



ORAMED 2011



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A REAL TIME ACTIVE PIXEL DOSIMETER FOR INTERVENTIONAL RADIOLOGY

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Real-time Active Pixel Dosimetry



Commissione Scientifica Nazionale V

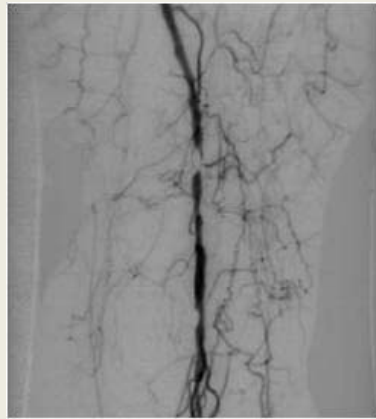
Proposed Experiments for the year 2011

Last update: December 2010

Linea	Esperimento	Sez. partecipanti	Resp. nazionali
in	RAPID*	PERUGIA	L. Servoli



Interventional Radiology (IR)



Good image quality minimizing the radiation doses absorbed by patients and staff members.



The practice of IR is considered at high risk level

NCRP 133: Radiation Protection for Procedures performed outside the radiology department

IR - Radiation Protection

Dose to medical staff

The complexity of interventional procedures requires operators to work:

- at short distances from the patient
- with prolonged exposure times
- often without proper shielding

thus exposing them to high levels of diffuse radiation and subsequent risk from deterministic effects, damage to hands and lens.

ICRP 85: Avoidance of Radiation Injuries from Medical Interventional Procedures

Radiological Technique

Example

*IR parameters procedures in the experience
@ Foligno Hospital (ASL n.3 Umbria)*

	Radiography Mean values/procedure				Radioscopy Mean values/procedure		
Procedures	N° exposure/procedure	kV	mA/mAs	Time (sec.)	kV	mA	time (min.)
Pace maker					80	30	2-5
PTA	14	76	400	4	80	30	10-45
ERCP	8	74	160	0,5	80	30	10-30
PTCA	15-30 fps-10 exp.		320	6	80	30	15-60

RAPID Project

Monitoring the effective & equivalent dose received during each procedure



The possibility to communicate in real time the dose to operators (alarms, monitors, etc.)

(currently the results of individual dosimetry is communicated from the dosimetry service about one-two months after monitoring);

RAPID Project

Application of the principle of dose optimization:

*"All doses due to medical exposure for radiological purposes ... shall be kept **as low as reasonably achievable** consistent with obtaining the required diagnostic information, taking into account economic and social factors. "*

Decreto Legislativo 26 maggio 2000, n. 187
Application of Council Directive of the European Community 97/43/Euratom



RAPID Project

Possibility of data storing in a remote archive (useful for example for the management of the operators' radiological activity).



Optimization of physical surveillance of operators by Qualified Expert, (i.e. immediate intervention in case of very high doses)

RAPID Project

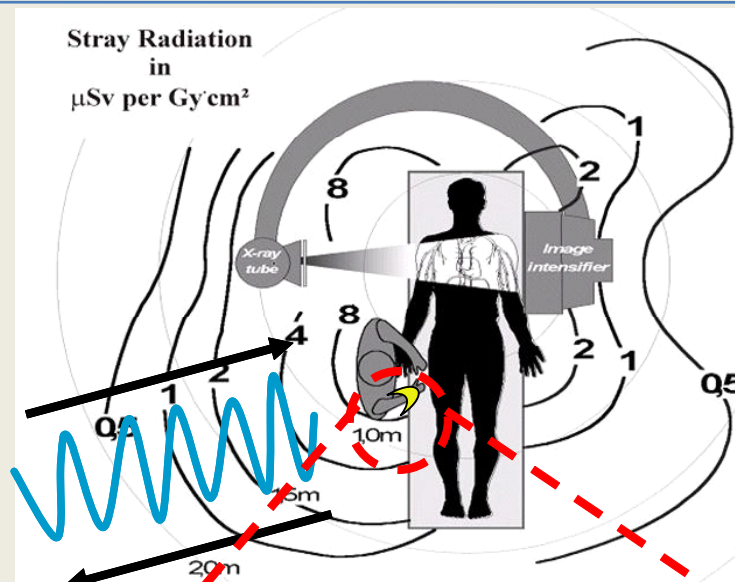
Small dimension (i.e. dosimetric wristlet)

Wireless communication eliminates the presence of cable support devices



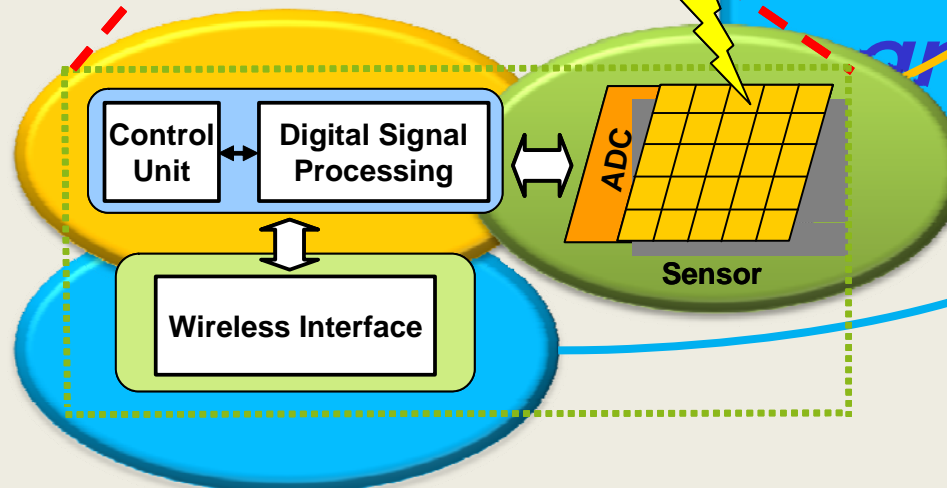
easy to use by operators

RAPID Project



Sensor


**Data
processing
wireless
&
graphical
interface**



RAPID Project

Sensor

Standard Commercial CMOS Imagers

- ✓ Are made using standard CMOS processes;
- ✓ Advanced technological nodes (130 nm or lower);
- ✓ Mass production (tens of million of pieces)  low cost!!
- ✓ Pixel Noise: 130 ± 13 eV
- ✓ Charge collection sensitivity and dynamical range for each pixel:
 $2 - 150$ keV
- ✓ High granularity (307.200 pixel / 9.6 mm^2):
Allows integrated single photon counting up to a rate of $\sim 10^6/\text{second}$

Micron MT9V011 Sensor (now Aptina)

*L. Servoli et al.: Journ. Of Instr. P07003 (2010) 001-013
Micron Imaging MT9SH06 technical documentation, Revision 2.8.0., 2007*

