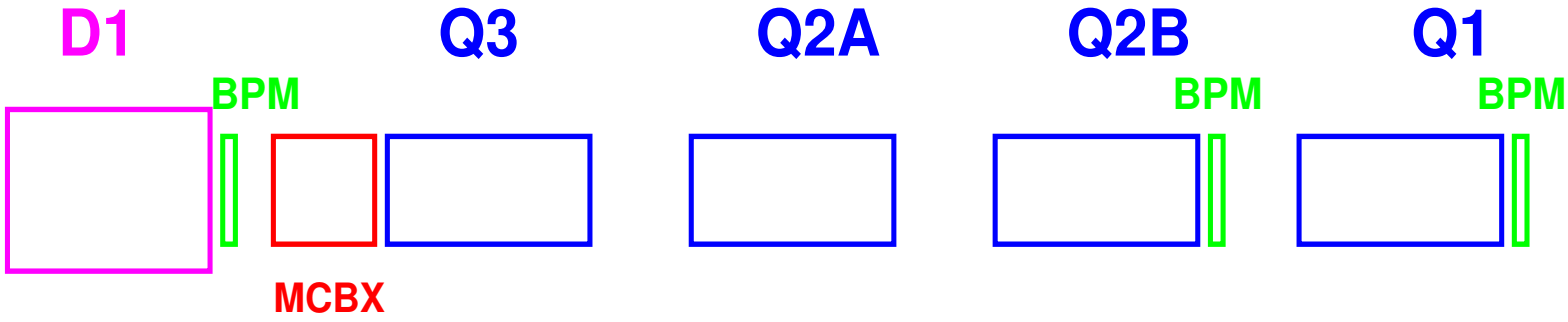
Orbit Correction

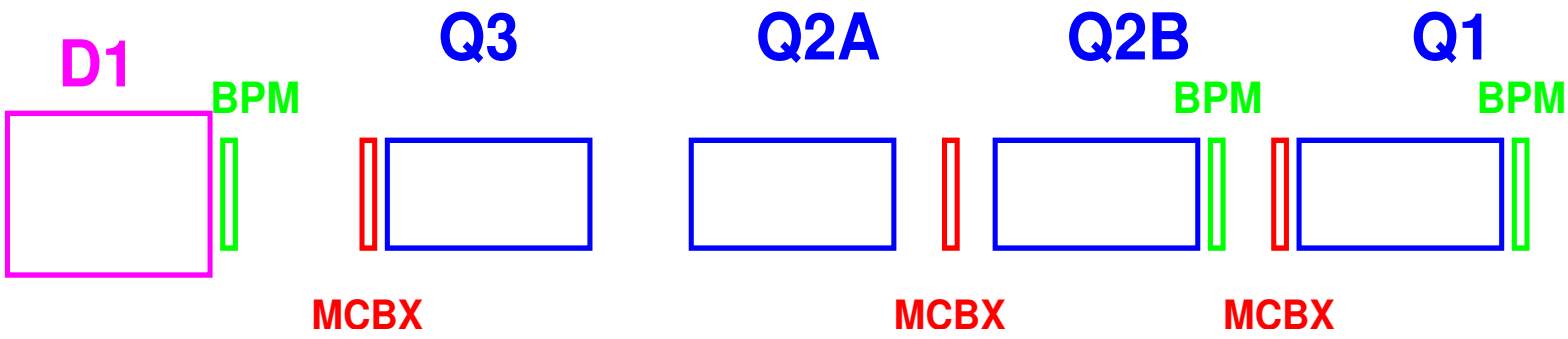
for the LHC Phase 1 Upgrade

(updated)

W. Herr

Assumed layout (schematic):





Corrector and monitor layout

- Monitor (BPM) layout assumed similar
- Three MCBX replaced by one next to MQX3
- Purpose of MCBX:
  - Provide additional strength for crossing angle
  - Correct orbit from triplet misalignment in the ring
  - Correct orbit from triplet misalignment in the triplet region

Crossing angle scheme

- **A single MCBX at MQX3 is sufficient**
- **See review in July for details**

Correction of triplet misalignment

- **Use optics from SF, July 2008 with 0.25 m**
- **Assume r.m.s. misalignment of 0.1 mm (MQX only ..)**
  - **Scale results for larger misalignment**
- **MCBX are shared by both beams:**
  - **All corrections done for both beams simultaneously using MADX with MICADO**
  - **No postprocessing of correction results, no special algorithms**
- **Try correction using three, two and one MCBX**

