



AIDA²⁰²⁰

Advanced European Infrastructures
for Detectors at Accelerators

AIDA-2020 - WP12.2 : Detector Characterization Facilities EMC characterization

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- 1. INTRODUCTION
- 2. TA EMC ACTIVITY
- 3. PUBLICATIONS
- 4. FUTURE ACTIVITIES
- 5. SUMMARY



1. Introduction

- The WP12 Transnational Access is focused on special detector and system characterization (**NEW FACILITIES**)
- WP12.2.- EMC Laboratory of Instituto Tecnológico de Aragon (**ITAINNOVA**) in Spain for **EM noise characterization**.



- **EMC facilities allow to perform Electromagnetic Compatibility Test.**
 - Non-standard test (Specially focused on HEP)
 - Standard (According to European Directive 2004/108/EC)



- These tests may be used to define in any electronic device installed in HEP experiment:
 - EM noise emission and immunity levels
 - Filters designs & grounding configurations
- 2-3 Experiments expected per year on target have been planned under the project .
- 1200 TA units have been estimated:
 - 8 standard accesses ~ 50 TA units per access
 - 4 extended accesses ~ 200 TA units per access



- 4 TA-WP12.2 accesses have been already approved
 - 3 extended accesses (3/4 - 75%)
 - 1 standard access (1/8 - 13%)
- 3 TA-WP12.2 accesses have been completed
 - TA-ITAINNOVA – (40 % TA units - Completed)
- Access has been requested from 3 countries
 - Germany, Austria and Italy

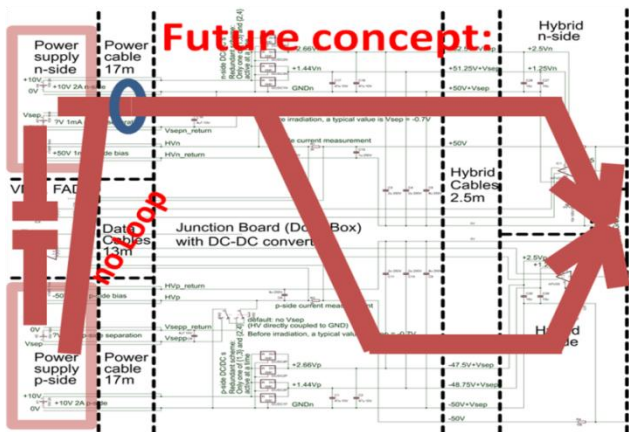
ITAINNOVA	User Projects		Total users	TA units
	Submiss.	Selected		
M1-M18	4	4	11	500
M1-M48	12		12	1200



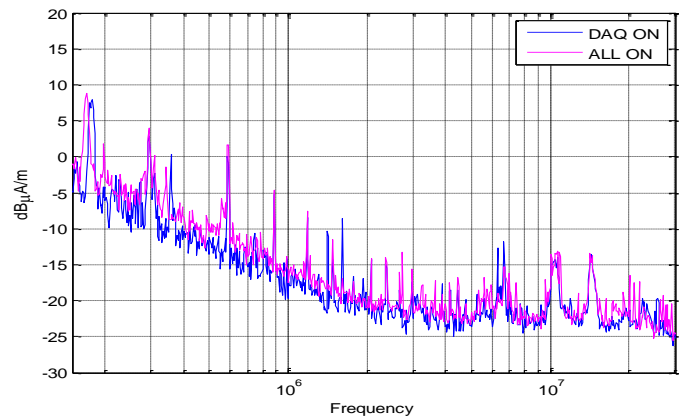
- **3 TA have been completed (500 hours).**
 - ✓ **AIDA-2020-EMC-2015-01** - EMC Studies with the Belle II SVD Readout System , HEPHY, Austria
 - ✓ EXTENDED ACCESS for EMC characterization of Large system (240 TA units)
 - ✓ 4 users - 3 users have been present at the facility. 1 has been covered by AIDA-2020
 - ✓ **AIDA-2020-EMC-2015-02** – *DC-DC converters noise emissions for Belle II SVD System, HEPHY Austria*
 - ✓ STANDARD ACCESS for EMC component testing (Remote access) 40 TA units
 - ✓ **AIDA-2020-EMC-2016-1** - EMC characterization of Belle II Pixel System, MPI Germany
 - ✓ EXTENDED ACCESS for EMC characterization of Large system (220 TA units)
 - ✓ 3 users have been present at the facility. 1 has been covered by AIDA-2020
- All of them have been focused on Belle II experiment
 - A complementary facility of other TA
- **They have produced very useful and interesting results**



