Status Report of the CG3G-Production

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University of Bonn

COMPASS/AMBER Technical Board
23.03.2021

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New Detectors for 2021 (CG3G)

- Triple-GEM tracking detector
- Replacement for CG1G detectors (30.7 cm x 30.7 cm active area)
- No spacer grids
- Cut strips without centre pixels (extendable in future)
- Additional copper etching
- Avoid gas blocking due to rims
- Central region can be deactivated remotely
- HV distribution via Stabilized-Voltage-Divider
- Helpful knowledge from previous production & ALICE upgrade
Status of Production TB 19.01.2021

- GEM foils and readout circuits for 2 detectors received from CERN, optical test ok
- frames for 2 detectors received, being prepared
- support plates for 2 detectors received, strong bending of large ones observed, will be reproduced by company
Status of Production TB 23.03.2021

• 3 GEM foils framed
• 1 drift-foil glued on HC-plate
• Successful reproduction of large HC-Plates
• Orders in preparation for material for 4 detectors (in total)
First Production

Glueing
First Production

Glueing
The CG3G-Production
(p.d. - per detector)

In lab:

• 3 framed GEMs
  (3 GEM foils, 2 spacer frames, 1 drift frame)
• 3 GEM foils
  (2 not yet tested and 1 with increasing current for a segment)
• 3 drift foils
• 3 R/O foils
  (2 random 1 complete tested- no shorts found)
• 2 spacer frames
• 2 R/O frames
• 1 drift frame
• 3 large HC plates
• 2 small HC plates

Additional material for 4 detectors in total:

• min. 7 GEM foils (+3 p.d.)
• min. 1 drift foil (+1 p.d.)
• min. 1 R/O foil (+1 p.d.)
• min. 4 spacer frames (+2 p.d.)
• min. 2 R/O frames (+1 p.d.)
• min. 2 drift frames (+1 p.d.)
• min. 1 large HC-plate (+1 p.d.)
• min. 2 small HC-plates (+1 p.d.)

Costs for additional material:

• ~18-20k for foils
• ~3k for HC-plates
• ~6k for pitch adapter -> see APV
Electronics

Current Status:

- 10 FE-cards in Lab
- Ca. 50 FE-cards possible with existing pitch adapters
- Wire bonding done at PI, Univ. Bonn
  New: potting of bonds

Required (p.d.):

- 24 FE-cards
- 4 fanout-cards
- 2 (new) ADCs

→ Ca. 50 FE-cards needed in addition (pitch adapter needed 3k+3k)
Electronics

ADC

Done:

- Schematic (Igor, TUM)
- Layout
  (C. Tezel, C. Honisch, HISKP Bonn)
- Order PCB / Pasting template for 3 prototypes

Necessary:

- Order components
  (Igor will provide some, still has to be clarified)
- Assembly (will be done at HISKP Bonn)
- Smoke test
  (we can probably do this in Bonn)
- Status of firmware?
- General functionality test (for this one needs suitable firmware and an IFTDC)

→ CG3G can only be fully read out with new ADC and corresponding R/O-chain
  (Currently not possible in Bonn -> to be set up)
Upgraded Triple GEMs (CG3G)

- **New ADC chain (iFTDC)** (for 24 APVs in total)
- **1 station = 2 detectors = 4 planes**
- **24 APV25 (S1) per plane**
- **Required Power Supply Rails for 1 Detector:**
  - 4 kV, 1 mA for GEMs & Drift
  - 3.3 V, 3 A (4x) for APV Supply (floating, remote sense wires)
  - 5 V, 3 A for each ADC (floating)

- **Flat cable:** EQDP-014-40.00-STR-SBL-5-B
- **S-HV cable:** HV COAX.CABLE HTC-50-1-1, 5kV, RED, type HTC-50-1-1
- **Rohde&Schwarz NGP804 | 4 chan. (each 20 A), 800 W**
- **A732N (6kV, 1mA)**
## LV Configurations

