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SIMULATION OF NEUTRON ENCODE IMAGING WITH (MICRON-LEVEL)LIQUID SCINTILLATOR FILLED CAPILLARY ARRAY

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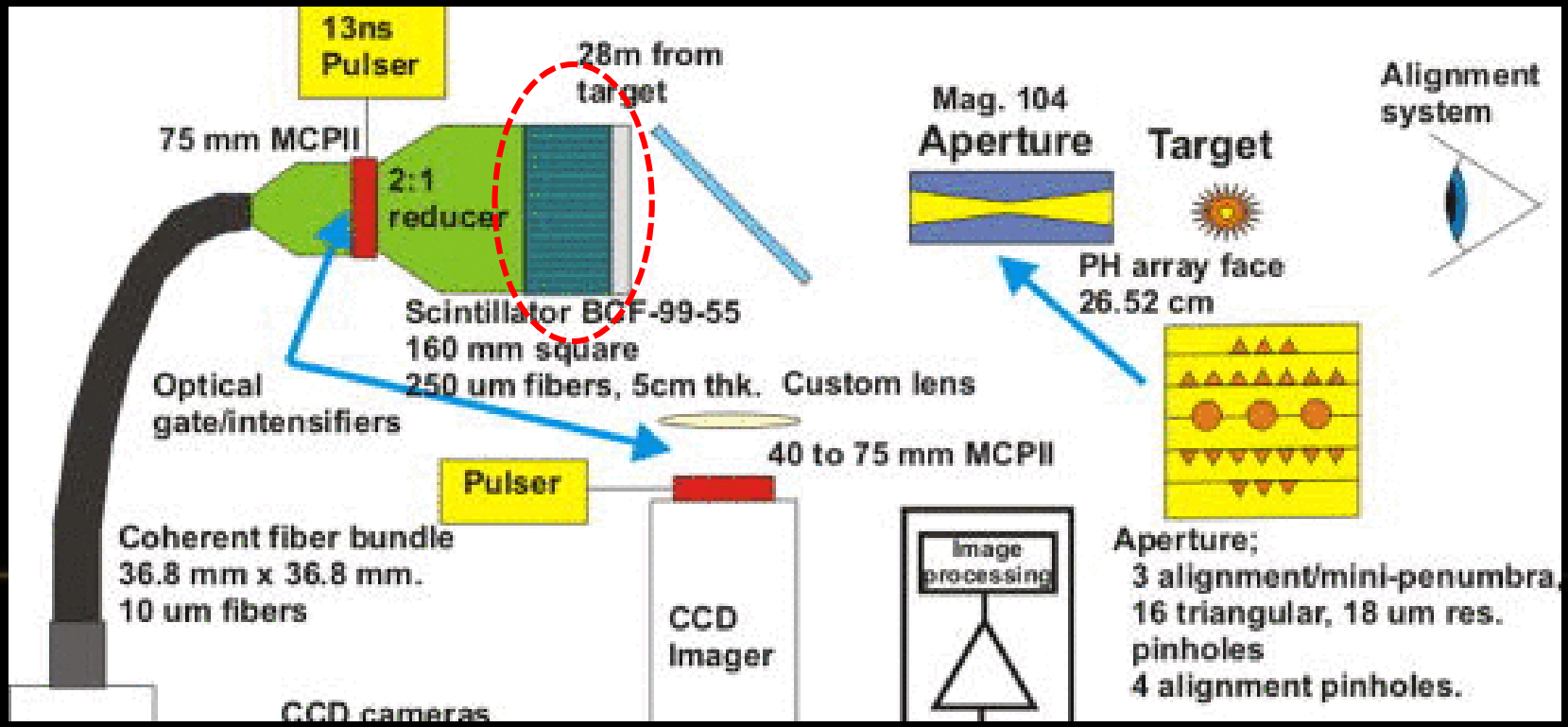
SUMMARY

- Neutron coded imaging system with micron-level liquid scintillator filled capillary array detector was suggested. In comparison with conventional design, the new system may reach higher resolution.
- Difficulties and/or challenges to realize the suggested system were also listed.



OUTLINE

- Interaction of neutron with liquid filled scintillator
- Neutron encoded imaging applied in inertial confinement fusion experiment
- Neutron encoded imaging system with micron-level liquid filled capillary array
- Difficulties, challenges to be faced
- Conclusion

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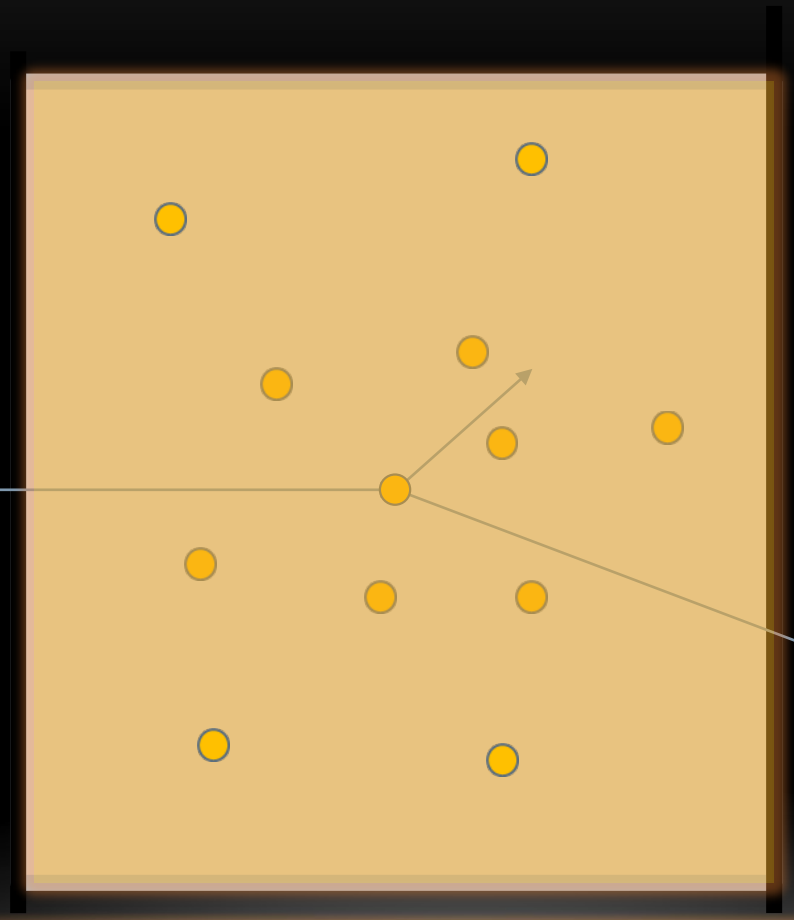
INTERACTION OF NEUTRON WITH (BULK) LIQUID SCINTILLATOR

