Instrumentation:
What To Expect Next Year

T. Levens

on behalf of the Beam Instrumentation group

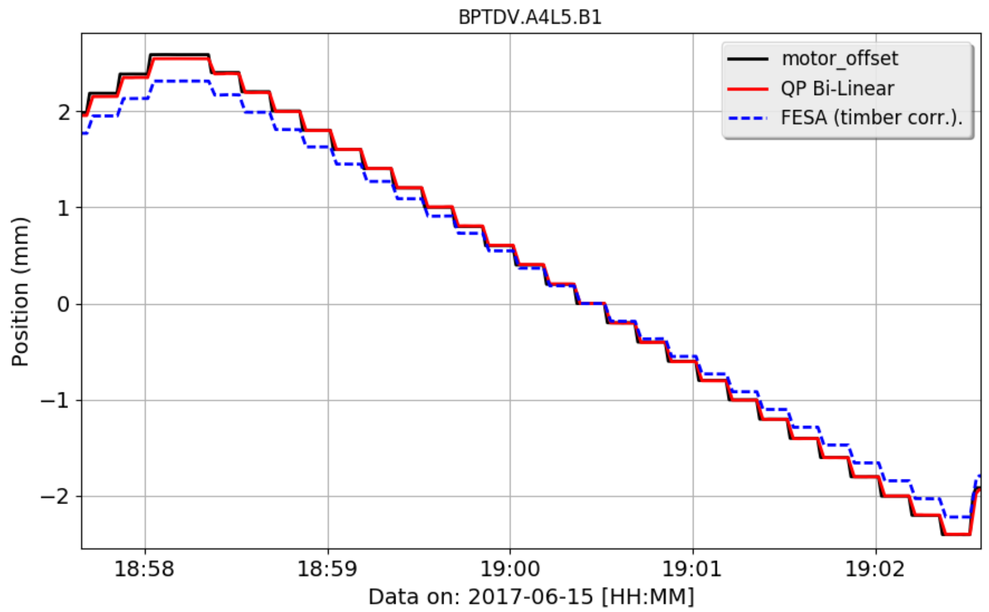
Table of contents

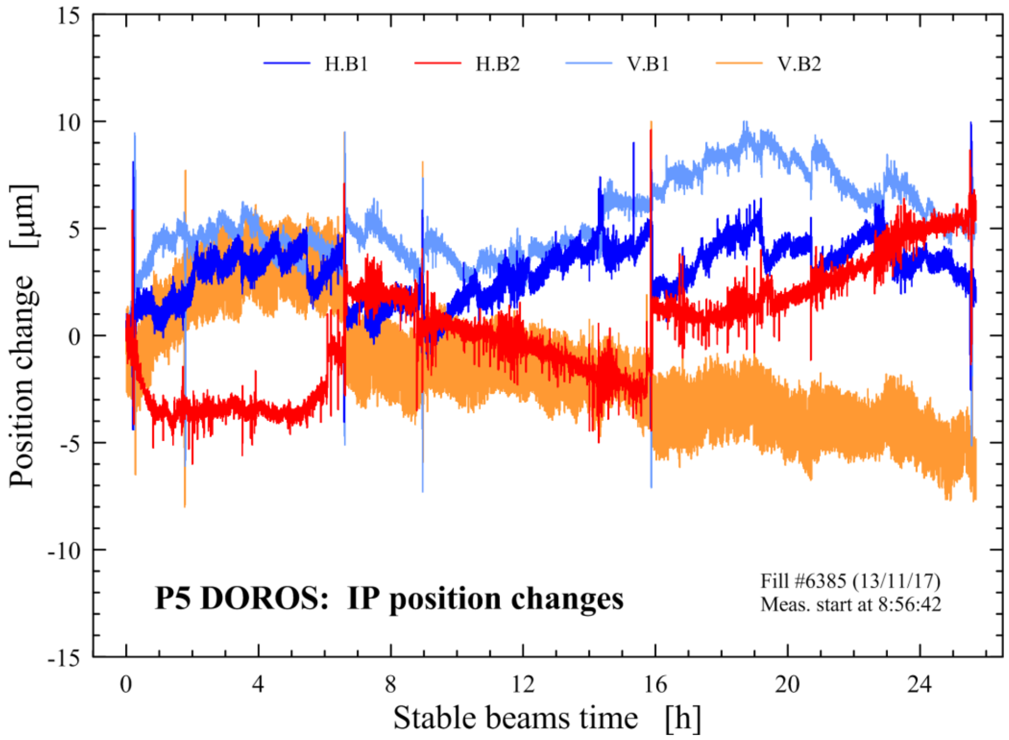
- Operational instruments
  - DOROS
  - Diamond BLMs
  - Head-Tail
  - Schottky
  - BSRT, WS, BGV → Covered by Georges
  - ADT + ObsBox → Covered by Helga & Xavier

- Developments
  - Coronagraph
  - BSRS
  - Emittance from Quadrupolar PU & Schottky

DOROS – status in 2017

- Large position errors have been reduced through better handling of the variable apertures of the collimator BPMs.
- Since TS2, DOROS coll. BPMs have been included in SIS – a lot of work has been done to make the system reliable.
- For standard BPMs, real-time linearity correction operational since fill #6371.
  - Reduces systematic position errors due to beam intensity changes at locations with large beam offsets.





DOROS – operational considerations

- The detector time constant (TC) is the only setting that must be changed during the operation. The optimal value depends on the number bunches and the filling pattern. The bunch intensity does not matter.

- In 2017 the TC had to be changed manually by an expert.

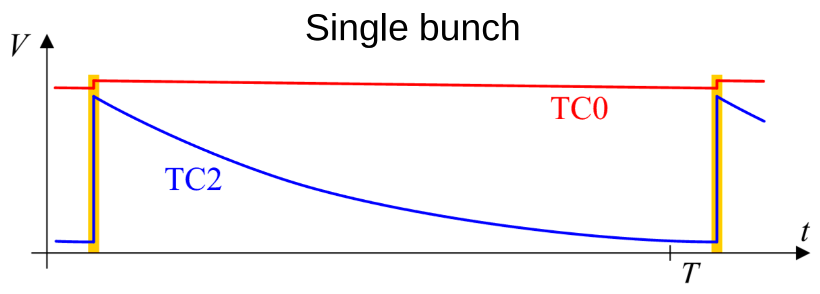
- Sometimes the wrong TC for the filling scheme has been used, resulting in bad quality measurements.

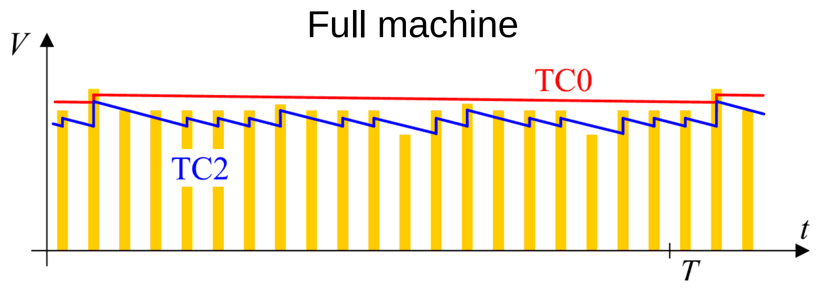
- An automatic procedure for TC setup has been developed and will be implemented in FESA for 2018.

bunches *	TC0	TC1	TC2
1 … 10	☺	☹	☹
10 ... 30	☺	☹	☹
30 … 100	☺	😐	☹
100 … 300	😐	☺	😐
300 … 1000	😐	☺	☺
1000 … 3000	😐	😐	☺

* EVENLY distributed

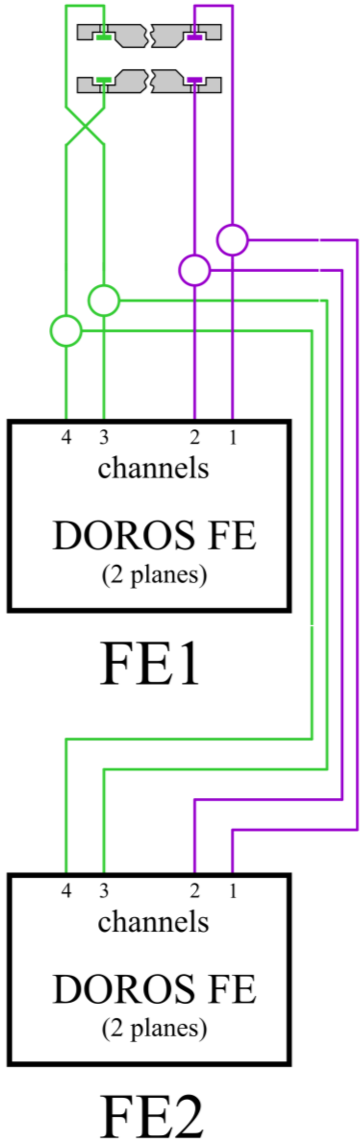
☺ = optimal measurement
😐 = correct measurement
☹ = wrong measurement





