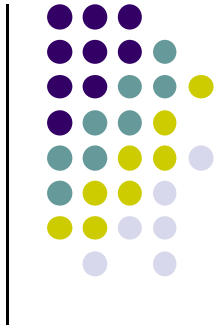
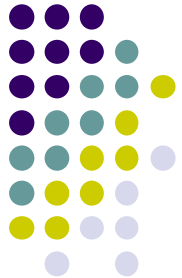


Electron Cooling

Issues for Studies at COSY

M. Steck, COSY Workshop, Jülich, November 18, 2016



Electron cooling of protons (antiprotons)

has been studied intensely in the last four decades
(Novosibirsk, CERN, Fermilab, IUCF, CELSIUS, COSY)

What is left or new?

High intensity hadron beams

- **e.g. electron heating (CELSIUS, COSY)**
- **but also: beam instabilities**
- **(some experience with antiprotons at RECYCLER)**

cooling of bunched hadron beams (relevance ?)

What is specific to COSY?

availability of two electron coolers with (some) overlap in energy

- **check of effects specific to a certain system**
- **combination of two system → increase of cooling power**
- **comparison/calibration of cooling power**

availability of electron cooling and stochastic cooling

- **simultaneous operation (halo – core cooling)**
- **complimentary operation (pre-cooling – final cooling)**
- **interference of the two systems**

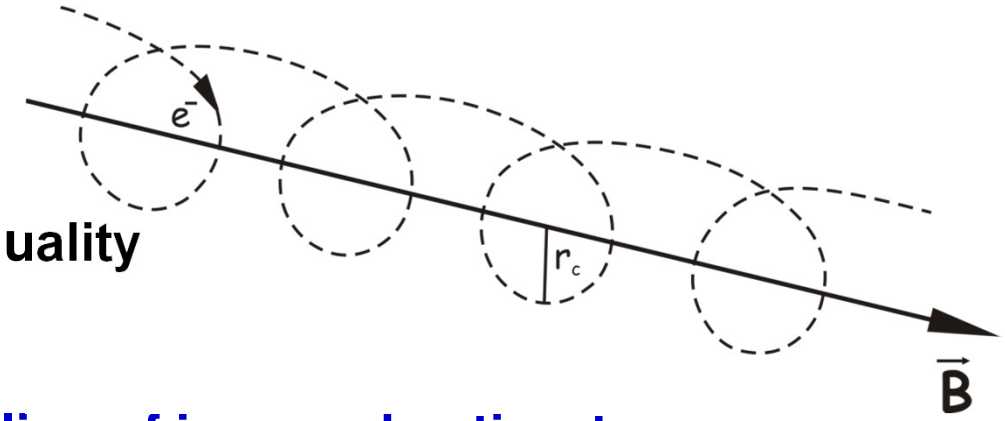
internal targets and advanced rf methods (e.g. barrier buckets)

large flexibility in adjusting the beta function in cooling section

remark: similar studies can be performed at the ESR (GSI), but the availability in the coming years will be low due to modifications and priorities (physics experiments)

Extension of Experimental Regime

electron cooling with magnetized electrons at relativistic energies



counteracting space charge
preservation of electron beam quality
increased cooling rate

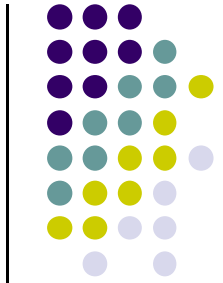
link to FAIR: HESR electron cooling of ions and antiprotons

recombination (neutral detection) can be powerful tool to diagnose electron temperature at COSY

requires:

- **powerful 3D- beam diagnostics**
- **good understanding and control of ion and electron beam operation**

New Technology, New Method



Development of an extraction system for pulsed operation of the electron beam

1) pulsed/bunched electron beam cooling

⇒ extension of electron cooling to highest energies (electron beam of some ten MeV)

