CERN-Protocol N° P079/LHC
PAEC-Ref: PAEC/CERN/2006

PROTOCOL

to

THE CO-OPERATION AGREEMENT
DATED 1st NOVEMBER 1994

between

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

and

THE GOVERNMENT OF THE ISLAMIC REPUBLIC OF PAKISTAN

concerning

The allocation of an additional grant of 5 MCHF by the Government of the Islamic Republic of Pakistan for CERN-Pakistan co-operation

2006

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH, hereafter referred to as "**CERN**", having its seat in Geneva, Switzerland, and represented by its Director-General, Mr. Robert Aymar,

on the one hand,

and

THE PAKISTAN ATOMIC ENERGY COMMISSION, hereafter referred to as "**PAEC**", having its seat in Islamabad, Pakistan, and represented by its Chairman, Mr. Anwar Ali,

on the other hand,

hereafter referred separately to as the "Party" and collectively as the "Parties"

CONSIDERING THAT:

On 1st November 1994, CERN and the Government of the Islamic Republic of Pakistan have signed a Co-operation Agreement concerning the Development of Scientific and Technical Co-operation in the Research Projects of CERN, hereafter referred to as "the 1994 Co-operation Agreement";

Since then, the Parties have concluded several Protocols for the purpose of implementing the intentions expressed by them in the 1994 Co-operation Agreement, most recently the Protocol dated 7 July 2003 concerning a Special Contribution by Pakistan towards the Construction of the LHC, hereafter referred to as "the 2003 Protocol";

On 27 January 2006, on the occasion of the visit to CERN of His Excellency General Pervez Musharraf, President of the Islamic Republic of Pakistan, the Parties have signed a Statement of Intent, to encourage extending the existing scientific, technical and educational co-operation between Pakistan and CERN, in particular in the fields of novel accelerator, detector and information technologies, as well as through the training and education of scientists and technical experts;

On the same occasion, the President of the Islamic Republic of Pakistan pledged an additional contribution of 5 MCHF by the Government of Pakistan, towards the enhanced co-operation outlined in the Statement of Intent,

IT IS AGREED AS FOLLOWS:

ARTICLE 1
Purpose of Protocol

This Protocol cancels and replaces the Statement of Intent, and defines the operational framework for the execution of the enhanced scientific, technical and educational co-operation between the Parties, through the increased contribution by Pakistan. The specifics of this contribution shall be detailed in technical Annexes, which shall form an integral part of this Protocol. Currently under consideration are:

Item 1: Collar for CMS Forward Hadron (HF) Calorimeter (Annex I)

Item 2: Radiation shielding wall for the CMS detector, referred to as YE4 (Annex II)

Item 3: Production of 160 Resistive Plate Chambers (RPC's) for CMS RPC Station 4 (Annex III)

Item 4: Contribution to the category A Maintenance and Operation costs of the CMS experiment, corresponding to three years of the normal share of the Pakistani group in CMS (Annex IV)

Item 5: Manpower contribution to the CMS experiment for a) Detector commissioning; b) Data analysis; and c) Software development and computing (Annex V)

Item 6: Contribution to the heavy ion physics programme at LHC, through students and physicists (Annex VI)

Item 7a: Contribution to the Superconducting Proton Linac (SPL) design studies, concerning the design and construction, the installation, the commissioning and operation of Linac4, and Ph.D student training (Annex VIIa)

Item 7b: Contribution to the Compact Linear Collider (CLIC) R&D and CTF3 projects, including the manufacturing of transition radiation monitors, the participation in design, assembly and installation of high frequency CLIC prototype structures; the manufacturing of test beam line (TBL) parts, the study of beam dynamics for the CLIC drive beam, the participation in CTF3 running and tests, and Ph.D. student training (Annex VIIb)

Item 8: Contribution to the next generation computing infrastructure for LHC experiments – the Worldwide LHC Computing Grid – the development of which is centred at CERN (Annex VIII).

