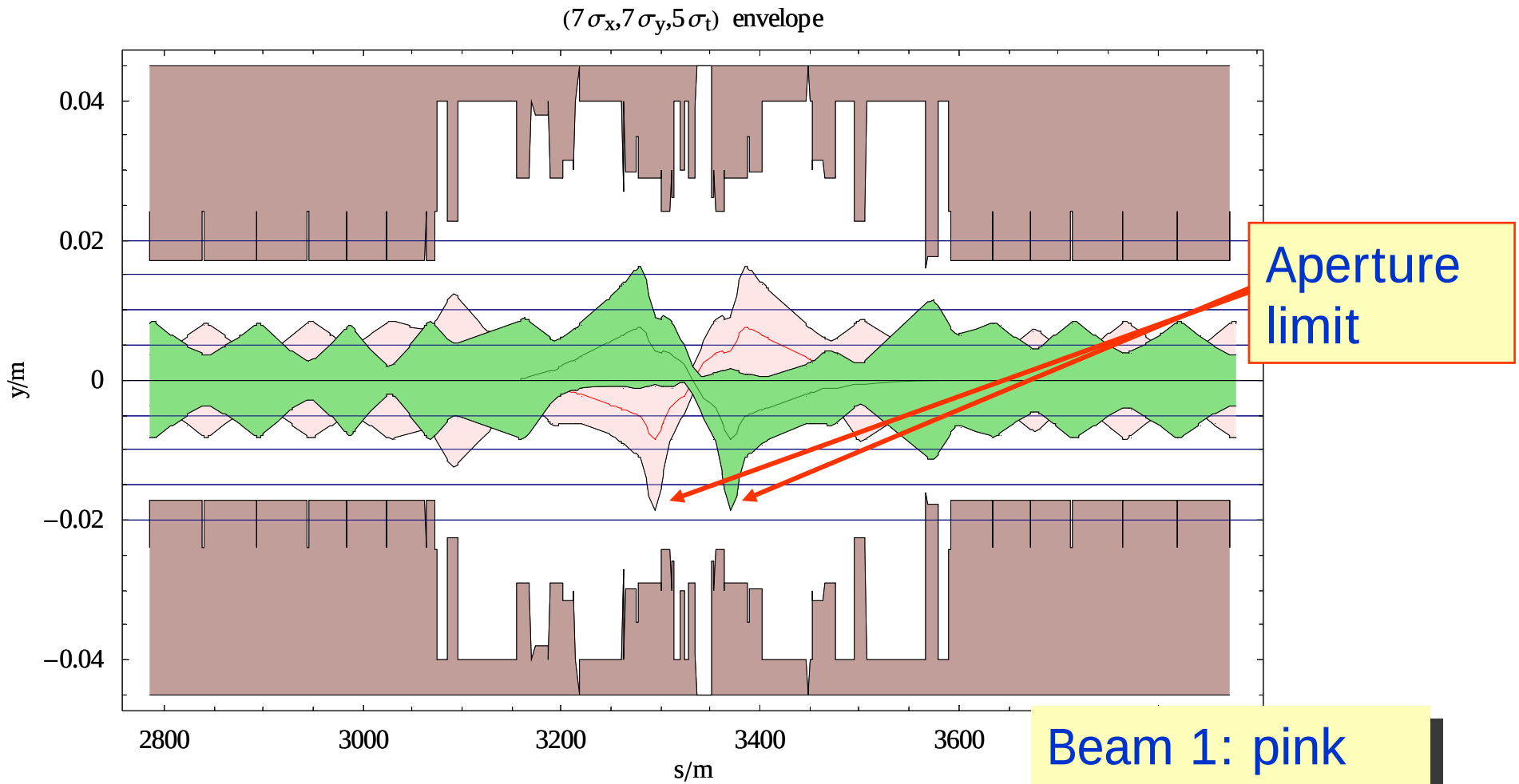
Displacement of IP2 at injection

- See my presentation in LOC meeting 11/4/2006.
- IP1 and IP5 have been displaced transversely in *collision* optics to gain aperture (S. Fartoukh)
- There is a similar aperture limitation in IR2 at *injection*
  - Showed that +1 mm vertical displacement of orbit at IP2 provides better aperture
    - Reverse sign for opposite ALICE spectrometer polarity
  - However some reduction in beam-beam separation
- Conditions for this revised study
  - V6.500 injection optics
  - ALICE spectrometer on
  - Latest “collimation” aperture model used
  - Larger vertical orbit displacement at IP2: 1.5 mm
  - Improve beam-beam separation with increased crossing angle

