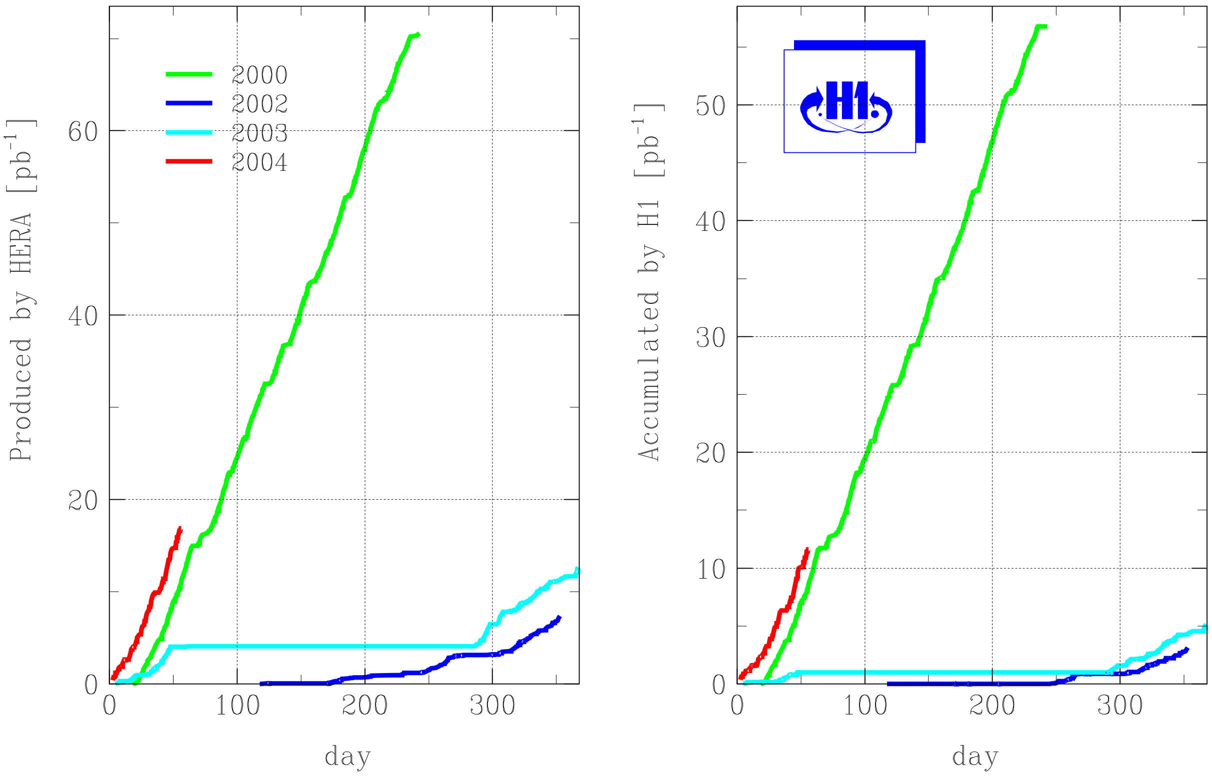
Status of LUMI System (including E-taggers)
and
Integrated Luminosity determination

Nelly Gogitidze

on behalf of H1 Lumi Group

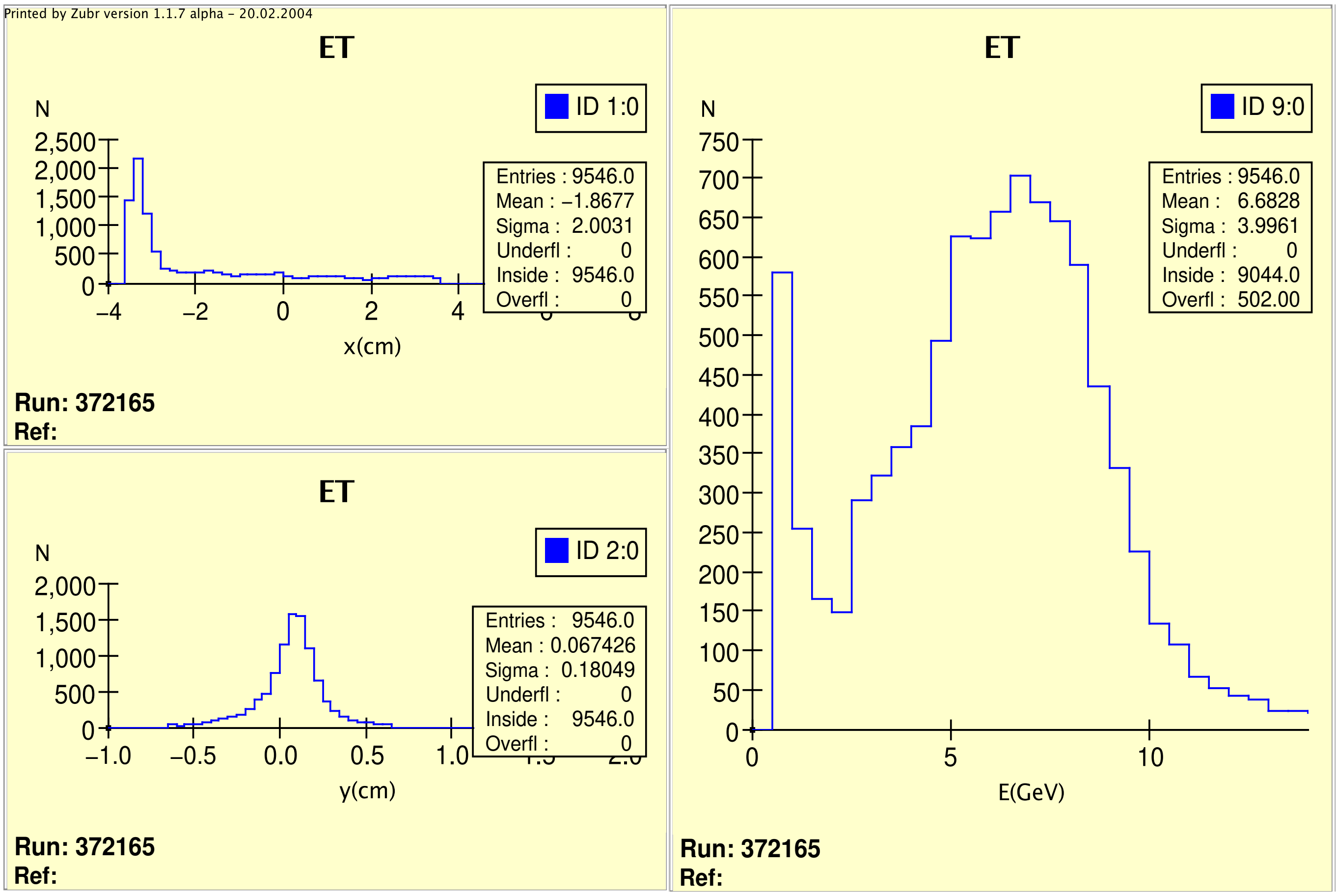
Integrated Luminosity
(status: 25.02.04 at 12:00)



