

High energy beam cooling

The latest developments in electron and stochastic beam cooling in Jülich

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ST2

Why beam cooling?

- Significant reduction of beam emittance and energy spread
- Mitigation of the beam blowup due to internal target operation
- Beam accumulation for future accelerators

COSY – perfect machine for beam cooling studies

- Two electron coolers (0.1 MeV and 2 MeV)
- Stochastic cooling system
- Both cooling techniques can be applied simultaneously
- Barrier bucket system
- Internal cluster and pellet targets
- Polarized beams
- Non-destructive beam instrumentation is readily available
 - Stochastic cooling pickups (medium and high energy)
 - Standard BPM pickups (any energy)
 - Bunch length / phase monitor
 - Ionization beam profile monitor (H+V)
 - H⁰ diagnostics (count rate)

Development of electron cooling

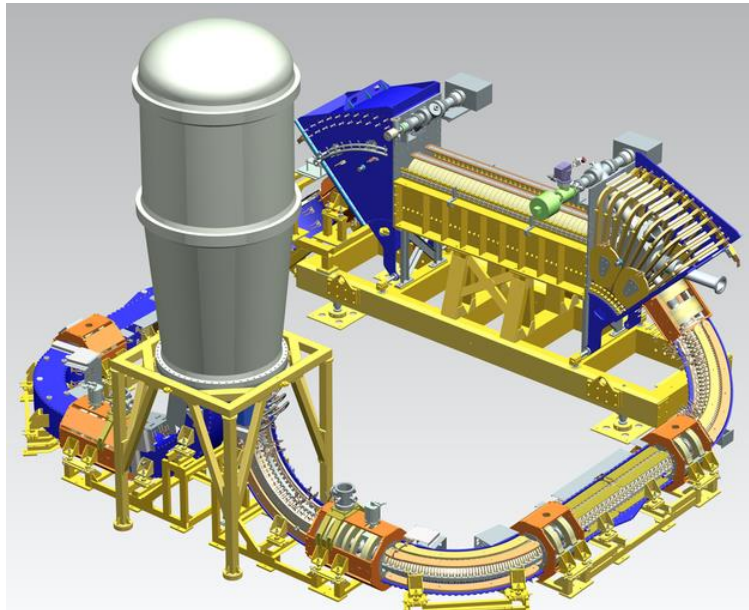
COSY