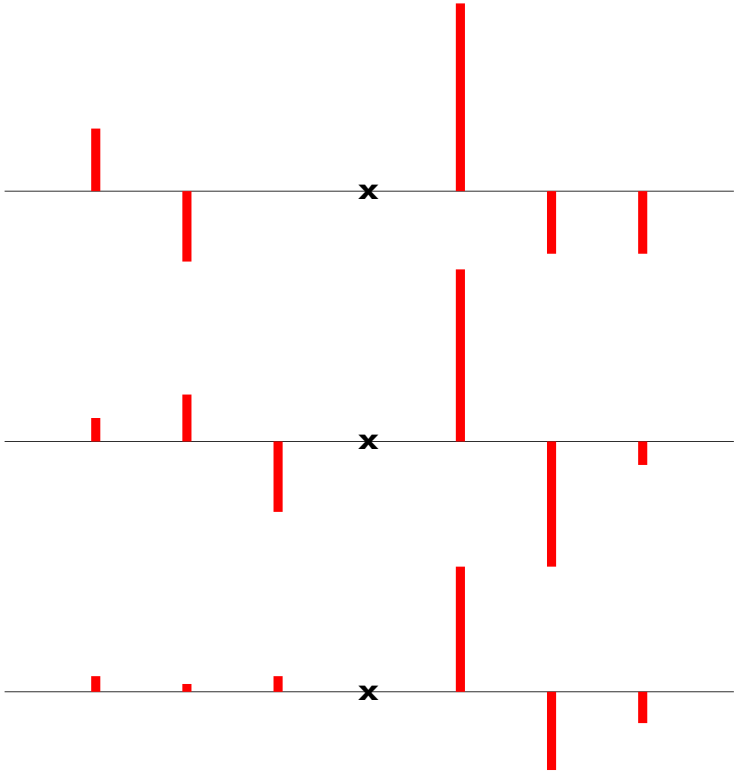
Correction of triplet misalignment in whole ring

- **For misalignment 0.1 mm r.m.s.**
- **Correction quality with MCBX3 only:**
  - **Orbit r.m.s. after correction satisfactory**
  - **Large orbit distortions well corrected (as well as with all MCBX)**
  - **Can expect r.m.s. maximum $\approx$ 0.1 - 0.2 mm after correction**
  - **Cannot correct to very small values**
  - **For larger misalignment: scaling is valid**

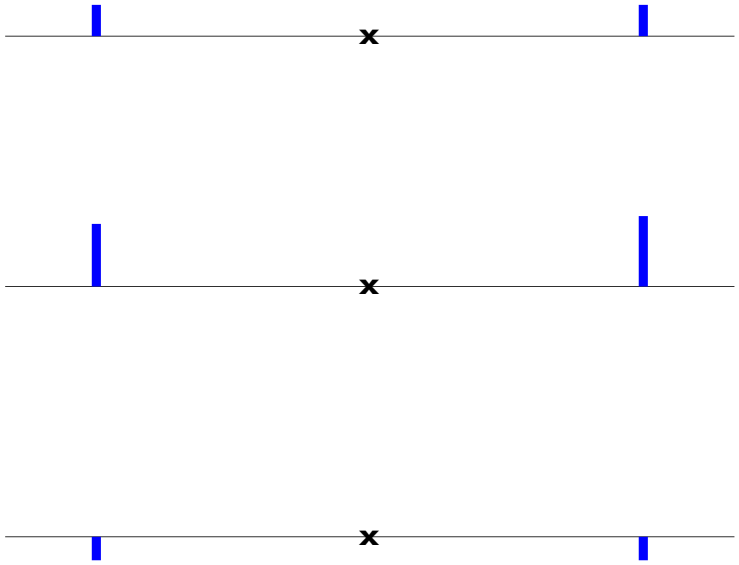
Correction with MCBX ...

- **Generic problems with correction of triplet errors:**
  - **Usually good global correction possible, but difficult to find source (especially low β^* optics)**
- **Using all MCBX:**
  - **Tendency to create local bumps, postprocessing or special treatment necessary (possible)**
- **Using single MCBX:**
  - **Tendency to create bumps across the IP,**
  - **As a single corrector: MCBX1 not ideal for correction, MCBX3 better**

