PS/PL/Min.93-38
23/06/93
JHB. Madsen

# Summary Notes of the CLIC/PS Meeting on 30 April 1993

## 1. The beam line for the gun and 4 cells including a bunch compressor (now called: 'Ligne canon 93' )

### 1.1 RF power for the gun and the 4 cells — R. Bossart

At first the RF distribution shown on fig.1 will be used.

Note that the klystron should deliver 30 MW.

Better beam performance is obtained with a LIPS and phase modulation: Fig. 2.

The system has been tested at low power and by producing a 60° phase step followed by a linear phase ramp to 180° with an RF programming: Fig. 3 & 4.

### 1.2 Magnetic bunch compressor (MBC) — H. Braun

The energy dispersion versus phase should have a negative correlation at the MBC entrance.

Due to beam loading the mean energy of the bunches in the train will differ. Consequently, compression is optimum for the reference bunch only. Counter measures are to be studied.

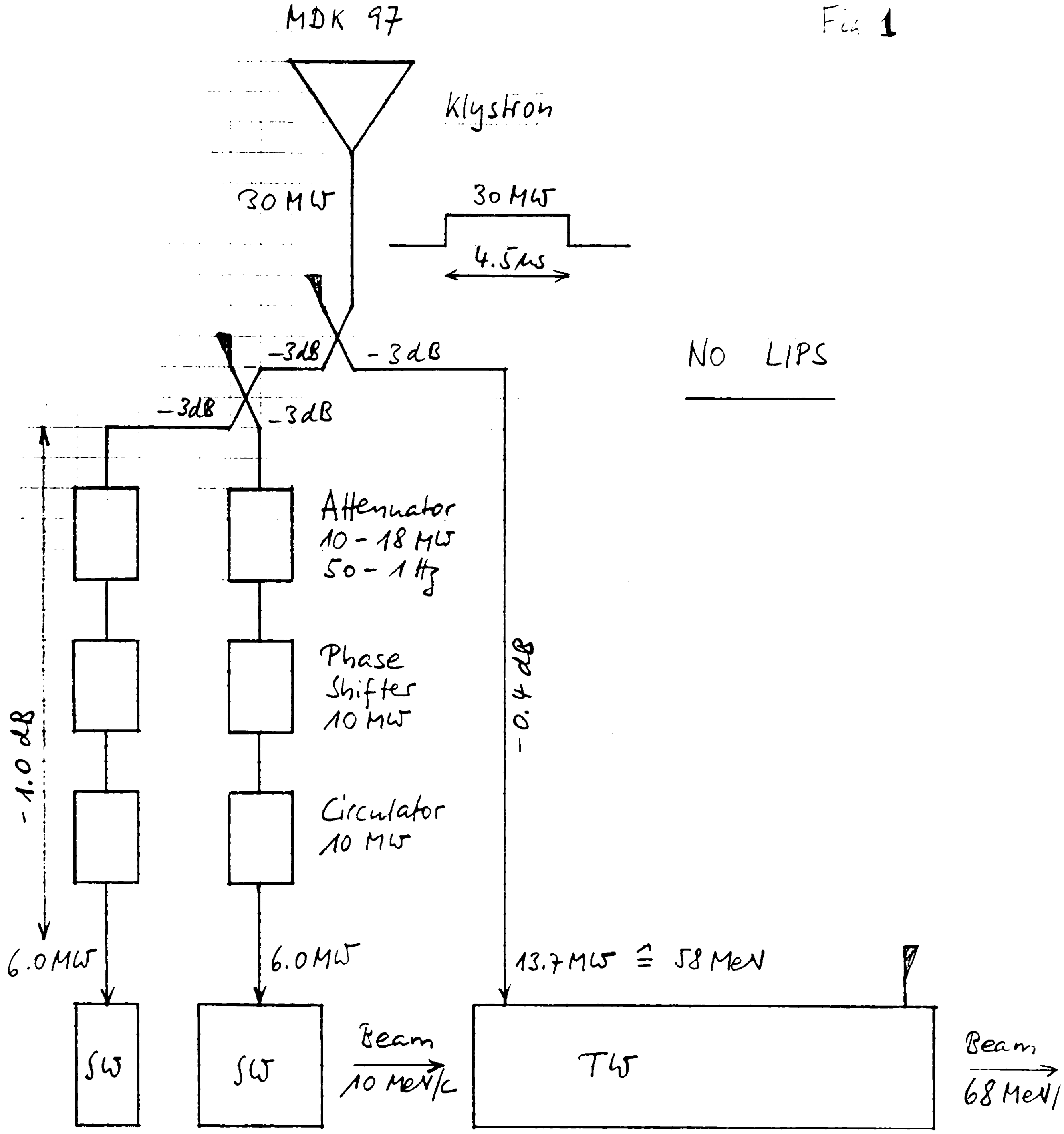
The basic arrangement is that of 4 identical dipoles of l = .2 m. Parmela runs for single bunch showed that a 18 ps bunch is compressed to 6 ps. In reality the results will depend on the input conditions and the charge. Strong effect of the fringe fields on the vertical optics. A doublet or triplet required at the outlet to match into LAS. About 2.0 to 2.5 m to be reserved for the MBC.

### 1.3 Layout and costs — JHB. Madsen

Seen the potentials of a MBC we decide to reserve room for it in the beam line we will install in autumn for the gun and the 4 cells. The 'ligne canon 93' will cost 80 - 100 kF. As the '93 budget for beam transport - 125 kF - has already been spent the probe beam we have to look for resources left on other codes.

