LA-UR- 04-3133

Approved for public release;
distribution is unlimited.

Title: Automated Variance Reduction for MCNP using Deterministic Methods

Author(s):
Jeremy Sweezy
Thomas Booth
Forrest Brown
Joseph Chiaramonte
William Preeg

Submitted to:
ICRS-10 / RPS2004
Funchal, Madeira, Portugal
May 9-14, 2004

Los Alamos
NATIONAL LABORATORY

AUTOMATED VARIANCE REDUCTION FOR MCNP USING DETERMINISTIC METHODS

J. Sweezy, F. Brown, and T. Booth
X-5, Applied Physics Division, Los Alamos National Laboratory
e-mail: jsweezy@lanl.gov, fbrown@lanl.gov, teb@lanl.gov

J. Chiaramonte and B. Preeg
Schlumberger-Doll Research
e-mail: jchiaramonte@ridgefield.oilfield.slb.com, preeg@swbell.net

Abstract:

In order to reduce the user's time and the computer time needed to solve deep penetration problems, an automated variance reduction capability has been developed for the MCNP Monte Carlo transport code. This new variance reduction capability developed for MCNP5 employs the PARTISN multigroup discrete-ordinates code to generate mesh-based weight windows. The technique of using deterministic methods to generate importance maps has been widely used to increase the efficiency of deep penetration Monte Carlo calculations. The application of this method in MCNP uses the existing mesh based weight window feature to translate the MCNP geometry into geometry suitable for PARTISN. The adjoint flux, which is calculated with PARTISN, is used to generate mesh-based weight windows for MCNP. Additionally, the MCNP source energy spectrum can be biased based on the adjoint energy spectrum at the source location. This method can also use angle-dependent weight windows.

AUTOMATED VARIANCE REDUCTION FOR MCNP USING DETERMINISTIC METHODS

Jeremy Sweezy, Tom Booth, and Forrest Brown

MCNP Development Team, X-5

X-Division (Applied Physics)

Los Alamos National Laboratory

Joe Chiaramonte and Bill Preeg

Schlumberger-Doll Research

ICRS-10/RPS 2004

Funchal, Madeira Island (Portugal)

May 9-14, 2004

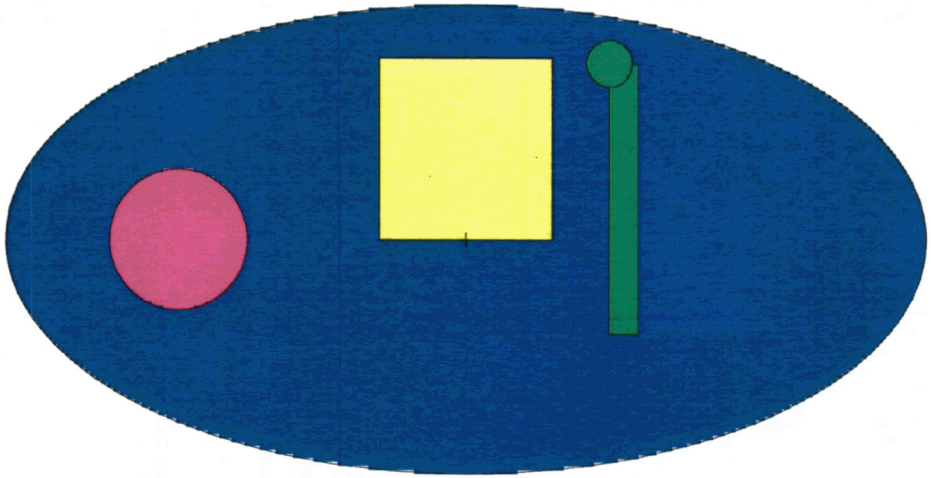
Introduction

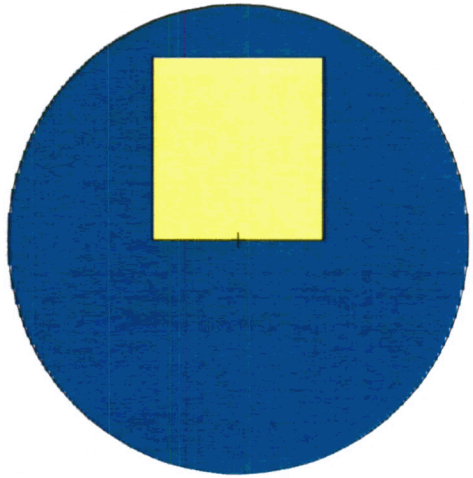
- Adjoint flux $\propto$ particle importance.
- Use of deterministic methods to calculate importance maps has been widely studied.
  - SCALE/SAS4
  - MCBEND
  - Tripoli
- Several attempts to create weight windows for MCNP using deterministic methods.
  - AVATAR
  - A3MCNP
  - ADVANTG
- This is an effort to create a Deterministic Adjoint weight window generator (DAWWG) as a standard MCNP feature.

