INNOVATIONS IN SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY

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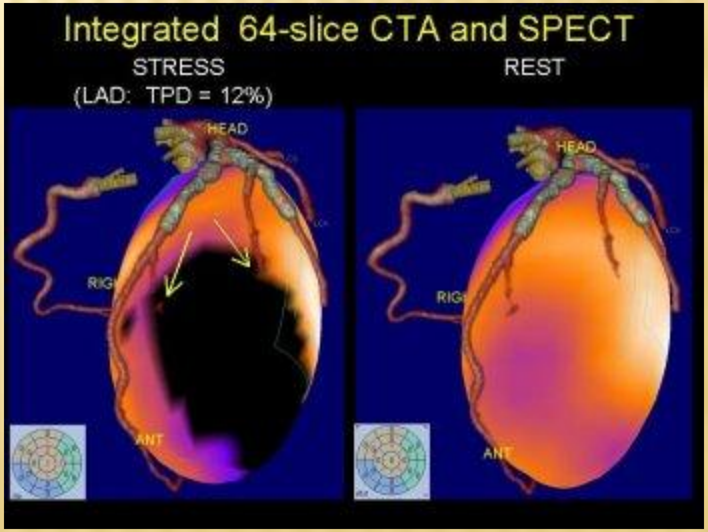
OVERVIEW

- **1) Walkthrough on SPECT**
- 2) Introducing with multiplexed measurement systems (MMS)
- 3) Advances in modeling MMS
- 4) Introducing with other types of coding devices in MMS
- 5) Conclusions

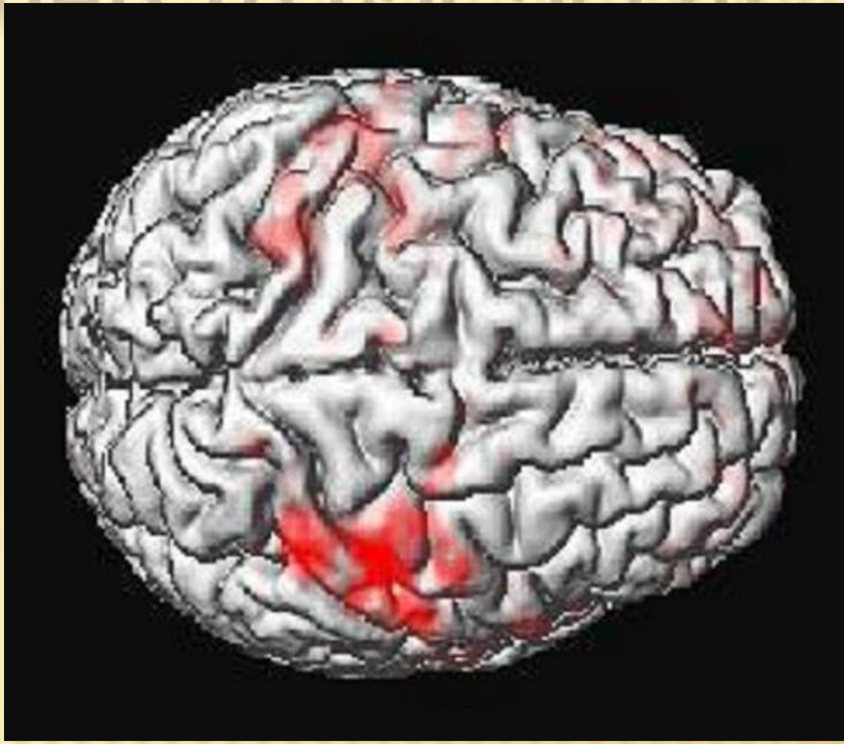
WHEN WE HAD TO USE SPECT?

- **Myocardial perfusion imaging**
  - Diagnosis of coronary artery disease (CAD) and various cardiac abnormalities.
  - Identifying location, criticality of existing coronary stenosis and degree of coronary artery disease (CAD) in patients with a history of CAD.
  - Prognostication (risk stratification) and evaluation of patients that are at risk of having a myocardial or coronary incident. (ex: myocardial infarction, myocardial ischemia, coronary aneurysm, wall motion abnormalities)
  - Assessment of viable myocardium in particular coronary artery territory following heart attacks to justify revascularization
  - Post intervention revascularization evaluation of heart.



WHEN WE HAD TO USE SPECT?

- **Functional brain imaging**
  - **Alzheimer's Disease/Dementia**
  - **Brain Trauma**
  - **Stroke**
  - **Seizures**
  - **Executive Dysfunction**
  - **Obsessive-Compulsive Disorder and Cognitive Rigidity**
  - **Bipolar Spectrum Disorders**
  - **Depression**



HOW LONG DOES IT WORKS?

Study	Half-life of radiopharma	Activity (MBq)	Radiation poisoning (µSv)	Rotation (degrees)	Projections	Time / projection (s)	Whole procedure time (min)
Bone scan	6 hours	800	8	360	120	30	60
Myocardial perfusion scan	6 hours	700	7	180	60	25	25
Brain scan	6 hours	555-1110	11	360	64	30	32
Tumor scan	13 hours	400	9	360	60	30	30
White cell scan	67 hours	18	invitro	360	60	30	30

Limit dose 1000 µSv / Year

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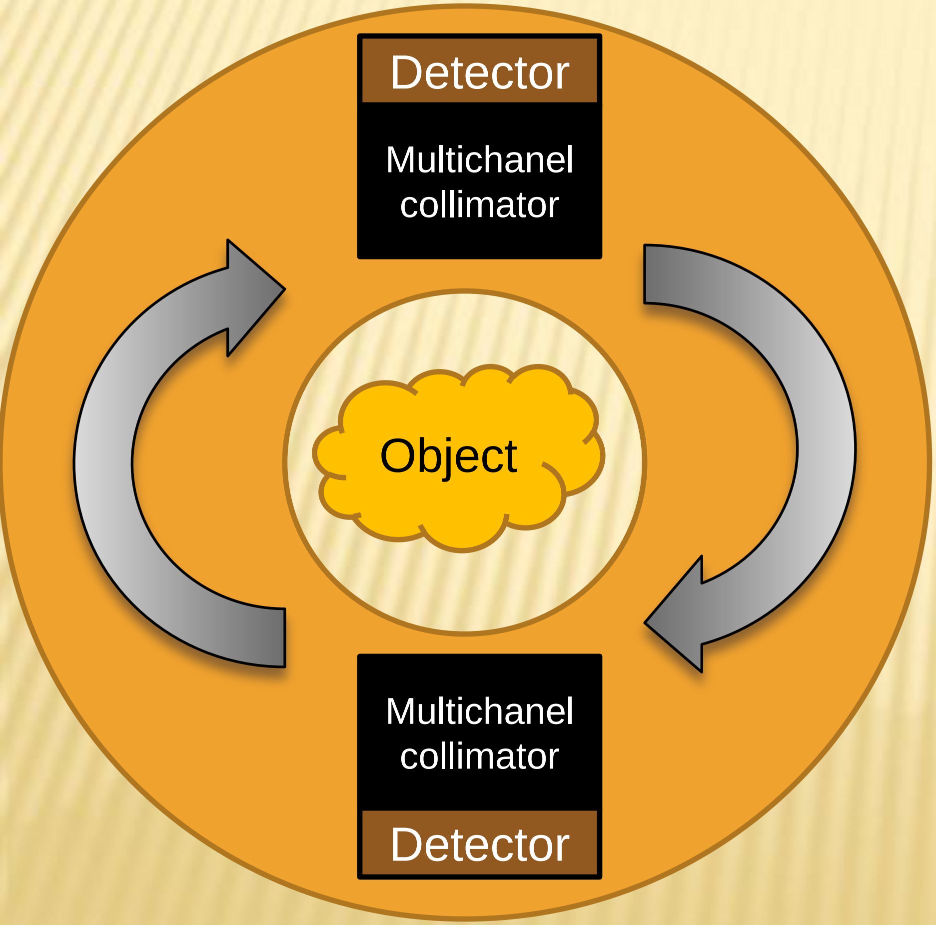
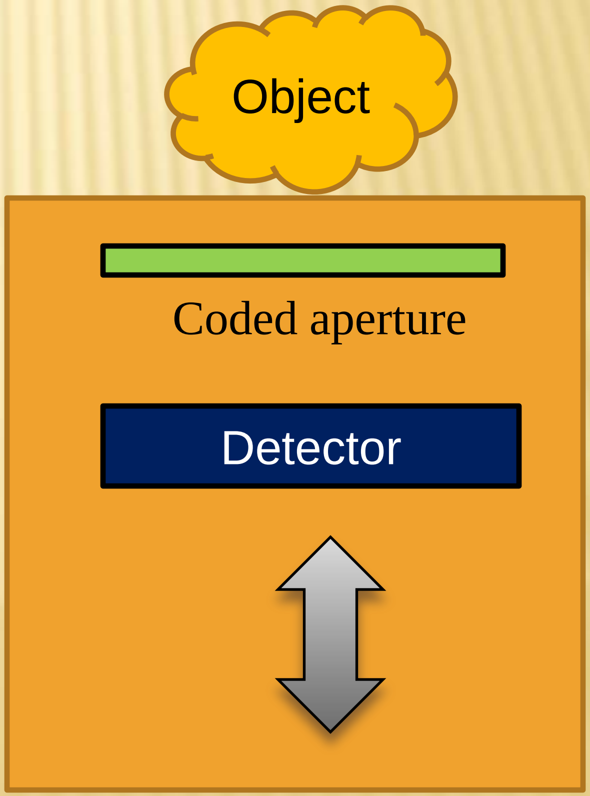
USING OF MMS IN MEDICAL DIAGNOSTIC

