RAPPORT - *REPORT*

nBLM SYSTEM
RISK ANALYSIS

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1. Introduction

1.1. Purpose

The purpose of the document is to answer to the requirements from the reviewers of the PDR1.2 [1]. This document aims to do a risk analysis of the proposed nBLM system to discuss possible failures and the mitigation strategy for the different subsystems: gas system, Front-End Electronics (FEE), Back-End Electronics (BEE) and detector.

1.2. Scope

The nBLM system is a BLM system based on the detection of fast neutrons with Micromegas detectors with a combination of convertors and moderators. The systems is described in detail in the PDR documents [1] and [2] and in CDR1.1 and in [3]. This document is part of the nBLM CDR1.2 data package.

The system is designed to be sensitive to low neutron fluxes for the low energy part of the accelerator where only neutral particles can escape. The extra advantage of the nBLM in this region is that is insensitive to gamma rays, i.e. insensitive to background produced by the RF cavities.

The use of Micromegas detectors, a type of MPGD, requires inescapably the use of a gas recirculation system. The other characteristic of the system is the placement of the amplifiers on-board in order to reduce the loss of the signal during transmission to the BEE rack.

1.3. Abbreviations, acronyms and definitions

Name or acronym	Definition
BEE	Back-End Electronics
CEA	Commissariat à l'Energie Atomique
CDR	Critical Design Review
ESS	European Spallation Source ERIC
EPICS	Experimental Physics and Industrial Control System
ESSI	ESS Irfu project
FEE	Front-End Electronics
FPGA	Field Programmable Gate Array
GND	Ground
GUI	Graphical User Interface
MPGD	Multi Pattern Gaseous Detectors
MTCA	Micro Telecommunications Computing Architecture
nBLM	Neutron sensitive Beam Lost Monitor
PDR	Preliminary Design Review
PLC	Programmable Logic Controller
TBD	To Be Decided
ToT	Time Over Threshold

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1.4. Related Documents

nBLM CDR1.1

2. Gas system possible failures and impact

A Micromegas detector is a gaseous ionization detector invented in 1992 [4] at CEA/Saclay by Ioannis Giomataris. Since their invention they have been largely used at different experiments proving their robustness. Moreover, different kind of techniques have been developed. For the nBLM detectors we will use bulk Micromegas [5].

Micromegas detectors operates in gas. The purity of the gas is important to keep the gain of the detector stable and to avoid possible discharges produced by attachment. Therefore, we propose to operate in open mode, i.e. without recirculating the gas. The flow will be constant of ~1l/h per detector and the detectors will operate at slightly more than atmospheric pressure.

The gas system has been designed to be reliable and stable over time and it will be controlled by PLC communicating with EPICs.

In this document we summarize the possible failures that can arrive to the gas system, their impact on the whole system and the mitigation strategy in order to minimize the contribution to possible downtimes of the machine.

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Problem	Impact on system	As a result of	Mitigation	Signal
Drop in gas flow	Detector gain will decrease slowly as purity of gas degrades	- Leak in line - Error in setting the system	- Flowmeter placed on IN and OUT lines - Calibration mode added to EPICs to check the gain stability + rate counter every certain time - Extra valve installed in patch panel (inside the accelerator) to by-pass a leaky line until more time available for reparation	Warning in EPICs
Increase in gas flow	- No impact in detector - Gas will finish earlier	- Error in setting the system	- Detected by flowmeters - Add into EPICs a calculation of how much gas remain in bottle	Warning in EPICs
No gas flow	Detector no operative	Empty bottle	- Add into EPICs a calculation of how much gas remain in bottle or digitize the bottle manometer – Add a **warning** when is down to a certain level - Calibration mode added to EPICs to check the gain stability + rate counter every certain time	Alarm in EPICs Flow will be 0
		Line cut	*Same as for "air enter in the system"*	
		Human error with our bottles	Enclosed the manometer in a cabinet with key	
Flowmeter / pressure gauge fail	Blind in one F or P but system operative	Electronic failure	- For all the controllers add a manual one - Detected by flowmeters	Alarm in EPICs

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Air enter in the system	Detector OFF	Line cut or empty bottles	Added pumping points to reduce time needed after reparation for gas to be ready again to use our system	Alarm in EPICs Flow will be 0
Gas system power OFF	Blind but system operative	Power down	For all the controllers add a manual one	Alarm in EPICs
Gas purity degradation	Detector gain drop	Drop in gas flow	*See* Drop in gas *point*	

In conclusion, some modifications have been proposed to the design in PDR1.2 in order to increase the reliability of the system and to mitigate some of the possible failures. They are the following:

- Include pumping points for the input and output lines
- Include manual flowmeters to by-pass any electronic one in case of failure
- Include bubbler before the exhaust to check flow still on in case of failure in the electronics controllers
- Enclosed the manometer in a key-protected box
- For all cases the monitoring, not only of the gas, but of the detector gain and rate in a given time window is necessary
- In addition, a calculation of the remaining gas in the gas bottles storage area is foreseen to be included in EPICs that will send a warning some time TBD before the finish and an alarm when is almost finish (times TBD).

The total increase of the cost of the system will be ~10-20k€.

