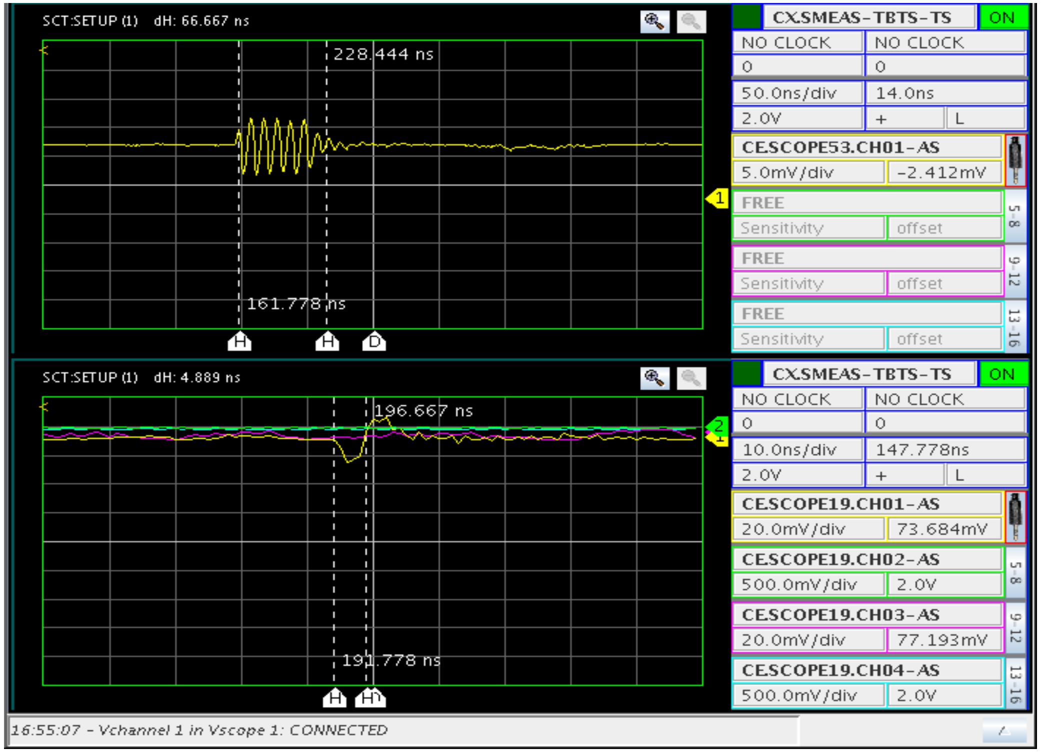
Recent TBTS measurements

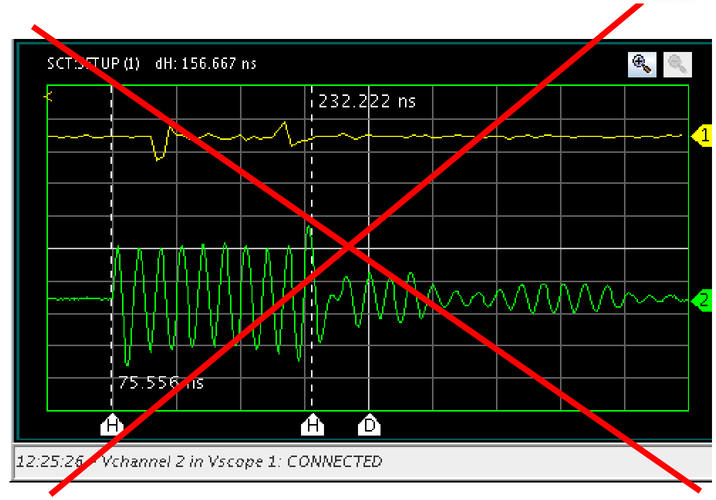
W. Farabolini and the CTF3 team

Outline

- ACS resonant frequency
- Method to calibrate time delays between diagnostics
- Conditioning of the newly installed ACS
- Acceleration with 2 ACS
- BDs with 2 ACS
- Processing of the last summer BDs data
- Conclusion

Short pulse resonant frequency



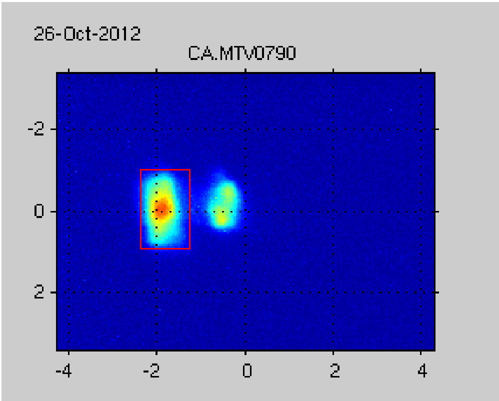


Erroneous evidence of other modes (mixer saturation)

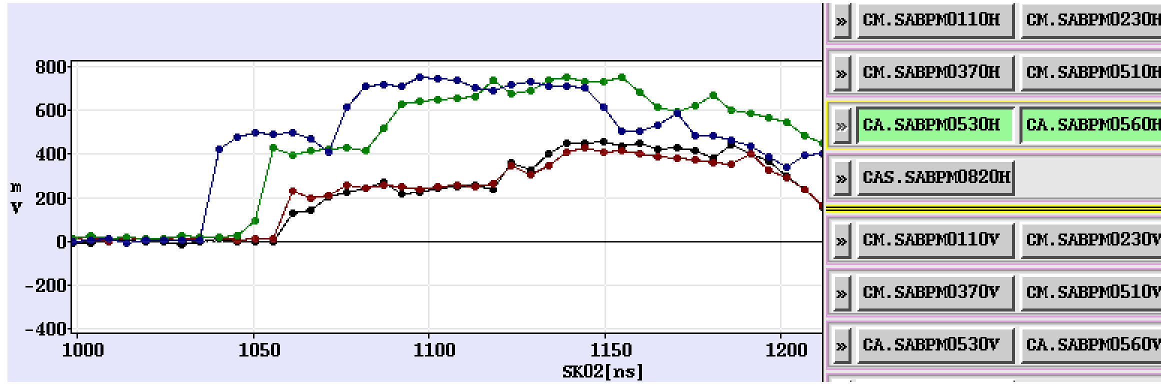
Pulse length 4 ns – RF output mixed with LO at 11.8942 GHz

- RF output measured on a dedicated coupler with lower attenuation
- Evaluating the downshift frequency by counting zero crossings (60 pulses averaged) gives 100 MHz +/- 1 (A. Andersson.)
    - the downstream ACS structure is well tuned at 11.9942 GHz.
- No other modes visible as previously though due to a mixer saturation

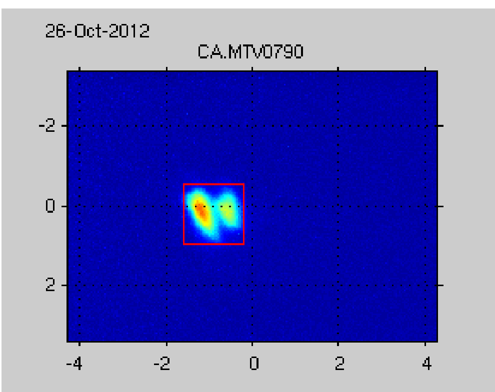
Other effect possibly wrongly attributed to the ACS



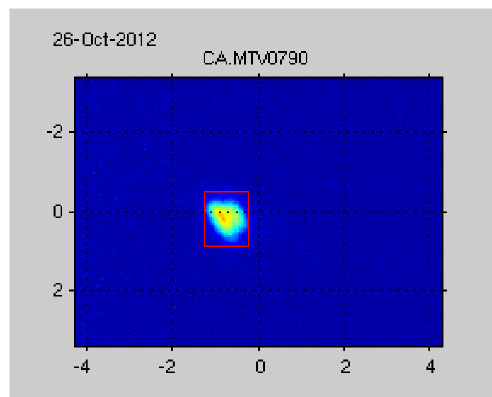
Pulse length 100 ns (150 bunches)
bunch charge 0.13 nC (0.21 A)



Horizontal BPMs signals before (brown and black) and after (blue and green) the ACS tank



