

The Ultra-low Storage Ring at FLAIR

Dr. Oleg Karamyshev

www.quasar-group.org

Overview

- Motivation
- Present situation and future projects
- Electrostatic rings
- USR
 - Design
 - Optimization, operation modes
 - Beam Instrumentation
- Conclusion

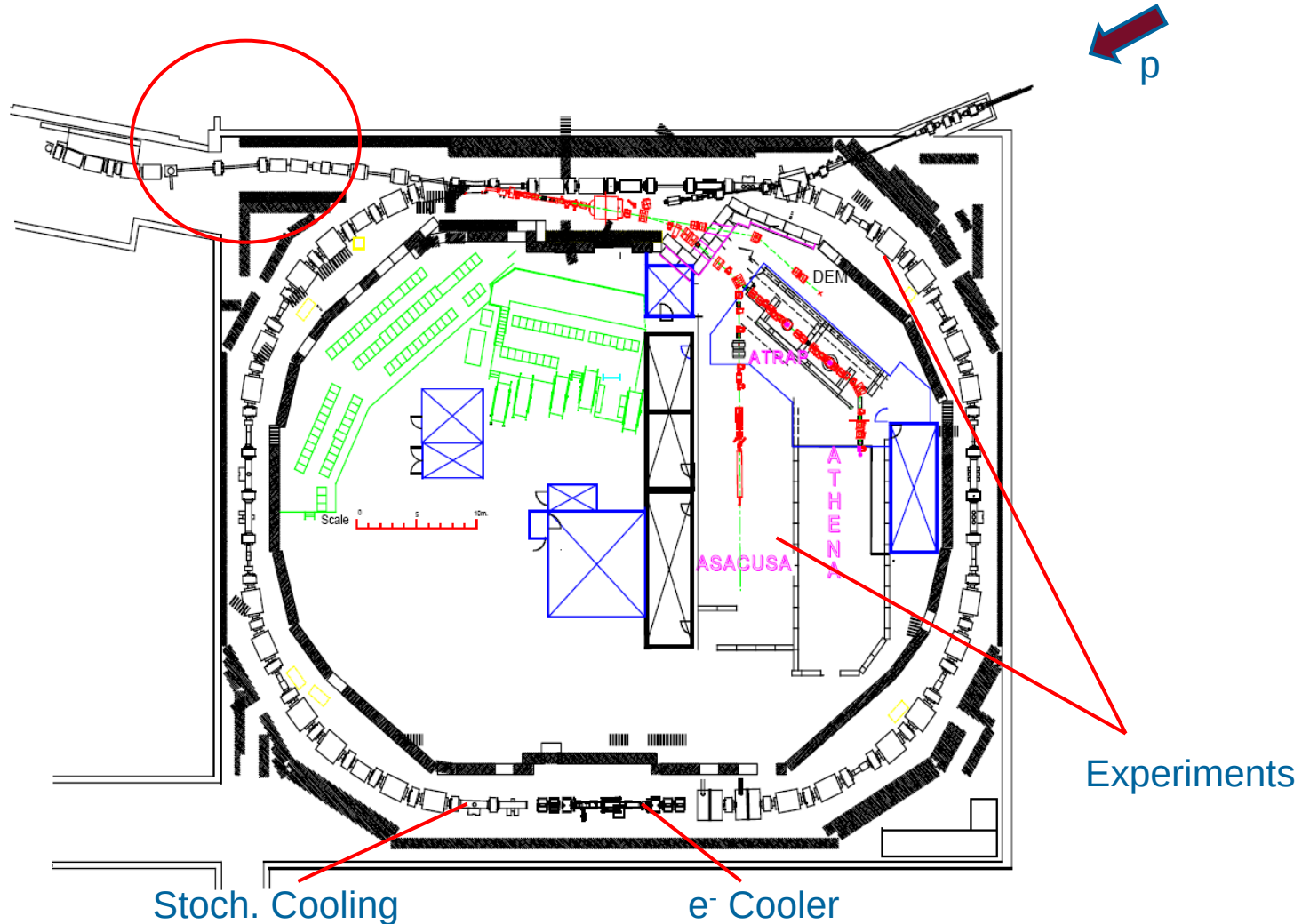
Present Situation: AD @ CERN

Target

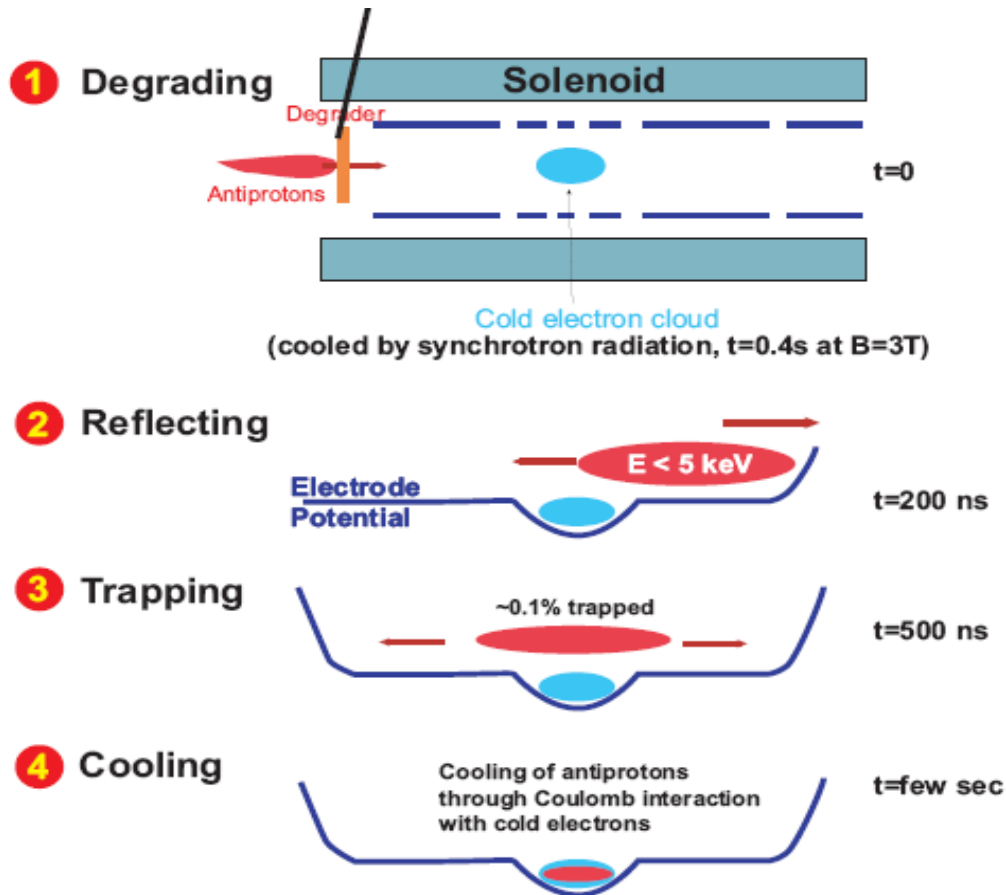
26 GeV/c p

→ 3.57 GeV/c $\bar{p}$

Yield: $4 \cdot 10^{-6}$



Problem: 5 MeV too high for trapping !