Created "bumps" in two options - 3 "bad" seeds

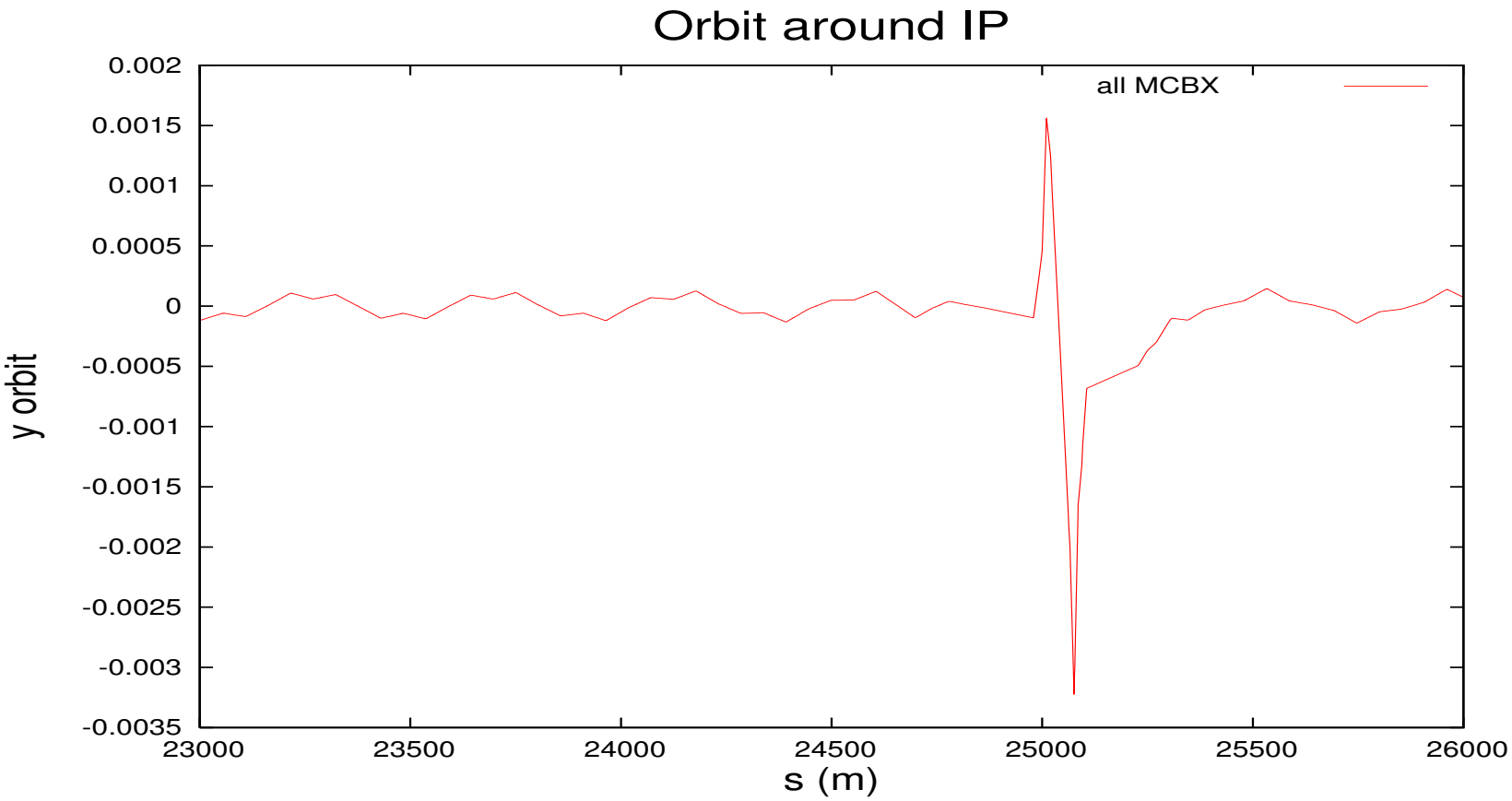


all MCBX

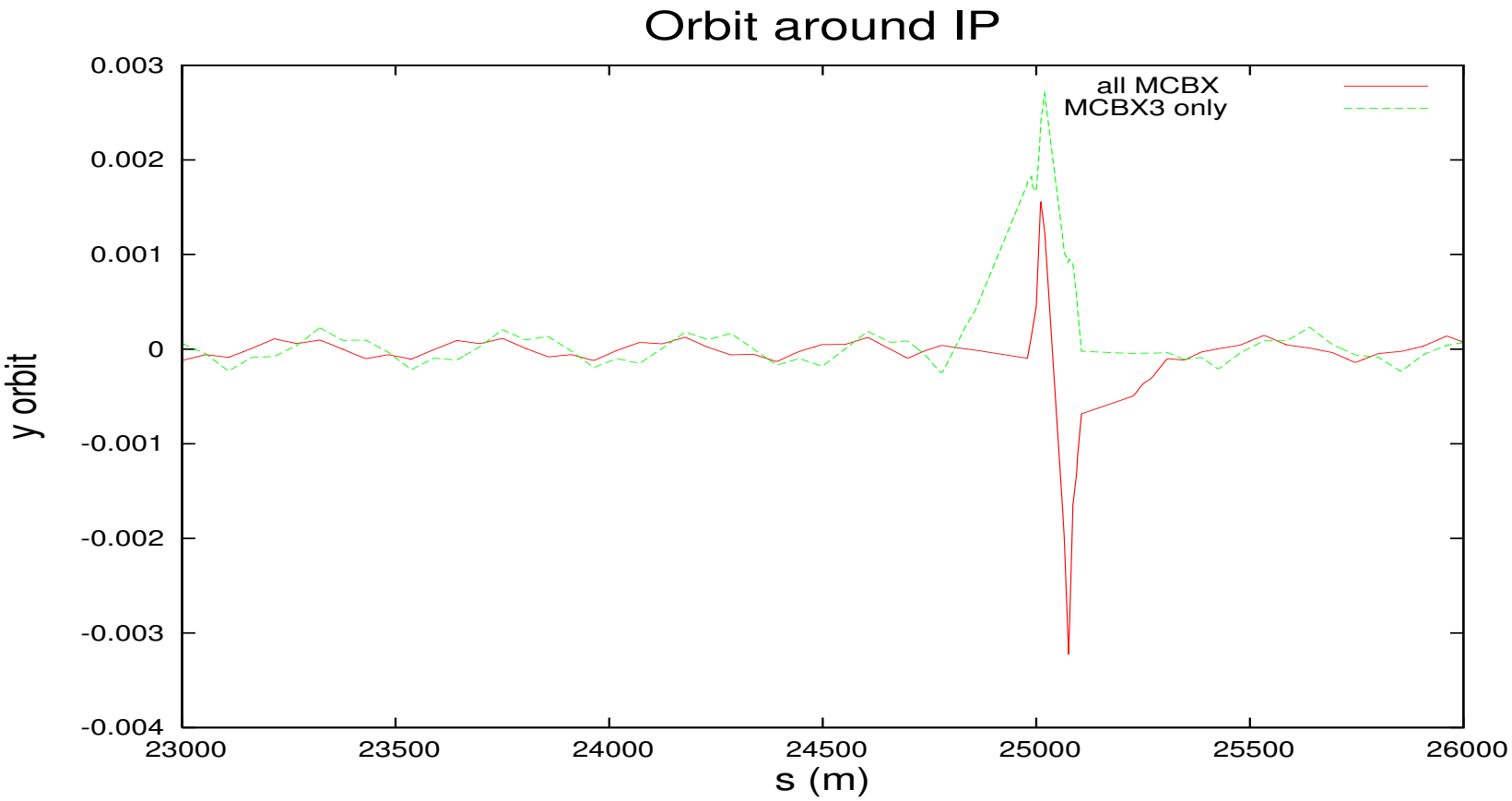


MCBX3 only

Orbit after triplet correction



Orbit after triplet correction



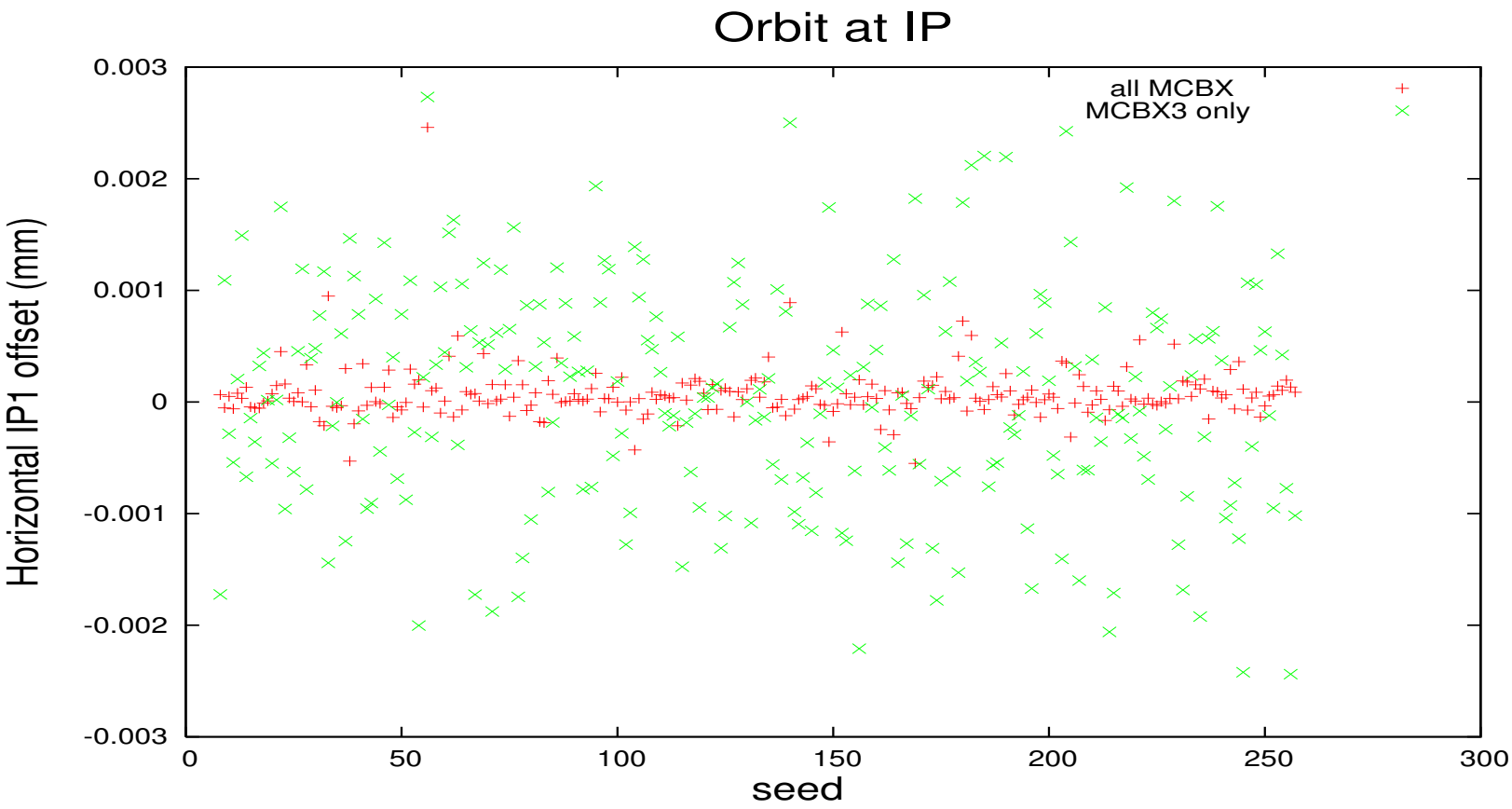
Created "bumps" in two options

- Both options can produce "bumps" with the straightforward correction algorithms
- Both types of bumps undesirable:
  - More aperture needed
  - Separation of beams
- Special (adapted) algorithms or postprocessing must be applied to avoid them
- This is only possible with several MCBX

