SPS Impedance Model: Latest Results from Simulations

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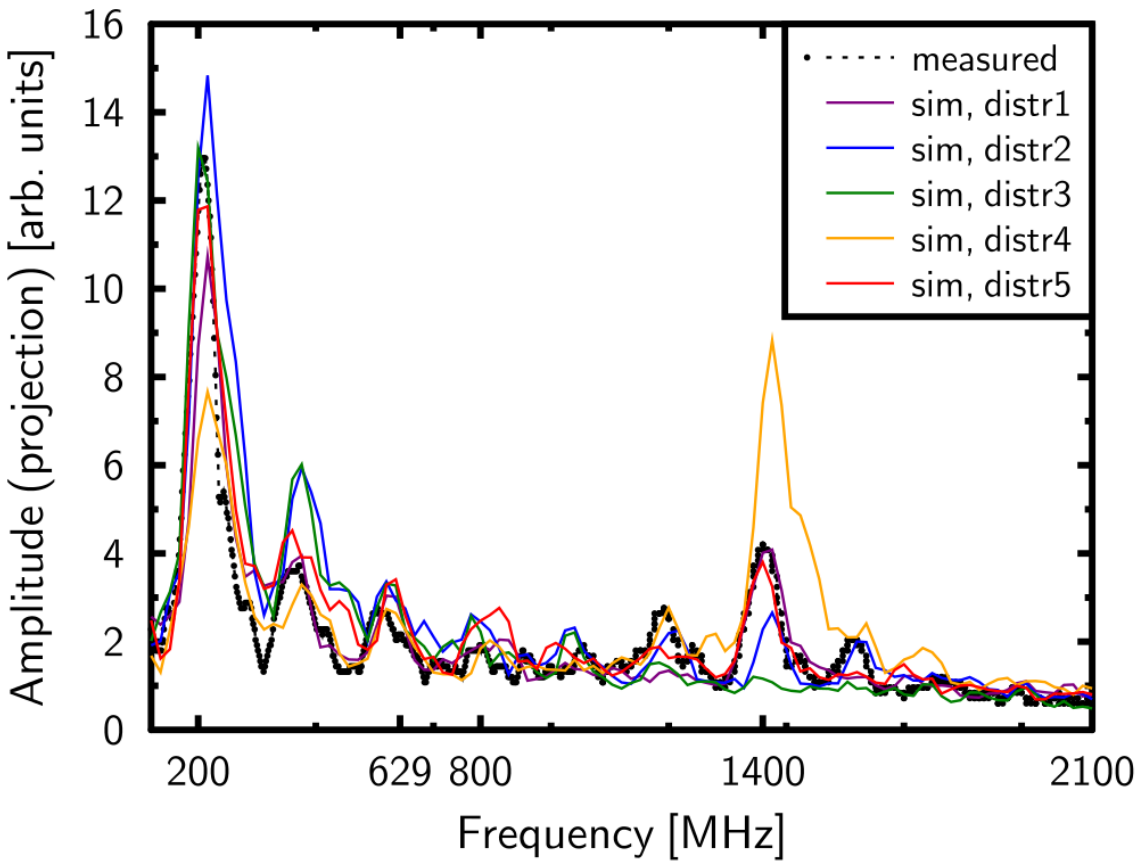
BE-RF-BR

Status at the previous meeting



No BPM&Zs impedance

Damping resistors, w/ R/Q increased; ~15 % higher R_{sh} at 1.4 GHz

Simulated w/ different *measured* distributions

Fits on average

N.B. non-linear scaling between amplitude and impedance

Uncertainties in our simulations

Sources of uncertainty in simulations

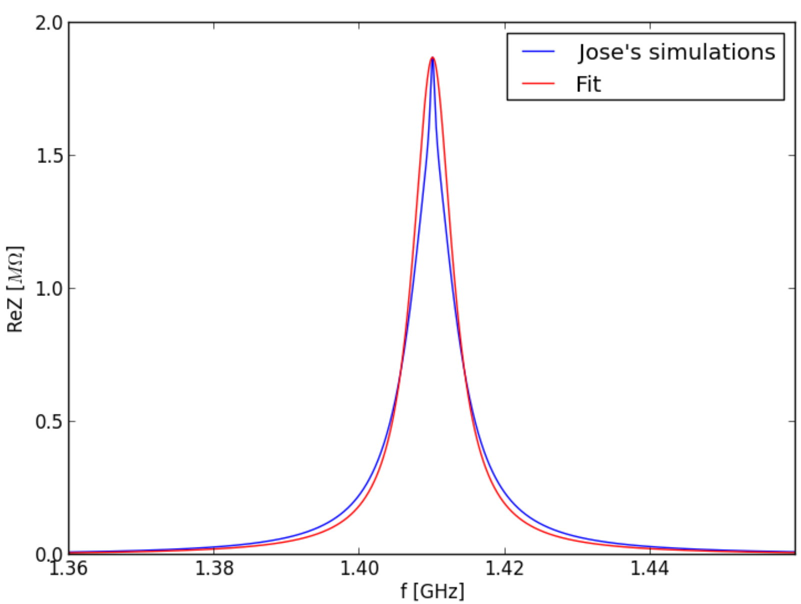
- Longitudinal phase-space distribution
  - Can affect the outcome largely!
- Impedance model
  - Flanges
  - Kickers
  - In-between Zs
  - 200 MHz and 800 MHz cavities

