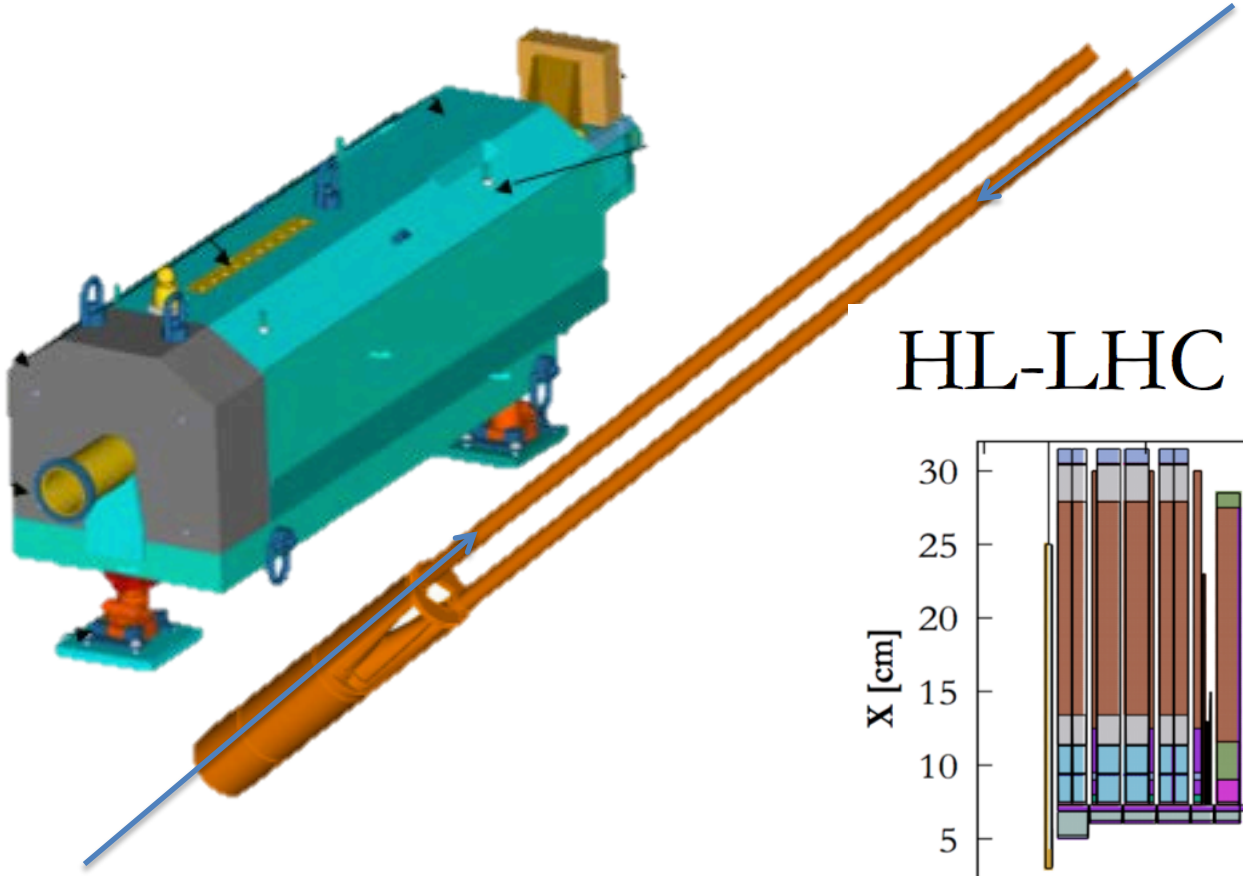
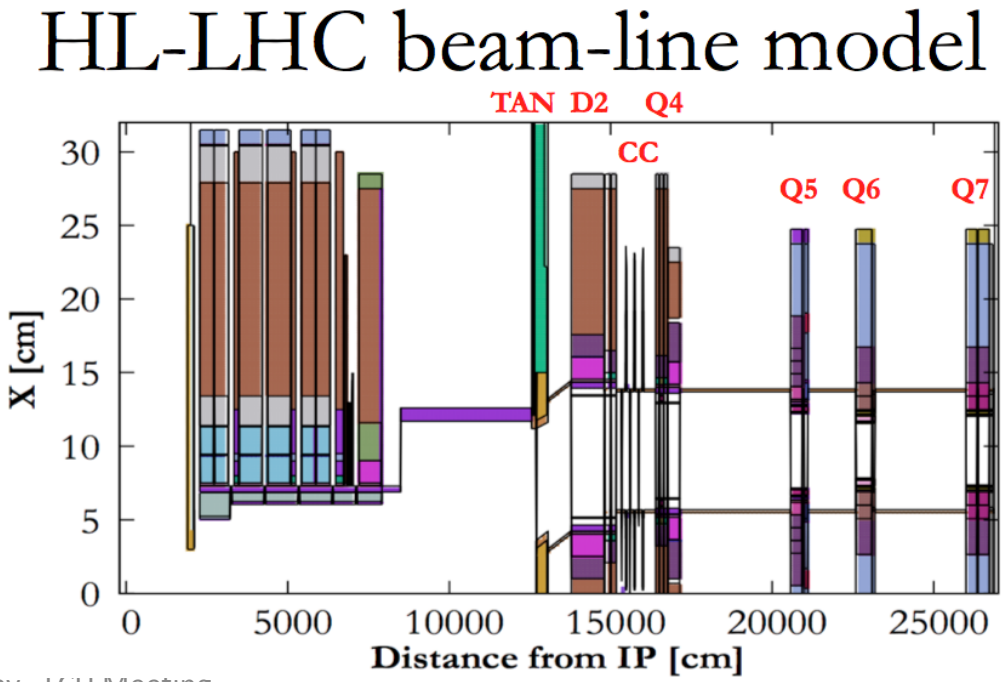
HL-LHC TAN aperture with reduced tolerances





n1 values for TAN (x/y)

(41/37,37/33.3,32.8/30,28.7/25.9)

Separation and crossing angles on

Element		Round (βx=β||=15 cm)		Flat (βx= 7.5 cm β||=30cm)		Flathv (βx= 30 cm β||=7.5cm)	
		εn=3.5 μmrad	εn=2.5 μmrad	εn=3.5 μmrad	εn=2.5 μmrad	εn=3.5 μmrad	εn=2.5 μmrad
D2							
TAN	41/37						
	10% (37/33)						
	20% (32.8/30)						
	30% (28.7/25.9)						
D1							
Q3							
Q2							
Q1							
TAS							

slhc/aperture/aperture_upgrade_MS.madx

```
r_tol_D2 =0.00084; h_tol_D2 =0.00136; v_tol_D2 =0.0010;
r_TAN_tol=r_D2_tol;h_TAN_tol=h_D2_tol;v_TAN_tol=v_D2_tol;
TANAL.4L1,  APERTYPE=RECTELLIPSE,
APERTURE={a_TAN,b_TAN,a_TAN,b_TAN},APER_TOL={r_TAN_tol,h_TAN_tol,v_TAN_tol};
TANAR.4R1,  APERTYPE=RECTELLIPSE,
APERTURE={a_TAN,b_TAN,a_TAN,b_TAN},APER_TOL={r_TAN_tol,h_TAN_tol,v_TAN_tol};
TANC.4L5 ,  APERTYPE=RECTELLIPSE,
APERTURE={a_TAN,b_TAN,a_TAN,b_TAN},APER_TOL={r_TAN_tol,h_TAN_tol,v_TAN_tol};
TANC.4R5 ,  APERTYPE=RECTELLIPSE,
APERTURE={a_TAN,b_TAN,a_TAN,b_TAN},APER_TOL={r_TAN_tol,h_TAN_tol,v_TAN_tol};
```

