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**Miniaturised HV Power Supply**

**Deliverable: D13.6**

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**Abstract:**

**Compact MPGD HV power supply:** The desktop AVD is a remotely controllable, compact HV power supply for the operation of MPGD based detectors with up to nine user-defined fields. Specially designed for the operation of gaseous detectors, this supply includes active field stabilizers to compensate for dynamic loads and circuitry to protect from short circuits and sparking. The embedded control and monitoring system supervises all parameters and, associated with online Labview software, records and displays trending data of all HV channels. The front panel controls, combined with a status display, allow for local operation. The NIM-AVD unit will be fully contained within a dual-sized NIM module and, via a power adapter, it can be operated as desktop MPGD supply without NIM crate.
AIDA-2020 Consortium, 2017  
For more information on AIDA-2020, its partners and contributors please see www.cern.ch/AIDA2020

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### Delivery Slip

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Executive summary

This report refers to Delivery D 13.6: High Voltage Power Supply for Micro Pattern Gaseous Detectors (MPGD). This development has been done in the subtask [Task 13.3.2] (“Tools to facilitate the detector development”) of the “Innovative Gaseous Detector” AIDA2020 Work Package [WP13]. Basic principle and concept, prototype implementation, software developments and plans are presented in this report.

1. INTRODUCTION

MPGD technologies are nowadays developed to a high maturity state and are widely used thanks to their measurement capabilities and overall performances. Boosted by the upgrades of some currently running HEP experiments, these detectors are very often selected for new measurements and applications. The already large user community is continuously growing. A proper detector R&D (focused on new developments, evaluation of requirement achievability and optimization) requires proper instrumentation.

Deliverable D13.6 has been produced in this context. It is part of a more generic effort on developing dedicated MPGD laboratory instruments (HV Power Supply, pico-ammeter, fast amplifiers, environmental sensors, PCB with integrated services) in the AIDA2020 framework (tasks 13.3.1 and 13.3.2) with the main goal of supporting and providing advanced detector infrastructures.

The design of the D13.6 high voltage module for MPGDs has two main focal points: providing safe (protection circuits) and stabilized (active) voltages to multi-electrode MPGDs. The development has adopted as test-bench GEM (Gas Electron Multiplier)-based detectors; nevertheless, it can be exported to any other MPGD technology [1].

2. AVD: ACTIVE VOLTAGE DIVIDER

Multi-electrode Micro Pattern Gaseous Detectors (GEM and Hybrids as examples) have been powered in the past using mostly passive resistive dividers. The need of a different powering scheme arises when operating larger detectors exposed to higher particle rates. In recent years, various companies have started developments of multichannel power supplies, following solutions introduced by R&D projects.

Compared to passive dividers, multichannel power supplies offer a more versatile solution. However, safe operation could be more complex than simple HV distribution and single HV main line configuration. Therefore, our group followed a different approach, the Active Voltage Divider (AVD). It represents an alternative and compact solution to replace HV distributions based on a passive divider. The AVD is targeted for applications both in R&D and in experiments.

Particular attention has been applied to the design of novel solutions for specific MPGD requirements: safe, electronically fused power distribution to segmented electrodes, decoupling circuits in case of failing detector areas, spark quenching circuits, real-time voltage and current monitoring for fast instruments like oscilloscopes. These developments have been realized as independent subprojects and are generally usable and implementable in a larger context.

Principle and concept are given in Section 2. In section 3 we report about the deliverable D13.6 and in section 4 we offer an opening towards further future developments.
2.1. PRINCIPLE AND CONCEPT

As already mentioned, the development has been done with reference to GEM (Gas Electron Multiplier)-based detectors but are exportable to any other MPGD technology. Therefore, in the next, we will often refer to GEM but what follows is not restricted to GEM operations.

The basic concept behind the AVD is sketched in Fig. 1, where a simplified scheme of the AVD is shown. The voltages across and in between the GEM (electrodes) follow the voltages across a primary resistor divider (R_divider). These high-impedance voltage supply channels are converted via HV transistors to low impedance ones with a small voltage offset of order 0.8 V. The HV transistor cascade compensates the horizontally varying detector currents by vertical currents provided by the HV supply. As a result, the currents taken by the detector from the primary resistor divider get divided by the β of the transistors (~100) and the overall stability of the divider is enhanced by the same factor.

