

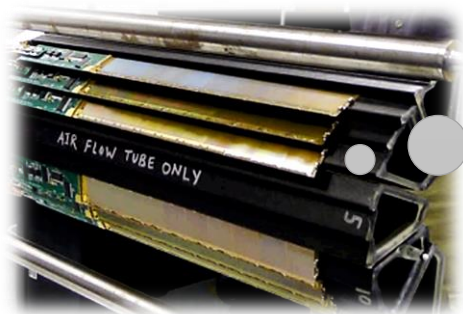
X- and β -ray sensitive CMOS Sensors for Science and Society

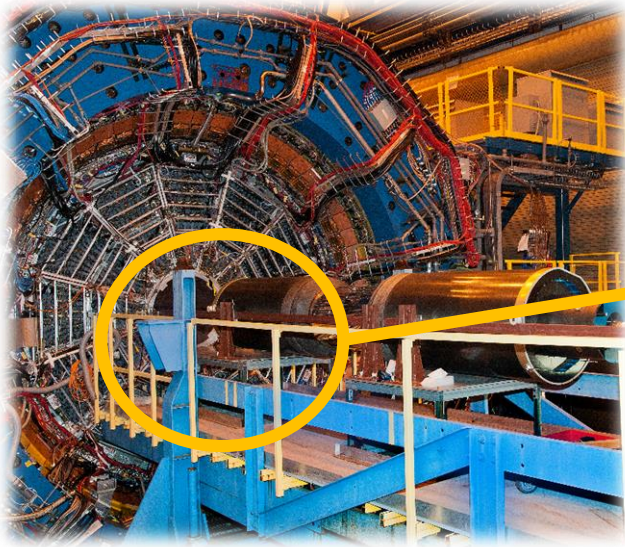
M. Deveaux¹, J. Baudot³, M. Kachel³, T. Schmid², J. Stroth¹, M. Winter³

¹ Institute for Nuclear Physics, Goethe-University Frankfurt/M

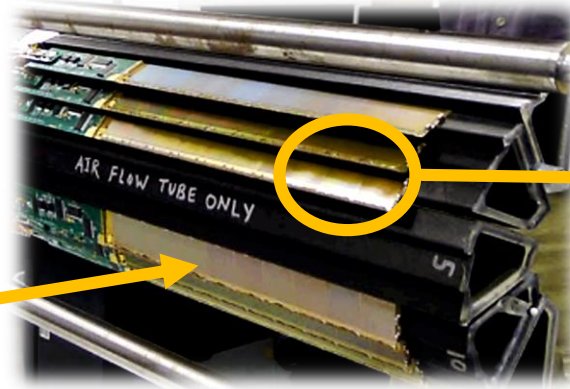
² Institute of Biochemistry 1 – Pathobiochemie, Goethe-University Frankfurt/M