2) operation of the electron beam as an electron lens

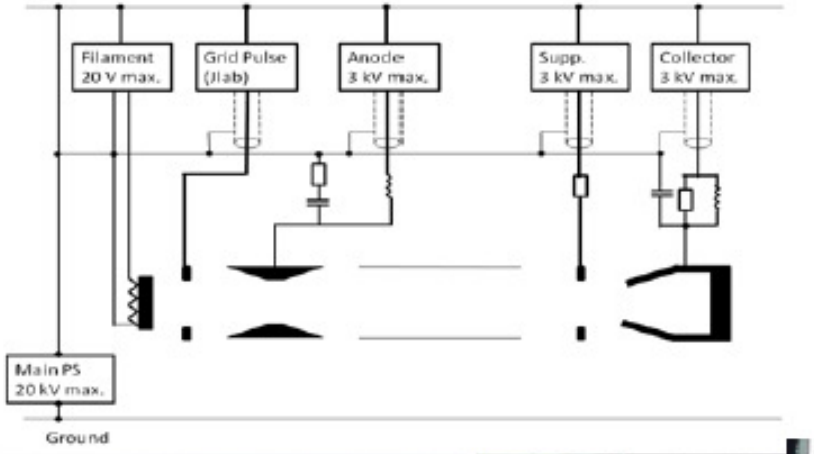
cooling by bunched electron beam – comparison with theoretical model

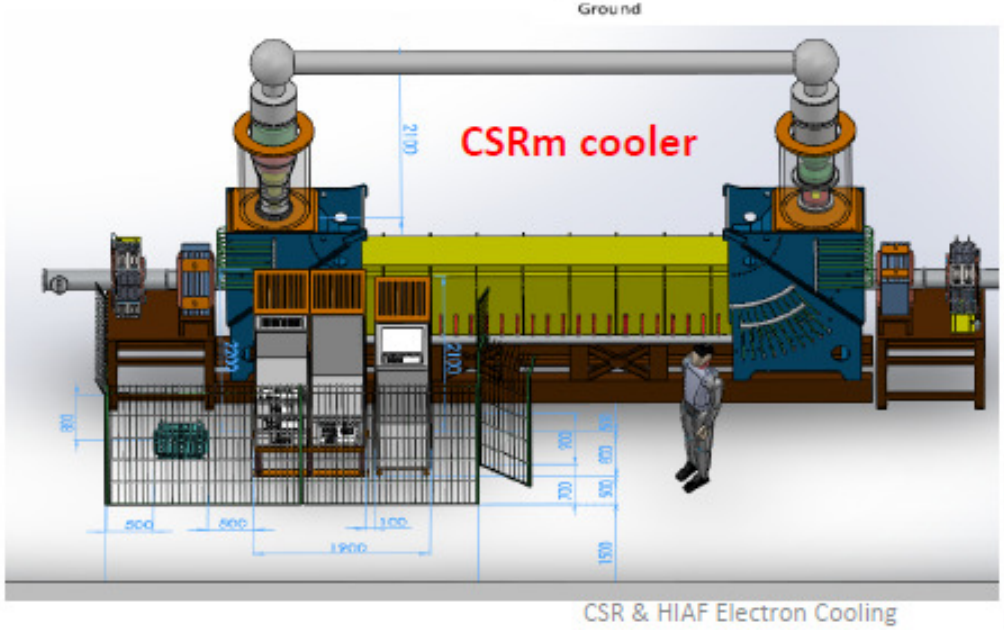
experimental simulation of increased momentum spread of bunched beam

synchronization with revolution frequency and/or rf system of the ring

Experiments at IMP Lanzhou with Pulsed Electron Beam (L. Mao, COOL16)

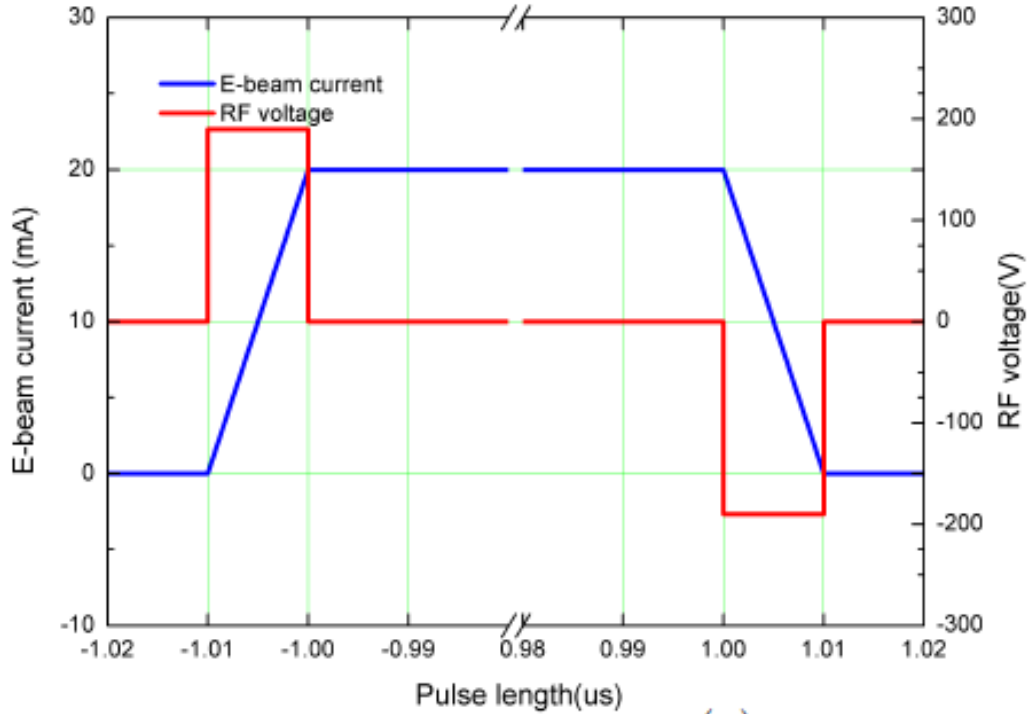
An RF modulate was installed on the grid power supply to switch on/off electron beam fast (<250kHz).





