```
(*Set initial directory*)
directory = NotebookDirectory[];

(*Display menu for nuclear species selection*)
Print["Select Nuclear Species:"];
Print["1. U-235_Data_JENDL5"];
Print["2. U-233_Data_JENDL5"];
Print["3. U-238_Data_JENDL5"];
Print["4. Th-232_Data_JENDL5"];
Print["5. Np-237_Data_JENDL5"];
Print["6. Pu-239_Data_JENDL5"];
Print["7. Pu-240_Data_JENDL5"];
Print["8. Pu-242_Data_JENDL5"];
Print["9. Am-241_Data_JENDL5"];

(*Get user selection*)
choice = Input["Enter number (1-9): "];

(*Load file based on selection*)


fileName = Switch[choice, 1, "U-235_Data_JENDL5.m", 2, "U-233_Data_JENDL5.m", 3,
   "U-238_Data_JENDL5.m", 4, "Th-232_Data_JENDL5.m", 5, "Np-237_Data_JENDL5.m", 6,
   "Pu-239_Data_JENDL5.m", 7, "Pu-240_Data_JENDL5.m", 8, "Pu-242_Data_JENDL5.m",
   9, "Am-241_Data_JENDL5.m", _, (Print["Invalid selection"];
    Abort[])];



(*Load file using full path*)
fullPath = FileNameJoin[{directory, fileName}];
Print["Attempting to load file from: ", fullPath];

If[FileExistsQ[fullPath], Get[fullPath];
  Print["Successfully loaded: ", fileName],
  Print["Error: File not found at ", fullPath]];

(*2*)


(*Initial Calculations for Nuclear Parameters*)
fragmentZ1 = atomicNumber / 2;(*First fragment atomic number*)
fragmentZ2 = atomicNumber / 2;(*Second fragment atomic number*)
reducedMass = N[Sqrt[fragmentZ1 * fragmentZ2 / (fragmentZ1 + fragmentZ2)]];


fitStartZ = 28;(*Starting atomic number for fitting*)
fitEndZ = atomicNumber - fitStartZ;(*Ending atomic number for fitting*)

fitStartIndex = fitStartZ - 22;(*Starting index for fitting data*)
fitEndIndex = fitEndZ - 22;(*Ending index for fitting data*)
(*Initialize distance parameter*)
```

```
(*Incident Neutron Kinetic Energy*)
neutronEnergy1 = 0;(*0.0253 eV*)
neutronEnergy2 = 0.5;(*500 keV*)
neutronEnergy3 = 14;(*14 MeV*)



effectiveDistance = .;

(*Initialize energy-dependent distance parameters*)
effectiveDistance0253eV = .;
effectiveDistance500keV = .;
effectiveDistance14MeV = .;

(*Initialize variable lists for each energy region*)
distanceVars0253eV = {};
distanceVars500keV = {};
distanceVars14MeV = {};

(*Initialize fermi correction lists*)
fermiVars0253eV = {};
fermiVars500keV = {};
fermiVars14MeV = {};

(*Initialize fermi correction energies*)
fermiEnergy1 = .;
fermiEnergy2 = .;
fermiEnergy3 = .;

(*Initialize various parameter lists*)
paramList0253eV = {};
paramList500keV = {};
paramList14MeV = {};
paramList5 = {};
paramList6 = {};
paramList7 = {};

fermiEnergies = {};
variablesList = {};
fissionYields = {};
neutronVars = {};
effectiveDistances = {};
distanceParams = {};

paramList50 = {};
paramList60 = {};
paramList70 = {};


Clear[theoreticalYield0253eV, theoreticalYield500keV, theoreticalYield14MeV,
 fittedYield0253eV, fittedYield500keV, fittedYield14MeV, optResult0253eV,
 optResult500keV, optResult14MeV, fermiVars0253eV, fermiVars500keV, fermiVars14MeV]
```

```
(*Mass retrieval function definition*)
getNuclearMass[Z_, A_] :=
 Module[{elementName, isotopeName, mass, numericMass}, (*Validate atomic number*)
  If[! NumberQ[Z] || Z < 1 || Z > 118, Return[Missing["NotAvailable"]]];
  (*Get element name*)elementName = ElementData[Z, "Name"];
  If[elementName === $Failed, Return[Missing["NotAvailable"]]];
  (*Format element name*)elementName =
   StringReplacePart[elementName, ToUpperCase[StringTake[elementName, 1]], {1, 1}];
  (*Create isotope name*)isotopeName = elementName <> ToString[A];
  (*Get mass data*)mass = IsotopeData[isotopeName, "AtomicMass"];
  (*Return numeric mass or missing value*)If[mass === Missing["NotAvailable"],
   Missing["NotAvailable"], numericMass = QuantityMagnitude[mass];
   numericMass]]


(*Energy pattern selection*)
{startEnergyIndex, endEnergyIndex} =
  Switch[energyPattern, 1, {1, 1}, (*0.0253 eV only*)2, {1, 2},
   (*0.0253 eV and 500 keV*)3, {1, 3}, (*All three energies*)4,
   {2, 2}, (*500 keV only*)5, {2, 3}  (*500 keV and 14 MeV*)];

(*Isotope existence check function*)
isIsotopeStable[z_, n_] :=
 Module[{element, isotope, mass}, element = ElementData[z, "Name"];
  element = StringReplacePart[element, ToUpperCase[StringTake[element, 1]], {1, 1}];
  isotope = element <> ToString[z + n];
  mass = IsotopeData[isotope, "AtomicMass"];
  mass =!= Missing["NotAvailable"] && NumberQ[QuantityMagnitude[mass]]]


(*3*)(*Main Nuclear Fission Calculation Function*)
CalculateFissionYields[energyPattern_] := Module[{dataTemp, results = {}},
  For[energyIndex = startEnergyIndex, energyIndex ≤ endEnergyIndex, energyIndex++,
   (*Set parameters for each energy region*){promptNeutronCount, incidentEnergy,
     effectiveDistance, variableList, yieldList, neutronVariables} =
    Switch[energyIndex, 1, {promptNeutrons1, neutronEnergy1, effectiveDistance0253eV,
      distanceVars0253eV, fissionYield0253eV, fermiVars0253eV}, (*Thermal*)
     2, {promptNeutrons2, neutronEnergy2, effectiveDistance500keV,
      distanceVars500keV, fissionYield500keV, fermiVars500keV}, (*Intermediate*)
     3, {promptNeutrons3, neutronEnergy3, effectiveDistance14MeV,
      distanceVars14MeV, fissionYield14MeV, fermiVars14MeV}   (*Fast*)];

   dataTemp =
    Reap[For[protonNumber1 = 23, protonNumber1 ≤ atomicNumber - 23, protonNumber1++,
       For[neutronCount1 = 0, neutronCount1 ≤ neutronNumber, neutronCount1++,
        protonNumber2 = atomicNumber - protonNumber1;
        neutronCount2 = neutronNumber - neutronCount1 - Round[promptNeutronCount];
        massNumber1 = protonNumber1 + neutronCount1;
        massNumber2 = protonNumber2 + neutronCount2;
        (*Check if both fragments are physically possible*)
        (*If[isIsotopeStable[protonNumber1,neutronCount1]&&
          isIsotopeStable[protonNumber2,neutronCount2],
         (*Calculate charge ratio of fission fragments*)
         chargeRatio=N[(protonNumber1/massNumber1)/(protonNumber2/massNumber2)];*)
```

```
If[ (protonNumber1 == 22 && 16 <= neutronCount1 <= 41) ||
   (protonNumber1 == 23 && 17 <= neutronCount1 <= 42) ||
   (protonNumber1 == 24 && 18 <= neutronCount1 <= 43) ||
   (protonNumber1 == 25 && 19 <= neutronCount1 <= 44) ||
   (protonNumber1 == 26 && 19 <= neutronCount1 <= 46) ||
   (protonNumber1 == 27 && 20 <= neutronCount1 <= 48) ||
   (protonNumber1 == 28 && 20 <= neutronCount1 <= 50) ||
   (protonNumber1 == 29 && 23 <= neutronCount1 <= 51) ||
   (protonNumber1 == 30 && 24 <= neutronCount1 <= 53) ||
   (protonNumber1 == 31 && 25 <= neutronCount1 <= 55) ||
   (protonNumber1 == 32 && 26 <= neutronCount1 <= 57) ||
   (protonNumber1 == 33 && 27 <= neutronCount1 <= 59) ||
   (protonNumber1 == 34 && 31 <= neutronCount1 <= 60) ||
   (protonNumber1 == 35 && 32 <= neutronCount1 <= 62) ||
   (protonNumber1 == 36 && 33 <= neutronCount1 <= 64) ||
   (protonNumber1 == 37 && 34 <= neutronCount1 <= 65) ||
   (protonNumber1 == 38 && 35 <= neutronCount1 <= 67) ||
   (protonNumber1 == 39 && 37 <= neutronCount1 <= 69) ||
   (protonNumber1 == 40 && 38 <= neutronCount1 <= 70) ||
   (protonNumber1 == 41 && 40 <= neutronCount1 <= 72) ||
   (protonNumber1 == 42 && 41 <= neutronCount1 <= 73) ||
   (protonNumber1 == 43 && 42 <= neutronCount1 <= 75) ||
   (protonNumber1 == 44 && 43 <= neutronCount1 <= 76) ||
   (protonNumber1 == 45 && 44 <= neutronCount1 <= 77) ||
   (protonNumber1 == 46 && 45 <= neutronCount1 <= 78) ||
   (protonNumber1 == 47 && 46 <= neutronCount1 <= 83) ||
   (protonNumber1 == 48 && 47 <= neutronCount1 <= 84) ||
   (protonNumber1 == 49 && 48 <= neutronCount1 <= 86) ||
   (protonNumber1 == 50 && 49 <= neutronCount1 <= 87) ||
   (protonNumber1 == 51 && 52 <= neutronCount1 <= 88) ||
   (protonNumber1 == 52 && 53 <= neutronCount1 <= 90) ||
   (protonNumber1 == 53 && 55 <= neutronCount1 <= 91) ||
   (protonNumber1 == 54 && 56 <= neutronCount1 <= 93) ||
   (protonNumber1 == 55 && 57 <= neutronCount1 <= 96) ||
   (protonNumber1 == 56 && 58 <= neutronCount1 <= 97) ||
   (protonNumber1 == 57 && 60 <= neutronCount1 <= 98) ||
   (protonNumber1 == 58 && 61 <= neutronCount1 <= 99) ||
   (protonNumber1 == 59 && 62 <= neutronCount1 <= 100) ||
   (protonNumber1 == 60 && 64 <= neutronCount1 <= 101) ||
   (protonNumber1 == 61 && 65 <= neutronCount1 <= 102) ||
   (protonNumber1 == 62 && 66 <= neutronCount1 <= 103) ||
   (protonNumber1 == 63 && 67 <= neutronCount1 <= 104) ||
   (protonNumber1 == 64 && 70 <= neutronCount1 <= 105) ||
   (protonNumber1 == 65 && 71 <= neutronCount1 <= 106) ||
   (protonNumber1 == 66 && 72 <= neutronCount1 <= 107) ||
   (protonNumber1 == 67 && 73 <= neutronCount1 <= 108) ||
   (protonNumber1 == 68 && 75 <= neutronCount1 <= 109) ||
   (protonNumber1 == 69 && 76 <= neutronCount1 <= 110) ||
   (protonNumber1 == 70 && 78 <= neutronCount1 <= 111) ||
 (protonNumber1 == 71 && 79 <= neutronCount1 <= 111) ||
 (protonNumber1 ⩵ 72 && 81 ≤ neutronCount1 ≤ 116) ||
 (protonNumber1 ⩵ 73 && 82 ≤ neutronCount1 ≤ 117) ||
 (protonNumber1 ⩵ 74 && 84 ≤ neutronCount1 ≤ 118) ||
 (protonNumber1 ⩵ 75 && 85 ≤ neutronCount1 ≤ 119),
(*Check nuclear chart range for second fragment*)
If[(protonNumber2 == 22 && 16 <= neutronCount2 <= 41) ||
  (protonNumber2 == 23 && 17 <= neutronCount2 <= 42) ||
  (protonNumber2 == 24 && 18 <= neutronCount2 <= 43) ||
  (protonNumber2 == 25 && 19 <= neutronCount2 <= 44) ||
  (protonNumber2 == 26 && 19 <= neutronCount2 <= 46) ||
  (protonNumber2 == 27 && 20 <= neutronCount2 <= 48) ||
  (protonNumber2 == 28 && 20 <= neutronCount2 <= 50) ||
  (protonNumber2 == 29 && 23 <= neutronCount2 <= 51) ||
  (protonNumber2 == 30 && 24 <= neutronCount2 <= 53) ||
  (protonNumber2 == 31 && 25 <= neutronCount2 <= 55) ||
  (protonNumber2 == 32 && 26 <= neutronCount2 <= 57) ||
  (protonNumber2 == 33 && 27 <= neutronCount2 <= 59) ||
  (protonNumber2 == 34 && 31 <= neutronCount2 <= 60) ||
  (protonNumber2 == 35 && 32 <= neutronCount2 <= 62) ||
  (protonNumber2 == 36 && 33 <= neutronCount2 <= 64) ||
  (protonNumber2 == 37 && 34 <= neutronCount2 <= 65) ||
  (protonNumber2 == 38 && 35 <= neutronCount2 <= 67) ||
  (protonNumber2 == 39 && 37 <= neutronCount2 <= 69) ||
  (protonNumber2 == 40 && 38 <= neutronCount2 <= 70) ||
  (protonNumber2 == 41 && 40 <= neutronCount2 <= 72) ||
  (protonNumber2 == 42 && 41 <= neutronCount2 <= 73) ||
  (protonNumber2 == 43 && 42 <= neutronCount2 <= 75) ||
  (protonNumber2 == 44 && 43 <= neutronCount2 <= 76) ||
  (protonNumber2 == 45 && 44 <= neutronCount2 <= 77) ||
  (protonNumber2 == 46 && 45 <= neutronCount2 <= 78) ||
  (protonNumber2 == 47 && 46 <= neutronCount2 <= 83) ||
  (protonNumber2 == 48 && 47 <= neutronCount2 <= 84) ||
  (protonNumber2 == 49 && 48 <= neutronCount2 <= 86) ||
  (protonNumber2 == 50 && 49 <= neutronCount2 <= 87) ||
  (protonNumber2 == 51 && 52 <= neutronCount2 <= 88) ||
  (protonNumber2 == 52 && 53 <= neutronCount2 <= 90) ||
  (protonNumber2 == 53 && 55 <= neutronCount2 <= 91) ||
  (protonNumber2 == 54 && 56 <= neutronCount2 <= 93) ||
  (protonNumber2 == 55 && 57 <= neutronCount2 <= 96) ||
  (protonNumber2 == 56 && 58 <= neutronCount2 <= 97) ||
  (protonNumber2 == 57 && 60 <= neutronCount2 <= 98) ||
  (protonNumber2 == 58 && 61 <= neutronCount2 <= 99) ||
  (protonNumber2 == 59 && 62 <= neutronCount2 <= 100) ||
  (protonNumber2 == 60 && 64 <= neutronCount2 <= 101) ||
  (protonNumber2 == 61 && 65 <= neutronCount2 <= 102) ||
  (protonNumber2 == 62 && 66 <= neutronCount2 <= 103) ||
  (protonNumber2 == 63 && 67 <= neutronCount2 <= 104) ||
  (protonNumber2 == 64 && 70 <= neutronCount2 <= 105) ||
  (protonNumber2 == 65 && 71 <= neutronCount2 <= 106) ||
            (protonNumber2 == 66 && 72 <= neutronCount2 <= 107) ||
            (protonNumber2 == 67 && 73 <= neutronCount2 <= 108) ||
            (protonNumber2 == 68 && 75 <= neutronCount2 <= 109) ||
            (protonNumber2 == 69 && 76 <= neutronCount2 <= 110) ||
            (protonNumber2 == 70 && 78 <= neutronCount2 <= 111) ||
            (protonNumber2 == 71 && 79 <= neutronCount2 <= 111) ||
            (protonNumber2 == 72 && 81 ≤ neutronCount2 ≤ 116) ||
            (protonNumber2 == 73 && 82 ≤ neutronCount2 ≤ 117) ||
            (protonNumber2 == 74 && 84 ≤ neutronCount2 ≤ 118) ||
            (protonNumber2 == 75 && 85 ≤ neutronCount2 ≤ 119),
           (*Calculate proton number ratio*) chargeRatio =
            N[(protonNumber1 / massNumber1) / (protonNumber2 / massNumber2)];


           (*Update variable lists based on energy region*)
           Switch[energyIndex, 1, fermiVars0253eV = Union[AppendTo[distanceVars0253eV,
                effectiveDistance0253eV[protonNumber1, protonNumber2]]],
            2, fermiVars500keV = Union[AppendTo[distanceVars500keV,
                effectiveDistance500keV[protonNumber1, protonNumber2]]],
