IAEA 3rd Technical Meeting on Radiation Detection Instruments
Emerging Technologies and Threats
VIENNA
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CODED APERTURE GAMMA CAMERAS
A WANNABE PASSENGER FOR UNCREWED AERIAL SYSTEMS

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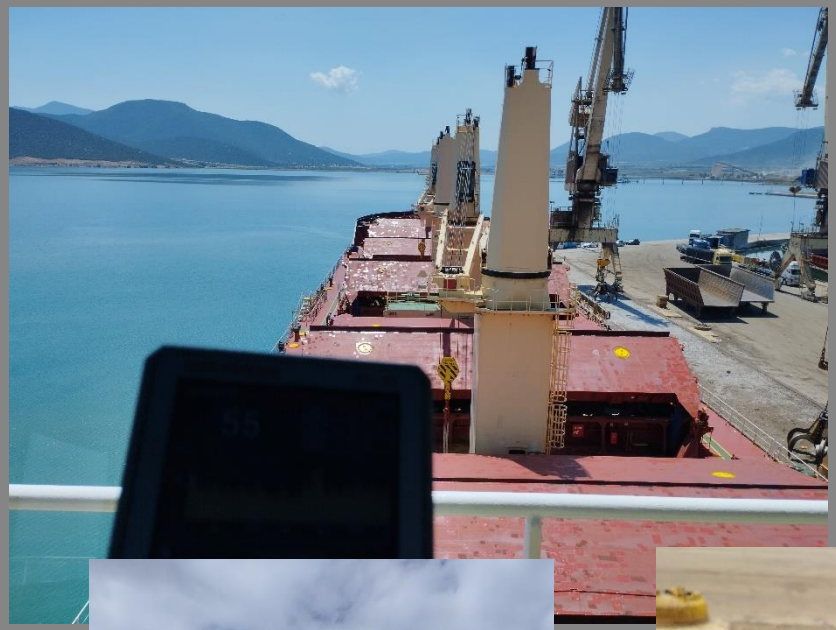
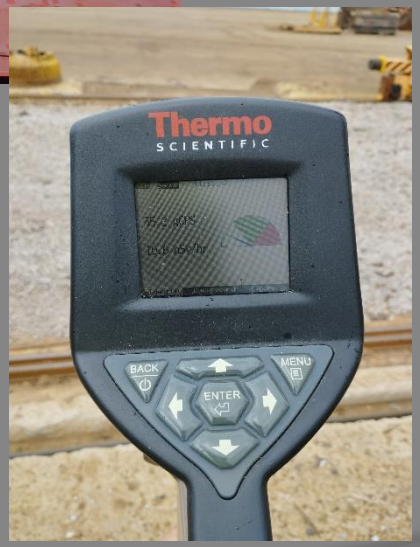
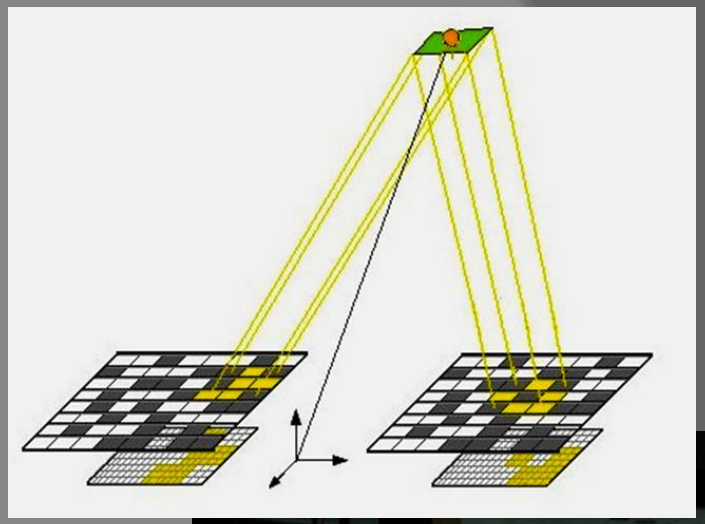
Scrap-Metal Cargoes in Merchant Vessels

