SAND2016-5120PE

Workshop challenge problems

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Imaging IB workshop

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Workshop challenge problem #1

Purpose

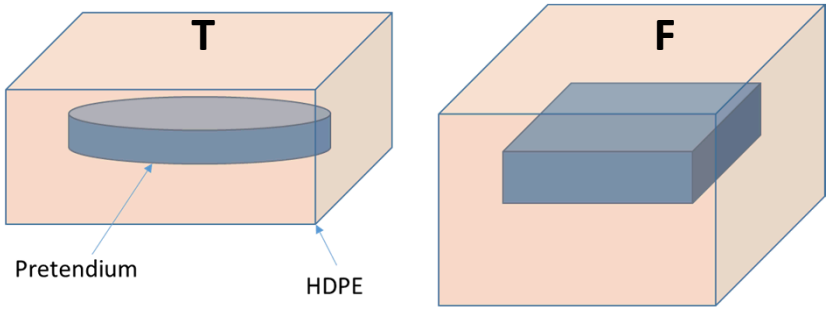
- Challenge problem for consideration in advance of the workshop.
- Common context to understand techniques.
  - Not for quantitative comparison of performance!
- Sufficient detail for radiation transport simulations, but flexible enough to accommodate range of methods.
  - Add in assumptions, caveats, etc. as needed to flesh it out for your technique.
- Abstract material storage scenario.
  - Materials and geometries, as well as declared “sensitive” information, are defined arbitrarily for this exercise.

Materials

- HDPE
- Pretendium (Pn)
  - Mass density of tungsten.
  - Radiation interaction cross-sections of lead.
  - Neutron source term of 1e5 n/s/kg (Cf-252 spectrum).
  - Gamma source term of 1e7 n/s/kg (Eu-152 spectrum).
  - IAEA significant quantity of pretendium is 10 kg.

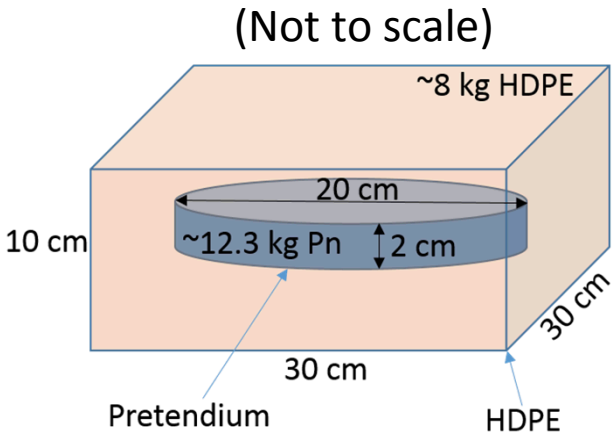
Scenario

- In a treaty, a type 1 TAI is defined as having at least 1 IAEA s.q. of pretendium in a circular plate (cylindrical) form, embedded in a block of HDPE.
  - All type 1 TAIs have the same quantity and form of Pn, not specified.
  - Dimensions of Pn, in particular its diameter *d*, are to be considered sensitive.
- Inspector has or had access to measure item T, a known valid TAI of type 1.
  - Allows for techniques relying on a template measurement or golden item.
- Verification process:
  1. Host declares item X as a type 1 TAI.
  2. Host presents item X for inspection.
     - Item is in some larger container for visual obstruction.
  3. Inspector needs to acquire confidence that item X is in fact a type 1 TAI.
     - Item F is an example of an object that should fail.
  4. Host must be confident that the inspector does not learn the diameter *d* of the pretendium.
     - Knowledge to std dev of 30% after 1000 measurements is OK.



Geometry

- Solid mass of Pn embedded in block of HDPE
  - Permits emission or transmission imaging
- Valid TAI details (not known to inspector):
  - 20 cm dia. x 2 cm Pn, 12.3 kg
  - 30 cm x 30 cm x 10 cm HDPE, ~8 kg
  - Pn centered in HDPE block
- Example of non-valid TAI:
  - Pn with square cross-section:
    17.7 cm x 17.7 cm x 2 cm, 12.3 kg



Challenge Tasks

- Each group defines
  - Measurement equipment
  - Sequence of events (CONOPS)
  - Other requirements (e.g. does item T need to be present?)
- Demonstrate that a second copy of item T should pass.
- Demonstrate that item F should fail.
- Demonstrate that diameter *d* of Pn cannot be determined by the inspector.
- Consider other fail items as desired. For example, let N vertices of the Pn in item F increase (hexagon, octagon, etc.)