            3, fermiVars14MeV = Union[AppendTo[distanceVars14MeV,
                effectiveDistance14MeV[protonNumber1, protonNumber2]]]];
           (*Calculate physical parameters*)
           effectiveDistanceVal = effectiveDistance[protonNumber1, protonNumber2];
           coulombEnergy = (1.44 * protonNumber1 * protonNumber2) / effectiveDistanceVal;

           (*Calculating Q value*)

           qValue = (getNuclearMass[atomicNumber, atomicNumber + neutronNumber] -
                getNuclearMass[protonNumber1, massNumber1] -
                getNuclearMass[protonNumber2, massNumber2] -
                promptNeutronCount * 1.008665) * 931.4940954;

           effectiveEnergy = coulombEnergy - qValue;

           (*Calculate fission probability*)
           probability = 1 / (1 + Exp[2 * Pi / (neutronSeparationEnergy + incidentEnergy) *
                  Sqrt[protonNumber1 * protonNumber2 / (protonNumber1 + protonNumber2)] /
                   reducedMass * effectiveEnergy]);

           Sow[{protonNumber1, probability}, yieldList];]]]],
       {yieldList}, Rule][[2, All, 1]];



    (*Process results*)
    fragmentData = Part[yieldList /. dataTemp];
    processYields[data_] :=
     (Total@# / {Length@#, Total@data[[All, 2]] / 2} &) /@ GatherBy[data, First];
    AppendTo[results, {energyIndex, processYields[fragmentData]}];];
   results]

 (*Execute main calculation*)
 fissionResults = CalculateFissionYields[energyPattern];
```

```
(*Process results based on energy pattern*)
{yieldData0253eVCalc, yieldData500keVCalc, yieldData14MeVCalc} =
  Switch[energyPattern, 1, {fissionResults[[1, 2]], Null, Null},
   2, {fissionResults[[1, 2]], fissionResults[[2, 2]], Null}, 3,
   {fissionResults[[1, 2]], fissionResults[[2, 2]], fissionResults[[3, 2]]},
   4, {Null, fissionResults[[1, 2]], Null}, 5,
   {Null, fissionResults[[1, 2]], fissionResults[[2, 2]]}];
```

```
(*4*)(*Optimization and Result Display Program for Fission Parameters*)
For[energyRegion = startEnergyIndex, energyRegion ≤ endEnergyIndex,
  energyRegion++, (*Setup variables and data for each energy region*)
  {neutronVarList, calcYieldData, fitYieldData, experimentalData, energyDescription,
    theoreticalYield, optimizationResult, fittedData} = Switch[energyRegion, 1,
    {paramList0253eV = Union[fermiVars0253eV], yieldData0253eVCalc, fitYield0253eV =
      yieldData0253eVCalc[[fitStartIndex ;; fitEndIndex]], yieldData0253eV[[
      fitStartIndex ;; fitEndIndex]], "1. Incident Neutron Energy: 0.0253eV",
     theoreticalYield0253eV, optResult0253eV, fittedYield0253eV}, 2,
    {paramList500keV = Union[fermiVars500keV], yieldData500keVCalc,
     fitYield500keV = yieldData500keVCalc[[fitStartIndex ;; fitEndIndex]],
     yieldData500keV[[fitStartIndex ;; fitEndIndex]],
     "2. Incident Neutron Energy: 500keV", theoreticalYield500keV,
     optResult500keV, fittedYield500keV}, 3,
    {paramList14MeV = Union[fermiVars14MeV], yieldData14MeVCalc,
     fitYield14MeV = yieldData14MeVCalc[[fitStartIndex ;; fitEndIndex]],
     yieldData14MeV[[fitStartIndex ;; fitEndIndex]],
     "3. Incident Neutron Energy: 14MeV", theoreticalYield14MeV,
     optResult14MeV, fittedYield14MeV}];
  (*Calculate logarithmic difference between theory and experiment*)
  logDifference = (Log@fitYieldData - Log@experimentalData)[[All, 2]];
```

```
  (*Optimize parameters using least squares method*)
  Switch[energyRegion, 1, optResult0253eV = Quiet[FindMinimum[
      Total[logDifference^2], Thread@{paramList0253eV}], FindMinimum::cvmit];
   fittedYield0253eV = optResult0253eV[[2, All, All]];
   theoreticalYield0253eV = fitYield0253eV /. optResult0253eV[[2, All, All]],
   2, optResult500keV = Quiet[FindMinimum[Total[logDifference^2],
      Thread@{paramList500keV}], FindMinimum::cvmit];
   fittedYield500keV = optResult500keV[[2, All, All]];
   theoreticalYield500keV = fitYield500keV /. optResult500keV[[2, All, All]],
   3, optResult14MeV = Quiet[FindMinimum[Total[logDifference^2],
      Thread@{paramList14MeV}], FindMinimum::cvmit];
   fittedYield14MeV = optResult14MeV[[2, All, All]];
   theoreticalYield14MeV = fitYield14MeV /. optResult14MeV[[2, All, All]]];
  (*Display results*)
  Print[Style[energyDescription <> ": Effective Fission Distance Reff
       derived from experimental charge distribution", 16]];



  Print["Analysis Results"];
  Print[
   "Calculation results demonstrating that the effective fission distance Reff " <>
    "derived from optimization calculations
      accurately reproduces experimental values " <>
    "(confirming agreement between JENDL-5 experimental and theoretical values, " <>
    "and validating calculations using Mathematica ver11.2 FindMinimum)"];


  (*Create visualization plot*)
  plotOptions = {Joined → {True, True}, PlotRange → {{15, 80}, {10^(-12), 5}},
    Epilog → Inset[Style[isotopeName, Bold, 20], Scaled@{0.14, 0.9}],
    PlotMarkers → Automatic, PlotStyle →
     {Directive[PointSize[1 / 100], Red], Directive[PointSize[1 / 100], Blue]},
    Frame → True, FrameLabel → {"Atomic Number", "Fission Yield (Independent)"},
    LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
    FrameStyle → {Thick, Thick, Thick, Thick},
    PlotLegends → Placed[PointLegend[Automatic, {"JENDL-5", "Theoretical"},
       Joined → {True, True, True}, Joined → {True, True},
       LabelStyle → Directive[Black, 18], LegendFunction → "Frame",
       LegendLayout → "Column", LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]],
      {{0.65, 0.25}, {1, 0.9}}], AspectRatio → 0.8, ImageSize → 450,
    Epilog → Inset[Style[isotopeName, Bold], Scaled@{0.1, 0.92}]};
  Print[ListLogPlot[{experimentalData, theoreticalYield}, Evaluate[plotOptions]]];


  Print[
   "-----------------------------------------------------------------------------
     ---"];];



(*5*)
(*Correlation Analysis of Fragment Charge Product and Effective Fission Distance*)
(*Process data for each energy condition*)
Do[With[{condition = Which[i == 1, {energyPattern == 1 || energyPattern == 2 ||
         energyPattern == 3, correlationData0253eV, fittedYield0253eV,
        "1. Analysis for Incident Neutron Energy: 0.0253eV"}, i == 2,
       {energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
        correlationData500keV, fittedYield500keV,
        "2. Analysis for Incident Neutron Energy: 500keV"}, i == 3,
      {energyPattern == 3 || energyPattern == 5, correlationData14MeV, fittedYield14MeV,
       "3. Analysis for Incident Neutron Energy: 14MeV"}]}, If[condition[[1]],
    Switch[condition[[2]], correlationData0253eV, correlationData0253eV =
      Thread[{condition[[3]][[All, 1, 1]], condition[[3]][[All, 2]]}][[
       fitStartIndex ;; fitEndIndex]], correlationData500keV, correlationData500keV =
      Thread[{condition[[3]][[All, 1, 1]], condition[[3]][[All, 2]]}][[
       fitStartIndex ;; fitEndIndex]], correlationData14MeV, correlationData14MeV =
      Thread[{condition[[3]][[All, 1, 1]], condition[[3]][[All, 2]]}][[
       fitStartIndex ;; fitEndIndex]]]]], {i, 1, 3}];

Print[
  "-------------------------------------------------------------------------
    -"];


(*Result explanation and plotting*)
Module[{plotOptions = {Joined → {True, True, True}, PlotRange → {{15, 85}, {0.8, 1.3}},
     Frame → True, FrameLabel → {"Atomic Number", "Effective Distance (fm)"},
     LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
     FrameStyle → {Thick, Thick, Thick, Thick}, AspectRatio → 1.1, ImageSize → 350}},
  (*Define fitting function*)analyzeFittingResults[correlationData_, energyLabel_] :=
   Module[{distanceFunction, coeffA, coeffB, coeffC, chargeNumber, normalizedFormula},
    Print[Style[energyLabel, FontSize → 16]];
    (*Fit quadratic function*)distanceFunction =
     Fit[correlationData, {1, x, x^2}, x];
    (*Extract coefficients*){coeffC, coeffB, coeffA} =
     CoefficientList[distanceFunction, x];
    (*Calculate characteristic charge number*)kValue = -coeffA;
    chargeNumber = coeffB / kValue;
    mValue = coeffC;
    (*Display formula*)Print[Column[{Style[HoldForm[Reff] ==
         N[mValue, 6] + N[kValue, 6] * (N[chargeNumber, 6] - x) * x, FontSize → 16]}]];
    distanceFunction (*Return function for later use*)];
  Print["\nAnalysis Results:"];
  Print["1. The effective fission distance
     Reff shows quadratic dependence on fragment charge"];
  Print["2. This dependence reflects fundamental laws of charge
     distribution in fission process"];
  Print["3. Similar dependence is maintained across different incident energies\n"];
  (*Create comparison plot*)plotData = Select[{correlationData0253eV,
     correlationData500keV, correlationData14MeV}, Length[#] > 0 &];

  (*Create data-dependent color and label lists*)colors = {};
labels = {};
If[Length[correlationData0253eV] > 0, AppendTo[colors, Blue];
   AppendTo[labels, "0.0253 eV"]];
If[Length[correlationData500keV] > 0, AppendTo[colors, Green];
   AppendTo[labels, "500 keV"]];
If[Length[correlationData14MeV] > 0, AppendTo[colors, Red];
   AppendTo[labels, "14 MeV"]];

  plotData = Select[{correlationData0253eV,
     correlationData500keV, correlationData14MeV}, Length[#] > 0 &];

  (*Execute plot*)
  Print[ListPlot[plotData, Evaluate[plotOptions],
    PlotStyle → (Directive[PointSize[1 / 100], #] & /@ colors),
    PlotLegends → Placed[LineLegend[colors, labels, LabelStyle → 14], {0.82, 0.85}],
    Epilog → {Inset[Style[isotopeName, Bold, 15], Scaled@{0.15, 0.85}],
      Inset[Style[databaseName, Bold, 15], Scaled@{0.15, 0.90}]}]]];
```

```
(*Define distance functions for each energy level*)
Module[{fitResult}, (*Define fitting and display functions*)
 fitAndPrint[correlationData_, energyLabel_] :=
  Module[{distanceFunction, coeffA, coeffB, coeffC, chargeNumber, normalizedFormula},
   Print[Style[energyLabel, FontSize → 16]];
   (*Fit with quadratic function*)
   distanceFunction = Fit[correlationData, {1, x, x^2}, x];
   (*Extract coefficients*){coeffC, coeffB, coeffA} =
    CoefficientList[distanceFunction, x];
   (*Calculate characteristic charge number*)kValue = -coeffA;
   chargeNumber = coeffB / kValue;
   mValue = coeffC;
   (*Display formula*)Print[Column[{Style[HoldForm[Reff] ==
        N[mValue, 6] + N[kValue, 6] * (N[chargeNumber, 6] - x) * x, FontSize → 16]}]];
   distanceFunction (*Return function*)];
 (*For 0.0253 eV case*)
 If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3, distanceFunction0253eV =
   fitAndPrint[correlationData0253eV, "Incident Neutron Energy: 0.0253 eV case"]];
 (*For 500 keV case*)If[energyPattern == 2 || energyPattern == 3 ||
   energyPattern == 4 || energyPattern == 5, distanceFunction500keV =
   fitAndPrint[correlationData500keV, "Incident Neutron Energy: 500 keV case"]];
 (*For 14 MeV case*)If[energyPattern == 3 || energyPattern == 5, distanceFunction14MeV =
   fitAndPrint[correlationData14MeV, "Incident Neutron Energy: 14 MeV case"]];
 Print["\nAnalysis Results:"];
 Print["1. The effective fission distance
    Reff shows quadratic dependence on fragment charge number"];
 Print["2. This dependence reflects fundamental laws of charge
    distribution in the fission process"];
 Print["3. Similar dependence is maintained across different incident energies\n"];]
```

```
(*6*)(*Display and Analysis of Reff Values by Atomic Number*)
(*Output header for display*)Print[Style[
   "Table of Effective Fission Distance (Reff) Values by Atomic Number [Unit: fm]:",
   Bold, 16]];
Print[Style["Displaying calculated values (pre-fitting)
     and post-fitting values for each energy", 14]];
Print[Style["Fitting calculation used fragment values from atomic number " <>
    ToString[fitStartZ] <> " to " <> ToString[fitEndZ], 14]];
```

```
(*Create headers based on energy pattern*)
tableHeaders = Switch[energyPattern, 1,
   {"Z1", "Z2", "Reff [fm]\n(0.0253 eV)\nCalculated", "Fitted Value"},
   2, {"Z1", "Z2", "Reff [fm]\n(0.0253 eV)\nCalculated", "Fitted Value",
    "Reff [fm]\n(500 keV)\nCalculated", "Fitted Value"}, 3,
   {"Z1", "Z2", "Reff [fm]\n(0.0253 eV)\nCalculated", "Fitted Value",
    "Reff [fm]\n(500 keV)\nCalculated", "Fitted Value",
    "Reff [fm]\n(14 MeV)\nCalculated", "Fitted Value"}, 4,
   {"Z1", "Z2", "Reff [fm]\n(500 keV)\nCalculated", "Fitted Value"}, 5,
   {"Z1", "Z2", "Reff [fm]\n(500 keV)\nCalculated", "Fitted Value",
    "Reff [fm]\n(14 MeV)\nCalculated", "Fitted Value"}];

(*Function to get fitted value*)
getFittedDistanceValue[atomicNumber_, distanceFunction_] :=
  If[fitStartZ ≤ atomicNumber ≤ fitEndZ,
   NumberForm[N[distanceFunction /. x → atomicNumber], {6, 5}], "-"];

(*Create data table*)
tableData =
