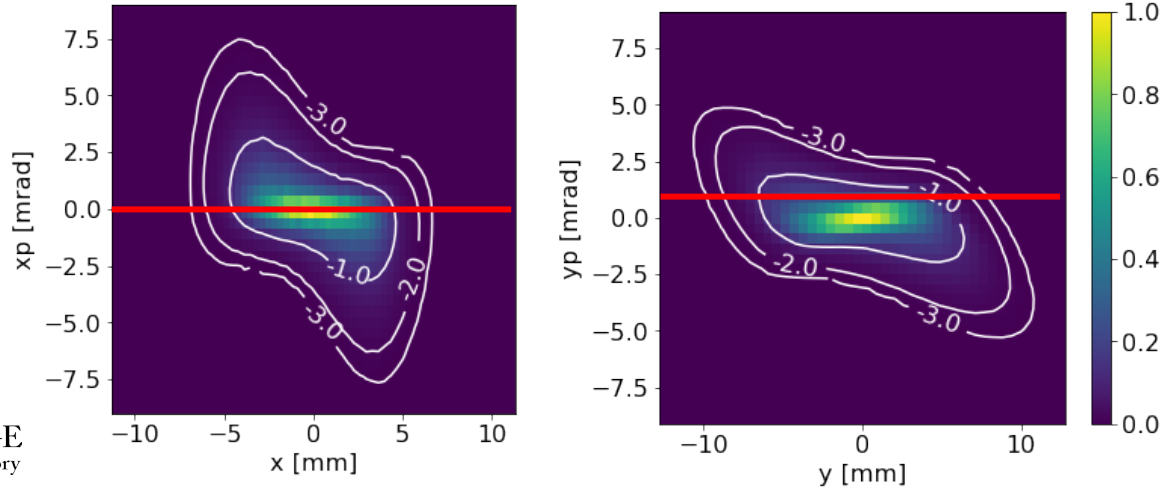

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Observations of 4D distribution

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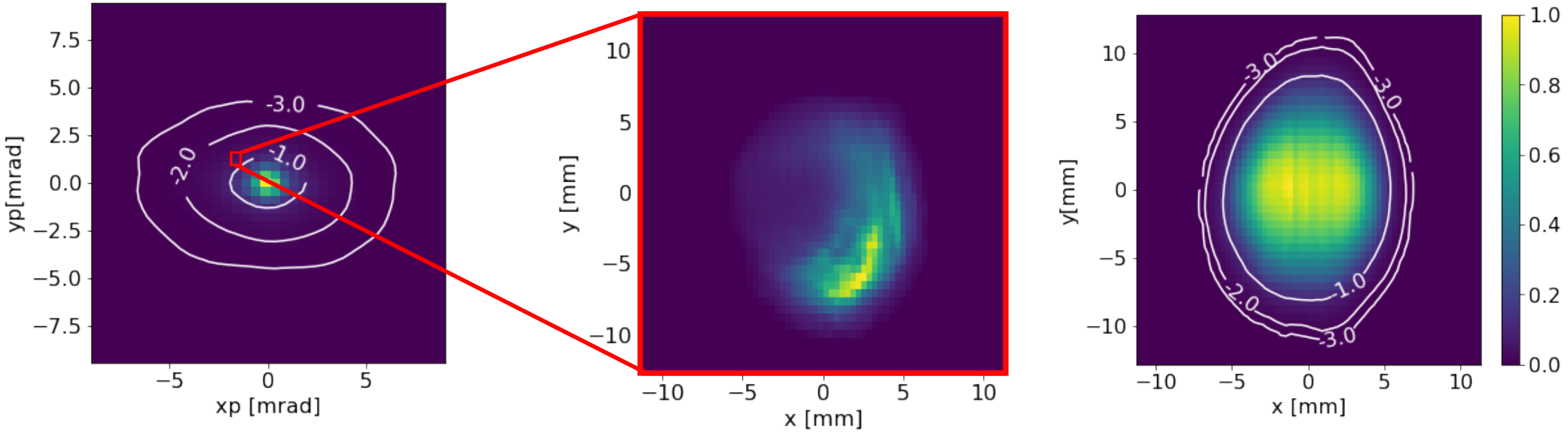

