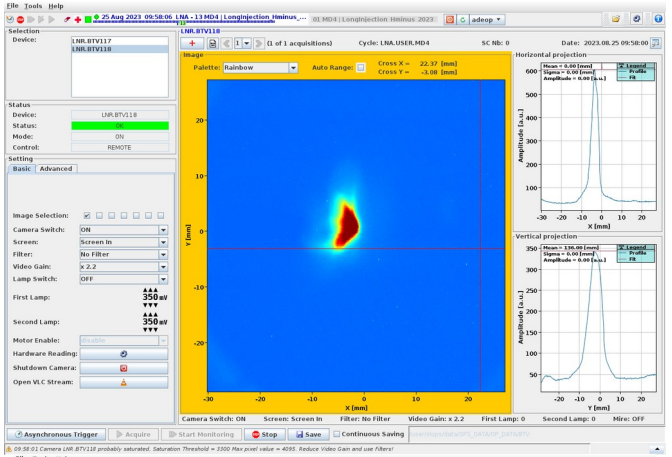
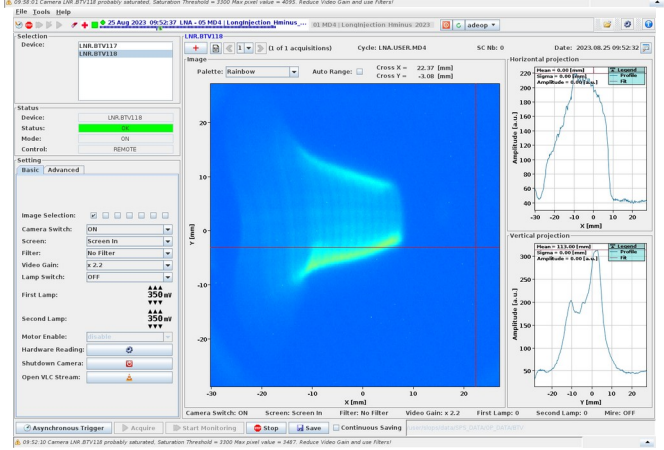
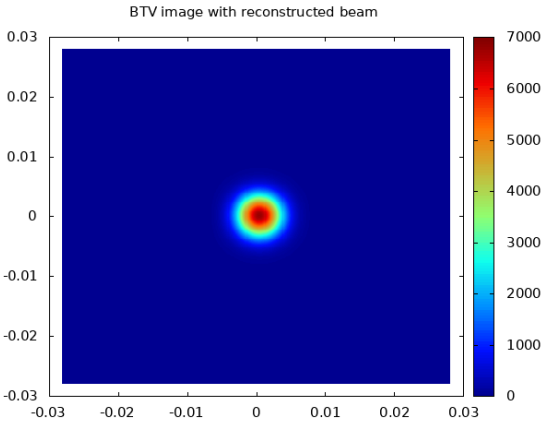
ELENA source characterization meeting 15/09/2023

Lajos Bojtar

Comparison of reconstructed image from tracking to measurement

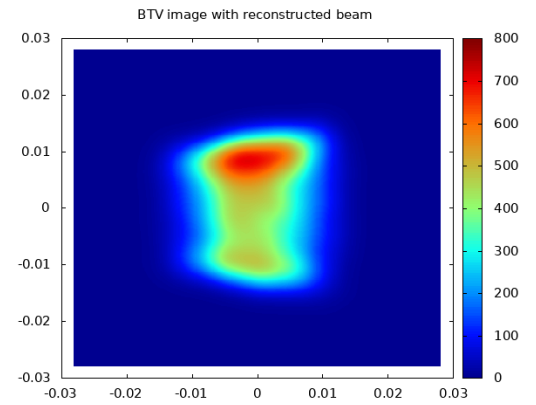






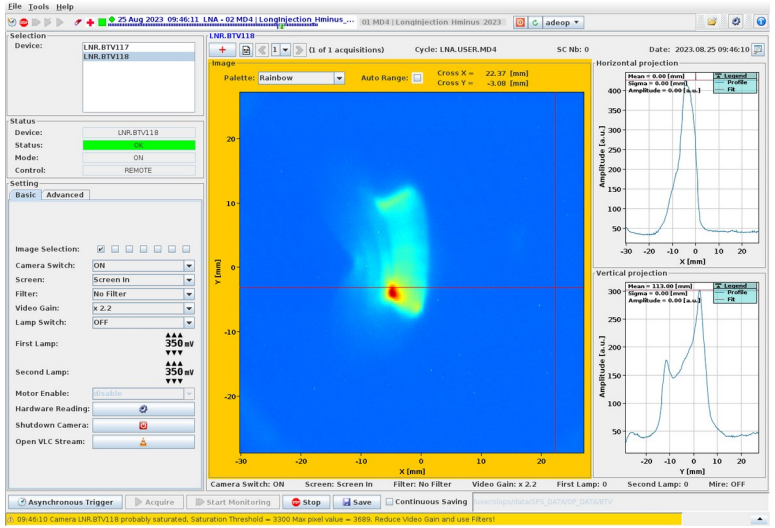
LNS.ZQMF.0020=1700 V

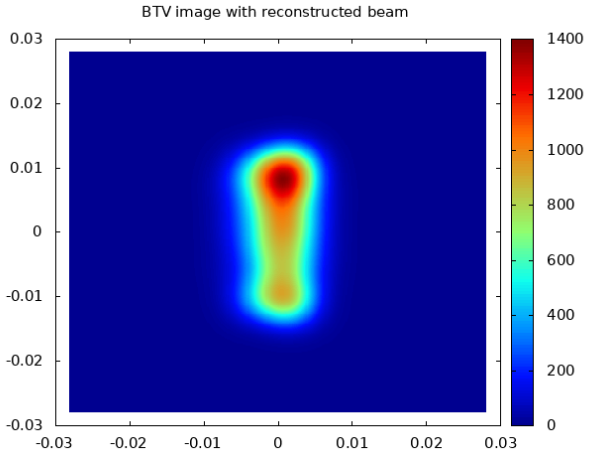
The images on the right was calculated by tracking 10000 particles and putting a Gaussian function with sigma=2 mm at the positions of each particle and adding them together to get a smooth distribution .



