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CTF3 Note 071

Parameter list of the CTF3 Linac and the CT line

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Abstract

This note is a comprehensive parameter list of the CLIC test facility CTF3, including all magnets, rf components and beam diagnostic tools in the Linac, the PETS- and the CT line.

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Contents

1 Introduction

This note is supposed to be a comprehensive parameter list of the compact linear collider test facility CTF3, including all magnets, rf components and beam diagnostic tools in the Linac, the PETS- and the CT Line. The Delay loop is not included so far. A complete drawing is attached at the end of the document. Any comments, changes or extensions should be communicated to the author, in order to keep the list updated.

2 Magnets

2.1 Solenoids

Several solenoids are used to focus the electron beam in the CTF3 injector (first three girders) after the exit of the electron gun. They are arranged according to Table 1.

Solenoid	"Name"	Long. Position [cm]	Comment
CL.SNA0105	bucking coil	0.2	
CL.SNB0110	lens	8.5	
CL.SNF0121	snf	12.4	common power supply
CL.SNF0123	snf	28.7	
CL.SNC0130	sigma fi	45.0	
CL.SNC0140	sigma fi	80.0	
CL.SNC0160	sigma fi	100.0	
CL.SNC0170	sigma fi	120.0	
CL.SND0210	snd	140.0	
CL.SND0220	snd	160.0	
CL.SND0240	snd	171.5	
CL.SND0250	snd	185.3	
CL.SND0260	snd	200.0	common power supply
CL.SND0265	snd	208.3	
CL.SND0275	snd	216.7	
CL.SND0280	snd	225.0	
CL.SNE0305	sne	265.0	common power supply
CL.SNE0310	sne	305.0	
CL.SND0320	snd	340.0	
CL.SND0325	snd	375.0	
CL.SND0330	snd	407.0	common power supply
CL.SND0335	snd	434.0	
CL.SND0345	snd	461.0	
CL.SND0350	snd	488.0	
CL.SND0355	snd	515.0	

Table 1: *Solenoids of the CTF3 injector.*

The first solenoid is powered with opposite polarity in order to obtain a zero magnetic field at the cathode. In 2005 two additional new coils have been installed to further decrease the transverse emittance of the beam. The parameters of the solenoids are listed in Tables 2 to 7. The dimensions originate from Ref. [9], information concerning the power supplies was found in Ref. [8].

Quantity	Value	Comment
mechanical length	36 mm	
inner diameter	218 mm	
outer diameter	292 mm	
number of windings	175	
magnetic field	B_0 [T] $= 8.6{\cdot}10^{-4}$ I [A]	
maximum current	10 A	
max. I & U of power supply	± 10/20 A & ± 60/30 V	
cooling		no cooling

Table 2: *Parameters of the bucking coil.*

Quantity	Value	Comment
mechanical length	68 mm	
inner diameter	90 mm	
outer diameter	135 mm	
number of windings	320	
magnetic field	B_0 [T] $= 3.35{\cdot}10^{-3}$ I [A]	
maximum current	10 A	
max. I & U of power supply	± 10/20 A & ± 60/30 V	
cooling		jammed on cooling circuit

Table 3: *Parameters of the lens.*

Quantity	Value	Comment
mechanical length	40 mm	
inner diameter	158 mm	
outer diameter	250 mm	
number of windings	400	
magnetic field	B_0 [T] $= 2.46{\cdot}10^{-3}$ I [A]	
maximum current	7 A	
max. I & U of power supply	± 10/20 A & ± 60/30 V	
cooling		air

Table 4: *Parameters of the new coils.*

Quantity	Value	Comment
mechanical length	99 mm	
inner diameter	411 mm	
outer diameter	612 mm	
number of windings	918	
magnetic field	B_0 [T] $= 2.26{\cdot}10^{-3}$ I [A]	
maximum current	8.4 A	
max. I & U of power supply	± 10/20 A & ± 60/30 V	
cooling		air

Table 5: *Parameters of the SNC type solenoids.*

Quantity	Value	Comment
mechanical length	45 mm	
inner diameter	460 mm	
outer diameter	844 mm	
number of windings	72	
magnetic field	B_0 [T] = 1.4·10^{-4} I [A]	
maximum current	700 A	
max. I & U of power supply	200 A & 30 V	separated coils
	500 A & 50 V	4 coils in series
	785 A & 301 V	5 coils in series
cooling		water

Table 6: *Parameters of the SND type solenoids.*

Quantity	Value	Comment
mechanical length	66 mm	
inner diameter	460 mm	
outer diameter	844 mm	
number of windings	108	
magnetic field	B_0 [T] = 2.1·10^{-4} I [A]	
maximum current	700 A	
max. I & U of power supply	785 A & 301 V	
cooling		water

Table 7: *Parameters of the SNE type solenoids.*

2.2 Dipoles

2.2.1 Spectrometer Dipoles

The magnetic properties of the two spectrometer dipoles CL.BHB1040 (located in girder 10) and the former CT.BHB0450[1)] are described in Ref. [1]. The magnets have the capability to achieve a bending angle of 22.75° up to an electron momentum of about 480 MeV/c with a central field of 1.4 T. Since typical particle momenta in the CTF3 Linac are well below this limit, linear behaviour of the magnets can be assumed.

Quantity	Value	Comment
effective length	479 mm	
mechanical length	400 mm	length of iron
aperture	100 mm	with respect to iron pole faces
aperture	60 mm	mechanical available space
magnetic field	B_0 [T] = 0.007419 I [A]	
total bending angle	22.75°	
momentum calibration	p [MeV/c] = 2.698 I [A]	
dispersion at location of the TV screens	0.0944 m + 0.4024 · l with $l = d$ - 0.2393	d is the distance magnet-center/screen
max. allowed current	240 A ?	
max. I & U of power supply	± 100 A & 30 V ± 210 A & 45 V	CL.BHB1040 CT.BHB0450
cooling		water

Table 8: *Parameters of the spectrometer dipoles [3].*

1) This spectrometer dipole has been removed at the beginning of 2006 and is going to be re-installed at the end of the CT Line after the delay loop.

