A Macro-Pulsed 1.2 MW Proton Beam for the PSI Ultra Cold Neutron Source

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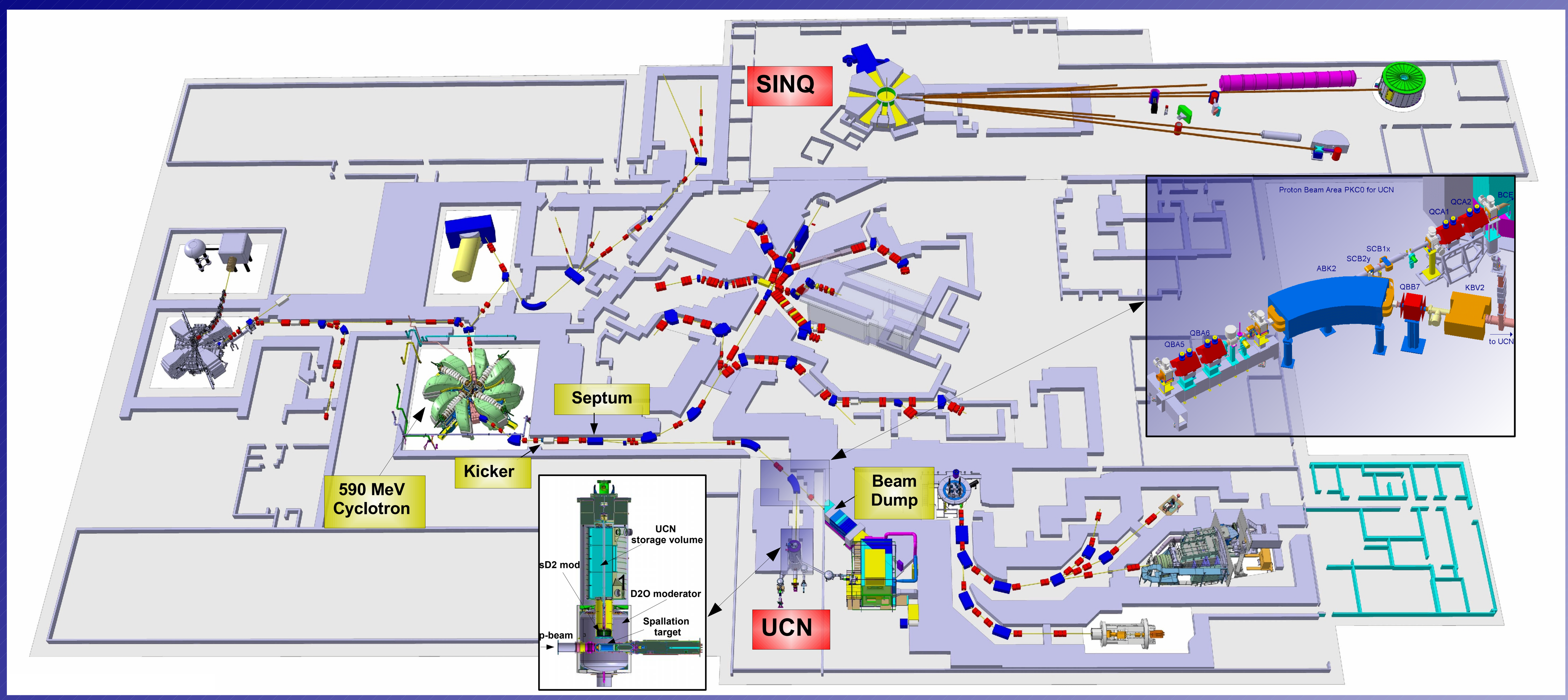
The new Ultra Cold Neutron Source at PSI