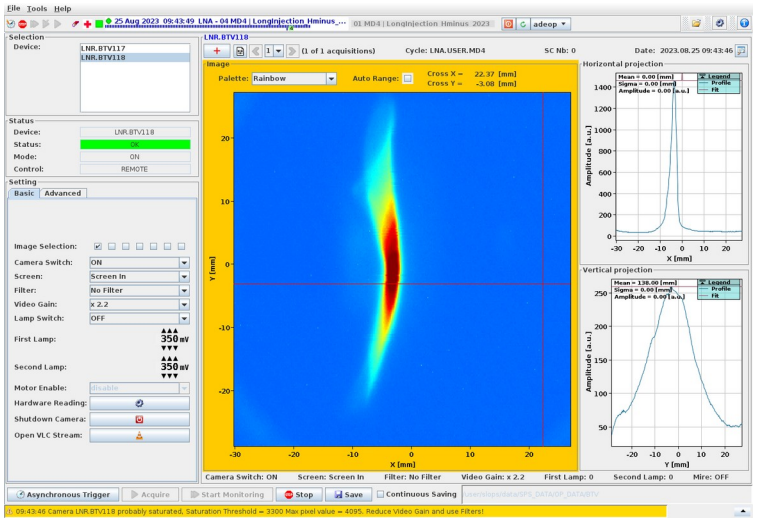
Inversion of left and right and up and down ?