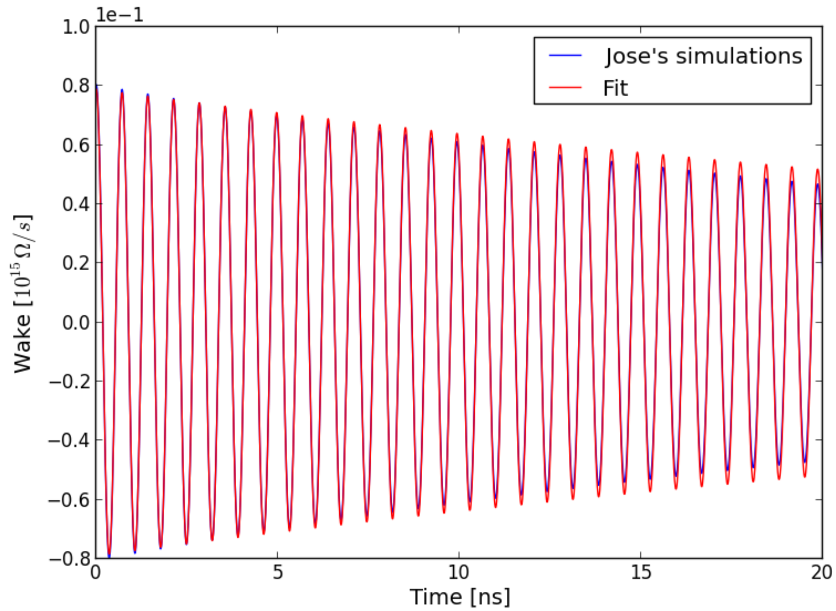
Let's try to reduce first some of these uncertainties.

