Design of Electrostatic Storage Rings & Beamlines

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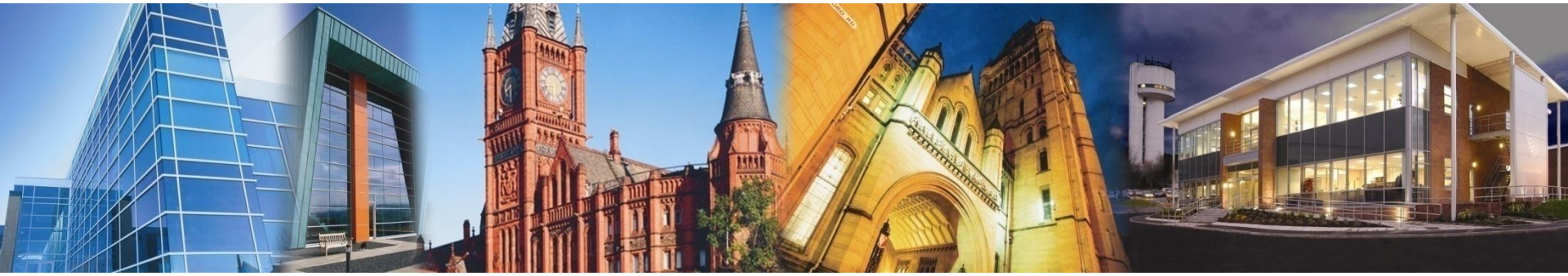