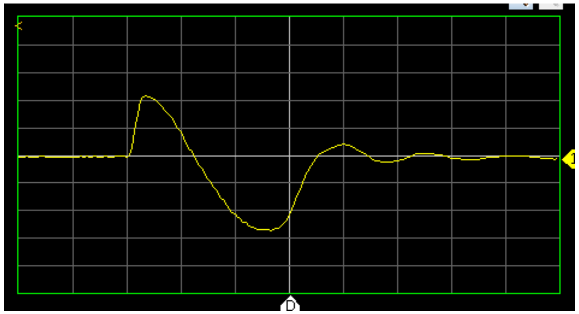
bunch charge 0.069 nC (0.115 A)



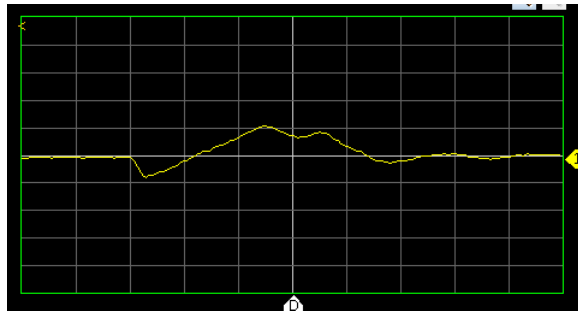
bunch charge 0.04 nC (0.067 A)

- Sudden beam kick for pulse length > 40 ns and bunch charge > 0.04 nC (67 mA)
- But this is meanly due to the Califes accelerator (still to be understood)

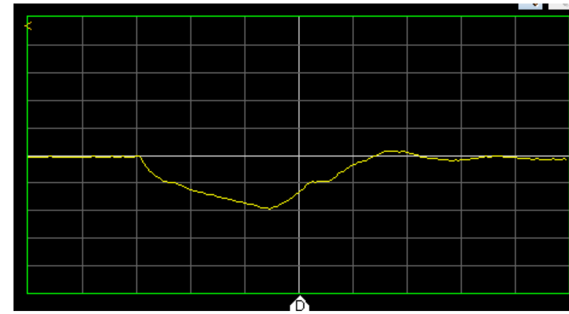
Direct evaluation of RF output downshift signal



