Real-time wireless personal dosimeter for Interventional Radiology Procedures

ASL VITERBO
USLUmbria2 Servizio Sanitario Regionale
AZIENDA OSPEDALIERA SANTA MARIA TERNI
L.Servoli[1] on behalf of RAPID Collaboration – [1]INFN Sezione di Perugia
UNIVERSITÀ DEGLI STUDI DI PERUGIA
INFN Istituto Nazionale di Fisica Nucleare

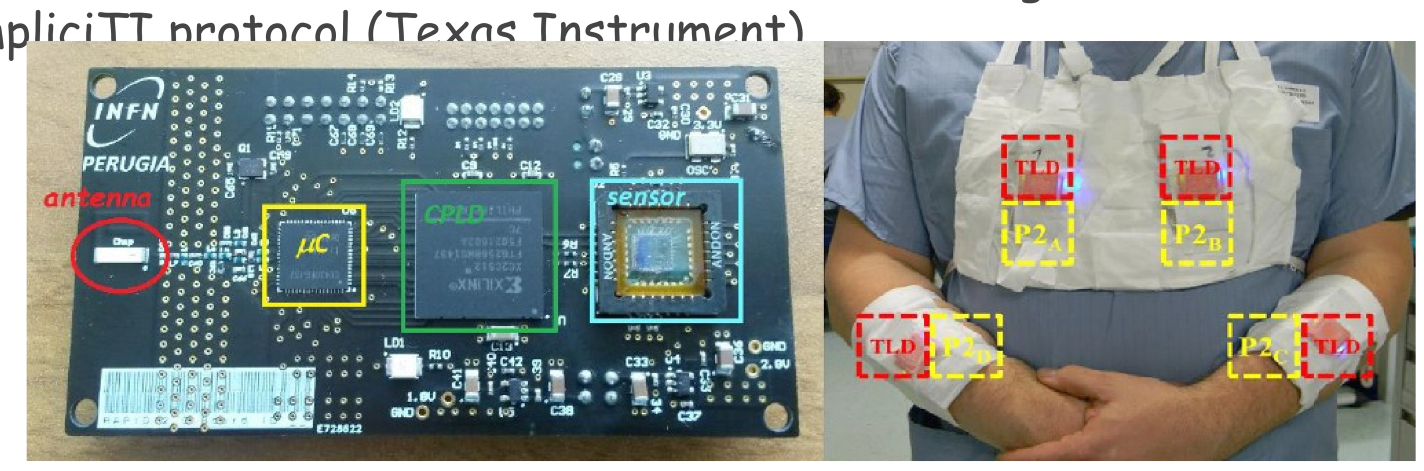
THE RAPID PROJECT 1

The continuous increase in the number and typology of Interventional Radiology procedures, as well as Haemodynamic and Vascular Surgery treatments, coupled with the new international limits for medical personnel exposure to ionizing radiation, makes very important to enhance the operators' quantitative awareness of their exposure[1].

Active Personnel Dosimeters promise in principle to satisfy such request, however the current products have some problems for pulsed mode and high dose-rate, and none of them is qualified as dosimeter, only as educational device[2].

The INFN RAPID project (Real-time Active PIxel Dosimeter) has developed a completely wearable wireless prototype based on a new sensing device, a commercial CMOS Imager (VGA format). It has already been calibrated and validated as proof of concept on more than 50 clinical procedures[3].