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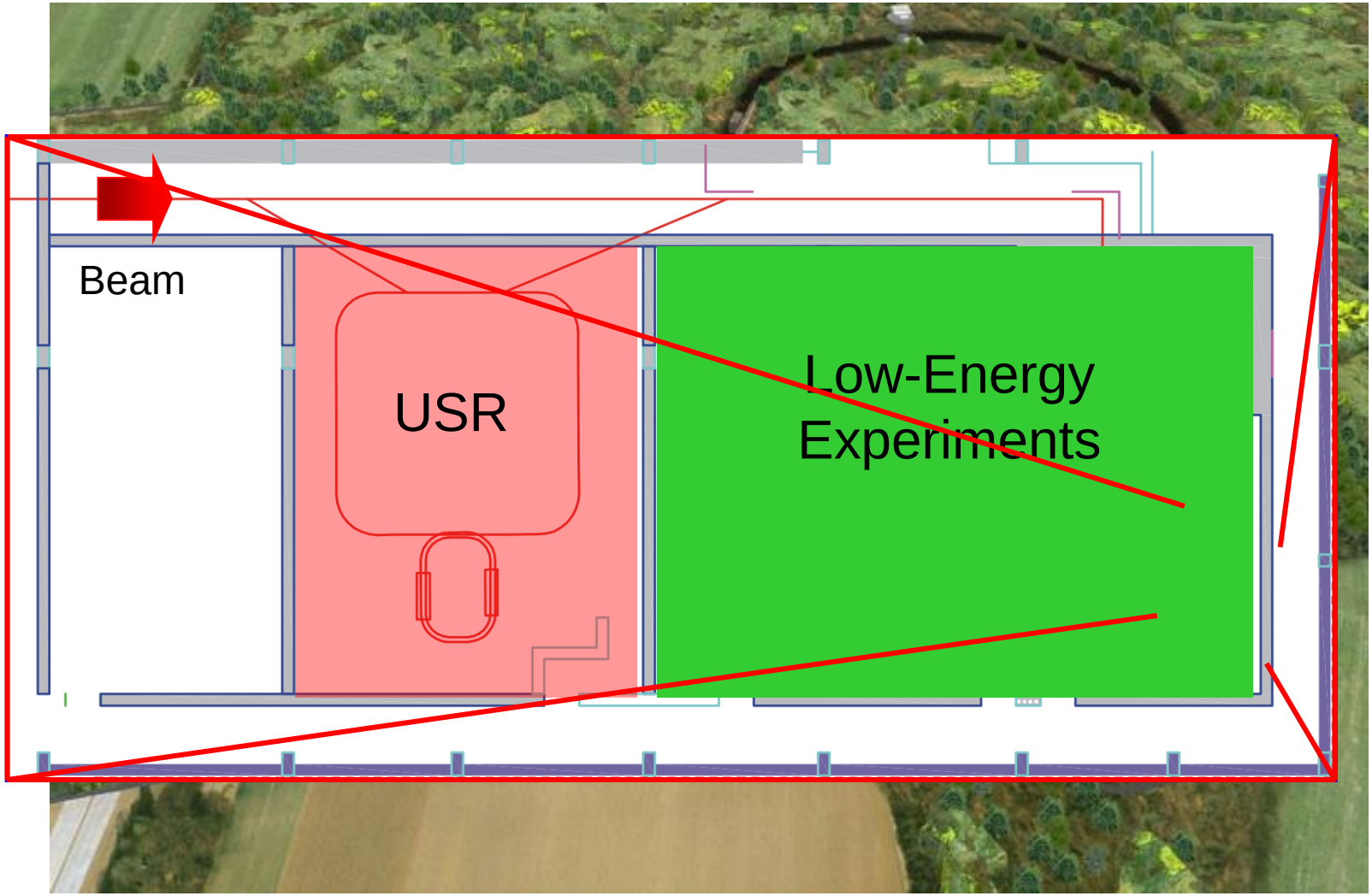
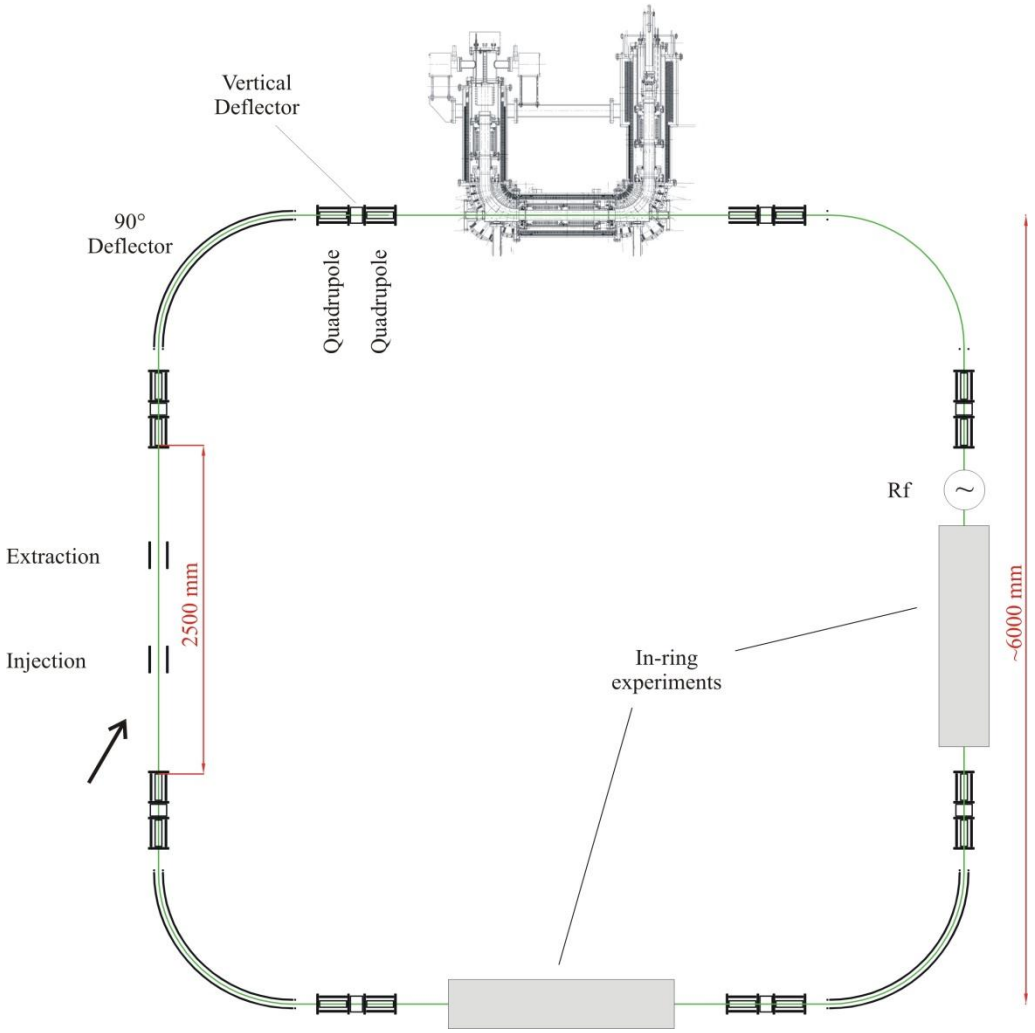
Outline

- Background: FLAIR
- USR as an example of studies done
- Overview of code packages used
- Mechanical design

