Beam tail measurements by wire scanners

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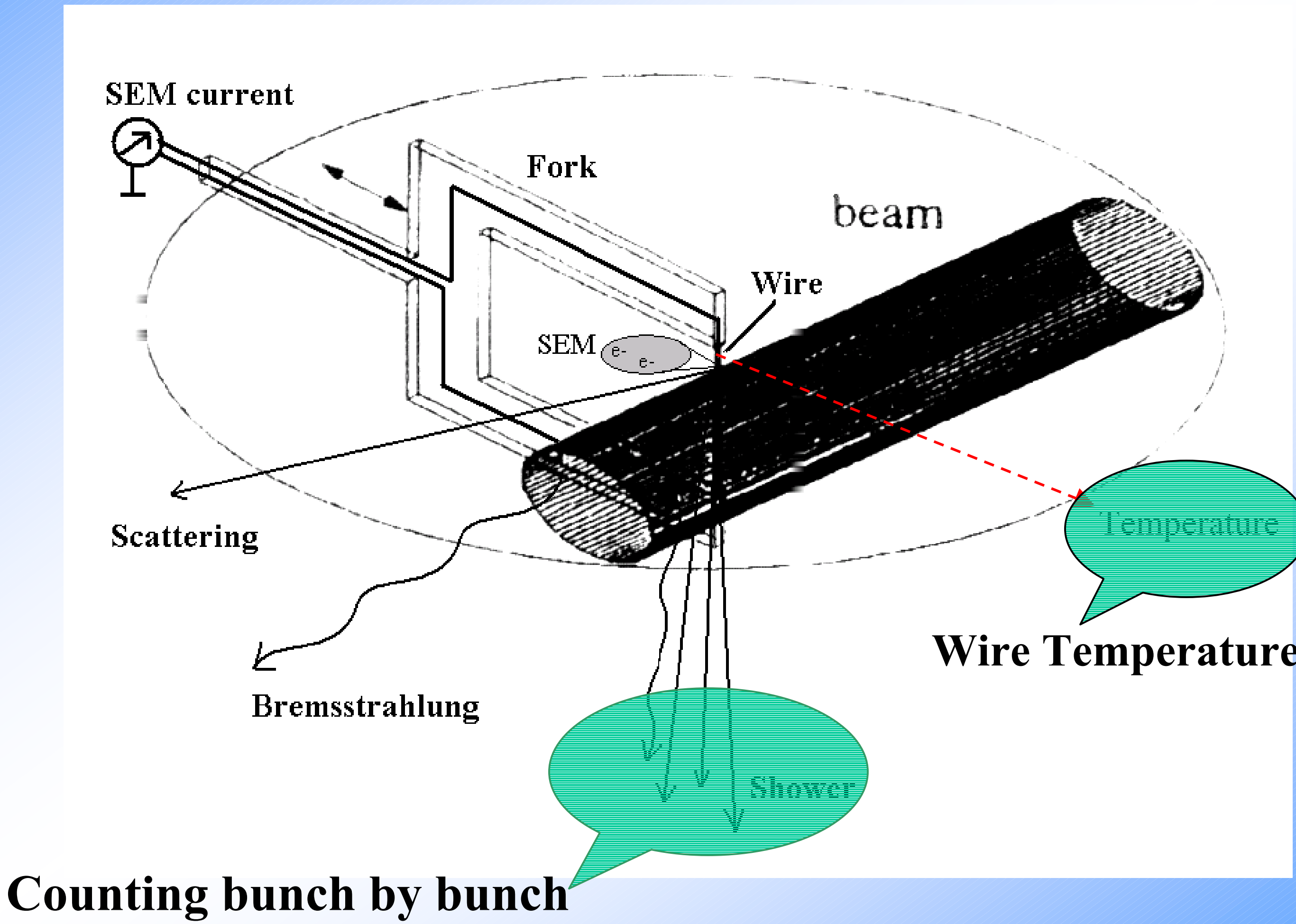
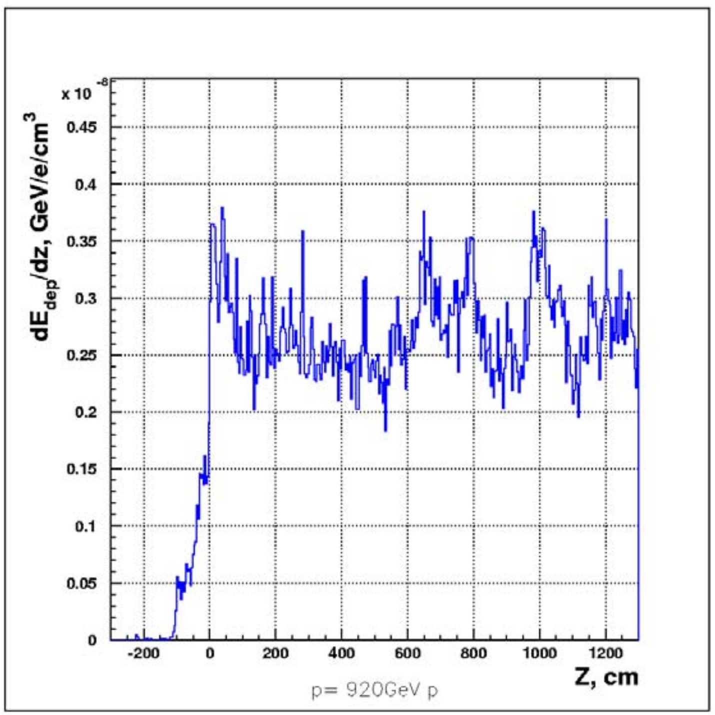
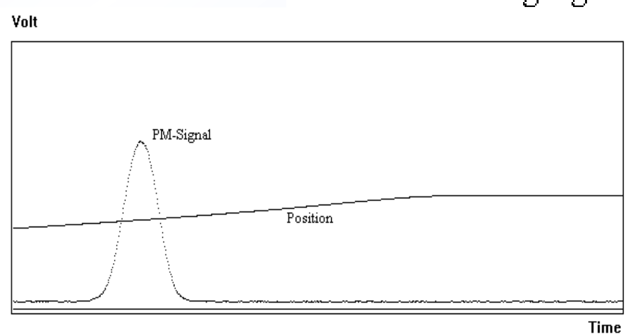
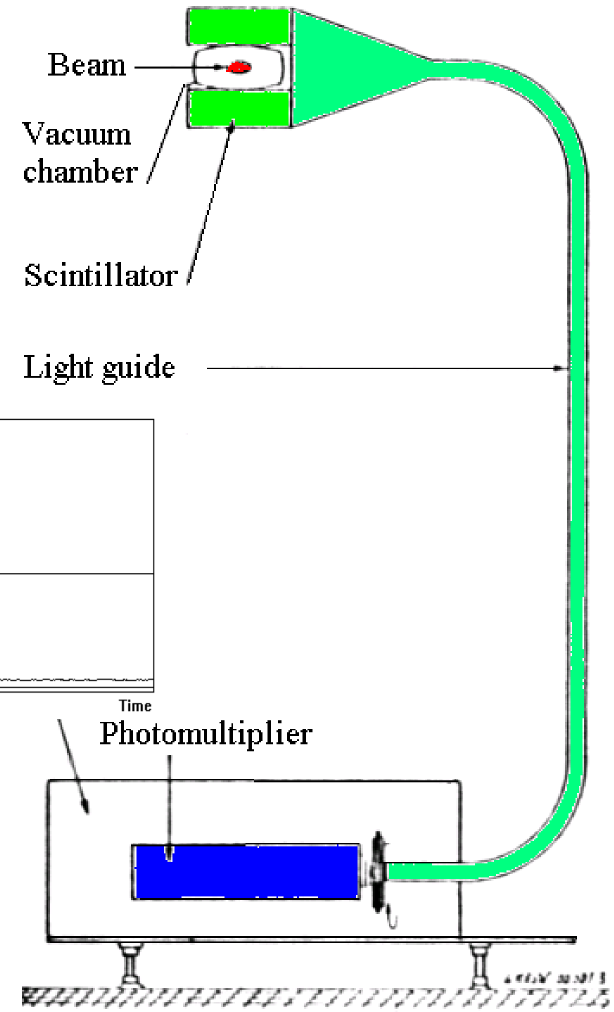


