BEAM-BEAM SIMULATIONS WITH SEPARATED BEAMS

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FEB 22-23, 2000

MOTIVATION

1) LOOK FOR UNDESIREABLE EFFECTS IN:
   a) LBNL LUMINOSITY MONITOR (W. TURNER)
   b) BRINGING SEPARATED BEAMS INTO COLLISION

2) PROPOSE MEASUREMENTS AT RHIC

CLOSELY RELATED WORK:

S. KRISHNAGOPAL, Y. ALEXAHIN } CERN WORKSHOP, APRIL 99

M. ZORZANO & F. ZIMMERMANN, LHC-BR-.... (OCT 99?)

SUMMARY

1) SIMULATION CODE FEATURES AND CALCULATION

2) a) LHC "NOMINAL" CASE

b) LHC "SWEEPING 06_02" CASE

c) LHC "CLOSED-ORBIT SQUEEZE"

d) RHIC Au^{79} "NOMINAL"

e) RHIC Au^{79} "SPLIT TUNES"

f) RHIC Au^{79} "SEMI-WEAK-STRONG"

g) LHC "WEAK-STRONG"

~~h) LHC "SEMI-WEAK-STRONG"~~

i) LHC "SPLIT TUNES"

j) LHC "COSED-ORBIT SQUEEZE, 5×NOM"

k) LHC "$3\sigma_y$ CONSTANT SEPARATION"

3) CONCLUSIONS

* THIS IS WORK IN PROGRESS; MOST OF THE RESULTS ARE ~ 1 MONTH OLD

1) <u>SIMULATION CODE</u> (BASED ON TENNYSON'S 'TRS')

* STRONG-STRONG GAUSSIAN CODE (WEAK-STRONG AS AN OPTION)
* ARBITRARY ASPECT RATIO σ_x/σ_y
* BUNCH LENGTH EFFECTS : SLICING
* PARTICLES: $e^+, e^-, \mu^+, \mu^-, p, \bar{p}, Au^{79}, Pb^{82}$ IN ANY COMBINATION
* RADIATION DAMPING + QUANTUM EXCITATION
* LINEAR LATTICE MAP + LINEAR SYNCHROTRON ROT.
* TIME-DEPENDENT CLOSED-ORBIT
* FEEDBACK (OPTIONAL)
* CROSSING ANGLE = 0
* ONE IP / TURN
* 6D PARTICLE KINEMATICS (BUT B-B KICK IS PURELY TRANSVERSE)
* NO PARASITIC COLLISIONS

2) <u>CALCULATE:</u>

$\langle x_1 \rangle, \langle y_1 \rangle, \langle x_2 \rangle, \langle y_2 \rangle$
$\sigma_{x1}, \sigma_{y1}, \sigma_{x2}, \sigma_{y2}$
$\mathcal{L}$ PER COLLISION
} AS A FUNCTION OF TIME

F.T. OF ALL THE ABOVE

TYPICALLY 10,000 MACROPARTICLES / BUNCH
25,000 TURNS

"LHC NOMINAL" case:
σ^*=15.9 μm
β^*=0.5 m
(ν_x,ν_y)=(0.31,0.32)
N=1.05*10**11 (protons)
ξ=-0.0034
γ=7460.52
σ_z= 7.7 cm
ν_s=0.0021
beam CO offset=0

"LHC SWEEP_06_02" case:
same beam parameters as in "NOMINAL" case; beam #1 closed orbit (CO) is constant in time and offset by 0.2 σ^* at 45° from the nominal (optical) collision point (OCP); beam #2 CO is time dependent, sweeping about the OCP with a period of 1000 turns and radius=0.6 σ^*

"LHC CLOSED ORBIT SQUEEZE" case:
same beam parameters as in "NOMINAL" case; beam #1 CO=0; beam #2 CO starts at t=0 displaced vertically by 3 σ^* from the NCP, and moves down to the NCP in 25000 turns with constant "speed"

"RHIC NOMINAL" case:
σ^*=396 μm
β^*=10 m
(ν_x,ν_y)=(0.19,0.18)
N=1*10**9 (Au79)
ξ=-0.0023
γ=106.5
σ_z=1 m
ν_s=0.000745
beam CO offset=0

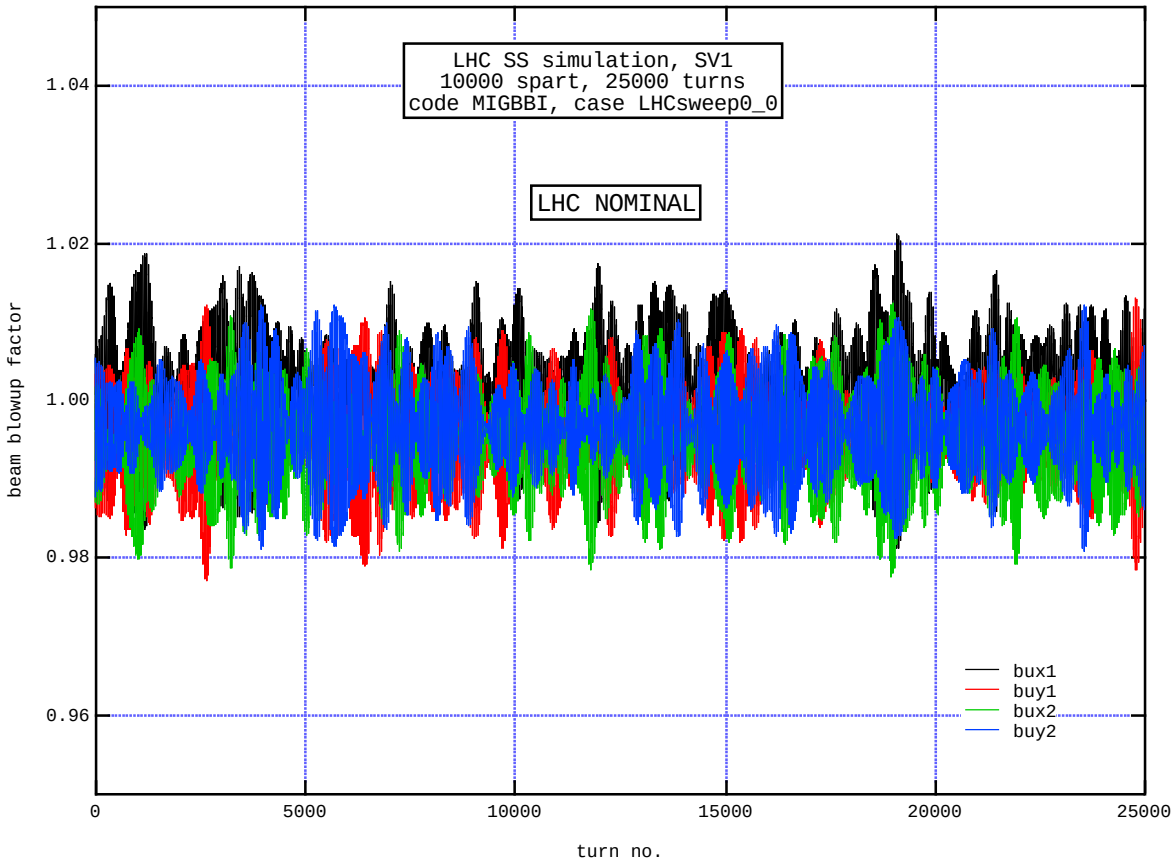
"RHIC SPLIT TUNES" case:
same as "RHIC NOMINAL" case, except $(\nu_x,\nu_y)_1$=(0.19,0.18) and $(\nu_x,\nu_y)_2$=(0.195,0.185)

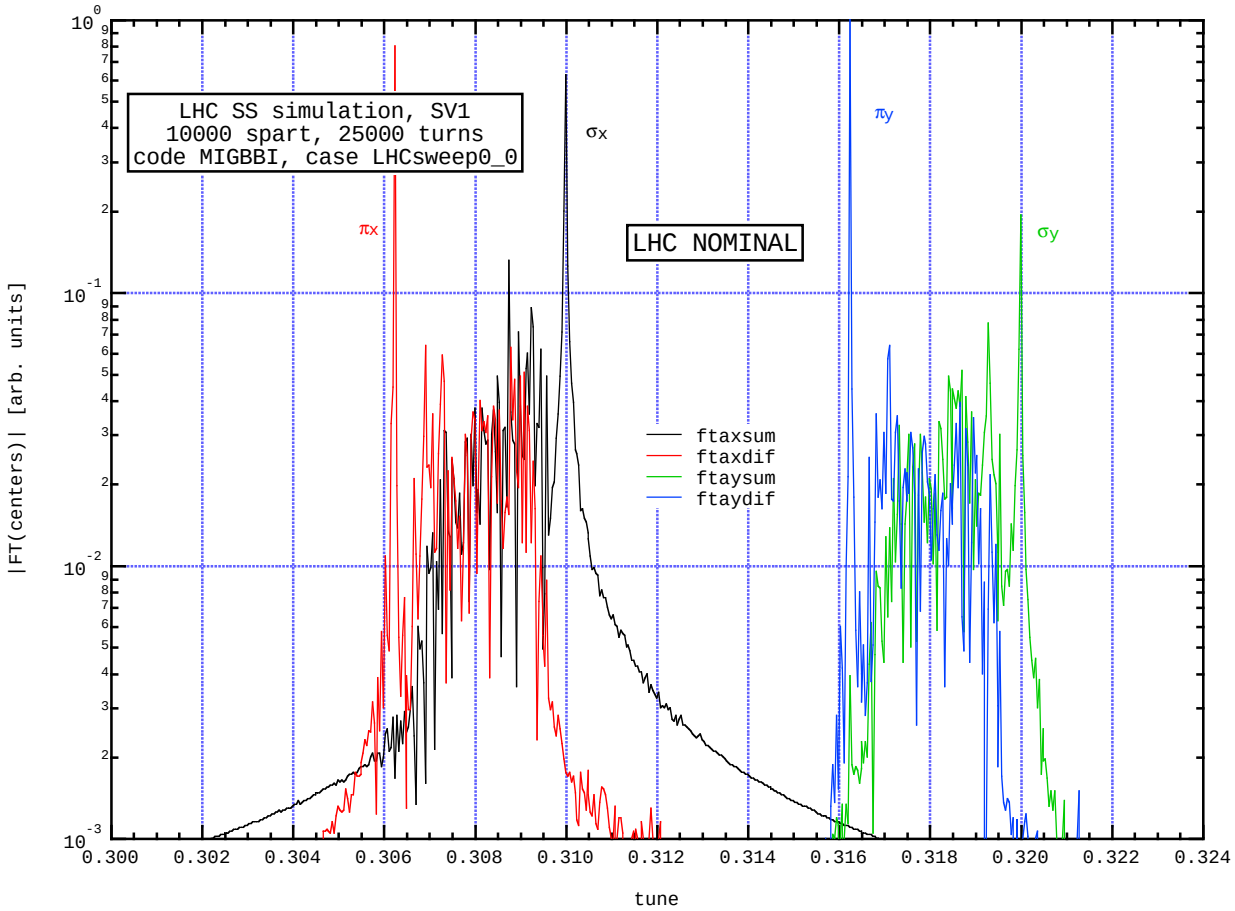
"RHIC SEMI-WEAK-STRONG" case:
same as "RHIC NOMINAL" case, except N_1=2*10**9, N_2=1*10**9

