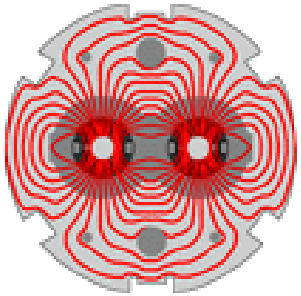
High Luminosity LHC



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Weak-strong beam-beam simulations

Specifications for BBLR. Vol. 1

A.Valishev (Fermilab/US LARP)

Thanks to: D.Banfi, J.Barranco, S.Fartoukh, Y.Papaphilippou, T.Pieloni, D.Shatilov

March 27, 2015

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Motivation and Plan

- Reduced crossing angle with flat optics to restore performance without crab cavities (Plan B, S.Fartoukh, 2013)

1. First, consider the range of parameters where BBLR might be useful
2. Evaluate beam-beam performance with/without wires
3. Evaluate limitations of technical solutions

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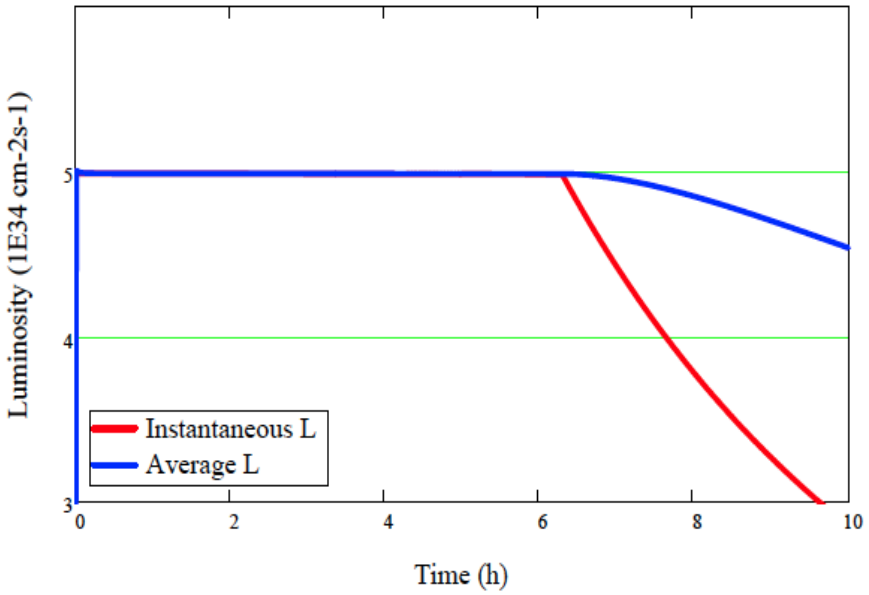
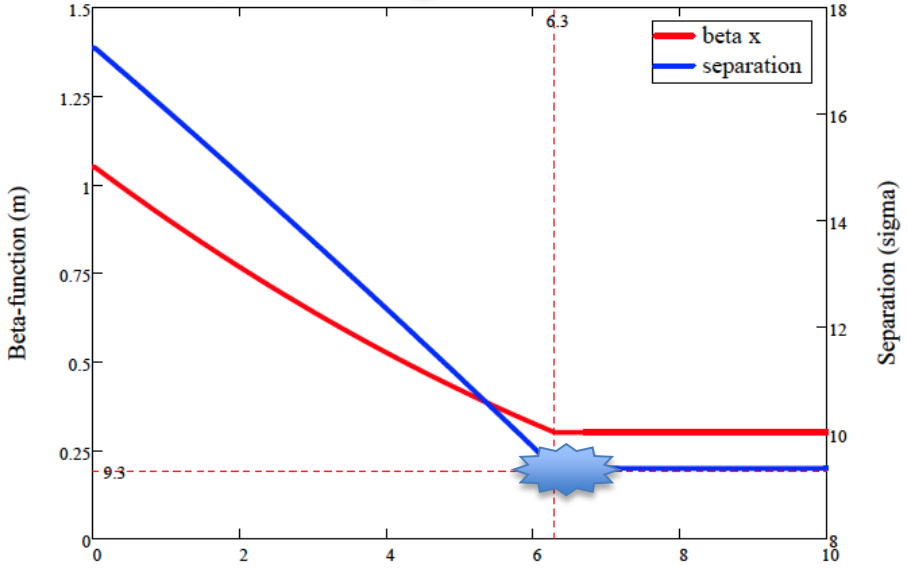
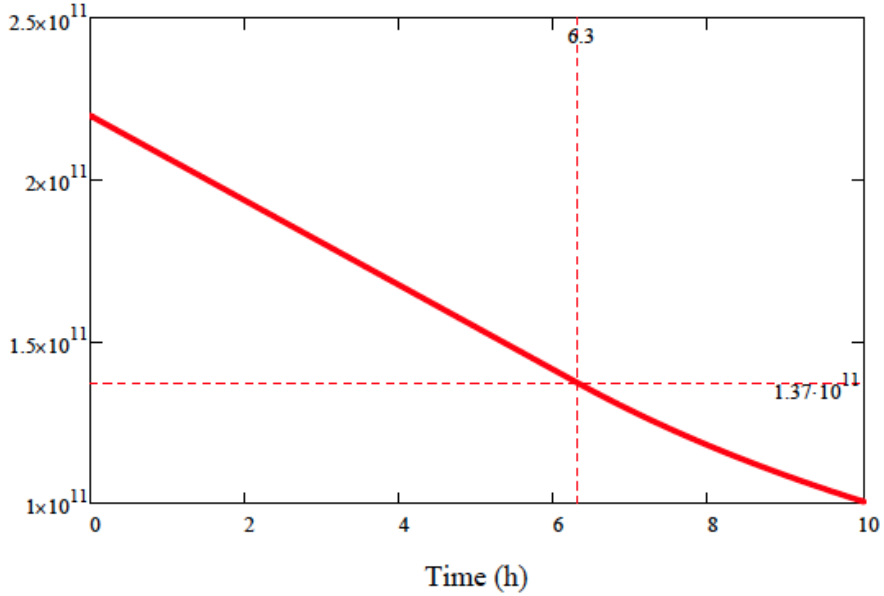
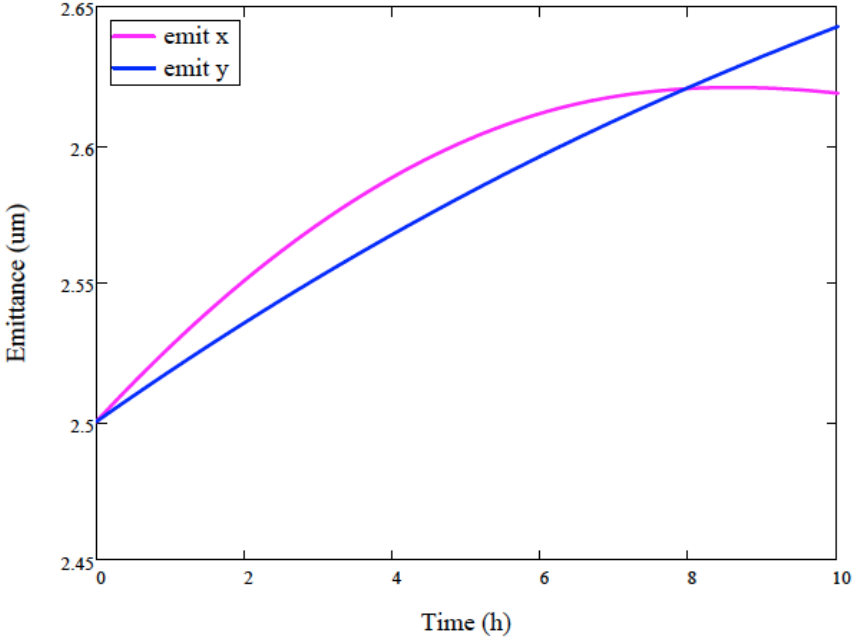
Luminosity Leveling at 5×10^{34} with Flat Optics $\beta x/\beta y=4$, CC=off, x-angle=320 urad



