

**ADDENDUM No. CTF 3/T.1**

**to**

**THE PROTOCOL DATED 15 FEBRUARY 2006**

**to**

**THE 1991 CO-OPERATION AGREEMENT, AS EXTENDED IN 2001**

**between**

**THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH  
(CERN)**

**and**

**THE DEPARTMENT OF ATOMIC ENERGY (DAE)  
OF THE GOVERNMENT OF INDIA**

**concerning**

**PARTICIPATION IN CTF-3 UNDER THE NOVEL ACCELERATOR  
TECHNOLOGIES PROJECT (NAT)**

**This Addendum defines the collaboration between CERN and the Department of Atomic Energy (DAE) of the Government of India for the Optics Design, including the studies, simulations, analysis and results, of the transfer line TL2 of CTF3 at CERN.**

**June 2007**



The European Organization for Nuclear Research (CERN), hereafter called "CERN", an Intergovernmental Organization having its seat at Geneva, Switzerland, represented by Dr. R.Aymar, Director-General,

on the one hand,

and

The Department of Atomic Energy (DAE) of the Government of India, hereafter called "DAE", represented by Dr. V. C. Sahni, Director, Raja Ramanna Centre for Advanced Technology (RRCAT) and Co-Chairman, DAE-CERN Joint Committee for Collaboration with CERN in the LHC,

on the other hand,

hereafter collectively referred to as "the Parties" and individually as "the Party";

## **CONSIDERING:**

The Co-operation Agreement signed by the Parties on 28 March 1991, as extended in 2001;

The Statement of Intent, signed by the Parties on 25 May 2005; and

The Protocol to the Co-operation Agreement, signed by the Parties on 15 February 2006;

## **TAKING INTO ACCOUNT:**

That India has been highly successful in the production of wide range of LHC equipment and in providing support for the magnetic tests and measurements of the superconducting LHC magnets, making it natural for CERN to invite India to participate in the CTF3 construction;

That in response to an invitation by CERN to participate in the CTF3 construction, DAE has conveyed its readiness to prepare the Optics Design, including the studies,

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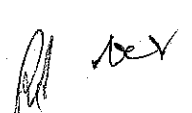
simulations, analysis and results, of the transfer line TL2 of CTF3 at CERN, its participation to be realized through RRCAT,

## **HAVE AGREED AS FOLLOWS:**

### **Article I Scope of the Addendum**

- 1.1 DAE shall contribute to CERN the Optics Design of the transfer line TL2 of CTF3 at CERN ("the Contribution").
- 1.2 The Contribution comprises the design, including the studies, simulations, analysis and results, in conformity with the technical specification and drawings as set out in Annex 1, which forms an integral part of this Addendum.
- 1.3 DAE shall provide a written report with the optics including all simulations.
- 1.4 The cost of this study will be based on the time an engineer or physicist at CERN would spend on this project and the subsistence which CERN pays to Unpaid Scientific Associates.

### **Article II Technical Responsibility and Co-ordination**

- 2.1 The overall authority for the CTF3 Project lies with CERN which shall co-ordinate the activities of the Parties.
  - 2.2 DAE shall be responsible for the technical and contractual implementation of its obligations under this Addendum.
  - 2.3 The Parties shall each nominate a Technical Co-ordinator, whose role is to co-ordinate the technical activities described in this Addendum.
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- 2.4 The Technical Co-ordinators shall jointly provide the Parties with quarterly progress reports.

### **Article III**

#### **Value of the Contribution**

- 3.1 The total estimated value of the Contribution, in accordance with Annex 1 to this Addendum, corresponds to nine (9) man-months work of a physicist/engineer. Based on the subsistence rate of 4'000 CHF (four thousand Swiss Francs) per month paid by CERN to Unpaid Scientific Associates this amounts to a total of 36'000 CHF (thirty six thousand Swiss Francs).

