

Dynamic aperture study for LHC

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Russenschuck

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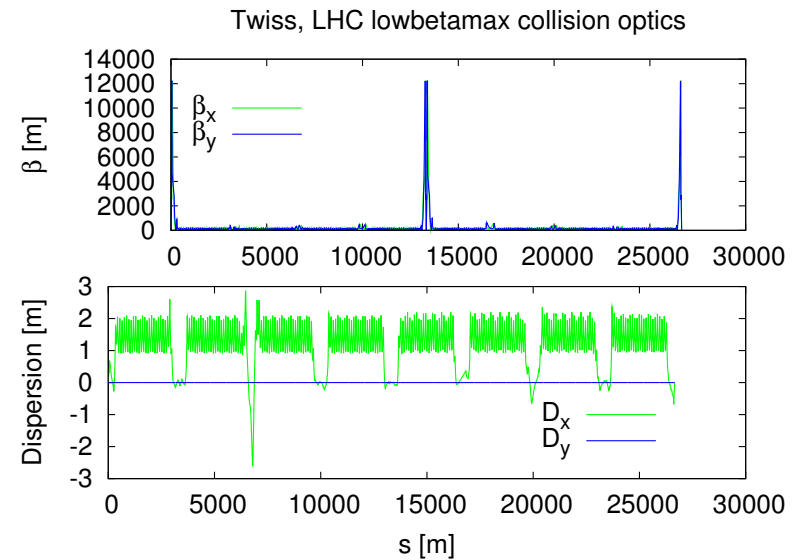
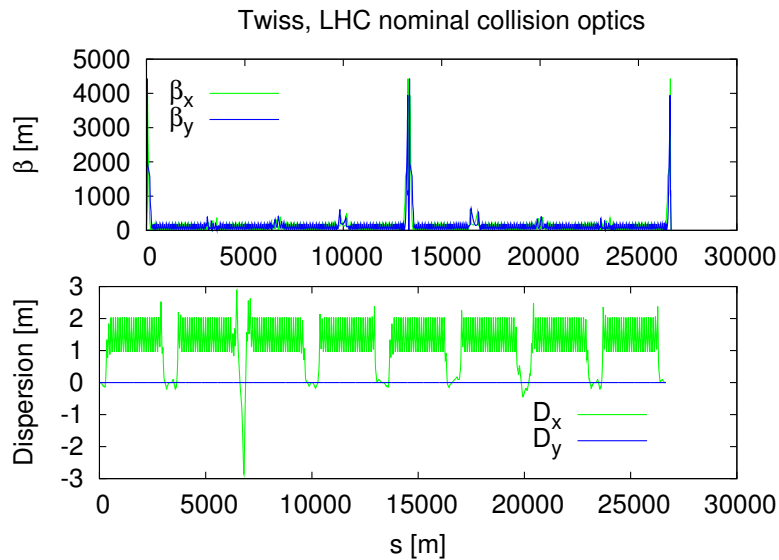
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- Tracking condition
- Comparison between MADX and SixTrack
- Dynamic aperture with crab cavity (CC)
- Dynamic aperture with CMS stray field

Tracking condition

- MADX: dynap module, 1024 turns
 - Modified thintrack module to include aperture check (1 m) at each drift
- SixTrack
 - 1000 and 100,000 turns Aperture check each element 1 m
 - 60 multipole error seeds
 - `/afs/cern.ch/user/r/rdemaria/dott/pool/errors/collision_errors*.tfs` (up to a15 & b15)
- Crab cavity: Local CC (LCC) and Global CC (GCC)
- CMS stray field: measured

Optics: LHC nominal and lowbetamax



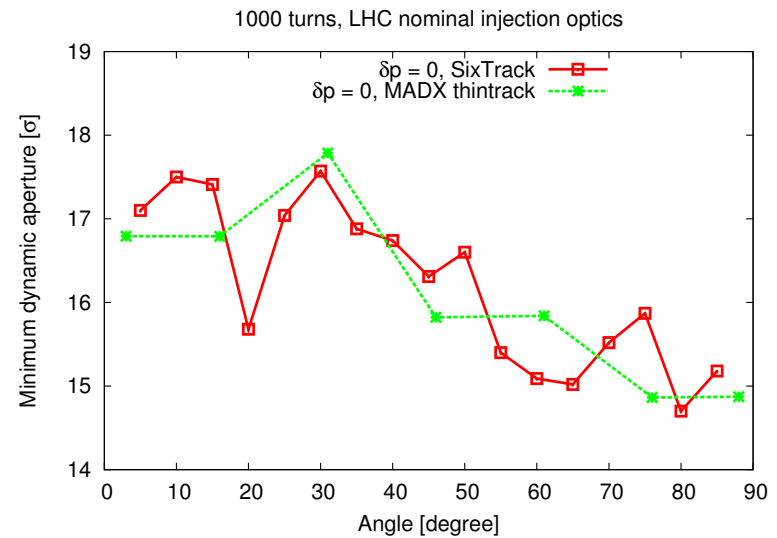
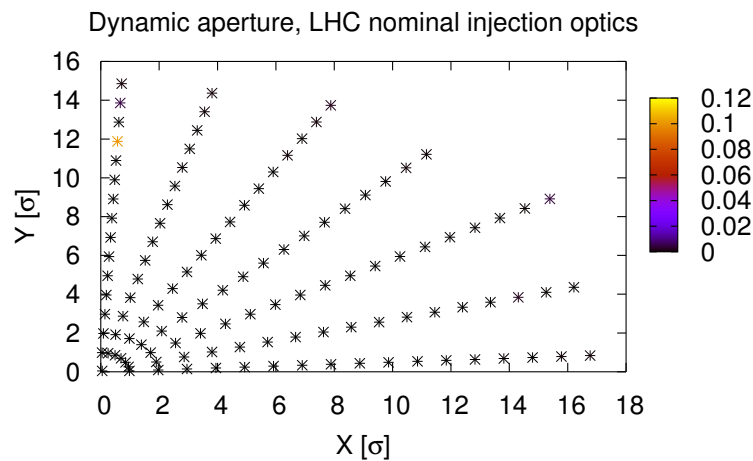
Left: LHC nominal collision optics

