INSTITUTO TECNOLÓGICO DE ARAGÓN

Grounding & EMC : Status and Plans

Belle II Focused Review

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On behalf of Belle II EMC (Grounding) working group

MAX-PLANCK-GESELLSCHAFT

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Outline

- 1.Introduction
- 2. GND & EMC strategy
- 3.Grounding issues
- 4.Cabling issues
- 5.EMC issues
- 6.Future plans
- 7.Conclusions

1. Introduction

- During last one and a half years a lot of activities have been carried out in order to ensure the correct integration of Belle II electronics.
- A working group has been created to coordinate this activities
  - Grounding & EMC working group
- We usually meet during Belle II general meetings in order to coordinate and follow up these activities.
  - 1st meeting Nov 2011
  - 2nd meeting Jul 2012
  - 3rd meeting March 2013
  - 4th Meeting - July 2013
- They have been very good and useful meetings
  - All sub-detectors have participated

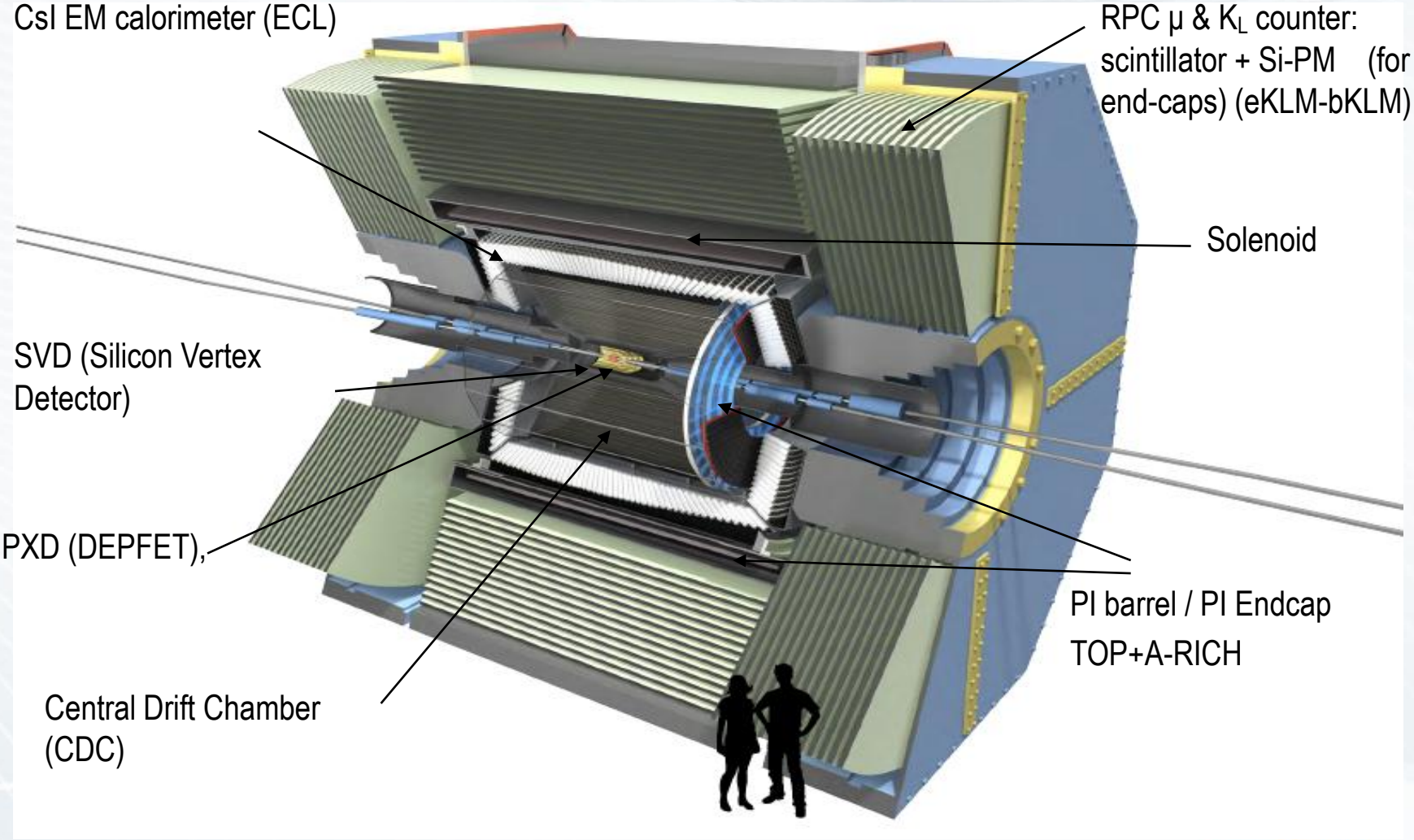
1. Introduction

- During the last meeting we have organized a review of the grounding and EMC activities in order to verify
  - Grounding topologies - Belle II grounding policy
  - Cable layout – Cable Installation
  - EMC plans - Control noise issues
- The review committee was created with Belle II members and external reviewers (EMC experts)
  - Manobu Tanaka
  - C.Rivetta
  - G.Varner
  - H.G. Moser / C.Kiesling
  - C. Irmler / K. Hara
  - Suji Uno
  - S. Korpar
  - I.Adachi
  - A. Kuzmin
  - P.Pakhlov/L.Pillonen
  - Yutaka Ushiroda
  - F.Arteche
- Many thanks to all of them

1. Introduction

- The review was a very good overview of sub detectors activities on these topics.
- We have made a lot of progress since first meeting
  - Big effort from everybody
- It has helped us to detect first incompatibilities before installation and commissioning.
- This is only one more step to full system integration
  - The discussion has only started .....
- The review committee has prepared a report with the most important issues of the meeting
- During the next slides I will summarize:
  - Grounding and EMC activities.
  - Main topics and conclusions from this review

2. GND & EMC strategy



2. GND & EMC strategy

- The main goal of Grounding & EMC integration strategy is to ensure the correct performance of Belle II experiment.
  - Ensure the compatibility in each sub-system
  - Ensure the compatibility among units – sub-systems
    - It establishes a safety margin
- EMC integration strategy has three parts:
  - Grounding issues
  - Cabling issues
  - EMC issues

3. Grounding

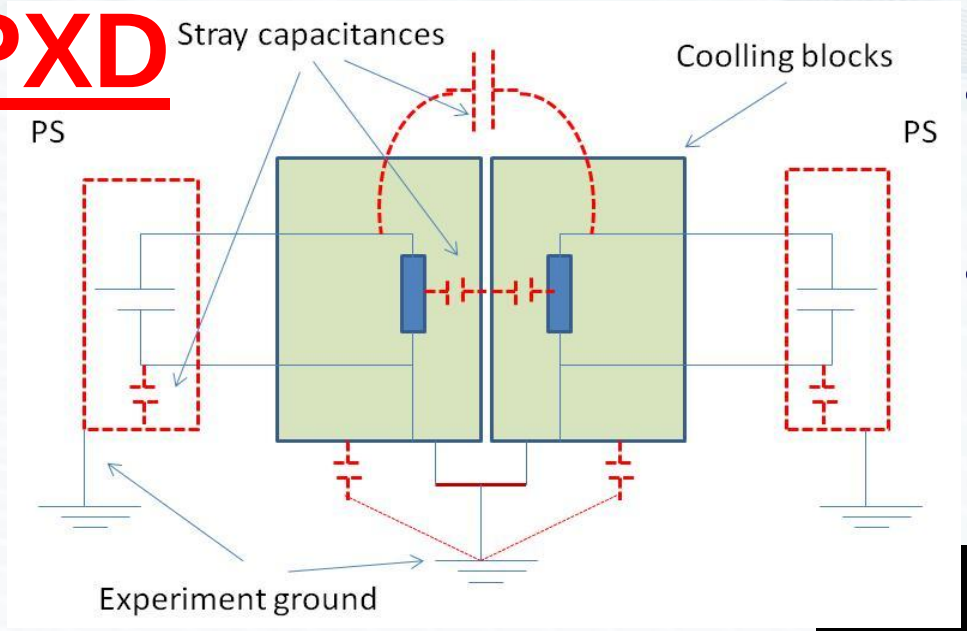
- What is a ground ?
  - It is a reference : Uniform reference voltage at any frequency
  - It is a structure to bypass currents
    - Fault (short circuits ..)
    - Noise
- Reasons for Grounding
  - Safety
  - Equipment protection
  - Equipment performance
- Golden rule:
  - ***"Make the system safe and then make it work "***
- Several recommendations were made.

