



Universidad de Zaragoza

Facultad de Ciencias

DISEÑO DE UN DETECTOR DE CONTAMINACIÓN
SUPERFICIAL DE ALFAS DE ALTA SENSIBILIDAD

– ANEXOS –

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Anexo I: Geiger-Nuttall

Gráfica del logaritmo de la vida media de isótopos frente a la energía de su decaimiento α .

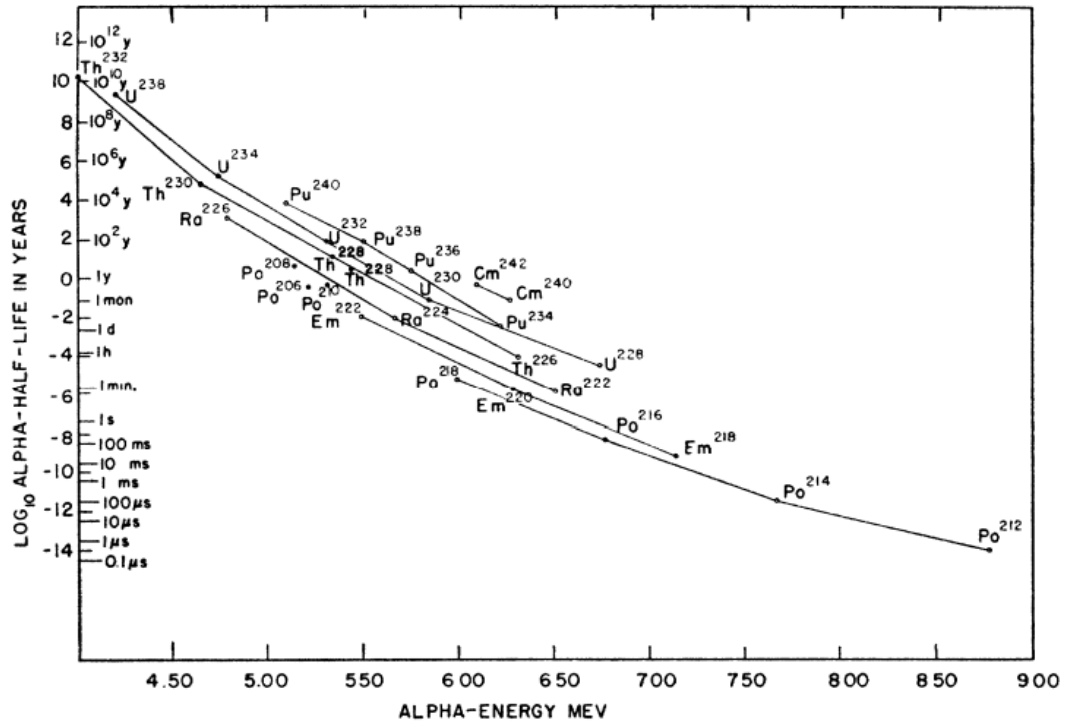


Figura 1: I. Perlman, A. Ghiorso and G. T. Seaborg. Phys. Rev. 75 (1949) 1096.

