RF Test for the HERMES Silicon Recoil Detector

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for the HERMES Experiment

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• Spin physics at HERA in DESY Hamburg

• The HERMES experiment:
  - longitudinal polarized $e^+/e^-$;
  - internal gaseous target: polarized H, D atoms, unpolarized H$_2$, D$_2$, N$_2$, etc

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The HERMES Silicon Recoil Detector

To detect recoil protons (120-750 MeV/c) from exclusive process:

Deep Virtual Compton Scattering: $ep \rightarrow ep\gamma$

- $99 \times 99$, mm$^2$ 300$\mu$m thickness double-sided silicon microstrip sensors and front-end electronics made by HELIX chips

Placed directly inside the HERA-e vacuum!

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RF Interference to the HERMES Silicon Recoil Detector

HERA-e bunched beam introducing RF field

- Saturation was observed with the read-out electronics of a similar HERMES silicon detector near the cell

  ⇒ Solved by isolating the detector from the target chamber with 75μm etched copper foil

- Improvement on the RF shielding design of the target cell by:

  - Spring fingers: shorter length 35mm → 5mm and narrower gap 5mm → 0.8mm
  - Pumping holes (2mm × 10mm): now covered with 20μm etched Nickel foil

  ⇒ RF leakage reduced by more than 2 orders in magnitude according to calculation

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The HERA-e Spectrum

I(t)

\[ I(t) = \sum_{j=-\infty}^{+\infty} I_p \cdot \exp \left[ -\frac{(t - j\Delta t)^2}{\sigma_t^2} \right] \]

\[ \tilde{I}(2\pi\nu) = \sum_{n=0}^{+\infty} \tilde{I}_0 \cdot \delta(\nu - \nu_n) \cdot \exp \left( -\frac{\nu_n^2}{\sigma_\nu^2} \right) \]

High peak current: \( I_p = 50A \)

Wide line spectrum: \( \nu_n = n \cdot 10.4\,MHz, \sigma_\nu = 5.46\,GHz \)

⇒ By coupling RF field directly to the electronics, influence to our front-end electronics was observed only below 400MHz

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- Electronics saturation was observed with 5-10 MHz

- Observed RF influences - shifts of the pedestal, increase of the noise level (rms) - are limited to low frequencies
Simulation of the HERA-e RF field

Build a transmission line to simulate the HERA-e current running through the cell, in which an Al. rod acts as the inner conductor and the cell acts as the outer conductor.

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Optimization of the Transmission Line Design by Microwave Studio

Layer type = Lessy metal
\mu = 1
E1. cond. = 3.745e+07 [S/m]

$S_{2,1}$  $S_{1,1}$

Calculated With Microwave Studio

$S_{2,1}$: power transmission
$S_{1,1}$: power reflection

- 5 mm diameter 50 cm Al. rod with two 45° tapers in the ends

- Target cell including the tapered shape, pumping holes and spring fingers are not included in the calculation

$\Rightarrow 50.4 \pm 4\Omega$, less than 5% of power are reflected up to 6 GHz

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Measured Local Impedance Distribution by Time Domain Reflection Method

- Impedance mismatch at the two ends due to the connections
- Impedance mismatch due to the tapered shape of the cell

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Less than 10% loss due to Reflection, sufficient for a good measurement up to 1GHz

Measuring Power picked up by the antenna⇒ scaled by the HERA-e spectrum⇒ converted to absolute field strength

The antenna is calibrated up to 100MHz and the calibration curve is extrapolated to 1 GHz since no resonance up to 1GHz

⇒ Less than 1 mGauss magnetic field up to 1 GHz
Outlook

- Study the E.M. field strength depending on the relative position in the target chamber

- Repeat the measurement with old design of spring fingers

- Measure with the real silicon detector
  - Frequency domain:
    sine wave, up to 500MHz, 10 times HERA-e components
  - Time domain:
    short pulse, simulate the HERA-e spectrum up to 200MHz with a relative amplitude of 0.2