H1 Collaboration meeting, 25.02.2004

Etag-6

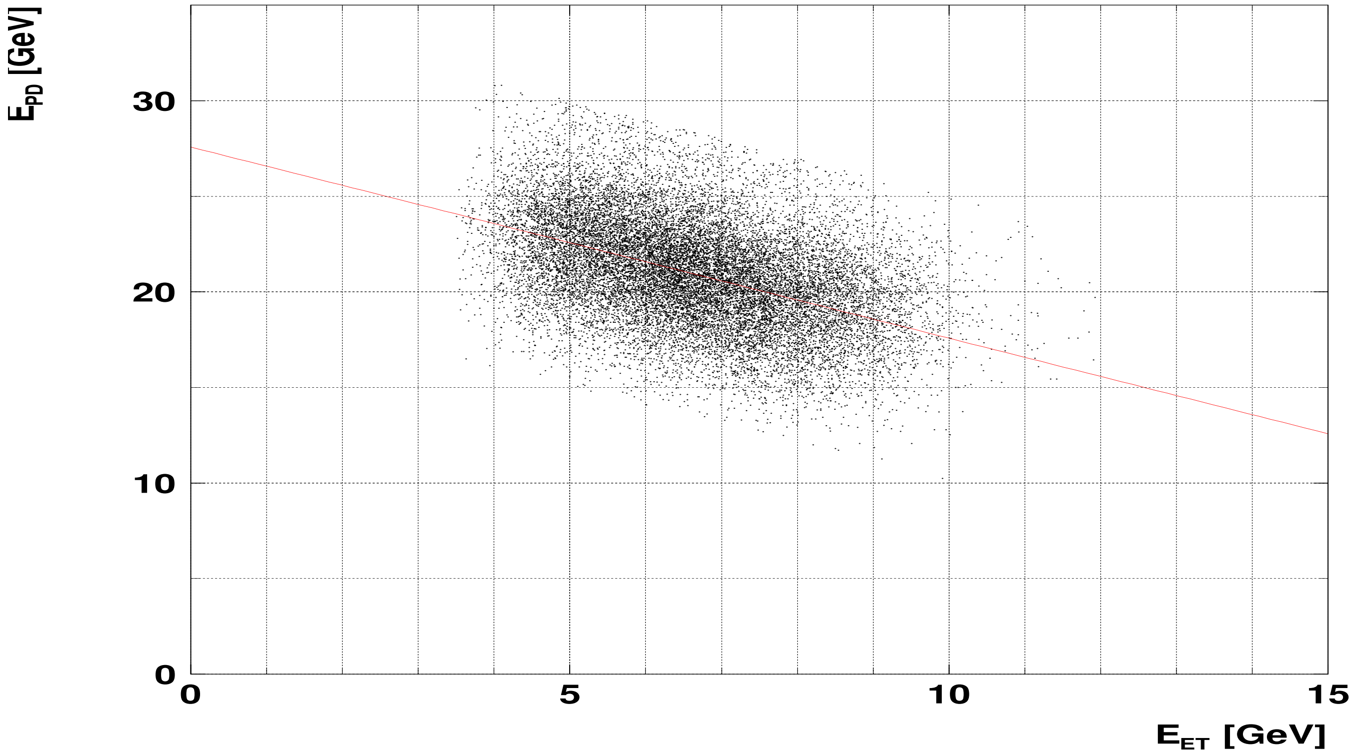
L4 online histograms



Running well, no problems.

HV adjusted for alignment of channel response
Calibrated (but still additional fine tuning is needed).

Etag-6: $e - \gamma$ Energy Correlation

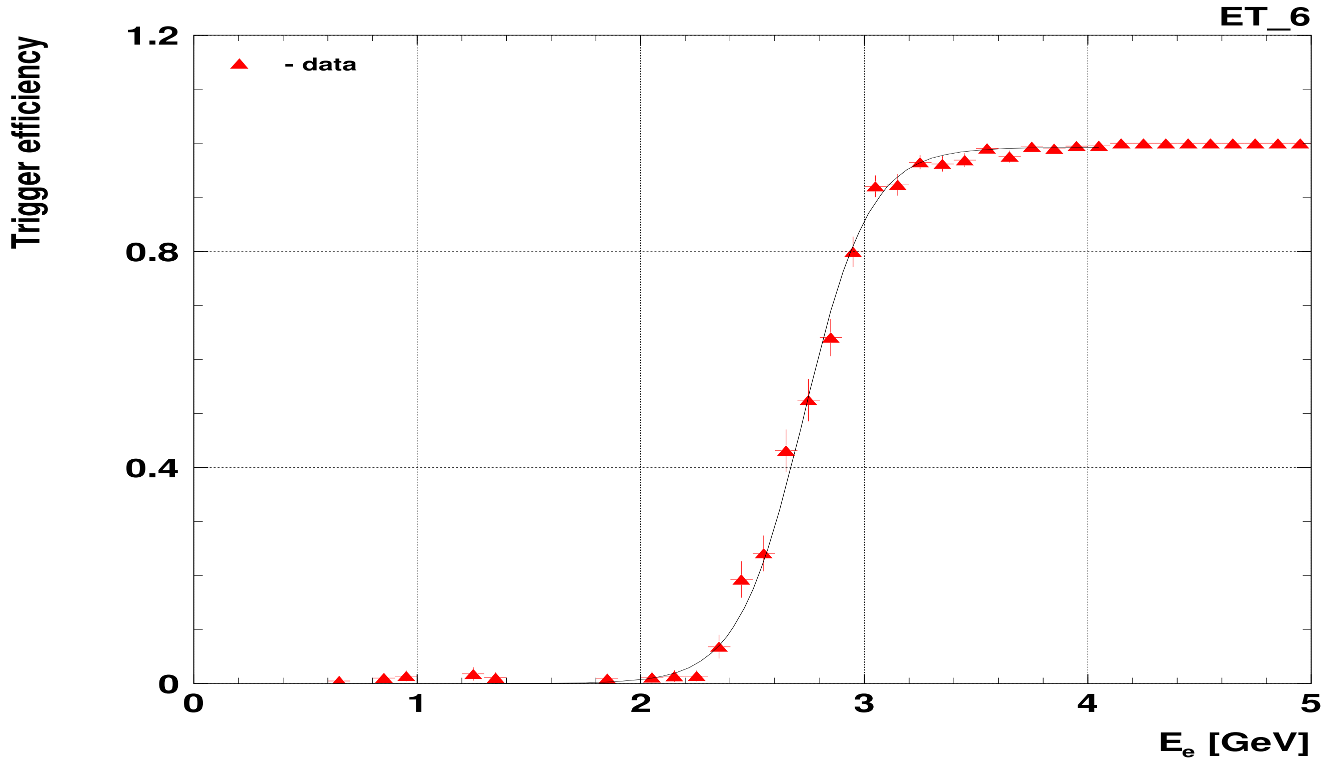


$$\mathbf{E}_e + \mathbf{E}_\gamma = \mathbf{E}_{e_{beam}}$$

Use E_{PD} and E_{ET6} in calibration of ET-6

Energy resolution $\sim$ **15% /** $\sqrt{E}$

Etag-6: Trigger Efficiency



TE: LU_ET_6 (nominal threshold 2.7 GeV)

s99: LU_ET_6 $\rightarrow$ Monitor trigger

s44, s46, s83, s87, s89, s113 $\rightarrow$ e - tagged Physics triggers

Etag-40

... not yet installed in the tunnel

The radiation level at 40 m, compared to HERA-I,
became rather high:
$\sim$ 100 times higher at working position,
$\sim$ 20 times higher at parking position.

This means:
with present value of I_p and I_e
ET40 would get $\sim 10^6$ Gy in 2 weeks time
$\rightarrow$ 25-30% deterioration of NBW crystal transparency

Protection measures are being worked out
on the basis of the experimental distribution
of the radiation field in the ET40 position.

Since January 2004 the radiation field
became weaker by factor 3.
New measurement to be made in March.

There is some hope to install ET40 rather soon
(during access day in April 2004?)

