Francesca Bisello
ESR 10

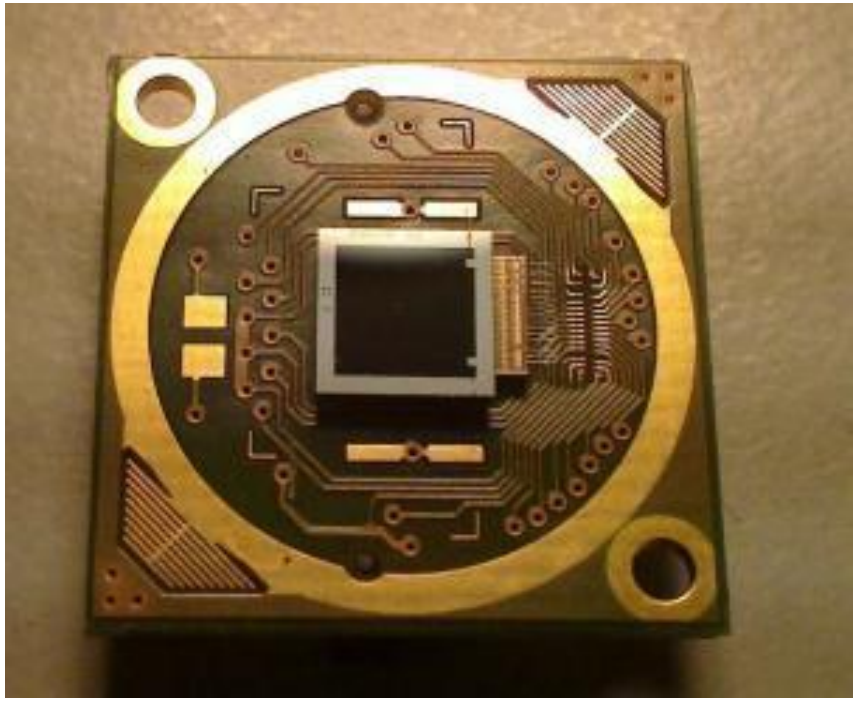
IV ARDENT Annual Workshop

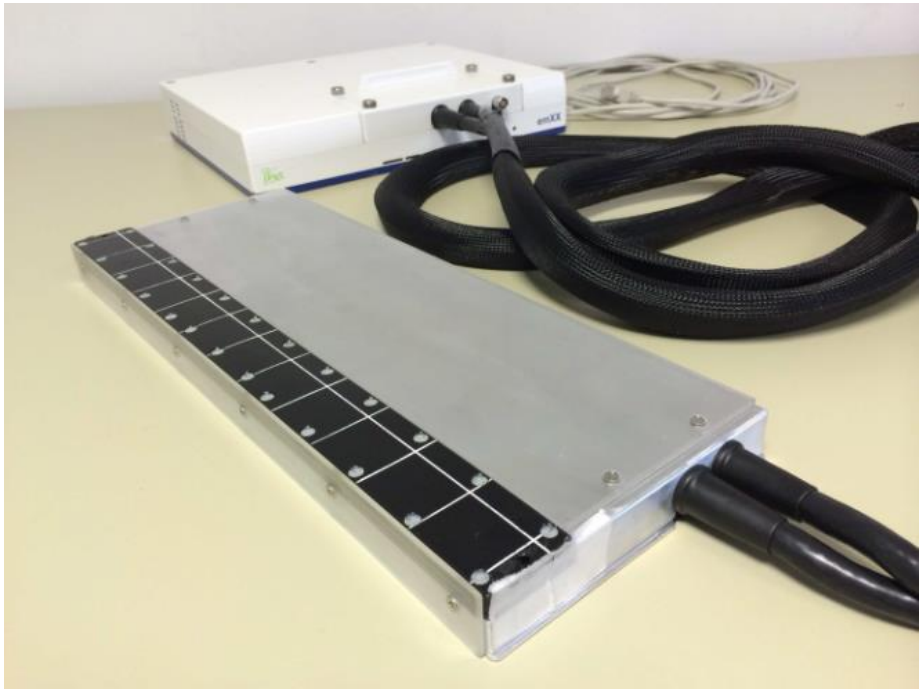
22-26/06/2015
Prague

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

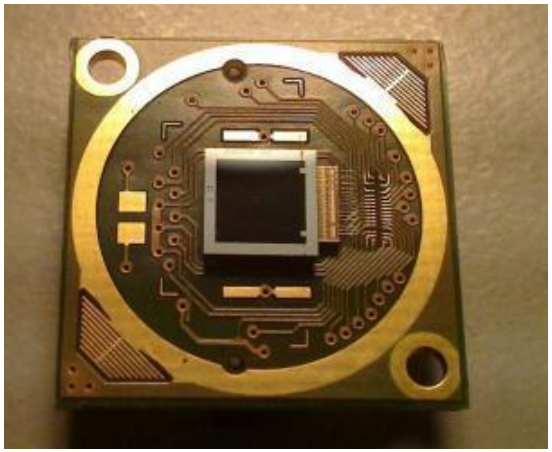




Dosepix: QA in Diagnostics- kVpmeter

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

Detector :