ARTICLE 2
Value of Contribution

2.1 It is understood that PAEC will, over a period of five years starting from the date of signature of this Protocol, aim to fund identified co-operation activities, within the framework of this Protocol, for a total of 5 MCHF in terms of purchase and/or manufacturing of equipment, payment of cash M&O obligations to the LHC experiments in which Pakistan is involved and the supply of manpower, hardware and software.

2.2 The estimated contributions currently under consideration are defined in the following table:

Item	Name	Contribution to item (kCHF)
1	HF Collar	450
2	YE4 Shielding Wall	800
3	Resistive Plate Chambers (RPC)	1250
4	Category A M&O cash contribution to CMS	100
5	Manpower for CMS	830
6	Heavy Ion Physics with ALICE	200
7a	Future Accelerators (SPL)	400
7b	Future Accelerators (CLIC)	800
8	GRID computing	170
TOTAL		5000

2.3 In the course of the execution of this Protocol, the list of items in section 2.2 may be modified with the agreement of the Parties, always within the same financial envelope of 5 MCHF.

ARTICLE 3
Organization

PAEC, through NCP, shall co-ordinate the execution of each contribution in close collaboration with CERN, the CMS and ALICE Collaborations, and any agreed partner in Pakistan, and shall be responsible for its successful and timely completion.

ARTICLE 4
Implementation and Co-ordination

For the purpose of the implementation of this Protocol, Pakistan shall be represented by the Chairman of PAEC and CERN shall be represented by its Director-General.

ARTICLE 5
Joint Pakistan-CERN Committee

5.1 The execution of this Protocol shall be monitored by the "Joint Pakistan-CERN Committee", which was established to monitor the 2003 Protocol, the members of which are nominated by the Chairman of PAEC, the Director-General of NCP and the Director-General of CERN.

5.2 The Committee shall include a review of this Protocol in its yearly meetings or whenever deemed necessary by the Parties.

ARTICLE 6
Status of Personnel

6.1 This Article applies to the personnel sent to CERN in the execution of the enhanced co-operation referred to in Article 1 ("the Pakistani Personnel").

6.2 For the duration of their presence at CERN, the Pakistani Personnel shall be given the status of Associated Members of the Personnel in the sense of the CERN Staff Rules and Regulations. They shall be registered in and assigned to the relevant CERN Departments.

6.3 The Pakistani Personnel shall remain employed by their home institutions, which as employer shall each bear exclusive responsibility for the remuneration of, and the procurement of social security for, its personnel, including health and accident insurance at levels prevailing in CERN's Host States, as well as insurance against the financial consequences of death and disability. PAEC shall hold CERN free and harmless from any liability in this respect.

6.4 Concerning Ph.D. students from Pakistan working at CERN under the terms of this Protocol, it is understood that each student will be registered

at a University in Pakistan, which shall provide the thesis supervision and award the degree. CERN's responsibility is limited to the offer of a research subject and local supervision. PAEC's responsibility for the procurement of social security, as detailed in section 6.3, shall apply as well in respect of the Ph.D. students from Pakistan working at CERN under the terms of this Protocol.

ARTICLE 7
Liability and Responsibility for Damages of all Kinds

The liability and responsibility for damages of all kinds caused by one of the Parties shall be settled in accordance with the terms of the 1994 Co-operation Agreement on the basis of the law of the country where the damage has been caused.

ARTICLE 8
Safety

8.1 The personnel of each Party shall comply with the rules for conduct and safety in force at the host establishment.

8.2 Any item of equipment constructed and used by personnel from either Party shall conform to the safety rules in force at the establishment where it will be installed and operated.

ARTICLE 9
Intellectual Property

The rights in intellectual property resulting from the execution of this Protocol shall be jointly vested in the Parties, who herewith agree to grant each other a free, irrevocable and perpetual licence to use such rights for any scientific, non-military purpose, including the right to sub-license such rights to any other party for scientific, non-military purposes. Each Party shall hold the other Party free and harmless from, and indemnify it for, any loss or damage resulting from its use (including any licensing) of such rights.

