Improved Tune monitors

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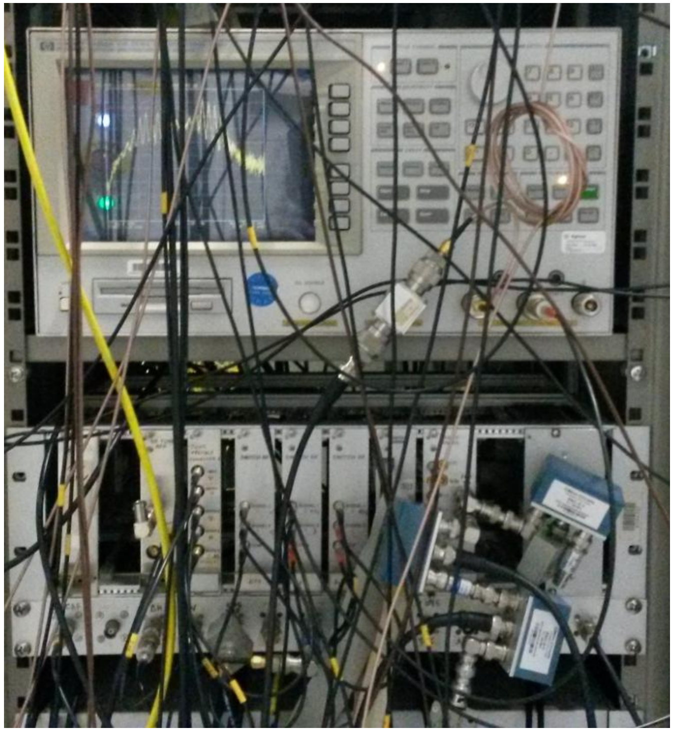
ESRF