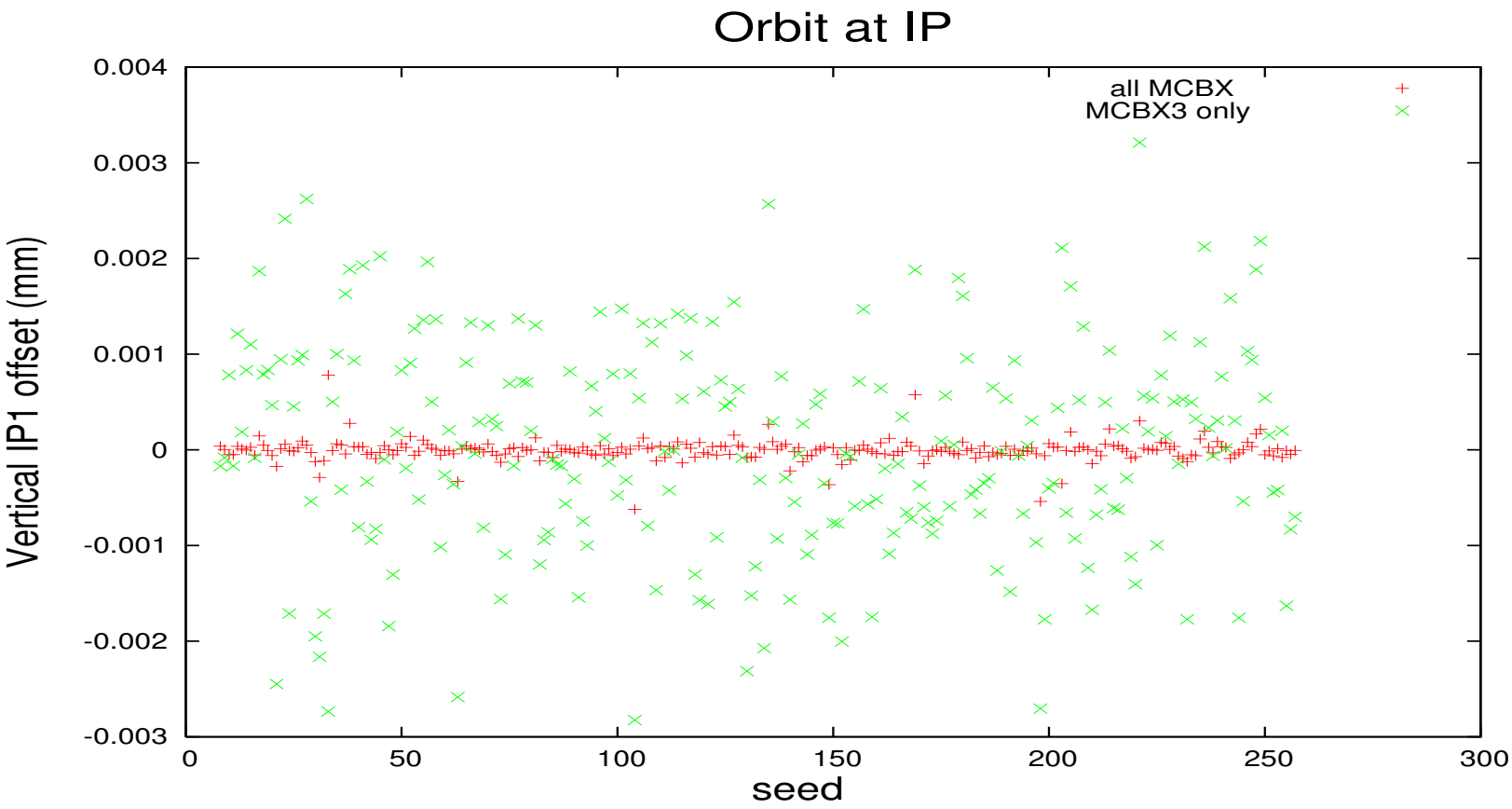
Created "bumps" in two options

- Correction is global, i.e. minimizes a r.m.s. (part or whole machine)
- No constraint of orbit at interaction point (missing correctors)
- Creates offset interaction point

IP offset


Orbit at IP
all MCBX
MCBX3 only
Horizontal IP1 offset (mm)
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
0
50
100
150
200
250
300
seed