1. A fast neutron shots in to the LS rich of hydrogen

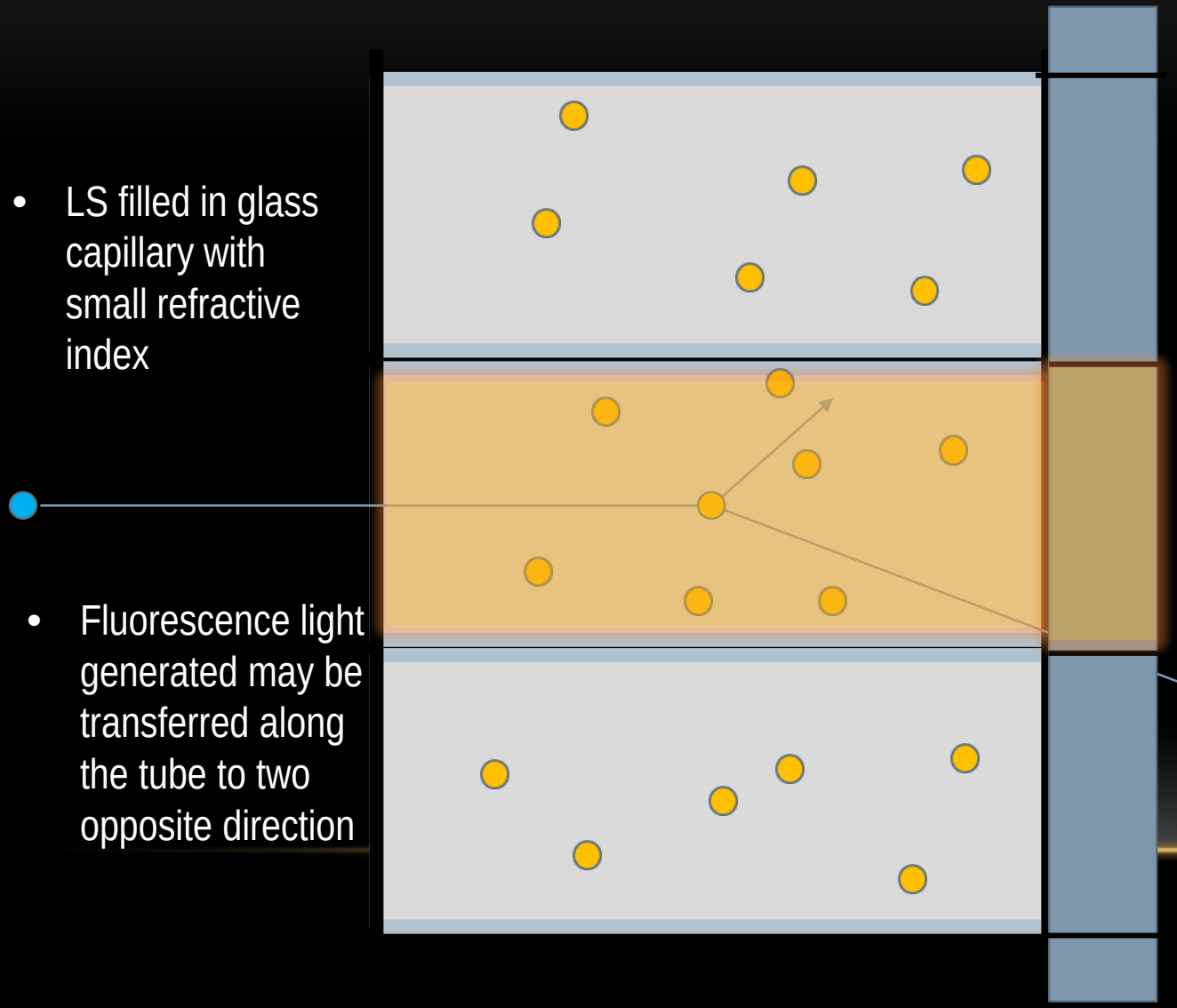


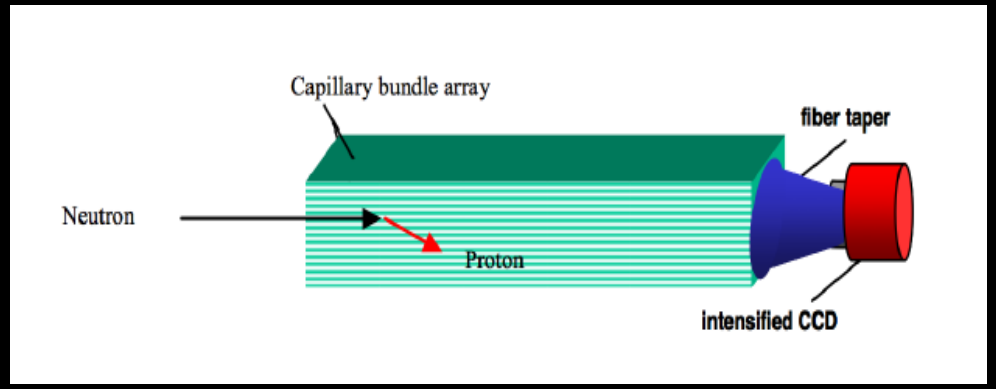
2. An energetic recoil proton may generated

3. The recoil proton flies in the LS and lost its energy, and emits fluorescence photons, lighting the whole space of the LS

INTERACTION OF NEUTRON WITH LIQUID SCINTILLATOR FILLED CAPILLARY ARRAY

- LS filled in glass capillary with small refractive index
- Fluorescence light generated may be transferred along the tube to two opposite direction





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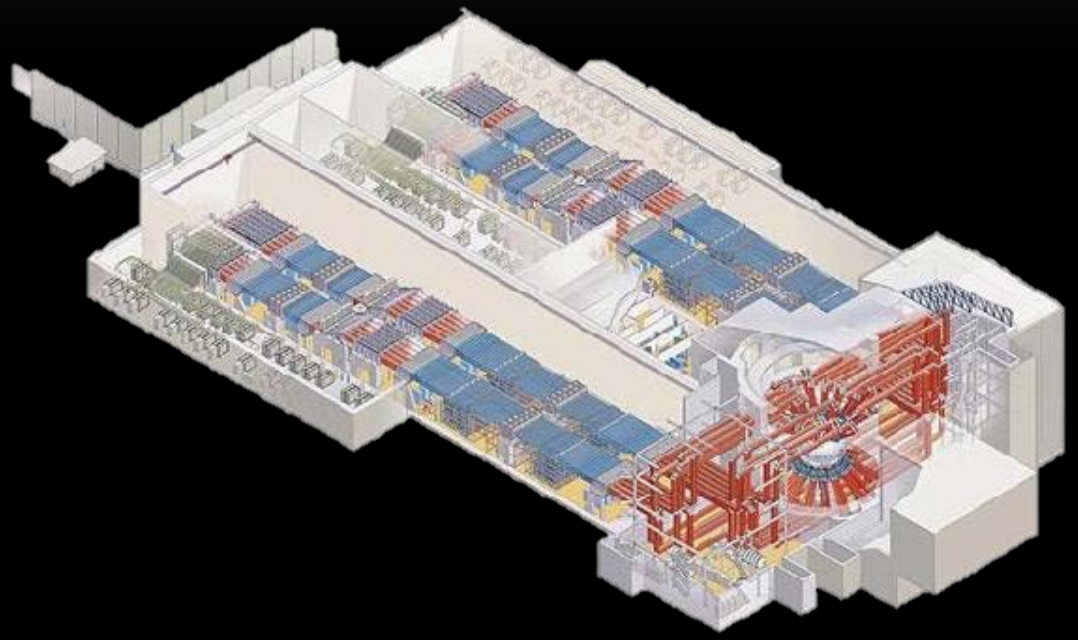
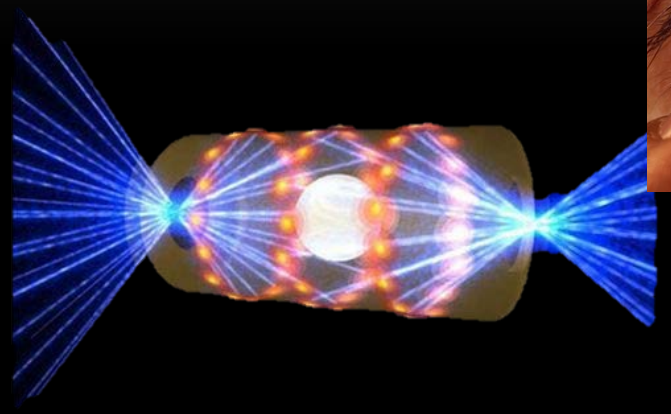
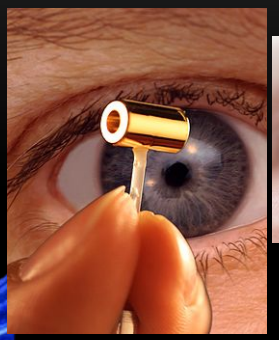
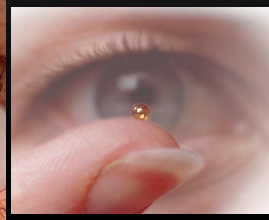
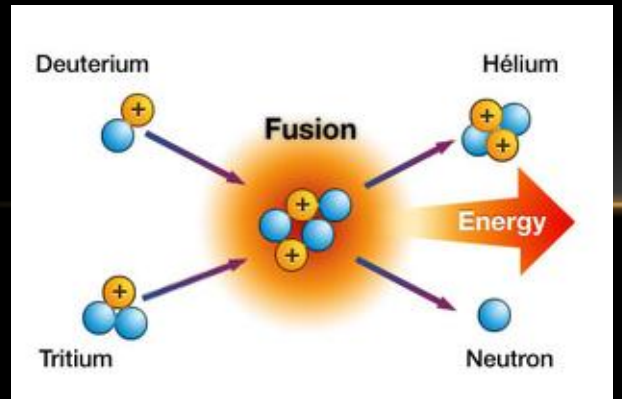
BRIEF INTRODUCTION OF LASER-DRIVEN INERTIAL CONFINEMENT FUSION