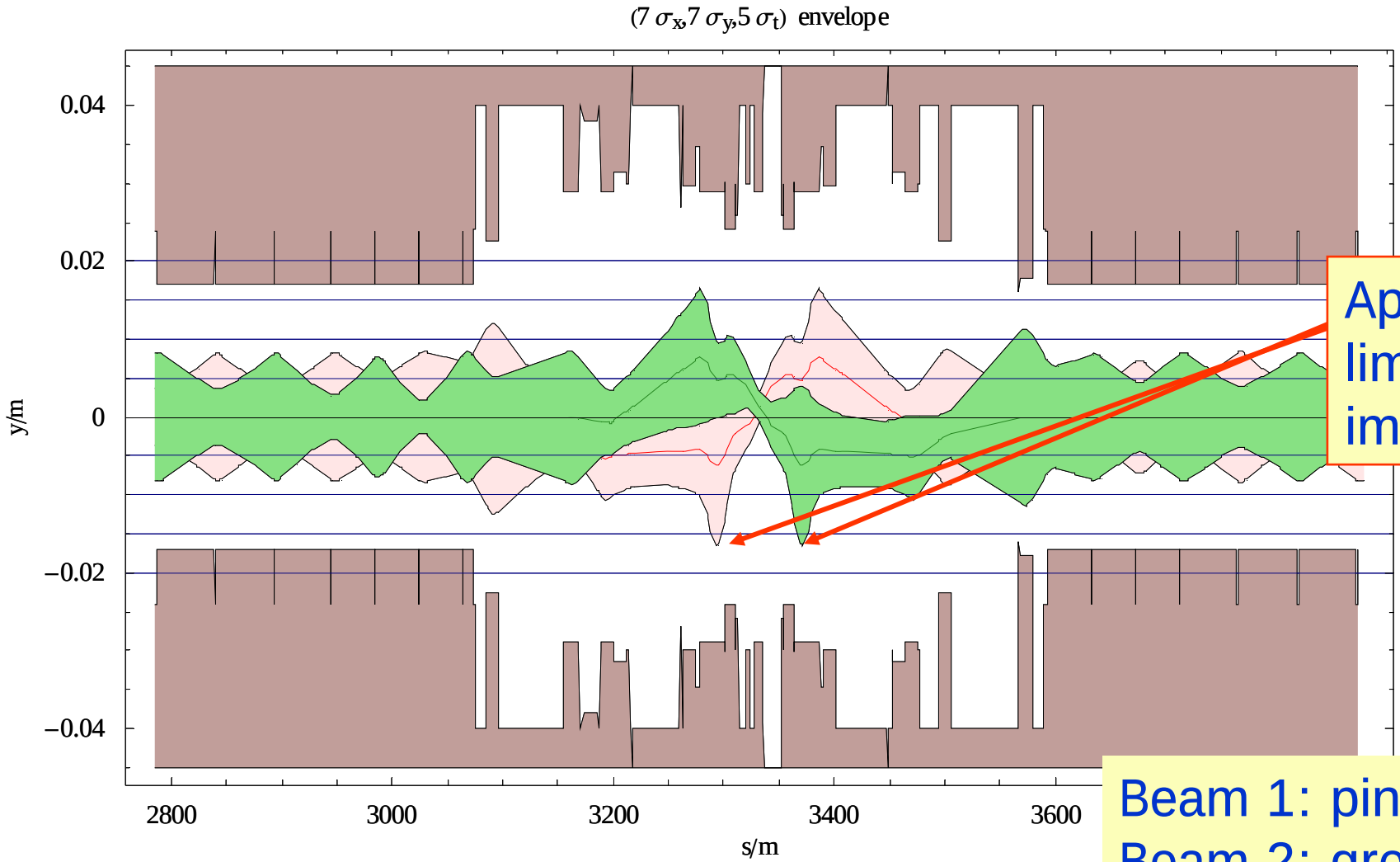
Vertical Beam envelopes, V6.500 injection optics, IR2

NAME	s	x_c	p_{xc}	y_c	p_{yc}
IP2	3332.44	0.002	0	0	0.00024
IP2	3332.28	-0.002	0	0	-0.00024



Vertical Beam envelopes, V6.500 injection optics, IP2 +1.5 mm

NAME	s	x_c	p_{xc}	y_c	p_{yc}
IP2	3332.44	0.002	0	0.0015	0.00024
IP2	3332.28	−0.002	0	0.0015	−0.00024



Aperture limit improved

Beam 1: pink
Beam 2: green

Maximum corrector strengths ?

What are the maximum strengths available?

(lxplus1) In[266]:=

```
FindList[seqFile, "kmax_MCBY"] // TableForm
```

(lxplus1) Out[266]//TableForm=

```
REAL CONST kmax_MCBYH_4.5k = 2.5;
REAL CONST kmax_MCBYH_1.9K = 3;
REAL CONST kmax_MCBYV_4.5k = 2.5;
REAL CONST kmax_MCBYV_1.9K = 3;
```

From Table 8.17 on page 242 of the LHC Design Report, it seems that these are fields in tesla. So we also need the lengths

(lxplus1) In[267]:=

```
FindList[seqFile, "l.MCBY"] // TableForm
```

(lxplus1) Out[267]//TableForm=

```
REAL CONST l.MCBYA = 0;
REAL CONST l.MCBYB = 0;
REAL CONST l.MCBYH = .9;
REAL CONST l.MCBYV = .9;
MCBYH : HKICKER, L := l.MCBYH;
MCBYV : VKICKER, L := l.MCBYV;
```

Maximum strength available at injection should be

(lxplus1) In[280]:=

```
e Bmax Lmag / p0 /. {Bmax -> 2.5 Tesla, Lmag -> 0.9 Meter,
  p0 -> 450 GeV / c} // N // ToFundamentalSI //
 ScientificForm
```

(lxplus1) Out[280]//ScientificForm=

1.49896×10^{-3}

Maximum strength available at collision should be

(lxplus1) In[281]:=

```
e Bmax Lmag / p0 /. {Bmax -> 2.5 Tesla, Lmag -> 0.9 Meter,
  p0 -> 7000 GeV / c} // N // ToFundamentalSI //
 ScientificForm
```

