Two-Beam Module experimental results

W. Farabolini on behalf of the CTF3 team

Outline

- RF power from DB and acceleration of PB
  - Direct RF production,
  - RF production with priming,
  - Reflected power
  - Bunch length measurement
  - Beam loading
- WFM
- Kick measurements
- Measurement methods based on Octupolar components
- Survey and girders mechanical coupling

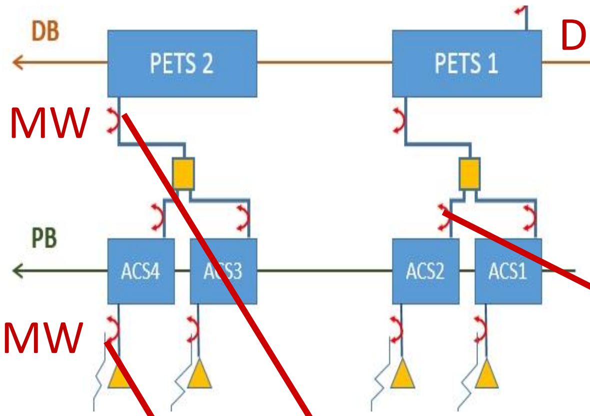
DB direct RF production with factor 8 recombination

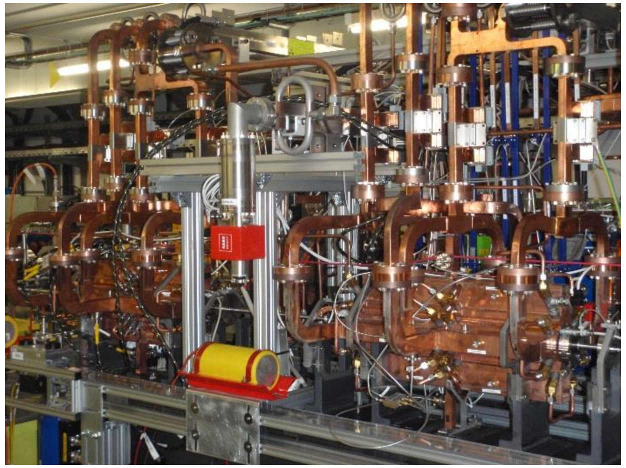
DB: 24 A

PETS: 25 MW
(x 2)

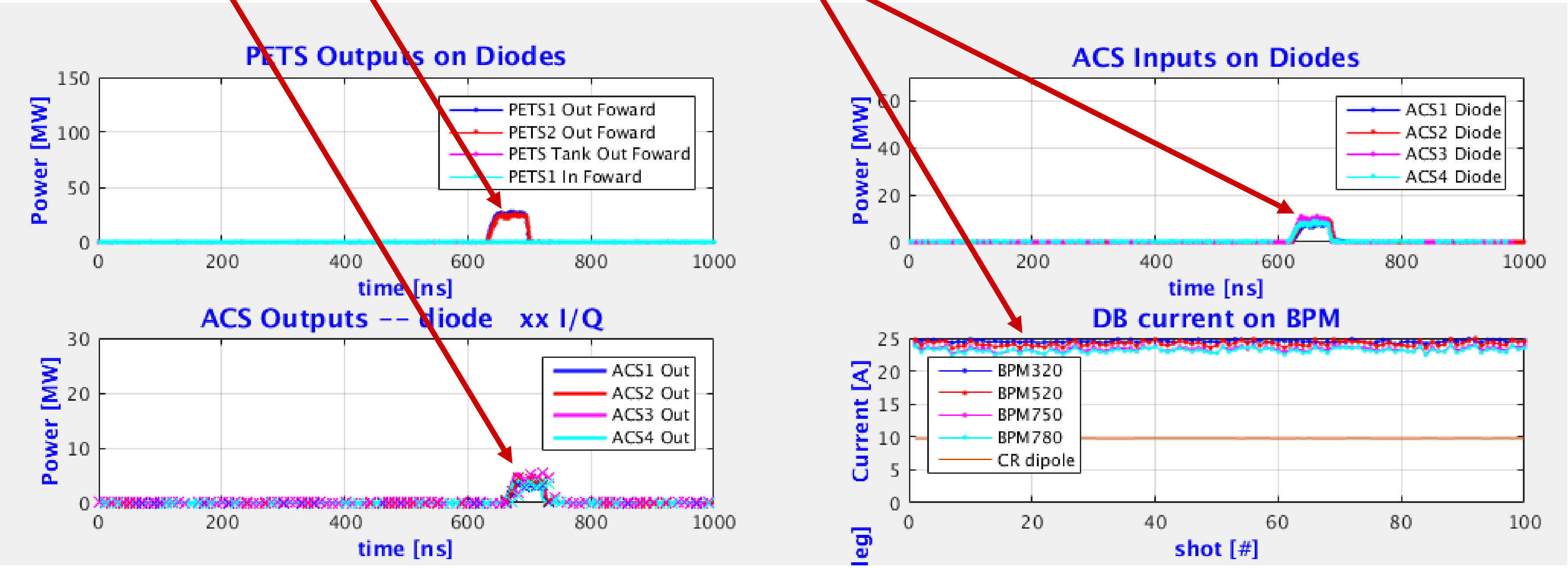
ACS out: 4 MW
(x 4)

ACS in: 10 MW
(x 4)

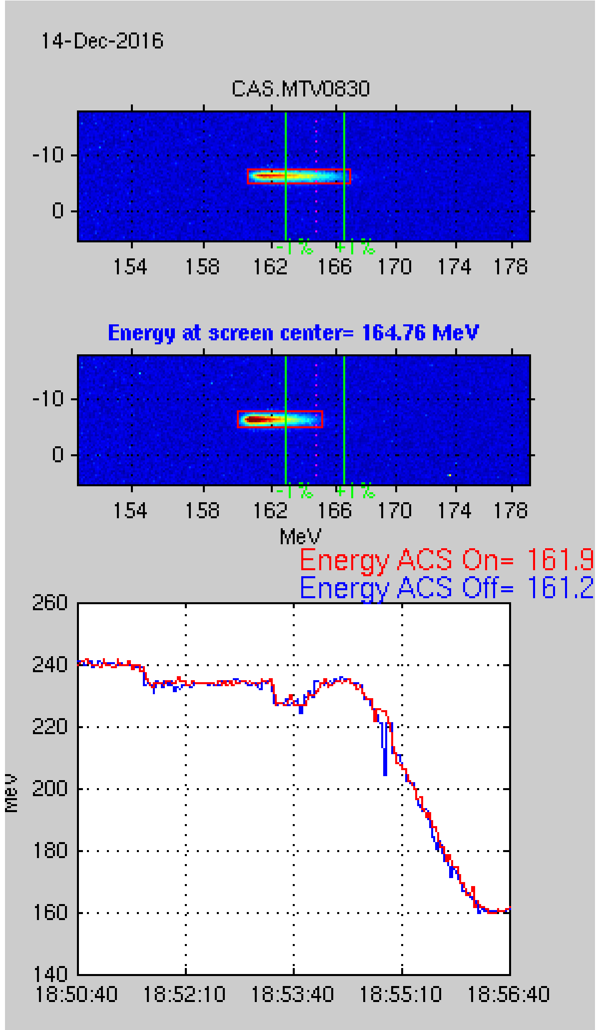


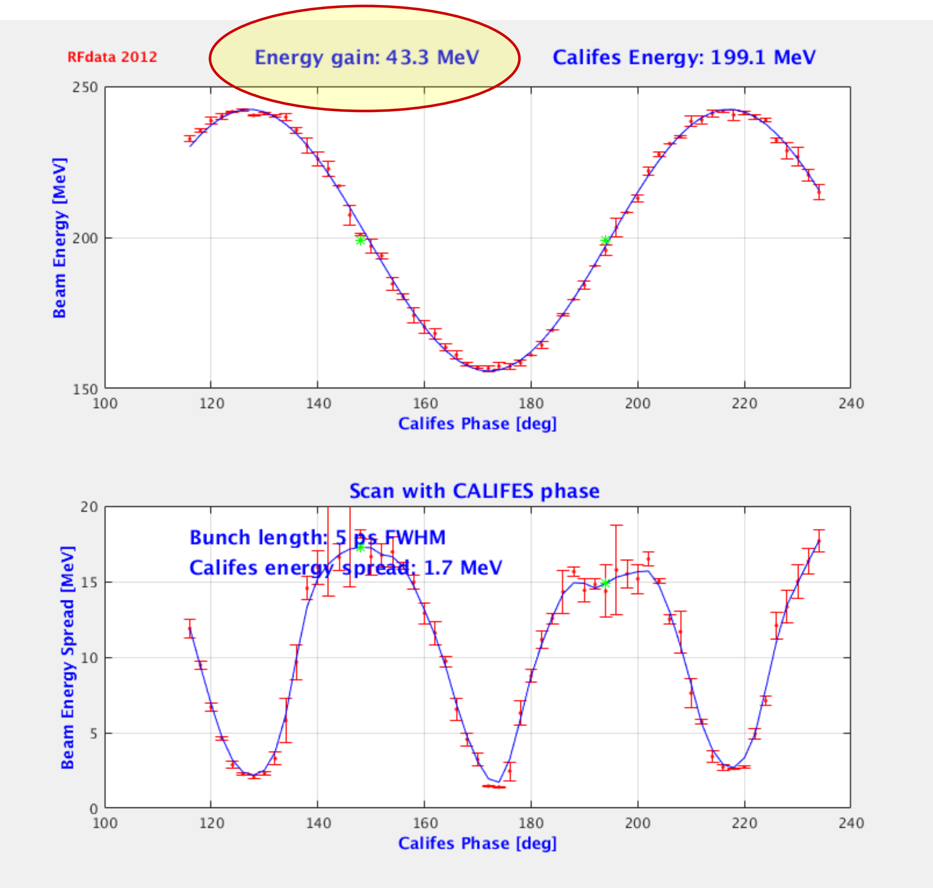


S_{12} = 0.64 for TD26CC
P_{out} = 0.41 x P_{in} (unloaded)



