Pilat, Bai, Bruno, Ptitsyn, Malitsky, Satogata, Tepikian

APEX Workshop 2007

Beta squeeze

BNL – November 1-2, 2007

outline

- Goals: lumi increase, dynamic beta* on the store for ions, part of lumi development plan for PP
- Short history (Run-4, Run-5)
- Report on Run-7
- Plans for Run-8 and beyond

β* squeeze and knobs (Run-4)

Pilat, Wittmer, VanZejits, Ptitsyn

<u>Preparation</u>

Calculated and prepared β* knobs for blue (MADX→RE) <u>limit 12%</u>

Checked RE model prediction for effects on mach parameters

<u>Experiments test in blue (February 25):</u>

- Center orbit in IR8, separate tunes
- Varied bo7-qd1 and bi8-qd1 by –ΔK and +ΔK in the range from 0 to 0.001 in steps of 0.0001 and took (PLL) tune shift data for β* measure (anti-symmetric excitation minimizes beta-beat for symmetric optics – more later on that)
- Tried out the beta* knobs at 5%, 10% and 12% (present limit) without lifetime degradation
- Measured dispersion and beta around the ring (AC dipole) to evaluate beta beating for different knobs levels

IR PS:

- IR supplies needs to be ramped slow (slowfactor 25+) 8b-qd1 QLI'ed during the first attempt to ramp knob to 12% (slowfactor 8)
- bi8-qf9 PS exceeded limits of 150A (166A)→leads problem (Ganetis) knobs will be modified to avoid that

Knobs could be ramped up to 12% without obvious problem with other machine parameters

No apparent hysteresis (checked by switching knobs on and off)

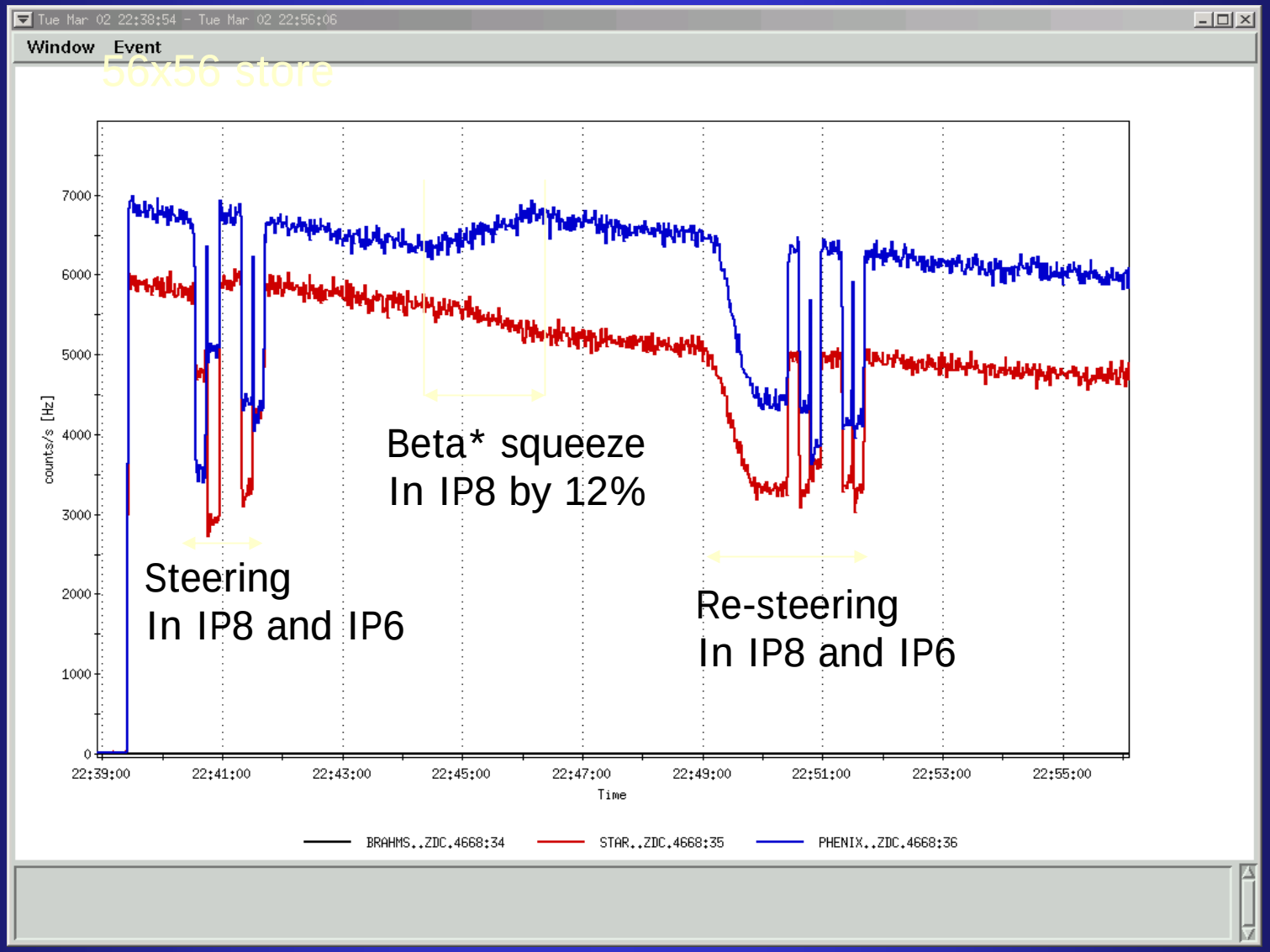
No observed effect on rates when we had beams in collisions (6 bunches in blue, 3 in yellow, no IR steering – etc.)