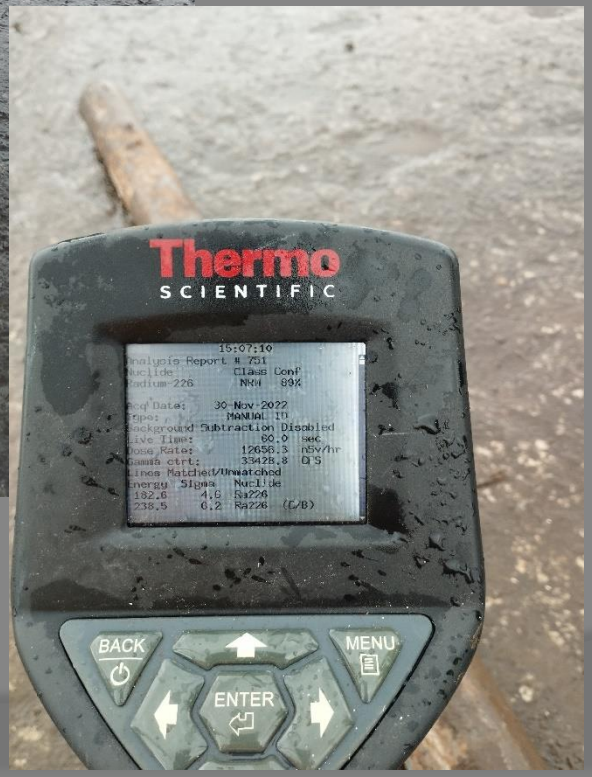


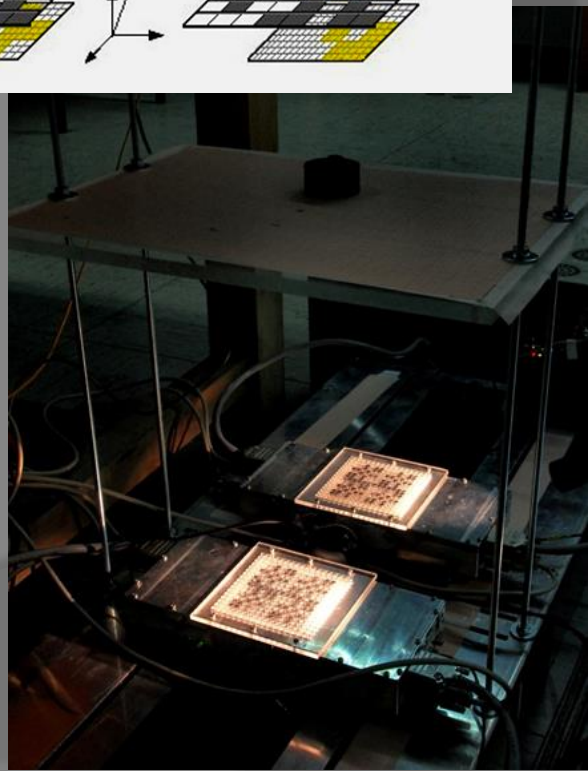


Scrap-Metal Cargoes in Merchant Vessels

Tube contaminated with Ra-226 salts







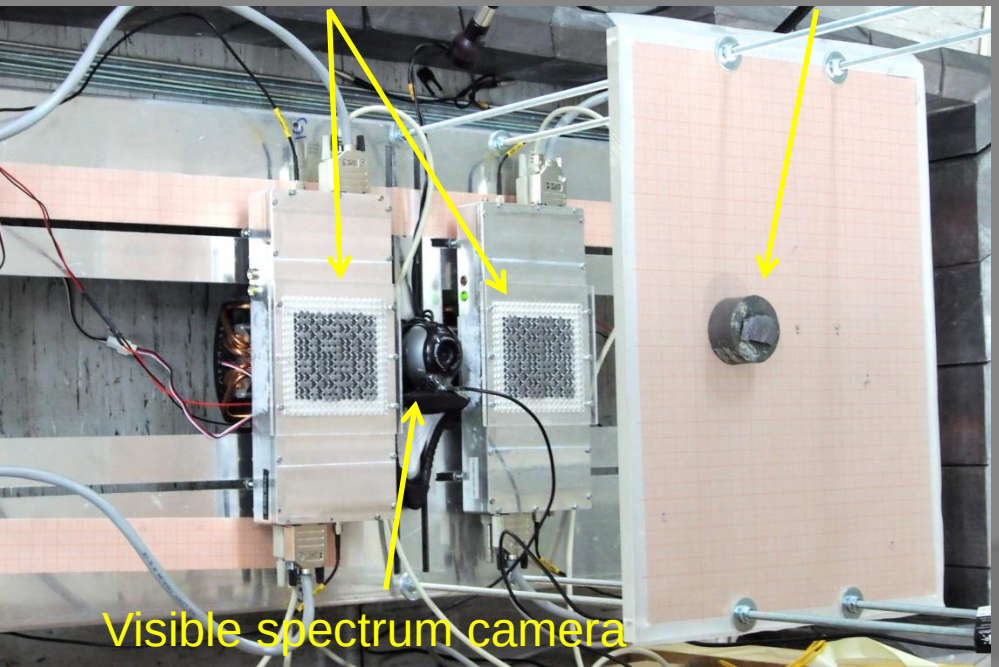
In short…: Exploit Parallax phenomenon of the shadowgrams of two γ-cameras with Coded Apertures

