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BWX Technologies, Inc.

Balancing the SCALE for 30 Years

Larry L. Wetzel, P. E.
Senior Advisory Engineer
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History

- Use of SCALE in the early 1980s
  - KENO-II and KENO-IV was used.
  - Global array, only one array allowed
  - Hansen-Roach 16 group library
  - 123 group library (LEU only)
- Moved to SCALE 4 in 1991
- Testing of SCALE-PC in 1993
- SCALE 4.2 used on HP Workstations in 1995
- SCALE 4.3 used on HP Workstations in 1996
- SCALE 4.4 used on HP Workstations and PCs in 1999
- SCALE 5.0 used on PCs in 2004
- SCALE 6.1 used on PCs in 2014

First Encounter with SCALE

- SCALE 3 was running on a water-cooled IBM mainframe
- As such, you needed JCL (Job Control Language)

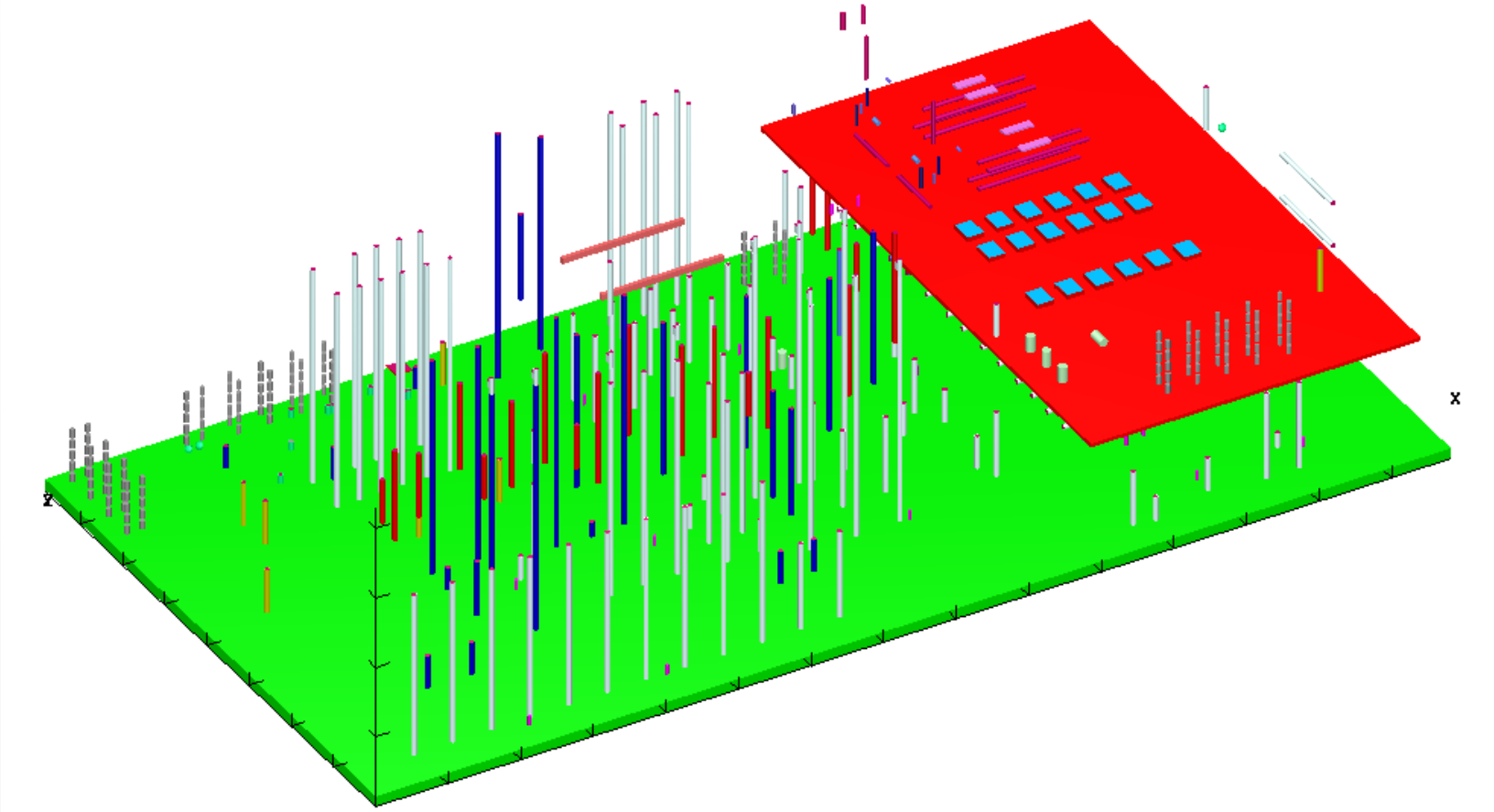
```
//LLWHC002 JOB (000420-LLW-P-050, BX17),WETZEL,MSGCLASS=X,CLASS=Z,
//   MSGLEVEL=1
//* DOD 99/99/99
//F1    OUTPUT CLASS=*,DEST=R6,JESDS=ALL
//COMP EXEC FORTQC
//FORT.SYSIN DD DSN=SCALE3.SOURCE(XSDOSE),DISP=SHR
//XSDOSE  EXEC SCAKEN5,GOSIZE=1920K,TME=48,OUT='*.F1'
//GO.SYSIN DD *
=NITAWAL
0$$  85 E 1$$ A2  6 E 1T
```