- $> 99.9\%$ of pbars lost in degrader.

~ 10.000 pbars/shot

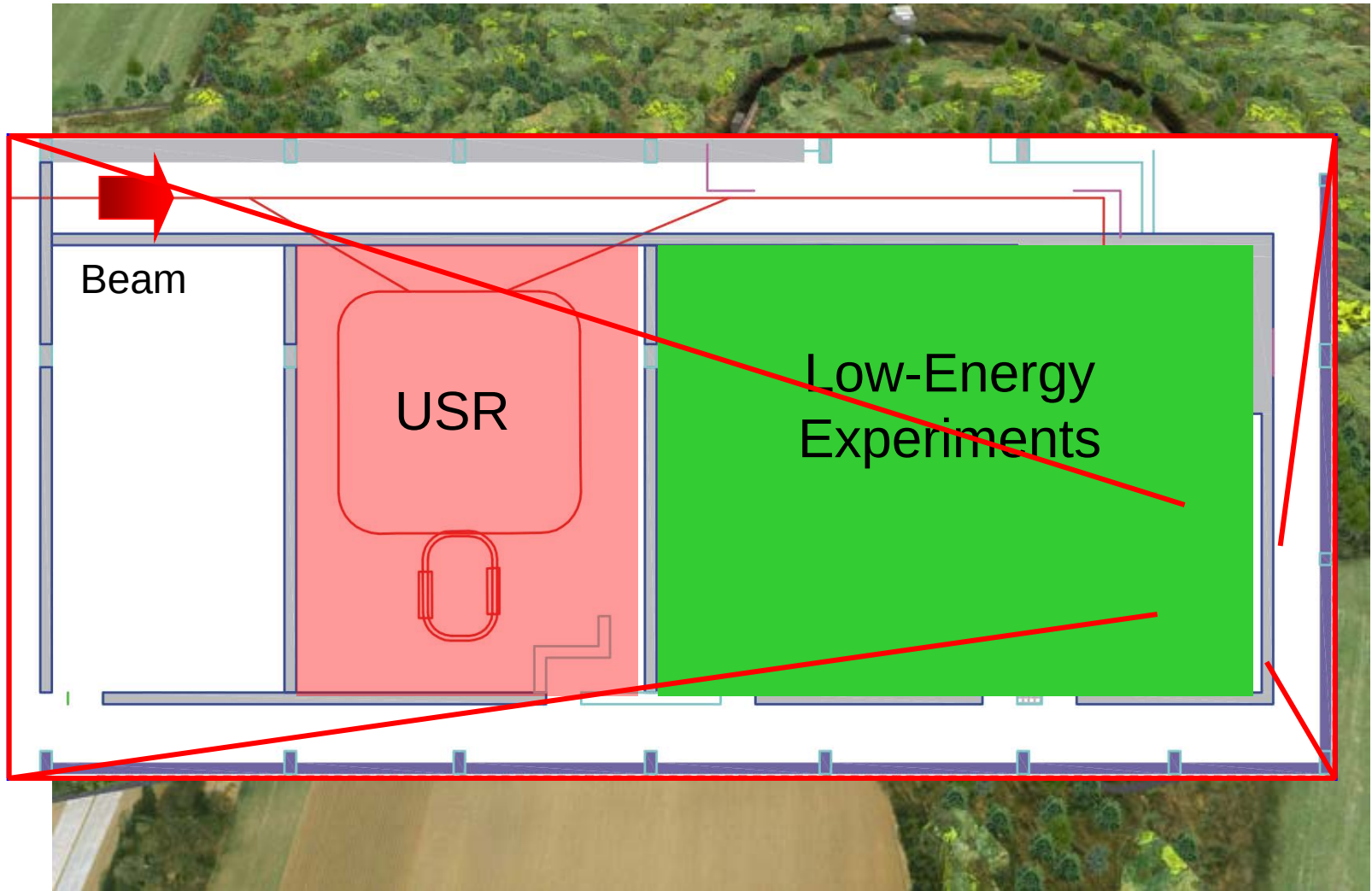
- ASACUSA: RFQ-D

$\sim 2.000.000$
pbars/shot

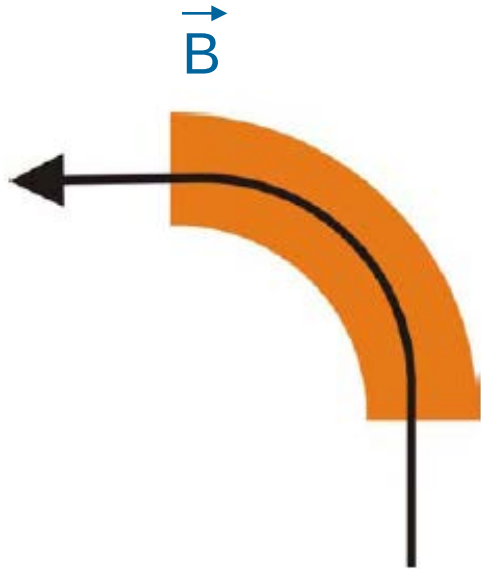
BUT: $\Delta E/E$, $\epsilon_{x,y}$

Low energy pbar rings

	AD	LSR	USR	ELENA
Energy range	Down to 5.3MeV	30 MeV – 300 keV	300 keV – 20 keV	5 MeV – 100 keV
Intensity	1.2×10^7	1×10^9 – 2×10^8	2×10^8 – 1×10^7	
Beam modes	Fast extraction	Fast extraction	Slow/fast extraction, ns bunches, merged beam	Fast extraction