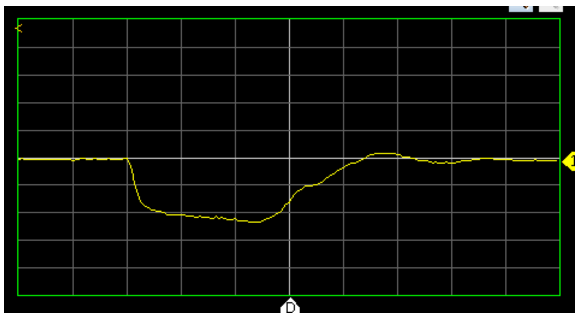
LO = 11994.2 - 10 MHz



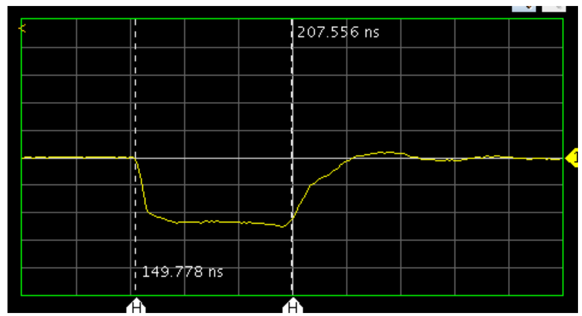
LO = 11994.2 - 3 MHz



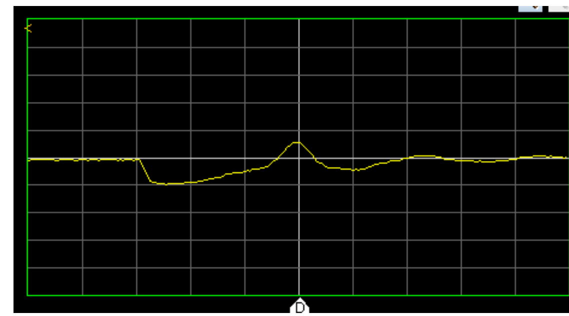
LO = 11994.2 - 2 MHz



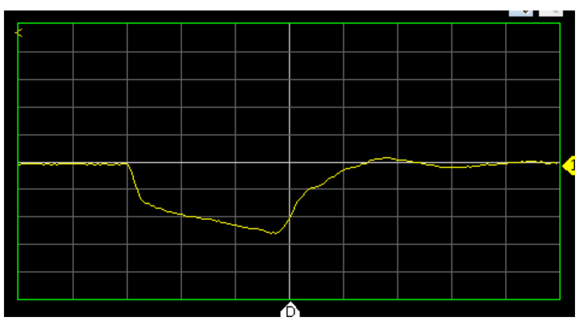
LO = 11994.2 - 1 MHz



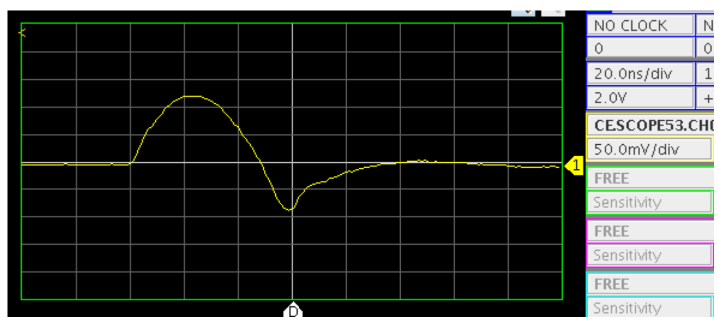
LO = 11994.2 MHz



LO = 11994.2 + 1 MHz

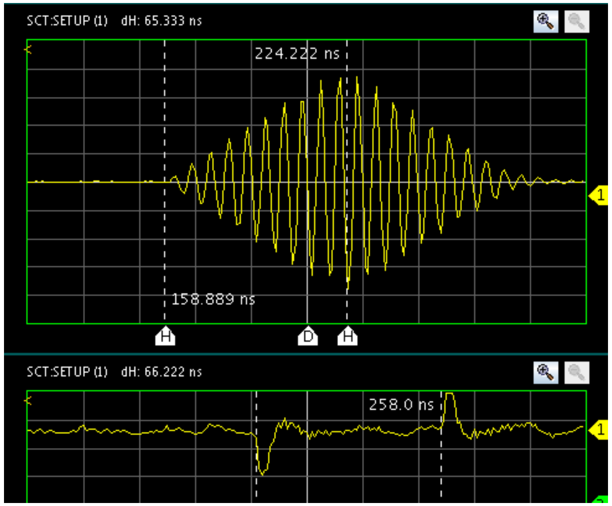


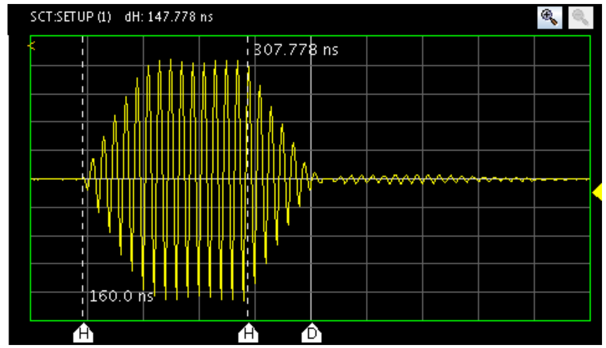
LO = 11994.2 + 2 MHz



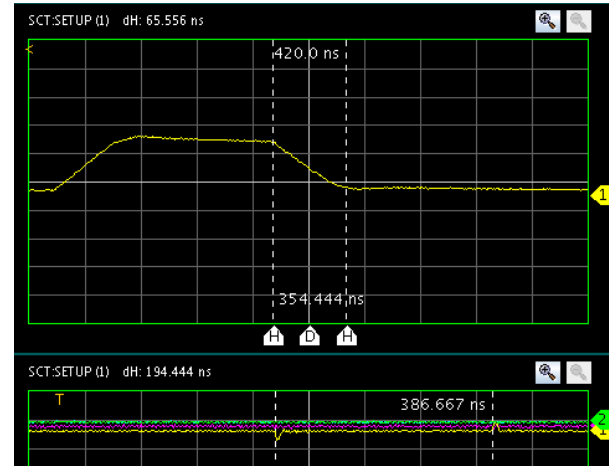
LO = 11994.2 + 10 MHz

RF production with longer pulses





Pulse 150 ns
LO = 11894.2 MHz

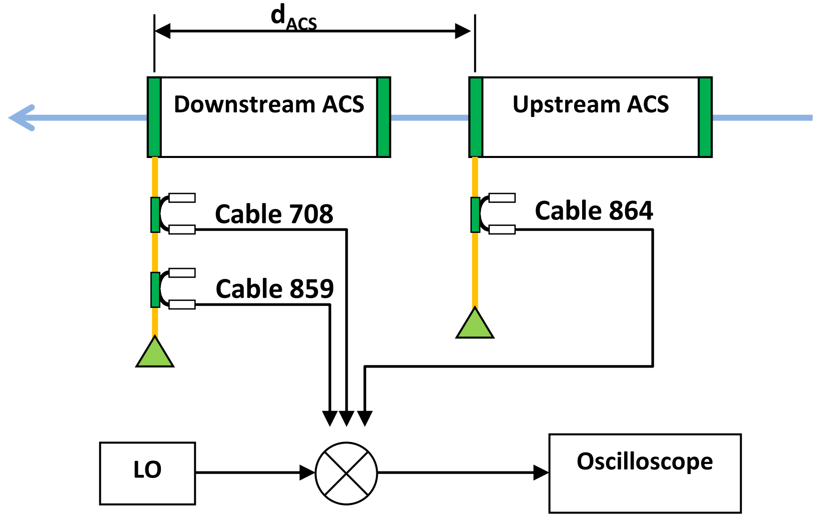


Pulse 66 ns LO = 11894.2 MHz
Extracted Faraday cup acts as a button pick-up

Pulse 194 ns LO = 11994.2 MHz

- RF output frequency is of course forced by the probe beam pulse frequency
- RF output rising time = ACS filling time (65 ns)
- RF output rising time + sustain time = pulse length
- RF output falling time = ACS filling time (65 ns)

RF couplers and beam diagnostics delays calibration

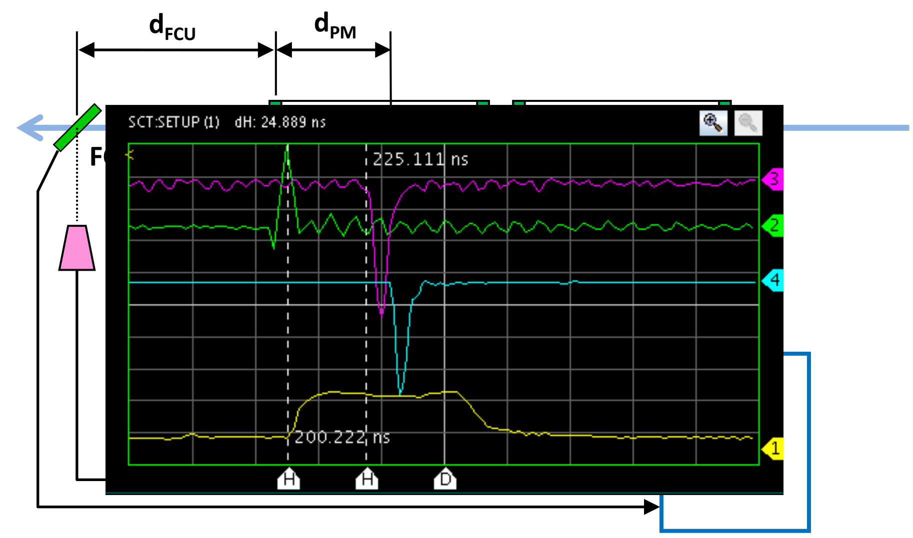


First step: calibrate delays between RF output couplers

d_{ACS} = 0.426 m

$$\Delta time\ [cable_{708} - cable_{859}] = t_{12} - t_{13} = -19.1\ ns$$

$$\Delta time\ [cable_{864} - cable_{859}] = t_{11} - t_{13} - \frac{d_{ACS}}{c} = -7.6\ ns$$



Second step: measure delays between beam diagnostics and the RF special coupler

d_{FCU} = 1.025 m

d_{PM} = 0.17 m (approx)

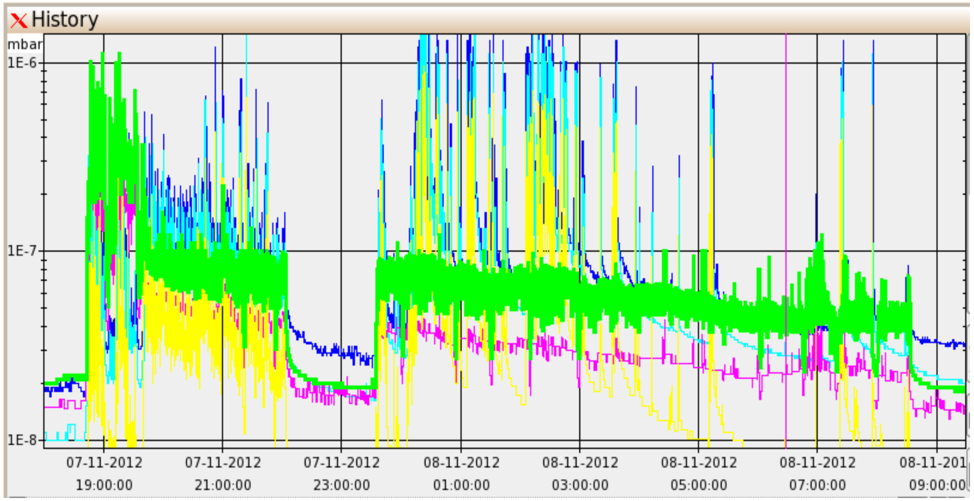
$$\Delta time\ [FCU - cable_{859}] = t_{31} - t_{34} - \frac{d_{FCU}}{c} = -9.2\ ns$$

$$\Delta time\ [PM_{FCU} - cable_{859}] = t_{32} - t_{34} - \frac{d_{FCU}}{c} = 28.6\ ns$$

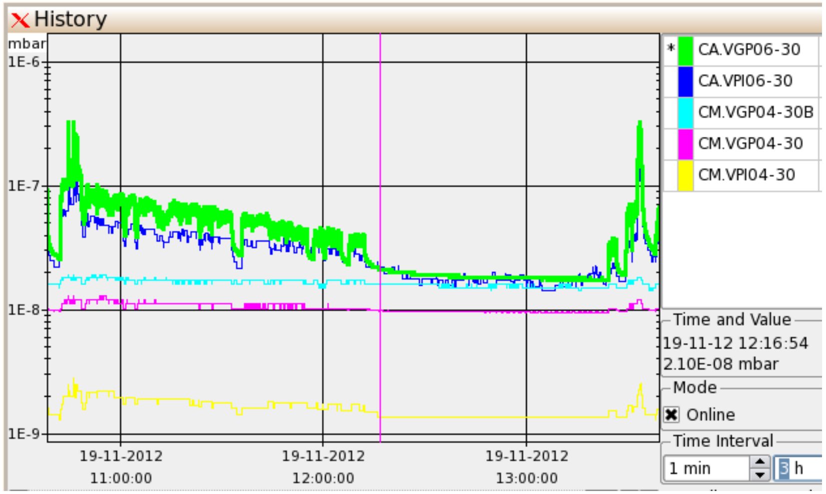
$$\Delta time\ [PM_{ACS} - cable_{859}] = t_{33} - t_{34} + \frac{d_{PM}}{c} = 25.5\ ns$$

- The probe beam is a common trigger for beam sensitive diagnostics (BPMs, FCU, PMs) and output RF couplers (beam propagation delay is known)
- Probe beam generated RF is still visible using mixer on “nominal couplers” when removing the gallery installed attenuators, but not using the diode crate

