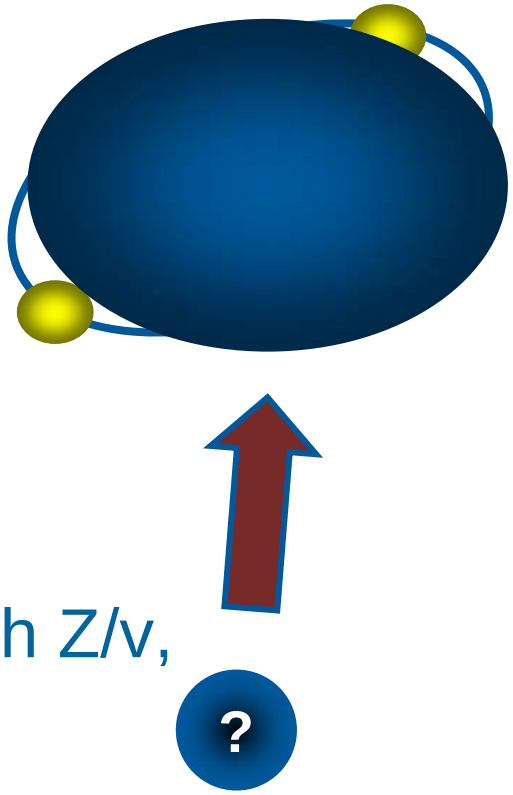
Atomic Physics and Accelerator Sciences in the

Carsten P. Welsch

The task:

Few-body problem: Interaction with "clean" projectile.



Important:

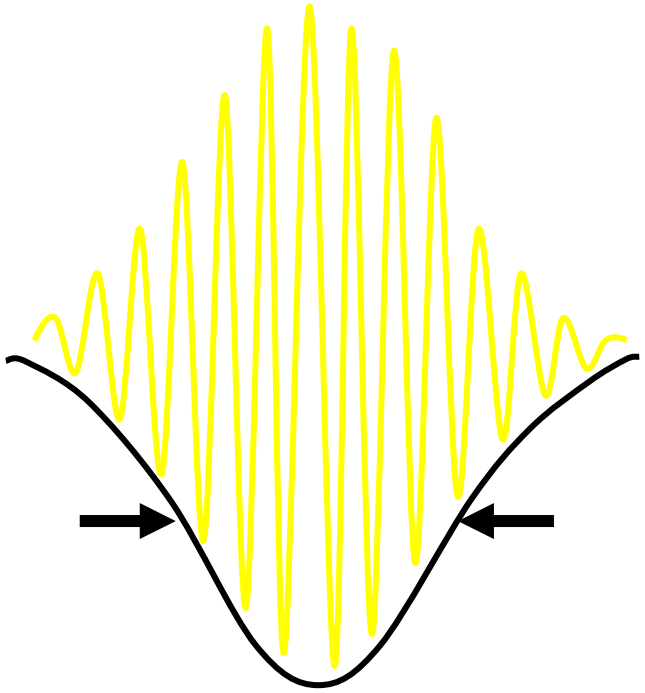
- No (or only few) add. reaction channels,

- Possibility to control perturbation strength Z/v,

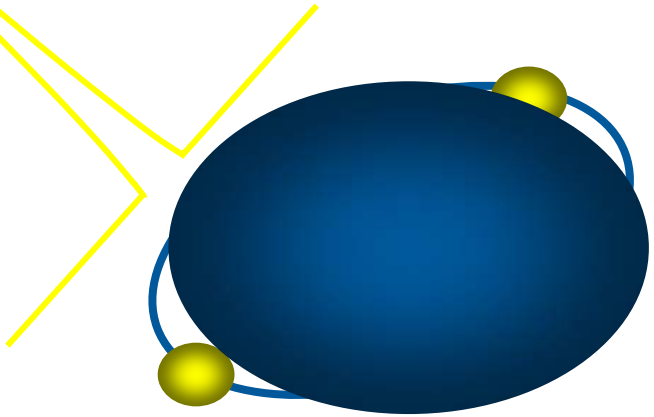
- Variation of interaction time between as => fs.

Why Antiprotons ?

Laser



$\tau \approx 150$ as



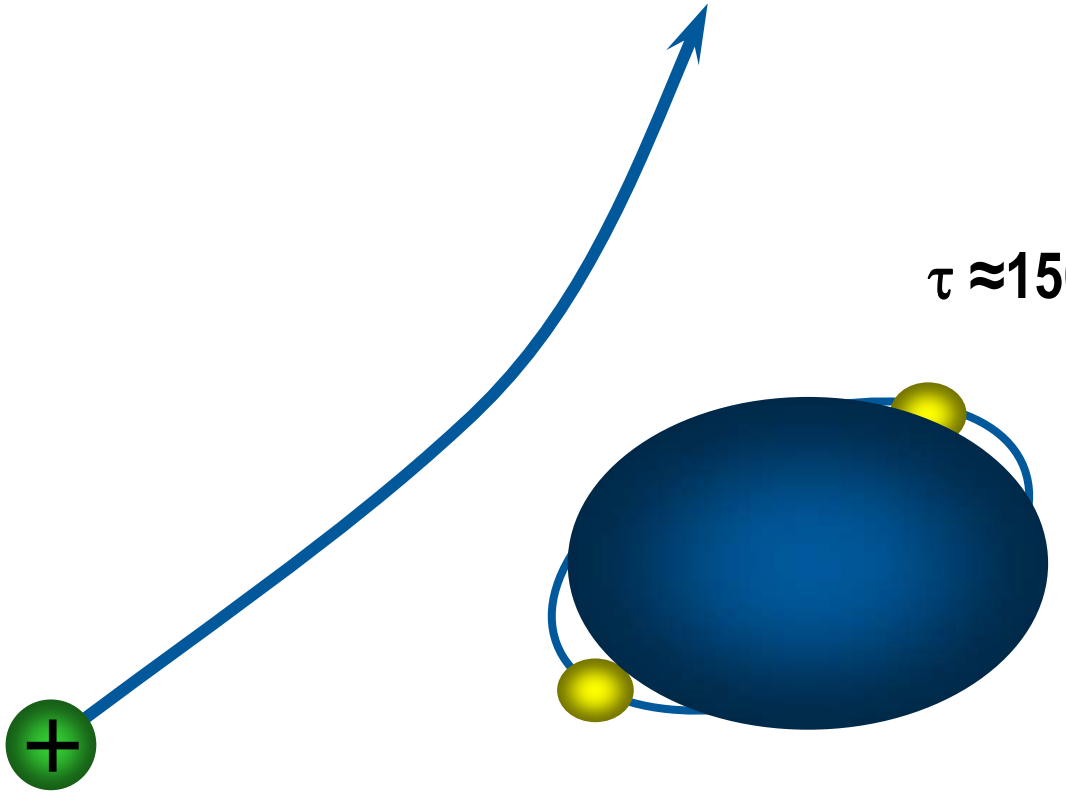
$t = 30 \ldots 6 \ldots 3.5$ fs

$I \geq 10^{15}$ W/cm^2

Why Antiprotons ?