ARTICLE 10
Duration

10.1 Subject to the continued validity of the 1994 Co-operation Agreement, this Protocol shall be in force for a period of five years from the date of its signature, or until the date on which the 5 MCHF contribution covered by this Protocol has been exhausted. In the latter case, the Parties shall meet to discuss the possibility of a new agreement. It is agreed that Articles 6, 7 and 9 of this Protocol shall survive its termination, howsoever caused.

10.2 At least two years before the end of the five year period and prior to the exhaustion the 5 MCHF contribution, the Parties shall discuss the possible extension of this Protocol.

ARTICLE 11
1994 Co-operation Agreement

This Protocol shall form an integral part of the 1994 Co-operation Agreement, whose terms shall apply hereto insofar as this Protocol does not stipulate.

Done in Geneva and Islamabad in two original copies in the English language.

For the European Organization
for Nuclear Research (CERN)

.....

By: Robert Aymar
Director-General

On: 11th December ...2006

For the Pakistan Atomic
Energy Commission (PAEC)

.....Anwar Ali

By: Anwar Ali
Chairman

On: 15th Dec....2006

Annex I

HF Collar

The high pseudorapidity detectors, placed in the forward regions on both sides of the CMS Experiment, need for their assembly a Collar Shielding System, hereafter referred to as the "Collars". The detailed description of such components as well as the limits of the supply are described in the Technical Specification CMS-ID-FS-0006.

PAEC proposes to supply these Collars, through its Scientific Engineering Services (SES) in Islamabad, Pakistan, under the following conditions.

CERN and SES have carried out a detailed study in order to estimate the total value of the Collars to be supplied hereunder and have agreed that this total value amounts to 450'000 CHF (four hundred and fifty thousand Swiss francs).

This value includes the cost of materials, work, transportation, insurance, customs, taxes, and any other costs associated with the manufacture of the Collars in Pakistan.

Annex II

YE4 Shielding Wall

The 4th Yoke Endcap Disks (YE4) are needed to increase neutron shielding at the LHC design luminosity and as support for the 4th Forward RPC station.

Each of the two Endcap elements of the Magnet Yoke is made by 3 dodecagonal disks approximately 14 m in diameter. A fourth dodecagonal disk named YE4 will be added on each side of the Magnet Yoke.

Each disk, 100 mm thick, will be supported by the cart of the previous one (YE+1 and YE-1).

The detailed description of the YE4 disks, as well as the limits of the supply are described in the Technical Specification CMS-SY-FS 0021 AB.

PAEC proposes to supply the YE4 disks, through its Scientific Engineering Services (SES) in Islamabad, Pakistan, under the conditions set up hereafter.

CERN has carried out a detailed study in order to estimate the total commercial value of the YE4 disks to be supplied hereunder and have agreed that this total value amounts to 1'400'000 CHF (one million, four hundred thousand Swiss francs).

This value includes the cost of materials, work, transportation, insurance, customs, taxes, and any other costs associated with the manufacture of the YE4 disks in Pakistan with delivery Incoterms CIF Rotterdam.

PAEC funding for this activity will be 800'000 CHF (eight hundred thousand Swiss francs).

The remaining amount will be funded by the CMS Collaboration.

Annex III

Resistive Plate Chambers (RPC's)

PAEC will undertake the construction of the Forward RPC layer number 4 (RPC4) detectors with a funding of 1'250'000 CHF (one million two hundred and fifty thousand Swiss francs). The list of components and their value to complete the RPC4 detectors (144 chambers plus 10% spares, i.e. 160 chambers total) is as follows:

Item	Item Description	Cost (kCHF)	Provided by
1	**Detector mechanics:** bakelite, honeycomb panels, readout strips, frames, Cu-Mylar sheets	300	PAEC
2	**Bakelite gaps**	300	CMS Collaboration
3	**Readout Electronics System**	120	PAEC
4	**Readout Electronics components**	200	CMS Collaboration
5	**Services:** High- and Low-voltage power supplies, cables and connectors, cooling, gas	350	PAEC
6	**Assembly:** laboratory operations, tooling, small items and consumables	130	PAEC
7	**Testing:** laboratory operations, gases, consumables	130	PAEC
8	**Transport:** from and to Italy, South Korea, Pakistan, Switzerland	130	PAEC
9	**Installation and Commissioning:** installation team at CERN, tooling	90	PAEC
TOTAL for PAEC		**1'250**	
TOTAL for CMS Collaboration		**500**	

The above-mentioned total value of 1.25 MCHF will be reported to the CMS Resources Review Board as the Pakistan contribution towards the completion of the CMS Detector for LHC at Design Luminosity.

