Experience with FCC-ee Lattice in MAD-NG

Leon van Riesen-Haupt, Laurent Deniau

Previous MADX-SAD Comparisons

- Comparison of SAD and MAD-X for FCC-ee studies 11/09/2019
  - Linear Optics
  - Momentum Detuning
  - Amplitude Detuning (Tracking)
- Comparison of SAD and MAD-X for FCC-ee studies 06/11/2019
  - Radiation effects
  - Emittance
- Radiation Integrals in MADX 20/05/2020
  - Radiation Integrals in General
  - Change of Radiation integrals with Momentum

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    - **Linear Optics**
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    - **Radiation Integrals in General**
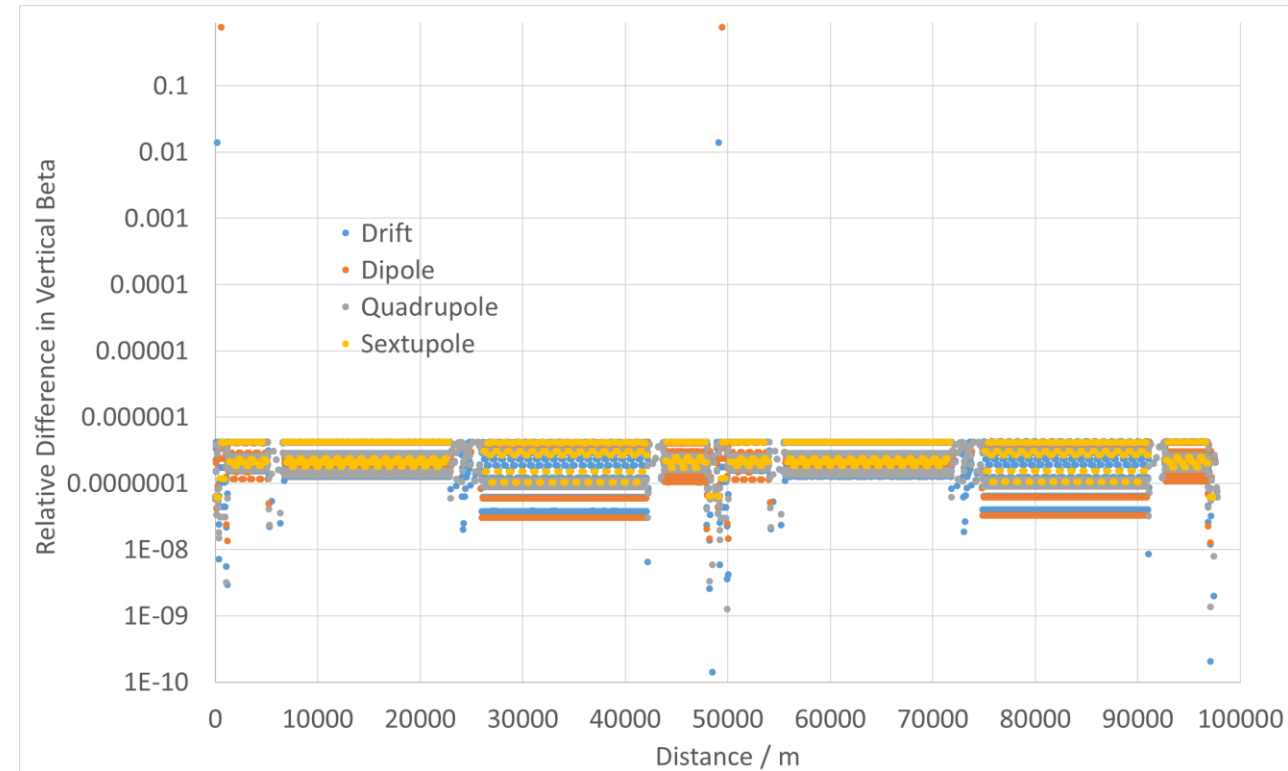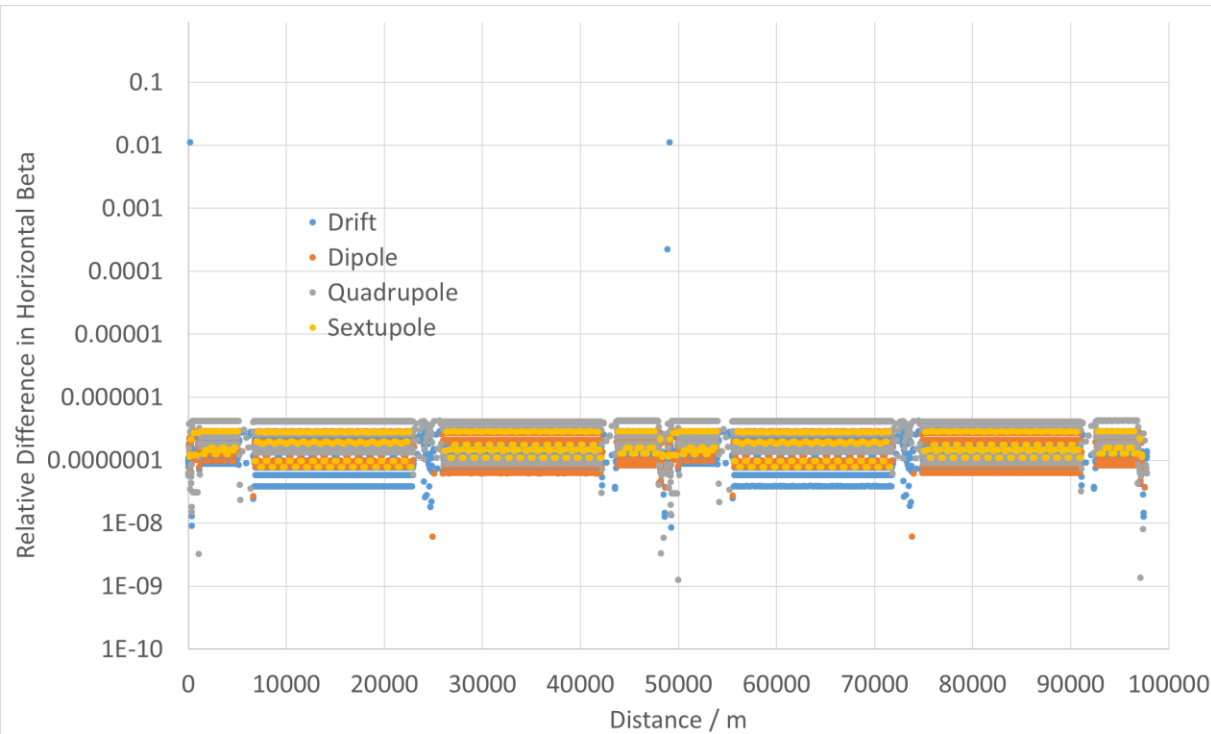   - **Change of Radiation Integrals with Momentum**

Linear Optics Comments

- Good agreement in beta functions and phase advance
  - $< 10^{-4}$ disagreement
  - Larger than numerical precision
- MADX and SAD seem to have a very slightly better agreement
  - $< 10^{-6}$ disagreement
  - Comparison of SAD and MAD-X for FCC-ee studies

