HESR-project in FAIR at GSI

High **E**nergy **S**torage **R**ing for antiprotons

in the

Facility for **A**ntiproton and **I**on **R**esearch

at GSI, Darmstadt, Germany

Contents

- Symbiosis between accelerator and experiment
- What are we talking about?
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Symbiosis (1)

Experimentalists cannot live without accelerator physicists and

accelerator physicists cannot live without experimentalists

You need accelerators, but no accelerator will be built without constant visible demand for the experiments. In the case of HESR we are talking about a phase of 5 – 8 years in which this demand should increase steadily

(~3 generations of thesis !)

Symbiosis (2)

Experiments and accelerator layout are intimately connected for state-of-the-art experiments. Seek discussion during the early planning phase of the accelerator. Some requirements might exclude each other.

Example: Idea for polarized antiprotons nearly missed the deadline for being included. Now the HESR can be planned to allow this extension.

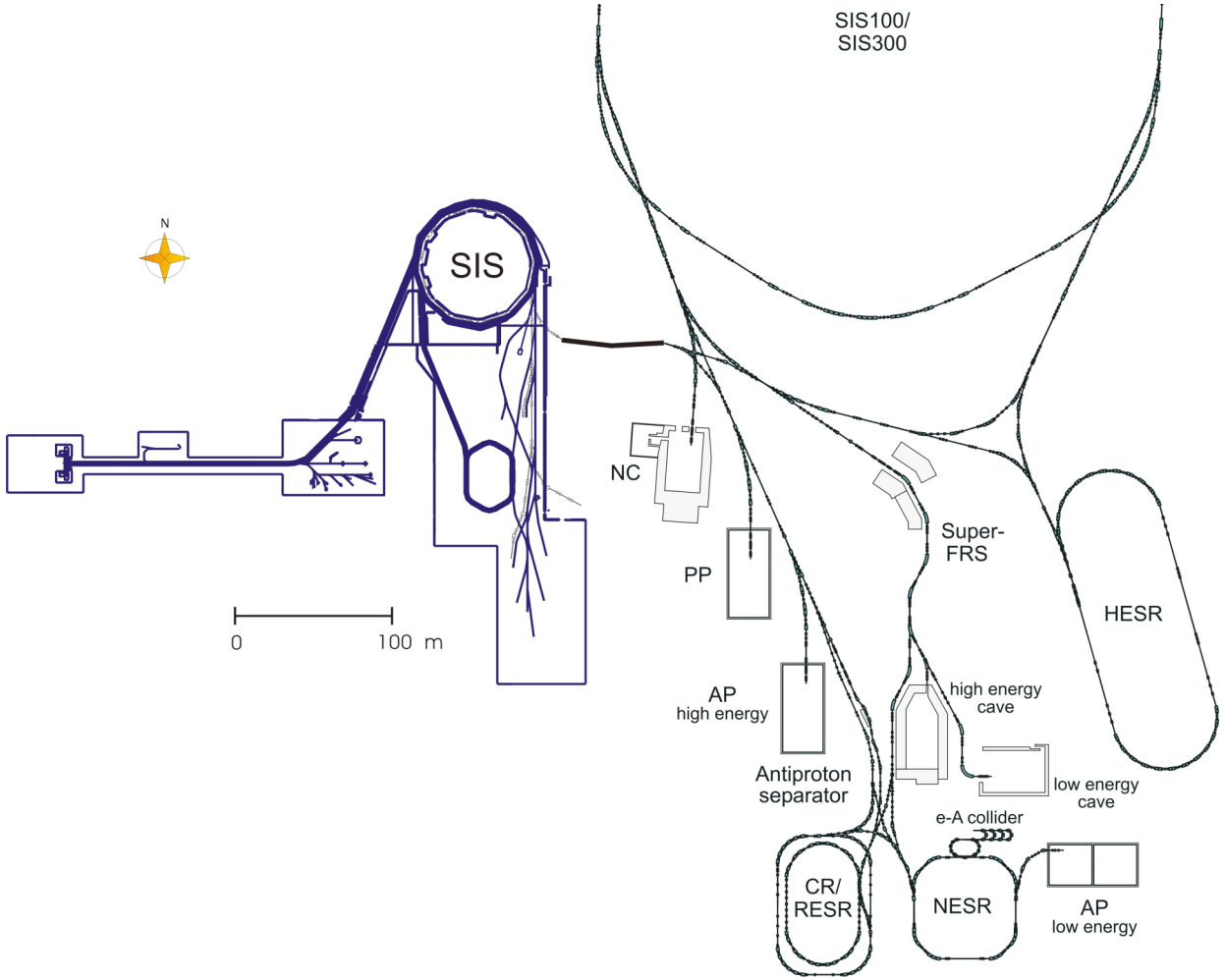
Mission of HESR

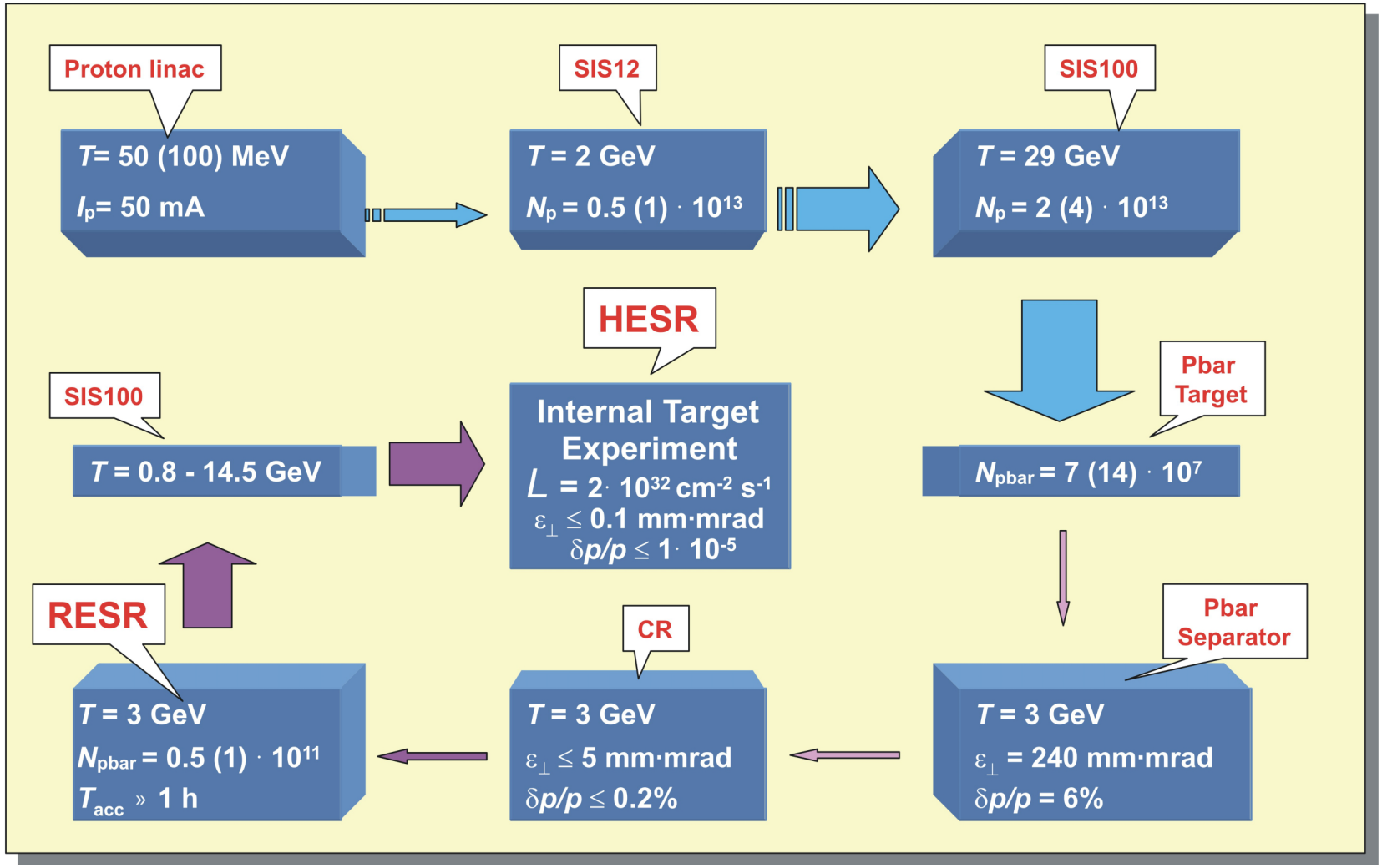
- Provide a door to the physics with antiprotons in the low GeV region
- Make precision antiproton beams available for state-of-the-art experiments