Test Board

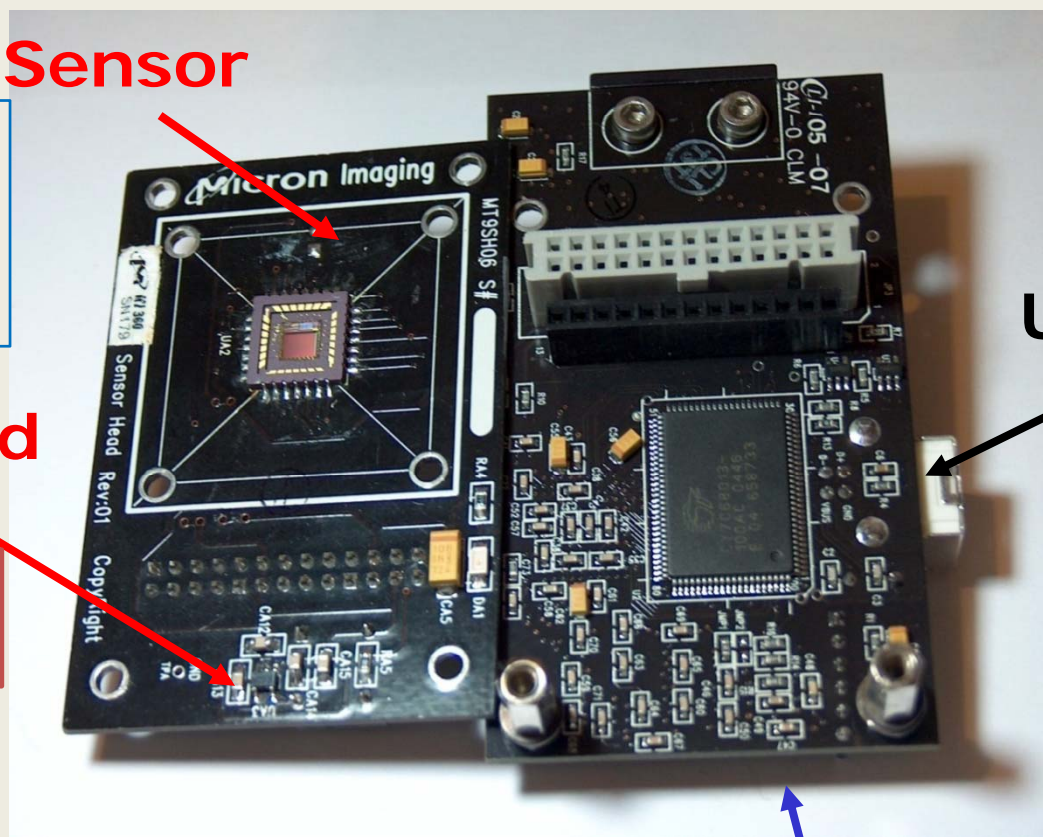
Optimized for visible light detection

- 640x480 pixels (VGA)
- 300k pixels
- 5.6x5.6 μ m pixel size
- 10-bit ADC
- Adjustable integration time from 56 μ s to 267ms
- Adjustable gain from 1 to 15.88

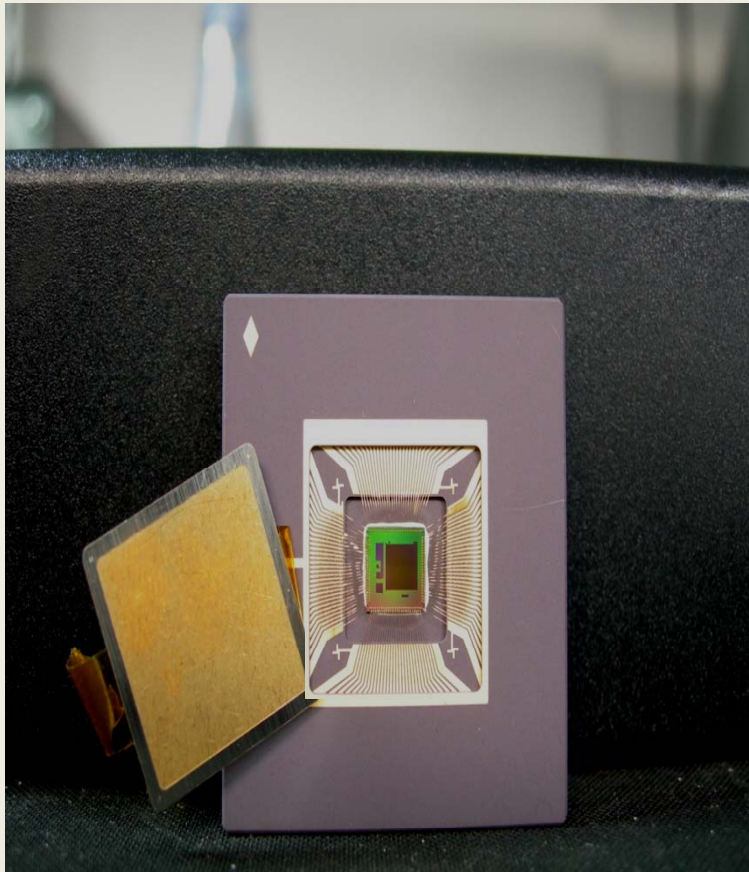
Sensor

USB

DAQ Board



RAPS03 prototype Sensor



The sensitive element is designed to optimize the performance for ionizing radiation

- 256x256 pixels
- 10.x10.μm pixel size
- up to 140 ms integration time
- 12-bit ADC

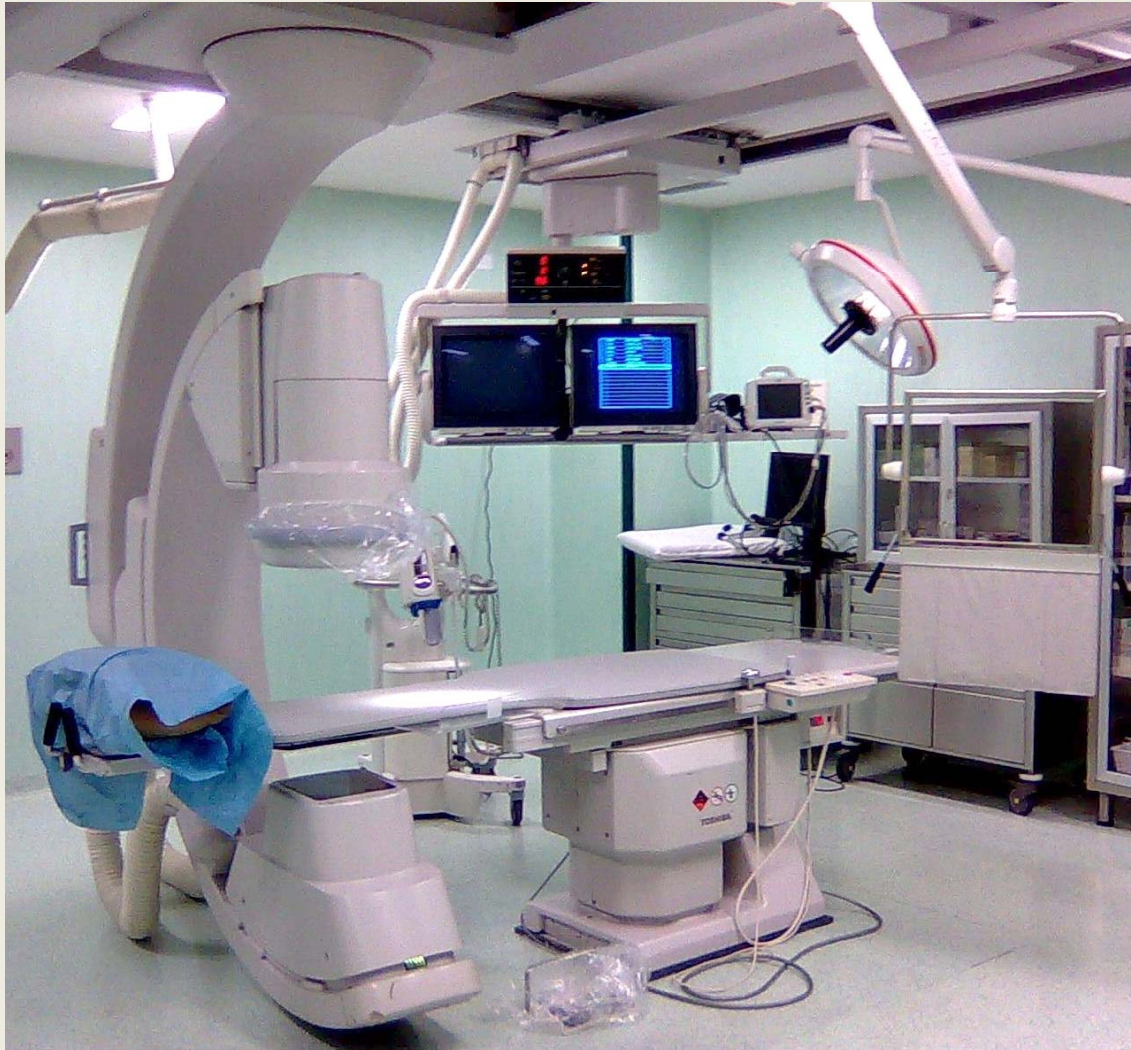
D. Passeri et al.: IEEE Trans. Nucl. Sci.: 52 1869-1872 (2005)

