BWA/cg

PS/DI/Note 95-21 (Min.)
26 October 1995

Minutes of PS Technical meeting N° 76
held on 25 October 1995

<u>*CLIC Test Facility*</u>

Présents: *B.W. Allardyce, J. Boillot, R. Bossart, H. Braun, J.P. Delahaye, B. Frammery, R. Garoby, R. Giannini, J. Gruber, G. Guignard(SL), H. Haseroth, H. Koziol, K. Hübner, J.H. Madsen, C. Metzger, D. Möhl, F. Perriollat, U. Raich, J.P. Riunaud, C. Serre, D.J. Simon, K. Schindl, G. Suberlucq, I. Wilson(SL)*

C.C: *B. Autin, S. Baird, J. Boucheron, M. Bouthéon, P. Bryant, D. Dekkers, P. Lefèvre, S. Maury, J.P. Potier, L. Thorndahl(SL)*

Note: In the morning of the meeting, J.P. Delahaye presented the world-wide effort on linear colliders in a PS seminar, including the technical aspects of the CERN part, now called Compact Linear Collider (CLIC).

1. J.P. Delahaye explained CERN's involvement in the world effort on future linear colliders: our job is to explore the two-beam, high frequency approach on behalf of the international community, leaving other laboratories to investigate other avenues. There is to be a review in 1999 by which time we must be in a position to say whether or not the 2-beam, 30 GHz approach is realistic. CTF1 has already made significant progress and the new CTF2 will enable us to answer many more questions.

2. The budget obtained since the start in 1989 was presented, and its evolution until 1999 as recently approved by the DG. Details of staff involved is the PPA code FRC were also shown (see annexes) amounting to 27.7 man-years at present in CERN as a whole.

3. J.H. Madsen presented the results achieved with CTF1 since 1990, in particular the evolution of the power obtained at 30 GHz which is now well above the design goal of 60 MW (see annexes). There have been many improvements, improved laser, better r.f. gun, better phtococathodes, better geometry. At present CTF1 is testing 30 GHz components for CTF2. The help obtained from the different PS groups was explained (see annex).

4. H. Braun explained the changes to be made in the CTF set-up and gave the time schedule. Building modifications start in early 1996 and the first stage of CTF2 facility should be operational by end 1996. He also presented a list of the help which will be required from PS groups in the future, in analogy to the list

presented by J.H. Madsen for CTF1. Many of the items are simply a continuation of the effort already made on a regular basis by individuals in the various groups. However various areas were identified as needing extra manpower, and the discussion which followed confirmed that certain areas, notably diagnostics, controls, vacuum readout, position-controls and the digital electronics of the timing "A-box" require considerable extra effort. It was decided that G. Rossat(RF) will act as "CTF manager".

5. Fears were expressed that the Division does not have enough manpower to allocate to CTF2 if other activities (notably LHC-PS and D-067 projects) are not to suffer. However, since this additional request for CTF2 is a new one, groups have not had time yet to consider ways of helping, consistent with the overall workplan of the Division. Further discussions and clarifications are needed with CO, BD and RF groups.

B.W. Allardyce

J-P. DELAHAYE

Main aim of the CLIC Study:

- Explore the option: "Two Beam at high Frequency" as one of the possible scheme for high energy linear Collider

⇒ CERN responsibility to L.C. World community (within the frame of mundial collaboration)

* Theoretical design of the whole complex (concentrate on CLIC specifity)

* Demonstration of the feasibility of the scheme in CTF2

* Draw a conclusion about this technology ⇒ Review in 1999

(* Build-up expertise at CERN about high technology of linear colliders)

(* Establish contacts with L.C. community to avoid isolation of CERN)

