OVERVIEW AND STATUS OF THE CTF3 INJECTOR

L. Rinolfi

26 Mai 2000

Convention

entre

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE

"CERN"

et

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
IN2P3

Objet : Etude, suivi de fabrication, tests au LAL, participation aux essais et mise en service au CERN d'un canon thermo-ionique type CLIO

For CERN Internal use only			
Framework Cooperation Agreement	-	Division/Groupe	PS-RF-CS
Implementing Cooperation Agreement	**K 614/PS/CLIC**	Team Account	-
Addenda reference	-	Budget Code	

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DRAFT

PROTOCOL DE COLLABORATION 2
CERN – IN2P3
pour la
CONSTRUCTION ET TEST D'UN CANON THERMIONIQUE ET DE DEUX SECTIONS HF DE PRE-GROUPEMENT

Entre:

L'Organisation Européenne pour la Recherche Nucléaire,
Meyrin, CH-1211 Genève 23, ci-après dénommée CERN,
Représentée par: Monsieur L. Maiani, Directeur-Général

Et

L'Institut National de Physique Nucléaire et de Physique des Particules
3, rue Michel-Ange F-75794 Paris Cedex 16, ci-après dénommé IN2P3
Représenté par: Monsieur J-J. Aubert, Directeur-Général

CONSIERANT QUE:

Le CERN s'est engagé dans l'étude d'un collisionneur linéaire (CLIC) d'électrons et de positrons avec une énergie dans le centre-de-masse de 0.5-5 TeV, et s'est aussi engagé dans la construction d'une nouvelle facilité de test (CTF3) pour démontrer la faisabilité technique du schéma de production de la puissance HF pour CLIC. L'injécteur du CTF3 représente un défi technologique important. La mise en opération progressive de CTF3 est planifiée entre 2001 et 2005 et commence par une phase préliminaire qui a pour but de démontrer le système de recombinaison par un facteur de 5 avec un faisceau de faible intensité.

Le LAL a une grand compétence et une grande expérience dans le domaine de la réalisation d'accélérateurs dont les injecteurs du LEP (Large Electron Positron Collider) et les structures accélératrice HCS (High Charge Structures) pour CTF2 (CLIC Test Facility 2) en collaboration avec le CERN, et d'un canon thermionique CLIO (Collaboration pour un Laser à électrons libres dans l'infrarouge à Orsay) en collaboration avec le LURE (Laboratoire pour l'Utilisation du Rayonnement Electromagnétique).

Le CERN et l'IN2P3 expriment leur volonté de collaborer étroitement dans le domaine de l'injecteur de CTF3 et en particulier la construction d'un canon thermionique et de deux cavités HF de pré-groupement qui seront utilisés pour produire, et faire le pré-groupement, du faisceau d'électrons pour CTF3. La mise en service au CERN du canon est prévu pour mars 2002, et des deux cavités HF pour mars 2003.

IL A ETE CONVENU CE QUI SUIT:

Article I: **Objet du Protocole**

1 Ce Protocole de collaboration, ci-après "le Protocole", a pour objet de définir le cadre conventionnel au sein duquel pourra se développer la collaboration entre le CERN et l'IN2P3 pour l'étude, le suivi de fabrication, les tests au LAL, la participation aux essais et la mise en service au CERN d'un canon thermionique et de deux cavités HF de pré-groupement.

2 Les parties conviennent d'établir une collaboration dans le domaine décrit au point 1. Ce domaine est décomposé en deux parties:

(i) Canon thermionique:
- L'étude, le suivi de fabrication, les tests au LAL

3rd October 2000

MEMORANDUM OF UNDERSTANDING
FOR A CERN/SLAC COLLABORATION
ON THE CTF3 INJECTOR

This memorandum of understanding defines the scope of the collaboration between SLAC and CERN on the CTF3 injector.