### **Article IV**

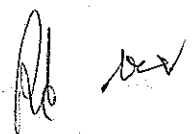
#### **Payment**

- 4.1 In consideration of the Contribution, CERN shall pay into the Novel Accelerator Technologies Fund (the "NAT Fund"), which has been created by the 2006 Protocol, a maximum amount of 18'000 CHF (eighteen thousand Swiss Francs), representing half of the maximum value stated in Article III of this Addendum, in accordance with the following provisions:
- 10 % following the signature of this Addendum;
  - 90% after the written design report is submitted by RRCAT and its acceptance by CERN experts.
- 4.2 CERN shall effect payment into the NAT Fund, in accordance with the terms stipulated in Article 4.1 of this Addendum, within thirty (30) working days following receipt and acceptance by the CERN Technical Co-ordinator of the corresponding financial statements submitted by DAE.

### **Article V**

#### **Schedule**

- 5.1 DAE shall prepare the Contribution according to the time scale set out below:

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- 5.2 The physical layout of the optics elements will be frozen after acceptance by CERN of the optics file which was delivered to it at the end of March 2007.
- 5.3 DAE shall finish the simulations and optimizations of the optics and communicate the results to CERN at the end of May 2007. A written design report shall be delivered to CERN one (1) month later.
- 5.4 This timescale is based on the assumption that the final parameters of TL2 have been frozen. If there is a change in TL2 parameters, new delivery dates would have to be agreed upon by the Parties.

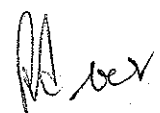
### **Article VI**

#### **Acceptance of Results of the Design Study, Calculations and Results**

- 6.1 CERN shall declare acceptance of the Contribution within three (3) months from the delivery of the design report together with the documents stipulated in Article V, provided they comply with this Addendum, including but not limited to the technical specification as set out in Annex 1 and any modification thereof agreed and signed by the Parties.
- 6.2 If acceptance has not been granted within three (3) months from the date on which DAE has notified that it has fulfilled all its obligations to this end and CERN has not advised it of any non-compliance, it shall be considered that the design study, calculations and manufacturing file have been accepted.

### **Article VII**

#### **Proprietary rights**

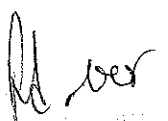
- 7.1 Intellectual property rights are defined in the Protocol to the Co-operation Agreement, signed by the Parties on 15 February 2006.
  - 7.2 Any publication of the results of the Contribution in scientific journals, at scientific conferences or by other means shall be discussed between the Parties and mutually agreed upon before such publication.
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## **Article VIII Modifications**

- 8.1 Whenever a Party considers that a modification of this Addendum is necessary, it shall inform the other Party and they shall agree on the measures to be adopted.
- 8.2 Any modification of this Addendum is subject to written confirmation by the authorized representatives of the Parties.

## **Article IX Cancellation**

- 9.1 In the event of a breach by DAE of its obligations under this Addendum, CERN reserves the right to cancel this Addendum in whole or in part by issuing a formal letter indicating the reasons and giving three (3) months, from the date of receipt by DAE of such letter, notice of cancellation. If no corrective action satisfactory to CERN is taken by DAE within that period, the termination will take effect and DAE shall refund to CERN the amounts already paid by CERN into the NAT Fund.
- 9.2 In the event of a breach by CERN of its obligations under this Addendum, DAE reserves the right to cancel this Addendum in whole or in part by issuing a formal letter indicating the reasons and giving three (3) months, from the date of receipt by CERN of such letter, notice of cancellation. If no corrective action satisfactory to DAE is taken by CERN within that period, the termination will take effect and DAE reserves the right to claim reimbursement by CERN of any costs and expenses necessarily incurred by DAE prior to the date of termination, it being understood that its total amount shall in no event exceed the unpaid part of the amount payable by CERN under this Addendum.

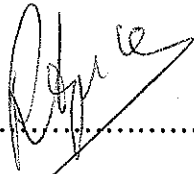


## Article XI Final Provisions

This Addendum shall form an integral part of the 2006 Protocol to the 1991 Co-operation Agreement, as extended in 2001.

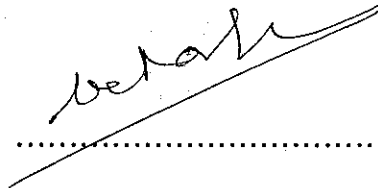
Done at Geneva on 22 June 2007 in two copies in the English language.

