PAX status report: Spin-filtering studies at COSY

http://www.fz-juelich.de/ikp/pax

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Roma, CSN III, 30 maggio 2006

Outline

- Preparatory work:
  Commissioning of ANKE Polarized Internal Target

- Spin-studies at COSY
  .Goal
  - Request for new interaction point
  - Experimental setup
  - Preparation of AD experiment

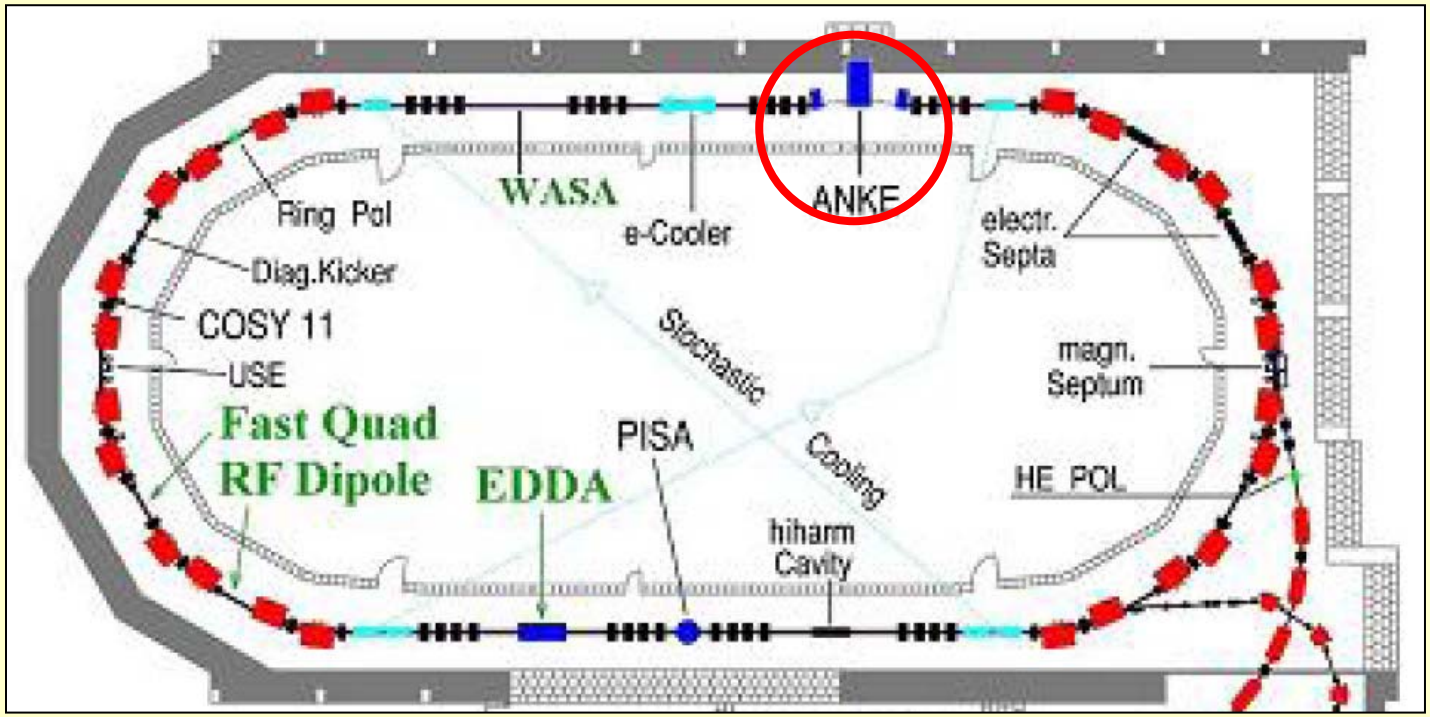
- Timeline

PAX timeline

Jan. 04	Letter of Intent for FAIR
Jan. 05	Technical Proposal for FAIR
Nov. 05	LoI to CERN-SPSC to perform spin-filtering experiments with antiprotons at the AD ring
Apr. 06	LoI to COSY-PAC for spin filtering experiments with protons at COSY

Commissioning of ANKE PIT

Propedeutical studies to spin-filtering experiments



Goal: installation of a storage cell with a polarized target in COSY

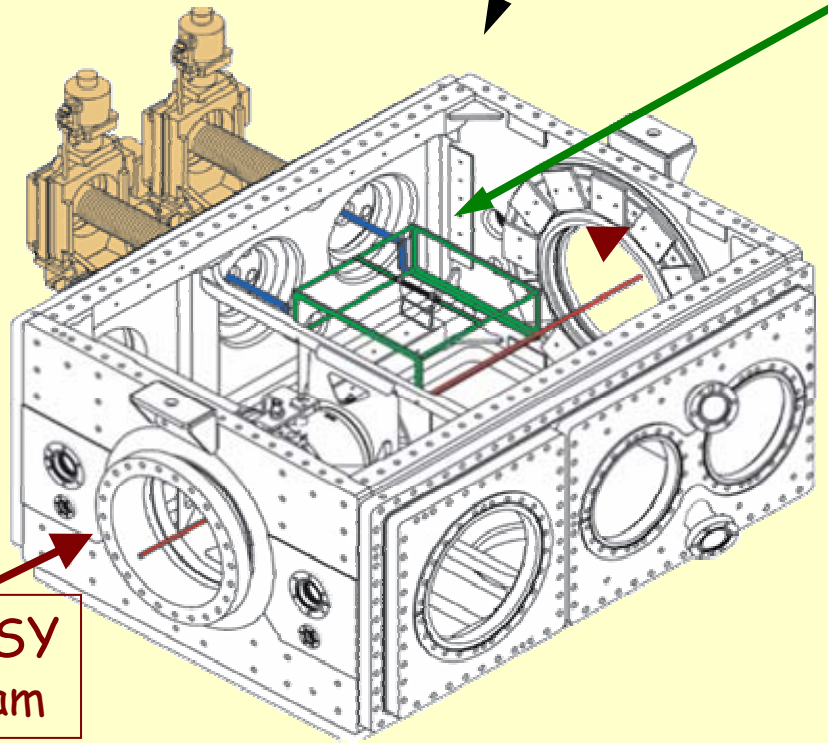
- Electron-cooling at injection with storage cell
- Stochastic cooling at 700 MeV
- Cooler stacking to increase particles in the ring

Storage Cell Setup (coll. Ferrara – FZJ)

