APEX studies in 2009 Run with the p-Carbon CNI polarimeter

A.Zelenski for polarimetry group

- Emittance measurements in RHIC.
- Rate dependence of Polarization measurements in RHIC.

APEX Workshop, November 12, 2009

Rate dependence of Polarization measurements in RHIC.

A.Zelenski for polarimetry group

- The rate dependence may produce large systematic errors in polarization measurements at high bunch intensities.
- This errors depend on: -bunch intensity;
  -number of bunches;
  - bunch spacing;
  - target thickness.

APEX Workshop, Dec.4, 2008

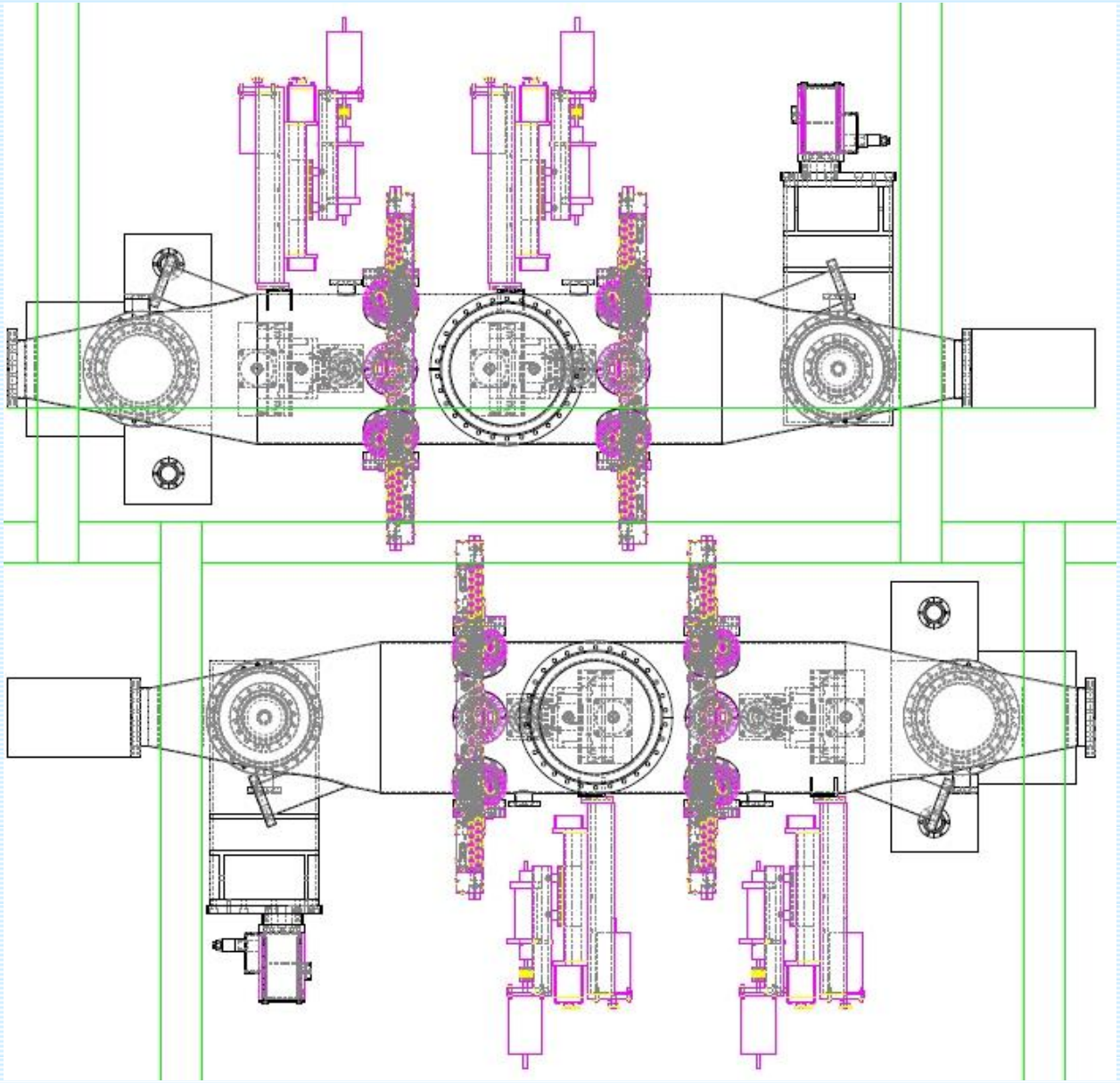
Emittance measurements in RHIC.

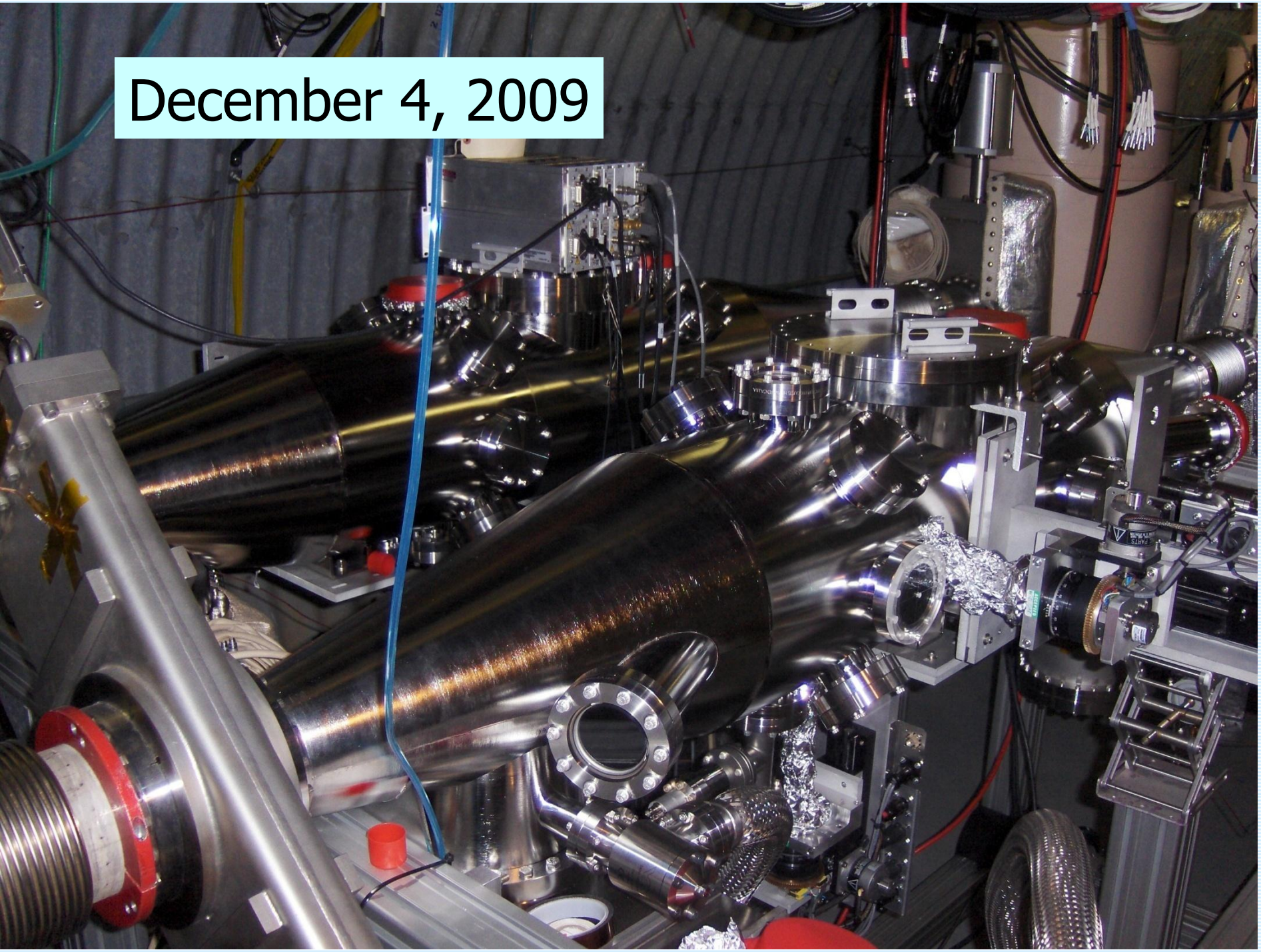
A.Zelenski, A. Bazilevskiy, G. Bunce, R.Gill, H.Huang, Y. Makdisi, B. Morozov, S.Nemesure, T.Russo, D.Steski, M. Sivertz, K.Yip

- Beam intensity profile measurements with the RHIC p-C CNI polarimeters.
- Cross-calibration with the other techniques.
- Bunch-by-bunch emittance measurements.
- Emittance measurements at injection energy.
- Emittance growth on the energy ramp.

APEX Workshop, December 5, 2008

Polarimeter upgrade for 2009 Run.




December 4, 2009

PolarControl: RHIC Polarization Analysis Tool [v02.04.09]

Setup Orbit Display Print Diagnostics Help

BLUE

Summary | Target Scans | Polarization Measurements | Emittance Measurements | Ramp Measurements

BLUE 1

Beam Energy: 23.702

Horizontal Target5

Target Positioning: Start 106000 End 116000 Actual 89910

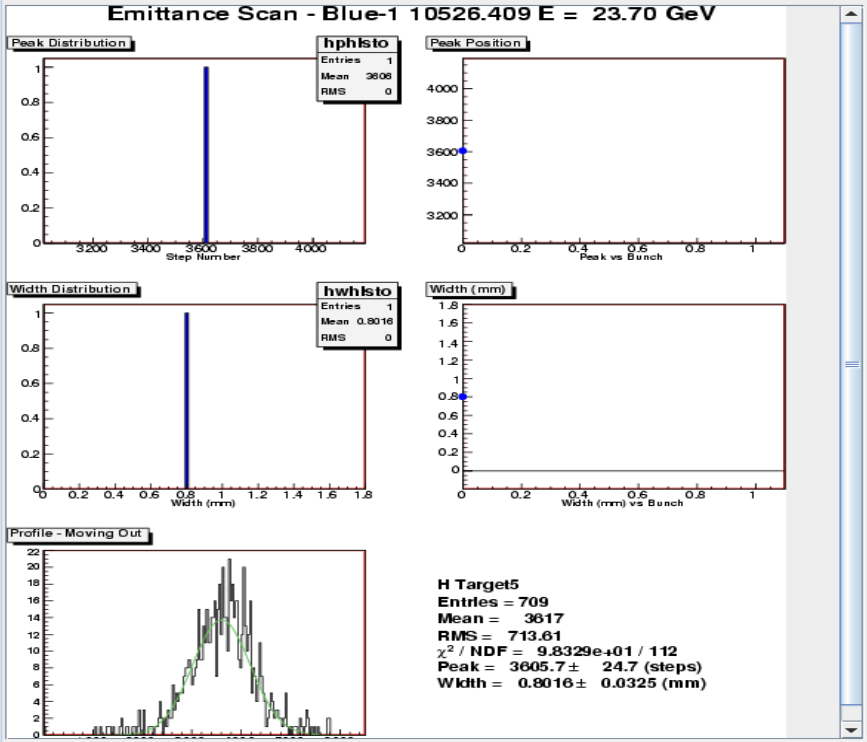
Target Velocity: Readback 0 Set 7000

Start Stop

Emittance Measurement Done

Emittance Result

Apr 10, 2009 7:45:00 AM



Click Graph To See Full Image

σ= 0.8 , ϵ= 4.792

Peak= 3,605.75 , Peak/# events= 5.09 , σ_{peak}= 0.16

BLUE 2

Beam Energy: 23.702

Vertical Target1

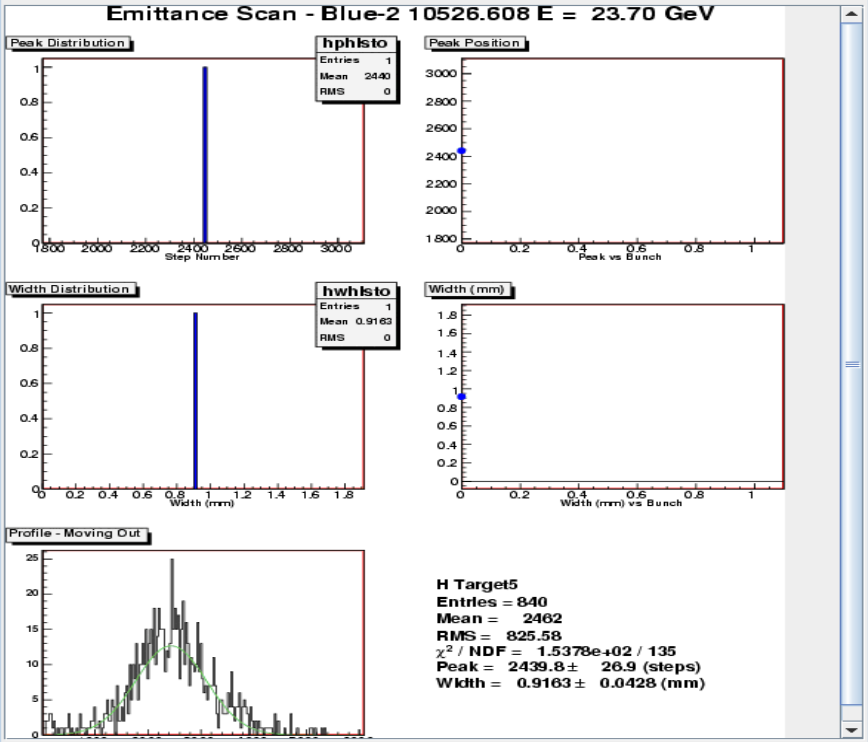
Target Positioning: Start 107000 End 117000 Actual 100192

Target Velocity: Readback 0 Set 7000

Start Stop

Emittance Result

Apr 10, 2009 7:44:31 AM



Click Graph To See Full Image

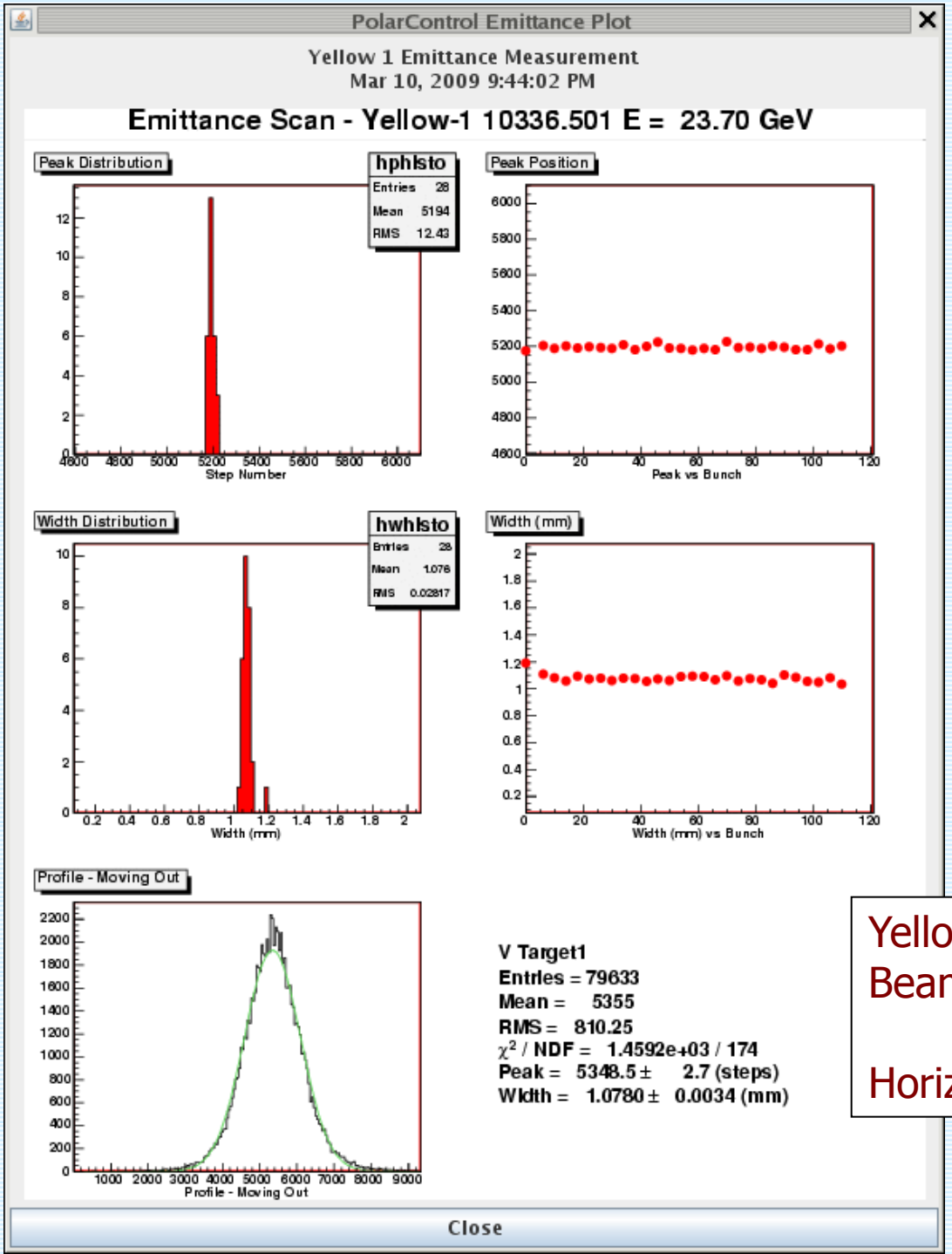
σ= 0.92 , ϵ= 5.603

Peak= 2,439.84 , Peak/# events= 2.9 , σ_{peak}= 0.27

Apr 10, 2009 7:42:09 AM: Detector Switch Completed Successfully
Apr 10, 2009 7:42:44 AM: Detector Switch Completed Successfully
Apr 10, 2009 7:44:11 AM: Detector Switch Completed Successfully
Apr 10, 2009 7:44:36 AM: Detector Switch Completed Successfully