Introduction

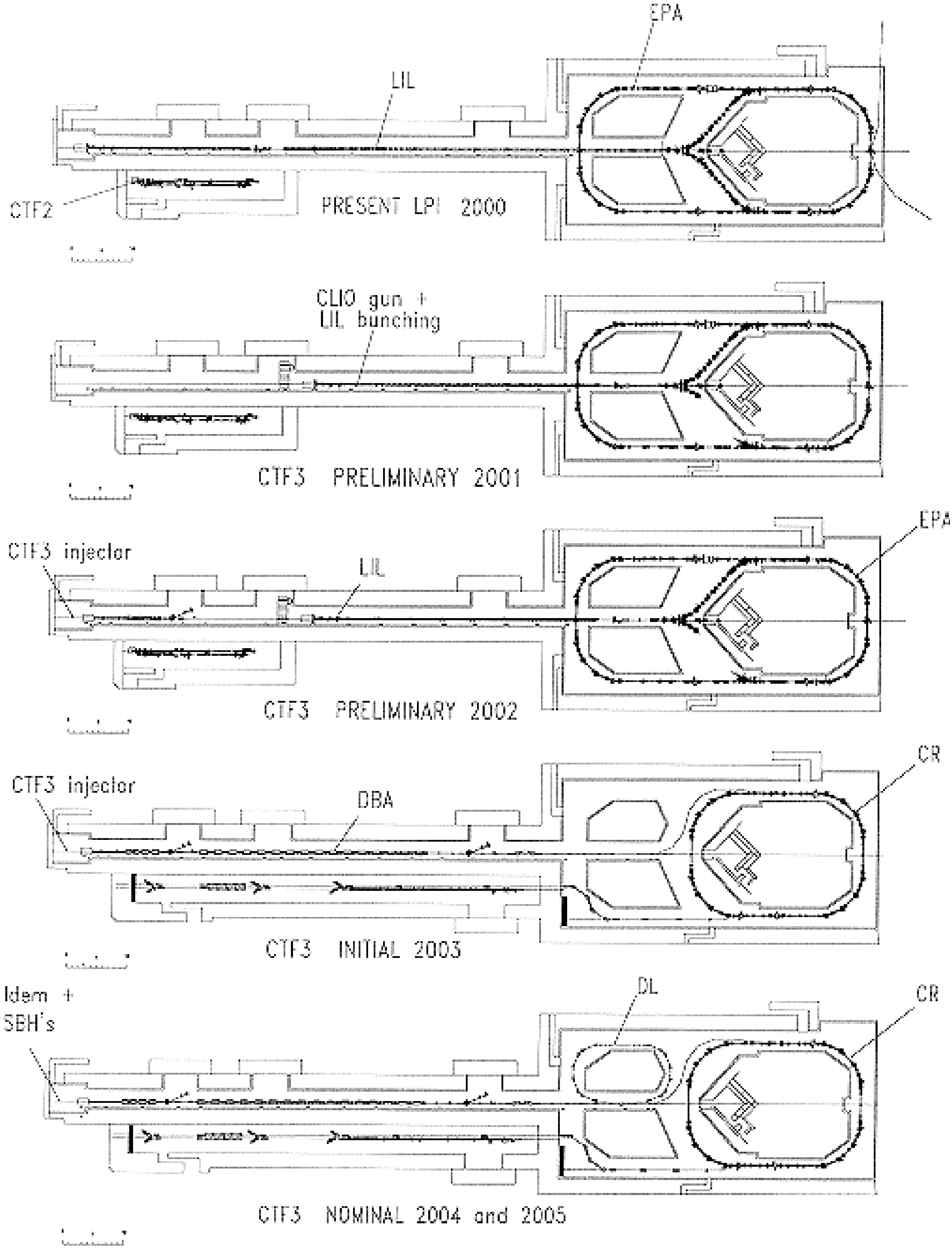
The CTF3 is a test facility designed to address important issues relevant to the development of a multi-TeV linear collider. This facility reuses equipment and infrastructure from the LEP injector complex to create a model drive beam generation system, which includes an injector, a high-current linac, a delay loop, a combiner ring and a drive beam decelerator linac. The final configuration of CTF3 is shown in Fig 1.

In order to generate the beam necessary for the linac, it is envisaged to build an injector that is designed to bunch the beam at L-band frequency in order to place a bunch on the crest of every other wavelength at S-Band. This injector consists of a thermionic gun, prebuncher cavities, an S-band travelling wave buncher and two S-band accelerator structures. Figure 2 gives a layout of the CTF3 injector. The parameters of the injector are given in Table 1. After the beam is bunched, it will be accelerated in a fully loaded linac prior to entering the Delay Loop and the Combiner Ring.

Scope of the collaboration

The SLAC contribution to the CTF3 consists of the theoretical design of the injector system. This involves the simulation and optimization of the injector design. This will be done in collaboration with CERN physicists, engineers and designers. This will require travel of people from SLAC to CERN and from CERN to SLAC. Travel costs will be shared with the sending side paying for travel, and the receiving side paying for hotel and meal allowance.

SLAC will also contribute a 150 kV gun designed to meet the specifications for the CTF3 injector. This gun will be high-voltage tested at SLAC prior to delivery to CERN on long-term loan for the collaboration. The plan is to deliver this gun to CERN before early 2002. The gun will be supplied with a blank-off flange in place of a cathode. The cathode, spare cathodes, and beam tests are not the responsibility of SLAC.



From LPI to CTF3

DBA = Drive Beam Accelerator
CR = Combiner Ring
DL = Delay Loop
SBH = Sub Harmonic Buncher

Target parameters at exit of CTF3 injector

Parameters	Unit	Prelim.	Initial	Nominal
Beam energy	MeV	4	≥ 20	≥ 20
Beam pulse	μs	2.53	1.54	1.54
RF pulse	μs	≥ 3.8	≥ 1.6	≥ 1.6
Beam current	A	0.3	3.5	3.5
Gun current	A	1	7	7
Charge/bunch	nC	0.1	1.17	2.33
Bunch spacing	m	0.1	0.1	0.2
Bunches/pulse		100	4200	2100
Charge/pulse	nC	10	4893	4893
Charge/satellite	%	-	-	≤ 5
Bunch length	ps- fwhh	7	≤ 12	≤ 12
Bunch length	mm-rms	0.9	≤ 1.5	≤ 1.5
Normalised rms emittances	mm.mrad	50	≤100	≤100
Energy spread (Single bunch)	MeV	≤ 0.5	≤ 0.5	≤ 0.5
Energy spread (on flat-top)	MeV	-	≤ 1	≤ 1
Charge variation bunch-to-bunch	%	≤ 20	≤ 2	≤ 2
Charge flatness (on flat-top)	%	-	≤ 0.1	≤ 0.1
Beam rep. rate	Hz	50	5	5
RF rep. rate	Hz	100	30	30

CTF3 Technical note 2000-008
10th April 2000

Technical description for the CTF3 gun

H. Braun, L. Rinolfi

The Note summarizes the technical specifications that will be used by LAL, as a "Cahier des charges" for the design and the construction of the CTF3 gun.
This gun should be used in the CTF3 "Initial and Nominal stages".

