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Treatment of the Proton Satellite Bunches in 1994 Data

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Abstract

The effect of the proton satellite bunches at HERA is investigated using data taken with H1 detector in 1994. The value of the luminosity correction for the standard H1 data analyses is determined with a precision of 9%, which corresponds in average to $\sim 0.45\%$ absolute contribution to the overall systematic error of the luminosity measurement in 1994. The integrated luminosity for ep-collisions from early p-satellite, used for the low x, low Q^2 DIS analysis, is determined with a precision of 7.1%. A utility routine is described, which provides the fraction of the total integrated luminosity, originating from a given z-range within the H1 Interaction Region of HERA.

1 Introduction

HERA – a unique ep collider – is a large multi-accelerator complex. Before the protons and electrons (or positrons) are brought into collisions, they have to pass a long injecting and preaccelerating chain. One of the important operations on that way is a bunch length compression, which is necessary to decrease a longitudinal size of the proton bunches to its design value of $\sigma_z \approx 11$ cm [1]. The technique used for that purpose works successfully and in general performs the required transformation. However, as a side effect some – typically small – fraction of the proton current escapes from the main bunches and forms parasitic satellites, separated by $\tau_{\rm sat}$ = 19.2 ns (from the 52 MHz RF system) and 4.8 ns (from the 208 MHz RF system). A major upgrade of the RF systems is necessary to get rid of this parasitic effect completely. Therefore, the experiments must presently take this as a matter of fact and operate in a complicated bunch structure environment. As a consequence, the integrated luminosity, $\mathcal{L}$ should be corrected to account for the satellite bunches effect.

The H1 luminosity system is equally sensitive to all bremsstrahlung events, used to measure the luminosity in the H1 Interaction Point (IP), which occur in a straight section of ± 5.8 m around the IP [2, 3]. On the other hand, only a limited region in the longitudinal z coordinate is used for the physics analysis. Typical fiducial cuts on the event vertex coordinate used in H1 are the following:

$-50\text{cm} < z < 50\text{cm}$ ($z > -100$ cm for `BSET` triggers) at L4 level [4],

± 30 cm around the nominal IP in the analysis stage.

The ep events from the closest satellites appear in the detector at

$$z_{\rm sat} - z_{IP} = c\tau_{\rm sat}/2 = \pm 72 \text{ cm}$$

and are usually cut off together with more distant satellite events and even with ep events from the tails of the main proton bunches. Thus, the luminosity originating from all satellites is not used in a standard analysis, and the corresponding correction to the total integrated luminosity must be made.

Although proton satellites cannot be eliminated completely at the present stage, they typically contribute only a few per cent to the total ep luminosity. Therefore, the relative precision required for the luminosity correction is of the order 10–20%. This allows to keep a contribution to the overall systematic error in $\mathcal{L}$ below 1% from the satellite bunch effect. The procedure described in the present note allows to achieve even better precision, and thus to use the 'forward satellite events' for physics analysis, in particular for F_2 measurement at low x and low Q^2.

2 Method

Different methods can be used in order to estimate the fraction of the total integrated luminosity originating from the satellite bunches. They belong to one of the following two categories:

1. The fraction of the proton current I_p in satellites is measured, and $\mathcal{L}_{\rm sat}$ is calculated using the theoretically expected $\mathcal{L}_{\rm sp}(z)$ value,

$$\mathcal{L}_{\rm sat} = \mathcal{L}_{\rm sp}(z_{\rm sat}) \cdot \sum (I_e I_p^{\rm sat}) \tag{1}$$

   where the sum is taken over all pairs of colliding bunches.

2. The fraction of any well defined class of ep events originating from the collisions of e bunches with p satellite bunches, is directly measured by analysing event z_{vx} distribution of the selected class of events.

First approach is based on the knowledge of the specific luminosity as a function of z which, for the head-on collisions of the beams having a gaussian spatial shape (being a very good approximation for HERA), can be written as

$$\mathcal{L}_{\rm sp}(z) = \left[2\pi e^2 f_H \sigma_x(z)\, \sigma_y(z)\right]^{-1} = \frac{13.1 \times 10^{25}}{\sigma_x(z)\, \sigma_y(z)} \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{mA}^{-2}, \tag{2}$$

where e is the electron charge and $f_H = 1/(220{\cdot}96\mathrm{ns}) \approx 47.35\,\mathrm{kHz}$ is HERA revolution frequency. The transverse beam sizes are defined by the optical parameters: the emittance ϵ and the beta function at IP β^*, and by the distance z from the IP:

$$\sigma_x(z) = \sqrt{\epsilon_{x,e}(\beta^*_{x,e} + z^2/\beta^*_{x,e}) + \epsilon_{x,p}(\beta^*_{x,p} + z^2/\beta^*_{x,p})},$$

$$\sigma_y(z) = \sqrt{\epsilon_{y,e}(\beta^*_{y,e} + z^2/\beta^*_{y,e}) + \epsilon_{y,p}(\beta^*_{y,p} + z^2/\beta^*_{y,p})}. \tag{3}$$

Typical z-dependencies of the specific luminosity, normalized to that at the nominal IP, are illustrated by Fig.1.