Min (n1 ATLAS, n1 CMS)

COR = 1 mm (maximum radial closed orbit uncertainty) (Note 1)

BBEAT = 1.05 (beta beating coefficient applying to beam size ➔peak βbeat **10.25%** (Note 2)

DP = 0 (bucket edge at the current beam energy)

HALOS = (6,6,6,6) (primary halo radius, secondary halo radial part, secondary halo horizontal cut, secondary halo vertical cut)

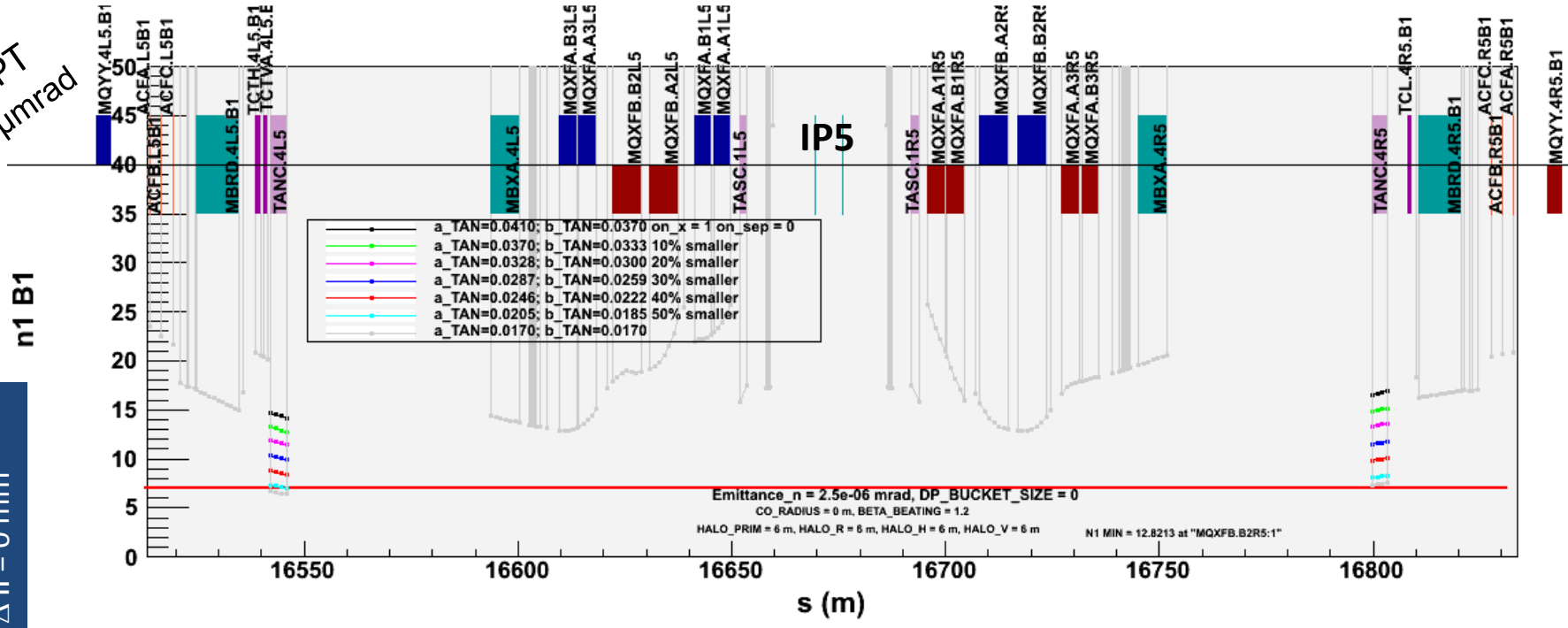
OFFSETELEM = slhc/aperture/ offset.ip5.b1.tfs & offset.ip1.b1.tfs ➔ TANAL.4L1 x_off =24.5 mm, TANAR.4R1 x_off =169.5 mm, TANC.4L5 x_off = 24.5 mm and TANC.4R5 x_off = 169.5 mm

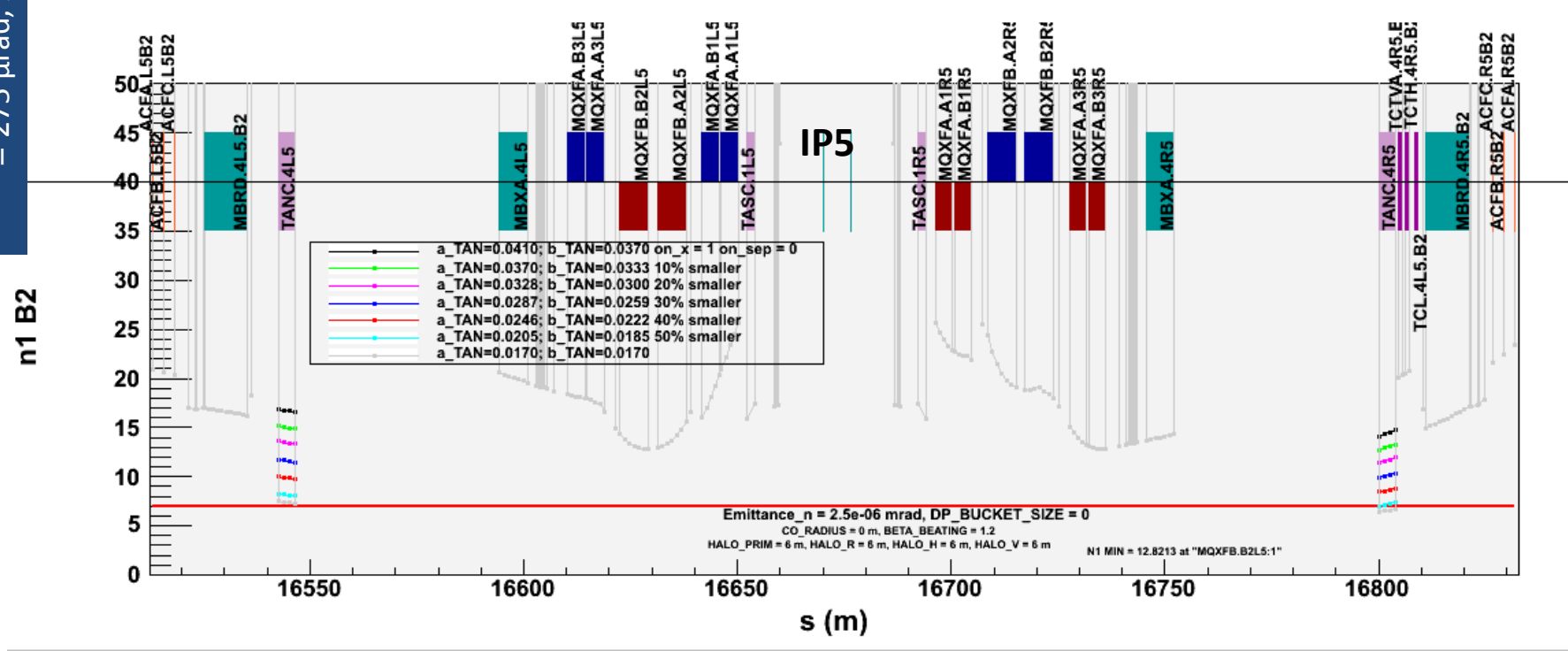
➔ Beam pipe separation of 145 mm (160 mm today's LHC)

