SDR-Based Feedback System for Beam Spill Control in Particle Accelerators

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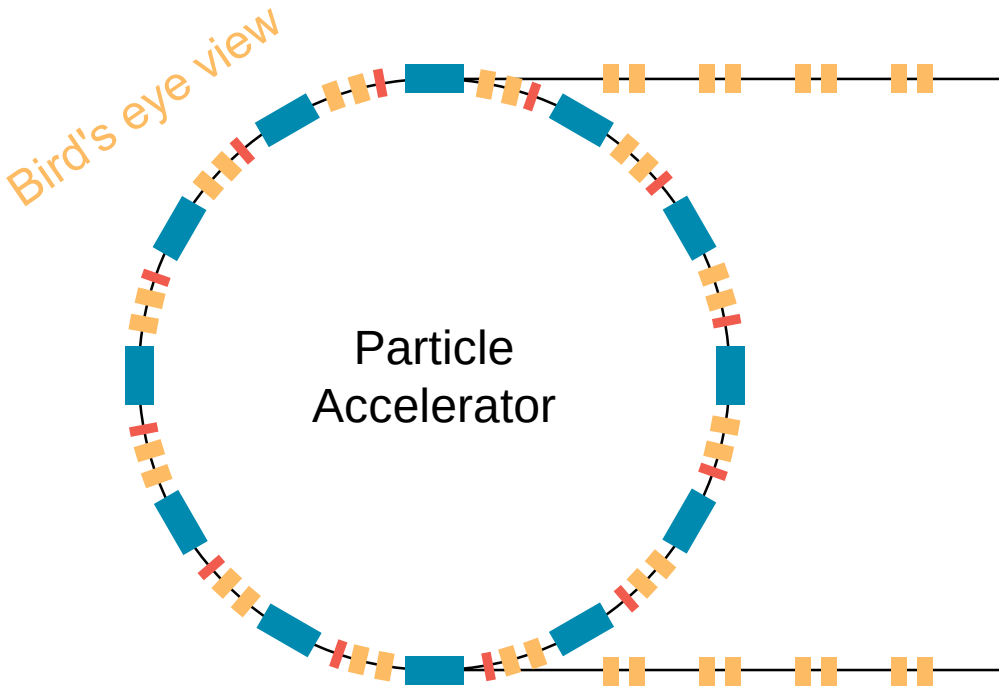
Abstract

Controlling stored beams in particle accelerators requires specially designed RF signals, such as needed for spill control via transverse excitation. The software-defined radio (SDR) technology is adopted as a low cost, yet highly flexible setup to generate such signals in the kHz to MHz regime. A feedback system is build using a combination of digital signal processing with GNU Radio and RF Network-on-Chip (RFNoC) on a Universal Software Radio Peripheral (USRP). The system enables digitization of signals from particle detectors and direct tuning of the produced RF waveforms via a feedback controller – implemented on a single device. To allow for triggered operation and to reduce the loop delay to a few ms, custom OOT and RFNoC blocks have been implemented. This contribution reports on the implementation and first test results with beam of the developed spill control system.

