

Francesca Bisello
ESR 10

IV ARDENT Annual Workshop

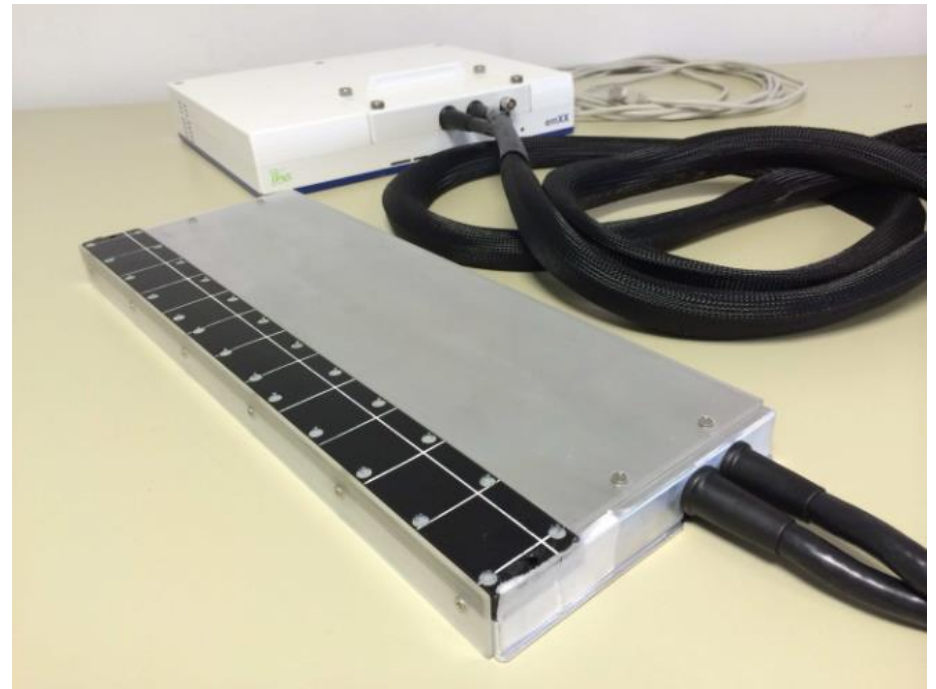
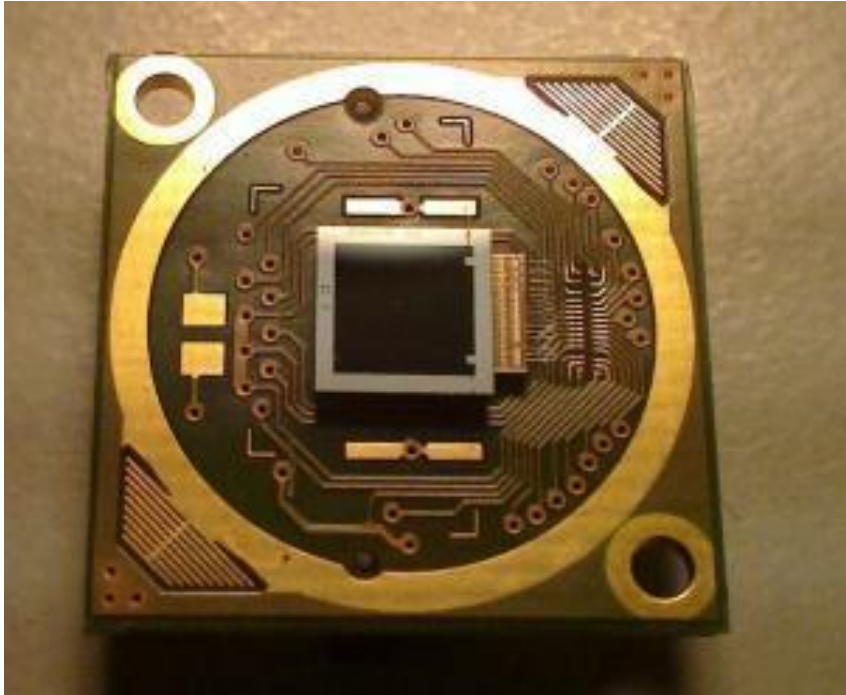
22-26/06/2015
Prague



Outline:

- **Research Activities**
 - **Dosepix detector**
 - **1D monolithic silicon array**
- **Trainings, Conferences, Outreach**
- **Future Activities**
- **Conclusions**

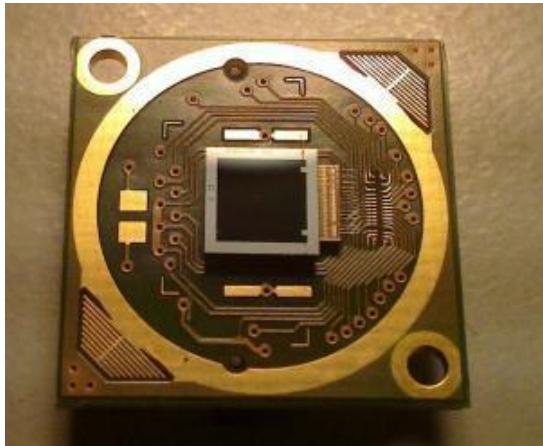
Research Activity: Semiconductor detectors in clinical QA in radiotherapy and diagnostics



Dosepix: QA in Diagnostics- kVpmeter

Non invasive kVp-meter: closely spaced photodiodes filtered by different thickness and materials : time consuming calibration curves

Detector :