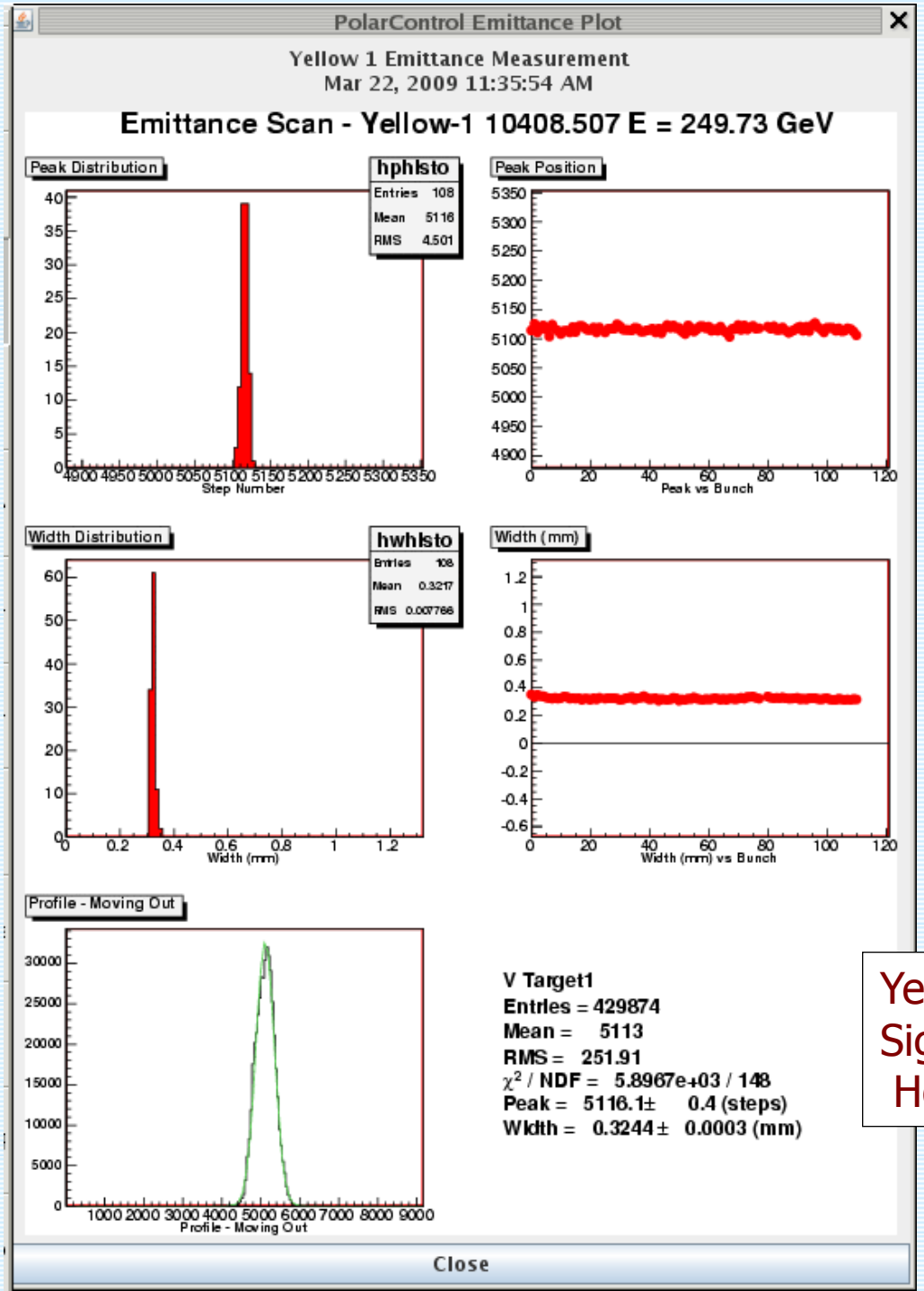
V-10.8pi, H-12.6pi

Fri Apr 10 07:44:58 EDT 2009

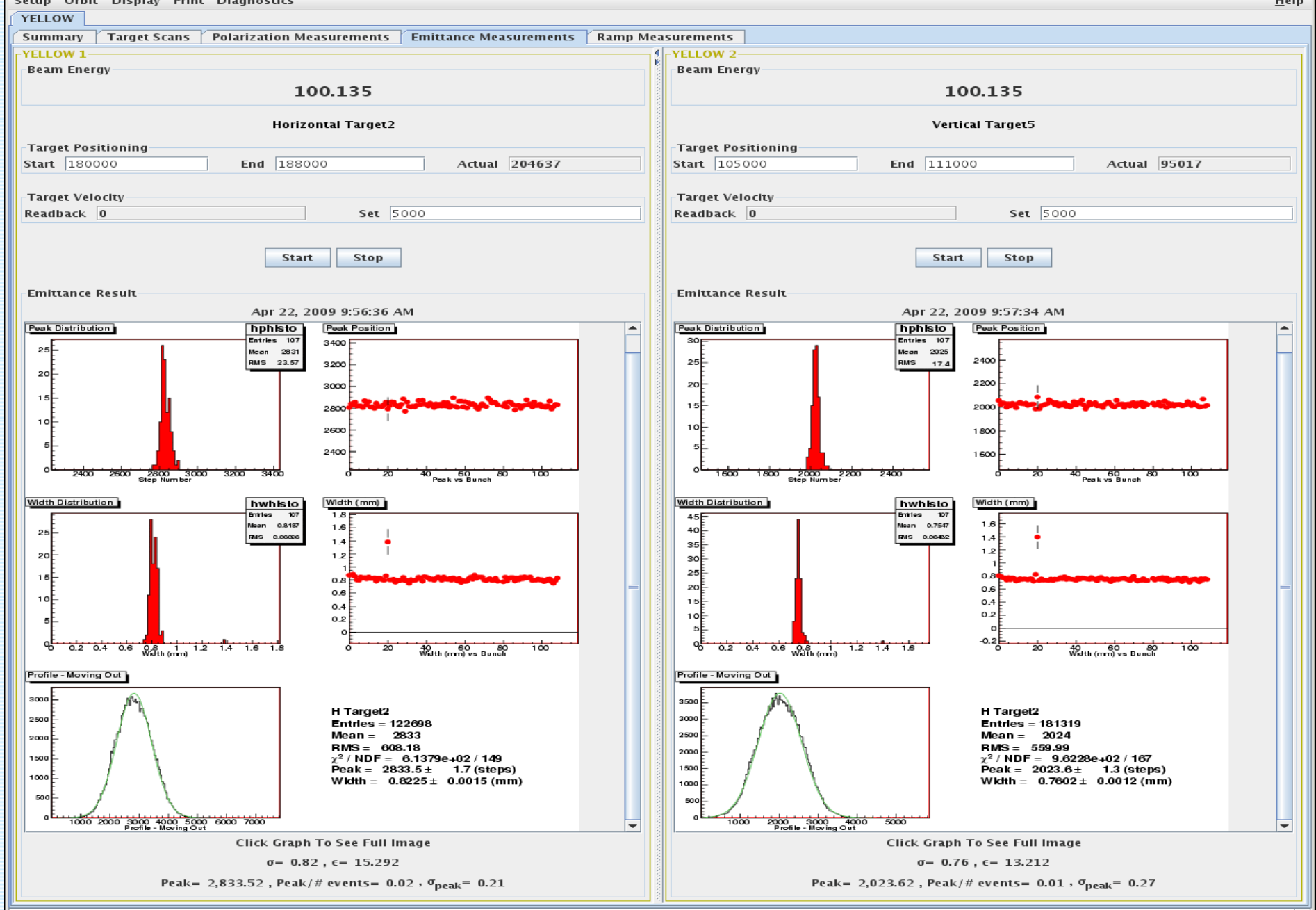


Yellow-1 at injection
Beam width (Sigma)-1.07mm

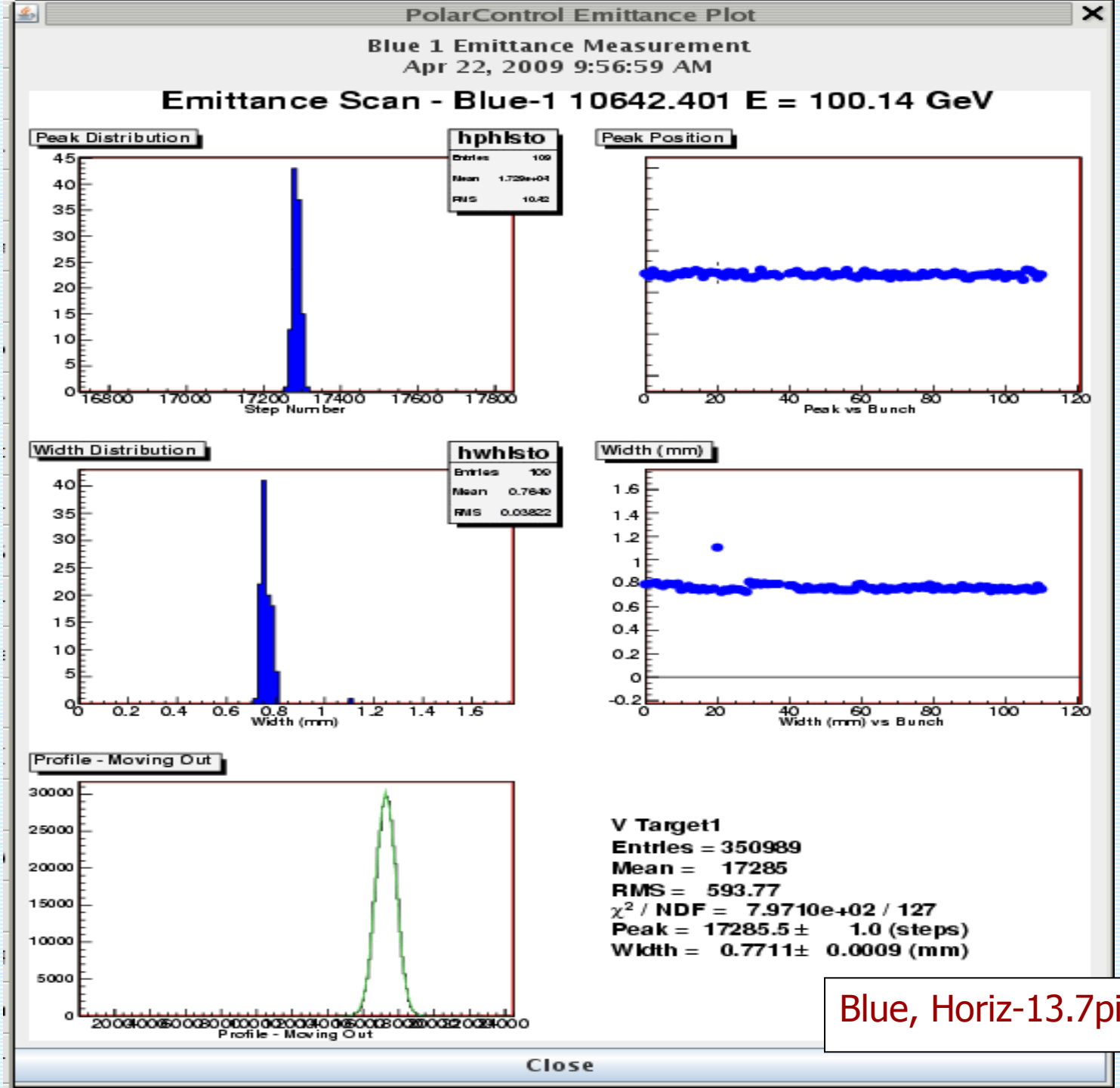
Horiz emittance-14.6pi



Yellow-1,
Sigma-0.48 mm
Horiz- 16.6pi



Yellow, Vertical-15pi, Horiz-13 pi



Blue, Horiz-13.7pi

PolarControl: RHIC Polarization Analysis Tool [v02.04.09]

Setup Orbit Display Print Diagnostics Help

BLUE

Summary | Target Scans | Polarization Measurements | Emittance Measurements | Ramp Measurements

BLUE 1

Beam Energy: 249.729

Vertical Target1

Target Positioning: Start 111000 End 124000 Actual 100035

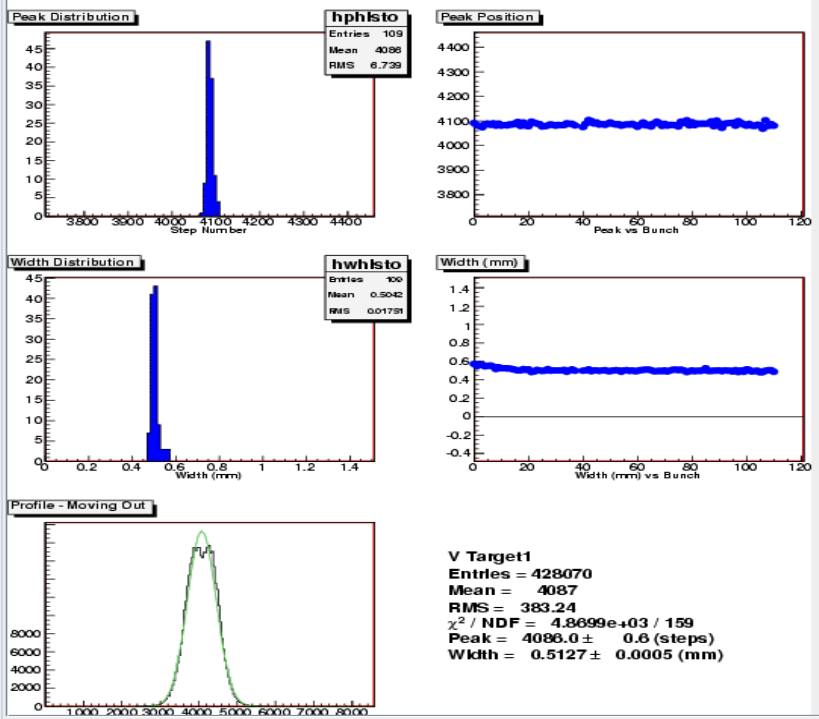
Target Velocity: Readback 0 Set 7000

Start Stop

Emittance Result

Mar 22, 2009 10:51:23 AM

Emittance Scan - Blue-1 10408.404 E = 249.73 GeV



Click Graph To See Full Image

σ= 0.51 , ϵ= 15.142

Peak= 4,086.03 , Peak/# events= 0.01 , σ_{peak}= 0.09

BLUE 2

Beam Energy: 249.729

Horizontal Target1

Target Positioning: Start 102000 End 116000 Actual 89550

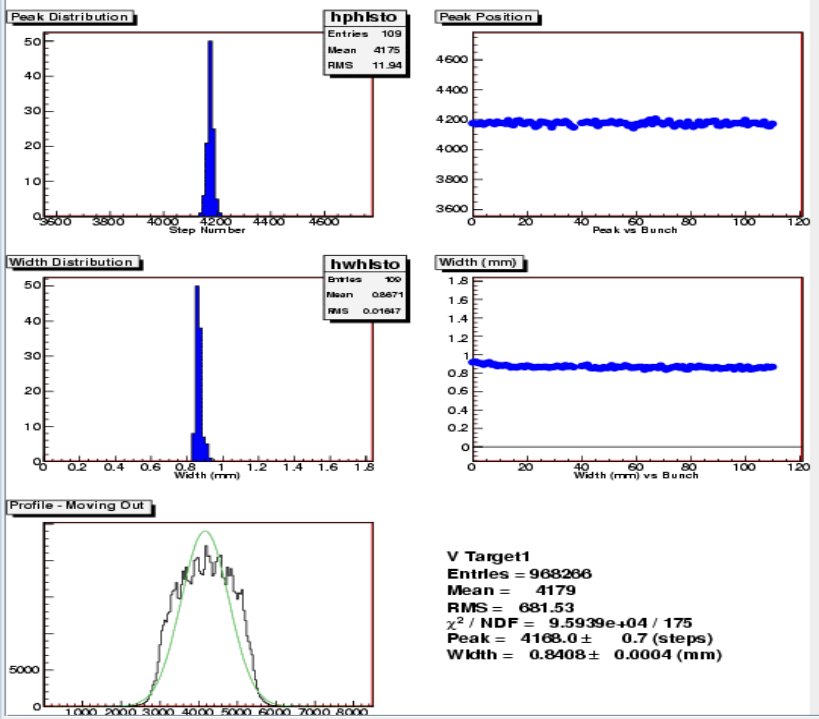
Target Velocity: Readback 0 Set 7000

Start Stop

Emittance Result

Mar 22, 2009 10:52:42 AM

Emittance Scan - Blue-2 10408.605 E = 249.73 GeV



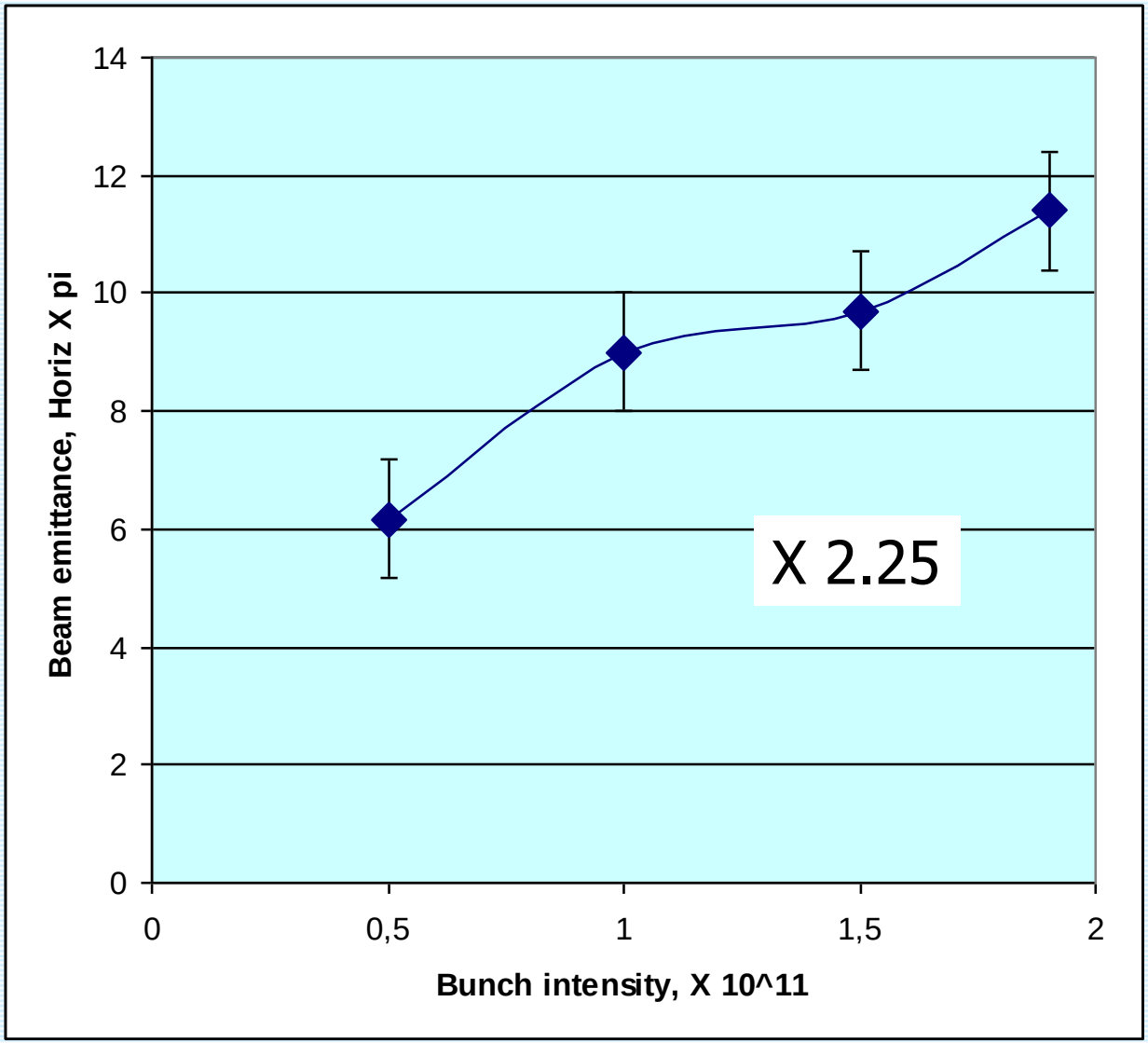
Click Graph To See Full Image

σ= 0.84 , ϵ= 10.235

Peak= 4,167.98 , Peak/# events= 0 , σ_{peak}= 0.15

Mar 22, 2009 10:02:28 AM: Detector Switch Completed Successfully
Mar 22, 2009 10:03:24 AM: Detector Switch Completed Successfully
Mar 22, 2009 10:04:06 AM: Detector Switch Completed Successfully
Mar 22, 2009 10:51:47 AM: Detector Switch Completed Successfully

