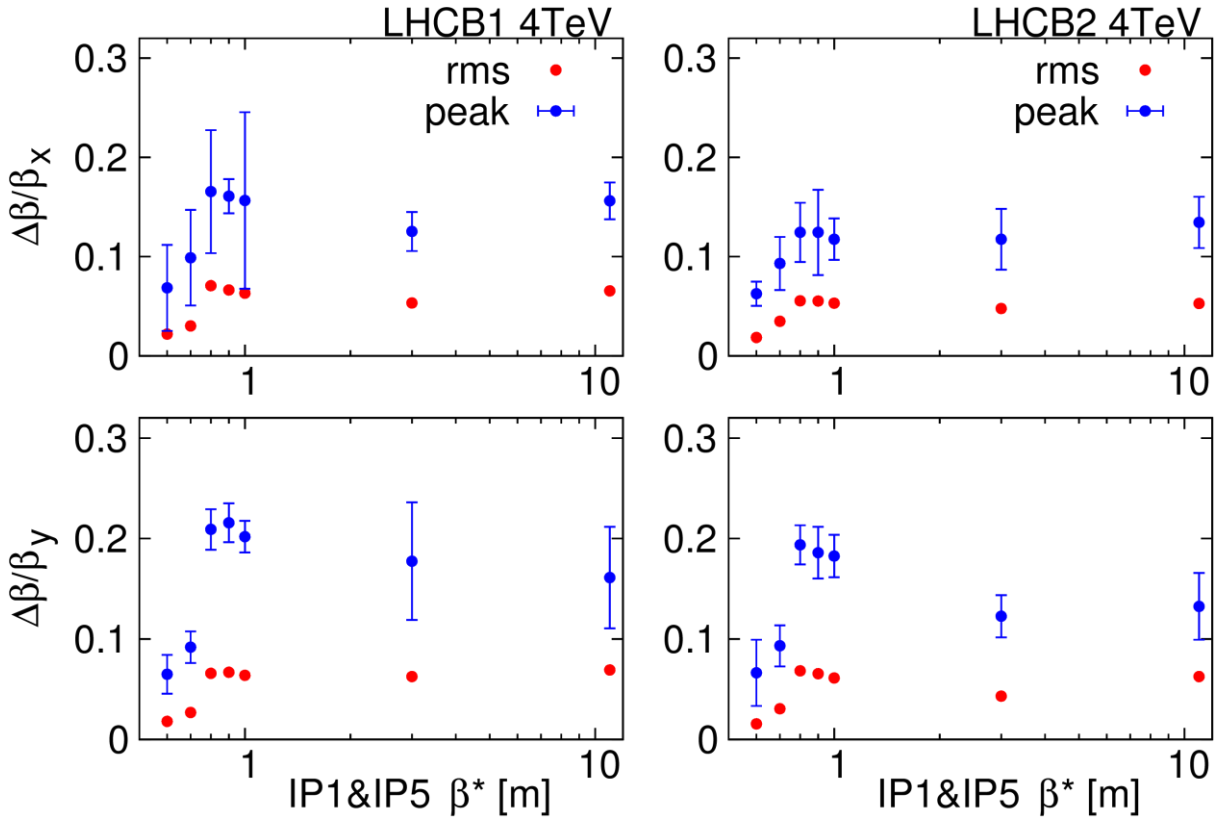
Measurements at 40cm and Computer Aided Segment By Segment corrections

Piotr Skowroński

Local Corrections aka Segment-by-Segment

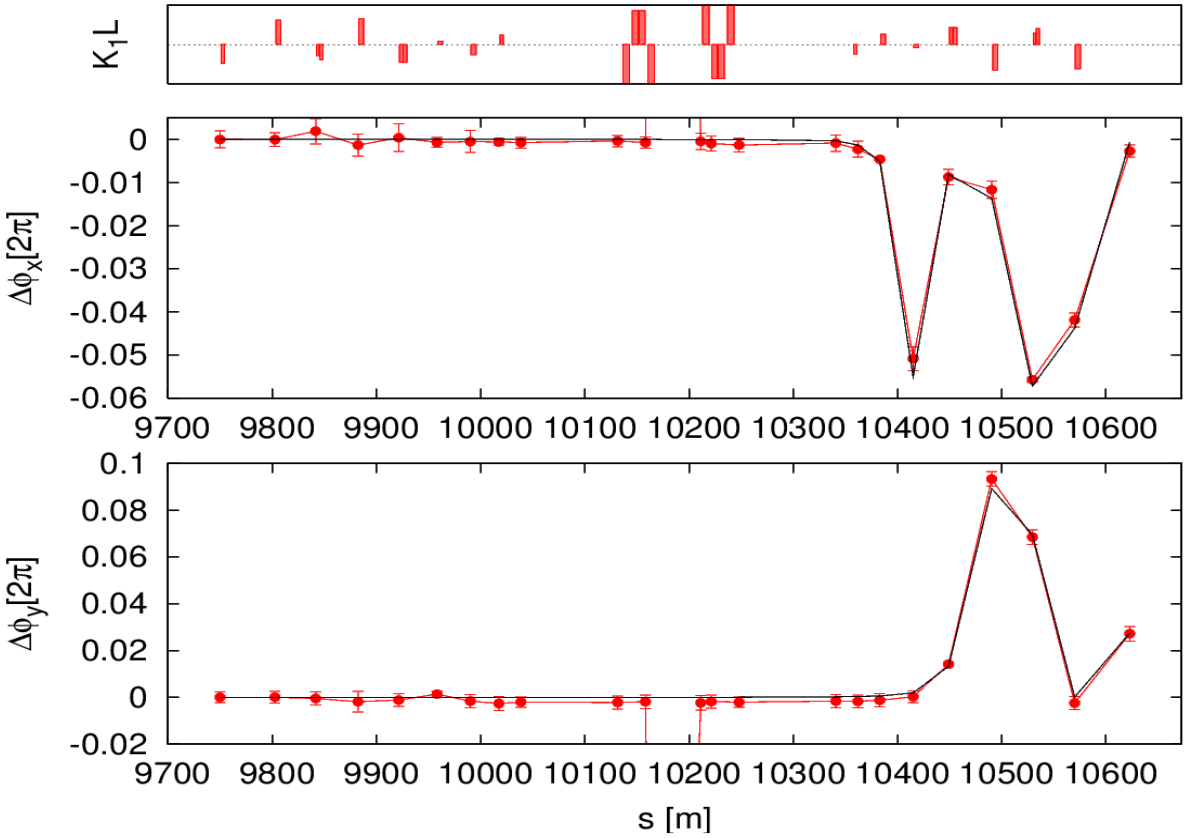
- The correction strategy:
  - First local errors around IRs are corrected with S-b-S
  - The global correction is applied only afterwards
- This method proved itself leading to beating below 7%



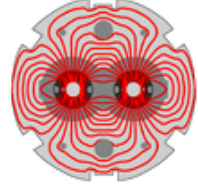
Segment by Segment

- The approach
  - Measured phase error for a given segment is generated
  - Quadrupoles setting reproducing the error pattern is searched
    - The setting applied with negative sign removes the error

IP5 Beam1
Nominal 60cm



Automatic Segment matching

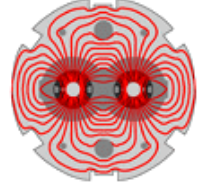


- The local corrections were found manually
  - Often not easy to get, and hence (precious MD) time consuming

→ Need for automatic or semi-automatic algorithm

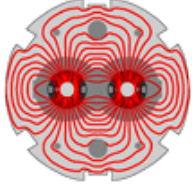
- Simultaneous **matching** of both beams with MADX
  - Common correcting quads at IRs