SCALE 3.0

- No direct connection to the IBM
- Used a modem to transmit
- Intermediate person submitted runs
- Next day, process was reversed for outputs
- KENO-V.a was the primary code but KENO-IV was used
- Hansen-Roach 16 Group Stand Alone Cross Sections
- Sigma-p calculations required

SCALE

- In 1990, built a model of Uranium Recovery



SCALE

- Took forever to run (12 hours for a dry condition)
- Why?

SCALE 3.0

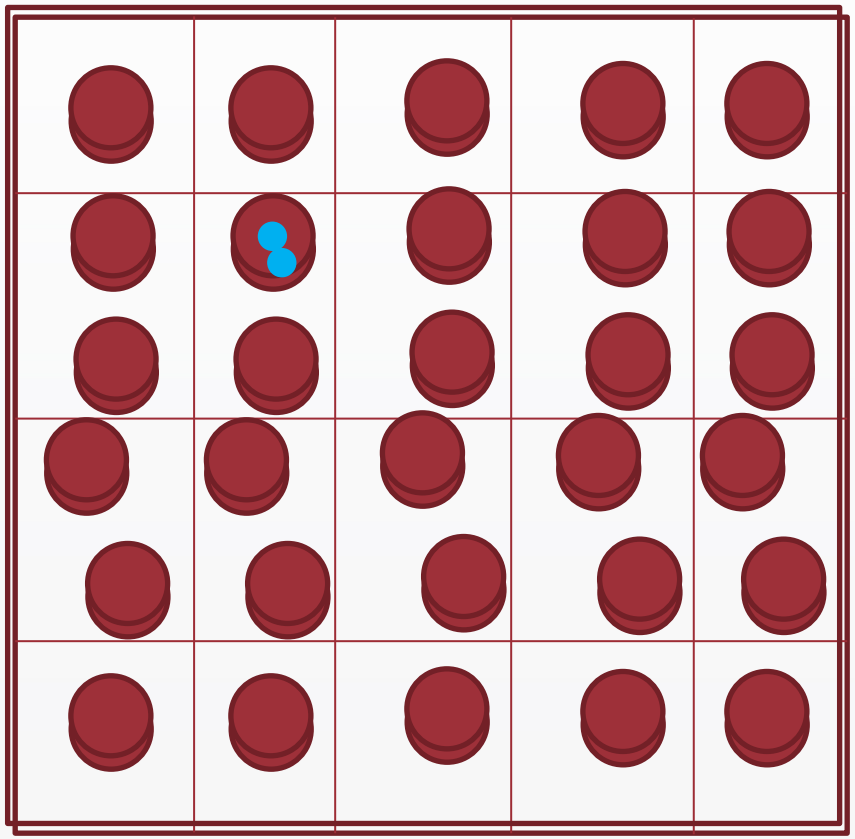
- Spent a week working with Nancy Landers and Lester Petrie
- Learned how the code works
- Model had a single cuboid with several hundred holes for equipment and process columns

How The Code Works

- Crossing of boundaries for a unit with holes.

Neutron crossed a boundary, so what region is it in?

Need to check every hole in the unit.