³ IPHC/CNRS – Université de Strasbourg, Strasbourg

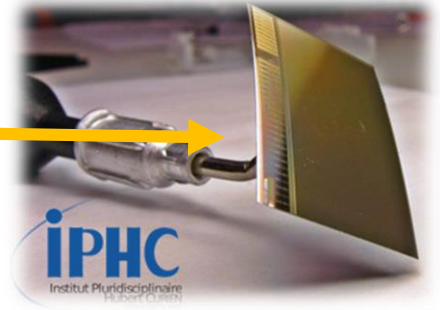




STAR-Experiment



STAR-Vertex detector



CMOS Sensor

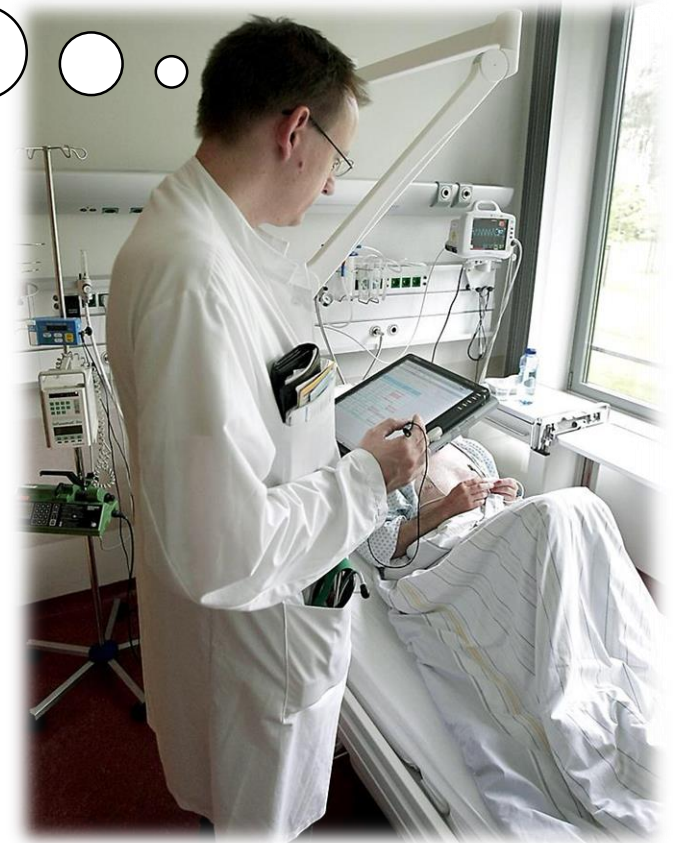
Features of CMOS Sensors (MAPS):

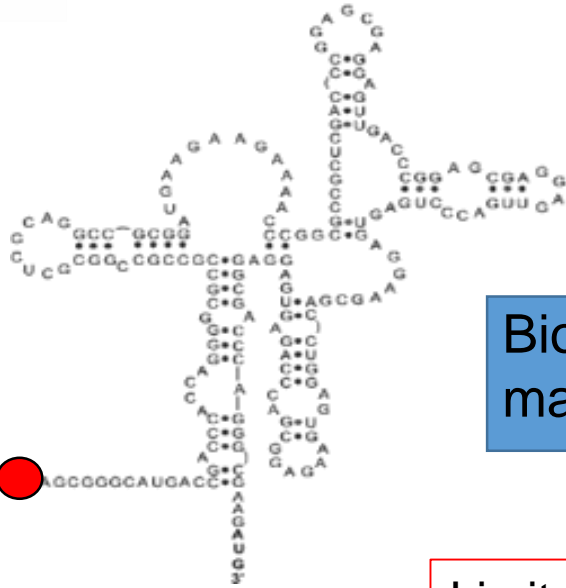
- Sensor and readout integrated on a chip
- Cheap commercial mass production
- Excellent for radiation detection
- Design and integration to complex systems is mastered

Can CMOS sensors help to answer this question?

How can I specifically suppress the production of tumor generating proteins?

The answer is hidden in the structure of the RNA!