Offset not optimized for the reduced apertures

FLAT OPT
ε_n = 2.5 µmrad

Collision optics HLLHCV1.0, flat (βx*=0.3m βy*=0.075m), half θx = 275 µrad, Δ II = 0 mm





n1 values for TAN (x/y)

(41/37,37/33.3,32.8/30,28.7/25.9)

Separation and crossing angles on

Element		Round (βx=β||=15 cm)		Flat (βx= 7.5 cm β||=30cm)		Flathv (βx= 30 cm β||=7.5cm)	
		εn=3.5 μmrad	εn=2.5 μmrad	εn=3.5 μmrad	εn=2.5 μmrad	εn=3.5 μmrad	εn=2.5 μmrad
D2		18.38	21.75	14.03	16.6	12.89	15.25
TAN	41/37	16.05	18.99	12.66	14.98	11.44	13.54
	10% (37/33)	13.88	16.43	11.13	13.17	9.91	11.72
	20% (32.8/30)	11.61	13.74	9.52	11.27	8.3	9.83
	30% (28.7/25.9)	9.4	11.12	7.95	9.41	6.74	7.97
D1		12.98	15.36	12.41	14.69	9.4	11.13
Q3		12.21	14.44	12.13	14.35	8.87	10.50
Q2		12.19	14.42	11.92	14.1	8.86	10.48
Q1		16.37	19.37	14.83	17.55	11.82	13.98
TAS		16.45	19.45	14.27	16.89	11.93	14.11

Min (n1 ATLAS, n1 CMS)

COR = 1 mm (maximum radial closed orbit uncertainty) (Note 1)

BBEAT = 1.05 (beta beating coefficient applying to beam size ➔peak βbeat **10.25%** (Note 2)

DP = 0 (bucket edge at the current beam energy)

HALOS = (6,6,6,6) (primary halo radius, secondary halo radial part, secondary halo horizontal cut, secondary halo vertical cut)

OFFSETELEM = slhc/aperture/ offset.ip5.b1.tfs & offset.ip1.b1.tfs ➔ TANAL.4L1 x_off =24.5 mm, TANAR.4R1 x_off =169.5 mm, TANC.4L5 x_off = 24.5 mm and TANC.4R5 x_off = 169.5 mm

➔ Beam pipe separation of 145 mm (160 mm today's LHC)

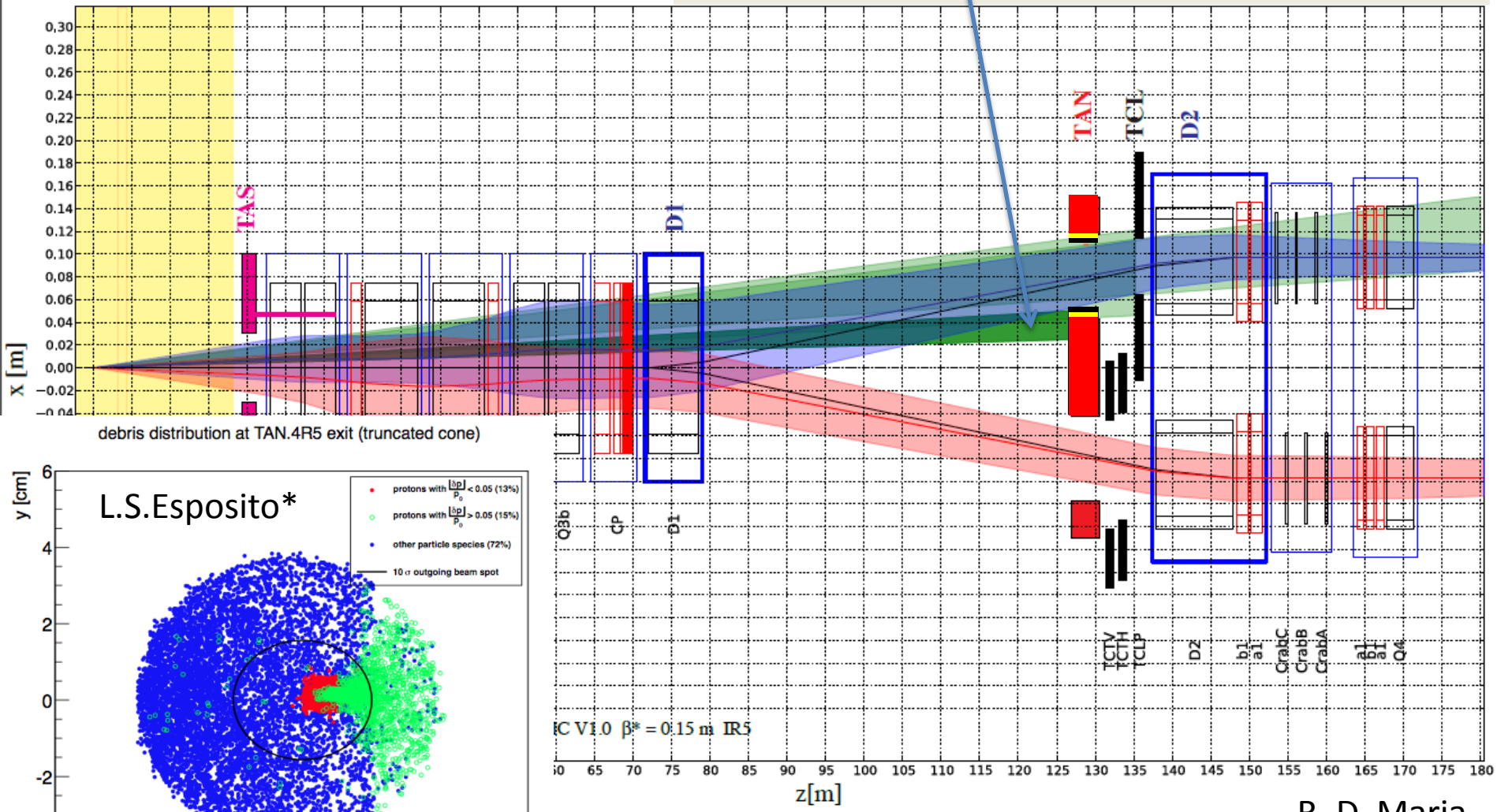
Offset not optimized for the reduced apertures

Note 1: From 2012 run ➔ on the flat reference orbit the largest (credible) BPM outliers are ~1.5 mm. The aperture measurements clearly indicated that the CO errors are very small at the level 1-2 mm, sort of compatible with the 1.5 mm. In the arcs the figures are better, ~1 mm (with the exception of 2 cells with 2 mm due to a missing [faulty] COD). Source: J. Wenninger.