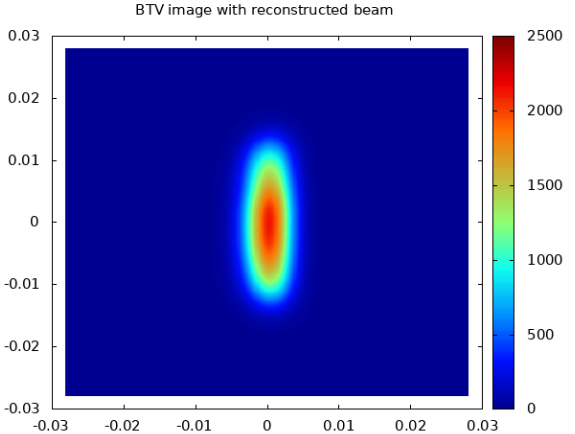
LNS.ZQMF.0020=2200 V



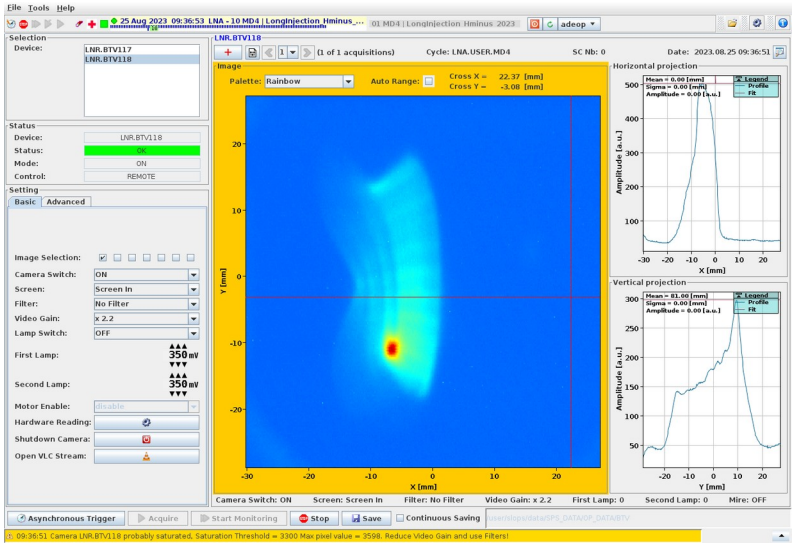


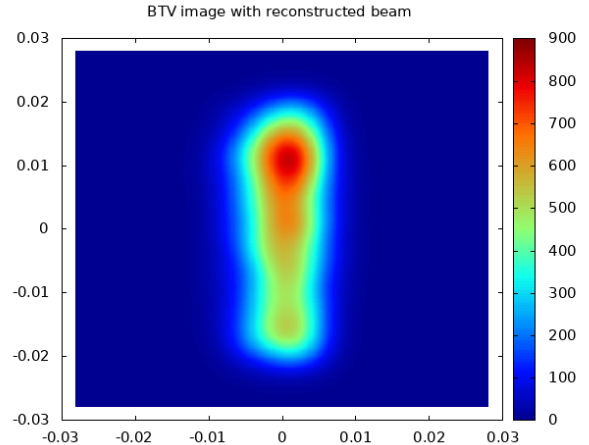
LNS.ZQMD.0021=900 V



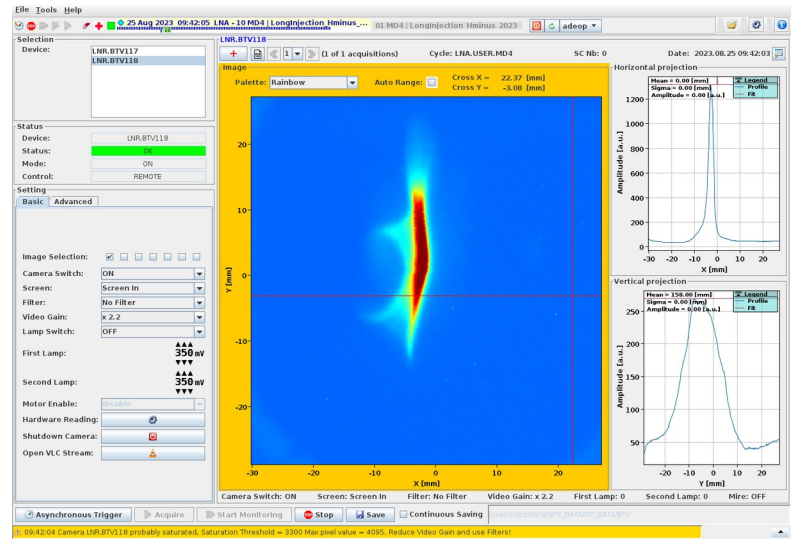


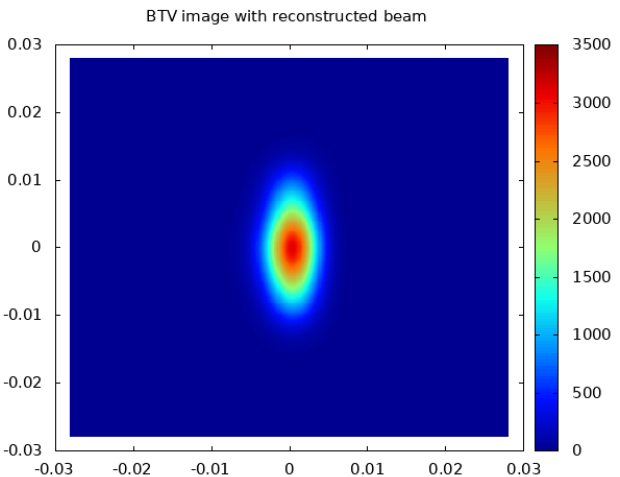
LNS.ZQMD.0021=1200 V



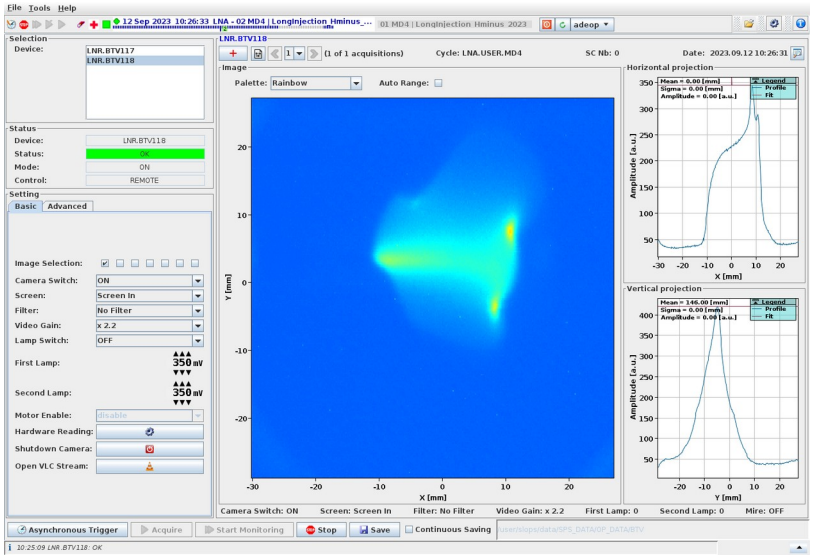


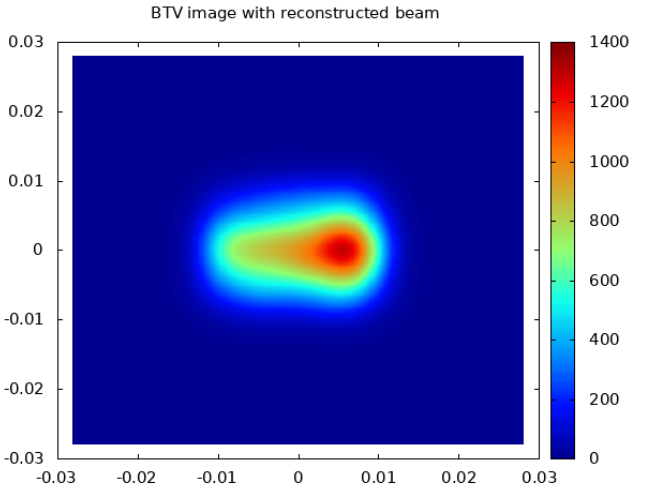
LNS.ZQMD.0050=1223 V



