R&D Plans for Impedance Driven Single-Bunch Instabilities (WBS 2.2.1)

M. Venturini (*presented* by M. Zisman)

LBNL

LCWS07 DESY, Hamburg May 30 - June 1, 2007

Why is it very-high priority?

- The main Linac will act as a noise amplifier. Low beam quality at extraction of the DRs can seriously compromise the achievement of the target luminosity.
- Experience with the operation of SLC (SLAC) has taught that, in particular, single-bunch longitudinal instabilities should be carefully avoided.
- Preliminary estimates (based on rough scaling arguments) for the OCS lattice during the Baseline Configuration studies placed the threshold current for instability below the design current.

SLC Damping Rings (early 90's) pushing current above $N=3*10^{10}$ caused strong saw-tooth instability

Evolution of bunch length

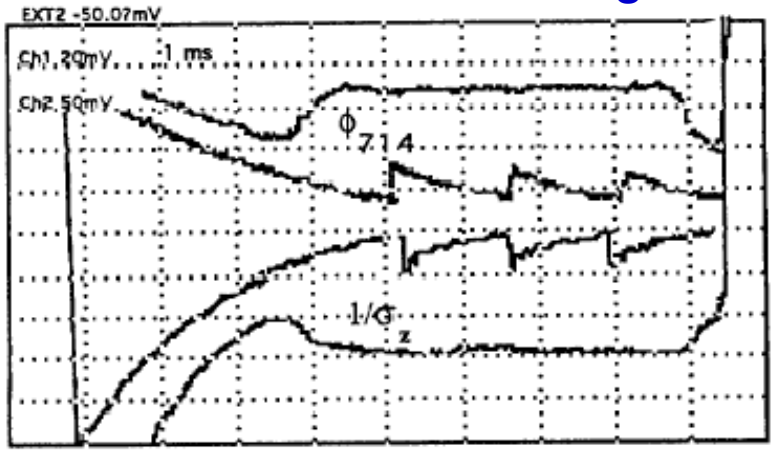

Fig. 2. The inverse bunch length signal and the beam phase signal exhibit sawtooth behavior during the instability. Upper and lower curves (no sawteeth) are with voltage ramp on.

Objectives

- This work-package consists of two objectives:
  1. Develop accurate impedance models for relevant sources.
  2. Characterize single-bunch instabilities and provide estimate instability current thresholds based on the accurate impedance models developed in 1.

Tasks for Objective 1: Impedance Modeling

- Ideally, modeling of impedance should go in tandem with the development of the technical design of machine components (e.g. the 650 MHz RF cavities).
- While a technical design for these components is being developed produce a preliminary assessment of the beam dynamics based on simplified models and/or designs scaled from devices in existing machines.

- Proposed tasks:
  - Compile a list of all relevant sources of short-range wake fields, and rank the list according to the expected significance of the contribution.
  - Construct or retrieve suitable designs for the relevant machine components. Scale available designs to meet the specifications for the damping rings.
  - Develop analytical models for those impedance sources that do not require detailed numerical description.
  - Develop simplified analytical models for the machine components in order to construct (tentative) preliminary estimates of the total machine impedance, while more detailed numerical models are being constructed.
  - Carry out numerical computations of the wake fields for the relevant machine components.

Deliverable for Objective 1: Impedance Modeling

- Inputs:
  - Specifications for the lattice and vacuum chamber components; with detailed technical designs of the vacuum chamber components if possible.
  - Designs of relevant machine components (these will be scaled from machines previously studied if the technical designs for the actual components in the damping rings are not available).

- Deliverables:
  - Detailed description of the total short-range wake fields for the damping rings, based on realistic modelling of machine components. This deliverable is required so that an estimate can be made of the current thresholds for single-bunch instabilities
  - Recommendations for optimization of parameters affecting beam stability.
  - Feedback and guidance regarding the technical design of relevant machine components

Current Status for Objective 1: Impedance Modeling

- Work is already on-going at SLAC and LBNL.
- A wake-field 2D calculation for a model of RF cavity (based on Cornell SC RF cavity design scaled to 650 MHz) has been completed. Wake-fields for the BPM's based on PEP-II are being evaluated. Analytical models for RW wakes and CSR have been assembled.
- Estimated effort needed is 3FTE/year for two years

Tasks for Objective 2: Characterization of Instabilities

- List of tasks/deliverables:
  - Acquire detailed and reliable models of the short-range wake potentials from all relevant machine sources
  - Use the available models of short-range wake fields to estimate the instability thresholds and characterize the nature of the instability.
  - Identify the main sources of instability.
  - Determine modifications (to the lattice design, and technical designs of components) required to ensure a reasonable margin of safety between the nominal operating parameters and the instability thresholds.

Current Status for Objective 2: Characterization of Instabilities

- Work is currently on-going at SLAC and LBNL.
- A benchmark of available tools/methods to simulate the instability has been completed. A first estimate of the instability thresholds based on the available modelling of the impedance developed so far is under way.
- Estimated effort needed is 1.5FTE/year for two years