Analysis of beta* data in progress:

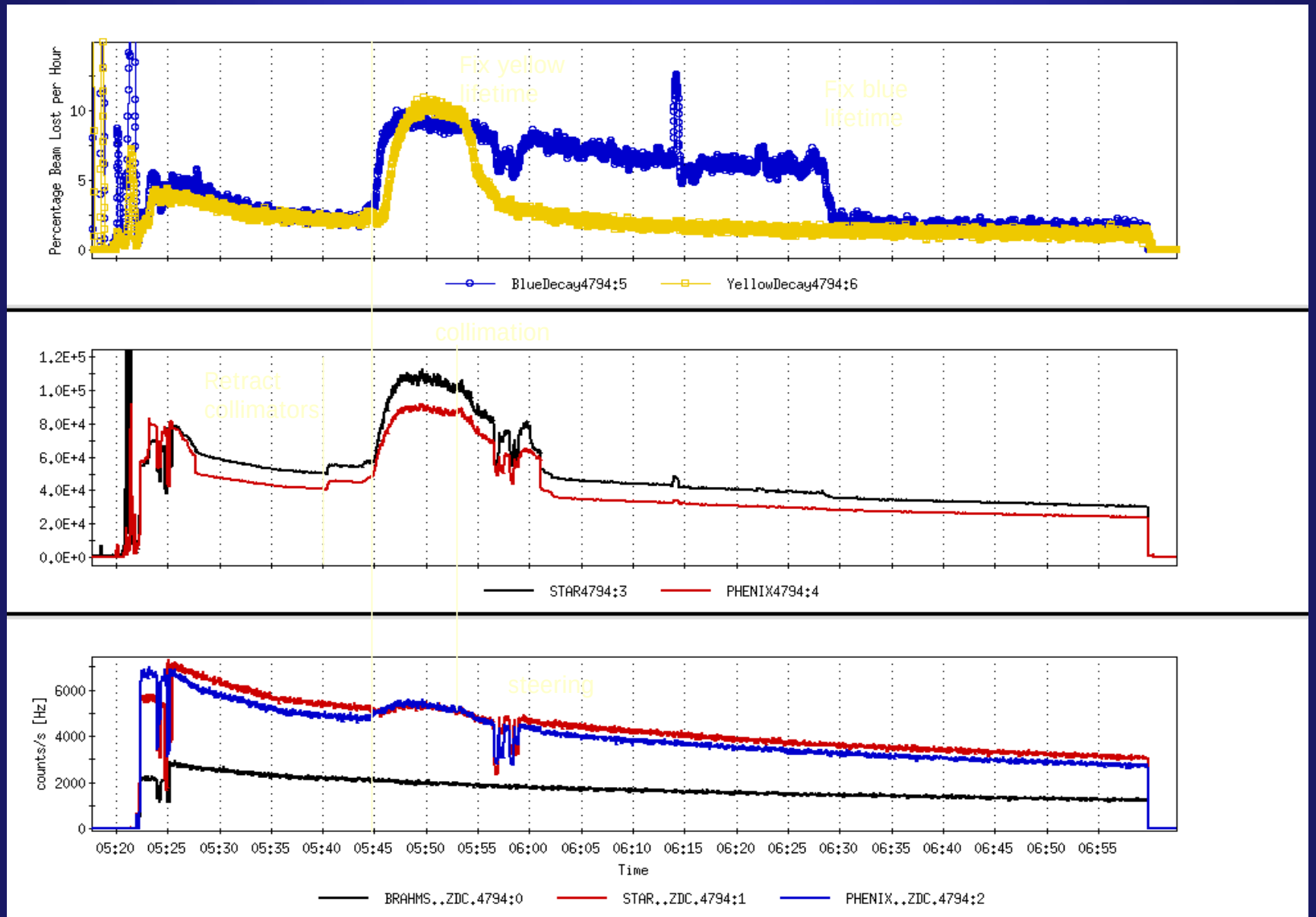
- (verify the quadratic dependence, assess impact of anti-symmetric optics)→measured beta* value
- Correlate AC dipole and dispersion measurements
- Calculation of new knobs (including triplet power supplies) to redistribute strength, avoid PS limits, possibly increase knob range to 15%-20?%

Beta squeeze in Phenix (Run-4)

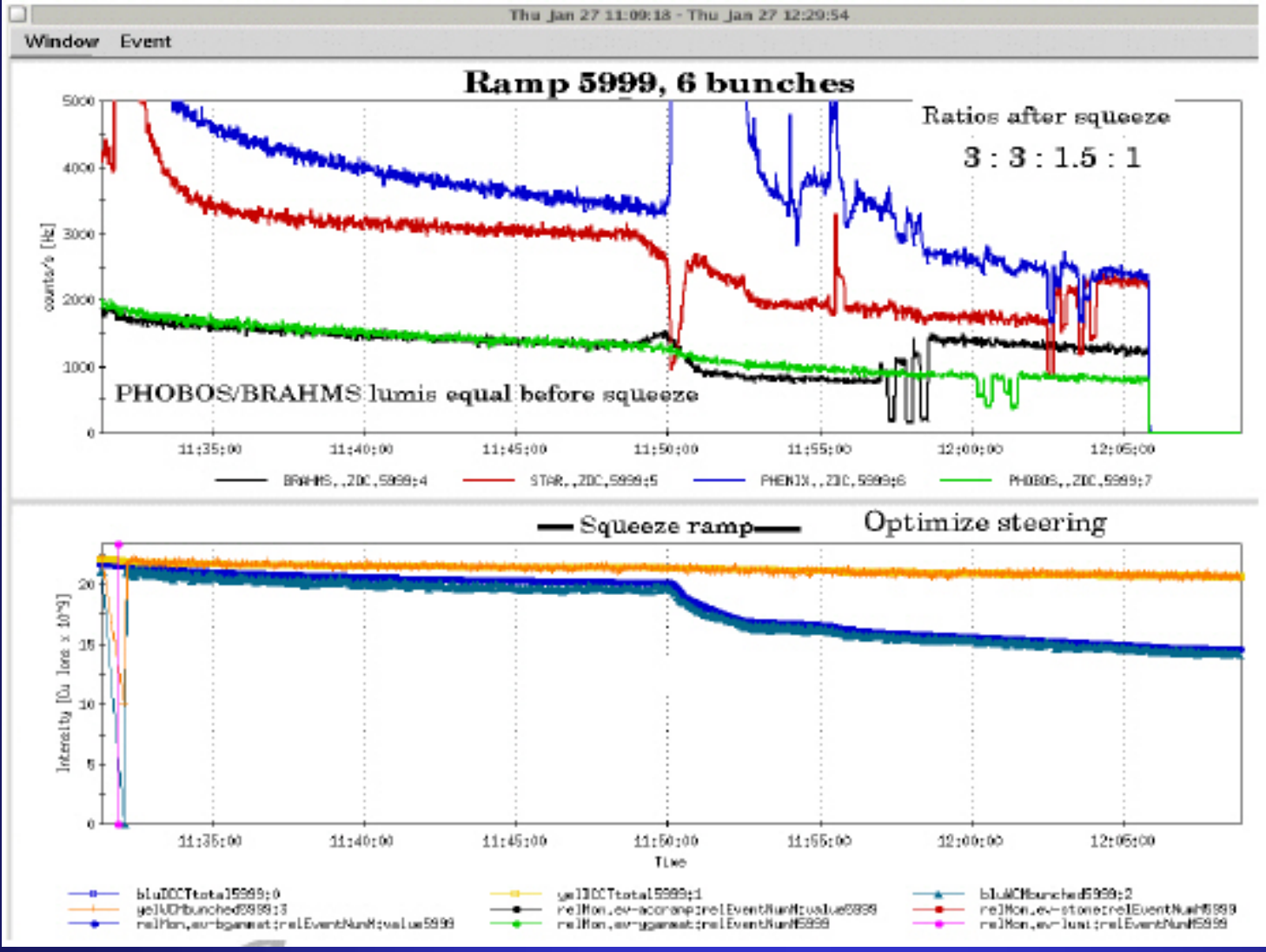
Pilat, Wittmer, VanZejits, Ptitsyn



B* squeeze in Phenix & STAR (Run-4)



