RADIATION RESISTANCE TESTING OF COMMERCIAL COMPONENTS FOR THE NEW SPS BEAM POSITION MEASUREMENT SYSTEM

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Abstract

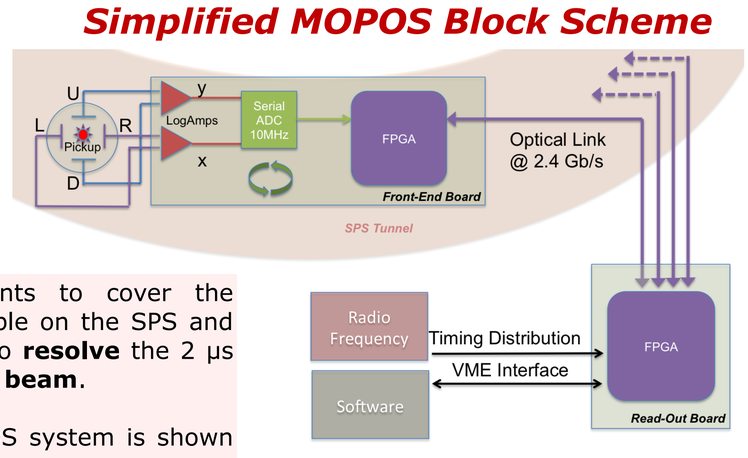
A new Front-End (FE) electronics is under development for the SPS Multi Orbit POsition System (MOPOS). To cover the large dynamic range of beam intensities (70 dB) to be measured in the SPS, the beam position monitor signals are processed using logarithmic amplifiers. They are then digitized locally and transmitted via optical fibers over long distances (up to 1 km) to VME acquisition boards located in surface buildings. The FE board is designed to be located in the SPS tunnel, where it must withstand radiation doses of up to 100 Gy per year. Analogue components, such as Logarithmic Amplifiers, ADC-Drivers and Voltage Regulators, have been tested at PSI (Paul Scherrer Institute) for radiation hardness, while several families of bidirectional SFP, both single-fiber and double-fiber, have been tested at both PSI and CNRAD. This poster gives a description of the overall system architecture and presents the results of the radiation hardness tests in detail.

Simplified MOPOS Block Scheme

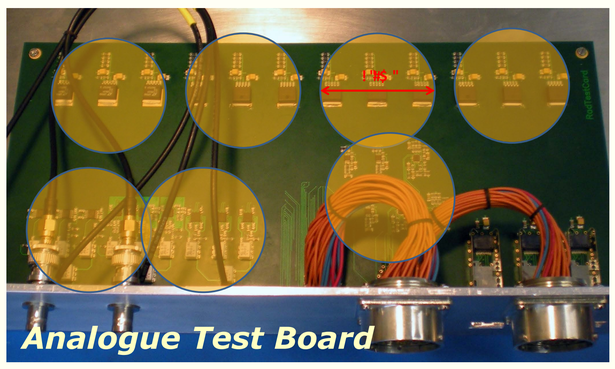
The **SPS** orbit and trajectory measurement system relies on 216 **Beam Positions Monitors** (BPM) distributed all around the machine.

The **upgrade** of the present MOPOS aims at developing a **radiation hard electronic system** capable to provide both high dynamic range measurements to cover the various beam configurations available on the SPS and a fast enough data sampling rate to **resolve** the 2 µs long **multi batch structure of the beam**.

A detailed description of the MOPOS system is shown in the poster **MOPC18**.



Logarithmic Amplifier, ADC Driver and Voltage Regulator Radiation Testing @ PSI — Proton Irradiation Facility (PIF)



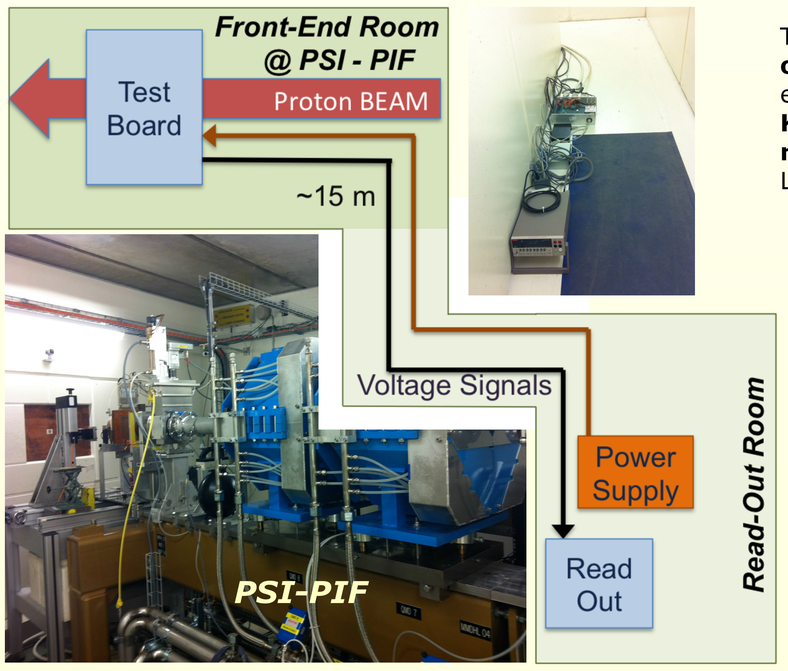
The Devices Under Test (DUTs), **Logarithmic Amplifiers**, **ADC drivers** and **voltage regulators**, are all soldered on the same analogue test board.

