RF Test for the HERMES Silicon Recoil Detector

Zhenyu Ye

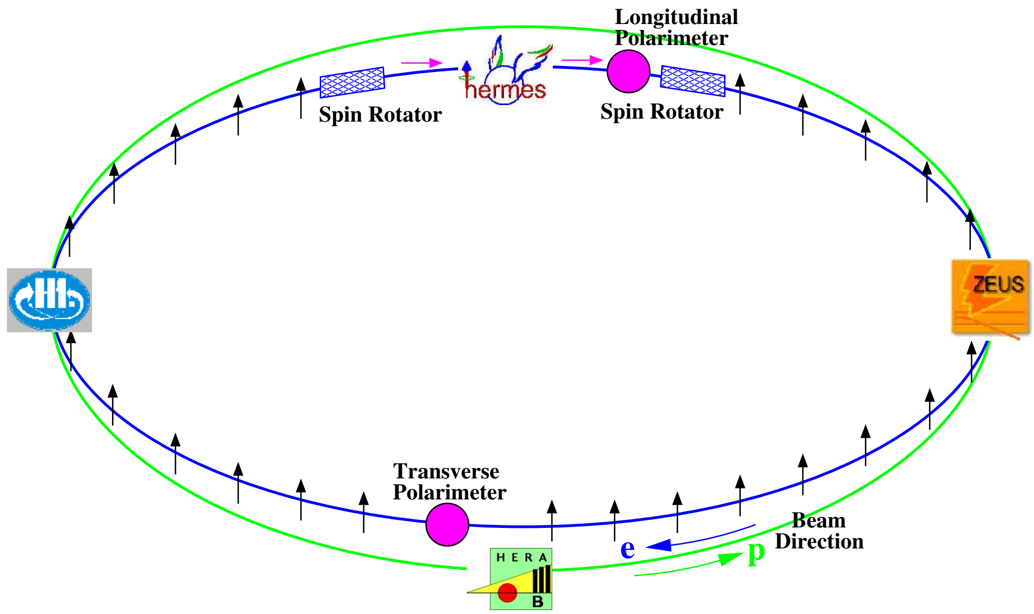
DESY Hamburg

for the HERMES Experiment

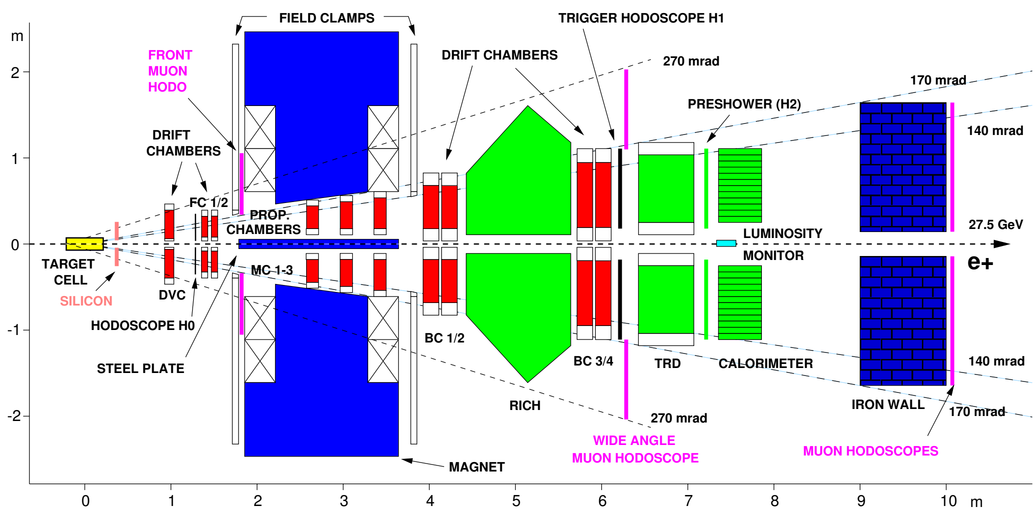
Contents

- The HERMES Experiment
- The HERMES Silicon Recoil Detector
- RF test for the HERMES Silicon Recoil Detector
- Outlook