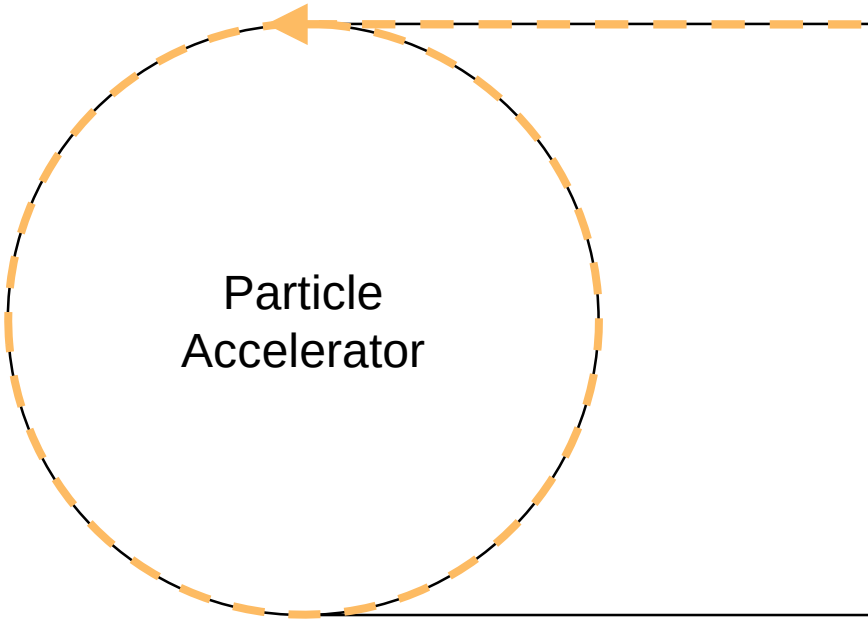
Spill Control in Particle Accelerators

- In a nutshell



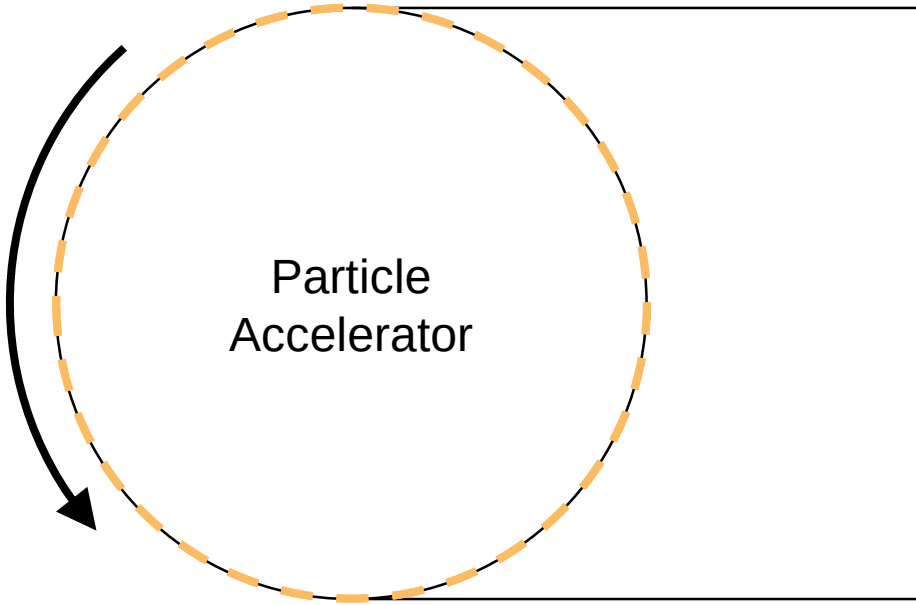
Spill Control in Particle Accelerators

- Inject & store particle beam

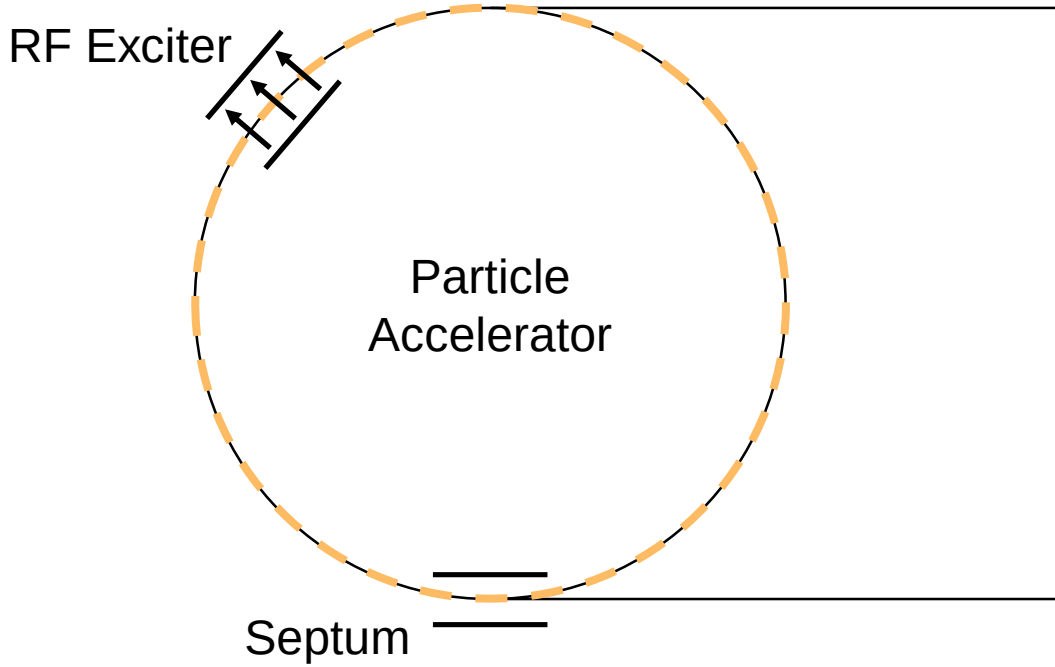