⇒ Collaborations

Secteur "ACCELERATEUR" PERSONNEL **STAF** DELAHAYE

Divisions : AC , AT , PS , SL , MT , ST

div	Nom_prenom	1995	96	97	98	99
AT	DI	0.3	0.3	0.1		
AT	MA	0.4	0.3			
AT	SU	0.5	0.5	0.5	0.5	0.4
FRC AT		1.2	1.1	0.6	0.5	0.4
MT	ESH	0.8	0.8	0.8	0.8	0.8
MT	ESM	0.2	0.2	0.2	0.2	0.2
MT	MF	2.3	2.3	2.2	2.2	2.0
MT	SM	0.5	0.5	0.5	0.5	0.5
FRC MT		3.8	3.8	3.7	3.7	3.5
PS	BD	0.8	0.8	0.8	0.8	0.8
PS	DI	0.1	0.1	0.1	0.1	0.1
PS	LP	12.5	11.7	10.1	8.7	7.5
PS	OP	0.3	0.3	0.3	0.3	0.3
PS	PO	0.8	0.8	0.8	0.8	0.8
PS	RF	1.0	1.0	1.0	1.0	1.1
FRC PS		15.5	14.7	13.1	11.7	10.5
SL	AP	1.3	1.3	1.2	1.0	1.0
SL	BI	0.5	0.5	0.5	0.5	0.5
SL	CO	1.0	1.0	1.0	1.0	1.0
SL	RF	4.4 6.0	6.0	5.9	5.9	4.6
FRC SL		7.2 ~~8.8~~	8.8	8.6	8.4	7.1
elerators & Experimental • R & D • CLIC		27.7 ~~29.3~~	28.3	25.9	24.2	21.4

Secteur "ACCELERATEUR" PERSONNEL

• Accelerators & Experimental Areas • R & D • CLIC

STAF

FRC

Division

JC DELAHAYE

CLIC Budget

Allocated in the past :

1989 :	1.44 MFrs	
1990	3.0 MFrs	
1991	3.0 MFrs	
1992	2.6 MFrs	14.685 MFrs
1993	2.245 MFrs	
1994	2.4 MFrs	

This year :

1995 : 2.7 + 0.4 MFrs } 3.1 MFrs

Foreseen in the future :

1996	2.0 MFrs	
1997	2.0 "	
1998	2.0 "	8.0 MFrs
1999	2.0 "	

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MAIN POINTS FOR PRESENTATION PS MEETING ON CTF

JHB.Madsen 24/10/95

1 Brief history CTF..... (as a reminder on the effort made)

2 CTF today.

3 Main results with CTF

4 Contributors : LP - beam dynamics
mechanical design together with firm (TPLAN)
construction/installation beam lines
photocathodes,dev.and construction (CsI by PPE)
laser (<1995 by AT) and optical path
3 GHz power and distribution
timing system
operating the CTF
execution of the experimental programme

: RF 3 GHz low power
design and testing RF guns
MAFIA support

: PO power convertors and cabling (42 p. conv.)
klystron modulators (2 mdk')

: BD UMA's (5)
TCM's (4),optical paths and streakcamera
SEM grids (not used today)

: CO PS controls software (working sets,UMA's,SEM's)
use of the 'Passerelle'

: OP support LP technicians (control problems,access)
: second job E.Ch. (MTV image handling , 8 MTV's,
controls photoemission lab.)

