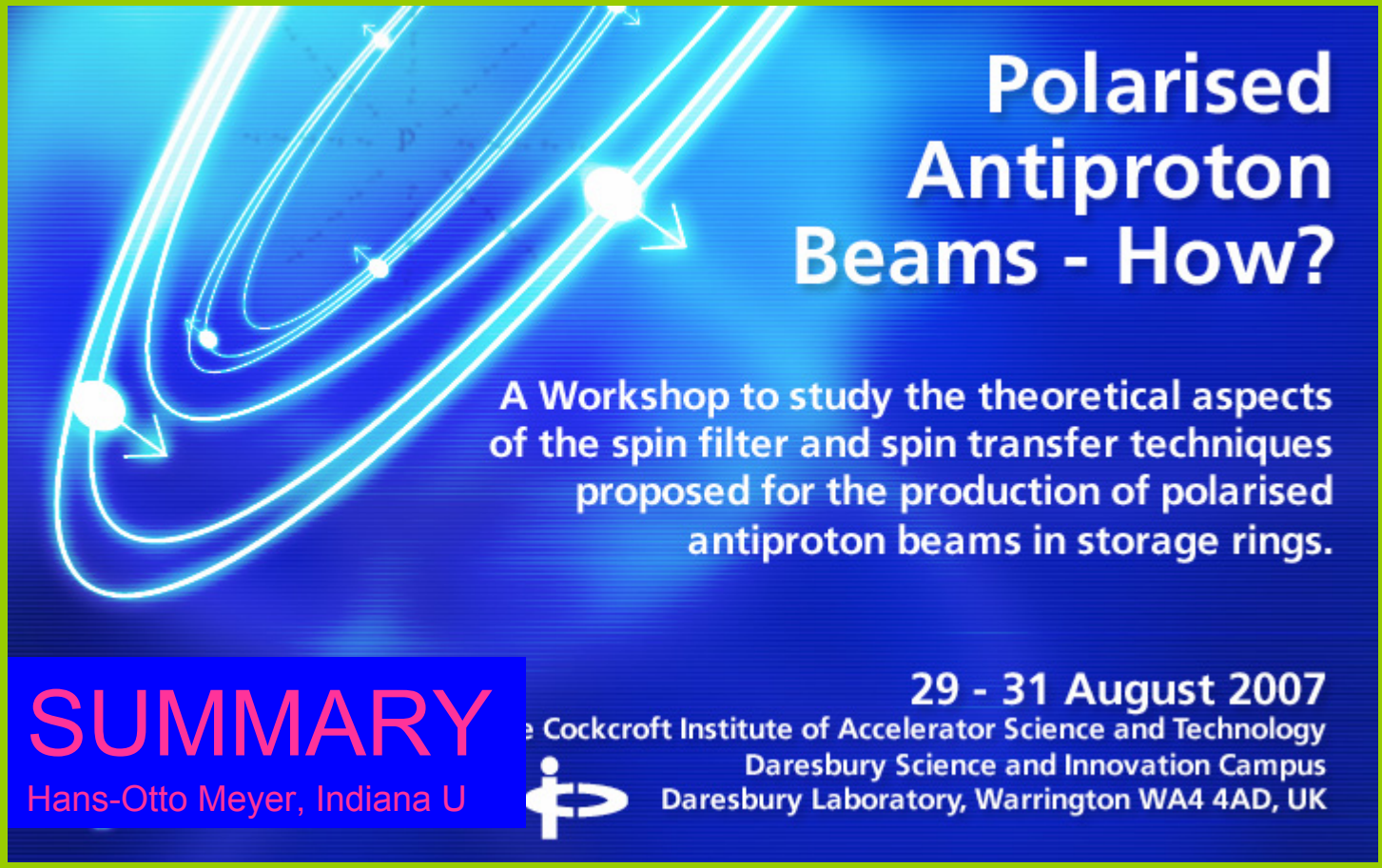


SUMMARY

Hans-Otto Meyer, Indiana U

Workshop on Polarized Antiprotons

Bodega Bay

April 18 – 21, 1985

Organized by O. Chamberlain and A. Krisch

American Institute of Physics
Conference Proceedings No. 145
AIP New York 1986

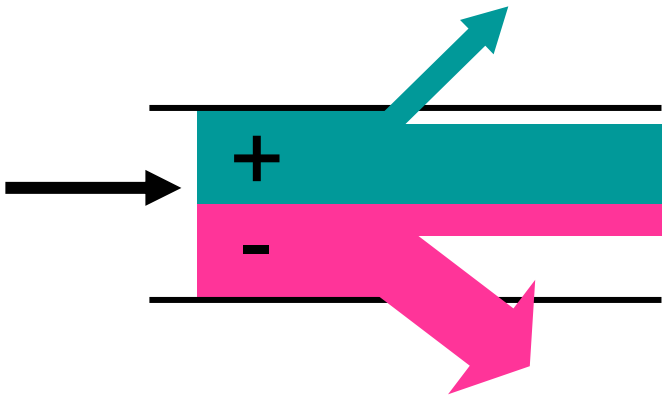
Alan Krisch

A Dozen Ways …

…of producing (a useful beam) of polarized antiprotons

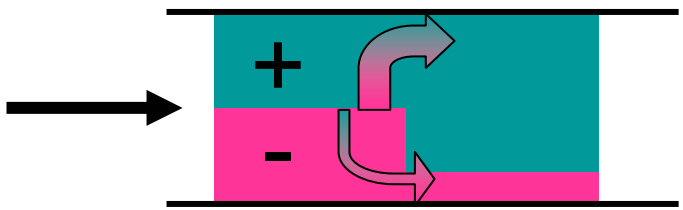
definitions

…we want to polarize a spin-1/2 ensemble (2 magnetic substates, up/down, +/-,…)



selective loss

discard (one) substate
(more than the other)