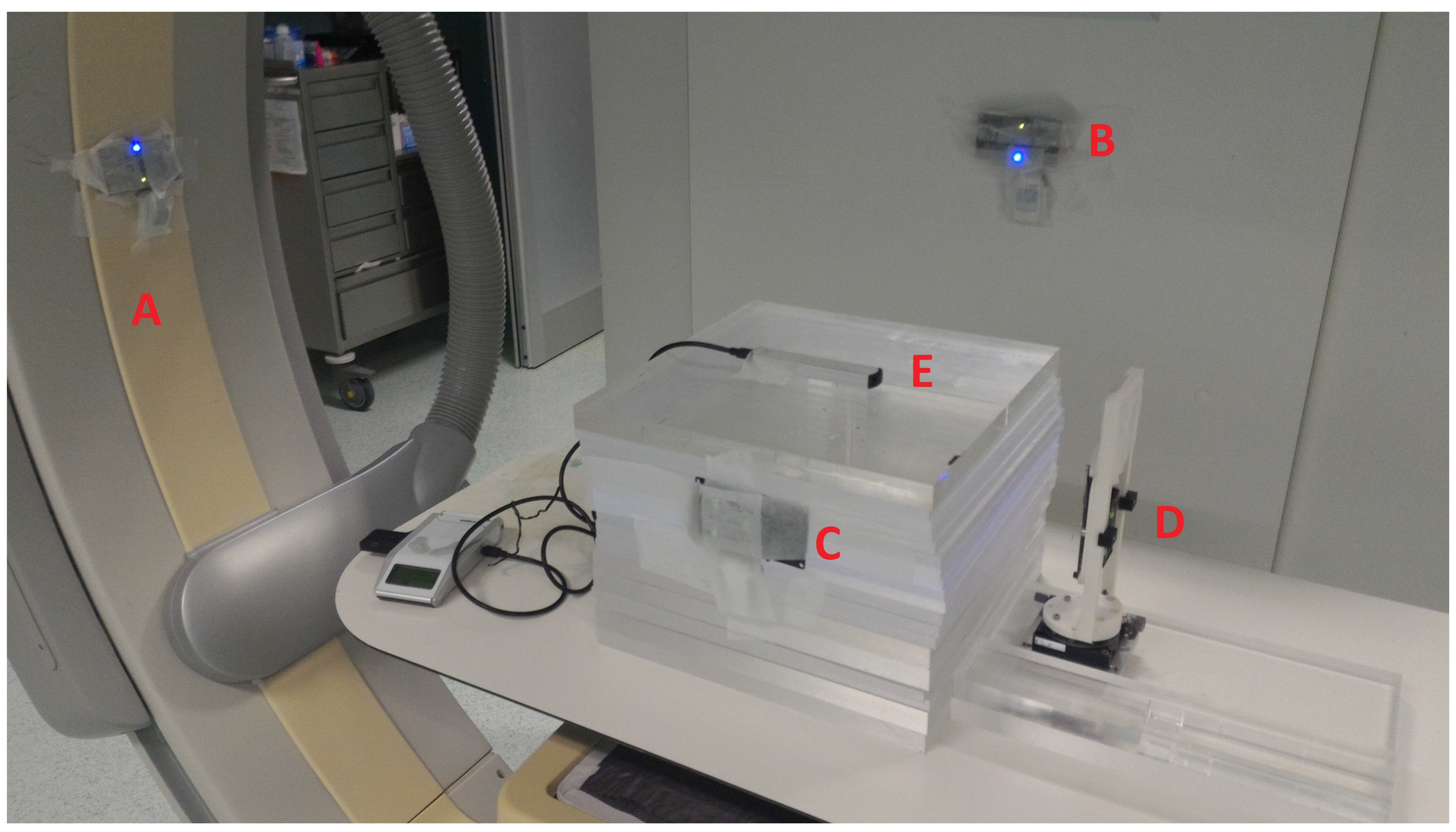
Device is operated through rechargeable batteries, > 8 hours continuous functioning. Communications with control unit are established using the standard 868 MHz frequency and SimpliciTI protocol (Texas Instrument).



AIM OF THE TEST AND SETUP 2

This work aims at demonstrating that operating the RAPID devices in a clinical environment, using a PMMA phantom to diffuse the X-ray radiation, both the relative precision of the measurement and the linearity of the response are well below the 10% figure.

The phantom (PMMA slabs) used has 30x30x24 cm^3 dimensions, 4 RAPID devices have been situated in position A, B, C, D, and a direct dosimeter (RaySafe Xi) in position E.