: support other divisions

AT vacuum system
magnet design and construction
survey

ST building and utilities

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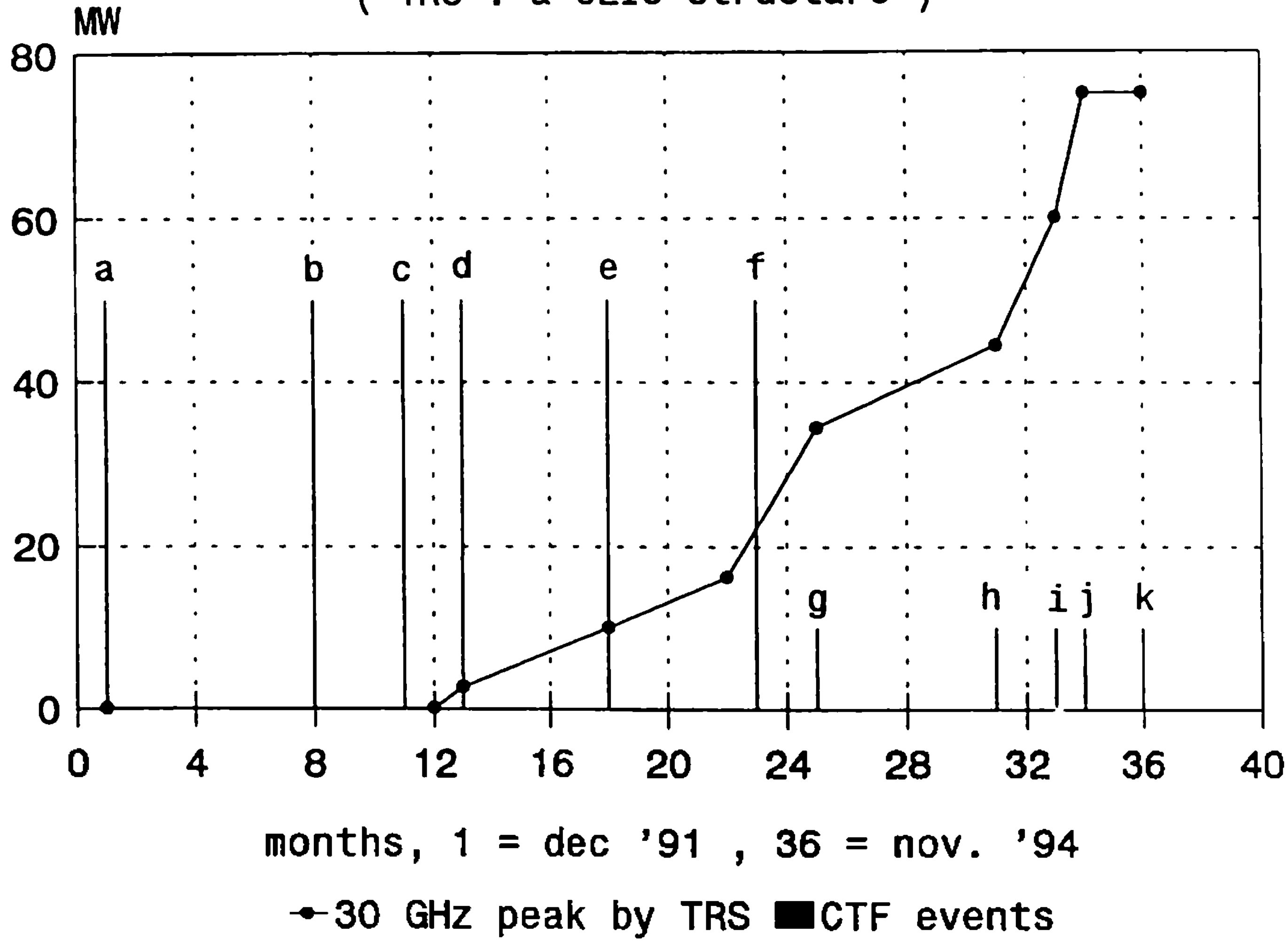
CTF:history of 30 GHz peak power by TRS

(TRS : a CLIC structure)



CTF events

- a : dec.'91; beam line in U - shape; long (13 ns) laser pulse at 213 nm; CsI cathode.
- b : use synchro laser at 209 nm; pulse 15+-2 ps FWHH; CsI
- c : rf gun,accelerating section and TRS on a straight line
- d : train of 8 bunches at 333 ps; 2.3 nC/b into TRS
- e : two trains of 8 bunches-4 b's missing between trains
- f : laser at 262 nm; pulse 8+-2 ps FWHH; Cs2Te cathode
- g : continuous train of 24 bunches; 1.6 nC/b
- h : booster behind rf gun; 24 b's and 1.8 nC/b
- i : second klystron : increase accelerating gradients; 24 b's and 3.2 nC/b
- j : further increase of gradient in acc. section with rf pulse compressor; max. p of beam into TRS 98 MeV/c; continuous train of 48 b's and 1.3 nC/b
- k : 24 b's and 3.3 nC/b