Conditioning of the newly installed ACS



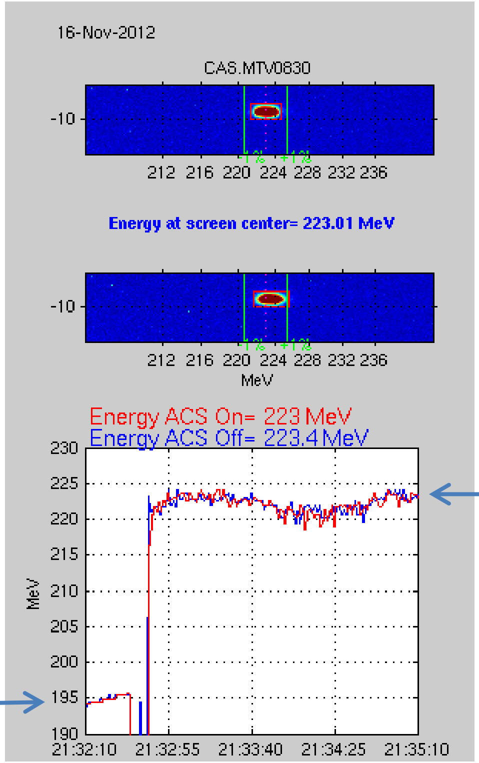
At the beginning : many BDs in the waveguide/phase shifter



Then out gazing of the ACS

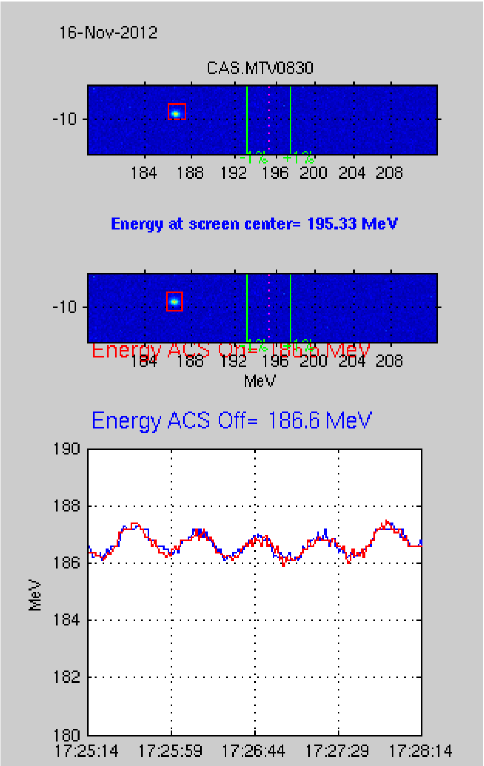
- We are trying to keep a reasonably soft conditioning, limiting vacuum increase as well as BD rate.
- Tail clipper is efficiently used to reduce pulse length
- Recirculation to increase pulse power in case of factor 4 recombination.
- Most often drive beam repetition rate is set to 1.67 Hz
- Conditioning program in development (stop RF power for a while after each BD, …)

Acceleration with the 2 ACS



RF On

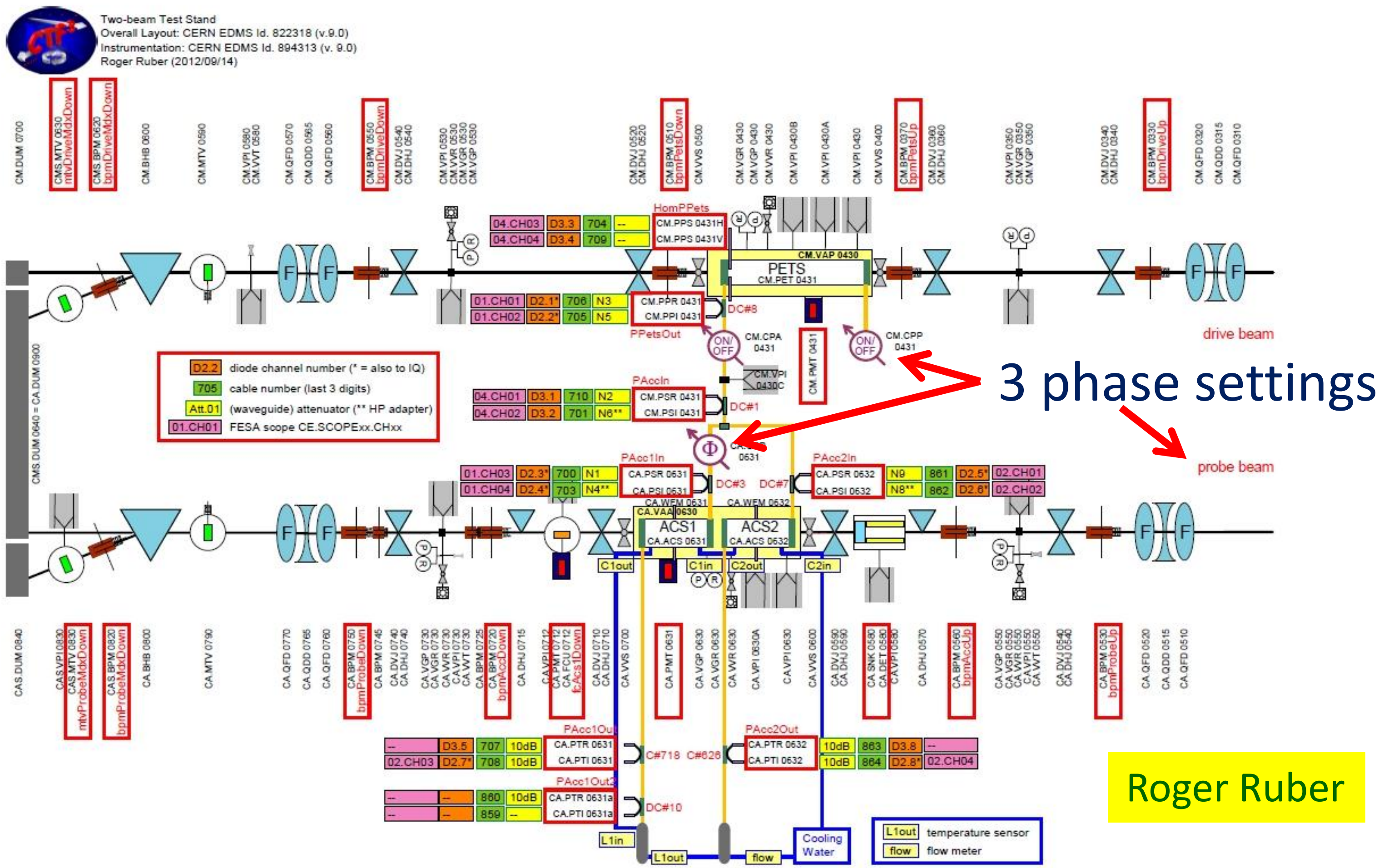
RF Off



Energy oscillations with and w/o RF power

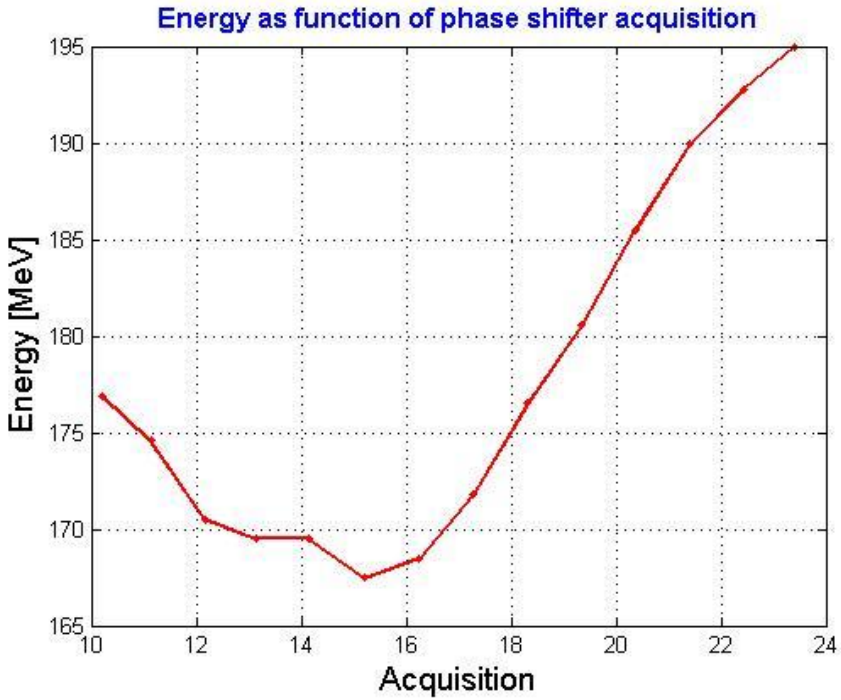
- With more than 30 MeV gain, it is no longer possible to observe the accelerated / non accelerated beam for the same dipole strength on the spectrum line screen
- Califes and RF power oscillations limit the measurement accuracy (+/- 1 MeV)