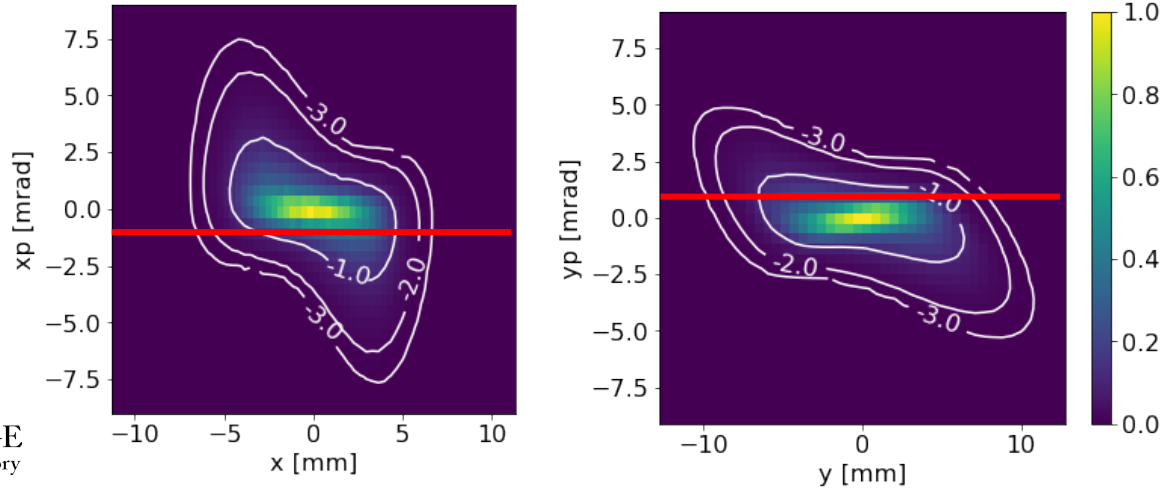

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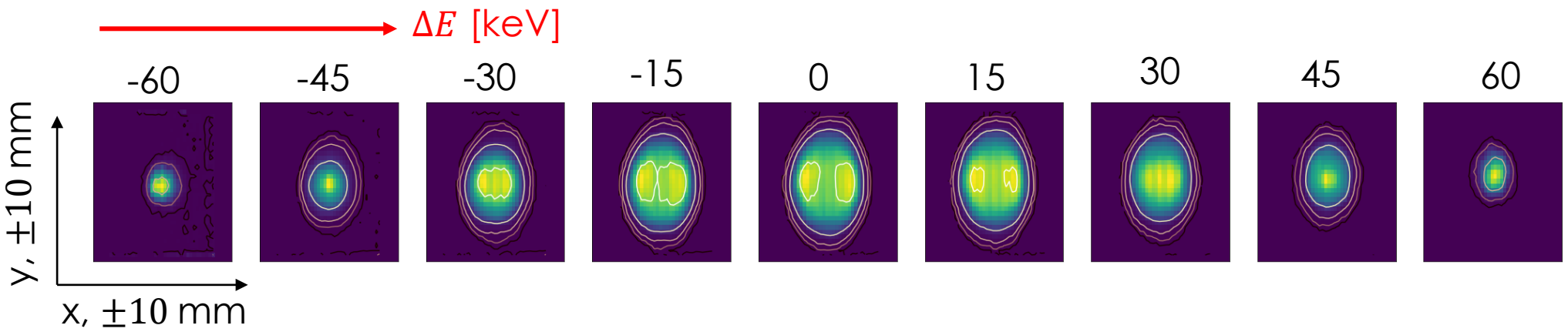