D. Passeri et al.: Nucl. Instr. Meth.: A581: 335-338 (2007)

P.Placidi et al. IEEE Nucl. Sci. Symp. Conf. Rec. NSS08 3459-3463 (2008)

Experimental setup

Equipments

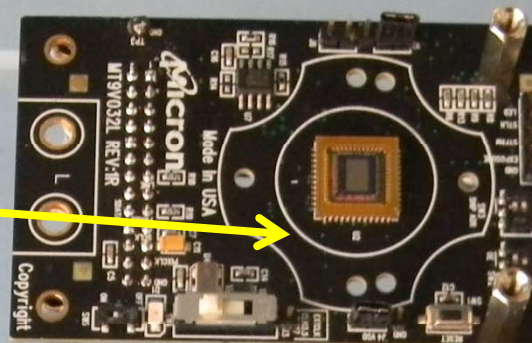


DSA Digital angiography

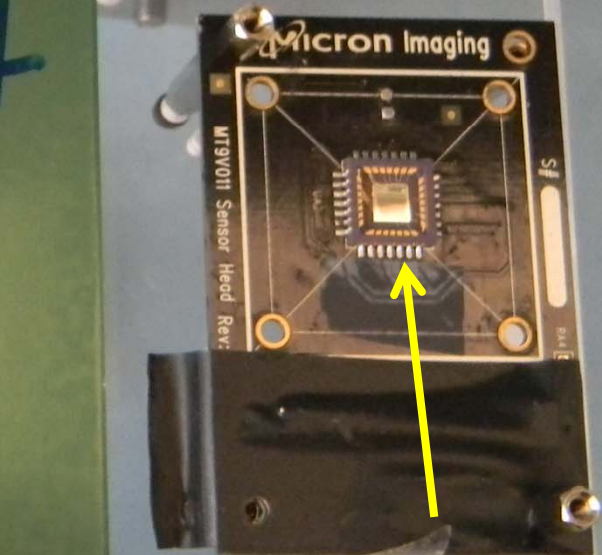
ASL 3 Umbria
Foligno Hospital

Dept. of Interventional
Radiology

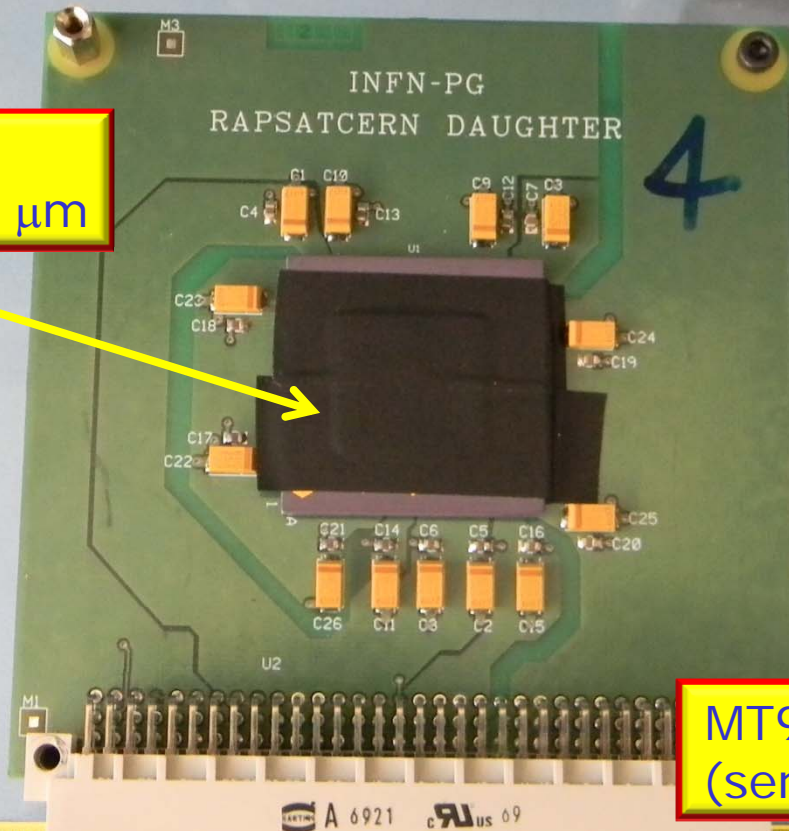
MT9V032 Micron CMOS
(sensitive layer: 12 μm)