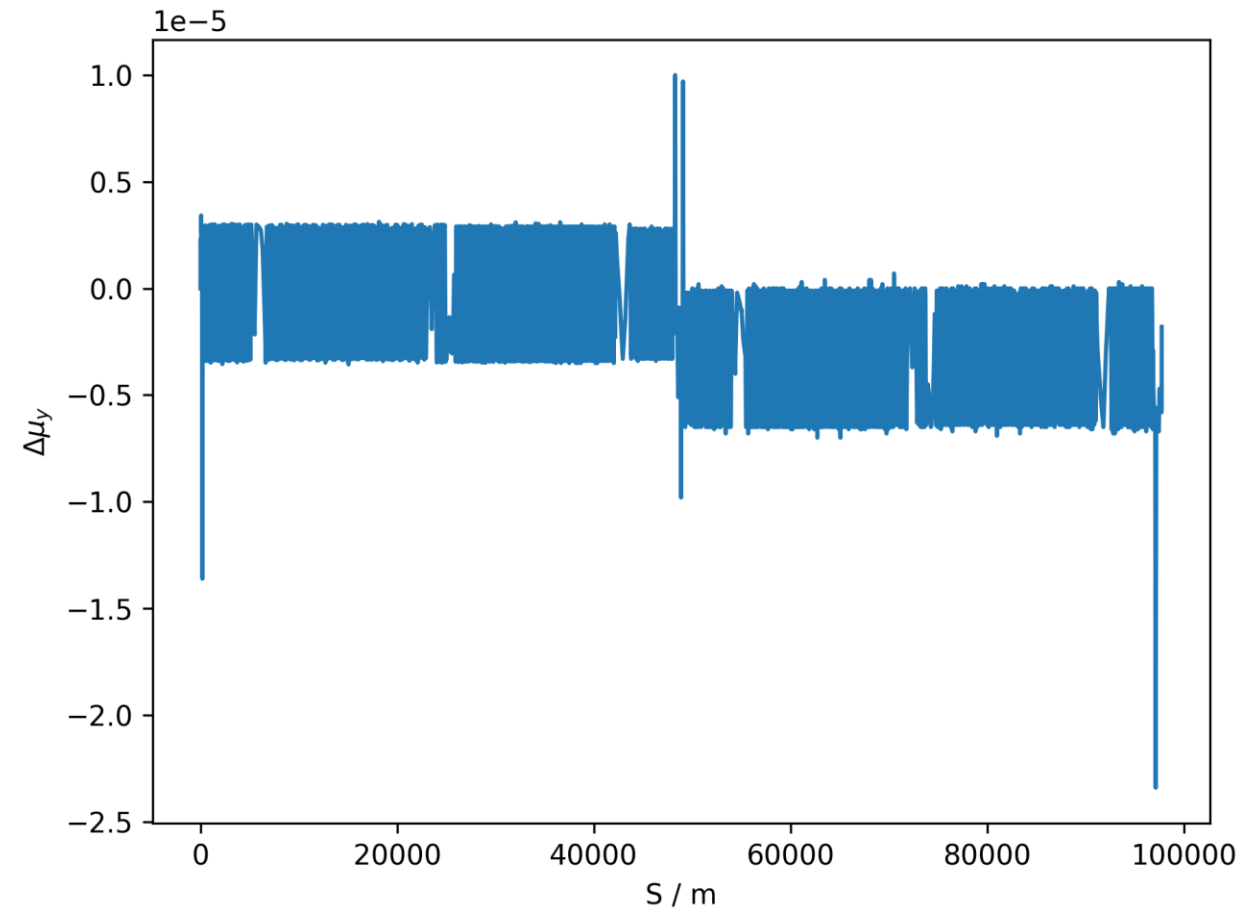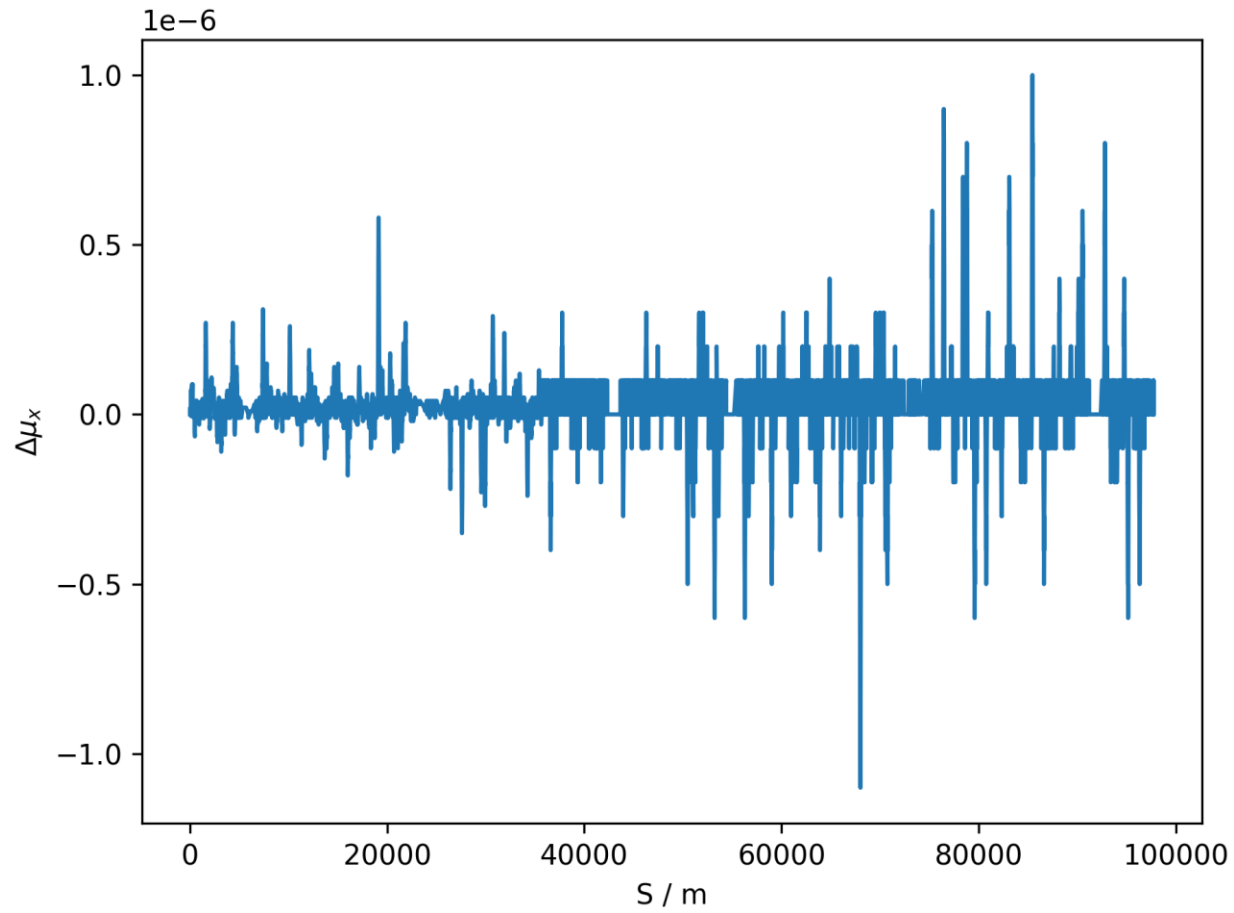# Beta Beat Between MADX and MAD-NG