Laser

Pos. Ions



$\tau \approx 150$ as

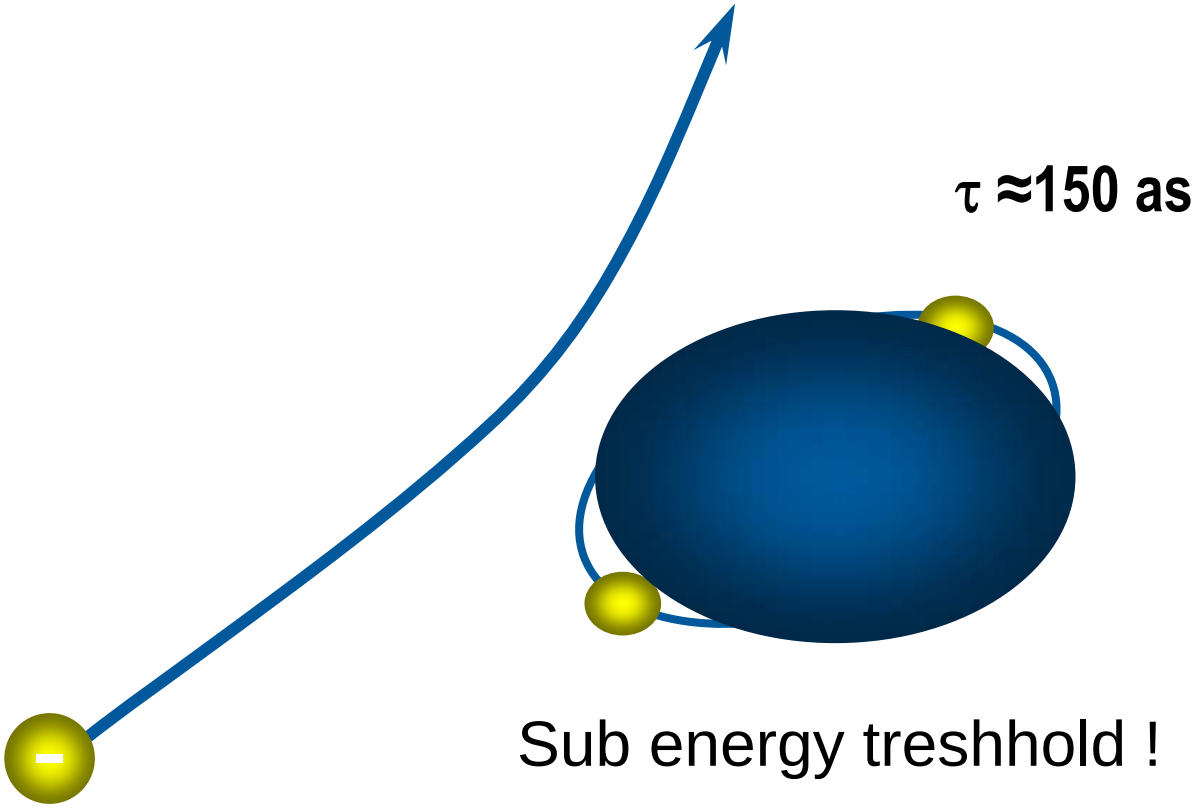
Dominated by capture !

Why Antiprotons ?

Laser

Pos. Ions

Electrons

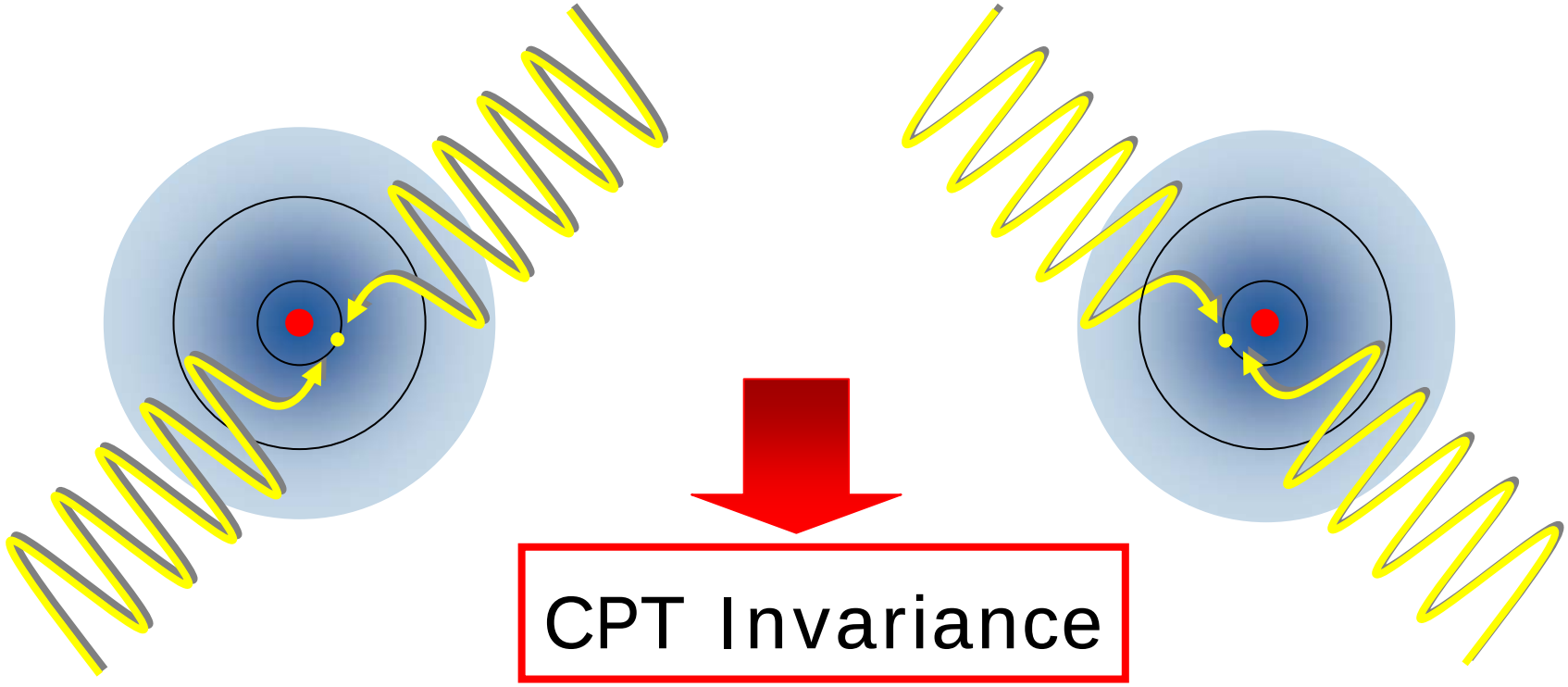


Sub energy treshhold !

Antiprotons !!!

Same Structure ?

Hydrogen **Anti-Hydrogen**

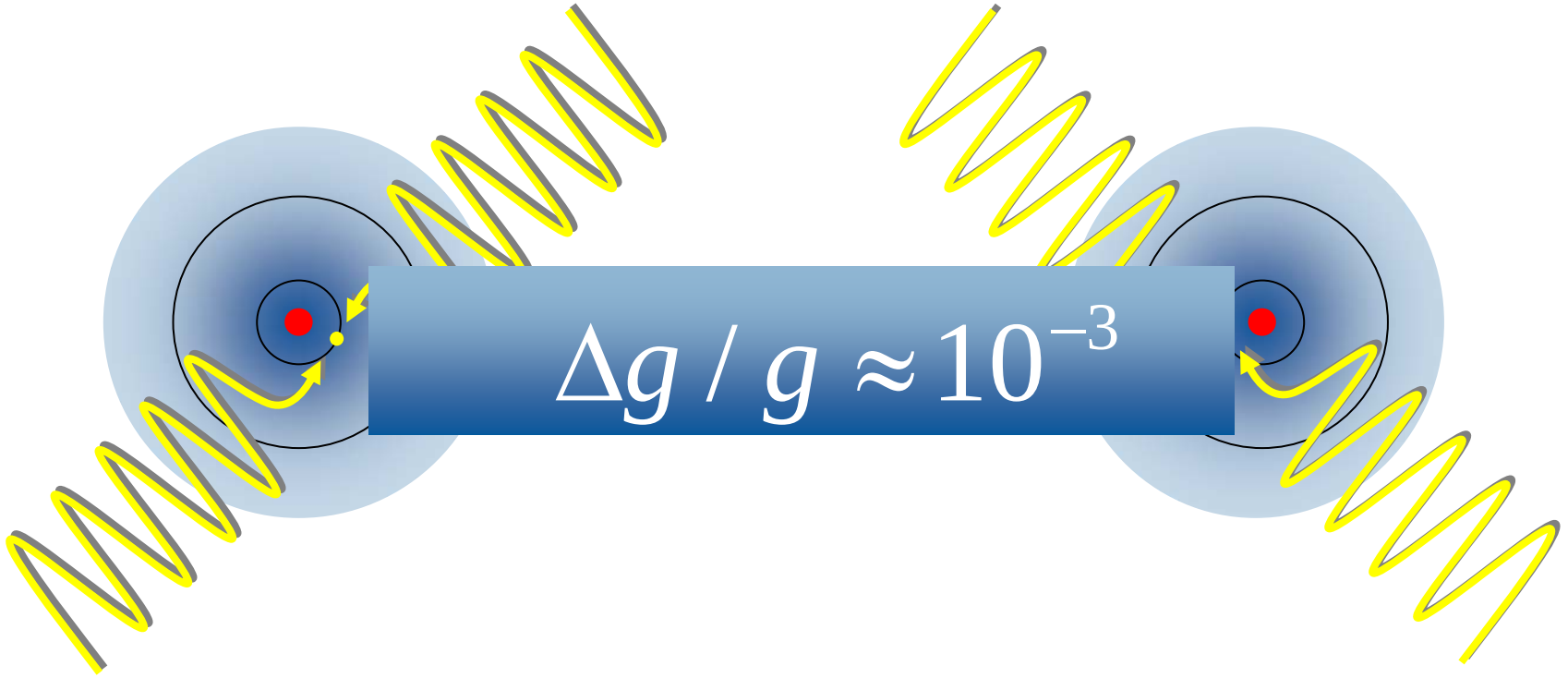


CPT Invariance

$$\Delta E / E \approx 10^{-14} .... 10^{-18}$$

Same Weight ?