  Table[Module[{z1 = z, z2 = atomicNumber - z}, Flatten[{z1, z2, (*0.0253 eV data*)
      Which[energyPattern == 1 || energyPattern == 2 || energyPattern == 3,
       {NumberForm[N[effectiveDistance0253eV[z1, z2] /. fittedYield0253eV], {6, 6}],
        getFittedDistanceValue[z1, distanceFunction0253eV]}, True, {}],
      (*500 keV data*)Which[energyPattern == 2 || energyPattern == 3 ||
        energyPattern == 4 || energyPattern == 5,
       {NumberForm[N[effectiveDistance500keV[z1, z2] /. fittedYield500keV], {6, 6}],
        getFittedDistanceValue[z1, distanceFunction500keV]}, True, {}],
      (*14 MeV data*)Which[energyPattern == 3 || energyPattern == 5,
       {NumberForm[N[effectiveDistance14MeV[z1, z2] /. fittedYield14MeV], {6, 6}],
        getFittedDistanceValue[z1, distanceFunction14MeV]},
       True, {}]}]], {z, 23, 69}];
```

```
(*Output formatted table*)
Grid[Prepend[tableData, tableHeaders], Frame → All, Alignment → Center,
 Background → {None, {LightGray, None}}, ItemStyle → {Bold, "Text"},
 Dividers → {Join[{2}, Table[2 i + 2, {i, 1, Length[tableHeaders] / 2 - 1}]] → True,
   {2 → True}}, Spacings → {1.5, 1.2}]

(*7*)(*Generate Effective Fission Distance Functions*)
(*Generate functions for each energy region*)
If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3,
  distanceData0253eV = Table[{x, atomicNumber - x} → distanceFunction0253eV,
    {x, fitStartZ - 6, fitEndZ + 6}]];

If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
  distanceData500keV = Table[{x, atomicNumber - x} → distanceFunction500keV,
    {x, fitStartZ - 6, fitEndZ + 6}]];

If[energyPattern == 3 || energyPattern == 5, distanceData14MeV =
   Table[{x, atomicNumber - x} → distanceFunction14MeV, {x, fitStartZ - 6, fitEndZ + 6}]];

(*Define effective distance functions*)
If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3, effDistanceFunc0253eV =
   Thread[Thread[effectiveDistance0253eV[distanceData0253eV[[All, 1, 1]],
       distanceData0253eV[[All, 1, 2]]]] → distanceData0253eV[[All, 2]]]];

If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
  effDistanceFunc500keV =
   Thread[Thread[effectiveDistance500keV[distanceData500keV[[All, 1, 1]],
       distanceData500keV[[All, 1, 2]]]] → distanceData500keV[[All, 2]]]];

If[energyPattern == 3 || energyPattern == 5, effDistanceFunc14MeV =
   Thread[Thread[effectiveDistance14MeV[distanceData14MeV[[All, 1, 1]],
       distanceData14MeV[[All, 1, 2]]]] → distanceData14MeV[[All, 2]]]];

(*Calculate final yield data*)
If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3,
  finalYield0253eV = fitYield0253eV /. effDistanceFunc0253eV];

If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
  finalYield500keV = fitYield500keV /. effDistanceFunc500keV];

If[energyPattern == 3 || energyPattern == 5,
  finalYield14MeV = fitYield14MeV /. effDistanceFunc14MeV];

(*Display separator*)
Print[
  "-----------------------------------------------------------------------------------
    -"];


(*8*)(*Comparison of Experimental and Theoretical Fission Yields*)
(*Display analysis summary*)
Print["Analysis of Fission Yields: Comparison
    between Experimental Data and Theoretical Calculations (Ex=0)"];
Print["\nTheoretical Analysis Results using Effective Fission
    Distance Reff proportional to fragment charge product,"];
Print["with zero Fermi Energy (Ex=0)"];
Print["- Quantitative reproduction of
    experimentally observed asymmetric fission yield distributions"];



(*Create common plot settings*)
commonPlotSettings = {Joined → {True, True},
   PlotRange → {{15, 80}, {10^(-12), 100}}, PlotMarkers → Automatic,
   Frame → True, FrameLabel → {"Atomic Number", "Fission Yield (Independent)
       "}, LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
   FrameStyle → {Thick, Thick, Thick, Thick}, AspectRatio → 0.8, ImageSize → 450};

(*Legend settings*)
legendSettings = Placed[PointLegend[Automatic,
    {"JENDL-5 (Experimental)", "Theoretical curve (Fermi Energy=0)"},
    Joined → {True, True}, LabelStyle → Directive[Black, 15],
    LegendFunction → "Frame", LegendLayout → "Column",
    LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]], {{0.26, 0.23}, {0.2, 0.9}}];


(*Plot style settings*)
plotStyles = {Directive[PointSize[1/100], Red],
   Directive[PointSize[1/100], Blue], Directive[PointSize[1/100], Green]};




(*Generate plots for each energy region*)
If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3,
  Print["1. Analysis for Incident Neutron Energy: 0.0253eV"];
  Print[ListLogPlot[{yieldData0253eV[[fitStartIndex ;; fitEndIndex]],
      finalYield0253eV}, Evaluate[commonPlotSettings],
    PlotStyle → plotStyles, PlotLegends → legendSettings,
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.16, 0.9}]}]];];

If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
  Print["2. Analysis for Incident Neutron Energy: 500keV"];
  Print[ListLogPlot[{yieldData500keV[[fitStartIndex ;; fitEndIndex]],
      finalYield500keV}, Evaluate[commonPlotSettings],
    PlotStyle → plotStyles, PlotLegends → legendSettings,
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.16, 0.9}]}]];];

If[energyPattern == 3 || energyPattern == 5,
  Print["3. Analysis for Incident Neutron Energy: 14MeV"];
  Print[ListLogPlot[{yieldData14MeV[[fitStartIndex ;; fitEndIndex]], finalYield14MeV},
    Evaluate[commonPlotSettings], PlotStyle → plotStyles, PlotLegends → legendSettings,
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.16, 0.9}]}]];];



(*9*)(*Analysis of Effective Fission Distance and Fission Probability*)
(*Display section separator*)Print[
  "-----------------------------------------------------------------------------------
    -"];
Print["Analysis of Effective Fission Distance and Fission Probability"];
Print[""];
Print["Analysis Contents:"];
Print["1. Calculation of Effective
    Fission Distance (Reff) for each incident neutron energy"];
Print["2. Evaluation of fission probability using η function"];
Print["3. Derivation of normalization factor κ (= Ex/Reff)"];
Print[""];
Print["The vertical axis κ represents the ratio of Fermi Energy(Ex)"];
Print["to effective fission distance (Reff)."];
Print[
  "κ ≈ 1 suggests the fission Fermi Energy is proportional to effective distance."];
Print[
  "-----------------------------------------------------------------------------------
    -"];
```

```
 (*Analysis and visualization module*)
Module[{}, (*Process for each incident neutron energy*)
  (*1. Calculate effective fission distance function values*)
  (*2. Calculate fission probability using η function*)
  (*3. Calculate normalization factor κ*)
  If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3, distanceData0253eV =
    Table[{x, atomicNumber - x} → distanceFunction0253eV, {x, fitStartZ, fitEndZ}];
   distanceFunc0253eV = Thread[Thread[effectiveDistance0253eV[distanceData0253eV[[All,
         1, 1]], distanceData0253eV[[All, 1, 2]]]] → distanceData0253eV[[All, 2]]];
   normFactor0253eV = Thread[{distanceData0253eV[[All, 1, 1]],
      fittedYield0253eV[[All, 2]][[fitStartIndex ;; fitEndIndex]] /
       distanceFunc0253eV[[All, 2]]}];];
  If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
   distanceData500keV =
    Table[{x, atomicNumber - x} → distanceFunction500keV, {x, fitStartZ, fitEndZ}];
   distanceFunc500keV = Thread[Thread[effectiveDistance500keV[distanceData500keV[[All,
         1, 1]], distanceData500keV[[All, 1, 2]]]] → distanceData500keV[[All, 2]]];
   normFactor500keV = Thread[{distanceData500keV[[All, 1, 1]],
      fittedYield500keV[[All, 2]][[fitStartIndex ;; fitEndIndex]] /
       distanceFunc500keV[[All, 2]]}];];
  If[energyPattern == 3 || energyPattern == 5, distanceData14MeV =
    Table[{x, atomicNumber - x} → distanceFunction14MeV, {x, fitStartZ, fitEndZ}];
   distanceFunc14MeV = Thread[Thread[effectiveDistance14MeV[distanceData14MeV[[All,
         1, 1]], distanceData14MeV[[All, 1, 2]]]] → distanceData14MeV[[All, 2]]];
   normFactor14MeV = Thread[{distanceData14MeV[[All, 1, 1]],
      fittedYield14MeV[[All, 2]][[fitStartIndex ;; fitEndIndex]] /
       distanceFunc14MeV[[All, 2]]}];];
  (*Common plot options*)
  plotOptions =
   {Joined → {True, True}, PlotRange → {{15, 80}, {0.9, 1.1}}, PlotMarkers → Automatic,
    Frame → True, FrameLabel → {"Atomic Number", "Normalization Factor κ = Ex/Reff"},
    LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
    FrameStyle → {Thick, Thick, Thick, Thick}, AspectRatio → 1, ImageSize → 400};
  (*Create visualization based on energy pattern*)
  Switch[energyPattern, 1, Print[ListPlot[{normFactor0253eV},
      Evaluate[plotOptions], PlotStyle → {Directive[PointSize[1 / 100], Blue]},
      PlotLegends → Placed[PointLegend[{"0.0253eV"}, LabelStyle → 14,
         LegendFunction → "Frame"], {{0.975, 0.925}, {1, 0.9}}],
      Epilog → {Inset[Style[isotopeName, Bold, 14], Scaled@{0.15, 0.95}],
        Inset[Style[databaseName, Bold, 14], Scaled@{0.15, 0.90}]}]], 2, Print[
    ListPlot[{normFactor0253eV, normFactor500keV}, Evaluate[plotOptions], PlotStyle →
      {Directive[PointSize[1 / 100], Blue], Directive[PointSize[1 / 100], Green]},
      PlotLegends → Placed[PointLegend[{"0.0253eV", "500keV"}, LabelStyle → 14,
         LegendFunction → "Frame"], {{0.975, 0.925}, {1, 0.9}}],
      Epilog → {Inset[Style[isotopeName, Bold, 14], Scaled@{0.15, 0.95}],
        Inset[Style[databaseName, Bold, 14], Scaled@{0.15, 0.90}]}]], 3,
   Print[ListPlot[{normFactor0253eV, normFactor500keV, normFactor14MeV},
      Evaluate[plotOptions], PlotStyle → {Directive[PointSize[1 / 100], Blue],
        Directive[PointSize[1 / 100], Green], Directive[PointSize[1 / 100], Red]},
      PlotLegends → Placed[PointLegend[{"0.0253eV", "500keV", "14MeV"},
         LabelStyle → 14, LegendFunction → "Frame"], {{0.975, 0.925}, {1, 0.9}}],
      Epilog → {Inset[Style[isotopeName, Bold, 14], Scaled@{0.15, 0.95}],
        Inset[Style[databaseName, Bold, 14], Scaled@{0.15, 0.90}]}]],
    4, Print[ListPlot[{normFactor500keV}, Evaluate[plotOptions],
      PlotStyle → {Directive[PointSize[1/100], Green]},
      PlotLegends → Placed[PointLegend[{"500keV"}, LabelStyle → 14,
         LegendFunction → "Frame"], {{0.975, 0.925}, {1, 0.9}}],
      Epilog → {Inset[Style[isotopeName, Bold, 14], Scaled@{0.15, 0.95}],
        Inset[Style[databaseName, Bold, 14], Scaled@{0.15, 0.90}]}]], 5, Print[
     ListPlot[{normFactor500keV, normFactor14MeV}, Evaluate[plotOptions], PlotStyle →
       {Directive[PointSize[1/100], Green], Directive[PointSize[1/100], Red]},
      PlotLegends → Placed[PointLegend[{"500keV", "14MeV"}, LabelStyle → 14,
         LegendFunction → "Frame"], {{0.975, 0.925}, {1, 0.9}}],
      Epilog → {Inset[Style[isotopeName, Bold, 14], Scaled@{0.15, 0.95}],
        Inset[Style[databaseName, Bold, 14], Scaled@{0.15, 0.90}]}]]];];

Print[
  "----------------------------------------------------------------------------------
    -"];



(*10*)(*Initialize Fermi Energy Variables and Main Calculation Function*)
(*Initialize Fermi Energy*)
fermiEnergy0253eV = .;
fermiEnergy500keV = .;
fermiEnergy14MeV = .;

(*Initialize parameter lists for each energy region*)
paramList0253eV = {};
paramList500keV = {};
paramList14MeV = {};

paramList5 = {};
paramList6 = {};
paramList7 = {};

(*Nuclear Fission Calculation Main Function*)
CalculateFissionYieldsWithfermi[energyPattern_] := Module[{tempData, results = {}},
  For[energyIndex = startEnergyIndex, energyIndex ≤ endEnergyIndex,
   energyIndex++, (*Set parameters for each energy region*)
   {promptNeutronCount, incidentEnergy, fermiEnergy, parameterList, yieldList,
     neutronVarList, effectiveDist, distanceFunc} = Switch[energyIndex, 1,
     {promptNeutrons1, neutronEnergy1, fermiEnergy0253eV, paramList0253eV,
      fissionYield0253eV, paramList5, effectiveDist0253eV, distanceFunction0253eV},
     (*Thermal*)2, {promptNeutrons2, neutronEnergy2, fermiEnergy500keV,
      paramList500keV, fissionYield500keV, paramList6, effectiveDist500keV,
      distanceFunction500keV}, (*Intermediate*)3, {promptNeutrons3,
      neutronEnergy3, fermiEnergy14MeV, paramList14MeV, fissionYield1400keV,
      paramList7, effectiveDist14MeV, distanceFunction14MeV} (*Fast*)];
   tempData = Reap[For[protonNumber1 = 23, protonNumber1 ≤ atomicNumber - 23,
       protonNumber1++, For[neutronCount1 = 0, neutronCount1 ≤ neutronNumber,
        neutronCount1++, protonNumber2 = atomicNumber - protonNumber1;
        neutronCount2 = neutronNumber - neutronCount1 - Round[promptNeutronCount];
        massNumber1 = protonNumber1 + neutronCount1;
```

```
massNumber2 = protonNumber2 + neutronCount2;


(*Check fragment existence*)