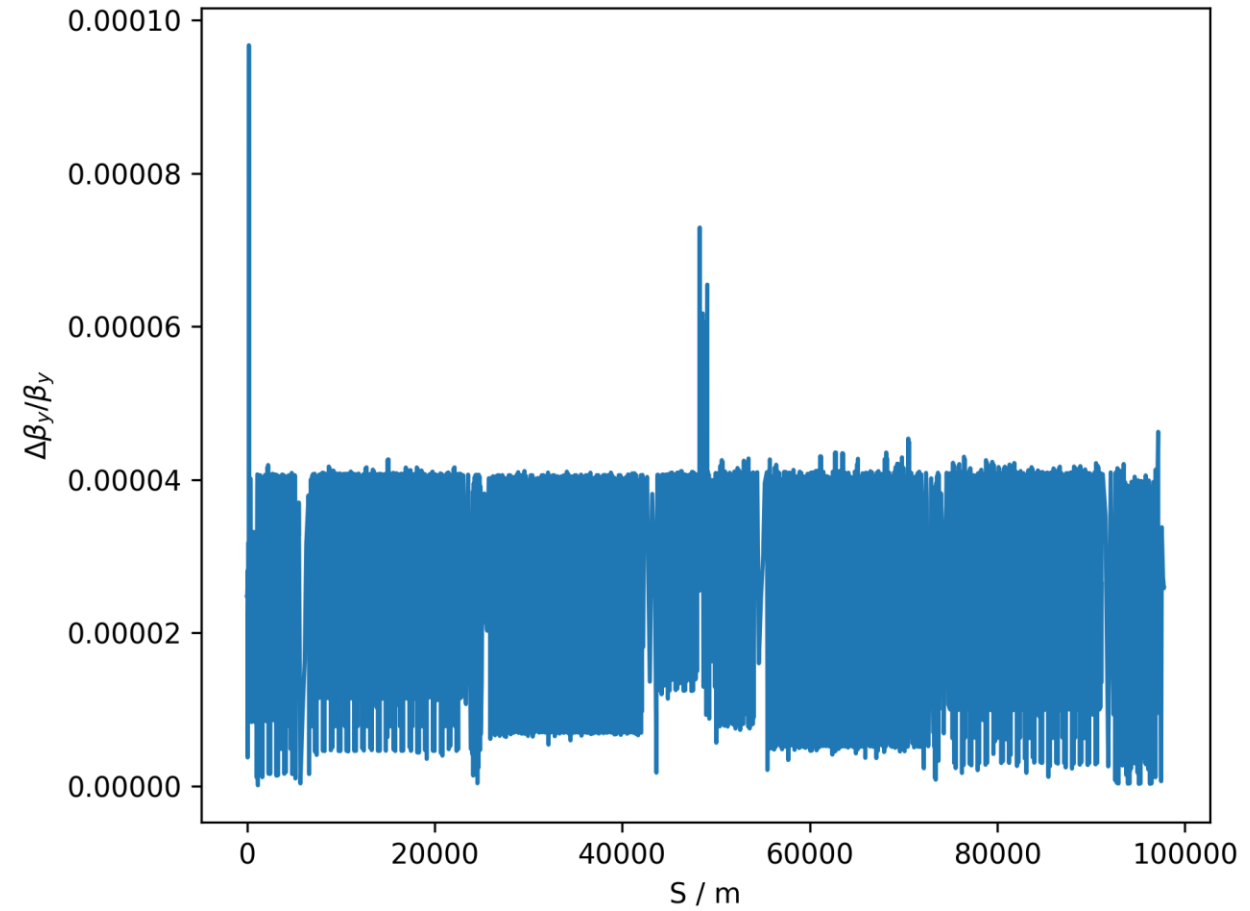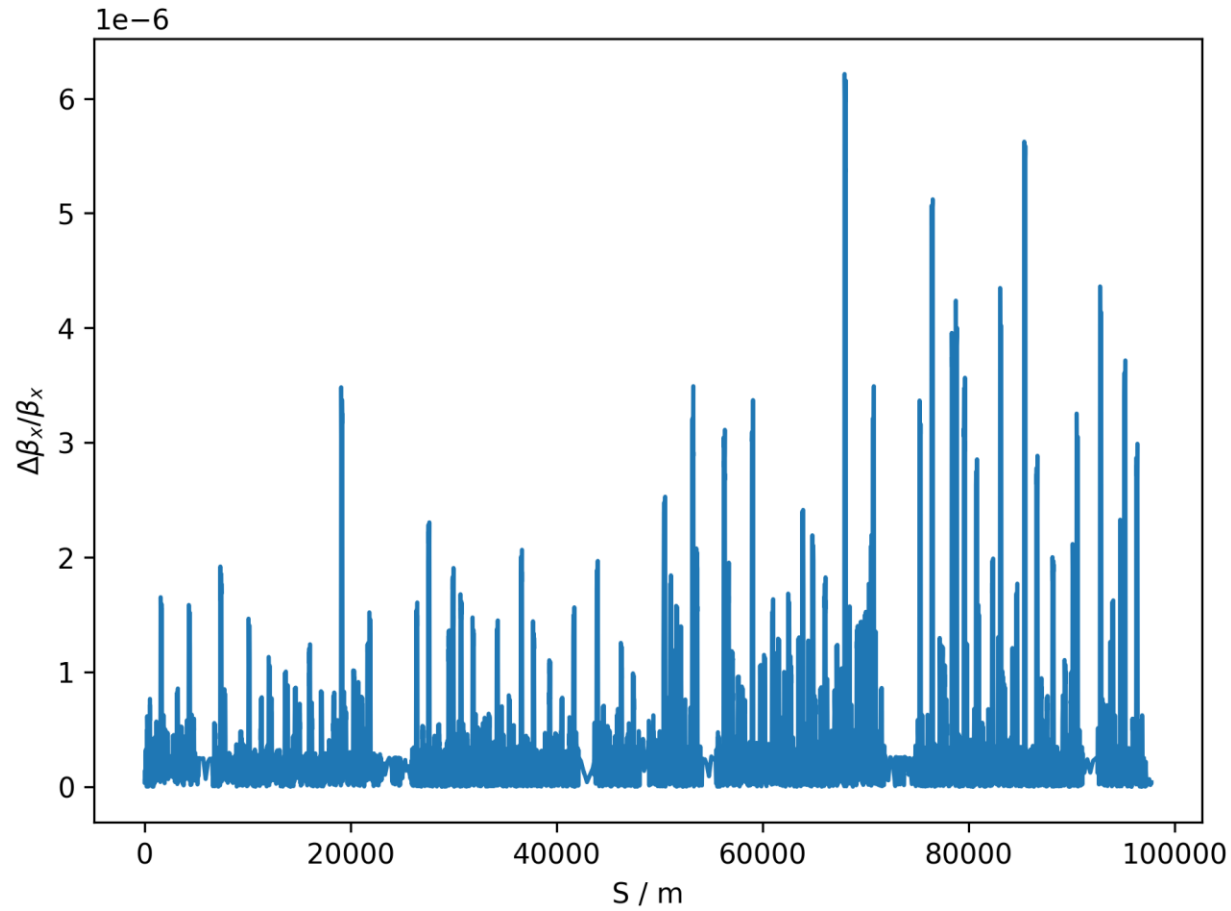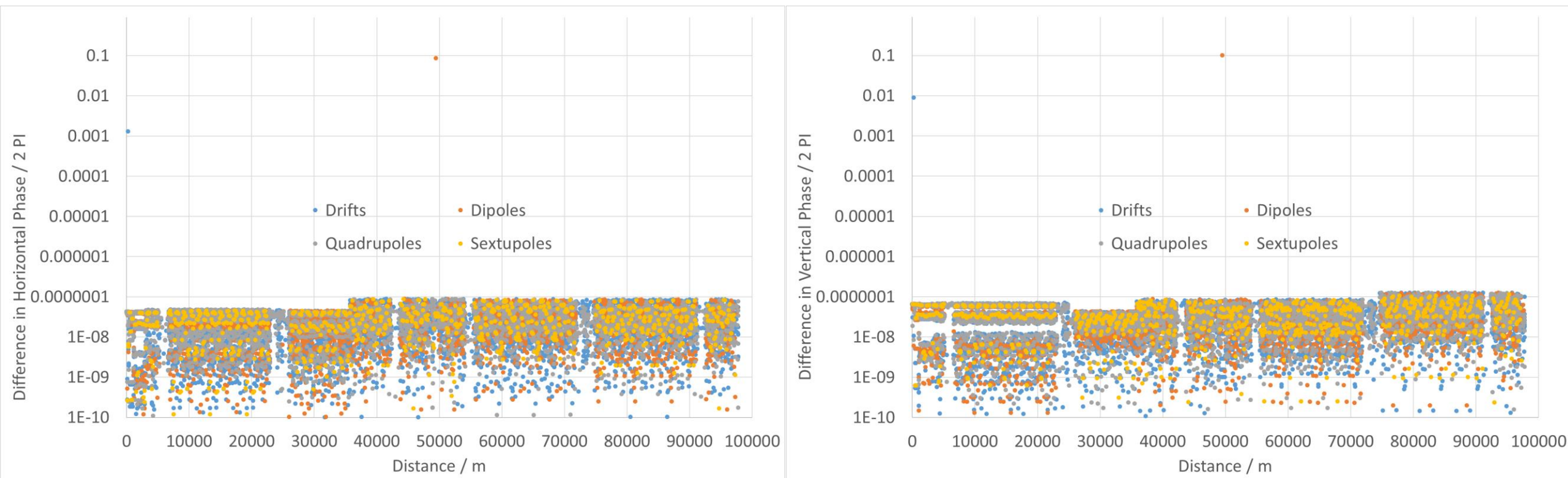
Comparison to MADX-SAD Study