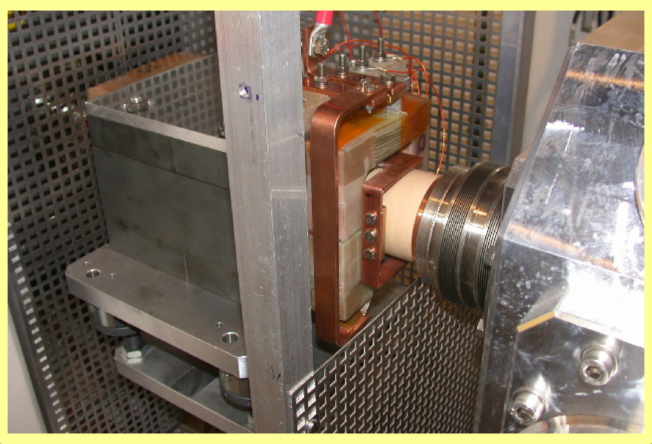
Features

- **At PSI, a new Ultra-Cold Neutron source** (UCN, kinetic energy < 300 neV) based on the spallation principle **will start operation at the end of 2009.** Its design intensity is ~100 times larger than the strongest source currently in operation.
- **Two neutron spallation sources** - the continous wave SINQ and the macro-pulsed UCN source will be **concurrently driven by the same accelerator facility.**
- The 590 MeV, 1.2 MW proton beam delivered by the ring cyclotron will be switched towards the new spallation target for about **8 s every 800 s.**
- Heart of the switching system is a **fast kicker magnet with a rise-time shorter than 1 ms.**
- A beam dump capable of absorbing the full-intensity beam for 10 ms has been installed after the last bending magnet: **the kicking process and the beam diagnostic can be checked independently from UCN operation.**
- Recent tests have demonstrated the **capability of switching the 1.2 MW beam with negligible losses and to center it through the beam line** by using fast beam position monitors. Much longer beam pulses (up to 6 s) with reduced beam intensity have also been performed successfully.

The Fast Kicker Magnet

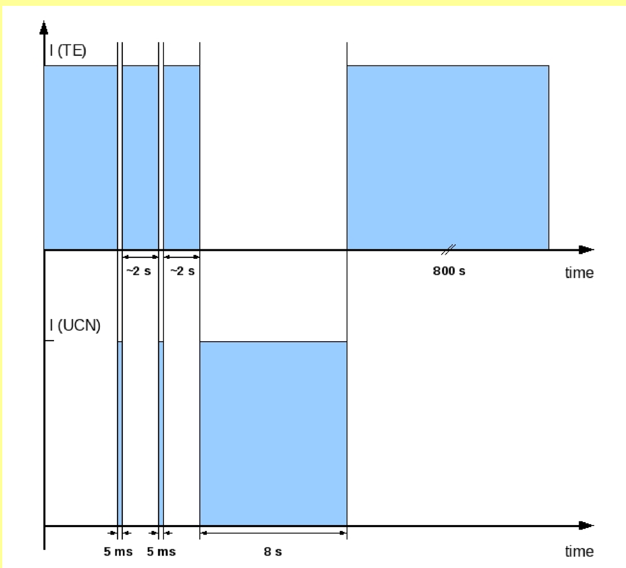
Magnet Design

- Ferrite yoke to achieve fast rise- and fall-time.
- Window frame to minimize inductance.
- Ceramic vacuum chamber to avoid eddy currents.
- Rise-time ~1ms, angular amplitude 6 mr.