Presently the following experiments are planned

- PANDA
- PAX, ASSIA

FAIR: The Facility




Proton linac
T= 50 (100) MeV
Ip= 50 mA
SIS12
T = 2 GeV
Np = 0.5 (1) · 10^13
SIS100
T = 29 GeV
Np = 2 (4) · 10^13
HESR
Internal Target Experiment
L = 2· 10^32 cm^-2 s^-1
ε⊥ ≤ 0.1 mm·mrad
δp/p ≤ 1· 10^-5
Pbar Target
Npbar = 7 (14) · 10^7
SIS100
T = 0.8 - 14.5 GeV
RESR
T = 3 GeV
Npbar = 0.5 (1) · 10^11
Tacc » 1 h
CR
T = 3 GeV
ε⊥ ≤ 5 mm·mrad
δp/p ≤ 0.2%
Pbar Separator
T = 3 GeV
ε⊥ = 240 mm·mrad
δp/p = 6%

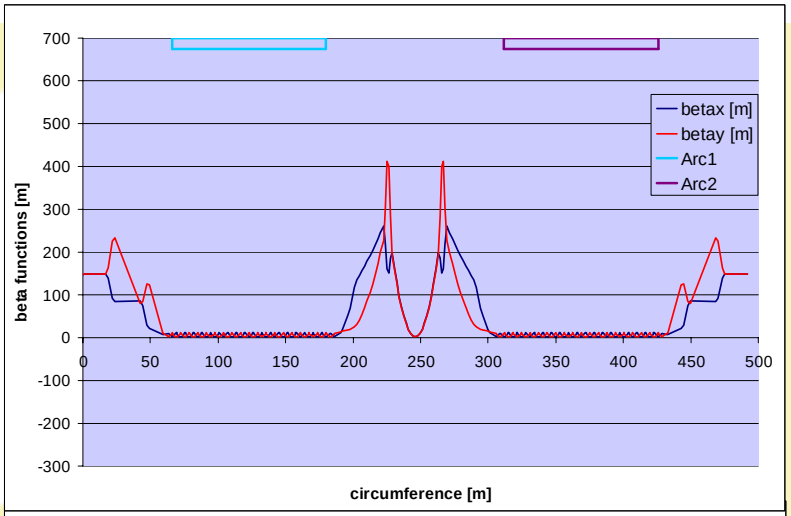
HESR Parameters and Layout

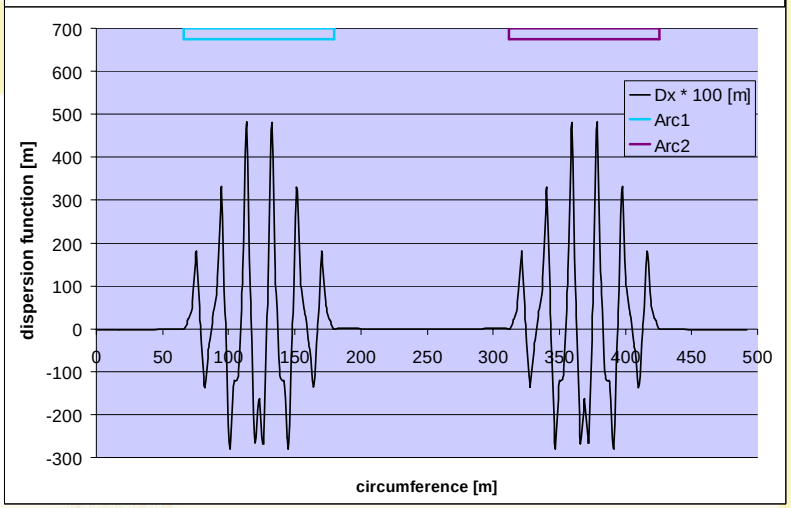
- HESR is a storage ring with cooling and ONE place for experiments
- Momentum range is 1.5 GeV/c to 15 GeV/c (0.831 GeV/c^2 to 14 GeV/c^2)
- At the target place a beam diameter < 1 mm will be provided
- Betafunctions at the target ~ 1 m

Lattice Parameters

(designed by Y. Senichev)

- Large β-functions at the Electron Cooler
- Small β-functions at the target position
- Large (or imaginary) $\gamma_{transition}$ for beam stability





HESR Modes (aims!)