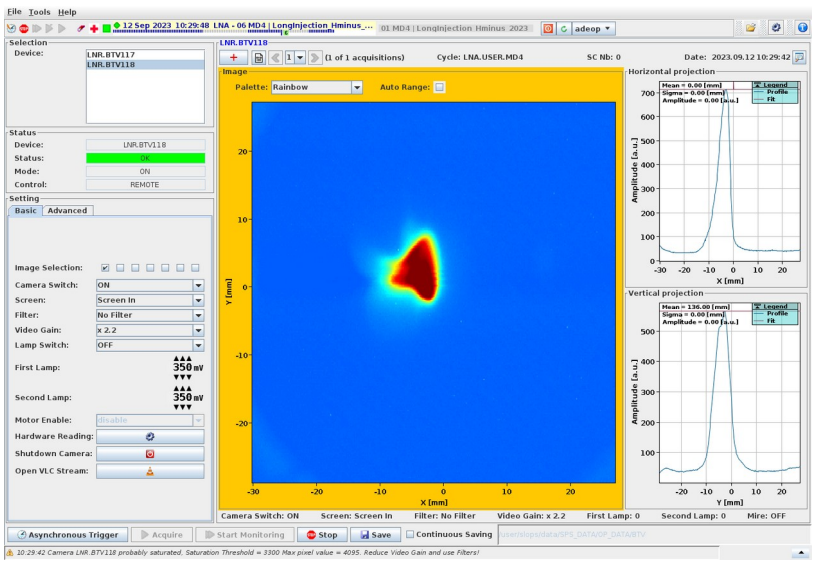


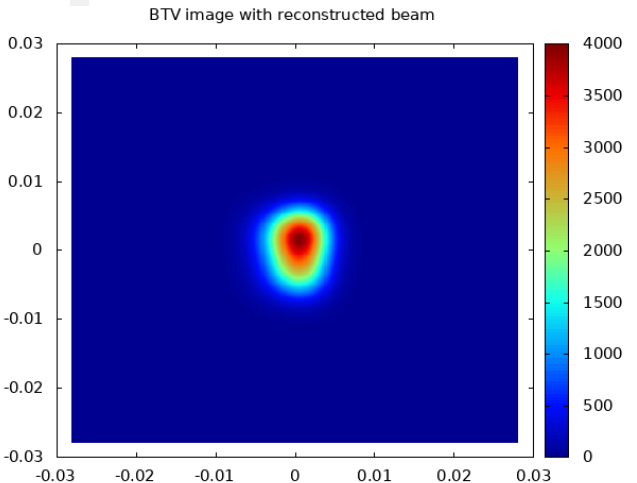
LNS.ZQMD.0050=1423 V





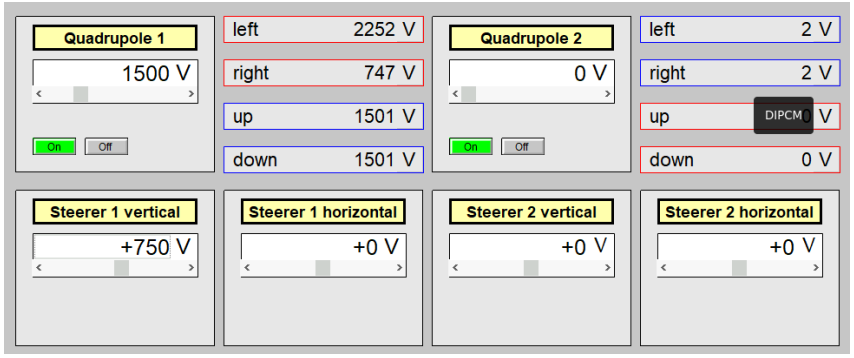
LNS.ZQMF.0051=1649 V

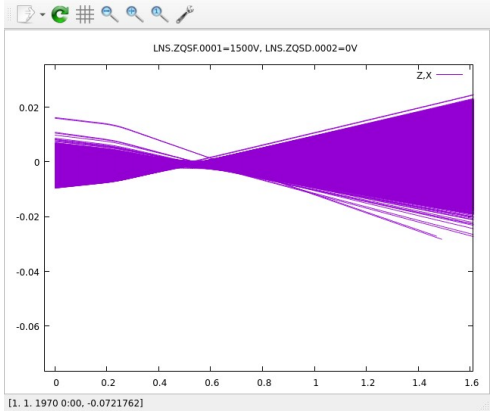


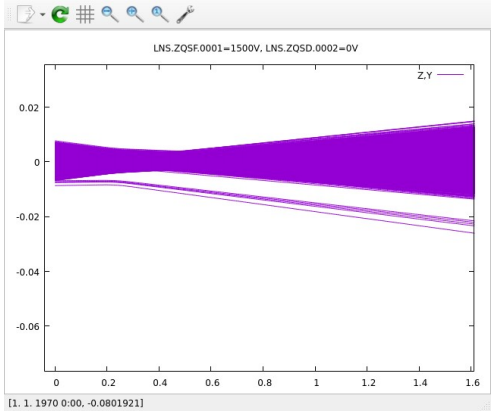


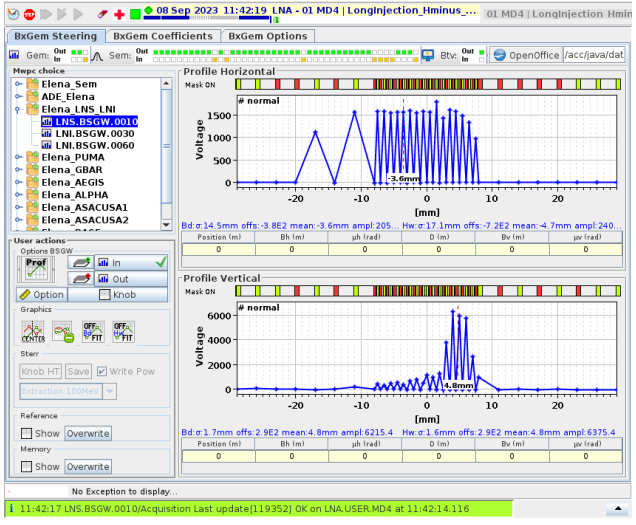
LNS.ZQMF.0051=1849 V

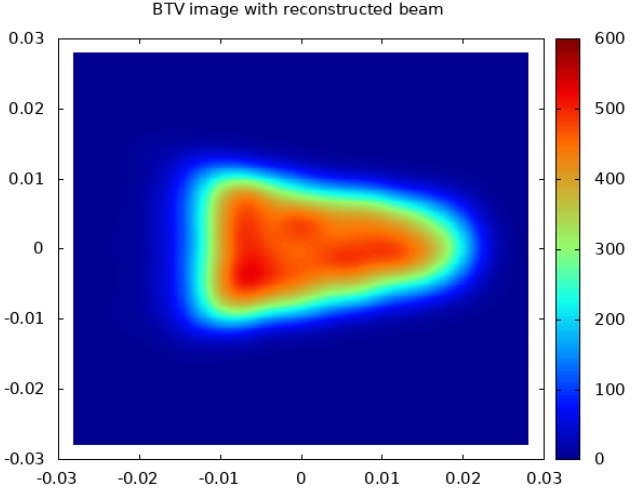