Hydrogen **Anti-Hydrogen**



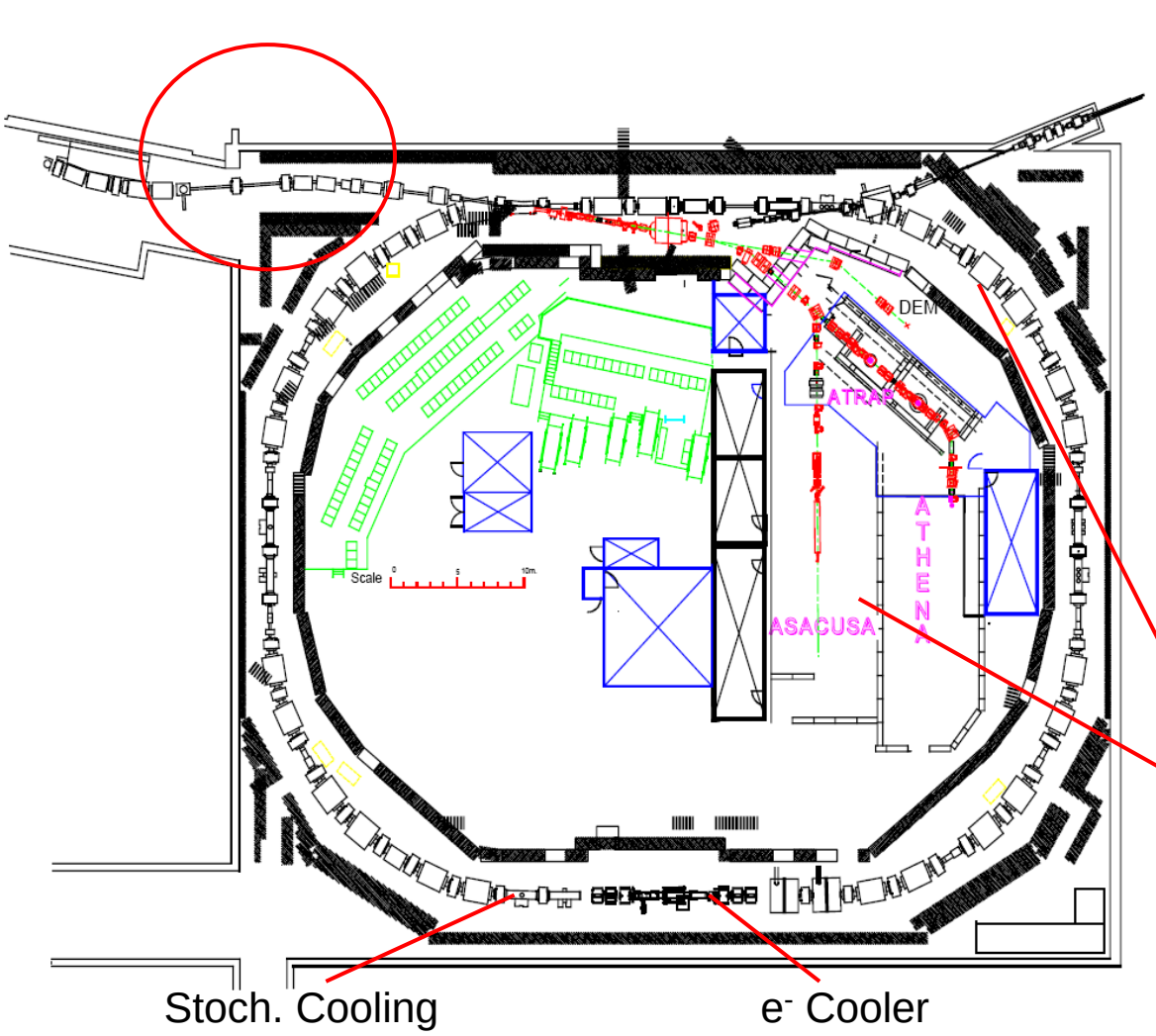
Present Situation: AD @ CERN

Target

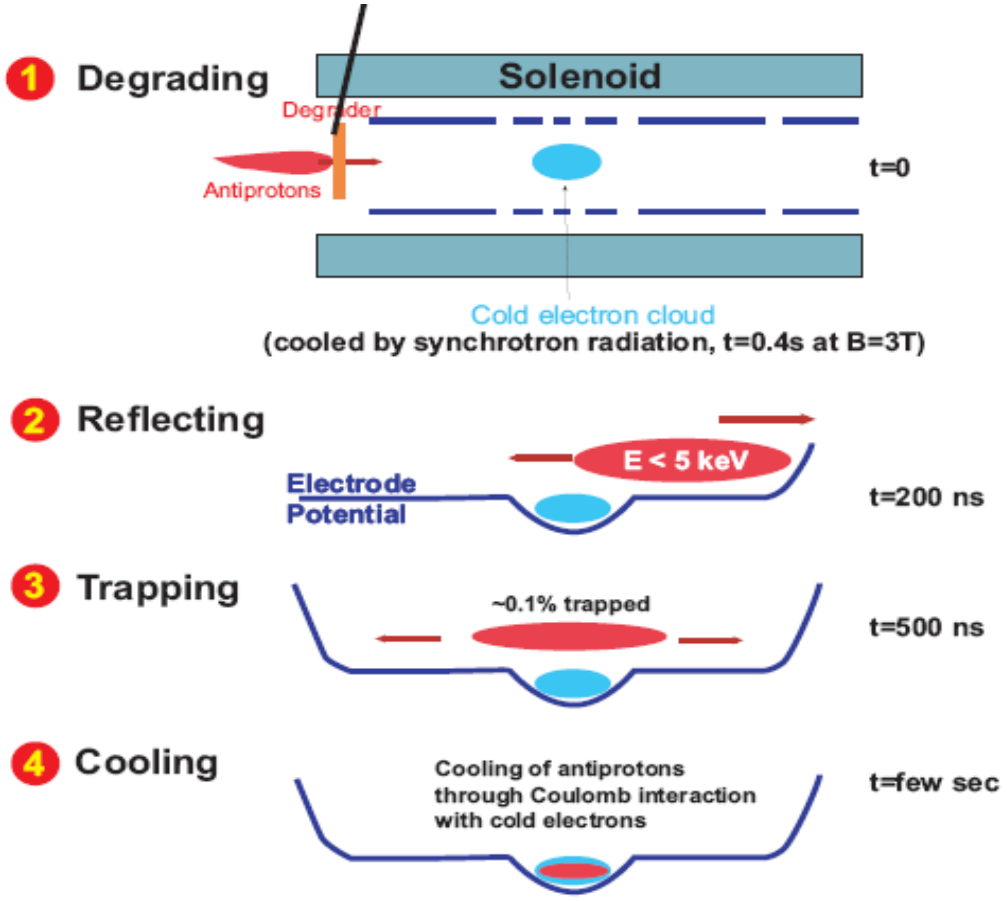
26 GeV/c p

➡ 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

  ~ 2.000.000 pbars/shot

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

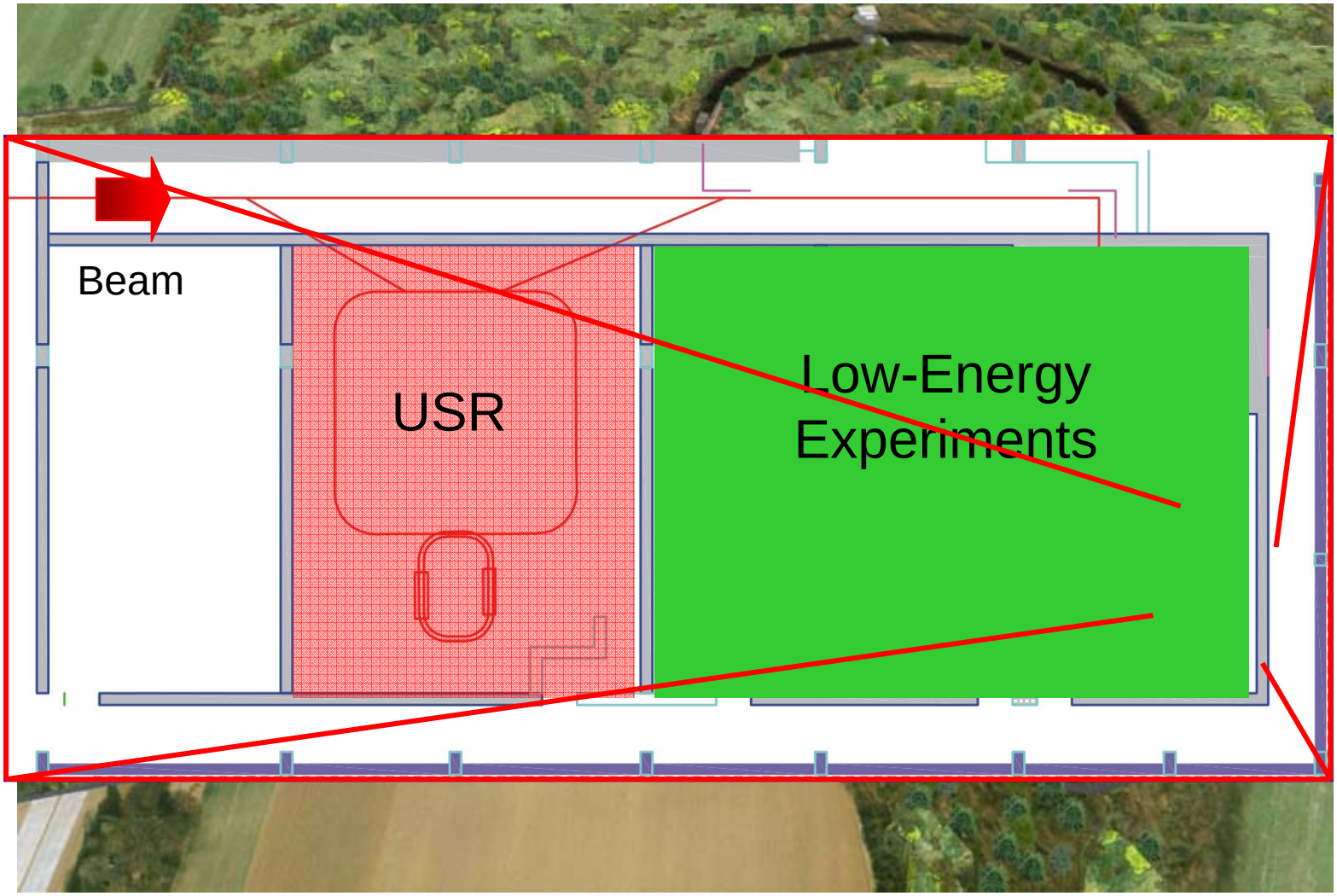
Idea: (add some) FLAIR to FAIR

- ***Austria*** (SMI, Vienna,TU)
- ***Canada*** (York, TRIUMPF)
- ***Denmark*** (Aarhus, ISA)
- ***Germany*** (GSI, Dresden, Frankfurt, MPQ, Giessen, MPI-K, FJZ, Mainz, Tübingen, Berlin)