Impedance model: Flanges

For simplicity: model with single BB resonator

f_r = 1.41 GHz, Q = 210, R_{sh} = 1.871 MΩ

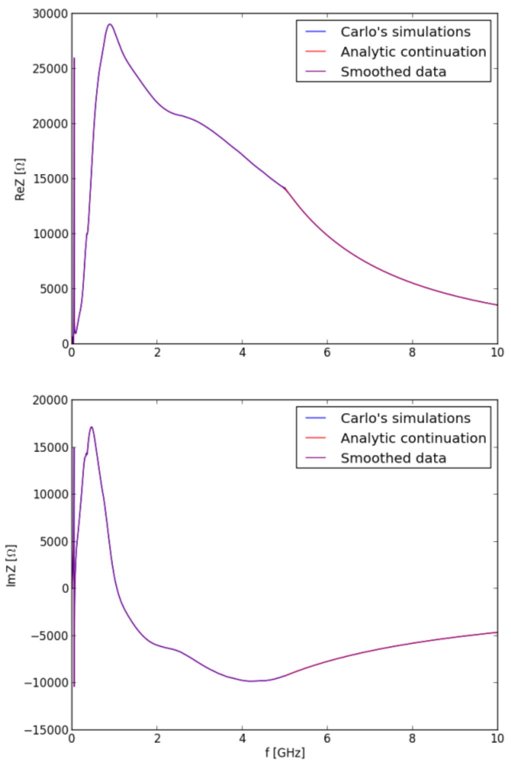


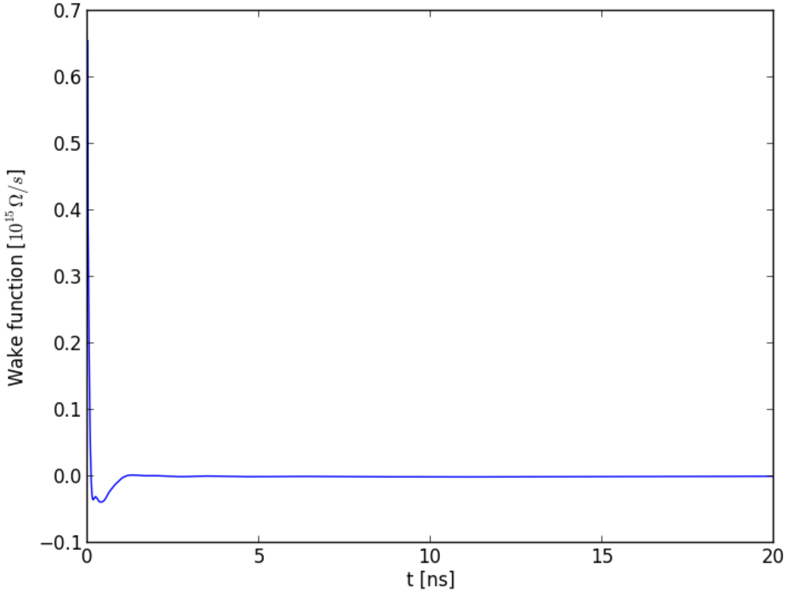


Impedance model: Kickers

Wake obtained as an FFT of Carlo’s data ← updated!

Using an analytic continuation of ReZ ~ $1/f^2$ and ImZ ~ $1/f$

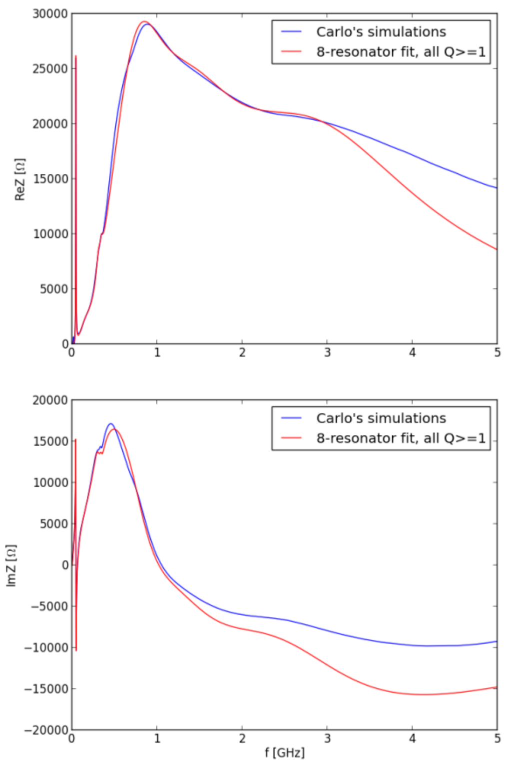


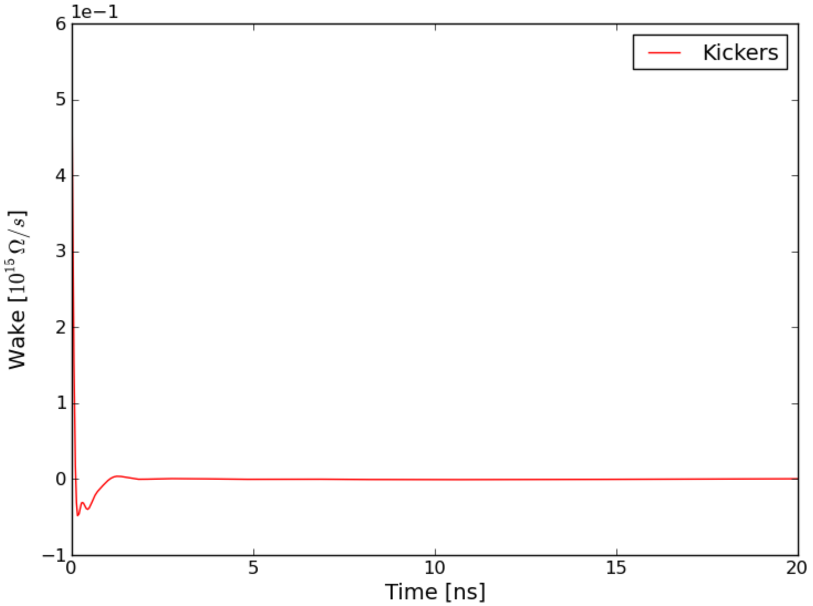


Impedance model: Kickers

Wake obtained as a resonator fit

An 8-resonator model (red) gives a very similar wake





Impedance model: Cavities

A more accurate model of the SPS TW cavities

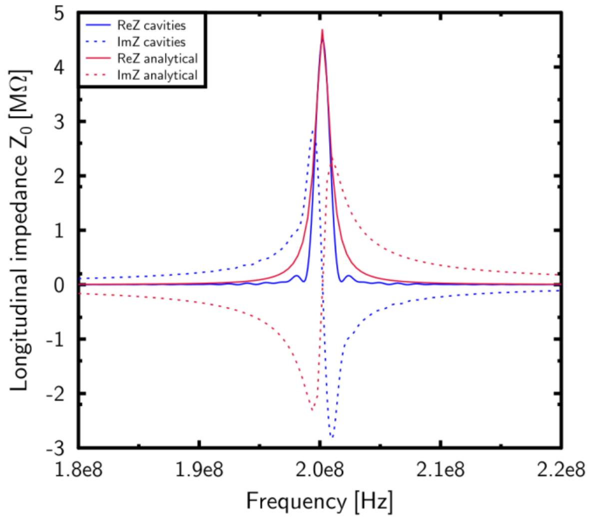
Following G. Dôme (CERN-SPS/ARF/77-11, 1977)