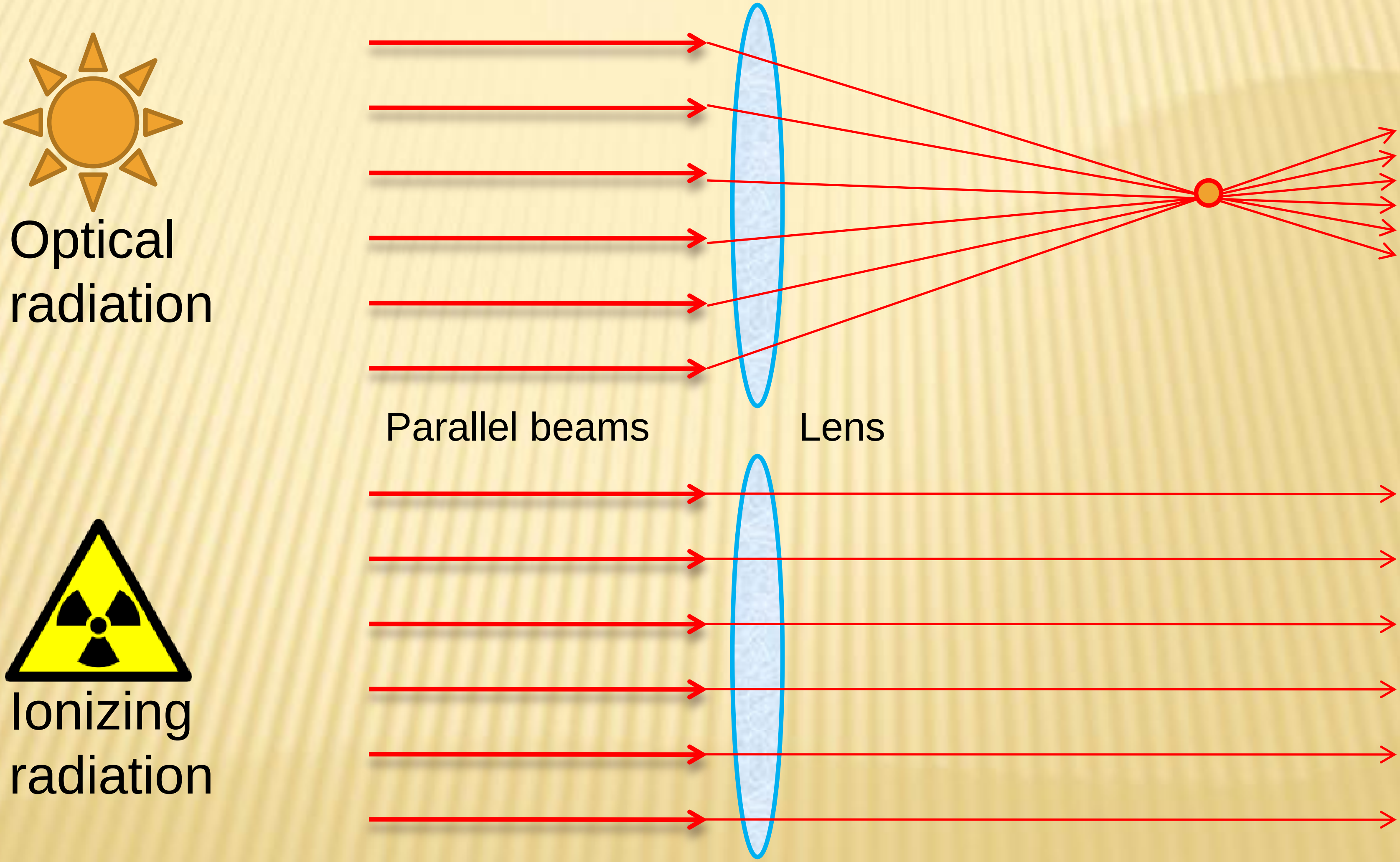
Traditional diagnostic scheme

Diagnostic scheme with usage coded aperture

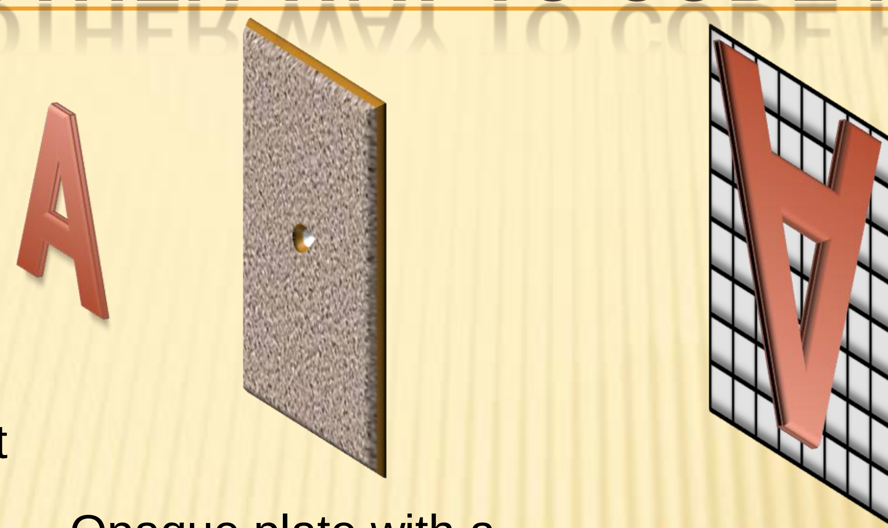




WHY CAN'T WE USE LENS



ANOTHER WAY TO CODE RADIATION



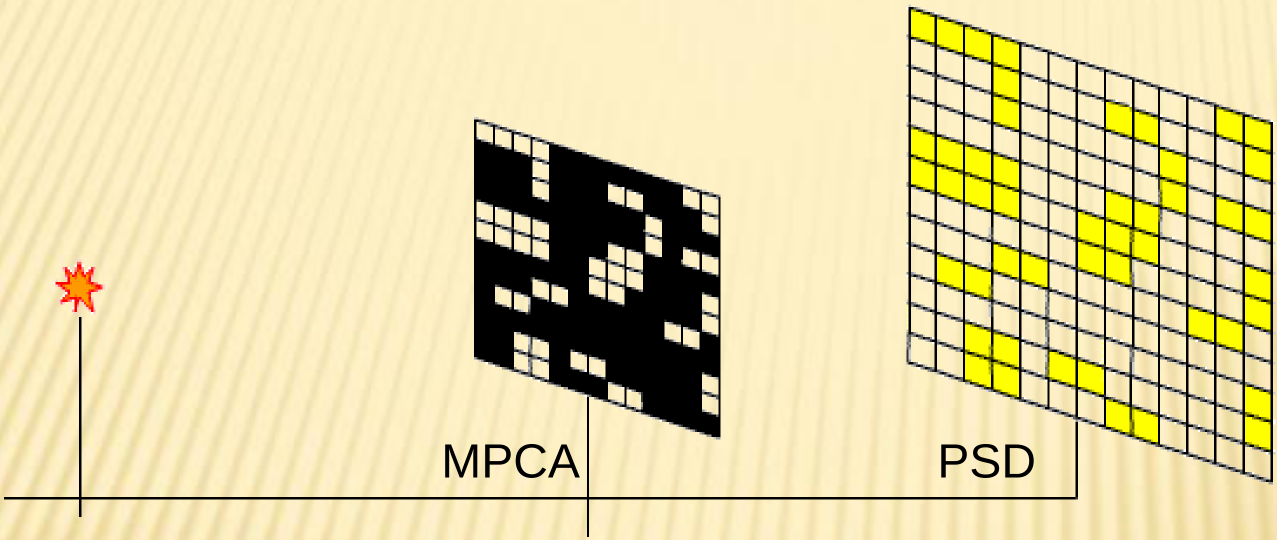
Flat radiating object

Opaque plate with a small hole (pinhole)

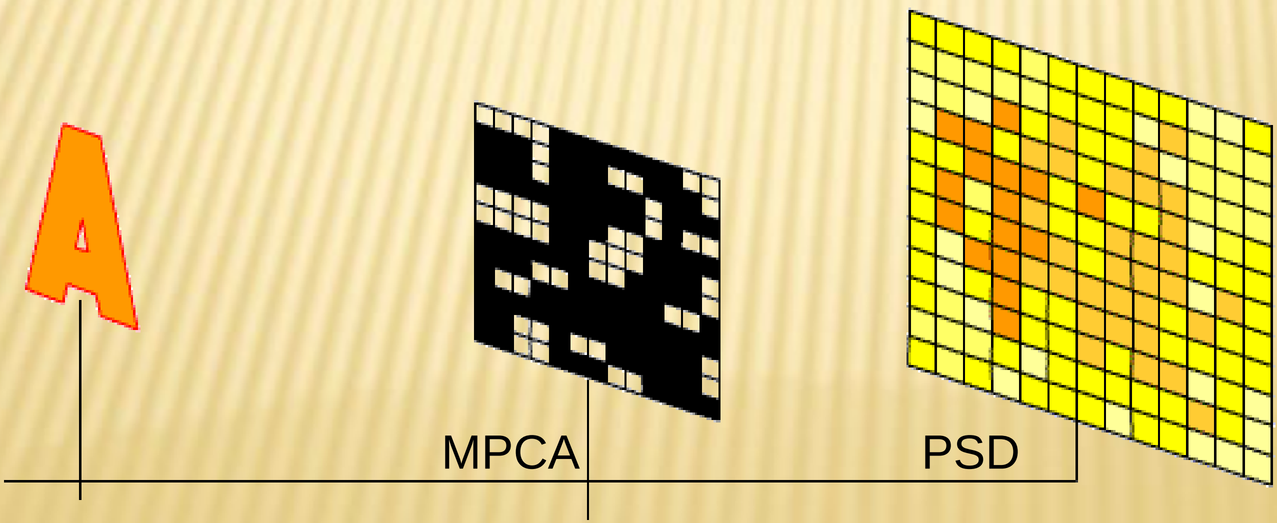
Position sensitive detector (PSD)

Volume radiating object

MULTI-PINHOLE CODED APERTURE (MPCA)



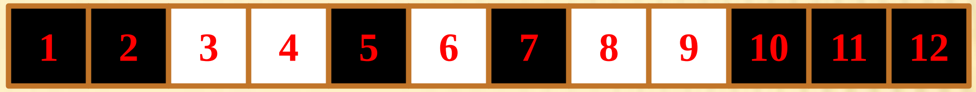
The shadow on the detector is a copy of the coded aperture. Decoding is required



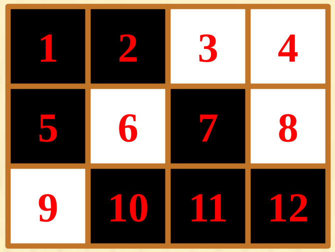
The shadow on the detector represents more difficult picture

CODED APERTURE CONSTRUCTION METHODS

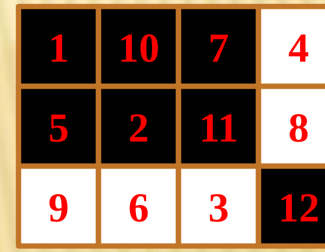
On the basis of **one** PRS:



Line-by-line method:

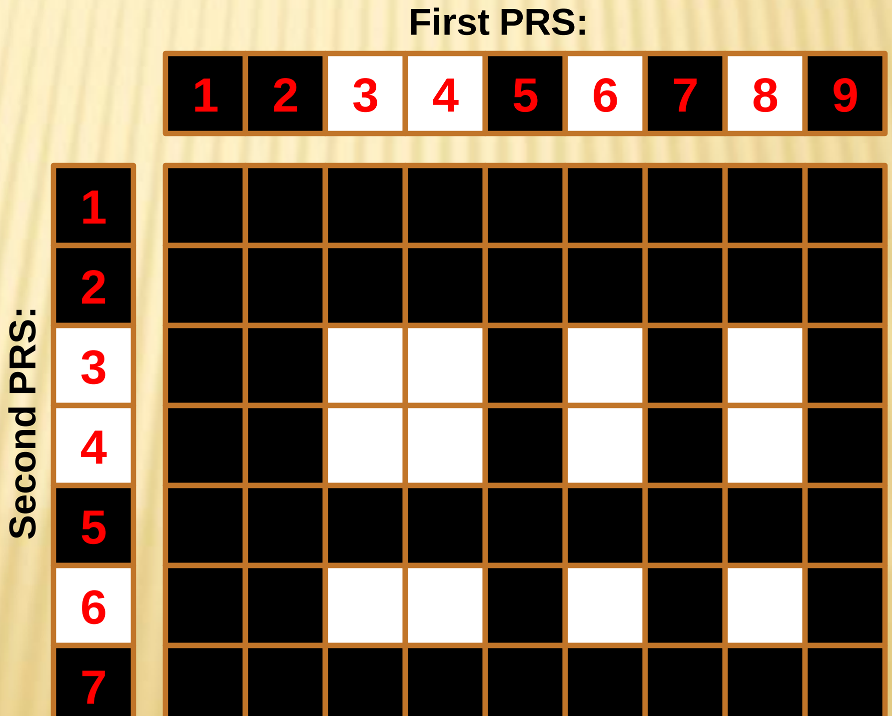


Diagonal method:



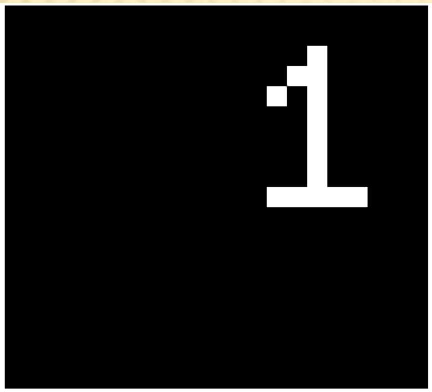
On the basis of **two** PRS:

Self-supporting method:

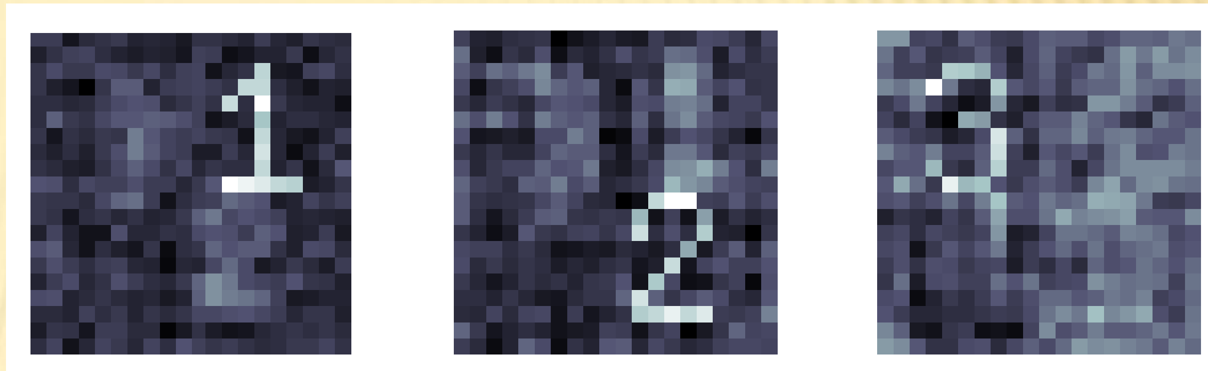


FOCUSED IMAGES

Focused image of the flat source



Focused image of the volume source in case 3 planes

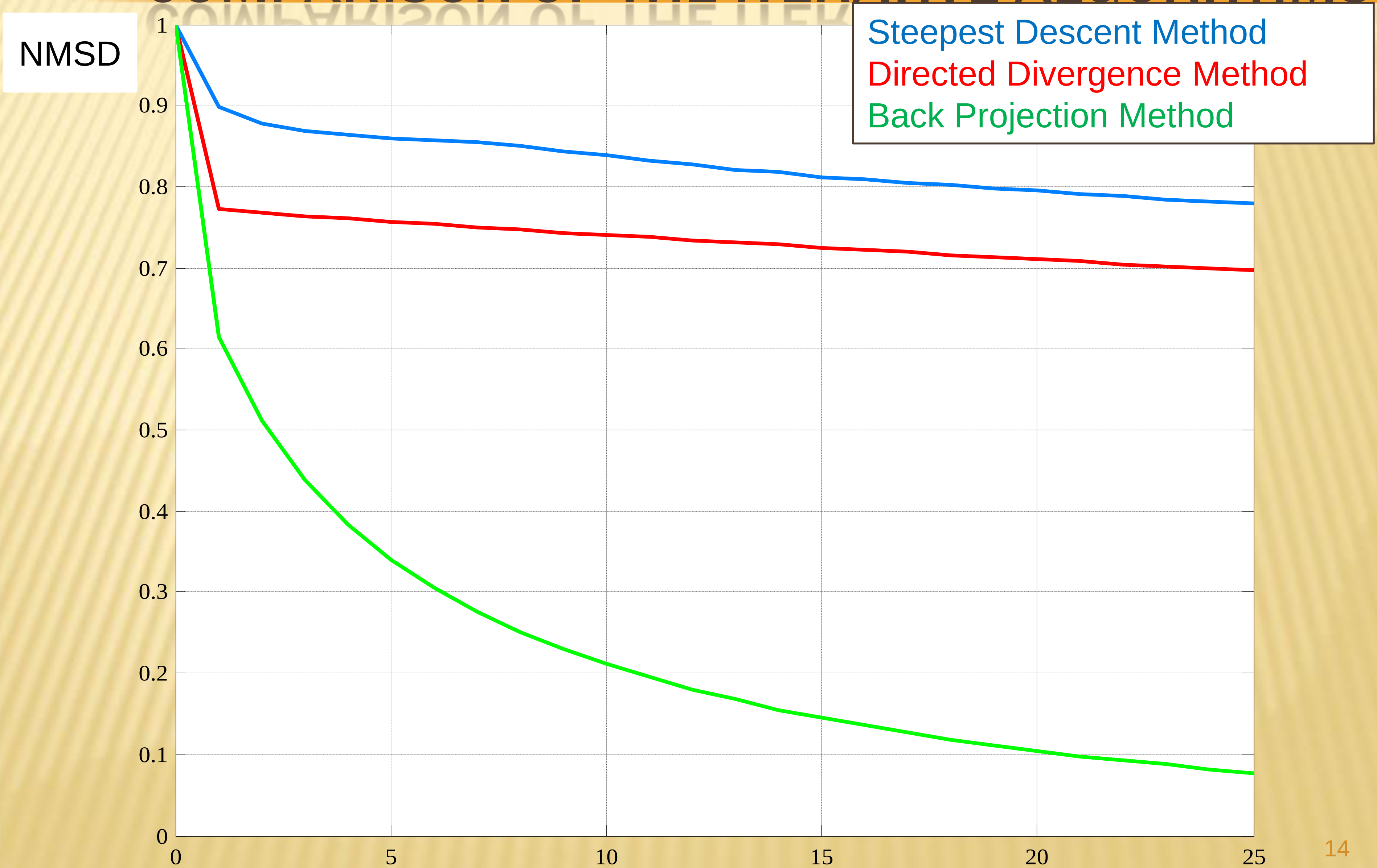


Focused image of the volume source in case 5 planes

ITERATIVE RECONSTRUCTION METHODS

- Steepest Descent Method
  - Rapid convergence in case of low transparent and small dimensional apertures
  - Slow convergence in other cases
- Directed Divergence Method
  - Rapid convergence in case of special types of test distributions (most part is zeros)
  - Slow convergence in other cases
- Back Projection Method
  - Rapid convergence in all cases (different transparent and dimension, different types of test distributions)
  - Requires large computational time