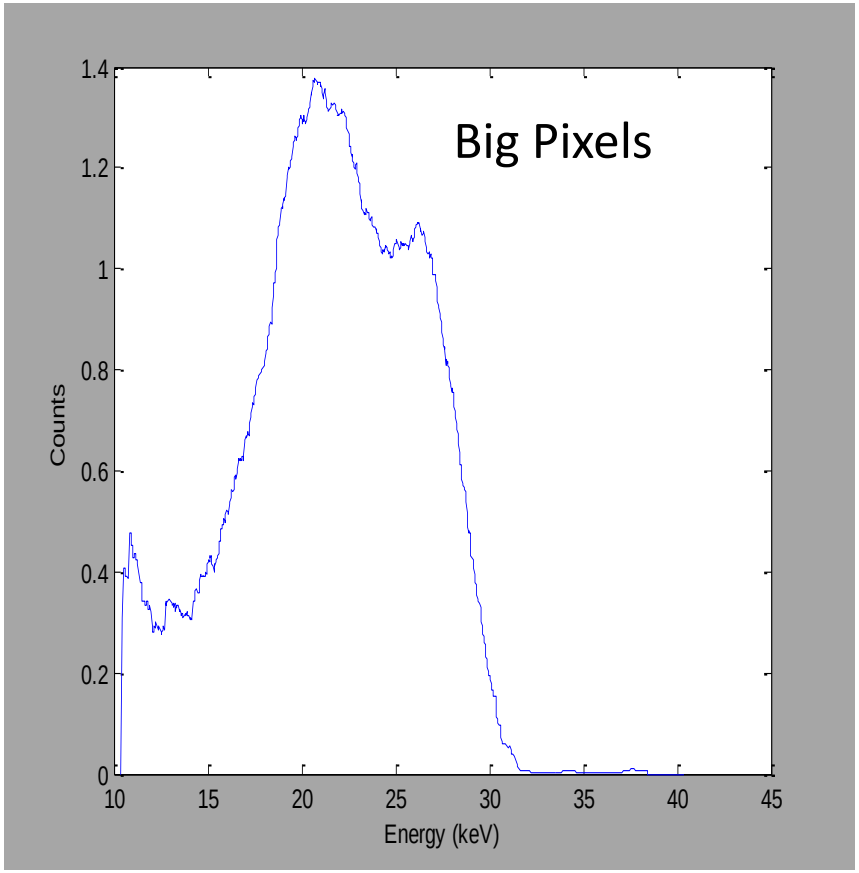
- Single photon counting detector
- 16 x 16 pixels
- Pixels size: 220x220 µm , 55x55 µm
- Sensor material : 300 µm silicon
- Time-over-Threshold
- Programmable front end settings
- 16 Digital Thresholds /pixel