Annex IV

Category A M&O cash contribution to CMS

In the framework of the Memorandum of Understanding for Maintenance and Operation of the CMS Detector (CERN-RRB-2002-033), PAEC will fund the category A M&O cash contribution for three years, starting in 2007.

The estimated cost of the contribution, based on the present number of Pakistani physicists, is 100'000 CHF (one hundred thousand Swiss francs).

Annex V

Manpower requirement for CMS

PAEC will maintain at CERN for six years, starting in 2007, three Pakistani scientists with experience at the postdoctoral fellowship level (eighteen person.years):

Task	Task Description
1	Maintenance and assurance of the smooth running of the sub-detectors made in Pakistan which will require one person to join a team on-call 24 hours a day, 7 days a week. This person will be part of the detector control and monitoring group and will assure that all detectors function properly during the data taking period at LHC.
2	Coordination of the Physics analysis activities for which a person will be required for attending daily analysis meetings during the initial running of LHC. After a couple of years the frequency of meetings will reduce to one per week. This person will play the role of data coordinator for Pakistan and will help fulfilling the requirements of physicists and students working in Pakistan in terms of the data they need to access from CERN.
3	Keeping up with the software upgrades and the new versions of analysis tools that will be released very frequently in first period of LHC operations. So a person with strong Physics and Computing background will be required to cope with this as the Computer software, Physics analysis tools and Grid computing will be central to Physics analysis at LHC.

The above tasks will be funded completely by PAEC, including travel, training and personal work equipment. The total value of this contribution is 830'000 CHF (eight hundred and thirty thousand Swiss francs).

Annex VI

Heavy Ion Physics with ALICE

The purpose of this contribution of 200'000 CHF (two hundred thousand Swiss francs) is to allow physicists from Pakistan to join the ALICE experiment, which is specialized in heavy ion physics at LHC, within a time period of three years. The fund allocated to this item will initiate the collaboration with support for a team of at least one senior physicist and several students, over a period of three years, and including a partial contribution to the requirements, as defined in the ALICE Constitution, when needed for formal membership in the Collaboration.

It should be noted that any new institute joining the ALICE Collaboration is required to make a contribution towards the Collaboration common fund, and an annual amount for Maintenance & Operation funds, depending of the number of physicists in the team.

The first phase of the effort towards the goal outlined above will consist in defining a scientific responsibility within ALICE, of either a contribution to the present ALICE detector or its upgrade, or the operation of the ALICE experiment, computing, and physics analysis.

Annex VIIa

Contribution to the LINAC4/SPL projects

1. Introduction

A project for a new linear accelerator for protons ("Linac4") is presently in its final phase of preparation at CERN, with the goal of being submitted for approval by the end of 2006 [1]. Linac4 will be the first step in the consolidation and upgrade of the injector chain feeding the LHC ("Large Hadron Collider") [2]. It will also have the potential to become the low energy injector to a multi-GeV superconducting proton linac (SPL); a very powerful and possible successor to existing accelerators on the CERN site [3].

The main characteristics of Linac4 are summarized in Table 1.

Table 1: Linac4 beam characteristics

Ion species	H^-
Output Energy (MeV)	160
Bunch Frequency (MHz)	352.2
Cycling rate (maximum) (Hz)	2
Beam Pulse Length (μs)	400
Mean current during pulse (mA)	40

Approximately 85 m long, the basic structure is sketched in Figure 1. The beam is accelerated from rest to a kinetic energy of 160 MeV, passing through 4 different types of accelerating structures (Table 2).