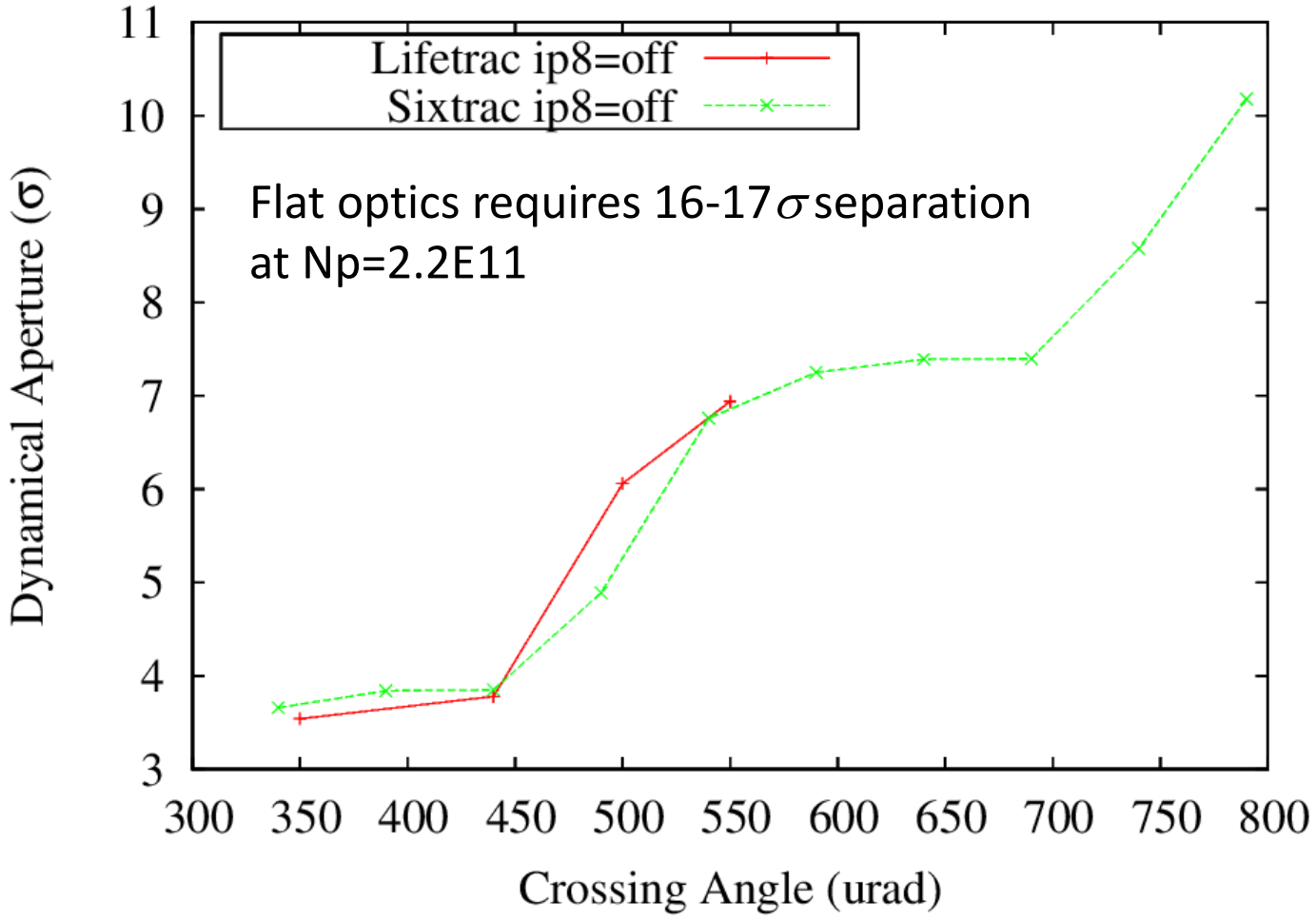






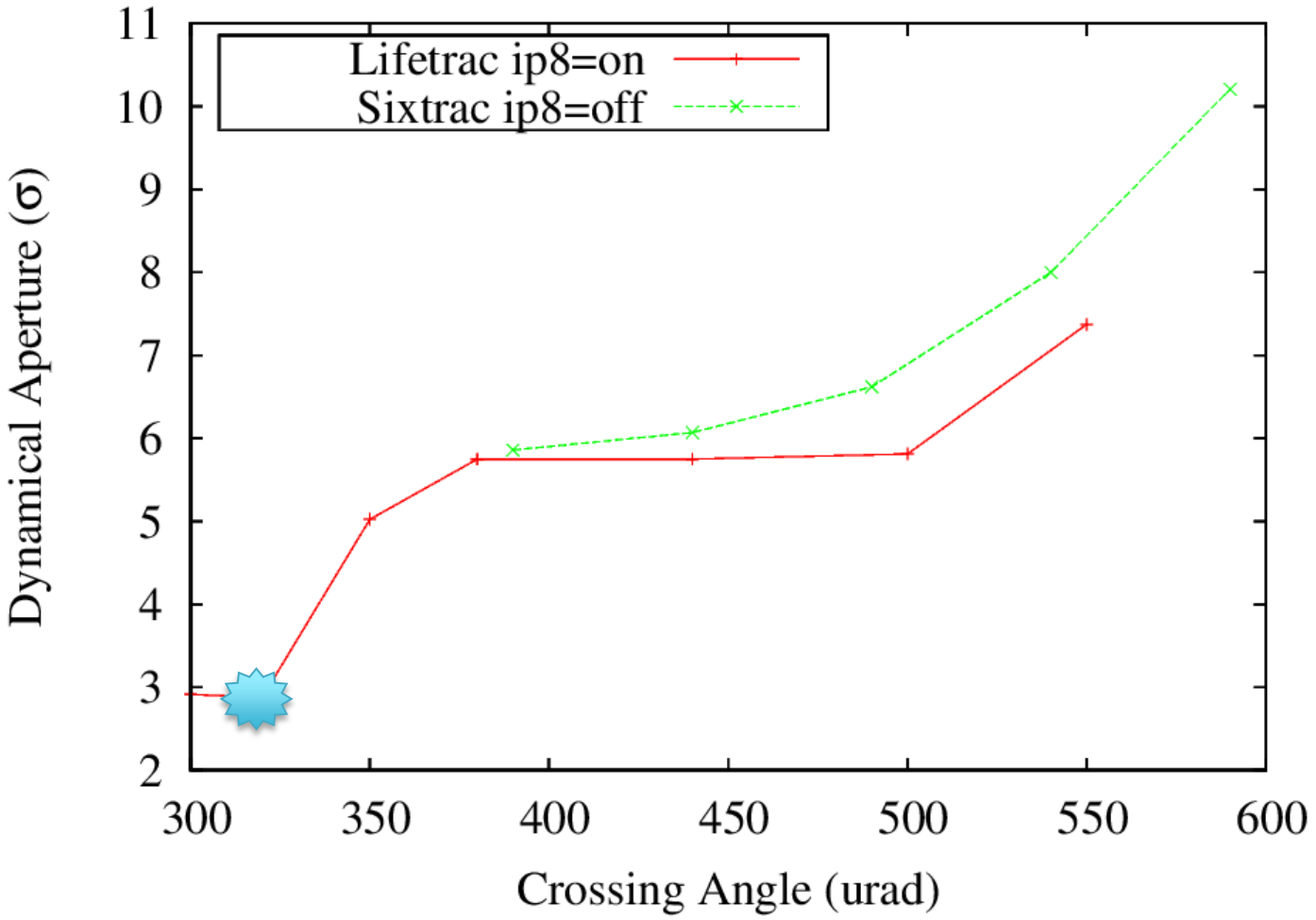
Flat Optics 30/7.5 cm

DA benchmarking with Sixtrack and Lifetrac:



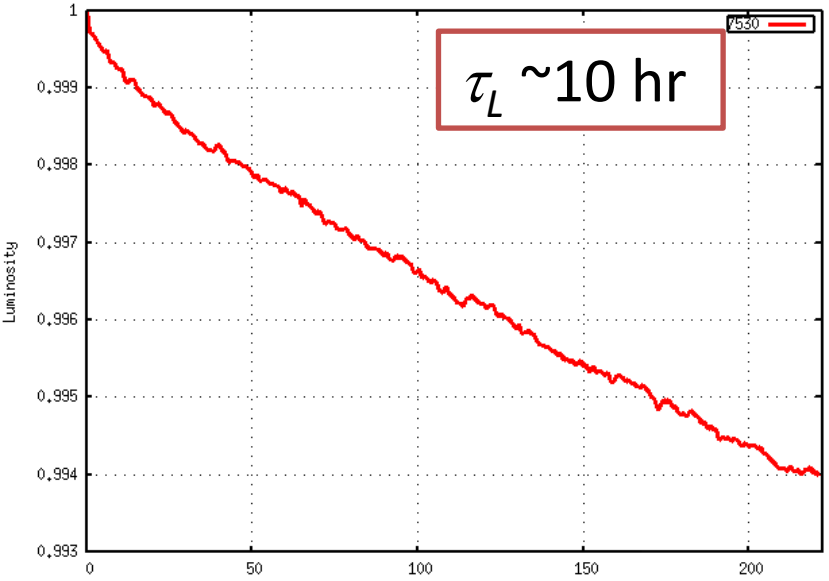
Flat Optics 30/7.5 cm