Note 2: measured peak beta beat in LHC of (7±3)% ➔ R. Tomas et al. "Record low β beating in the LHC, Phys. Rev. Special Topics – Accelerators and Beams 15, 091001 (2012)

10%
20%
30%

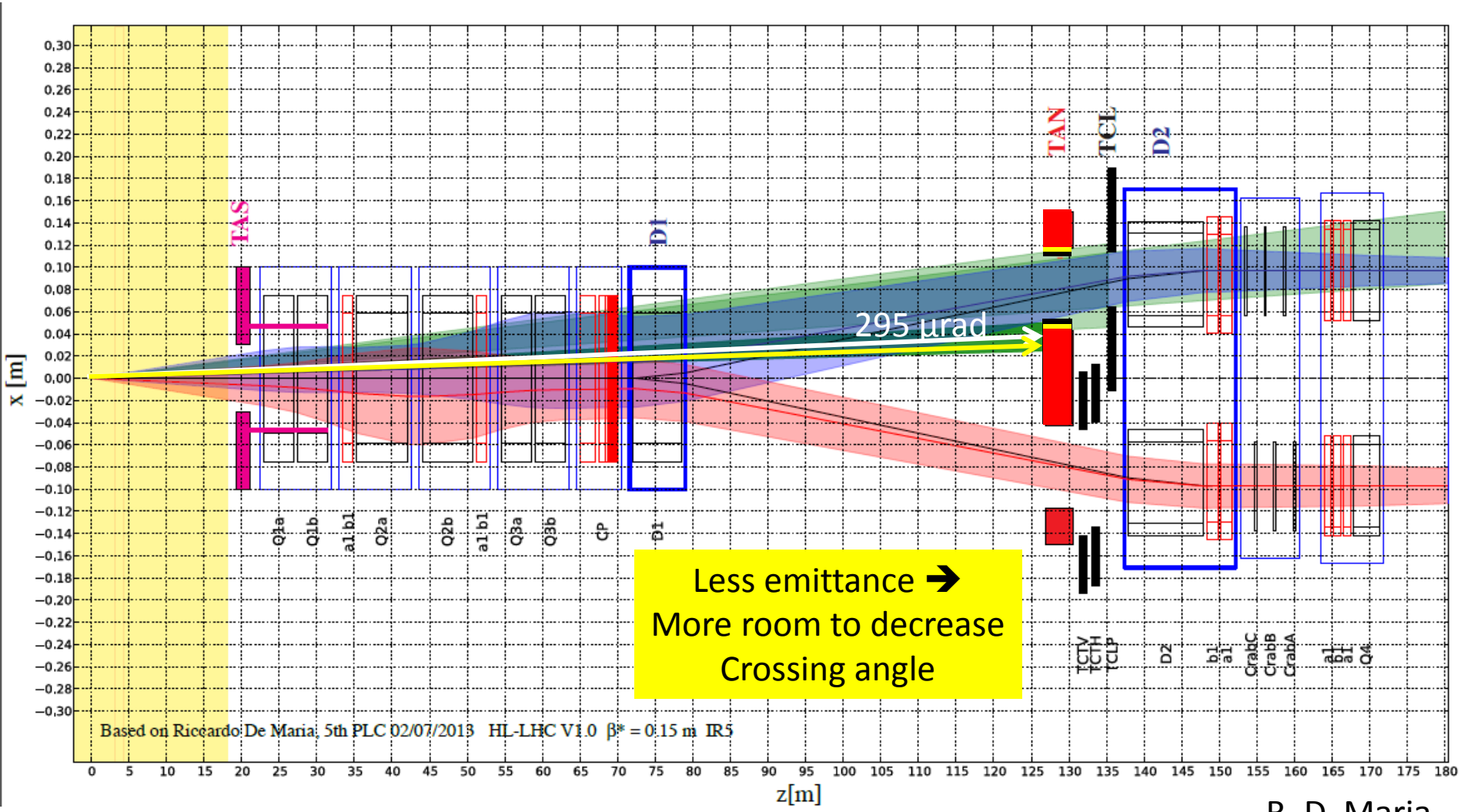
30% reduction w.r.t. 41/37 intercepts the 100 µrad neutrals fan, but clearly, one should check the debris distribution at the TAN exit



R. D. Maria

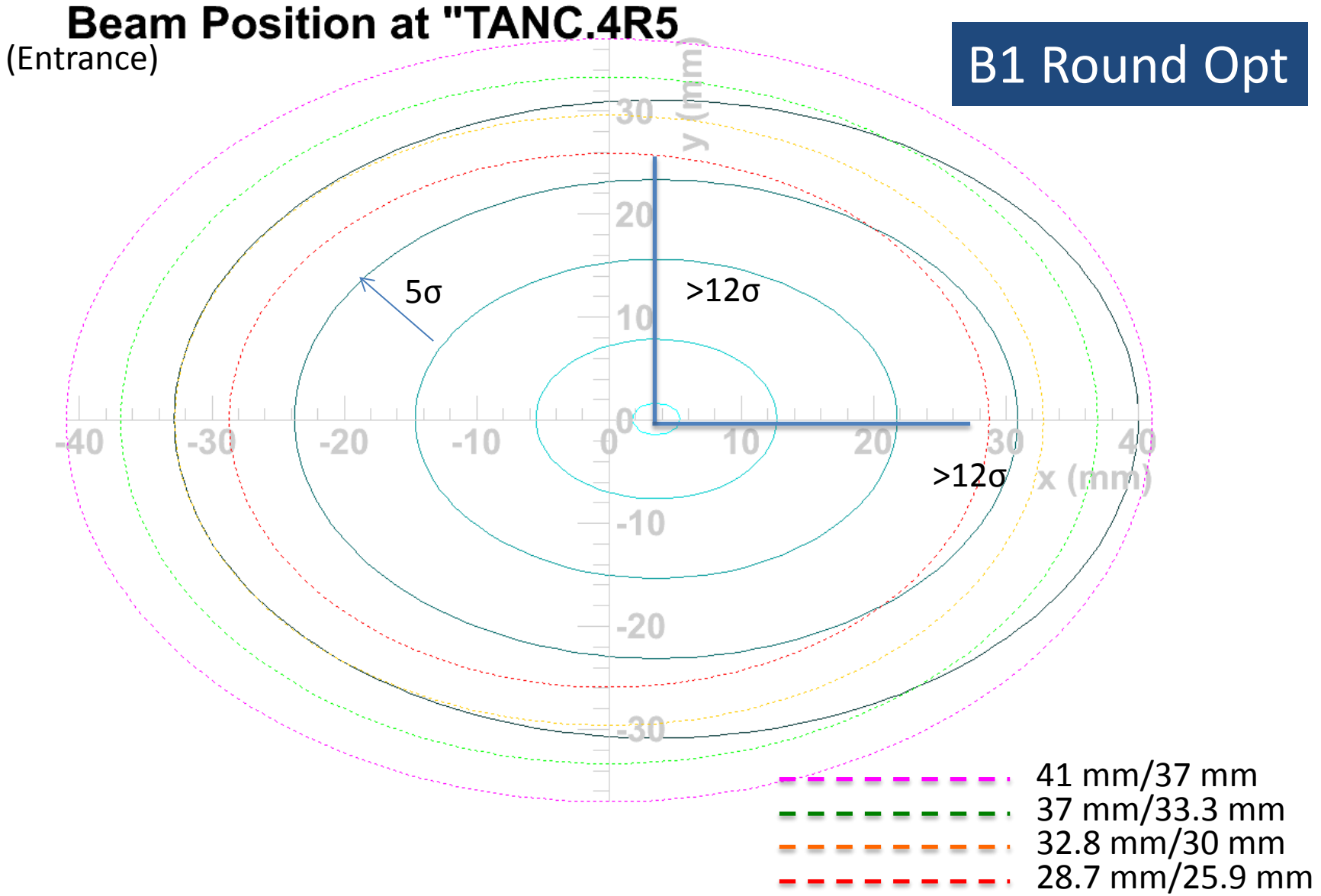
*13th HL WP2 Task Leader Meeting 13.08.2013

