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Proposal to Complement the H1 Backward Silicon Tracker (BST) with ϕ-Strip Detectors [1]

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Abstract:

This proposal describes the physics tasks and the layout of the H1 Backward Silicon Tracker (BST) in the high luminosity phase of HERA. The detector will comprise 8 planes of Silicon strip detectors which permit to measure both coordinates (radius r and azimuth ϕ) in order to perform precision measurements of the deep inelastic scattering cross section up to large y and to extend the analysis of charm and beauty particle production towards low $x \simeq 10^{-3} ... 5 \cdot 10^{-5}$. The modifications due to the possible introduction of an elliptic beam pipe are discussed and cost and time schedule are given for upgrading the BST with ϕ detectors. This 'ϕ detector option' has been part of the Technical Proposal [1] for BST and CST but it was staged during its initial discussion.

[1] Addendum 2 to the Technical Proposal to build Silicon Tracking Detectors for H1, PRC 92/01.

1 First Results with the BST

In 1997 the H1 Backward Silicon Tracker was run in its first year with new readout electronics permitting on-line hit finding and zero suppression which are necessary for routine operation [2]. The detector was equipped with 4 planes of silicon wafers with p-type strips concentric around the beam axis. First large statistics results become available. These are based on a mean signal-to-noise ratio of S/N $\simeq$ 14, and a mean occupancy of about 1-2 hits per detector using a hit selection cut of S/N $>$ 4.

Fig. 1a shows the 'triplet sagitta' distribution, scaled to resolution, which exhibits a clear, narrow peak of 16 μm width over a flat combinatorial background. This resolution is obtained with 96 μm readout pitch and one intermediate strip. It permits a polar angle measurement with an internal resolution of about 0.1 mrad. Fig. 1b shows the backward calorimeter (SPACAL) energy distribution in the kinematic peak region for those events which have a track in the BST and both a vertex determined with the BST, with $|z_{BST}| < 30$ cm, and a vertex determined with the central tracking detector (CT) (open distribution). The hatched distribution represents events with a track in the BST but without a central tracker vertex reconstructed. Without the BST these events were not reconstructed in the analysis. The BST thus allows the measurement to be extended towards high x saving a large fraction of the kinematic peak events. Fig.1c displays the efficiency of finding the scattered electron by validating its calorimetric energy deposition with a track signature in the BST. This efficiency, quoted here for the dedicated low Q^2 running period in 1997, is larger than 90%. The acceptance limits of the 4-plane BST are about 171^o and 176^o for the polar angle of the scattered electron. From tagged photoproduction events, for SPACAL energies of $6 < E' < 12$ GeV, preliminary studies show that about 70% of the low energy background can be rejected by demanding a valid track signature in the BST in front of energy clusters in the SPACAL. This is very important for the high y measurement of the DIS cross section. At even lower energies the track recognition has to be complemented by the measurement of the track charge in order to reliably control the photoproduction background which is charge symmetric.

The Backward Silicon Tracker has been used also to measure elastic J/Ψ photoproduction. This is demonstrated in Fig. 2 which shows the preliminary J/Ψ signal in the H1 backward detector without using the BST (top) and with (bottom). The effect of the silicon tracker is to validate tracks thereby rejecting neutrals, which considerably reduces the QED background, and to define the vertex and the polar angle, which improves the resolution. This way the BST permits to extract a clean J/Ψ signal and to measure its production cross section.

The Backward Silicon Tracker is being upgraded for the shutdown 1997/1998 to eight planes of r-strip detectors in order to cover the full θ range between 164^o and 176^o. This

[2] Prior to this DAQ upgrade the detector was operated and readout using the OnSiRoC module [2] and the first results and the BST design were published in [3].

fulfills the proposal from January 1996, i.e. Addendum I of the Technical Proposal [4]. The time schedule depends fully on the delivery of wafers by MICRON Semiconductor which were delayed by about one year. Presently (6.1.1997) 45 wafers are delivered out of 70 ordered and the delivery proceeds nearly as promised by MICRON in September 1997. The following section deals with the physics motivation to equip the BST with further 8 planes of wafers with strips that allow the momentum of backward scattered particles to be measured.

2 Physics with the Upgraded BST

The proposed detector configuration is sketched in Fig. 3. The BST will be equipped with 8 planes of strip detectors each plane comprising single sided detectors, mounted back to back, to measure the polar angle θ (r-strip disk) -these will exist in 1998- and also to measure the azimuthal angle (ϕ-strip disk) -these are proposed to be added. The detector will then permit to measure p_t with about 4% accuracy using the run interaction vertex and, in the region of overlap with the CJC, to measure impact parameters in the transverse plane to about 130 μm resolution without using the vertex, see below. The momentum, charge and impact parameter measurements define the physics for which the upgraded BST will be essential.

2.1 Measurement of the Longitudinal Structure Function

The measurement of the longitudinal structure function F_L of the proton is one of the most important tests of QCD to next to leading order. It requires a very high precision measurement of the cross section [5], in particular at low scattered electron energy. The BST is necessary to identify the electron, to reconstruct the kinematics independent of the interaction vertex, and to reject the large background from photoproduction and DIS at low energies. The background rejection is efficiently done by requiring a track linked to the SPACAL electron candidate and performing a statistical subtraction of the cross section measured with tracks of charge opposite to that of the incoming lepton. In the Q^2 region of the BST this charge subtraction can be done only with ϕ detectors.

At larger Q^2 this procedure has been used for the first time at HERA in a recent measurement of the DIS cross section performed by the H1 Collaboration [6]. The charge of the DIS candidates was determined with the CJC. This preliminary cross section measurement is shown in Fig. 5. At largest y possible deviations from the expected cross section behaviour are observed which may imply that the structure function F_L in the low x range is different from its QCD expectation.

The future measurement of F_L has been one of the major reasons to add ϕ detectors to the present BST set-up in order to control the huge photoproduction background at low energies and to depend less on the hadronic final state simulation. Fig. 6 demonstrates the possibility to measure F_L using beams at different energies (open points) and the subtraction method (closed points). The errors are full systematic and statistical errors added in quadrature assuming conservatively that the minimum scattered electron energy is 5 GeV.

2.2 Heavy Flavour Physics

2.2.1 Kinematics and Resolutions

The BST will contribute to heavy flavour physics at low x where the hadronic flow is directed backwards. Despite rather large opening angles of charm particles emitted backwards, this enlarges the acceptance for charm particles at low x. Fig. 7, based on a full simulation of the H1 detector, illustrates the considerable gain at low x for charm reconstruction by comparing the charm acceptance of the present, central detector system of CJC and Central Silicon Tracker (open points) with the acceptance obtained by adding the BST (closed points). The BST, equipped with ϕ-detectors of about 20 μm resolution, has a momentum resolution $\delta p_T/p_T^2 \simeq 4\%$ both when combined with the run vertex and, independently of the vertex, for $170^o \leq \theta \leq 164^o$ when combined with CJC track segments, assuming to have at least 3 BST hits and 8 CJC hits. This momentum resolution translates to an $r - \phi$ impact parameter resolution for single tracks of about 130 μm. This can be compared with decay lengths of charm and beauty particles between 120 μm (D^o), 380 μm (D$^+$) and 600 μm (D^o from $B \rightarrow D^oX$). The inclusion of the BST into the charm particle reconstruction will enable to reconstruct charm with the mass difference method with a resolution of ΔM of 1.3 MeV.

2.2.2 Physics Goals

The potential of the heavy flavour physics programme at HERA has been emphasized by H1 in a document adressed to the H1 funding agencies [7]. The future heavy flavour physics at HERA has been outlined in detail in [8, 9]. The upgraded BST covers the range of low x and of large W. Some of the important goals of heavy flavour measurements with the BST are:

- Measurement of the charm structure function [8] at low x, see fig. 8. This extends the measurement of the gluon distribution at low x [10] by 1-2 orders of magnitude towards low x where the charm contribution to F_2 is large. The constraints on xg from the F_2 scaling violations, F_L and this measurement will lead to a gluon distribution determined to a few per cent accuracy at low x. The BST extends the charm acceptance range and it permits to measure the DIS cross section up to largest y and x as described above.

- The BST acceptance covers well the charm production threshold $Q^2 \simeq m_c^2$ and precise measurements are necessary to clarify the QCD treatment of the heavy flavours near threshold.