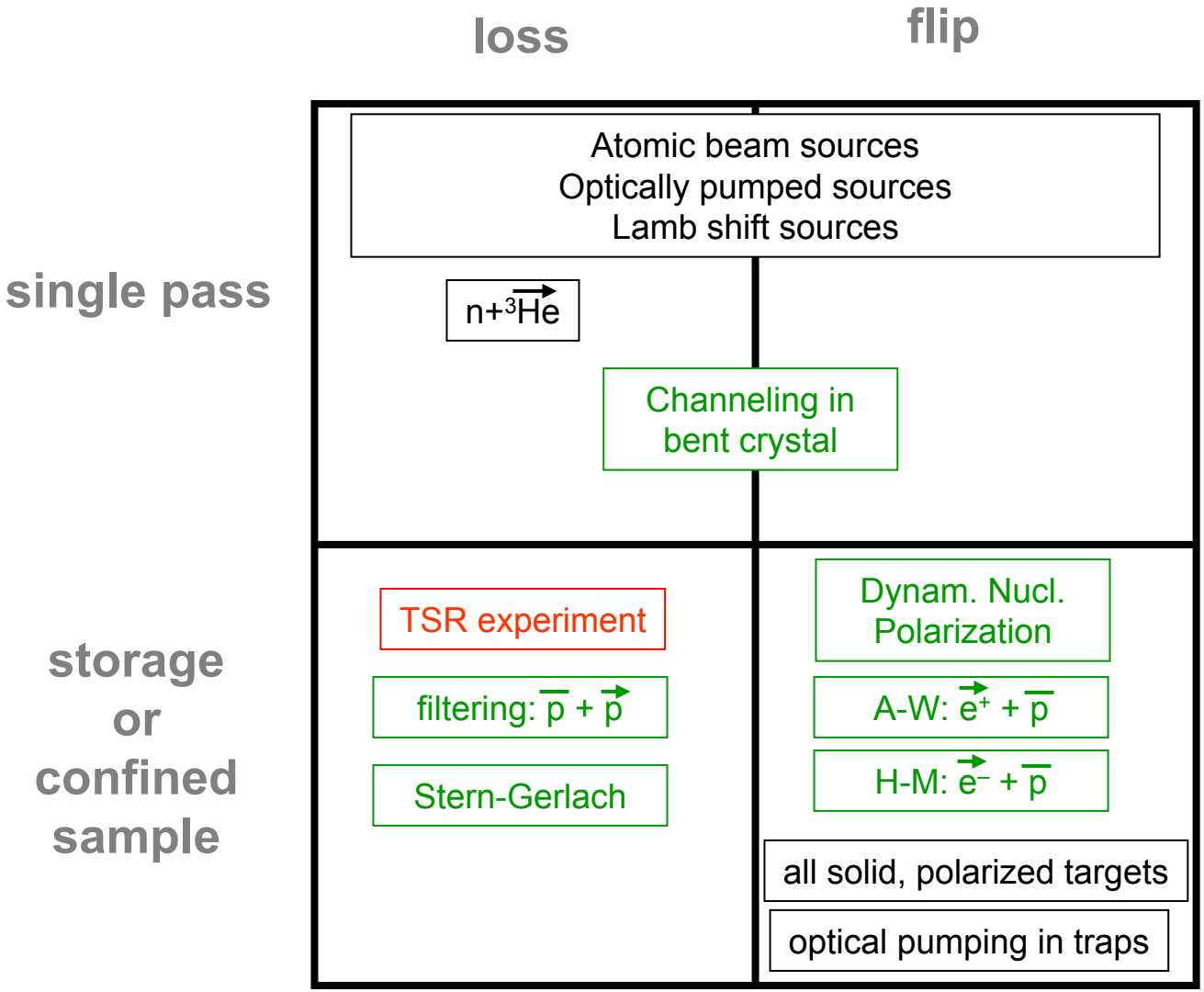
selective flip

reverse (one) substate
(more than the other)

definitions

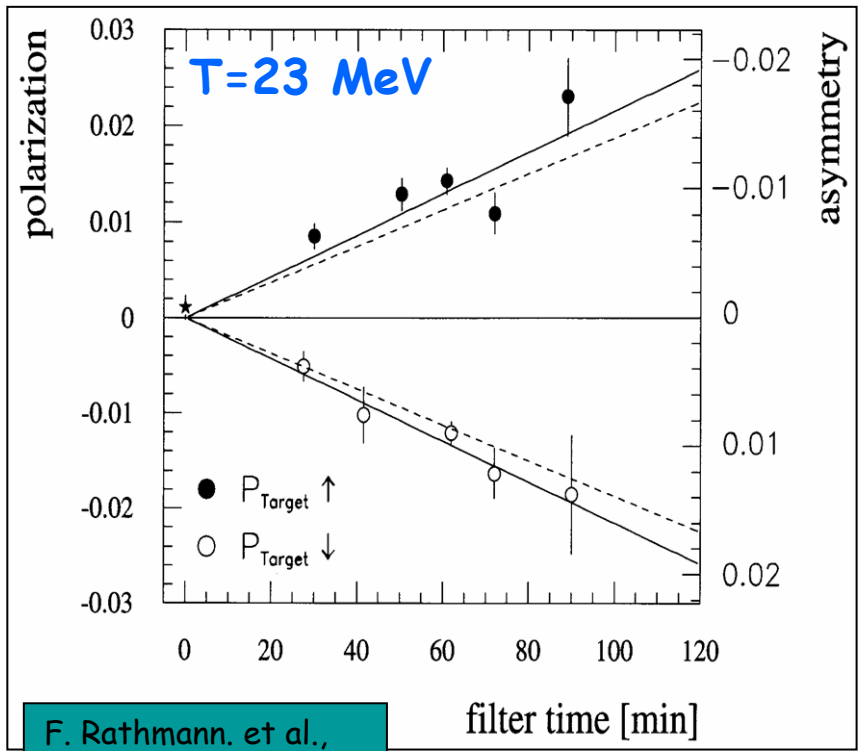
single pass	make one passage through the apparatus; time: ps - ms
storage (confined sample)	isolate the sample (e.g., in a ring) and operate on it; time: minutes - days