Anexo II: geometry.gdml (parte 1)

```
<solids>
  <box name="WorldSolid" x="world_size" y="world_size" z="world_size" lunit="mm"/>

  <box name="vesselSolid1" x="VesselXSize" y="VesselYSize" z="VesselZSize" lunit="mm" />

  <box name="gasSolid1" x="VesselXSize-2*vessel_thickness" y="VesselYSize-2*vessel_thickness" z="VesselZSize-2*vessel_thickness" lunit="mm" />

  <box name="topSolid1" x="VesselXSize" y="VesselYSize" z="vessel_thickness" lunit="mm" />

  <tube name="capsuleSolid1" startphi="0" deltaphi="360" rmin="0" rmax="capsule_radius" z="capsule_thickness" aunit="deg" lunit="mm" />

  <tube name="capsuleholeSolid" startphi="0" deltaphi="360" rmin="0" rmax="capsulehole_radius" z="capsule_thickness" aunit="deg" lunit="mm" />

  <box name="windowSolid" x="windowXSize" y="windowYSize" z="vessel_thickness" lunit="mm"/>

  <box name="mylarSolid" x="windowXSize" y="windowYSize" z="mylar_thickness" lunit="mm"/>

  <tube name="wireSolid" startphi="0" deltaphi="360" rmin="0" rmax="wire_radius" z="wire_length" aunit="deg" lunit="mm" />

  <box name="muestraSolid" x="muestraXSize" y="muestraYSize" z="muestra_thickness" lunit="mm" />

  <box name="readoutSolid" x="readout_size" y="readout_size" z="readout_thickness" lunit="mm"/>

<!-- The vessel -->

  <subtraction name="vesselSolid2">
    <first ref="vesselSolid1"/>
    <second ref="gasSolid1"/>
  </subtraction>

  <subtraction name="vesselSolid">
    <first ref="vesselSolid2"/>
    <second ref="topSolid1"/>
    <positionref ref="top_position"/>
  </subtraction>

  <subtraction name="topSolid">
    <first ref="topSolid1"/>
    <second ref="windowSolid"/>
    <positionref ref="window_position"/>
  </subtraction>

  <subtraction name="capsuleSolid">
    <first ref="capsuleSolid1"/>
    <second ref="capsuleholeSolid"/>
    <positionref ref="capsule_position"/>
  </subtraction>

<!-- The target -->

  <subtraction name="gasSolid2">
    <first ref="gasSolid1"/>
    <second ref="readoutSolid"/>
    <positionref ref="readout_position"/>
  </subtraction>

  <union name="gasSolid" >
    <first ref="gasSolid2" />
    <second ref="windowSolid" />
    <positionref ref="window_position" />
  </union>

<!--The cathode -->

  <union name="wirePlaneSolid_1" >
    <first ref="wireSolid" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_01r" />
  </union>
  <union name="wirePlaneSolid_2" >
    <first ref="wirePlaneSolid_1" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_02r" />
  </union>
  <union name="wirePlaneSolid_3" >
    <first ref="wirePlaneSolid_2" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_03r" />
  </union>
  <union name="wirePlaneSolid_4" >
    <first ref="wirePlaneSolid_3" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_04r" />
  </union>
  <union name="wirePlaneSolid_5" >
    <first ref="wirePlaneSolid_4" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_05r" />
  </union>
  <union name="wirePlaneSolid_6" >
    <first ref="wirePlaneSolid_5" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_06r" />
  </union>
  <union name="wirePlaneSolid_7" >
    <first ref="wirePlaneSolid_6" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_07r" />
  </union>
  <union name="wirePlaneSolid_8" >
    <first ref="wirePlaneSolid_7" />
    <second ref="wireSolid" />
    <positionref ref="wire_position_08r" />
  </union>
```

Anexo II: geometry.gdml (parte 2)

```
<union name="wirePlaneSolid_9" >
  <first ref="wirePlaneSolid_8" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_09r" />
</union>
<union name="wirePlaneSolid_11" >
  <first ref="wirePlaneSolid_9" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_01l" />
</union>
<union name="wirePlaneSolid_12" >
  <first ref="wirePlaneSolid_11" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_02l" />
</union>
<union name="wirePlaneSolid_13" >
  <first ref="wirePlaneSolid_12" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_03l" />
</union>
<union name="wirePlaneSolid_14" >
  <first ref="wirePlaneSolid_13" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_04l" />
</union>
<union name="wirePlaneSolid_15" >
  <first ref="wirePlaneSolid_14" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_05l" />
</union>
<union name="wirePlaneSolid_16" >
  <first ref="wirePlaneSolid_15" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_06l" />
</union>
<union name="wirePlaneSolid_17" >
  <first ref="wirePlaneSolid_16" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_07l" />
</union>
<union name="wirePlaneSolid_18" >
  <first ref="wirePlaneSolid_17" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_08l" />
</union>
<union name="wirePlaneSolid" >
  <first ref="wirePlaneSolid_18" />
  <second ref="wireSolid" />
  <positionref ref="wire_position_09l" />
</union>
</solids>

<structure>

  <!-- {{{ Volumes definition (material and solid assignment) -->

  <volume name="gasVolume">
    <materialref ref="{GDML_GAS}" />
    <solidref ref="gasSolid" />
  </volume>

  <volume name="vesselVolume">
    <materialref ref="{GDML_VESSEL_MATERIAL}" />
    <solidref ref="vesselSolid" />
  </volume>

  <volume name="capsuleVolume">
    <materialref ref="PTFE" />
    <solidref ref="capsuleSolid" />
  </volume>

  <volume name="capsuleholeVolume">
    <materialref ref="Air" />
    <solidref ref="capsuleholeSolid" />
  </volume>

  <volume name="topVolume">
    <materialref ref="{GDML_TOP_MATERIAL}" />
    <solidref ref="topSolid" />
  </volume>

  <!-- Cathode/Window -->

  <volume name="mylarVolume">
    <materialref ref="Mylar" />
    <solidref ref="mylarSolid" />
  </volume>

  <volume name="wirePlaneVolume">
    <materialref ref="Stainlesssteel" />
    <solidref ref="wirePlaneSolid" />
  </volume>

  <!-- Readout -->

  <volume name="readoutVolume">
    <materialref ref="Copper" />
    <solidref ref="readoutSolid" />
  </volume>

  <!-- Muestra -->

  <volume name="muestraVolume">
    <materialref ref="{GDML_MUESTRA_MATERIAL}" />
    <solidref ref="muestraSolid" />
  </volume>
```