In the case of large-size GEM-based MPGDs, the AVD is used to supply segmented electrodes. In the presence of a short circuit across one sector of a GEM foil, the other sectors will stay at an approximately constant potential. The dynamic vertical currents can be monitored (U_mon) and are proportional to the sum of all load-induced currents. U_mon is available as a very fast trip signal of the primary HV supply. In the proposed configuration, all the filtering capacitors cannot discharge into detector.

2.2. FEATURES

- **Active Divider**: Active divider converts a high-resistor divider to low-impedance voltages
- **Fields**: Electrode fields defined by primary resistor divider (user-defined choices)
- **Stability**: AVD stabilizes all MPGD fields against rate-fluctuations
- **Glitch-Free**: All MPGD fields stay proportional resulting in no field glitch
- **Shorts**: Short on foils or grids have minimal influence on other MPGD fields
- **eFuse**: MPGD eFuse technology limits short circuits to O(5uA) within 100ns
- **Spark Quenching**: Spark quenching circuits minimize the capacitive energy
- **HV**: Negative High Voltage up to 5kV, generated and monitored internally
- **Powering**: Generate HV from low Voltage (i.e. standard NIM crate voltages)
- **Max Current**: Dynamic current though active stage up to 2mA
- **Monitoring**: I-U monitoring in pA-kV range at 12 bit@5 MHz on all electrodes
- **Display**: Front panel display of all monitoring parameters
- **Front Panel I/O**: outputs for prompt monitoring via fast instruments
- **Rear Panel**: SHV connectors for 9 output HV lines
- **Data Reaout**: to Laptop or PC via USB

### 3. DESKTOP PROTOTYPE (DELIVERABLE D13.6)

The AVD desktop prototype, built and fully tested, is the demonstrator described in this section. It represents the AIDA-2020 deliverable D13.6.

#### 3.1. DESKTOP AVD

In Fig. 2 a drawing of the desktop AVD is shown. The Desktop AVD is made of three independent boards with different functionalities (AVD itself, e-fuse and spark protection, monitoring). In the desktop version, the main HV supply is outside the AVD box, in the final NIM version, a HV module has been embedded in the AVD. See “Ultravolt High Voltage Module” section for the main HV line and “NIM PROTOTYPE (NEXT UPGRADE)” section for the fully integrated AVD.

![Fig. 2: AVD (right board) with eFuse (left board) and Arduino Monitoring Board (under the eFuse board).](image_url)

The desktop AVD has internal monitoring via a microcontroller. Various outputs (among them: Voltages at the divider or at the output, main HV current) are available for external readout (as, for instance, read-out by digital multimeter)

![Fig. 3: AVD & eFuse Desk Prototype](image_url)
The HV distribution can be adjusted by resistors in the primary HV resistor divider that it is used to drive the transistors cascade. In Fig.3 AVD/eFuse boxes and relative PCBs are shown.

3.1.1. MPGD field configuration

The AVD board contains the primary voltage divider and transistor cascade for a maximum of nine High Voltages on HV passivated PCB. Providing nine voltage supplies, the AVD can operate a four-stack MPGD including the electrode to establish the drift field. Jumpers allow configuring the AVD for two-and three stack detectors.

The fields are defined as for standard resistor dividers by the choice of the divider resistors in the primary resistor chain. Indicatively, the additive value of all series resistors $R_{tot}$ should be chosen in order that the maximum applied input Voltage, $HV_{in}$, from the HV module delivers 50% of the AVD current, as illustrated by the following example:

For a maximum AVD current of 2mA @ 5 kV (50% = 1 mA)

$$R_{tot} = \frac{5000\text{V}}{1\text{mA}} = 5 \text{M}$$

Thanks to the 50% choice, the transistor cascade can operate with a dynamically varying regulation current of 1 mA.

For a given selection of the number of electrodes, and the field values, an Excel calculator provides all the resistor values for the AVD primary resistor chain. These have to be implemented as for a standard resistor divider with high stability and HV (min 800V) resistors of low temperature coefficient. Commercially available resistors normally do not match the calculated $R$ values; in order to overcome this difficulty, the AVD board contains parallel and series adaptor resistor possibilities such that any desired resistance value can be easily combined from available resistors.