Beta squeeze in Brahms (Run-5)



Fulvia, Todd, Nikolay, Mei, Steve

Can be made operational

Proposal 07-21 Run-7

Goal: Squeeze β^* at store to < 0.8m and prove viability for operations

PLAN:

6 bunch ramp, one IP:

- test 'knobs' – incrementally – to see what is feasible
- fix machine conditions as needed (tunes, chrom)
- Measure beta, dispersion
- *Measure non-linearities*

Physics ramp:

- Steering, collimation→ *STAR and PHENIX data taking ~10-15 min*
- Ramp beam *for normal physics operations*
- Take collimator out
- Squeeze **X%** (both beams, likely 1 IP at the time)
- Fix lifetime
- Steering, collimation
- *STAR and PHENIX data taking*

Preparation Run-7

- “Resurrect” squeeze software
- Establish limits of possible squeeze (model)
- PS and leads

Core team:

Pilat, Bai, Malitsky, Ptitsyn, Satogata, Tepikian

Experiment must be planned with Phenix and Star

Thomas → develop ramp to small beta+collimation on the ramp*

Ramp 70+extra stones

First attempt Run-7: April 18

Objectives: dynamic β^* squeeze operational procedure + Ramp Designer module for offline and online optics changes

Plan:

- Ramp 12 bunches, normal intensity, no rebucketing
- Squeeze beta in 4 installments **from 0.8 to 0.6 m**
  - Calculate and change the IR8 model for both rings
  - Adjust tune and chromaticities
  - Set slow factor 4 (not faster than 0.5 A/sec)
  - Commit changes
  - Check orbit, tunes and lifetime, correct if needed
  - Measure collision rate in IP8 and IP6
  - Measure dispersion
  - Measure optics with AC dipole
  - Revert the store stone

Blue Optics after online matching

$\beta^* = (0.70, 0.70)$ in IR 8

Yellow Optics after online matching

$\beta^* = (0.71, 0.77)$ in IR 8

OptiCalc | Design | Ramp: Au72 | Config: dbconfig/1170444958 | Blue Species: Au | Yellow Species: Au

Options	BetaStarSlopes	DR8toDRG	DipoleHarmonics	FamilyTF	WarmTF	polyField	specificTF
State	On	On	Off	On	On	On	On

Blue | Yellow | DxAngles

DipoleRamp | BetaStar | TuneChrom | Lattice | Optics | MagCurr | Strengths | TransFunc | BDL | ShuntCurr | ShuntVolt

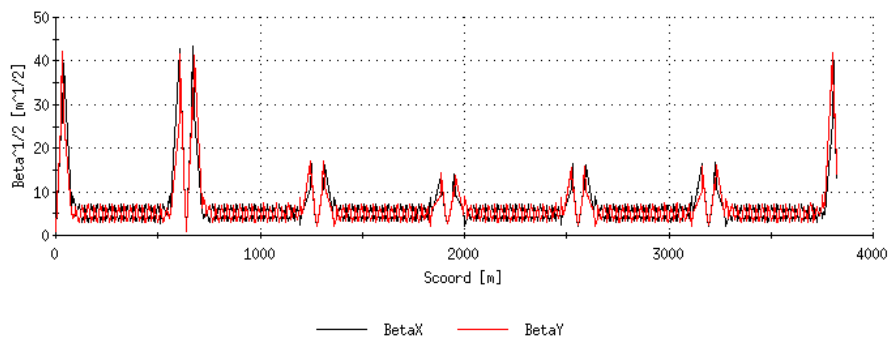
prompt Au72::store

Twiss | Orbit

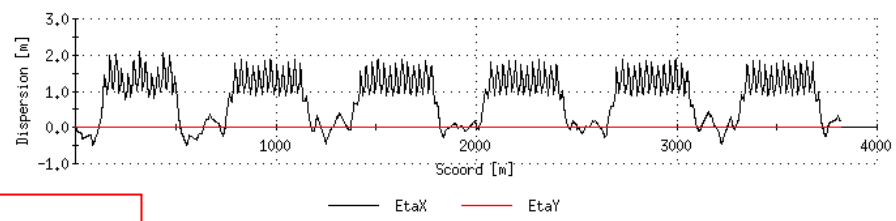
Tunes/Chroms

Stone #	17.000000000
Time [sec]	300.000000000
Gamma	107.396089446
BetaGamma	107.391433682
Brho [T-m]	831.763013200
Qx	28.223971720
Qy	29.228178582
ChromX	-1.776649785
ChromY	0.321655407
ChromX2	-1388.948704577
ChromY2	1994.770547945
ChromX3	429968.514589721
ChromY3	239759.601426145
GammaT	23.271874879