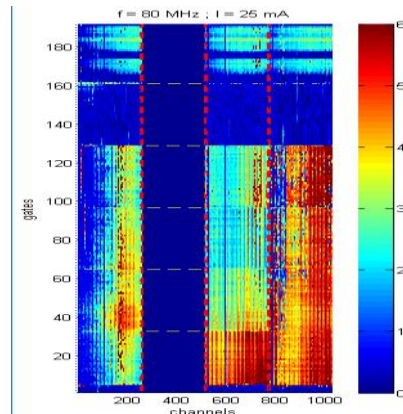
2. TA EMC activity



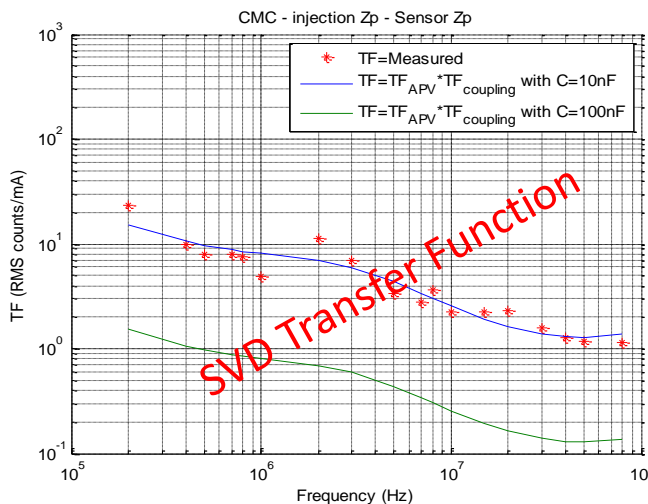
DC-DC converters noise emissions



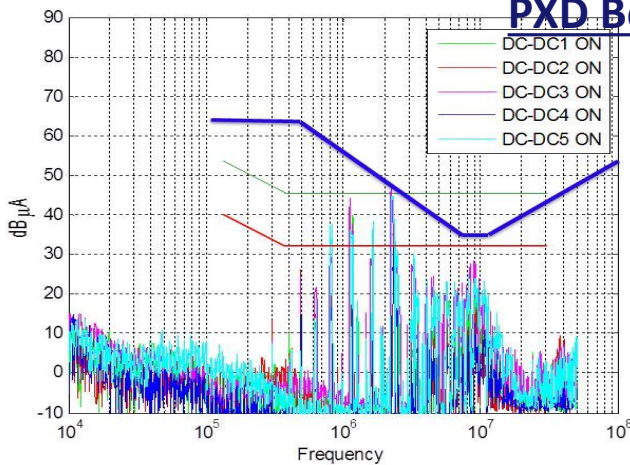
Belle II Pixel Noise mapping



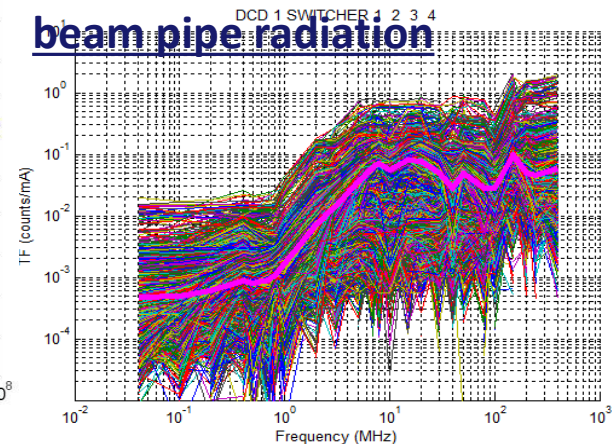
SVD belle II FEE - Redesign



PXD Belle II - Noise compatible level



PXD Belle II - susceptibility level to beam pipe radiation





• PUBLICATIONS

➤ 2 paper have already been published

✓ Journal of Instrumentation, “EMC Studies for the Vertex Detector of the Belle II Experiment”, JINST 11 (2016) 01, C01044.