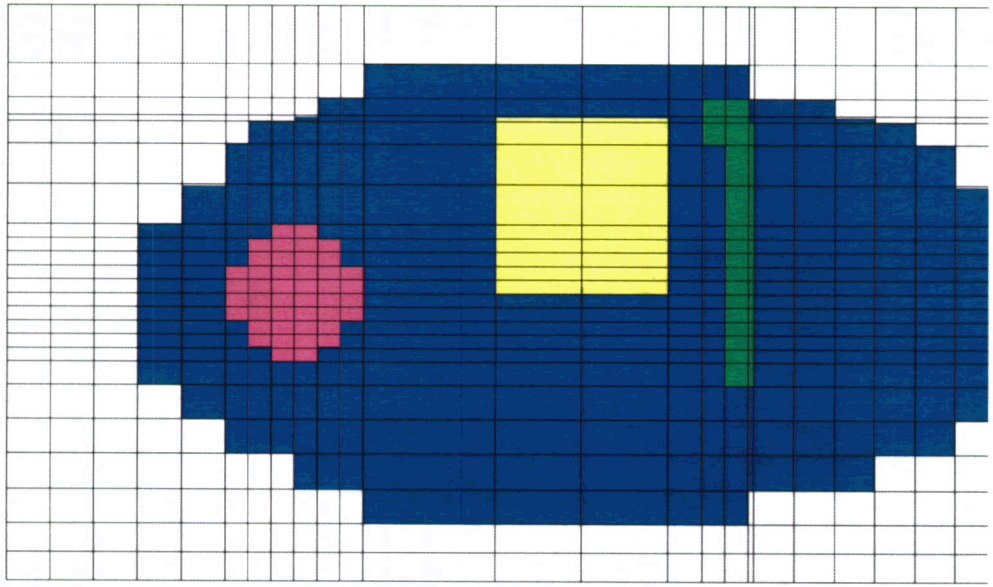
MCNP → PARTISN

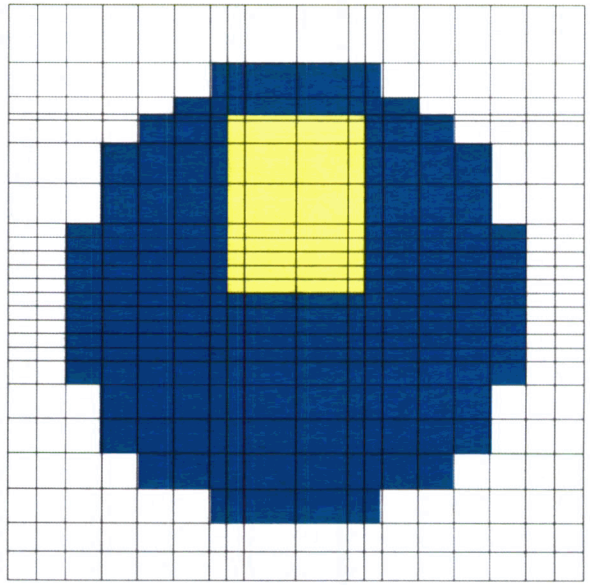
- DAWWG uses PARTISN to calculated adjoint fluxes.
- User defined WWG mesh is used to convert MCNP geometry to PARTISN geometry.
- MCNP ZAIDs are mapped to multi-group library materials.
- Tally information used to construct adjoint source.

MCNP geometry → PARTISN geometry









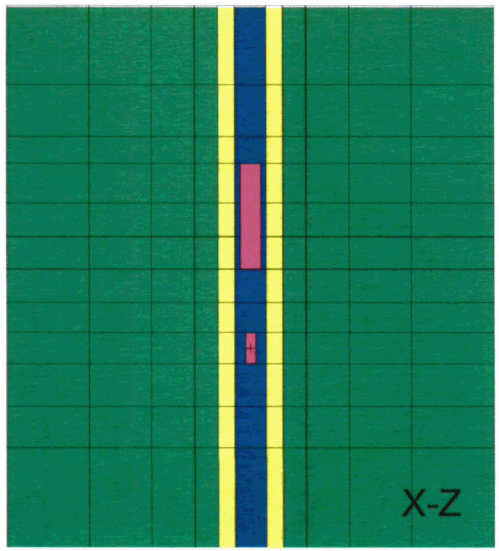
PARTISN → MCNP

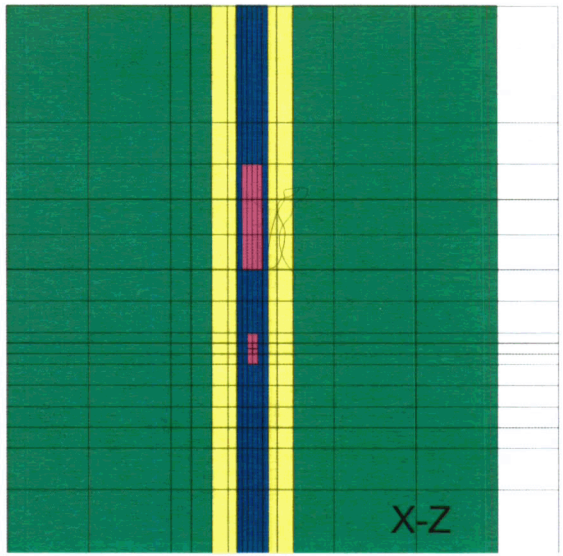
- Convert adjoint fluxes to weight windows:
  - Normalize adjoint fluxes to reference point.
  - Take inverse of adjoint fluxes.
  - Place upper limits on weight windows.
- Optional source energy biasing.
- Angular weight windows (from AVATAR).
- Weight window plotting.

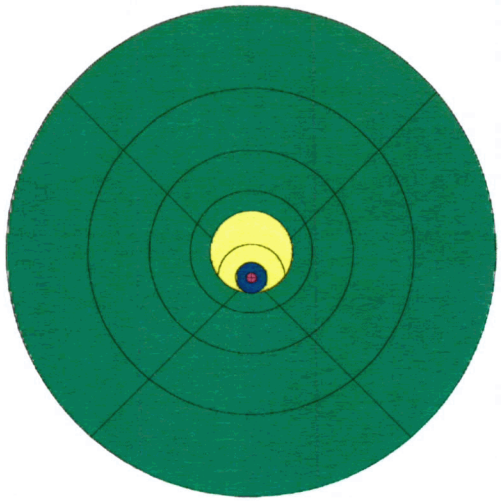
Test Problem 1: "Oil Well Logging Problem"