$$Z(f) = R\left\{\left(\frac{\sin\left(\frac{a(f-f_r)}{2}\right)}{\frac{a(f-f_r)}{2}}\right)^2 - 2i\,\frac{a(f-f_r)-\sin(a(f-f_r))}{(a(f-f_r))^2}\right\}$$

$$W(t) = \frac{2R}{\tilde{a}}\left(1-\frac{t}{\tilde{a}}\right)\cos(\omega_r t),\ \text{where } \tilde{a} = \frac{a}{2\pi}.$$

Cavity	R (MΩ)	a (μs)
200 MHz Short	2×0.876	3.56
200 MHz Long	2×1.38	4.47
800 MHz	2×0.969	2.07

Less impedance than before



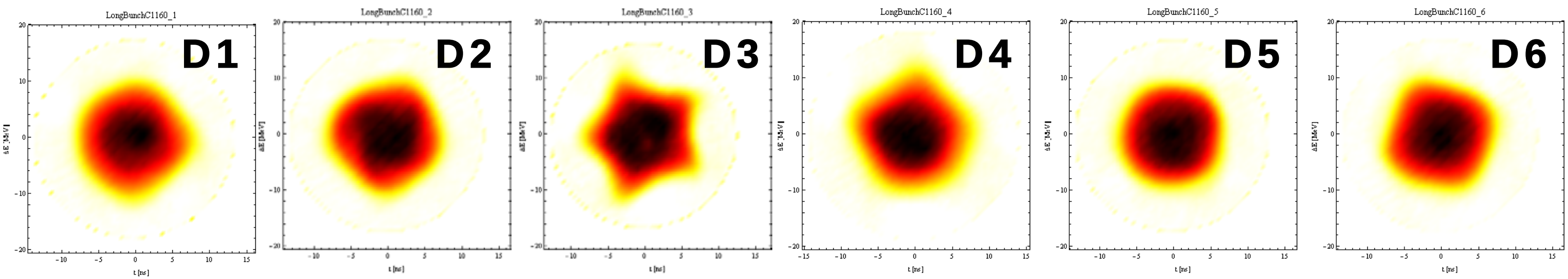
SPS impedance in total

f_r (GHz)	R_{sh} (MOhm)	Q	R/Q (kOhm)	
0.629	0.388	500	0.78	200 MHz HOM
0.885	0.0146	482	0.030	BPMs
0.892	0.0198	493	0.040	
1.052	0.1597	773	0.207	
1.062	0.1903	773	0.246	
1.069	0.0454	654	0.069	
1.092	0.0570	667	0.085	
1.185	0.0116	610	0.019	
1.215	0.0012	624	0.002	
1.598	0.0426	672	0.063	
1.613	0.5975	686	0.871	
1.859	0.2951	896	0.329	
1.960	0.0721	1993	0.036	
0.550	0.2275	1000	0.228	Zs (?)
1.050	0.2275	1250	0.182	
1.41	1.871	210	8.91	Flanges