E-GUN simulations will be performed to check that the beam radius does not exceed 10 mm between the anode and the exit of the gun monitor that allows measuring the beam current. These simulations should be performed for nominal beam characteristics, i.e. 7 A for both voltages 150 kV and 100 kV.

The gun pulser should be able to deliver the train of pulses given in Figure 1 with a repetition rate of 5 Hz. Studies will be done in order to modulate the grid at 1.5 GHz with a large bandwidth amplifier (250 MHz).

Table 1 gives the CTF3 gun characteristics.

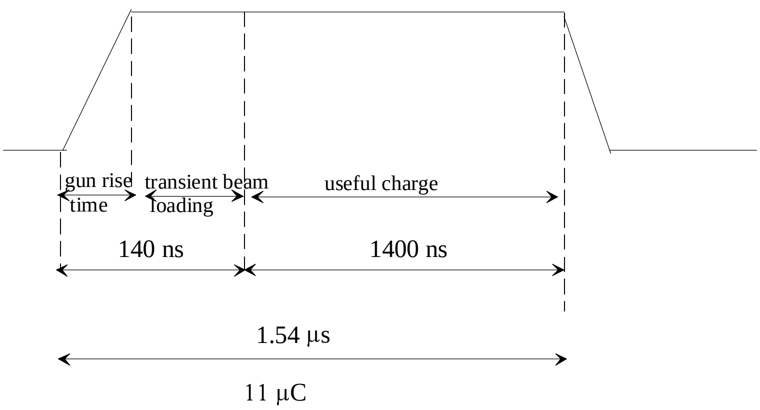


Figure 1: Pulse at the CTF3 gun exit

Table 1: Parameters for the CTF3 gun used for the Initial and Nominal stages

Parameters	**Unit**	**Initial and Nominal**
Voltage	kV	150
Pulse length	µs	1.6
Gun current	A	7
Charge per pulse	µC	11
Rise/ Fall time	ns	≤ 10
Voltage stability ΔV/V	%	≤ 0.1
Charge flatness on flat top	%	≤ 0.1
Emittance (norm., rms)	mm.mrad	≤ 10
Repetition rate	Hz	5

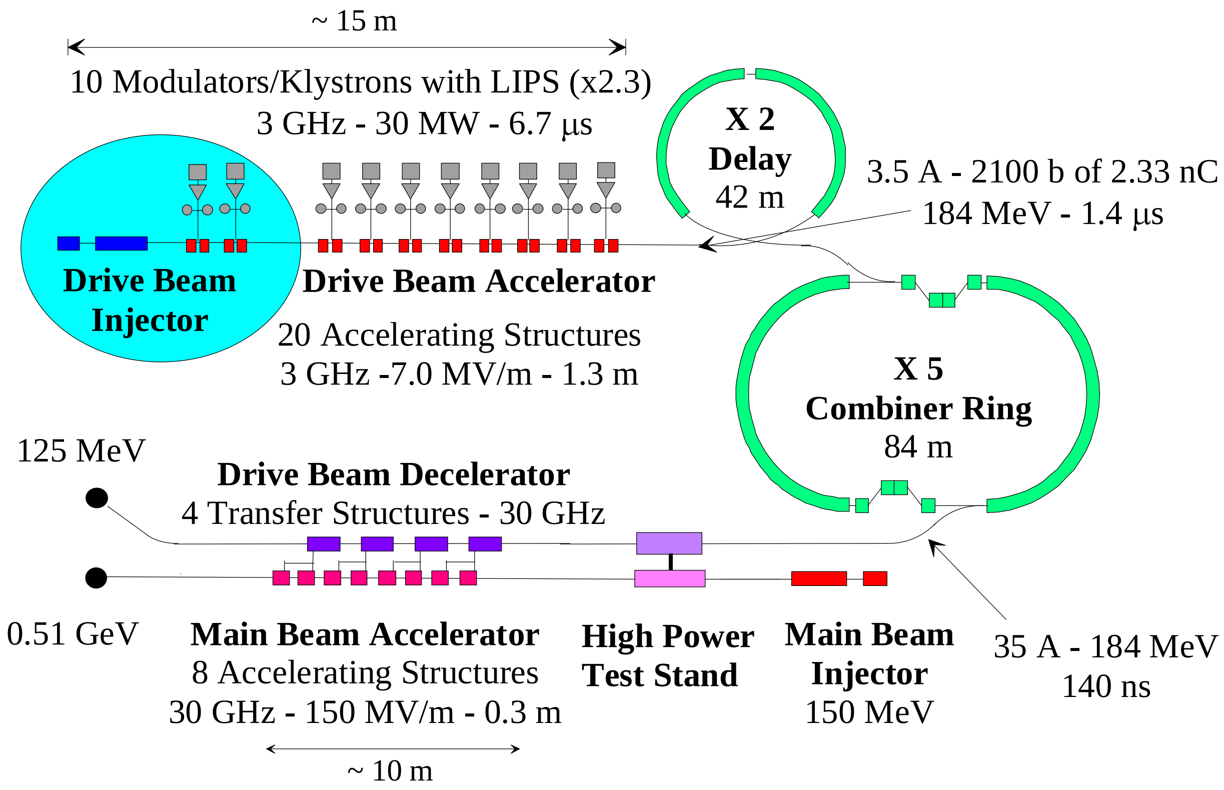
An Injector for the CLIC Test Facility (CTF3)