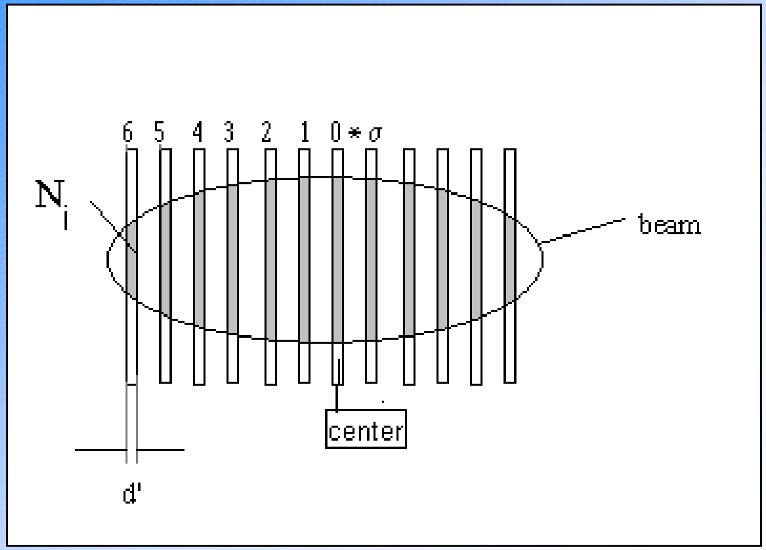
HERA at 920 GeV/c

Deposited energy in the counter = $5.3 \cdot 10^{-7}$ Gev/p.
The efficiency of the counter is less than 2%.
The photon yield in the frequency range of PM is ≈ 1 photon per 100eV of ionization energy loss,
typical efficiency of PM cathode ≈0.1, **hence the expected signal is $1.1 \cdot 10^{-2}$ photoelectrons per proton intersecting the wire area.**









$$N_i = n_{bunch} \cdot \int_{i\cdot\sigma-\frac{d'}{2}}^{i\cdot\sigma+\frac{d'}{2}} \frac{1}{\sigma_h \cdot \sqrt{2\cdot\pi}} \cdot \exp\left(\frac{-x^2}{2\cdot{\sigma_h}^2}\right) dx$$

N = **protons intersecting wire area**

σ = beam width (0.7 mm)

d' = wire diameter (7 μm)

$N_{bunch} = 10^{11}$ protons

Bunch Rate = 1/96 ns = 10.4 MHz

Rate [Signals/bunch]

N_i	**Position**	Eff_i
$3.989\cdot 10^{8}$	Center	398.941
$2.42\cdot 10^{8}$	1 σ	241.971
$5.399\cdot 10^{7}$	2 σ	53.992
$4.432\cdot 10^{6}$	…	4.432
$1.338\cdot 10^{5}$		0.134
$1.487\cdot 10^{3}$		0.001
6.077		$6.077\cdot 10^{-6}$
0.009		$9.137\cdot 10^{-9}$
$5.054\cdot 10^{-6}$		$5.054\cdot 10^{-12}$
$1.028\cdot 10^{-9}$		$1.028\cdot 10^{-15}$
$7.698\cdot 10^{-14}$		0

Satturation

Assume signal efficiency of 10^{-6}

Black body radiation: The temperature T_{bb} at which the radiated power is equal to the deposited energy in the wire P_{dep} [MeV/s] can be calculated from the Stefan-Bolzmann-law:

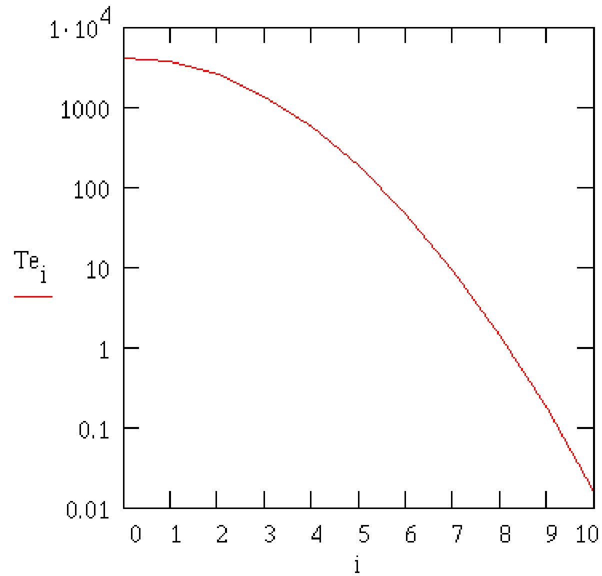
$$T_{bb} = \sqrt{\sqrt{\frac{P_{dep}}{s \cdot A}}} \quad [K]$$

where s = 35.4 MeV / (s^1 cm^2 $^0K^4$) is the Stefan-Bolzmann-constant and A is the area of radiating surface. The surface of the heated wire portion A is approx $2 \cdot \sigma_{v,h} \cdot d \cdot \pi$ [cm^2]. The power can be calculated by:

$$P_{dep,i} = \alpha \cdot N_i \cdot dE/dx \cdot d' \cdot f_{bunch} \quad [MeV/s]$$

