AGATA PROJECT

EMC Qualification @ AGATA

By: N. Karkour and M. Tripon
Outline

- EMC Requirements for Agata.
- EMC qualification Methods.
- Legnaro Demonstrator Campaign
- MDR cable Qualification
- Agata Triple Cluster (ATC) detector
- GSI phase1 Campaign
- GANIL 1 PI Campaign
- IPHC and CSNSM installations and qualifications.
- Conclusion
EMC Requirements for Agata

- AGATA signal resolution is severe ($10^{-4}$ or .1 keV)
- AGATA construction is Highly Expensive
- Insure proper signal integrity from detector to DAQ
- Immunity to High Frequency noise above 100 MHz. 2 mV @ 1 KV fast transient pulse
EMC Qualification Methods

- A meeting should be held with the infrastructure (usually mechanical) team during mechanical design.

- A specification for the EMC requirements specific for the project should be written and distributed which integrates all the precautions to be taken.

- A verification process to insure that the requirements fulfill the specification before manufacturing.

- 2 EMC qualification campaigns programmed: before detector mounting and after detector mounting.

- 3 measurements are made (resistance calculation, direct and capacitive injection) during each campaign.
The 4 wire resistance measurement is a very accurate way to measure the resistivity between different mechanics in the same array @ DC level.

- It requires 2 wires to inject a known DC current between two points.
- Measure the voltage drop between the contact points.
- The resistance value of the structure = the voltage drop by the current. 
  \[ R_{mec} = \frac{DV}{I_{amps}} \]
Direct and Capacitive Injection

- Capacitive injection through aluminum foil
- Direct injection through ground for common mode rejection

Preamplifier connected to a dummy card with 50 ohms resistance. The diagram also shows a scope with a waveform indicating pulse and burst signals. The repetition period depends on the test voltage level.
Legnaro Demonstrator Campaign

Qualification made with A. Charoy, A. Richard, M. Tripon et N. Karkour
Legnaro Demonstrator Campaign

N. Karkour

Journée CEM Mars 2015

Digitiser

DAC output

ADC

DAC

Preamplifier measurements

Analog inspection lines
250 mV p-p equivalent to 1 MeV noise

- Results on the noise injected into the detector mechanics chassis
- The fast transient noise generator output has been directly connected to the mechanics.
- The fast transient noise output is 500 V signal because @ 1 kV the preamplifier output was saturating.
- The following measurements were made at the Analog inspection lines of the digitisers. They concern the core preamplifier signal for the 3 crystals

1 V p-p equivalent to 4 MeV noise
The MDR cable shield is stopped at the input of the connector. There is 100 mΩ resistance between the connector shell and the cable shield.

Long copper ground wires, plastic brades

the MDR cables are not shielded externally by a metallic tray
Legnaro Demonstrator Campaign
Setup for the MDR Cable Qualification
Infrastructure Setup for the Cable Qualification
MDR Cable Qualification results

MDR CABLE

MDR CABLE Vpp ~13 mV
Vpp < 6 mV if scope intrinsic noise is deduced

COAXIAL CABLE

SCOPE FREE INPUT

COAXIAL CABLE ~ 45 mV
SCOPE FREE INPUT
Vpp between 6.56 mV and 7.5 mV

N. Karkour

Journée CEM Mars 2015
Conclusions on the Legnaro Campaign

- MDR cable connector shield must be modified.
- MDR cable must be surrounded by metallic sleeve from beginning to the end.
- All mechanical structure should be connected with Large copper connections
- Meeting with the cologne and CTT company to improve preamplifier mother board grounding (Preamplifier motherboard was rerouted)
- Propositions to improve grounding connections to the digitisers bay from Legnaro people will be done somewhere in 2010.
Agata Triple Cluster (ATC) detector

- Qualification made with M. Tripont et N. Karkour
Agata Triple Cluster (ATC) detector
The FTPG output was adjusted to 1 kV signal

Direct: \( V_{p-p} = 5 \, \text{mV} \) OK
-106 dB

Capacitive: \( V_{p-p} = 45 \, \text{mV} \) just fine limit
-87 dB
AGATA Phase 1 @ GSI

- Design Review with the mechanical engineers
- Design verifications Review
- 2 qualification trips by N. Karkour and M. Tripon
Design Review and Recommendations

Beam Direction
HECTOR Target
AGATA

LYCCA
Earthing Straps to be mounted at these locations
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4 wire resistor measurements