Luminosity System H/W Status

- **Nov 05,03 (MD) :**
  increased geometrical acceptance
  by widening the window in the lead wall between beryllium synchrotron radiation filter and Photon Detector

- **Nov 14,03 :**
  calculation of channel inter-calibration and application of HV correction $\rightarrow$ **ΔL^{ONL}/L = -0.12**

- **Nov 26,03 :**
  switching from PD analog sumY to sumX,
  due to troubles with shaper power supplies.
  Staying with sumX for online luminosity measurement

- **Jan 10,04 :**
  shift of pedestal to negative values, beyond reach of adjustable pedestal compensation in shapers
  $\rightarrow$ **truncated E spectrum** $\rightarrow$ **wrong lumi measurement.**
  short term H/W fix: set pedestal to 0 (decoupling cap's)
  long term: VME controlled pedestal compensator (study)

3 new versions of online DAq program since Oct.2003

- ▷ **online data format close to final**
  $\rightarrow$ **analysis status (includingLED test pulse system)**
- ▷ **raw data saving, activated by shift crew** $\rightarrow$ **studies**
- ▷ **file transformation machinery (raw** $\rightarrow$ **RooT) set up and working (F.Salvaire, HAM2)**
- ▷ **several bugs and cosmetical flaws removed (e.g. more reliable HERA timing measurement by TDC)**

Luminosity Measurement

Luminosity measurement in H1 is based on the Bethe-Heitler reaction:

$$ep \to e\gamma p$$

Use PD to measure Rate and Energy of scattered photons.

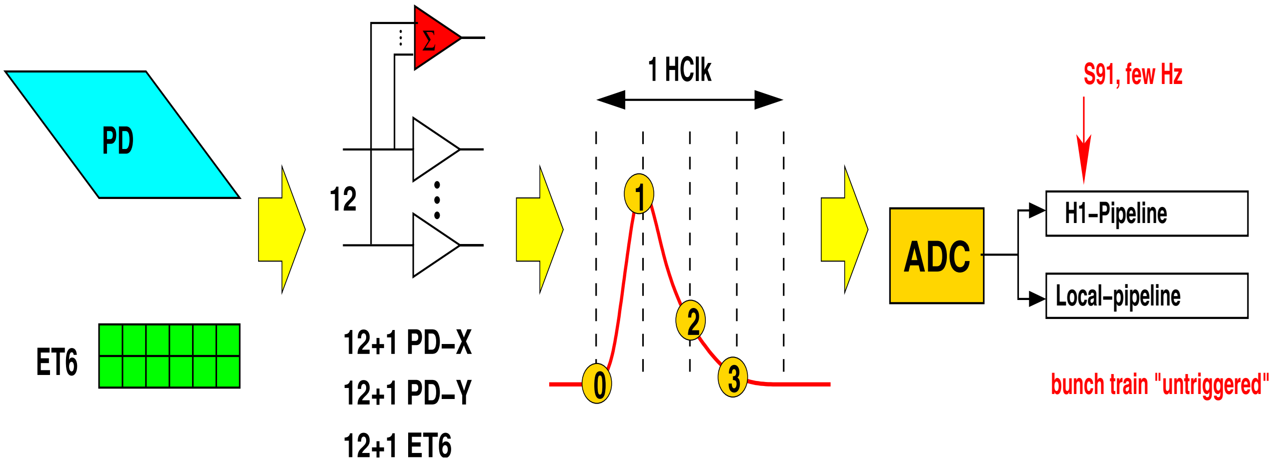
- **Online Measurement $\to$ displays, e.g. in Control Room**
- **Online/Offline Measurement $\to$ LH1R / LH1T banks in DB**
- **Offline Measurement $\to$ LOFF correction factors**

Final Physics **"$\mathcal{L}$ = LOFF * LH1R"**

or

"$\mathcal{L}$ = LOFF * LH1T" with HV ON selection

Online Luminosity Measurement



- **Photon Detector (PD): 12 strips in X and 12 in Y**
- **X and Y: 2 independent interleaved sampling calos**
- **analog summing of 12 channels (PDX, PDY, ET6)**
- **4 ADC samples per HERA clock, H1 independent pipeline**
- **"un-triggered" r/o mode $\rightarrow$ 3 analog sums: $\sim$ 500 kHz**
- **triggered r/o mode $\rightarrow$ all channels (24 + 2): $\sim$ 100 kHz**

Present online Luminosity calculation method

- **Count number of BC where measured E_{PD} above fixed threshold after eventwise pedestal subtraction**
- **Fix threshold and E scale (ADCC /GeV) by calibration**
- **No pile-up correction: $E_{thr} \sim$ 5 GeV (minimal pile-up)**
- **Fixed acceptance correction (A = 0.975)**
- **Devide by fixed integrated BH cross section (76 mb^{-1}) convoluted with PD detector resolution (no beam-size effect).**

Online/Offline Luminosity

- **PD Event data:**

  every 10 sec.: KEEP-bank LUMO

  ▷ **220 bunch rates, averaged over last 10 sec.**

- **At Runend the TCL-job writes DB banks using PD bunch rates (LUMO) and bunch currents (TCUR)**

  ▷ **LH1R:**
  Integrated Lumi Summary Bank

  ▷ **LH1T:**
  Combined information of
  Integrated lumi and HV-bits (HEAR Words 9 - 11)
  ⇒ new Table-Row every 10 sec.
  ⇒ corresponding to LUMO banks

- **Input to the TCL-job are TCL-files (RUNDATA event records, containg KEEP-banks)**

LH1T bank

Tot_time (msec)	Act_time (msec)	Int.Lumi (mb-1)	HEAR09	HEAR10	HEAR11
798	731	8995	A0080000	971FE060	0
10527	5140	63251	A0000000	971FE060	0
21163	13942	170687	A0000000	971FE000	0
30895	20800	253531	A0000000	971FE000	0
41445	28103	341741	A0000000	971FE000	0
50893	35349	429509	A0000000	971FE000	0
61477	43397	527178	A0000000	971FE000	0
71217	51031	619859	A0000000	971FE000	0
81087	59501	722235	A0010010	971FE003	3
91730	69173	838846	A0010010	971FE003	3
102162	78642	953375	A0010010	971FE003	3
111835	87424	1059304	A0010010	931FE003	3
......					
373320	331275	4003791	A06B0010	921FEC7B	3
382419	340115	4114276	A06B0010	921FEC7B	2
392528	349953	4237641	A06B0010	921FEC7B	2
......					
1271995	1182631	14679476	A00A0000	921FE078	0
1282677	1192339	14801044	A00A0000	921FE078	0
1292456	1201340	14913757	A00A0000	921FE078	0
......					
1381559	1262743	15682511	80020000	92000018	0
1391538	1267660	15743900	80020000	92000018	0
1398706	1271971	15797723	80020000	92000018	0

Integrated Lumi $\mathcal{L}$ values in the LH1T bank

$$\mathcal{L} = \Delta t * L = \Delta t * \frac{Rate_{BH}}{\sigma_{BH}}$$

Pile-up not accounted for
Possible shifts in PD Calibration not accounted for
Possible changes of PD Acceptance not accounted for

$\rightarrow$ **LH1R / LH1T values need corrections**

Need careful offline determination of Integrated Lumi.