The distance d corresponds to 1.18 m for spectrometer 10 and to 1.195 m in case of the spectrometer at the end of the CT Line.

2.2.2 Dipoles of the magnetic chicane

The parameters of the four dipoles CL.BHA0425, CL.BHA0430, CL.BHA0450 and CL.BHA0455 in the magnetic chicane are described in Table 9. Additional information can be found in Ref. [6].

Quantity	Value	Comment
effective length	149 mm	
mechanical length	83 mm	length of iron
aperture	60 mm	mechanical available space
magnetic field	B_0 [T] = 0.001474 I [A]	
total bending angle	30.0°	
momentum calibration	p [MeV/c] = 0.131 I [A]	
dispersion at location of the TV screens	0.053 m + 0.533 · l with $l = d$ - 0.086	d is the distance magnet-center/screen
max. allowed current	300 A	
max. I & U of power supply	± 300 A & 30 V ± 200 A & 30 V	CL.BHA0425/55 CL.BHA0430/50
cooling		water

Table 9: *Parameters of BHA type dipoles [6].*

The first bending magnet can be used to bend particles to the opposite side towards the segmented dump. For this operation the bending angle corresponds to 30.0°, the distance d measures 0.818 m.

2.2.3 Dipole magnets of the PETS line

The PETS (Power Extraction and Transfer Structure) produce 30 GHz power for the high-gradient accelerating structure tests in CTF2. The parameters of the dipoles CP.BHC0105 and CP.BHC0145 in order to bend the beam into the PETS are listed in Table 10.

Quantity	Value	Comment
effective length	223 mm	
mechanical length	150 mm	length of iron
aperture	70 mm	
magnetic field	B_0 [T] = 0.00247 I [A]	
total bending angle	10.00°	
momentum calibration	p [MeV/c] = 0.947 I [A]	
max. allowed current	130 A	
max. I & U of power supply	± 140 A & 45 V 140 A & 45 V	CP.BHC0105 CP.BHC0145
cooling		water

Table 10: *Parameters of PETS line dipoles [3].*

2.2.4 BHE-type dipoles

BHE-type dipoles are located in the INFN/Frascati chicane and at the end of the CT-line after the delay loop[2)]. The INFN/Frascati chicane allows either to compress or to lengthen the beam bunches by means of an adjustable R56 value. The parameters of the dipoles CT.BHE0210, CT.BHE0240, CT.BHE0260, CT.BHE0290 (common power supply) and CT.BHE0540 are described in Table 11.

Quantity	Value	Comment
effective length	561 mm	
mechanical length	510 mm	length of iron
aperture (horiz./vert.)	120 mm / 45 mm	
magnetic field	B_0 [T] = 0.00262 I [A]	
total bending angle	26.00°	for CT.BHE0540
momentum calibration	p [MeV/c] = 1.408 I [A]	
max. allowed current	680 A	
max. power dissipation	12 kW	
max. I & U of power supply	500 A & 100 V ±3*100 A & 30 V	Frascati chicane dipoles CT.BHE0540
cooling		water

Table 11: *Parameters of BHE type dipoles [4].*

2.2.5 Dipole correctors

In order to correct the electron beam trajectory, horizontal (H) and vertical (V) steering magnets are installed in CTF3. There is a total of 26 horizontal and vertical dipole correctors, which are classified in five different types.

The injector part contains three A- and three B-type correctors: CL.DHA/DVA0120, CL.DHA/DVA0150, CL.DHA/DVA0230, CL.DHB/DVB0270, CL.DHB/DVB0315, CL.DHB/DVB0340.

In the Linac (girder 4 to girder 15) and PETS line, 14 horizontal and vertical steering magnets (C- and D-type) are mounted on a common support frame: CL.DHC/DVC0410, CL.DHC/DVC0480, CL.DHC/DVC0520, CL.DHC/DVC0620, CL.DHC/DVC0720, CL.DHC/DVC0820, CL.DHC/DVC0920, CL.DHC/DVC1020, CL.DHD/DVD1120, CL.DHD/DVD1220, CL.DHD/DVD1320, CL.DHD/DVD1420, CL.DHD/DVD1520, CP.DHC/DVC0220.

The calibration coefficient for the C-type dipole correctors is given by [6]:

$$\alpha[\text{mrad}] \cdot \text{p}[\text{MeV/c}] = 65.4 \cdot \text{I[A]} \pm 19.6, \quad (1)$$

where α is the bending angle, p the particle momentum and I the magnet current.

In the CT line and Frascati chicane D- and E-type dipole correctors are used: CT.DHD/DVD0160, CT.DHD/DVD0360, CT.DVE0245, CT.DHE0255, CT.DVE0410, CT.DHE0420, CT.DHD/DVD0495, CT.DHD/DVD0505. In case of the E-type dipoles, the horizontal and vertical correctors are separated and are mounted inside the aperture of the quadrupoles.

All dipole correctors are fed by ± 10/20 A & ± 60/30 V power supplies.

[2)] for the first part of the run 2006.

2.3 Quadrupoles

2.3.1 Abbreviations

For simplification the old and new abbreviations of the quadrupoles are listed in Table 12, where X stands for F (focusing) or D (defocusing) respectively.

old abbreviation	new abbreviation
QS	QXA
QL1	QXB
QL2	QXC
QL3	QXD
Large	QXE
QN	QXF

Table 12: *Old and new abbreviations for CTF3 quadrupoles.*

2.3.2 List of all quadrupoles

- CL line (37 quadrupoles):
  CL.QFA0405, CL.QDA0415, CL.QFA0420, CL.QFA0460, CL.QDA0465, CL.QFA0505, CL.QDA0510, CL.QDA0605, CL.QFB0610, CL.QDA0615, CL.QDB0705, CL.QFC0710, CL.QDB0715, CL.QDB0805, CL.QFC0810, CL.QDB0815, CL.QDB0905, CL.QFC0910, CL.QDB0915, CL.QDB1005, CL.QFC1010, CL.QDB1015, CL.QDB1105, CL.QFC1110, CL.QDB1115, CL.QDB1205, CL.QFC1210, CL.QDB1215, CL.QDD1305, CL.QFD1310, CL.QDD1315, CL.QDD1405, CL.QFD1410, CL.QDD1415, CL.QDD1505, CL.QFD1510, CL.QDD1515.