Comparison of SAD and MAD-X for FCC-ee studies 11/09/2019

Phase Advance Difference MADX and MAD-NG

Comparison to MADX-SAD Study

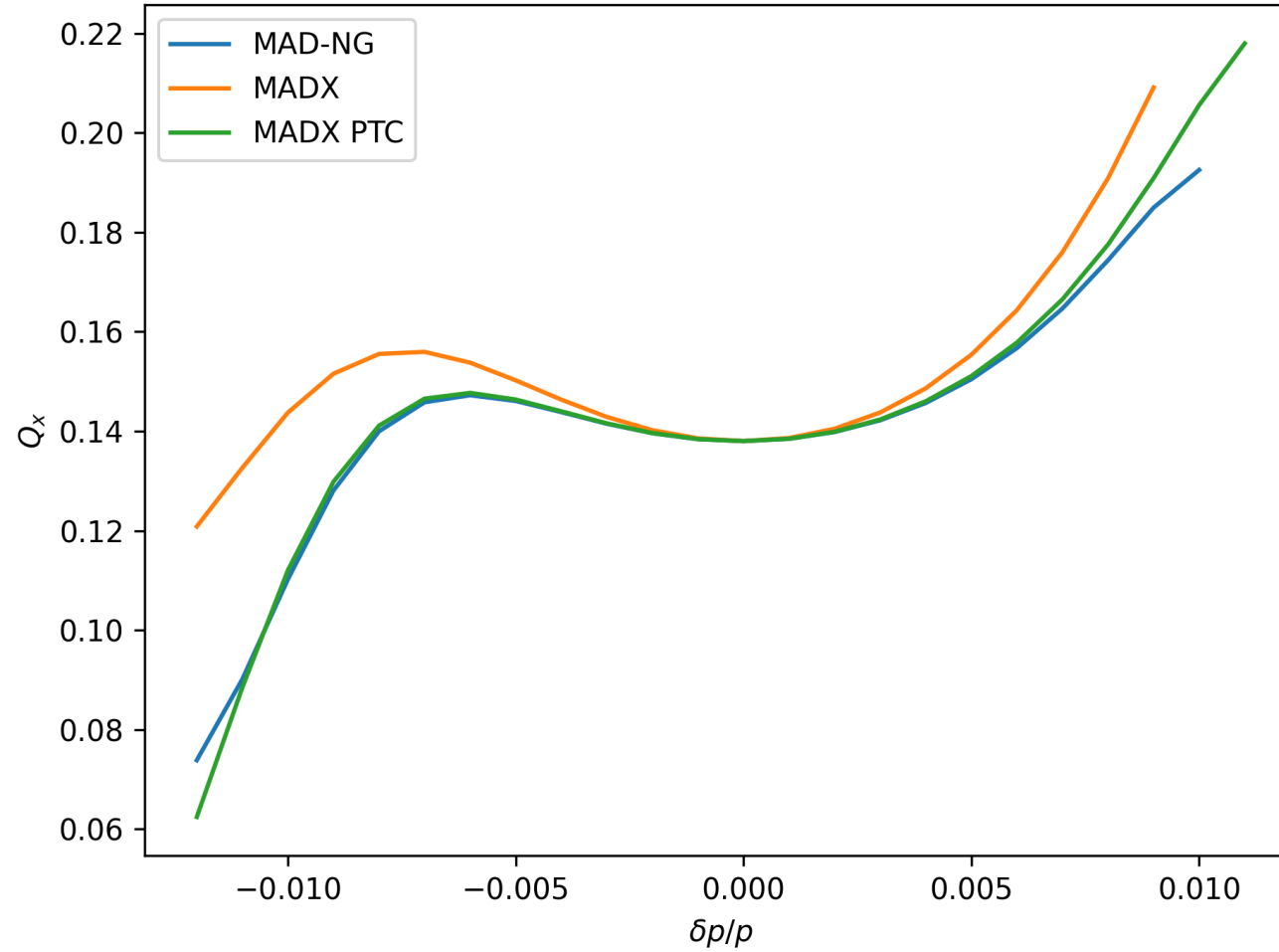Comparison of SAD and MAD-X for FCC-ee studies 11/09/2019

Momentum Detuning Comments

- Very Good agreement with PTC
  - Somewhat expected
- Good Agreement with MADX
- Previously demonstrated MADX, PTC and SAD have good agreement
  - Comparison of SAD and MAD-X for FCC-ee studies
- Time taken for Twiss at 23 momenta (on lxplus):

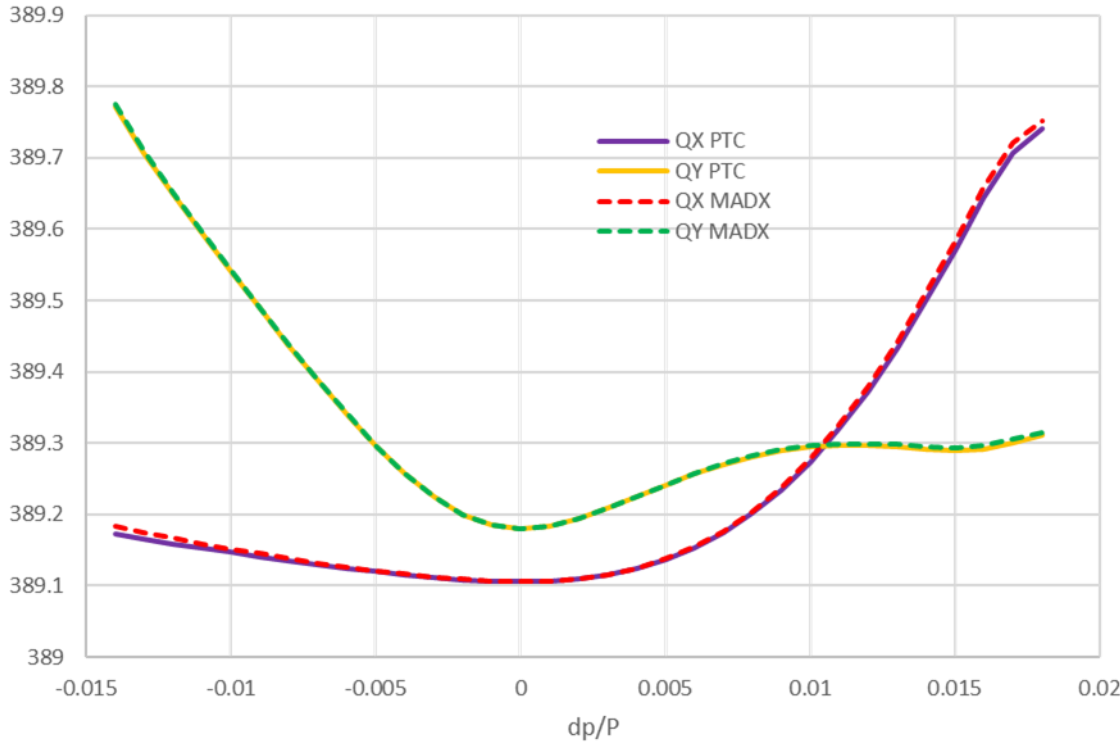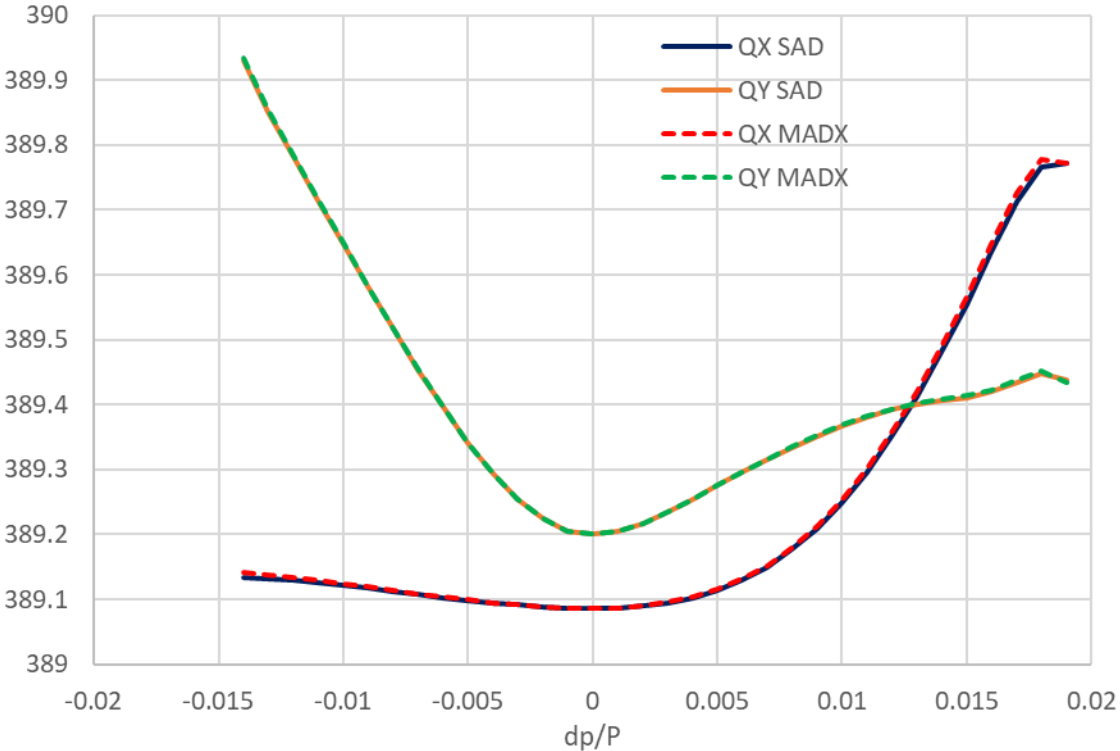| Program	MADX	PTC	MAD-NG
Time Taken	49.309s	22m39.948s	2m2.321s