The automatic tool



- Input: location of the beam measurement results for both beams
  - The tool creates local copy for safety of the data
- The tool uses the madx files generated the SbS anlysis tool
  - They are automatically stream edited such that they can be called one after another from the matching script
    - Remove name clashes
    - Path substitution to the local directory, etc
  - Decided not to create a new template/mask to avoid additional maintenance item
- Using the provided measurement results
  - Define the ranges for both lines
  - Create madx files with
    - Variables
    - **`vary`** commands, one for each beam and one for the commons variables
    - **`constraint`** commands
- Matching done with use_macro mode

The matching script



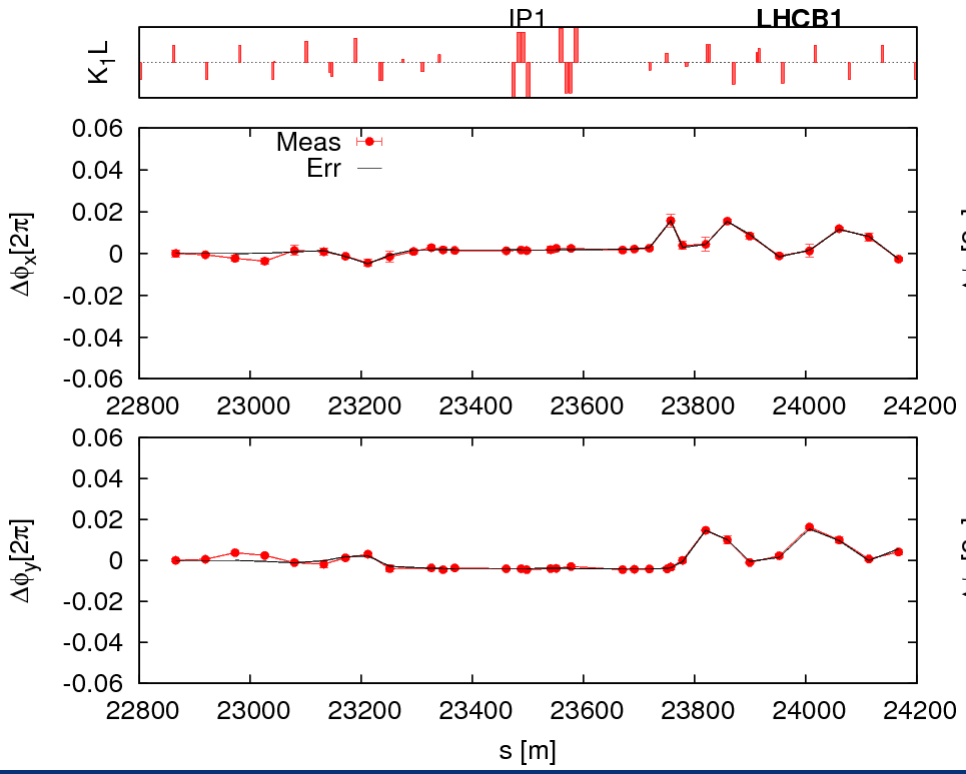
```
call, file="Beam1/sbs/t_IP__IPNO__.madx";
call, file="Beam2/sbs/t_IP__IPNO__.madx";

system, "python genphases.py __IPNO__";

beam, particle = proton, sequence=LHCB1, energy = 450.0, bv=1;
use, period=LHCB1, range=__RANGEB1__;
twiss, beta0=b1, chrom;
call, file="phases0b1.seqx";

beam, particle = proton, sequence=LHCB2, energy = 450.0, bv=-1;
use, period=LHCB2, range=__RANGEB2__;
twiss, beta0=b2, chrom;

call, file="phases0b2.seqx";
call, file="phases.seqx";

system, "python genconstraints.py __IPNO__";

system, "python genvariables.py __IPNO__";
call, file="svariables.seqx";
call, file="dvariables.seqx";
call, file="genchangpars.seqx";
```

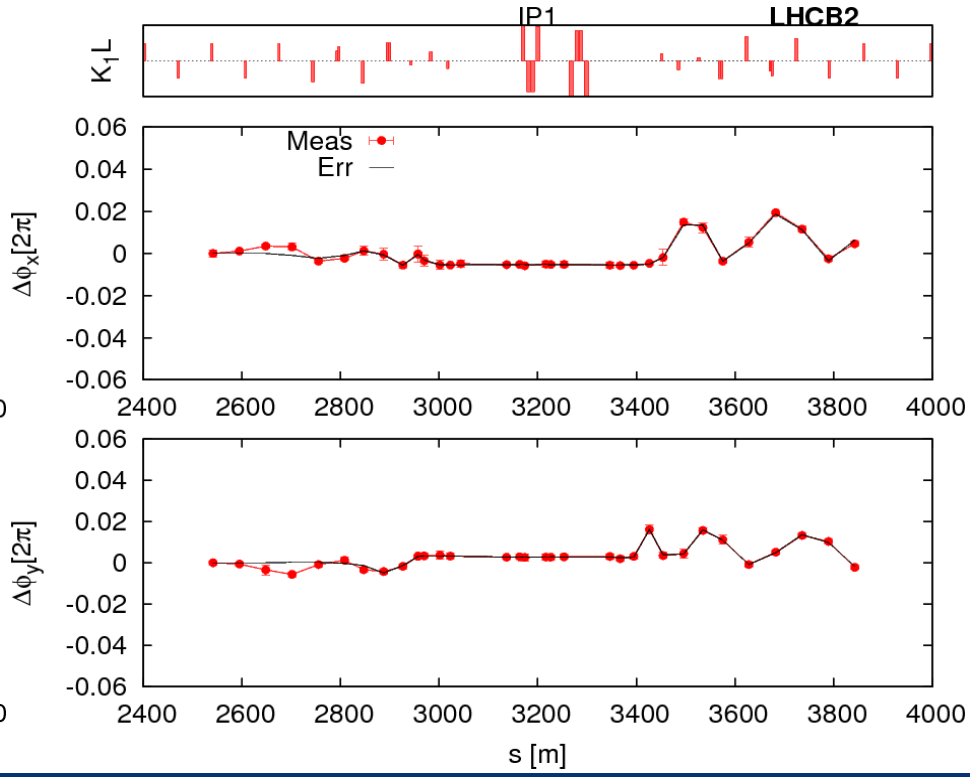
```
match, use_macro;
   call, file="variablesb1.seqx";
   call, file="variablesc.seqx";
   call, file="variablesb2.seqx";
   mab1: macro =
    {
      beam, particle = proton, sequence=LHCB1, energy = 450.0, bv=1;
      use, period=LHCB1, range=__RANGEB1__;
      twiss, beta0=b1, chrom, file="Beam1/sbs/twiss_IP__IPNO___cor.dat";

      call, file="dumpb1.seqx";
      system, "gnuplot dumpB1.gplot";
      system, "./mergedump.sh 1";
    };

   call, file="constraintsb1.seqx";

   mab2: macro =
    {
      beam, particle = proton, sequence=LHCB2, energy = 450.0, bv=-1;
      use, period=LHCB2, range=__RANGEB2__;
      twiss, beta0=b2, chrom, file="Beam2/sbs/twiss_IP__IPNO___cor.dat";


      call, file="dumpb2.seqx";
      system, "gnuplot dumpB2.gplot";
      system, "./mergedump.sh 2";
    };

   call, file="constraintsb2.seqx";

   lmdif,    tolerance:=1e-24, calls:=120;

endmatch;

call, file="genchangpars.seqx";
```

