Bunch-by-bunch Data Analysis of RHIC Polarized Proton Beam

Z. Duan, M. Bai

Dec 13, 2012

Outline

- Motivation
- Data Analysis Method
- Asymmetry analysis
- Bunch Intensity analysis
- Summary

Motivation

- Cause of polarization lifetime is not fully understood.
- Beam-beam contributions to polarization decay?

Data Analysis Method

- Bunch-by-bunch asymmetry data of P-Carbon polarimeter is used.
- Compare bunches with single collisions against bunches with double collisions.
- Statistical combination of asymmetries of bunches with similar conditions of all physics fills.

Flow Chart

Get physics fills and reasonable measurements

Rely on ev-lumi & softev-physics-off tags in Elog, measurements within 15 minutes after physics-off are also included.

Get collision number of each bunch.

Geometric consideration of IPs & bunches from two beams.

Get Asymmetry data from ROOT files.

Follow scripts by Anders to get the L-R asymmetry, and a root script to calculate Sqrt Formula based on hDetVsBunchId histogram in ROOT file.

Combine asymmetry among similar bunches

Remove bunches with unreasonable asymmetry or error bar.

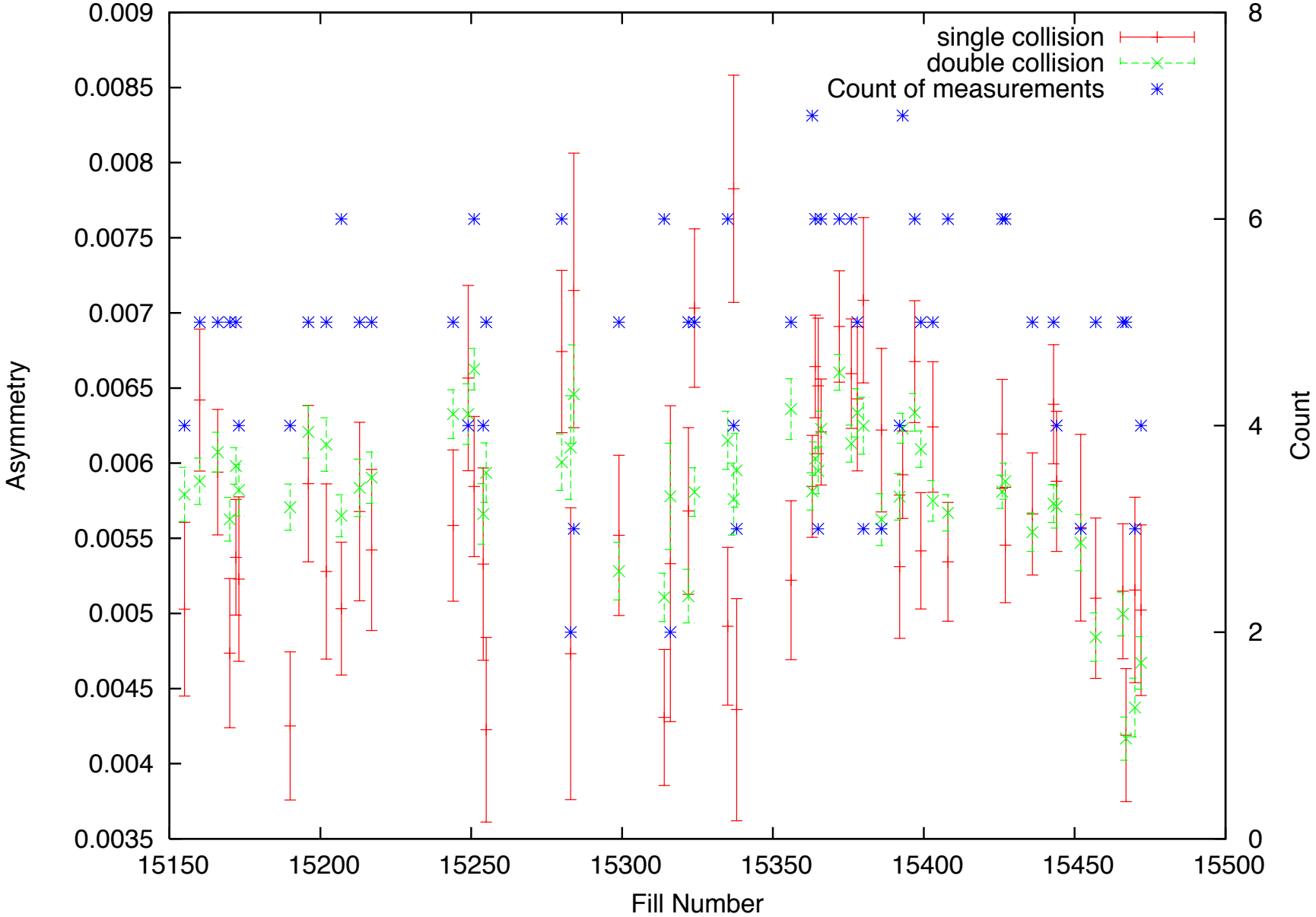
Combine asymmetry among fills

$$< A >= \frac{\sum_i \frac{A_i}{\sigma_{A_i}^2}}{\sum_i \frac{1}{\sigma_{A_i}^2}} \quad \sigma_{<A>} = \frac{1}{\sqrt{\sum_i \frac{1}{\sigma_{A_i}^2}}}$$

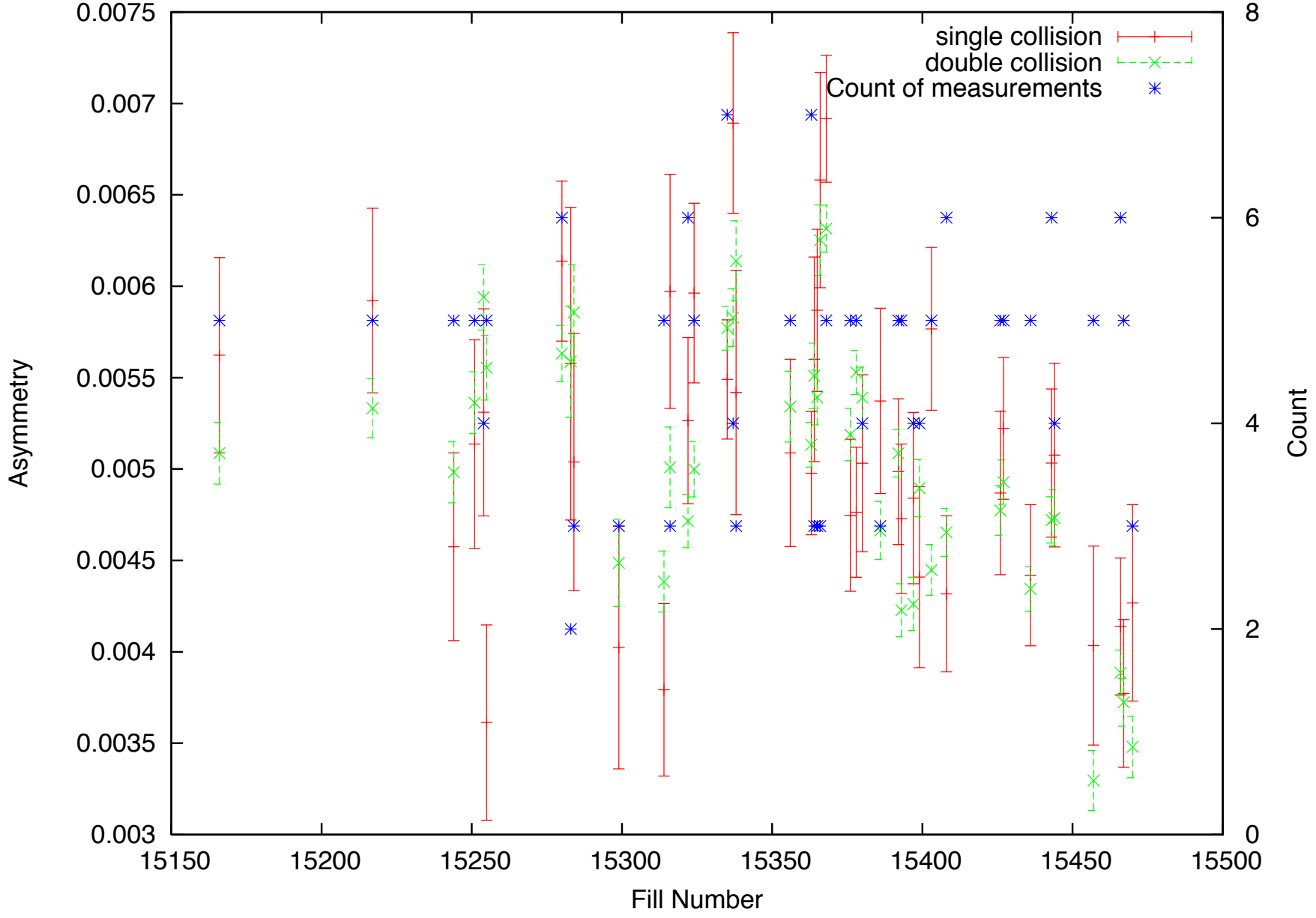
Asymmetry Results

- Run 11 250GeV, Run 12 100GeV and 255GeV
- Blue 2 polarimeter in Run 12 is not included.
- Fill-by-Fill Plots
- Table summary of each run