Horizontal Momentum Detuning

Vertical Momentum Detuning
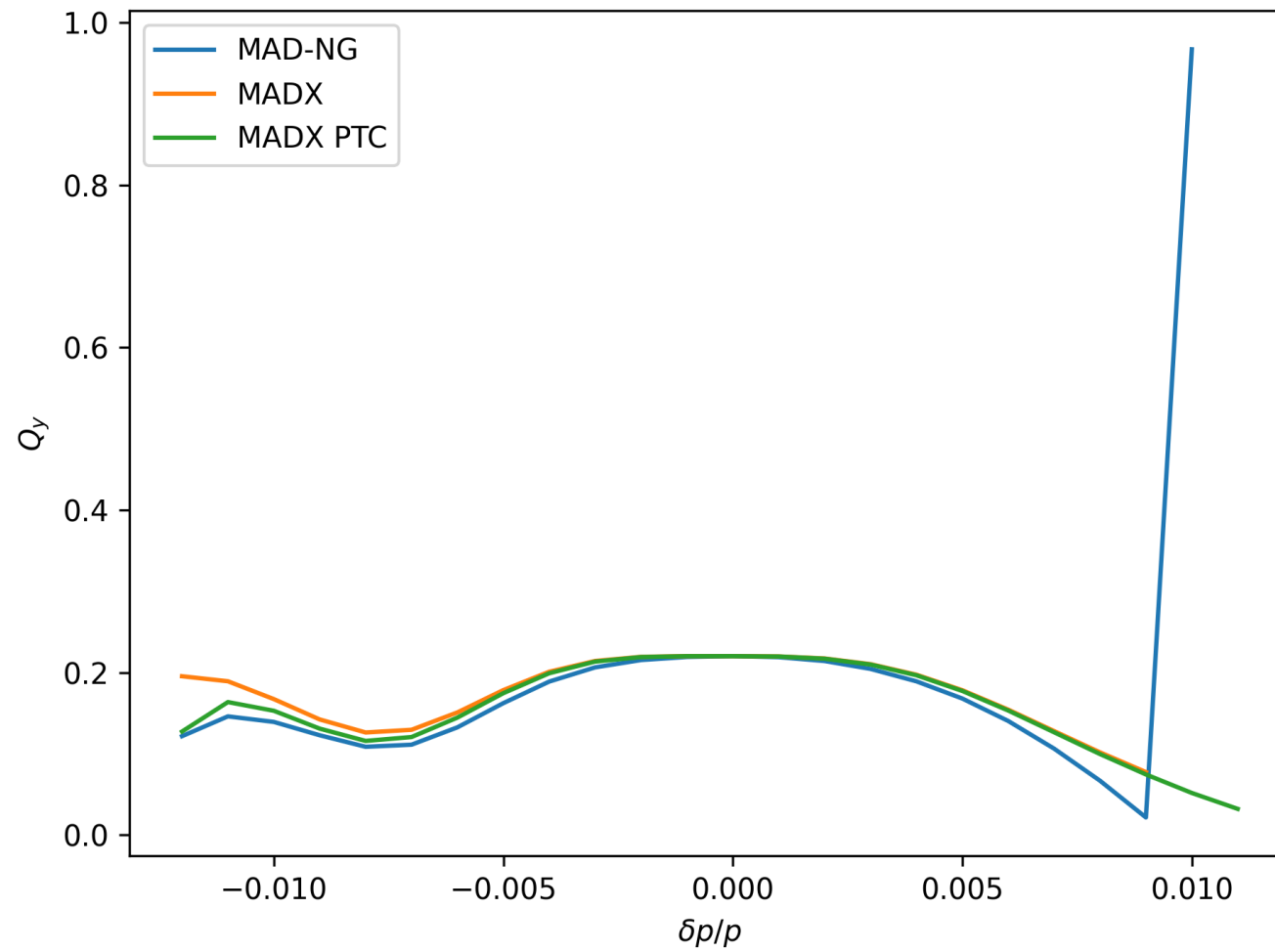
Comparison MADX-SAD (Different Lattice)

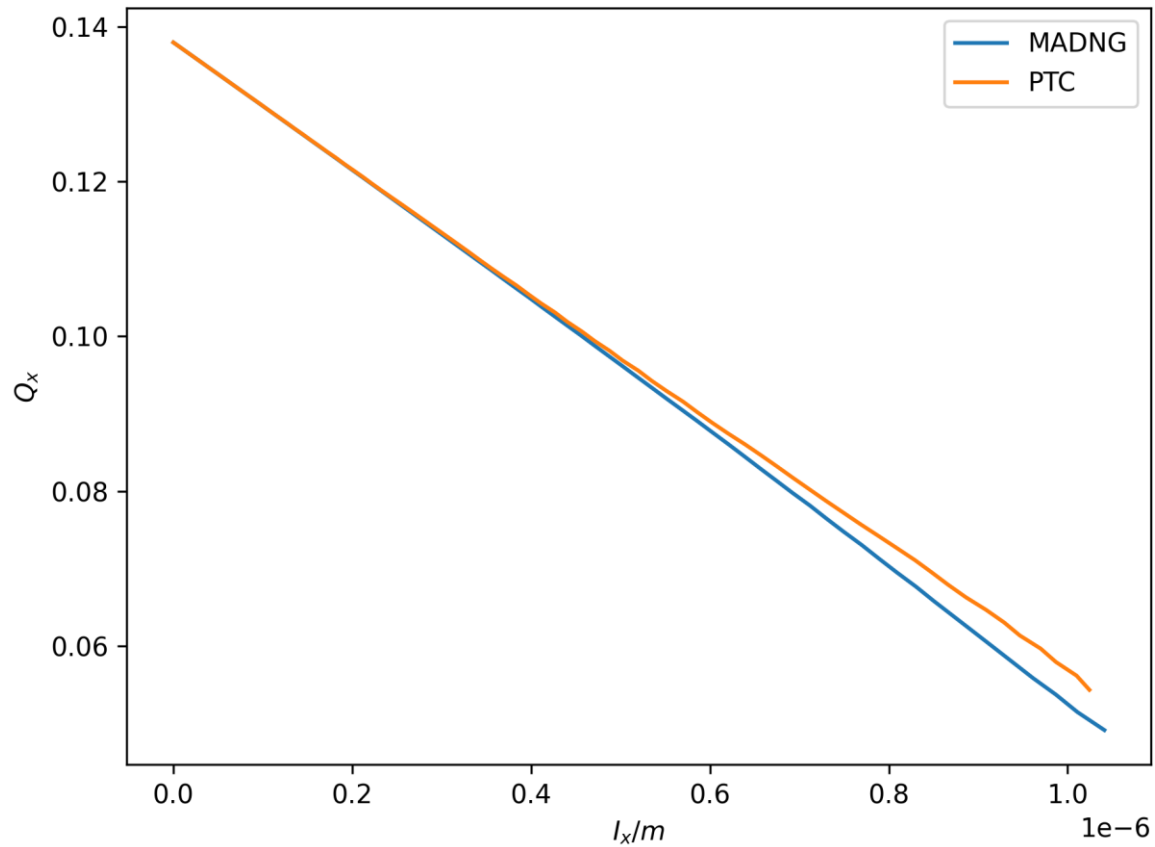Comparison of SAD and MAD-X for FCC-ee studies 11/09/2019
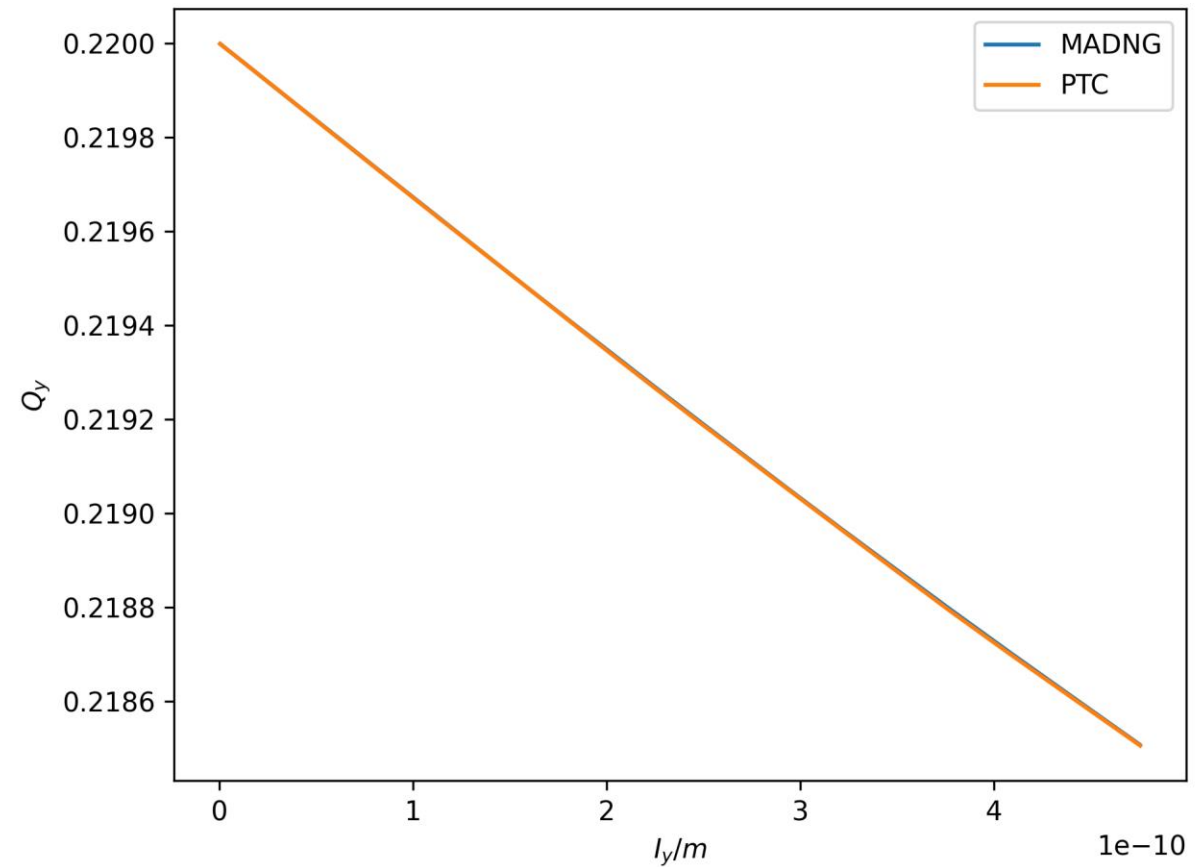
Amplitude Detuning