An updated layout: fig. 5

Fig 1



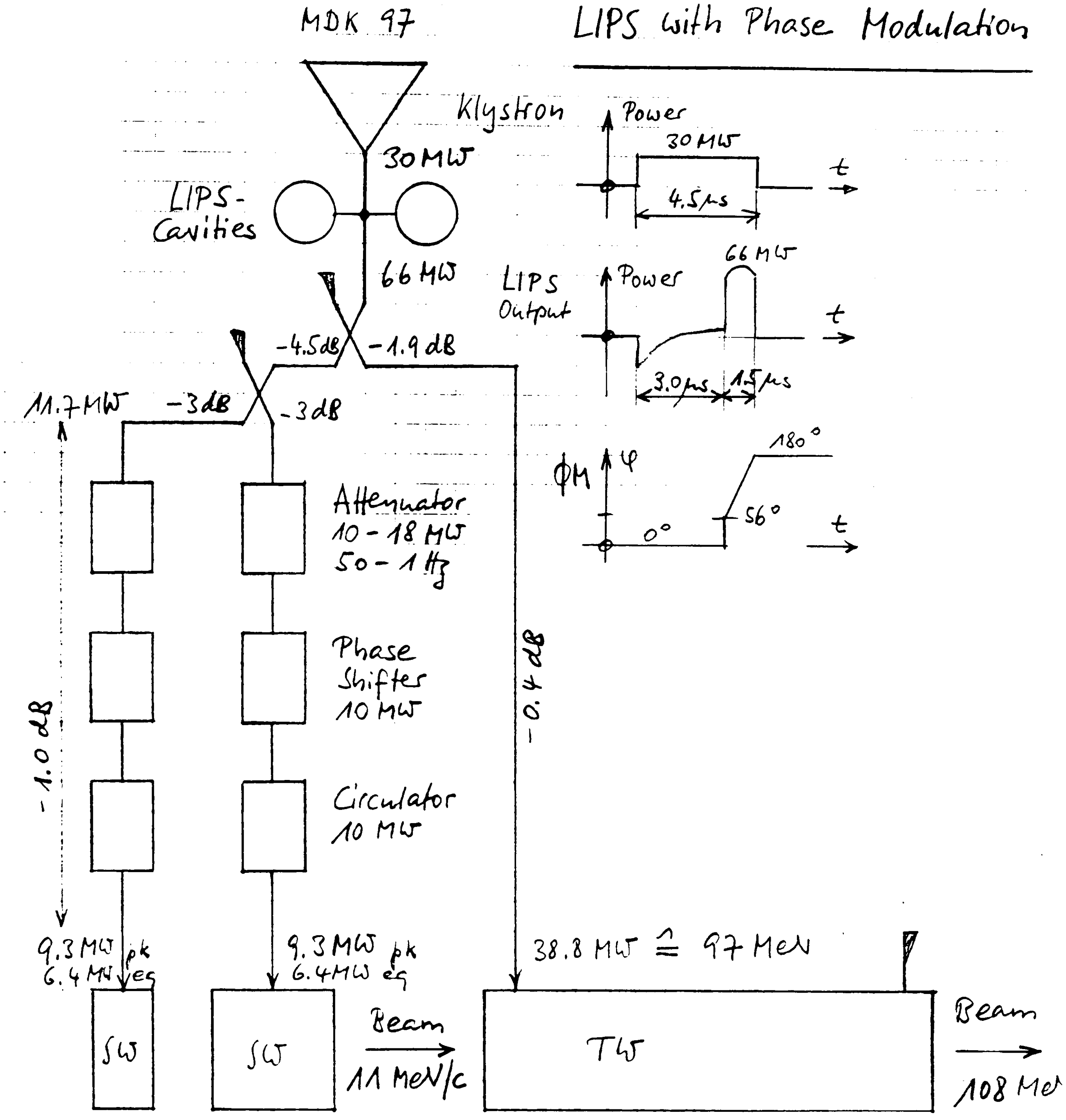

| Gun | Booster | LAS - Section |
|---|---|---|
| 1½ Cells | 4 Cells | 135 Cells |
| 100 MV/m | 60 MV/m | 17 MV/m |

## RF - Network for Multicell Gun

RB, 29.4.93

Fig 2

## LIPS with Phase Modulation




| Gun | Booster | LAS - Section |
|---|---|---|
| 1½ Cells | 4 Cells | 135 Cells |
| 107 MV/m | 63 MV/m | 29 MV/m |

## RF - Network for Multicell Gun

RB, 29.4.93

Fig 3.

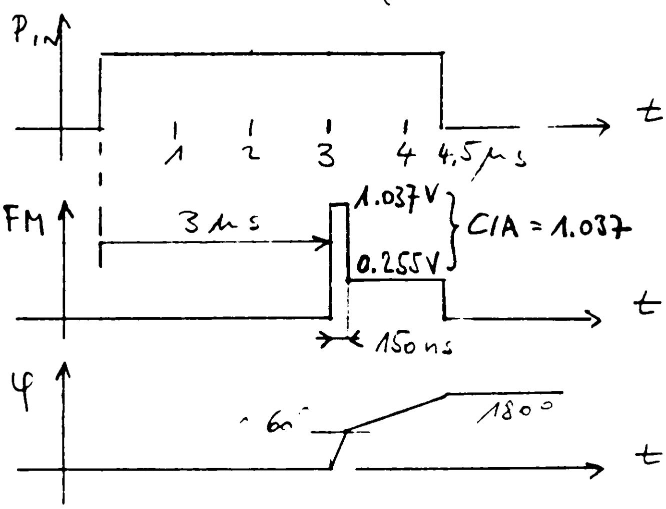
# Tests of LIPS for CTF  26-29. 1. 93

S. Lütgert, G. Rossat, R. Bossart

## Purpose of the tests

1. to measure the power gain of the pulse compression with a double LIPS #3 having a coupling factor $\beta \cong 9$ instead of $\beta = 5$ during the prototype tests on 23.10.92
2. to find a new RF-program with an initial phase step of ~60° followed by a linear phase ramp to 180° in 1.5 μs.