First beam in CTF from rf gun in dec.'90

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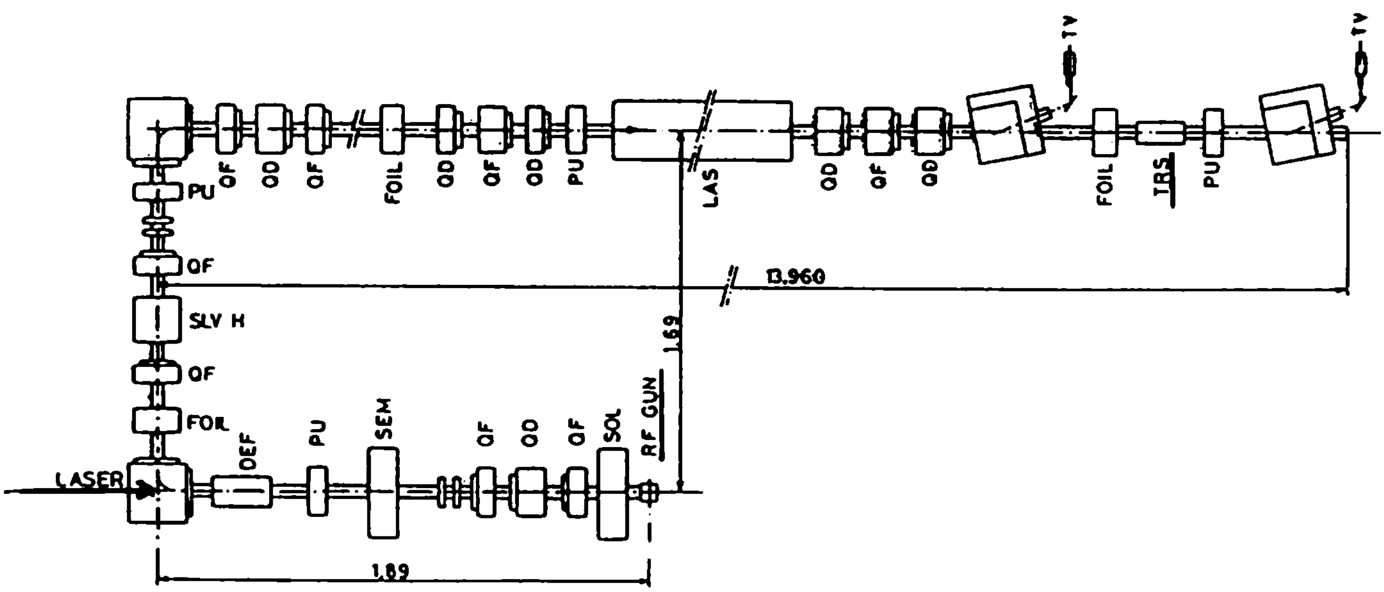
AN RF GUN EQUIPPED WITH A LASER DRIVEN PHOTOCATHODE OPERATES AT 3 GHZ.

THE GUN PRODUCES E- BUNCHES OF A MOMENTUM OF 4.5 MEV/C AT THE NOMINAL FIELD OF 100 MV/M. THESE BUNCHES ARE THEN ACCELERATED TO 45 MEV/C IN A 4.5 M LONG TW STRUCTURE.