Energy gain with direct production factor 8





Energy and energy spread as function of PB phase

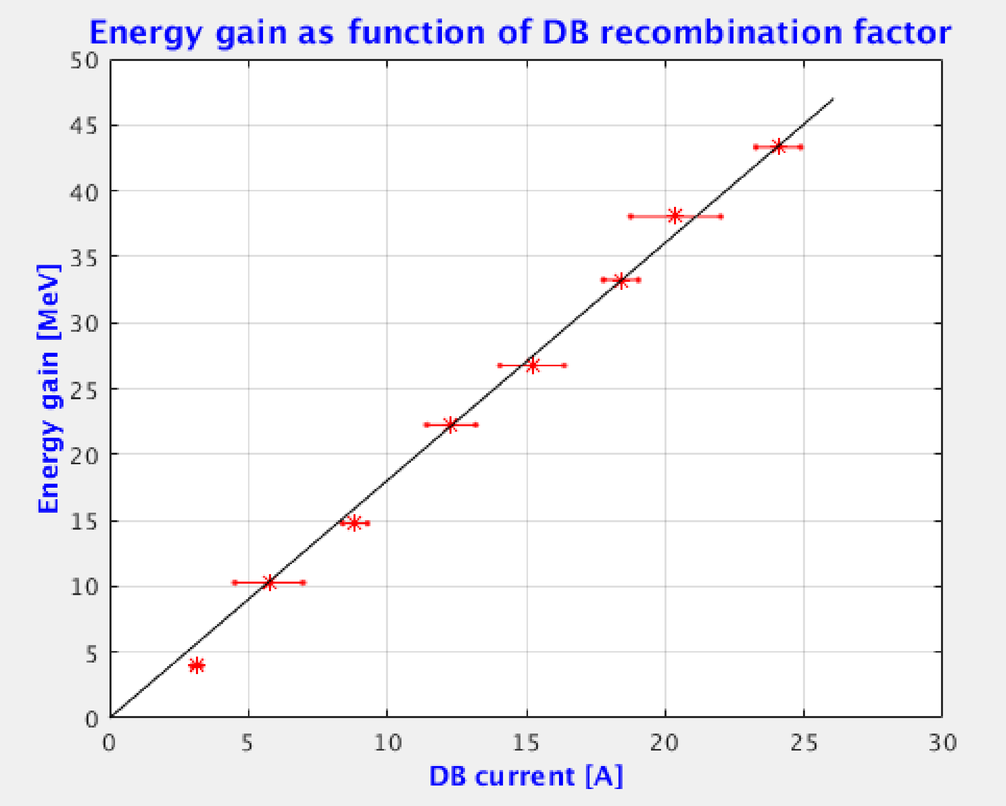
Wed 14/12 18:43
DB Current: 25 A

- Probe beam phase is scanned over 360 deg.
- Energy recorded in the spectrometer line with magnet current tracking.
- Sinusoidal fit gives PB input energy and energy gain.
- Measures of energy spread on crest and at zero crossing allow to compute bunch length.

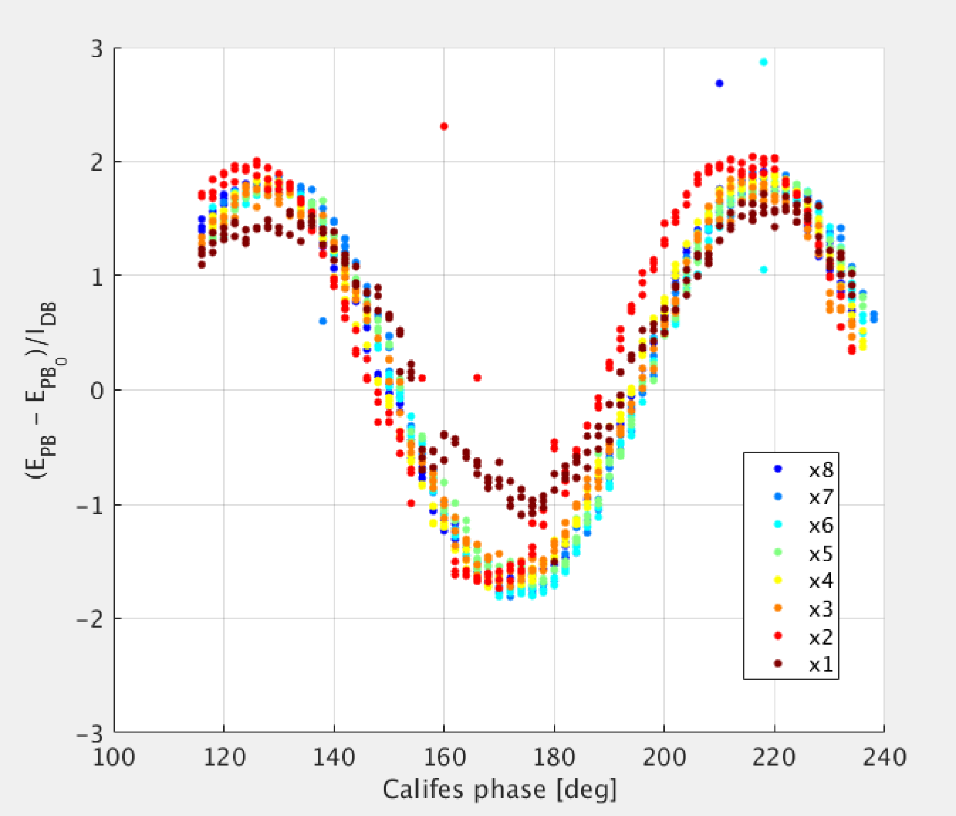
V_{28}[V]@1W = 3520 for 26 + 2 cells (*)
E_{gain} [10MW] = 11.1 MeV per ACS

* Table of parameters for TD26_vg1.8_R05_CC, A. Grudiev

Direct production for recombination factors from 1 to 8



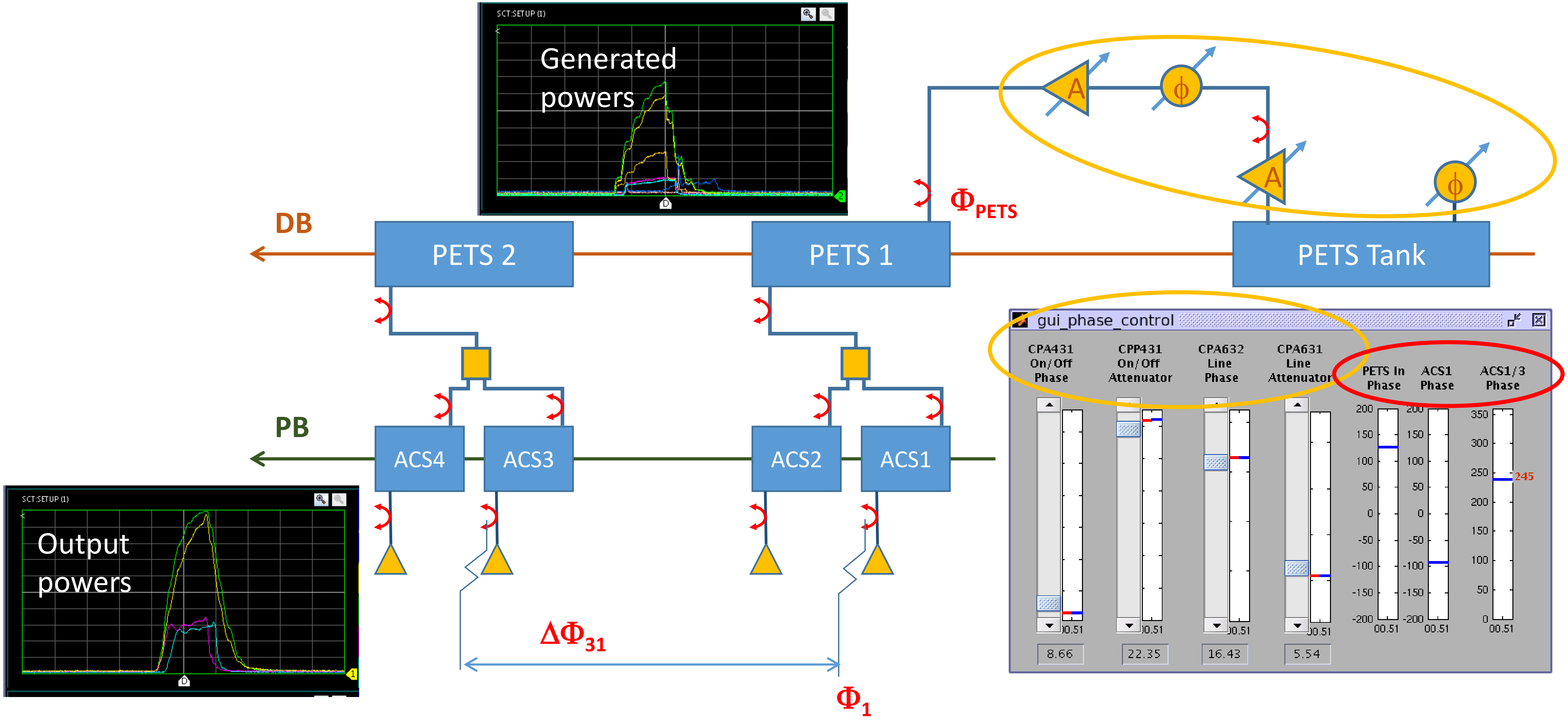
Energy gain (direct production) as function of DB current obtained for various recombination factors