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

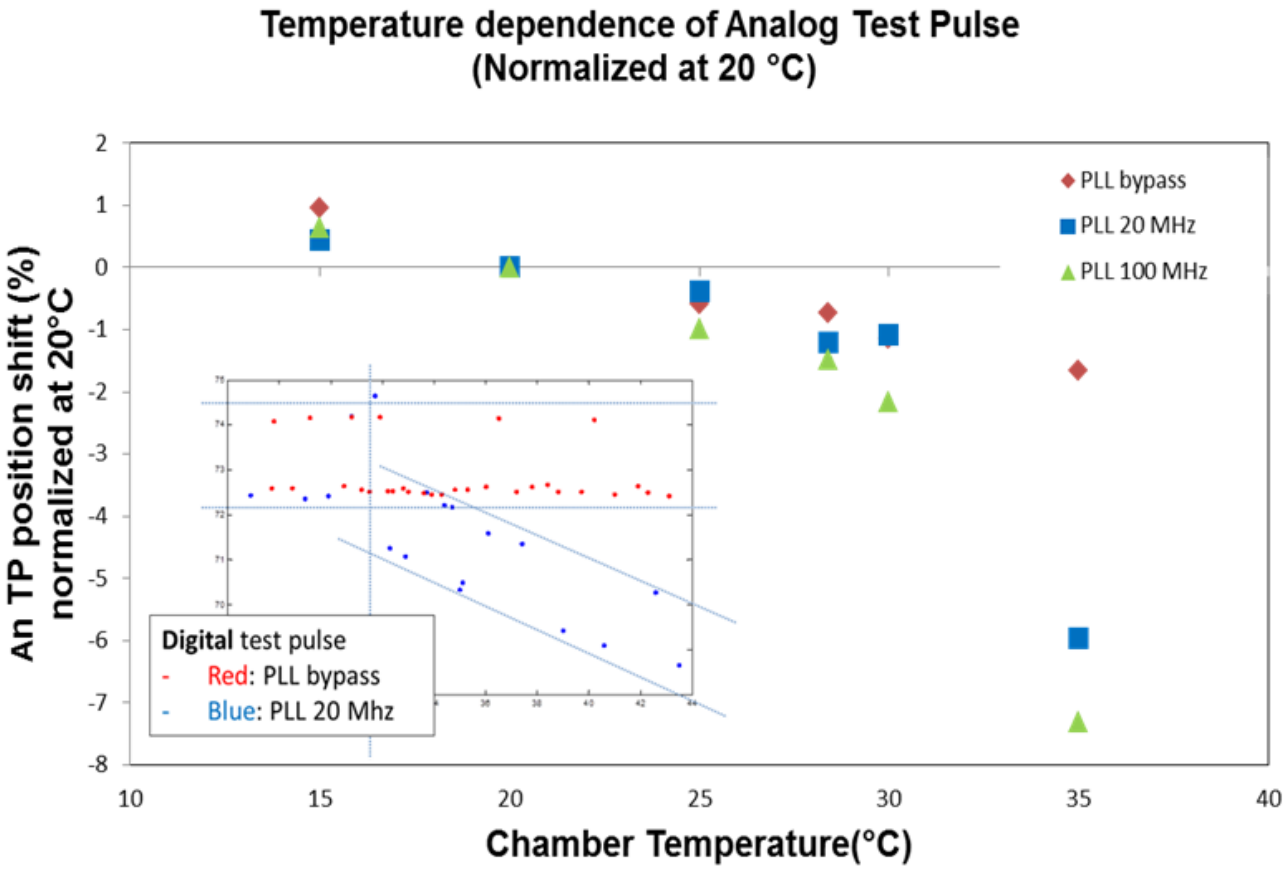


Tube setting:
30 kV, 20 mAs
Mo-Mo

Dosepix: QA in Diagnostics- kVpmeter

Detector characterization II

- Source of instability for temperature fluctuation: PLL circuit

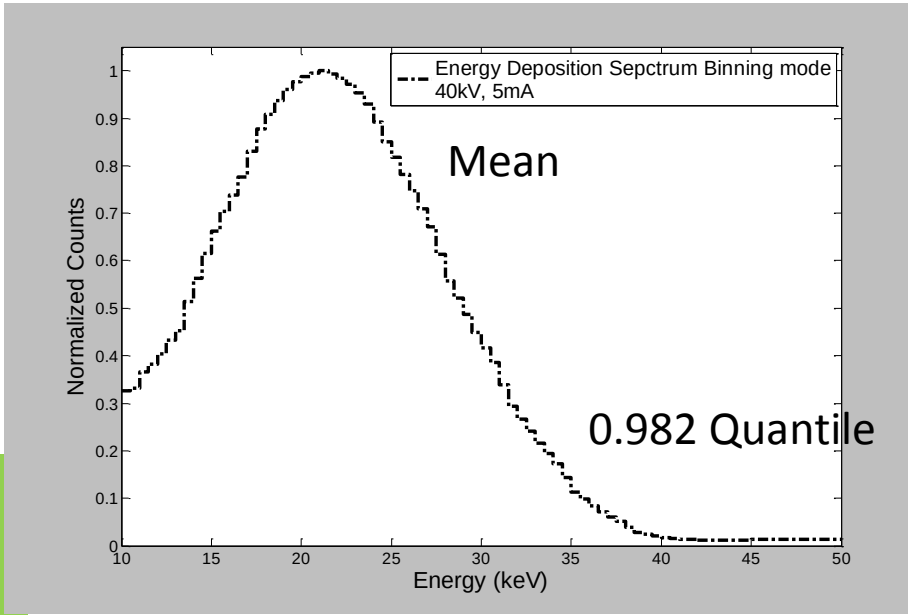


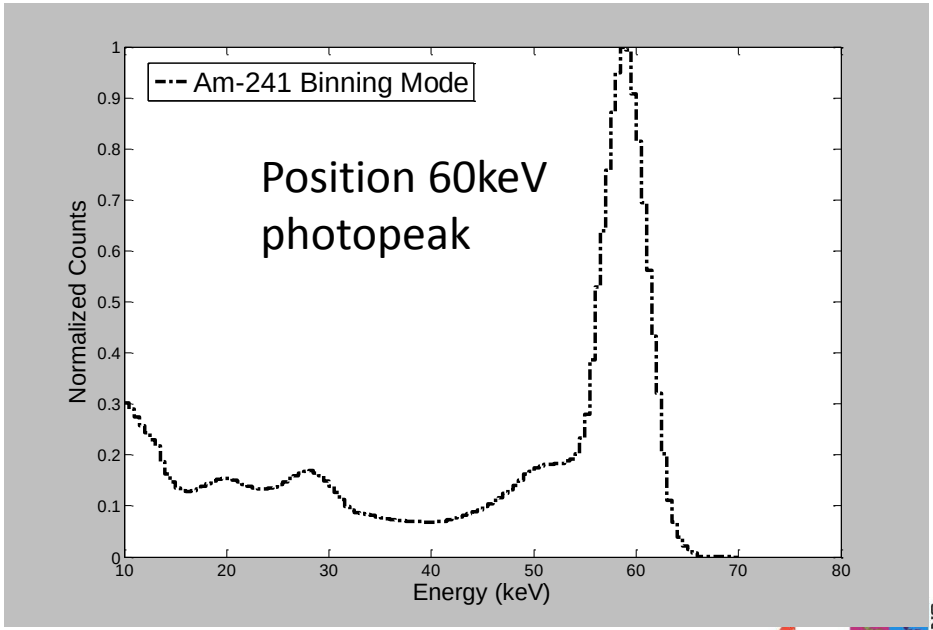
Dosepix: QA in Diagnostics- kVpmeter

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

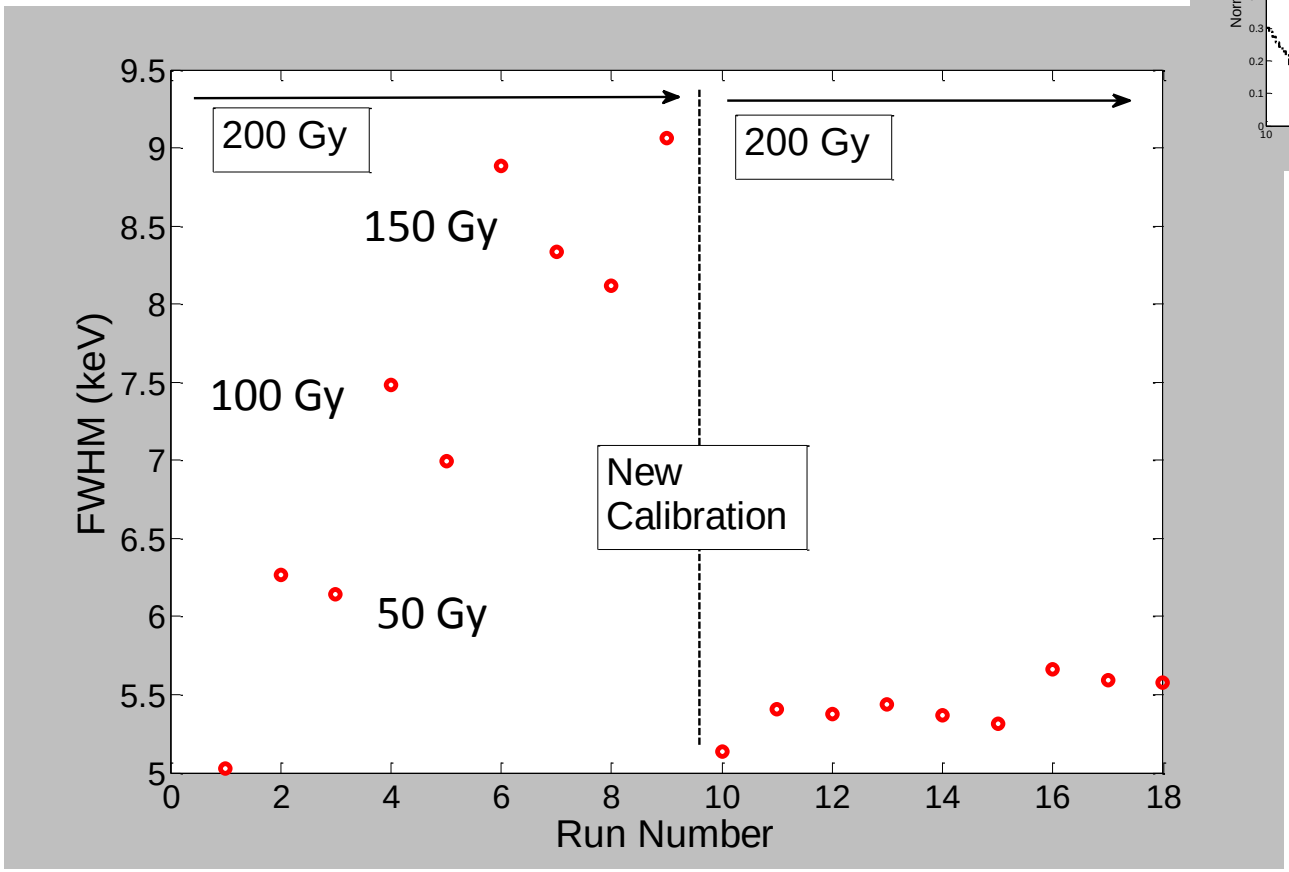


