PHASE DAMPING IN THE SNS LINAC



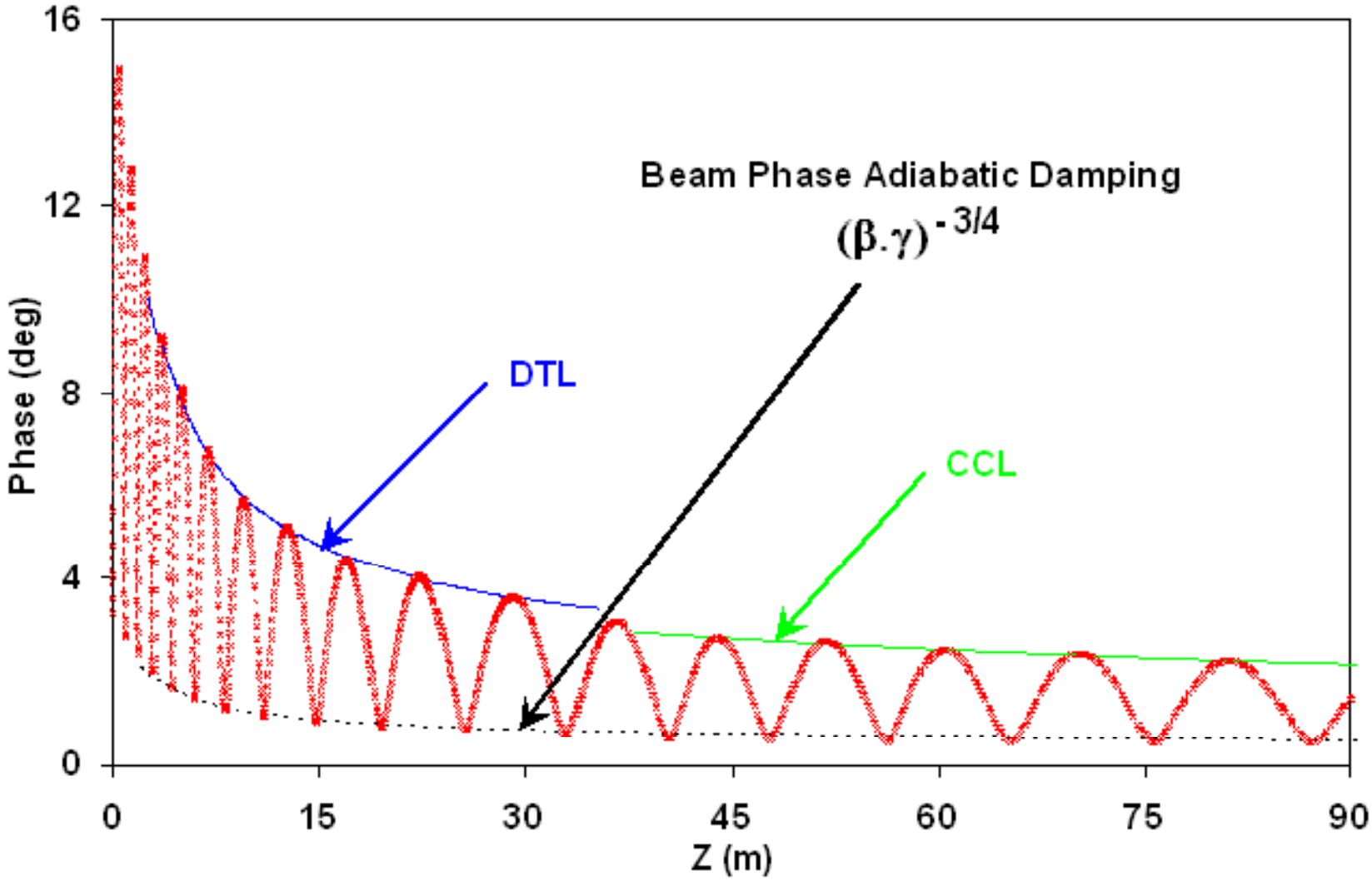
Yan Zhang

42nd ICFA, HB2008, Nashville, USA, August 25-29, 2008

Managed by UT-Battelle
for the Department of Energy

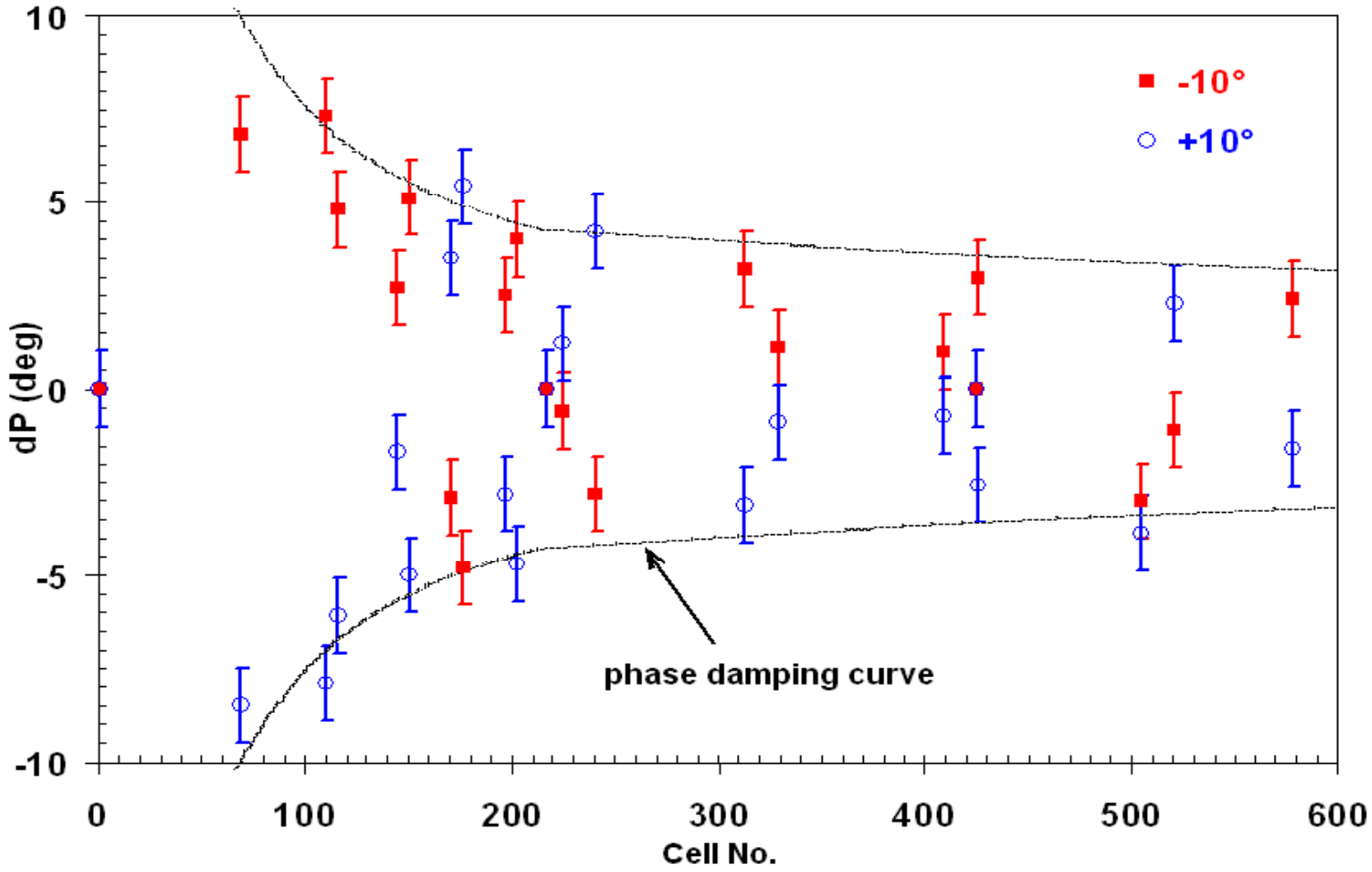
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Beam RMS Phase Adiabatic Damping



Normal conducting linac, linear map and zero current with IMPACT
Excepted: DTL1 front, as synchronous phase ramps up -45° to -30°