FLAIR @ Facility for Antiproton and Ion Research



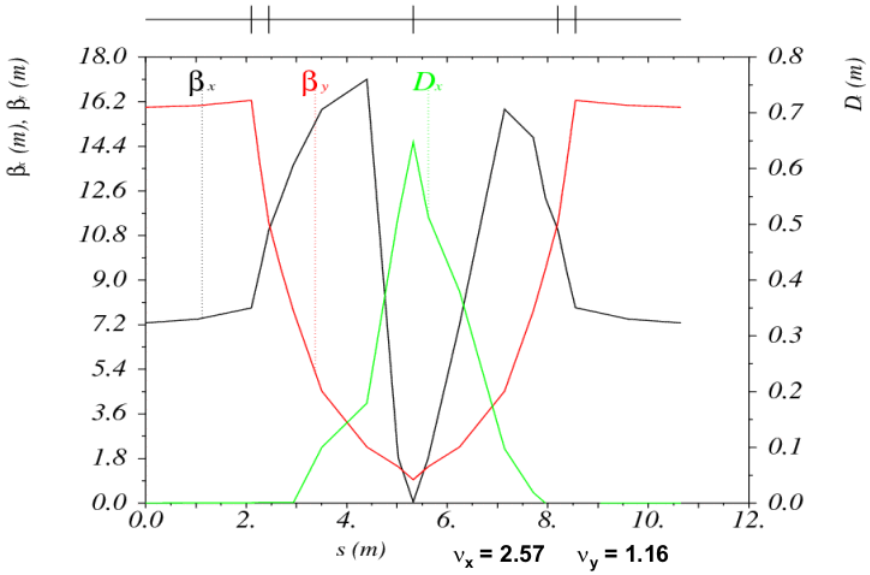
USR: First Design in 2005

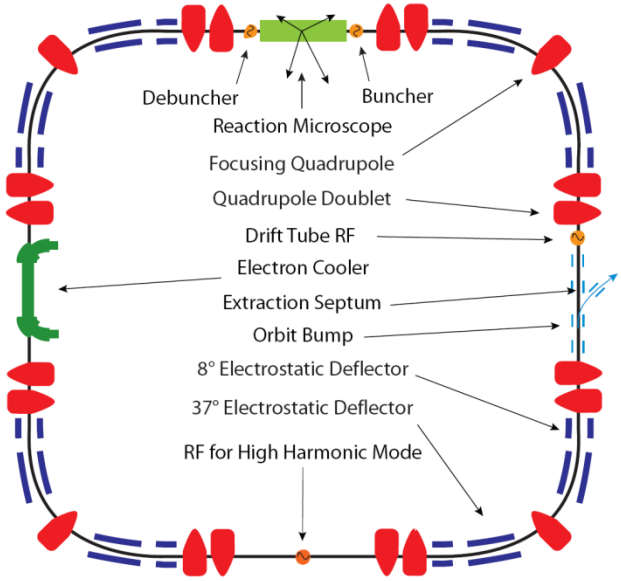


Welsch, C.P., et al.
Nucl. Instrum. Methods A **546**
405–417 (2005)

Modification to USR Lattice

- "Split-achromat" geometry, new concept

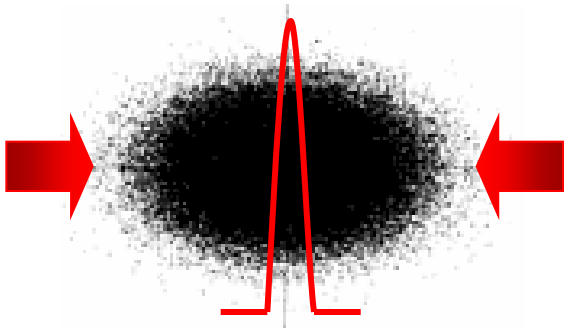




- Achromatic section, D=0 in straights
- D never > 0.6 m. MAD-X, COSY

A.I. Papash, et al, Proc. PAC (2009)
C.P. Welsch, et al., Hyp. Inter. 194 (2009)

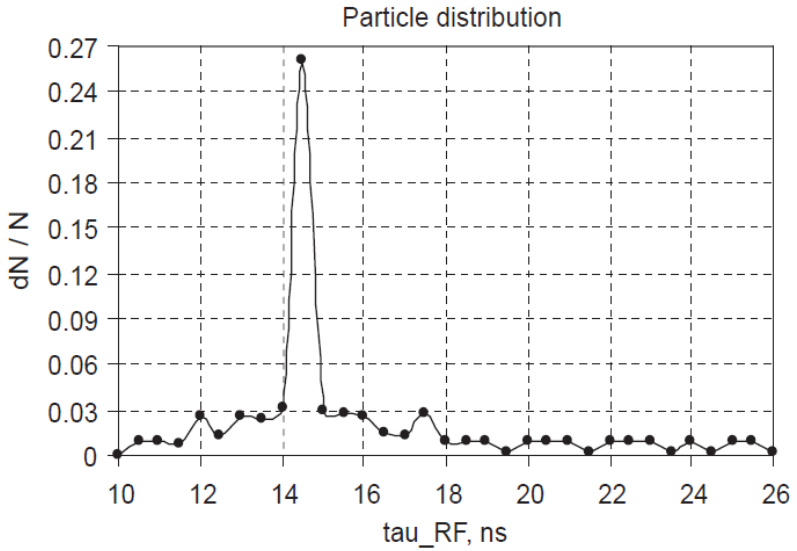
USR – Ring Re-Design



ns Bunching

How to realize nanosecond bunches ?