✓ IEEE publication “Analysis and quantification of coupling mechanisms of external signal perturbations on silicon detectors for particle physics experiments”, DOI: 10.1109

➤ 3 Contributions to Conferences (2 oral contributions & 1 Poster)

✓ Topical Workshop on Electronics for Particle Physics, TWEPP 2015 (Sep. 2015, Lisbon)

✓ ESA Workshop on Aerospace EMC, Valencia, May 2016

✓ 2nd Electromagnetic Pulse Workshop, Warsaw, Poland, January 2017

➤ 2 contributions to Newsletter have been focused on some of the test campaigns


✓ Susceptibility characterization of DEPFET Pixel Systems : Hans-Günther Moser (MPI, Germany)

✓ EMC-TA On Track: Electromagnetic noise under control : F.Arteche (ITAINNOVA, Spain)

➤ 1 paper is on preparation

✓ Journal of Instrumentation, “Characterization of the susceptibility for the PXD Detector in the Belle II Experiment”, JINST


➤ 1 Tesis is on preparation based on some of the measurements performed



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EMC strategies to control the noise issues in High Energy Physics Experiments

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Abstract—Electromagnetic interference (EMI) has been a major concern during the electronics integration of the CMS experiments at CERN (Switzerland) and Belle II experiment at KEK (Japan). Grounding and shielding problems and electromagnetic compatibility (EMC) issues have arisen during the integration of the LHC and SuperKEKB experiments in different sub-detectors requiring time and important number of tests and studies to solve them. This poster presents a general overview of the EMC plan and tests that have been applied to a two high energy physics experiment (CMS and Belle II) before the installation and commissioning of the electronics system. This talk shows several techniques to control the noise emissions as well as how to deal with them. Also, the impact of different FEE topologies in the final sensitivity to electromagnetic interference of the subsystem is analysed to improve the EMC of the detectors in view of the future challenging electronics topologies.

HEP experiments are complex EM environment

CMS experiment - CHIPS

- ⇒ FEE Millions readout channels
- ⇒ Thousands > Half million of chips
- ⇒ Detector & Process signals (a few fC nA); Intrinsic noise ($0.5-1.6\mu\text{C}$)
- ⇒ Measurements is done synchronously (5Hz - 100kHz, 40 MHz...)
- ⇒ Power = 0.5 Magawatt - 5000 10000 (DC-DC converters)
- LV - 1.25 V up to 6.5 V (0 - 100 amps per unit)
- HV - 30 600 V up to 10 kV (few mA)

Belle II experiment - CHIPS

EMC strategy

The main goal is to ensure the correct performance of HEP detectors or experiment.

- ⇒ Ensure the compatibility in each sub-system
- ⇒ Ensure the compatibility among units - sub-systems
- It establishes a safety margin
- Compatibility

EMC integration strategy is carried out in 3 stages:

- Block diagram (EMC map)
- EMC unit analysis

Grounding Topology

Reasons for ground:

- Safety
- Equipment protection
- Equipment performance

Golden Rule:
Try to make the system safe and then make it work.

Sub-detector and Experiment grounding has to be

Experiment level

EMC Map

The EMC map is used to:

- Identify sub-systems
- Power levels
- Noise sources and victims
- Coupling phenomena
- It helps to define the EMC unit

CMS EMC Map

How is possible to tackle the EMC unit analysis?

