Design of the Transfer Line-2 for the CTF3 at CERN

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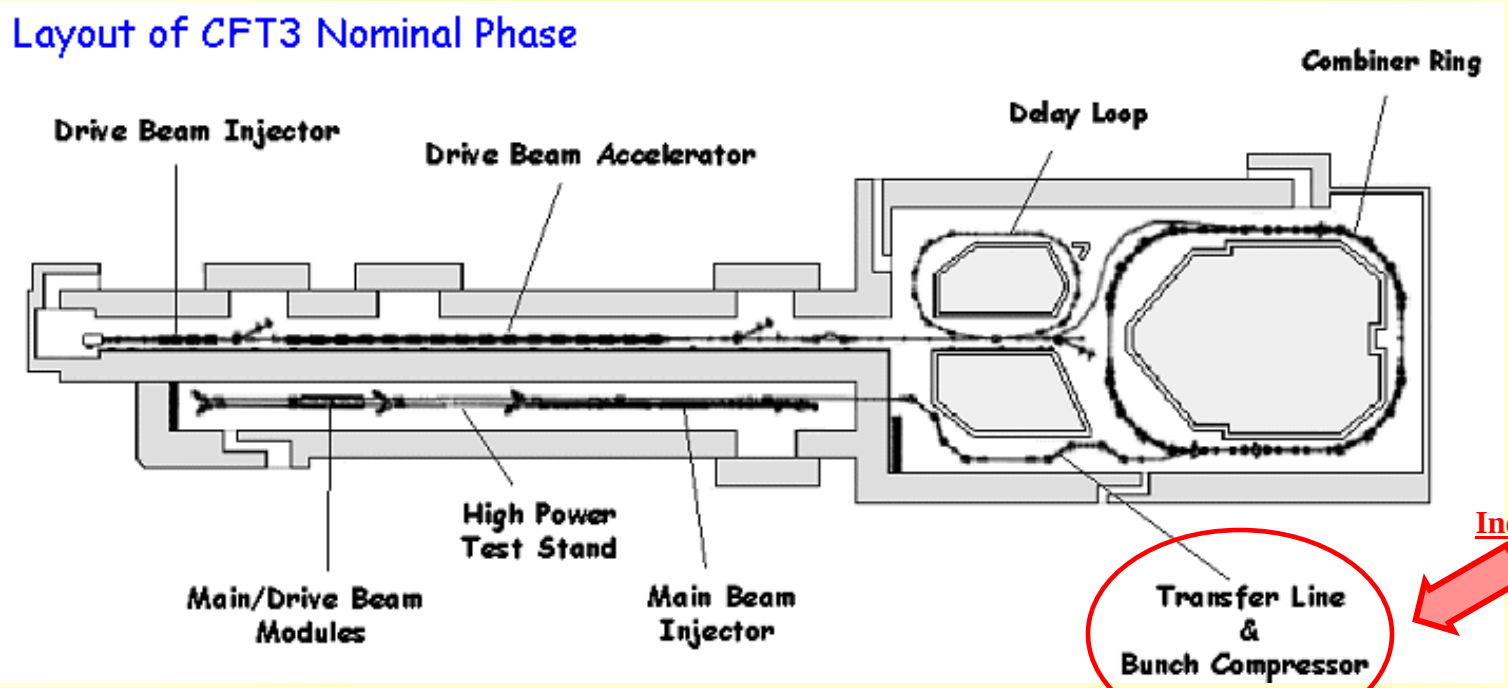
APAC 2007, RRCAT, India

CTF-3 and Indian participation



Main requirements of design

- **R_{56} from -0.35m to +0.35m.** → *Now from -0.28 to +0.28*
- **T_{566} = 0 in entire range of tuning.**
- **β = 4-5m and α = 0 at exit in both planes.**
- **Emittance dilution < 10%.**
- **4m dispersion free region for the tail clippers (collimators).**
- **Available magnets to be used.**
- **Line implementation in the existing building.**