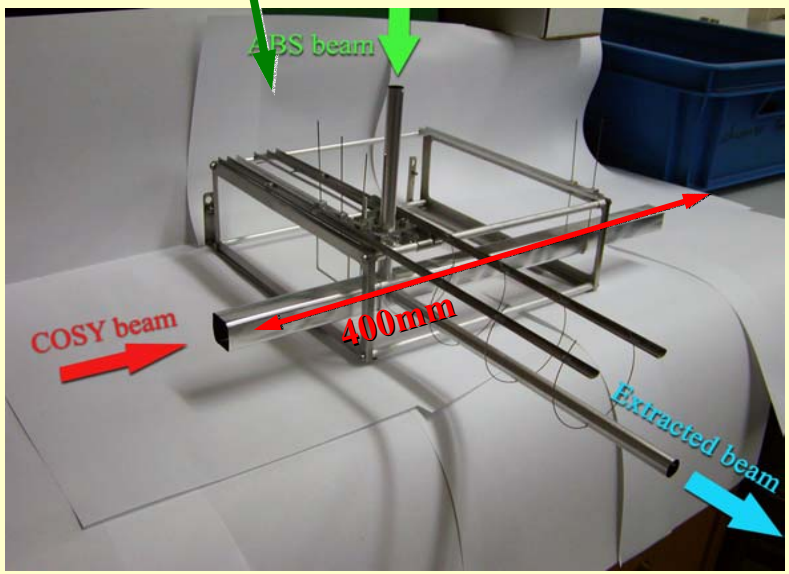
XY-table

Target chamber

Frame with storage cell and aperture

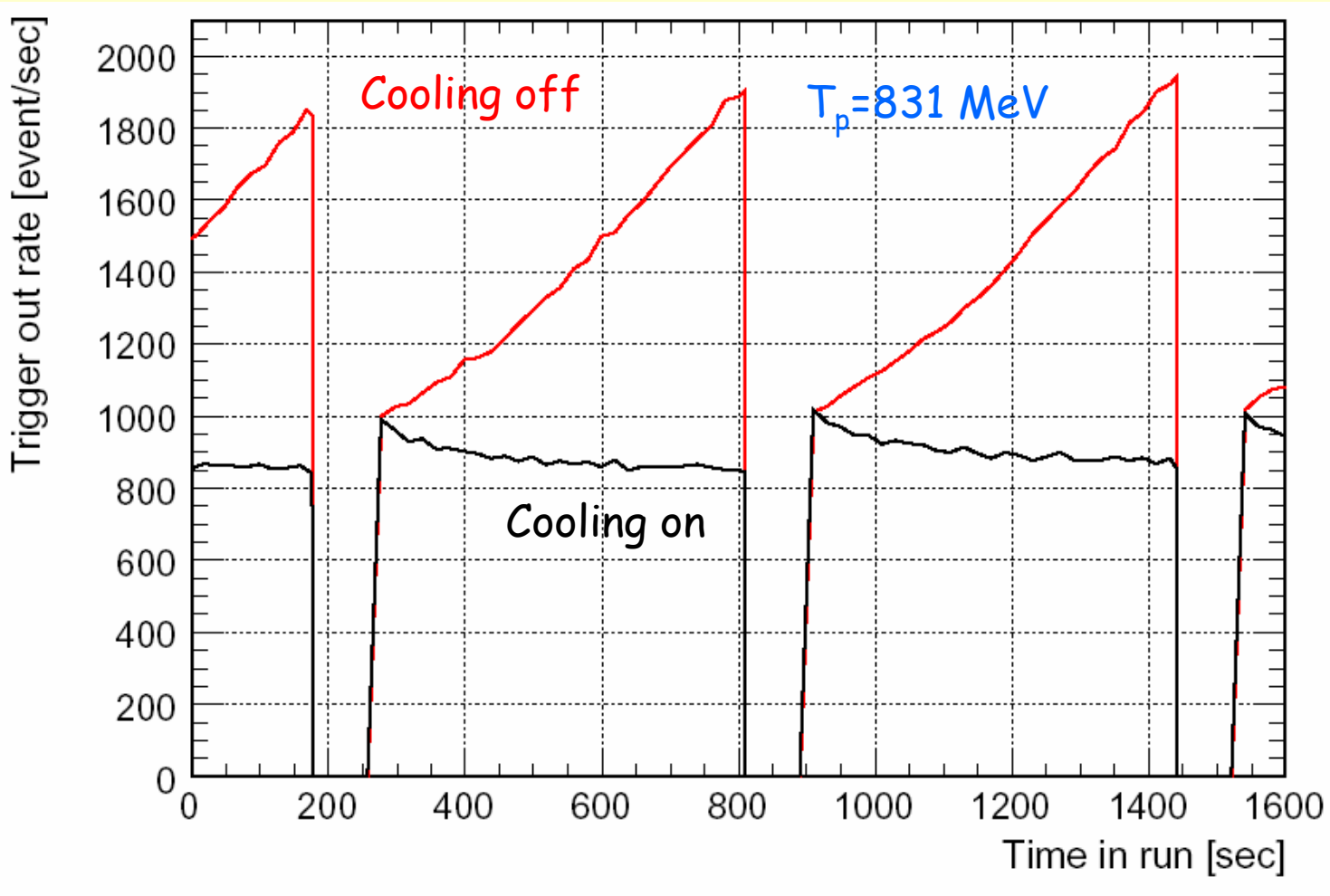


COSY beam

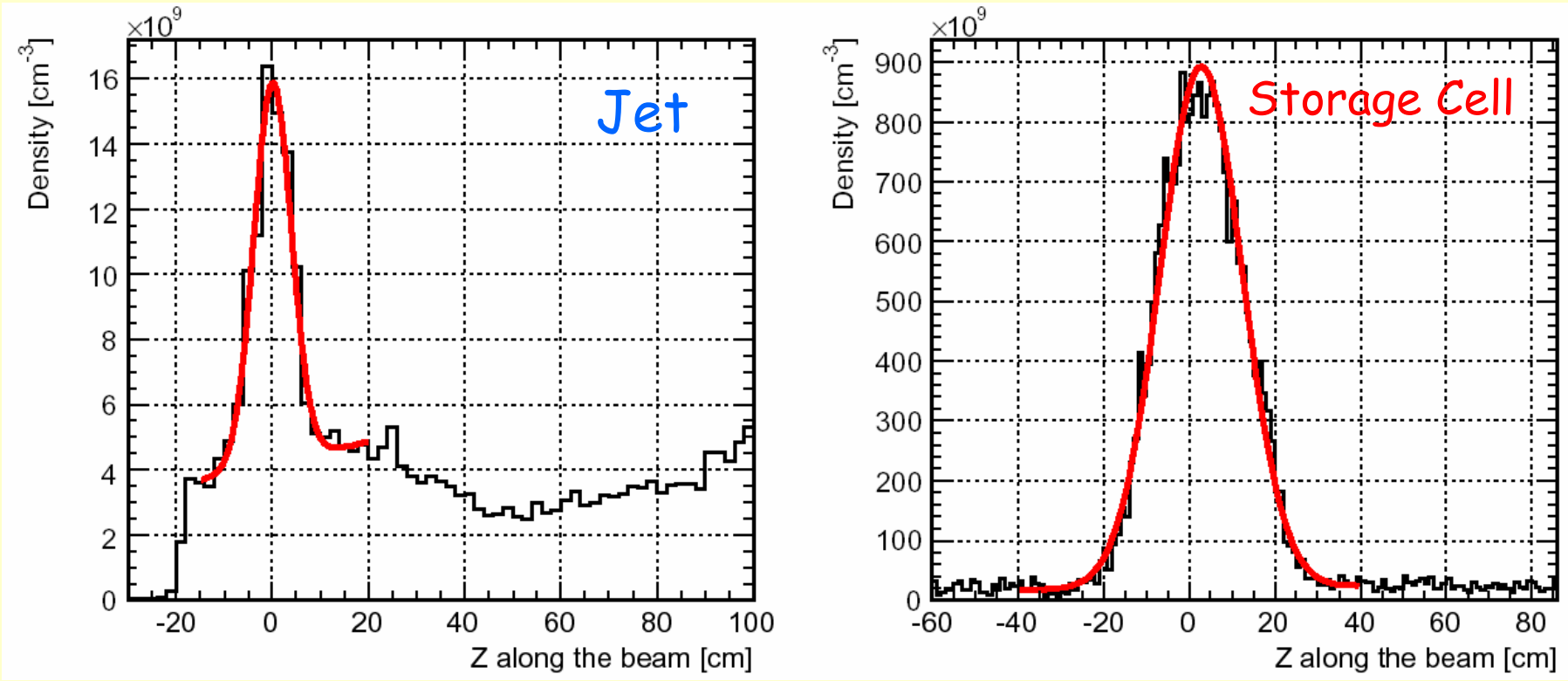


Feeding tube: l = 120 mm, Ø = 10 mm
Extraction tube: l = 230 mm, Ø = 10 mm
Beam tube : l = 400 mm, 20x20 mm^2

Storage cell and stochastically cooled beam



Target Thickness (from pp→dπ+)

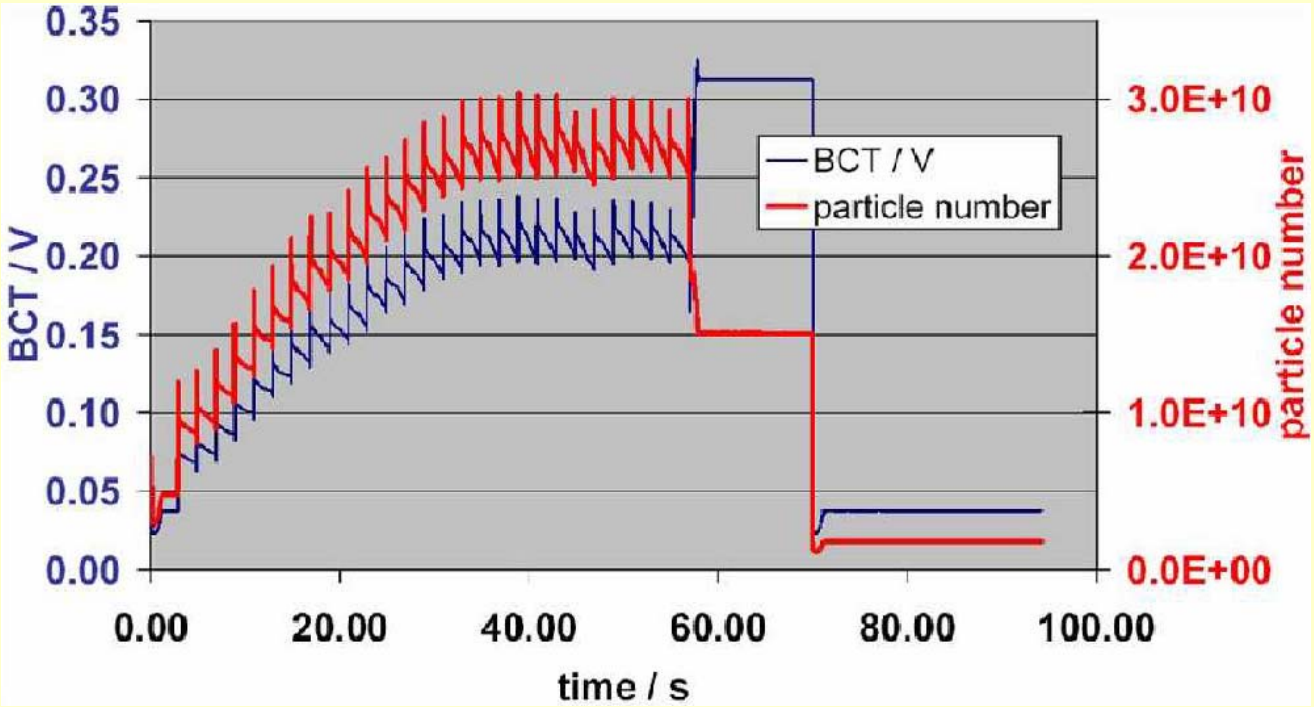


Method	Jet [atoms/cm^2]	Storage Cell [atoms/cm^2]
ABS flux (+ cell geometry)	(1.6±0.1)·10^{11}	(1.9±0.1)·10^{13}
Rates (pp→dπ+)	(1.5±0.1)·10^{11}	(2.1±0.1)·10^{13}

Cooler Stacking into the Storage Cell

28 stacks followed by

- 2s electron cooling
- after 58s acceleration to T_p=600 MeV

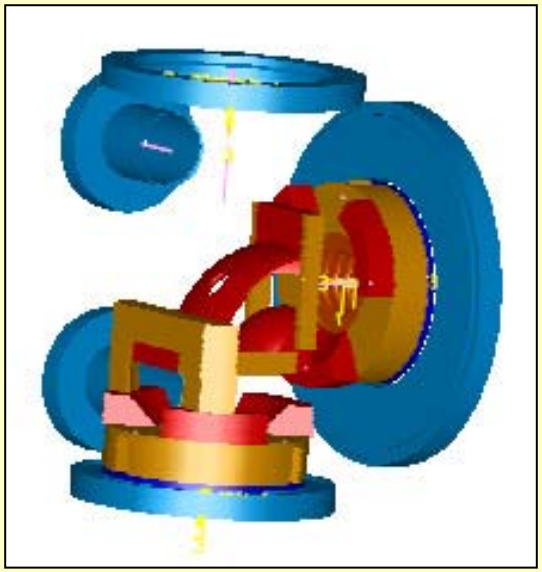


Cooler Stacking allows for higher polarized beam intensities with cell.