Beta Function



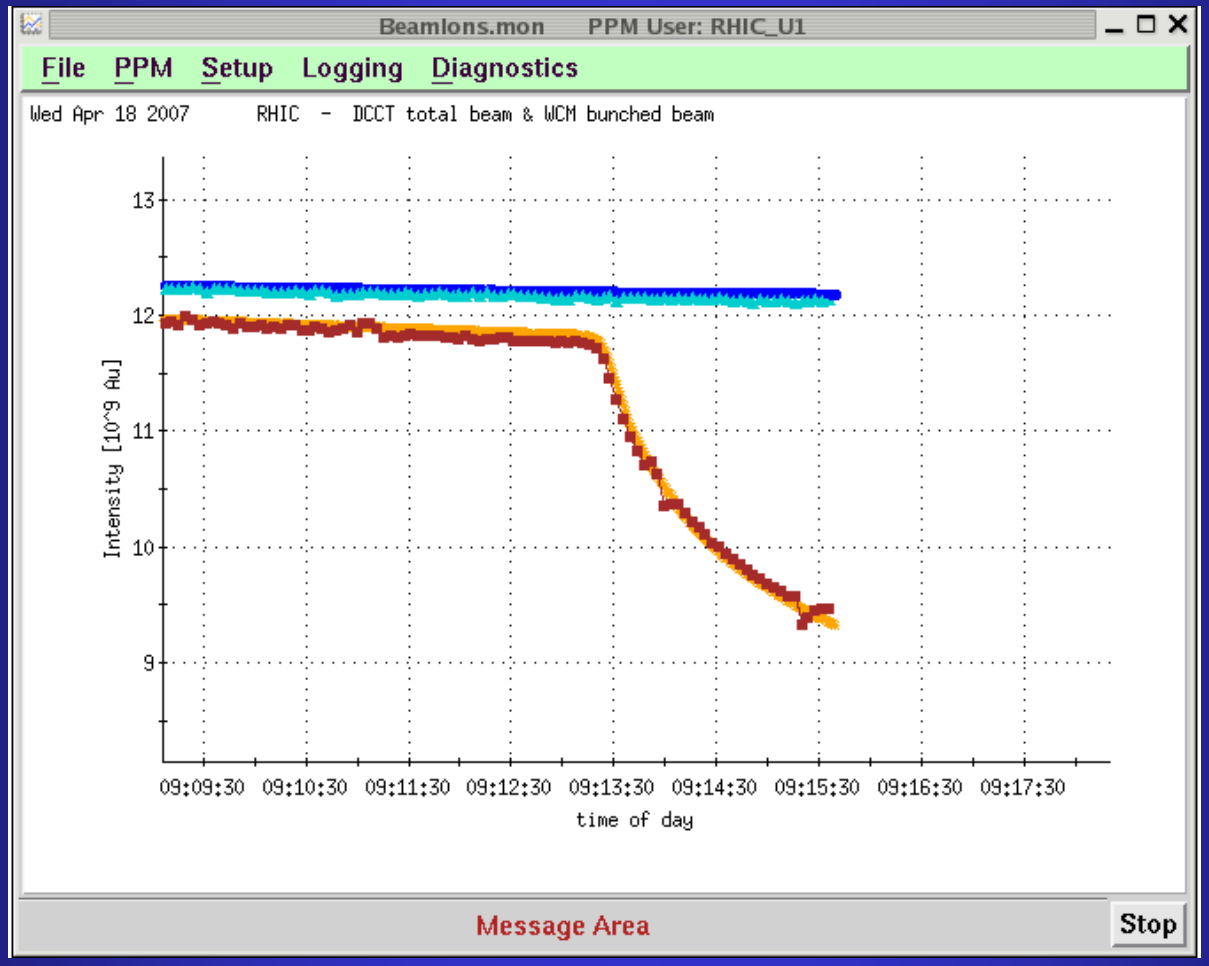
Dispersion Function



IP Parameters

Value/IP	IP6	IP8	IP10	IP12	IP2	IP4
BetaX [m]	0.828928	0.713793	4.97786	7.0064	4.98663	4.87959
BetaY [m]	0.741395	0.766054	4.63498	6.87383	5.502	5.31347
AlphaX	0.0345934	-0.0883759	0.0243745	-0.0306822	0.034702	-0.0295176
AlphaY	0.0516283	0.0821402	0.0536027	0.0848806	-0.017425	-0.101413
EtaX [m]	0.0251856	0.0224026	-0.0208803	0.0155177	0.0229235	0.000271592

Blue and Yellow behavior during the 0.75m β* squeeze.



Summary April 18

- Blue can go down to 0.7m without a glitch.
- In Yellow, we lost the beam on slow losses on both attempts when squeezing down to 0.75 even after compensating for the tune shift.
- We need to understand why even in the model the yellow squeeze is more difficult

Run-7 second attempt: June 13

- Ramped 12 bunches (no Artus, IPM)
- Cogged - no rebucketing – measured collision rates
- Squeezed IP8 (blue and yellow) successively:

  0.80 → 0.75 no adjustment needed (orbit, tunes)

  0.75 → 0.70 readjusted horizontal tune in yellow

  0.70 → 0.65 collimation needed to measure rates in STAR(high backgrounds) + yellow tunes adjustment + angle bump in STAR

  At 0.65 after collimation and steering optimization:

  Measured collision rate ratio Phenix/STAR: 1.19

  Predicted collision rate ratio Phenix/STAR: 1.23
- Optics measurements

  dumped beams (attempting to dump only yellow)

  ramped 6 bunches in blue into the 0.65 squeezed optics, then AC dipole measurements were done in blue

Blue (design + trim)

OptiCalc | Design+Trim | Ramp: Au72s | Config: dbconfig/1170444958 | Blue Species: Au | Yellow Species: Au

Options	BetaStarSlopes	DR8toDRG	DipoleHarmonics	FamilyTF	WarmTF	polyField	specificTF
State	On	On	Off	On	On	On	On

Blue | Yellow | DxAngles

DipoleRamp | BetaStar | TuneChrom | Lattice | Optics | MagCurr | Strengths | TransFunc | BDL | ShuntCurr | ShuntVolt