/afs/cern.ch/user/r/rtomas/w1/sixjobs/mask/lhc_normal.mask

Right: Lowbetamax collision optics

/afs/cern.ch/user/r/rtomas/w1/sixjobs/mask/lhc_lowbeta-WH.mask

Comparison(1): LHC nominal injection

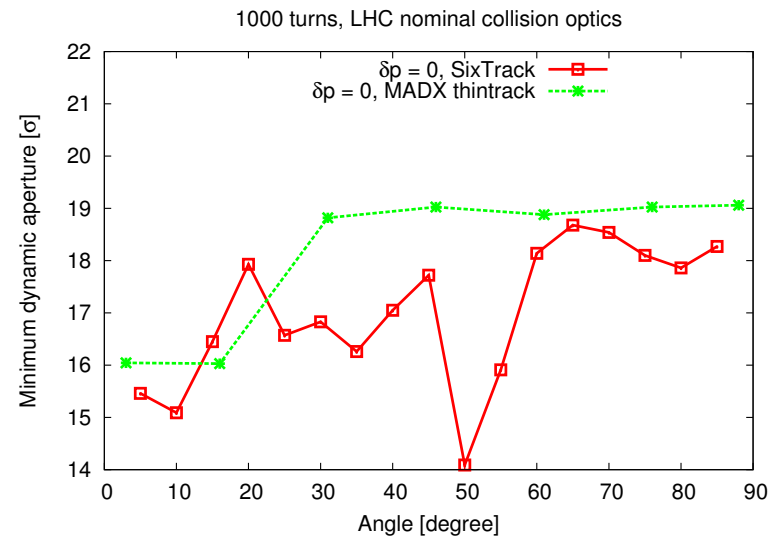
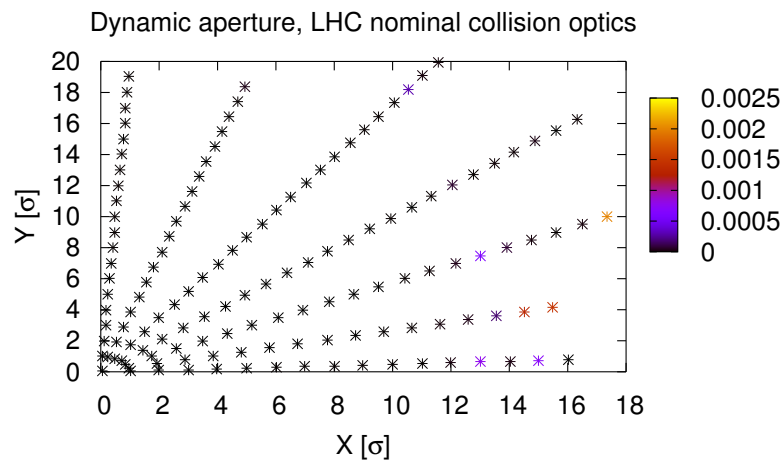


1000 turns, with error seed 1

Left: MADX (16 σ);

Right: MADX .VS. SixTrack (16 σ)

Comparison(2): LHC nominal collision

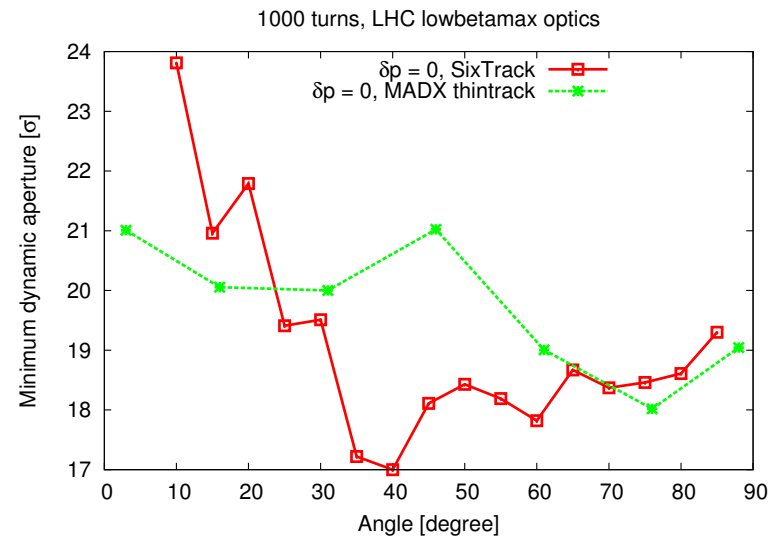
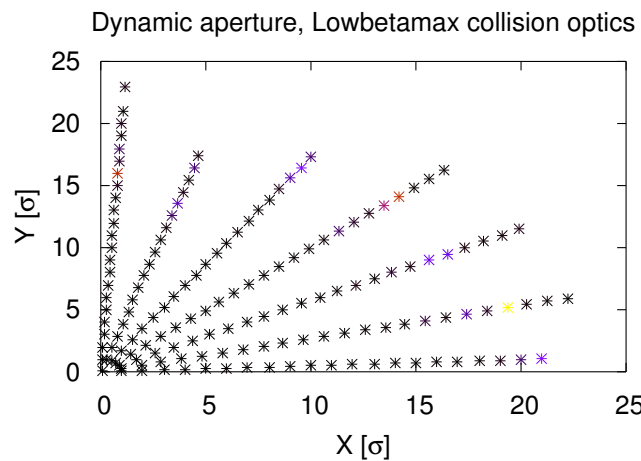


1000 turns, with error seed 1

Left: MADX (18.5σ);

Right: MADX .VS. SixTrack (17.5σ)

Comparison(3): lowbetamax collision

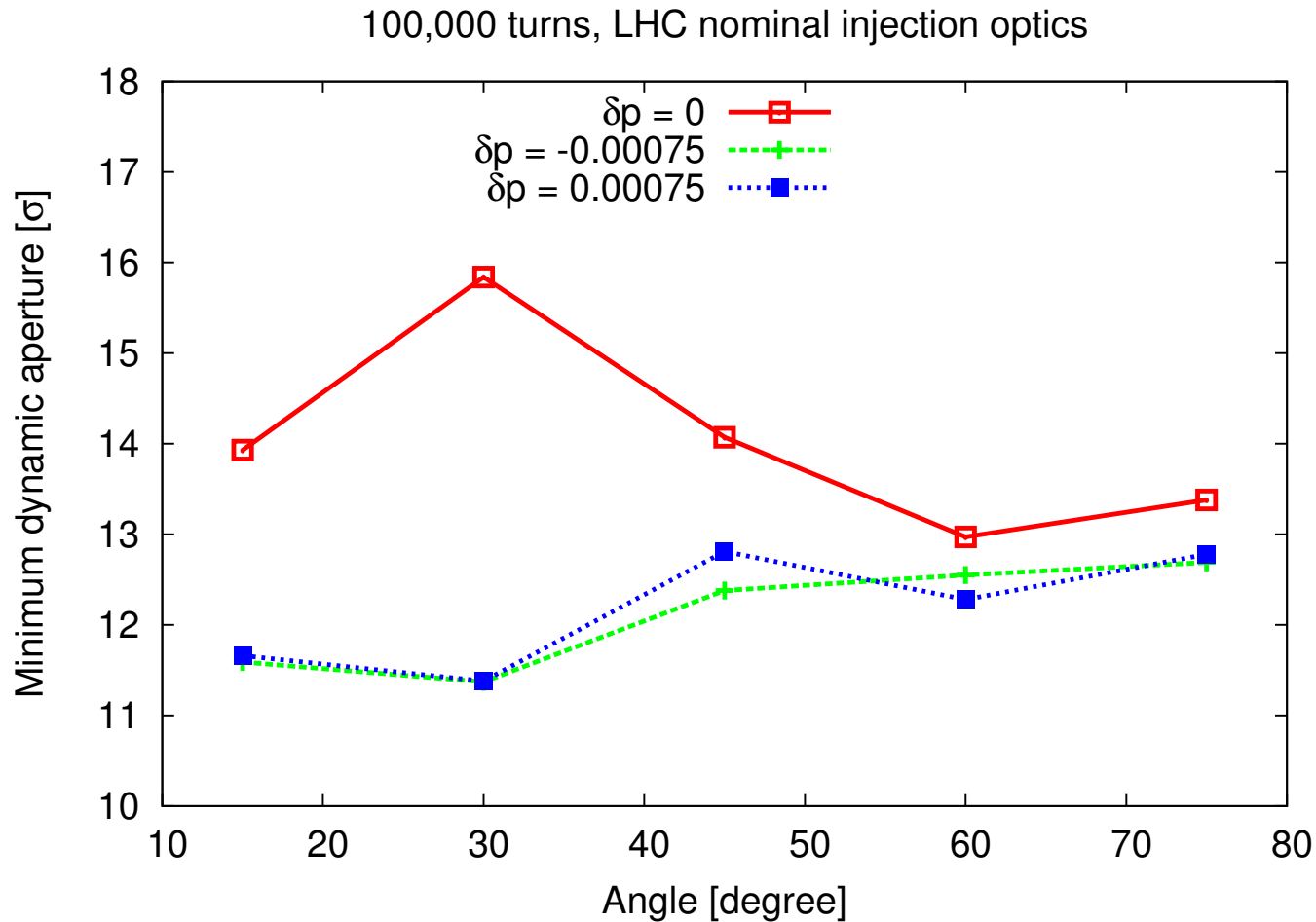


1000 turns, with error seed 1

Left: MADX(20 σ);

