Measurements of the RF breakdown influence on the probe beam

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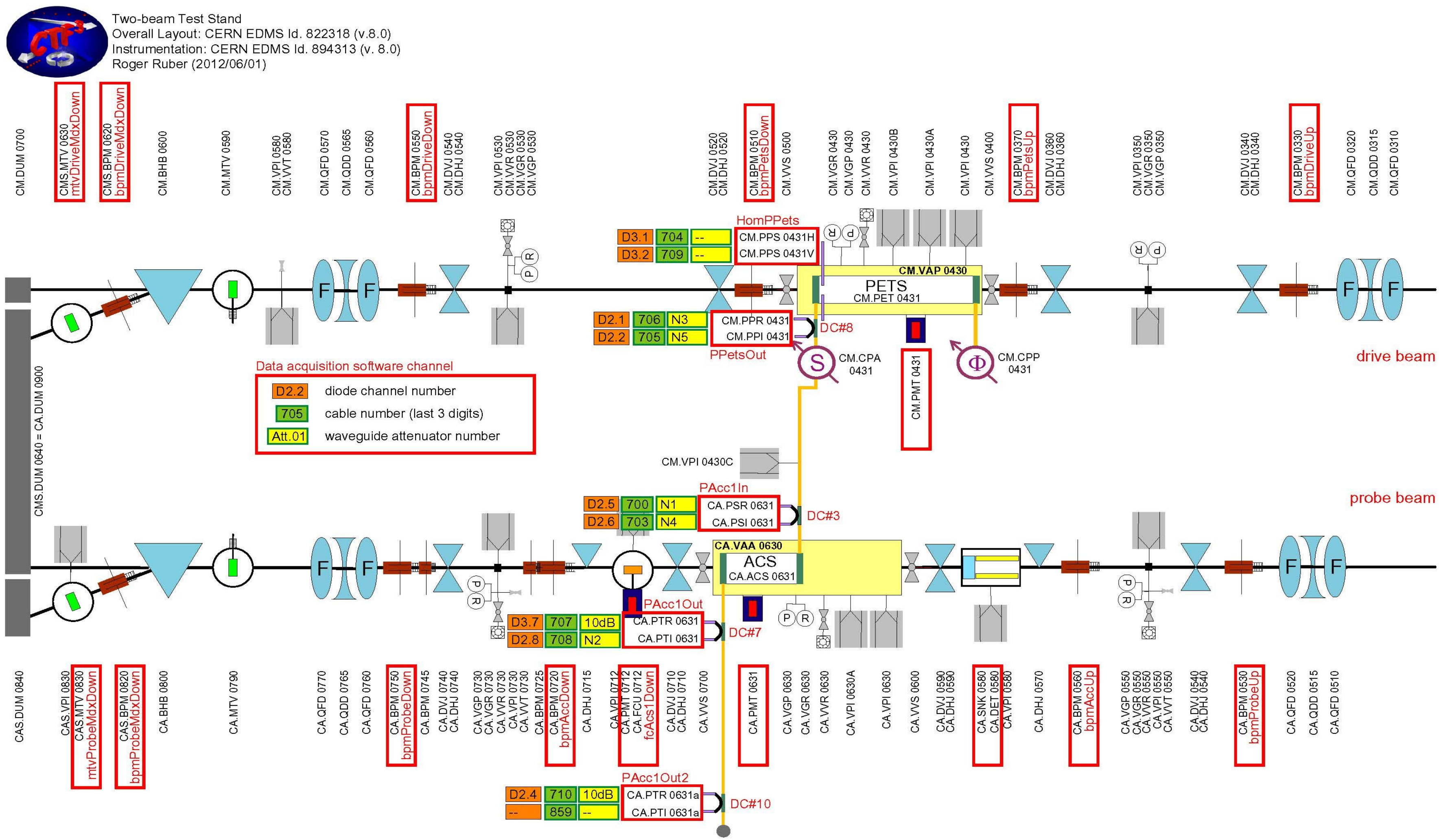
A. Palaia, W. Farabolini

June/July 2012 data taking

(good data sets are highlighted)

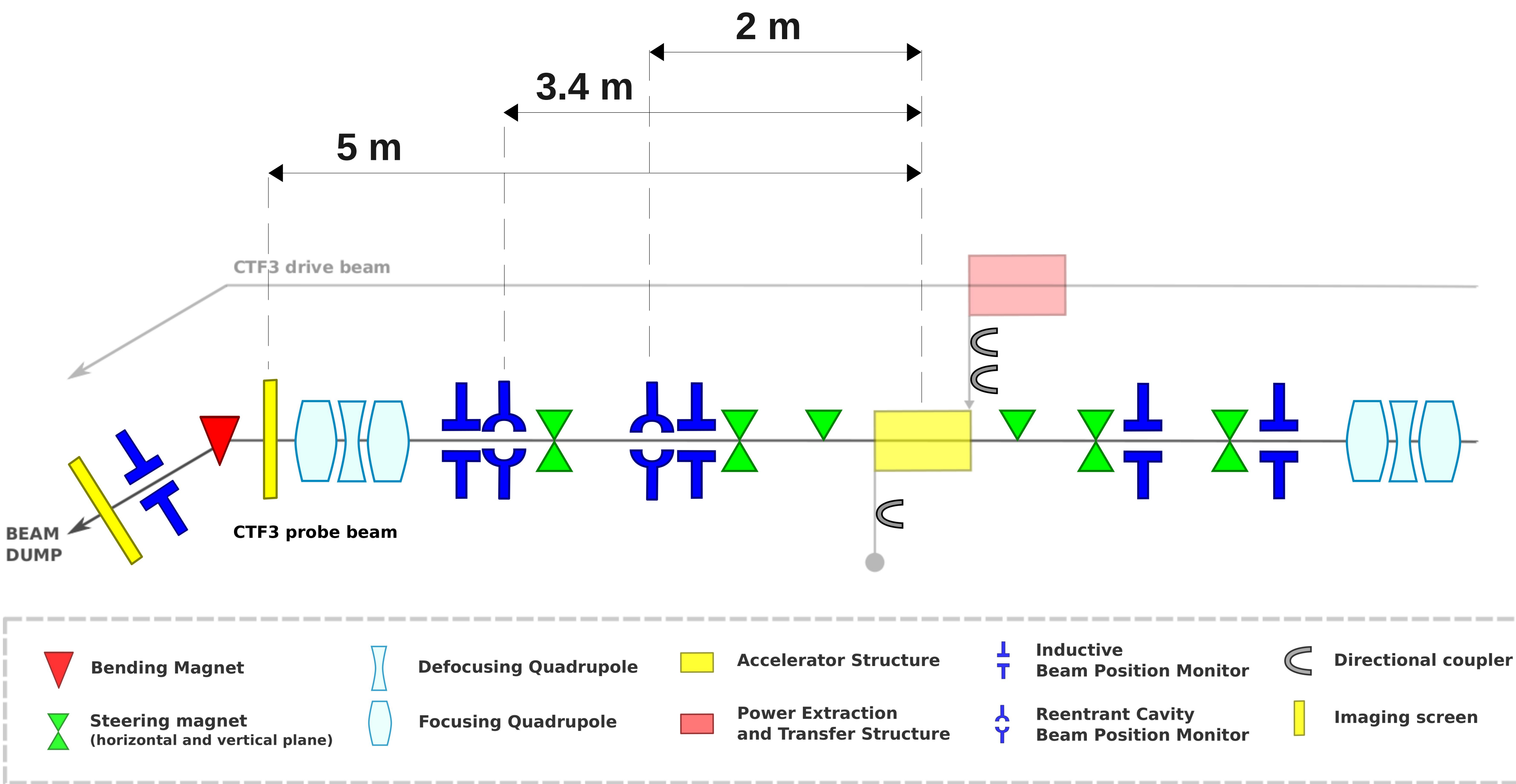
RUN	# BD	# events	COMMENTS
20120612	7		no cavity BPM data, no MTV and BPM timestamps MTV images non synchronized with RF kick visible on 1 MTV image (run with low energy CALIFES beam, < 150 MeV)
20120613	504		no cavity BPM data, the beam moves during data taking (probably someone steering) first 80 MTV images frozen (camera off)
20120618	101		
20120619	313		the beam moves during first 70 events (probably someone steering)
20120622	243		
20120626	108		
20120626bis	2		
20120703 – 20120704 over night CALIFES operation	13 + 232		
20120710 over night CALIFES operation, drive beam until 23.50 p.m.	9		
20120711 – 20120712 over night CALIFES operation, drive beam until 2.45 a.m.	12 + 29		very noisy cavity BPMs signals
20120712	248	732	
20120713 – 20120715 weekend operation	100		