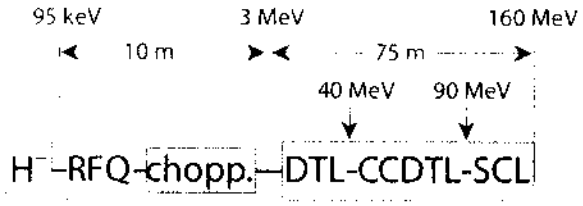

Figure 1: Basic structure of LINAC4

The first 10 m are already under construction. They are based on the "IPHI" Radio Frequency Quadrupole ("RFQ") designed and built by CEA and IN2P3 in France. The rest of the accelerator is the subject of R & D in collaboration with other laboratories in the CERN member states and in Russia.

Table 2: Accelerating structures

	RFQ	DTL	CCDTL	SCL
Output Energy (MeV)	3	40	91.7	160.1
RF Frequency (MHz)	352.2	352.2	352.2	704.4
Gradient E_0(MV/m)	-	3.3-3.5	2.8/3.9	4
Quadrupole type	-	Permanent magnets	Electro-magnets	Electro-magnets
Aperture Radius (mm)	1.8 – 2	10	14	16
Diameter (m)	0.20	0.52	0.52	0.30
Number of tanks	-	3	24	20
Length (m)	5.95	12.85	25.2	28.0

2. Subjects of collaboration with Pakistan

Taking into account the existing commitments of other partners, the collaboration between Pakistan and CERN will encompass the following subjects, for a total amount of 400 kCHF (four hundred thousand Swiss francs):

Subject	Details
Contribution to mechanical design and construction of parts of the accelerator (e.g. vacuum chamber for the transfer line which implies high accuracy machining of stainless steel and special assembly and cleaning processes	Construction of mechanical items in Pakistan. Presence of a mechanical engineer at CERN: – for 3 months at the beginning of 2007 to participate in the design. – for 3 months in 2010 to monitor the installation of the Pakistani components, – for limited periods during the rest of Linac4 installation to supervise the Pakistani technicians (see last task below).
Contribution to the operation of the 3 MeV test stand (setting-up and measurements with beam, participation to the analysis)	1 engineer + 1 technician during 1.5 years between January 2008 and June 2009.
Contribution to the commissioning of Linac4 (RF conditioning, accelerator commissioning without and later with beam, beam measurements, adjustments, etc.)	1 engineer + 1 technician for 2 years between June 2009 and June 2011.
Contribution to the installation of Linac4 (participation to the assembly, installation, cabling and alignment of the components of Linac4)	2 technicians for 2 years between June 2008 and June 2010.
Ph. D. training	Two descriptions are proposed for theses in accelerator physics and technology (see Appendix 1 and section 6.4).

REFERENCES

[1] "Linac4, a New Injector for the CERN PS Booster", presented at: European Particle Accelerator Conference EPAC'06, Edinburgh, Scotland, UK, 26 - 30 June 2006, Bellodi, G; Garoby, R; Gerigk, F; Hanke, K; Lombardi, A; Pasini, M; Rossi, C; Sargsyan, E; Vretenar, M, CERN-AB-2006-027, http://doc.cern.ch/archive/electronic/cern/preprints/ab/ab-2006-027.pdf

[2] "Preliminary Accelerator Plans for maximizing the integrated LHC luminosity", Benedikt, M; Garoby, R; Ruggiero, F; Ostojic, R; Scandale, W; Shaposhnikova, E; Wenninger, J, CERN-AB-2006-018-PAF, http://paf.web.cern.ch/paf/Documentation/PAFviews.pdf

[3] "Conceptual design of the SPL II: A high-power superconducting H^- linac at CERN", Baylac, M *et al.*, CERN-2006-006

Appendix 1 to Annex VIIa: Subjects for Ph.D. theses in accelerator physics & technology