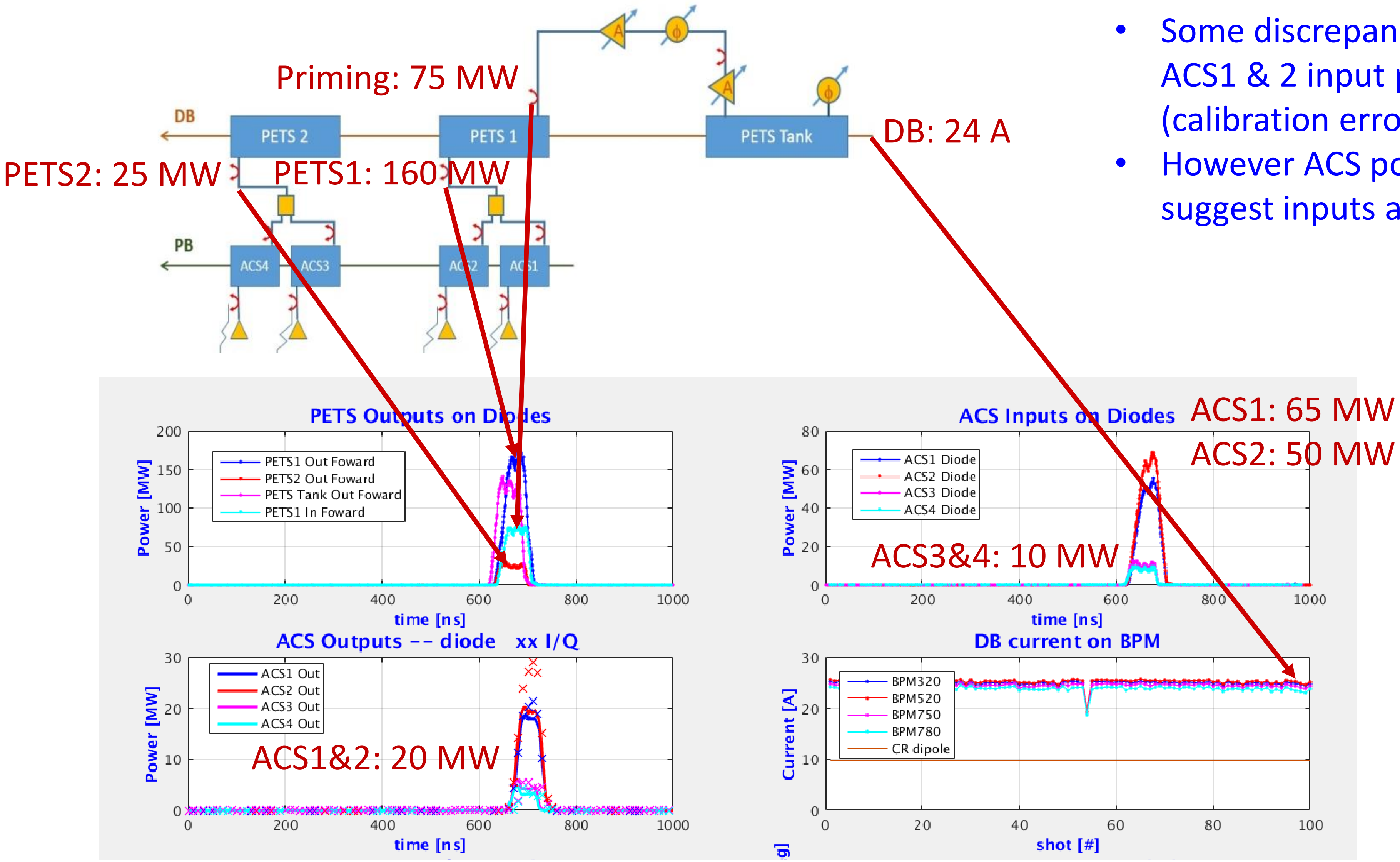
Energy gain over DB current during PB phase scan (D. Gamba)

The DB form factor remains quite constant with recombination factor

Test Beam Module (TBM) control

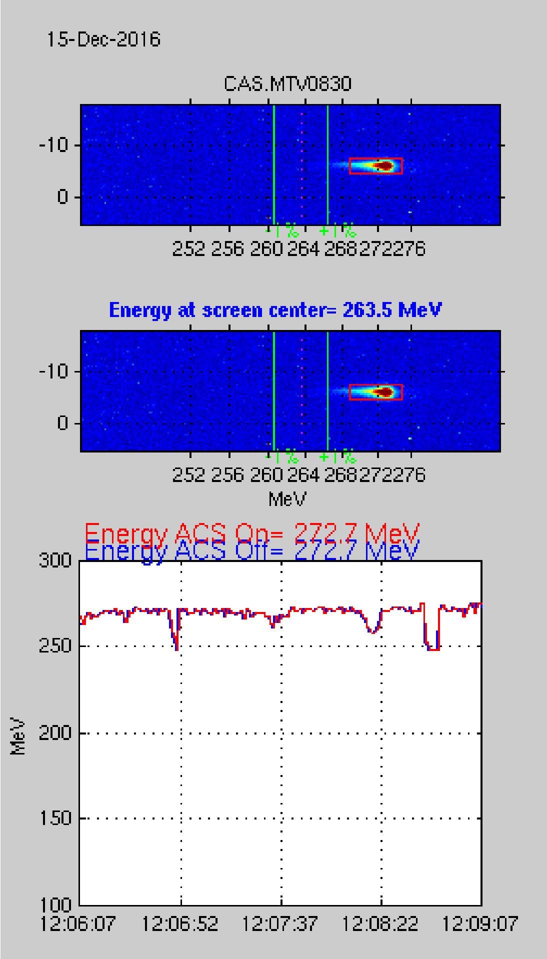


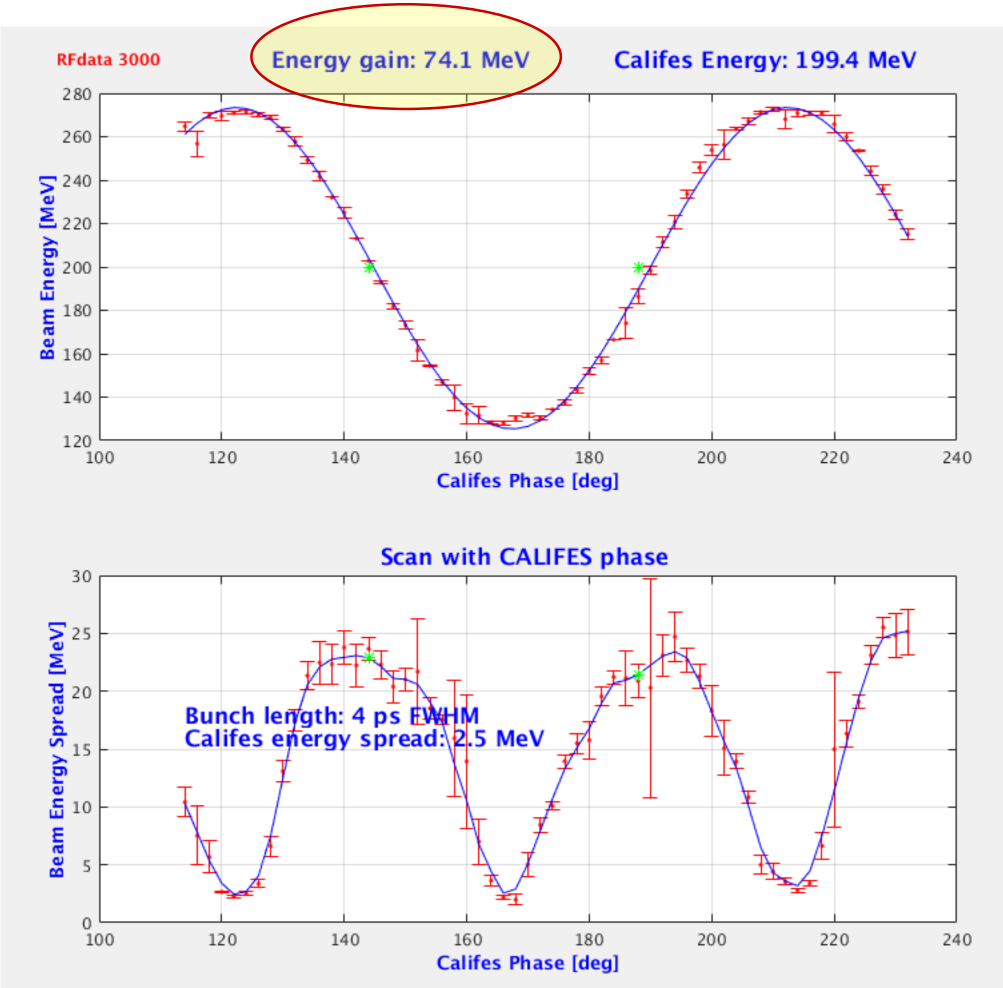
Now with RF priming on first PETS



- Some discrepancies between ACS1 & 2 input powers (calibration error ?)
- However ACS powers out suggest inputs at 50 MW

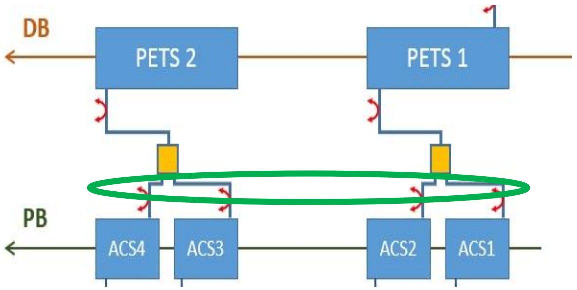
Highest acceleration obtained on 15th Dec.

