TESLA-N
Polarized Electron-Nucleon Scattering at TESLA

The TESLA-N Study-Group

http://www.ifh.de/hermes/future

— THE BASIC IDEA —

A Polarized Fixed-Target Experiment at TESLA

Basic Idea: Use one arm of the TESLA collider for a polarized fixed-target experiment in parallel to the collider experiments.

- electron arm cannot be used, because kicker magnets would not be fast enough to divert only a part of the beam

⇒ use positron arm for e^- acceleration

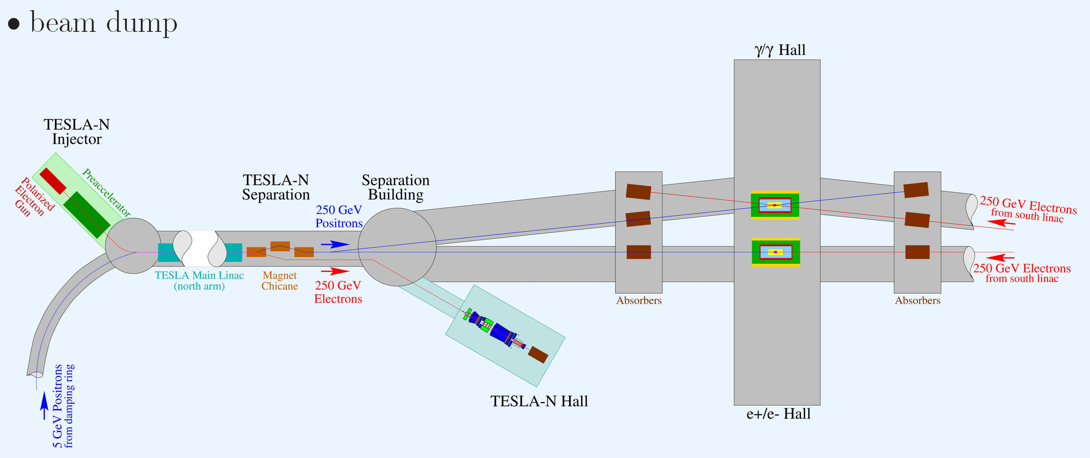
⇒ static magnet system for electron/positron separation

- the polarized beam constitutes only about 0.04% of the main current

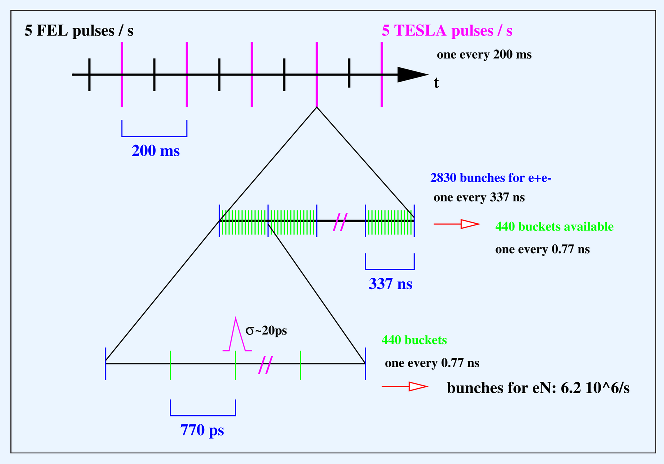
⇒ additional energy consumption is negligible

additionally needed for the experiment, besides target and spectrometer:

- polarized source and injector
- magnet chicane
- short tunnel and experimental hall
- beam dump



Polarized Electron Beam



machine frequency	1.3 GHz ⇒ one bucket every 0.77 ns
bunches / s	$6.2 \cdot 10^6$
max. current	20 nA
# e^- / bunch	20000

source	strained GaAs (SLAC type)
energy	250 GeV also 25-100 GeV possible
polarization	≥ 90 %

Polarized Target

- ^{4}He evaporator cryostat guarantees temperature of 1 K for a heat load of 1 W

⇒ sufficient polarization only in a high magnetic field of 5 T

- longitudinal and transverse polarization

⇒ symmetric Helmholtz design

- target polarization must survive high radiation doses

⇒ deuteron/proton material: ^{6}LiD/NH_3

- areal target density ∼ 1 g/cm^2

⇒ beam current ≤ 20 nA

Luminosity

TESLA-N ansatz for efficiencies:

$\varepsilon_{lumi} = \varepsilon_{up-time} \cdot \varepsilon_{exp} = 0.33 \cdot 0.75 = 0.25$ ⇒ 600 fb^{-1} per year

Comparison:

Experiment	c.m. Energy [GeV]	Luminosity [cm^{-2}s^{-1}]
TESLA-N	22.3	$7.5 \cdot 10^{34}$
COMPASS	20	$5.0 \cdot 10^{32}$

Conservative assumptions:

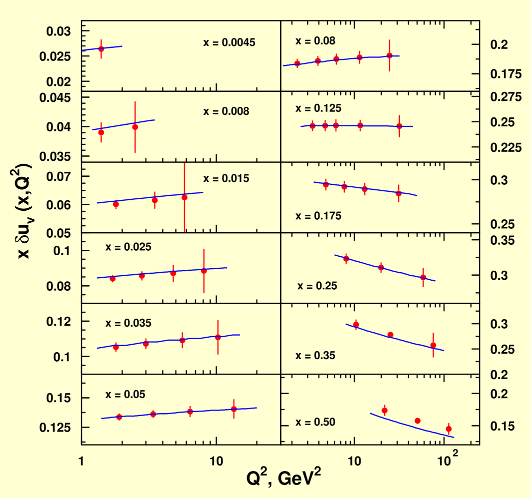
- only the time resolution of COMPASS can be reached (2 ns)
- only half of the maximum current is used to keep the multiple event fraction small

⇒ 100 fb^{-1} per year.

— THE PHYSICS —

Main Physics I: δq

$\delta q(x, Q^2)$: quark transversity distributions



(Projection for the valence u-quark transversity distribution based on 100 fb^{-1} and a minimum detector acceptance of 5 mrad.)

tensor charge:

$$\delta\Sigma(Q^2) = \sum_q \int_0^1 dx(\delta q(x,Q^2) - \delta\bar{q}(x,Q^2))$$

projected accuracies at $Q^2 = 1$ GeV^2:

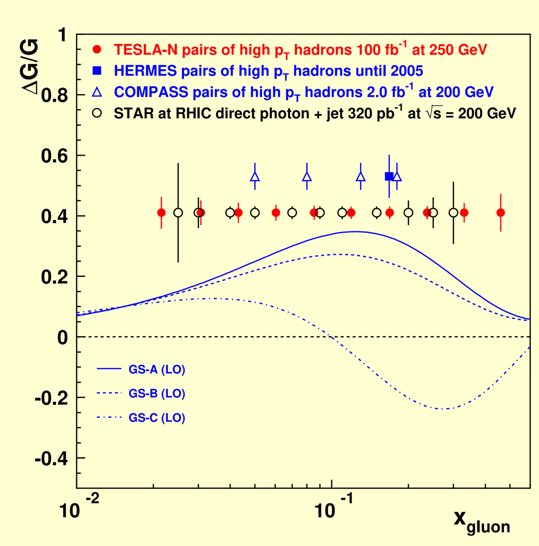
$\delta u = 0.88 \pm 0.01, \delta d = -0.32 \pm 0.02$

Main Physics II: ΔG

$\Delta G(x, Q^2)$: gluon contribution to the nucleon spin

Use pairs of *high* $-p_t$ hadrons originating from a light quark pair produced in photon-gluon fusion [COMPASS, HERMES]

$$A_{LL} \sim \frac{\Delta G}{G}$$



(Projected statistical accuracies for direct measurements of $\Delta G/G$.)

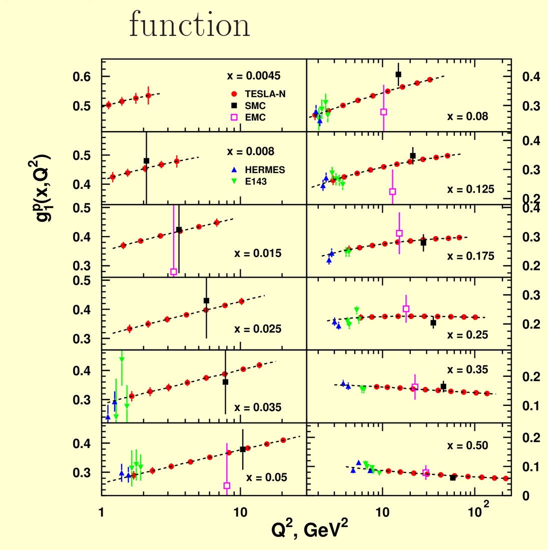
⇒ Good sensitivity over a wide range of x_g

Precision Measurements

$\Delta q(x, Q^2)$: helicity distributions

$g_2(x, Q^2)$: polarized twist-3 structure function

$g_1(x, Q^2)$: polarized twist-2 structure function



(Projected statistical accuracy for a measurement of $g_1^p(x, Q^2)$ at TESLA-N, based on a luminosity of 100 fb^{-1} and a minimum detector acceptance of 5 mrad. Two EMC/SMC data points are outside of the shown vertical range.)

More Physics . . .

- deeply virtual Compton scattering (DVCS)
- fragmentation functions (as input for B-factories and LHC)
- unpolarized gluon distribution function $G(x)$ at high x
- specific deuteron structure functions $b_{1,2}(x, Q^2)$ and $\Delta(x, Q^2)$
- nuclear effects in electron-nucleus scattering
- real photon scattering from nucleons and nuclei

Most of these topics have not yet been studied in the context of TESLA-N.

