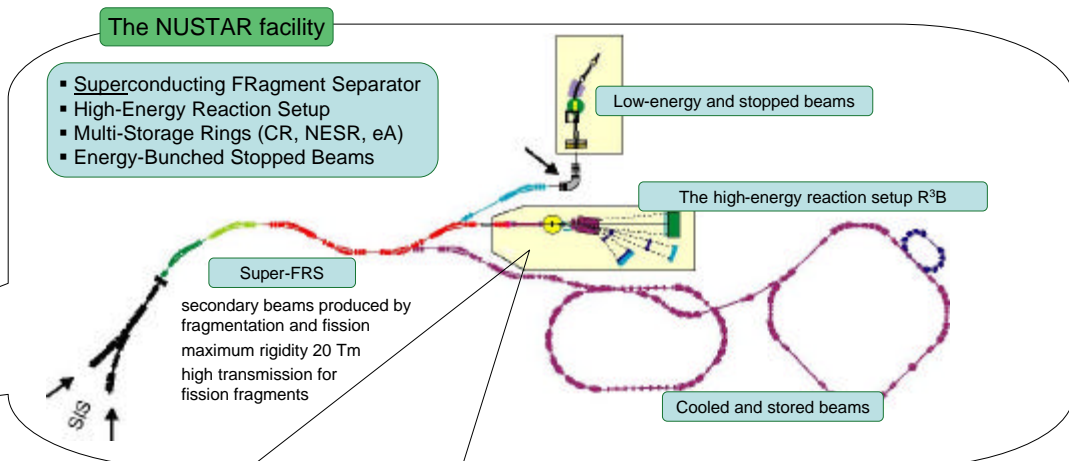
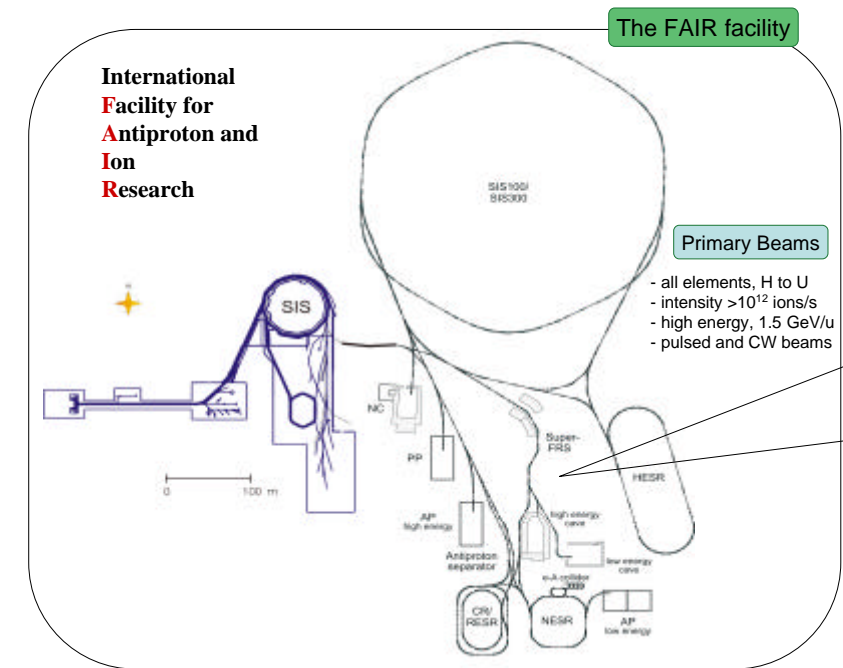


The high-energy branch of the Super-FRS:

A universal setup for kinematical complete measurements of Reactions with Relativistic Radioactive Beams