- Measurement of the beauty structure function which represents a few % of the charm cross section. The measurement of F_2^b requires to enrich the beauty sample with vertex tagging for which the BST impact parameter resolutions are suitable.

- Heavy flavour physics and vector meson production both in DIS and photoproduction. The BST will permit to enlarge the acceptance to rare processes and to measure cross sections at large $W_{\gamma p}$. Some new channels as $J/\Psi \rightarrow \mu^+\mu^-$ will become accessible in this region for the first time.

- Study of charm correlations with double tagging. This will profit most from the extension of the kinematic range and improved acceptance by the BST. In particular it can make use of the momentum reconstruction of the slow pion which currently is used as a tag for associated charm production.

2.2.3 Multiple Scattering

The geometry of the H1 central tracker and the increase of multiple scattering at very large angles imply that only the BST part near to the CST will be directly useful for charm vertex tagging. The part close to the SPACAL is necessary for mass reconstruction in a maximum possible range. In the transverse plane multiple scattering leads to a scatter of the impact parameter of

$$\rho_{MS} = \frac{r_p/cm}{p_T/GeV} \cdot \sqrt{\sin\theta} \cdot \ 10\mu m \tag{1}$$

for a particle with transverse momentum p_T having traversed the beam pipe of radius r_p at a polar angle θ, here measured with respect to the lepton beam direction. This uses the material of the H1 beam pipe to be installed in 1998 which is made of 1 mm carbon fibre with 300 μm aluminium coating. For transverse momenta of the order of 0.5 GeV, as for K or π from charm decays, one obtains contributions from multiple scattering of about 30 μm. Thus the BST ϕ resolution and lever arm determine the measurement accuracy.

Similar formulae hold for vertex reconstruction in z. The BST measures the z vertex position, relatively to the beam axis, with an accuracy of

$$\Delta_{Si} = \frac{\sigma_r}{\sin\theta} \cdot \frac{L}{D} \tag{2}$$

where $\sigma_r \leq 20\mu$m is the radial measurement precision, θ the crossing polar angle, L the distance in the $r-z$ plane from the vertex to the silicon detector and D is the length the particle traversed in the BST. This gives a resolution, in very good agreement with

Monte Carlo simulations, of 800 μm at $\theta = 5^o$ improving to 400 μm at $\theta = 15^o$. With the same notations as in eq.1 one has for the amount of multiple scattering

$$\Delta_{MS} = \frac{r_p}{p_T} \cdot \frac{10\ \mu m}{(\sin\theta)^{3/2}}. \tag{3}$$

This dominates the $r - z$ vertex resolution at low angles. Δ_{MS} is about 3.5 mm at $\theta = 5^o$ but it rapidly decreases to 600 μm at $\theta = 15^o$. These numbers have to be compared with z decay lengths of 1 mm (D^o) and 3 mm (D^+).

2.3 Future Low x Physics

2.3.1 Precision Measurements

Even after the HERA running period with design luminosity the lower Q^2 programme will not be completed [7]. Two important examples, the measurement of F_L and heavy flavour physics, were discussed above. Many other semi-inclusive scattering processes like diffractive deep inelastic scattering or vector meson production require large statistics and precision for completion and really confronting theory with experiment [11].

One of the key tasks of HERA is the measurement of α_s using the scaling violations of F_2. This requires to measure the DIS cross section to a precision of a few per cent in the Q^2 region of the BST, to control the influence of F_L, and to reach maximum overlap at large x with the fixed target DIS data. This will be accomplished in H1 with precise hadron measurements (low noise LAr calorimeter readout) and by recouping the truly inclusive events at large x which leave a track only in the BST and deposit electromagnetic energy in the backward calorimeter. Without such a precision measurement of the DIS cross section, the α_s determination at HERA will be only of modest accuracy ($\simeq 0.005$) [12].

With ϕ detectors the BST will have a momentum resolution of $\delta p/p^2 \simeq 4\%$ and of 2.5% in the region of overlap with the CJC using the interaction vertex. This permits a precise calibration of the electromagnetic and the hadronic energy scales of the SPACAL calorimeter at low energies which is essential for structure function and final state physics.

2.3.2 Measurement of Electron-Deuteron Scattering Cross Sections

Acceleration of deuterons in the proton ring will be necessary to complete the structure function programme with unpolarized nucleons at HERA. It may lead to the discovery of non-linear effects expected at low x [13]. The measurement of the neutron structure function is necessary for precision tests of QCD [12]. It permits to disentangle the singlet and non-singlet part of F_2 with HERA data, it allows the quark distributions, like the difference of strange and charm quark distributions [14], to be accessed, and it will test the assumption of a flavour symmetric sea down to lowest x with an accuracy of a few % limited by shadowing corrections at low x. The precision requirements are as stringent as those for the ep case, and thus the BST resolution, vertex reconstruction, charge determination and background rejection capabilities are essential also for electron-deuteron scattering.

2.3.3 Polarized Protons in HERA

It is possible that in the future protons will be polarized in the HERA ring. This would open a new era in spin physics as for the first time polarized structure functions would be measured down to low x [15]. This would constrain sum-rules which today require extrapolations. The 'repetition' of the cross section measurement programme and in particular the small asymmetries to be measured require a high resolution backward tracking detector.

3 Technical Realization, Cost and Time Schedule

3.1 BST Configuration after 1999

Fig. 9 presents a view on the Backward Silicon Tracker with the left part of 4 planes close to the CST and the already existing part of 4 planes next to the repeater electronics. All detector planes will carry r strip and ϕ strip detectors in order to have a precise measurement of the transverse coordinates. It is likely that there will be an elliptic beam pipe replacing the present circular pipe. This requires modifications for 4 (16) sectors of the BST to adapt to that geometry, see below.

The detector hybrids are cooled with a water pipe circuit as drawn in the figure. The detector volume is flushed with cool Nitrogen transmitted through thin pipes between the detector wheels.

The detector part close to the SPACAL measures the lower Q^2 region of the BST. It is not covered by the trigger proportional chambers (CIP). Thus it will have four extra wheels carriing the BST silicon pad detectors for triggering on vertex pointing tracks and/or rejecting proton beam induced background.

The readout of the BST strip detectors was described in [4, 17]. Briefly it uses the APC-r/o chip [16], signal buffering and distribution on the repeater, converter cards for voltage supply and signal conditioning and RIO2 data aquisition modules with fast ADC and a download-programmable, power PC based processor for hit finding. The APC readout is steered by the programmable OnSiRoC II VME module [2]. This system was fully operational in 1997 and it will be extended to operate also the ϕ detectors. Thus no R and D work is required for the readout electronics. An exception is due to the repeater which requires modifications in order to read out the fully equipped system.

item	specification
general	single sided, single metal detector
size	wedge shaped, 4 inch, see Fig.10
thickness	280 ± 20 μm
strip array	1921 diode strips, every third read out
readout	AC coupled
biasing	punch through (chosen by prototype manufacturer)
resistivity	≥ 4 kΩcm
depletion voltage	< 50V, 90 V maximum
leakage current	2 nA per strip, < 4 μA total at 20% overdepletion
guard current	< 2 μA
failures	$< 2\%$

Table 1: *Specification of the BST ϕ strip silicon detector as used for the prototype fabrication.*

3.2 ϕ-Detectors

Detectors to measure p_T are proposed to be added to the existing detectors which have strips arranged concentrically around the beam axis to measure the polar angle θ. With the beam axis off center in H1 these strips will not be concentric. In the Technical Proposal a detector with strips at constant ϕ, of 1 mrad pitch, was considered and a prototype was tested at DESY [18]. Yet, the requirement of optimum resolution, due to the now considered low x heavy quark physics, enforced a modification of that design and foresees now strips parallel to one of the detector edges. This improves the momentum resolution by a factor of 1.8 as compared to the original design given in the Technical Proposal [1].

A prototype ϕ detector was designed at Zeuthen and MPI München (Fig. 10). The specifications of this detector are summarized in Table 1. A prototype series was delivered by CIS Erfurt in December 1997. Fig. 11 shows very encouraging results from static measurements of these prototypes. The guard currents are very small and the active area leakage currents are below 1 μA at depletion voltage level. The detectors are presently biased for a longer period to check the behaviour of the currents with time. The long strips have a measured capacitance of 2.5 pF at depletion voltage. One thus anticipates that the S/N is only weakly dependent on the strip length due to the dominance of the constant term in the ENC of the APC [16].

