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UNIVERSITY OF MYSORE

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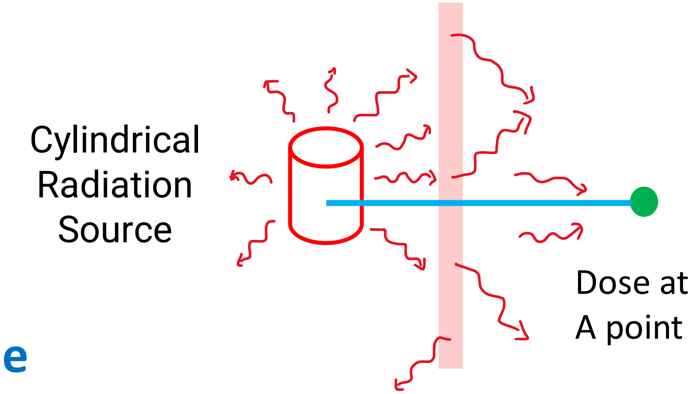
Development of Point Kernel Gamma Ray Shielding Code

Sachin Shet and K. V. Subbaiah

Introduction

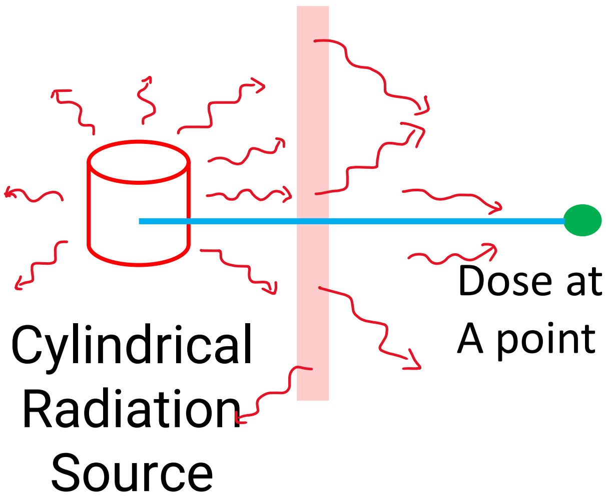


Radiation Shielding with **Point Kernel Technique**

Developed **point kernel module**

Incorporated to MCkeff program to solve shielding problems of any used defined geometry

Method – Point Kernel



- Source broken into many small kernels
- Contribution from each kernel is evaluated for a common point
- Contributions are summed

$$D(r) = k \int_V \frac{S(r')B(\mu|r-r'|, E)\exp(-\mu|r-r'|)dV}{4\Pi|r-r'|^2}$$

k	- Flux to Dose conversion factor
S(r’)	- source density in Becquerel/cc
B(μ|r - r’|, E)	- Dose build-up factor at gamma ray energy E.
μ	- Gamma ray linear attenuation coefficient at energy E
|r - r’|	- Distance between the detector and source point

Modules Developed in this work

Point Kernel Method

$$D(r) = k \int_V \frac{S(r')B(\mu|r - r'|, E)\exp(-\mu|r - r'|)\mathrm{d}V}{4\Pi|r - r'|^2}$$

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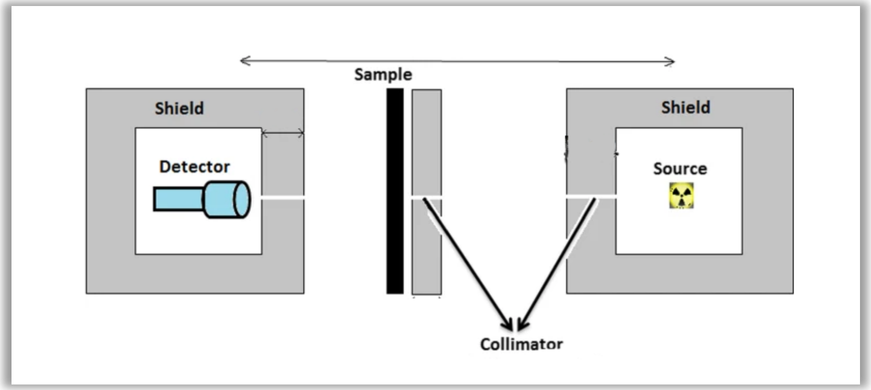
Combinatorial Solid Geometry