- Problem inp12 of MCNP regression test set.
- Simulates a neutron porosity tool used in oil-well logging field.
- Two detectors placed in a cylindrical borehole
  - filled with water
  - surrounded by a 20 P.U. limestone formation
- ^{241}AmBe point source

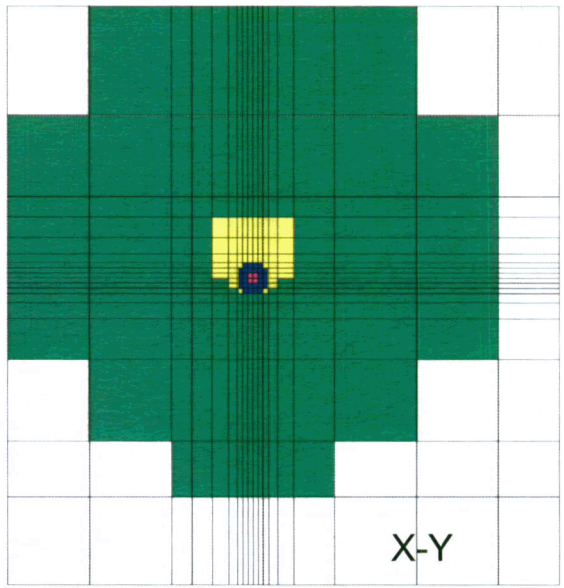
Test Problem 1: "Oil Well Logging Problem"