The HERMES Experiment



- Spin physics at HERA in DESY Hamburg

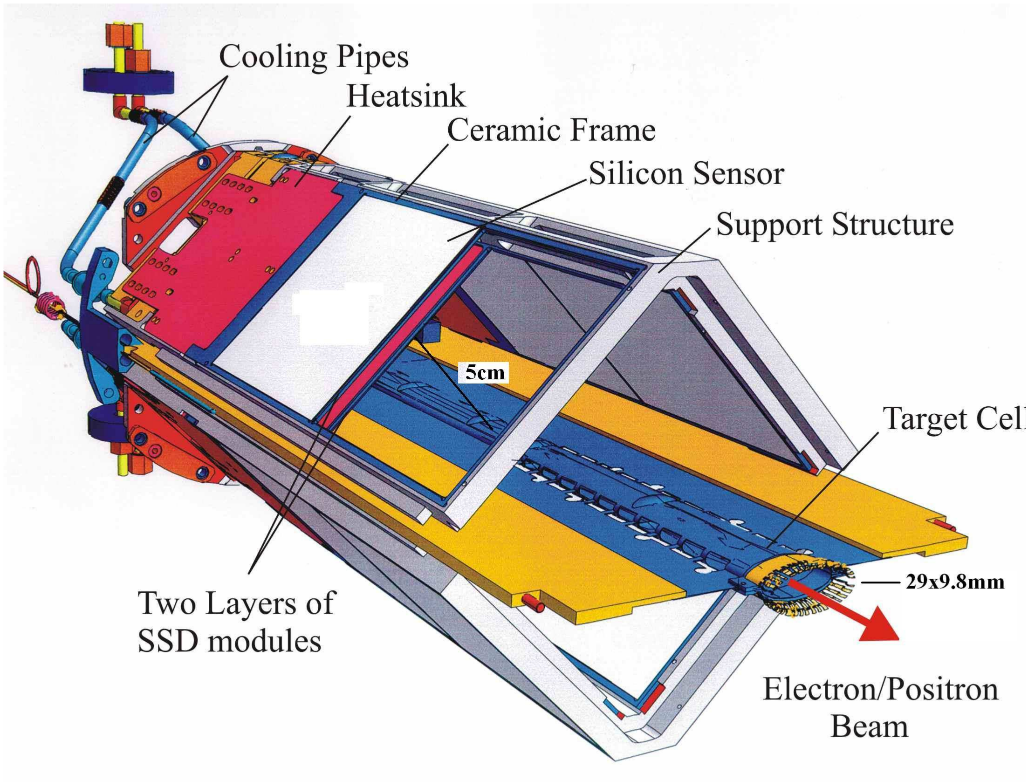


- The HERMES experiment:

- longitudinal polarized e^+/e^-;

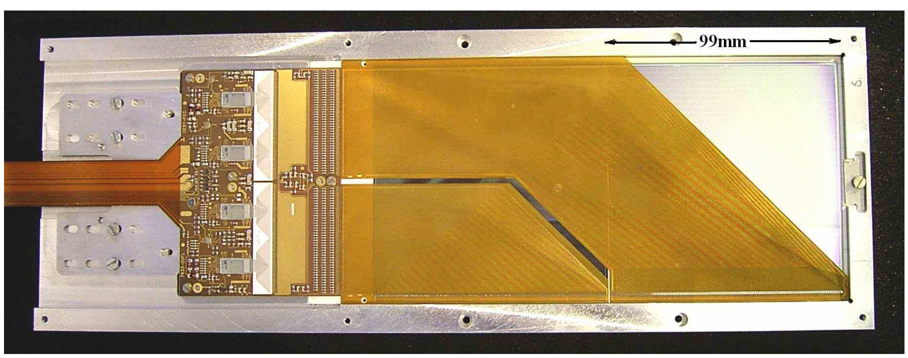
- internal gaseous target :
  polarized H, D atoms, unpolarized H_2, D_2, N_2, etc