fully magnetized e-beam transport

0.1 MeV
up to 80 mT



2 MeV
up to 200 mT



J. Dietrich et al., COOL05

HESR: 4.5 MeV

upgradeable
to 8 MeV



B. Gålnander, HESR CM25

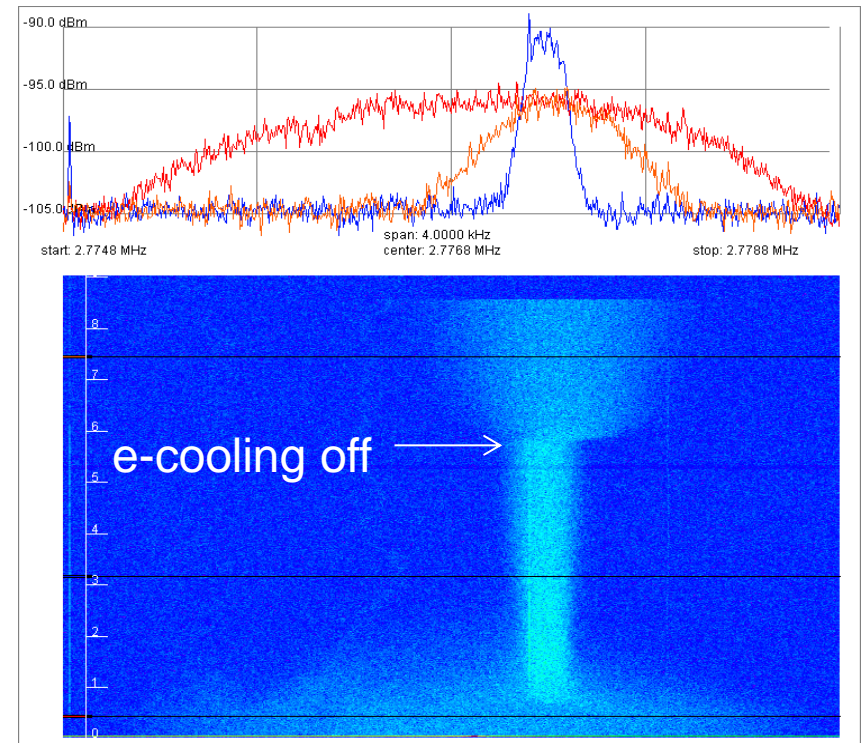
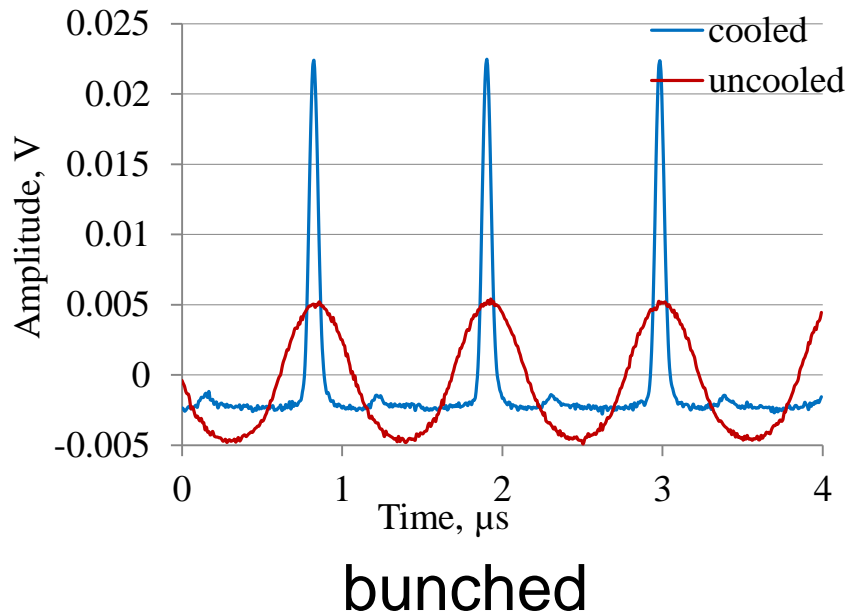
bunched beams?

2 MeV electron cooler at COSY, project milestones

- **2003 first ideas and discussions**
- 2004 development of prototype components started at BINP
- 2005 feasibility study
- **2005 dedicated working group on COSY 2 MeV cooler at COOL05 in Galena**
- 2005-2006 applications for funding
- 2006-2008 further reports completed (prototype of HV sections)
- 03.2009 allocation of funding
- 07. 2009 signing the contract with BINP for the development and manufacturing of the 2 MeV cooler
- **12. 2009 CDR finished**
- 2010-2012 Manufacturing at BINP
- 2012 initial commissioning with e-beam at BINP
- 12.2012 delivery to Jülich
- 04.2013 installation in COSY
- **10.2013 first beam cooling**