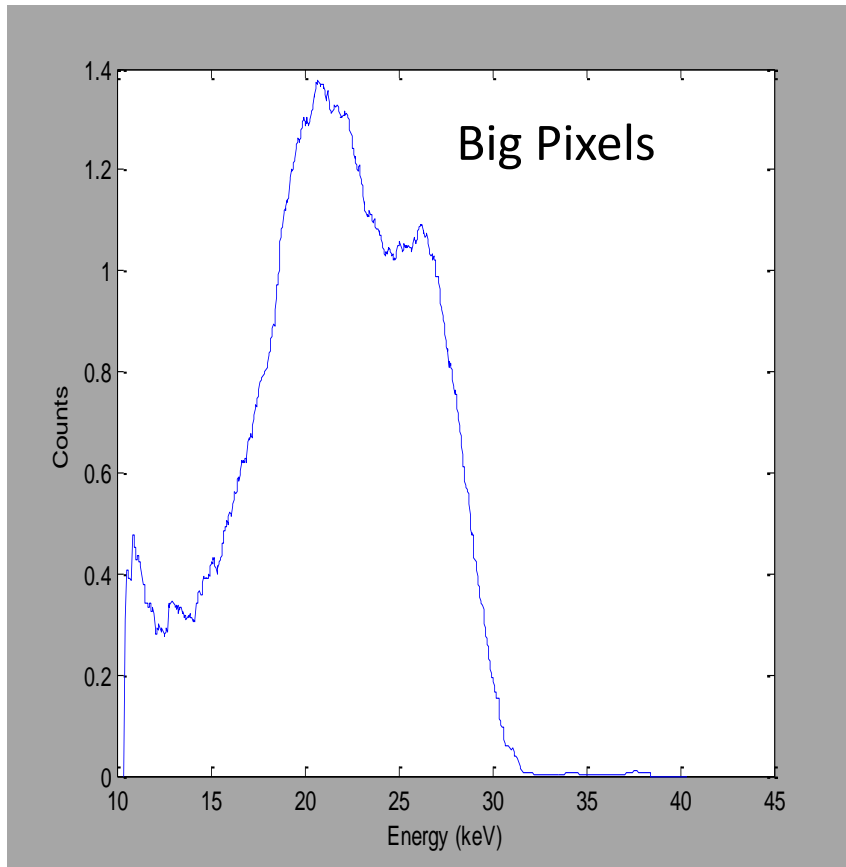
- Single photon counting detector
- 16 x 16 pixels
- Pixels size: 220x220 μm , 55x55 μm
- Sensor material : 300 μm silicon
- Time-over-Threshold
- Programmable front end settings
- 16 Digital Thresholds /pixel

Performed studies: 1. Chip Characterization
2. kVp-meter in Mammography (22-35 kV) by the analysis of the impinging spectrum

Dosepix: QA in Diagnostics- kVpmeter

Detector characterization I

- 0.1-0.3 mm Cu additional filtration to prevent spectra distortion due to analog pile up