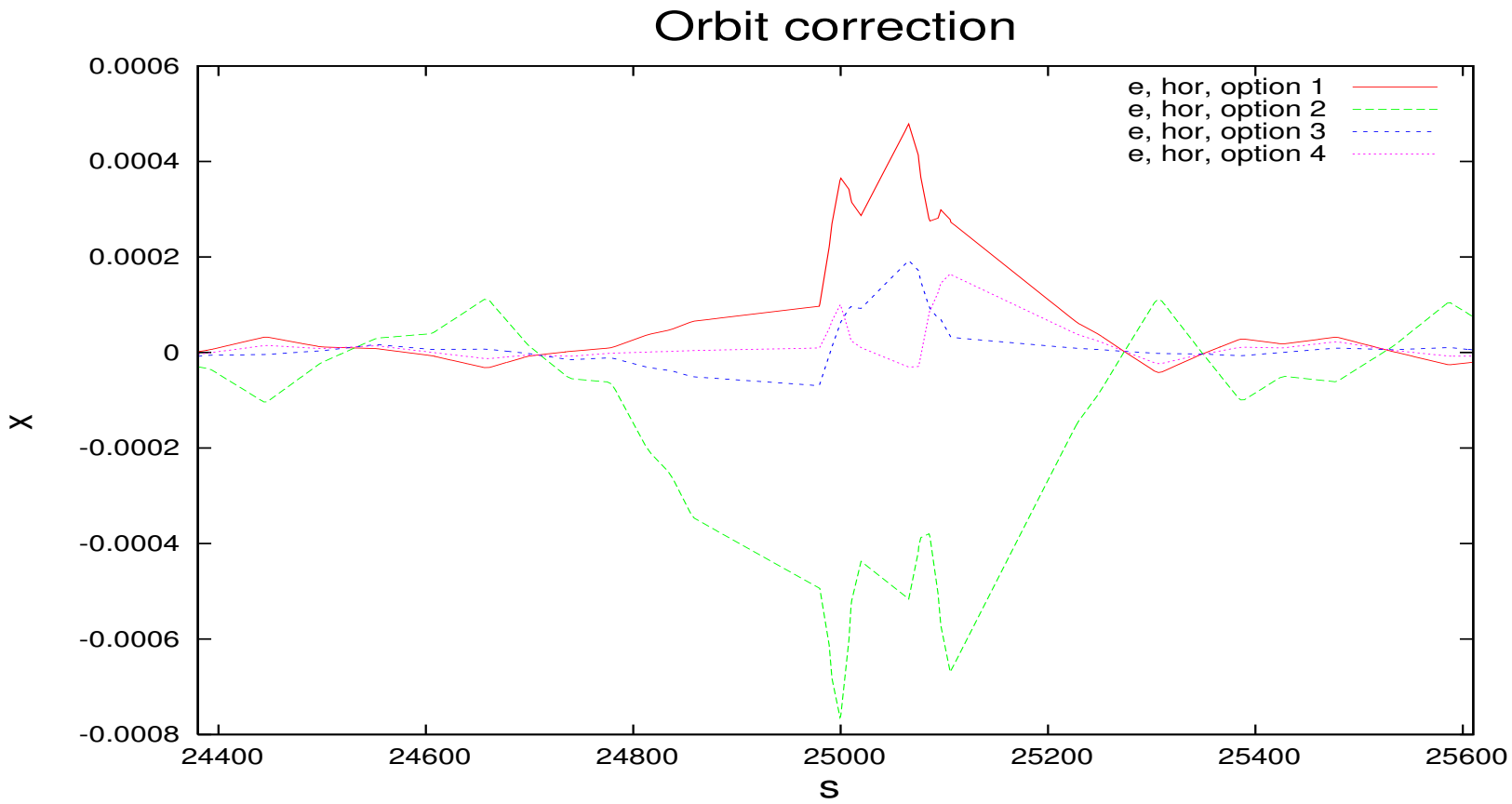
IP offset


Orbit at IP
all MCBX
MCBX3 only
Vertical IP1 offset (mm)
0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
0
50
100
150
200
250
300
seed