The HERMES Silicon Recoil Detector



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

  Deep Virtual Compton Scattering: $\mathbf{ep} \rightarrow \mathbf{ep}\gamma$



- 99 $\times$ 99, mm^2 300μm 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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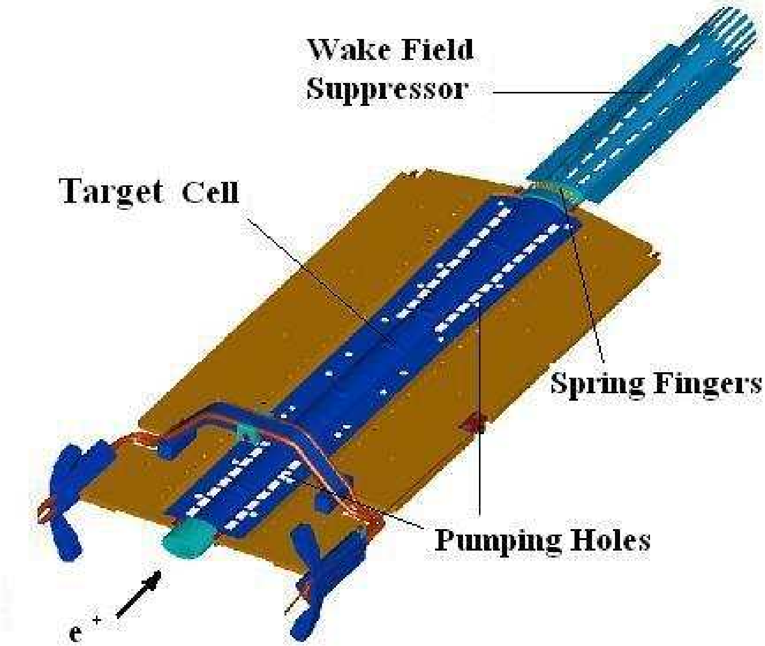
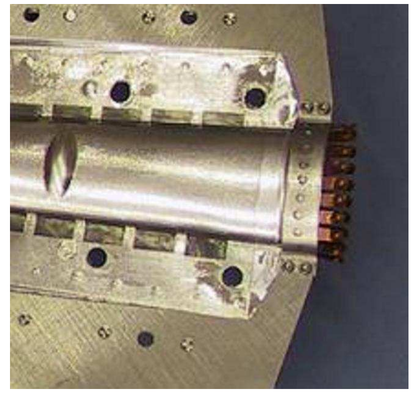
RF Interference to the HERMES Silicon Recoil Detector





New Design

Old Design

HERA-e bunched beam introducing RF field

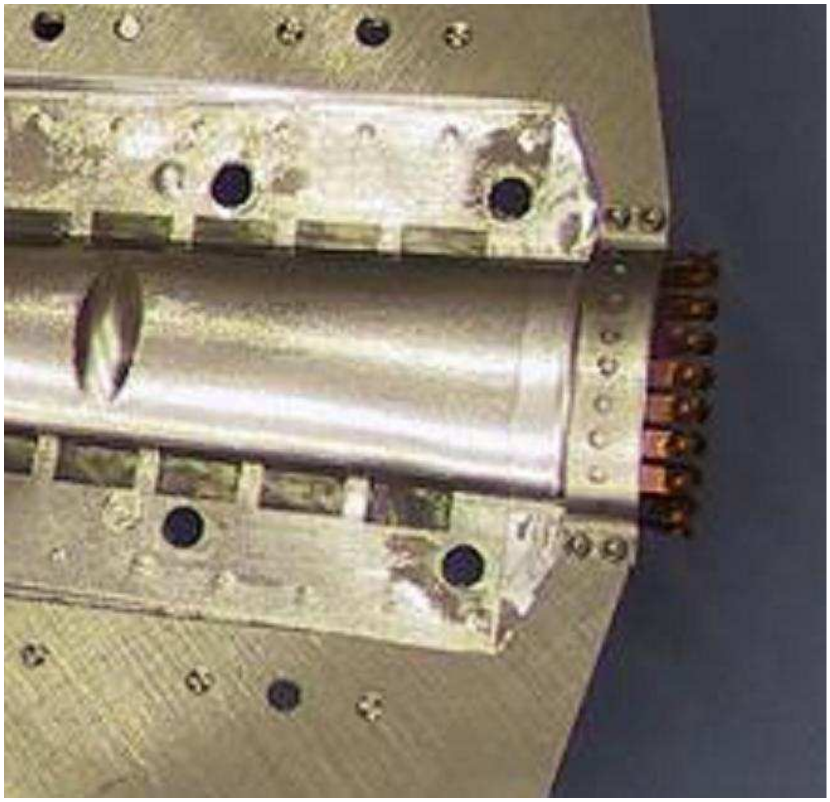
- Saturation was observed with the read-out electronics of a similar HERMES silicon detector near the cell

  ⇒ Solved by isolating the detector from the target chamber with $75\mu m$ etched copper foil