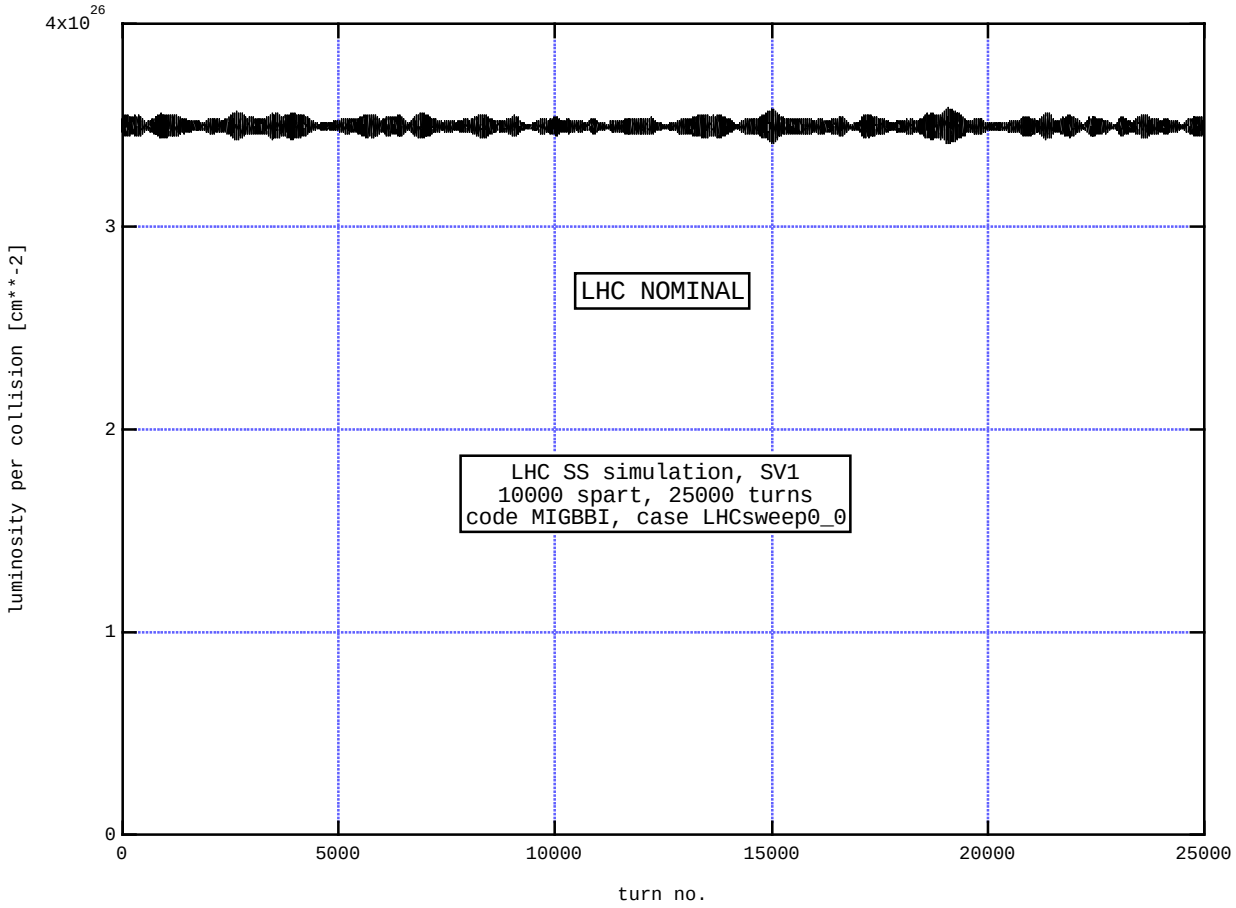
"LHC WEAK-STRONG" case:
same as "LHC NOMINAL" case, except beam 2 is a static gaussian thick lens

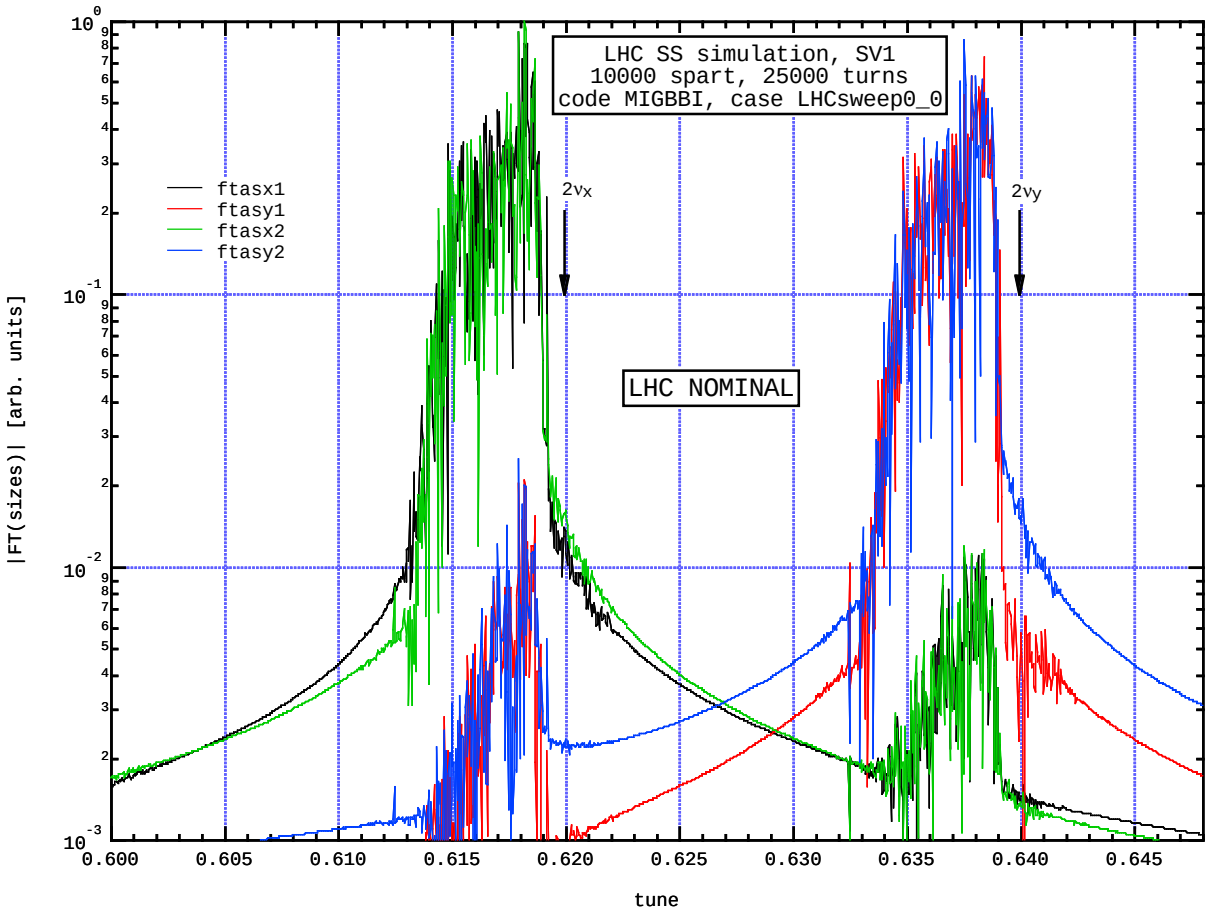
"LHC CLOSED ORBIT SQUEEZE, 5XNOM" case:
same as "LHC CLOSED ORBIT SQUEEZE" case, except N=5*10**11

"LHC 3SIGY CONSTANT SEP" case:
same as "LHC CLOSED ORBIT SQUEEZE" case, except beam #2 CO remains displaced vertically by 3 σ^* from the NCP

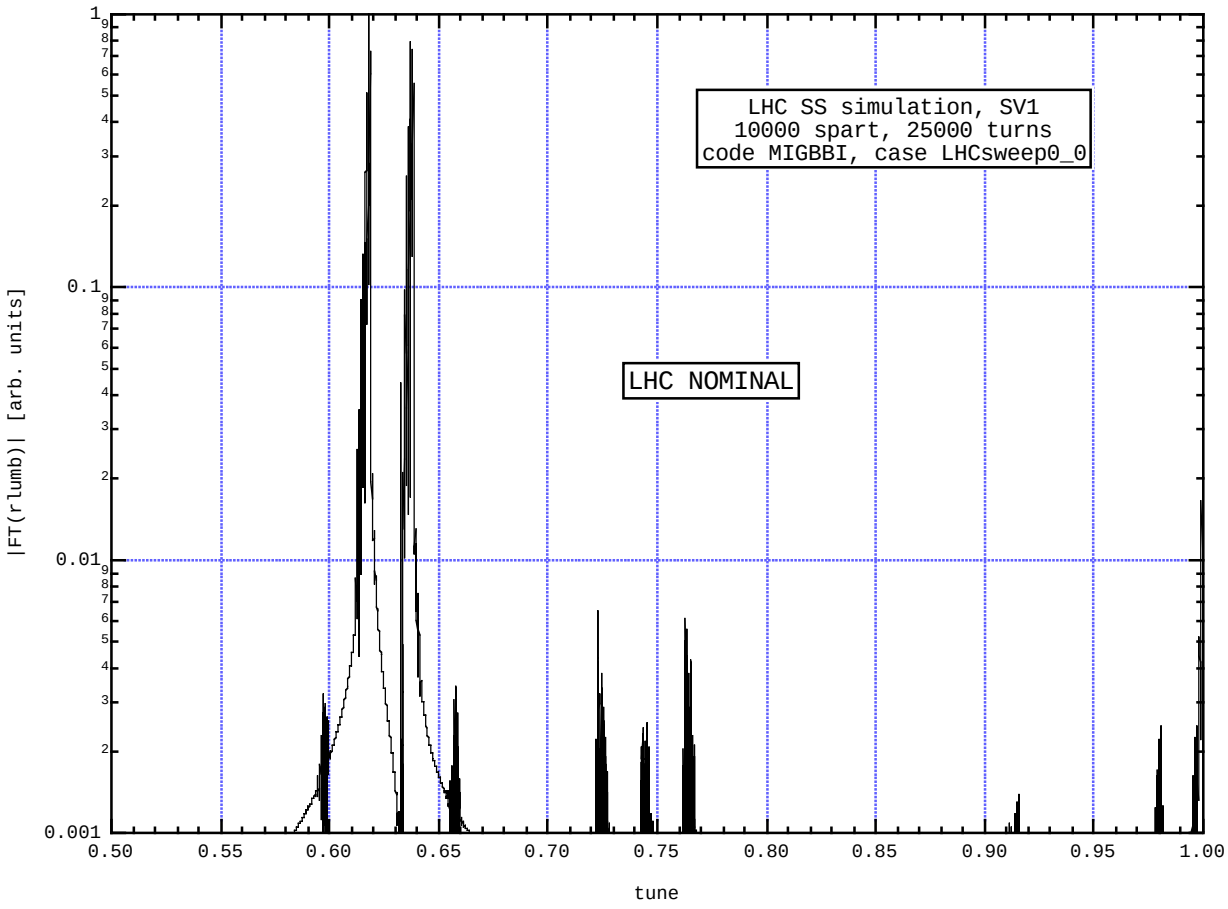

LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep0_0
LHC NOMINAL
beam blowup factor
1.04
1.02
1.00
0.98
0.96
0
5000
10000
15000
20000
25000
turn no.
bux1
buy1
bux2
buy2


LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep0_0
LHC NOMINAL
πx
σx
πy
σy
ftaxsum
ftaxdif
ftaysum
ftaydif
|FT(centers)| [arb. units]
tune
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0.314
0.316
0.318
0.320
0.322
0.324