producing polarized hadrons



Frank Rathmann

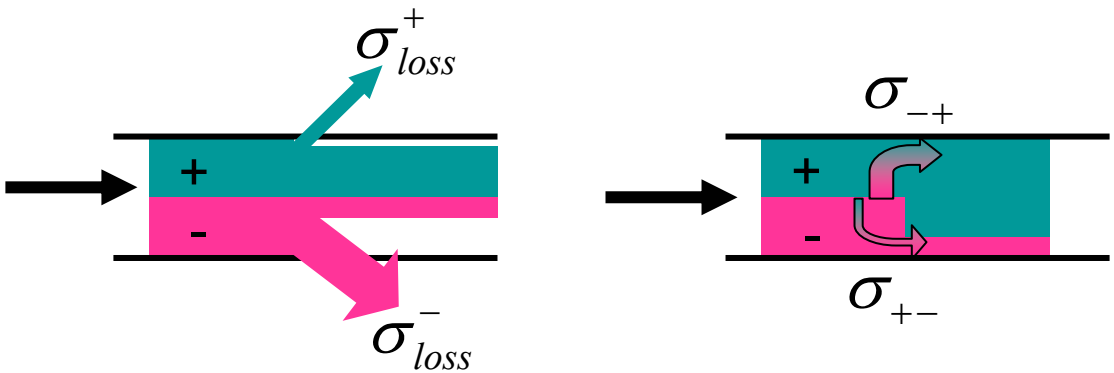
1992 Filter Test at TSR with protons



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

evolution of stored beam polarization

Nigel Buttimore
Donie O'Brien
Vladimir Strakhovenko



$$\frac{d}{dt}\begin{pmatrix} N^+ \\ N^- \end{pmatrix} = -t \begin{pmatrix} \sigma^{+}_{loss} + \sigma_{+-} & -\sigma_{-+} \\ -\sigma_{+-} & \sigma^{-}_{loss} + \sigma_{-+} \end{pmatrix} \begin{pmatrix} N^+ \\ N^- \end{pmatrix}$$

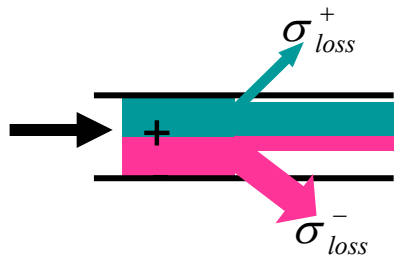
Target thickness traversed in 1s

$$\frac{d}{dt}\begin{pmatrix} N^+ + N^- \\ N^+ - N^- \end{pmatrix} = -t \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} N^+ + N^- \\ N^+ - N^- \end{pmatrix}$$

…equivalent, but not as transparent

polarization by selective loss ("filtering")

