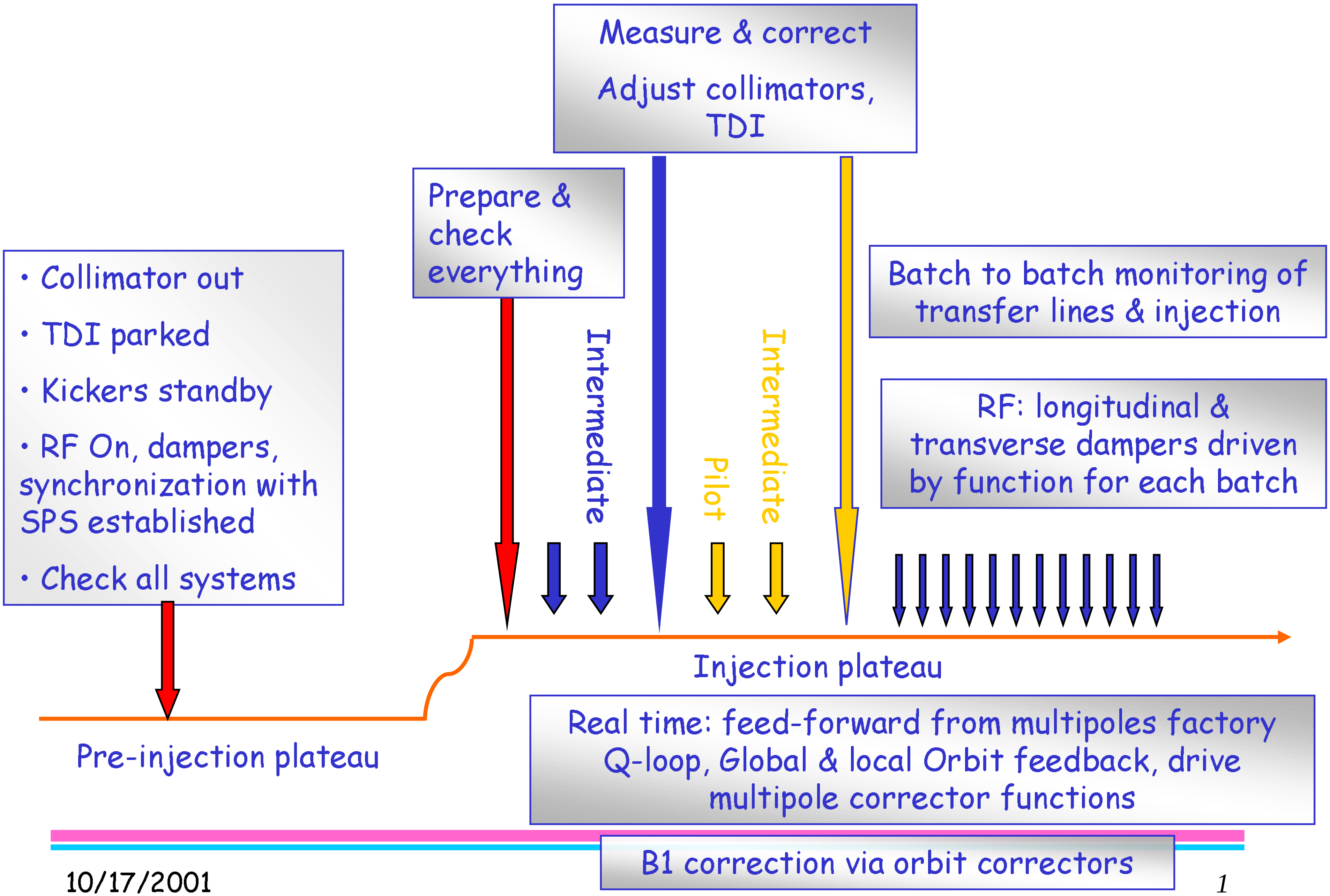