![AVD primary and secondary divider board](image)

The final AVD PCB will be implemented with resistor plugins for standard MPGD fields, such that users do not need to solder resistors.
MPGD detectors are subject to unavoidable sparks. The high voltage distribution has to be designed in a way that the detector will be protected against the destructive energy stored in the capacitive elements of the detector. Furthermore, the charge supply path from the HV supply must be instantaneously disconnected when currents reach limits of order 10μA. The detector field after sparking must build up without overshoot and with slow time constant. The eFuse contains a spark quenching circuit designed to dissipate the stored energy in a resistive shunt.

In addition to these “real-time” features, the high voltage distribution line should be able to provide proper voltages even when detector regions are malfunctioning (shorts across sectors of a large electrode – large and segmented foils as an example).

This section describes the solution adopted in the AVD. As already mentioned, these solutions are however not strictly limited to the AVD. They can also be used for other HV powering schemes.

In the desktop AVD prototype, designed specifically for GEMs, small mezzanine eFuses are serially connected to each top electrode of each GEM foil. The eFuse and spark quencher mezzanine card is shown in Fig. 6 together with the circuit of the spark quencher. It consists of a resistor and an inductance inserted in the HV line. The specific circuit has been designed for GEMs. More optimization work is needed to correctly qualify eFuses for all types of MPGD detectors.

The eFuse will disconnect the low ohmic supply line in case of over currents of user defined levels like 10μA and becomes instantaneously (~10 ns) very highly ohmic. This allows to operate the detector even with permanent short circuits between MPGD sectors, all other sectors supplied by the same AVD stay unaffected. If the short circuit disappears, the eFuse will automatically become low ohmic and recharge the sector to its nominal field.
3.1.3. Monitoring Unit

In the current version of the AVD (desktop) two micro-controllers (Arduino Due) are taking care of the AVD and of the main HV power line. See section “Ultravolt Control and Monitoring Unit” for a detailed description of the second one [3]. In the final AVD Version (NIM), all functionalities will be controlled by a single micro-controller.

The micro-controller currently installed in the desktop AVD box [2] is for monitoring purposes and has no control function. All voltages and currents can be measured via plugs for fast instruments, or be recorded via the Arduino. In Fig. 7 a simplified scheme of the monitoring circuits is shown.
A design of the monitoring board is shown in Fig. 8. It is installed under the eFuse board (see Fig. 2 and Fig. 3, right board). High impedance voltage divider for Voltage monitoring, amplifiers and calibration potentiometers are installed on it to properly perform the mentioned measurements [2].

### 3.2. ULTRAVOLT HIGH VOLTAGE MODULE

In the actual desktop prototype, the high voltage power module is not yet integrated and it is (ad interim) replaced by a standard external HV supply. A dedicated HV module has been designed and realized with a printed circuit board for integration on the final NIM module [3][4]. This allows to study the performances before going to the final PCB and integration in the final NIM AVD. (see section “NIM PROTOTYPE (NEXT UPGRADE)”).

We have selected the following requirements for the HV and monitoring/control board:

- Stable HV supply @ 2mA up to 5kV (negative) with absolute stability less than 1V
- Manual and remote control of HV voltage supply current.
- Monitoring of HV and supply currents at 1%
- Monitoring of all detector Voltages and currents at 1% and for currents in a dynamic range from 1pA to 20 uA (above eFuse threshold)
- Safety circuits eFuse and spark quencher in each MPGD sector
- Noise levels measured from the MPGD must be comparable to conventional HV supplies

#### 3.2.1. ULTRAVOLT Module

The module we selected belongs to the A Series of ULTRAVOLT High Voltage Modules. In particular, we selected the following one:

- 6A24N20-FM-25PM-I5-WS 1
- DC/DC High Voltage Power Supply
- 6A24-N20-F-M-25PPM-I5-WS, A-Series
- 24 Vdc Input,
- 0 to -6 kVdc Output
- 3.3 mA
- 20 Watts
- With option -F-M-25PPM-I5-WS

![ULTRAVOLT HV module, 6A24-N20-F-M-25PPM-I5-WS](image)

In tables 1-4 all the main characteristics of the model are reported.