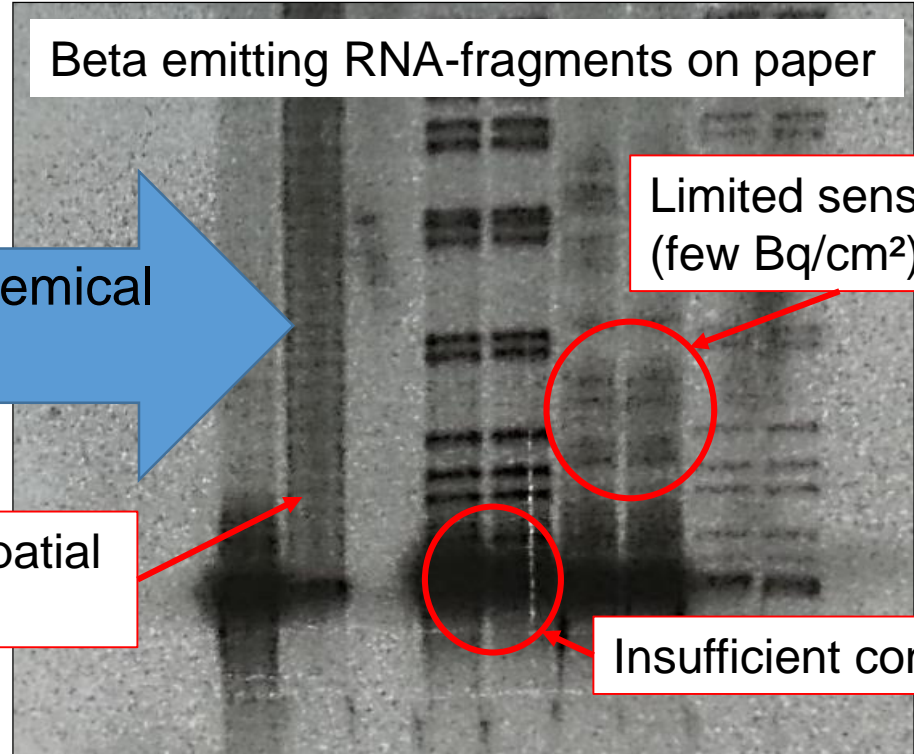




RNA is labeled with radioactive label

Bio-chemical magic

Beta emitting RNA-fragments on paper



Limited sensitivity (few Bq/cm²)

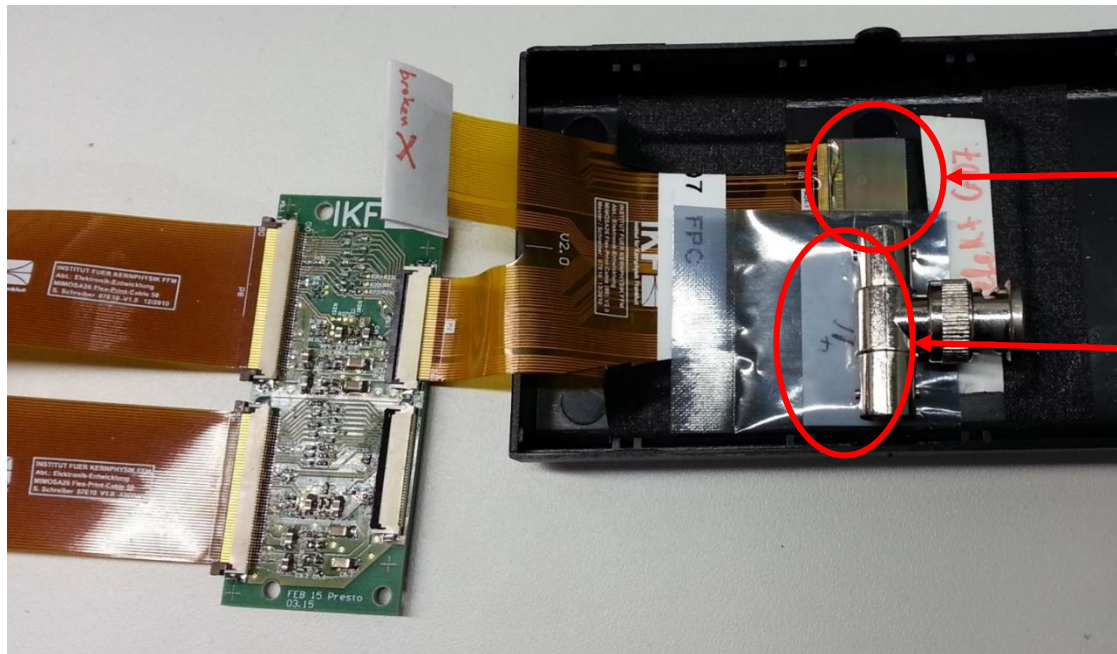
Limited spatial resolution

Insufficient contrast

Picture of commercial beta imager

Better, more sensitive beta imagers might:

- Reduce activity needed (less nuclear waste, working exposure)
- Increase spatial resolution with digital post processing