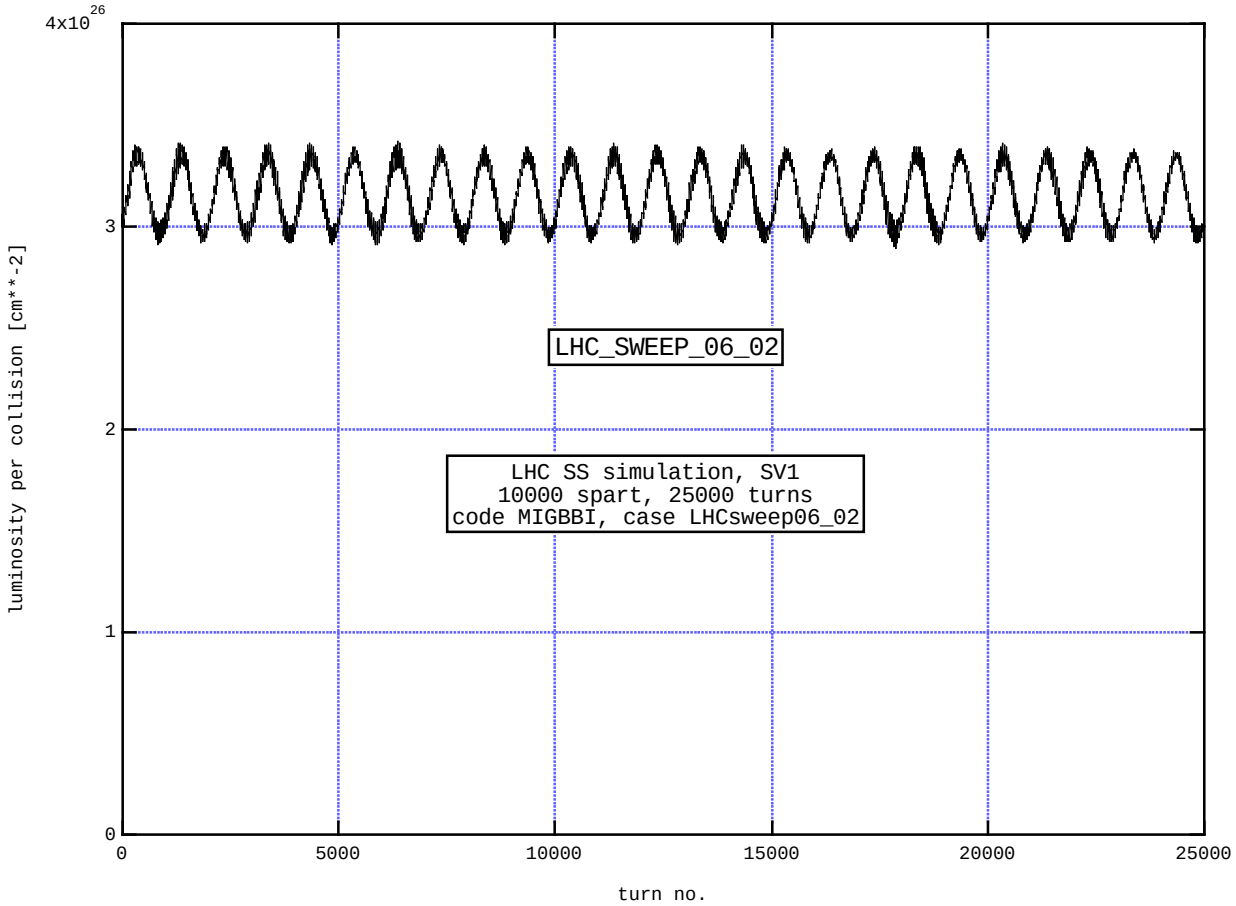

4x10^26
3
2
1
0
luminosity per collision [cm**-2]
LHC NOMINAL
LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep0_0
0
5000
10000
15000
20000
25000
turn no.



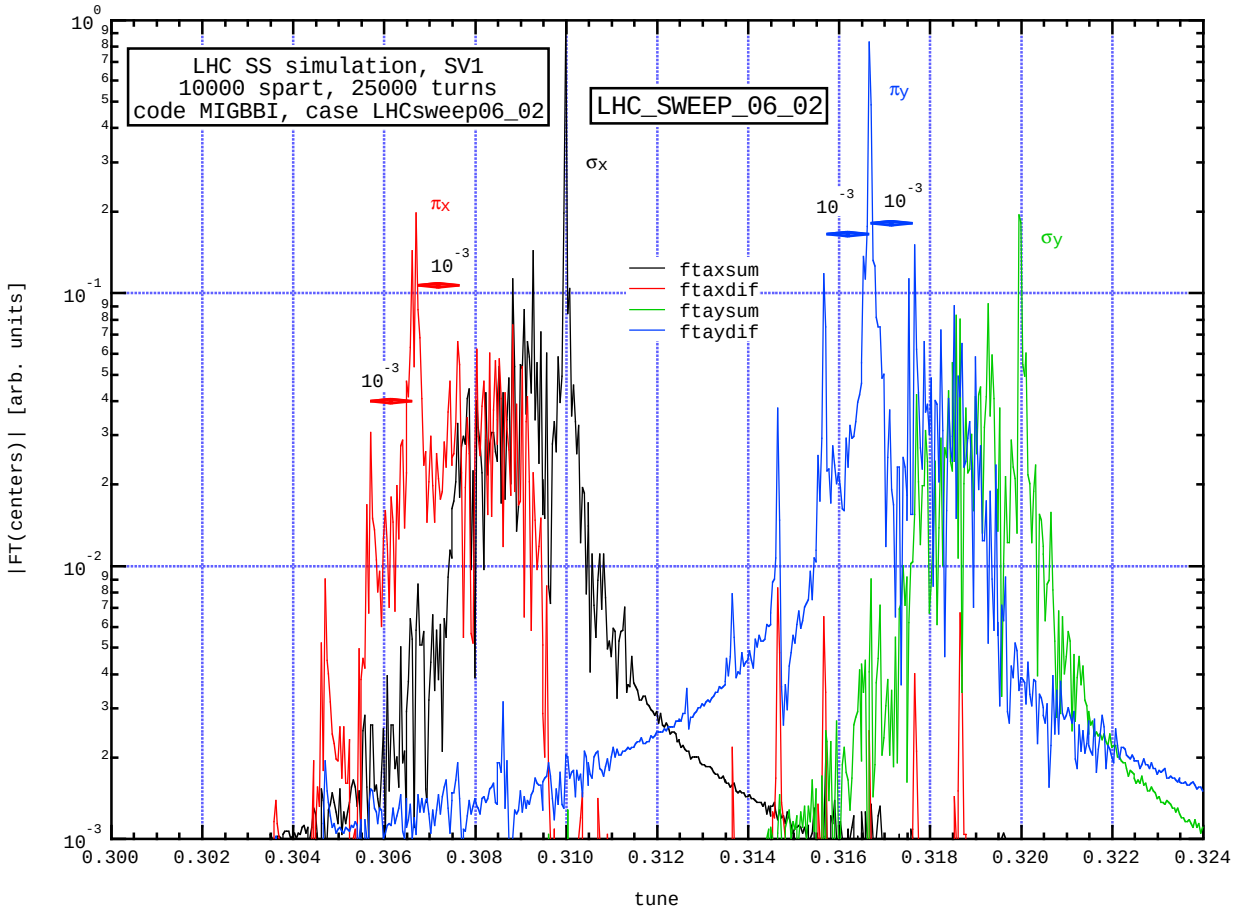
stsrttghsr
a


LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep0_0
LHC NOMINAL
|FT(rlumb)| [arb. units]
tune
1
0.1
0.01
0.001
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00

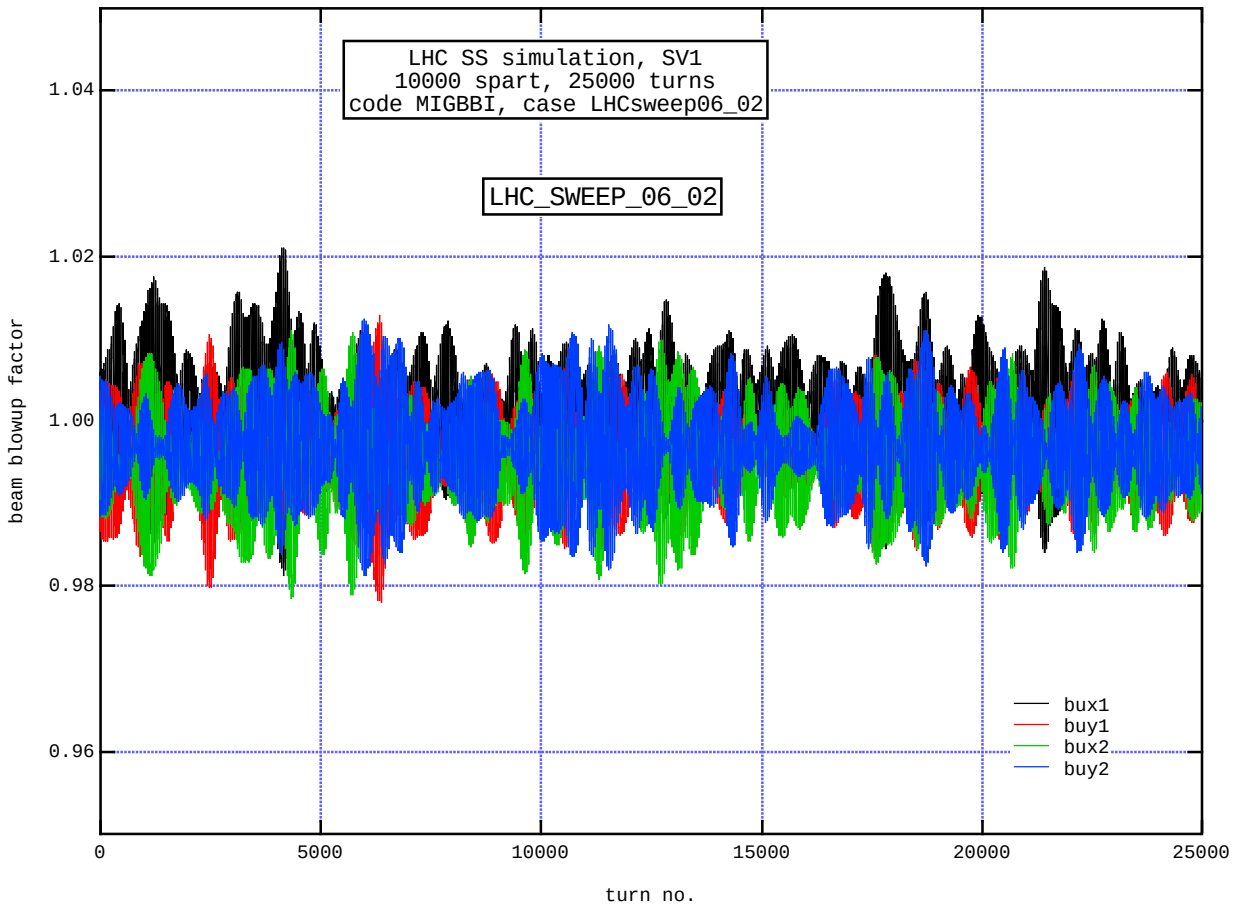
a


4x10^26
3
2
1
0
luminosity per collision [cm**-2]
LHC_SWEEP_06_02
LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep06_02
0
5000
10000
15000
20000
25000
turn no.

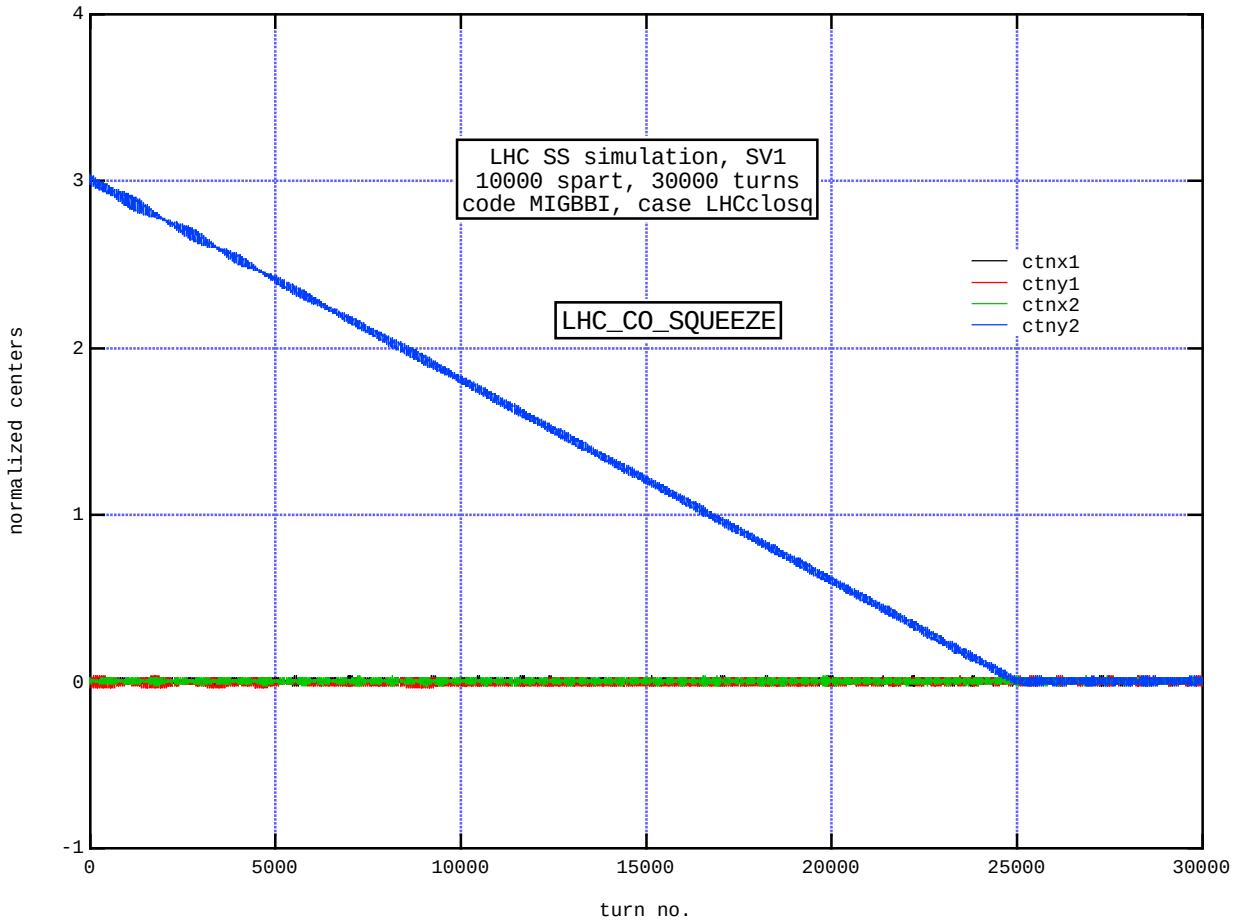
a


LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep06_02
LHC_SWEEP_06_02
ftaxsum
ftaxdif
ftaysum
ftaydif
σx
πx
πy
σy
10^-3
|FT(centers)| [arb. units]
tune