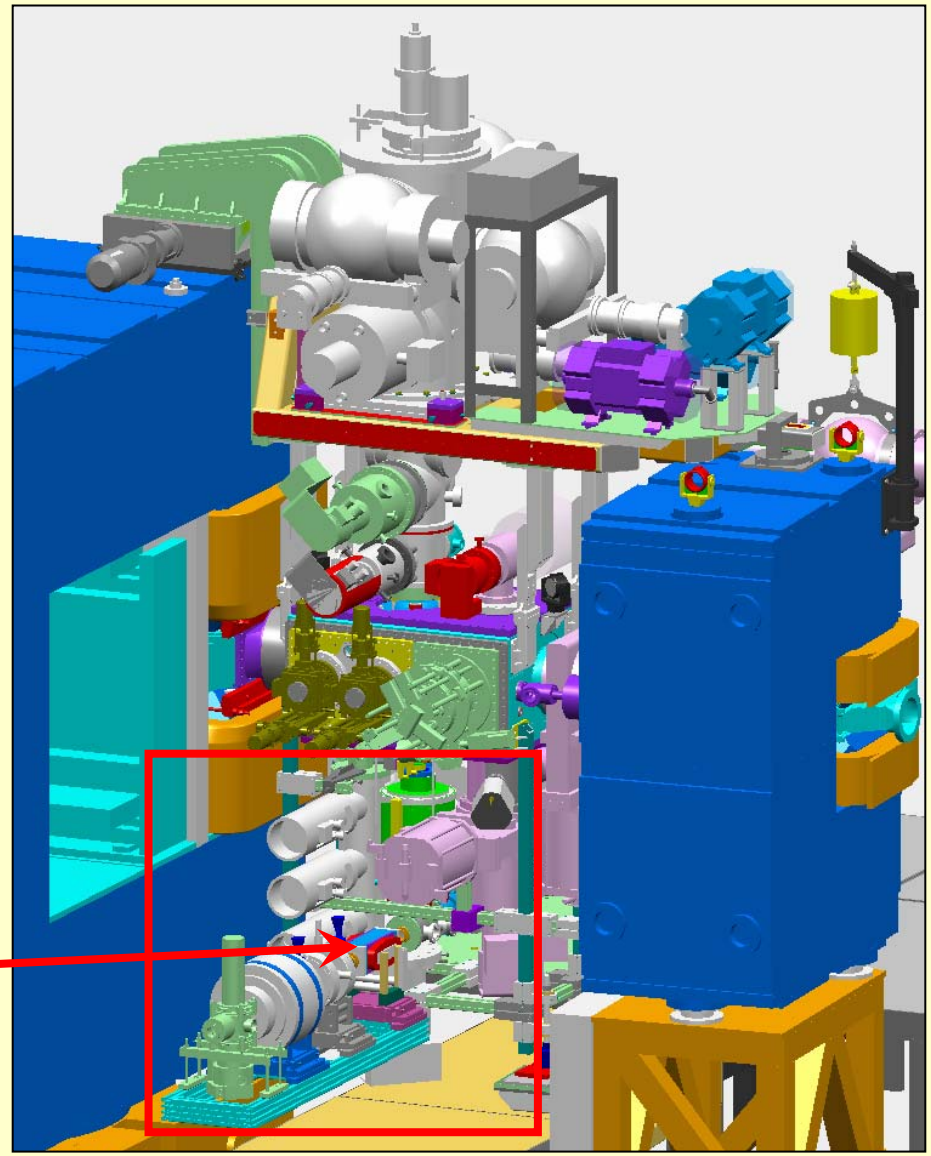
$2.5 \cdot 10^{10}$ protons have been injected in the ring

Next step: Installation of the Lamb-shift polarimeter

October 2006



Ferrara is building an ion-deflector



Polarized antiprotons: present situation

Intense beam of polarized pbar never produced:

- Conventional methods (ABS) not appliable

- Polarized pbar from antilambda decay
  - $I < 1.5 \cdot 10^5\ s^{-1}$ ($P \approx 0.35$)

- Pbar scattering off liquid H_2 target
  - $I < 2 \cdot 10^3\ s^{-1}$ ($P \approx 0.2$)

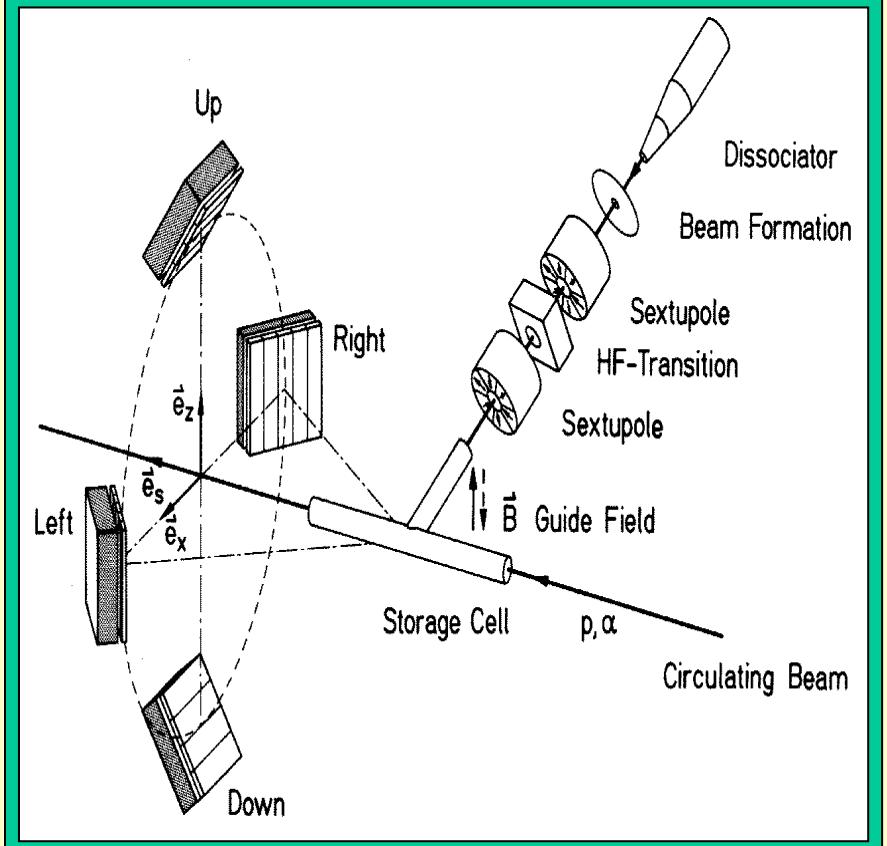
- Stern-Gerlach separation of a stored beam (never tested)
  - M. Conte and M. Pusterla asked for support

- 15.05.2006 (Th. Walcher et al) polarized electron beam

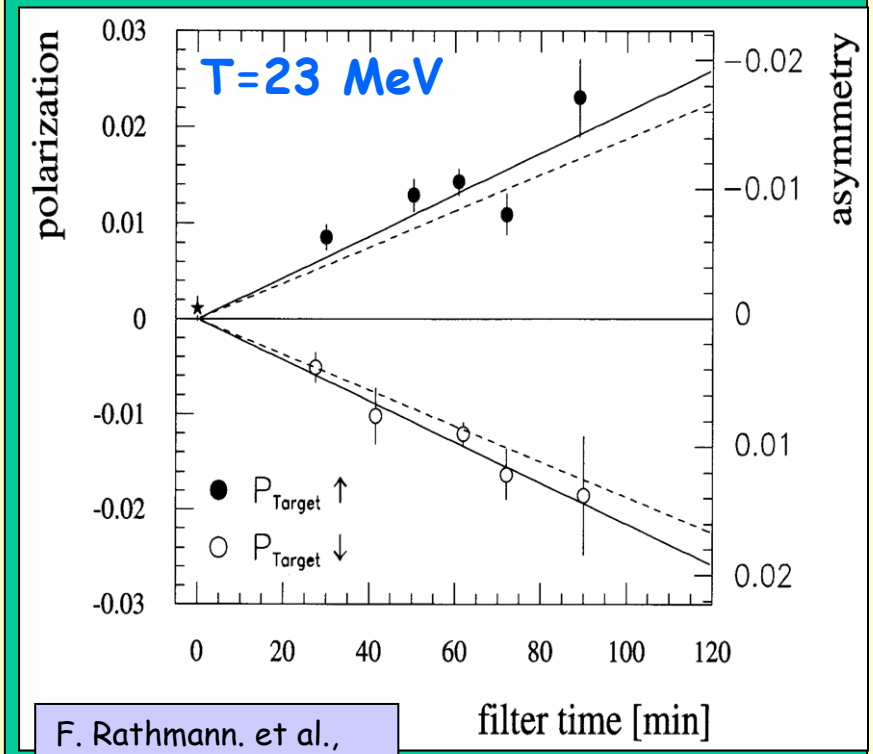
Spin-filtering is the only succesfully tested technique

1992 Filter Test at TSR with protons

Experimental Setup



Results



F. Rathmann. et al.,
PRL 71, 1379 (1993)

Two interpretations of FILTEX result

Observed polarization build-up: $dP/dt = \pm (1.24 \pm 0.06) \times 10^{-2}\ h^{-1}$

$P(t)=\tanh(t/\tau_1)$, $1/\tau_1=\sigma_1 Q d_t f$

$\sigma_1 = 72.5 \pm 5.8$ mb

Spin-filtering works! But how?

