

Nonlinear analysis and dynamic aperture

Yuri Nosochkov (SLAC), Demin Zhou (KEK)

Acknowledgements:

M. Benedikt, M. Crouch, L. Deniau, R. De Maria, E. Forest, S. Fartoukh, M. Giovannozzi, M. Hofer, K. Oide, T. Risselada, L. Riesen-Haupt, D. Sagan, D. Schoerling, I. Tecker, R. Tomas, P. Thrane, E. Todesco, D. Tommasini, F. Zimmermann

FCC Week 2017, Berlin, 1 June, 2017

Outline

➤ Introduction

- HE-LHC optics under design
- See Y. Nosochkov's talk for HE-LHC optics design efforts

➤ Resonance driving term (RDT) and dynamic aperture (DA) calculation

- Only applied to injection optics w/o errors for HE-LHC for this moment
- Only lattice sextupoles taken as sources of non-linear effects

➤ Summary and outlook

1. Introduction

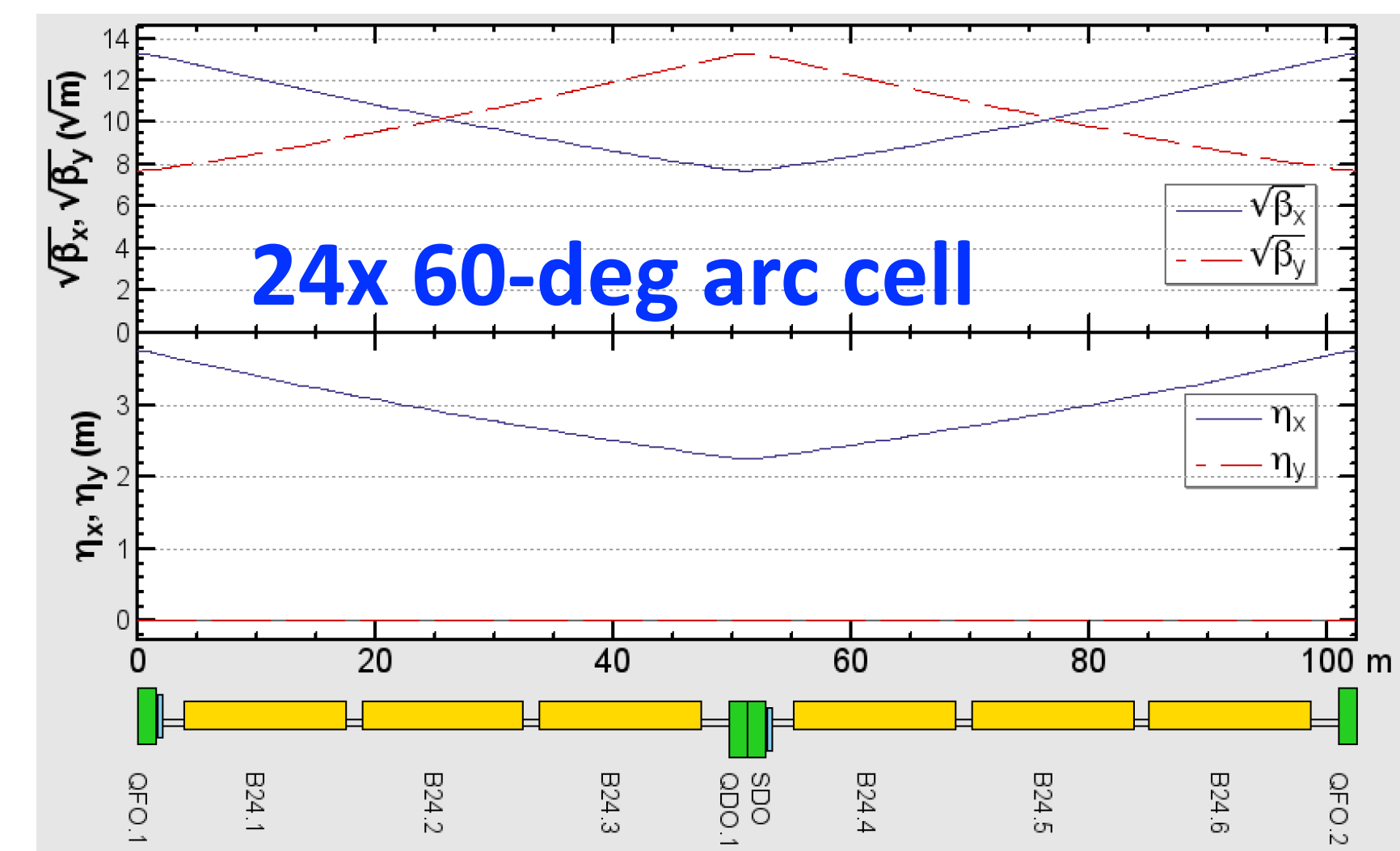
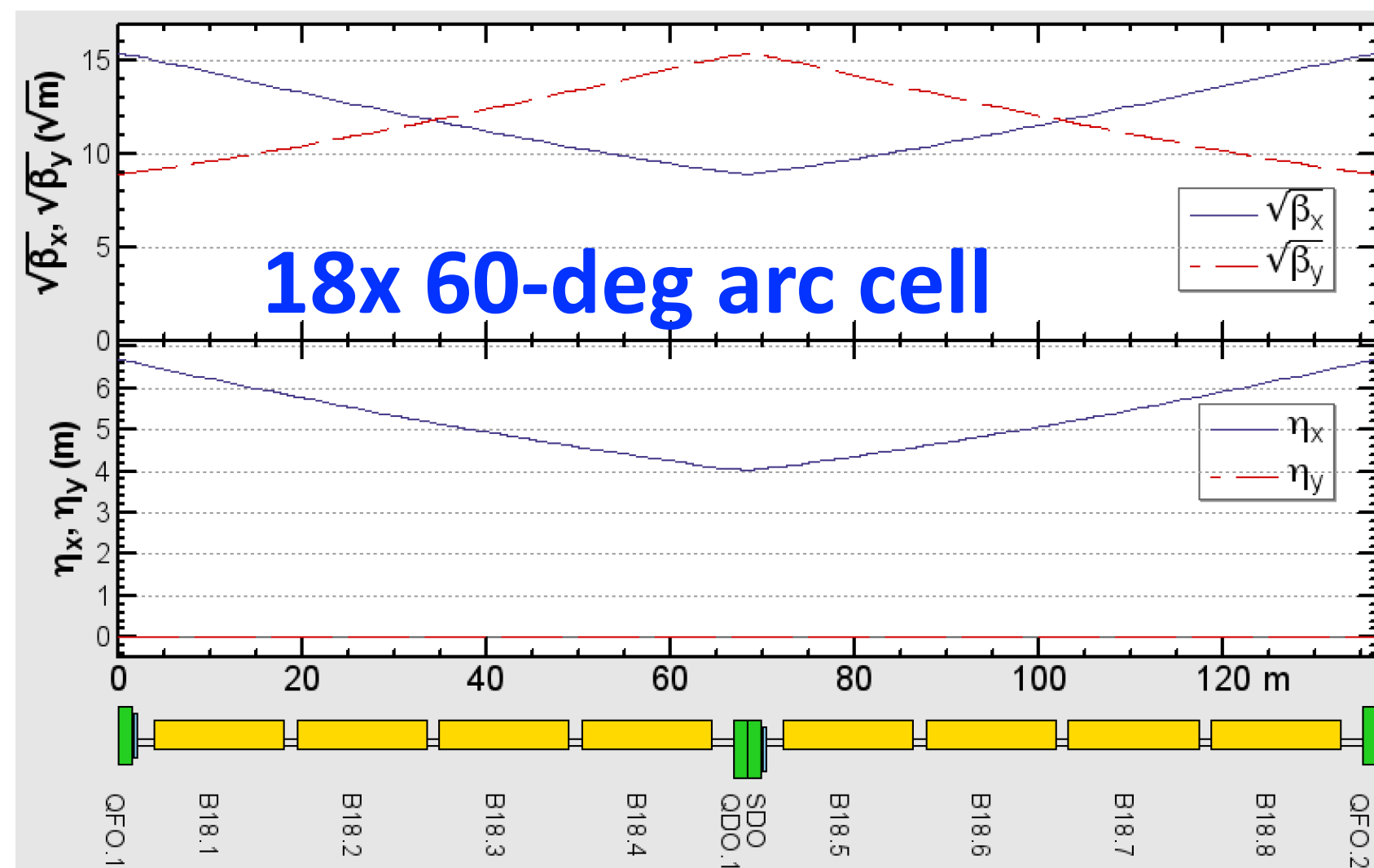
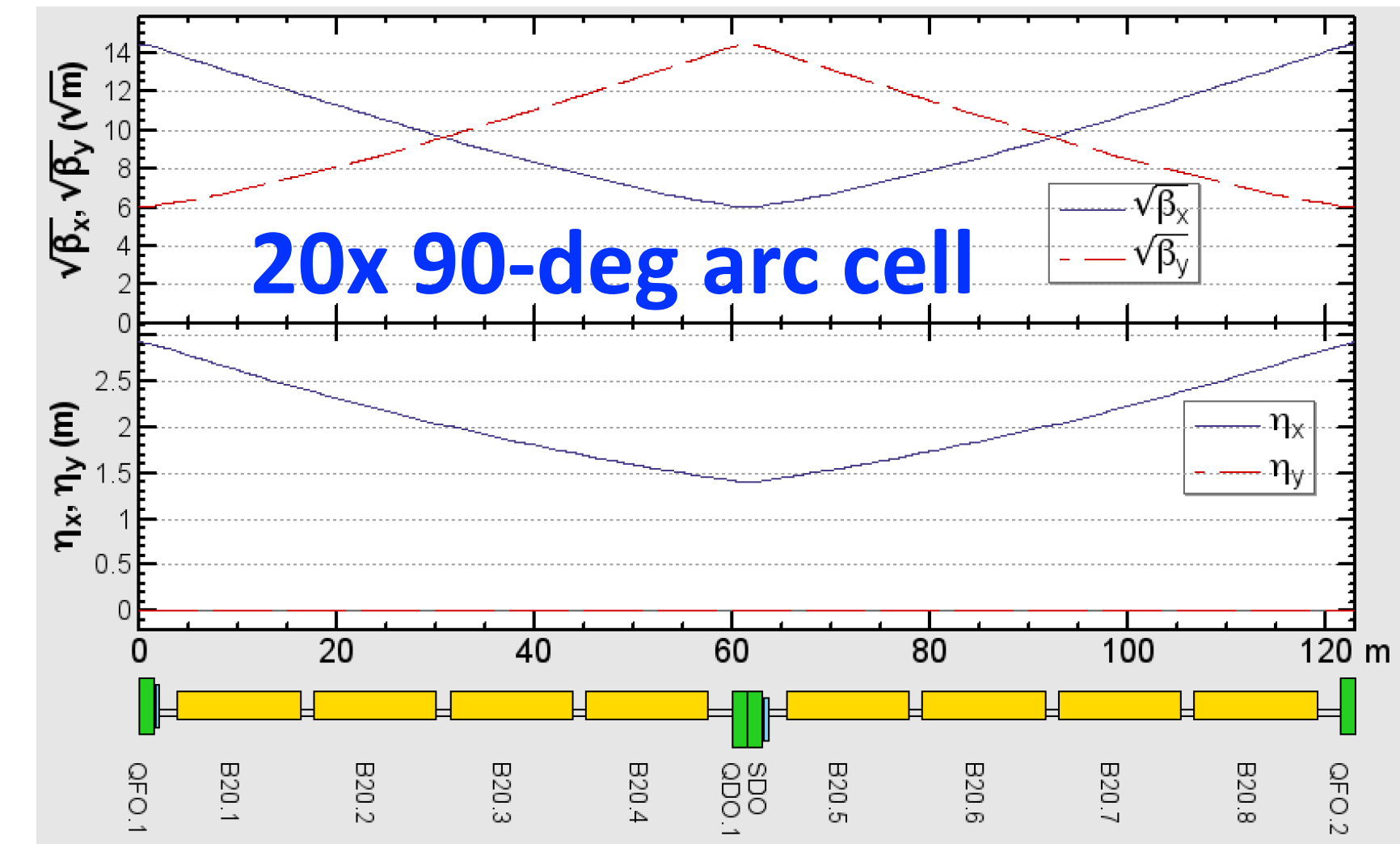
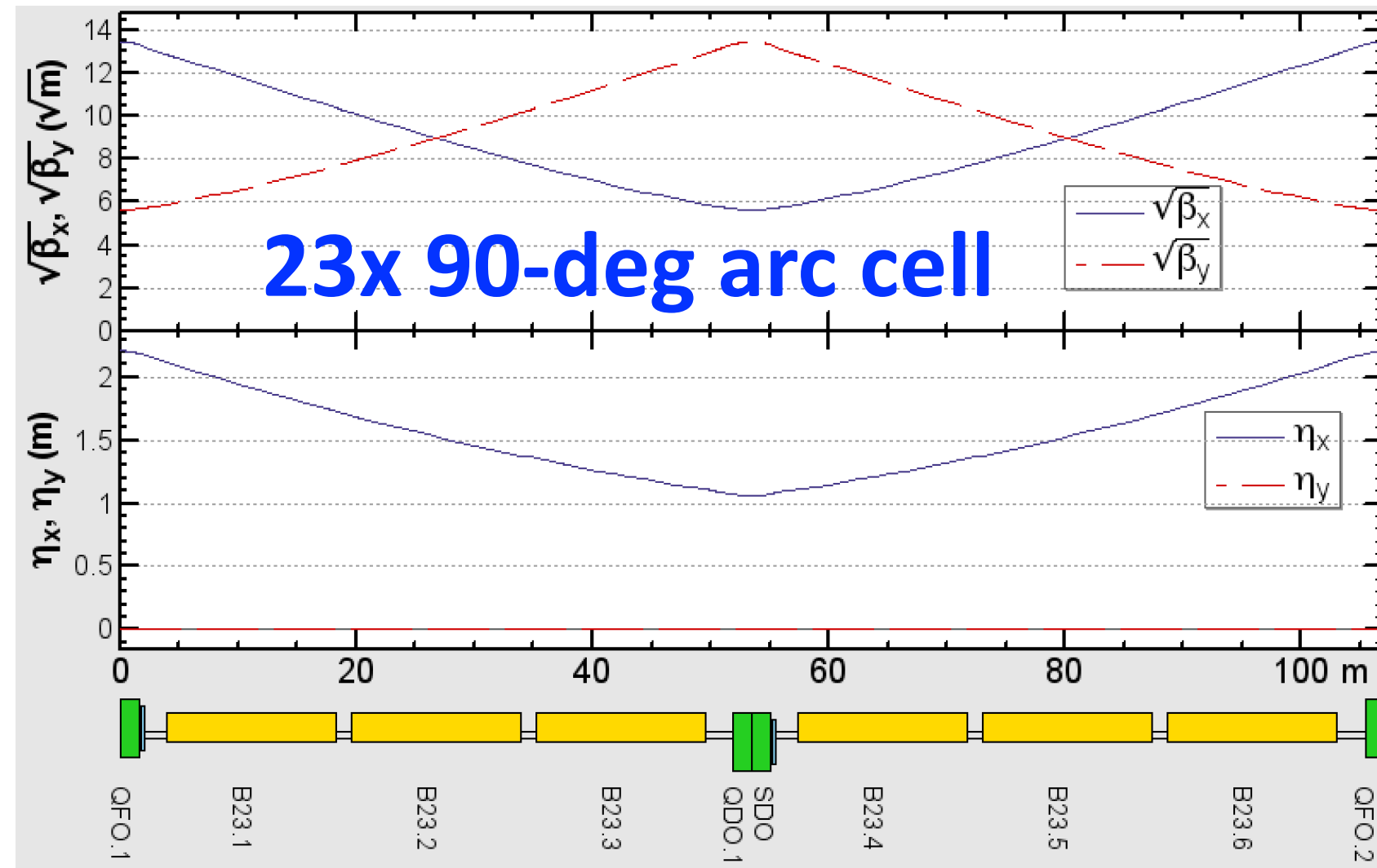
➤ Alternatives for arc cells fitting to the geometry of LHC arcs

- Motivation: simply scaling (HL-)LHC hits the limits set by FCC technologies
- Rules: Assume the same drifts between magnets as LHC; Fit to the arc length of LHC

	LHC-like	24x 60° HE-LHC	20x 90° HE-LHC	18x 60° HE-LHC
Arc cell phase advance [deg]	90/90	60/60	90/90	60/60
Arc cell length [m]	106.9584	102.5018	123.00	136.669
K1 [m ⁻¹]	0.02697	0.0199	0.0234	0.01485
$\beta_{\max/\min}$ [m]	181.3/31.54	176.6/59.48	208.68/36.24	235.74/79.22
$\eta_{\max/\min}$ [m]	2.21/1.07	3.75/2.26	2.92/1.41	6.67/4.02
Dipole length [m]	14.3 [x6]	13.56 [x6]	12.39 [x8]	14.1 [x8]
Dipole field [T]@13.5TeV	16.06	16.23	15.99	15.61
Filling factor	0.802	0.794	0.806	0.825

1. Introduction

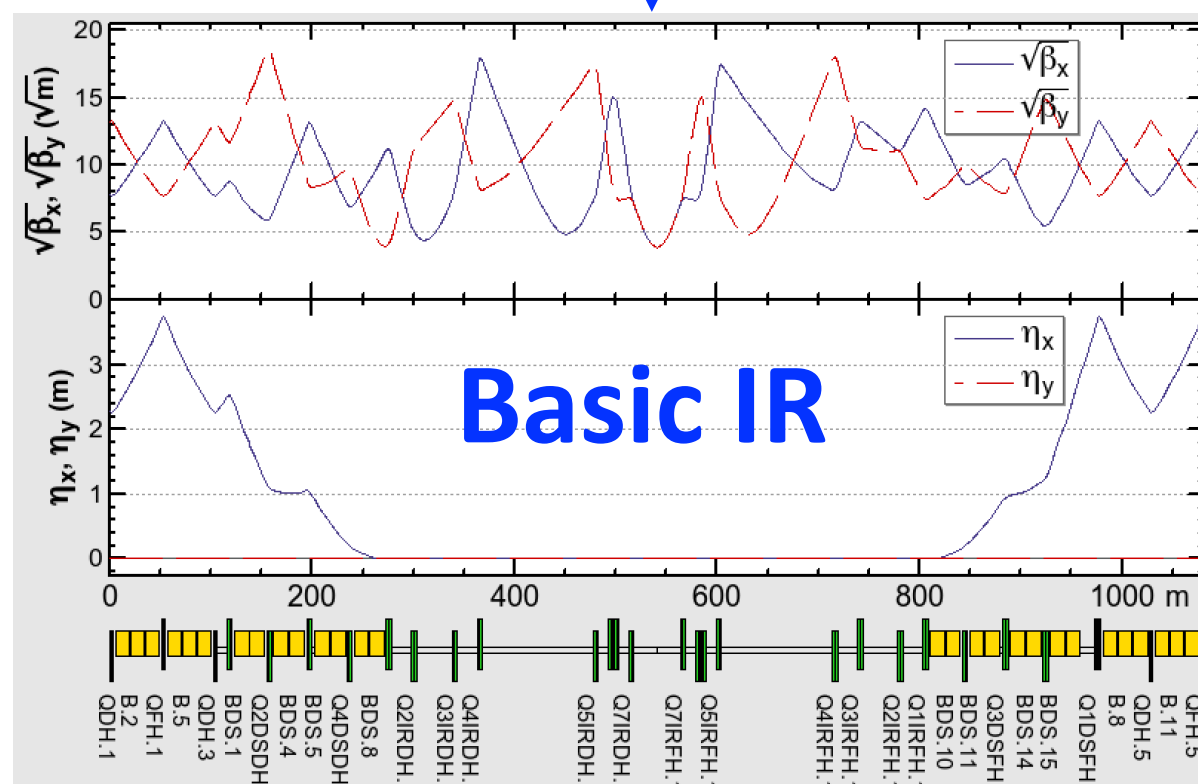
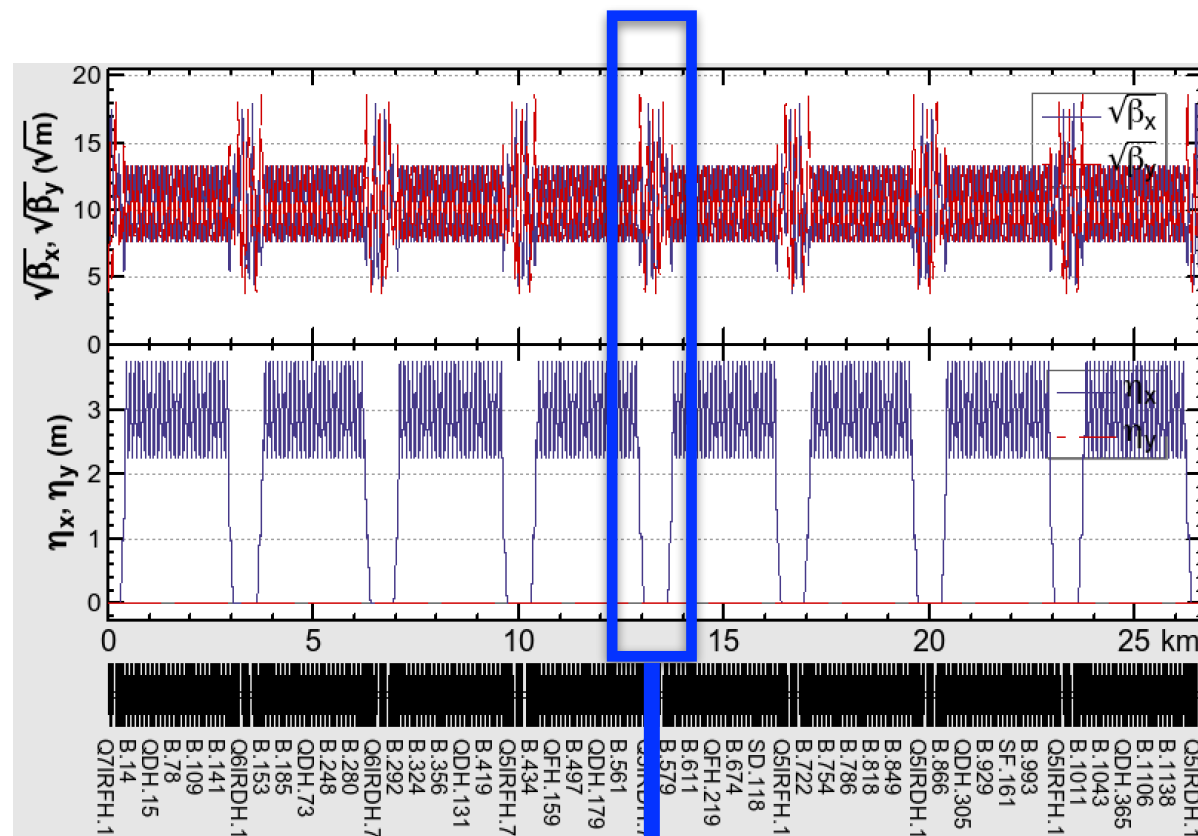
➤ Alternatives for arc cells