Since the working total dose foreseen in **the SPS** is about **100 Gy/year,** the total dose targeted for the irradiation is **1 kGy per DUT**. The devices have been tested at **PSI-PIF**.

The analogue test board is composed of **3 units of each DUT** for **reproducibility** and **statistical** reasons. The test is performed **moving the proton beam** across the board over **7 different zones**.

The analogue test board is powered by a custom-made power supply located in an adjacent technical room and therefore not exposed to radiation.

Particle Type	proton
Energy [MeV]	230
Flux [p/cm^2/sec]	1.6 10^8
Collimator [cm]	5.8
Fluence [p/cm^2]	1.874 10^{12}
Angle [deg]	90



The **acquisition** of each DUT **output voltage** is performed every 3 minutes using a **Keithley multimeter, remotely controlled** by LabView.

— — Test Results — —

The **Logarithmic Amplifiers** and the **ADC drivers** have not shown **any sign of failure nor deterioration**. The output voltages remain the same with respect to the reference values, measured during and after irradiation.

The test of **voltage regulators** indicates that they are **quite sensitive to radiation**: the **output voltage starts drifting** with respect to the expected value.
The **LP3875-ADJ** present a voltage drift as high as 700 mV for all 3 components.

The test of **LT1963AEQ** is not conclusive since one component died after 100 Gy while the two others have shown a good resistance to radiation.

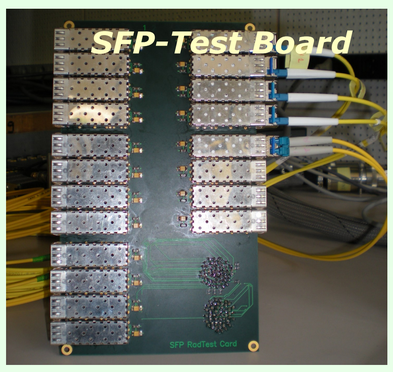
Voltage regulators **TL1963-KTT** and **TPS7A4501KTT** have shown very little output voltage variation, lower than 100 mV over 3.5 V, and **can be selected** for our application.

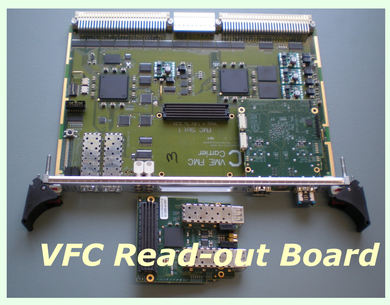
DEVICE	COMPANY	DUT
Logarithmic Amplifier	**Analog Devices**	**AD8302**
	Analog Devices	**ADL5519**
	MAXIM	**MAX2016**
ADC Driver	**Analog Devices**	**ADA4932-2**
	Texas Instruments	**THS4521**
Voltage Regulator	**Linear Technology**	**LT1963AEQ**
	Texas Instruments	**TL1963-KTT**
	Texas Instruments	**LP3875-ADJ**
	Texas Instruments	**TPS7A4501KTT**

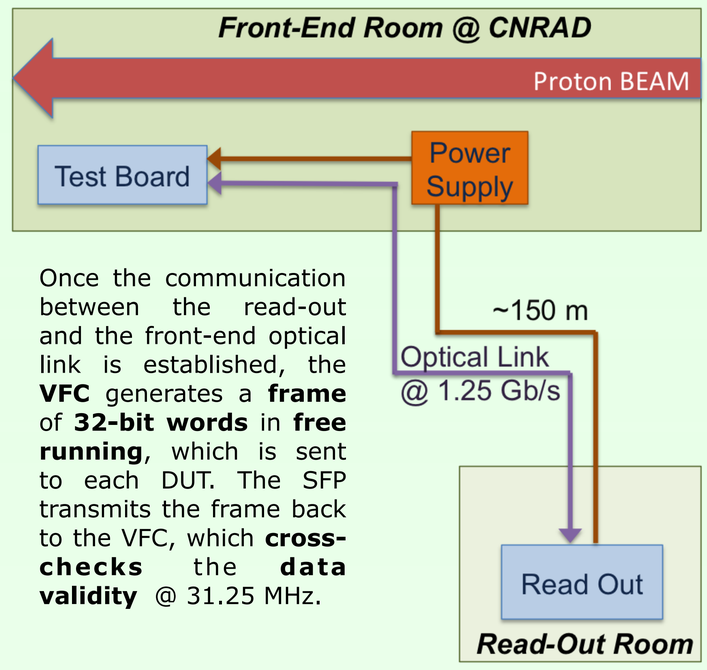
SFP Radiation Test @ PSI-PIF and CNRAD

Small Form-factor Pluggable (**SFP**) **optical transceivers** have been tested up to a total dose of 1 kGy. A **dedicated test bench** has been developed and installed at **PSI-PIF** and at **CERN CNRAD** (TSG 45, Area 451) facilities.