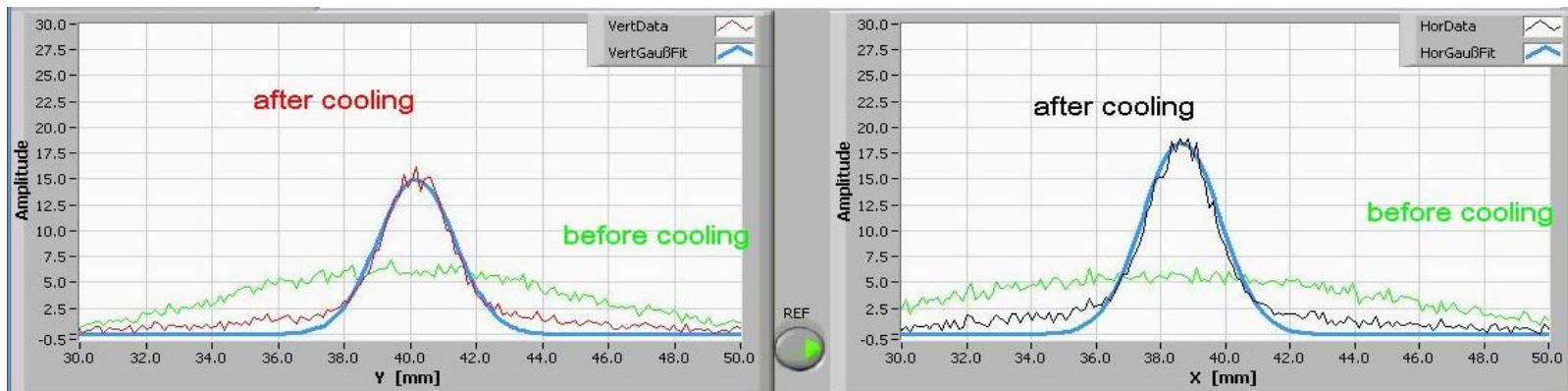
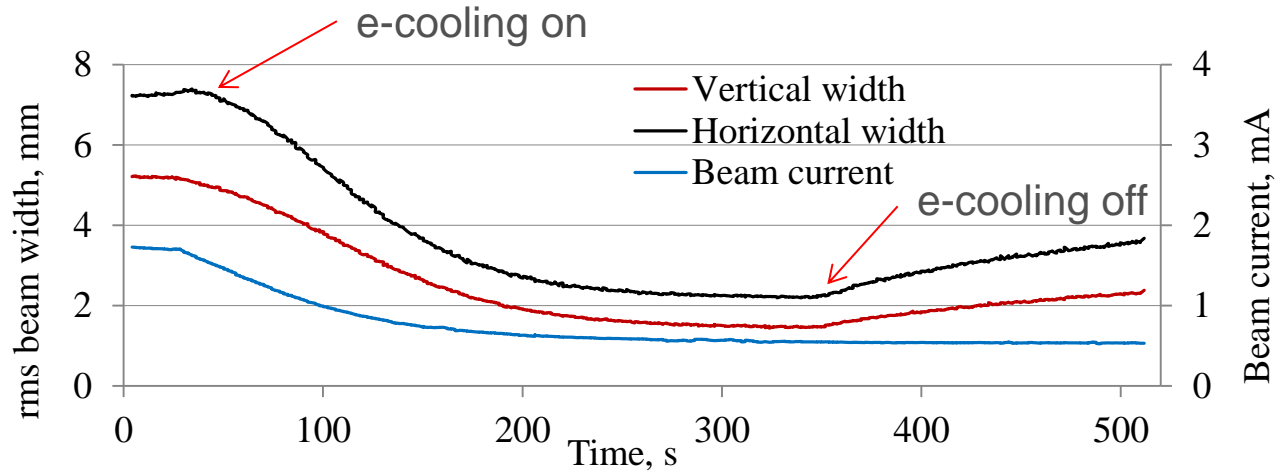
First electron cooling, 200 MeV protons



