SAND2017-2634C

Abstract for presentation to the Rio Grande Chapter of the Health Physics Society 2017 Spring Technical Meeting

Title: Neutron Dose in Whole Body Dosimeter Algorithm at Sandia National Laboratories

Presented by: David Farrar

Abstract:

The whole body dosimeter used at Sandia National Laboratories is used to measure occupational dose to personnel from external radiation. A discovery was made regarding the determination of dose measured by the dosimeter. There are instances where dose from neutrons could be missed. This presentation discusses the dosimeter; provides the overall dosimeter-to-dose process; and describes the discovery, its impact, and its remedy.

Exceptional service in the national interest

Sandia National Laboratories

Neutron Dose in Whole Body Dosimeter Algorithm at Sandia National Laboratories

David R. Farrar, CHP

Radiation Protection Department

Radiation Protection Dosimetry Program

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Outline

Sandia National Laboratories

- SNL whole body dosimeter and algorithm for calculating dose
- Algorithm for dose from neutrons
- Discovery
- Impact
- Remedy

SNL Dosimeters

- Two types of personnel dosimeters used at SNL to measure occupational dose
  - Extremity dosimeter
    - Worn on finger
    - Not sensitive to neutrons
  - Whole body dosimeter
    - Worn on chest
    - Sensitive to neutrons
    - Focus of presentation, “dosimeter” hereafter

Dosimeter

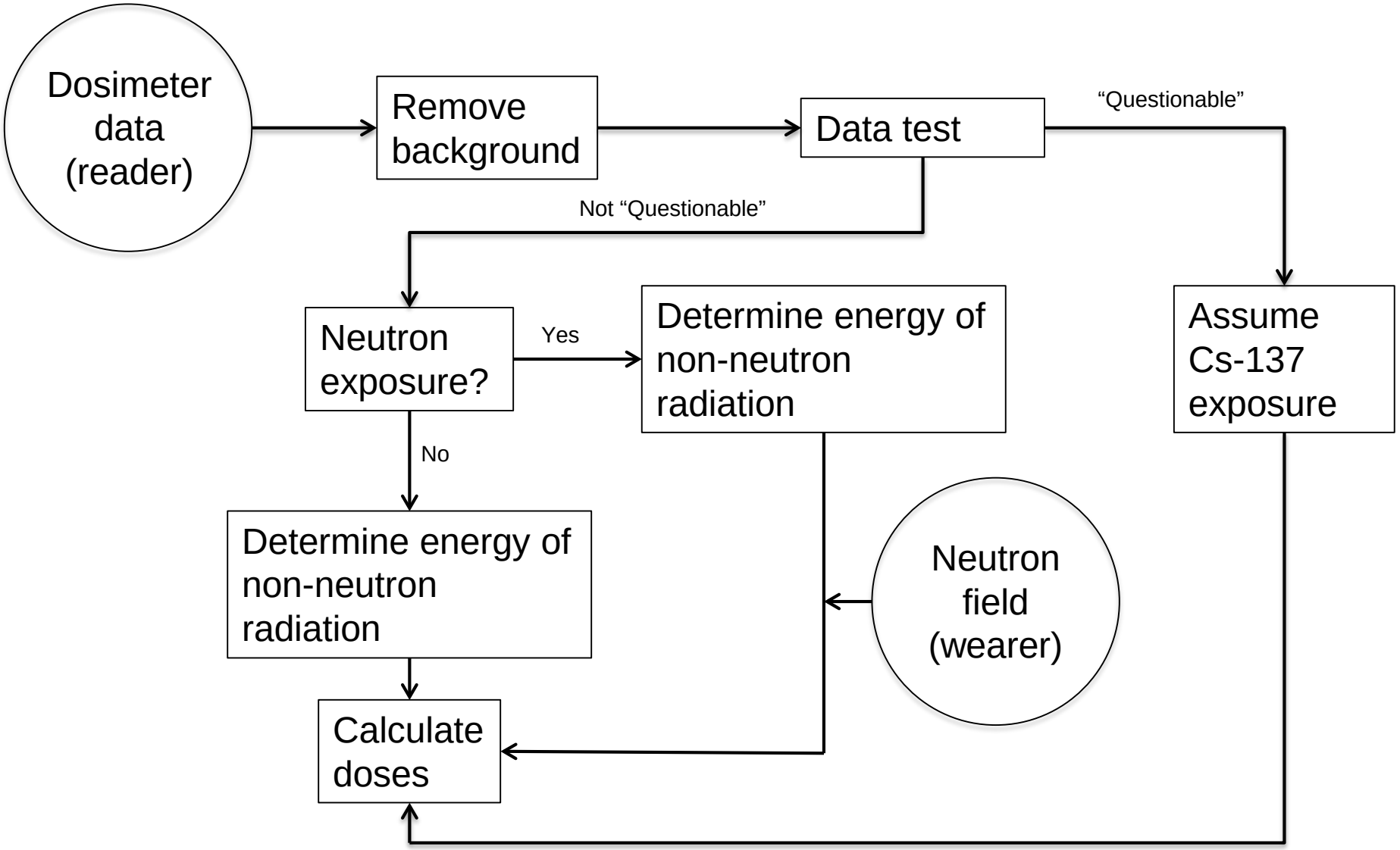
- Consists of 4 thermoluminescent dosimeter (TLD) chips
- Chips read in reader to get data about radiation exposure
- Each chip sensitive to radiation
  - Chips 1-3: non-neutrons only
  - Chip 4: non-neutrons & neutrons