## RF - programme of LIPS  CTF 56 FM  Frequency Modulation




RF-input power $P_{IN}$

FM Programme 1MHz/V

$1.037\,\text{MHz} \times 0.15\,\mu s \times 360° = 56°$

$0.255\,\text{MHz} \times 1.35\,\mu s \times 360° = 124°$

Phase Programme

## Test Set-up

PIN-Switch, LIPS #3, Ringing Cavity (Prototype)

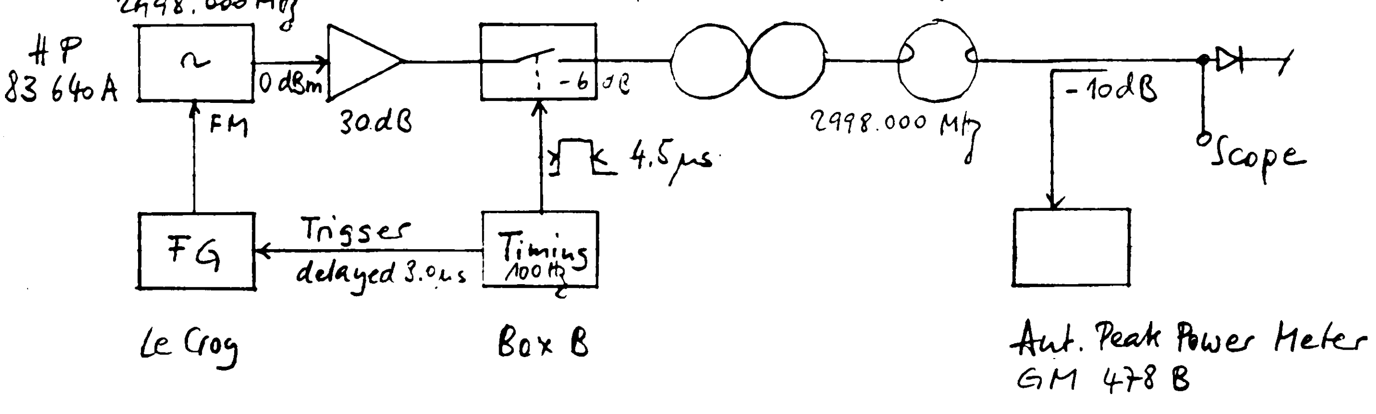


Fig 4

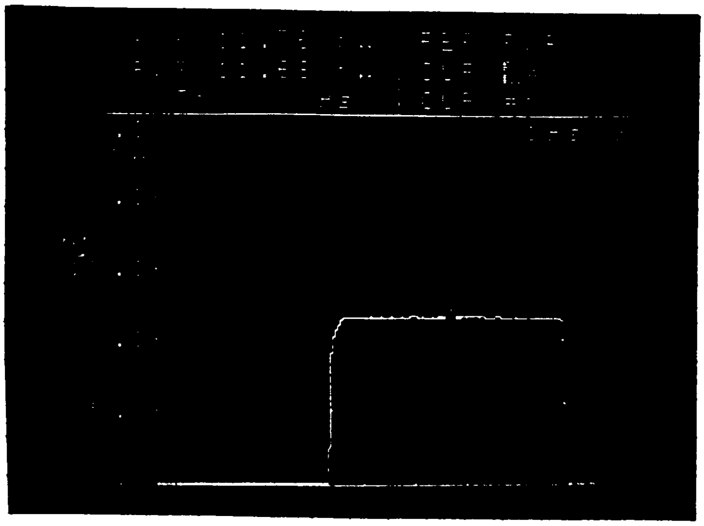


**Photo 1**

RF-power pulse, output of PIN-switch measured by Automatic Peak Power Meter (without LIPS, without Ringing Cavity)

$1\mu s/div$, $5mW/div$, No FM

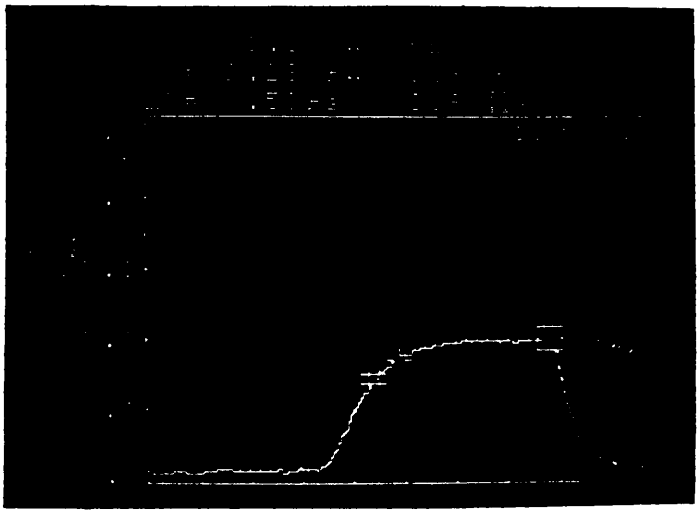


**Photo 2**

Pulse Response of Ringing Cavity

$f_0 = 2998.000$ MHz ; $Q_0 = 5000$ (without LIPS). Insertion Loss:

$$S21 = \frac{101\,\mu W}{11.7\,mW} = \frac{1}{116} = -20.6\ dB$$

\# power raise after $1\mu s$ : 72 %

\+ power raise after $1.5\mu s$ : 86 %

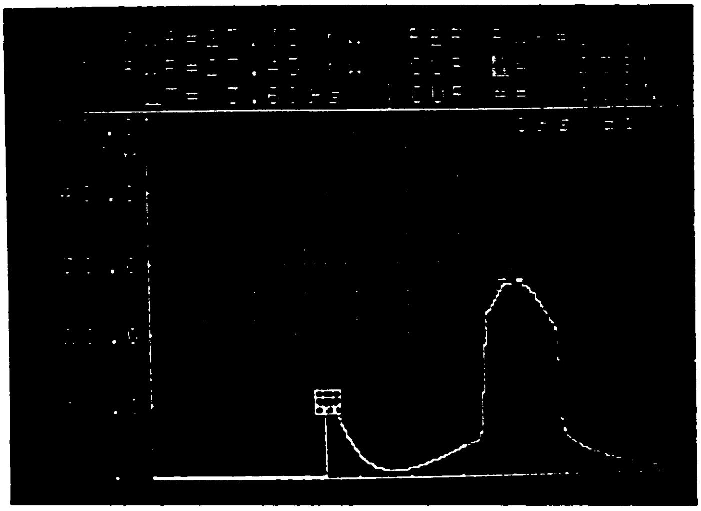


**Photo 3**

Pulse Response of LIPS without Ringing Cavity. Zero Crossing:

$t_0 = 1.3\,\mu s$, $\beta = 10$ (overcoupled)

Peak Power Gain $G_{TW} = \frac{27.4\,mW}{11.7\,mW} = 2.34$

with FM prog. CTF56FM (C/A = 0.7V)

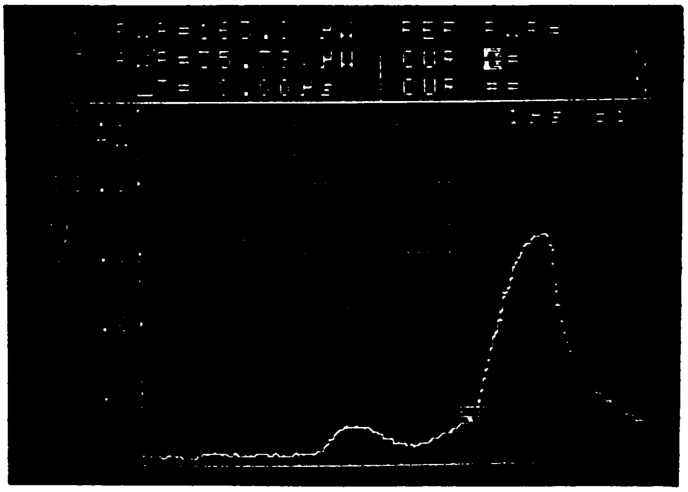


**Photo 4**

Pulse Response of LIPS + SW cavity

\# Start of FM-programme

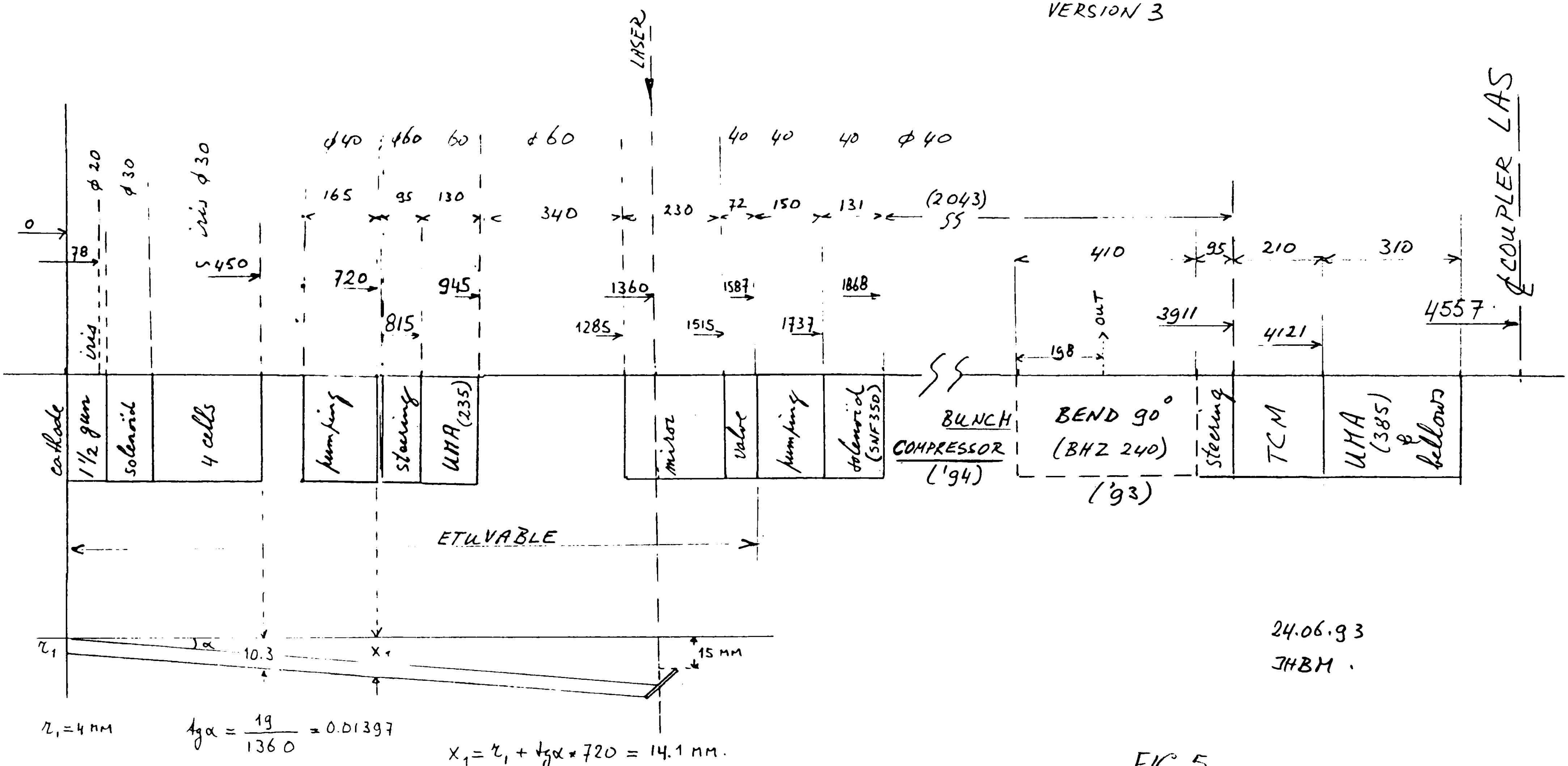
SW Cav. Power $G_{SW} = \frac{163\,\mu W}{101\,\mu W} = 1.61$