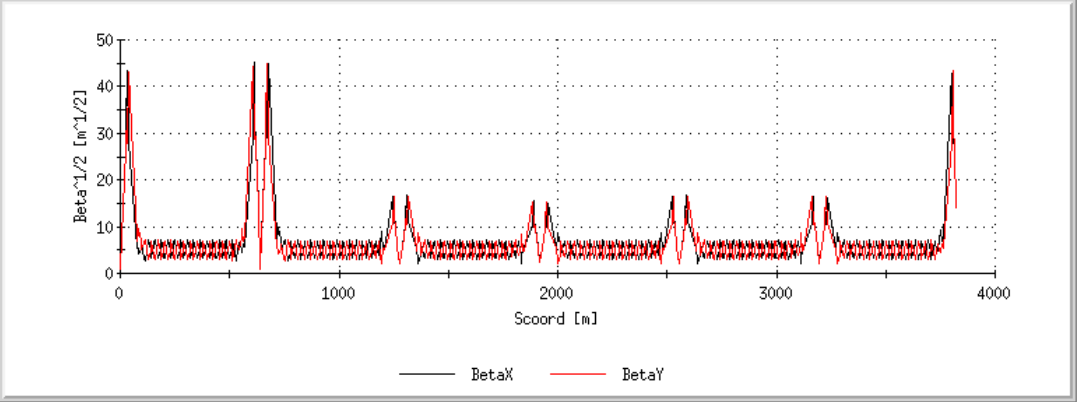
prompt: Au72s::store

Twiss | Orbit

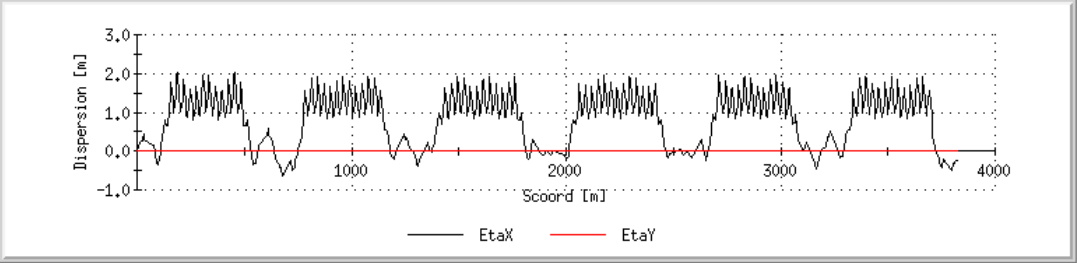
Tunes/Chroms

Stone #	17.000000000
Time [sec]	300.000000000
Gamma	107.396089446
BetaGamma	107.391433682
Brho [T-m]	831.763013200
Qx	28.214490340
Qy	29.277157928
ChromX	-6.303624811
ChromY	0.087440358
ChromX2	199.384227939
ChromY2	585.103035049
ChromX3	-103235.679146820
ChromY3	-231276.094844172
GammaT	23.262813213

Beta Function



Dispersion Function



IP Parameters

Value/IP	IP6	IP8	IP10	IP12	IP2	IP4
BetaX [m]	0.705251	0.646297	4.80575	5.80387	4.80838	5.09897
BetaY [m]	0.702301	0.656054	5.00632	5.76543	4.99043	5.01034
AlphaX	0.00640835	-0.00462059	-0.0420139	0.0620395	-0.0361284	0.0469442
AlphaY	0.0113082	0.00367526	-0.0149979	0.0167403	-0.0118632	0.0183897
EtaX [m]	-0.00651716	-0.00535861	0.0340707	-0.0421517	-0.0488992	0.0360566
EtaY [m]	0	0	0	0	0	0
EtaX'	0.0203904	-0.0246814	-0.00449175	-0.0063004	0.00490044	0.00639711
EtaY'	0	0	0	0	0	0

Yellow (design + trim)

OptiCalc | Design+Trim | Ramp: Au72s | Config: dbconfig/1170444958 | Blue Species: Au | Yellow Species: Au

Options	BetaStarSlopes	DR8toDRG	DipoleHarmonics	FamilyTF	WarmTF	polyField	specificTF
State	On	On	Off	On	On	On	On

Blue | Yellow | DxAngles

DipoleRamp | BetaStar | TuneChrom | Lattice | Optics | MagCurr | Strengths | TransFunc | BDL | ShuntCurr | ShuntVolt

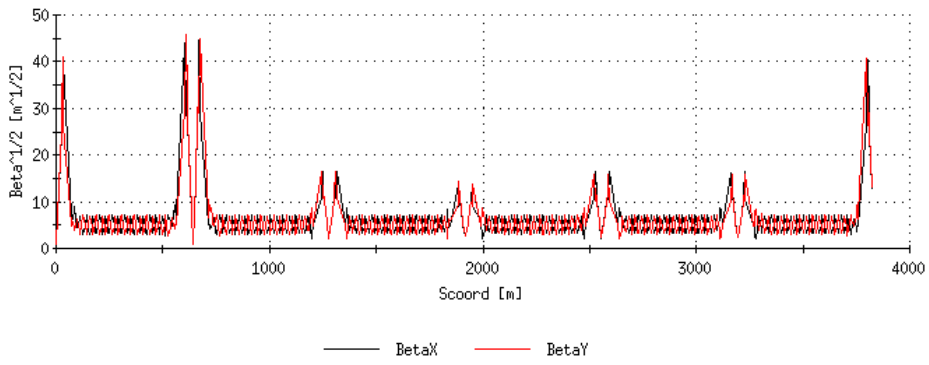
prompt Au72s::store

Twiss | Orbit

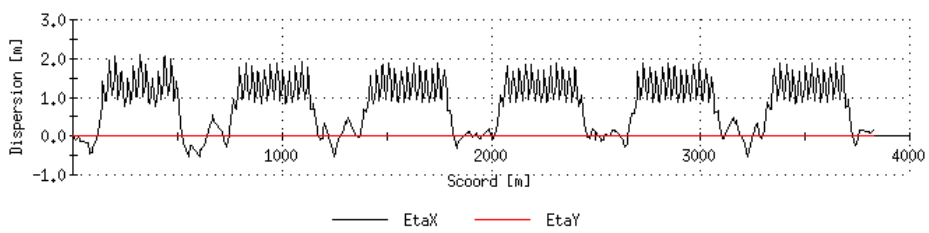
Tunes/Chroms

Stone #	17.000000000
Time [sec]	300.000000000
Gamma	107.396089446
BetaGamma	107.391433682
Brho [T-m]	831.763013200
Qx	28.242339129
Qy	29.360675269
ChromX	-13.319671164
ChromY	-3.686922972
ChromX2	-764.590138638
ChromY2	5473.782988491
ChromX3	263988.746727523
ChromY3	-62201.700575373
GammaT	23.301398101