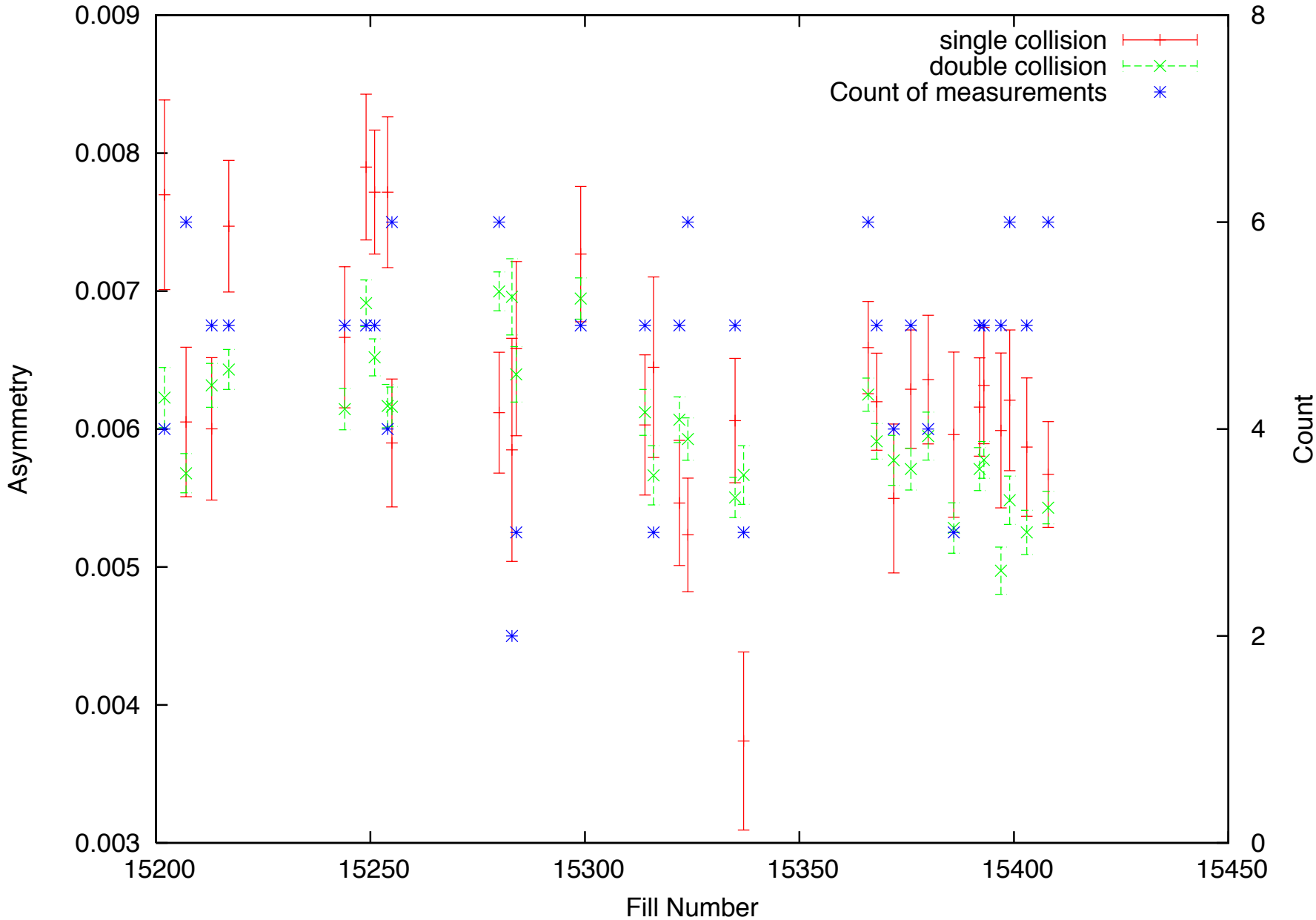
Run II Blue I


single collision
double collision
Count of measurements
Asymmetry
Count
Fill Number
0.009
0.0085
0.008
0.0075
0.007
0.0065
0.006
0.0055
0.005
0.0045
0.004
0.0035
8
6
4
2
0
15150
15200
15250
15300
15350
15400
15450
15500

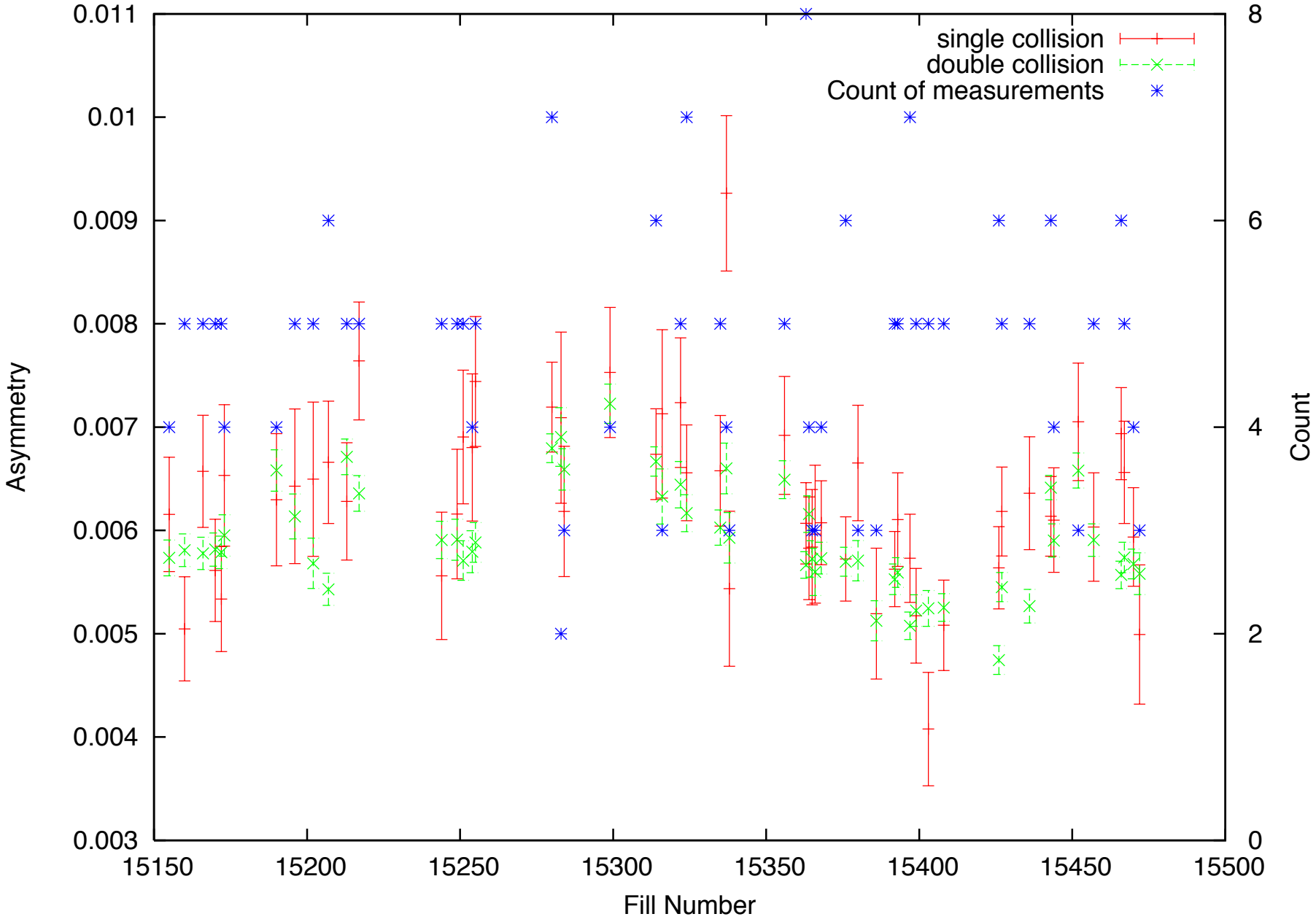
Run 11 Blue 2


single collision
double collision
Count of measurements
Asymmetry
Count
Fill Number
0.0075
0.007
0.0065
0.006
0.0055
0.005
0.0045
0.004
0.0035
0.003
8
6
4
2
0
15150
15200
15250
15300
15350
15400
15450
15500