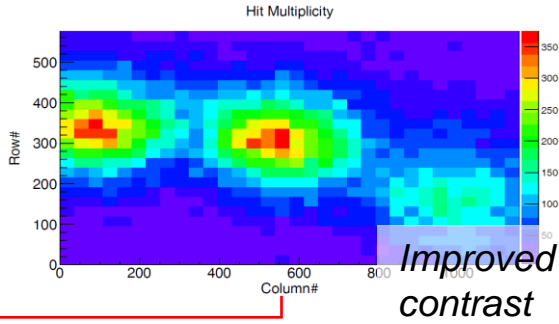
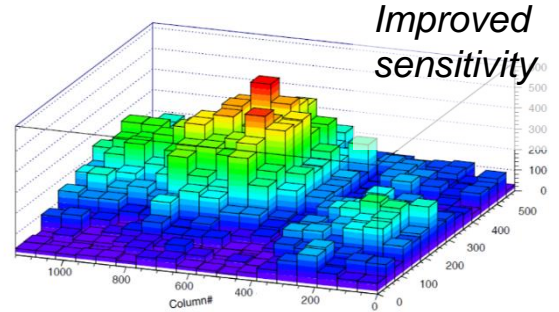
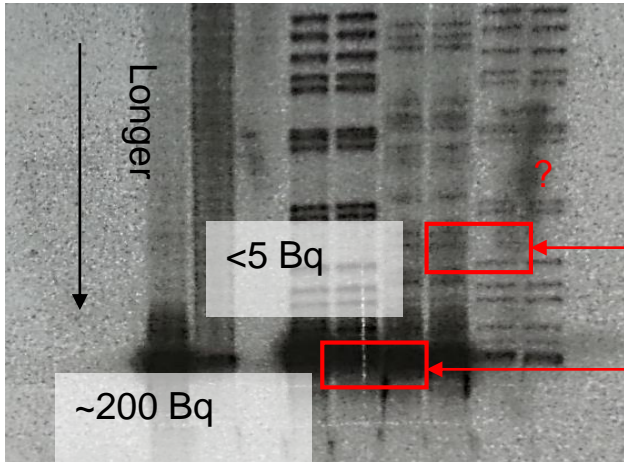
Sensor (not optimized)

mRNA sample

A test with vertex detector hardware from CBM

Can MAPS do it?

After ~10% of usual exposure time:

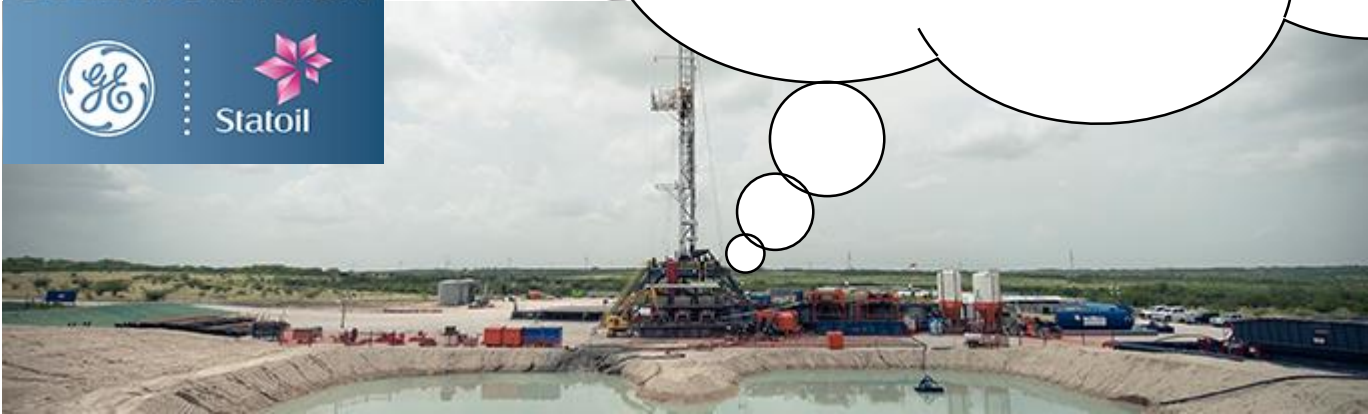


*RNA as seen by CMOS
MAPS (~ 2h, not optimized)*

Excellent results with non-optimized hardware

Is there a real time sensor to check if recycled water is really clean?