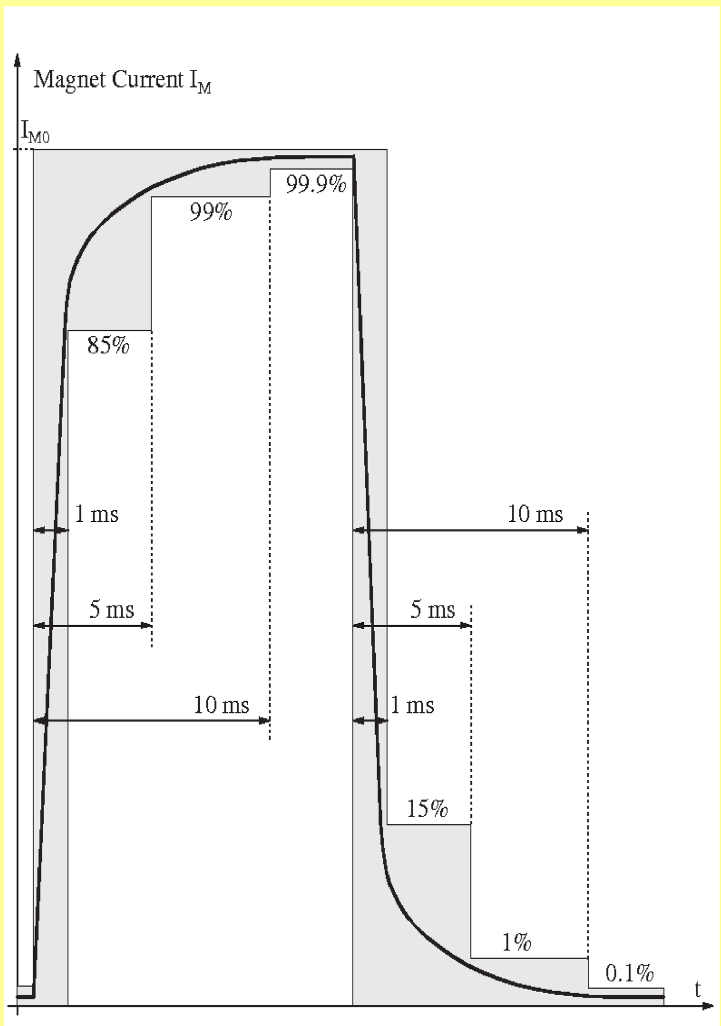
Kicking Scheme

- UCN duty cycle: 8 s every 800 s (1%).
- Two short kicks (5 ms) precede long kick for diagnostic purposes.

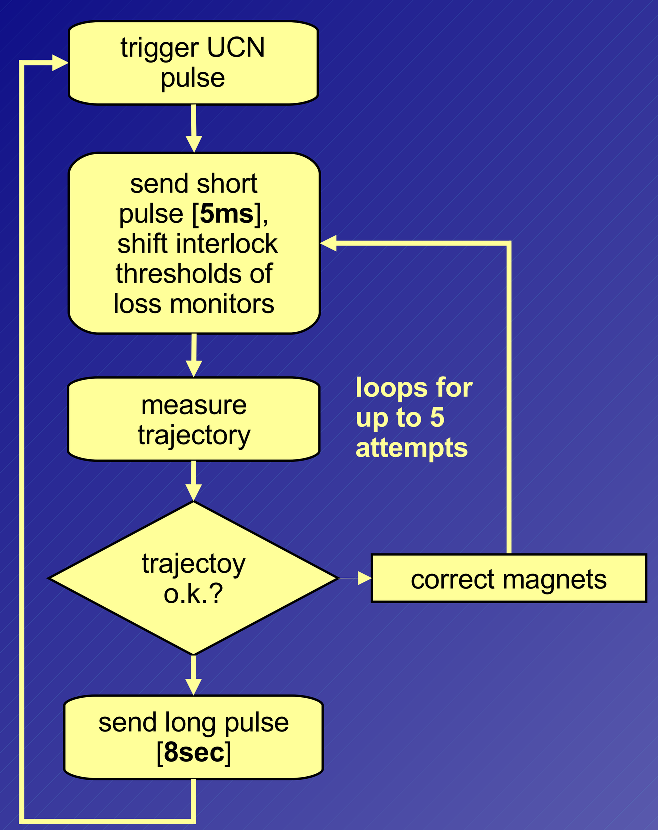


Power-Supply Requirement

- During the central part of the kicking phase, the beam hits the tungsten collimator of the septum magnet.
- Very fast rise- and fall-time (< 1ms) up to 85% of the angular deflection in order to limit losses.
- Slower kicking speed between 85% and 100% to avoid overshooting.
- Power supply duty cycle 1%.