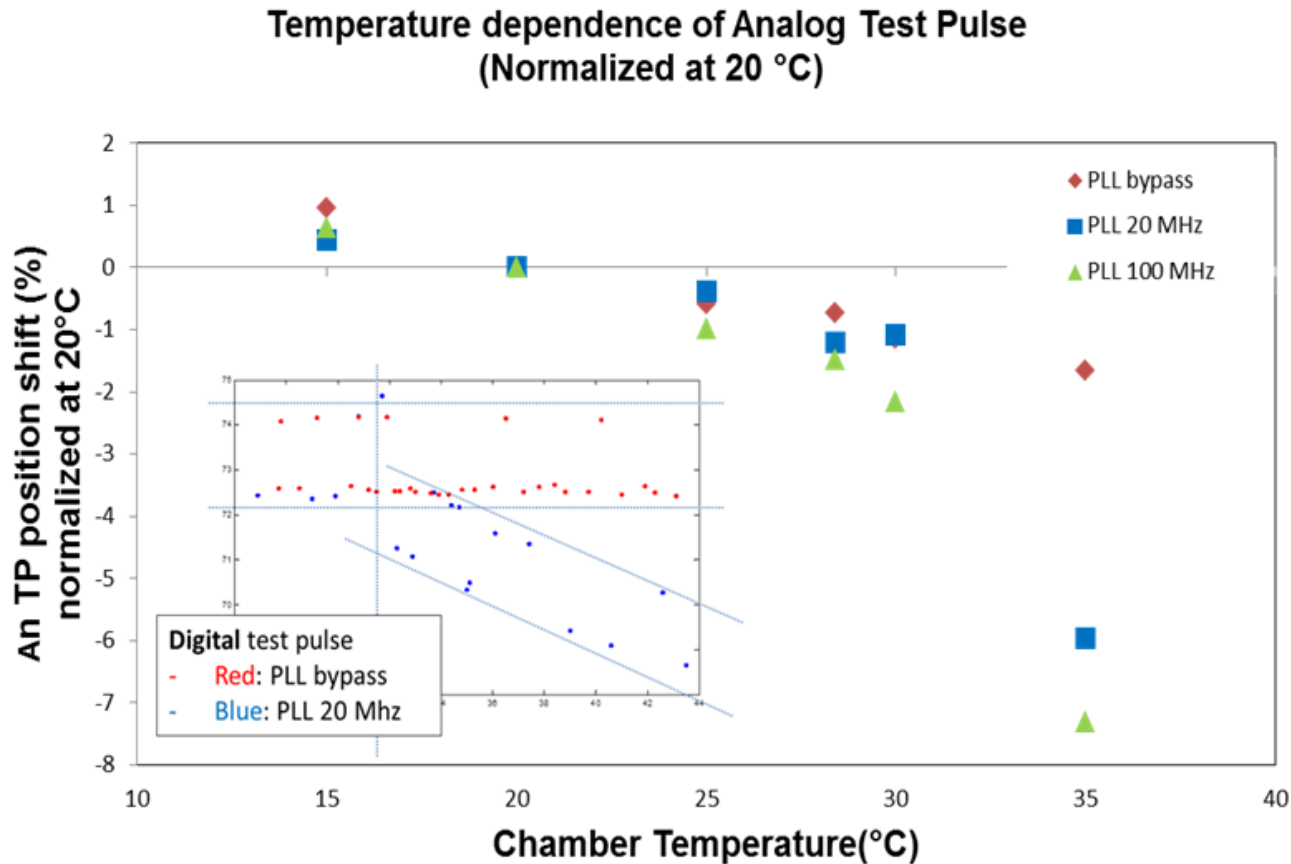


Tube setting:
30 kV, 20 mAs
Mo-Mo

Dosepix: QA in Diagnostics- kVp meter

Detector characterization II

- Source of instability for temperature fluctuation: PLL circuit

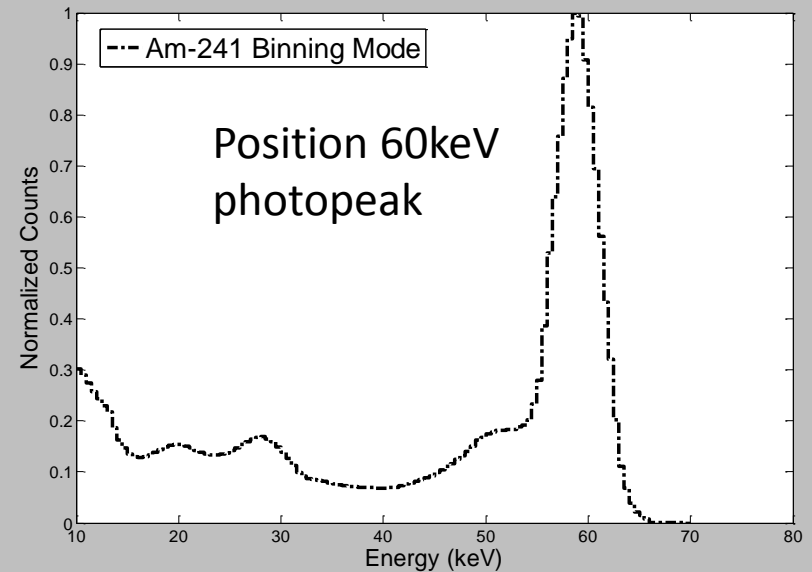
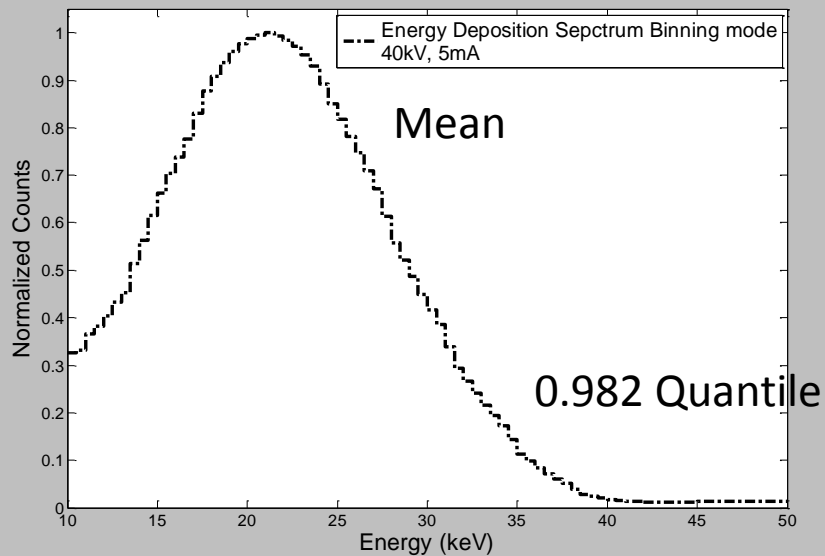


Dosepix: QA in Diagnostics- kVpmeter

Detector characterization III

Radiation Tolerance studies

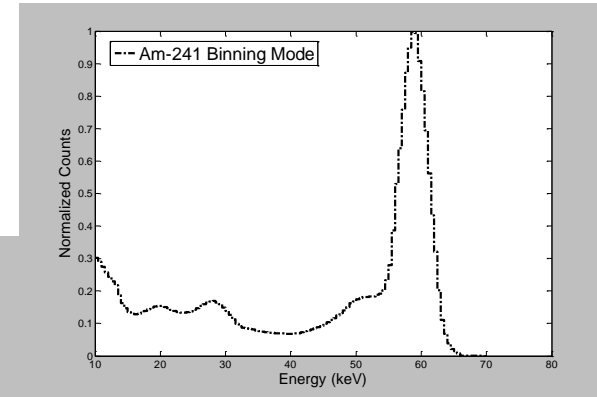
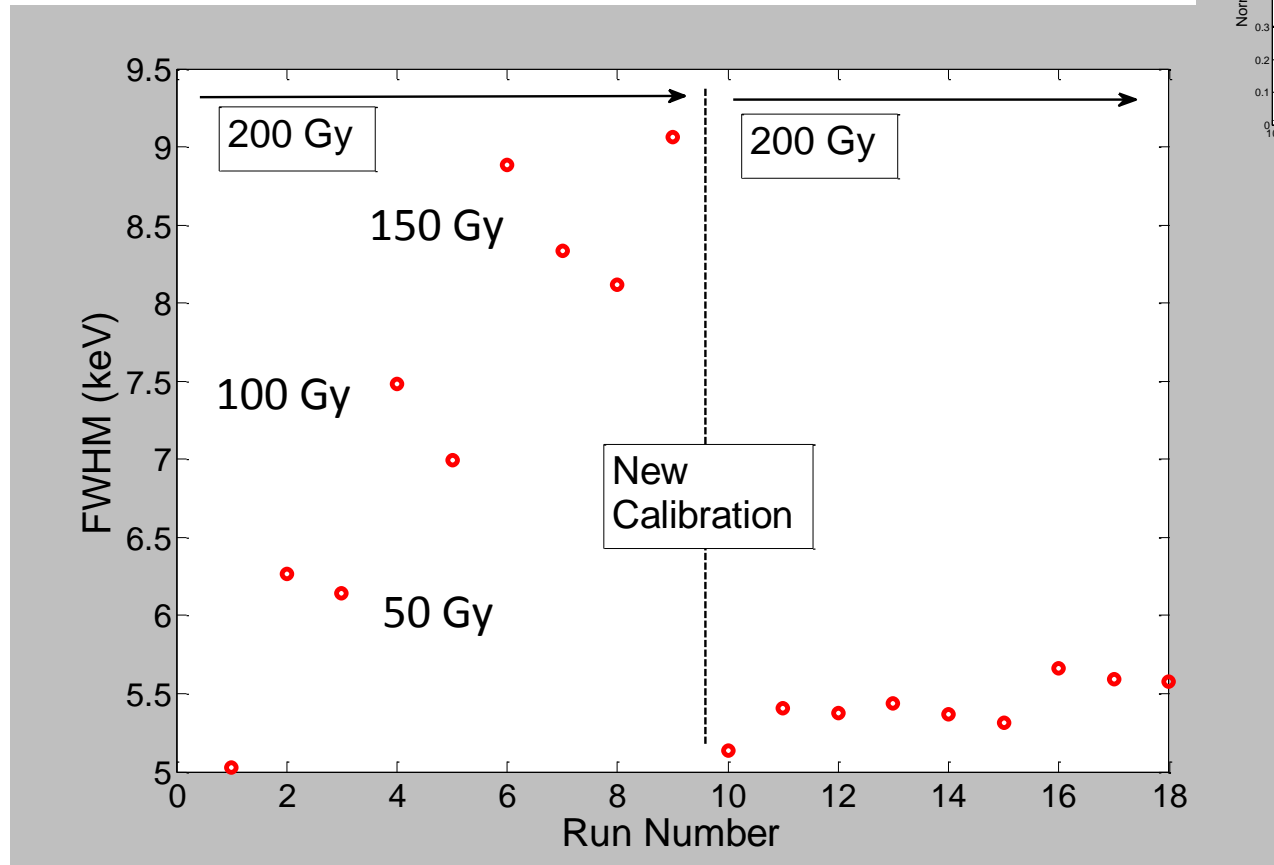
- Radiation tolerance of the assembly
- kVp-meter in radiology based on calibration curves (50 Gy /calibration curve)
- Stability of Spectrum (Binning Mode)
- Irradiation: 40kV photons, X-Ray tube, W-anode
- 200 Gy, 50Gy/step, 3 days annealing



