Initial Experiences using Advantg for fusion and spallation, a users perspective

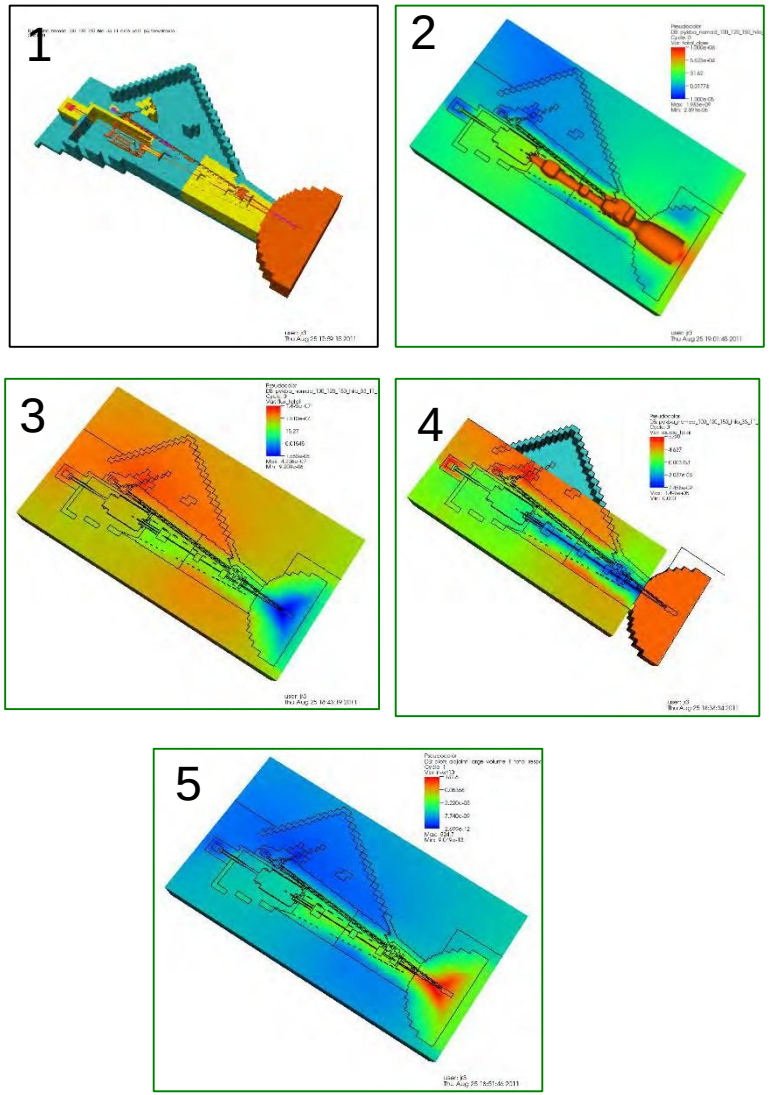
Steven Lilley

What Is Advantg?

- Developed by ORNL, available from NEA and RSICC
- It automates the implementation of the CADIS and FWCADIS method for generating weight windows for MCNP
- CADIS for target based single tallies
- FW CADIS for mesh or multiple tallies
- Uses Denovo for deterministic transport to calculate forward and adjoint flux. This is then used to generate the weight window and if appropriate source biasing
- Denovo is modern 3D block based deterministic transport simulation code
- Neutrons and Photons only, limited by Denovo

CADIS= Consistent Adjoint Driven Importance Sampling

What is Advantg?



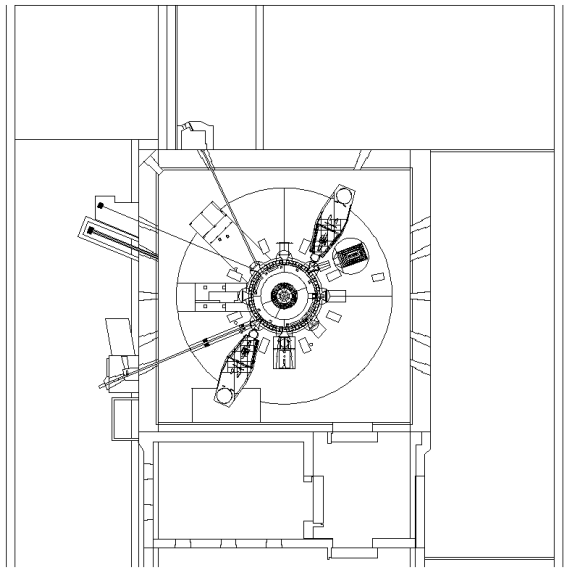
Advantg process:
Very simple input file and MCNP input