DA at minimum β-function, end of fill Np=1.3E11

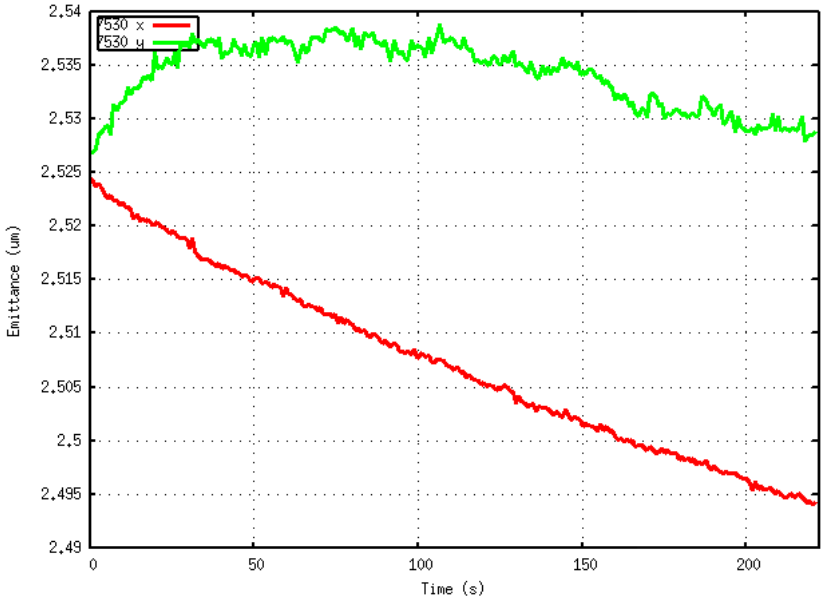


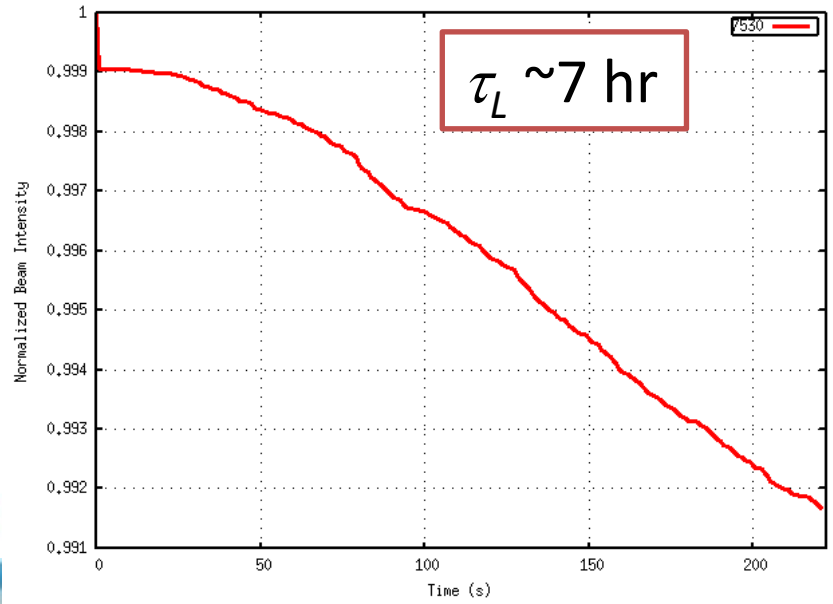
Macroscopic Beam Parameters During Luminosity Leveling at 5×10^{34}

