

ADSA09–Workshop
Boston
Oct. 22nd, 2013

P Radisson



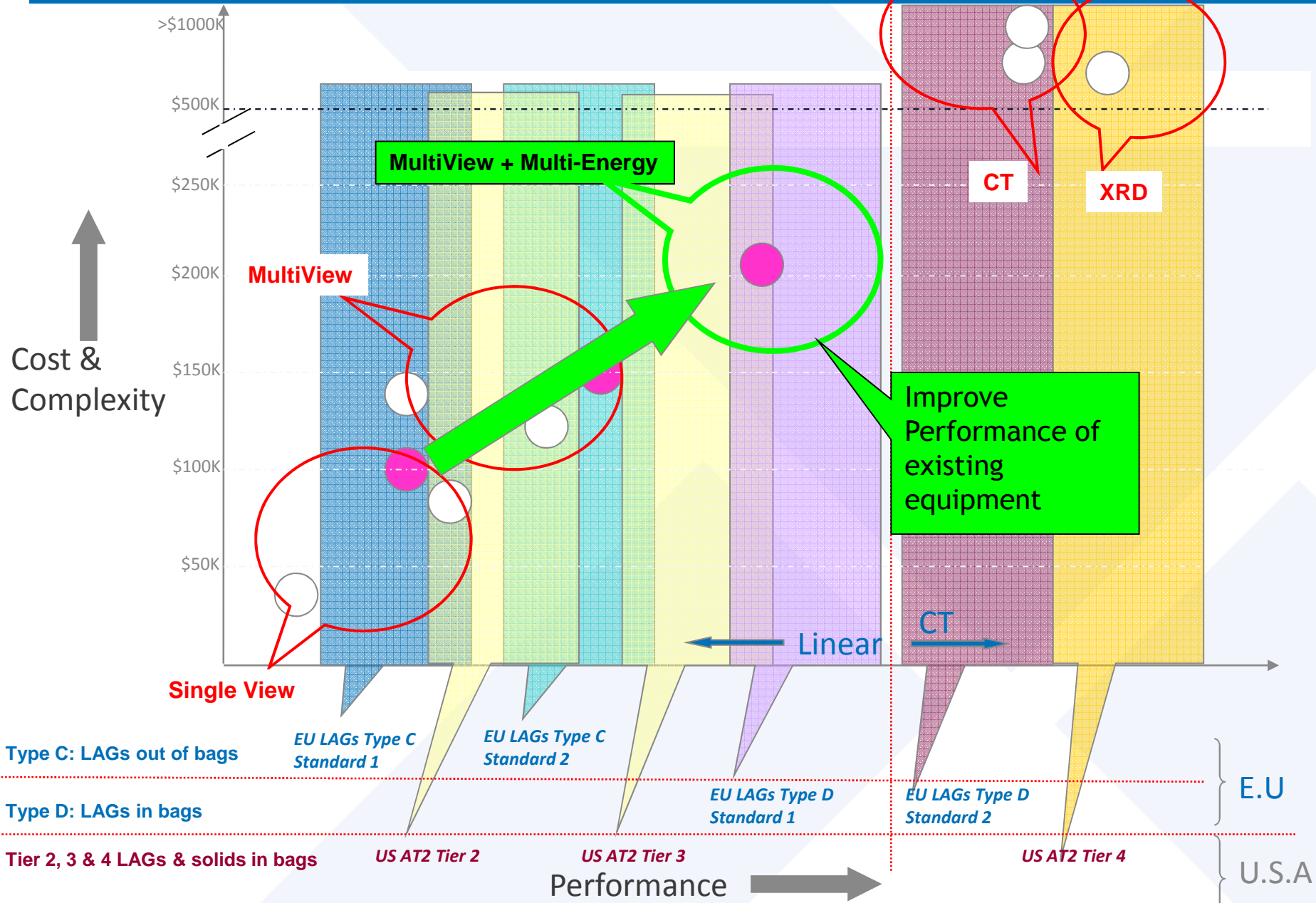
Oct. 22nd, 2013
MULTIX/174/13

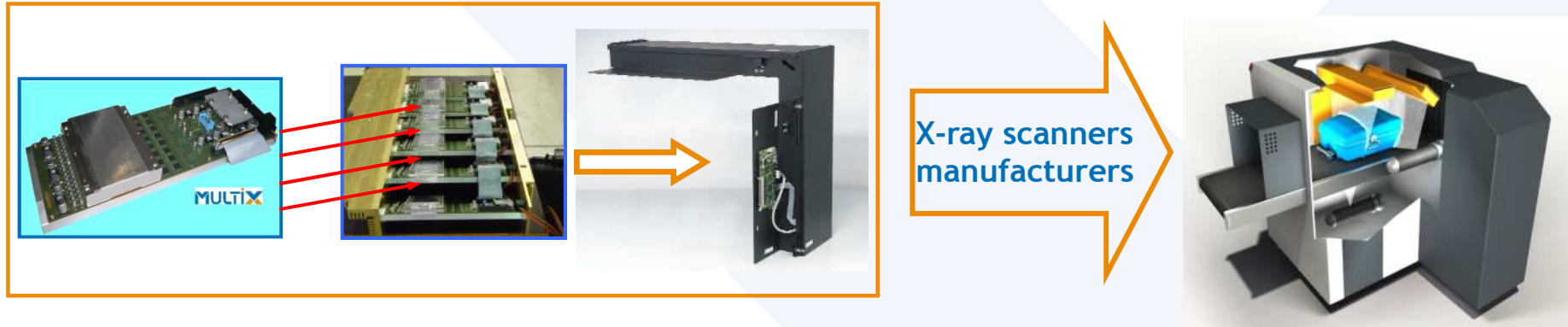
- ME100 real time X-ray transmission spectrometric grade detector under high photon flux is available to leverage baggage scanners.
- New ME based algorithms will benefit from ME rich information for
 - improving material discrimination capabilities
 - improving Image analysis

In order

- To improve threat detection performance in reducing FAR for ALL x-ray based detection systems
- To support platform performance improvements and lifecycle extension
- To Fill the performance gap between current dual energy, multi-view and CT technology

- **Description:** French start-up company incorporated in 2010. Spin off from Thales and venture capital backed.
- **Business:** High resolution multi-energy X-ray detector acquisition system developer for new builds or retrofit to existing x-ray systems dedicated for automated explosives identification/discrimination.
- **Market:** X-ray scanner manufacturers (conventional, CT and XRD), new build or retrofit to meeting existing and future regulations.
- **Technology:** Mature building blocks, major partnership with CEA/LETI French public Lab, patent portfolio.
- **Maturity:** Team engaged in the project since 2007. COTS product (ME100). CT and scatter development started in 2013.



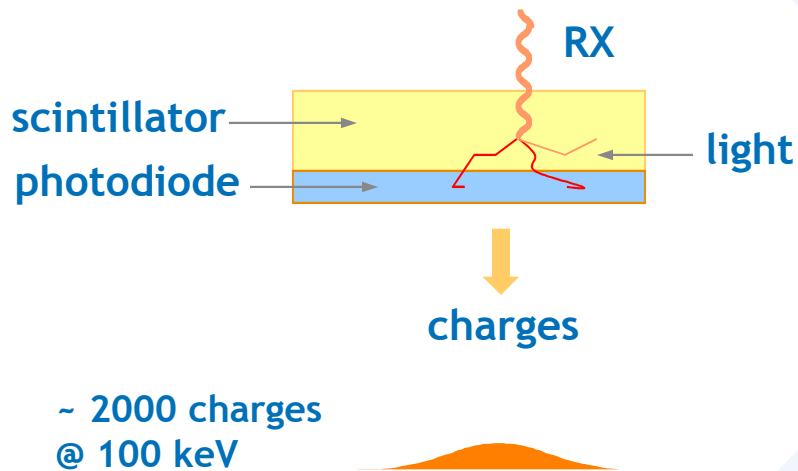


Multi-Energy X-ray DAS, the ME100 consisting of:

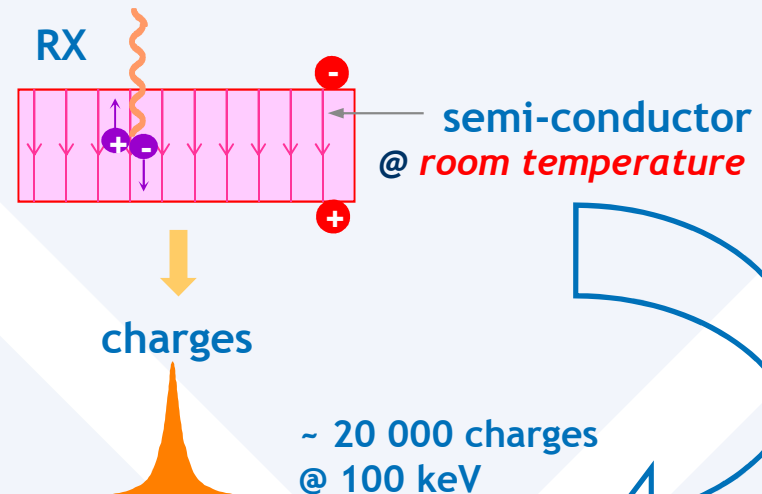
- An energy resolving sensor for spectrometric analysis
- High-speed front-end electronics for real-time photon counting and precision photon energy measurement
- Dedicated spectrometric real-time signal processing method for identification of all materials