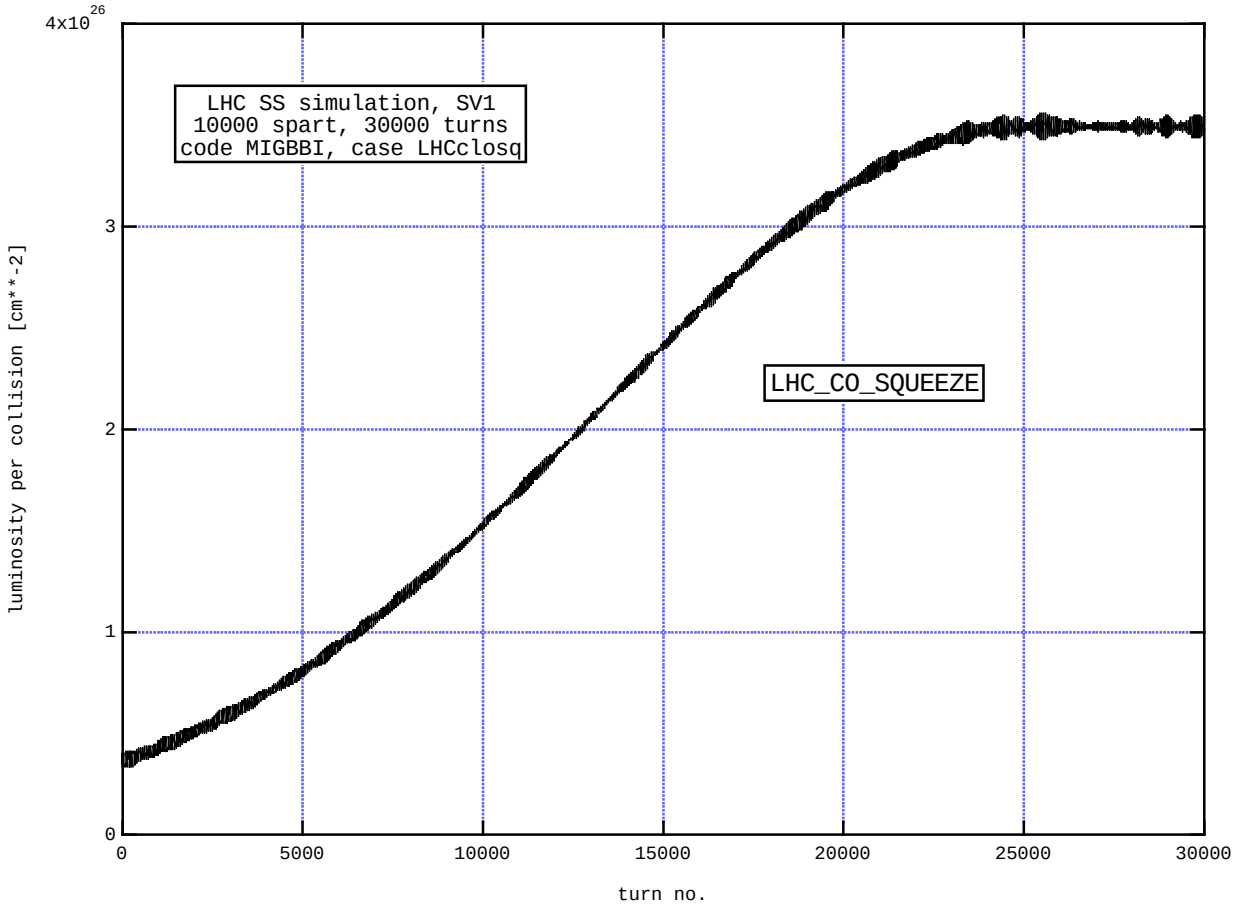
a


LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCsweep06_02
LHC_SWEEP_06_02
beam blowup factor
1.04
1.02
1.00
0.98
0.96
0
5000
10000
15000
20000
25000
turn no.
bux1
buy1
bux2
buy2

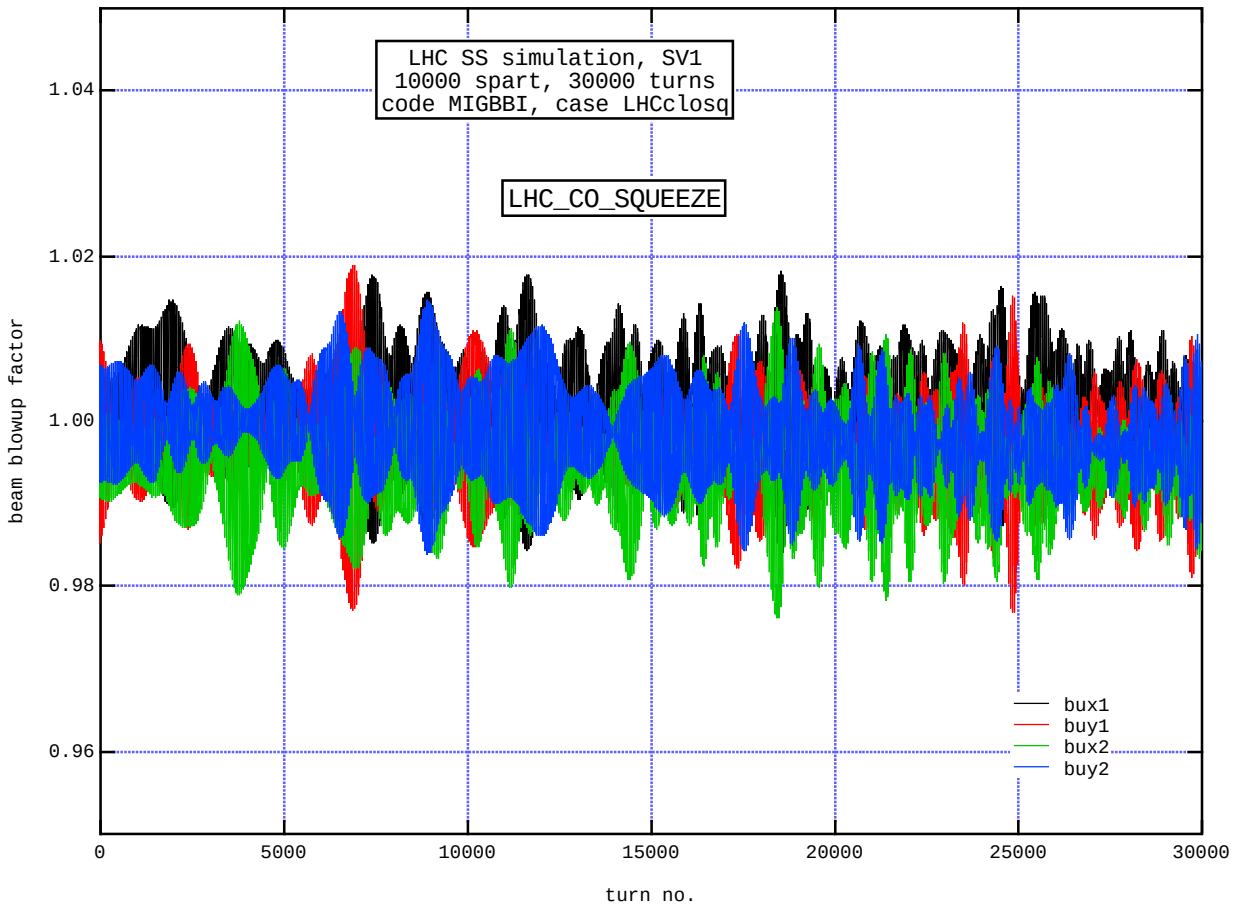
a


LHC SS simulation, SV1
10000 spart, 30000 turns
code MIGBBI, case LHCclosq
LHC_CO_SQUEEZE
ctnx1
ctny1
ctnx2
ctny2
normalized centers
turn no.
4
3
2
1
0
-1
0
5000
10000
15000
20000
25000
30000

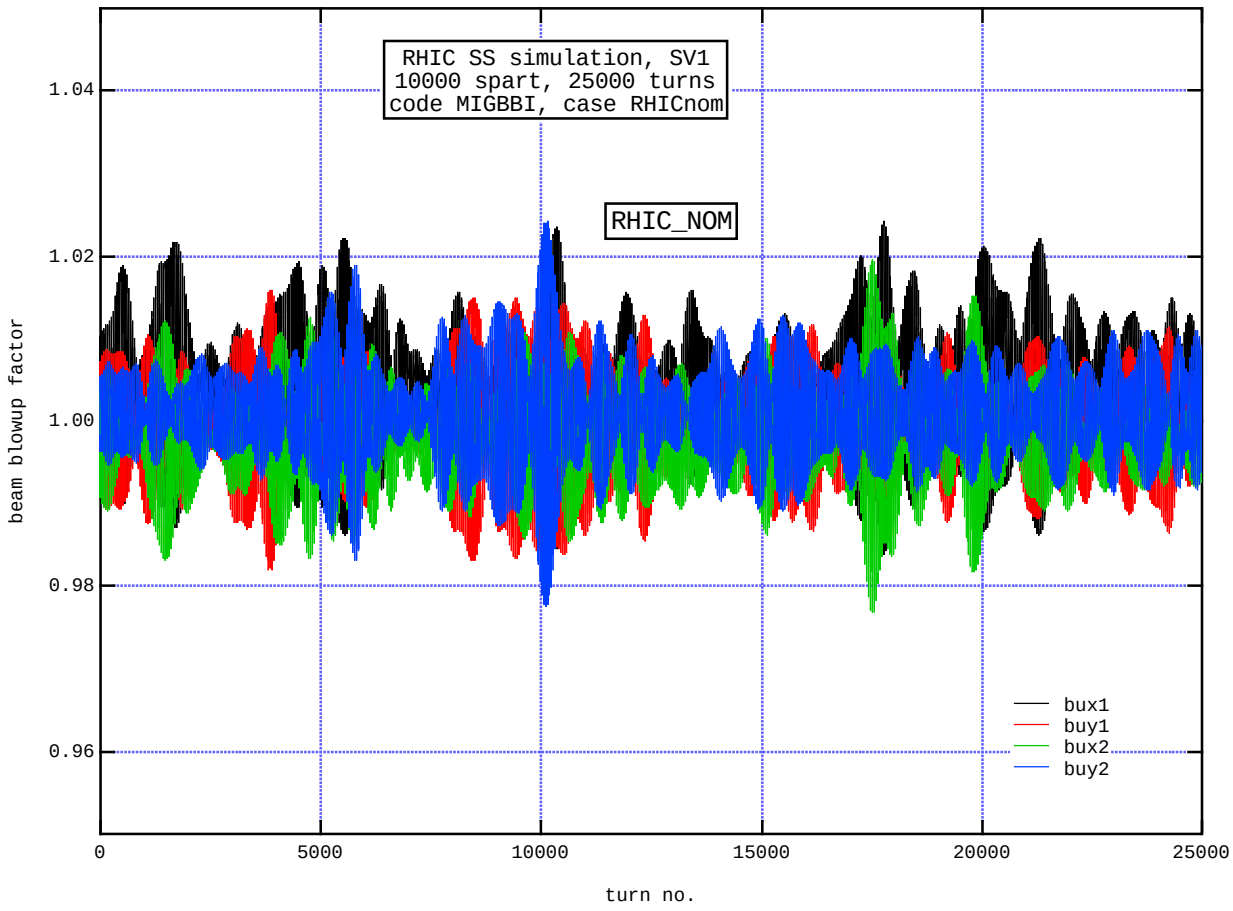
a


4x10^26
3
2
1
0
0
5000
10000
15000
20000
25000
30000
turn no.
luminosity per collision [cm**-2]
LHC SS simulation, SV1
10000 spart, 30000 turns
code MIGBBI, case LHCclosq
LHC_CO_SQUEEZE