How to extract the beam ?



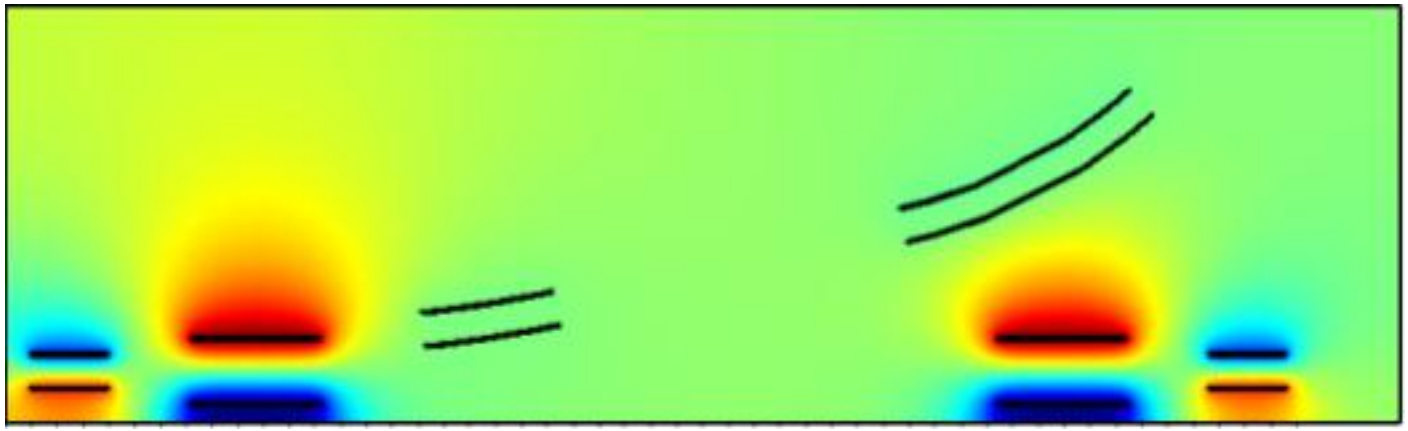
A.I. Papash, C.P. Welsch, Part Phys. Nucl. Letters **3** (2009)
A.I. Papash, C.P. Welsch, Nucl. Instr. and Meth. A **620** (2010)

Steps:

- General feasibility
- 1-D simulation (ESME)
- Full study (OPERA, MAD-X)

USR - slow/fast Extraction

Goal: Combined systen, providing highly-flexible extraction



Motivation: Nuclear physics-type experiments.

➡ First time in electrostatic ring !

Used: Comsol, benchmarked against OPERA results.

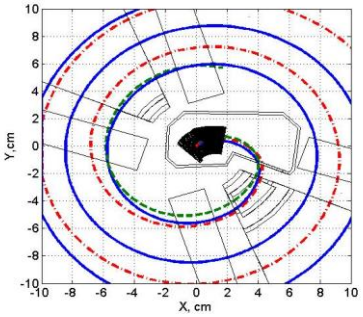
G. Karamysheva, A.I. Papash, C.P. Welsch, Part Phys. Nucl. Letters **8** (2011)