POINT SOURCE

VOLUMETRIC SOURCE

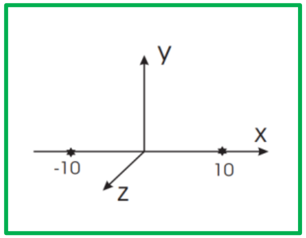
DEGENARATE SHAPES

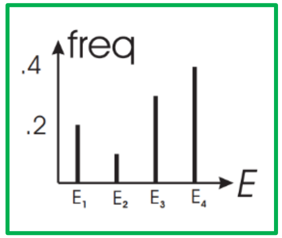
Radiation Sources with different Geometrical configurations

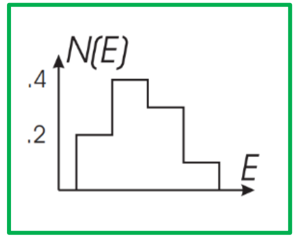


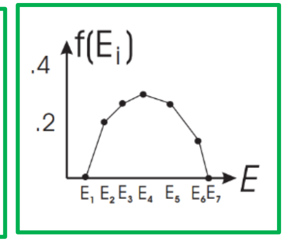
Problems solved with various source configuration

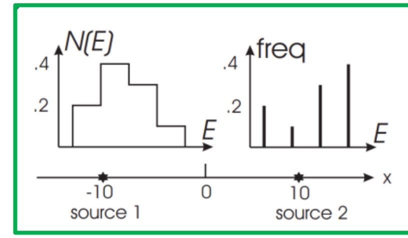
POINT SOURCE



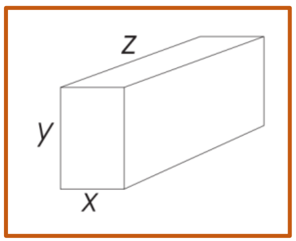


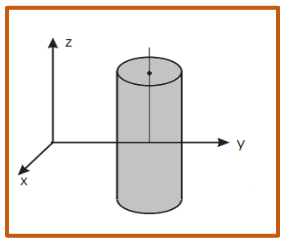


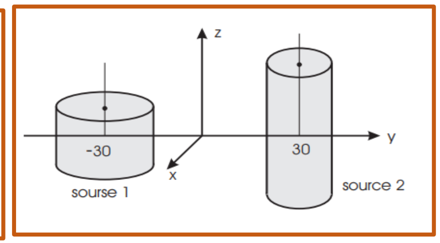




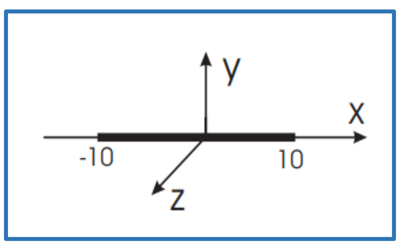
VOLUMETRIC SOURCE

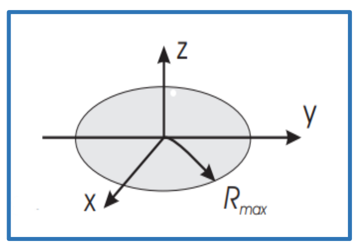


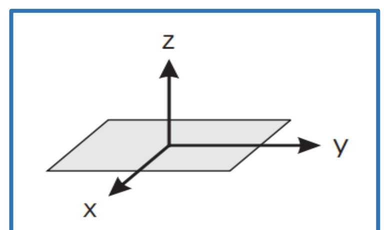


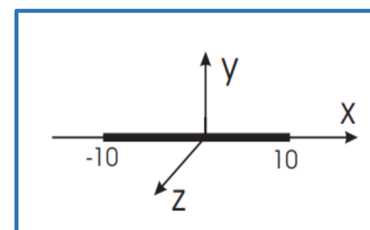


DEGENARATE SHAPES





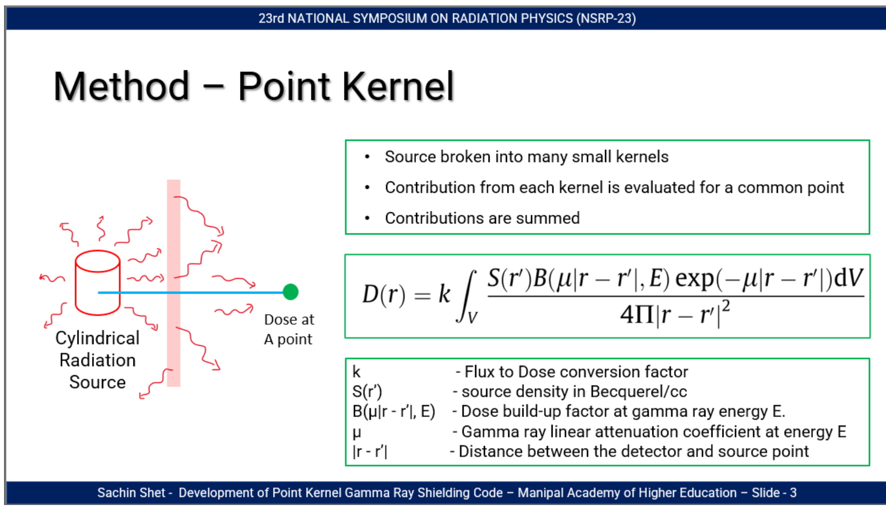




Results

PN	Problem title	UCF*.3.7e+10 (1 Curie) MCNP Code	UCF*.3.7e+10 (1 Curie) MCKeff Code	Air Medium MCNP	Air Medium MCKeff
1	Two Point Isotropic Sources at Different Positions→2P	2.734e+05	2.734e+05	9.123e+04	9.110e+04
2	Point Isotropic Source with Discrete Energy Photons→P4DE	2.944e+05	2.945e+05	1.727e+04	1.660e+04