Dosimeter → Dose (Algorithm)

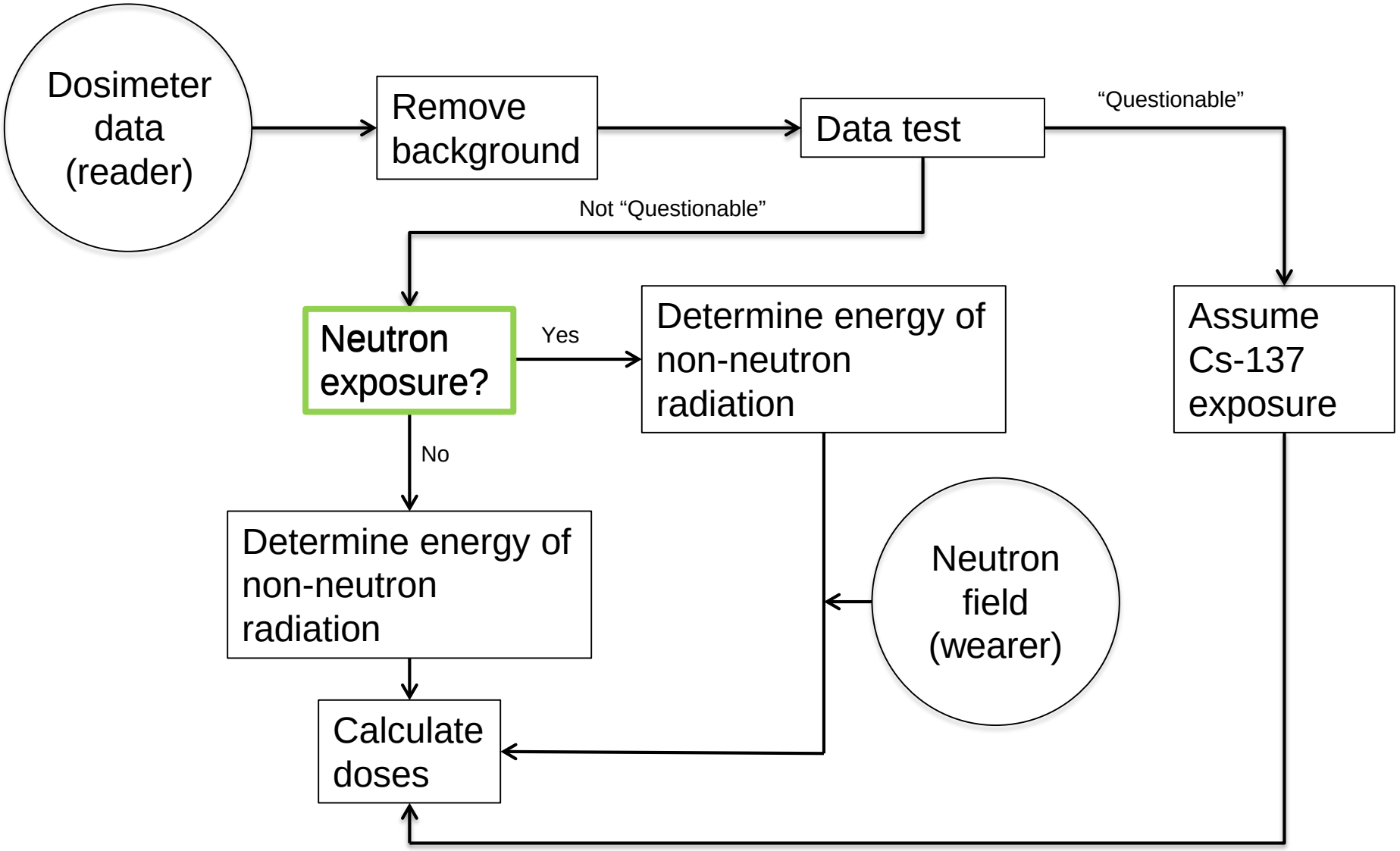
Sandia National Laboratories

- Dosimeter data used in an algorithm to calculate occupational doses
  - Algorithm calculates deep dose from photons, deep dose from neutrons, eye dose, and shallow dose
  - Algorithm contains decision point on potential neutron exposure of dosimeter
    - If potential neutron exposure found, assessment of dose from neutrons made
  - Prior to the decision point the algorithm has another decision point due to a data test