Spill Control in Particle Accelerators

- Accelerate particle beam

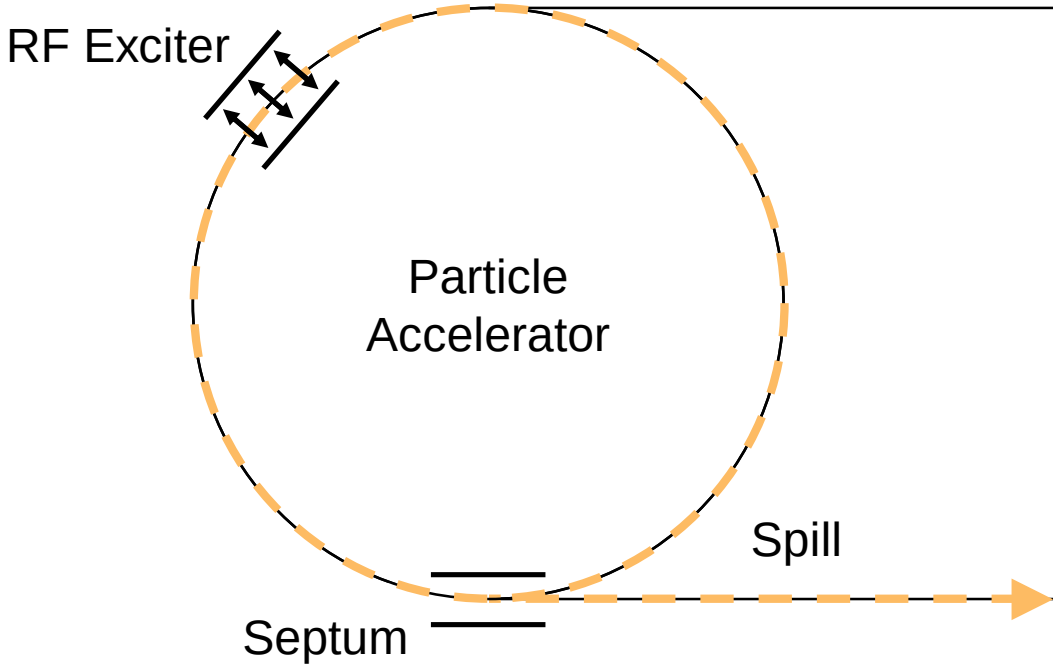


Spill Control in Particle Accelerators



Spill Control in Particle Accelerators

- Excite & extract particle beam
  → „Spill“

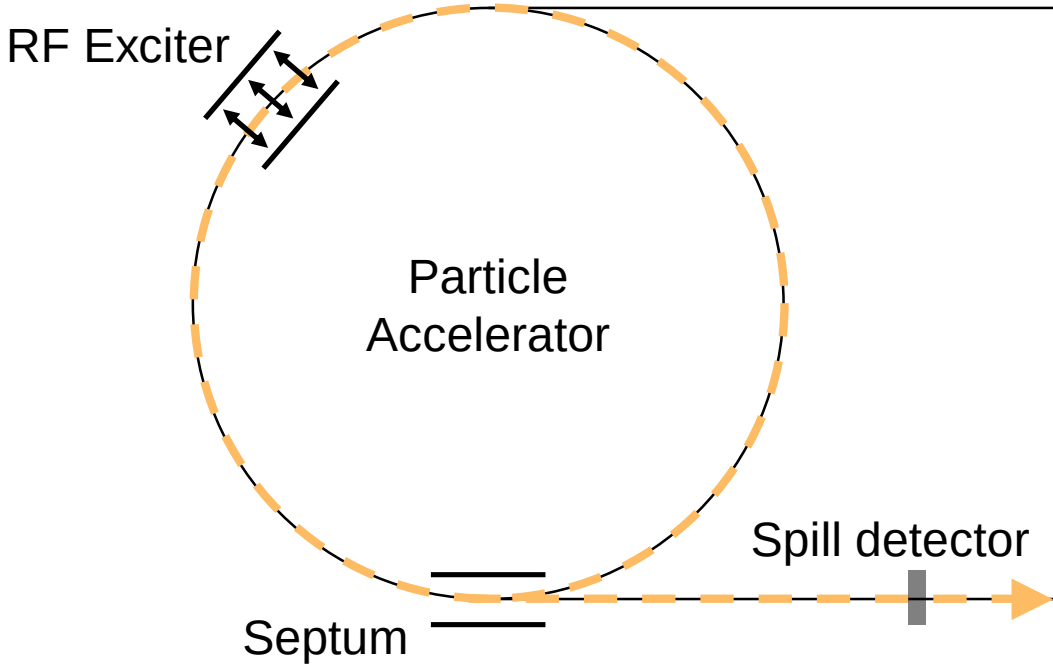