CLIC frequency: 12 GHz from 30 GHz ***H.Braun in this conference***

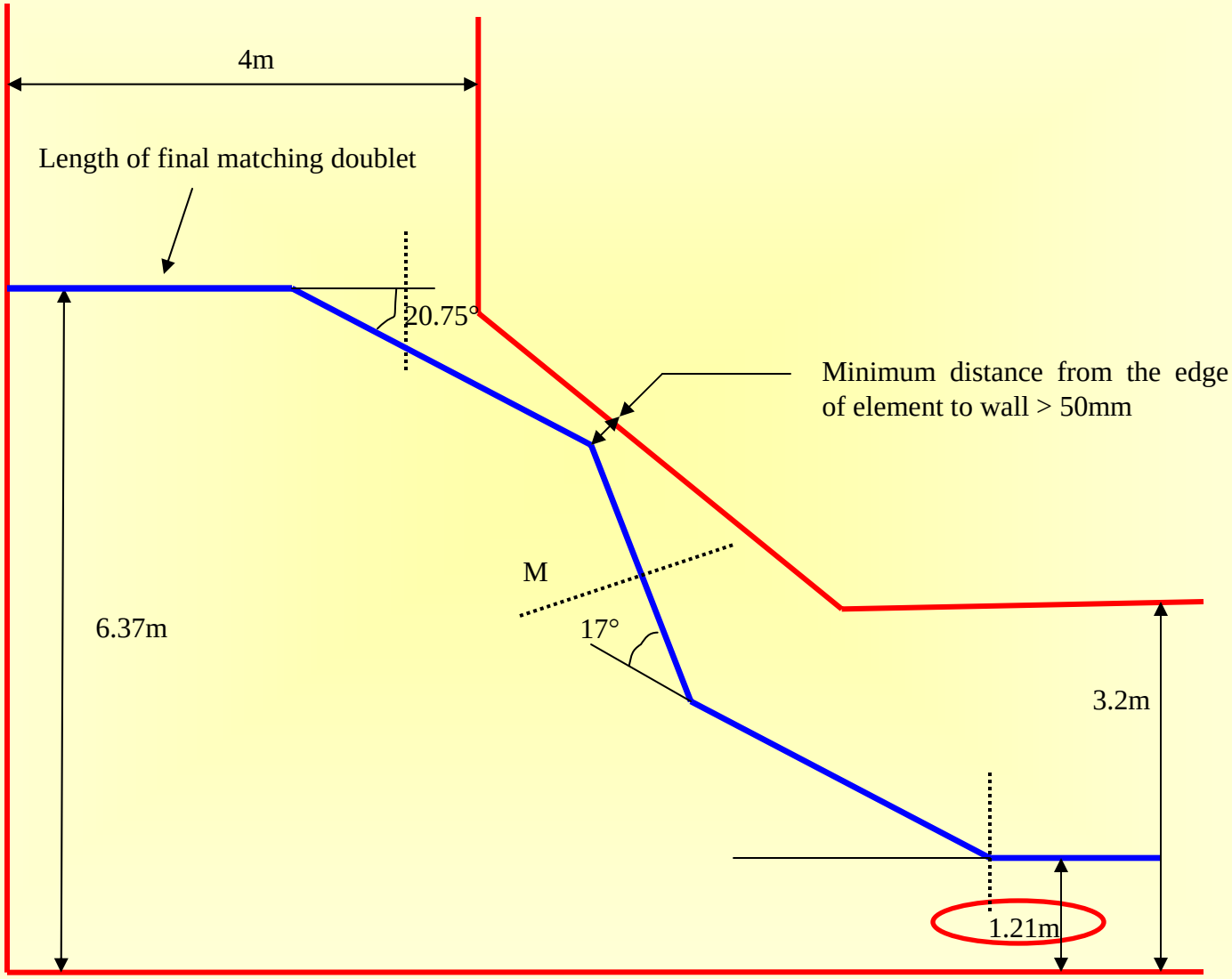
Beam parameters

Parameters	@ Input	Requirement @ Output
Nominal energy	150 MeV	150 MeV
Maximum energy	300 MeV	300 MeV
β_x , β_y (m)	8.1, 3.5	4 - 5
α_x , α_y	0.12, 0.31	0.0, 0.0
η	0.0	0.0
η'	0.0	0.0
dp/p (%)	1%	1%
σz (rms)	8.3 ps	1.3 ps
Height above ground	1.35 m	0.85 m

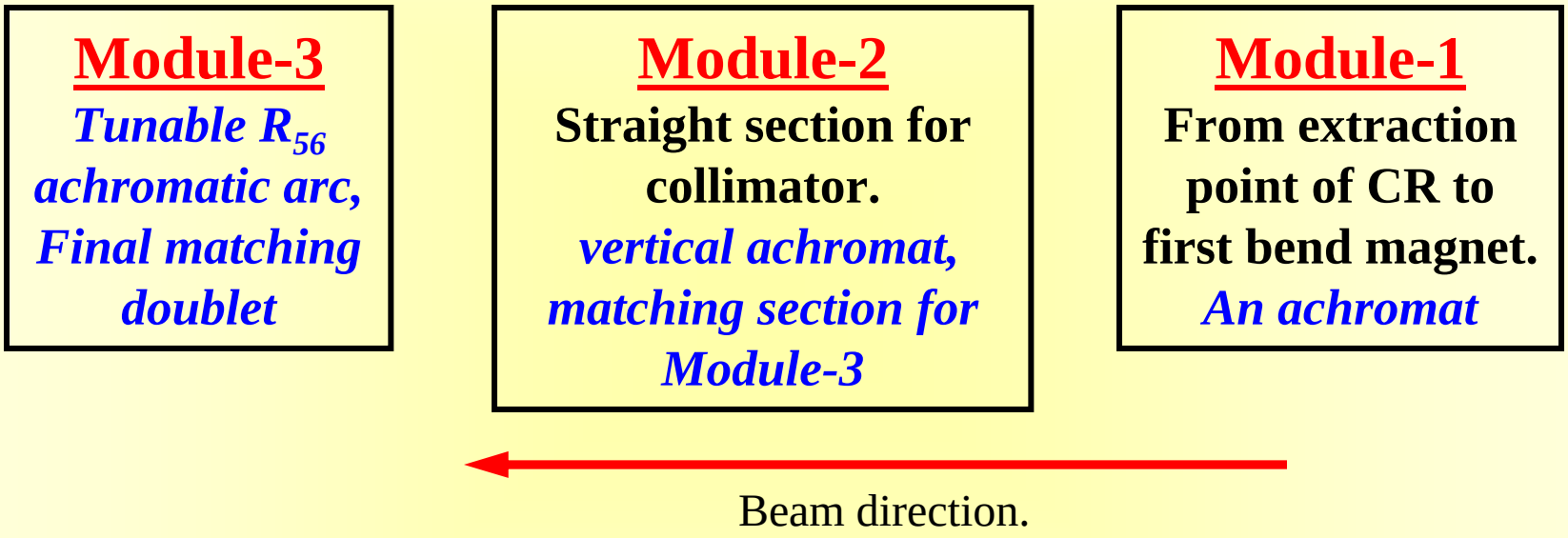
Magnets available

	Dipole – Type-1	Dipole – Type-2	Stnd. Quadrupole	Slim Quadrupole	TSL Quadrupole	Sextupole
Mech. length (m)	0.770	0.520	0.592	0.384	0.430	0.350
Mech. width (m)	0.794	0.794	0.819	0.340	0.650	0.420
Effective length (m)	0.518	0.268	0.380	0.300	0.295	0.246
Aperture (mm)	100×45	100×45	184	100	101	167
Strength	1.3 T	1.3 T	5.4 T/m	8 T/m	10.6 T/m	44 T/m^2
Number	02	03	26	02	16	12