β^* = 30/7.5cm, x=320 urad
IP8=on, CC=off



τ_L ~10 hr





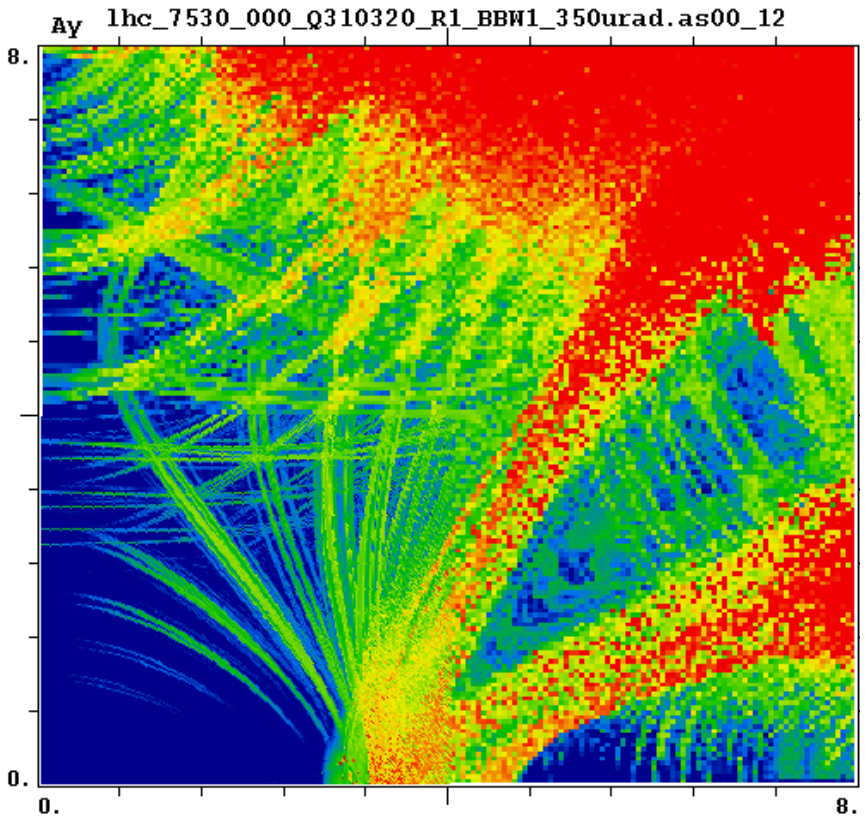
τ_L ~7 hr

Evolution of Tails

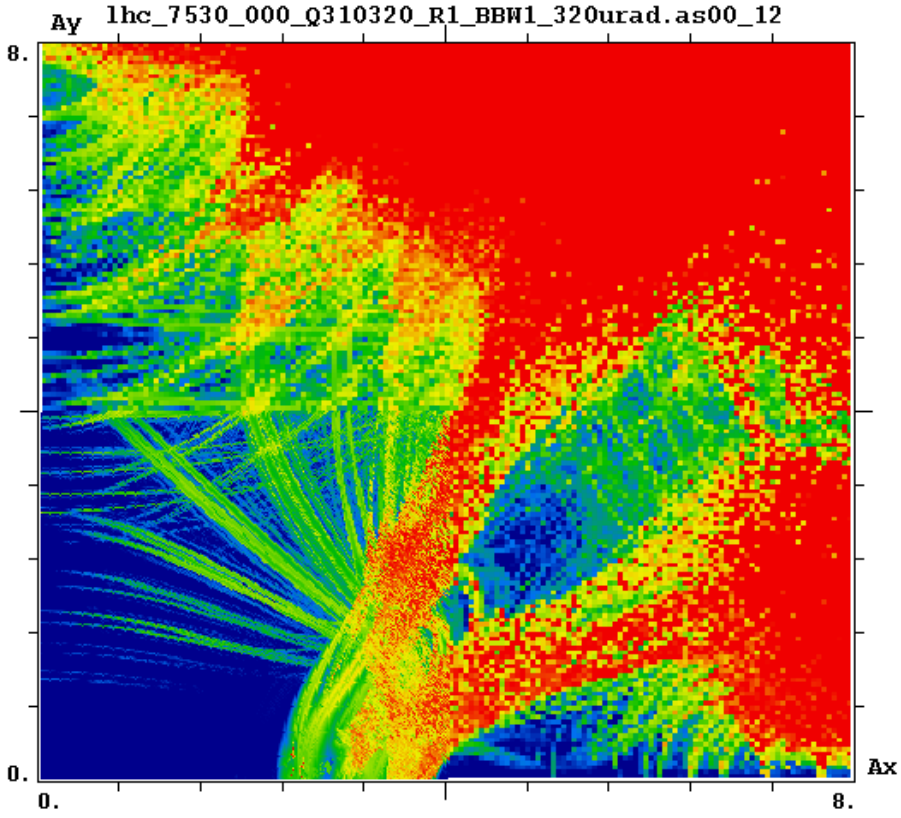
β^* = 30/7.5cm, x=320 urad
IP8=on, CC=off

FMA Flat Optics β^*=30/7.5cm, Np=1.2×10^{11}

350 urad



320 urad



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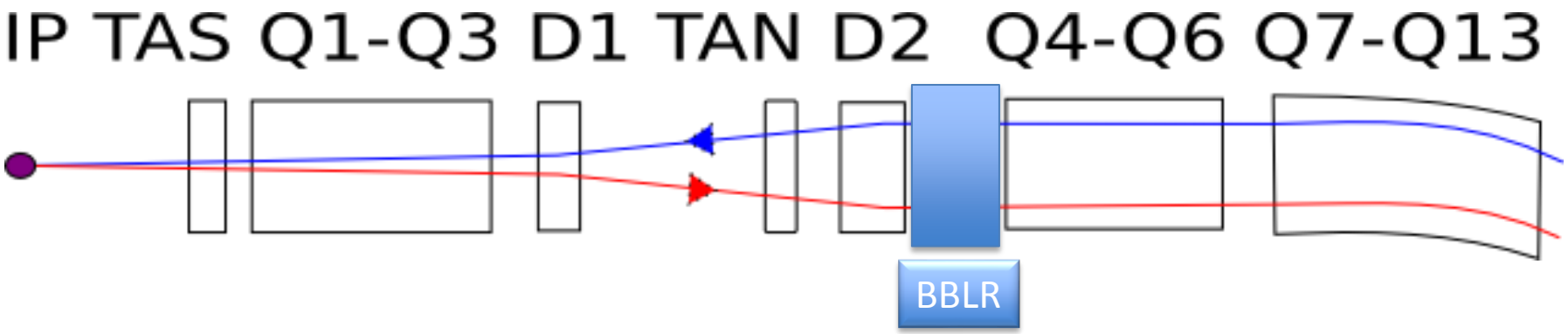
Enter the wires

- Significant degradation of luminosity lifetime (τ~10 hr) at x-angle 320 urad (DA=3σ), significant tail growth (1-2 orders of magnitude)

