Introduction to the Conceptual Design for the Cold Linac NPM

CEA Saclay: CEA-ESS-DIA-RP-0020 v0.1

	Name	Role/Title
Owner	Jacques Marroncle	In-Kind Principle Responsible for the NPM Cold Linac
Reviewer	Cyrille Thomas	System Lead for the NPM system
Approver		

TABLE OF CONTENT **PAGE**

Short name	Definition
CDR	Critical Design Review
IPM	Ionization Profile Monitor
NPM	Non invasive Profile Monitor (1 NPM = 1 IPM_X + 1 IPM_Y)
PDR	Preliminary Design Review
SC	Space Charge

1. INTRODUCTION

We briefly describe the delivery of the cold NPM for the PDR, namely reports devoted to its preliminary activities done at CEA Saclay, started on April 2016.

Hereunder are presented the subjects that cover this preliminary NPM study, identified during the discussions with the cold NPM manager, Cyrille Thomas. Few of them are critical, thus they have been investigated since they may compromise the use of IPMs. All these topics were also addressed in the NPM technical annex[1], as well as in the in-kind contract[2], accordingly to our discussions about cold NPM designs.

The next paragraph presents the contents of all these subjects, which are supposed to cover mainly this PDR.

2. CONTENTS

As said previously, the feasibility of such cold NPM based on residual gas ionization by the incident beam particles is very challenging, particularly due to:

- The strength of the ionization signal,
- The space charge effect,
- The uniformity of the field electric.

Therefore, the feasibility will have to be demonstrated in a preliminary step and the PDR conclusion conditioned to a GoNoGo gate allowing, or not, to resume our activities toward the next step, the CDR.

Below are quoted all investigated topics and they constitute the body of this PDR report.

[1] Scope of Work for the In-Kind Collaboration with CEA SACLAY on the Non-invasive Profile Monitors for the ESS Cold Linac

[2] IKC Schedule_AIK 7.3 (CEA 1.6) – "Non-invasive profile monitors for the ESS cold linac diagnostics", THE IN-KIND CONTRIBUTION AGREEMENT SIGNED BETWEEN ESS and CEA Saclay

2.1. The strength of the ionization signal

Ionization signal depends on the beam high energies (90 MeV to 2 GeV), for which the cross sections are quite small (in the 10^{-20} cm^2), the target which is a very low residual gas pressure (10^{-9} mbar) and the beam current intensity. In order to evaluate the intensity level of signal to be produced for the IPM measurement, calculation specific to the ESS beam and the IPMs locations have been produced and are reported in the document "Ion-Electron pairs production in the ESS Cold Linac (ESS-0092071)"

2.2. The Space Charge effect

Space Charge (SC) is very relevant in a high intensity beam such as the ESS one. When ionization by-products drift under the action of the IPM electric field, they are also submitted to the electric field generated by the proton beam itself. This additional field deviates drift trajectories, distorting the measured profiles. Detail and accurate modelling of the IPM and beam generated SC have been developed in order to support simulations and investigate the impact of SC on the profile measurement. Studies have been published in conference proceedings of IBIC 2016. A more detail document can also be found in CHESS: Space Charge based model of an IPM (ESS-0092068)

2.3. The uniformity of the electric field

Uniformity of the electric field inside an IPM is a critical condition to get a non-distorted profile measurement. In order to investigate the geometry and the quality and homogeneity of the HV IPM electric field, a simulation tool has been used, taking into account the design already frozen of the LWUs, in which the NPMs will be installed. In addition, the tool has been used to model the whole system and investigate the cross-talk between the two HV IPMs: "Electric Field Uniformity studies in the ESS LWU configuration for the NPM (ESS-0092070)"

2.4. ESS background

Data provided by ESS is analysed and discussed to check the contribution of incident protons non-energy beam correlated, does not compromise the profile measurement. Inside, but also outside of the beam pipe, background particles may be large enough to damage, or even destroy, read-outs and front-end electronics. Unfortunately, data expected in order to investigate the background signal could not be received in time to produce this documents. However, based on the necessity to maintain low loss for the accelerator, and based on experimental measurement on other facilities, we are confident the background should not play a significant role to the NPM. Yet, this will be investigated if possible during the detail design phase of the project.

2.5. The read-out system for the IPM

This contribution takes into account the conclusions from the previous ones, to propose different possible read-out systems. These systems are compliant with the requirements for the profile measurements. However, performance of each of these systems,

operational lifetime, maintenance, are different aspects of the system that have to be discussed before the selection of the readout system is done.
The attached document describes the design and implementation of pre-selected readout systems, their expected performance, operation and maintenance aspects. Also, real evaluation and comparison of these systems can only be done in details after real technical implementations on a test bench. This can also be read in the document, which sketches the bench test setup and criteria selection of the read-outs. With this experimental approach, numerous effects might be studied within the production and test of the prototypes: sparking limits, SC simulation validation, electric field uniformity, electron of ion signal choice, radiation damaging, calibration, reliability, maintenance… and control system. Corresponding document: "Read-Out systems for cold NPM (ESS-0092072)"

2.6. Interfaces and Risks

This last document presents the identified interfaces and risks that might impact the Cold Linac NPMs. Interfaces are critical for the installation and integration of the NPMs. They support the necessary agreements to be made between the device and its environment; it establishes how it is attached to the vacuum chamber, which procedure should be followed to perform installation, maintenance, any hazard associated to the installation and operation of the device, etc.

Corresponding document: "ESS-0092073 - Interface and Risk Management for the Cold Linac NPMs"

We wish you a pleasant reading