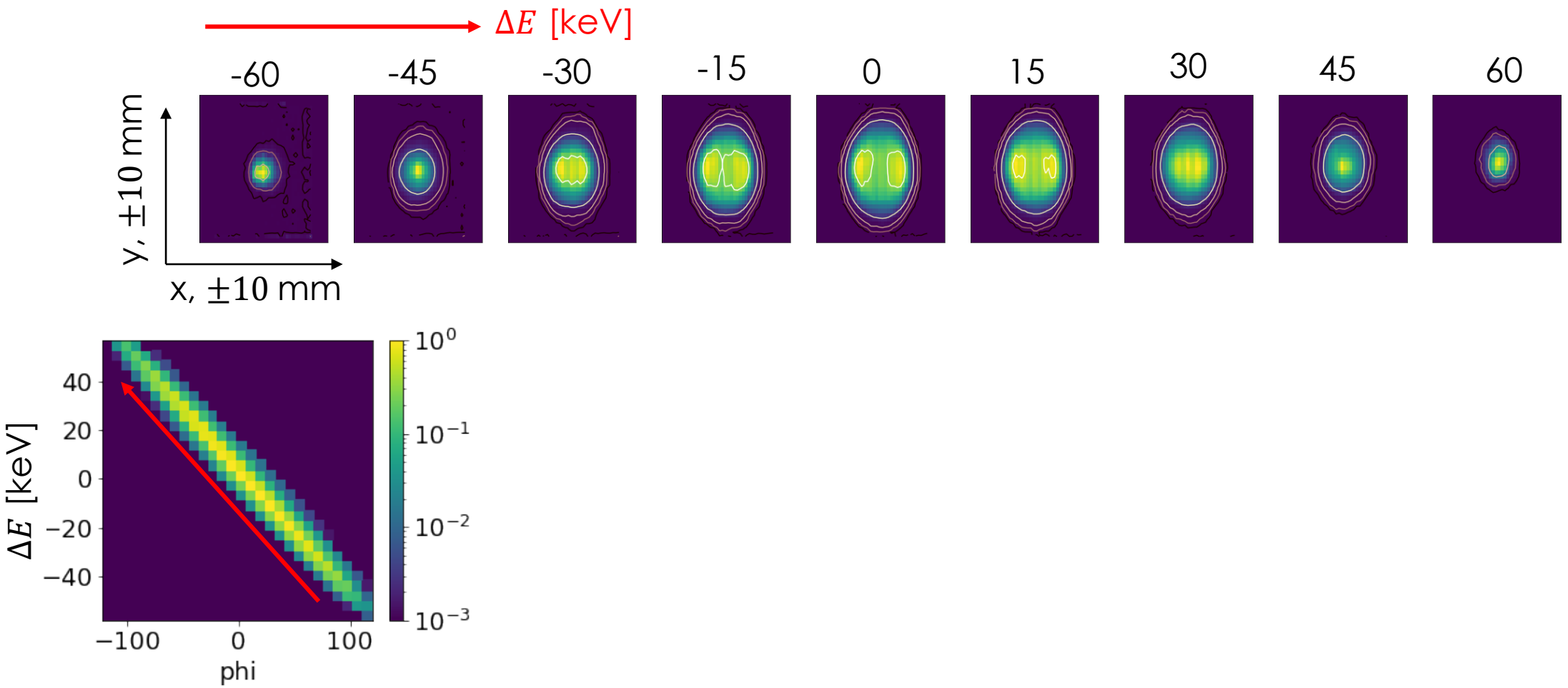

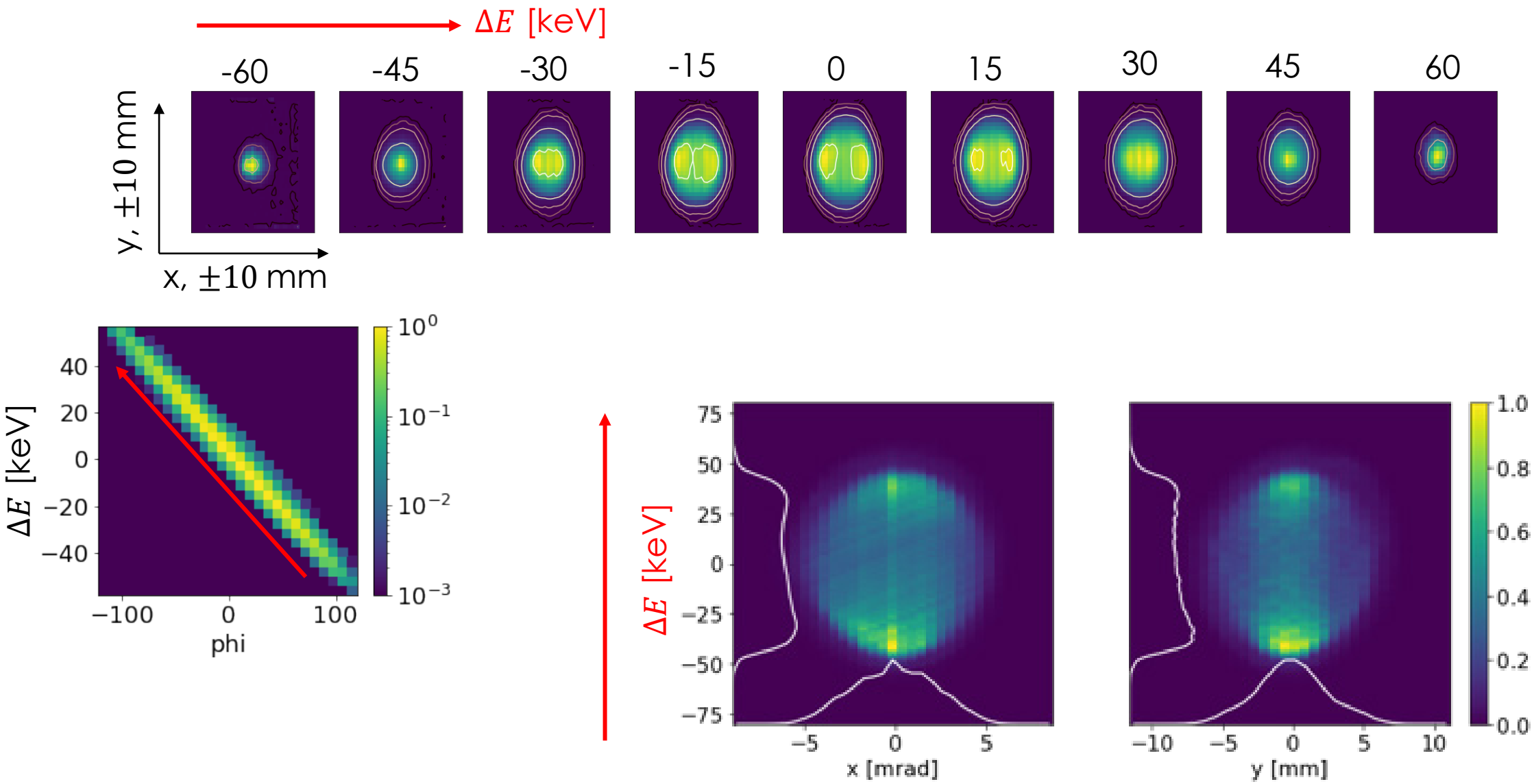

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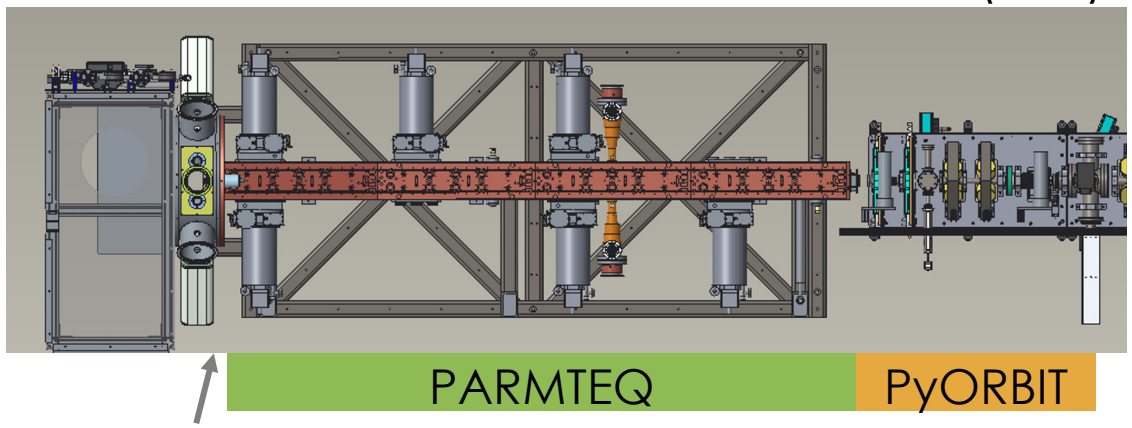
Previous work compared predicted and measured longitudinal distribution

LEBT: 50 mA

MEBT: 30 mA (~60%)
42 mA sim. (85%)



Measured x-x', y-y'

K. Ruisard, A. Aleksandrov, S. Cousineau, V. Tzoganis, A. Zhukov *PRAB (2020)*, doi: 10.1103/PhysRevAccelBeams.23.124201.