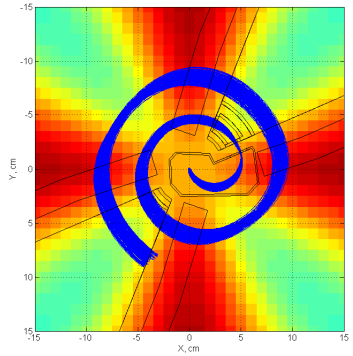
Detailed Studies: Simulink Code

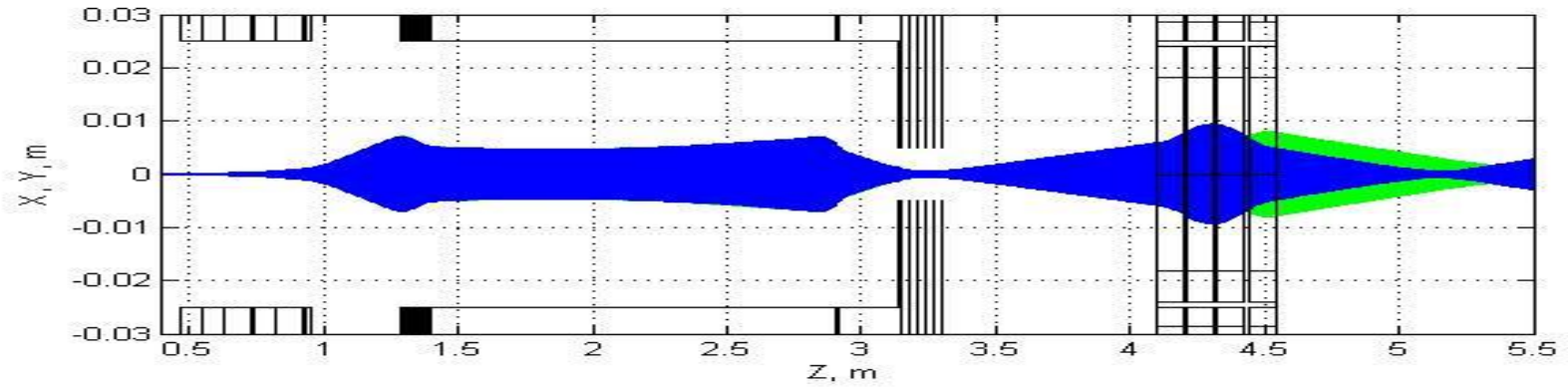
- Code can use electromagnetic field maps from various sources:
  - Opera,
  - Comsol,
  - CST Studio,
  - ANSYS
- Experimentally measured field maps
- Analytically calculated

Previous work (examples)

- Code was used to simulate:
  - Extraction from traps
  - Injection/extraction systems
  - Beam dynamics in cyclotrons
  - MUSASHI trap
  - Electrostatic ring USR

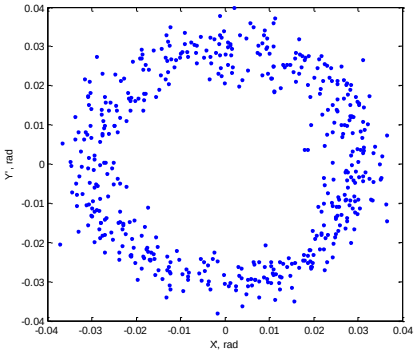


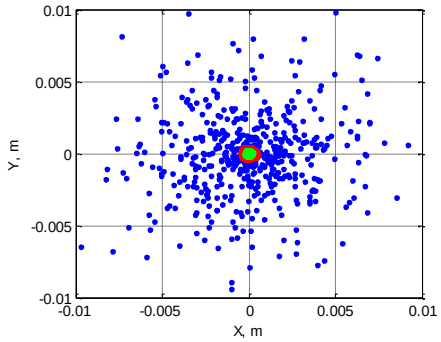


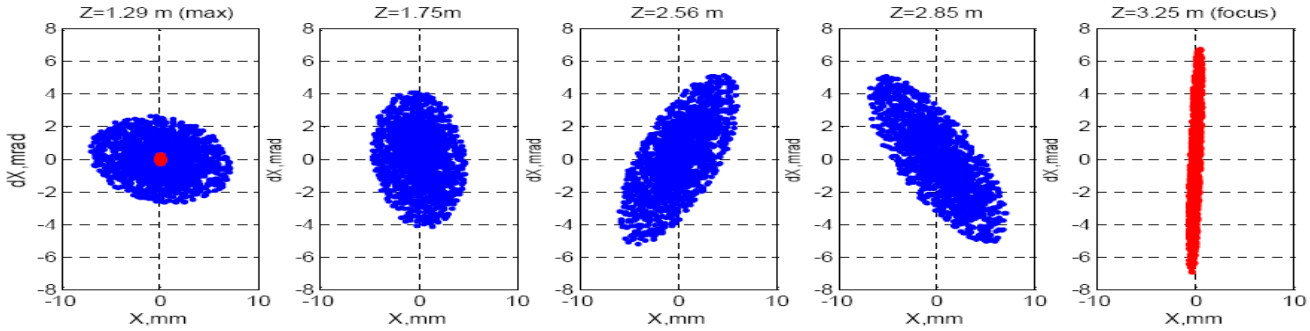


Applications

- Easy to simulate **any** initial particle distribution;
- Extensions such as space charge effects, interaction with residual gas, stray fields, etc possible;
- Great post processing capabilities.