TBTS layout

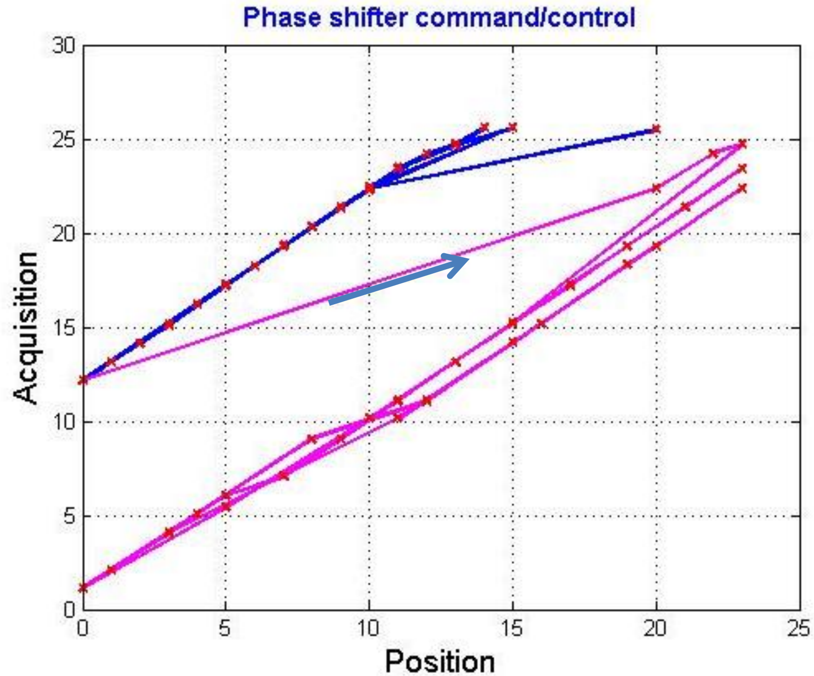


- The Layout is becoming very dense
- Many diagnostics, signals and settings

2 phase shifters scan



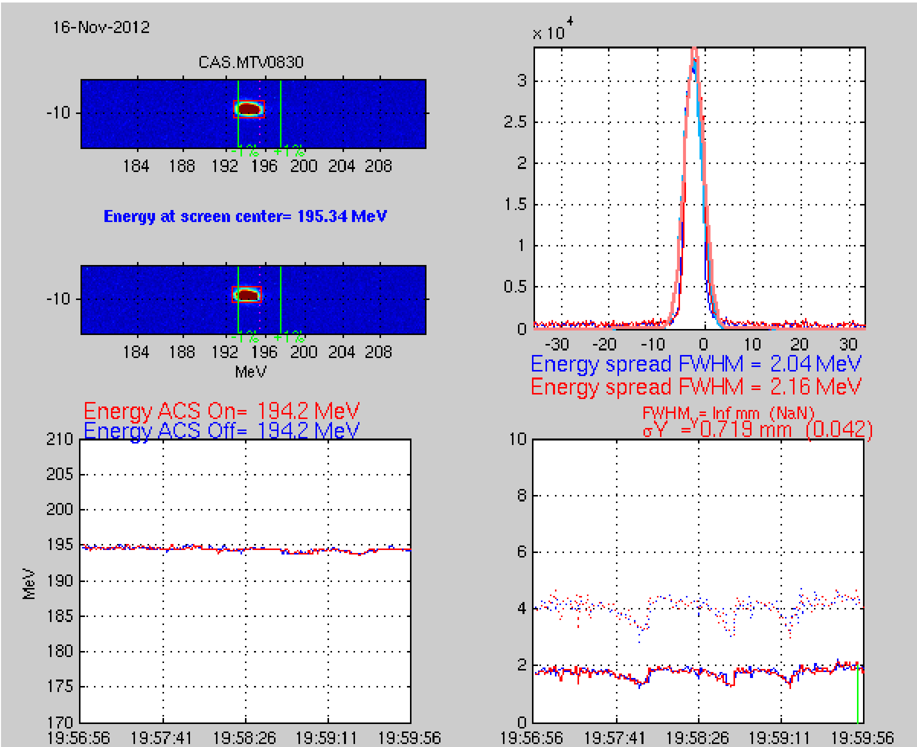
ACS phase shifter scan



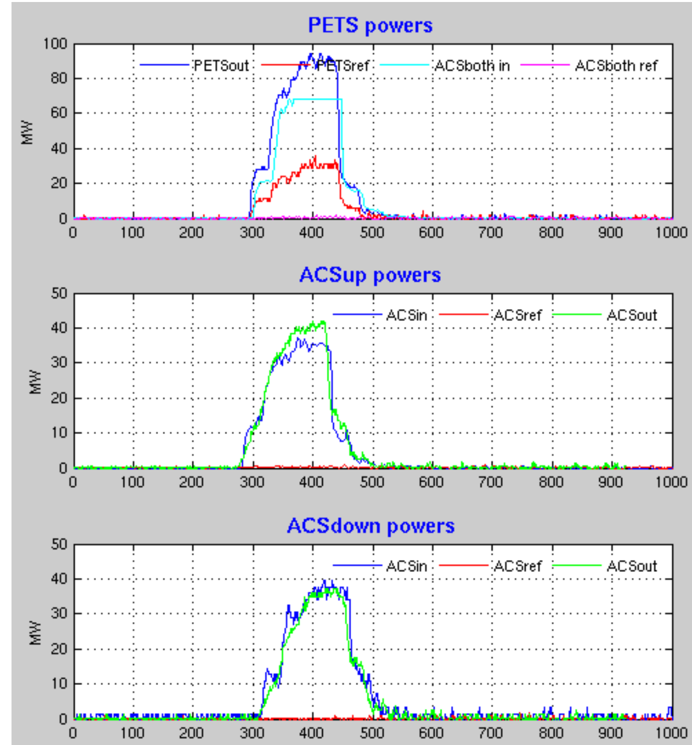
Poor reproducibility of the ACS phase shifter

- For a given Califes phase vs. Drive beam, it seems that we cannot reach the maximum acceleration by scanning the inter-structures phase shifter (command/control limitation)
- However the command/control is not really reproducible and “insisting” allows to enlarge the range !

Method to set the inter-ACS phase shifter



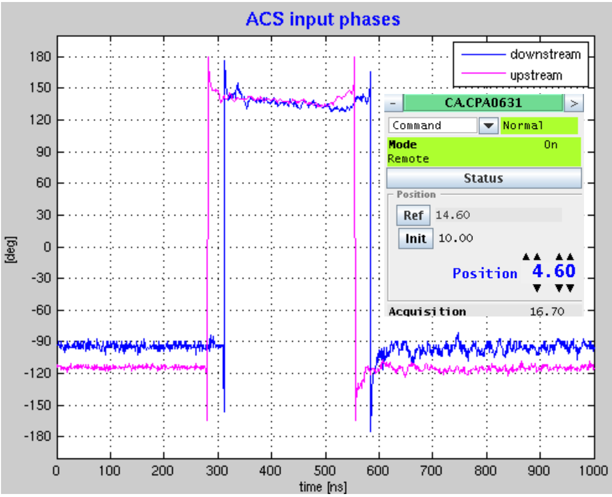
Califes phase scan
constant energy = Califes energy



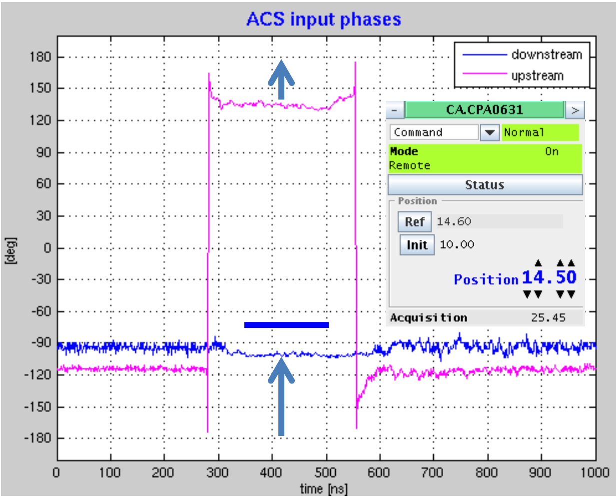
RF power control

- For phase shifter at 16.86, the energy gain by the 2 ACSs is 0 whatever the Califes phase.
- This shows also that the 2 ACS are opposing each other and receive the same RF power.
- From this phase (measured with I/Q on input coupler), 180 deg shift is required for both structures to work together.