COMPARISON OF THE ITERATIVE ALGORITHMS



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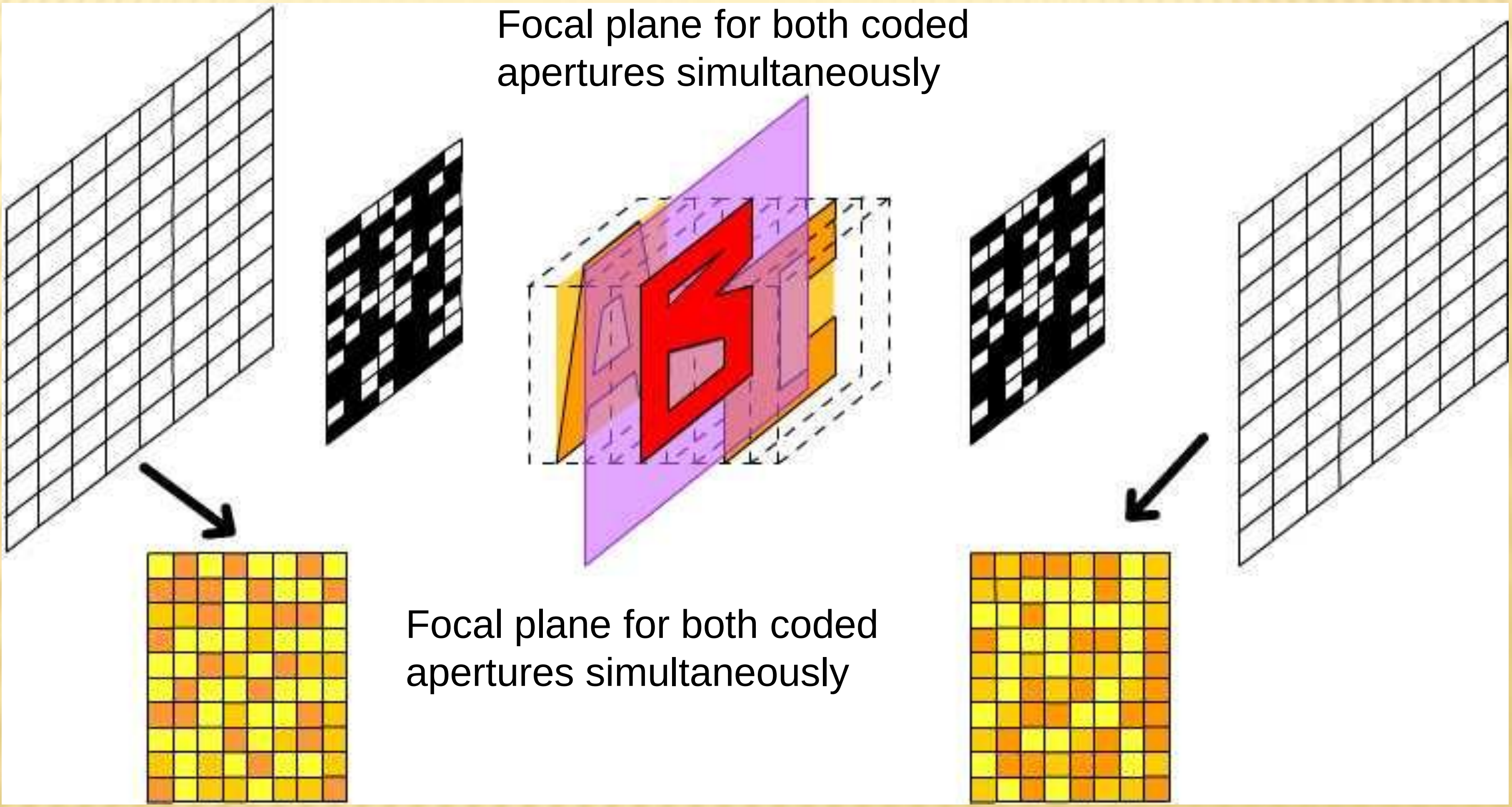
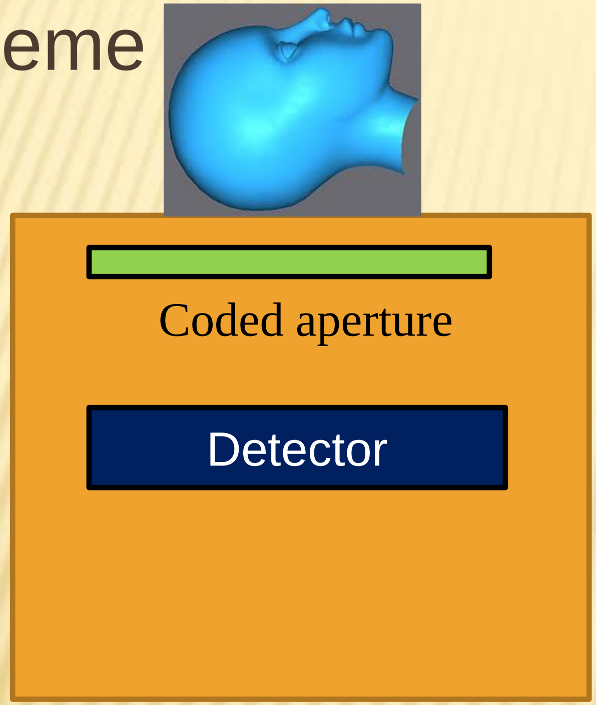
BIPOLAR MEASUREMENT SCHEME