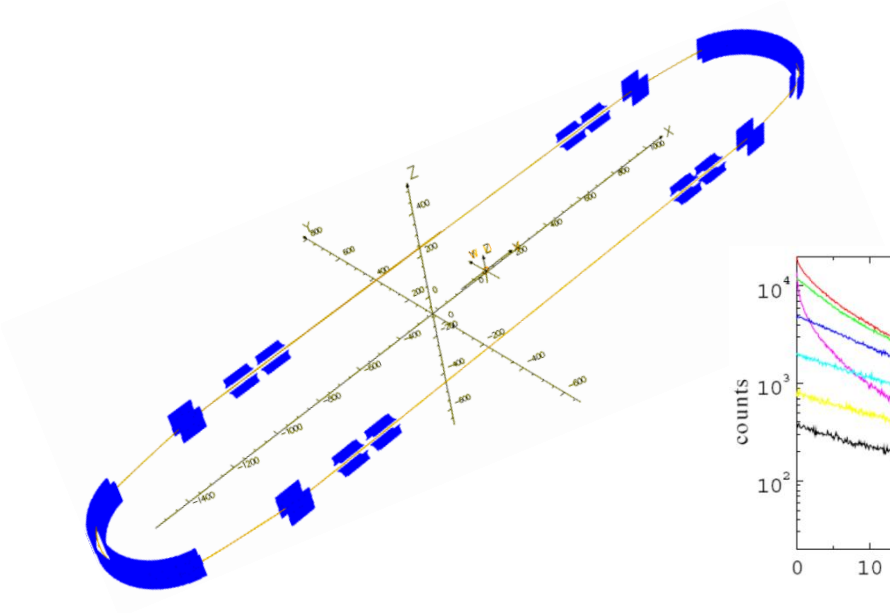


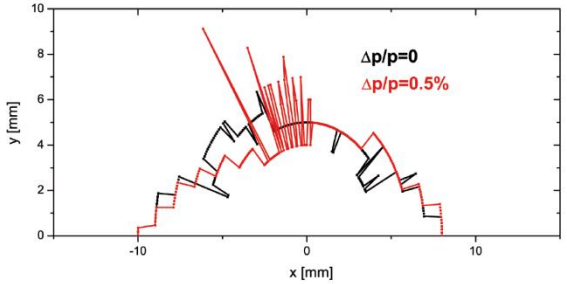




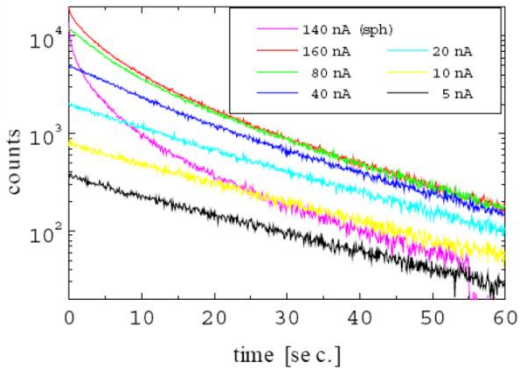
USR – Advanced Studies

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

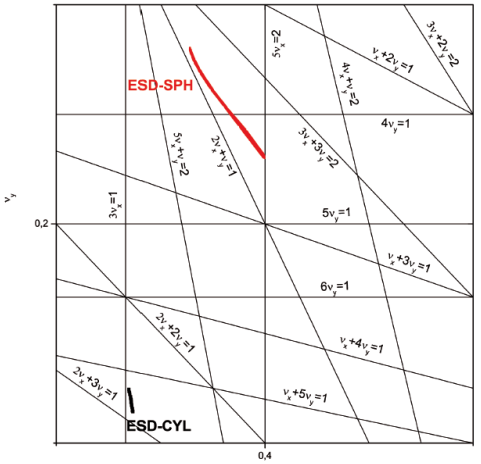




Dynamic Aperture



Beam Loss



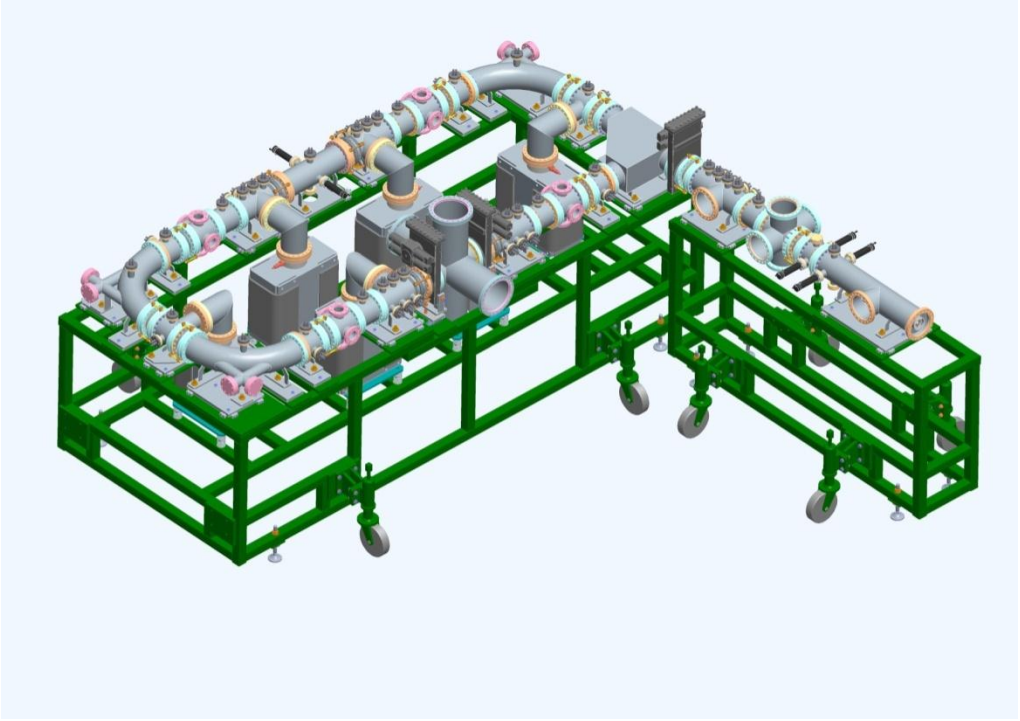
Tune Shift

O. Gorda, A.I. Papash, C.P. Welsch, Proc. IPAC (2010)
A.I. Papash, et al., Proc. IPAC (2011)

Mechanical Design