If[ (protonNumber1 == 22 && 16 <= neutronCount1 <= 41) ||
   (protonNumber1 == 23 && 17 <= neutronCount1 <= 42) ||
   (protonNumber1 == 24 && 18 <= neutronCount1 <= 43) ||
   (protonNumber1 == 25 && 19 <= neutronCount1 <= 44) ||
   (protonNumber1 == 26 && 19 <= neutronCount1 <= 46) ||
   (protonNumber1 == 27 && 20 <= neutronCount1 <= 48) ||
   (protonNumber1 == 28 && 20 <= neutronCount1 <= 50) ||
   (protonNumber1 == 29 && 23 <= neutronCount1 <= 51) ||
   (protonNumber1 == 30 && 24 <= neutronCount1 <= 53) ||
   (protonNumber1 == 31 && 25 <= neutronCount1 <= 55) ||
   (protonNumber1 == 32 && 26 <= neutronCount1 <= 57) ||
   (protonNumber1 == 33 && 27 <= neutronCount1 <= 59) ||
   (protonNumber1 == 34 && 31 <= neutronCount1 <= 60) ||
   (protonNumber1 == 35 && 32 <= neutronCount1 <= 62) ||
   (protonNumber1 == 36 && 33 <= neutronCount1 <= 64) ||
   (protonNumber1 == 37 && 34 <= neutronCount1 <= 65) ||
   (protonNumber1 == 38 && 35 <= neutronCount1 <= 67) ||
   (protonNumber1 == 39 && 37 <= neutronCount1 <= 69) ||
   (protonNumber1 == 40 && 38 <= neutronCount1 <= 70) ||
   (protonNumber1 == 41 && 40 <= neutronCount1 <= 72) ||
   (protonNumber1 == 42 && 41 <= neutronCount1 <= 73) ||
   (protonNumber1 == 43 && 42 <= neutronCount1 <= 75) ||
   (protonNumber1 == 44 && 43 <= neutronCount1 <= 76) ||
   (protonNumber1 == 45 && 44 <= neutronCount1 <= 77) ||
   (protonNumber1 == 46 && 45 <= neutronCount1 <= 78) ||
   (protonNumber1 == 47 && 46 <= neutronCount1 <= 83) ||
   (protonNumber1 == 48 && 47 <= neutronCount1 <= 84) ||
   (protonNumber1 == 49 && 48 <= neutronCount1 <= 86) ||
   (protonNumber1 == 50 && 49 <= neutronCount1 <= 87) ||
   (protonNumber1 == 51 && 52 <= neutronCount1 <= 88) ||
   (protonNumber1 == 52 && 53 <= neutronCount1 <= 90) ||
   (protonNumber1 == 53 && 55 <= neutronCount1 <= 91) ||
   (protonNumber1 == 54 && 56 <= neutronCount1 <= 93) ||
   (protonNumber1 == 55 && 57 <= neutronCount1 <= 96) ||
   (protonNumber1 == 56 && 58 <= neutronCount1 <= 97) ||
   (protonNumber1 == 57 && 60 <= neutronCount1 <= 98) ||
   (protonNumber1 == 58 && 61 <= neutronCount1 <= 99) ||
   (protonNumber1 == 59 && 62 <= neutronCount1 <= 100) ||
   (protonNumber1 == 60 && 64 <= neutronCount1 <= 101) ||
   (protonNumber1 == 61 && 65 <= neutronCount1 <= 102) ||
  (protonNumber1 == 62 && 66 <= neutronCount1 <= 103) ||
  (protonNumber1 == 63 && 67 <= neutronCount1 <= 104) ||
  (protonNumber1 == 64 && 70 <= neutronCount1 <= 105) ||
  (protonNumber1 == 65 && 71 <= neutronCount1 <= 106) ||
  (protonNumber1 == 66 && 72 <= neutronCount1 <= 107) ||
  (protonNumber1 == 67 && 73 <= neutronCount1 <= 108) ||
  (protonNumber1 == 68 && 75 <= neutronCount1 <= 109) ||
  (protonNumber1 == 69 && 76 <= neutronCount1 <= 110) ||
  (protonNumber1 == 70 && 78 <= neutronCount1 <= 111) ||
  (protonNumber1 == 71 && 79 <= neutronCount1 <= 111) ||
  (protonNumber1 ⩵ 72 && 81 ≤ neutronCount1 ≤ 116) ||
  (protonNumber1 ⩵ 73 && 82 ≤ neutronCount1 ≤ 117) ||
  (protonNumber1 ⩵ 74 && 84 ≤ neutronCount1 ≤ 118) ||
  (protonNumber1 ⩵ 75 && 85 ≤ neutronCount1 ≤ 119),
 (*Check nuclear chart range for second fragment*)
If[ (protonNumber2 == 22 && 16 <= neutronCount2 <= 41) ||
   (protonNumber2 == 23 && 17 <= neutronCount2 <= 42) ||
   (protonNumber2 == 24 && 18 <= neutronCount2 <= 43) ||
   (protonNumber2 == 25 && 19 <= neutronCount2 <= 44) ||
   (protonNumber2 == 26 && 19 <= neutronCount2 <= 46) ||
   (protonNumber2 == 27 && 20 <= neutronCount2 <= 48) ||
   (protonNumber2 == 28 && 20 <= neutronCount2 <= 50) ||
   (protonNumber2 == 29 && 23 <= neutronCount2 <= 51) ||
   (protonNumber2 == 30 && 24 <= neutronCount2 <= 53) ||
   (protonNumber2 == 31 && 25 <= neutronCount2 <= 55) ||
   (protonNumber2 == 32 && 26 <= neutronCount2 <= 57) ||
   (protonNumber2 == 33 && 27 <= neutronCount2 <= 59) ||
   (protonNumber2 == 34 && 31 <= neutronCount2 <= 60) ||
   (protonNumber2 == 35 && 32 <= neutronCount2 <= 62) ||
   (protonNumber2 == 36 && 33 <= neutronCount2 <= 64) ||
   (protonNumber2 == 37 && 34 <= neutronCount2 <= 65) ||
   (protonNumber2 == 38 && 35 <= neutronCount2 <= 67) ||
   (protonNumber2 == 39 && 37 <= neutronCount2 <= 69) ||
   (protonNumber2 == 40 && 38 <= neutronCount2 <= 70) ||
   (protonNumber2 == 41 && 40 <= neutronCount2 <= 72) ||
   (protonNumber2 == 42 && 41 <= neutronCount2 <= 73) ||
   (protonNumber2 == 43 && 42 <= neutronCount2 <= 75) ||
   (protonNumber2 == 44 && 43 <= neutronCount2 <= 76) ||
   (protonNumber2 == 45 && 44 <= neutronCount2 <= 77) ||
   (protonNumber2 == 46 && 45 <= neutronCount2 <= 78) ||
   (protonNumber2 == 47 && 46 <= neutronCount2 <= 83) ||
   (protonNumber2 == 48 && 47 <= neutronCount2 <= 84) ||
   (protonNumber2 == 49 && 48 <= neutronCount2 <= 86) ||
   (protonNumber2 == 50 && 49 <= neutronCount2 <= 87) ||
   (protonNumber2 == 51 && 52 <= neutronCount2 <= 88) ||
   (protonNumber2 == 52 && 53 <= neutronCount2 <= 90) ||
   (protonNumber2 == 53 && 55 <= neutronCount2 <= 91) ||
   (protonNumber2 == 54 && 56 <= neutronCount2 <= 93) ||
   (protonNumber2 == 55 && 57 <= neutronCount2 <= 96) ||
   (protonNumber2 == 56 && 58 <= neutronCount2 <= 97) ||
              (protonNumber2 == 57 && 60 <= neutronCount2 <= 98) ||
              (protonNumber2 == 58 && 61 <= neutronCount2 <= 99) ||
              (protonNumber2 == 59 && 62 <= neutronCount2 <= 100) ||
              (protonNumber2 == 60 && 64 <= neutronCount2 <= 101) ||
              (protonNumber2 == 61 && 65 <= neutronCount2 <= 102) ||
              (protonNumber2 == 62 && 66 <= neutronCount2 <= 103) ||
              (protonNumber2 == 63 && 67 <= neutronCount2 <= 104) ||
              (protonNumber2 == 64 && 70 <= neutronCount2 <= 105) ||
              (protonNumber2 == 65 && 71 <= neutronCount2 <= 106) ||
              (protonNumber2 == 66 && 72 <= neutronCount2 <= 107) ||
              (protonNumber2 == 67 && 73 <= neutronCount2 <= 108) ||
              (protonNumber2 == 68 && 75 <= neutronCount2 <= 109) ||
              (protonNumber2 == 69 && 76 <= neutronCount2 <= 110) ||
              (protonNumber2 == 70 && 78 <= neutronCount2 <= 111) ||
              (protonNumber2 == 71 && 79 <= neutronCount2 <= 111) ||
              (protonNumber2 ⩵ 72 && 81 ≤ neutronCount2 ≤ 116) ||
              (protonNumber2 ⩵ 73 && 82 ≤ neutronCount2 ≤ 117) ||
              (protonNumber2 ⩵ 74 && 84 ≤ neutronCount2 ≤ 118) ||
              (protonNumber2 ⩵ 75 && 85 ≤ neutronCount2 ≤ 119),


             Switch[energyIndex, 1, paramList5 = Union[AppendTo[paramList0253eV,
                 fermiEnergy0253eV[protonNumber1, protonNumber2]]], 2,
              paramList6 = Union[AppendTo[paramList500keV, fermiEnergy500keV[
                   protonNumber1, protonNumber2]]], 3, paramList7 = Union[AppendTo[
                 paramList14MeV, fermiEnergy14MeV[protonNumber1, protonNumber2]]]];
             (*Calculate fission parameters*)effectiveDistVal =
              distanceFunc /. x → protonNumber1;
             coulombEnergy = (1.44 * protonNumber1 * protonNumber2) / effectiveDistVal;
             qValue = (getNuclearMass[atomicNumber, atomicNumber + neutronNumber] -
                 getNuclearMass[protonNumber1, massNumber1] -
                 getNuclearMass[protonNumber2, massNumber2] -
                 promptNeutronCount * 1.008665) * 931.4940954;
             effectiveEnergy = coulombEnergy - qValue;
             (*Calculate fission probability with fermi correction*)
             probability = 1 / (1 + Exp[2 * Pi / (neutronSeparationEnergy + incidentEnergy) *
                    Sqrt[protonNumber1 * protonNumber2 / (protonNumber1 + protonNumber2)] /
                     reducedMass * (effectiveEnergy -
                      fermiEnergy[protonNumber1, protonNumber2])]);
             Sow[{protonNumber1, probability}, yieldList];]]]], {yieldList}, Rule][[
       2, All, 1]];
    (*Process results*)fragmentData = Part[yieldList /. tempData];
    processYields[data_] :=
     (Total@# / {Length@#, Total@data[[All, 2]] / 2} &) /@ GatherBy[data, First];
    AppendTo[results, {energyIndex, processYields[fragmentData]}];];
   results]

 (*Execute calculation with Pattern selection*)
 {startEnergyIndex, endEnergyIndex} =
   Switch[energyPattern, 1, {1, 1}, 2, {1, 2}, 3, {1, 3}, 4, {2, 2}, 5, {2, 3}];

 (*Main calculation*)
```

```
results = CalculateFissionYieldsWithfermi[energyPattern];
{yieldData0253eVCalc, yieldData500keVCalc, yieldData14MeVCalc} =
  Switch[energyPattern, 1, {results[[1, 2]], Null, Null}, 2, {results[[1, 2]],
    results[[2, 2]], Null}, 3, {results[[1, 2]], results[[2, 2]], results[[3, 2]]}, 4,
   {Null, results[[1, 2]], Null}, 5, {Null, results[[1, 2]], results[[2, 2]]}];

(*11*)

(*Common Plot Generation Functions for Fission Yields*)
(*Define general yield plot function*)
CreateFissionYieldPlot[experimentalData_, calculatedData_, energyLabel_, plotColor_] :=
  ListLogPlot[{experimentalData, calculatedData}, (*Basic plot settings*)
   Joined → {True, True}, PlotRange → {{15, 80}, {10^(-12), 100}}, PlotMarkers →
    Automatic, (*Style settings*)PlotStyle → {Directive[PointSize[1/100], Red],
     Directive[PointSize[1/100], plotColor]}, (*Frame settings*)
   Frame → True, FrameLabel → {"Atomic Number", "Fission Yield (Independent)"},
   LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
   FrameStyle → {Thick, Thick, Thick, Thick}, (*Legend settings*)
   PlotLegends → Placed[PointLegend[Automatic, {"JENDL-5", "Theoretical Curve"},
      Joined → {True, True, True}, Joined → {True, True},
      LabelStyle → 16, LegendFunction → "Frame", LegendLayout → "Column",
      LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]], {{0.72, 0.25}, {1, 0.9}}],
   (*Layout settings*)AspectRatio → 0.8, ImageSize → 400, (*Title and isotope
    label*)Epilog → Inset[Style[isotopeName, Bold, 18], Scaled@{0.14, 0.94}]];

(*Define data analysis function*)
AnalyzeIsotopeYield[yieldData_, label_] :=
  Module[{maxZ1, maxZ2, maxYield1, maxYield2, peakAvgYield},
   (*Display analysis header*)Print[label];
   (*Find primary peak*)
   maxZ1 = Position[yieldData, Max[yieldData[[All, 2]]]][[1, 1]] + fitStartZ - 1;
   maxZ2 = atomicNumber - maxZ1;
   maxYield1 = Max[yieldData[[All, 2]]];
   maxYield2 = yieldData[[maxZ2 - fitStartZ + 1]][[2]];
   (*Display isotope information*)
   For[atomicNum = 23, atomicNum ≤ 71, atomicNum++,
    If[maxZ1 == atomicNum, Print["Primary Fragment: ", ElementData[atomicNum, "Name"],
      "(Z=", atomicNum, ")", "; Yield: ", maxYield1, " MeV"]];
    If[maxZ2 == atomicNum, Print["Secondary Fragment: ", ElementData[atomicNum, "Name"],
      "(Z=", atomicNum, ")", "; Yield: ", maxYield2, " MeV"]];];
   (*Calculate and display average peak yield*)
   peakAvgYield = (maxYield1 + maxYield2) / 2;
   Print["Average Peak Yield: ", peakAvgYield, " MeV"];
   Print[
    "-----------------------------------------------------------------------------
      ---"];];


(*12*)(*Optimization Program for Fermi Energy*)(*Display program description*)
Print[
  "Theoretical Analysis and Experimental Comparison of Fission Yield Distributions"];
Print[""];
Print["Calculation Process:"];
Print["1. Evaluate logarithmic differences between
    JENDL-5 experimental data and theoretical calculations"];
```

```
Print["2. Optimize Fermi Energy (Ex) using least squares method"];
Print["3. Generate theoretical curves using optimized Ex"];
Print["4. Compare and verify experimental vs theoretical values"];
Print[""];
Print["Optimization Goals:"];
Print[
  "・Theoretical reproduction of experimentally observed asymmetric fission yields"];
Print["・Understanding fission mechanisms at each incident neutron energy"];
Print["・Systematic determination of Fermi Energy (Ex)"];
Print[""];
Print["Evaluation Methods:"];
Print[
  "・Minimize sum of squared logarithmic differences between theory and experiment"];
Print["・Parameter optimization using FindMinimum function"];
Print["・Validation of theoretical curves with optimized parameters"];
Print[
  "----------------------------------------------------------------------------------
    -"];



(*Main optimization loop for each energy region*)
For[energyRegion = startEnergyIndex, energyRegion ≤ endEnergyIndex, energyRegion++,
  (*Initialize variables for each energy region*)If[energyRegion == 1,
   fermiParams0253eV = Union[paramList5] (*Thermal neutron parameters*)];
  If[energyRegion == 2, fermiParams500keV = Union[paramList6]
   (*Intermediate energy parameters*)];
  If[energyRegion == 3, fermiParams14MeV = Union[paramList7]
   (*Fast neutron parameters*)];
  (*Prepare theoretical calculation data*)If[energyRegion == 1,