3.1 Grounding Topologies

- Most of the grounding topologies has been presented
  - Multipoint ground
  - Floating PS units (LV)
- It is time to define a common topology for all sub-detectors
- First “hot” areas have arisen
  - Grounded vs Floating (FEE)
  - Performance vs Safety (HV)
- Safety issues have become a priority concern
  - Belle II electrical safety requirements
    - KEK electrical safety rules (Coordination)
  - They may have an impact on the design

3.1 Grounding Topologies

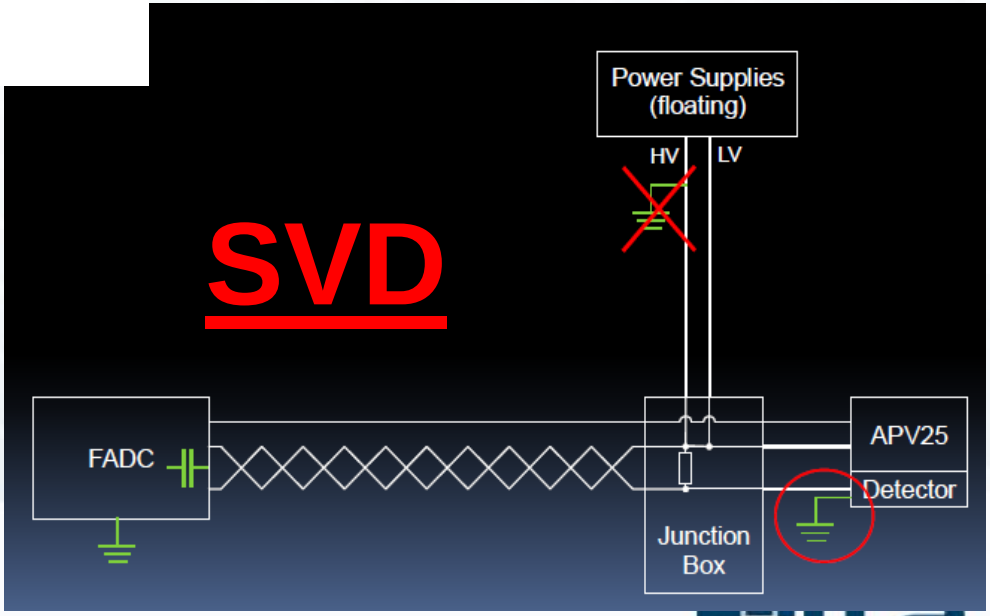
PXD



- Multipoint GND using cooling blocks
- LV floating power supply
  - DC-DC converters

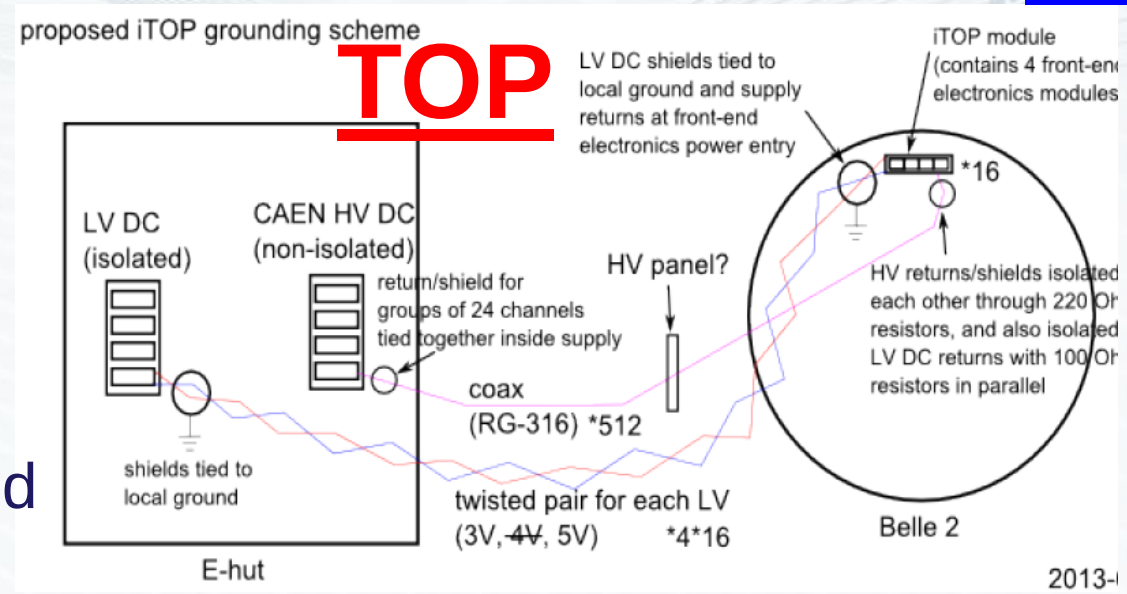
- Multipoint GND at DOCK box
  - DOCK connected to CDC (detector structure)
- Isolated LV – DC-DC
- Non Isolated HV
  - Gnd via resistors
- FDAC – Differential Transmi.

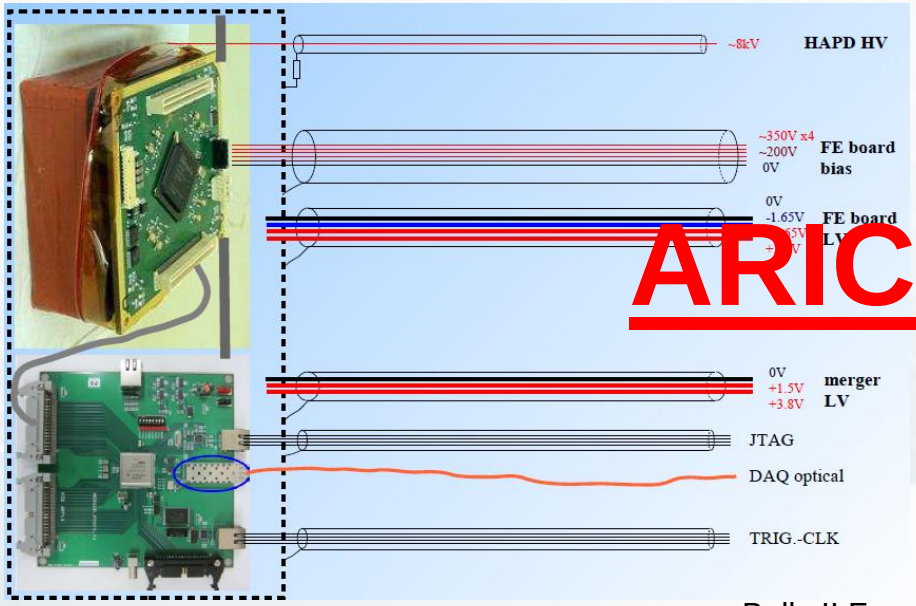
SVD



3.1 Grounding Topologies

- Multipoint GND
- Isolated LV
- Non-isolated HV
  - 100/200 ohms common ground at FEE
- LV shields connected locally



