Slice emittance measurement at TTF -Introduction-

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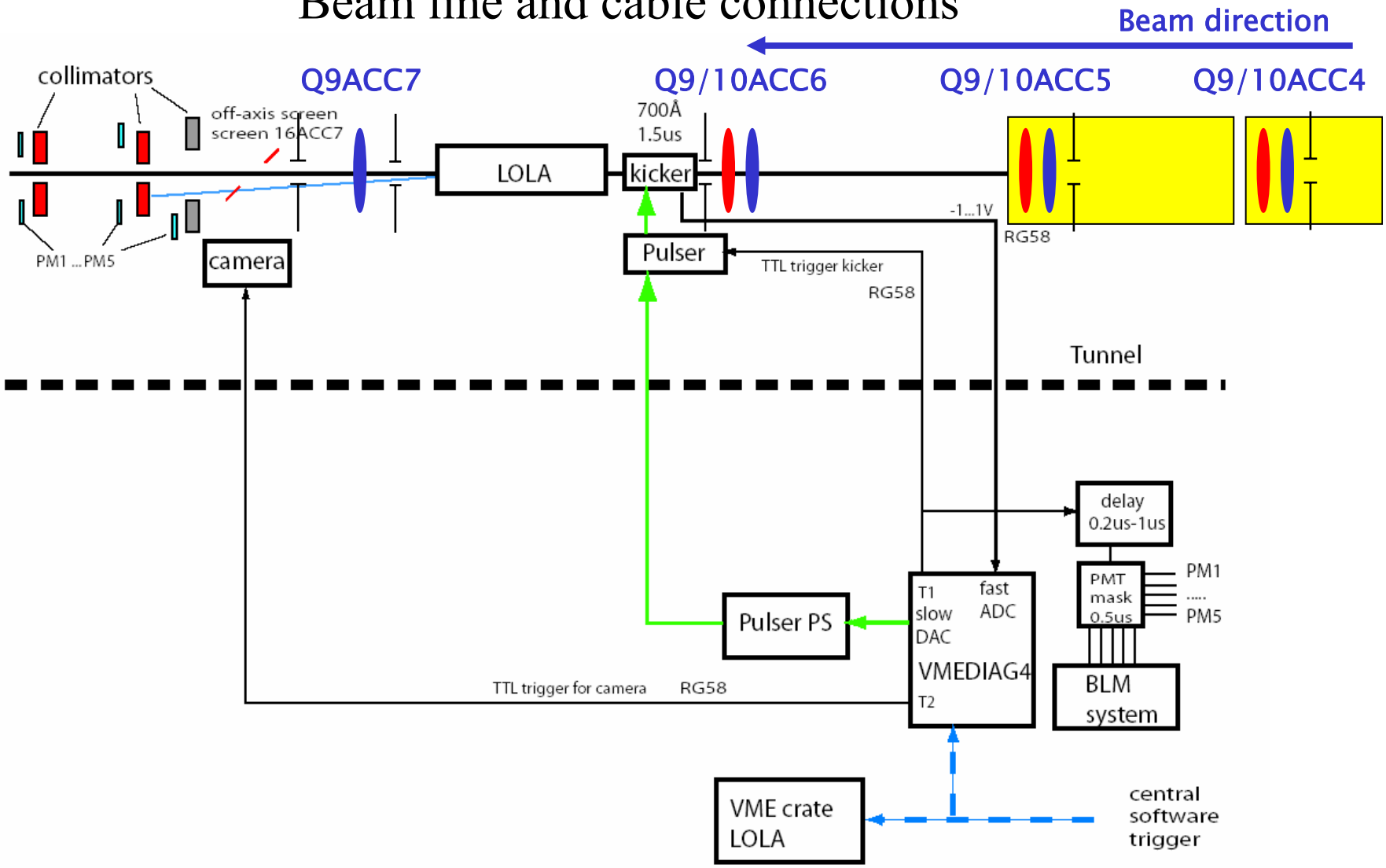
- **overview 'LOLA upgrade'**
- **program/done**
  - **machine setup**
  - **calibration of LOLA streak**
  - **complete data base in DOOCS for quads**
  - **calibration of BPMs (ACC4-ACC7)**
  - **measurement of transfer function**
  - **BC2 and BC3 emittance measurements (+ matching)**
  - **check of multi-knob for slice emittance phase space tomography**
  - **quad scan for x slice emittance + results (Michael Röhrs)**
  - **y-z tomography measurement**

Upgrade for LOLA

Beam line and cable connections

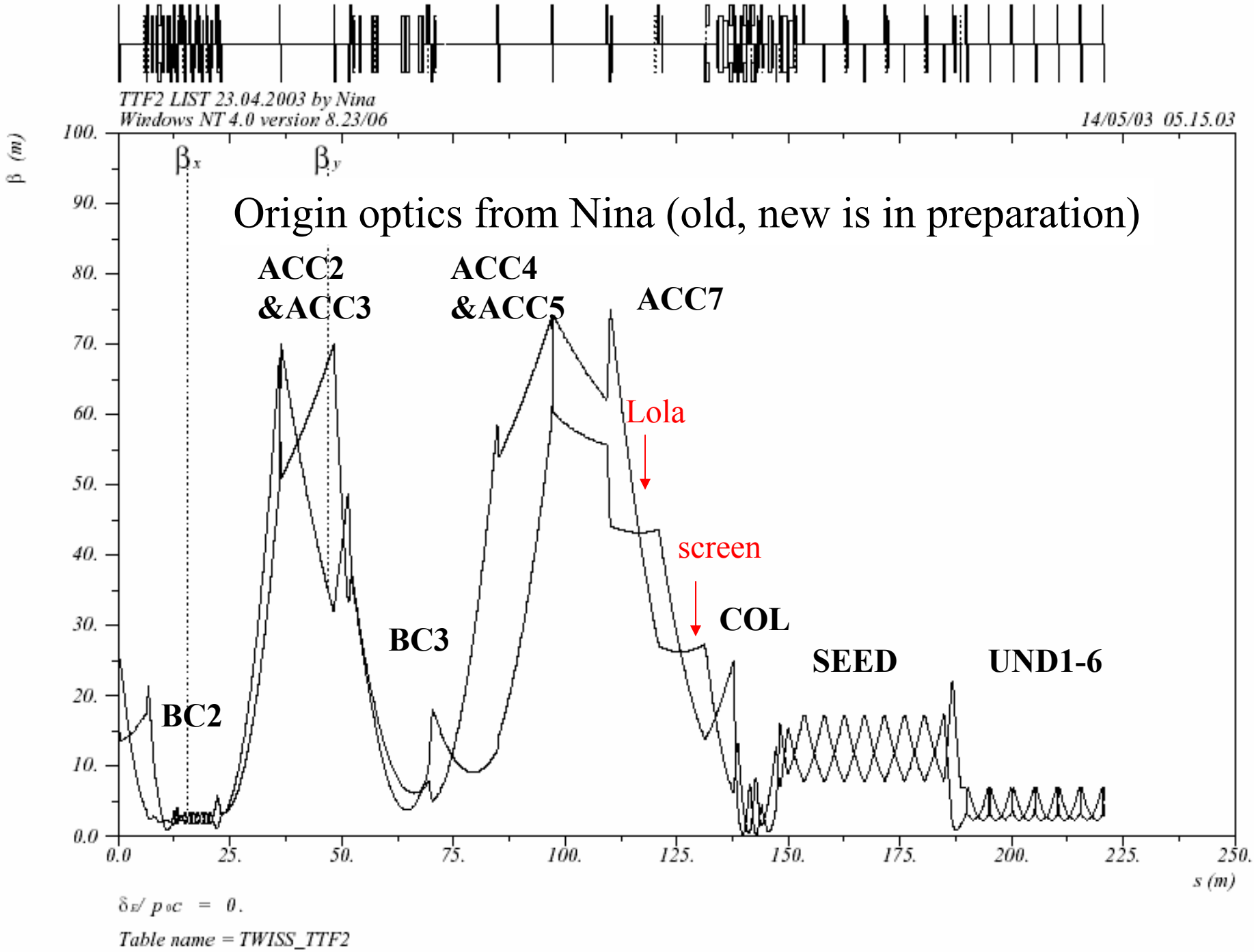


Upgrade for LOLA

Devices added to beam line:

- fast strip-line kicker
  - integral field — $B \cdot L \approx 3.8$ mT m @ I = 1000 A*
  - duration — ΔT (99%) < 1μs*
  - length of ceramic — L = 335 mm
  - bore diameter — d = 38 mm
  - delay time trigger to max field — $\tau \approx$ 800 ns*
- BPM with larger spatial range
  - linear range — $\Delta x, \Delta y \approx \pm 15$mm
  - prior off-axis screen ⇒ no secondary particles effect measurements
- off-axis screen
  - distance to beam — Δx = 7 mm
  - screen size — t x w x h =280μm x 8 mm x 26.5 mm
  - aluminum coated silicon wafer
  - rotation — 45° versus y axis