Voltage detection wires are messed up in the source, but this does not effected the results.



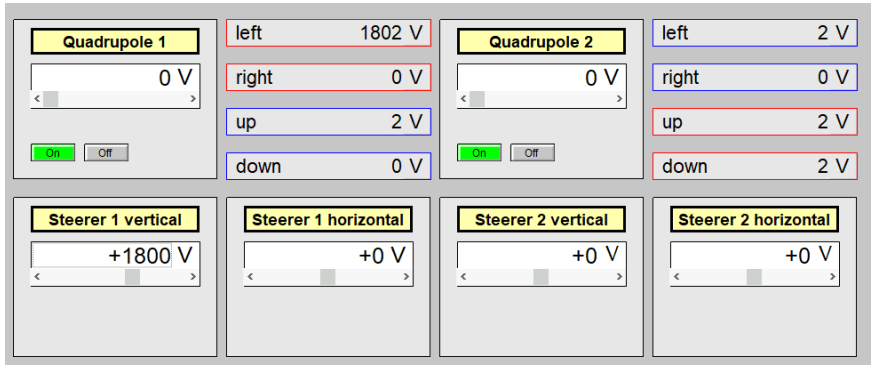


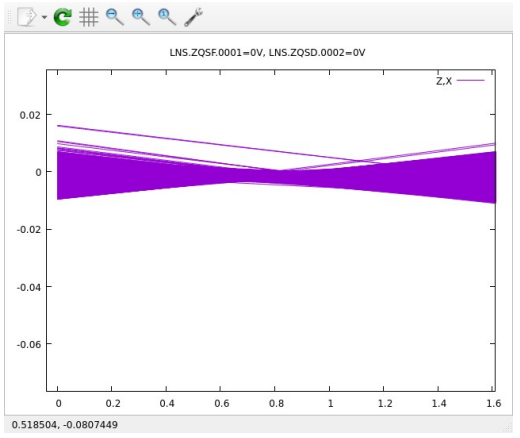


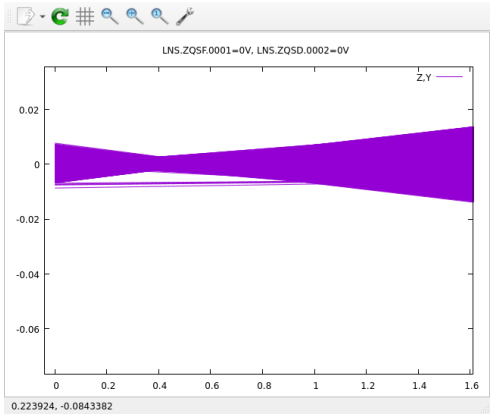


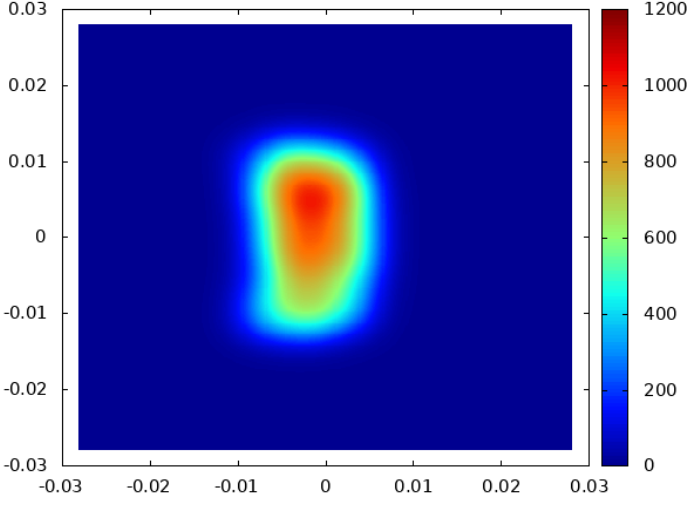


The reconstructed distribution on BSGW10 wire chamber is consistent with the measurement on the wire chamber with different quadrupole settings.