AMPTTEK X-123
Spectrometer

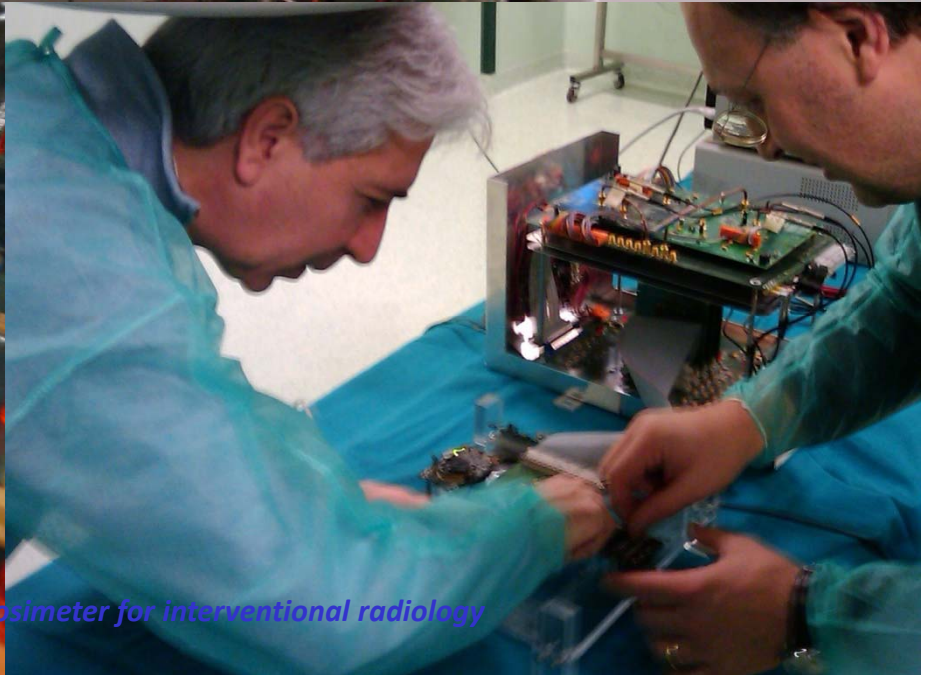
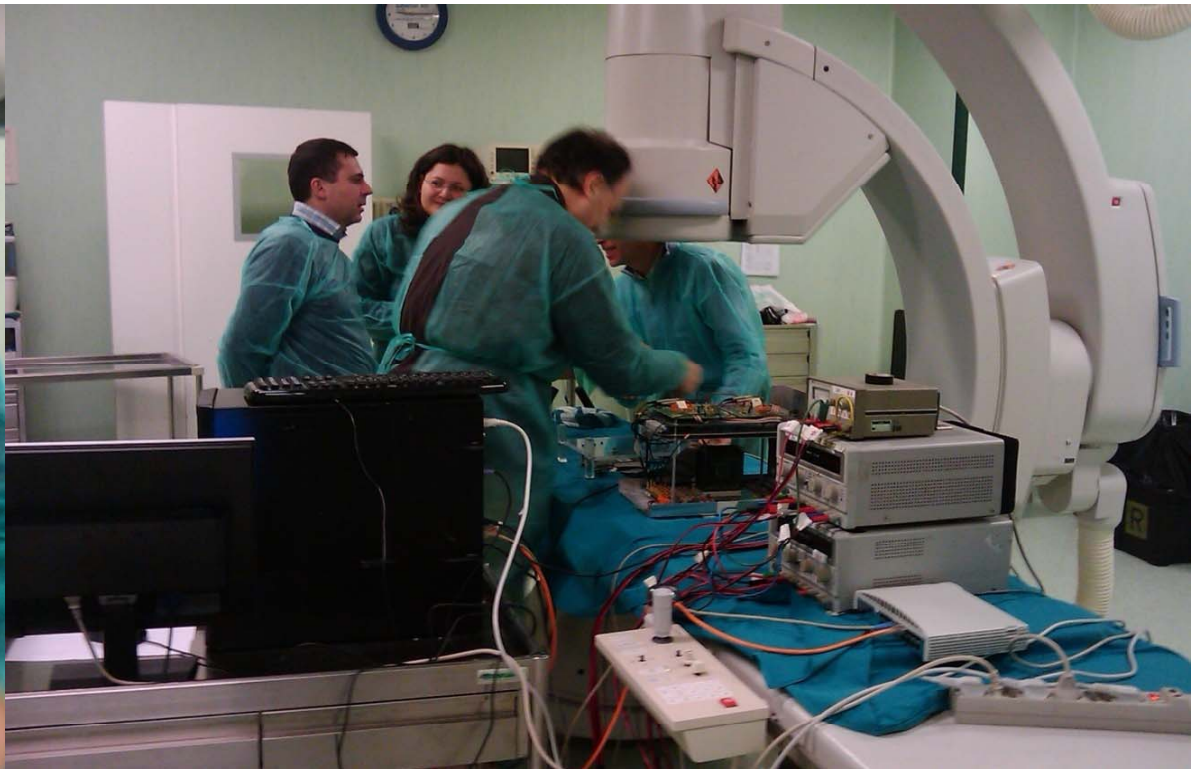
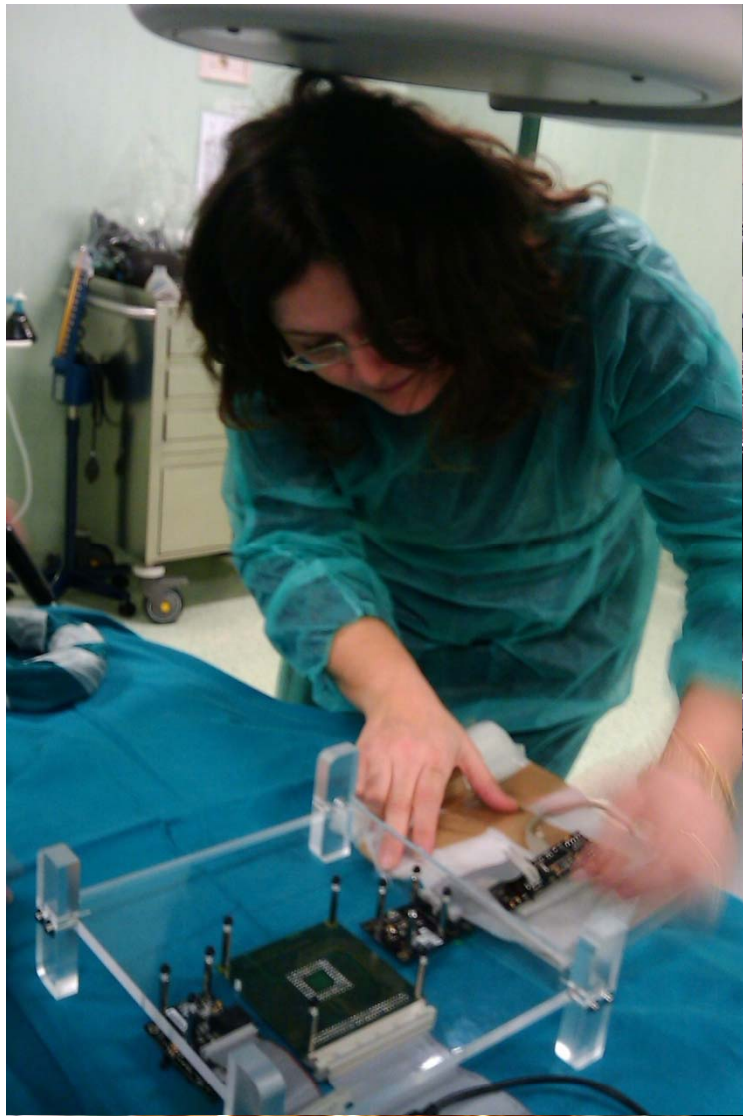


RAPS03
Sensitive layer: 25 μm



MT9V011 Micron CMOS
(sensitive layer: 4 μm)