For the European Organization for  
Nuclear Research  
(CERN)



Dr. R. Aymar  
Director-General

For the Department of Atomic Energy  
(DAE) of the Government of India



Dr. V.C. Sahni  
Director, RRCAT  
and Co-Chairman, DAE-CERN Joint  
Coordination Committee  
for Collaboration with CERN in the LHC  
Project

## ANNEX 1

### Specifications of TL 2

The CTF3 Transfer Line 2 (TL2) transfers the beam from the Combiner Ring (CR) to the CLIC experimental area (CLEX) and transforms longitudinal and transverse beam parameters from CR extraction values to the required values at the entry of CLEX.

Table 1 summarises beam parameters at the beginning and the end of the line. Although the extraction region of CR is not part of TL2 proper, initial Twiss parameters are given at a reference point before extraction from the CR, since TL2 has to compensate the dispersion generated in the extraction system.

The functions of TL2 can be broken up in four building blocks:

1. Compensation of dispersion from CR extraction kicker and septum magnet with appropriate combination of quadrupoles and bending magnets.
2. Parallel vertical displacement of the beam by 50 cm with an achromatic magnet system.
3. An achromatic magnet system for horizontal displacement of the beam and simultaneous bunch compression. Bunch compression for nominal CR parameters requires  $R_{56}=0.25\text{m}^1$ . However, to keep enough flexibility for tuning and alternative operation modes an  $R_{56}$  variable from  $-0.28\text{m}$  to  $+0.28\text{m}$  or more is required. Appropriately placed sextupole magnets shall allow tuning the second order coefficient  $T_{566}$  to zero over the whole  $R_{56}$  range. The transverse emittance growth has to be kept below 10%.
4. Matching of the transverse Twiss parameters to the CLEX requirements.

The functionalities of block 3 and 4 may be combined in a single subsystem.

The 3 sigma beam size due to transverse emittance and energy spread should stay everywhere within the dimensions of the vacuum chamber (see addenda CTF3/V.1a and CTF3/V1.b).

A beam dump should be integrated somewhere in TL2 to allow dumping of the beam after the CR extraction by switching one of the TL2 dipole magnets.

Straight line space without magnets of 4m has to be reserved in TL2 to allow the future installation of a tail clipper with collimator.

The beam line has to fit in the existing building with proper start and end points as defined in drawings provided by CERN.

CERN has provided specifications and available numbers of vertical bend, quadrupole and sextupole magnets to be used in TL2.

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<sup>1</sup> Positive  $R_{56}$  implies shorter path length for lower energies

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Horizontal dipole magnets to be used in TL2 are built by RRCAT according to addendum No. CTF 3/B.1.

The footprint of the beam line has to be approved by CERN for compatibility with building and component access.

Table 1 - Beam parameters at CR extraction and CLEX injection.

	<b>CR extraction</b> Reference point in CR as provided by CERN (centre quadrupole Q540)	<b>CLEX injection</b> Reference point half way in wall separating CR and CLEX buildings
Maximum beam energy	300 MeV	300 MeV
Nominal beam energy	150 MeV	150 MeV
Nominal bunch charge	2.33 nC	2.33 nC
Bunch spacing	83.4 ps	83.4 ps
Train duration	140 ns	140 ns
$\beta_H$	4.23 m	<20 m in entire separation wall
$\alpha_H$	2.76	not specified
$\varepsilon_H$ (normalised, $1\sigma$ r.m.s.)	$100 \pi$ mm mrad	<110 $\pi$ mm mrad
$\beta_V$	7.79 m	<20 m in entire separation wall
$\alpha_V$	-2.47	not specified
$\varepsilon_V$ (normalised, $1\sigma$ r.m.s.)	$100 \pi$ mm mrad	<110 $\pi$ mm mrad
$\eta$	0 m	0 m
$\eta'$	0	0
$\Delta P/P$ (r.m.s.)	1%	1%
Height of beam-line above ground	1.35 m	0.85 m

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