- ***Hungary*** (KFKI, ATOMKI, Debrecen)
- ***India*** (VECC)
- ***Italy*** (Brescia, Firenze, Genova)
- ***Japan*** (RIKEN, Tokyo)
- ***Netherlands*** (Amsterdam, FOM)
- ***Poland*** (Warsaw, Soltan Inst.)
- ***Russia*** (JINR, Moscow, VNIIM, St. Petersburg, Troitsk, Moskva)
- ***Sweden*** (MSL, Stockholm)
- ***UK*** (Queens, Wales)
- ***USA*** (Harvard, Pbar Labs, New Mexico, Texas, Indiana)

150 Scientists ***15 Countries*** ***50 Institutes***

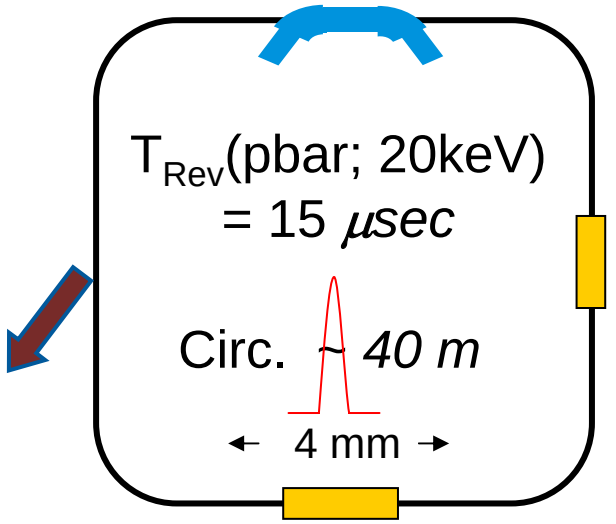
CI in Steering Committee; USR Project Leader.