TBTS as of July 2012

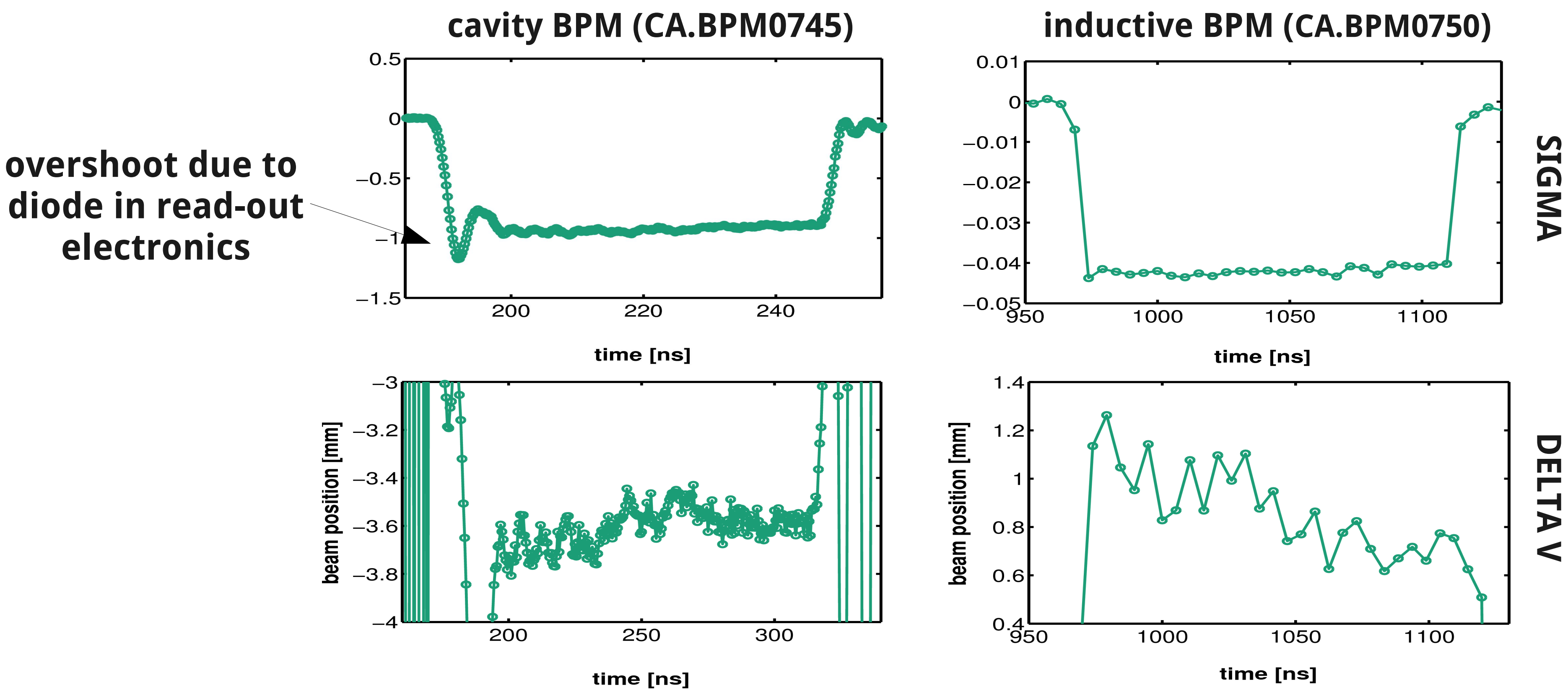


Reference: EDMS document 894313 v.8

TBTS probe beam as of July 2012



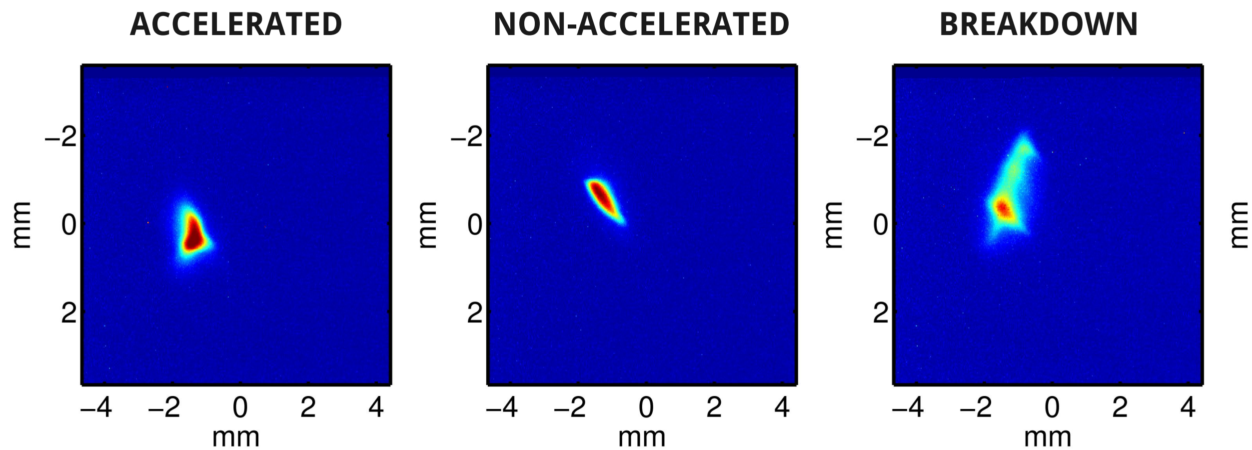
BPM performance



Remarks:

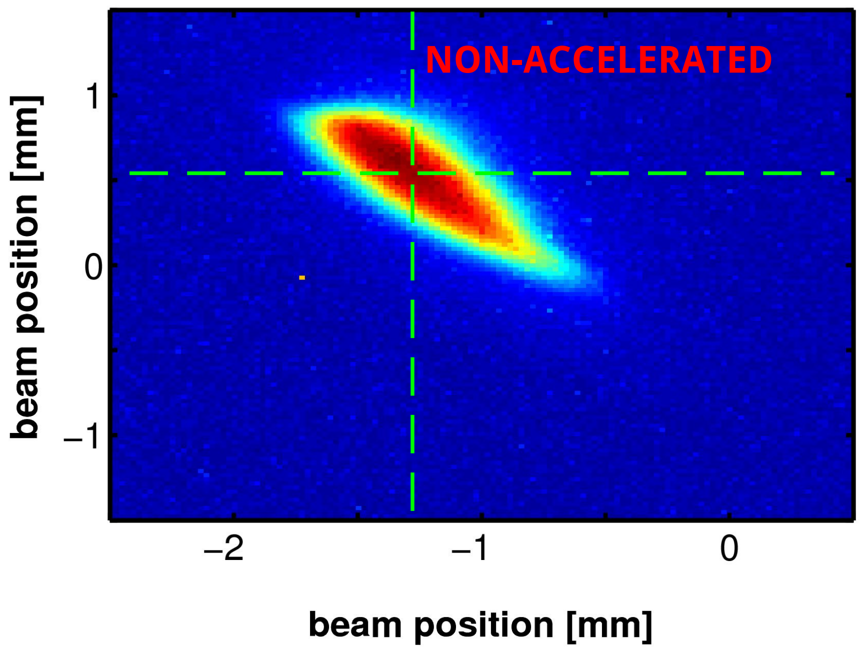
- the sign of the DELTA V signal of the BPM is wrong and corrected in the calibration
- bandwidth of cavity BPMs is ~600 MHz centered at 6 GHz, sampling rate is 2 GHz
- bandwidth of inductive BPMs is ~100 MHz, sampling rate is 192 MHz

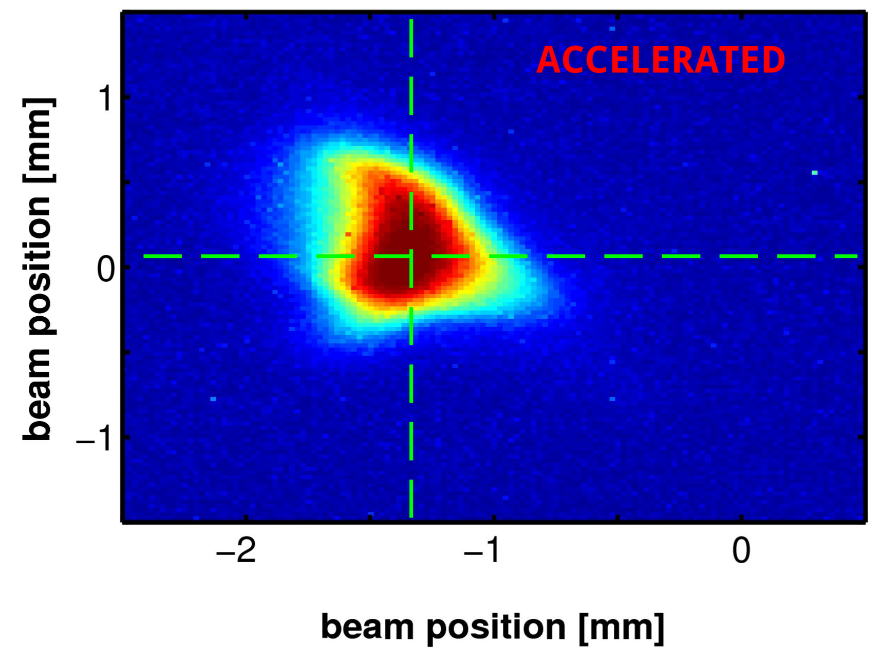
Measurements strategy



- breakdown triggered on reflected RF signal;
- for each breakdown triggered 2 accelerated and 2 non accelerated pulses are saved (probe beam rep rate double than drive beam rep rate);
- screen image, raw BPMs signals and raw RF signals corresponding to the same pulse are saved (calibration is applied off-line except for the signals used as trigger);
- all correctors and quadrupoles are not powered during this measurement.

Example of non-breakdown events (1)

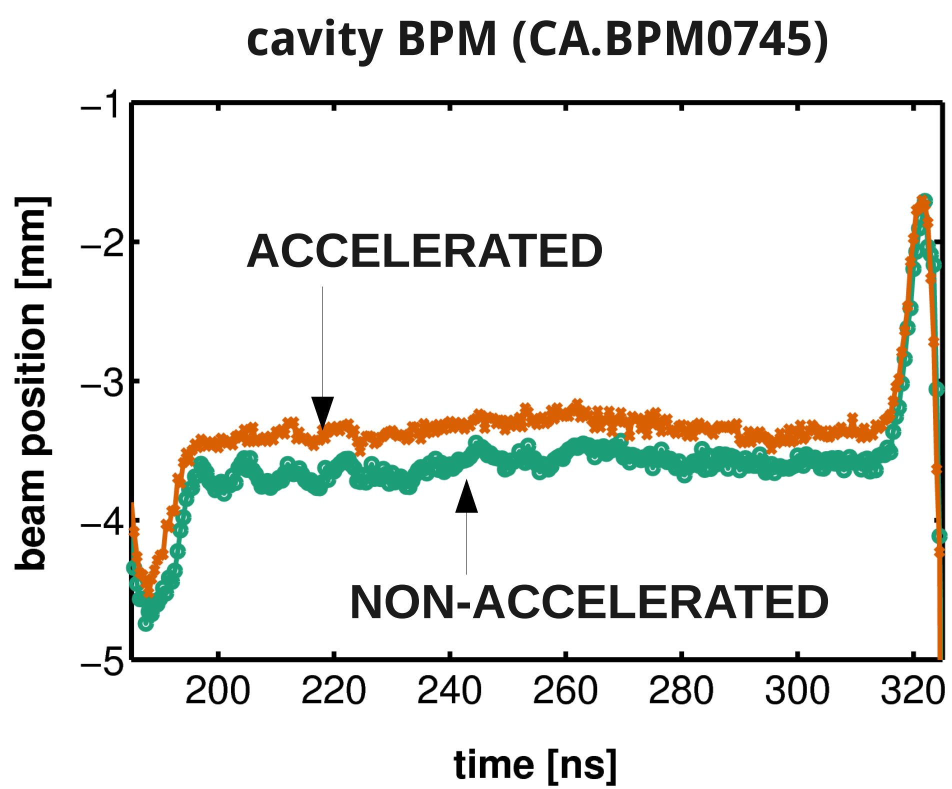




- non-accelerated spot is tilted
  possibly because of horizontal/vertical coupling in CALIFES
- centroids of non-accelerated/accelerated spot have different position
  because of kick due to possibly misaligned ACS
- shape and orientation of the beam spot changes when it is accelerated
  possibly because of RF focusing in ACS