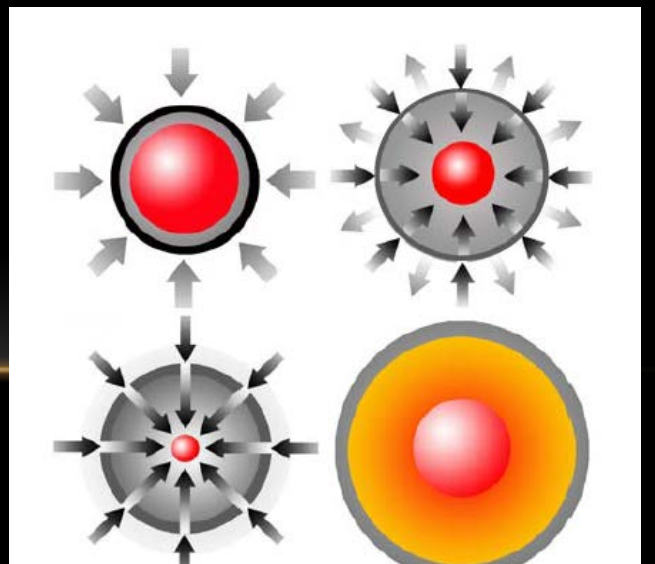




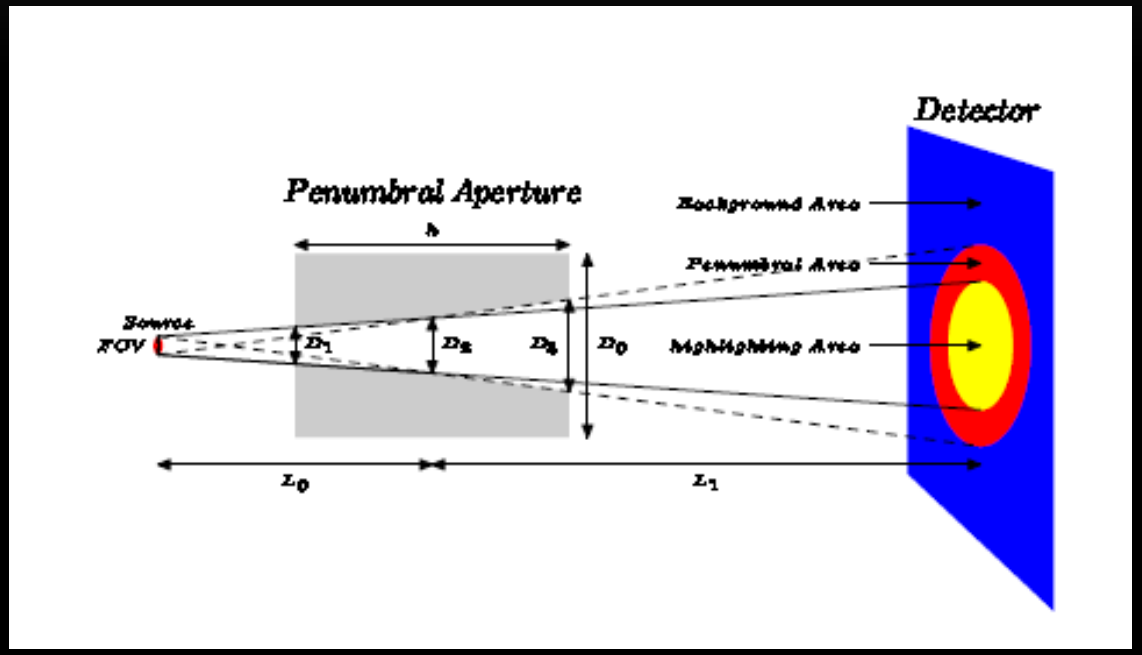


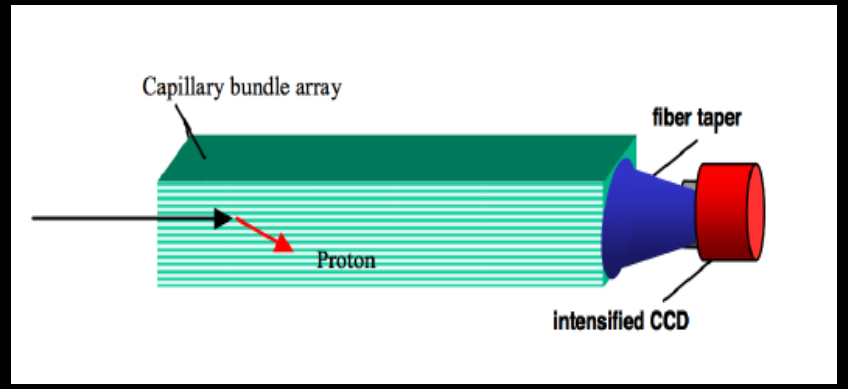


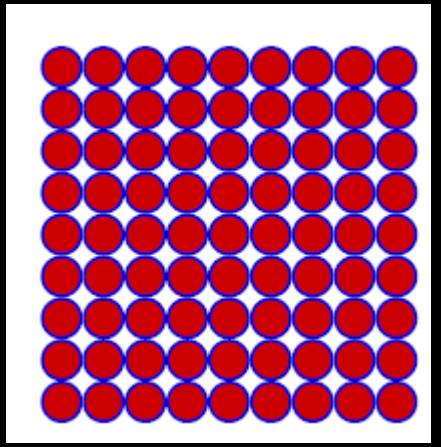
Size of fusion core region :~ 50 micron



NEUTRON PENUMBRAL IMAGING：COMMON USED METHOD FOR FUSION REACTION REGION DETECTION







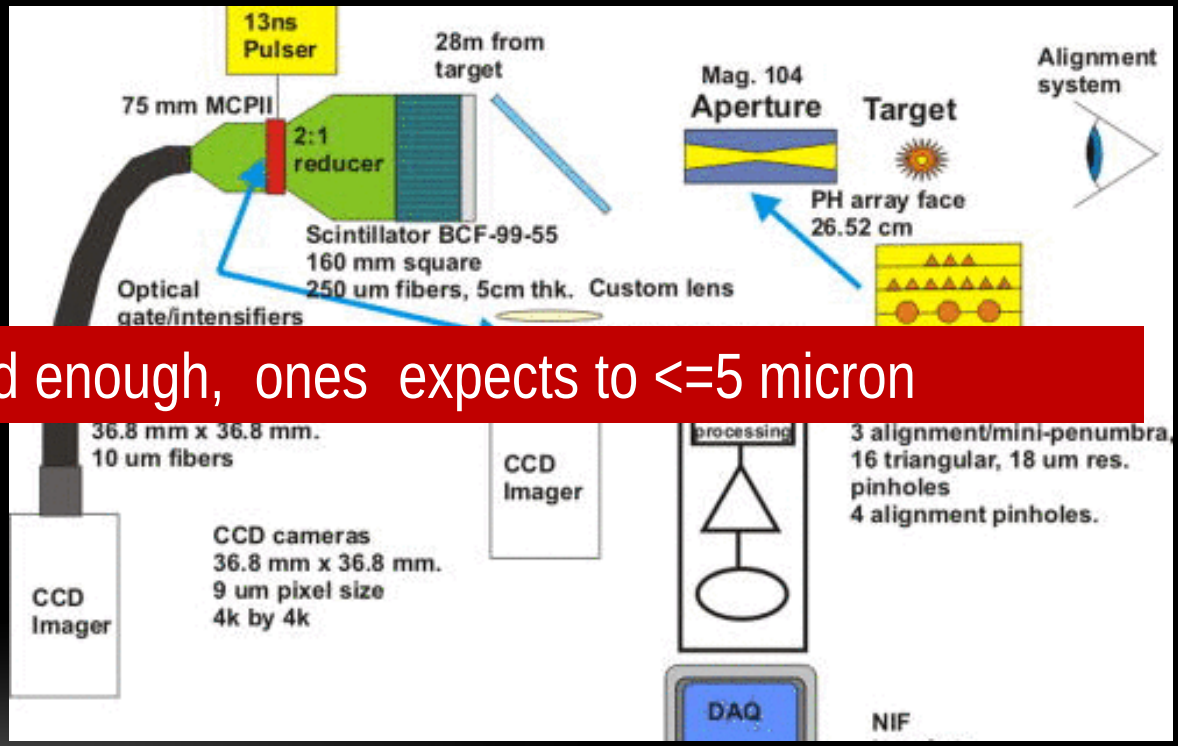
$$g(x,y) = f(x,y) \otimes h(x,y) + n(x,y)$$