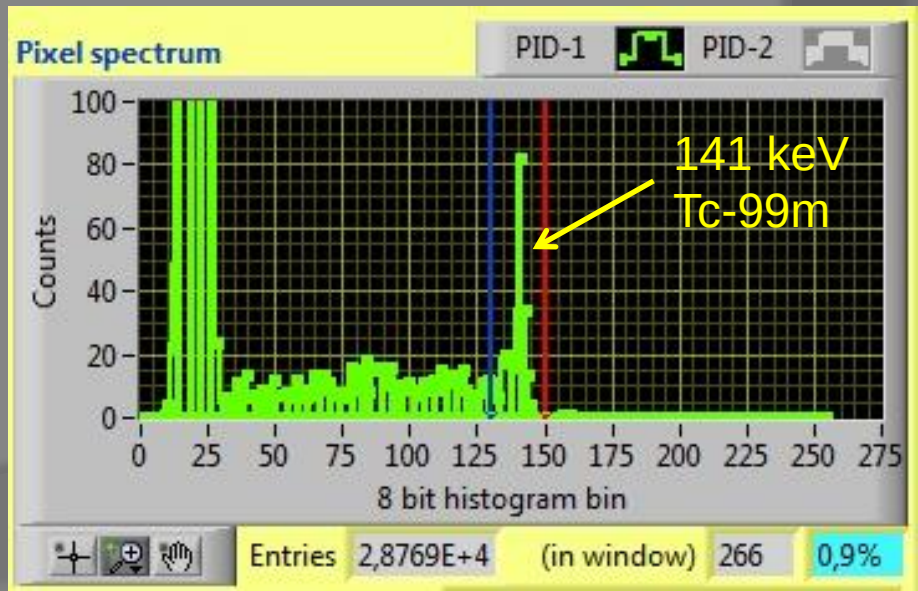
Capable for:

- 3D localization
- Resolving two radioactive spots in 3D
- Resolving photon energy