FLAIR @ Facility for Antiproton and Ion Research

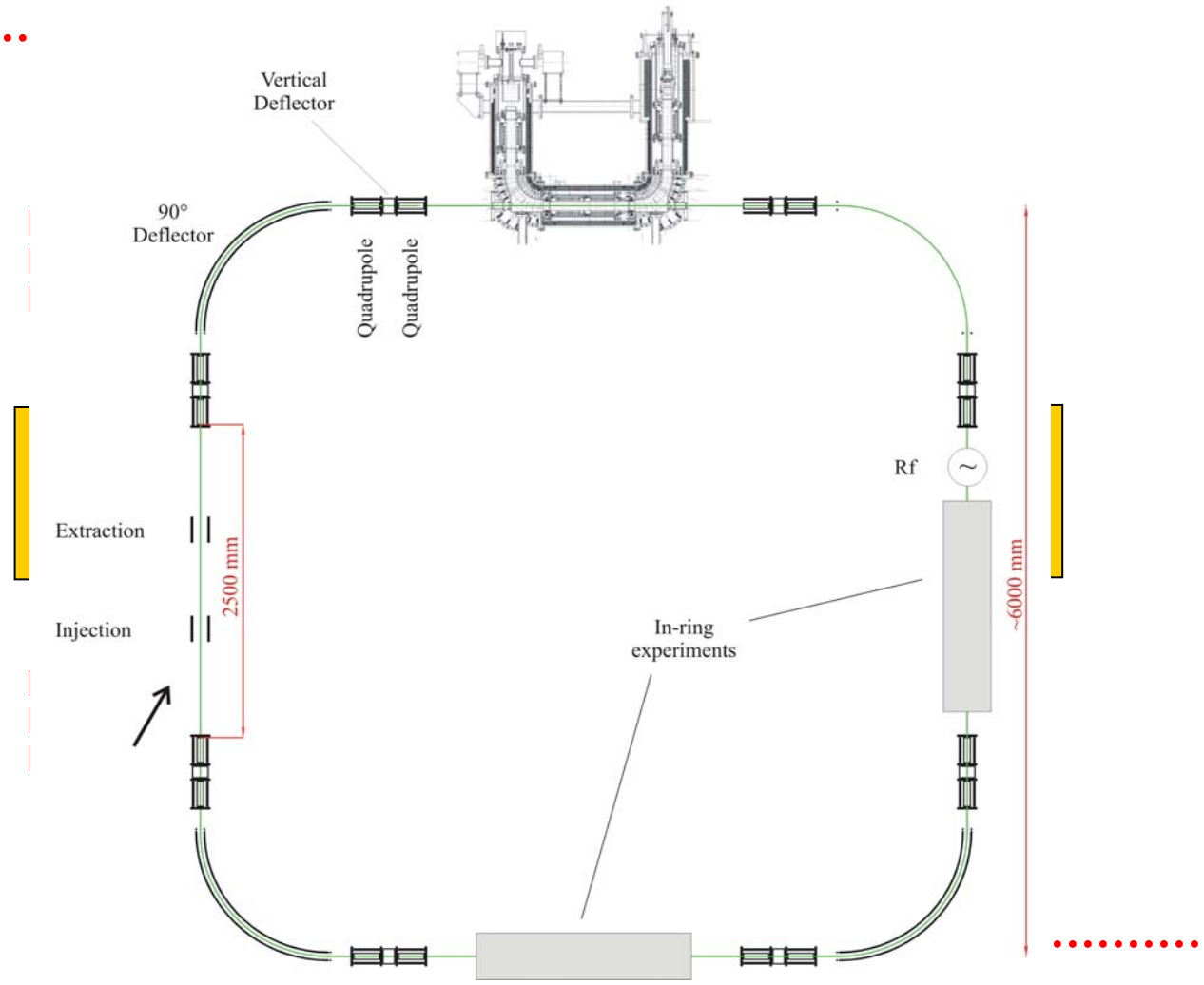


USR - Goals

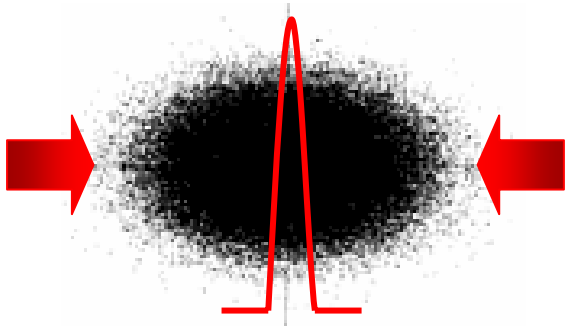
- Variable to lowest energies
  - 300 keV ~ 20 keV
- High luminosity for in-ring experiments
- Well-defined extracted beams:
  - Small emittance
  - Small momentum spread
- Multi-user operation:
  - 2 straight sections for in-ring experiments
  - Slow and fast extraction
  - Additional beam lines possible
- Central requirements
  - Δt ~ 500 nsec for Injection in traps
  - Δt ~ 2 nsec / 10^4 ions for collision studies



USR: At a Glance



USR – Subprojects in QUASAR Group



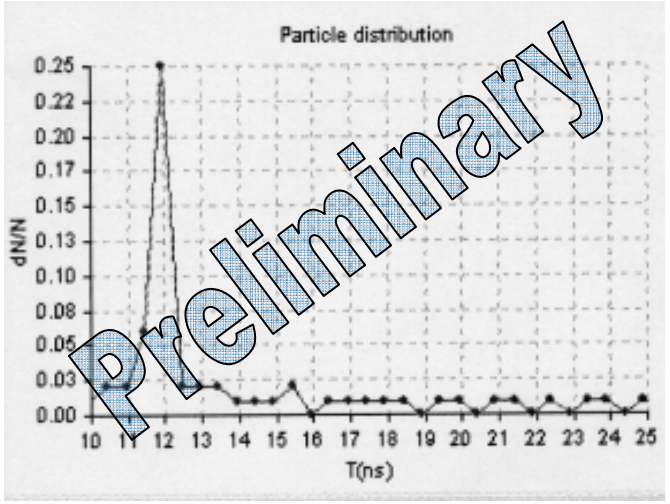
ns Bunching

How to realize nanosecond bunches ?

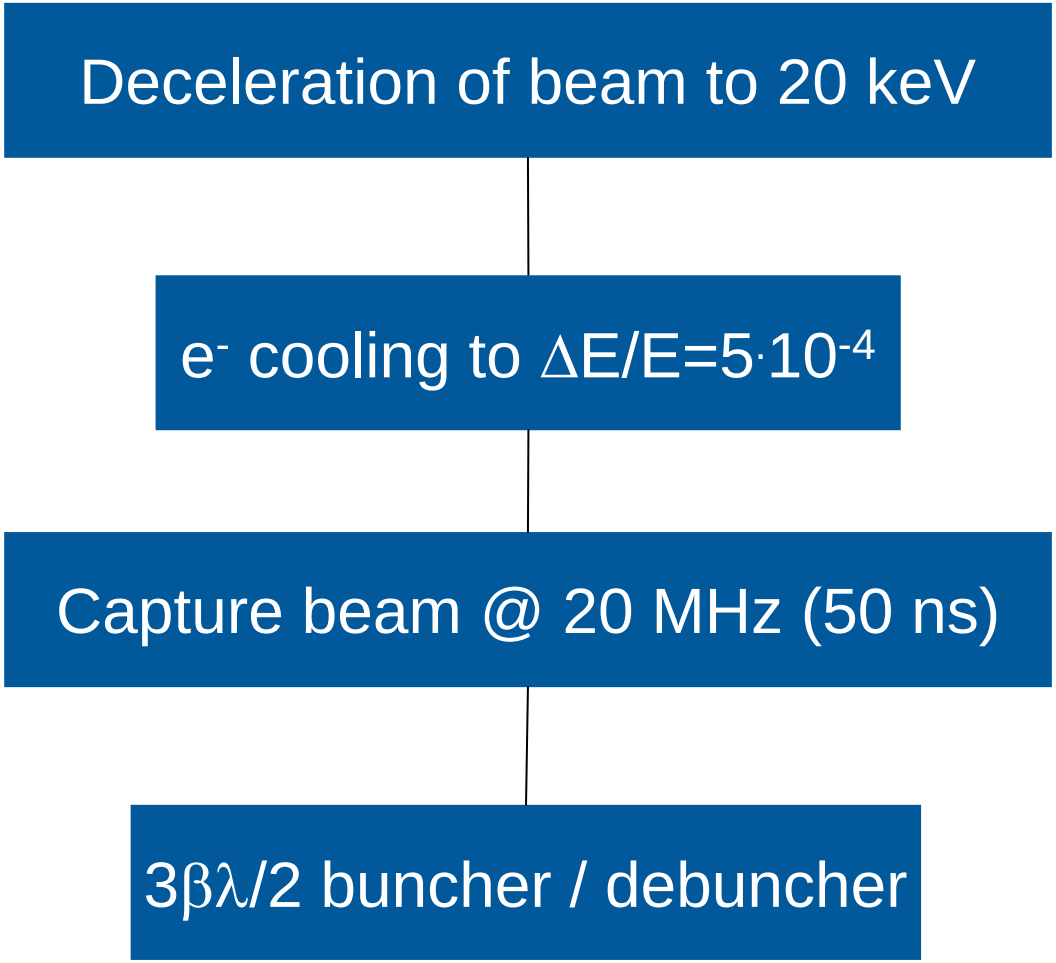
A. Papash

Steps:

- General feasibility
- 1-D simulation
- Full study

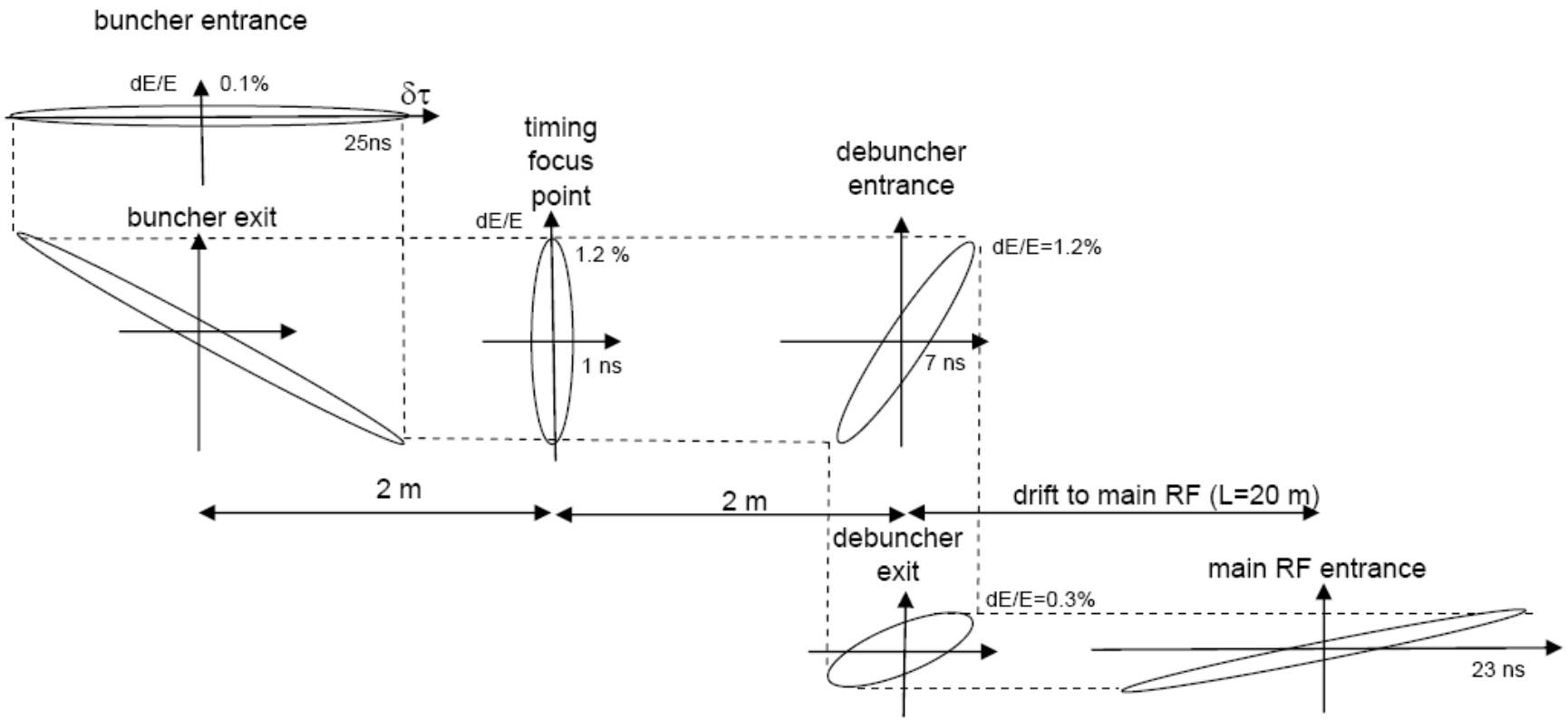


Staged approach



Full details: EPAC 2008

Evolution in Phase Space



Crucial: Dispersion in straight section !

Full details: EPAC 2008

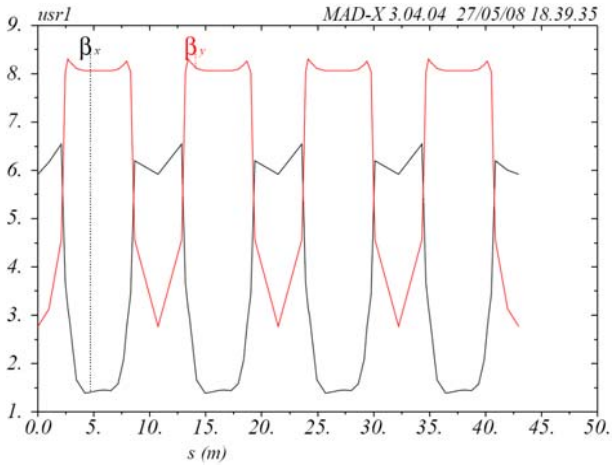
Points not addressed here

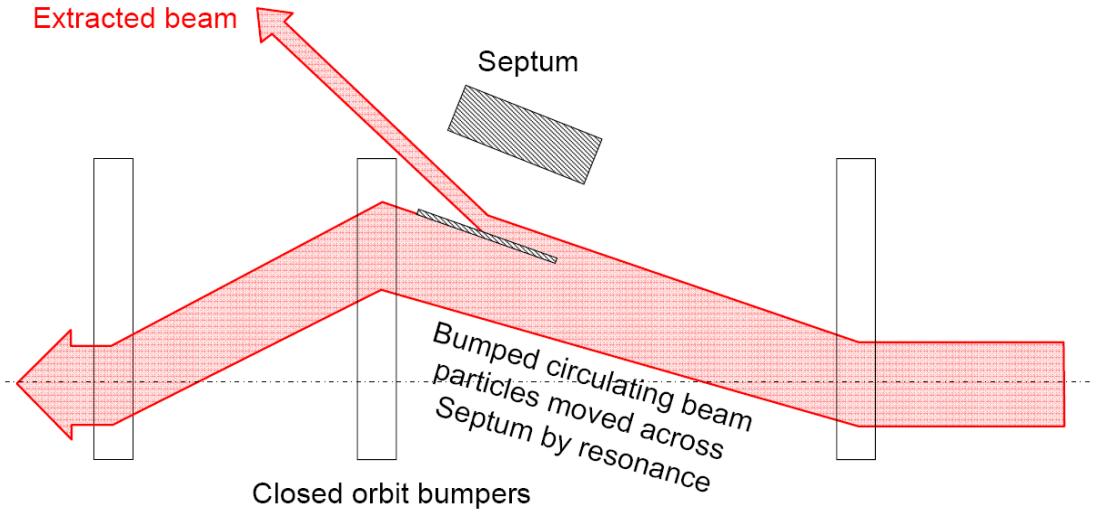
- How to optimize the buncher geometry ?
- What happens to beam with non-zero $\Delta p/p$?
- How to get parameters of energy compressor ?
- Choice of rf cavity ? Filling mode ?

Proc. European Part. Acc. Conf. (2008)

USR - Subprojects in QUASAR Group

Highly-flexible Beam Extraction



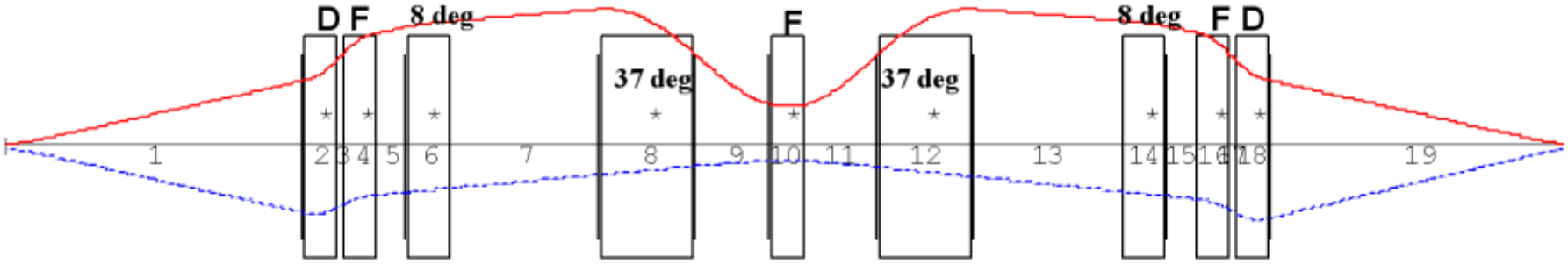


Motivation: Nuclear physics-type experiments.

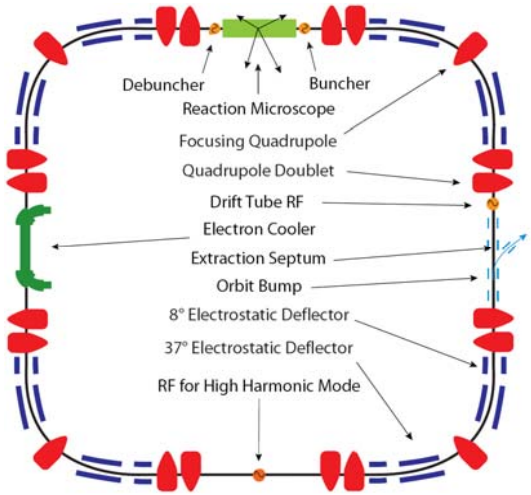
➡ First time in electrostatic ring !