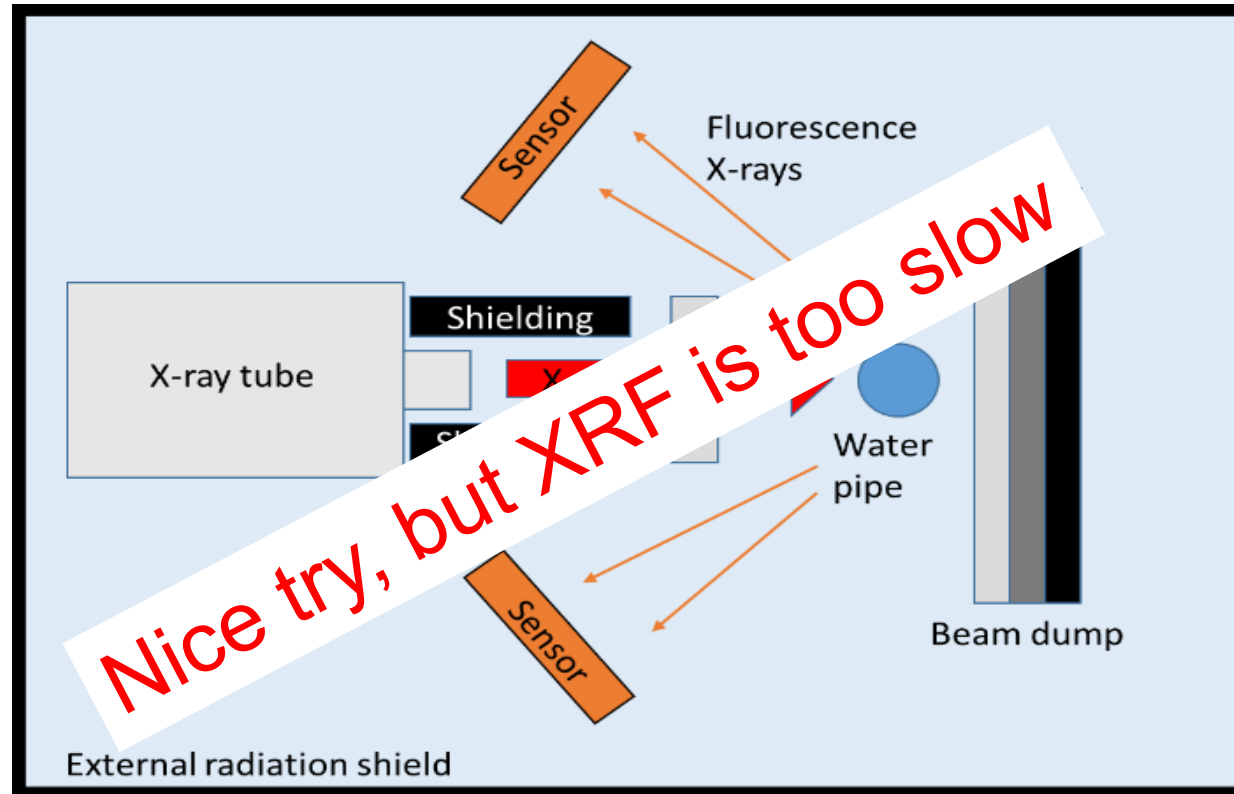
POWERING
COLLABORATION



Question asked in the “Reduced Use of Water in Onshore Operations Challenge”

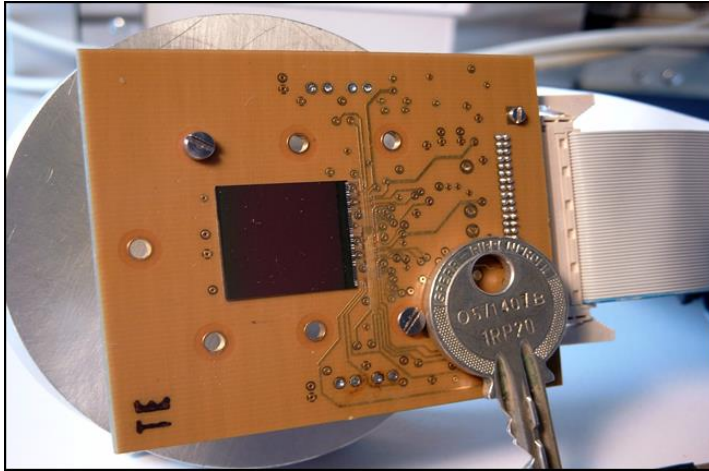
Could one build a **near time broad band sensor** for liquid composition?