Right: MADX .VS. SixTrack (19 σ)

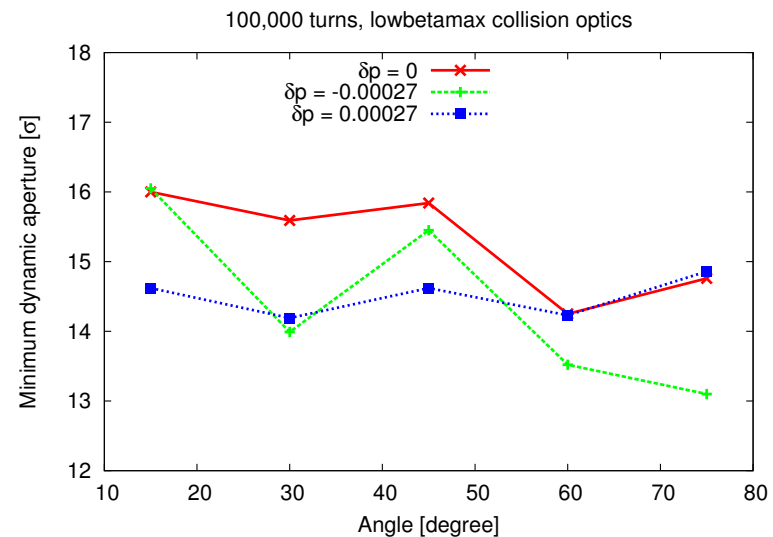
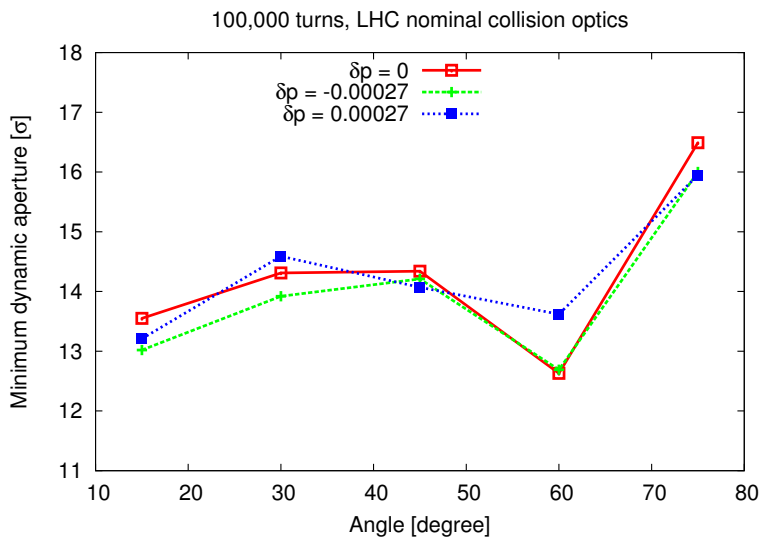
DA .VS. Momentum (1): injection



LHC nominal injection optics, [SixTrack](#) (60 seeds min)

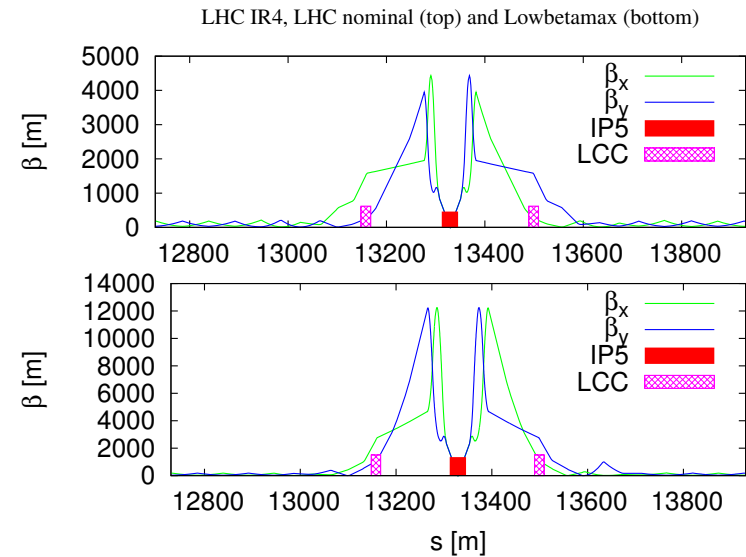
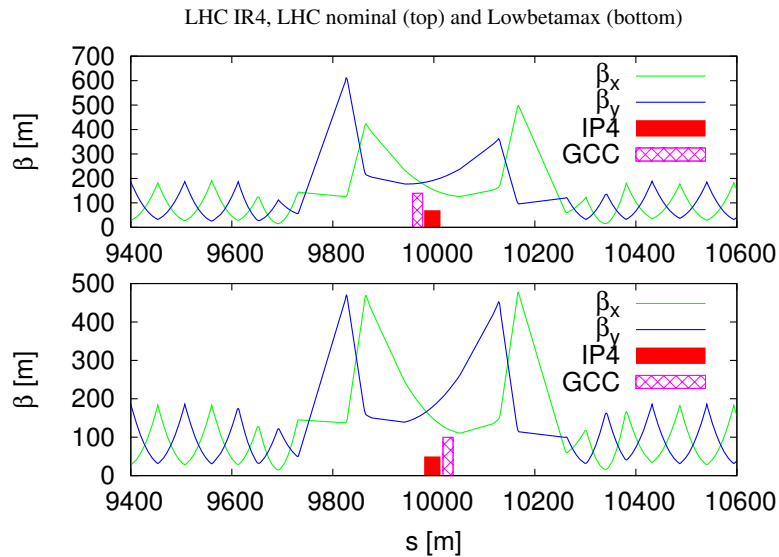
Driven by the cross-check with MAD-X