<table>
<thead>
<tr>
<th>Generation</th>
<th>p.s. type</th>
<th>GMnnU1</th>
<th>GMnnV1</th>
<th>GMnnX1</th>
<th>GMnnY1</th>
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</thead>
<tbody>
<tr>
<td>CG1G</td>
<td>APV: CAEN A516</td>
<td>2ch, ±3.5V, -0.9A, +0.7A</td>
<td>2ch, ±3.5V, -0.9A, +0.7A</td>
<td>2ch, ±3.5V, -0.9A, +0.7A</td>
<td>2ch, ±3.5V, -0.9A, +0.7A</td>
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<tr>
<td></td>
<td>APV: NGP804</td>
<td>2ch, ±3.5V, -1.8A, +1.4A</td>
<td>2ch, ±3.5V, -1.8A, +1.4A</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>ADC: DN35-5</td>
<td></td>
<td>2ch, ±5V, +3.2A, -0.6A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG2G (PGEM)</td>
<td>APV: DN35-5</td>
<td>2ch, ±3.5V, -1.8A, +1.4A</td>
<td>2ch, ±3.5V, -1.8A, +1.4A</td>
<td>2ch, ±3.5V, -1.8A, +1.4A</td>
<td>2ch, ±3.5V, -1.8A, +1.4A</td>
</tr>
<tr>
<td></td>
<td>ADC: DN35-5</td>
<td></td>
<td>3ch, ±5V, +6A, -3A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CG3G</td>
<td>APV: NGP804</td>
<td>1ch, +3.3V, 8-12A</td>
<td>1ch, +3.3V, 8-12A</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>ADC: NGP804</td>
<td>1ch, +5V, &lt;6A</td>
<td>1ch, +5V, &lt;6A</td>
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<td></td>
</tr>
<tr>
<td>CG4G</td>
<td>VMM (SRS): NGP804</td>
<td>1ch, 1.9-3.5V, 19.2A</td>
<td>1ch, 1.9-3.5V, 19.2A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Auxiliary</td>
<td>1ch, 2.9-3.5V, 2.4A</td>
<td>1ch, 2.9-3.5V, 2.4A</td>
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</table>

For Center HV switch: 1 ch 12V, no current ⇒ find simpler solution
## LVPSU Costs

### Item Details

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
<th>Description / Estimated Delivery (Weeks)</th>
<th>Part Number</th>
<th>Qty, pc.</th>
<th>Unit Price CHF</th>
<th>Total Price CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NGP800 Power Supply</td>
<td>Four-channel power supply 0V to 32V, max. 20A per channel max. 200W per channel (800W total) 5” capacitive touch screen QuickArb, Sense electronic fuse, FuseLink OVP, OPP, OTP USB/LAN interface Country of Origin: Malaysia</td>
<td>5601.4007.02</td>
<td>10</td>
<td>4,290.00</td>
<td>42,900.00</td>
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<td>1.1</td>
<td>NGP804</td>
<td></td>
<td>5601.4007.02</td>
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<td>-15.00%</td>
<td>36,465.00</td>
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<td>1.2</td>
<td>ZZA-GE23</td>
<td>19 inch rack adapter, 2HU, for R&amp;S®NGP800 power supplies (accessory)</td>
<td>5601.4059.02</td>
<td>10</td>
<td>286.00</td>
<td>2,860.00</td>
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Country of Origin: Malaysia

Country of Origin: Czech Republic

### Item Price (1) CHF

<table>
<thead>
<tr>
<th>Item Price (1) CHF</th>
<th>Total Net Price CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,576.00</td>
<td>45,760.00</td>
</tr>
<tr>
<td>-15.00%</td>
<td>-15.00%</td>
</tr>
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</table>

Total Net Price CHF: 38,896.00

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Essential technical modifications may make it necessary to replace certain items ordered by the customer with new successor items. In this case, the customer agrees to the modification of the subject matter of the contract even after placement of the order, provided that the agreed terms and conditions are retained and that the successor item complies with the technical specifications of the item ordered by the customer.

The customer has to make all payments from a bank account under their name. The customer is liable for all payments from the contractual relationship and must ensure compliance with all applicable legislation, in particular on the prevention of money laundering.
# Status of GEM Stations

<table>
<thead>
<tr>
<th>Station</th>
<th>Status/Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM03-GM05, GM06XY, GM07-GM09, GP02</td>
<td>tested without Problems</td>
</tr>
<tr>
<td>GM01 und GM02</td>
<td>not tested</td>
</tr>
<tr>
<td>GM06UV (port 5)</td>
<td>problem concerning FPGA (comment 63023) -&gt;port 5&amp;6 were excluded in database</td>
</tr>
<tr>
<td>GM10</td>
<td>cable too short for HV (comment 63024) -&gt;only LV was turned on</td>
</tr>
<tr>
<td>GPXX</td>
<td>some empty entries while occupancy measurement -&gt;should be tested in next dry run</td>
</tr>
</tbody>
</table>

-> Plan: all stations will be ready for dry run (except GM11)
Thanks

- stay healthy

CG3G in fictional Lab
First Production

HC-Plates
First Production

APV
STRETCHING TOOLS

- Foil stretching by pneumatic DEK (Vectorguard®) frame produced by ASM Assembly.
- Foils equipped in aluminium profiles (Optiguard®) – see “QA of GEM foils”
- Foil in a profile is installed in the DEK frame
- By applying 0.5 MPa pressure DEK claws open allowing foil to be installed
- Releasing pressure closes DEK claws which stretch GEM
- DEK frame stretching force: 10 N/cm
Triple GEMs with VMM (CG4G)

Auxiliary front-end electronics: $(2.9 - 3.5) \text{ V}, 2.4 \text{ A} \rightarrow 6.9 - 8.4 \text{ W}$

Example SRS VMM hybrid:
- 2 VMM ASICs, Aux. (FPGA, ...)
- VMMs: $(1.9-3.5) \text{ V} @ 1.67 \text{ A}$
- Aux.: $(2.9-3.5) \text{ V} @ 0.1 \text{ A}$
→ 24 hybrids/detector