1994. Meyer and Horowitz: three distinct effects

1. Selective removal through scattering beyond θ_{acc}=4.4 mrad ($\sigma_{R\perp}$=83 mb)
2. Small angle scattering of target prot. into ring acceptance ($\sigma_{S\perp}$=52 mb)
3. Spin-transfer from pol. el. of target atoms to stored prot. ($\sigma_{E\perp}$=-70 mb)

$\sigma_1 = \sigma_{R\perp} + \sigma_{S\perp} + \sigma_{E\perp} = 65$ mb

2005. Milstein & Strakhovenko + Nikolaev & Pavlov: only one effect

1. Selective removal through scattering beyond θ_{acc}=4.4 mrad ($\sigma_{R\perp}$=85.6 mb)

No contribution from other two effects

(cancellation between scattering and transmission)

$\sigma_1 = 85.6$ mb

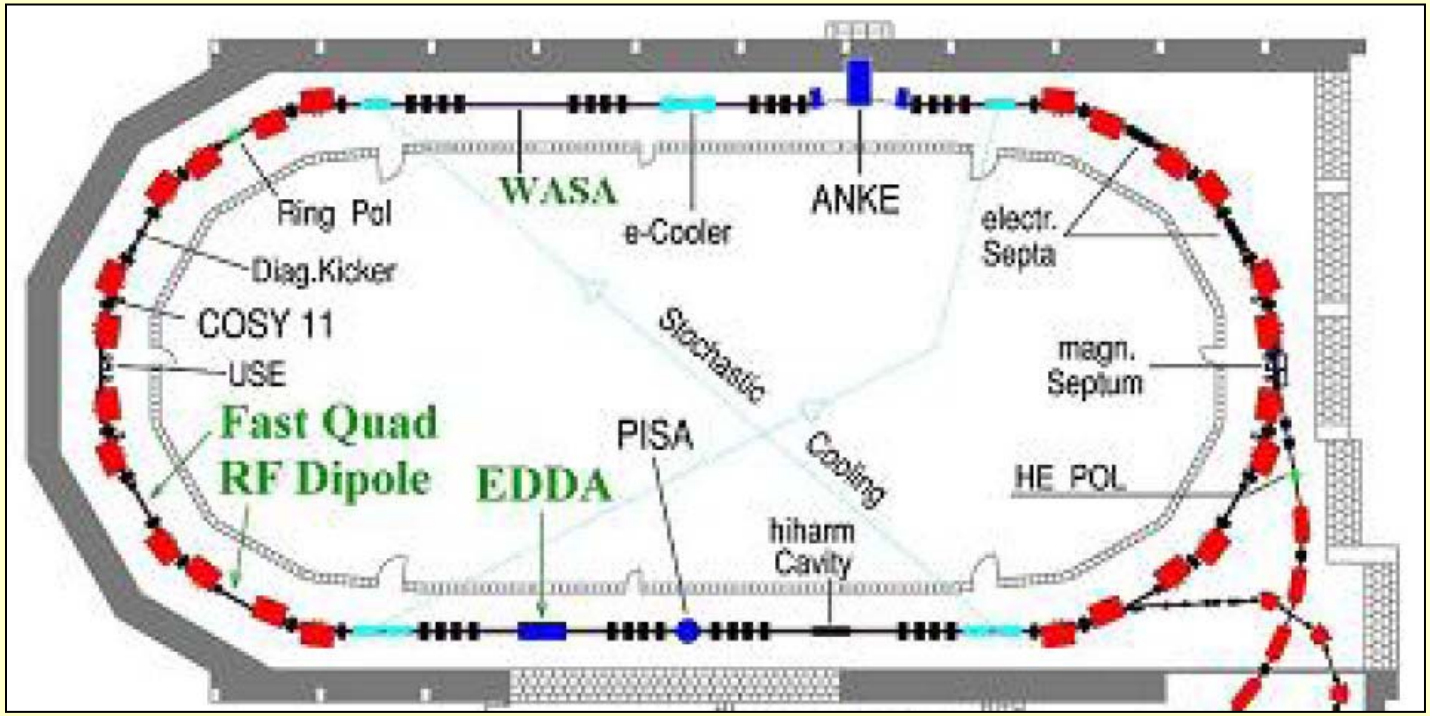
Spin-filtering: Present situation

Spin filtering works, but:

- controversial interpretations of TSR result
- no experimental basis for antiprotons

Experimental tests:
- Protons (COSY)
- Antiprotons (AD)

Spin-filtering studies at COSY

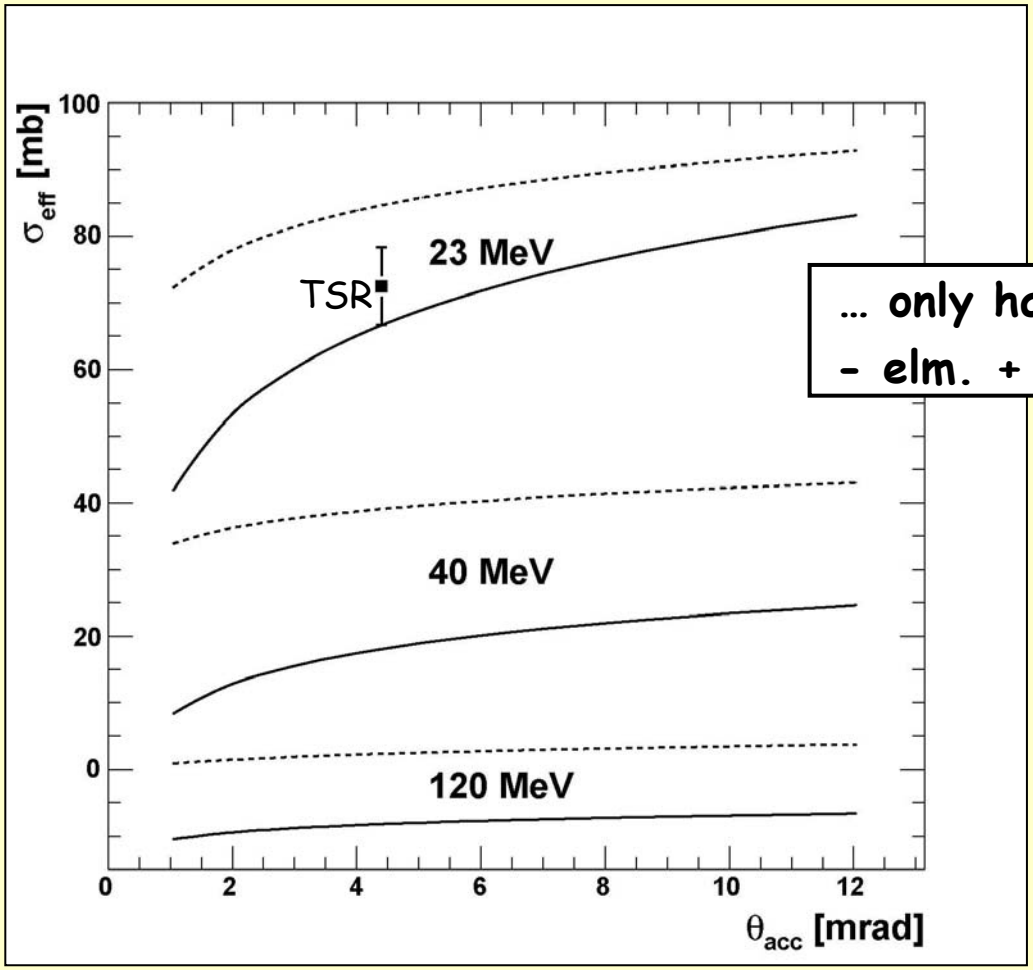


Goal: deeper understanding spin-filtering mechanism

Disentangle between two interpretations of TSR result.

- Electromagnetic + hadronic contributions
- Only hadronic

Polarizing cross-section for the two models



A measurement of σ with 10 % precision is needed.

Polarization measurement with ΔP/P = 10% requested.

How to disentangle had. and elm contributions?

1: Injection of different combination of hyperfine states

Different combinations of elm. and hadronic contributions:

Null experiment (elm. component = 0) possible in strong holding field

Inj. states	P_e	P_z	Interaction	Holding field	
|1>	+1	+1	Elm. + had.	Transv. + Long.	Weak (20 G)
|1>+|4>	0	+1	Only had.	Long.	Strong. (3kG)
|1>+|2>	+1	0	Only elm		

Strong field can be applied only longitudinally (minimal beam interference)

- Snake necessary

Target polarimetry difficult for pure electron polarization.

At ANKE only weak transverse field possible.

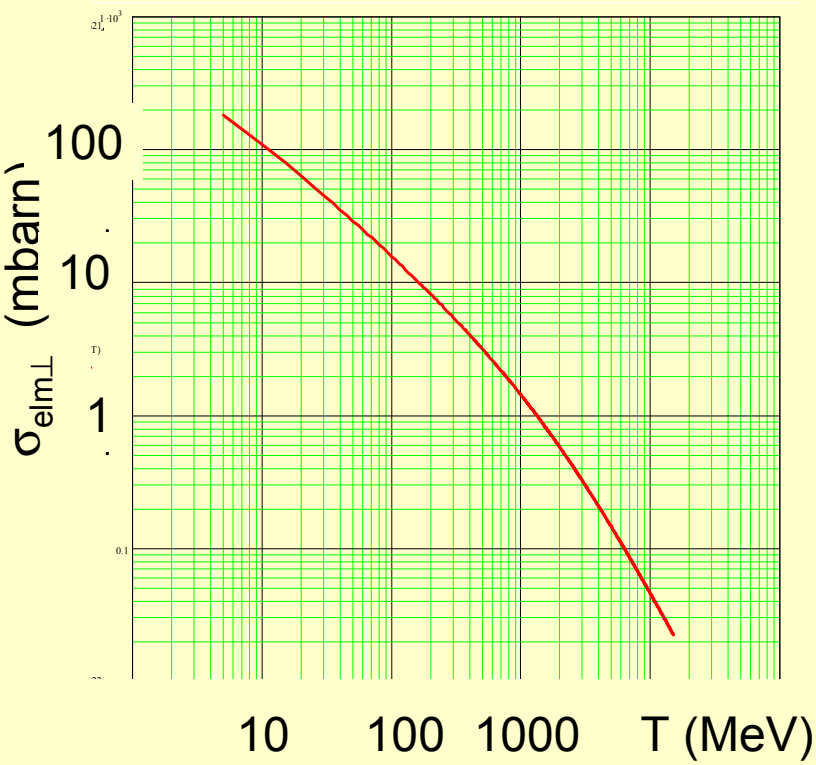
Experiment at AD will require both transverse and longitudinal (weak)field.

How to disentangle had. and elm contributions?