at end of $1.5\mu s$-pulse

29. 1. 93

# LIGNE CANON 93

VERSION 3




24.06.93
JHBM.

FIG 5.

# Summary Notes of the CLIC/PS Meeting on 18 June 1993

## 1. The layout of the photocathode transfer system under construction

**G.Suberlucq**

The system is shown on fig. 1

The photocathodes - pc's - are made in the preparation chamber and then tested in the dc gun. Via the transit chamber the pc's are loaded in the transport carrier. The carrier is moved to the CTF and the pc's pushed to the RF gun transfer chamber. As today, the pc can be introduced into the RF gun. All the movements described are done under high vacuum. Consequently, we will not any longer remain limited to CsI and the laser at 209 nm. An important design and construction effort is needed to get this system ready. The existing preparation chamber and its support are completely renewed; the dc gun adapted to the new cathode plug; the transit chamber and the transport carrier are new; the RF gun transfer chamber adapted to receive the carrier.

## 2. Reports on the workshop 'High intensity $e^-$ sources, Legnaro, May 24-28

### 2.1 L.Rinolfi

On the contents and participation: see appendix 1. The results of the working group on RF guns are summarised in app. 2 Fig. 2: parameters of existing RF guns (compiled by C. Travier/LAL ).

### 2.2 G. Suberlucq

About half of the talks concerned cathodes. Quite some interest in pc's with negative electron affinity, see fig. 3.

Best known NEA pc: GaAs.

Applications: polarised $e^-$'s, small energy dispersion

Good QE: 5 % at 800 nm and 14% at 488 nm.

Life time about two weeks for high vacuum, $10^{-11}$ T.

But current density low, about 30 mA/cm$^2$ and long relaxation time, many tens of ps.