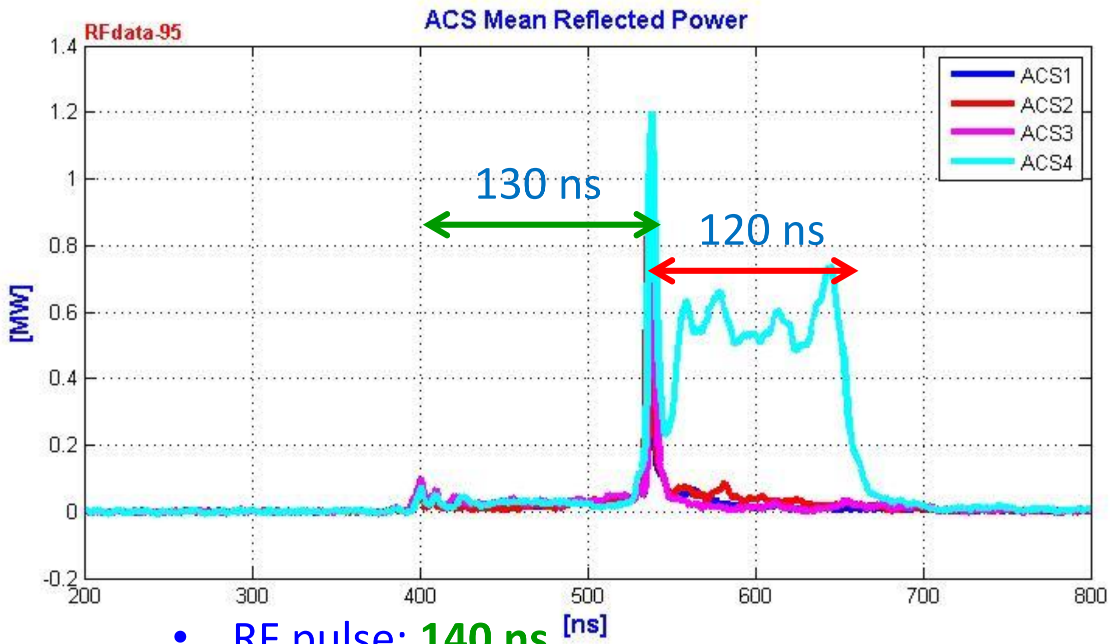


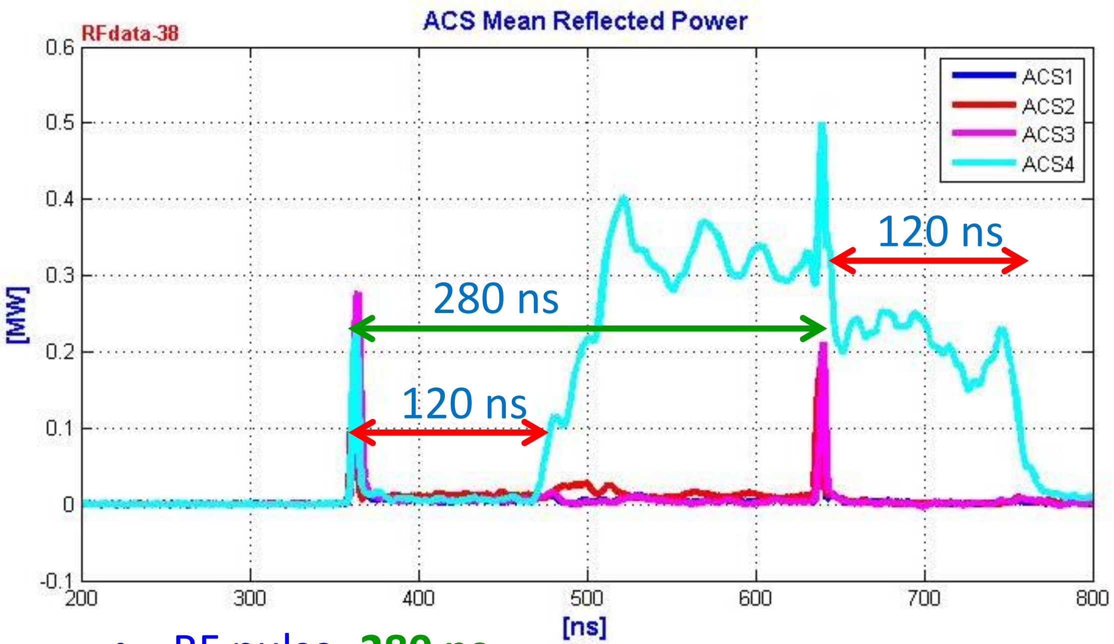


- ACS1&2 gain :
  74.1 – (2x11.1) = 51.9 MeV
- ACS1 or 2: 26 MeV for 23.26 cm
  Accel. Grad. = 110 MV/m
  Corresponding to 53 MW input power (43.7 MW for 100 MV/m)
- BD rate was the limiting factor (lack of conditioning)

Structures reflected power





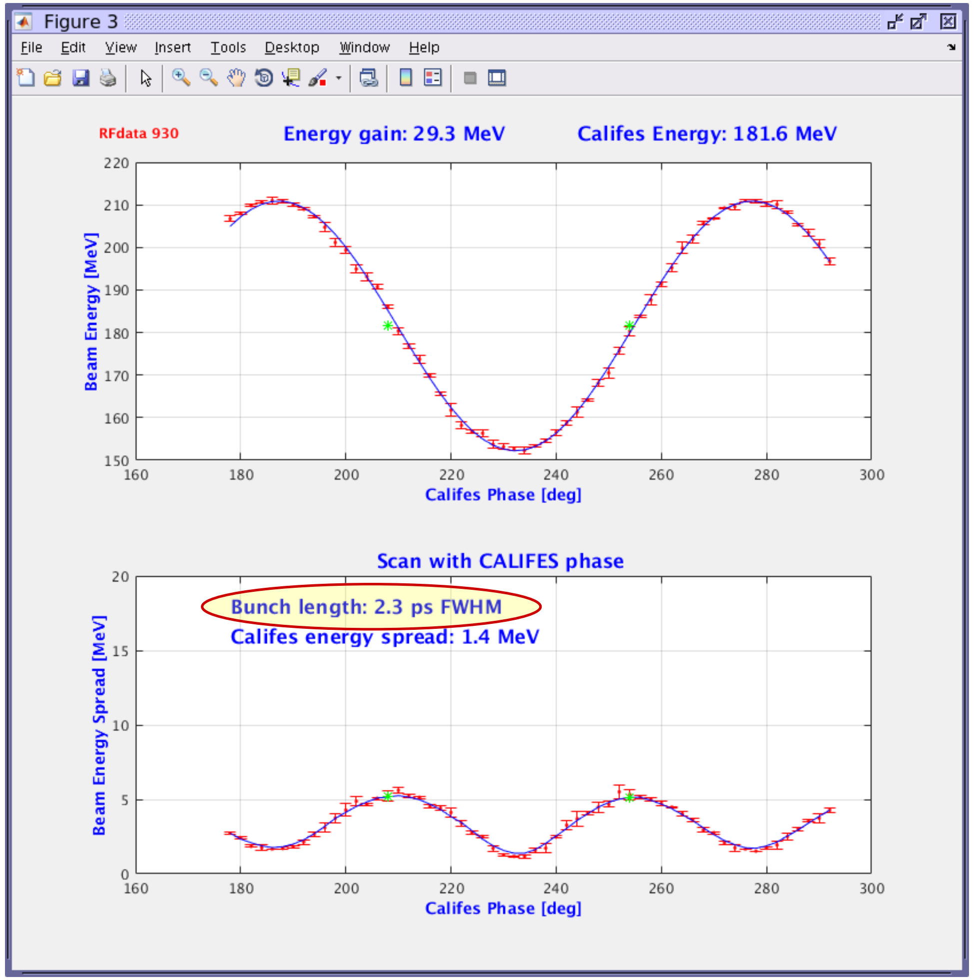


- RF pulse: **140 ns**
- ACS4 reflects power during 120 ns

- RF pulse: **280 ns**
- ACS4 Reflected Power appears after 120 ns and lasts 120 ns after the end of the RF pulse

- ACS filling time: 65 ns
- ACS4 reflection default close to the end the structure (output port ?) to be investigated in the lab.

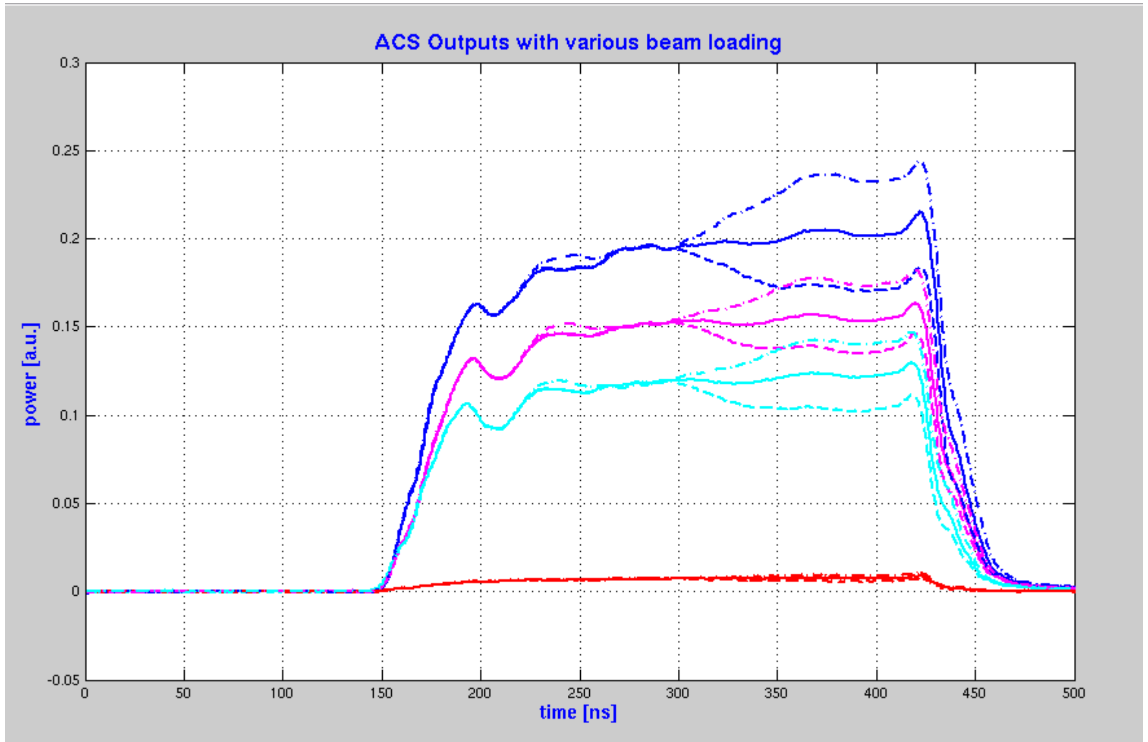
PB bunch length with compression



DB phase scan with compressed bunch

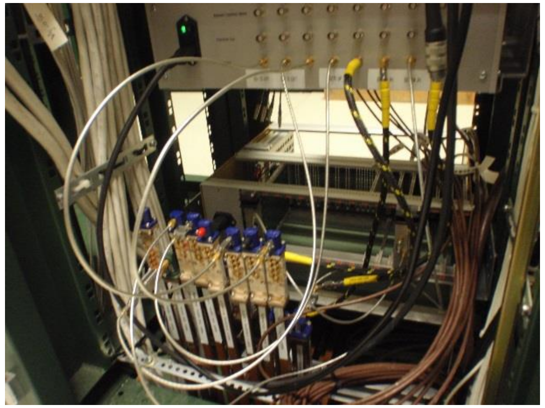
- First Califes structure phase tuned for velocity bunching (lower energy but bunch compression)
- 2.3 ps FWHM quickly obtained instead of 5 ps uncompressed
- X-band structures is the most practical tool to measure bunch length (compared to S-band deflecting cavity, streak camera and Electro-Optical System)

Beam loading



Beam loading (and anti-loading) with CALIFES long train (250 ns) visible on ACSs output coupler