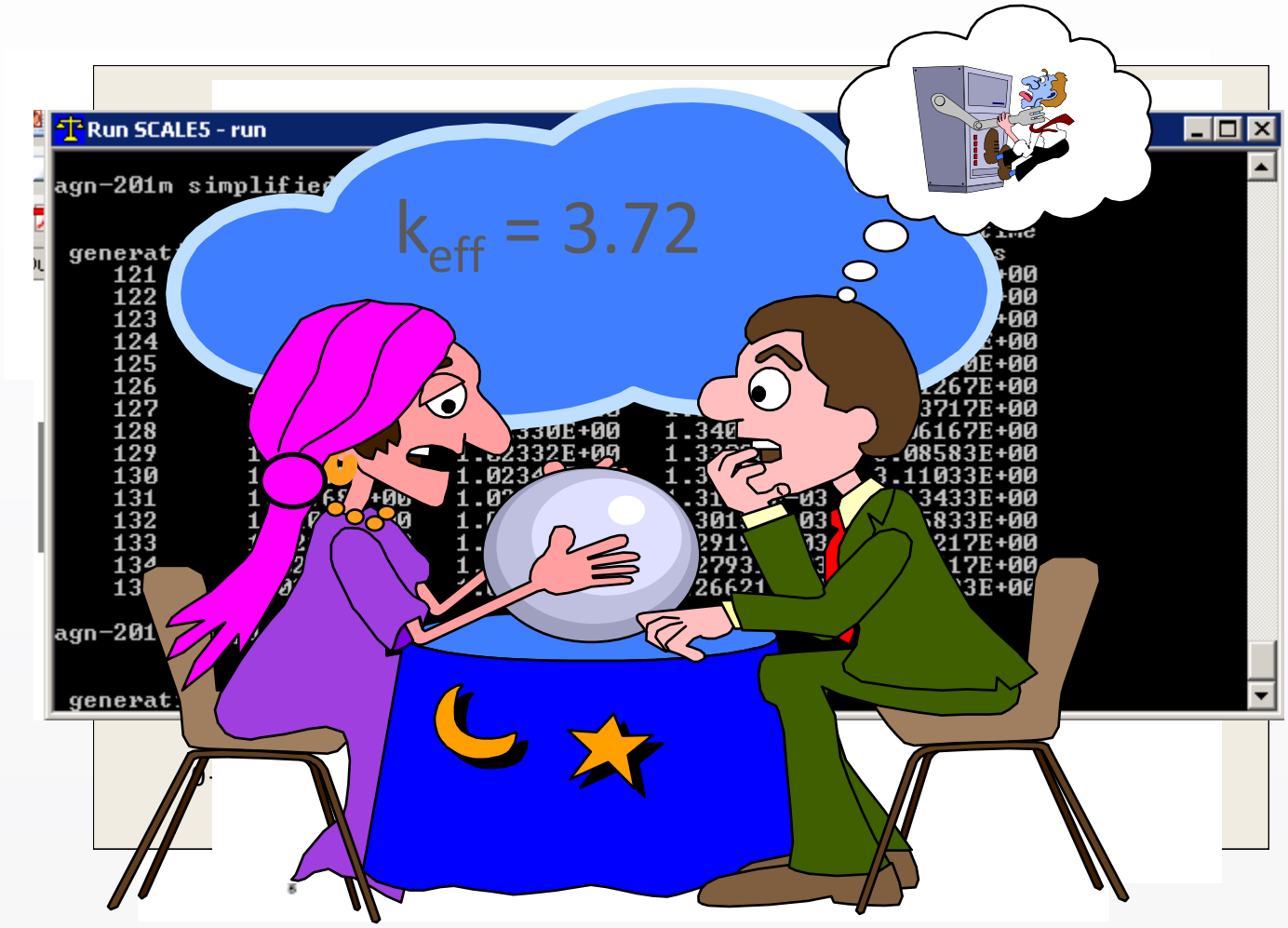
29 Holes

1 hole

SCALE 3.0

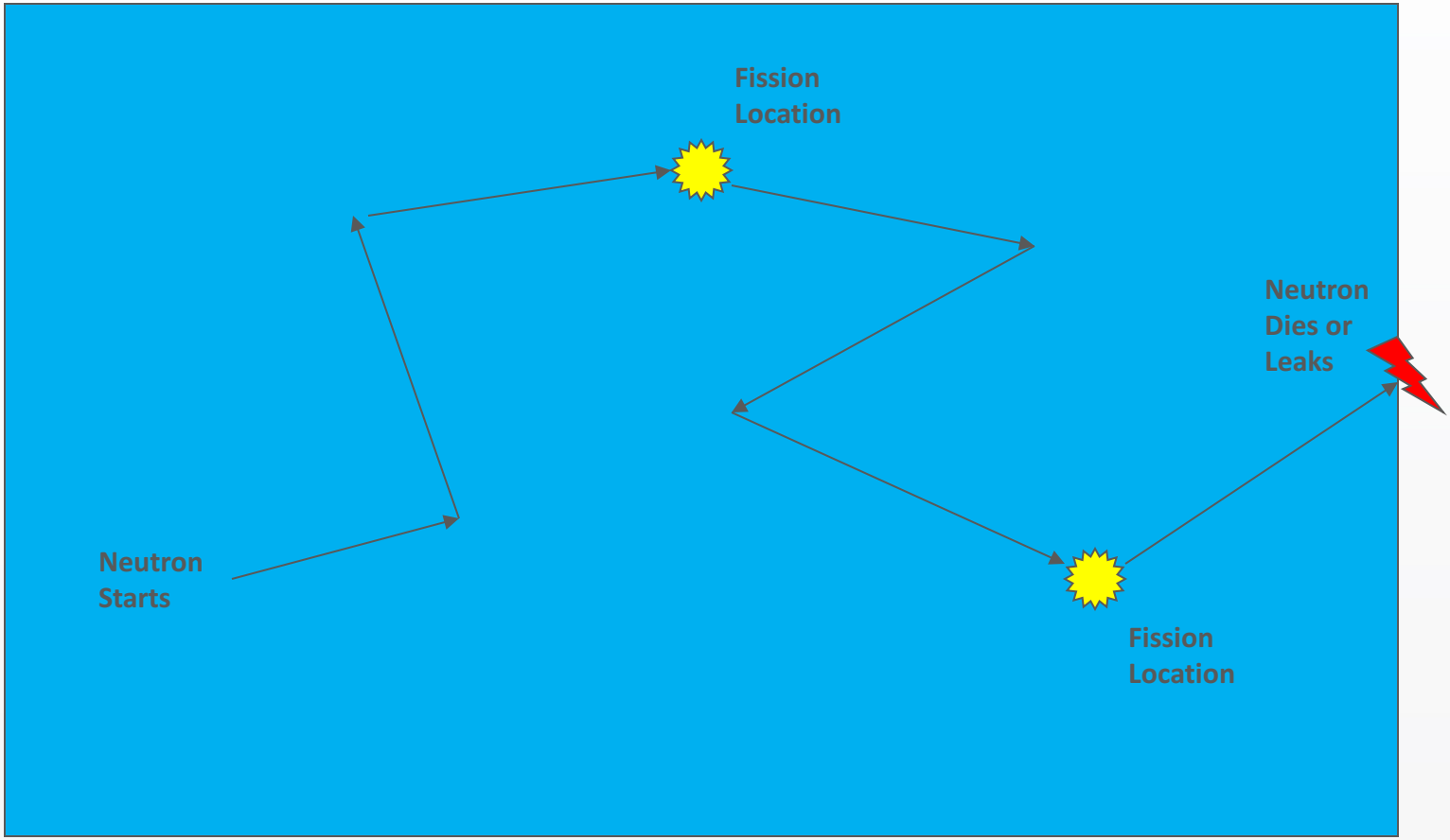
- 1993 PC KENO was in development
  - Jezebel with 103 generation and 300 neutrons per generation
  - 12 MHz PC
  - 20 minutes to complete