* Precise measurements soon


TTF2 LIST 23.04.2003 by Nina
Windows NT 4.0 version 8.23/06
14/05/03 05.15.03
β (m)
βx
βy
Origin optics from Nina (old, new is in preparation)
ACC2
&ACC3
ACC4
&ACC5
ACC7
Lola
screen
COL
BC3
SEED
UND1-6
BC2
100.
90.
80.
70.
60.
50.
40.
30.
20.
10.
0.0
0.0
25.
50.
75.
100.
125.
150.
175.
200.
225.
250.
s (m)
δE/ p0c = 0.
Table name = TWISS_TTF2

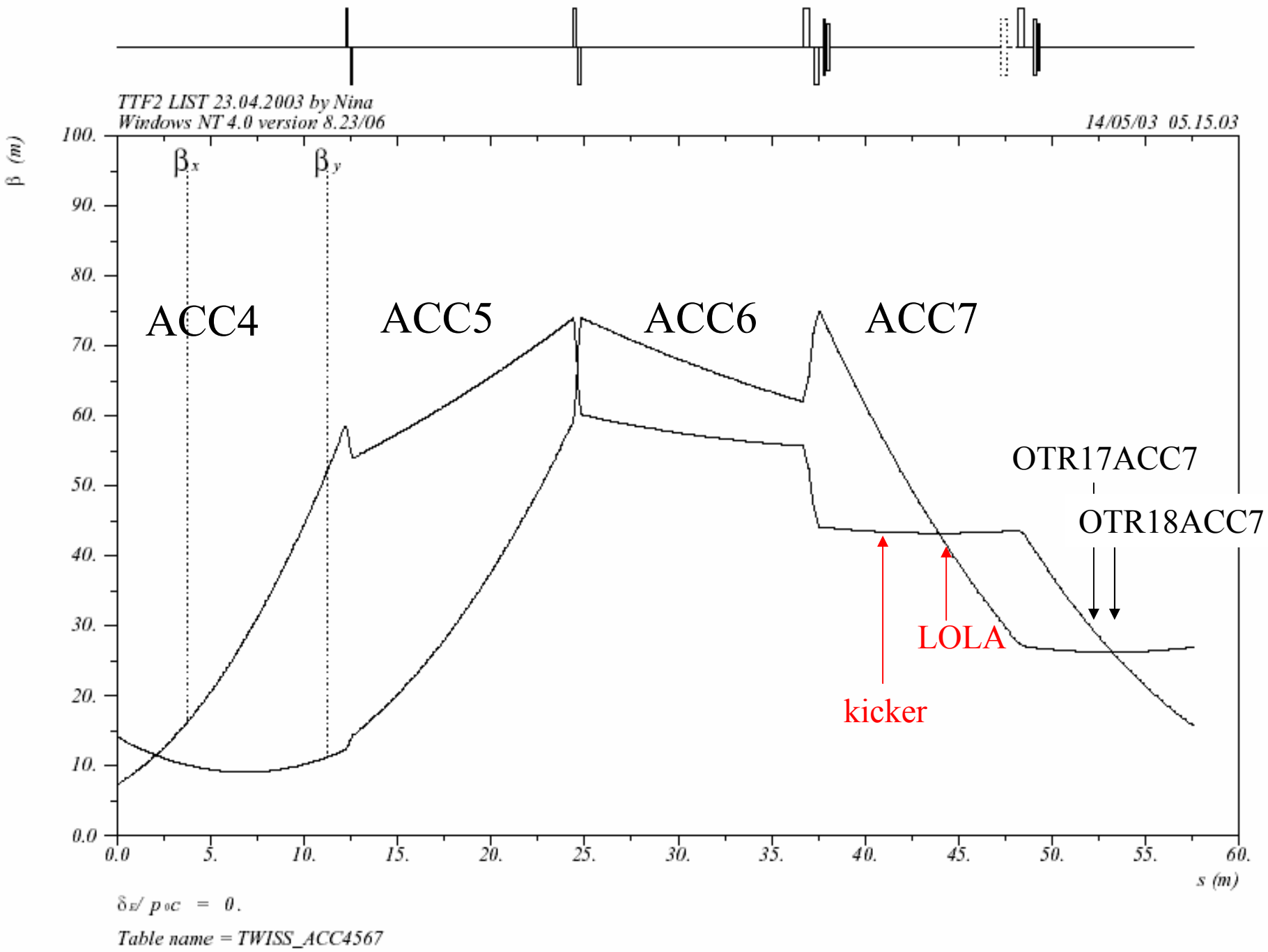

TTF2 LIST 23.04.2003 by Nina
Windows NT 4.0 version 8.23/06
14/05/03 05.15.03
β (m)
βx
βy
ACC4
ACC5
ACC6
ACC7
OTR17ACC7
OTR18ACC7
LOLA
kicker
100.
90.
80.
70.
60.
50.
40.
30.
20.
10.
0.0
0.0
5.
10.
15.
20.
25.
30.
35.
40.
45.
50.
55.
60.
s (m)
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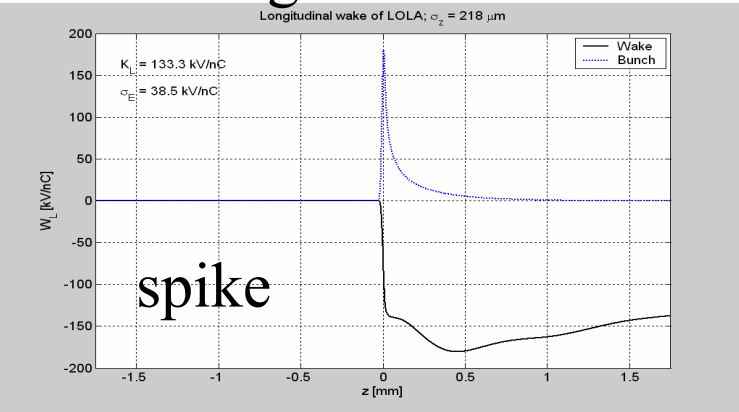
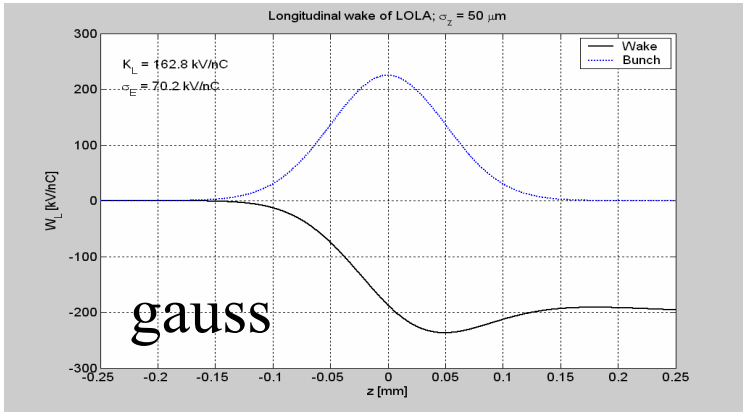
Table name = TWISS_ACC4567

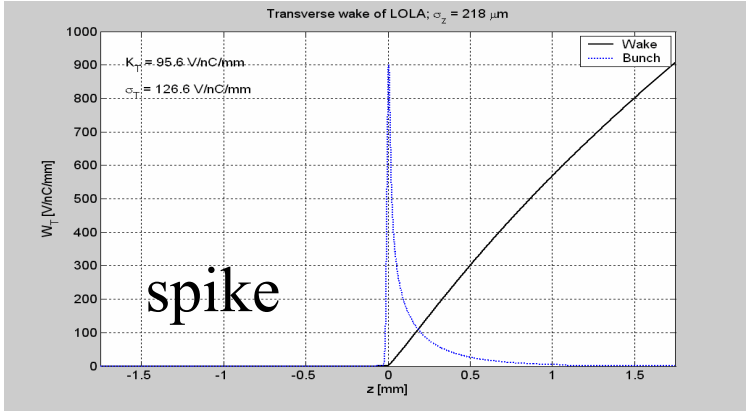
Upgrade for LOLA
- Wake fields -

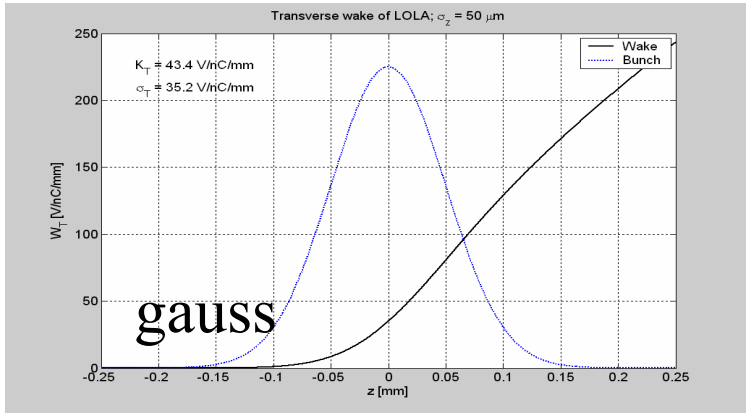
longitudinal





transverse





Typical angular spread of beam σ' ~ 5-10 urad in LOLA

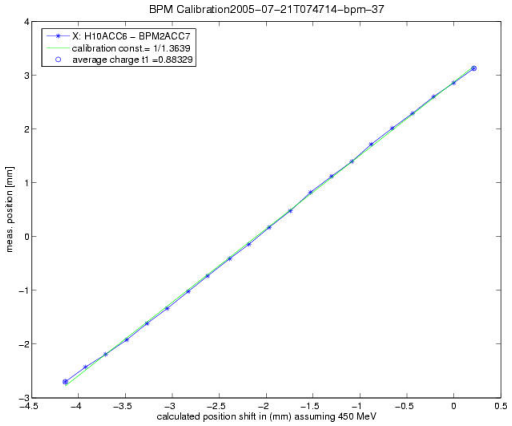
Typical kick due to wakes (3mm offset) ~ 500 eV ⇒ x' ~ 1 urad