Conventional Detection:
Indirect (*2-stage*) detection
Integration mode



MULTIX
Direct detection: CdTe solution
Photon counting + *128 energy bins*

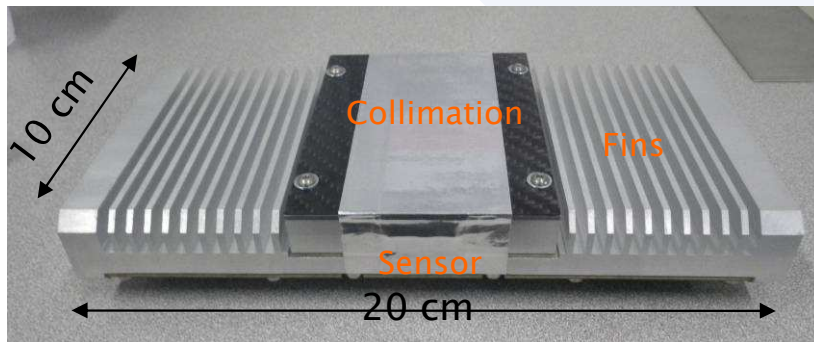


Advantages of direct detection :

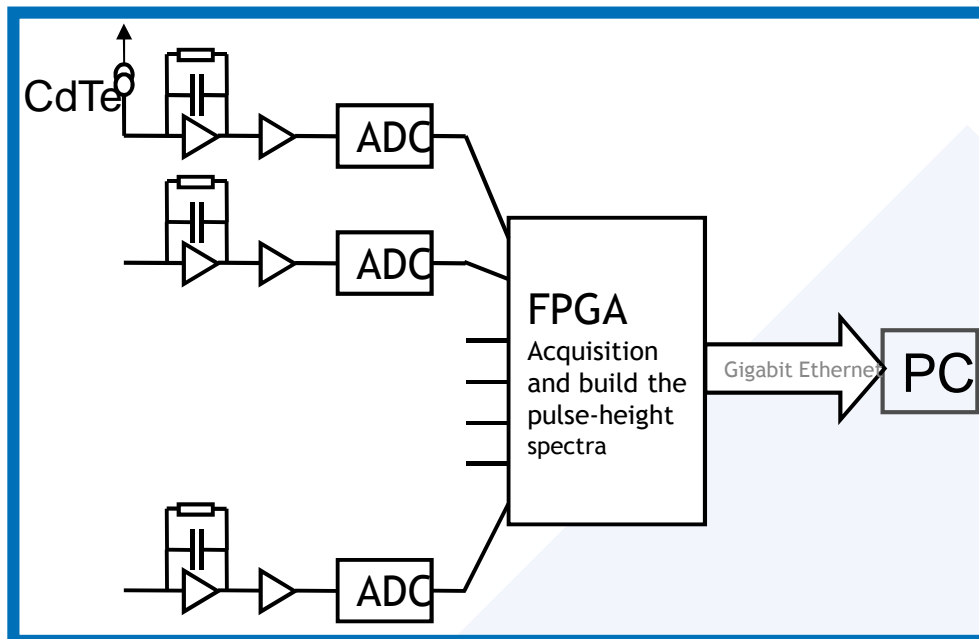
- Increased sensitivity
- Improved spatial resolution
- spectrometric performances

CEA/LETI
technology : Lab.
world leader in
the domain

Single available
product on the
market



Current COTS ME100 Detector board



Original architecture combining high-speed electronics and advanced signal (pulse) processing :

- Charge Induction
- Charge sharing
- Pile-up

To provide

- “cleaned spectra”
- Reduced “dead time”
- High photon dynamic range
- Non paralyzable behaviour

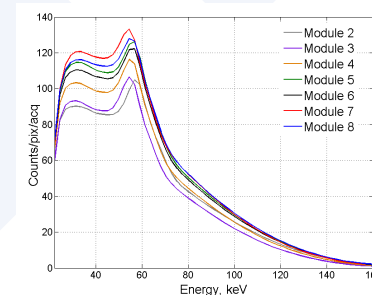
In real time!

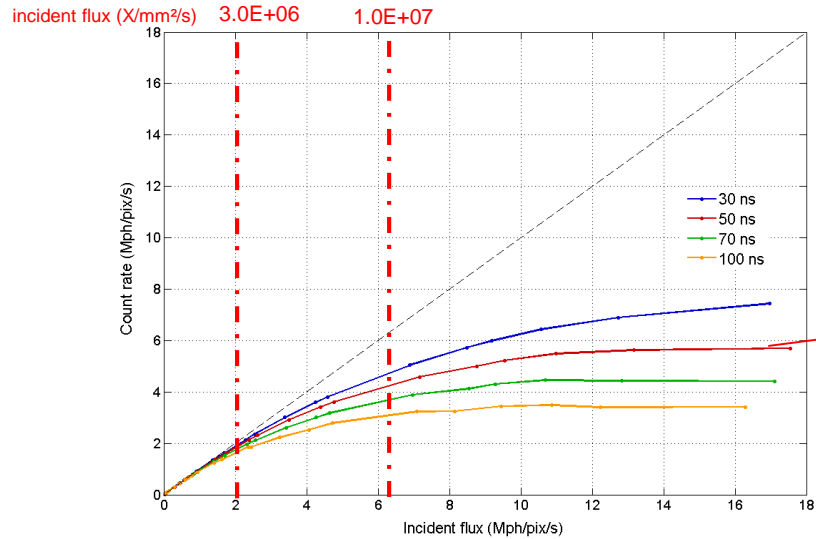
■ Main features:

- Linear array, N modules 128 pixels
- Pixel pitch: 800 μm
- Material: CdTe or CdZnTe
- Energy range: 20 - 160 keV
- Spectrometry up to 128 energy bins within **a single acquisition**

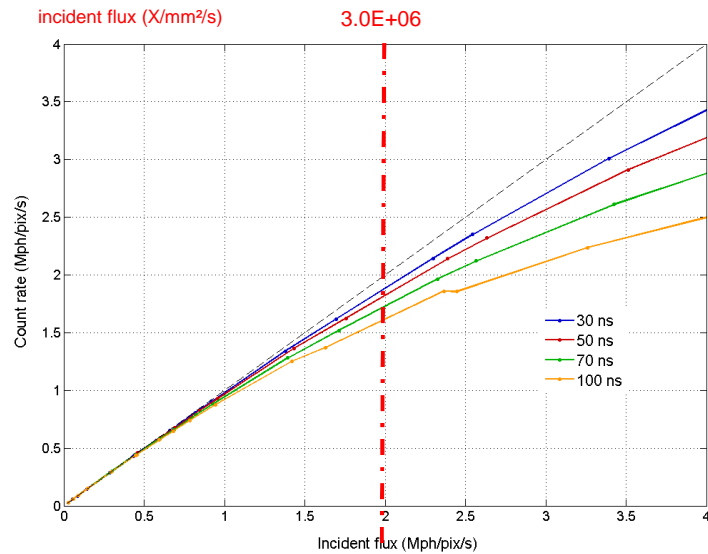
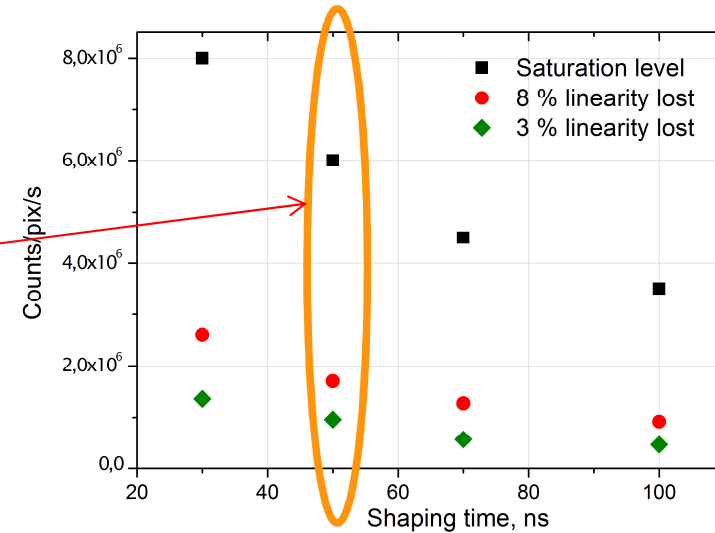