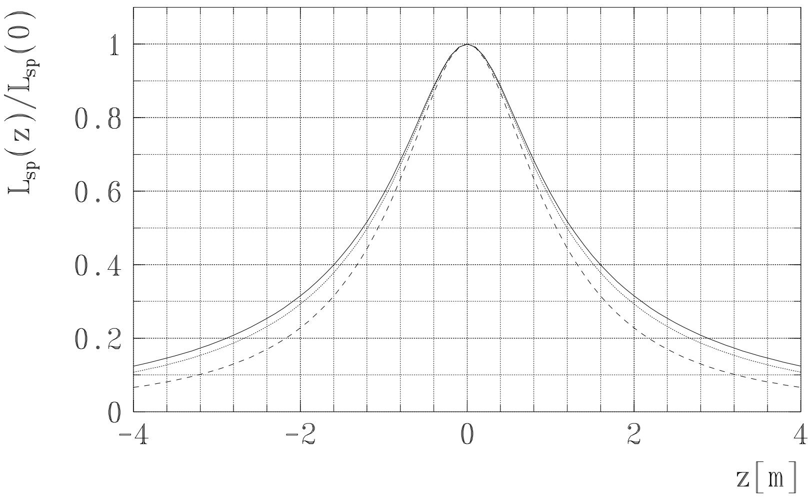

Figure 1: A normalized specific luminosity as a function of the distance from the nominal IP for different beam optics, used in 1994. Dashed curve illustrates the situation of a small crossing angle between e and p beams according to a maximal measured tilt of the e beam (~ 0.2 mrad).

Both approaches have their advantages and drawbacks. In the first approach the precision is limited by the knowledge on the real optics, being especially critical for the distant satellites (see the spread of the curves in Fig.1). More important, however, is to get a reliable estimate of the proton current structure. The latter could be provided, for instance, by a pick-up device with sufficient sencitivity (of the order of 1 μA) and time resolution ($\sim$ 1 ns). In 1994 the forward ToF data [5] were used as a best available source of the proton bunch structure information. So-called FToF 'qvt' plots are produced from the detector signals, proportional to the number of charged secondaries originating from p-gas or p-wall interactions and hitting FToF scintillators. In the absence of p-wall background contribution, the FToF responce would indeed be proportional to the proton current. However, since the behaviour of the tails in the main proton bunches and the satellites are in general different ($\sigma_p = \sigma_p(z)$), they produce different amount of secondary particles per unit of current (from beam-wall interactions) which contribute to the FToF signals. Therefore, one expects that the number of entries in the 'qvt' plots is proportional to something more complicated than I_p, like

$$N_{tof} \sim I_p \cdot (1 + \alpha\sigma_p) \tag{4}$$

with *a priori* unknown proportion α of the beam-wall contribution.

A major problem in the second approach is related to the difficulty of identical event sample selections for the main and satellite bunches. If for example DIS events are used to estimate a fraction of the luminosity originating from the satellites, one has to ensure the same range of Q^2 for both samples (to have equal cross sections). On the other hand, scattered electrons(positrons) from ep collisions with the same Q^2 (or the same scattering angle θ_e), but different z-vertex positions, enter different areas of the H1 apparatus, thus leading to different systematics (trigger efficiency, calibration, background contamination etc.). In addition, only a limited part of the 'satellite' events is 'seen' by the tracking system, survive early L1–L4 cuts and can be used in the analysis by this method. Finally, to estimate precisely the efficiency of the event vertex reconstruction as a function of z in a wide z-range is also a non-trivial task.

All this resulted in a combined approach used in present analysis. In short, the following procedure was adopted.

- We used a second method (based on low Q^2 DIS events) to define an integrated luminosity only for the forward (early) satellite events. In doing so, the events from a shifted vertex data were exploited for the normalization, since they appear in the detector approximately at the same z coordinates as the forward satellite events from the nominal ep-collisions:

$$\mathcal{L}_{\rm fw.sat} = \mathcal{L}_{\rm z-sh} \cdot N_{\rm fw.sat}/N_{\rm z-sh}. \tag{5}$$

  To select low Q^2 DIS events ($N_{\rm fw.sat}$ and $N_{\rm z-sh}$) the identical criteria were used. It is evident, that detector effects (vertex finding efficiency, calibration etc.) are practically the same in both samples.

- Based on the fact that the optics is in a good approximation symmetric in z around IP, the ratio $R_{\rm tof}$ between FToF signals from forward and backward p-satellites allowed to compute their relative luminosities. Thus,

$$\mathcal{L}_{\rm sat} = \mathcal{L}_{\rm fw.sat} \cdot (1 + R_{\rm tof}). \tag{6}$$

- For the final $\mathcal{L}(z)$ function, an additional correction for the (small) luminosity tail from distant satellites were made, using equation (1) and assumption (4). The value of the unknown parameter α in (4) was obtained by comparing the FToF peaks from the main proton bunches and their closest satellites. Since α is in general also z-dependent, an error was conservatively determined by varying α between 0 (pure p-gas contribution to the FToF response) and ∞ (pure p-wall contribution). Although the relative precision of this last correction was estimated to be only 20%–50%, its absolute contribution to the overall luminosity error from the p-satellite effect is very small.

3 Analysis

The procedure described in section 2 was applied separately for each sub-sample of the 1994 data. All three main data samples of 1994 were included in the analysis: e^-p and e^+p events collected at the nominal IP position and e^+p data at the shifted IP. They were further subdivided into smaller sub-samples, if any of the critical parameters – such as the average z position of the ep event vertecies, or the relative size of the satellites seen by FToF – changed significantly. In total 14 different run periods have been defined and analysed.

3.1 FToF Data Analysis

The forward ToF data are packed into the `BRTQ` banks [6] and stored together with other non-event data in a special `'KEEP'` event files (`HERA03.H1TCL.C94xxxxx`). Approximately 70% of all 1994 luminosity runs (and practically all proton fills) have statistically significant FToF information and were used in this analysis.

Two typical examples of accumulated FToF 'qvt' spectra are presented on Fig. 2. Only a half of the time interval between the HERA bunches is shown, although a complete information is available in 'qvt' plots. Time along the t-axis represents an internal FToF timing centered around main proton bunches.