- CP line (6 quadrupoles):
  CP.QFC0110, CP.QDC0120, CP.QFC0130, CP.QDC0205, CP.QFC0210, CP.QDC0215.

- CT line (19 quadrupoles):
  CT.QDD0110, CT.QFD0130, CT.QFD0150, CT.QDD0220, CT.QFE0230, CT.QDF0245, CT.QFE0250, CT.QDF0255, CT.QFE0270, CT.QDD0280, CT.QFD0310, CT.QFD0330, CT.QDD0350, CT.QDF0410, CT.QFF0420, CT.QDF0470, CT.QFF0480, CT.QDD0520, CT.QFD0530.

The main parameters of the quadrupoles are given in Tables 13 to 18. The information concerning the power supplies originates from [8]. For the QXC, QXD, QXE and QXF type quadrupoles different power supplies are used.

Quantity	Value	Comment
effective length	126 mm	
mechanical length	104 mm	
inscribed radius	29 mm	
magnetic gradient	B' [T/m] = 0.2506 I [A]	
focal length	f [m] = 0.105 $\frac{P[\mathrm{MeV/c}]}{I[\mathrm{A}]}$	
max. allowed current	10 A	
max. dissipated power	0.036 kW	
max. I & U of power supply	± 10/20 A & ± 60/30 V	
cooling		air cooled

Table 13: *Type A quadrupoles [3].*

Quantity	Value	Comment
effective length	224 mm	
mechanical length	200 mm	
inscribed radius	29 mm	
magnetic gradient	*B'* [T/m] = 0.2506 *I* [A]	
focal length	f [m] = 0.0596 $\frac{P[\text{MeV/c}]}{I[\text{A}]}$	
max. allowed current	10 A	
max. dissipated power	0.053 kW	
max. I & U of power supply	± 10/20 A & ± 60/30 V	
cooling		air cooled

Table 14: *Type B quadrupoles [3].*

Quantity	Value	Comment
effective length	224 mm	
mechanical length	200 mm	
inscribed radius	29 mm	
magnetic gradient	*B'* [T/m] = 0.0555 *I* [A]	
focal length	f [m] = 0.268 $\frac{P[\text{MeV/c}]}{I[\text{A}]}$	
max. allowed current	100 A	
max. dissipated power	0.564 kW	
max. I & U of power supply		Ref. [8]
cooling		water cooled

Table 15: *Type C quadrupoles [3].*

Quantity	Value	Comment
effective length	224 mm	
mechanical length	200 mm	
inscribed radius	29 mm	
magnetic gradient	*B'* [T/m] = 0.0574 *I* [A]	
focal length	f [m] = 0.259 $\frac{P[\text{MeV/c}]}{I[\text{A}]}$	
max. allowed current	200 A	
max. dissipated power	2 kW	
max. I & U of power supply		Ref. [8]
cooling		water cooled

Table 16: *Type D quadrupoles [7].*

Quantity	Value	Comment
effective length	380 mm	
mechanical length	300 mm	
available aperture	100 mm	
magnetic gradient	*B'* [T/m] = 0.031 *I* [A]	
focal length	f [m] = 0.283 $\frac{P[\text{MeV/c}]}{I[\text{A}]}$	
max. allowed current	150 A	
max. dissipated power	8.25 kW	
power supply		Ref. [8]
cooling		water cooled

Table 17: *Type E quadrupoles [4].*

Quantity	Value	Comment
effective length	328 mm	
mechanical length	262 mm	
available aperture	78.5 mm	
magnetic gradient	B' [T/m] = 0.016 I [A]	
focal length	f [m] $= 0.636\ \frac{P[\mathrm{MeV/c}]}{I[\mathrm{A}]}$	
max. allowed current	250 A	
max. dissipated power	2.8 kW	
power supply		Ref. [8]
cooling		water cooled

Table 18: *Type F quadrupoles [4].*

3 Instrumentation

3.1 Beam Position Monitors

3.1.1 Inductive Pick-Ups

24 inductive Pick-Ups (PUs)are installed in the CTF3 Linac, PETS- and CT line in order to observe the beam position. The BPM-type PUs were developed at CERN and detailed information can be found in Ref. [10]. The BPIs were built by INFN and are used in the Frascati chicane and the CT line.

The main parameters of the BPMs and BPIs are listed in Tables 19 and 20.

Quantity	Value	Comment
length	168 mm	with bellows
aperture	40 mm	
Σ signal bandwidth	300 Hz - 250 MHz	
Δ signal bandwidth	800 Hz - 150 MHz	
Σ signal amplifier gain	5 / 25 dB	low / high
Δ signal amplifier gain	15 / 35 dB	low / high
linearity	50 μm	within $\pm$ 5 mm
beam position [mm]	10 mm * Δ/Σ	
resolution	$\approx$ 0.1 mm	

Table 19: *Parameters of the inductive Pick-Ups (BPM type) [10].*

Quantity	Value	Comment
length	171 mm	with bellows
aperture	90 x 37 mm	rectangular
bandwidth	400 kHz - 200 MHz	
horiz. beam position [mm]	34.5 mm * Δ/Σ	
vert. beam position [mm]	31.3 mm * Δ/Σ	
resolution	$\approx$ 0.1 mm	

Table 20: *Parameters of the inductive Pick-Ups (BPI type) [11, 12].*

3.1.2 Electrostatic and Button Pick-Ups

In the injector inductive PUs can not be used because of the magnetic coils. Instead electrostatic and Button Pick-Ups are installed. They are referred to as BPEs and BPRs respectively. In case of the BPRs a RF signal is picked up via a waveguide to obtain information about the bunch length. Presently bunch length information can be acquired at three positions, after the buncher, after the magnetic chicane and at the end of the CT line. The main parameters are listed in Tables 21 and 22.