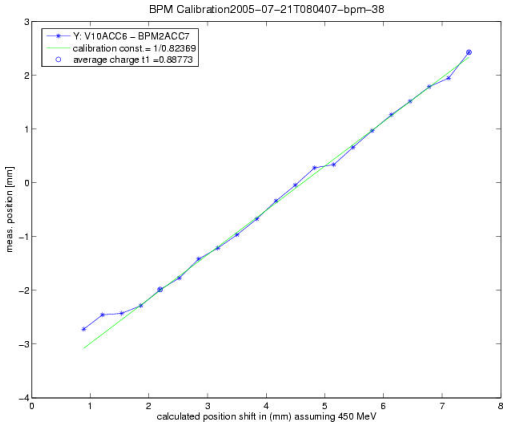
⇒ Effect of transverse wakes due to operation of the horizontal kicker is expected to be small and only visible for the long tails or long bunches

BPM calibration

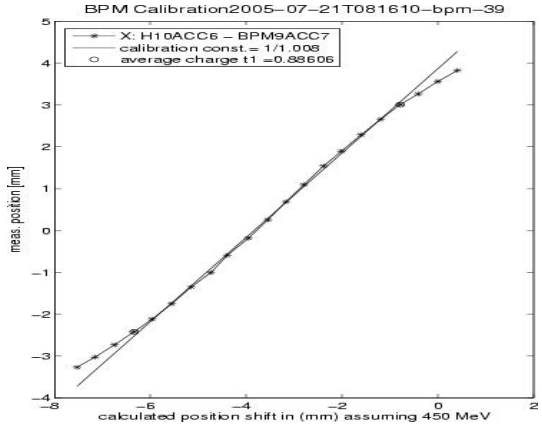
- corrector + drift => calibration (uncertainty dE/E~3%, BdL~3%)

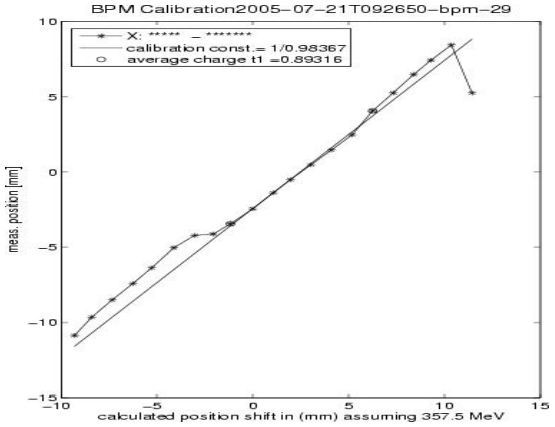
BPM2ACC7



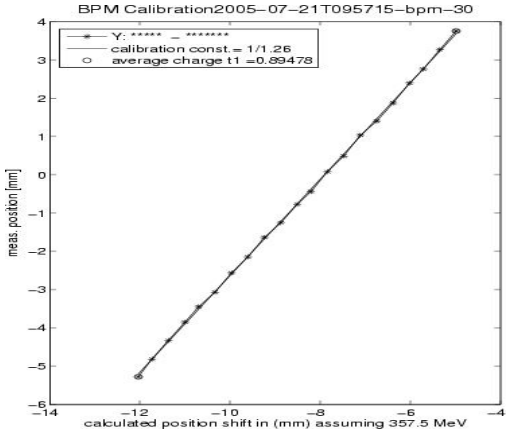


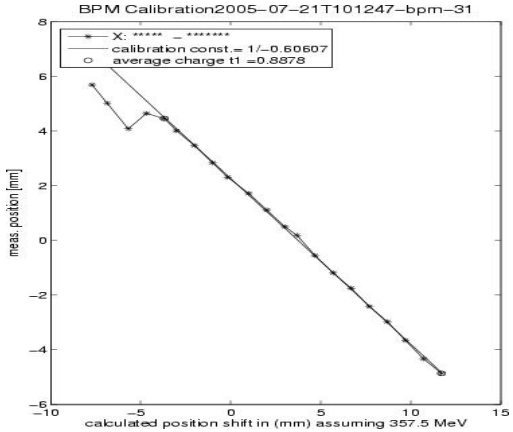
BPM9ACC4





BPM9ACC5





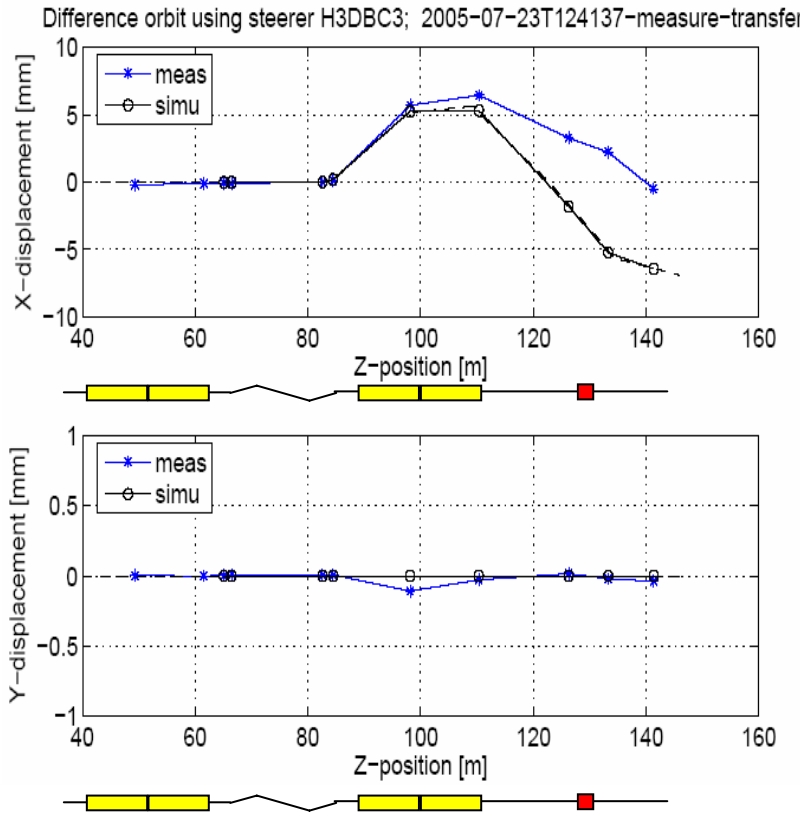
Also BPM9ACC7 and BPM16ACC7

Measurement of transfer function

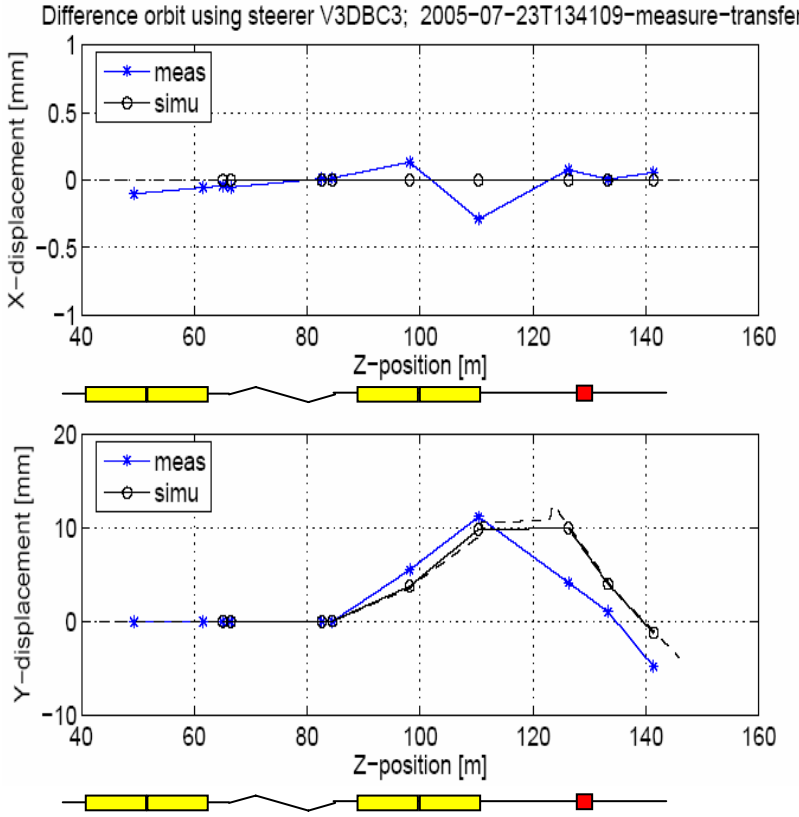
- using last steerer in DBC3

⇒ Phase advance in both planes wrong!