**Conclusions: fig. 4**

**Enclosures**

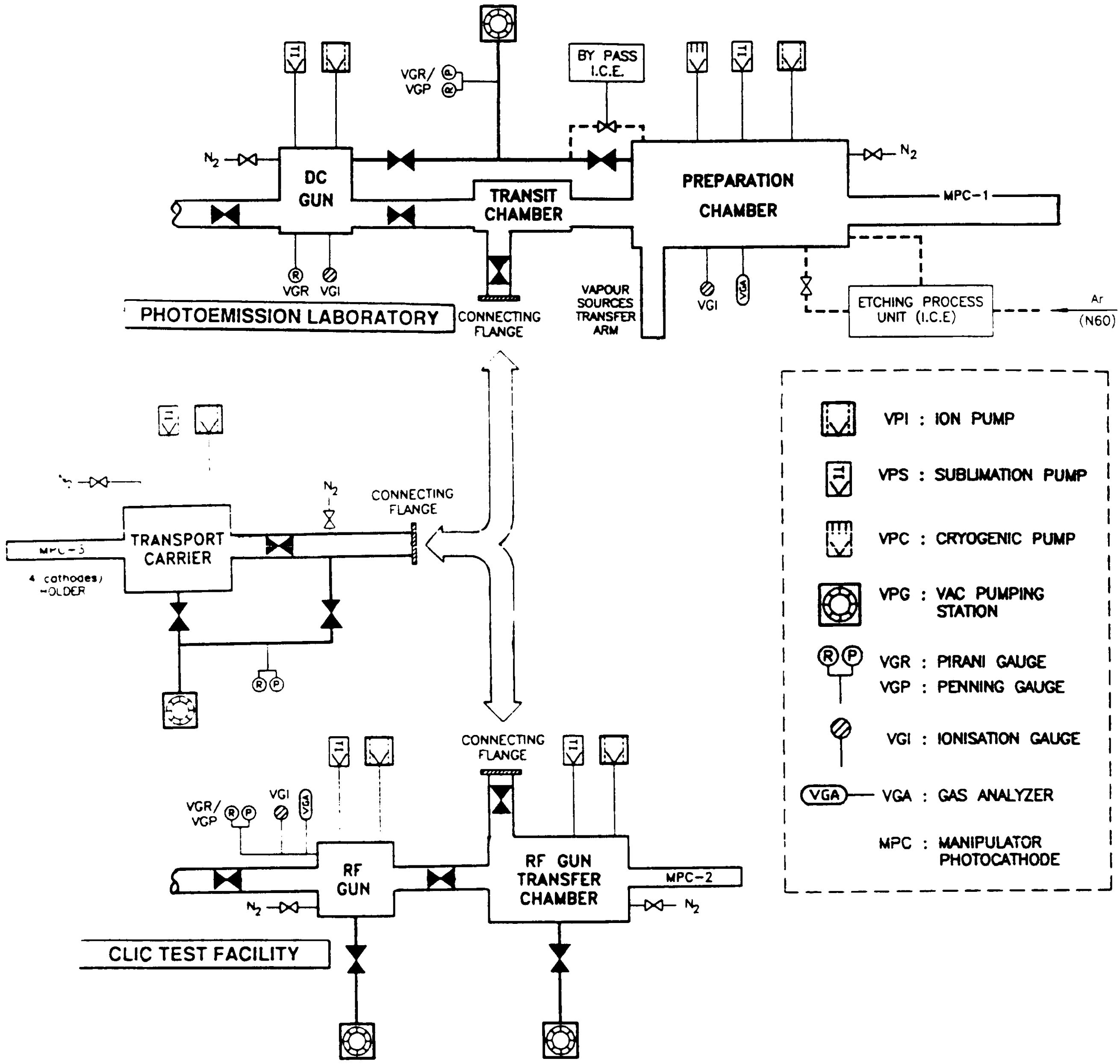



*Figure 1* The photocathode transfer system

APP. 1

# Workshop

LEGNARO

7 invited talks

31 contributions

55 participants

## 3 Working groups

Photoemission (J. Clendenin) SLAC

RF guns (R. Bossart) CERN

Ferro electric (H. Gundel) Berlin

## CERN contributors

(Chronological order)

K. Geissler — Generation of short laser pulses

H. Riege — Electron emission from ferroelectrics - a review

A. Meineke — Self-emission and enhancem of laser-induced emissio

L. Rinolfi — Present status and future of the CTF

G. Suberlucq — Photocathodes tested in the DC gun ...

R. Bossart — Modular RF-gun consisting of two RF-section ...

P. Devlin-Hill — Pulse train generator at 209 nm

J. Knott — Breakdown limits for short pulses.

## Laboratories

Switzerland : CERN

USA : BNL Livermore SLAC UCLA

Russia : Dubna Novosibirsk

Japan : Tsukuba

France : Bruyères-le-Châtel Clermont-Ferrand Grenoble Marseille Orsay Saclay Velizy

Germany : Berlin Heidelberg

Italy : Bari Ferrara Frascati Lecce Legnaro Milano Torino

**WORKSHOP ON "HIGH INTENSITY ELECTRON SOURCE"**

**24-28 May 1993**

**INVITED TALKS**

1) **BALAKIN Prof. Vladimir** - BINP - Russia
Title: High Intensity Electron Tubes in BINP (Protvino-Novosibirsk).

2) **CLENDENIN Dr. James** - SLAC - U.S.A.
Title: Polarized Electron Beams for Linear Colliders.

3) **GALLERANO Dr. Gian Piero** - ENEA - Frascati RM - Italy
Title: The Free Electron Laser: State of the Art, Developments and Applications.

4) **GEISSLER Dr. Kryno Karl** - CERN - CH
Title: Generation of Short Laser Pulses.

5) **PAGANI Prof. Carlo** - INFN-LASA - Segrate MI - Italy
Title: High Brightness, Long Pulse, Electron Beam Production with SC Photo-Injectors.

6) **SERAFINI Dr. Luca** - INFN - Milano - Italy
Title: Beam Dynamics in RF Guns and Emittance Correction Techniques.

7) **TRAVIER Dr. Christian** - LAL Orsay - France
Title: A Simple Approach Toward RF-GUN Design.

APP. 2

# Working group on RF guns

## Participants

| | |
|---|---|
| R. Bossart | Y.Y. Chibnkov |
| J.P. De Brion | J.M. Dolique |
| K.K. Geissler | L. Gianessi |
| S. Hartman | A. Larionov |
| A. Novokhatsky | C. Pagani |
| L. Rinolfi | L. Serafini |
| C. Travier | |

8) SC RF guns

- Cornell $E_{acc} \gtrsim 20$ MV/m (St.... technique)
- Saclay $E_{acc} \simeq 17$ MV/m
- KEK $E_{acc} \simeq 15$ MV/m

- Wuppertal experiment with SC-RF gun has proven that photo-cathode and SC-cavity are compatible

- QE (1.9°K) $\geq$ QE (300°K) for $Cs_3Sb$

but strong RF power dissipation on the cathode (dielectric origin)

## Summary of the working group

1) RF guns can fulfill requirements for linear collider, ep factories and inertial fusion.

2) Beam intensity limited on photo-cathodes
   $Cs_3Sb$ $J < 1000$ A/cm²
   $CsI$ $J \lesssim 1500$ A/cm²

3) Maximum charge extracted from the photo-cathode limited by the self-field of the bunch
   Charge density : $\sigma \lesssim \varepsilon_0 \frac{E_c}{5}$

4) At frequencies (0.5 - 3 GHz), the photo-cathode surface can be increased → higher bunch charge

5) Different correction schemes of emittance growth are possible

6) Clipping the tail of the laser pulse (transverse) → Improve:
   - linearity of the space charge force
   - emittance

7) Necessity to compare simulation codes (PARMELA, MAFIA, ITACA) with beam measurements