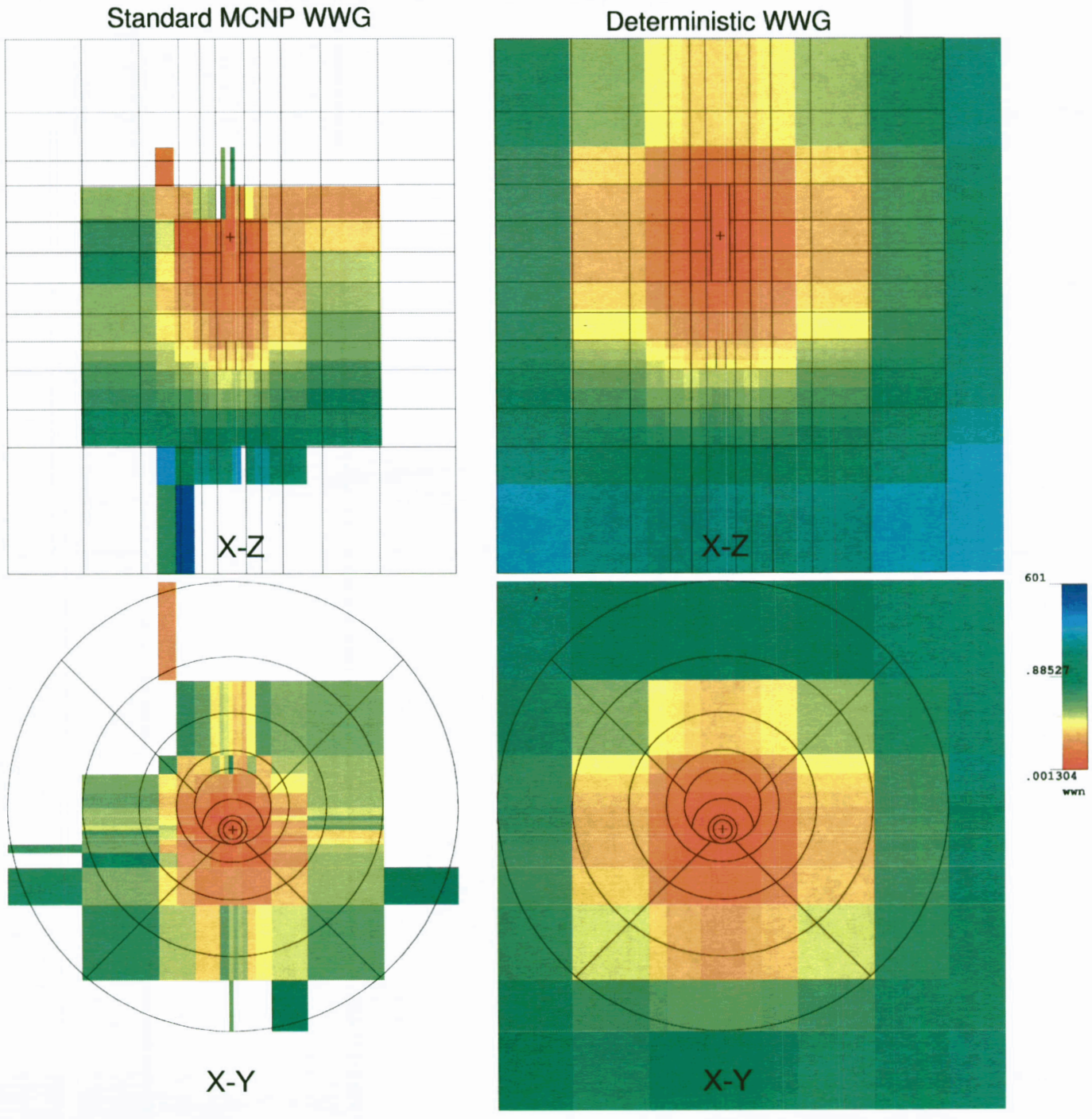




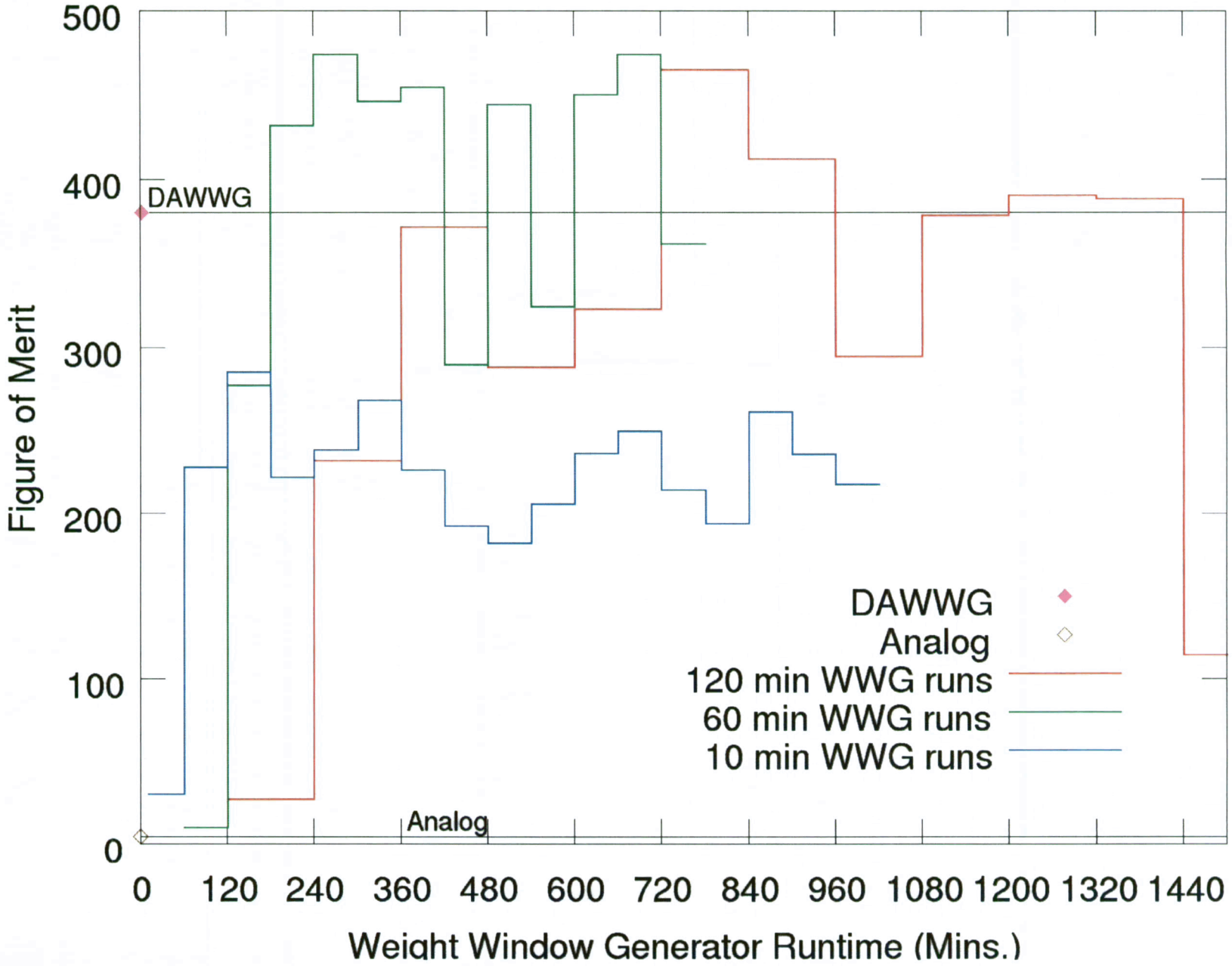
X-Y



Test Problem 1: "Oil Well Logging Problem"



Test Problem 1: "Oil Well Logging Problem"

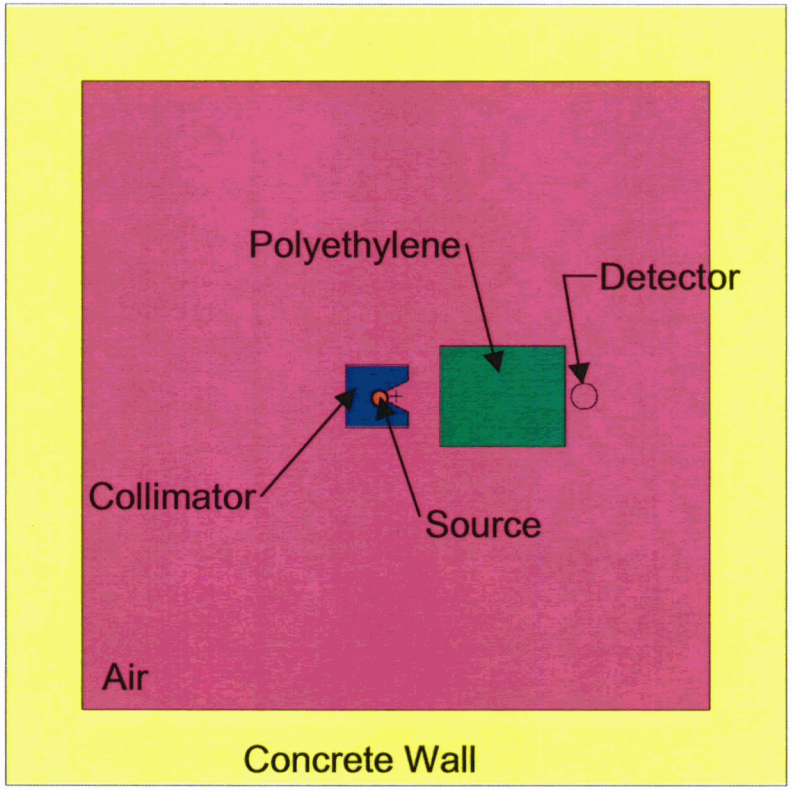


Test Problem 1: "Oil Well Logging Problem"