Horiz. Yellow-2 emittance measurements vs bunch intensity



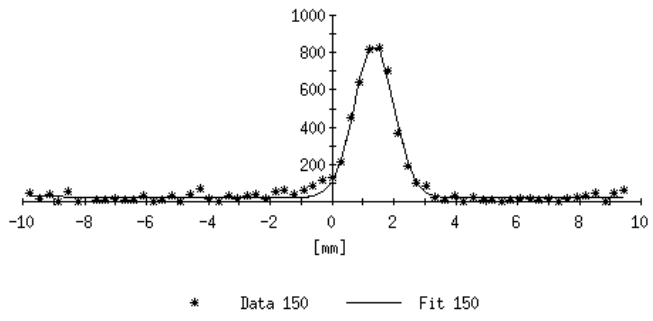
Rhic Ionization Profile Monitor

File Setup Help

Blue_Horizontal

Function	Blue_Horizontal
Time-stamp	Mar 22, 2009 -- 11:00:44
Bucket	150
Emit [pi*urad]	24.4056
Sigma [mm]	0.631948
Intensity	5836.2

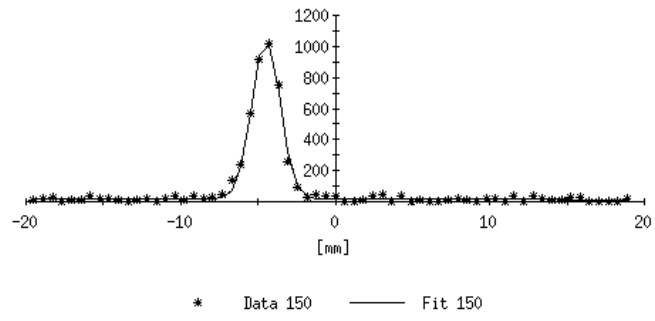
Details...



Blue_Vertical

Function	Blue_Vertical
Time-stamp	Mar 22, 2009 -- 11:00:44
Bucket	150
Emit [pi*urad]	16.8987
Sigma [mm]	0.918979
Intensity	4806.34

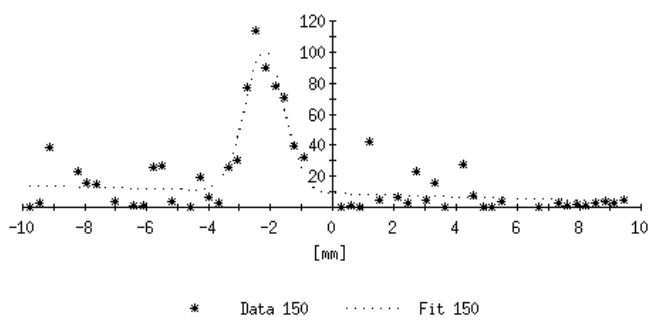
Details...



Yellow_Horizontal

Function	Yellow_Horizontal
Time-stamp	Mar 22, 2009 -- 11:00:44
Bucket	150
Emit [pi*urad]	24.3543
Sigma [mm]	0.620125
Intensity	894.21

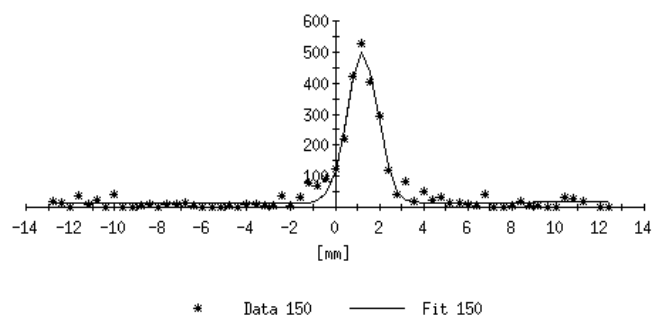
Details...

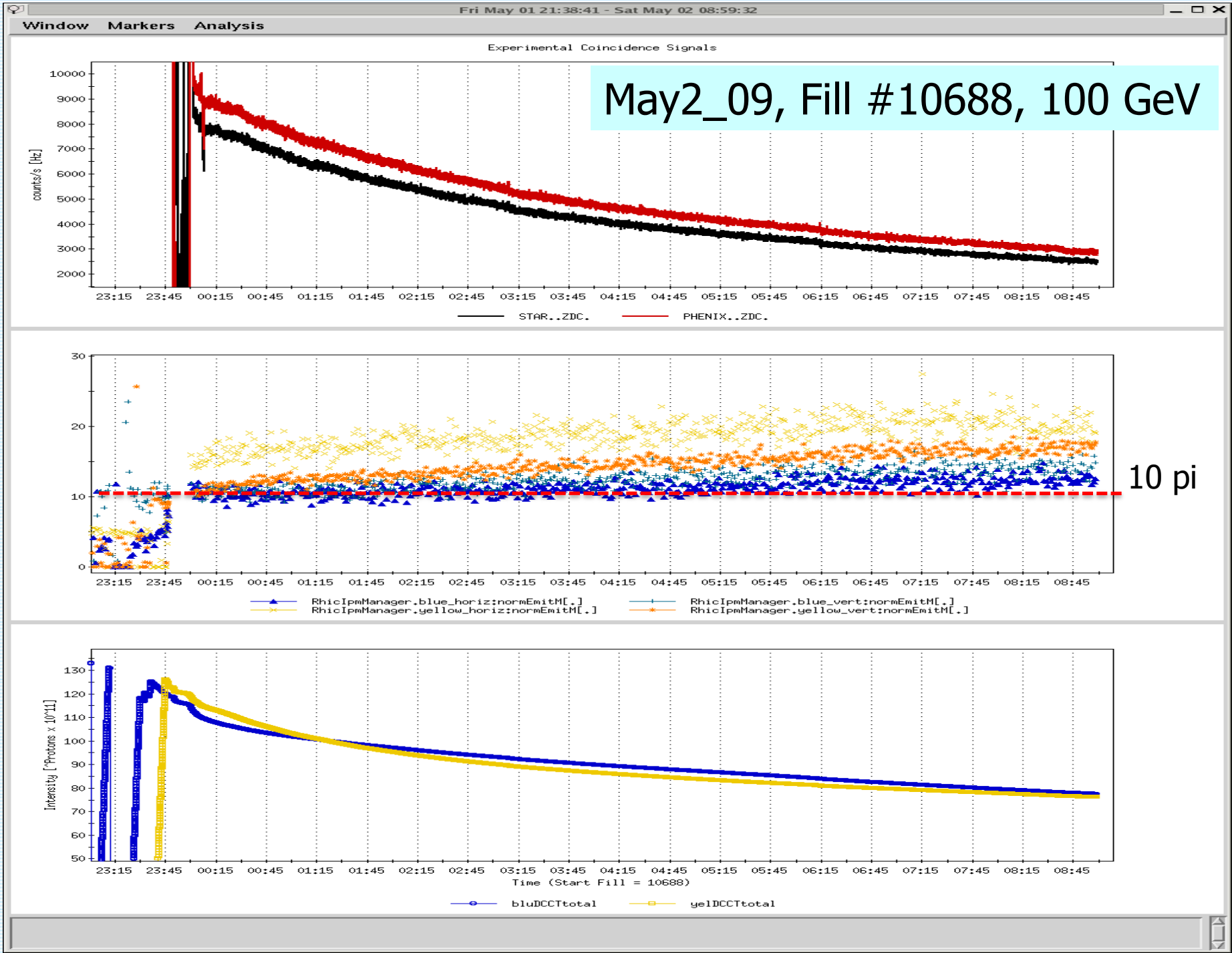


Yellow_Vertical

Function	Yellow_Vertical
Time-stamp	Mar 22, 2009 -- 11:00:44
Bucket	150
Emit [pi*urad]	9.27365
Sigma [mm]	0.69422
Intensity	2951.17

Details...




Fri May 01 21:38:41 - Sat May 02 08:59:32
Window Markers Analysis
Experimental Coincidence Signals
May2_09, Fill #10688, 100 GeV
counts/s [Hz]
STAR..ZDC.
PHENIX..ZDC.
10 pi
RhicIpmManager.blue_horiz:normEmitM[.]
RhicIpmManager.yellow_horiz:normEmitM[.]
RhicIpmManager.blue_vert:normEmitM[.]
RhicIpmManager.yellow_vert:normEmitM[.]
Intensity [^Protons x 10^11]
Time (Start Fill = 10688)
bluDCCTtotal
yelDCCTtotal

Small emittances in RHIC

- Linac injector upgrade reduced emittances from 15 pi to about 5-8 pi. High polarized source intensity allowed to reduce linac pulse duration, which reduces the multiple scattering in the stripping foil.

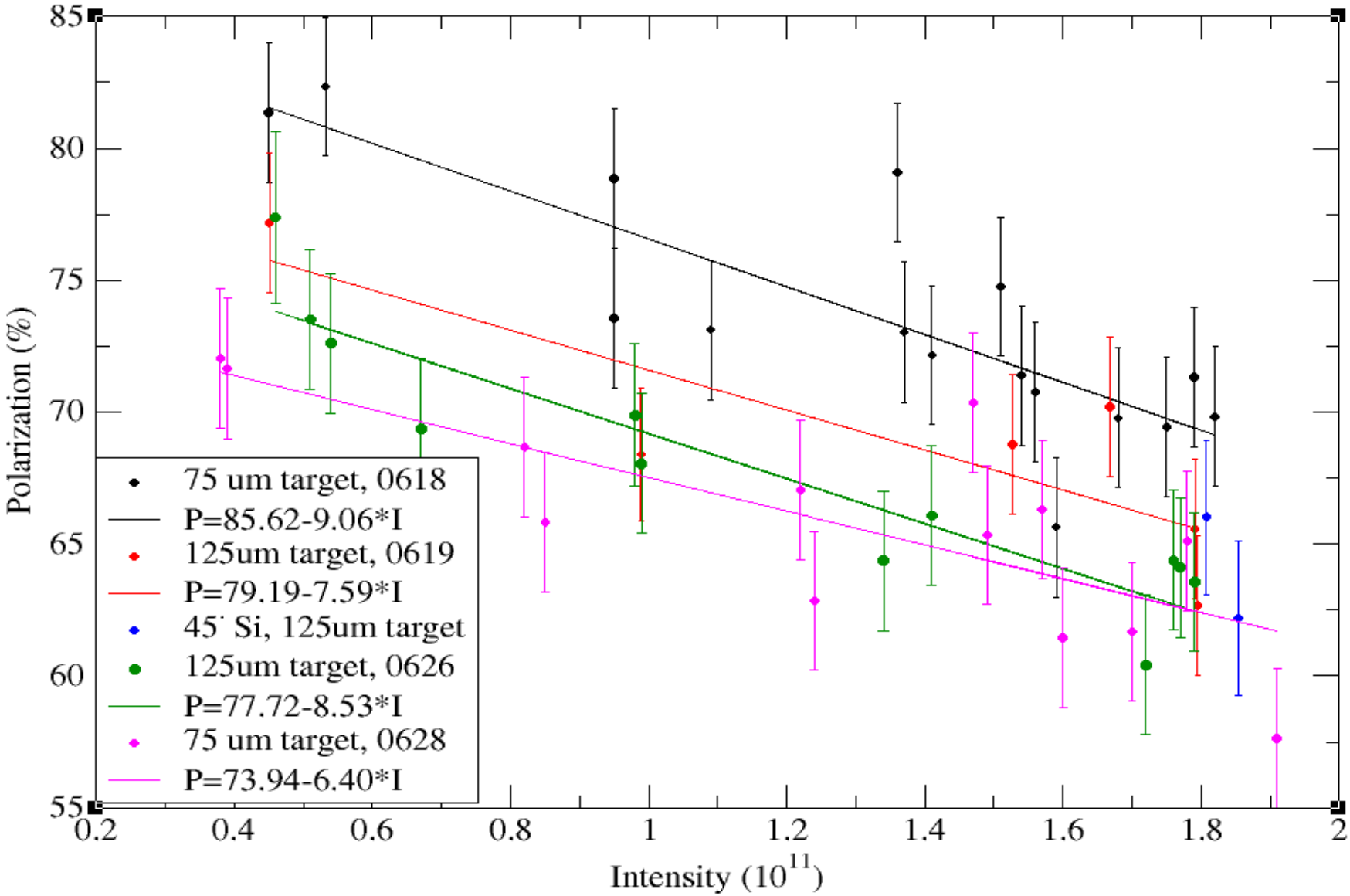
- Even with short linac pulse, the beam intensity is sufficient to use vertical scraping in Booster (about 50%) to reduce vertical (and in less extent horizontal) beam emittances.

- Less emittance blowout was obseved with the new BtA and AGS setup. Small emittances in AGS helps to reduce depolarization.

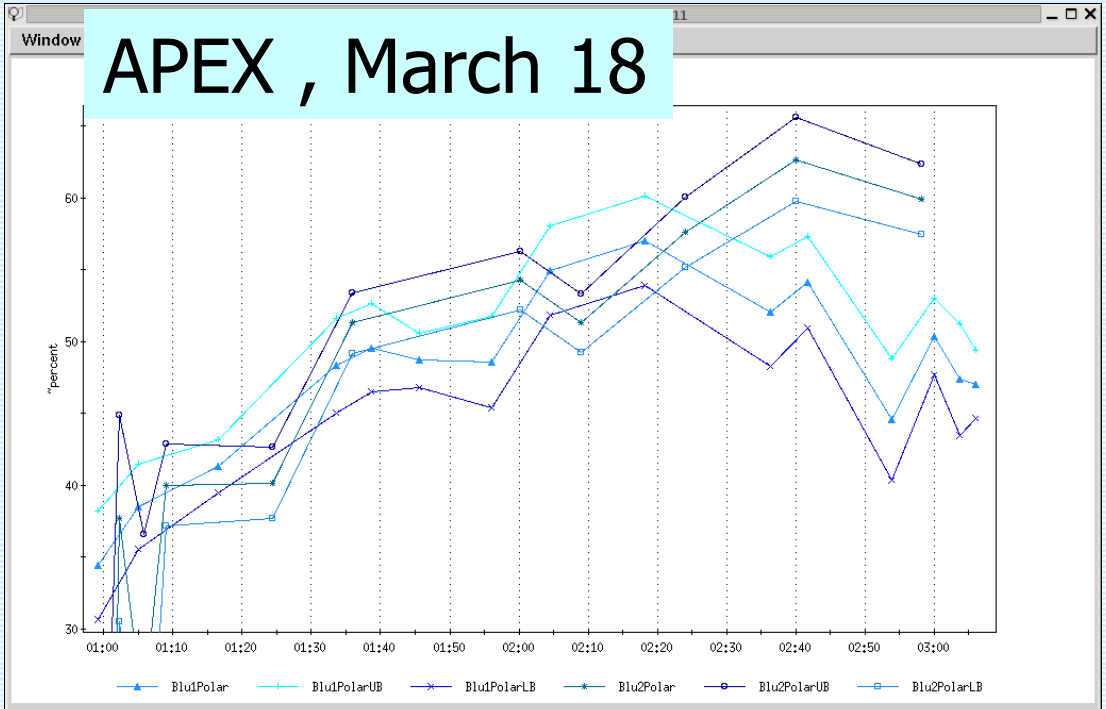
- It was demonstrated that for a number of RHIC fills there is no emittance growth during the acceleration (at least at moderate bunch intensity).