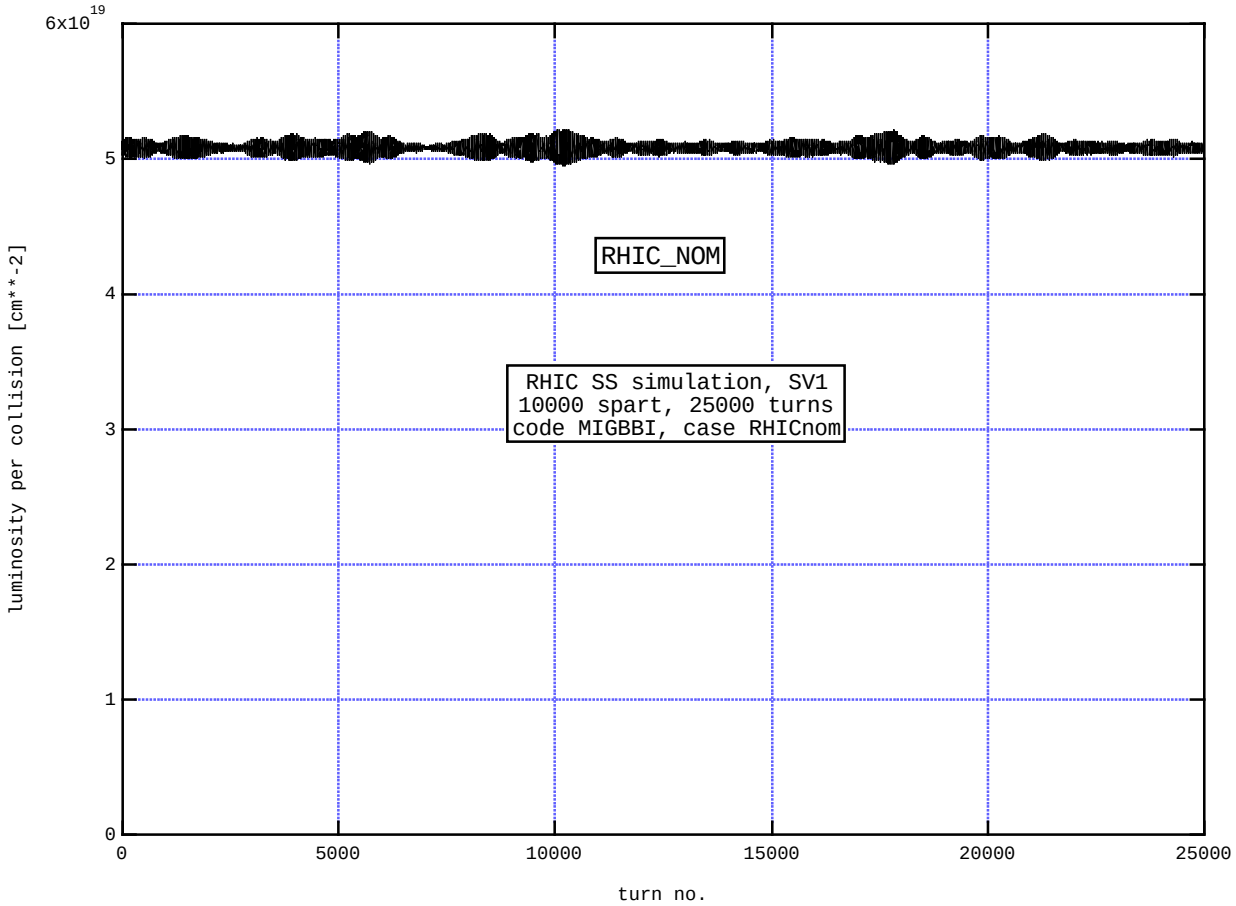
a


LHC SS simulation, SV1
10000 spart, 30000 turns
code MIGBBI, case LHCclosq
LHC_CO_SQUEEZE
beam blowup factor
1.04
1.02
1.00
0.98
0.96
0
5000
10000
15000
20000
25000
30000
turn no.
bux1
buy1
bux2
buy2

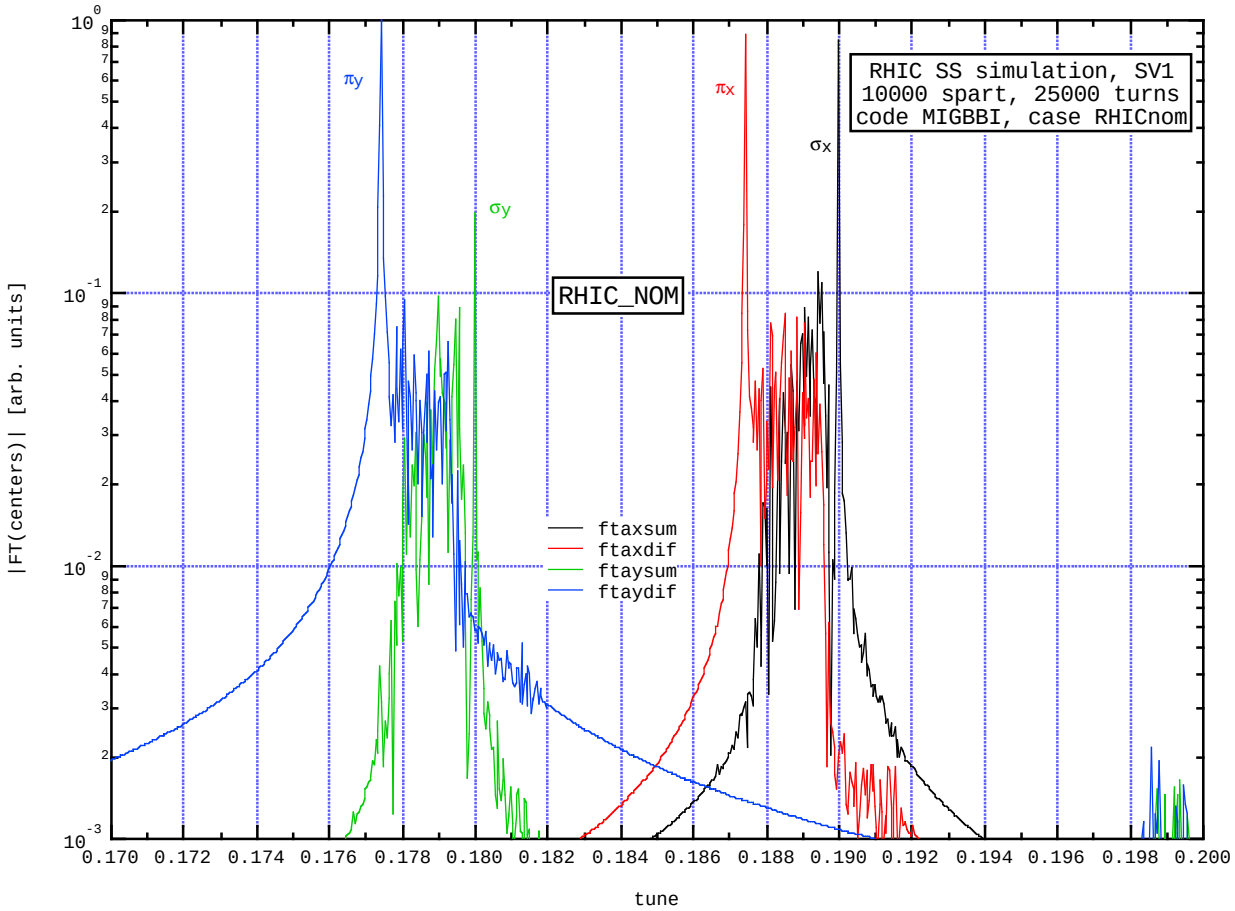
a


RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICnom
RHIC_NOM
beam blowup factor
1.04
1.02
1.00
0.98
0.96
0
5000
10000
15000
20000
25000
turn no.
bux1
buy1
bux2
buy2

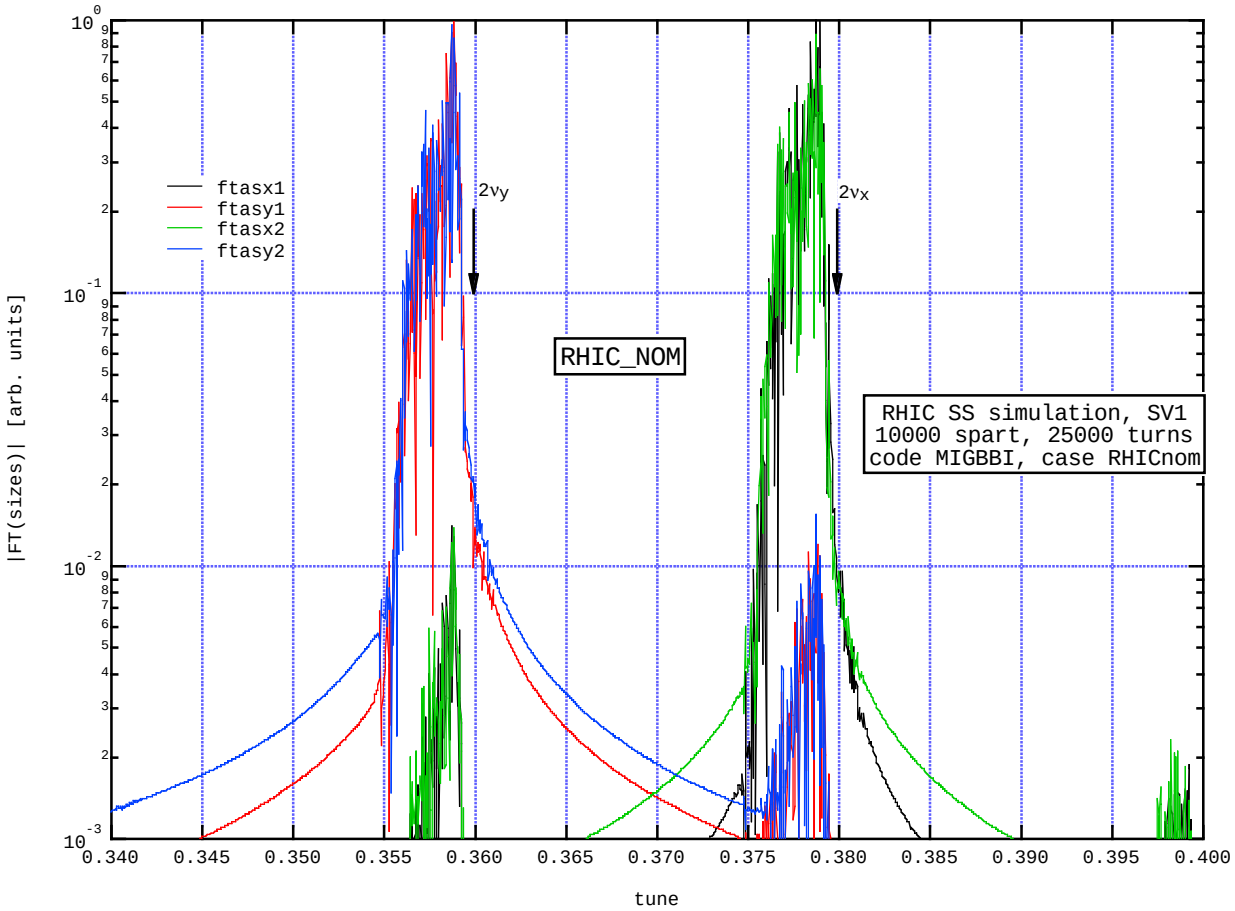
a


6x10^19
5
4
3
2
1
0
luminosity per collision [cm**-2]
RHIC_NOM
RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICnom
0
5000
10000
15000
20000
25000
turn no.