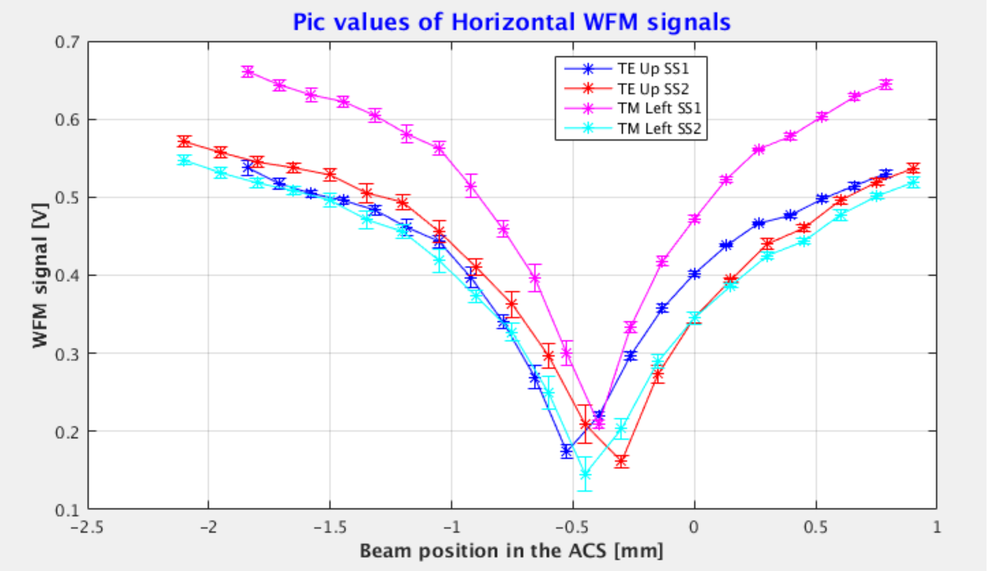
WFM studies



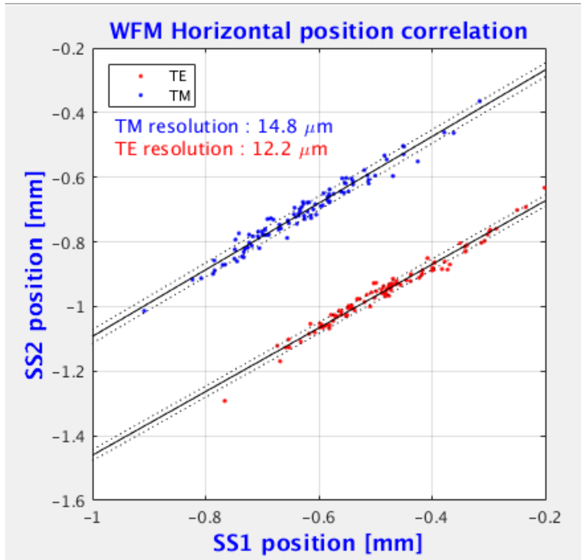
WFM waveguides in CLEX and in the gallery

- One set of Wake Field Monitors per superstructure on the 2nd cell of the 2nd structure
  - TE-like and TM-like modes pick-up
  - Horizontal and Vertical channels
- Main issues: resolution and sensitivity to the DB noise

All the details in Reidar's next talk

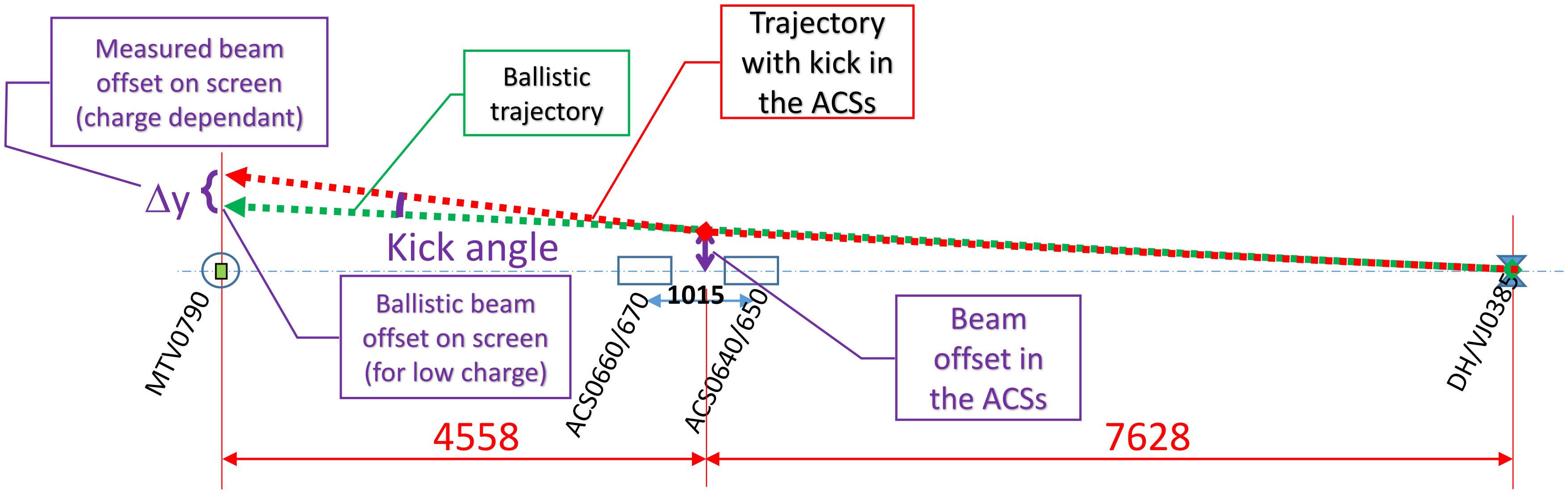


Horizontal beam scan using corrector and response of the WFM.

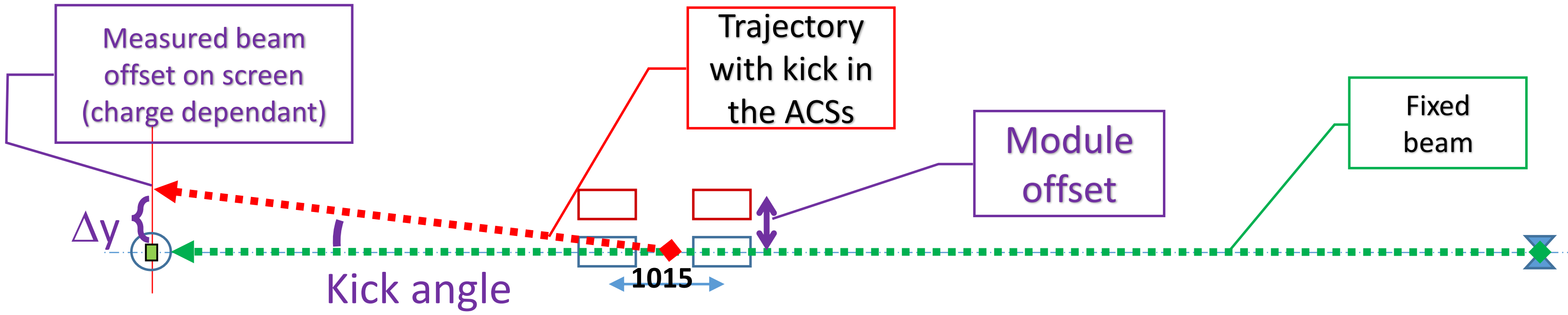


Method to derive WFM resolution despite beam position jitter

Transverse kicks induced by beam misalignment

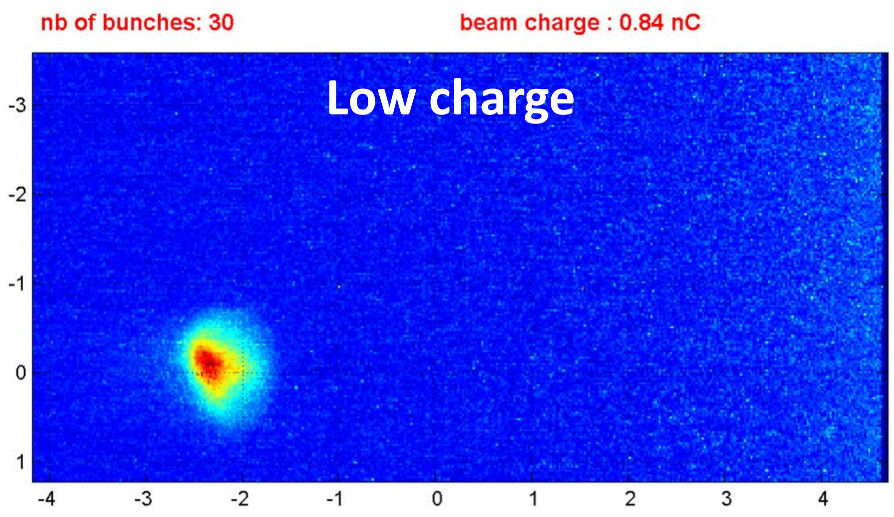


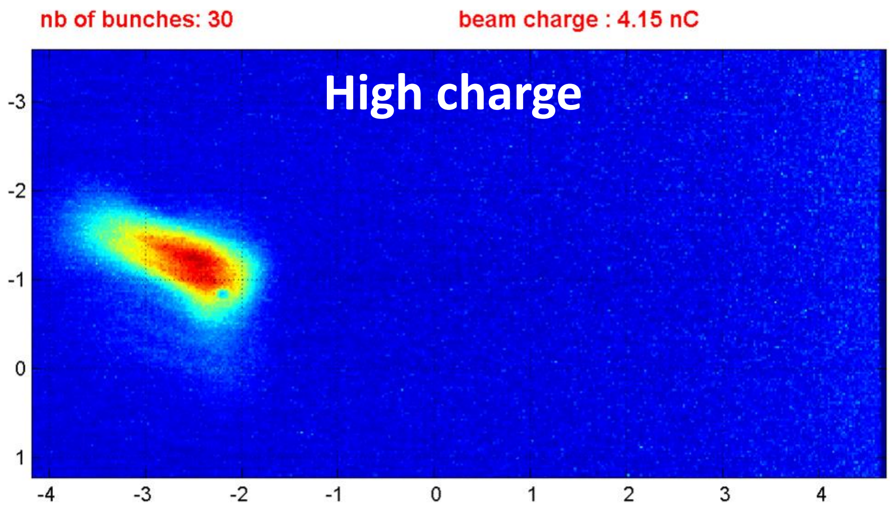
First method: beam displacement using corrector