(lxplus1) Out[281]//ScientificForm=

9.63618×10^{-5}

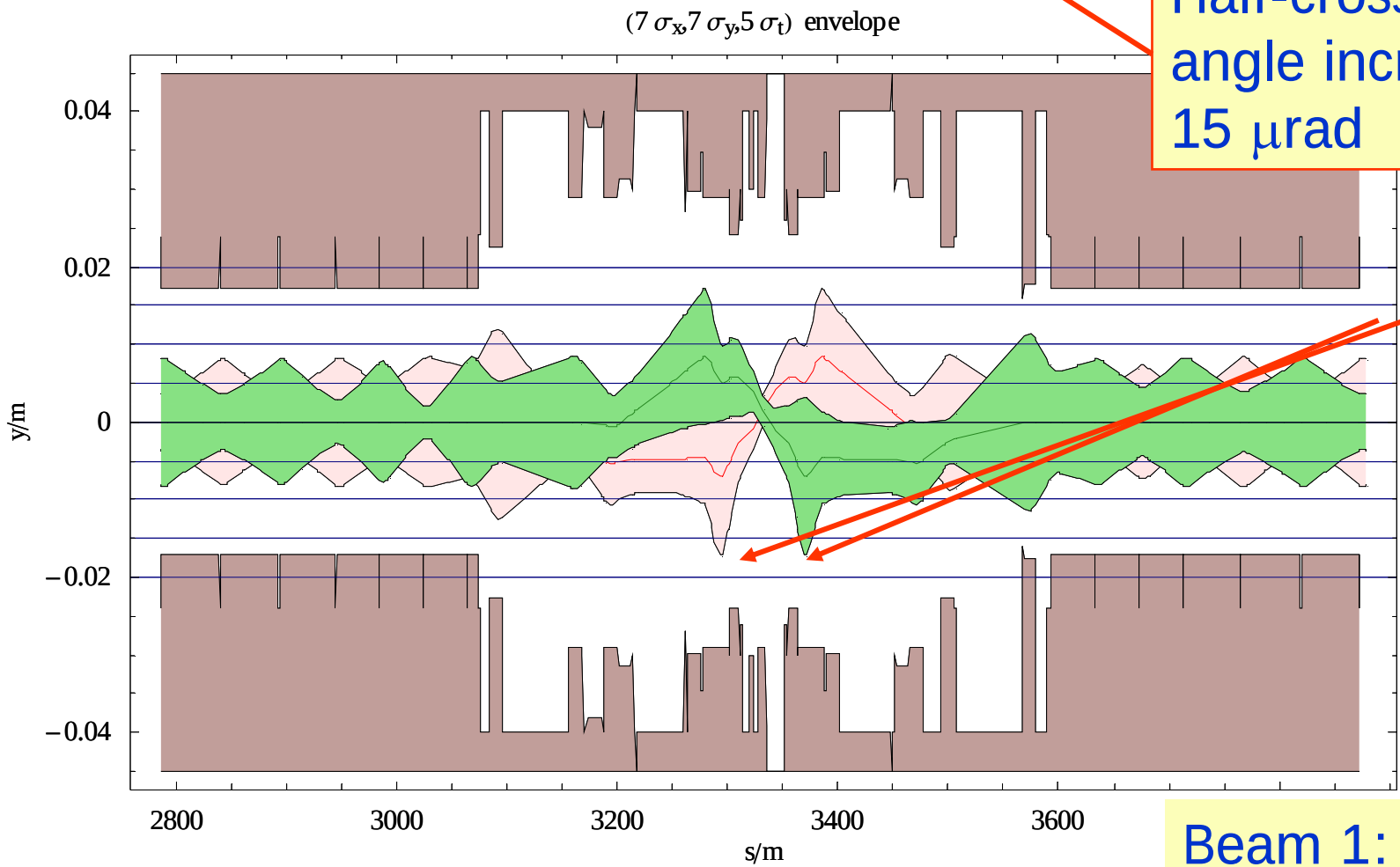
Corrector strengths, V6.500 injection optics, IP2 +1.5mm

```
Strengths before matching:

ACBCV6.L2B1 =       -7.771488E-06 ;
ACBCV6.R2B2 =        -7.57375E-06 ;
ACBCVS5.R2B1 =       5.7337946E-05 ;
ACBYVS4.L2B1 =      -6.9601072E-05 ;
ACBYVS4.L2B2 =      -1.3481602E-05 ;
ACBYVS4.R2B1 =      -3.2639812E-05 ;
ACBYVS4.R2B2 =      -6.6937891E-05 ;
ACBYVS5.L2B2 =       4.5792594E-05 ;

Strengths after matching:

ACBCV6.L2B1 =    -3.484124777E-05 ;
ACBCV6.R2B2 =     -3.39547325E-05 ;
ACBCVS5.R2B1 =    -2.375369296E-05 ;
ACBYVS4.L2B1 =    -7.903633837E-05 ;
ACBYVS4.L2B2 =     0.0001415135948 ;
ACBYVS4.R2B1 =     0.0001494503189 ;
ACBYVS4.R2B2 =    -6.709669971E-05 ;
ACBYVS5.L2B2 =    -1.897076573E-05 ;
```

Within acceptable corrector strength range

Vertical Beam envelopes, V6.500 injection optics, IP2 +1.5mm

NAME	s	x_c	p_{xc}	y_c	p_{yc}
IP2	3332.44	0.002	0	0.0015	0.000255
IP2	3332.28	-0.002	0	0.0015	-0.000255