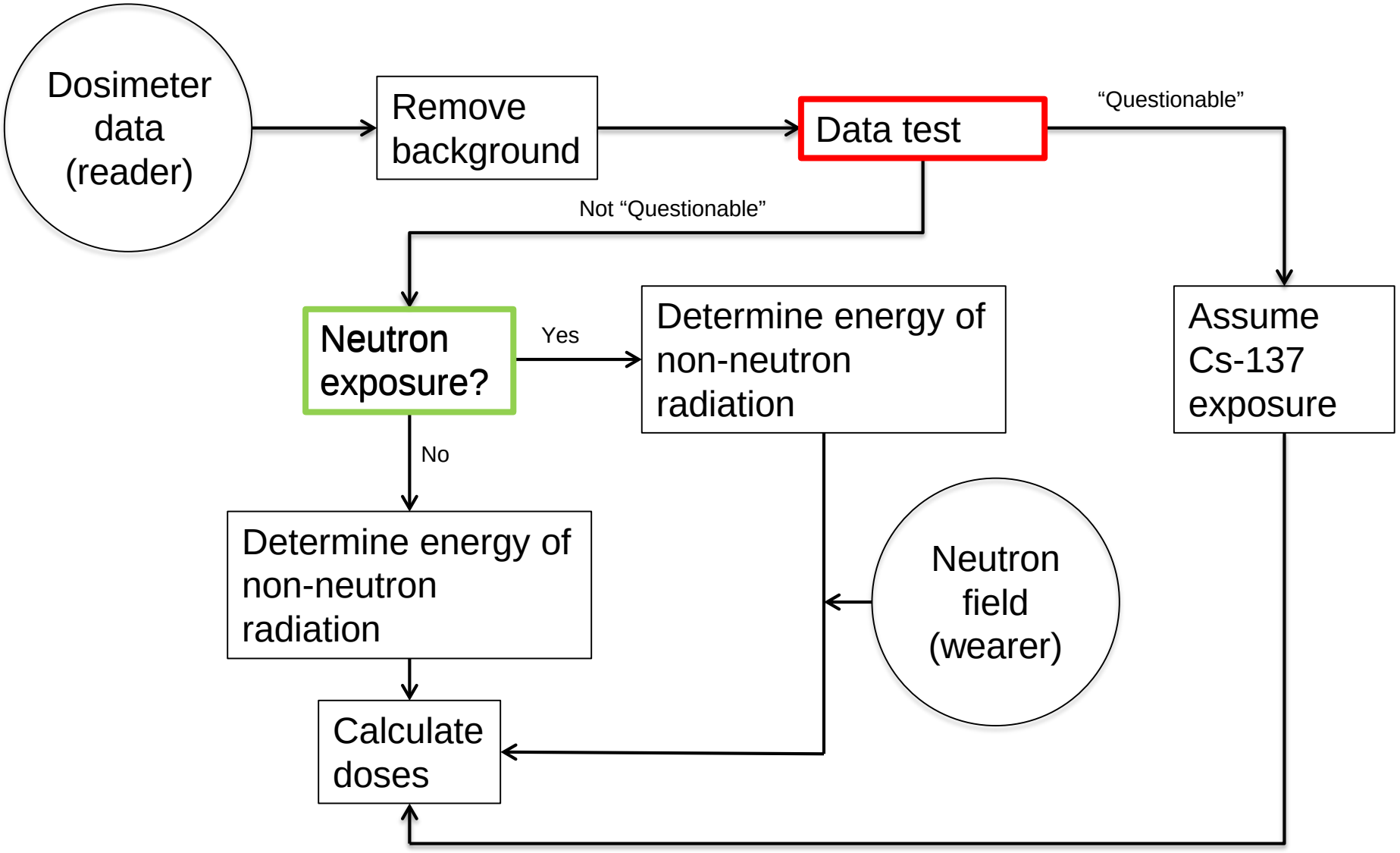
Dose algorithm



Dose algorithm



Dose algorithm



Data Test

Sandia National Laboratories

- Algorithm tests ratios of chip responses
  - Ratios are checked against boundary conditions
  - No tests consider response from neutron-sensitive chip (L4)
- If data "questionable", algorithm assumes Cs-137 exposure and does not consider neutron exposure as a possibility

Discovery

- In late 2014, examination of dosimeter data found a couple slightly elevated chip 4 (neutron sensitive) readings for individuals that work around devices capable of generating neutrons
- Due to previous work experience supporting devices, knew that neutron exposure was possible and could result in non-trivial doses
- Examination of algorithm results found the algorithm deemed these dosimeter results to be "questionable"
  - No assessment of neutron exposure performed by algorithm

Work Around

- Work around: Added step in dose approval process to manually check for missed neutron doses
  - Prior to dose approval, dosimeter data checked with spreadsheet
  - Check performs neutron exposure evaluation regardless if dosimeter data “questionable”
    - Same evaluation used in algorithm
  - If check determines neutron exposure with possible dose consequence may have been missed by algorithm, issue dose investigation

Impact

- So far:
  - Found ~15 dosimeters assigned to personnel where algorithm missed neutron dose