Offline Luminosity Determination

The Integrated Lumi $\mathcal{L}$ given by

$$\mathcal{L} = \frac{N_{BH}}{\sigma_{BH}}$$

Complications:

- **relate number of observed events to the true number of events (as predicted by theory)**
- **calculate the acceptance corrected σ_{BH}**

$$\mathcal{L} = \frac{\frac{\sum_i (W_i^{tot}(E_{min}) - W_i^{bgr}(E_{min}))}{\epsilon_{trig}(E_{min})}(1 - \delta_{n\gamma}(L, E_{min})) \cdot \delta_{trig.scr.cor.}}{\sigma_{BH}(E_{min}) \cdot A_{PD}(\theta_x, \theta_y)}$$

- $W_i = P_i N_i$ **- total and background number of events N_i after accounting for the prescaling P_i. (i = Run number)**
- $A_{PD}(\theta_x, \theta_y)$ **- geometrical Acceptance of PD**
- $(1 - \delta_{n\gamma}(L, E_{min}))$ **- correction factor for Pile-up effect**
- $\epsilon_{trig}(E_{min})$ **- Trigger Efficiency**
- $\sigma_{BH}(E_{min})$ **- cross section of Bethe-Heitler reaction**
- $\delta_{trig.scr.cor.}$ **- correction factor for Trigger Screening effect**
- E_{min} **- Min. cut-off Photon Energy**

Offline Luminosity Determination

- **Event selection**
  Events triggered by $s91$ (`LU_PD_low`),
  nominal threshold $\sim$ 5-6 GeV, L1 rate $\sim$ 1 Hz , ($P_i \approx$ 500000),
  with energy deposit $E > E_{min}$ = 10 GeV

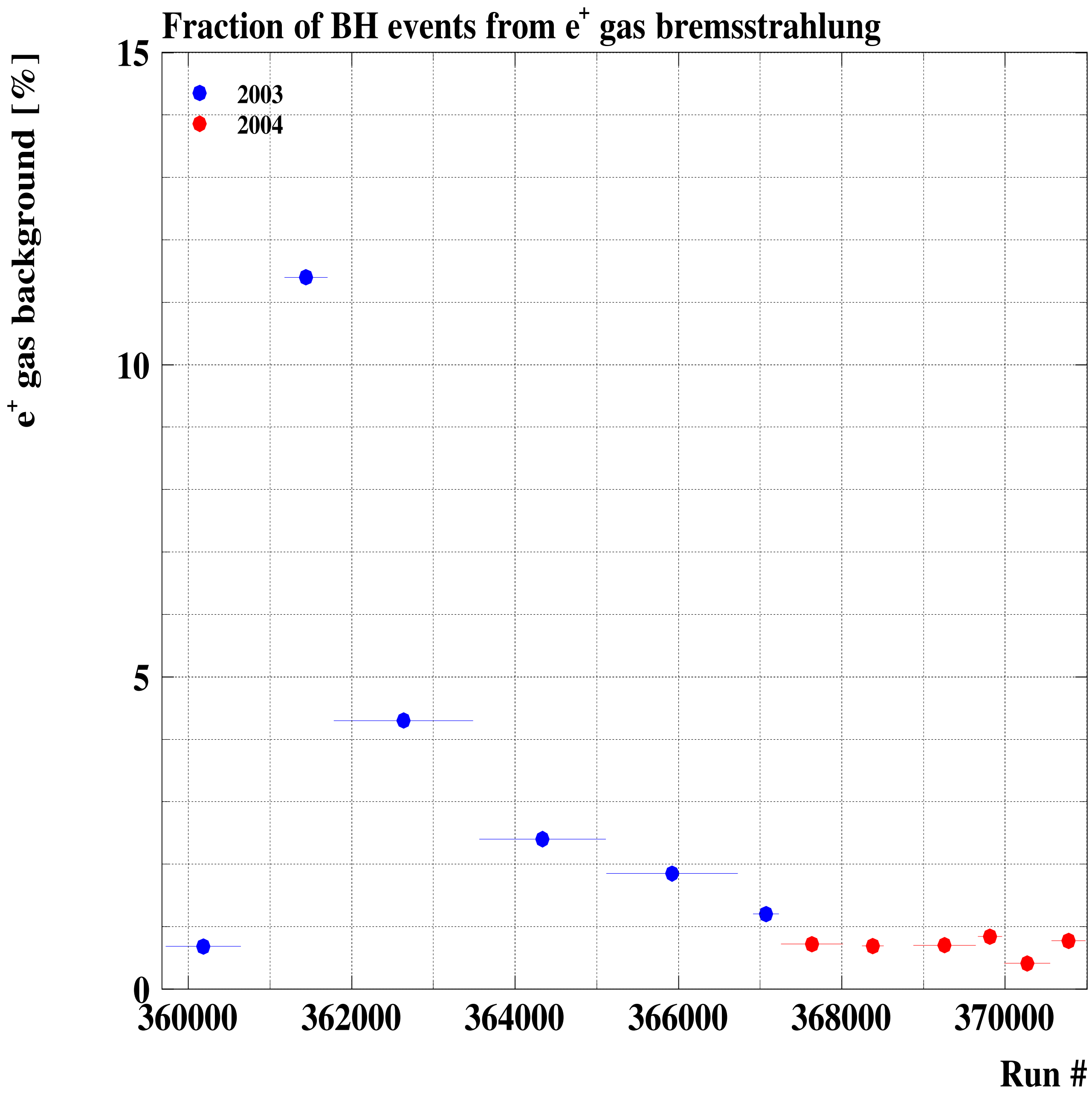
- **e gas background**
  determined from e pilot bunch events,
  weighted with factor $R_e = I_e^{total}/I_e^{pilot}$
  statistically subtracted from the full distribution.
  The fraction of background events reflects the vacuum quality
  in the beam pipe around the IP. (plot)

- **Trigger efficiency of S91**
  determined from random trigger events. (plot)