Anexo II: geometry.gdml (parte 3)

```
<!-- }}} -->
<!-- {{{ Physical volume definition (volume and position assignment) -->

<volume name="World">
  <materialref ref="Air"/>
  <solidref ref="WorldSolid"/>

  <physvol name="gas">
    <volumeref ref="gasVolume"/>
    <position name="gasPosition" x="0" y="0" z="0"/>
  </physvol>

  <physvol name="vessel">
    <volumeref ref="vesselVolume"/>
    <position name="vesselPosition" x="0" y="0" z="0"/>
  </physvol>

  <physvol name="top">
    <volumeref ref="topVolume"/>
    <positionref ref="top_position"/>
  </physvol>

  <physvol name="capsule">
    <volumeref ref="capsuleVolume"/>
    <positionref ref="capsule_position"/>
  </physvol>

  <physvol name="capsulehole">
    <volumeref ref="capsuleholeVolume"/>
    <positionref ref="capsule_position"/>
  </physvol>

  <physvol name="mylar">
    <volumeref ref="mylarVolume"/>
    <positionref ref="mylar_position"/>
  </physvol>

  <physvol name="grid1">
    <volumeref ref="wirePlaneVolume"/>
    <positionref ref="wire_plane1_position"/>
    <rotationref ref="RotateY90" />
  </physvol>

  <physvol name="grid2">
    <volumeref ref="wirePlaneVolume"/>
    <positionref ref="wire_plane2_position"/>
    <rotationref ref="RotateXY90" />
  </physvol>

  <physvol name="muestra">
    <volumeref ref="muestraVolume"/>
    <positionref ref="muestra_position"/>
  </physvol>

  <physvol name="readout">
    <volumeref ref="readoutVolume"/>
    <positionref ref="readout_position"/>
  </physvol>
</volume>
<!-- }}} -->
```

Anexo II: setup.gdml

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<!DOCTYPE gdml [
<!ENTITY geometry SYSTEM "geometry.gdml">
<!ENTITY materials SYSTEM "https://sultan.unizar.es/materials/materials.xml">
]>

<gdml xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://service-spi.web.cern.ch/service-spi/app/releases/GDML/schema/gdml.xsd">

  <!-- Just an example of a simple cylinder geometry file : setup.gdml
  This file just defines de parameters of the geometry.
  The geometry it is defined in geometry/BoxGeometry.gdml
  The materials are defined in geometry/materials.xml
  Author : G. Luzon   Date :Nov-2016   Edit : E. Lupon   Date : Jul-2021
  -->

  <!-- All values should be in mm -->

  <define>
    <variable name="world_size" value="{GDML_WORLD_SIZE}" />
    <!-- The TPC gas target -->
    <variable name="targetGasDensity" value="{GDML_GAS_DENSITY}" />
    <variable name="quencherFraction" value="{GDML_QUEENCHER}" />
    <variable name="quencherDensity" value="{GDML_QUEENCHER_DENSITY}" />
    <variable name="gasTemperature" value="300" /> <!-- K -->
    <variable name="gasPressure" value="{GDML_PRESSURE}" /> <!-- bar -->