Dosepix: QA in Diagnostics- kVp meter

Detector characterization

Radiation Tolerance studies



Dosepix: QA in Diagnostics- kVpmeter

Detector characterization

Radiation Tolerance studies

Conclusion

- Additional filtration reduce influence of analog pile up (0.1-0.3mm Cu)
- Source of instability vs external temperature: PLL circuit

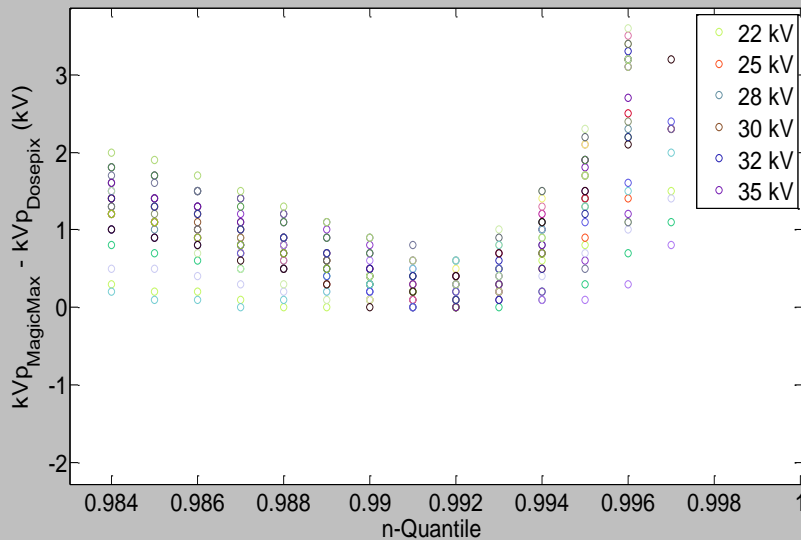
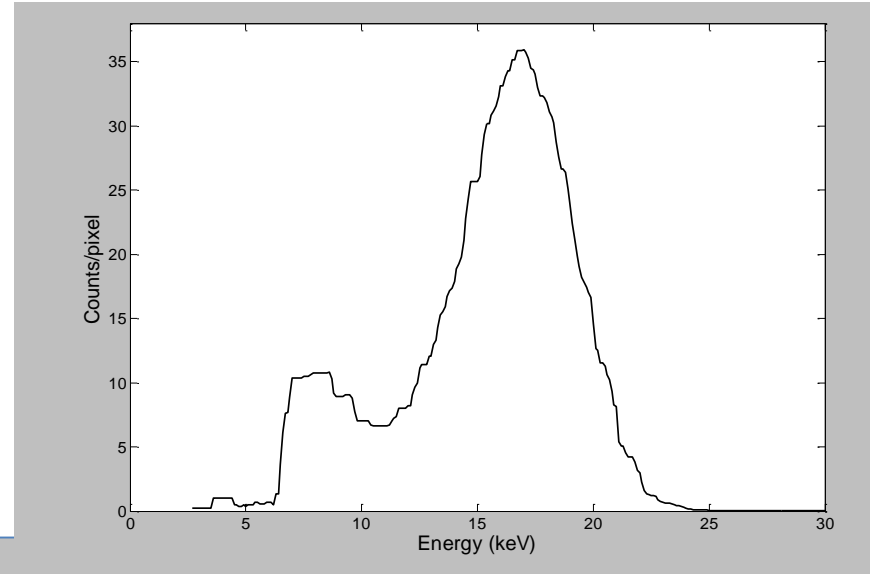
Radiation tolerance studies:

- Higher cumulated dose to stabilize the electronics
- Deviation within 2%: regulation limit
- Re-calibration recovers damages due by radiation
- Tests on going:
 - One chip: 5kGy cumulated dose, 1 months annealing

Dosepix: QA in Diagnostics- kVpmeter

kVpmeter Algorithm

Operation Voltage	22 – 35 kV
Current·s	20 mAs
Inherent Filtration	0.3mm Mo
Dose	1.7-7.4 mGy
Dose Rate	8.2-21.4 mGy/s
Additional filtration	0.1 mm Cu



Reference detector:

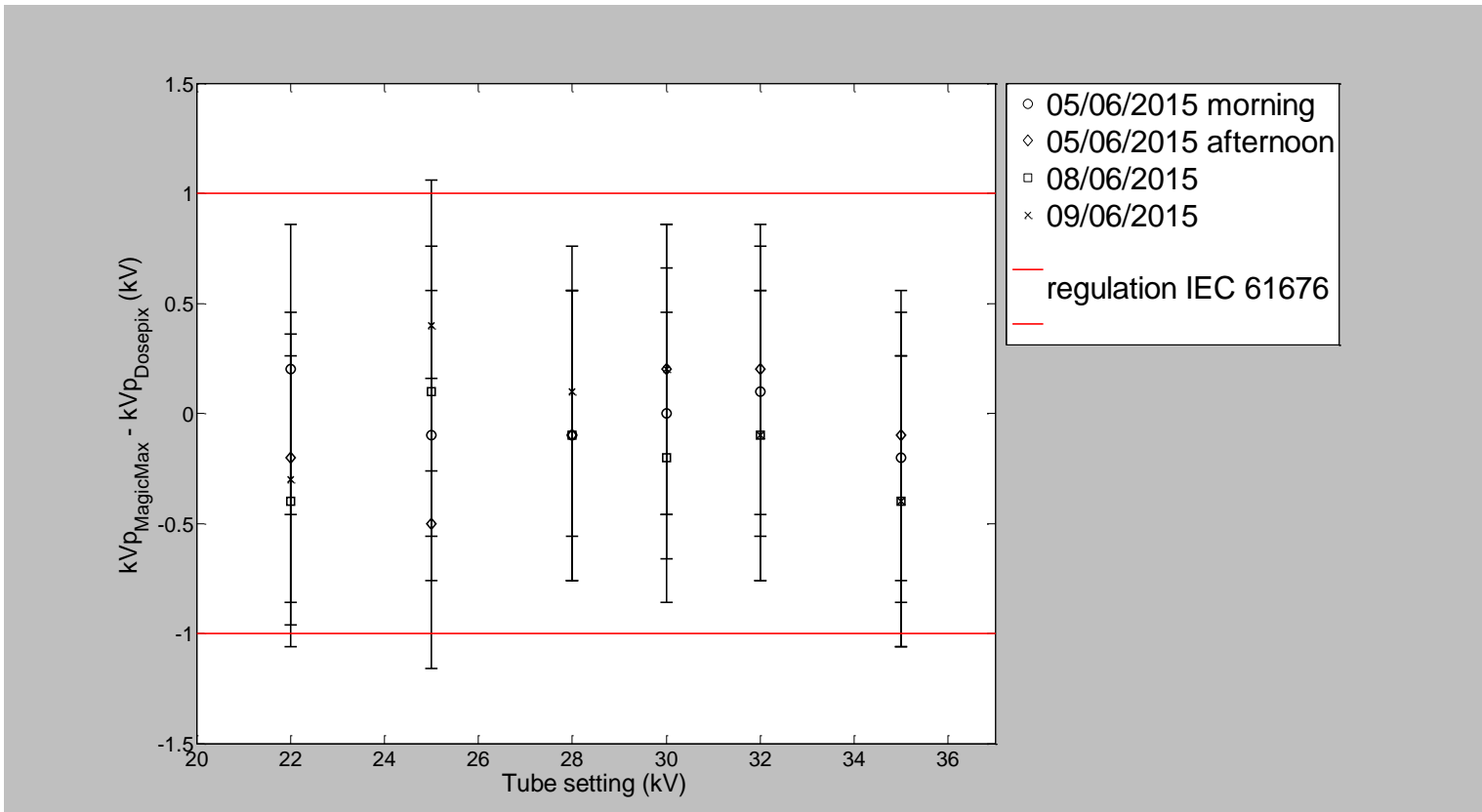
- MagicMax Universal, IBA Dosimetry GmbH, Schwarzenbruck (DE)

Method:

- Find the quantile who minimizes the difference with reference detector

Dosepix: QA in Diagnostics- kVp meter

kVp meter Algorithm



Conclusions:

- Experimental method for kVp reconstruction in mammography within regulation
- Long term stability on going

1D Silicon Array: QA in Radiotherapy

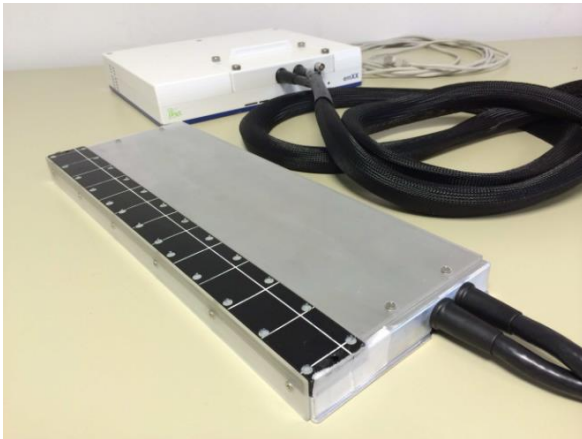
Needs in Radiotherapy: High spatial resolution

Large sensitive area

Radiation Tolerance

Low sensitivity changes with dose-rate (dose per pulse)

Detector :



- Epitaxial monolithic Silicon diodes
- 1mm pitch
- 24 cm length
- sensitivity changes with dose (0.2%/kGy)
- dose per pulse changes ($\pm 1\%$ in the range 0.1–2.3 mGy/pulse)

Facilities: IBA Dosimetry, ICC Doselab, schwarzenbruck, Germany

Azienda Ospedaliera Universitaria Careggi, Florence, Italy

Perelman Center for Advanced Medicine, Philadelphia, PA, USA

True Beam and Clinac iX, Varian Medical System, Palo Alto, CA

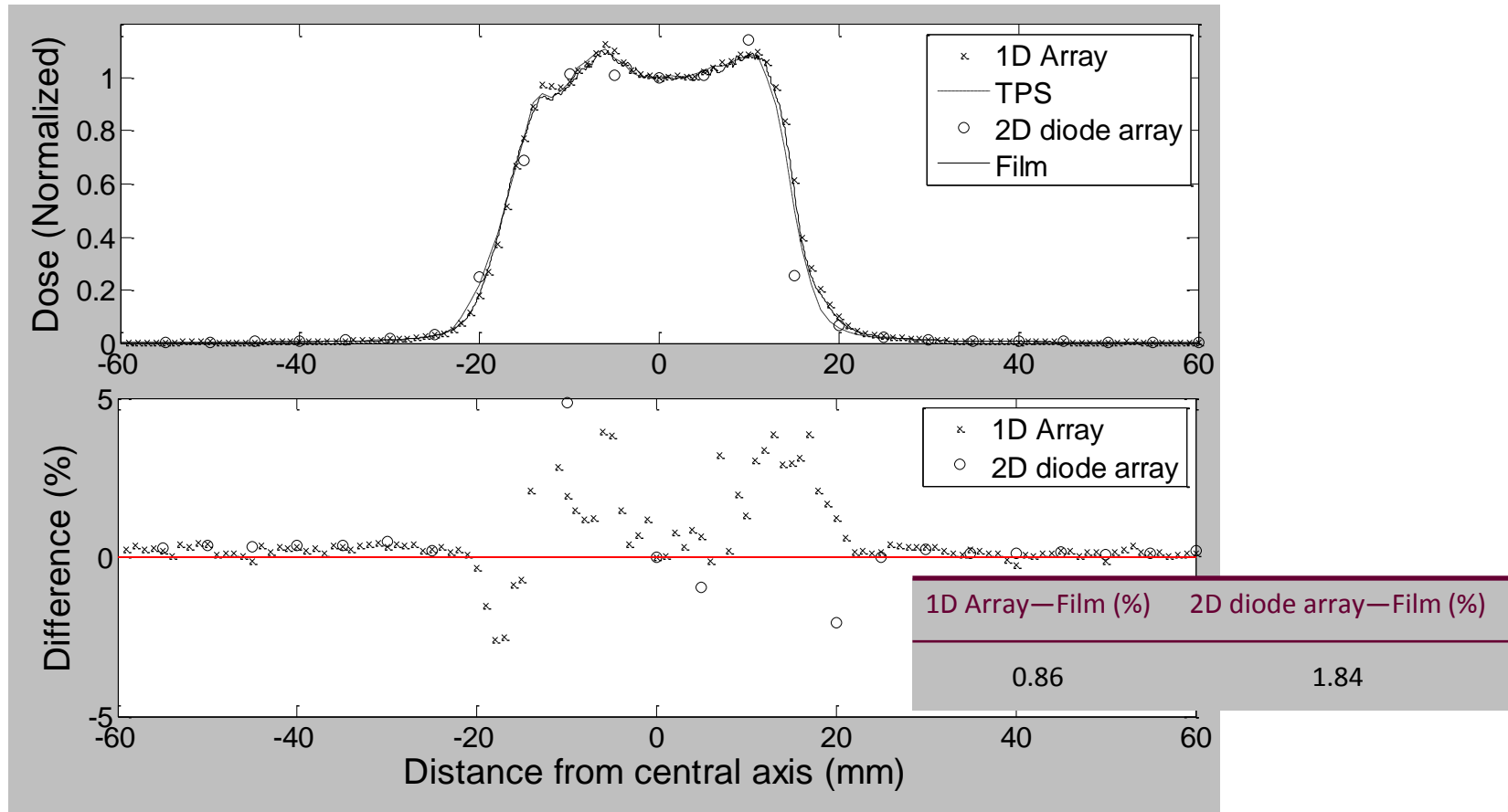
Pennsylvania Hospital, Philadelphia, PA, USA