### Table 1 ULTRAVOLT 6A24-N20 Specification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage range (VDC)</td>
<td>Full power: +23 to 30</td>
<td></td>
</tr>
<tr>
<td>Derated power range: +9 to 32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input current (mA)</td>
<td>Standby/disable: &lt;30</td>
<td></td>
</tr>
<tr>
<td>No load, max E&lt;sub&gt;OUT&lt;/sub&gt;: &lt;90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max load, max E&lt;sub&gt;OUT&lt;/sub&gt;: -1350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC ripple current (mA p-p)</td>
<td>Nominal input, full load: &lt;80</td>
<td></td>
</tr>
<tr>
<td>Output voltage range</td>
<td>0 to 6000 VDC</td>
<td>Nominal input</td>
</tr>
<tr>
<td>Nominal input voltage</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Output power (W)</td>
<td>20</td>
<td>Nominal input, max E&lt;sub&gt;OUT&lt;/sub&gt;</td>
</tr>
<tr>
<td>Output current (mA)</td>
<td>3.3</td>
<td>Lout entire output voltage range</td>
</tr>
<tr>
<td>Current monitor scaling (mA/V)</td>
<td>48.5</td>
<td>Full Load</td>
</tr>
<tr>
<td>Voltage monitor scaling</td>
<td>100:1 ±2% into 10 MΩ</td>
<td>With -Y5 option</td>
</tr>
<tr>
<td>Ripple (% V p-p)</td>
<td>0.073</td>
<td>Full load, max E&lt;sub&gt;OUT&lt;/sub&gt;</td>
</tr>
<tr>
<td>Ripple with -F-M Option* (% V p-p)</td>
<td>0.0012</td>
<td>Full load, max E&lt;sub&gt;OUT&lt;/sub&gt;, 300 pF bypass cap</td>
</tr>
<tr>
<td>Dynamic load regulation (V pk)</td>
<td>&lt; 6.0</td>
<td>½ to full load, Max E&lt;sub&gt;OUT&lt;/sub&gt; per 0.1mA</td>
</tr>
<tr>
<td>Line regulation (VDC)</td>
<td>&lt; 0.01 %</td>
<td>Nom. input, max E&lt;sub&gt;OUT&lt;/sub&gt;, full power</td>
</tr>
<tr>
<td>Static load regulation (VDC)</td>
<td>&lt; 0.01 %</td>
<td>No load to full load, max E&lt;sub&gt;OUT&lt;/sub&gt;</td>
</tr>
<tr>
<td>Stability (VDC)</td>
<td>&lt; 0.01%/&lt; 0.02%</td>
<td>30 min. warmup, per 8 hr/ per day</td>
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### Table 2 Ultravolt –F option, RIPPLE STRIPPER® OUTPUT FILTERS


<table>
<thead>
<tr>
<th>MODEL</th>
<th>VOLTAGE</th>
<th>POWER</th>
<th>WITH –F</th>
<th>WITH -F-M</th>
<th>50% LOWER THAN - F-M RIPPLE WITH EXTERNAL CAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 A 24</td>
<td>6 kV</td>
<td>20 W</td>
<td>&lt; 0.0086%</td>
<td>&lt; 0.0012%</td>
<td>1500 pF/X7R</td>
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</table>
Table 3 ULTRAVOLT Programming and Control

<table>
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<tr>
<th>Input impedance (MC)</th>
<th>Nominal input</th>
<th>All types: + output models 1.1 MΩ to GND, - output models 1.1 MΩ to +5 Vref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust resistance (Ω)</td>
<td>Typical potentiometer values</td>
<td>All types: 10 to 100 K (Pot. across Vref. and signal GND, wiper to adjust)</td>
</tr>
<tr>
<td>Adjust logic</td>
<td>0 to +5 for +Out, +5 to 0 for - Out</td>
<td>All types: +4.64 VDC for +output or +0.36 for - output = nominal Eout</td>
</tr>
<tr>
<td>Output voltage and impedance</td>
<td>T=+25°C</td>
<td>All types: + 5.00 VDC ± 2%, Zout = 464 Ω ± 1%</td>
</tr>
<tr>
<td>Enable/disable (VDC)</td>
<td>0 to +0.5 disable, +2.4 to 32 enable (default = enable)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 ULTRAVOLT Environmental