Quantity	Value	Comment
aperture	40 mm	
bandwidth	1 kHz - 100 MHz	
gain ratio	≈ 2.8	Δ/Σ amplifier gain
beam position [mm]	≈ 10.3 mm * Δ/Σ	
resolution	0.1 mm	

Table 21: *Parameters of the electrostatic Pick-Ups (BPE type) [13].*

Quantity	Value	Comment
aperture	40 mm	
bandwidth	1 kHz - 100 MHz	
gain ratio	1.5	Δ/Σ amplifier gain
beam position [mm]	9.67 mm * Δ/Σ	
resolution	0.1 mm	

Table 22: *Parameters of the Button Pick-Ups (BPR type) [13].*

3.2 Wall Current Monitors

Four Wall Current Monitors (WCMs) are integrated in the Linac to get detailed knowledge on the time structure along the pulse. Wall Current Monitors with two outputs were designed to cope with the CTF3 Linac requirements. Details are found in [14]. The main parameters of the WCMs are summarised in Table 23.

Quantity	Value	Comment
length	256 mm	
aperture	40 mm	
bandwidth	250 kHz - 10 GHz	direct output
bandwidth	10 kHz - 300 MHz	integrator output

Table 23: *Parameters of the Wall Current Monitor [14].*

3.3 Profile Monitors

3.3.1 Screens

Nine screens are mounted in the Linac, the appertaining spectrometer lines and the CT line. An overview on the screens and the corresponding observation tools is given in Table 24. Four screens can presently be used to measure transverse beam parameters by means of quadrupole scans: CL.MTV0500, CL.MTV1030, CT.MTV0435 and CT.MTV0550.

Screen	Foils	Observation Tools	Comments
CL.MTV0165	P on Al, C	Proxitronic	hole in screen
CLS.MTV0440	Al	CCD camera	
CL.MTV0500	Al	CCD camera	+ PMT for beam halo
CL.MTV1030	Al, C	CCD camera	
CLS.MTV1050	Al, parabolic	CCD camera	SR mask
CT.MTV0435	SiC, Al	CCD camera, Proxitronic	
CT.MTV0550	Si coated with Al, C	CCD camera, Streak camera	
CTS.MTV0605	Al, parabolic	CCD camera	SR mask
former CTS.MTV0460	diffuse Al	CCD camera	SR mask

Table 24: *Overview on screens in the CTF3 Linac [27, 28].*

The gated and intensified camera from Proxitronic allows an observation of the evolution of the beam size in time over the pulse. The time resolution corresponds to 100 ns for the first Proxitronic and 5ns for the second one respectively. Detailed information concerning the Streak camera can be found in [3].

3.3.2 Synchrotron Radiation Ports

At present three synchrotron radiation light monitors are mounted up to the delay loop, one in the PETS line and two in Frascati chicane. The light is observed with CCD cameras.

3.3.3 Segmented Photo Multipliers

A segmented photo multiplier (PMT) is installed in the spectrometer line 10 and a second PMT is going to be installed in the future "end of CT spectrometer line". The OTR light coming from a parabolic Al screen is observed with 31 channels. The horizontal distance covered by the photo multipliers is 90 mm and a spatial resolution of 2.8 mm is achieved [28]. The time resolution of approximately 10 ns is given by the ADC.

3.3.4 Segmented dump

A water cooled segmented dump built of 24 tungsten plates (2 mm thick) spaced by 1 mm is used in spectrometer line 4 [28]. The time resolution corresponds to about 10 ns.

3.3.5 Slit dump monitor

A slit dump monitor is located in spectrometer line 10 as a back up solution in case the segmented photo multiplier does not work properly.

3.4 Beam Loss Monitors

Beam loss monitors (BLMs) are installed along the Linac and the PETS line in order to map beam losses, both in amplitude and during the beam pulse at the tenth of a percent level. Along the girders 5, 6, 7, 11 and 12 three Faraday Cups are arranged respectively, one close to the quadrupole region and two sensitive to the entrance of each accelerating structure. Furthermore PMTs used as Cherenkov detectors are installed in girders 11 and 12 in the quadrupole regions.

In the PETS line six Aluminium Cathode Electron Multiplier (ACEM) are placed, two after the collimator, one after the second bending magnet and three along the PETS. The fast time response of 2ns allows to observe the time evolution of the beam losses.

3.5 Bunch Phase Monitor

In order to study the electron bunch train combination after the delay loop, a coaxial pick-up has been installed. It permits the measurement and comparison of the amplitudes of five harmonics of the fundamental beam frequency. Detailed information can be found in Ref. [15].

3.6 Additional Equipment

3.6.1 Photo Multiplier

One photo multiplier is mounted in the PETS line which is sensitive to visible light from the PETS due to RF breakdown.

3.6.2 Collimators

Three collimators, made up of tungsten jaws mounted on water cooled copper blocks, are presently used. Table 25 gives an overview on position and the basic parameters of these collimators.

Location	max. slit position	max. aperture	Comment
magnetic chicane	±33 mm	66 mm	movable slit
PETS - “dogleg”	±20 mm	40 mm	movable slit
in front of PETS		8 mm	fixed collimator

Table 25: *Parameters of the three collimators.*

4 Electron gun

A thermionic electron gun with a 2 cm^2 gridded cathode is presently used in CTF3. The gun is designed for a 9 A space charge limited current at 140 kV. The basic parameters are summarised in Table 26.

Quantity	Value	Comment
max. gun current	9 A	
current flatness	≤0.1 %	for 5 Hz rep. rate
min./max. heater voltage	5.5/7.0 V	
max. high voltage/current	160 kV/ 5mA	
bias voltage	0 to -300 V	normally set to -60 V
pulser voltage	-850 V	
max. pulse length	1.6 μs	
max. rep. rate	5 Hz 100 Hz	for pulser, according to LAL specs. for HV power supply

Table 26: *Parameters of the RF gun [17, 18].*

According to the LAL specifications the repetition rate for the pulser is 5 Hz. At higher rates the amplitude is stable but frequency dependent. In 2005 the gun was operated up to 50 Hz.

5 RF Components

5.1 Buncher and Accelerating structures

The bunching system consisting of three 1.5 GHz sub-harmonic bunchers (SHBs), one pre-buncher (PB) and one travelling wave buncher (B), is followed by 16 travelling wave accelerating structures (AS, two in the injector, 14 in the Linac), each providing an average energy gain of 7 MeV.