Workshop challenge problem #2

Purpose

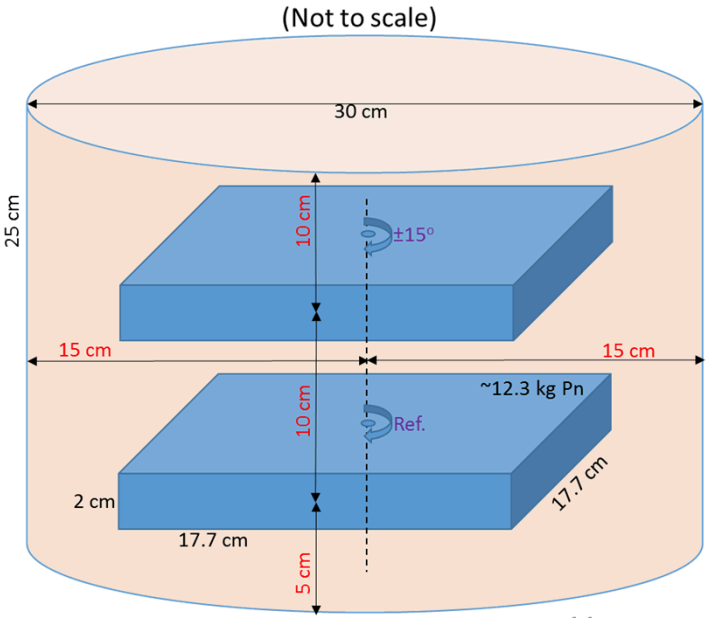
- Challenge problem for consideration in breakout discussions at the workshop.
- Add some feature/complexity with respect to original scenario.
- Add in assumptions, caveats, etc. as needed to flesh it out for your technique.
- Abstract material storage scenario.
  - Materials and geometries, as well as declared "sensitive" information, are defined arbitrarily for this exercise.

Materials

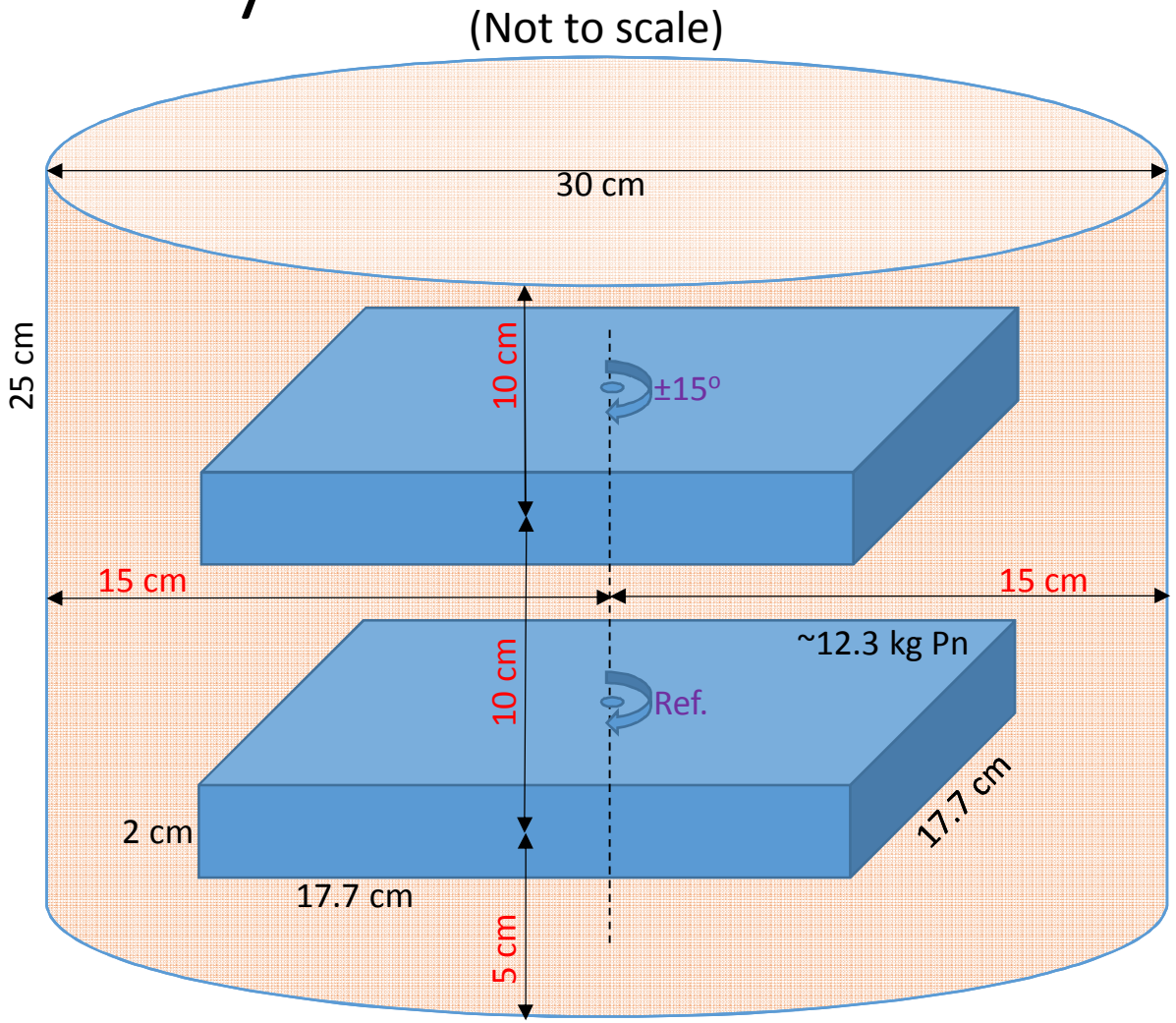
- HDPE
- Pretendium (Pn)
  - Mass density of tungsten.
  - Radiation interaction cross-sections of lead.
  - Neutron source term of 1e5 n/s/kg (Cf-252 spectrum).
  - Gamma source term of 1e7 n/s/kg (Eu-152 spectrum).
  - IAEA significant quantity of pretendium is 10 kg.