Idea: Use X-Ray Fluorescence analysis (XRF)



- Irradiate sample, e.g. water, with X-rays
- Measure spectrum of Fluorescence X-rays
- Extract atomic composition of sample from spectrum

Can MAPS do something here?

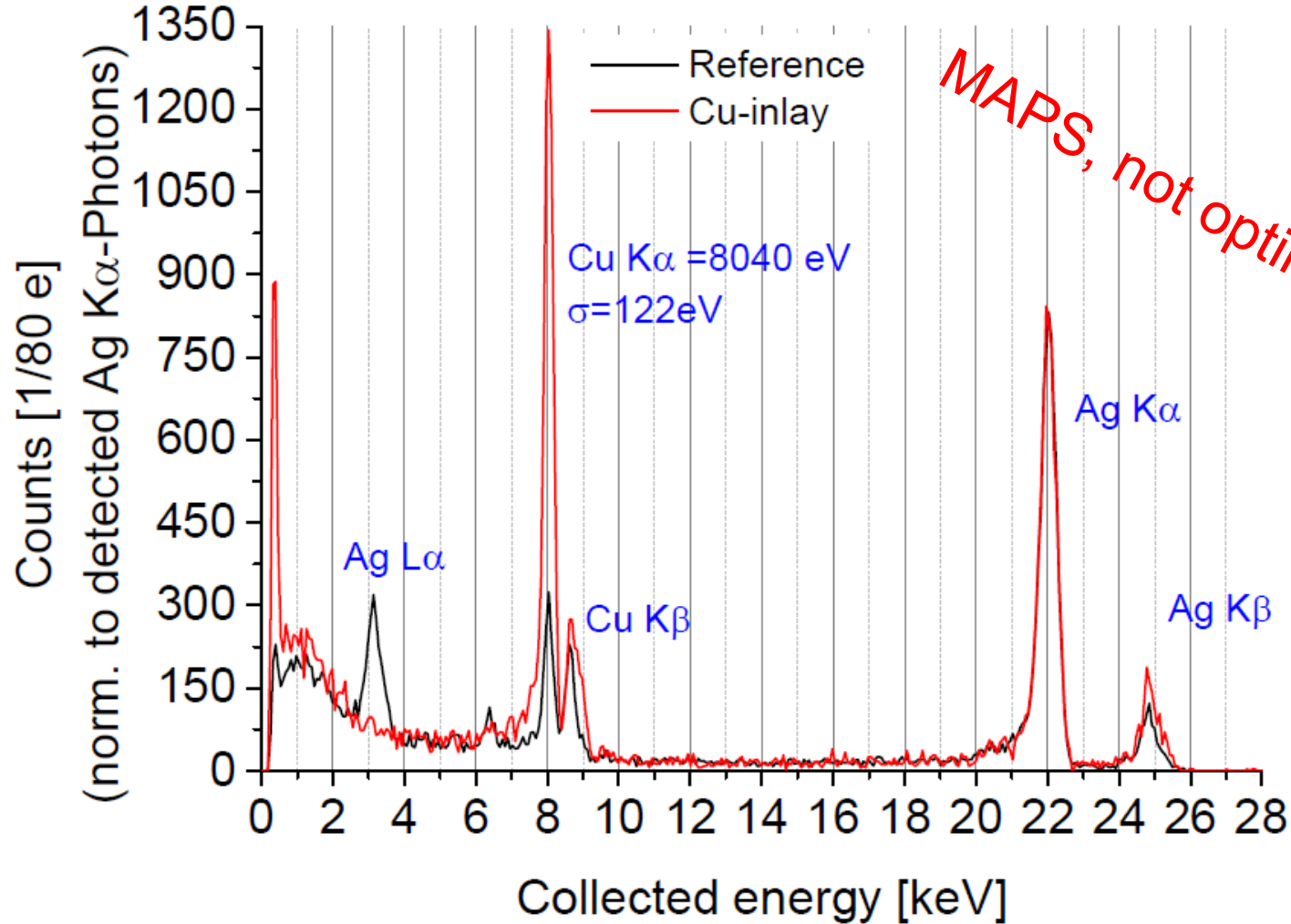


*MAPS with 1 MPixel
and fully analog readout.*

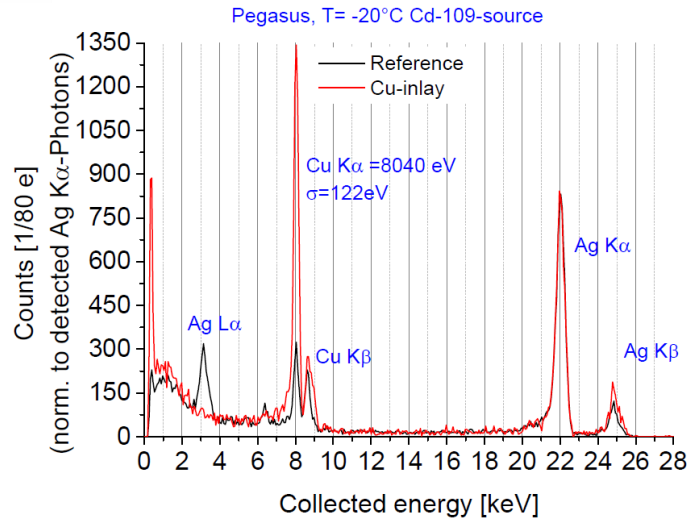
	Diodes per Sensor	Rate per diode	Total rate