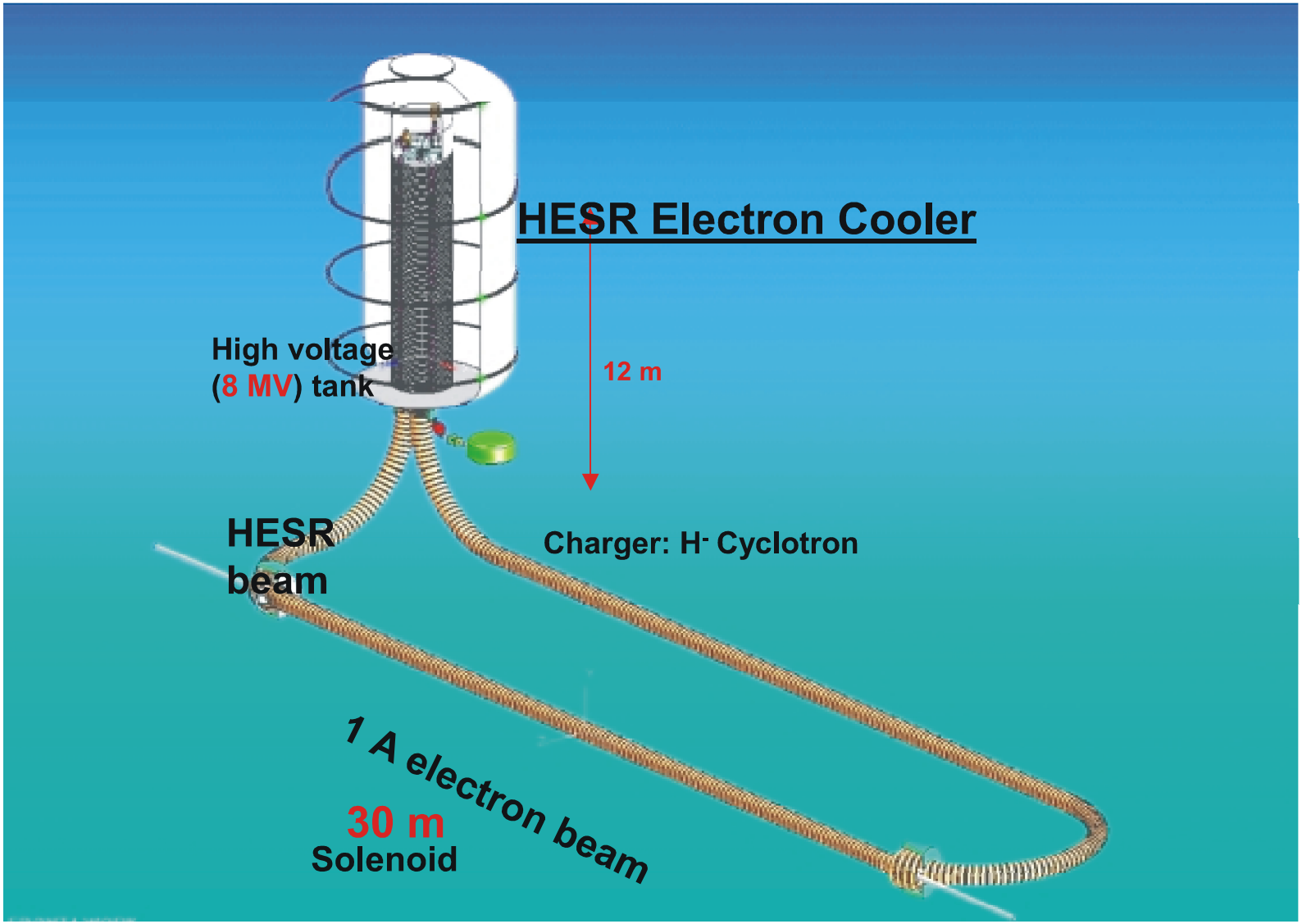
- **The users would like to get :**

high luminosity mode : $2*10^{32}cm^{-2}sec^{-1}$ with ~ 10^{-4} momentum spread
high resolution mode : $10^{31}cm^{-2}sec^{-1}$ with ~ 10^{-5} momentum spread