Phase damping measurement with linac BPMs

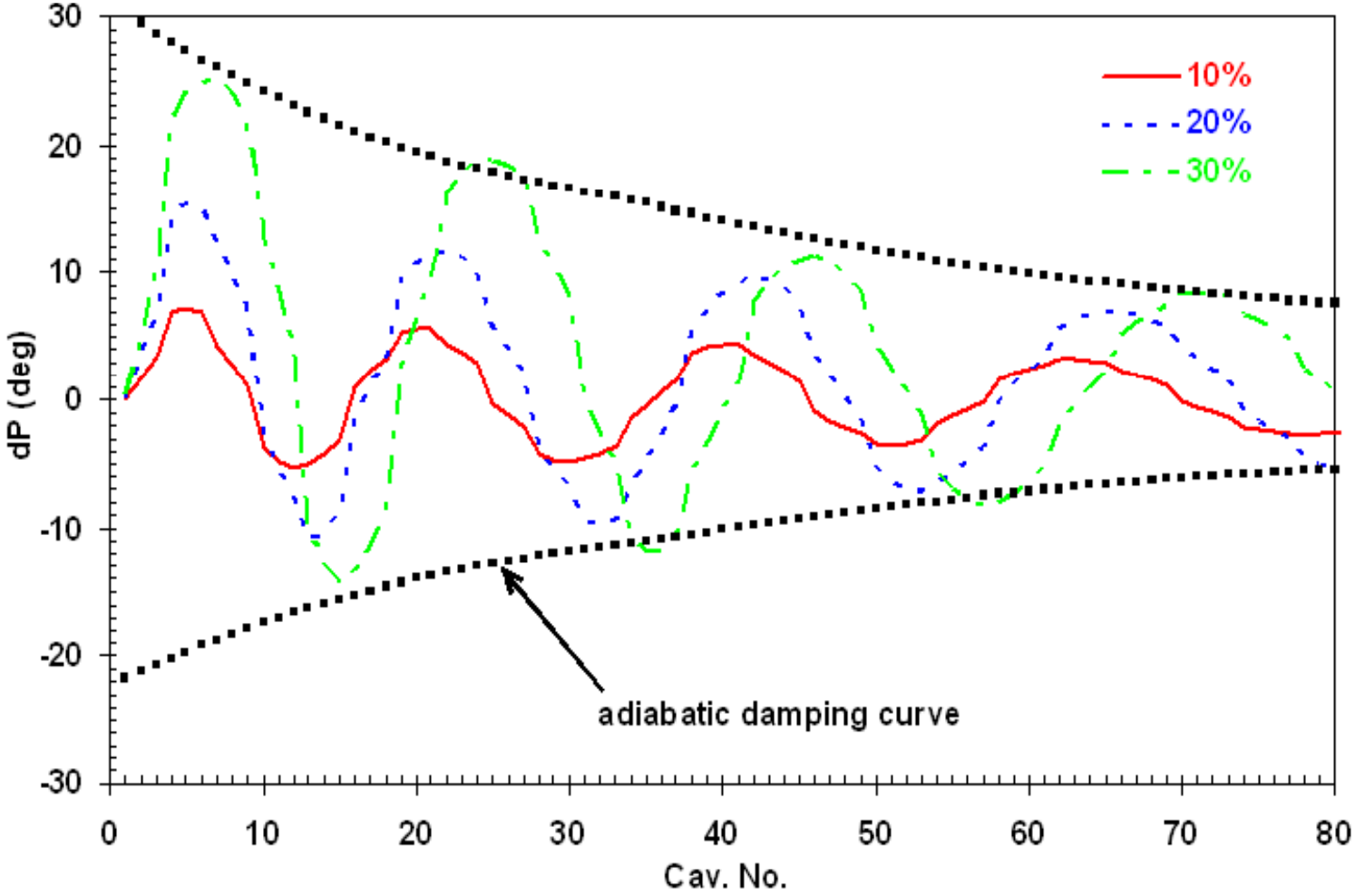


Shift DTL1 phase by +10° and -10°, measure the responses of all BPMs

Measured in Feb. 2006

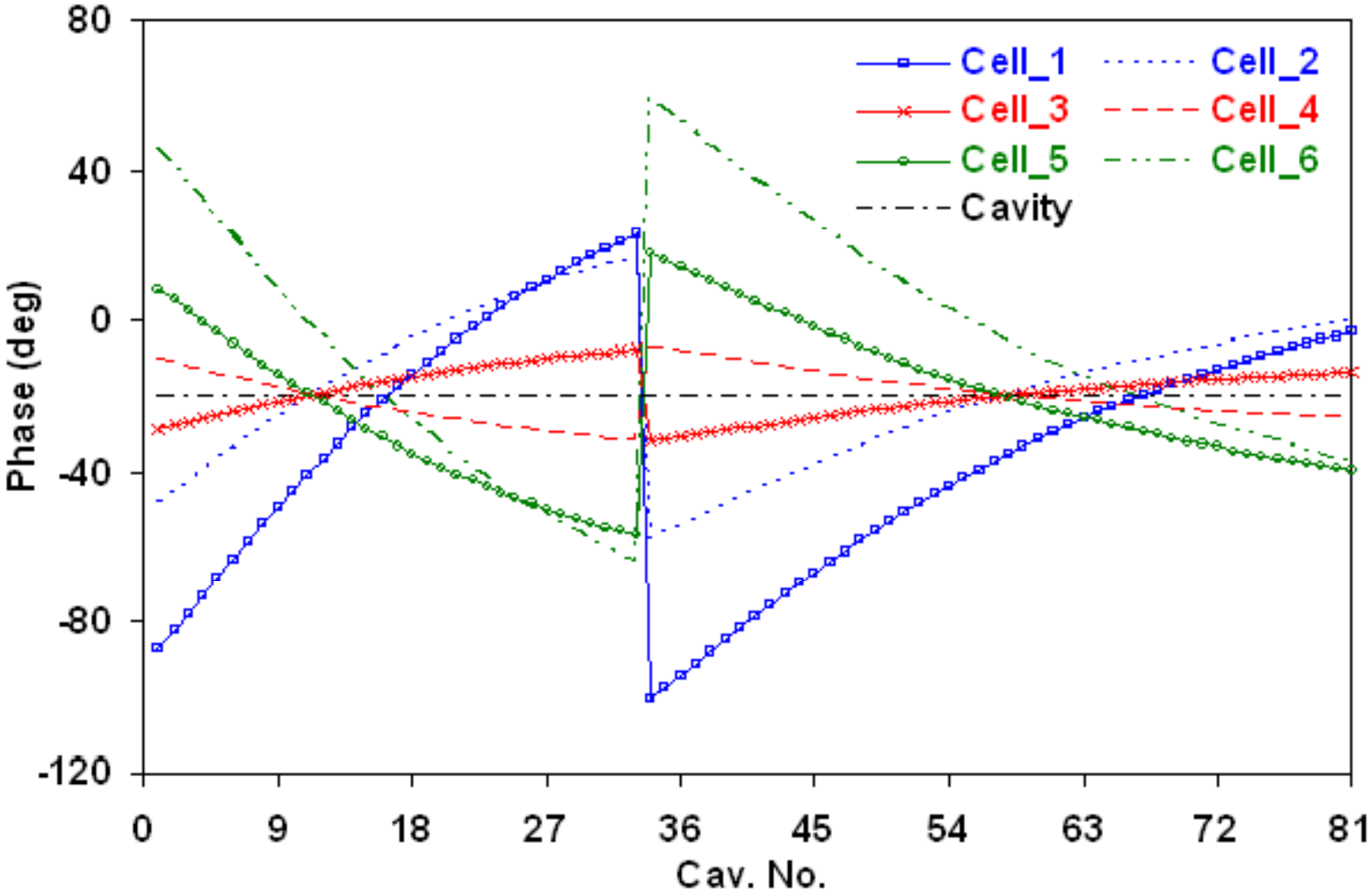
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Phase centroid oscillation in the baseline SCL

