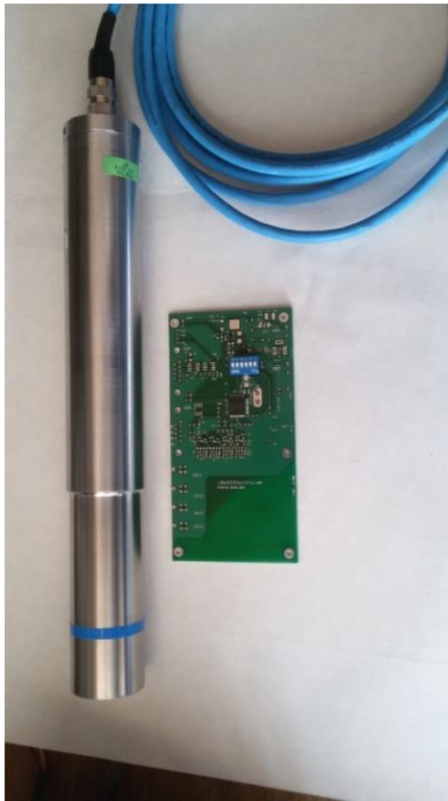


Instantaneous dose-rate monitor (DRM) for GIF++ and test of SiPM + scintillator as a DRM for Gif++

1. Instantaneous dose-rate monitor (DRM) for GIF++

P.laydjiev, L.Dimitrov, I.Vankov, G.Mitev, L. Ratchev (INRNE-Sofia)

User requirements for the instantaneous dose rate monitoring were satisfied with the design and test of the new online dose-rate monitor based on Berthold LB 6500 Geiger-Mueller Dose Rate Probes. The **eight-channel** monitor with the data transmission via an RS422/485 serial port is a simple and flexible device for measuring the instantaneous dose rate at several positions in GIF++. This work was performed within the framework of AIDA-2020 WP 15.5.



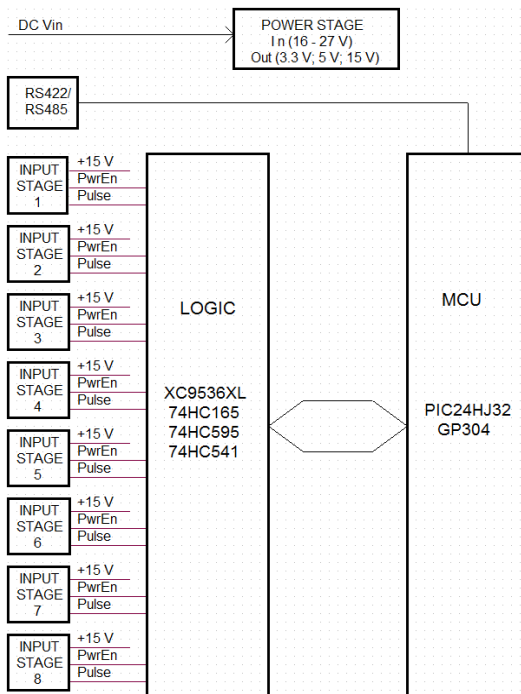
Berthold GM LB6500-3-H10 Technical Data	
Dose Rate Range	10 μ Sv/h – 1 Sv/h
Energy Range	50 keV – 1.3 MeV (+/-40%) with regard to Cs-137 at 0°
Intrinsic Background	approx. 0.015 cps
Calibration Factor	7.05 μ Sv/h per cps

AIDA-2020-MS85 (<http://cds.cern.ch/record/2311230>)

Plamen laydjiev (INRNE-Sofia)

The block diagram and the view of the eight-channel monitoring board and a picture of the installed at GIF++

