Beam Quality Check with EPICS data analysis

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PRIMEX note 71

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Abstract

PrimEx-2 beam quality was checked by EPICS data analysis (PGP and BPM) for pi0 production runs. T-counters timing was also checked for stability. Data base with beam parameters was created. Run intervals with parameters out of normal values have to be eliminated from analysis. Beam current and position stability will be analyzed using this data base. PGP and BPM data appears to be correlated with each other.

1. Beam Parameters Monitoring.

The beam position is one of many experimental factors in PrimEx-2 that must be closely monitored in order to achieve the desired precision. It this chapter information about beam position and current measured by PGP and BPM is presented.

Typical amplitude distribution in pgp X and Y shown on Fig. 1. Such distributions were fitted for each EPICS event using double Gaussian distribution with linear background.

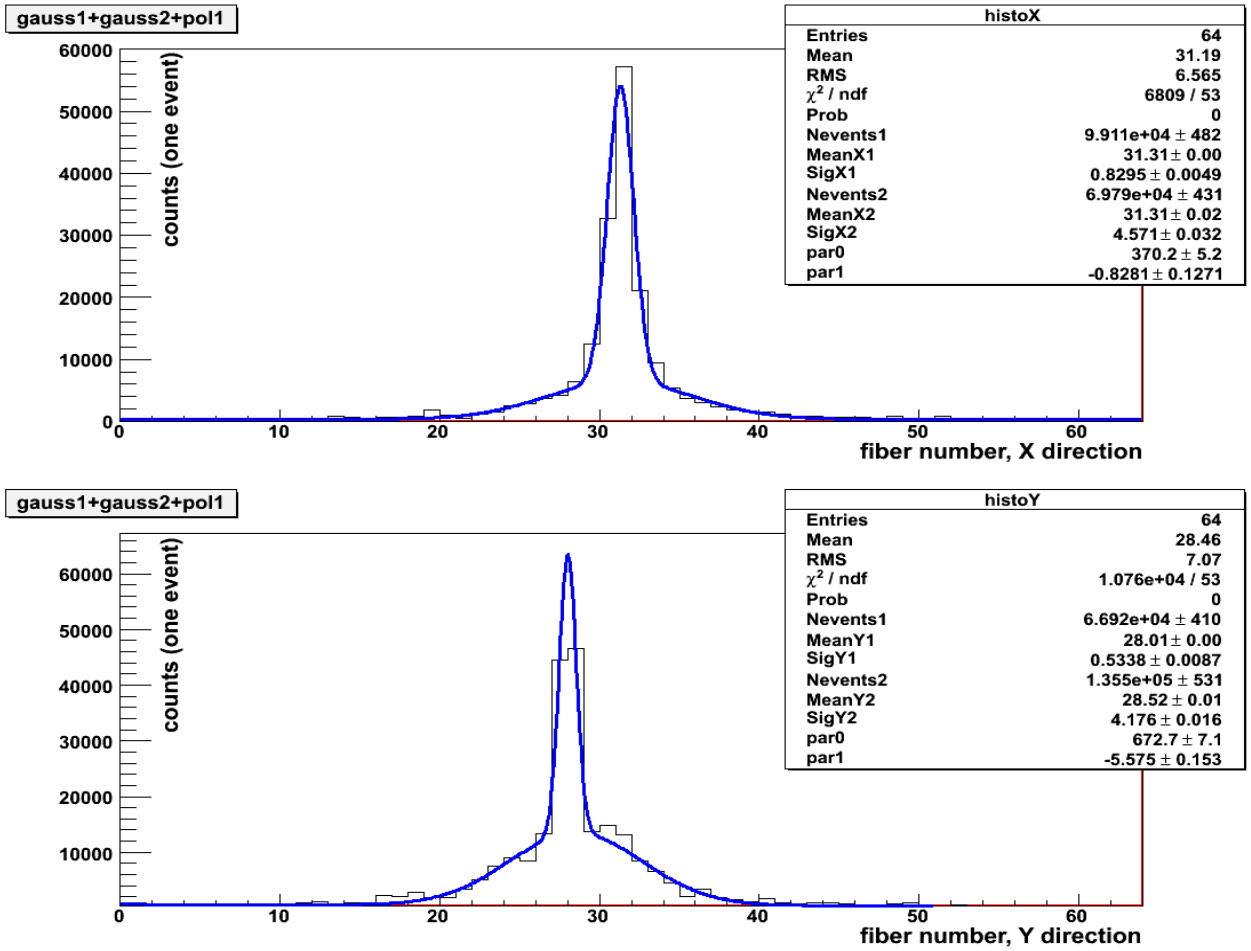

Fig. 1. pgp amplitude distribution for one EPICS event (top – X, bottom - Y).

Gain factors [1] were applied to the counts read from EPICS. After fitting, all parameters were converted from channel number into X or Y coordinates in millimeters using formulas [1]:

$$x = (\text{channel\#} - 30) \cdot 2 \cdot (-1) \qquad (1)$$

$$y = (\text{channel\#} - 31) \cdot 2 \qquad (2)$$

On program level channel enumeration starts from 0, but in enumeration used in [1] it starts from 1. So values 29 and 30 were actually used in formulas (1) and (2). Factor "-1" in formula (1) shows that pgp X axis has opposite to Hall-B direction.

Behavior of each fit parameter as a function of event number for run 64784 shown on

figures #1-7.

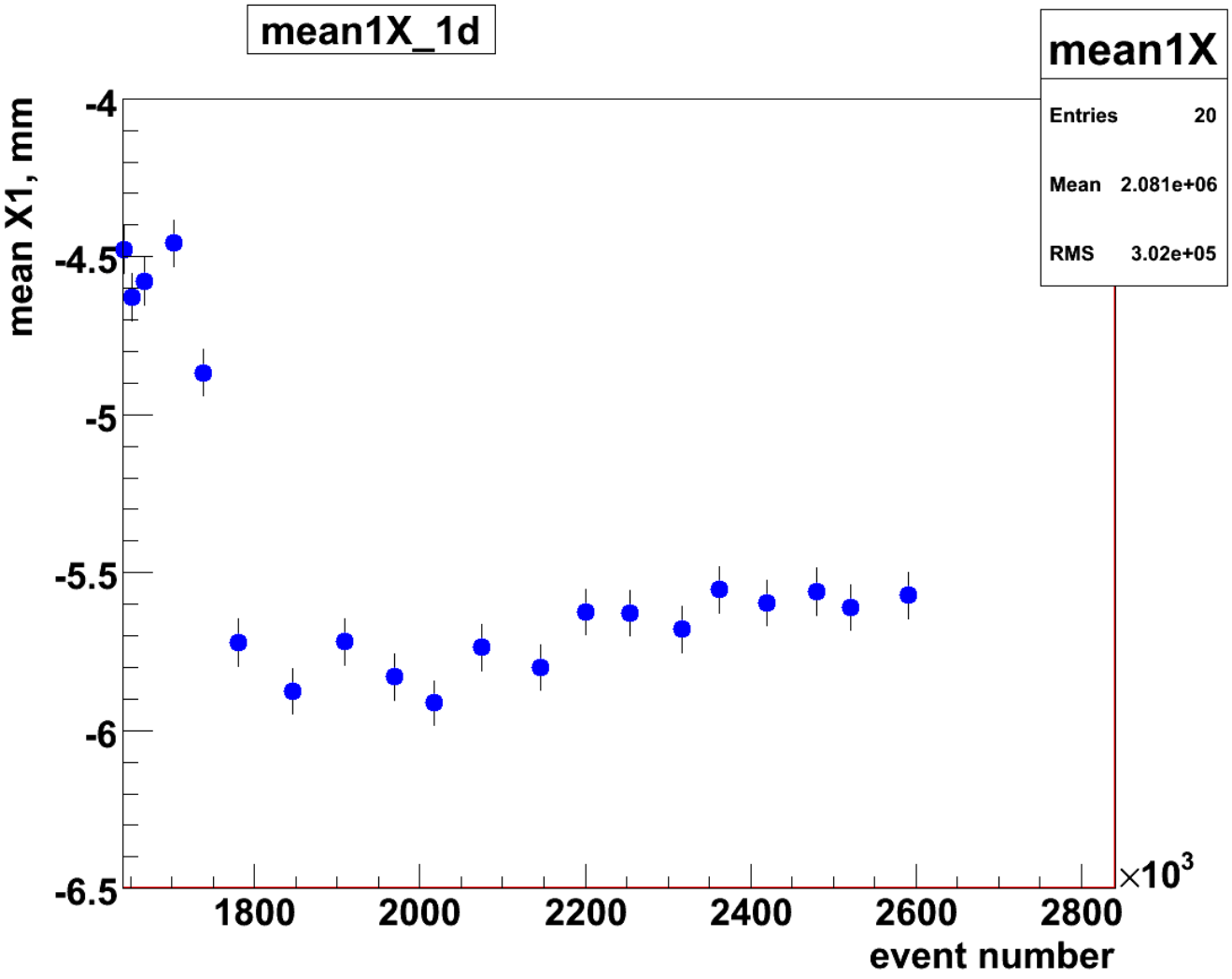

Fig. 2. X of narrow Gauss in the fit versus event number.