- AD Recycler Ring and USR
  - Full mechanical design;
  - EM shielding;
  - Alignment & transport

ELENA and its beam lines have similar requirements



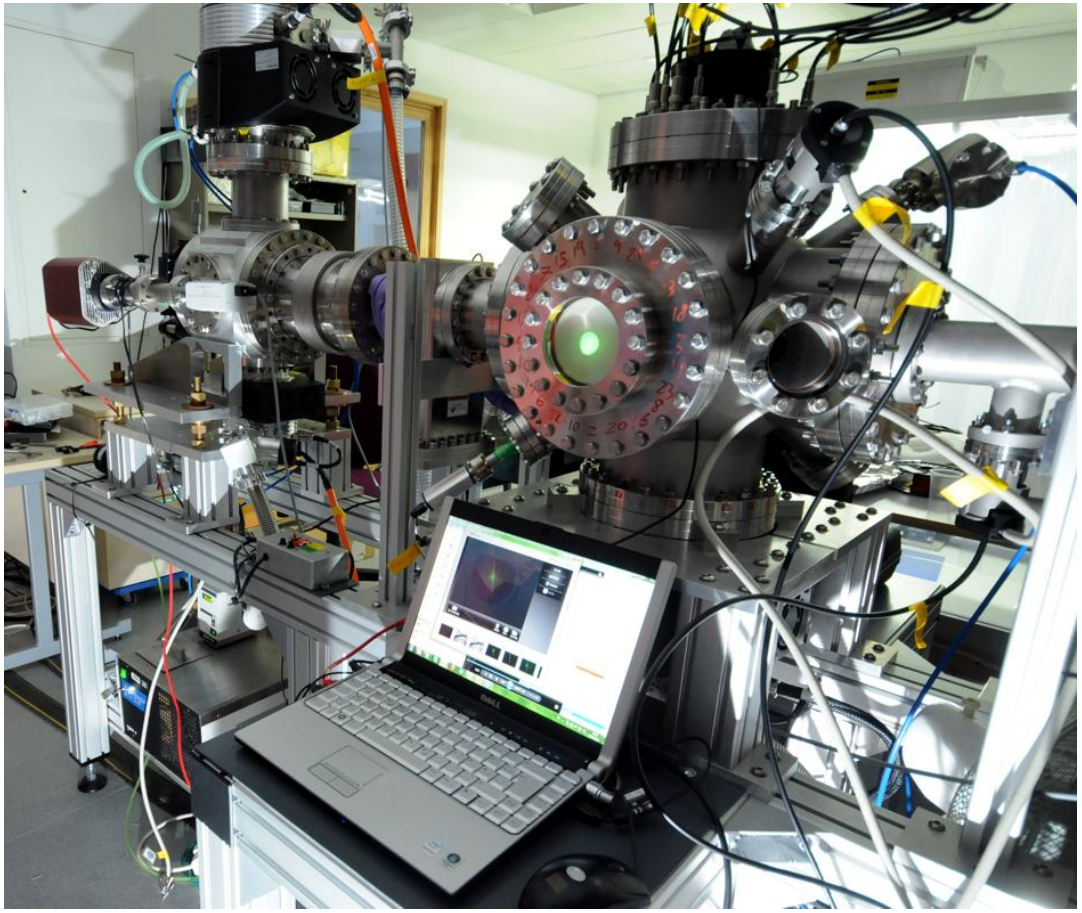
R&D Program in LE Diagnostics

- Beam position measurements
  - Capacitive electrostatic BPM

- Transverse beam profile measurements
  - Secondary Emission Monitor;
  - Screen developments;
  - Curtain gas jet based 2D monitor;

- Faraday Cup (p/H^-), diamond, etc.