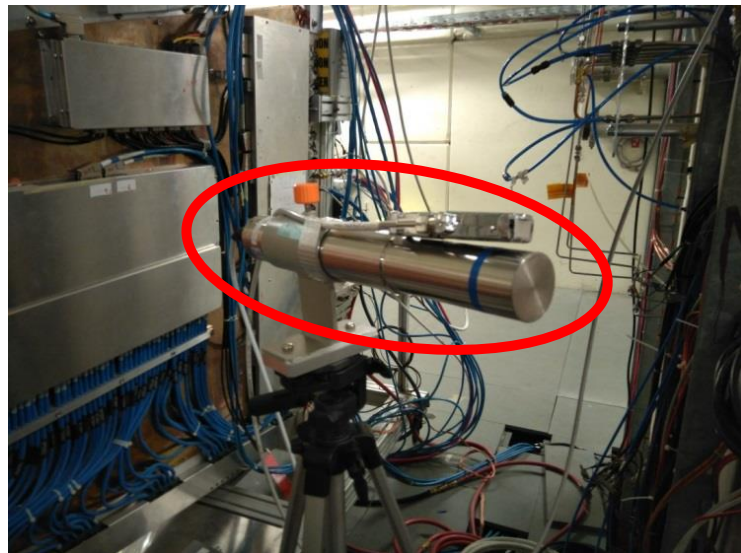
The board is built around a 16-bit PIC24HJ32GP304 microcontroller (MCU). The block LOGIC includes complex programmable logic device (CPLD) XC9536XL and integrated circuits 74HC165 (parallel in/ serial out shift register, used for reading 6-bit board address and 2-bit mode set from 8-bit DIP switch), 74HC595 (serial in/ parallel out shift register, used to enable power supply to the dose probes), 74HC541 (eight stage buffer for input pulses). The **self-adapting method of measurement allows automatically selecting of pre-set time** depending of input pulse rate. The pre-set time is changing from 1 s to 128 s in steps of the power of two. The pre-set time can be different for each individual channel.



TEST OF THE INSTANTANEOUS DOSE-RATE MONITOR AT GIF++

The eight-channel version was tested in 2017 at GIF++ in parallel with a RADMON accumulated dose sensor. The Berthold LB 6500 Geiger-Mueller Dose Rate Probe was tested and compared with RADMON measurements at the same position in GIF++. The result shows good agreement in the limit of precision for the RADMON and Berthold probe: **166 mGy/h for the RADMON** and **178 mGy/h for the Berthold probe**.

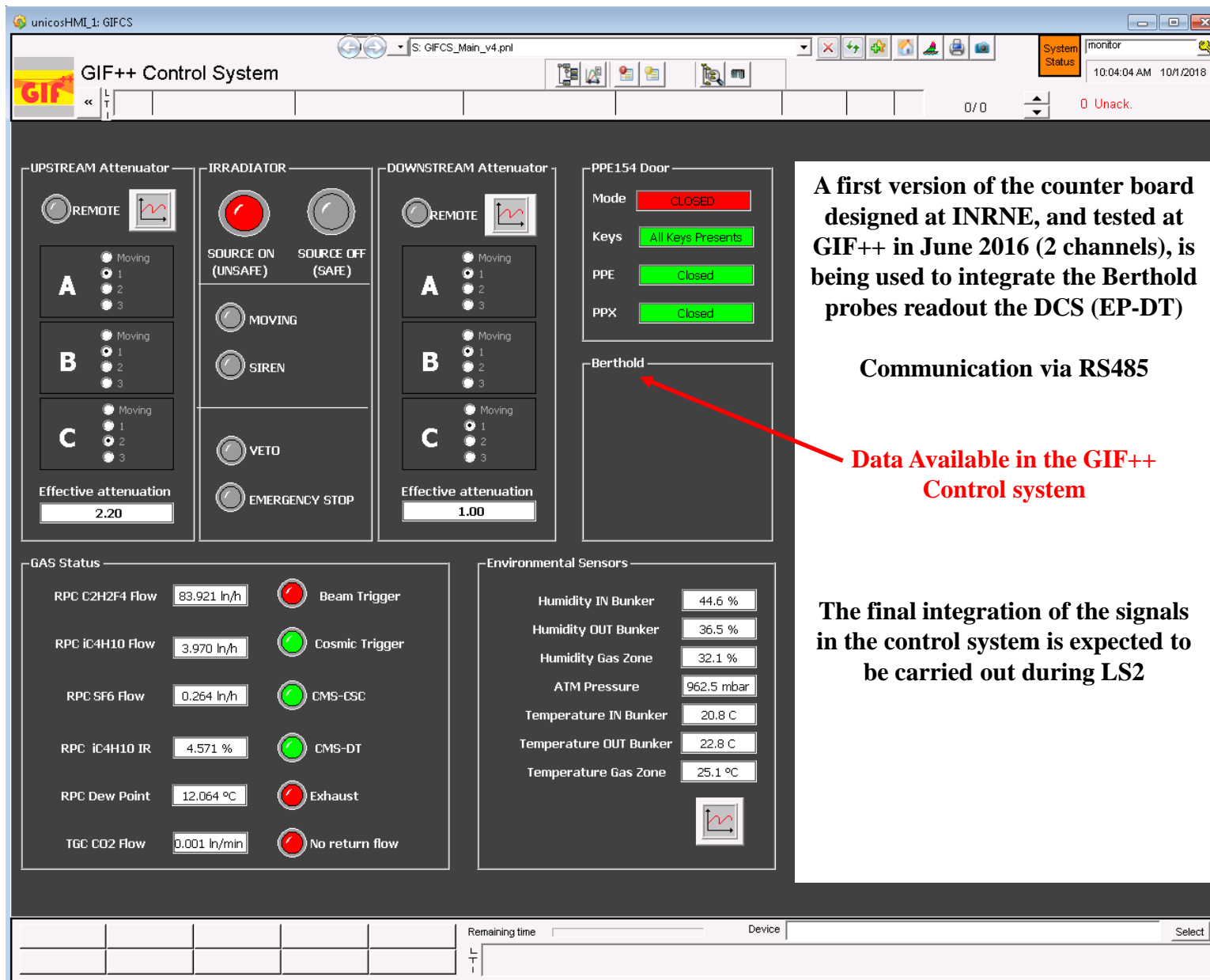
	Total dose Gy	Irradiation time hours	Dose per hour (RADMON) mGy/h	Probe counts cps	Probe cps (dead time correction)	Dose per hour (probe) mGy/h	Maximum cps per probe for the correct dose estimation
RADMON2 + probe2	15.9	96	166	18500	25342	178	45500