The hybrid for these detectors is a mirror version of the r-strip detector hybrid since the detectors are mounted back-to-back. This hybrid has been designed and prototypes will be delivered in February 1998. It is planned that one sector of the 4 planes close to the CST will be equipped with ϕ-detectors using these hybrids when the BST will be installed in H1 in April 1998.

3.3 BST with Elliptical Beam Pipe

The upgrade of the HERA luminosity leads to modifications of the inner region of the H1 detector [7]. In the present version the BST will surround an approximately elliptic beam pipe, concentric with the BST, and with a beam line offset of 1.5 cm towards the inner side of the accelerator in order to have a safe space of 7 cm for the synchrotron radiation fan. Protype studies are under way to fabricate a pipe as thin as the one which will be installed for the 1998 run of the H1 detector. This requires to modify two ϕ sectors of the BST on both sides, see Figure 12. In order to maintain the full 2π acceptance it is proposed to install detectors which are identical to the ϕ detectors apart from their radial excursion. The shorter version of these detectors can be built with minor modifications of the wafer masks and thus at minimum extra effort. The presently existing carbon fibre support structure can be used with some modifications necessary to avoid touching the beam pipe and to carry an elliptic inner shield. The cooling circuits can be used, also the outer detector shielding and the installation tools.

3.4 Cost and Time Schedule

The ϕ-detectors were foreseen in the original BST design and thus fit into the existing detector with the exception of the modifications of the repeater and those connected with the elliptic beam pipe which requires changes for 4 out of 16 sectors of the detector. The time schedule is largely determined by the wafer delivery. Due to the complexity of the BST a detector access time of at least a month will be necessary to complement the BST with new detectors. The BST installation schedule depends thus also on the HERA shutdown schedule. If the wafer order and delivery proceed as expected in the time schedule given in table 3 then most of the modules will be ready for installation in 1999/2000. In this scenario the installation of the full detector in the extended luminosity upgrade shutdown, scheduled now for 2000/2001, does not pose a time problem.

The upgraded detector can be built by the present BST group, i.e. DESY-Zeuthen and the Academy of Sciences Prague, with help from RAL for the integration of the new detectors into the CDAQ. The ϕ-wafer mask design was carried out and the detector production will be followed by the Semiconductor Lab of MPI München. The required APC production will be monitored by PSI Villigen.

We thus request the funding in Table 2 for the BST ϕ detectors from DESY in order to complete the BST as described above.

item	price per piece/ kDM	number	sum/ kDM
ϕ detectors	1.4	96 and spares	150
ϕ detectors (short)	1.4	64 and spares	120
hybrids	0.4	128	50
APCs	-	800	30
PowerPC's	8	8	65
converter cards	3	8	25
repeater			15
cables			20
mechanics modifications			10
total cost			485

Table 2: *Cost for upgrading 8 planes of the BST detector with ϕ detectors. The cost for the wafers is an estimate based on information by CIS Erfurt and the limited complexity of the wafer design. The prototype cost of about 30 kDM is not included in the sum. It was shared by MPI München and DESY-Zeuthen. The design requires two versions of the ϕ detector with different radial length because of the elliptic beam pipe. The spending profile, roughly, requires 150kDM in 1998, 300kDM in 1999 and 50kDM in 2000, depending mainly on when the wafers will be delivered, see Table 3.*

item	time of production	test	installation
ϕ detector prototype	fall 1997	I/98	II/98
hybrids	1998	1998	2000
wafers	IV/98 - II/99	1999	2000

Table 3: *Time schedule for upgrading the BST with ϕ detectors. Installation can start early 2000 assuming the wafers can be ordered mid 1998 and the HERA shutdown schedule permits access to the BST.*

References

[1] H1 Collaboration, “Technical Proposal to build Silicon Trackers for H1”, PRC 92/01 (1992).

[2] J. Bürger et al., “Online Readout and Control Unit for Silicon Tracking Detectors”, NIM **A386**(1997)269.

[3] W. Eick et al., H1 BST Group, “Development of the H1 Backward Silicon Strip Detector”, NIM **A386**(1997)81.

[4] H1 Collaboration, “Upgrade of the H1 Backward Silicon Tracker”, PRC 96/02 (1996), Addendum 1 to the Technical Proposal.

[5] L.A.T. Bauerdick, A.A. Glazov and M. Klein, “Future Measurement of the Longitudinal Structure Function at HERA” in ”Future Physics at HERA”, proceedings of the workshop 1995-6, Vol.1, p.77, eds. G. Ingelmann, A. DeRoeck and R. Klanner, DESY 1996, http:/www.desy.de/heraws96.

[6] H1 Collaboration, “A Measurement of the Inclusive Deep Inelastic ep Scattering Cross Section at Low Q^2 at HERA”, paper 260, submitted to the International Europhysics Conference on High Energy Physics, Jerusalem, Israel, 1997, http://www-h1.desy.de/h1/www/psfiles/confpap/jerusalem97/list.html.

[7] H1 Collaboration, “ep Physics Beyond 1999”, paper submitted to the H1 funding agencies, H1-10/97-531, October 1997.

[8] K. Daum, “Open Heavy Flavour Production in Deeply Inelastic ep Scattering at HERA”, in proceedings of the International Workshop “New Trends in HERA Physics”, Ringberg, May 1997.

[9] Reports of the Working Group “Heavy Quark Production and Decay”, in ”Future Physics at HERA”, proceedings of the workshop 1995-6, Vol.1, p.343-496, eds. G. Ingelmann, A. DeRoeck and R. Klanner, DESY 1996, http:/www.desy.de/heraws96.

[10] H1 Collaboration, C. Adloff et al., Z.Phys.**C72** (1996)593;
“Determination of the Gluon Density in the Proton from Deep Inelastic Charm Production using NLO QCD”, paper 275 submitted to the International Europhysics Conference on High Energy Physics, Jerusalem, Israel, 1997,
http://www-h1.desy.de/h1/www/psfiles/confpap/jerusalem97/list.html.

[11] Reports of the Working Group “Diffractive Hard Scattering”, in “Future Physics at HERA”, proceedings of the workshop 1995-6, Vol.2, p.633-756, eds. G. Ingelmann, A. DeRoeck and R. Klanner, DESY 1996, http:/www.desy.de/heraws96.

[12] M. Botje, M. Klein and C. Pascaud, “Future Precision Measurements of $F_2(x, Q^2)$, $\alpha_s(Q^2)$ and $xg(x, Q^2)$ at HERA”, in “Future Physics at HERA”, proceedings of the workshop 1995-6, Vol.1, p.33, eds. G. Ingelmann, A. DeRoeck and R. Klanner, DESY 1996, http:/www.desy.de/heraws96.

[13] Reports of the Working Group “Light and Heavy Nuclei at HERA”, in ”Future Physics at HERA”, proceedings of the workshop 1995-6, Vol.2, p.883-1092, eds. G. Ingelmann, A. DeRoeck and R. Klanner, DESY 1996, http:/www.desy.de/heraws96

[14] J. Blümlein et al., “Structure Functions, Quark Distributions and Λ_{QCD} at HERA”, in ”“Future Physics at HERA”, proceedings of the workshop 1987, Vol.1, p.67, ed. R. Peccei, DESY 1988.

[15] Proceedings of the Workshops on the Prospects of Spin Physics at HERA, Zeuthen, DESY-95-200 (1995), ed. by J. Blümlein and W.-D. Nowak and DESY-97-200 (1997), ed. by J. Blümlein et al.