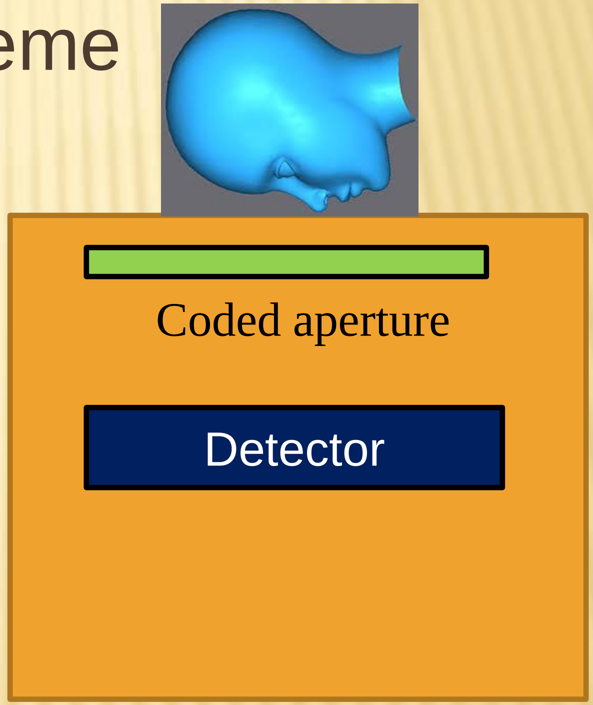


HOW BIPOLAR SCHEME CAN BE REALIZED

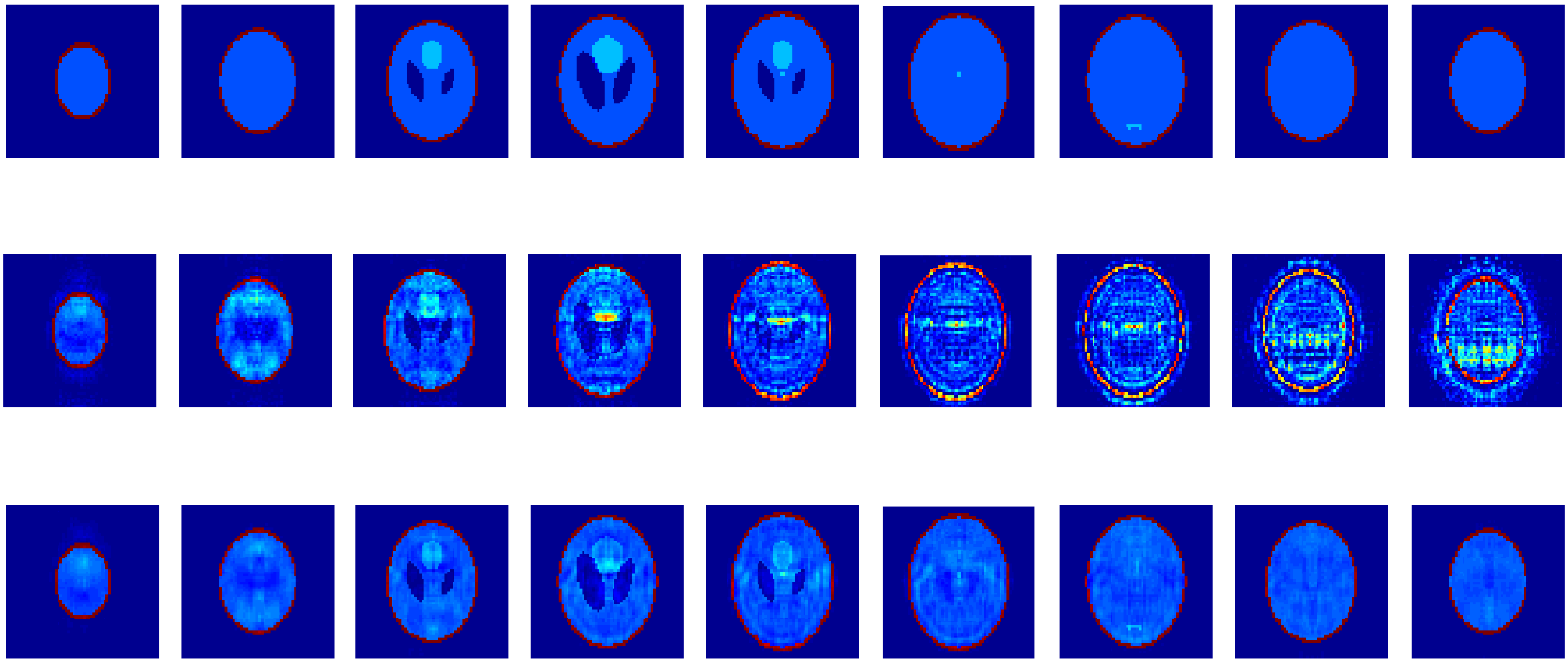
- 1) Direct unipolar scheme



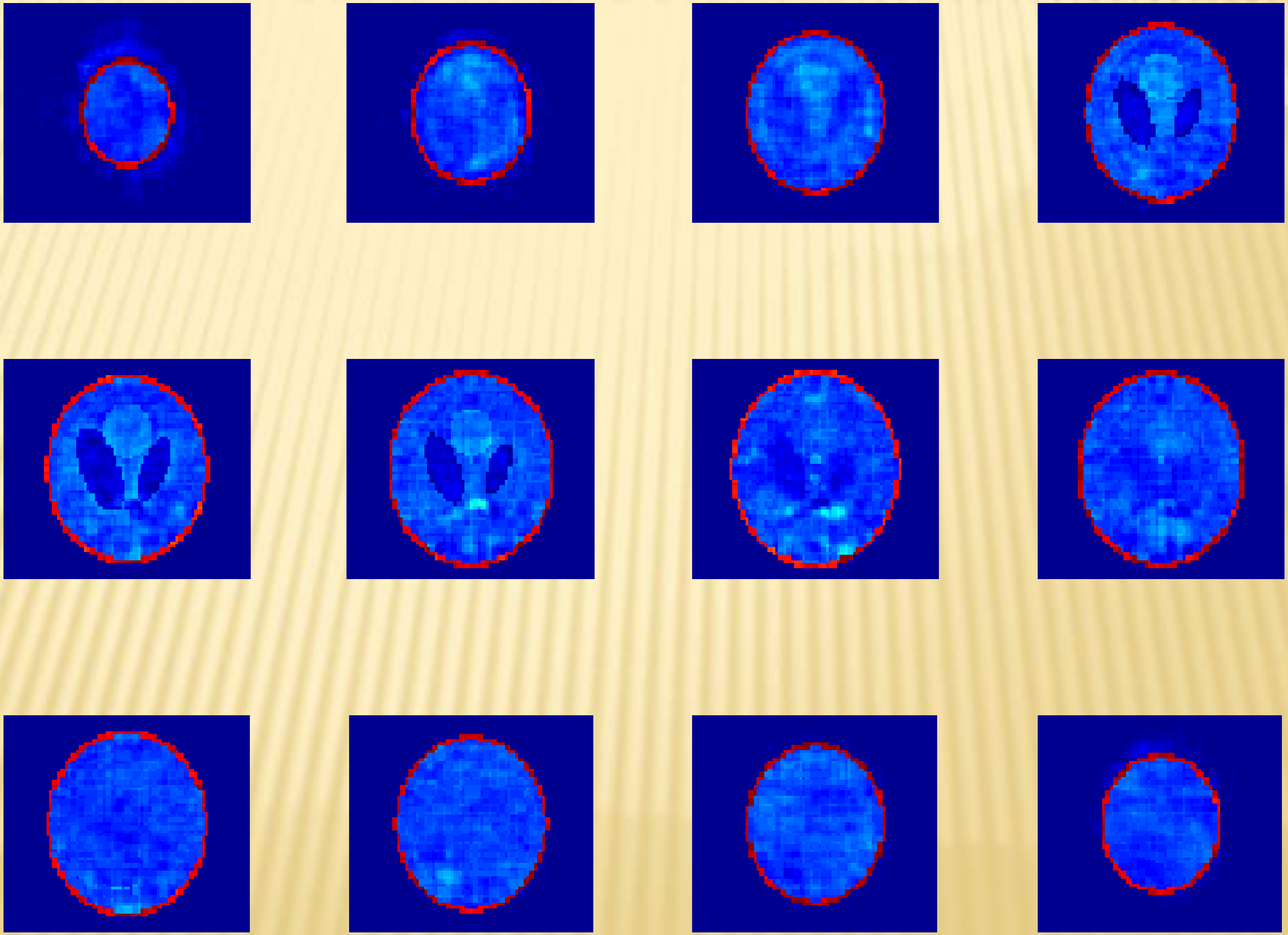
- 2) Reverse unipolar scheme



COMPARISON UNI- AND BI- POLAR SCHEMS