H. Braun, R. Pittin, L. Rinolfi, F. Zhou, CERN, Geneva, Switzerland

B. Mouton, LAL, Orsay, France

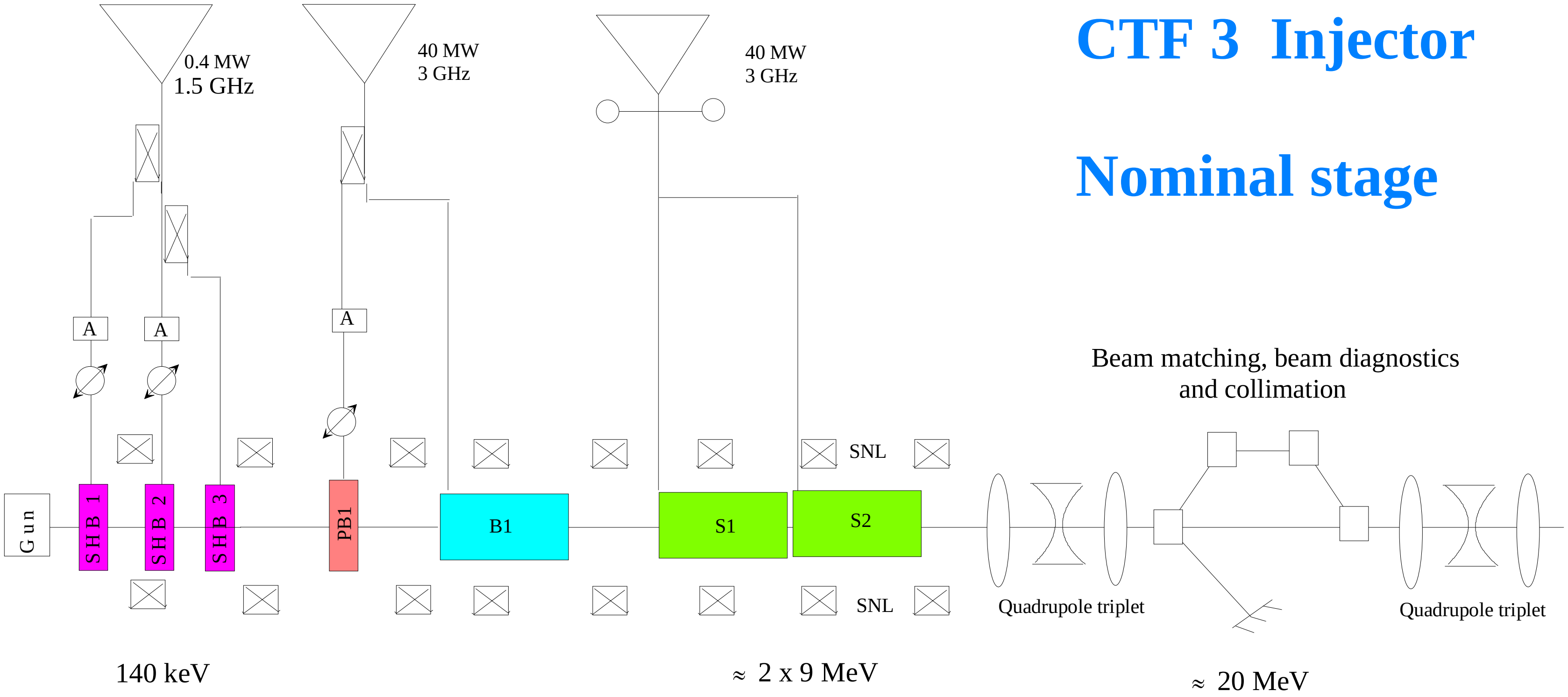
R. Miller, D. Yeremian, SLAC, Stanford, CA94309, USA

Poster MOB02



CTF 3 Injector

Nominal stage



f $_{RF}$ = 2.99855 GHz for all RF structures except the SHB

SHB = Sub-Harmonic Buncher

PB1= Pre-buncher

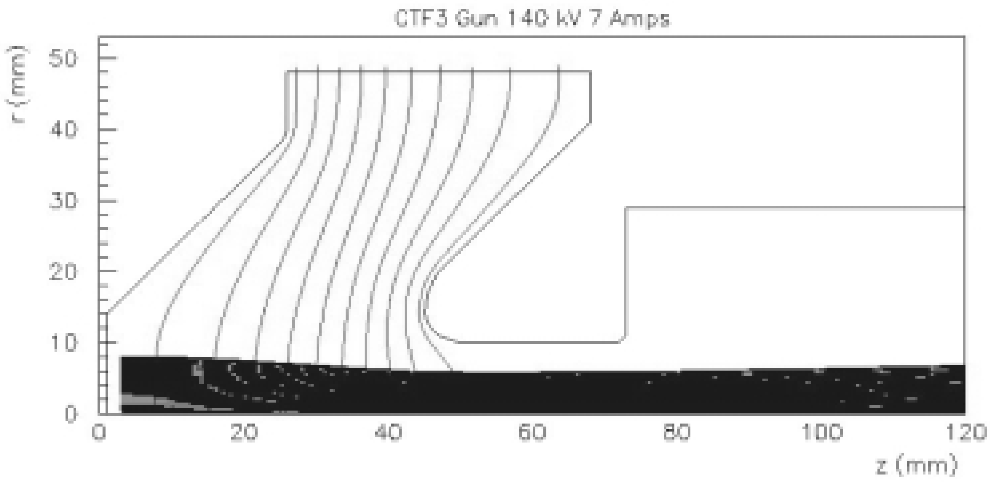
B1 = Bunching (TW structures)