- **the HESR ring with dedicated cooling systems can deliver :**

	High luminosity mode	High resolution mode
0.85 GeV	• beam intensity : $5*10^{10}$ • effective target thickness :$3*10^{15}$ cm^{-2} ⇒ luminosity of $10^{32}cm^{-2}sec^{-1}$ • radius σ_T : 0.78 mm ⇒ 0.2 mm • momentum spread σ_p/p : $7.2*10^{-4}$ ⇒ $1*10^{-4}$	• beam intensity : $5*10^{10}$ • effective target thickness :$3*10^{13}$ cm^{-2} ⇒ luminosity of $10^{30}cm^{-2}sec^{-1}$ • radius σ_T : 0.78 mm ⇒ 0.1mm (#) • momentum spread σ_p/p :$7.2*10^{-4}$ ⇒ $0.15*10^{-4}$(*)
6 GeV	• beam intensity : $5*10^{11}$ • effective target thickness :$3*10^{15}$ cm^{-2} ⇒ luminosity of $10^{33}cm^{-2}sec^{-1}$ • radius σ_T : 0.37 mm ⇒ 0.1 mm • momentum spread σ_p/p :about $1.4*10^{-4}$(*)	• beam intensity : $5*10^{10}$ • effective target thickness :$3*10^{14}$ cm^{-2} ⇒ luminosity of $10^{31}cm^{-2}sec^{-1}$ • radius σ_T : 0.37 mm ⇒ 0.05 mm • momentum spread σ_p/p : $1.4*10^{-4}$ ⇒ $0.5*10^{-4}$(*)
15 GeV	• beam intensity : $5*10^{11}$ • effective target thickness :$3*10^{15}$ cm^{-2} ⇒ luminosity of $10^{33}cm^{-2}sec^{-1}$ • radius σ_T : 0.22 mm ⇒ 0.6 mm • momentum spread σ_p/p : $0.6*10^{-4}$ ⇒ $2*10^{-4}$	• beam intensity : $5*10^{10}$ • effective target thickness :$3*10^{14}$ cm^{-2} ⇒ luminosity of $10^{31}cm^{-2}sec^{-1}$ • radius σ_T : 0.22 mm⇒ 0.1 mm • momentum spread σ_p/p : $0.6*10^{-4}$ ⇒ $0.2*10^{-4}$(*)

σ_T is the rms beam radius at target($ß_T$ = 1m at target) : (#) is 0.1 tune spread ; σ_p/p is the rms momentum spread : numbers marked by (*) are the limiting values for 100 Ω impedance and pulse width σ_b = 0.11 µsec


HESR Electron Cooler
High voltage
(8 MV) tank
12 m
HESR
beam
Charger: H- Cyclotron
1 A electron beam
30 m
Solenoid

Cooling

- Electron cooling links transverse and longitudinal cooling. 8 MV not done before. 8 MV corresponds to 15 GeV/c.
- Stochastic cooling can be used separately for longitudinal, horizontal and vertical particle motion.
- Sophisticated combination of electron and stochastic cooling under investigation. Modelling (beam-target interaction, intrabeam scattering)!

Relation of IKP / FZJ to HESR

- FZ Jülich (IKP-COSY Group) takes over the responsibility for building the HESR
- Formal commitment / agreement pending, first draft of MoU is circulating
- Successful application for EU money (Design Study) together with other subprojects of FAIR
  - Contract negotiations with EU in progress. 90% of the applied money will be granted. For HESR ~ 1.3 M€ can be expected for 2005-2007. HESR consortium between FZJ, TSL and GSI.

Extension: Polarization

To polarize antiprotons two ideas have been proposed:

The first, called Spin Filter (see talk by Frank Rathmann), is based on the fact that absorption of antiprotons in a polarized proton target is different when the two spins are parallel or antiparallel. If the spin-dependent cross-sections sigmaL or sigmaT are not negligible, the transmitted beam can be (slightly) polarized.

The effect is enhanced in the case where a polarized hydrogen target based on the storage cell technique is installed in a storage ring.

Preferred!