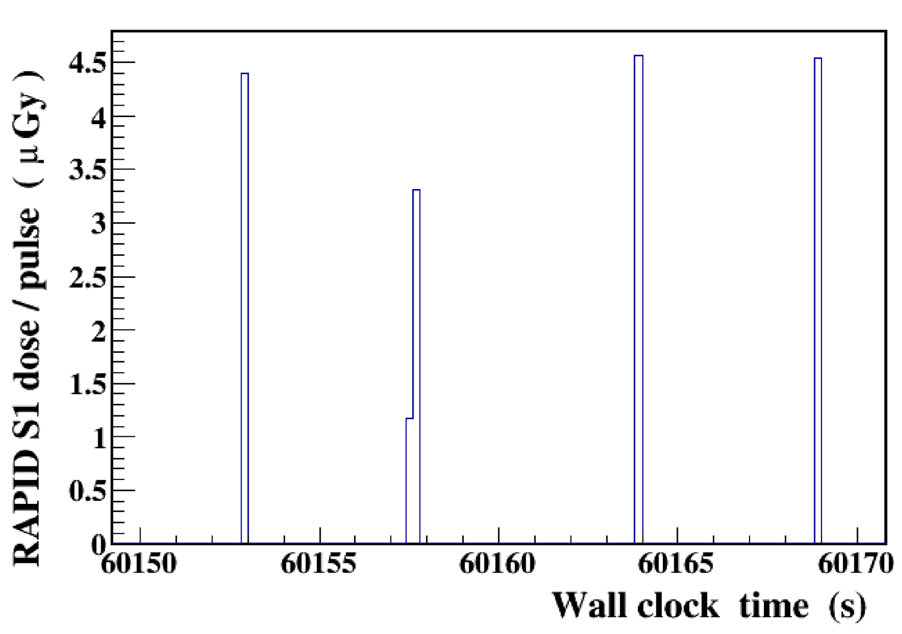
The receiving antenna is located inside the operating room to minimize the packet loss, and is connected via an active USB cable with the control station outside. All devices are synchrhronized among them and use the same integration time (200 ms). Being capable of detecting single diffused photons, they have a very low threshold for measuring the dose-rate (~ 12 pGy/200 ms)[4].

DATA TAKING AND DETECTOR QUALITY 3

Only the fluorography mode has been used, being the more intense mode, sending several single pulses for each measurement point, all equal, to obtain an evaluation of the measurement uncertainty due to the RAPID devices. Several machine settings have been varied, to explore as much as possible the entire parameter space that can be used during clinical operations.

If the pulse spans two consecutive detector integration intervals, then the two contributions are clustered together. Thresholds have been chosen as low as possible to avoid noise.

Being capable of detecting a single diffused photon, RAPID devices have a very low threshold for measuring the dose-rate (~ 12 pGy/200 ms).

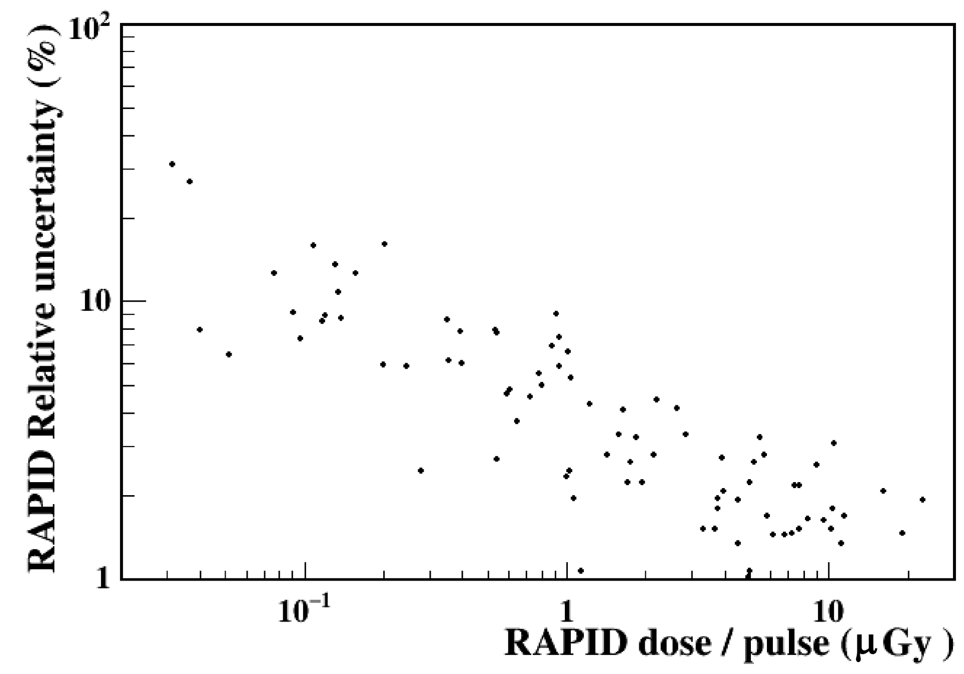


MEASUREMENT UNCERTAINTY 4

The main factors causing uncertainty in the measurement of dose-rate are both the number of interacting photons and the the fluctuation of signal produced by each interacting photon is in the pixel matrix.