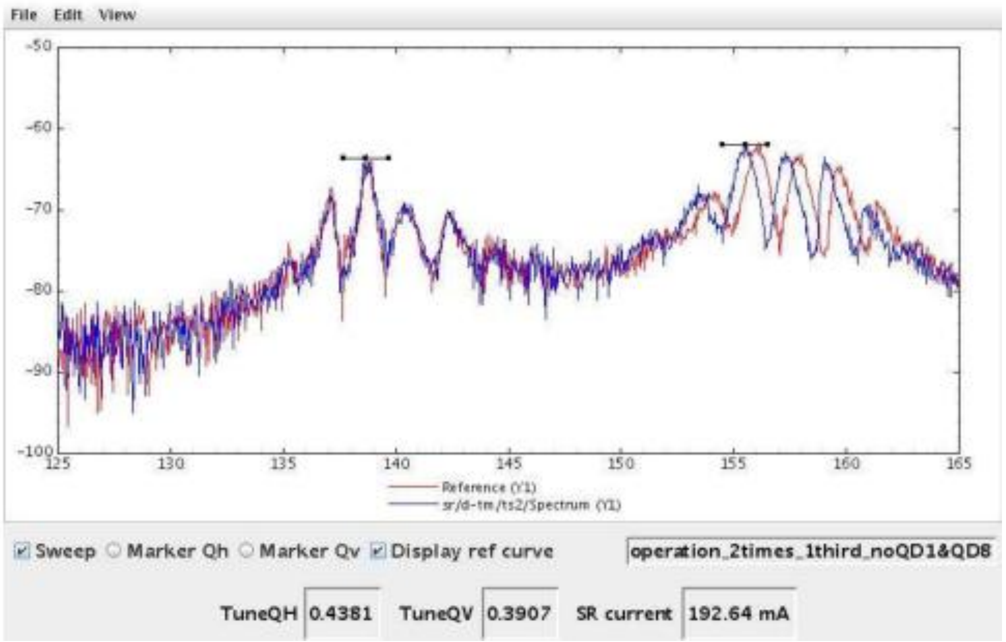
Current tune monitor at the ESRF

- Based on an (expensive) network analyzer



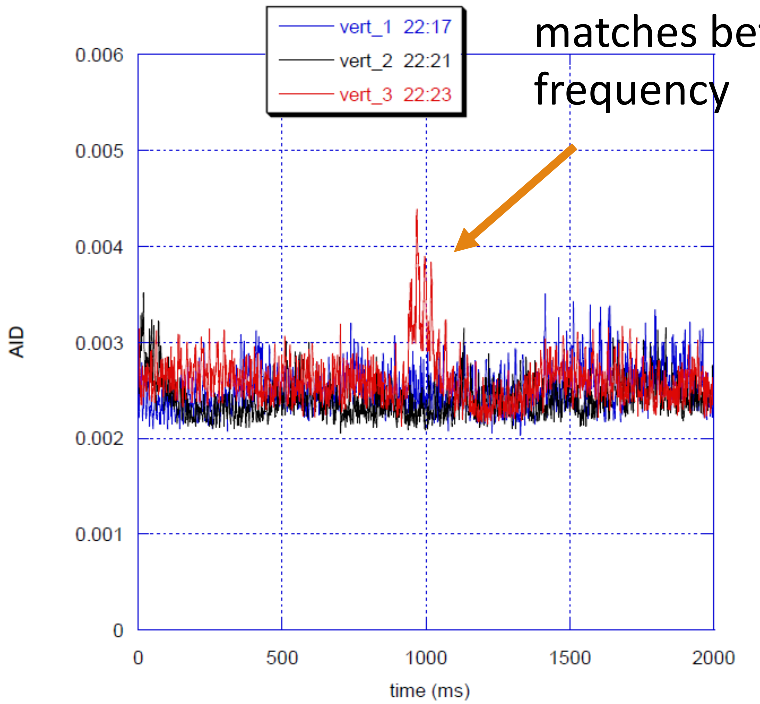
- GPIB controlled (obsolete)
- Only one channel (both plane on the same graph)
- 3 s. sweep time
- Two set of pick-up (H + V), + a spare pick-up (but removed a few years ago)
- 2 sets of shakers (H + V) + 2 spares (signal sent over large distances)
- home-made electronics for homodyne detection at RF frequency (phase sensitive)

Current tune monitor at the ESRF



- SR is operated with high chromaticity
- it makes it difficult to determine the correct tune
- today the correct tune is determine by human expertise (we select the correct pick)
- software pick tracking (slow drifts only)

Current tune monitor at the ESRF



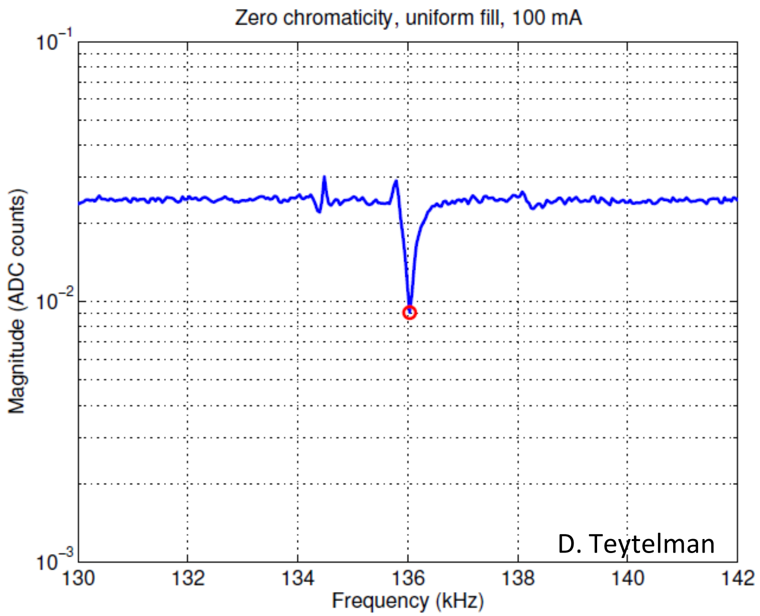
excitation frequency matches betatron frequency

Current tune monitor is based on a frequency sweep with a period of 3 s.

During a test with beam scientists, they could see a perturbation with a large excitation (3x the usual one)

→ A fastest sweep would be averaged over their integration period.

Bunch by Bunch feedback notch tune monitoring



Noise suppression by the feedback loop.