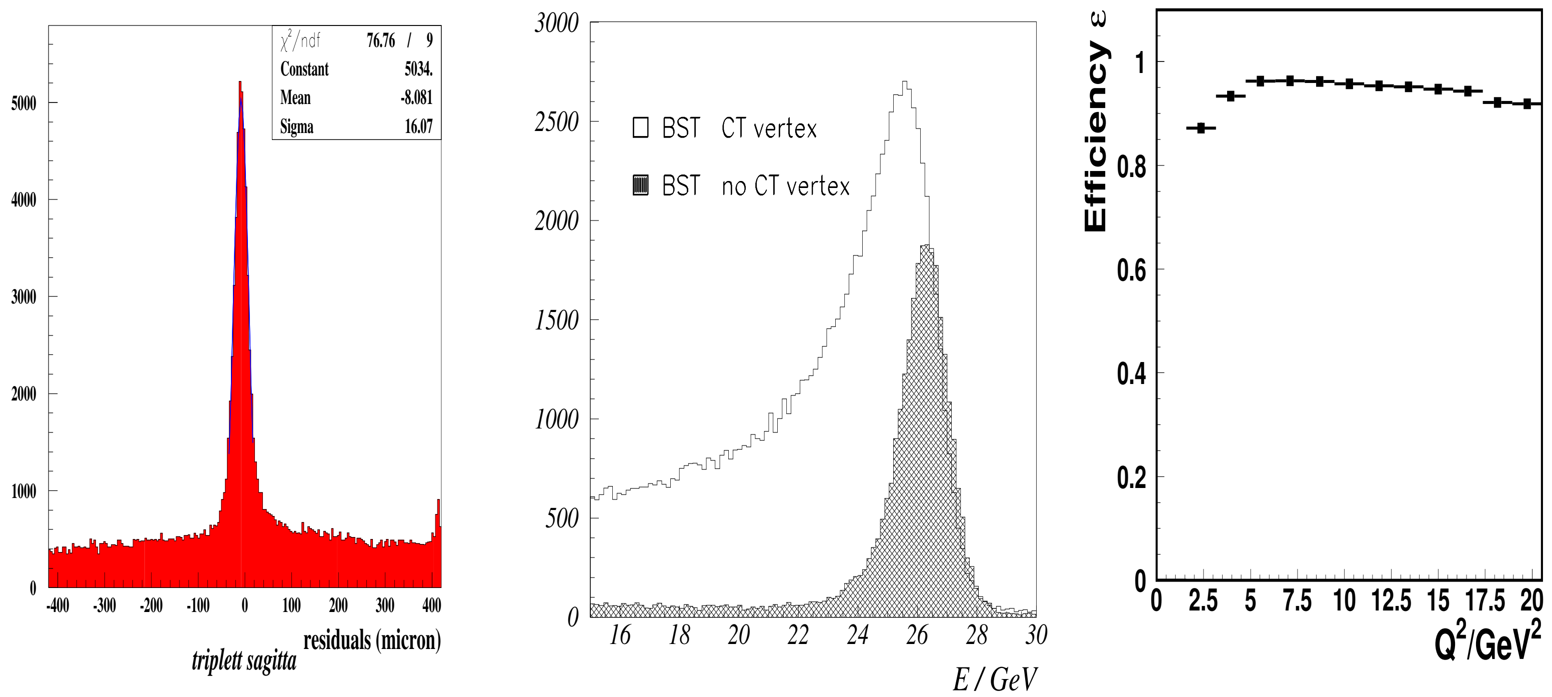
[16] R. Horisberger and D. Pitzl, NIM **A326**(1993)92.

[17] W.J. Haynes et al., “The H1 silicon tracker data acquisition system”, Nucl. Instr. and Methods **A403** (1998)313;
W.J. Haynes, ”Silicon Tracker Data Acquisition”, RAL-P-97-002, May 1997, Proc. Sixth LeCroy Int. Conf. Electronics for Particle Physics, Chestnut Ridge, New York, 28-29 May 1997, pp 25-42.

[18] M. Schreckenberg, Diploma Thesis, Hamburg Universität, 1996.

[19] M. Glück, E. Reya and A. Vogt, Z.f.Phys. C**67**(1995)433.
A. Vogt, Proc. Workshop on DIS and QCD, Paris (1995) 261.

[20] A.D. Martin, R.G. Roberts and W.J. Stirling, Phys. Rev. D**50**, 6734 (1994).



(a) (b) (c)

Figure 1: Distributions characterizing the 1997 BST performance. a) The sagitta distribution determines the resolution of the BST r-strip detectors to be 16 μm. b) SPACAL energy distribution for DIS candidate events with a track reconstructed in the BST for L=4.3 pb^{-1}. Open: events with an interaction vertex reconstructed using the central drift chambers. Hatched: events without a central tracker vertex, i.e. with a single track measured in the BST pointing to the SPACAL cluster of energy E. The low energy tail of the 'BST no CT vertex' distribution is due to radiation. c) Efficiency vs Q^2 of finding a DIS electron track in the BST as determined from events with $E' > 15$ GeV, compare Figure 4.

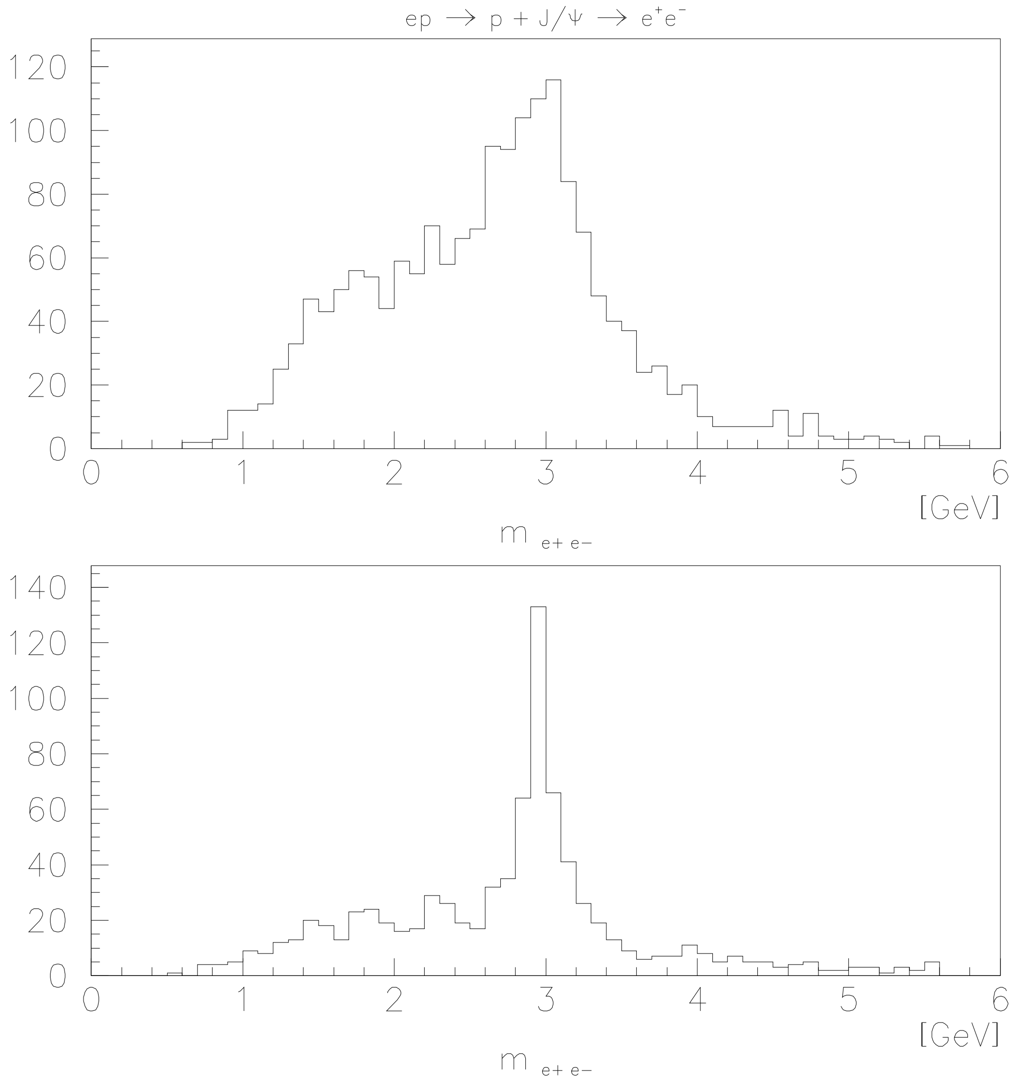


Figure 2: Preliminary observed signal of elastic J/Ψ photoproduction at large $W \simeq 250$ GeV. Top: Invariant mass of two SPACAL clusters with one electron in the acceptance range of the BST. The mass is calculated using the cluster energies and θ is obtained from the BDC and the default vertex position. Bottom: Same as top but the vertex is defined by the BST and also θ. The track signature requirement in the BST removes a large part of the QED Compton background.