S1, S2 = Accelerating (TW, 1.3 m, 9.2 MV/m)

SNL = Solenoids

August 2000

EGUN simulation results for the CTF3 gun



Cathode emitting surface: 2 cm^2

Distance cathode-anode: 45 mm

Electrode angle: 45 ^{o}

Max. field on the contour: 10 MV/m

$\gamma\,\varepsilon$ = 9.5 mm.mrad for a beam current of 7.4 A

$\gamma\,\varepsilon$ = 7 mm.mrad at the anode exit (PARMELA simulations)

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Design Studies for a High Current Bunching System for CLIC Test Facility (CTF3) Drive Beam

Y. Thiery, J. Gao, and J. Le Duff

XX International Linear Accelerator Conference, USA,
August, 2000

CERN-European Organization for Nuclear Research

CTF3 Tech. Note 2000-015
(Injector)

Updated Beam Dynamics for a CTF3 Injector

F.Zhou, H.Braun, CERN, Geneva, Switzerland

Abstract

A CTF3 drive beam injector for the nominal stage is proposed, which includes a thermionic DC gun, three Sub-Harmonic Bunchers (SHBs), one prebuncher, one 6-cell travelling wave buncher and two accelerating structures. Its beam dynamics is simulated by PARMELA. It is shown that all important parameters, e.g. satellite charge, bunch length and normalized transverse emittance can be met with the design goals if about 400 kW RF power for 3 SHBs is available. In addition, the beam dynamics of the injector for the initial stage has been simulated.

Geneva, Switzerland
21st September 2000

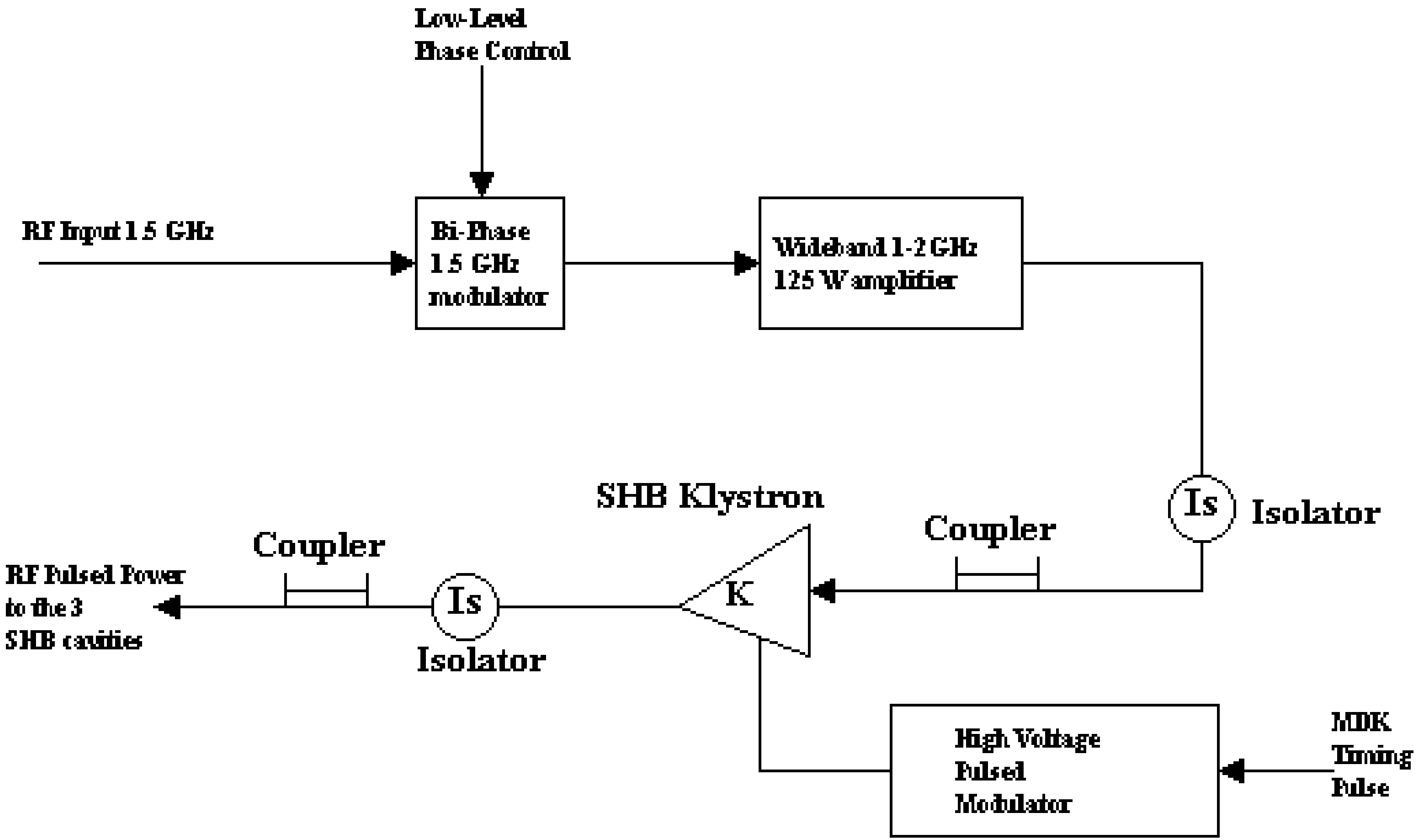
Two versions of a wide band Klystron for the SHB scheme