Geometrical constraints



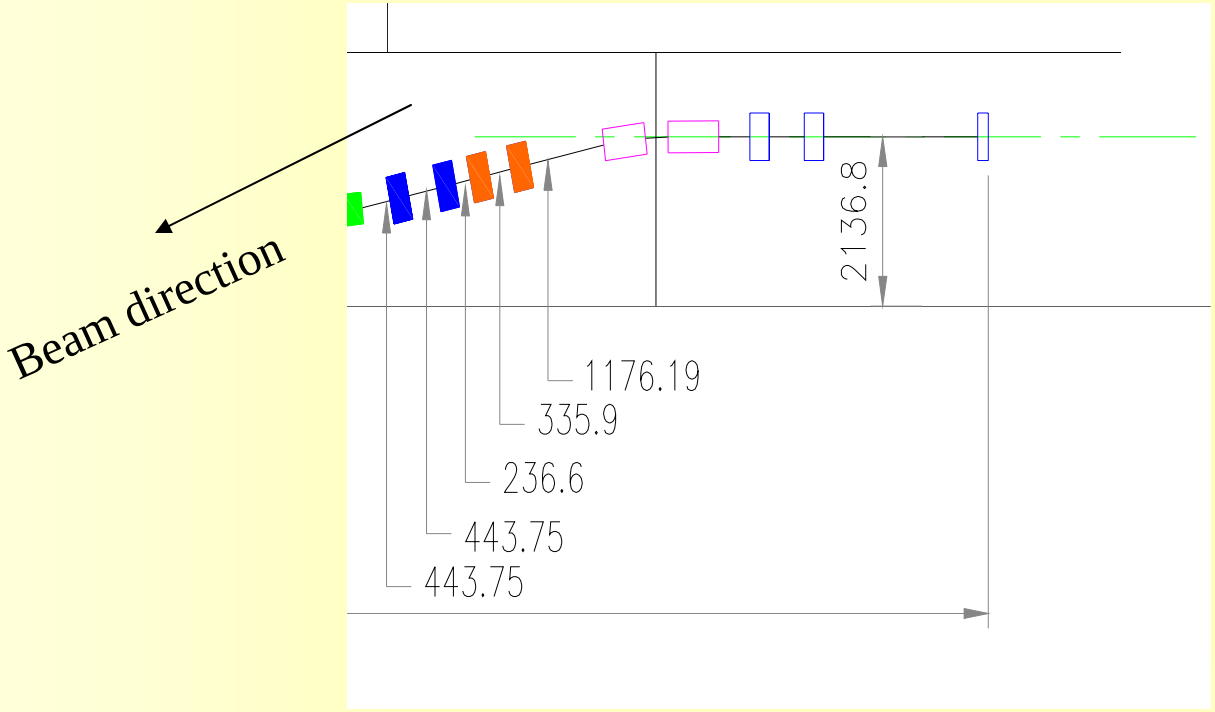
Design approach



The design studies are carried out using MAD-8 program.