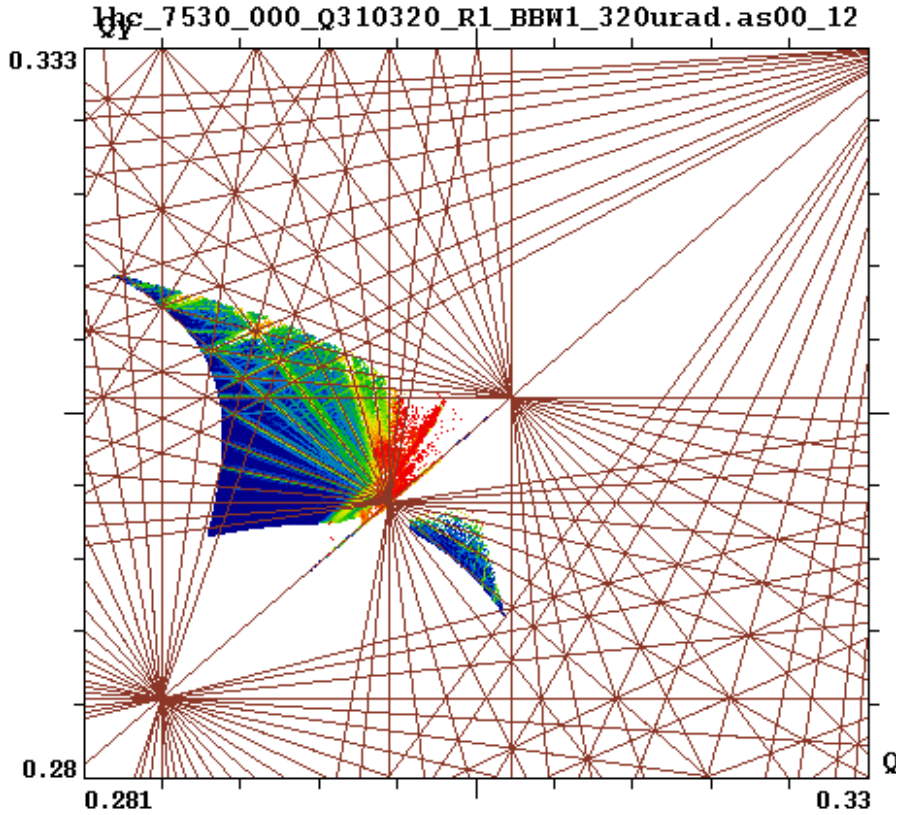
Wire configuration



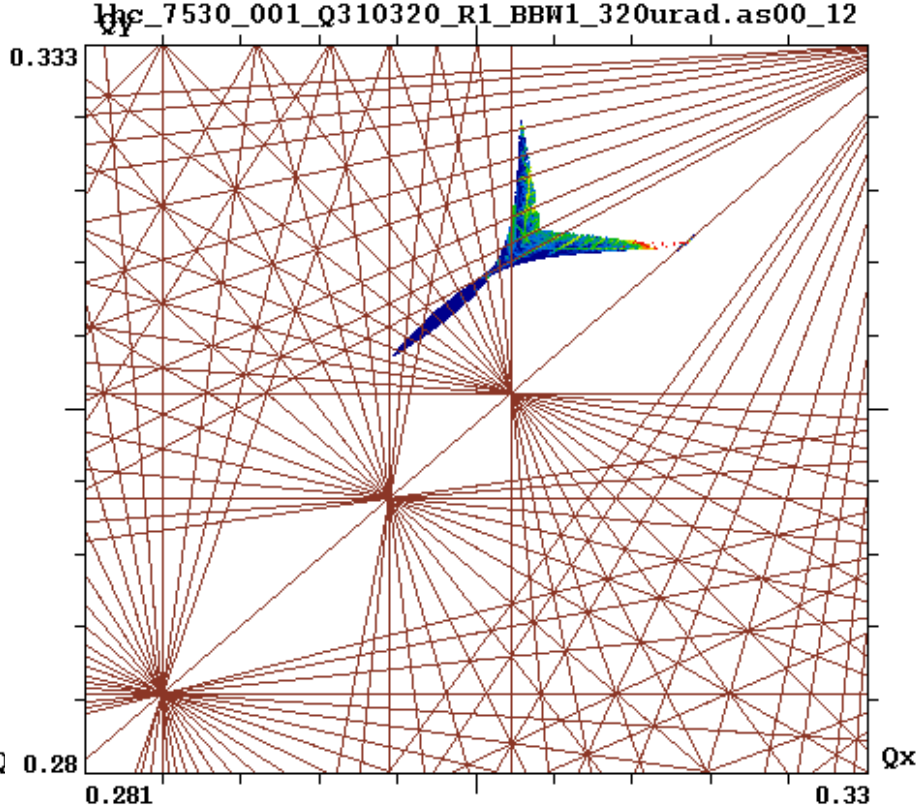
- Distance from IR 150 m (replaces CC)
- Adjust
  a. distance to beam
  b. current

FMA Flat Optics β^*=30/7.5cm, 320urad, Np=1.2×10^{11}

BBLR=off



BBLR=on



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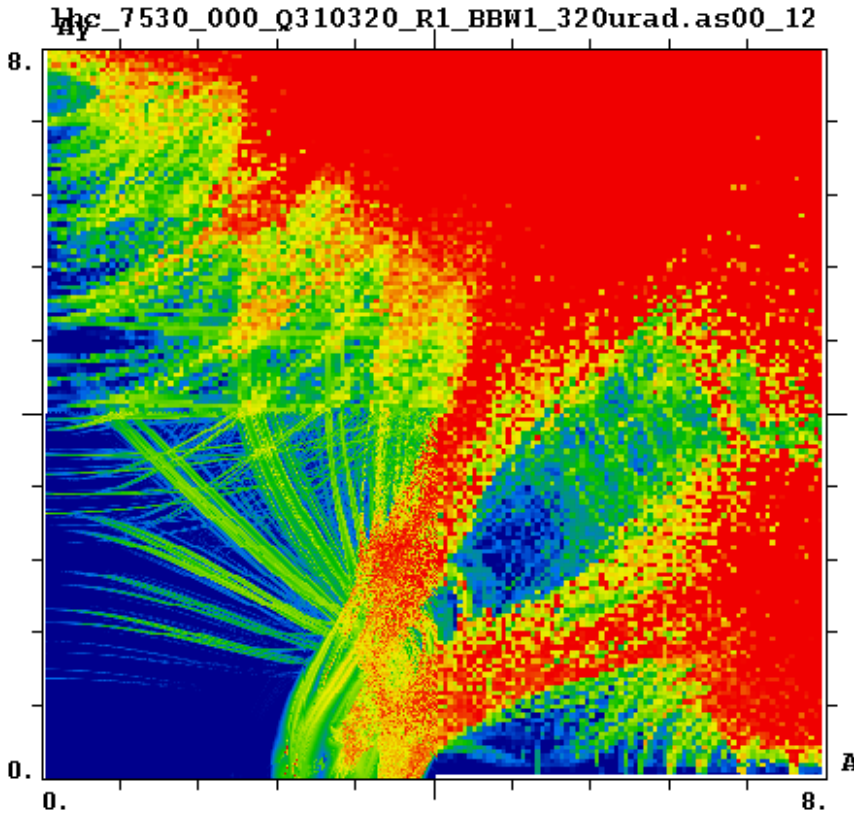
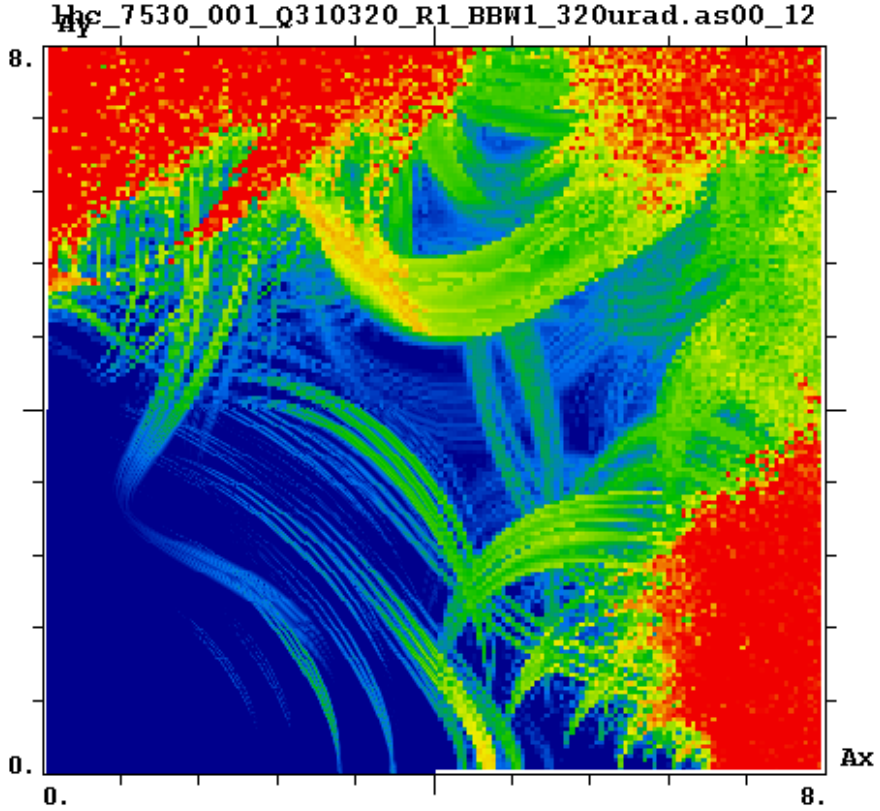
FMA Flat Optics β^*=30/7.5cm, 320urad, Np=1.2×10^{11}