(both designs are derivatives of an existing tube PT6006)

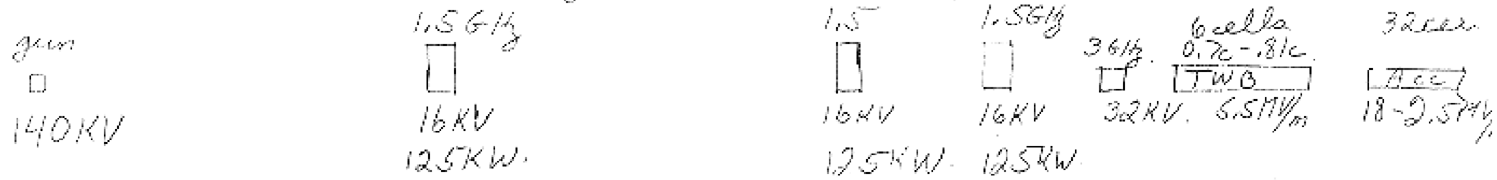
- 100 kW peak output
- Bandwidth (-1dB) of ~100 MHz
- Large signal gain 30dB
- Efficiency ~ 24%
- Beam voltage 34 kV
- Beam current 12.5 A

- 400 kW (min) peak output
- Bandwidth (-1dB) of ~150 MHZ
- Large signal gain ~40dB
- Efficiency ~ 20%
- Beam voltage 63 kV
- Beam current 32 A

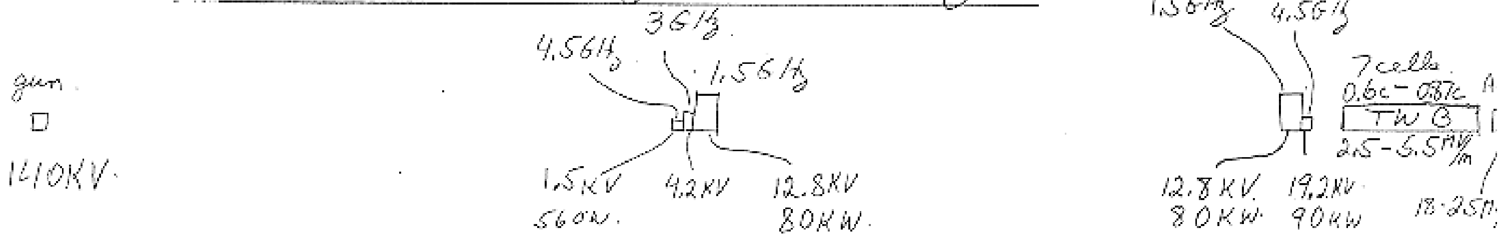
Possible RF network for SHB Klystron-Modulator