α is the expected loss from secondaries = 0.3

dE/dx = 4.1 MeV/cm (carbon)



Te_i
$4.257 \cdot 10^3$
$3.756 \cdot 10^3$
$2.582 \cdot 10^3$
$1.382 \cdot 10^3$
576.081
187.028
47.289
9.312
1.428
0.171
0.016

Position

Center

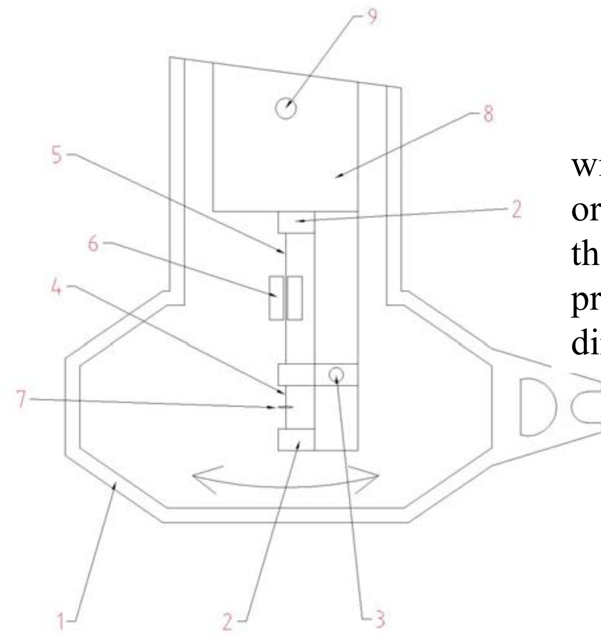
1 σ

2 σ

…

$T_{melt} = 3000\ ^0C$

For wire temperature measurement is proposed to use the strong dependence of frequency of normal oscillations of tensioned wire on temperature. Excitation can be a parametric resonant mechanism generated by special piezoelectric transducers. Oscillations can be detected by piezoelectric or optical ways and can also serve as source of beam profile information. The temperature sensitivity of the vibrating wire sensor estimated on the level 10^{-4} °C.



wire oscillation orientation along the beam propagation direction

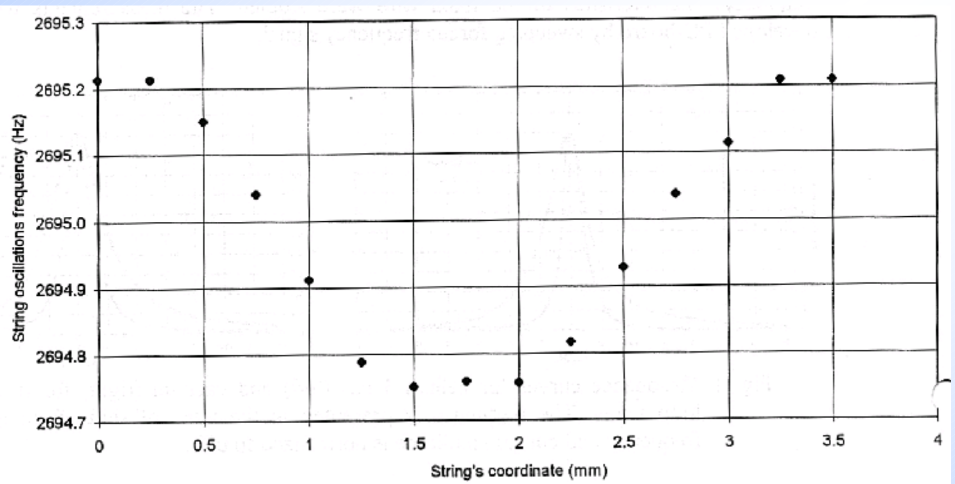
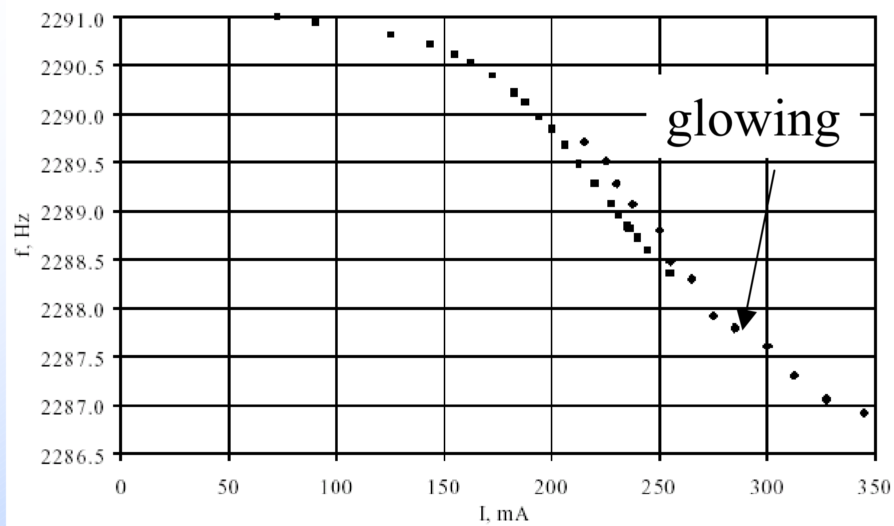


Fig 3. Laser beam scanning by vibrating wire.