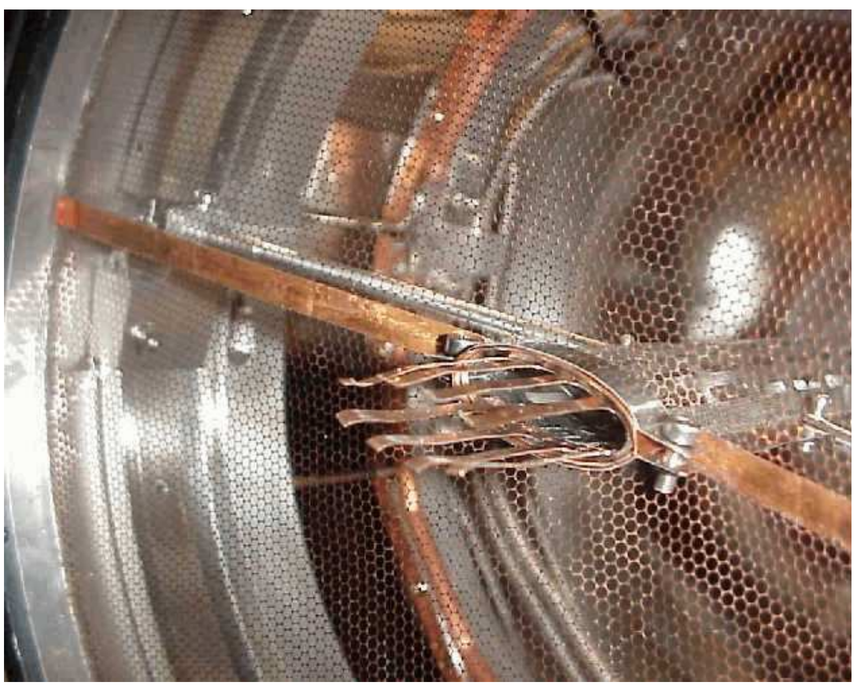
- Improvement on the RF shielding design of the target cell by:

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

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

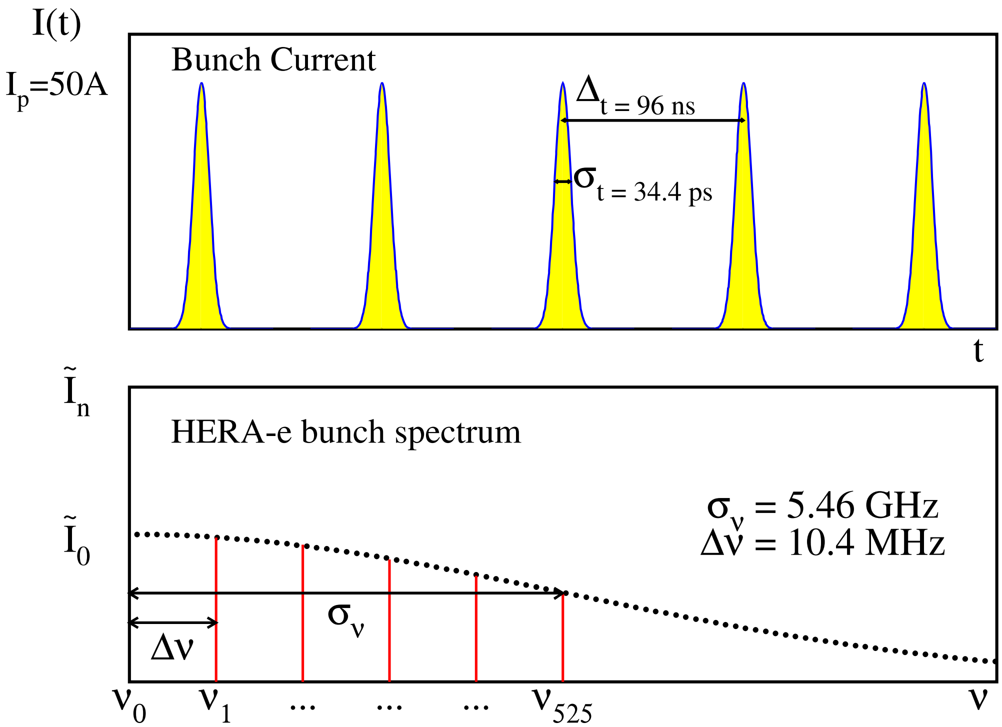


New Design



Old Design

The HERA-e Spectrum



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

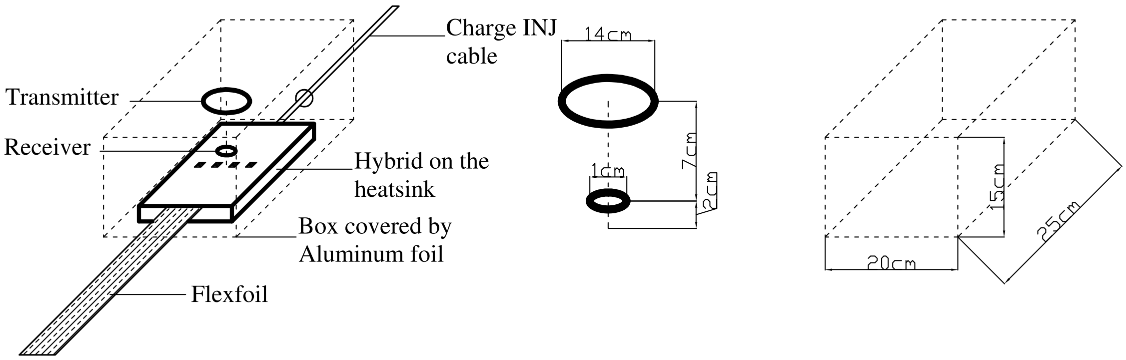
$$\tilde{I}(2\pi\nu) = \sum_{n=0}^{+\infty} \tilde{I}_0 \cdot \delta(\nu - \nu_n) \cdot \exp\left(-\frac{\nu_n^2}{\sigma_\nu^2}\right)$$

High peak current: $I_p = 50A$

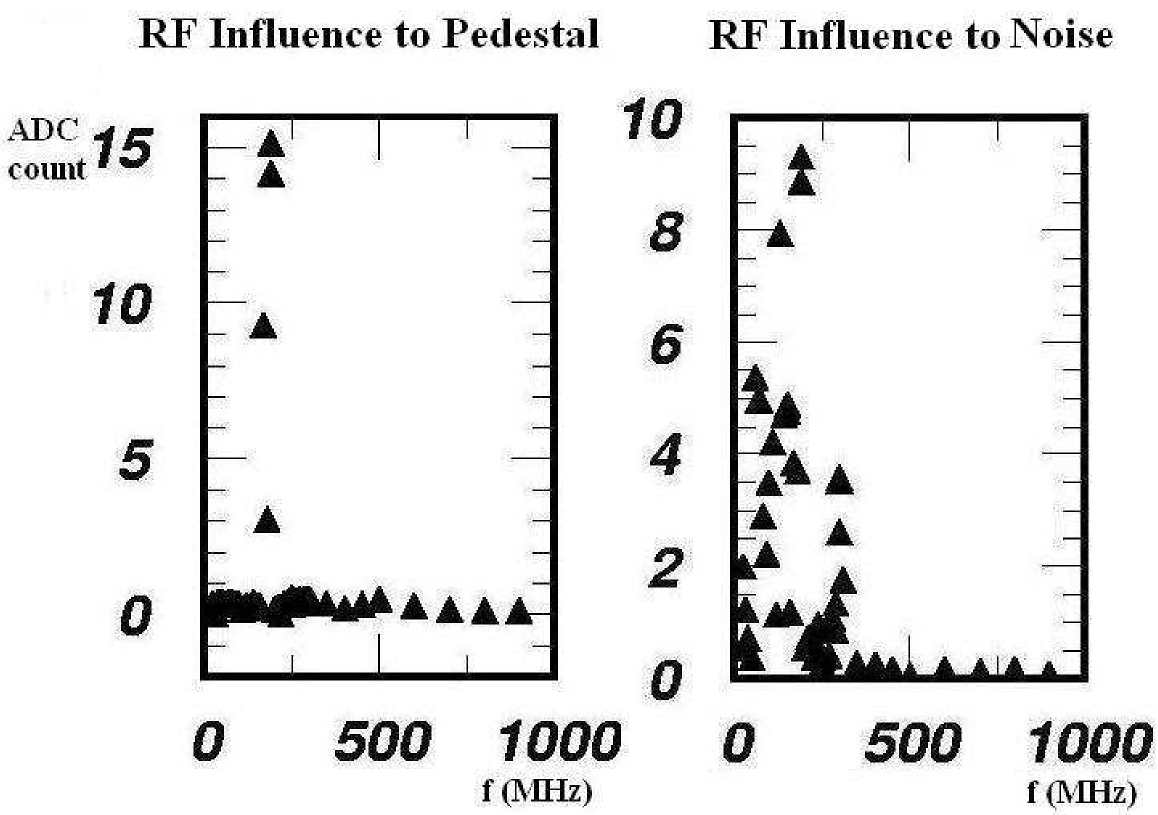
Wide line spectrum: $\nu_n = n \cdot 10.4 MHz$, σ_ν =5.46GHz