1) Generates meshed geometry for Denovo
2) Solve forward problem using Denovo
3) Construct importance source
4) Solve adjoint problem using Denovo
5) Create weight windows

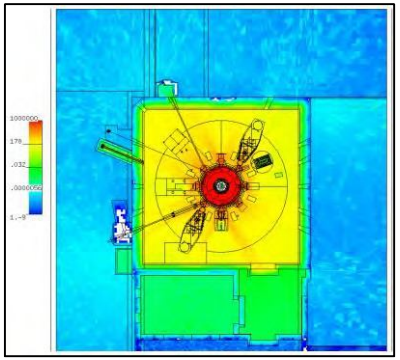
With thanks to J Risner @ ORNL

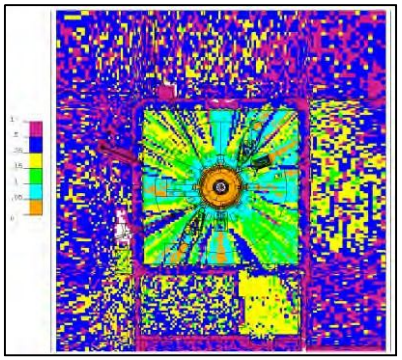
Experience at JET

Global optimisation for bulk shielding calculations thanks to J Naish, CCFE

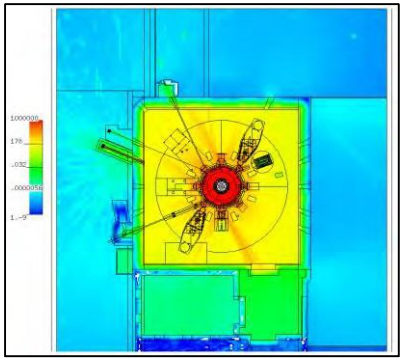


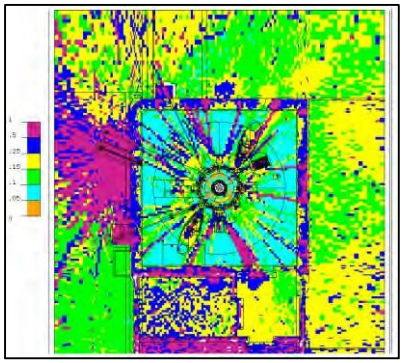
Magic





Advantg

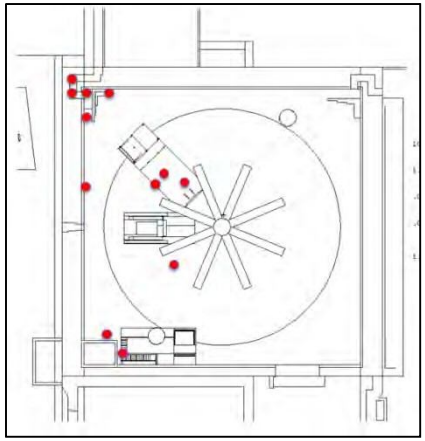


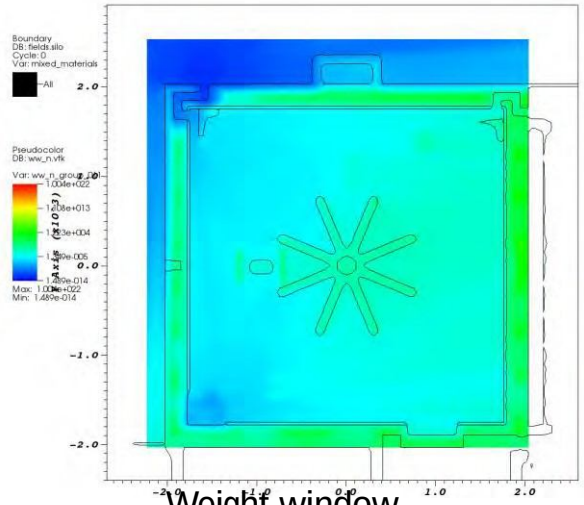


Both 10000 CPU min

ADVANTG took 67 minutes on 64 processors to run 2,394,240 elements to create the weight window file compared with 5 days on 64 processors using global magic method (variation of Coopers method)