Frequency dependence on current in a 70µm tungsten wire

Vibrating wire scanner: first experimental results on the injector beam of Yerevan synchrotron

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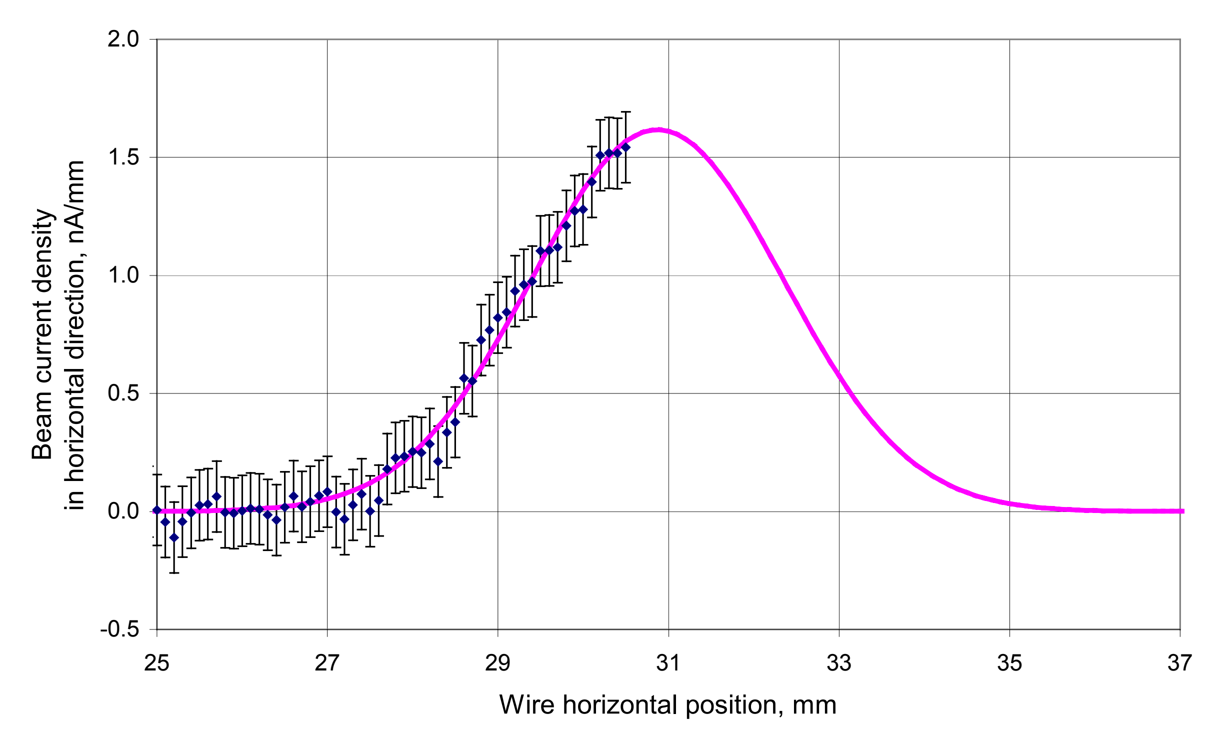
Yerevan Physics Institute

The first experimental results of the transversal scanning of the injector electron beam (6 nA after collimation) of Yerevan synchrotron by scanner based on the vibrating wire (vibrating wire scanner - VWS) are presented and the corresponding horizontal beam profiles are obtained. The information from the beam local intensity is picked up from the measuring of wire natural oscillations depending on wire temperature.

vibrating wire: 90 μm beryl-bronze wire



The overall current of the beam is set I_0 = 6 nA. Because of short traveling distance only half of the beam was scanned.

Counting Mode

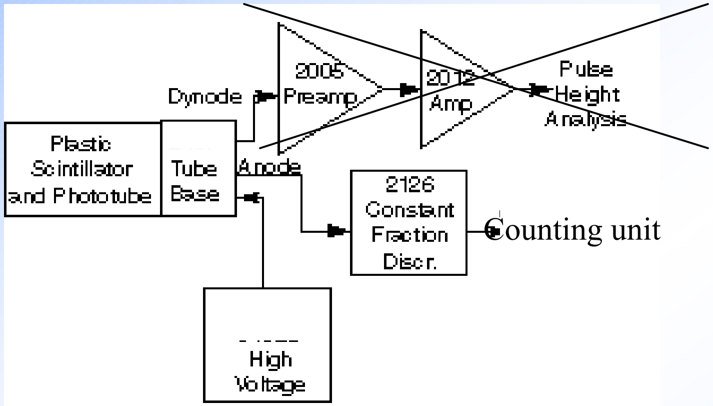
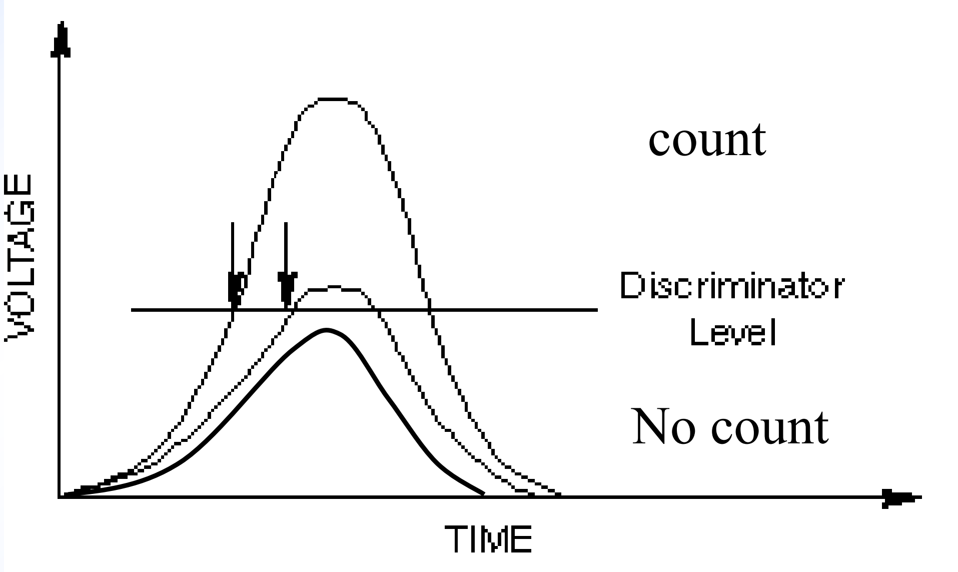