Half-crossing angle increased 15 μrad

Aperture limit still better

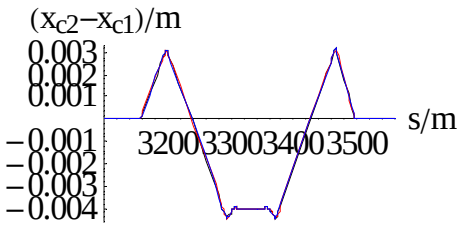
Beam 1: pink
Beam 2: green

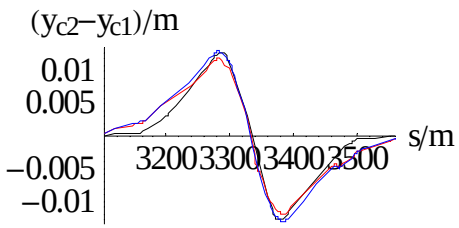
Corrector strengths, V6.500 injection optics, IP2 +1.5mm

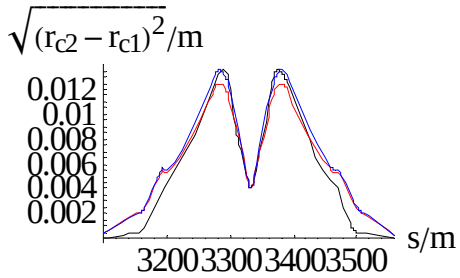
```
Strengths before matching:

ACBCV6.L2B1 =       -7.771488E-06 ;
ACBCV6.R2B2 =        -7.57375E-06 ;
ACBCVS5.R2B1 =       5.7337946E-05 ;
ACBYVS4.L2B1 =      -6.9601072E-05 ;
ACBYVS4.L2B2 =      -1.3481602E-05 ;
ACBYVS4.R2B1 =      -3.2639812E-05 ;
ACBYVS4.R2B2 =      -6.6937891E-05 ;
ACBYVS5.L2B2 =       4.5792594E-05 ;

Strengths after matching:

ACBCV6.L2B1 =    -3.552696732E-05 ;
ACBCV6.R2B2 =    -3.462300455E-05 ;
ACBCVS5.R2B1 =    -1.869446244E-05 ;
ACBYVS4.L2B1 =     -8.51776094E-05 ;
ACBYVS4.L2B2 =     0.0001403240416 ;
ACBYVS4.R2B1 =     0.0001465703354 ;
ACBYVS4.R2B2 =    -7.300298417E-05 ;
ACBYVS5.L2B2 =    -1.493024269E-05 ;
```