Standard MCNP	MCNP WWG		Deterministic WWG	
FOM	Time (min)	FOM	Time (min)	FOM
4.7	180	415±66	2.64	380

Test Problem 2: "Poly Shield "

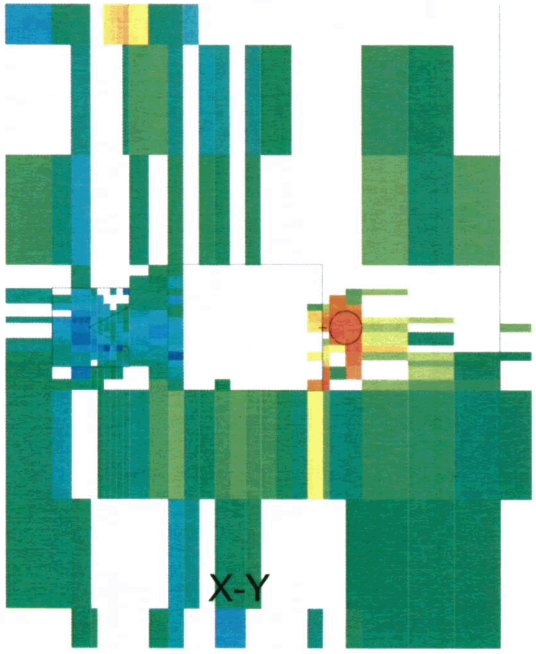
- Cf-252 Source
- 100-cm Polyethylene Shield
- Measuring Neutron Dose
- In 5-meter room with 61-cm thick concrete walls.

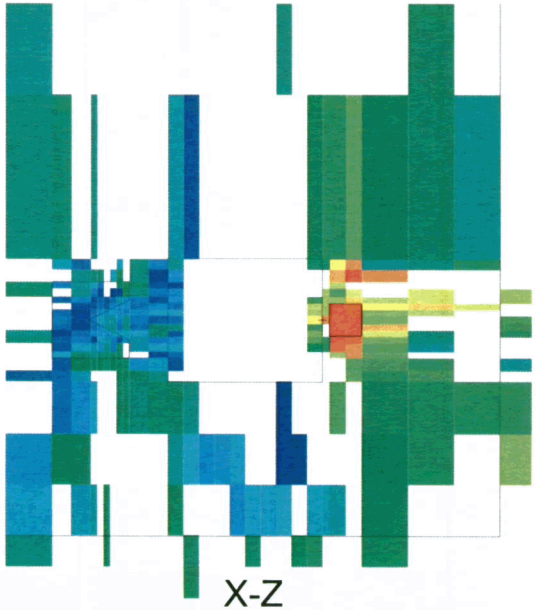


X - Y

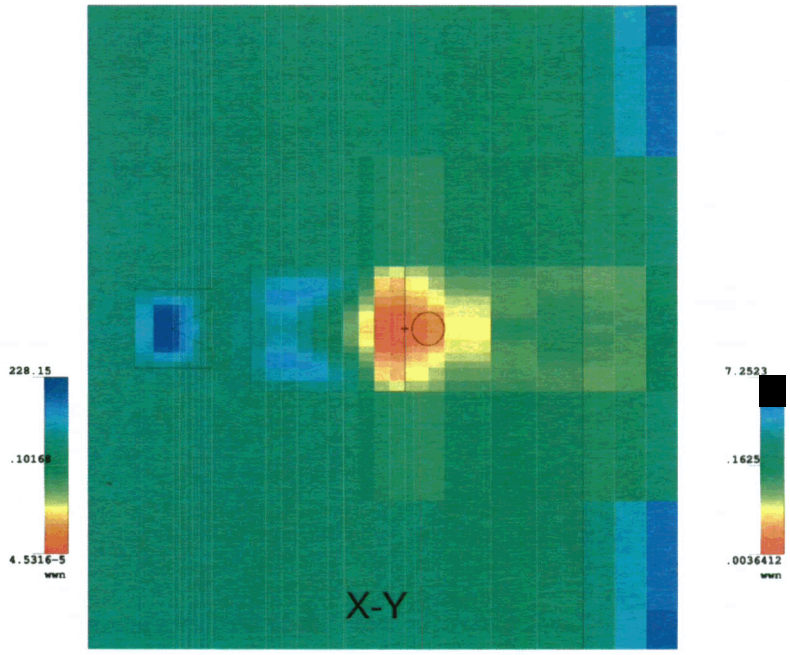
Test Problem 2: "Poly Shield "