   yieldData0253eVTheory = yieldData0253eVCalc[[fitStartIndex ;; fitEndIndex]]];
  If[energyRegion == 2, yieldData500keVTheory =
    yieldData500keVCalc[[fitStartIndex ;; fitEndIndex]]];
  If[energyRegion == 3, yieldData14MeVTheory =
    yieldData14MeVCalc[[fitStartIndex ;; fitEndIndex]]];
  (*Prepare experimental data*)If[energyRegion == 1,
   expData = yieldData0253eV[[fitStartIndex ;; fitEndIndex]] (*JENDL-5 0.0253eV*)];
  If[energyRegion == 2, expData = yieldData500keV[[fitStartIndex ;; fitEndIndex]]
   (*JENDL-5 500keV*)];
  If[energyRegion == 3, expData = yieldData14MeV[[fitStartIndex ;; fitEndIndex]]
   (*JENDL-5 14MeV*)];
  (*Calculate logarithmic differences*)If[energyRegion == 1,
   logDiff0253eV = (Log@expData - Log@yieldData0253eVTheory)[[All, 2]]];
  If[energyRegion == 2, logDiff500keV =
    (Log@expData - Log@yieldData500keVTheory)[[All, 2]]];
  If[energyRegion == 3, logDiff14MeV =
    (Log@expData - Log@yieldData14MeVTheory)[[All, 2]]];
  (*Perform least squares optimization*)If[energyRegion == 1,
   optResult0253eV = Quiet[FindMinimum[Total[logDiff0253eV^2],
      Thread@{fermiParams0253eV}], FindMinimum::cvmit]];
  If[energyRegion == 2, optResult500keV = Quiet[FindMinimum[Total[logDiff500keV^2],
      Thread@{fermiParams500keV}], FindMinimum::cvmit]];
  If[energyRegion == 3, optResult14MeV = Quiet[FindMinimum[Total[logDiff14MeV^2],
      Thread@{fermiParams14MeV}], FindMinimum::cvmit]];
  (*Store optimized parameters*)If[energyRegion == 1,
    fittedParams0253eV = optResult0253eV[[2, All, All]]];
  If[energyRegion == 2, fittedParams500keV = optResult500keV[[2, All, All]]];
  If[energyRegion == 3, fittedParams14MeV = optResult14MeV[[2, All, All]]];
  (*Display optimized parameters*)
  If[energyRegion == 1, Print[fittedParams0253eV[[fitStartIndex ;; fitEndIndex]]]];
  If[energyRegion == 2, Print[fittedParams500keV[[fitStartIndex ;; fitEndIndex]]]];
  If[energyRegion == 3, Print[fittedParams14MeV[[fitStartIndex ;; fitEndIndex]]]];
  (*Calculate theoretical yields with optimized parameters*)If[energyRegion == 1,
   theoreticalYield0253eV = yieldData0253eVTheory /. optResult0253eV[[2, All, All]]];
  If[energyRegion == 2, theoreticalYield500keV =
    yieldData500keVTheory /. optResult500keV[[2, All, All]]];
  If[energyRegion == 3, theoreticalYield14MeV =
    yieldData14MeVTheory /. optResult14MeV[[2, All, All]]];
  (*Generate and display plots for each energy region*)
  If[energyRegion == 1, Print["1. Analysis for Incident Neutron Energy: 0.0253eV"];
   Print[CreateFissionYieldPlot[expData,
     theoreticalYield0253eV, "0.0253eV", Blue]];];
  If[energyRegion == 2, Print["2. Analysis for Incident Neutron Energy: 500keV"];
   Print[CreateFissionYieldPlot[expData, theoreticalYield500keV, "500keV", Blue]];];
  If[energyRegion == 3, Print["3. Analysis for Incident Neutron Energy: 14MeV"];
   Print[CreateFissionYieldPlot[expData, theoreticalYield14MeV, "14MeV", Blue]];];
  (*Display separator*)Print[
   "----------------------------------------------------------------------------
     ---"];];



(*13*)(*Analysis and Visualization of Optimization Results*)
(*Display analysis title*)
Print["Quantitative Analysis Results of Fermi Energy Ex"];
Print["Based on Optimization Calculations using Experimental Fission Yield Data"];

(*Process and display results for each energy region*)
If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3,
  Print["1. Analysis for Incident Neutron Energy: 0.0253eV"];
  Print[fermiData0253eV = Thread[{fittedParams0253eV[[All, 1, 1]],
       fittedParams0253eV[[All, 2]]}][[fitStartIndex ;; fitEndIndex]]];];

If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
  Print["2. Analysis for Incident Neutron Energy: 500keV"];
  Print[fermiData500keV = Thread[{fittedParams500keV[[All, 1, 1]],
       fittedParams500keV[[All, 2]]}][[fitStartIndex ;; fitEndIndex]]];];

If[energyPattern == 3 || energyPattern == 5,
  Print["3. Analysis for Incident Neutron Energy: 14MeV"];
  Print[fermiData14MeV = Thread[{fittedParams14MeV[[All, 1, 1]],
       fittedParams14MeV[[All, 2]]}][[fitStartIndex ;; fitEndIndex]]];];

Print[
  "-----------------------------------------------------------------------------
    -"];


Print[" Systematic Analysis Results of Fermi Energy Ex"];
```

```
Print[" Using Optimized Effective Fission Distance Reff"];
```

```
(*Define common plot settings*)
plotBaseSettings = {PlotRange → {{15, 75}, {-8, 12}}, PlotMarkers → Automatic,
   Frame → True, FrameLabel → {"Atomic Number", "Energy (MeV)"},
   LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
   FrameStyle → {Thick, Thick, Thick, Thick}, AspectRatio → 1.1, ImageSize → 400};
```

```
(*Create visualization based on energy pattern*)
Switch[energyPattern, 1, (*0.0253eV only*)plotData = {fermiData0253eV, {}, {}};
  Print[ListPlot[Select[plotData, Length[#] > 0 &],
    Joined → {True, True}, Evaluate@plotBaseSettings, PlotStyle →
     {Directive[PointSize[1/100], Blue], Directive[PointSize[1/100], Green],
      Directive[PointSize[1/100], Red]}, PlotLegends →
     Placed[PointLegend[Automatic, {"0.0253eV"}, Joined → {True, True, True},
       LabelStyle → 14, LegendFunction → "Frame", LegendLayout → "Column",
       LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]], {{0.955, 0.95}, {1, 0.9}}],
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.15, 0.95}],
      Inset[Style[databaseName, 20, Bold], Scaled@{0.15, 0.90}]}]], 2,
  (*0.0253eV and 500keV*)plotData = {fermiData0253eV, fermiData500keV, {}};
  Print[ListPlot[Select[plotData, Length[#] > 0 &],
    Joined → {True, True}, Evaluate@plotBaseSettings, PlotStyle →
     {Directive[PointSize[1/100], Blue], Directive[PointSize[1/100], Green],
      Directive[PointSize[1/100], Red]}, PlotLegends →
     Placed[PointLegend[Automatic, {"0.0253eV", "500keV"}, Joined → {True, True, True},
       LabelStyle → 14, LegendFunction → "Frame", LegendLayout → "Column",
       LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]], {{0.955, 0.95}, {1, 0.9}}],
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.15, 0.95}],
      Inset[Style[databaseName, 20, Bold], Scaled@{0.15, 0.90}]}]],
  3, (*All three energies*)plotData = {fermiData0253eV,
    fermiData500keV, fermiData14MeV};
  Print[ListPlot[Select[plotData, Length[#] > 0 &], Joined → {True, True},
    Evaluate@plotBaseSettings, PlotStyle → {Directive[PointSize[1/100], Blue],
      Directive[PointSize[1/100], Green], Directive[PointSize[1/100], Red]},
    PlotLegends → Placed[PointLegend[Automatic, {"0.0253eV", "500keV", "14MeV"},
       Joined → {True, True, True}, LabelStyle → 14,
       LegendFunction → "Frame", LegendLayout → "Column",
       LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]], {{0.955, 0.95}, {1, 0.9}}],
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.15, 0.95}],
      Inset[Style[databaseName, 20, Bold], Scaled@{0.15, 0.90}]}]],
  4, (*500keV only*)plotData = {fermiData500keV};
  Print[ListPlot[plotData, Joined → True, PlotRange → {{20, 75}, {-8, 12}},
    PlotMarkers → Automatic, PlotStyle → Directive[PointSize[1/100], Blue],
    Frame → True, LabelStyle → Directive[Black, 19],
    FrameTicks → Automatic, FrameStyle → {Thick, Thick, Thick, Thick},
    PlotLegends → Placed[PointLegend[{Blue}, {"500keV"}, Joined → True,
        LabelStyle → 14, LegendFunction → "Frame", LegendLayout → "Column",
        LegendMarkers → {Graphics@Disk[]}], {{0.955, 0.95}, {1, 0.9}}], AspectRatio →
     1.1, Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.15, 0.95}],
      Inset[Style[databaseName, 20, Bold], Scaled@{0.15, 0.90}]}]], 5,
  (*500keV and 14MeV*)plotData = {{}, fermiData500keV, fermiData14MeV};
  Print[ListPlot[Select[plotData, Length[#] > 0 &], Joined → {True, True},
    PlotRange → {{20, 75}, {-8, 12}}, PlotMarkers → Automatic, PlotStyle →
     {Directive[PointSize[1/100], Green], Directive[PointSize[1/100], Red]},
    Frame → True, LabelStyle → Directive[Black, 19], FrameTicks → Automatic,
    FrameStyle → {Thick, Thick, Thick, Thick},
    PlotLegends → Placed[PointLegend[Automatic, {"500keV", "14MeV"},
        Joined → {True, True}, LabelStyle → 14, LegendFunction → "Frame",
        LegendLayout → "Column", LegendMarkers → Array[{Graphics@Disk[], 10} &, 3]],
       {{0.955, 0.95}, {1, 0.9}}], AspectRatio → 1.1,
    Epilog → {Inset[Style[isotopeName, 20, Bold], Scaled@{0.15, 0.95}],
      Inset[Style[databaseName, 20, Bold], Scaled@{0.15, 0.90}]}]]];
(*14*)(*Final Analysis and Visualization of Nuclear Species*)
(*Fragment Analysis Function*)
AnalyzeIsotopeYield[yieldData_, label_] := Module[{centerZ = Floor[atomicNumber/2],
    (*Calculate center atomic number*)rangeStart = Floor[atomicNumber/2] - 10,
    (*Lower bound*)rangeEnd = Floor[atomicNumber/2] + 10, (*Upper bound*)
    maxZ1, maxZ2, maxYield1, maxYield2, peakAvgYield, filteredData},
   (*Display analysis header*)Print[label];
   (*Filter data to only include atomic numbers within our range*)
   filteredData = Select[yieldData, rangeStart ≤ First[#] ≤ rangeEnd &];
   (*Find maximum yield within our range*)maxYield1 = Max[filteredData[[All, 2]]];
   maxZ1 = First[First[Select[filteredData, #[[2]] == maxYield1 &]]];
   maxZ2 = atomicNumber - maxZ1;
   maxYield2 = yieldData[[maxZ2 - First[yieldData][[1]] + 1, 2]];
   (*Display fragment information*)Print["Secondary Fragment: ",
    ElementData[maxZ1, "Name"], "(Z=", maxZ1, "); Yield: ", maxYield1, " MeV"];
   Print["Primary Fragment: ", ElementData[maxZ2, "Name"],
    "(Z=", maxZ2, "); Yield: ", maxYield2, " MeV"];
   (*Calculate and display average peak yield*)
   peakAvgYield = (maxYield1 + maxYield2)/2;
   Print["Average Peak Yield: ", peakAvgYield, " MeV"];
   Print[
    "--------------------------------------------------------------------------
      ---"];];

(*Perform isotope analysis for each energy region*)
If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3, AnalyzeIsotopeYield[
   fermiData0253eV, "1. Analysis for Incident Neutron Energy: 0.0253eV"]];

If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
  AnalyzeIsotopeYield[fermiData500keV,
   "2. Analysis for Incident Neutron Energy: 500keV"]];

If[energyPattern == 3 || energyPattern == 5, AnalyzeIsotopeYield[
   fermiData14MeV, "3. Analysis for Incident Neutron Energy: 14MeV"];
  Print[
   "--------------------------------------------------------------------------
     ---"]];
```

```
(*Define logarithmic scale transformation function*)
LogScaleTransform[value_] := Rescale[Log10[value], {-8, 1}, {-8, 12}];

(*Common plot settings for combined visualization*)
combinedPlotSettings =
  {Joined → {True}, PlotRange → {{15, 75}, {-10, 12}}, PlotMarkers → Automatic,
   Frame → True, FrameLabel → {{Style["Energy (MeV)", 19, Black],
      Style["Fission Yield (Independent)", 19, Black]},
     {Style["Atomic Number", 19, Black], None}},
   LabelStyle → Directive[Black, 19], FrameTicks →
    {{Automatic, ({LogScaleTransform[10^#], If[# == 0, 1, Superscript[10, #]]} &) /@
       {-8, -6, -4, -2, 0, 2}}, {Automatic, None}},
   FrameStyle → {Thick, Thick, Thick, Thick}, AspectRatio → 1.1,
   ImageSize → 400, Axes → {True, False}};

(*Plot generation function*)
CreateEnergyPlot[fermiData_, yieldData_, energy_, color_] := Module[{scaledYieldData},
   scaledYieldData = ({#[[1]], LogScaleTransform@#[[2]]} &) /@ yieldData;
   ListPlot[{fermiData, scaledYieldData[[fitStartIndex ;; fitEndIndex]]},
    Evaluate[combinedPlotSettings],
    PlotStyle → {Directive[PointSize[1/100], color], Directive[PointSize[1/100],
       GrayLevel[0.6 - 0.2 * Position[{Blue, Green, Red}, color][[1, 1]]]]},
    PlotLegends → Placed[PointLegend[Automatic, {"Fermi Energy",
        "Charge Distribution (" <> databaseName <> ")"}, Joined → True,
       LabelStyle → 14, LegendFunction → "Frame", LegendLayout → "Column",
       LegendMarkers → Array[{Graphics@Disk[], 10} &, 2]], {{0.94, 0.19}, {1, 0.9}}],
    Epilog → {Inset[Style[ToString[isotopeName] <> " " <> energy, 18, Bold],
       Scaled@{0.4, 0.94}]}]];

(*Generate plots for each energy region*)
Module[{}, If[energyPattern == 1 || energyPattern == 2 || energyPattern == 3,
   Print[CreateEnergyPlot[fermiData0253eV, yieldData0253eV, "0.0253eV", Blue]]];
  If[energyPattern == 2 || energyPattern == 3 || energyPattern == 4 || energyPattern == 5,
   Print[CreateEnergyPlot[fermiData500keV, yieldData500keV, "500keV", Green]]];
  If[energyPattern == 3 || energyPattern == 5,
   Print[CreateEnergyPlot[fermiData14MeV, yieldData14MeV, "14MeV", Red]]];];

(*Final separator*)
Print[
  "-----------------------------------------------------------------------------
    -"];
```