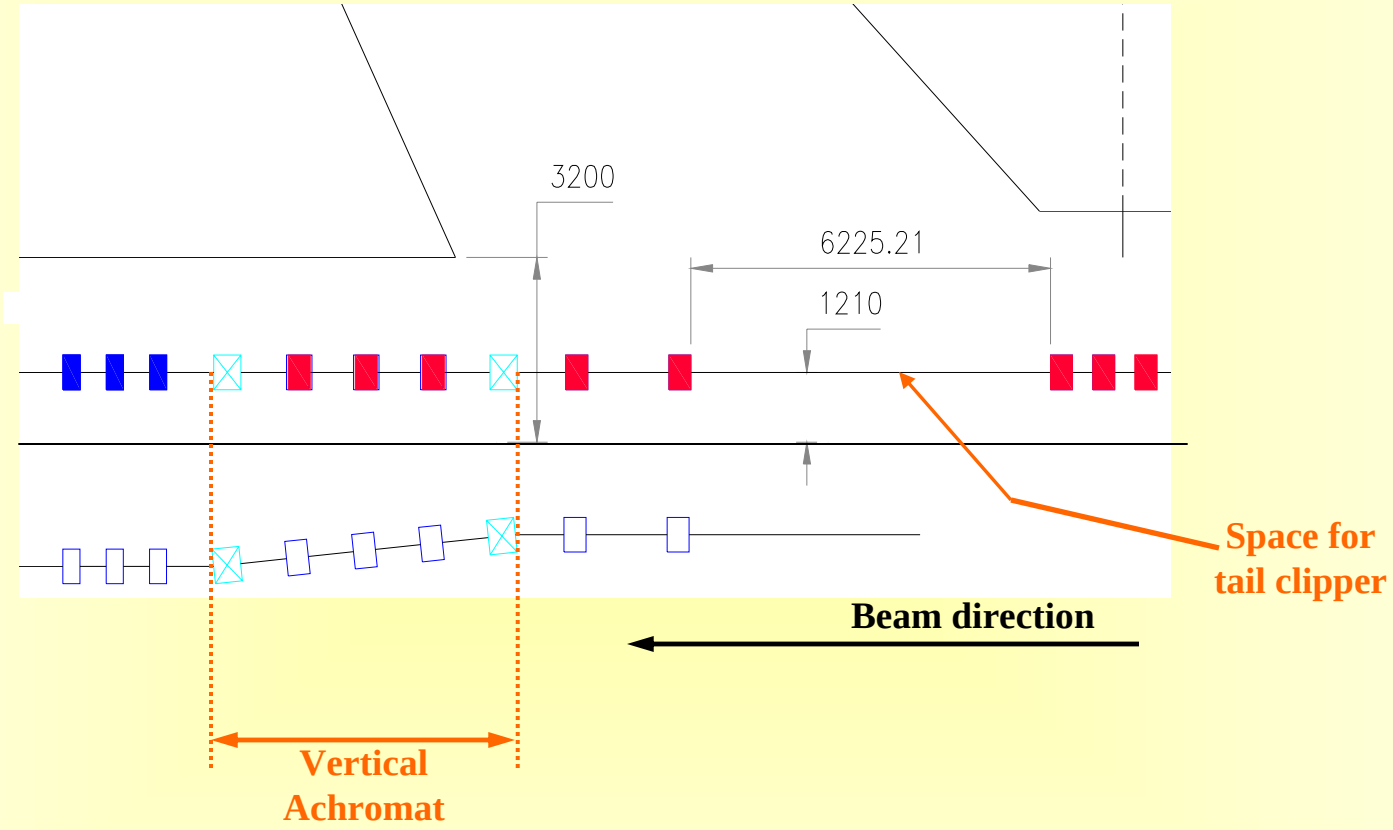
Design details: Module-1

Module-1 is an achromat with opposite bends from extraction septa of CR to first bend.



- *Very low flexibility in achromat.*
- *Quadrupoles close to its highest strength.*
- *High α at exit of Module-1 => Rapid rise in β.*

Design details: Module-2



Bunch length control

Two steps process:

1. First RF-field modifies δ, leaving z unchanged.

$$z_1 = z_0 \qquad \delta_1 = R_{65} z_0 + R_{66} \delta_0$$

2. Magnetic optics: opposite effect → changes z leaving δ unchanged.

$$z_2 = z_1 + R_{56} \delta_1 \qquad \delta_2 = \delta_1$$

Control in TL-2, module-3

Bunch length control *Continued…*

The linear matrix element R_{56} for controlling the bunch length, function of the dispersion distribution in all the bending magnets.

$$R_{56} = -\int_{BM} \frac{\eta ds}{\rho}$$

Second order relation between path length and momentum deviation

$$z_2 = z_1 + R_{56}\delta_1 + T_{566}\delta_1^{\,2}$$

Bunch length control *Continued…*

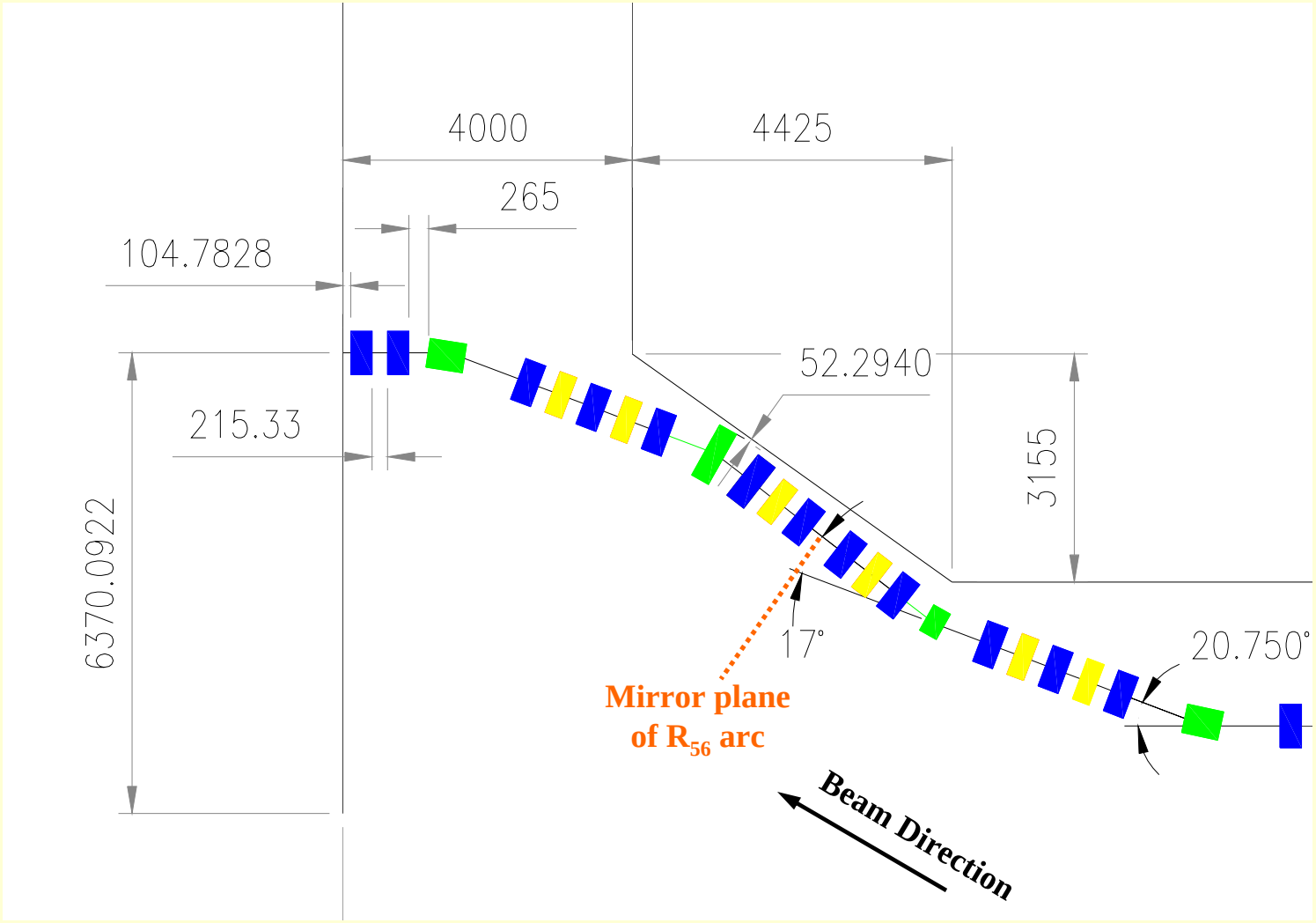
Bunch length control (linear)

$$\sigma_{z,f} = \sqrt{(1+R_{65}R_{56})^2\sigma_{z,i}^2 + R_{56}^2R_{66}^2\sigma_{\delta,i}^2}$$

Bunch length control (including second order terms)

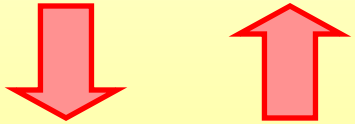
$$z_f = z_i\left(1+R_{65}R_{56}\right)+ z_i^{\,2}\left(T_{655}R_{56} + R_{65}{}^2T_{566}\right)$$

Layout of Module-3



Approach

Find out dispersion and its derivative for required R_{56} and to form an achromat.