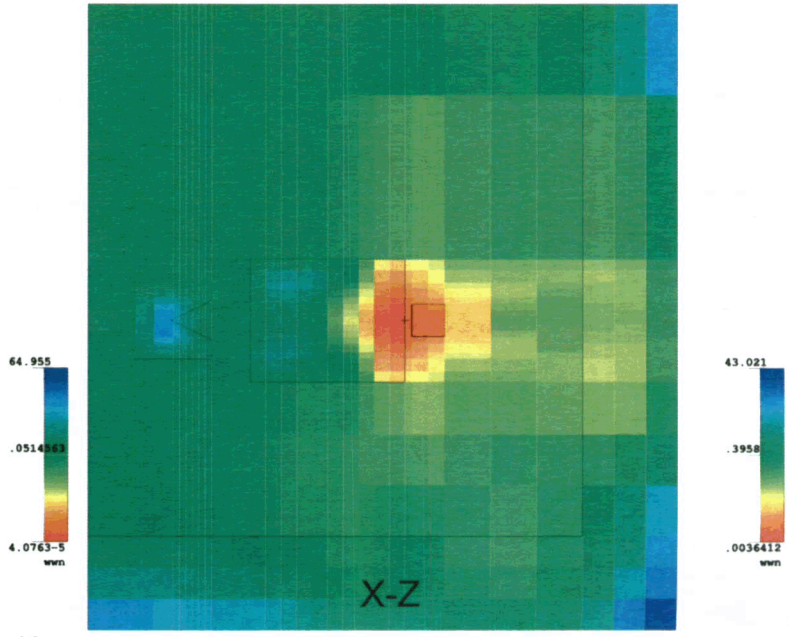
WWG



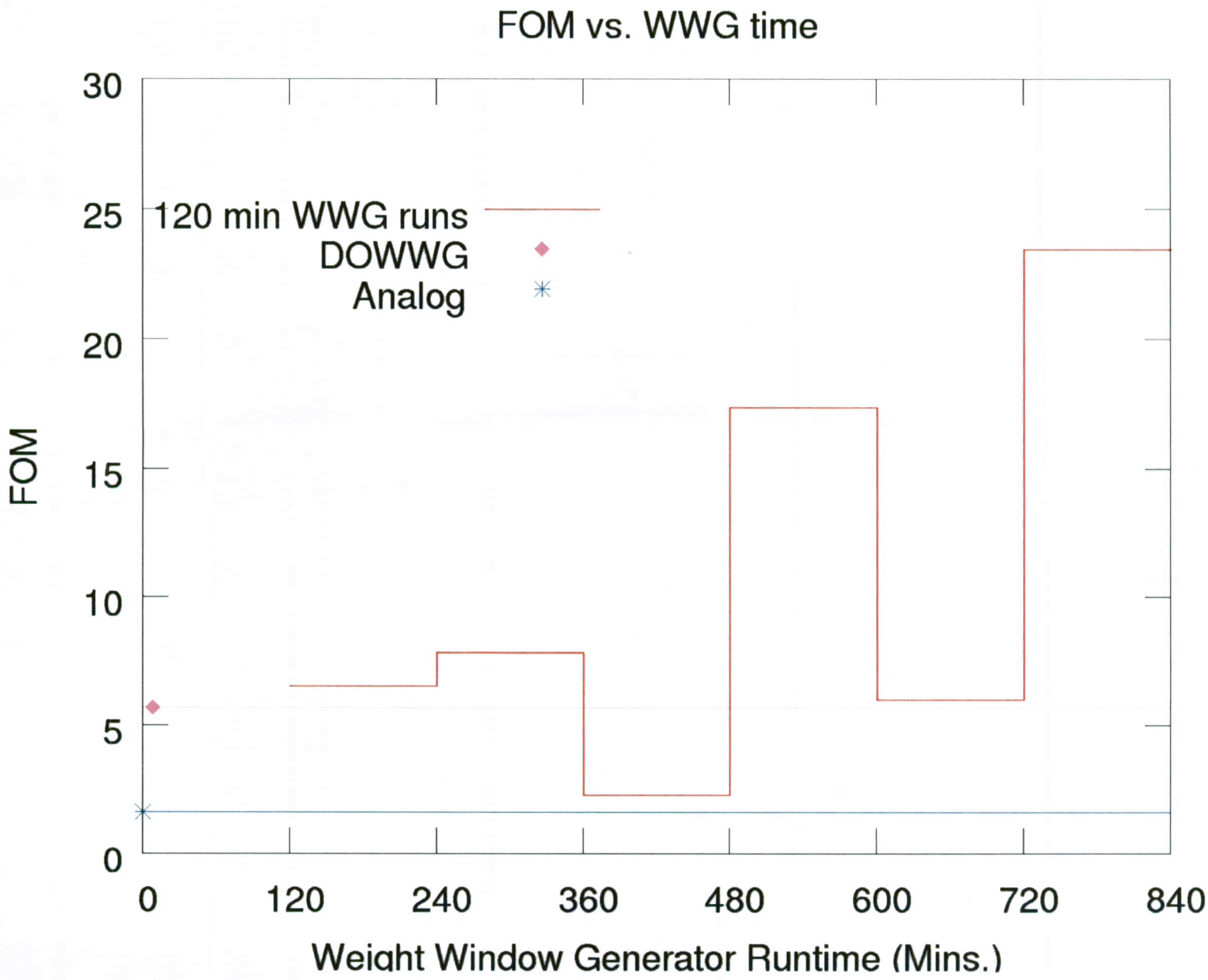


DAWWG





Test Problem 2: "Poly Shield "