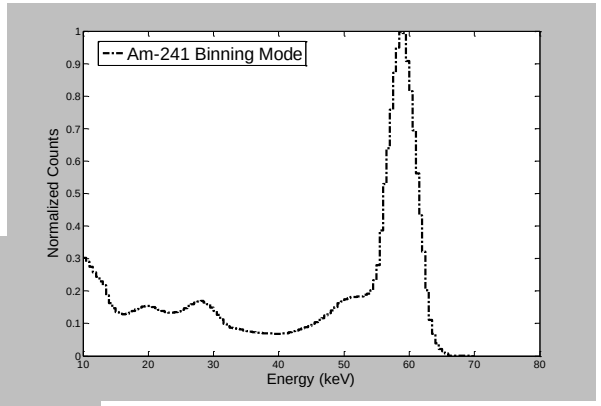


Dosepix: QA in Diagnostics- kVpmeter

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

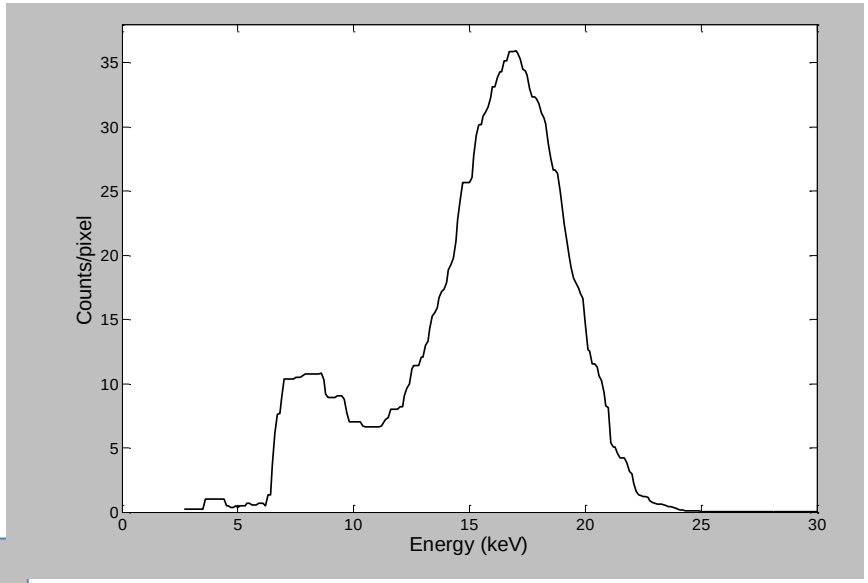
Radiation tolerance studies:

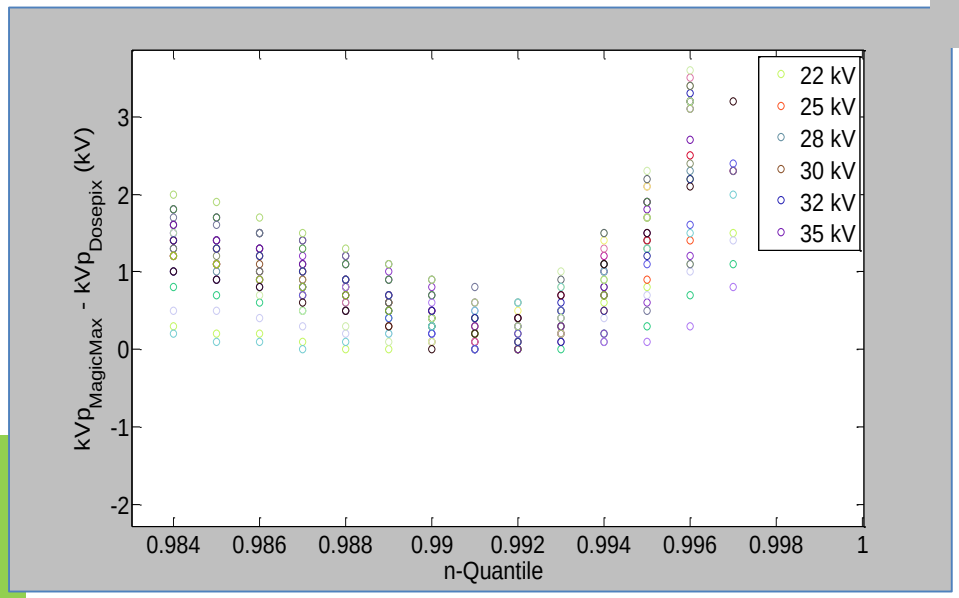
- Higher cumulated dose to stabilize the electronics
- Deviation within 2%: regulation limit
- Re-calibration recovers damages due by radiation
- Tests on going:
  One chip: 5kGy cumulated dose, 1 months annealing