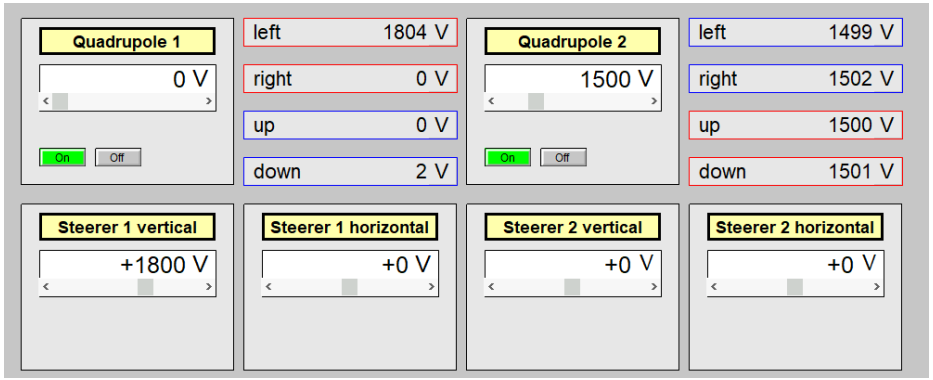


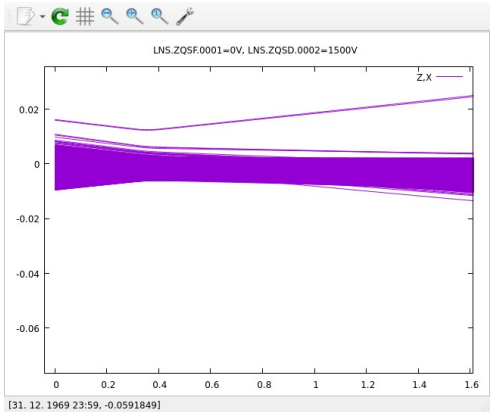


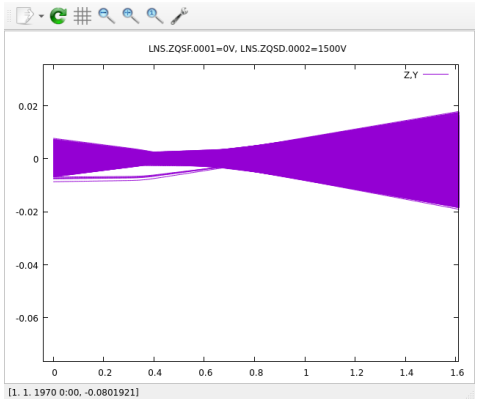


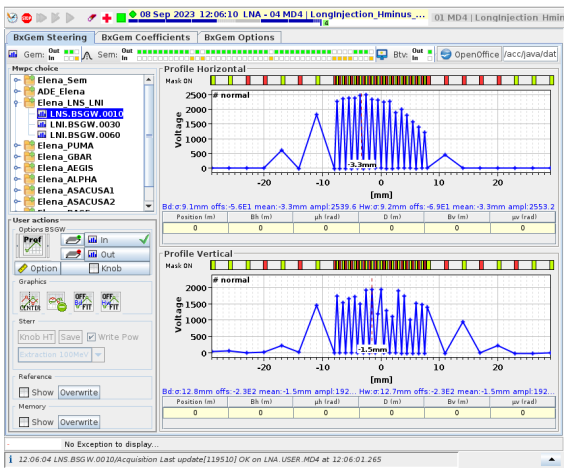


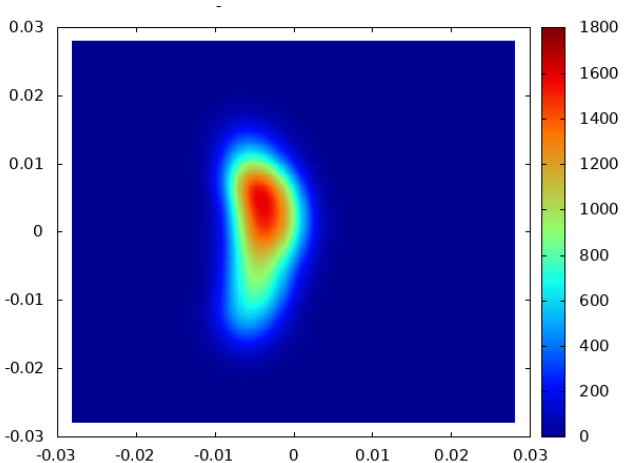
Both quads at 0 V, we see a deviation from the measurement. The beam in reality has the same size in both planes. This is expected since we did not reconstructed the real distribution, but only the part which got to the BTV118. This is consistent with the result got earlier that we loose in the H plane with the operational settings.











The second quad at 1500V we see again that the measurement shows a bigger beam in the H plane than the reconstruction.

Conclusions of the checking

- Large voltage on the first vertical source corrector is needed (+1800 V) to center the beam on BSGW.10. It means the beam comes out of the source with 25 mrad vertical angle. This is not included in the tracking (I can, but have no benefit..)
- A positive voltage on the vertical corrector moves the beam in the negative Y direction(downward). Is this an inversion in the wire chamber or on the corrector ?
- It seems there is an inversion of directions either in the reconstructed distribution or the BTV.
- The model of the beam line seems to be quite accurate, behaves as expected .
- The reconstructed distribution is reasonably good. We can not expect to have exactly the same image obtained from the tracking as on the BTV when there are losses. I showed during the previous meeting that the beam line have limitations in the horizontal plane.
- There is a cabling issue in the source of the voltage detection an both quads. This does not effected the results.

Matching the source to the ring

- Implemented matching in SIMPA.
- Two algorithms are available at the moment:

  - BOBYQA a local optimization algorithm. Faster, but can be stuck into a local minimum.

  - CMA-ES is a state of the are genetic algorithm, explores the whole search space if the parameters are set so. More likely to find global minimum, but slower.