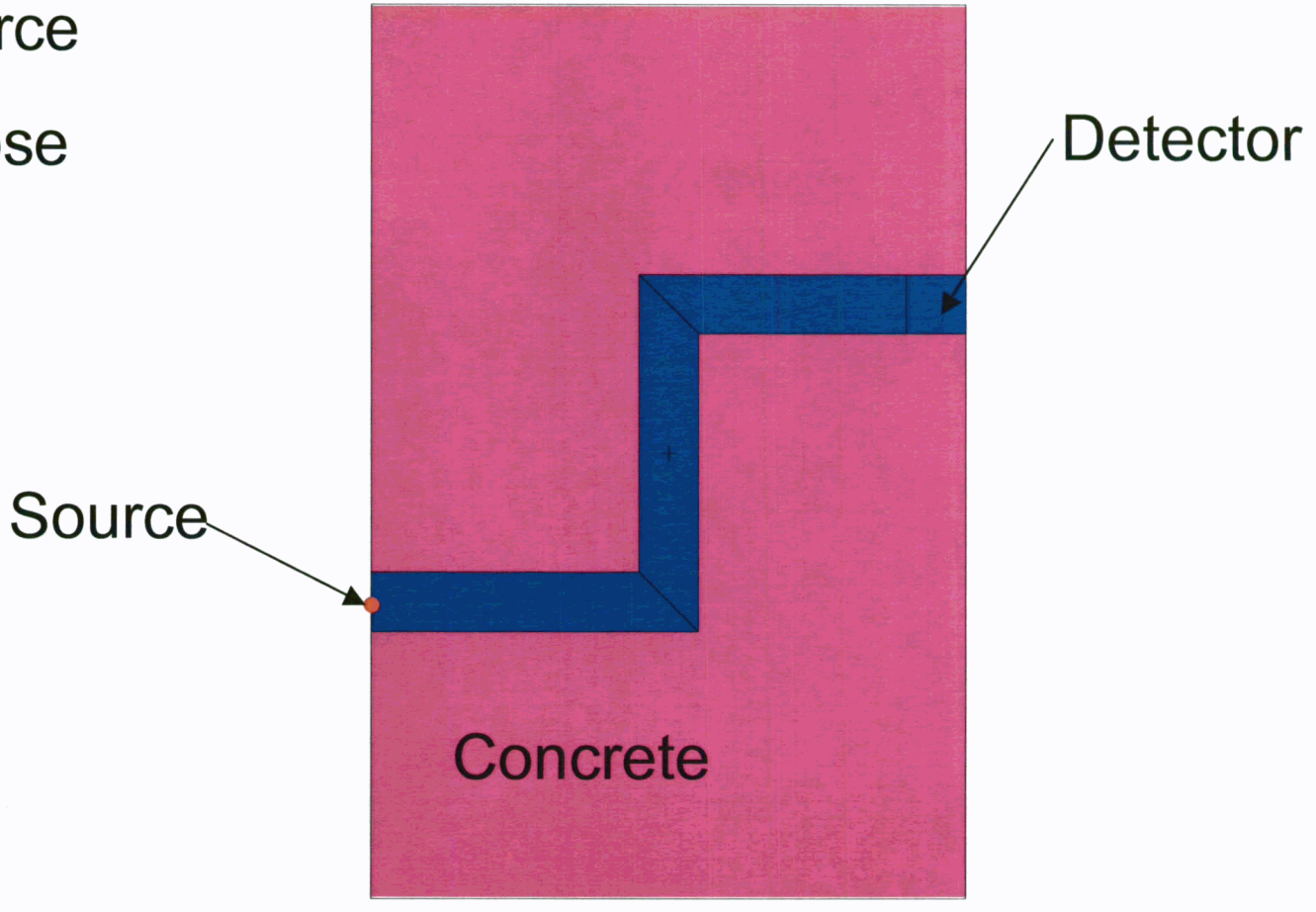


Test Problem 2: "Poly Shield "

Standard MCNP	MCNP WWG		Deterministic WWG	
FOM	Time (min)	FOM	Time (min)	FOM
3.3	120	10.6±8.1	8.15	5.7

Test Problem 3: Dogleg in Concrete

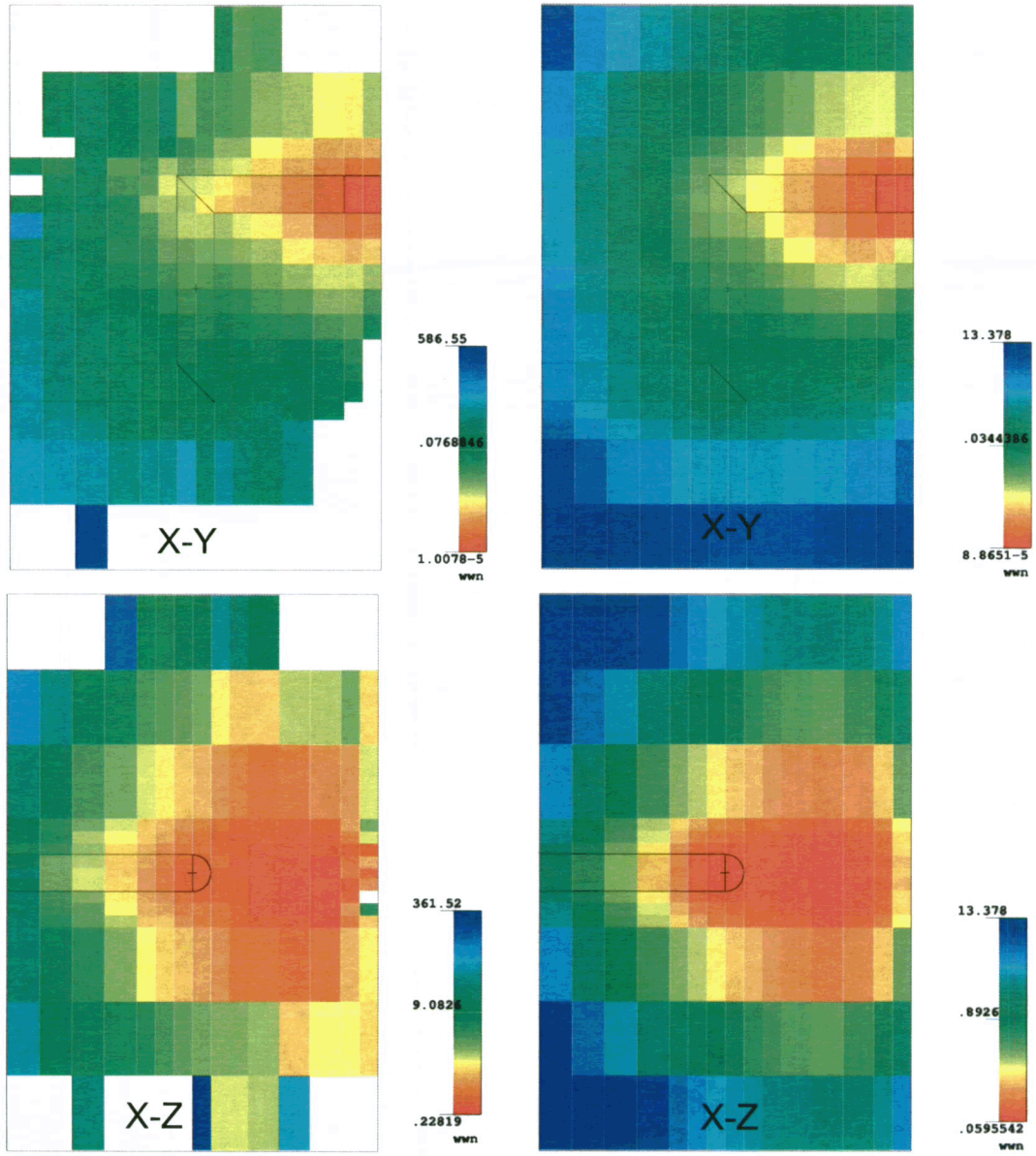
- Dogleg in Concrete
- Cf-252 point source
- Tally Neutron Dose