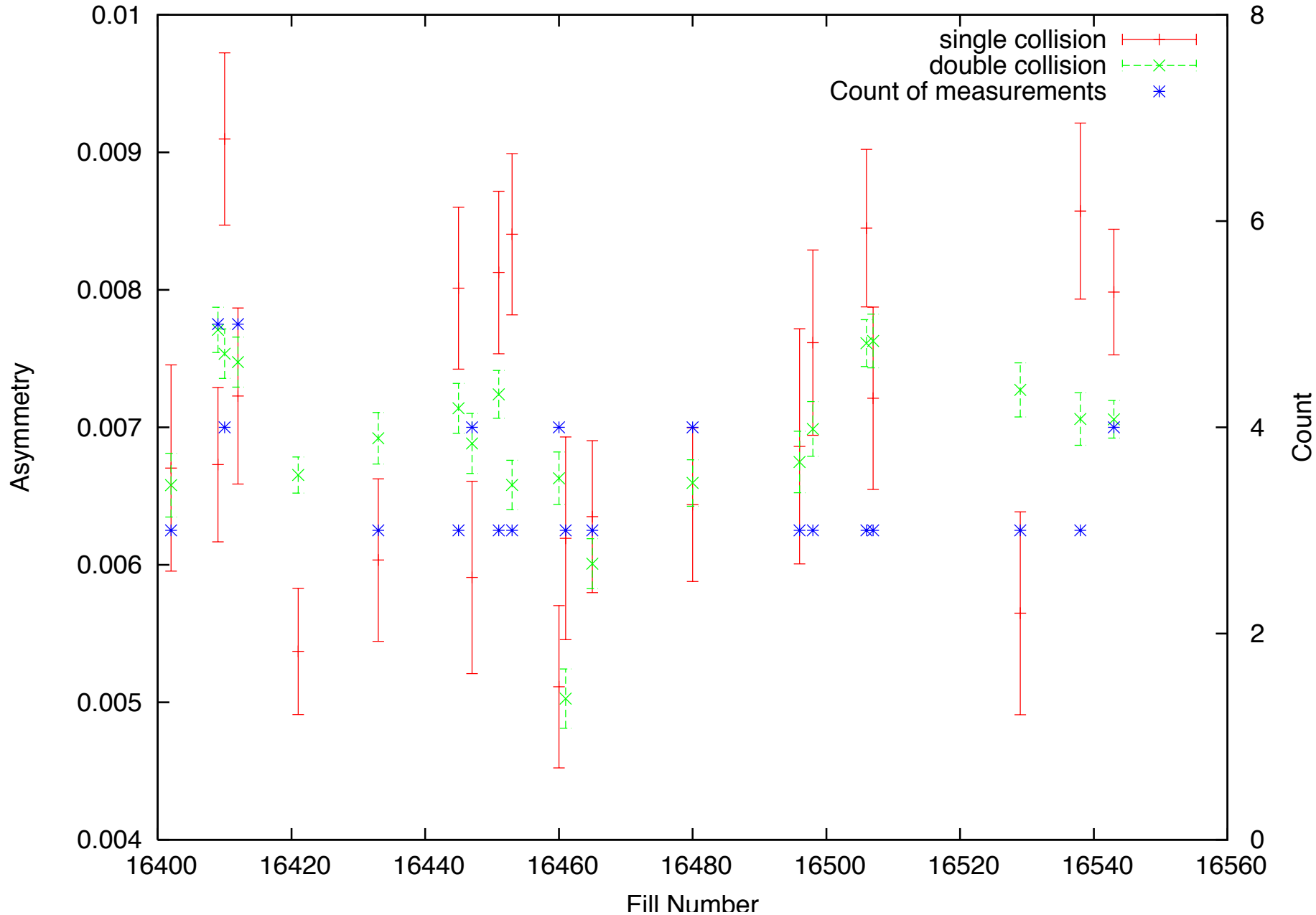
Run 11 Yellow 1



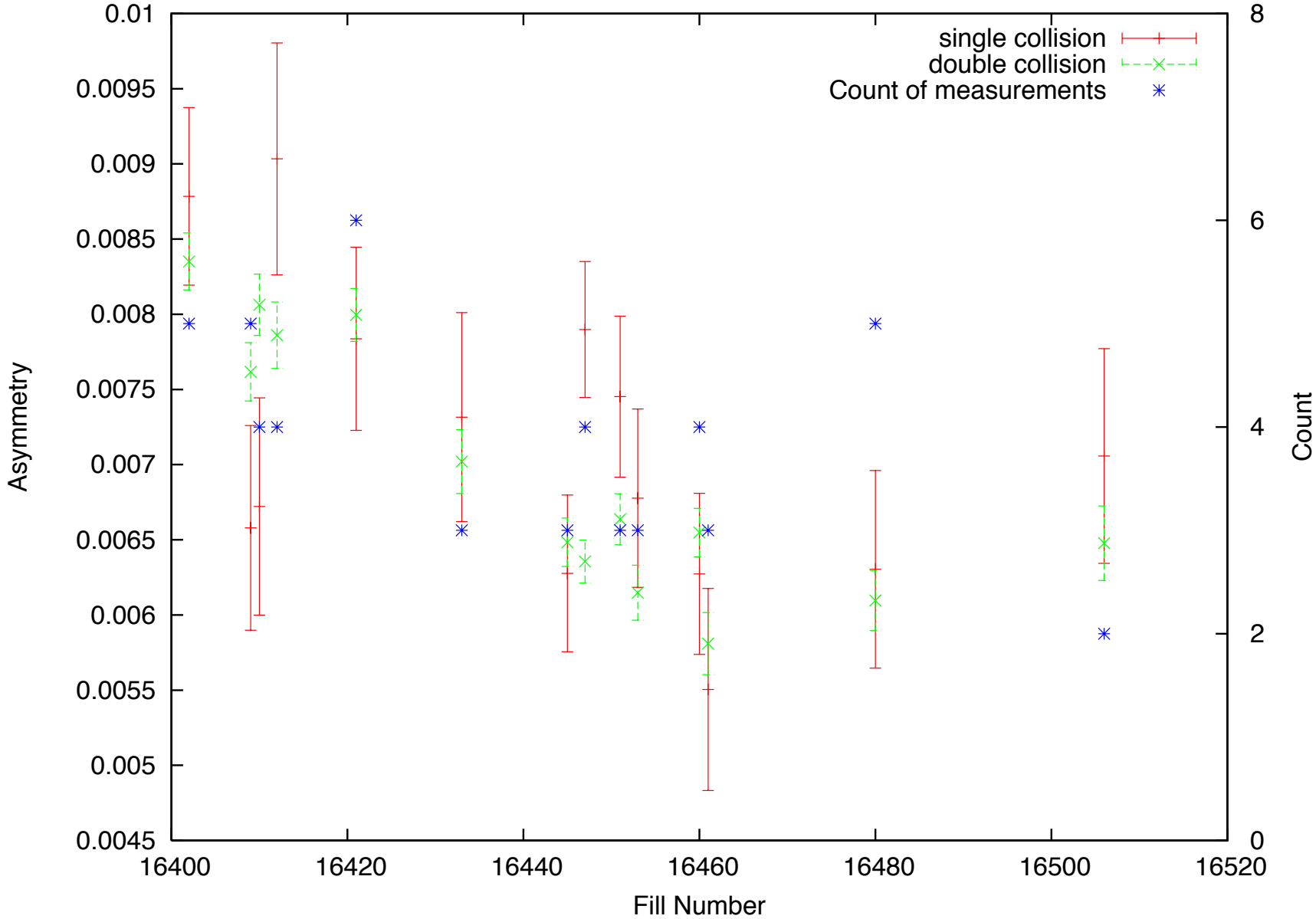
Run 11 Yellow2



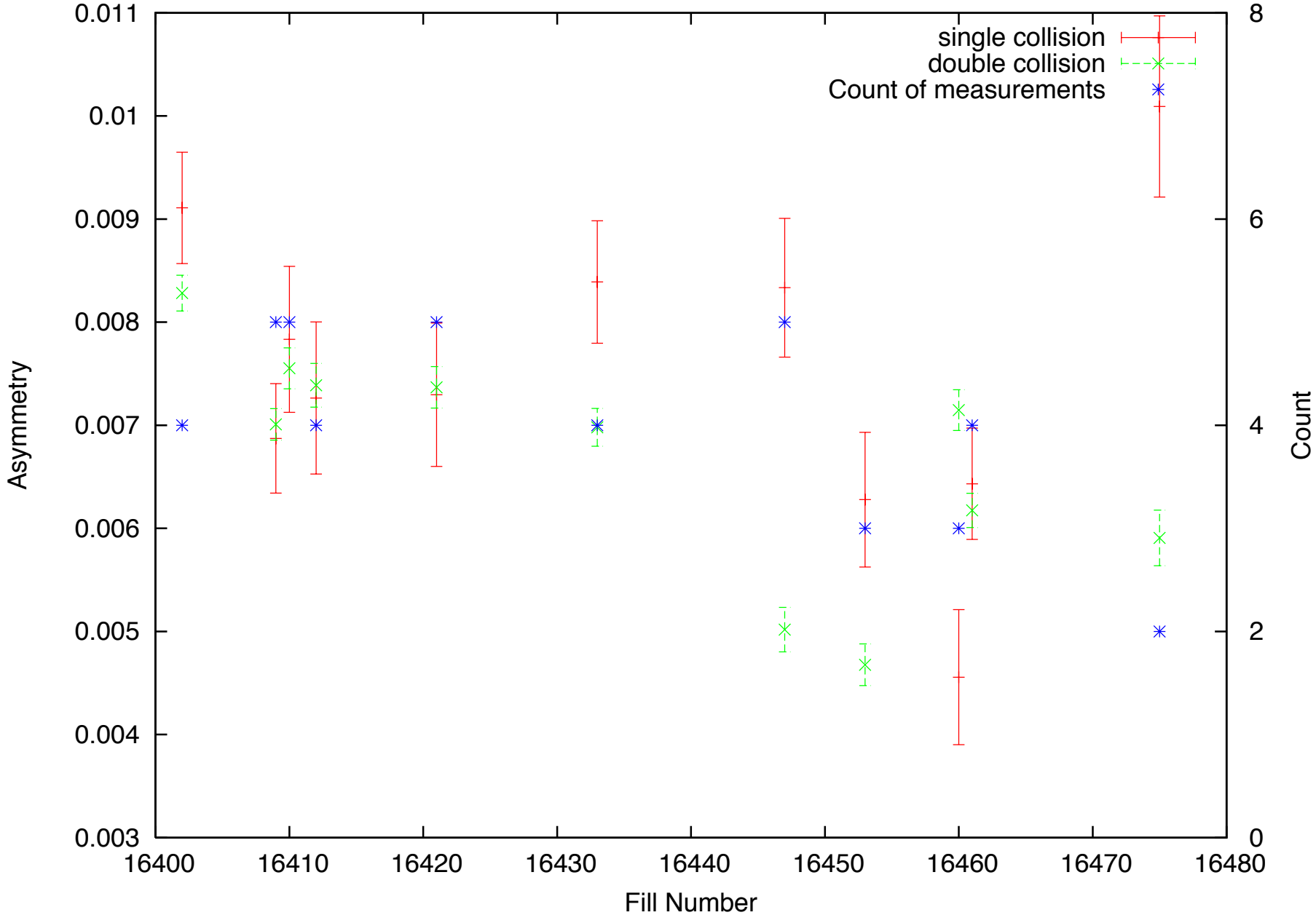
Run 12 100GeV Blue I



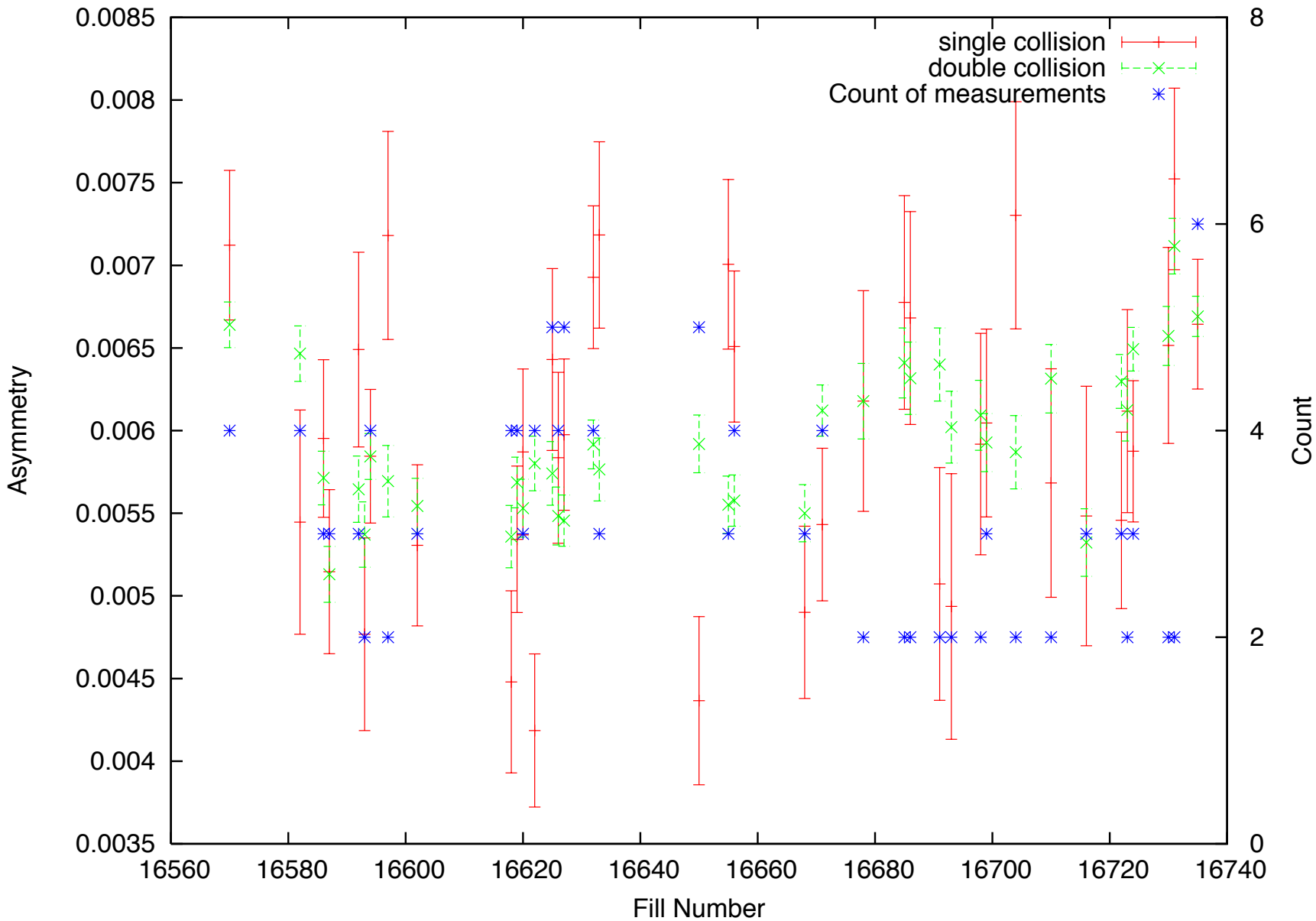
Run 12 100GeV Yellow1



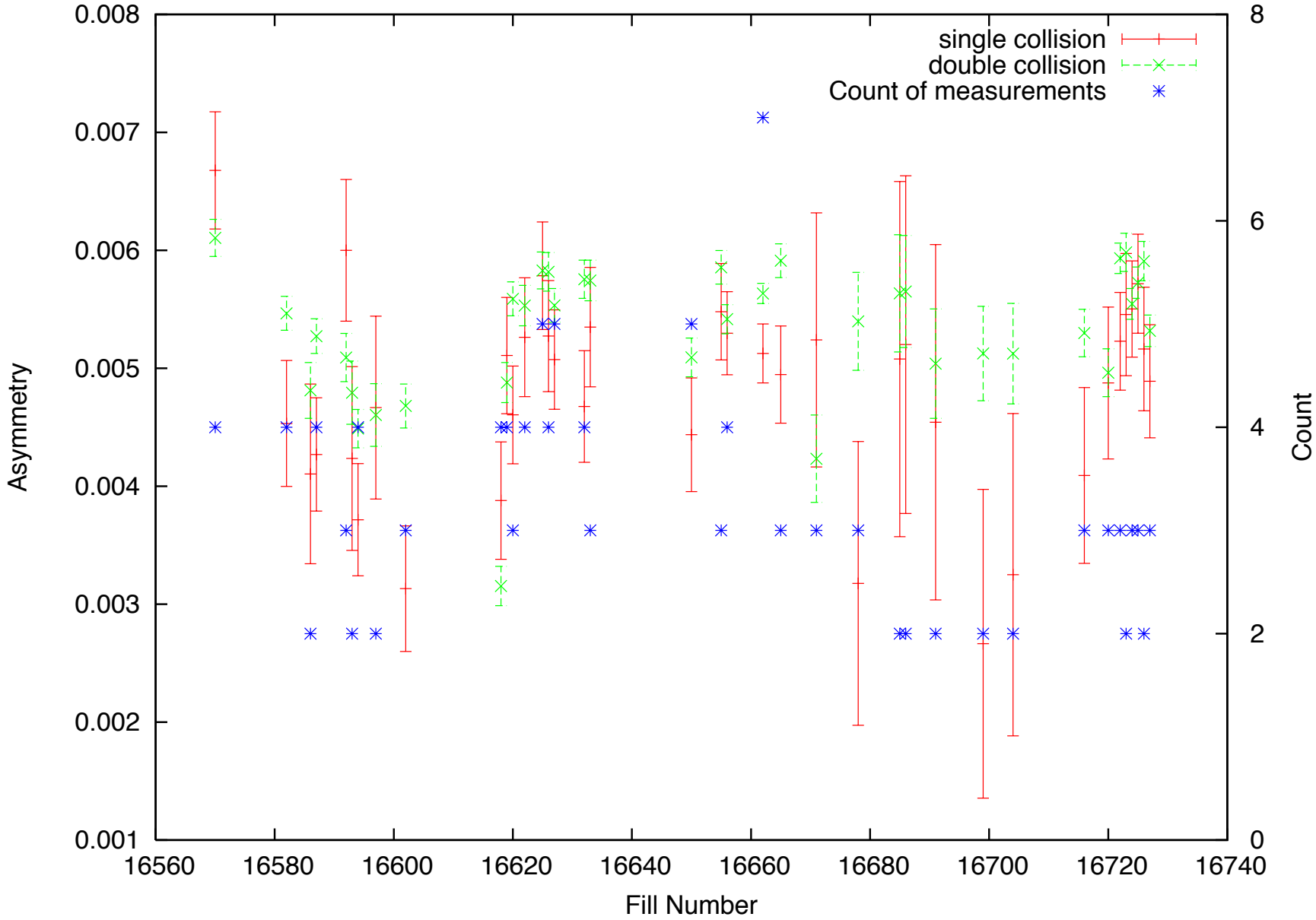
Run12 100GeV Yellow2



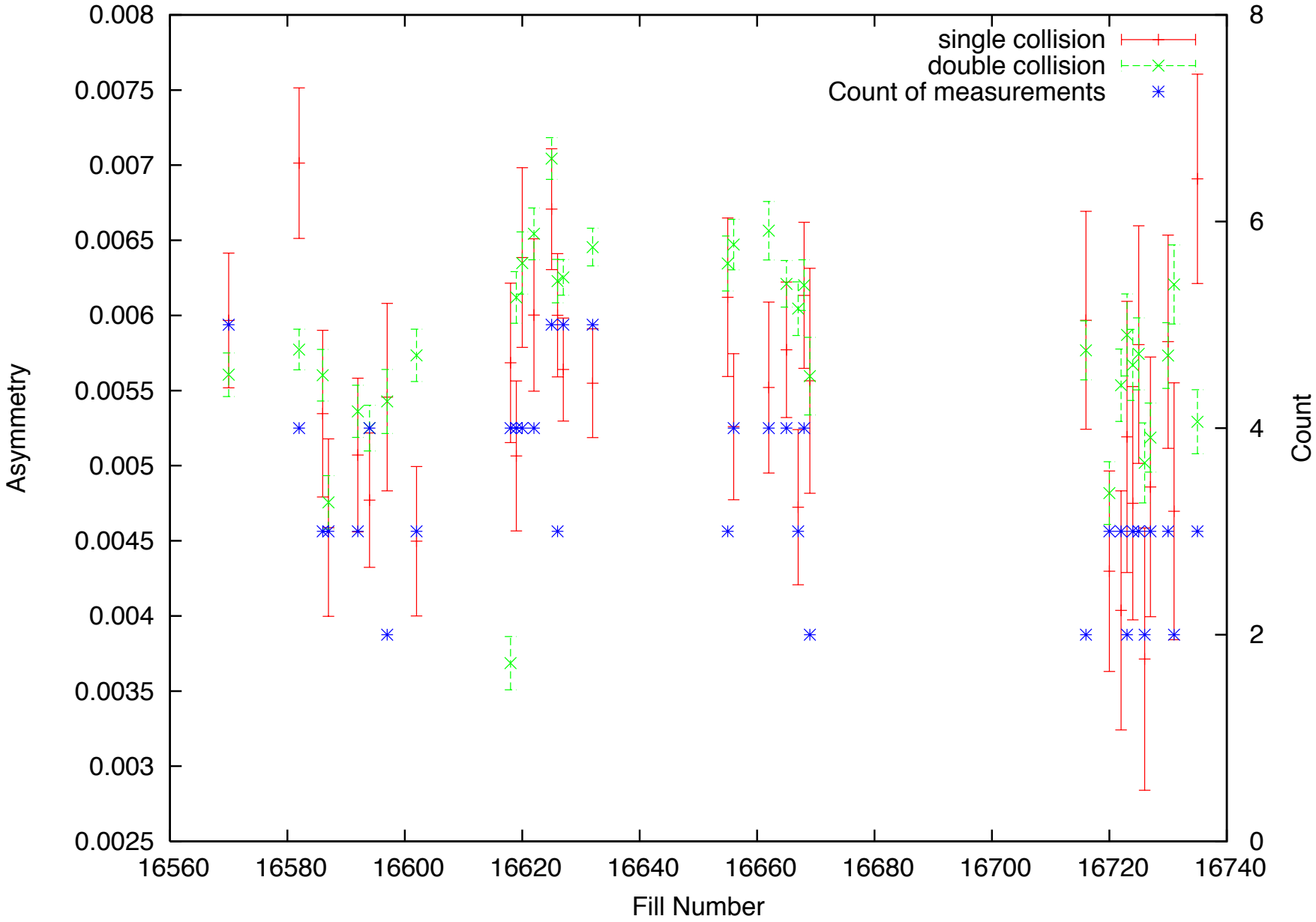
Run 12 255GeV Blue1



Run 12 255GeV Yellow1



Run 12 255GeV Yellow2



Run11 250GeV(Combination of X45 and X90 and separation of Yellow 1 and Yellow2)

Asymmetry*10^3		<All fills>		<fills time duration>5hours>	
		L-R	Sqrt	L-R	Sqrt