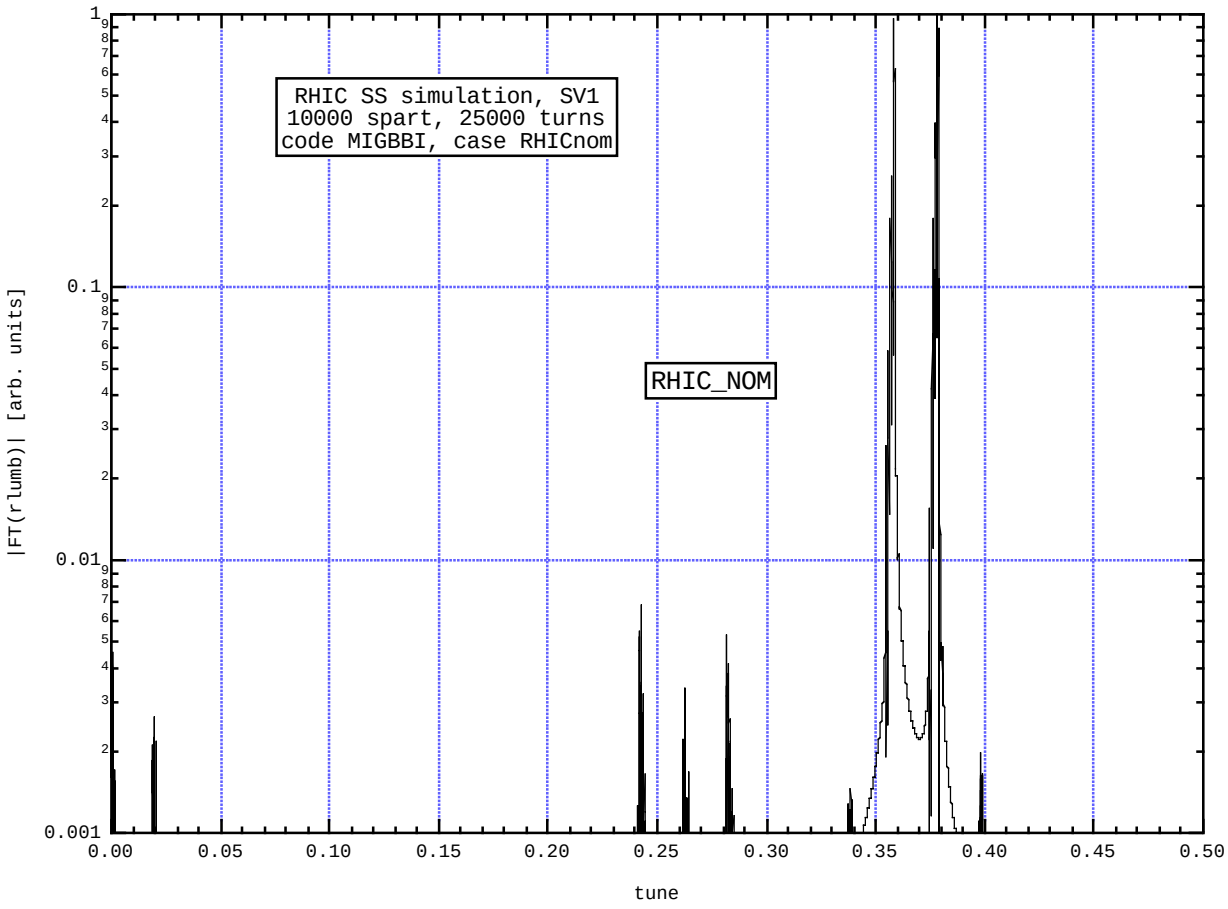
a


RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICnom
RHIC_NOM
πy
σy
πx
σx
ftaxsum
ftaxdif
ftaysum
ftaydif
|FT(centers)| [arb. units]
tune

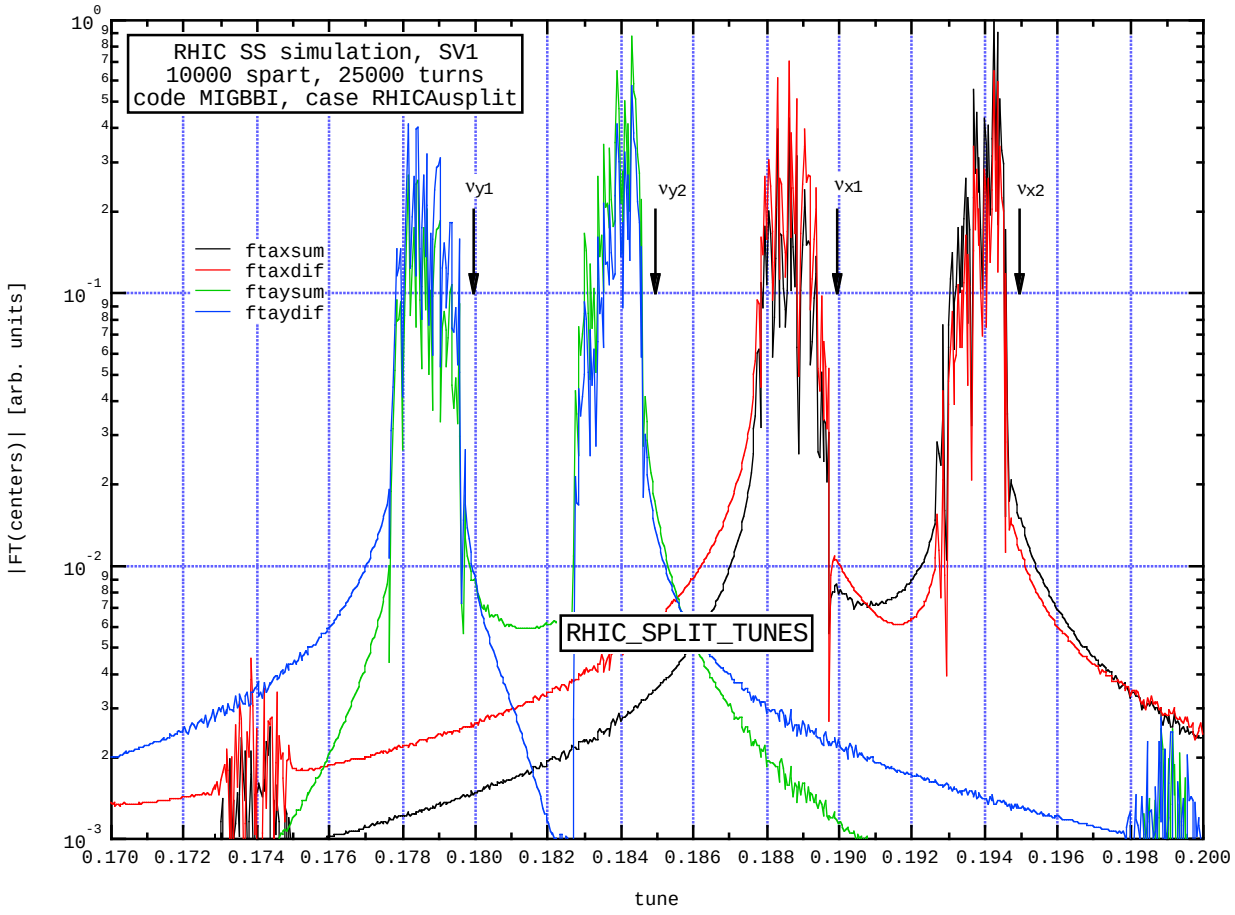
a


ftasx1
ftasy1
ftasx2
ftasy2
2νy
2νx
RHIC_NOM
RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICnom
|FT(sizes)| [arb. units]
tune
0.340
0.345
0.350
0.355
0.360
0.365
0.370
0.375
0.380
0.385
0.390
0.395
0.400

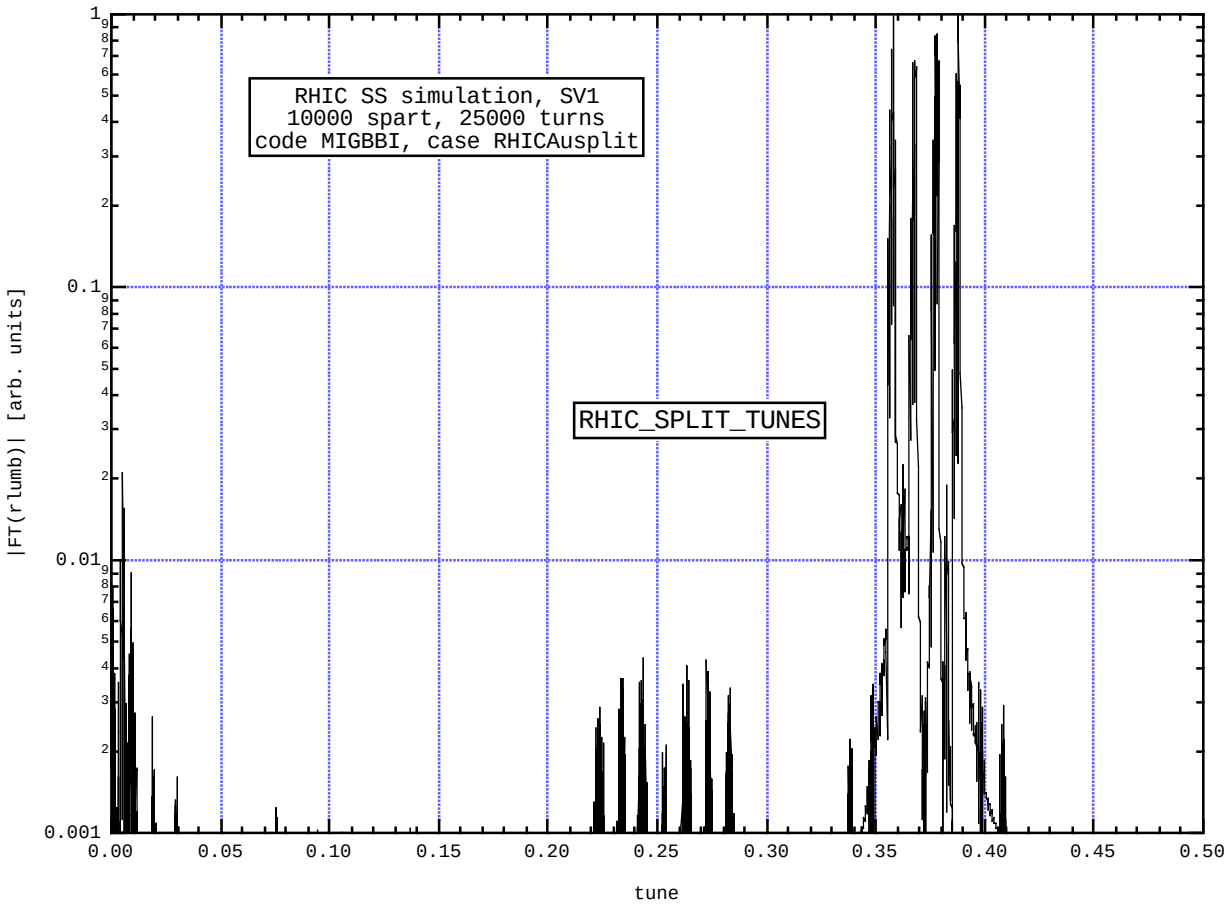
a


RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICnom
RHIC_NOM
|FT(rlumb)| [arb. units]
tune
1
0.1
0.01
0.001
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50

a


RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICAusplit
ftaxsum
ftaxdif
ftaysum
ftaydif
νy1
νy2
νx1
νx2
RHIC_SPLIT_TUNES
|FT(centers)| [arb. units]
tune

a


RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICAusplit
RHIC_SPLIT_TUNES
|FT(rlumb)| [arb. units]
tune
1
0.1
0.01
0.001
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50