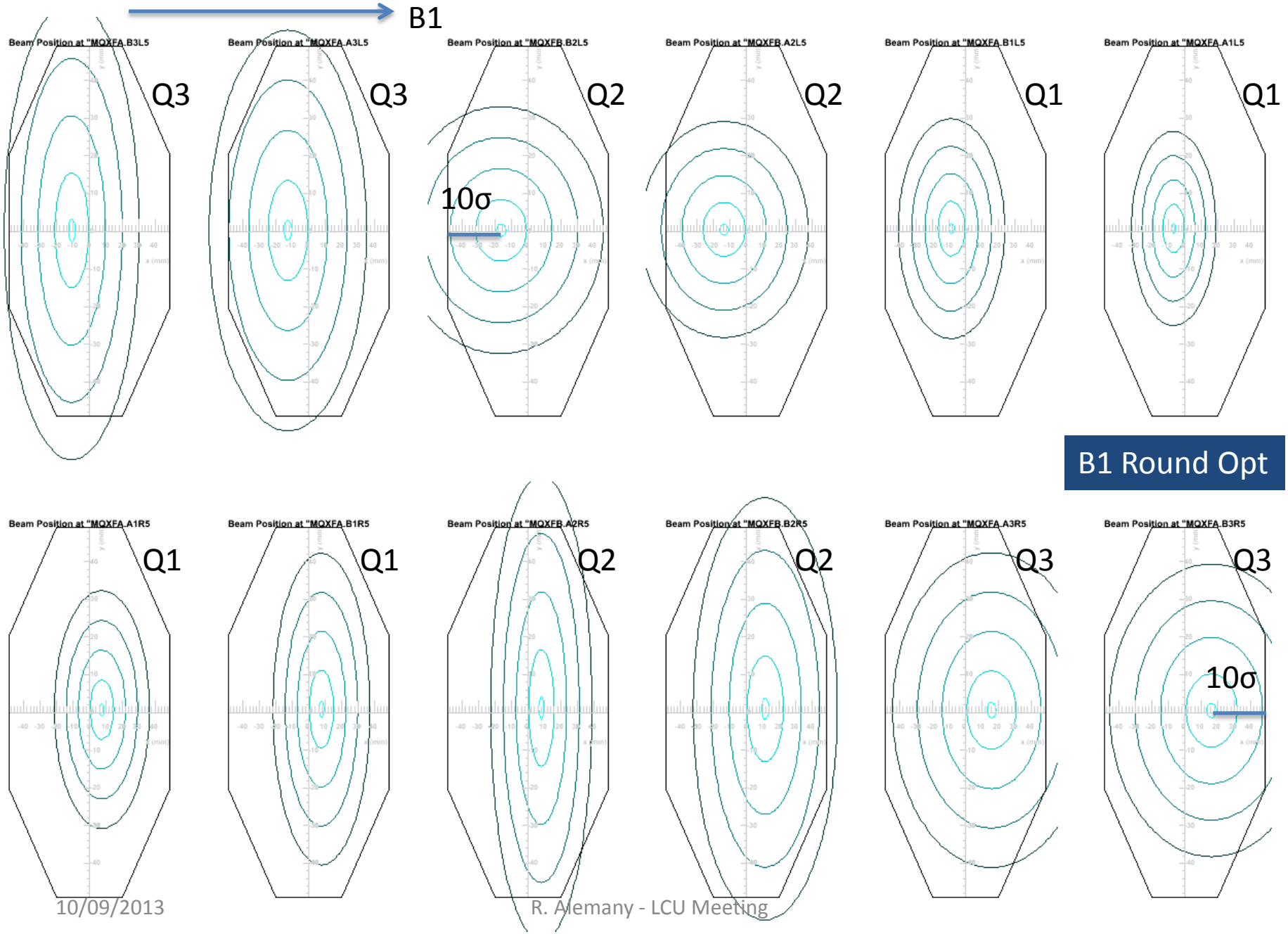
10%
20%
30%

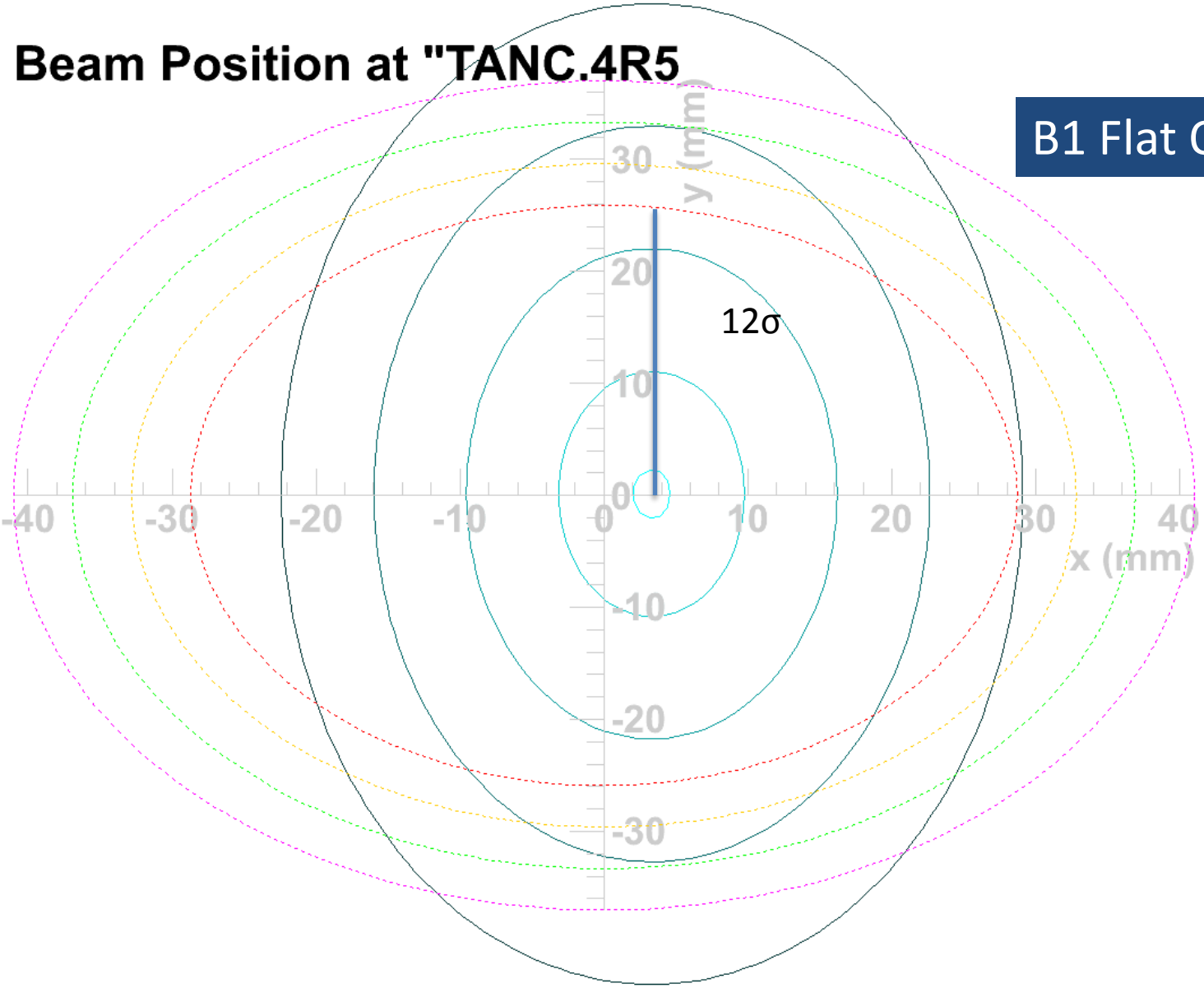


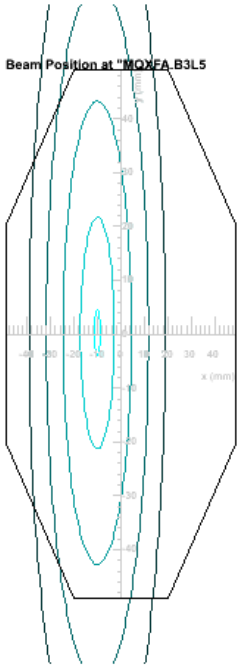
R. D. Maria

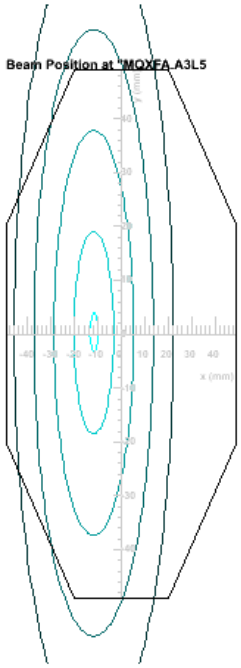
“Geometrical” beam size ➔ √(βε)




B1
Beam Position at "MQXFA.B3L5
Q3
Beam Position at "MQXFA.A3L5
Q3
Beam Position at "MQXFB.B2L5
Q2
10σ
Beam Position at "MQXFB.A2L5
Q2
Beam Position at "MQXFA.B1L5
Q1
Beam Position at "MQXFA.A1L5
Q1
B1 Round Opt
Beam Position at "MQXFA.A1R5
Q1
Beam Position at "MQXFA.B1R5
Q1
Beam Position at "MQXFB.A2R5
Q2
Beam Position at "MQXFB.B2R5
Q2
Beam Position at "MQXFA.A3R5
Q3
Beam Position at "MQXFA.B3R5
Q3
10σ


Beam Position at "TANC.4R5
B1 Flat Opt
12σ
y (mm)
x (mm)
30
20
10
0
-10
-20
-30
-40
-30
-20
-10
0
10
20
30
40