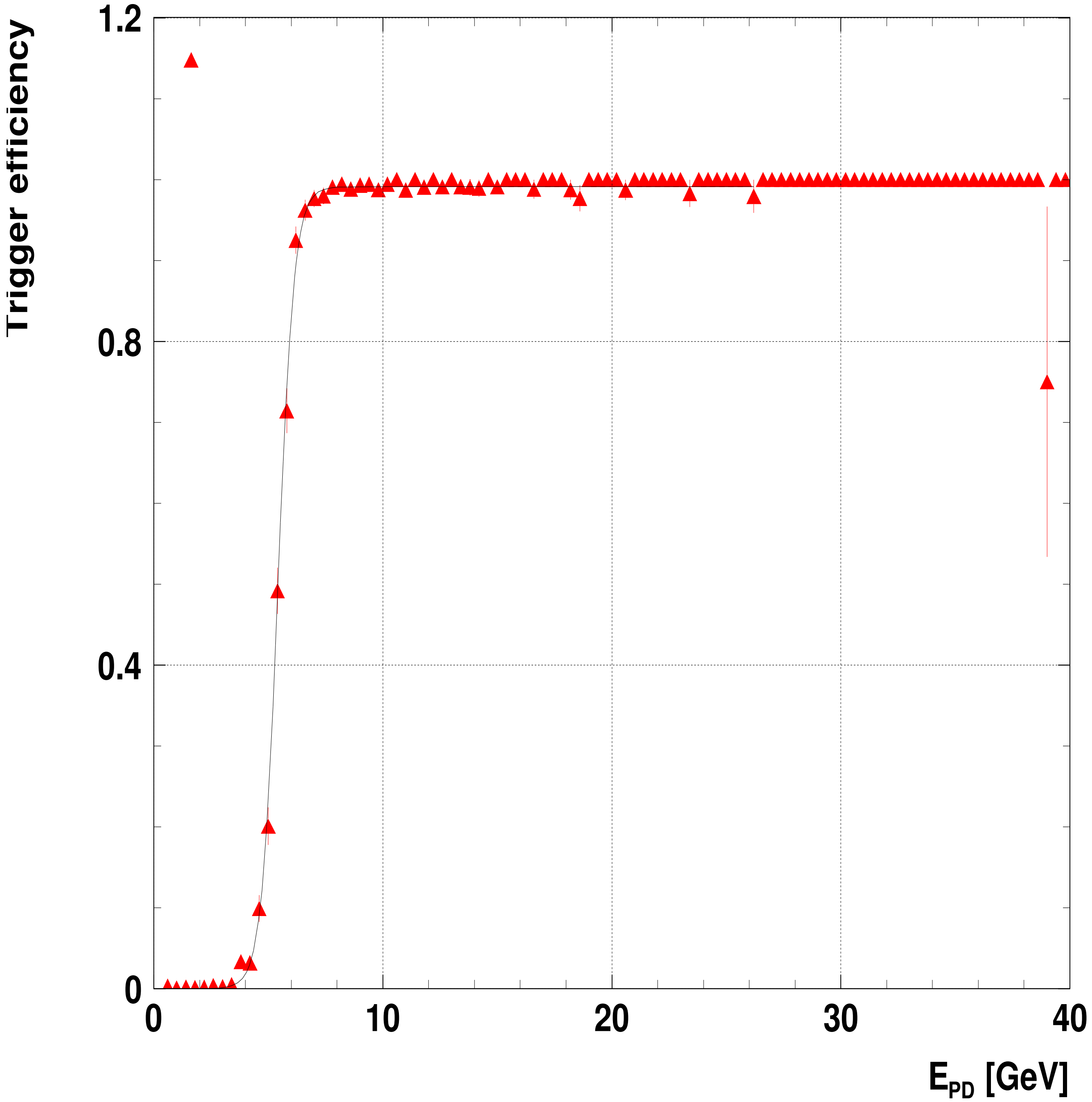
- **Acceptance of the Photon Detector**
  mainly determined by the e-beam parameters:
  horizontal and vertical beam tilts θ_x, θ_y, the beam emittance,
  defining the angular divergence of the
  beam leptons, and hence the irradiated photons.
  The beam tilt and divergence are monitored experimentally
  by the coordinate distribution of photons at the PD. (plot)

  Acceptance variations are determined
  from the data, fitting the regions not affected by
  the aperture cuts,
  from Monte Carlo, using the lepton beam parameters,
  tuned to describe the measured coordinate distributions.

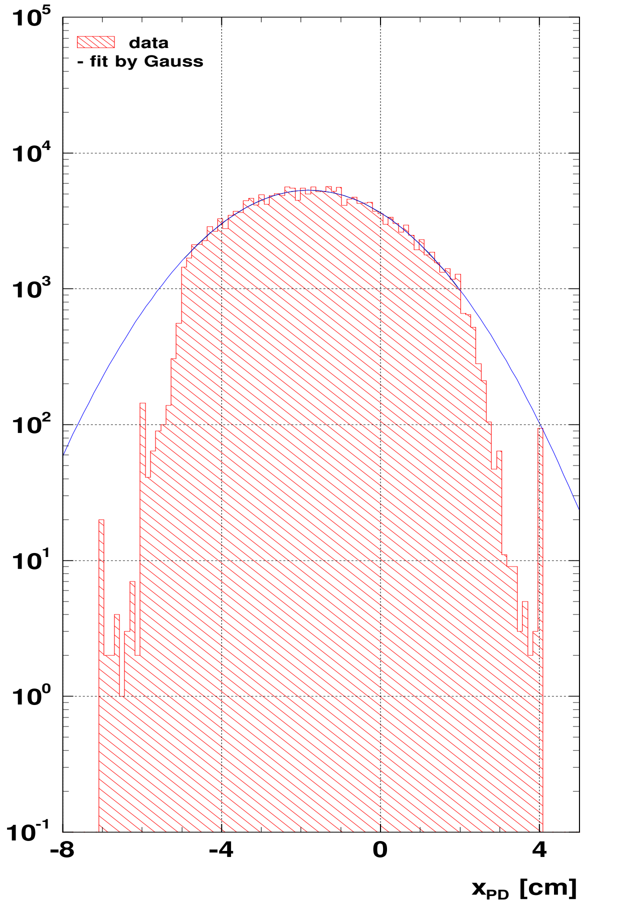
Time variation of e gas background, 2003-2004