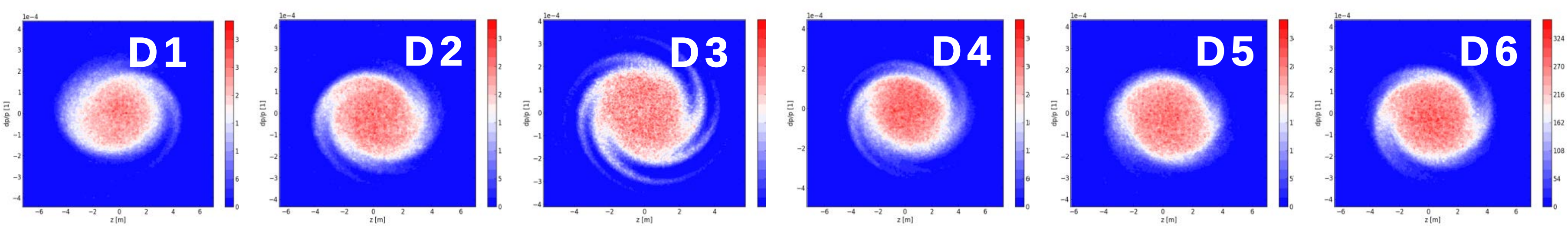
+ cavity & kicker impedance

Distributions: from tomoscope

At PS flat top C1160 – measured within ~5 ms

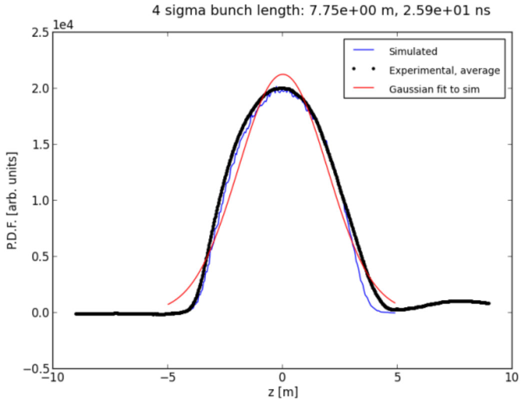


At injection to the SPS (after tracking in ESME)