DA .VS. Momentum (2): collision



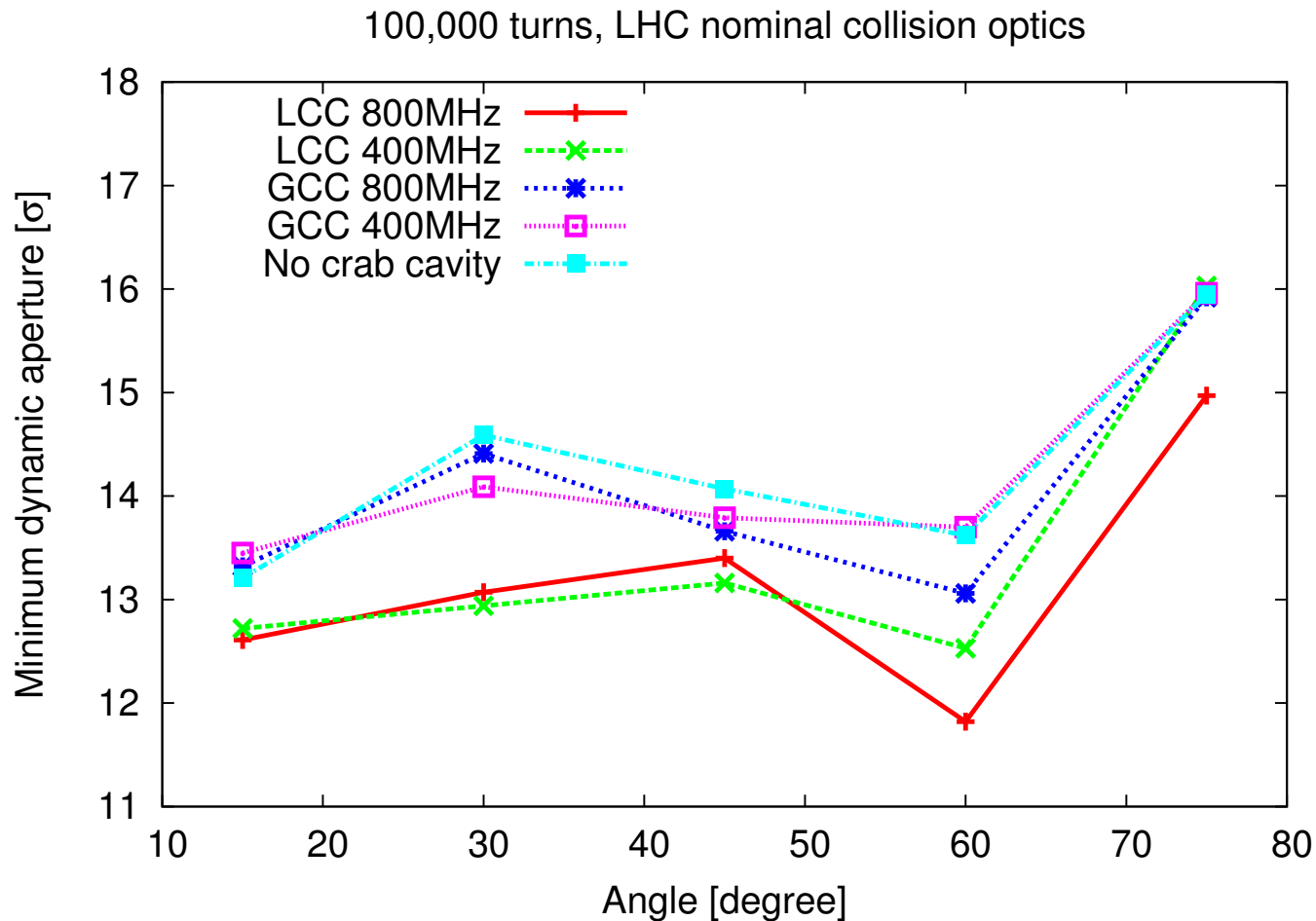
Left: LHC nominal collision optics; Right:
Lowbetamax collision optics
SixTrack (60 seeds min)

Optics: GCC and LCC



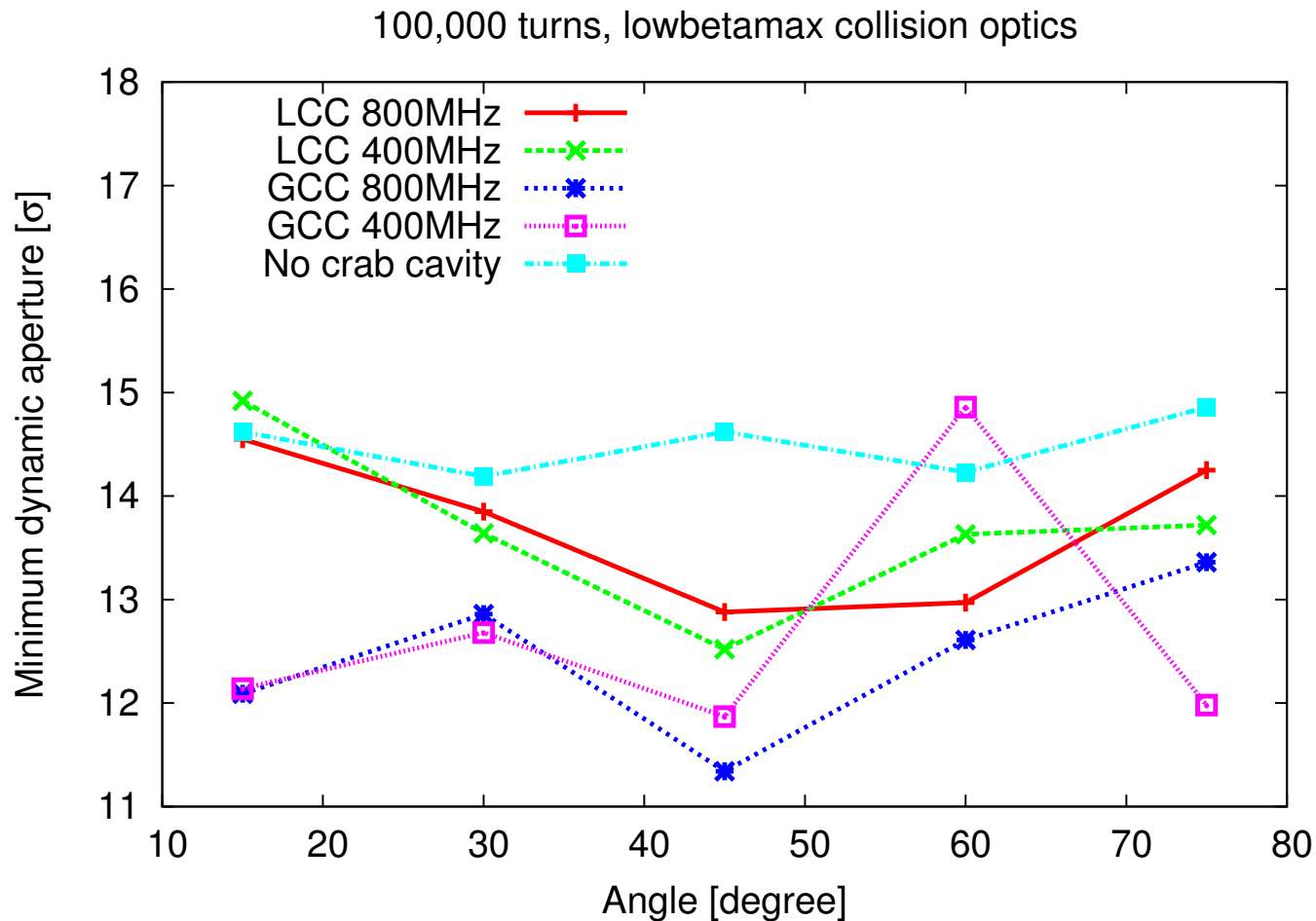
Left: IR4, Global CC; Right: IR5, Local CC