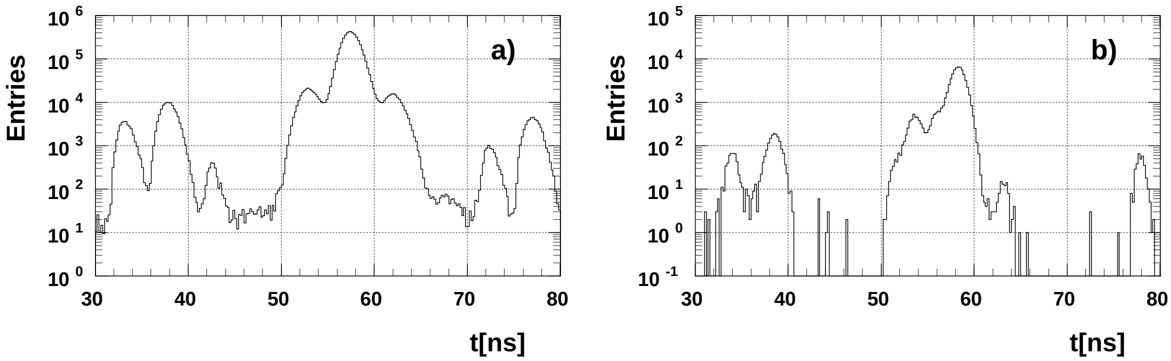

Figure 2: FToF spectra accumulated in e^+p collisions: (a) with a nominal position of the IP, (b) with the IP shifted by $\sim$ 65cm in $+z$ direction.

In order to estimate the ratio R_{tof} between the backward (+4.8 ns) and forward (−4.8 ns) satellites, to be used in the relation (6), the central parts of the FToF spectra for each lumi run were fitted by a superposition of 3 gaussians and a simple constant background. Some fit results are shown on Fig. 3. The change in the position of the proton bunches from ~ 73 ns to ~ 60 ns in the middle of the e^-p running (Lumi run ≈ 450) is purely internal FToF technical thing and, evidently, is not important for the analysis. The distances between the satellites and the main proton bunches were found to be in rough agreement with the naive expectations (see Introduction), but are systematically smaller by $\sim 8\%$. We did not try to study this fact deeper, since it is irrelevant for the purpose of the present analysis.

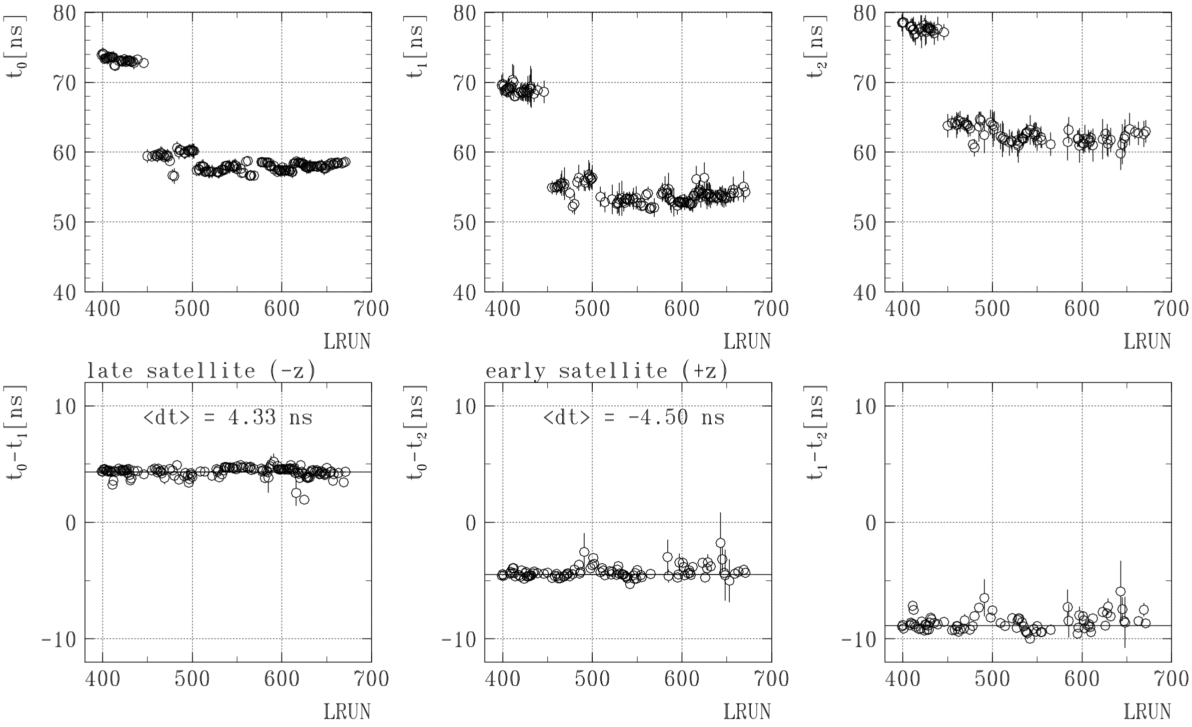

Figure 3: Fitted parameters of the main proton bunch and the closest early and late satellites. The uppper plots show the average positions of the main peak and the closest satellites. The distances between the peaks are shown on the bottom plots.

The obtained ratio $R_{tof} = N_+/N_-$ is shown on Fig. 4 as a function of the luminosity run number. Here N_+ and N_- denote number of entries in the FToF spectra for the late and early satellite peaks respectively. A large spread for the values of R_{tof} demonstrates, that the proton bunch configuration was in general not reproducable. In average, $<R_{tof}> = 0.876 \pm 0.048$ was obtained for 1994 running conditions. One can see however, that after the end of August'94 (Lumi Run ≈ 550) when a special measures were requested to be taken by HERA crew to suppress the most dangerous from the p-background point of view 'backward' satellites, the ratio – with one exception – was kept at a low level, of about 0.3.