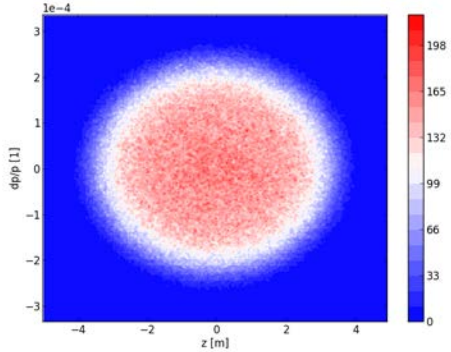


Distributions from average profile

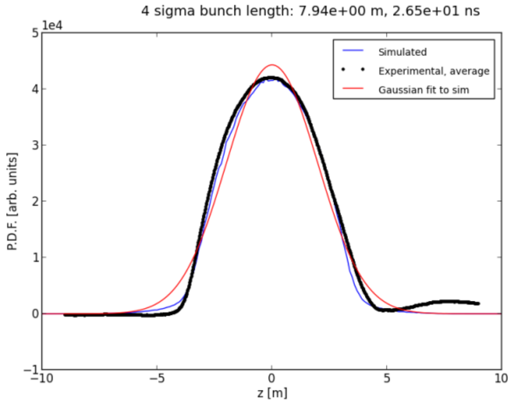
Reconstructed average



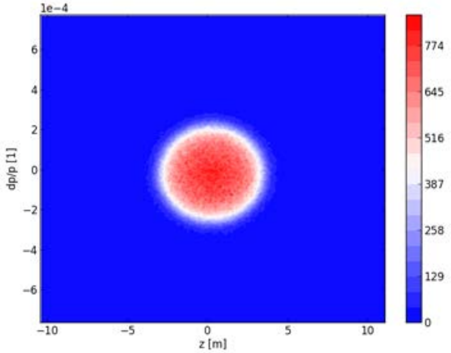
25.9 ns



Reconstructed + Gaussian

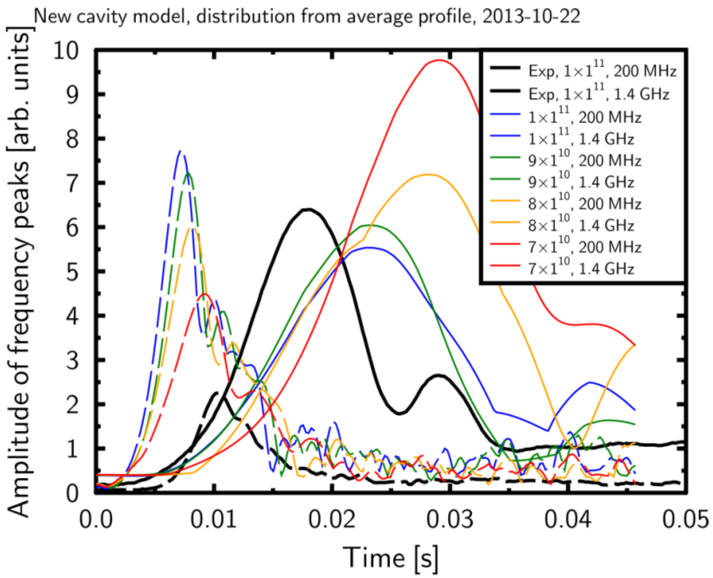


26.5 ns

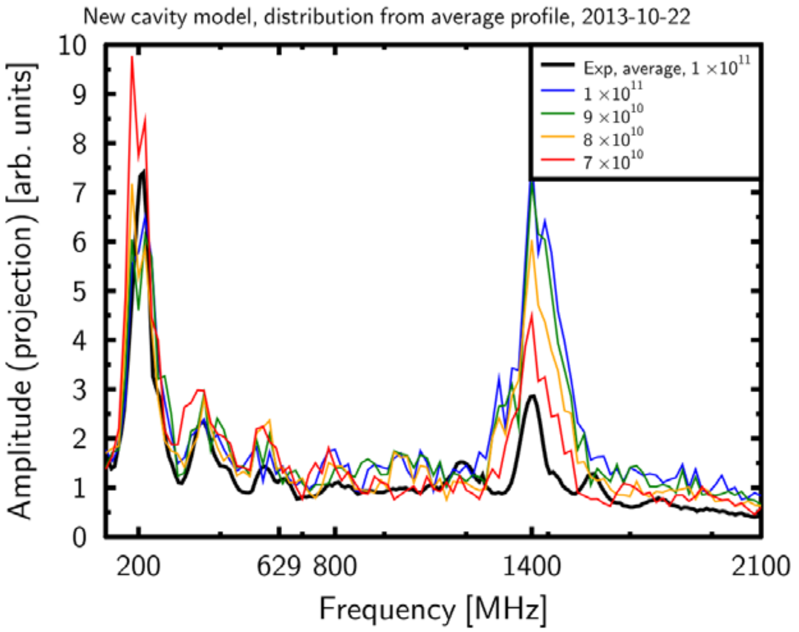


Reconstructed distribution

Amplitude evolution



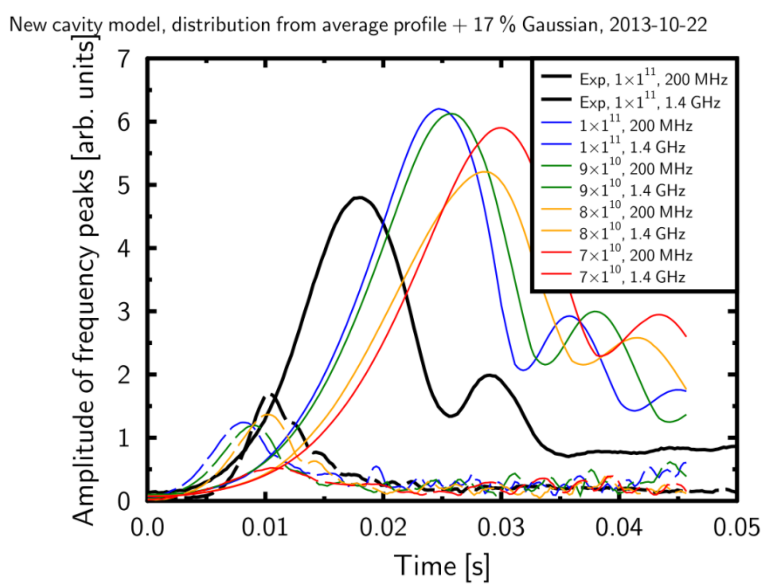
Projection



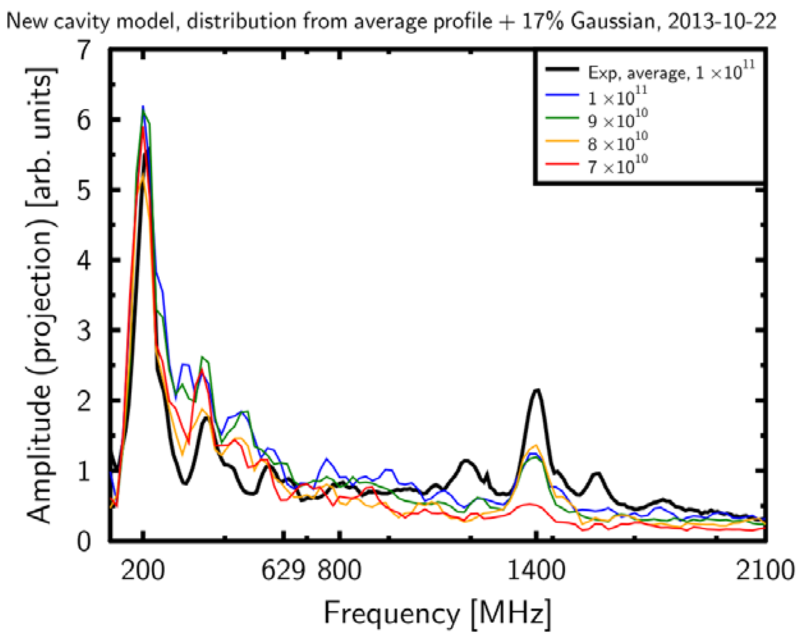
Doesn't fit the measurements: 1.4 GHz grows too fast, 200 MHz too slowly