3 SHB (1.5GHz) + 1 PB (3GHz)



2 SHB + 1 3GHz + 2 4.5GHz



Dian
Louis
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Roger M

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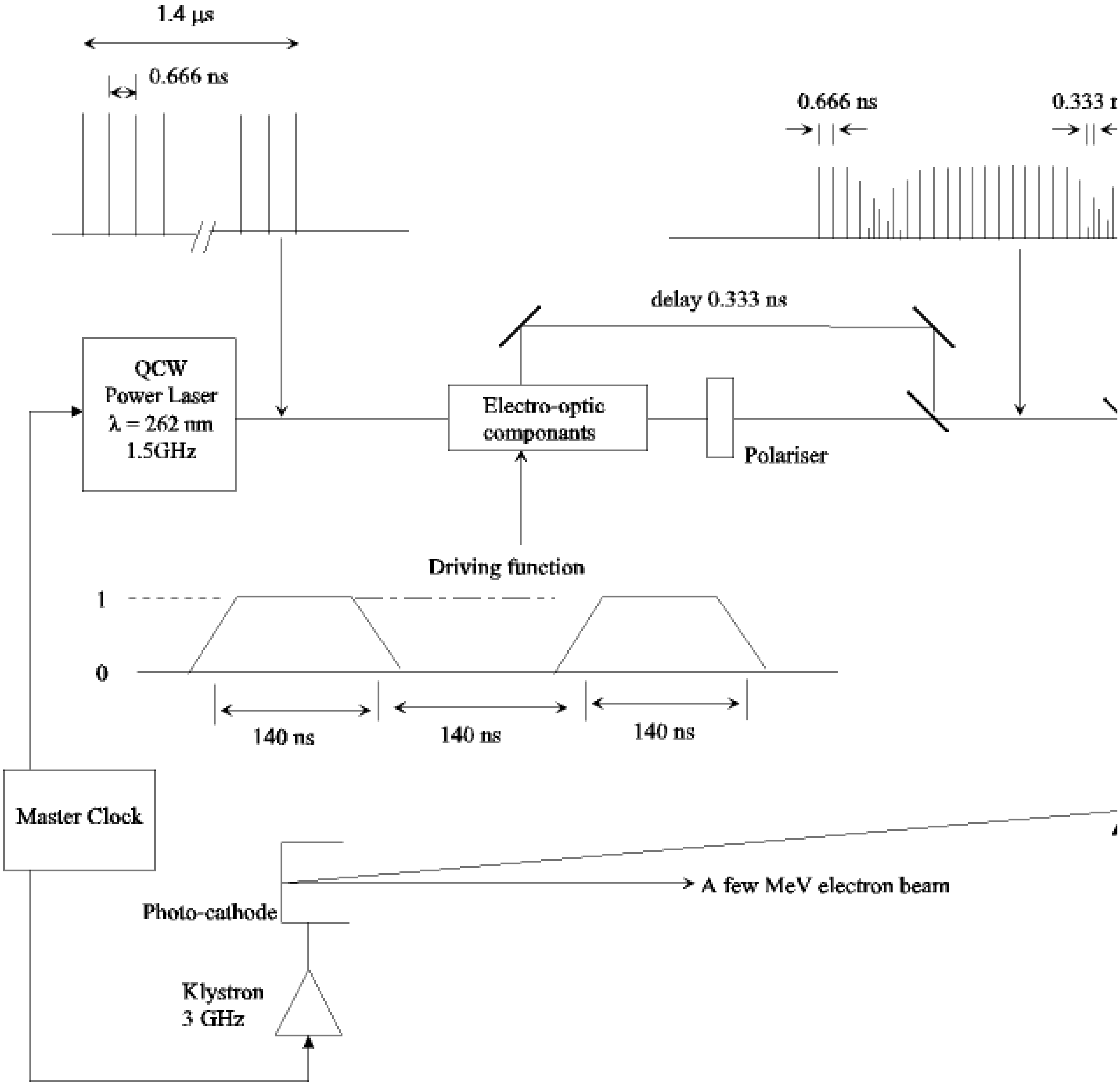
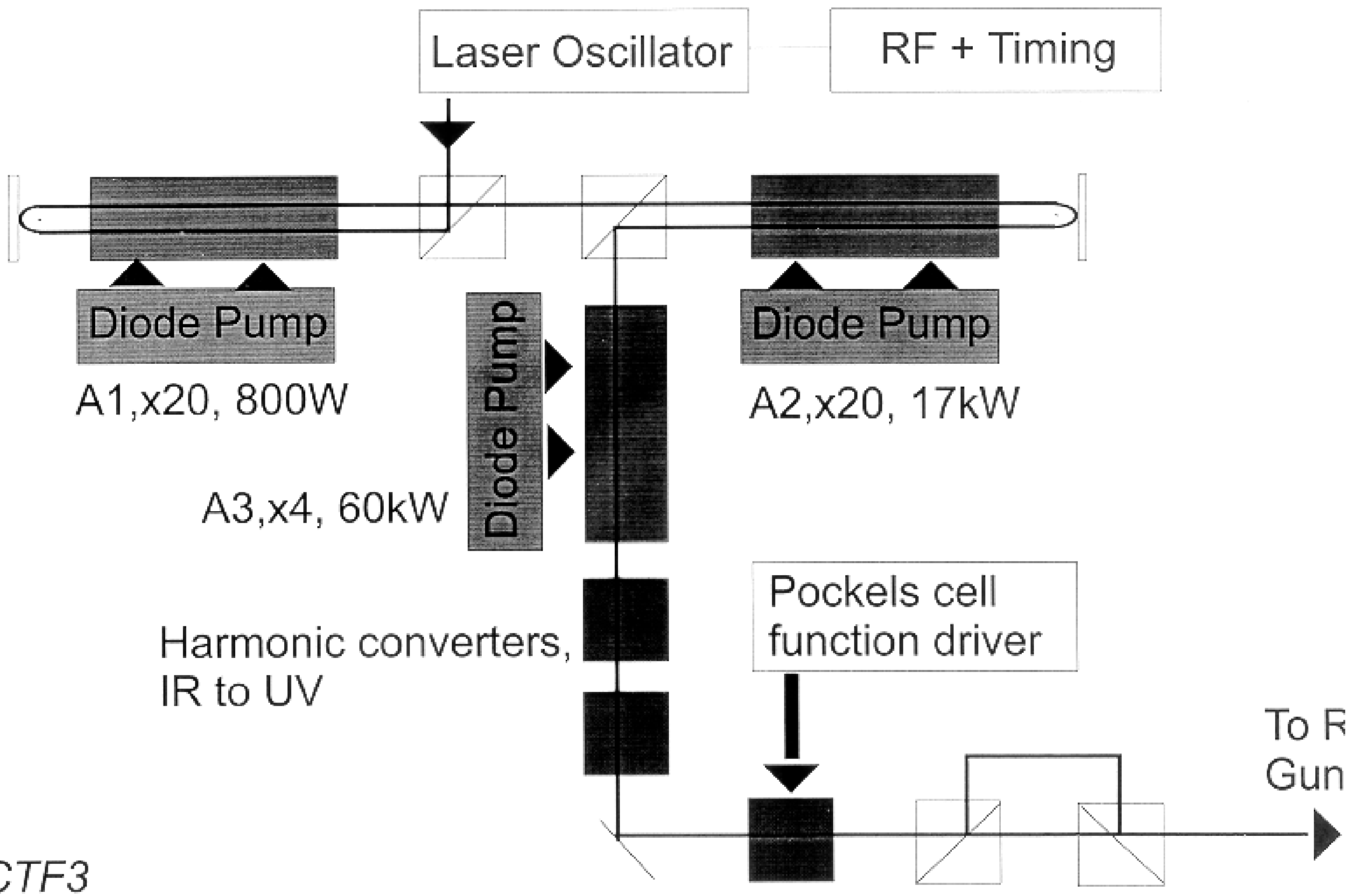
RF photo-injector for CTF3