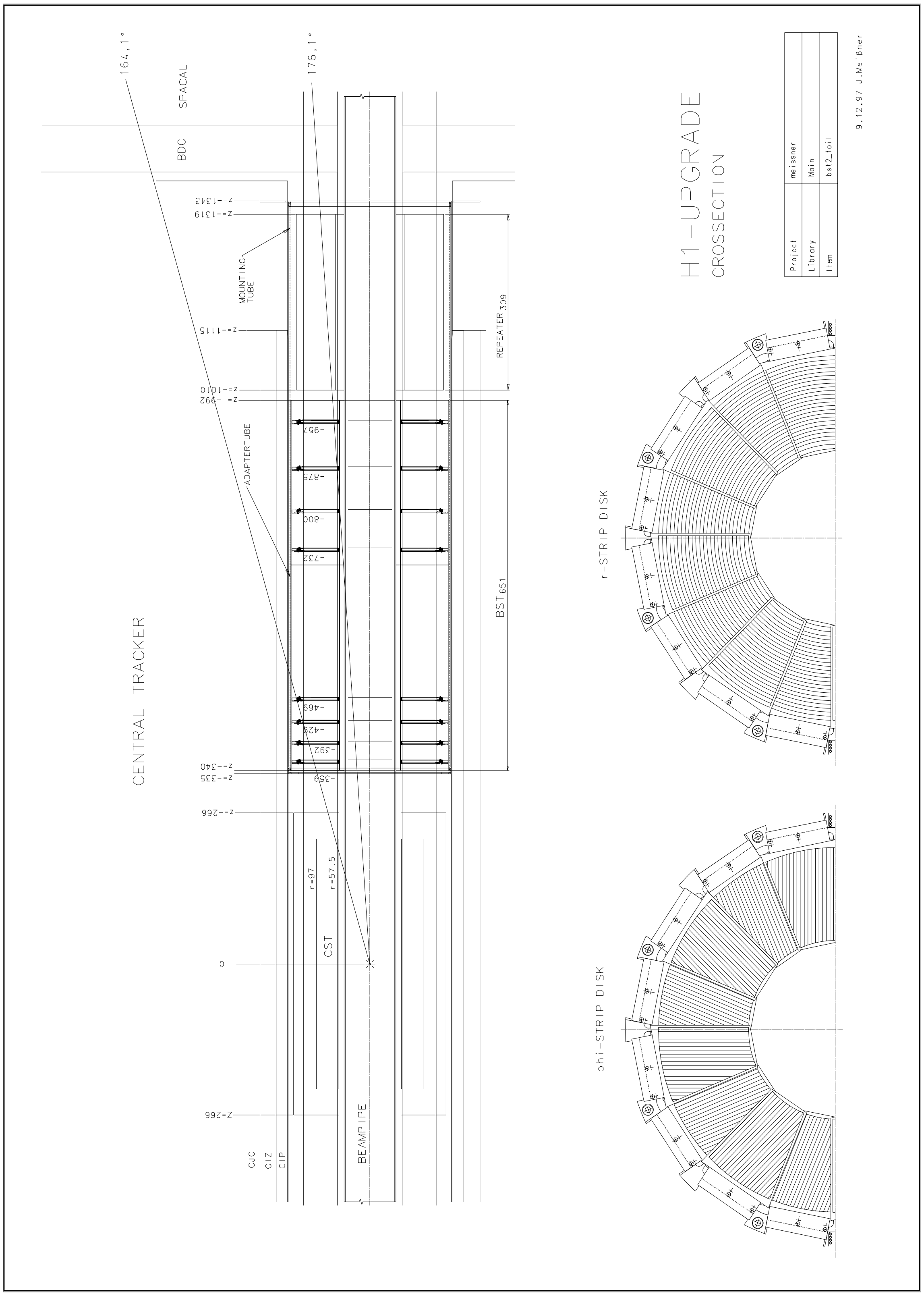


Figure 3: Side view of the H1 Backward Silicon Tracker.

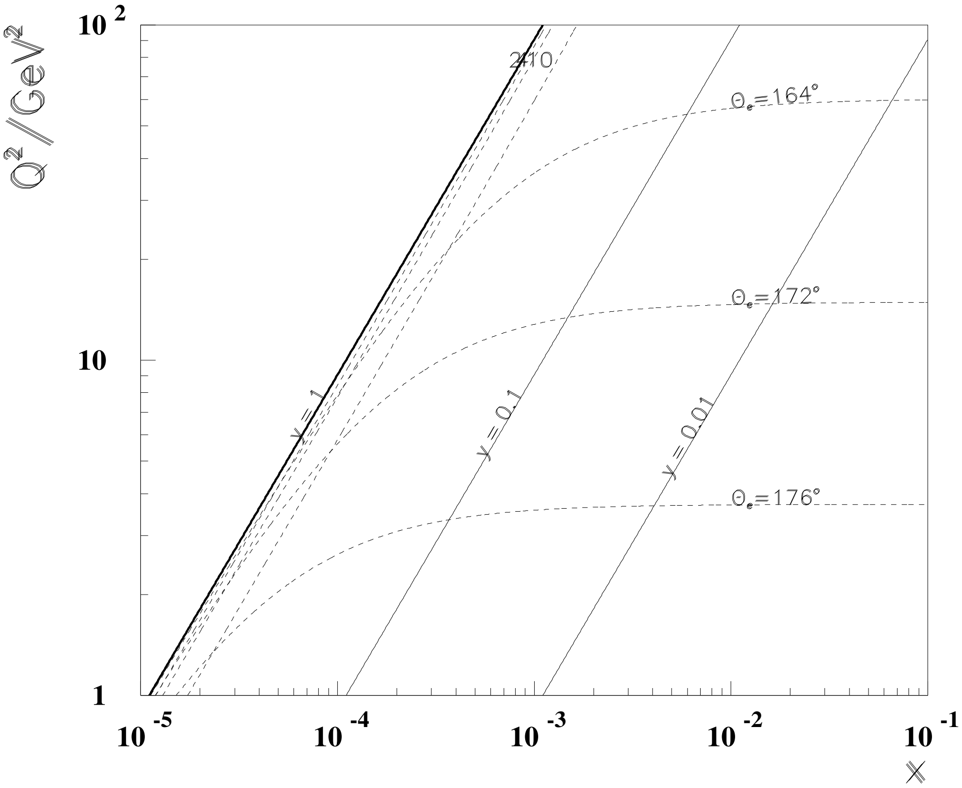


Figure 4: DIS kinematics and polar angle range covered by the BST, compare Figure 3. The BST acesses the lower Q^2 region in the kinematic plane. The ϕ detectors will permit to access the region of very low scattered electron energies or high y with the goal of precision measurements of the longitudinal structure function F_L. At high x the vertex is reconstructed also for those events which leave no track in the central detector (see Fig.1b). This extends the acceptance of structure function measurements towards the region covered by fixed target experiments.

