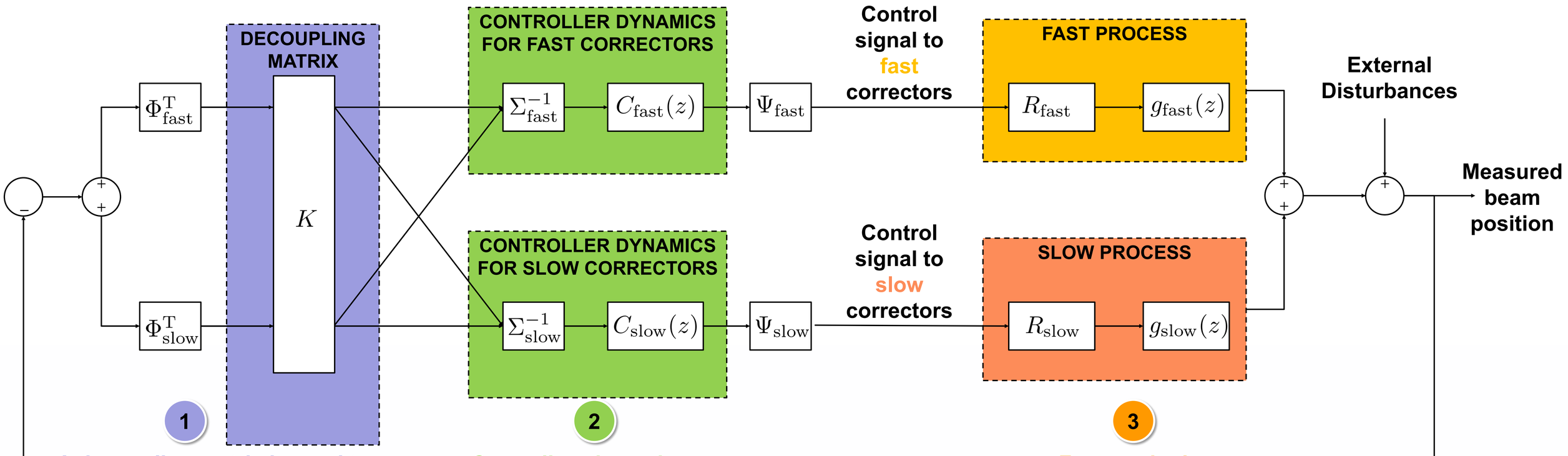
A UNIFIED APPROACH TO THE DESIGN OF ORBIT FEEDBACK WITH FAST AND SLOW CORRECTORS

S. Gayadeen, M.T. Heron and G. Rehm, Diamond Light Source, UK

CONTROL DIRECTIONS

- For a storage ring with two arrays of correctors (fast and slow), the response matrices are: $R_{\text{slow}} = \Phi_s \Sigma_s \Psi_s^{\text{T}}$ and $R_{\text{fast}} = \Phi_f \Sigma_f \Psi_f^{\text{T}}$
- The overlap between the controllable subspaces of each matrix can be determined by $\Phi_f^{\text{T}} \Phi_s = \Phi_A \Sigma_A \Psi_A^{\text{T}}$ where $\Sigma_A = \text{diag}\{\cos(\theta_{A_1}), \ldots, \cos(\theta_{A_{N_s}})\}$
- The **control directions are determined by the angle (θ_{A_i}) between the subspaces:**
  1. When $\cos(\theta_{A_i}) \approx 1$ the directions are decoupled and the fast and slow controllers are designed independently.
  2. When $0 < \cos(\theta_{A_i}) < 1$ either actuator can be used.
  3. When $\cos(\theta_{A_i}) = 0$ the control directions almost line up and both fast and slow correctors must be used.
     - **Mid-ranging control is ideal to determine the control inputs to the two correctors.**

CONTROLLER STRUCTURE



A decoupling matrix is used to choose control directions i.e. how much effort is required from both fast and slow correctors to correct disturbances at a particular mode