H3DBC3



V3DBC3

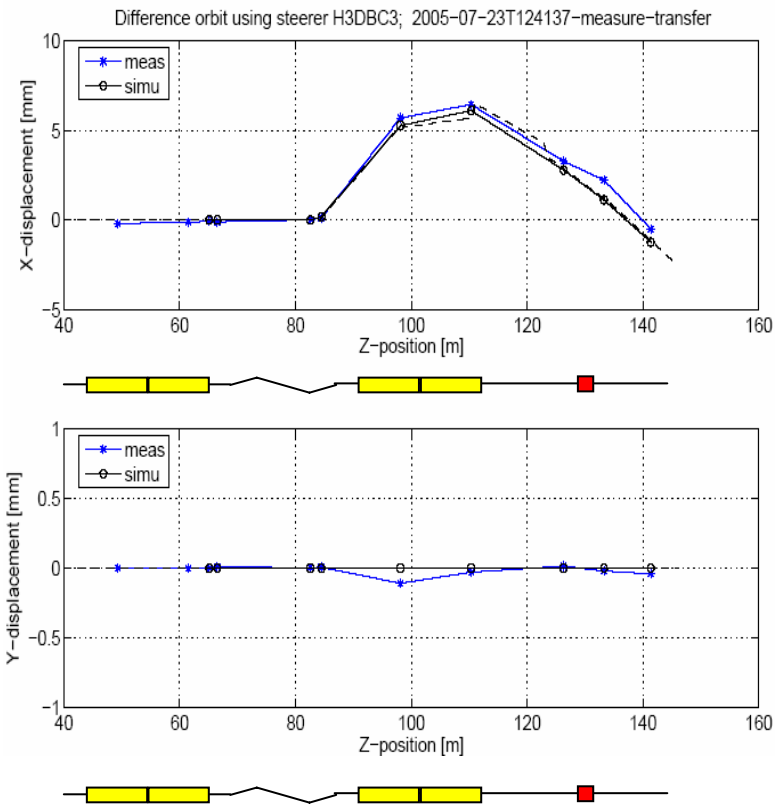


Measurement of transfer function

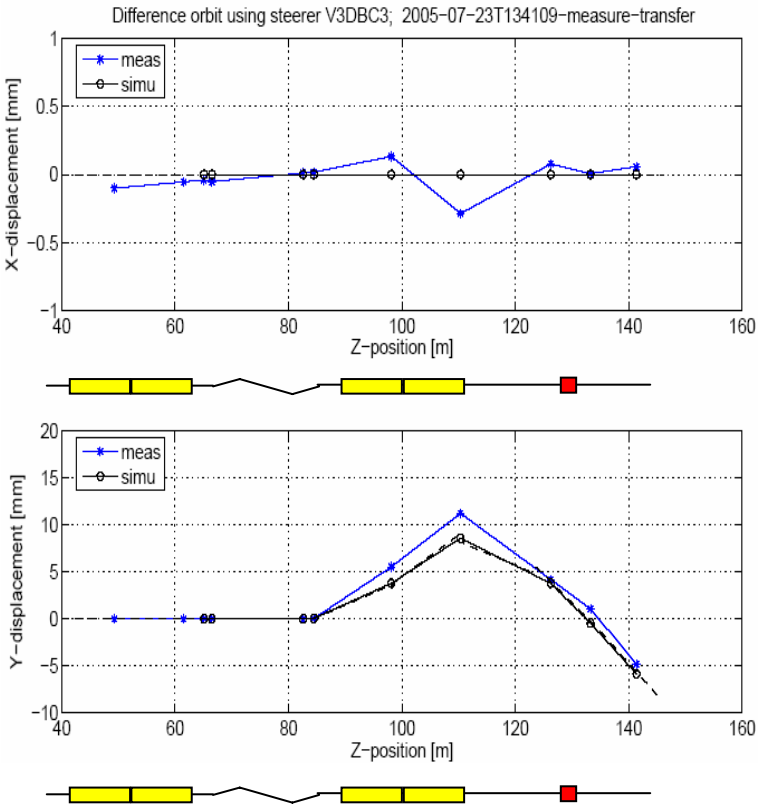
- using last steerer in DBC3, but changing Q9/10ACC5 polarity

⇒ Phase advance in both planes right!

H3DBC3



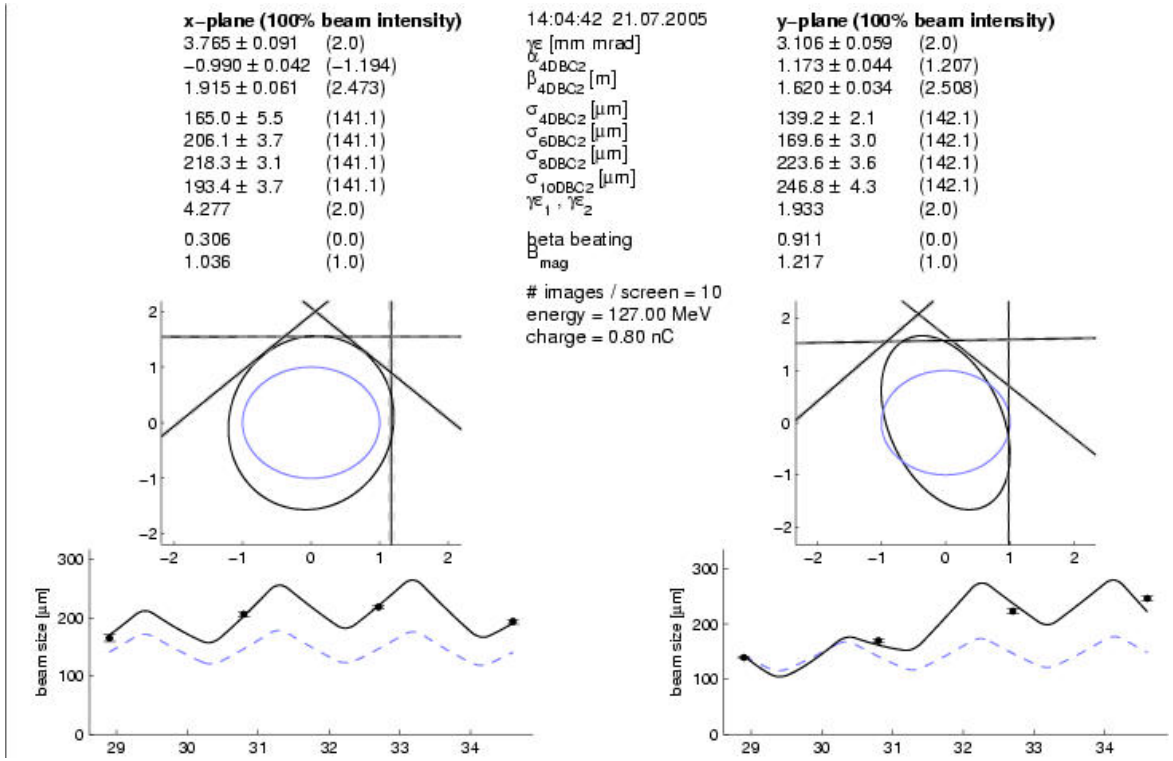
V3DBC3



Emittance measurement and matching

• start with DBC2, adjust ACC1 phase such that no tail in X occur, two iteration with matching, phase +3.5 deg from compression

⇒ Reasonable good emittance, good matching in X, Y naja …

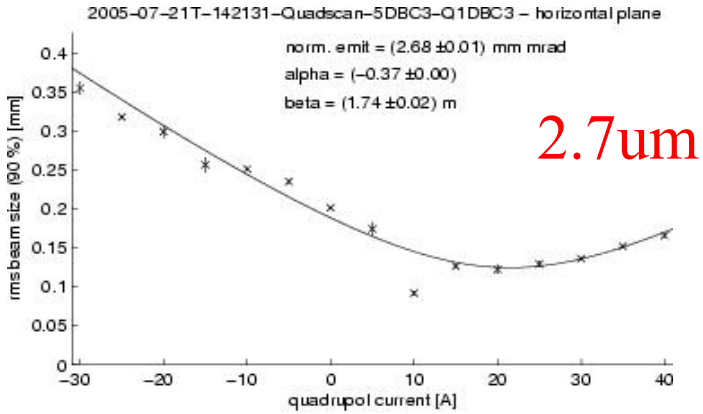


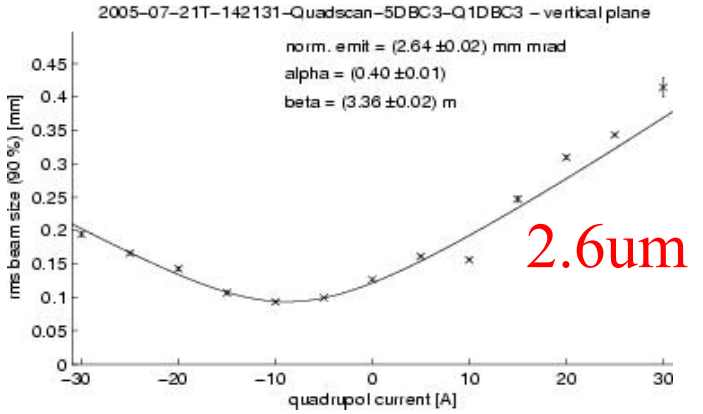
Emittance measurement and matching

- continued with measurement in DBC3 (quad scan)