DOROS – changes for 2018

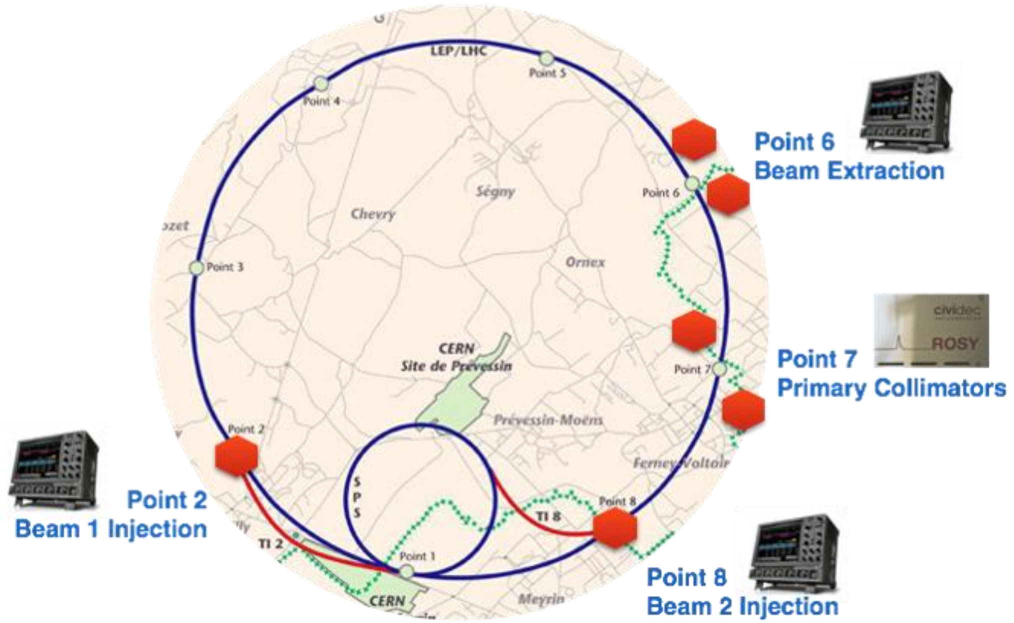
- For 2018 it is planned to make the interlocked DOROS front-ends fully redundant:
  - Two front-ends operating in parallel with shared BPM signals
  - With redundancy a faulty front-end will not block operation and can be replaced during the next access.
- The front-ends installed on four Q7 and two AFP BPMs in P1 will publish data via DIP.
- Two additional front-ends will be installed for dedicated observation and logging of the low frequency beam spectra.
  - The exact locations are being discussed.
- New OP GUI for system monitoring.



Diamond BLMs – installation for 2018

Operational systems

- P2,8 (inj) + P6 (extr) + P7 (TCPs + crystal coll.)
  - Total 10 detectors
  - Including temporary installation for 16L2
- Using either oscilloscopes or ROSY boxes
- All systems remain as is for 2018 to avoid disruption in the last part of the run



Development systems

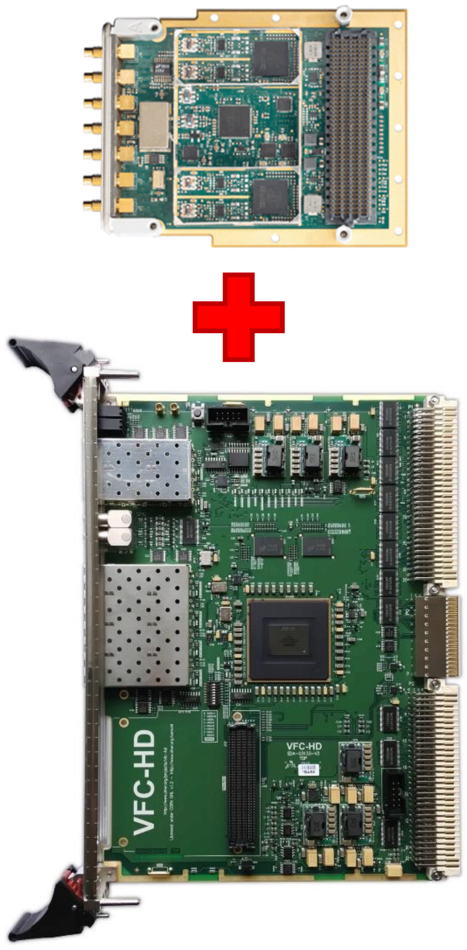
- P2,8 (inj) + P7 (crystal coll.)
  - Total of 4 detectors connected in parallel to 3 new (VFC) acquisition systems
  - Note: also 3 more in SPS
  - More to be added as the electronics arrive (mid-2018)
- Analogue signals split before input to allow:
  - Benchmarking with current systems
  - Uninterrupted development and deployment

OR

Currently used electronics for the operational systems

Diamond BLMs – electronic development

- Electronics are based on:
  - Commercial FMC with 2x 1GSPS 14bit ADCs
  - BI standard VFC-HD carrier
  - Standard VME crate and FEC
- Firmware and FESA server already available with main functionality implemented
  - More features for data reduction and synchronisation to become available throughout 2018
- Advantages
  - Standard electronics that integrate better in our controls and timing environments
  - Histograms and waveform acquisitions of both channels in parallel with separate settings and finer control
  - Code maintained by BI
  - Synergy with FBCT developments

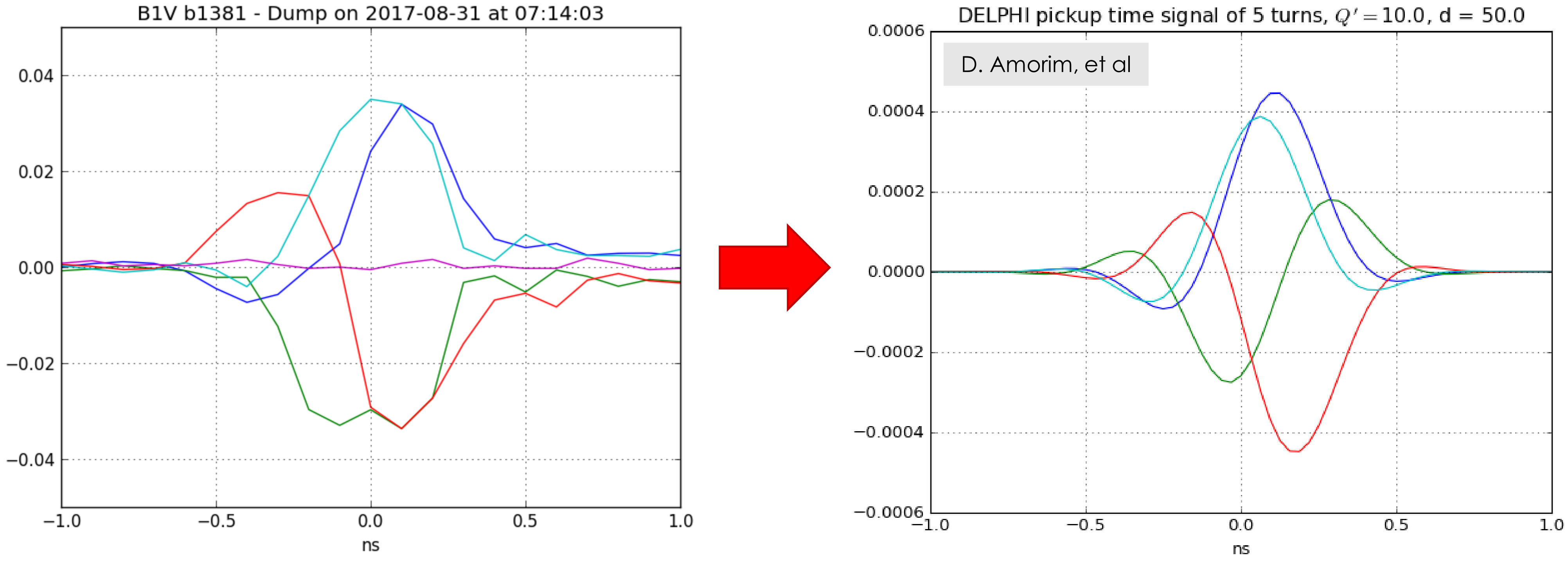


Future electronics for the operational systems

Will be the operational acquisition system after LS2

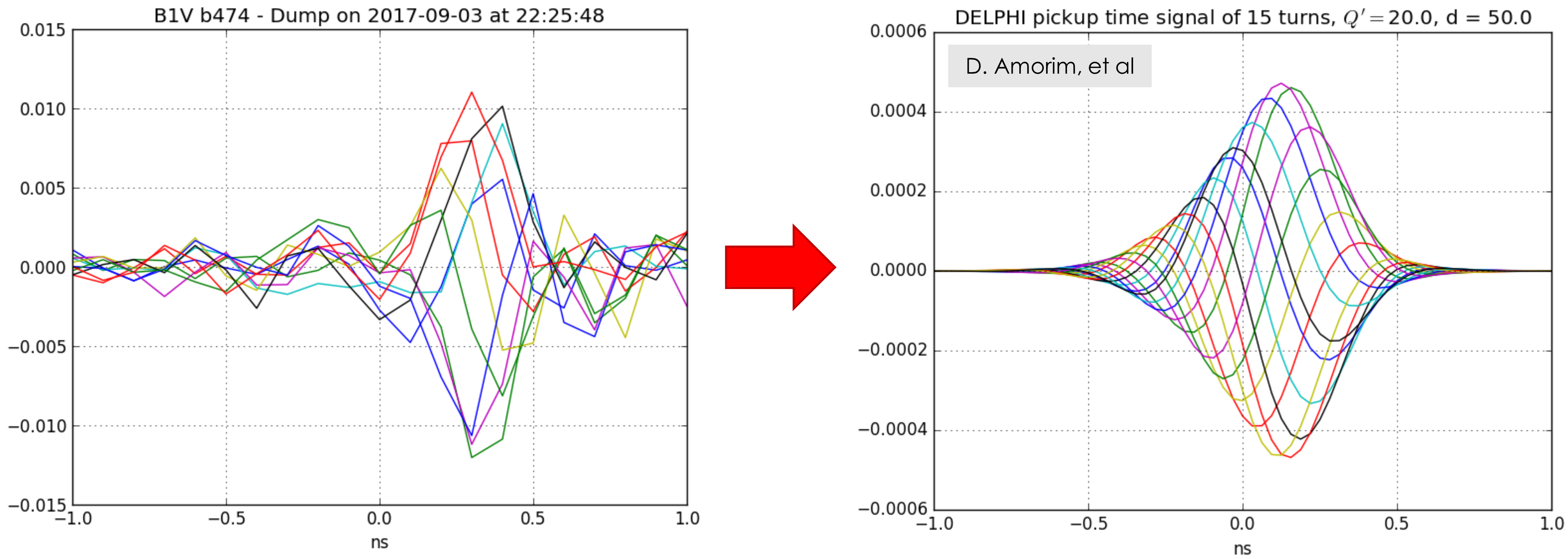
Head-Tail Monitor – status in 2017

- During 2017, Head-Tail Monitor has been used regularly for MDs and during operation.
- Added a low latency beam-dump trigger with a direct connection to BIS "beam info" signal.
- Provided valuable input for 16L2 diagnostics allowing verification of simulation models:

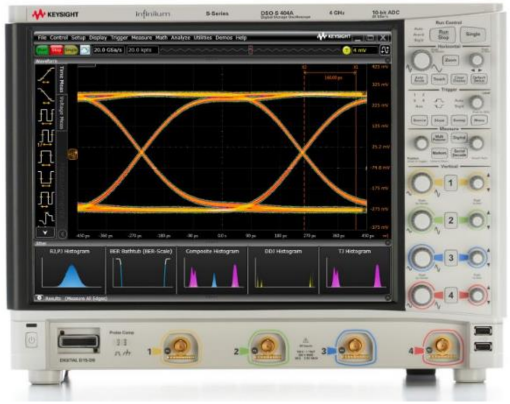


Head-Tail Monitor – status in 2017

- During 2017, Head-Tail Monitor has been used regularly for MDs and during operation.
- Added a low latency beam-dump trigger with a direct connection to BIS “beam info” signal.
- Provided valuable input for 16L2 diagnostics allowing verification of simulation models:



Head-Tail Monitor – upgrades for 2018

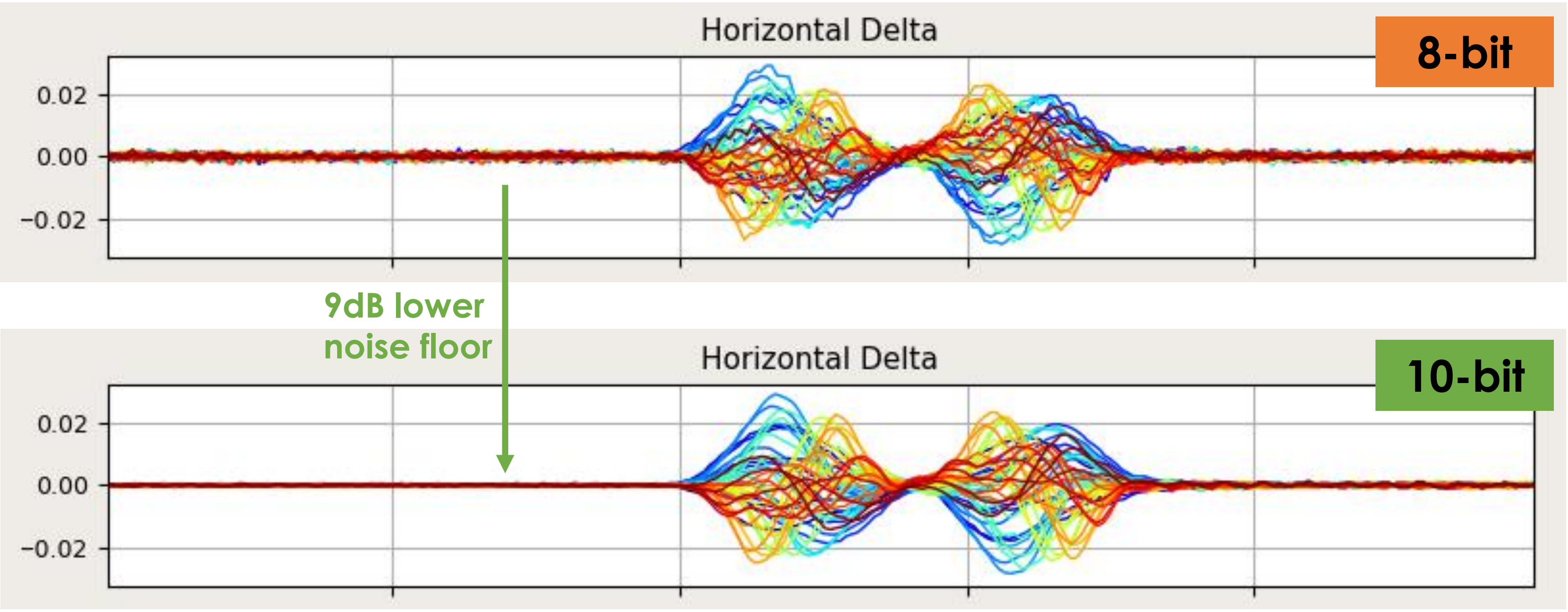


Keysight DSOS404A

For 2018, new digitizers will be installed:

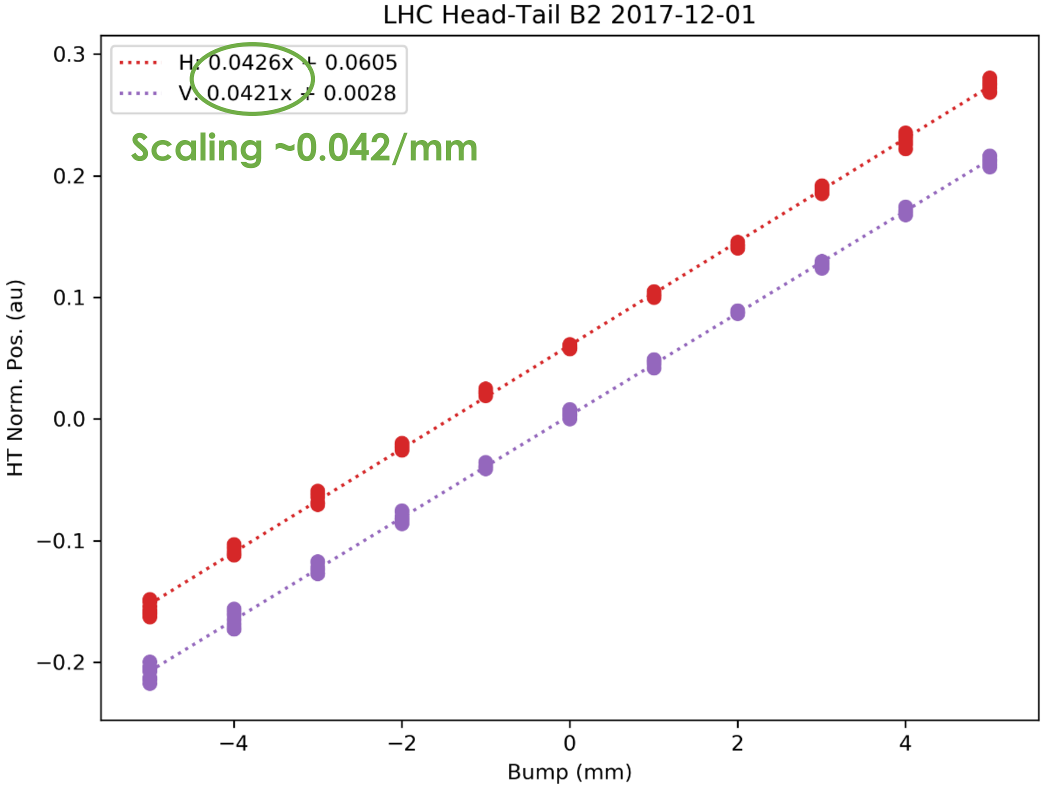
- 11 turns → 450 turns ☺
- 8-bit → 10-bit ☺
- 40MB → 3.2GB 😐

Already tested in SPS, showing greatly improved signal to noise ratio:



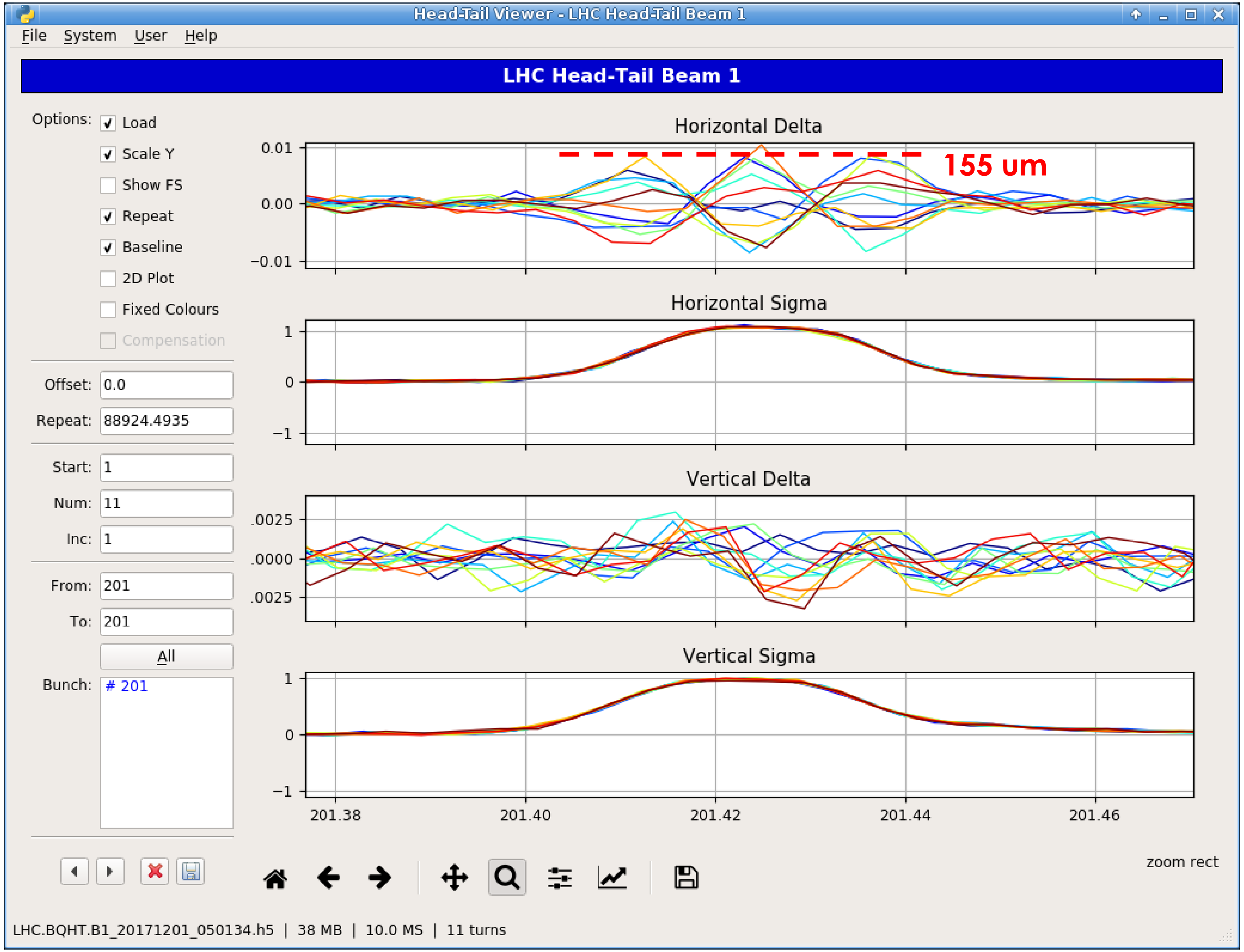
Head-Tail Monitor – calibration

Calibration of LHC Head-Tail Monitor for B2 done as a "parasitic" MD during MD2408/2733:



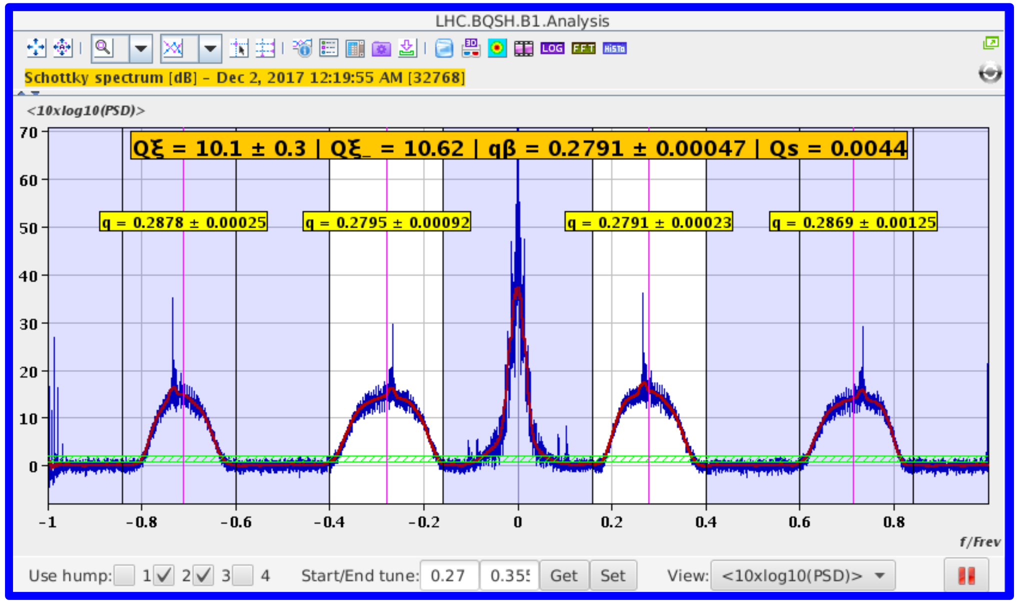
It is proposed to repeat this calibration during commissioning after YETS.

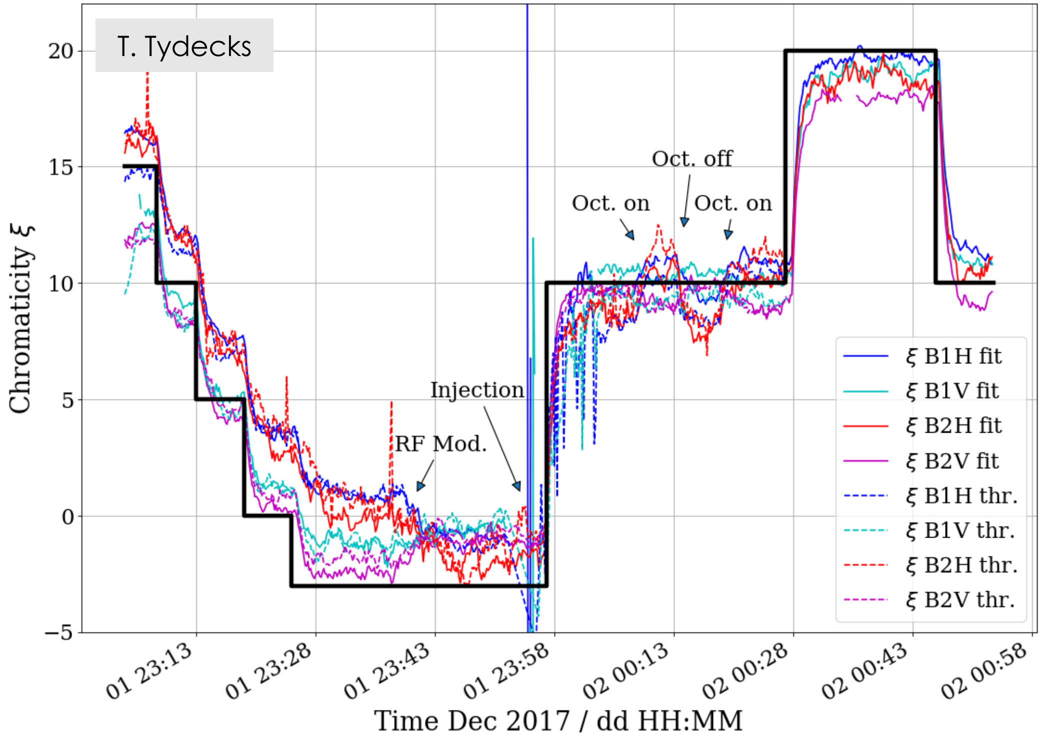
Head-Tail Monitor – calibration



Schottky Monitor

- Calculation of tune/chromaticity is performed online:
  - CCC fixed display is available
  - Data is logged to TIMBER
- Bunch gating selection is configured automatically based on filling scheme
- Now available for operational use at injection for continuous, non-invasive, chromaticity measurement
  - Integration into Accelerator Cockpit?
- Discrepancy w.r.t. RF modulation measured in MD2408 as < 2 units

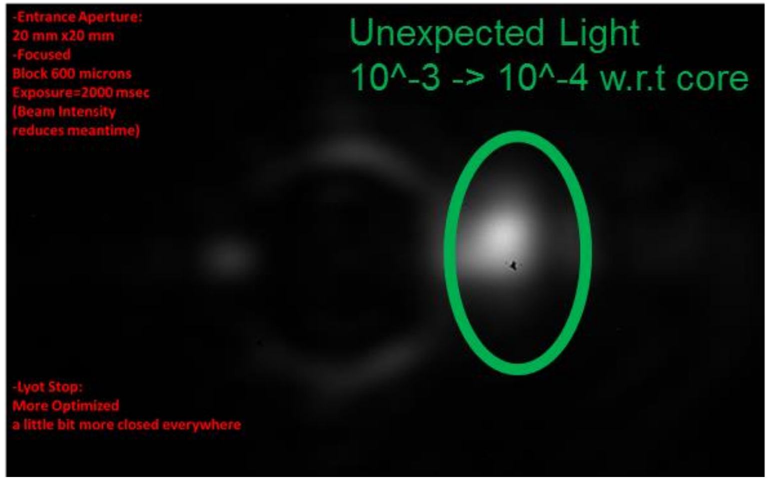




Coronagraph

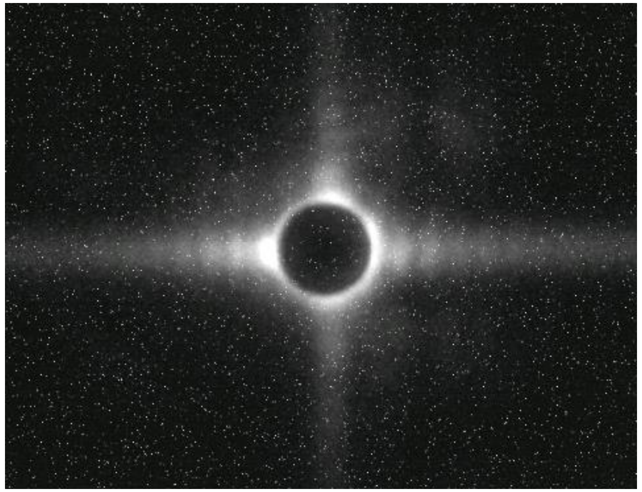
2016

- Coronagraph installed on Beam 2
- Working principle demonstrated at 450 GeV
- Interpretation difficult at 6.5 TeV as halo dominated by a parasitic light source



2017

- Coronagraph dismounted during EYETS, layout slightly changed to better control the SR entrance
- Installation of observation cameras in the system and gated intensified camera (bunch by bunch)
- Shaving edge radiation reduces the parasitic light
- Measurements are now possible