BBLR=off, DA=2.8



BBLR=on, DA=5.6



Wire at optimal* distance 9.3σ, current 198 A×m

* S.Fartoukh, RDT cancellation

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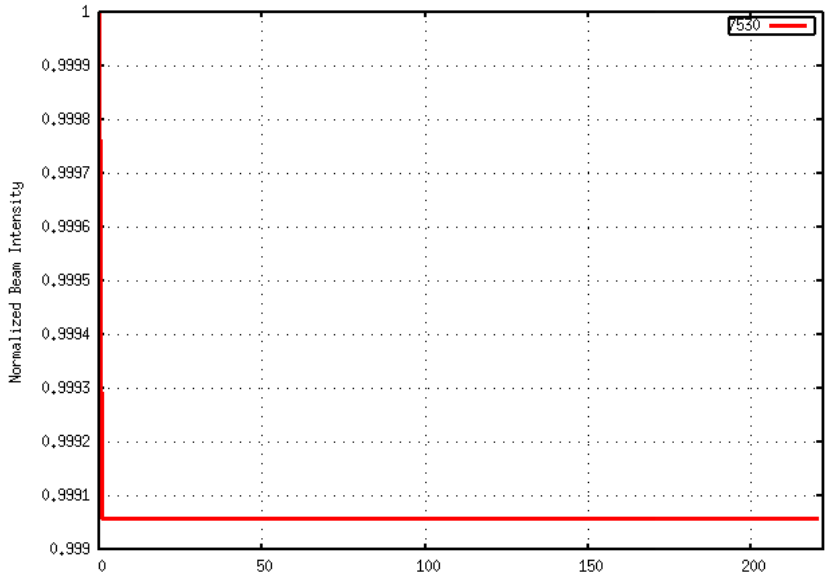
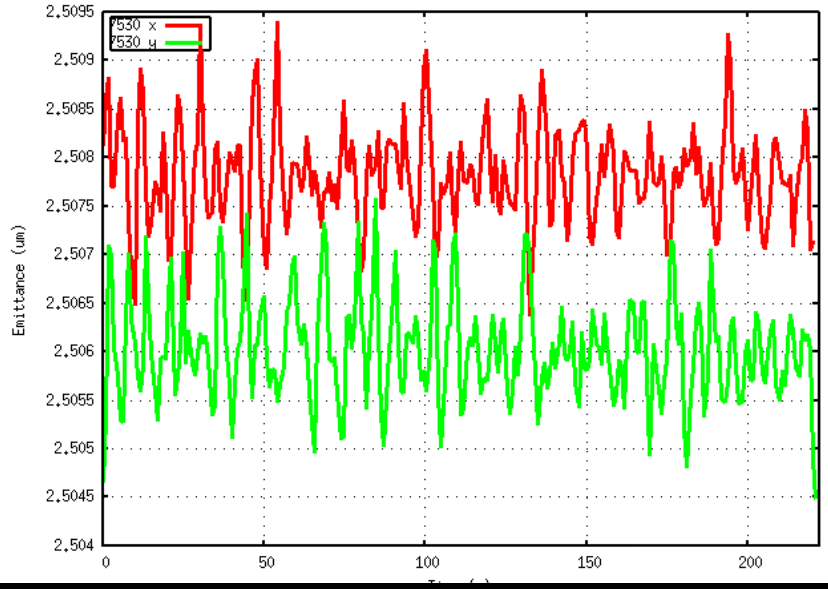
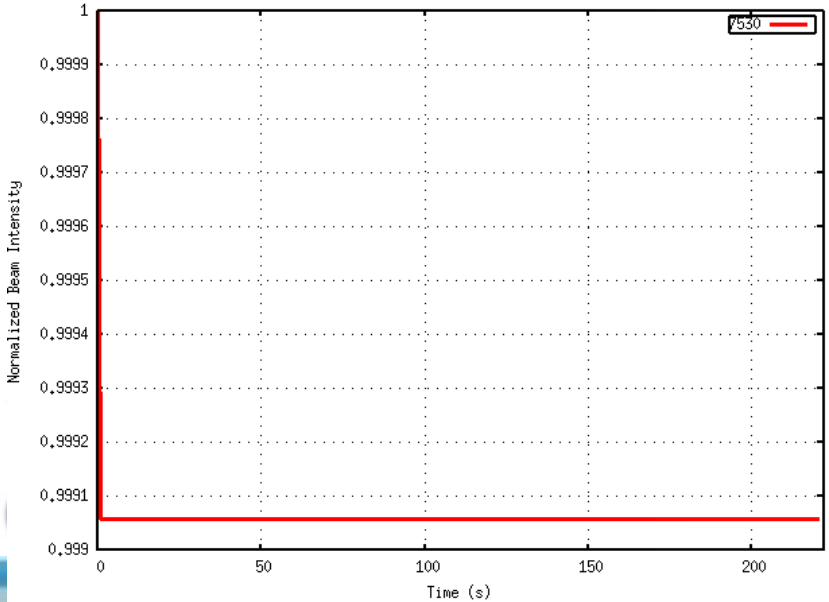
Macroscopic Beam Parameters During Luminosity Leveling at 5×10^{34}