⇒ Required special setup of optics to achieve reliable measurements

Last measurement





8/15/2005

Set of measurement from previous day

location	vert emitt	horiz emitt	comment
5DBC3	2.56 +- 0.02	3.21 +- 0.04	Q1 quad scan, specialoptics (ACC1 Phase=+3.5deg)
5DBC3	2.81 +- 0.01	10.80 +- 0.06	Q1 quad scan, specialoptics (ACC1 Phase=+2.5deg)
5DBC3	10.18 +- 0.09	5.03 +- 0.07	Q3 quad scan,new optics (which quad is best?)
5DBC3	5.79 +- 0.16	6.20 +- 0.04	Q2 quad scan,new optics (which quad is best?)
5DBC3	6.79 +- 0.05	4.56 +- 0.11	Q1 quad scan,new optics (which quad is best?)
5DBC3	4.10 +- 0.03	4.15 +- 0.03	Q1 quad scan,before energy scaled opticschange
4-10DBC2	1.78 +- 0.04	2.37 +- 0.05	pre-BC3 4screen meas

Test of multi-knob

- Purpose:

  change phase advance in X by 180deg while keeping beta function at screen constant!!!!

- Software tool worked
- Steering was minor problem after centering the beam

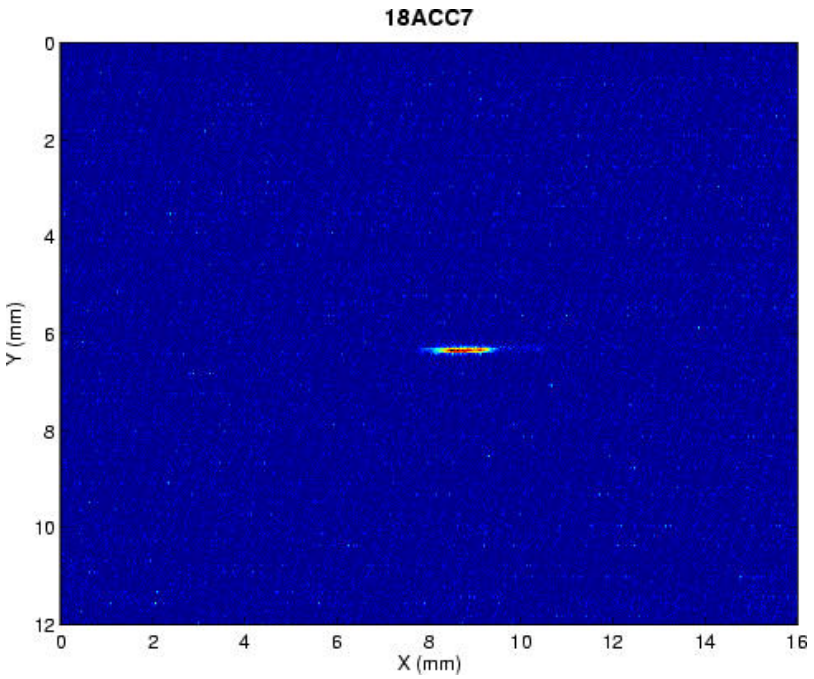
- but the beam spots were a disaster

- incoming beta function to different (mismatch to be removed but the matching tool for BC3 was not finished)
- wrong transfer function used

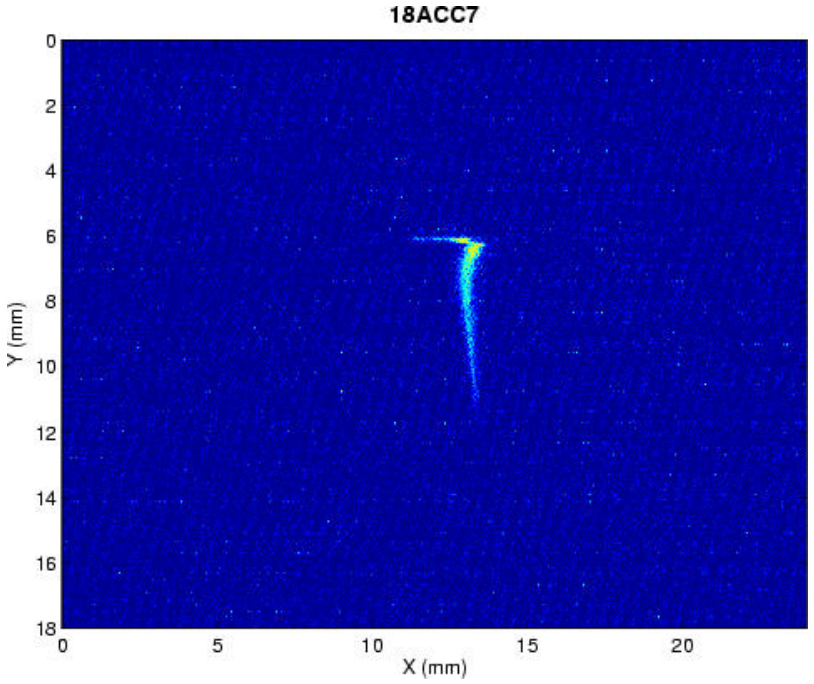
Setup of machine

• with quads ACC4-ACC6 focus beam in Y tightly to screen

Not streaked



Streaked



• observed large centroid distortion of beam

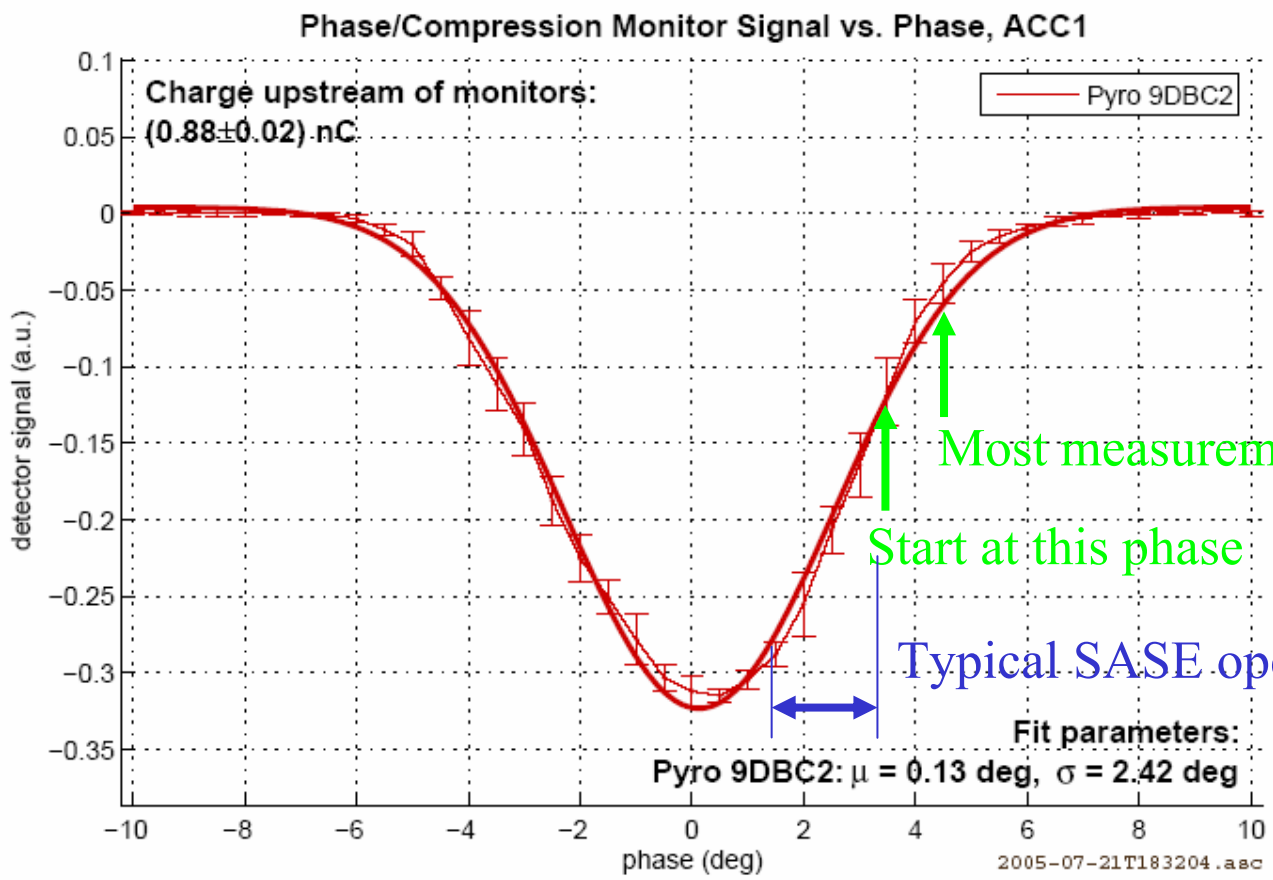
⇒Try to remove by changing linac orbit,

⇒ but failed (not enough time)

Operation of TTF2 for slice meas.