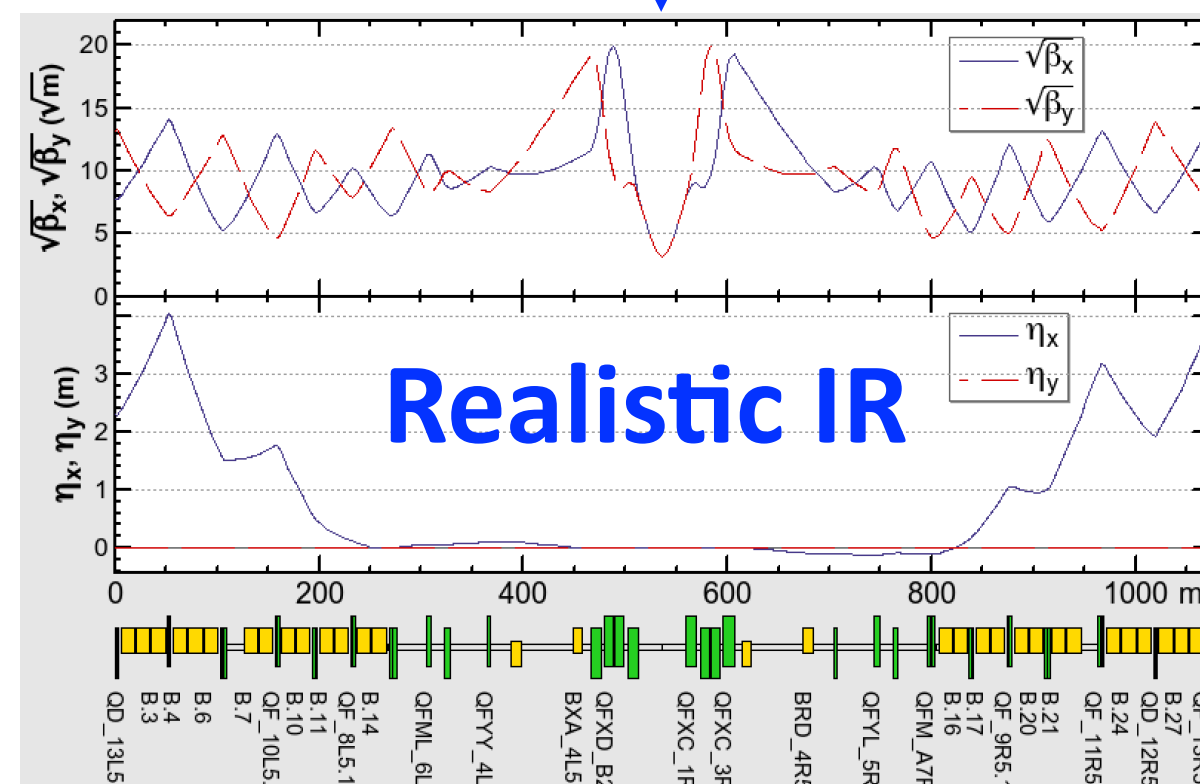
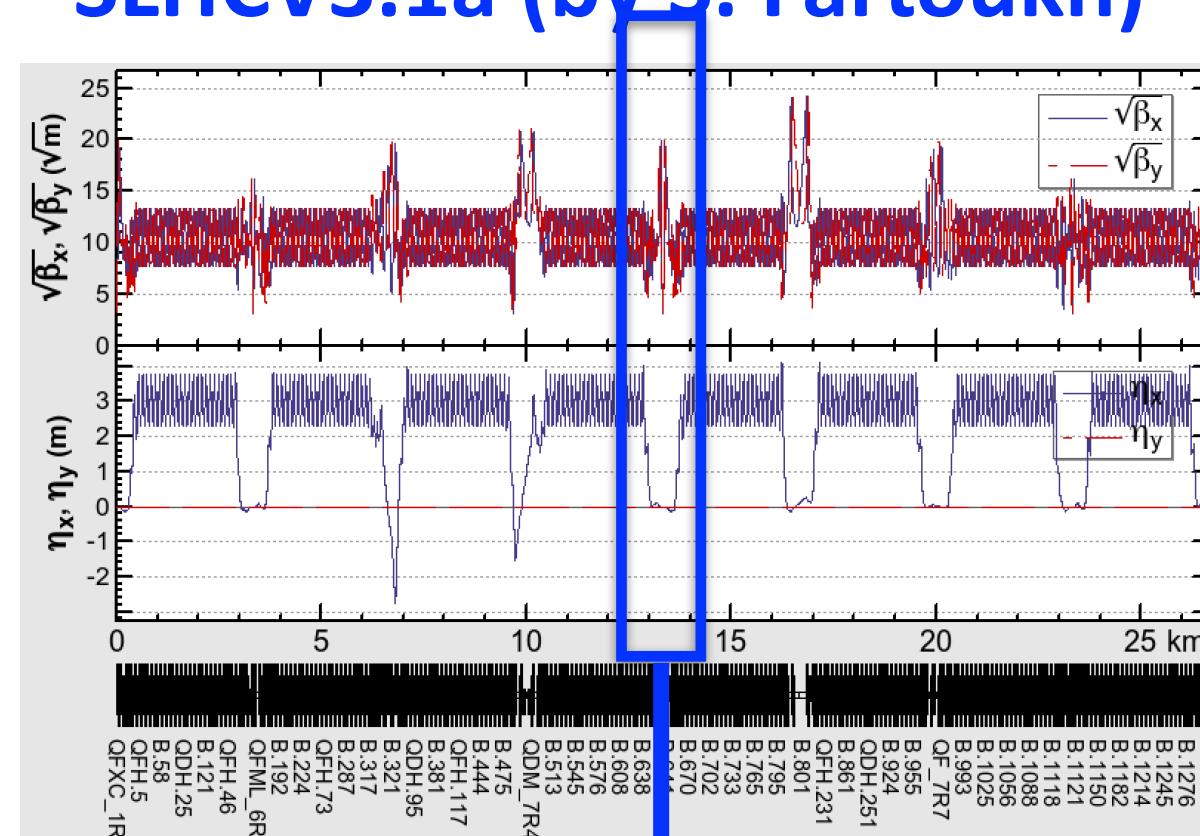
1. Introduction

➤ Integration with IRs (Start from IP1 for plots)

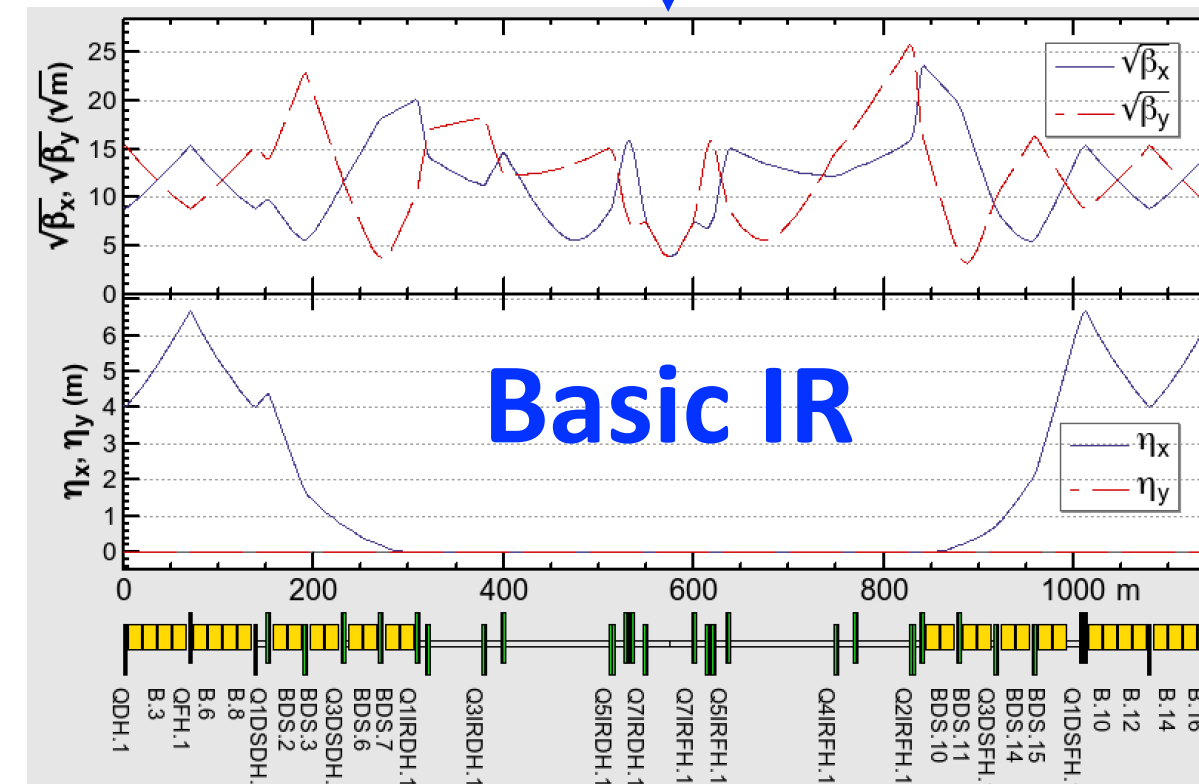
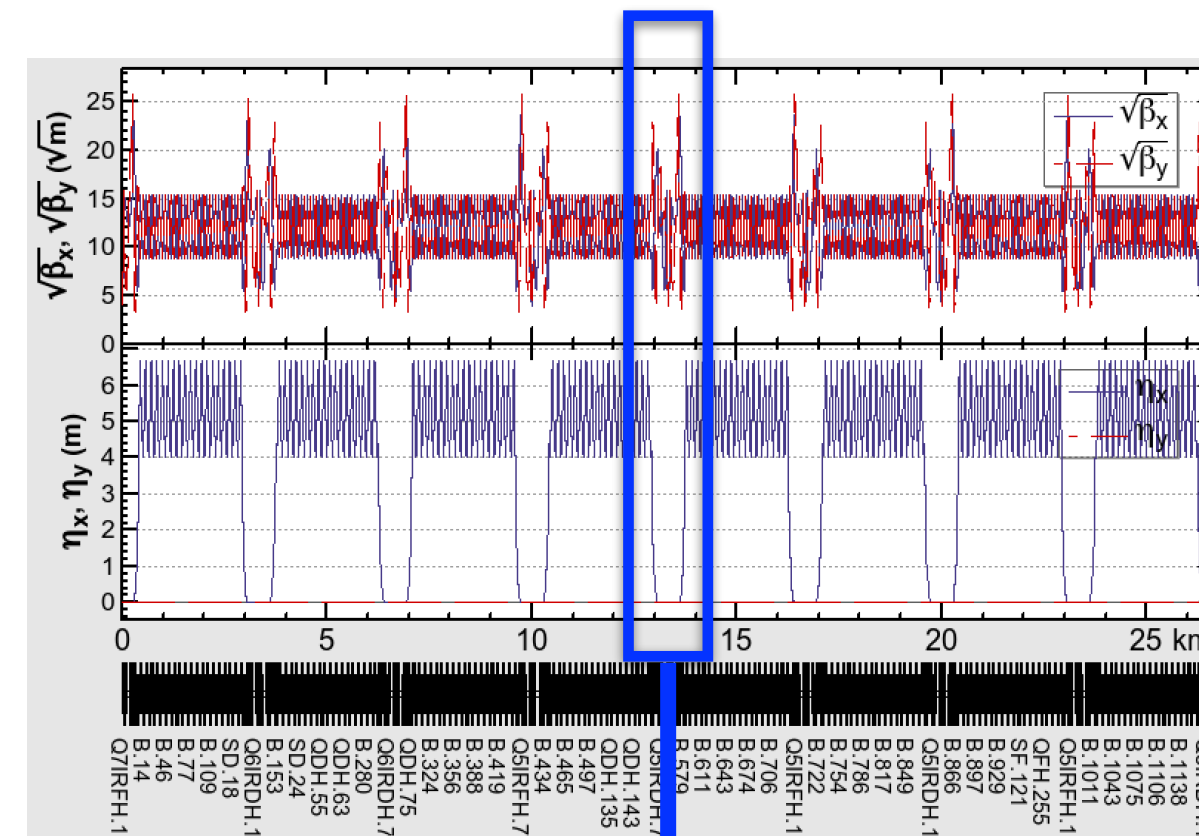
Injection lattice by Y.N.
24x 60-deg arcs



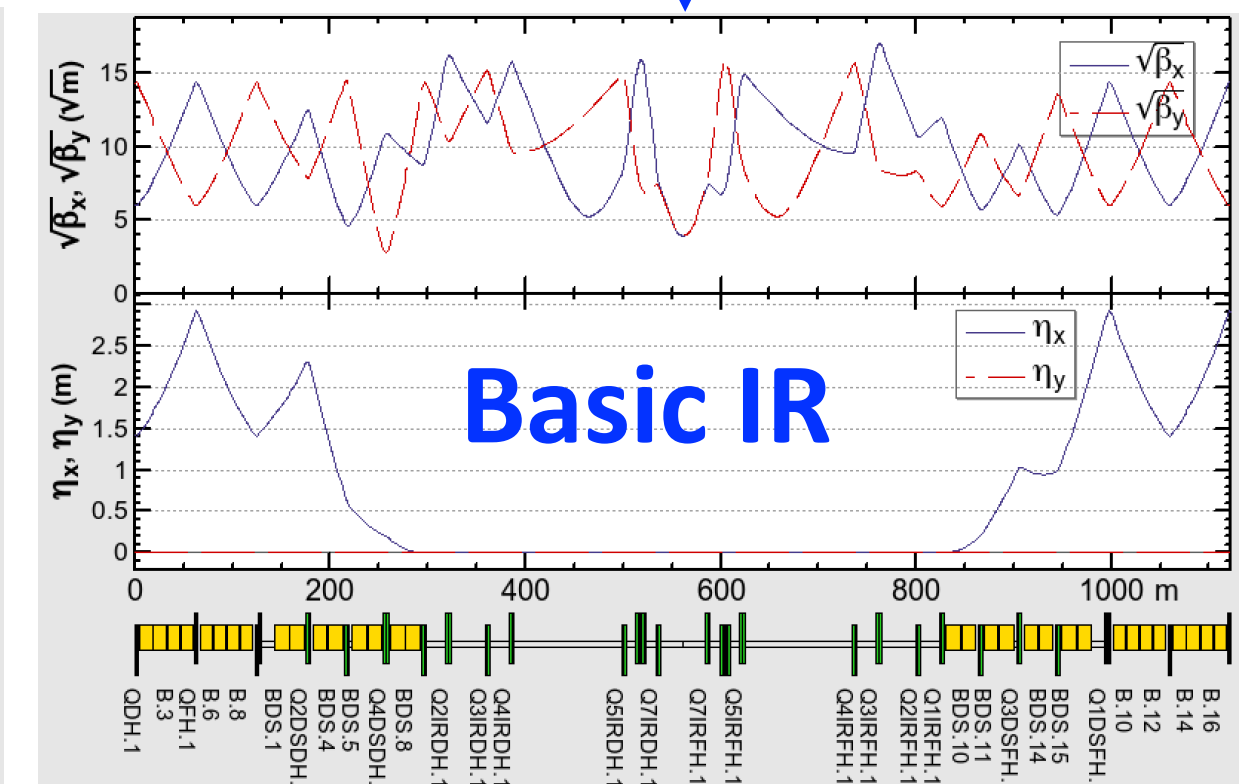
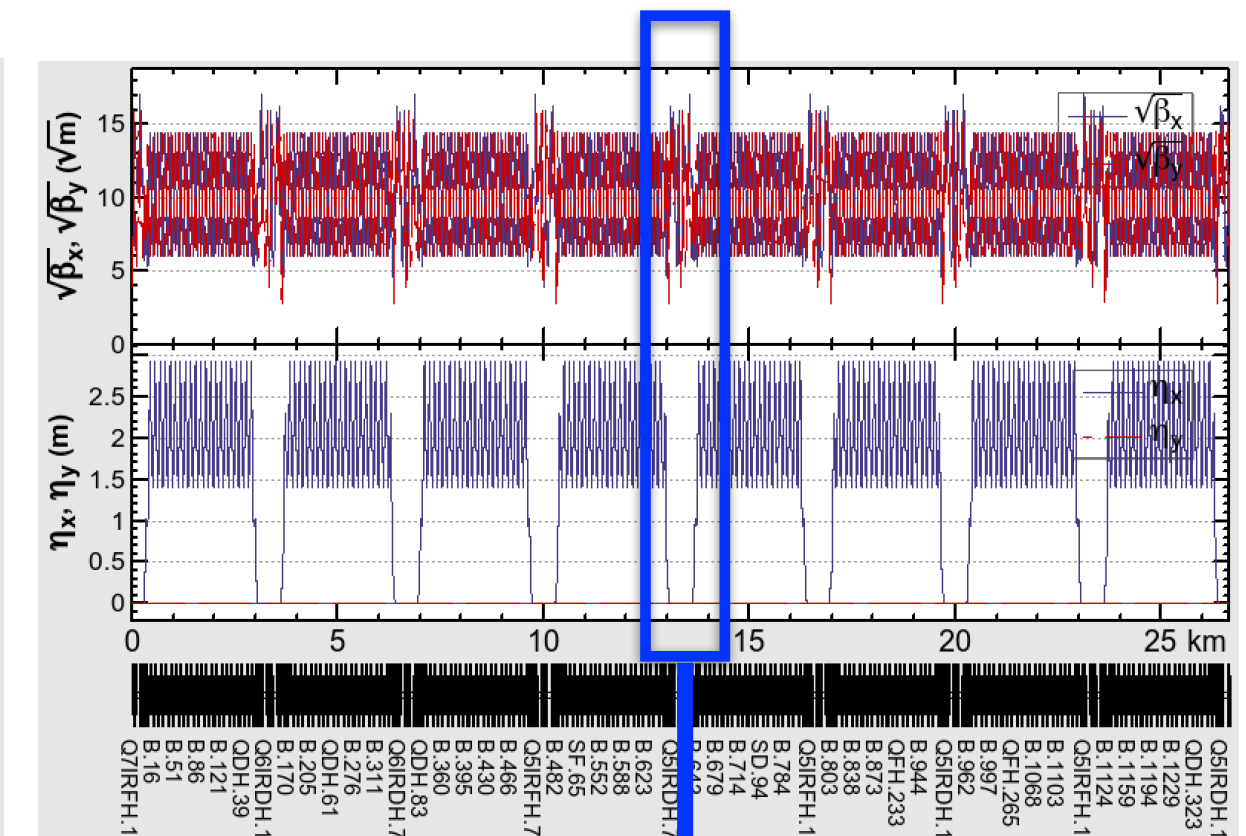
Modified HL-LHC injection
lattice by T. Risselada
24x 60-deg arcs + IRs of
SLHCV3.1a (by S. Fartoukh)



Injection lattice by Y.N.
18x 60-deg arcs



Injection lattice by Y.N.
20x 90-deg arcs

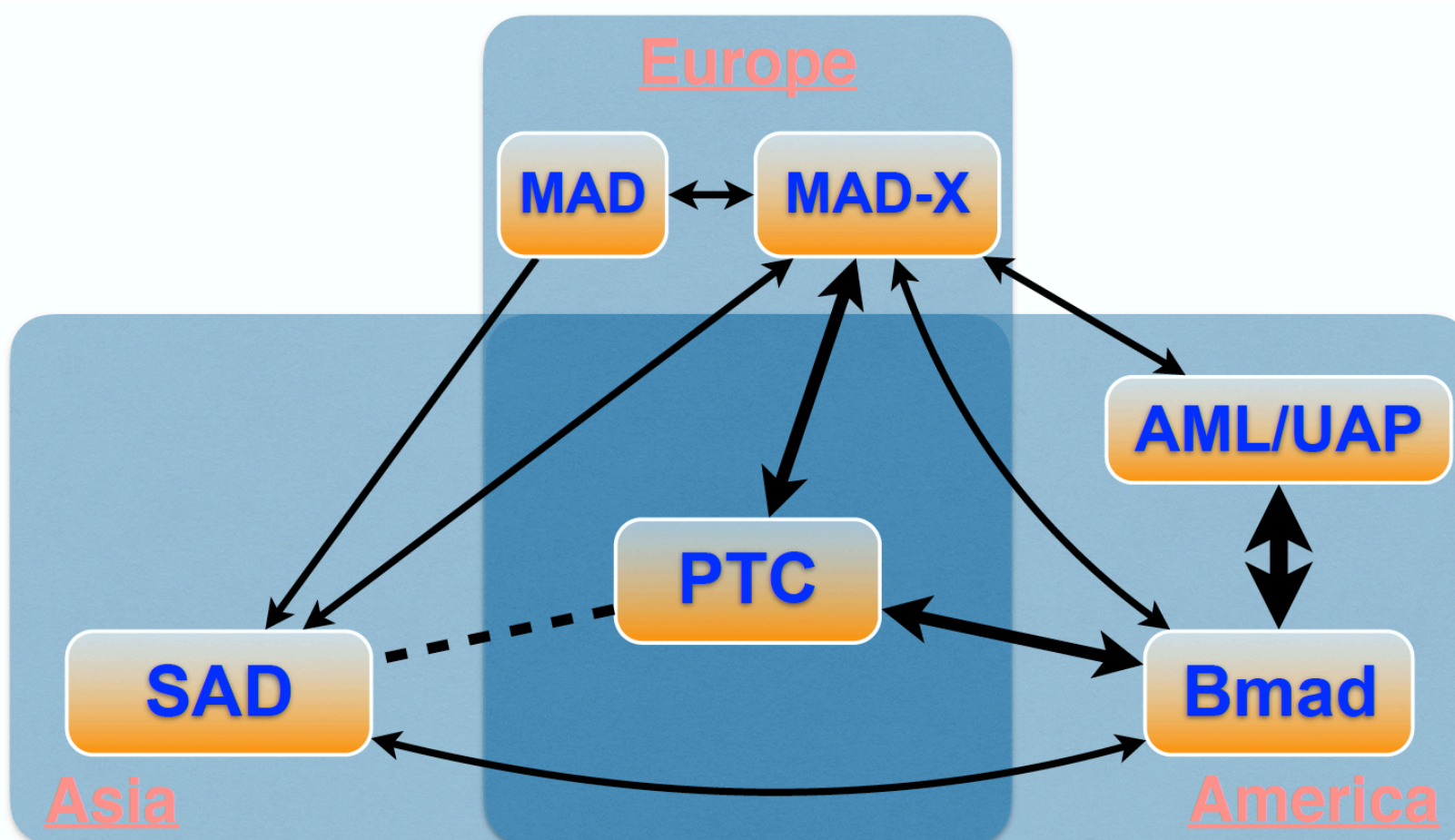


1. Introduction

➤ Simulation tools

- PTC developed by E. Forest at KEK
 - * MAD8/MAD-X lattices translated to PTC flat format via Bmad or AML/UAP
- SAD developed by K. Oide et al. at KEK
 - * MAD8/MAD-X lattices translated to SAD via Bmad or SAD scripts
- Translators developed (still under development, and collaborations always welcomed!)

with collaborative efforts by M. Biagini, L. Deniau, E. Forest, M. Giovannozzi, H. Koiso, A. Morita, K. Oide, D. Sagan, D. Zhou, et al., and strong support from M. Benedikt and F. Zimmermann.