already produced experimental _ esults

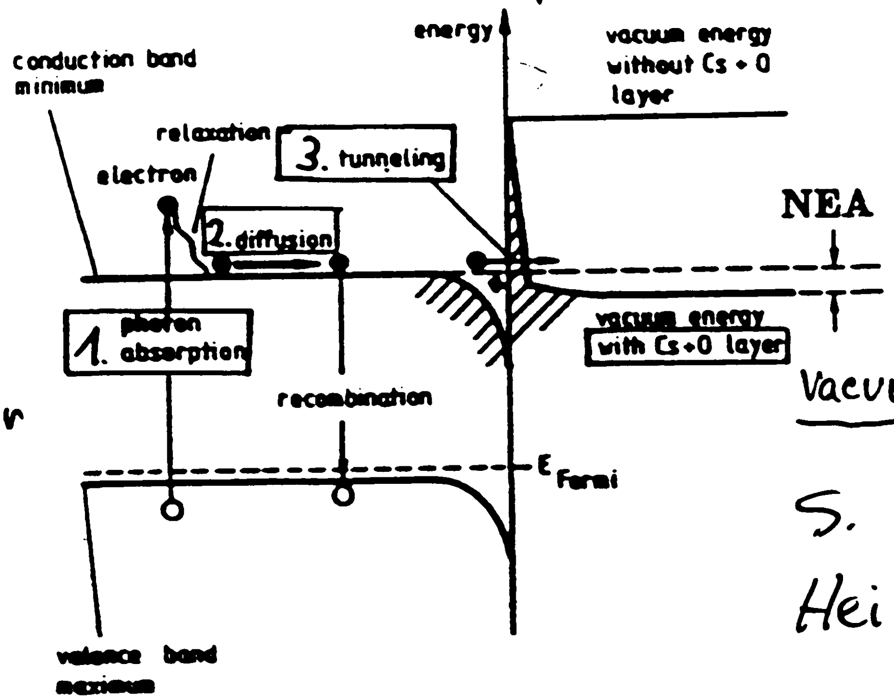
| | | CEA | Boeing | APEX | | AFEL | | | | BNL | KEK | UCLA | CERN | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Unit | [redacted] | [redacted] | [redacted] | | [redacted] | | ANL | TU | [redacted] | [redacted] | [redacted] | [redacted] | LAL | MIT |
| Last update | | 5/93 | 4/93 | 5/93 | | 5/93 | | 3/93 | 3/93 | 5/93 | 5/93 | 3/93 | 5/93 | 5/93 | 5/93 |
| **Cavities caracteristics and RF performances** | | | | | | | | | | | | | | | |
| Number | | 1 | 4 | 6 | | 11 | | 1 | 6 | 2 | 1 | 2 | 2 | 2 | 2 |
| Frequency | MHz | 144 | 433 | 1300 | | 1300 | | 1300 | 1300 | 2856 | 2856 | 2856 | 2998 | 2998 | 17000 |
| Shunt impedance | MΩ/m | 33 | | 53 | | 53 | | 55 | 50 | 57 | 63 | 58 | 59.7 | 63 | 140 |
| Aperture radius | mm | 30 | | 12 | | 12 | | 24 | 12 | 10 | 10 | 10 | 10 | 5 | 1.8 |
| Cathode type | | $CsK_2Sb$ | $CsK_2Sb$ | $CsK_2Sb$ | | $CsK_2Sb$ | | Cu | CsSb | Cu | $CsK_2Sb$ | Cu | CsI | WBaO | Cu |
| Field at cathode | MV/m | 28 | 26 | 26 | | 20 | | 92 | 26 | 98 | 40 | 83 | 100 | 50 | 250 |
| Peak power | MW | 2 | 0.6 | 1.8 | | 8.7 | | 1.5 | 1.8 | 6.2 | 1.2 | 6 | 6 | 2.7 | 5 |
| Macropulse | μs | 200 | 8300 | 100 | | 10 | | 8 | 15 | 3.5 | 2 | 4 | 2.5 | 2 | 0.03 |
| Repetition | Hz | 1 | 30 | 1 | | 10 | | 30 | 10 | 6 | 5 | 10 | 10 | 12.5 | 10 |
| **Gun performances** | | | | | | | | | | | | | | | |
| Experiment (E)/Simulation (S) | | E | E | E | | E | | S | S | E | E | E | E | S | S |
| Kinetic energy | MeV | 1.4 | 5 | 6 | | 13 | | 1.8 | 6 | 4.6 | 0.9 | 3.5 | 4.1 | 2.9 | 2.2 |
| $\sigma_{\Delta E}$ (rms) | keV | 27 | 40 | 12 | | 44 | | 150 | 12 | 18 | | 10 | 3.3 | 8 | 4 |
| Laser spot (rms) | mm | 2.8 | 2 | 1.5 | 2.5 | 1.5 | 1.5 | | | 1 | | 0.4 | 3 | 1.5 | 0.5 |
| $\sigma_x$ gun exit (rms) | mm | | | | | | | 9 | | 3 | | 0.6 | 3 | 2 | 0.7 |
| $\sigma_b$ (rms) | ps | 42 | 22 | 3 | 6 | 4.2 | 4.2 | 7 | 20 | 5 | | 5 | 6.3 | 5 | 0.39 |
| $\epsilon$ (rms) | π mm mrad | 25 | 10 | 3.3 | 13 | 2.1 | 6.5 | 300 | 6 | 4 | | 10 | 52 | 8.5 | 0.43 |
| $Q$ | nC | 2 | 7 | 1 | 5 | 1 | 3 | 100 | 7 | 2 | 3.2 | 0.5 | 12 | 2 | 0.1 |
| $I$ | A | 19 | 127 | 135 | 330 | 95 | 285 | 5700 | 140 | 160 | | 40 | 760 | 160 | 102 |
| Brightness | $10^{10}A/m^2rad^2$ | 0.6 | 25.7 | 251 | 40 | 436 | 137 | 1.3 | 79 | 203 | | 8.1 | 5.7 | 45 | 11200 |
| **Laser** | | | | | | | | | | | | | | | |
| Type | | Nd:YAG | Nd:YLF | Nd:YLF | | Nd:YLF | | Dye | Nd:YLF | Nd:YAG | Nd:YAG | Nd:YAG | Nd:YLF | Ti:Sa | Ti:Sa |
| Fundamental λ | nm | 1064 | 1054 | 1054 | | 1054 | | 497 | 1054 | 1064 | 1064 | 1064 | 1054 | 800 | 800 |
| Useful λ | nm | 532 | 527 | 527 | | 527 | | 248 | 527 | 266 | 532 | 266 | 209 | 266 | 266 |
| Rms length | ps | 20 | 22 | 7 | | 3 | | 3 | 21 | 2.5 | 4.2 | 1.7 | 5 | 1 | 1.4 |
| Repetition | MHz | 14.4 | 27 | 21.7 | | 108.3 | | 1 pulse | 81.25 | 40.8 | 178.5 | 1 pulse | 1 pulse | 1 pulse | 1 pulse |
| Energy | μJ | 15 | 0.17 | 12 | | 10 | | 5000 | 2.5 | 100 | 150 | 300 | 10 | 100 | 200 |
| Macropulse | μs | 200 | 10000 | 200 | | 10 | | - | 15 | 2.5 | 1 | - | - | - | - |