*Typ. acquisition time = a few ms
With Sub-ms capabilities*





Count rate performances adjustments

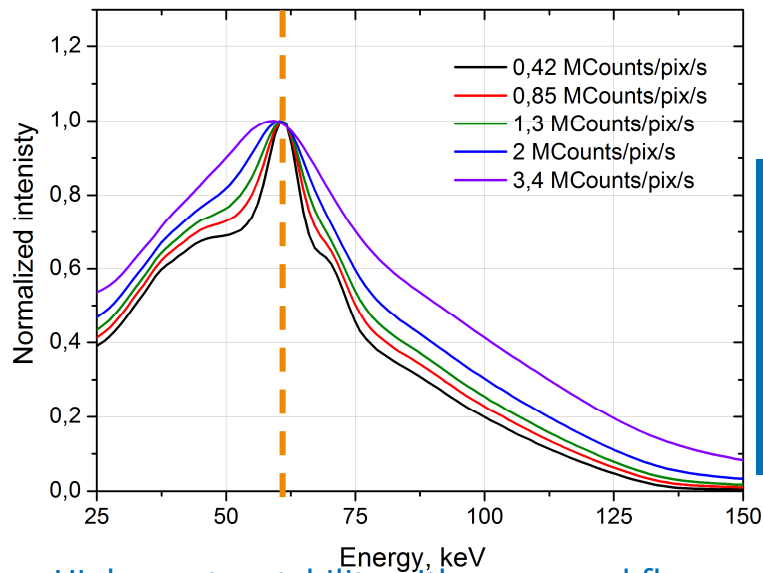
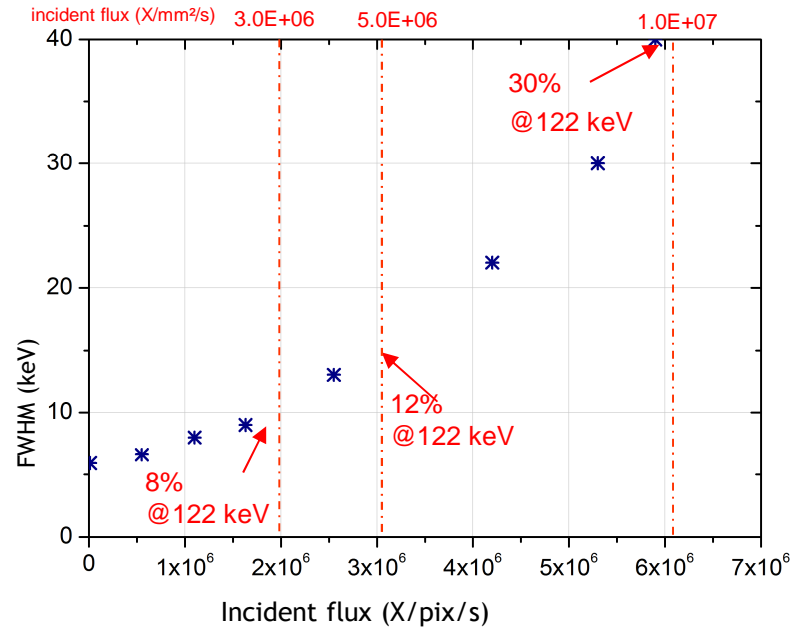
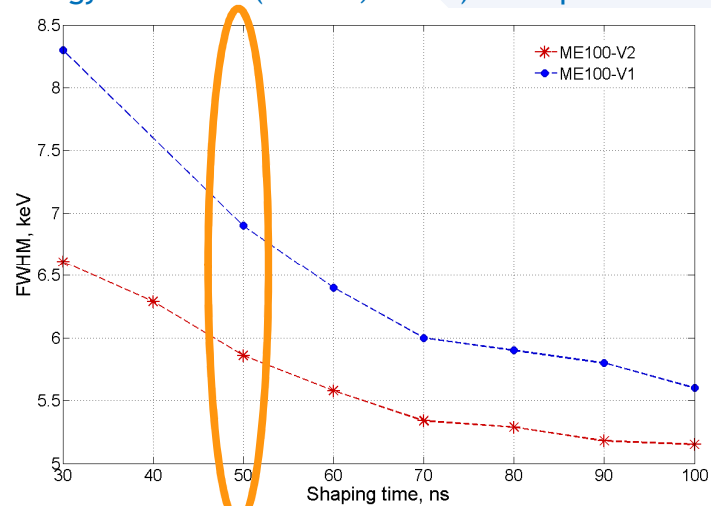


Linearity performance improvement via shaping time adjustment

Applications :

➔ Trade-off count rate vs energy resolution

Energy resolution(60keV , ²⁴¹Am)- Low photon Flux



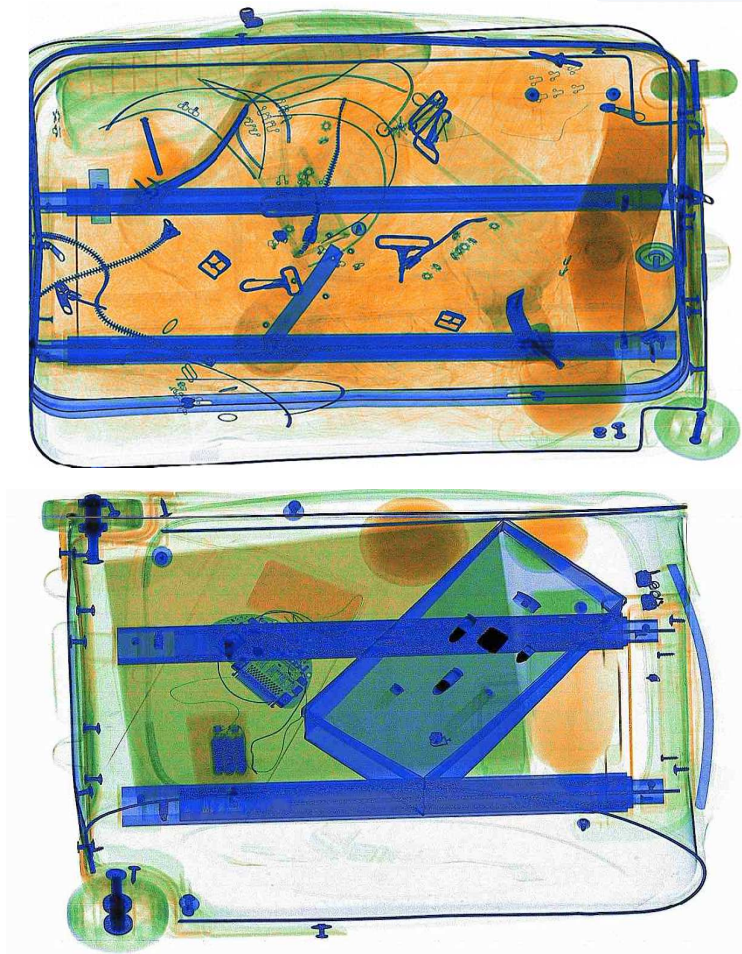
High spectra stability with measured flux

Good energy resolution up to 2–3 MCounts/pix/s
Applications :
➔ Trade-off count rate vs energy resolution

IMAGE ANALYSIS IMPROVEMENTS ALLOWED THANKS TO

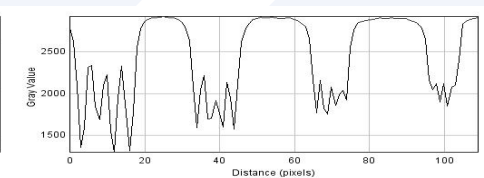
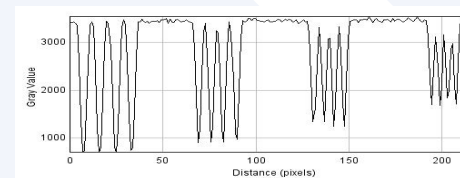
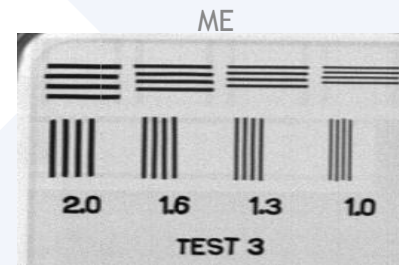
- Inherent Image Quality (IQ) improvement (spatial resolution..)
- Processing of Multiple Band of energy

o Improved Image quality (DE like images)



Standard ASTM

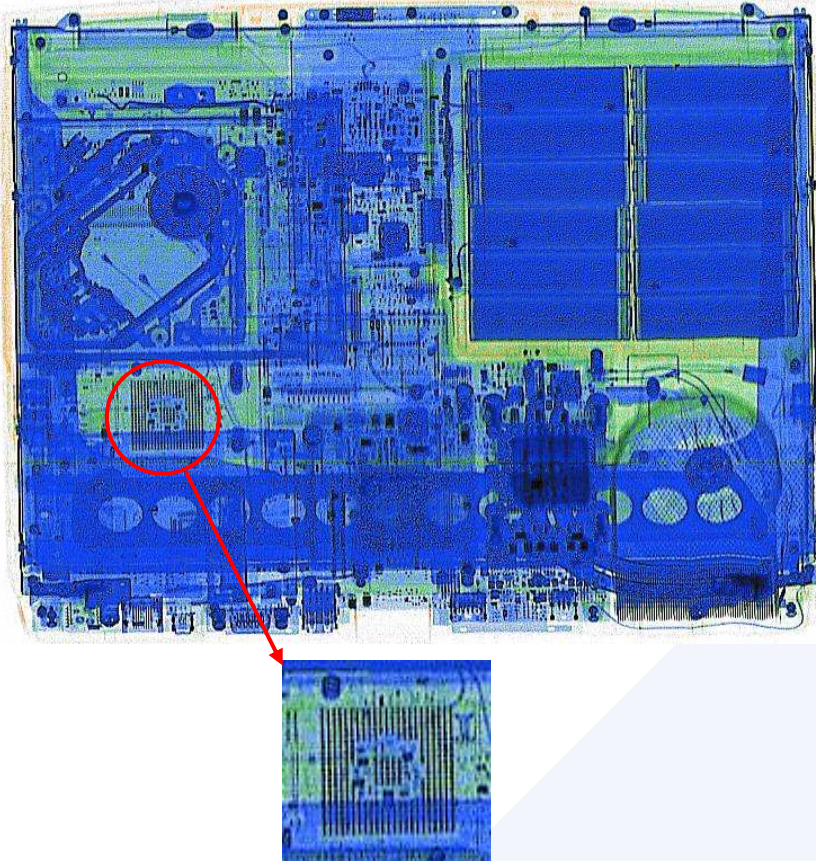
- > Test 1 Wire Resolution: 36 AWG in air
- > Test 2 Wire Resolution: 32 AWG under 9.5 mm Al
- > Test 3 Spatial Resolution: less than 1 mm V and H
- > Test 4 Steel Penetration: 30 mm