DA with CC, LHC nominal



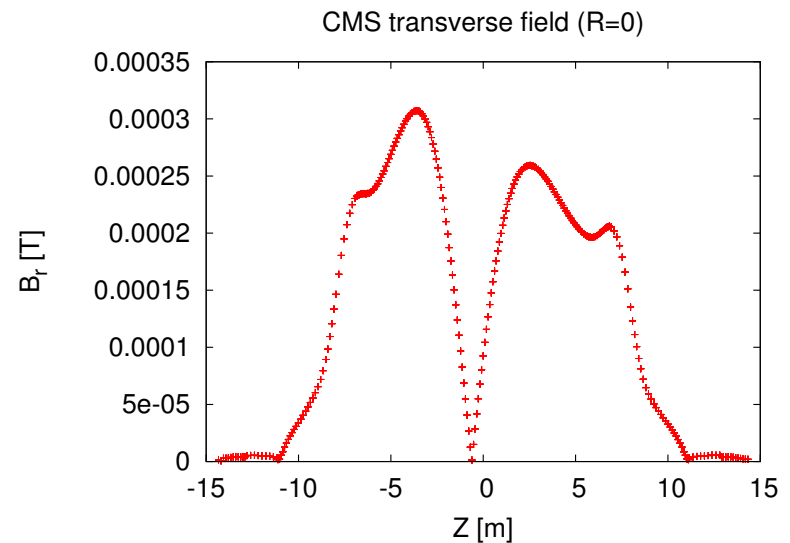
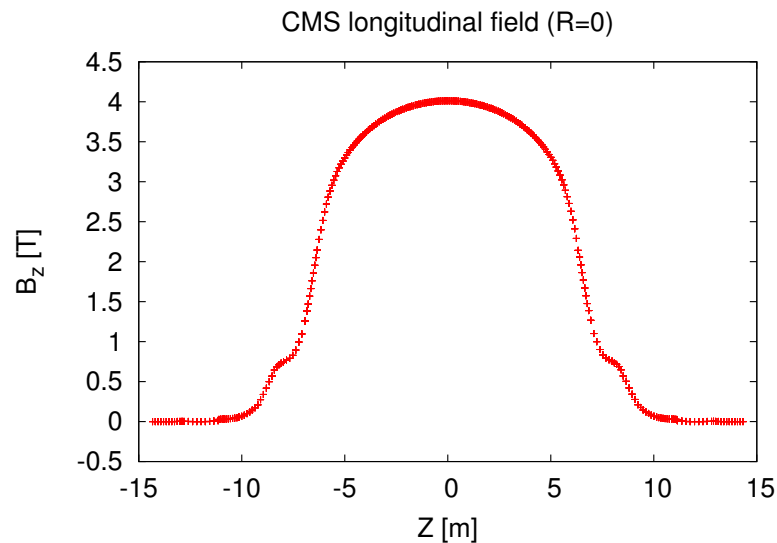
SixTrack, 60 seeds minimum averaged

DA with CC, LHC lowbetamax



SixTrack, 60 seeds minimum averaged

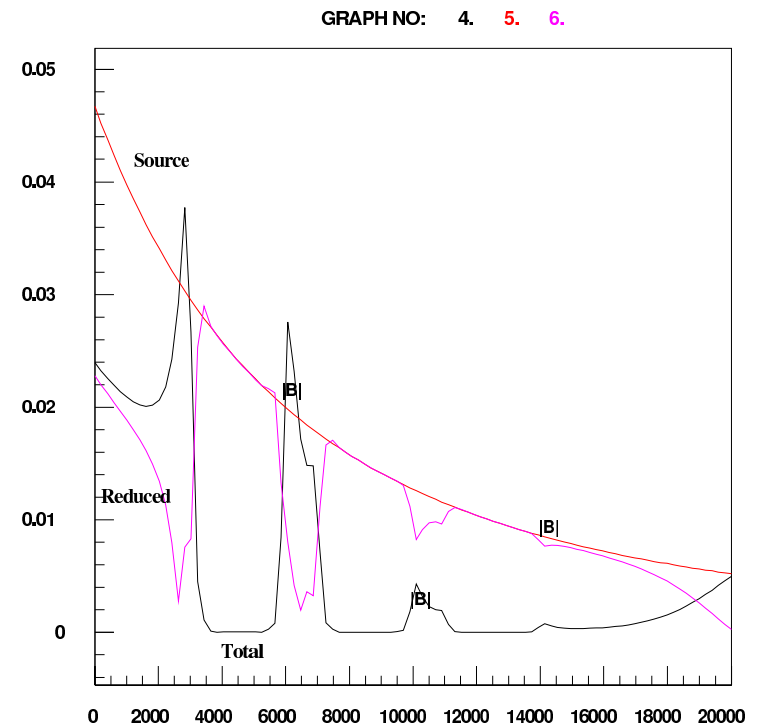
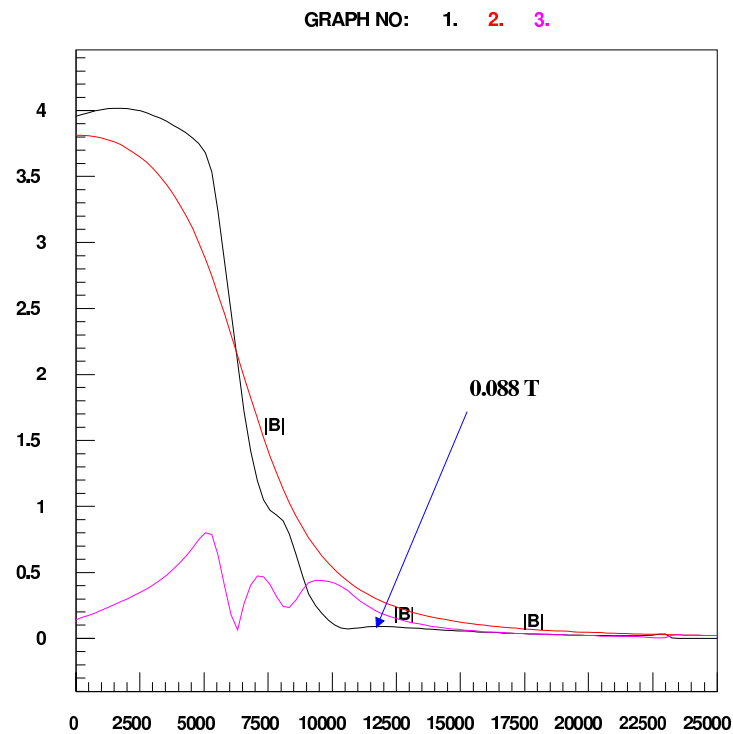
CMS measured field (R=0)



[/afs/cern.ch/cms/OO/mag_field/version_11031_071212_4t](https://afs.cern.ch/cms/OO/mag_field/version_11031_071212_4t)

Left: longitudinal component; Right: transverse component (data B. Dalena)

CMS simulated field (S. Russenschuck)