$$f_{k+1} = f_k\left(h \odot \frac{g}{h \otimes f_k}\right)$$

Lucy-Rechardson algorithm

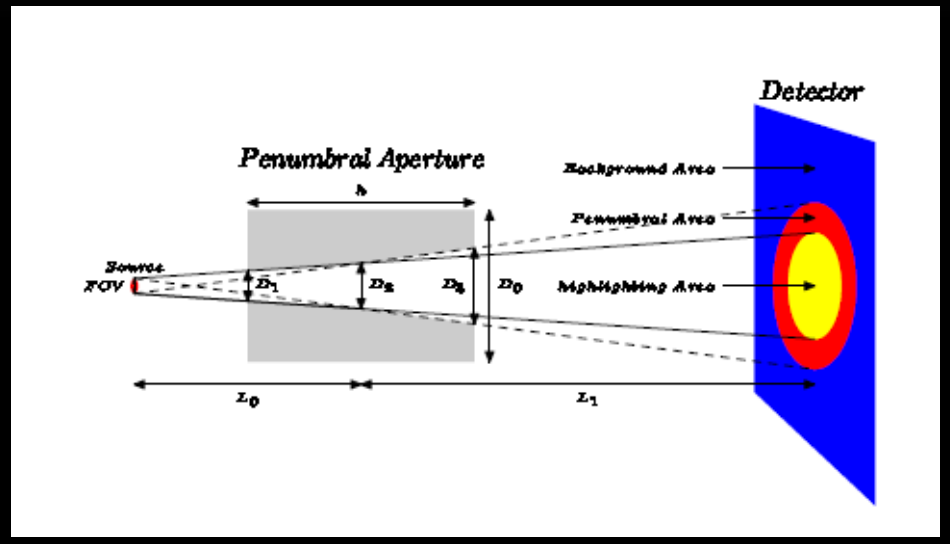
NEUTRON PENUMBRA IMAGING：STATE OF THE ART

Distance from Target to encode aperture	265mm
Distance from encode aperture to detector	28020mm
Material of a	
Features of aperture	200mm in thickness
Aperture Size	273 micron，300mcron，437micron
Pixel number of detector	640X640
Pixel size	250 micron in diameter
Final resolution	15 micron



Resolution of 15 micron is not good enough, ones expects to <=5 micron

FACTORS AFFECTING THE IMAGE RESOLUTION

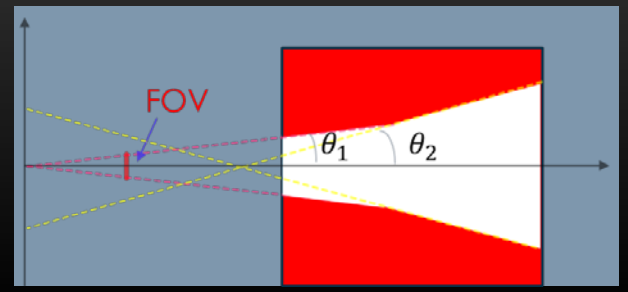


$$\Delta s = \sqrt{\Delta s^2_{\text{aperture}} + \Delta s^2_{\text{detector}} \times \left(\frac{L_0}{L_0 + L_1}\right)^2}$$

$$\Delta s_{\text{aperture}} = \frac{\ln(2)\text{FOV}}{2L_0\mu}$$

- L_0, Detector resolution, Magnification

RESOLUTION CALCULATION



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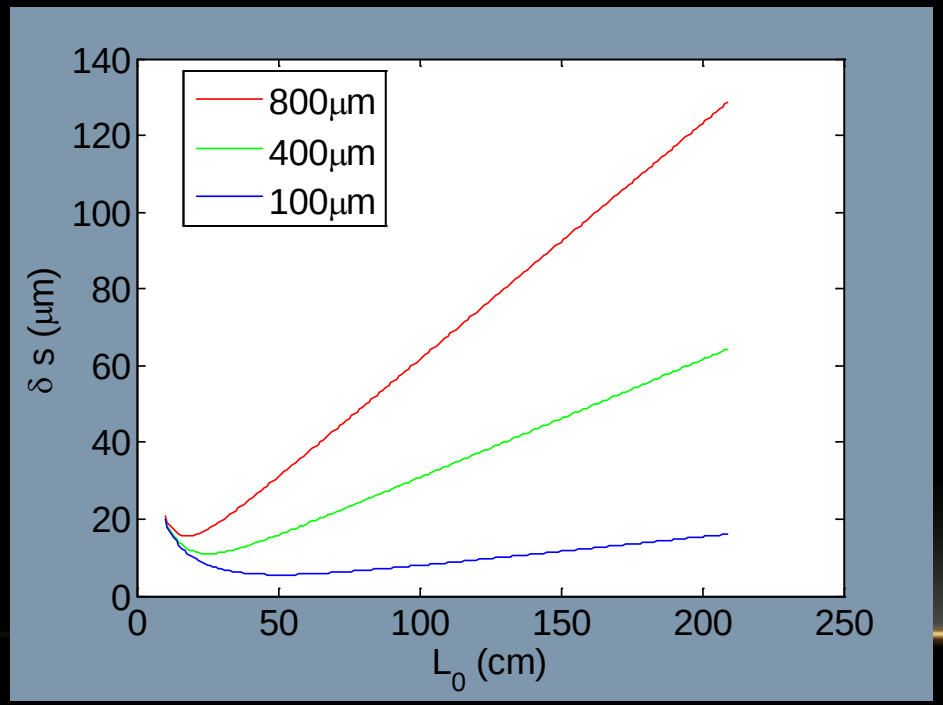
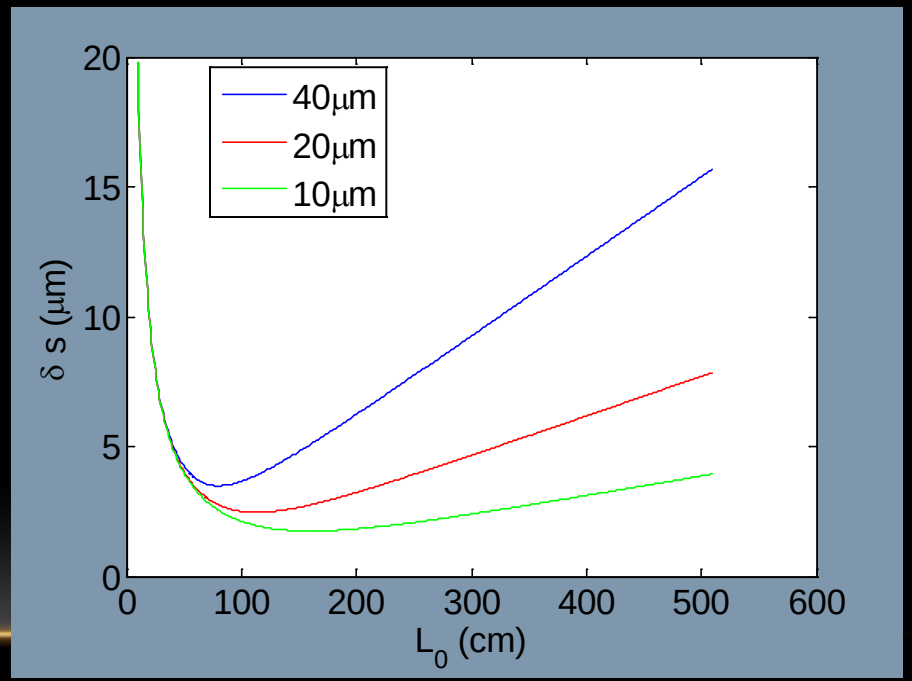
$$\Delta s_{\text{aperture}} = \frac{\ln(2)\text{FOV}}{2L_0\mu}$$