CTF3
Laser/Photocathode source

sch 10/200

Laser power

	CTF3	CLIC	
Pulse train	2200	42880	pulses
Energy (UV)	0.84	4.9	μJ per pulse
Energy (IR)	17	98	μJ per pulse
Pulse spacing	667	2130	ps
Optical power (IR train out)	25000	47000	Watts
Average laser power	0.15	430	Watts

Subjects of concern:

Harmonic conversion eff

Amplifier gain control

Pumping efficiency

Feedback stabilisation

Fracture limit of Nd:YLF

UV/visible pulse manipulation

Optical measurements

Thermal distortion comp.

1.5GHz oscillator.

Synchronisation drift during pulse train

All these issues must be addressed before a design report can be produced

CERN – European Organization for Nuclear Research

EUROPEAN LABORATORY FOR PARTICLE PHYSICS

CLIC Note 462

Feasibility Study for the CERN 'CLIC' Photo-Injector Laser System

I.N. Ross, Central Laser Facility, Rutherford Appleton Laboratory

Abstract

This study is designed to contribute to the development of the Cern Linear Collider (CLIC). One route to the generation of the required electron injection into this system is through the use of photo-cathodes illuminated with a suitably designed laser system. The requirements of the accelerator and photo-cathodes have led to a specification for the laser system given in Table 1. Because CLIC will not be built directly but in stages, notably via CLIC Test Facilities (CTF), this table also includes the specification for a photo-injector laser system for CTF3 which will be required before the final system for CLIC. Although there are significant differences between these two specifications it will be necessary to design the CTF3 system such that it can be easily upgraded to the system for CLIC and will be able to check all the critical issues necessary for CLIC.

Geneva, Switzerland
5/10/2000

Planning indicative for the CERN/LAL/SLAC collaboration on the CTF3 Injector

(*) Legend: [P] = Preliminary stage [I] = Initial stage [N] = Nominal stage

Year 2000

August 2000:	Linac 2000 conference (21-25 August)
September 2000:	PARMELA simulations for [I] at LAL and CERN
October 2000:	Based on latest accelerating structure characteristics (SHB+PB+B), update PARMELA simulations [N]. Produce SUPERFISH files defining basic geometry of components. Start detail RF design and fabrication drawings for Buncher at CERN. Beam loading analysis.
October 2000:	Collaboration meeting CERN/LAL/SLAC (26-27 October).
November 2000:	Start mechanical engineering layout [N]. Start beam diagnostic layouts at SLAC and CERN [N]. Start to resolve mechanical conflicts [N]. PARMELA simulations from Nominal to Initial stage at SLAC. Start CTF3 gun (150 kV) hardware modifications at SLAC. Start Gun electrical system (HV deck and electronics) design at LAL.
December 2000:	Send S - Band PB specifications [I]. Start Beam matching, beam diagnostics and collimation [I][N]. Complete beam dynamics basic design studies of the injector [I] [N]. Complete beam loading analysis [N].

Year 2001

January 2001:	Start design of prebunchers and supports [I] [N]. Start design of solenoids and supports (if necessary) [I] [N]. Start design of diagnostics and supports [I] [N]. Iterate with PARMELA as mechanical conflicts are solved.
April 2001:	End of LAL tests of CLIO gun [P]. Start modifications of LIL front-end for CTF3 [P].
June 2001:	Install CLIO gun in LIL [P]. Start commissioning of injector [P]. In case of new solenoids, start solenoid measurements [I]. Run CTF3 injector at low current [P]. Construction of 2 PBs (at LAL) and the Buncher (at CERN).

Year 2002

January 2002:	CTF3 gun and electrical system (150 kV) available at CERN [I][N] Start design of SHB [N] Start design of MDK 1.5 GHz (for SHB) [N] Install CTF3 injector [I]: Gun 150 kV + diagnostics + bunching system (2 PB +Buncher) Then add 2 RF accelerating structures (prototypes) and solenoids 2 klystrons 40 MW are available (with CTF2 ON in parallel).
March 2002:	Test and commissioning of CTF3 injector [I] In parallel, run CTF3 complex [P]
December 2002:	End of the CTF3 Preliminary stage [P] End of the commissioning for CTF3 injector [I].

Year 2003

January 2003:	Installation of the Drive Beam Accelerator linac [I] Construction of SHB's and tests at CERN [N] Construction of MDK 1.5 GHz [N] Installation of a test stand at 1.5 GHz (for SHB) [N]

In parallel

January 2003:	Installation of the Combiner ring [I] + Transfer lines + Bunch compressor + RF deflectors.
	Run CTF3 with the injector implemented for [I] RF power tests at CERN of the SHB with fast phase switch [N]

Year 2004

January 2004:	Installation of the Delay loop [N] Install CTF3 injector for [N] (**)
March 2004:	Commissioning of the injector for [N]
July 2004:	Run CTF3 with the injector implemented for [N]

Year 2005

March 2005:	Run CTF3 for [N].

(**) If the RF photo-injector is implemented, it will be installed for the Nominal stage [N] at this date.