Example of non-breakdown events (2)

- accelerated and non-accelerated orbits are different
- distance between orbits consistent with the position of the centroids measured on screen CA.MTV0790
- the two orbits are consistent with a kick of 36 keV or 0.2 mrad, which corresponds to a misalignment of the ACS of ~200 um

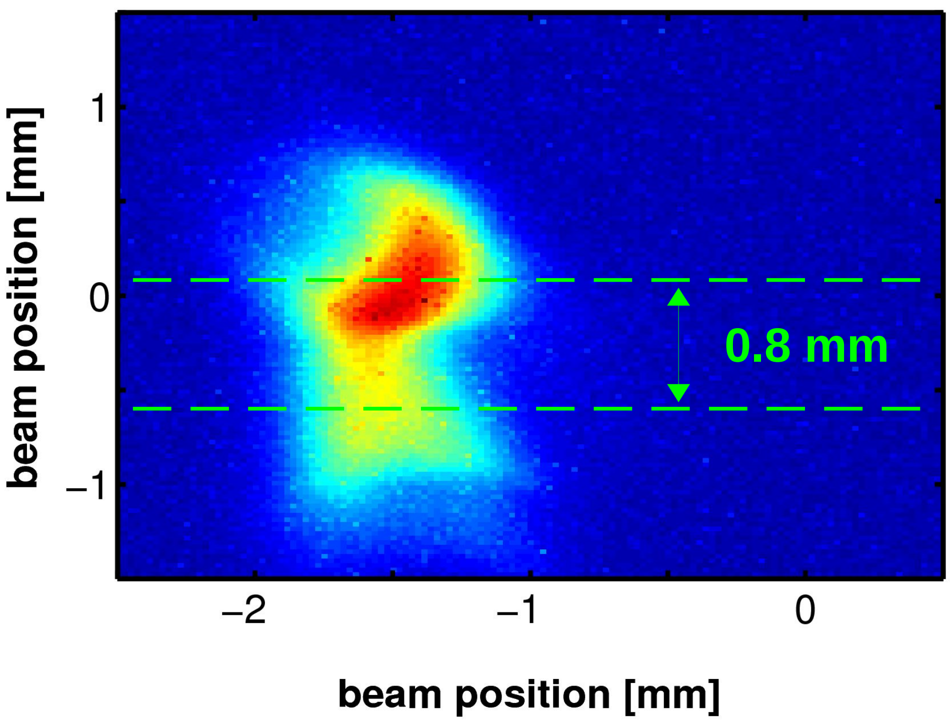


- we take advantage of the possible* ACS misalignment to have an indirect indication of the beam energy (assuming no variation of incoming orbit from pulse to pulse) also during a breakdown (unless a transverse kick interferes)

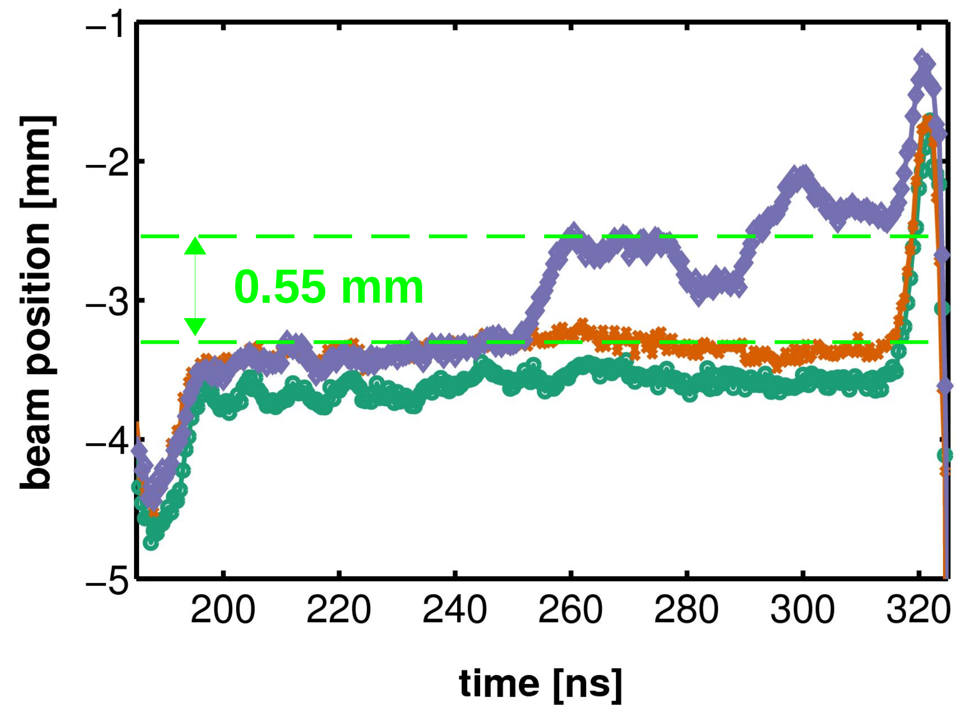
* mechanical tolerances to be confirmed

Example of breakdown event

YAG screen (CA.MTV0790)



cavity BPM (CA.BPM0745)