1. Linear accelerator design

Supervisor: Alessandra Lombardi (CERN/AB/ABP)
Subject: The design of a linear accelerator facility involves numerous computer simulations to study the influence of the beam line parameters on the dynamics of the charged particle beam. Since a real accelerator facility is subject to fabrication tolerances of the components, to temperature variations and power-supply jitter, its parameters always differ from the nominal values. To study the effect of these deviations already in the design process, one usually runs simulations with a systematically varied set of beam line parameters. The goal is to derive conclusions about the reliability and accuracy of the simulations and the stability of the beam optics under realistic conditions.
The thesis comprises the following aspects:

- Develop and implement meaningful mathematical measures of the quantities in questions (beam emittance, power losses, etc.)
- Develop and implement meaningful statistical methods to analyze the data
- Test and evaluate the new capabilities of the code PATH, compare the effectiveness of the error study approach with traditional methods from other codes

Required skills
Programming languages: Visual basic, C and basic knowledge of Fortran
Basic knowledge of accelerator physics and statistics

2. Study of superconducting accelerating structures for linac application

Supervisor: Frank Gerigk (CERN/AB/RF)
Subject: The future Superconducting Proton Linac (SPL) at CERN will make extensive use of superconductive elliptical multi-cell accelerating structures. The electromagnetic fields induced in these structures by the passage of the beam may have a detrimental effect on the beam itself and therefore deserve a detailed investigation, especially concerning the higher order modes (HOM). In the process, the student will have to develop a good understanding of electromagnetism and beam dynamics, and an appropriate practice of the available codes. As a first step the higher order modes of the SPL cavities need to be identified and characterised using a 3D electromagnetic code. Secondly the interaction of the HOM fields with the beam under realistic conditions will be evaluated.
Depending on the results, the study may continue with the design of a cure, probably in the form of the design of an HOM coupler. Else, other issues could be addressed, like the effects of mechanical vibrations and Lorentz force detuning, as well as the investigation of possible cures.

Required skills
Good knowledge and understanding of electromagnetism. Basic knowledge of accelerator physics.

Annex VIIb

A contribution to CLIC Study and to the CTF3 Project

Introduction

One of the options for a future e^+/e^- collider is the Compact LInear Collider, CLIC. The unique feature of CLIC compared with other technologies is the potential to reach centre of mass energies as high as 3 TeV. The CLIC study at CERN aims to demonstrate the technical feasibility of the CLIC scheme by 2010 [1,2,3,4]. The main vehicle for the experimental demonstration is the CLIC Test Facility CTF3. CTF3 is an accelerator complex built in phases by an international collaboration with presently 15 member institutions. A detailed description of the CTF3 strategy, design and status can be found in [5,6,7]. The present CTF3 collaboration is committed to providing most parts of CTF3 up to the beam-line entering the CLIC experimental area (CLEX) and some of the facilities in CLEX.

List of collaboration items

It is proposed that Pakistan, as a new partner in the CTF3 collaboration, focuses on items related to the test beam line (TBL) in CLEX. TBL is a scaled down version of a CLIC drive beam decelerator sector, consisting of a string of RF power extraction structures (PETS) interleaved with focusing quadrupoles. In order to analyse the beam before and after passage through TBL optical-transition-radiation-beam-profile-monitors (OTRM) will be used. Completion of TBL is planned for mid 2009, but the required resources for TBL are presently only partly covered by the CTF3 collaboration.

Other items for collaboration are studies for the CLIC injector and drive beam design and participation in the operation and experimentation with CTF3.
Table 1 gives a concise listing of all items proposed including the estimated value and schedule. The total value of the contributions is 800 kCHF (eight hundred thousand Swiss francs).