dc

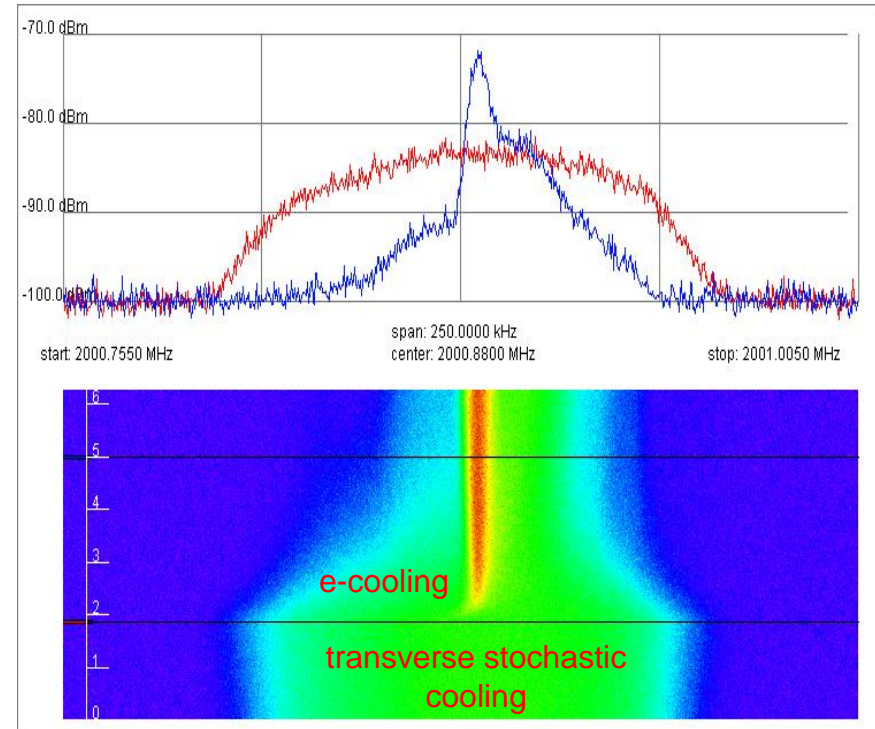
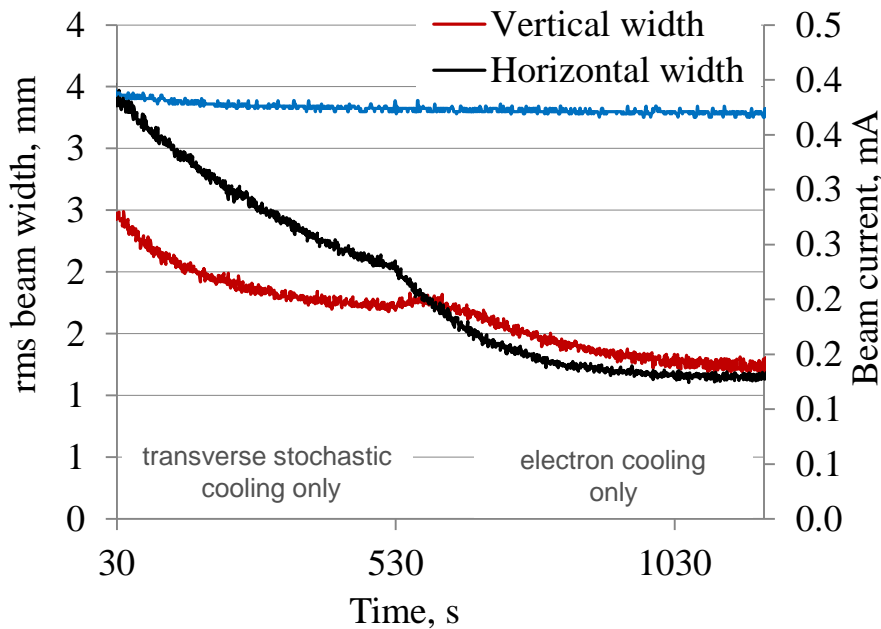
electron energy 109 keV, electron current 0.2 A