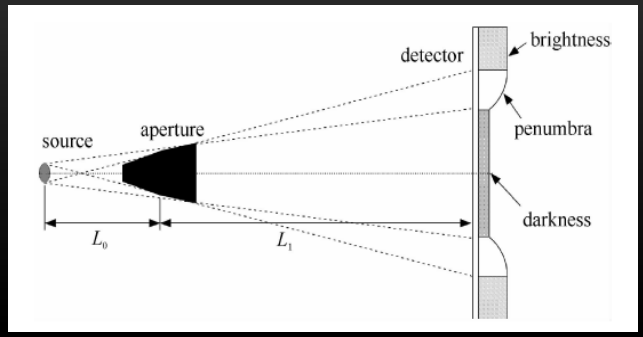
Let: FOV=200μm , μ=0.35/cm , L1=1300cm



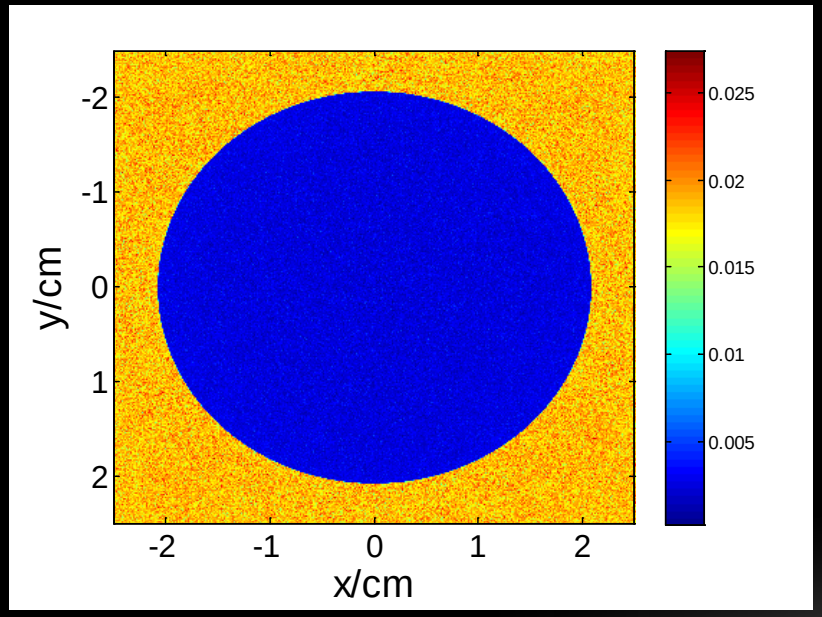


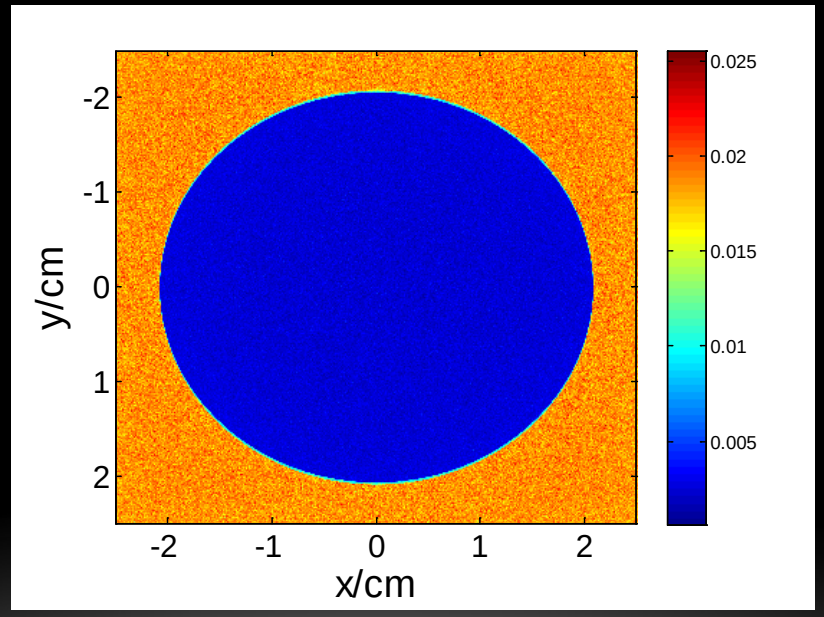
Let: pixel size = 20 micron, L0=110cm, one can get a resolution reach to 2.5 micron