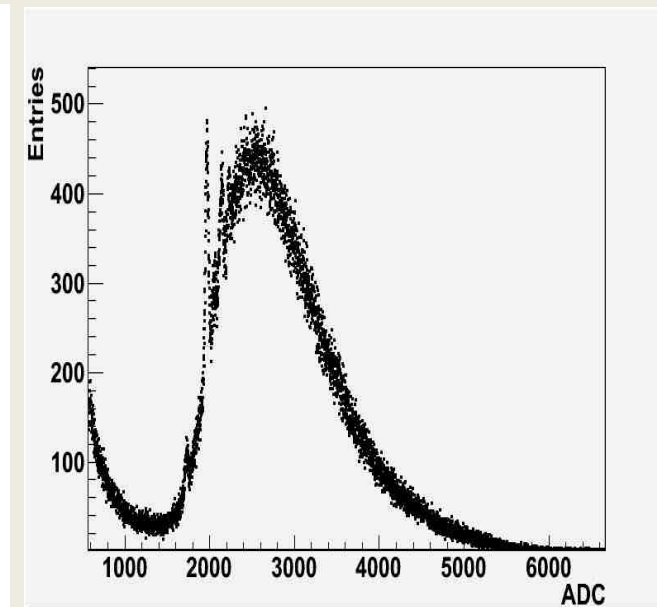
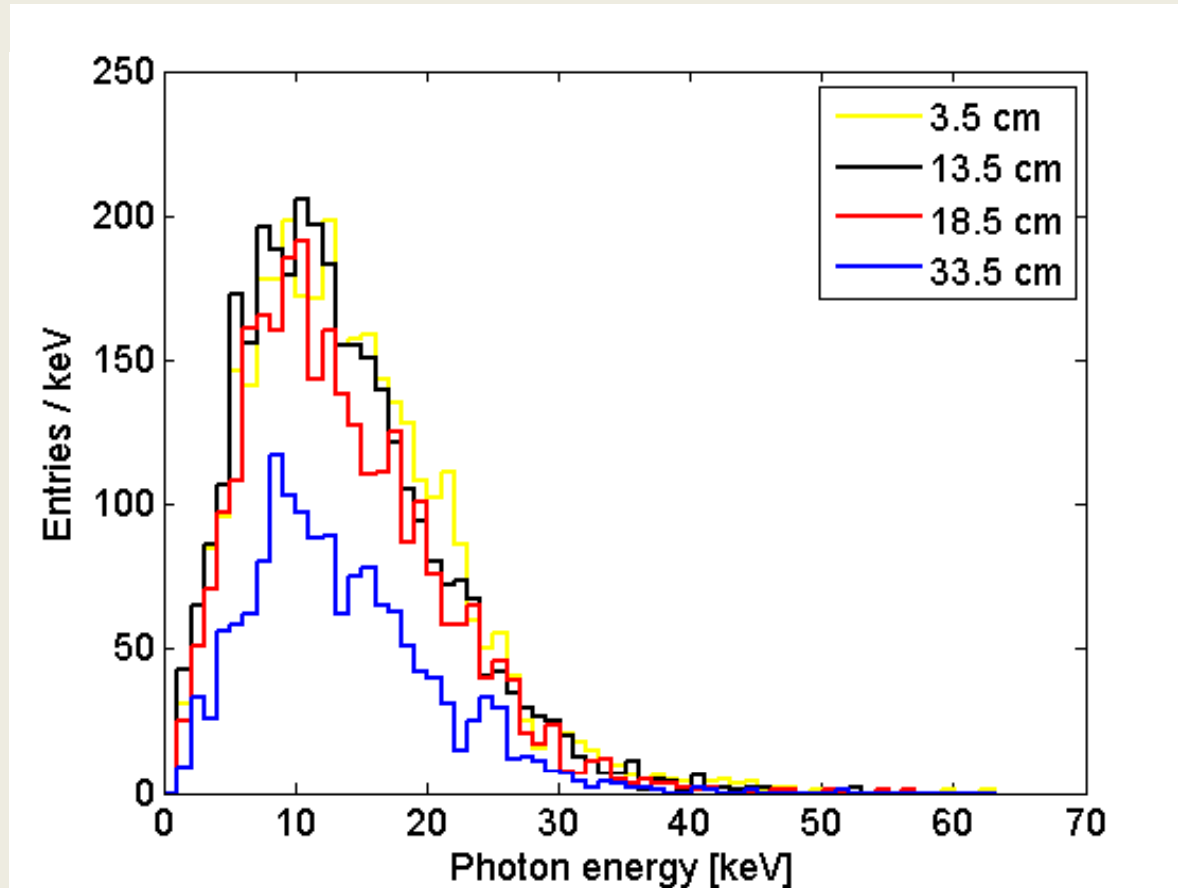