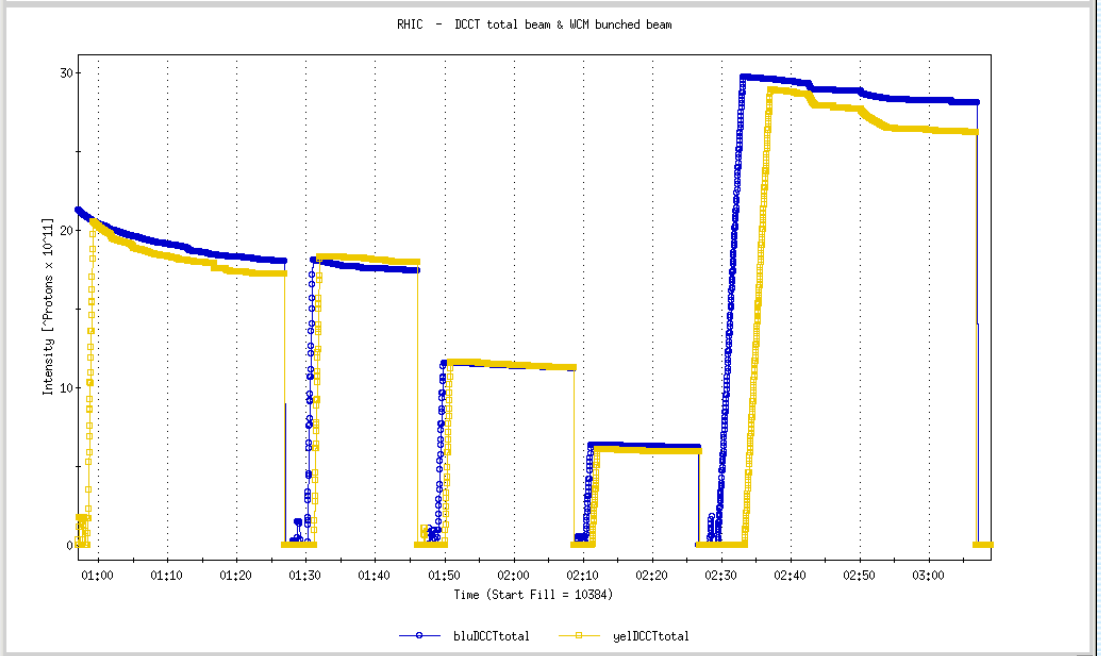
- The only CNI emittance measurements were available for the Yellow beam, since horizontal IPM was not operational.
- The horizontal Blue IPM measurements required large were done after CNI calibrations.

Similar Slopes but Lower Polarization Level As Leakage Currents Went Up



APEX , March 18





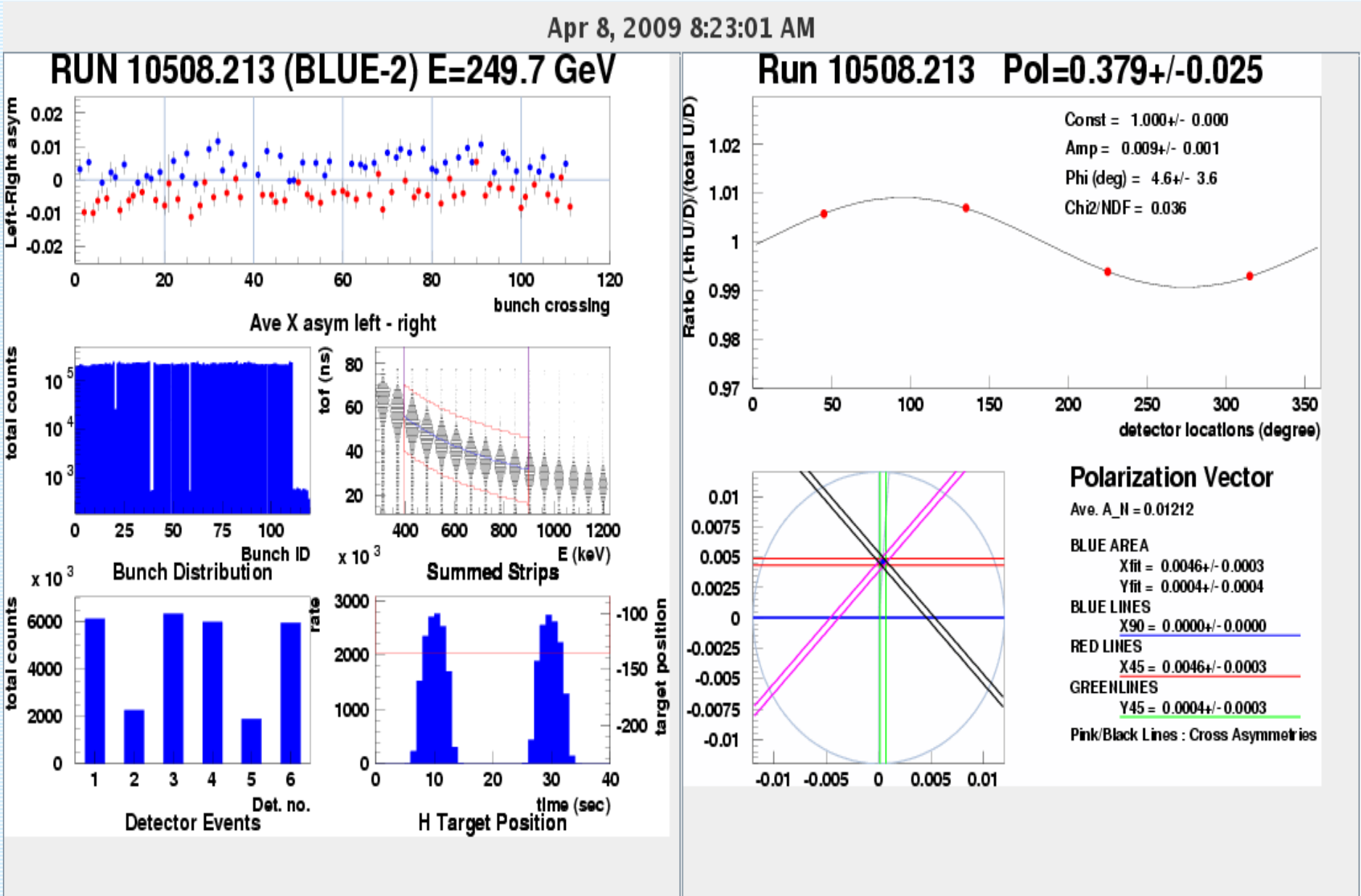
Time = Wed Mar 18 03:05:27 2009, bluDCCTtotal = 28.0959
Time = Wed Mar 18 03:01:00 2009, yelDCCTtotal = 26.3173

Polarization vs bunch intensity measurements in RHIC

Bunch Intensity x 10^11	AGS	Blue-1	Blue-2	Yellow-1	Yellow-2
0.5 249.7 GeV	59.4	50.4 47.0	59.9	46.1	43.0
0.5 23.7 GeV	59.4	54.2	62.7	52.3	61.4
1.0 23.7 GeV	59.0	48.6 55.0	54.3 51.3	55.1	49.8
1.5 23.7 GeV	52.5	48.3 48.7	51.3	55.1	51.0
1.9 23.7 GeV	47.5 44.0	39.7 38.1	41.1 40.2	39.7	40.1

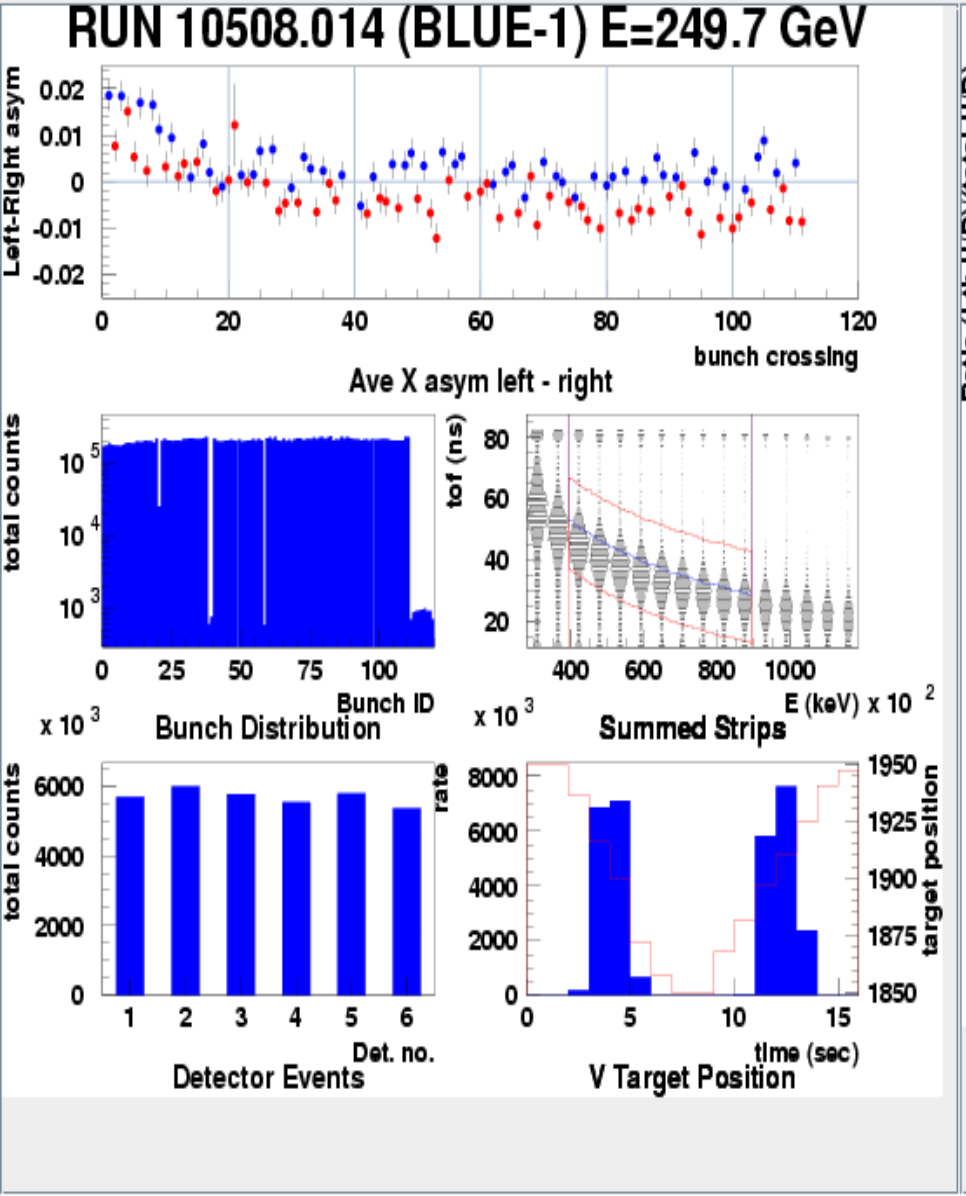
Measurements at injection with the 12 bunches (fixed target).

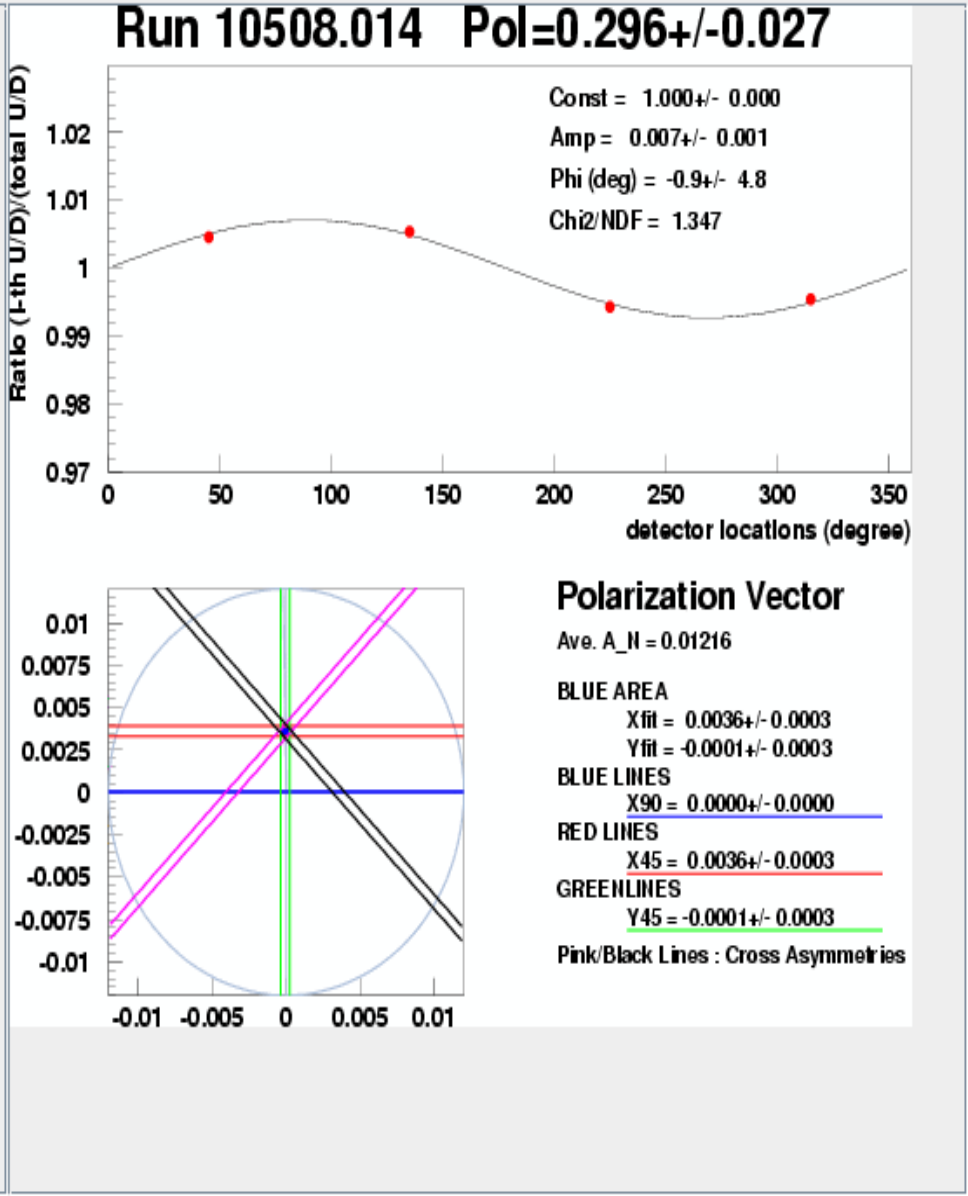
Blue-2, H#1, (2-effective target thickness)



Blue-1, V#2 (8- effective thickness))