Magnetic $\leftrightarrow$ Electrostatic



$$\frac{mv^2}{R} = q \cdot v \cdot B$$

$$R \cdot B = \frac{1}{q} \cdot \sqrt{2 \cdot m \cdot E_{Kin}}$$

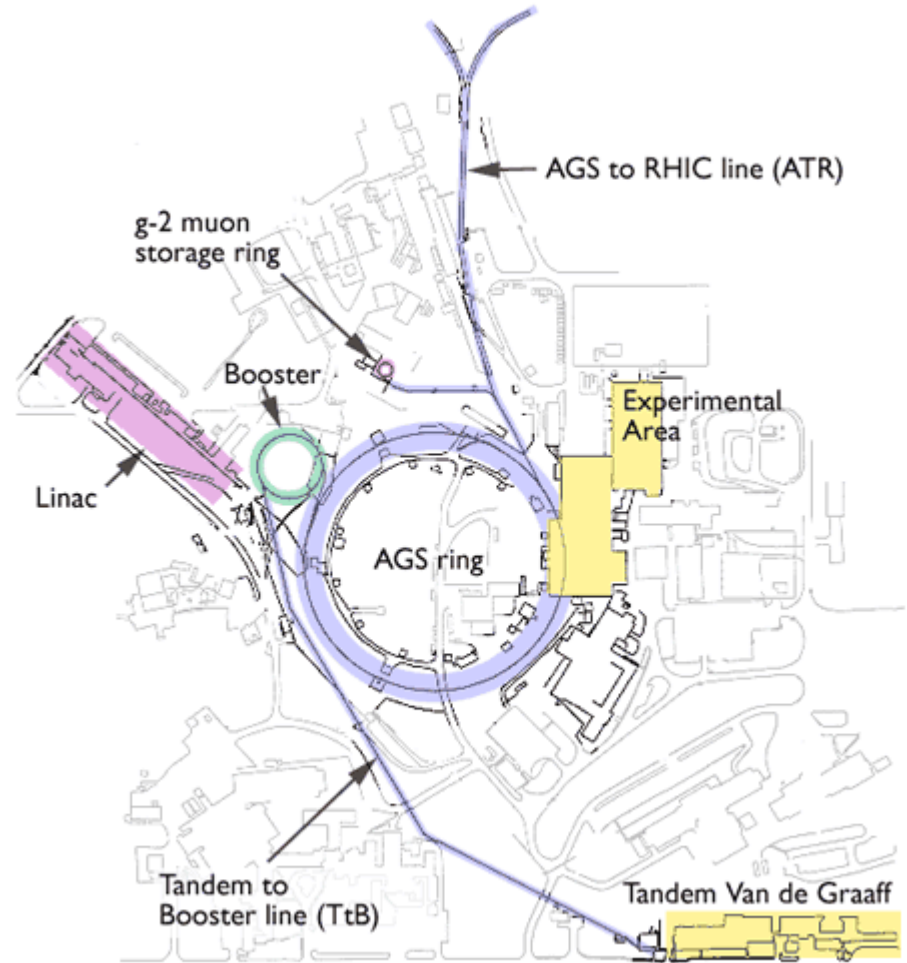
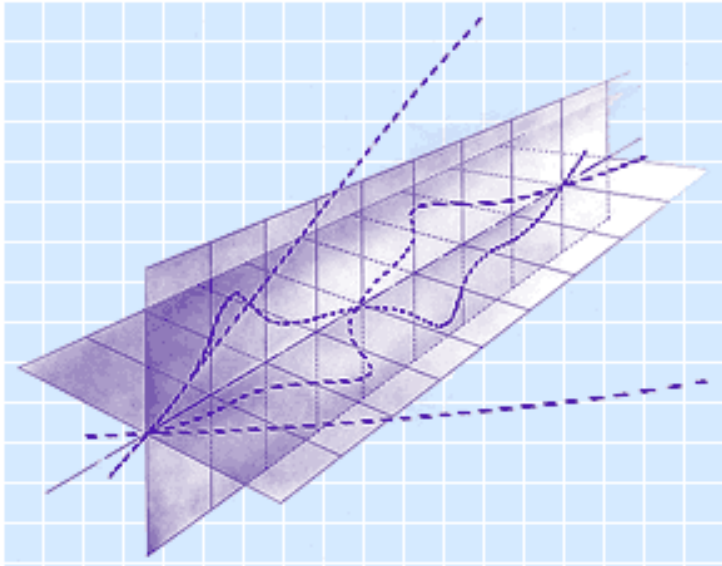


$$\frac{mv^2}{R} = q \cdot E$$

$$R \cdot E = \frac{2 \cdot E_{Kin}}{q}$$

The First Electrostatic Ring

Prototype for the AGS in Brookhaven



Existing Electrostatic Rings



ELISA, Denmark



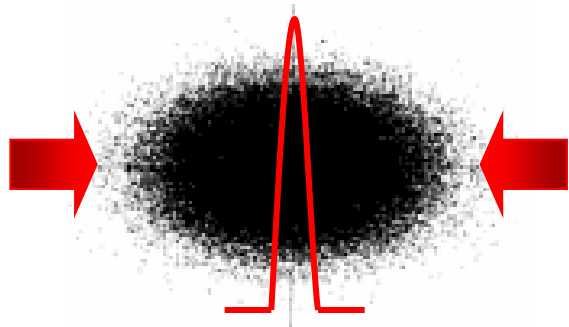
KEK, Japan



TMU

USR – First Design in 2005 and Ring Re-Design

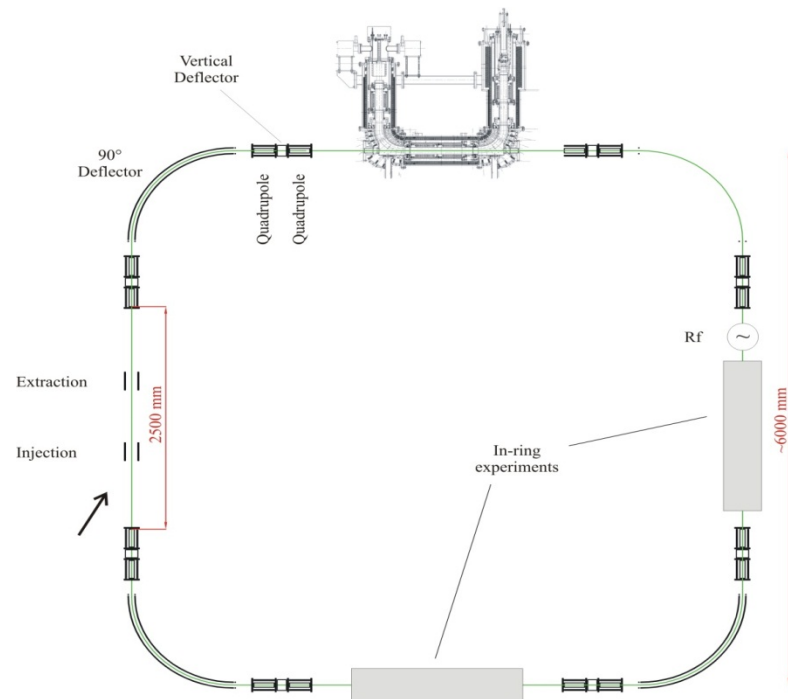
How to realize nanosecond bunches ?
How to extract the beam ?



ns Bunching

Steps:

- General feasibility
- 1-D simulation
- Full study



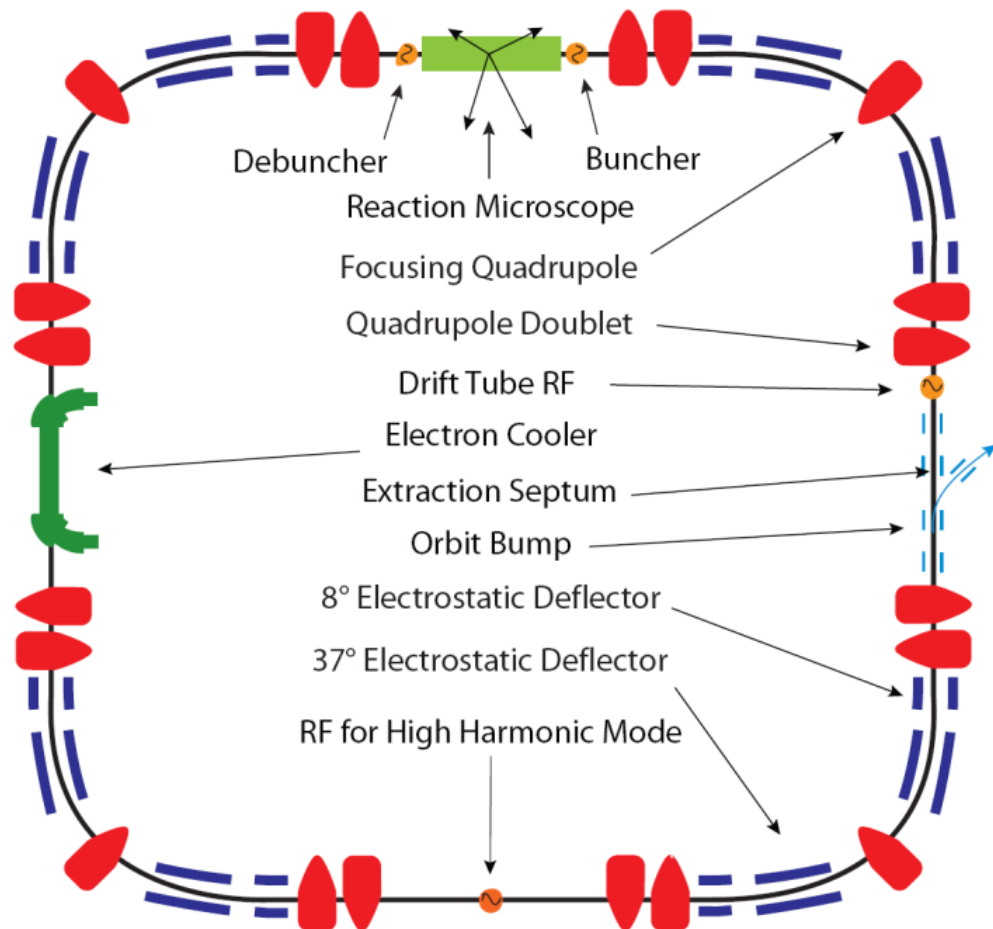
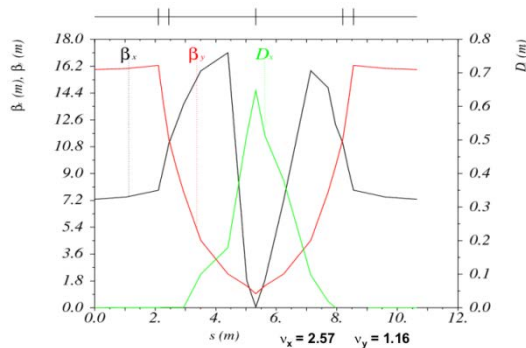
Welsch, C.P., et al.
Nucl. Instrum. Methods A **546**
405–417 (2005)

Modification to USR Lattice

"Split-achromat" geometry, new concept.

Achromatic section, $D=D'=0$ in straights.

D never > 0.6 m.



A.I. Papash, et al, Proc. PAC (2009)

Staged approach

Deceleration of beam to 20 keV

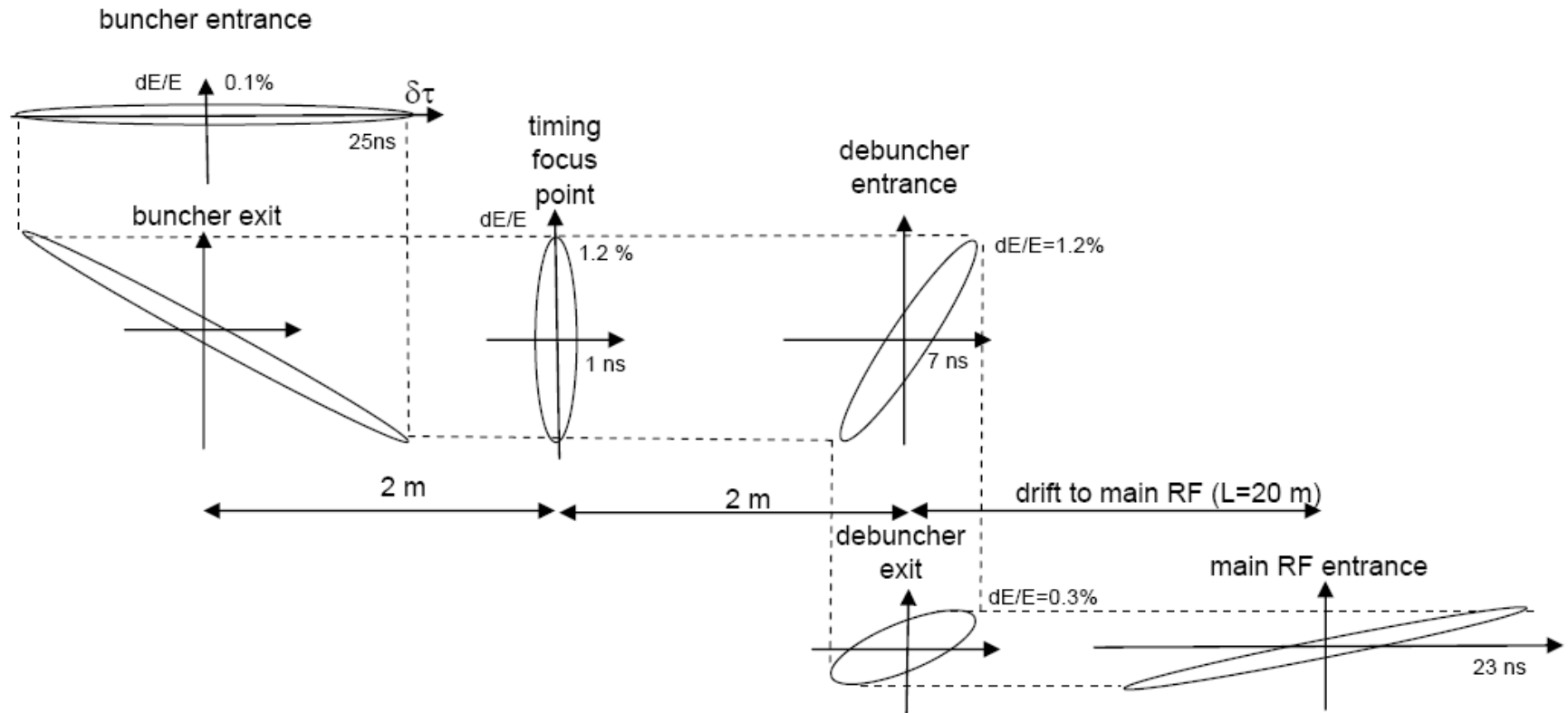
e^- cooling to $\Delta E/E = 5 \cdot 10^{-4}$

Capture beam @ 20 MHz (50 ns)