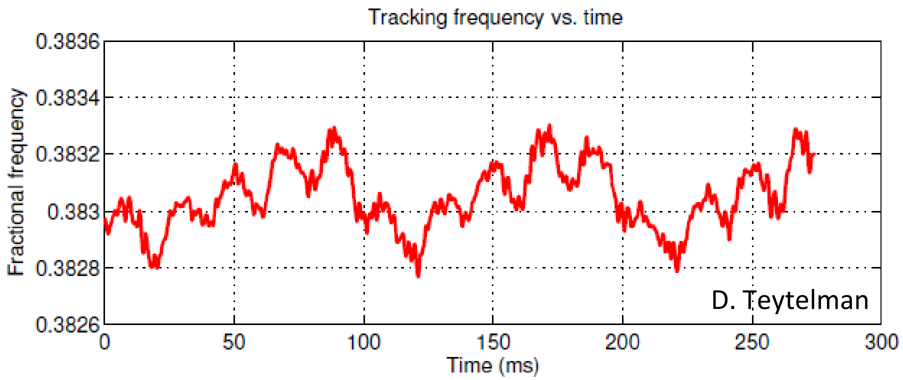
It is a side effect of a bunch by bunch feedback system.

(see tomorrow's presentation *"Outcome of a test/demonstration of the Dimtel B-b-B system"*)

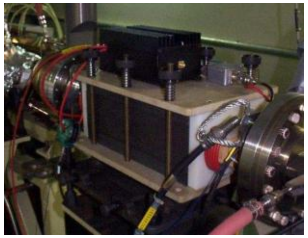
→ At the ESRF we don't usually need the BbB feedback.

Other interesting characteristics for a tune monitor

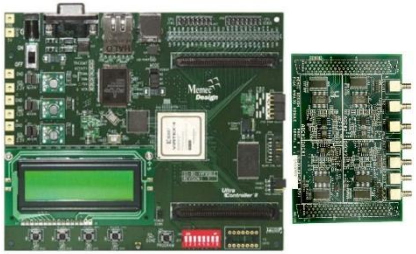
- Single bunch tune monitor (just spoil emittance for 1 bunch)
- Phase tracking (see tomorrow's presentation *"Outcome of a test/demonstration of the Dimtel B-b-B system"*)
- Fast tune monitor



A Spark-based tune monitor



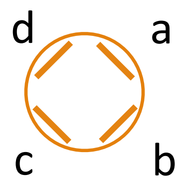
Magnetic kicker (1 MHz BW)



Memec Virtex-4 FX12 LC + P160 analog module

Beam excitation with deterministic noise

Trigger signal + SR clock

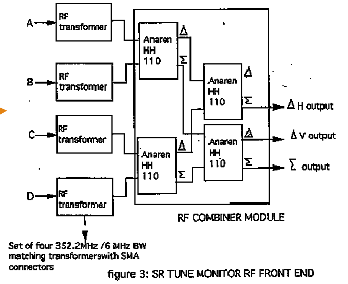


BPM Pick-up

directly plugged to Spark

or

with a front-end



Beam measurement

A Spark-based tune monitor

Advantages:

- Few components, few interconnections (signals are not sent over large distances)
- Relatively low cost (~ 6000 euros for the electronics)
- Same Spark as for the SR (control is already available, no need for dedicated spares)

Drawbacks:

- No fast or single bunch measurement capabilities
- Obsolete FPGA card

Data processing

The Spark cannot acquire a continuous flow of data.

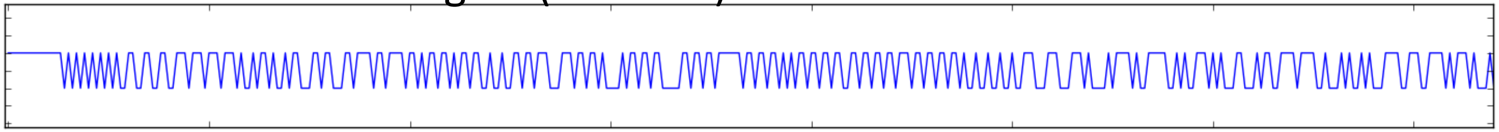
We acquire a data set at 4 Hz. One acquisition corresponding to a PRBS sequence, i.e. 92 ms.

It corresponds to 37 % of measurement time, and 63 % of dead time.