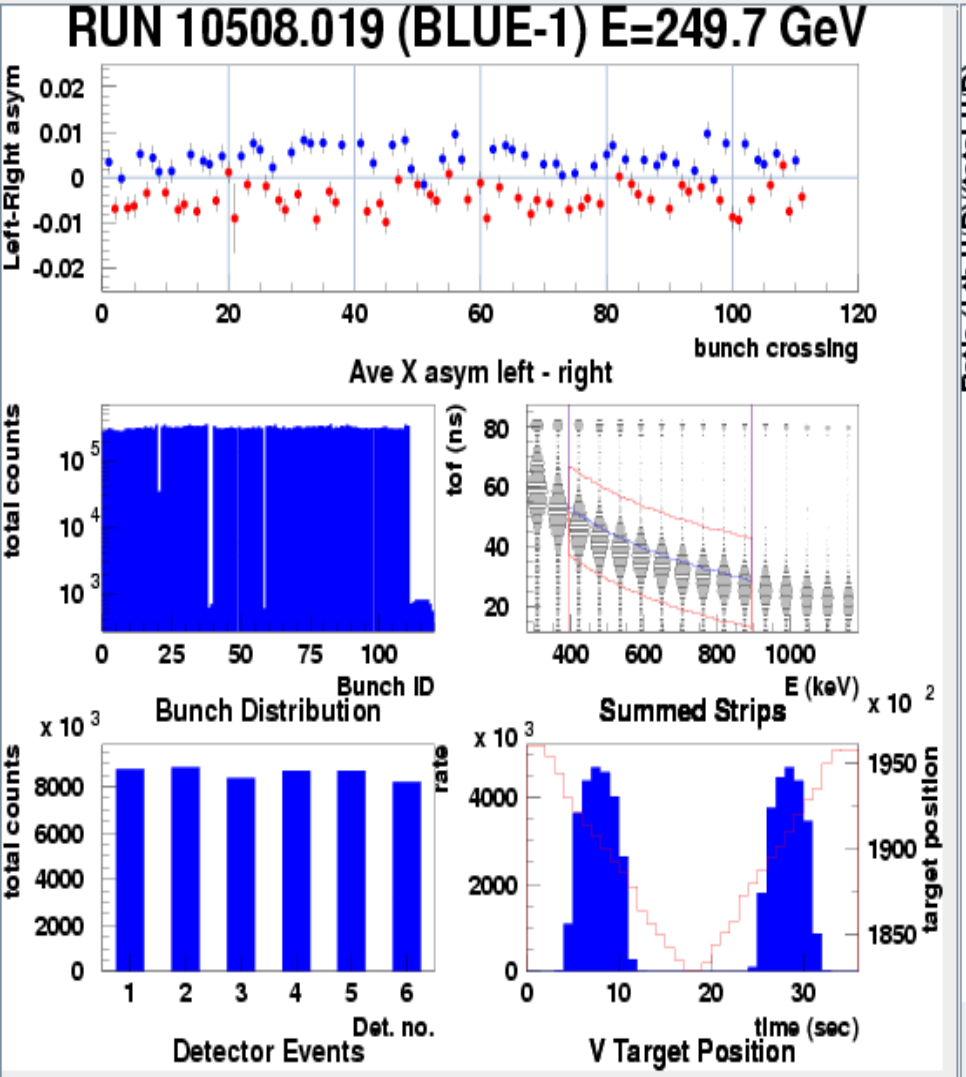
Apr 8, 2009 8:24:32 AM

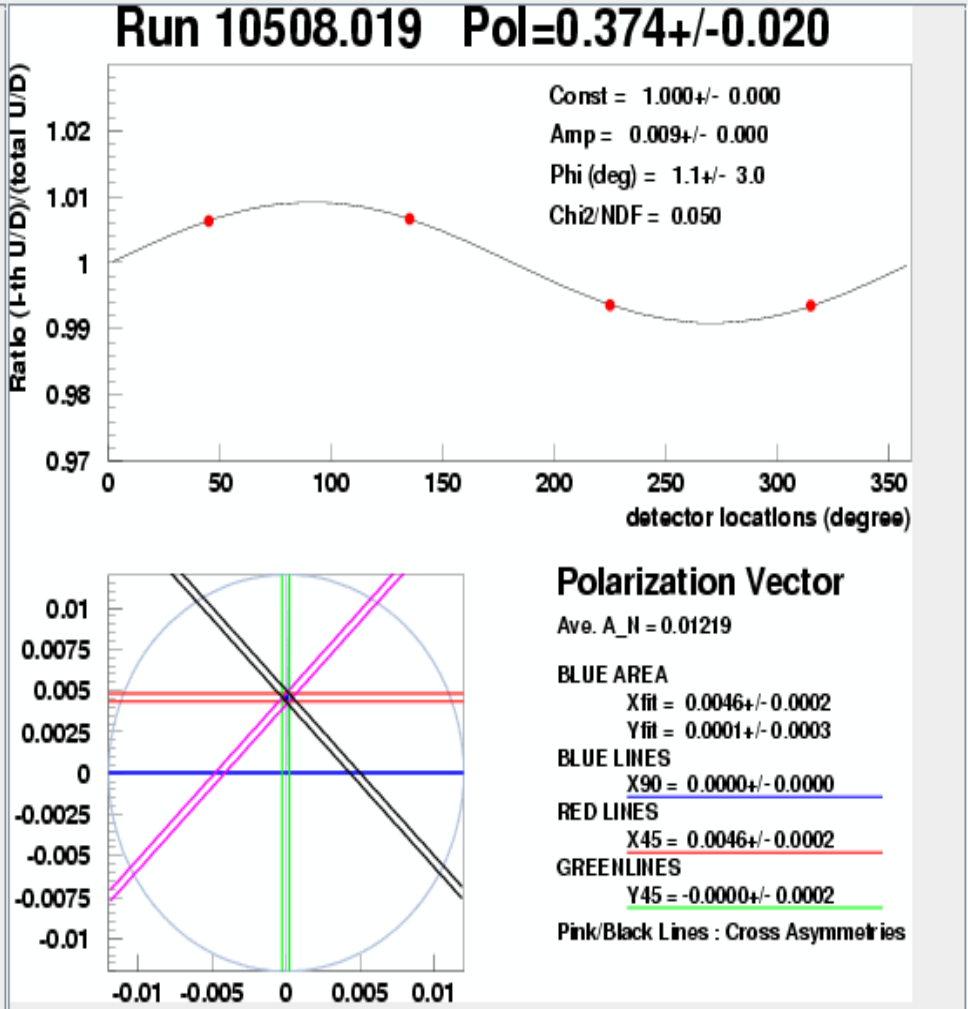




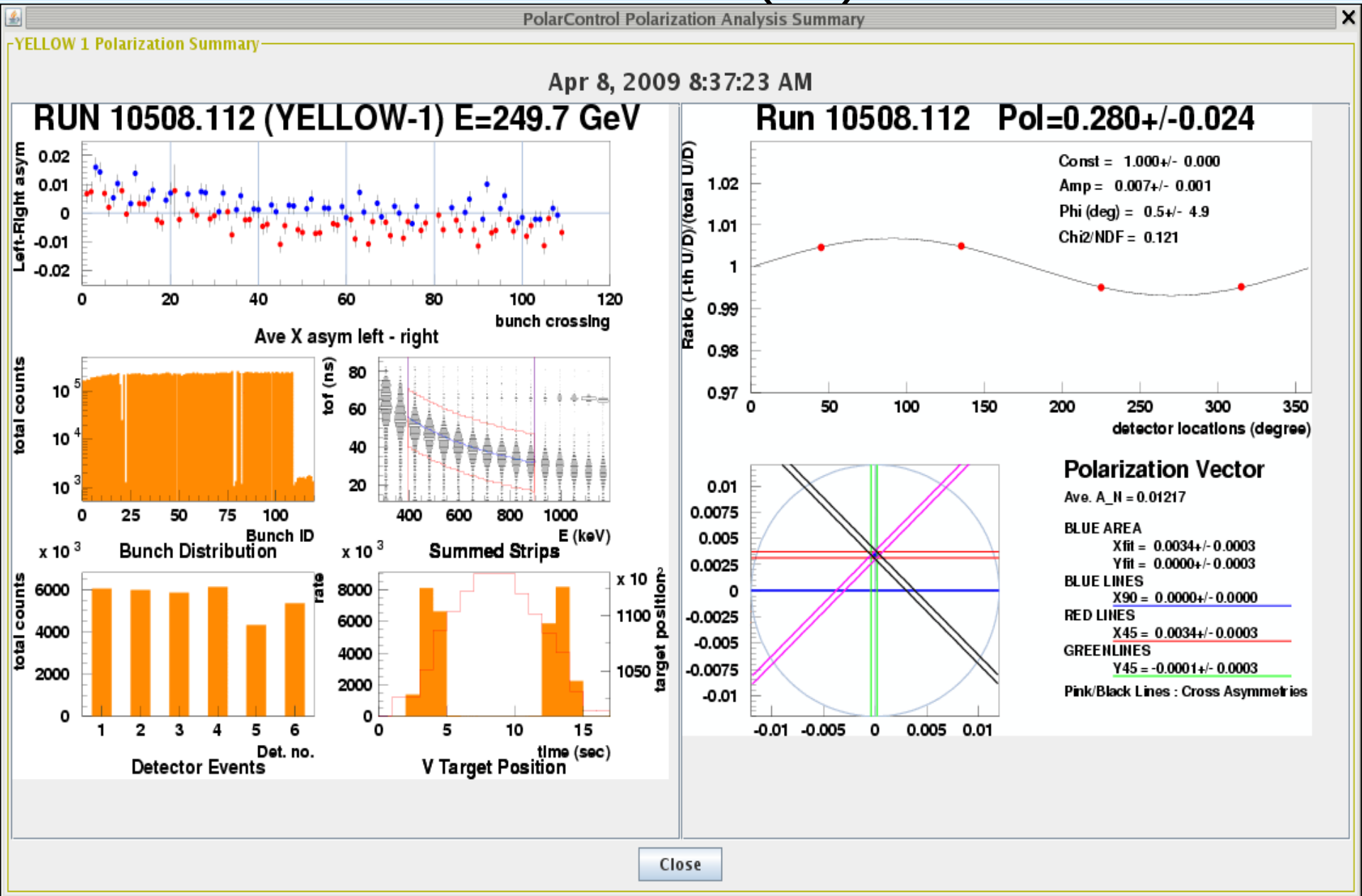
Blue-1, V#4 (3)

Apr 8, 2009 8:36:32 AM



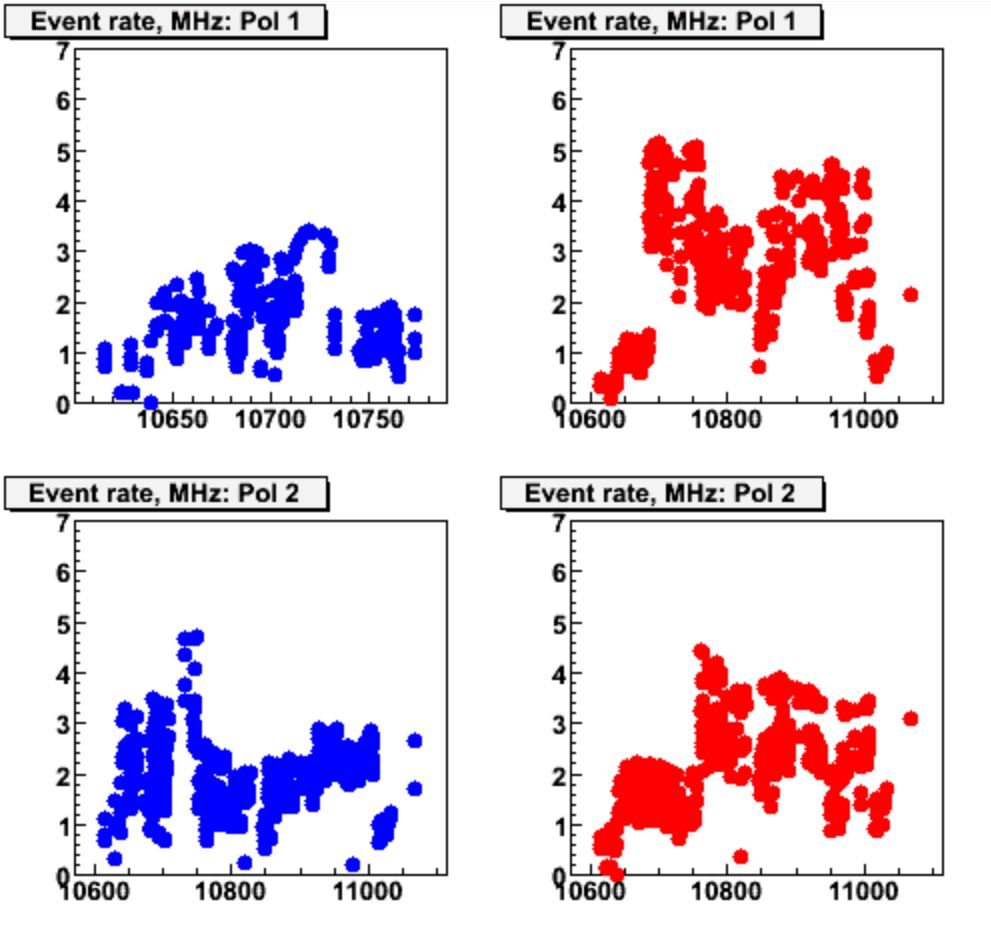


Y-1, V#5 (12)


PolarControl Polarization Analysis Summary
YELLOW 1 Polarization Summary
Apr 8, 2009 8:37:23 AM
RUN 10508.112 (YELLOW-1) E=249.7 GeV
Left-Right asym
bunch crossing
Ave X asym left - right
total counts
Bunch ID
Bunch Distribution
tof (ns)
E (keV)
Summed Strips
total counts
Det. no.
Detector Events
rate
target position
time (sec)
V Target Position
Run 10508.112 Pol=0.280+/-0.024
Ratio (I-th U/D)/(total U/D)
Const = 1.000+/- 0.000
Amp = 0.007+/- 0.001
Phi (deg) = 0.5+/- 4.9
Chi2/NDF = 0.121
detector locations (degree)
Polarization Vector
Ave. A_N = 0.01217
BLUE AREA
Xfit = 0.0034+/- 0.0003
Yfit = 0.0000+/- 0.0003
BLUE LINES
X90 = 0.0000+/- 0.0000
RED LINES
X45 = 0.0034+/- 0.0003
GREEN LINES
Y45 = -0.0001+/- 0.0003
Pink/Black Lines : Cross Asymmetries
Close

Rate “problems”

√s=200 GeV



In “banana” cut:

Run9-250 GeV: up to 150 kHz/strip

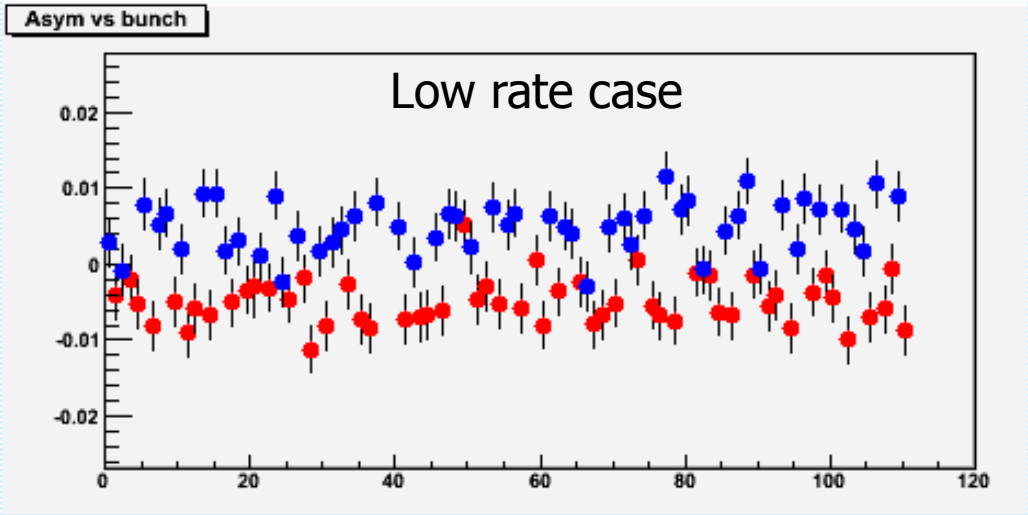
Run9-100 GeV: up to 100 kHz/strip

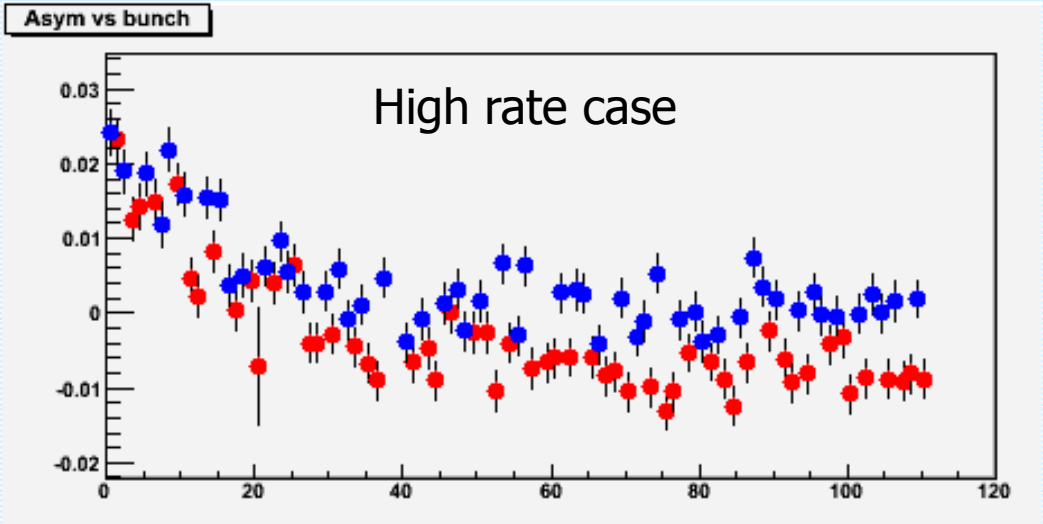
Run8-100 GeV: up to 50 kHz/strip

Run6-100 GeV: up to 30 kHz/strip

Effectively rates are twice higher (in the ToF-Energy window at the entrance of WFD)

Rate effects: asymmetry vs bunch

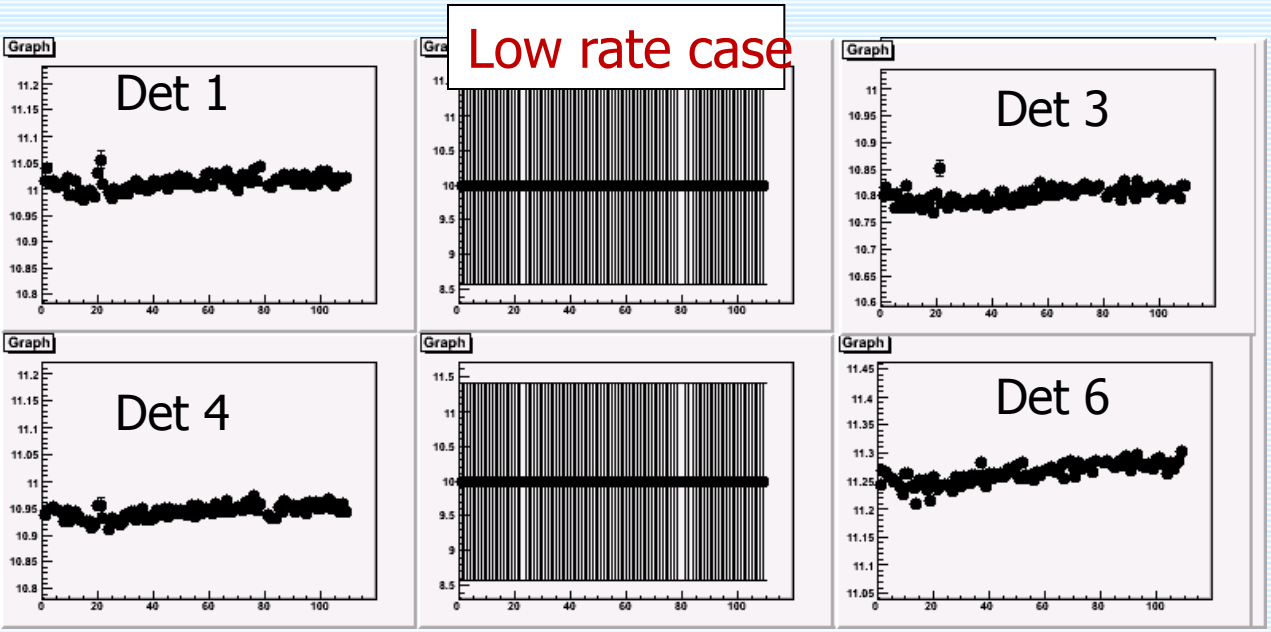




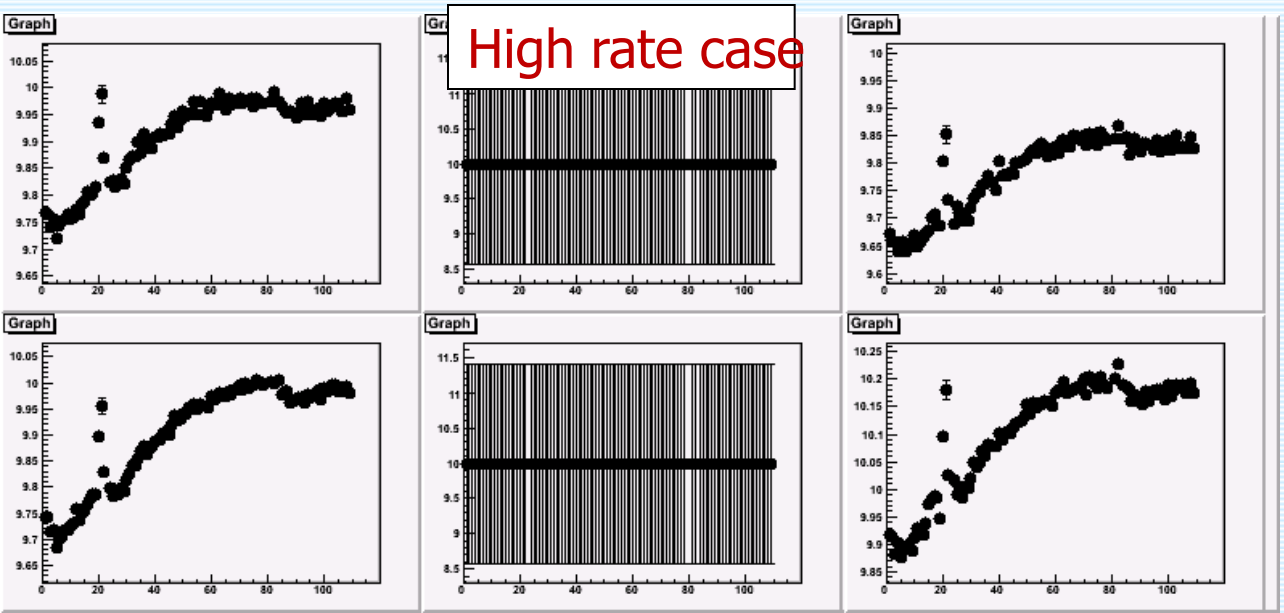
Detector asymmetry is a function of bunch #:

Detector (system) performance may vary vs bunch (after abort gap) and vs detector

Rate effects: Mass vs bunch



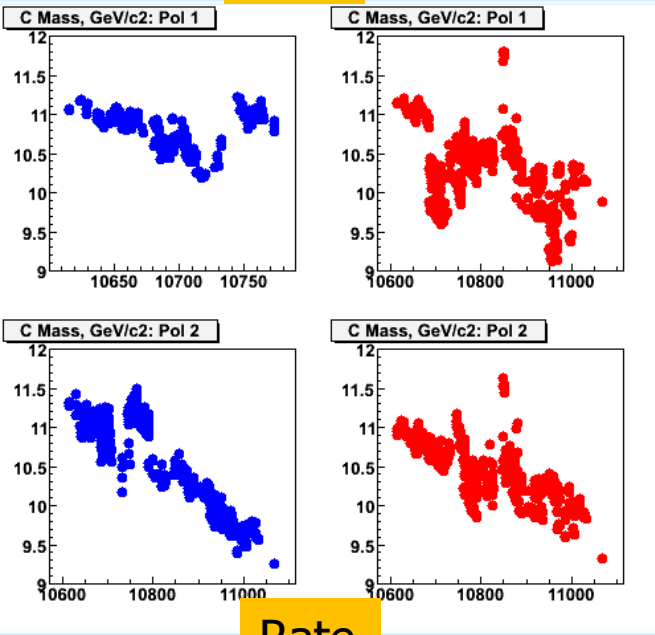
4%



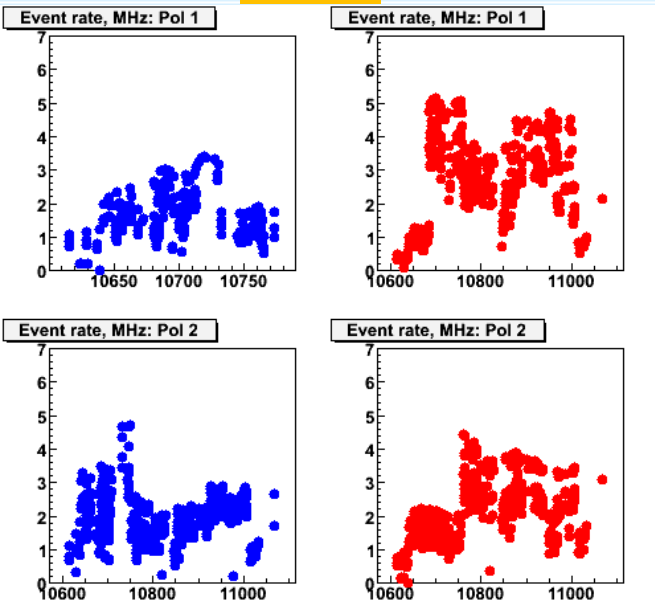
Bunch dependence of mass ⇒ Bunch dependence of system performance (energy, tof etc.)

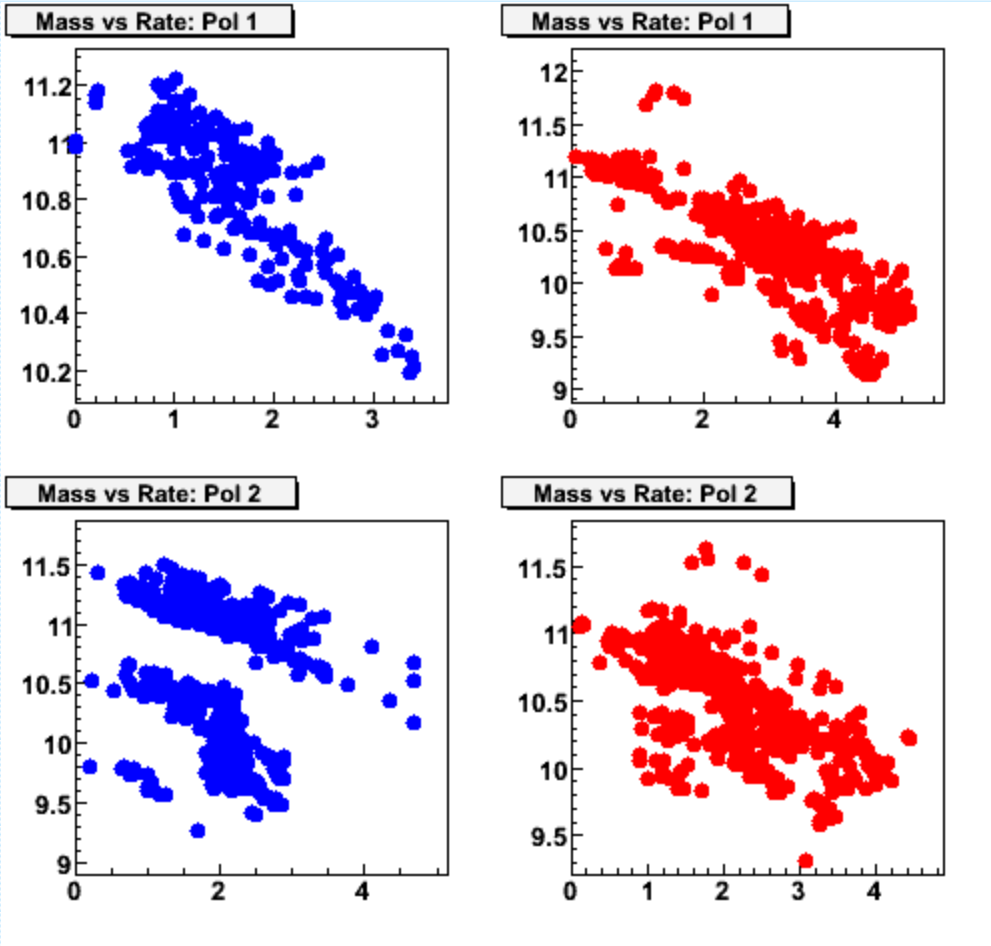
Rate effects: Mass vs Rate

Mass



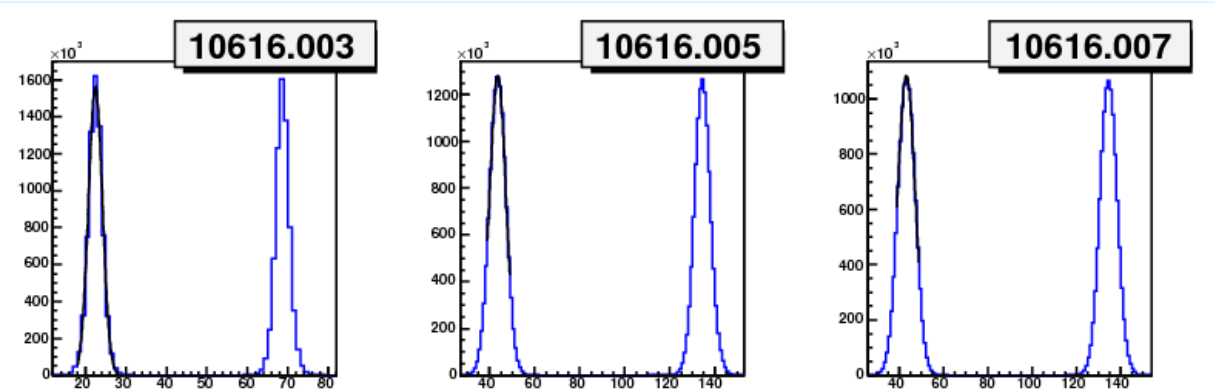
Rate





Different correlation patterns
$\Rightarrow$ not only rate problems (but also T0 drift etc.)

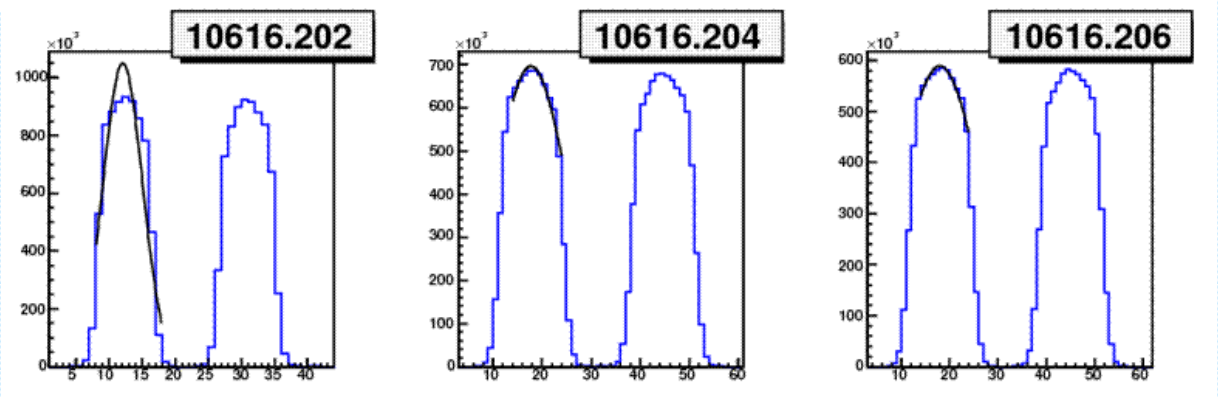
Intensity profiles



Good profile:

Perfect gaussian

Low rate

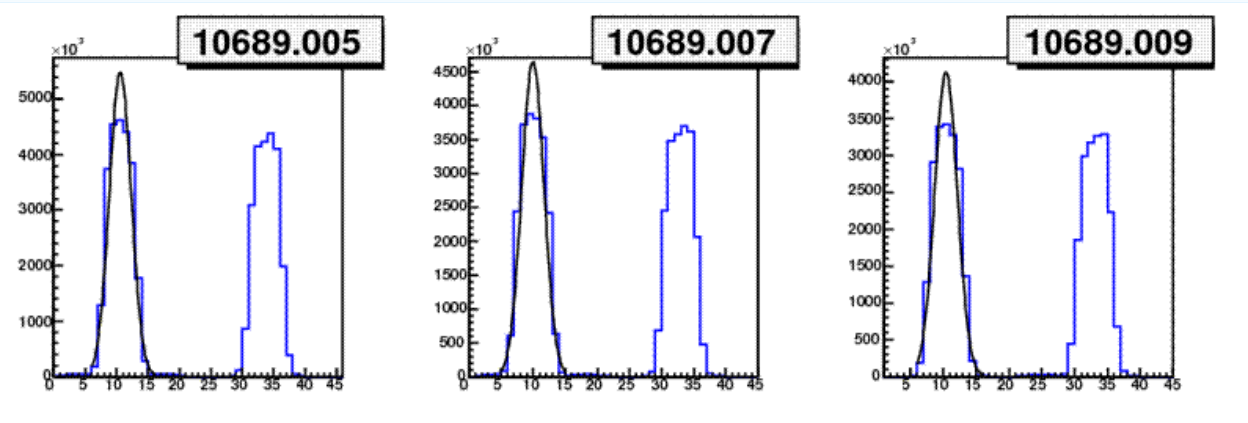


Bad profile:

Non-gaussian

Low rate

Target positionig problem?



Bad profile:

Non-gaussian

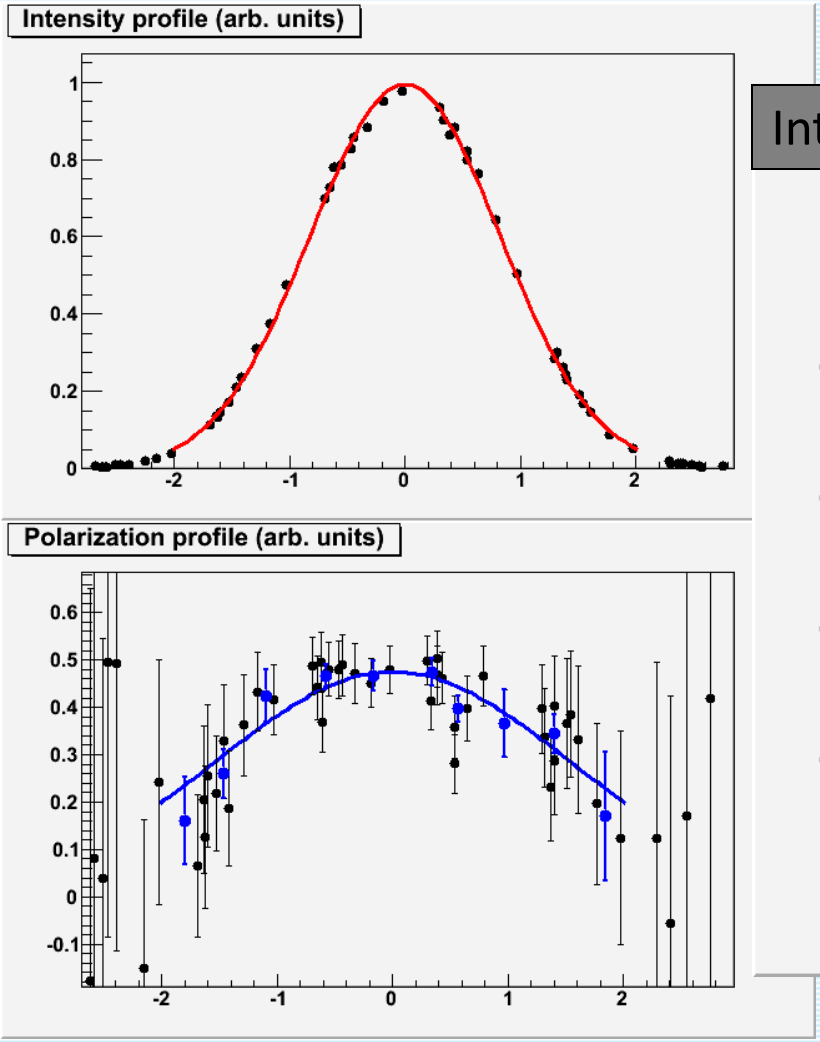
High rate

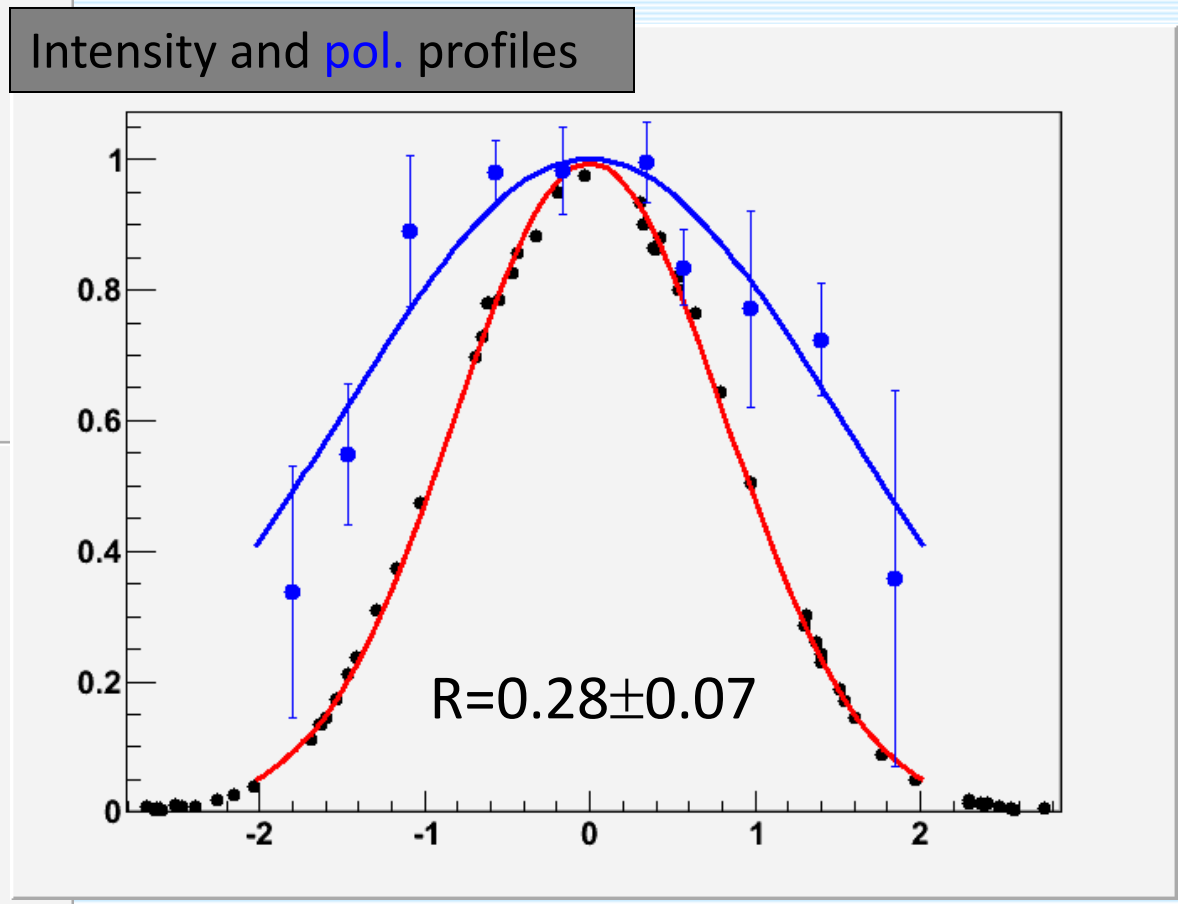
Rate problem?