BEAM LAYOUT 1991/92

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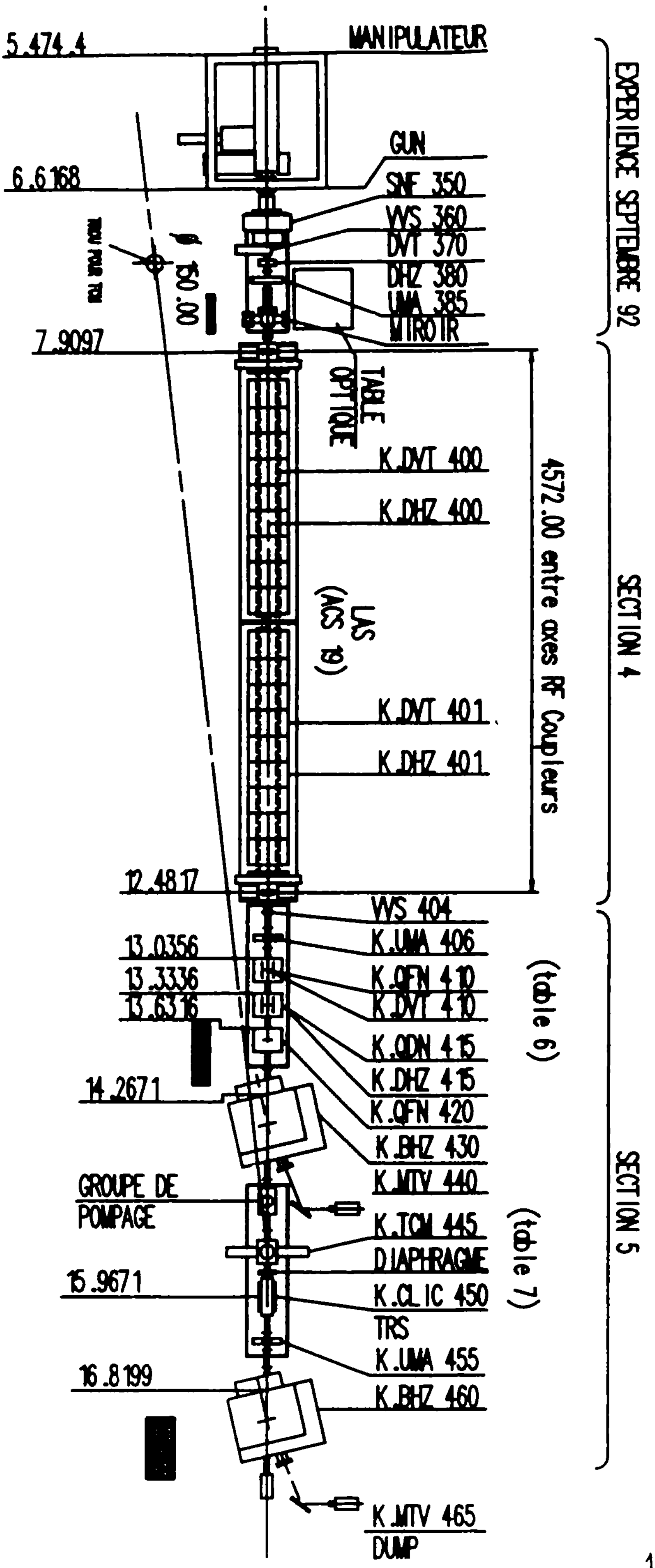

1992

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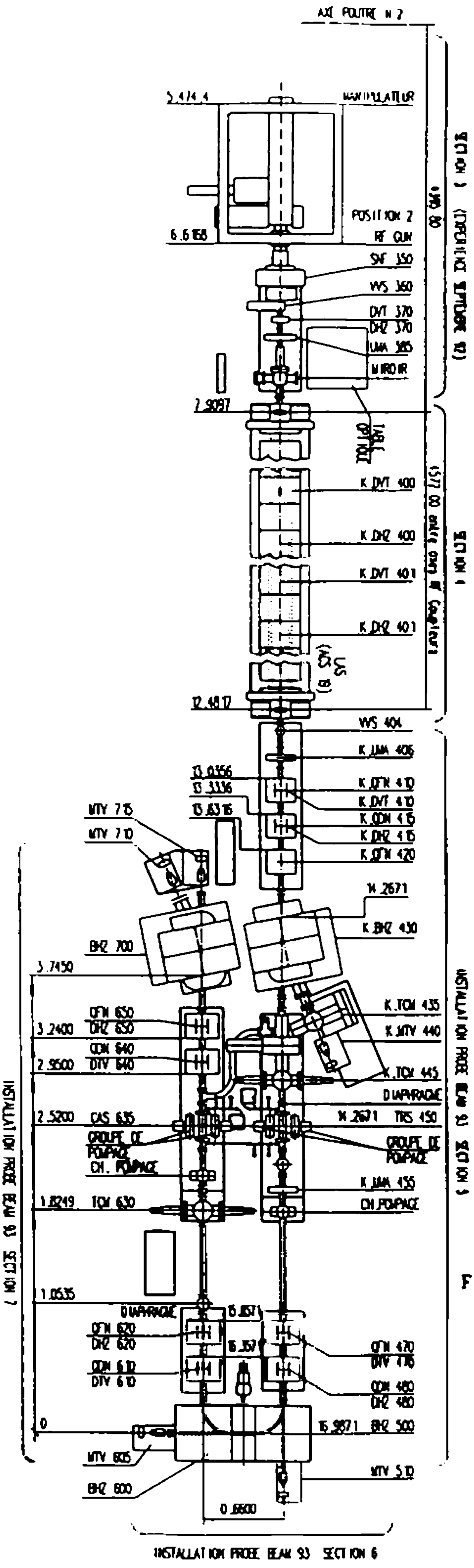