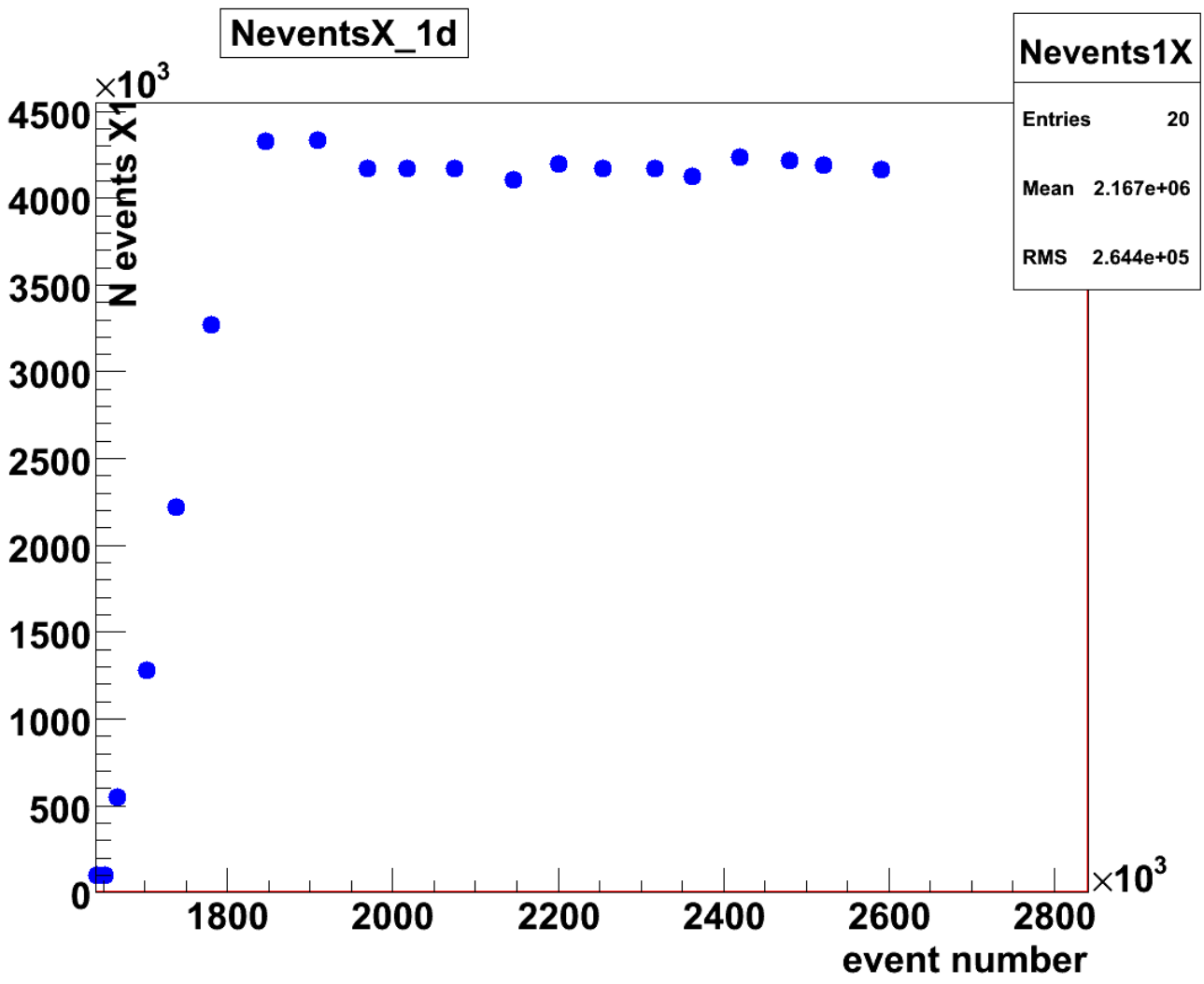

Fig. 3. Integral of the narrow Gaussian in x direction versus event number.

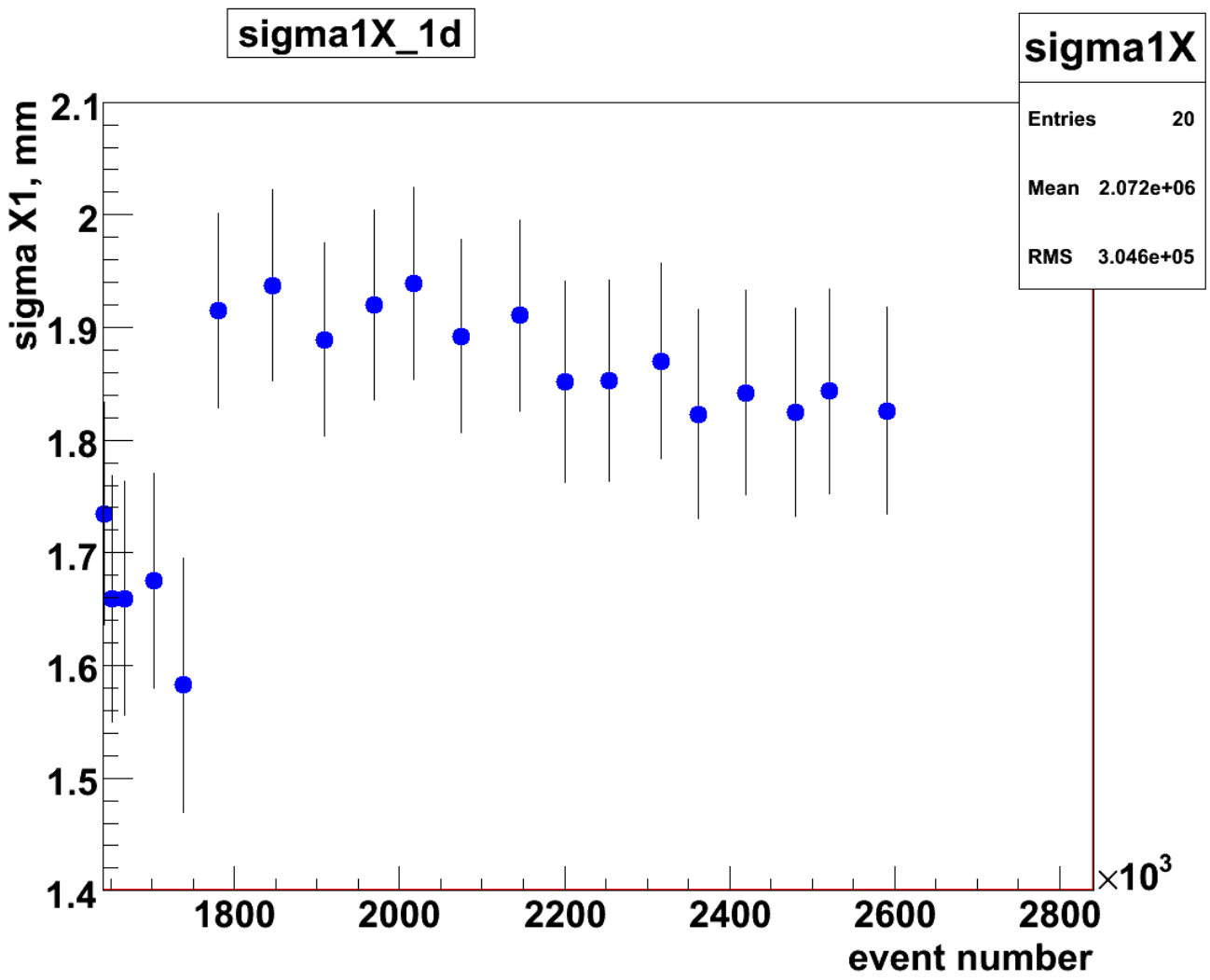

Fig. 4. Sigma X of the narrow Gauss versus event number.