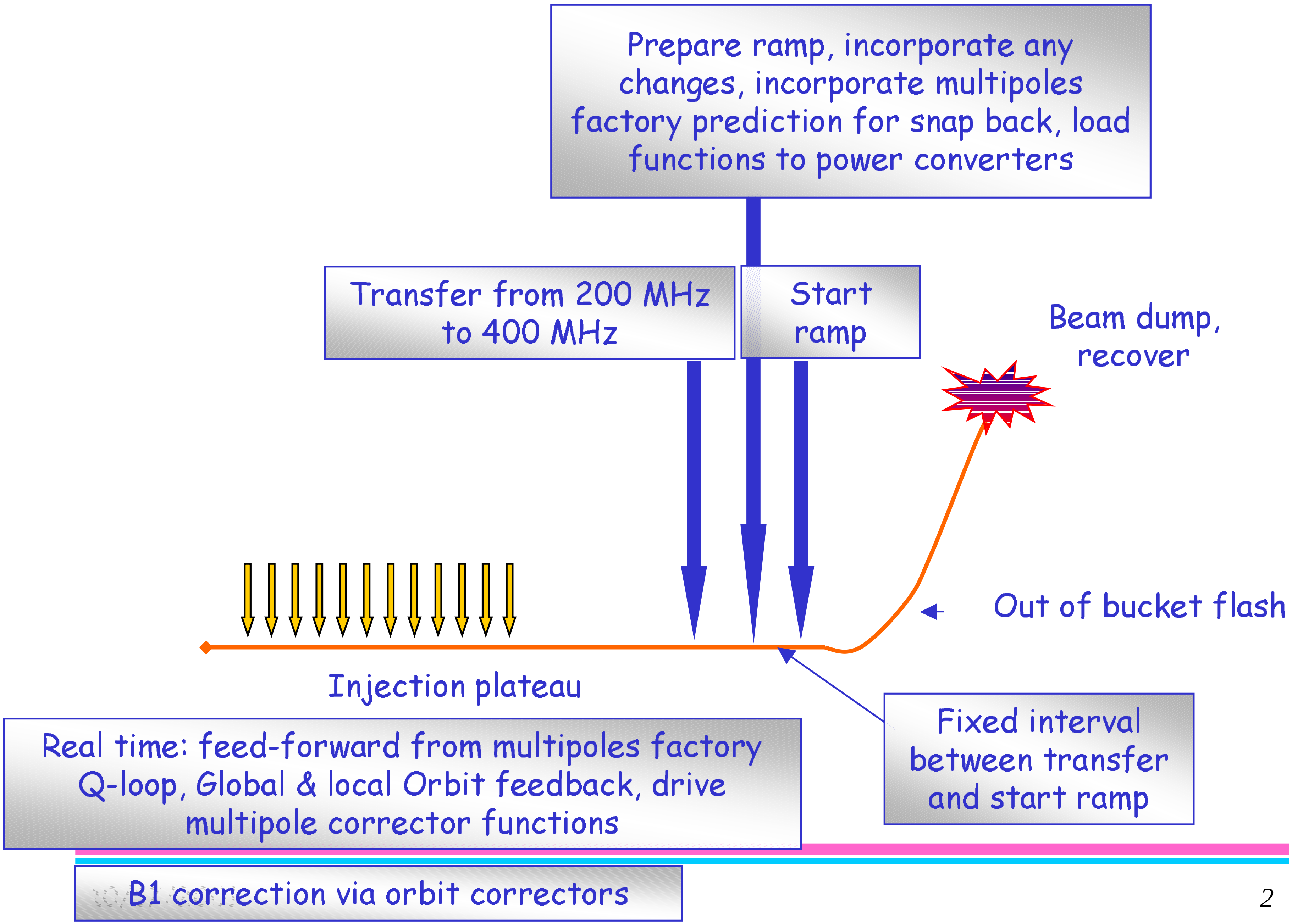
Injection…