Figure 1.8: Plastic Scintillation Detector Electronics



HERA-B Detector

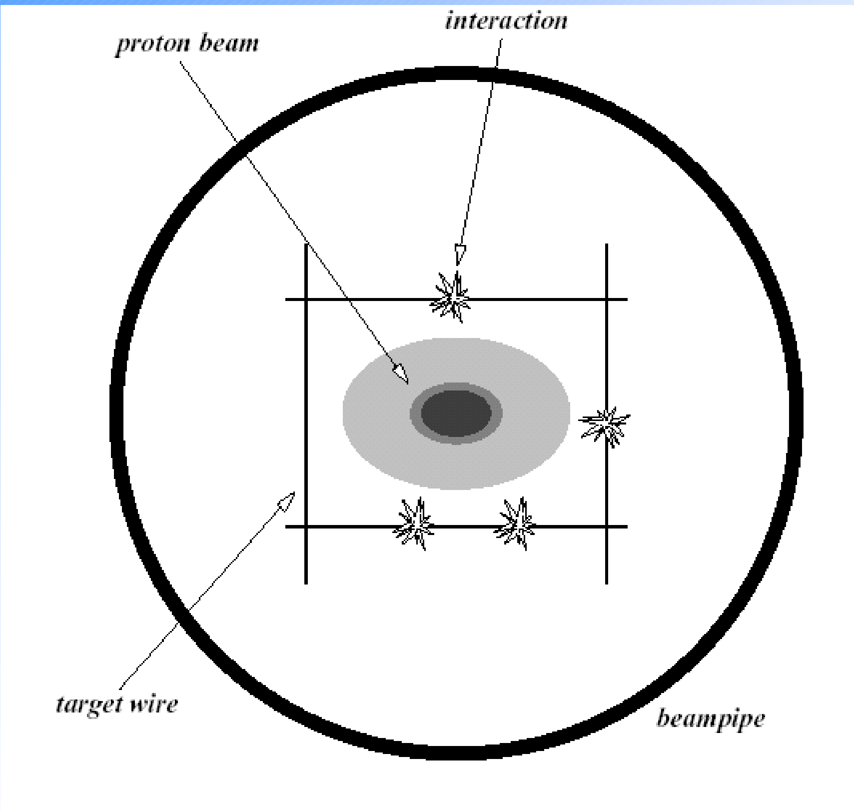
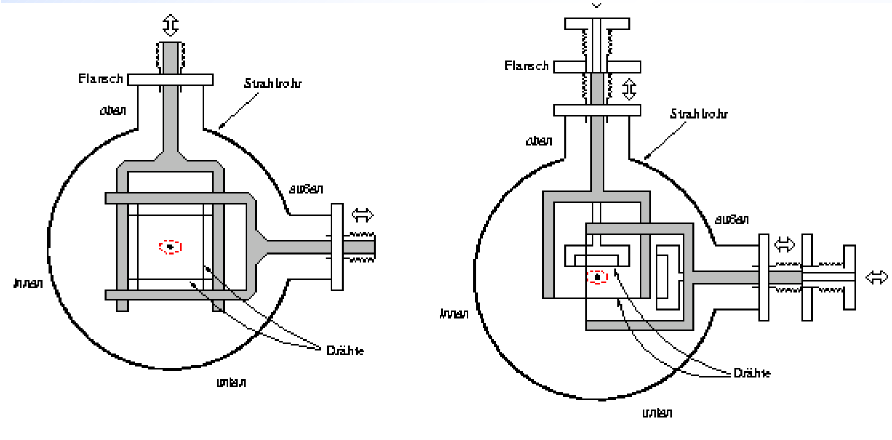
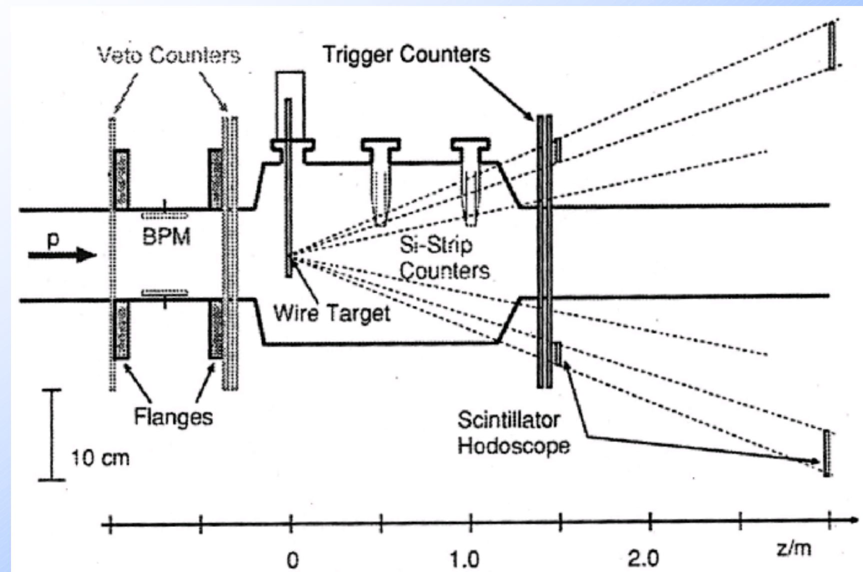


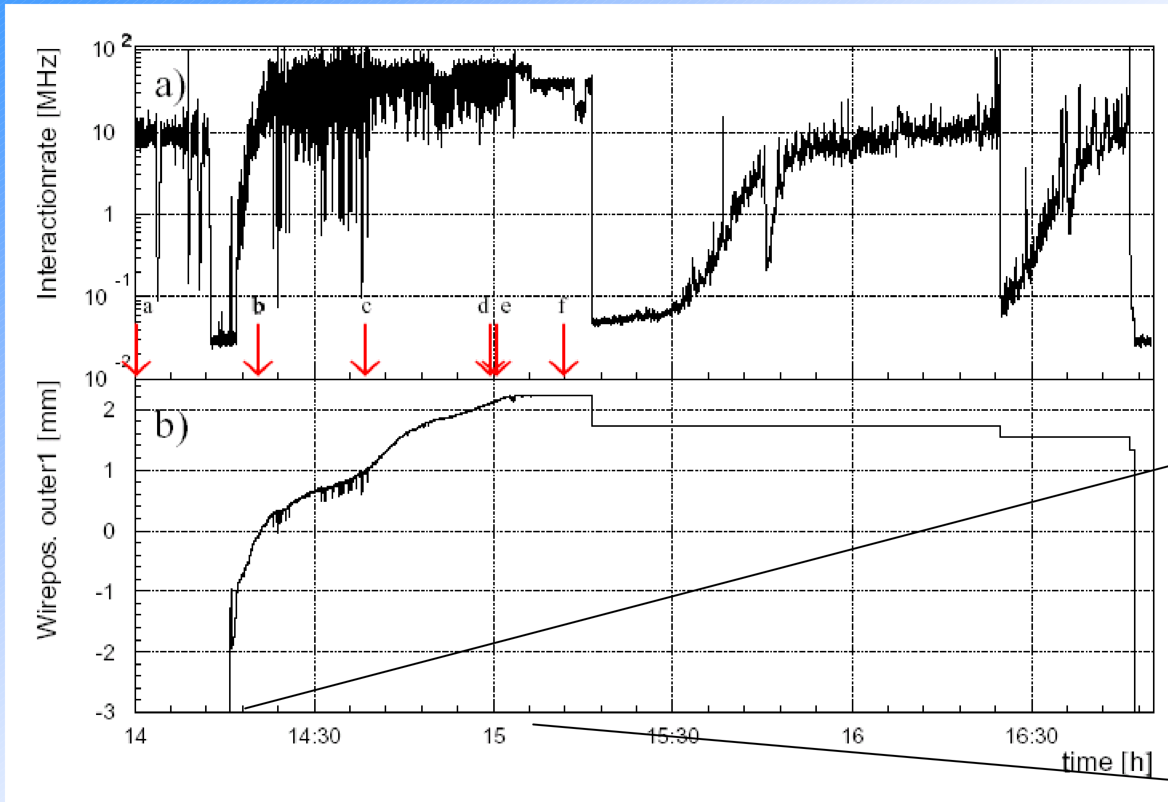
Figure 1: Schematic view of the HERA–B wire target.