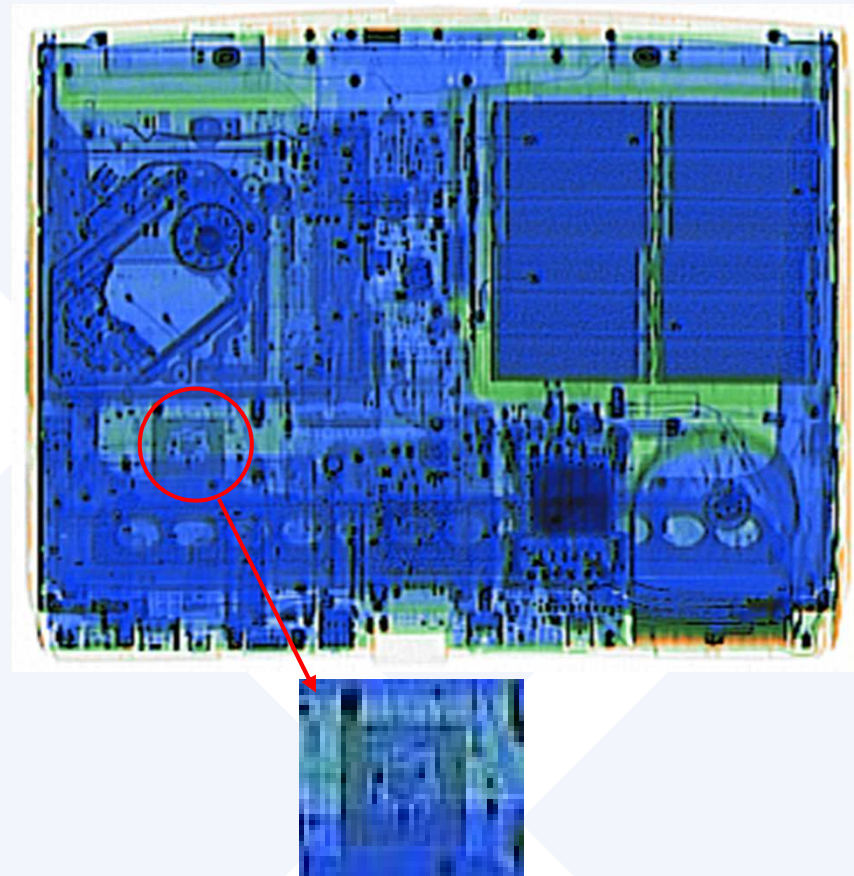
(1) Look up table for ME still to be optimized

(12)

ME100 Detector (0.8mm pitch)



Dual Energy Detector (ab. 1.6 mm pitch)



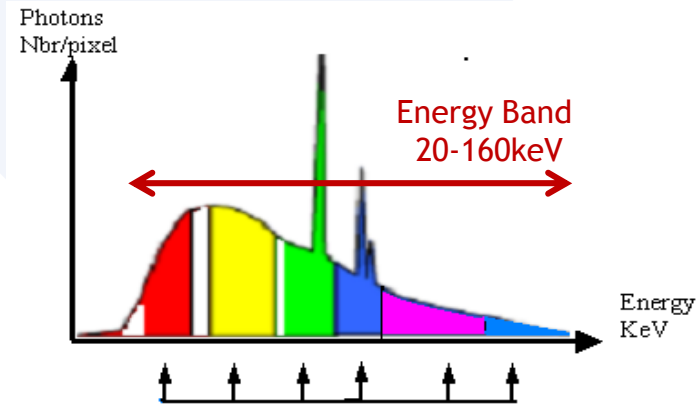
Improved Spatial Resolution with ME Detectors : No lag–No crosstalk

ME100 Detector (0.8mm pitch)

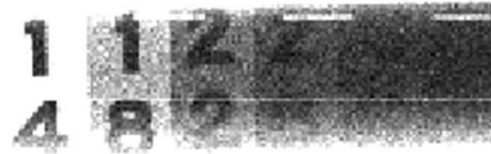


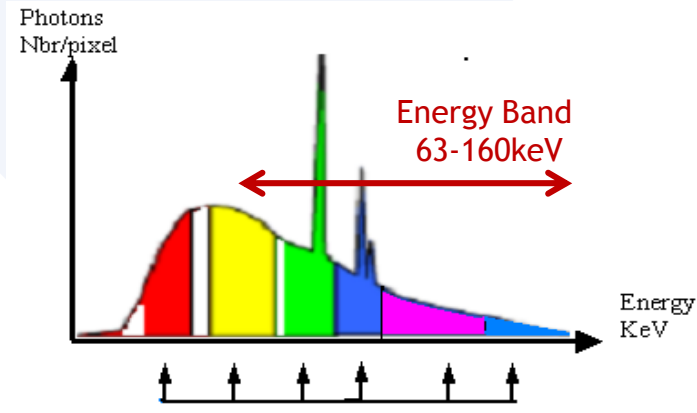
Dual Energy Detector (ab. 1.6 mm pitch)