Kolya Nikolajev
Vladimir Strakhovenko

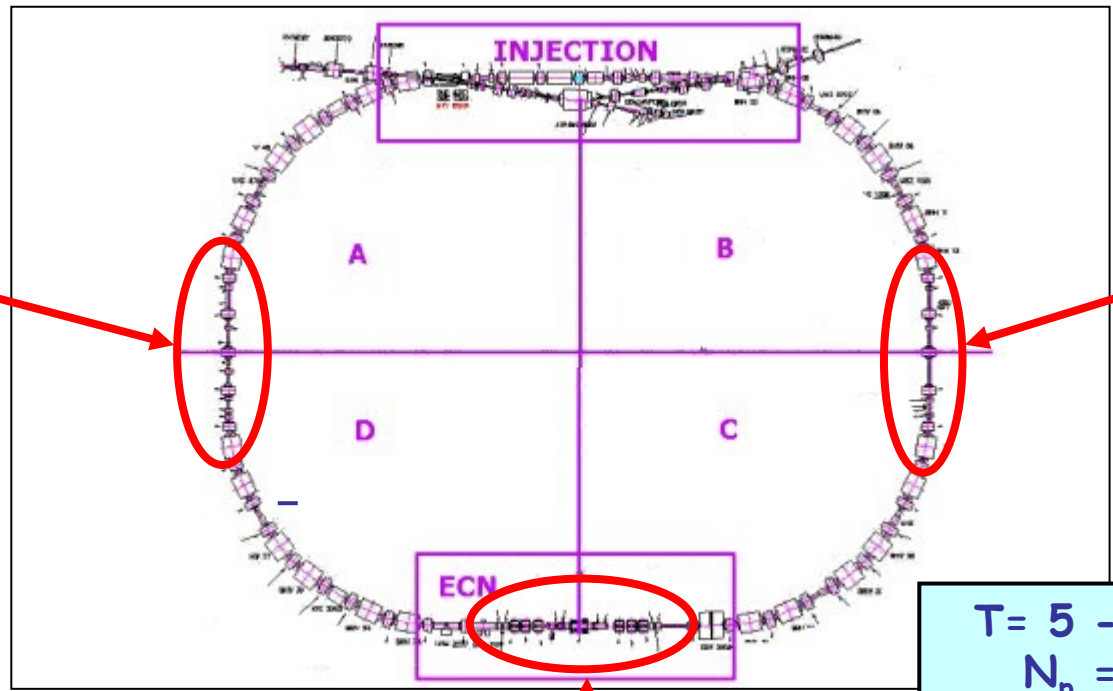


- electron target: no loss
- $p+\vec{p}$: re-analysis of TSR experiment, re-calculation of filter effect…no longer significant disagreement between data and theory
- $\bar{p}+\vec{p}$: theoretical estimates, many attempts, not reliable;urgently need experiment with antiprotons

AD ring at CERN

Frank Rathmann

Study of spin filtering in pbar-p (pbar-d) scattering



Target

Snake

E-cooler

T= 5 - 2.8 GeV
$N_p = 3 \cdot 10^7$

Measurement of effective polarization buildup cross-section

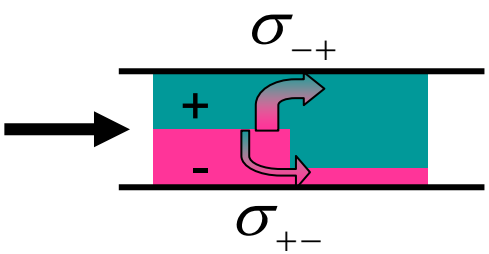
- Both transverse and longitudinal
- Variable acceptance at target
- Test also polarized D target

First ever measurement for spin correlations in pbar-p (and pbar-D)

polarization by selective flip

Thomas Walcher
Donie O'Brien
Vladimir Strakhovenko

(induced by (almost) co-moving e^+ beam)



$$\sigma_{polar} = \sigma_{-+} - \sigma_{+-}$$

…we now all agree that this is not the same as the spin transfer cross section $\sigma_0 K_{l00l}$

calculate relevant quantity and see (Arenhoevel)

COSY experiment to measure flip effect (or establish a limit) under way

positrons

* Spin flip needs hyperfine interaction

* Hyperfine interaction needs an electron or positron

* Arenhoevel/Walcher realize that (at low energy) lepton-hadron is very different for equal or opposite sign charge

• follows: positrons may be in our future…

Kurt Aulenbacher
Ian Bailey

small angles

…there is an angular range that is never seen in conventional experiments but the most important part in a storage ring…

Kolya Nikolajev

- Transmission: Polarized target is an optically active medium with the polarization dependent refraction index

$$n = 1 + \frac{2\pi}{p^2} N \hat{f}(o)$$

Scattering calculations at small angles get difficult, perhaps a new approach brings new insight…