Beam Position at "MQXFA.B3L5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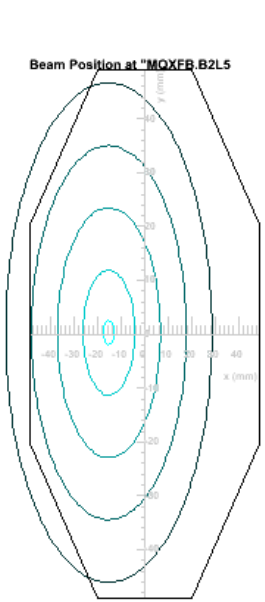
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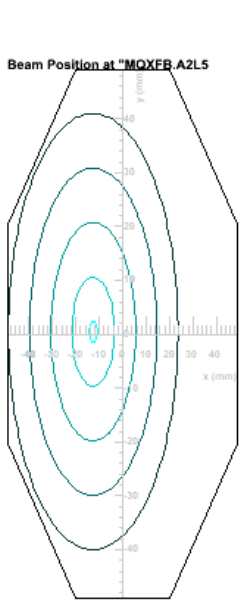
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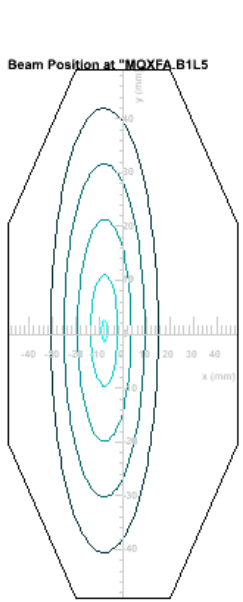
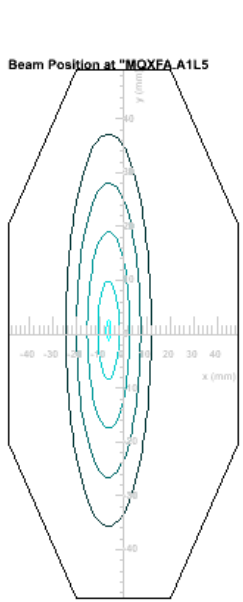
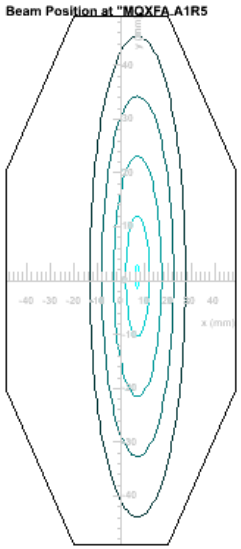
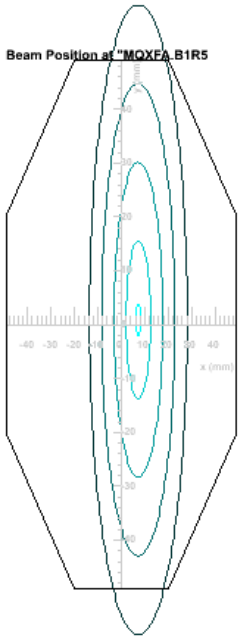

Beam Position at "MQXFA.B1L5


Beam Position at "MQXFA.A1L5

B1 Flat Opt


Beam Position at "MQXFA.A1R5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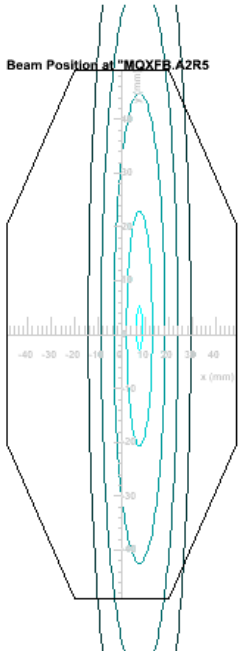
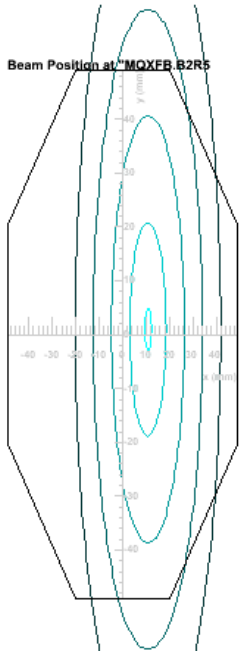
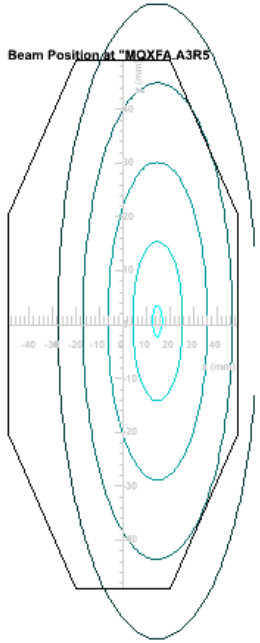
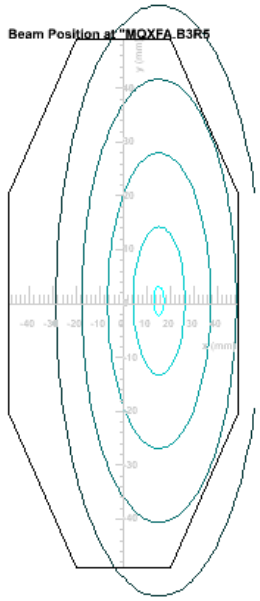