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:

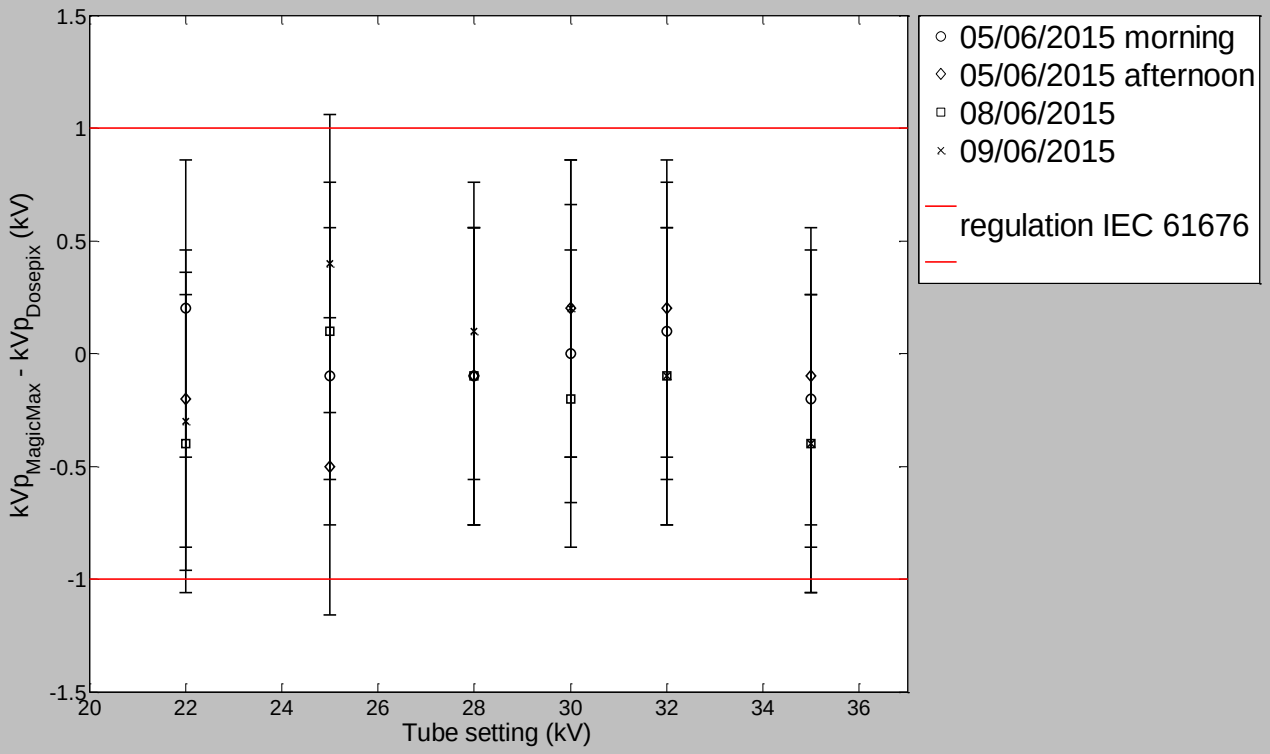
- MagicMax Universal, IBA Dosimetry GmbH, Schwarzenbruck (DE)

Method:

- Find the quantile who minimizes the difference with reference detector

Dosepix: QA in Diagnostics- kVpmeter

kVpmeter Algorithm



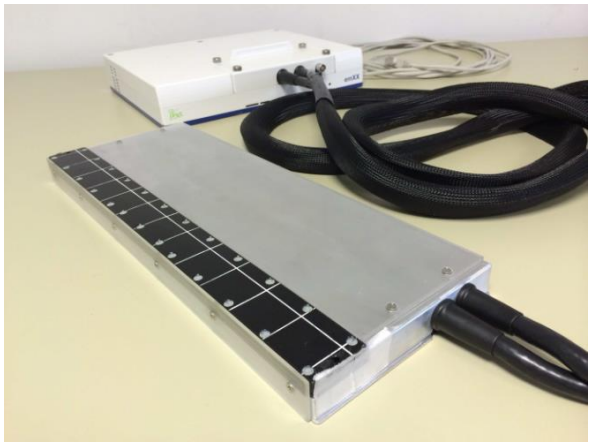
Conclusions:

- 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 :