Results

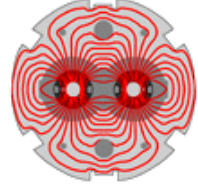
- For vast majority of the cases a satisfactory result is found within 120 matching iterations
  - Matching takes around 90 seconds
- For illustration, the remaining S-b-S plots in this presentation show automatically calculated correction

ATS 40cm IP1





Future developments

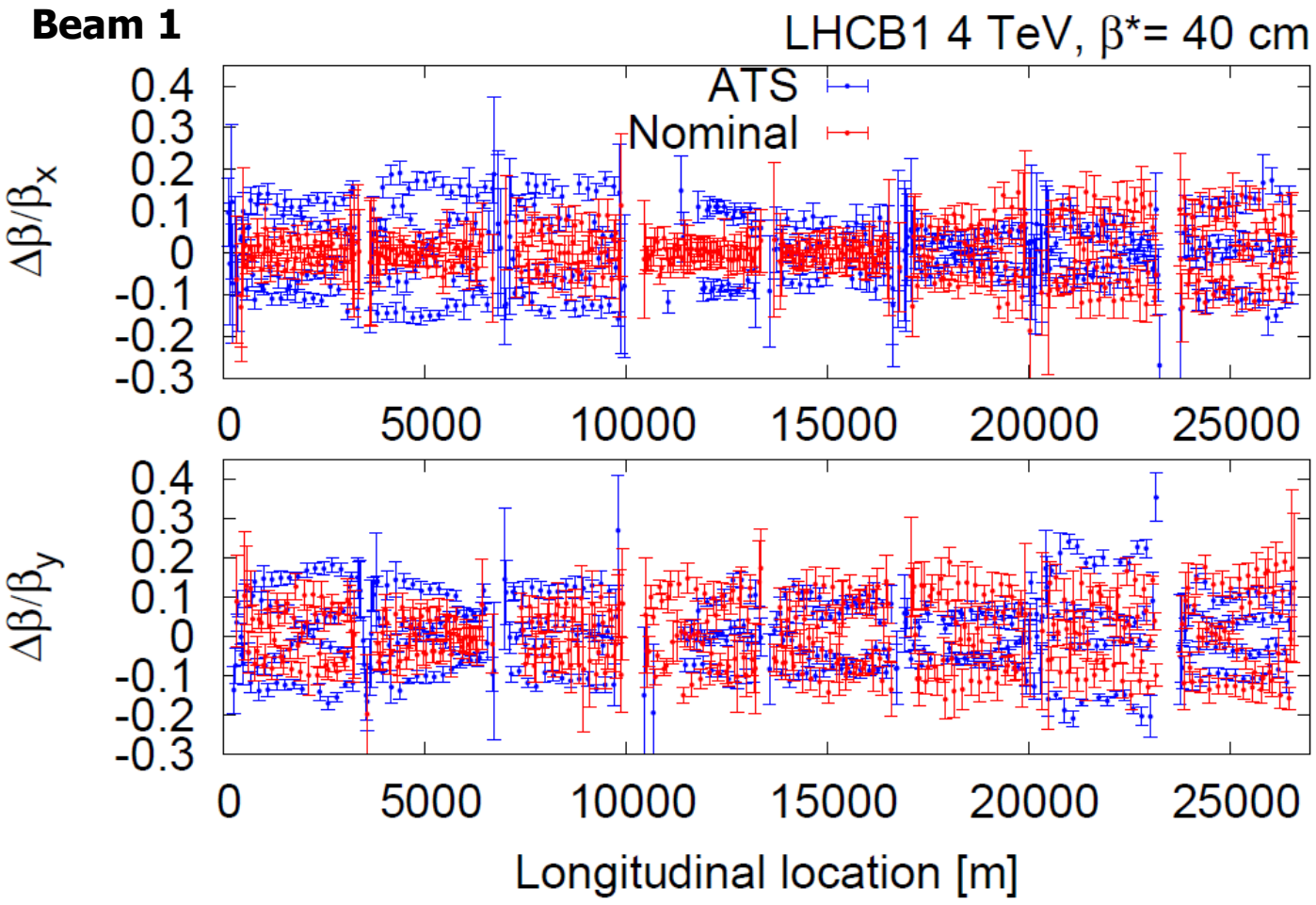


- The tool shall be integrated into the beta-beat GUI
  - Invocation with a simple button
  - User friendly selection of variables
    - The tool uses all the available correction knobs, while normally only 2 to 4 the most important knobs are sufficient to obtain a good result
  - User friendly selection of constraints
  - Integrated data display
  - Automatized knob generation
- Study all available data, find corrections and look for systematic effects

Measurements at 40cm (and 20cm)

Nominal and ATS

- The nominal and ATS optics were measured at 40cm
- Beta-beating is quite similar for both of them