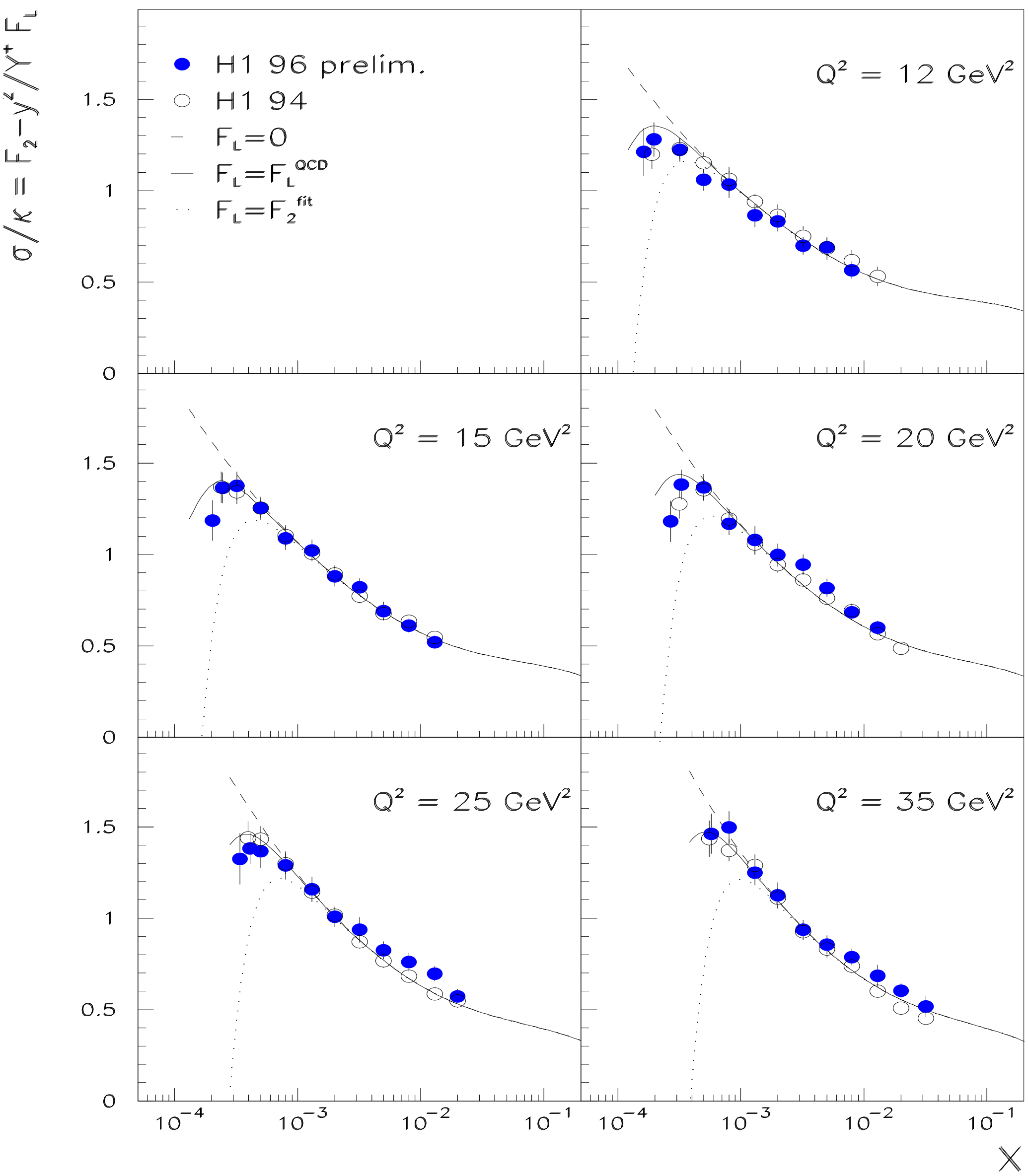


Figure 5: Measurement of the DIS cross section divided by the kinematic factor $\kappa = (2\pi\alpha^2 \cdot Y_+)/(Q^4 x)$. Closed points: preliminary data presented to the 1997 EPS Conference. Open points: H1 data from the 1994 run. The curves use QCD calculations of F_2 and of F_L (closed curve) or the extreme assumptions $F_L = F_2$ (dotted curve) and $F_L = 0$ (dashed curve). The largest central y values are 0.82. For $Q^2 \geq 35$ GeV^2 this y range is outside the SPACAL acceptance. With the BST ϕ detectors this measurement will be extended down to $Q^2 \simeq 1$ GeV^2 and to $y \simeq 0.9$.

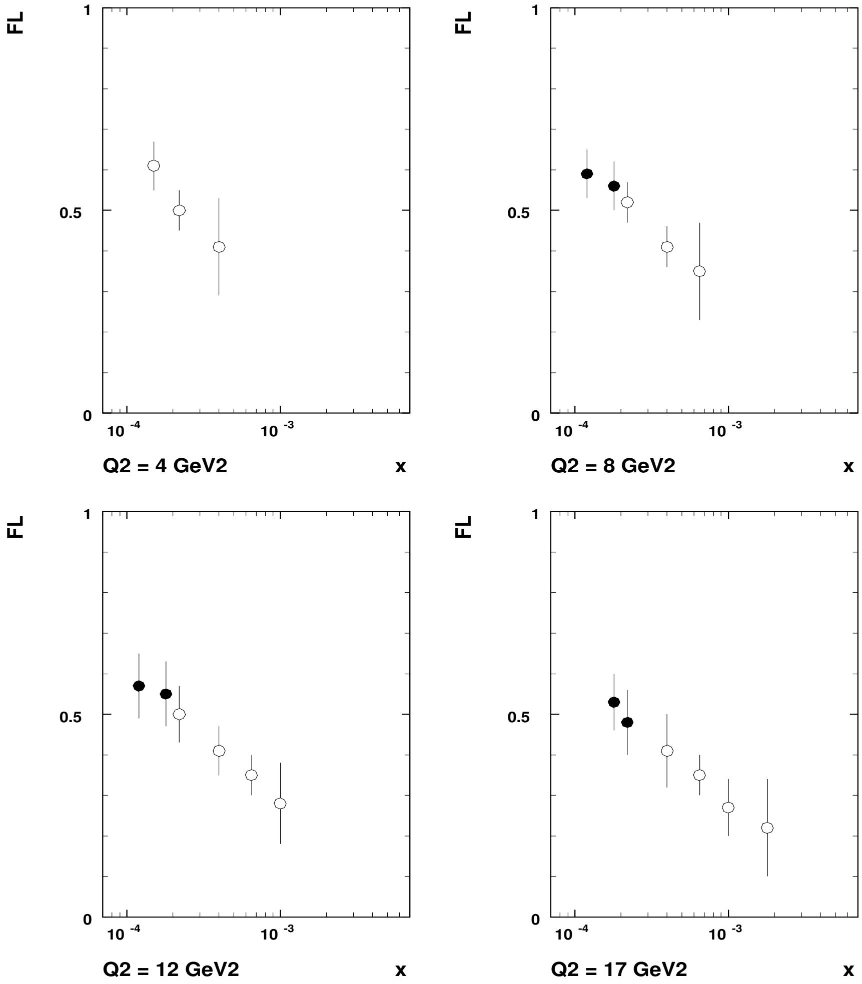


Figure 6: Estimated total accuracy of a future measurement of the longitudinal structure function $F_L(x, Q^2)$ simulating data for an electron beam energy of 27.5 GeV and proton beam energies of 250, 350, 450 and 820 GeV with luminosities of 10 pb^{-1} per beam energy setting (open points). The closed points at lowest x represent the result of a simulation study using the method to determine F_L after subtraction of F_2. These points are based on the highest energy data set. The minimum energy in this analysis was assumed to be 5 GeV [5]. Note that the H1 Jerusalem data reached 4 GeV [6], and with 'charge subtraction' it is feasible to go as low as 2-3 GeV, i.e. up to $y \simeq 0.9$ instead of 0.8. In this region the sensitivity to F_L gets greatly enhanced as can be seen in Fig. 5 which implies a further possible error reduction.

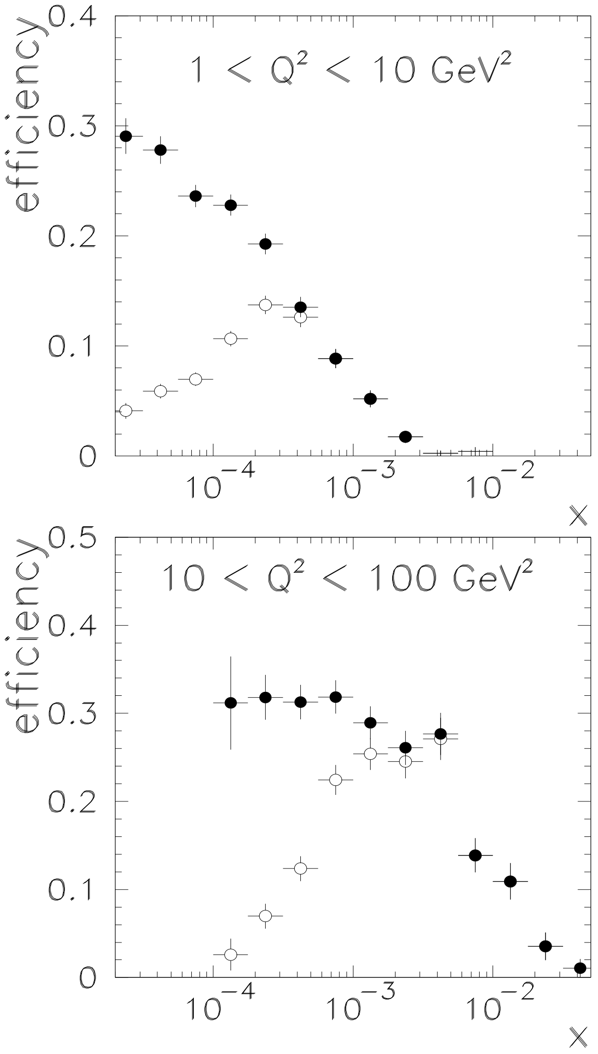


Figure 7: Acceptance for charm events ($ep \rightarrow D^*X \rightarrow D^o\pi_sX \rightarrow K\pi\pi_s + X$) using the central drift chambers and the CST (open points) and adding the BST (closed points). The acceptance gain at low x is substantial.