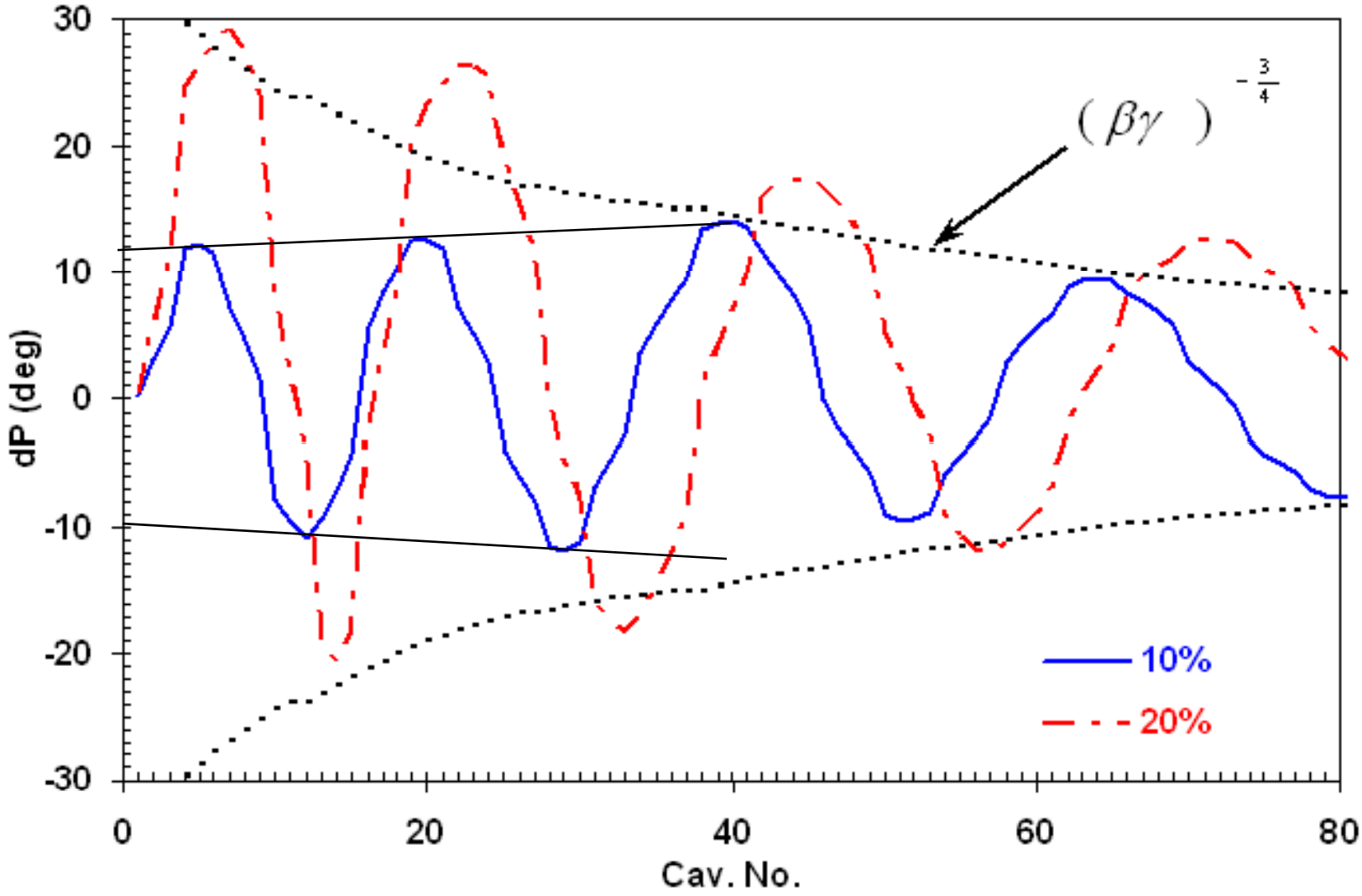


SCL longitudinal model, thin lens approximation and absolute phase
Small acceleration not appropriate, cavity TTF varies widely, roughly

Cell Phase and Cavity Phase of the SCL

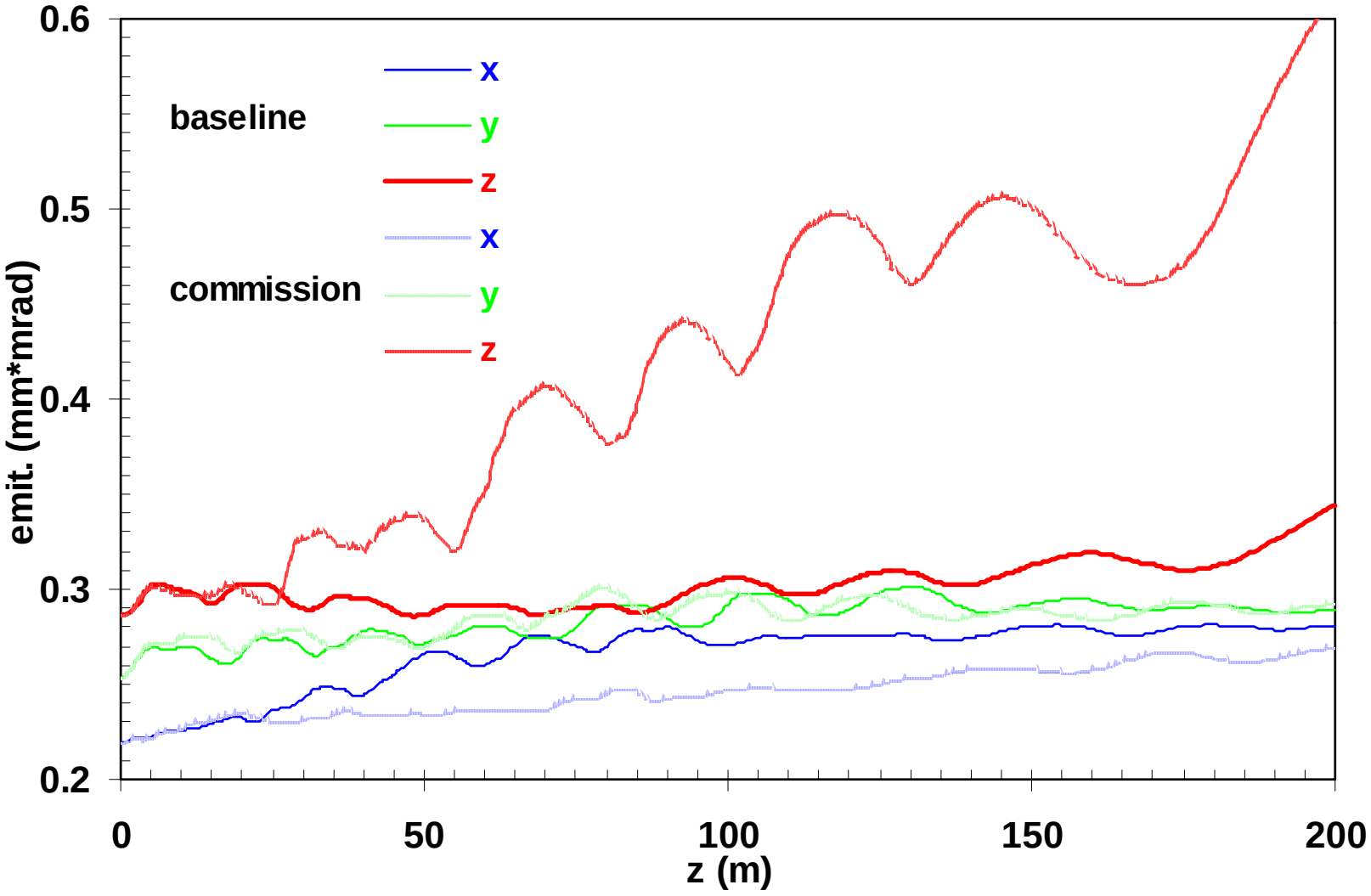


Cell phase varies > 100° in the baseline SCL, but a smooth longitudinal focusing can still be estiblished by the average. In operations, cavity gradient is scattered from 0 to 180% that of the nominal design value, smooth focusing is important.



Phase oscillations in one of the SCL commissioning lattices: instead of damping, the oscillation amplitude increased at the beginning half because fixed phase rule is applied, but cavity gradient doesn't favor