SUBVERSION REPOSITORIES MADX

(root)/branches/madX-SAD/tools/translators/ - Rev 6099

Rev HEAD Go

Last modification | View Log | Download | RSS feed

Path	Last modification	Log	Download	RSS
branches/	6078 41d 23h dezhou	Log	Download	RSS
madX-SAD/	6078 41d 23h dezhou	Log	Download	RSS
cmake/	5933 168d 03h ylevinse	Log	Download	RSS
doc/	6058 48d 00h alatina	Log	Download	RSS
examples/	6029 82d 04h rdemaria	Log	Download	RSS
lib32/	2785 2035d 02h ylevinse	Log	Download	RSS
lib64/	2594 2231d 23h frs	Log	Download	RSS
libs/	6061 46d 00h skowron	Log	Download	RSS
make/	5959 138d 08h ldeniau	Log	Download	RSS
scripts/	6010 100d 07h ldeniau	Log	Download	RSS
src/	6061 46d 00h skowron	Log	Download	RSS
syntax/	6015 95d 07h ylevinse	Log	Download	RSS
testing/	4206 1335d 02h ghislain	Log	Download	RSS
tests/	6068 42d 03h skowron	Log	Download	RSS
tools/	6078 41d 23h dezhou	Log	Download	RSS
numdiff/	6015 95d 07h ylevinse	Log	Download	RSS