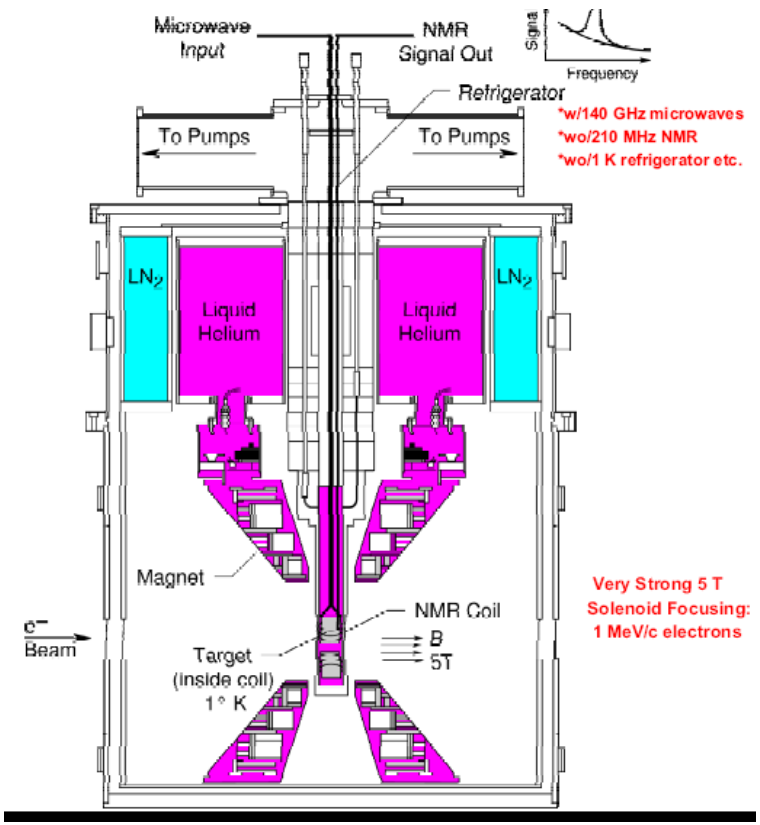
DNP

19 Apr 85

1. $e_\uparrow$ Density
   10^8 (OK), 10^{10} (Difficult), 10^{18} (SLC)
   $3\ 10^{-4}$ cm 10^{-1} cm long
2. May need ~ 10^{15} for DNP X_0 work
3. Niinikoski: Rotating B-Field
   Rather than Microwaves
4. Jeffries: Pol Transfer Rate ~ $1/r^6$
   $\Rightarrow$ Occasional very close interactions may be main effect
5. Need at least 2000 Oscill of μW or Rot B to transfer pol from e to $\bar{p}$??
   $\Rightarrow$ Length of Int Region $\geq 2000\ \lambda$

Dynamic nuclear polarization

Alan Krisch



..like in a solid target…

extrapolate from ammonia to overlapping beams (very different density regime)

can one induce the relevant double-spin-flip (and only it) when e and p are not bound?

would the scheme work with a much lower B field?

Stern-Gerlach separation of substates

Des Barber
Thomas Walcher

…is impossible for fundamental reasons

- there is no cumulative effect in a ring
- the uncertainty principle forbids a separation if the particles are charged
- in the past N. Bohr, W. Pauli made similar statements (6eme conseil de physique Solvay)