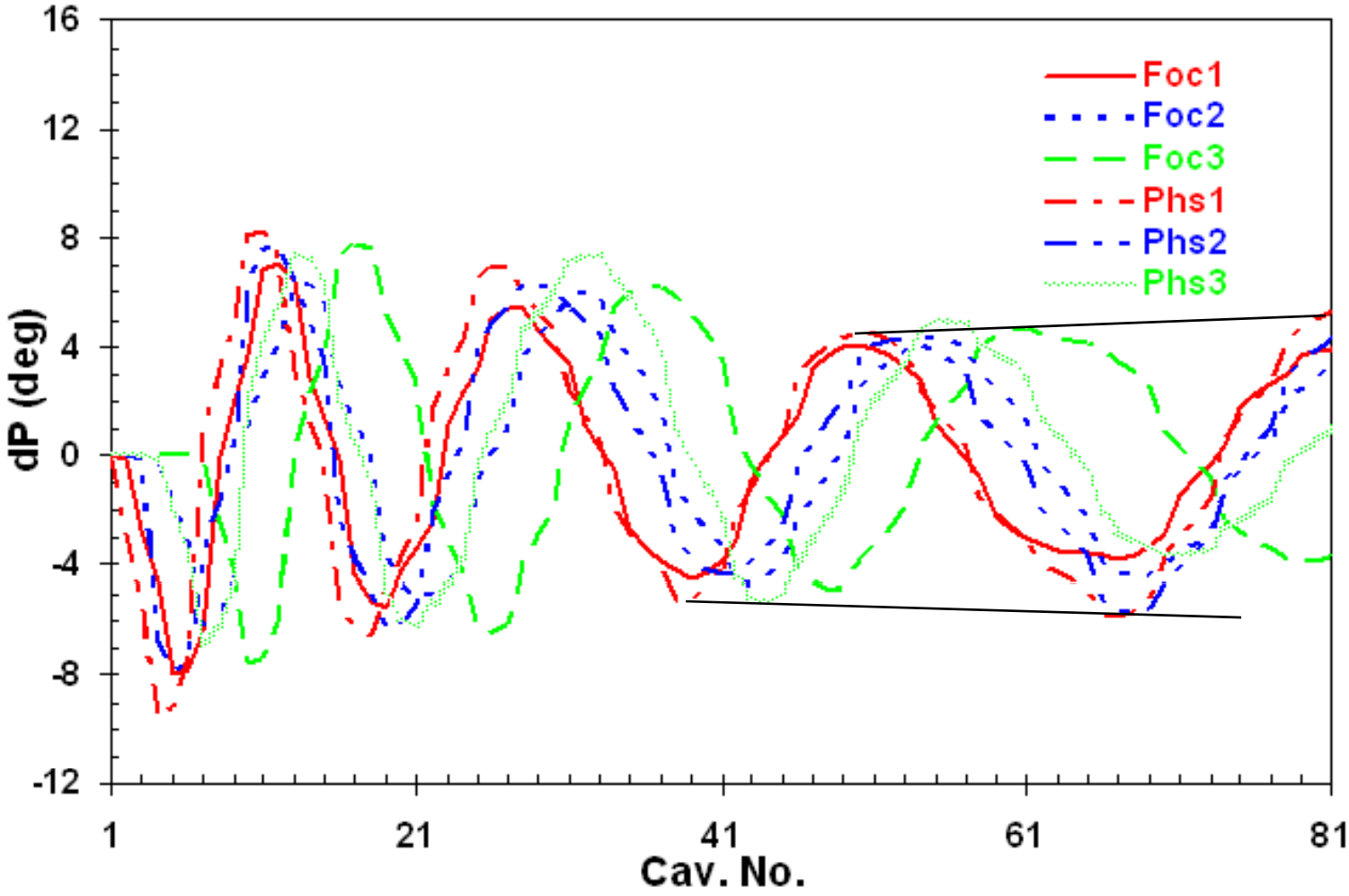
Longitudinal beam emittance increase in the SCL commissioning lattice



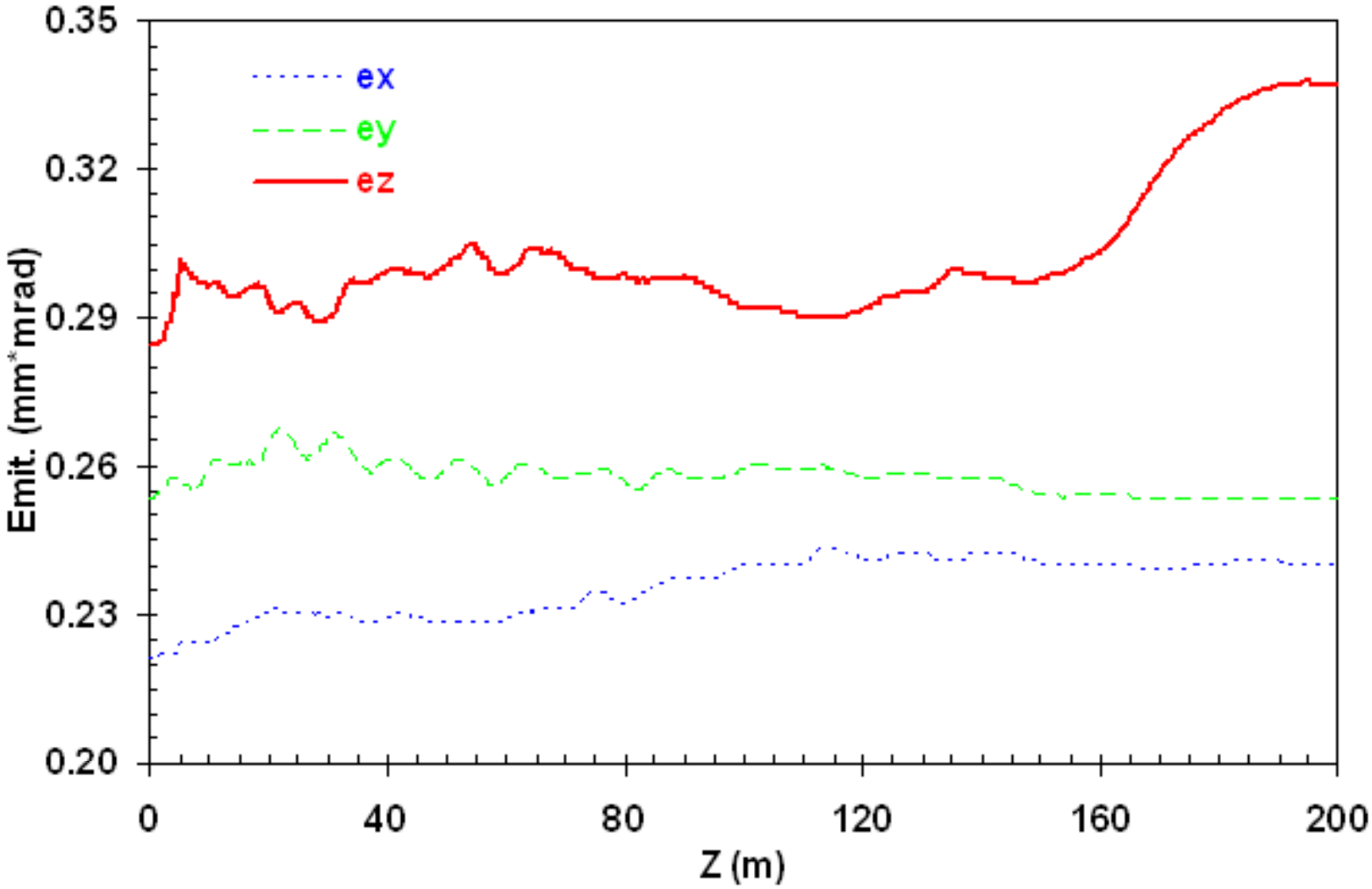
Simulations with IMPACT, for beam current 20 mA