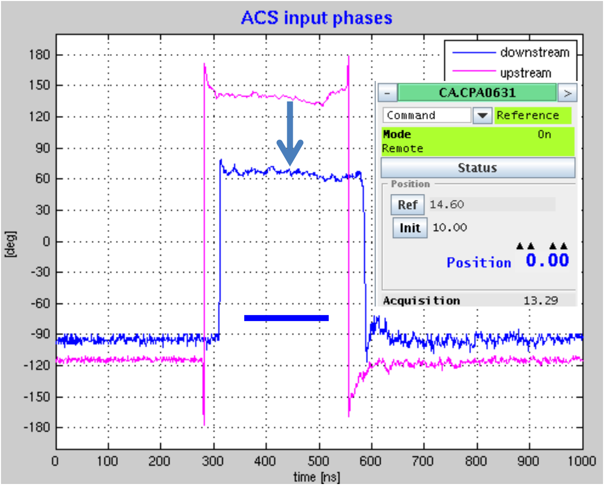
I/Q phase measurement



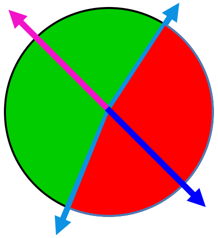
Input phases when ACSs in opposition



ACS downstream phase (-100 deg) at upper limit switch

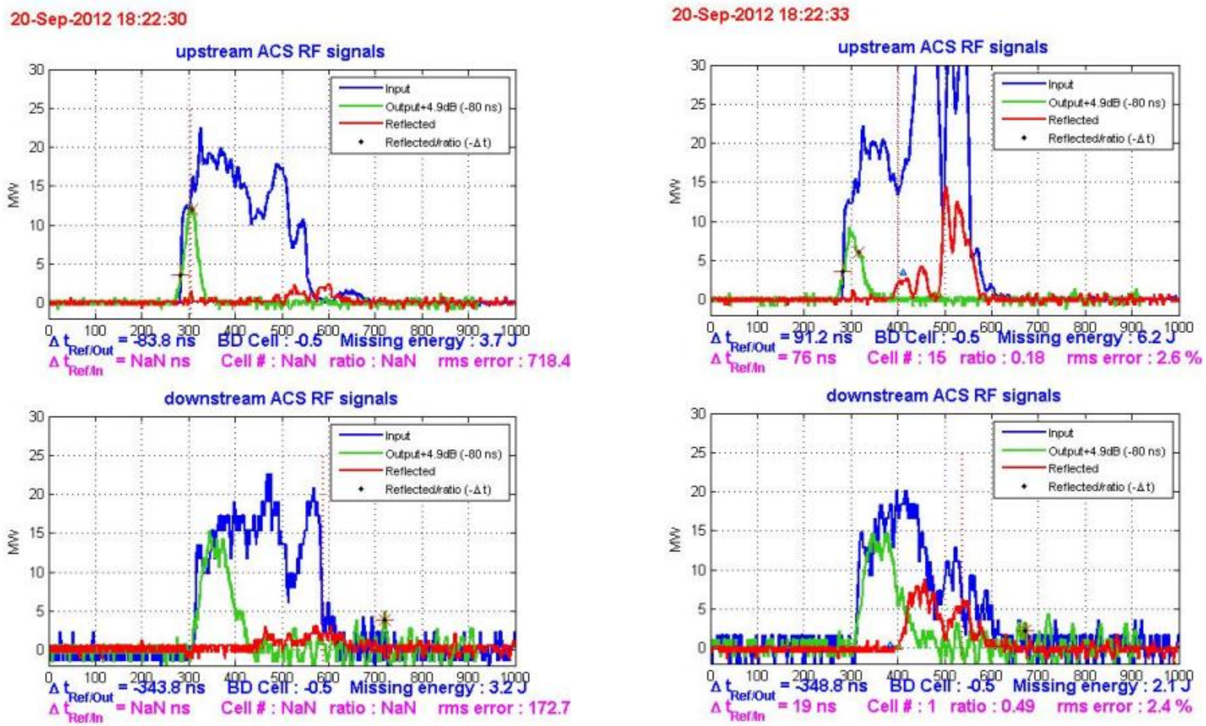


ACS downstream phase (60 deg) at lower control



- In that state of the command/control the requested position (-40 deg) is not reachable
- However C/C can drift as seen before and the phase measurements are to be reconsidered with I/Q offset cancellation.