β^* = 30/7.5cm, x=320 urad
IP8=on, CC=off, BBLR=on







Open questions

In the found solution, wire is at 9.3 σ beam = 7.4 mm

For wire embedded in TCT, wire-jaw=3mm, +10-11σ beam = total distance 14-15σ

1. *Can wire be effective at larger distance?*

2. *Can parameter optimization (WP, RDT's) improve DA?*

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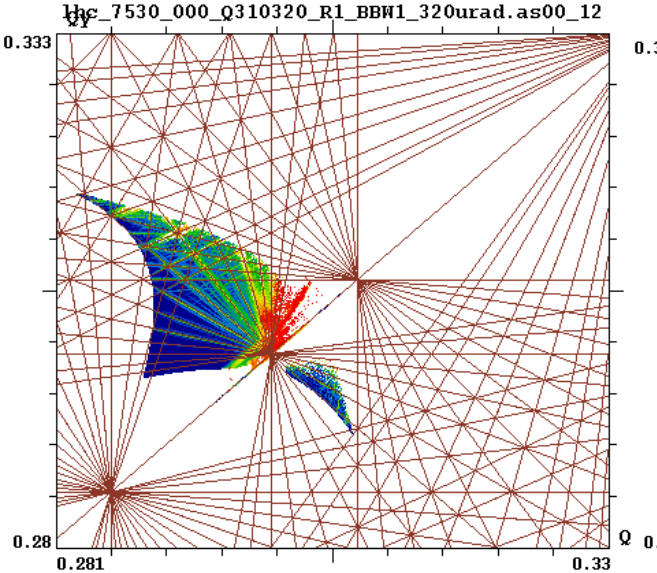
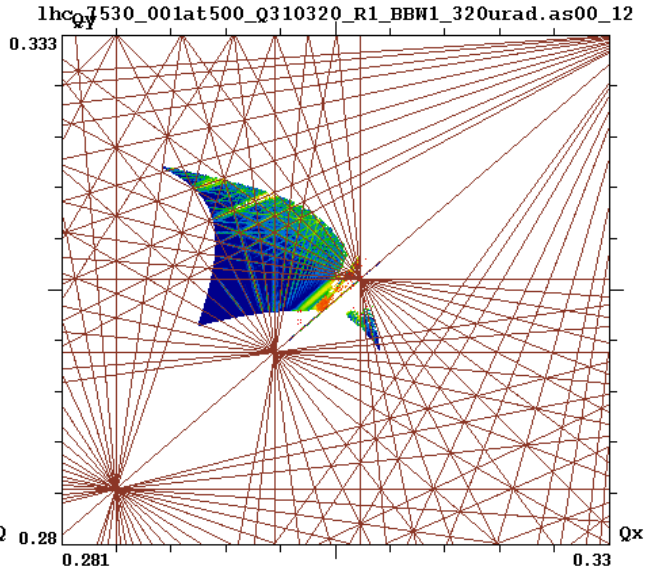
FMA Flat Optics β^*=30/7.5cm, 320urad, Np=1.2×10^{11}

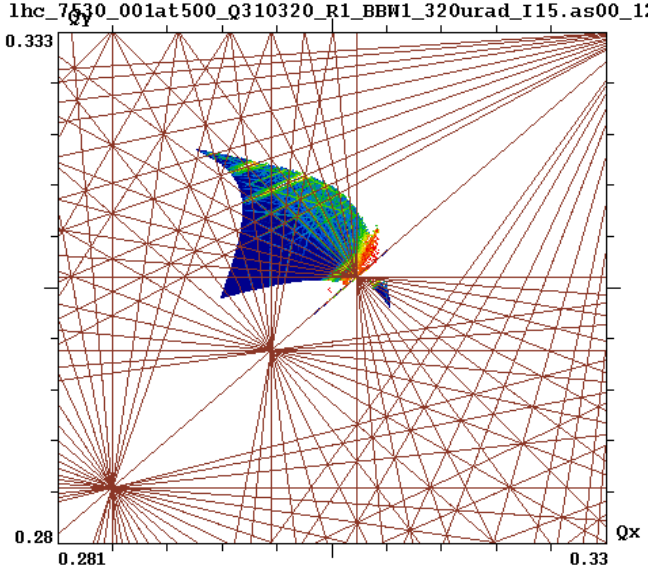
BBLR=off



BBLR=on at 14 σ, I=198



I=300



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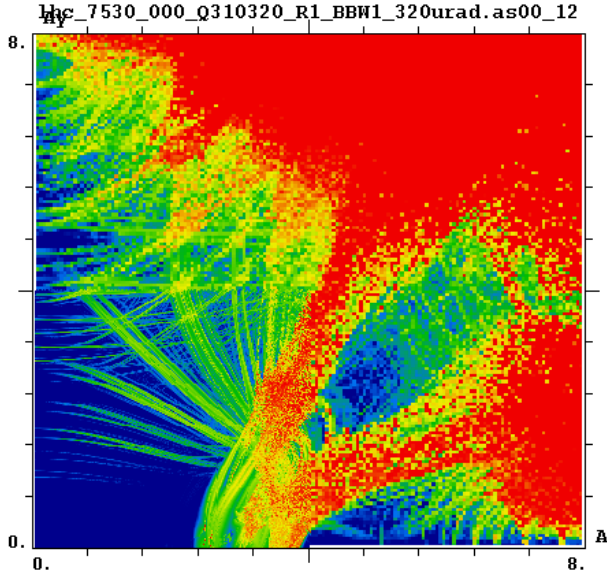
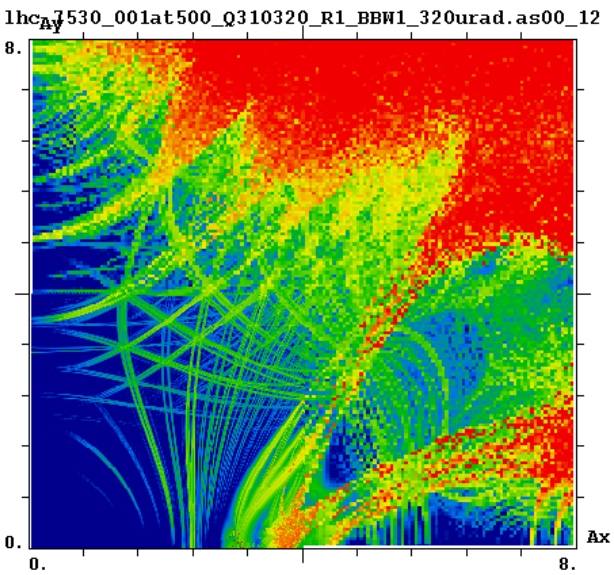
FMA Flat Optics β^*=30/7.5cm, 320urad, Np=1.2×10^{11}