Pol. Profile: 250 GeV

$$R = \frac{\sigma_I^2}{\sigma_P^2}$$

Fill 10525, Blue2





<u>4 runs (8 scans) combined:</u>

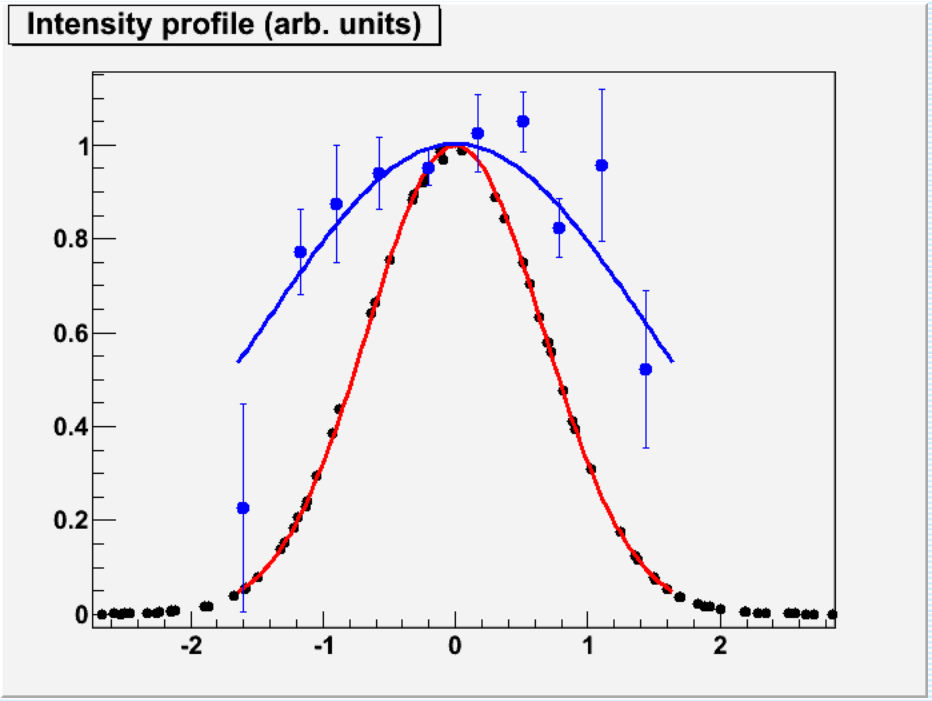
Peak of intensity profile is normalized to 1

X coordinate is rescaled to correspond to σ_I of 1st scan

Pol. Profile: 250 GeV

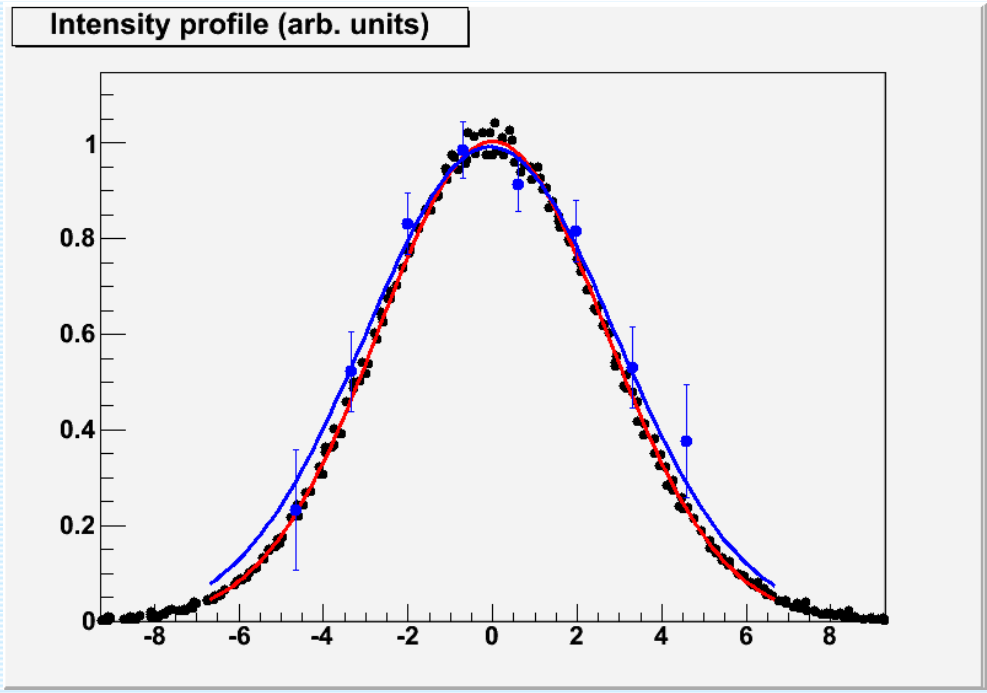
$$R = \frac{\sigma_I^2}{\sigma_P^2}$$

Fill 10373, Yellow1



R=0.17±0.06

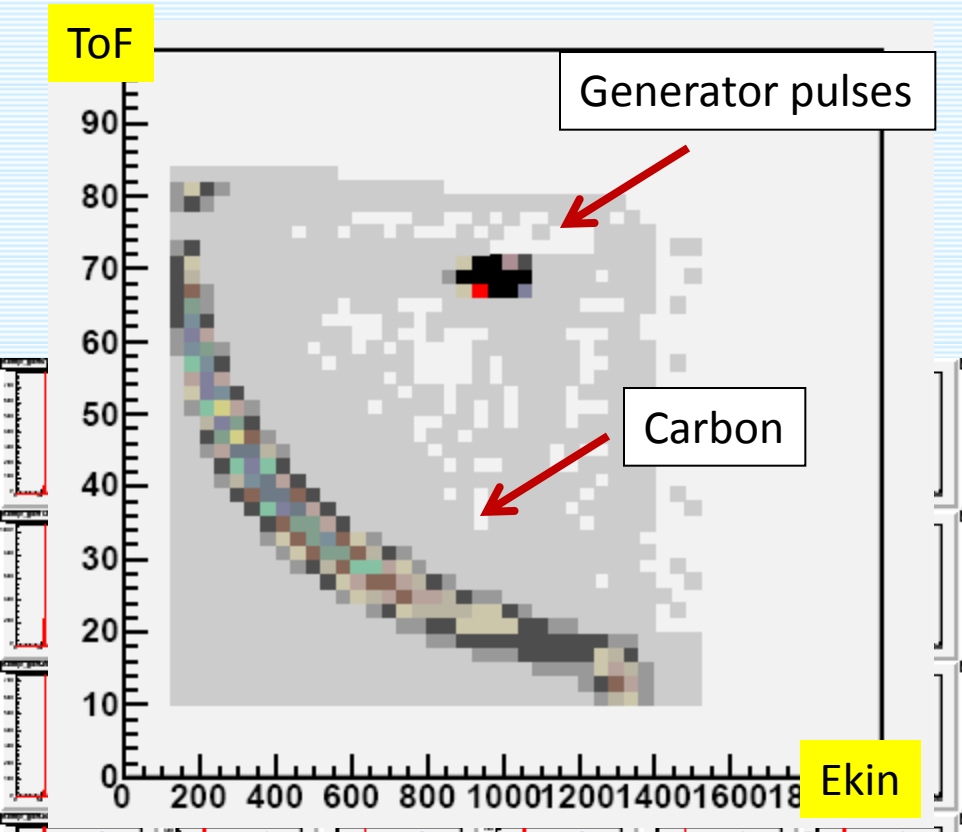
Fill 10486, Yellow2



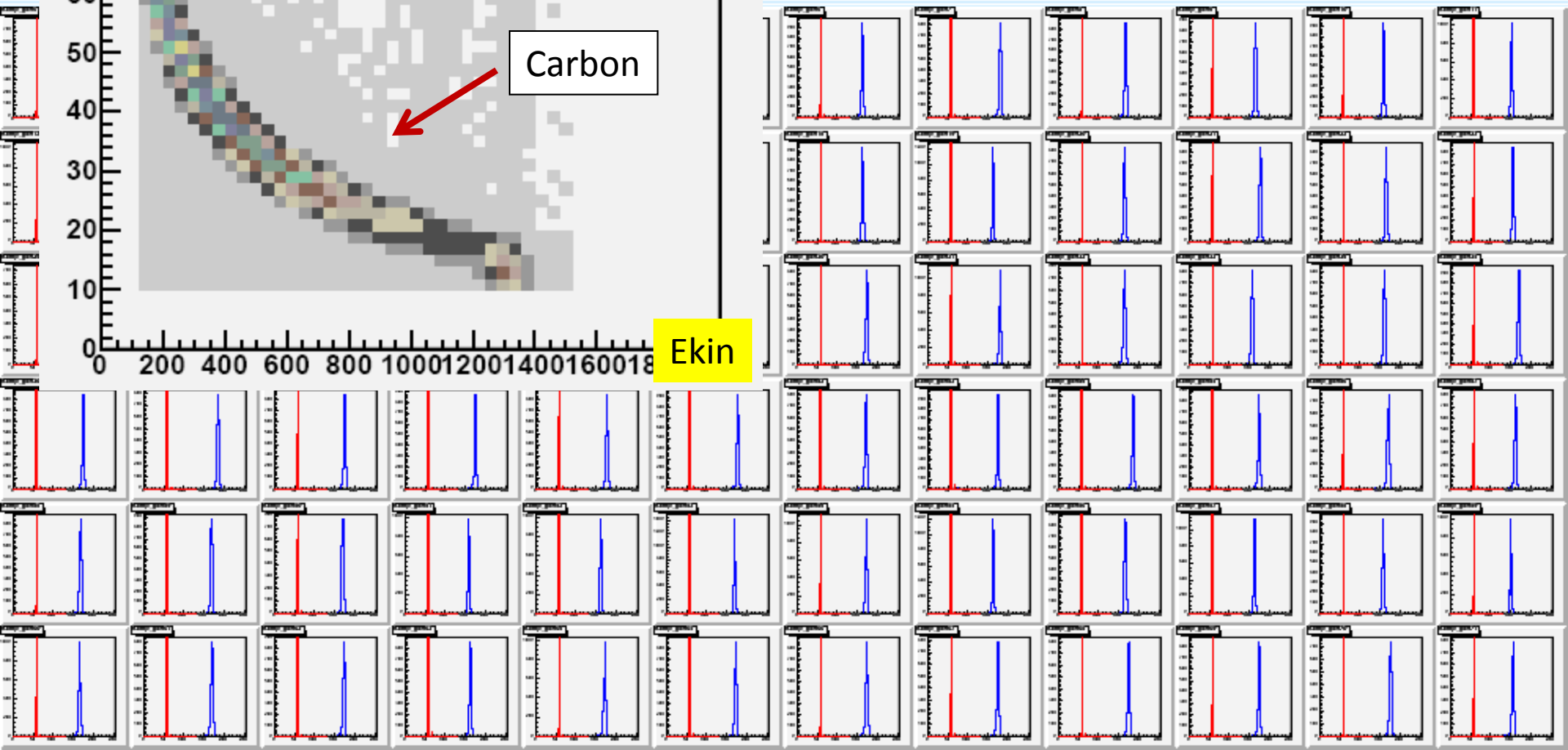
R=0.72±0.12

Pol. profile varies from fill to fill

pC Monitoring with pulser



Blue1

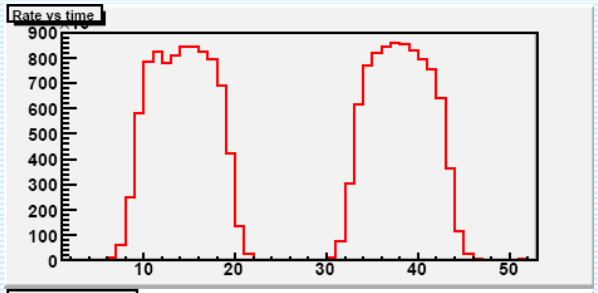


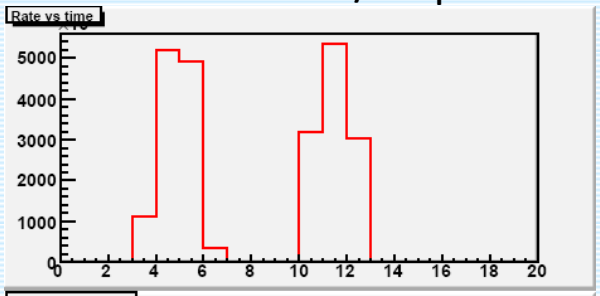
pC Monitoring with pulser

Low rate example: 10429.013
20 kHz/strip

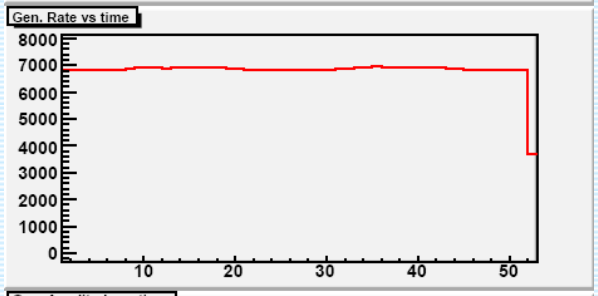
High rate example: 10346.007
100 kHz/strip