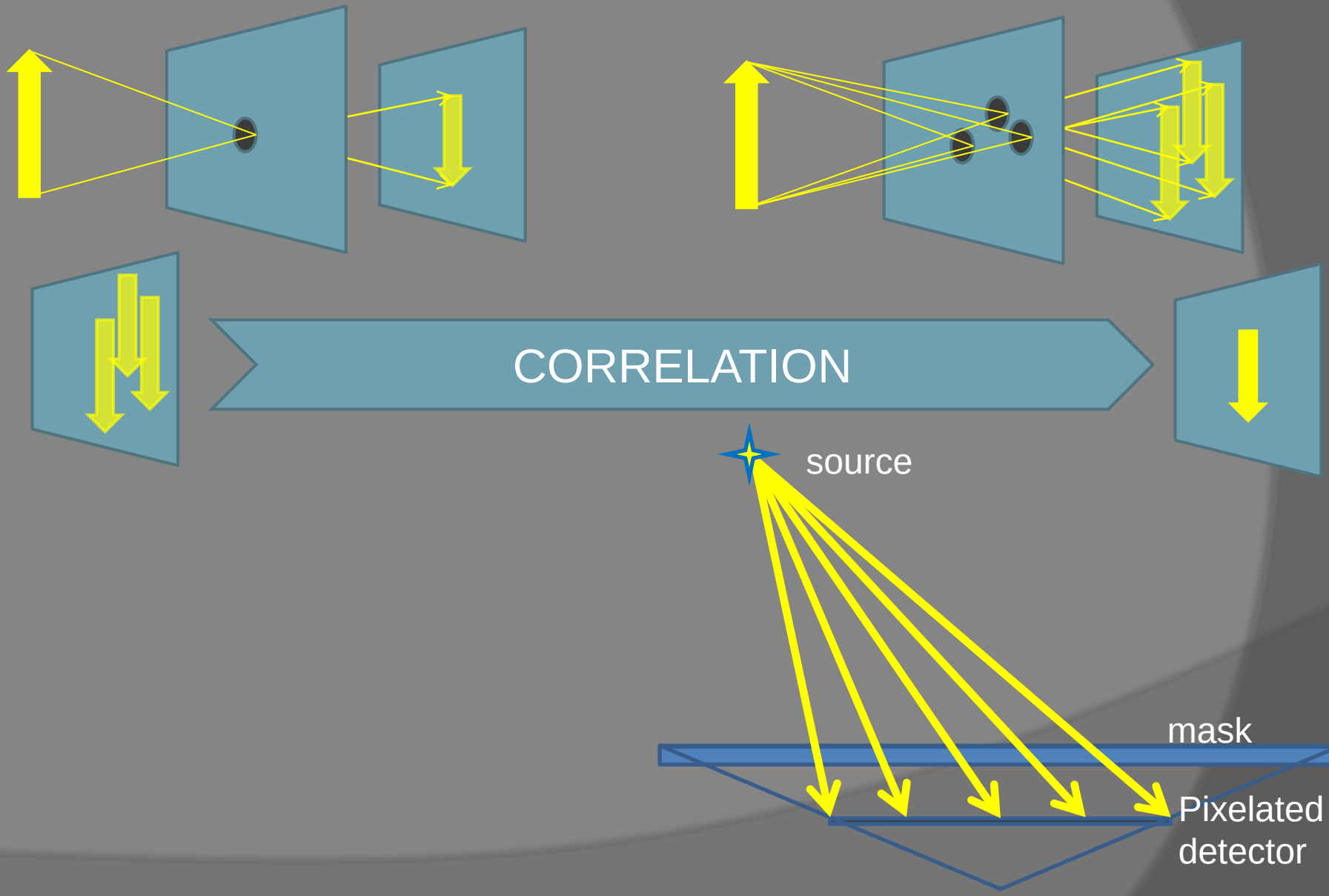
Two CdTe γ-cameras

^{57}Co radioactive source



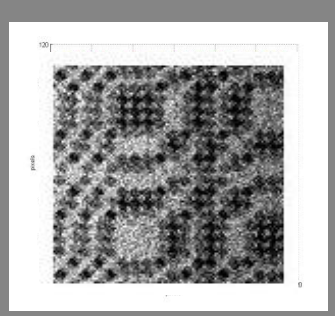


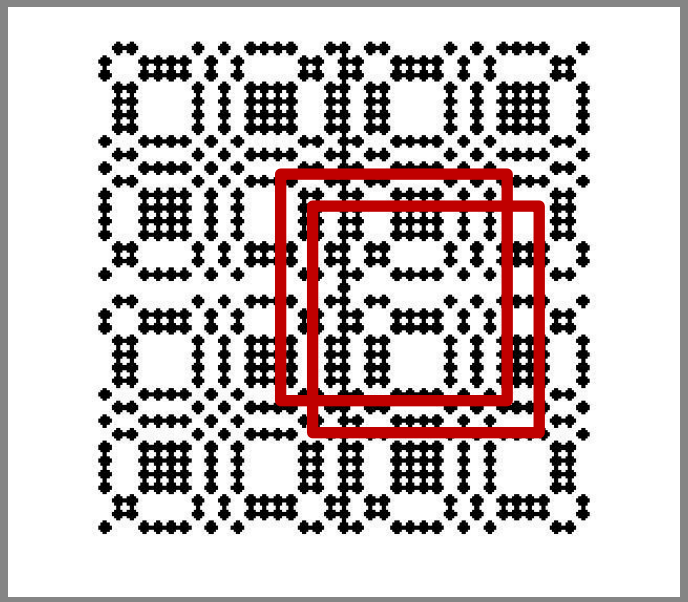
From Pinhole Aperture to Coded Aperture

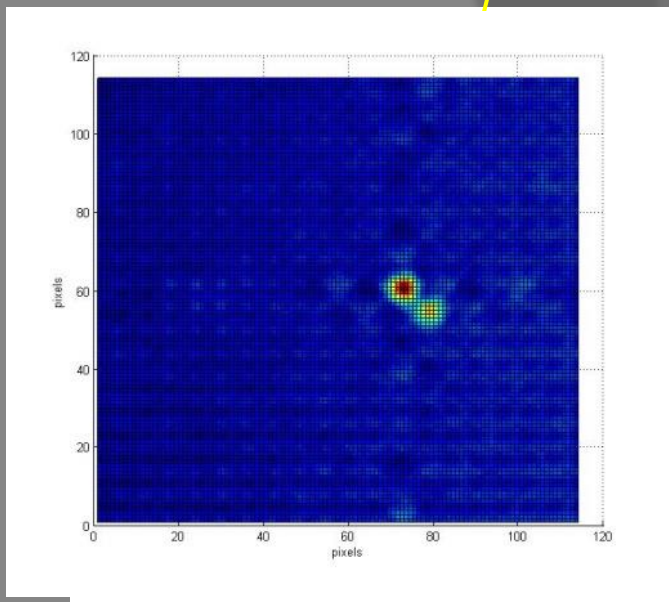


From Shadowgram to Point Spread Function (PSF)