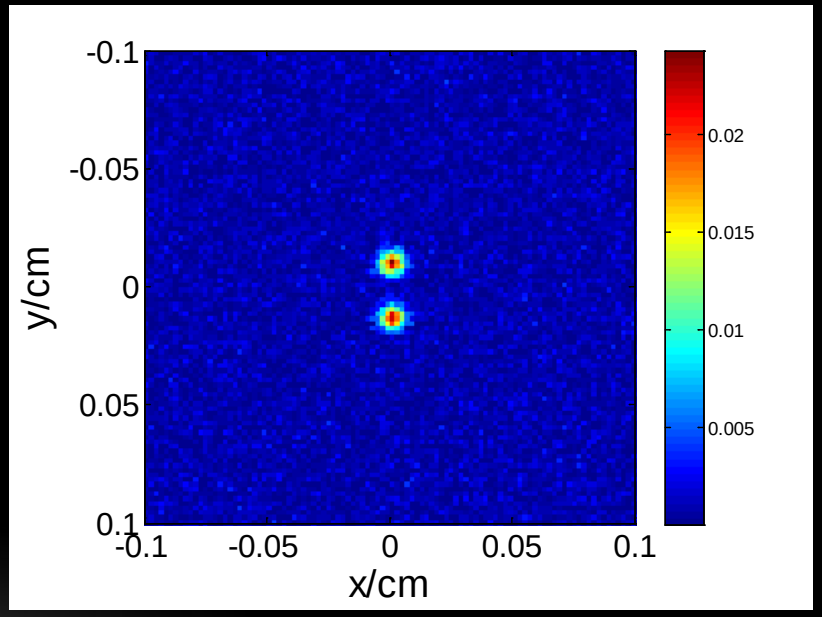
SIMULATION WITH 20 MICRON DETECTOR



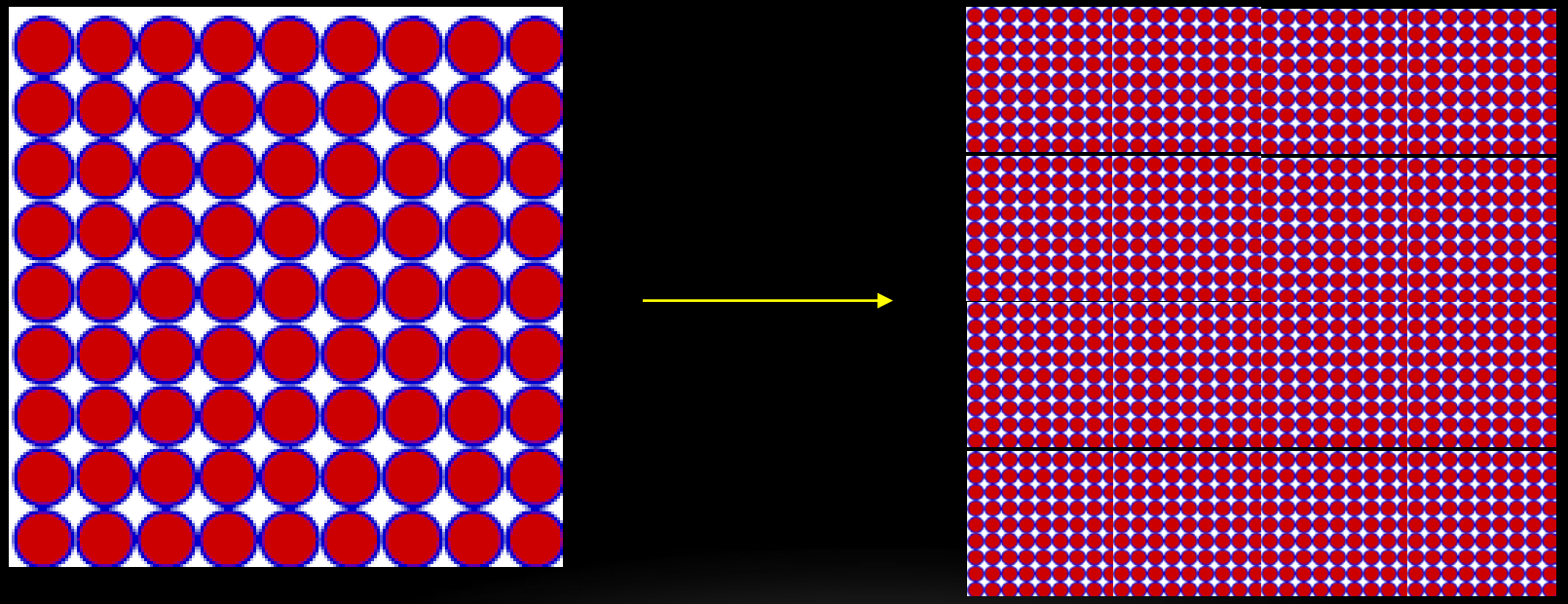
6mrad，2e8 neutrons，two round point with diameter of 2 micron, the between distance is 20 micron







NATURAL IDEA



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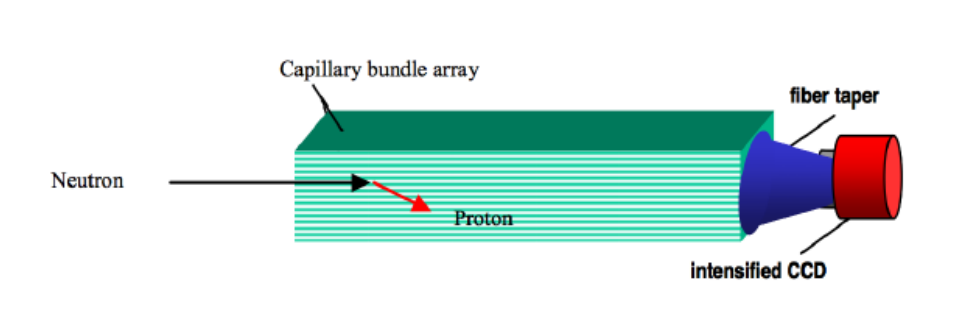
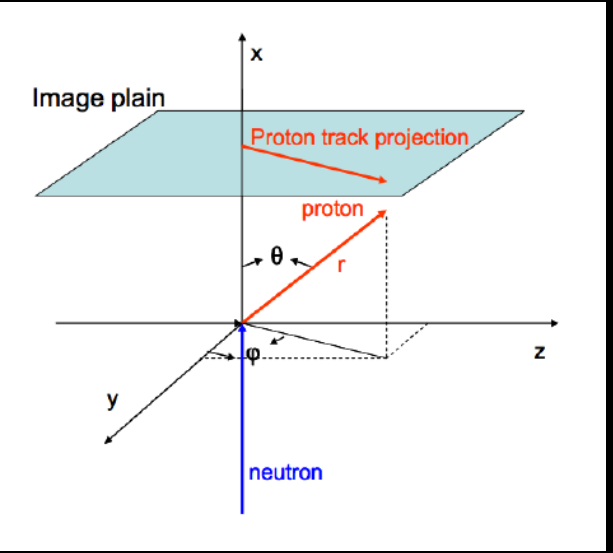
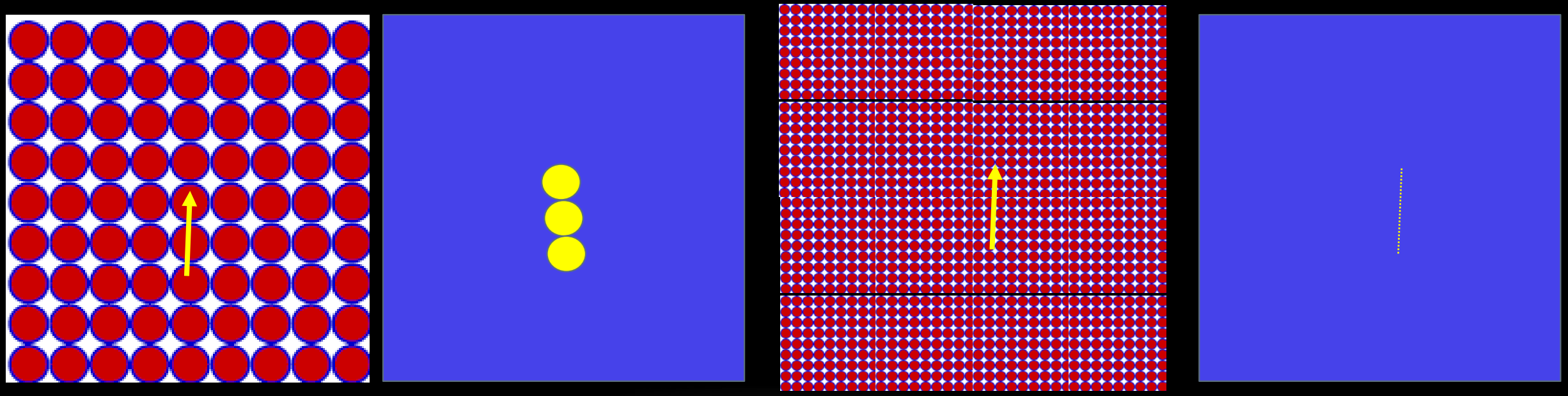
RECOIL PROTON MOTION IN SCINTILLATOR