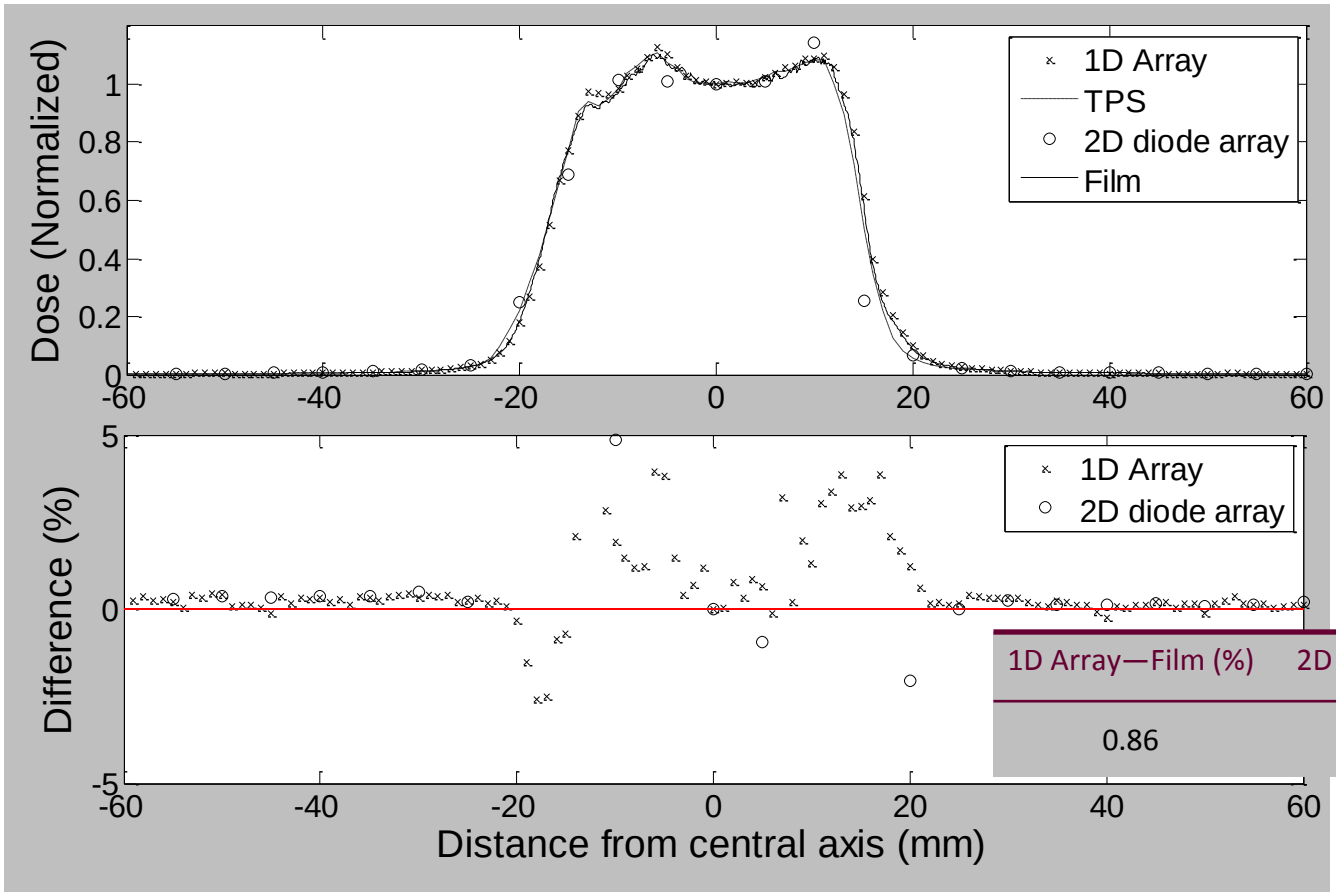
- Epitaxial monolithic Silicon diodes
- 1mm pitch
- 24 cm length
- sensitivity changes with dose (0.2%/kGy)
- dose per pulse changes (±1% in the range 0.1–2.3 mGy/pulse)

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 Array—Film (%)	2D diode array—Film (%)
0.86	1.84

1D Silicon Array: QA in Radiotherapy

2. Machine Quality Assurance

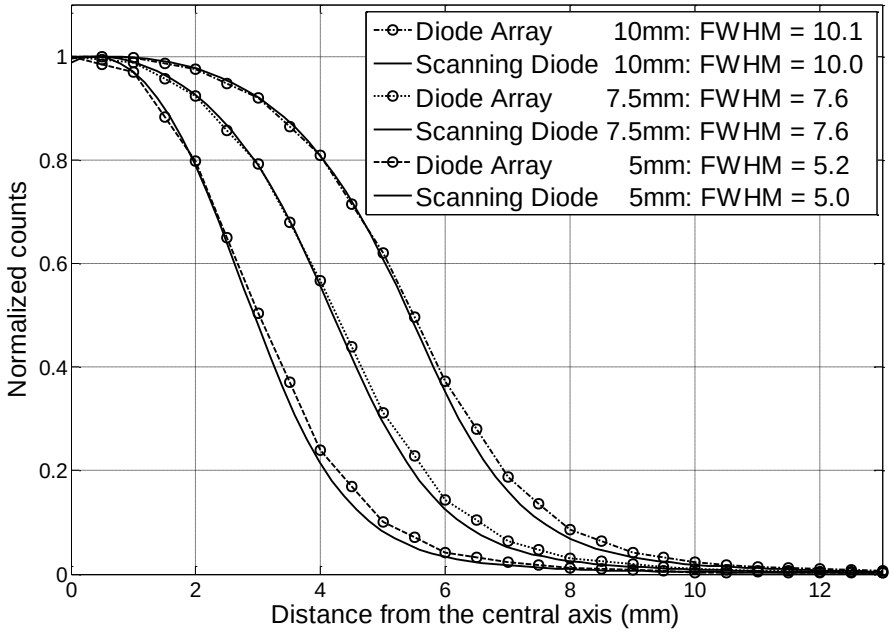
Commissioning of an Iris Collimator for robotic radiosurgery: physical properties