3	Point Isotropic Source with a Histogram of Energies→P4HE	2.944e+05	2.945e+05	3.743e+03	6.585e+03
4	Point Isotropic Source with Tabulated Energy Distribution→P7AE	2.944e+05	2.945e+05	4.707e+04	3.790e+04
5	Two Point Sources with Different Energy Distributions (FPOS)→	3.153e+05	3.155e+05	2.179e+05	2.183e+05
6	Rectangular Parallelepiped Parallel to Axes →RPP	2.912e+05	2.945e+05	2.641e+05	1.587e+04
7	Sphere→SPH	2.968e+05	2.631e+05	2.634e+05	2.631e+05
8	Cylinder→RCC	3.244e+05	3.245e+05	3.185e+05	3.184e+05
9	Two Cylindrical Sources with Different Energy Photons →FERG	4.136e+05	4.142e+05	3.791e+05	3.795+05
10	Line Source: Degenerate Rectangular Parallelepiped →RPLX	2.937e+05	2.945e+05	1.008e+05	1.017e+05
11	Disk Source: Degenerate Cylindrical Source →RCXY	2.962e+05	2.963e+05	1.618e+05	1.609e+05
12	Plane Source: Degenerate Rectangular Parallelepiped →RPXY	2.949e+05	2.950e+05	6.722e+04	6.638e+04
13	Line Source: Degenerate Cylindrical Source →RCLX	2.974e+05	2.974e+05	1.008e+05	1.017e+05

Combinatorial Solid Geometry



MCkeff

Monte-Carlo k-effective estimation code

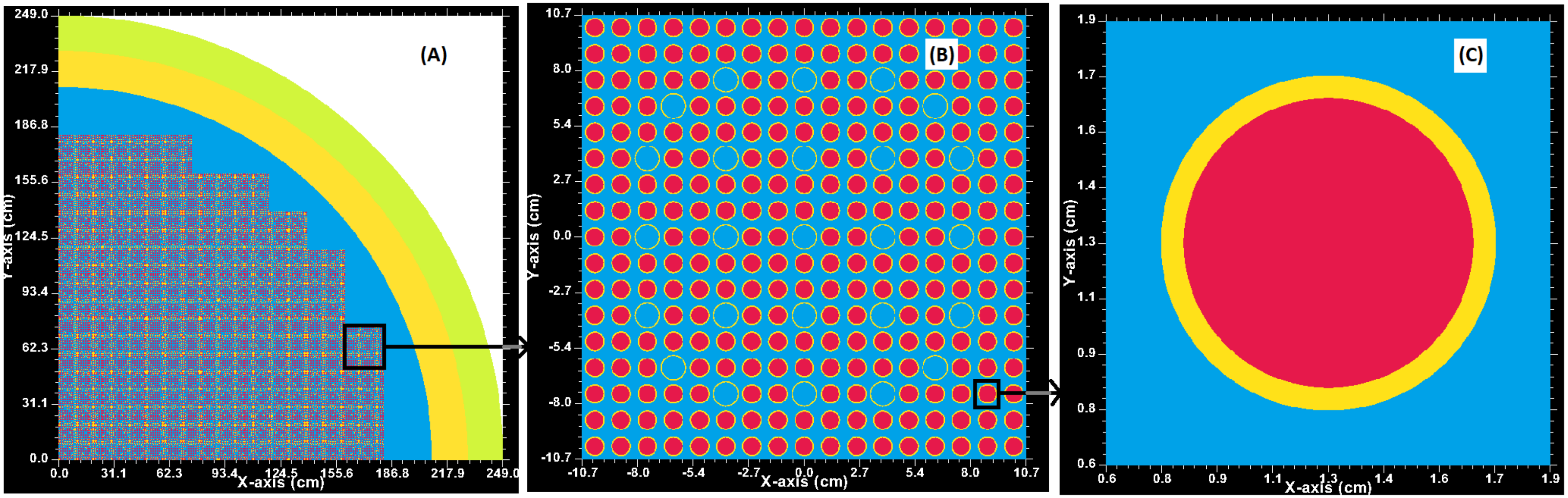
Well established Combinatorial geometry package