Beta Function



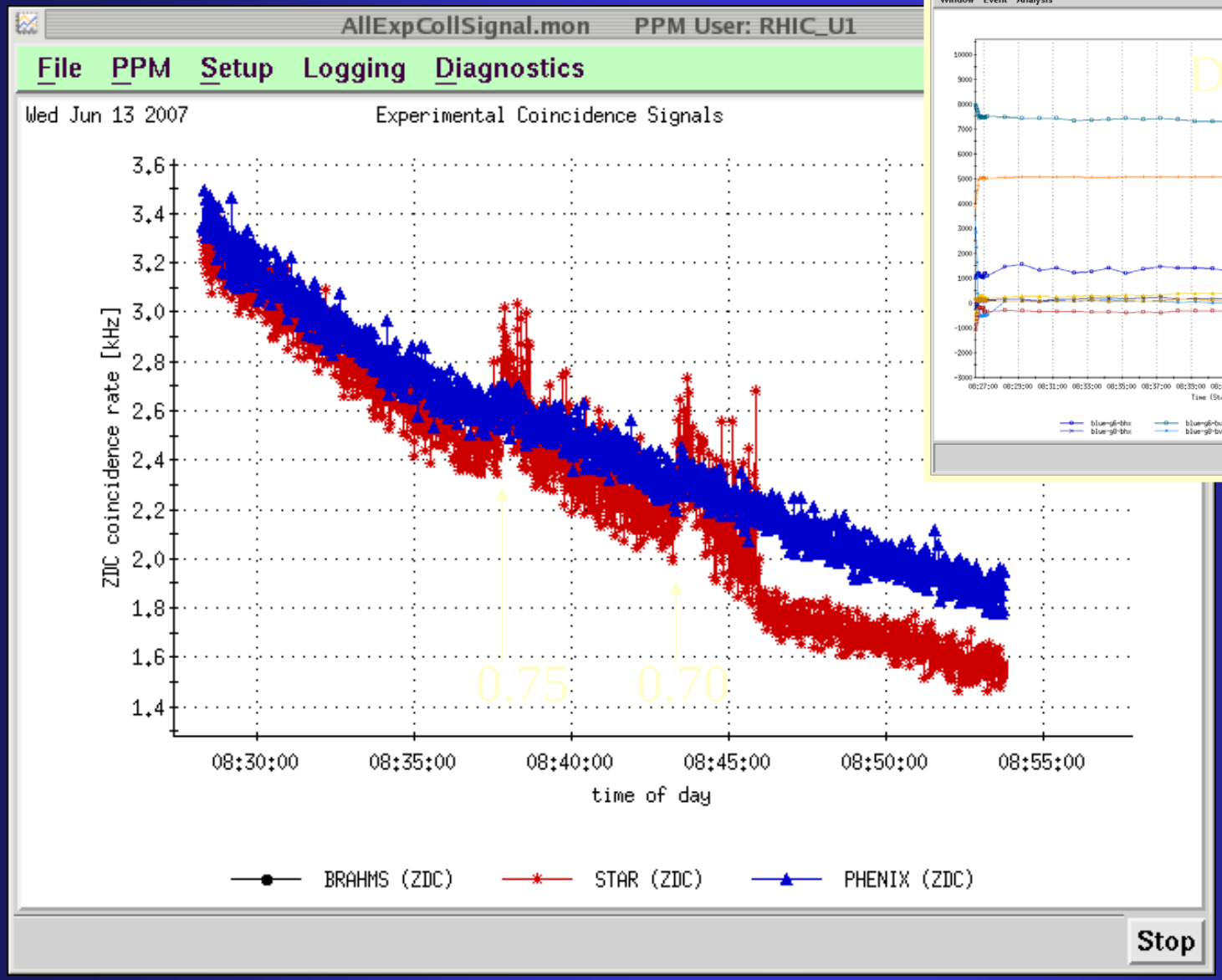
Dispersion Function

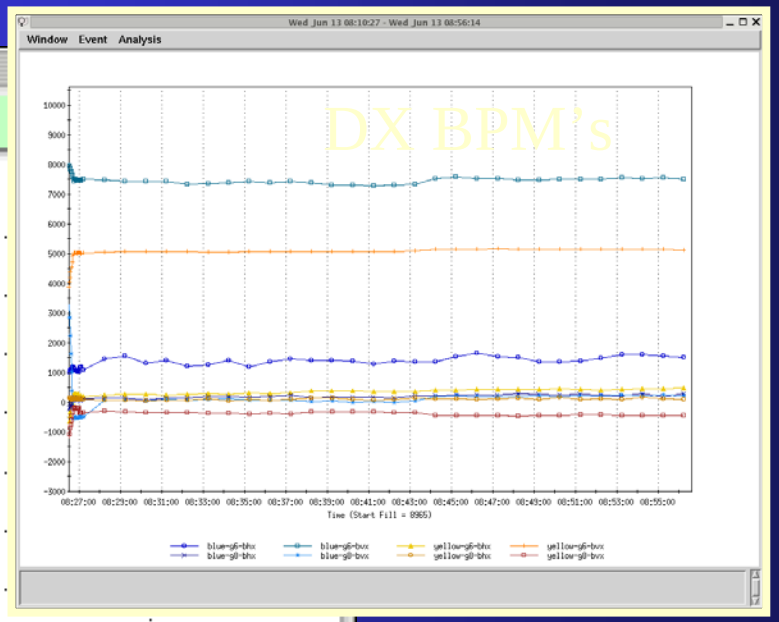


IP Parameters

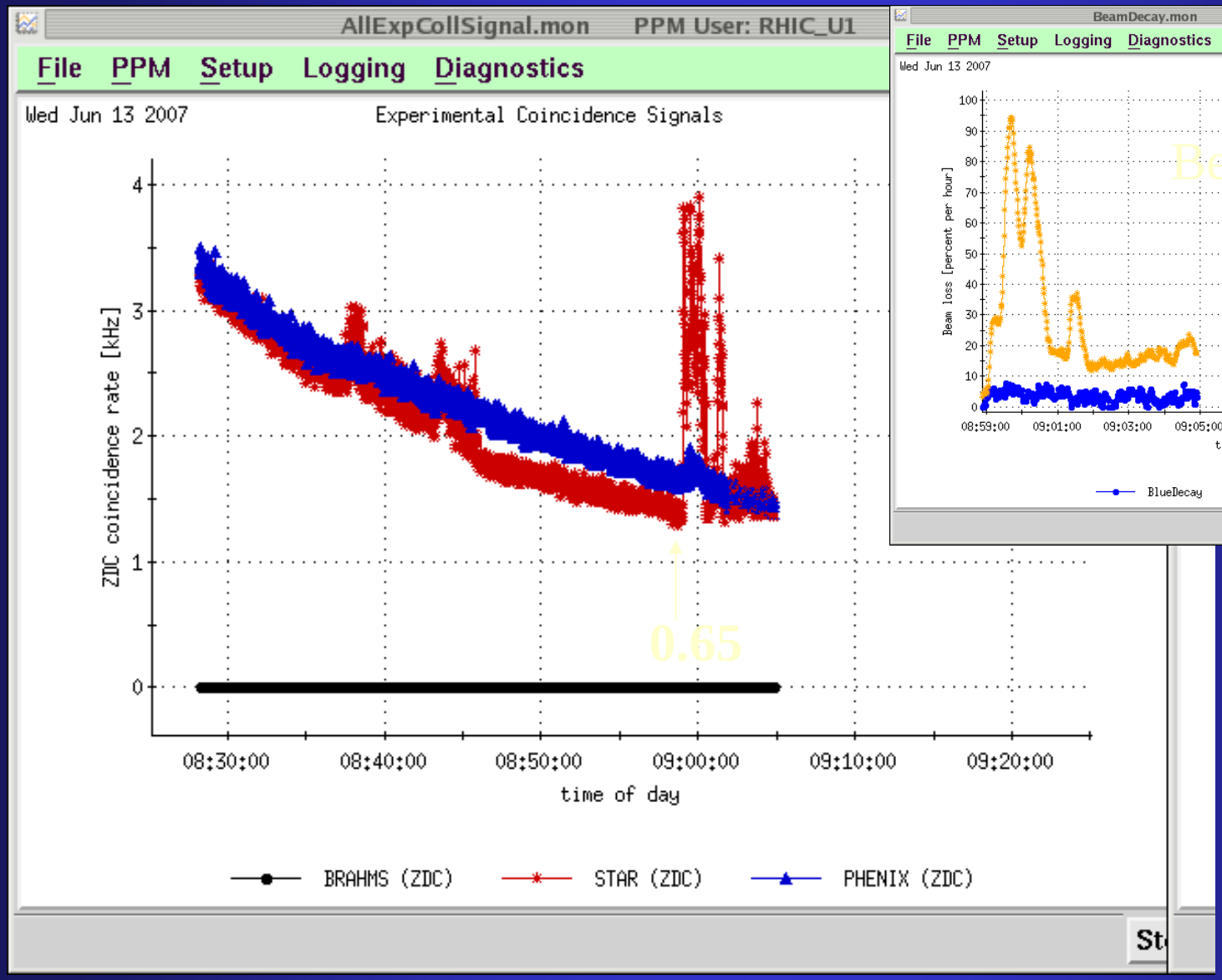
Value/IP	IP6	IP8	IP10	IP12	IP2	IP4
BetaX [m]	0.810832	0.663305	4.99382	7.21847	5.01524	5.04719
BetaY [m]	0.783725	0.635649	4.90816	6.95224	5.34969	5.42479
AlphaX	-0.00808578	0.0168836	-0.0326743	0.0159508	-0.0188304	0.0102782
AlphaY	-0.0403602	-0.0143089	0.0288832	0.0388806	0.0147868	-0.0239935
EtaX [m]	0.0225759	0.0174639	-0.0234273	0.0223504	0.0233197	-0.00842543