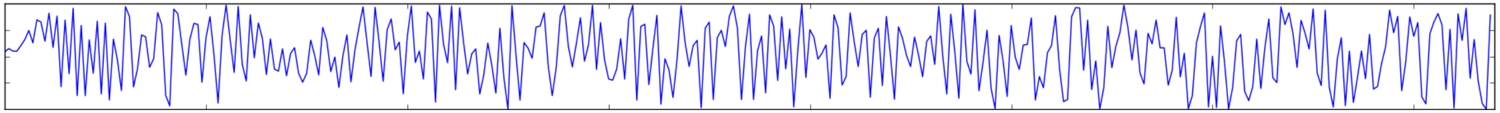
The signal processing (Fourier transform calculations, etc.) is performed on a separate computer.

Data processing

Excitation signal (PRBS-15)



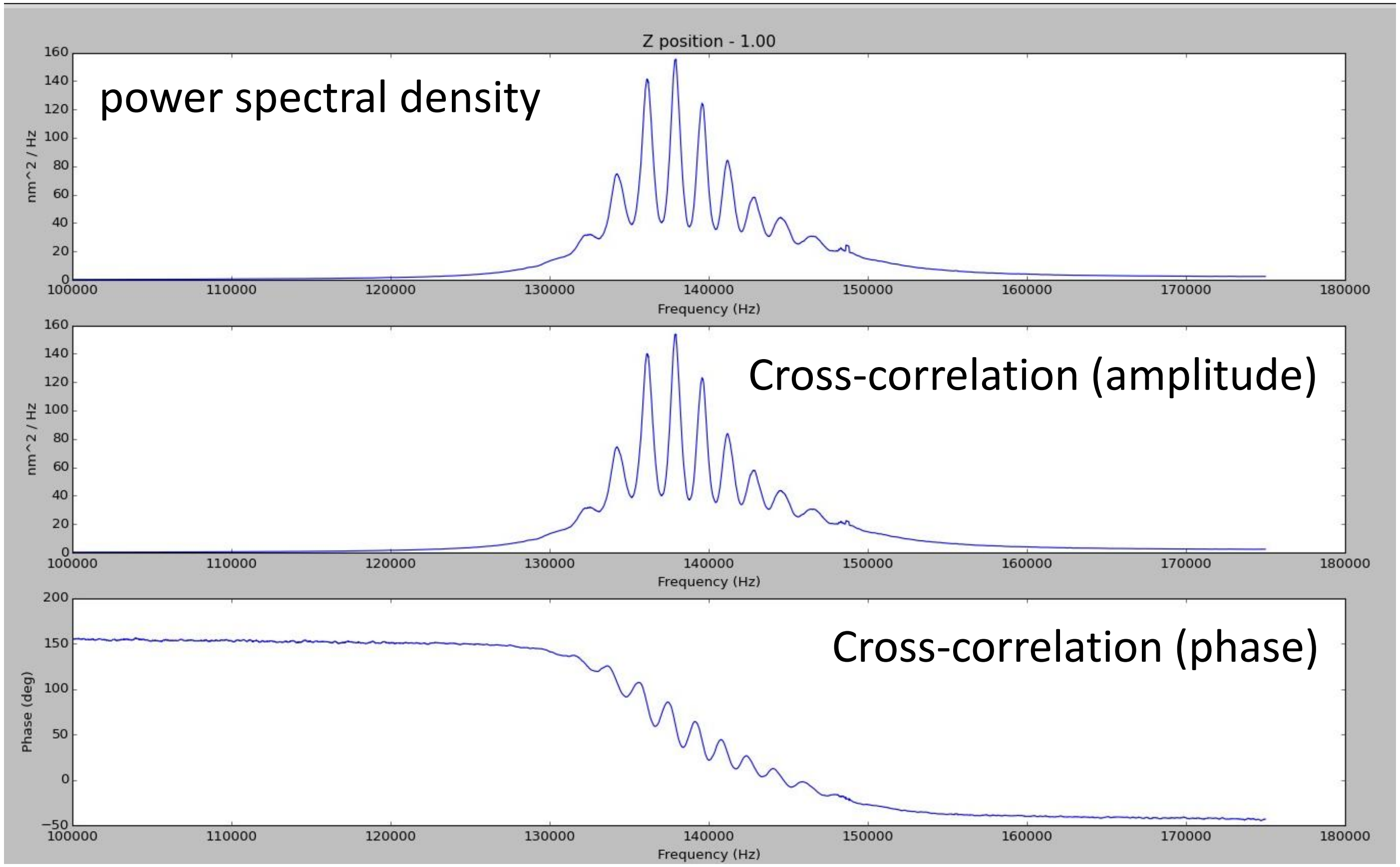