- Working point:

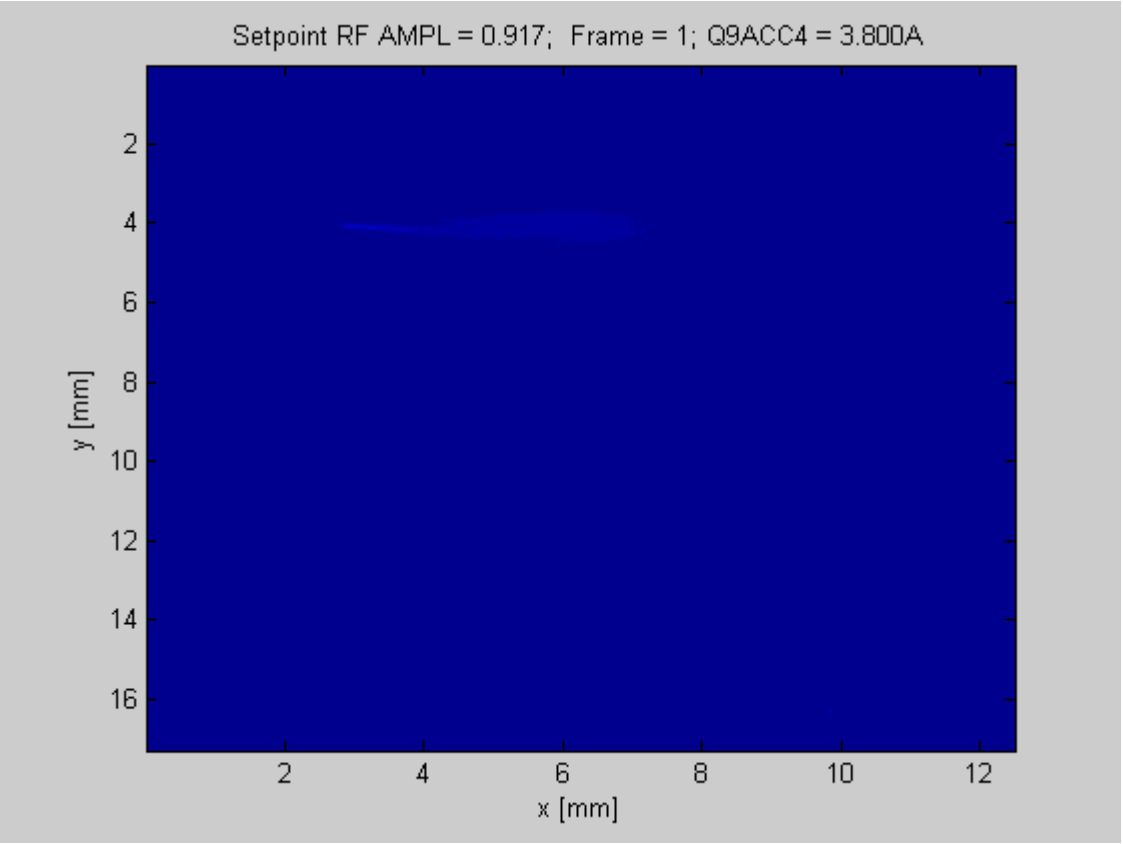
ACC1 phase +3.5deg and +4.5deg from max. compression
ACC2-ACC5 on crest, E=445 MeV



Pyro electric scan at 9DBC2 diff. screen to determine the phase of ACC1

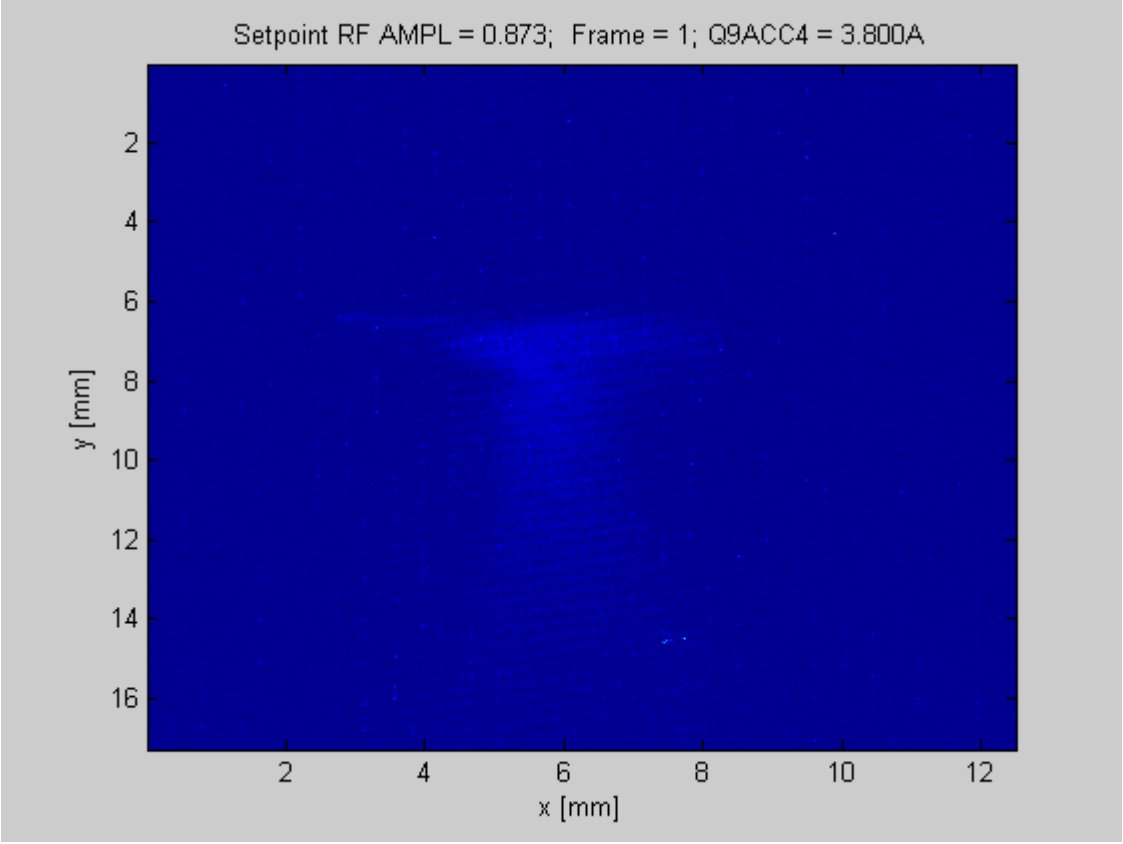
Its movie time!

No streak, quad scan Q9ACC4 (in module)



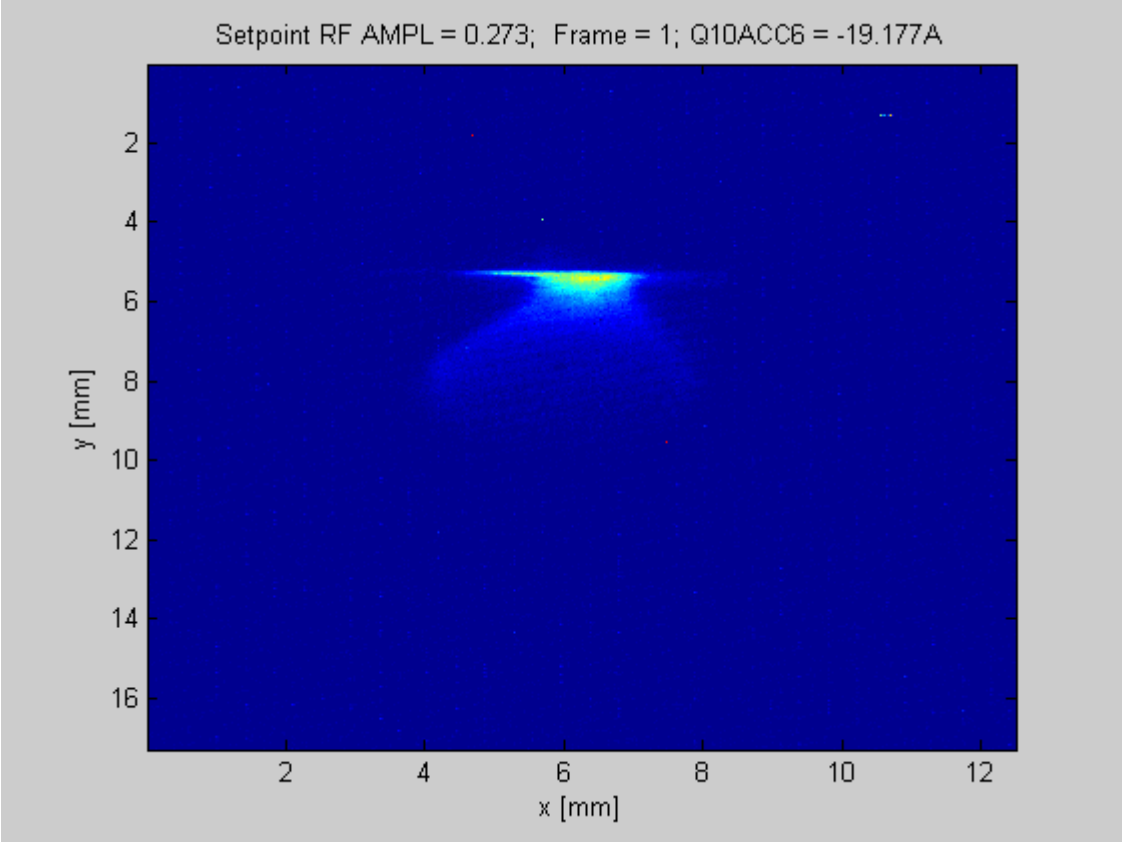
Its movie time!