M. Paolucci – A real time active pixel dosimeter for interventional radiology

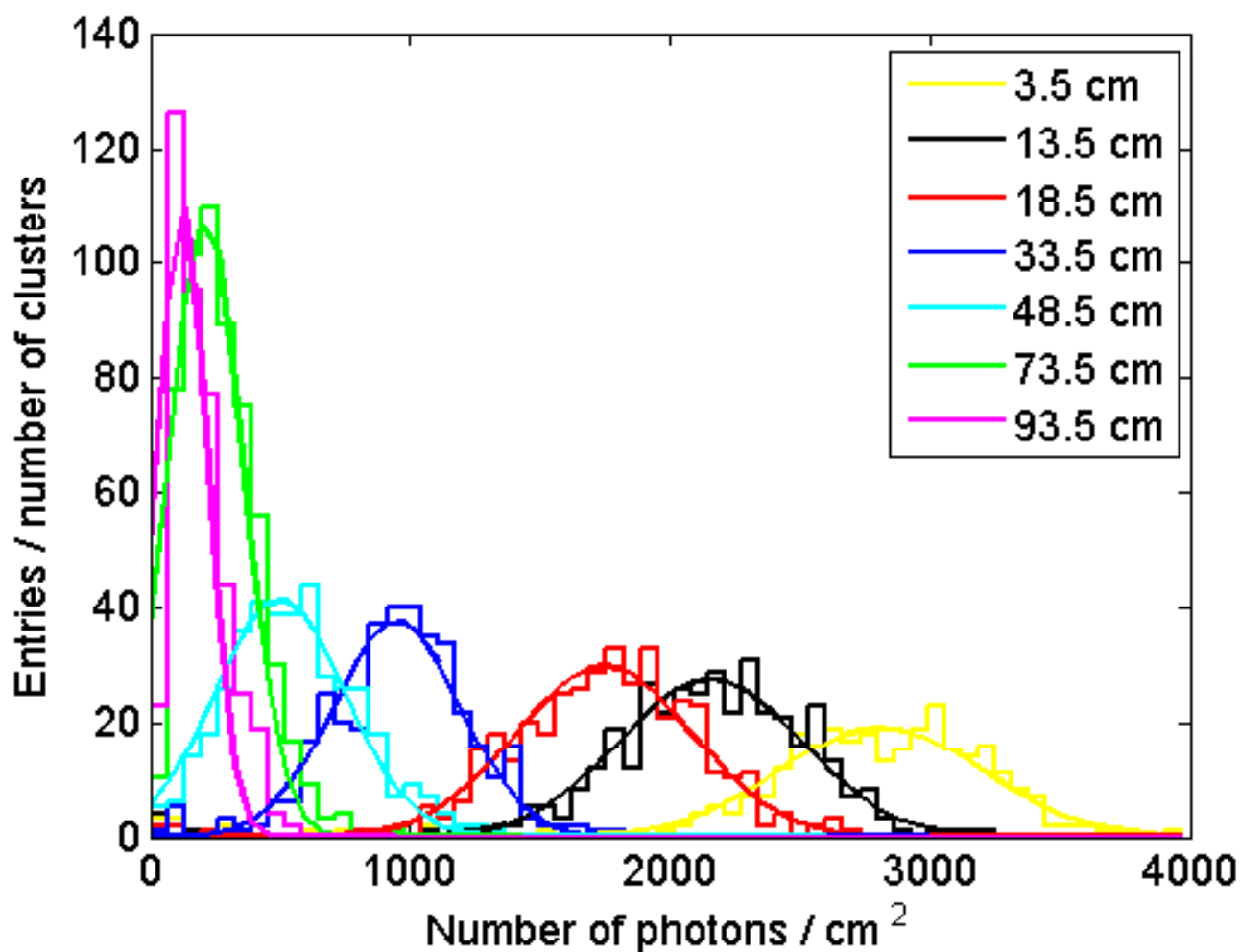
Preliminary results

RAPS03 Photon spectrum

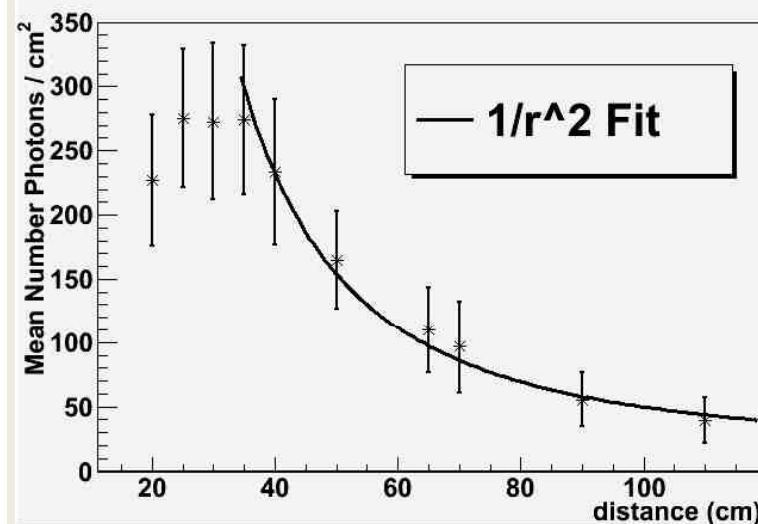
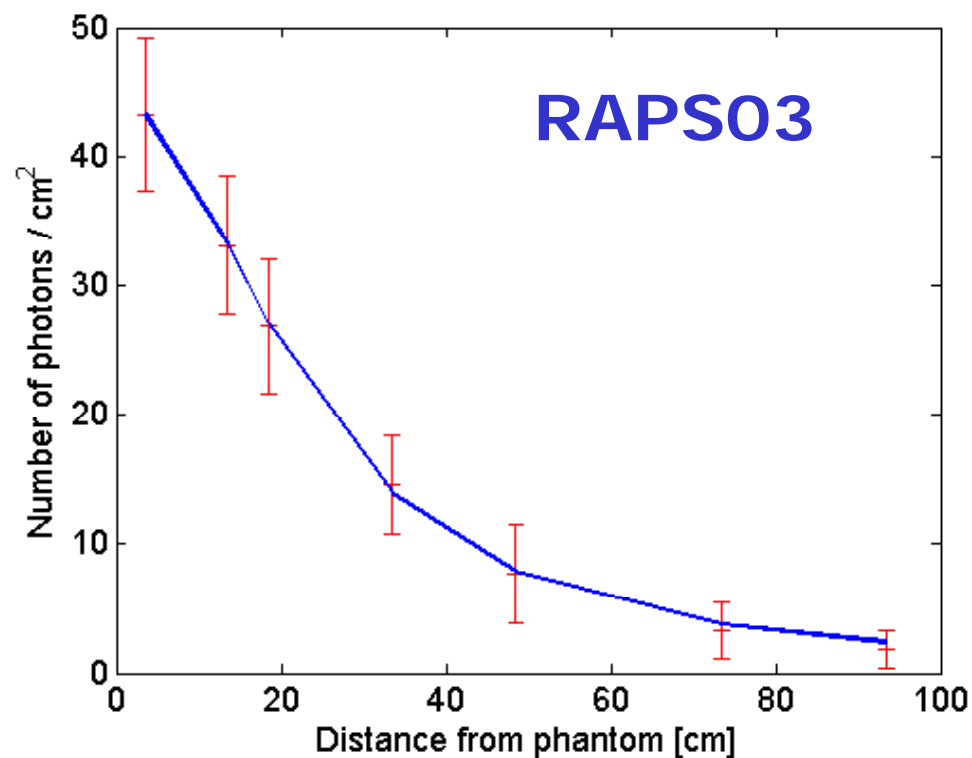


Scattered photon
spectra measurement

Photon distribution/frame – RAPS03

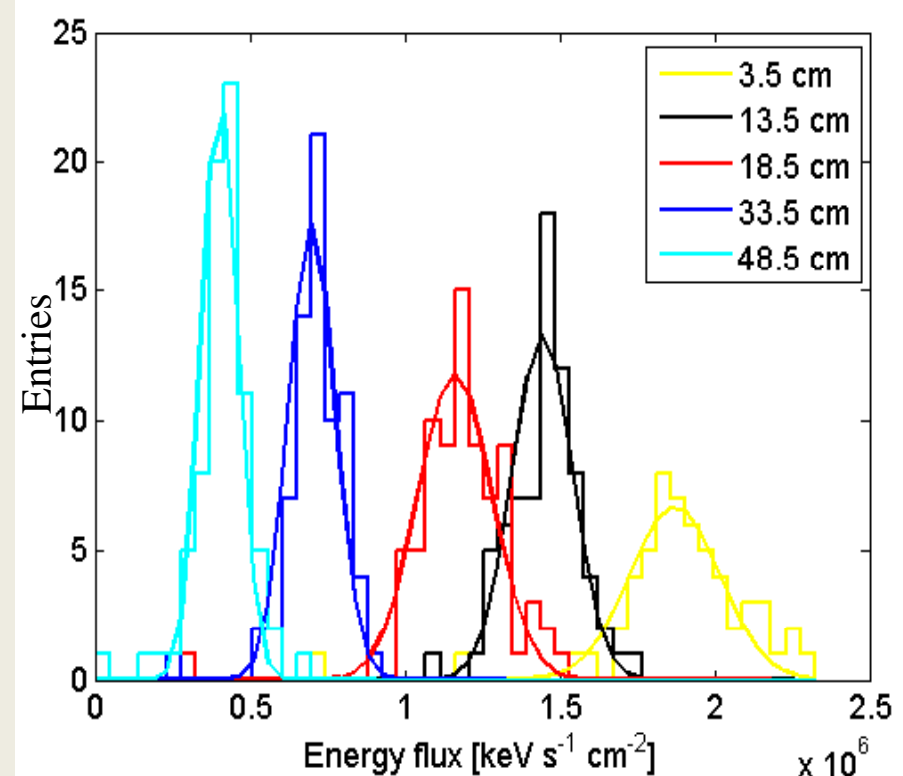
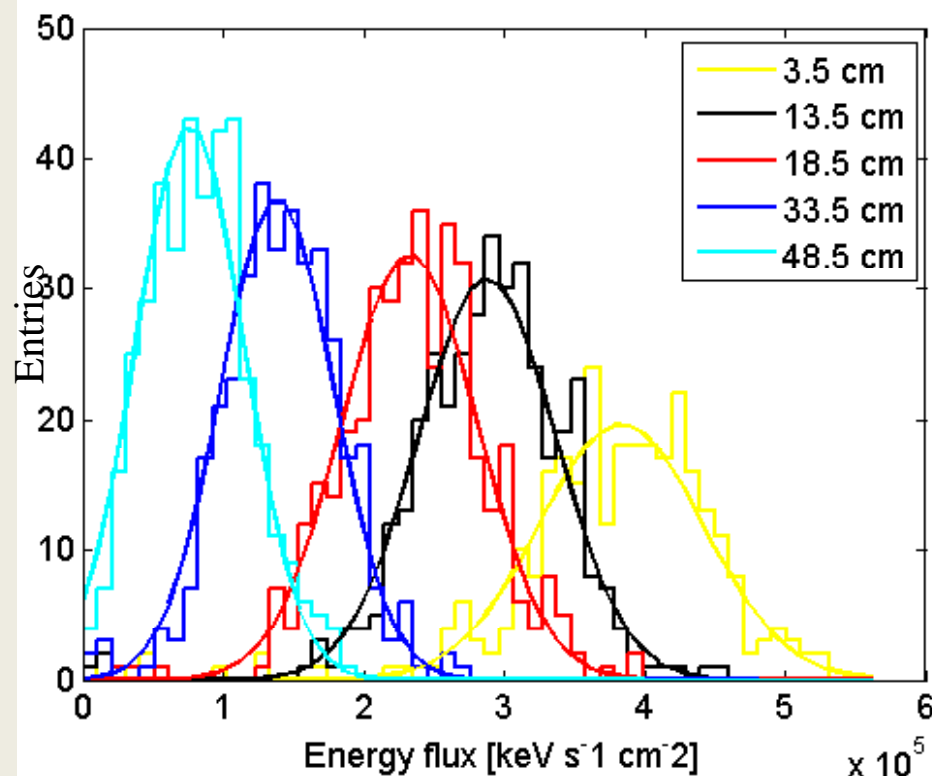