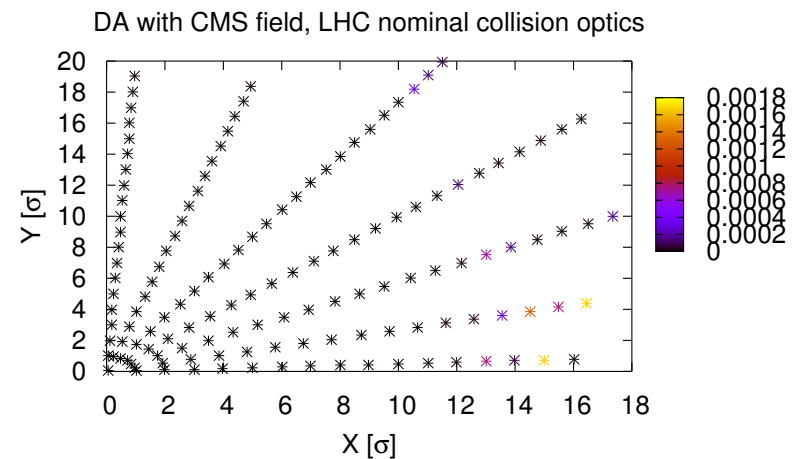
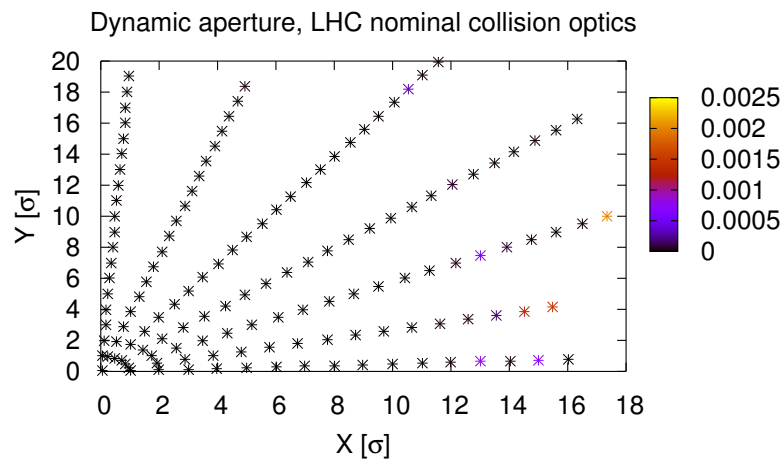


Left: CMS main field (compare slide 13 (left));
Right: Stray field (before & after shield)

7 Solenoids

- Handbook P. 299: $\theta = k_s L/4$ and $k_s = B_z/B\rho$, for 7 TeV
- CMS main field (1 in all)
 - solecms: SOLENOID, L=0, KS=4.28e-5, KSI=4.7e-4; 4 Tesla
- CMS stray field (6 in all)
 - solecms1: SOLENOID, L=0, KS=4.28e-7, KSI=4.28e-7; 0.04 Tesla
 - solecms2: SOLENOID, L=0, KS=3.21e-7, KSI=3.21e-7; 0.03 Tesla
 - solecms3: SOLENOID, L=0, KS=4.28e-8, KSI=4.28e-8; 0.004 Tesla