Beam's response



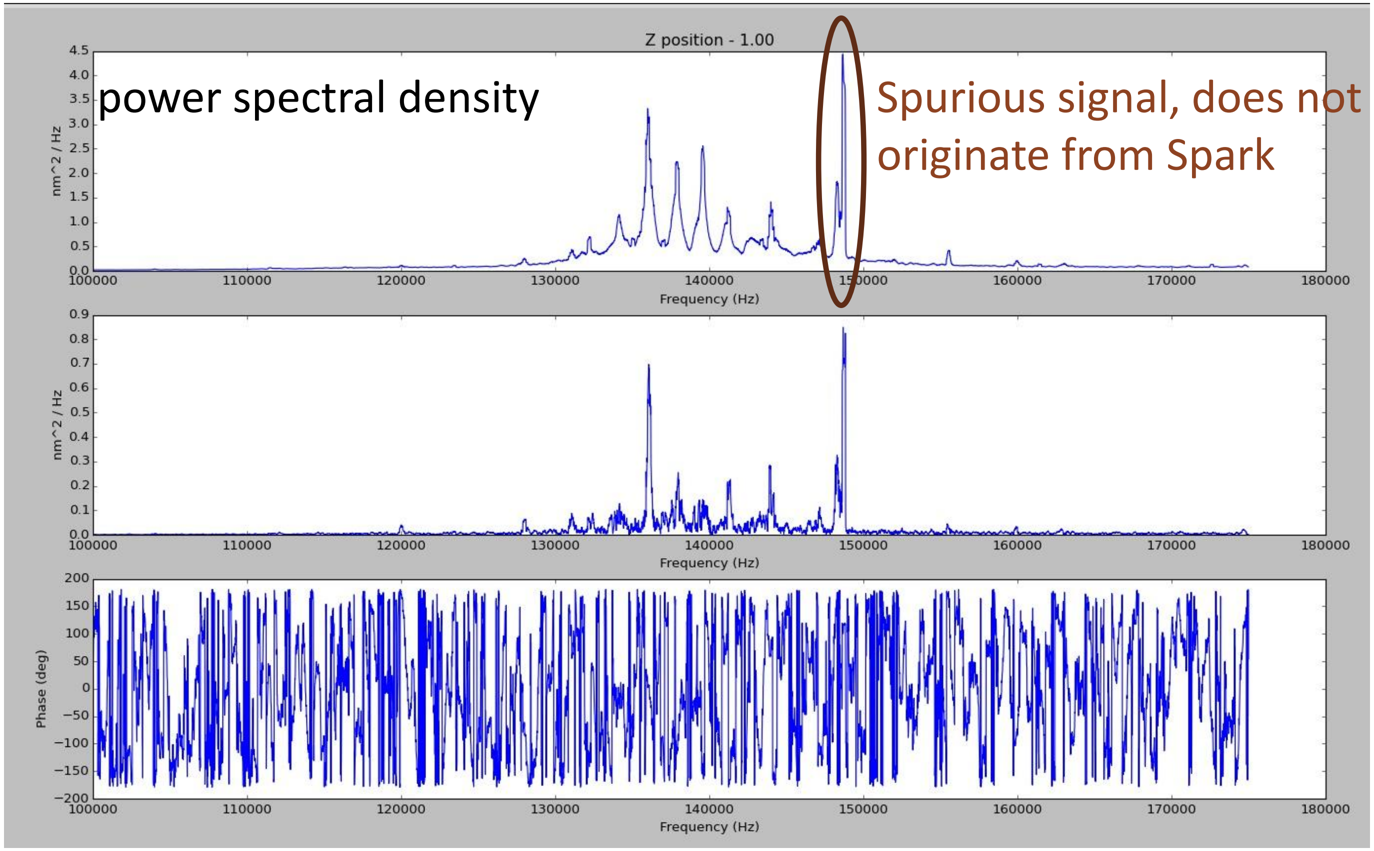
One computes:

- The power spectral density of beam's response
- The cross-correlation between excitation signal and beam's response