Experience at JET

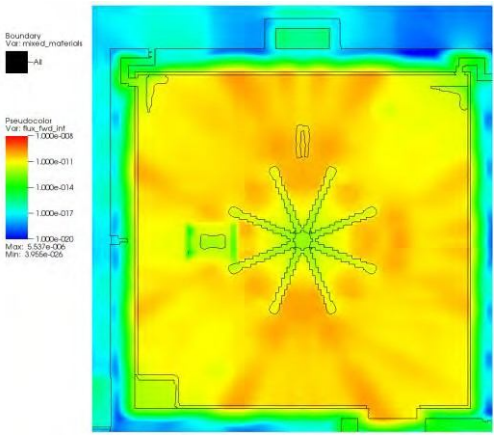




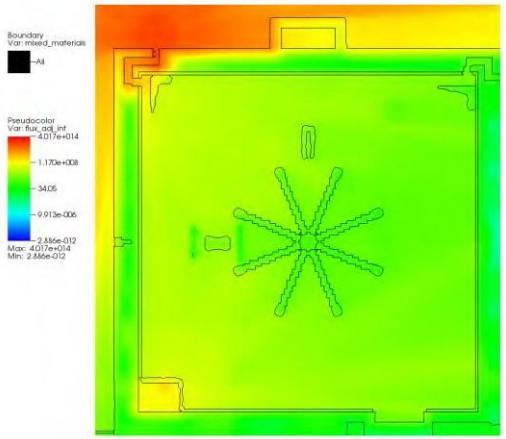
Weight window

The Second example is using ADVANTG to create a weight window optimised for the TLD detectors placed around JET.

ADVANTG took approximately 4 hours on 16 processors to generate the weight window and 10k CPU minute to get results



Forward flux from DENOVO

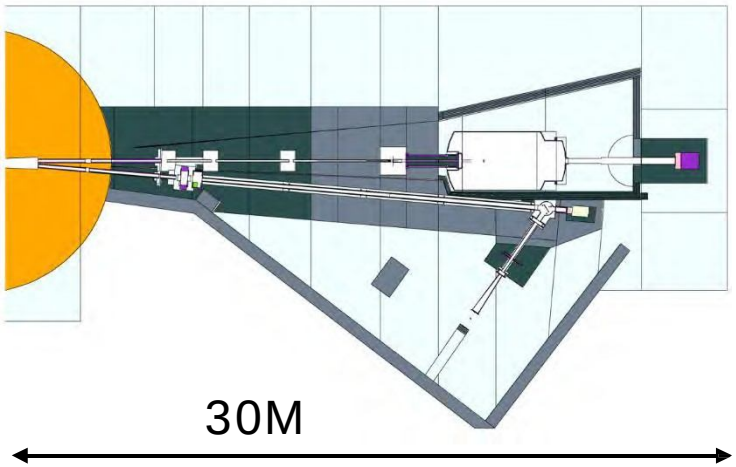


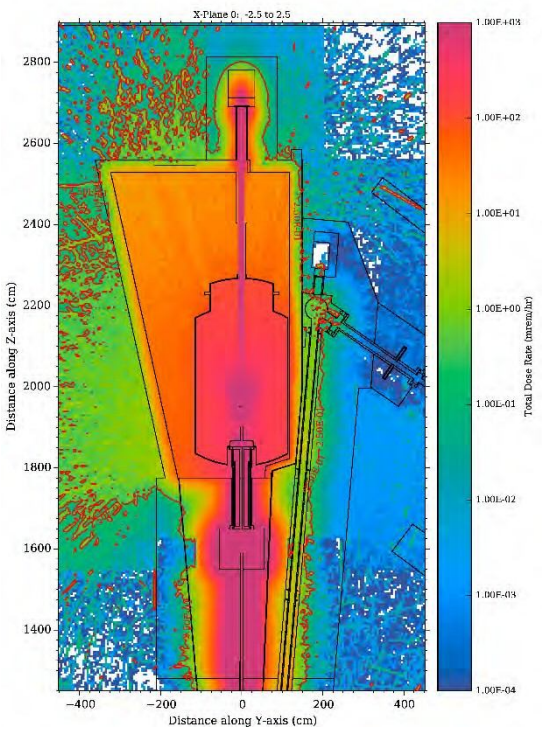
adjoint flux from DENOVO

The previous MCNP calculation took about a week to generate the weight window and ~3 days on 64 cores to generate equivalent results.