The correlation of Shadowgram with G matrix produces the Correlation Matrix







PSF: Point Spread Function

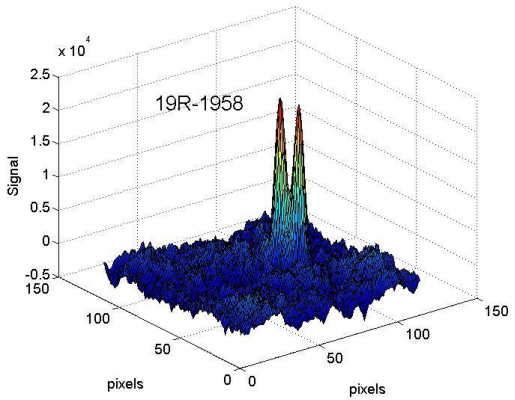
ACF: Auto Correlation Function

PSLA: Point Source Location Accuracy

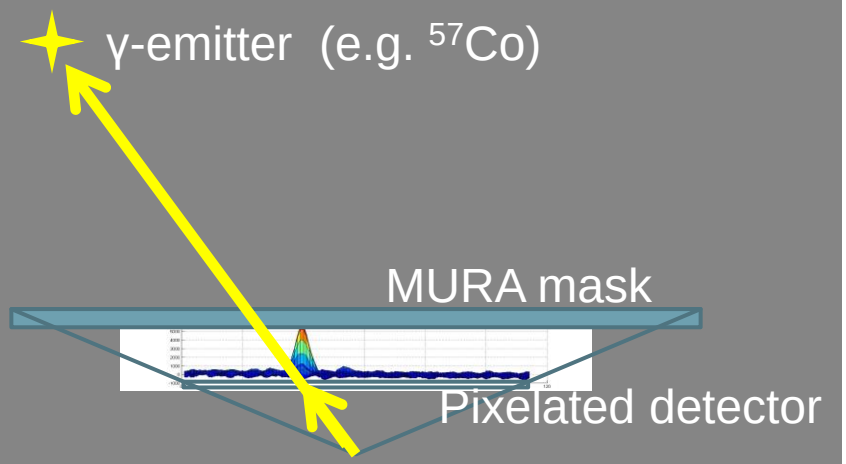