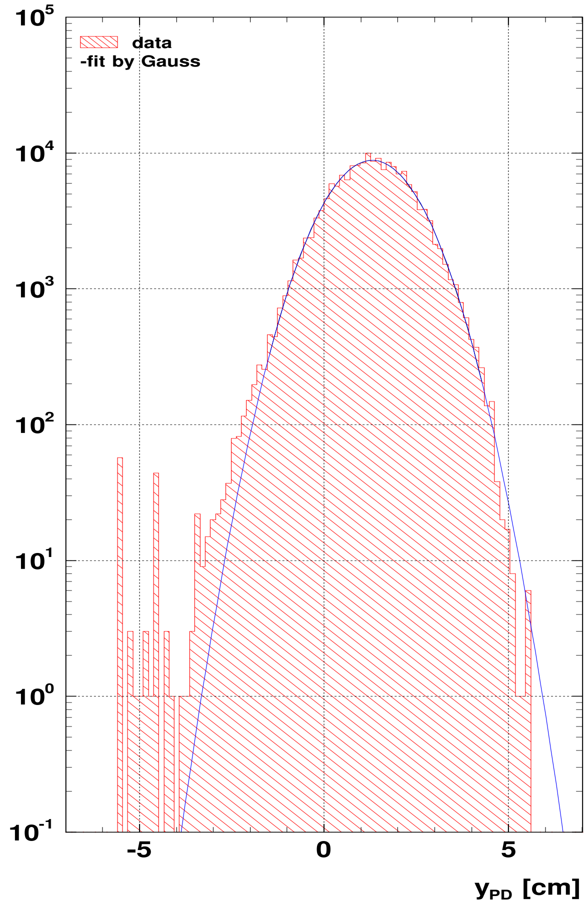


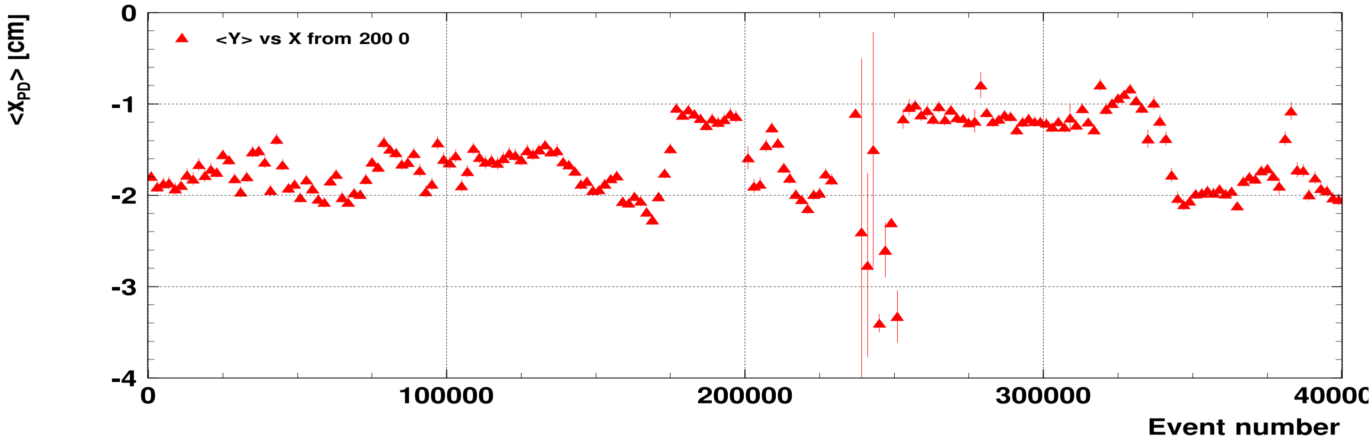
Trigger efficiency of `LU_PD_low`

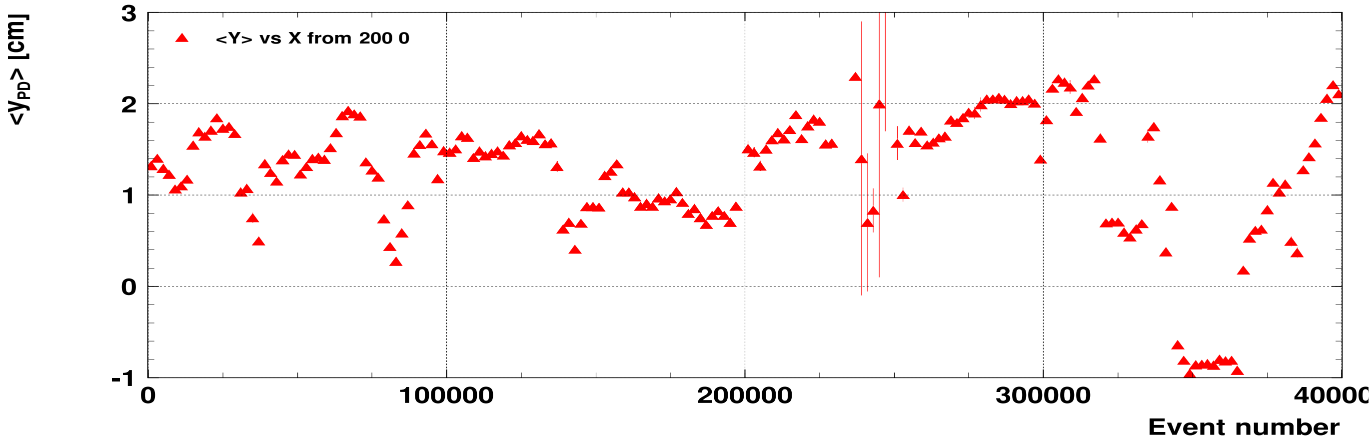


The Photon Coordinate distributions at PD
Variation over time

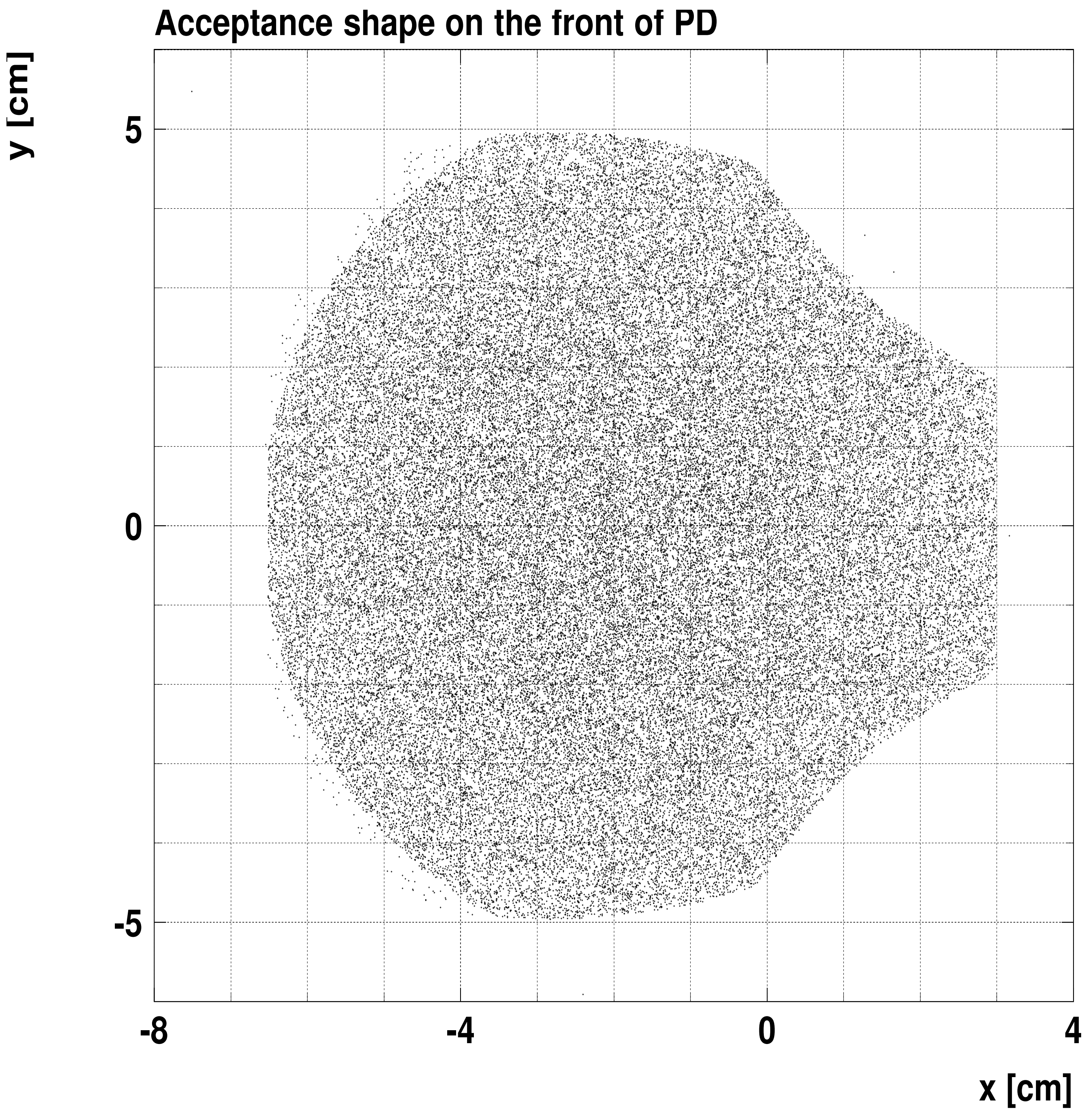








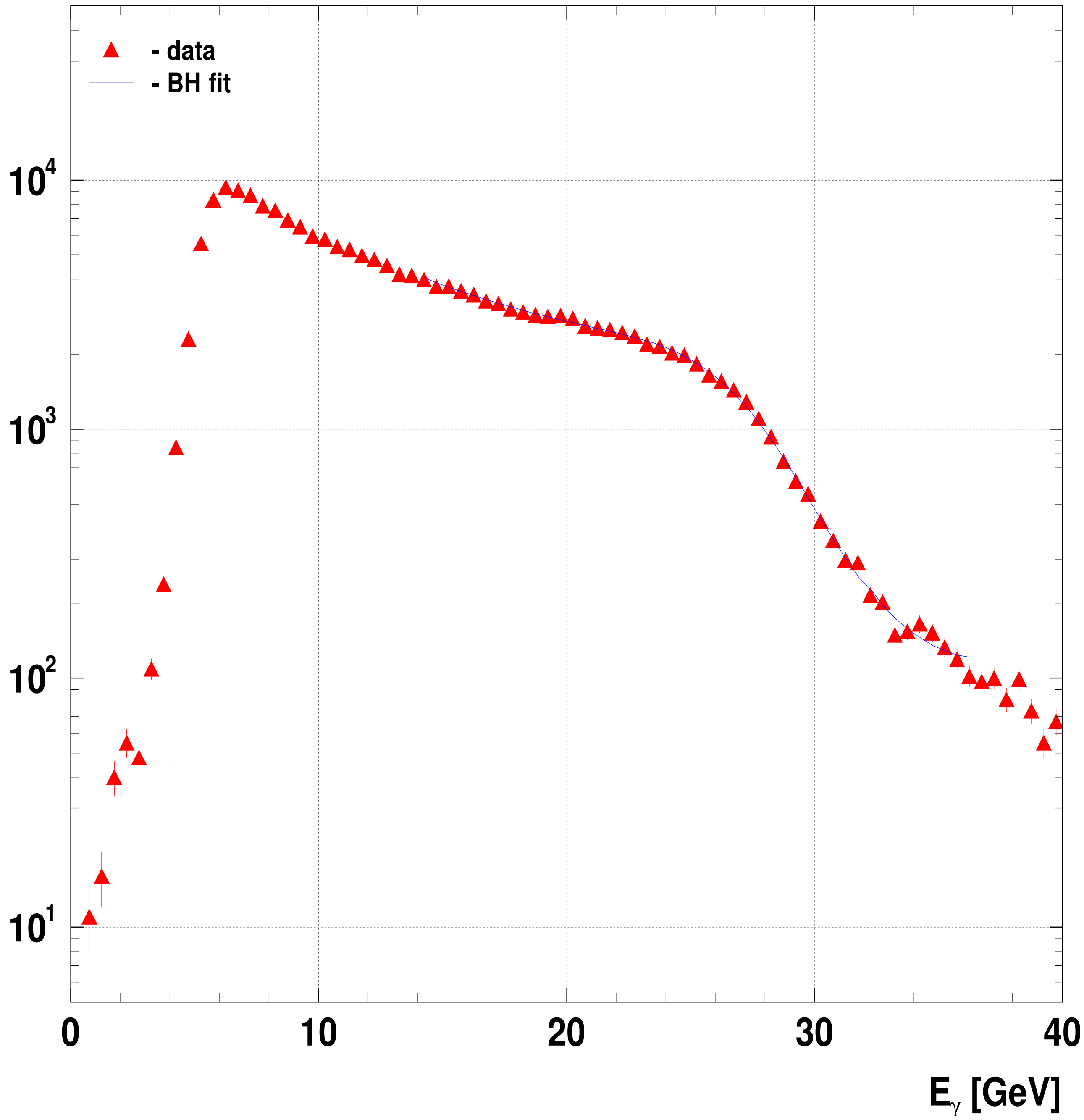
Shape of PD acceptance (MC)



Offline Luminosity determination

- **Photon Energy scale**
  After overall calibration of the Photon Detector,
  the energy scale is verified (and if necessary - corrected),
  by fitting the high energy part of the E_γ spectrum
  between (12$\pm$2) and (30$\pm$1) GeV, using Bethe-Heitler formula,
  convoluted with the detector resolution function. (plot)
  Energy shift due to pile-up effect is accounted for.
- **Pile-up effect**
  more than one BH photon from the same bunch crossing within
  the acceptance of the Photon Detector.