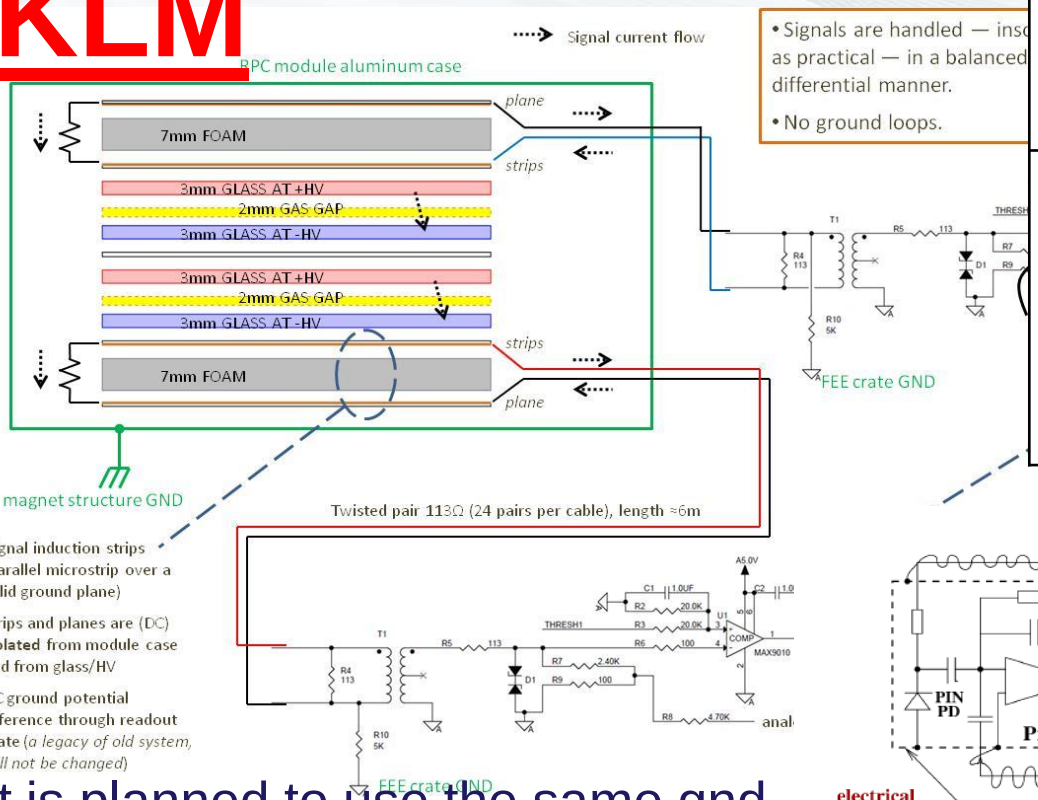


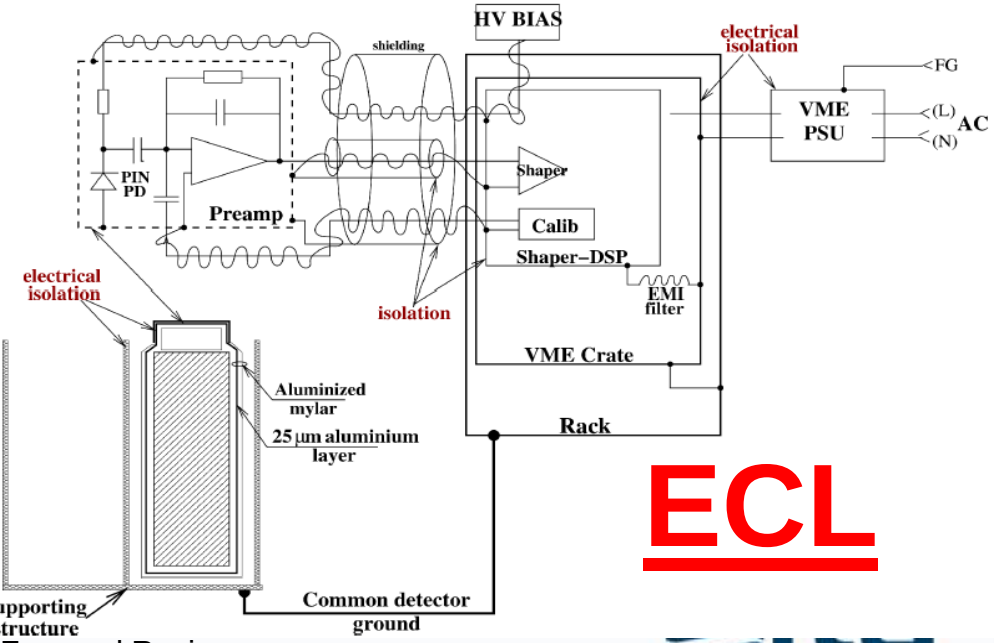
- Plan to ground at the detector side – support structure
- LV, HV, Bias, DAQ cables connected to the detector
- Signal processing done at the front-end board shielded.
- Pick-up noise not observed

3.1 Grounding Topologies

bKLM

Grounding topology	“Single-point” at each detector module (multipoint)
Grounding connections	AC ground at detector, DC ground at readout crate; HV DC ground at power supply