Photon distribution/distance – RAPS03



ISR law verified for all sensors.
MT9V011: difference at small distance due to its position

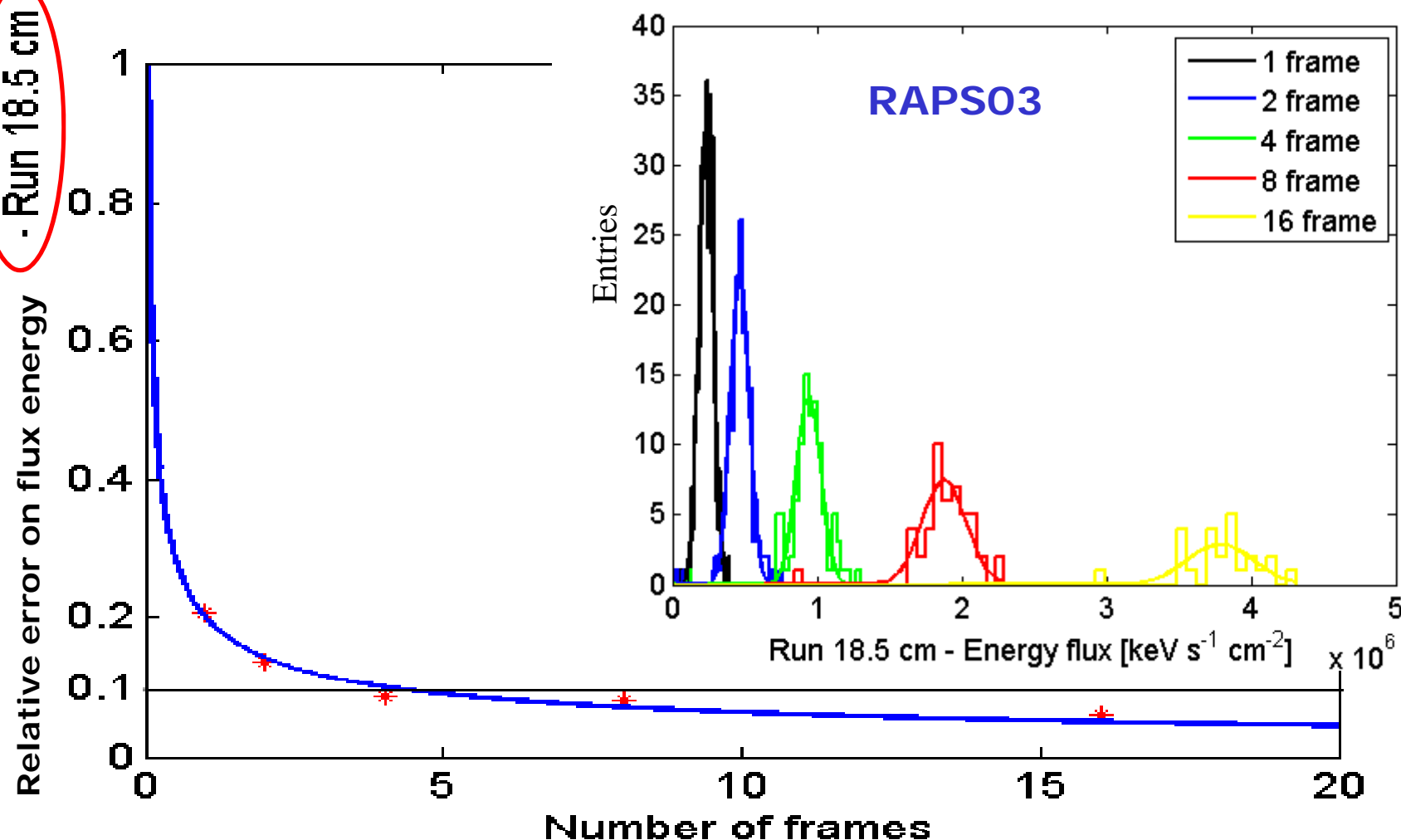
Photon energy flux – RAPS03



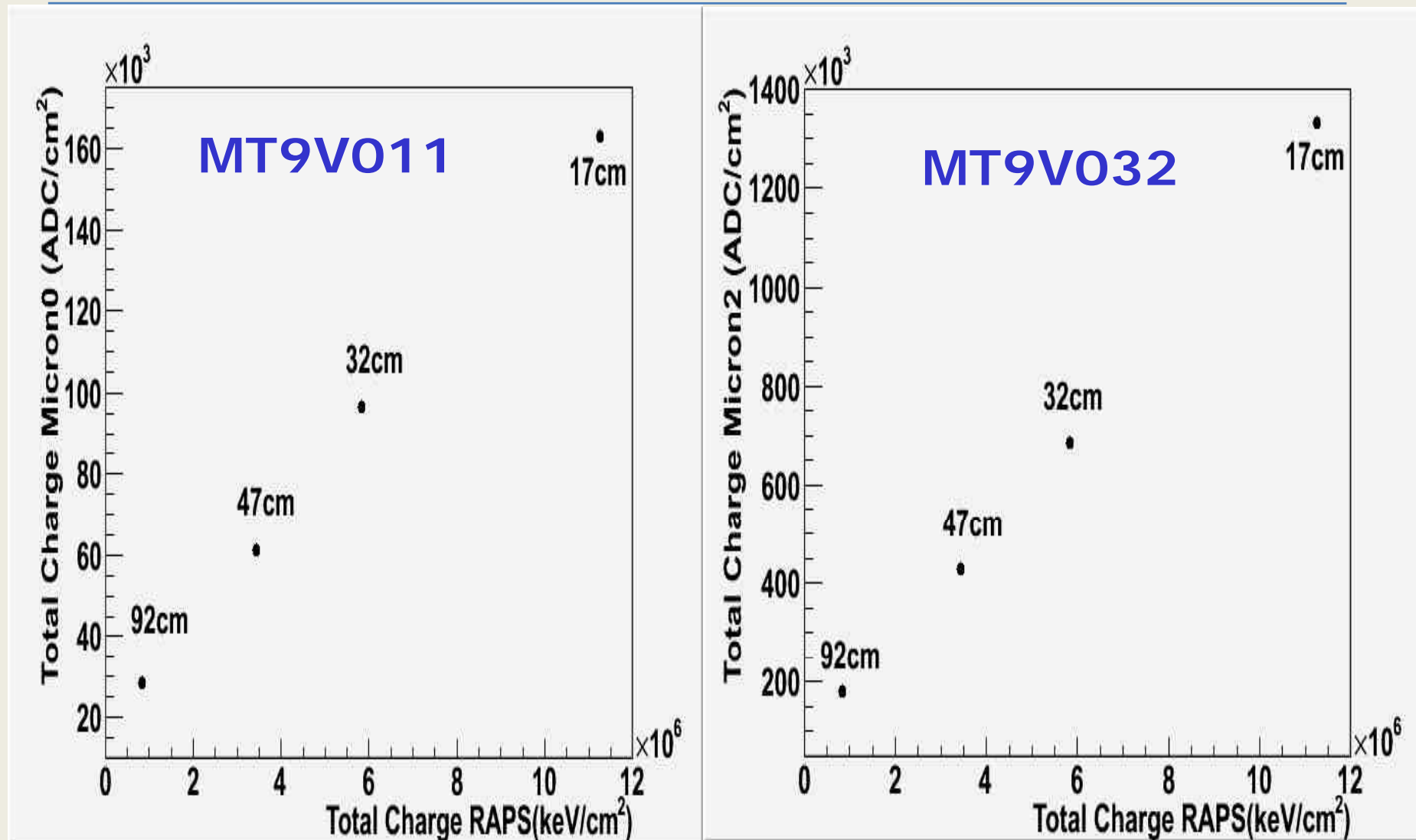
Smaller error for energy fluence measurement