Table 27 gives an overview on the bunching system and the accelerating structures including the available power supplies. SICA and TDS stand for two different structure types, LIPS and BOCS are the acronyms for two pulse compression systems.

Structure	Location	Power supply	Pulse compression system
SHB 1, 2 and 3	girders 1 & 2	MKS01; 40 kW/TWT, 1.5 GHz	
PB and B	girder 2	MKS02; 42 MW, 3 GHz	
AS 1 & 2, type: TDS, SICA	girder 3	MKS03; 45 MW, 3 GHz	LIPS
AS 3 & 4, type: SICA	girder 5	MKS05; 45 MW, 3 GHz	LIPS
AS 5 & 6, type: SICA	girder 6	MKS06; 35 MW, 3 GHz	BOCS
AS 7 & 8, type: SICA	girder 7	MKS07; 35 MW, 3 GHz	BOCS
AS 9 & 10, type: SICA	girder 11	MKS11; 35 MW, 3 GHz	LIPS
AS 11 & 12, type: SICA	girder 12	MKS12; 37 MW, 3 GHz	LIPS
AS 13 & 14, type: SICA	girder 13	MKS13; 37 MW, 3 GHz	BOCS
AS 15 & 16, type: SICA	girder 15	MKS15; 37 MW, 3 GHz	LIPS

Table 27: *Overview on the bunching system and accelerating structures[20].*

5.1.1 *Sub-harmonic Buncher*

The phase coding in order to deflect only every second bunch train into the delay loop is done by a fast 180° phase switch in three sub-harmonic bunchers working at 1.5 GHz. The main parameters are summarised in Table 28.

Quantity	Value	Comment
frequency	1.49928 GHz	
number of cells	6	
iris diameter	66 mm	
cell length	26 mm	
input power	40 kW	

Table 28: *Main parameters of the sub-harmonic bunchers [21].*

Since the beamloading is different in the three sub-harmonic bunchers, the structures are detuned individually. The parameters of each SHB are listed in Tables 29 to 31 [21].

phase advance per cell	74.82°	
phase velocity/c	0.63	
group velocity/c	0.048	
R/Q	10.7 Ω/structure	circuit convention
fill time	11 ns	

Table 29: *Individual parameters of the first sub-harmonic buncher.*

phase advance per cell	70.21°	
phase velocity/c	0.67	
group velocity/c	0.050	
R/Q	12.4 Ω/structure	circuit convention
fill time	10 ns	

Table 30: *Individual parameters of the second sub-harmonic buncher.*

phase advance per cell	68.23°	
phase velocity/c	0.69	
group velocity/c	0.051	
R/Q	13.4 Ω/structure	circuit convention
fill time	10 ns	

Table 31: *Individual parameters of the third sub-harmonic buncher.*

5.1.2 *Pre-buncher*

Quantity	Value	Comment
frequency	2.99855 GHz	
length	20 mm	
voltage - power relation	$V[kV] = 2.75 \cdot \sqrt{P[kW]}$	
input power	100 kW	

Table 32: *Parameters of the pre-buncher [19].*

5.1.3 Buncher

Quantity	Value	Comment
frequency	2.99855 GHz	
number of cells	17	incl. input and output coupler
iris diameter	35.7 - 29.2 mm	smallest at the end
cell length	33.33 mm	from cell six on
input power	42 MW	
phase advance per cell	$2\pi/3$	
phase velocity/c	0.7 - 1.0	largest at the end
R/Q	1.4 - 3.9 kΩ/m	Linac convention
group velocity/c	0.047 - 0.024	lowest at the end
fill time	$\approx$ 50 ns	

Table 33: *Parameters of the buncher [22].*

5.1.4 SICA Structure

At the moment 15 SICA (Slotted Iris - Constant Aperture) structures are installed in CTF3. One structure consists of 34 cells (including input and output coupler) and has a total length of 1.22 m. Detuning and modulation of the group velocity is done by nose-cone variation while keeping the iris diameter constant. The main parameters for the SICA structure are listed in Table 34.

Quantity	Value	Comment
frequency	2.99855 GHz	
number of cells	34	incl. input and output coupler
cell length	33.32 mm	
iris diameter	34 mm	
total length	1.22 m	
integrated acceleration	$V[MV] = 2.44 \cdot \sqrt{P[MW]} - 1.55 \cdot I[A]$	
input power	35 to 45 MW	
phase advance per cell	$2\pi/3$	
R/Q	3.15 - 3.29 kΩ/m	Linac convention
Q-factor	10941 - 13874	
group velocity/c	0.052 - 0.023	lowest at structure output
fill time	98 ns	

Table 34: *Parameters of the SICA structure [23].*

5.1.5 TDS

One TDS (Tapered Damped Structure) is installed in the CTF3 injector. The structure consists of 33 cells (including input and output coupler). Detuning and modulation of the group velocity is done by iris variation. The main parameters for the TDS are listed in Table 35.

Quantity	Value	Comment
frequency	2.99855 GHz	
number of cells	33	
cell length	33.32 mm	
iris diameter	42.45 - 41.09 mm	smallest at the end
total length	1.19 m	
integrated acceleration	$V[MV] = 2.44 \cdot \sqrt{P[MW]} - 1.55 \cdot I[A]$	
input power	45 MW	
phase advance per cell	$2\pi/3$	
group velocity/c	0.050 - 0.025	lowest at structure output
fill time	$\approx$ 100 ns	

Table 35: *Parameters of the TDS [24].*

5.2 PETS

The PETS (Power Extraction and Transfer Structure) produce 30 GHz power for the high-gradient accelerating structure tests. In order to reach 100 MW power, three 500 mm long travelling wave structures with different iris apertures have been installed. The main parameters of the PETS are summerised in Table 36.

Quantity	Value	Comment
iris diameter [mm]	9.0, 6.7, 9.0	for the three segments
total length	1.5 m	
PETS power	$P_{PETS}[MW] = 4.762 \cdot I[A]^2$	for zero bunch length
phase advance per cell	$2\pi/3$	
R/Q [kΩ/m]	5.87, 11.26, 5.87	
group velocity/c	0.398, 0.243, 0.398	

Table 36: *Parameters of the PETS [25, 26].*

The quoted power corresponds to the power at the output of the PETS. About 60% of this power arrives at the first cell of the accelerating structure in CTF2 [29].