Hence the uncertainty could be modeled by Poisson statistics, convoluted with a variable gaussian distribution.

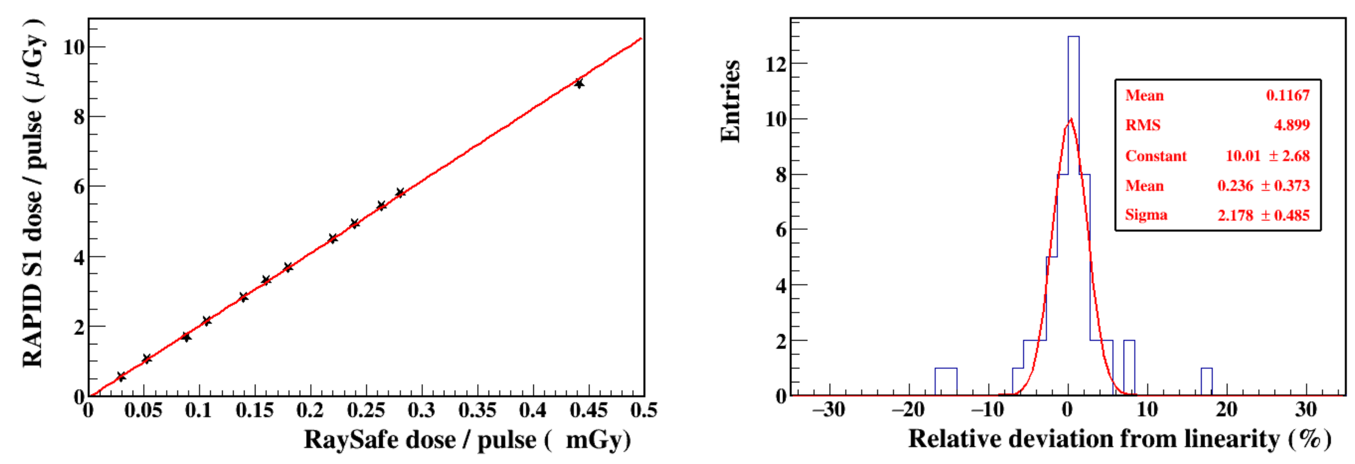
For low signal we do expect to have a greater relative uncertainty, but this should not weight too much in the total dose measurement uncertainty.



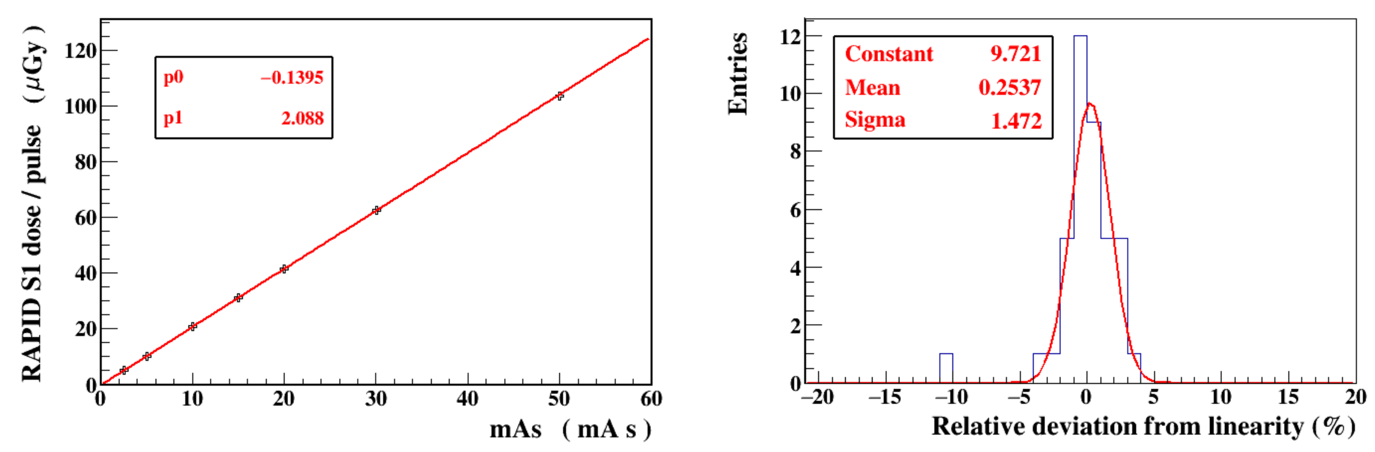
We observe that for most of the conditions the relative uncertainty is below 10% if the measured dose rate is greater than 100 pGy/pulse.