  - Both can handle constraints, like power supply limits.
- Took the Twiss parameters obtained from back tracking Vittorio’s reconstructed distribution.
- Used the CMA-ES algorithm with all 6 quads to match 5 parameters (alphas, betas and dispersion) + 6 power supply limits on the quads. Aperture constraints are automatically taken into account by giving a very high value to the objective function when particles are lost. This matching problem may or may not have solution !
- The matching did not converge perfectly, but found a solution quite close to it.

Matching result

Value of variables: LNS.ZQSF.0001_38.bin = 1399.6052302554858 LNS.ZQSD.0002_38.bin = 2509.9012680084556 LNS.ZQMF.0020_38.bin = 2597.550014637519
LNS.ZQMD.0021_38.bin = 1855.4192548466883 LNS.ZQMD.0050_38.bin = 0.0 LNS.ZQMF.0051_38.bin = 1028.7303872155314

H_BETA target= 1.865 actual value= 1.864999542412393

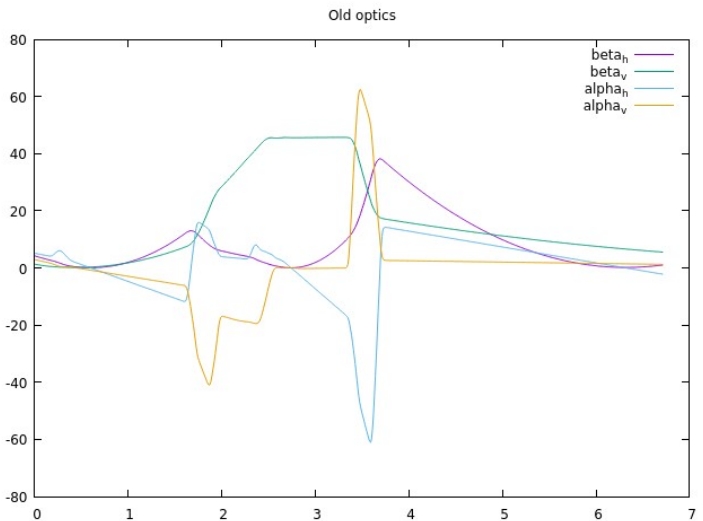
V_BETA target= 2.218 actual value= 2.1269588675834337

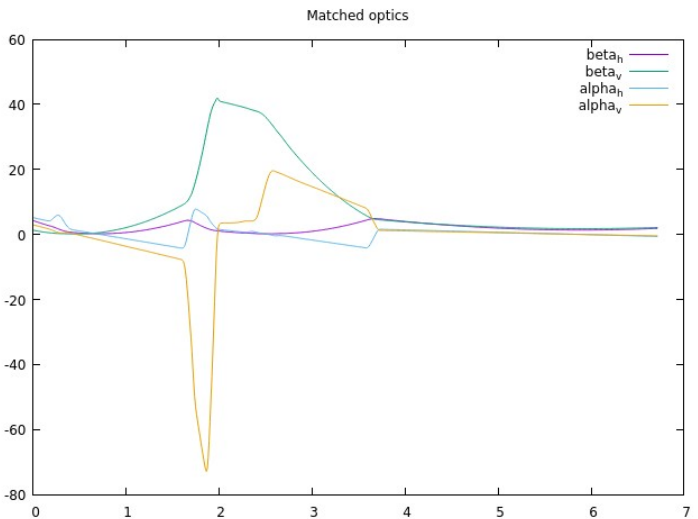
H_ALPHA target= -0.6086 actual value= -0.6085993752965245

V_ALPHA target= -0.4487 actual value= -0.4486999778161012

H_DISPERSION target= 0.26137 actual value= 0.2615060512283499

RESIDUAL = 0.09117828811989742





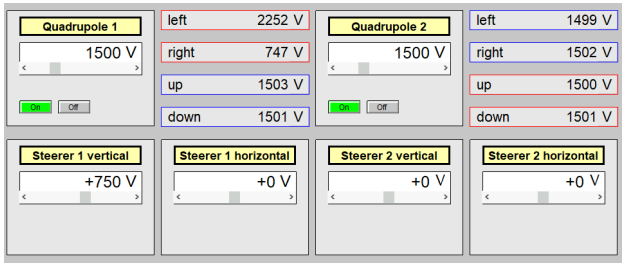
Putting the new optics into practice

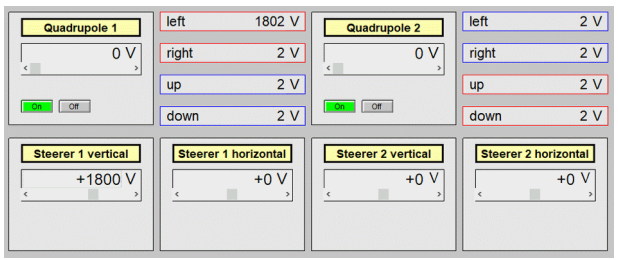
- Despite several days of trying, I did not manage keeping more beam in ELENA with the new settings.
- Its hard to beat years of empirical optimization.
- Matching maybe does not make much sense when the distribution is very far from the Gaussian as in our case.
- The coherent oscillations at injection wasn’t well compensated (Bertrand is away and the software has a half finished modification, can’t be used at the moment)

