

Antiprotons in FLAIR and NUSTAR – *future Darmstadt research programme*

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Future projects at FAIR at Darmstadt

http://www.gsi.de/zukunftsprojekt/index_e.html

Future \simeq 10 years (\sim 2010)

FAIR:



International Facility for Antiproton and Ion Research

- NUSTAR (NUclear STructure, Astrophysics, and Reaction Research)
- FLAIR (A Facility for Low Low-energy Antiproton and Ion Research)

NUSTAR

<http://www.gsi.de/forschung/kp/kp2/nustar.html>

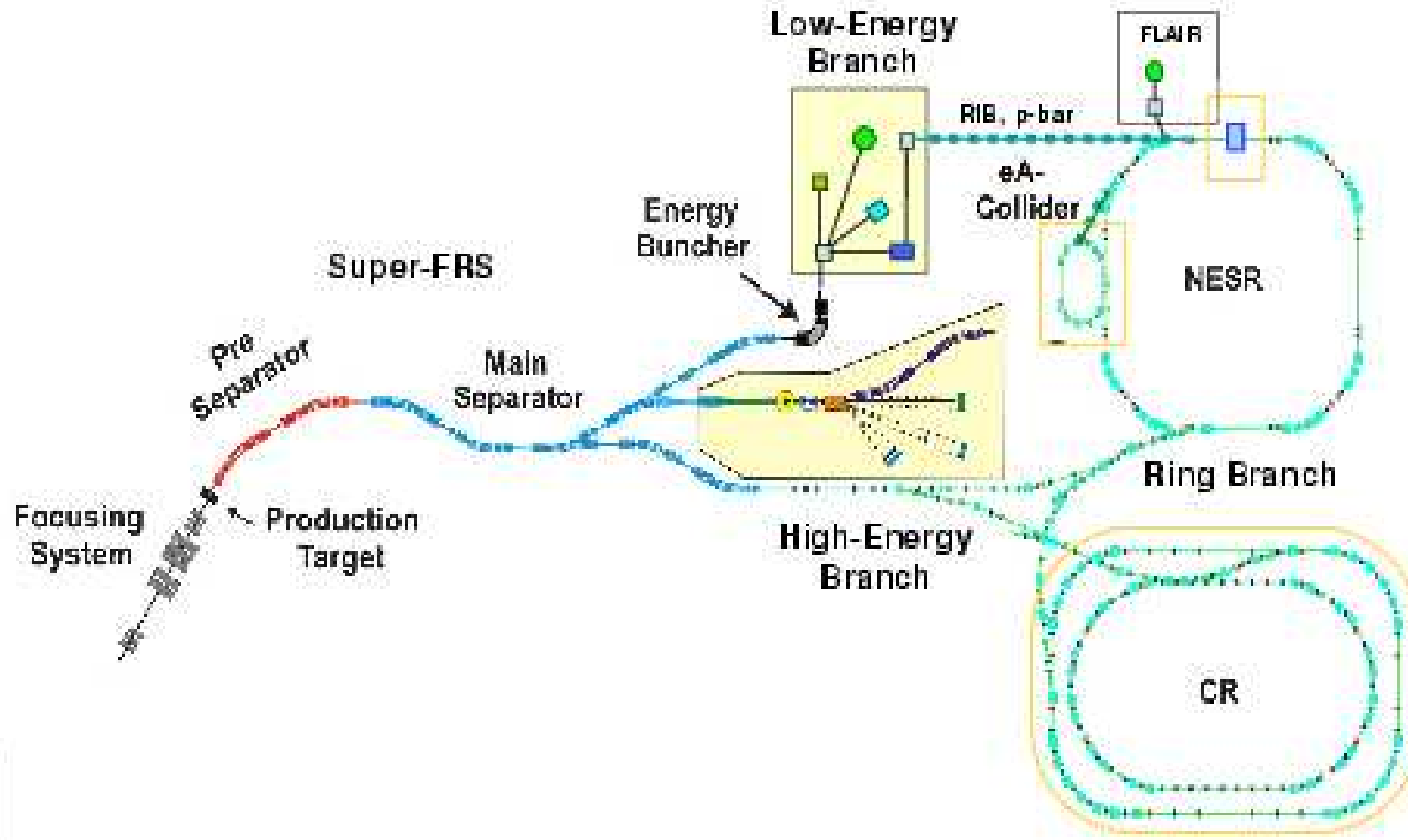
NUSTAR: 12 projects

- **High Energy Branch (R3B):** A universal setup for kinematical complete measurements for Reactions with Relativistic Radioactive Beams
- **Ring Branch (STORIB):** Study of Isomeric Beams, Lifetimes and Masses (ILIMA); Exotic nuclei studied in light-ion reactions at the NESR storage ring (EXL); Electron-Ion scattering in a Storage Ring (ELISe); Antiproton-Ion Collider: A tool for the measurement of neutron and proton rms radii of stable and radioactive nuclei; Spectroscopy of Pionic Atoms with Unstable Nuclei (PIONIC);

NUSTAR *(continuation)*

- **Low Energy Branch (LEB):** High-resolution in-flight spectroscopy (HISPEC), Decay spectroscopy with implanted beams (DESPEC), Precision measurements of very short-lived nuclei using an advanced trapping system for highly-charged ions (MATS), LASER spectroscopy for the study of nuclear properties (LASPEC) Neutron-capture measurements (NCAP), Antiprotonic radioactive nuclides (Exo+pbar)