Reconstructed + Gaussian

Amplitude evolution



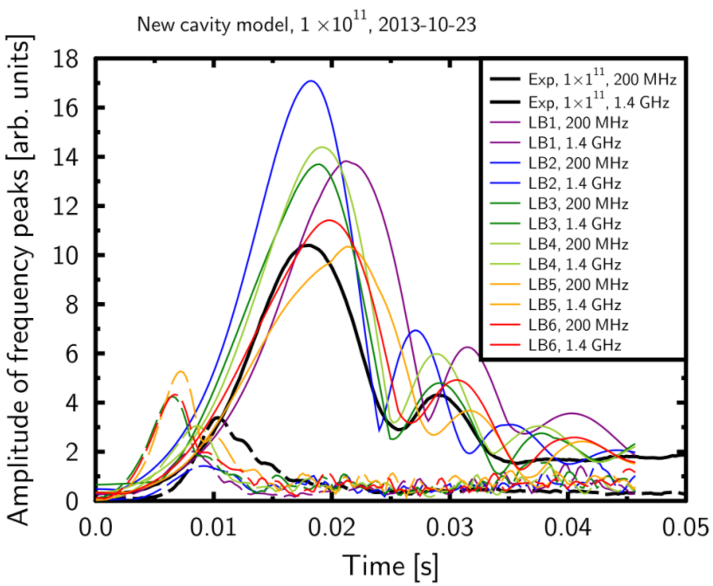
Projection



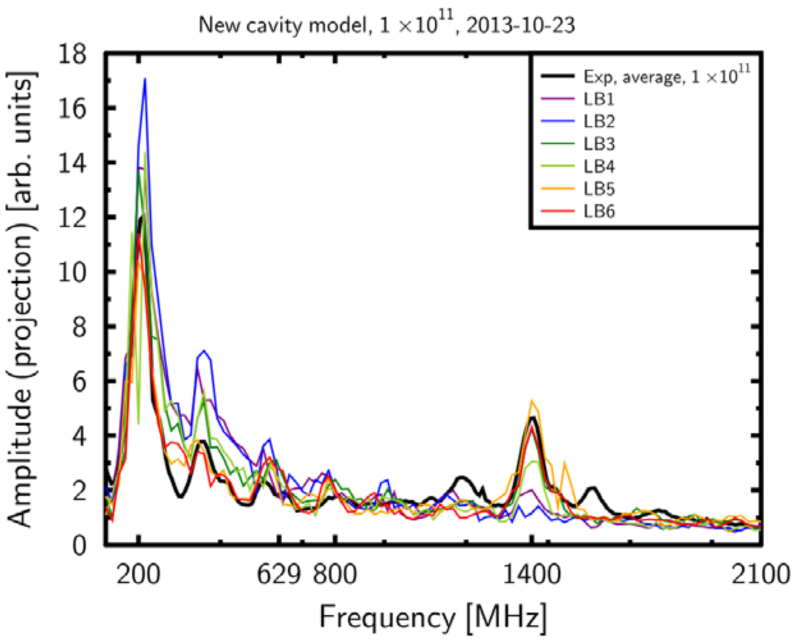
Better: 1.4 GHz is more reasonable, but 200 MHz is still too slow