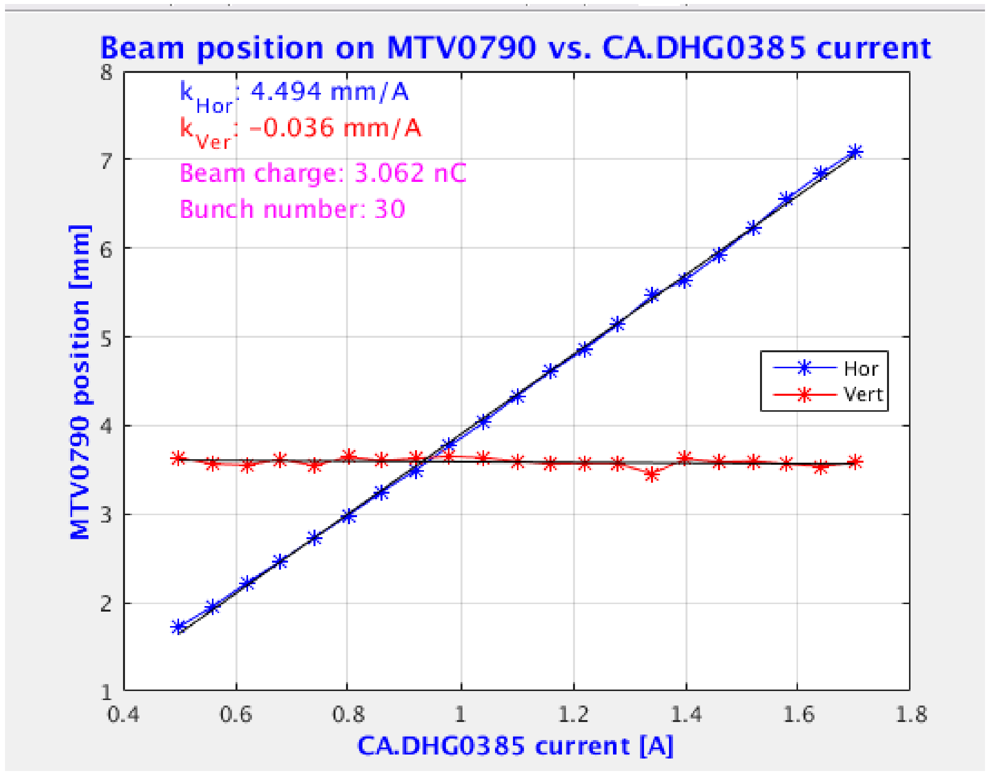


Second method: ACSs displacement with fixed beam using module girder movers

Scan corrector current and beam position on MTV

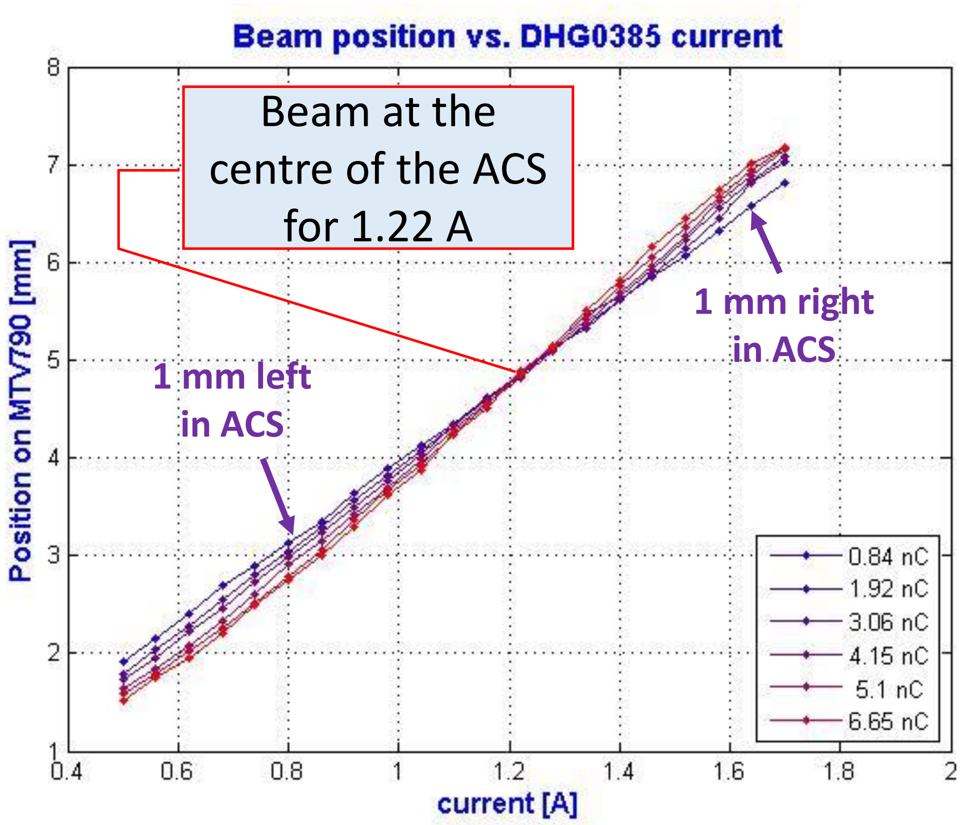


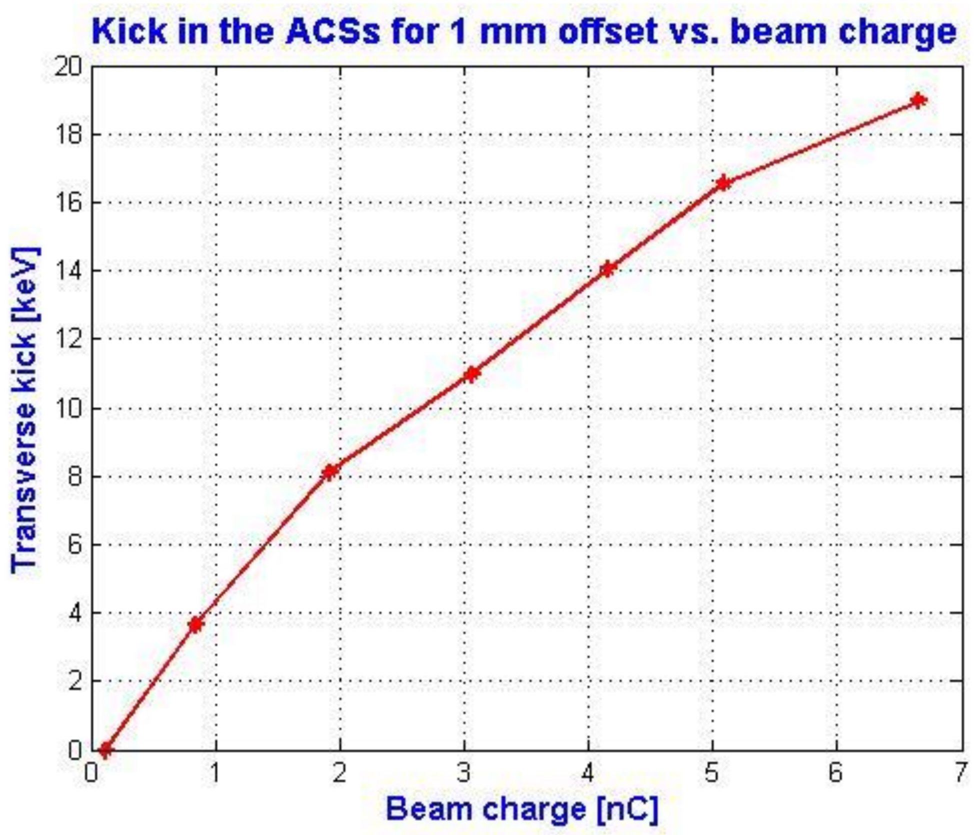




A position scan using corrector DHG0385 and slope fitting

Results for various beam charges and 30 bunches



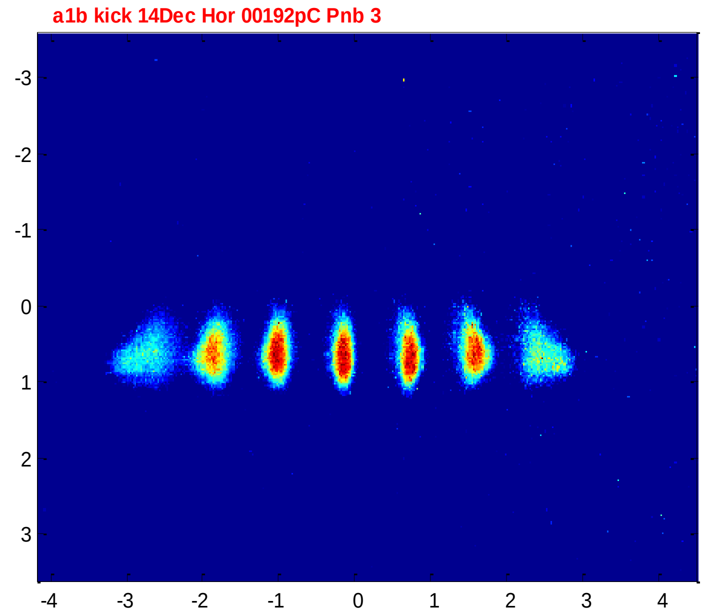


Position scan for 6 various beam charges and 30 bunches [CTF logbook 28-09-16 8:23]

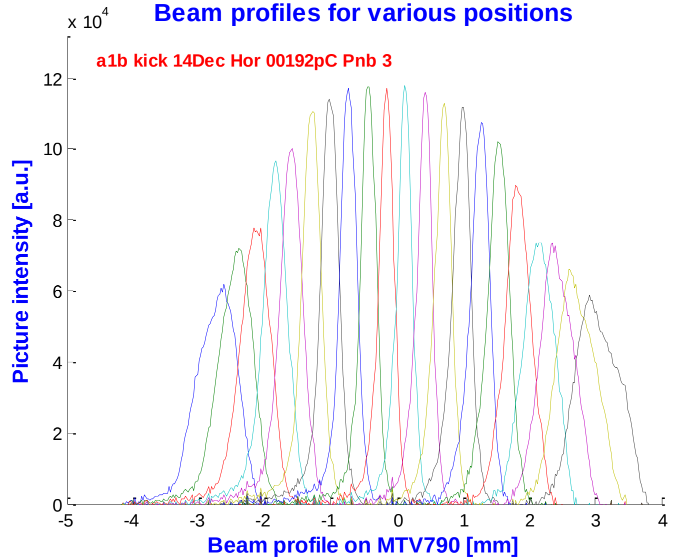
Kick up to 19 kV for 1 mm offset and 0.22 nC per bunch, 30 bunches: 85.5 kV /nC /mm /m

Kick angles by the ACSs for beam offset 1 mm up to 0.094 mrad for beam charge 6.7 nC (30 bunches of 0.22 nC)