- Computed from tracking
- Requires to track various particles over 1000 turns
- Slower in MAD-NG than in MADX PTC
  - Tracking one particle for 1000 turns takes:
    - 53.085s in MADX PTC
    - 6m20.368s in MAD-NG
      - (big improvement compared to 0.9.2)
      - 2m4.257s with optimised LuaJIT settings
- Very good agreement with MADX PTC
  - And by extension with SAD (Comparison of SAD and MAD-X for FCC-ee studies)
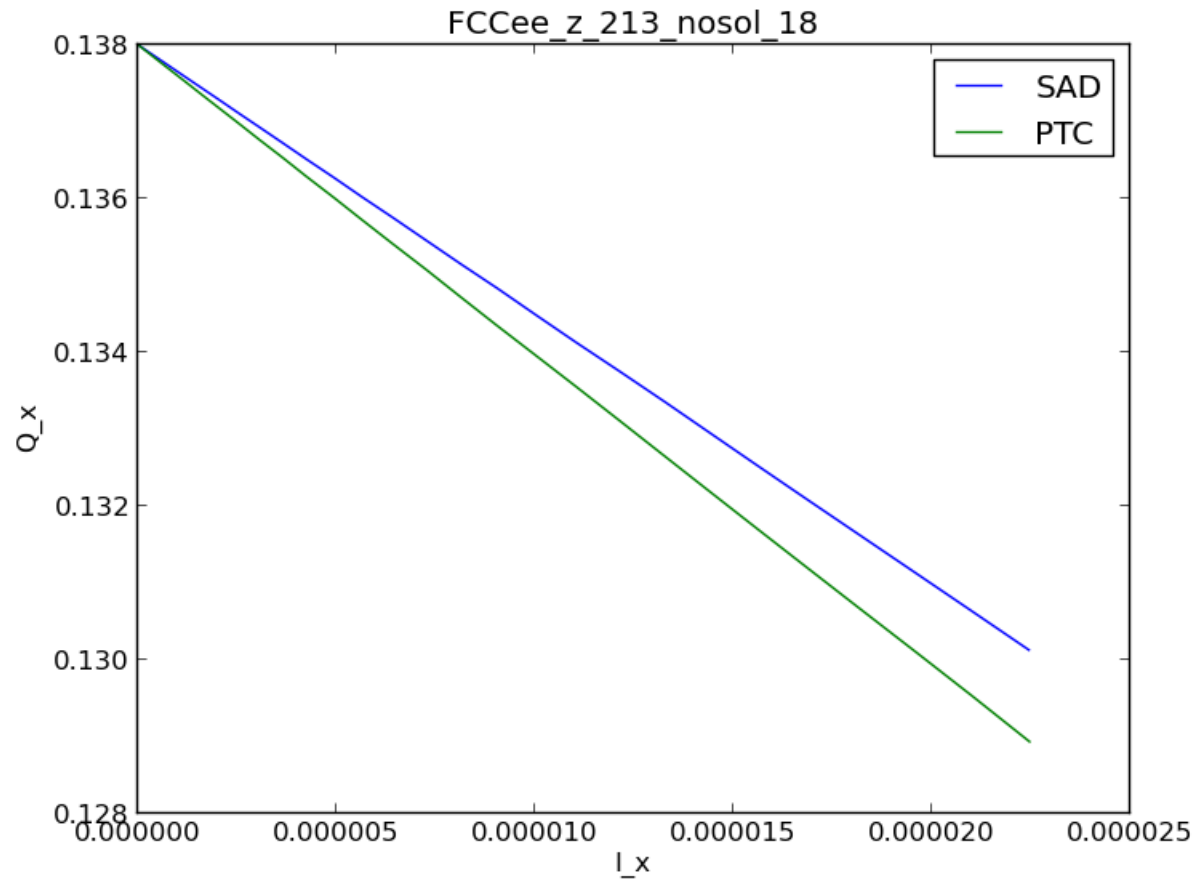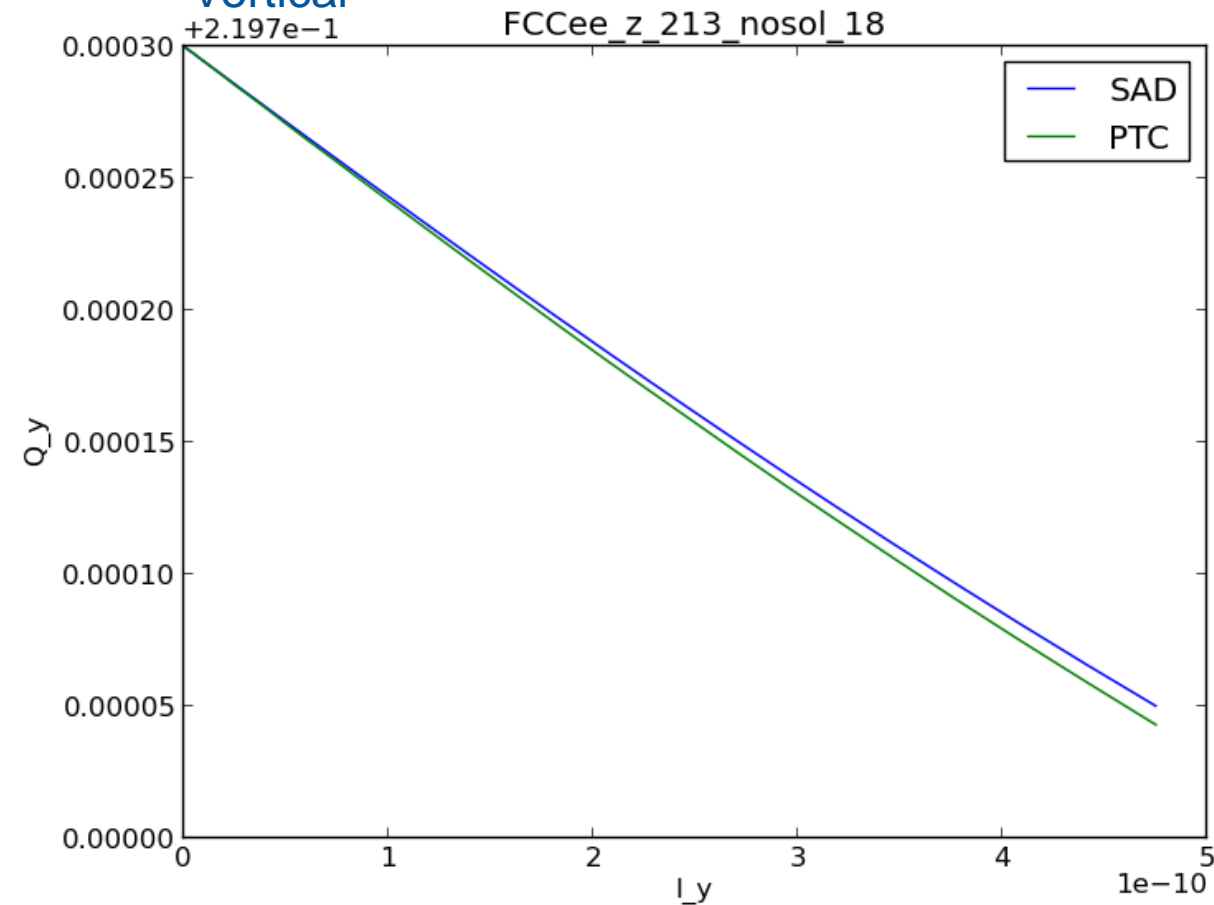
Amplitude Detuning