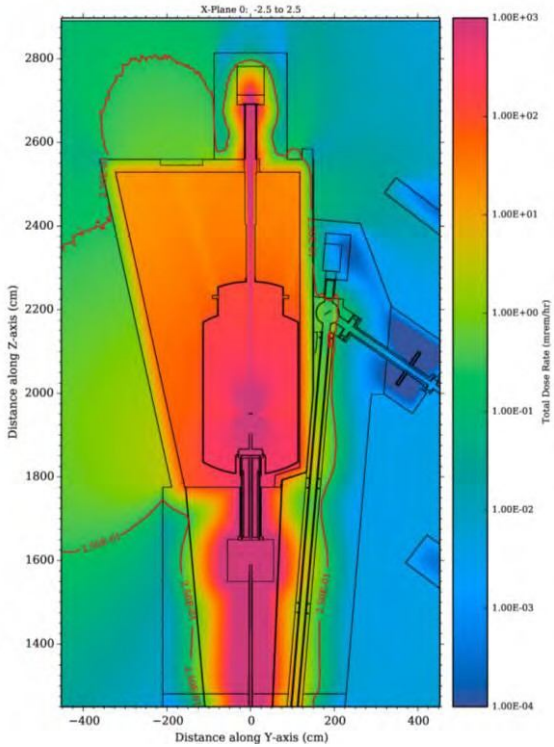
SNS Example - NOMAD

High energy up to 300MeV
Small beamline 10x12cm
Combination of small penetrations, thick shielding and scattering





Geometry Splitting
Total Dose Rate (mrem/hr)
(red contour line at 0.25 mrem/hr)



Hybrid
Total Dose Rate (mrem/hr)
(red contour line at 0.25 mrem/hr)

Images courtesy of J Risner,
See SATIF-12 Evaluation of SNS Beamline Shielding Configurations Using MCNPX Accelerated by ADVANTG