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

Sensitive Frequency Range of the Silicon Fron-End Electronics

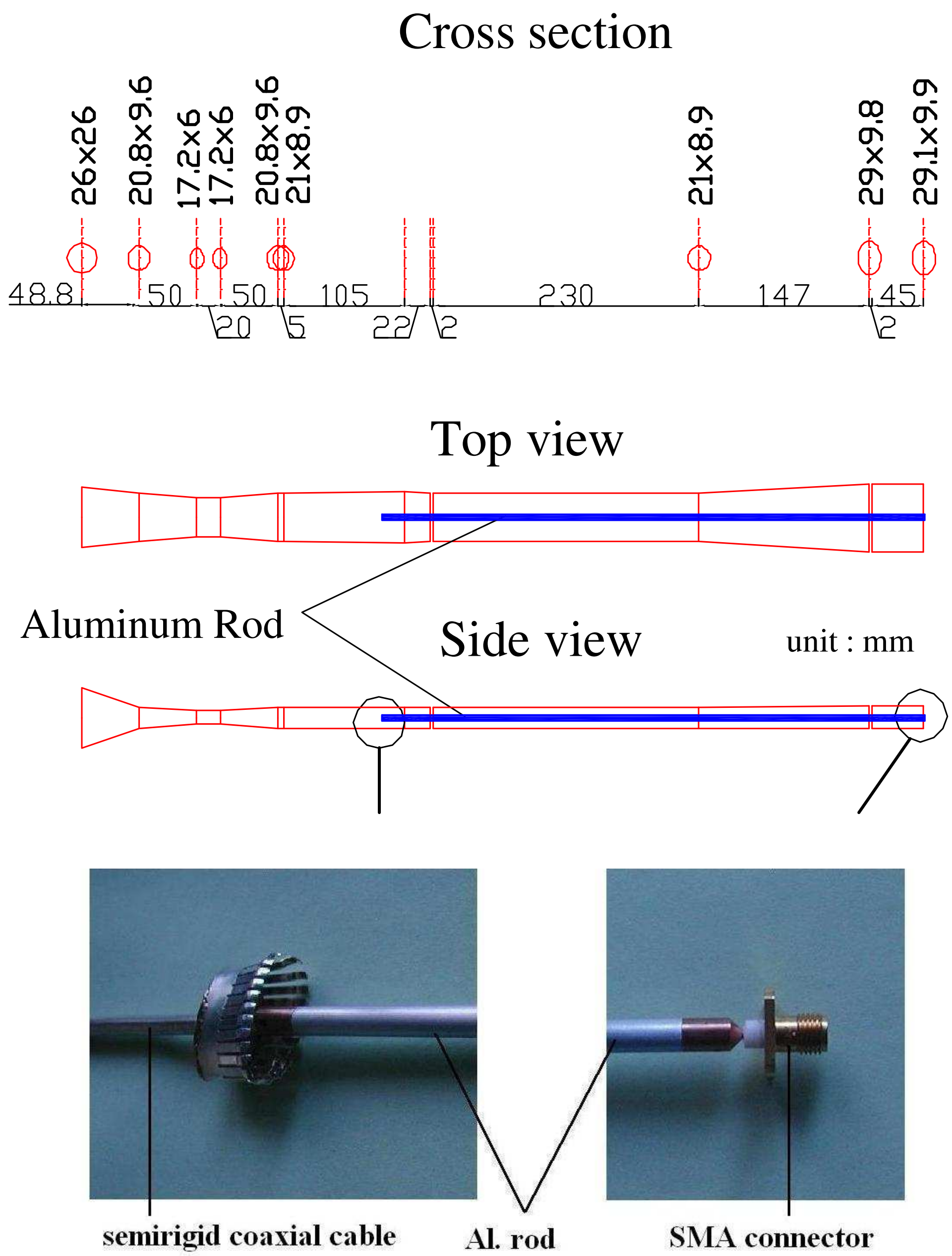


- Electronics saturation was observed with 5-10 MHz



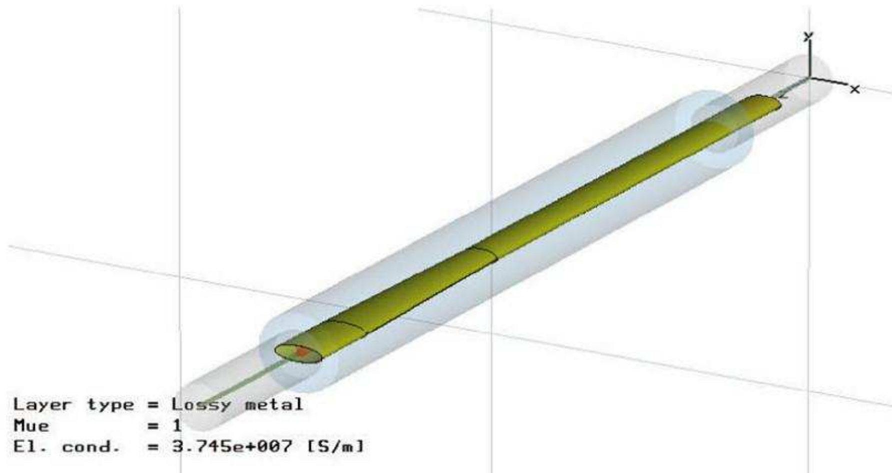
- Observed RF influences - shifts of the pedestal, increase of the noise level (rms) - are limited to low frequencies