— THE DETECTOR —

Detector Design Considerations

- beam energy 250 GeV (lower energy possible)

⇒ overall dimensions similar to COMPASS

- good momentum resolution

⇒ 3-stage spectrometer

Stage 1 'Hadron Stage'
Stage 2 'Hadron/Electron Stage'
Stage 3 'Forward Spectrometer'

- horizontal dipole fields, to direct 'sheet of flame' to the hall floor

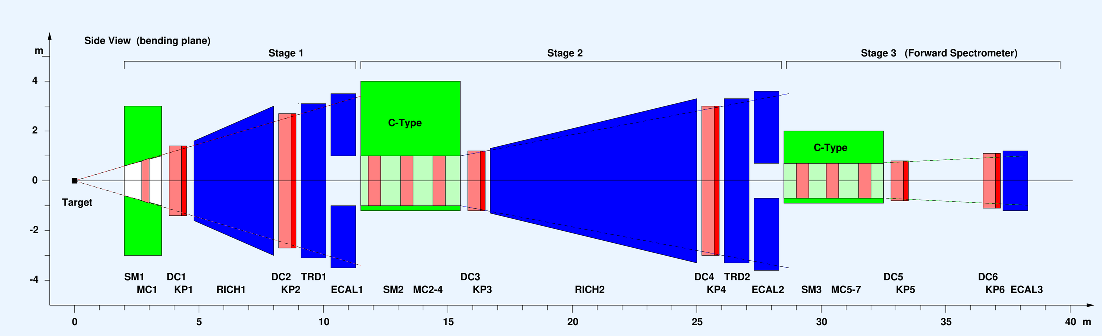
⇒ two symmetric halves of the spectrometer: left and right

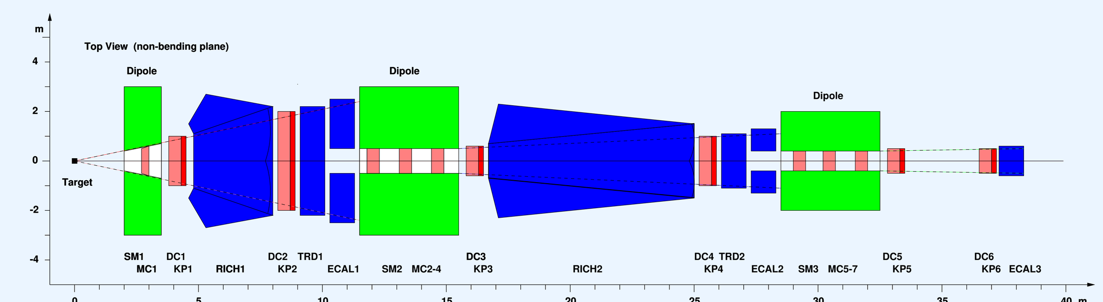
⇒ C-type magnets

- semi-inclusive measurements:

⇒ PID as in HERMES:
RICH, TRD, ECAL
for Stage 1 and Stage 2,
Stage 3 only with ECAL

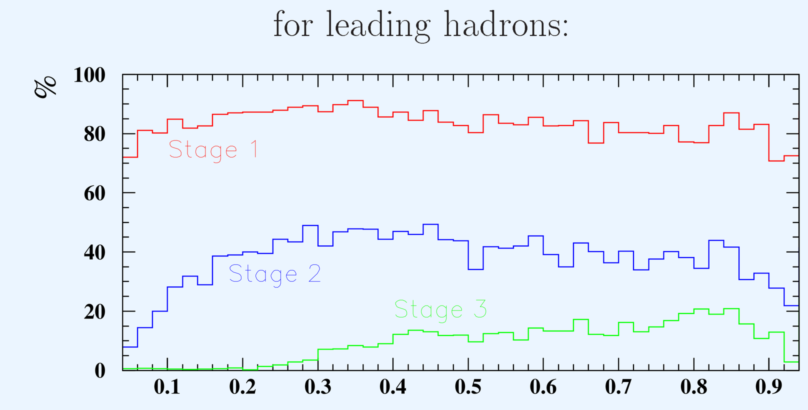
Schematic Spectrometer Design



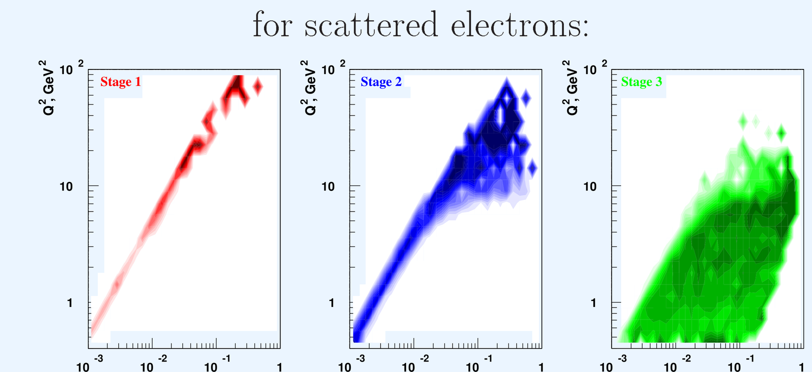


Acceptance . . .

for leading hadrons:



for scattered electrons:



(400.000 Monte-Carlo Events)

Frank Ellinghaus and Elke C. Aschenauer, DESY Zeuthen

Poster session Spin-2000, Osaka, Japan