Finally, in order to obtain the R_{tof} values for different run ranges, the individual ratios were weighted with H1 gated luminosities: $<R> = \sum(\mathcal{L}_i R_i)/\sum \mathcal{L}_i$.

The systematic uncertainty in the determination of R_{tof} value was estimated from the avail-

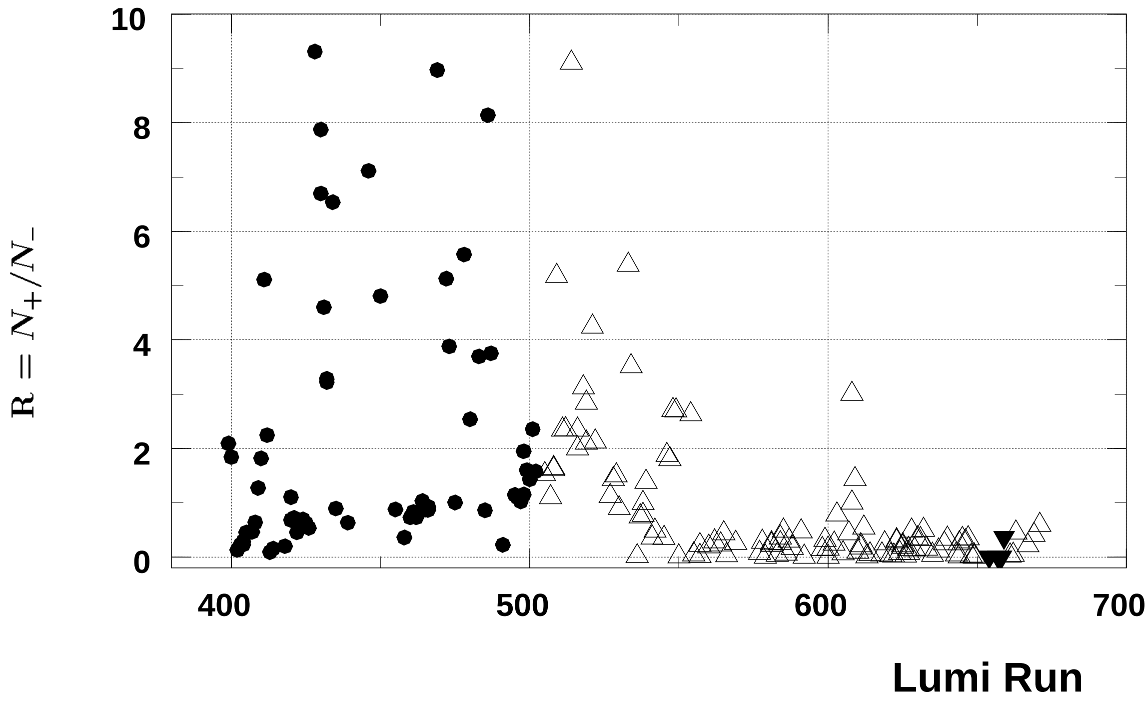

Figure 4: Ratio of the events originating from the late and early satellites, determined from FToF data for different Lumi runs. Circles – e^-p data, open triangles – e^+p data, filled triangles – shifted IP data.

able statistics in the FToF spectra and by varying the fitting procedure and counting the number of entries under the corresponding FToF peaks. In average, the systematic error is $\delta R_{tof} = 5.5\%$.

3.2 Analysis of the z-vertex Distributions

Low Q^2 deep inelastic scattering events were used to determine the fraction of the total integrated luminosity originating from the electron(positron) collisions with the closest to the main p-bunch early proton satellite. To select a clean DIS event sample strict conditions were required. These can be grouped in two categories: 1) run selection, 2) event selection.

1) The criteria used for the run selection are the following:

- run quality: Good or Medium
- trigger phase: 3, 4
- detector status: HV correction to the run luminosity $< 20\%$, where the following subdetectors are required to be on: `CJC1, CJC2, CIP, COP, BPC, LAr, BEMC, ToF`.

2) The event selection criteria are similar to those used for the standard low Q^2 DIS analyses with only minor modifications related to the z-vertex fiducial cut:

- the event belongs to *class 11* at DST4 (status of February, 1995)
- the event is found in the *colliding* bunch
- the z-vertex (as determined by the tracker) lies within ± 20 cm around the central $<z_{vx}>$ value for the given run range

- error of the reconstructed z-vertex position, $\mathrm{d}z < 5$ cm
- BPC - BEMC cluster matching, `DCLBP` < 5 cm
- `ECRA` < 5 cm
- box cut of 15 cm on the BPC hit
- $|x_{\mathrm{BPC}}| + |y_{\mathrm{BPC}}| > 18$ cm
- `ZORRO` cut to reject beam related background
- BEMC energy outside the triangles > 10 GeV, to avoid corrections to the `BSET` trigger efficiency in the 'closed triangles' runs.

Fig. 5 shows the z-vertex distribution for e^+p events satisfying all run selection and the first event selection criteria. One can see that, in addition to the main bunch events, only a 'forward' satellite events are clearly visible in the distribution. Both peaks are well described by gaussian curves with $\sigma_z \approx 10.5$ cm.