MULTIPLANE RECONSTRUCTION



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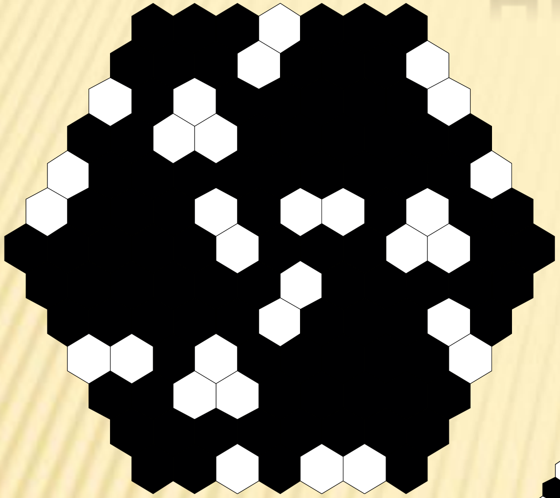
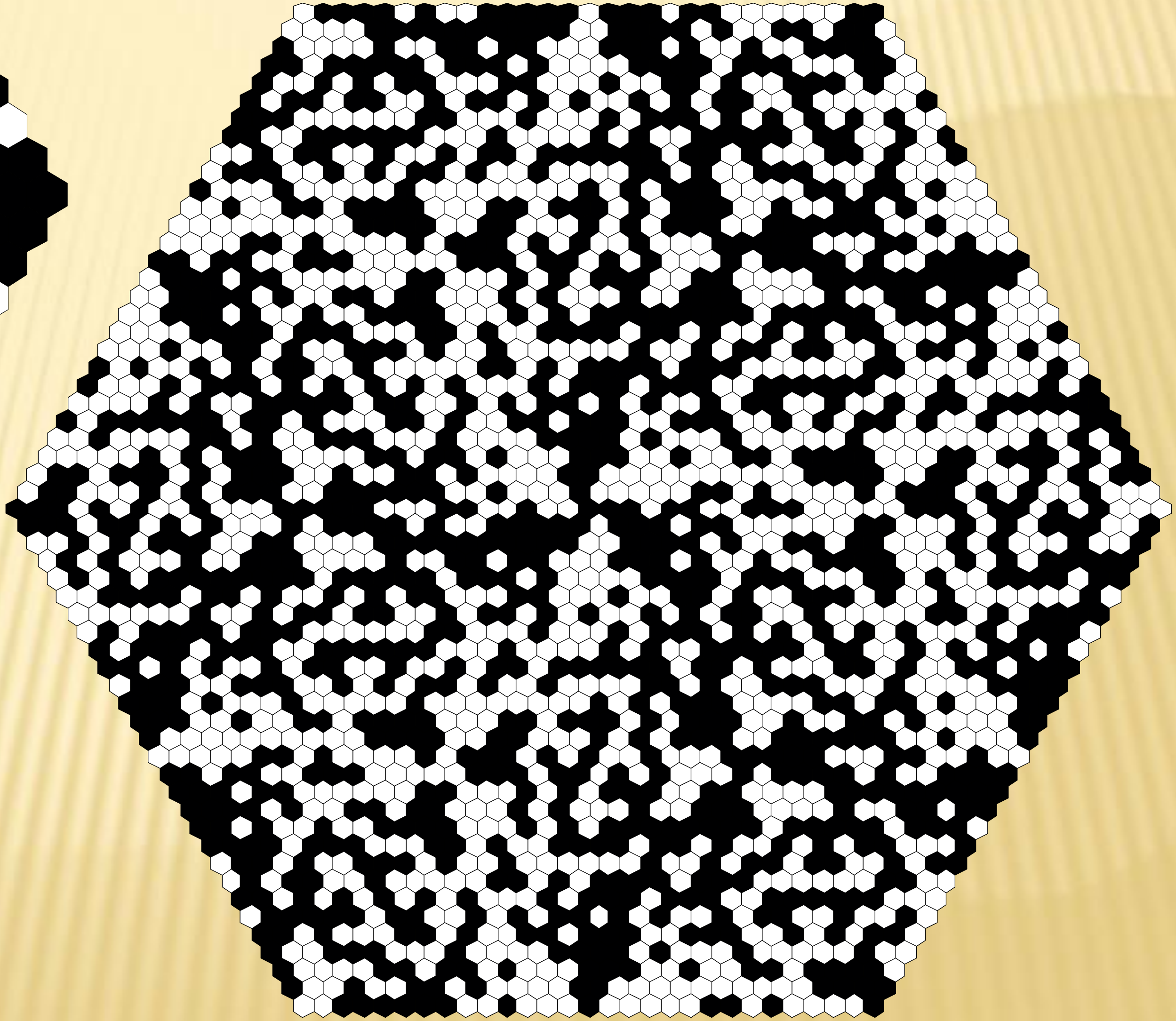
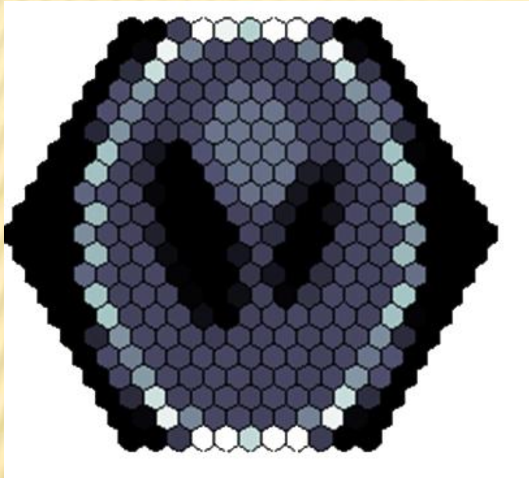
HEXAGONAL CODED APERTURES