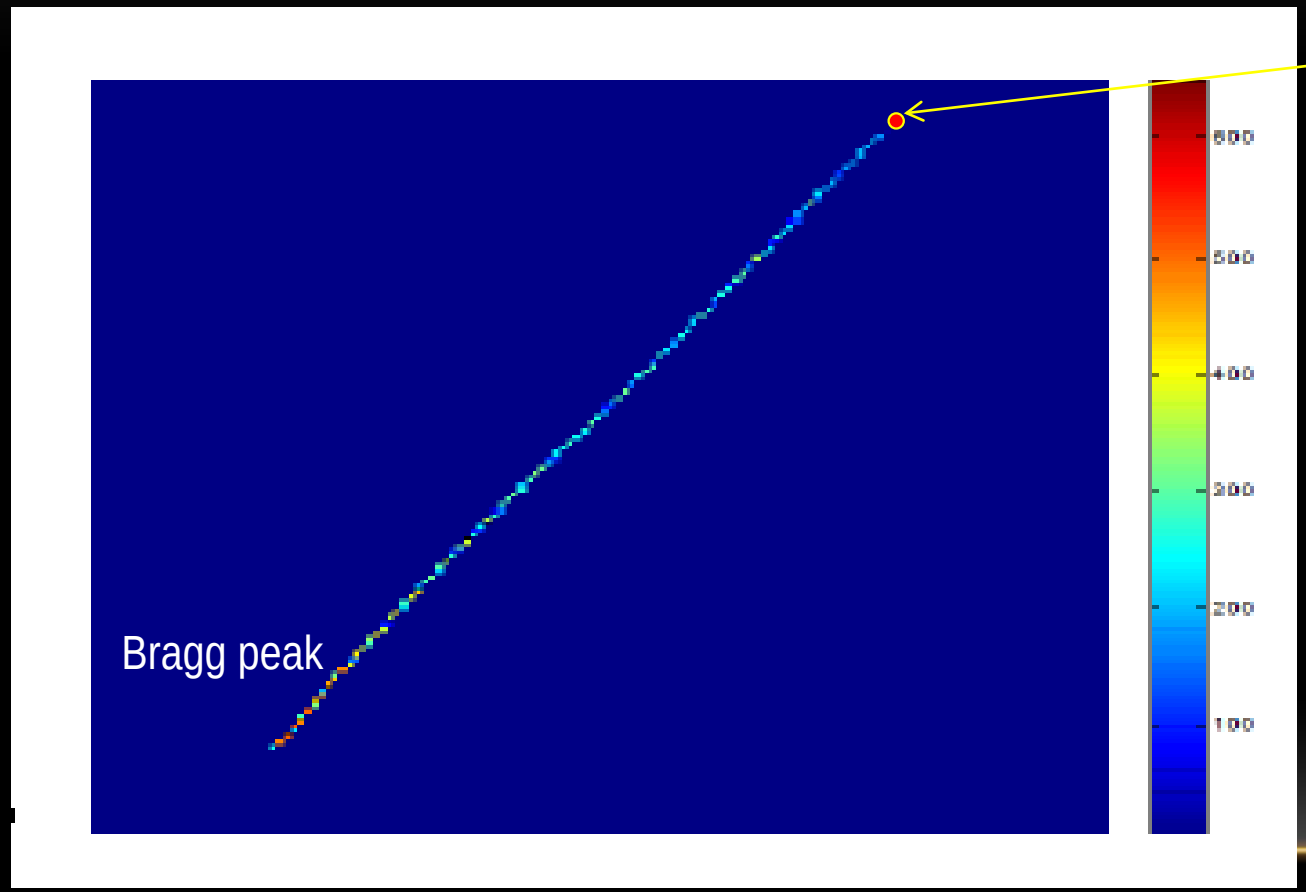


MAIN IDEA: DECREASE CAPILLARY DIAMETER

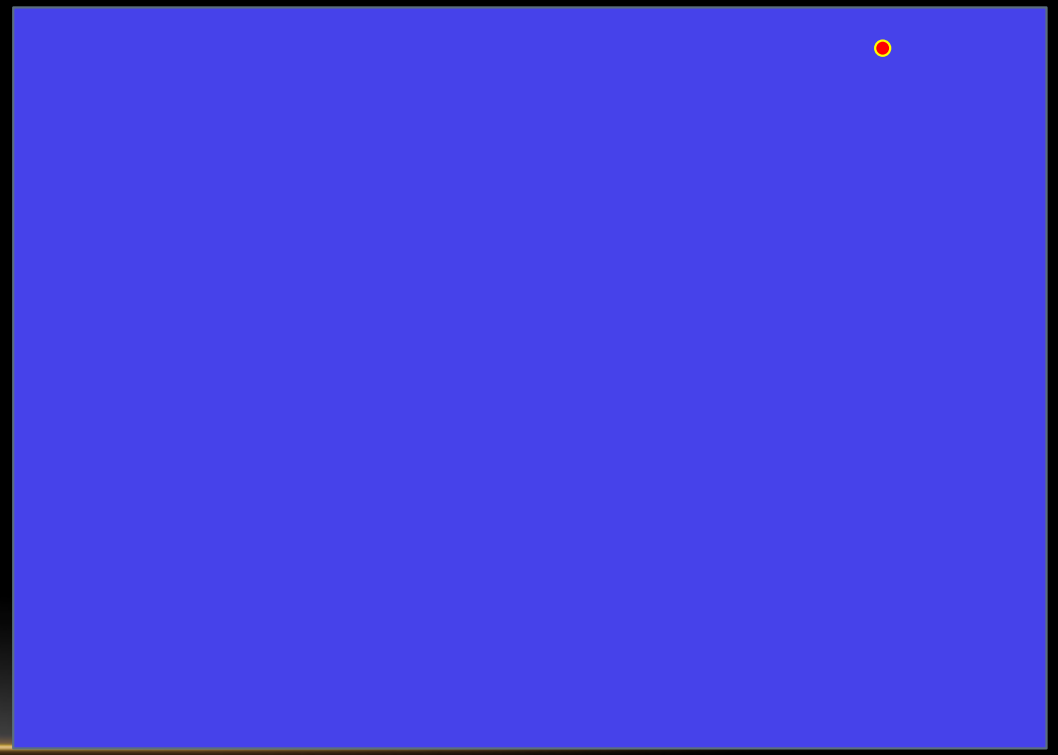
From 250 micron to 20 micron



HOUGH TRANSFORM: RECONSTRUCTION OF NEUTRON'S POSITION



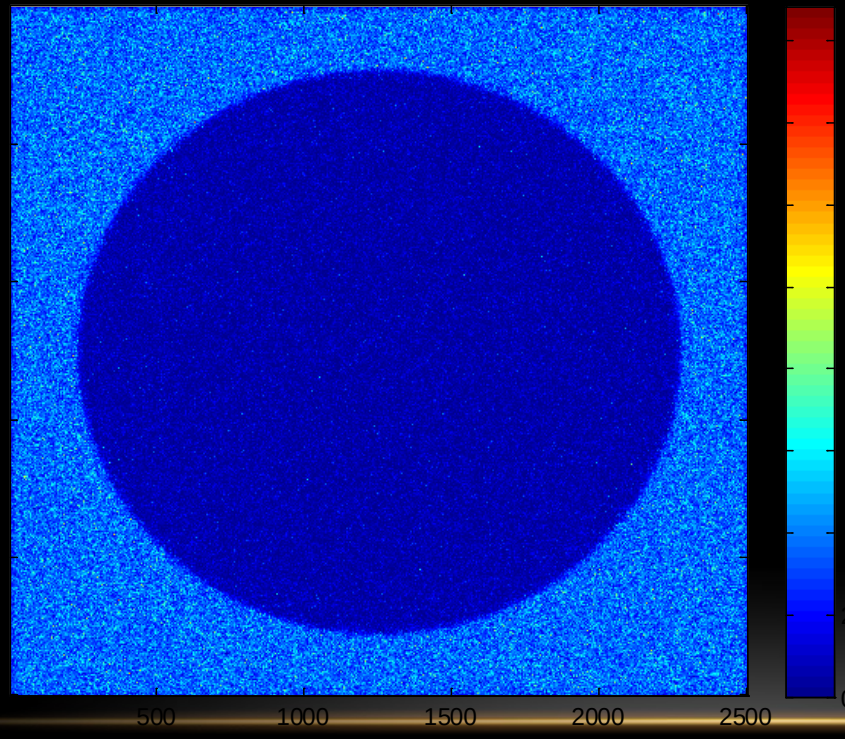
The position of the neutron

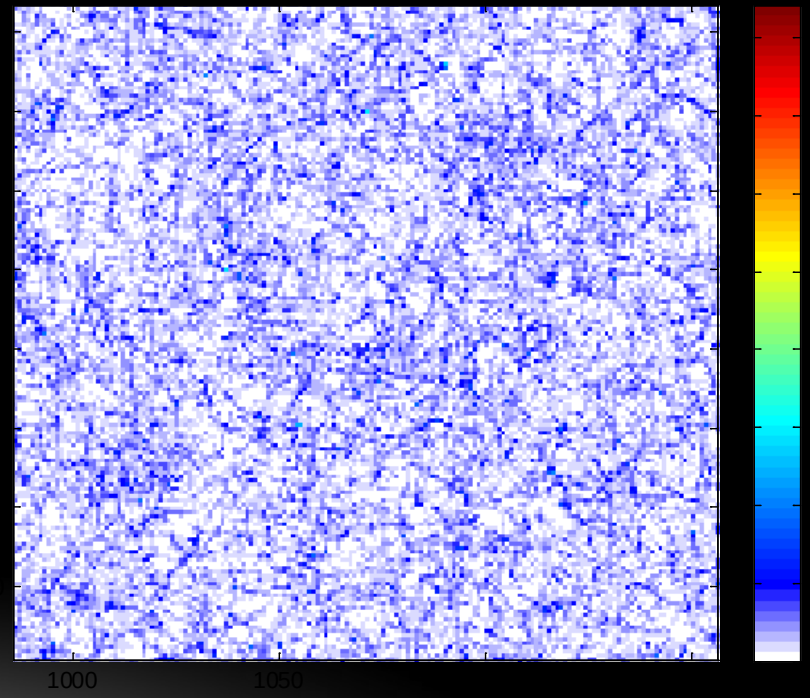


The position of the neutron

SIMULATION: 20 MICRON CAPILLARY

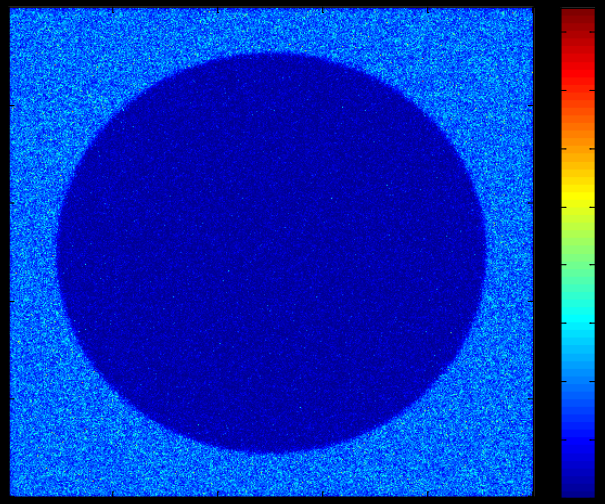
6mrad，2e8 neutron inside;
Detector size: 5cm X 5cm

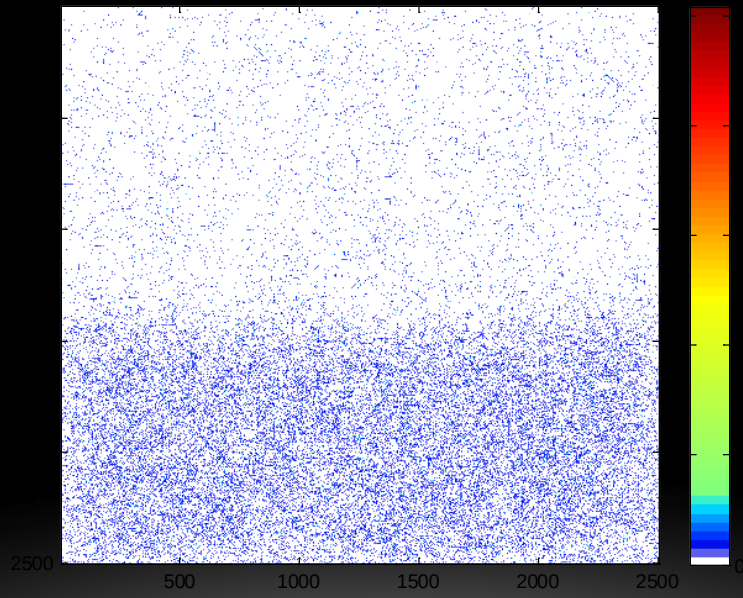


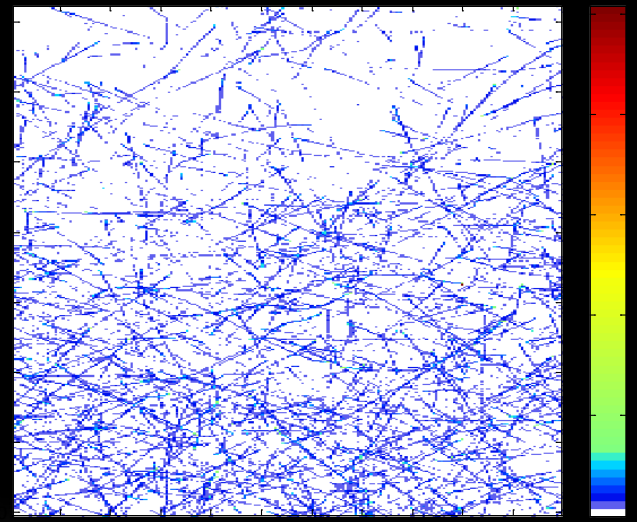


SIMULATION: FROM 2MICRON TO 20 MICRON