Spill Control in Particle Accelerators

- Excite & extract particle beam
  - → „Spill“

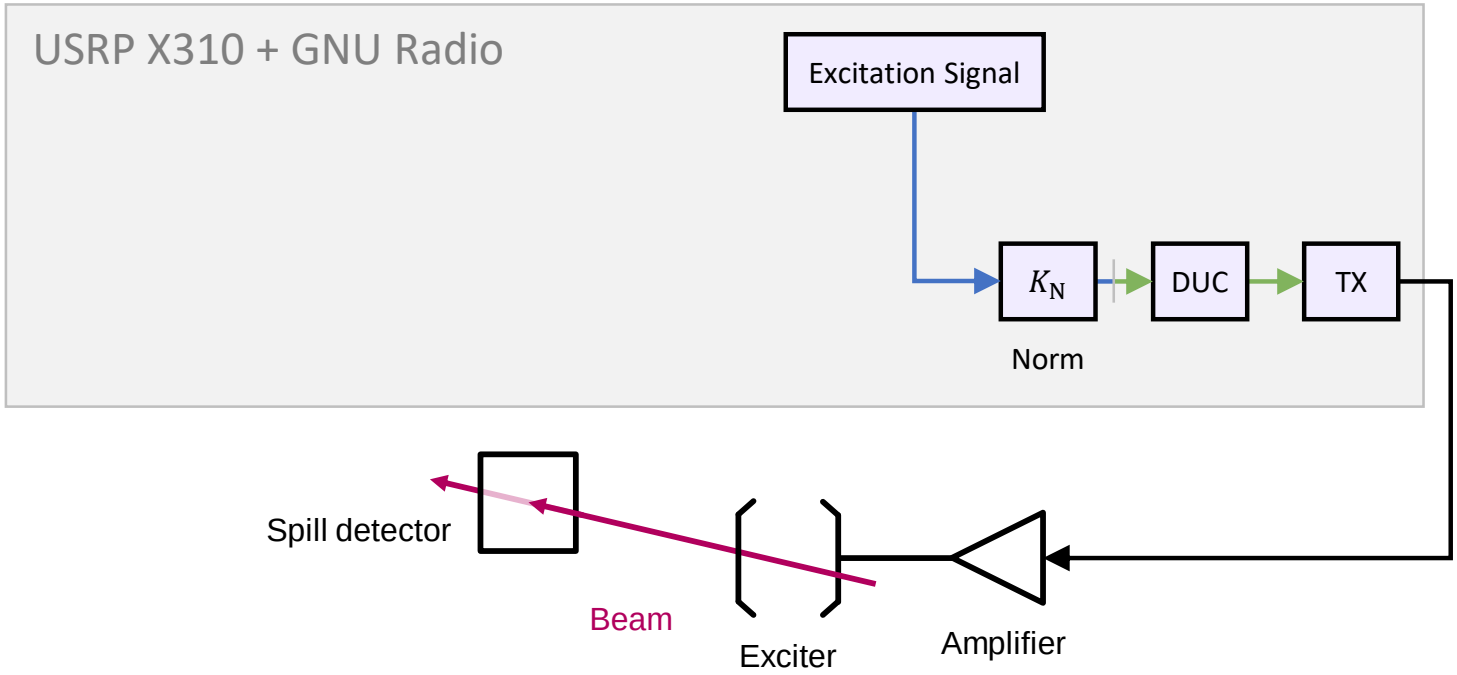
- We need to
  - Generate RF signals (kHz ~ MHz)
  - Process detector signals (few ns)
  - Feedback control of the spill (few s)