Horizontal

Vertical

Amplitude Detuning SAD vs PTC

Horizontal

Vertical

Radiation Integrals Comments

- Good agreement for $I_2 - I_6$
  - In line with MADX and SAD
- I_1 and I_8 seem incorrect
- Radiation integrals do not vary with δp
  - (Except I_5)
  - Behaves like in MADX not SAD
  - Behaviour depends on "definition" of integrals
   - This is now (partly) covered by I_8

Radiation Integrals

Integral	MADX	Python	SAD	MADNG
1	0.7100081	0.70971549	0.7100081	0.5669974051
2	5.8860840×10^{-4}	$5.86318537 \times 10^{-4}$	5.8860828×10^{-4}	5.8860839×10^{-4}
3	5.4659304×10^{-8}	$5.44812934 \times 10^{-8}$	5.4659284×10^{-8}	5.4659304×10^{-8}
4	$-2.2581086 \times 10^{-10}$	$6.12737765 \times 10^{-9}$	$-2.2581082 \times 10^{-10}$	$-2.2581114 \times 10^{-10}$
5	$1.7514444 \times 10^{-11}$	$1.73428611 \times 10^{-11}$	$1.7535621 \times 10^{-11}$	$1.1298345 \times 10^{-11}$
6	308.9578842	278.223191	-	308.9578655
8	0.08490657652	0.0849090719	-	0.009387432728