First electron cooling, 200 MeV protons, dc



electron energy 109 keV, electron current 0.2 A

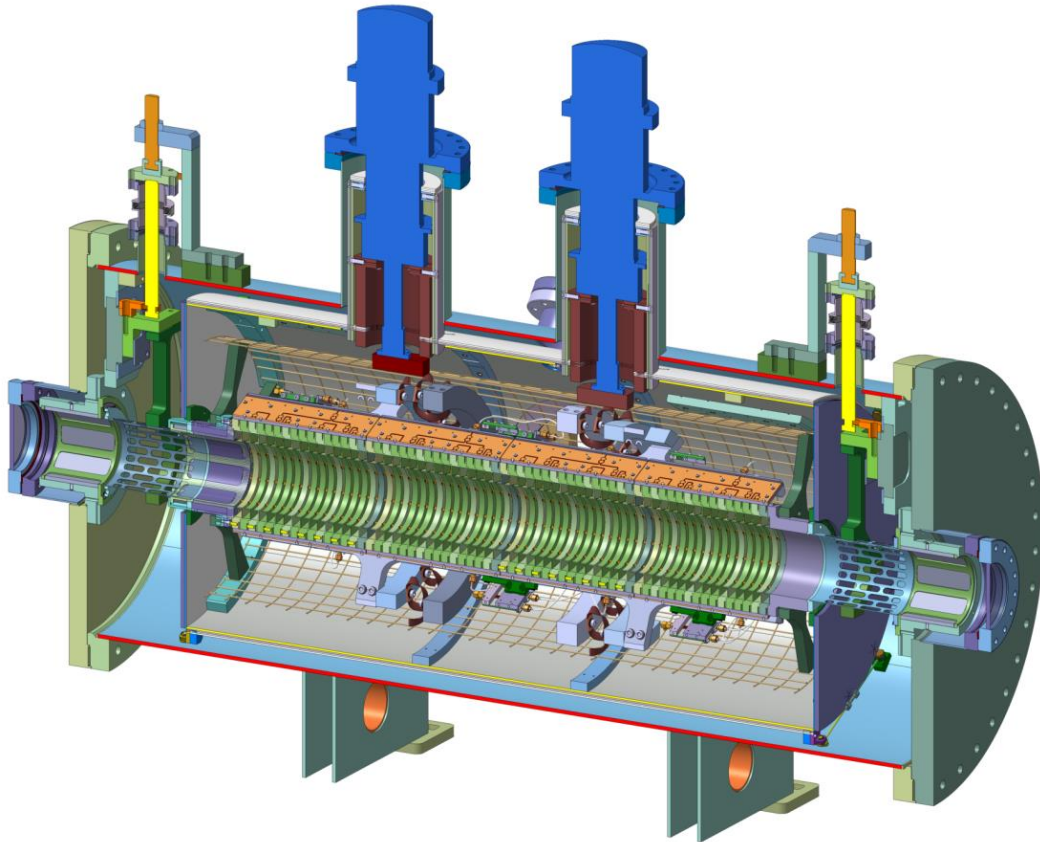
First electron and stochastic cooling 1670 MeV protons, dc



Transverse stochastic cooling was applied first. After turning off st. cooling e-cooling was applied