Blue1	Single Collision	5.788±0.056	5.898±0.070	5.760±0.059	5.849±0.074
	Double Collision	5.850±0.018	5.834±0.018	5.823±0.019	5.809±0.019
Blue2	Single Collision	5.205±0.065	5.055±0.080	5.115±0.071	5.041±0.085
	Double Collision	5.035±0.021	5.091±0.021	4.980±0.023	5.063±0.022
Yellow1	Single Collision	6.276±0.056	6.265±0.079	6.283±0.086	6.288±0.086
	Double Collision	6.093±0.025	6.103±0.026	6.058±0.028	6.017±0.028
Yellow2	Single Collision	6.191±0.050	6.172±0.051	6.165±0.054	6.147±0.055
	Double Collision	5.940±0.016	5.945±0.016	5.873±0.017	5.877±0.017

Run12 100GeV(Combination of X45 and X90 and separation of Yellow 1 and Yellow2)

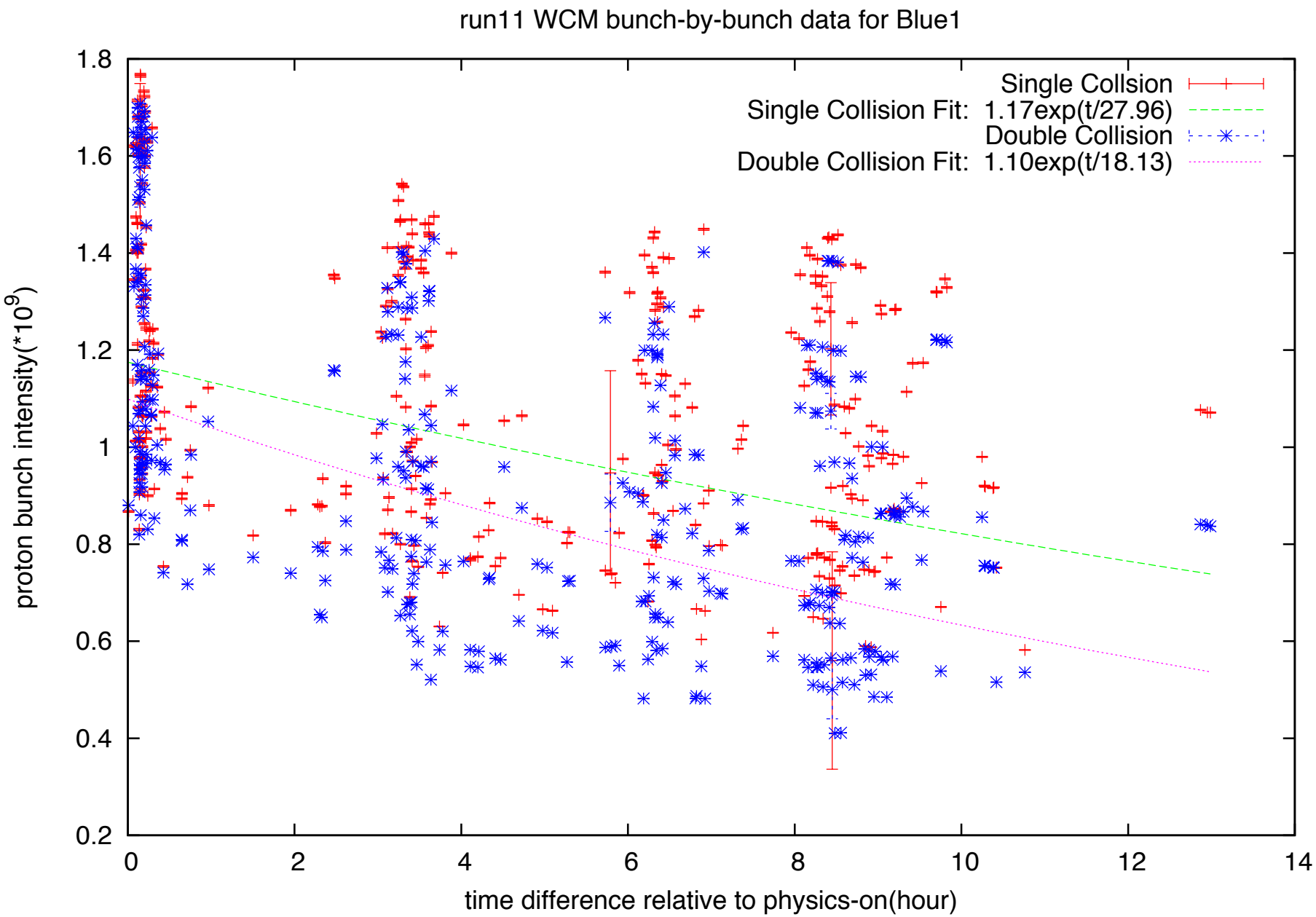
Asymmetry*10^3		<All fills>		<fills time duration>5hours>	
		L-R	Sqrt	L-R	Sqrt
Blue1	Single Collision	7.211±0.072	7.131±0.077	7.018±0.104	6.921±0.111
	Double Collision	7.145±0.021	7.085±0.023	6.973±0.031	6.915±0.033
Yellow1	Single Collision	6.870±0.097	6.579±0.086	7.073±0.133	6.885±0.120
	Double Collision	6.366±0.030	6.144±0.027	6.655±0.041	6.421±0.036
Yellow2	Single Collision	7.092±0.110	6.886±0.111	7.023±0.135	6.885±0.137
	Double Collision	6.486±0.034	6.470±0.034	6.500±0.041	6.476±0.041