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

- Used in clinics : fields > 10 mm

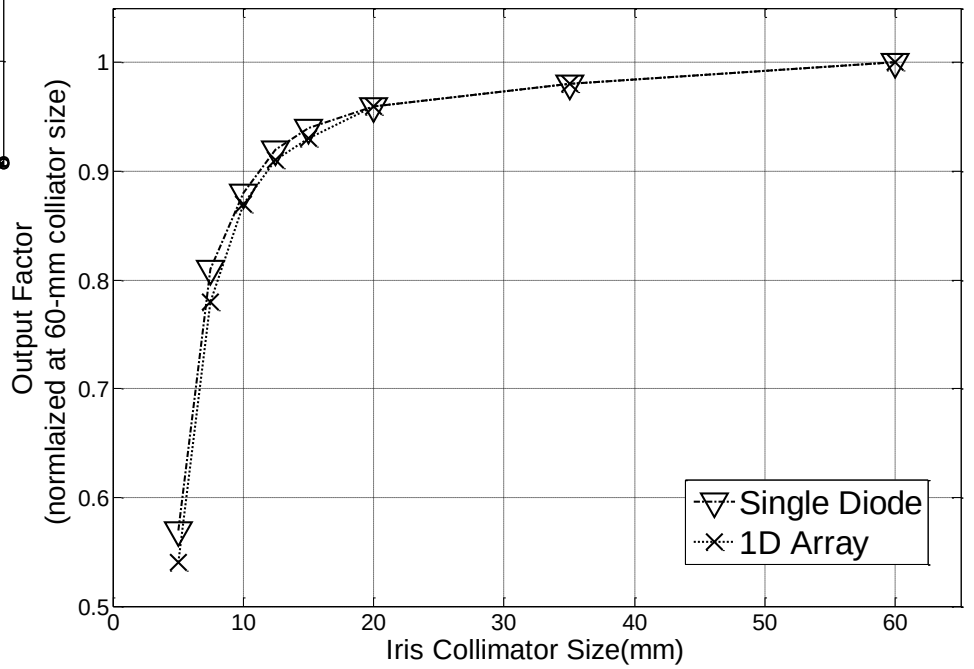
1D Silicon Array: QA in Radiotherapy

Commissioning routine for small photon field



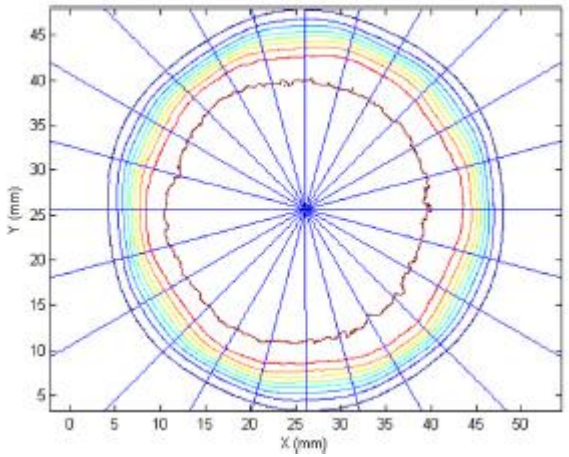
Iris collimator beam profiles:

- 1D array
- Scanning diode

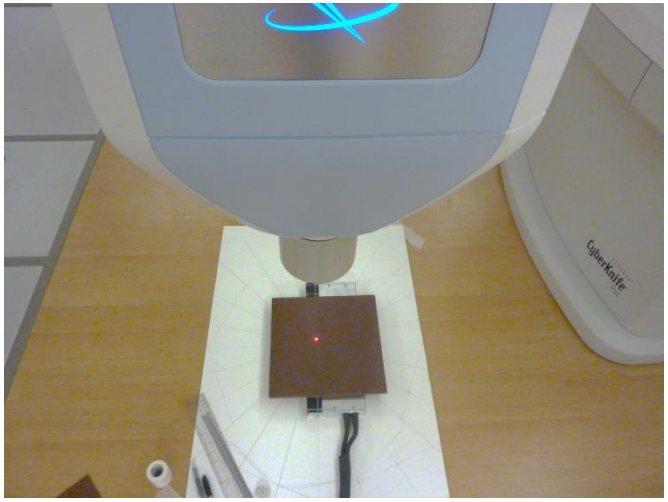


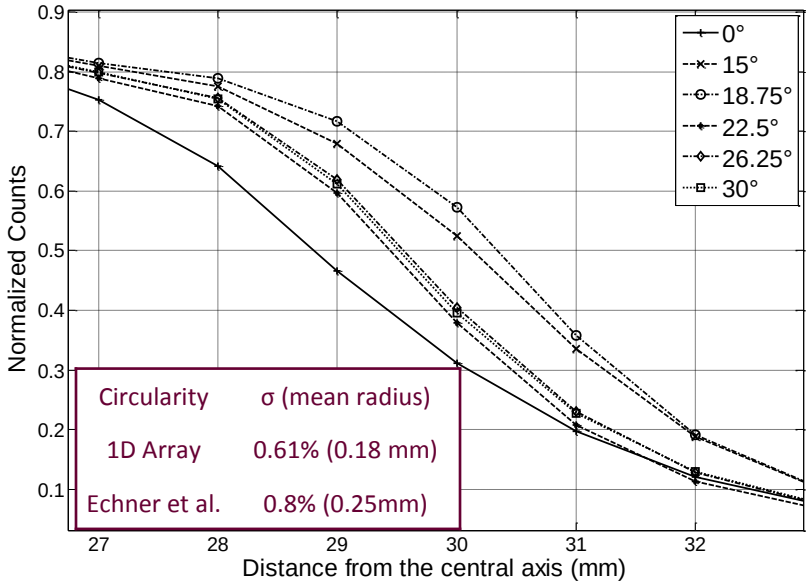
1D Silicon Array: QA in Radiotherapy

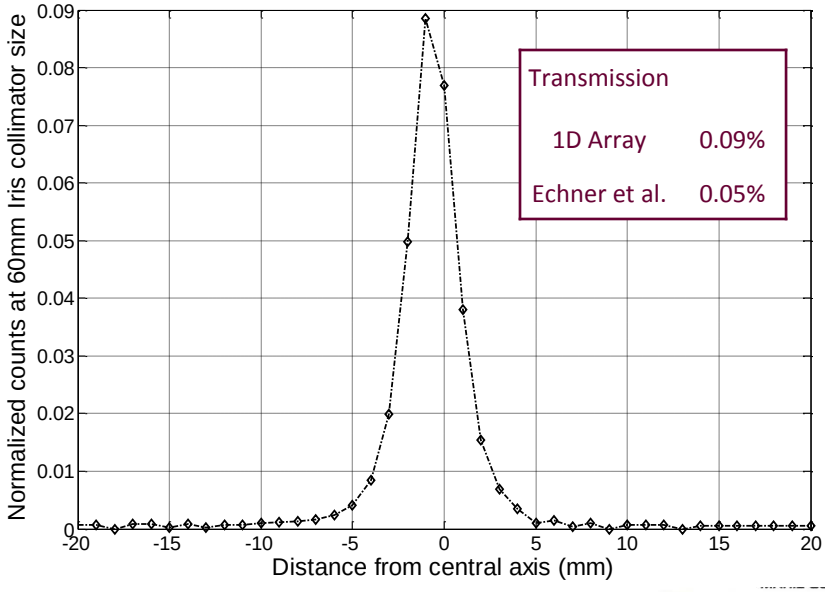
Characterization of Iris collimator



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







1D Silicon Array: QA in Radiotherapy

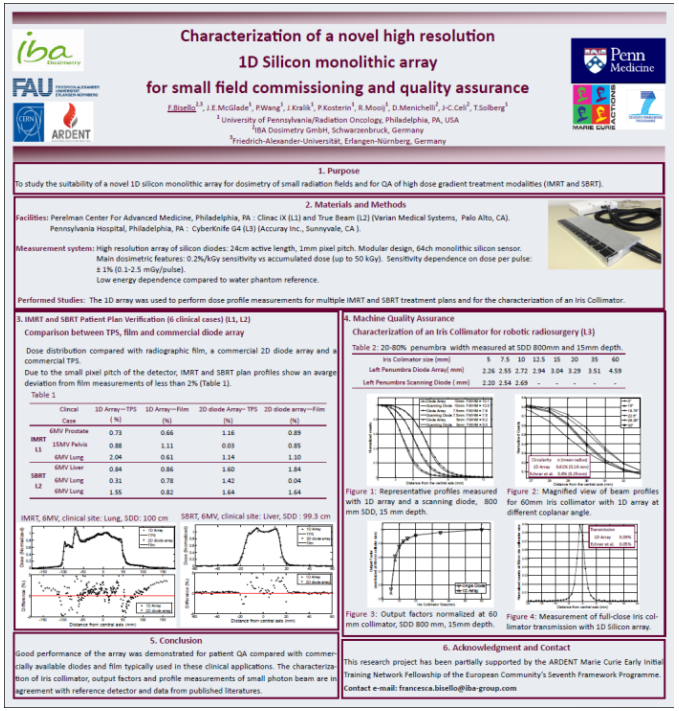
Conclusions

- 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"



B&A Training : ST Microlectronics
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

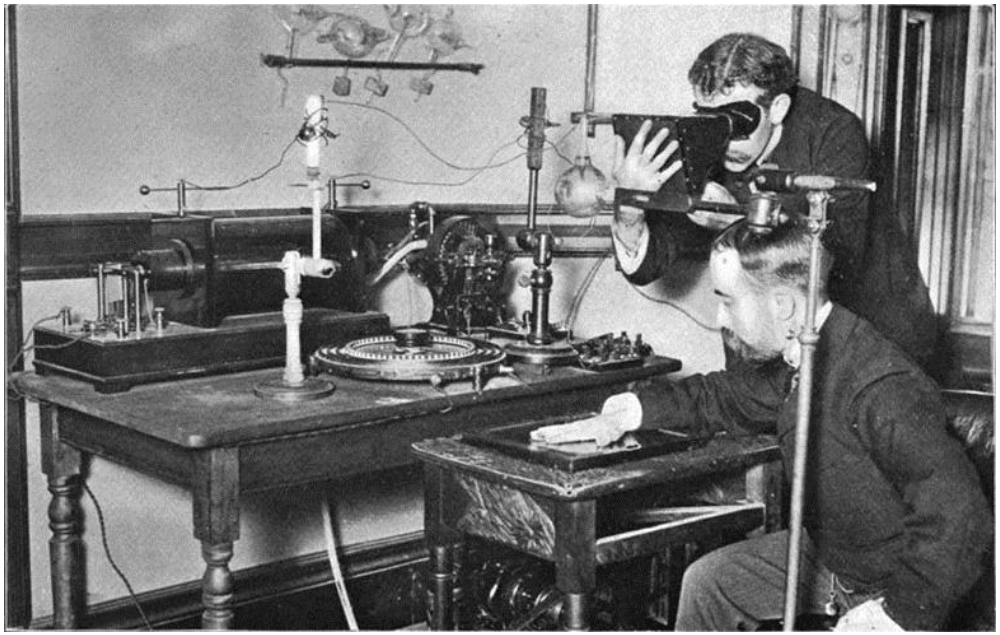
- Presentation for high school students part of Educational guidance activities "Physiscs in Medicine: Research and Application", January 8, 2015

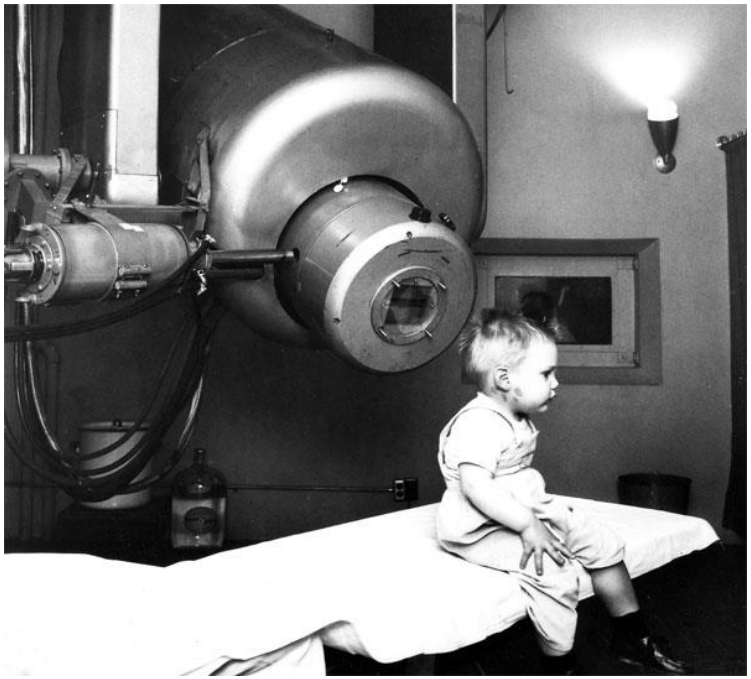
Conclusions

- 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 Acitivities: PhD Thesis





Thank you for your attention

Backup

Dosepix: QA in Diagnostics- kVpmeter

Detector characterization

Radiation Tolerance studies