Science & Technology Facilities Council
ISIS

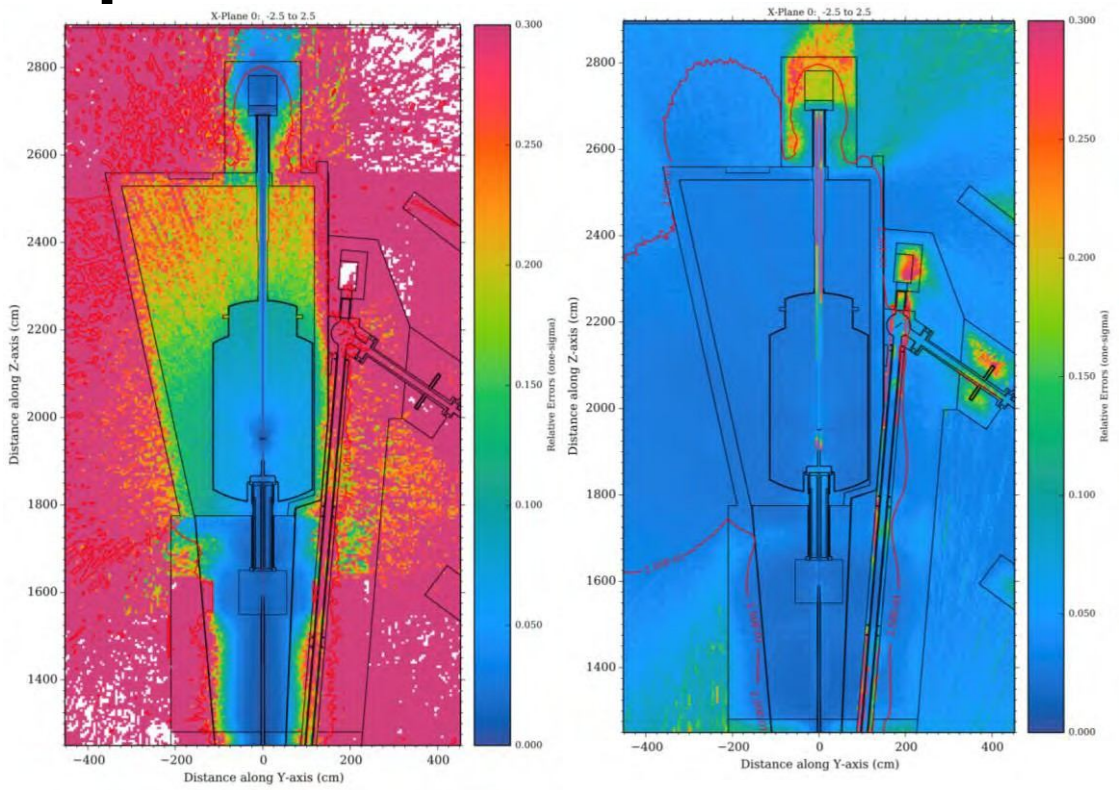
SNS Example - NOMAD

Used a plane source of neutrons, derived from target and moderator

Used Lobatto quadrature as it has ordinate along beam axis, this reduces long histories

Denovo run took 190 CPU hours

Weight-window file is approximately 1.8 GB



Geometry Splitting: ~5000 CPU Hours
Relative Error (1σ)

Hybrid: ~1000 CPU Hours
Relative Error (1σ)

Images courtesy of J Risner,
See SATIF-12 Evaluation of SNS Beamline Shielding Configurations Using MCNPX Accelerated by ADVANTG

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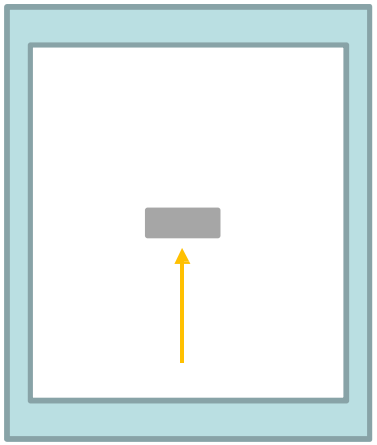
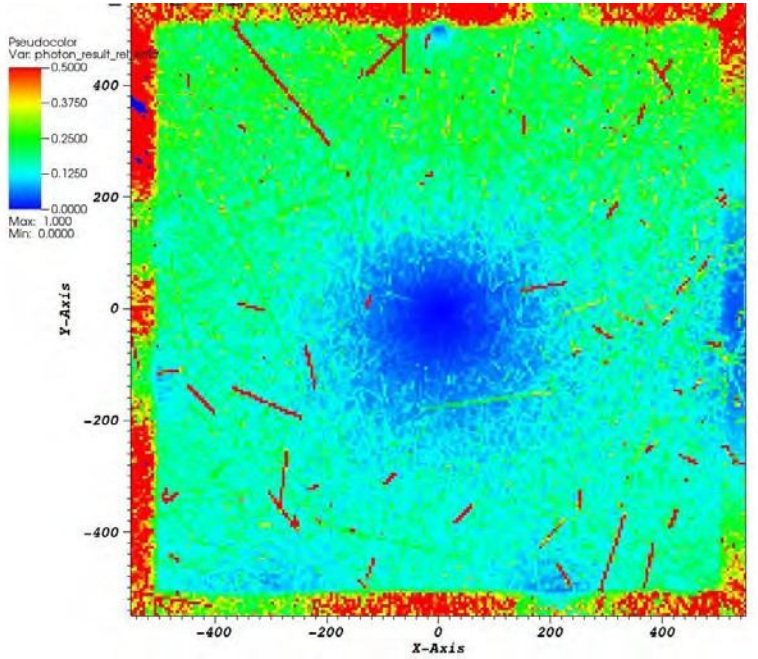
Initial tests