Beam Position at "MQXFB.A2R5

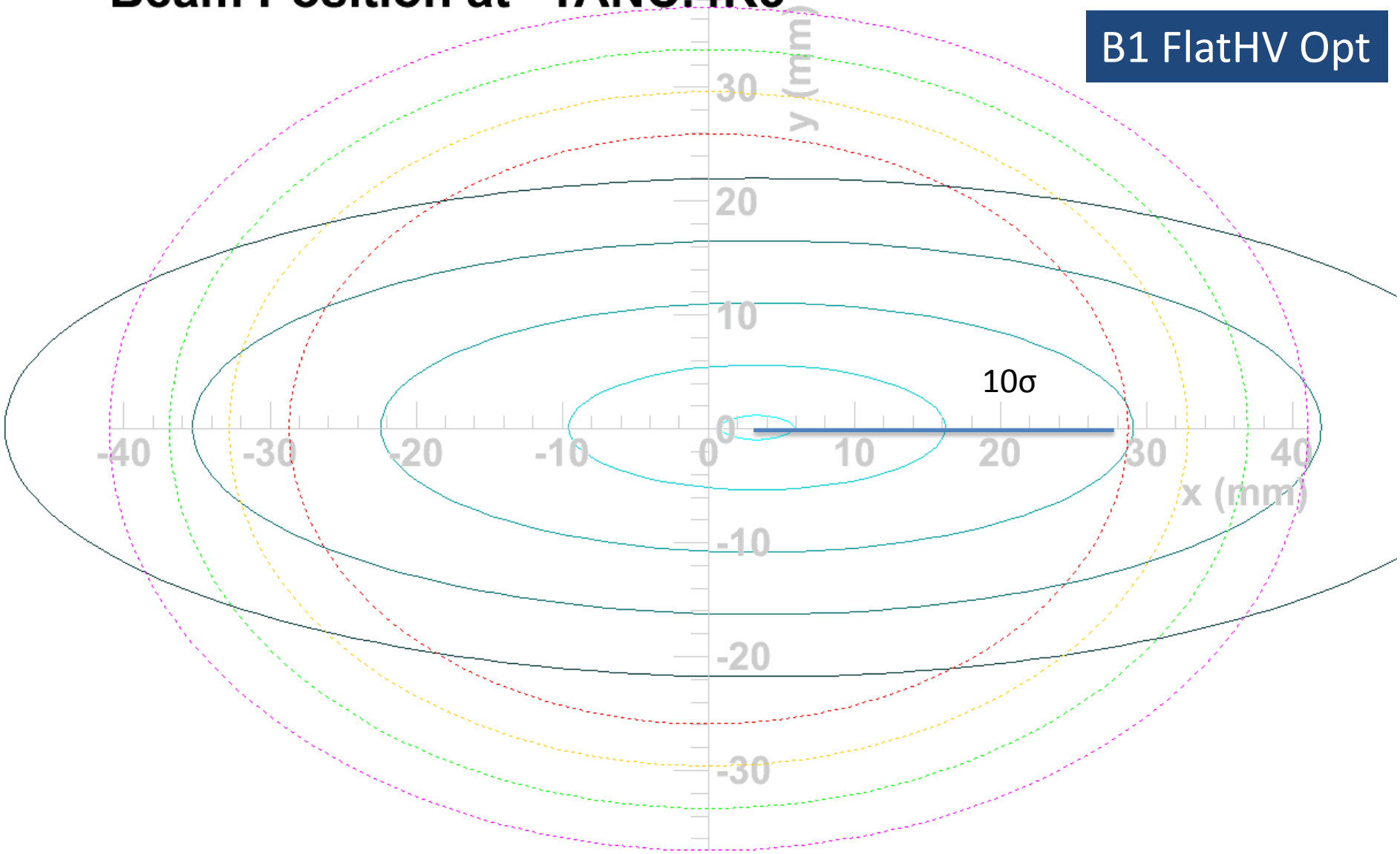

Beam Position at "MQXFB.B2R5

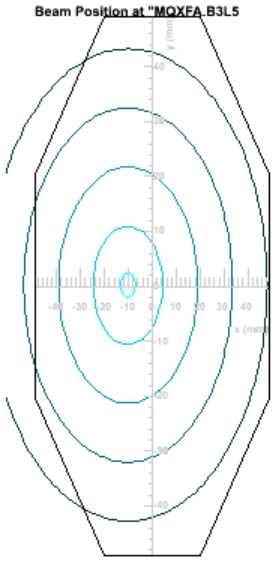

Beam Position at "MQXFA.A3R5

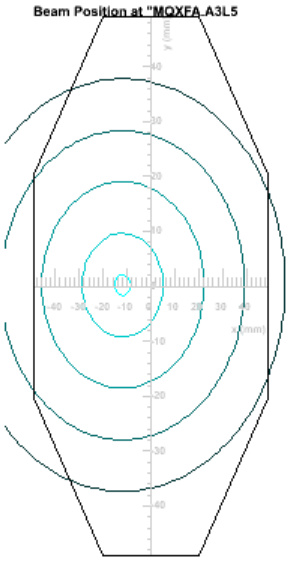

Beam Position at "MQXFA.B3R5

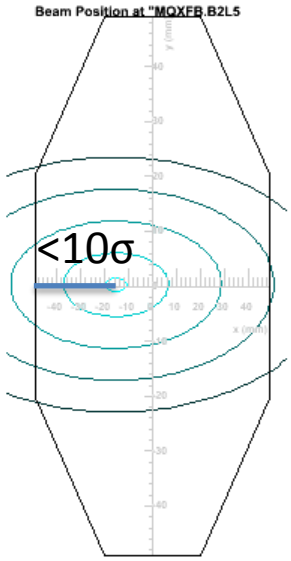
Beam Position at "TANC.4R5

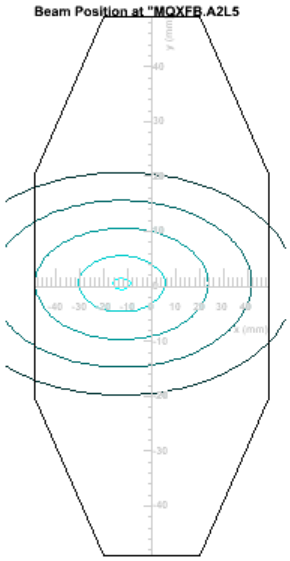
B1 FlatHV Opt

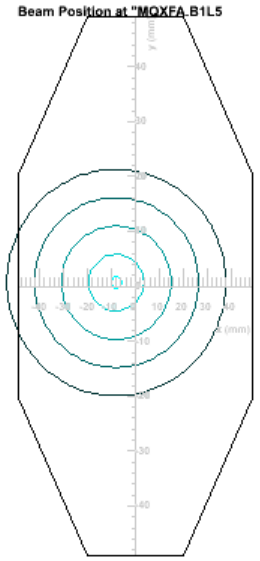




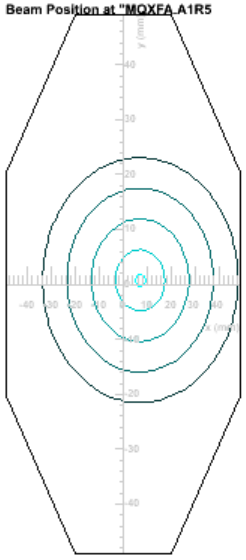


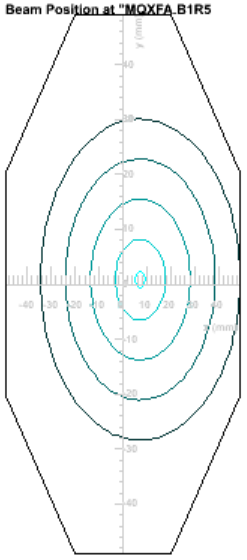


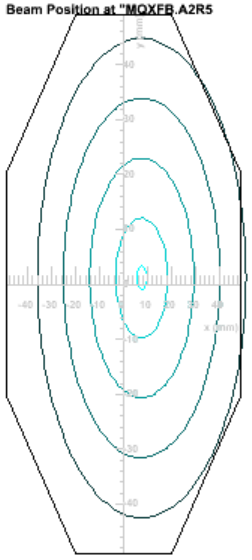


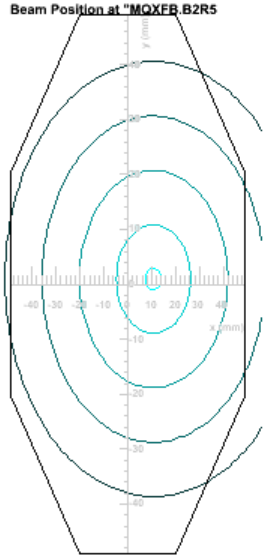


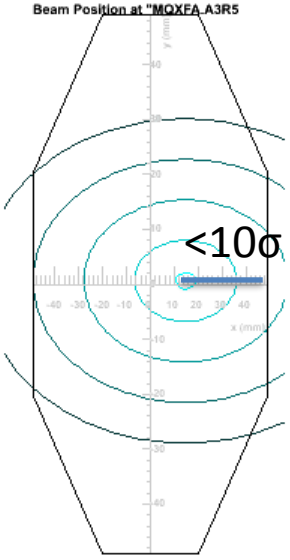
B1 FlatHV Opt

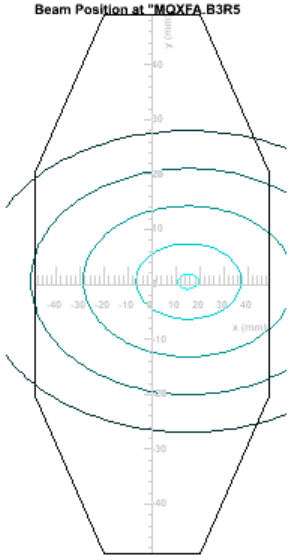