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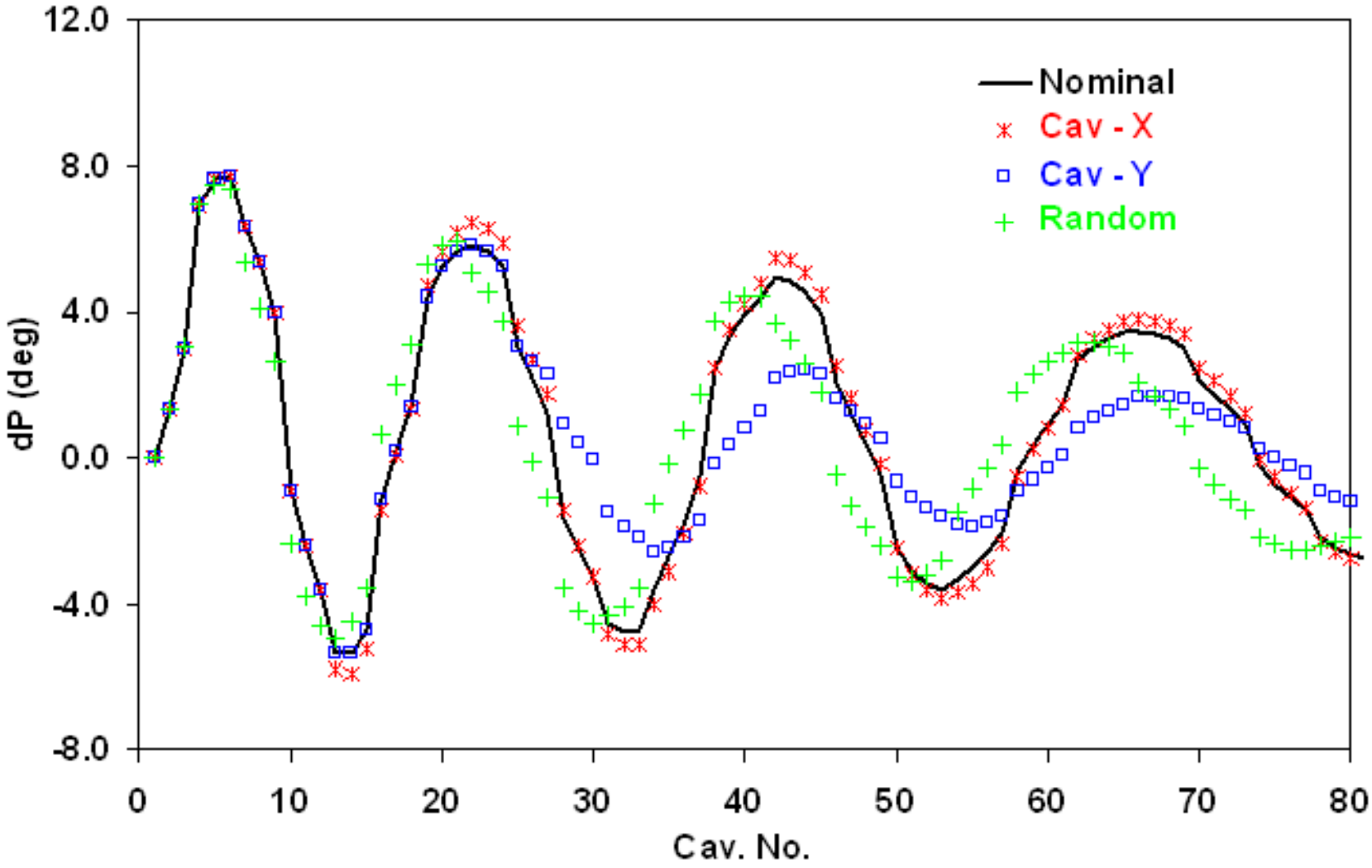
Phase oscillation in recent neutron productions



Fixed phase and fixed focusing, both will work, and longitudinal emittance dilution could be expected at the end - not a concern.

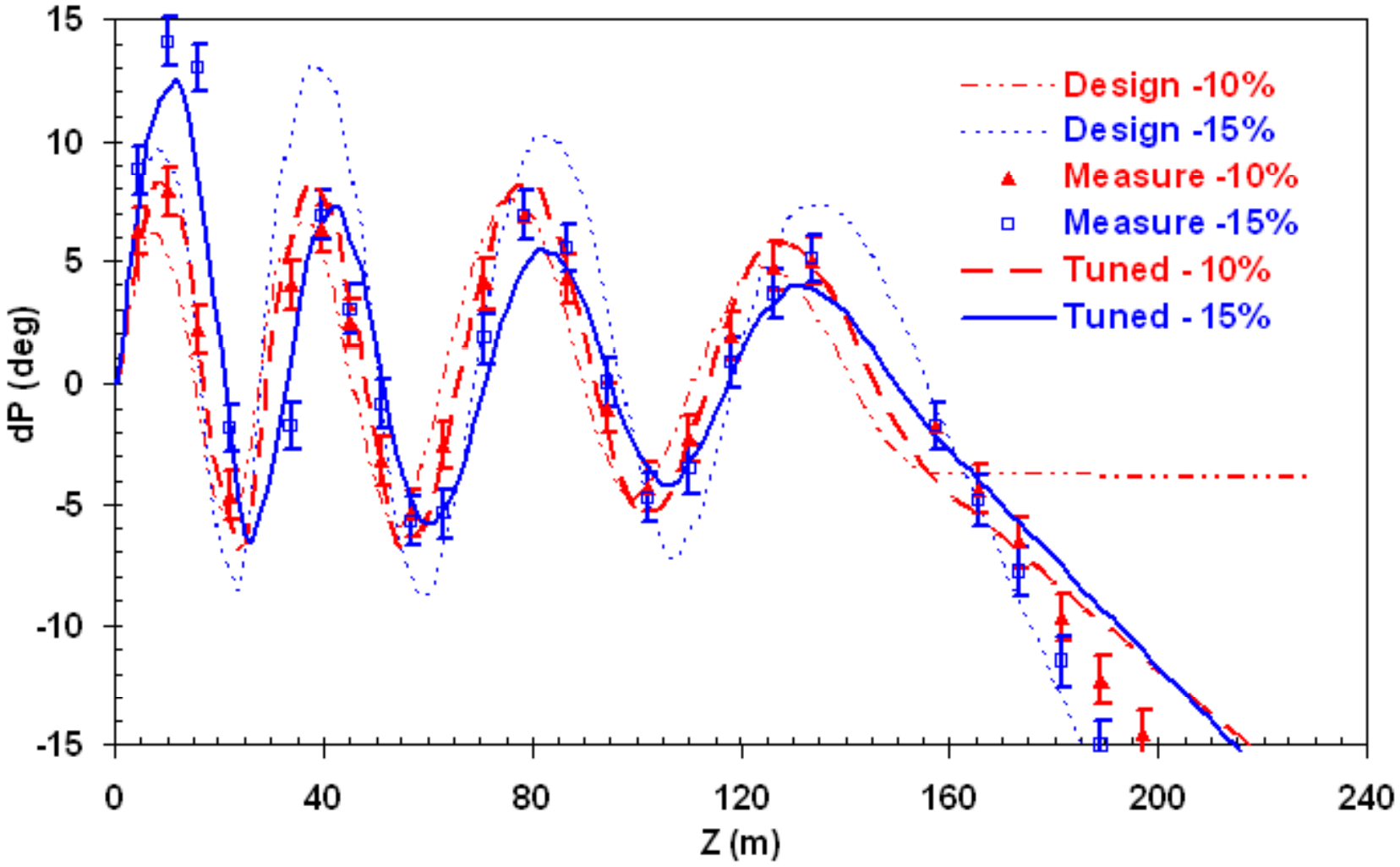


Normalized beam emittances in the simulations with IMPACT, longitudinal emittance increased at the end as been expected



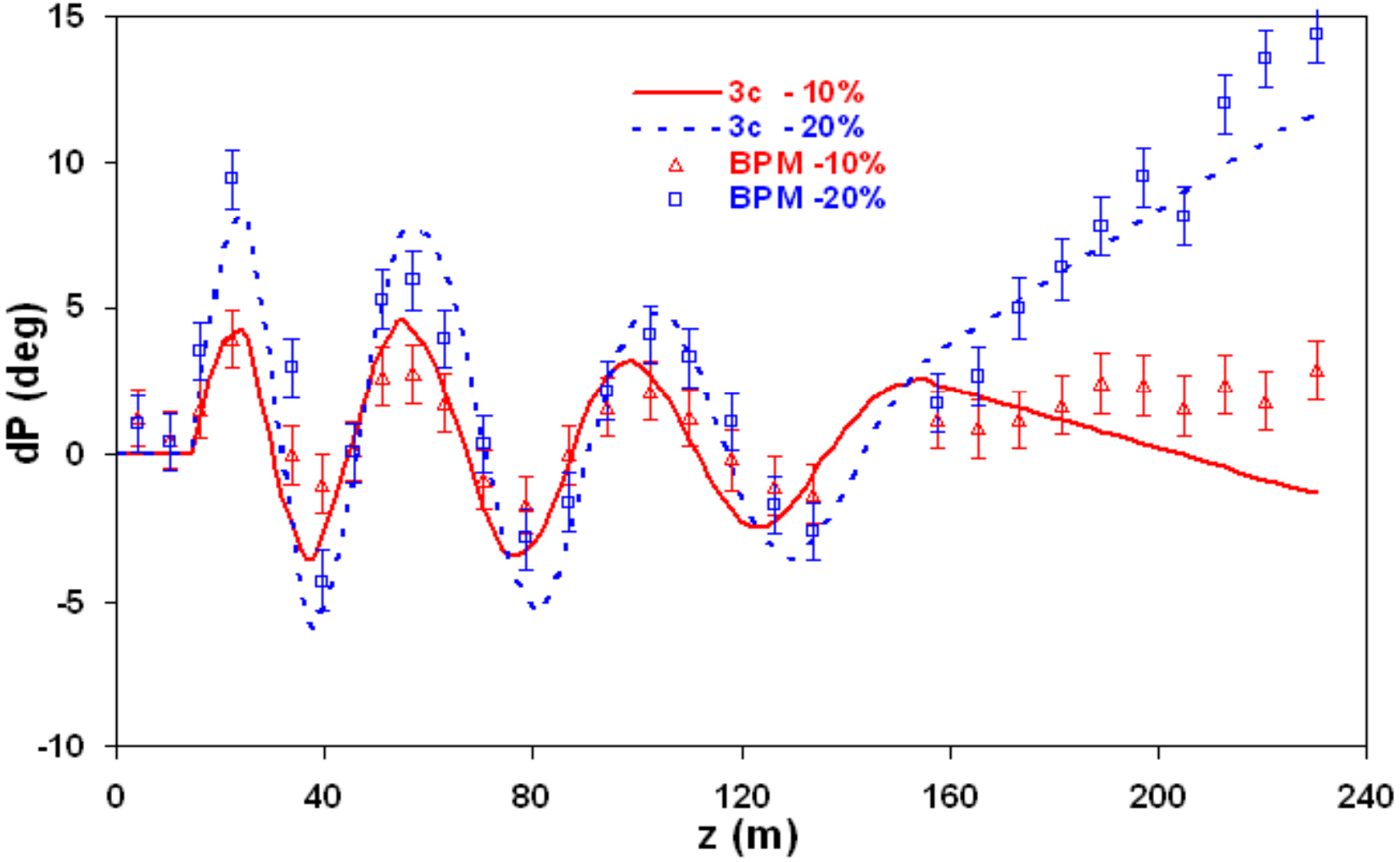
Beam phase oscillation and damping are sensitive to RF errors for low or medium energy proton and heavy ion beams – diagnostics !