Monte Carlo Calculaton of k_{eff}



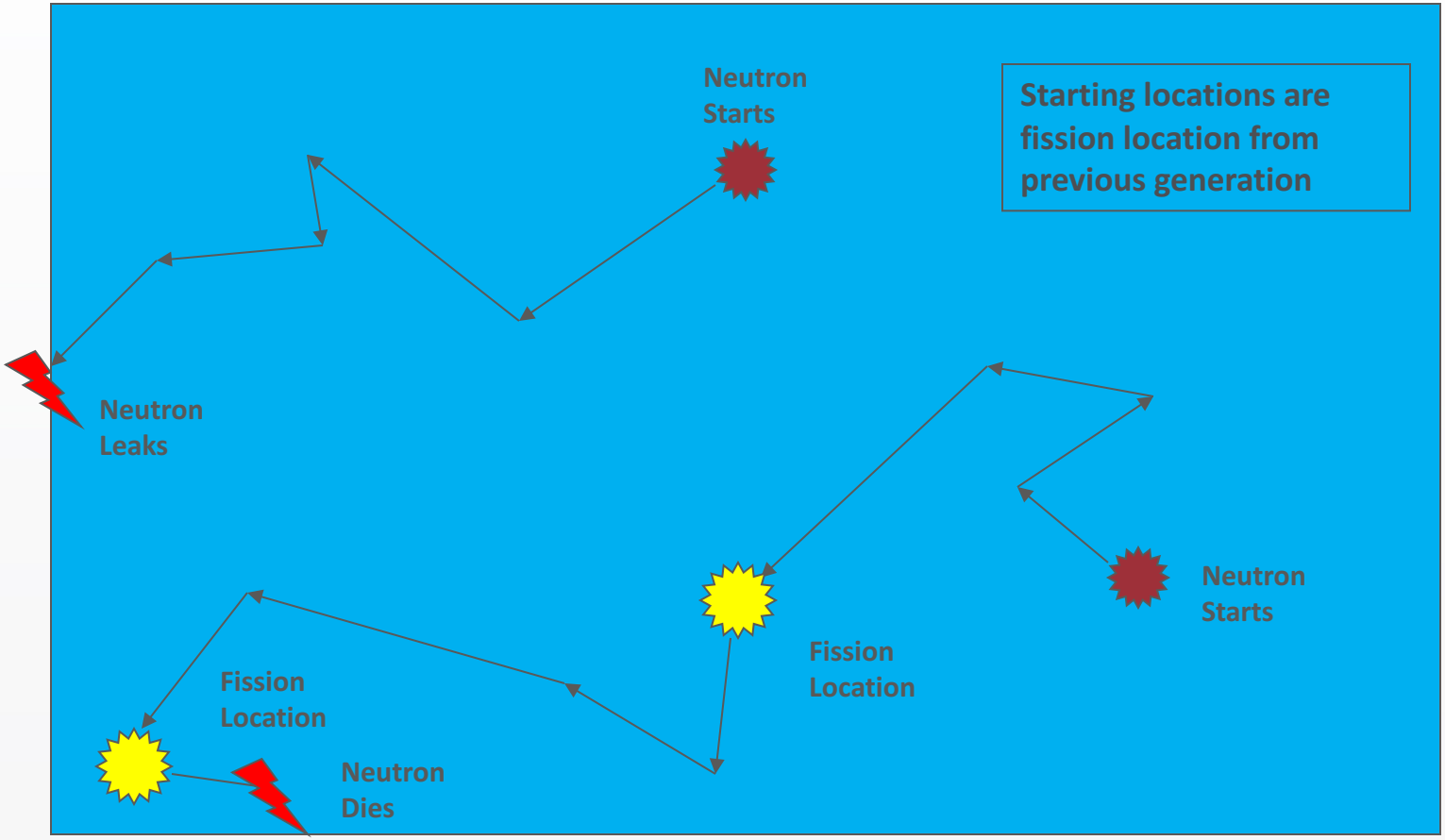
Simple Monte Carlo

First Generation



Simple Monte Carlo

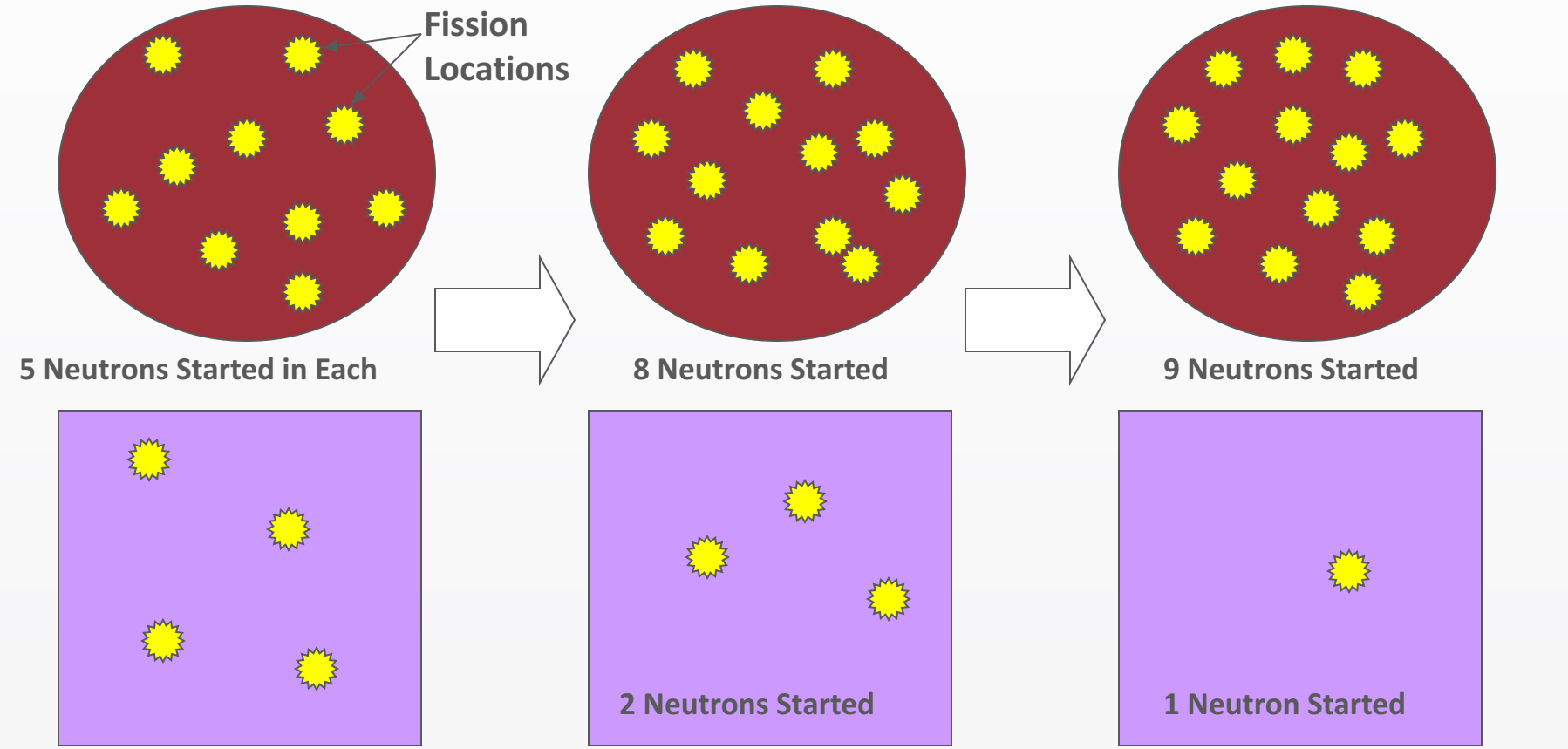
Second Generation



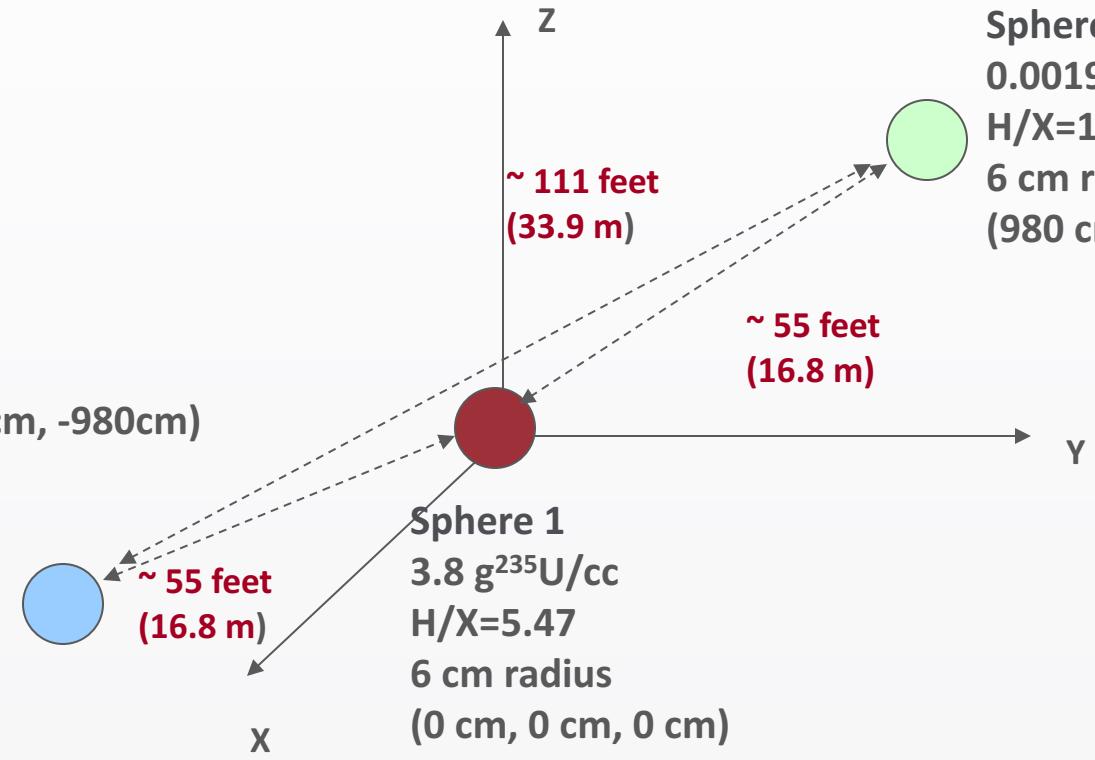
Calculate k_{eff}

- k_{eff} = $\frac{\text{\# of Fission Locations (generation N)}}{\text{\# of Fission Locations (generation N-1)}}$
- Average k_{eff} over (N – skipped) generations
- What about a system with two fissile components????

Two Fissile Components



Test Case



Results

Gen. Skipped	k_{eff}	Sphere 1 (3.8g/cc) Fission Den	Sphere 2 (0.0019 g/cc) Fission Den	Sphere 3 (15.2 g/cc) Fission Den
Equal Number Started in Each Sphere (START TYPE 6)				
1	0.665	1.34E-06	0	7.33E-04
10	0.665	0	0	7.35E-04
All Started in Sphere 1				
1	0.390	4.31E-04	0	0
10	0.390	4.31E-04	0	0
100	0.391	4.35E-04	0	0
All Started in Sphere 2				
1	0.0118	0	1.31E-05	0
10	0.0117	0	1.31E-05	0
All Started in Sphere 3				
1	0.663	0	0	7.34E-04
10	0.664	0	0	7.34E-04