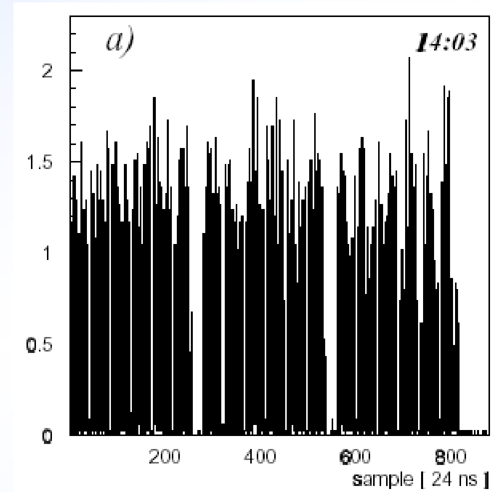


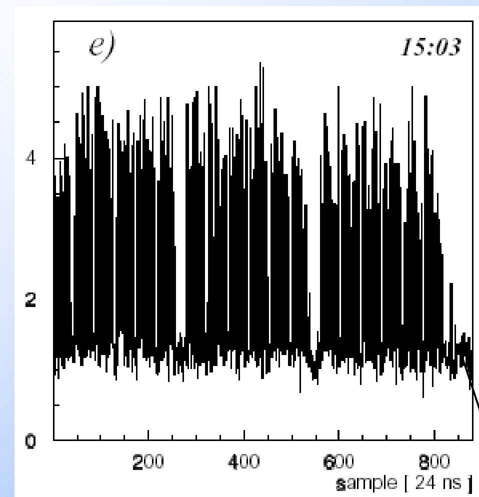


Detection efficiency > 50%

Detection of coasting beam

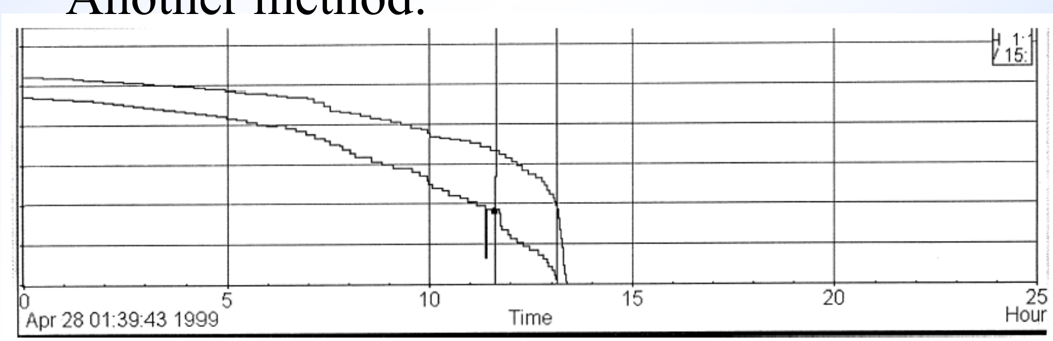






Note the increased rate in the Bunch gaps (=coasting beam)

Another method:



Total DC current (upper) and total bunch current (lower)

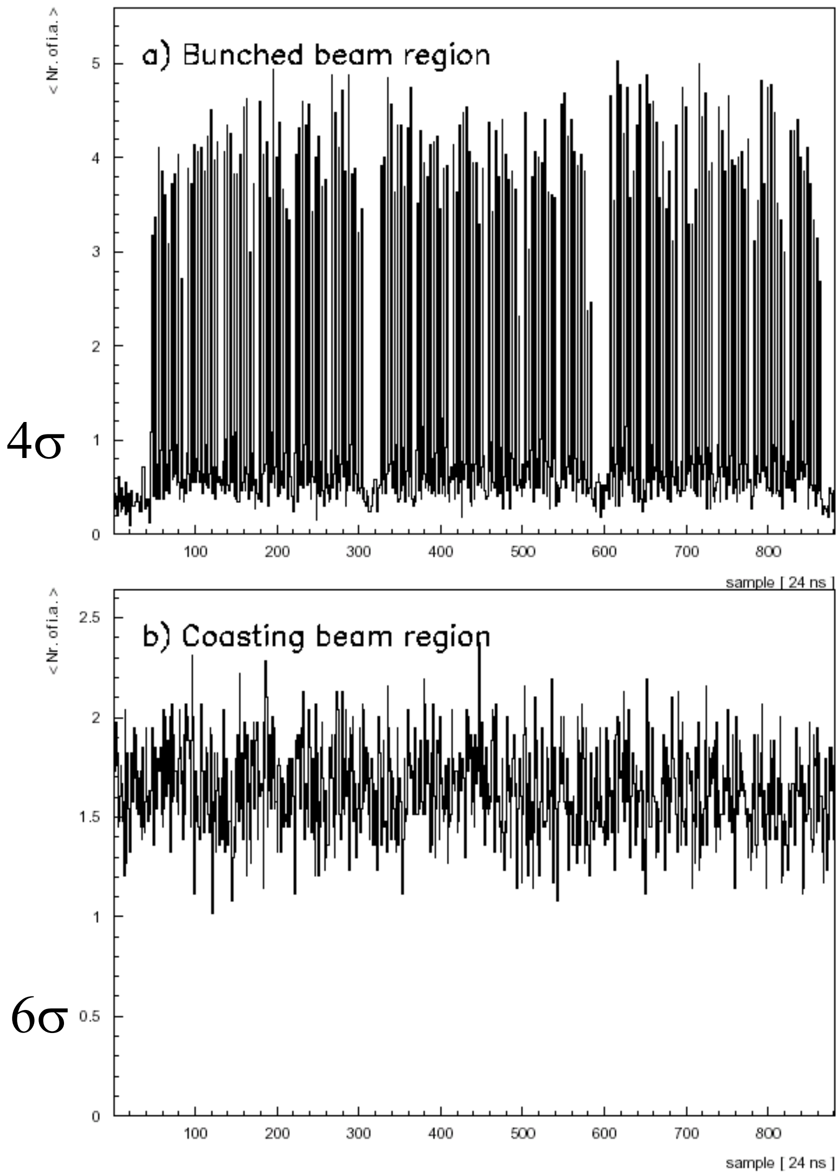
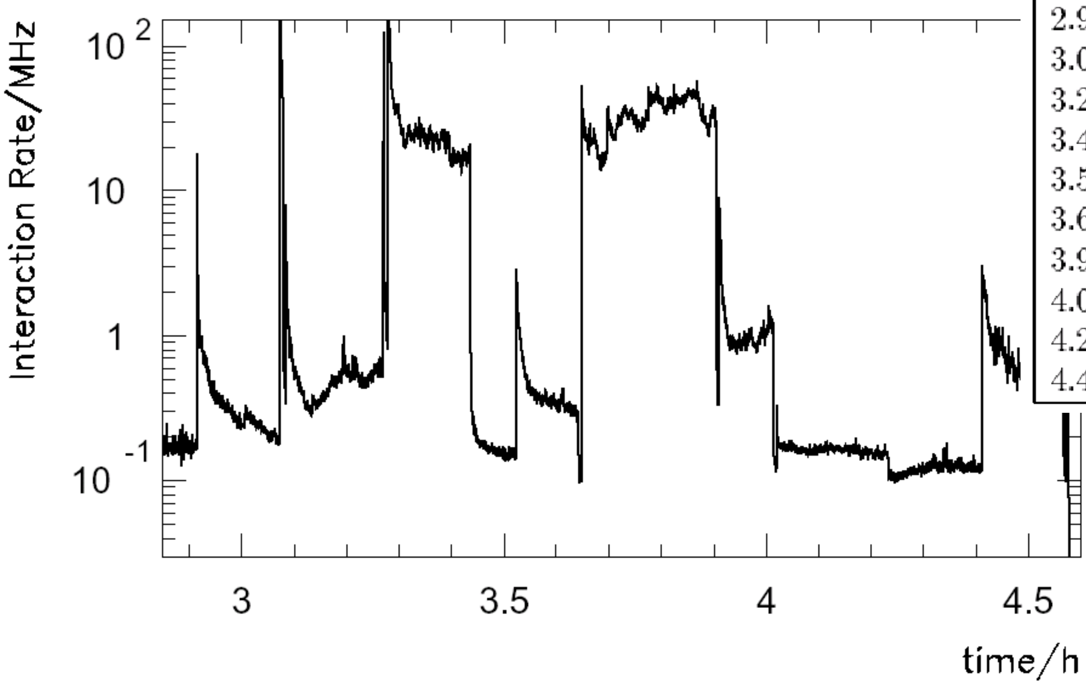