→ SDR-Based implementation



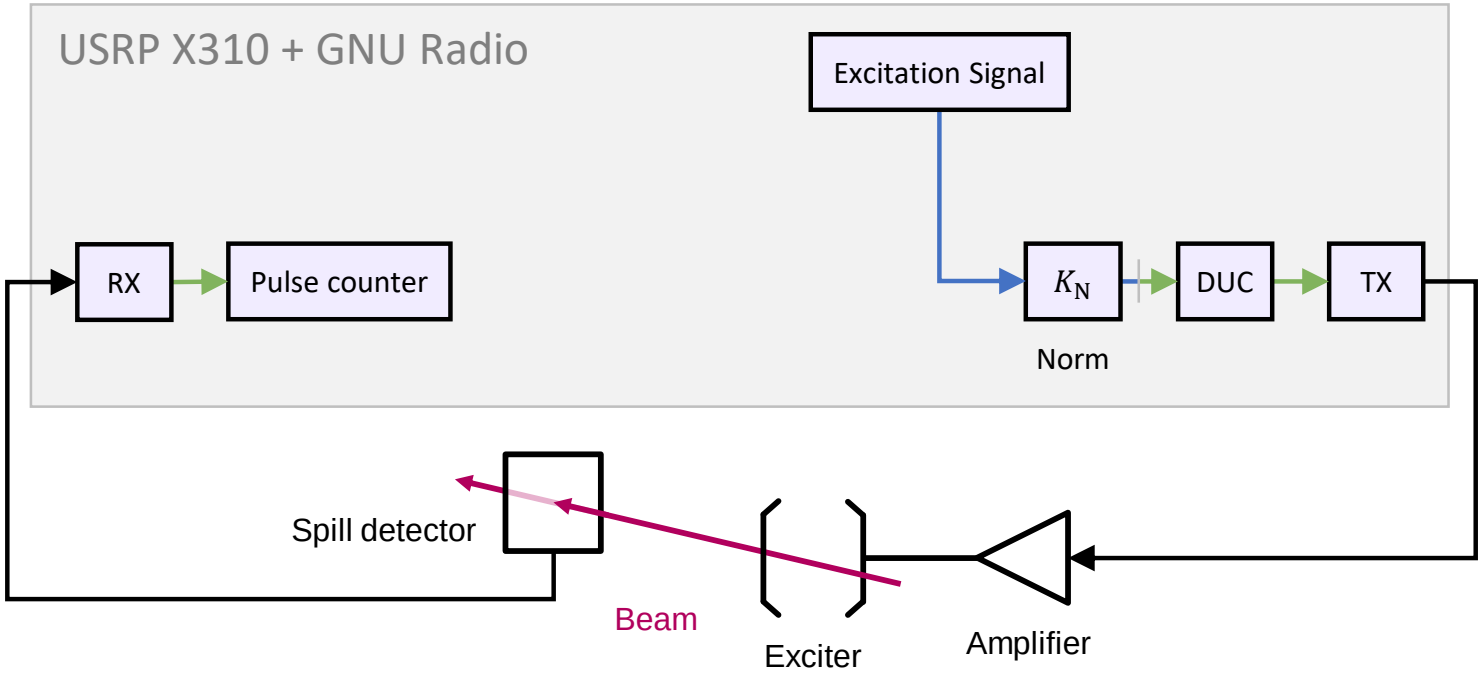
SDR System

- Generate RF signals (kHz ~ MHz)