SIGNAL DEPENDENCE FROM X-RAY PARAMETERS 5

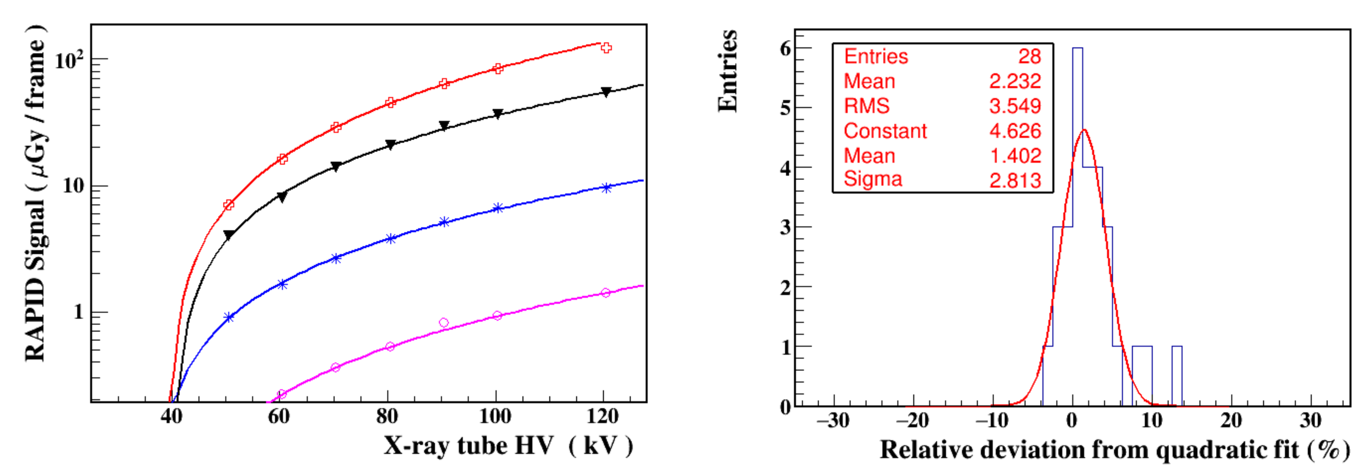
→ ***Scan in delivered dose / pulse : [30 – 450 µGy** (measured by RaySafe Xi)**]***



→ ***Scan in mAs [50-500 mA @ 100 ms pulse width]***



→ ***Scan in X-ray tube HV [50-120 kV @ 100 mA and 100 ms]***



For all the parameters range the relative deviation from the predicted behaviour (linear or quadratic) is in average less than 3% with almost all points lying in a ± 10% range.

CONCLUSIONS 6

→ We have operated 4 RAPID sensors at the same time on a photon field generated by an angiograph and diffused by PMMA phantom.

→ *Several X-ray tube parameters have been varied to study the uncertainty in the measurements and we have found it to be smaller than 10% in most of the interesting dose-rate range.*

→ ***The correspondence of the dose-rate measurement to the expected dependence from parameters has been found to be better than 5%.***

REFERENCES

[1] S. Chiriotti et al.: Radiat. Meas 2011;46:1266–70. doi:10.1016/j.radmeas.2011.05.073
[2] F.A. Bacchim Neto et al: Physica Medica 32 (2016) 1019-1024, doi:10.1016/j.ejmp.2016.06.014
[3] L. Servoli et al: Physica Medica 32 (2016) 1724-1730, doi:10.1016/j.ejmp.2016.11.006
[4] L. Bissi et al: IEEE 2013 Nucl. Sci. Symp.(NSS/MIC), doi:10.1109/NSSMIC.2013.6829624

This work is partially supported by Fondazione Cassa di Risparmio di Perugia – Project RIPARI 2017.0104.021