Scenario

- In a treaty, a type 1 TAI is defined as having two square plates of pretendium, 12.3 kg each, embedded in a block of HDPE.
  - The Pn shape and size (17.7 cm x 17.7 cm x 2 cm) is known to the inspector and is to be confirmed.
  - The location of the two plates within the HDPE is not specified. All type 1 TAIs have the same such positioning. The corresponding dimensions (e.g. the distance between the two plates) are to be considered sensitive.
  - The two plates are generally aligned, but there is a +/- 15 degree variability in their relative rotation. (Nuisance parameter.)
- Inspector has or had access to measure item T, a known valid TAI of type 1.
  - Allows for techniques relying on a template measurement or golden item.
- Verification process:
  1. Host declares item X as a type 1 TAI.
  2. Host presents item X for inspection.
     - Item is in some larger container for visual obstruction.
  3. Inspector needs to acquire confidence that item X is in fact a type 1 TAI.
  4. Host must be confident that the inspector does not learn the locations of the pretendium blocks within the HDPE.
     - Knowledge to std dev of 30% after 1000 measurements is OK.



Geometry


(Not to scale)
30 cm
25 cm
10 cm
±15°
15 cm
15 cm
~12.3 kg Pn
10 cm
Ref.
2 cm
17.7 cm
17.7 cm
5 cm

Geometry

- New features relative to previous scenario:
  - Two Pn plates
  - Sensitive information is positioning of plates
  - Presence of a nuisance parameter that varies from one valid TAI to another: relative orientation of plates
- Examples of non-valid TAIs (all with appropriate HDPE):
  - A single square plate of Pn
  - Two circular plates of Pn
  - Two square plates, 10 cm x 10 cm x 2 cm each, of Pn

Group discussion questions

- What changes in measurement equipment or CONOPS would be needed relative to the first scenario? Goals remain the same:
  - To demonstrate that a true type 1 TAI will pass.
  - To demonstrate that some false items F will fail.
  - To demonstrate that the locations of Pn plates (e.g. distance between them) cannot be determined by the inspector.
- Does the performance or applicability of the method differ with respect to the first scenario?
- How does the introduction of a nuisance parameter affect the method?