$3\beta\lambda/2$ buncher / debuncher

A. Papash, C.P. Welsch, Part Phys. Nucl. Letters **3** (2009)

Evolution in Phase Space



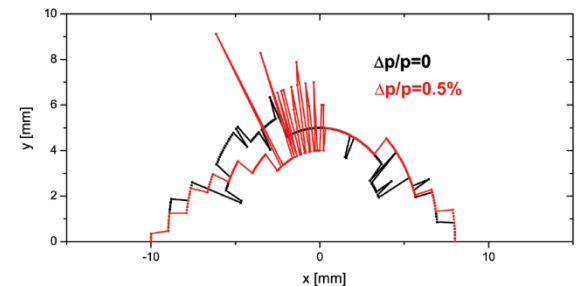
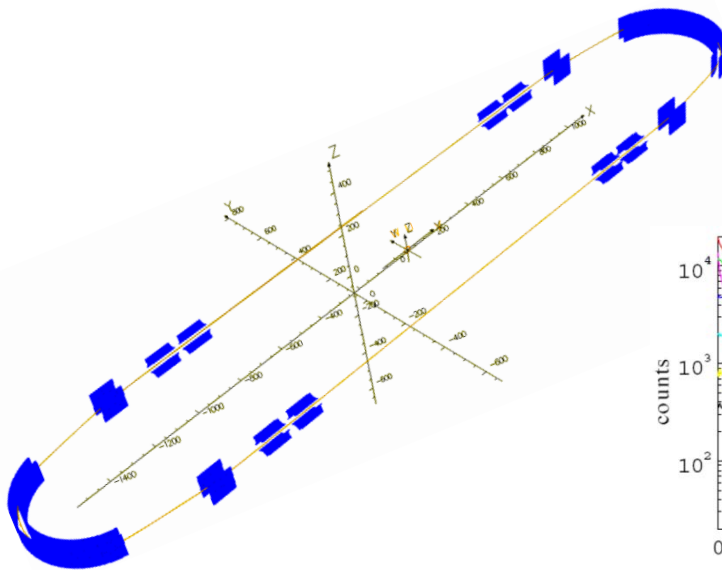
Crucial: Dispersion in straight section !

A.I. Papash, C.P. Welsch, PPNL 6 (3) (2009)

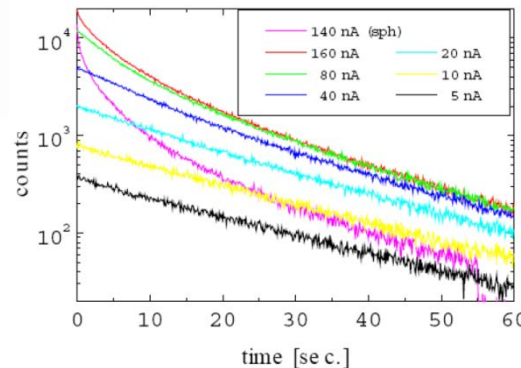
A.I. Papash, C.P. Welsch, Nucl. Instr. Meth. A 620 (2010)

USR – Advanced Studies

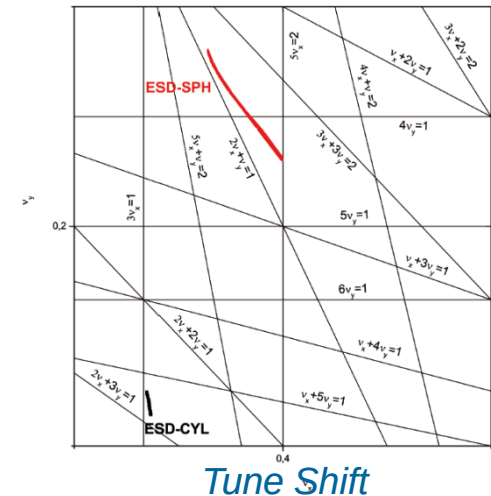
- Full 3D ring model, detailed studies (OPERA, MAD-X)
- Explained life time, $\Delta p/p$, etc.



Dynamic Aperture



Beam Loss

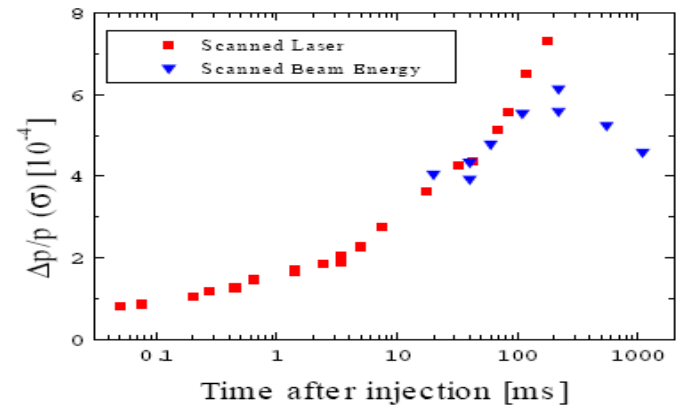
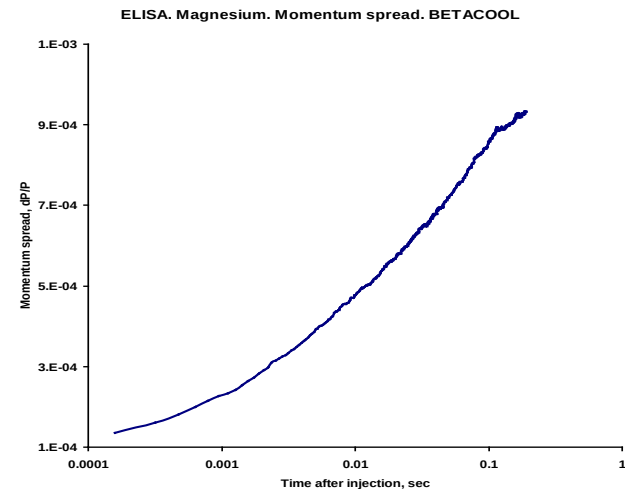
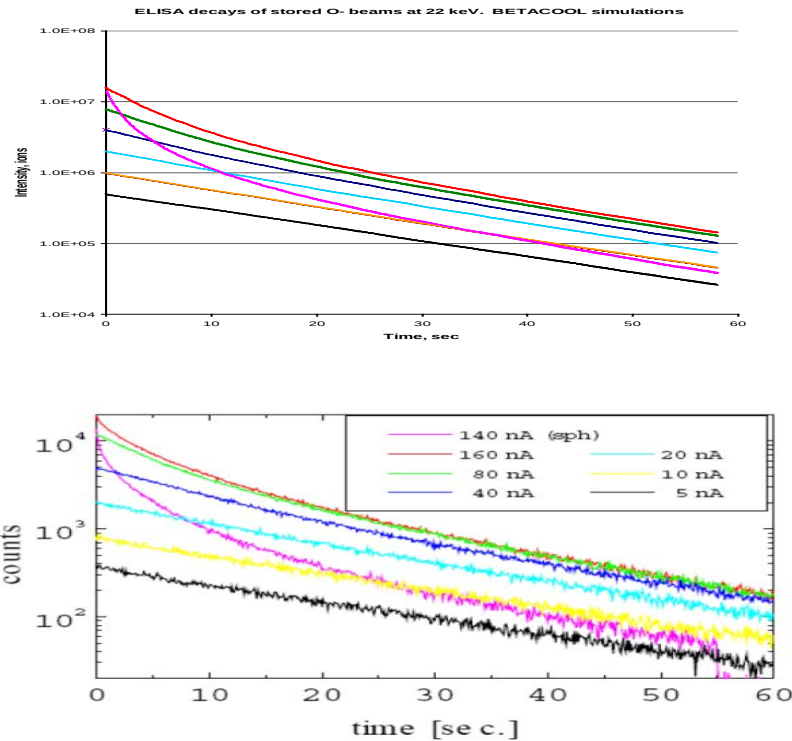