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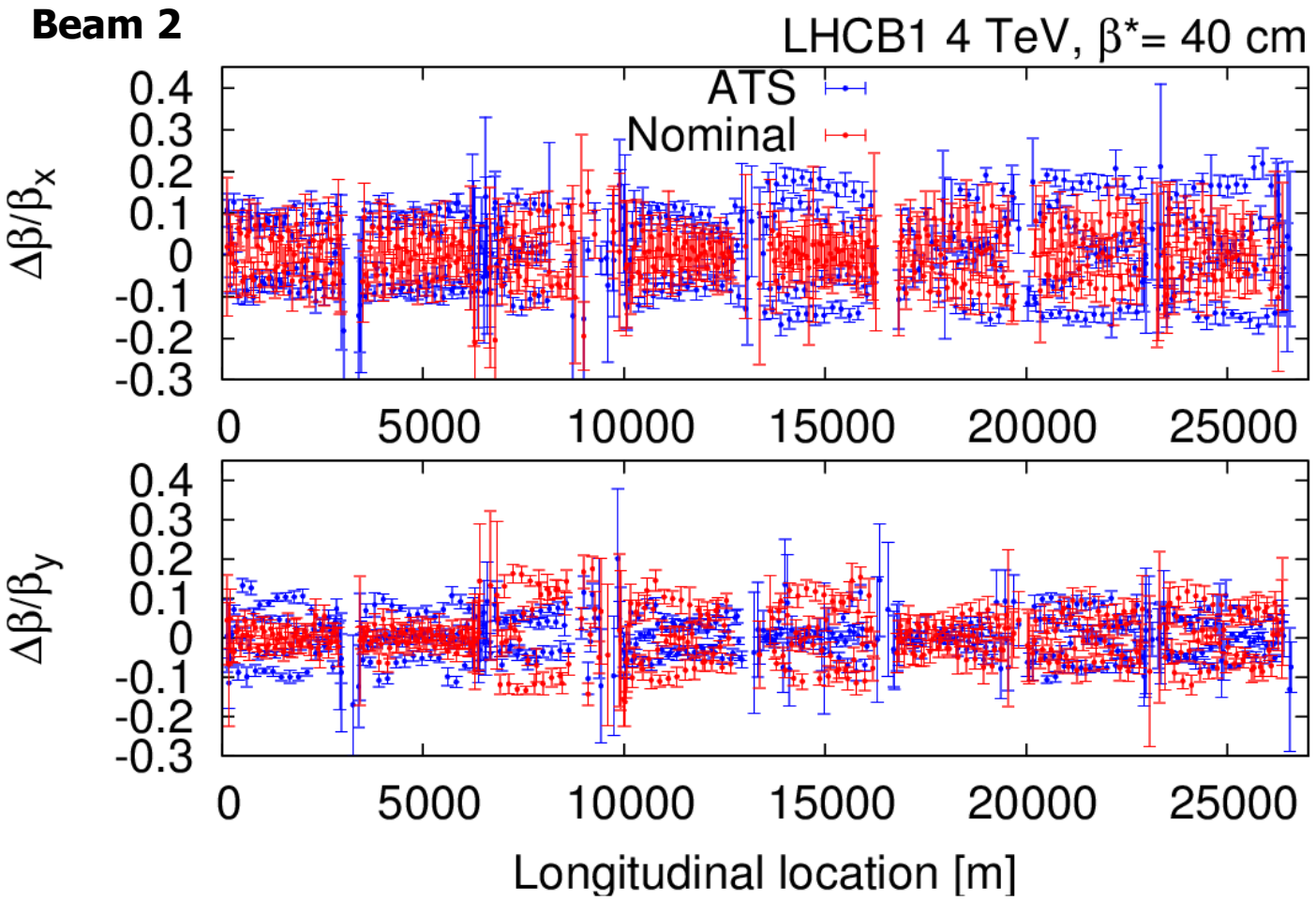
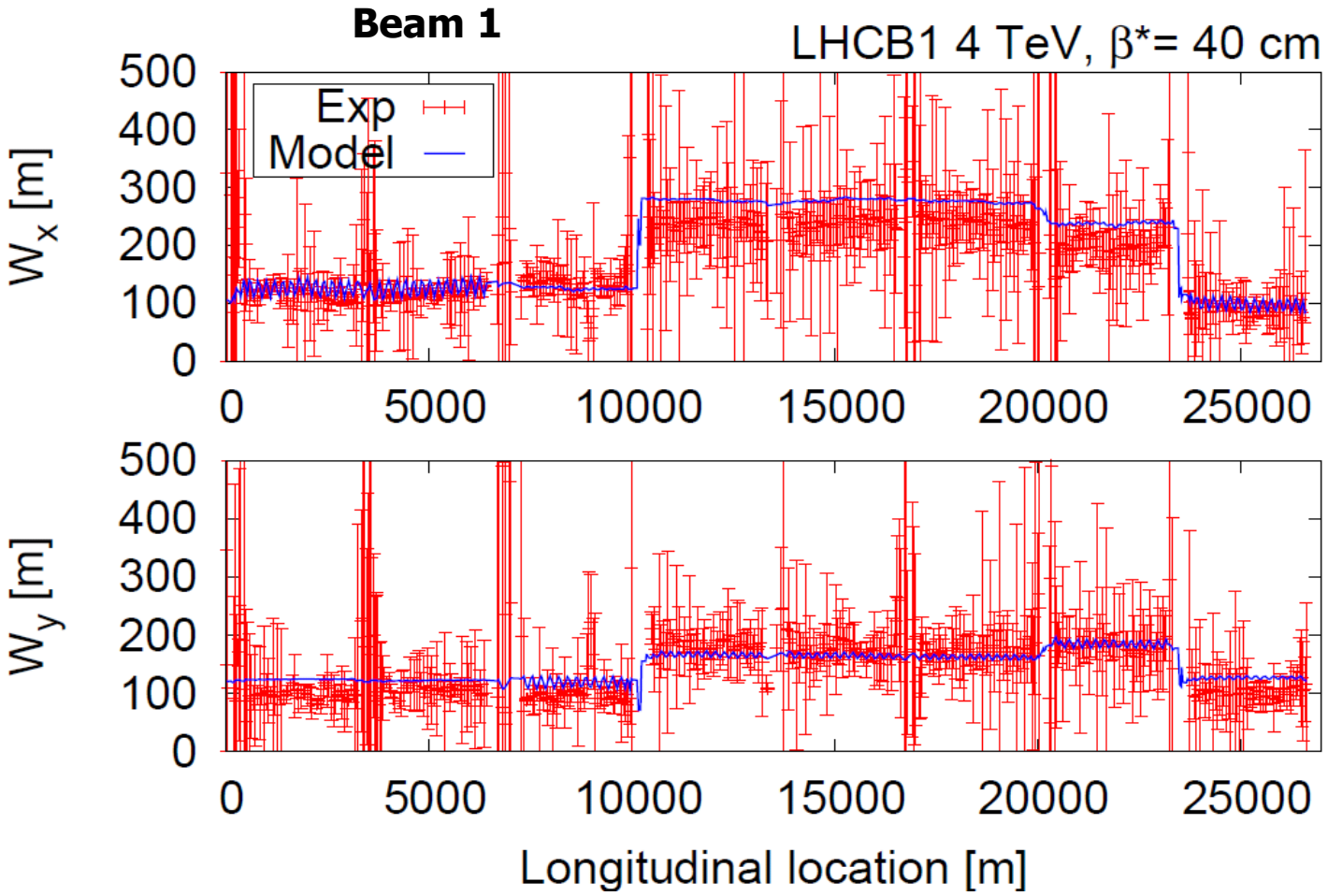


Chromatic β-beating

- Well predicted by the model
- Measurement and model at 40cm for the nominal optics
  - ATS was not measured with off-momentum