electron energy 908 keV, electron current 0.32 A

2-4 GHz Pickup



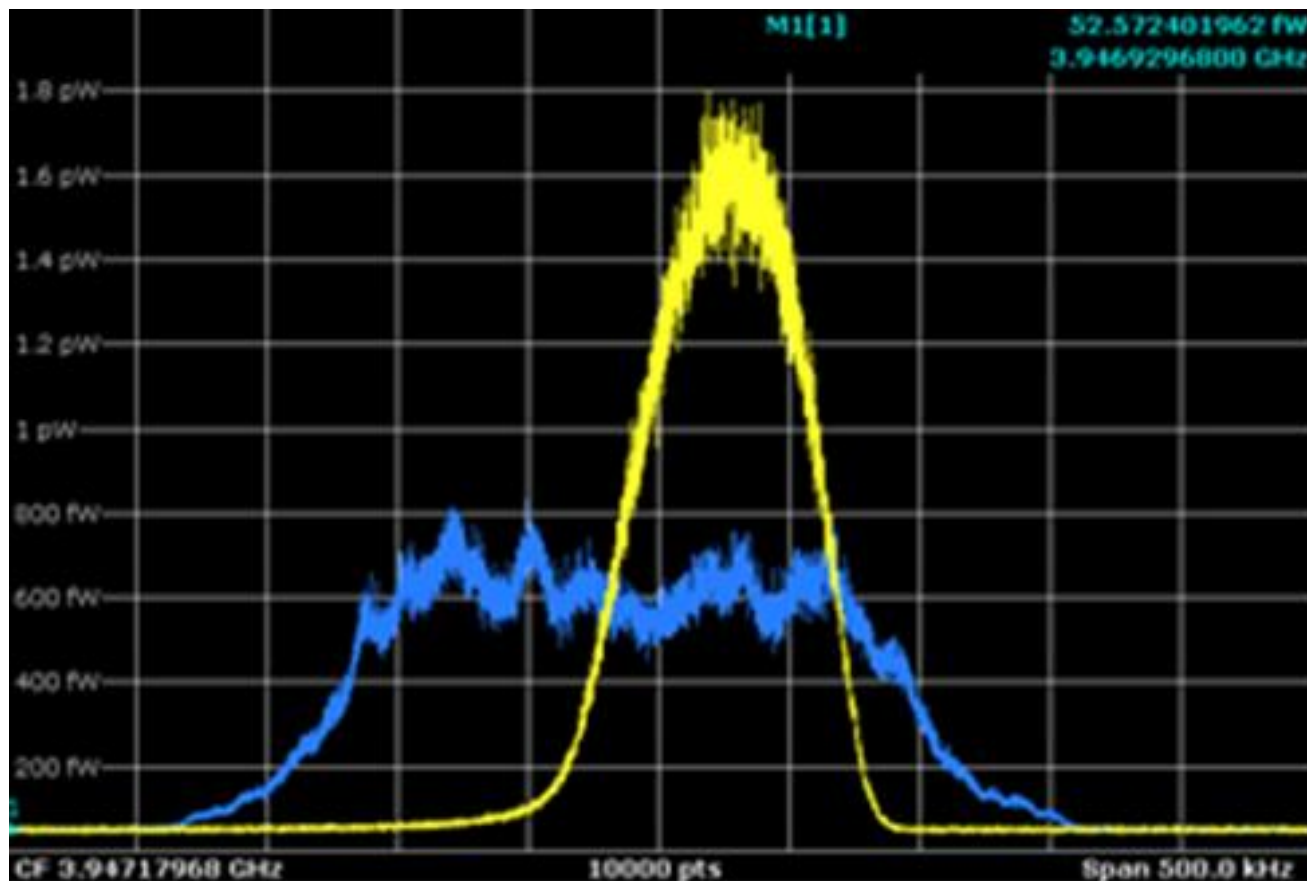
Development of a novel structure

R.Stassen, HESR CM34 Talk



Tests at COSY

First successful momentum cooling at the Nuclotron



20th of March 2013

Beam parameters:
Ions: D+
2E9 particles
Energy: 3 GeV/u
Time between blue
(initial distribution)
and yellow (final
distr.) 480 s

It's the first time that this structures have been used as Kicker!