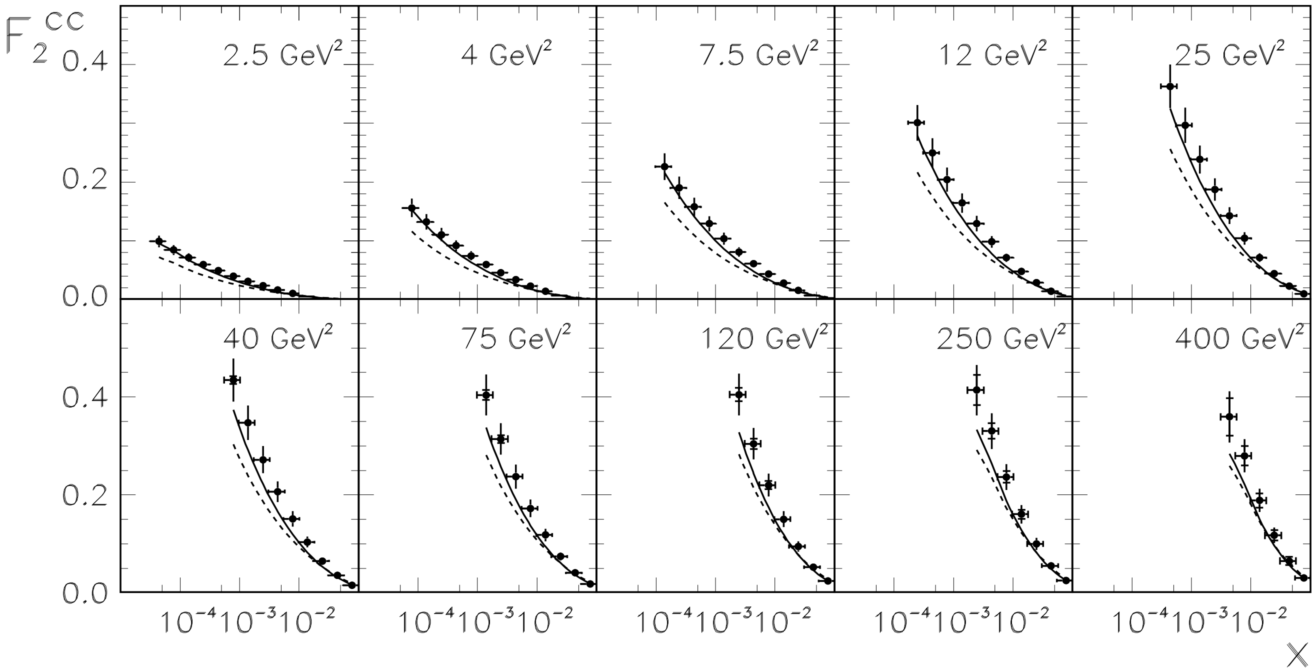


Figure 8: Simulated measurement of the charm structure function [8] with full errors and statistical errors (inner bars) for 200 pb^{-1}. The points are placed according to the gluon distribution as obtained from the H1 QCD analysis of the F_2 scaling violations. The solid curve used the GRV [19] and the dashed curve the MRSH [20] gluon in order to illustrate the sensitivity of the measurement anticipated.

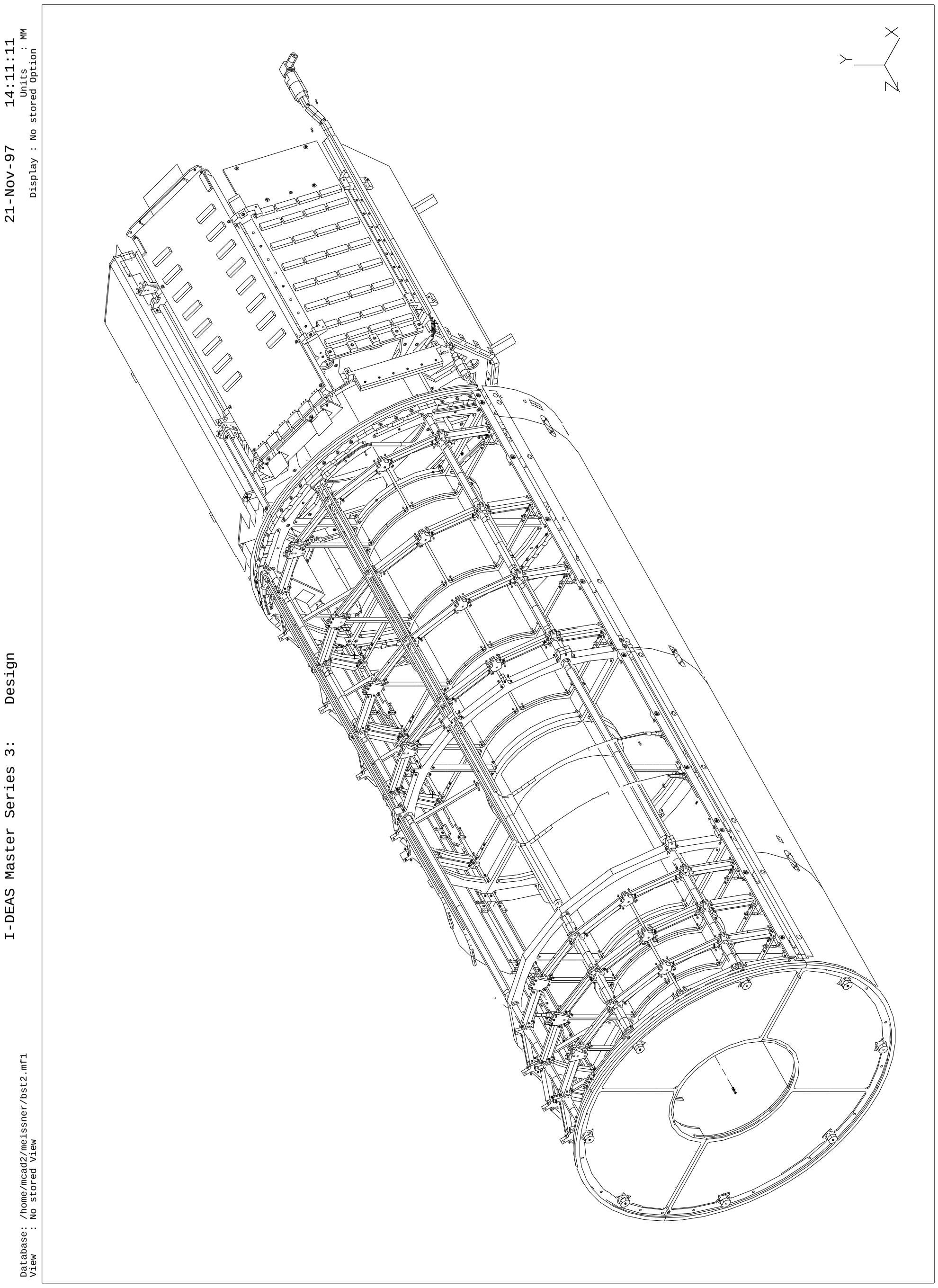


Figure 9: The H1 Backward Silicon Tracker.