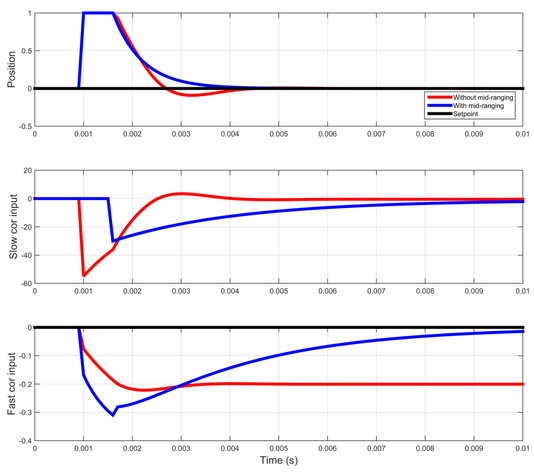
Controller dynamics are designed to make use of specific dynamics of fast and slow correctors.

Fast and slow correctors act together to correct beam position

MID-RANGING CONTROL PERFORMANCE

Mid-ranging control manipulates both inputs upon an upset to control electron beam position but then gradually resets or mid-ranges the fast input to its desired setpoint to avoid saturation.

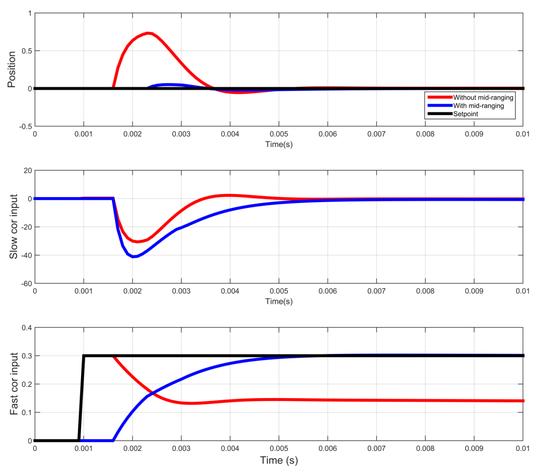
Responses of position, fast input and slow input to a ***step change in disturbance***



Non-mid ranging:
Fast actuator settles at unknown steady state which may be close to saturation limit and demands more control effort from the slow corrector.

Mid-ranging:
Manipulates the fast corrector first to correct disturbance then uses the slow corrector to ensure that the fast actuator does not saturate by returning it to the zero setpoint.

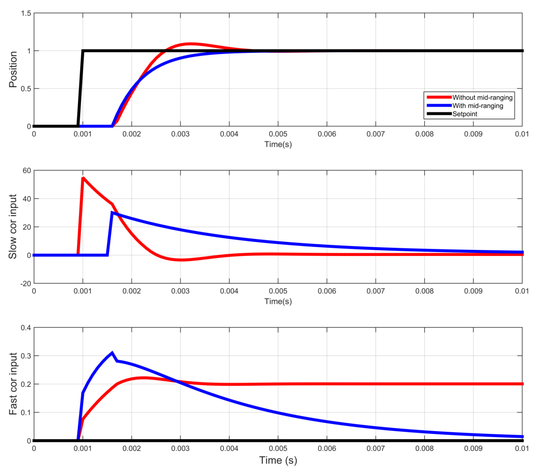
Responses of position, fast input and slow input to a ***step change in fast corrector setpoint***



Non-mid ranging:
The effect of changes to the fast actuator and position is not decoupled so any setpoint changes to the fast actuator are observed as a disturbance on position.

Mid-ranging:
The fast actuator achieves the requested setpoint and the effect on the output is decoupled so that changes to the fast actuator setpoint does not affect the output.

Responses of position, fast input and slow input to a ***step change in position setpoint***



Non-mid ranging:
The position achieves the required setpoint change but the fast corrector remains at a steady state which can lead to saturation and requires more effort from the slower actuator.

Mid-ranging:
The fast corrector is returned to its mid-point so that saturation is unlikely and uses less effort from the slow corrector to achieve the new position setpoint.

For more information please visit www.diamond.ac.uk or contact Sandira Gayadeen at sandira.gayadeen@diamond.ac.uk