TOP - DOWN - BOTTOM - UP

- ⇒ Detector level - Subsystem level - Component level
- EMC characterization & design rule (it is part of the design)
- ⇒ Component level - Subsystem level - Detector level
- Compatibility level definition / Verification / EMC test

Belle II SVD - EMC unit

NOISE SOURCE - EMISSION TESTS

Belle II SVD

CMS Tracker

Belle II - Pixel sub-detector

COUPLING PATH / NOISE PROPAGATION

Cable MTL MODEL (Simulation)

CM noise distribution

Radiated field - Power Network Measurement

CMS Tracker - sub-detector

NOISE VICTIM - IMMUNITY TESTS

Belle II EMC test chamber (EMASERO Project)

CMS Tracker compatible

<http://aida2020.yes.com.ch/content/ita-innova>

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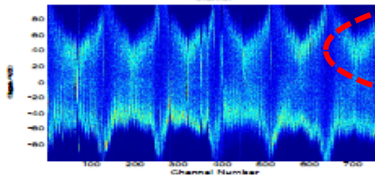
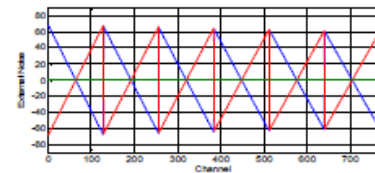


Figure 15. Noise distribution per channel in Belle II-SVD: simulated (up) and measured (down)

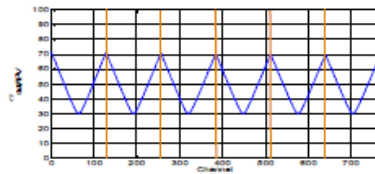


Figure 16. Total noise distribution for the Belle II-SVD Detector (simulated).

recommendations and guidelines that could be used to reduce the noise incidence in the system and enhance the integration of the detector power line.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

1. Arteche, F. & Rivetta, C. (2004). EM Immunity studies for front-end electronics in high-energy physics experiments. *Proc. of EMC Europe 2004*, Eindhoven, The Netherlands, pp. 533-538.
2. CMS Collaboration (2008). The CMS experiment at the CERN LHC. *Journal of Instrumentation*, JINST 3 S08004, Volume 3.
3. Friedl, M., et al. (2013). The Belle II Silicon Vertex Detector readout chain. *Journal of Instrumentation*, JINST 8 C02037.
4. Raymond, M. et al. (2000). The APV25 0.25 μm CMOS readout chip for the CMS Tracker. *Proc. IEEE Nuclear Science Conference*, Lyon, France, pp. 9/113 - 9/118.

and conducted emission tests required for the power supplies in order to implement properly the grounding and shielding strategies.

Acknowledgments

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References

- [1] Z. Dotzertal and S. Uno, *Belle II technical design report*, KEK Report 2010-1 (2010) [arXiv:1011.0352].



- **1 new TA proposal has been submitted in March.**
 - ✓ AIDA-2020-EMC-2017-01 - Electromagnetic compatibility characterization of the new neutron spectrometer CYSP , Italy
- **More proposals are now under discussion TA**
 - ✓ They will be submitted soon : Italy and Germany
 - ✓ Some of the new proposals come from “different area”(Short-Pulse Lasers Facilities)
 - In January we have participated in an special Workshop focused on EMP generated in Laser Pulse Facilities
- **In may, we will participate in two other workshops focused on:**
 - ✓ Experiments installed in neutrino facilities
 - ✓ Linear Colliders Vertex Detector Workshop
 - ✓ We will probably have more requests for the TA facility



- WP12.2 TA access is going well
 - 4 TA-WP12.2 access have been already approved
 - 3 TA-WP12.2 access have been completed (500/1200 TA units)
- Most of the requested accesses are full EMC characterization
 - We have already covered the 75% of what we have planned
 - It will not generate any problem due to the low demand of standards access.
- TA activity has generated several publications, conference talks, posters as well as a Thesis (it is on going)
- Activity has been mainly focused on Belle II experiment but new proposals from different areas have recently been received.
- Some “marketing ” focused on TA-EMC has been very useful and positive (we plan to keep this activity during this year)