translators/	6078 41d 23h dezhou	Log	Download	RSS

LAST MODIFICATION

Rev 6078 2017-01-17 17:35:00

Author: dezhou

Log message:
Creating subdirectory ./tools/translators containing the SAD <-> MADX translators

translators/	6105	3m	dezhou
bmad_to_sad/	6105	3m	dezhou
mad8_to_sad/	6105	3m	dezhou
madx_to_bmad_via_uap/	6105	3m	dezhou
madx_to_ptc/	6105	3m	dezhou
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sad_to_bmad/	6105	3m	dezhou
sad_to_madx/	6105	3m	dezhou
README	6105	3m	dezhou

See webpage: <http://svnweb.cern.ch/world/wsvn/madx/branches/madX-SAD/tools/translators/>

1. Introduction

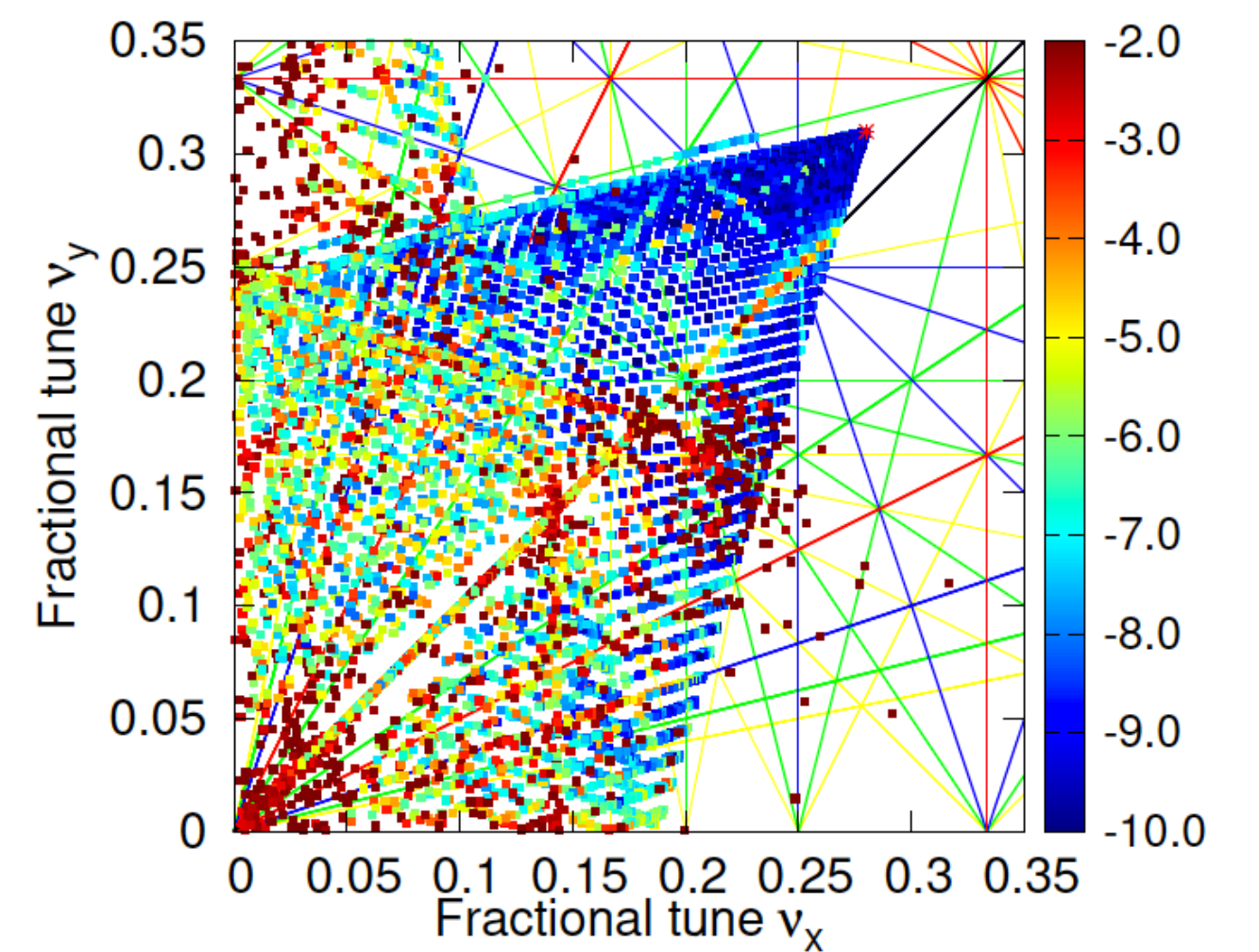
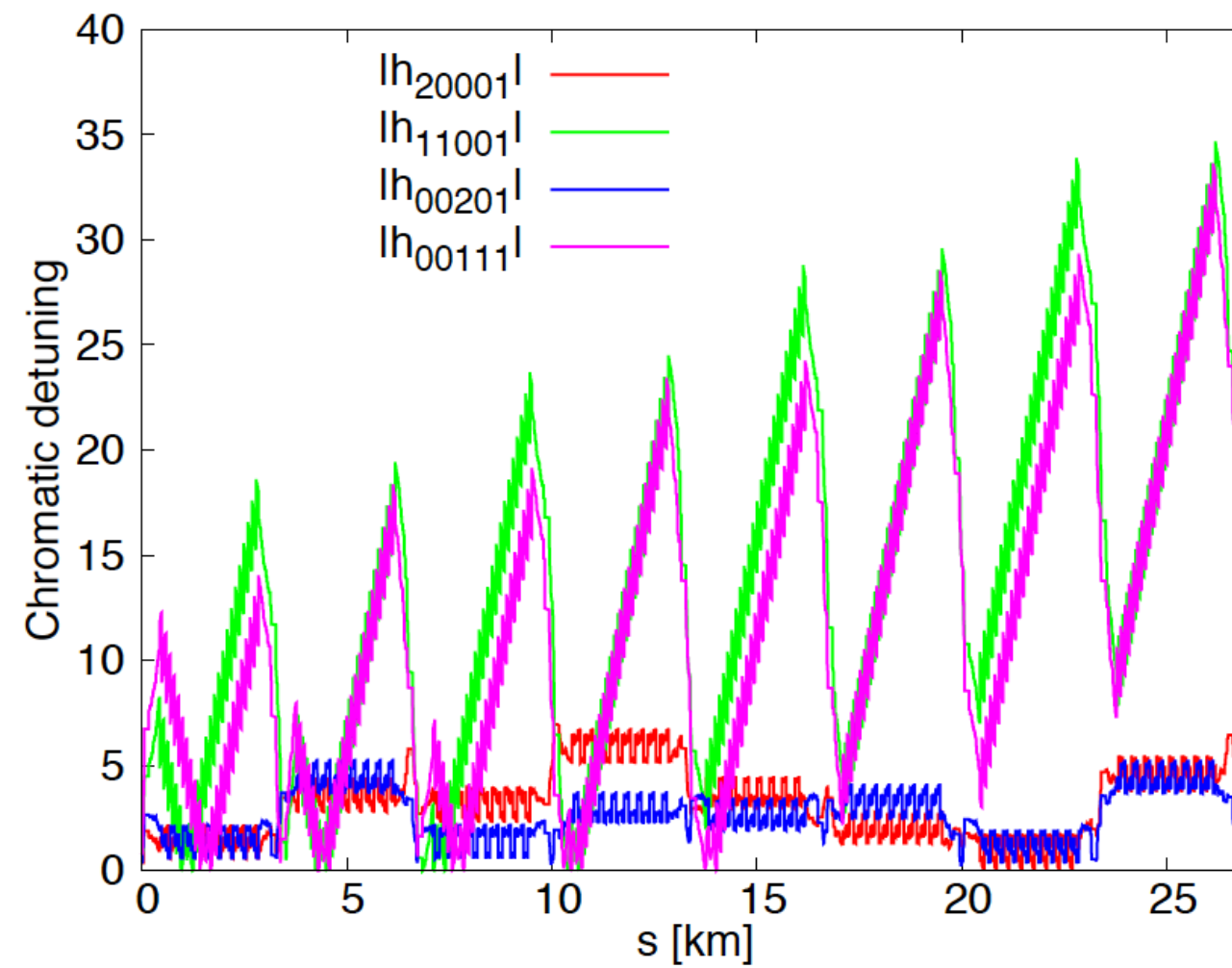
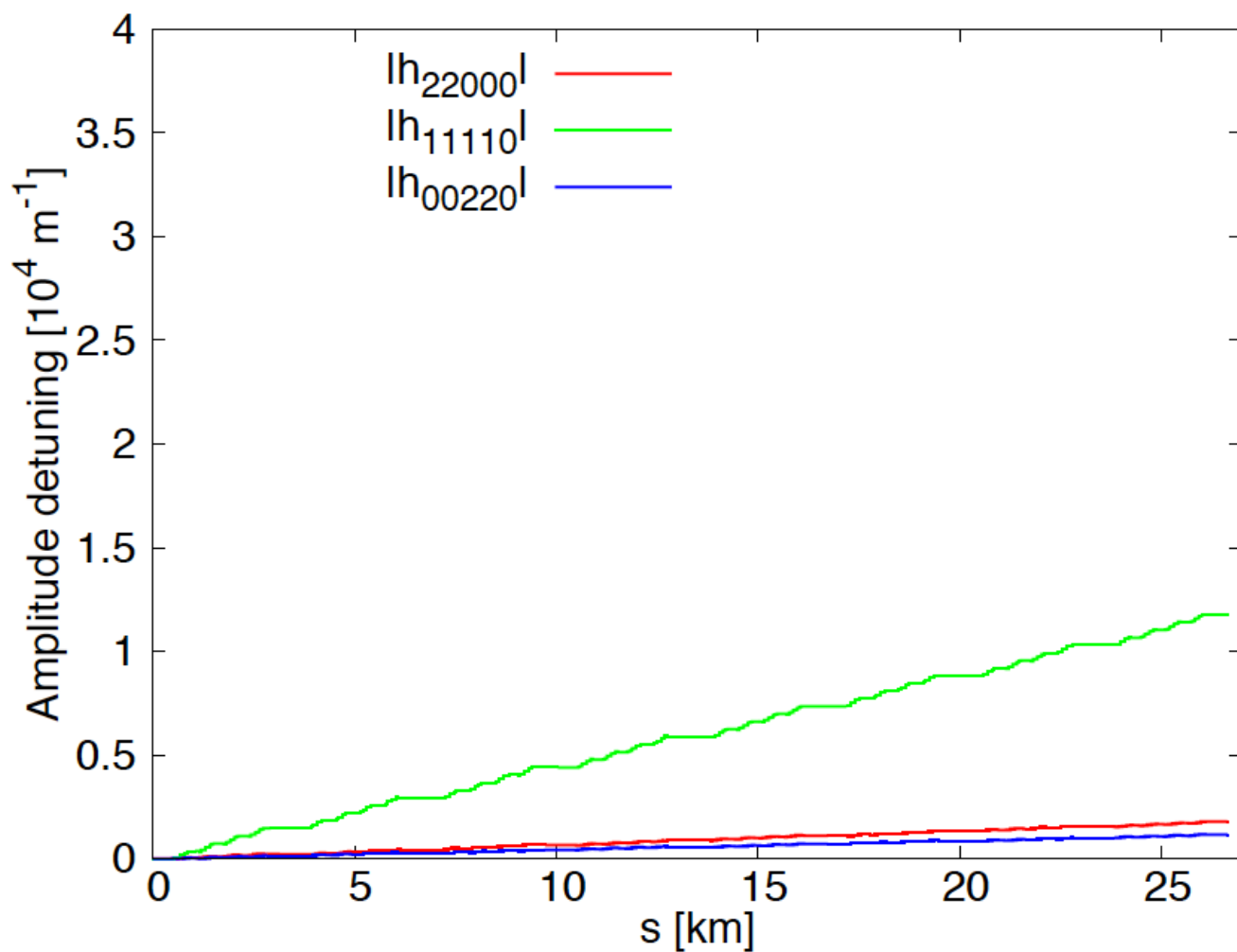
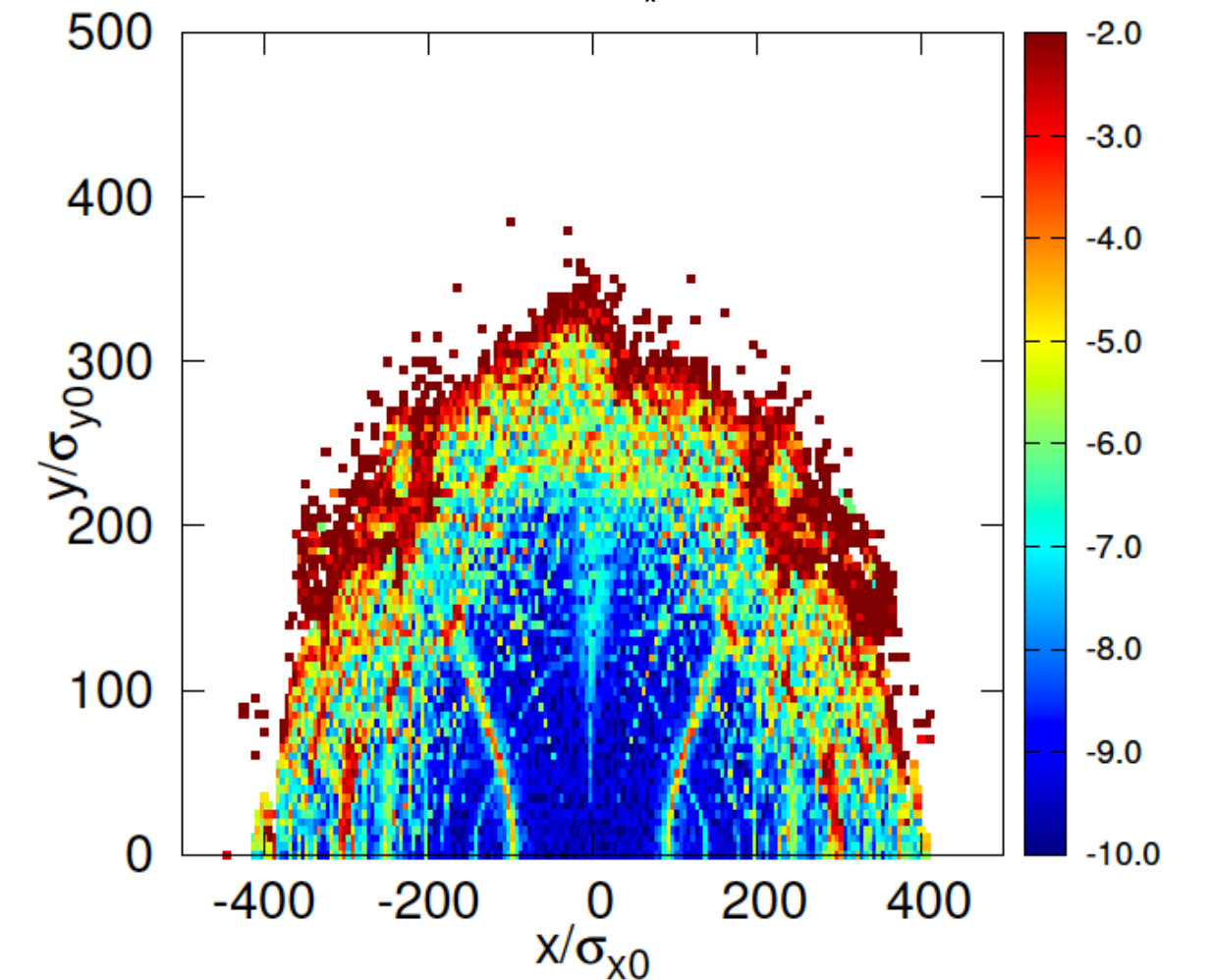
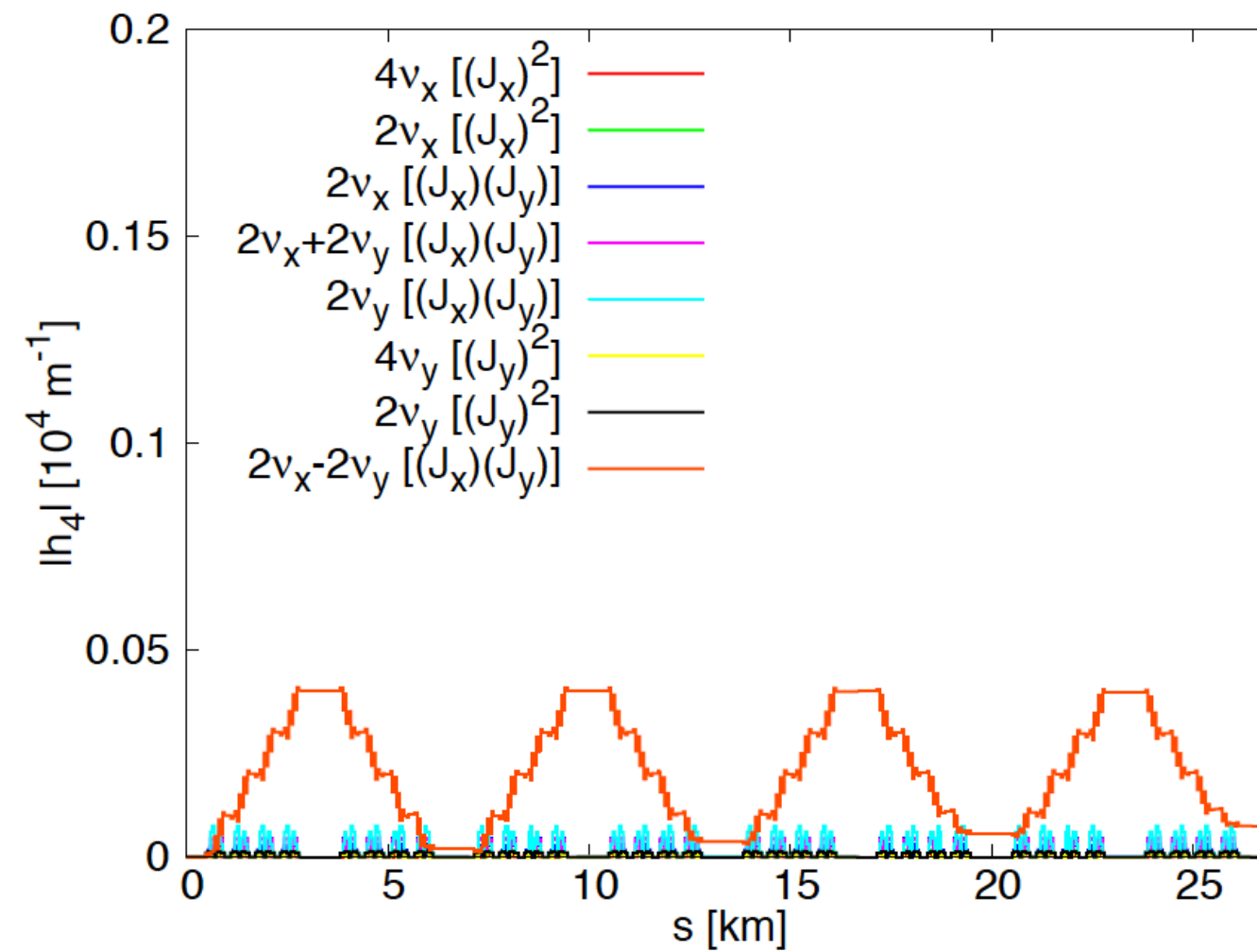
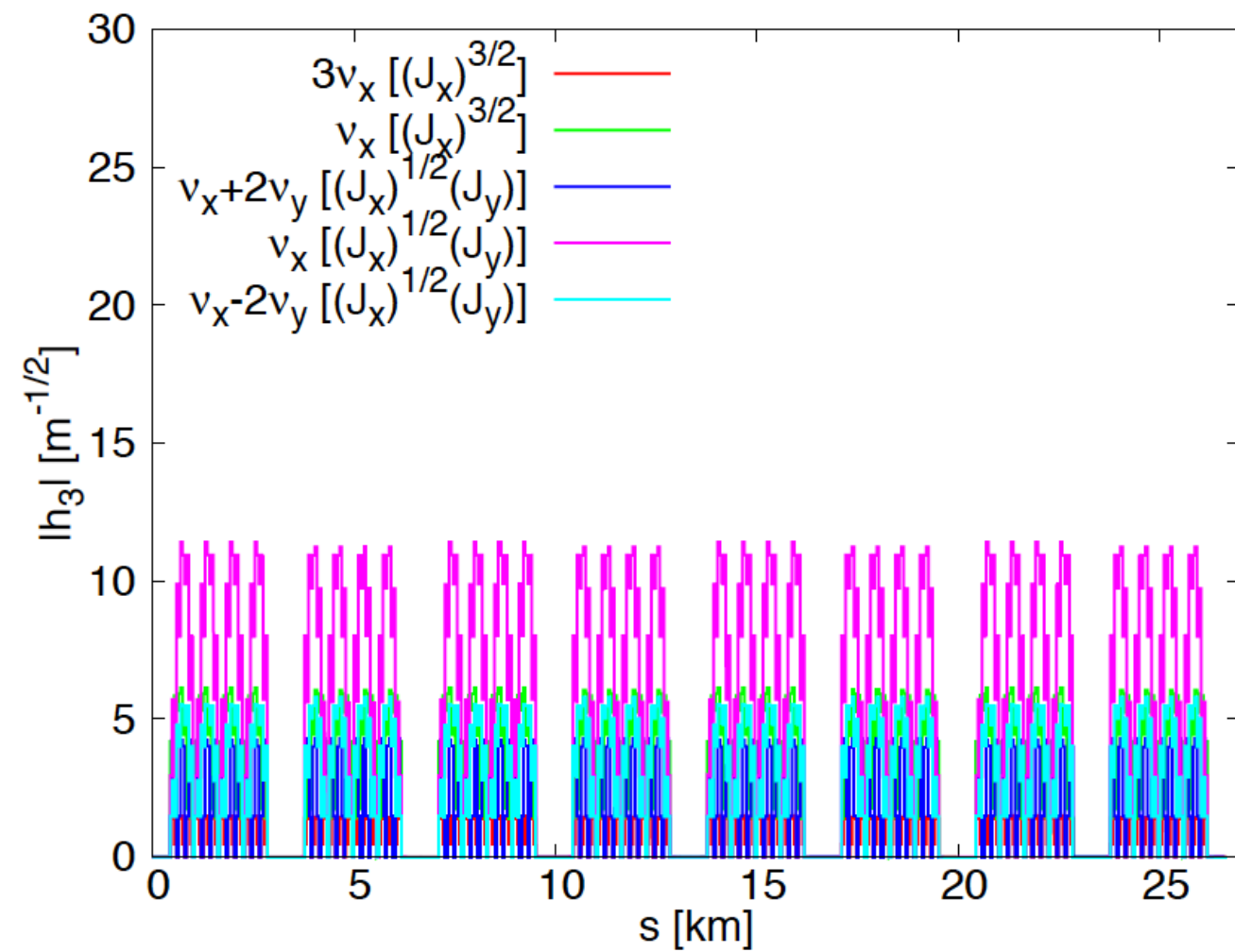
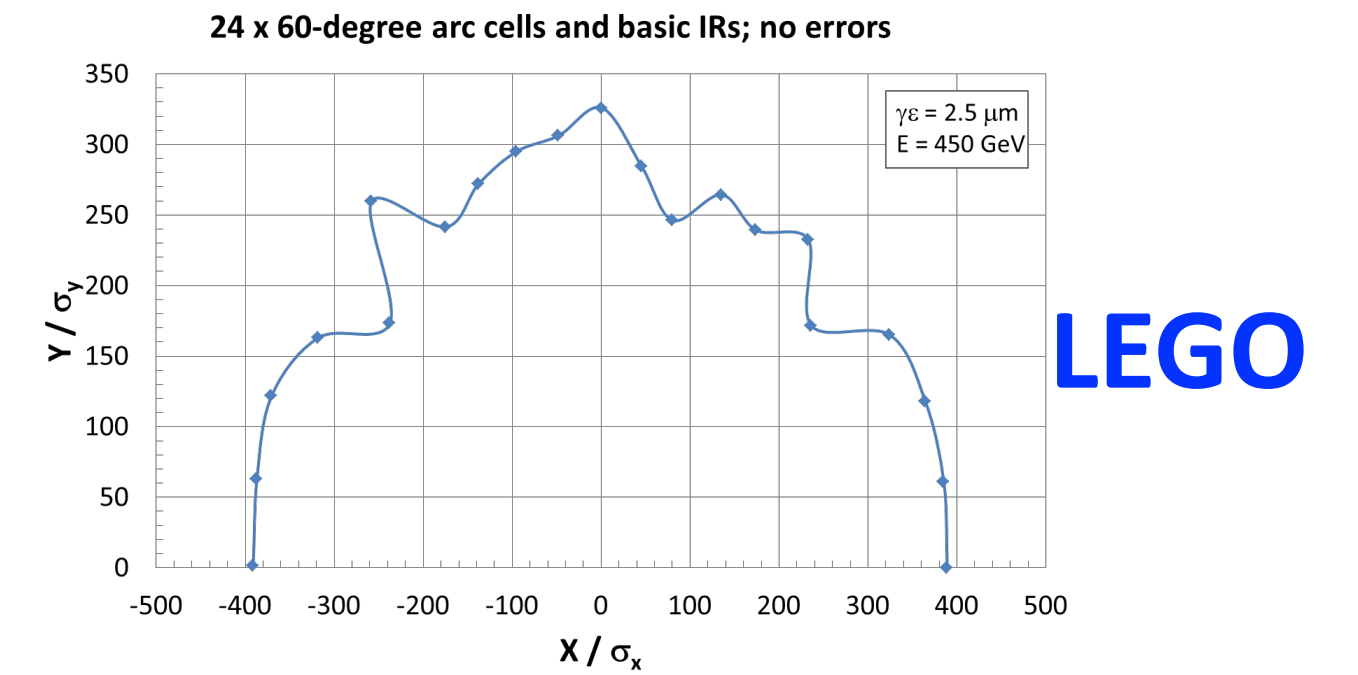
➤ Simulation conditions