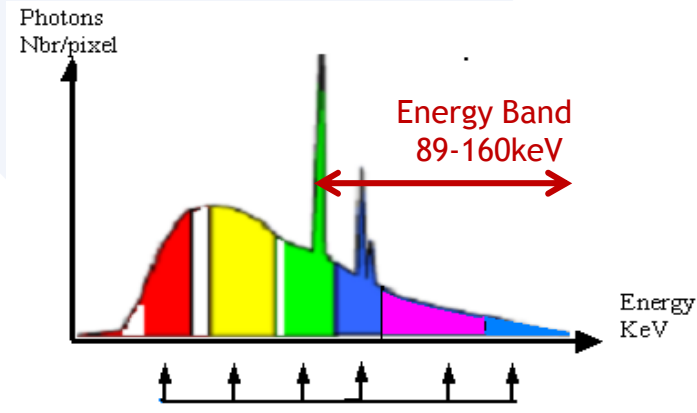
Energy Band
20-160keV





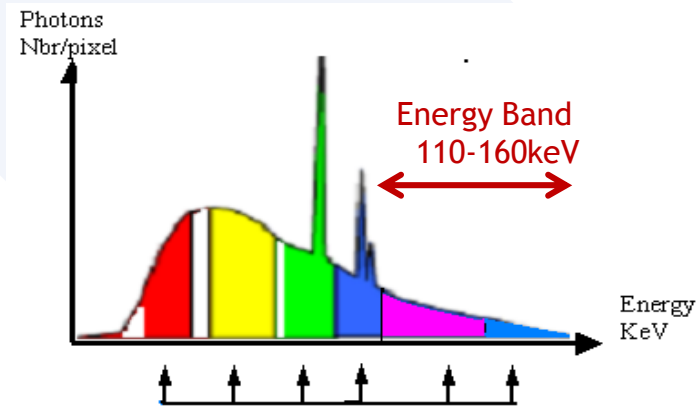
Energy Band
63-160keV





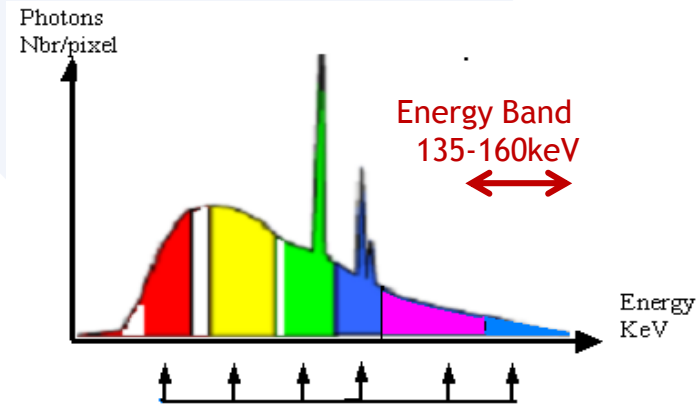
Energy Band
89-160keV





Energy Band
110-160keV





Energy Band
135-160keV



1. Plastics

- 1. Delrin 13 mm
- 2. Pmma 15 mm
- 3. Delrin 5mm

2. metals

- 1. Aluminium foil 4 mm
- 2. Fe 2mm
- 3. A piece in steel with a number W

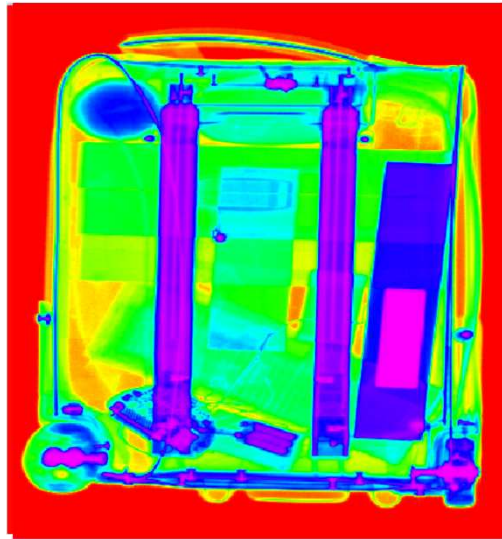
3. Other organics

- 1. Orange
- 2. Shampoo
- 3. 2 packs of cigarettes



Attenuation Image

Standard DE view: LE

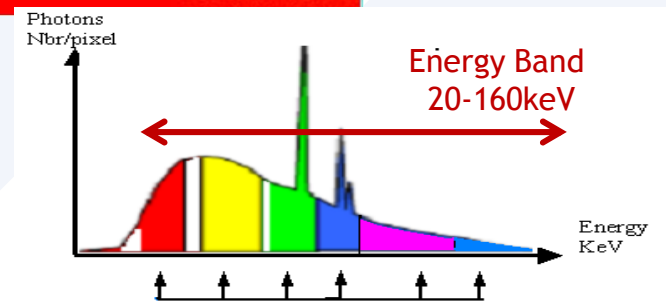
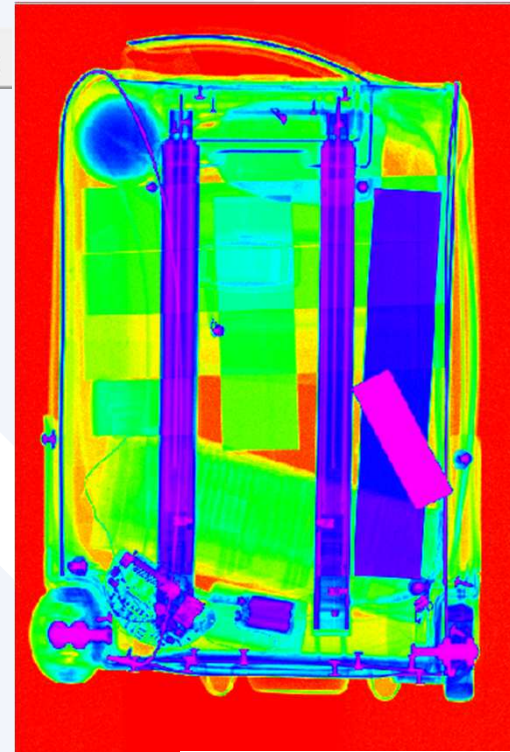


Attenuation colour range



Air Flux
Attenuation

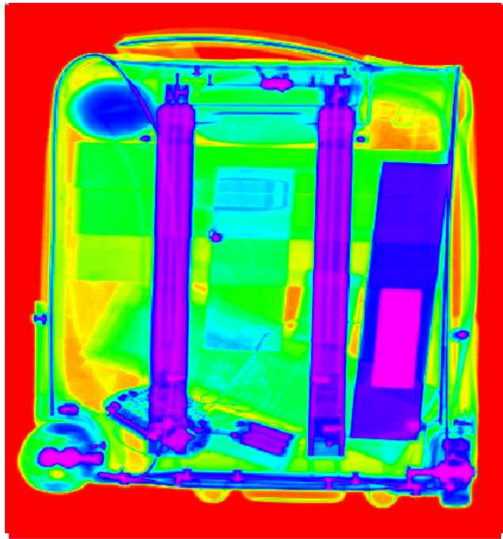
ME view: Energy band 20-160keV



Standard scanner conditions :160keVp,...

Attenuation Image

Standard DE view: LE

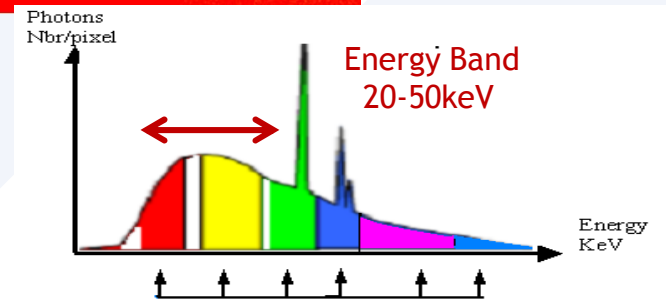


Attenuation colour range



Air Flux
Attenuation

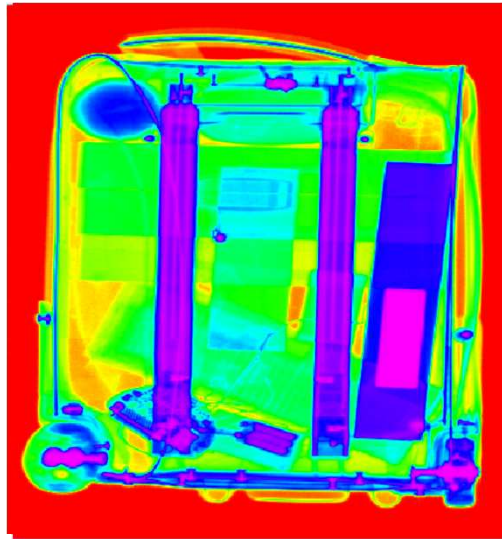
ME view: Energy band 20-50keV



Standard scanner conditions :160keVp,...

Attenuation Image

Standard DE view: LE

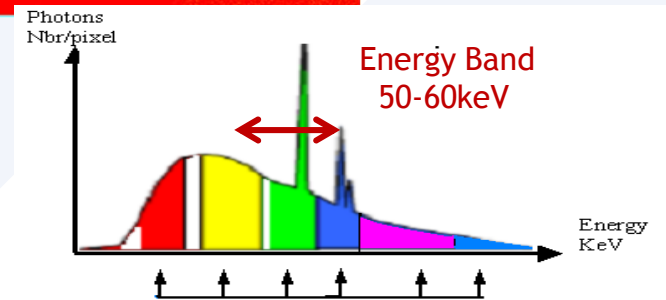


Attenuation colour range



Air Flux
Attenuation

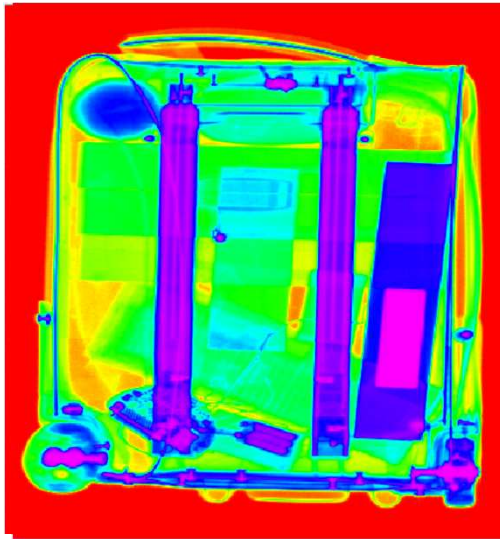
ME view: Energy band 50-60keV



Standard scanner conditions :160keVp,...

Attenuation Image

Standard DE view: LE

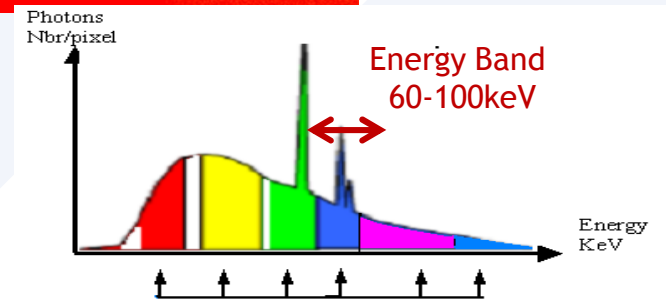
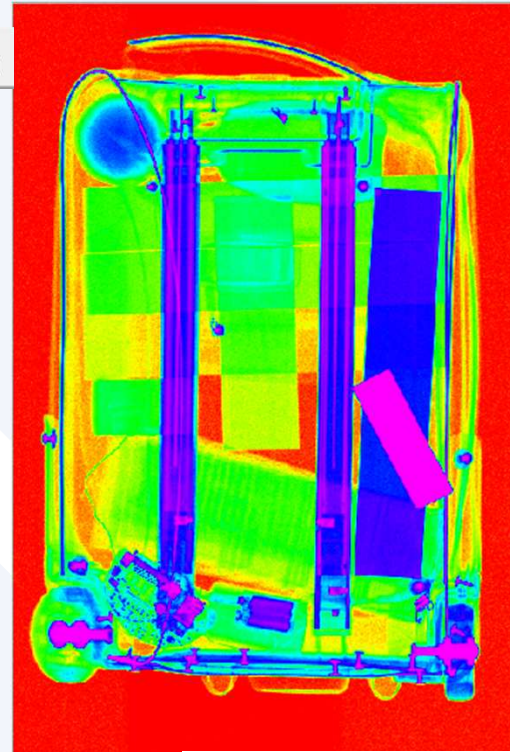


Attenuation colour range



Air Flux
Attenuation

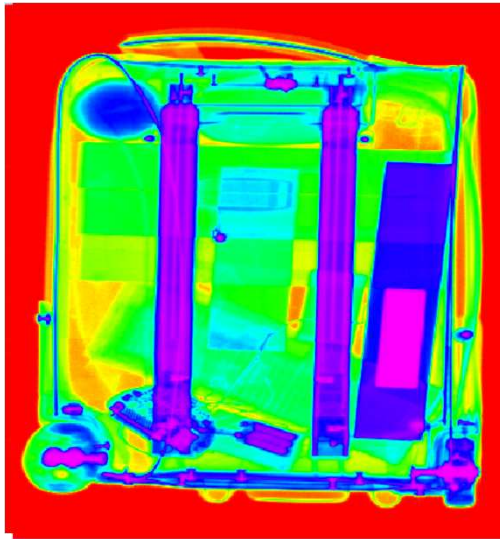
ME view: Energy band 60-100keV



Standard scanner conditions :160keVp,...