Relative Error vs time (frame units)

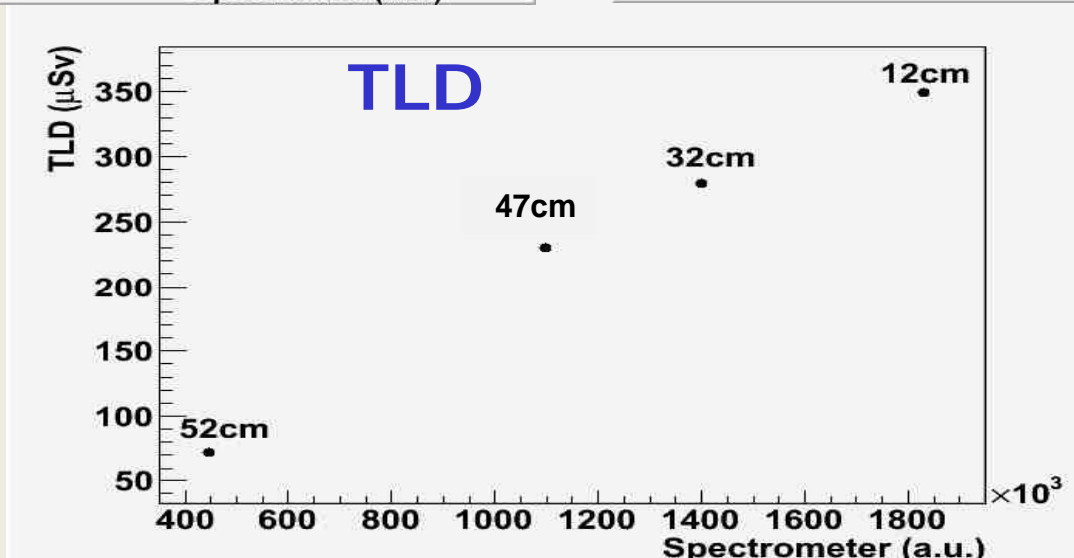
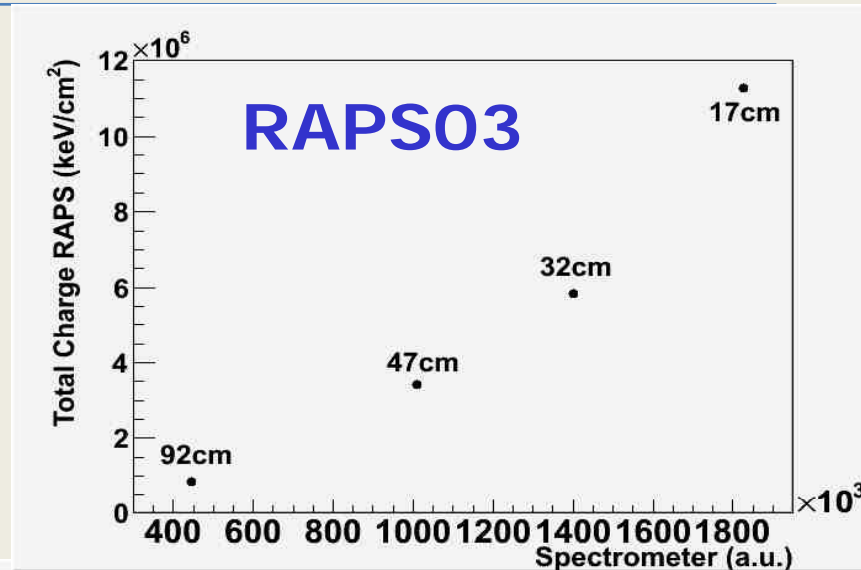
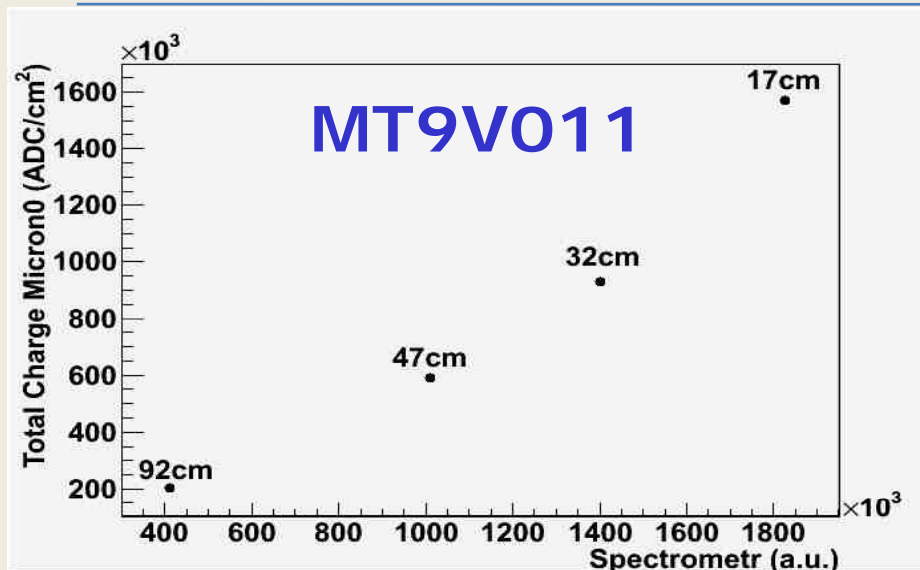
- Run 18.5 cm



Correlation among RAPS03 & Micron



Correlation among spectrometer & sensors



Results & Future development

- Encouraging results in the consistency of the imagers
- CMOS dose calibration
- Implementation of a prototype dosimeter & wireless system
- Clinical tests with medical staff



Thank you!!!