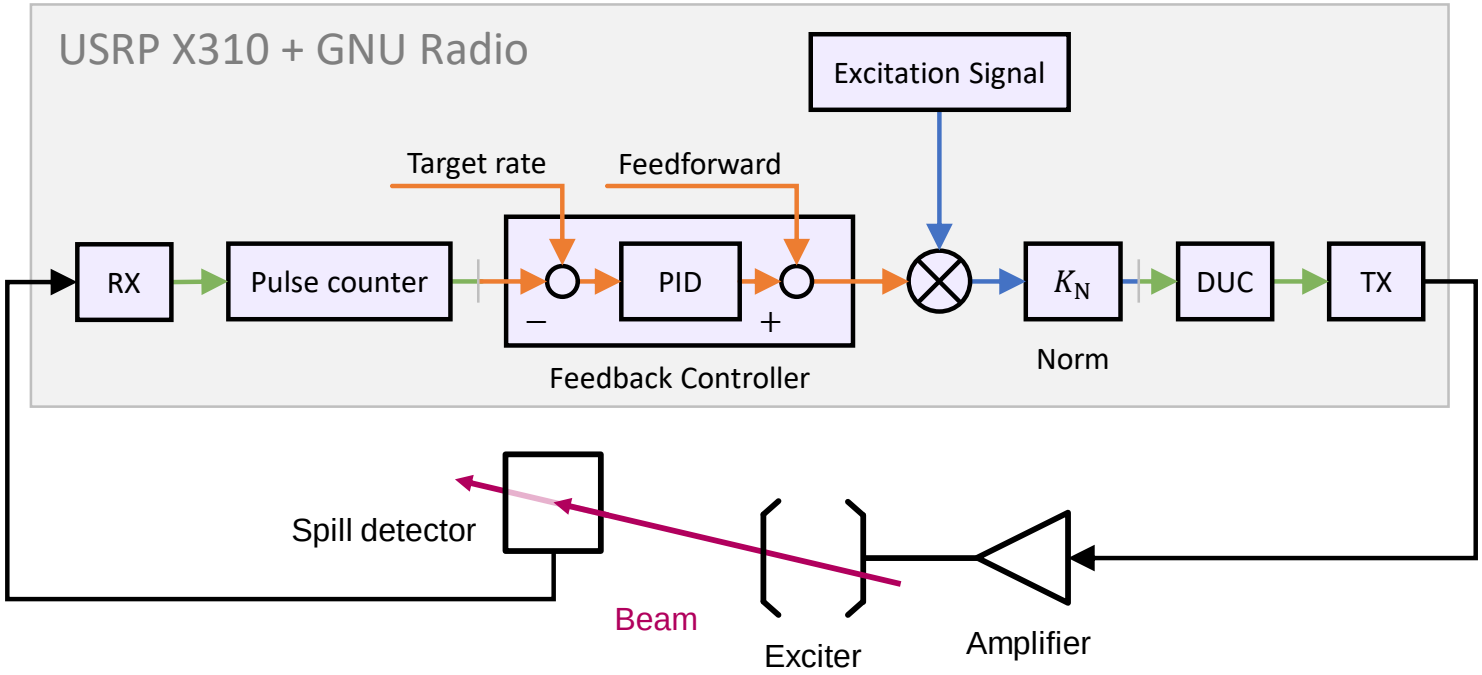
SDR System

- Process detector signals (few ns)