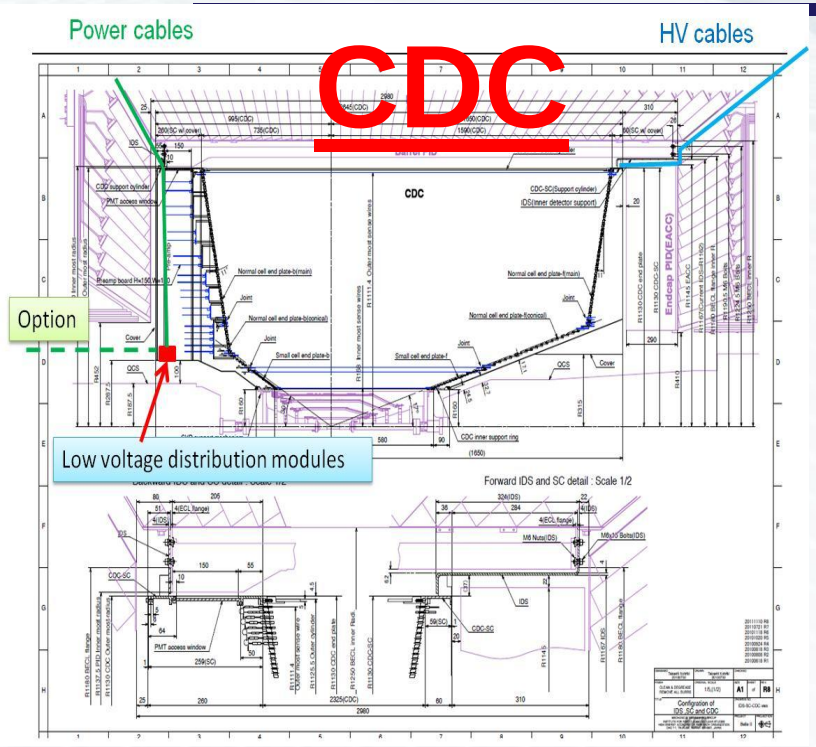




ECL

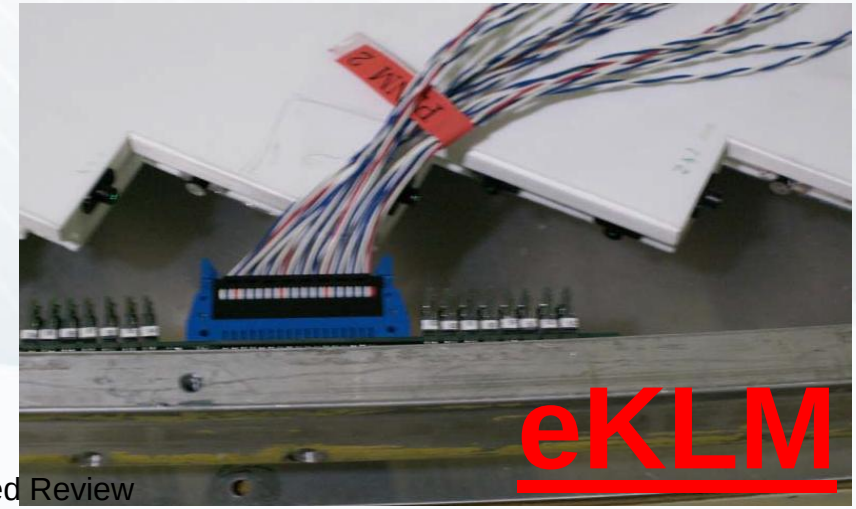
- It is planned to use the same gnd scheme as for Belle. (good results)
- No connect:
  - Mech.structure - FE board
- Connection: FE amp gnd frame
- Shield connected 1s

3.1 Grounding Topologies



- It proposes an isolation ground philosophy.
- It required to be separated from Belle-II structure, BPID, SVD and others.
- Signal ground connected to:
  - The backward end plate in the CDC
  - Through the power modules in the electronics hut.
- High voltage ground may be disconnected from the forward end plate.

- Grounding topology still open
- Some test set-up are ready for noise measurements:
  - They plan to study several ground topologies.



3.2 Grounding summary

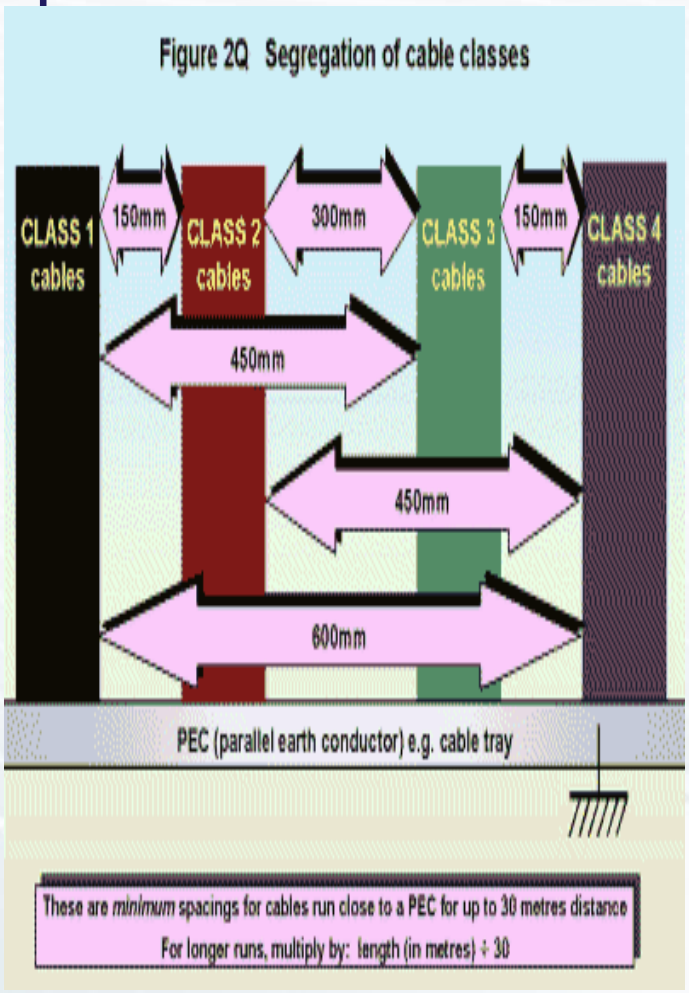
- The sub-detectors have presented different gnd strategies
  - Locally , floating, multipoint ,…
- A general **grounding policy should be defined.**
- Even in sub-detectors that are intrinsically immune to noise, grounding should be coordinated in order to avoid EM radiation to neighbors.
  - **Special attention should be paid to large floating system** due to the creation of uncontrolled noise paths.
- **A detailed definition of electrical schematics and grounding techniques may be used to start coordinating the installation of sub-systems**
  - These activities will be carried out by a group of people (Belle II)
- **It is recommended to evaluate the grounding technique at prototype level before installation**
  - It will help to take corrective actions in advance

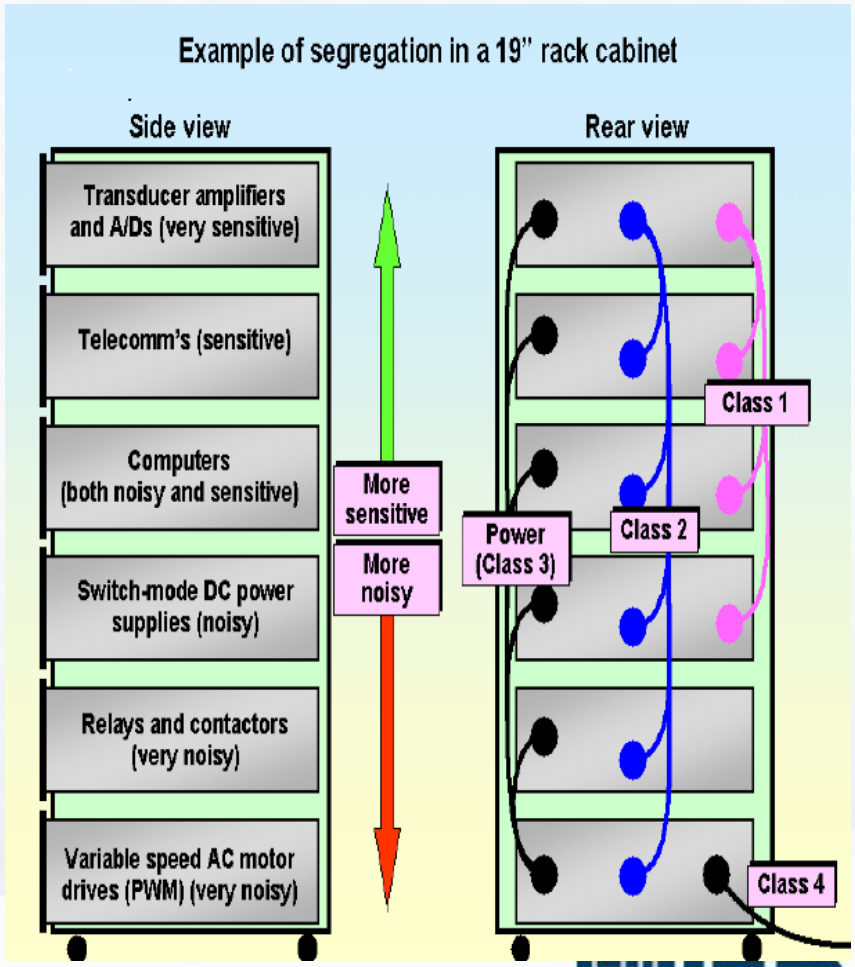
4. Cabling issues

- There are two elements that play an important role in the electromagnetic noise level of any experiment:
  - Cables
  - Racks
- They may cause many EMC problems:
  - Cable radiation
  - Cable susceptibility
  - Malfunctions due to high electronics density
- The EMC effects of this type of elements may be decreased by design (layout and connectivity)
  - Some recommendations were presented
  - They may be implemented wherever possible