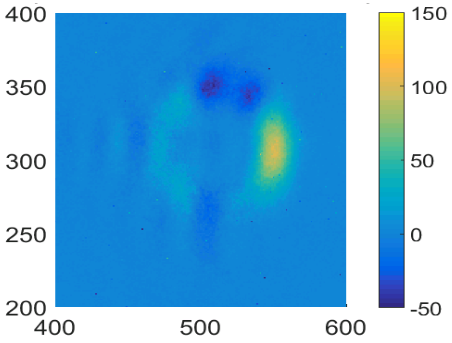


Coronagraph – 2017 MDs at 6.5 TeV

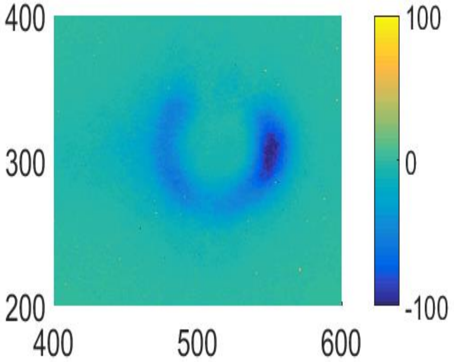
J. Barros, E. Bravin, G. Trad

Halo Control

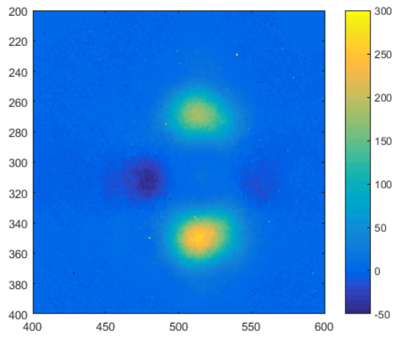
H Blow Up



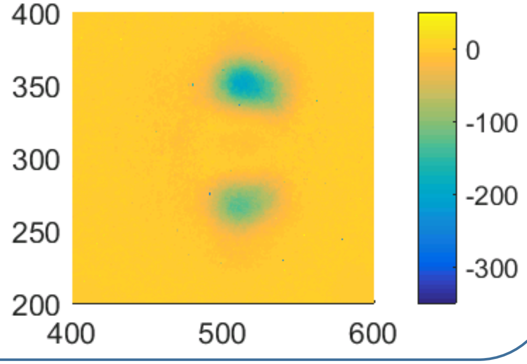
H Scraping



V Blow Up

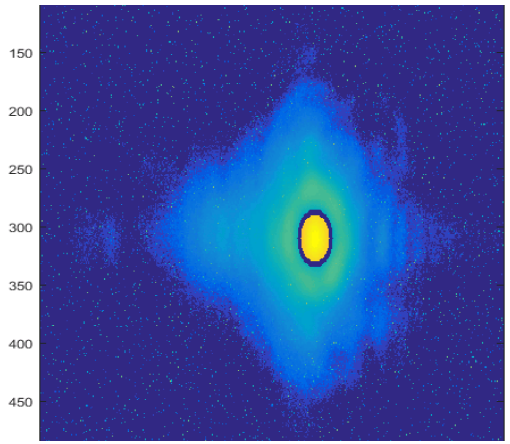


V Scraping

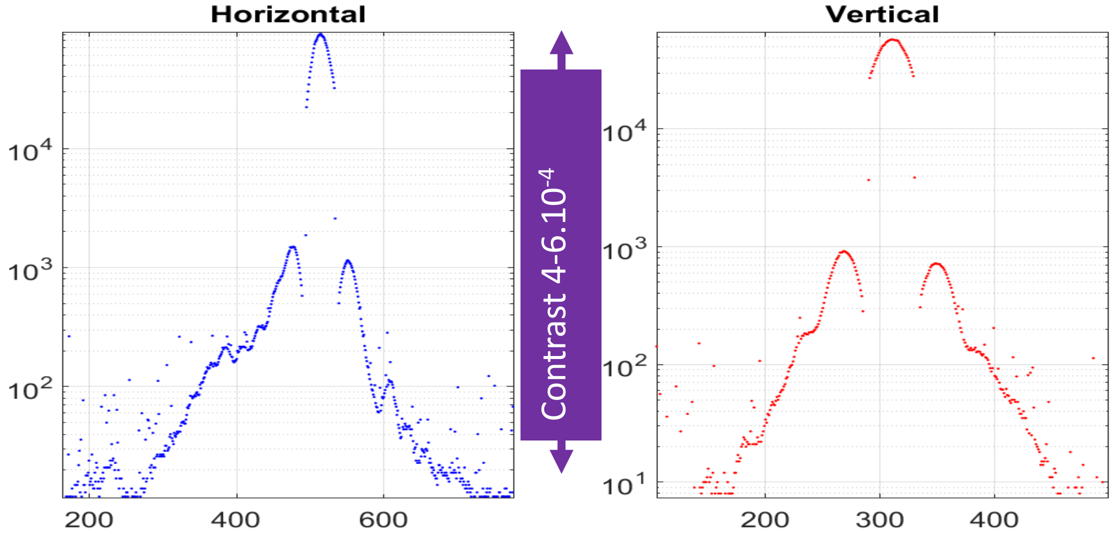


Halo Variation Sensitivity:
H = $2x10^9$ protons
V = $2x10^8$ protons

Contrast Reach



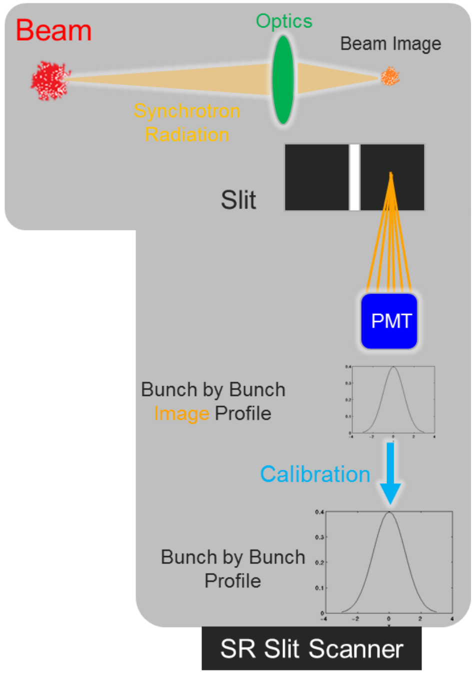
Core Integration 15 ms
Halo Integration 1 s

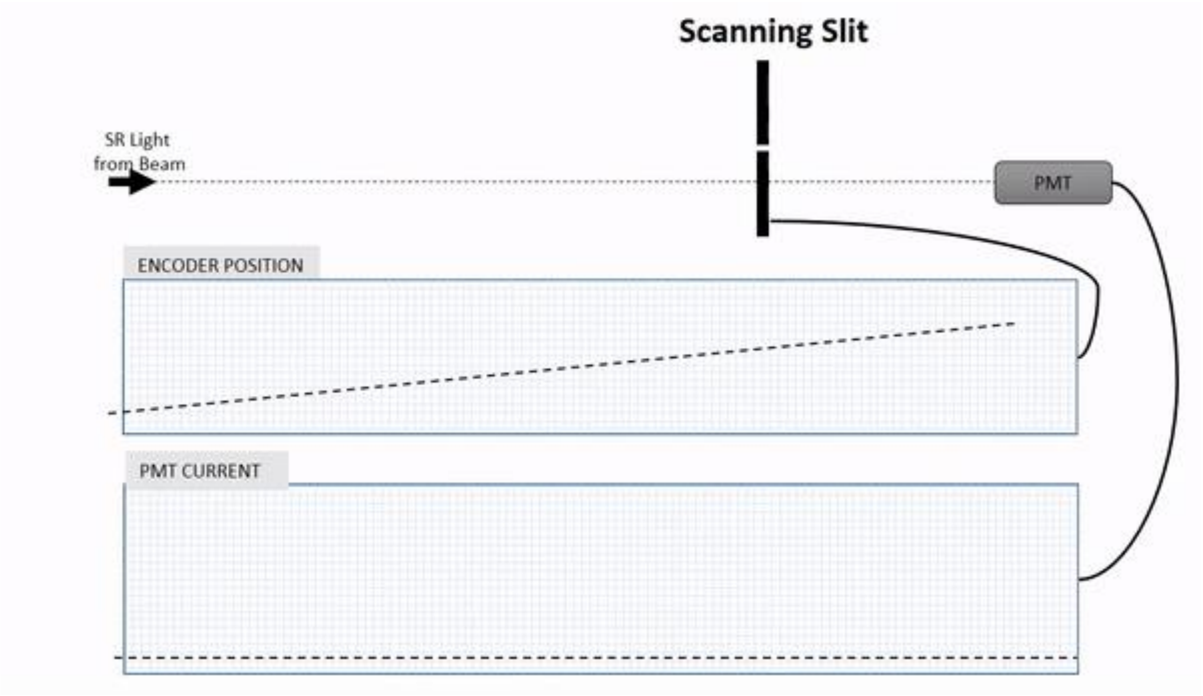


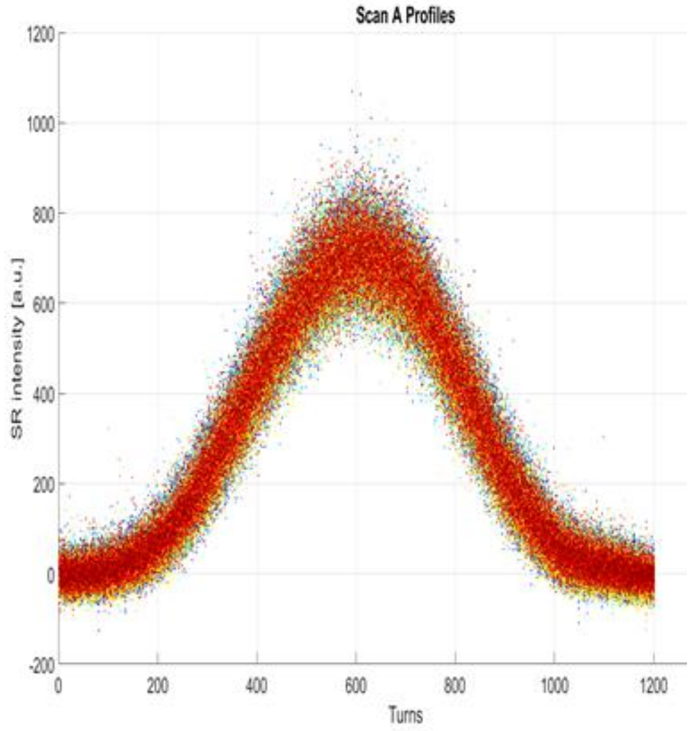
BSRS – Slit Scanner

G. Trad

- Potential to overcome the profile distortion due to intensifier ageing
- Ageing reduces the total sensitivity but does not distort the profile
- Full machine profiles acquisition in few hundreds of msec
- R&D instrument, will be Installed in parallel to the B2 imaging line in 2018