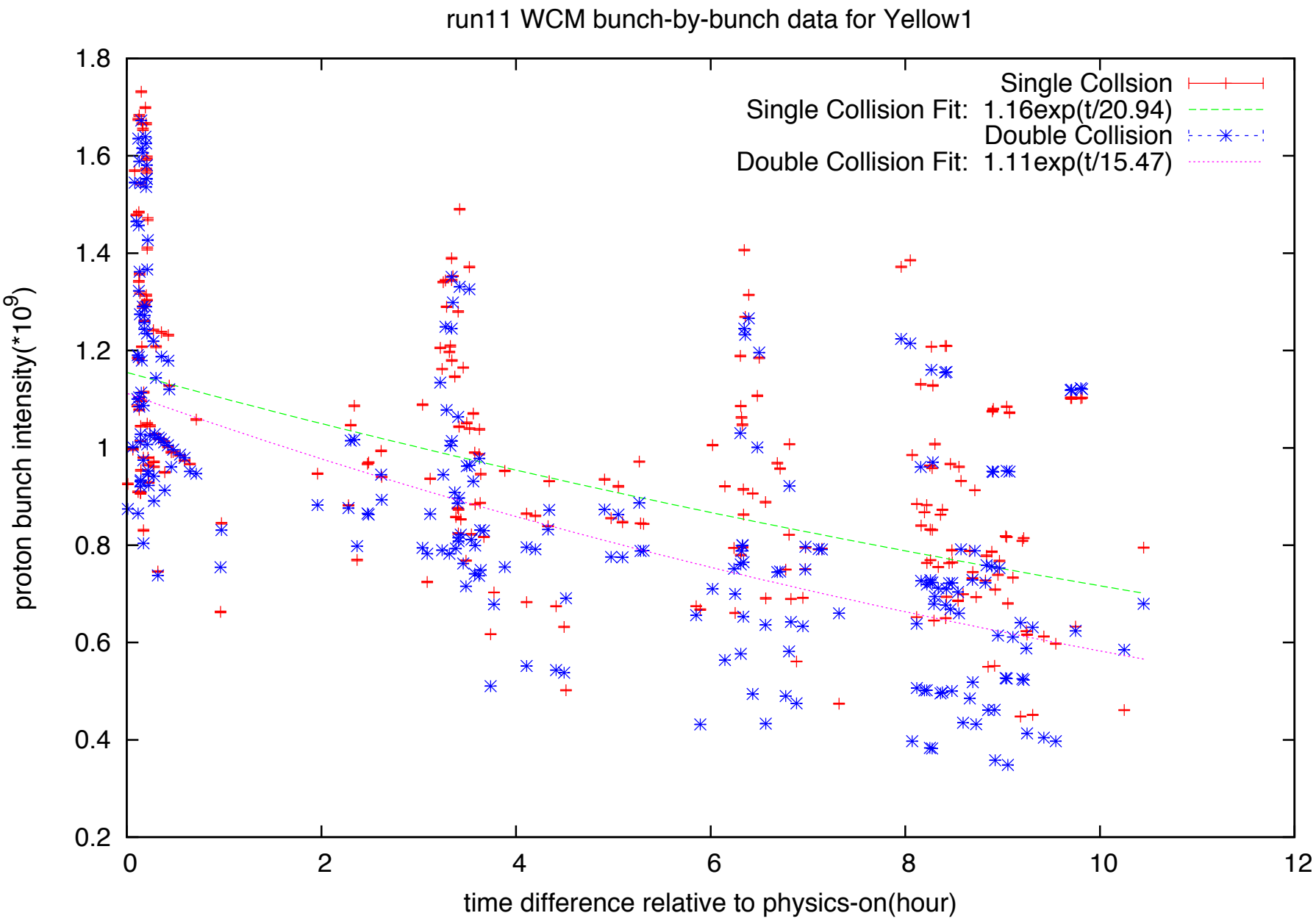
Run12 255GeV(Combination of X45 and X90 and separation of Yellow 1 and Yellow2)

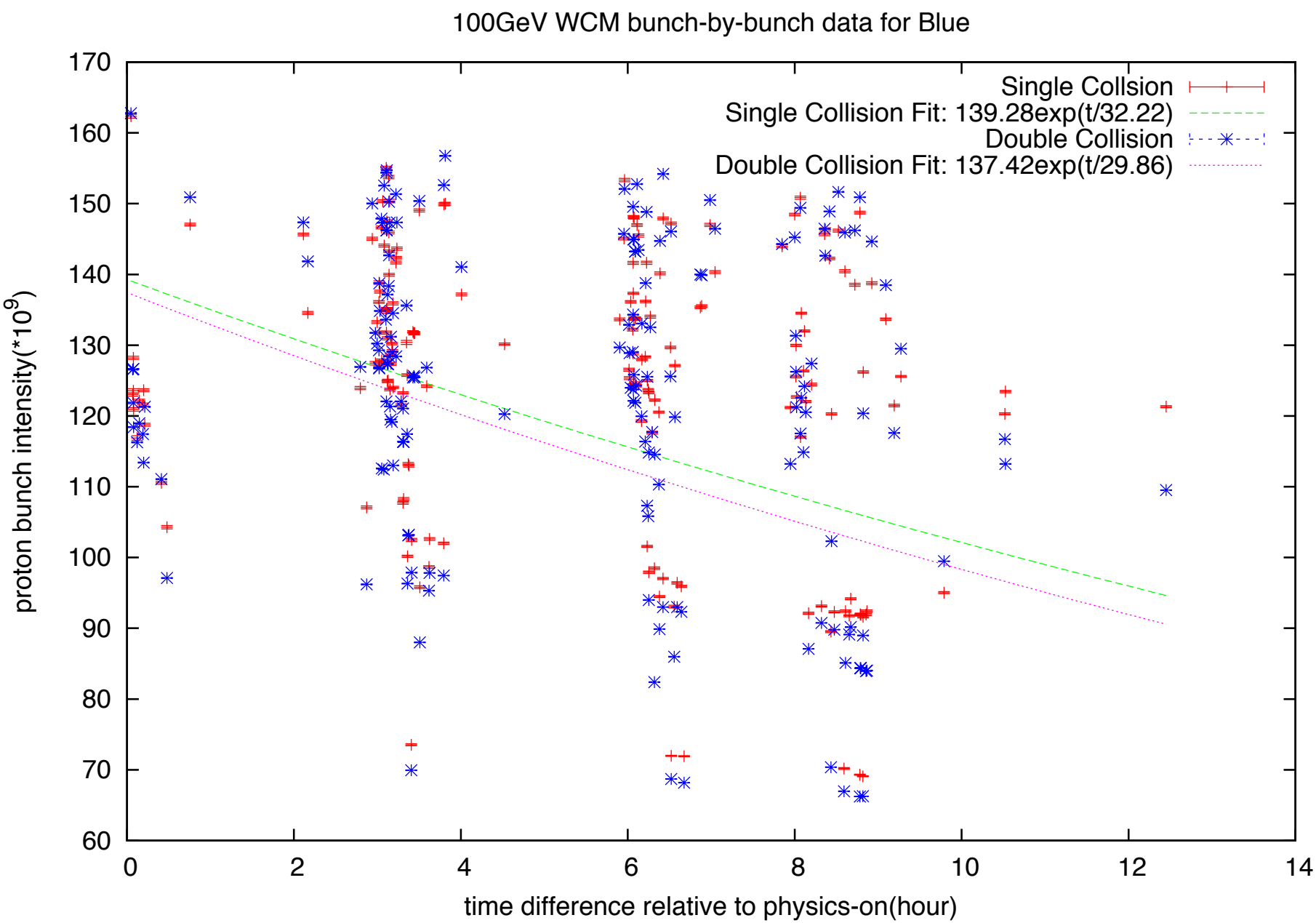
Asymmetry*10^3		<All fills>		<fills time duration>5hours>	
		L-R	Sqrt	L-R	Sqrt
Blue1	Single Collision	5.911±0.079	6.036±0.086	5.818±0.086	5.928±0.094
	Double Collision	5.995±0.026	6.100±0.027	5.969±0.028	6.084±0.030
Yellow1	Single Collision	4.952±0.061	4.955±0.063	4.953±0.066	4.957±0.068
	Double Collision	5.383±0.020	5.412±0.020	5.379±0.022	5.411±0.022
Yellow2	Single Collision	5.623±0.083	5.597±0.087	5.637±0.088	5.583±0.093
	Double Collision	5.946±0.028	6.029±0.029	5.959±0.029	6.048±0.031