4. Cabling issues

- Cables and racks components of different EMC categories should be laid separately wherever possible

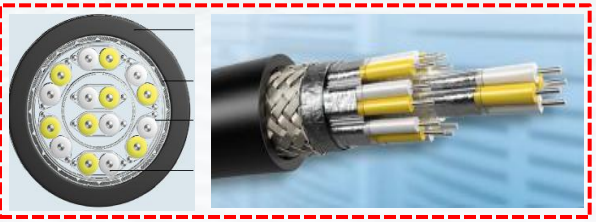


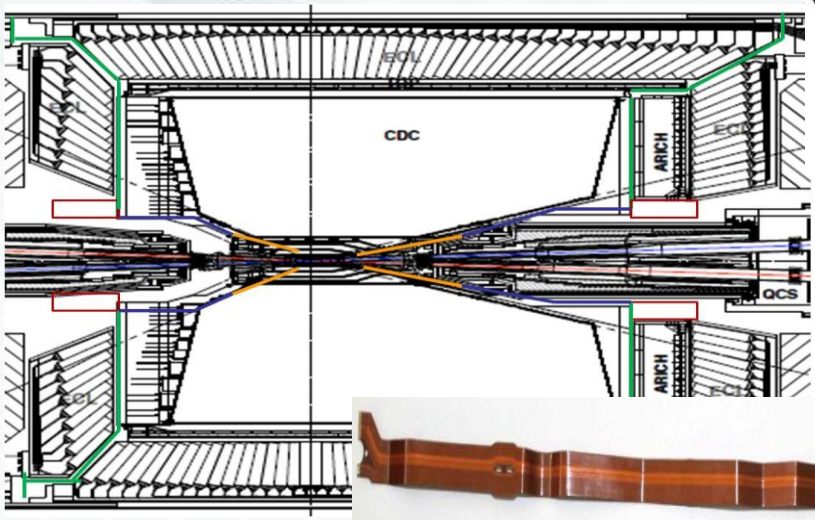


4.1 Sub-detector cabling

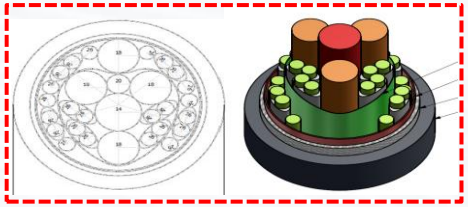
- The cable layout and power levels of each sub-detector have been discussed during the meetings.
- There is a wide variability of different options
  - Type of cable
    - Some of them are new
    - In some cases it is planned to use Belle I cables
  - Power levels
    - KV, V, Signal , power …
- Common cable channels have been shown
  - There are some areas that need to be analyzed in detail to avoid interference problems
    - Some cables are shielded and others not at all