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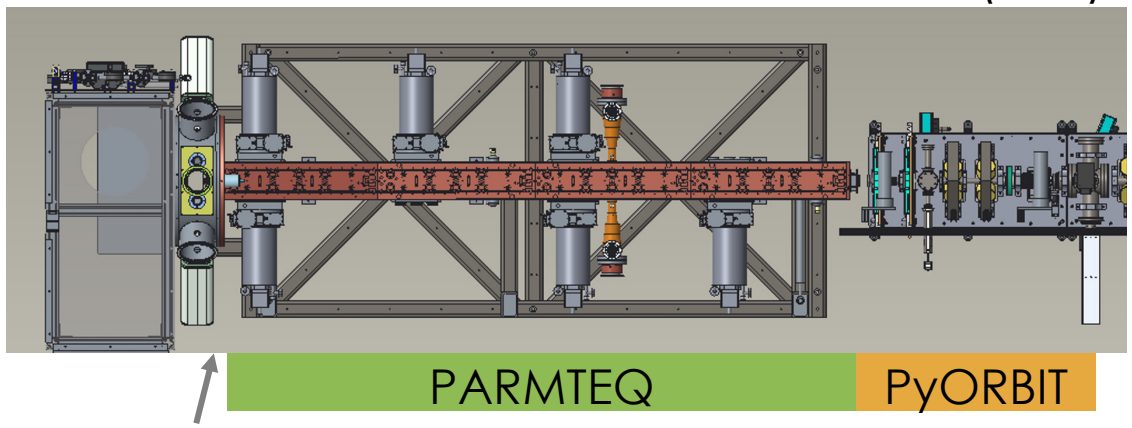
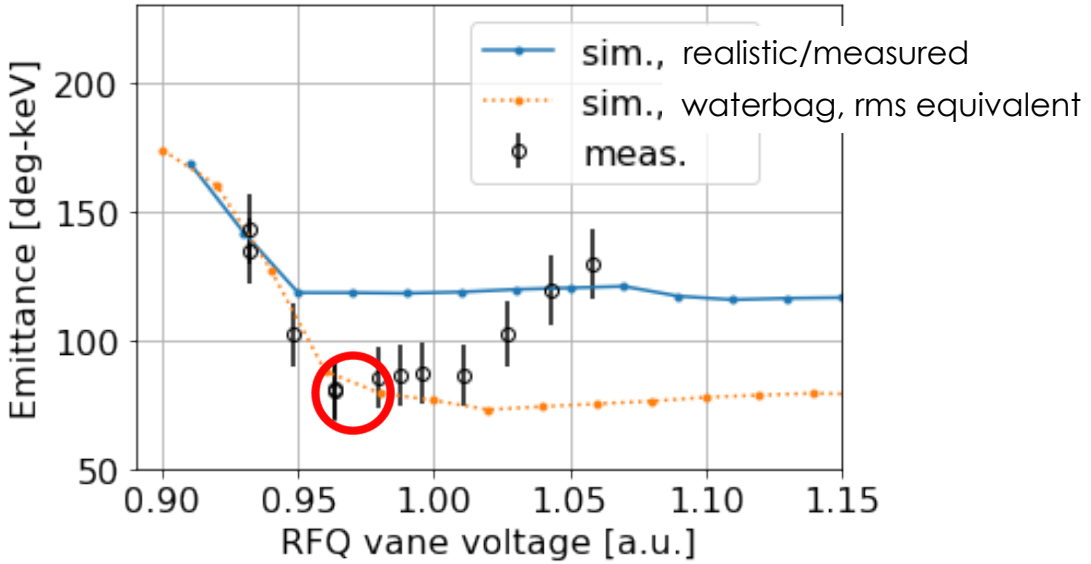


Measured x-x', y-y'

Measurement done at **25 mA** output current



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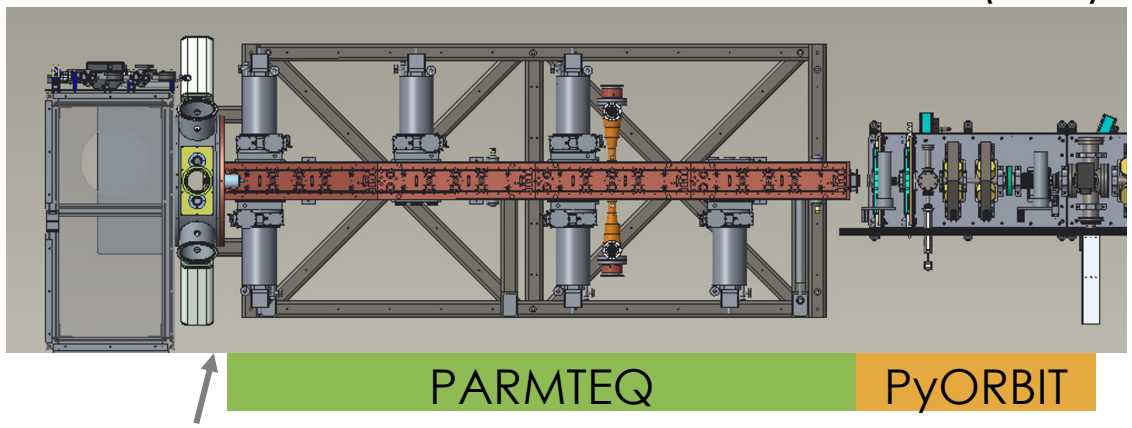