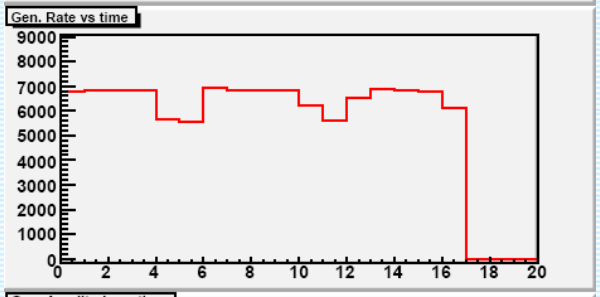
Event rate vs time



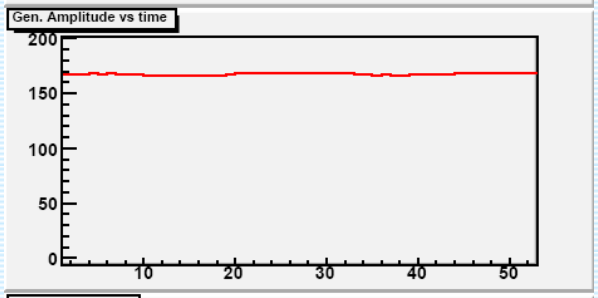


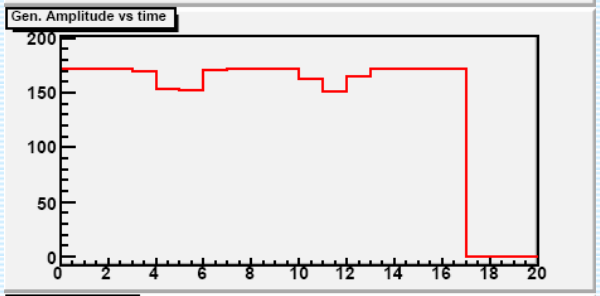
Pulse rate vs time



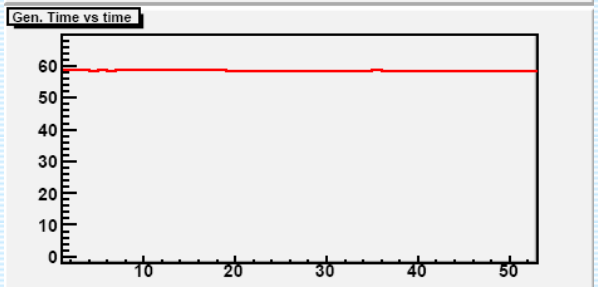


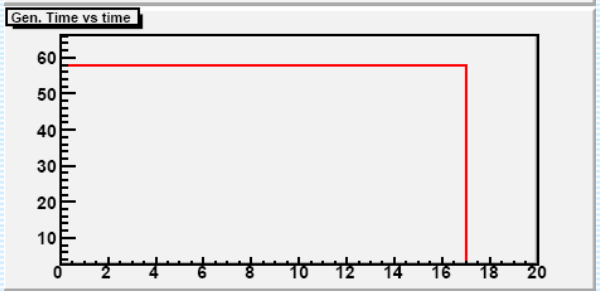
Pulse amplitude vs time





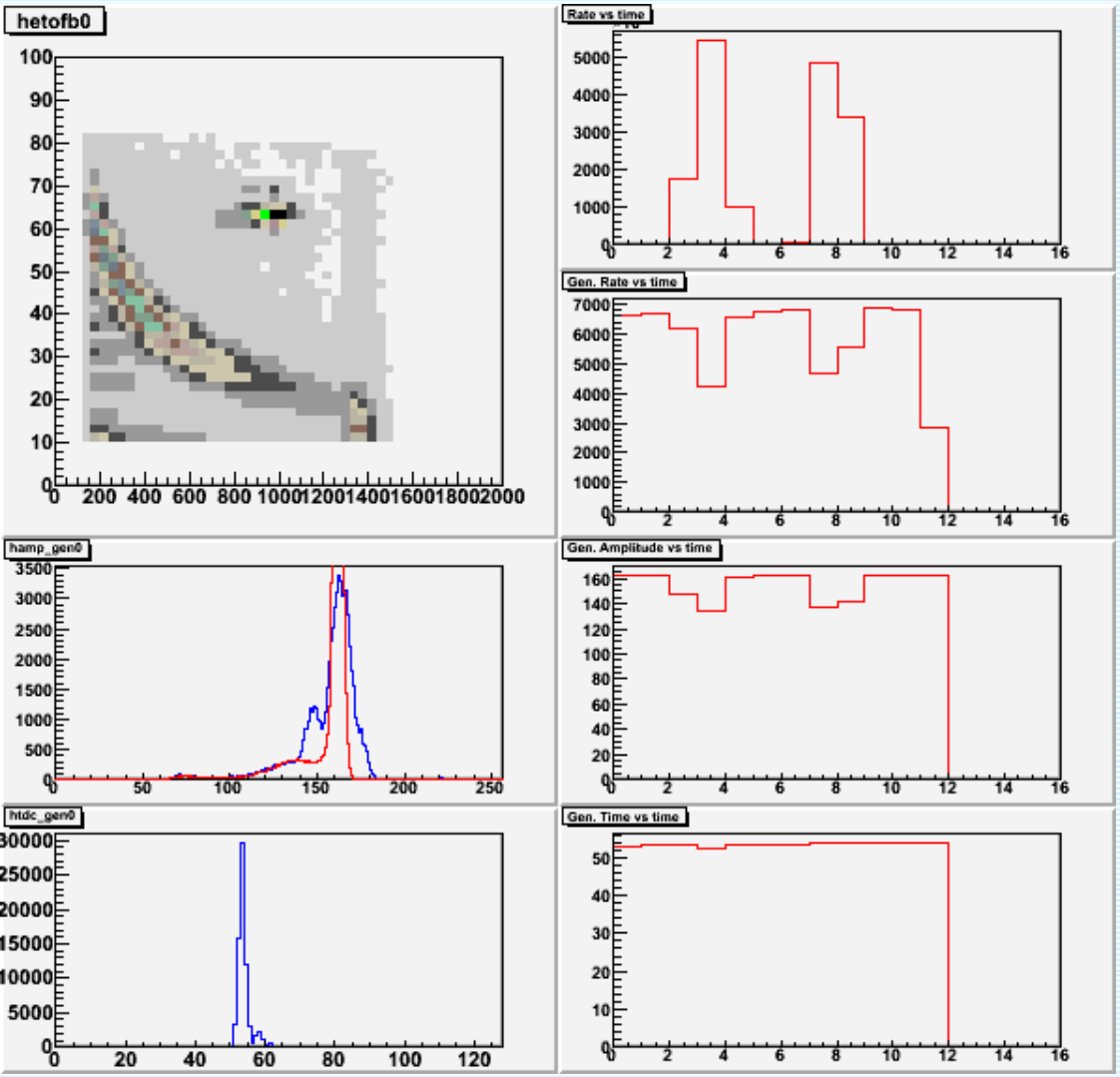
Pulse ToF vs time





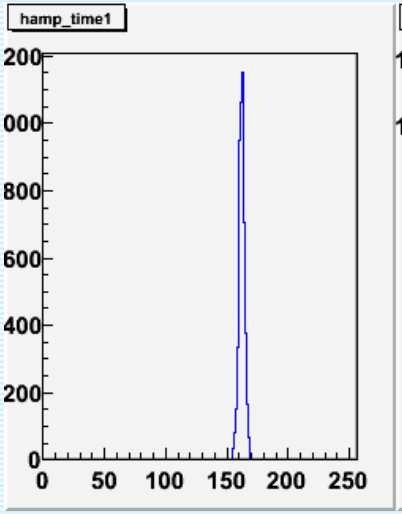
pC Monitoring with pulser

Run 10450.116
110 kHz/strip

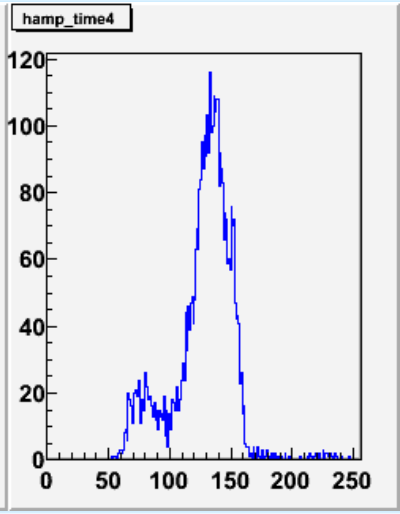


Pulser Amplitude distribution

No Rate

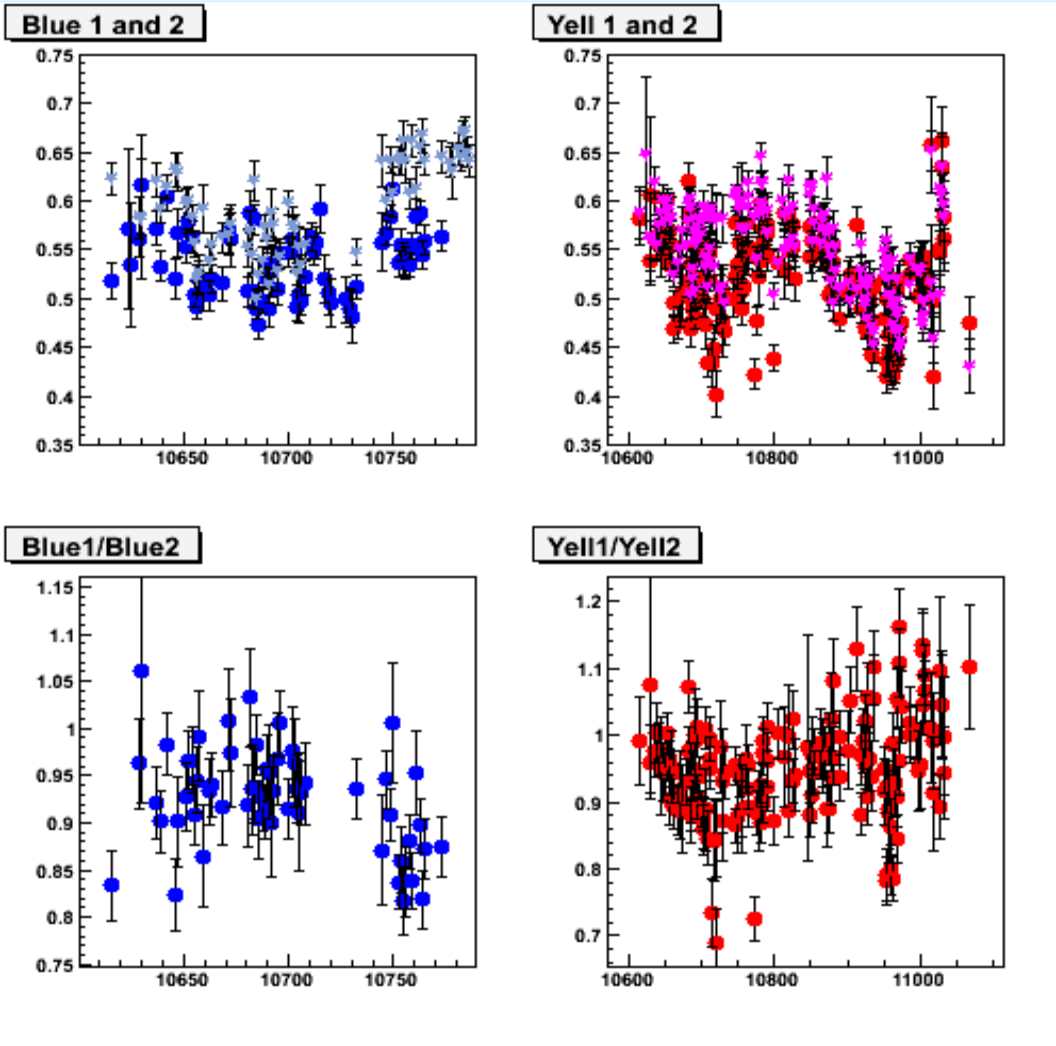


High Rate



Pol1 vs Pol2

$\sqrt{s}$=200 GeV



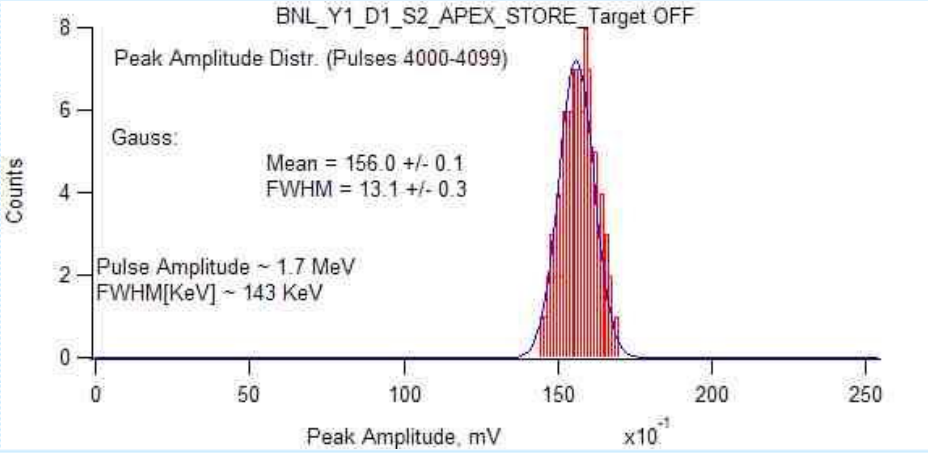
±10% variation in the Pol1/Pol2 ratio vs fill

(±20% variation at $\sqrt{s}$=500 GeV)

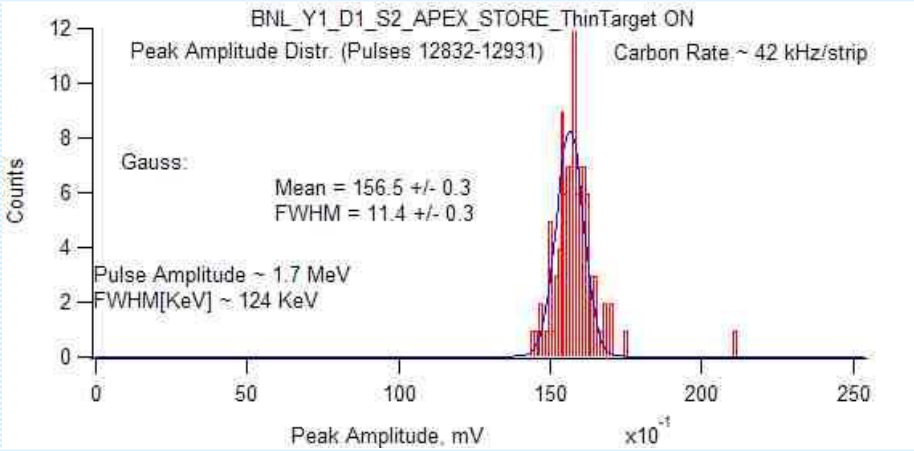
No obvious correlation with "obvious" observables, such as rate, C-mass

APEX Rate Studies

Injected Generator pulse
No target

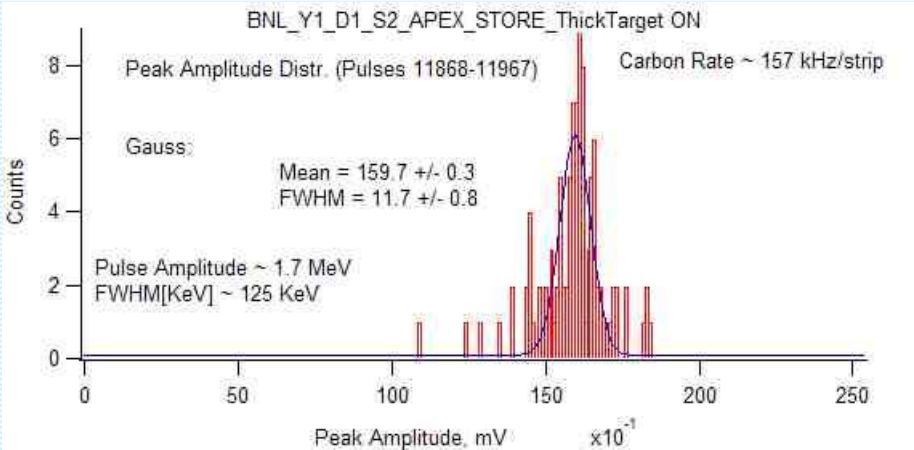


With a thin Carbon target
Carbon rate 42 kHz/ strip

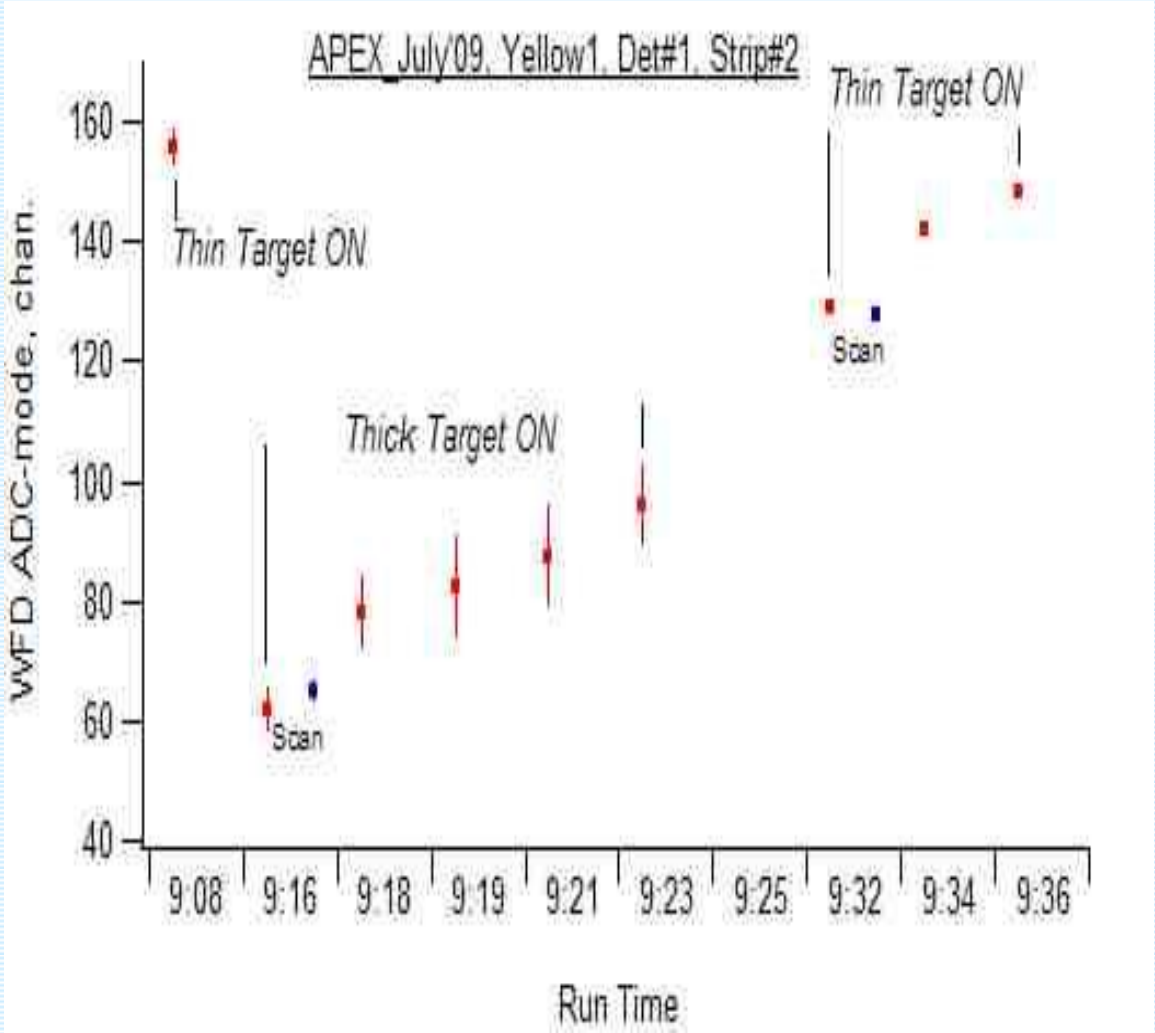


With a thick target
Carbon rate 157 kHz/strip

No appreciable change observed



Pulse generator measurement with WFD



Summary

- Polarimeter survived all the upgrades.
- Reliable operation in switching mode (between vertical and horizontal planes) was demonstrated .
- Beam intensity profile measurements made essential contribution to emittance calibration and knowledge of absolute values.
- Upgrade facilited new detectors and electronics
    - New detectors tested (B.Morozov, G. Atoian)
    - Crucial cross check from the comparison of Pol1 vs Pol2
- Systematic effects observed
    - Rate effects (saturation, energy shift, ToF shift).
    - Detectors “aging” effects
- Plans
- Improve target production technique (laser ablation?).
- More robust detectors, smaller acceptance (B.Morozov, G.Atoian)
- Faster preamps
- Replace WFD with simple ADC/TDC scheme? Test the scheme in AGS in Run10.

Midterm notices on p-Carbon polarimeter operation..

- Polarimeter survived all the upgrades. Reliable operation in switching mode (between vertical and horizontal planes) was demonstrated after a few software glitches were fixed.
- Beam intensity profile measurements made essential contribution to emittance calibration and knowledge of absolute values.
- Rate problem for polarization measurements.
- Maximum rate up to 8 million event/s , about 100 kHz/strip,
- ~1 event/bunch crossing/72 strips.
- Detectors and DAQ were not designed to handle this rate.
- About 3-4 rate variation was observed for the regular target thickness.
- It looks like thinner target lifetime is the same (or better?) than thicker targets.
- Another possibility to reduce event rate /detector is solid angle reduction.
  4 mm^2 vs 20 mm^2 with the Hamamatsu strip detectors.

To accumulate required statistics ~ 20 millions events target should sit longer time in the beam. The effect to the beam emittances and luminosity is negligible at store. The only problem would be target lifetime.

Increase number of DAQ channels?