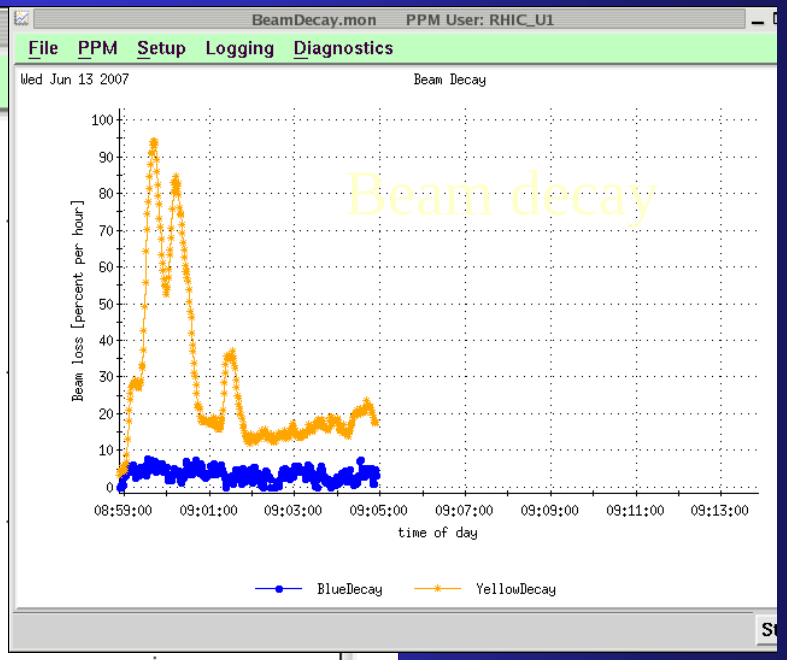
0.80→0.75→0.70


AllExpCollSignal.mon
PPM User: RHIC_U1
File
PPM
Setup
Logging
Diagnostics
Wed Jun 13 2007
Experimental Coincidence Signals
ZDC coincidence rate [kHz]
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
0.75
0.70
08:30:00
08:35:00
08:40:00
08:45:00
08:50:00
08:55:00
time of day
BRAHMS (ZDC)
STAR (ZDC)
PHENIX (ZDC)
Stop