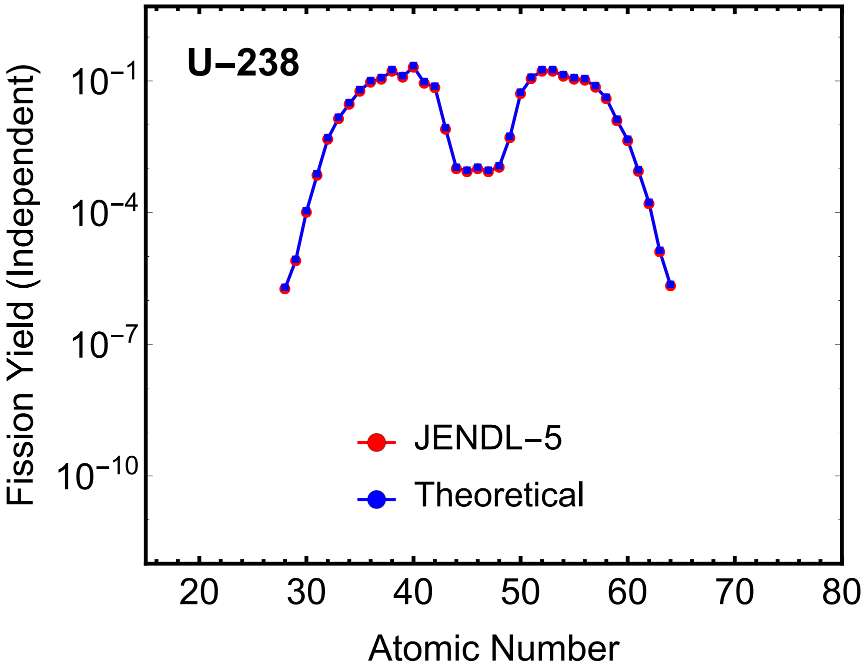
```
Select Nuclear Species:

1. U-235_Data_JENDL5

2. U-233_Data_JENDL5

3. U-238_Data_JENDL5

4. Th-232_Data_JENDL5

5. Np-237_Data_JENDL5
```

```
6. Pu-239_Data_JENDL5

7. Pu-240_Data_JENDL5

8. Pu-242_Data_JENDL5

9. Am-241_Data_JENDL5

Attempting to load file from: C:\Users\etctr\Desktop\Fermi-mathematica2\U-238_Data_JENDL5.m

Successfully loaded: U-238_Data_JENDL5.m
```