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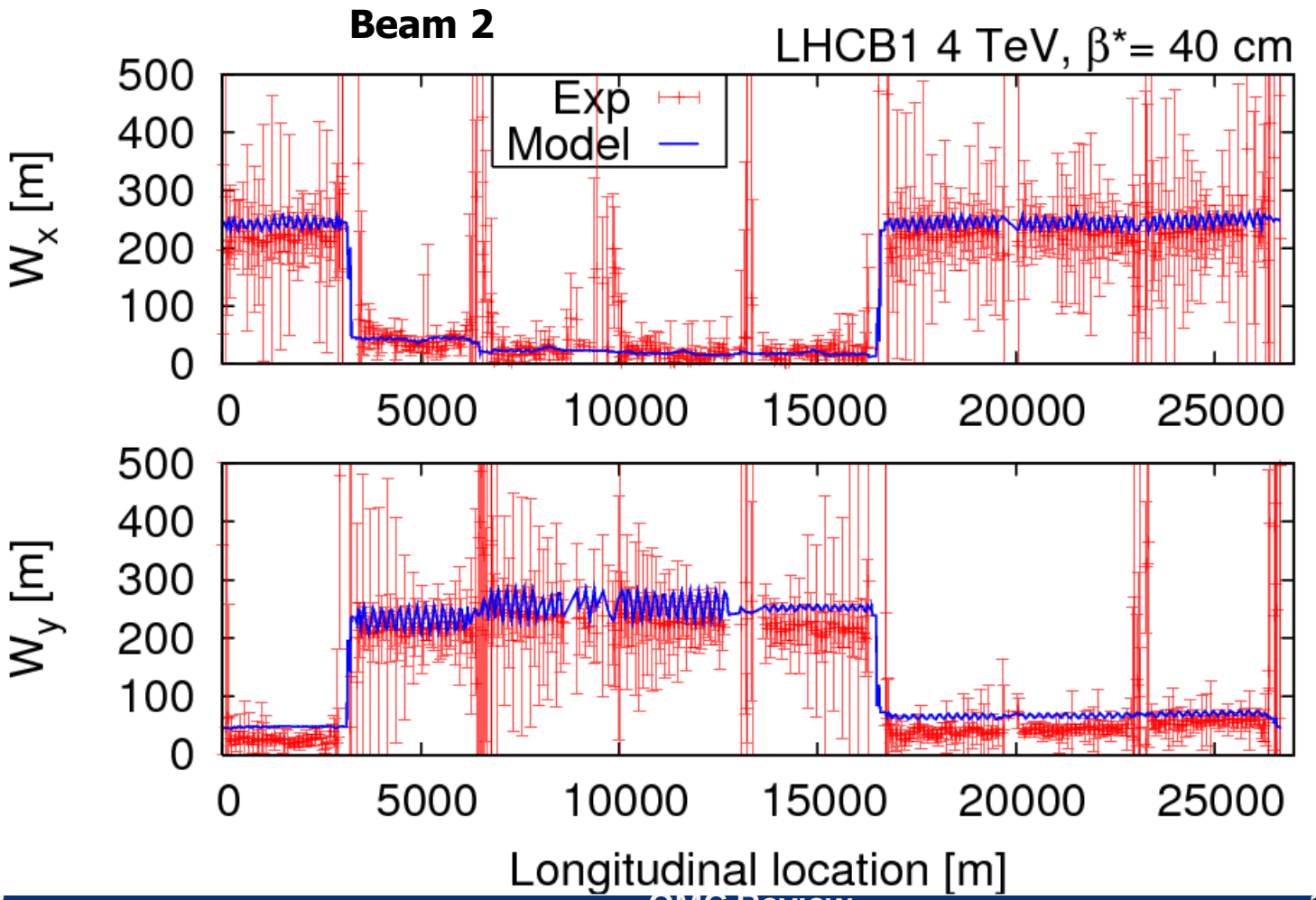
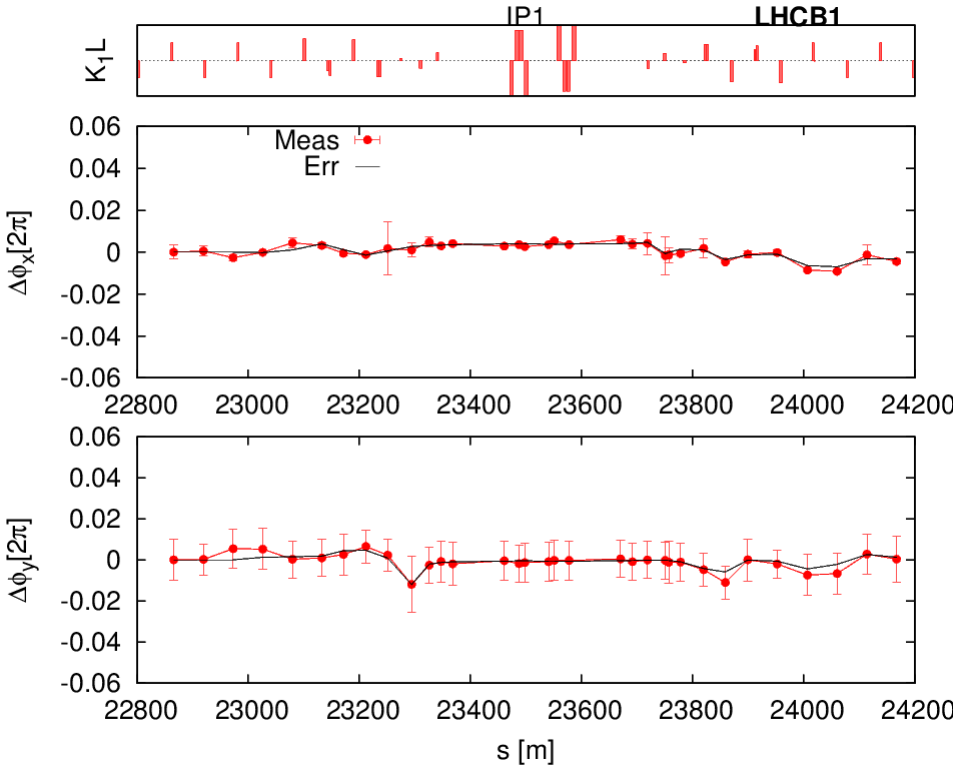
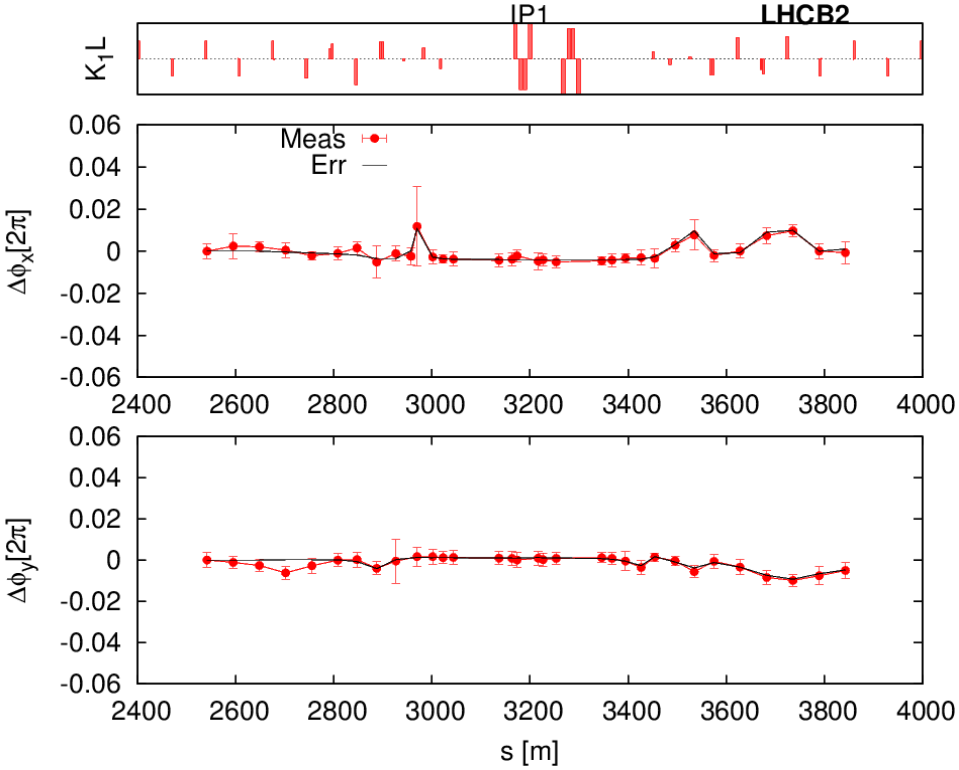


Nominal β^*= 40cm S-b-S IP1

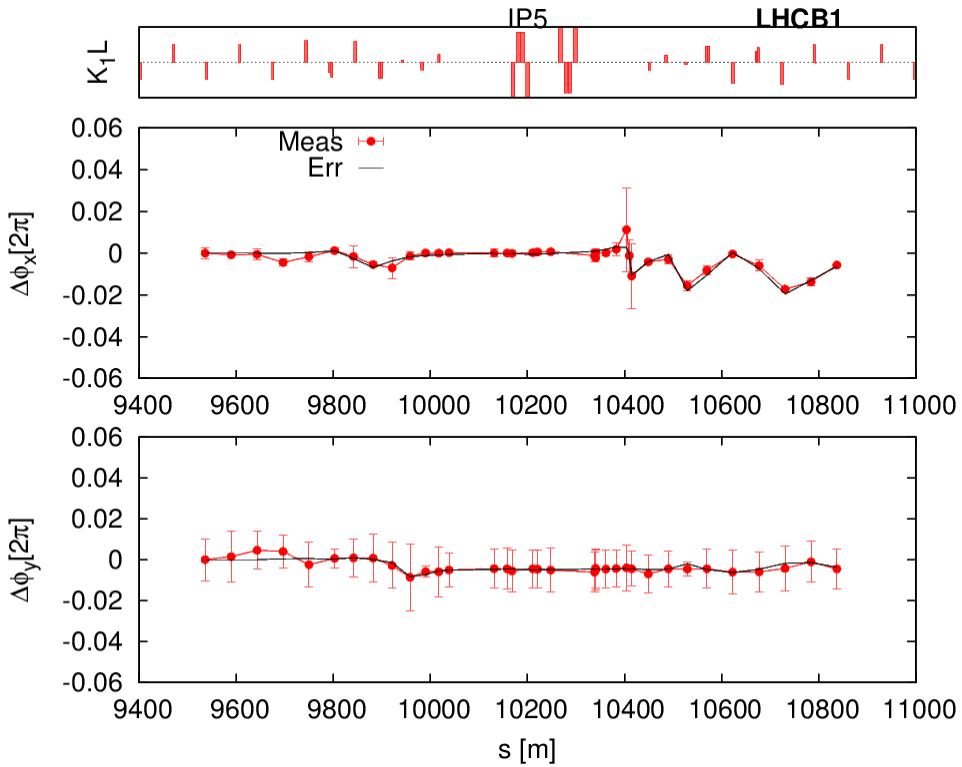
- Corrections done at 60cm well preserved at 40cm