    <!-- Vessel definitions -->

    <constant name="vessel_thickness" value="{GDML_VESSEL_THICKNESS}" /> <!-- in mm's -->
    <constant name="VesselXSize" value="{GDML_VESSEL_XSIZE}" />

    <constant name="VesselZSize" value="{GDML_VESSEL_ZSIZE}" />
    <constant name="VesselYSize" value="{GDML_VESSEL_YSIZE}" />

    <!-- Capsule variables -->

    <constant name="capsule_thickness" value="{GDML_COVER_THICKNESS}" />
    <constant name="capsule_radius" value="{GDML_CAPSULE_RADIUS}" />
    <constant name="capsuleHole_radius" value="{GDML_CAPSULE_HOLE_RADIUS}" />
    <constant name="capsule_distance" value="{GDML_CAPSULE_DISTANCE}" />

    <!-- Micromegas variables -->

    <constant name="readout_thickness" value="{GDML_READOUT_THICKNESS}" />
    <constant name="readout_size" value="{GDML_READOUT_SIZE}" />
    <constant name="readout_distance" value="{GDML_READOUT_DISTANCE}" />

    <!-- Window/Cathode on top of the chamber -->

    <constant name="wire_radius" value="{GDML_CATHODE_WIRE_RADIUS}" />
    <constant name="wire_length" value="{GDML_CATHODE_WIRE_LENGTH}" />
    <constant name="mylar_thickness" value="{GDML_CATHODE_MYLAR_THICKNESS}" />
    <constant name="windowXSize" value="{GDML_CATHODE_WINDOW_XSIZE}" />
    <constant name="windowYSize" value="{GDML_CATHODE_WINDOW_YSIZE}" />
    <constant name="wire_distance" value="{GDML_CATHODE_WIRE_DISTANCE}" />
    <position name="wire_position_01r" unit="mm" x="0" y="wire_distance*1" z="0" />
    <position name="wire_position_02r" unit="mm" x="0" y="wire_distance*2" z="0" />
    <position name="wire_position_03r" unit="mm" x="0" y="wire_distance*3" z="0" />
    <position name="wire_position_04r" unit="mm" x="0" y="wire_distance*4" z="0" />
    <position name="wire_position_05r" unit="mm" x="0" y="wire_distance*5" z="0" />
    <position name="wire_position_06r" unit="mm" x="0" y="wire_distance*6" z="0" />
    <position name="wire_position_07r" unit="mm" x="0" y="wire_distance*7" z="0" />
    <position name="wire_position_08r" unit="mm" x="0" y="wire_distance*8" z="0" />
    <position name="wire_position_09r" unit="mm" x="0" y="wire_distance*9" z="0" />
    <position name="wire_position_01l" unit="mm" x="0" y="-wire_distance*1" z="0" />
    <position name="wire_position_02l" unit="mm" x="0" y="-wire_distance*2" z="0" />
    <position name="wire_position_03l" unit="mm" x="0" y="-wire_distance*3" z="0" />
    <position name="wire_position_04l" unit="mm" x="0" y="-wire_distance*4" z="0" />
    <position name="wire_position_05l" unit="mm" x="0" y="-wire_distance*5" z="0" />
    <position name="wire_position_06l" unit="mm" x="0" y="-wire_distance*6" z="0" />
    <position name="wire_position_07l" unit="mm" x="0" y="-wire_distance*7" z="0" />
    <position name="wire_position_08l" unit="mm" x="0" y="-wire_distance*8" z="0" />
    <position name="wire_position_09l" unit="mm" x="0" y="-wire_distance*9" z="0" />

    <!-- Muestra -->
    <constant name="muestraXSize" value="{GDML_MUESTRA_XSIZE}" />
    <constant name="muestraYSize" value="{GDML_MUESTRA_YSIZE}" />
    <constant name="muestra_thickness" value="{GDML_MUESTRA_THICKNESS}" />
    <constant name="muestra_distance" value="{GDML_MUESTRA_DISTANCE}" />