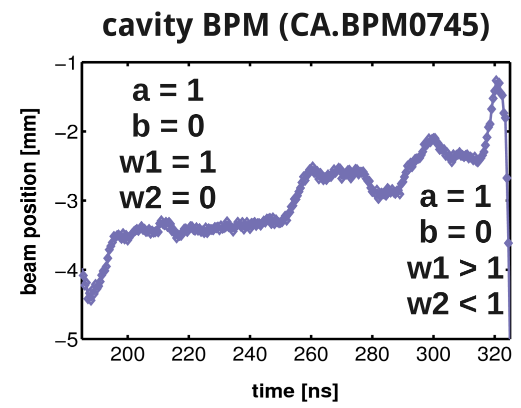


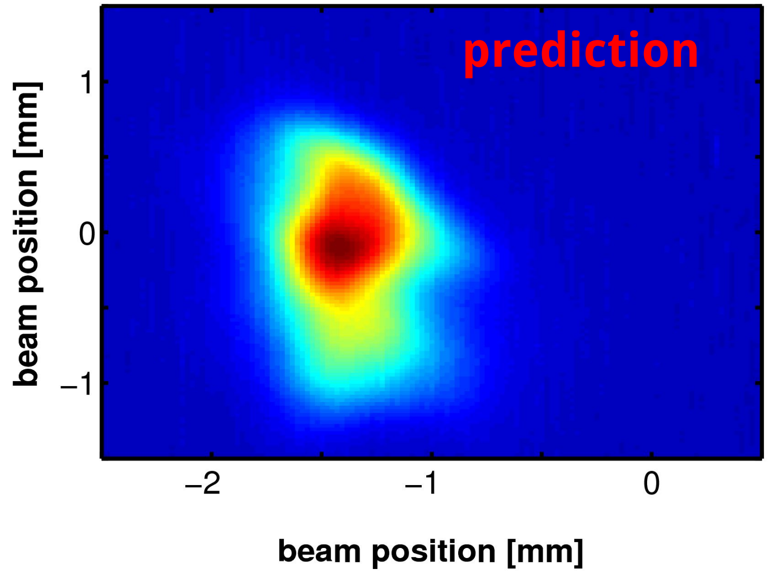
- distance between centroids of two spots on the screen (CA.MTV0790) is consistent with the change of orbit during a breakdown measured on the cavity BPM CA.BPM0745 scaled by the distance between BPM and screen

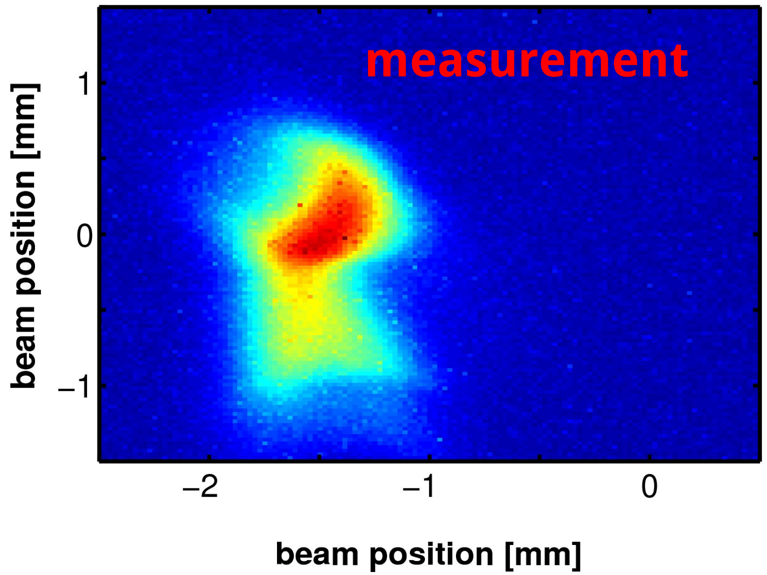
Prediction of BD beam spot

A prediction of BD beam spot is obtained smearing the convex sum of the accelerated and non-accelerated beam spot images along the BD BPM trace. The coefficients of the sum are also weighted according to the amount of RF power leaking through the breakdown:

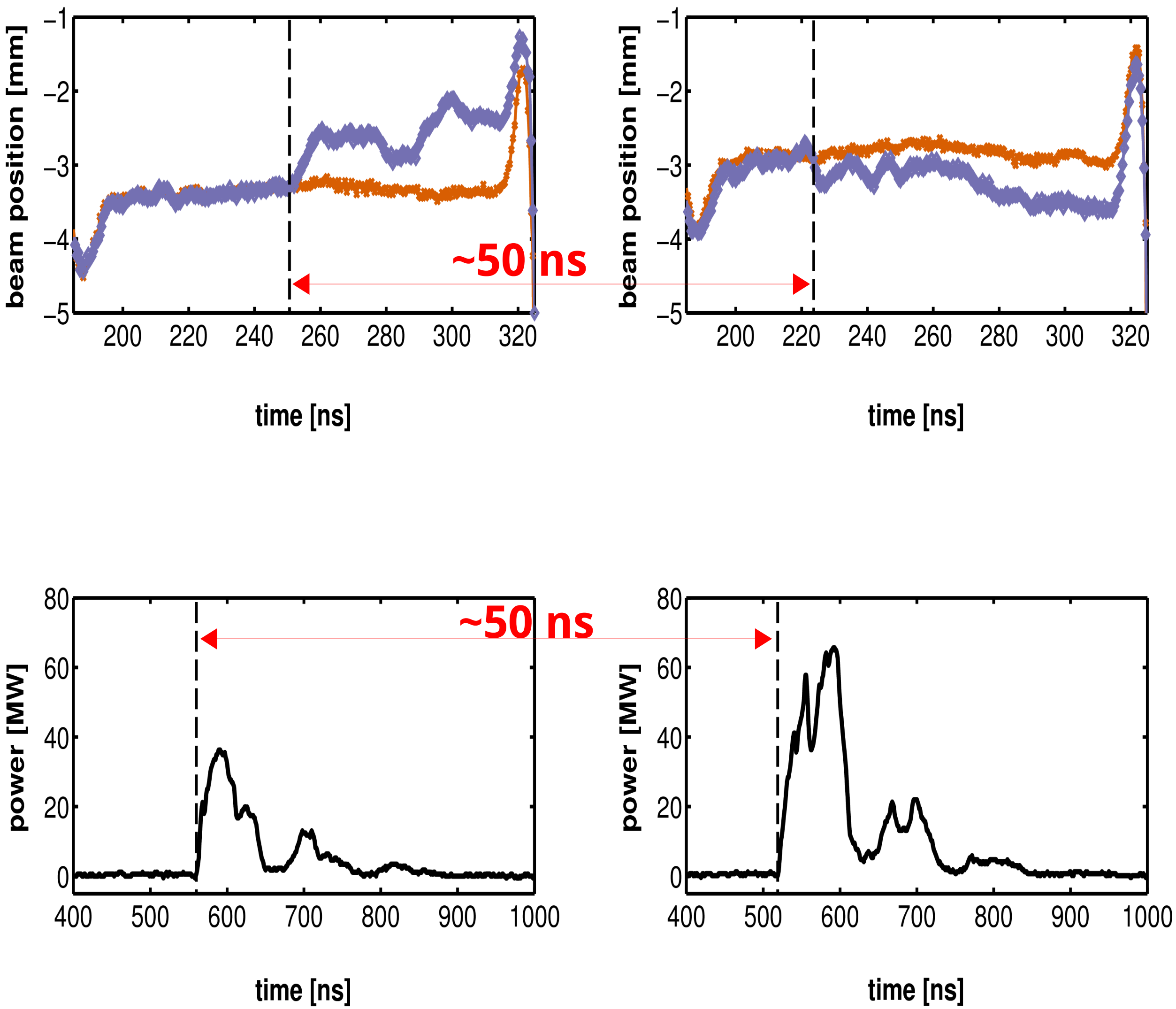
$$w_1 \cdot a \cdot (\text{accelerated spot}) + w_2 \cdot b \cdot (\text{non-accelerated spot})$$