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3. FEE possible failures and impact

The same exercise can be carried out with the FEE. The components of the FEE are placed on-board, i.e. inside the accelerator tunnel. The system have been also designed to be stable and reliable. Similar components have been tested before and ageing tests are also foreseen. Possible problems and their impact on the system are listed on the following.

Problem	Impact on system	As a result of	Mitigation	Signal
Malfunctioning of one of the amplifiers / or components	Detector gain will be different or unstable	- Ageing - Some unpredictable electronics failure	- Calibration mode added to EPICs to check the gain of the detectors - Electronics designed in a mezzanine card to allow for a quick replacement (~1h/detector) - Ageing tests are foreseen	Alarm in EPICs
Dead amplifiers	No signal	- Unknown reasons - Sparks	- Calibration mode added to EPICs to check the gain of the detectors + rate counter == 0 - Electronics designed in a mezzanine card to allow for a quick replacement (~1h/detector) - Protection against sparks placed on board	Alarm in EPICs

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4. BEE possible failures and impact

We repeat the study for the acquisition and the HV and LV modules. All the components are from CAEN/CAENes or IOxOS.

Problem	Impact on system	As a result of	Mitigation	Signal
FMC-3111 no working or malfunctioning	No signal acquired or gain different	- Power OFF of module or rack - FMC failure	- Calibration mode added to EPICs to check the gain of the detectors + rate counter - Detectors that covered similar region (within ~2m) connected to 2 different FMCs into different racks	Alarm in EPICs
IFC-1410 no working or malfunctioning	No signal acquired	- Power OFF of module or rack - IFC failure	- Calibration mode added to EPICs to check the gain of the detectors + rate counter =0 - Detectors that covered similar region (within ~2m) connected to 2 different FMCs that are connected to different IFC into different racks - Monitor IFC status check in EPICS	Alarm in EPICs
MTCA no working or malfunctioning	No signal acquired	- Power OFF of module or rack - MTCA failure	- Calibration mode added to EPICs to check the gain of the detectors - Detectors that covered similar region (within ~2m) connected to 2 different FMCs that are connected to different IFC into different racks	Alarm in EPICs
HV down	No gain in detectors	- Power OFF of module or rack	- Calibration mode added to EPICs to check the gain of the detectors + rate counter	Alarm in EPICs

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LV down	No gain in detectors	- Power OFF of module or rack	- Monitor HV/LV module status in EPICS - Detectors that covered similar region (within ~2m) connected to 2 different HV cards - Extra power module for SY crate	Alarm in EPICs
HV instabilities	Gain different than expected	- Electronic problem	- Calibration mode added to EPICs to check the gain of the detectors - Monitor status in EPICs	Warning in EPICs
LV instabilities	Gain different than expected	- Electronic problem	- Calibration mode added to EPICs to check the gain of the detectors - Monitor status in EPICs - V regulator on-board	Warning in EPICs

For the HV and LV our initial proposition was to have one SY CAEN crate to power all the needed cards (4 of 48 channels) due to the reliability of the module itself. However, with the new distribution of detectors seems reasonable to have one for the high energy region of the accelerator.

A secondary power supply (A-4533) can be added into the SY crate (and should be added if we feed all the cards with one) that gives some extra security. For example, if the main power (A4531 that connects to the SY-4527 B) fails in the 48V used to feed the HV modules, there are the 48V provided by the A4533 that will continue to provide power to the boards. However, if the failure is in the 5V output, the CPU will stop working and so will the Main Frame. Therefore, it will depend on the failure of the main power supply.

For the LV and HV we will connect the detectors in the way that the half and half of same region are connected to different ones (as for the FMCs channels).

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5. Detector possible failures and impact

Problem	Impact on system	As a result of	Mitigation	Signal
Drop in gain	Change in detector gain	Instabilities in HV module	- HV level and intensity will be monitored in EPICS - Check gain in EPICs	Warning in EPICs
		Electronics failure	*Discussed before*	
		Gas impurities	*Discussed before*	
		Ageing of detector itself by unknown reason	- MMs detector proved to be stable under radiation [6] -Plan to do further tests of radiation - Check gain in EPICs	Warning in EPICs
		LV not stable	-Monitor status in EPICs - V modulator on-board - Check gain in EPICs	Warning in EPICs
Sparks	Can hide positive signals from neutrons	Too high voltage	-Operates always very far from high gain region -Sparking point will be determined in advance -Possible recognition of spark by software?	Alarm in EPICs
		Gas impurities	*Discussed before*	

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6. Bibliography

[1] L. Segui et al., “nBLM PDR1.2,” CEA-ESS-DIA-RP-0027, 2017.

[2] L. Segui et al., «PDR1.1,» CEA-ESS-DIA-RP-0013, (ESS-0110762), 2016.

[3] L. Segui et al., “nBLM system signal modes,” 2017.

[4] Y. Giomataris Ph. Rebourgeard J.P. Robert G. Charpak, «MICROMEGAS: a high-granularity position-sensitive gaseous detector for high particle-flux environments,» *NIM A,* vol. 376, n° %11, pp. 29-35, 1996.

[5] I. Giomataris and al, “Micromegas in a bulk,” *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment,* vol. 560, no. 2, pp. 405-408, 2006.

[6] J. Galan et al., “An ageing study of resistive micromegas for the HL-LHC environment,” *Journal of Instrumentation,* vol. 8, no. 04, p. P04028, 2013.

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