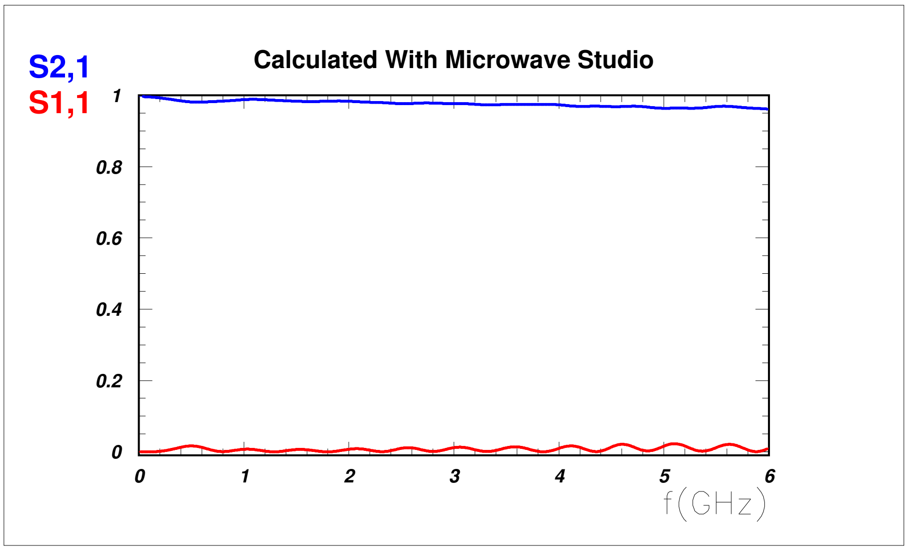
Simulation of the HERA-e RF field



- Build a transimission 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

Optimization of the Transmission Line Design by Microwave Studio



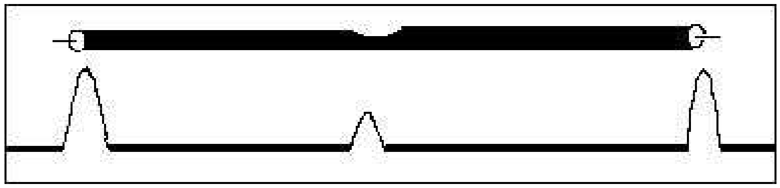


$S2,1$: power transmission
$S1,1$: power reflection

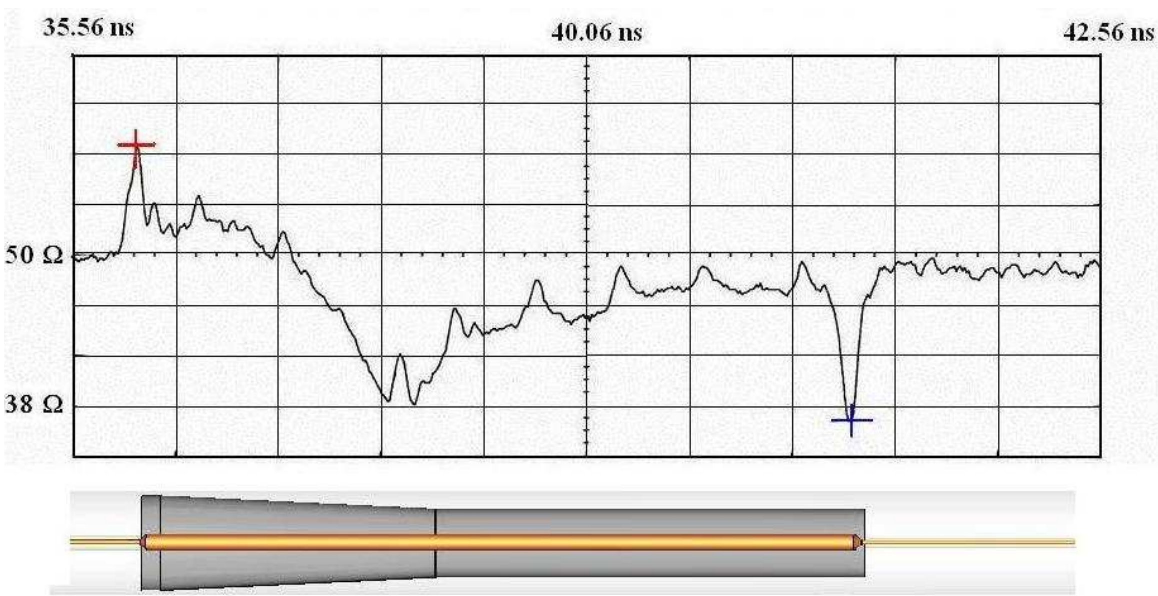
- 5 mm diameter 50 cm Al. rod with two 45° tapers in the ends
- Target cell including the tapered shape, pumping holes and spring fingers are not included in the calculation

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

Measured Local Impedance Distribution by Time Domain Reflection Method

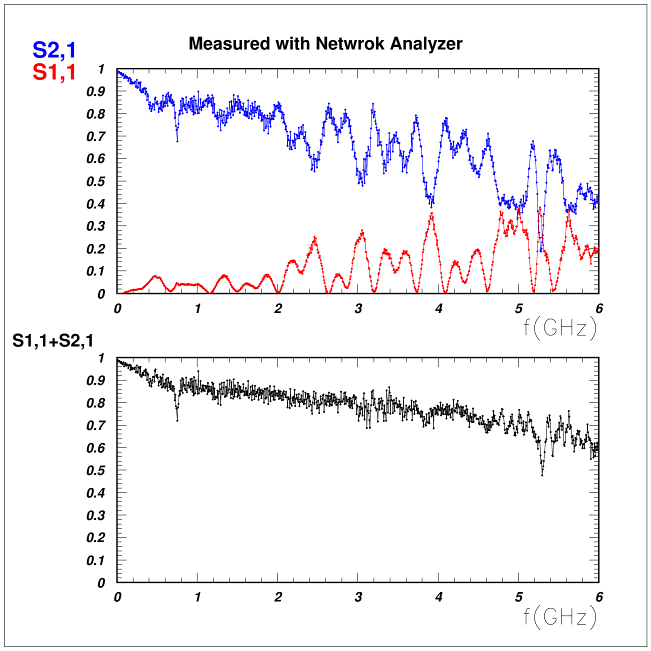