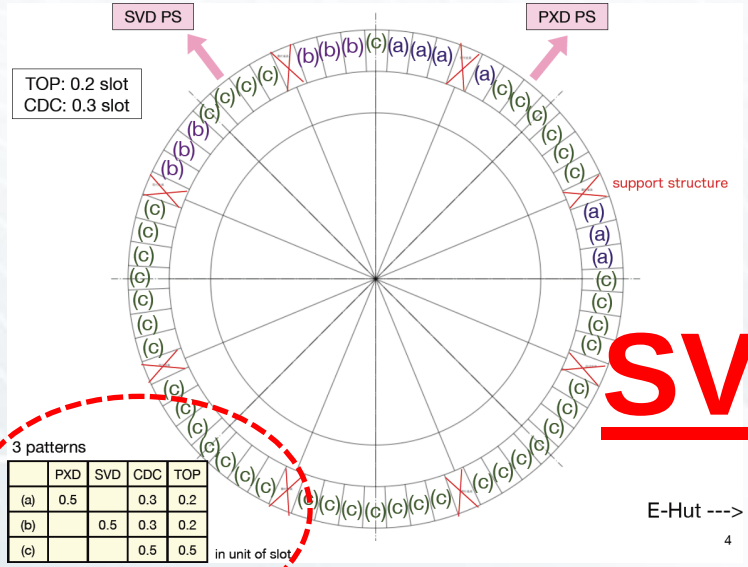
4.1 Sub-detector cabling





PXD



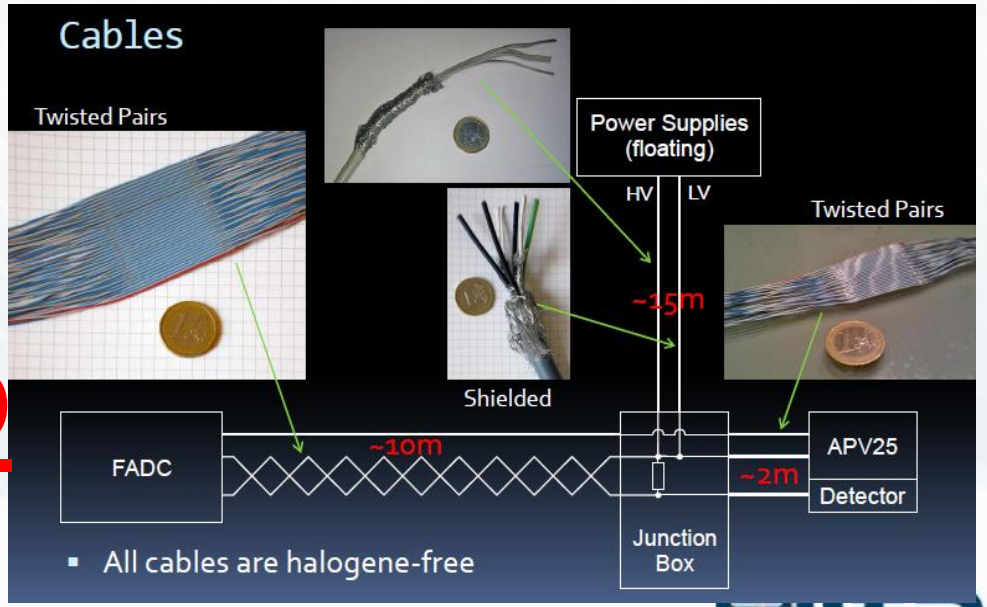


3 patterns

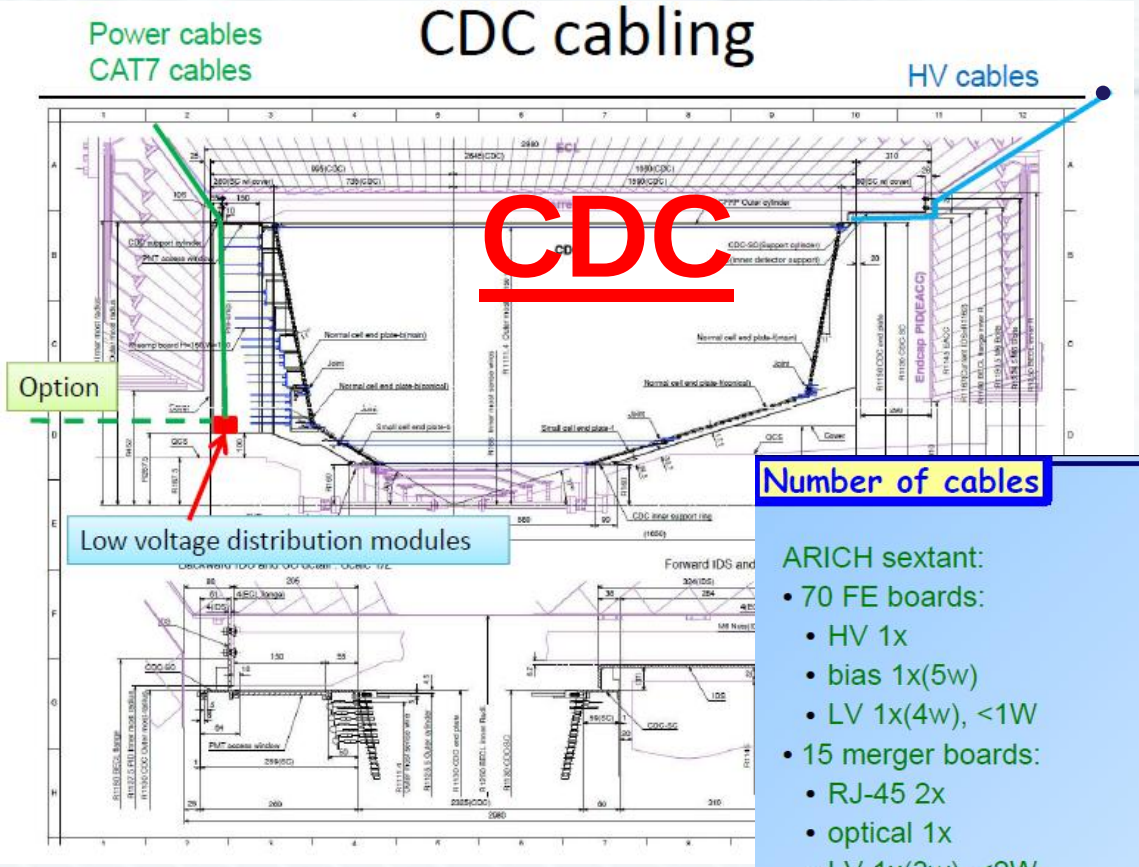
	PXD	SVD	CDC	TOP
(a)	0.5		0.3	0.2
(b)		0.5	0.3	0.2
(c)			0.5	0.5

in unit of slot

SVD



4.1 Sub-detector cabling



Definition of cable power levels

- +5.5, +3.8, +2.0, +1.5

Number of cables

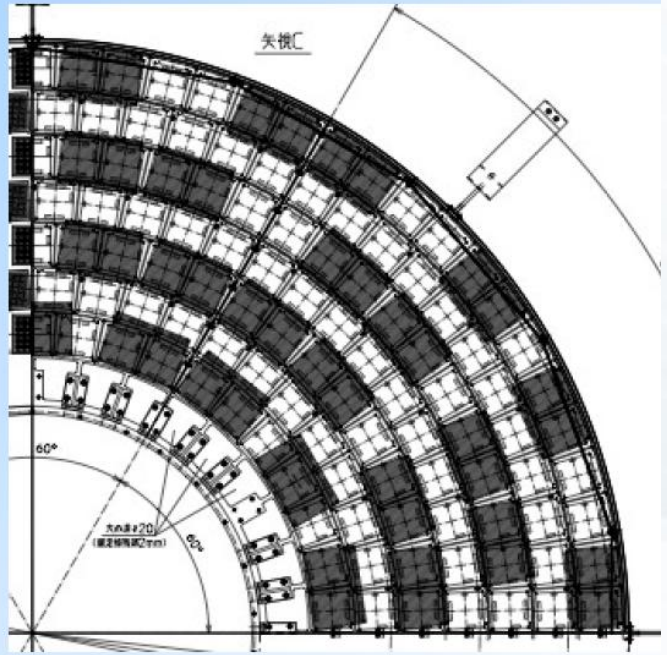
ARICH sextant:

- 70 FE boards:
  - HV 1x
  - bias 1x(5w)
  - LV 1x(4w), <1W
- 15 merger boards:
  - RJ-45 2x
  - optical 1x
  - LV 1x(3w), <2W

In total:

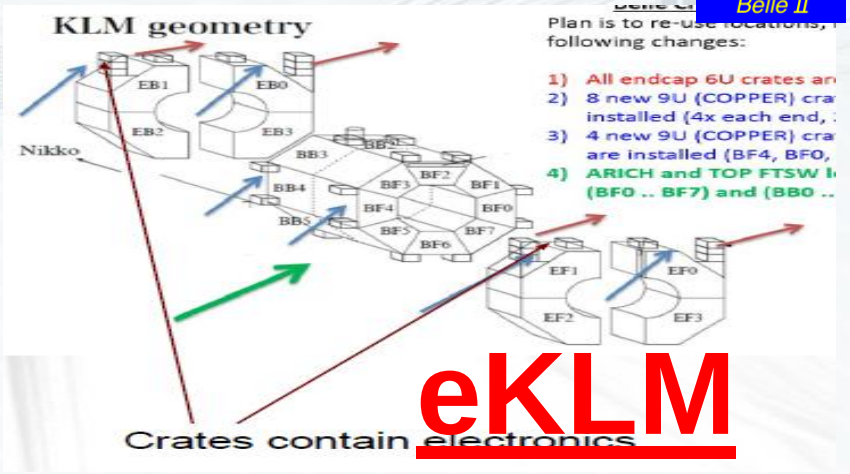
- 420 FE boards
- 90 merger boards

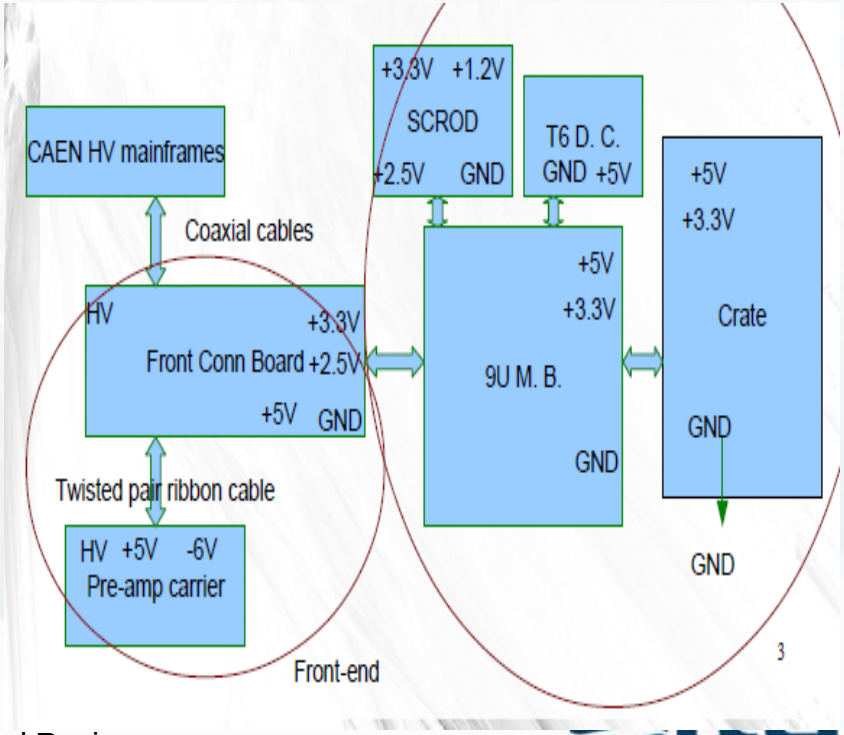
ARICH



4.1 Sub-detector cabling

layout	Exit radially from the magnet to readout crates nearby on perimeter of magnet
levels	12V, 5V, 6kV , -3.5kV
Types	Unshielded twist-n-flat signal cable, RG-59 HV cable