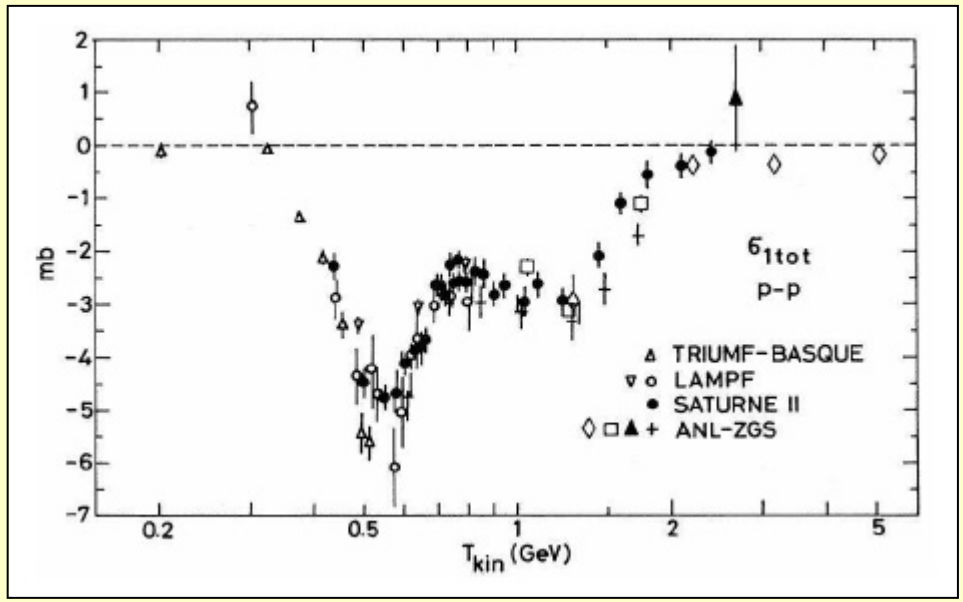
2: Use of different energy dependence of the processes

Measurement at different energies

Spin-transfer

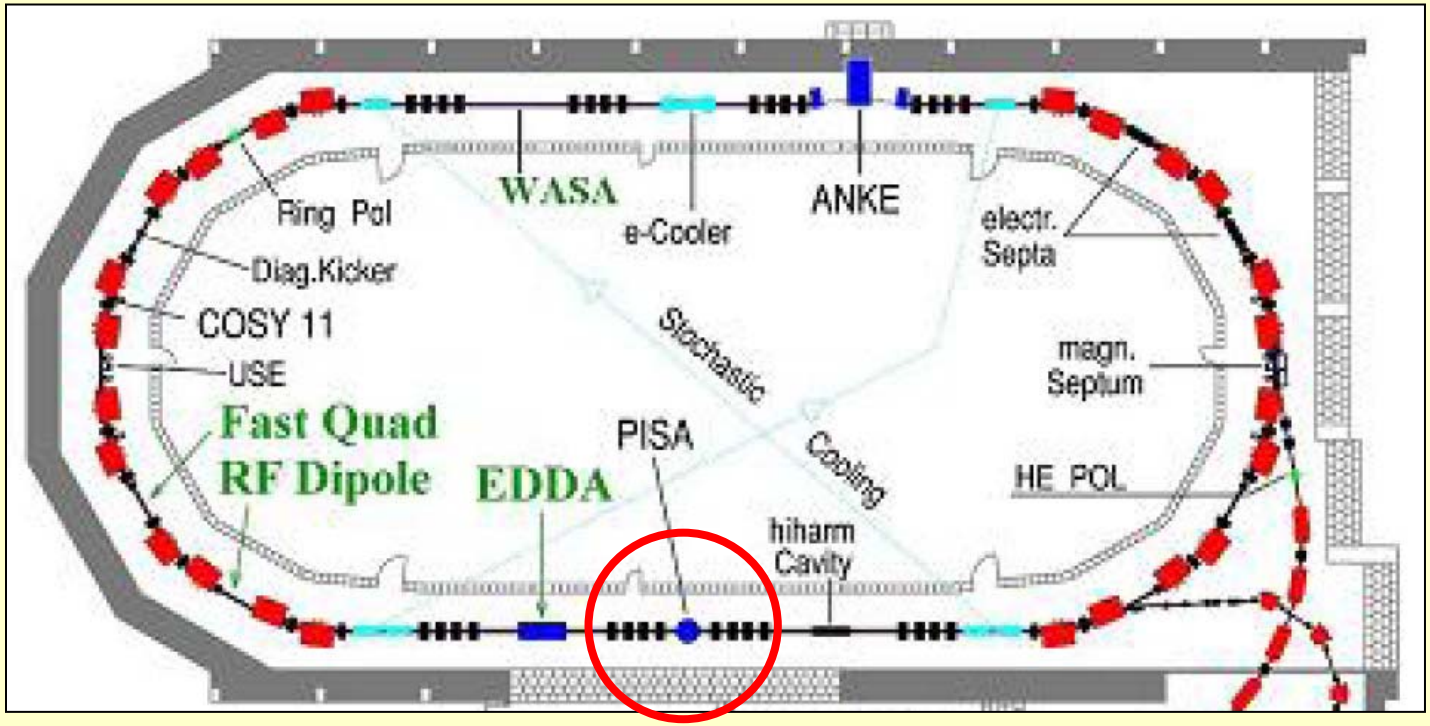


Hadronic



(Transverse case)

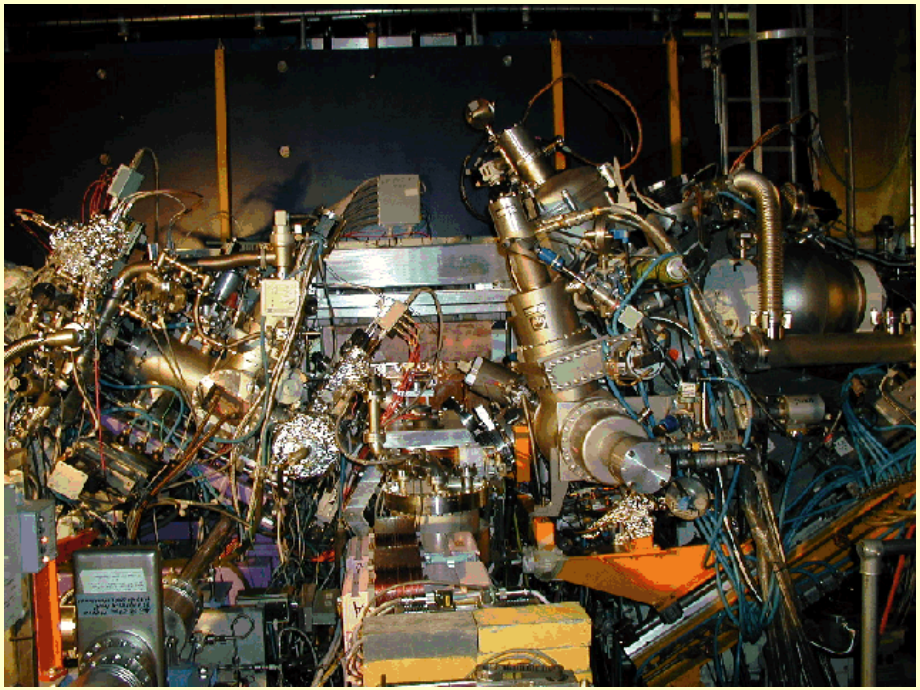
Experimental setup

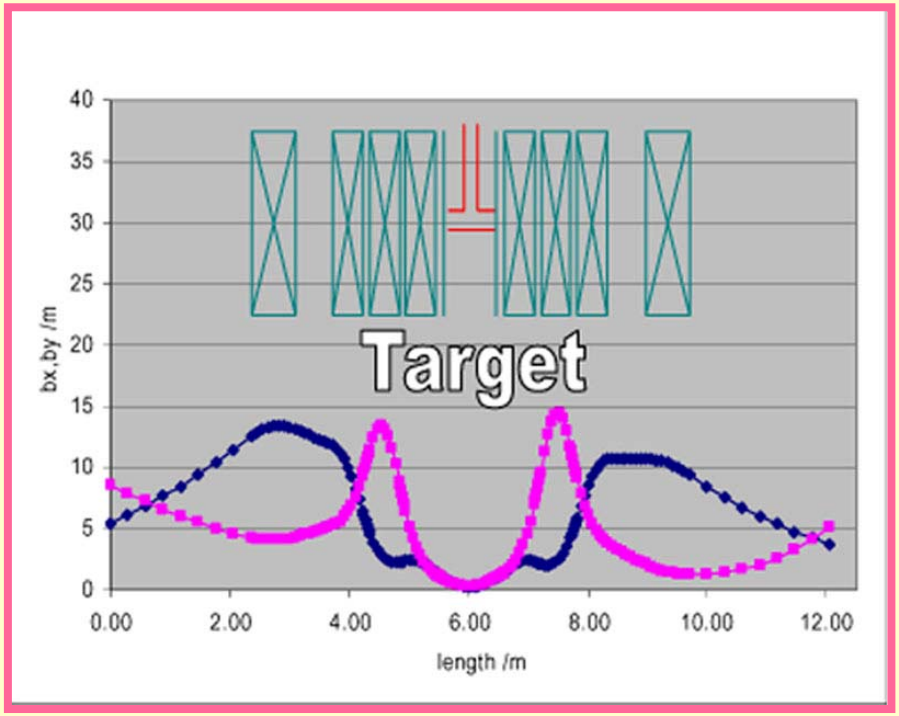


- Low-beta section
- Polarized target (HERMES)
- Detector
- Snake
- Commissioning of AD setu-up

Low beta section

- $\beta_{x,y}^{new}$=0.3 -> increase a factor 30 in density respect ANKE
  - Lower buildup time, higher rates
  - Higher polarization buildup-rate due to higher acceptance
- Use of HERMES target (in Jülich since March 2006)