Time Domain Reflection

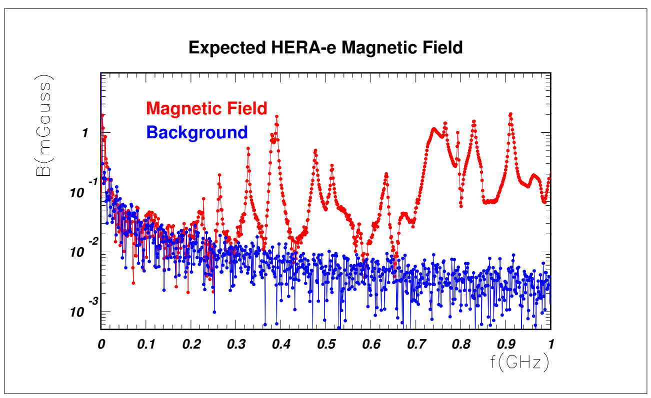


- Impedance mismatch at the two ends due to the connections
- Impedance mismatch due to the tapered shape of the cell

Measurement with Network Analyzer



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



- Measuring $\frac{\text{Power picked up by the antenna}}{\text{Input power on the transmission line}}$
  $\Rightarrow$ scaled by the HERA-e spectrum
  $\Rightarrow$ 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

$\Rightarrow$ Less than 1 mGauss magnetic field up to 1 GHz

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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 tp 200MHz with a relative amplitude of 0.2