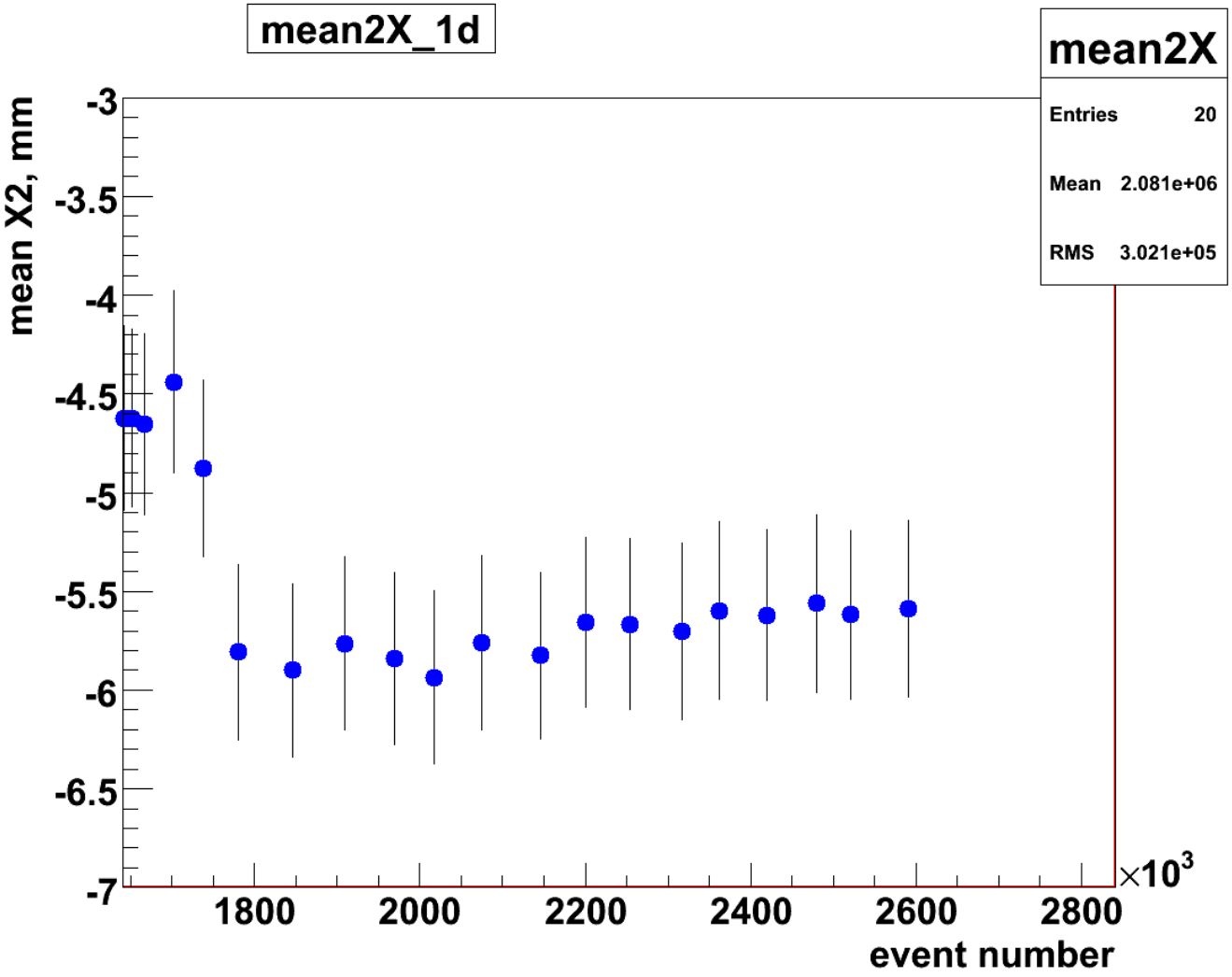

Fig. 5. Center X of wider Gauss versus event number.

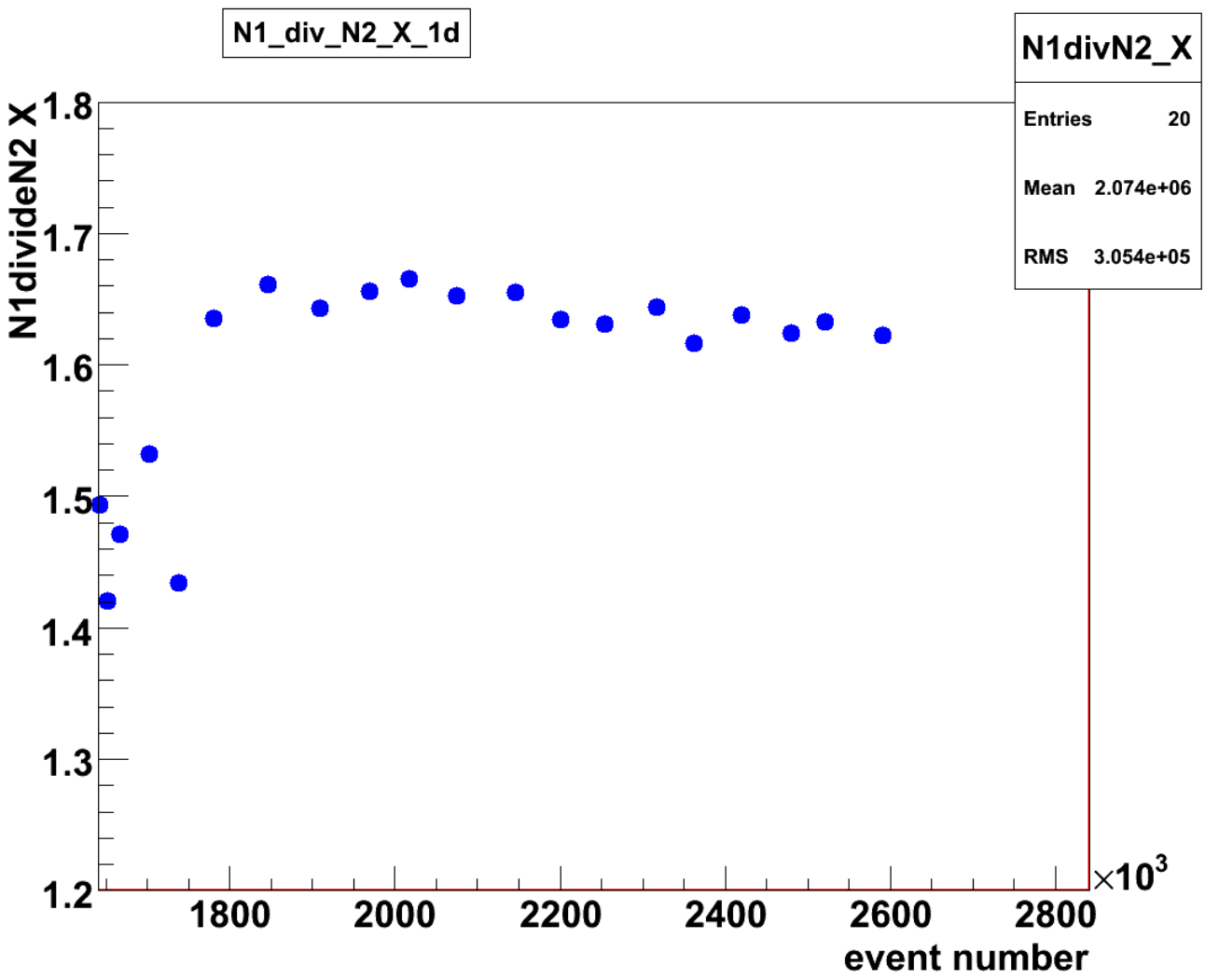

Fig. 6. Ratio of integral under narrow Gaussian to the integral under wider Gaussian (N_{1X}/N_{2X}) versus event number (X direction).

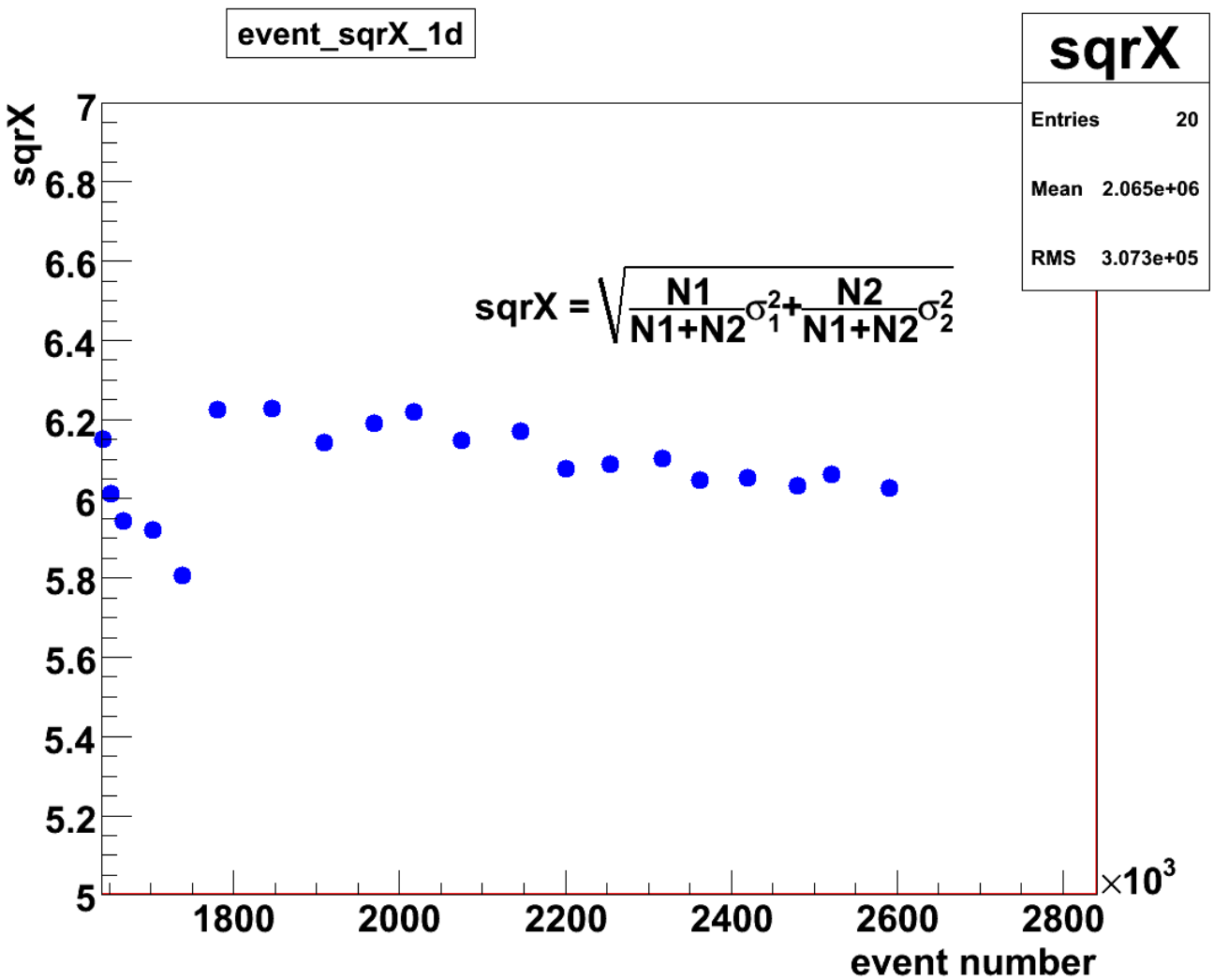

Fig. 7. Mean width of double Gauss fit ($<\sigma_x>$) versus event number .