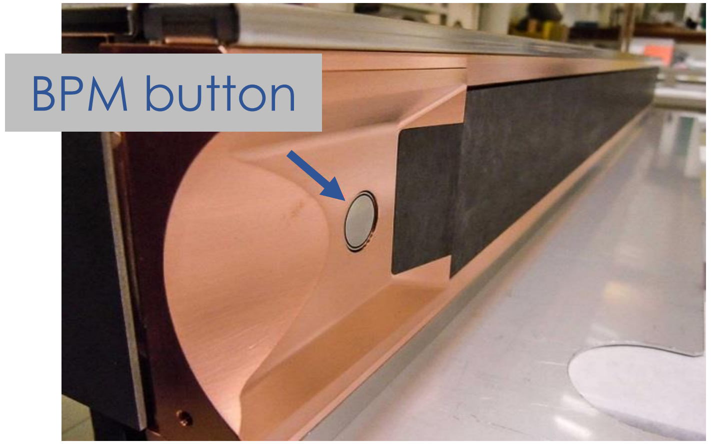


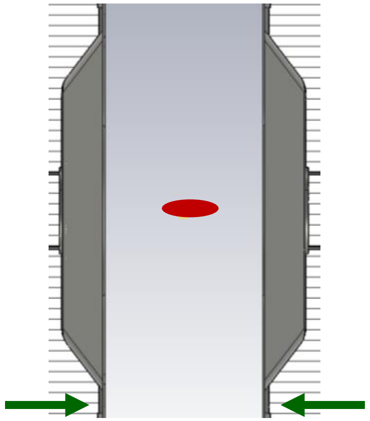




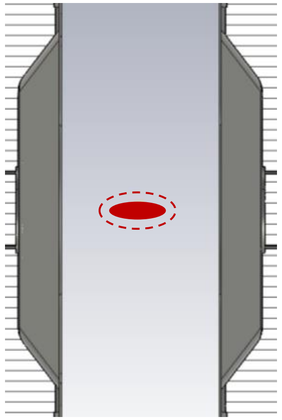
Quadrupolar PU

A. Sounas





Abs. Measurement (aperture scans)

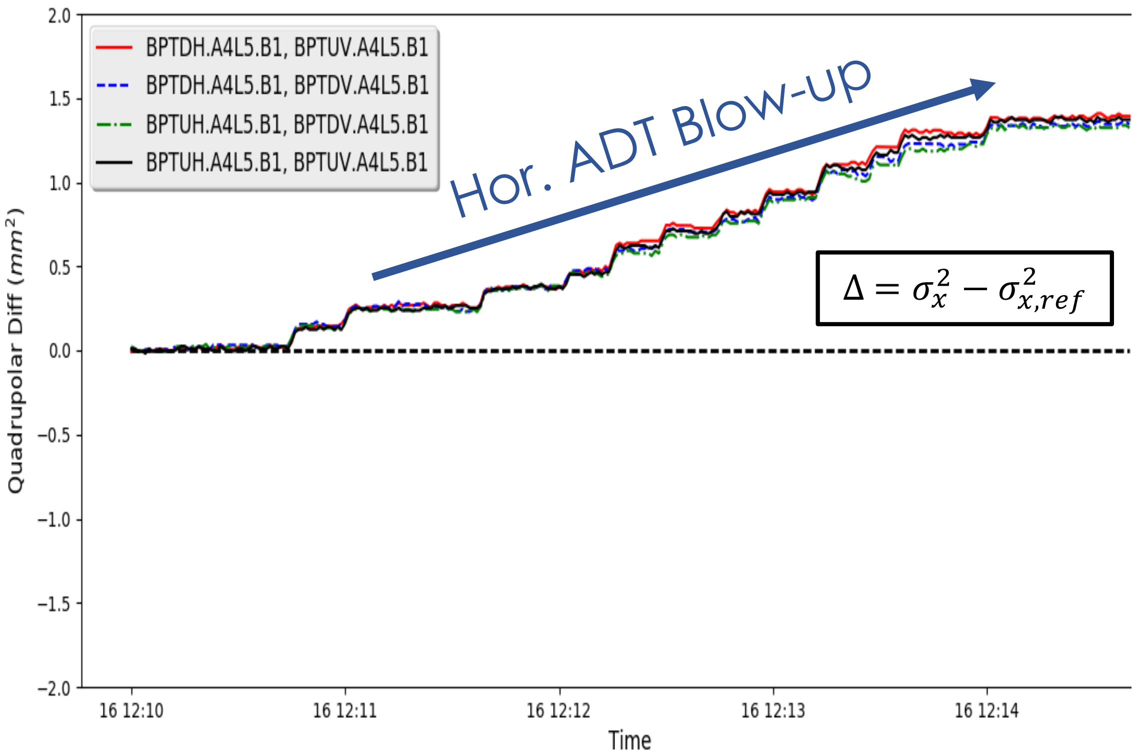


Diff. Measurement (const. aperture)

Principle: *beam size information in button's signal*

$$V = i_b\left[c_0 + c_1 x + c_2\left(x^2 - y^2 + \sigma_x^2 - \sigma_y^2\right) + \cdots\right]$$

Beam size



Preliminary Results 05/2017*

*Differential Measurement using 4 different Hor-Ver pairs of collimator BPMs. Single bunch at Injection.

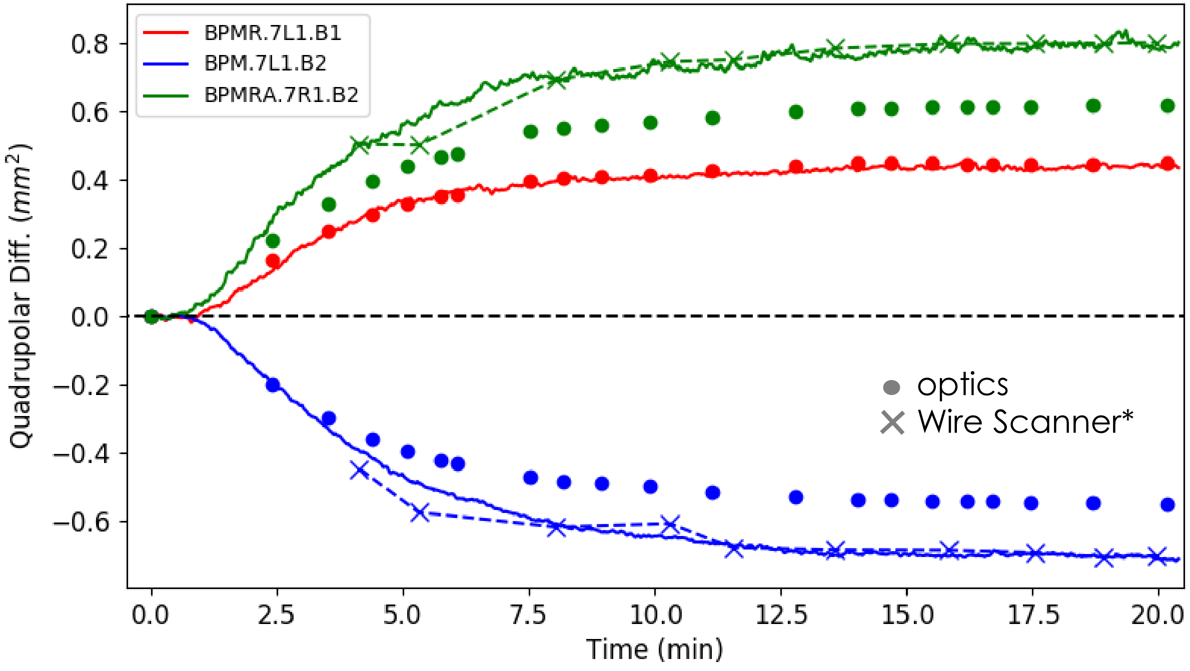
Quadrupolar PU – MD2733

HOT OFF THE PRESS

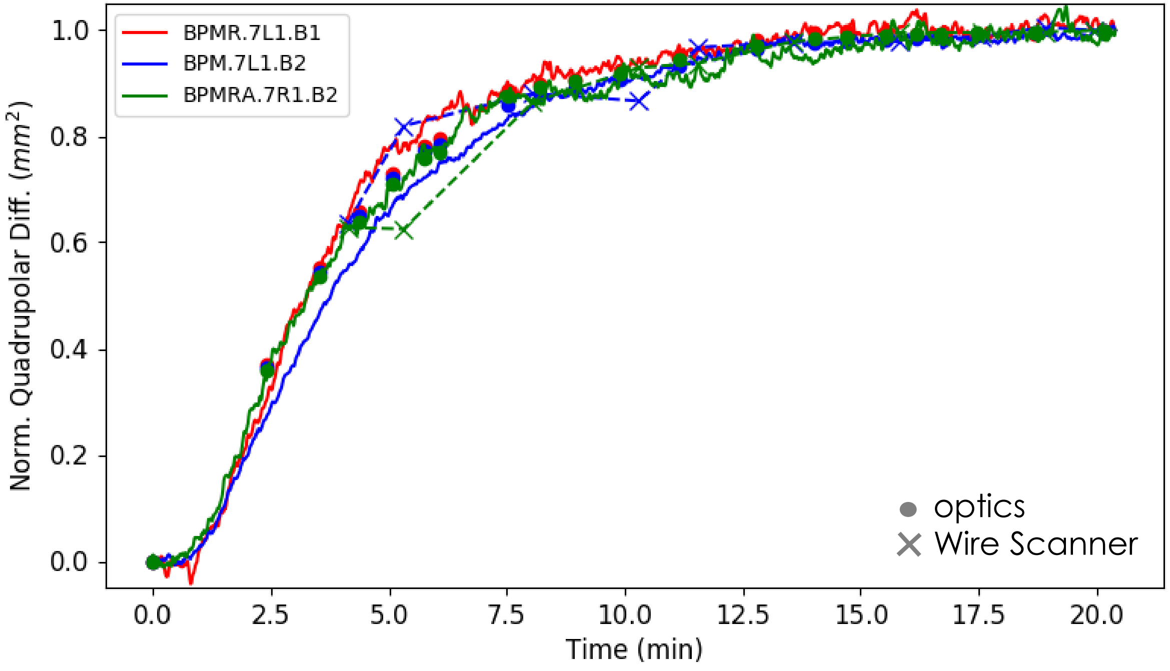
A. Sounas

Differential measurements at 1Hz with DOROS at Q7L/R1 during the ramp:

$$Q = \sigma_x^2 - \sigma_y^2$$



$$\Delta = Q - Q_0$$



$$\Delta_{norm} = \frac{\Delta}{Q_{FT}}$$

*Aligned with the BPM measurements in the Flat Top

Schottky – MD2408 emittance measurement

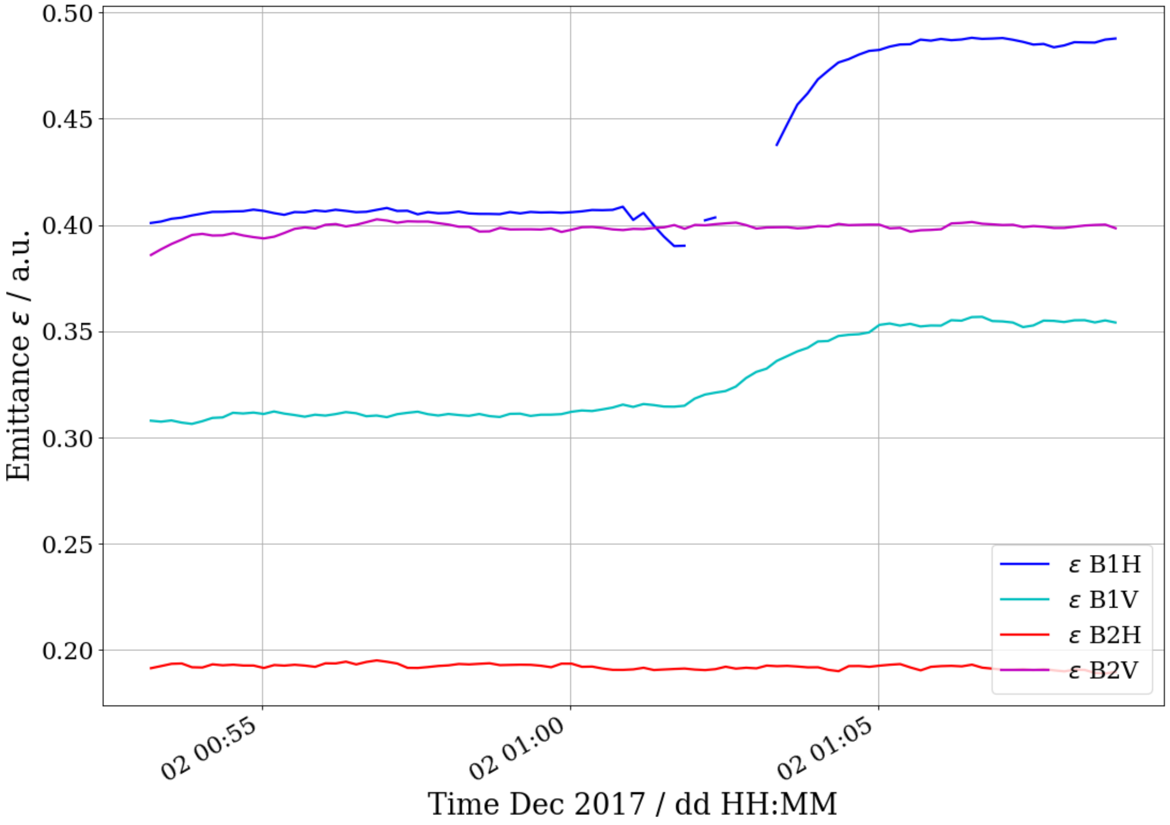
T. Tydecks

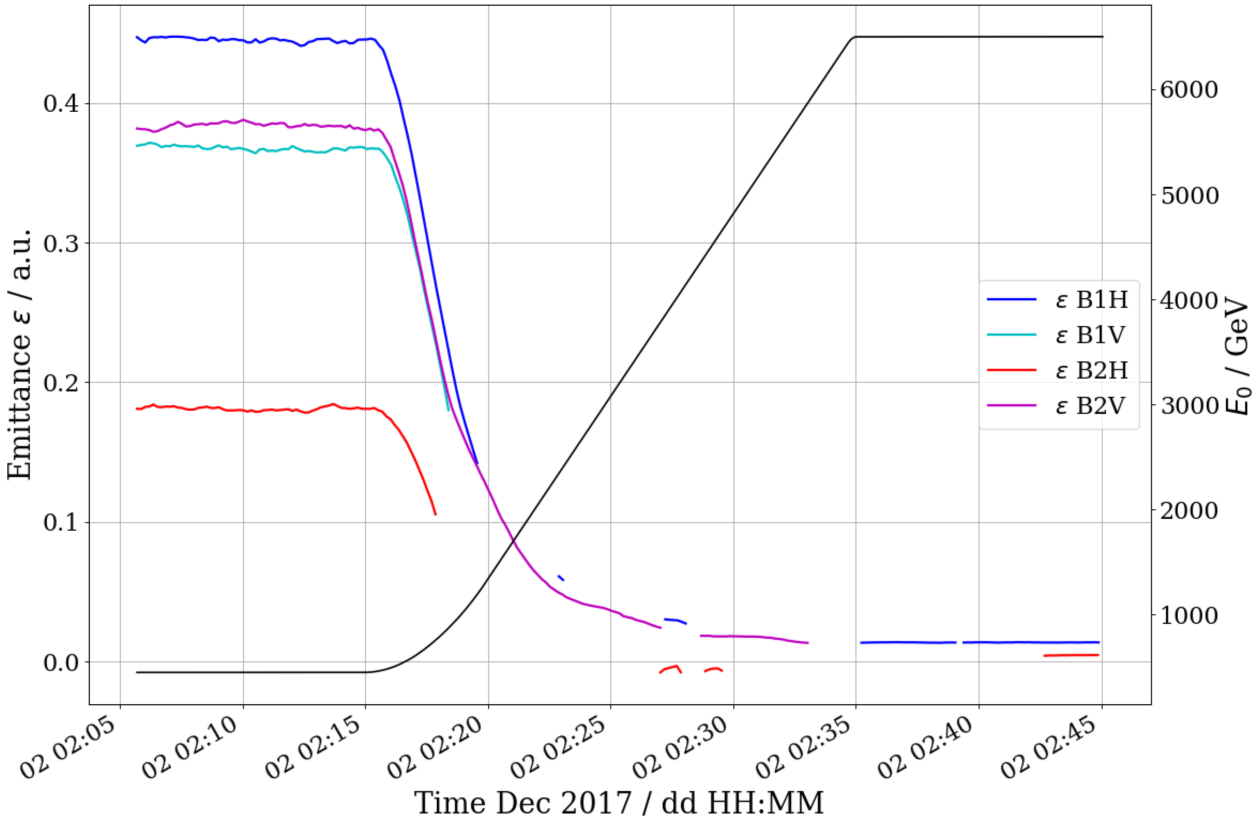
B1H blown up from 1 um to 3.5 um.

Change in Schottky spectrum clear but ratio smaller than expected.

Change of Schottky emittance during energy ramp:

Final ratio in right ballpark:
0.04 vs 450/6500 = 0.07





Conclusions

- DOROS
  - Linearity improved through on-line correction
  - Position errors reduced with better handing of variable collimator aperture
  - Automatic time constant switching to be made operational
  - Redundancy planned for front-ends used by SIS

- Diamond BLMs
  - No change to operational system acquisition before LS2
  - New acquisition system being developed and deployed in parallel

- Head-Tail Monitor
  - New digitizers to be installed during YETS
  - More turns & higher resolution available, but much larger file sizes

Conclusions, cont.