SCL phase oscillation measured in February 2006



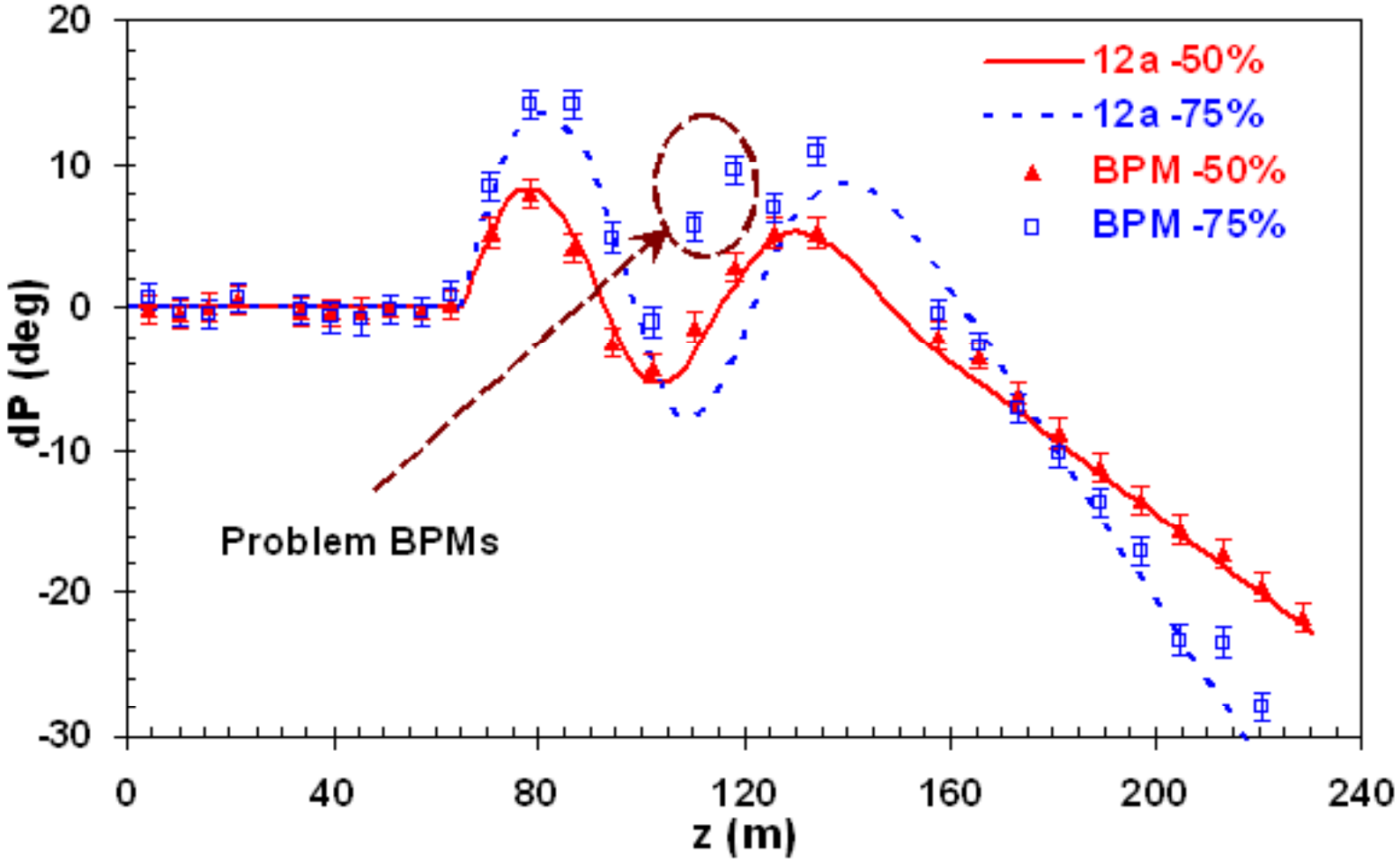
First cavity gradient 10% & 15% reduction, model & measurement

One of the Feb. 2006 measurements



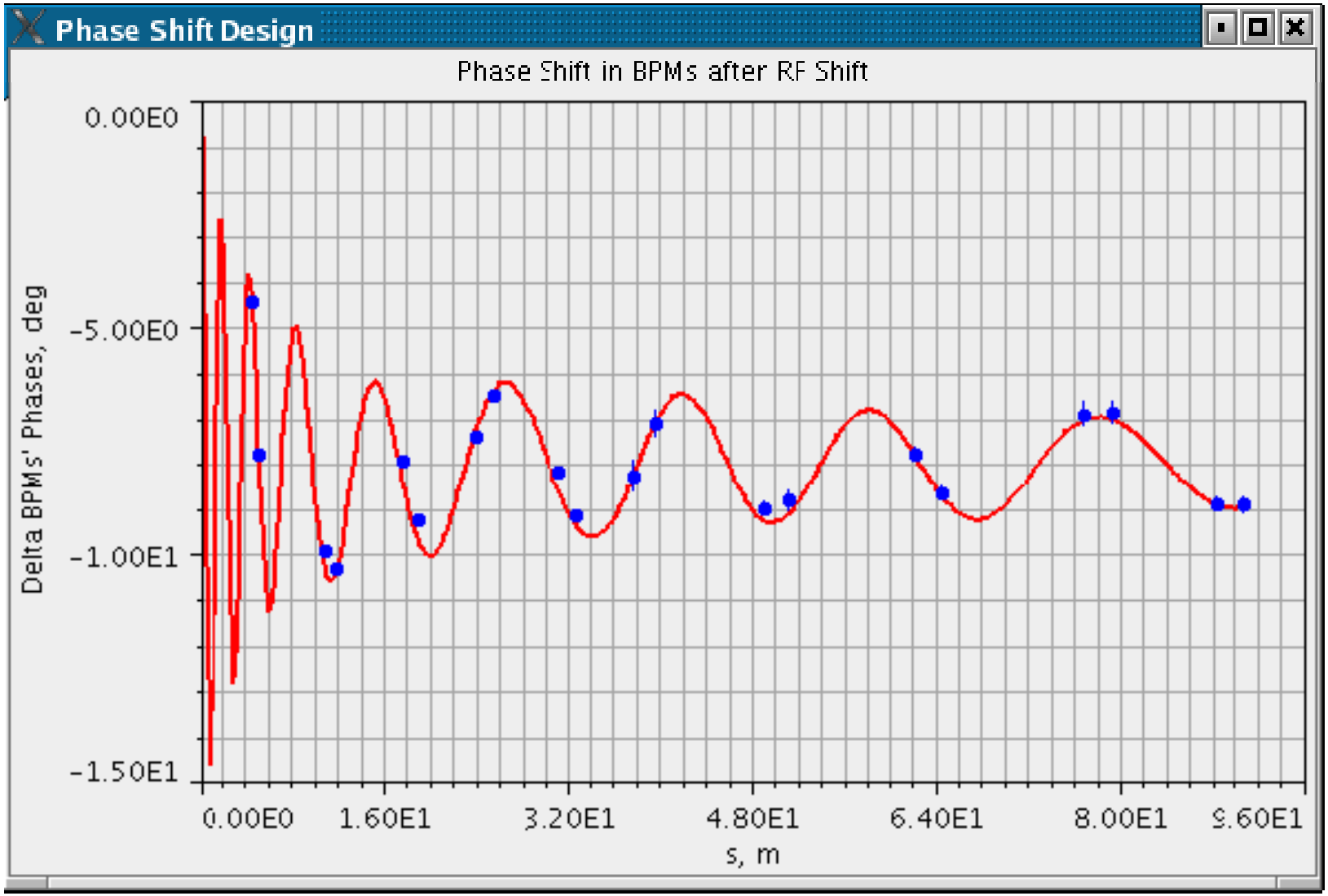
Major error: RF drifting in the linac, measured beam phase drifting up to 5°