Measured distributions, 1×10^{11}

Amplitude evolution



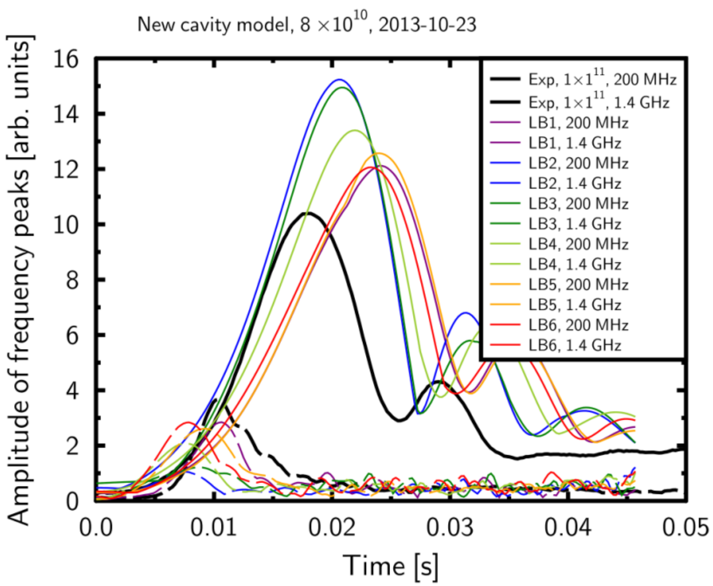
Projection



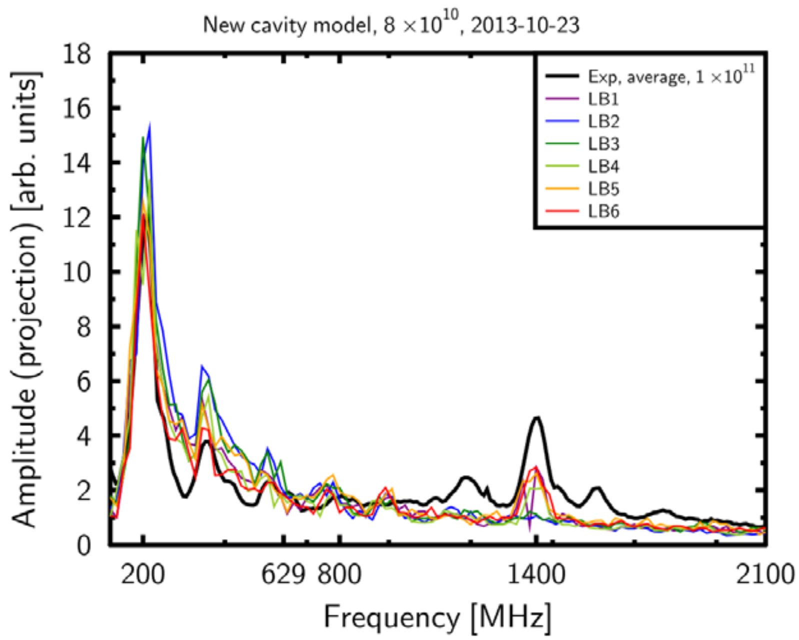
Better, but growth rates are still not perfect, hence the sidebands cannot be seen

Measured distributions, 8×10^{10}

Amplitude evolution



Projection



In measurements, 8×10^{10} was the threshold of 1.4 GHz instability.
This is correctly reproduced here, but the 1.4 GHz growth rate is sill not correct

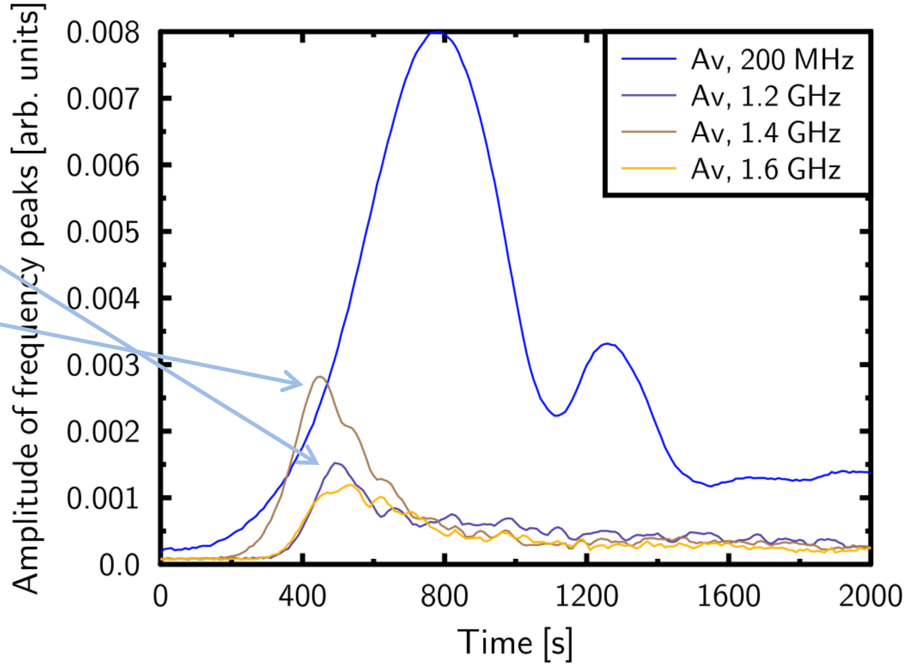
Sidebands at 1.2 GHz and 1.6 GHz

Sidebands observed experimentally

Are due to the interaction between 200 MHz and 1.4 GHz

When the 2 modulations overlap, the sidebands always follow the 1.4 GHz

When there is no overlap, no sidebands are seen



Why are sidebands important?

Source of 1.4 GHz peak: flanges

Now we are confident: flange impedance is sufficient to explain the 1.4 GHz peak in the de-bunching spectrum

Is this impedance harmful?

Does it lead to microwave instability?

- Need simulations with RF on to answer this question
- $\rightarrow$ Need an accurate SPS impedance model
- $\rightarrow$ Need to know whether missing sidebands are due to a wrong distribution or an incomplete impedance model (or both)

Conclusions, Plans

1.4 GHz peak identified

- Flange impedance is enough to explain the peak

Importance of the 1.4 GHz impedance

- Not yet fully understood
  - Too many uncertainties in our model
- Will have to find an impedance model that explains all our measurements; only then we can know whether or not the 1.4 GHz impedance is harmful