    <!-- Z Positions -->

    <constant name="top_ZPosition" value="0.5*VesselZSize-0.5*vessel_thickness" />
    <constant name="readout_ZPosition" value="-0.5*VesselZSize+1.0*vessel_thickness+0.5*readout_thickness+readout_distance" />
    <constant name="window_ZPosition" value="0.5*VesselZSize-0.5*vessel_thickness" />
    <constant name="muestra_ZPosition" value="0.5*VesselZSize+0.5*muestra_thickness+muestra_distance" />
    <constant name="capsule_ZPosition" value="0.5*VesselZSize+1.0*mylar_thickness+0.5*capsule_thickness+capsule_distance" />

    <position name="top_position" unit="mm" x="0" y="0" z="top_ZPosition" />
    <position name="muestra_position" unit="mm" x="0" y="0" z="muestra_ZPosition" />
    <position name="readout_position" unit="mm" x="0" y="0" z="readout_ZPosition" />
    <position name="mylar_position" unit="mm" x="0" y="0" z="0.5*VesselZSize+0.5*mylar_thickness+2.0*wire_radius" />
    <position name="wire_plane1_position" unit="mm" x="0" y="0" z="0.5*VesselZSize+3.0*wire_radius+1.0*mylar_thickness" />
    <position name="wire_plane2_position" unit="mm" x="0" y="0" z="0.5*VesselZSize+1.0*wire_radius" />
    <position name="window_position" unit="mm" x="0" y="0" z="window_ZPosition" />
    <position name="capsule_position" unit="mm" x="0" y="0" z="capsule_ZPosition" />

    <!-- Rotations -->
    <rotation name="RotateY90" unit="deg" x="0" y="90" z="0" />
    <rotation name="RotateXY90" unit="deg" x="90" y="0" z="90" />
  </define>
  &materials;
  &geometry;
  <setup name="Default" version="1.0">
    <world ref="World" />
  </setup>
</gdml>
```

Anexo II: AlphaDetector.sh

```
#####
# Library of BASIC simulations- paths
#####
export BASIC_PATH="$HOME/BASIC" ## Change this to your GitLab source directory.
export BASIC_SIMPATH="$BASIC_PATH/basic-simulations"
export REST_DATAPATH="$HOME/restData/Basic" ## Path should be a temporary scratch volume.
export EXPERIMENT="BASIC"
export GEOMETRY="alphadetector" ## more options "box" "cylinder" "micromegas"
export BASIC_GEOMETRY="$BASIC_PATH/basic-geometry/alphadetector/setup.gdml"
#####
# Library of BASIC simulations- variables
# available materials on https://sultan.unizar.es/materials/materials.xml
# pressure in bars, density in mg/cm3 and dimensions in mm
#####

export GDML_GAS="Ar_ISO"
export GDML_QUEENCHER="0.02"
export GDML_PRESSURE="1.0"
export GDML_GAS_DENSITY="1.61"
export GDML_QUEENCHER_DENSITY="0.05"
export REST_NEVENTS="20000"
export GDML_WORLD_SIZE="5000"

export GDML_VESSEL_MATERIAL="Aluminium"
export GDML_TOP_MATERIAL="PE"
export GDML_MUESTRA_MATERIAL="Copper"
export GDML_VESSEL_THICKNESS="10"
export GDML_VESSEL_XSIZE="450"
export GDML_VESSEL_YSIZE="450"
export GDML_VESSEL_ZSIZE="180"
export GDML_MUESTRA_XSIZE="50"
export GDML_MUESTRA_YSIZE="20"
export GDML_MUESTRA_THICKNESS="5"
export GDML_READOUT_SIZE="250"
export GDML_READOUT_THICKNESS="1.0"
export GDML_READOUT_DISTANCE="50.0" # mide distancia desde fondo interior del detector
export GDML_MUESTRA_DISTANCE="3.002" #tiene solo en cuenta el vessel y su propio espesor, actualmente sobre las rejillas
export GDML_CATHODE_WIRE_RADIUS="0.75"
export GDML_CATHODE_WIRE_LENGTH="240"
export GDML_CATHODE_WIRE_DISTANCE="13"
export GDML_CATHODE_MYLAR_THICKNESS="0.002"
export GDML_CATHODE_WINDOW_XSIZE="240"
export GDML_CATHODE_WINDOW_YSIZE="214" #214
export GDML_CAPSULE_THICKNESS="5"
export GDML_CAPSULE_RADIUS="9"
export GDML_CAPSULE_HOLE_RADIUS="3"
export GDML_CAPSULE_DISTANCE="500" #solo tiene en cuenta vessel, mylar y su propio espesor (sin rejillas), actualmente arbitrario