Fig.8 CTF

Present beamline and future probe beam

1993

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INTRODUCTION

The objectives of the CLIC Test Facility (CTF) are to study the generation of short intense electron bunches using a laser driven photocathode in an RF gun, to generate 30 GHz RF power for high gradient tests of prototype CLIC components, and to test beam position monitors. The performance of the CTF has improved dramatically in the course of the past year and highlights are presented here. The layout of the CTF is shown in Fig. 1.

The RF gun now has a Cs_2Te photocathode, enabling the use of the fourth harmonic of the YLF laser system (262 nm). Laser pulse lengths down to 8 ps full-width-half-height (FWHH) and energies of 0.5 mJ have been produced. The CTF operates with a repetition rate of 10 Hz with either single bunches or trains of up to 48 bunches. Trains are produced by splitting the laser pulse. The RF gun consists of a 1 1/2 cell cavity, a photocathode, a focusing solenoid and a 4 cell booster cavity. The beam exits the gun with a momentum of 4.5 MeV/c and is then accelerated up to 92 MeV/c by the S-band travelling wave accelerating section. 30 GHz power is generated when the beam is passed through the - un-powered - prototype CLIC main linac accelerating section [1]. The power is fed to the second prototype main linac accelerating section and the accelerating gradient produced in it is directly measured by reaccelerating the lead bunch of the drive train.

PERFORMANCES

In the 1994 run, the CTF produced 30 GHz powers of up to 76 MW, which corresponds to a peak gradient of 123 MV/m in the 30 GHz decelerating section and an average gradient of 94 MV/m in the 30 GHz accelerating section. Consistency between accelerating fields determined through RF power measurement and reacceleration was confirmed up to 76 MV/m. There has never been any sign of RF breakdown in either accelerating section, any 30 GHz component or waveguide at any power level achieved so far. In addition, the output periodically loaded waveguide of a prototype transfer structure was tested to 60 MW without RF breakdown. These results show that CLIC can be operated at nominal field levels with little or no conditioning.

The maximum power achieved in the 1994 CTF run was almost a factor 2 higher than that achieved in the 1993 run [2]. This improvement is mainly due to an increased beam energy of 92 MeV which reduces the detrimental effect of long range transverse wakefields in the decelerating section.

position in beamline	single bunch [nC]	48 bunches [nC]
RF Gun exit	35	450
3GHz structure exit	20	160
30GHz structure exit	7	81