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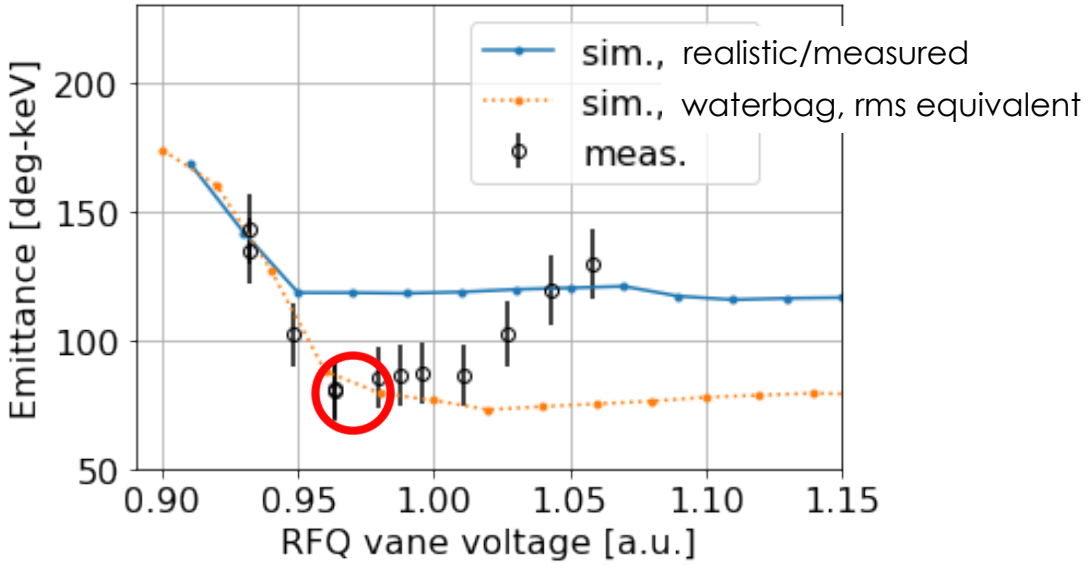
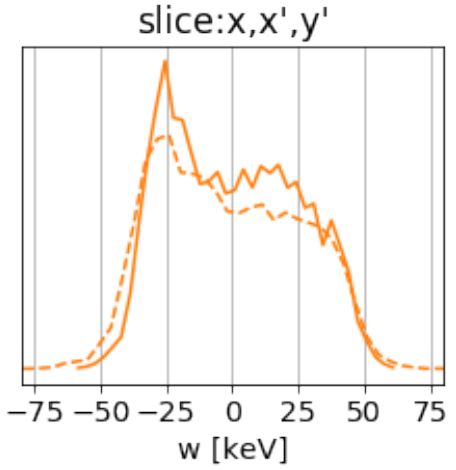