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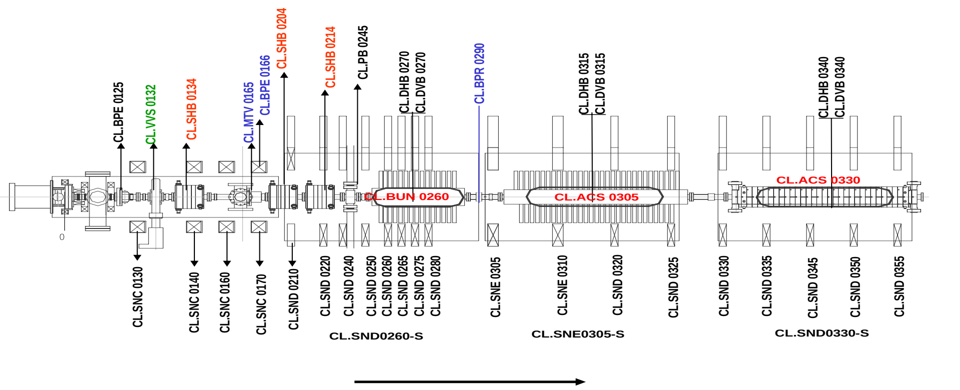
New CTF3 Injector with Sub-Harmonic Bunchers



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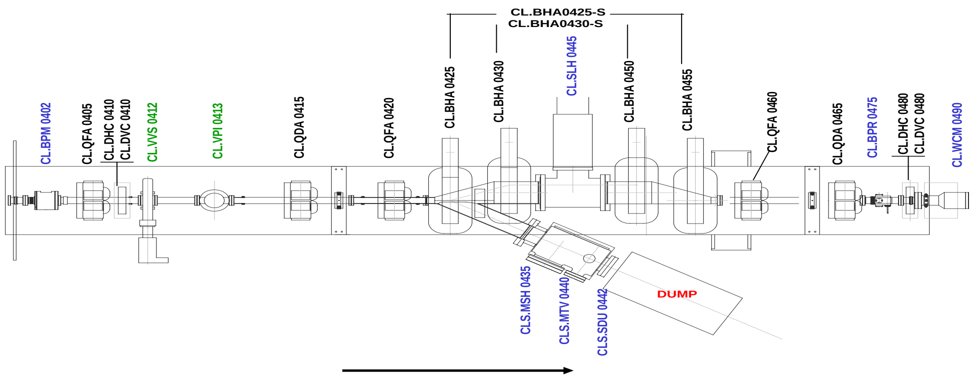

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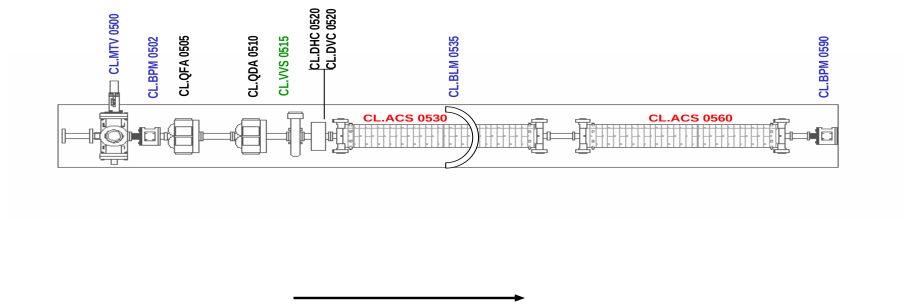

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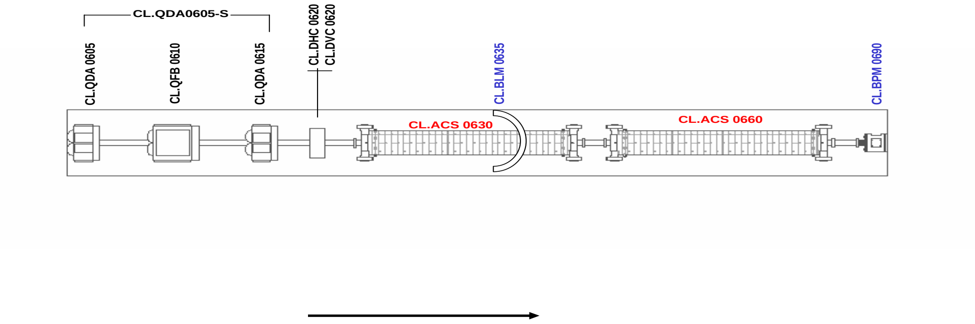

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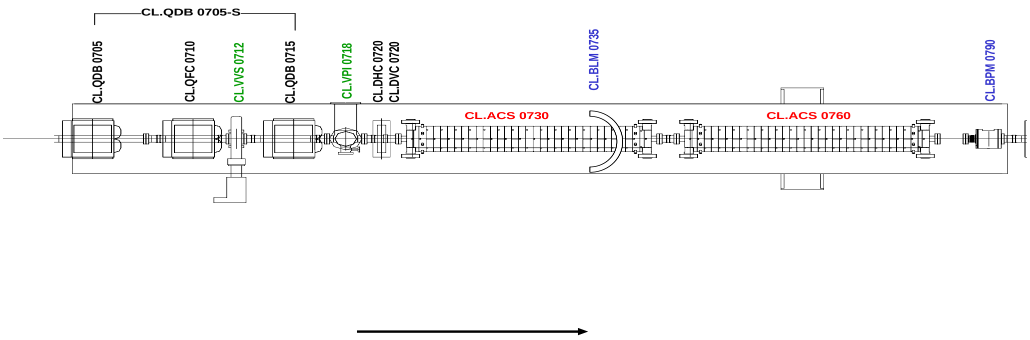