MCkeff

Neutron Multiplication factor of a system – Criticality - k_{eff}

Well established Geometry Package – Input structure and geometry modules as per MCNP

Validated with over **100s** of standard criticality benchmark problems

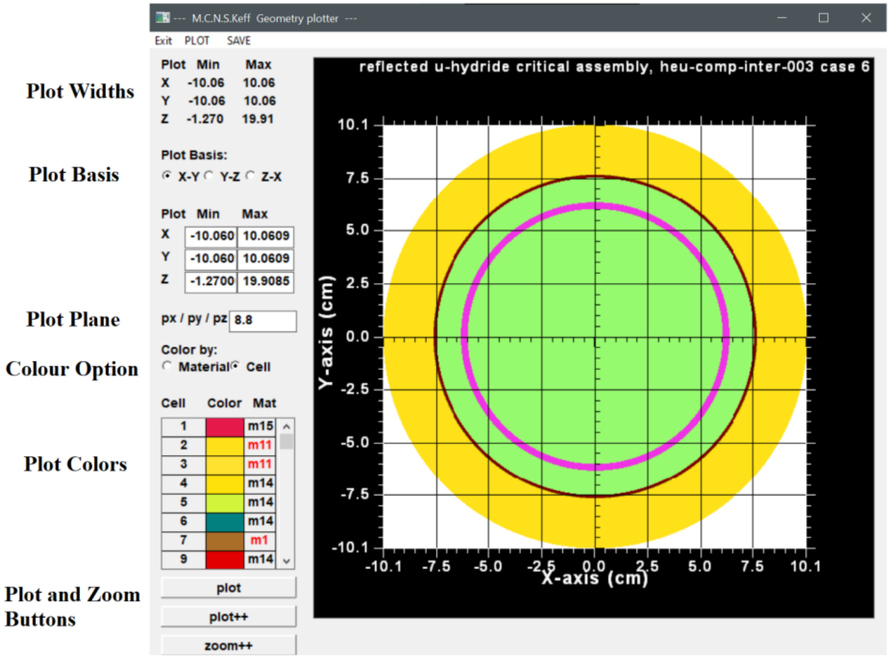


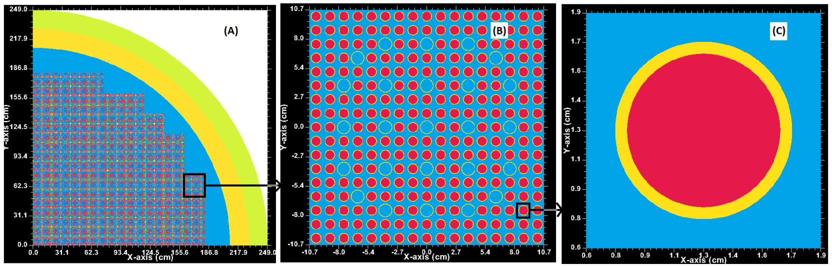
MCkeff

https://cutt.ly/mckeff

https://sachinsdp.github.io/mckeff/

User Interface of MCkeff





This work

Adopted Point Kernel Method into the **MCkeff**

Future developments of MCkeff code to incorporate essential capabilities

Additional physics, geometry and tally modules.

References

- Briesmeister, (2000), MCNP, LA-UR-13709- MCNP Manual.
- J. K. Shultis, (2011), AN MCNP PRIMER, Kansas State University Manhattan, KS 665062011, 2011
- Sachin Shet et al., (2022), MCkeff: An Indigenous Monte Carlo Code for estimation of Neutron Multiplication factor of Fissile Systems, Journal of Information and Computational Sciences., Volume 12, Issue 4., 931-947.

Thank You

MCkeff

https://cutt.ly/mckeff

https://sachinsdp.github.io/mckeff/

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