Experiments at IMP Lanzhou with Pulsed Electron Beam (L. Mao, COOL16)

The pulsed electron beam can provide not only a cooling effect, but also a RF voltage due to the space charge field in the edge.

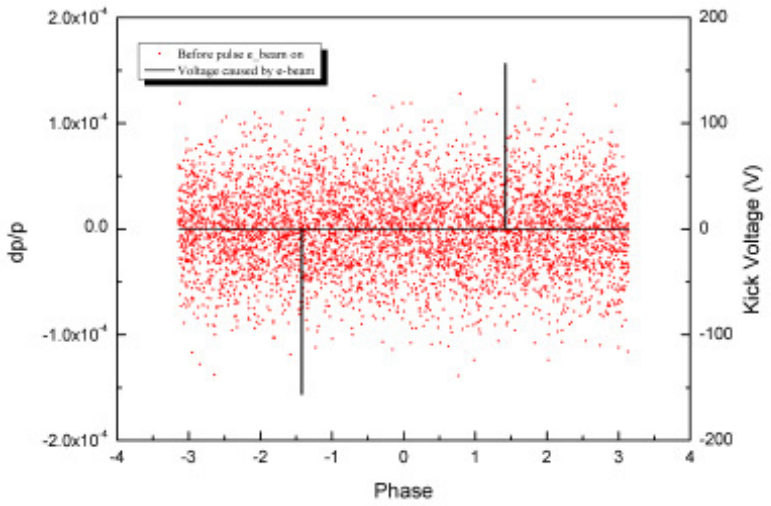


$$E_z(z) = -\frac{g}{4\pi\varepsilon_0\beta c\gamma^2}\frac{dI_e(z)}{dz}$$

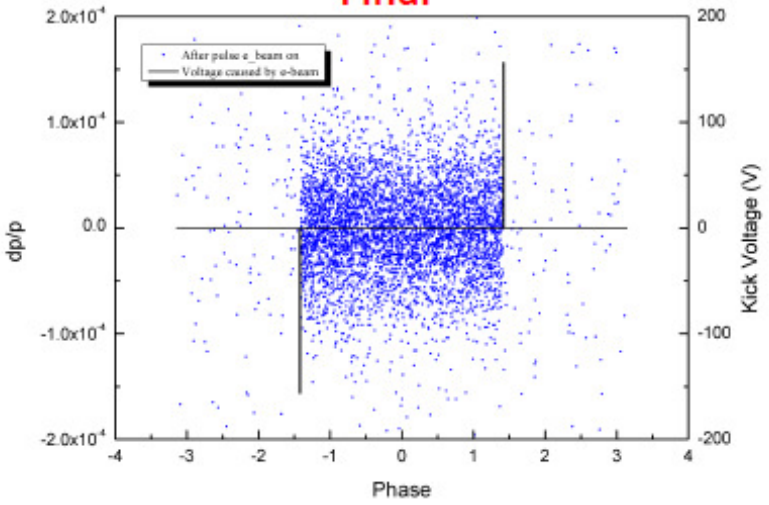
Experiments at IMP Lanzhou with Pulsed Electron Beam (L. Mao, COOL16)