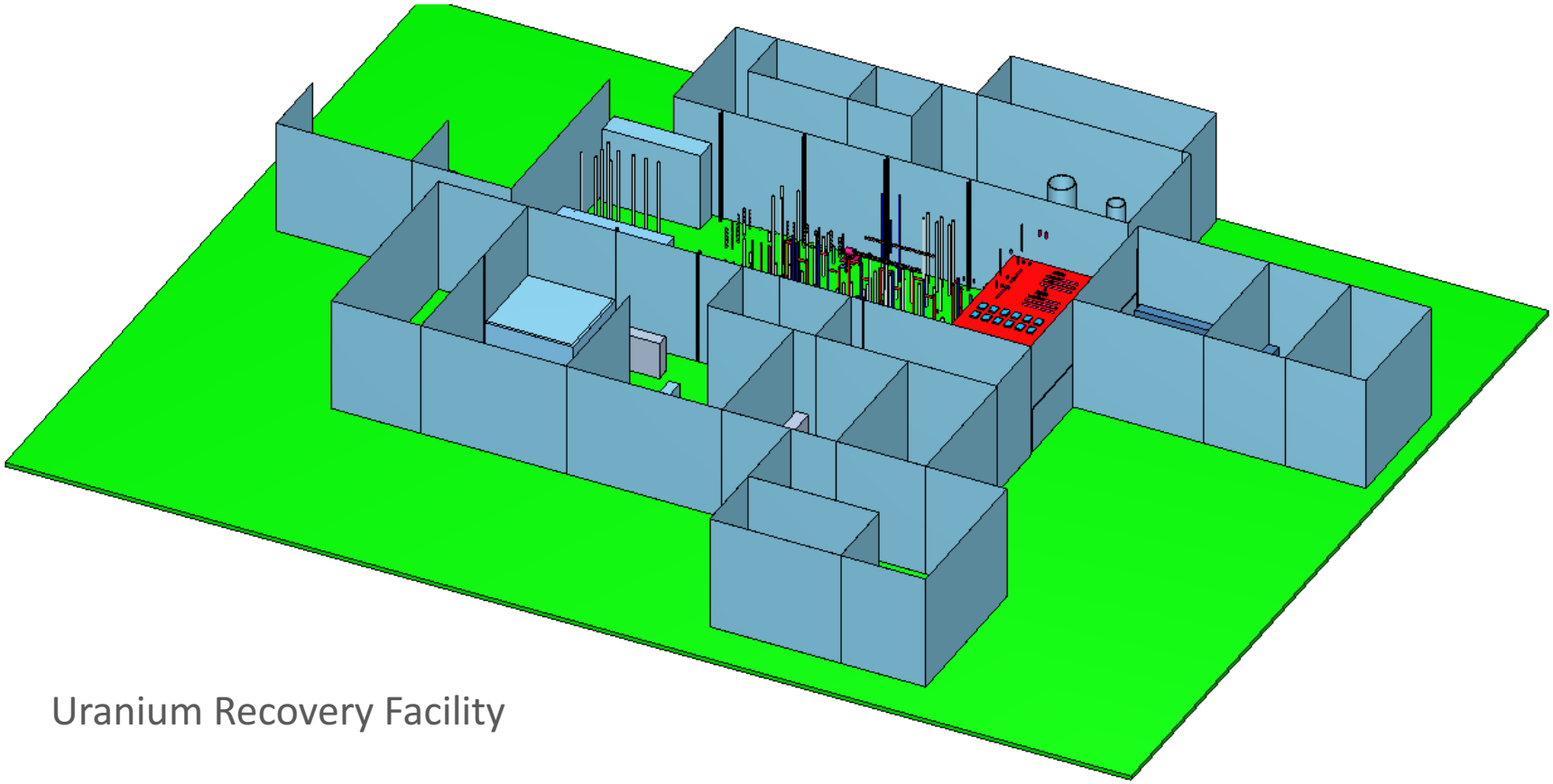
Current Applications

- CSAS5 is our workhorse
  - V7-238 group cross sections
  - Run on individual PCs
- CSAS6 is available but rarely used
  - Slower running, but has geometry capabilities that are unique
- TSUNAMI
  - Limited use at the moment
  - Would like to utilize capability in the future

Current Applications

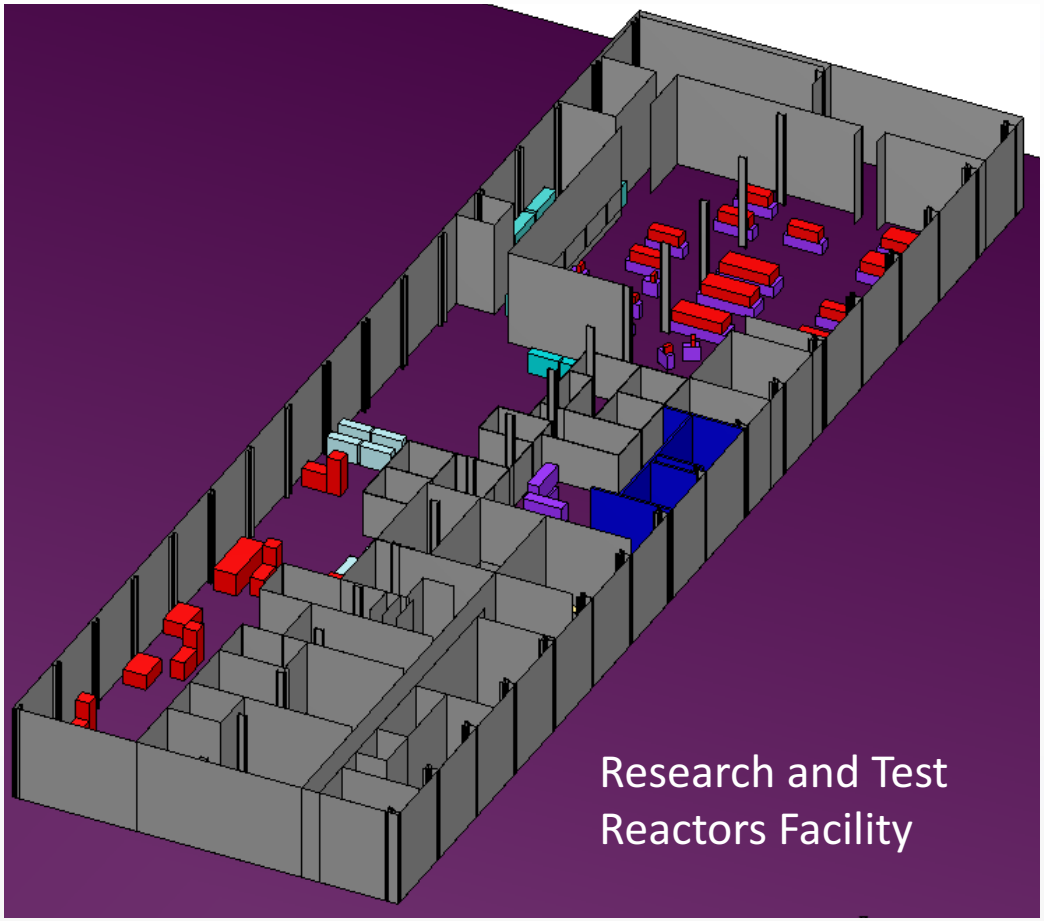
- MAVRIC
- Criticality Accident Alarm System (CAAS) detector placement
  - Coupled neutron-gamma library
  - Multiple utilities routines needed
  - Paradigm shift, what is conservative