One more in Feb. 2006



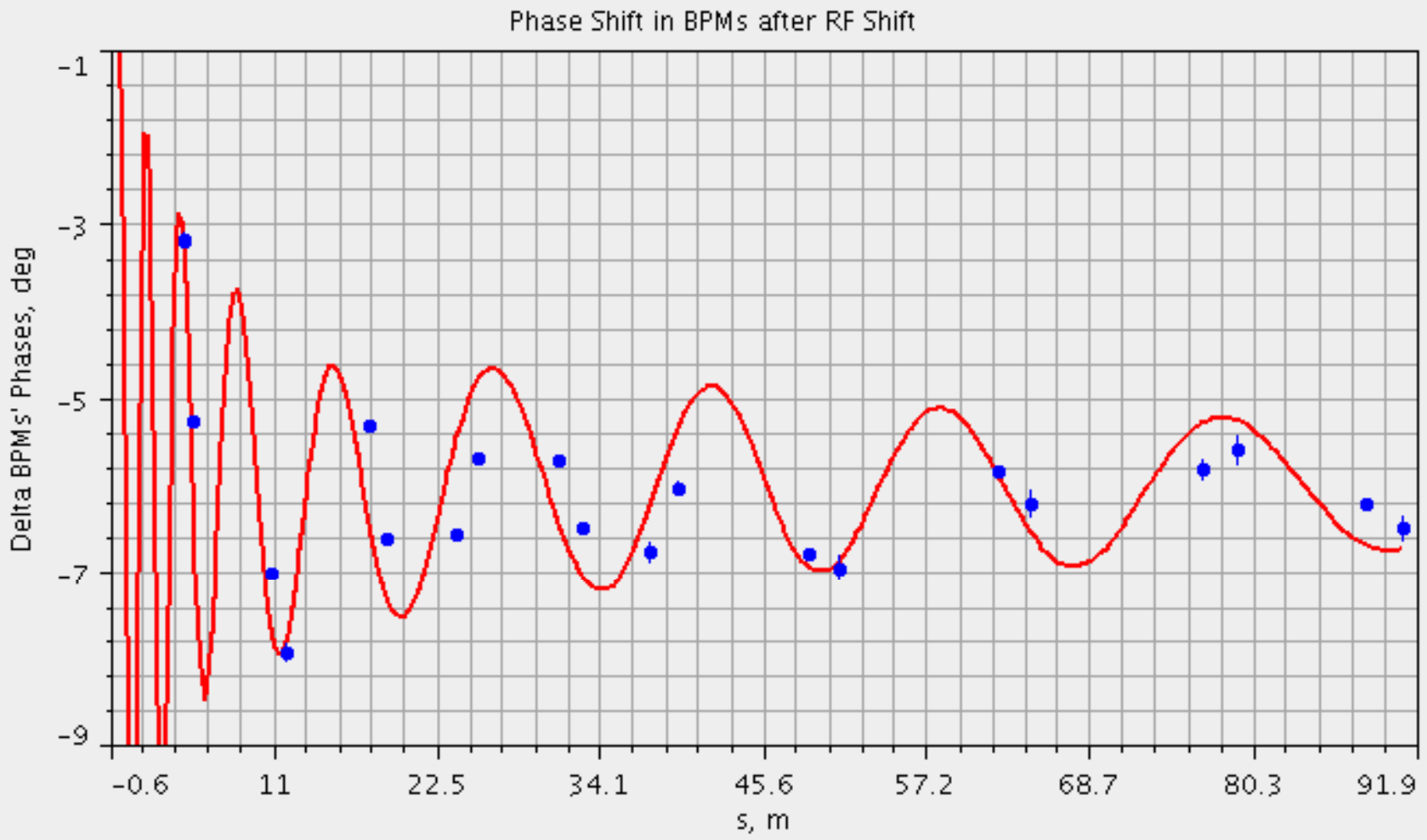
Other errors: beam jitters, BPM noise, error of the model …

A. V. Aleksandrov, et. al., EPAC2008



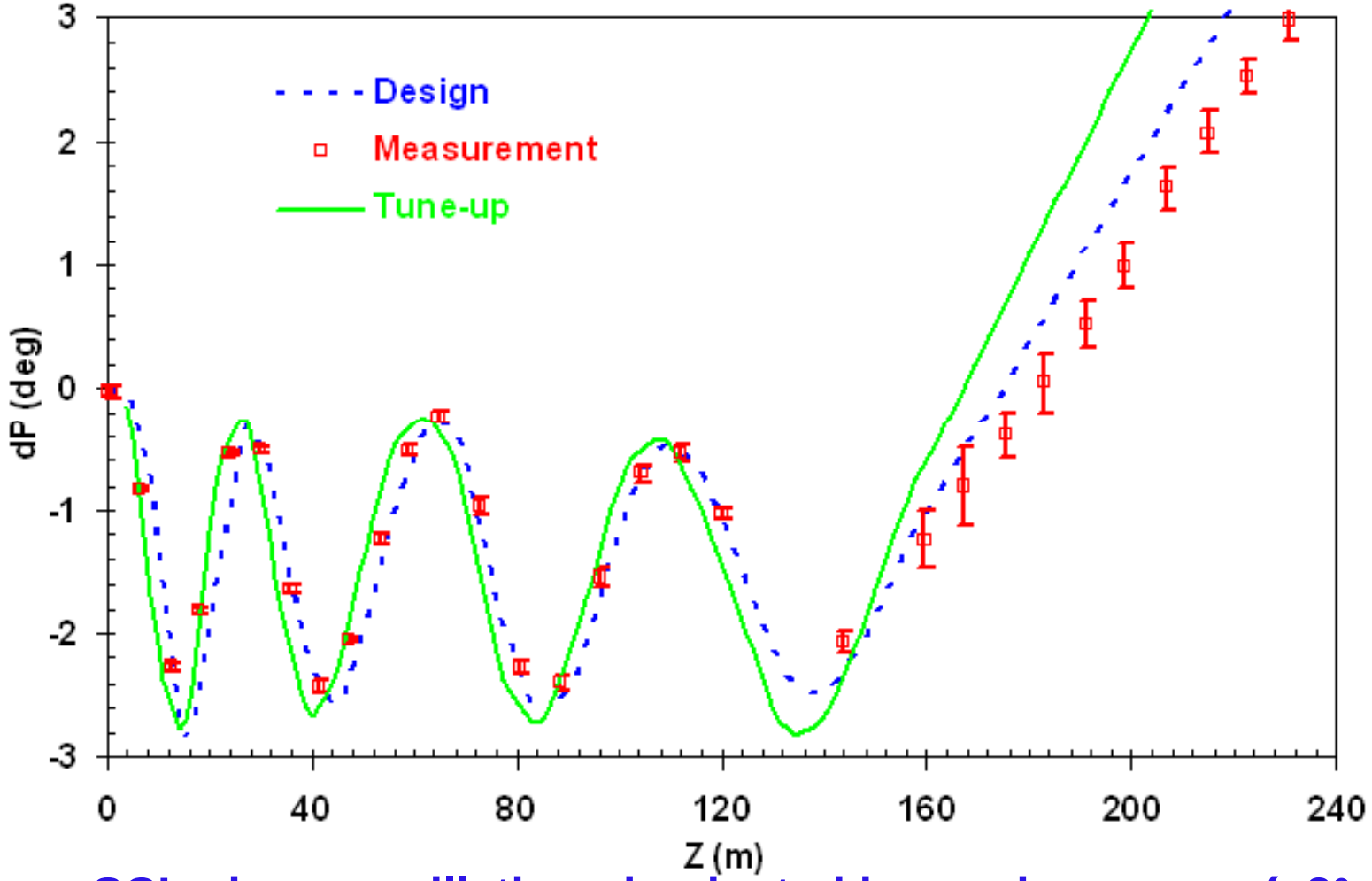
RF Shaker, the warm linac delta-t model and BPM measurements Helped to tune the linac more precisely, and tackled RF failures.