presented by Thomas Aumann at INPC2004



The physics Nuclear structure far off stability

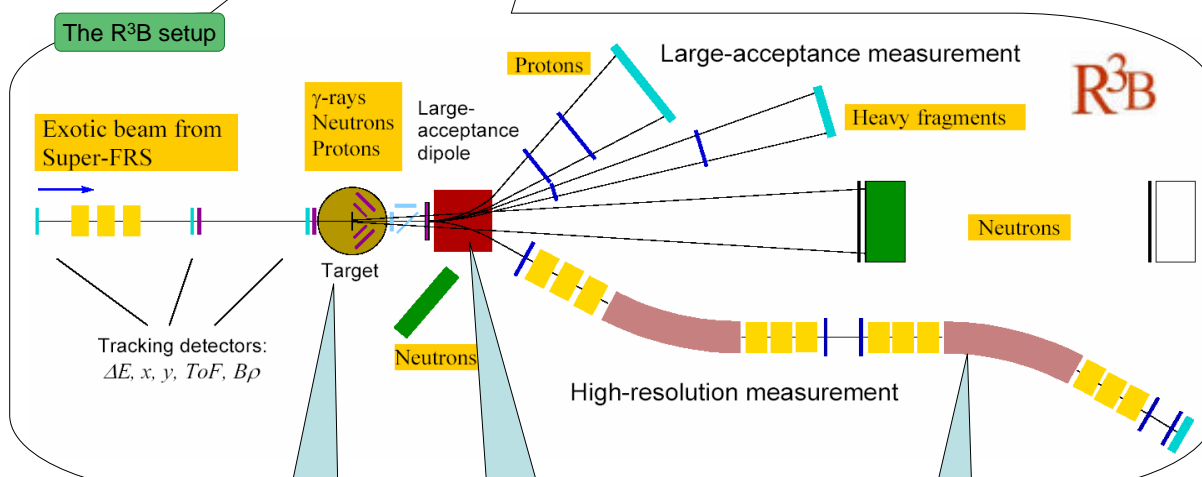
- Halos and neutron skins
- (New) collective excitations
- Evolution of shell structure
- Astrophysics
- Nuclei beyond the neutron drip-line
- Correlations
- ...

The method Scattering experiments with radioactive nuclei at high energy

- heavy-ion inelastic (elm) scattering
- peripheral reactions
- proton-induced scattering
- ...

Key features of the experimental approach

- capable to accept high beam energies (up to maximum rigidity of Super-FRS: 20Tm)
? max transmission for fission products (max intensity)
- and full emittance: 'individual cooling' (tracking and momentum measurement, $\Delta p/p \sim 10^{-4}$)
- access to short-lived nuclei (flight path $\sim \mu\text{s}$)
- use of thick targets ($\sim \text{g/cm}^2$) ? luminosity gain
- kinematical complete measurement
- full-solid angle measurement plus high detection efficiency
- quantitative description of reaction mechanisms
- fully stripped ions even for heavy nuclei
- large cross sections for many reactions (e.g. elm excitation ~ 1 b, knockout ~ 100 mb)
- ? compensating low beam intensities
- ? experiments possible for very exotic and short-lived nuclei (even with low rates, ~ 1 ion/sec)



Technical developments and challenges

Total-absorption gamma spectrometer

Design goals:

- High efficiency for high-energy γ (~ 10 MeV)
- High γ sum-energy efficiency
- Good resolution ($\sim 1-2\%$ including Doppler broadening)

Cooled pure CsI seems to be a possible and cost-effective solution

Superconducting large-acceptance dipole

High field integral (5 Tm) ? high beam energies (up to 20 Tm)

Active shielding ? dipolar field, low fringe fields

Large acceptance ? full-acceptance measurements for heavy ions, neutrons and light charged particles

Superconducting coils ? compact design, low operation cost

Momentum resolution $\Delta p/p \sim 10^{-3}$ in conjunction with tracking

High-resolution magnetic spectrometer

Design goals:

- momentum resolution $\Delta p/p \sim 10^{-4}$
- dispersion matching? or tracking
- acceptance: = acceptance of Super-FRS

possible solution: 2 Super-FRS dipole stages

Detector developments

- High-resolution Neutron ToF spectrometer
- Si strip tracker for target (proton)-recoil detection
- Large-area fast-timing ToF wall for charged fragments
- High-rate capable position sensitive detectors, e.g., diamond detectors

Detector developments

- Large-area tracking detectors for protons and heavy ions
- Low-energy neutron detector (target recoils)
- Cherenkov detector for velocity measurements
- Active Target

A broad physics programme

Experiment	Experiment
Nuclear radii, density distributions, halos and skins, nuclear equation of state	Total-absorption measurements, proton elastic scattering, knockout and momentum distributions, spin-dipole excitations
Shell structure far off stability, single-particle occupancies, spectral functions	Knockout reactions, quasi-free scattering, Coulomb breakup
Dipole response of exotic nuclei, giant dipole resonance and soft modes	Heavy-ion induced electromagnetic excitation
Nuclei beyond the neutron drip-line	Knockout reactions
Astrophysics	(γ, n) and (γ, p) cross sections (Coulomb breakup) Gamov-Teller transitions (charge-exchange)
Gamma spectroscopy	Knockout and fragmentation
Large-amplitude motion	Multifragmentation and fission
Reaction mechanisms/applications (hybrid reactors etc.)	Spallation and fission

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