Bare VMM ASIC: $\sim 0.8 \text{ A} @ 1.2 \text{ V}$
48 VMM ASICs need/detector

VMM ASIC Power: $(1.9 - 3.5) \text{ V}, 4 \times 10 \text{ A} \rightarrow 76 - 140 \text{ W}$
Upgraded Triple GEMs (CG3G)

- 1 station = 2 detectors = 4 planes
- 24 APV25 (S1) per plane

Required Power Supply Rails for 1 Detector:
- 4 kV, 1 mA for GEMs & Drift
- 3.3 V, 3 A (4x) for APV Supply (floating, remote sense wires)
- 5 V, 3 A for each ADC (floating)

New ADC chain (iFTDC) (for 24 APVs in total)

Status GEM Detectors - TB 19.01.2021 - Bernhard Ketzer

1. Rohde&Schwarz HMP4040 | 4 chan. (each 10 A), 384 W
2. Rohde&Schwarz NGP804 | 4 chan. (each 20 A), 200 W p.ch.

(-> only one PS per station?)
Open Questions

- GEM11? (place GEM04)
- Status of spare-electronics for first generation
- Status PoSu
- Summation-cards for first tests of CG3G
- Business travel to CERN for Tasks?
- Which tasks need to be done before dry-run?
Ongoing large-size GEM (CG3G)

- 30.7 cm x 30.7 cm active area
  - Strips divided in the centre to reduce occupancy
- 13-fold top-sectored GEM
- Spacer without grids
- Gas-inlet via drift plate
- Honeycomb plates

<table>
<thead>
<tr>
<th>Electrode</th>
<th>COMPASS / V</th>
<th>BONN / V</th>
</tr>
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<tbody>
<tr>
<td>Drift</td>
<td>−4100</td>
<td>−3255</td>
</tr>
<tr>
<td>GEM1 TOP</td>
<td>−3353</td>
<td>−2508</td>
</tr>
<tr>
<td>GEM1 BOT</td>
<td>−2943</td>
<td>−2102</td>
</tr>
<tr>
<td>GEM2 TOP</td>
<td>−2196</td>
<td>−1751</td>
</tr>
<tr>
<td>GEM2 BOT</td>
<td>−1822</td>
<td>−1384</td>
</tr>
<tr>
<td>GEM3 TOP</td>
<td>−1075</td>
<td>−1068</td>
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<tr>
<td>GEM3 BOT</td>
<td>−747</td>
<td>−747</td>
</tr>
<tr>
<td>PCB</td>
<td>(GND) 0</td>
<td>(GND) 0</td>
</tr>
</tbody>
</table>
Frames for one Detector
Figure B.4: 2D efficiency maps for each projection of GEM4 for years 2008, 2015, 2016 and 2017
Stabilized Voltage Divider

- Prototypes assembled + tested
  - Output voltage stable for small loads
  - Current limited (~15µA)
  - Even smaller voltage change when loading neighboring pad
- Todo:
  - Test in detector

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<tr>
<td>GEM3 BOT</td>
<td>-747</td>
<td>-747</td>
</tr>
<tr>
<td>PCB</td>
<td>(GND) 0</td>
<td>(GND) 0</td>
</tr>
</tbody>
</table>
Progression of Compass Gem Generations

- **CG1G**: Large-size GEM
- **CG2G**: Updated Large-size
- **CG3G**: Large-size with Pixel
- **CG4G**: Self triggered readout e.g. with VMM
- **CG5G**: Large-size with Pixel

Timeline:
- 2001
- 2008
- 2021
- 2022
- 2023 - 2024?

COMPASS GEM DETECTORS - K. J. Flöthner
APV Frontend

Christian Honisch (honisch@hiskp.uni-bonn.de)

• One Detector:
  ▪ 4x Supply card
    ➞ Each 6x APV Front-End

• Improved input protection

• I²C temperature sensor

• I²C addresses: via detector connection
APV Frontend

Christian Honisch (honisch@hiskp.uni-bonn.de)

- Provides Power, Clock, Trigger to APV-FE
- Concentrates analog signals from APV-FE
- **Clock, Trigger, Analog: Matched Lengths**

- **Power Input**
  - 3.3V, 3A(max)

- **GPIO**
  - I²C, 16 IO

- **Clock / Trigger Fanout**
  - Outputs Matched to 150ps

- **Ribbon Cable Connector**
  - Analog
  - Clock, Trigger
  - I²C
ALICE IROC GEM foil in stretching frame
GEM Foil Design

- Triple GEM stack
- Foils segmented on one side: 12 sectors + centre
- All lines guided through one corner with coverlay protection
- Foils rotated in stack by 90°
- Cu thickness reduced
Readout Plane

- Readout from all sides
- 4x768 strips (cut in middle)
- Hirose FX10 replace older Panasonic P5 series