2. Incident Neutron Energy: 500keV: Effective Fission Distance Reff derived from experimental charge distribution

Analysis Results

Calculation results demonstrating that the effective fission distance Reff derived from optimization calculations accurately reproduces experimental values (confirming agreement between JENDL-5 experimental and theoretical values, and validating calculations using Mathematica ver11.2 FindMinimum)



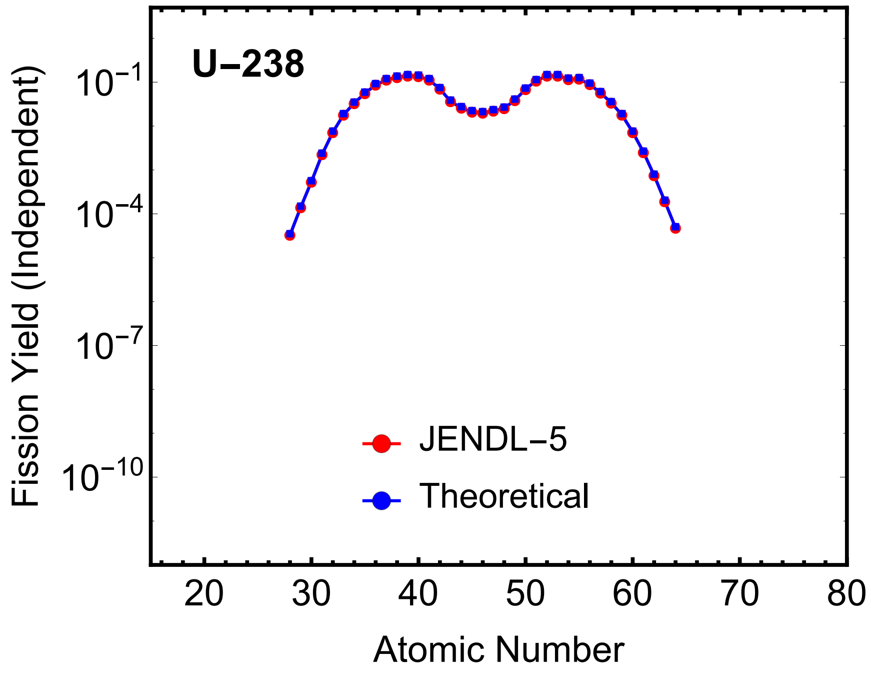
```
--------------------------------------------------------------------------------
```

FindMinimum: The line search decreased the step size to within the tolerance specified by AccuracyGoal and PrecisionGoal but was unable to find a sufficient decrease in the function. You may need more than MachinePrecision digits of working precision to meet these tolerances.

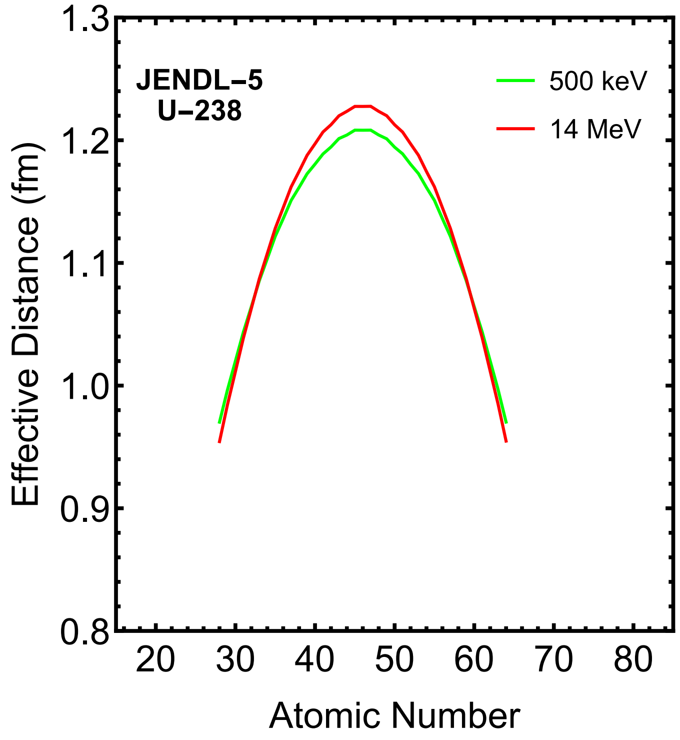
3. Incident Neutron Energy: 14MeV: Effective Fission Distance Reff derived from experimental charge distribution

Analysis Results

Calculation results demonstrating that the effective fission distance Reff derived from optimization calculations accurately reproduces experimental values (confirming agreement between JENDL-5 experimental and theoretical values, and validating calculations using Mathematica ver11.2 FindMinimum)



```
Analysis Results:
1. The effective fission distance Reff shows quadratic dependence on fragment charge
2. This dependence reflects fundamental laws of charge distribution in fission process
3. Similar dependence is maintained across different incident energies
```



```
Incident Neutron Energy: 500 keV case
```

$\text{Reff} == -0.339285 + 0.000731257\,(92.0027 - x)\,x$

Incident Neutron Energy: 14 MeV case

$\text{Reff} == -0.552813 + 0.000841549\,(92.0065 - x)\,x$

Analysis Results:

1. The effective fission distance Reff shows quadratic dependence on fragment charge number

2. This dependence reflects fundamental laws of charge distribution in the fission process

3. Similar dependence is maintained across different incident energies

Table of Effective Fission Distance (Reff) Values by Atomic Number [Unit: fm]:

Displaying calculated values (pre-fitting) and post-fitting values for each energy

Fitting calculation used fragment values from atomic number 28 to 64

Z1	Z2	Reff [fm] (500 keV) Calculated	Fitted Value	Reff [fm] (14 MeV) Calculated	Fitted Value
23	69	0.186941	-	0.173896	-
24	68	0.560606	-	0.440984	-
25	67	0.767136	-	0.733742	-
26	66	0.833462	-	0.873794	-
27	65	0.904254	-	0.919993	-
28	64	0.970222	0.97118	0.954349	0.95540
29	63	0.996506	0.99678	0.984405	0.98486
30	62	1.020050	1.02091	1.011450	1.01263
31	61	1.043630	1.04358	1.038740	1.03873
32	60	1.064300	1.06479	1.062830	1.06314
33	59	1.085500	1.08454	1.087090	1.08586
34	58	1.103410	1.10282	1.107600	1.10691
35	57	1.121630	1.11964	1.128180	1.12627
36	56	1.136030	1.13500	1.145010	1.14395
37	55	1.150960	1.14890	1.162000	1.15994
38	54	1.161590	1.16133	1.174640	1.17425
39	53	1.172630	1.17230	1.187710	1.18688
40	52	1.180540	1.18181	1.197100	1.19783
41	51	1.188830	1.18985	1.206750	1.20709
42	50	1.194480	1.19644	1.212630	1.21467
43	49	1.201370	1.20156	1.219920	1.22057
44	48	1.204260	1.20522	1.223580	1.22478

45	47	1.208250	1.20741	1.227590	1.22731
46	46	1.208180	1.20815	1.227570	1.22816
47	45	1.208250	1.20742	1.227670	1.22732
48	44	1.204290	1.20522	1.223560	1.22480
49	43	1.201190	1.20157	1.220020	1.22060
50	42	1.194340	1.19645	1.212610	1.21471
51	41	1.188930	1.18987	1.206700	1.20714
52	40	1.180450	1.18183	1.197110	1.19789
53	39	1.172760	1.17233	1.187740	1.18696
54	38	1.161490	1.16136	1.174490	1.17434
55	37	1.150960	1.14893	1.162070	1.16004
56	36	1.136070	1.13504	1.145040	1.14406
57	35	1.121700	1.11968	1.128200	1.12639
58	34	1.103520	1.10287	1.107620	1.10704
59	33	1.085470	1.08459	1.087070	1.08601
60	32	1.064270	1.06485	1.062830	1.06329
61	31	1.043710	1.04364	1.038890	1.03889
62	30	1.020210	1.02097	1.011850	1.01281
63	29	0.996668	0.99685	0.984777	0.98504
64	28	0.970281	0.97125	0.954779	0.95559
65	27	0.904254	-	0.919993	-
66	26	0.833462	-	0.873794	-
67	25	0.767136	-	0.733742	-
68	24	0.560606	-	0.440984	-
69	23	0.186941	-	0.173896	-

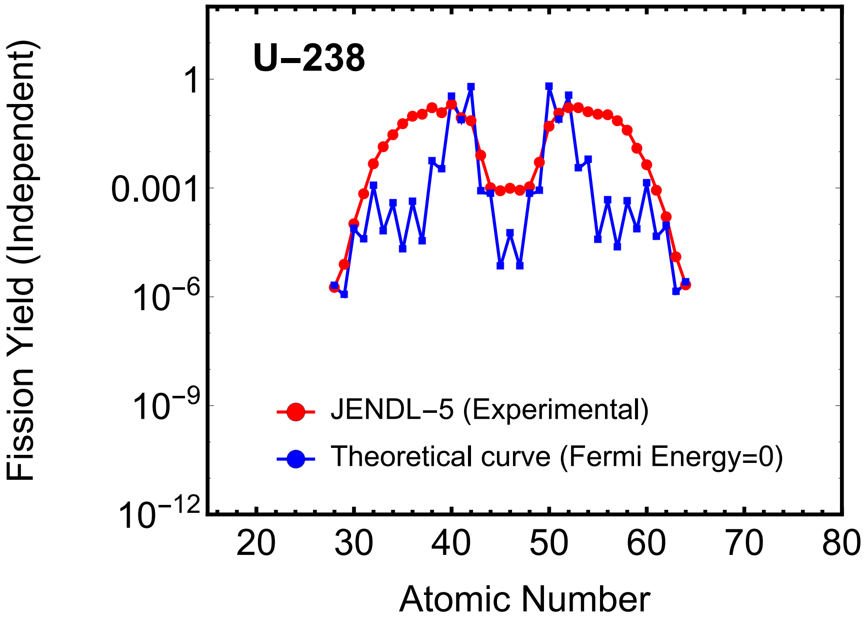
Analysis of Fission Yields: Comparison
between Experimental Data and Theoretical Calculations (Ex=0)