    - Each missed neutron dose ~40 mrem, maximum 50 mrem
  - Found ~10 dosimeters used for area monitoring where algorithm missed neutron dose
    - All from areas that are evacuated prior to neutron exposure

Avg Dose (rem)/Shot

Deep	Shallow	Neutron	Neut Sig (gU) Location
0.029	0.029	7.957	429.28 1) - +90 deg - 1 - morning
0.028	0.028	6.930	374.99 2) - +90 deg - 2 - morning
0.043	0.043	6.727	377.30 3) - +90 deg - 3 - morning
0.027	0.027	7.578	409.71 4) - +90 deg - 4 - morning
0.029	0.029	7.105	383.61 5) - 0 deg - 1 - morning
0.031	0.042	<LLD	393.20 6) - 0 deg - 2 - morning
0.031	0.041	<LLD	376.12 7) - 0 deg - 3 - morning
0.030	0.030	7.801	420.44 8) - 0 deg - 4 - morning

Area dosimeters exposed to device capable of generating neutrons. “0 deg” dosimeters exposed to same neutron field.

Fix

- Fix: Working to modify SNL dose algorithm
  - Reverse steps of data test and determination of neutron exposure in algorithm
    - No longer need manual check
      - Save time and reduce human errors
  - Tested modified algorithm with data from Department of Energy Laboratory Accreditation Program (DOELAP) performance tests
    - Performance tests based on exposing dosimeters to isotopes (including deuterium-moderated Cf-252) and/or x-rays
    - Results from modified algorithm identical to results from current algorithm
  - Got approval from DOE Laboratory Accreditation Program to use algorithm
    - Updating documentation prior to 2017 implementation

Future Algorithm