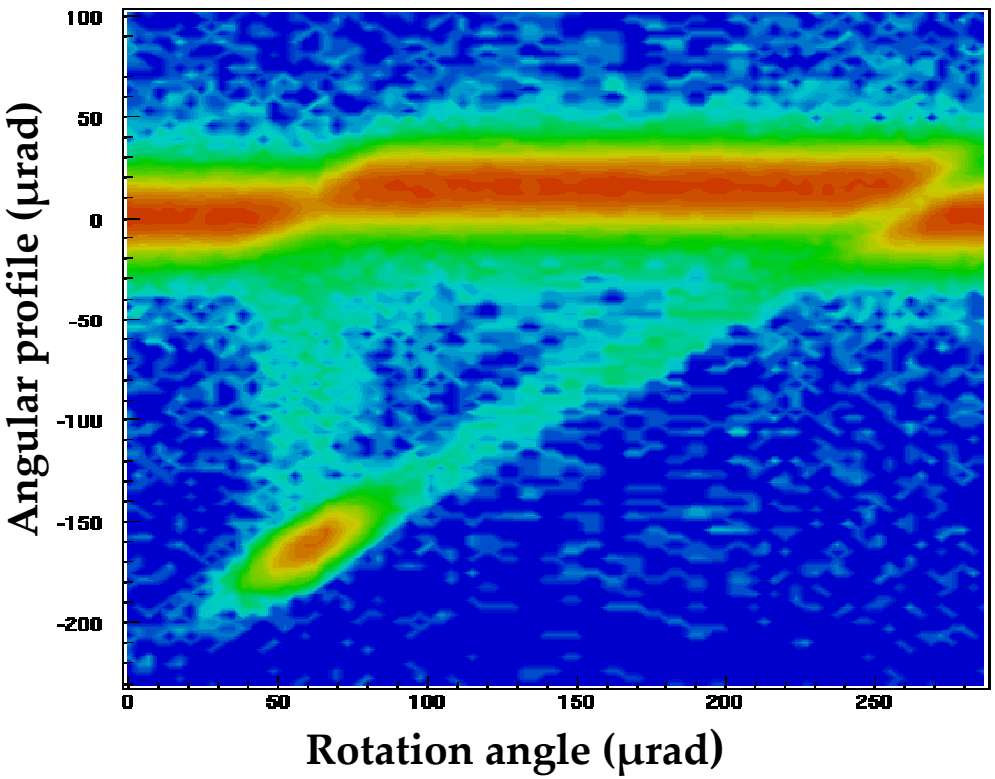
however…

- "it is possible to separate spin states of an electron with magnetic fields" H. Batelaan (PRL79, 4517 (1997)
- Aulenbacher: longitudinal substate SG separation of electrons has been observed

Channeling in Bent Crystals

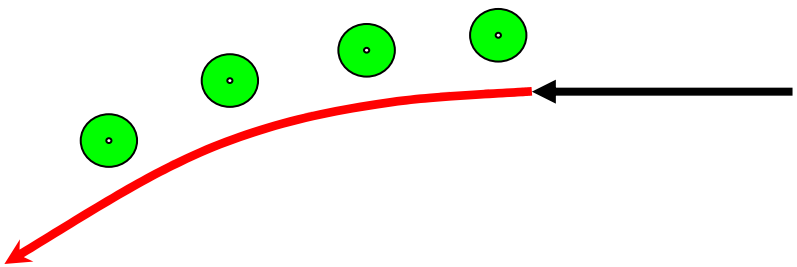
Nigel Buttimore
Massimiliano Fiorini

Nigel gives basic channeling equations



Polarization by channeling in Bent Crystals

Mikhail Ukhanov



…well, perhaps

say more clearly why there should be a polarization build up (detailed mechanism)

Loss or flip? Analyzing power describes neither!

do tracking MC calculations (no averaging over z)

consider experiment at COSY (with polarized beam)

More stuff on single pass schemes

Massimiliano Fiorini

- Polarization of deuteron beam passing through a magnetized Ni single crystal **[Phys. Rev. Lett. 23, 819, 1969]**
  - Measurement of P_{zz}: (-0.32 ±0.01)
  - Hyperfine interaction with unbound electrons?
- First observation of magnetic moment precession of channeled particles in bent crystals at FNAL **[Phys. Rev. Lett. 69, 3286, 1992]**
- Channeling of 1.4 MeV antiprotons **[NIM B 207, 402, 2003]**
  - Evidence of a clear channeling effect

Why do we need polarized antiprotons?

Paolo Lenisa

Polarized antiprotons will open the way to a new spin-physics era:

* Proton-spin structure:
  Complete map of transversity flavour separation

* Electromagnetic Form Factors
  Independent extraction of moduli of G_E-G_M in Time-Like region.Test of the Rosenbluth separation in TL. Measurement of the phase

* Hard p-pbar scattering
  Additional measurement in one of the most intriguing puzzles of HF

- Hadron spectroscopy

Thomas Walcher
Elliot Leader
…more

$\vec{\bar{p}}$ Why do we need polarized antiprotons?

Structure of the nucleon,
Maas: also important to have $\vec{\bar{p}}$ in context of non-leptonic processes

Paolo Lenisa, direct measurement of transversity
Curent indir extraction of transversity from exps at HERMES, BeLLE, COMPASS yeilds discrepancies with theory.
Electromag formfactors, GE/GM data say that single-photon exchange may not be sufficient (pol antip w/ pol target in PAX
Thomas Walcher,

Thomas Walcher, Elliott Leader (discussion)