<table>
<thead>
<tr>
<th>Operating (°C)</th>
<th>Full load, max EOUT, case temp.</th>
<th>-25 PPM option: +10 to +45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature coefficient (PPM/°C)</td>
<td>Over the specified temperature</td>
<td>-25 PPM option: +25</td>
</tr>
<tr>
<td>Thermal shock (°C)</td>
<td>Mil-std 810, method 503-4, proc. II</td>
<td>Standard: -40 to +65</td>
</tr>
<tr>
<td>Storage (°C)</td>
<td>Non-operating, case temp.</td>
<td>Standard: -55 to +105</td>
</tr>
<tr>
<td>Humidity</td>
<td>All conditions, standard package</td>
<td>Standard: 0 to 95%, non-condensing</td>
</tr>
<tr>
<td>Altitude</td>
<td>Standard package, all conditions</td>
<td>Standard: Sea level through vacuum (Vacuum may require -P2 option. Contact factory for details.)</td>
</tr>
<tr>
<td>Shock (Gs)</td>
<td>Mil-std-810, method 516.5, proc. IV</td>
<td>Standard: 20 (standard), 40 (-C option)</td>
</tr>
<tr>
<td>Vibration (Gs)</td>
<td>Mil-std-810, method 514.5, fig.14.5C-3</td>
<td>10 (standard), 20 (-C option)</td>
</tr>
</tbody>
</table>

In order to evaluate the performance of the ULTRAVOLT module and of the specific control/monitoring/protection circuitry, a preliminary setup has been built (Fig.10). Microcontroller, environmental sensor board and TFT display are shown in Fig.11.

![Functionality test of the ULTRAVOLT HV module and of the reset circuit.](Image)
Once the basic functionality was validated, a comparative test was performed with a commercially available power supply. A resistive divider has been used for the comparison. In Fig. 12 a noise and a Fe$^{55}$ spectrums have been acquired with a triple GEM detector. The results showed that the two powering modules are fully comparable and that the ULTRAVOLT module can be implemented as main HV power line in the AVD distribution.

![Fig. 11](image)

**Fig. 11**: (left) Arduino Due Microcontroller for the Ultravolt Module Operation, (center) BME280 Humidity-Pressure-Temperature Sensor, (right) LCD Display, 1.77” TFT LCD Screen

![Fig. 12](image)

**Fig. 12**: (Left) Noise Spectrum Comparison Red Colored –HV Prototype, Purple Line –Commercial Power Supply. (Right) $^{55}$Fe Radiation Source Energy Spectrum Comparison Red Colored –HV Prototype, Purple Line –Commercial Power Supply

### 3.2.2. ULTRAVOLT Control and Monitor

In view of a complete integration in the AVD in one compact NIM module, an ULTRAVOLT PCB carrier has been designed and realized for the prototype. It consists of all the circuitry needed to host and operate the ULTRAVOLT HVPS, an Arduino II microcontroller, the HV control and monitoring circuit, the Digital Logic safety circuit, the LCD and sensors, I/O connectors and USB communication port.
In Fig. 13 the schematics, assembly and final PCB are shown. The microcontroller is interfaced with the PC and is used to control the powering of the AVD. Using internal sensors or driven by the PC software, it allows the user to implement voltage regulation in feedback mode.

### 3.2.3. ULTRAVOLT Protection Circuits

Two protection systems have been implemented in the AVD. One has been described in section “eFuse and spark protection” and is focused on the detector side. The other one operates on the main high voltage power line, i.e. the ULTRAVOLT Module.

Different levels of protection have been developed for the ULTRAVOLT module control, hardware (high priority, faster) and software based.

- **Current Limit:** the module can operate in current generator mode or it can kill/ramp down the high voltage if overcurrent is detected. The user can choose the operating mode.
- **AVD real-time dynamic current output** ($I_{mon}$): Analog current measuring the output dynamic current in the AVD transistor cascade. This fast signal can be used for triggering externally safety logic.
- **A NIM input for fast power off of the high voltage main module.**

Manual and software resets are available to switch off the high voltage main module.

### 3.3. SOFTWARE

Different software programs have been developed for the AVD operation. In the desktop design, two microcontrollers are used. One of them is related to the AVD monitoring, the other one is related to the ULTRAVOLT HV module control and monitoring. Each microcontroller has its own internal code (arduino). Labview programs have been written in addition, to provide the user interface to the AVD desktop.