CyberKnife G4 Accuray Inc., Sunnyvale, CA

1D Silicon Array: QA in Radiotherapy

1. IMRT and SBRT Patient Plan Verification: 6 clinical cases Comparison with TPS, film and diode array

SBRT, 6MV, clinical site: Liver, SDD : 99.3 cm



1D Silicon Array: QA in Radiotherapy

2. Machine Quality Assurance

Commissioning of an Iris Collimator for robotic radiosurgery: physical properties



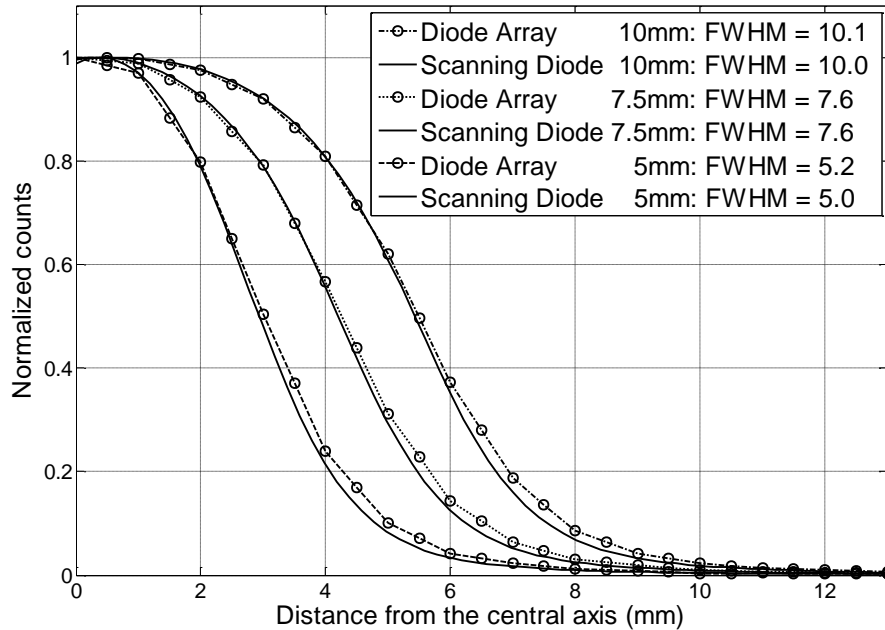
- 6 degree freedom
- Collimator 5 to 60 mm
- Constant tumor tracking



- Used in clinics : fields > 10 mm

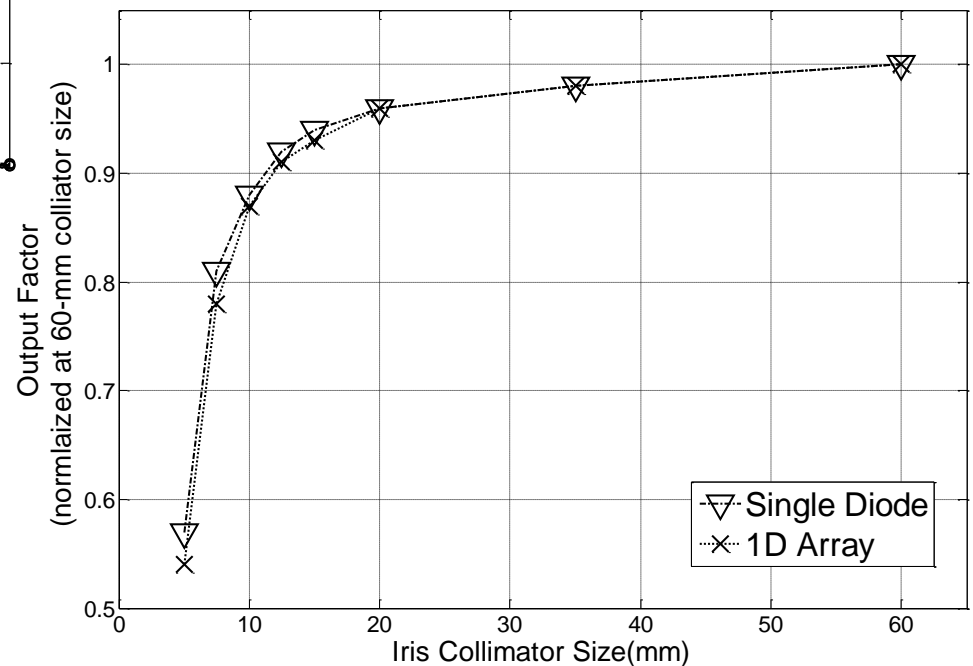
1D Silicon Array: QA in Radiotherapy

Commissioning routine for small photon field



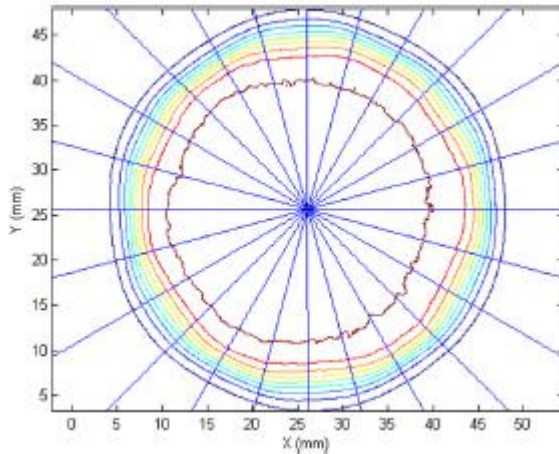
Iris collimator beam profiles:

- 1D array
- Scanning diode

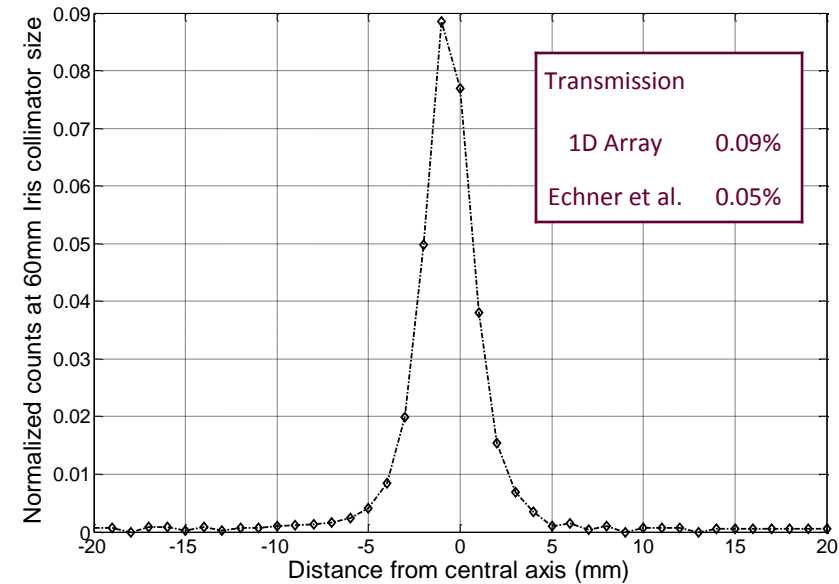
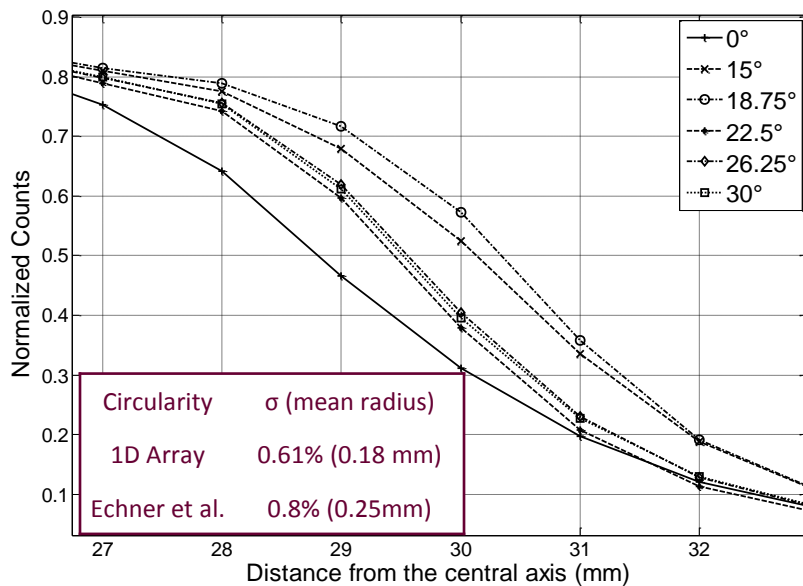


1D Silicon Array: QA in Radiotherapy

Characterization of Iris collimator



G.Echner et al. Phy.Med. Biol. 54 (2009)5359-5380



1D Silicon Array: QA in Radiotherapy

Conclusions

- Good performance in dose plan verification of conformational radiotherapy compared with commercial solution
- The characterization of Iris collimator provide goods results compared with radiographic films.
- Poster Presentation, 57th AAPM Annual Meeting, Anaheim, CA
“Characterization of a novel high resolution 1D Silicon monolithic array for small field commissioning and quality assurance”

Characterization of a novel high resolution 1D Silicon monolithic array for small field commissioning and quality assurance

F. Bisello^{1,2}, J. E. McGlade³, P. Wang⁴, J. Kravá, P. Kostern⁵, R. Mool⁶, D. Menichelli⁷, J.-C. Cels⁸, T. Solberg⁹
¹University of Pennsylvania/Radiation Oncology, Philadelphia, PA, USA
²Rad Dosimetry GmbH, Schwarzenbruck, Germany
³Friedrich-Alexander-Universität, Erlangen-Nürnberg, Germany

1. Purpose
 To study the suitability of a novel 1D silicon monolithic array for dosimetry of small radiation fields and for QA of high dose gradient treatment modalities (IMRT and SBRT).

2. Materials and Methods
Facilities: Perelman Center for Advanced Medicine, Philadelphia, PA; Clinac (X (L1) and True Beam (L2)) (Varian Medical Systems, Palo Alto, CA), Pennsylvania Hospital, Philadelphia, PA; CyberKnife G4 (L3) (Accuray Inc., Sunnyvale, CA).
Measurement system: High resolution array of silicon diodes: 24cm active length, 1mm pixel pitch. Modular design, 64ch monolithic silicon sensor.
 Main dosimetric features: 0.2%/kGy sensitivity vs accumulated dose (up to 50 kGy). Sensitivity dependence on dose per pulse: ±1% (0.1-2.5 mGy/pulse).
 Low energy dependence compared to water phantom reference.

Performed Studies: The 1D array was used to perform dose profile measurements for multiple IMRT and SBRT treatment plans and for the characterization of an Iris Collimator.

3. IMRT and SBRT Patient Plan Verification (6 clinical cases) (L1, L2)
Comparison between TPS, film and commercial diode array
 Dose distribution compared with radiographic film, a commercial 2D diode array and a commercial TPS.
 Due to the small pixel pitch of the detector, IMRT and SBRT plan profiles show an average deviation from film measurements of less than 2% (Table 1).