Tune Shift

O. Gorda, A.I. Papash, C.P. Welsch, Proc. IPAC (2010)

A.I. Papash, A. Smirnov, C.P. Welsch, Phys. Rev. STAB 16 060101 (2013)

Beam Dynamics



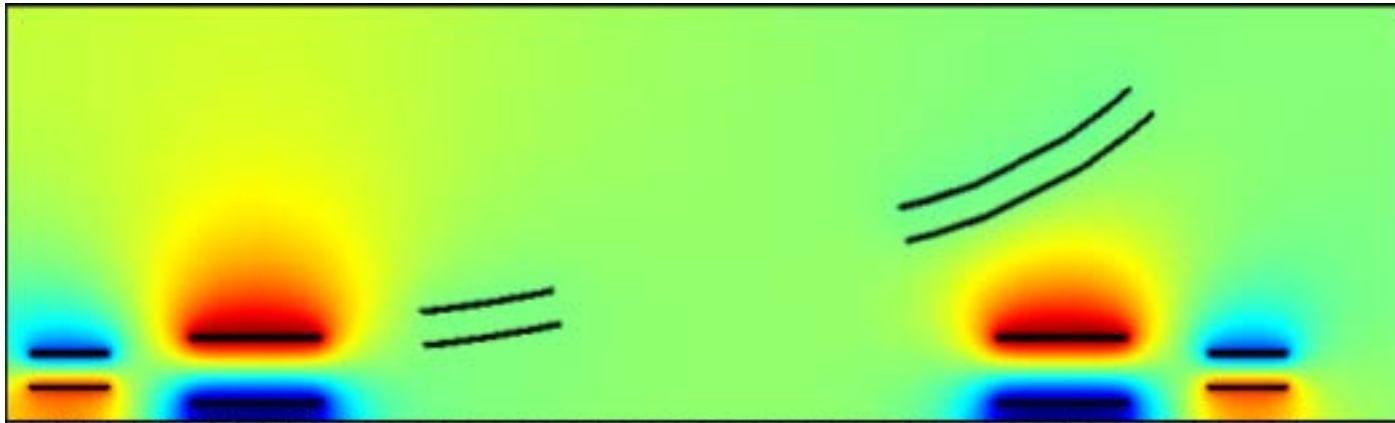
■ Use ELISA for benchmarking

A.I. Papash, A. Smirnov, C.P. Welsch, Phys. Rev. STAB 16 060101 (2013)

S.P. Moller. „Intensity Limitations of the Electrostatic Storage Ring ELISA“. Proc. of EPAC-2000. p.788-790

USR - slow/fast Extraction

Goal: Combined system, providing highly-flexible extraction



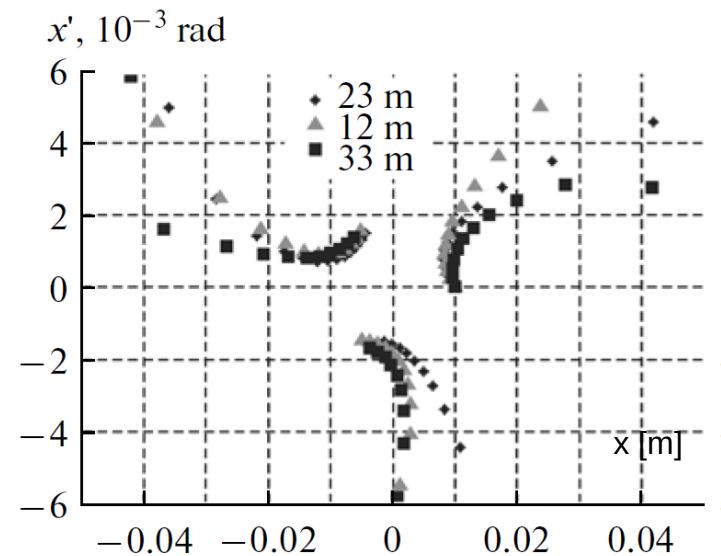
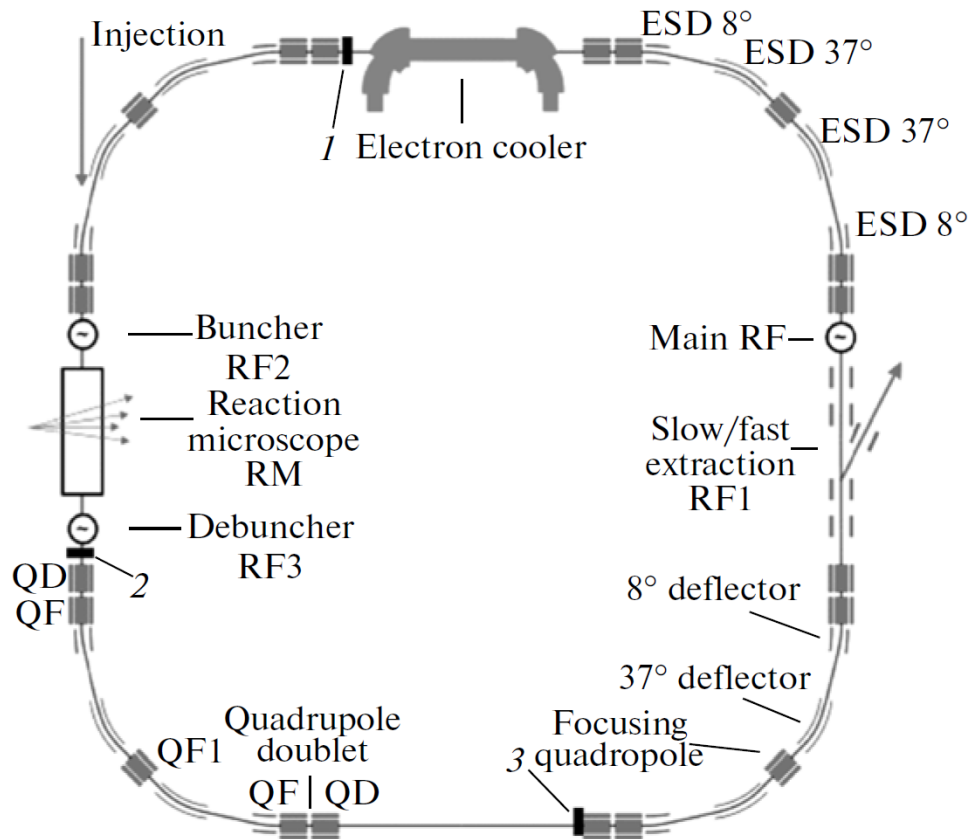
Motivation: Nuclear physics-type experiments.