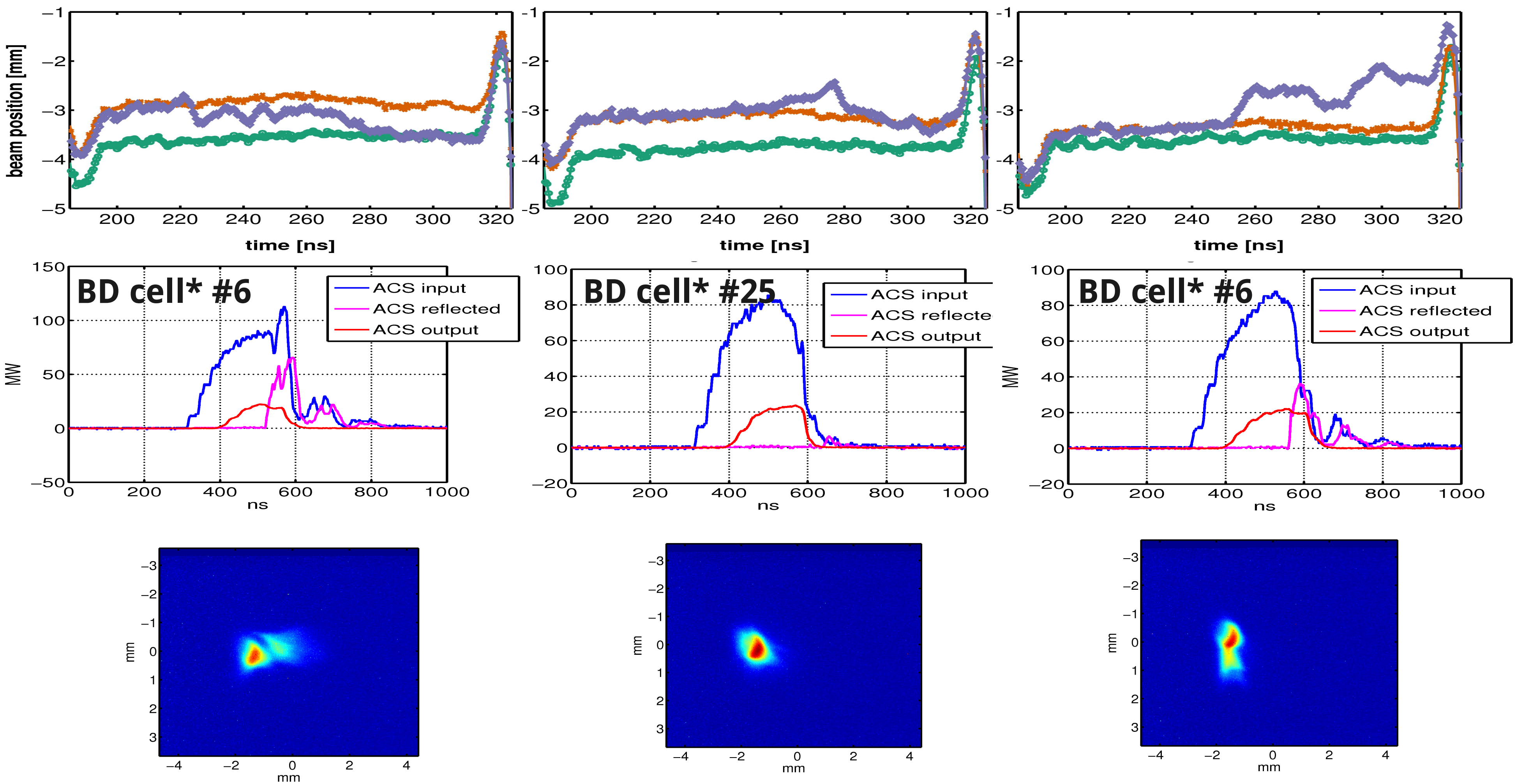


BPM vs RF measurements



- comparison between two consecutive breakdown events;
- the time difference between reflected RF signals (rising edges) is close to the time difference between the kick signature on the BPMs signals;
- small differences can be explained by different breakdown locations in the ACS which makes traveling time of reflected power to the measurement point different;
- note different bandwidths and sampling rates (250 MHz BW, 1GS/s for RF and 1GHz BW, 2GS/s for cavity BPM)

Breakdown scenarios

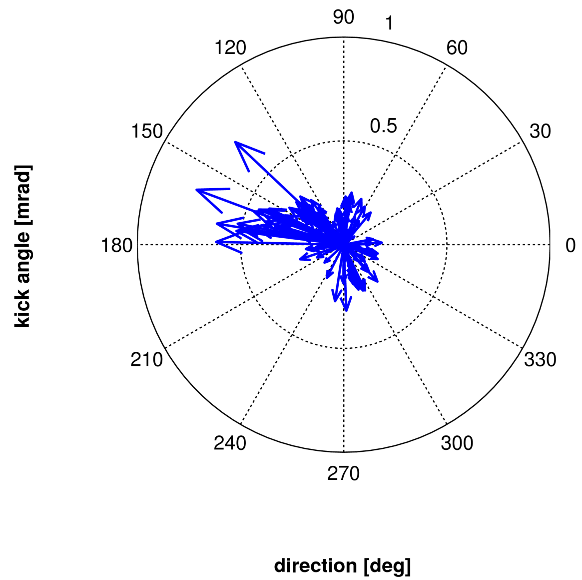


*BD cell estimated comparing transmitted and reflected RF (Wilfrid's analysis applied to this dataset)

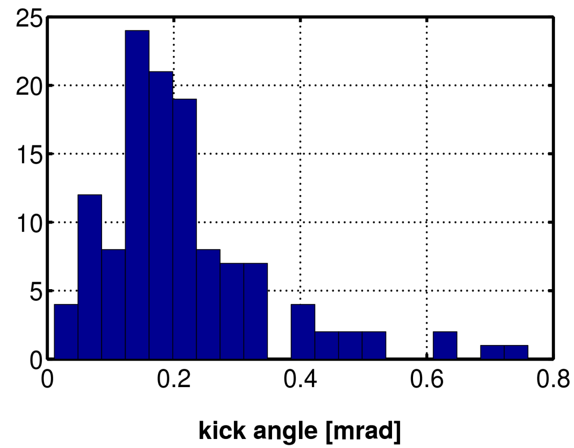
Kick angle and direction (MTV)

cfr. data from July 12, 2012

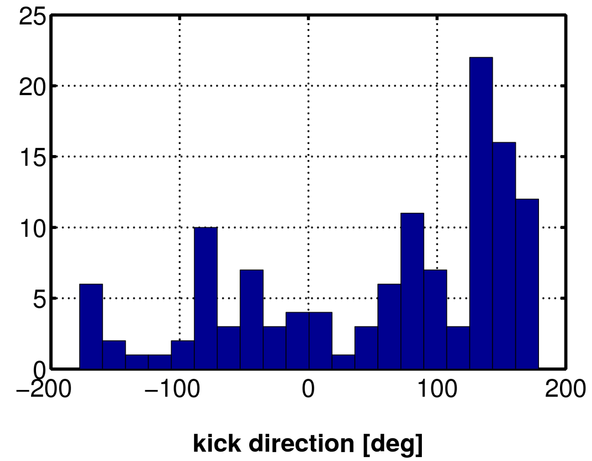
kick magnitude and direction



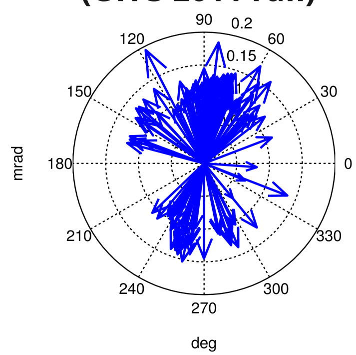
kick magnitude



kick direction (polar angle)



kick magnitude and direction (CTF3 2011 run)