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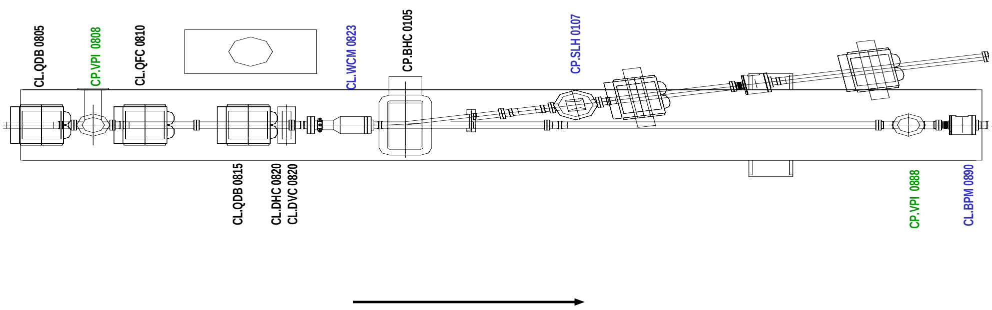

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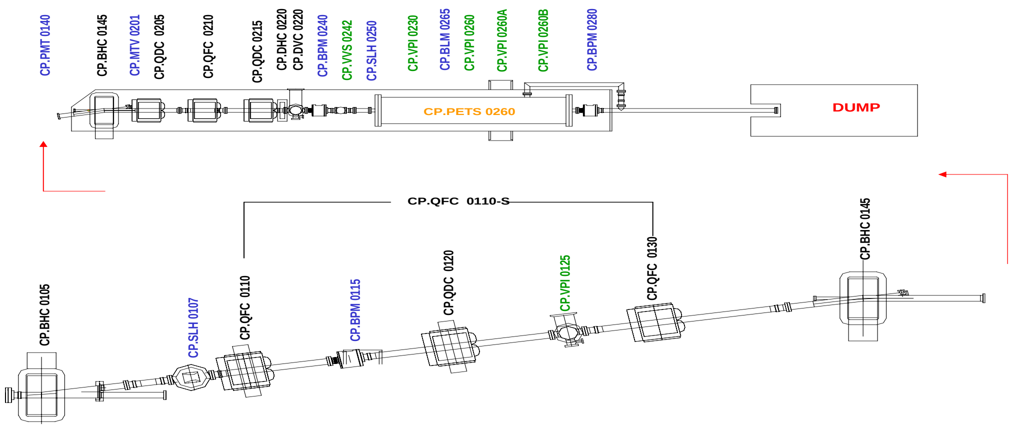

PETS LINES

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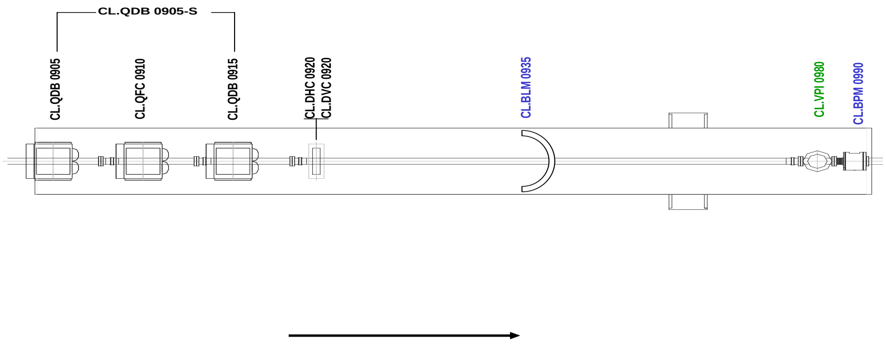

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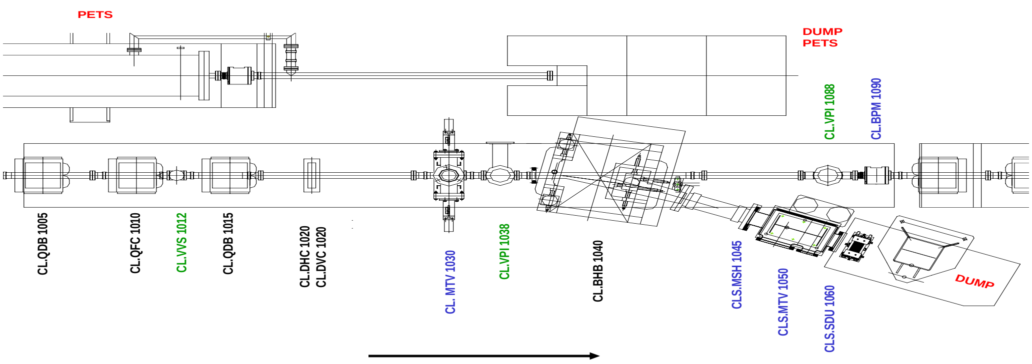

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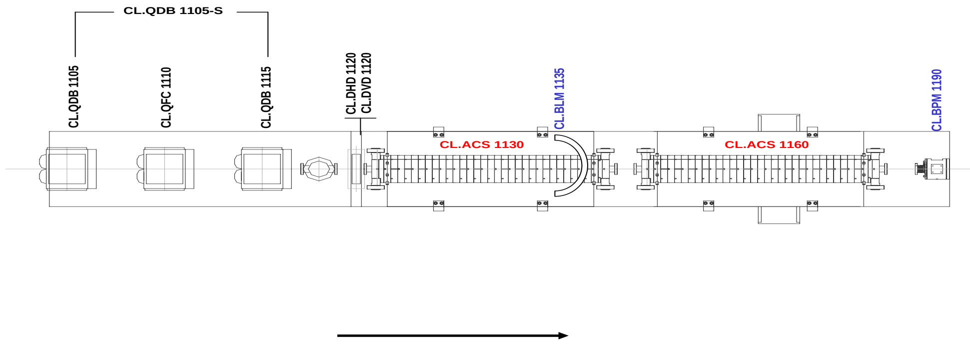