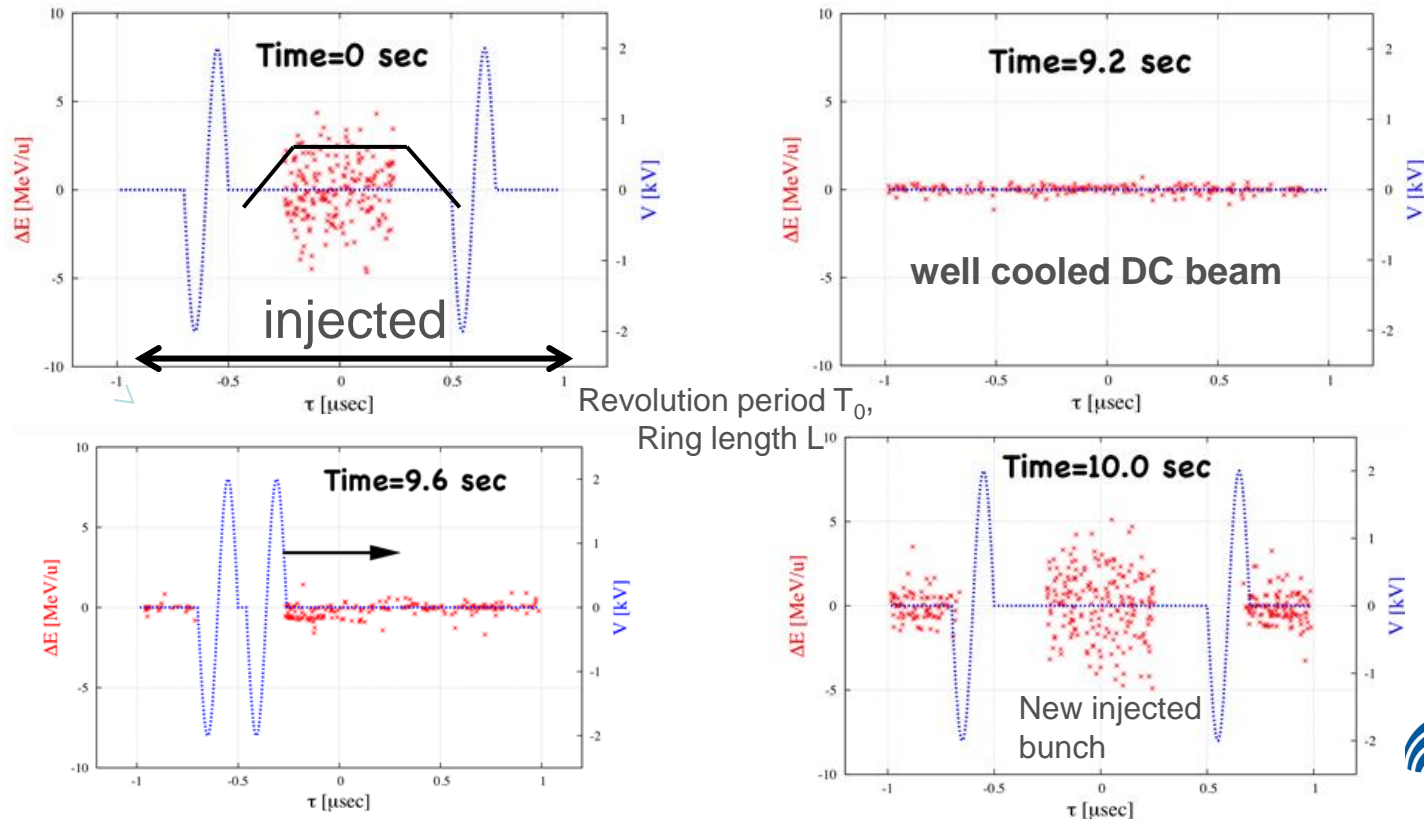
Antiproton beam accumulation in the HESR

Every 10 s one bunch with 10^8 antiprotons injected from CR into a gap created by two barrier pulses

Repeat 100 times for final 10^{10} antiprotons

Stochastic Momentum Cooling is essential!

M. Steck et al., POP Experiments 2010, COOL11
T.Katayama, et al., COOL13



Outlook

- Acquire experimental data on how the cooling rate scales with energy for comparison with existing models
- Investigate cooling performance in presence of internal targets
- Study/optimize interaction of the accelerator and the cooler
- Study intensity/impedance effects
- Explore simultaneous electron and stochastic cooling
- Dedicated beam time at COSY in March 2015
- Study the non-linearity of the power amps for stochastic cooling
- Design and test of 4-6 GHz structures

Summary

- The 2 MeV electron cooler at COSY is a unique device worldwide as it combines high energy and a fully magnetized e-beam transport
- The experimental data is needed to compare with existing models of high energy electron cooling (e.g. for HESR@FAIR, NICA)
- Novel pickup/kicker structures have been developed for the 2-4 GHz stochastic cooling system at HESR
- A prototype structure has been successfully tested at COSY and Nuclotron
- A novel beam accumulation scheme using barrier bucket and stochastic cooling has been worked out for future machines (HESR etc.)
- Operational experience (technological aspects, controls etc.) is mandatory for the future machines
- Collaboration on bunched beam electron cooling

Thanks for collaboration

BINP, BNL, CERN, GSI, HIM, JINR,
Nihon University