Case	1D Array-TPS		2D diode Array-Film		2D diode array-TPS	
	(%)	(%)	(%)	(%)	(%)	(%)
IMRT	6MV Pelvis	0.73	0.66	1.15	0.89	0.89
	6MV Lung	2.04	0.61	1.14	1.10	1.10
	6MV Liver	0.84	0.86	1.60	1.84	1.84
SBRT	6MV Lung	0.31	0.78	1.42	0.84	0.84
	6MV Lung	1.55	0.82	1.64	1.64	1.64

IMRT 6MV, clinical site: Lung, SDD: 100 cm SBRT 6MV, clinical site: Liver, SDD: 99.3 cm

4. Machine Quality Assurance
Characterization of an Iris Collimator for robotic radiotherapy (L3)
 Table 2: 20-80% penumbra width measured at SDD 800mm and 15mm depth.

Iris Collimator size (mm)	7	7.5	10	12.5	15	20	35	60
Left Penumbra Scanning Diode (mm)	2.18	2.18	2.72	2.94	3.04	3.29	3.51	4.59
Right Penumbra Scanning Diode (mm)	2.20	2.14	2.69	-	-	-	-	-

Figure 1: Representative profiles measured with 1D array and a scanning diode, 800 mm SDD, 15 mm depth.
 Figure 2: Magnified view of beam profiles for 60mm Iris collimator with 1D array at mm SDD, 15 mm depth.
 Figure 3: Output factors normalized at 60 mm collimator, SDD 800 mm, 15mm depth.
 Figure 4: Measurement of full-close Iris collimator transmission with 1D Silicon array.

5. Conclusion
 Good performance of the array was demonstrated for patient QA compared with commercially available diodes and film typically used in these clinical applications. The characterization of Iris collimator, output factors and profile measurements of small photon beam are in agreement with reference detector and data from published literatures.

6. Acknowledgment and Contact
 This research project has been partially supported by the ARDENT Marie Curie Early Initial Training Network Fellowship of the European Community's Seventh Framework Programme.
 Contact e-mail: francesca.bisello@iba-group.com

B&A Training : ST Microelectronics

12-23 January 2015

- B&A topics (see Michele's presentation)
- Technical topics:
 - Steps involved in the wafer processing
(Photolithography, Ion Implantation, Wet etching...)
 - Visit at production lines

Conferences

57th AAPM annual meeting, July 12-16, Anaheim, CA

- AAPM DIAGNOSTIC PHYSICS REVIEW COURSE
- Small photon field Dosimetry

Outreach

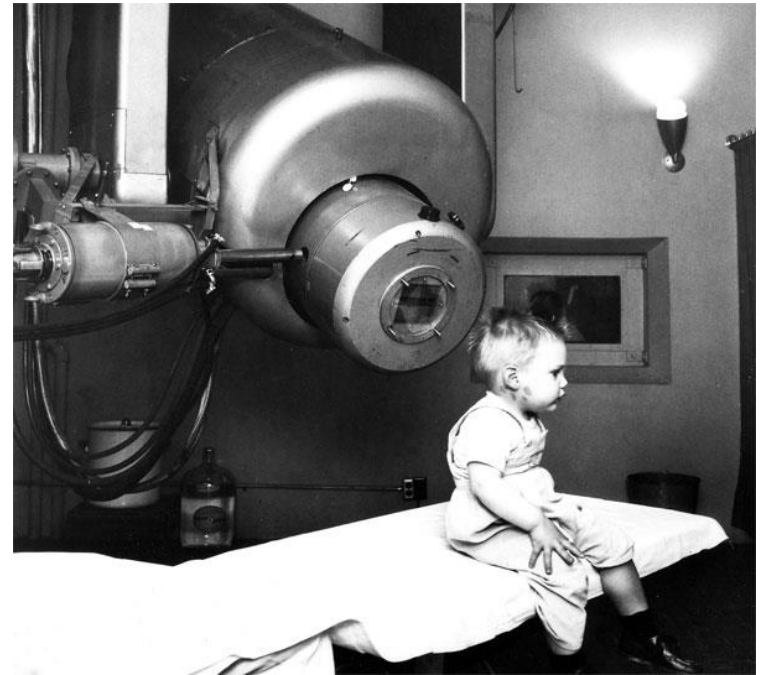
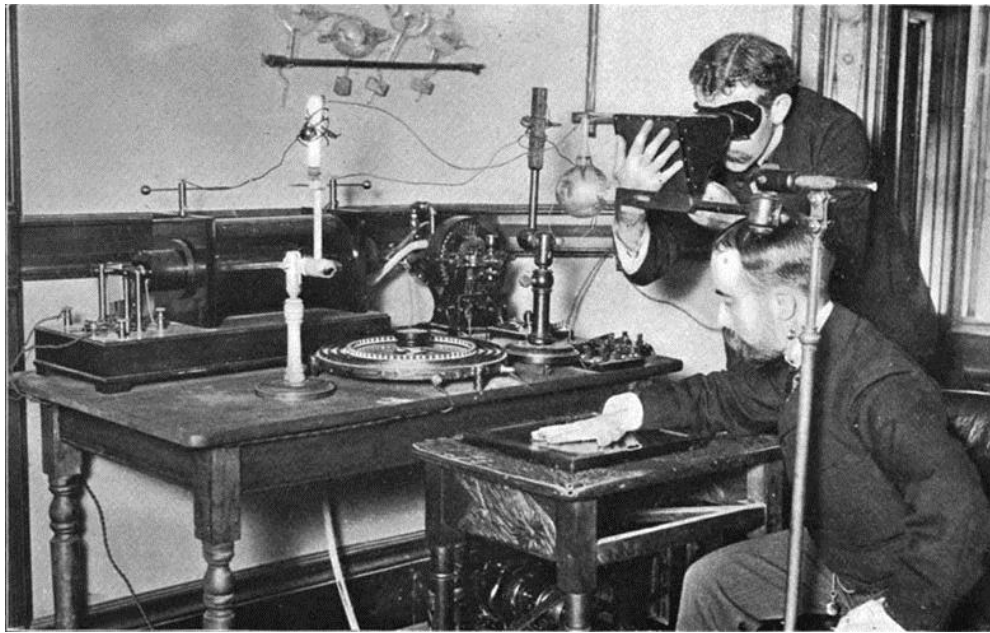
- Presentation for high school students part of Educational guidance activities
“Physics in Medicine: Research and Application”, January 8, 2015

Conclusions

- Dosepix detector has been characterized in the mammography flux and energies
- An experimental method for the kVp reconstruction has been established
- Planned activity: simulation of analog pile up in the chip front end

- 1D monolithic silicon array has been characterized as machine and quality assurance tool
- Good agreement with commercial and reference detectors

- Next Activities: PhD Thesis



Thank you for your attention

Backup

Dosepix: QA in Diagnostics- kVpmeter

Detector characterization

Radiation Tolerance studies