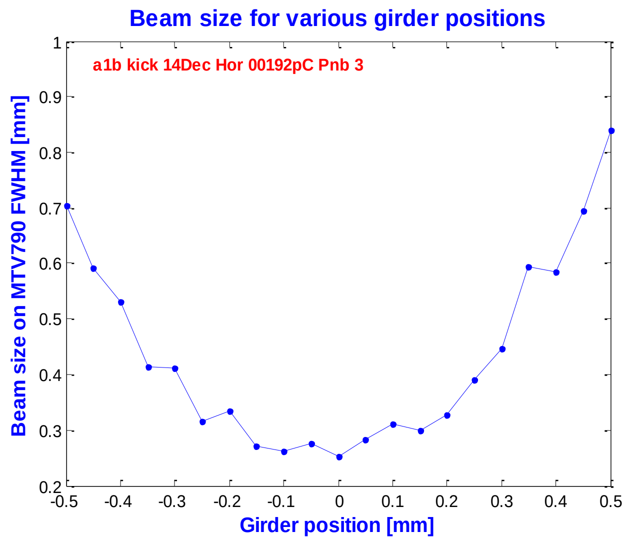
1st method: Beam position scan



Superposition of 7 beam trajectories on MTV790

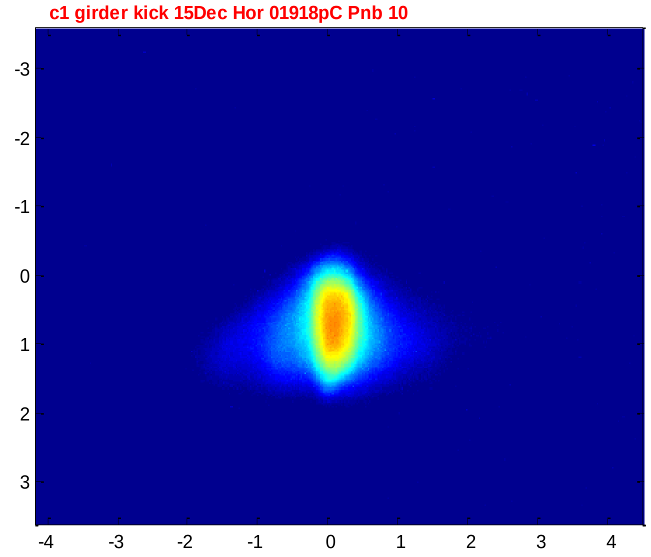


Beam profile for 22 trajectories

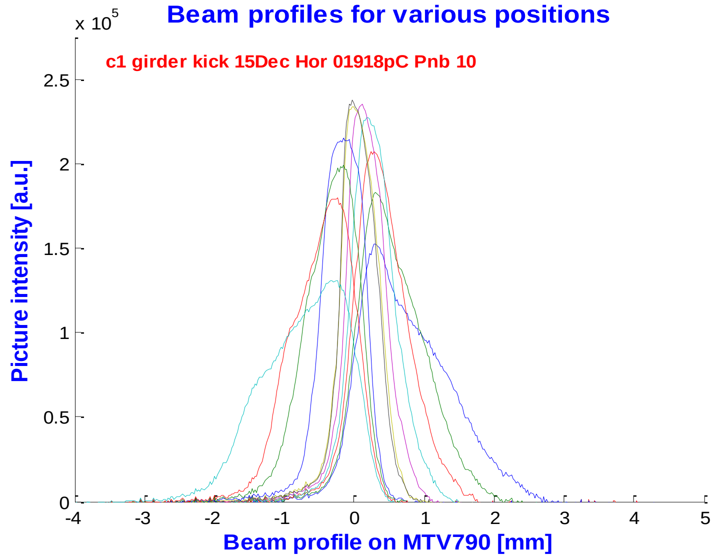


Beam profile for 22 trajectories

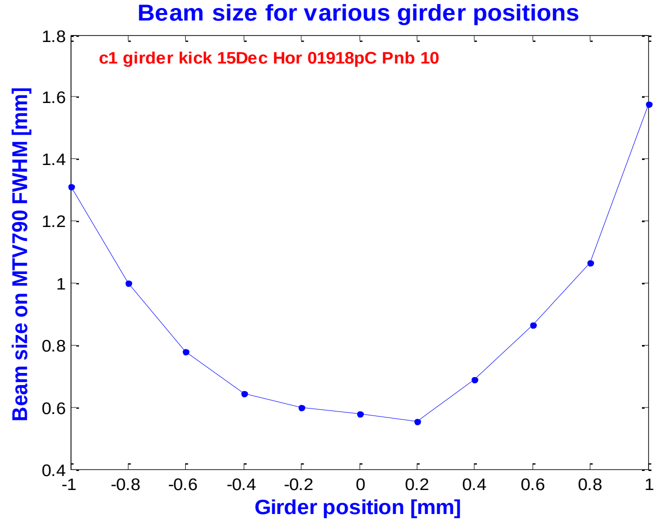
2nd method: Girder position scan



Superposition of 7 beam trajectories on MTV790



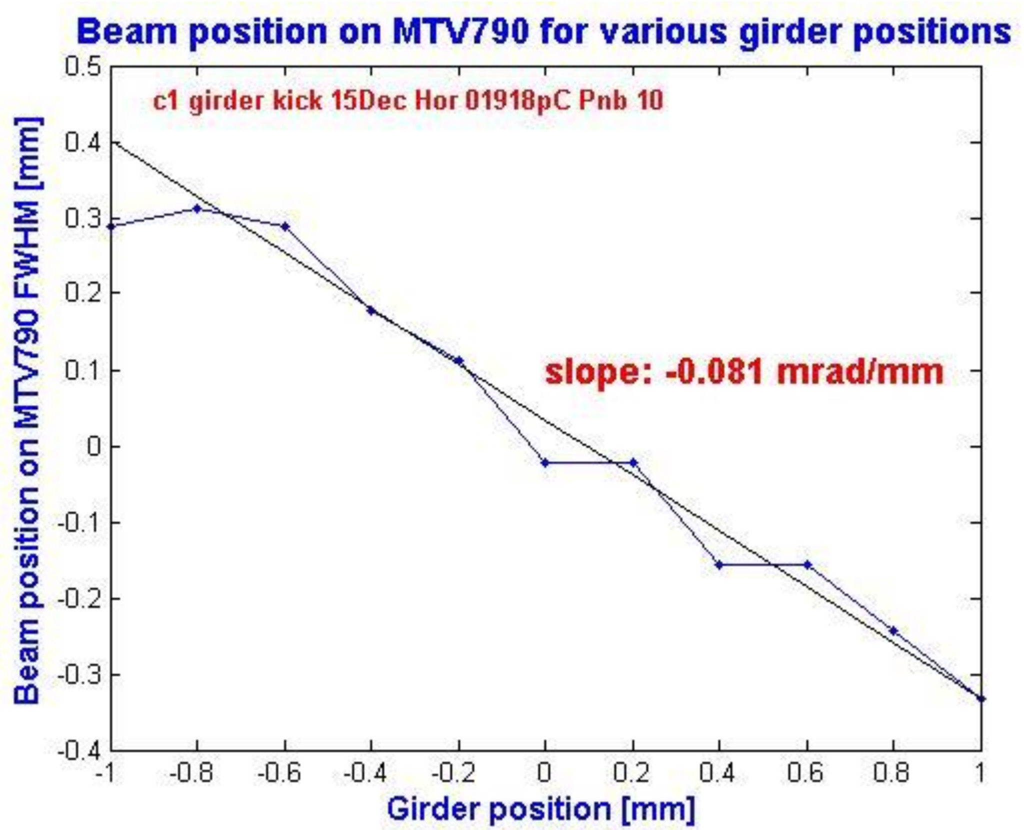
Beam profiles on MTV790 for 11 girder positions



Beam size on MTV790 for 11 girder positions

Thanks to Anna et Vivien from EN-ACE-SU

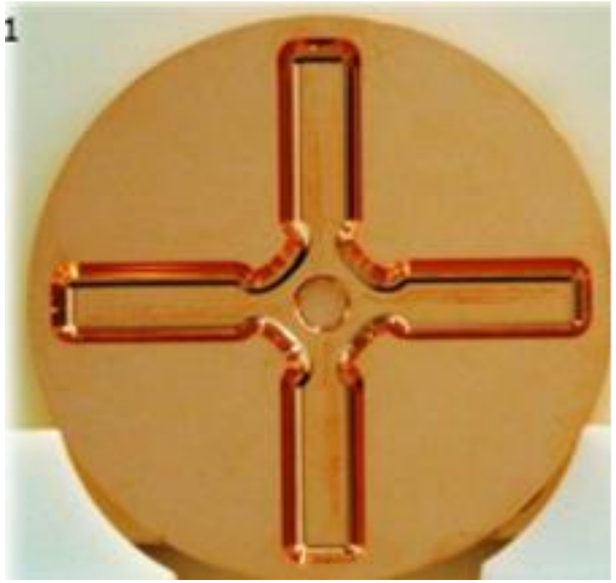
Kick measured with girder position scan



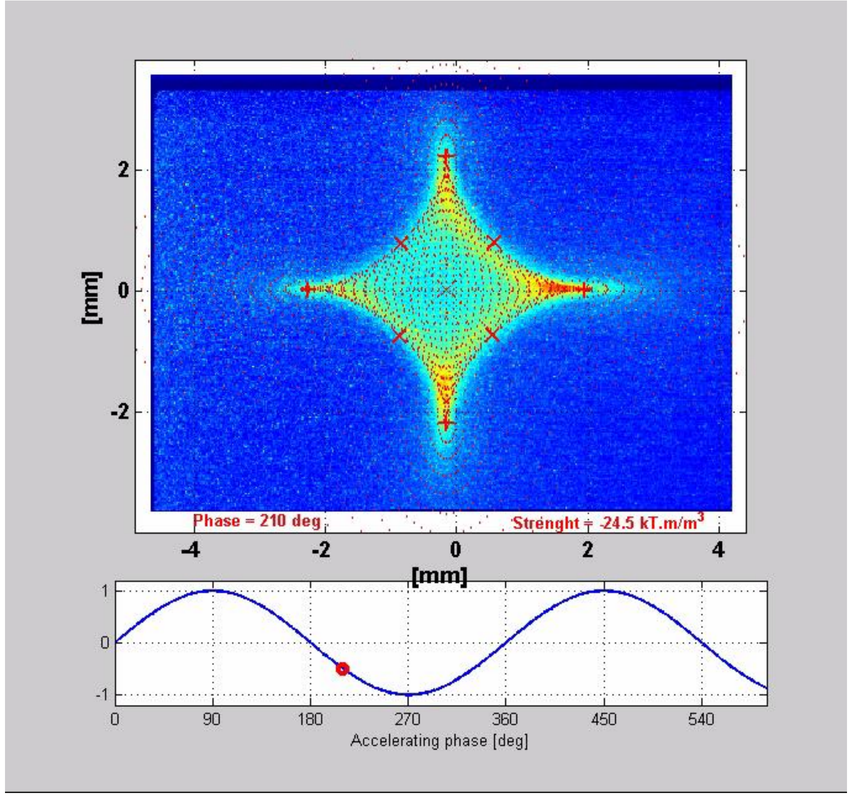
Beam position for 11 trajectories on MTV790