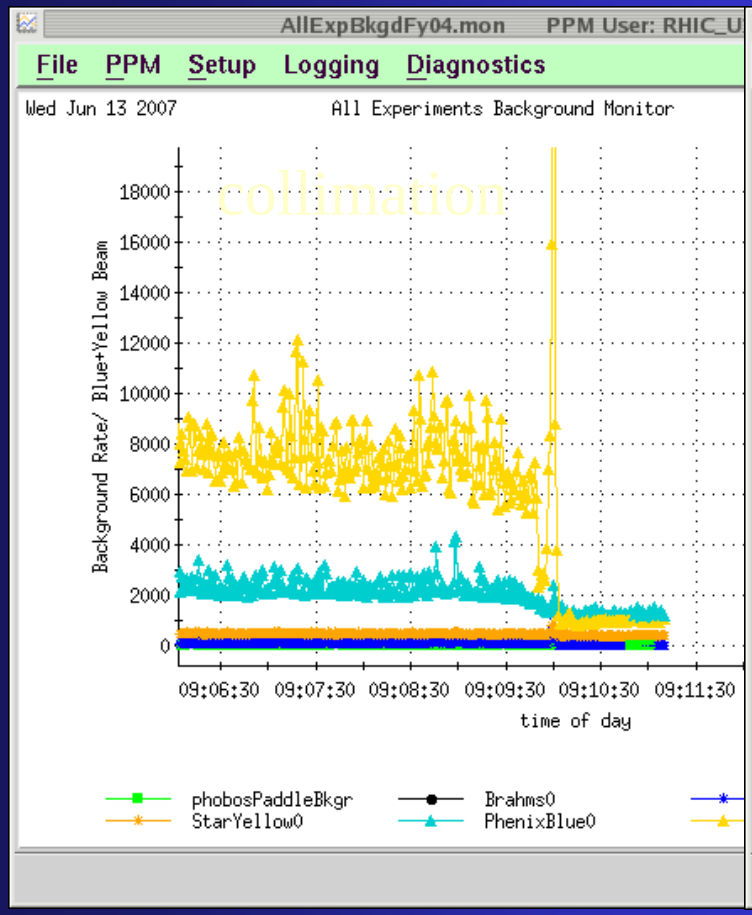

Window
Event
Analysis
DX BPM's

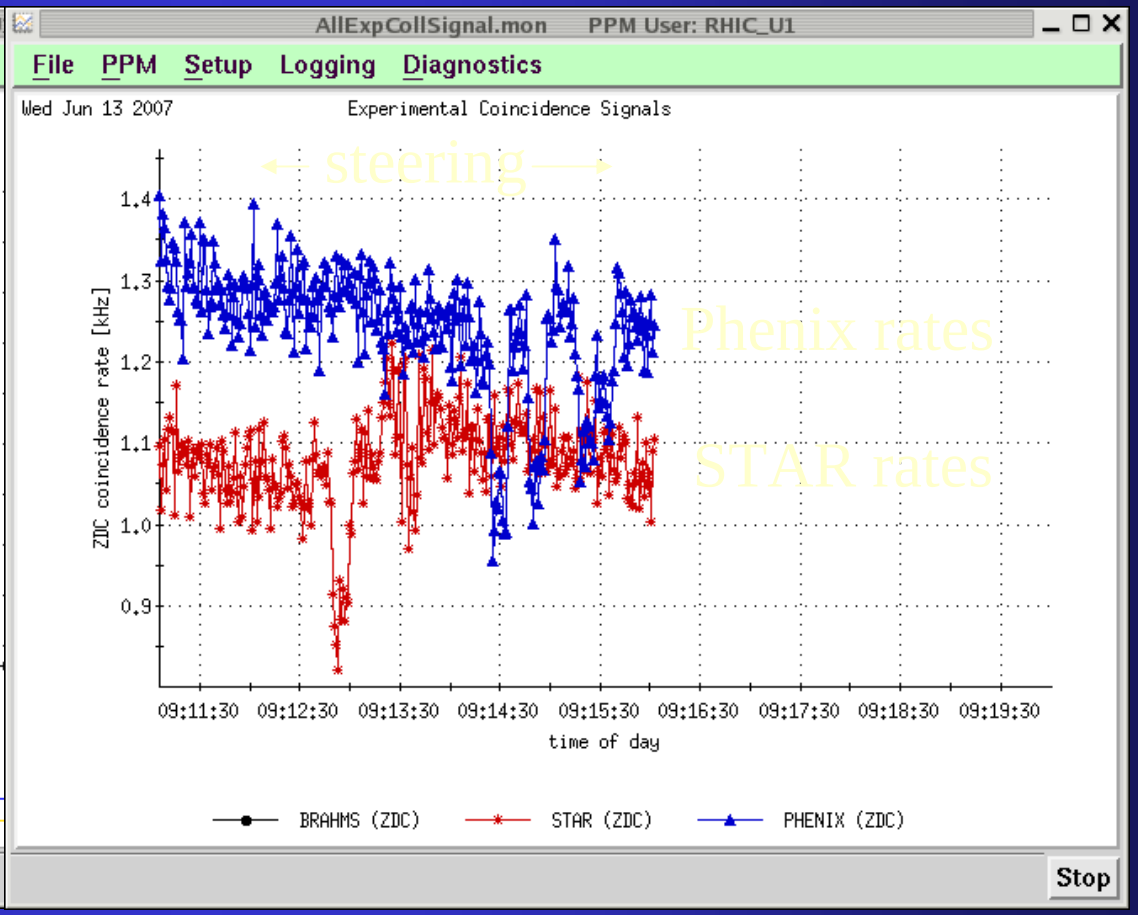
To 0.65m


AllExpCollSignal.mon
PPM User: RHIC_U1
File
PPM
Setup
Logging
Diagnostics
Wed Jun 13 2007
Experimental Coincidence Signals
ZDC coincidence rate [kHz]
0
1
2
3
4
08:30:00
08:40:00
08:50:00
09:00:00
09:10:00
09:20:00
time of day
0.65
BRAHMS (ZDC)
STAR (ZDC)
PHENIX (ZDC)


BeamDecay.mon
PPM User: RHIC_U1
File
PPM
Setup
Logging
Diagnostics
Wed Jun 13 2007
Beam Decay
Beam decay
Beam loss [percent per hour]
0
10
20
30
40
50
60
70
80
90
100
08:59:00
09:01:00
09:03:00
09:05:00
09:07:00
09:09:00
09:11:00
09:13:00
time of day
BlueDecay
YellowDecay

To 0.65m


AllExpBkgdFy04.mon PPM User: RHIC_U
File PPM Setup Logging Diagnostics
Wed Jun 13 2007
All Experiments Background Monitor
collimation
Background Rate/ Blue+Yellow Beam
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
09:06:30 09:07:30 09:08:30 09:09:30 09:10:30 09:11:30
time of day
phobosPaddleBkgr
StarYellow0
Brahms0
PhenixBlue0


AllExpCollSignal.mon PPM User: RHIC_U1
File PPM Setup Logging Diagnostics
Wed Jun 13 2007
Experimental Coincidence Signals
steering
Phenix rates
STAR rates
ZDC coincidence rate [kHz]
1.4
1.3
1.2
1.1
1.0
0.9
09:11:30 09:12:30 09:13:30 09:14:30 09:15:30 09:16:30 09:17:30 09:18:30 09:19:30
time of day
BRAHMS (ZDC)
STAR (ZDC)
PHENIX (ZDC)
Stop

Operational?

- Experiment done with 12×10^9 in both rings: minor adjustments necessary, collimation essential. Could easily ramp into the squeezed optics

Operational ?:

- Control of transverse emittance (no transition instability), likely limit on bunch intensity
- Collimation on the ramp
- Tunable beta* on the store (good practice for cooled beams)
- Test ramp for protons in Run-8 ?

Plans for Run-8 - DRAFT

Run-8 goals:

- squeeze (0.6-0.7) on the ramp
- Test in physics conditions, collimation, data taking

d-Au run:

Operation lattice in blue→likely aperture limitation

Operations lattice in yellow → IBS, probably solution to 0.6-0.7m OK

Plans dependent on operational experience during set-up and early ops

d-Au PLAN A:

- Good ramp design to 0.6-0.7m in blue and yellow
- Ramp development in APEX
- Test of a physics ramp

→ *Likely prerequisite: collimation on the ramp*

d-Au PLAN B:

- Squeeze only in yellow

d-Au PLAN C:

Squeeze at store (as in Run-7) but test with physics store

Plans for Run-8 - DRAFT

PP run:

Depending on experience with d-Au but in general as before:

- Good ramp design to 0.6-0.7m in blue and yellow
- Ramp development in APEX
- Test of a physics ramp

Feedback obviously appreciated and encouraged

Will write a specific APEX proposals after the workshop and discussion with team and others