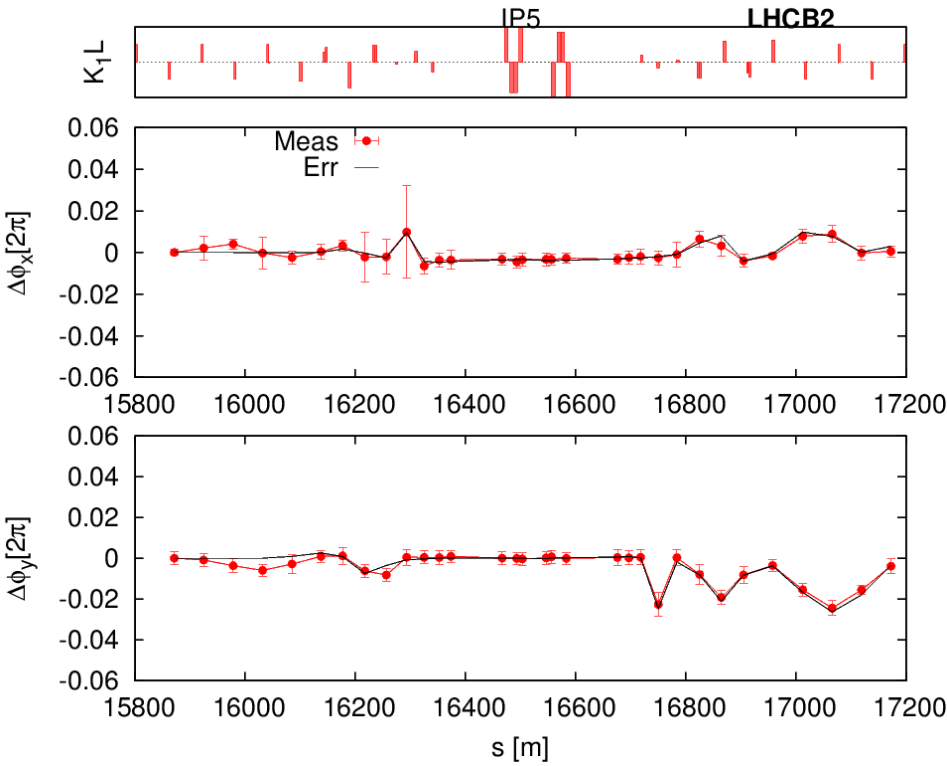




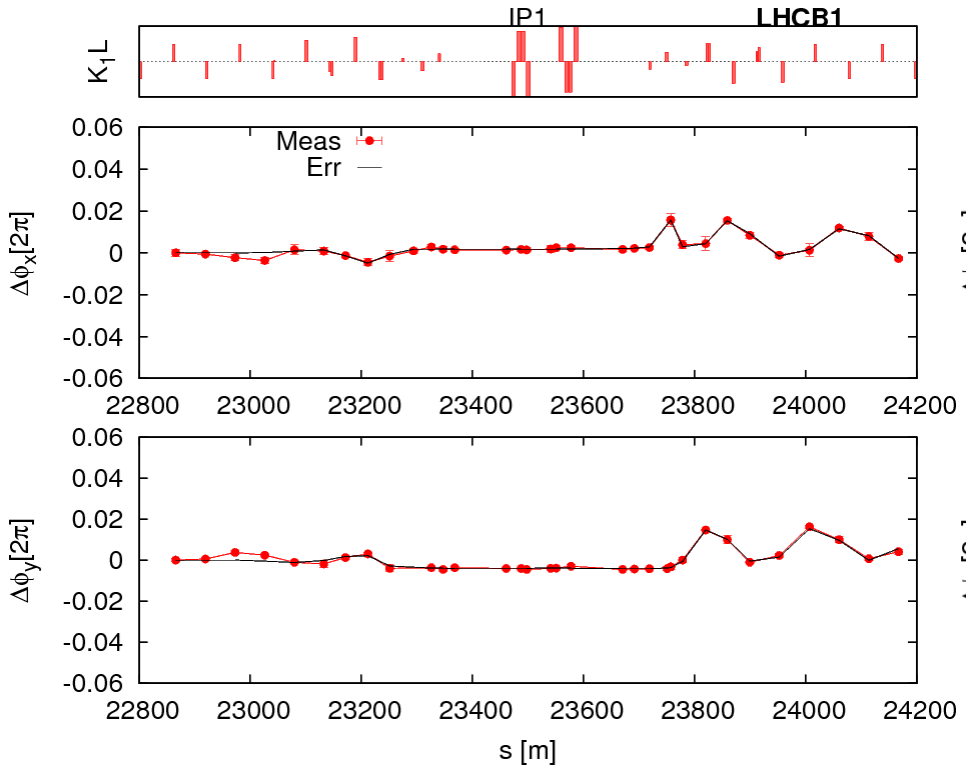
Nominal β^*= 40cm S-b-S IP5

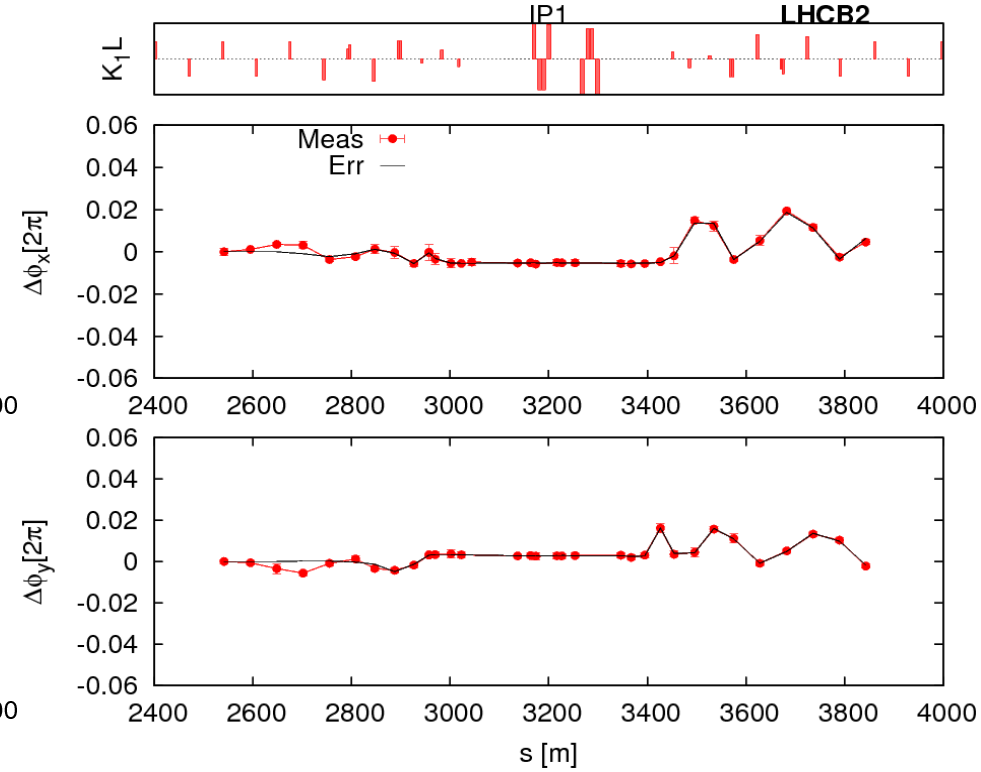
- Correction at 60cm quite well preserved at 40cm