Attenuation Image

Standard DE view: LE

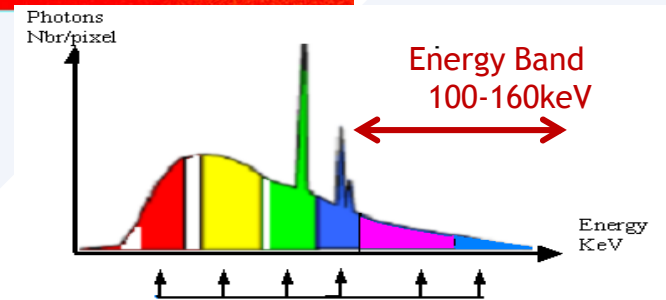
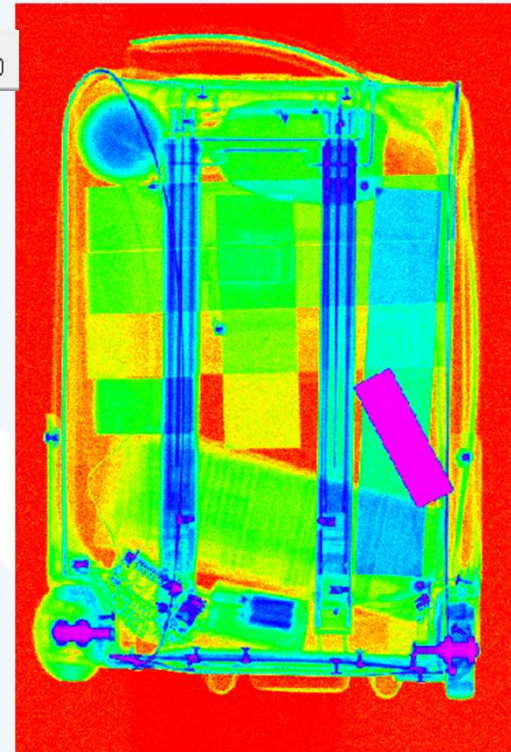


Attenuation colour range



Air Flux
Attenuation

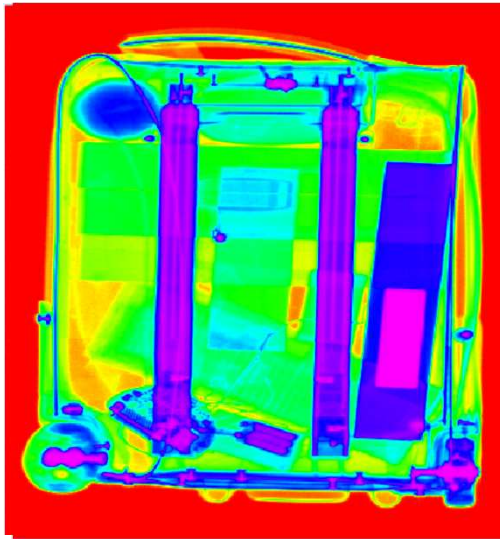
ME view: Energy band 100-160keV



Standard scanner conditions :160keVp,...

Attenuation Image

Standard DE view: LE

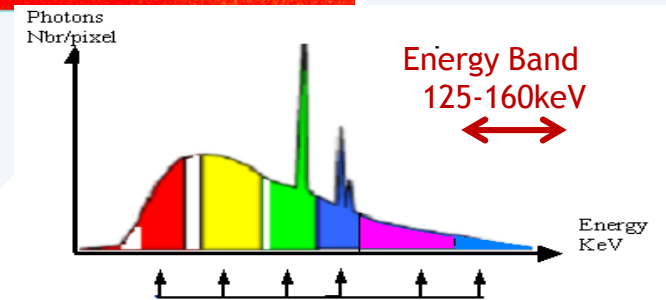
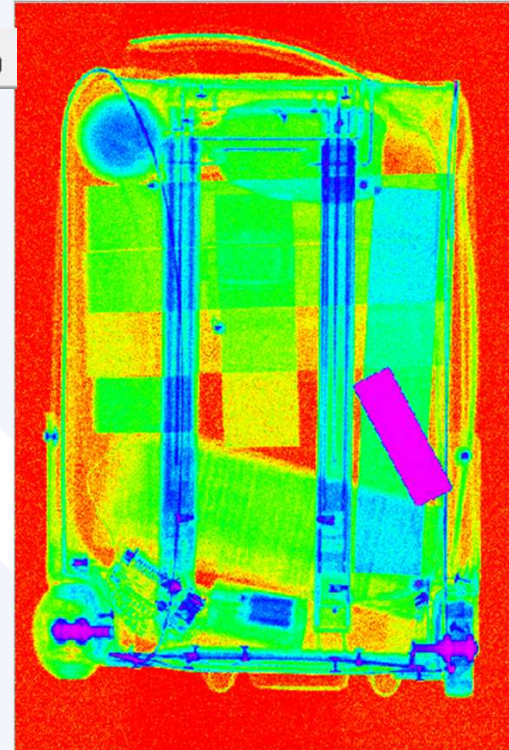


Attenuation colour range



Air Flux
Attenuation

ME view: Energy band 125-160keV



Standard scanner conditions :160keVp,...

MATERIAL DISCRIMINATION IMPROVEMENTS ALLOWED THANKS TO

→Spectral information

→Dedicated ME algorithms

› Multi-energy information :

→ Dual energy method can't be used

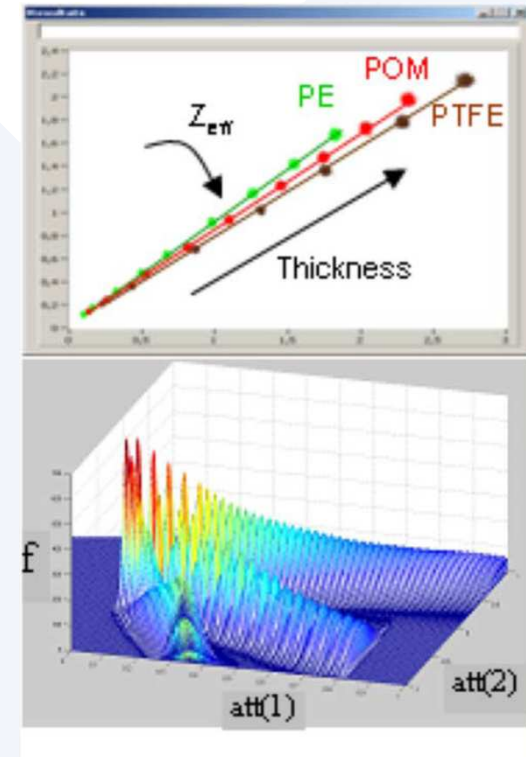
› Developpement of a specific method :

- N-dimensional space(attenuations)
- Calibration with noise learning,
- Multi-Gaussian approximation
- Method using probability densities

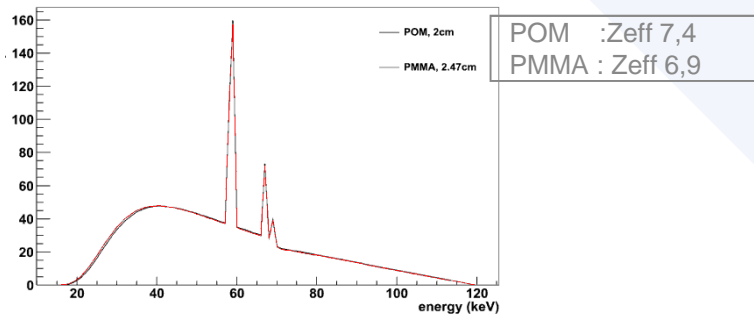
› Output :

- Material likelihood
- Equivalent thickness
- Density
- Z_{eff}
- False detection rate

... A tool to be integrated into equipments



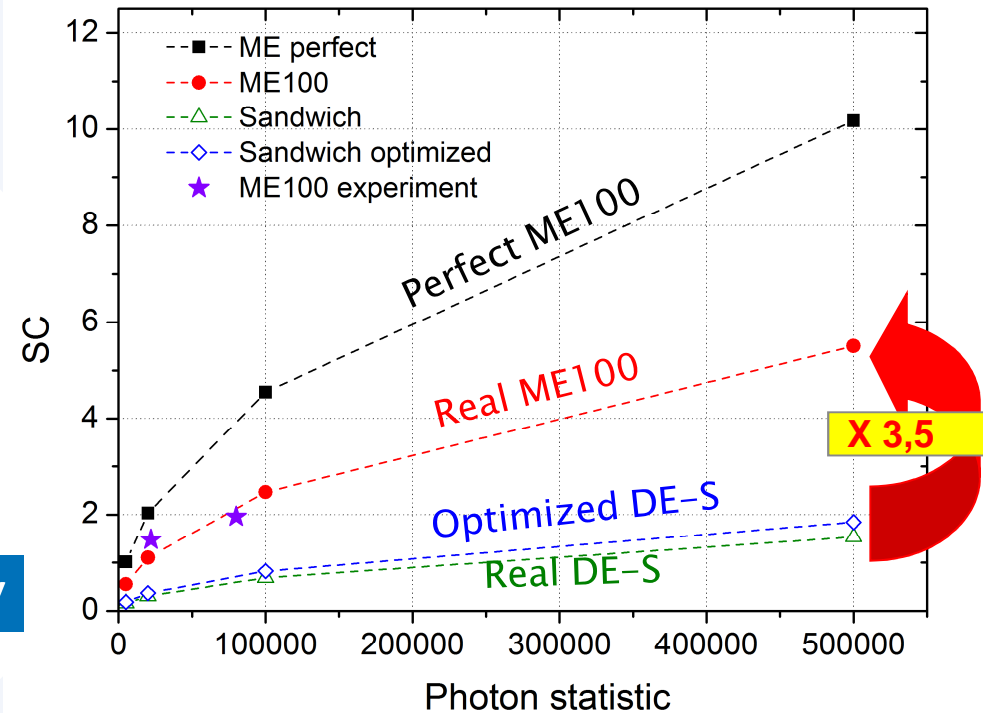
Evaluation of Separability Criterion with photons statistics



$$SC^2 = \sum_{i=1}^k \frac{(att_i^1 - att_i^2)^2}{(\sigma_i^1)^2 + (\sigma_i^2)^2}$$