For Y direction plots look similar to X ones.

Beam current, X and Y coordinates in BPM presented on figures #8-9.

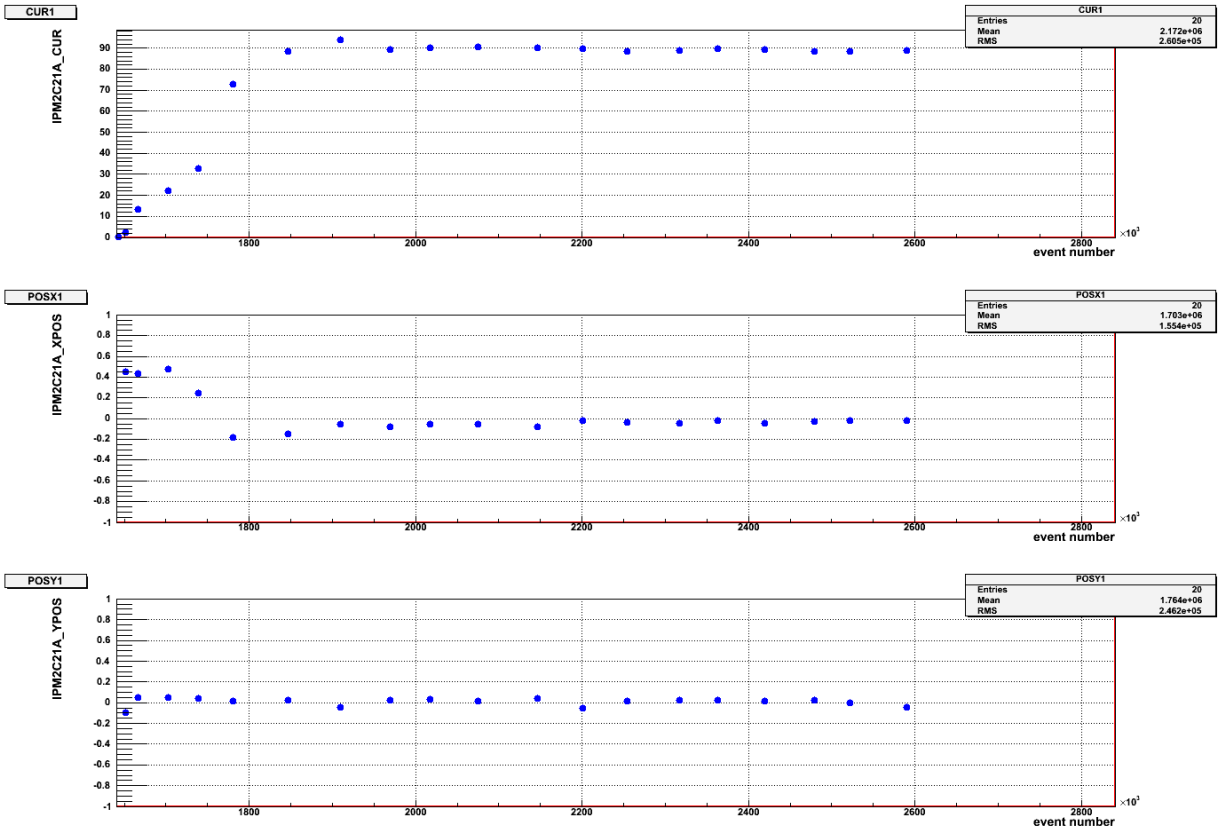

Fig. 8. Beam current (top), X(middle) and Y(bottom) position in electron BPM versus event number.

On fig. 8 horizontal axis – event number, vertical – value of variables:

top - IPM2C21A_CUR

middle - IPM2C21A_XPOS

bottom - IPM2C21A_YPOS

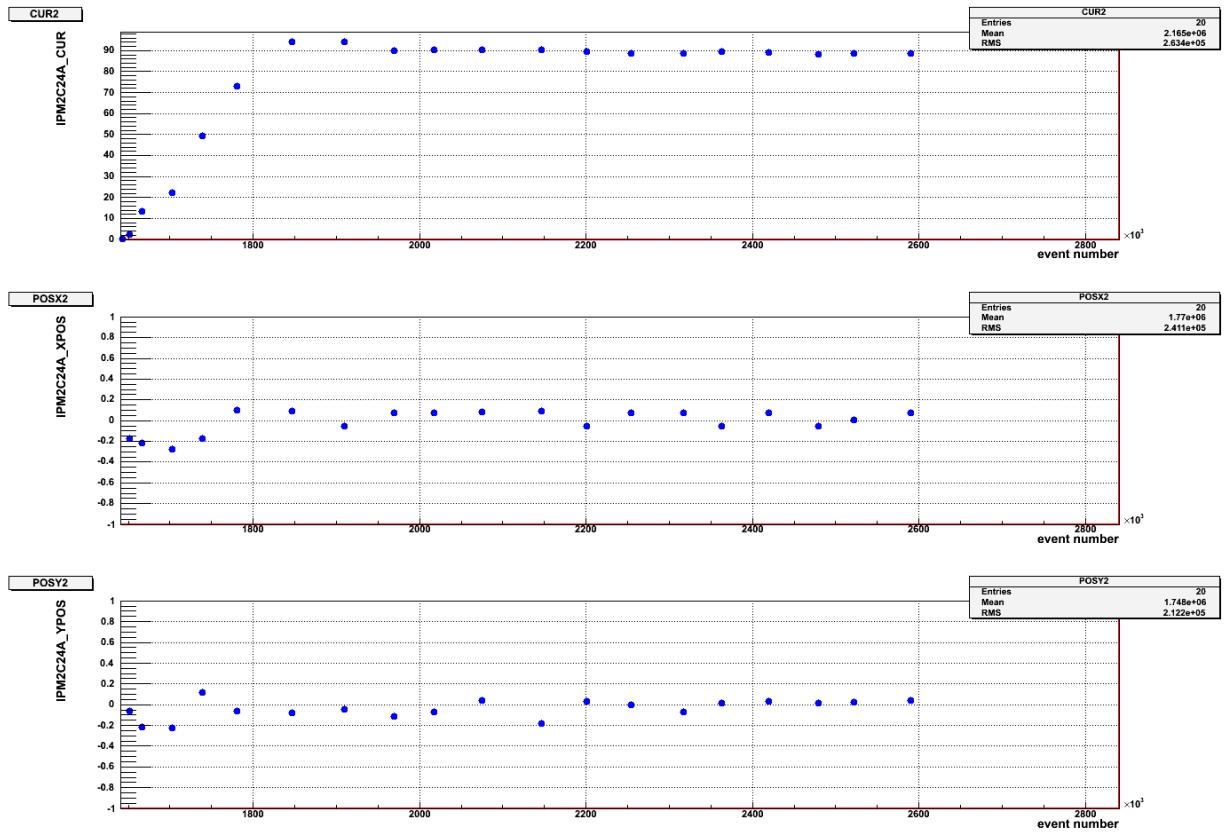

Fig. 9. Beam current (top), X(middle) and Y(bottom) position in electron BPM versus event number.

On fig. 9: horizontal axis – event number, vertical – value of variables:

top - IPM2C24A_CUR

middle - IPM2C24A_XPOS

bottom - IPM2C24A_YPOS

Mean X and Y of main Gauss, $<\sigma_X>$ and $<\sigma_Y>$, $(N_{1X}+N_{2X})$/ IPM2C21A_CUR, $(N_{1X} + N_{2X})/(N_{1Y}+N_{2Y})$ dependence on run number presented on figures #10-14.