- RDT calculation
 - * PTC tracking w/o SR, w/o errors
 - * Integrate RDTs along beam orbit
- DA calculation
 - * SAD tracking w/o SR, w/o errors
 - * Use standard FMA algorithm
 - * Short-term DA by tracking 1024 turns (also see Y.N.'s talk)
- Normalized emittance $\gamma\varepsilon=2.5 \mu\text{m}$; Beam energy $E=450 \text{ GeV}$
- Linear chromaticity set at $(Qx', Qy')=(3, 3)$ for all lattices under consideration

2. RDT and DA calculation

➤ Injection lattice with 24x 60-deg arcs (by Y.N.)

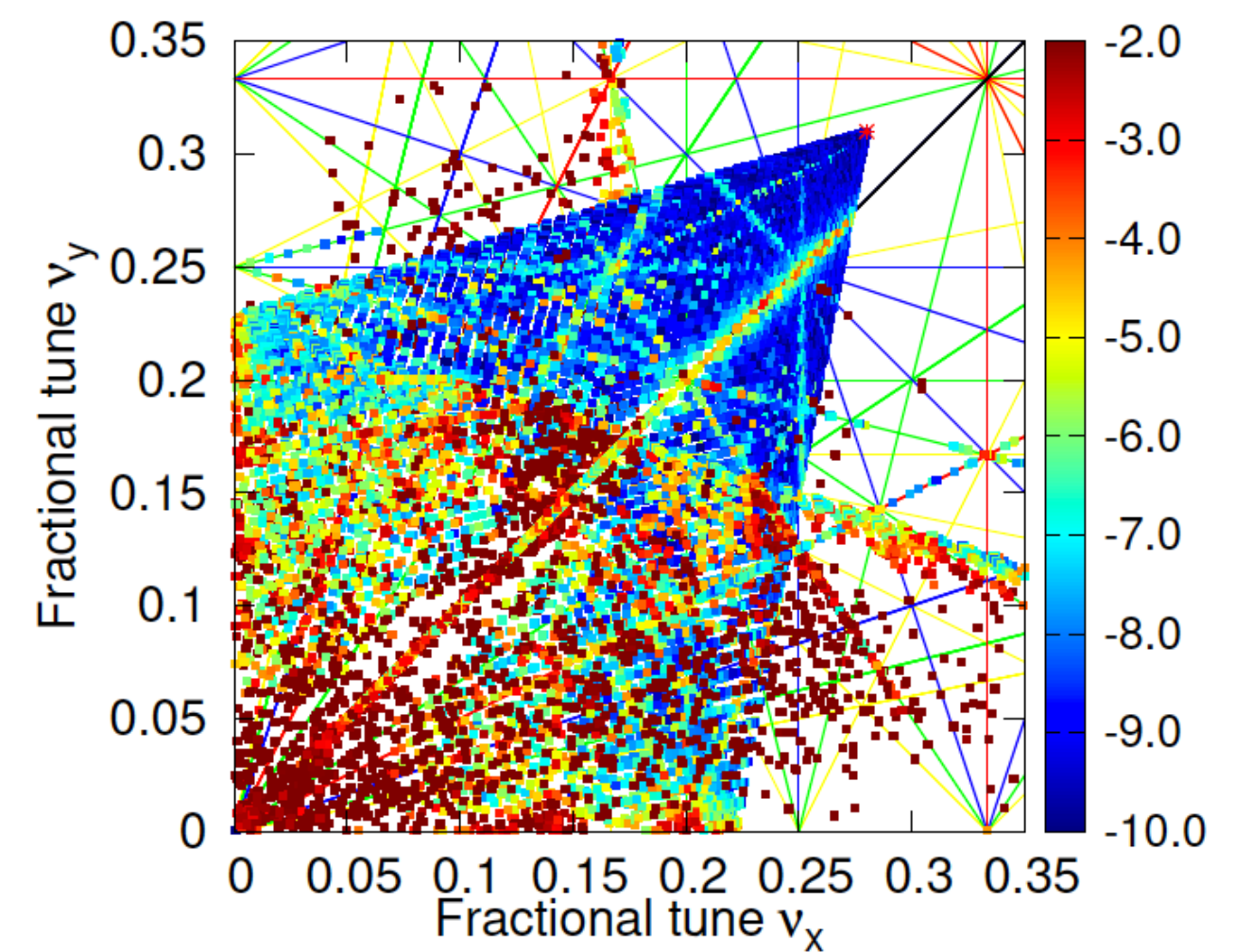
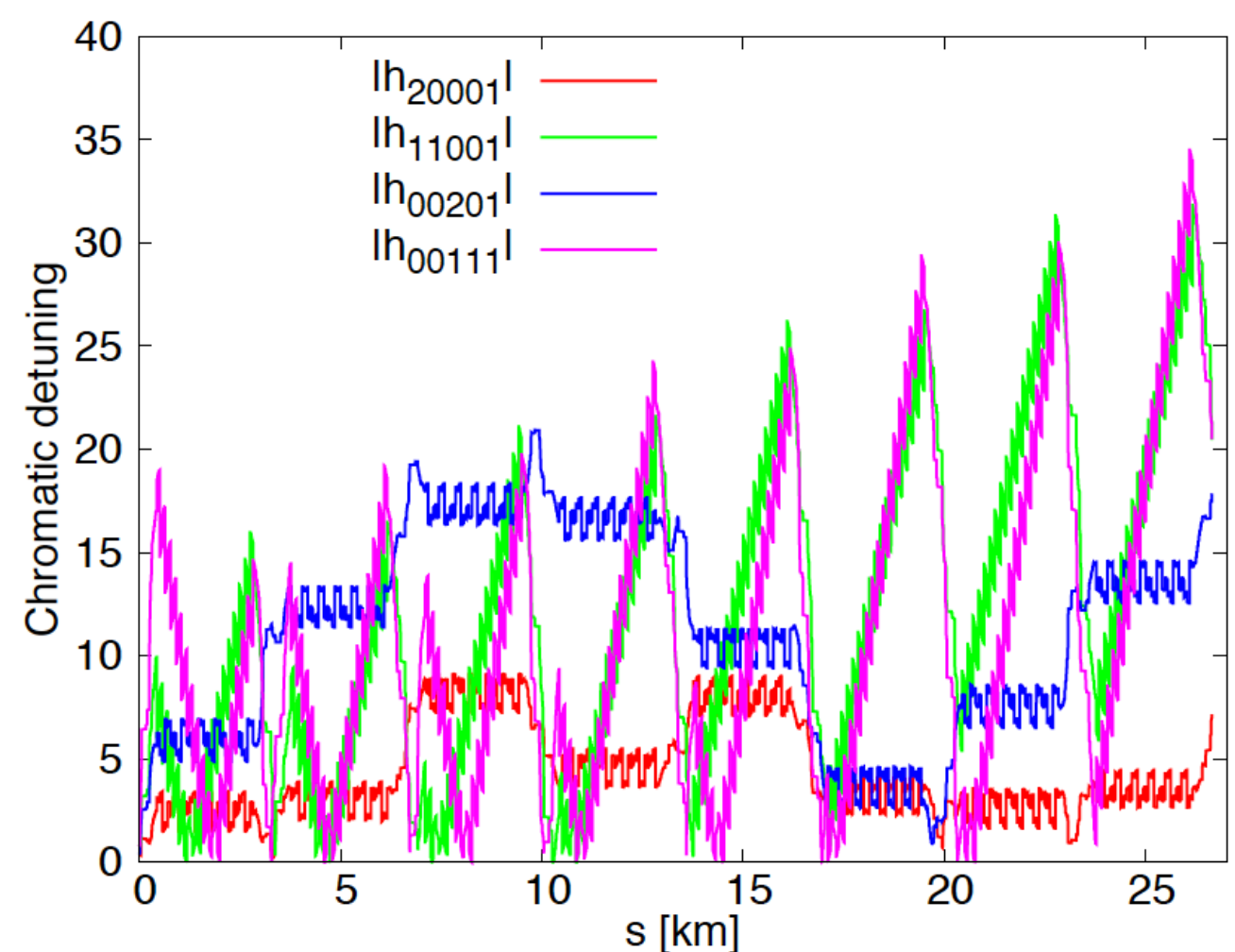
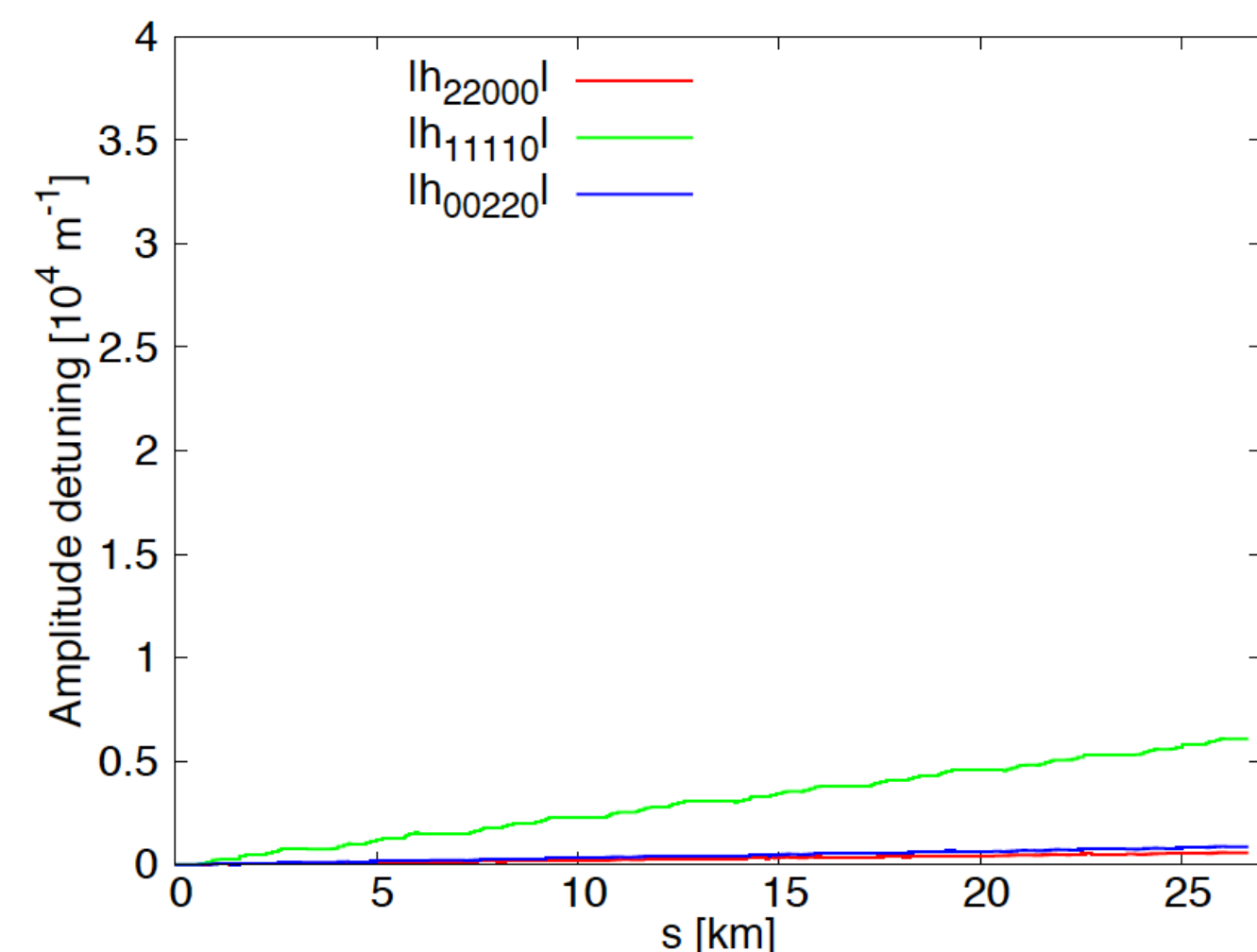
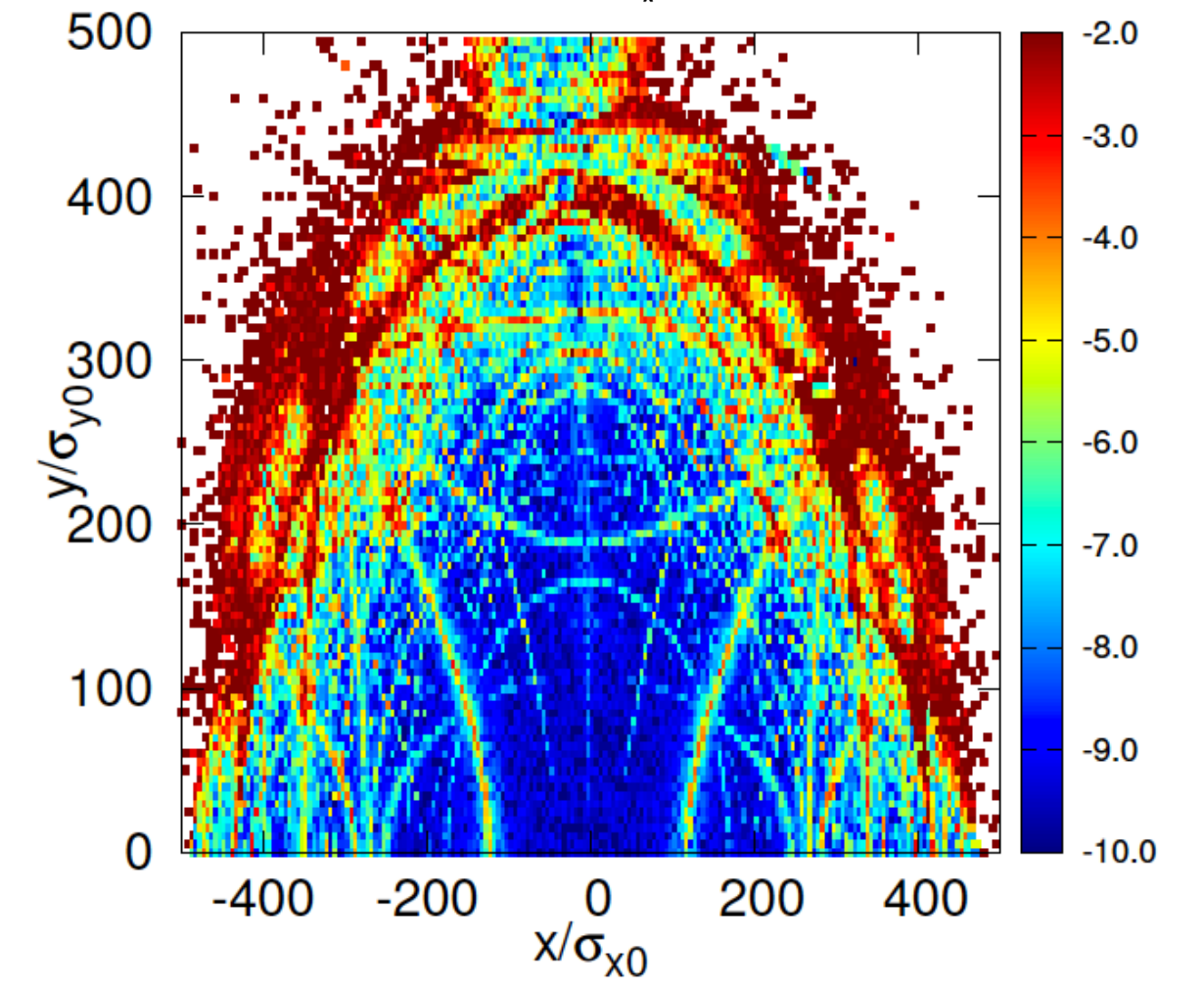
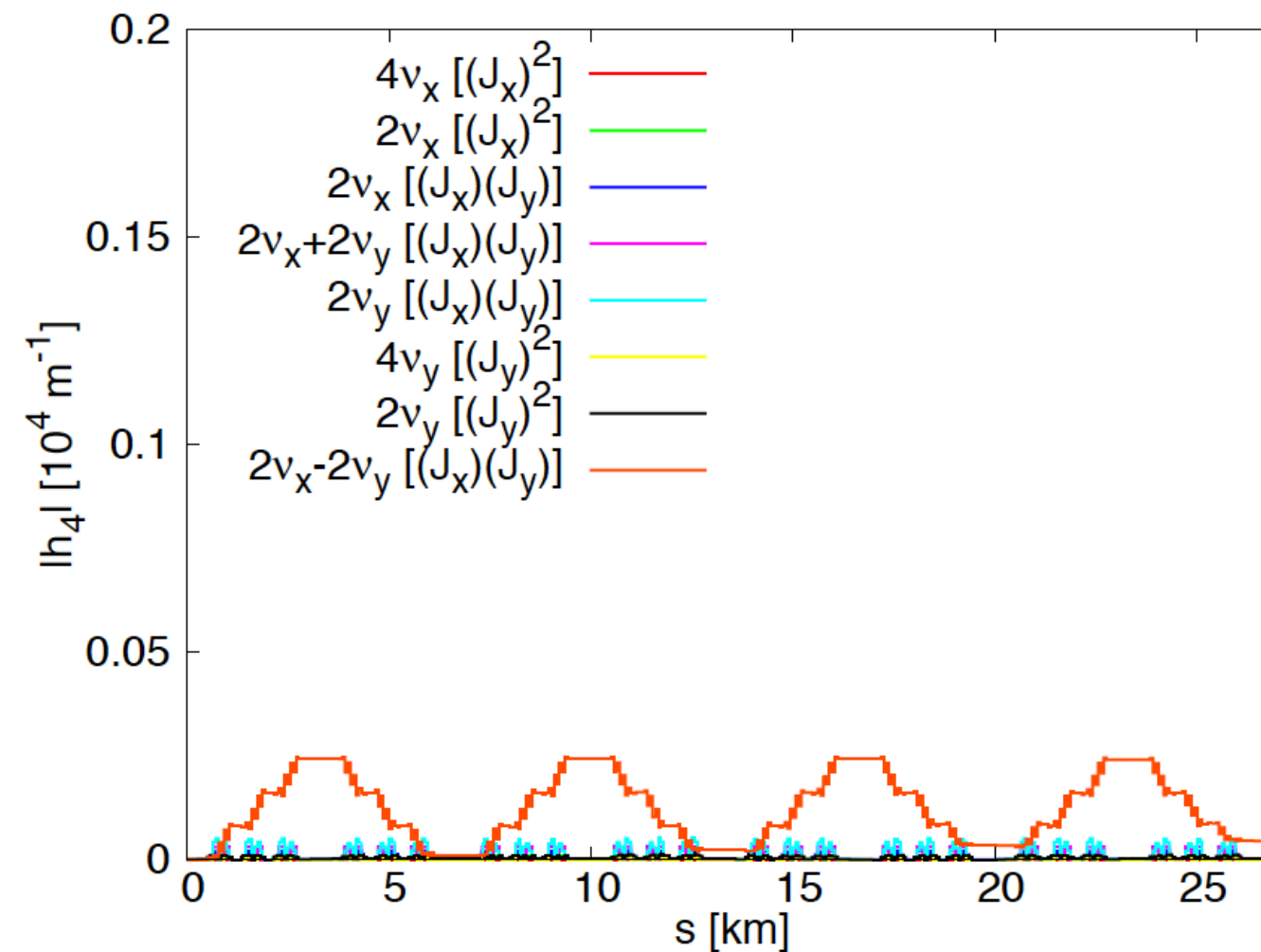
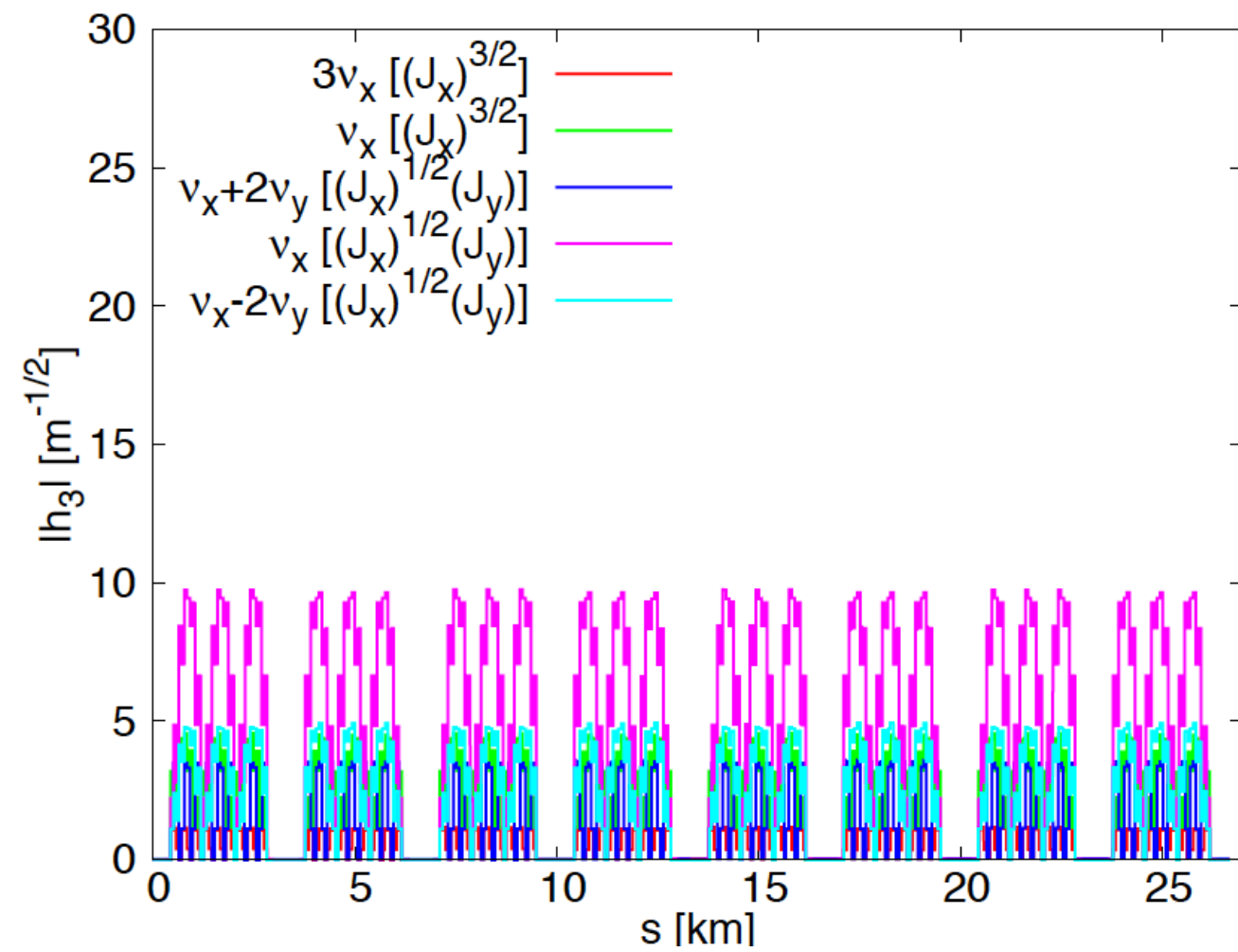
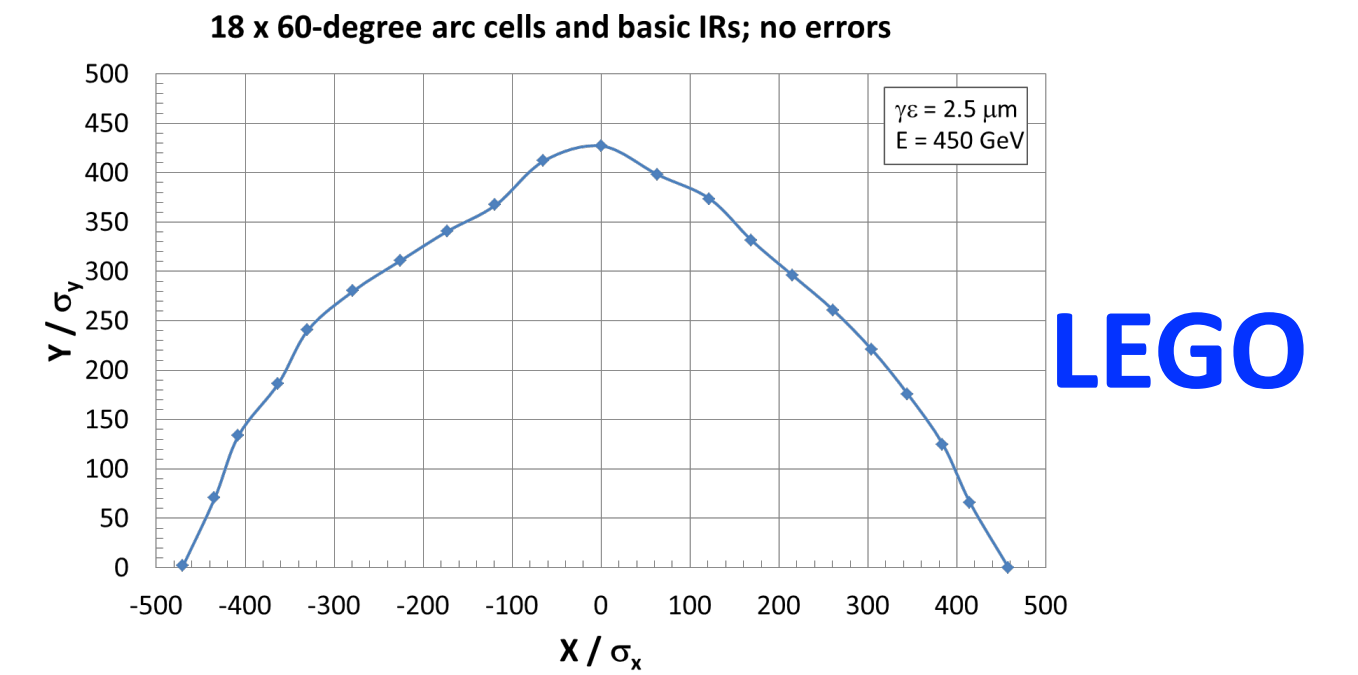
- Use basic IRs
- Working point (49.28, 47.31)