➡ First time in electrostatic ring !

Used: Comsol, benchmarked against OPERA results.

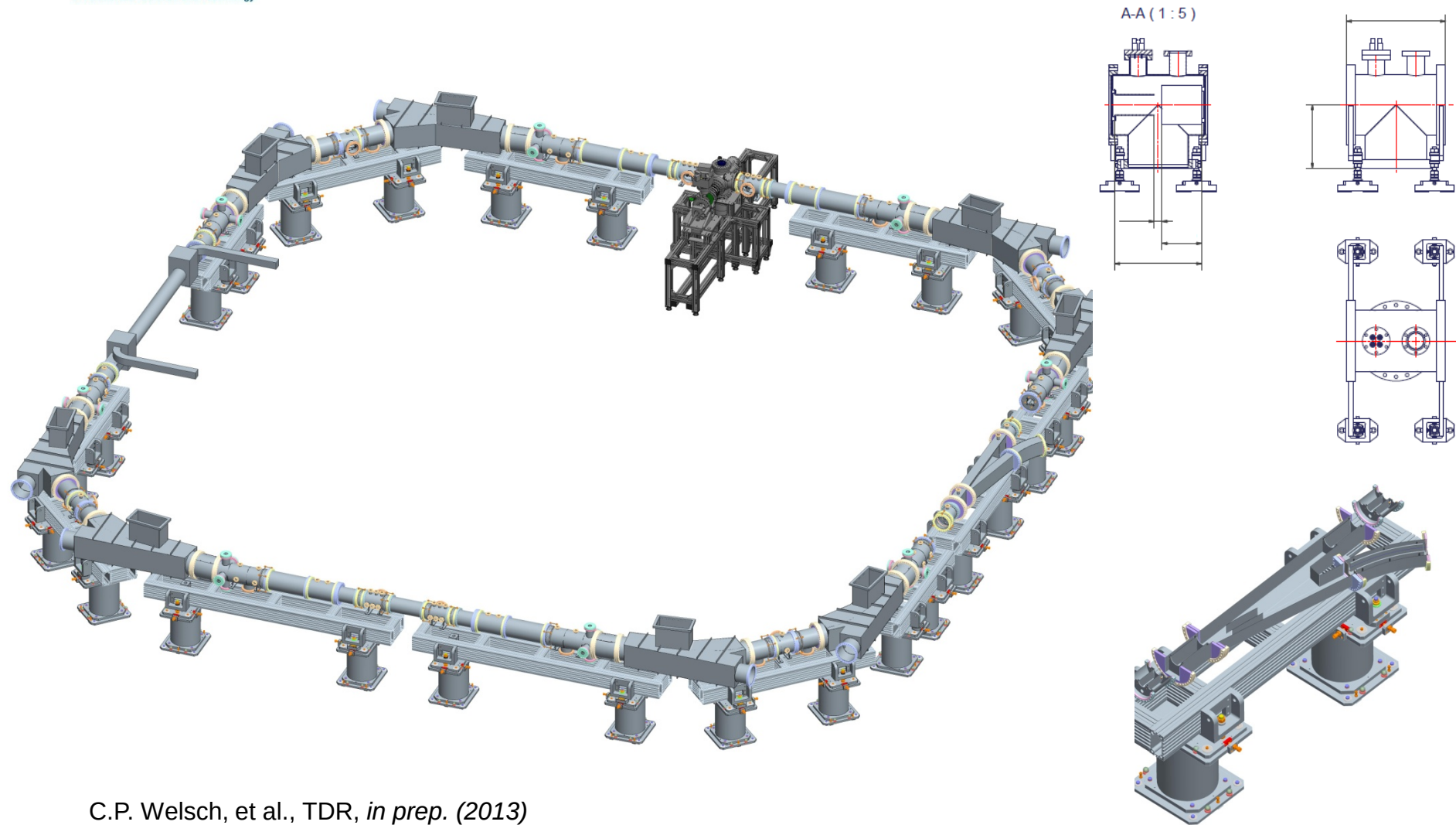
G. Karamysheva, A.I. Papash, C.P. Welsch, Part Phys. Nucl. Letters **8** (2011)

Sextupole Integration



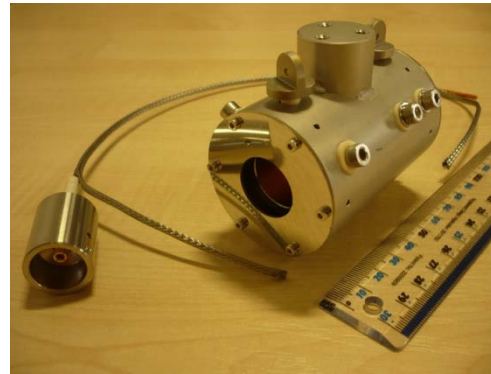
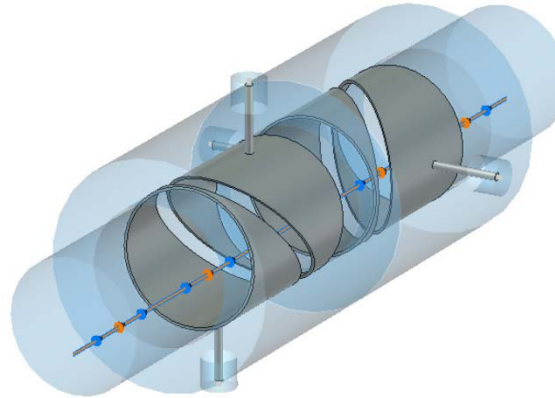
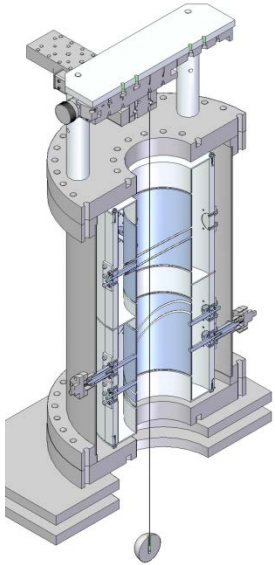
G. Karamysheva, A.I. Papash, C.P. Welsch, Part Phys. Nucl. Letters **8** (2011)