Modification to USR Lattice

- "Split-achromat" geometry, new concept



- Achromatic section, D=0 in straights !
- D never > 0.6 m.

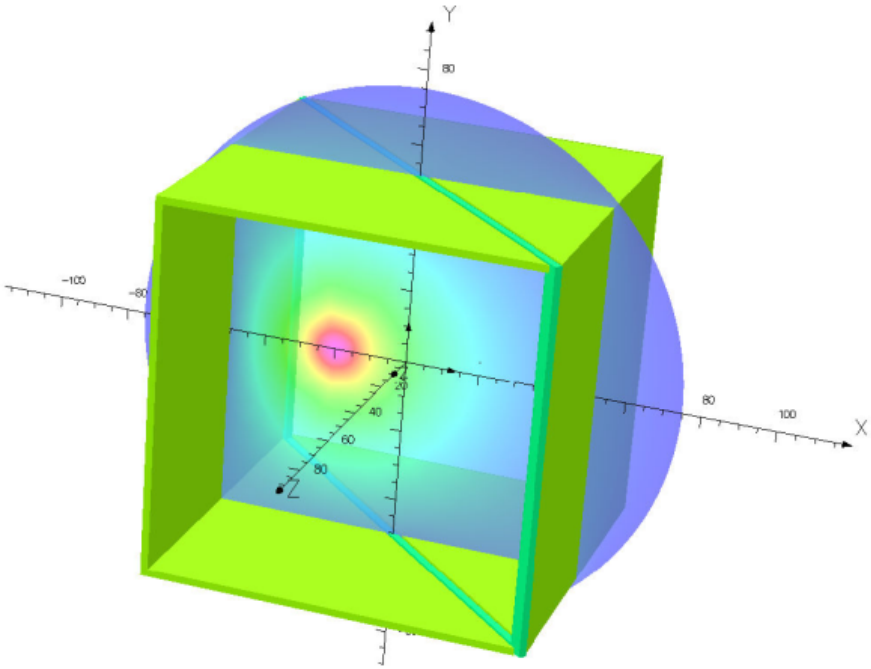


USR – Subprojects in QUASAR Group

Pbar diagnostics

- Position
- Profile
- Intensity
- ...

How to measure the beam characteristics ?

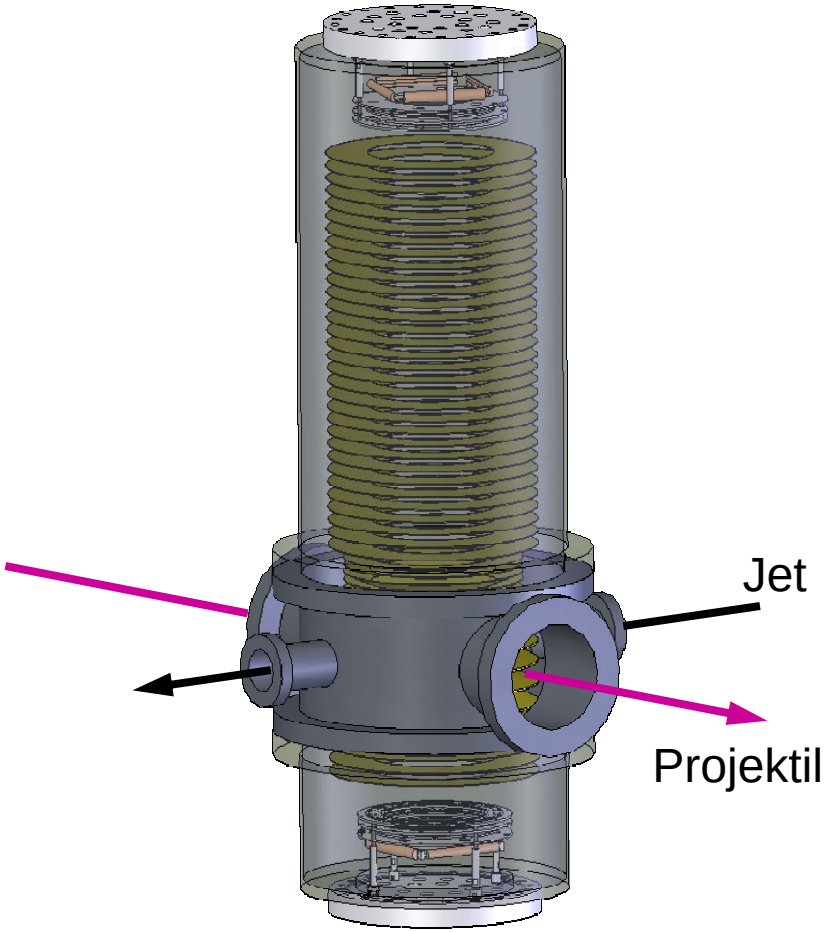


J. Harasimowicz

A. Mokrzycka

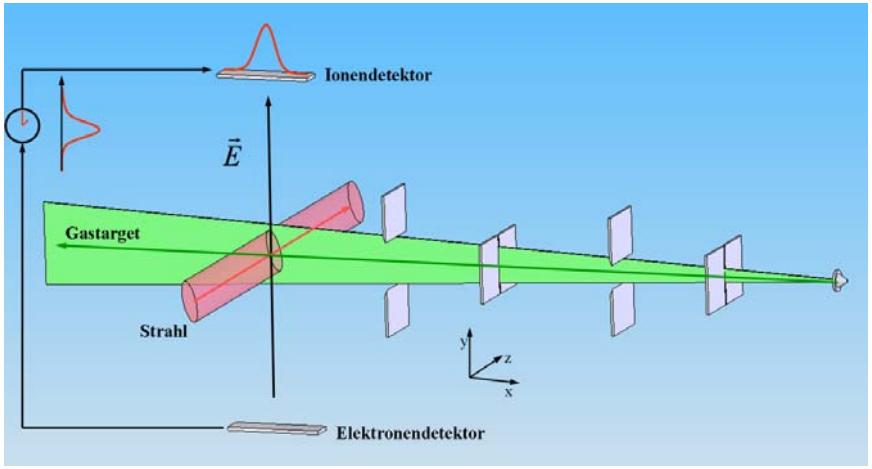
S. Brylka

USR – Subprojects in QUASAR Group



In-ring Reaction Microscope

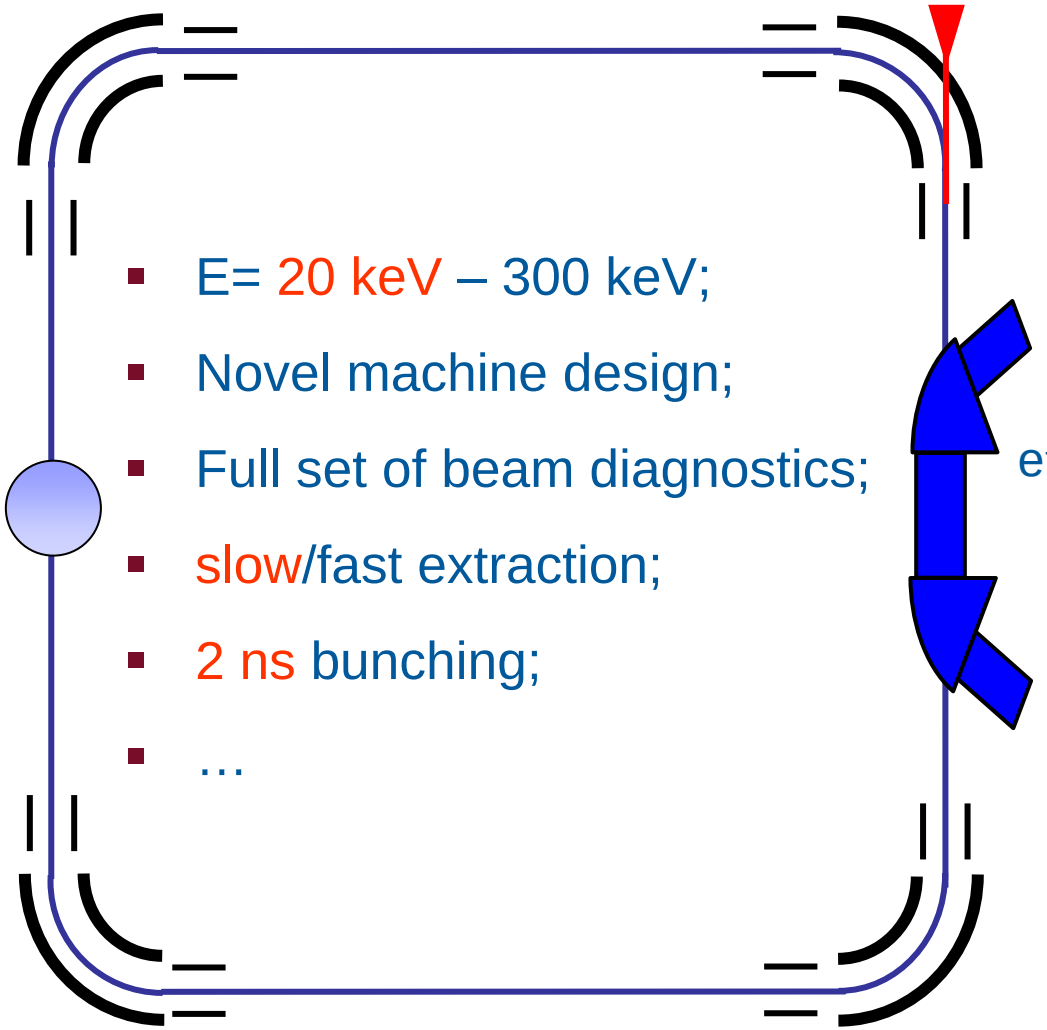
Design of the experiment.