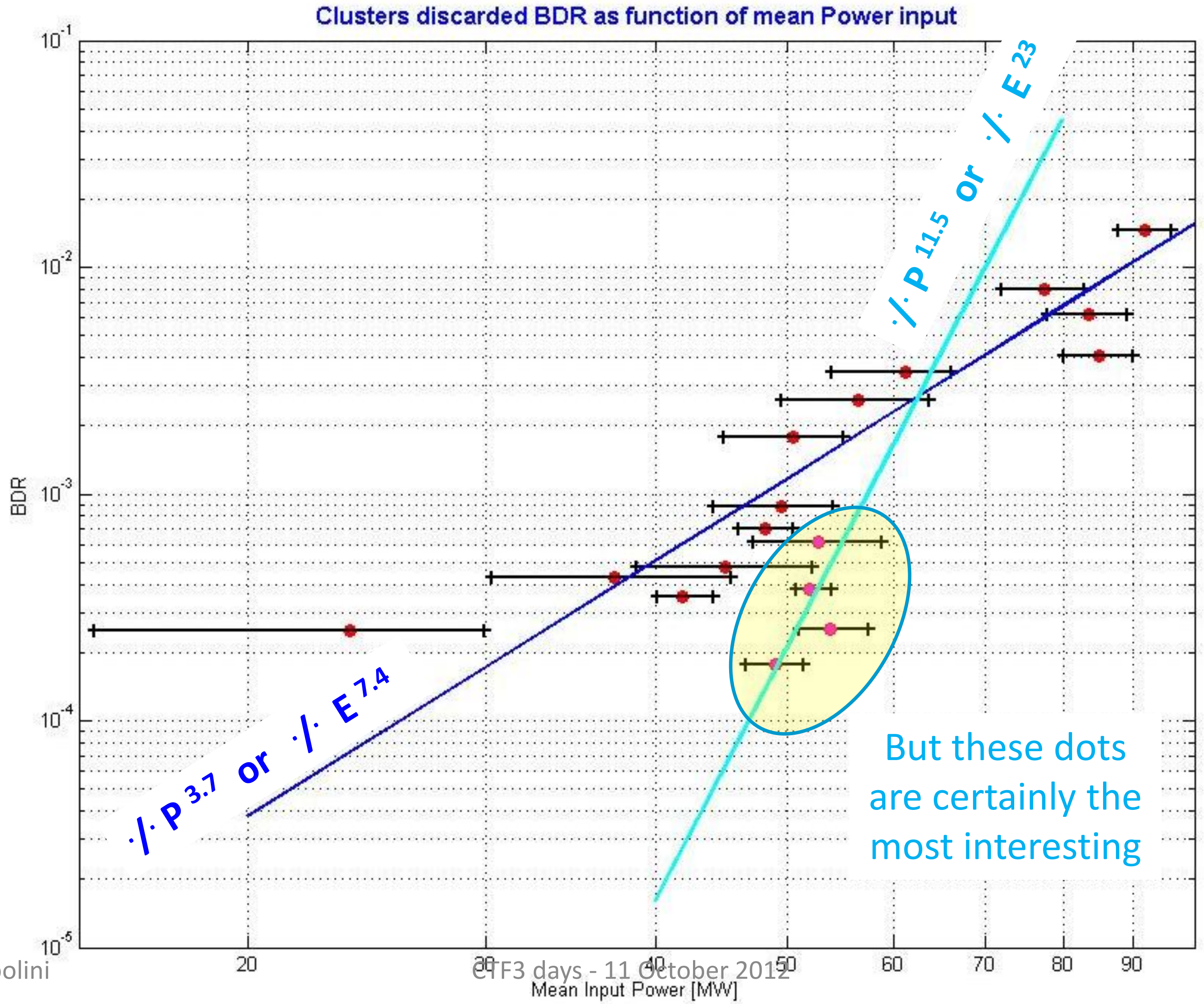
BD in the 2 ACS



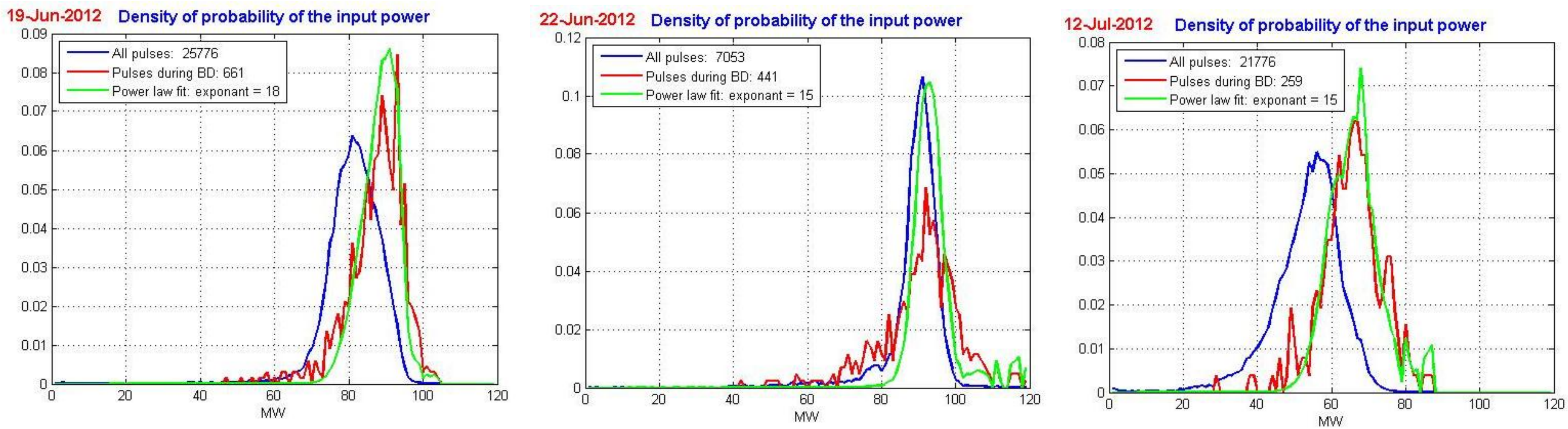
- There are occurrences of BDs in the 2 ACS during the same RF pulse (RF reflected ?)

Last summer data processing on single ACS TBTS

BDR as function of RF input Power (discarding BDs within clusters)



Distribution of RF power

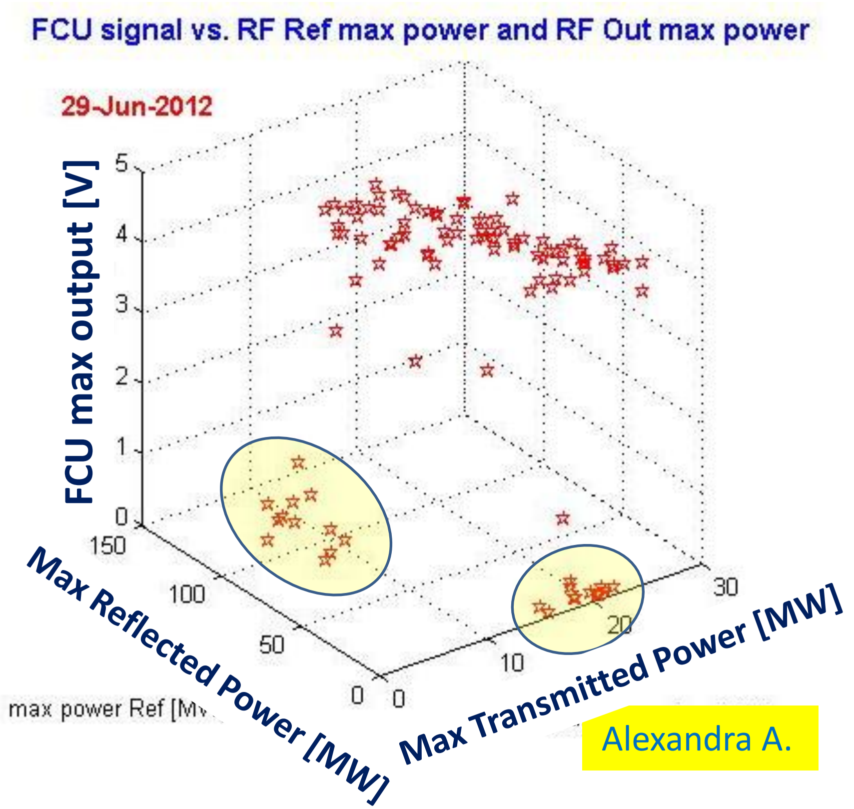


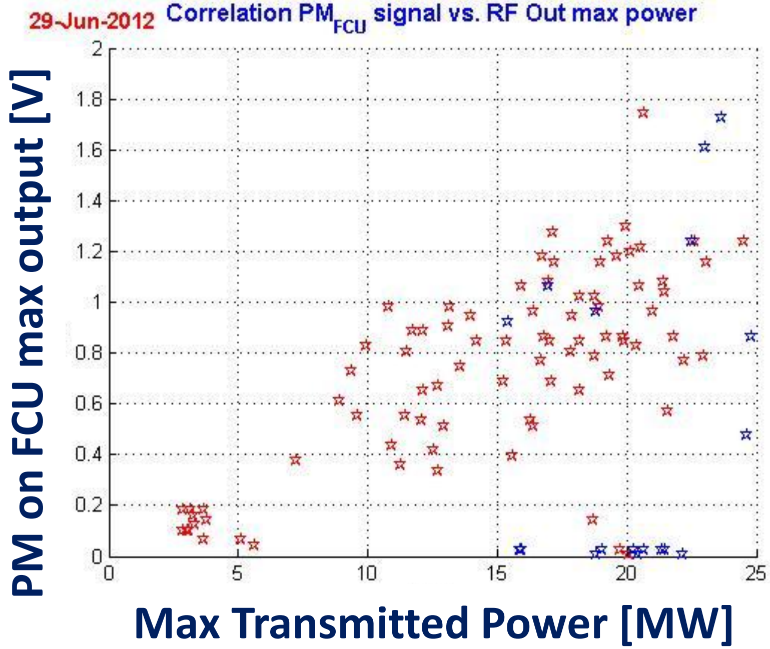
RF power density of Probability of all RF pulses (blue), of RF pulse with BD (red) and power law fit of BD probability (green)

- Fitting the Power distribution when BD by a power law of the power distribution of all pulses provide an exponent between 15 and 18.

$$P_{BD}(power) = \frac{P_{pulse}(RF\ power)\ .\ (RF\ power)^{\alpha}}{\int_{RF\ power} P_{pulse}(RF\ power)\ .\ (RF\ power)^{\alpha}}$$