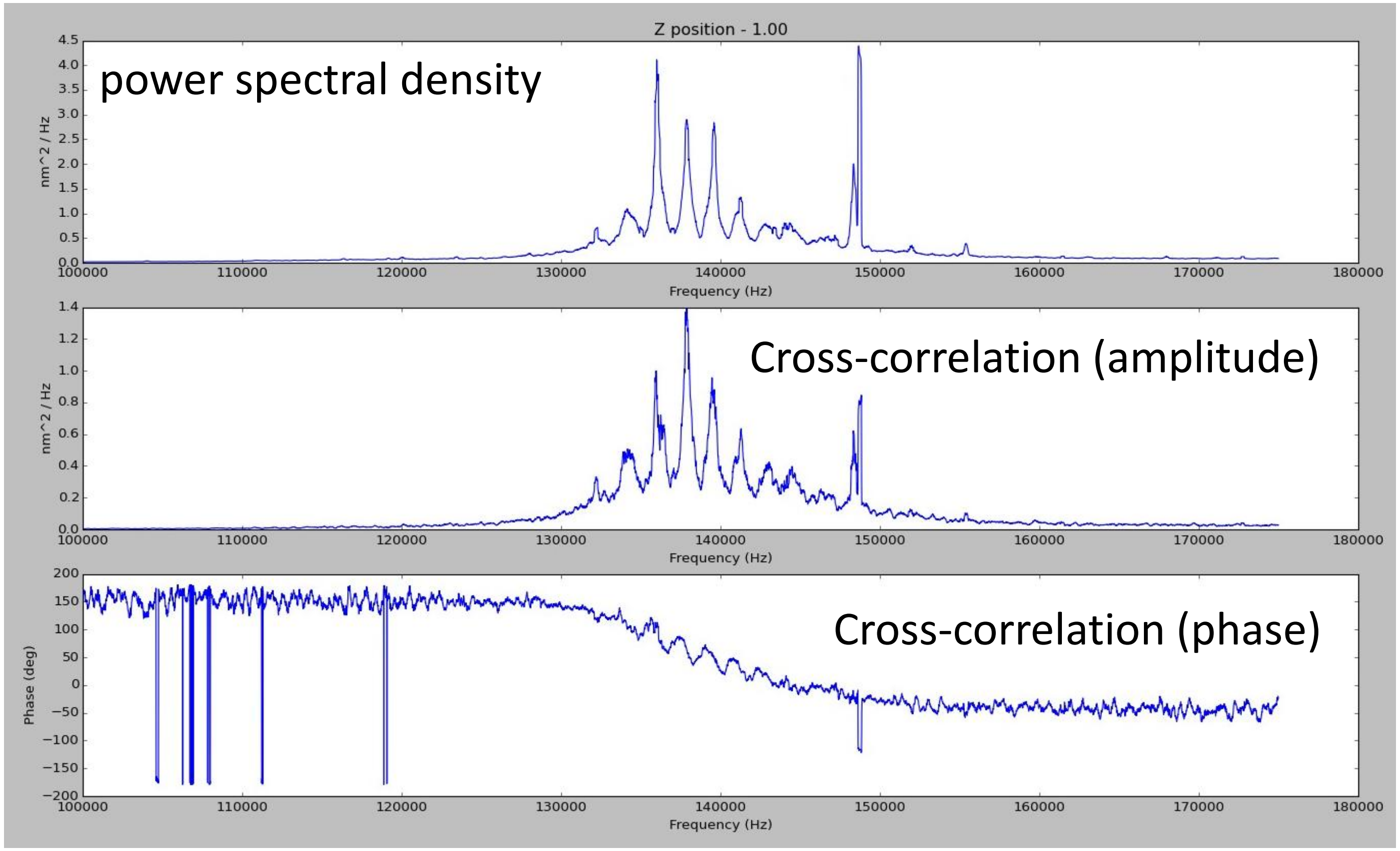
With a large excitation



Without excitation (natural beam excitation)



Small beam excitation (+ 0.1 pm on V emittance)



Front-end or no front-end?