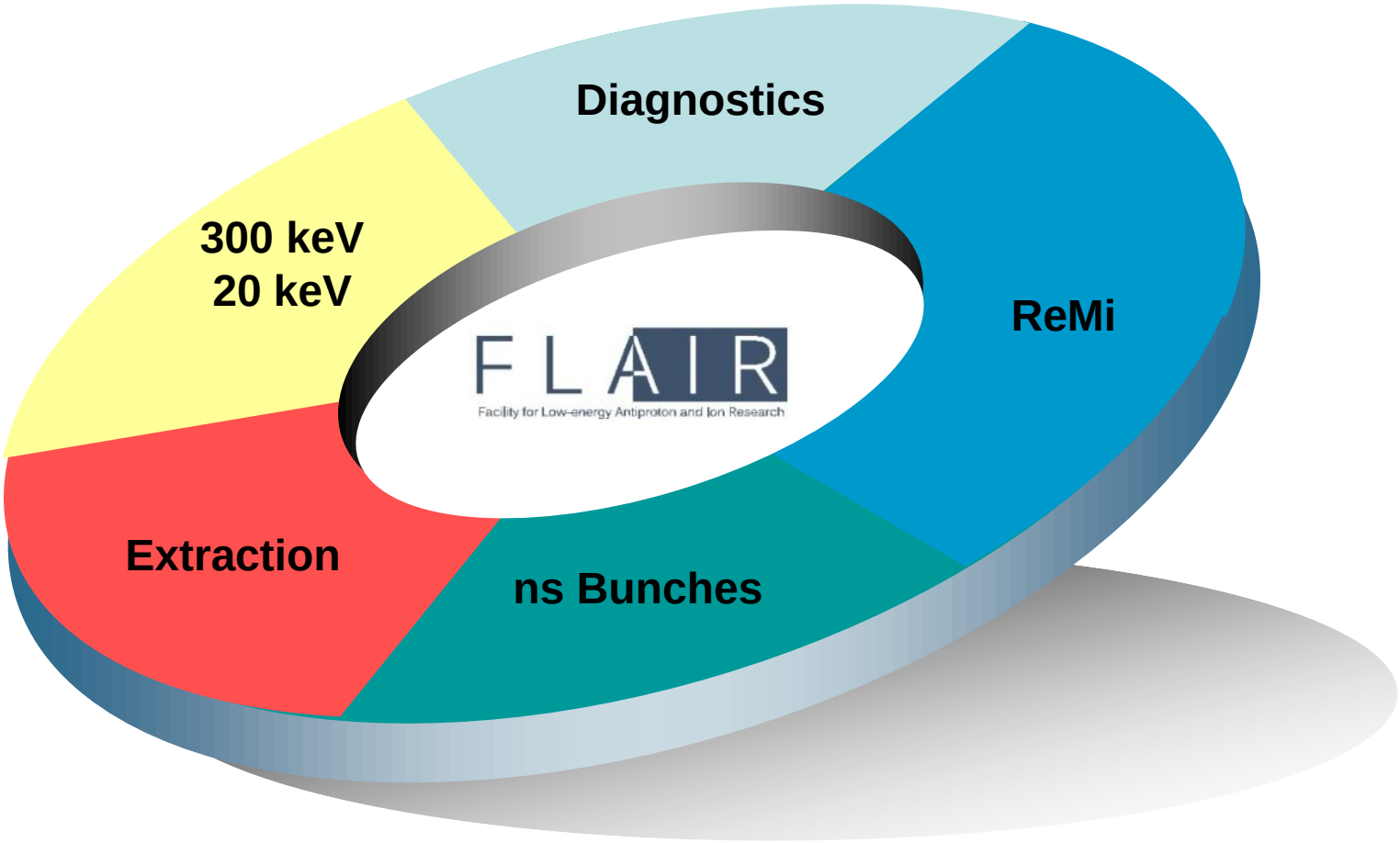
Profile Measurement and Collision Experiments: Prototype Setup



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

M. Putignano, C.P. Welsch, Hyperfine Interact. (2009)
M. Putignano, C.P. Welsch., Proc. IPAC (2011)

USR - Challenges



Many of these are shared with ELENA !

Summary

- Ring and beam line design;
- Broad experience with different codes and their limitations; benchmarking done, own developments;
- Beam diagnostics and instrumentation for keV beams;
- Mechanical design and component construction;
- Commissioning (and operation);

Questions ?