SC ⇔ Z separability

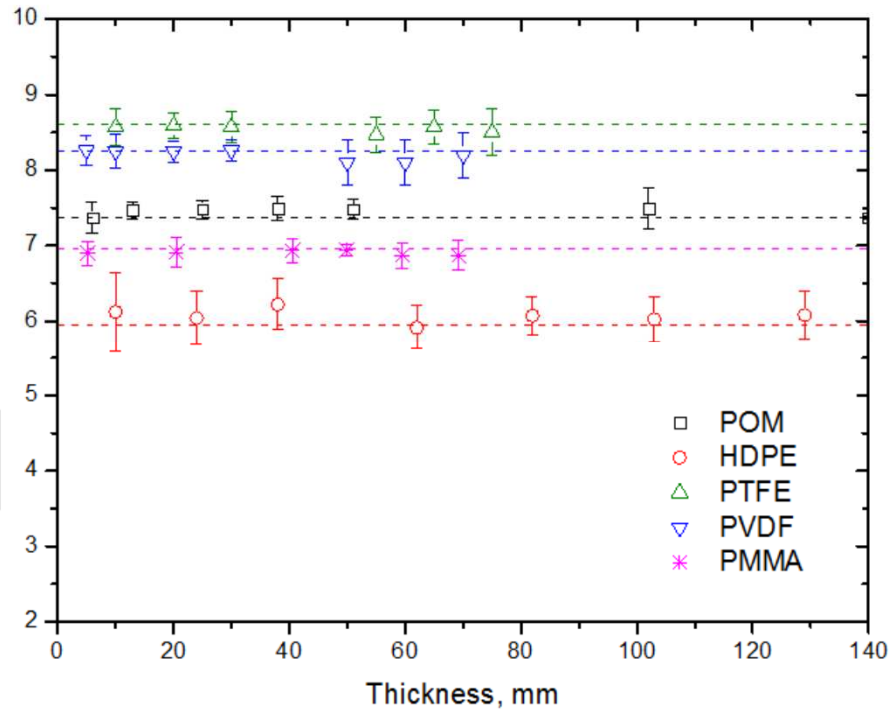
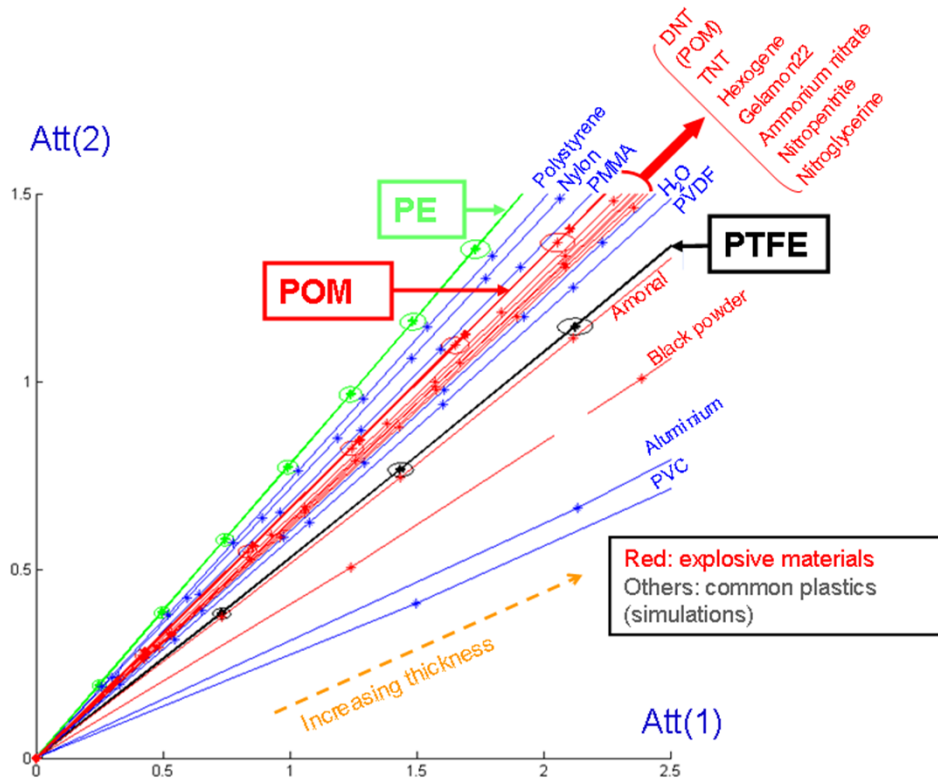
$$Separation = \frac{|Z_1 - Z_2|}{\sqrt{\sigma^2(Z_1) + \sigma^2(Z_2)}}$$



Considering two materials with close X-ray absorption properties:

- Multi-energy detector separability is 3.5 times higher than Dual Energy detector
- ME100 performance can be improved further and thus enhance discrimination

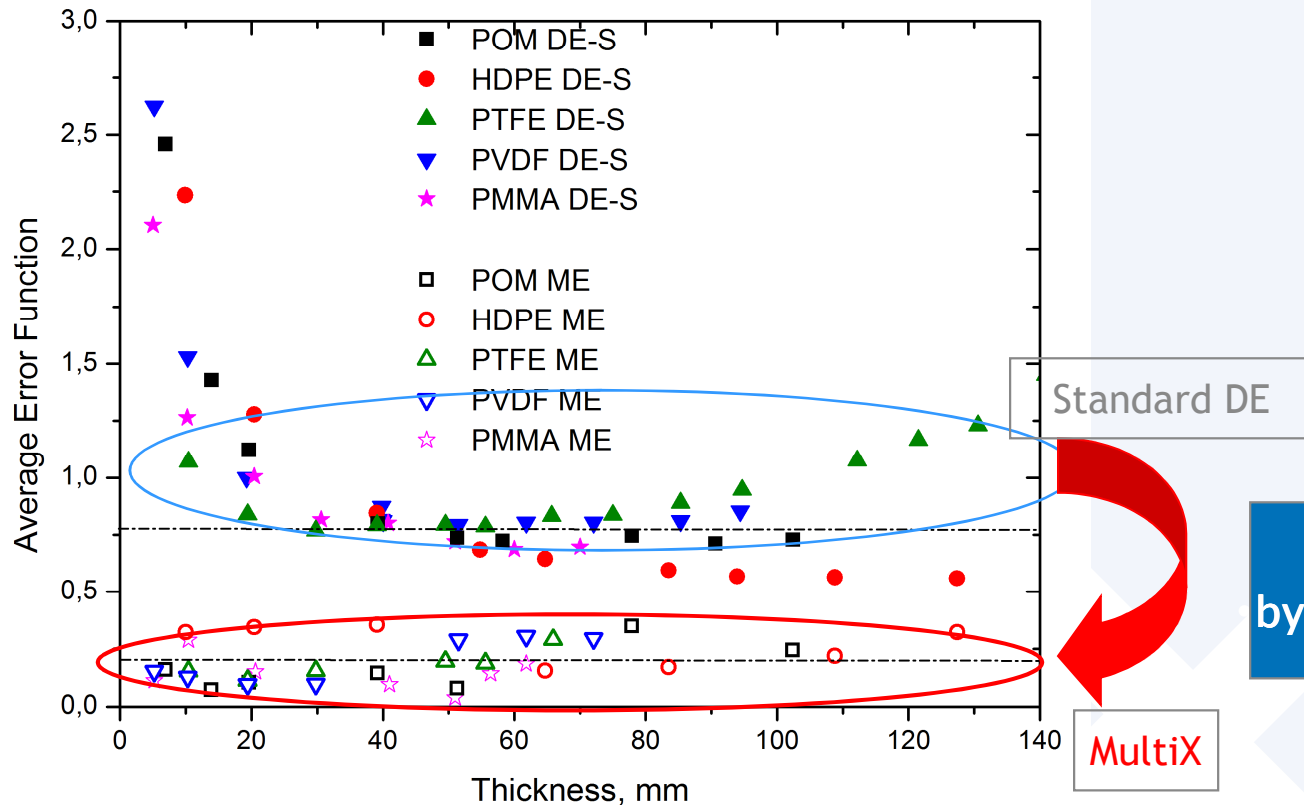
Conditions
 Real scanned data
 Binning 2 x 2 : pixel 0,8 x 0,8 → 1,6 x 1,6
 Rol for σ : 20 x 20 pixels
 raw data is used, without any filtering



Identification method :
 → good accuracy and precision on a large thickness range

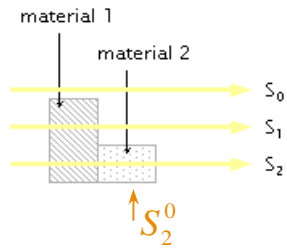
Average Error Function (AEF) combining accuracy (bias) and precision (σ)

$$\text{Average Error Function} = (Z_{eff}^{exp} - Z_{eff}^{theor}) \cdot \text{erf} \left(\frac{Z_{eff}^{exp} - Z_{eff}^{theor}}{\sqrt{2} \cdot \sigma} \right) + \sqrt{\frac{2}{\pi}} \cdot \sigma \cdot \exp \left(-\frac{(Z_{eff}^{exp} - Z_{eff}^{theor})^2}{2 \cdot \sigma^2} \right)$$



Standard scanner conditions :160kVp,...