position of the RADMON+ Berthold GM Upstream and Downstream at Gif++



1. Instantaneous dose-rate monitor (DRM) for GIF++



The screenshot displays the 'GIF++ Control System' interface. At the top, it shows the window title 'unicosHML_1: GIFCS' and the file path 'S: GIFCS_Main_v4.pnt'. The system status is 'monitor' with a timestamp of '10:04:04 AM 10/1/2018' and '0 Unack.'.

The main interface is divided into several sections:

- UPSTREAM Attenuator:** Includes 'REMOTE' controls, 'A', 'B', and 'C' channels with 'Moving' indicators, and an 'Effective attenuation' of 2.20.
- IRRADIATOR:** Features 'SOURCE ON (UNSAFE)' and 'SOURCE OFF (SAFE)' buttons, 'MOVING', 'SIREN', 'VETO', and 'EMERGENCY STOP' indicators.
- DOWNSTREAM Attenuator:** Similar to the upstream attenuator, with 'A', 'B', and 'C' channels and an 'Effective attenuation' of 1.00.
- PPE154 Door:** Shows 'Mode' as 'CLOSED', 'Keys' as 'All Keys Presents', and 'PPE' and 'PPX' as 'Closed'.
- GAS Status:** Lists various flow rates and triggers:

RPC C2H2F4 Flow	83.921 l/h	Beam Trigger
RPC iC4H10 Flow	3.970 l/h	Cosmic Trigger
RPC SF6 Flow	0.264 l/h	CMS-CSC
RPC iC4H10 IR	4.571 %	CMS-DT
RPC Dew Point	12.064 °C	Exhaust
TGC CO2 Flow	0.001 l/min	No return flow
- Environmental Sensors:** Displays various sensor readings:

Humidity IN Bunker	44.6 %
Humidity OUT Bunker	36.5 %
Humidity Gas Zone	32.1 %
ATM Pressure	962.5 mbar
Temperature IN Bunker	20.8 C
Temperature OUT Bunker	22.8 C
Temperature Gas Zone	25.1 °C

Annotations on the right side of the interface:

- A red arrow points from the 'Berthold' section to the text: **Data Available in the GIF++ Control system**.
- Text in a white box: **A first version of the counter board designed at INRNE, and tested at GIF++ in June 2016 (2 channels), is being used to integrate the Berthold probes readout the DCS (EP-DT)**
- Text below: **Communication via RS485**
- Text at the bottom: **The final integration of the signals in the control system is expected to be carried out during LS2**

2. TEST at INRNE of the SiPM and Plastic scintillator as a dose rate monitor – first results

Test configuration

SiPM - Hamamatsu S13360-1325CS (57.28V)
 Photosensitive area: 1.3 x 1.3 mm, Pixel pitch:
 25 μm , reduced crosstalk and dark count,
 Gain (typ.) - 7.0×10^5

Scintillator

- $250 \times 10 \times 7 \text{ mm}^3$, extruded polystyrene bar supplemented with 1.5% paraterphenyl (PTP) and POPOP 0.01%;
- 30-100 micron layer Uniplast actng as a diffusive reflector;
- Light shifter WLS Y11 KURARAY Φ 1 mm

Preamp – simple 2 transistors charge sensitive (RC = 22 μs)

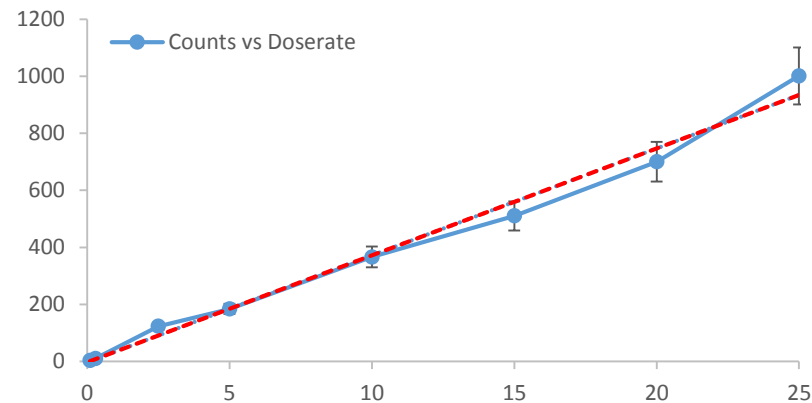
Amplifier - Canberra 2024, shaping time 2 μs

ADC – 4k, custom made

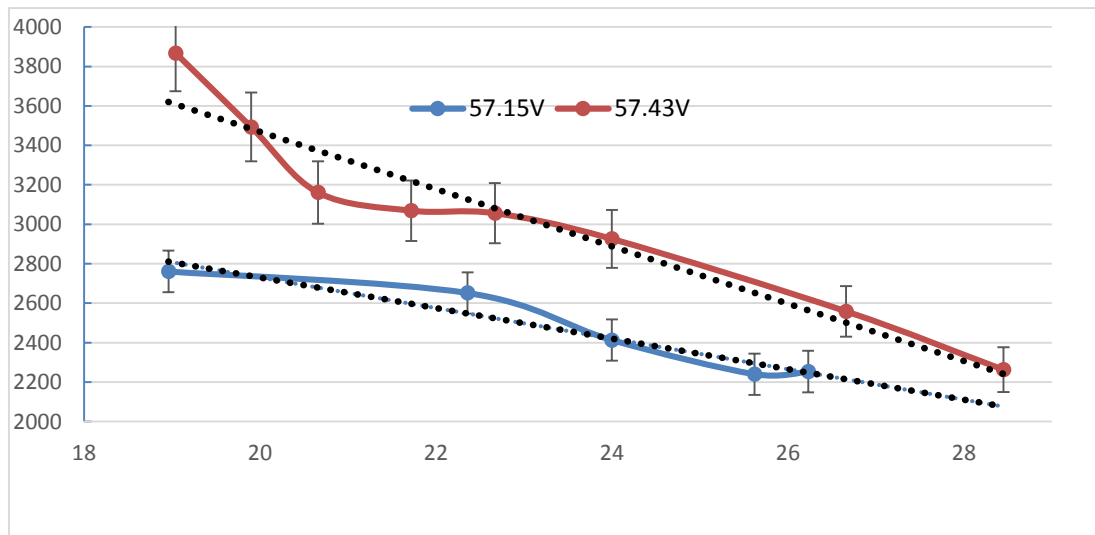
The calibration factor for SiPM probe with 250 mm scintillator is 0.027 (mean value)