Silicon Drift Det.	1	100 kHz	100 kHz

MAPS may accelerate XFR by factor 100 – 1000
=> Game changer for some applications?

Pegasus, T= -20°C Cd-109-source



MAPS show a highly competitive energy resolution



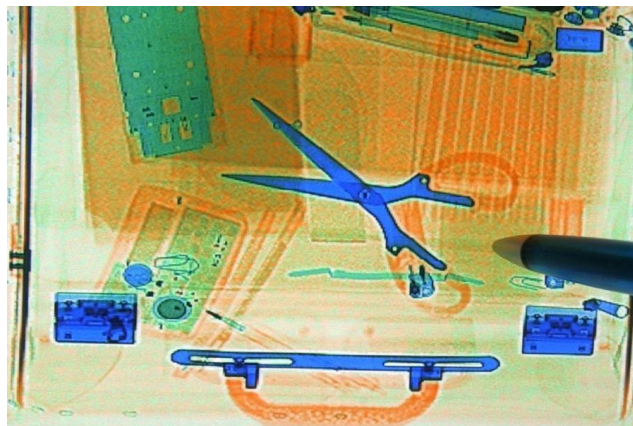
Energy resolution

+

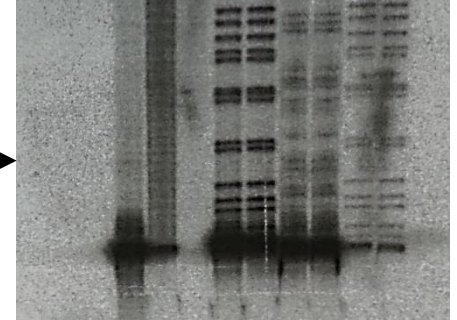
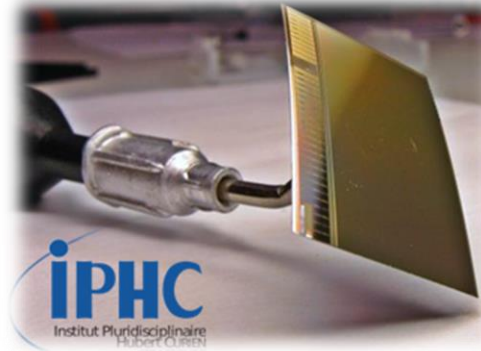


