MD 13543: Statistical properties of Schottky spectra

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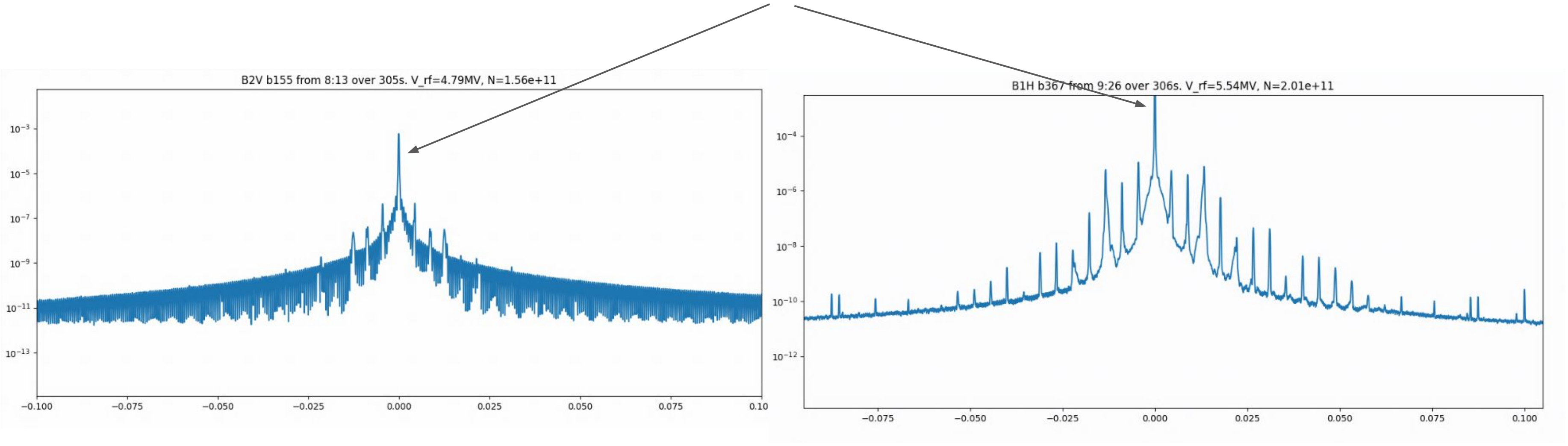
Motivation

Schottky spectra sometimes exhibit particularly strong central satellites.

These may disrupt the analysis during the RAMP and at early flattop, making it difficult to accurately extract beam and machine parameters from the spectrum.

Strong central satellite



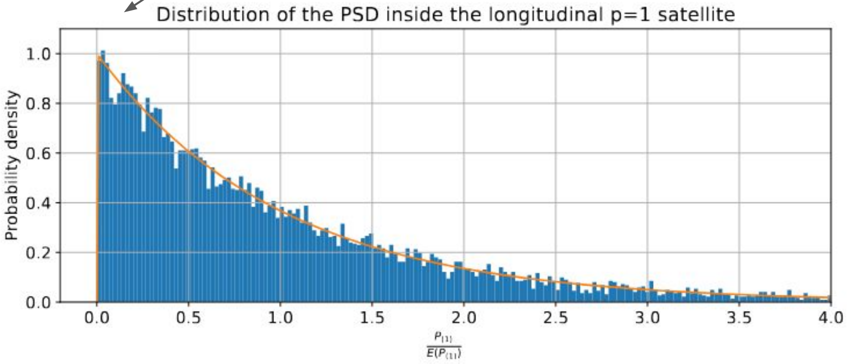
Motivation

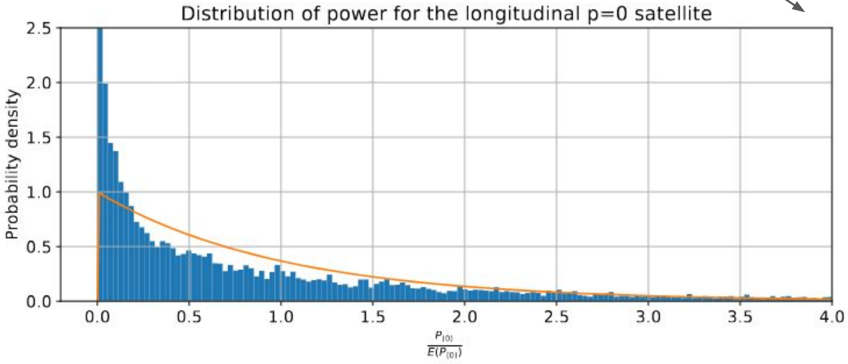
Schottky spectra are inherently random. Two “identical” bunches will give two different spectra.