But only a few hours later …



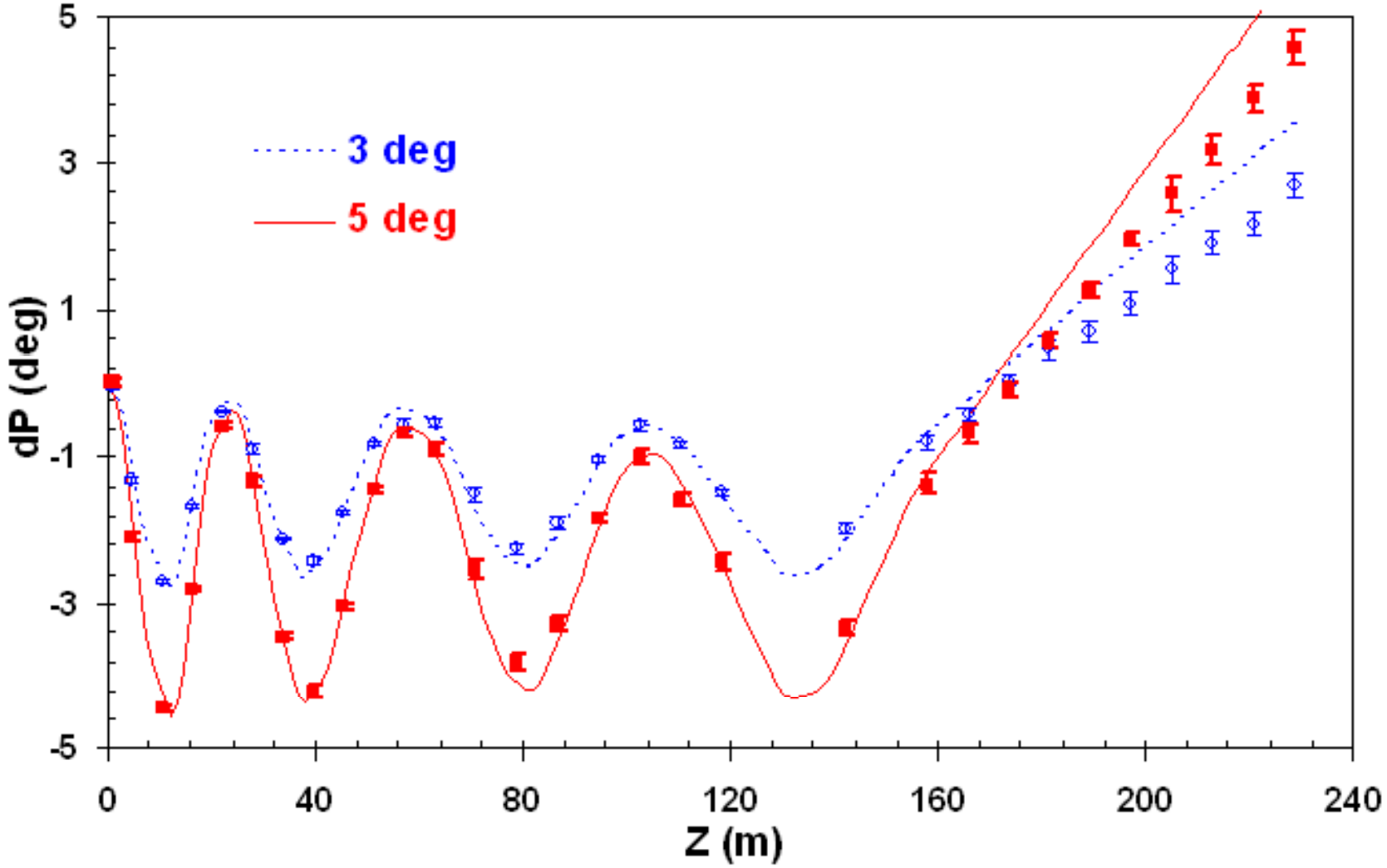
RF drifting is always in the linac, including the SCL tuning process beam phase drifting of ~2° and beam energy ~0.4 MeV into the SCL

Recent SCL measurements using the RF shaker



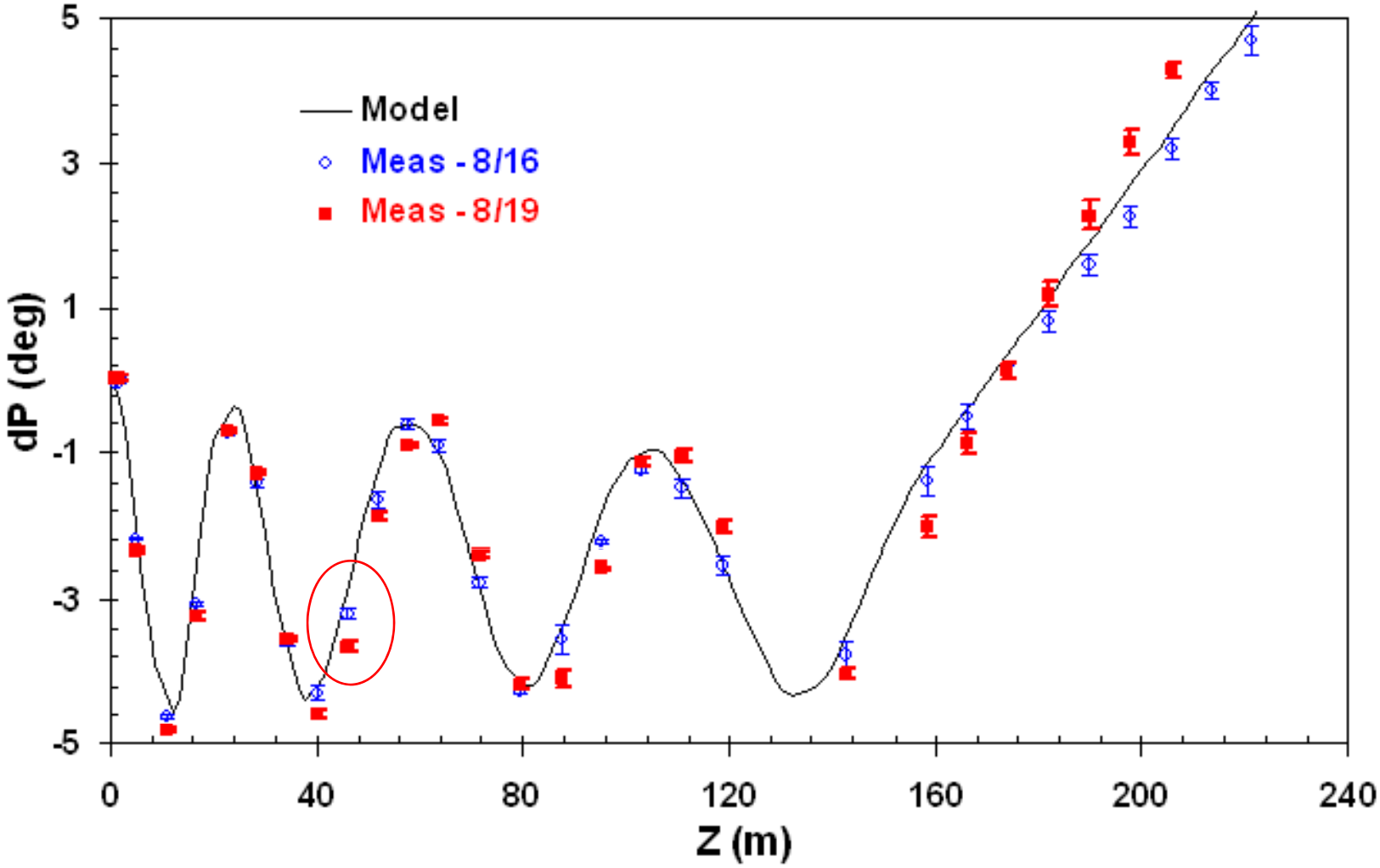
SCL phase oscillation, dominated by random errors (~2° phase, ~2% amplitude) and likely caused by RF drifting. When beam is highly relativistic, phase damping study could not provide any helpful information of the lattice.

SCL RF Cavity Phase Scaling



Model versus BPM measurements with a scaled SCL phase

Most recent SCL measurements



SCL was tuned on Aug.14, RF shaker measurements on Aug.16 and Aug.19
linac LLRF system was touched on Aug.18 (Cav8c at 43m - phase changed)