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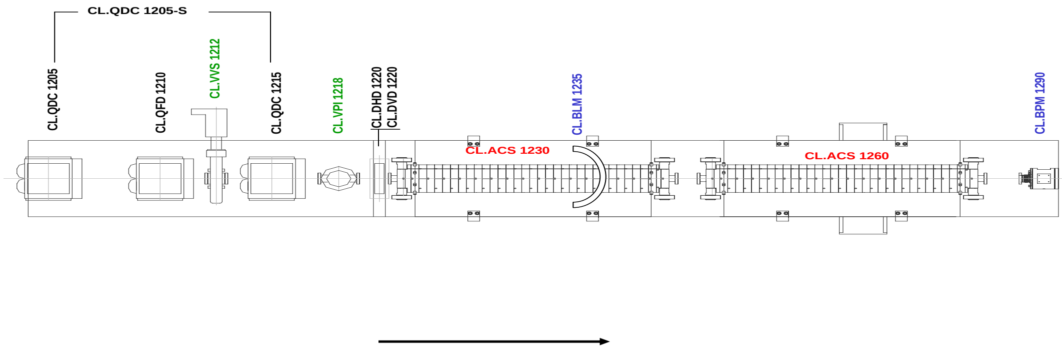

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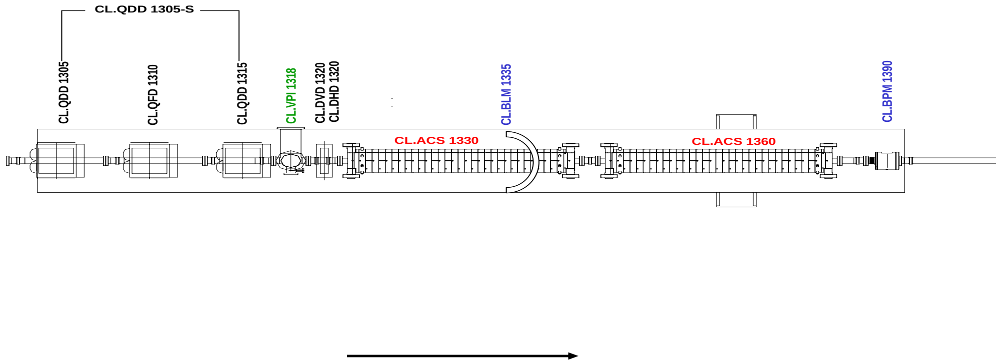

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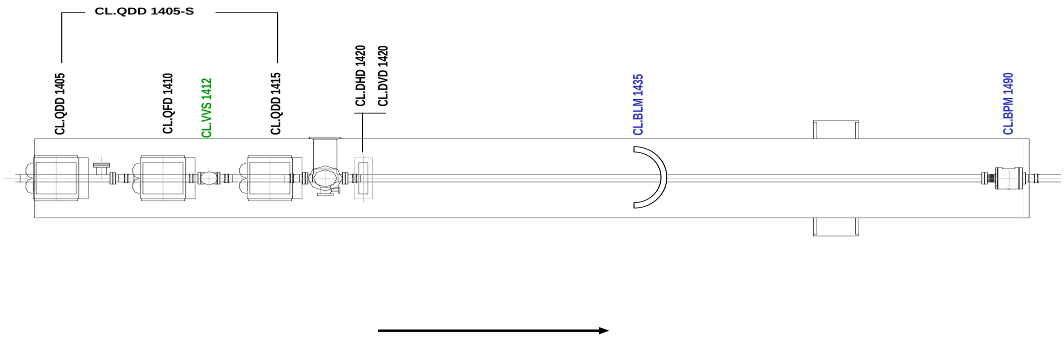

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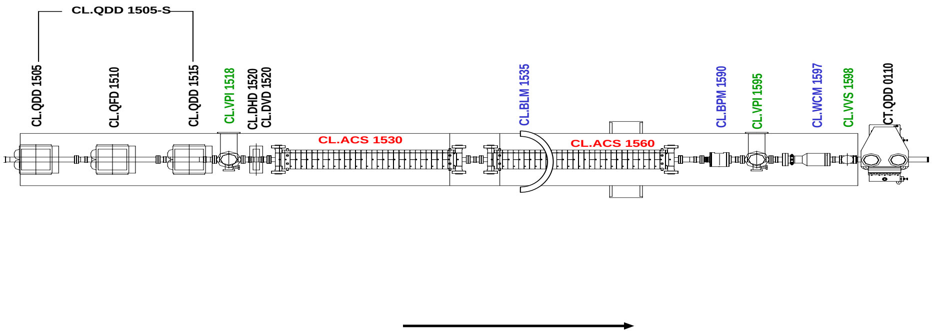

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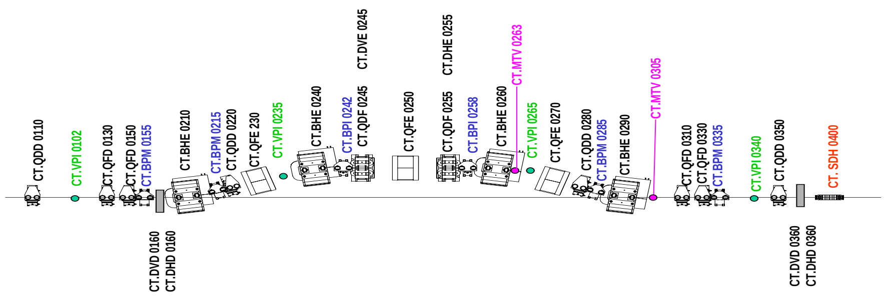
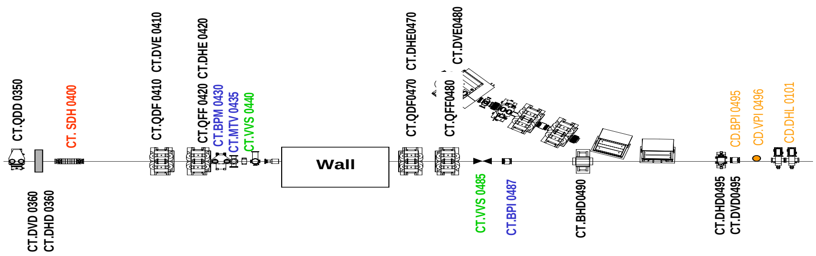
CT Line at the chicane



CT Line before the Delay Loop



CT Line after the Delay Loop