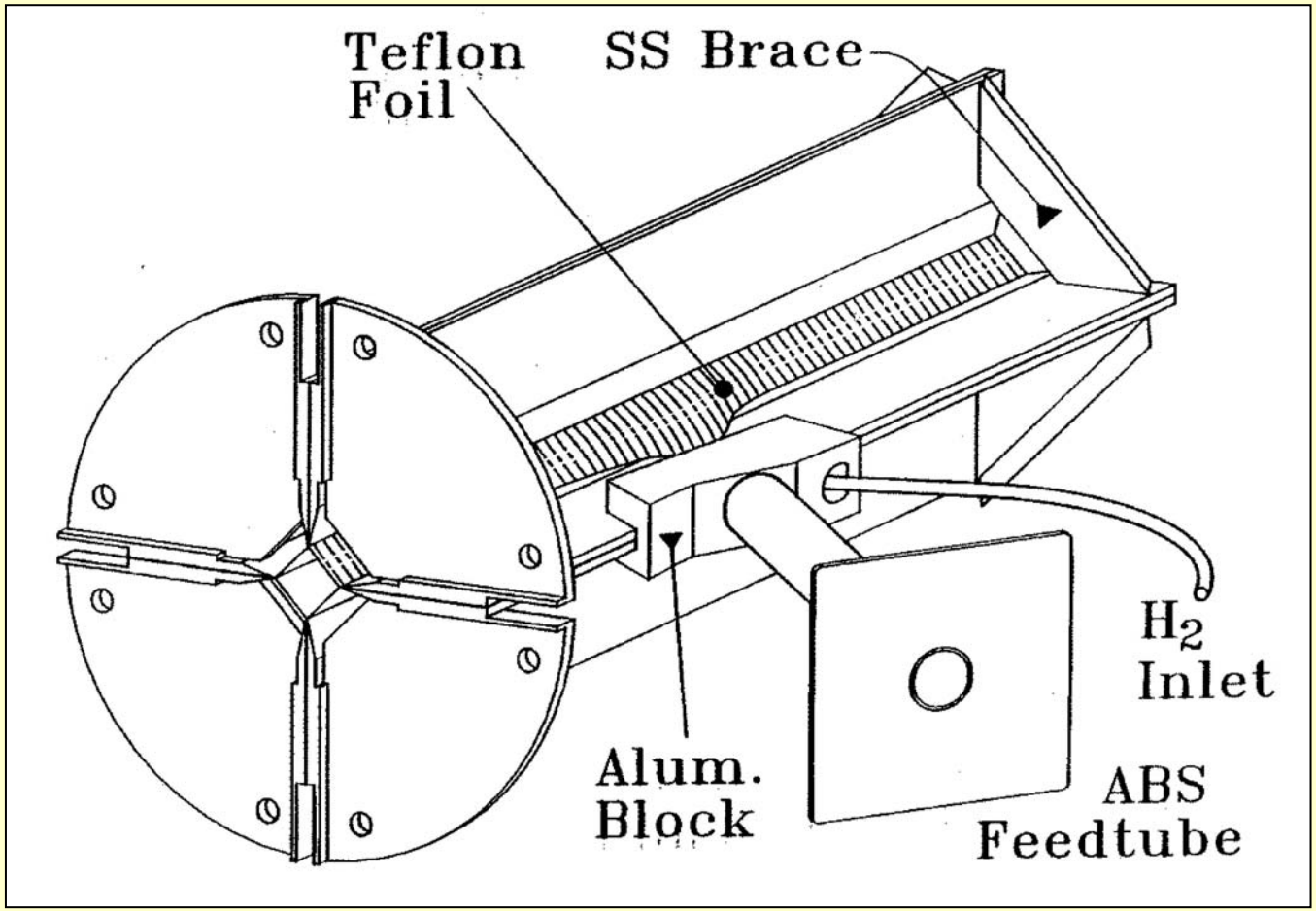


S.C. quadrupole development applicable to AD experiment

Detector concept

- Reaction:
  - p-p elastic (COSY)
  - p-pbar elastic (AD)
- Good azimuthal resolution (up/down + left/right asymmetries)
- Low energy recoil (<8 MeV)
  - Teflon cell requested

Teflon cell (IUCF - 2002)



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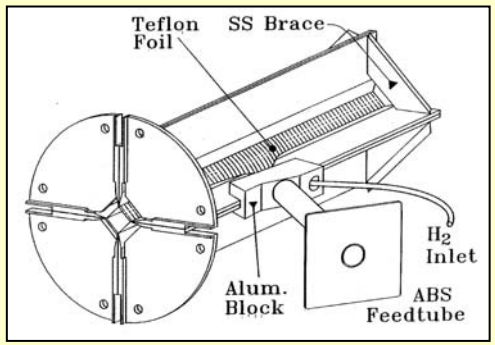
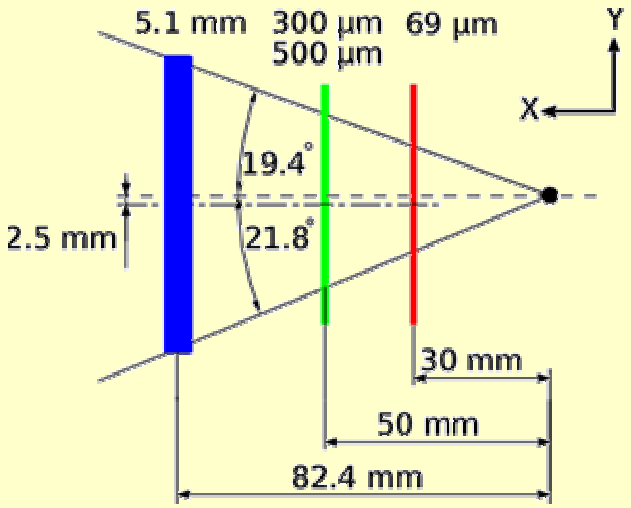
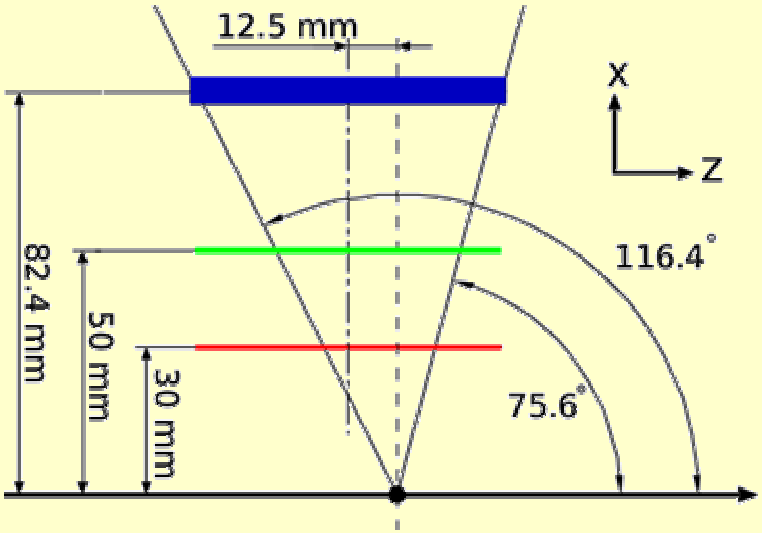
  - Silicon tracking telescope

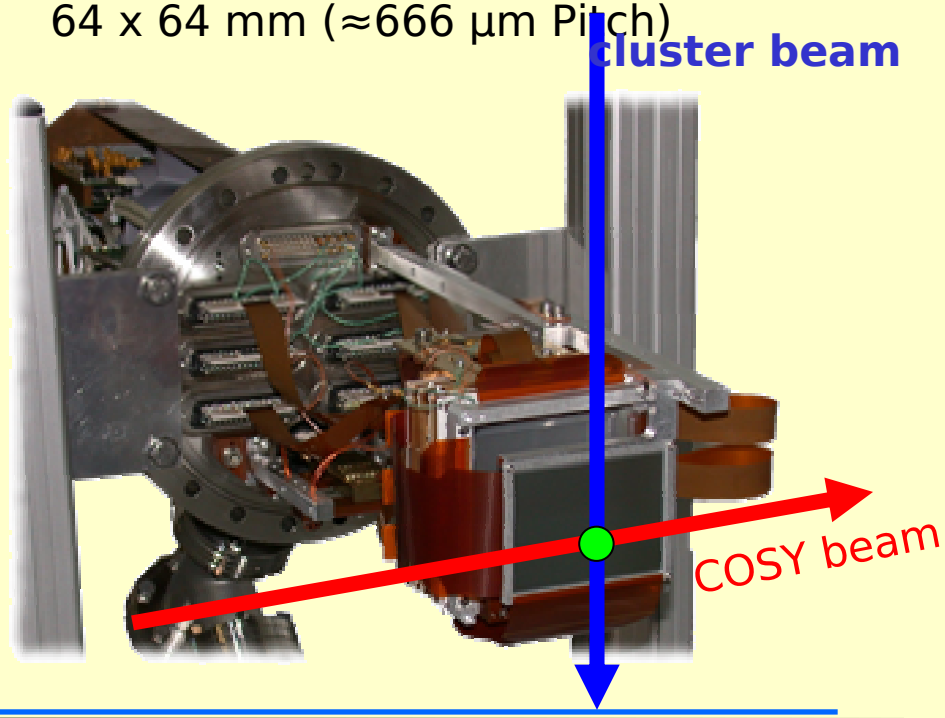


The ANKE silicon tracking telescope



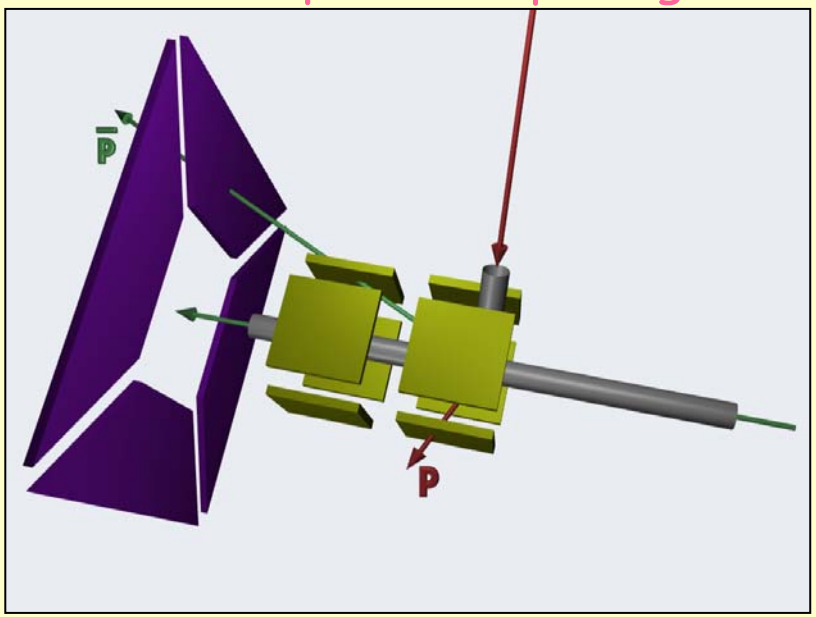


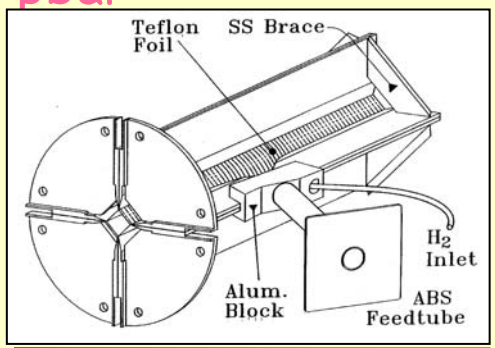
- 3 silicon detector layers
  - → 69 µm silicon
  - → 300/500 µm silicon
    - 128 x 151 segments
    - 51 x 66 mm (≈400 µm pitch)
  - → >5 mm Si(Li)
    - 96 x 96 strip
    - 64 x 64 mm (≈666 µm Pitch)