  The probability of multiple photon overlap is described by
  Poisson statistics and depends on luminosity L.
  The photon pile-up leads to difference between the visible
  and the predicted photon spectra, with $E_\gamma > E_{min}$.
  The final correction factor $\delta_{n\gamma}$ depends on L and the E_{min} cutoff.

The Bethe-Heitler Photon Energy Distribution



Offline Luminosity determination

- **Trigger Screening effect**
  If Trigger Elements occur in several consequtive bunches, only the first TE is counted by CTL as a subtrigger, the following TEs are missed and not counted.

  The downscaling of ST91 does not take this effect into account. The lost TEs are not counted (at least not yet) and are not available for offline corrections.

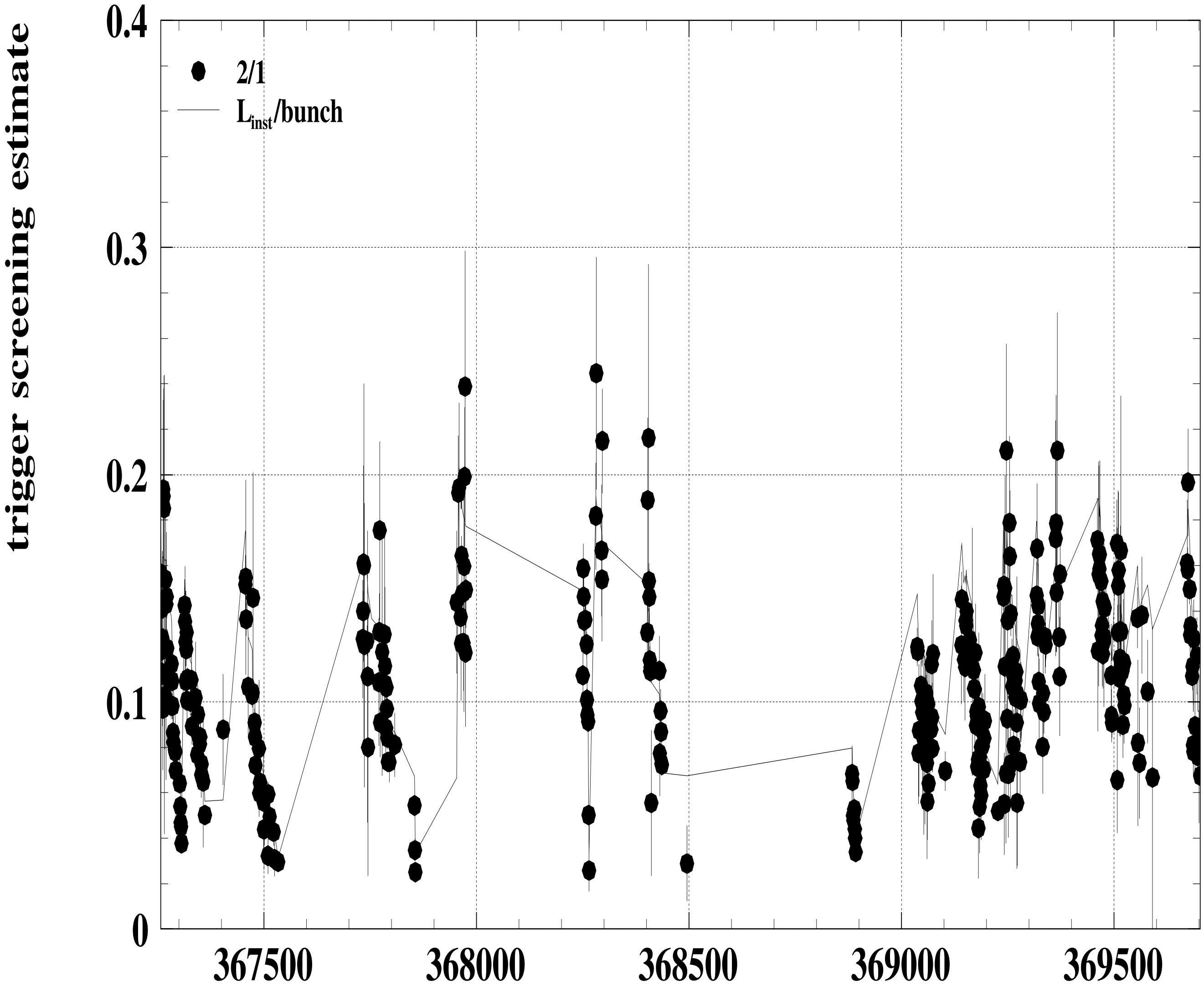
  A rough estimate was made from $\pm$ 5 bunch crossings, available in the TEL1 banks.
  Unfortunately, with rather low statistics.