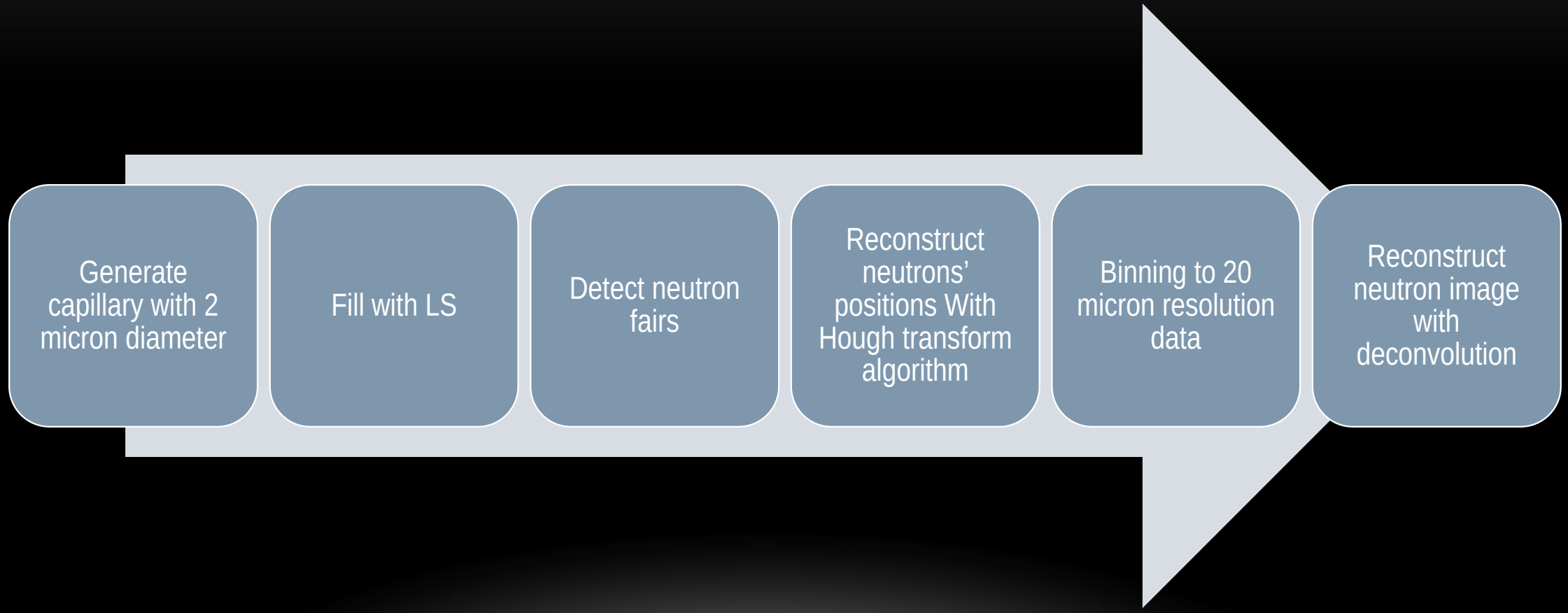
6mrad，2e8 neutron inside;
Detector size: 5cm X 5cm







SUMMARY OF THE SUGGESTION: SCHEME TO REALIZE 2.5 MICRON RESOLUTION



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CHALLENGE & POSSIBLE SOLUTION

- Large area capillary array
  - 2 micron diameter
  - Large thickness: >1 cm
  - Ultra high aspect ratio: 5000:1
  - Ultra large pixel number ICCD with ultra resolution of 2 micrometer.
- All above are not exist at present
- Future, lets see

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Thank you for your attention !