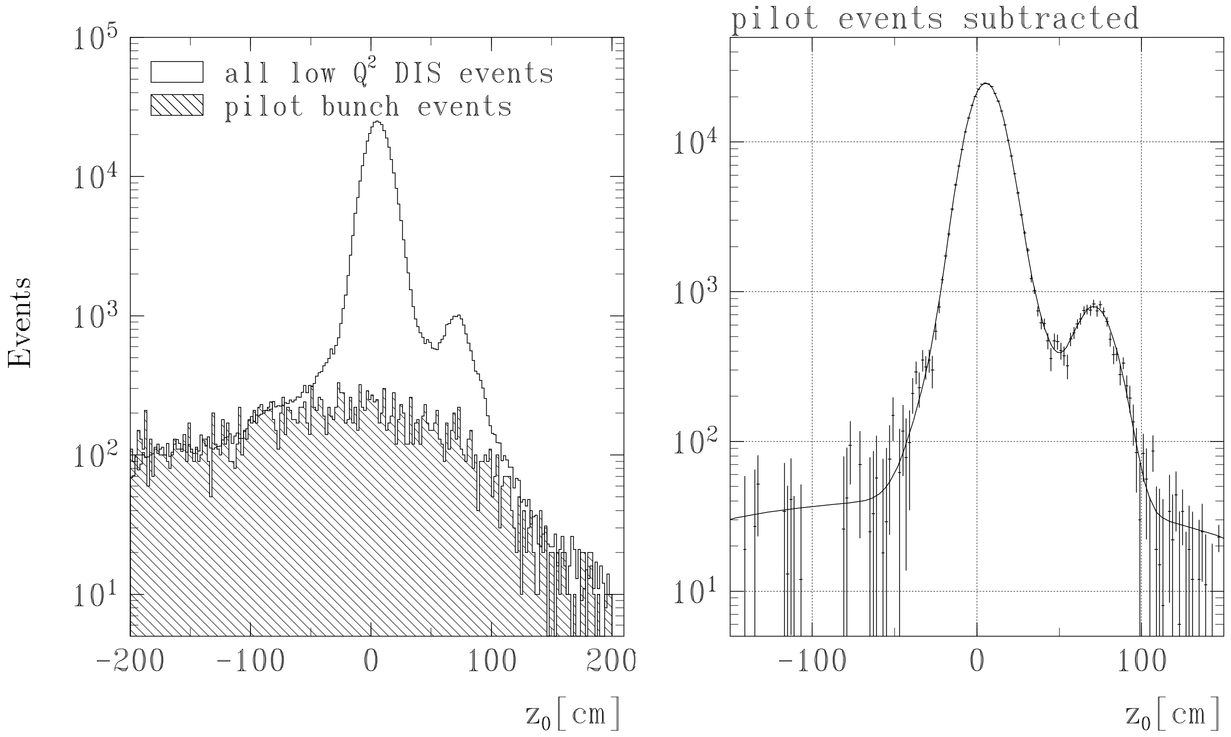

Figure 5: z-vertex distributions in the events, classified as low Q^2 DIS events, in colliding and pilot bunches. Pilot bunch events are scaled up by the ratio I_p^{tot}/I_p^{pil} to represent the complete beam related background.

The corresponding distribution, after the same selections, but for the 'shifted IP' data sample is shown on Fig. 6. In this sample, the events from the *main* p-bunch were used for the normalisation and determination of the 'forward satellite' integrated luminosity in the nominal vertex samples (see eq.(5)). Thus, the integrated luminosity of the 'shifted IP' sample itself should be corrected for the satellite bunch effect. In Fig. 6 'backward' satellite events are expected around $z \approx 0$, but are not seen, since they were strongly suppressed during the filling and ramping stages (see Fig. 2,b). On the other hand, a 'forward' satellite events, appearing

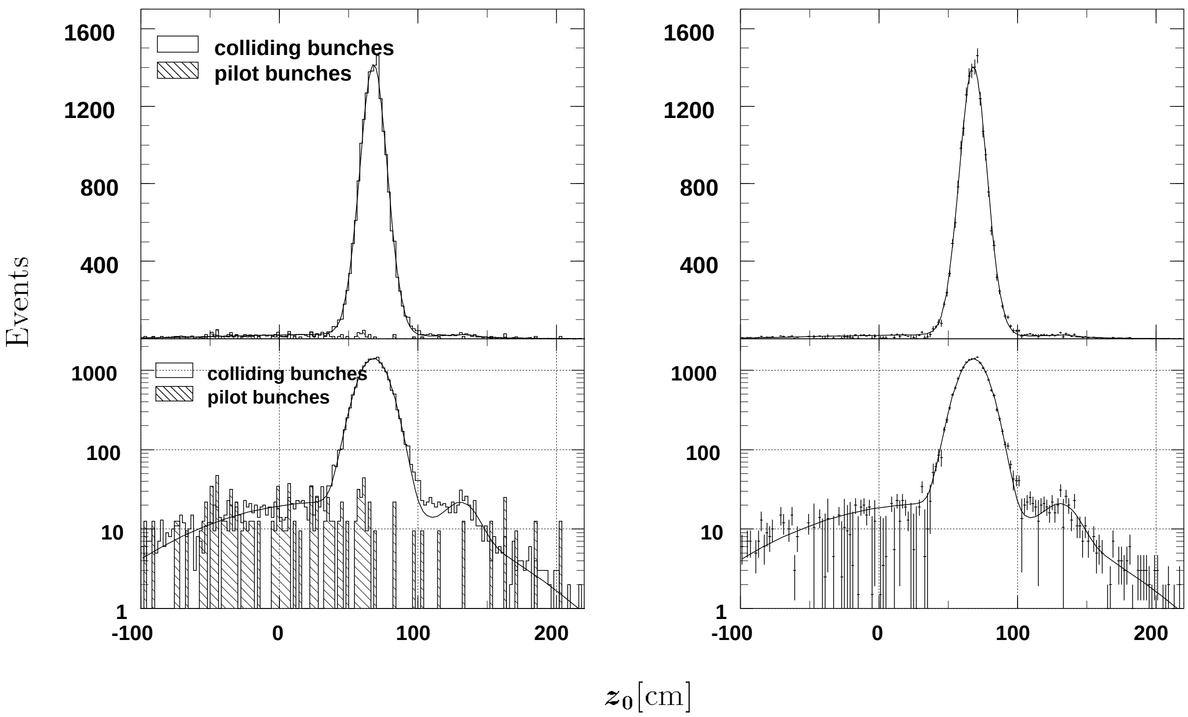

Figure 6: z-vertex distributions for the events, classified as low Q^2 DIS events, from the 'shifted IP' data sample. The bottom figures represent the same data as on the top ones, but shown in logarithmic scale. Pilot bunch events are scaled up by the ratio I_p^{tot}/I_p^{pil} to represent the complete beam related background.