Same quad scan Q9ACC4 (in module) but with streak



Its movie time!

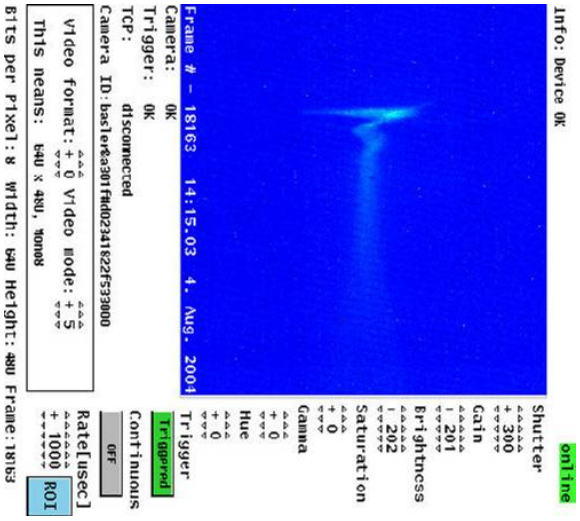
Tomography y-z by changing the streak strength!



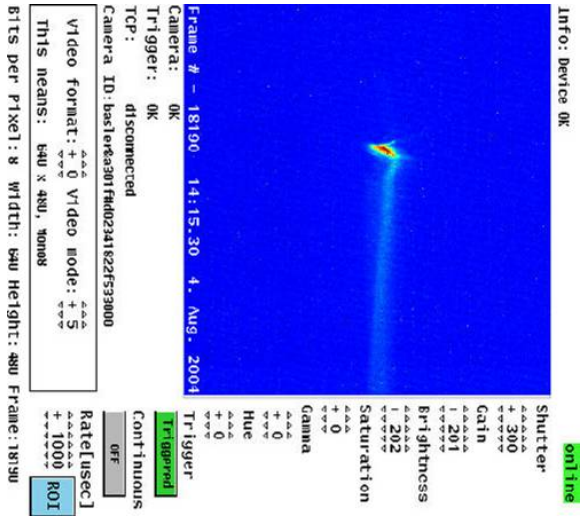
Some fancy observations !?!

- when scanning the Q9ACC4 quadrupole

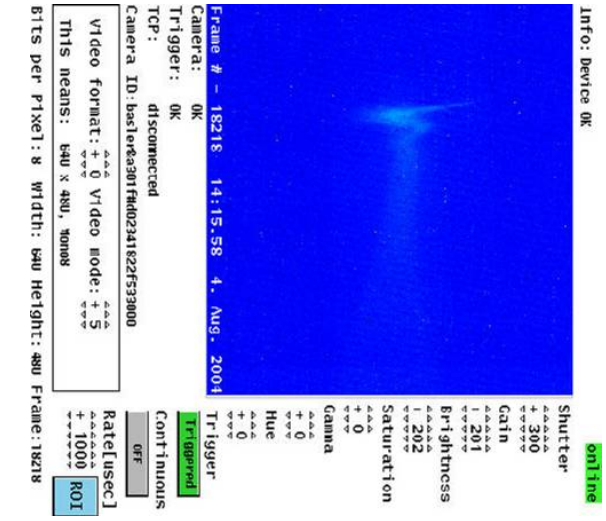
5.4 A

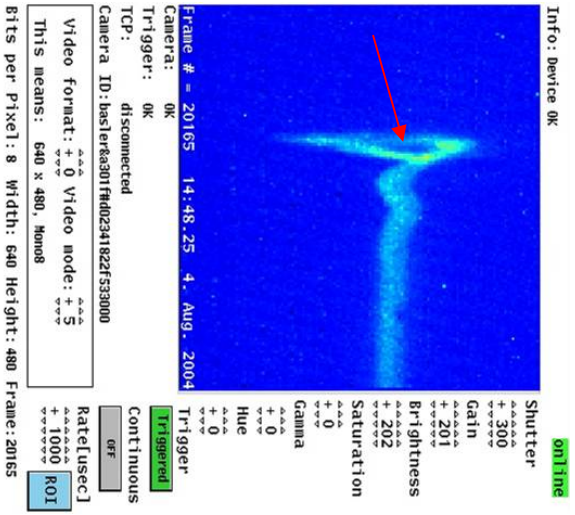


4.7 A



4.2 A



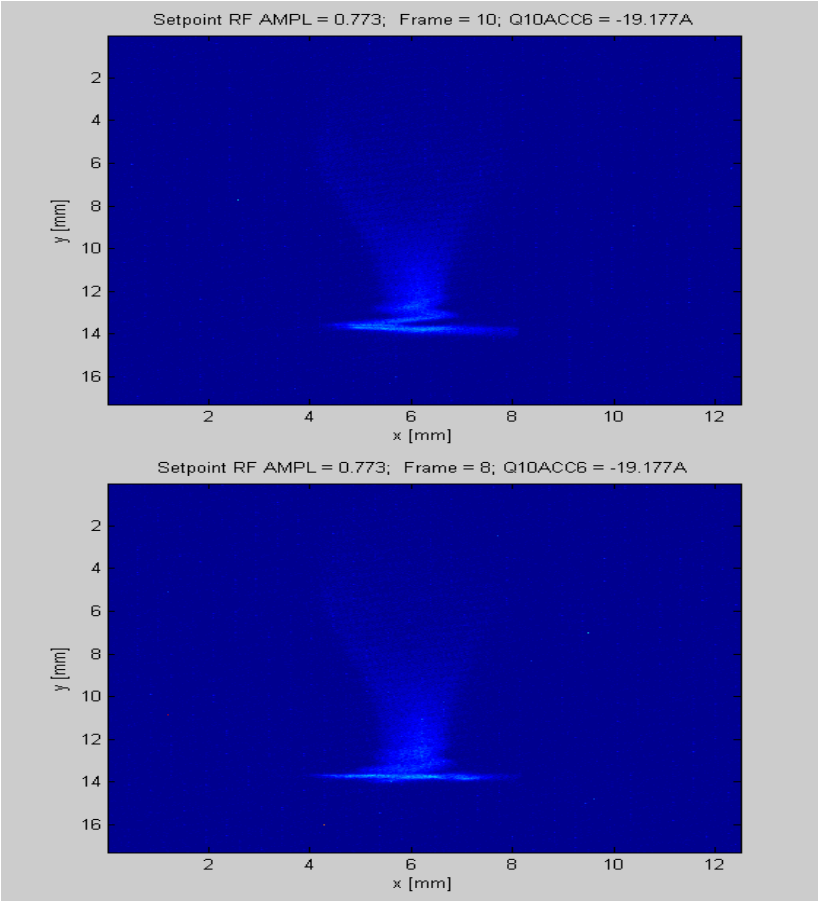


Problem:
beam is clipped in X direction
(screen 3.4mm not big enough) &
Holes in head of beam appear => see zoom