The second idea is the Spin Splitter which based on the separation of particles with opposite spins by Stern-Gerlach effect in the inhomogeneous field of a quadrupole.

Polarization: HESR add-ons

Additional equipment in the HESR

Acceleration from 1.5 GeV/c to 15 GeV/c (830 MeV to 14 GeV)

- **Synchrotron Magnets**
- **Dynamic Power supplies**
- **Control**
- **Polarisation conservation**
- **Polarimeter**
- **Full and helical snakes**
- **RF Dipole**
- **Pulsed quadrupoles**
- **Proton Injection**
- **Larger Circumference: 1 M€ per 10 m**

Estimated Costs and Manpower: 45M€+25 M€ & (350 MY for HESR)

The Antiproton Polarizer

Ring itself

- **Acceleration from 240 MeV/c to 1.5 GeV/c (30 MeV to 830 MeV)**
- **Electron Cooler**
- **Full snake at low energy**
- **Polarisation conservation (Fast Quads, RF Dipole)**
- **Polarimeter**

2 Injections
2 Extractions
Targetstation
Polarized H^--source

30 MeV injector

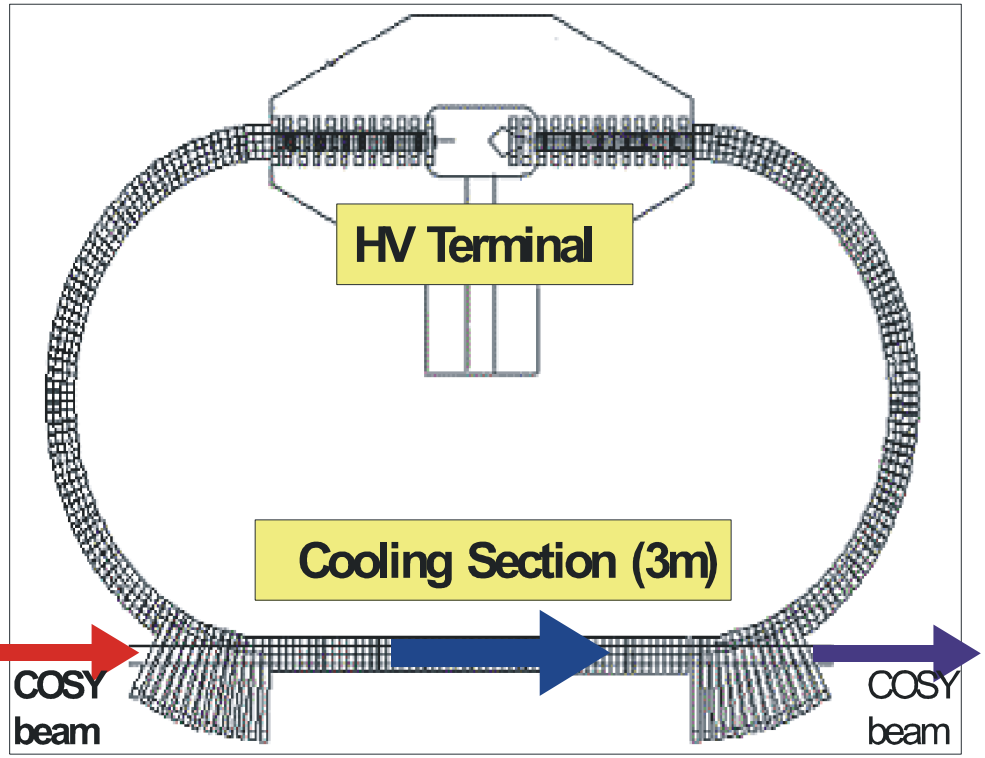
Estimated Costs and Manpower: 30 M€ & 150 MY without infrastructure costs

Synergy with future COSY activities

- Experience with the planned 2 MV cooler for a COSY upgrade will influence the proposed 8 MV cooler for HESR

COSY 2 MV cooler

Basic concept proposed by V.V. Parkhomchuk et al. (Budker Institute, Novosibirsk, RUS)



Main Parameters

HV terminal:
- 0.25-2 MV, 3 A
- cascade charger
- 10 bar SF_6

Cooling section:
- length 3 m
- magnetic field 0.05-0.2 T
- beam diameter 14-29 mm