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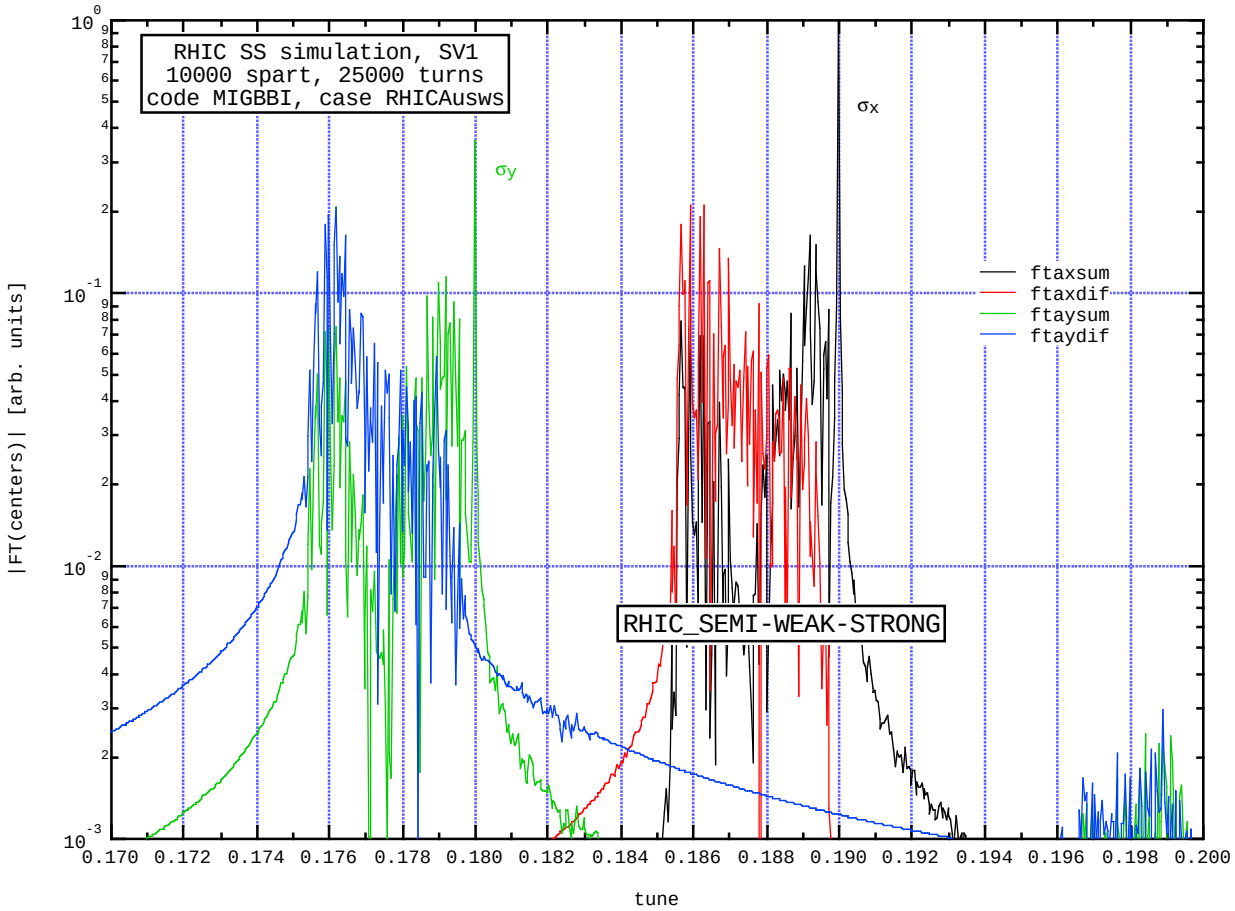
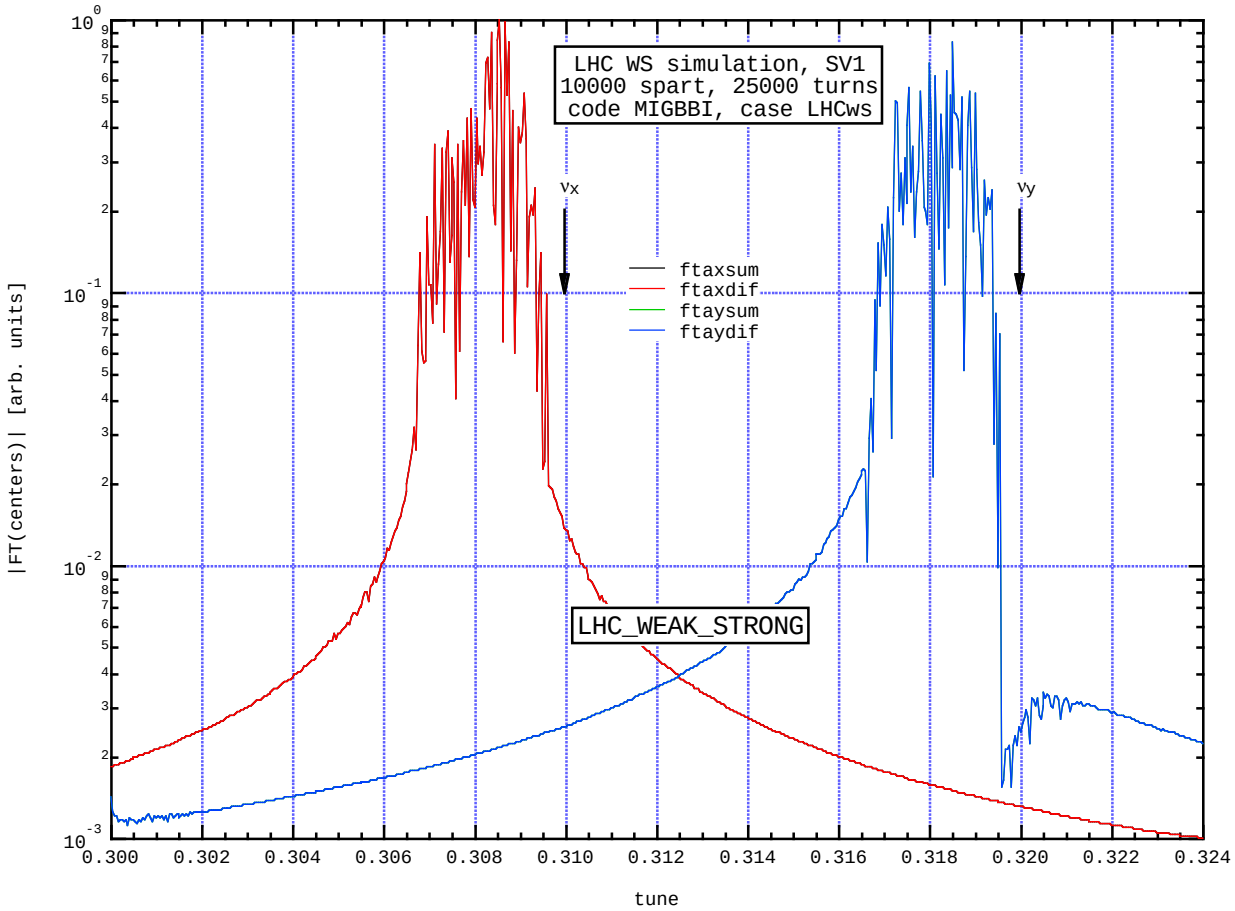
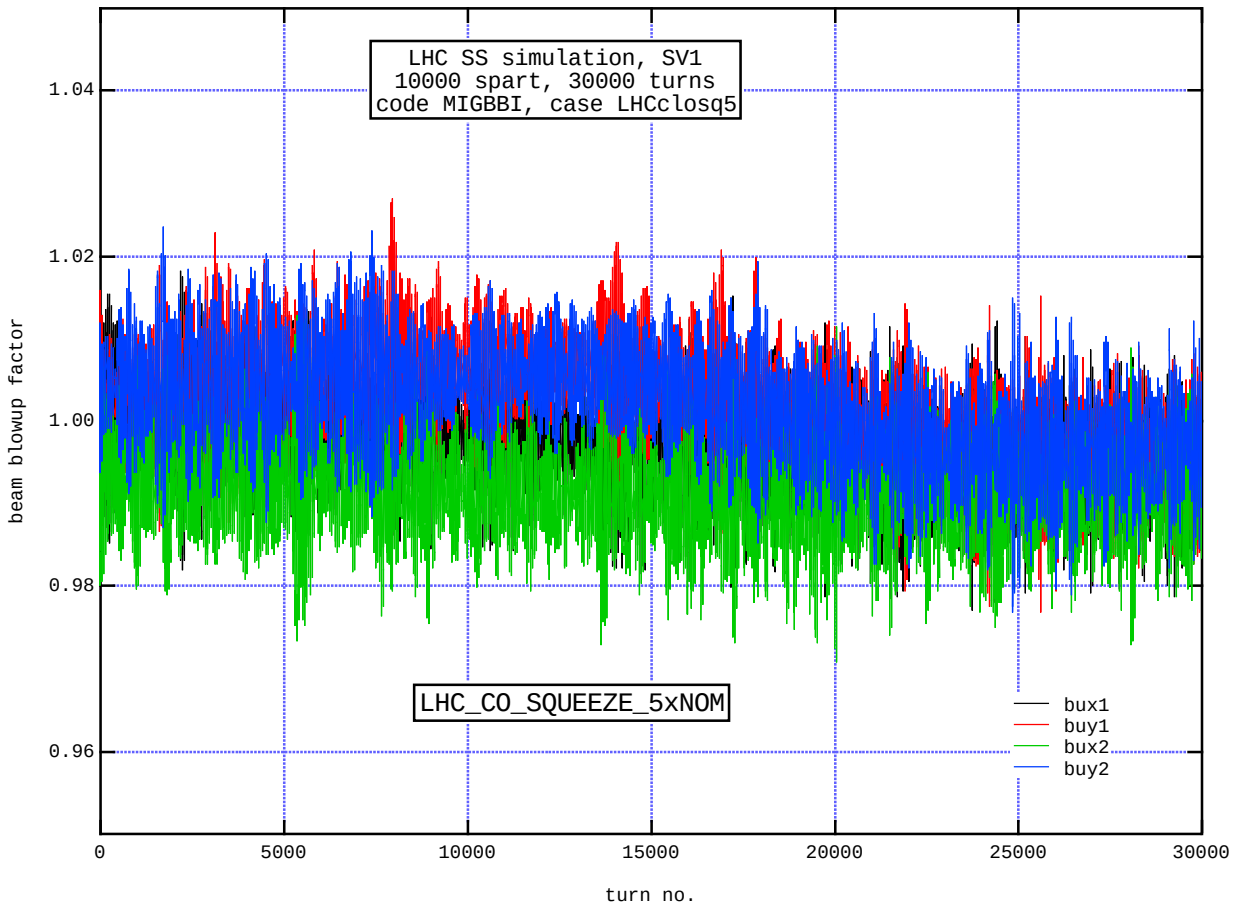

RHIC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case RHICAusws
σx
σy
ftaxsum
ftaxdif
ftaysum
ftaydif
RHIC_SEMI-WEAK-STRONG
|FT(centers)| [arb. units]
tune