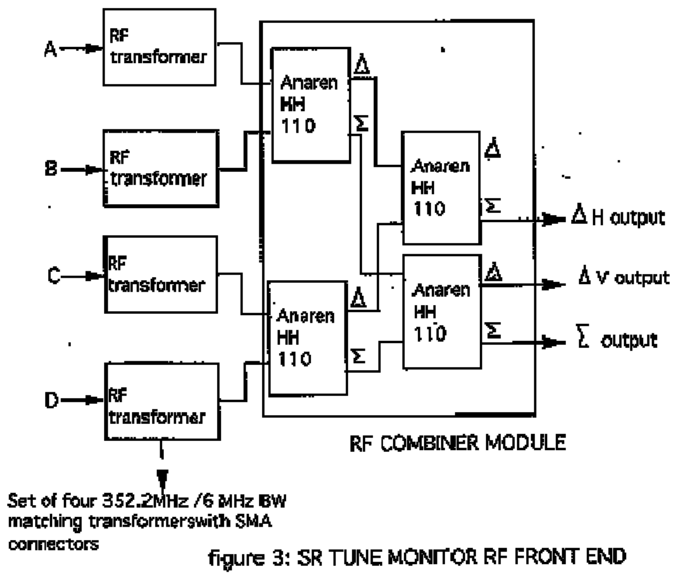
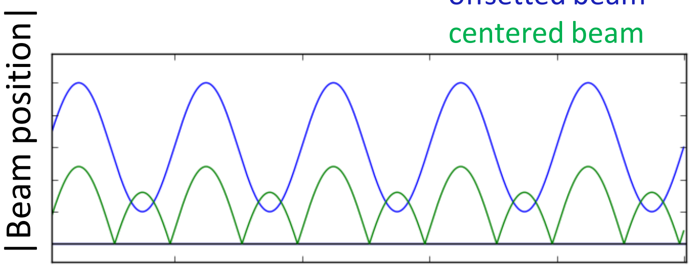


figure 3: SR TUNE MONITOR RF FRONT END

ΔH and ΔV can be fed directly into a Spark input.

The amplitude measured by the Spark is proportional to the absolute value of the position.

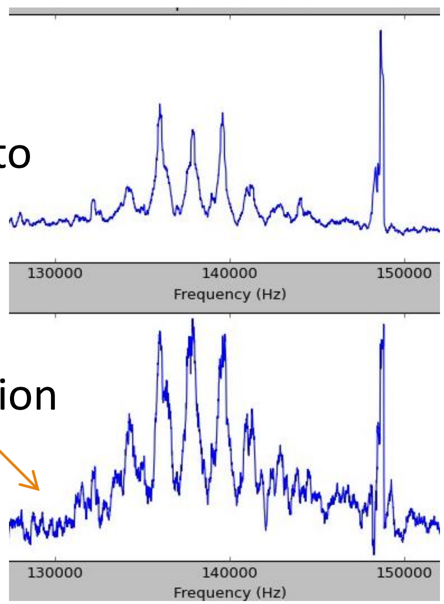
It can be an issue if the beam is perfectly well centered.



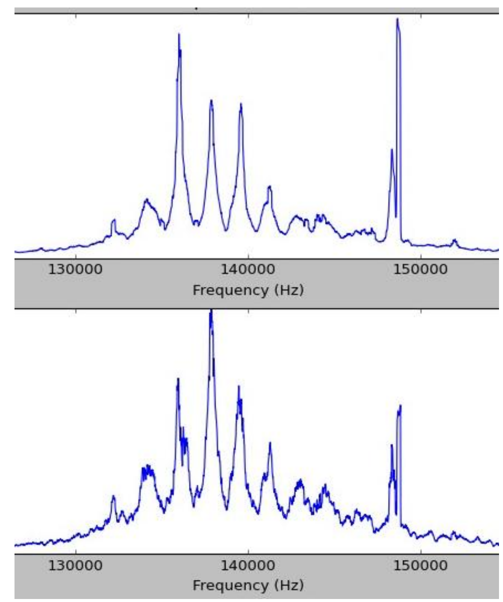
Front-end or no front-end?

Noise floor due to amplifiers

Cross-correlation more noisy



31 dB attenuation at Spark's input



12 dB attenuation at Spark's input

A Spark-based tune monitor (conclusion)

- We will have two independent setups (BPM pick-up + Spark + electronics for beam excitation + shaker)

reliable

- Excitation and measurement only coupled with timing signals
- not phase sensitive

simple

- no spoil of the beam emittance (no slow sweep)
- Spark windowing capabilities enable to measure tune on a small number of buckets (approx. 50)
- Can phase information help to automatically find correct tune value?

User-friendly

Thank you for you attention…