#### 3.3.1. AVD CONTROL and Monitoring Software

The Arduino code is constantly reading voltages for each HV output line and the current for part of them. The measurements are transmitted to a PC via the USB Arduino connection. [2],[3],[4].

In Fig. 14 and 15 the front panel of the dedicated Labview software that has been developed is shown. The right part of the panel is the control part of the main HV power line. The left part is the AVD monitoring with Voltages (top) and currents (bottom) plots. The control part of the main HV power line can be adapted to the HV source. Software versions compatible with CAEN/ISEG power supplies (Fig. 14) and with the ULTRAVOLT module (Fig. 15) are shown.
Fig. 14: Labview Control & Monitoring software of the AVD Arduino Voltage and Current. CAEN/Iseg compatible version.

Fig. 15: Labview Control & Monitoring Integrated Software. ULTRAVOLT Module version.
3.4. DELIVERABLE D13.6 SUMMARY

In Fig.16 is shown a triple GEM detector operated using the final desktop AVD (deliverable D13.6). The typical setup consists of:

- Desktop AVD (“AVD/eFuse”) - [sec. 3.1].

- ULTRAVOLT module and carrier PCB for local and remote control (“ULTRAVOLT Main HV Power Line Module”) - [sec. 3.2].

- Control PC (“LAPTOP for Remote Control”) - [sec. 3.3].

Every part of the AVD has been described in this report. The R&D on the current AVD desktop version is completed. However, we are planning to do more work on the qualification of the e-Fuse and on the spark quencher protection capabilities. Further noise optimization will be moreover required for the ULTRAVOLT/microcontroller integrated version, discussed in next section.

4. NIM PROTOTYPE (FUTURE UPGRADE)

Based on the results obtained with the desktop AVD, the design of the final NIM version has started. It will integrate AVD, eFuse/spark-quencher, monitoring and main HV module boards in a dual-width NIM-case. A single micro-controller takes care of remote control/monitoring operation.
In Fig. 17 the four main boards in the version compatible with the integration in a single NIM-case are shown (AVD, eFuse/sparkquencher, monitoring, ULTRAVOLT carrier). In Fig. 18 the integration into a double NIM case is shown. The AVD-NIM can be operated/powered in standard NIM crates or, optionally, powered via a power adapter plug as a desktop device.

![Fig. 18: Nim Chassis AVD version. Ultravolt HVPS fully integrated.](image)

The front panel of the AVD is shown in Fig. 19. Together with the TFT Display for local monitoring, various input/output lines will be available.

- Outputs: Monitoring of V/I of each line, I/V HV module status.
- Input: NIM reset, remote/local control and V/I trimmer (for local operation)
- Button Reset.
- USB port for remote connection.

![Fig. 19: Front Panel Functions](image)

In the backside of the AVD module, nine high voltage lines with SHV connectors are available. A standard NIM power connector is available on the rear side. A DSUB-9 AUX power output connector is available to supply other ancillary devices using the NIM power lines (for instance, a preamplifier).
5. CONCLUSIONS

A prototype of the “Miniaturised HV power supply”- D13.6, leading beneficiary CERN and expected delivery date 30/04/2017, has been designed, optimized, engineered and tested. It satisfies a central requirement for the operation of MPGDs, namely the need for a compact supply that provides the required electric fields of up to four electrode pairs in an MPGD detector. The implementation with the characteristics of an active voltage divider ensures that, at any time, all voltages are strictly proportional with instantaneous regulation on dynamically varying loads between electrodes, even down to short circuits. The supply has monitoring features that provide both tracking and display of all voltages and currents via an embedded processor and real-time signals for interfacing fast instrumentation.

Further engineering activities are foreseen in order to realize also a fully integrated version of the power supply.
6. REFERENCES

REPORTS


ANNEX: GLOSSARY

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<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>MPGD</td>
<td>Micro Pattern Gaseous Detector</td>
</tr>
<tr>
<td>AVD</td>
<td>Active Voltage Divider</td>
</tr>
<tr>
<td>HEP</td>
<td>High Energy Physics</td>
</tr>
<tr>
<td>GEM</td>
<td>Gas Electron Multiplier</td>
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