2. RDT and DA calculation

➤ Injection lattice with 18x 60-deg arcs (by Y.N.)

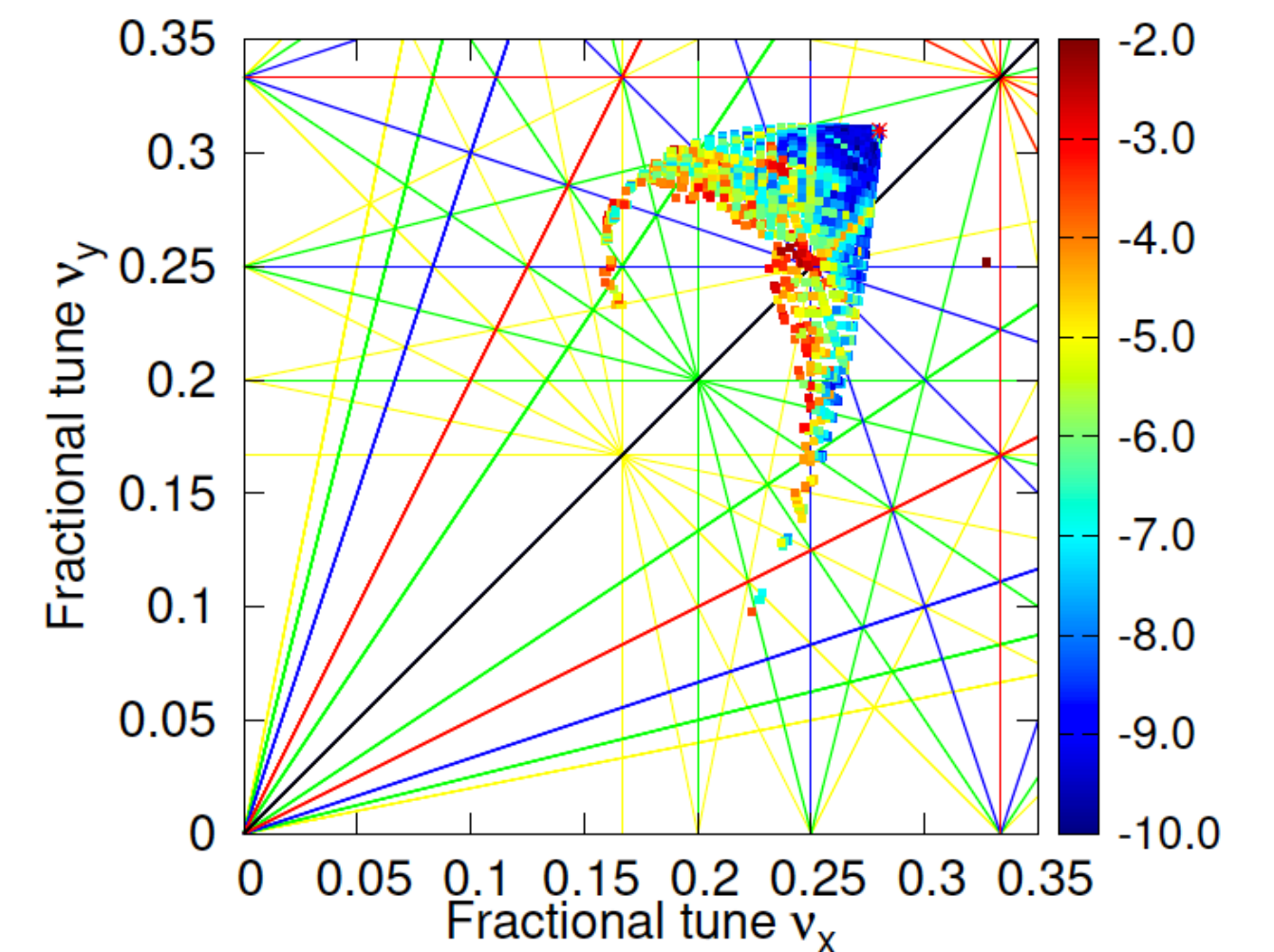
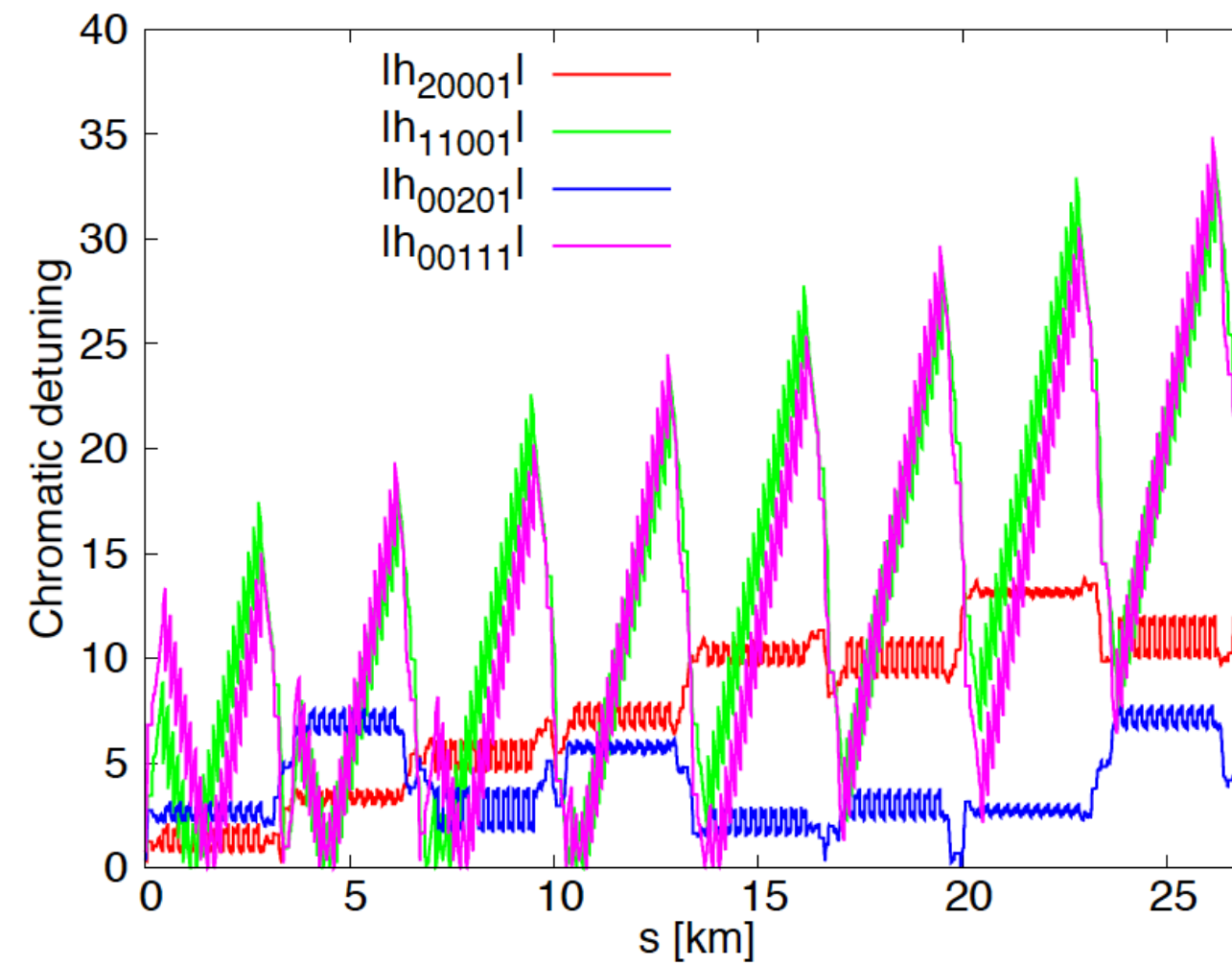
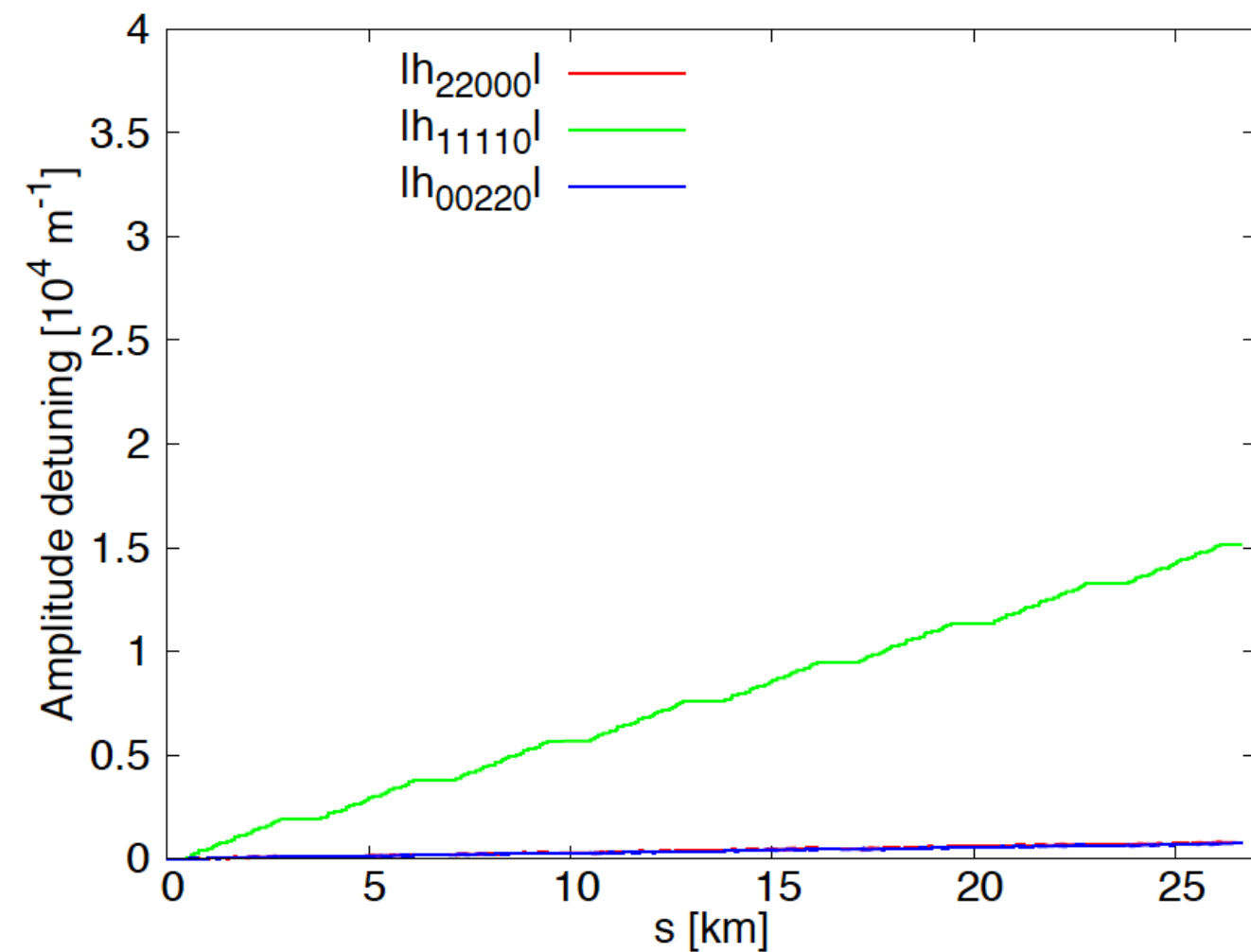
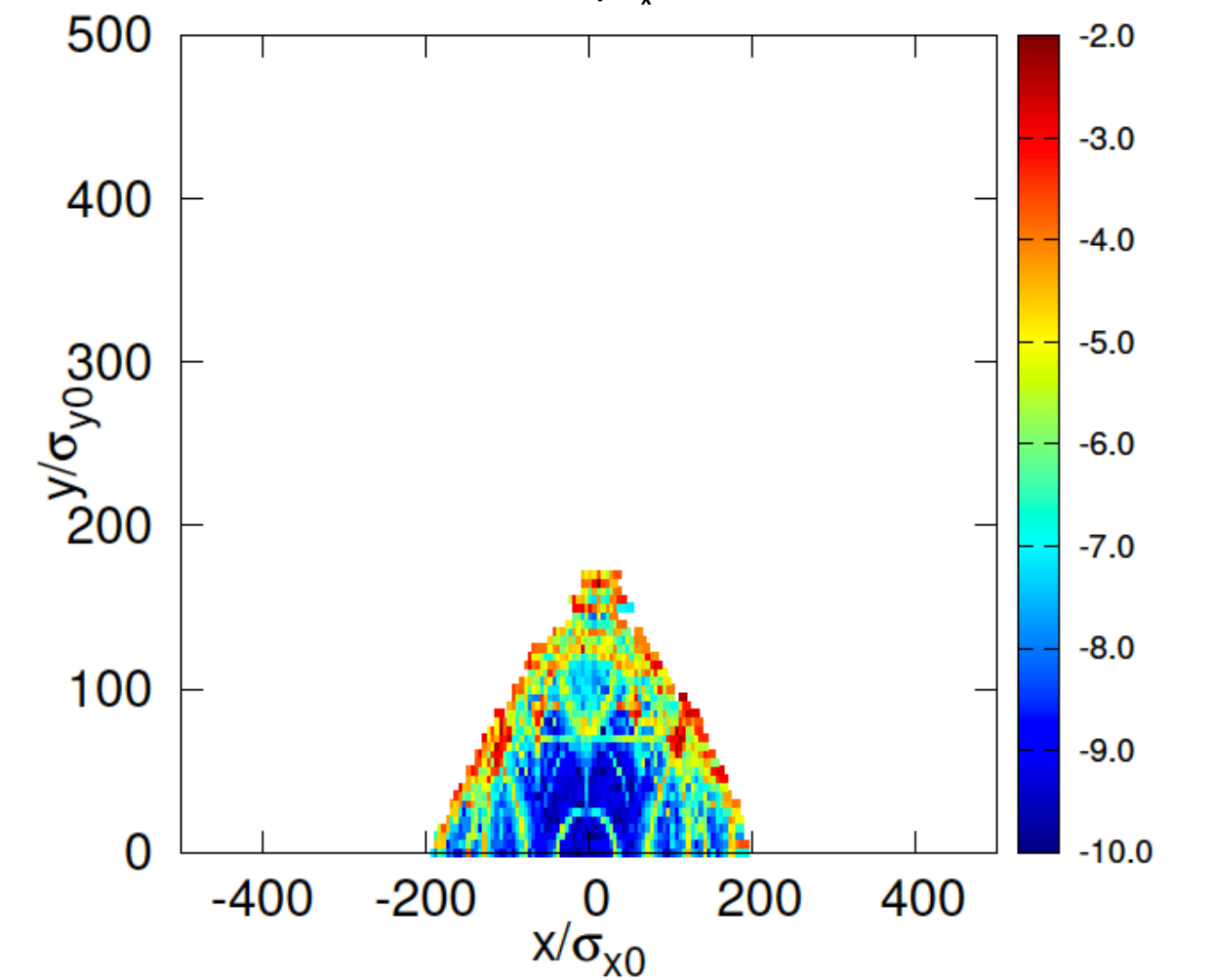
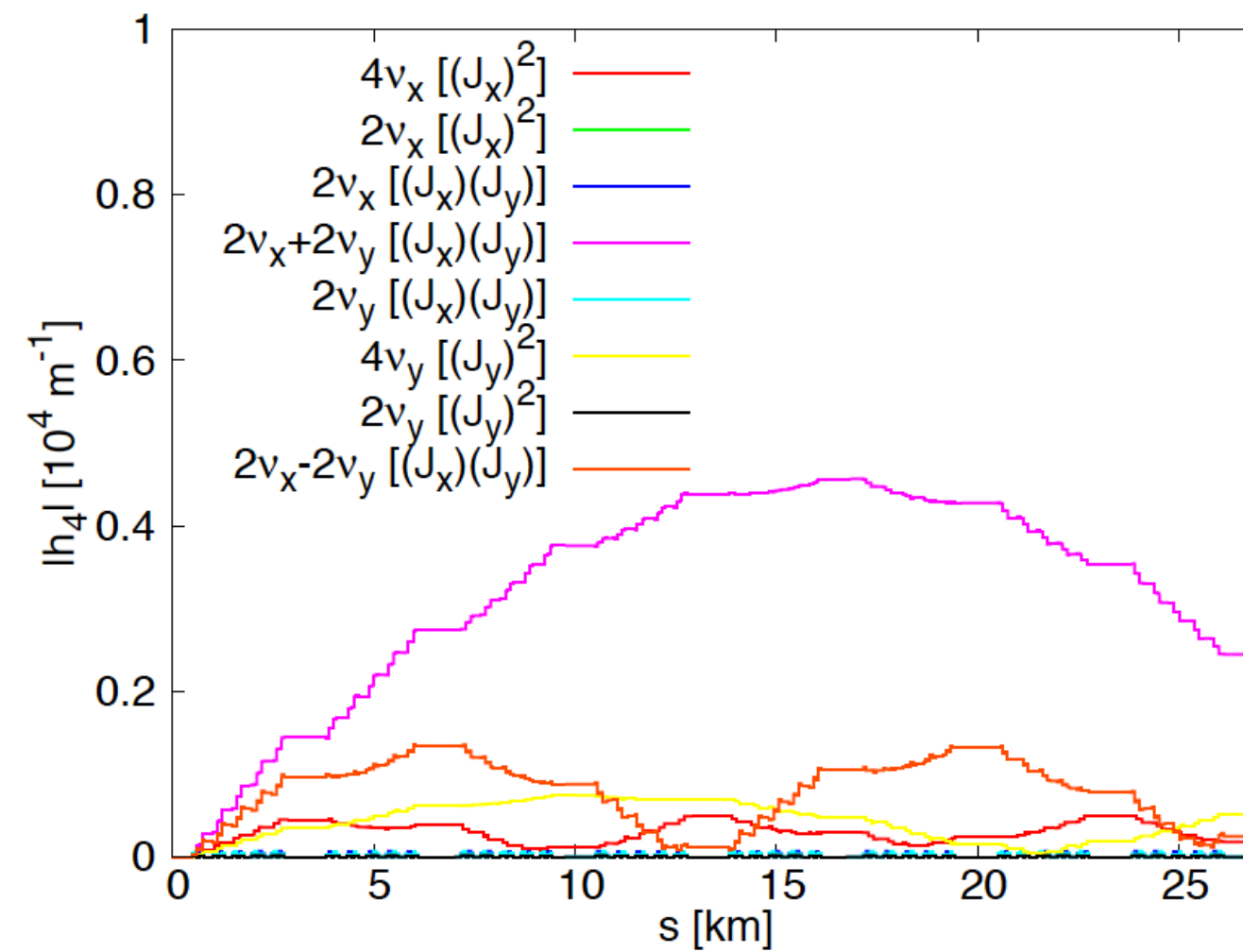
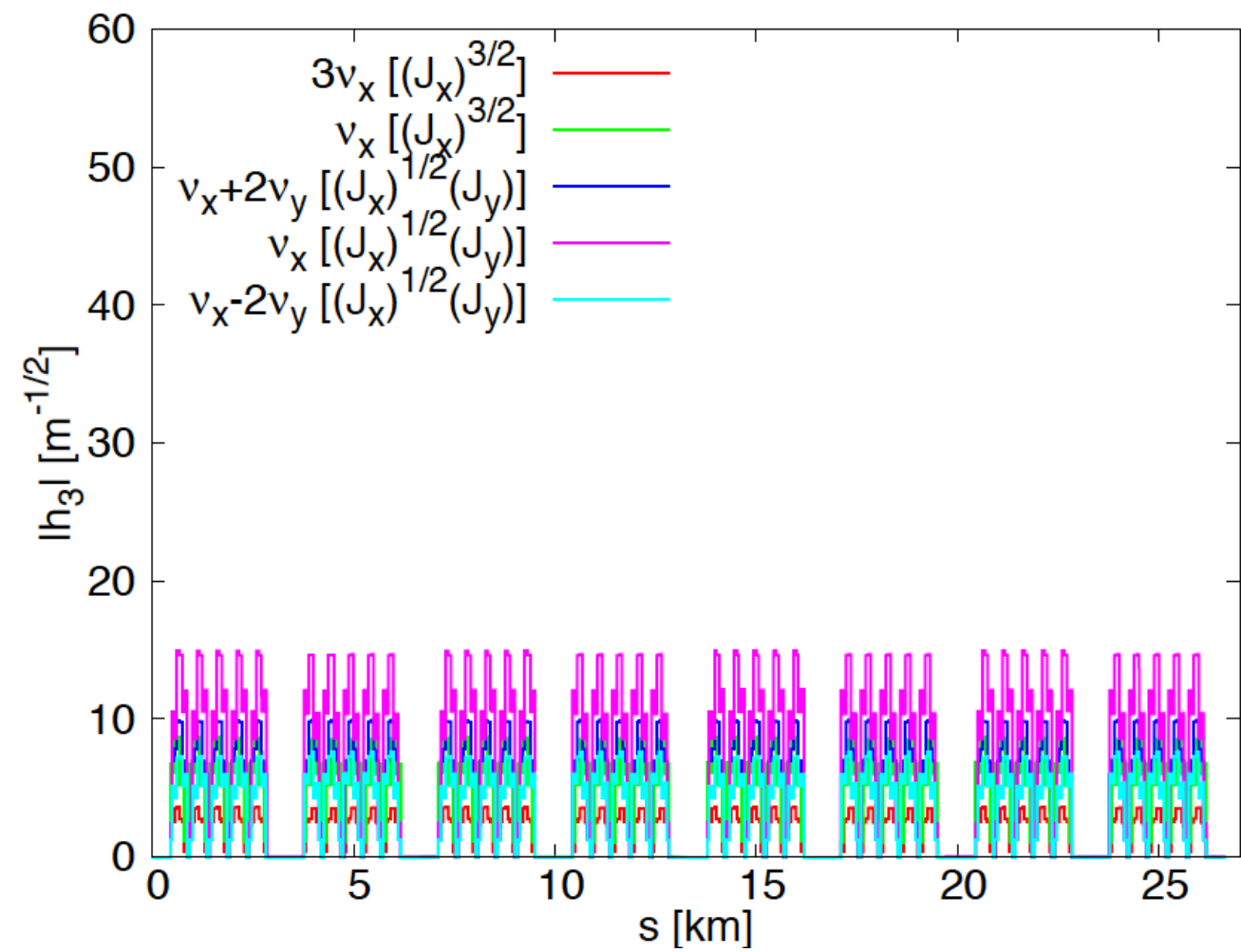
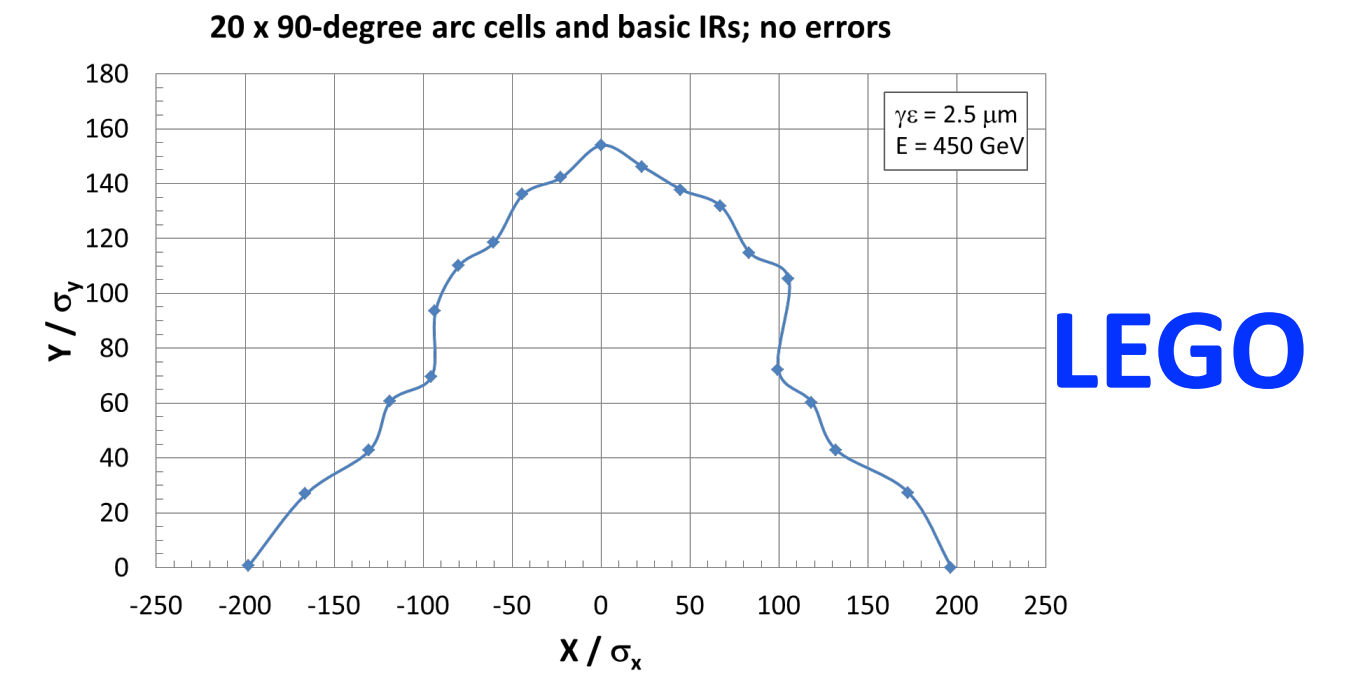
- Use basic IRs
- Working point (37.28, 39.31)



2. RDT and DA calculation

➤ Injection lattice with 20x 90-deg arcs (by Y.N.)