Figure 11.2: The time structure of the proton interaction for an outer target wire at different distances of the wire to the beam center: a) wire $\approx 4\sigma$ from the beam center and b) wire $\geq 6\sigma$ from the beam center.

The negative horizontal dispersion leads to signals on the outside wires

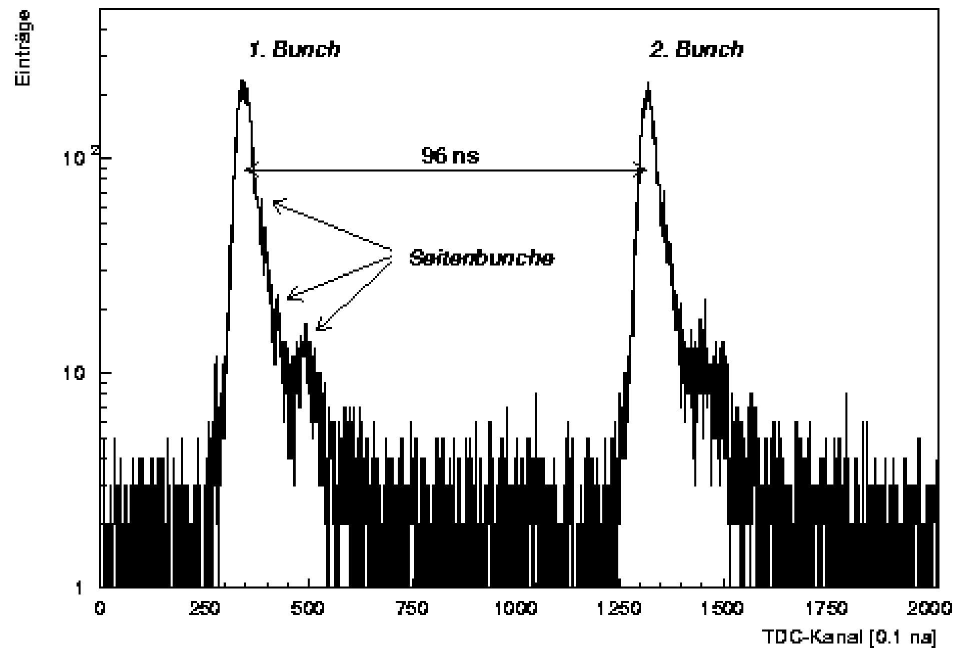
The HERA–B experiment [43] uses an internal wire target inserted into the halo of the stored HERA proton beam. While machine performance was improved during recent years, this halo practically vanished. Therefore the wire target has to be moved close to the beam core at about 3 to 4 σ in order to keep the actual rate constant at the design rate of five interactions per bunch crossing. As it was observed, this leads to a high sensitivity of the interaction rate to beam orbit jitter of very small amplitudes. To overcome this situation, it has been suggested to artificially create some beam halo by means of tune modulation [42].