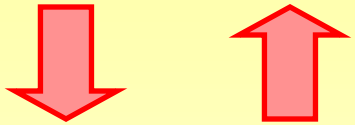


Find a solution, such that

1. High η @ sextupoles to control T_{566}.

2. Decoupled βs @ sextupole locations.

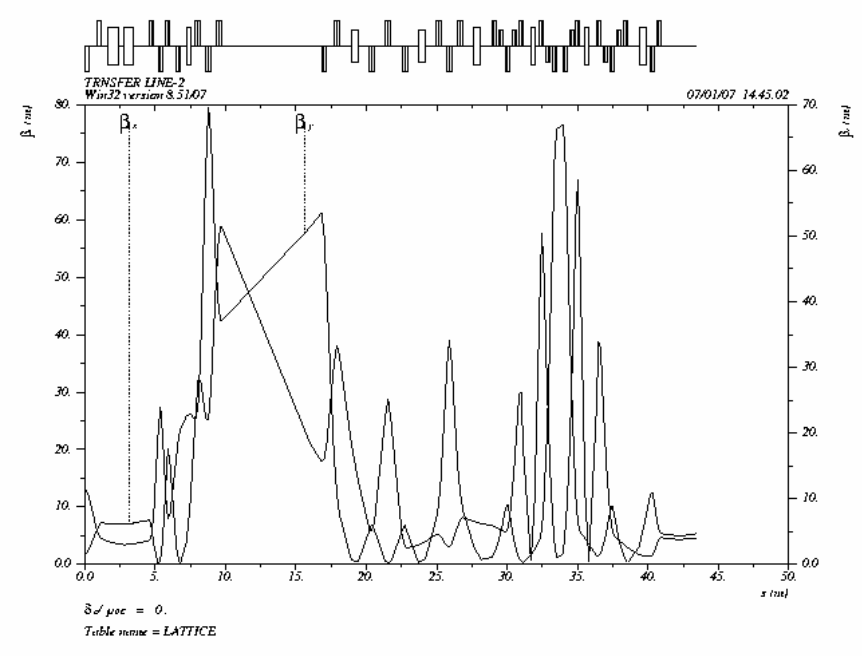
3. Identity – transformer between sextupoles.