Measure & correct
Adjust collimators, TDI
Prepare & check everything
• Collimator out
• TDI parked
• Kickers standby
• RF On, dampers, synchronization with SPS established
• Check all systems
Intermediate
Pilot
Intermediate
Batch to batch monitoring of transfer lines & injection
RF: longitudinal & transverse dampers driven by function for each batch
Injection plateau
Pre-injection plateau
Real time: feed-forward from multipoles factory Q-loop, Global & local Orbit feedback, drive multipole corrector functions
B1 correction via orbit correctors

Injection...



Prepare ramp, incorporate any changes, incorporate multipoles factory prediction for snap back, load functions to power converters
Transfer from 200 MHz to 400 MHz
Start ramp
Beam dump, recover
Out of bucket flash
Injection plateau
Fixed interval between transfer and start ramp
Real time: feed-forward from multipoles factory Q-loop, Global & local Orbit feedback, drive multipole corrector functions
B1 correction via orbit correctors

Beams

	Bunch Spacing	Charges per bunch	bunches per batch
Pilot	25 ns	5×10^{9}	1
Intermediate	25 ns	3.4×10^{10}	72
Intermediate	75 ns	8.3×10^{10}	24
Commissioning	25 ns	1.8×10^{10}	216/288
Nominal	25 ns	1.1×10^{11}	216/288
Ultimate	25 ns	1.8×10^{11}	216/288
Nominal Lead	125 ns	5.6×10^{9}	608 per beam
Machine Studies	x	y	N
TOTEM		1.1×10^{11}	36

Pilot

- Here we assume the machine has been cycled and set to injection level. Something is taking care of the effects of persistent current decay. Orbit movements are clearly of importance in what follows and the impact of the plan to compensate the effect on energy of b1 drifts using the horizontal orbit correctors will have to be checked.

- Pilot is essentially "safe without protection". (5 10^9 per bunch is not able to provoke quench). Will need an intensity inhibit via SPS BCT. If mode = pilot and total intensity greater than x don't inject into LHC. Clearly needed to avoid equipment damage.

- The collimators will be "all out". What's out? Greater than 10 sigma or on the switches? This clearly might vary as experience grows.

Pilot II

- Acquire and correct closed orbit. Asynchronously position collimators at around 8 sigma with respect to closed orbit. Rough - first cut.

- What is beam size at collimators?
- How do we take care of the effects of beta beating?

Intermediate intensity

- Having acquired a pilot and positioned collimators and TDI, the pilot is dumped and preparation is made to accept a intermediate intensity beam.
- Although there's some discussion, this mode makes use of the increase resolution of the BPMs with intensity and number of bunches, this allows:
  - exploration of aperture > to be specified
  - adjustment of TDI - check optics > to be specified
  - fine adjustment of collimators > to be specified
- Prerequisites: Collimators in, TDI in and possibly some auxiliary collimators (2 secondary betatron and 2 secondary momentum).
- Note en passant: during commissioning will need bumps and BLMs to home on aperture limits...

Full intensity

- Prerequisites: All collimators in at specified positions. n1 = 6 sigma, n2 = 7 sigma (to be discussed). Positions with respect to average closed orbit.
- Ionisation monitors attached to collimators to monitor beam losses on the collimators.
- Closed orbit clearly. Orbit feedback as required in cleaning sections. What stability is required?
- Beam loss monitors
- TDIs in position
- Some discussion about possible emittance variation coming from transfer line mismatch, up to 100% could be expected. But assume here 50% instability in emittances. (Scraping in SPS... dump in SPS if too large.. variation in mismatch due to temperature variation in transfer line...) Whole issue to be followed up.

Full intensity

- At least some collimators will be able to action a beam dump if losses greater than a variable threshold are sustained. For example that incurred if the emittance are too large. Thresholds to be determined but figure of 1% beam loss mentioned. Thresholds will clearly have to be adjustable.

Ramp

- **After injection process has finished, the momentum collimators will move in to finer settings and then stay where they are during the ramp.**
- **Secondary collimator movement has to shadow primary collimator movement.**
- **Orbit feedback will be required in cleaning sections (3 & 7) hold to hold collimator positions fixed with respect to closed orbit (average position of bunches). Detailed specification of requirements for feedback systems necessary**
- **Essentially collimators will stay where they were at the end of the injection process. Some question about emittance increase during snapback and possible tail formation. At 500 GeV or so the collimators could be brought in to chop the tails.**

Squeeze

- The collimators have to track the squeeze. The ratio n1/n2 between primary and secondary has to remain fixed (wrt the closed orbit) and again the secondary collimator movement has to shadow primary collimator movement.
- The collimators need to move first and then the TDE to avoid the TDE becoming the aperture limit.
- The collimators need to be positioned to 0.1 sigma or 10 microns (1 sigma ~ 0.4 mm at beta ~ 200 m.) The 10 microns represents the most extreme resolution required. Step sizes of 1 micron will be required. To be discussed!

Control

- Some discussion about how to synchronise the movement of the collimators. Full synchronisation is not possible because the power is shared by up to four motors. Either force synchronicity at high level by asynchronously applying very small steps to each collimator in turn, or possibly command to low level controller (go from here to here in this time). Functional specification required.
- Synchronicity requirements between the 2 beams were also questioned.