Table 1: Maximum measured charges

48 b. nC	24 b nC
109	80
109	80
81	59

FOR 30GHz generation

H. BRAUN

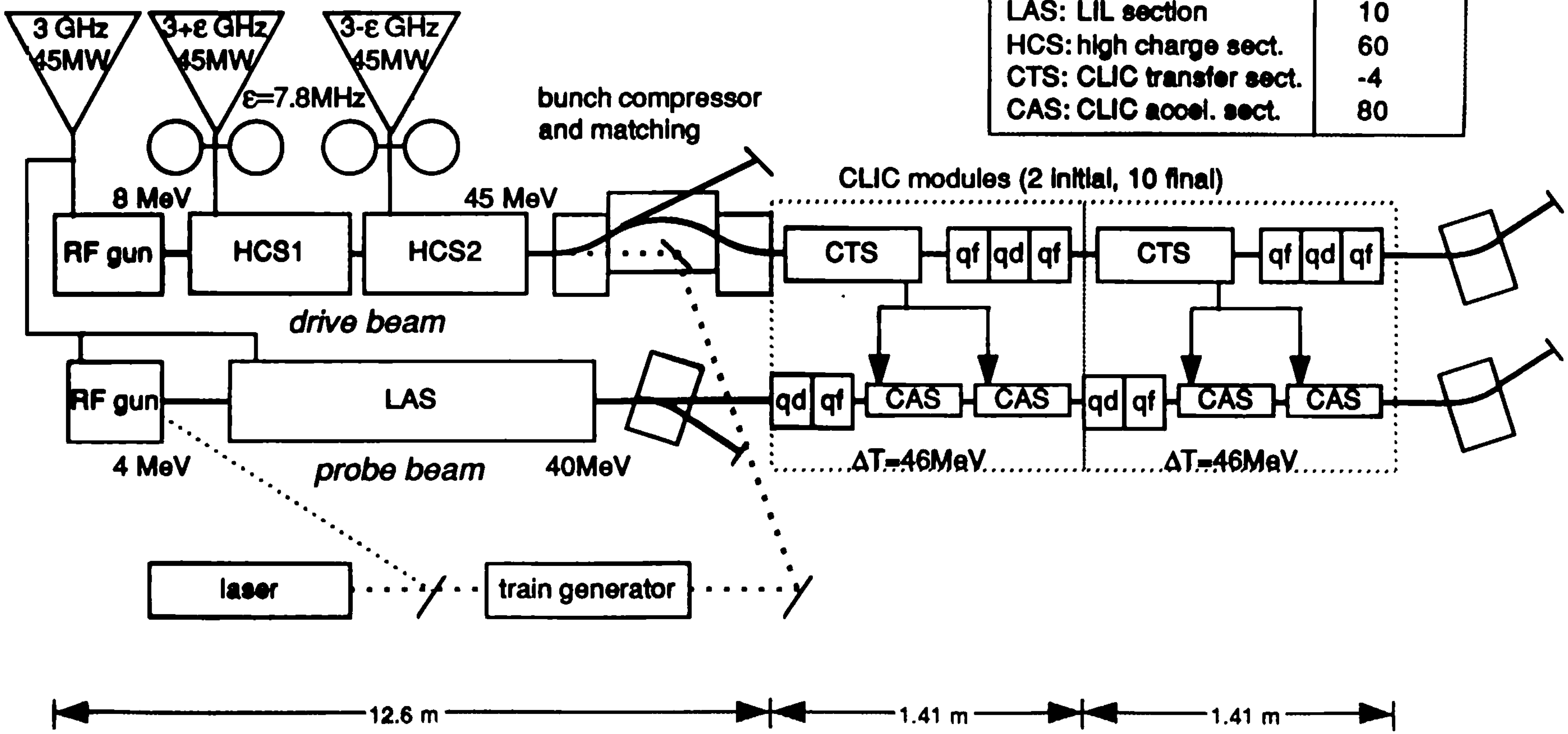
CTF II

Objectives:

- Test two beam acceleration in 30GHz technology
- Build and test prototypes of CLIC modules
- Study drive beam dynamics
- Test active alignment system
- Test CLIC beam monitoring

	Drive beam	probe beam (initial)
n_b	48	1
q_b [nC]	21	0.1
σ_t [ps]	<2	<3

RF structure	E_z [MV/m]
LAS: LIL section	10
HCS: high charge sect.	60
CTS: CLIC transfer sect.	-4
CAS: CLIC accel. sect.	80



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Schedule for CTF II

Winter '96	Extension of CTF building
Spring '96	Installation of 3 GHz part
Summer '96	Commissioning 3 GHz part
Autumn '96	Installation of two 30 GHz modules
'97	hardware modifications according to experience gained beam experiments Installation of two more 30 GHz modules
'98	hardware modifications according to experience gained beam experiments Installation of two more 30 GHz modules
'99	consolidation, running

H: BRAUN

CTF II contributions

(desired new activities in red):

LP
- running, execution of experiments
- beam dynamics
- mechanical design together with firm (TPLAN)
- photocathodes (with some support from PPE)
- laser
- 30 GHz components
- 3 GHz high power sources and distribution
- timing

RF
- CTF manager (Ghislain Rossat)
- new Box A with at least 10 bit phase resolution (analog, digital by OP)
- 3 GHz low power
- maintenance of RF Guns / participation in RF Gun related experiments
- design of low beam loading RF Gun
- MAFIA calculations