Table1: List of collaboration items

Subject	Manpower requirement	Estimated value	Schedule	CERN technical contact	Added value for Pakistan
Fabrication of 4 optical transition radiation monitors (OTRM) for CTF3		100 kCHF for 4 OTRM	Completion before end 2007	Thibaut Lefevre AB/BI	These types of devices will be needed for a future Pakistani SR light source
Participation in design, assembly and installation of high frequency CLIC proto-type structures. Link person with workshops in Pakistan	1 design engineer & 1 technician for 2 years at CERN	48x4 = 192 kCHF	Construction in phases Completion before mid 2009	Walter Wuensch AB/RF	Know how in mechanical design of accelerators and high precision machining of accelerator components.
Building of TBL-PETS parts in Pakistan		244 kCHF			
Beam dynamics studies for CLIC drive beam	Pakistani postdoc experienced with large simulation programs for 2 years at CERN	24x4 = 96 kCHF	Completion before end 2009	Daniel Schulte AB/ABP	Know how in beam dynamics of accelerators
Participation in CTF3 running and experimentation	Postdoc experienced with accelerator running	24x4 = 96 kCHF	Completion before end 2009	Roberto Corsini AB/ABP	Know how in accelerator operation.
PhD Thesis on CLIC main beam injector design (see appendix).	Doctoral student, located at CERN for two years	24x3 = 72 kCHF	Completion before end 2009	Louis Rinolfi AB/ABP	Know how in accelerator design

References

[1] The CLIC Study Team (edited by G. Guignard), "A 3 TeV e^+/e^- Linear Collider Based on CLIC Technology," CERN report 2000-008

[2] M. Battaglia, A. de Roeck, J. Ellis, D. Schulte (editors), "Physics at the CLIC Multi-TeV Linear Collider, rep. of the CLIC Physics Working Group," CERN report 2004-005

[3] H.H. Braun et al., "CLIC Progress towards Multi-Tev Linear Colliders," Proc. PAC'05 and CLIC note 628, 2005

[4] F. Tecker (ed.), "Updated CLIC parameters 2005," CLIC note 627, 2005

[5] G. Geschonke, A. Ghigo (editors), "CTF3 Design Report," CERN/PS 2002-008(RF), LNF-02/008(IR)

[6] I. Wilson et al., "CLIC Accelerated R&D," CLIC note 620 and CERN-AB-2005-003

[7] G. Geschonke et al., "Status of the CLIC Test Facility (CTF3)," proc. LINAC'06, 2006

[8] G. Bienvenu et al., "A Thermionic Electron Gun for the Preliminary Phase of CTF3," proc. EPAC 2002

[9] Jean-Claude Godot et al., "A New Front-End for the LEP Injector Linac," proc. PAC 1991

Appendix to Annex VIIb: Subject for a Ph.D. thesis in accelerator physics and technology

Subject: Design of a CLIC polarized electron source and the following linear accelerators

Supervisor:
Louis Rinolfi (CERN/AB/ABP)

Subject
The design of a polarized electron source for the Linear Collider CLIC involves numerous computer simulations. The beam dynamics should be studied from a DC gun illuminated by a laser up to the end of the Pre-injector Linac at energy of 200 MeV. The influence of the space charge and beam loading of the charged particles should be evaluated. When the space charge effects become negligible, beam dynamics should be studied up to 2.42 GeV. The goal is to derive a complete set of beam parameters at the entrance of the electron damping ring with conservation of the beam polarization.

The thesis comprises the following aspects:
- Develop and implement beam dynamics simulations to evaluate the beam characteristics (beam emittances, energy spread, bunch length, beam losses, polarization level, etc.)
- Study an electron source based on a RF gun (superconducting or at room temperature) and compare the data.
- Characterize the beam parameters at the entrance of:
    - the electron Pre-injector Linac,
    - the Injector Linac
    - the Damping ring.

Required skills
Programming languages: C and basic knowledge of Fortran.
Basic knowledge of accelerator physics and statistics.
Basic knowledge of some codes like Parmela, Transport or MAD would be useful.

Annex VIII

A contribution to GRID computing

Pakistan has already signed with CERN the MoU for Collaboration in the Deployment and Exploitation of the Worldwide LHC Computing Grid (CERN-C-RRB-2005-01/Rev.), pledging a Tier-2 Federation with defined capacity plans to serve with priority the CMS experiment. Resources are already allocated to this through the annual recurring budget of the National Centre for Physics (NCP).

The additional 170'000 CHF (one hundred seventy thousand Swiss francs) contribution will be used locally in Pakistan to enable the hiring of three operational staff for the Pakistan Tier-2 Federation.