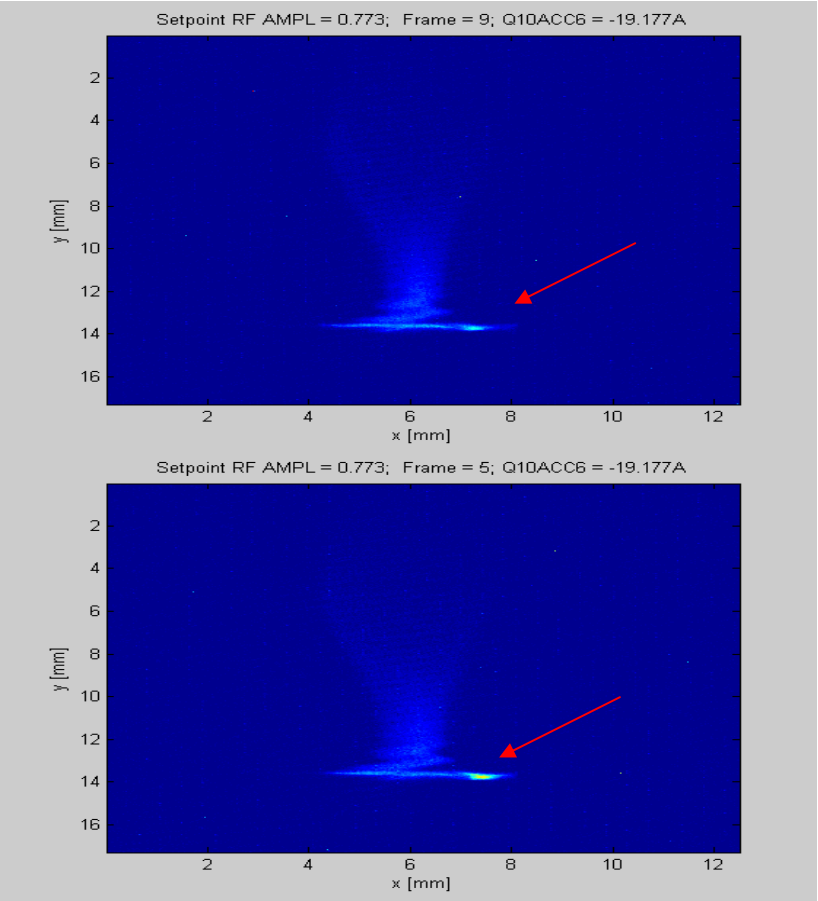
Sudden bright spot

- for certain adjustment of quadrupole occasionally bright spot appear

No spot

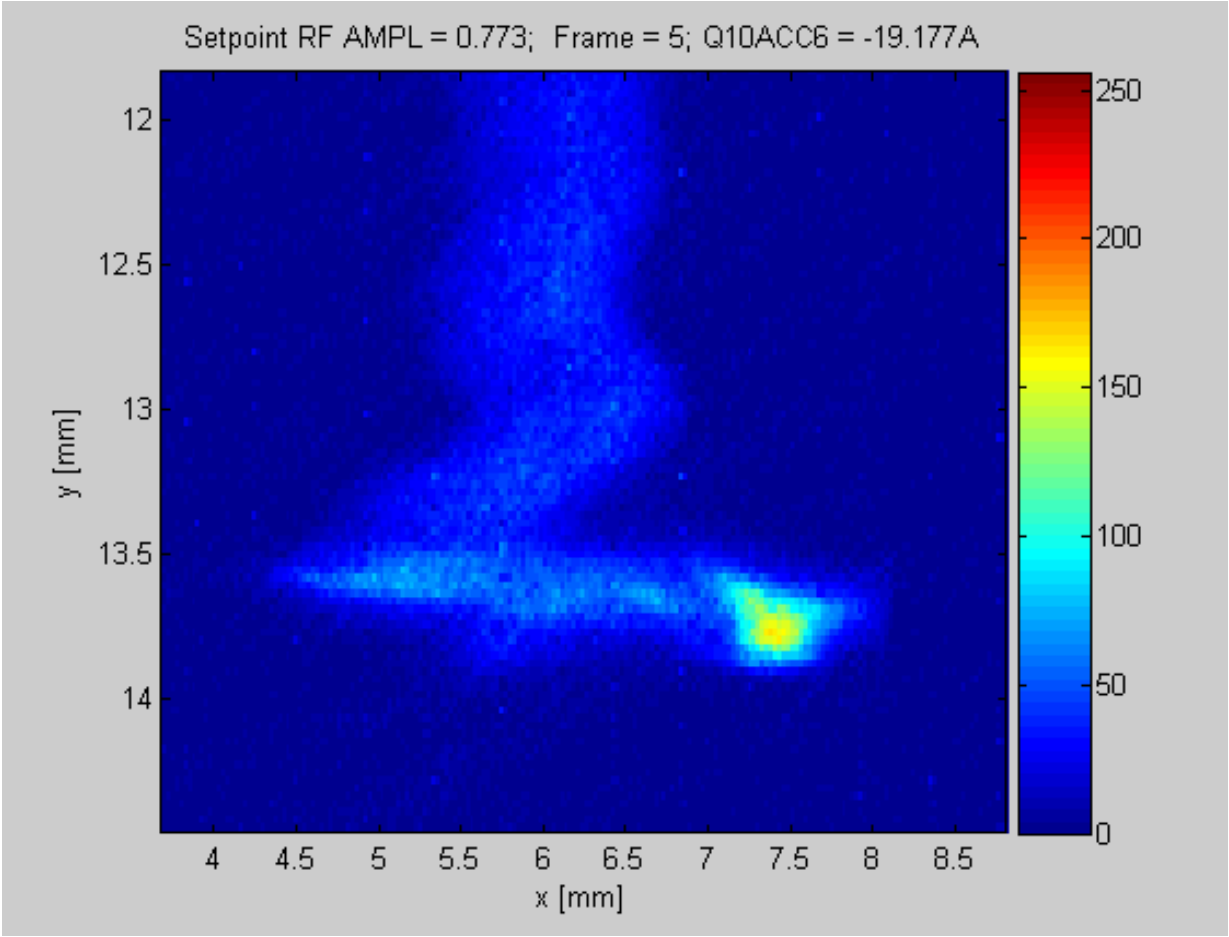


With spot



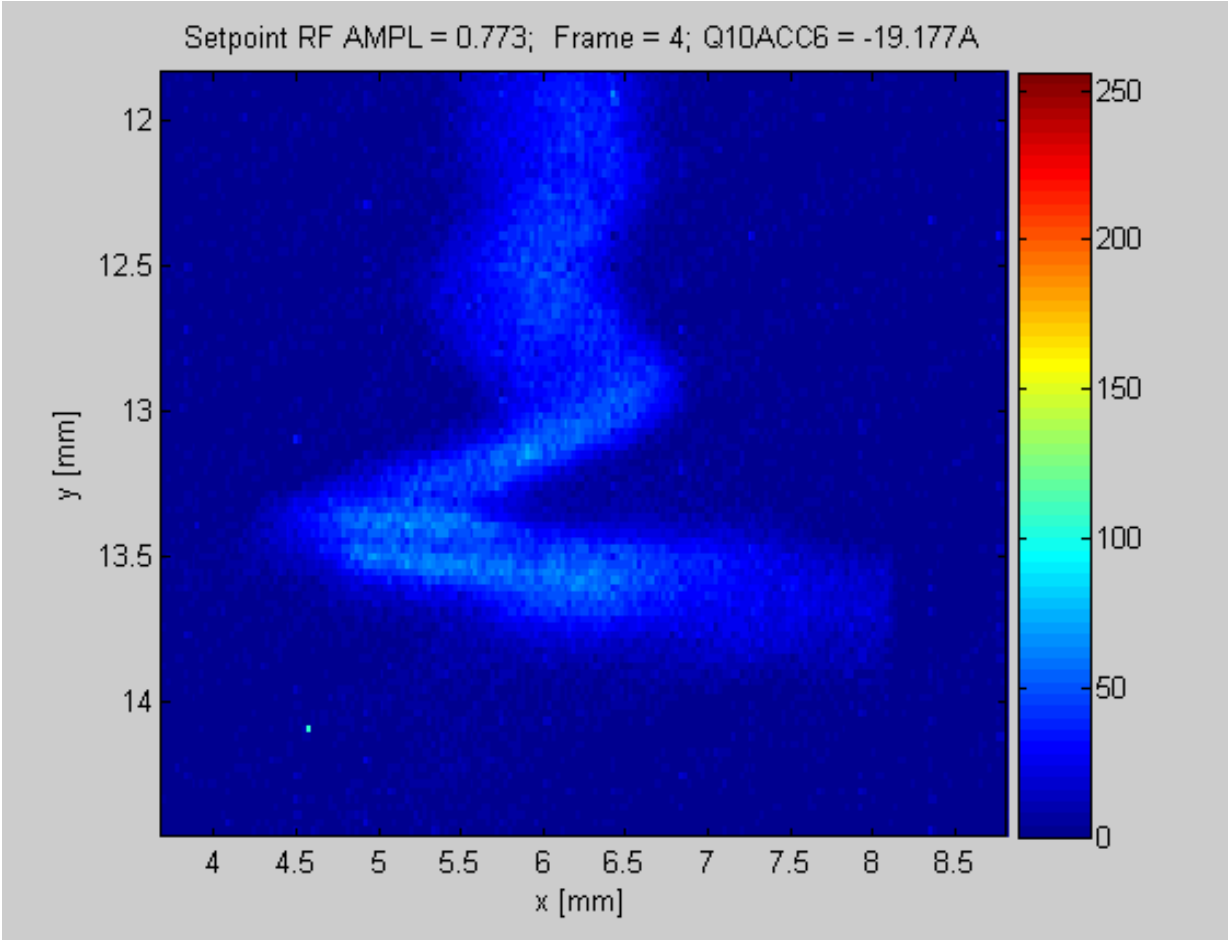
Sudden bright spot

- Zoom in head of bunch with hot spot



Sudden bright spot

- Zoom in head of bunch without hot spot



Upgrade for LOLA

Devices added to beam line:

- pre-collimator
  - downstream of off-axis screen
  - collects secondary particles from screen
  - prevents head on beam loss on vacuum flange
  - bore diameter $d = 30$ mm
  - special Aluminum to survive longer beam losses (AlMg 4.5Mn F27)
- CMOS camera with own readout computer
  - 1286H x 1030V pixel, 12 bit nominal/ 10 bit effective
  - radiation harder then CCD
  - expected more 10 Hz readout with new image DOOCS server
  - imaging 2:1 with 200mm objective, camera tilted
  - imaged screen area $w \times h = 14.3$ mm x 17.9 mm
  - expected camera resolution $\Delta = 14$ µm
- mask electronics allowing losses of individual bunches
  - inhibits for 0.5 µs detection of losses at 5 PM channels