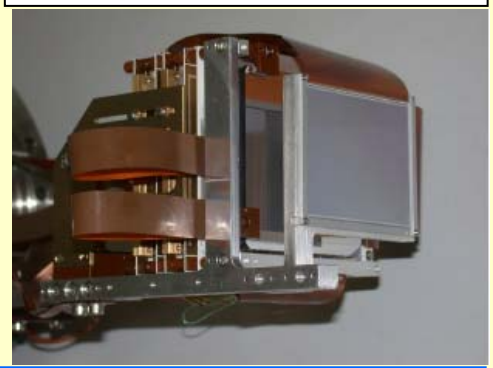


Detector concept

- Reaction:
  - p-p elastic (COSY)
  - p-pbar elastic (AD)
- Good azimuthal resolution (up/down asymmetries)
- Low energy recoil (<8 MeV)
  - Teflon cell
  - Silicon tracking telescope
- Angular resolution on the forward particle for p-pbar
- AD experiment will require an opening-cell

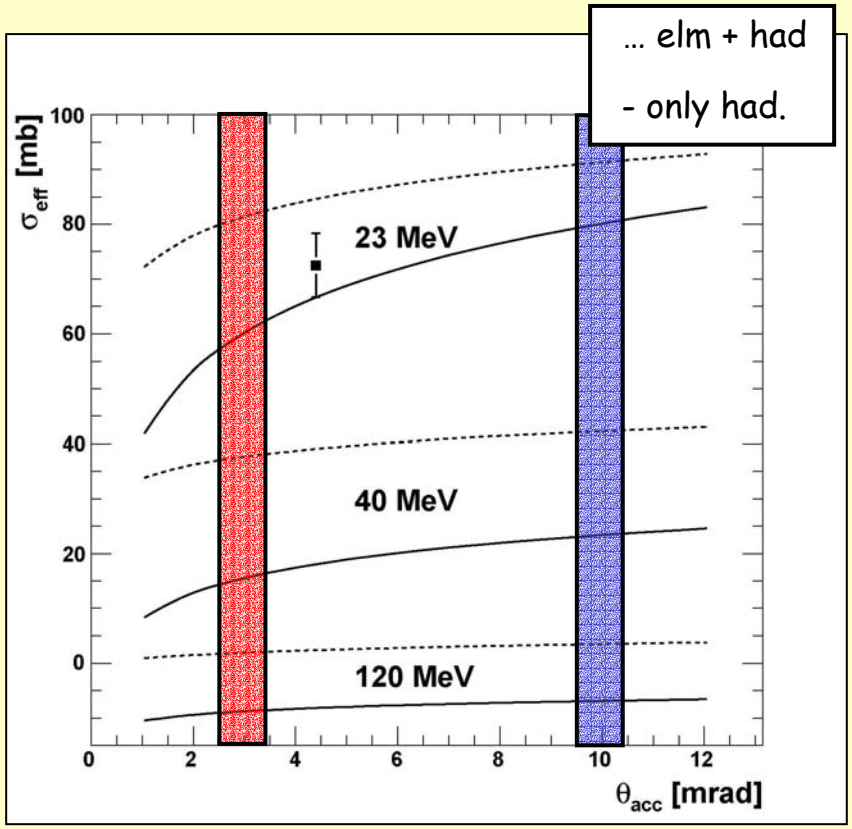




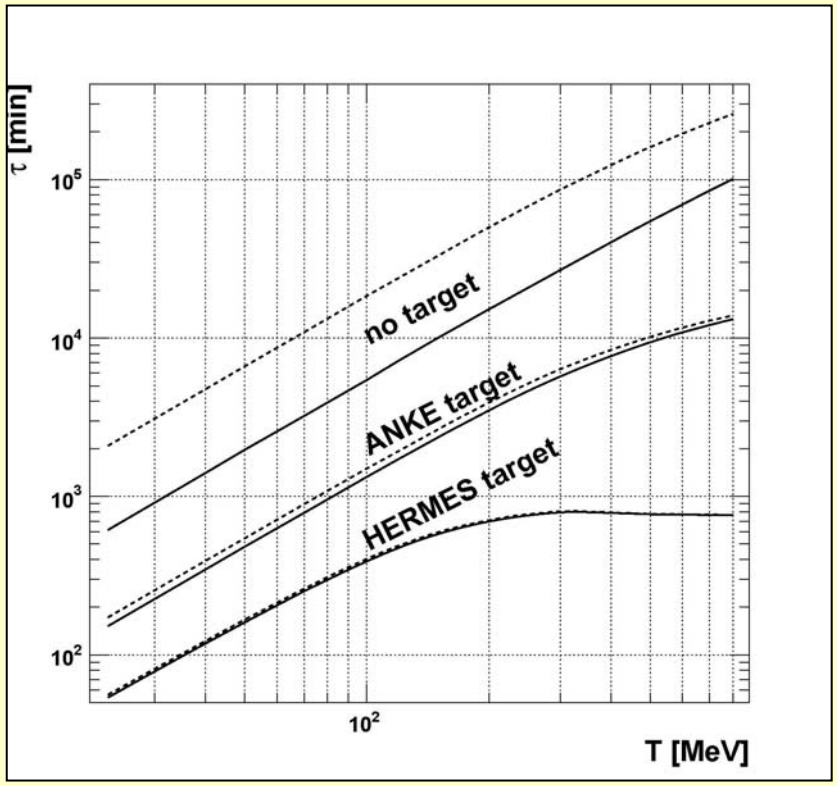


ANKE vs new interaction point

Cross sections



Lifetimes

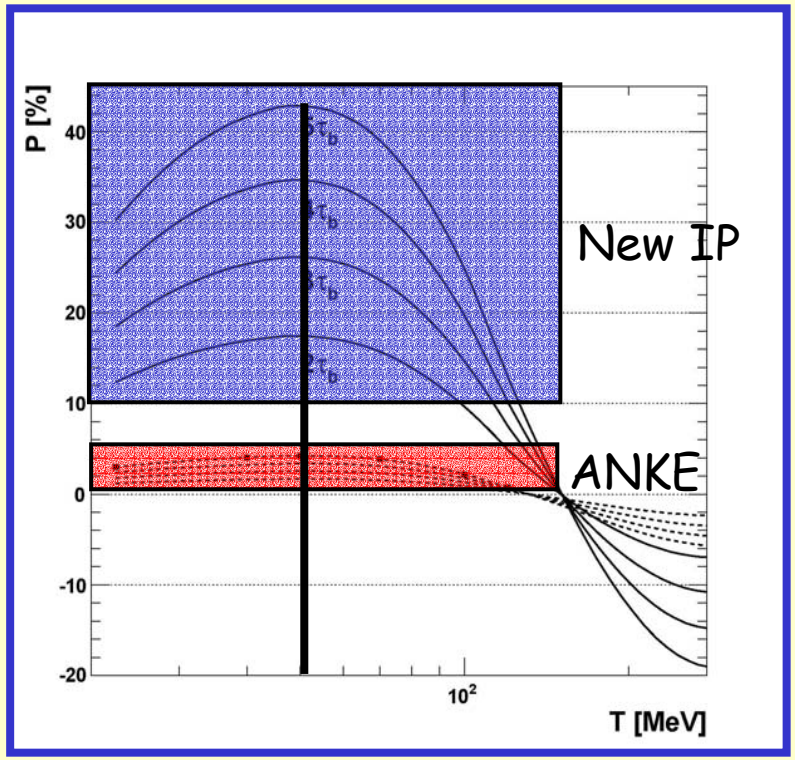


Acceptance @ ANKE

Acceptance @ new-IP

ANKE vs new interaction point

Polarization

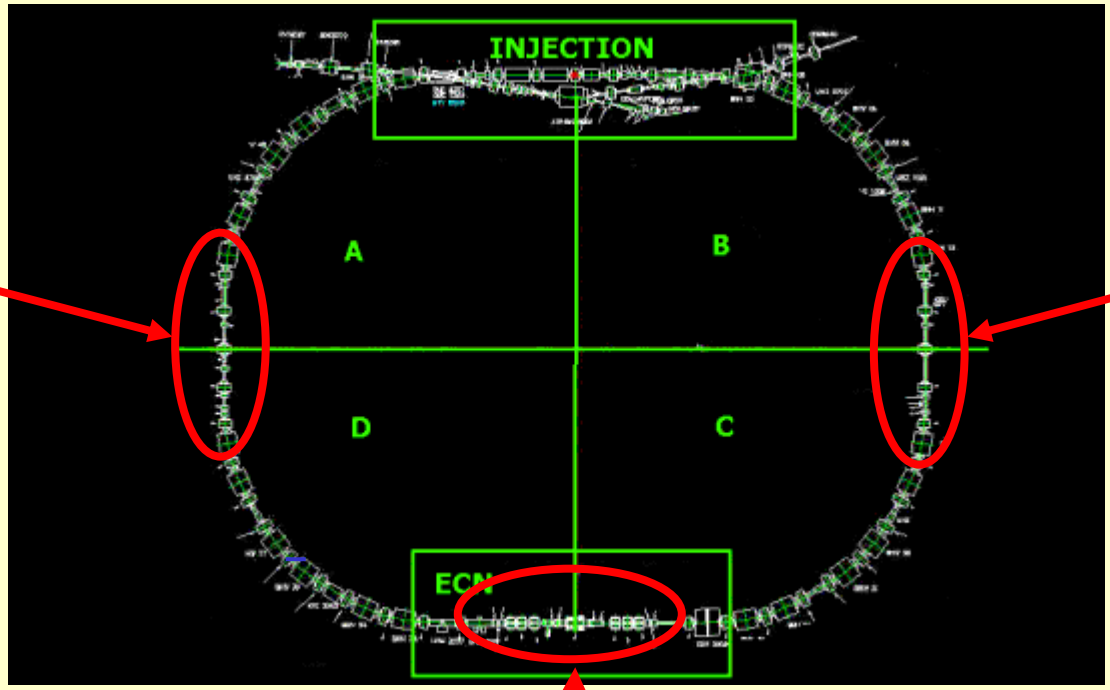


T=40 MeV $N_{inj}=1.5\times10^{10}$

PIT	Filter. time	Polar.	Total rate	Meas. Time ($\Delta P/P=10\%$)
ANKE	2τ = 16 h	1.2 %	7.5×10^2 s^{-1}	44 min
	5τ = 42 h	3.5 %	5×10 s^{-1}	26 min
New IP	2τ = 5 h	16 %	2.2×10^4 s^{-1}	1 s
	5τ = 13 h	42 %	1.5×10^3 s^{-1}	< 1 s

Measurements at AD at CERN (2009-2010)

study of spin-filtering in $p\bar{p}$ scattering



Target

Snake

E-cooler

T:5 MeV÷2.8 GeV

$N_p = 3 \cdot 10^7$

Measurement of effective polarization cross-section.