4.2 Cabling summary

- The cable layout and power levels of each sub-detector have been partially presented
- Some areas are common to different sub-detectors and mix different types of cables – Detail analysis is required
- Attention should be paid to cable shield as well as noise sources.
  - Interference evaluation: Noise sources vs type of cable
- A collection of safety rules beyond the ampacity of the cables should be defined and communicated to all sub-detectors
  - Noise & Transients
  - fuse coordination , electronic protection, de-rating cable ampacity for cable bundles
- It is recommended to create a committee that reviews and enforces that the cable and wire layout complies with rules
  - Belle II and KEK members

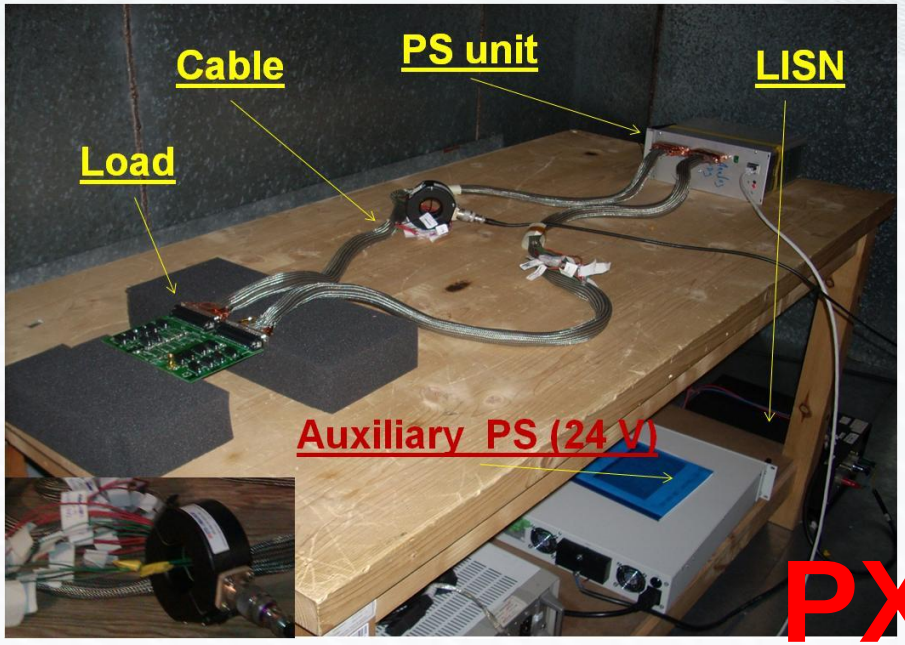
5. EMC issues

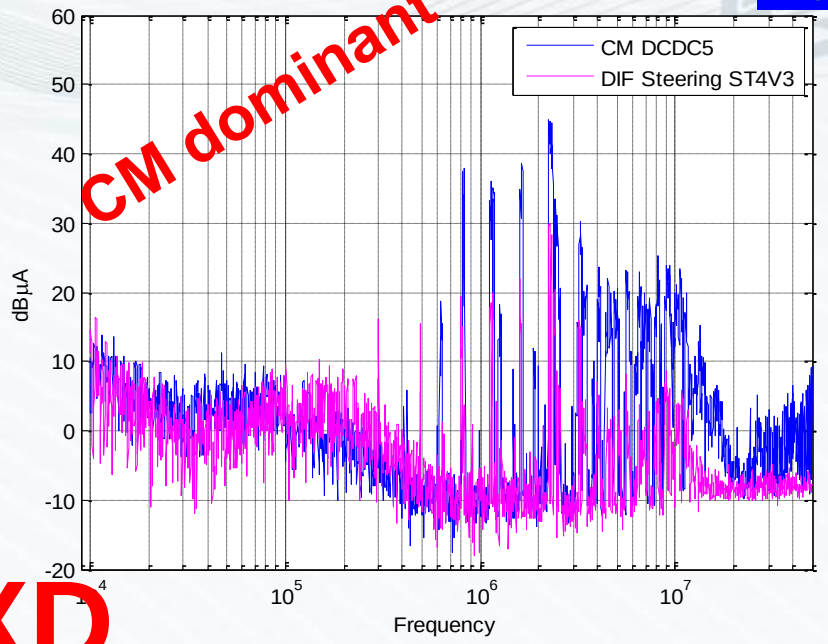
- Analysis & tests to ensure the compatibility level among noise sources and victims have started
- This noise control is being tackled at two levels
  - **Noise emissions analysis**
    - Noise emission test (conducted and radiated)
  - **Noise immunity analysis**
    - Signal circuit analysis
      - It will help to define grounding topologies
    - Noise Immunity test
      - Evaluate grounding topologies
      - Ensure the compatibility of the FEE
    - Subsystem evaluation: Signal to noise quantification

5.1 EMC issues - Emissions

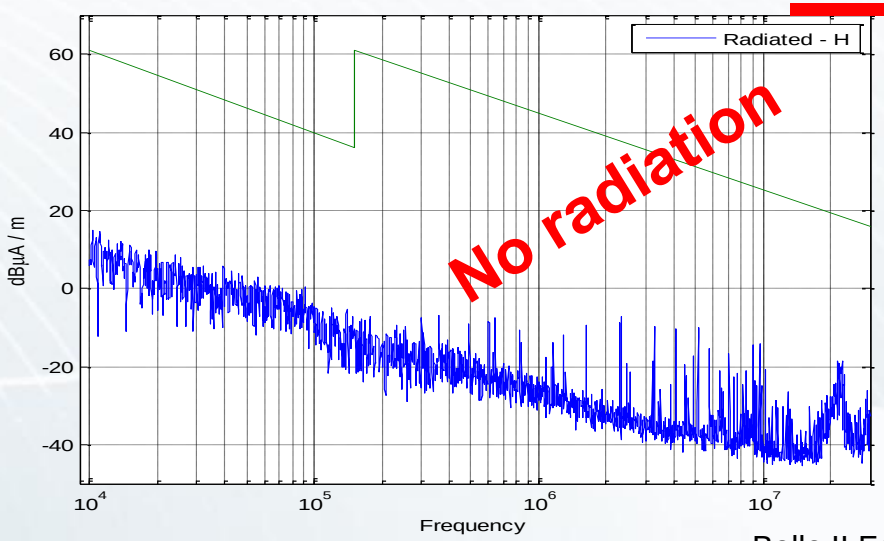
- One of the most important noise sources in Belle II are the power supplies.
  - Several of them have been developed with DC-DC
- They have EM emissions
  - Radiated
  - Conducted Emissions
- The spectra content is very closely related to :
  - Switching frequency - Topology
  - Few kHz up to MHz
- The emission level of the power supply has to be coordinated:
  - Sub-detector level
  - Experiment level