The variability of *instantaneous spectra* is characterised by the coefficient of variation: **CV = StdDev/Mean**

Developed theory predicts for nominal LHC bunches:

Non-central satellites:	Central satellite:
CV = 1	CV = $\sqrt{2}$
Change quickly with time. Confirmed with measurements and simulations.	Change slowly with time. Confirmed with simulations only ⇒ **MD goal**

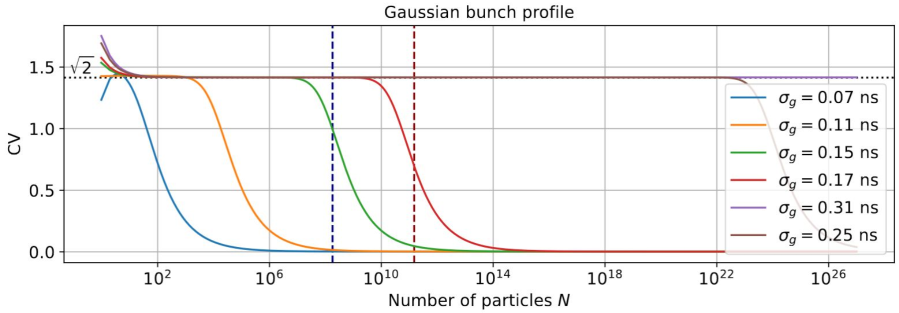




MD Goals

- Benchmark experimentally the theory on the statistical properties of Schottky spectra.
  - Measure the CV of the central satellite in nominal configuration.
  - Expecting a CV = √2.

- Explore how non-nominal beam parameters affect the power and variability of the spectrum.
  - Bunch length affects both CV and the expected power
    - Confirmed general theory might be useful for the design of future Schottky monitors (FCC hh, RHIC)



MD Plan

- Three injections, differing in the bunch lengths (0.1 eV - 0.3 eV).
- Small number of short bunch trains (e.g. 20 trains of 20 bunches - high statistics needed)
- low intensity to limit impedance effects.

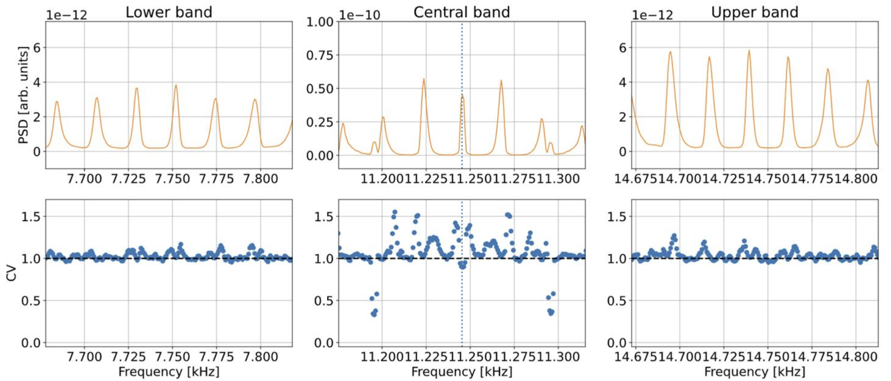
- The following procedure could be repeated for the different bunch lengths:
  - Inject a small number of trains.
  - Scan with the Schottky monitor the power of the central peak of every bunch (400 bunches ~ 1.5h).
  - Dump and inject trains with a different bunch length.

Required time: 8 hours. Preferable both beams, but would also profit from one.

Backup

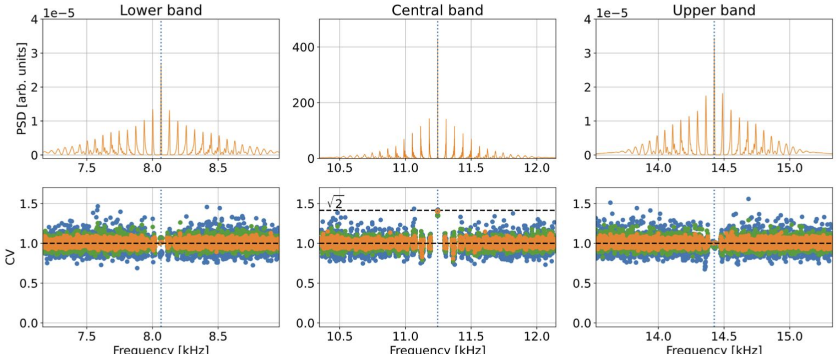
Theory benchmark

Measurement



(For the central satellite the measurements need to be averaged over different bunches and not over time)

Simulation



100 (blue) / 300 (green) / 1000 (orange) bunches tracked over 10k turns each

Theory predicts for nominal bunches:

Non-central satellites:	Central satellite:
CV = 1	CV = $\sqrt{2}$
Confirmed with measurements and simulations.	Confirmed with simulations only ⇒ MD goal