Switching a MW Proton Beam to the UCN Target



Accelerator Issues

- Trajectory must be verified before sending the high power pulse (melts steel in 10 ms).
- Average beam power to UCN must be limited (~1%) by hardware interlock.
- High losses from septum collimator should not trigger interlock.

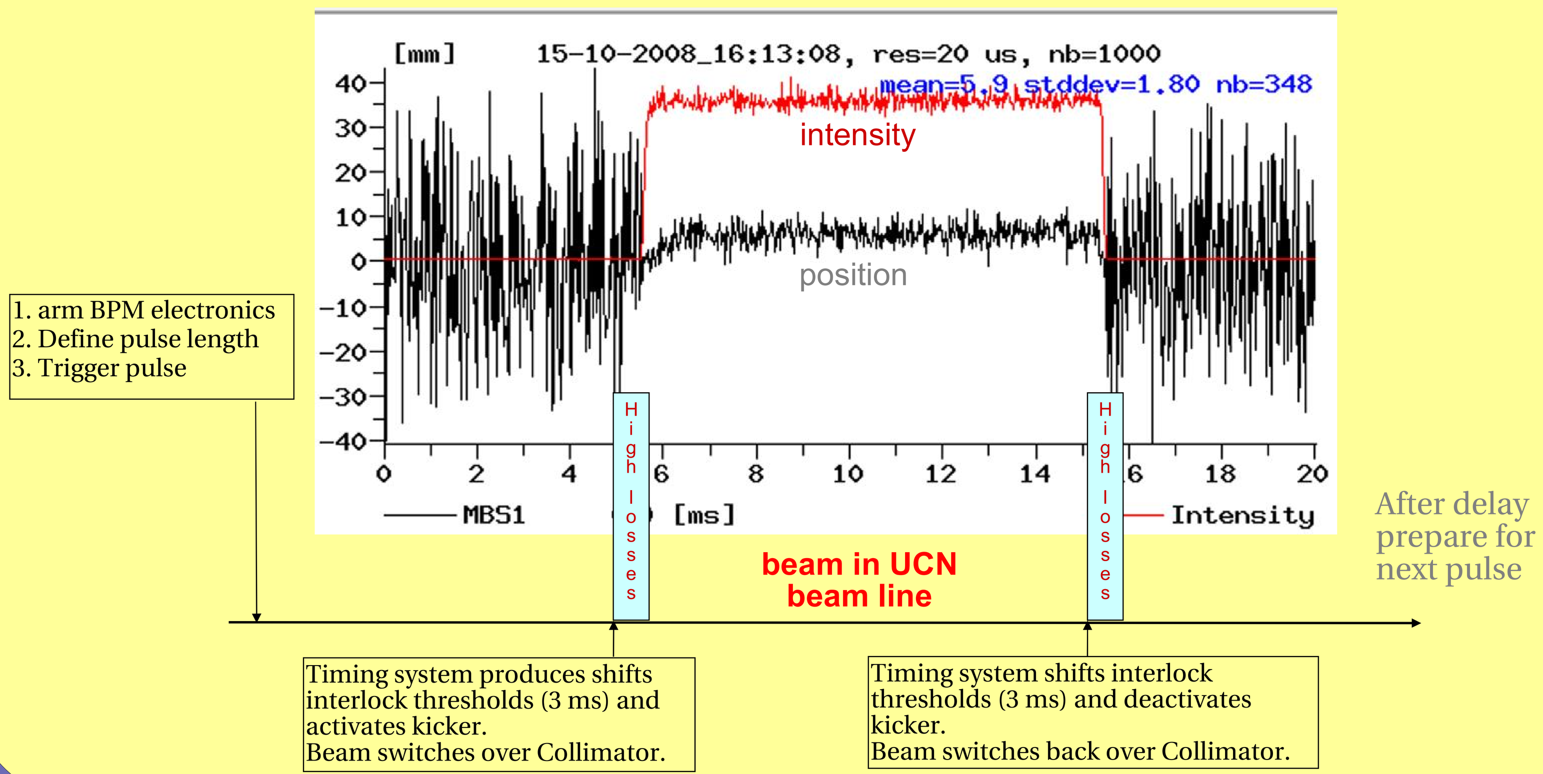
Achieved in Tests 2008

- Timing system is implemented and gives the expected behavior.
- Beam position monitors work well in the millisecond range with 50 KHz scanning.
- Controls- and beam trajectory correction applications are already performing well.