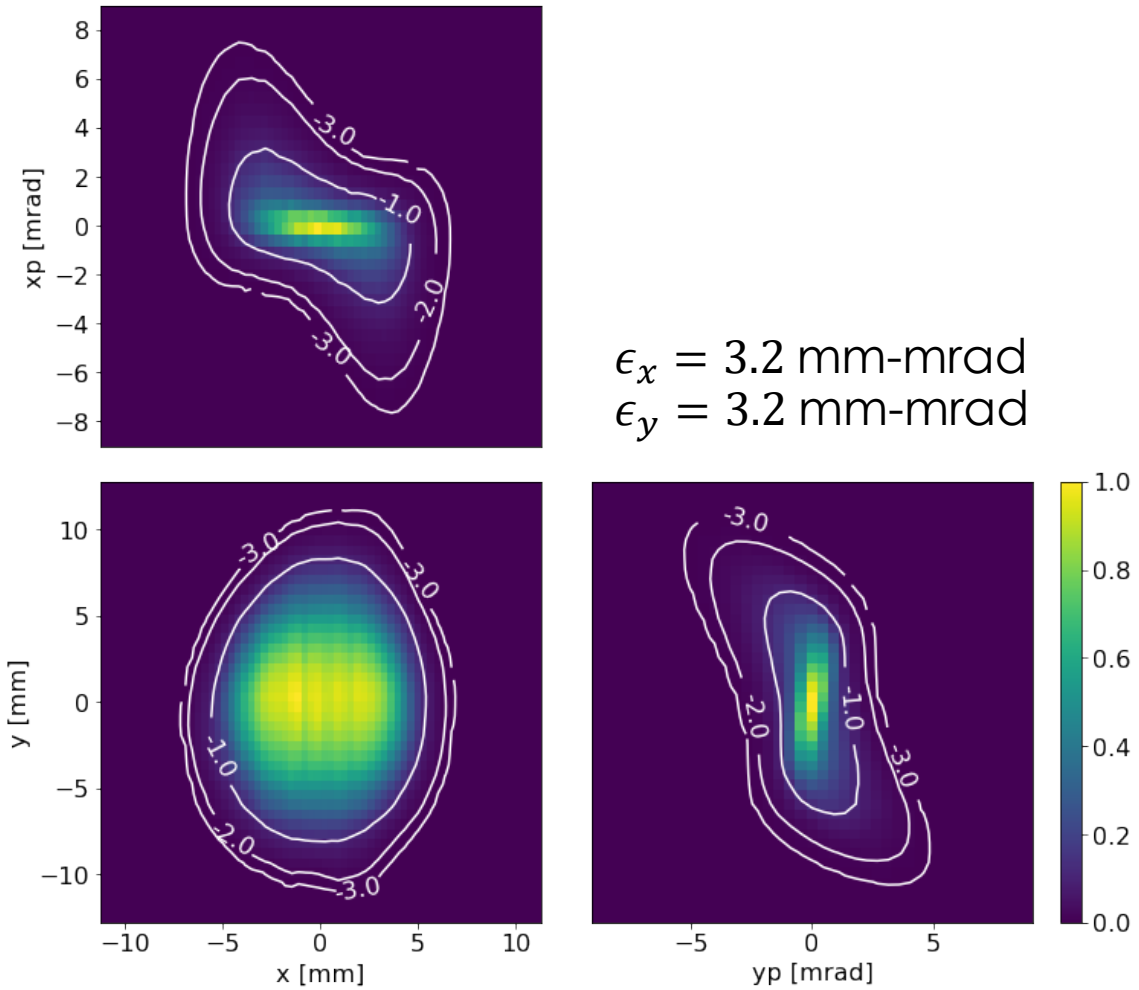


Solid: measured
Dashed: simulated

K. Ruisard, A. Aleksandrov, S. Cousineau, V. Tzoganis, A. Zhukov *PRAB (2020)*, doi: 10.1103/PhysRevAccelBeams.23.124201.

