ATF2 Software tasks:
- EXT Bunch-Bunch FB
- IP Bunch-Bunch FB
- FB Integration
Status and plans

Javier Resta-Lopez
JAI, Oxford University

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Bunch-Bunch FB Systems

Aim:

- Position and angle jitter corrections to achieve goal 2: control of the beam position at level $\approx 5\ \%\ \sigma^*_y$ (ATF2 goal 2)

Studies on progress:

- Design of a fast intra-train FB to be located in the ATF2 EXT line (FONT project)
- Design of a fast intra-train IP-FB to achieve the desired position control
- Simulations to understand the dynamics of the system, assuring an optimal performance of the FB system
- Realistic simulations: understand and determine the several error sources
- Joint operation of the different FB systems: bunch-bunch, pulse-pulse (FB integration)
- Check the robustness of the model and possible integration in flight simulator (collaboration with other tasks)

Simulation infrastructure

- Using the tracking code PLACET-Octave (developed at CERN)
- First only considering the y, y' correction (most critical). Straight extension to x, x' correction
- Study the jitter propagation
- EXT-bunch-bunch FB system:
  - Two kickers (K1 & K2) for vertical position (Y) and angle (Θ) correction
  - Three pickups (P1, P2, P3) for transfer matrix reconstruction and for FB loop
  - Assuming a BPM rms noise of 1 μm (input BPM resolution)
  - Assuming a kicker strength error (Here we assume < 0.5 %)
- Normal random distribution of initial vertical jitter positions with a width of +/- 40 % σ_y (rms beam size at the entrance of the extraction line)
- Apply static misalignment using "standard errors" (list by GW) + alignment procedure (connection with other tasks: BBA methods and orbit-steering)
- Introducing ground motion (GM) misalignment (model K)
- IP-bunch-bunch FB system:
  - IP-BPM (resolution ~ nm)
  - Kicker in between of the final doublet quadrupoles
  - More detailed study in progress

EXT Bunch-Bunch FB

Using a SVD algorithm:

- The SVD algorithms easy to implement and very robust. Commonly used in orbit steering correction (using several correctors and BPMs), it can also be used for fast FB

- In the case of a fast-FB important to select appropriate BPMs and correctors for the FB (optimisation of the FONT element positions)

- Measure the position and angle jitter of the first bunch in a train

- Knowing the response matrix, apply the SVD method to correct the rest of the bunches of the train

Alternative: using a classical PID control loop

IP Bunch-Bunch FB

Preliminary simulations have shown that GM motion (10s model K) produces a mean beam offset at IP of ~ 60% σ^*_y. Additional y position jitter and gradient errors in the FD quadrupoles produce another significant mean beam offset at IP. Intra-train IP-FB necessary to achieve goal B ($5\ \%\ \sigma^*_y$ level stability)

Using Honda IP-BPM with nm resolution level
(Y. Honda et al., Phys. Rev. ST-AB 11, 62801 (2008))

Necessary:

- Specify kicker position

- Detailed design and optimisation of a robust FB algorithm:
  PID control loop, adaptive system ?

- Performance simulation and study of the limitations

FB Integration (preliminary)

• Misalignment with survey errors (GW table: https://confluence.slac.stanford.edu/display/ATF/Software+Projects)

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• BBA procedure (preliminary): 11 correctors (ZH & ZV) and 50 BPMs along the lattice to minimise $\sqrt{(\sigma^*_x \sigma^*_y)}$. Establish a more realistic model (inter-tasks collaboration)

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• EXT-FB & IP-FB (possibility to join both using a common response matrix and SVD method? In reality may be challenging!)

• Simulated 100 events (pulses), with 3 (20) bunches per event

• 40 % σ_y (rms beam size at the beginning of the EXT line) offset

• 10 % σ_y position jitter between events

Plan, schedule and remarks

- A PLACET-Octave based ATF2 model with FB systems. PLACET-Octave (easily callable from Octave and/or Matlab)
- We plan to improve the model, adding the missing error sources (list from Glen White). [To be completed in September/October]
- Optimisation of the FB parameters (gain factors). Check the model robustness and benchmarking with other codes (?) [To be completed September/October]
- Joint operation of the different FB system (EXT + IP). Integrated simulations with slow and fast FB systems. At this point, very important collaboration with other tasks:
  - Extraction line orbit correction/Feedback (Y. Renier)
  - FFS Orbit-Steering/FB (A. Scarfe)
  - BBA alignment (G. White, R. Tomas, …)
- Please, contact me if interested in this collaboration
- Possibility to include the bunch-bunch model on flight simulator. To be discussed with Yves and Glen.