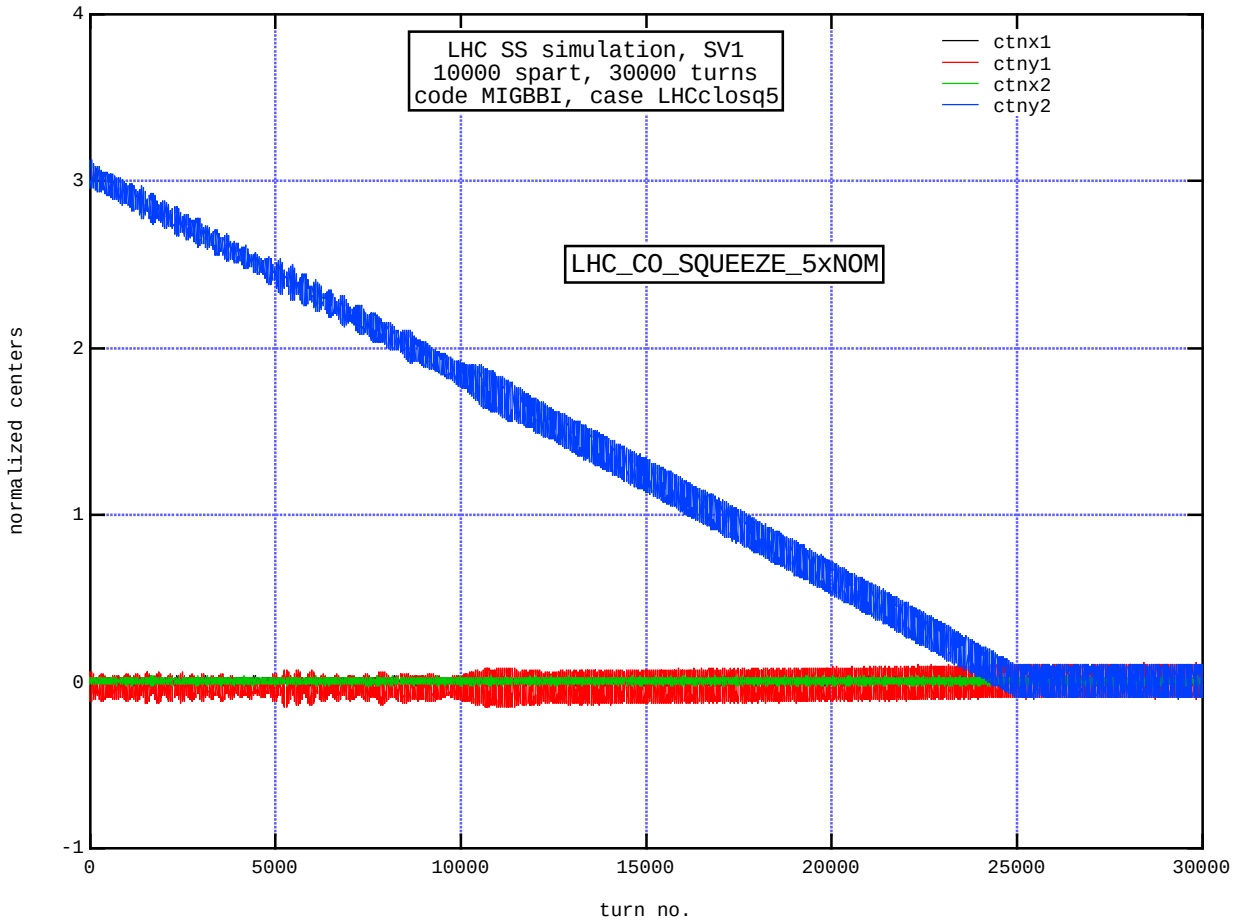
a


LHC WS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHCws
νx
νy
ftaxsum
ftaxdif
ftaysum
ftaydif
LHC_WEAK_STRONG
|FT(centers)| [arb. units]
tune
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0.314
0.316
0.318
0.320
0.322
0.324

a


LHC SS simulation, SV1
10000 spart, 30000 turns
code MIGBBI, case LHCclosq5
LHC_CO_SQUEEZE_5xNOM
bux1
buy1
bux2
buy2
beam blowup factor
turn no.
1.04
1.02
1.00
0.98
0.96
0
5000
10000
15000
20000
25000
30000

a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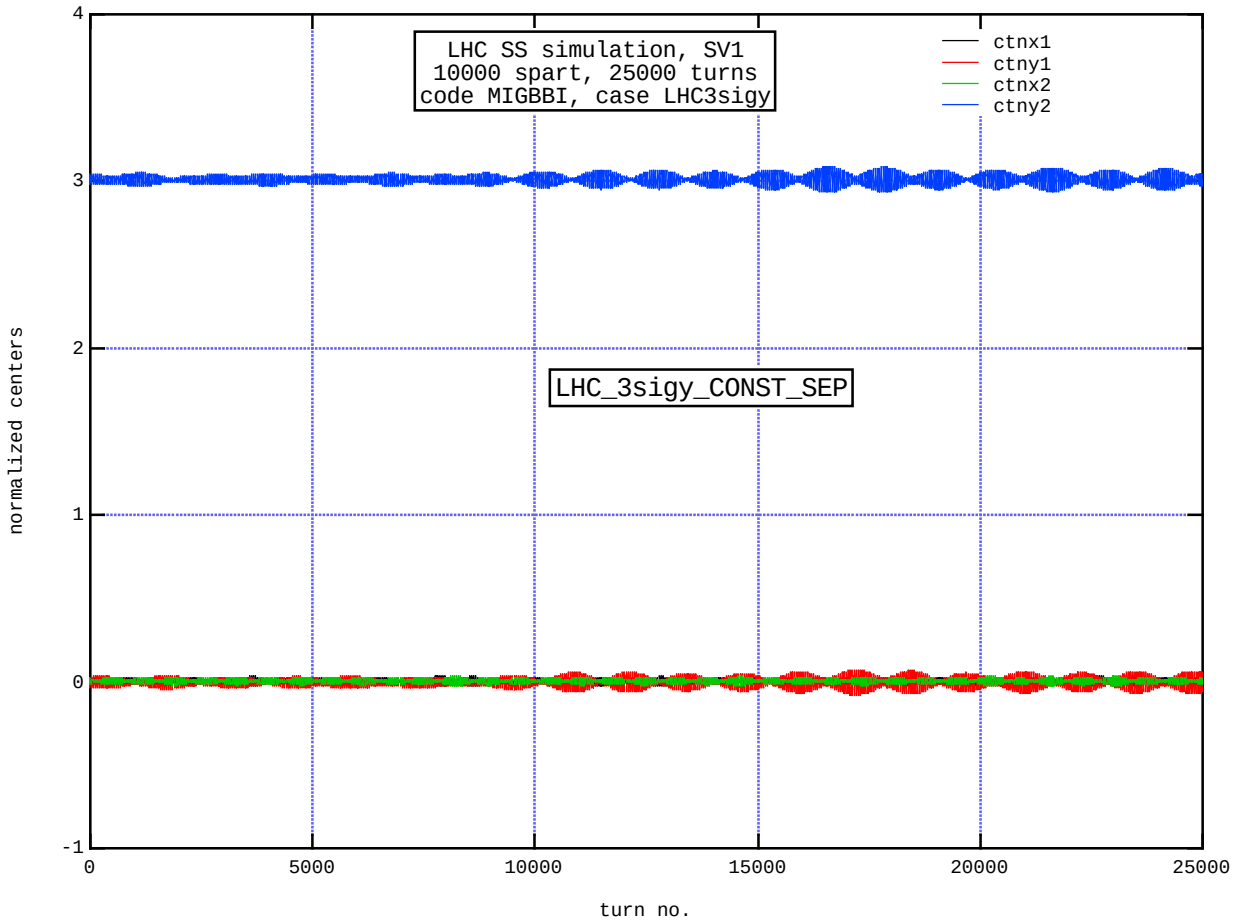
10000 spart, 30000 turns
code MIGBBI, case LHCclosq5
LHC_CO_SQUEEZE_5xNOM
ctnx1
ctny1
ctnx2
ctny2
normalized centers
turn no.
4
3
2
1
0
-1
0
5000
10000
15000
20000
25000
30000

a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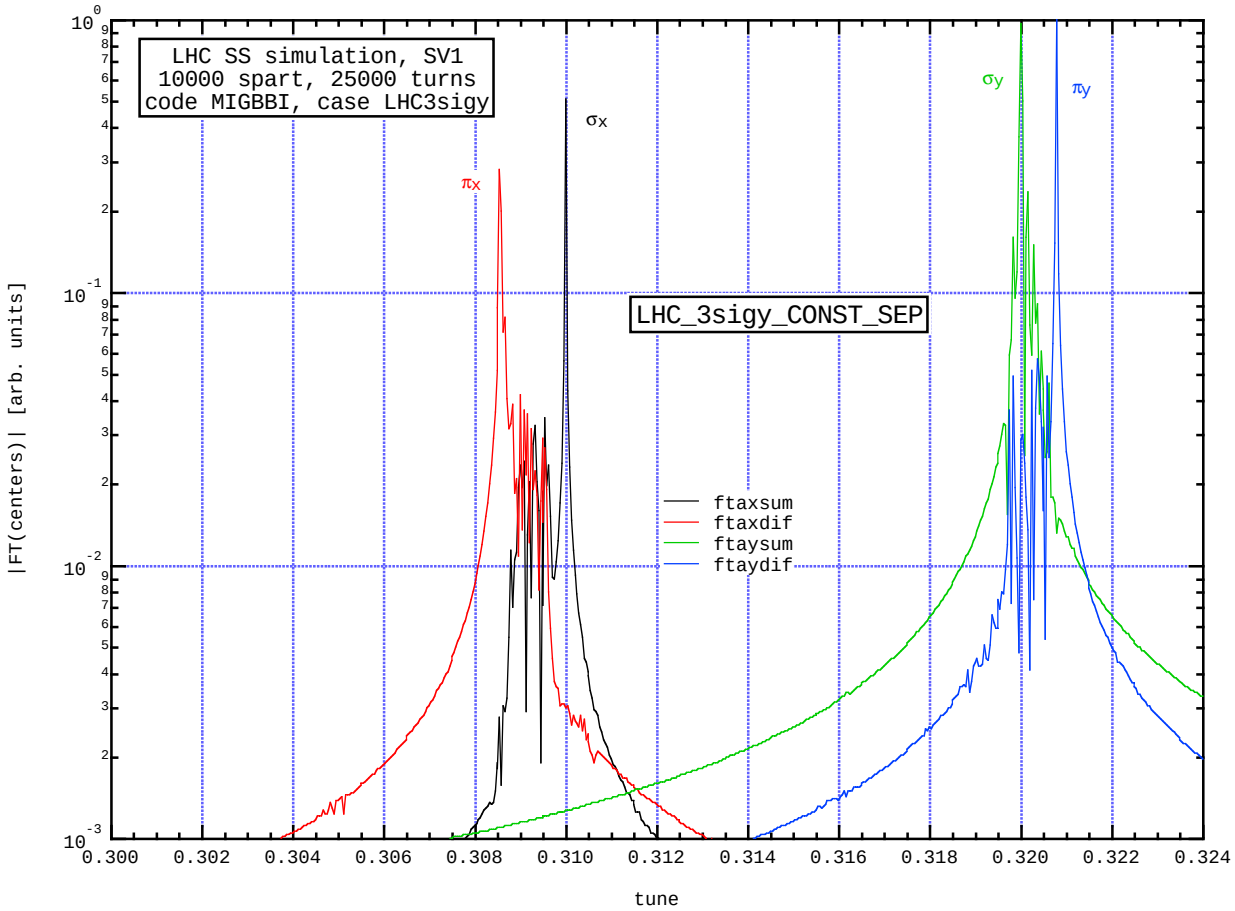
code MIGBBI, case LHC3sigy
ctnx1
ctny1
ctnx2
ctny2
LHC_3sigy_CONST_SEP
normalized centers
turn no.
4
3
2
1
0
-1
0
5000
10000
15000
20000
25000

a


LHC SS simulation, SV1
10000 spart, 25000 turns
code MIGBBI, case LHC3sigy
LHC_3sigy_CONST_SEP
σx
πx
σy
πy
ftaxsum
ftaxdif
ftaysum
ftaydif
|FT(centers)| [arb. units]
tune
0.300
0.302
0.304
0.306
0.308
0.310
0.312
0.314
0.316
0.318
0.320
0.322
0.324

a

CONCLUSIONS

0) IN AGREEMENT WITH ZORZANO-ZIMMERMANN

1) NEGLIGIBLE BEAM BLOWUP UP TO 25,000 TURN

→ HEAD-ON

→ SEPARATED BEAMS AT FIXED DISTANCE

→ CLOSED-ORBIT SQUEEZE

→ SWEEPING

2) COHERENT SPECTRUM LOOKS REASONABLE

* $\nu_\pi < \nu_\sigma$ FOR LIKE-CHARGED BEAMS
  $\nu_\pi > \nu_\sigma$ " OPPOSITELY- " "

* $|\nu_\pi - \nu_\sigma| \equiv F \cdot \xi$, $F = 1.1$ IN DISAGREEMENT (?) WITH THEORY (MSYKA)

* π-MODE DISAPPEARS FOR SPLIT TUNES

* π-MODE " " SEMI-WEAK-STRONG

* π AND σ MODES DISAPPEAR FOR WEAK-STRONG

3) IT WOULD BE NICE TO TEST ALL THIS AT RHIC OR TEVATRON

4) TO DO:

* CROSSING ANGLE
* PARASITIC COLLISIONS
* UNDERSTAND NUMERICAL LIMITATIONS

S. KRISHNAGOPAL

* UNDERSTAND A DISCREPANCY WITH KRISHNAGOPAL'S PIC CODE "CBI"