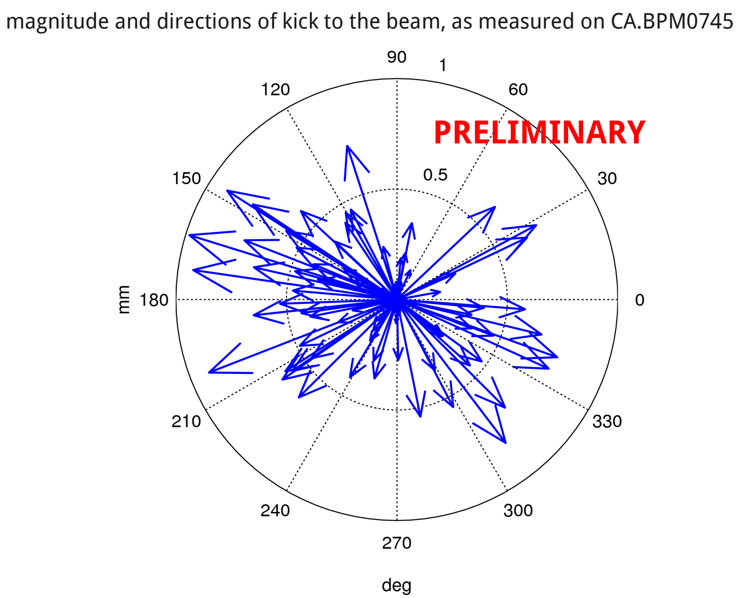


- kick magnitude and angle distributions measured on the imaging screen confirm measurements during CTF3 2011 run;
- asymmetry of measured kick direction is still visible but is different with respect to previous measurements (cfr. CTF3 2011 run);

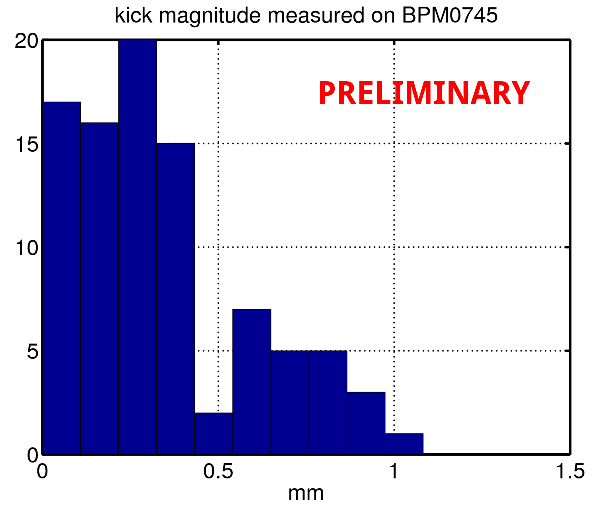
Kick angle and direction (BPM)

cfr. data from July 12, 2012

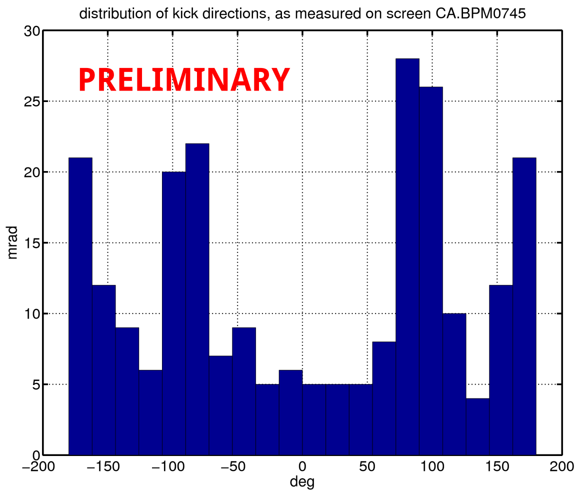
kick magnitude and direction



kick magnitude



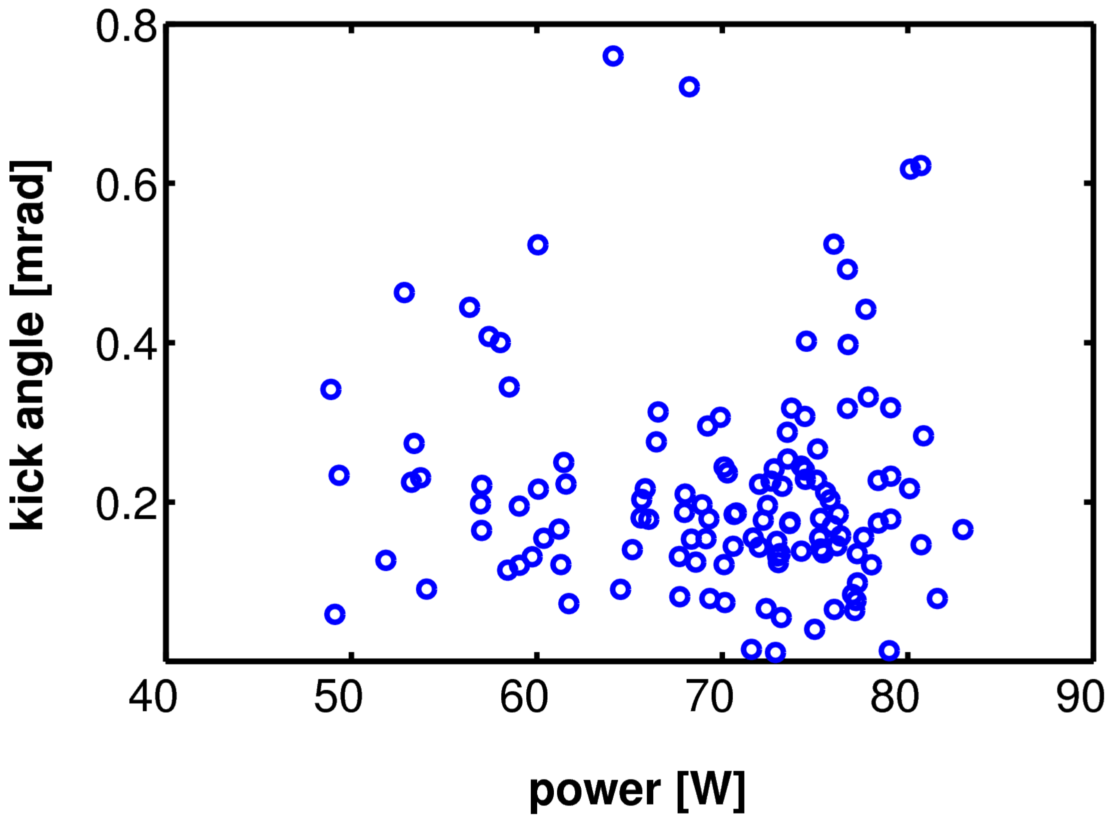
kick direction (polar angle)