Radiation Integrals in MADX 20/05/2020

Variation of Radiation Integrals

Integral	MADX
1	0.7100081
2	5.8860840×10^{-4}
3	5.4659304×10^{-8}
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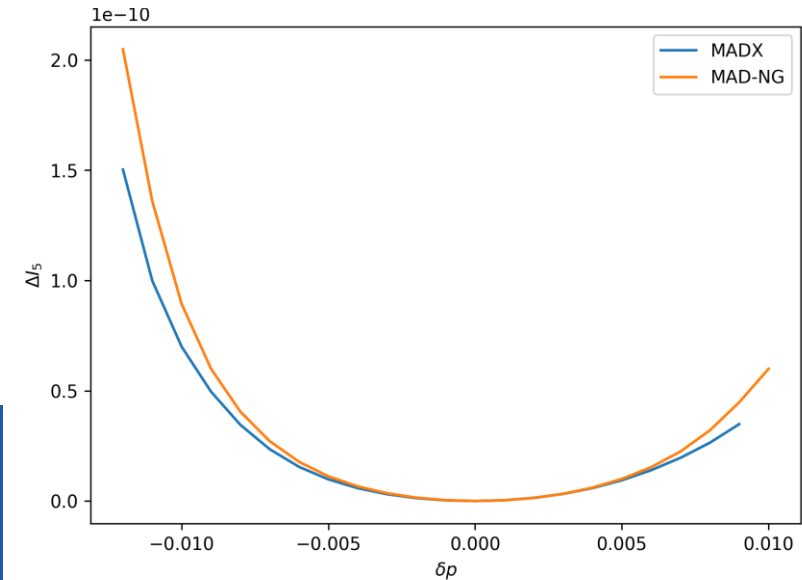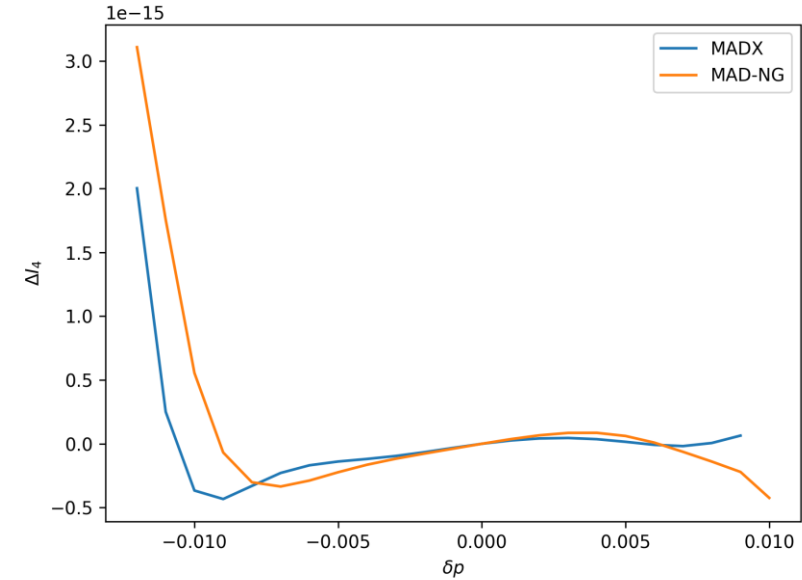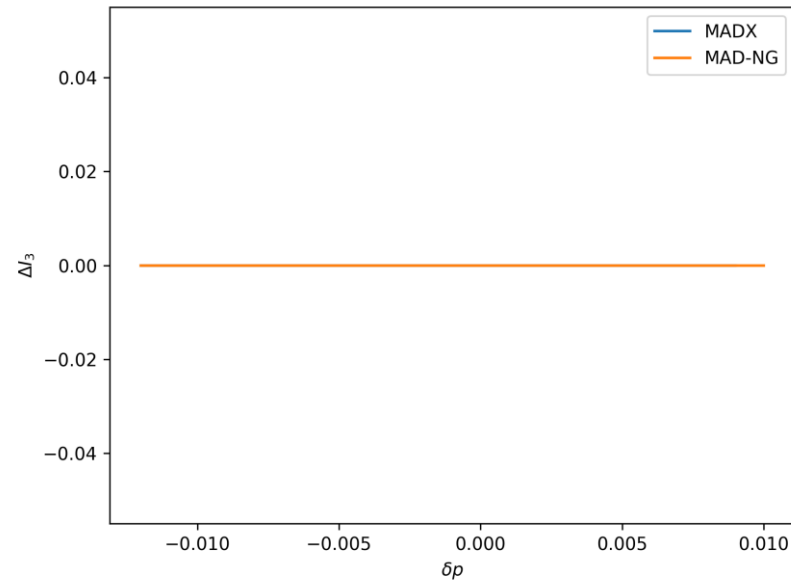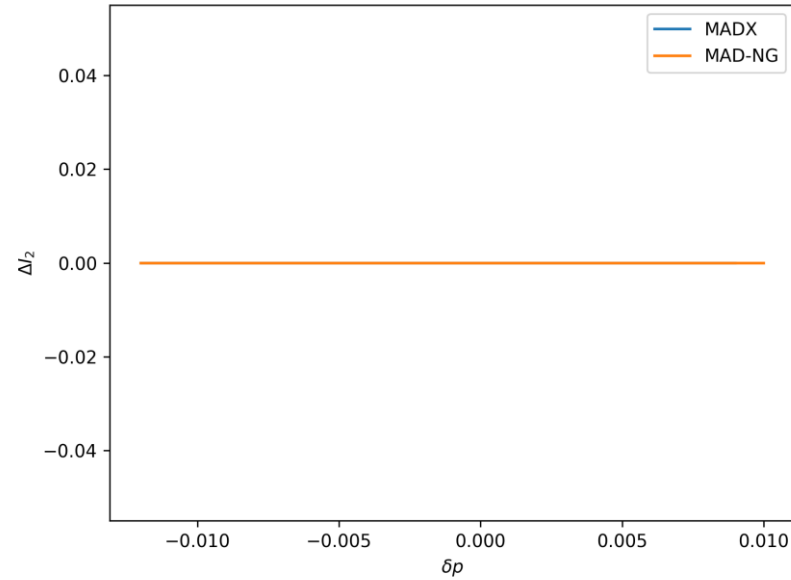
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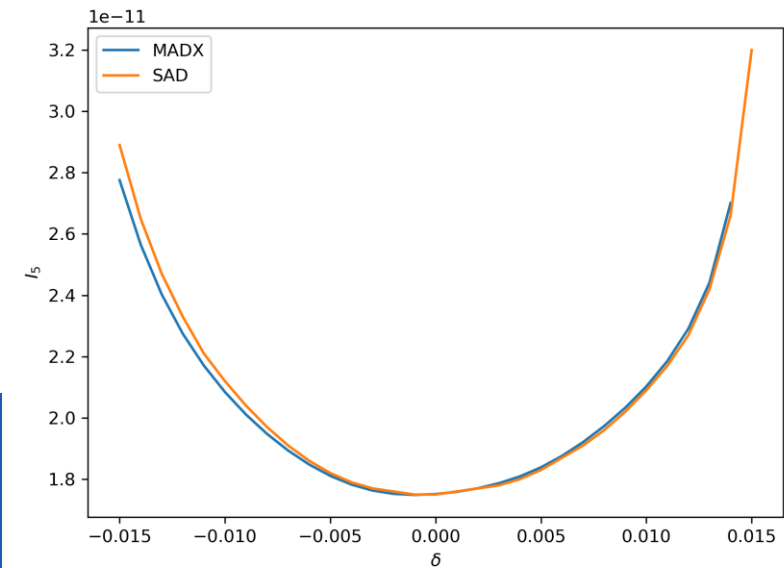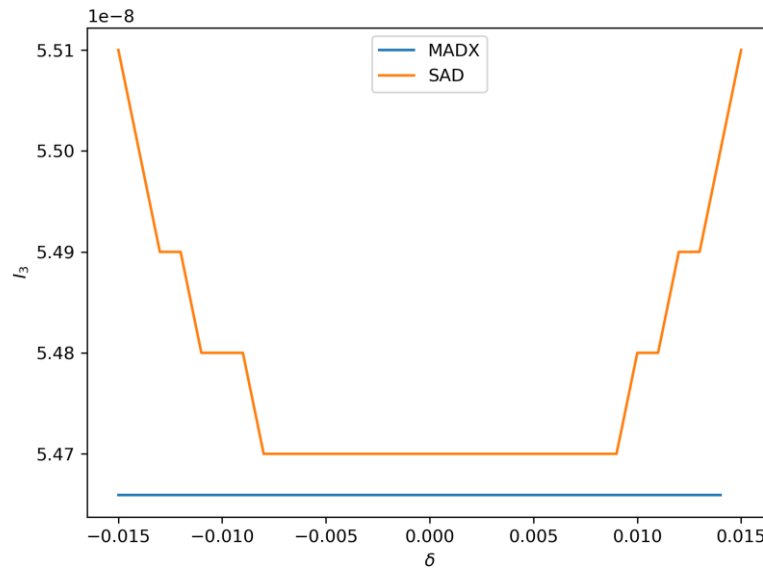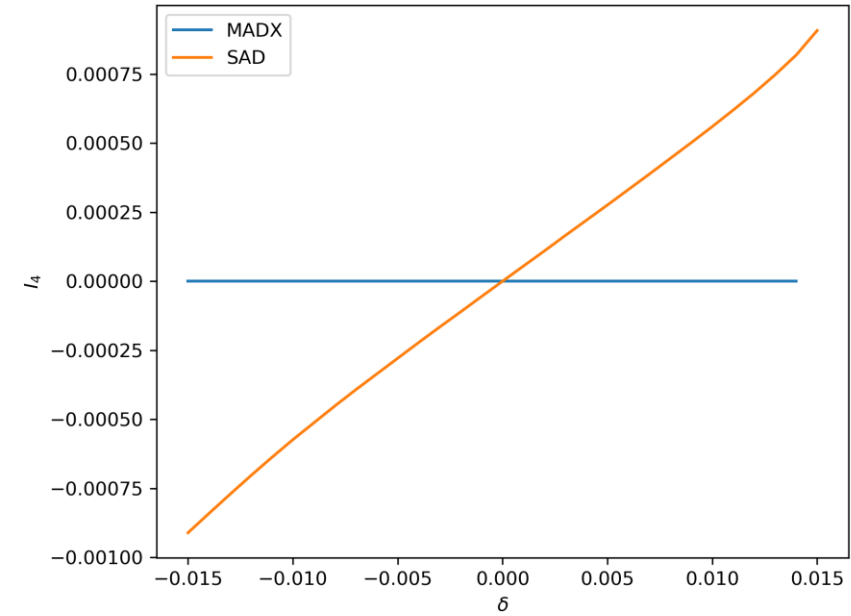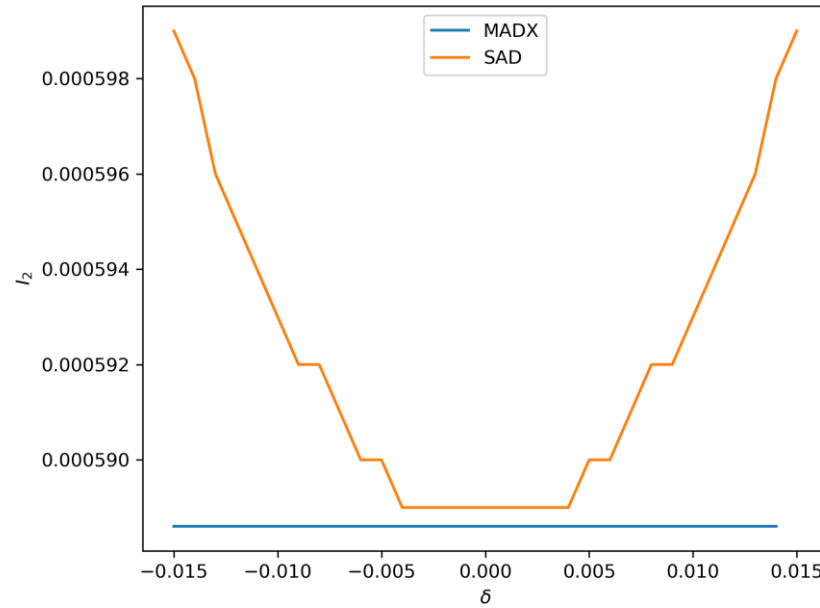
Conclusions

- MAD-NG is able to produce linear optics that agree with MADX and SAD

  - Even in large machine with complicated optics

- Momentum detuning is in good agreement with MADX and PTC

  - And by extension with SAD

  - MAD-NG slightly slower than MADX but significantly faster than PTC

- Amplitude detuning from tracking is in good agreement with MADX PTC

  - And by extension with SAD

  - MAD-NG twice as slow as MADX PTC with optimised LuaJIT setting

- Radiation integrals behave like defined in MADX

  - With the exception in I_1 and I_8

Backup

Some Technical Details

- MADNG version 0.9.3
  - Flags used in twiss:
    - method=6, nslice=3, cofind=true, ptcmodel=true
  - Flags used in tracking:
  - method=6, nslice=3, ptcmodel=true
- PTC Model Flags:
  - time=true,model=2,method=6,nst=3,exact=true
  - Flags used in twiss:
    - ICASE=6, no=2, closed_orbit=true, deltap_dependency = true
  - Flags used in tracking:
    - icase=6