  The Trigger Screening effect depends not only on Luminosity, but also on Bunch Structure:

many consequtive bunches:	**Big effect**	**(plot)**
101010 structure:	**No effect**	

- **Data Samples**
  2003 and 2004 data divide naturally into 6 samples, according to "happenings" in HERA and H1:
  $\rightarrow$ **Access days, Hardware / Software actions.**

Trigger Screening Effect, 2003-2004



2003 Data Samples
Preliminary

Data Samples	N01	N02	N03	N04	N05	N06
Date	30.10.03 04.11.03	08.11.03 14.11.03	14.11.03 25.11.03	26.11.03 08.12.03	08.12.03 23.12.03	31.12.03 02.01.04
Run Range	359723 360643	360922 361702	361782 363488	363559 365109	365118 366726	366913 367230
N_{s91}^{tot}	73654	24245	358282	343919	250199	75619
$<L>[10^{30}s^{-1}cm^{-2}]$	7.20	2.10	2.40	2.90	3.70	8.10
A_{PD}^{MC}	0.953	0.920	0.938	0.949	0.968	0.972
S91 Trig.Eff.	0.9860	0.9900	0.9870	0.9850	0.9910	0.9945
Trig.Screen.Eff.	0.0904	0.0645	0.0337	0.0375	0.0483	0.1055
$(1-\delta_{2\gamma})$ pile-up	0.9725	0.9885	0.9875	0.985	0.982	0.9705
$\mathcal{L}$(LH1R)[nb^{-1}]	551.17	40.41	723.13	889.88	750.25	527.38
$\mathcal{L}_{off}$[nb^{-1}]	519.63	42.22	800.10	973.47	791.95	550.30
$\Delta\mathcal{L}/\mathcal{L}$ [%]	-5.72±0.63	4.49±1.26	10.64±0.31	9.39±0.30	5.56±0.34	4.35±0.62

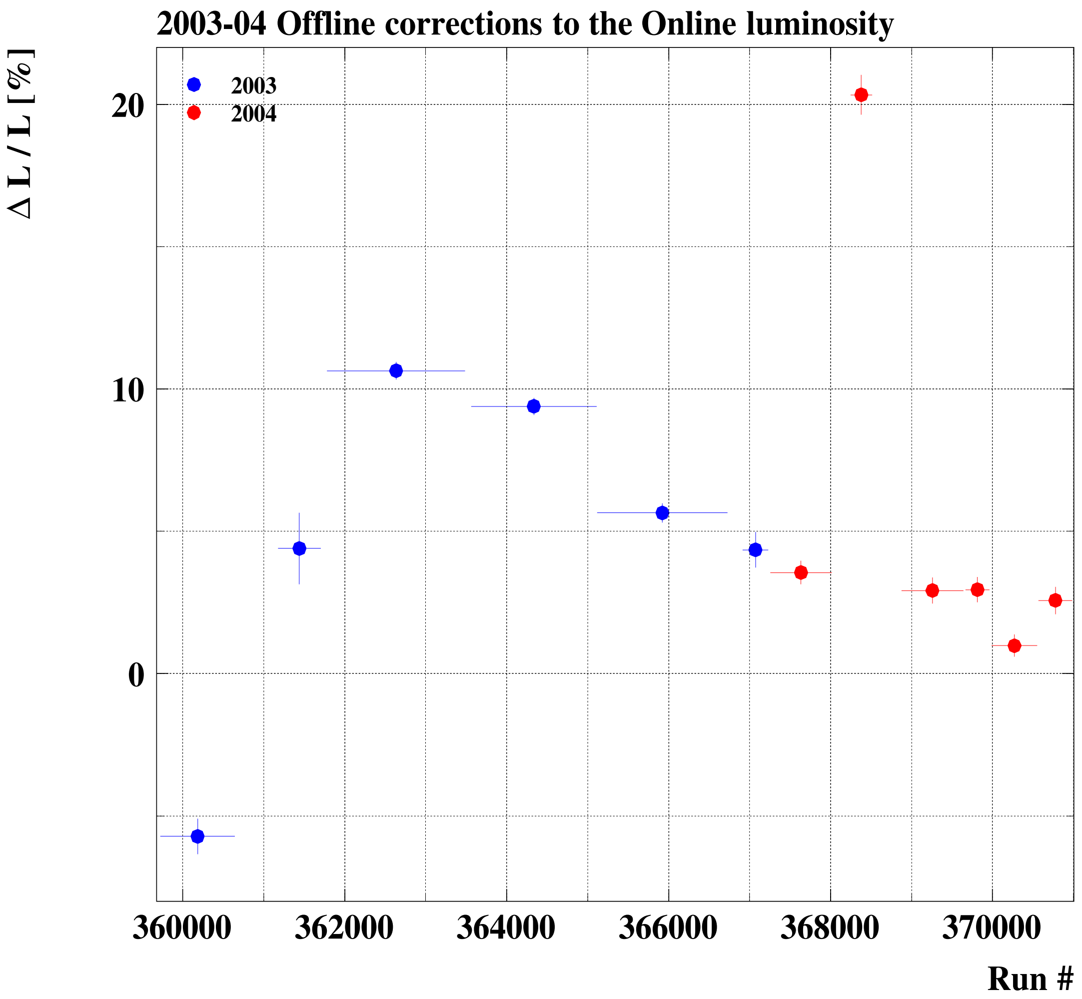
Remark: Previuos high value in N03 now revised

2004 Data Samples
Preliminary

Data Samples	N01	N02	N03	N04	N05	N06
Date	02.01.04 08.01.04	10.01.04 12.01.04	15.01.04 21.01.04	21.01.04 26.01.04	26.01.04 31.01.04	31.01.04 05.02.04
Run Range	367253 368017	368249 368510	368874 369641	369664 369961	369989 370550	370568 370984
N_{s91}^{tot}	162290	56981	133185	145973	186143	121270
$<\mathrm{L}>[10^{30} s^{-1} cm^{-2}]$	7.60	7.90	8.70	8.30	8.60	10.90
A_{PD}^{MC}	0.966	0.969	0.967	0.975	0.973	0.968
S91 Trig.Eff.	0.9945	0.9928	0.9949	0.9912	0.9823	0.9939
Trig.Screen.Eff.	0.1047	0.1231	0.1157	0.1156	0.1172	0.1572
$(1 - \delta_{2\gamma})$ pile-up	0.9715	0.9710	0.9692	0.9700	0.9693	0.9650
$\mathcal{L}$(LH1R)[nb^{-1}]	1157.47	435.51	1010.38	1222.75	1367.21	1107.69
$\mathcal{L}_{off}$[nb^{-1}]	1198.55	524.08	1039.87	1258.80	1380.65	1136.14
$\Delta\mathcal{L}/\mathcal{L}$ [%]	3.55$\pm$0.41	20.34$\pm$0.70	2.92$\pm$0.46	2.95$\pm$0.45	0.98$\pm$0.39	2.57$\pm$0.48

Remark: The 20.34% in N02 are understood!
(negative pedestals)

LUMI 2003-2004
Preliminary!



Samples	online (LH1R) $\mathcal{L}$ [nb^{-1}]	offline $\mathcal{L}$ [nb^{-1}]	$\Delta\mathcal{L}/\mathcal{L}$ [%]
2003	3482	3678	5.6
2004	6301	6538	3.8