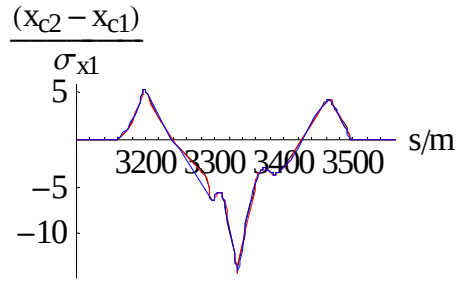
Half-crossing angle increased 15 μrad

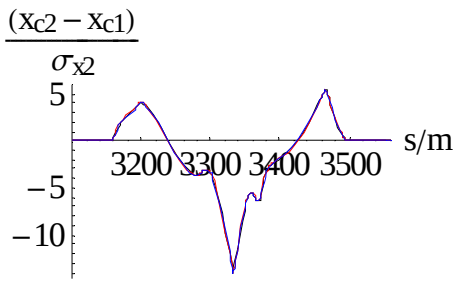
Beam-beam separation

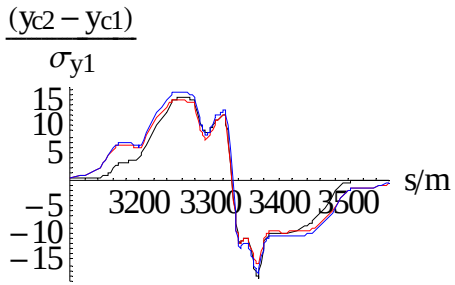


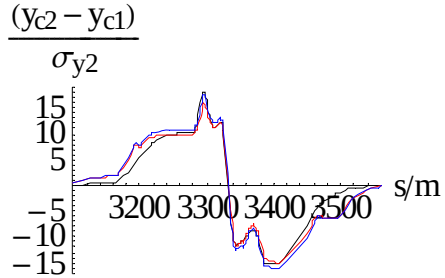


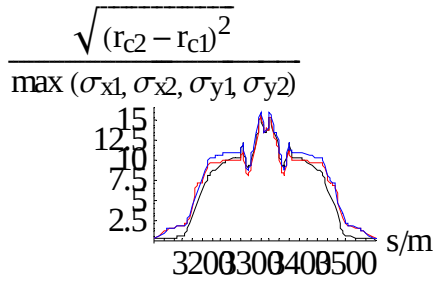












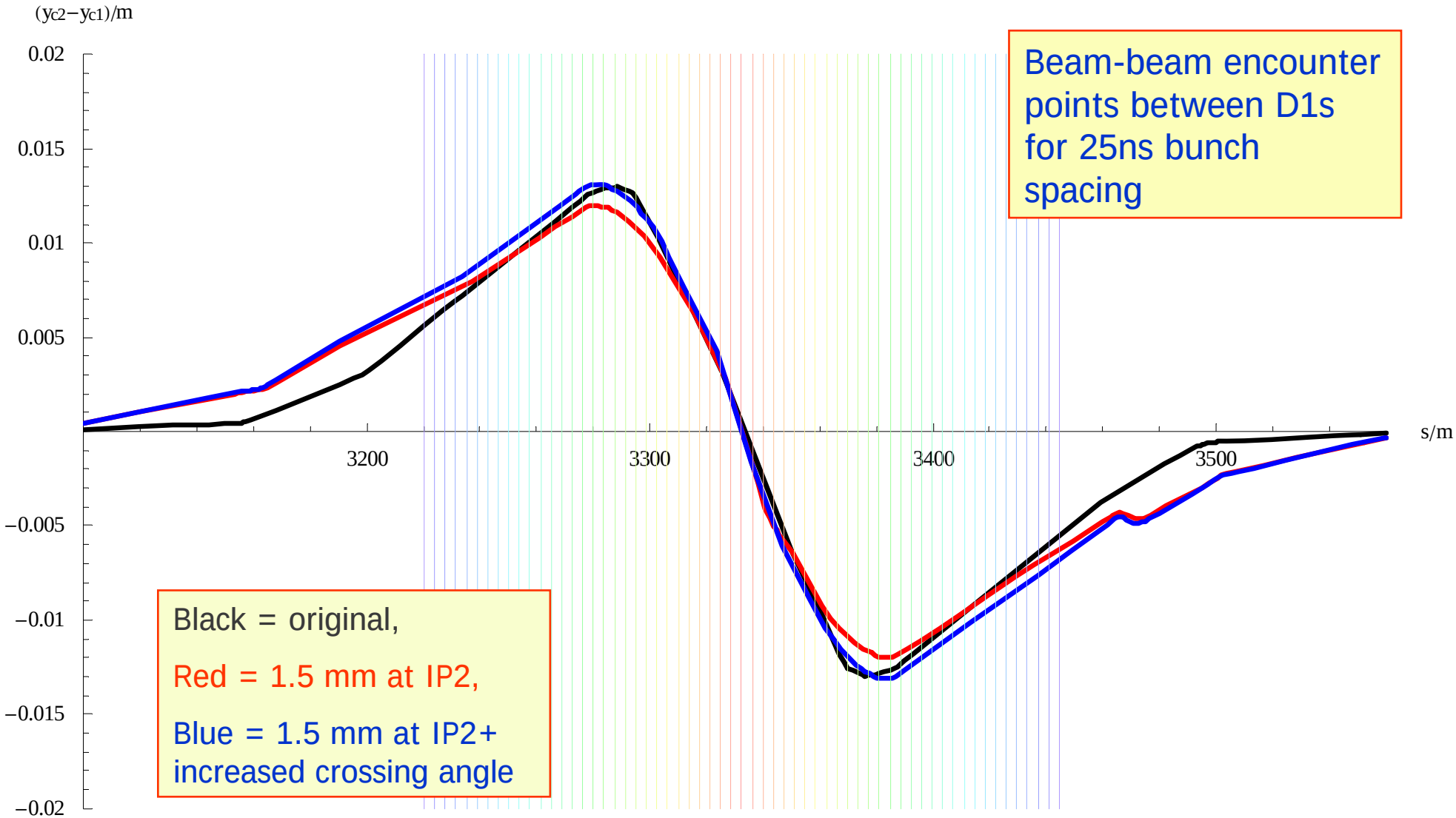
Black = original,

Red = 1.5 mm at IP2,

Blue = 1.5 mm at IP2+ increased crossing angle

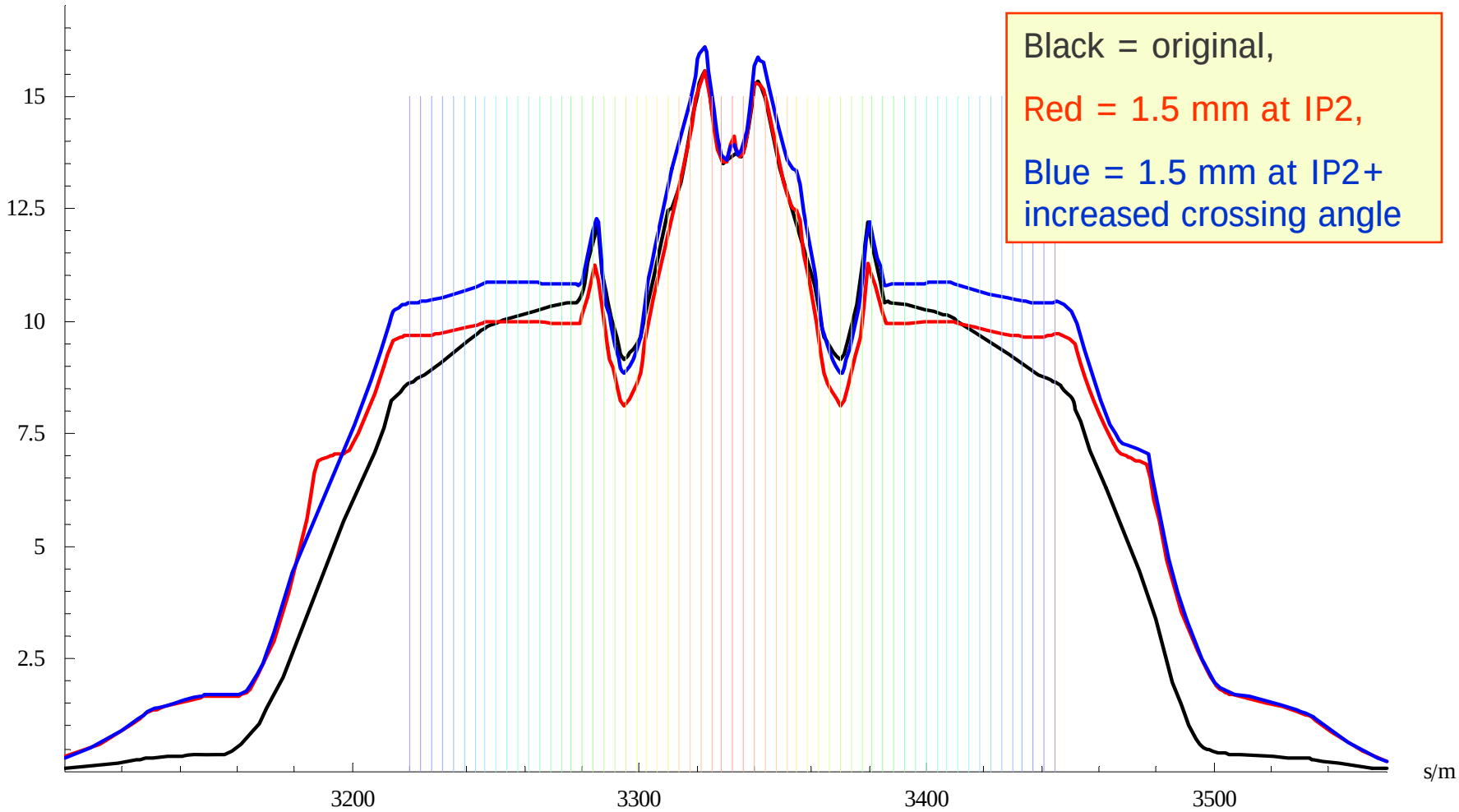
- Various possible separation criteria
  - Separation in each plane
  - Total separation
  - Separation in units of sigma (different for each beam) in each plane
  - Total separation in units of largest of 4 sigmas