DA with CMS field, LHC nominal collision

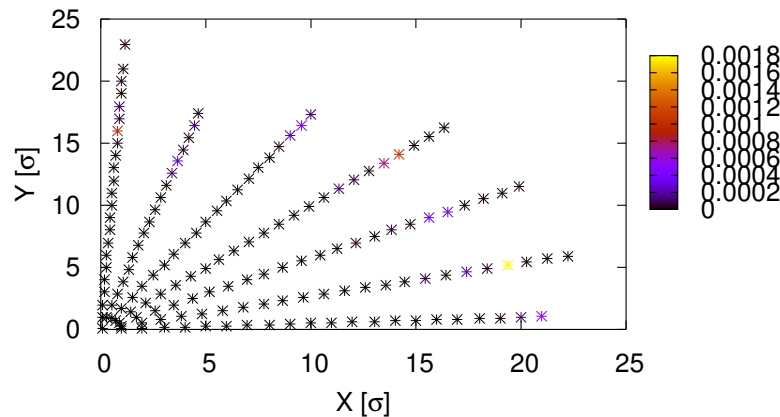


1000 turns, with error seed 1, **MADX**

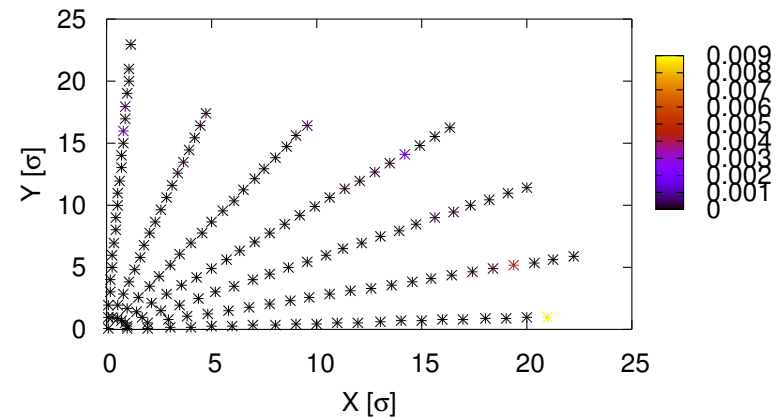
Left: no CMS; Right: with CMS

DA with CMS field, LHC Lowbetamax

Dynamic aperture, Lowbetamax collision optics



DA with CMS field, Lowbetamax collision optics

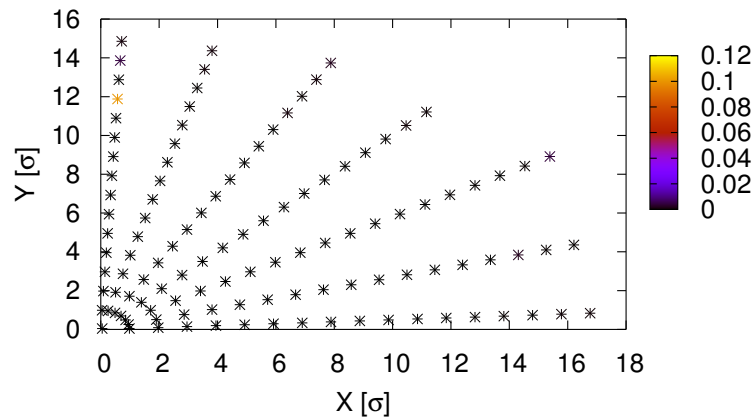


1000 turns, with error seed 1, **MADX**

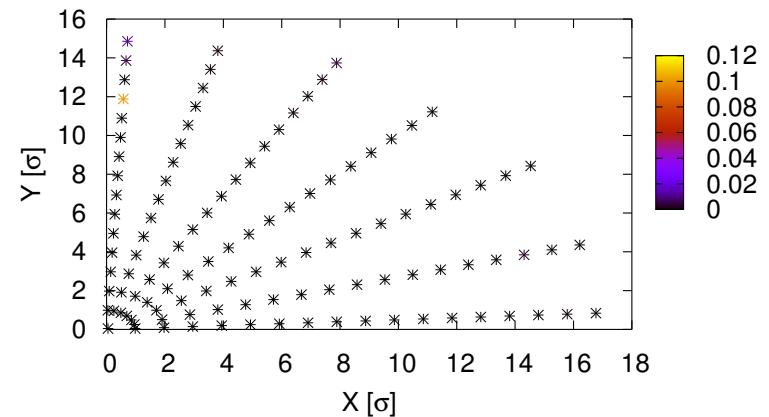
Left: no CMS; Right: with CMS

DA with CMS field, LHC injection optics

Dynamic aperture, LHC nominal injection optics



DA with CMS field, LHC nominal injection optics



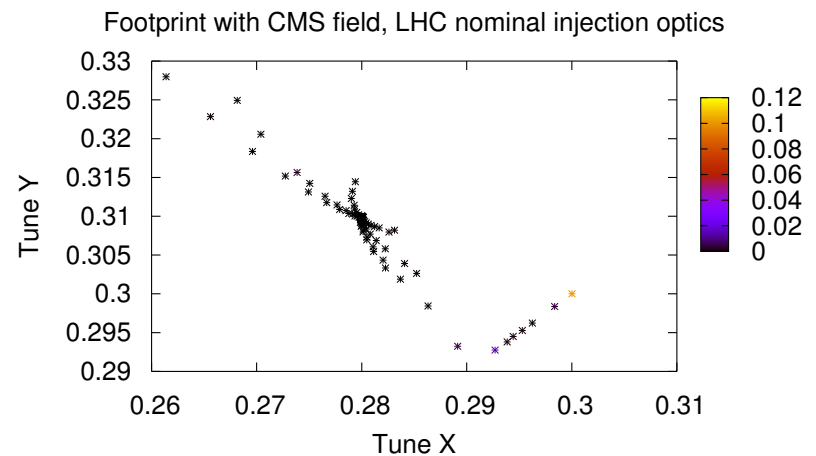
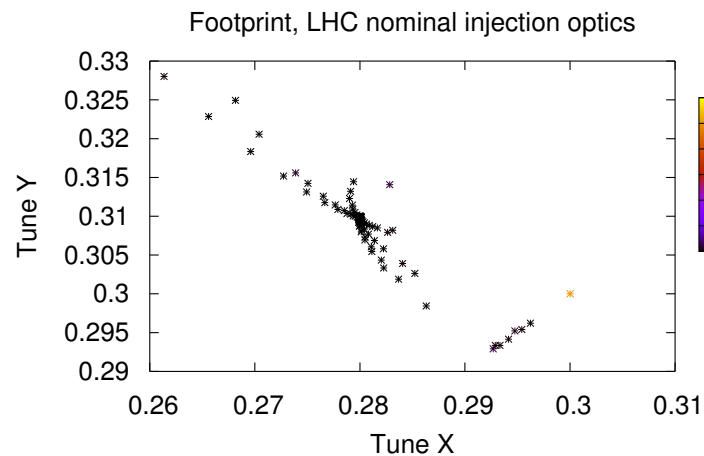
/afs/cern.ch/user/g/giovanno/w3/sixjobs/mask/lhc270_1.mask

/afs/cern.ch/user/g/giovanno/w1/WISE/testMADX/injection_errors-emfqcs-1.tfs

1000 turns, with error seed 1, **MADX**

Left: no CMS; Right: with CMS

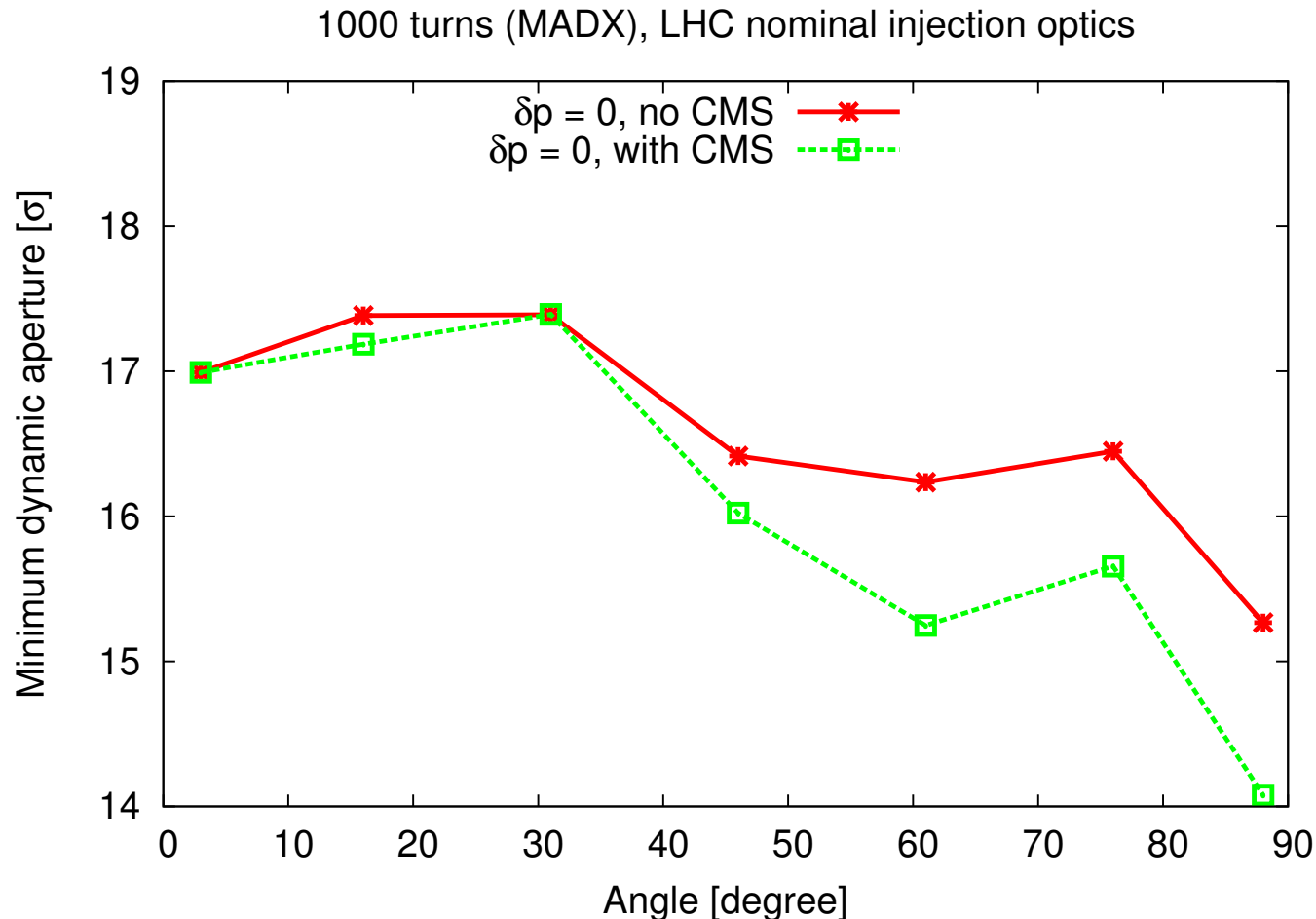
Footprint with CMS field, LHC injection



1000 turns, with error seed 1, **MADX**

Left: no CMS; Right: with CMS

DA with CMS field, LHC injection (2)