- Schottky Monitor
  - Online chromaticity available at injection, discrepancy w.r.t. RF modulation < 2 units
  - Initial tests of emittance measurement performed during last MDs
  - Measurement during the ramp and at FT remains challenging

- Coronagraph
  - Remains a development instrument, installed only on B2
  - Promising results from 2017 MDs

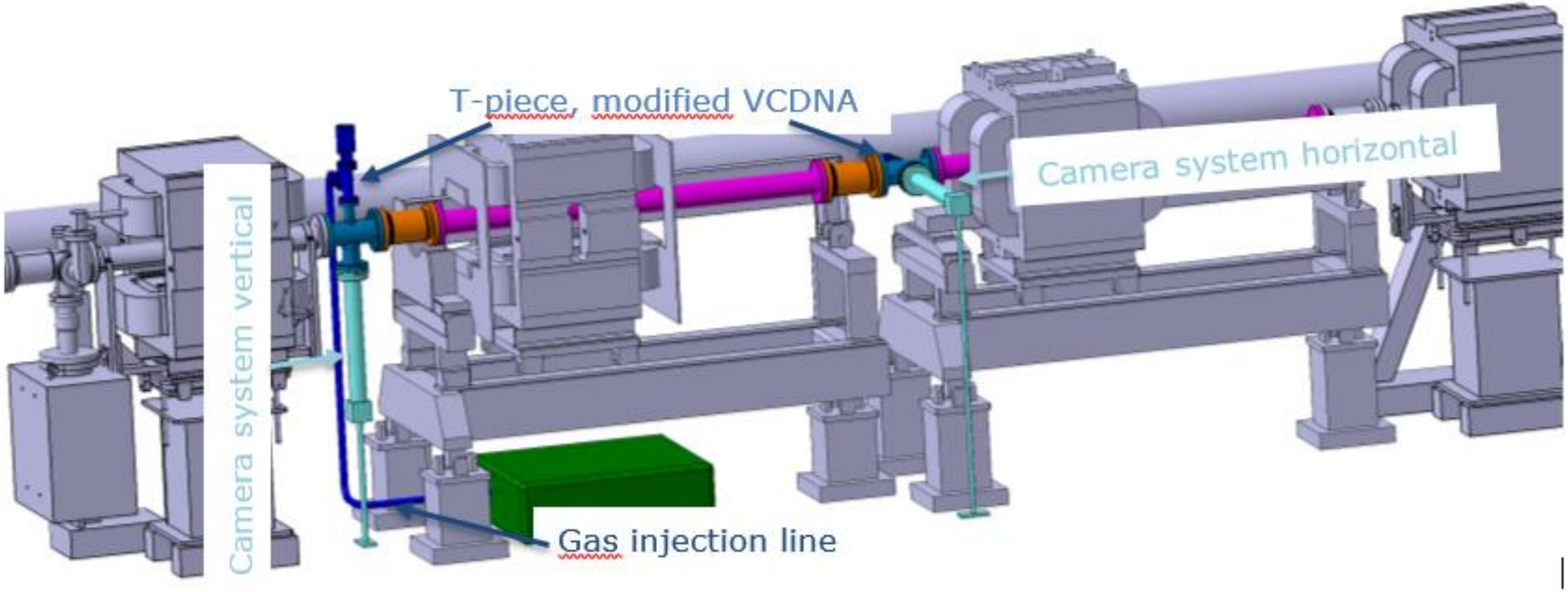
- BSRS (slit scanner)
  - Potential remedy for profile distortion due to image intensifier aging
  - Will be installed in parallel to imaging line of B2 during YETS for tests in 2018

- Quadrupolar PU
  - Potential for beam size measurements with DOROS BPMs under study

www.cern.ch

Beam Gas Curtain

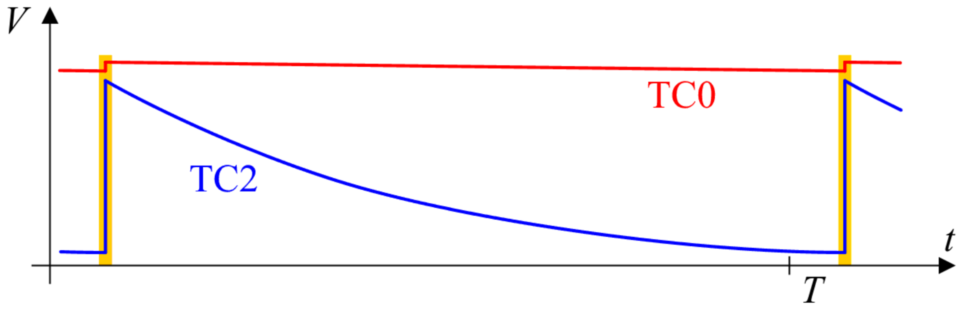
- Installed in place of the BGIs in D5L4.B and reusing their existing gas injection system.
- Provides a basic fluorescence test in view of an overlap instrument for the hollow electron lens which is foreseen for installation in LS3.
- A demonstrator instrument foreseen to be installed in LS2.



Time constant (TC) setup: bunch number

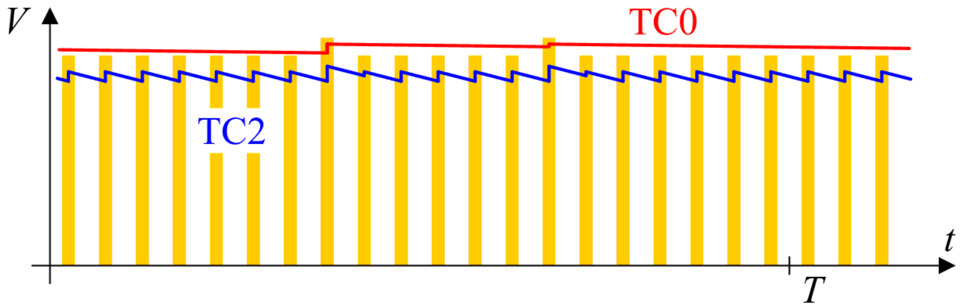
Operation with a single (or a few) bunches:

The only choice is TC0, as TC2 provides too much discharge at the output of the diode detectors for so rare charging, making the average signal very low. Operation with TC2 in such conditions would cause the automatic gain control increasing the RF gain, which in turn would lead to a fatal signal saturation.

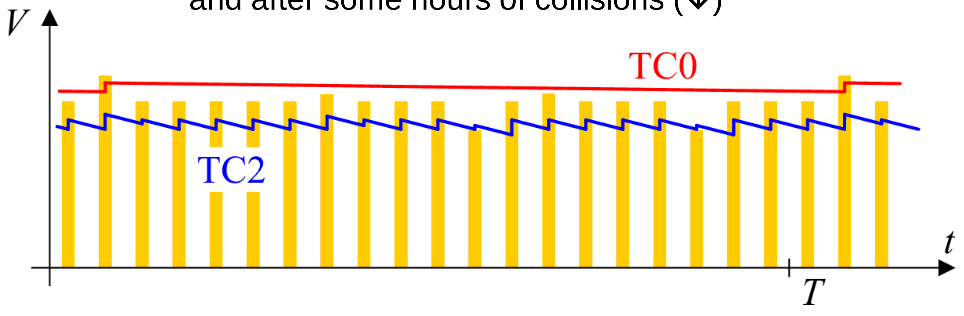


Operation with the full machine (or many bunches):

The only choice is TC2, as TC0 makes the detectors to operate at the bunches with the largest intensity. If the maximum intensity bunch changes, then the detector would shift its operation to that bunch.
If the beam has a large beam offset, then TC0 may cause the detectors of the BPM electrode pair operating at different bunches.
With TC2 the detectors operate more in the "average" mode, in which the changing bunch intensity does not modify significantly the detector operation.



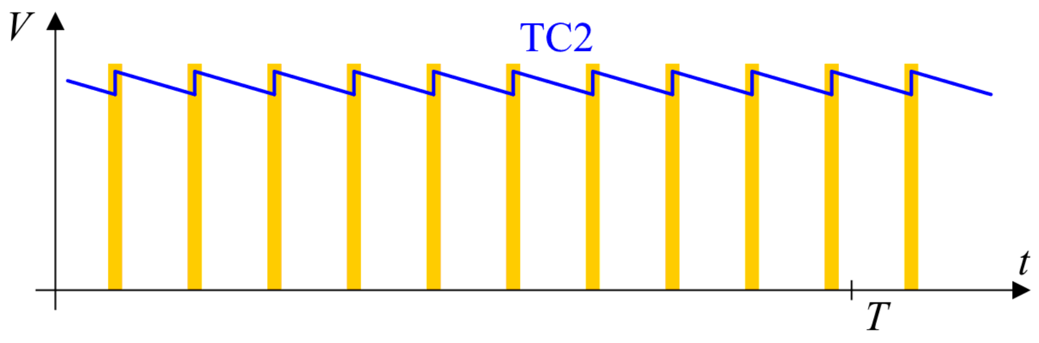
LHC fill at its beginning (↑)
and after some hours of collisions (↓)



Time constant (TC) setup: bunch pattern

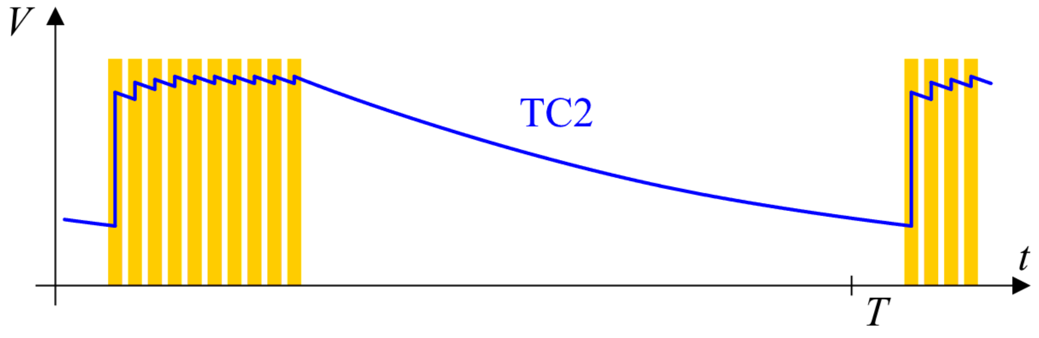
Operation with distributed bunches

From some hundred distributed bunches any time constant is acceptable. However, TC1 and TC2 would help to avoid systematic errors during long measurements, caused by the intensity decay.



Operation with “grouped” bunches:

If the bunches are not distributed, then TC2 must not be used, as it would make the average detector signal too small.



Automatic setup of the time constant (TC)

- Each fill starts with TC0, which is kept until the beam injections are finished, that is until the beam mode changes to “prepare ramp”.

- A the beginning of “prepare ramp” FESA runs the following procedure:
  - Switch to TC1.
    If the detector signal drops by more than 5 % (1) (too much discharge), then
    - return to TC0 and finish the procedure.
  - Switch to TC2.
    If the detector signal drops by more than 5 % (2) (too much discharge), then
    - return to TC1 and finish the procedure.

- The setup time constant is used until the end of the cycle.

(1) - programmable FESA parameter TCsetupChange01

(2) - programmable FESA parameter TCsetupChange12