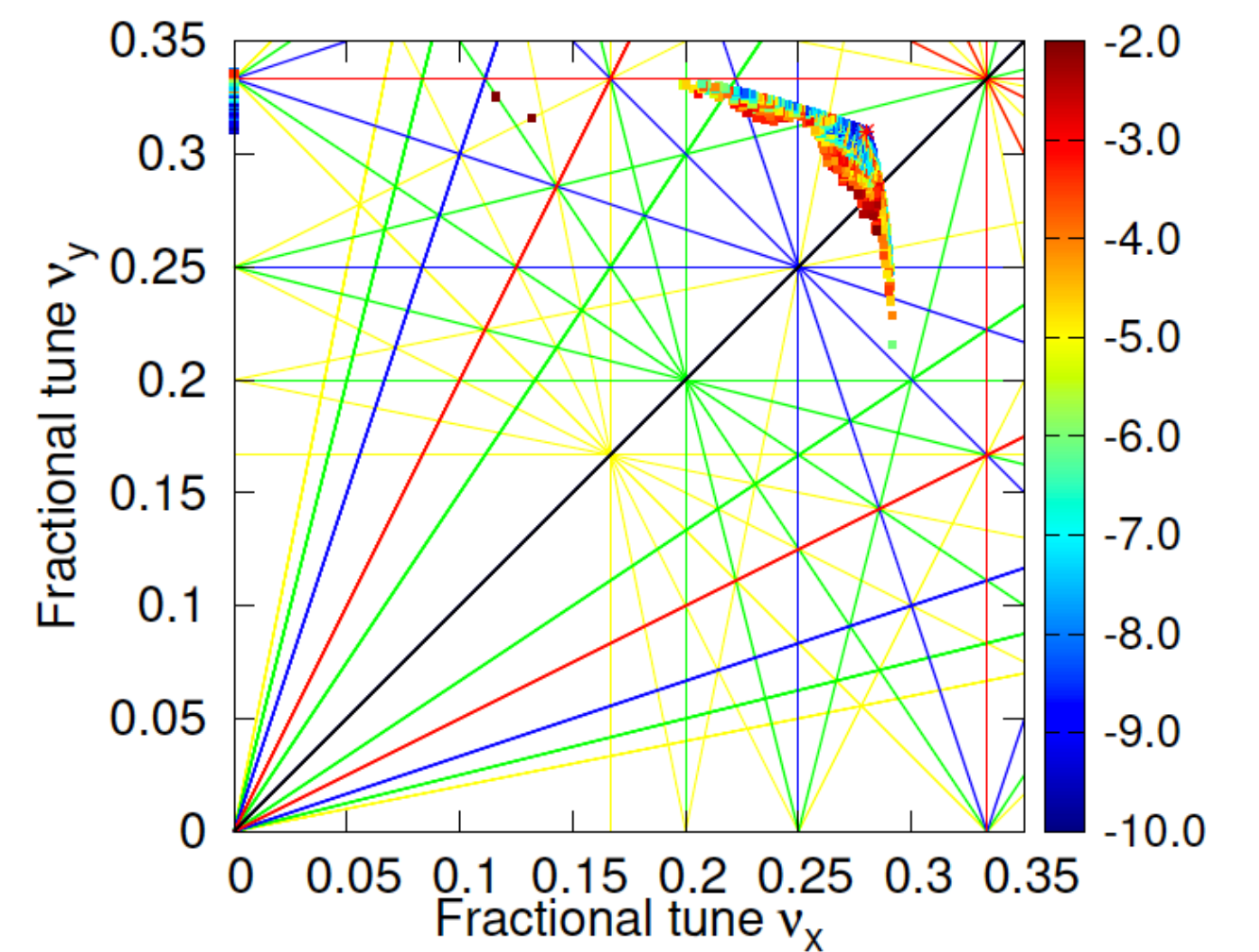
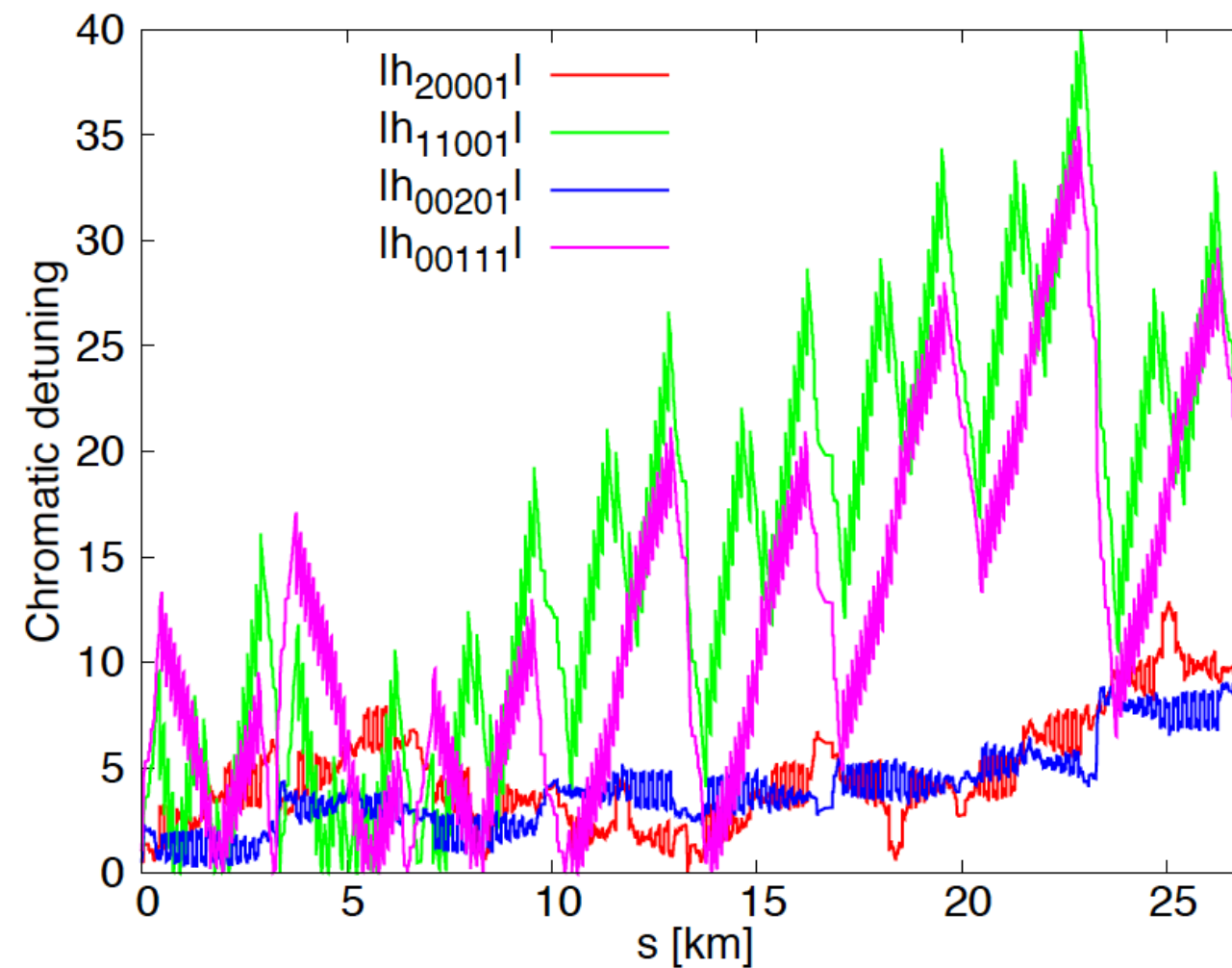
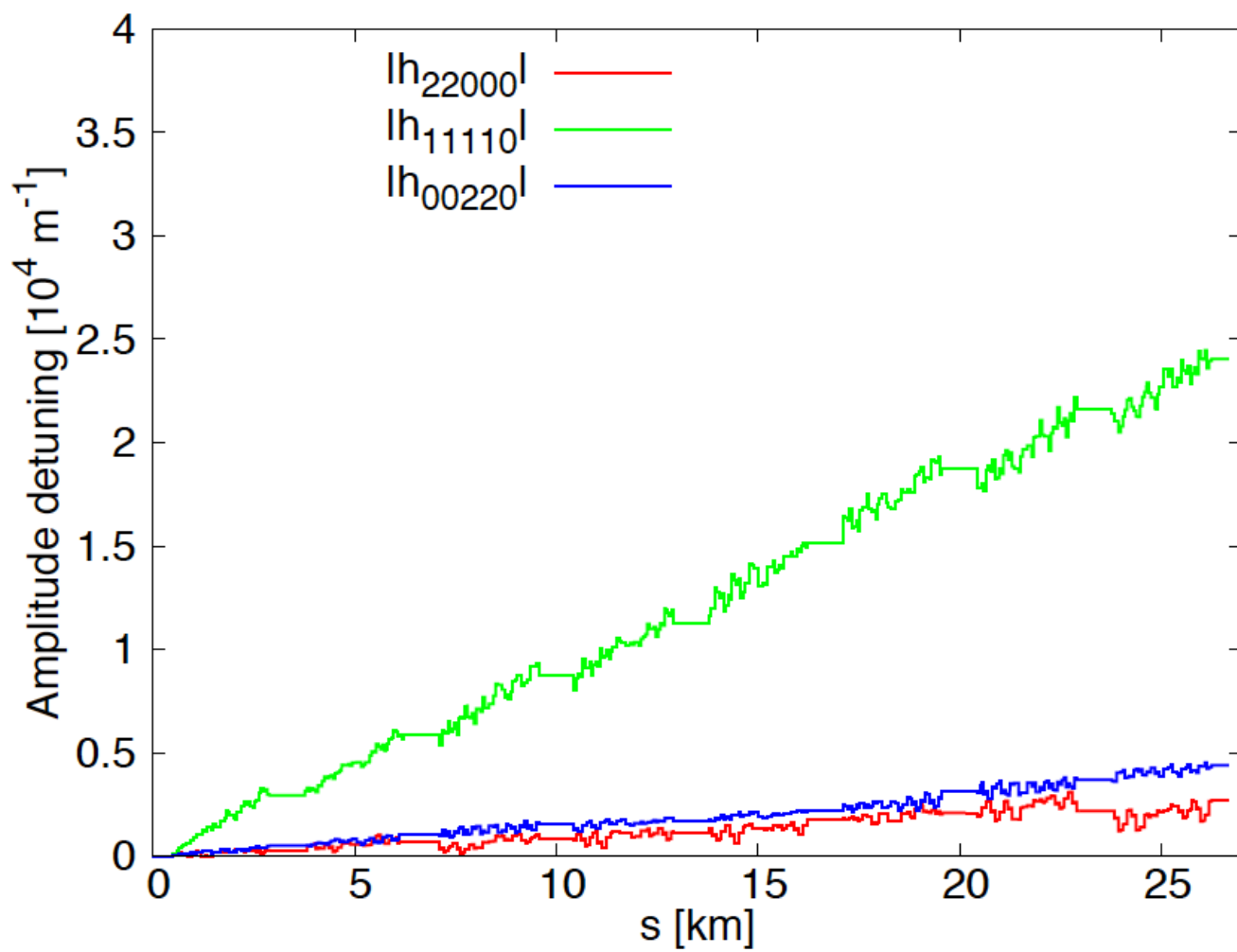
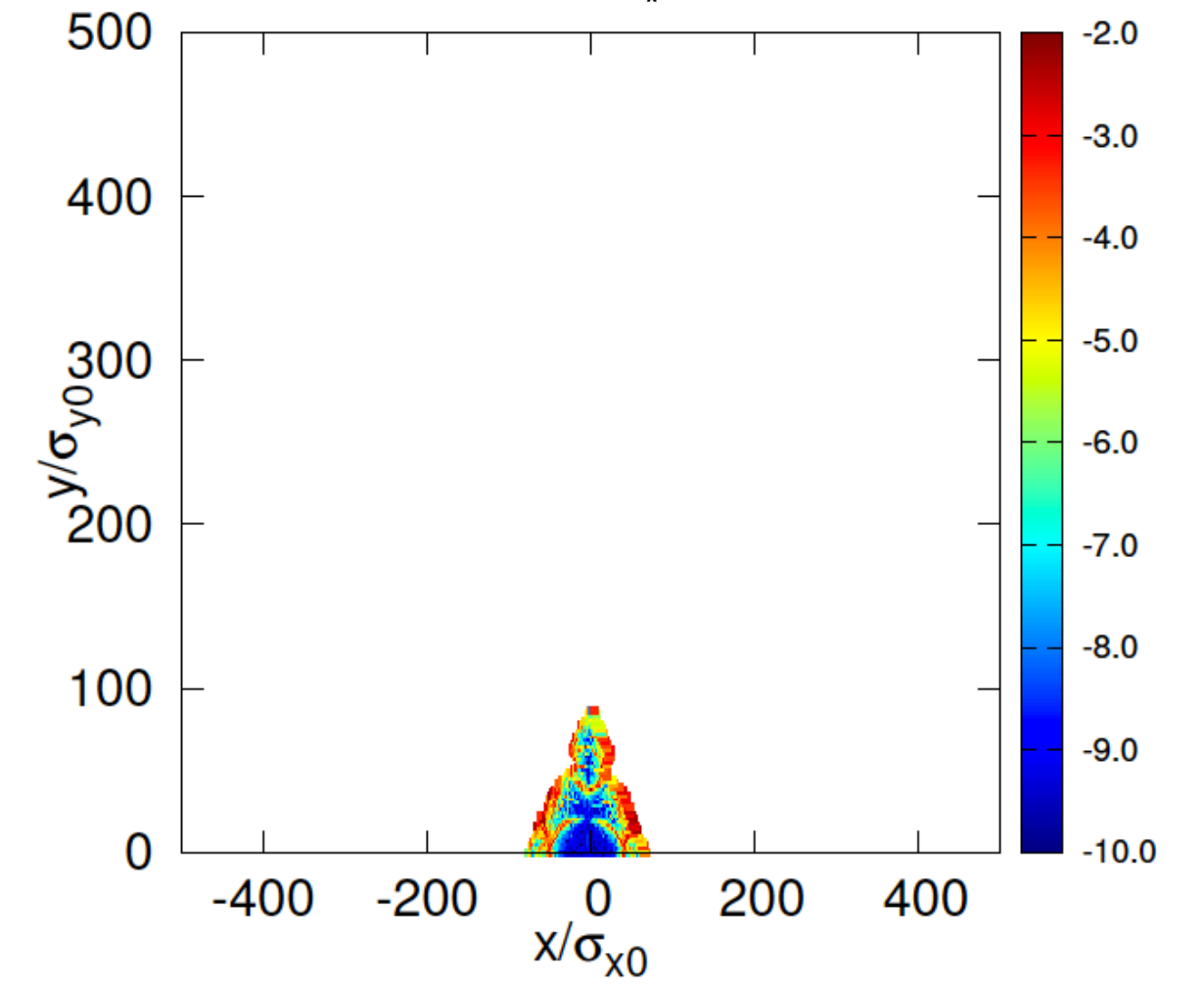
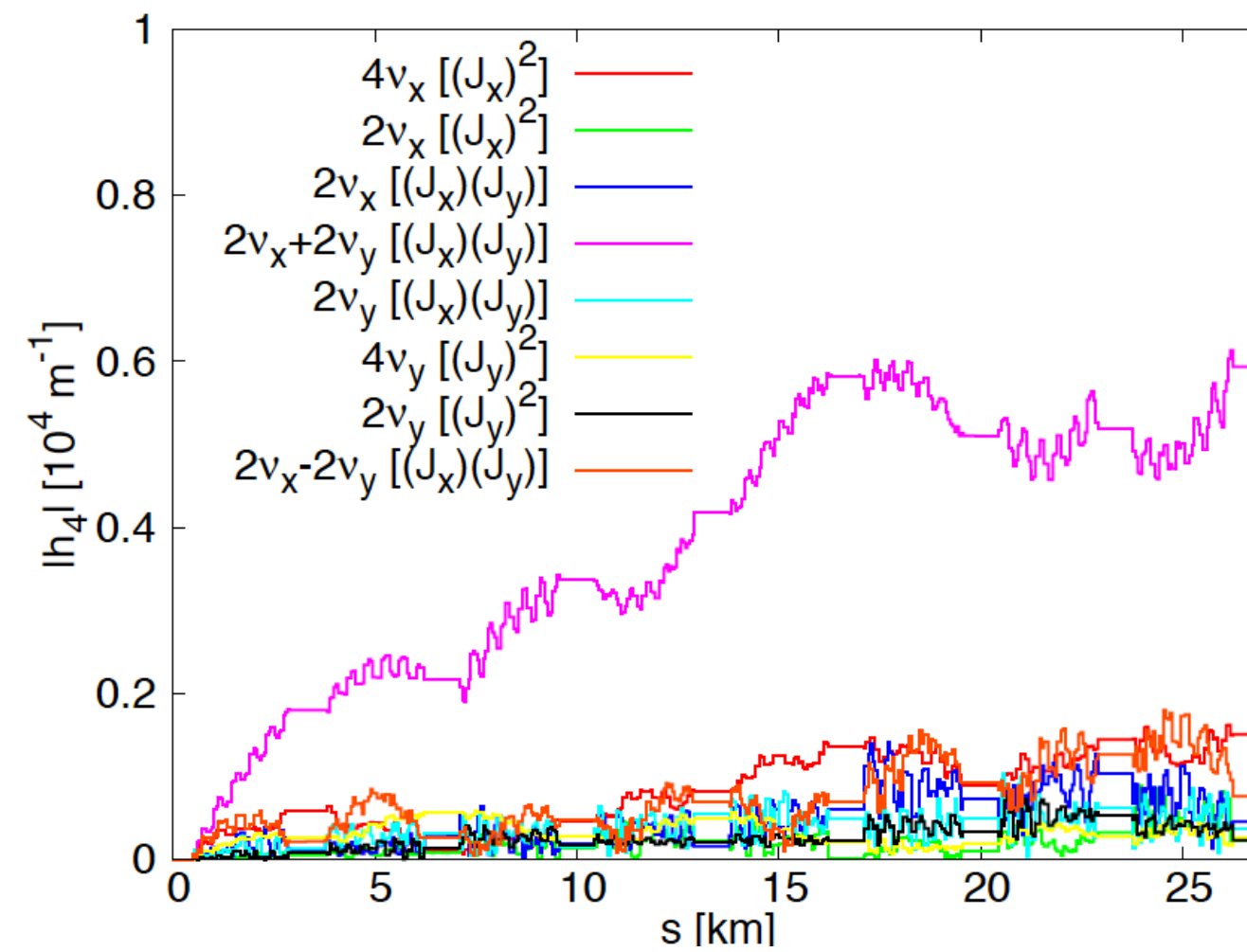
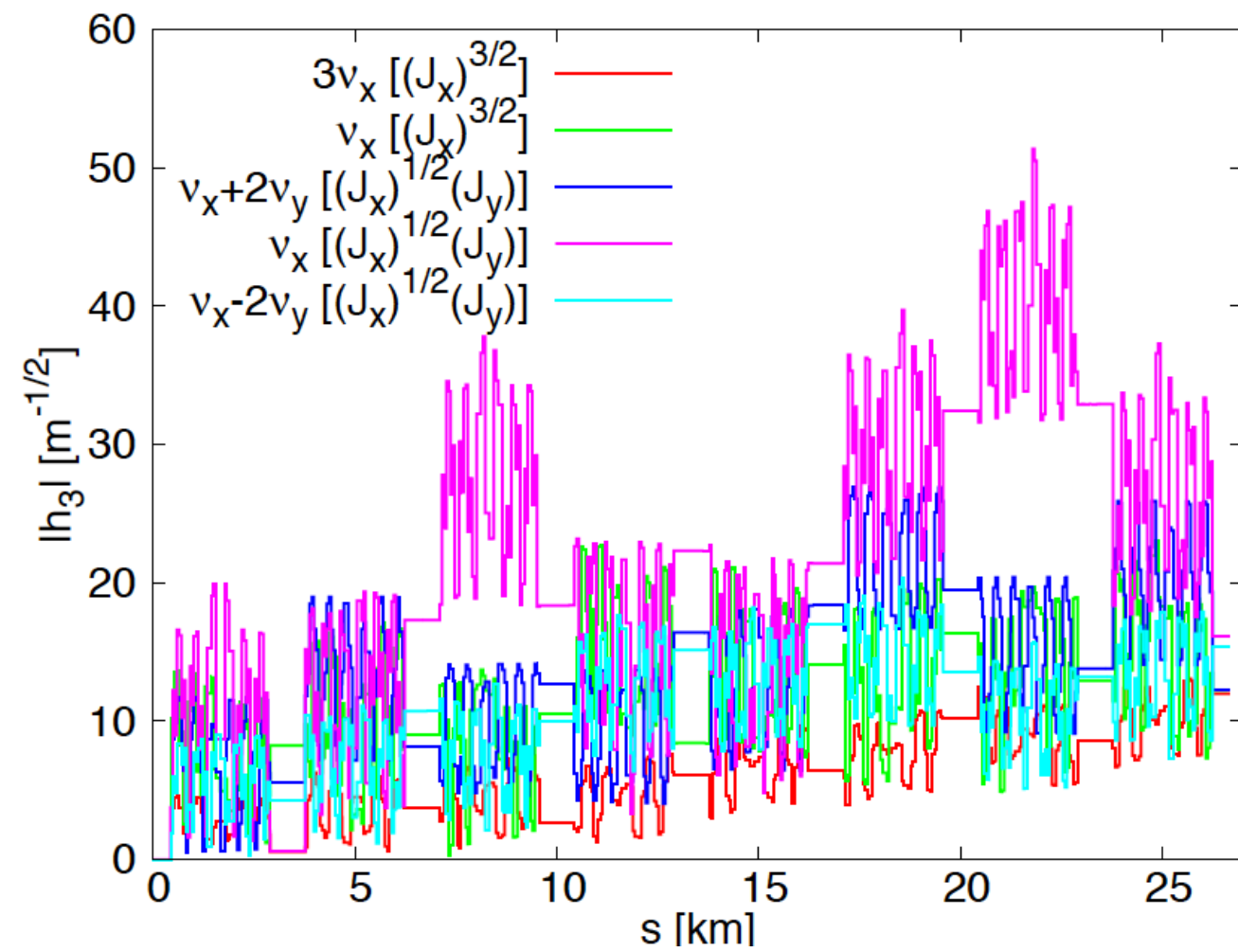
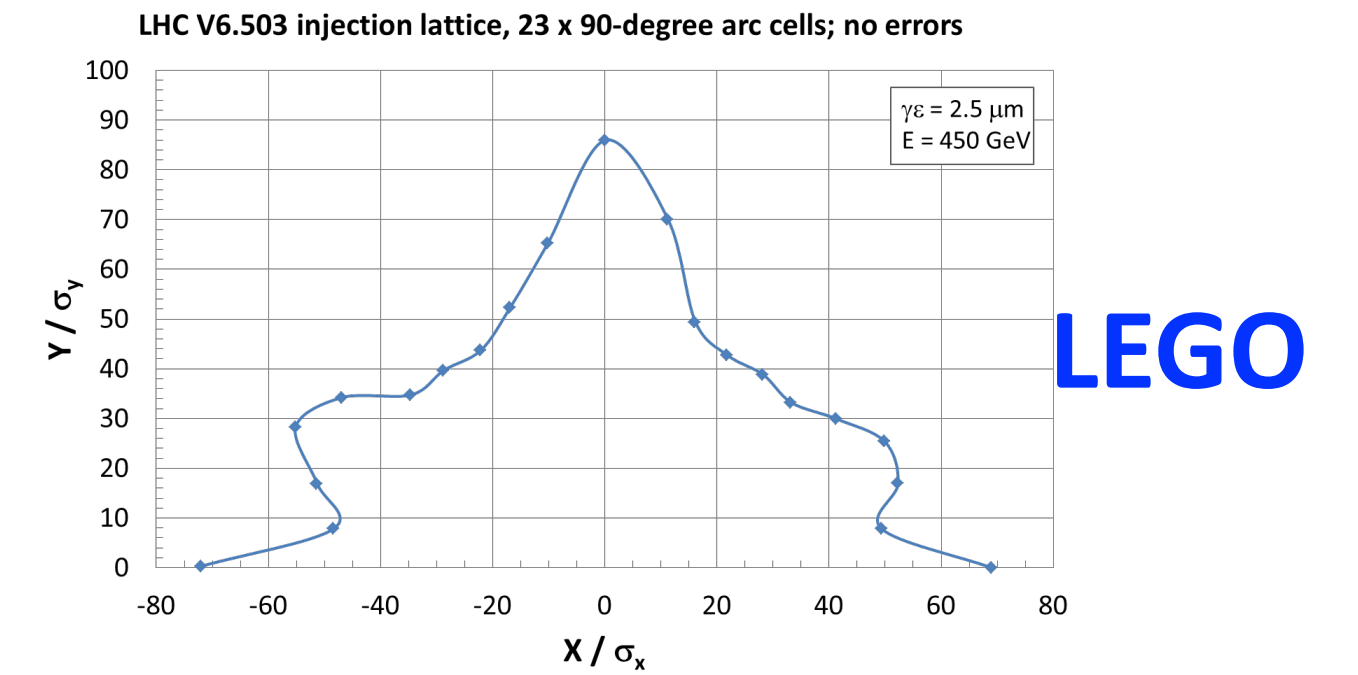
- Use basic IRs
- Working point (56.28, 57.31)



2. RDT and DA calculation

➤ LHC injection lattice (Ver. V6.503)