Importance of storage rings

Theortical basis

Des Barber

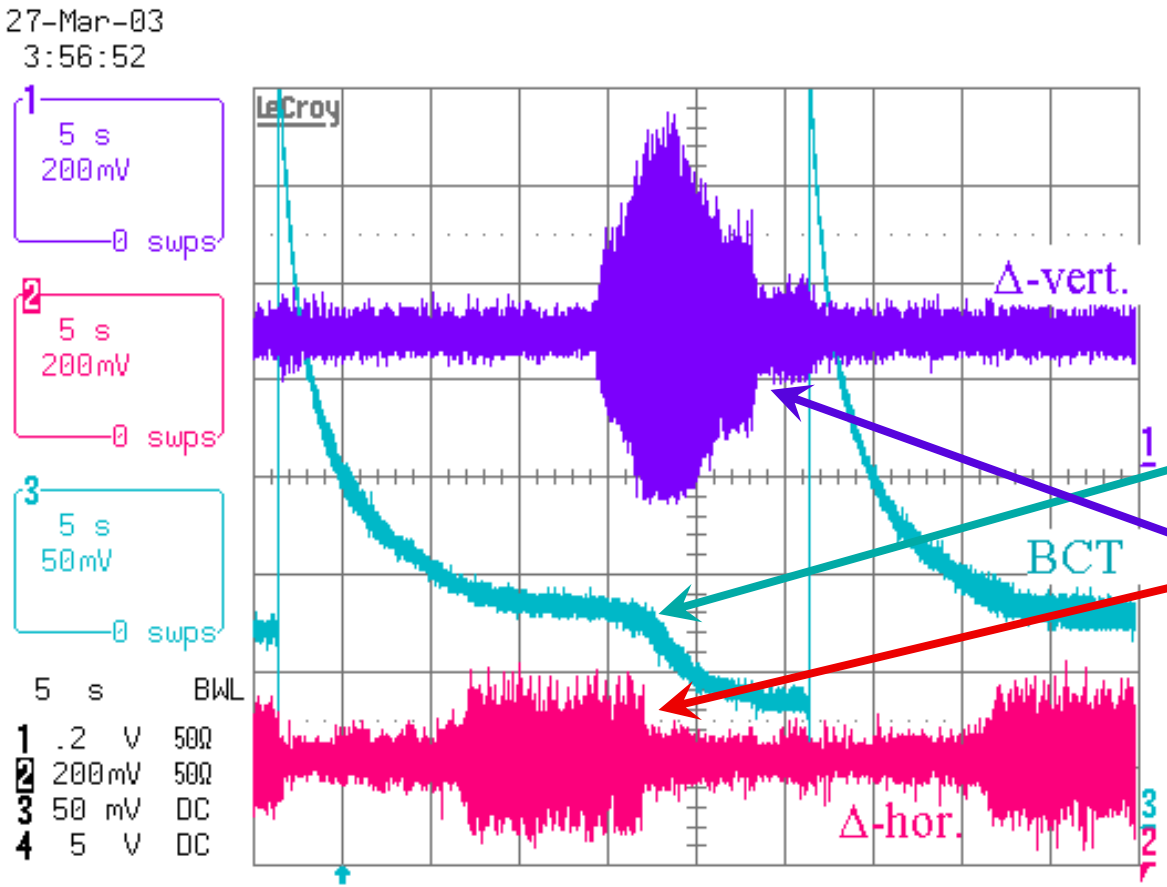
Andreas Lehrach

- **Polarization lifetime:**
  higher-order spin resonances → tune adjustment

- **Beam lifetime:**
  geometric acceptance → low beta section
  dynamic aperture → tune adjustment, multipole correction
  collective effects of cooled beams → feedback, shaker, hollow electron beam

Andreas Lehrach

Coherent Betatron Oscillations



- **Observation**
  - Sudden particle losses
  - Coherent horizontal oscillations
  - Coherent vertical oscillations

Experiments with Cooled Beams at COSY by Jülich –Dubna group

Conclusions on “How?”

Channeling, dynamic nucl pol	Far out, but worth more attention Intriguing open physics questions
Polarizing beam in a ring by loss	works in principle, but we need Axx+Ayy, and Azz for $\overrightarrow{p} + \overrightarrow{p}$
Polarizing beam in a ring by flip	not the miracle cure that we hoped for

Thanks to the speakers

Thanks to our discussion leaders!

Elliot Leader
Erhard Steffens

Next meeting

2029

perhaps even earlier

expect results of measurements inspired by the “Daresbury workshop”

and, of course, another round of crazy ideas

Thanks to the Cockroft Instiute:

Thanks to the Organizing Committee :

Desmond Barber, DESY, Hamburg, Cockcroft Institute, UK

Nigel Buttimore, Trinity College, Dublin

Geoffrey Court, University of Liverpool

Erhard Steffens, University of Erlangen-Nürnberg