around $z \approx 140$ cm, suffer from the vertex finding efficiency and also cannot be reliably used for satellite luminosity correction in the 'shifted IP' sample. Therefore, special minimum bias γp data, taken with the z-unbiased `eTAG*ToF_IA` trigger [7], were used to determine $\Delta\mathcal{L}_{\rm sat}$ in the 'shifted IP' sample. Due to the larger cross section ($\sigma_{\gamma p} \gg \sigma_{DIS}$) 46 ± 7 events from this sample were clearly identified in the 'late' satellite peak, at $|z_{vx}| < 25$ cm. After renormalization by the FToF data, $\Delta\mathcal{L}_{\rm sat} = 2.26 \pm 0.66\%$ was obtained for the 'shifted IP' sample. Finally, after all selections, described in the beginning of this section, $\mathcal{L}_{\rm z-sh} = (59.6 \pm 2.3)$ nb^{-1} was determined as a normalization value for the equation (5).

The systematic error of 5.7% was estimated for this method, by varying the event selection criteria. Taking into account the error in the normalization luminosity of the 'shifted IP' sample, $\delta\mathcal{L}_{\rm sh-z} = 4.0\%$, the total integrated luminosity of the 'forward' satellite events in all e^+p collisions of 1994 was found to be

$$\mathcal{L}_{\rm fw.sat} = (73.8 \pm 5.2)\ \mathrm{nb}^{-1}$$

3.3 Results

Fig.7 shows a history of the average z-vertex position as measured in low Q^2 DIS events and tabulated in the database, for use by the luminosity correction tool, described in the Appendix. The final values for the luminosity correction for the proton satellite bunch effect is shown in Fig.8. In average, the corrections amount to:

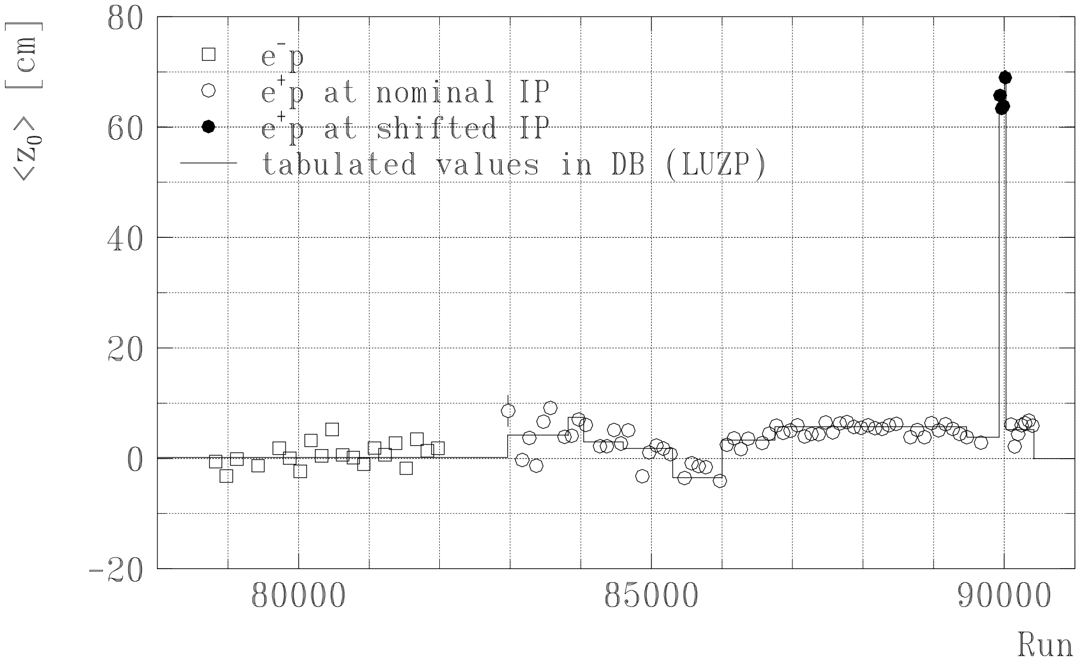

Figure 7: Average z-vertex position as a function of the run number measured in low Q^2 DIS event sample and tabutated in the LUZP bank in the database.

$$\Delta L_{\text{sat}}(e^- p - 1994) = (3.90 \pm 0.34)\%,$$
$$\Delta L_{\text{sat}}(e^+ p - 1994) = (4.22 \pm 0.38)\%.$$

In both cases the effect is larger than the overall luminosity error and definitely cannot be neglected in the analyses. The period with a high level of satellites (H1 run range $84041 - 85300$) was found to be in direct correlation with the time (17-31/08/94, shown by the shaded area in the figure), when the proton transmitter was not operational. This gives us an additional confidence in the correctness of the obtained results.

The precision achieved in the integrated luminosity values originating from the 'satellite' collisions is summarized in Tab 1.

Table 1: Systematic errors in the satellite luminosity determination.