<table>
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<th>Measured point</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>2.7</td>
<td>2.68</td>
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AGATA @ GSI

Direct injection measurements

Measuring noise @ 2 kV < -110 dB

Results: \( V_{\text{noise}} = 10 \text{ mV} \) OK
AGATA @ GSI

Capacitive injection measurements
AGATA @ GSI

Capacitive injection measurements

Measuring noise @ 2 kV < -110 dB

Results: $V_{\text{noise}} = 6.40 \text{ mV OK}$

Results: $V_{\text{noise}} = 6.21 \text{ mV OK}$
AGATA Phase 1 PI @ GANIL

- Design Review with the mechanical engineers
- Technical Specification
- Design verifications Review
- 2 qualification trips by N. Karkour and M. Tripon
AGATA @ GANIL

Recommendation on the design and what was done
AGATA @ GANIL
4 wire resistance measurements

resistance value( mOhm)

N. Karkour
Journée CEM Mars 2015
Conclusion: a crocodile clip was the cause of the bad contact
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Direct Injection measurements

FTP Generator output fixed to 4 kV!!

- This figure shows 63 mV Voltage difference on the point B of the electronics Bay
- The SNR = -96.0 dB
• This figure shows a 69 mV Voltage difference on the VAMOS electronics Bay.

the SNR = -95.26 dB
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Direct Injection measurements

FIGURE1. Graphics showing the SNR value of each measured point in direct injection
4 Wires resistance measurement results on the 5th of November 2014

The resistance measurement made on the 5th of November between the AGATA mechanical ground and the ATC5 gave a resistance value from 2.60 to 14 mΩ. See the figure below.
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4 Wires resistance measurement results

value from 2.60 to 14 mΩ.
• We chose digitiser 20 with the analogue inspection lines outputs of core and segment.
• And digital inspection lines where the ADC raw data coming out of DAC.
• The same setup described in the first measurements was used (4 kV of FTP).

Core Inspection line before connecting the CSP.
• Yellow signal the segment analog inspection line (-98 dB)
• Pink signal is the core analog inspection line (-82)
• Blue is segment raw ADC data to LLP through DAC (- 96 dB)
• Green is core raw ADC data to LLP through DAC (- 88 dB)
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Capacitive Injection results

- Yellow signal is the segment analog inspection line (-95 dB)
- Pink signal is the core analog inspection line (- 71 dB)
- Blue is segment raw ADC data to LLP through DAC (- 94 dB)
- Green is core raw ADC data to LLP through DAC (- 79 dB)
Capacitive Injection results

- Black without FTP, red with FTP.
- A low energy (nearly 0) red peak.
- The energy resolution is not effected. It is filtered by the MWD algorithm.
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Capacitive Injection results

- Long trace of the core and the corresponding segment channel where the gamma ray was detected.
- The red trace is the core signal (with spikes).
- The black trace is the segment signal (no spikes).
- The same as the EMC measurements showed above. The FTP effect can affect the Tracking and PSA algorithms.
Conclusions from the GANIL Measurements

- Excellent EMC qualification results. Except the core Preamps (already observed while qualifying the ATC 5 in cologne).
- Direct injection 4 kV signal peak to observe noise effect.
- Capacitive injection rejection is made with detectors mounted.
- Three measurements during installation is extremely important. It gives time to mechanical modifications if needed.
- Other measurements can be made after adding more detectors or if there are any noise on detectors. Don’t hesitate.
- Many thanks to the Local Staff who helped us in this campaign during the infrastructure installations (bays, racks, cables, electricity, etc...)
Mesures CEM à l’IPHC Exemple à suivre

CMRR < -110 dB
Vinj = 4kV
V out < 15 mV
FM Jacket to eliminate trace noise

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Mesures CEM dans la salle SIRIUS BETA2 au CSNSM

CMRR < -110 dB
Vinj = 4kV
V out < 15 mV
Mesures CEM dans la salle SIRIUS BETA2 au CSNSM

4 Wire resistor : < 10 mOhm

Direct injection :
< 15 mV @4kV
<-110 dB
Mesures CEM dans la salle SIRIUS BETA2 au CSNSM

Test sur signal gene 4,5 V avec

-20 dB
-40 dB
-60 dB
-70 dB

Canal 12126
Canal 1222
Canal 122
Canal 40