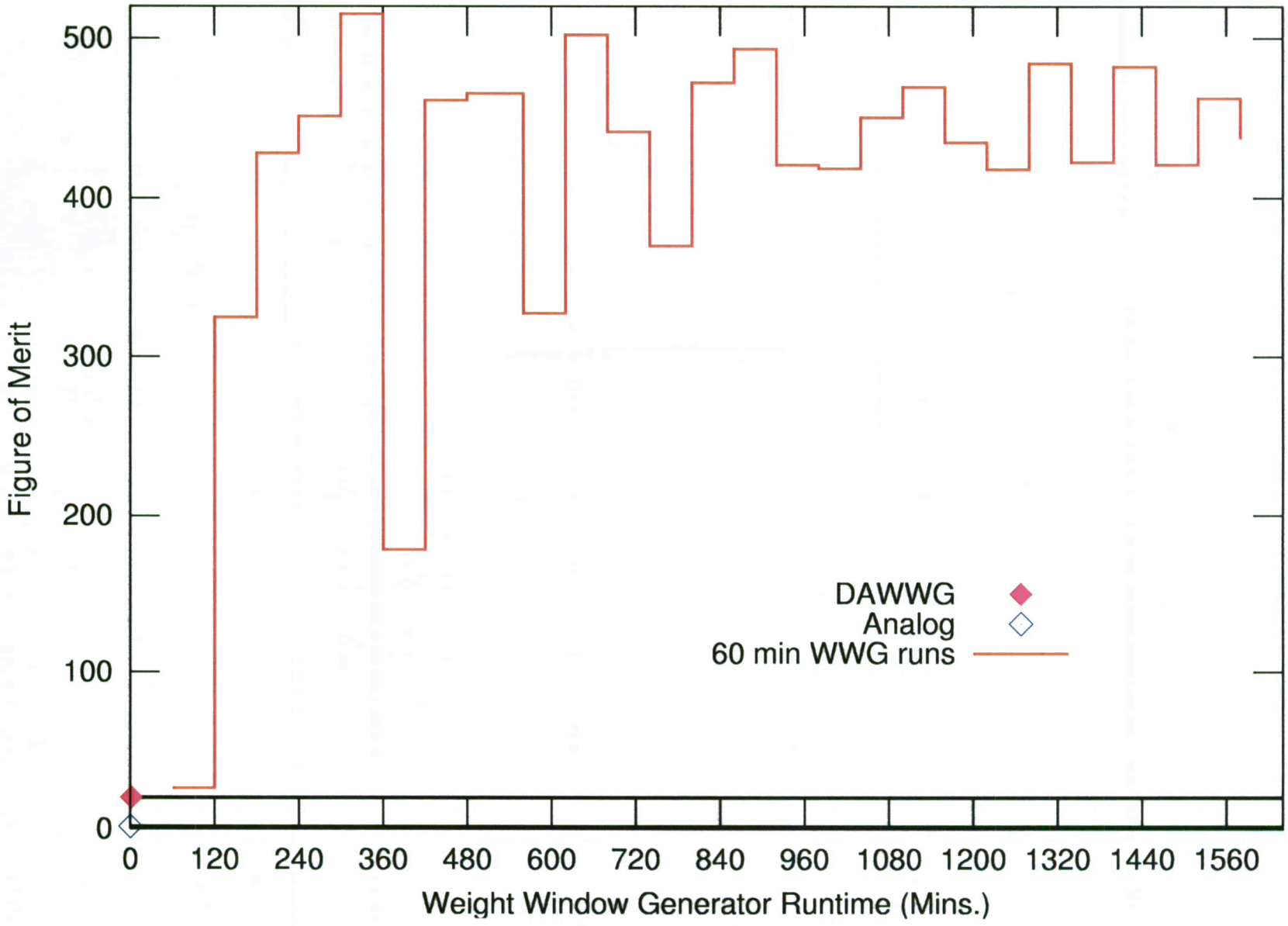
Test Problem 3: Dogleg in Concrete

WWG

DAWWG



Test Problem 3: Dogleg in Concrete



Test Problem 3: Dogleg in Concrete

Standard MCNP	MCNP WWG		Deterministic WWG	
FOM	Time (min)	FOM	Time (min)	FOM
1.6	180	429±82	1.58	20

Conclusions

- DAWWG is easy and fast method of generating weight windows.
- DAWWG will allow novice MCNP users to generate useful weight windows quickly.
- Users will have the ability to visualize the resulting weight windows.
- Save considerable time over standard WWG.
- DAWWG produces a weight window map that is defined for the complete geometry
- Some highly angular dependent problems the DAWWG is not as effective as the WWG.
- For many types of problems the DAWWG is as effective as the standard WWG.