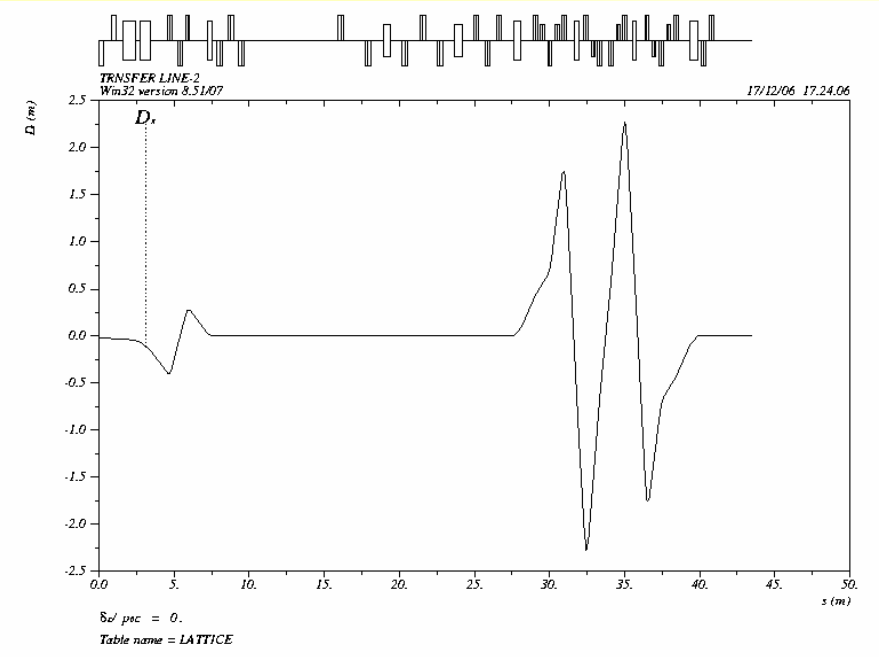


Required Twiss parameters at Matching point

Twiss parameters and dispersion

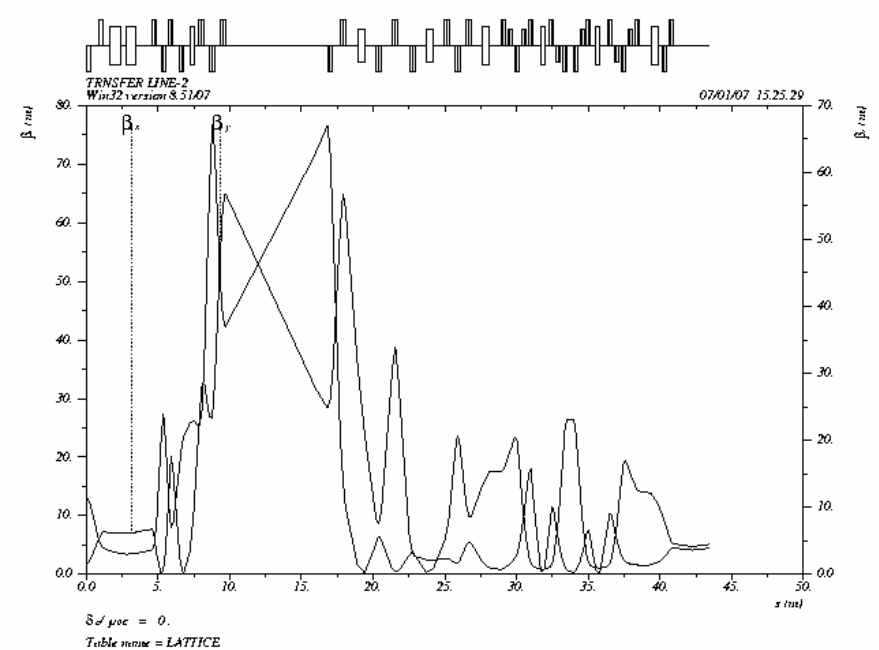
R_{56} = +0.35 (MAD sign convention)