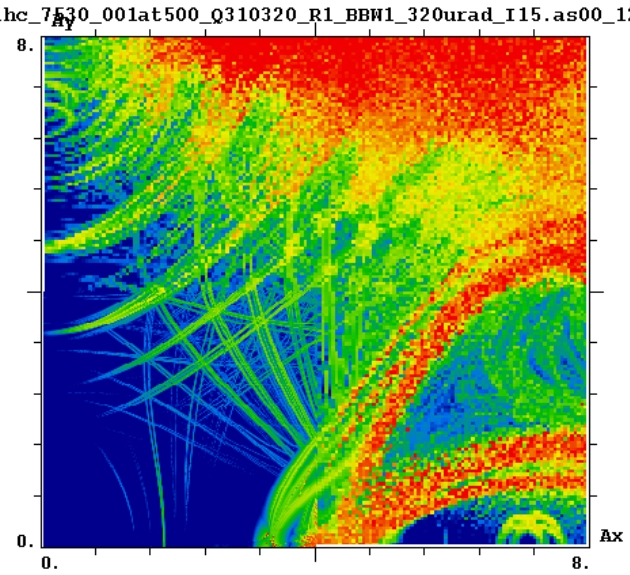
BBLR=off



BBLR=on at 14 σ, I=198



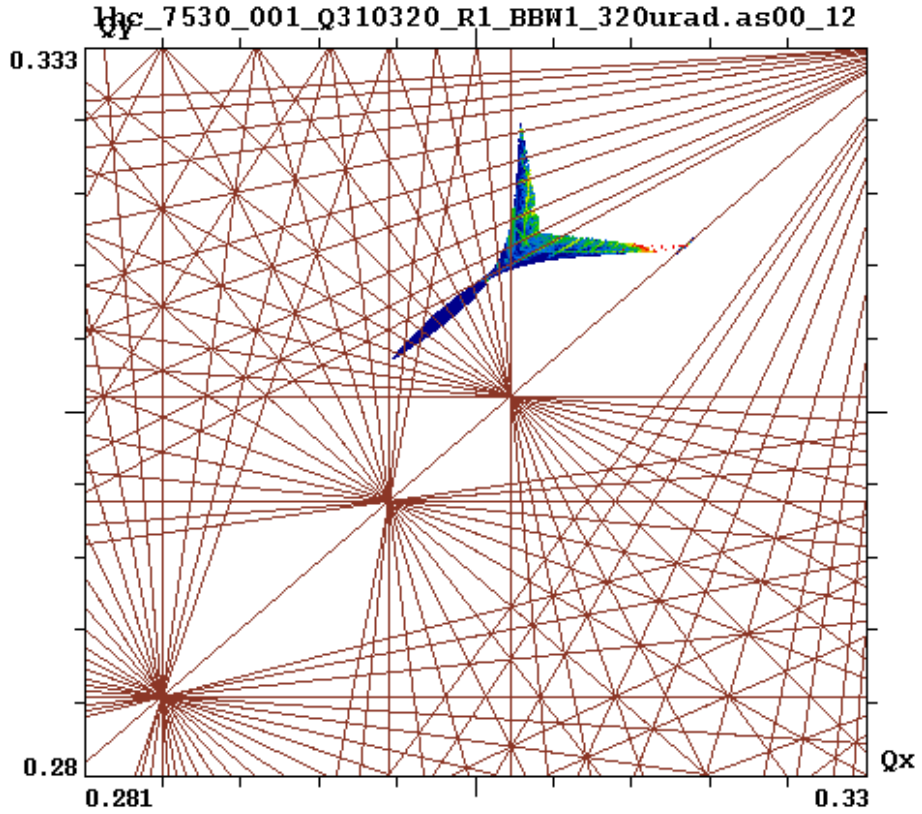
I=300



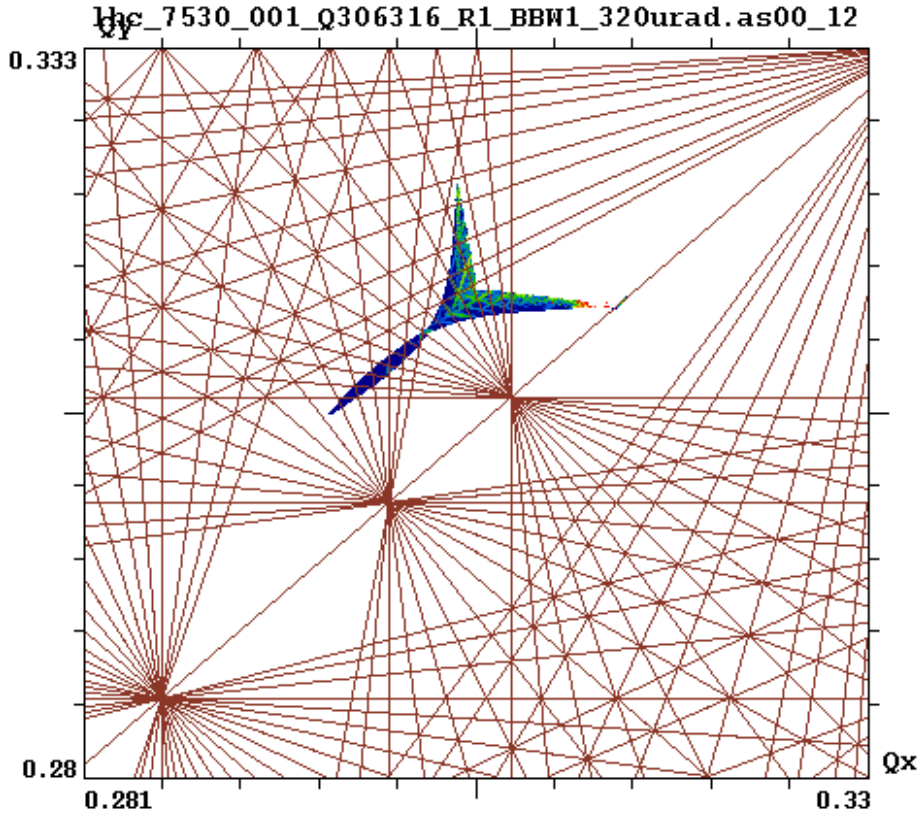
Conclusion: so far could not find a solution for compensation with wires at 14 σ

FMA Flat Optics β^*=30/7.5cm, 320urad, Np=1.2×10^{11,} WP optimization

BBLR=on, .310,.320, DA=5.6



BBLR=on, .306, .316, DA=6



Also varied wire strength from predicted optimum, size

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Summary, Vol. 1

- Reduced crossing angle with flat optics to restore performance without CC is feasible with wire long-range compensation.
- Wires restore DA from 2.8 to almost 6 sigma at smallest separation of 9.3 at end of fill. Macroscopic parameter evolution is unaffected by beam-beam
- Wires need to be at 9.3 sigma, a solution with larger distance has not been found so far.
- Since wires need to be turned on towards the end of fill, the required current is 200A×m – good for immaterial wire with E-Lens, would require 33A×m EL.
- Further optimization in progress.

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