Absolute vertical separation between beams

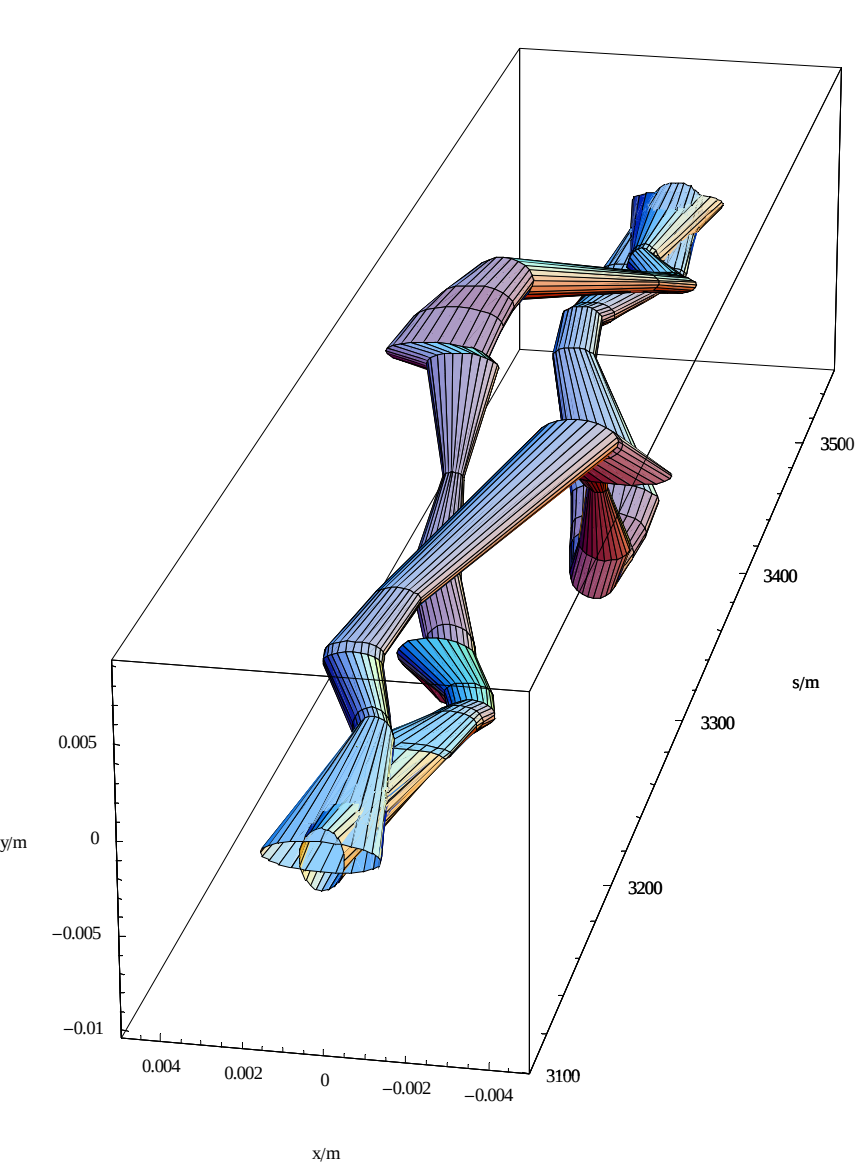


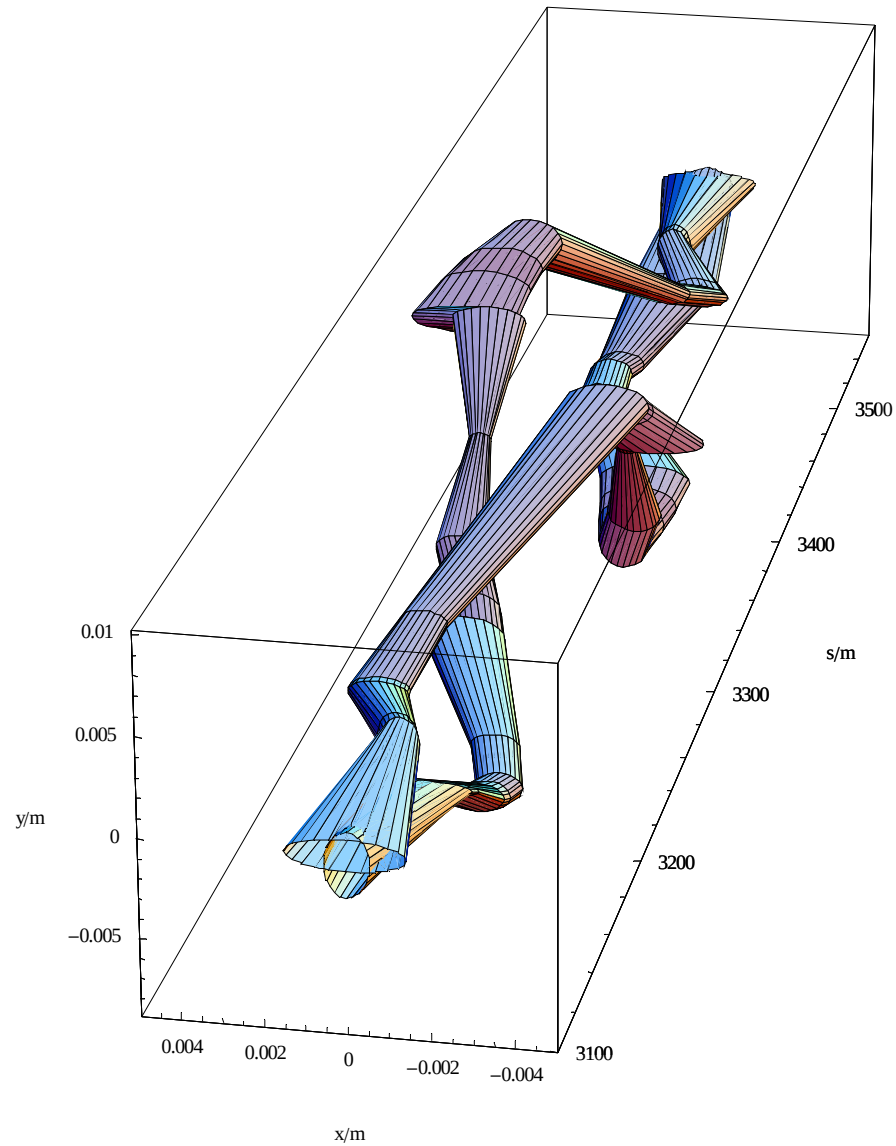
Total separation in units of largest of 4 sigmas

$$\frac{\sqrt{(r_{c2}-r_{c1})^2}}{\max(\sigma_{x1},\sigma_{x2},\sigma_{y1},\sigma_{y2})}$$



Original and final separations





Conclusions

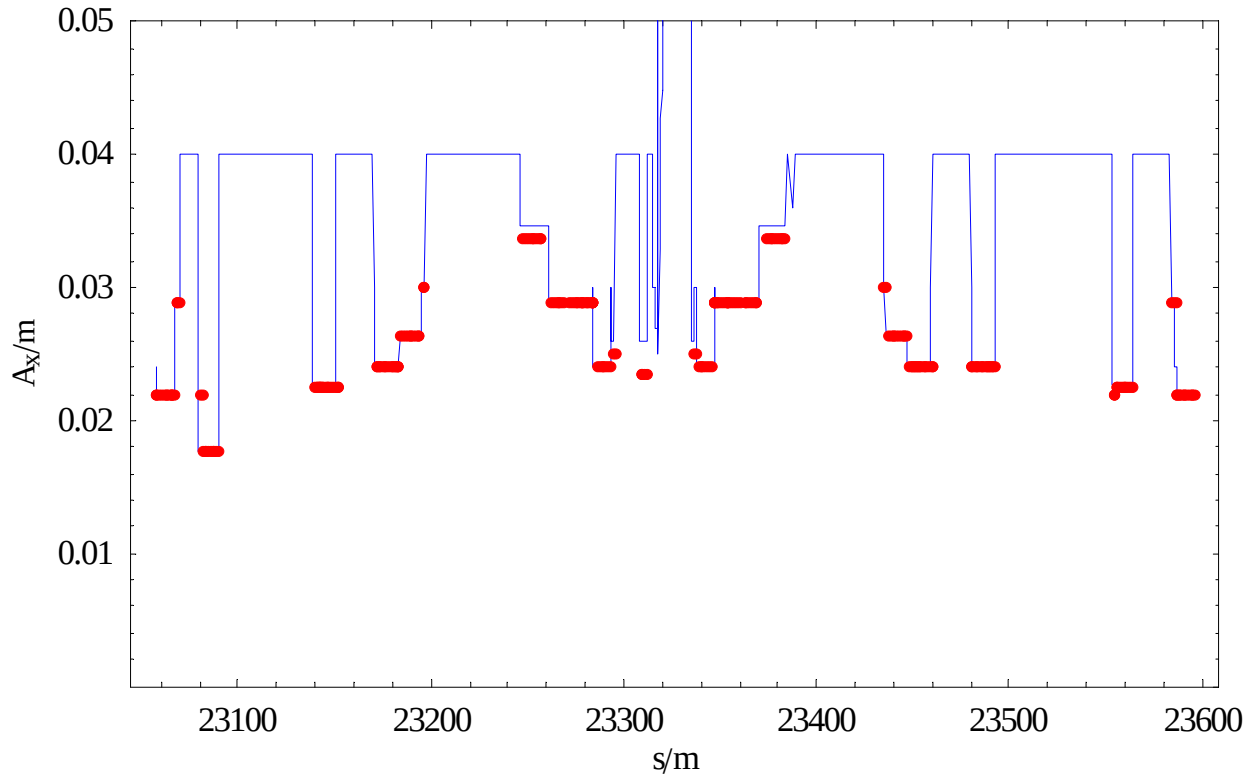
- Aperture of IR2 at injection can be optimised by +1.5 mm vertical displacement of orbit at IP2
  - Opposite sign for other ALICE polarity
  - Some increased corrector strengths
  - Some reduction of beam-beam separation
- Beam-beam separation can be recovered, if necessary, by increasing half-crossing angle by 15 μrad
  - Most of aperture improvement preserved
- Vertical displacement of IP2 (like the crossing angle) should be considered as a “knob”, to some extent at least.