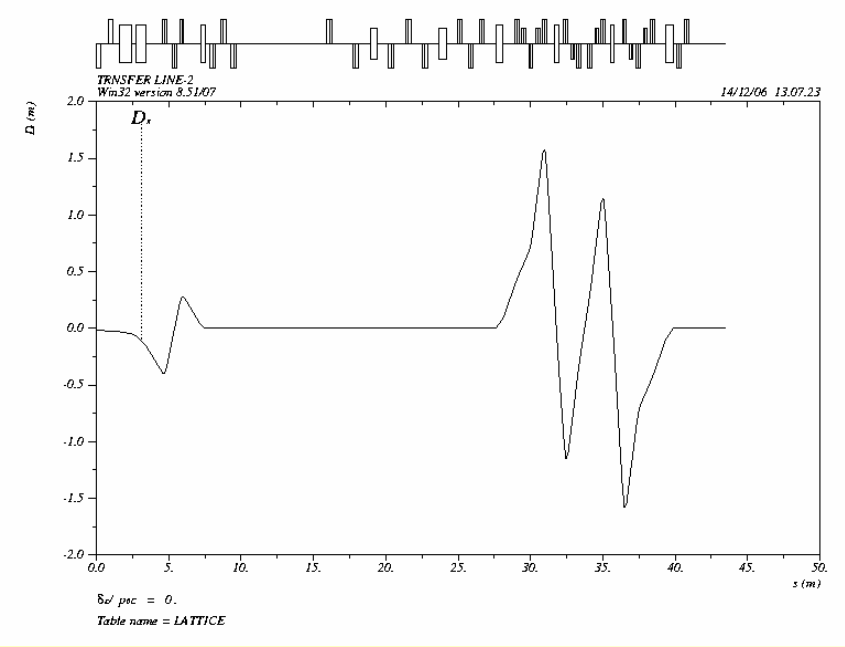




Twiss parameters and dispersion *Continued…*

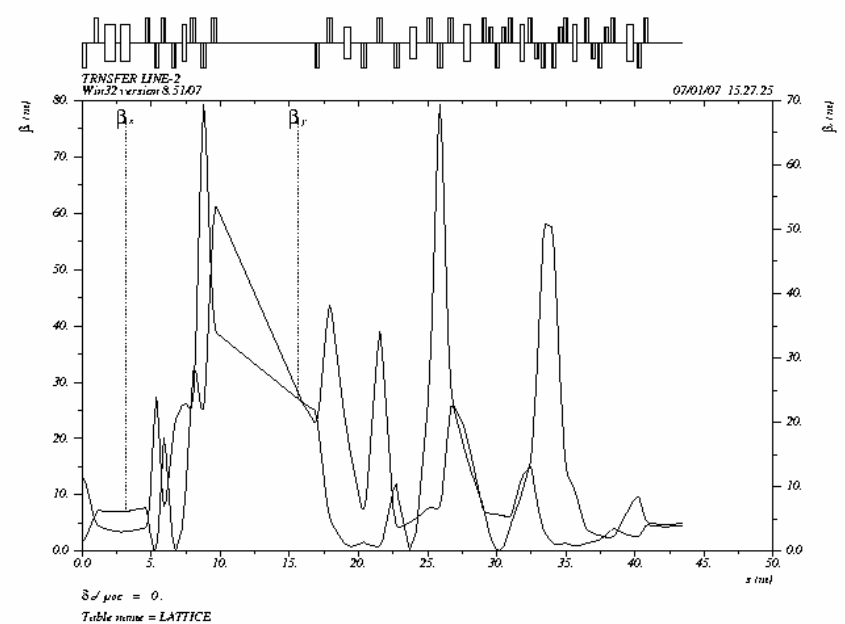
$R_{56} = 0.00$

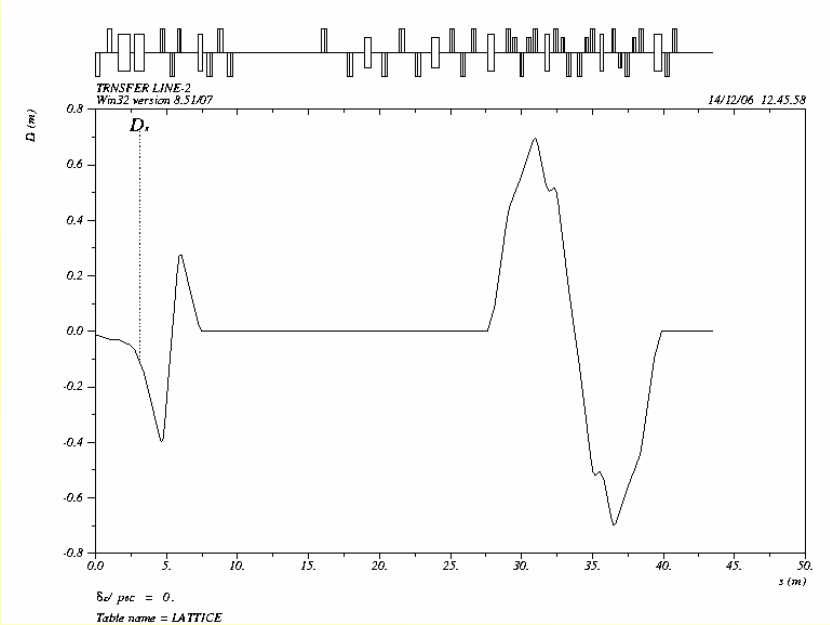




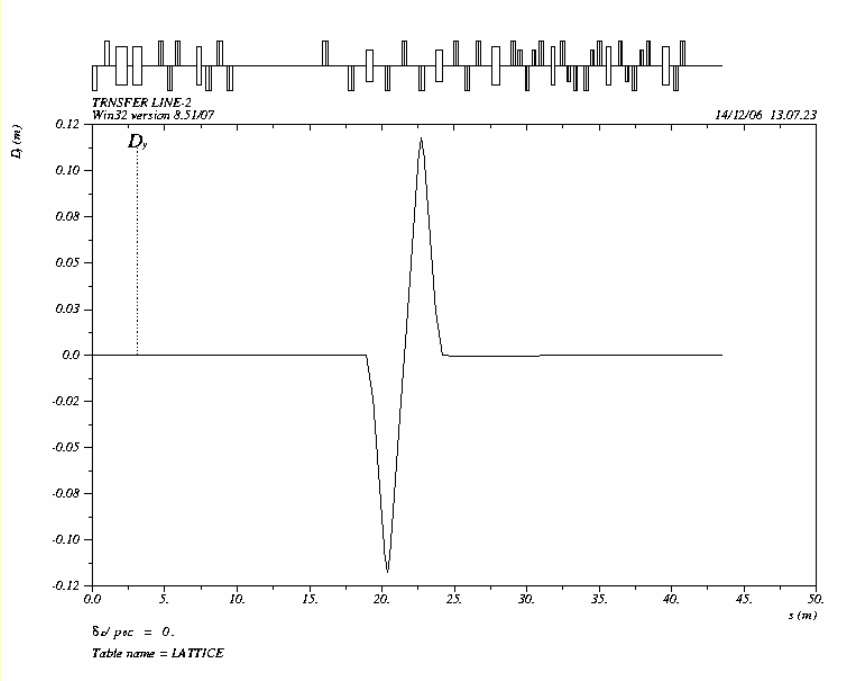
Twiss parameters and dispersion *Continued…*

R_{56} = -0.35





Vertical dispersion



T_{566} correction and phase space distortion

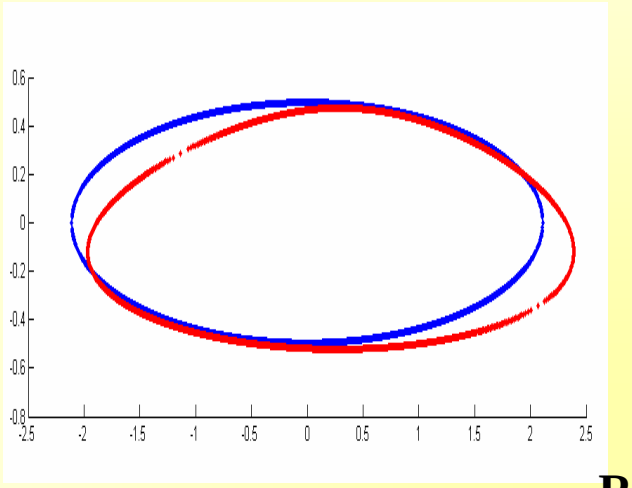
T_{566} Correction with sextupoles ⟹ Phase space distortion

- **Various constraints on line → Identity transformer not possible**

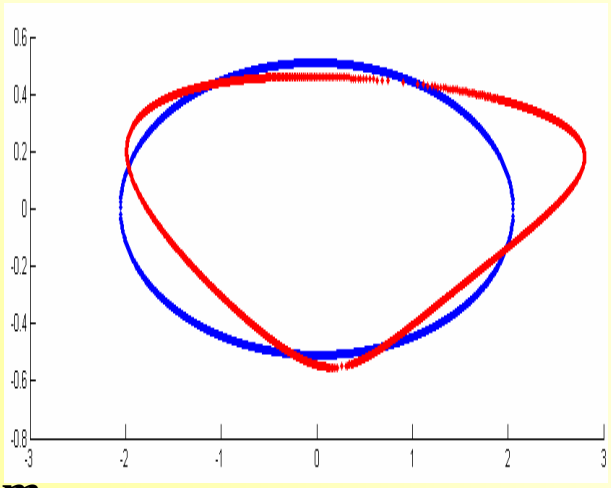
- **Therefore partial cancellation of sextupolar kicks by adjusting β-functions and μ at the location of the sextupoles → Obtained with matching the proper initial Twiss parameters of Module-3.**

- **Lower down the phase space distortion in the negative side of R_{56} and in isochronous mode.**