FCU and PM_{FCU} signals reliability

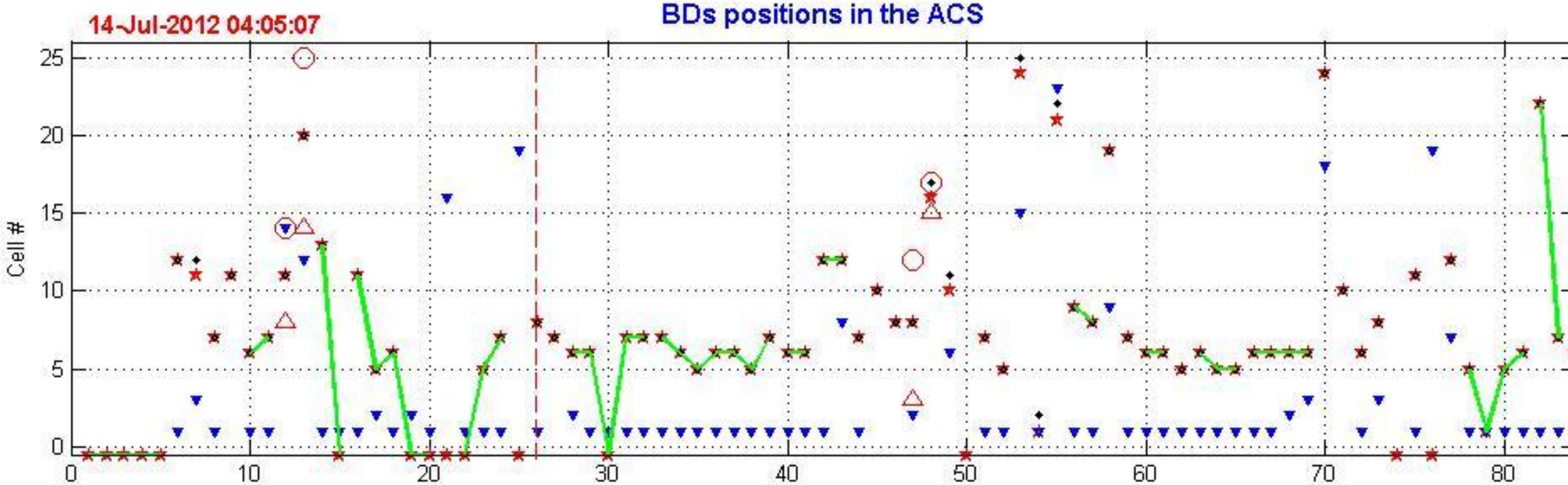


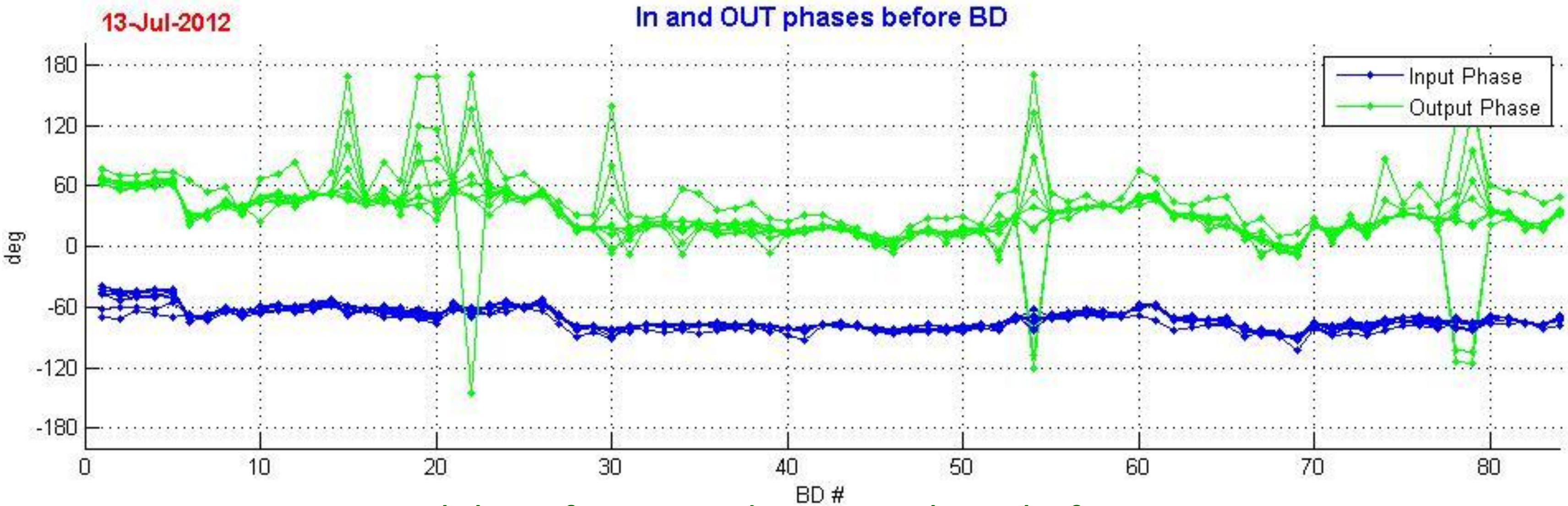


OTR light seen on FCU mirror surface is **current and energy** dependent but not saturated.
(Blue dots correspond to **low reflected power**)

- When **RF transmitted** power is **low** (early BD), BD produced electrons are not likely to reach the FCU (not accelerated towards the FCU)
- Also when **RF reflected** power is low FCU signal is often weak (why ?)

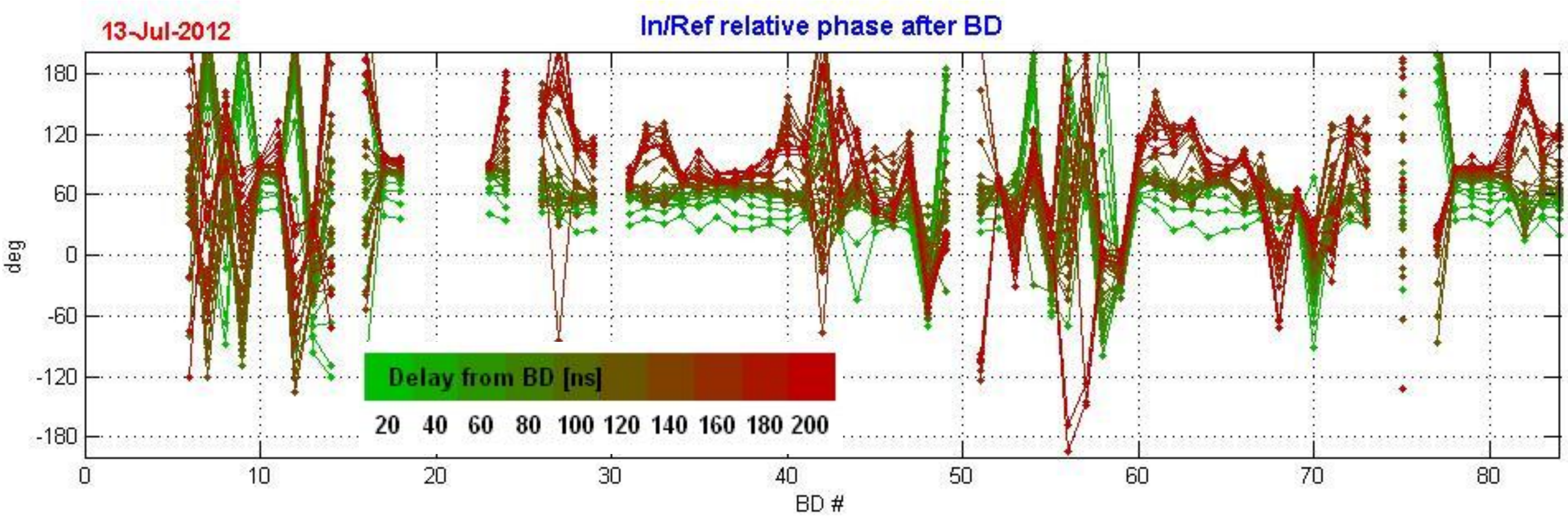
BD location and phases





Stability of Input and Output phase before BD

Ref / In phases evolution with time



- Phase difference between the Reflected and Input RF taking into account the delay according to BD position
- No clear information yet to be derived from phase

Conclusion

- The two ACS are still under conditioning (40 MW reached)
- Their behavior seems nominal
- The acquisition chains have required some effort to host the additional signals and calibration are still improving
- More efforts are necessary to adapt the BD data processing routines to all the 2 ACS signals
- Analysis continue on the former single ACS data
- A lot of work is to come (BDR studies, WFM, Flash Box, kicks…)

THANK YOU FOR YOUR HELP