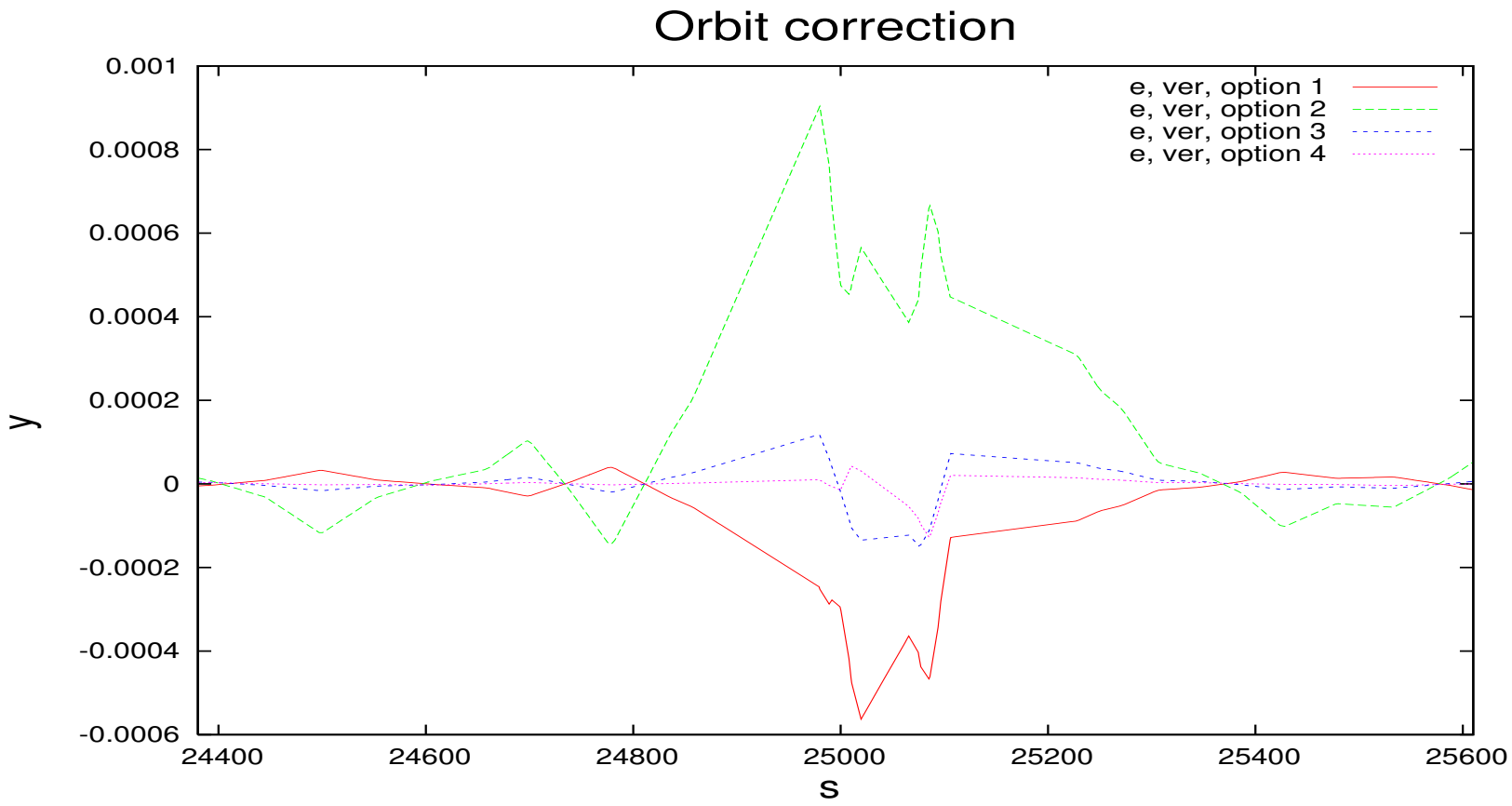
Options for triplet corrections

- **Option 1: corrector at Q3 only**
- **Option 2: corrector at Q1 only**
- **Option 3: correctors at Q1 and Q3**
- **Option 4: correctors at Q1, Q2 and Q3**
- **Select some cases with significant IP offsets**