PO
- power converters and cabling (≈46 p. conv.)
- klystron modulators (3 mdk)
- Avoid undefined states of DB steering magnets during polarity switching

BD
- UMA's (3)
- TCM's (4) and streakcamera major modifications in '96
- spectrometer instrumentation
- radiation monitoring

CO
- general controls, continuing 'Passerelle' support
- real time acquisition of photodiode and 30 GHz signals
- read out of vacuum levels (with >0.5 Hz)
- linkman

OP
- new Box A with at least 10 bit phase resolution (digital, analog by RF)
- VXI readout of drive beam BPM's
- access control
- consulting
- second job of Eric Chevallay
  - control of laser beam position & energy
  - MTV image handling for 6 MTV's,
  - Automatization photocathode production,

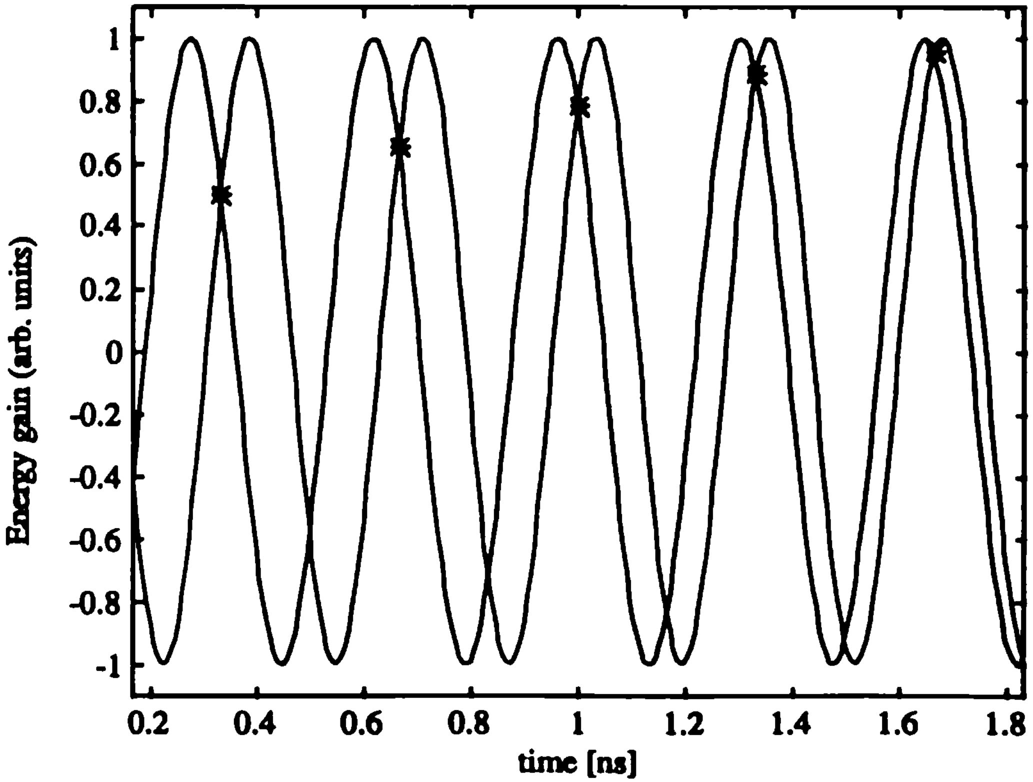
Contributions from outside PS:

AT magnets, vacuum, survey; ST building, climatisation, water;

LAL/Orsay New S-band structures

H. GRAUN

Principle of two frequency beam loading compensation



Most bunches will be on the linear part of the RF wave, therefore 1^0 phase error of one section will cause an energy variation of

$$\Delta T = \frac{E \cdot L \cdot \pi}{T \cdot 180^0} = \frac{60\text{MV}/\text{m} \cdot 0.65\text{m} \cdot \pi}{45\text{MeV} \cdot 180^0} = 1.5\%$$

Present Box A has 8 bit resolution for 360^0, thus the least significant bit will cause already an energy variation of

$$\Delta T/_{bit} = \frac{360^0}{256} \cdot 1.5\% = 2.1\%$$