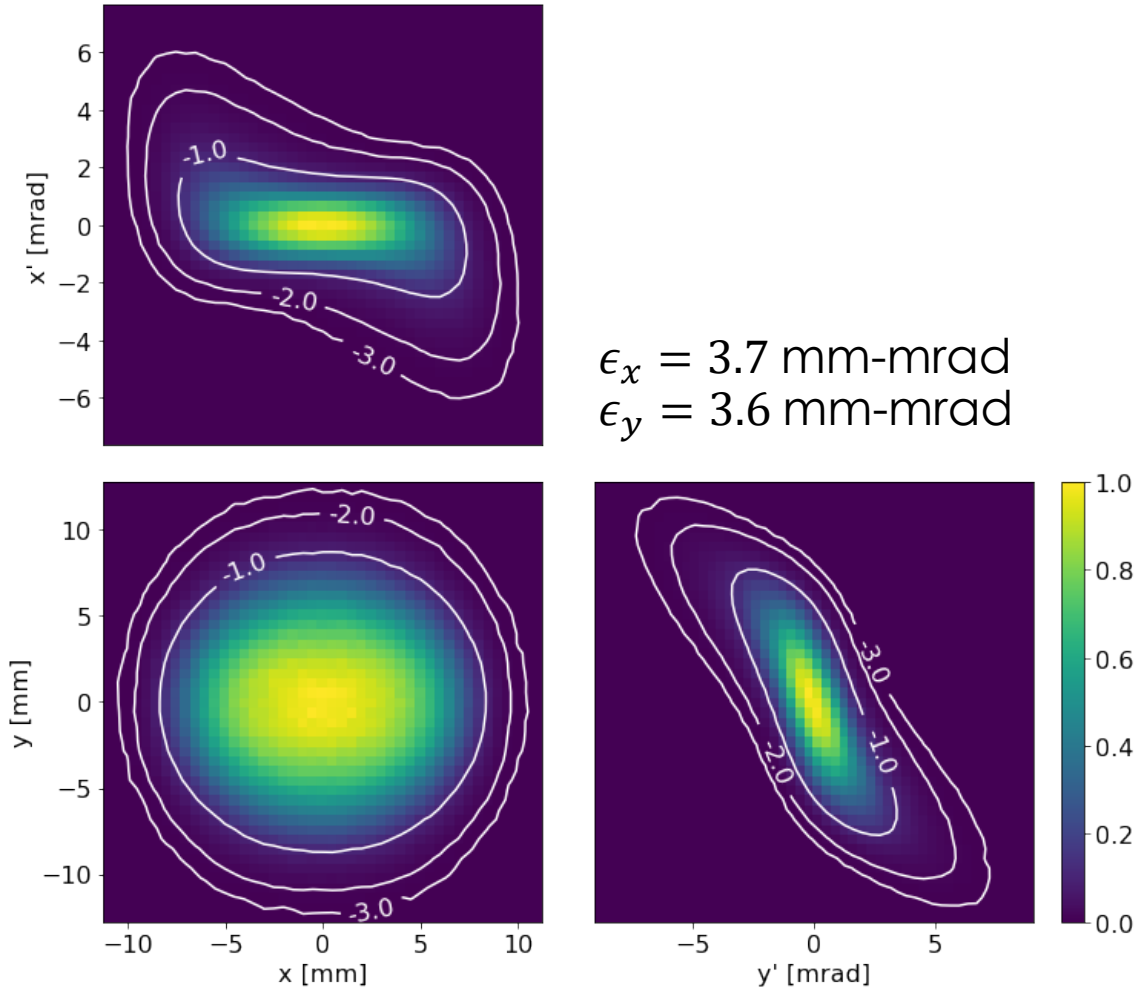
Full-projection show discrepancy

Measured



$\epsilon_x = 3.2$ mm-mrad
$\epsilon_y = 3.2$ mm-mrad

Simulated



$\epsilon_x = 3.7$ mm-mrad
$\epsilon_y = 3.6$ mm-mrad

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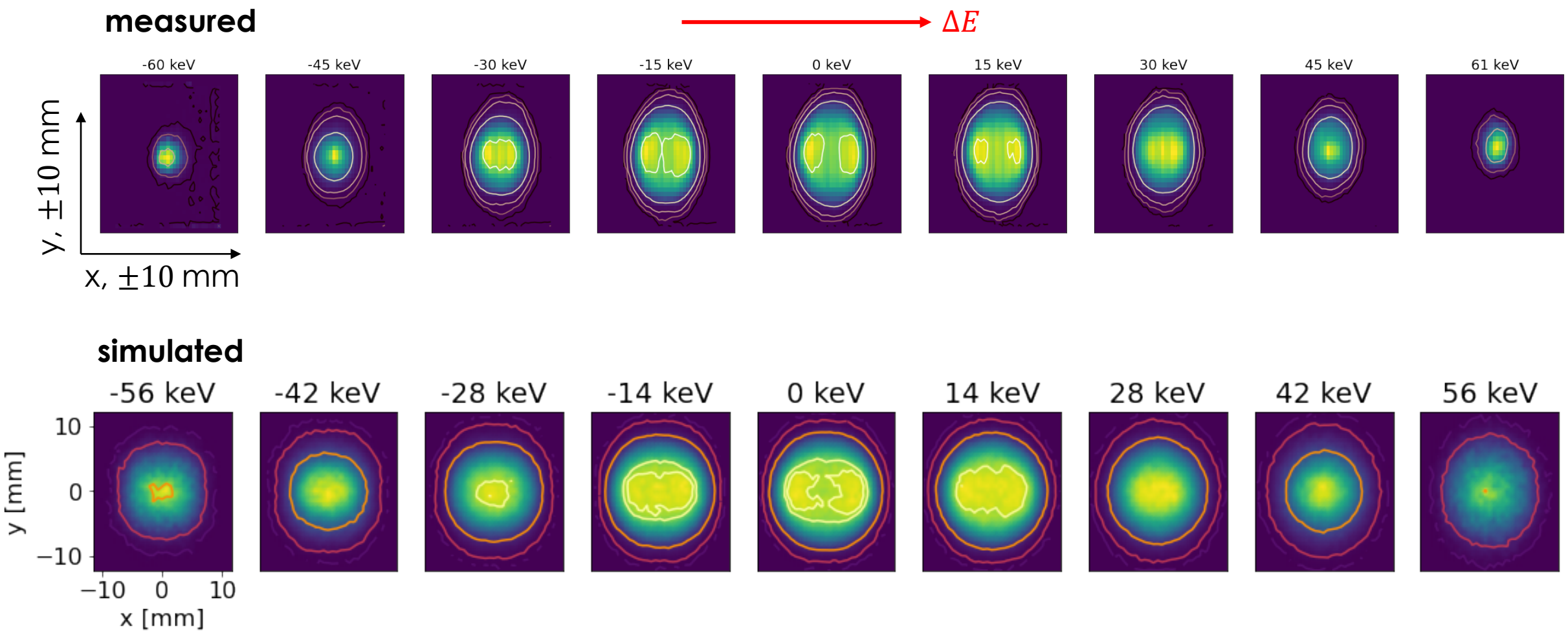
“Core hollowing” feature is reproduced in simulation



Summary

- SNS BTF project leverages **high-dimensional** measurement of **initial beam distribution** for improved predictive modeling
- Higher-resolution measurements reveal **additional transverse-longitudinal** correlation
  - dependence of the horizontal distribution on longitudinal energy coordinate
  - likely driven by space charge
  - Complementary to longitudinal-transverse correlation previously reported
- This dependence is predicted by PARMTEQ/PyOrbit simulation, although RMS parameters do not agree

A. Araujo, THXD3 on Thursday

A. Hoover, FRXD3 on Friday

Acknowledgements

This work benefited greatly from the support of SNS operations as well as the SNS Accelerator Physics and Beam Instrumentation groups.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of High Energy Physics