Gaining intensity differently

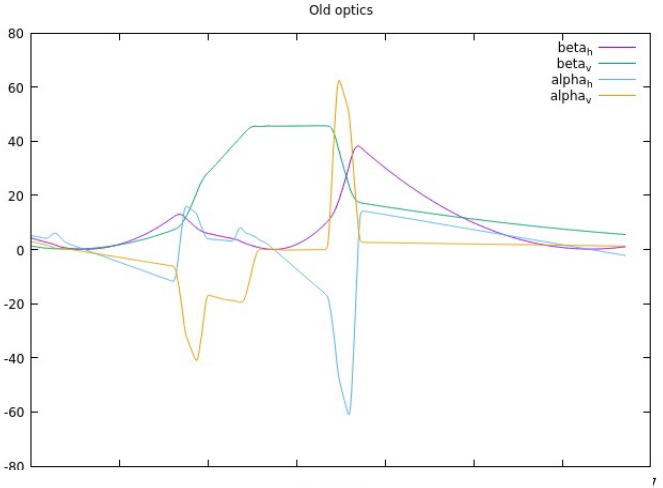
- The analysis up to now however showed quite convincingly that the current operational settings lead to losses in the horizontal plane.
- Tried to estimate and optimize the intensity on the LNI.BSGWA.0010
- To center the beam in the vertical plane the first source corrector needs +1800V. This deflects the beam 25 mrad down.
- Moving the beam in the horizontal plane seems to select different part of a wide horizontal distribution. Zero volt seems to be the best.
- Got best intensity on LNI.BSGWA.0010 and in the ELENA ring is with both quads and all correctors at 0V except the first vertical corrector witch is at +1800V.
- Kept everything else in the LNS and LNI line at the same value.
- Based on a statistics of about 20 shots the injected intensity is 36% higher. The ejected intensity is 11 % higher. Maybe the coherent oscillations at injection can be improved.

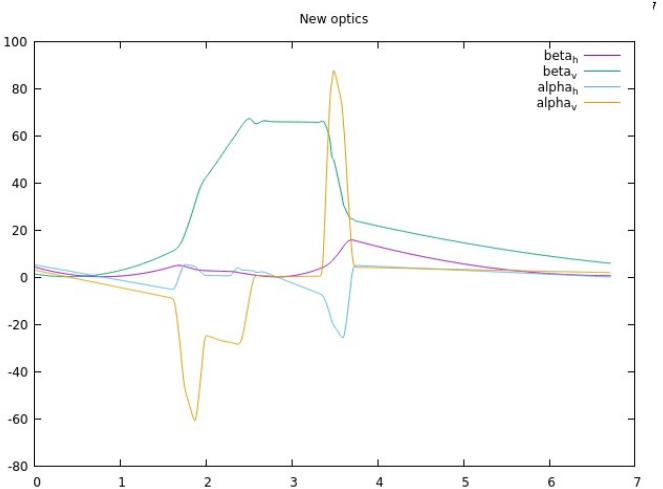
Comparing the old and new settings

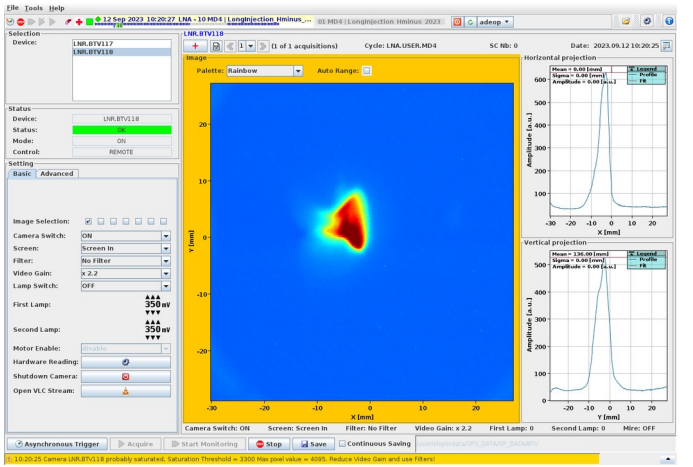


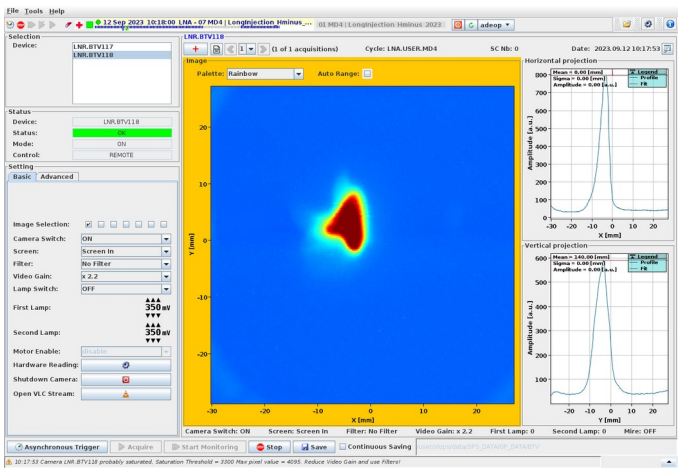


Beta functions at the BTV118 are very similar, but in the hor. beta peaks of the new settings are smaller and this makes the difference in losses.









Conclusions

- We have a reasonably good estimate of the source beam distribution, but this has been reconstructed with an optics which has at least 36 % losses.
- Should we repeat the procedure with the new optics ?
- The procedure of my part is fully automated, so the effort needed for the analysis is modest.
- Is that the case also for Vittorio ?
- We need to put the BTV118 in the LNI line, so the measurement part might not be fully automatic, unless we get a dedicated beam time. Alternatively, I can do the measurement shot by shot manually and parasitically during pbar physics.

With old settings

With new settings