SNR: Signal to Noise Ratio

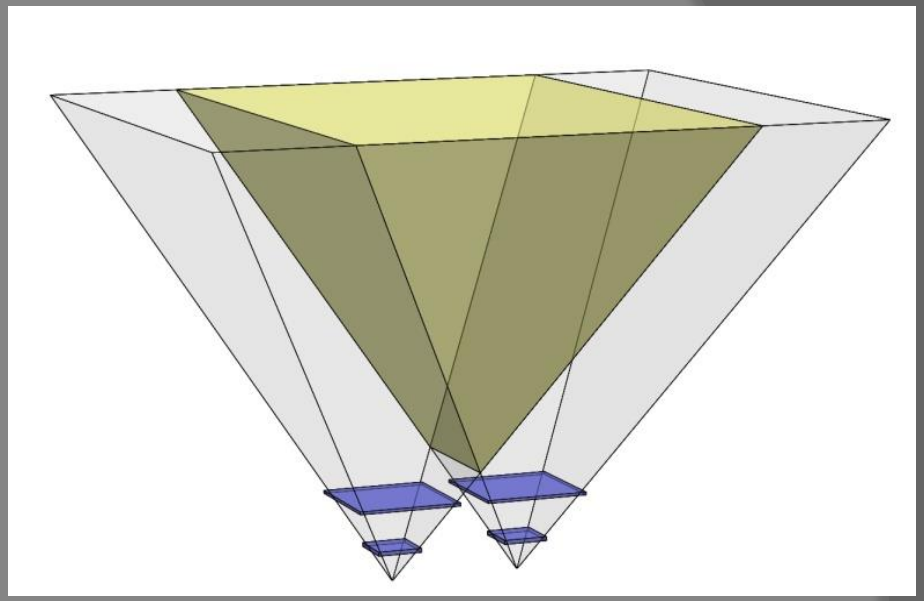
AR: Angular Resolution =

=FWHM of PSF



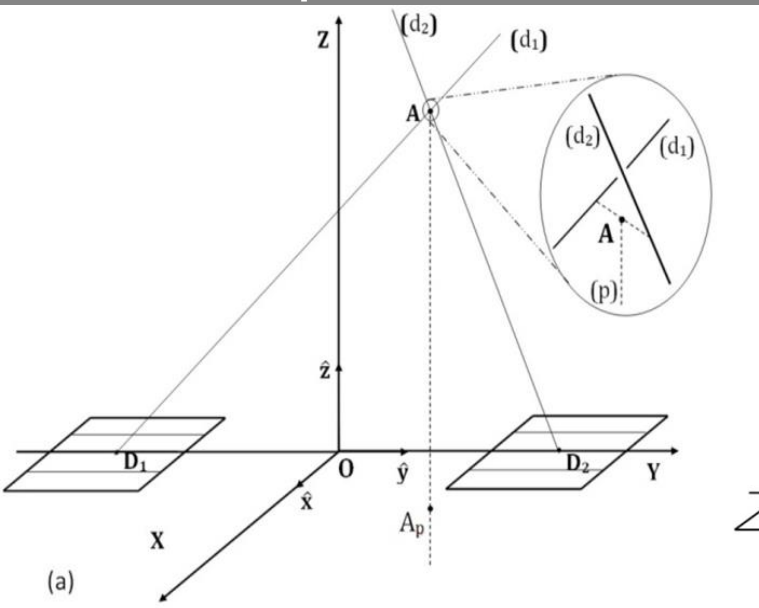
Localization in 3D with Triangulation Algorithm

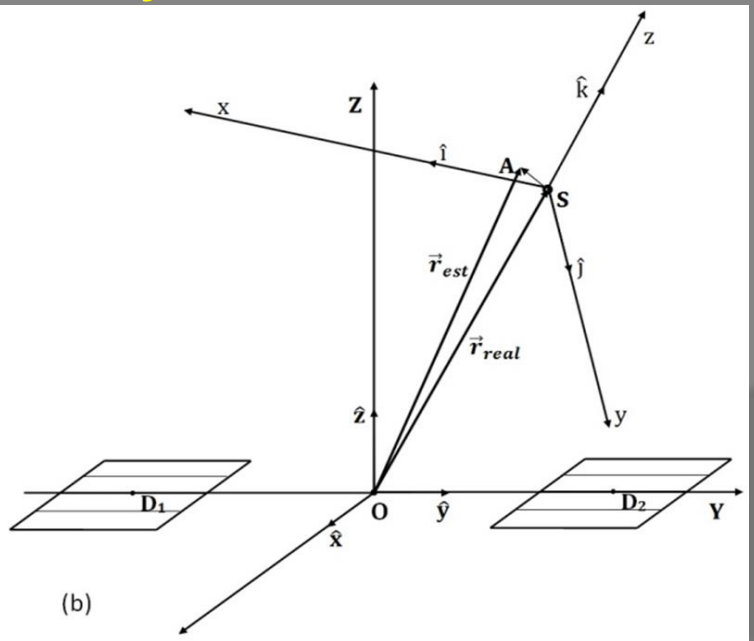




$FCFOV_S$:

Common place of the two Fully Coded Field of View

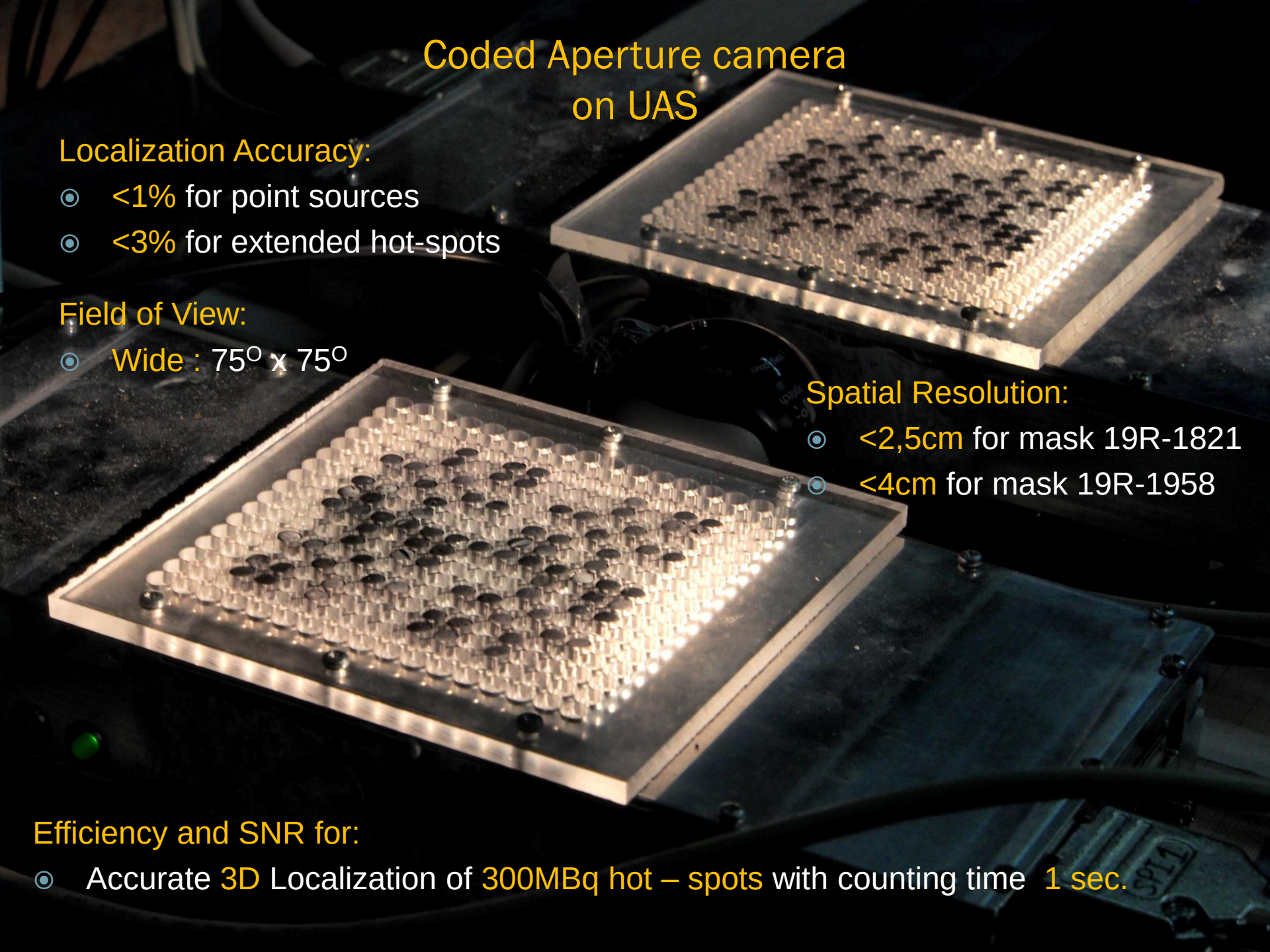




3D SLA:
Source Location Accuracy

VR:
Voxel Resolution

Coded Aperture camera on UAS



Localization Accuracy:

- <1% for point sources
- <3% for extended hot-spots

Field of View:

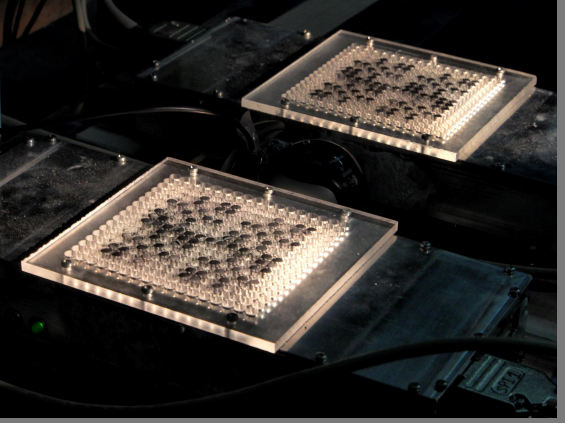
- Wide : 75^{O} x 75^{O}

Spatial Resolution:

- <2,5cm for mask 19R-1821
- <4cm for mask 19R-1958

Efficiency and SNR for:

- Accurate 3D Localization of 300MBq hot – spots with counting time 1 sec.