SDR System

- Feedback control of the spill (few s)

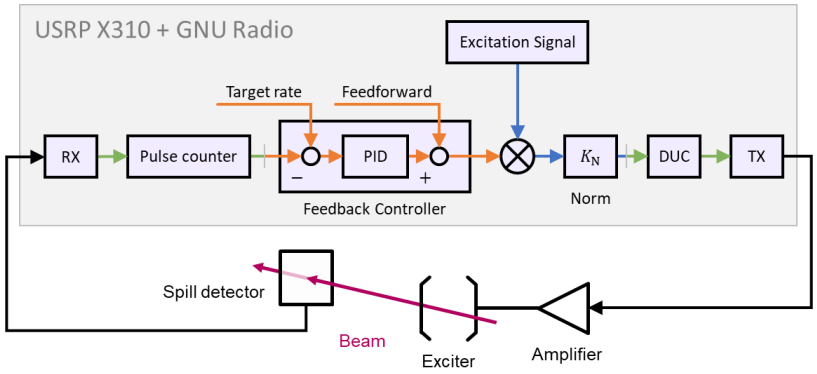


Minimizing loop delay

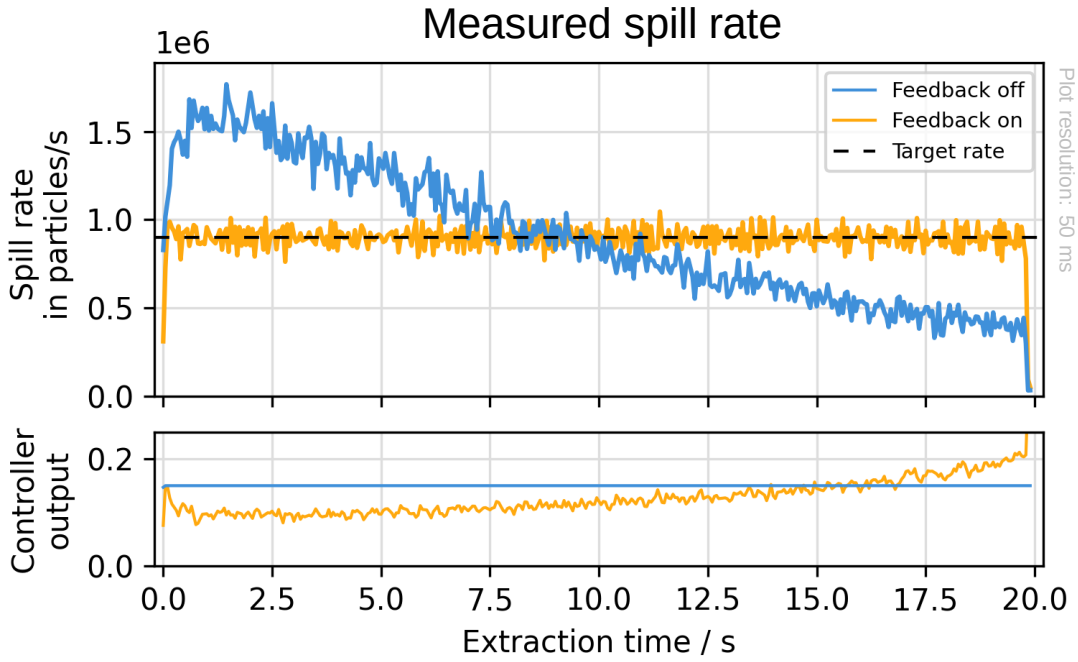
- Buffer, transmission, processing latency
- Triggered operation mode → signal bursts

- Measures
  - Buffer flushing (OOT block)
  - Real-time scheduling
  - Reduce streamer buffer size
  - PCIe connection

- Achieved (1.28 ± 0.33) ms



Commissioning at COSY Accelerator

- Feedback system
  - Generates RF excitation signals
  - Processes detector signals
  - Corrects drift of spill rate

git.gsi.de/p.niedermayer/exciter