#####
## Extended source simulations
#####
export REST_WSIZE="(5,2,0)cm"
export REST_WPOSITION="(0,0,9.3002)cm" #90 vessel + 0.75*4 rejillas * 0.002 mylar
export REST_ISOTOPE="Po210"
restG4 $BASIC_SIMPATH/signal/ExtendedSource.rml
```

Anexo II: ExtendedSource.rml

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>

<!--
First concept author: G. Luzón (16-11-2020) -->

<restG4>

  <globals file="../../common/globals.xml"/>

  <TRestRun file="../../common/run.xml" />

  <TRestGeant4Metadata name="restG4 run" title="ExtendedSource-#{REST_WSIZE}-#{REST_ISOTOPE}-FullChainOFF">

    <parameter name="gdml_file" value="{BASIC_GEOMETRY}"/>
    <parameter name="subEventTimeDelay" value="100us" />

    <parameter name="Nevents" value="{REST_NEVENTS}" />

    <parameter name="saveAllEvents" value="false" />
    <parameter name="printProgress" value="true" />

    <generator type="surface" shape="wall" size="{REST_WSIZE}" position="{REST_WPOSITION}" rotation="(0,0,0)" >
      <source particle="{REST_ISOTOPE}" excitedLevel="0.0" fullChain="off">
        <angularDist type="isotropic" />
        <energyDist type="mono" energy="0" units="MeV" />
      </source>
    </generator>

    <storage sensitiveVolume="gas">
      <parameter name="energyRange" value="(0,10)MeV"/>
      <activeVolume name="gas" chance="1" maxStepSize="0.02mm"/>
    </storage>
  </TRestGeant4Metadata>

  <TRestGeant4PhysicsLists name="default" file="../../common/physics.xml" />
.
</restG4>
```

Anexo III: Poder de frenado y rango calculados con SRIM

Tabla A. Poder de frenado y rango de partículas α en Aire, Dry ICRU-104 (gas).

Energy (MeV)	dE/dx Elec. (MeV mg ⁻¹ cm ²)	dE/dx Nuclear (MeV mg ⁻¹ cm ²)	Projected Range (mm)
7,7	5,644E-01	3,498E-04	52,00
7,0	6,045E-01	3,804E-04	44,65
6,5	6,382E-01	4,061E-04	39,72
6,0	6,761E-01	4,357E-04	35,05
5,5	7,192E-01	4,703E-04	30,66
5,0	7,687E-01	5,113E-04	26,54
4,5	8,262E-01	5,608E-04	22,69
4,0	8,942E-01	6,215E-04	19,13

Tabla B. Poder de frenado y rango de partículas α en Mylar ICRU-222 (sólido).

Energy (MeV)	dE/dx Elec. (MeV mg ⁻¹ cm ²)	dE/dx Nuclear (MeV mg ⁻¹ cm ²)	Projected Range (μ m)
7,7	6,013E-01	3,899E-04	57,21
7,0	6,439E-01	4,242E-04	49,17
6,5	6,798E-01	4,528E-04	43,76
6,0	7,203E-01	4,859E-04	38,65
5,5	7,664E-01	5,246E-04	33,84
5,0	8,195E-01	5,705E-04	29,33
4,5	8,812E-01	6,257E-04	25,12
4,0	9,539E-01	6,937E-04	21,22

Tabla C. Poder de frenado y rango de partículas α en Argón ($\rho = 1,61$ mg/cm³, gas).

Energy (MeV)	dE/dx Elec. (MeV mg ⁻¹ cm ²)	dE/dx Nuclear (MeV mg ⁻¹ cm ²)	Projected Range (mm)
7,7	3,999E-01	2,555E-04	76,85
7,0	4,254E-01	2,775E-04	66,34
6,5	4,468E-01	2,959E-04	59,23
6,0	4,709E-01	3,171E-04	52,48
5,5	4,982E-01	3,419E-04	46,08
5,0	5,296E-01	3,711E-04	40,05
4,5	5,660E-01	4,063E-04	34,39
4,0	6,088E-01	4,495E-04	29,12