Large surface pixel sensor

=



Colored X-ray pictures

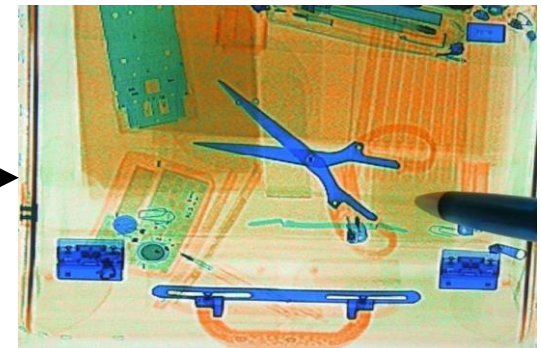
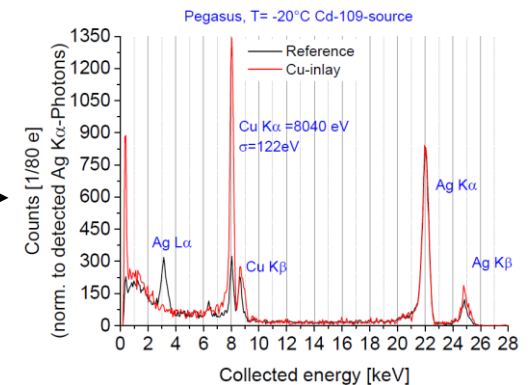


Complement existing MAPS with:

- Back thinning
- Stitching
- Analog/digital high speed readout

Build β - and X-ray imagers and commercialize them.

Boost science and applications in the field of analytics and industrial quality control





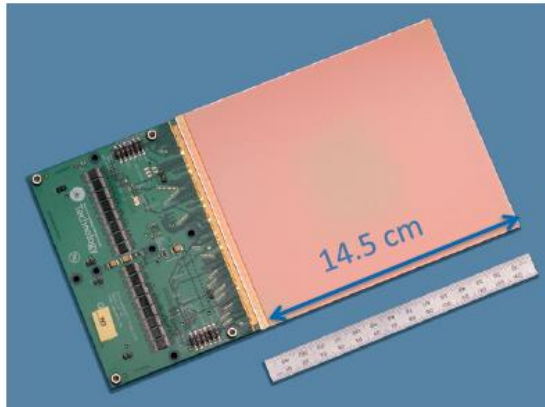
Back thinning: Bring active volume to surface.
G. Deptuch et al., Nucl. Instr. Meth. A543 , 537 (2005)

Depletion + spectroscopic readout :
D. Doering et al., JINST C01013 (2016)

Stitching: Sensors with big surfaces
S.E. Bohndiek et al., *IEEE TNS*, vol. 56, p. 2938 (2009)

The technologies are individually demonstrated.
Merge them to step forward.

Wafer-scale integration



Courtesy: N. Guerrini Rutherford Appleton Laboratory



Silicon Genesis 20 μm thick wafer

W. Snoeys, CERN, FCC 2016
Rome, 11-15 April 2016

Wafer-scale integration possible due to stitching

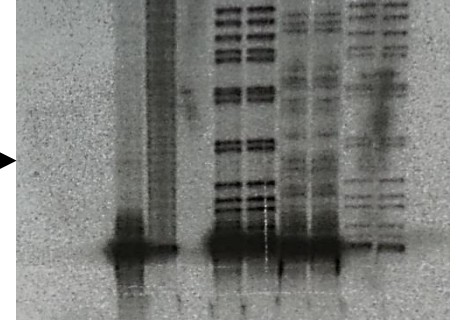
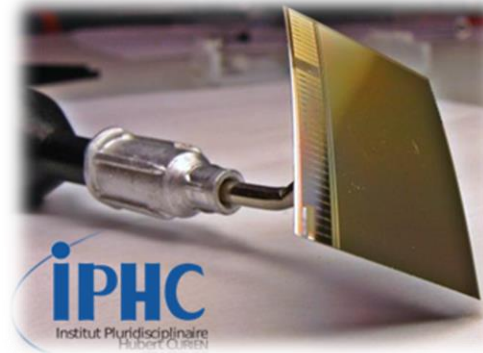
- Would ease assembly of large areas
- Will further push for low power design
- One fab in a foundry: 1Mwafers/year, for ALICE (10 m²) 1.4 kwafers (200 mm)

Flexible nature of thin Si (limits still to be tested with CMOS on top)

- Can we take advantage of this for lower mass detectors ?

walter.snoeys@cern.ch

Pushing those technologies will guide experiments in high energy physics to new limits.



Complement existing MAPS with:

- Back thinning
- Stitching
- Analog/digital high speed readout

Build β - and X-ray imagers and commercialize them.

Boost science and applications in the field of analytics and industrial quality control