Simple thermal beam source, scattering on Fe plate and generating photons



Run	Rel err
Analog	0.059
Advantg	0.035

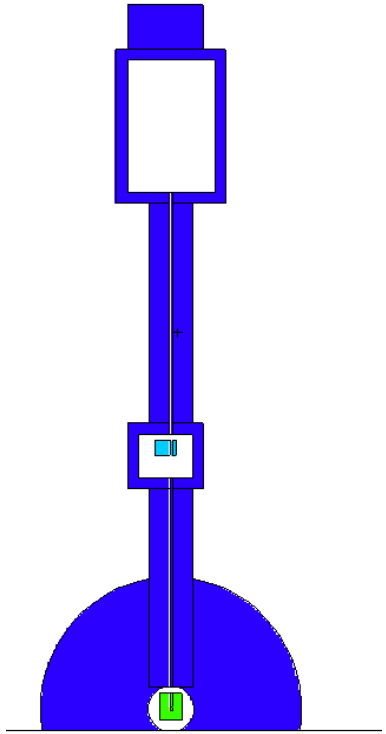


Rel err plot for Advantg WW run

Mixed success, energy bin results significantly improved, but the path from scatter to tally had higher error.

Initial tests

Fake beam line – lots of thick shielding, small volume water moderator source in Be reflector, long streaming path, 10cm diameter roughly 35m long



Attempting global WW using FWCADIS with default settings led to very long particle histories
The manual makes various suggestions to avoid long histories

- Improve Denovo mesh resolution
- Omitting low energy groups
- Different quadrature set

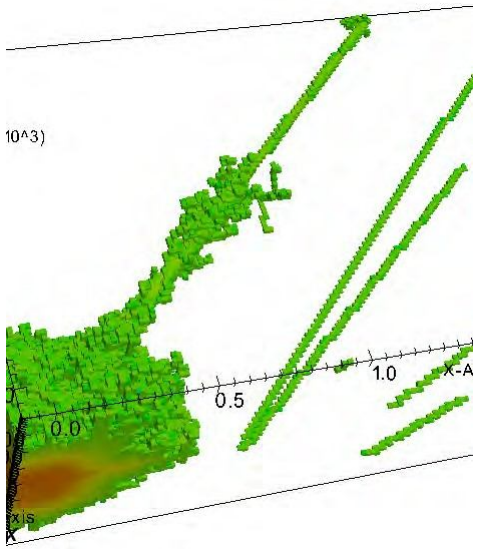
But so far none have been successful!

Real beam line model

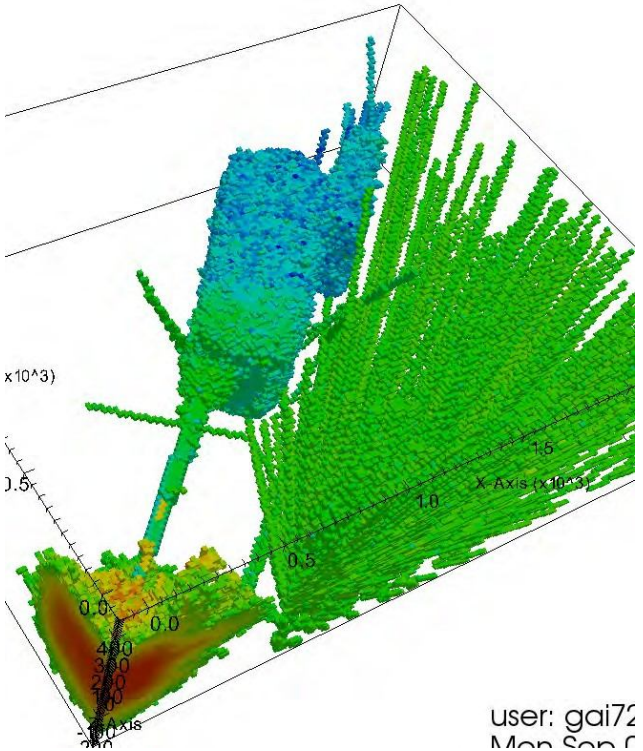
CHIPIR model
Target based WW target in front of beam stop
Fake 15MeV volume source in ISIS TS2 target

Definite improvement

But some long histories & might be only a few histories contributing



analog



ADVANTG

Conclusion

Advantg can produce very efficient weight windows, in fraction of the time an iterative method might take

But not a black box
Just like most variance reduction techniques requires practice and experience to make it work effectively

Long history generation appears to be a major issue for typical spallation instrument geometries

Would it be useful to have a spallation focused training course?

Thanks

Thanks to Jon Naish at UKAEA and Robert Grove, Joel Risner and Scott Mosher at Oak Ridge National Laboratory