Parameters of existing RF guns

FIG 3

# Emission process of photocathode with negative electron affinity

NEA : vacuum energy < conduction band minimum
is achieved by band bending and reduction of electron affinity



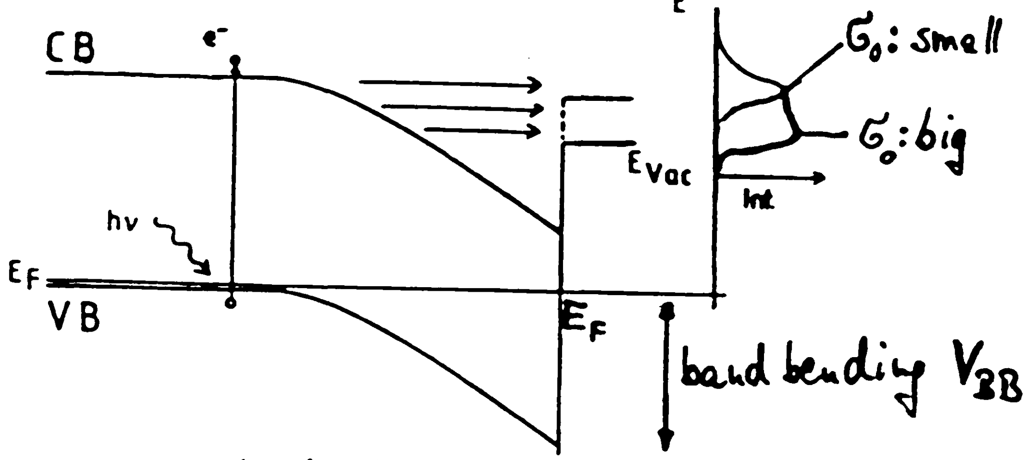

p-doped semiconductor

Vacuum

S. Zwickler
Heidelberg

A lot of electrons that reach the surface are reflected and loose additional energy in the band-bending region:

Energy distribution depends on NEA, which can be varied by Cs and O on surface:




In this case : constant band bending
but different values of electron affinity.

# CONCLUSIONS

FIG 4

**NEA** : → $e^-$ polarisés et $\frac{\Delta E}{E}$ petit

- $50 \leq \tau \leq 500$ ps
- Beaucoup d'études en cours pour réduire $\tau$ et $E > 10$ MV/m
- Problèmes de courant d'obscurité
- Nécessité d'ajouter du Cs
  Sauf à BNL avec Diamant + Bore

→ NEA réservé à $e^-$ pol. ou $\frac{\Delta E}{E}$ <

**METALLIQUES** : QE ↗ (x 100) :

- Nettoyage sous vide (ICE, LASER)
- Surface granulaire

**ALCALINES** : Peu de nouveauté sur les cathodes mais :

- tendance pour $260 \leq \lambda \leq 355$
- transport sous vide
- Cavité supra-conductrice avec $Cs_3Sb$

**FERRO-CERAMIQUES** : Très nombreuses applications envisagées → workshop séparé

**Thermo-ioniques** : • Utilisées à froid problème ~~de~~ temps de réponse dus aux excitons

- Chaudes : (VLEPP)

dans Klystron 14 GHz : 60 MW peak - 150 A
5 A/cm²

IrCe, IrLa : ~ 20 A/cm² : durée de vie > $10^4$ h

# CLIC/PS

PS/LP
23. 6. 93

**NEXT MEETING : FRIDAY 2 JULY 1993**

**9 hrs in the large PS CONFERENCE ROOM**

**J.H.B. MADSEN**

## *AGENDA*

1. First results of analysing the spatial energy distribution in the laser beam with a ccd camera.

   P. Joly

2. Choice of laser pulse train generator for 262 nm on the pc

3. Comments on the results of the last CTF run

   H. Braun and JHB. Madsen

Distribution:

| | | | |
|---|---|---|---|
| Autin B. | PS | Kugler H. | PS |
| Battisti S. | PS | Lütgert S. | PS |
| Bossart R. | PS | Madsen J.H.B. | PS |
| Braun H. | PS | Martucci P. | SL |
| Brouet M. | AT | Millich A. | SL |
| Caspers F. | PS | Pearce P. | PS |
| Corsini Roberto | PS | Pirkl, W. | PS |
| Delahaye J.-P. | PS | Potier J.-P. | PS |
| Devlin-Hill P. M. | PS | Riche A.J. | PS |
| Fischer C. | SL | Riege H. | AT |
| Garoby, R. | PS | Rinolfi L. | PS |
| Geissler K.K. | AT | Schnell W. | SL |
| Godot J.-Cl. | PS | Schreiber S. | AT |
| Guignard G. | SL | Suberlucq G. | PS |
| Hübner K. | PS | Thorndahl L. | PS |
| Hutchins S. | PS | Van Rooy M. | AT |
| Jensen E. | PS | Warner D. | PS |
| Johnson C. D. | PS | Wilson E.J.N. | PS |
| Joly Pierre | PS | Wilson I. | SL |
| Kamber I. | PS | Wuensch W. | SL |
| Koziol, H. | PS | | |