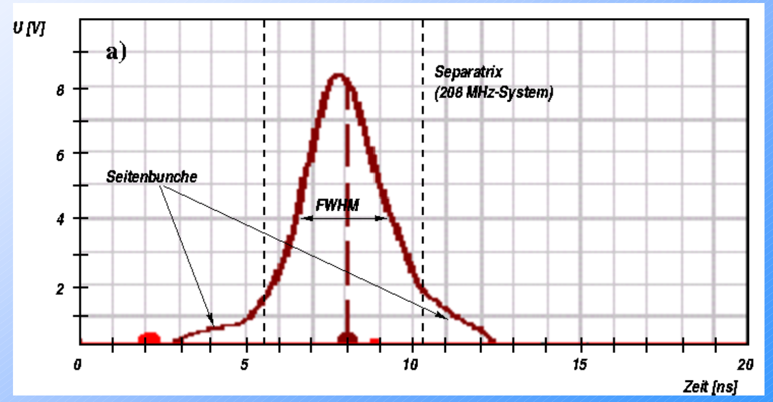
time/h	f_1/Hz	U_1/V	f_2/Hz	U_2/V	rate/MHz
2.8	0	0	0	0	0.18 ± 0.03
2.92	40	2.5	190	2.5	0.27 ± 0.03
3.08	20	2.5	190	2.5	0.35 ± 0.04
3.27	10	2.5	190	2.5	23 ± 5
3.4	0	0	0	0	0.16 ± 0.02
3.52	10	2.5	0	0	0.35 ± 0.05
3.65	10	2.5	190	2.5	30 ± 0.8
3.9	10	1.875	190	1.875	0.9 ± 0.15
4.02	10	1.25	190	1.25	0.17 ± 0.02
4.23	10	0.625	190	0.625	0.12 ± 0.015
4.42	10	2.5	0	0	0.6 ± 0.1

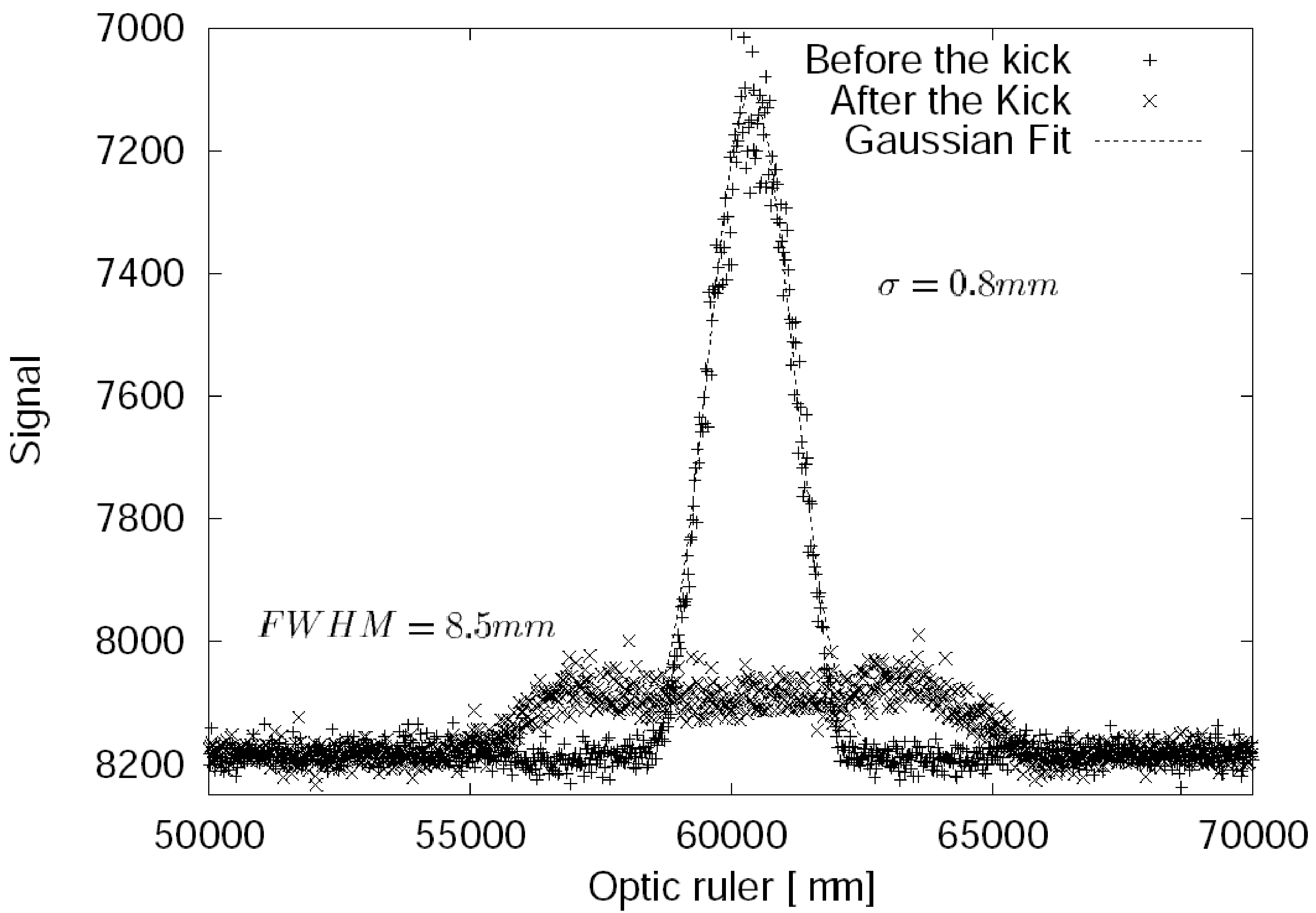
Neighbor-buckets

Abbildung 5.3: *Das TDC–Spektrum beim Betrieb eines äußeren Drahttargets zeigt die zeitliche Zuordnung der Wechselwirkungen innerhalb eines Zeitraums von 202 ns bei einer zeitlichen Auflösung von 0,1 ns. Wechselwirkungen von Protonen zwischen den gefüllten Bunchen sind wie in Abbildung 5.2 beim Betrieb eines äußeren Targetdrahtes auch in den Daten des TDC–Systems zu sehen.*



Another method: Fast wall current monitor





Before the kick
After the Kick
Gaussian Fit
σ = 0.8mm
FWHM = 8.5mm
Signal
7000
7200
7400
7600
7800
8000
8200
50000
55000
60000
65000
70000
Optic ruler [mm]

References

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS, VOLUME **2**, 122801 (1999)
Vibrating wire for beam profile scanning
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Yerevan Physics Institute, Alikhanian Brothers Street 2, 375036, Yerevan, Armenia
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MAGNETIC FIELD DISTRIBUTION MEASUREMENT BY
VIBRATING WIRE STRAIN GAUGE
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Mailian M.R., Sinenko I.G., Sinjavski A.V., Vasiniuk I.E.

Problems of Installation of Vibrating Wire Scanners into Accelerator Vacuum Chamber
S. Arutunian, A. Avetisyan, N. Dobrovolski, M. Mayilyan, I. Vasiniuk, YerPhI, Yerevan;
K. Wittenburg, DESY, Hamburg; R. Reetz, HTM Reetz GmbH, Berlin
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HERA Accelerator studies 1999 2000
DESY HERA 00-02, DESY-HERA 00-07

Observation of coasting beam at the HERA proton-ring
K. Ehret et al.,
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