- distance between two beam orbits (kicked and non kicked) is calculated as follows:
  - compute difference between accelerated (non breakdown) and breakdown orbits;
  - histogram of the difference orbit and fit with sum of two Gaussian (1D);

Kick dependence on ACS power

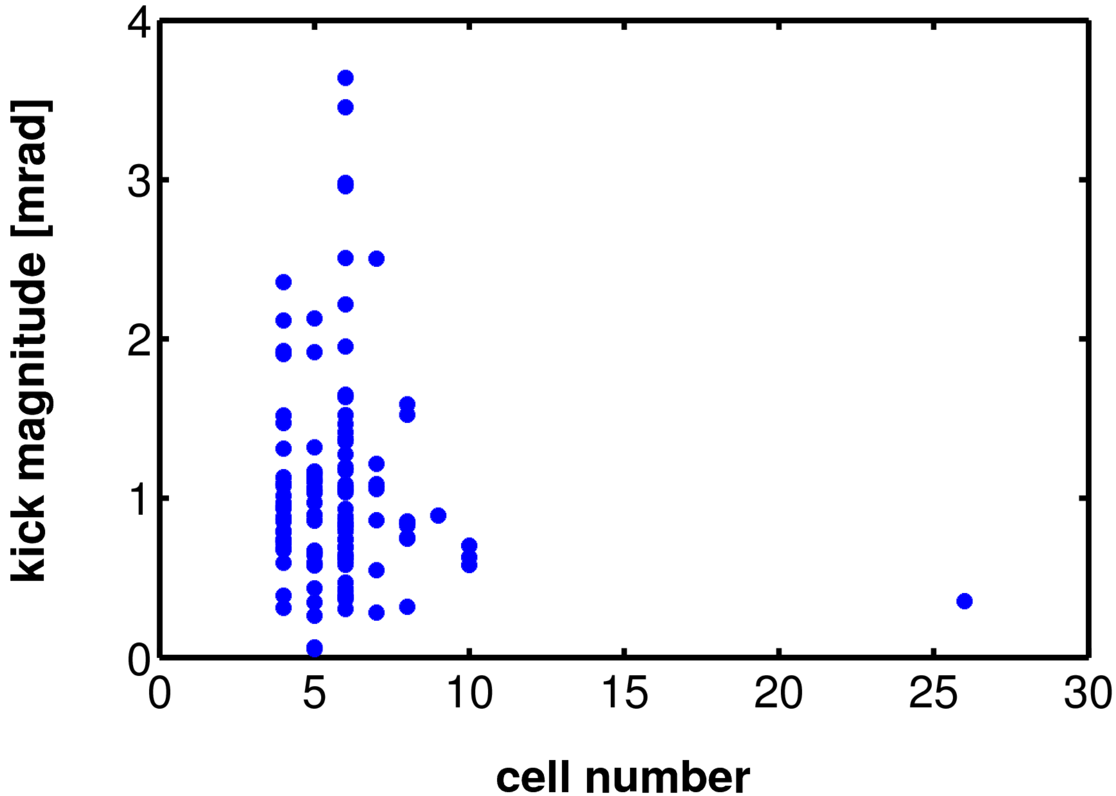
cfr. data from July 12, 2012



no correlation found between the kick magnitude and the power seen by the beam in the ACS (measured RF averaged at flat top)

Kick dependence on BD cell

cfr. data from July 12, 2012



no correlation found between the kick magnitude and the BD cell*

*BD cell estimated comparing transmitted and reflected RF – Wilfrid's analysis applied to this dataset

Conclusions

Diagnostics

- CALIFES type re-entrant cavity BPMs can resolve fast changes in the beam orbit

Acceleration

- evidence for some RF focusing effect in ACS
- possible ACS misalignment accounts for (non-breakdown) kicks to the beam orbit that we use as indirect energy measurement

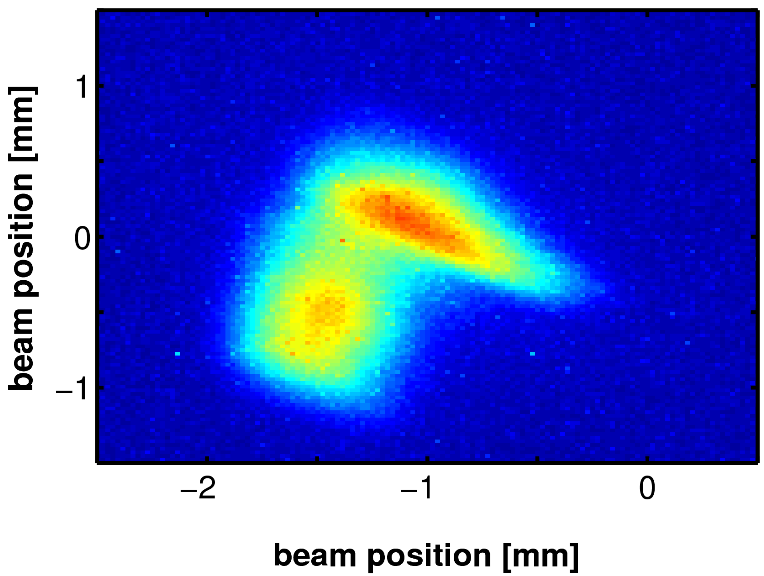
RF breakdown

- evidence for RF breakdown kicks to the beam are supported by BPM, imaging screen and RF measurements
- possible measurement of RF breakdown kick + absence of power in ACS in some cases but difficult to disentangle

- kick from ACS misalignment can explain measured kick anisotropy
- kick magnitude confirmed also from BPM measurements
- no correlation found between kick magnitude and power or BD location in ACS

spare slides

Beam spot image fit



The sum of two 2-dimensional Gaussian complete of the correlation terms between x and y is fitted to the images of the beam spot

$$A_1 \exp\left\{-a_1(x-\mu_{x,1})^2 - b_1(y-\mu_{y,1})^2 - 2c_1(x-\mu_{x,1})(y-\mu_{y,1})\right\} +$$
$$A_2 \exp\left\{-a_2(x-\mu_{x,2})^2 - b_2(y-\mu_{y,2})^2 - 2c_2(x-\mu_{x,2})(y-\mu_{y,2})\right\}$$

The minimization is highly unstable due to the number of parameters (12) therefore critically dependent of the choice initial parameters which are calculated fitting the sum of two 1-dimensional Gaussian to the horizontal and vertical projections of the same image