1)	For the 'forward' satellite luminosity:	
	a) event selection systematics	5.7%
	b) luminosity error in the shifted IP sample	3.9%
	c) satellite correction for the shifted IP sample	0.7%
	d) statistics (for full e^+p sample)	1.2%
	Total error	7.1%
2)	For the total satellite luminosity:	
	a) forward satellite luminosity	7.1%
	b) backward/forward satellite ratio (FToF data)	5.5%
	Total error	9.0%

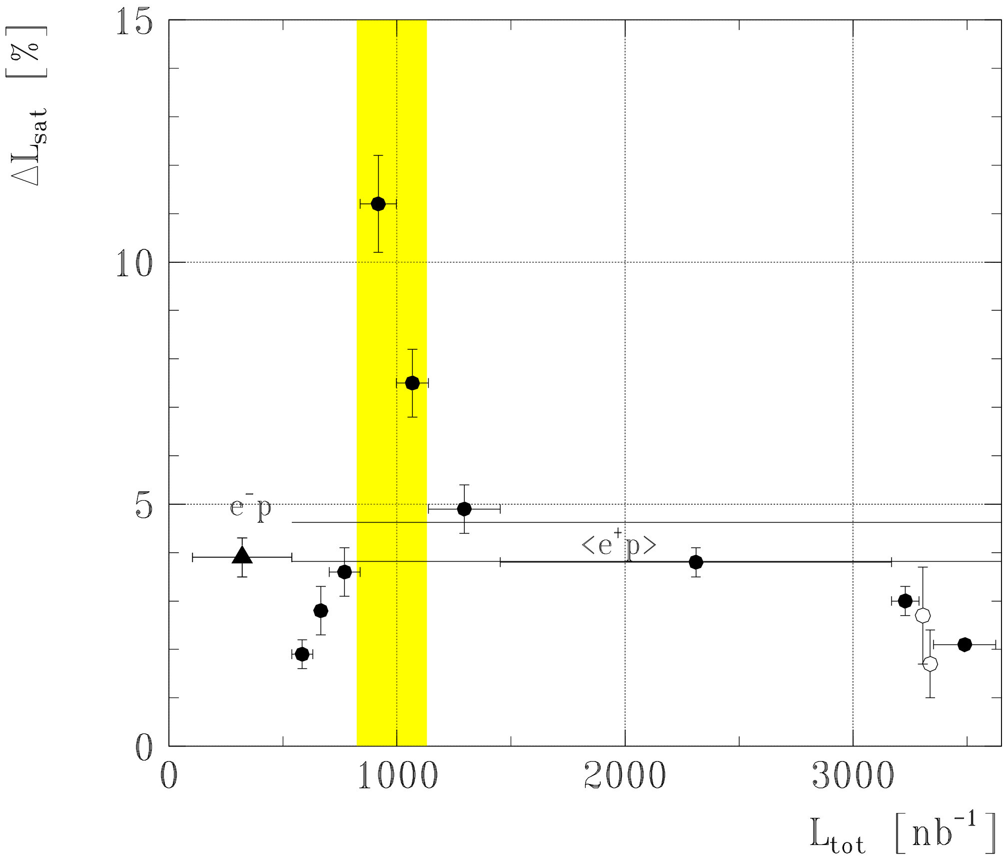

Figure 8: Satellite bunch correction to the measured luminosity in the H1 interaction region for different run periods of 1994, presented as a function of the total integrated luminosity. The shaded area corresponds to the period with one broken proton transmitter (17-31 Aug, 1994)

Note, that the $\Delta L_{\rm sat}$ in Fig.8 includes only the two satellites closest to the main p-bunches. For real physics analysis, a precise value of the integrated luminosity corresponding to a given event sample depends obviously on the z-vertex cut made. For that purpose a special function is provided which is described in the Appendix. The following average value of the luminosity correction corresponds to a typical (run dependent!) 3σ cut, $|z_{vx} - \overline{z}_{\rm RUN}| < 3\sigma_z$:

$$\Delta L_{\rm sat}(e^+p - 1994) = (4.80 \pm 0.44)\%.$$

This has to be compared to a 'simple' estimate, $(4.22 \pm 0.38)\%$, given earlier in this section. The larger of the two values includes in addition to the closest satellites, also a correction for the distant satellites and for the tails of the main p-bunch, which fall off the $3\sigma_z$ cut.

4 Conclusions

It has been shown that the integrated luminosity used for standard physics analysis must be corrected for the satellite bunch effect by a non-negligible value of $\Delta\mathcal{L}_{\rm sat} \approx 4.8\%$, which is significantly larger than the systematic error of the luminosity determination in 1994: $\delta\mathcal{L} = 1.5 \div 2.0\%$ [8]. The correction is not uniform in time, and therefore must be treated in a run dependent way. A special tool is provided for this purpose, which also allows to determine an integrated luminosity as a function of the fiducial cut along z axis.

High precision is achieved in the integrated luminosity correction for the satellite bunch effect (or more general – for the 3σ z-vertex fiducial cut): $\delta\mathcal{L}_{\rm sat} = 0.45\%$. It is shown, that the 'forward satellite ep events' can be used for the physics analysis with a relatively small absolute normalization error of $\delta\mathcal{L}_{\rm fw.sat} = 7.1\%$.

These two main results demonstrate an impressive progress compared to the 1993 data analysis situation [9]. They also prove, that a successful high precision physics analysis is possible in a complicated proton bunch structure environment by exploiting all available in 1994 information.

There is however a lesson for the future. Obtained results would be significantly less precise if the 'shifted IP' data were not available. This is, however, a typical situation expected in the future, since the (useful!) exercise with shifting the ineraction point is rather an exception. A more direct and precise information on the time structure of the proton bunches is thus necessary in order to exploit fully a first method of the satellite luminosity determination, as described in section 2.

Acknowledgements

We would like to thank Gerry Lopez and Phillip Biddulph for their help in the understanding of the FToF data and for stimulating discussions.