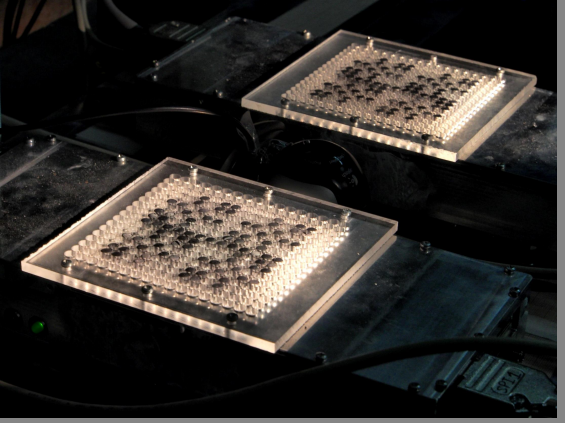
Coded Aperture camera on UAS

Experimental measurements with:

- Isotope: Am-241
- Activity: 10mCi
- Coded Aperture: MURA 7x7
- Wide FOV = 75^{O} x 75^{O}

For good accuracy (R=2%) the SNR is desired to be >7

	Distance	(mm)		456	456	1000	1000	3000	3000	5000	5000
Activity	Acquis. time (sec)	(min)	SNR	R (mm)	Counts	R (mm)	Counts	R (mm)	Counts	R (mm)	Counts
370 MBq	30		12,2	2,56	144704		30089	65	3343	109	1204
370 MBq	15		11,5	2,83	76198		15844	65	1760		634
370 MBq	7		11,2	2,87	37459	22	7789		865		312
370 MBq	3		11,1	3,31	15224	22	3166		352		127
370 MBq	1		8	9,9	5285	22	1099		122		44
1 MBq	300	5		9,9	3911		813		90		33
1 MBq	150	3		9,9	2059		428		48		17
1 MBq	70	1		9,9	1012		211		23		8
10 kBq	3000	50			391		81		9		3
10 kBq	1500	25			206		43		5		2
10 kBq	700	12			101		21		2		1

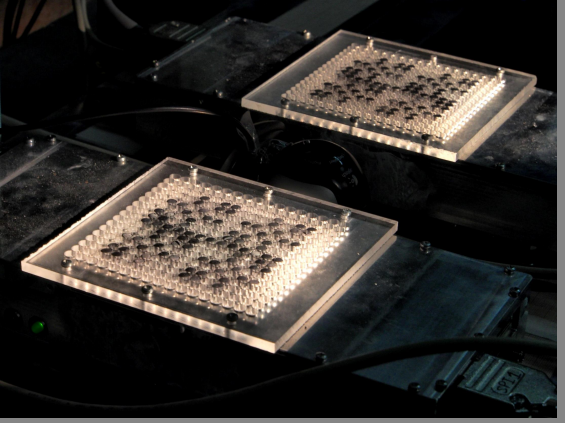


Coded Aperture camera on UAS for Nuclear Security

A scanning scenario of scrap metal suspected for radioactive contaminants, like Cs-137, Am-241, Ra-226, Co-60

Scanning a scrap metal pile or loaded ship with scrap metal:

- Flight height : 3m above the scrap pile
- Surface of the pile under the FOV : ~10 m^2
- Acquisition time for each location: 15 sec
- Total surface to be scanned : 60 x 20 = 1200 m^2
- Total acquisition time : 120 x 15 = 1800 sec = ½ h
- Localization Accuracy of radioactive hot-spots of ~300 MBq: 7 cm

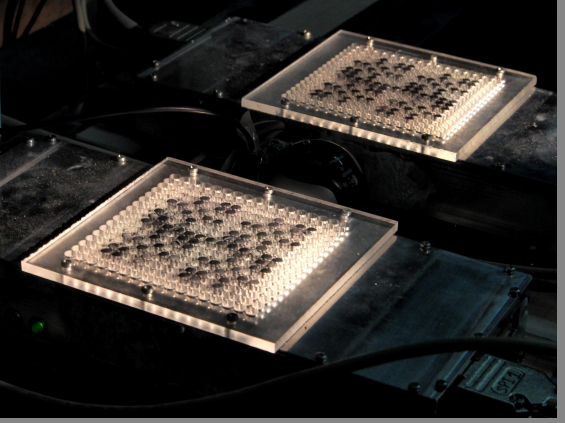


Coded Aperture camera on UAS for Nuclear Security

For localizing sources with activities about the exemption limits, Efficiency matters

Improving Efficiency by:

- Choosing thick detectors
- Choosing sensitive materials with high atomic number and high density
- Accumulating counts from neighbor pixels
- Using high transparency coded apertures
- …



Thank you for your attention