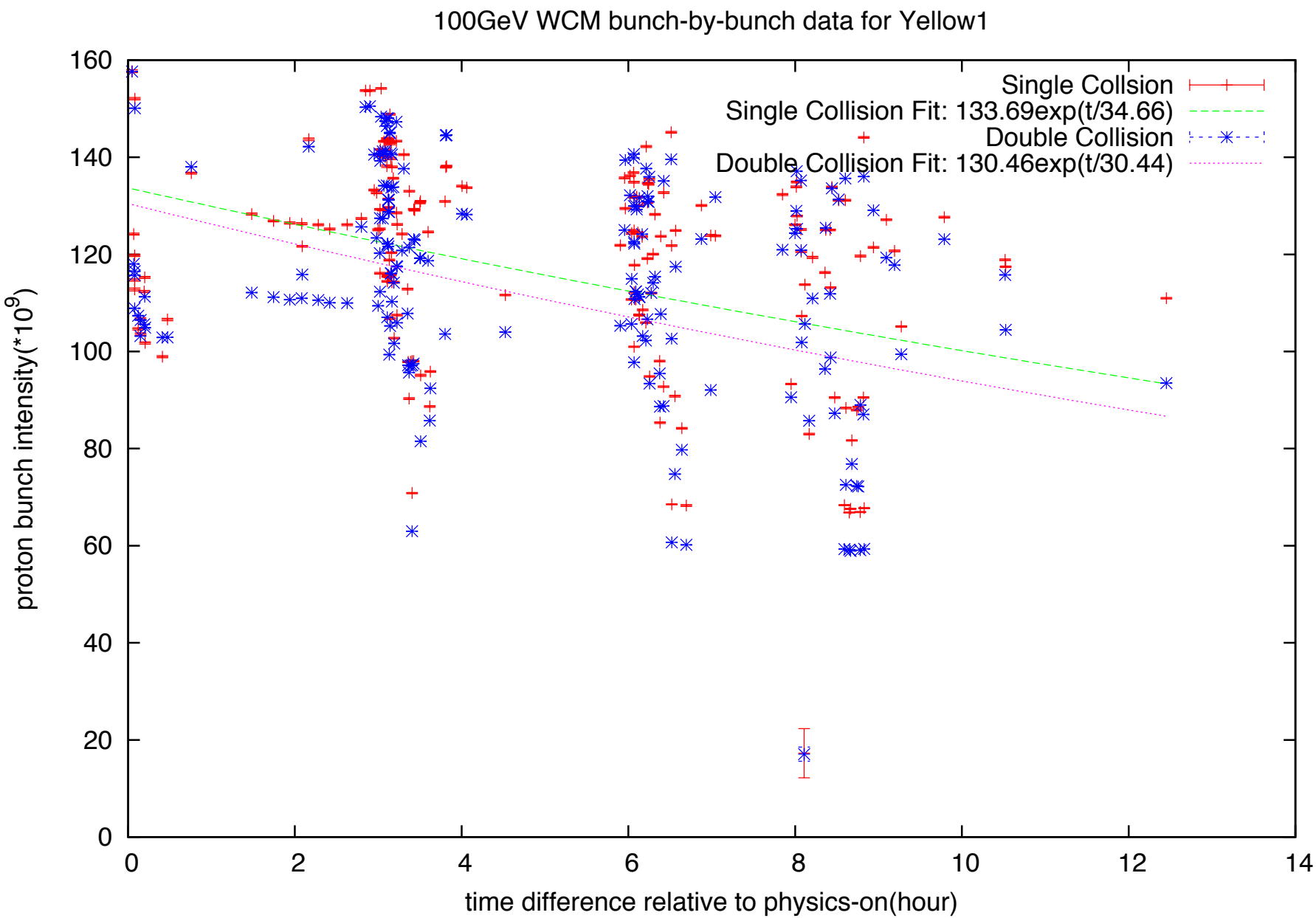
Bunch-by-bunch Intensity

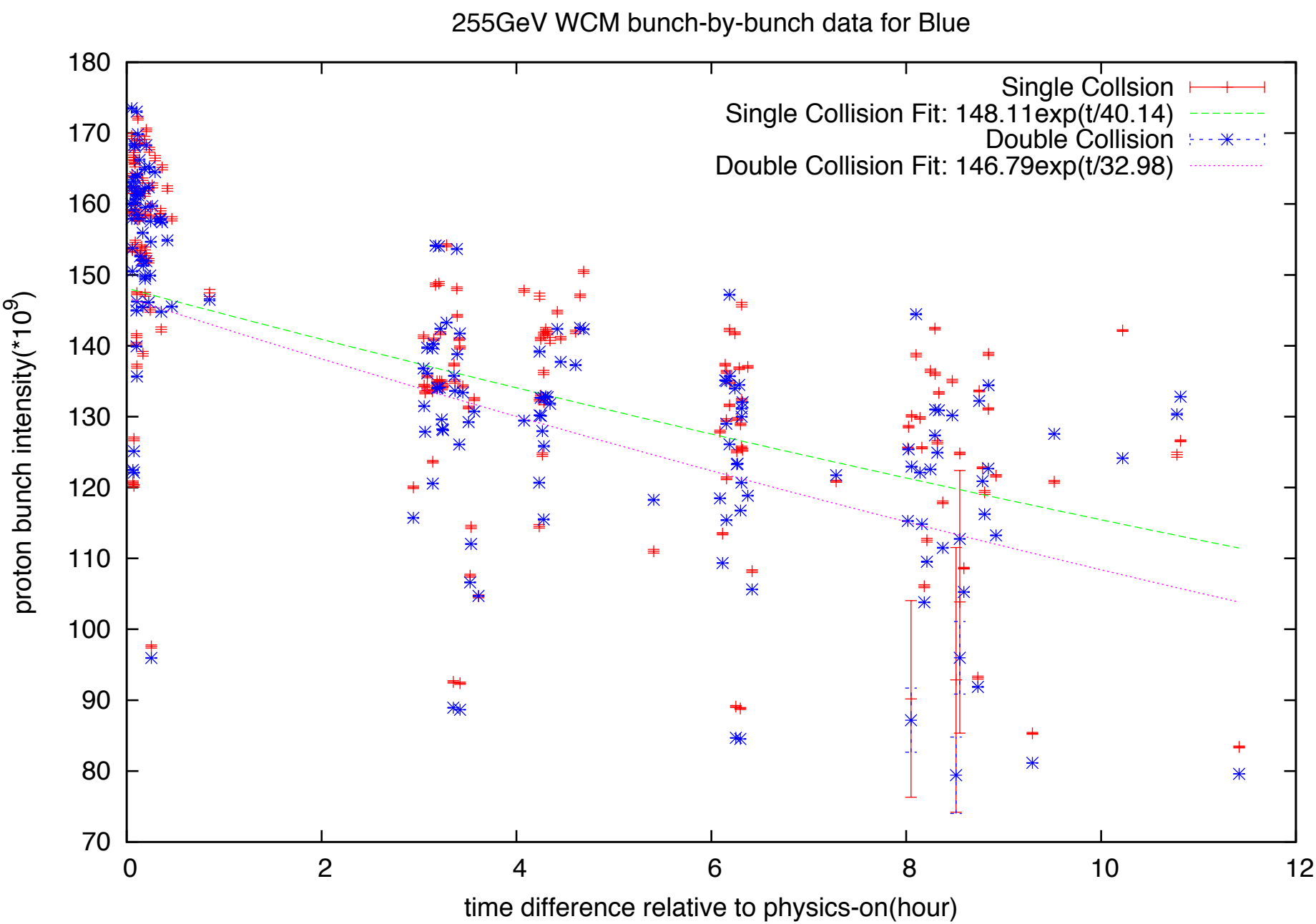
- Bunch-by-bunch intensity data from Wall Current Monitor are sampled for 2 minutes after each polarization measurement.
- Combination among bunches with single collision and bunches with double collisions.
- Plot against time after ev-lumi tag.