Counts vs Dose rate measurements

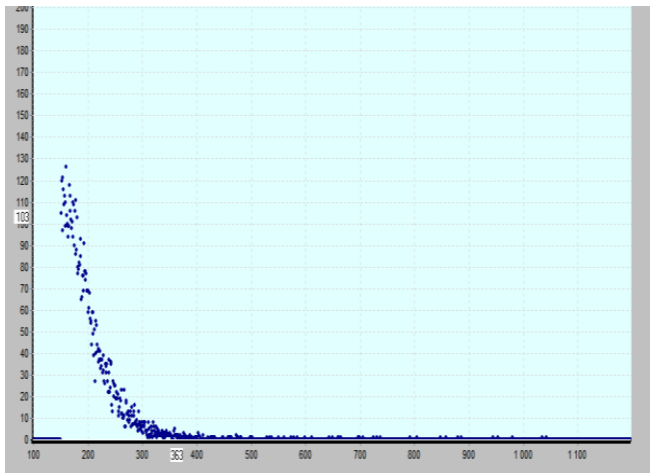
$^{\circ}\text{C}$	$\mu\text{Sv/h}$	n	cf
22.75	0.1	3.55	0.028
22.28	0.3	10.91	0.027
22.26	2.5	123.6	0.02
22.6	5	184.4	0.027
22.6	10	366.5	0.027
22.54	15	510.4	0.029
22.42	20	700.3	0.029
22.74	25	1001	0.025



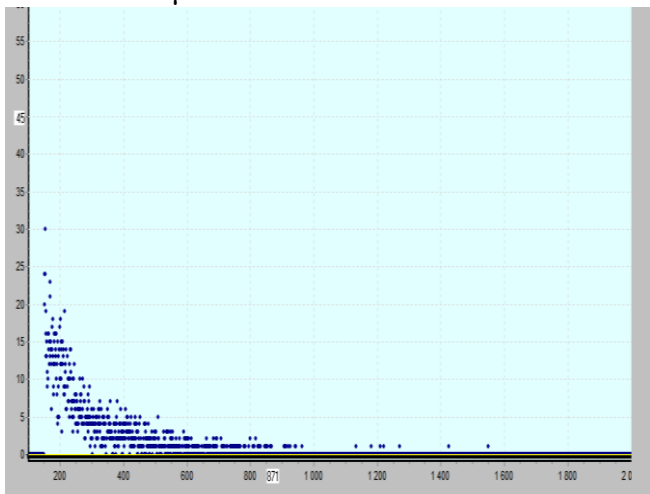
Temperature dependences for two SiPM voltages



Samples of CS137 and background spectra



T = 1 min; n = 123.6 cps
Dose = 2.5 μ Sv/h



T = 10 min; n = 3.55 cps
Background

Dose rate and energy ranges of the currently available Berthold gamma probes

Berthold GM LB6500–3– H10 Technical Data	LB6500–3 - H10	LB6500–4 - H10
Dose Rate Range	10 μ Sv/h – 1 Sv/h	500 nSv/h – 3 mSv/h
Energy Range	50 keV – 1.3 MeV (+/-40%) with regard to Cs-137 at 0°	65 keV – 1.3 MeV (+/-40%) with regard to Cs-137 at 0°
Intrinsic Background	approx. 0.015 cps	approx. 0.08cps
Calibration Factor	7.05 μ Sv/h per cps	0.617 μ Sv/h per cps

Conclusions:

- Plastic scintillator + SiPM could be used as an Instantaneous dose-rate monitor (DRM) for GIF++
- With the small amount of the scintillator (250x10x10) mm, the calibration factor is 0.027 (mean value) - shorter than for the Berthold probes.
- The peak from the Cs-137 photons is not seen because photons could not transfer all energy in the scintillator.
- Test at Gif++ could be made with the larger amount of the present scintillator, or, with another type of scintillator (NaI(Tl), BaF₂ ...) for better understanding of the multiple scattering spectra.