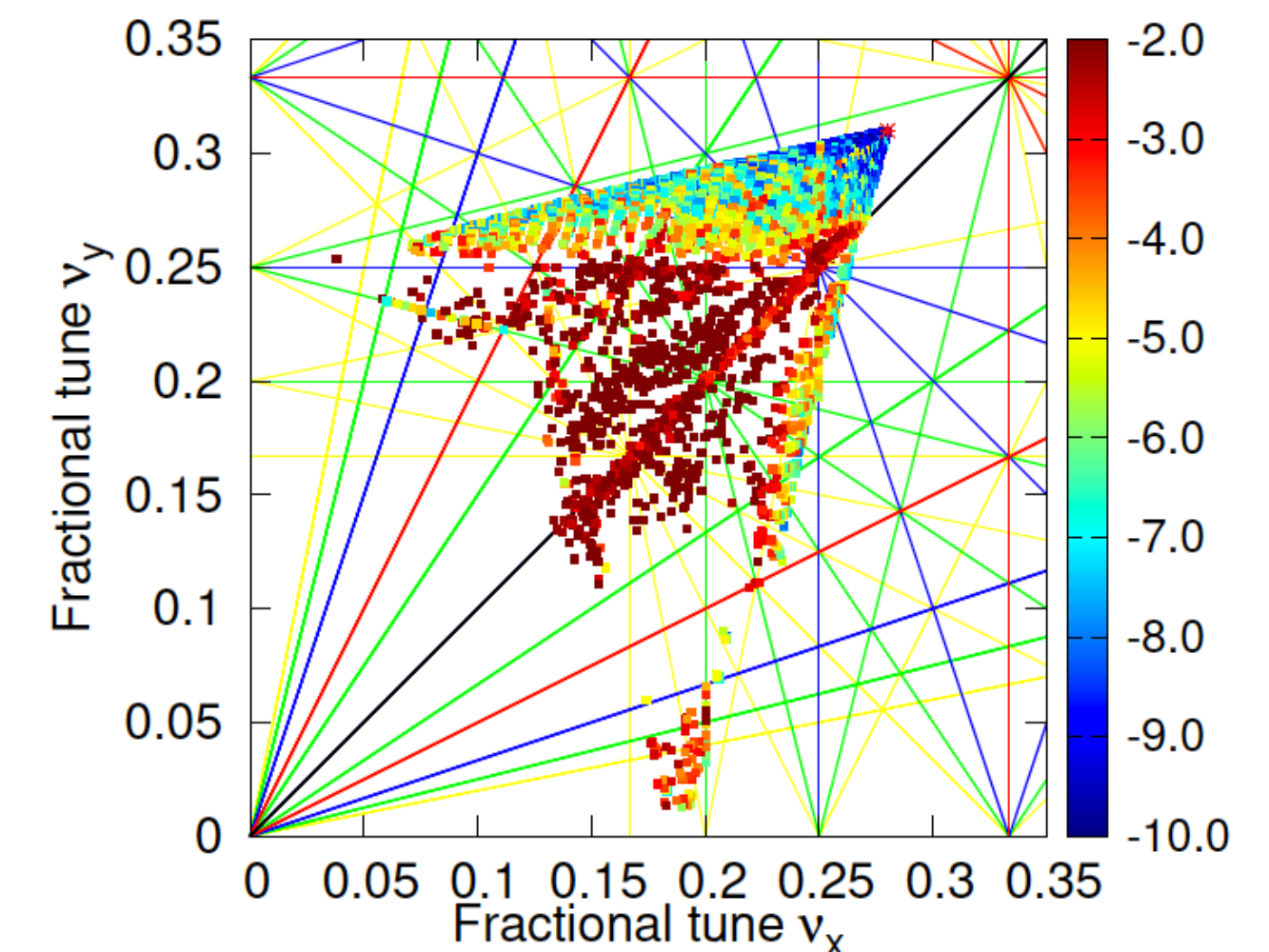
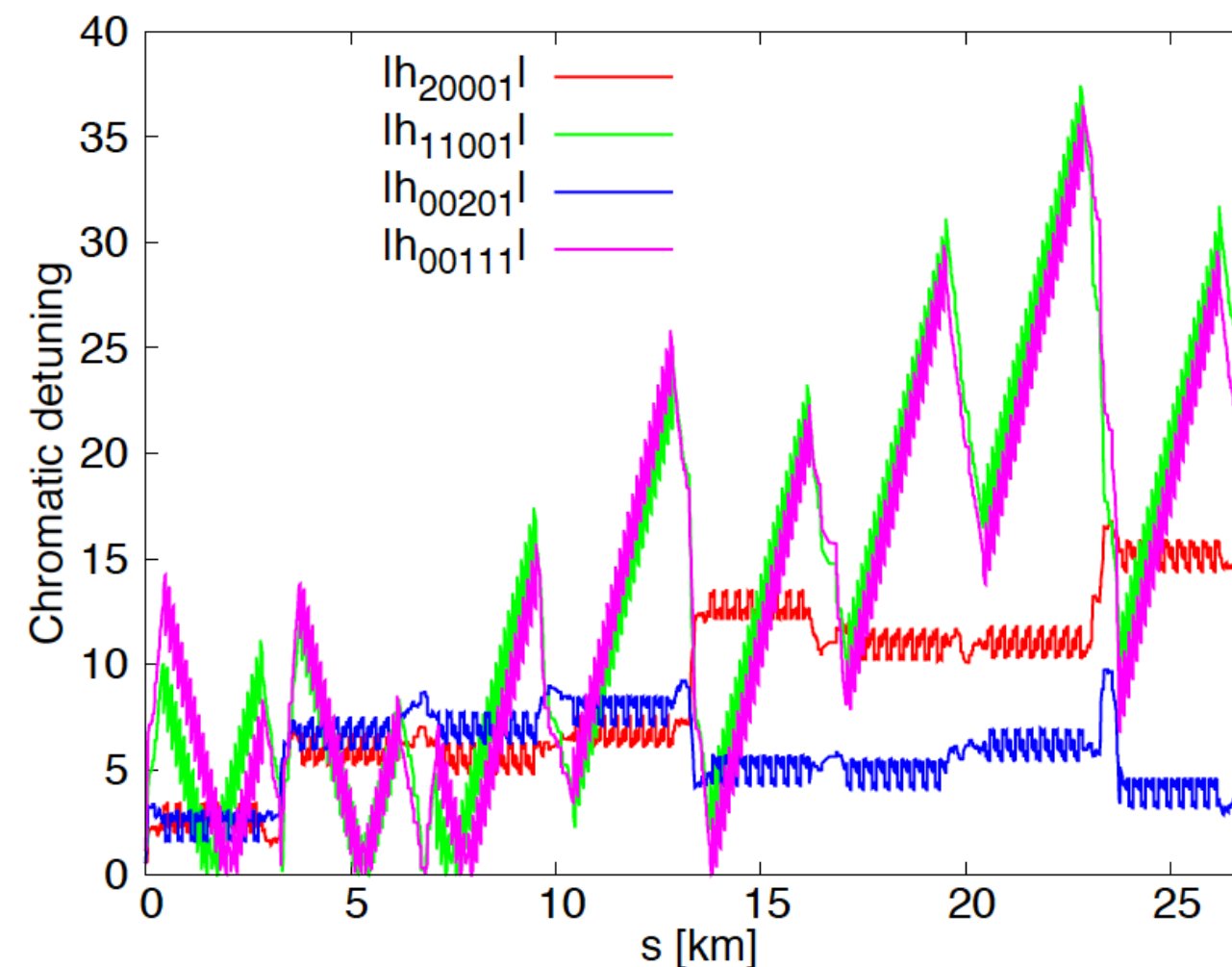
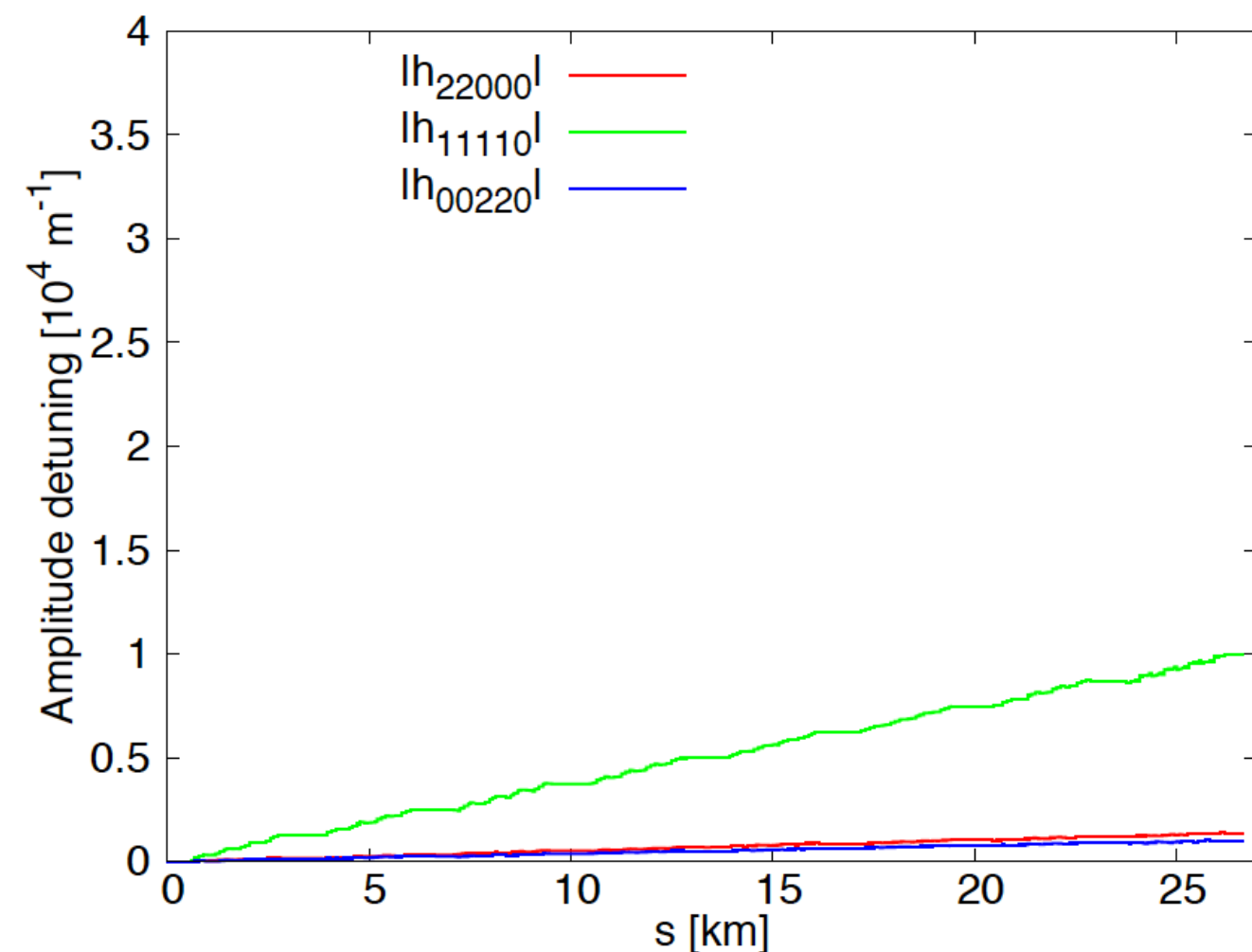
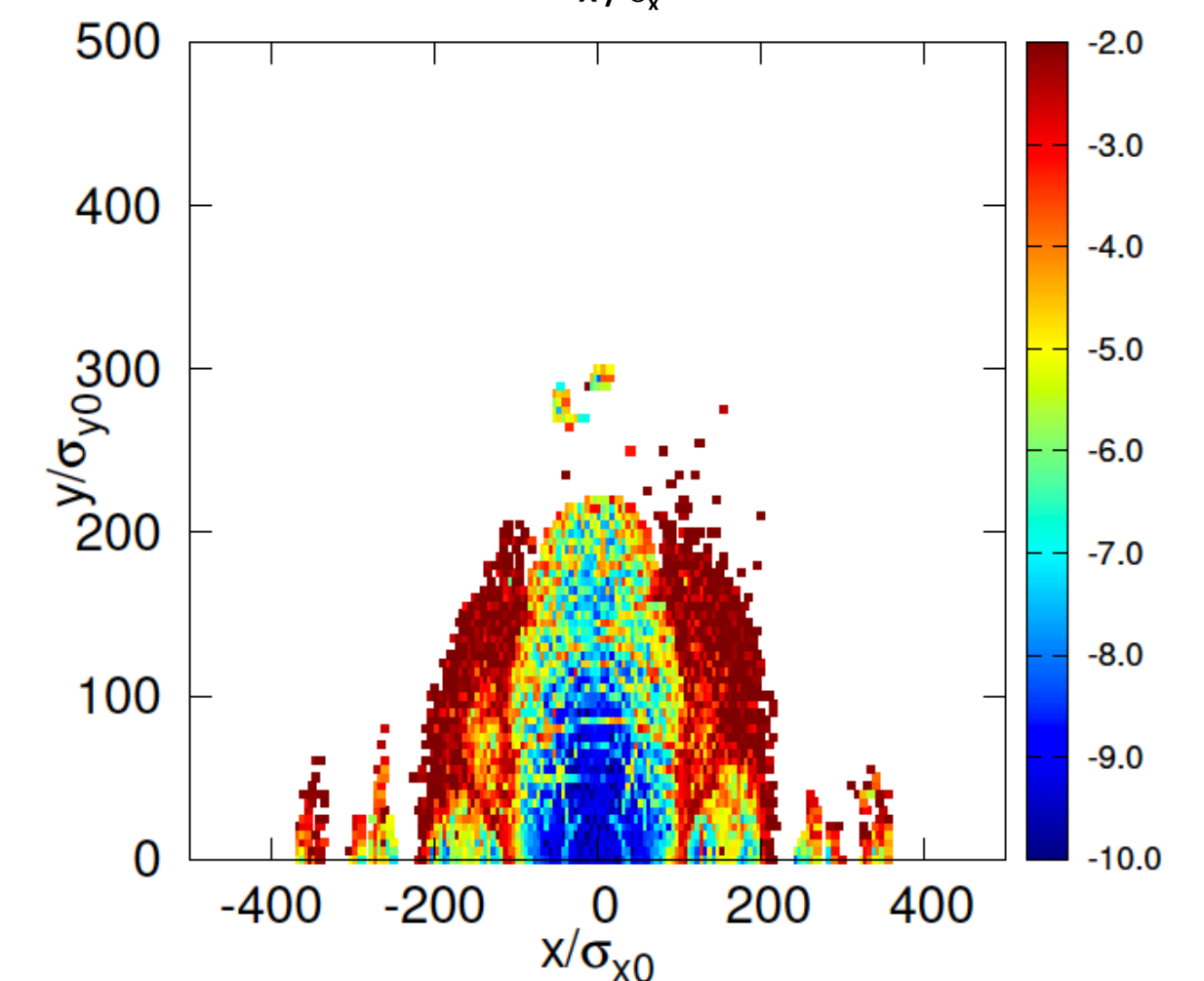
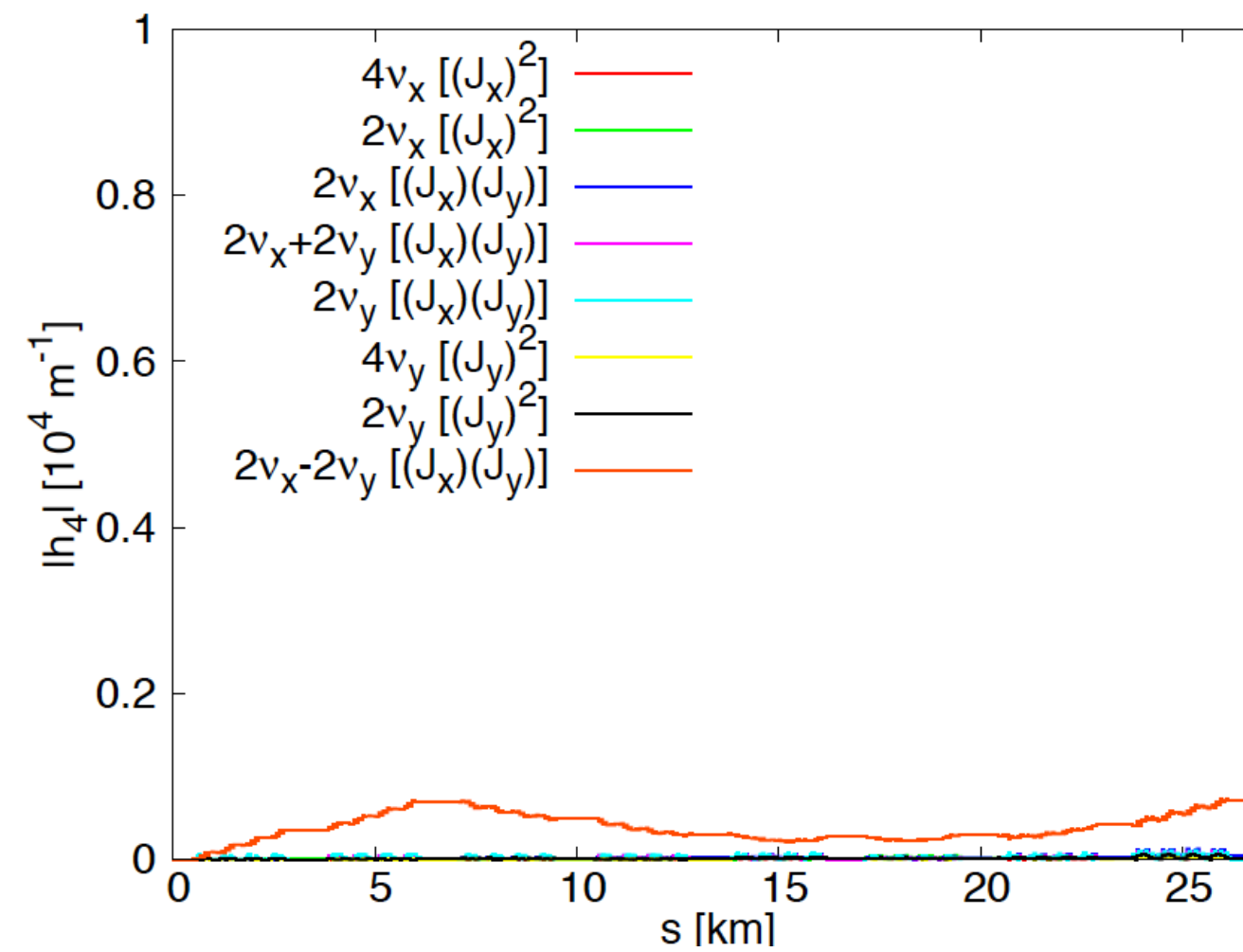
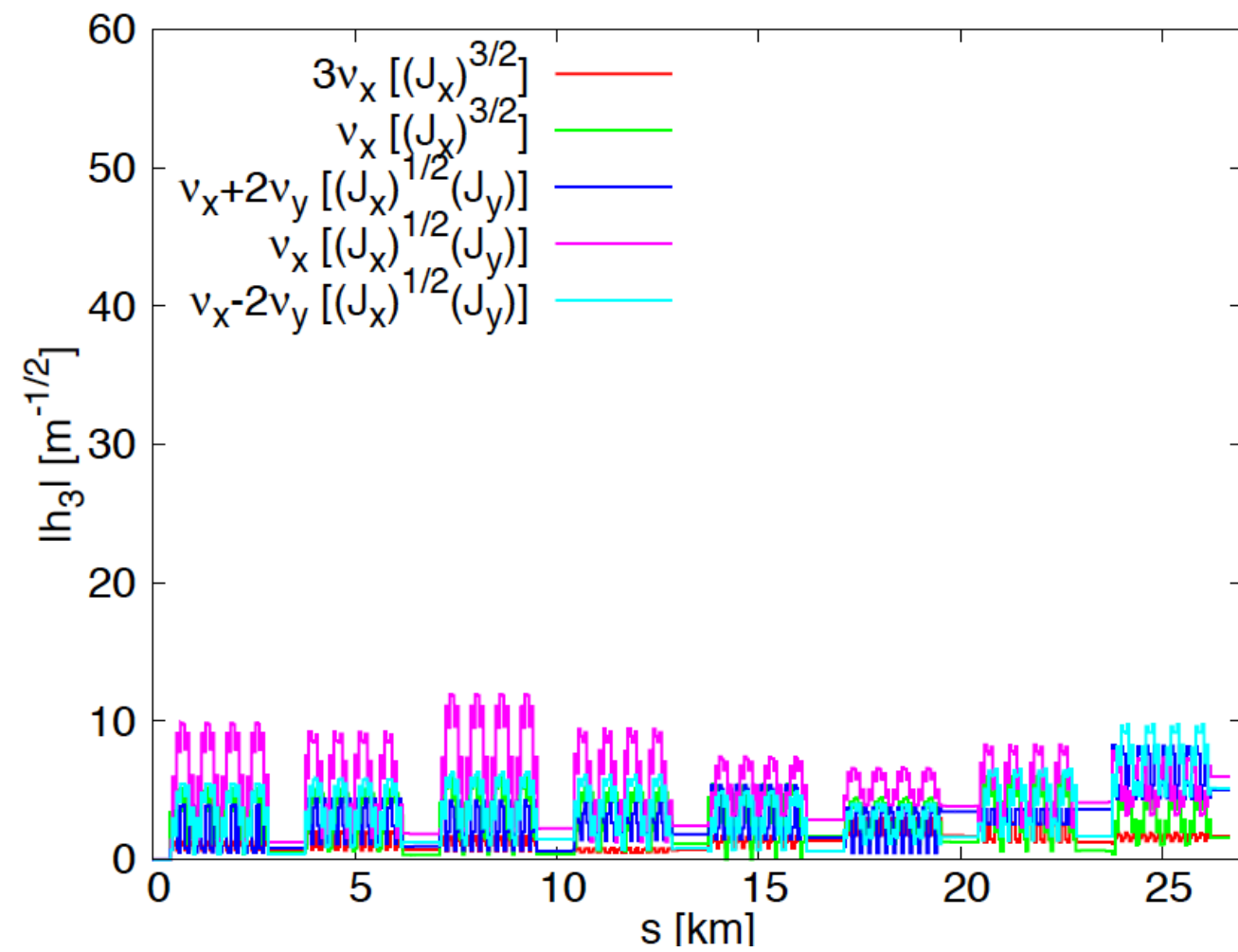
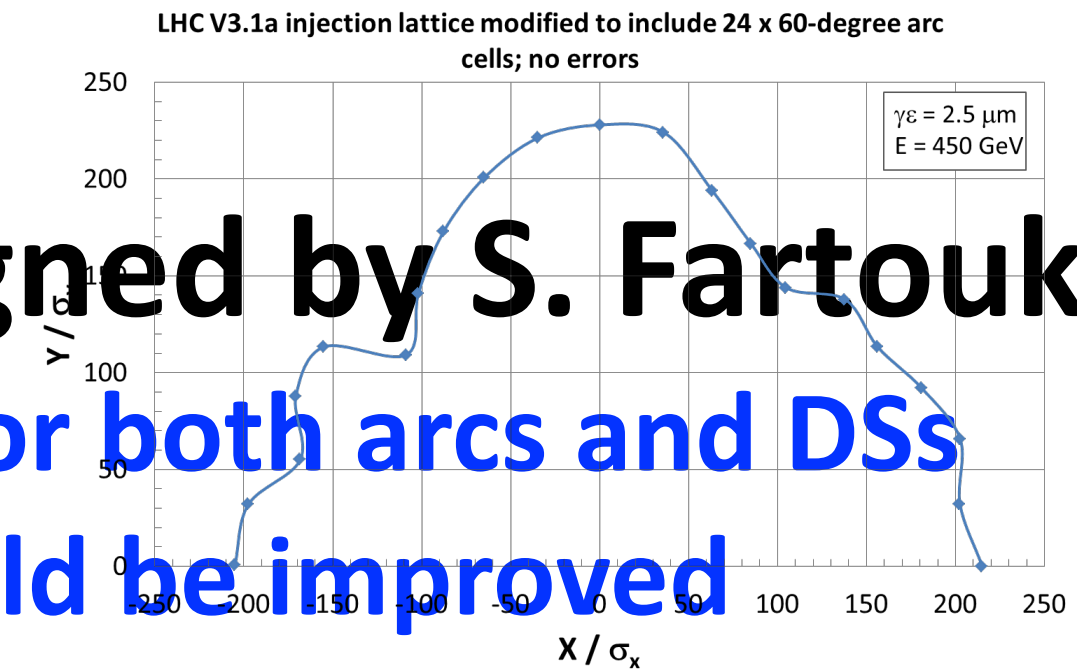
- 23x ~90-deg arcs, same dipole for both arcs and DSs
- Working point (64.28, 59.31)



2. RDT and DA calculation

➤ Modified HL-LHC injection lattice (SLHCV3.1a designed by S. Fartoukh)

- Use 24x 60-deg arcs (developed by T. Risselada), same dipole for both arcs and DSs
- Tune matched to (46.28, 45.31). No nonlinear optimization could be improved



2. RDT and DA calculation

➤ Theory of resonance cancelation

- Cancellation condition (C.C.):

$$N_c(n_x\mu_{xc}+n_y\mu_{yc})=2k\pi \text{ \& \ } (n_x\mu_{xc}+n_y\mu_{yc})\neq 2k'\pi$$

N_c : number of cell; μ_{xc} , μ_{yc} : Phase advance per cell

- 60-deg cell:

- * C.C.: $N_c=6N$

- * Lowest order resonances: $n_x-n_y=0$ and $n_x+n_y=6$

- 90-deg cell:

- * C.C.: $N_c=4N$

- * Lowest order resonances: $n_x-n_y=0$ and $n_x+n_y=4$

Proceedings of the 1999 Particle Accelerator Conference, New York, 1999

RESONANCE FREE LATTICES FOR A.G. MACHINES

A. Verdier
CERN SL Division

3. Summary and outlook

➤ RDT and DA calculation for HE-LHC injection lattices w/o errors

- 60-deg arc cells show huge DAs mainly resulted from:
 - * Large beta and dispersion functions, and weaker sextupoles
 - * Well-suppressed 3rd and 4th RDTs
- 90-deg arc cells show relative smaller DAs mainly resulted from:
 - * Stronger sextupoles
 - * 4th RDTs not well-suppressed

➤ Outlook

- Impact of errors and relevant tolerances to be investigated
- Integration of 60-deg arc cells to collision lattices (in parallel to design efforts on insertions of HE-LHC) to be investigated

Thank you for your attention!