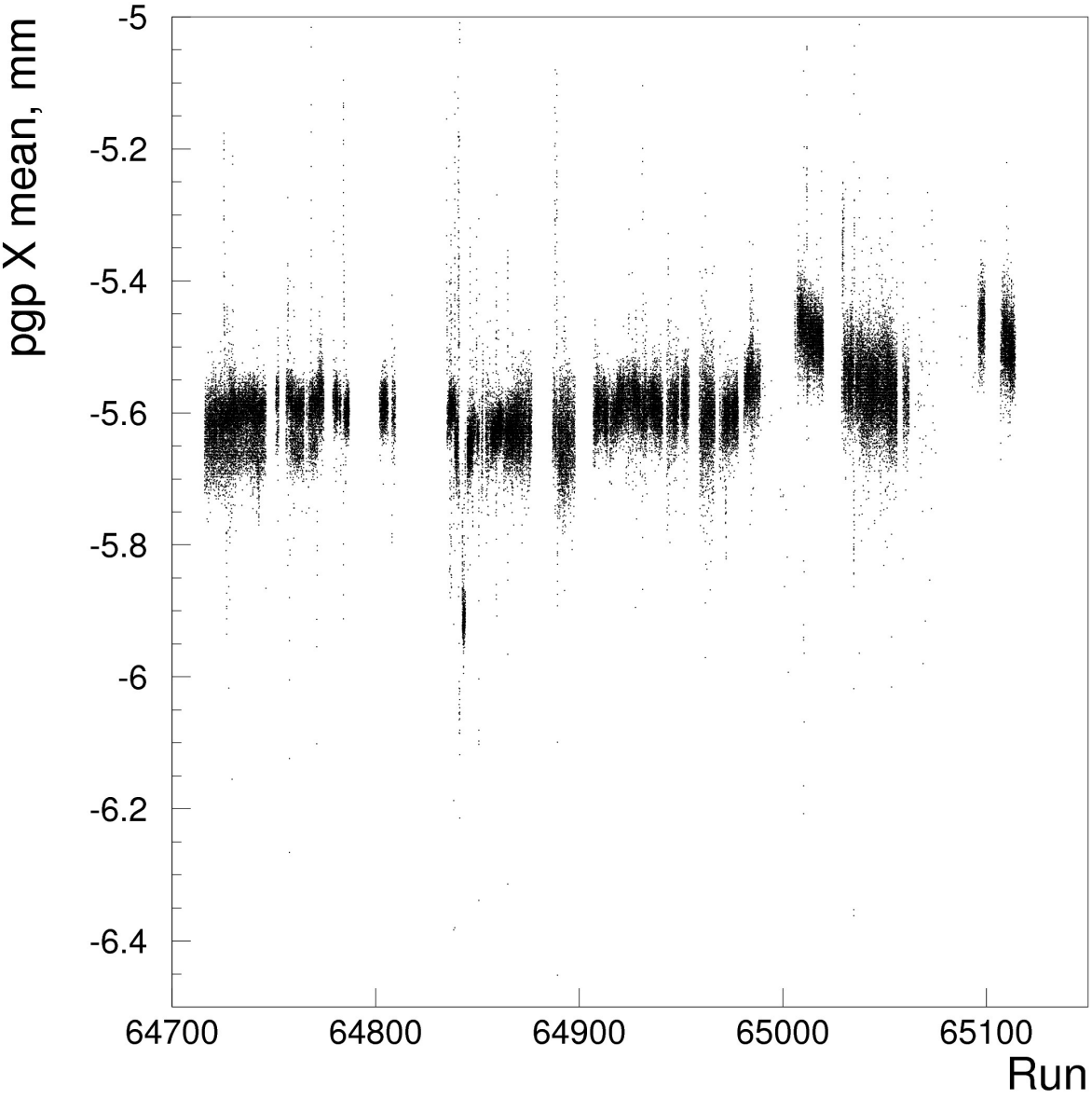

Fig. 10. X of main (more narrow) Gauss versus run number.

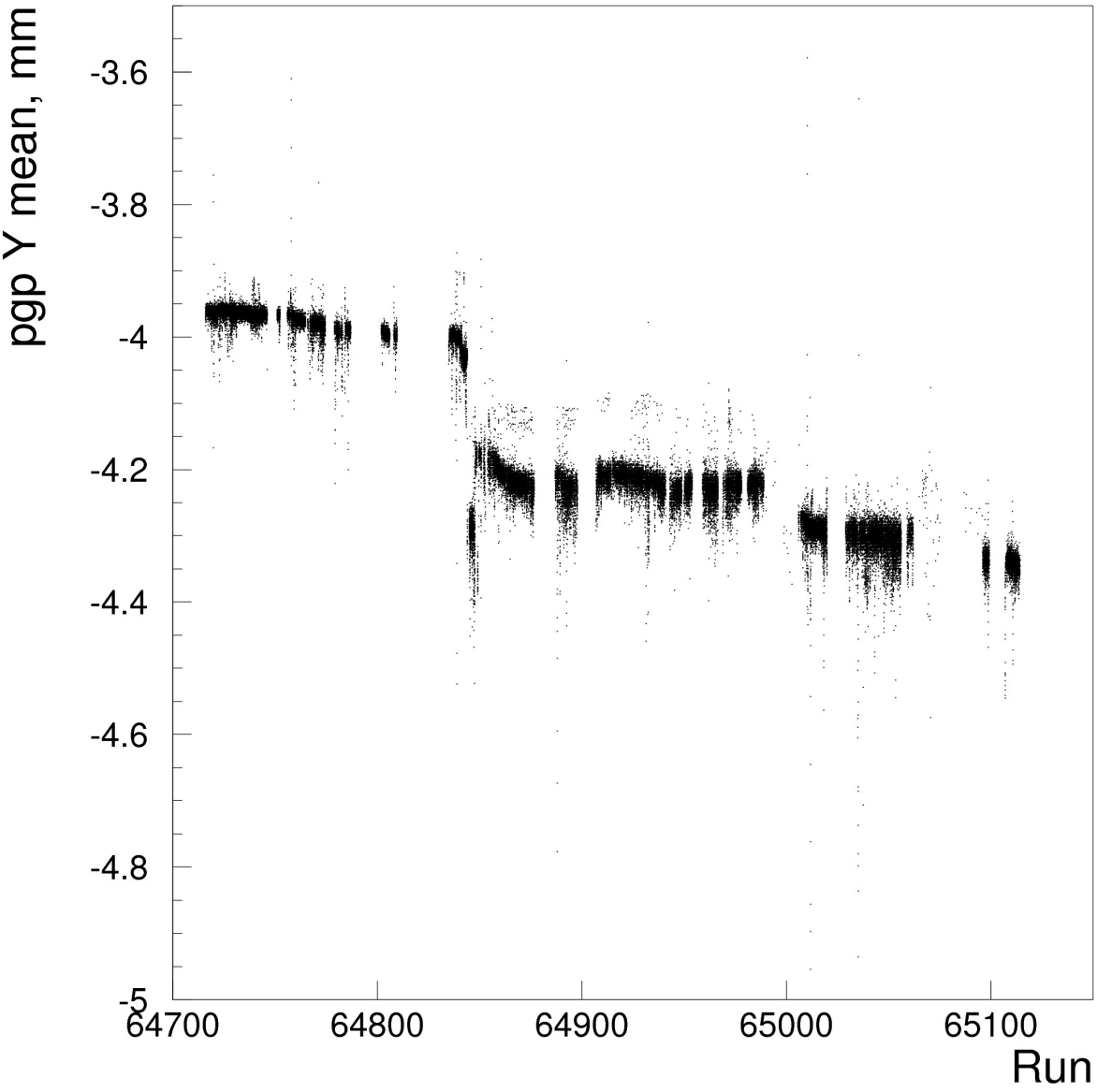

Fig. 11. Y of main (more narrow) Gauss versus run number.