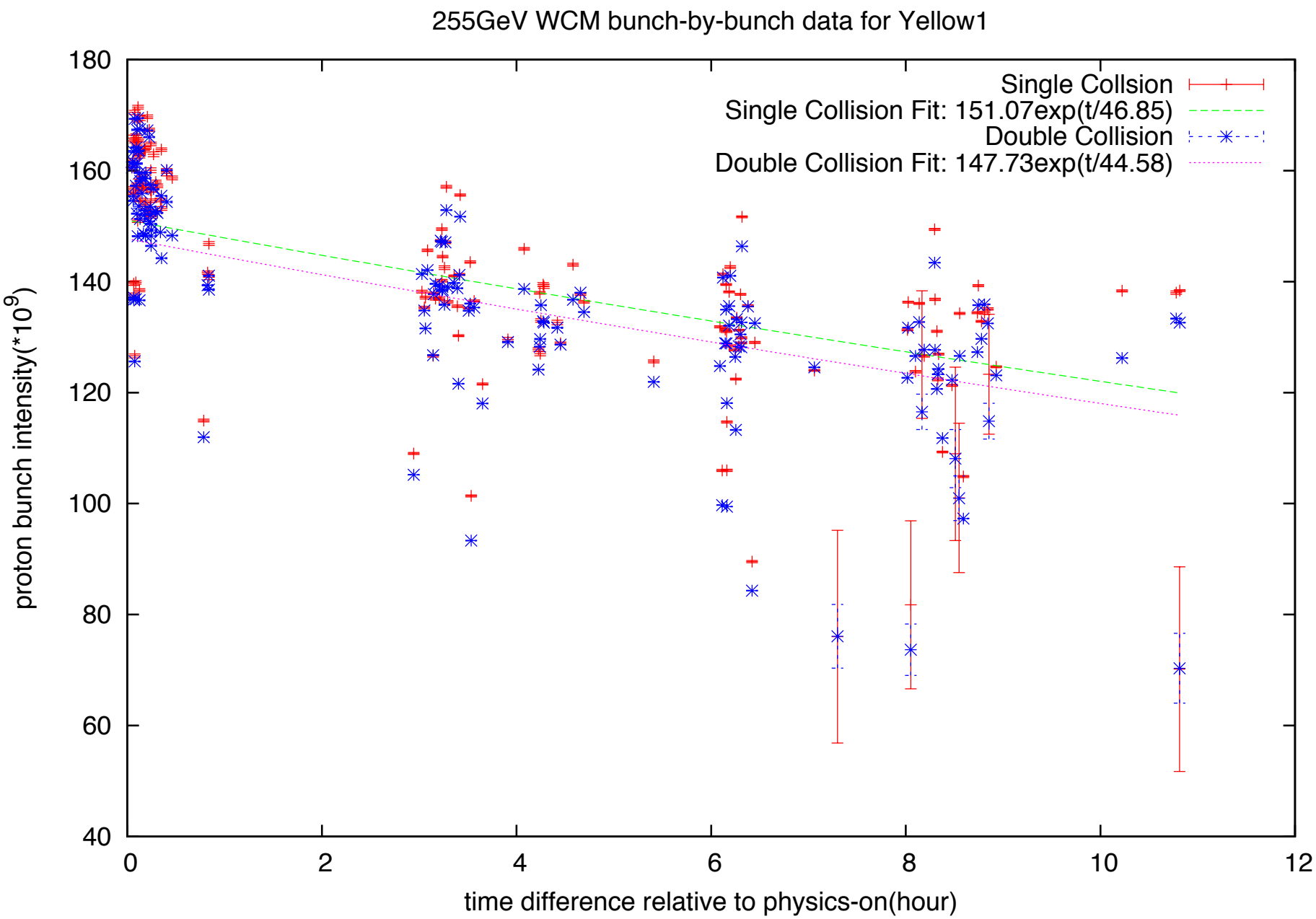

run11 WCM bunch-by-bunch data for Blue1
Single Collsion
Single Collision Fit: 1.17exp(t/27.96)
Double Collision
Double Collision Fit: 1.10exp(t/18.13)
proton bunch intensity(*10^9)
time difference relative to physics-on(hour)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14


run11 WCM bunch-by-bunch data for Yellow1
Single Collsion
Single Collision Fit: 1.16exp(t/20.94)
Double Collision
Double Collision Fit: 1.11exp(t/15.47)
proton bunch intensity(*10^9)
time difference relative to physics-on(hour)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12


100GeV WCM bunch-by-bunch data for Blue
Single Collsion
Single Collision Fit: 139.28exp(t/32.22)
Double Collision
Double Collision Fit: 137.42exp(t/29.86)
proton bunch intensity(*10^9)
time difference relative to physics-on(hour)
170
160
150
140
130
120
110
100
90
80
70
60
0
2
4
6
8
10
12
14


100GeV WCM bunch-by-bunch data for Yellow1
Single Collsion
Single Collision Fit: 133.69exp(t/34.66)
Double Collision
Double Collision Fit: 130.46exp(t/30.44)
proton bunch intensity(*10^9)
time difference relative to physics-on(hour)
0
20
40
60
80
100
120
140
160
0
2
4
6
8
10
12
14

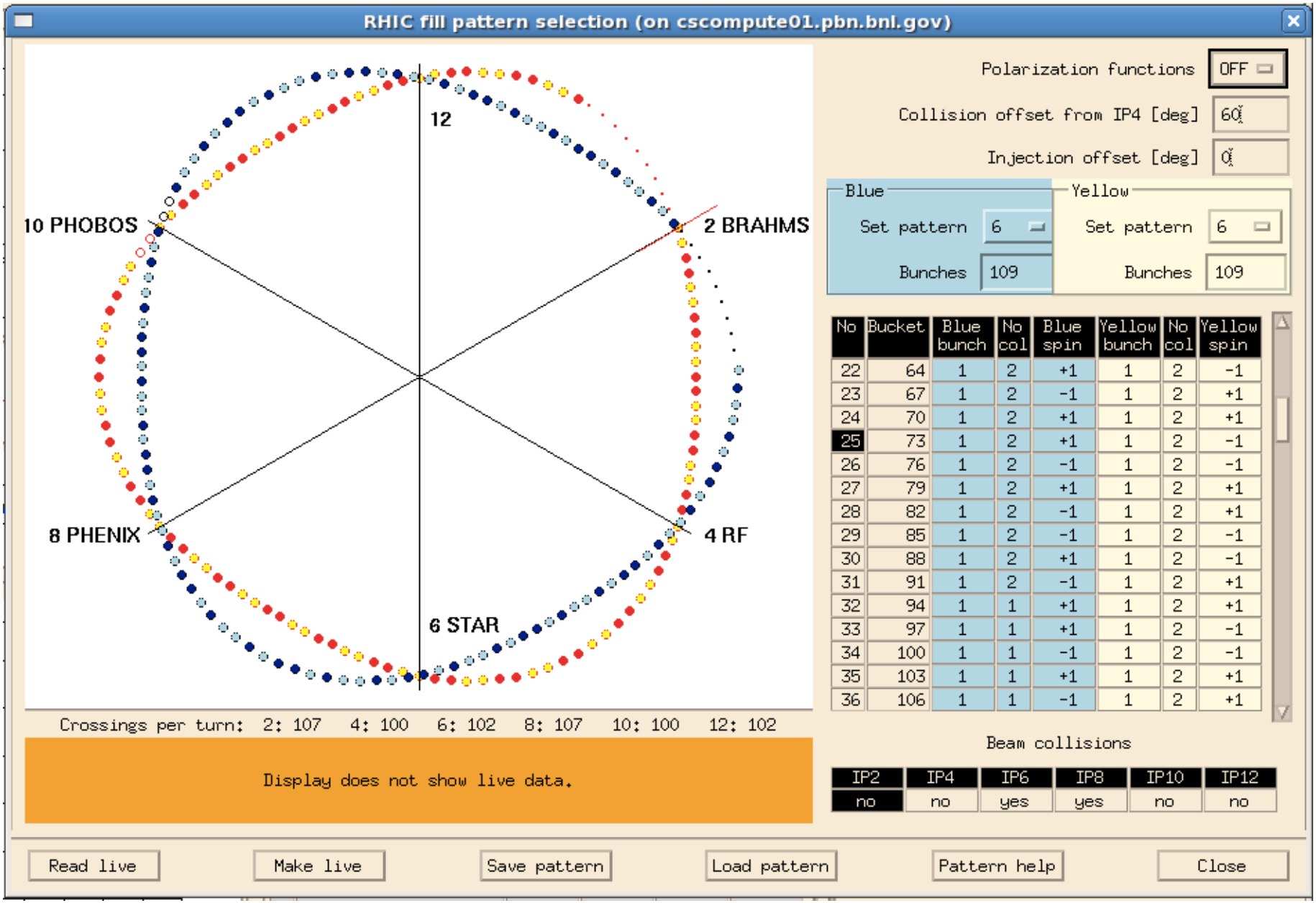

255GeV WCM bunch-by-bunch data for Blue
Single Collsion
Single Collision Fit: 148.11exp(t/40.14)
Double Collision
Double Collision Fit: 146.79exp(t/32.98)
proton bunch intensity(*10^9)
time difference relative to physics-on(hour)
180
170
160
150
140
130
120
110
100
90
80
70
0
2
4
6
8
10
12


255GeV WCM bunch-by-bunch data for Yellow1
Single Collsion
Single Collision Fit: 151.07exp(t/46.85)
Double Collision
Double Collision Fit: 147.73exp(t/44.58)
proton bunch intensity(*10^9)
time difference relative to physics-on(hour)
180
160
140
120
100
80
60
40
0
2
4
6
8
10
12

Summary

- Preliminary bunch by bunch polarimeter data analysis hasn't shown conclusive impact of beam-beam effects on polarization within statistical error
  - No difference in Blue between bunches with different number of collisions
  - Yellow 250 GeV Run and 100 GeV Run indicate statical better asymmetry of bunches with single collisions vs. bunches with double collisions. However, its latest 255GeV run shows the reversed behavior between these two groups of bunches.
- WCM data analysis shows consistently larger beam loss rate for double collision bunches vs. single collision bunches
- Other systematic errors of polarimeter were not included

Thanks!


RHIC fill pattern selection (on cscompute01.pbn.bnl.gov)
12
2 BRAHMS
4 RF
6 STAR
8 PHENIX
10 PHOBOS
Crossings per turn: 2: 107 4: 100 6: 102 8: 107 10: 100 12: 102
Display does not show live data.
Polarization functions OFF
Collision offset from IP4 [deg] 60
Injection offset [deg] 0
Blue
Set pattern 6
Bunches 109
Yellow
Set pattern 6
Bunches 109
No Bucket Blue bunch No col Blue spin Yellow bunch No col Yellow spin
22 64 1 2 +1 1 2 -1
23 67 1 2 -1 1 2 +1
24 70 1 2 +1 1 2 +1
25 73 1 2 +1 1 2 -1
26 76 1 2 -1 1 2 -1
27 79 1 2 +1 1 2 +1
28 82 1 2 -1 1 2 +1
29 85 1 2 -1 1 2 -1
30 88 1 2 +1 1 2 -1
31 91 1 2 -1 1 2 +1
32 94 1 1 +1 1 2 +1
33 97 1 1 +1 1 2 -1
34 100 1 1 -1 1 2 -1
35 103 1 1 +1 1 2 +1
36 106 1 1 -1 1 2 +1
Beam collisions
IP2 IP4 IP6 IP8 IP10 IP12
no no yes yes no no
Read live
Make live
Save pattern
Load pattern
Pattern help
Close