Both transverse and longitudinal.

Variable ring acceptance.

First measurement at all for spin correlations in $p\bar{p}$ (not pure text experiment!)

Setup summary

Low-beta section

To be designed and constructed (with AD in mind)

Polarized target

Already at FZJ (from HERMES)

Detector

Use of ANKE STT development

Additional forward detector needed for AD

Snake for longitudinal running

COSY beam-lifetime studies needed

Italian contribution

Groups:

- Ferrara
  - Work already done:
    - HERMES target at FZJ
    - cell for ANKE
    - ion-deflector for Lamb-shift polarimeter
  - Bari (E. Nappi & N. Colonna) expressed interest
  - Ex Roma Sanità (F. Garibaldi) expressed interest

Future involvment:

- Design and construction of interaction point (coll. with FZJ)
- Opening mechanism
- Cell
- Silicon tracking telescope

Funding (besides INFN)

BMBF financed application by prof E. Steffens (U. Erlangen)

Application to FZJ innovation fund

SC quads for low-beta section

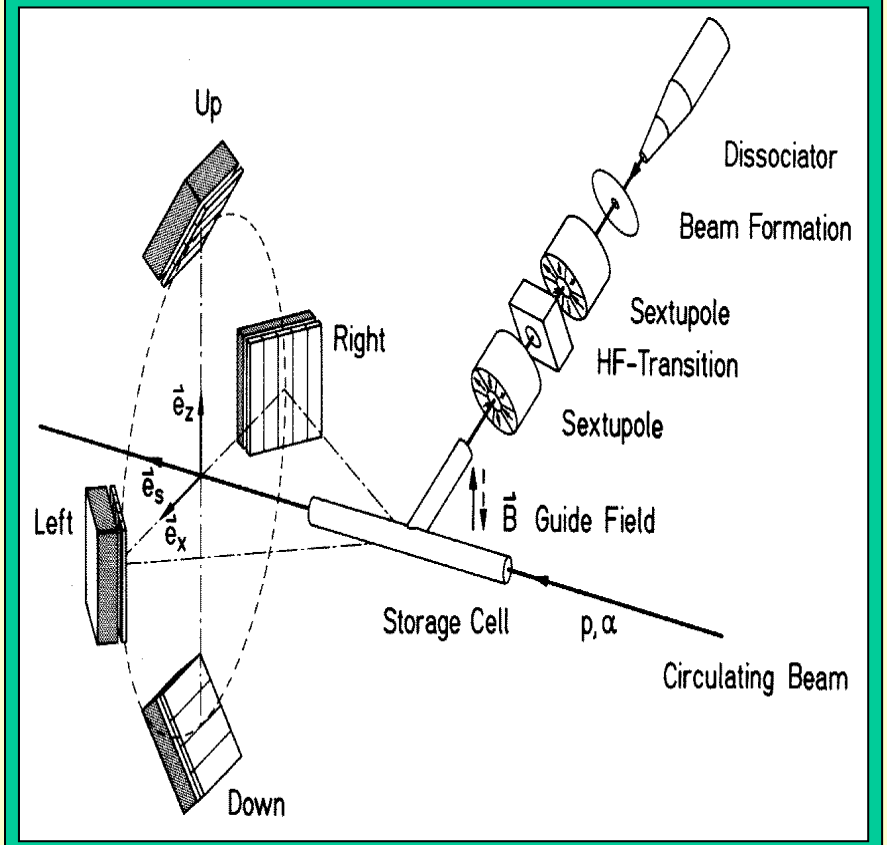
Application to FP7 for spin-filtering studies

Timeline

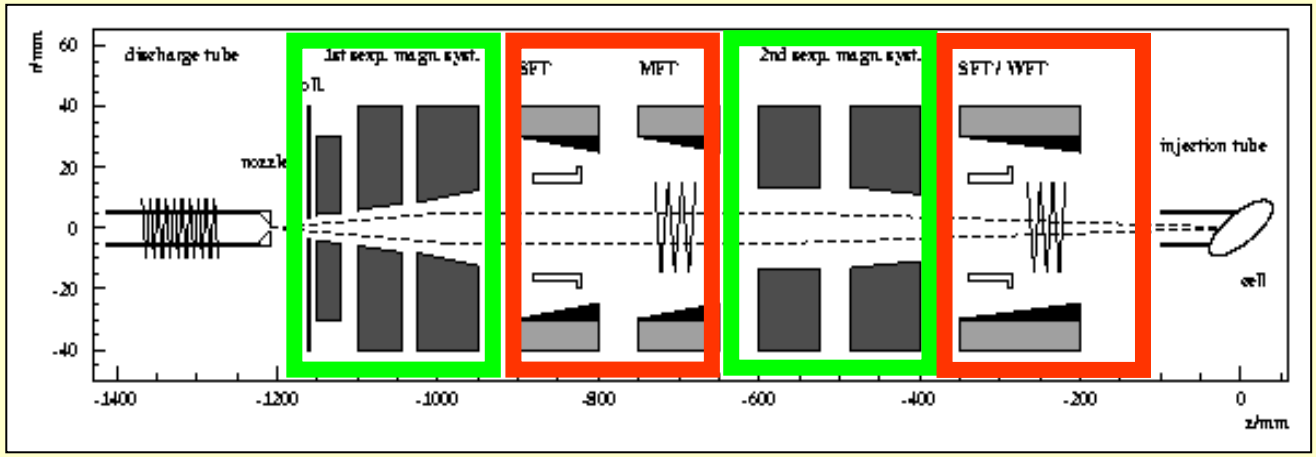
Fall 2006	Submission of Technical Proposal for COSY
Spring 2007	Submission of Technical Proposal for AD
2006-08	Design and construction phase COSY
2008	Spin-filtering studies at COSY Commissioning of AD experiment
2009	Installation at AD
2009-2010	Spin-filtering studies at AD

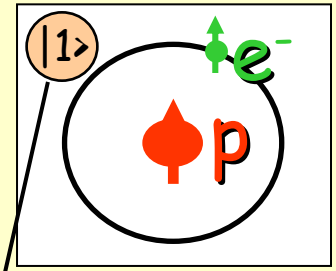
1992 Filter Test at TSR with protons

Experimental Setup



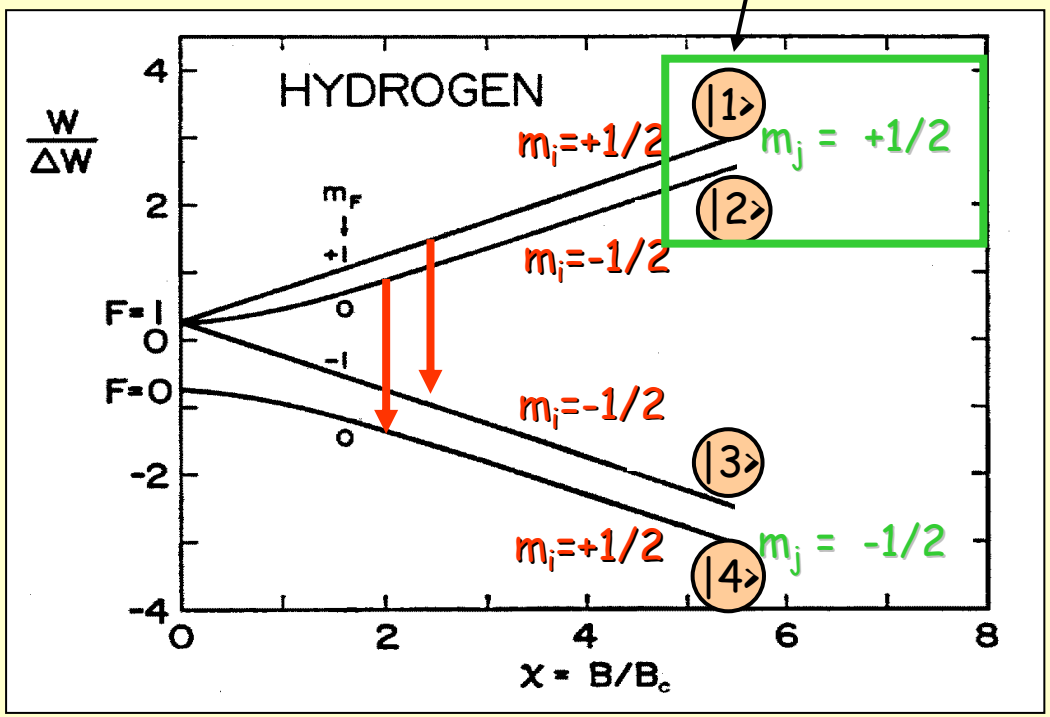
Polarized atomic beam source





Atoms with $m_j=+\frac{1}{2}$ focused in sextupole magnets.

RF transitions select HFS.



Hadronic Interaction in p-pbar: Longitudinal Case

Beam Polarization