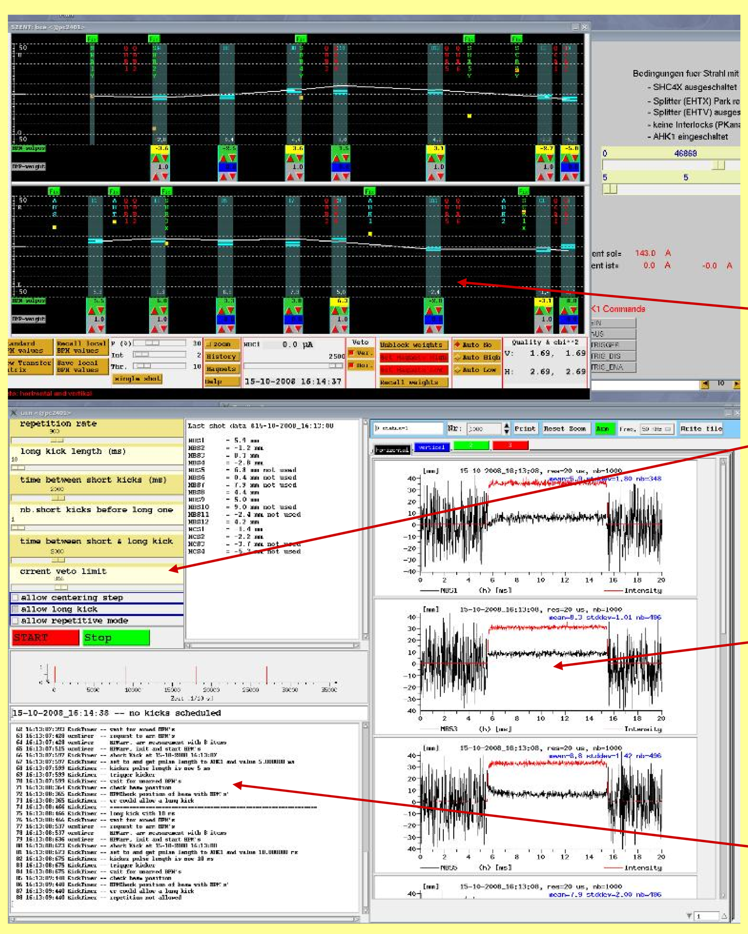
➨ 2 mA beam current successfully kicked to UCN for 10ms

Timing Overview of Beam Switching

During a 5 ms pulse the positions in the beam line are measured and a correction of the trajectory is calculated and performed



Overview of Control and Trajectory Centering Applications



Beam Losses during the UCN Kick

Measurements of Beam Losses

- Very fast ion-chambers (< 1ms) employed as beam loss monitors and beam interlock trigger.
- Upper plot:
  - beam intensity measurements in the main (blue line) and UCN (purple line) beam lines during a 5 ms beam kick.
- Lower plot:
  - during transitions, losses are mainly located upstream of the ABS septum magnet because of septum collimator (compare green and purple lines);
  - during the entire pulse, larger losses close to beam dump (blue line) due to back-scattering.
- 2008 tests:
  - 2 mA beam kicks up to 10 ms and lower intensity kicks up to 6 s;
  - during beam transitions, interlock thresholds of beam loss monitors are increased by three orders of magnitude.

➨ **after beam line tuning, 1.2 MW beam kicks successfully performed with no interlock triggered by beam loss monitors!**