- Kick angle: 0.081 mrad for a beam offset of 1 mm with bunch charge 0.19 pC
  85.3 kV /nC /mm /m
- To be compared with 1st method: 0.094 mrad/mm with bunch charge 0.22 pC
  85.5 kV /nC /mm /m

Evidence on octupolar components of the accelerating field

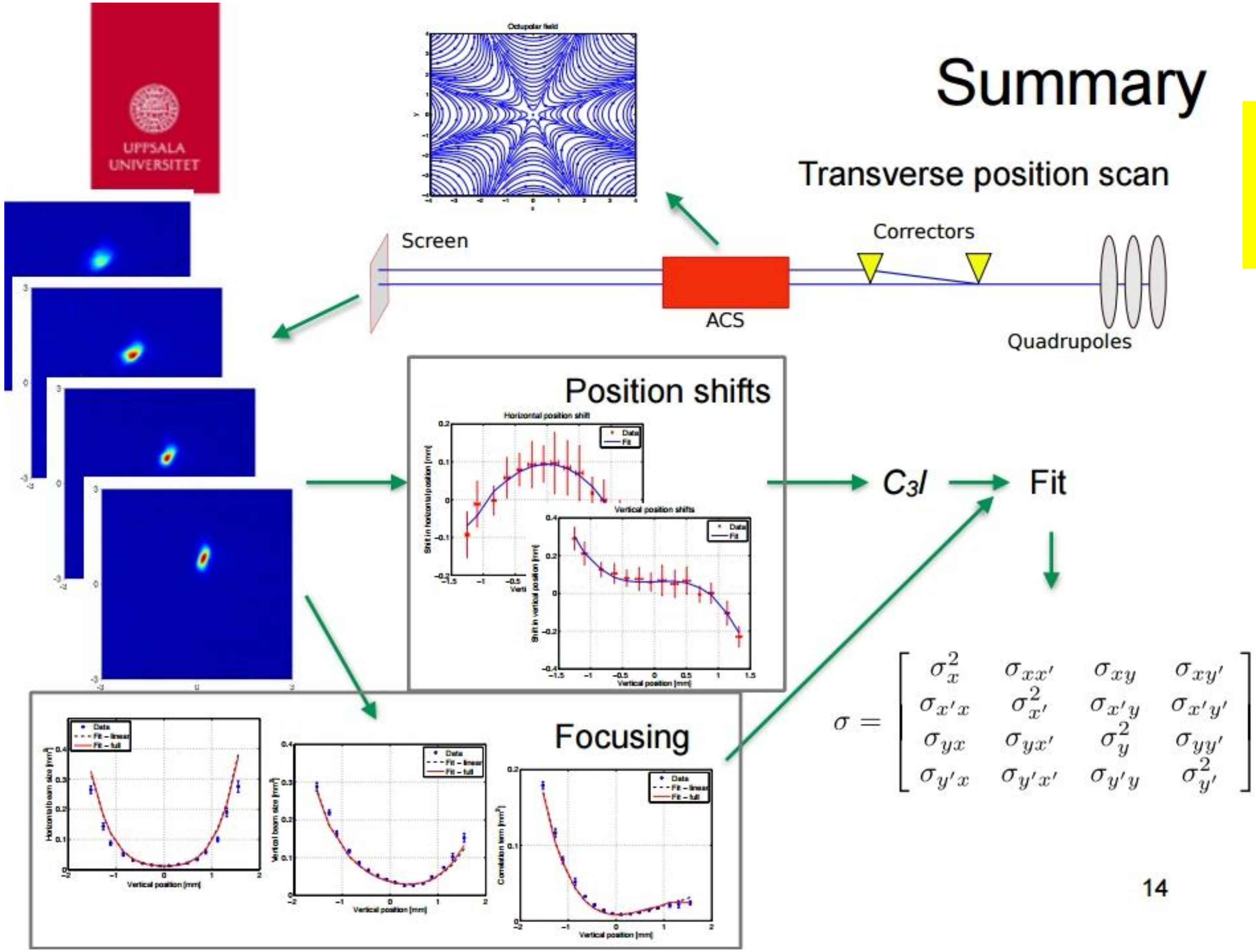


Structure disk



Due to the non axial symmetry of the cell an octupolar component of the accelerating field is present

Extensive study from Uppsala University



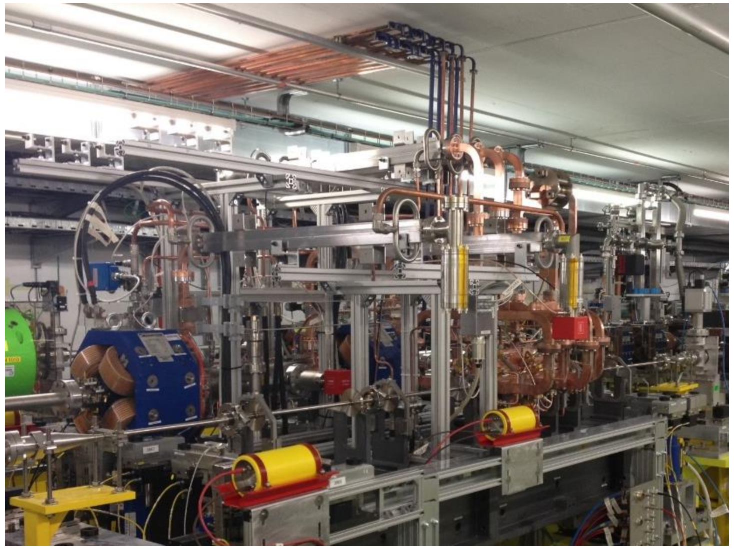
Beam-based diagnostic of octupole component in CLIC accelerating structure, Jim Ögren

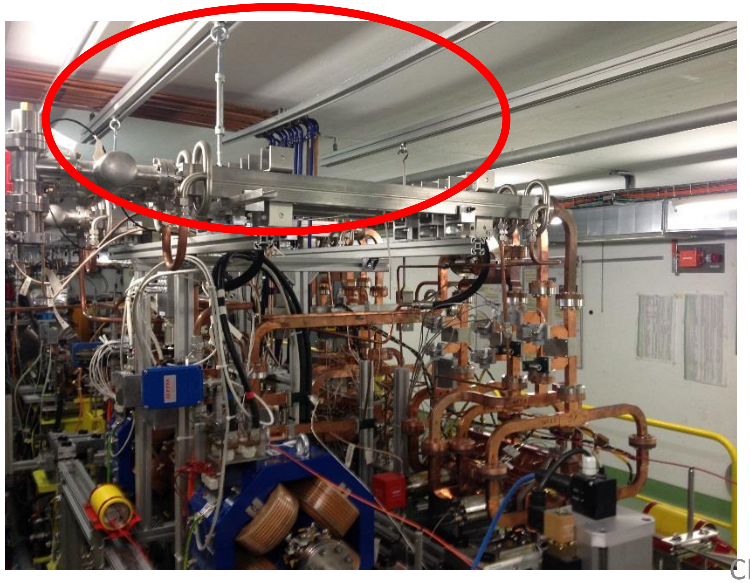
Mechanical coupling between DB and MB girders

Vertical displacement on DB (500 µm)

2015

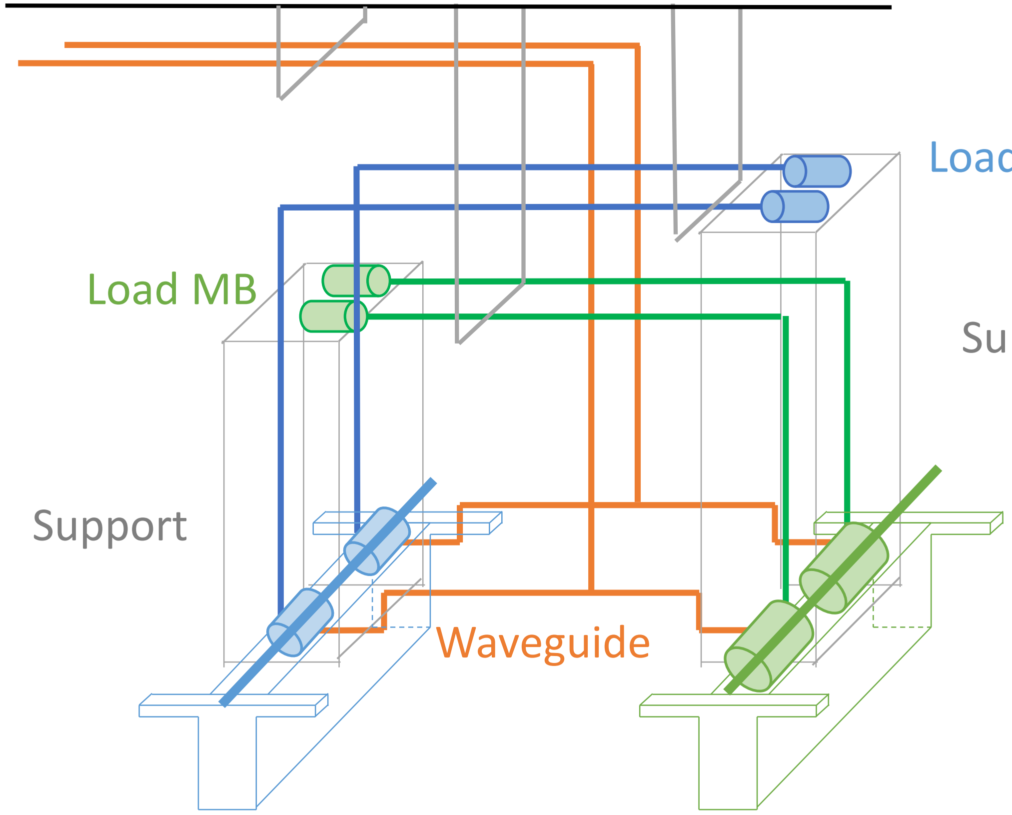
Roll of 72 µrad on the MB





2016

Roll of 17 µrad on the MB



CLEX update, Vivien Rude

Conclusions

- We have extensively used the TBM installed in CLEX to validate its performances and characteristics.
- However its complexity and the RF production scheme made sometimes studies tedious.
- Some studies will continue this year in CLEAR with a single superstructure (WFMs, kicks…)
- We expect next year to connect CLEAR to the Xbox1 in order to resume tests of structures with beam and RF power.