The **SFPs convert optical signals** into **electrical signals** or vice versa. On the SFP-Test Board the electrical transmission and reception channels are in loop-back. The **read-out** board is a general beam instrumentation, custom made, **VME FMC carrier**, called VFC. The two Xilinx SPARTAN-6 FPGAs on the VFC are configured to manage 6 independent SFP test lines.



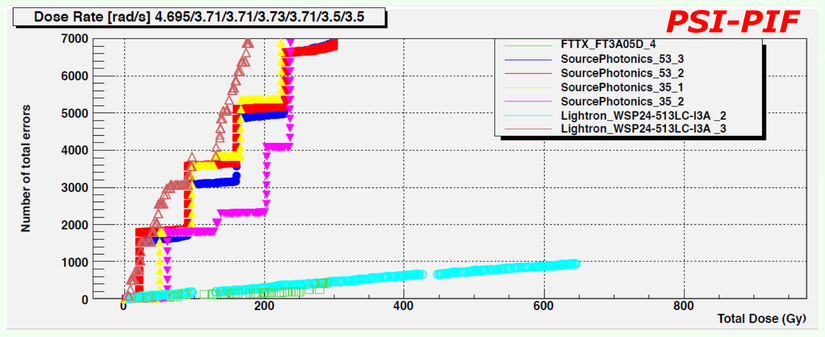




Once the communication between the read-out and the front-end optical link is established, the **VFC** generates a **frame** of **32-bit words** in **free running**, which is sent to each DUT. The SFP transmits the frame back to the VFC, which **cross-checks** the **data validity** @ 31.25 MHz.

Facility	PSI-PIF	CNRAD
Particle Type	proton	mixed
Energy [MeV]	230	-
Flux [p/cm^2/sec]	(0.12 ÷ 1.7) 10^8	-
Collimator [cm]	5.8	-
Angle [deg]	90	-
Mean Dose Rate [rad/s]	0.6 ÷ 9.5	0.005
Total Dose Rate [rad]	(12 ÷ 820) 10^2	0.35 10^5

Three 8-bit counters are implemented for each DUT to monitor both single (**SEU**), multiple (**MBU**) and the total numbers of errors. An **unexpected** behaviour (referred herein as *step-error*) has been observed, which refers to consecutive readings of a FULL on the "total-error counter" with an error rate > 8.16 10^{-6}.



— Test Results —

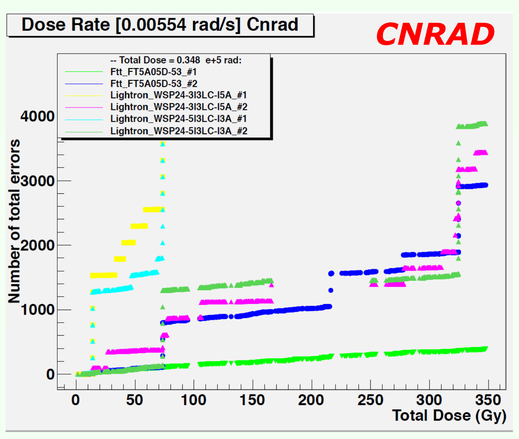
At **PSI, Ligent** and **Yamasaki** SFPs were quite sensitive to the irradiation, working at best up to **300 Gy** and **80 Gy** respectively.

SFPs from **Source-Photonics** resisted up to **350 Gy** but with *step-errors.*

Double-fiber **FTT** and **Lightron-I3A** SFPs are **promising** as they showed a good radiation resistance up to **300 Gy** and **800 Gy** respectively.

At **CNRAD**, **Huihong** SFPs have been rejected, since they had a mechanical issue with the fiber connection, producing error counts even without radiation.

Ligent SFPs work up **250 Gy**, but produce many *step-errors*.



FTT double-fiber and **Source-Photonics** SFPs keep working correctly up to **250 Gy** and **200 Gy**.

Single-fiber FTT and **Lightron** SFPs present the best radiation hardness with no degradation throughout the whole run (up to 350 Gy).

For the **MOPOS** electronics **upgrade** we are now considering to use specifically designed **radiation hard** optical transceivers.

COMPANY	DUT	# PSI	# CNRAD
FTT double-fiber	**FTTX-FT3A05D**	5	1
FTT	**FTTX-FTA05D-35**	-	2
	FTTX-FTA05D-53	-	2
Ligent	**LTE5350-BC**	3	1
	LTE3550-BC	1	1
Source Photonics	**SPL-35-GB-CDFM**	2	2
	SPL-53-GB-CDFM	3	2
Yamasaki	**541315L-15B**	1	-
	541315L-15Y	1	-
Lightron	**WSP24-313LC-15A**	2	2
	WSP24-513LC-13A	3	2
Huihong	**HGLC-BX-D**	-	1
	HGLC-BX-H	-	1

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