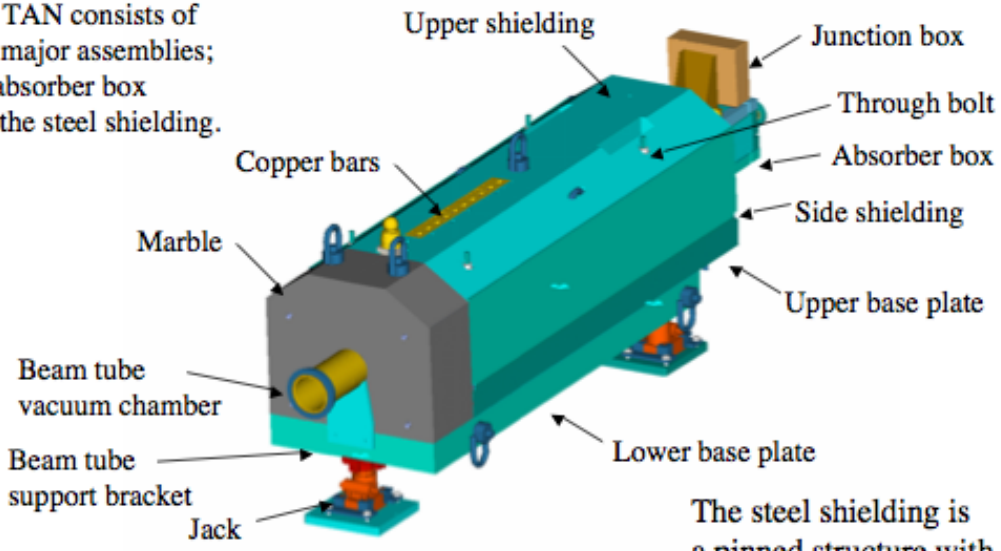


Acknowlegments

- Helmut, Frederic, Francesco, Luigi Salvatore, Roderick, Riccardo

TAN Nomenclature

The TAN consists of two major assemblies; the absorber box and the steel shielding.

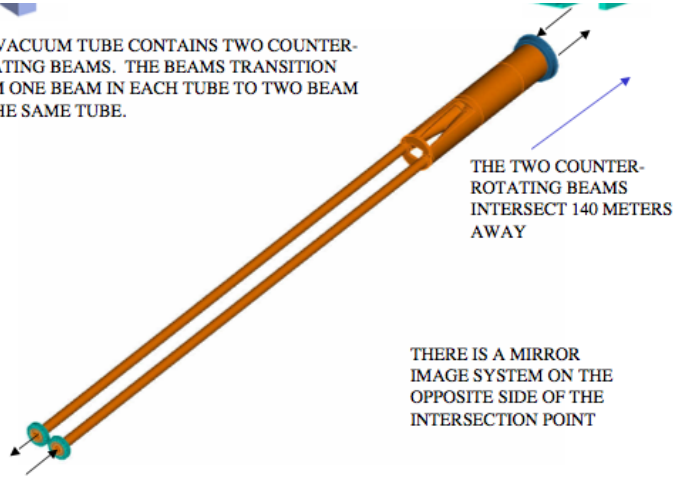


The steel shielding is a pinned structure with four through bolts for transport.

Bill Elliott
TAN/TAS ASSEMBLY

2

THE VACUUM TUBE CONTAINS TWO COUNTER-ROTATING BEAMS. THE BEAMS TRANSITION FROM ONE BEAM IN EACH TUBE TO TWO BEAM IN THE SAME TUBE.



THE TWO COUNTER-ROTATING BEAMS INTERSECT 140 METERS AWAY

THERE IS A MIRROR IMAGE SYSTEM ON THE OPPOSITE SIDE OF THE INTERSECTION POINT