Backup slides from 11 Apr 2006

Comparison of horizontal aperture models in IR2

(lxplus1) In[400]:=

```
DisplayTogether[apXcollPlot, apXseqPlot, FrameLabel→ {"s/m", "Ax/m"}, Frame→ True]
```



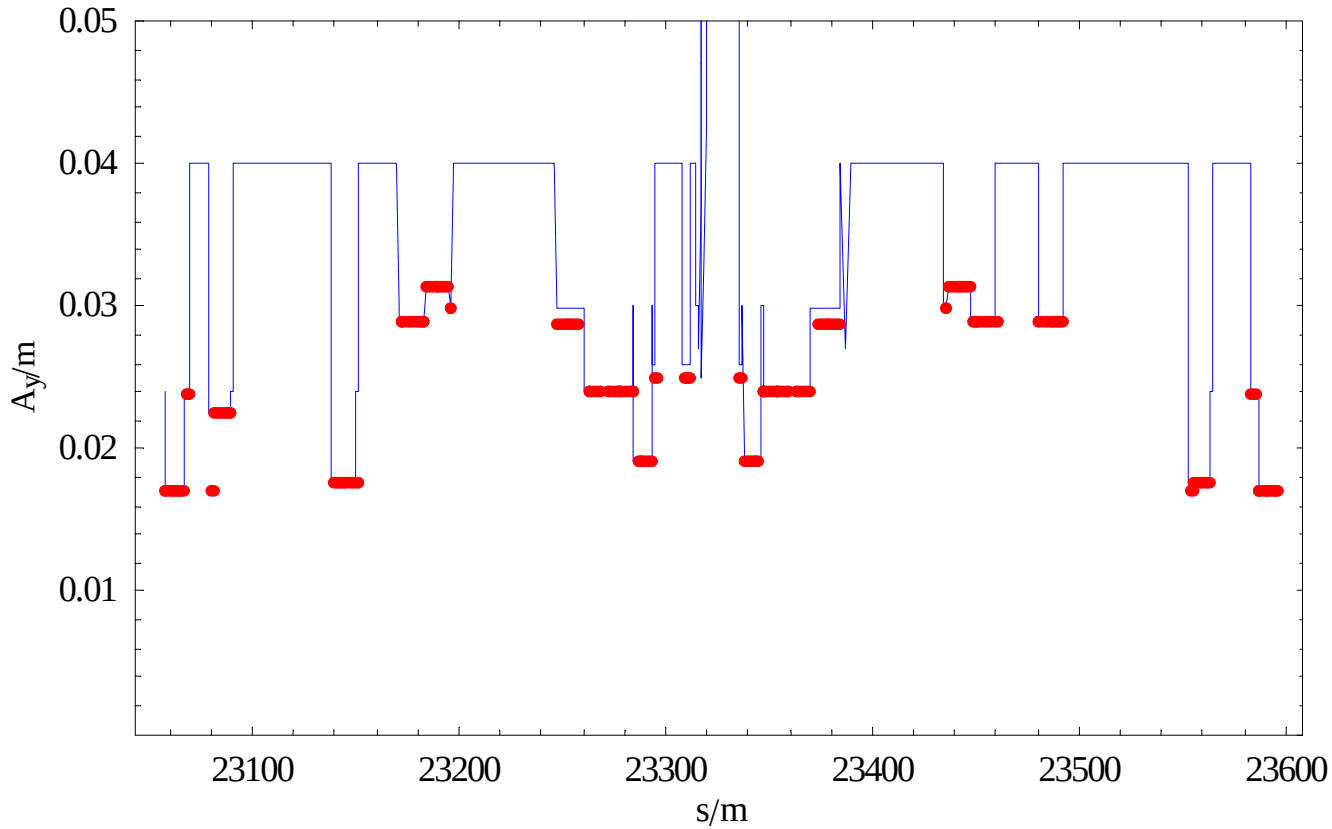
Latest minimal collimation model vs. aperture in special sequence file

“seq_sf”

Comparison of vertical aperture models in IR2

(lxplus1) In[401]:=

```
DisplayTogether[apYcollPlot, apYseqPlot, FrameLabel→ {"s/m", "Ay/m"}, Frame→ True]
```



Latest minimal collimation model vs. aperture in special sequence file

"seq_sf"