CAAS Placement

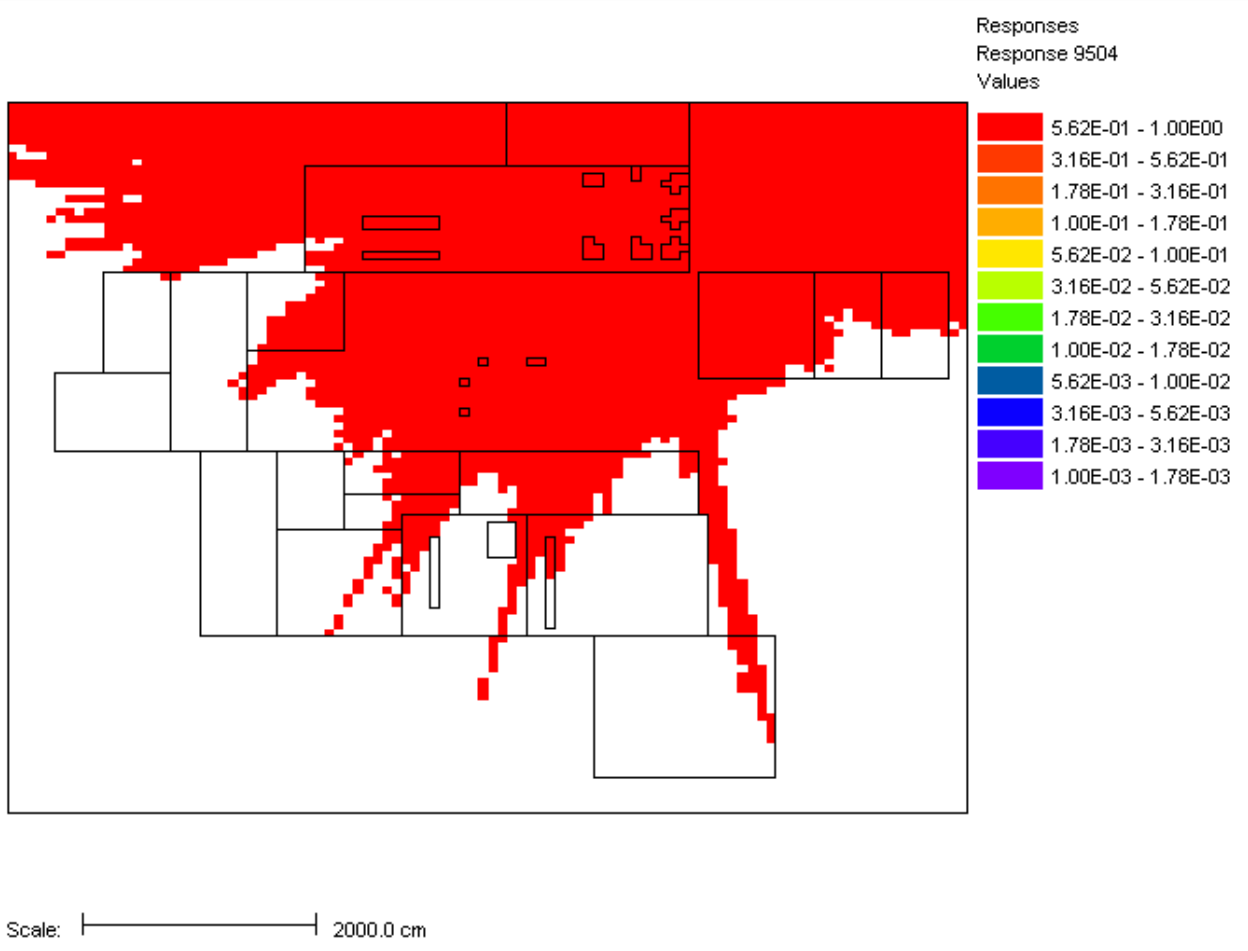


Uranium Recovery Facility

CAAS Placement



CAAS Maps



Takeaways

- SCALE has many more capabilities than one person needs
- Understand the physics and how the code represents the physics
- Understand how the code operates

Questions