Appendix

A utility routine `ZCLUMI` (from `H1UTIL` library, author: S.Levonian, status: 7-Apr-1995) corrects a total H1 gated luminosity for the so-called 'proton satellite bunch' effect. It makes use of the information on the z-vertex distribution, measured by the H1 tracking system, and FToF 'qvt' plots giving the time structure of the proton bunches.

Final $L(z)$ correction gives the result depending on the required $[z_{min}, z_{max}]$ area. It also corrects for a (small) lumi tail from the 'distant' (>5 ns from the main peak) satellites.

```
                ---- -- ---
CALL ZCLUMI (IRUN,Z0,DZ0,FLM,EFLM,FLSP,FLSN,IRET)
                             --- ---- ---- ---- ----

Returns a fraction of the total luminosity in run IRUN,
which corresponds to the fiducial cut [z0-dz0, z0+dz0]

Input:  IRUN   run number
        Z0     central value of z-region [cm]
        DZ0    half width of z-region [cm]
               LUZP bank from the database
```

```
Output: FLM    fraction of the total lumi within [z+-dz0] region
        EFLM   estimated error of FLM
        FLSP   lumi fraction in [z+-dz0] region remaining from
               'z-positive' satellite (early satellite, -4.8ns)
        FLSN   lumi fraction in [z+-dz0] region remaining from
               'z-negative' satellite (late satellite, +4.8ns)
        IRET   return flag (0 - ok,  -1 if LUZP bank is not found)
```

```
 BANK   LUZP                 ! Lumi z-Parametrization (database bank)
!
!   ATTributes:
!   -----------
!COL ATT-name FMT Min    Max  ! Comments
!
  1  LSF      F    0.     1.  ! Fraction of the lumi originating from
                              ! the 'forward' satellite (-4.8ns)
  2  ELSF     F    0.     1.  ! Error of LSF
  3  RTOF     F    0.    99.  ! Ratio of the 'backward' to 'forward'
                              ! satellites, as measured by FToF
  4  ERTOF    F    0.    99.  ! Error of RTOF
  5  LTAIL    F    0.     1.  ! Lumi fraction in the tails ('distant'
                              ! satellites)
  6  ELTAIL   F    0.     1.  ! Error of LTAIL
  7  DZSIG    F    0.     1.  ! Precision of sigma-z determination
  8  Z00      F -100.   100.  ! <Z_vx> of the main bunch          [cm]
  9  SZ00     F    0.    30.  ! Sigma-z of the main bunch         [cm]
 10  ZS1      F  -50.   200.  ! <Z_vx> of the forward satellite   [cm]
 11  SZ1      F    0.    30.  ! Sigma-z of the forward satellite  [cm]
 12  ZS2      F -150.    50.  ! <Z_vx> of the backward satellite  [cm]
 13  SZ2      F    0.    30.  ! Sigma-z of the backward satellite [cm]
 END BANK
```

This is a full set of LUZP banks in H1 database:

Bank-ID	Rtyp	Dtyp	Version	1.Run	L.Run	Words	Date	Author
2	e-p	data	503242128	1	62571	13	950324	F11LEV
3	e-p	data	503242128	62572	66301	13	950324	F11LEV
4	e-p	data	503242128	66302	66407	13	950324	F11LEV
5	e-p	data	503242128	66408	66609	13	950324	F11LEV
6	e-p	data	503242128	66610	76344	13	950324	F11LEV
21	e-p	data	503262009	76345	78380	13	950326	F11LEV
22	e-p	data	503262011	78381	82005	13	950326	F11LEV
8	e-p	data	503242128	82006	82960	13	950324	F11LEV
23	e-p	data	503262013	82961	83819	13	950326	F11LEV
24	e-p	data	503262015	83820	84040	13	950326	F11LEV
33	e-p	data	504071138	84041	84600	13	950407	F11LEV

34	e-p	data	504071144	84601	85300	13	950407	F11LEV
26	e-p	data	503262017	85301	86000	13	950326	F11LEV
27	e-p	data	503262017	86001	86750	13	950326	F11LEV
28	e-p	data	503262018	86751	89468	13	950326	F11LEV
29	e-p	data	503262018	89469	89928	13	950326	F11LEV
30	e-p	data	503262019	89929	90003	13	950326	F11LEV
31	e-p	data	503262023	90004	90026	13	950326	F11LEV
32	e-p	data	503262023	90027	90419	13	950326	F11LEV
18	e-p	data	503242128	90420	0	13	950324	F11LEV

References

[1] G. Wolf, HERA: Physics, Machine and Experiments, DESY 86-089 (1986)

[2] S.Levonian, H1LUMI - A Fast Simulation Package for the H1 Luminosity System, H1 note H1-04/93-287 (1993)

[3] H1 Collaboration (I. Abt, et al.), The H1 Detector at HERA, DESY preprint 93-103 (1993), to be published in Nucl. Instr. and Methods.

[4] R. Prosi, The 1994 L4 filter farm selection algorithm, H1 note 03/95-433 (1995)

[5] J.Heatherington et al., Analysis of FToF TDC data, H1 note 06/94-362 (1994)

[6] M.Landon, DDL description of the BRTQ bank in `/h1/h1banks.cmz` library.

[7] H1 Collaboration (S. Aid, et al.), Measurement of the Total Photon Proton Cross Section and its Decomposition at 200GeV Centre of Mass Energy. DESY-95-162 (1995), to be published in Z.Phys. C.

[8] S.Levonian, LUMI-94. Final analysis results. Report on H1 meeting, 1-Dec-94.
S.Levonian, in H1 lumi www pages:
http://dice2.desy.de/h1/iww/iwork/ilumi/H1LUMI.PREC94.PS

[9] H1 Collaboration (T. Ahmed, et al.), Experimental Study of Hard Photon Radiation Processes at HERA. Z.Phys. C66 (1995) 529-542.