5.1 EMC issues - Emissions





PXD



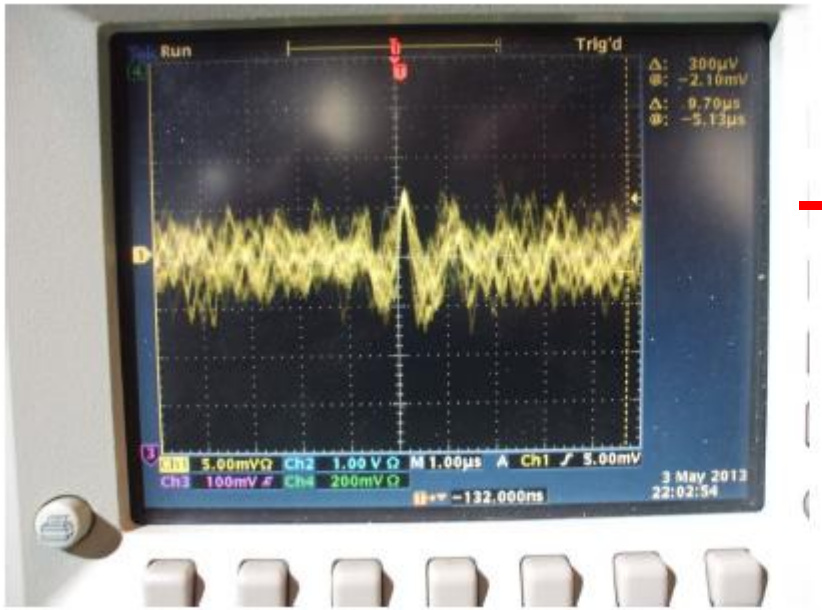
5.2 EMC unit analysis: Noise immunity

- Are the PS noise emissions (or other) compatible with the FEE ??
  - Do we have enough safety margin ?
- Noise sources that deteriorate the FEE performance are:
  - Intrinsic thermal noise
  - EM contribution detector – FEE – PS - others

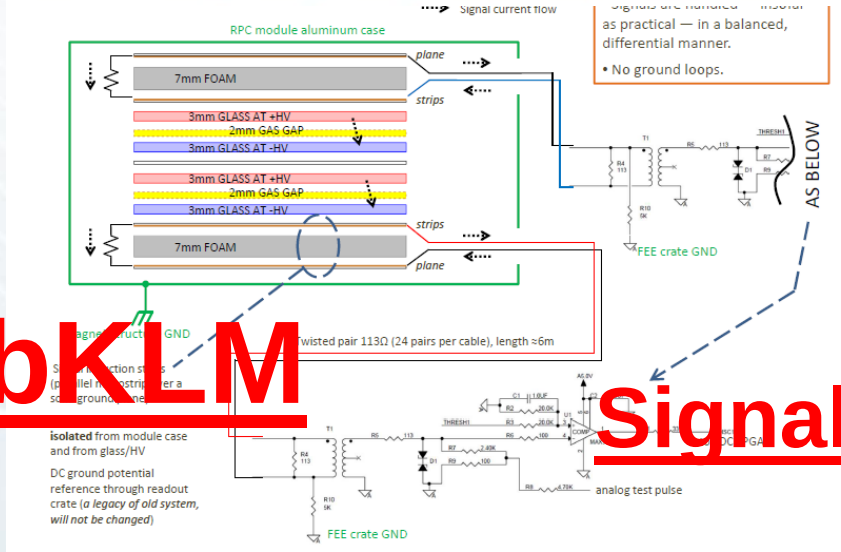
$$n_a(t) = n_{th}(t) + n_{in}(t) + n_{ps}(t) + \ldots$$

- This noise defines the minimum signal level that the FEE can process – Thermal noise dominant effect
  - EMI contribution characterization important
- The characterization of EMI contributions may be carried out via :
  - Modeling and simulation of system
  - Immunity tests on prototypes
- The main goals of this EM characterization are:
  - Evaluate grounding topologies
  - Ensure the compatibility of the FEE
  - Subsystem evaluation : Signal to noise quantification

5.2 EMC issues - Immunities



ECL
System Verification



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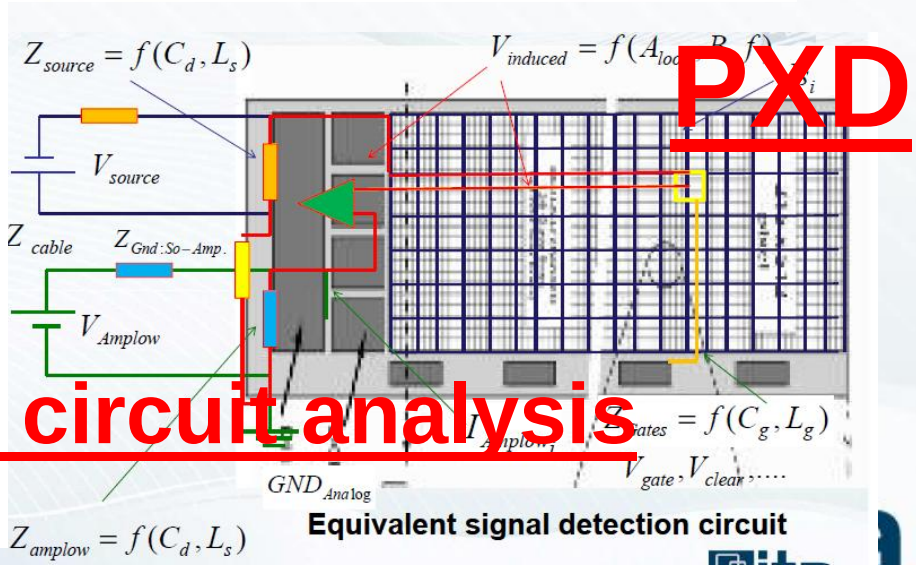

PXD

Signal circuit analysis

5.3 EMC summary

- Analysis and test to ensure the compatibility level among noise sources and victims has started .
- The noise control is tackled at two levels
  - Noise emissions
  - Noise immunities
- Some subsystems have presented EMC plans and tests but it is still necessary to prepare a detailed global plan.
- This plan will help to define sensitive frequencies that may interfere among sub-detectors
- Some of the immunity tests will be very useful for final grounding topology of each sub-detector
  - Still under development

6. Future Plans

- Electrical safety rules for Belle II need to be clarified.
- An overall "Belle II" grounding diagram and more detailed EMC plan should be prepared.
  - Each sub-detector system will provide a very detailed /grounding overview (simplified schematic) & EMC plans
- It will be necessary to establish a grounding and EMC responsible at KEK in order to follow the indications.
  - This person may act now as a link person Belle II - KEK
- It is planned to follow up all plans in order to define global aspects of the Belle II integration
  - Cabling (Short term)
  - Grounding (Short-medium term)
  - EMC (long term)

7. Conclusions

- A general overview of the status and plans of the grounding and EMC issues has been presented
- EMC & grounding activities started one and a half years ago
  - All sub-detectors have been involved
  - Several meetings were held
- On July , we had a GND & EMC review at VPI, USA
- This review has produced a significant step forward
  - Groundings configuration
  - Cables layout
  - EMC issues
- This is only the beginning of a long work.