- **Cooling by pulsed electron beam**
  - Synchronous

Initial



Final

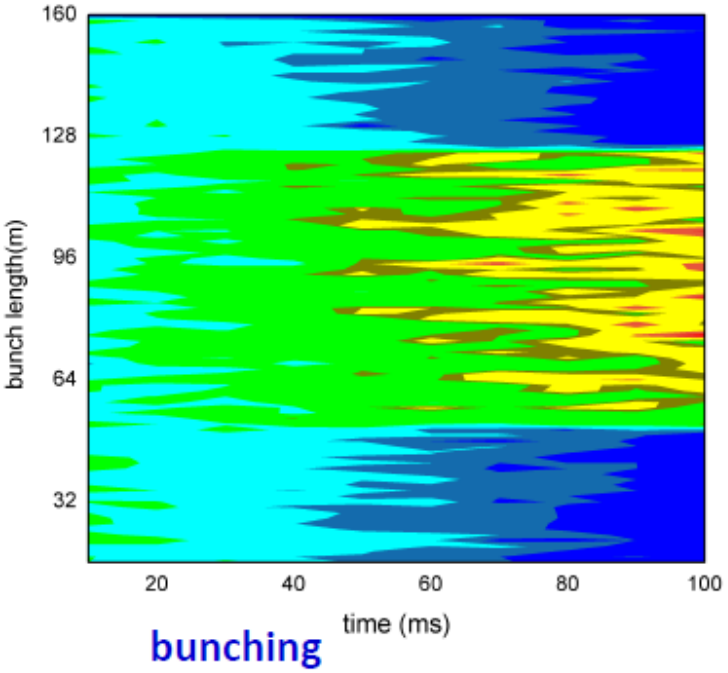


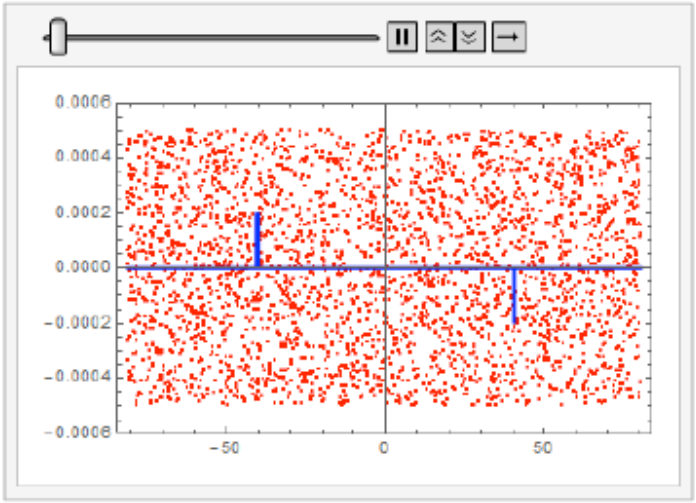
The ions can be cooled and captured by the pulsed electron beam.

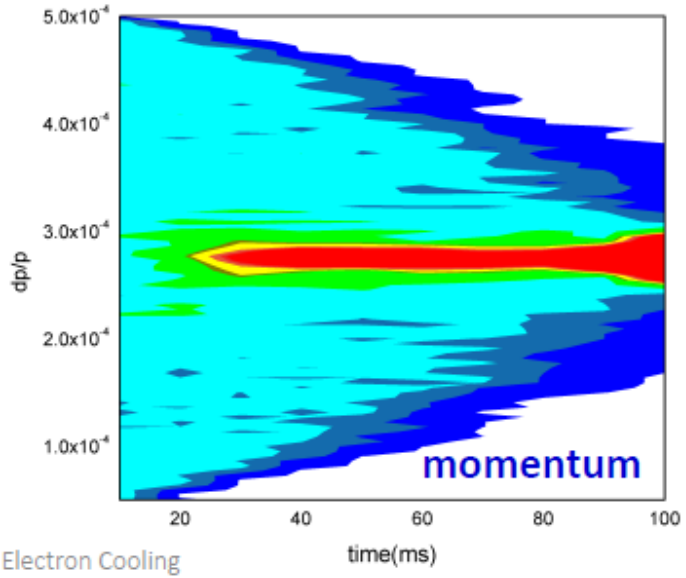
Cooling & Barrier Bucket

Experiments at IMP Lanzhou with Pulsed Electron Beam (L. Mao, COOL16)

- Cooling by pulsed electron beam
  - Synchronous







CSR & HIAF Electron Cooling

Experiments at IMP Lanzhou with Pulsed Electron Beam (L. Mao, COOL16)

- Cooling by pulsed electron beam