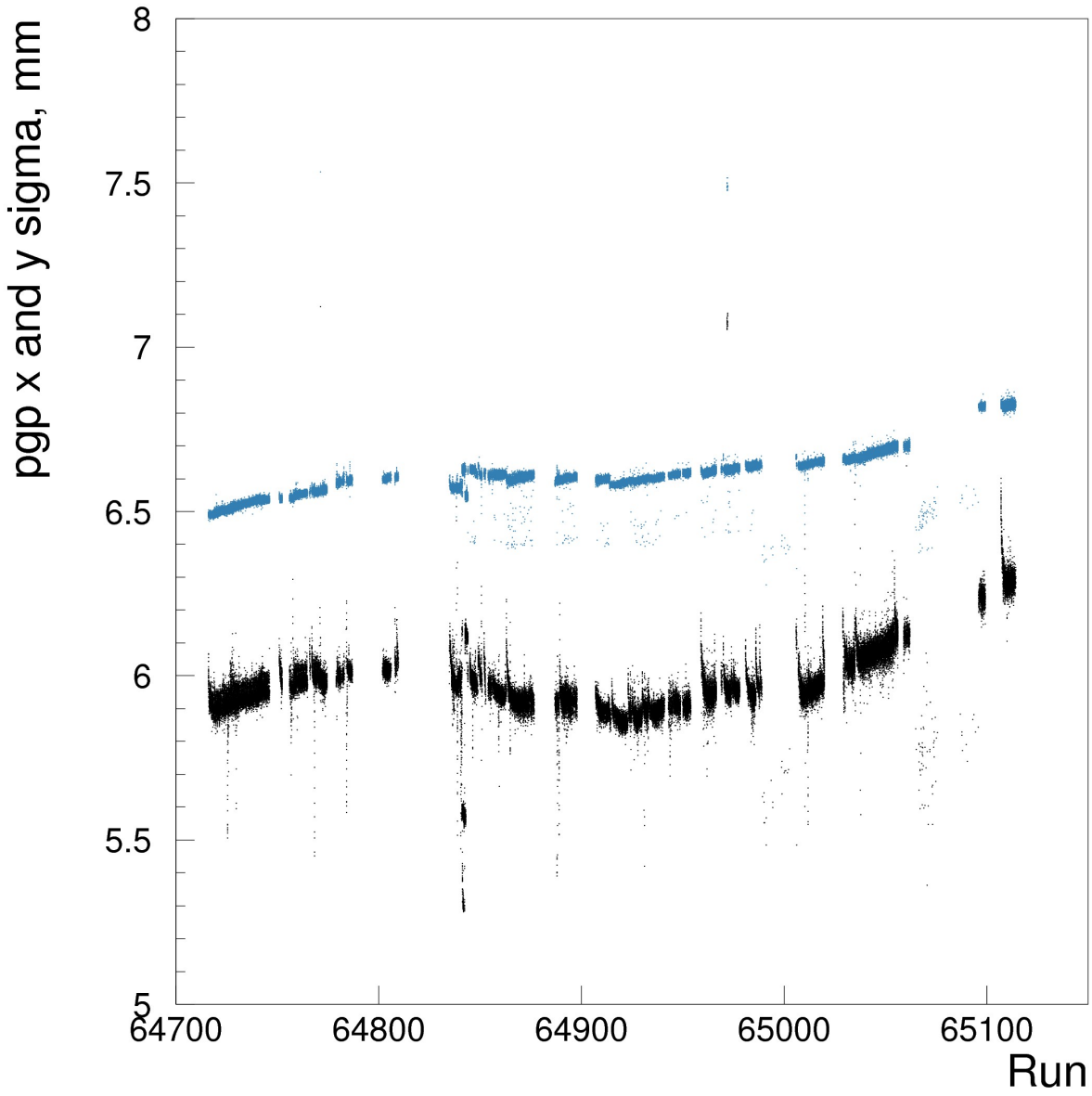

Fig. 12 . $<\sigma_X>$ (bottom) and $<\sigma_Y>$ (top) versus run number.

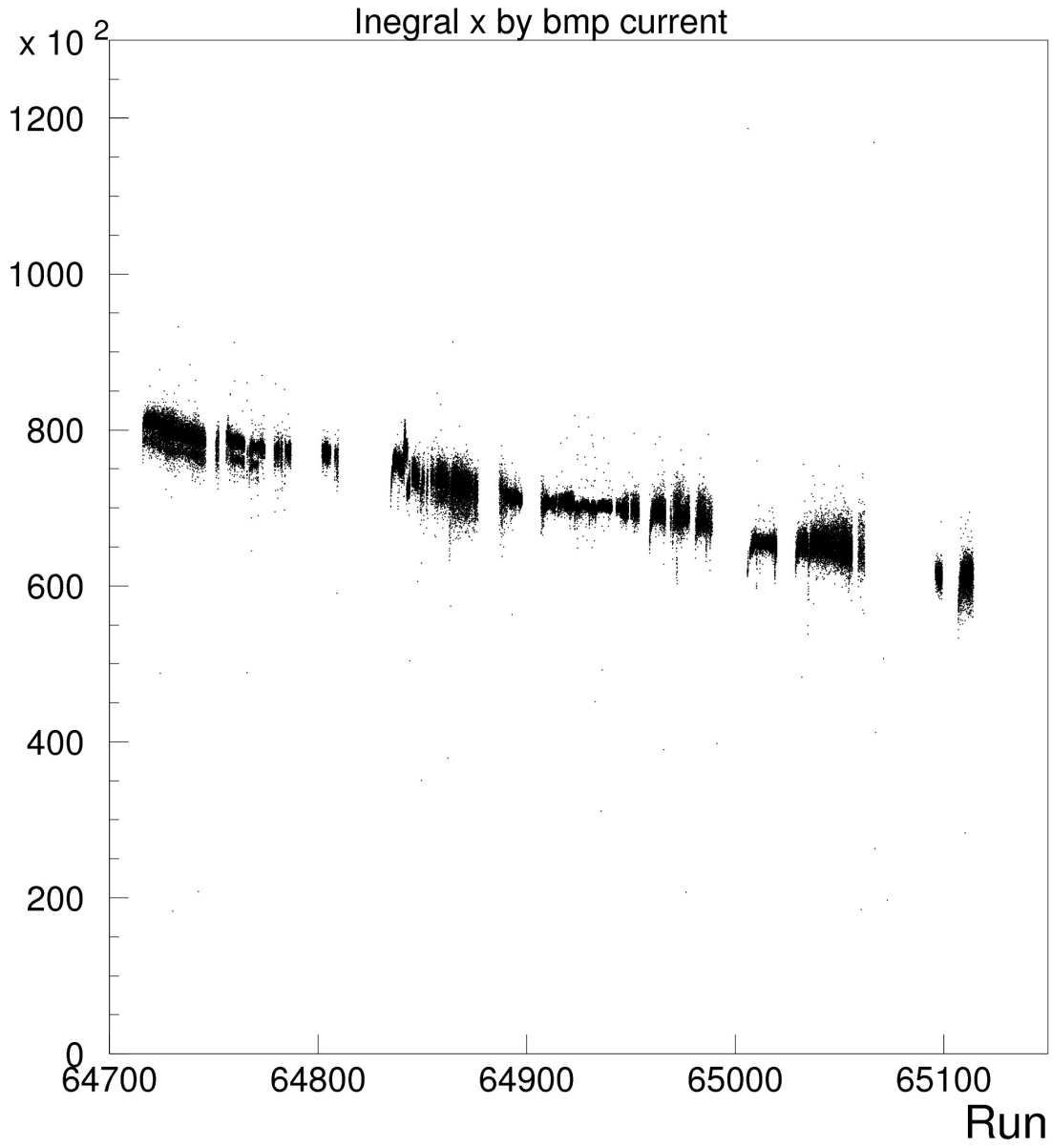

Fig. 13. Integral of two Gaussian fit normalized to beam current read from BPM $(N_{1X}+N_{2X})$/IPM2C21A_CUR versus run number.

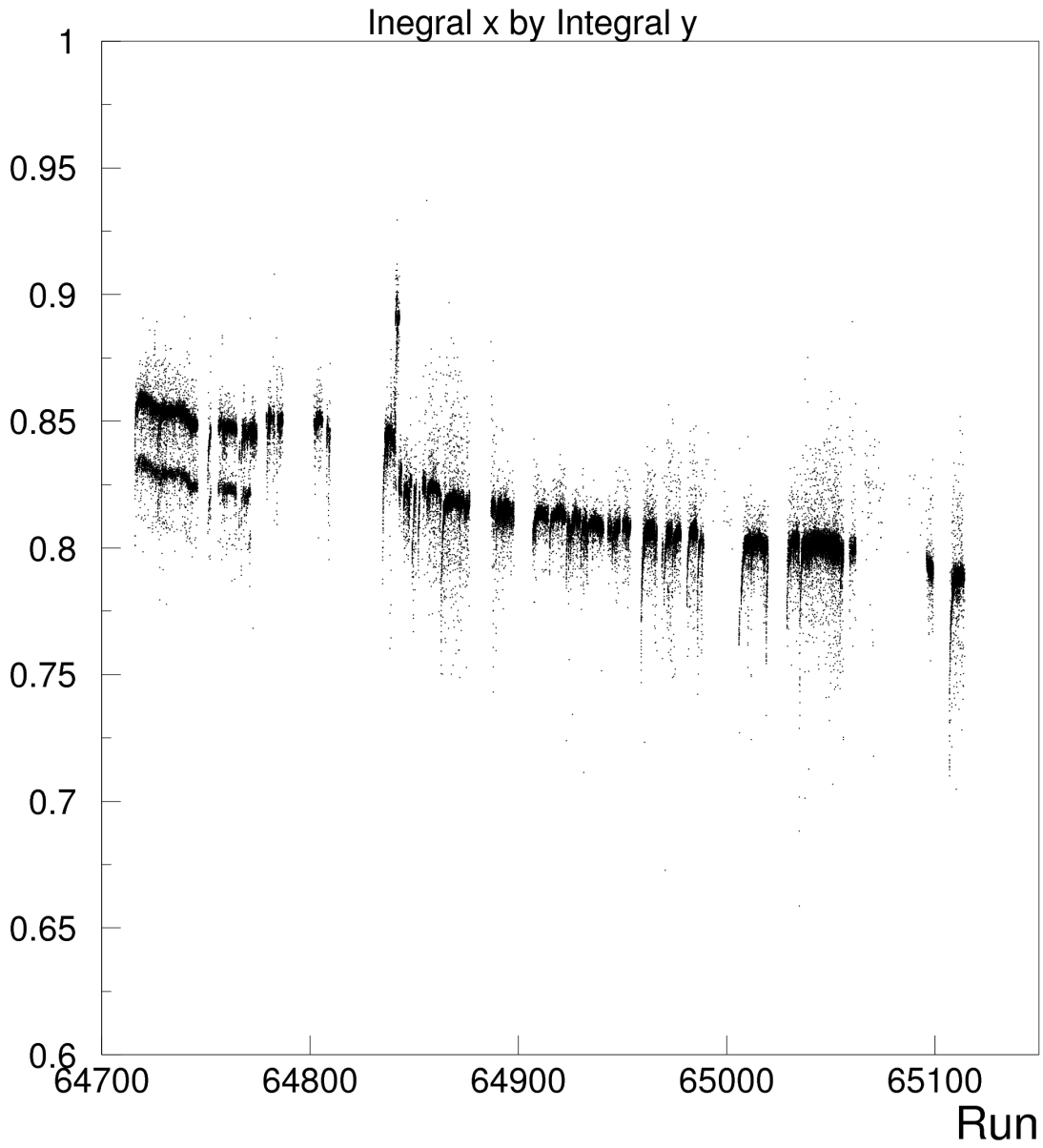

Fig. 14. Integral of two Gaussian in X direction divided to the integral in Y direction $(N_{1X} + N_{2X})/(N_{1Y}+N_{2Y})$ versus run number.