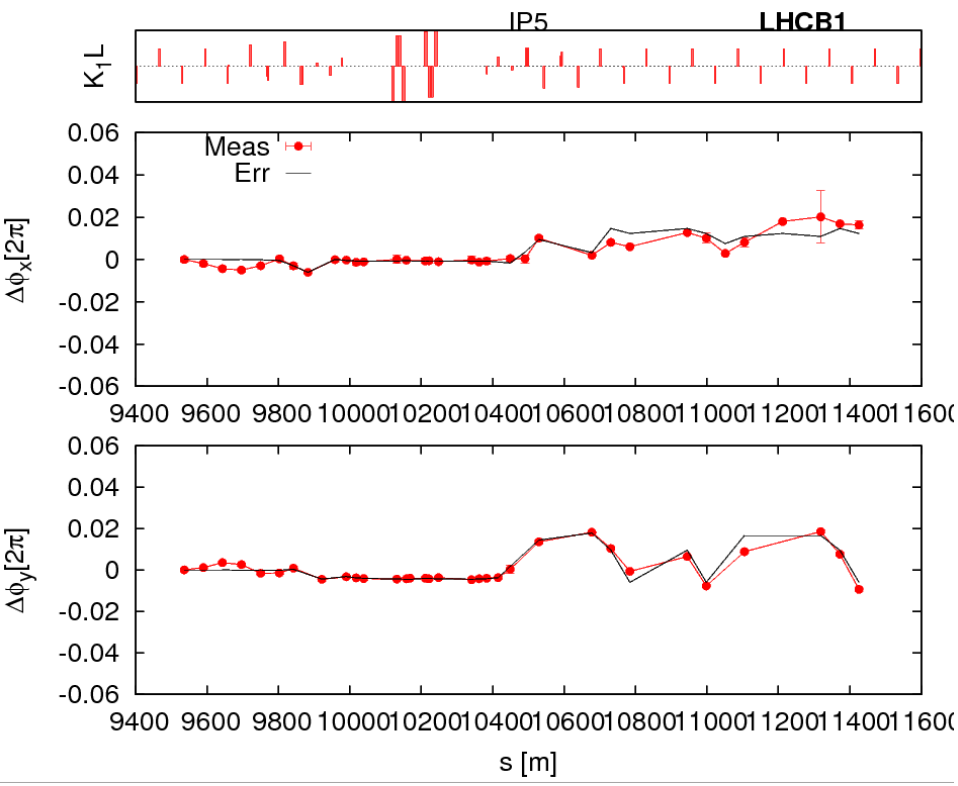


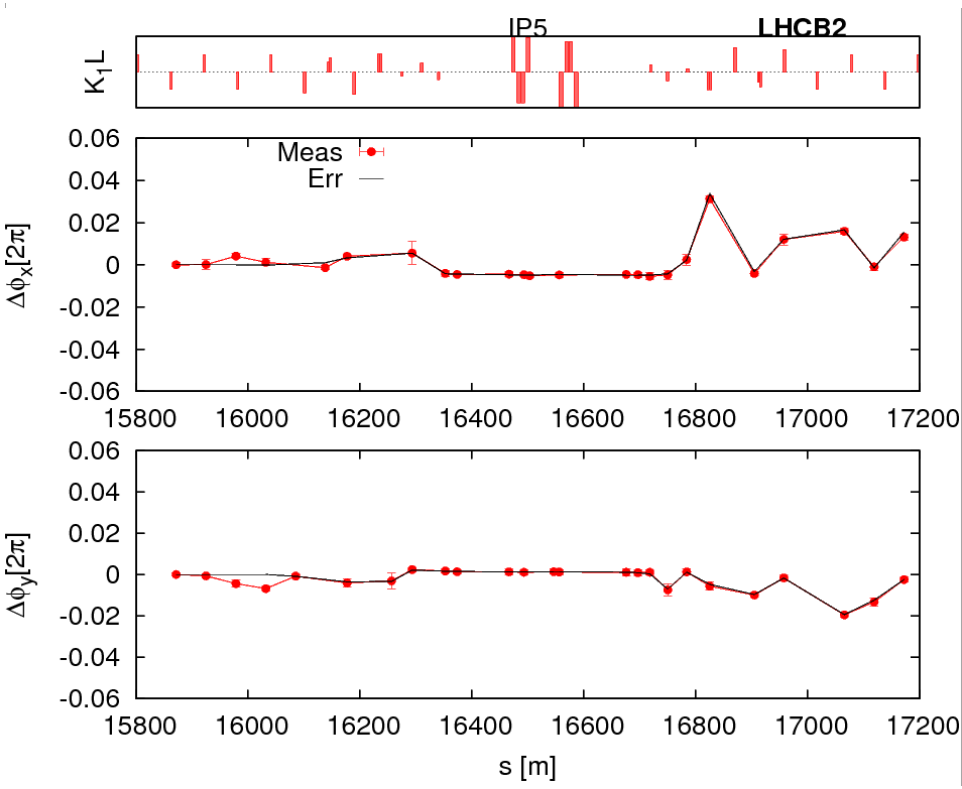
ATS β*=40cm S-b-S IP1





ATS β^*=40cm S-b-S IP5

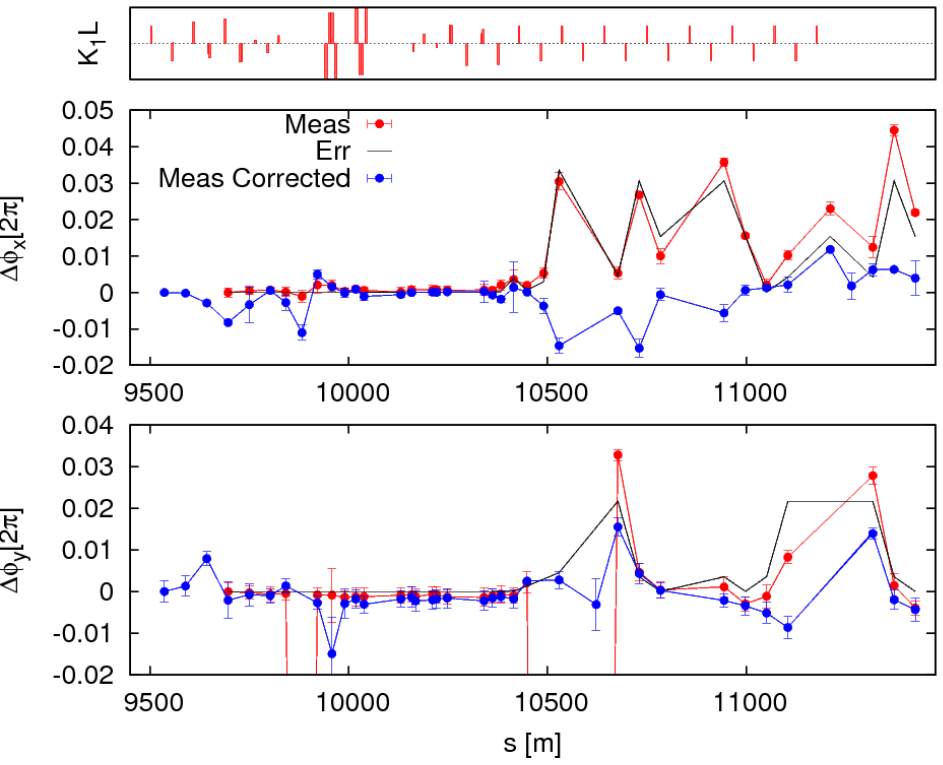




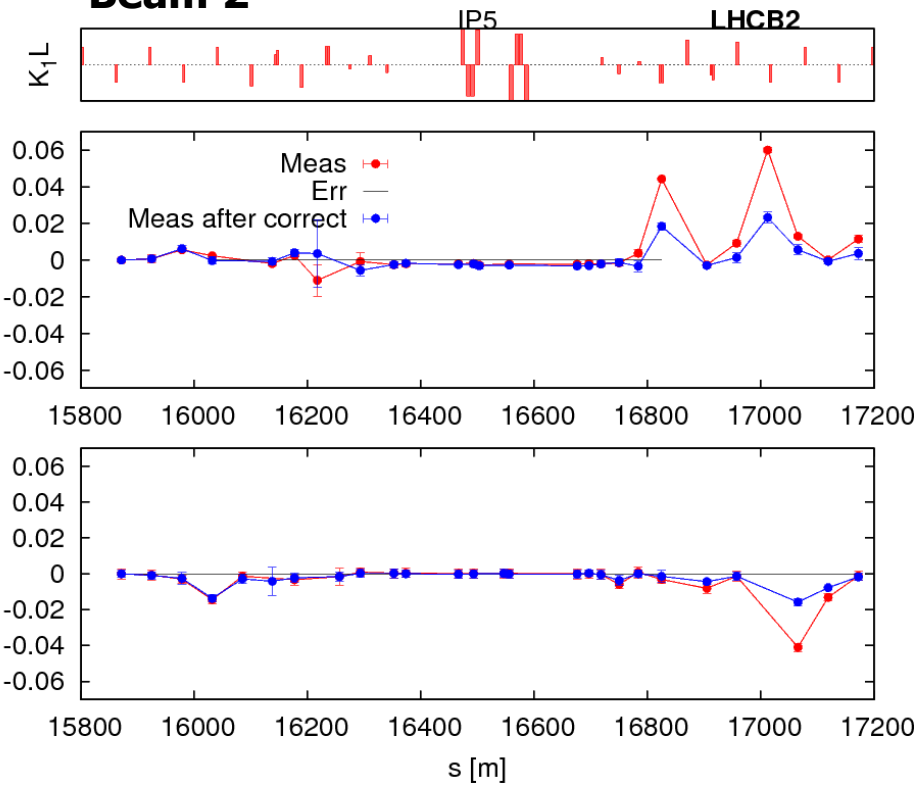
ATS β^*=20cm S-b-S IP5

- Corrections were done at 20cm did not work as expected
  - Definitely needs more attention to understand the problem
  - One of the possible errors is in initial Twiss parameters