K.U. Kühnel

M. Putignano

USR - Challenges



- E= 20 keV – 300 keV;
- Novel machine design;
- Full set of beam diagnostics;
- slow/fast extraction;
- 2 ns bunching;
- …

Injection

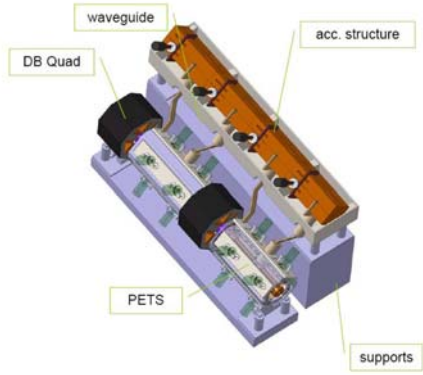
Atomic beam
+
Reaction
microscope

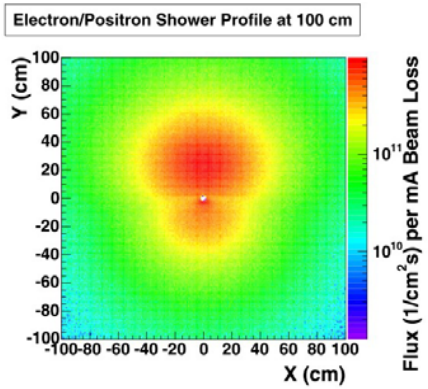
e^- cooler
- Photocathode
- $\Delta E \sim 1$ meV

Add. Projects in QUASAR Group

- Beam Loss Instrumentation at CTF3

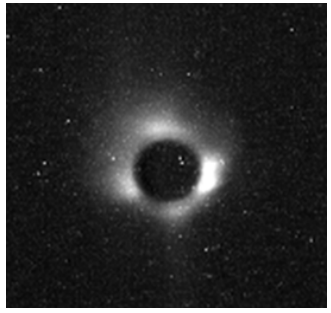
A. Intermite

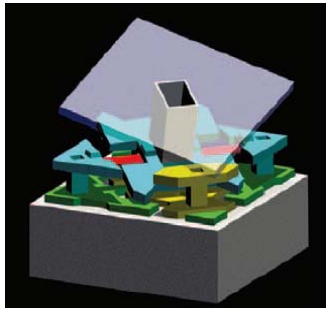




- Halo-Measurements

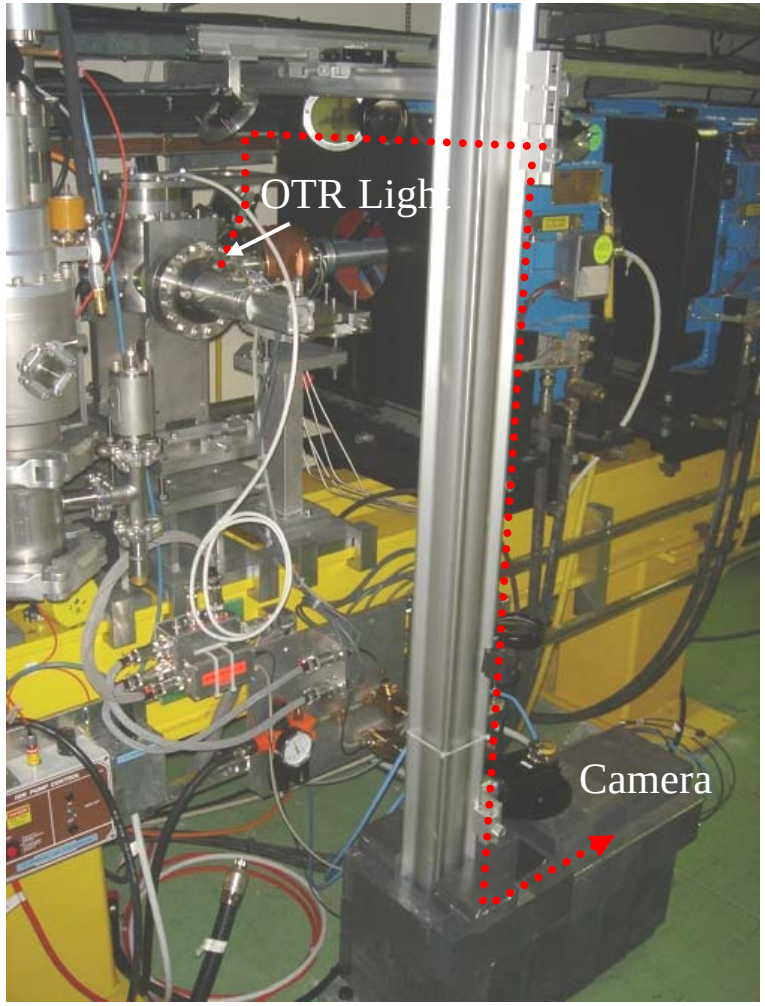
J. Egberts





S. Artikova

A „typical“ Monitor



- Material sciences
- Thermodynamics
- Electro-Magnetism
- Optics
- Mechanics
- Electronics
- Nuclear Physics
- …

➡ Multi-disciplinary field !

Diagnostics: International Role

DITANET

‹‹ novel **DI**agnostic **T**echniques for future particle **A**ccelerators:
A Marie Curie Initial Training **NET**work ››

➡ Coordinated by QUASAR Group.

What is DITANET ?

- One of the largest Marie Curie Networks ever funded by EU !
- Aim: Training of young scientists.
- Gives industry an important role.
- Allows for intersectorial collaboration.
- Recognized importance of beam diagnostics at European level !
  (only 68 from 905 selected)

Further Projects in QUASAR Group

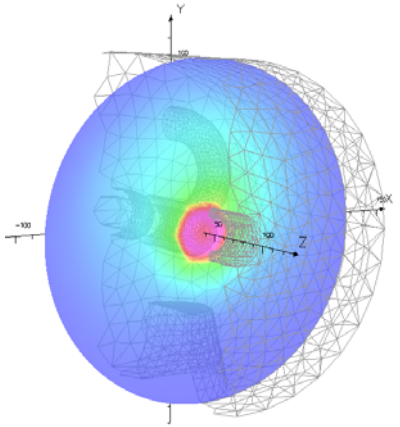
- Field-based Beam Control

C. Schömers

- Development of Rf-Accelerators

M. Schuh

T. Junginger



Conclusion

- Research at the interface between atomic physics and accelerator sciences;
- Many challenges in the keV

  and the TeV-range.