In figure #11 in the area between runs 64800 and 64900 one can see the shift of beam position measured by pgp. Review of the logbook [2] shows comment that "beam position and tagger beam spot was changed" in run number 64843.

Figures #15 and #16 show how pgp amplitude distribution looks before (#15) and after (#16) that run.

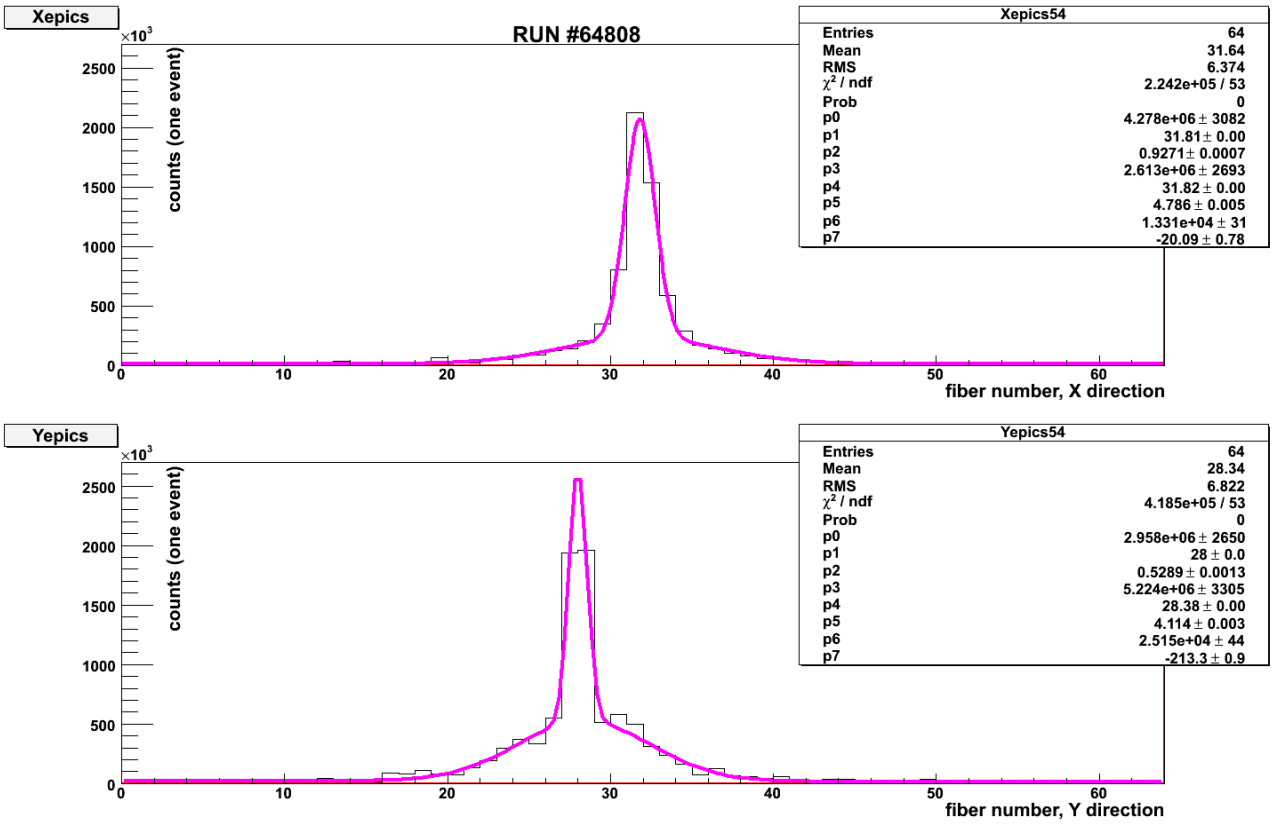

Fig. 15. pgp amplitude distribution for one EPICS event in run number 64808 (top -X, bottom -Y).

MeanX1(narrow) – 31.81, MeanY1(narrow) – 28.00;
MeanX2(wide) – 31.82, MeanY2(wide) – 28.38;

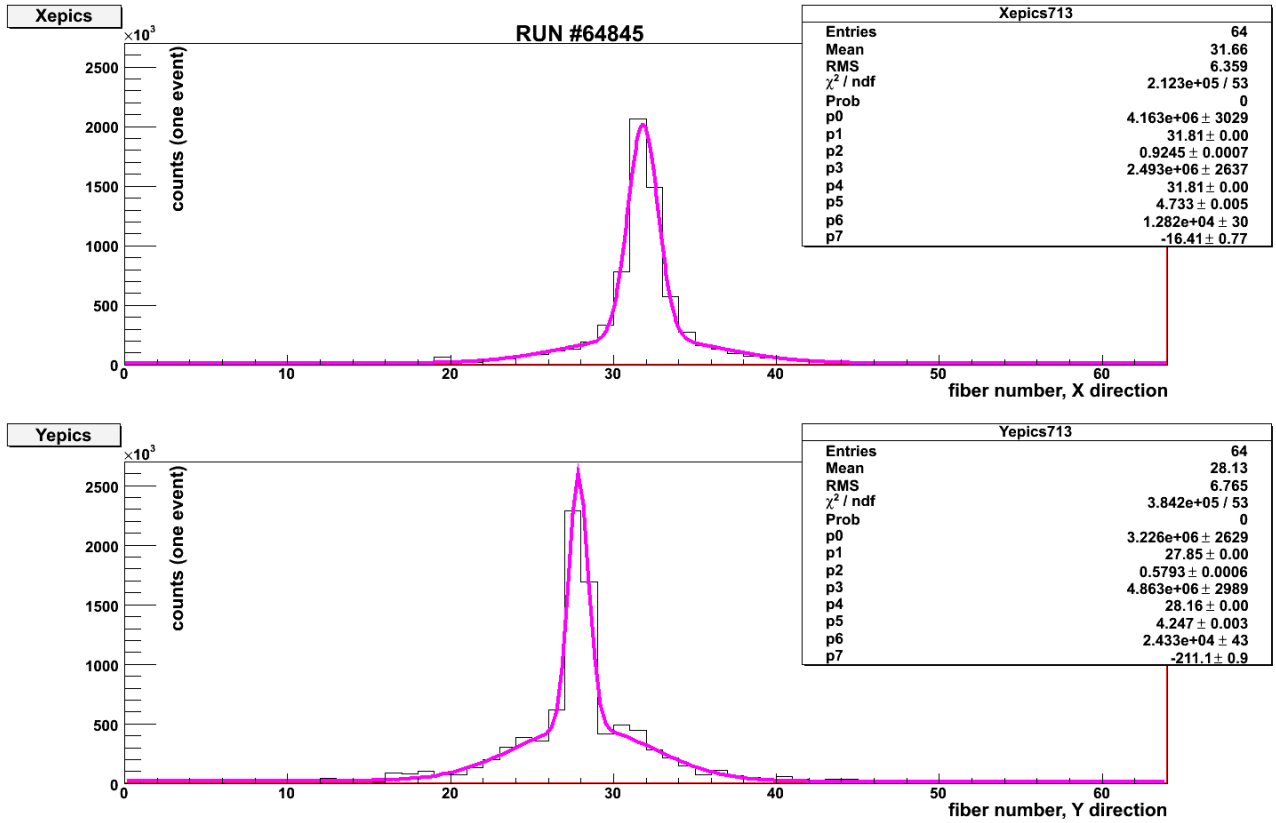

Fig. 16. pgp amplitude distribution for one EPICS event in run number 64845 (top -X,bottom -Y).

MeanX1(narrow)- 31.81, **MeanY1(narrow) – 27.85;**
MeanX2(wide) – 31.81, **MeanY2(wide) – 28.16;**

It is noticeable from figures #15 and #16 that shape of distribution in Y direction differs for these runs.

In the data were found some EPICS events with identical numbers and (or) incomplete EPICS pgp/bpm information. These events were written in the data base. They will be excluded in the further analysis.

2. **T-counters timing stability.**

Figures #17 and #18 show typical difference between right and left time for each T-counter (T1-T19). It was calculated as an average value for each 3K events. It is plotted in conjunction with RMS shown as error bars. For T-counter T16 instead of

right-left time difference only right value was used, because there are no values for left part for this counter. For this analysis banks TAGTRHIT and TAGTLHIT were used.