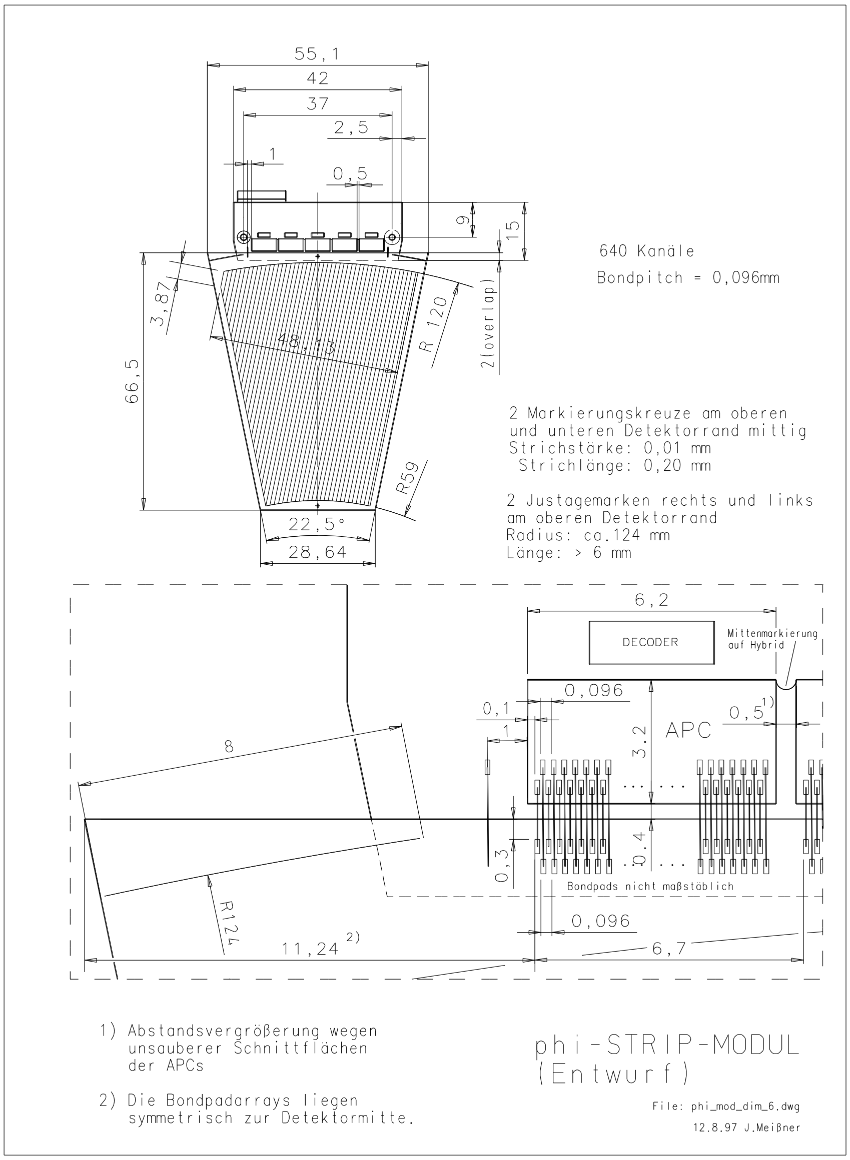


Figure 10: Prototype design for ϕ detector to be installed in 1998. The detector has 640 strips readout and two field shaping strips in between. The design for the shorter version of this detector is identical apart from modifying the radial dimension of 66.5 mm to a smaller value to be defined when the beam pipe dimensions are finally fixed.

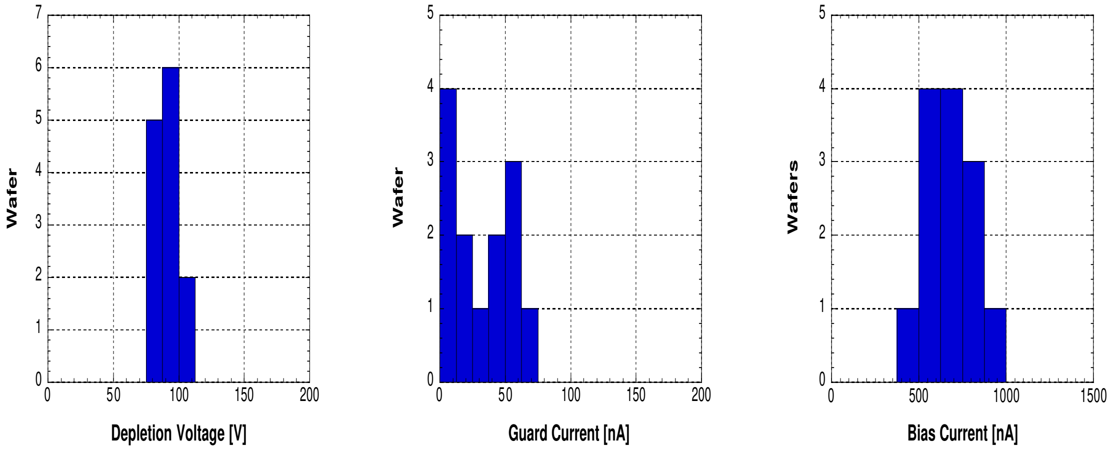


Figure 11: Measurement results of the prototype ϕ detectors as delivered end of December 1997. The histograms display the depletion voltages, obtained from C-V curves, the guard currents and the active area leakage (or bias) currents of 15 prototype detectors measured upon arrival at Zeuthen.

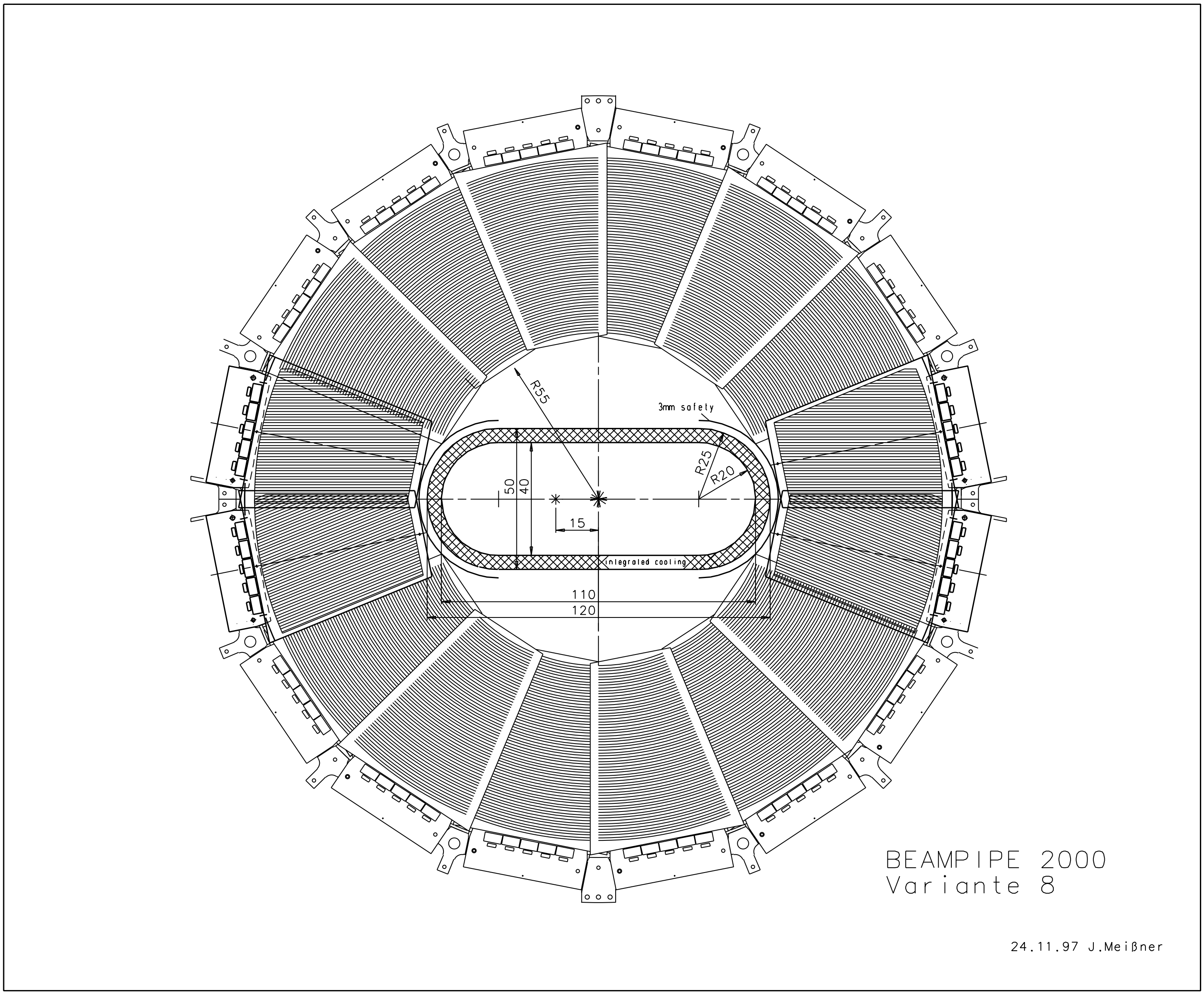


Figure 12: Arrangement of wafers around an elliptical beam pipe. The sectors nearest to the opening of the BST will have to be modified since the present r-strip detectors are too long in radius. These will be replaced by ϕ-detectors as drawn. The beam pipe design is not yet finalized.