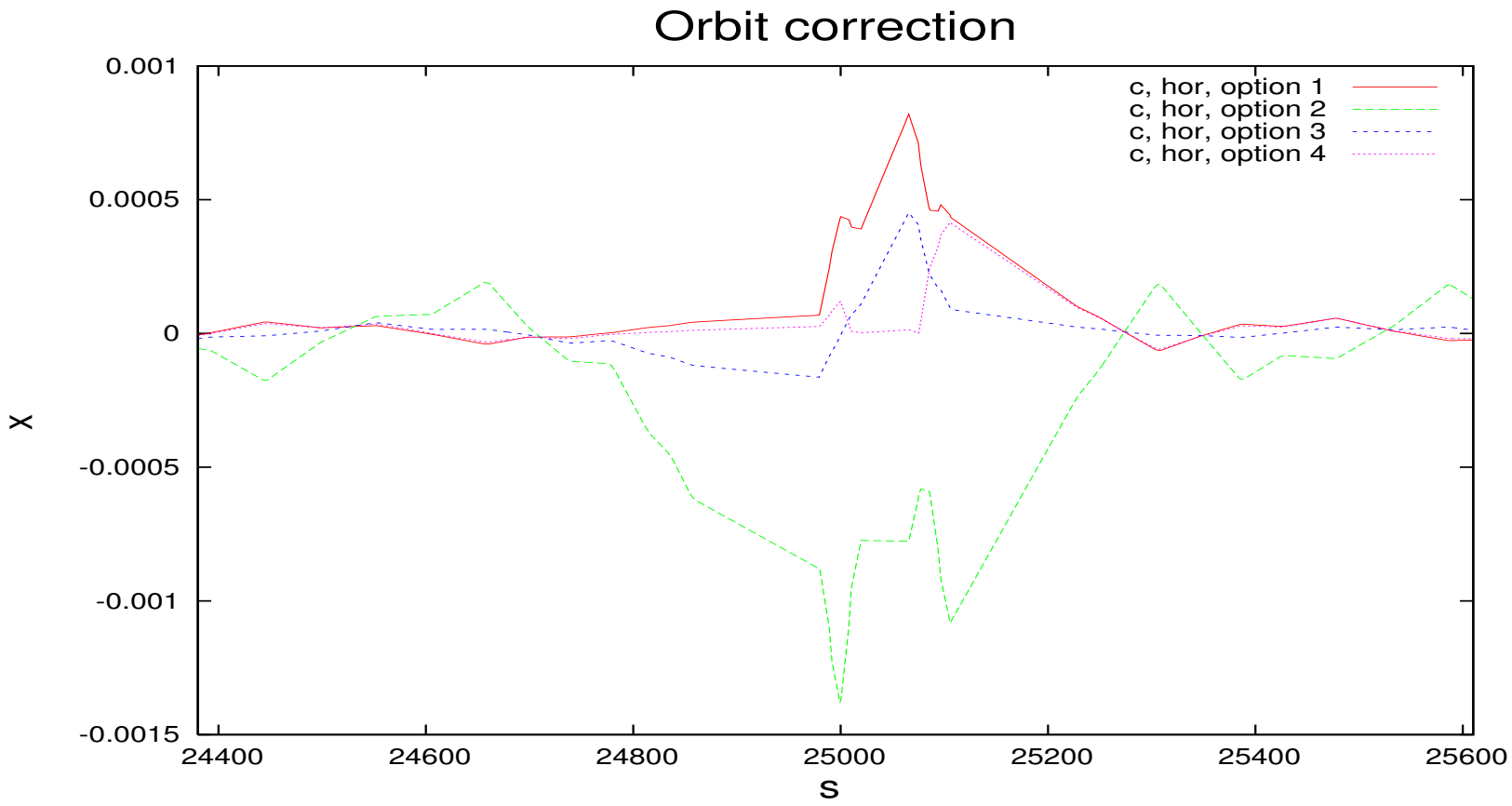
Orbit in triplet



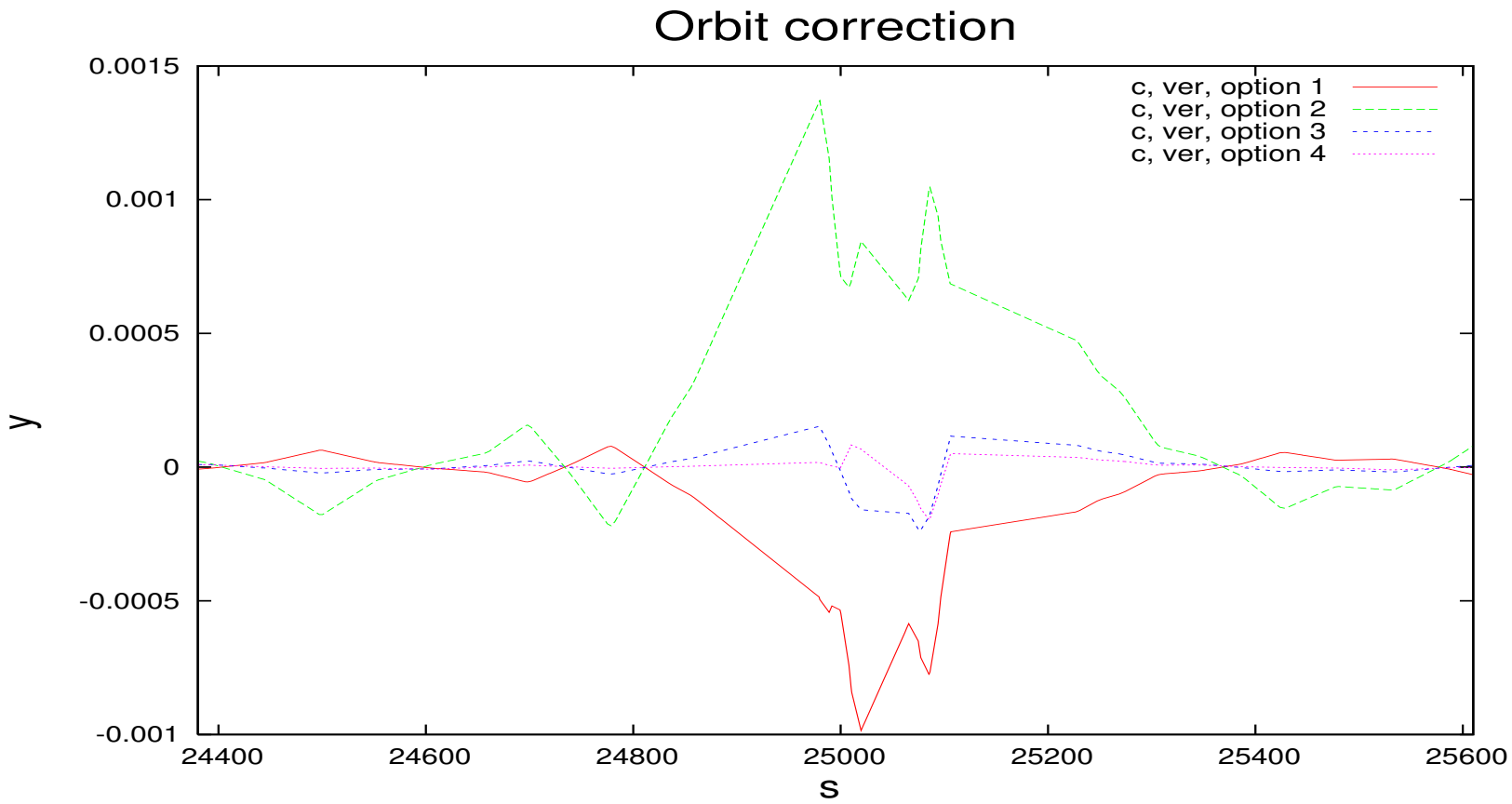
Orbit in triplet



Orbit in triplet



Orbit in triplet



Orbit in triplet

- Correction quality very different for the three options
- Single corrector cannot keep the orbit small:
  - More aperture required
  - Danger to separate the beams
  - Beam separation with crossing angle strongly affected

Summary (preliminary)

- **Crossing angle with MCBX3 only:**
  - **Does no show any problem**
- **Orbit correction with MCBX:**
  - **ring orbit can be corrected with single MCBX, problem is to keep the orbit small in the triplet region at the same time !**
  - **Single MCBX creates large orbits in straight sections**
  - **Two or three MCBX improve, but still need "short length" correction algorithm to avoid artefacts**
  - **No such remedy for single MCBX**