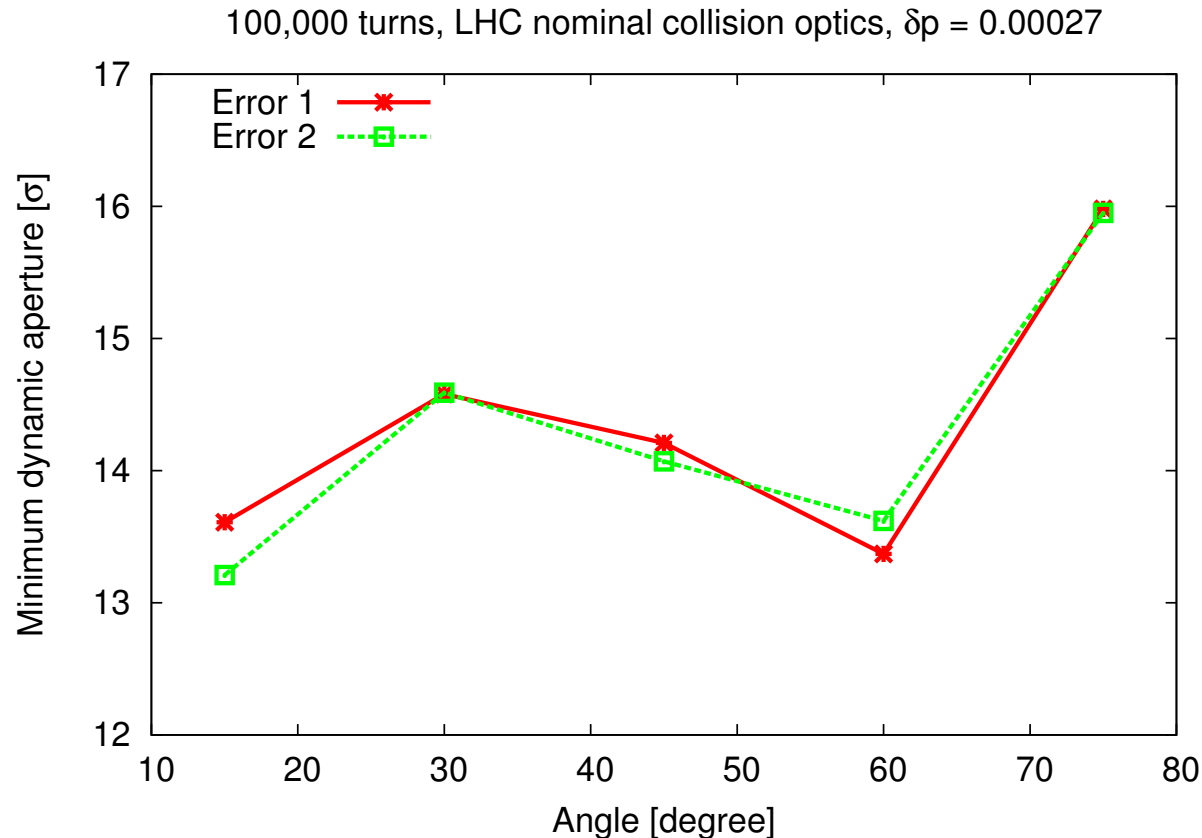


1000 turns, with error seed 1, **MADX + 0.2 σ**
resolution, no coupling correction

Conclusion

- Aperture check added in **MADX thintrack module** for dynamic aperture studies; short-term DA, MADX agrees SixTrack?
- CMS longitudinal field (main + stray field) decrease dynamic aperture by 0.5σ , from **MADX + LHC injection**; some change on the tune
- OFF momentum DA a little bit smaller than ON momentum (SixTrack)
- 1 to 2σ degradation due to crab cavity
- In progress: Solenoid in SixTrack (F. Schmidt)

Backup slide (1)

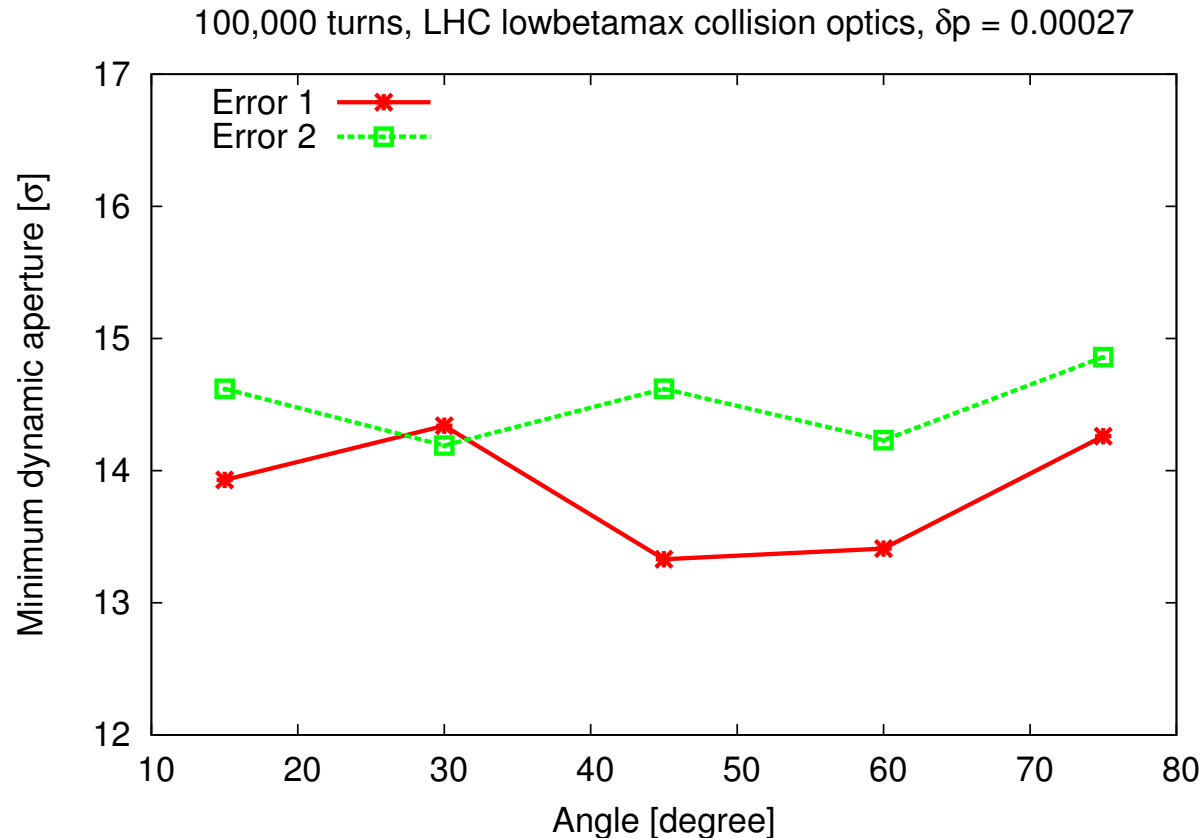


60 error seeds, LHC nominal collision optics

Error 1: `/afs/cern.ch/user/g/giovanno/w1/WISE/testMADX/collision_errors*.tfs`

Error 2: `/afs/cern.ch/user/r/rdemaria/dott/pool/errors/collision_errors*.tfs`

Backup slide (2)



60 error seeds, LHC lowbetamax collision optics

Error 1: `/afs/cern.ch/user/g/giovanno/w1/WISE/testMADX/collision_errors*.tfs`

Error 2: `/afs/cern.ch/user/r/rdemaria/dott/pool/errors/collision_errors*.tfs`