USR - Technical Design

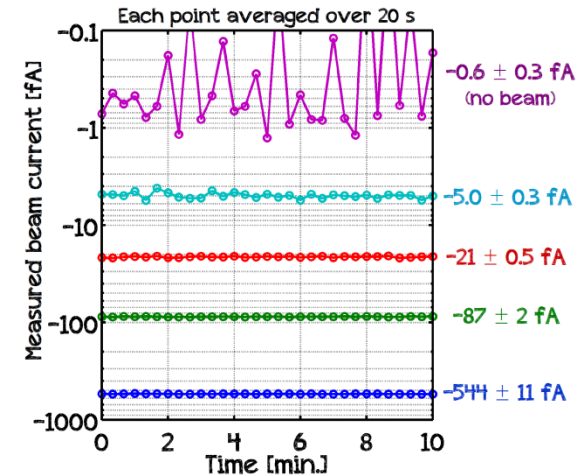


C.P. Welsch, et al., TDR, *in prep.* (2013)

USR – Diagnostics



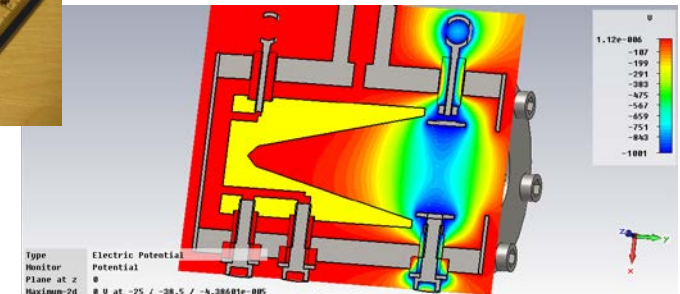
- Position
- Profile
- Intensity
- AEgIS Setup – see poster



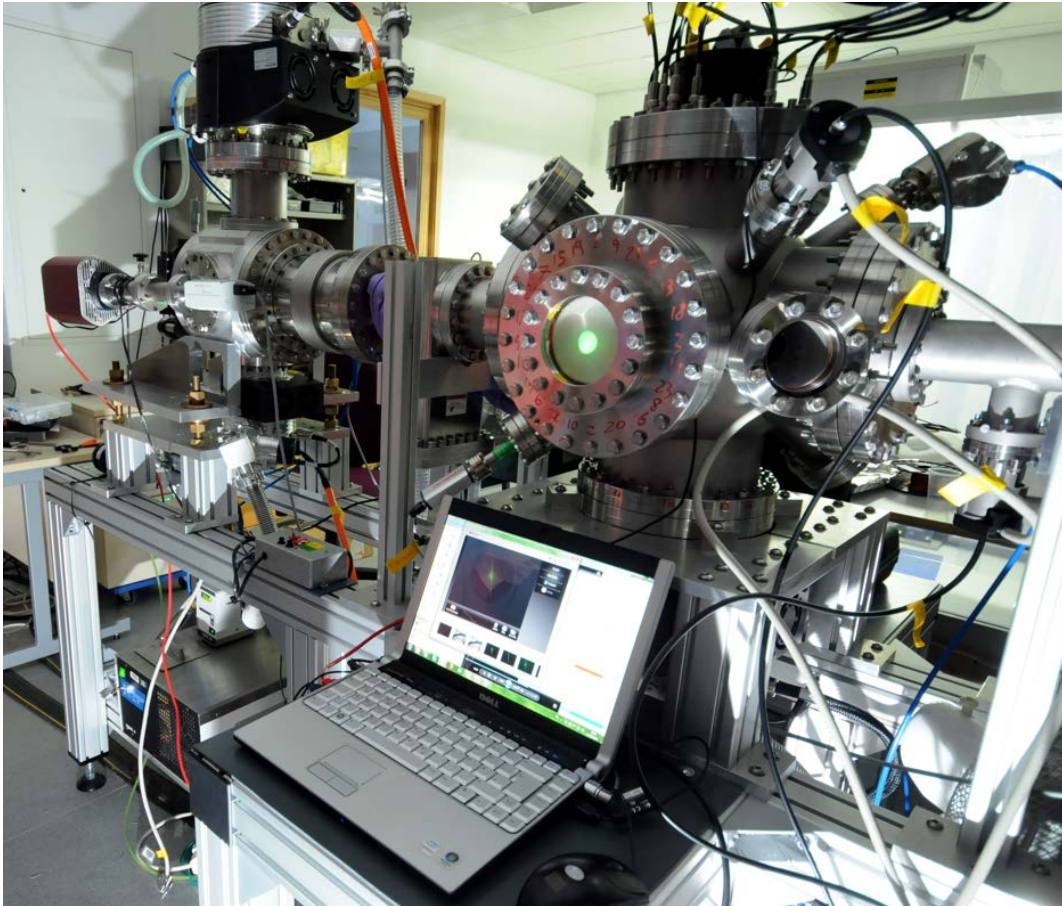
J. Harasimowicz, et al.,
Hyperfine Interact. (2009)

J. Harasimowicz, et al.,
Rev. Sc. Instr. **81** (9) (2010)

J. Harasimowicz, et al.,
Phys. Rev. STAB **15** (2012)



Profile Measurement and Collision Experiments: Prototype Setup



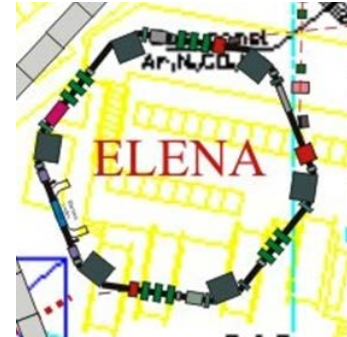
- Proof-of-principle setup at the CI;
- Gas jet and IPM;
- Designed for use with low energy antiproton beams:
 - Profile Monitor
 - Atomic physics experiments.

M. Putignano, C.P. Welsch, Hyperfine Interact. (2009)
M. Putignano, C.P. Welsch, Nucl. Instr. Meth. A (2012)

Antimatter Research – Future

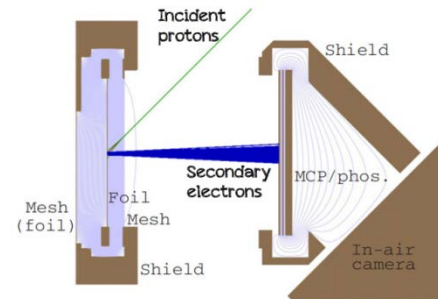
■ USR TDR being finalized

- Ring design
- All diagnostics
- Optimization done against experimental program



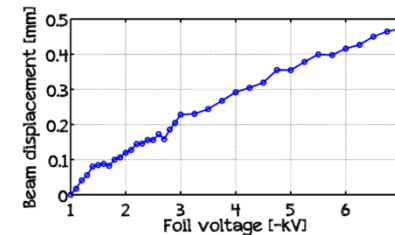
■ ELENA Storage Ring

- Ring design
- Life time studies
- Beam lines



■ AEgIS setup

- Detector and instrumentation tests



Conclusion

- Low energy pbars exciting tool for fundamental research;
- USR ring design, incl. mechanical design, done and TDR submitted;
- Detailed understanding of beam dynamics;
- Beam instrumentation prototypes developed and tested; setup at AEgIS

Many thanks for your attention !

...and to all QUASARs who contributed.