Cuts applied to select events for this analysis:

Absolute Value of (Time_right – Time_left) < 5.0;

for T-counter #16 Absolute Value (Time_right) < 5.0;

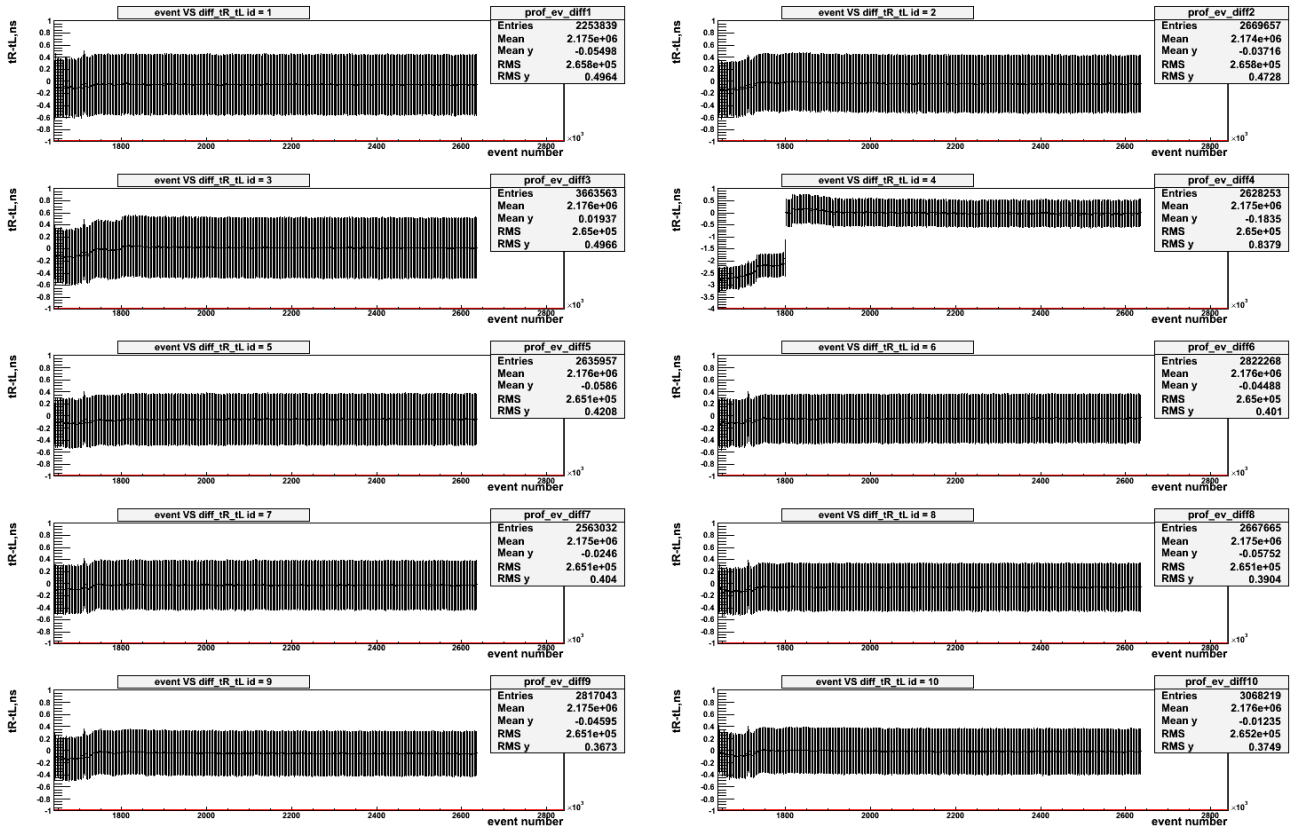

Fig. 17. Difference between Right and Left time for T-counters T1-T10 vs event number(for one data file primex2_064784.dat.001).

The “problem” area is clearly seen on fig. 17 and 18 for first events in these plots. The data has been searched for such intervals to ensure stable work of all T counters.

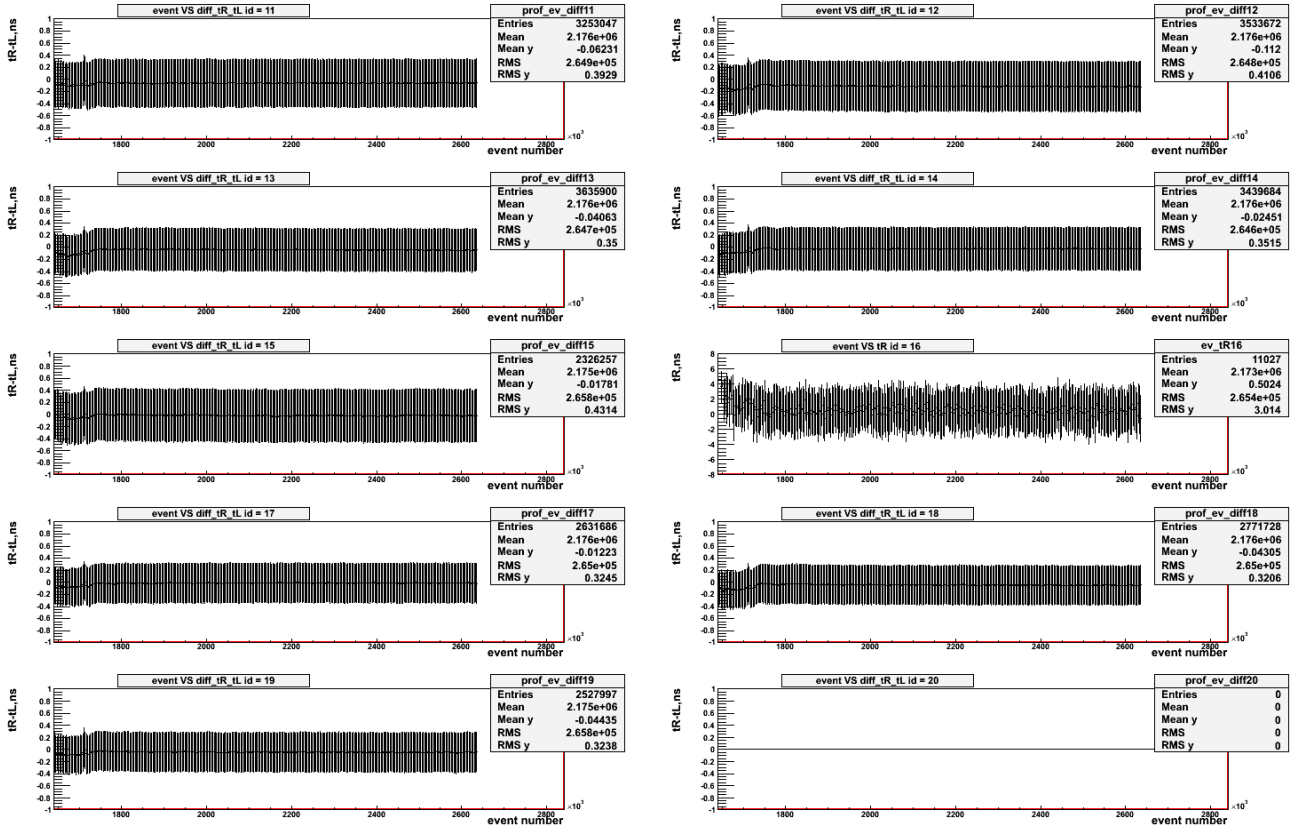

Fig. 18. Difference between Right and Left time for T-counters T11-T19 vs event number (for one data file primex2_064784.dat.001).

3. Data Base Structure.

Tables #1 and #2 present structure PGP and BPM data from EPICS banks which was used to write data in the data base. If there are no pgp or bpm events in EPICS banks, 0.000 values were written. For right and left T-counter time difference data base contains the following values: run number, event number (last event in interval), T-counter id, right and left time difference and its RMS. If there are no events in TAGTRHIT/TAGTLHIT banks for the interval, 0.000 values were written.

Table #1. PGP INFO

RUN
EVENT
N_{X1}
$<X_1>$
ΔX_1
σ_{X1}
$\Delta\ \sigma_{X1}$
$< X_2>$
ΔX_2
σ_{X2}
$\Delta\ \sigma_{X2}$
N_{X1}/N_{X2}
$<\sigma_X>$
$\chi^2{}_X$
N_{Y1}
$<Y_1>$
ΔY_1
σ_{Y1}
$\Delta\ \sigma_{Y1}$
$< Y_2>$
ΔY_2
σ_{Y2}
$\Delta\ \sigma_{Y2}$
N_{Y1}/N_{Y2}
$<\sigma_Y>$
$\chi^2{}_Y$

*$<\sigma_x> = \mathrm{sqrt}((N_{X1} \cdot \sigma_{X1}{}^2 + N_{X2} \cdot \sigma_{X2}{}^2)/(N_{X1} + N_{X2}))$;
*$<\sigma_y> = \mathrm{sqrt}((N_{Y1} \cdot \sigma_{Y1}{}^2 + N_{Y2} \cdot \sigma_{Y2}{}^2)/(N_{Y1} + N_{Y2}))$;

Table #2. BPM INFO.

IPM2C21A_CUR
IPM2C21A_XPOS
IPM2C21A_YPOS
IPM2C24A_CUR
IPM2C24A_XPOS
IPM2C24A_YPOS

This data will be used together with beam flux analysis and monitoring for elimination of problem events. This data base was stored in mss:

/mss/hallb/primex2/production/epics_and_flux.tar.gz

References

[1] “Photon beam profiler software problems during primexII.” PrimEx note #68.

[2] ”PrimEx II Logbook.” PrimEx note #67.