    - ATS has more systematic errors in the measurement
  - Sign errors?

Beam 1



Beam 2



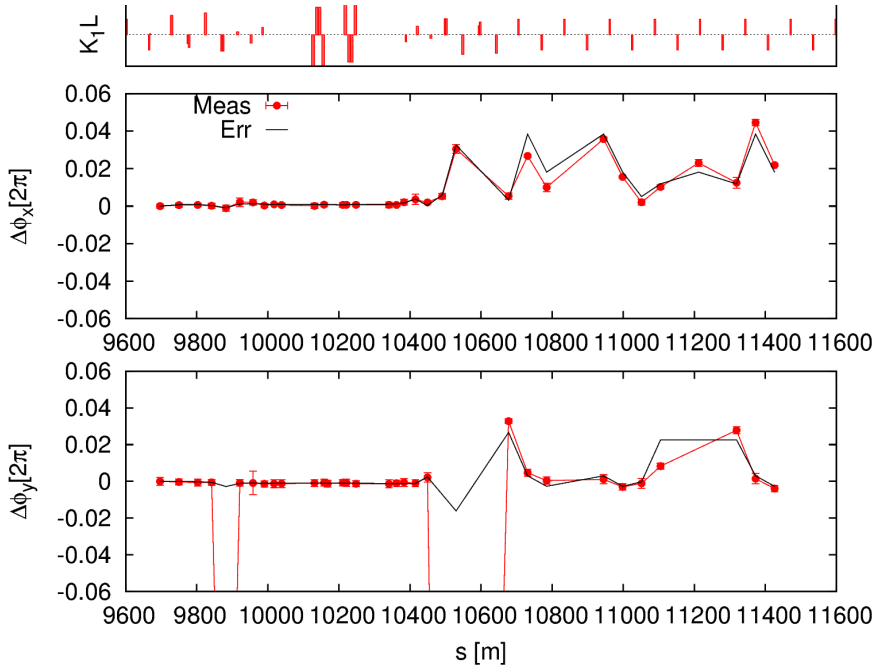
Backup

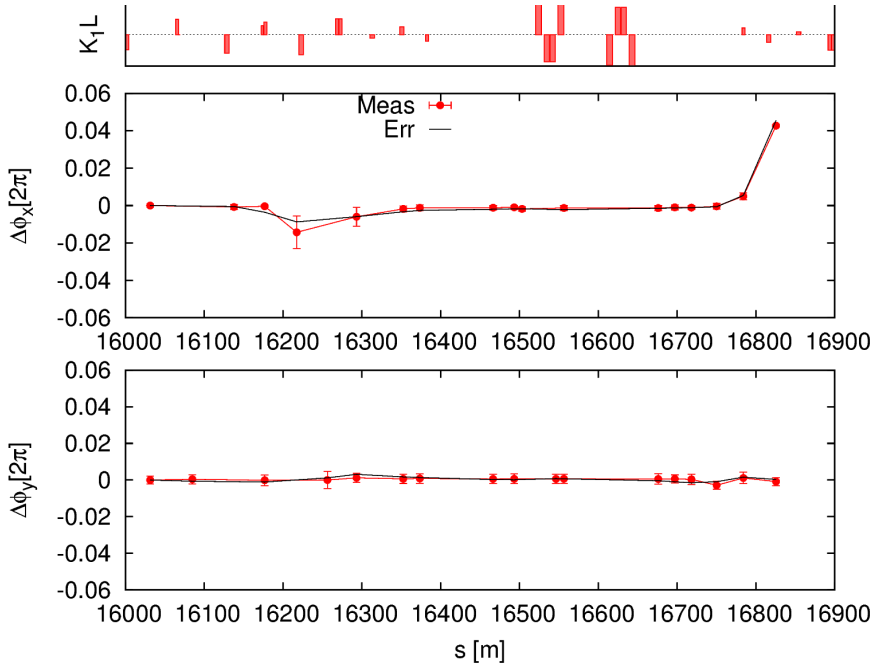
- Backup slides

Results

- For vast majority of the cases a satisfactory result is found within 120 matching iterations
  - Matching takes around 90 seconds

ATS 20cm IP2





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