NUSTAR & FLAIR – layout



FLAIR <http://www-linux.gsi.de/flair/>

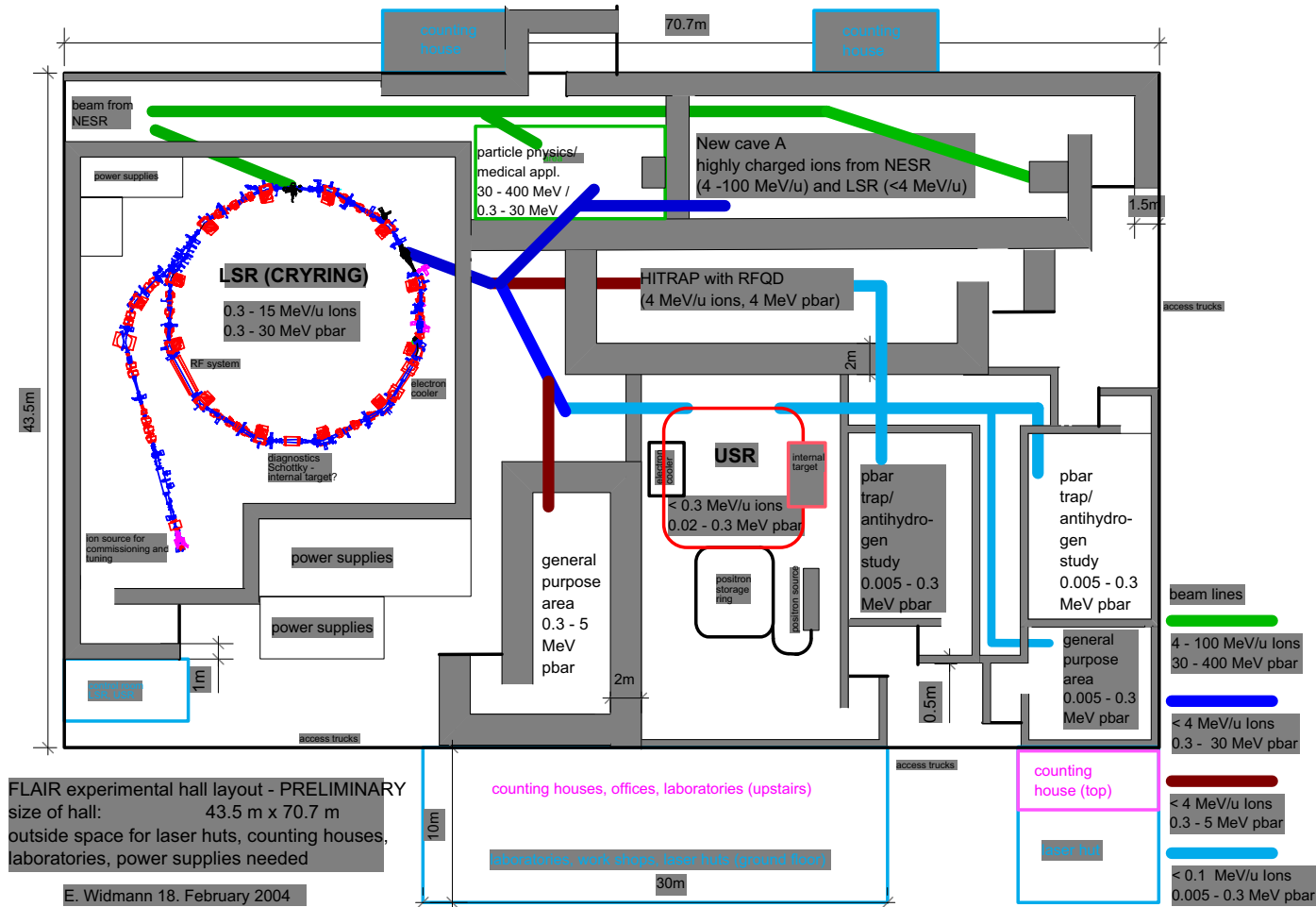


Figure 15: Preliminary layout of the low-energy antiproton and heavy ion facility.

FLAIR – physics planned

- Precision spectroscopy of antiprotonic atoms and antihydrogen for tests of fundamental interactions and symmetries (especially CPT)
- Gravitation of antimatter
- Matter-antimatter rearrangement and larger antimatter systems
- Interaction of antimatter with matter: exploring subfemtosecond correlated dynamics

FLAIR – physics planned *(continuation)*

- Nuclear and particle physics with antiprotons:
 - Measurement of protonium and other X-ray spectra
 - Antiprotonic X-rays of heavy isotopes and nuclear structure
 - Antiprotonic radioactive nuclides in traps
 - Antineutron production and precision cross section measurements at low momenta
 - Production of strangeness -2 baryonic states
- Biological effectiveness of antiproton annihilation

ex-PS209 collaboration plans:

- with NUSTAR
 - ↪ Antiprotonic radioactive nuclides (Exo+pbar)
- with FLAIR
 - ↪ Antiprotonic X-rays of heavy isotopes and nuclear structure
 - ↪ Antiprotonic radioactive nuclides in traps

Exo+pbar collaboration

Collaboration:

H. Geissel, W. Quint, C. Scheidenberger, M. Winkler
(GSI, Germany)

J. Äystö, A. Jokinen, S. Kopecky, I. Moore, A. Nieminen
(JYFL Jyväskylä, Finland)

M. Wada, Y. Yamazaki (RIKEN, Japan)

J. Jastrzębski, W. Kurcewicz, A. Trzcińska (HIL UW, Poland)

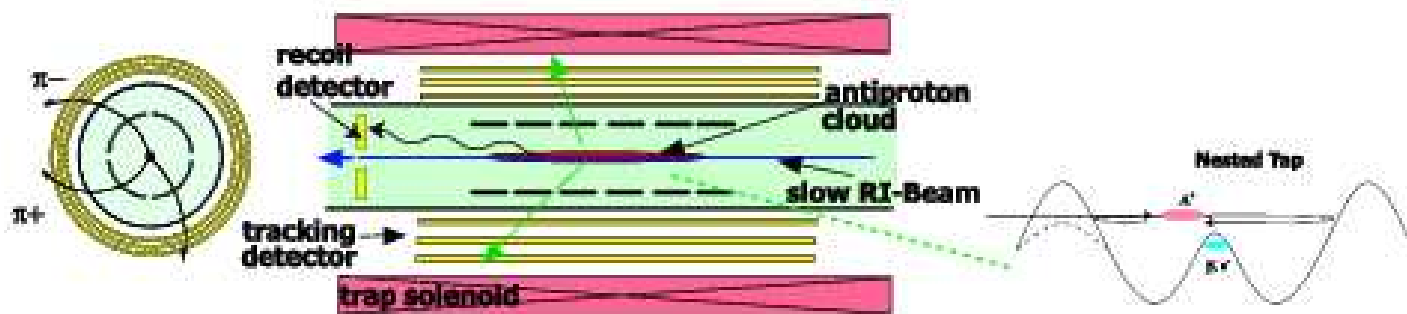
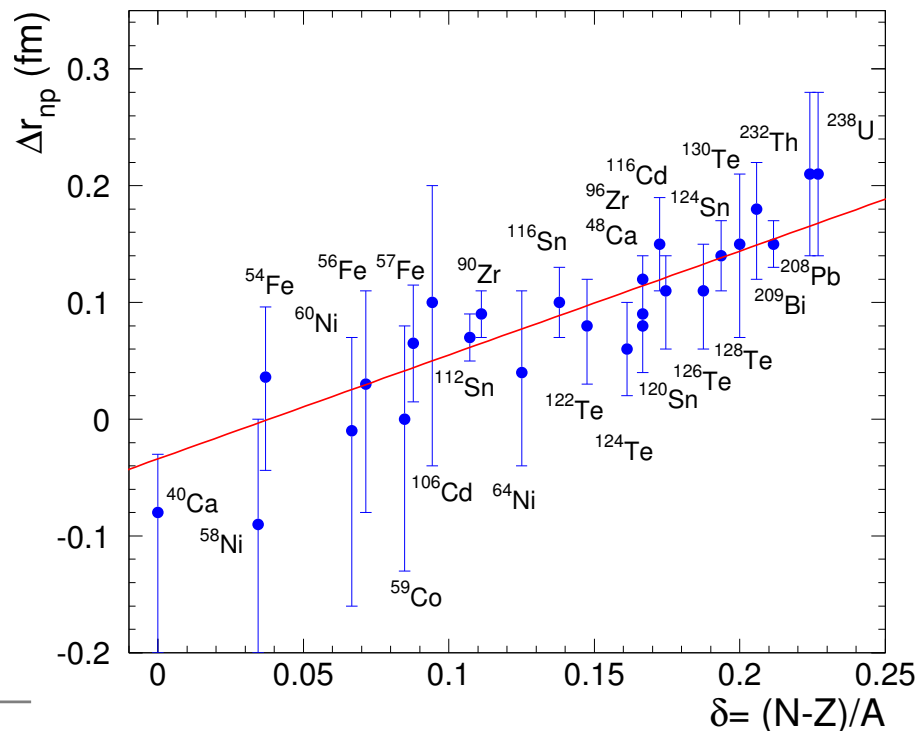


Figure 1: Nested trap and detector set-up for anti-protonic radioactive atom experiments. The set-up, with a space requirement of $10 \times 10 \text{ m}^2$, will be located in the Low Energy Cave and requires a connecting beam line for the anti-protons from the NESR.

Antiprotonic X-rays of heavy isotopes

- History: 1993-1996 @CERN (LEAR) – nuclear periphery studies with antiprotons (f_{halo} , antiprotonic X-rays)
- Results: neutron densities and rms radii (4 Ph.D. thesis: P.Lubiński, B.Kłos, A.Trzcińska, R.Schmidt):



A.Trzcińska et al.,
PRL 87(2001)082501

Antiprotonic X-rays of heavy isotopes

@FLAIR: continuation/extension of our previous antiprotonic X-rays studies

Collaboration:

HIL WU, Warsaw

GSI, Germany

U Tokyo,

IMEP Wien

FLAIR project – status

- First Meeting of the "Users group for low-energy antiproton physics at GSI": Sept. 18–19, 2003
- LOI – submitted on January 15th, 2004
- July 6th, 2004 – PAC at GSI approved FLAIR and project got the green light for writing a Technical Proposal
- dead line for the Techn. Proposal: January 15th, 2005
- source of a financial support – ??

Antiprotonic X-rays – status

Polish contribution to the project (X-rays measurements):

- man/woman-power
- experience
- detectors, electronics
- financial source – a grant of CSR (KBN) – ??