ME based Spectrum Recovery Process (SRP)



> POM 30mm after Al 5mm

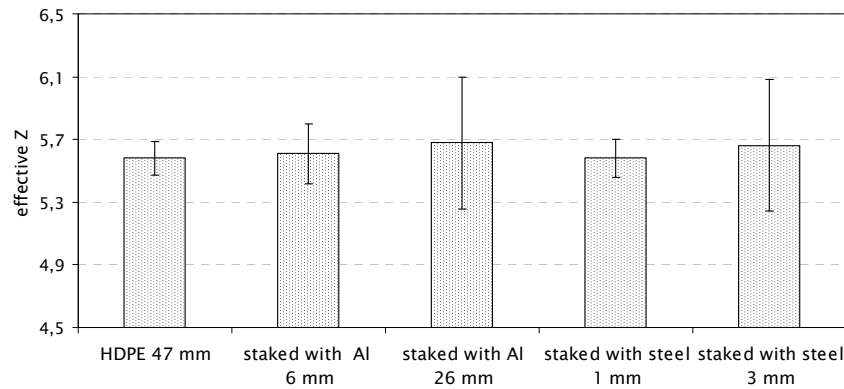
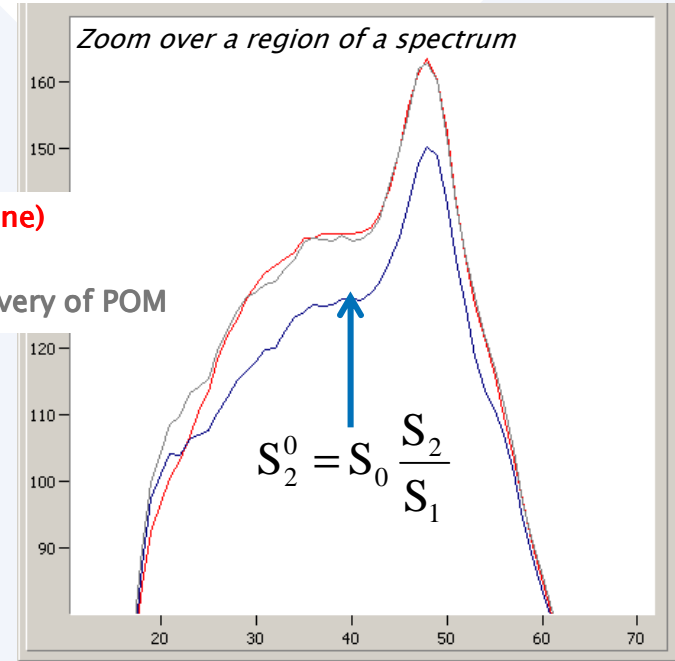
Al, 5 mm

POM, 30 mm

Reference spectrum (POM alone)

Natural recovery of POM

MLX/LETI correction for Recovery of POM



> Zeff (mean & st. dev.) for HDPE (47mm) recovered after:

- Al 6 mm,
- Al 26 mm,
- steel 1 mm
- steel 3 mm.

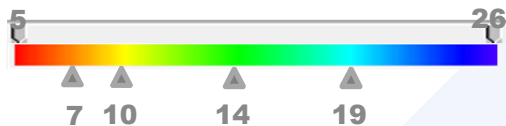
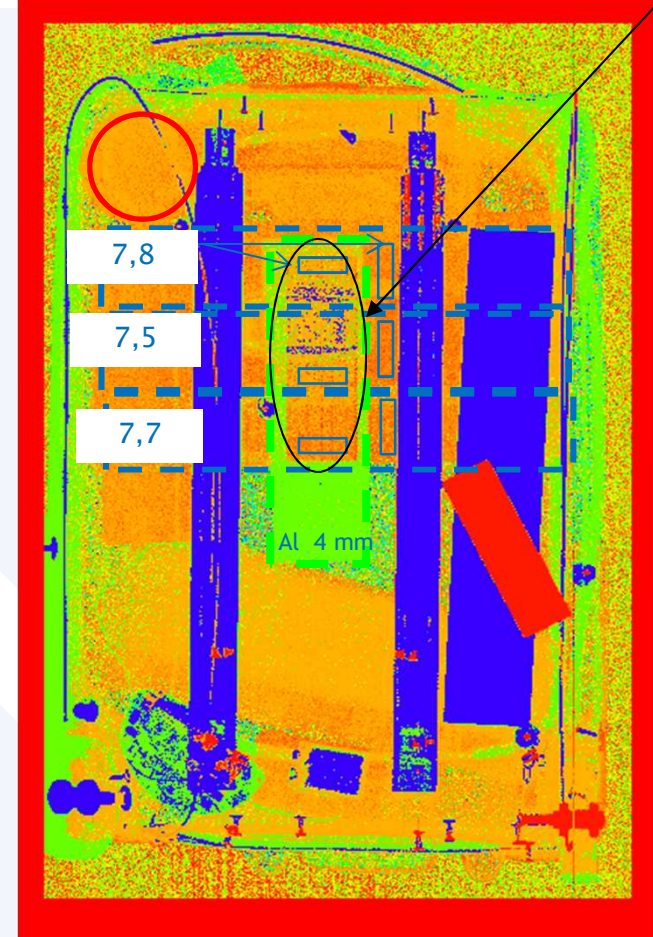
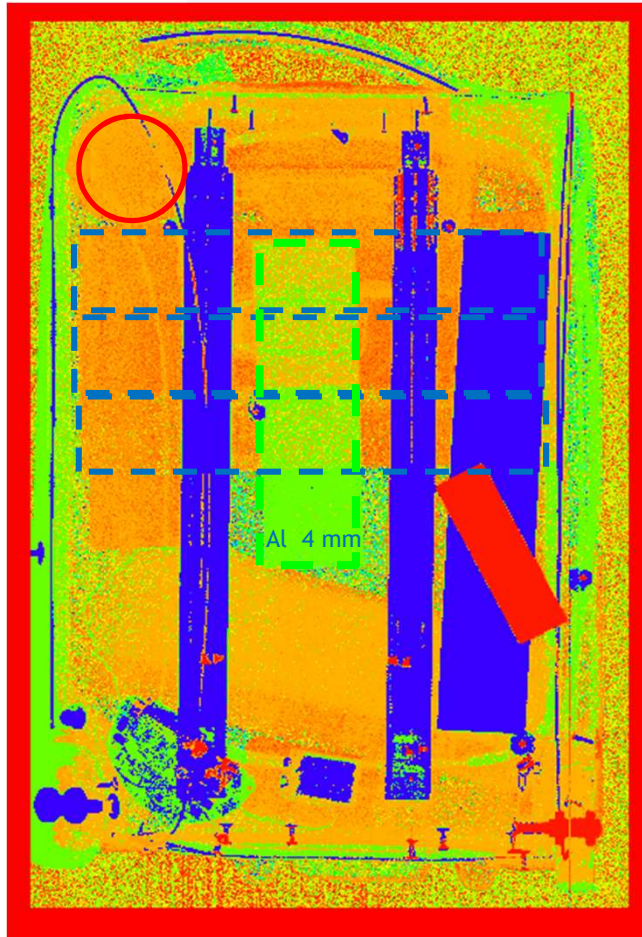
Dedicated ME based methods (SRP) → good recovery (accuracy and precision) of the hidden material spectrum (patent pending)

Preliminary

ME Zeff processing

ME Zeff processing with SRP on ROI

Delrin 13 mm
PMMA 15 mm
Delrin 5 mm

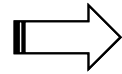


ME allows to recover Zeff while keeping precision and separability even when overlapped with Al
Metal frame of the tag appears clearly as metal (blue)

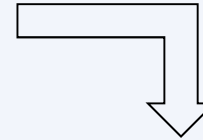
> Benefits are twofold:

ME100

Improved
"image Quality"



- Spatial resolution
- Penetration
- Multi energy-band "segmentation"

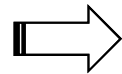


New adapted
ME-class
algorithms

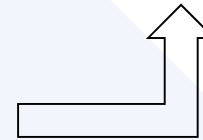
- to leverage ALL scanners
FAR ↘ Pd ↗
- New and retrofit

ME100

Improved
Material
discrimination



- Z_{eff}
- equivalent thickness & density
- SRP capabilities
- ...



- ME100 real time X-ray transmission spectrometric grade detector under high photon flux is available to leverage baggage scanners.
- New ME based algorithms will benefit from ME rich information for
 - improving material discrimination capabilities
 - improving Image analysis

In order

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- To support platform performance improvements and lifecycle extension
- To Fill the performance gap between current dual energy, multi-view and CT technology



● Contacts

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