T_{566} correction and phase space distortion *continued…*

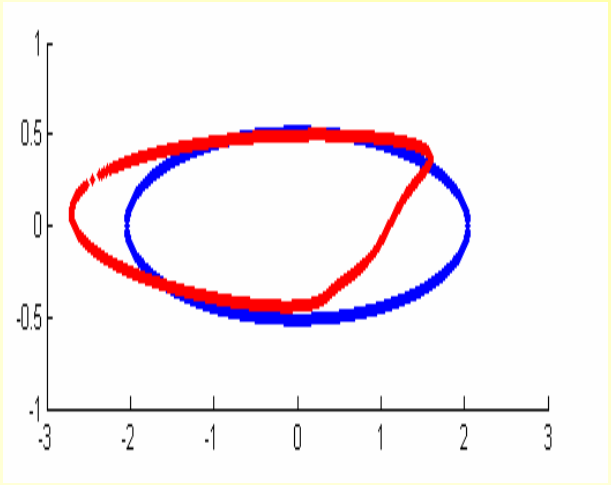


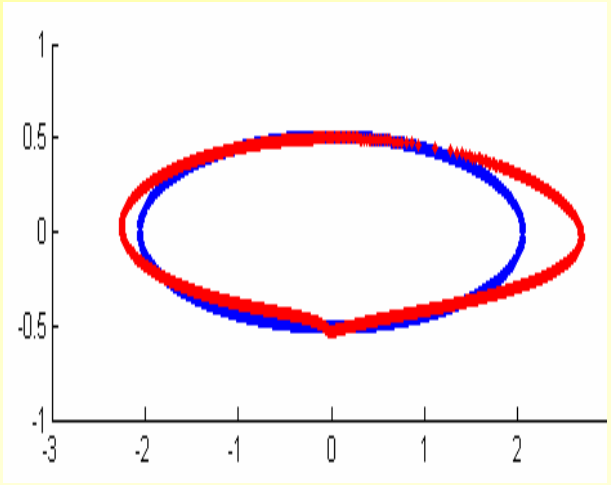
X-Plane



Y-Plane

R_{56} = -0.35m





R_{56} = 0.00

Available Magnets and Power Supplies Needed

Dipole magnets

	Module-1	Module-2	Module-3
Magnets	**1** *[type-2]*	**2** *[sector type for vertical bend]*	**4** *[2 of type-1 and 2 of type-2]*
Power supplies	**1**	**1**	**2**

Quadrupole magnets

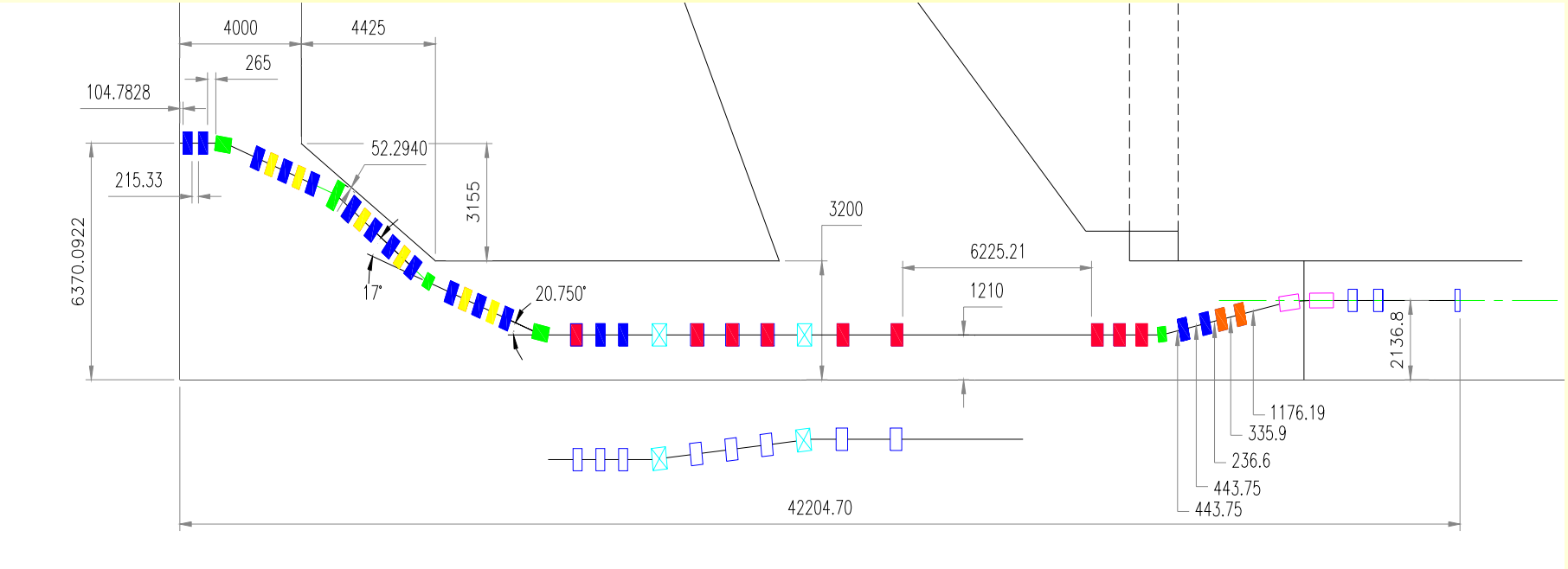
	Module-1	Module-2	Module-3
Magnets	**4** *[2 slim and 2 TSL]*	**11** *[9 standard and 2 TSL]*	**12** *[TSL-type]*
Power supplies	**4**	**10**	**7**

Available Magnets and Power Supplies Needed…

Sextupole magnets

	Module-1	Module-2	Module-3
Magnets	**----**	**----**	**6**
Power supplies	**----**	**----**	**3**

Complete layout of line with building



Summary

- **Optics design in linear zone done for the R_{56} from -0.35m to +0.35m.**

- **T_{566} correction studies in progress and preliminary results of R_{56} = 0.00 and -0.35 obtained.**

- **β-functions higher in Module-2 beginning.**

- **Modification in line by relaxation in geometrical constraints.**

Acknowledgements

We are thankful to

CERN:

Hans Braun
Gunther Gaschonke
Frank Tecker

RRCAT:

V.C.Sahni
S.Kotaiah

Thanking you for your kind attention