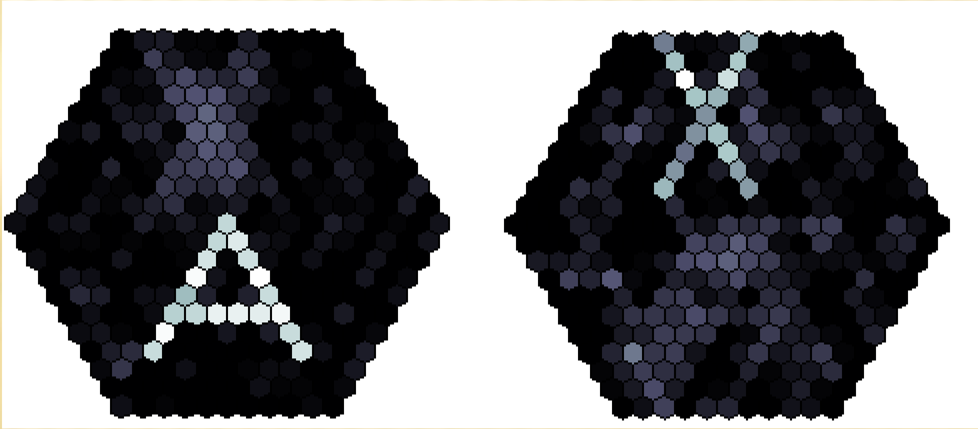


FOCUSED IMAGES FOR HEX'S

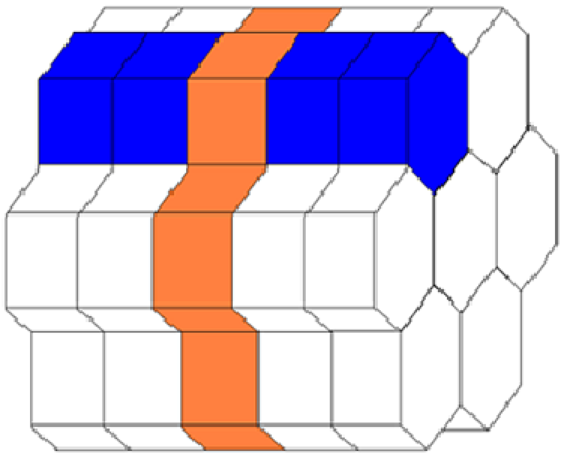
Focused image of the flat source



Focused image of the volume source in case 2 planes

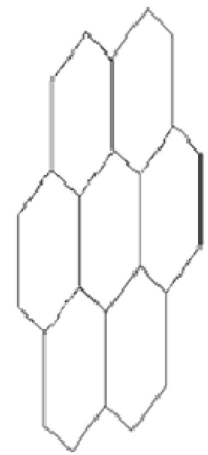


POINT SPREAD FUNCTION FOR HEX'S

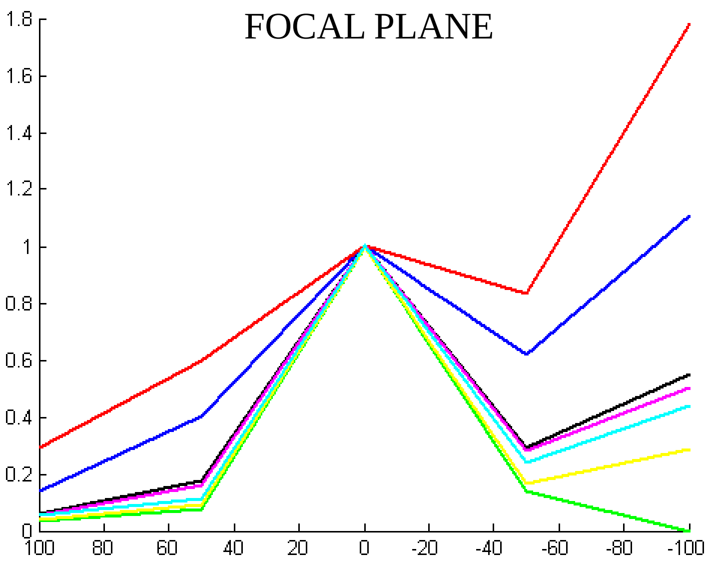


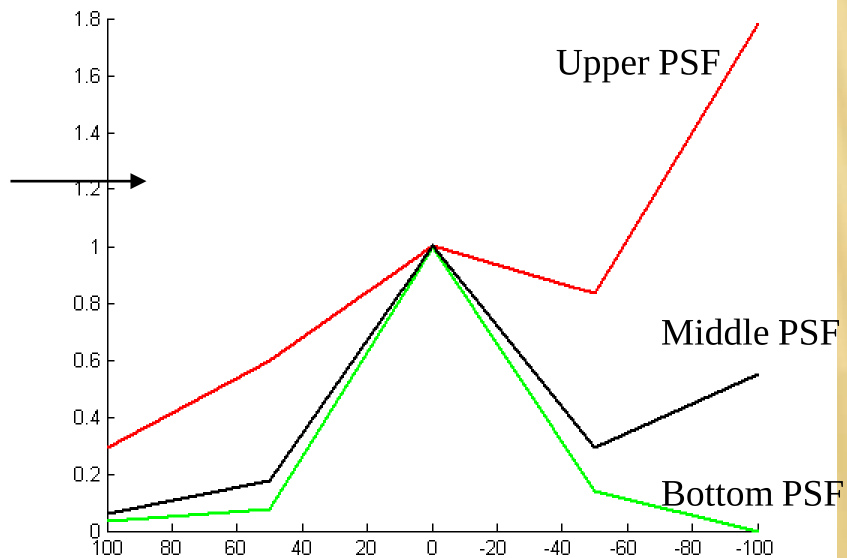
FOCAL PLANE

HEXAGONAL
CODED
APERTURE

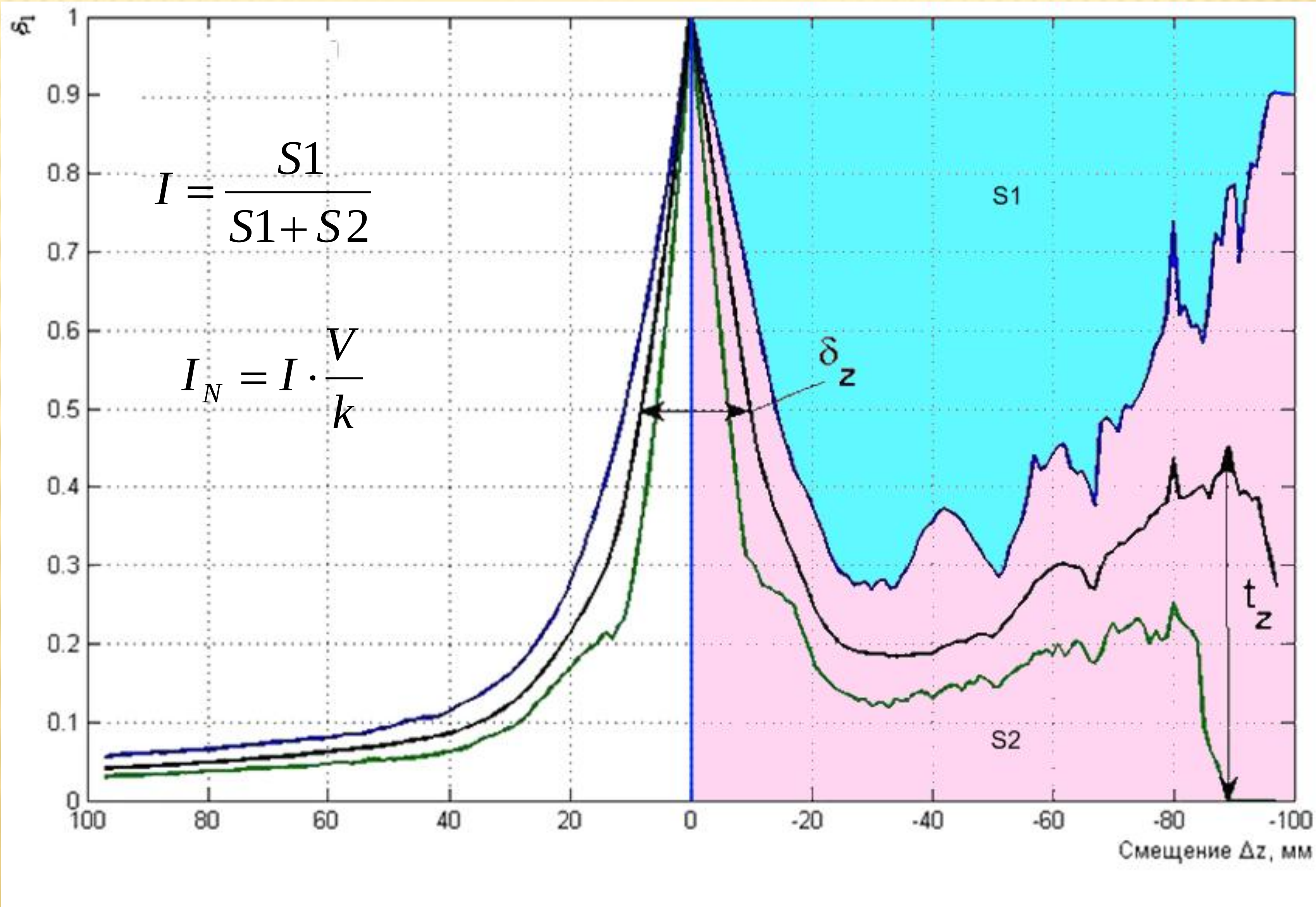


POSITION
SENSITIVE
DETECTOR





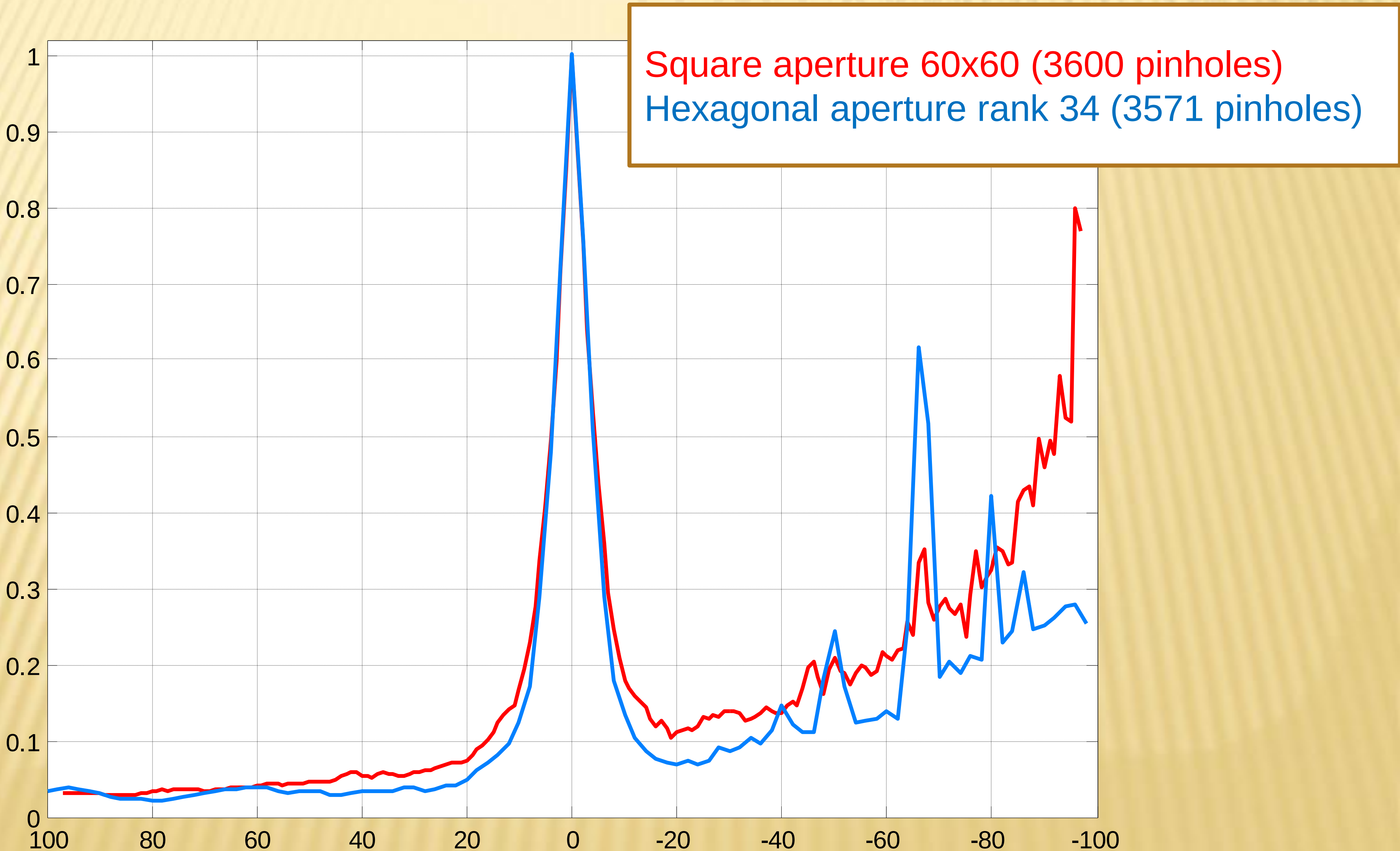
POINT SPREAD FUNCTION'S CHARACTERISTICS



$$I = \frac{S1}{S1 + S2}$$

$$I_N = I \cdot \frac{V}{k}$$

FEW EXAMPLES OF PSF



CONCLUSION

1. SPECT is one of the most intelligent and promising diagnostic procedure
2. Using MMS allows to replace rotating motion by the translating motion, which also can be applied when rotating around object is impossible
3. Bipolar measurement scheme double number of measurements but more then five times decrease mean-squared deviation in the iterative algorithms
4. Using hexagonal coded apertures is new and promising direction of the MMS development