Theoretical Analysis Results using Effective
Fission Distance Reff proportional to fragment charge product,

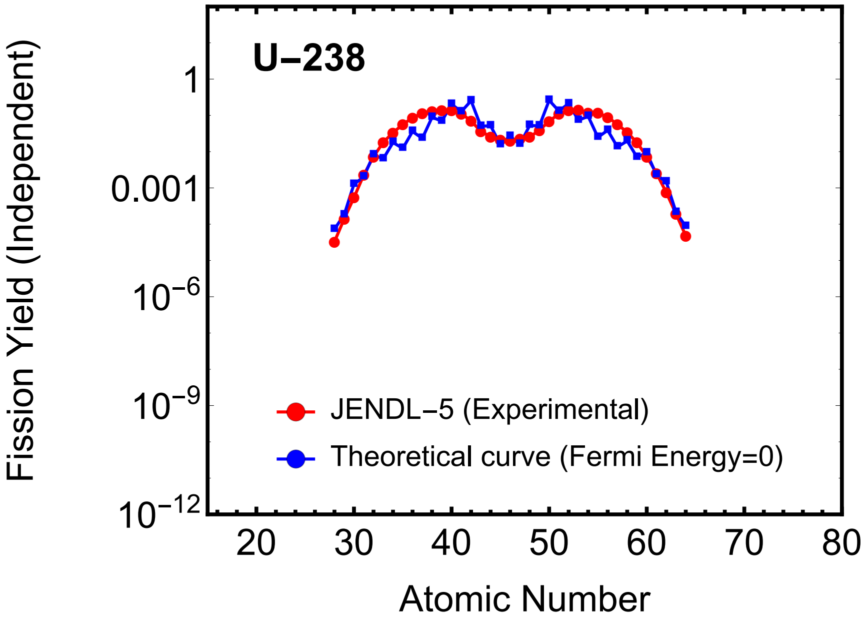
with zero Fermi Energy (Ex=0)

- Quantitative reproduction of experimentally observed asymmetric fission yield distributions

2. Analysis for Incident Neutron Energy: 500keV



3. Analysis for Incident Neutron Energy: 14MeV



Analysis of Effective Fission Distance and Fission Probability

Analysis Contents:

1. Calculation of Effective Fission Distance (Reff) for each incident neutron energy

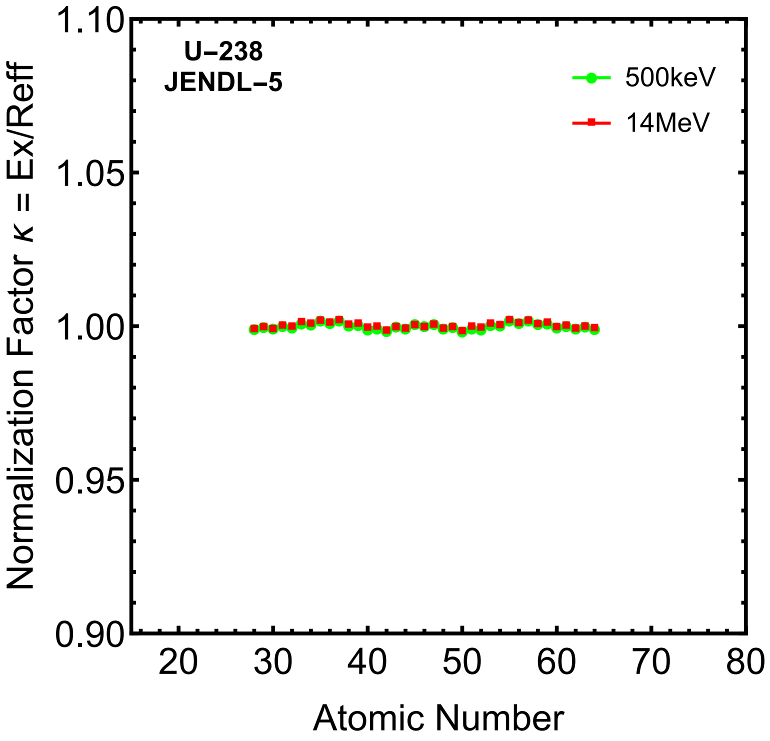
2. Evaluation of fission probability using η function

3. Derivation of normalization factor κ (= Ex/Reff)

The vertical axis κ represents the ratio of Fermi Energy(Ex)

to effective fission distance (Reff).

$\kappa \approx 1$ suggests the fission Fermi Energy is proportional to effective distance.



Theoretical Analysis and Experimental Comparison of Fission Yield Distributions

Calculation Process:

1. Evaluate logarithmic differences
   between JENDL-5 experimental data and theoretical calculations
2. Optimize Fermi Energy (Ex) using least squares method
3. Generate theoretical curves using optimized Ex
4. Compare and verify experimental vs theoretical values

Optimization Goals:

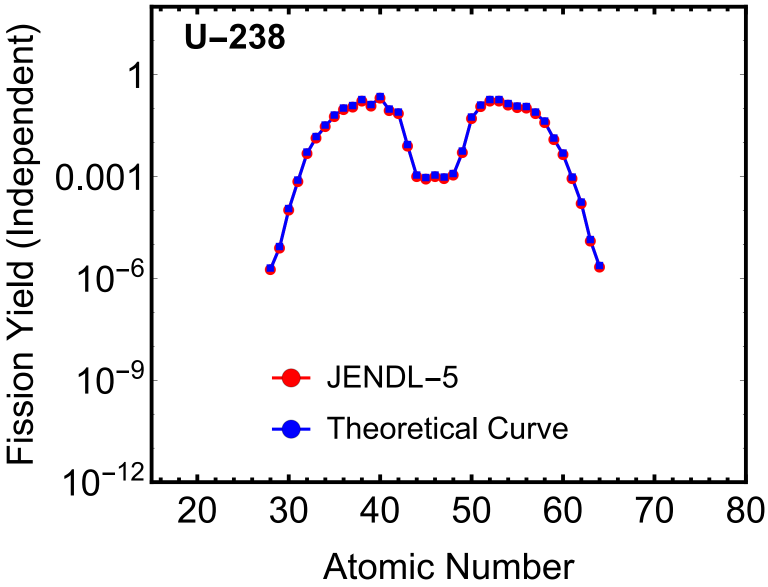
- Theoretical reproduction of experimentally observed asymmetric fission yields
- Understanding fission mechanisms at each incident neutron energy
- Systematic determination of Fermi Energy (Ex)

Evaluation Methods:

- Minimize sum of squared logarithmic differences between theory and experiment
- Parameter optimization using FindMinimum function
- Validation of theoretical curves with optimized parameters

```
{fermiEnergy500keV[28, 64] → -1.56169,
 fermiEnergy500keV[29, 63] → 0.3376, fermiEnergy500keV[30, 62] → -1.16065,
 fermiEnergy500keV[31, 61] → 1.17071, fermiEnergy500keV[32, 60] → -0.173082,
 fermiEnergy500keV[33, 59] → 3.33069, fermiEnergy500keV[34, 58] → 2.40112,
 fermiEnergy500keV[35, 57] → 5.5554, fermiEnergy500keV[36, 56] → 3.32206,
 fermiEnergy500keV[37, 55] → 5.58605, fermiEnergy500keV[38, 54] → 1.56423,
 fermiEnergy500keV[39, 53] → 1.72106, fermiEnergy500keV[40, 52] → -1.7341,
 fermiEnergy500keV[41, 51] → -1.19027, fermiEnergy500keV[42, 50] → -3.15629,
 fermiEnergy500keV[43, 49] → 0.584982, fermiEnergy500keV[44, 48] → -1.01494,
 fermiEnergy500keV[45, 47] → 2.72812, fermiEnergy500keV[46, 46] → 1.06602,
 fermiEnergy500keV[47, 45] → 2.72393, fermiEnergy500keV[48, 44] → -0.969206,
 fermiEnergy500keV[49, 43] → 0.185465, fermiEnergy500keV[50, 42] → -3.47541,
 fermiEnergy500keV[51, 41] → -1.01448, fermiEnergy500keV[52, 40] → -1.97286,
 fermiEnergy500keV[53, 39] → 1.93248, fermiEnergy500keV[54, 38] → 1.27867,
 fermiEnergy500keV[55, 37] → 5.49443, fermiEnergy500keV[56, 36] → 3.32866,
 fermiEnergy500keV[57, 35] → 5.62973, fermiEnergy500keV[58, 34] → 2.5504,
 fermiEnergy500keV[59, 33] → 3.11864, fermiEnergy500keV[60, 32] → -0.370704,
 fermiEnergy500keV[61, 31] → 1.22311, fermiEnergy500keV[62, 30] → -0.916085,
 fermiEnergy500keV[63, 29] → 0.590737, fermiEnergy500keV[64, 28] → -1.59301}
```

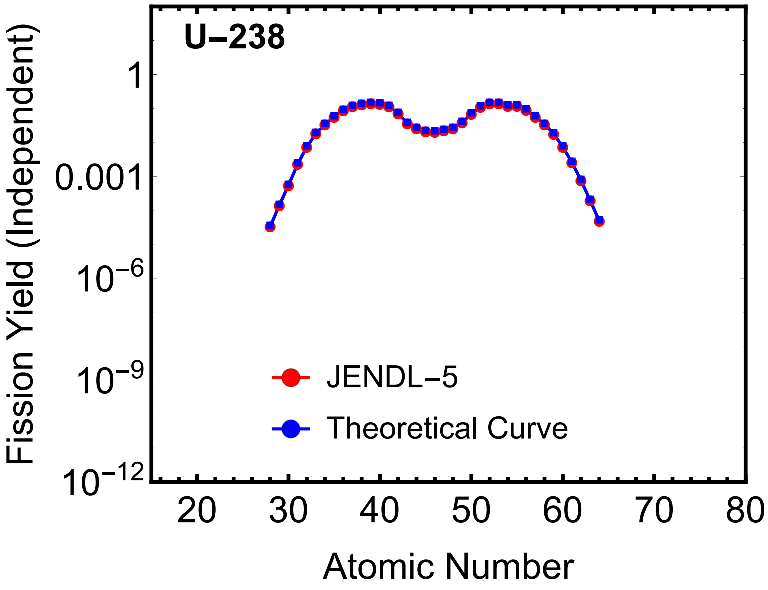
```
2. Analysis for Incident Neutron Energy: 500keV
```



```
-----------------------------------------------------------------------------
```

```
{fermiEnergy14MeV[28, 64] → -1.88673,
 fermiEnergy14MeV[29, 63] → -0.155585, fermiEnergy14MeV[30, 62] → -2.04149,
 fermiEnergy14MeV[31, 61] → 1.084, fermiEnergy14MeV[32, 60] → 0.282822,
 fermiEnergy14MeV[33, 59] → 3.94455, fermiEnergy14MeV[34, 58] → 2.61983,
 fermiEnergy14MeV[35, 57] → 5.33736, fermiEnergy14MeV[36, 56] → 3.36444,
 fermiEnergy14MeV[37, 55] → 5.48282, fermiEnergy14MeV[38, 54] → 1.83721,
 fermiEnergy14MeV[39, 53] → 2.75763, fermiEnergy14MeV[40, 52] → -0.52659,
 fermiEnergy14MeV[41, 51] → 0.287263, fermiEnergy14MeV[42, 50] → -3.20195,
 fermiEnergy14MeV[43, 49] → -0.324308, fermiEnergy14MeV[44, 48] → -1.43479,
 fermiEnergy14MeV[45, 47] → 1.5575, fermiEnergy14MeV[46, 46] → -0.189,
 fermiEnergy14MeV[47, 45] → 1.69964, fermiEnergy14MeV[48, 44] → -1.52909,
 fermiEnergy14MeV[49, 43] → -0.194718, fermiEnergy14MeV[50, 42] → -3.31533,
 fermiEnergy14MeV[51, 41] → 0.0821332, fermiEnergy14MeV[52, 40] → -0.635475,
 fermiEnergy14MeV[53, 39] → 2.64598, fermiEnergy14MeV[54, 38] → 1.32209,
 fermiEnergy14MeV[55, 37] → 5.42411, fermiEnergy14MeV[56, 36] → 3.19929,
 fermiEnergy14MeV[57, 35] → 5.10801, fermiEnergy14MeV[58, 34] → 2.36284,
 fermiEnergy14MeV[59, 33] → 3.56416, fermiEnergy14MeV[60, 32] → -0.0738606,
 fermiEnergy14MeV[61, 31] → 1.03851, fermiEnergy14MeV[62, 30] → -1.45224,
 fermiEnergy14MeV[63, 29] → 0.350391, fermiEnergy14MeV[64, 28] → -1.22285}
```

3. Analysis for Incident Neutron Energy: 14MeV



```
--------------------------------------------------------------------------------
```

Quantitative Analysis Results of Fermi Energy Ex

Based on Optimization Calculations using Experimental Fission Yield Data

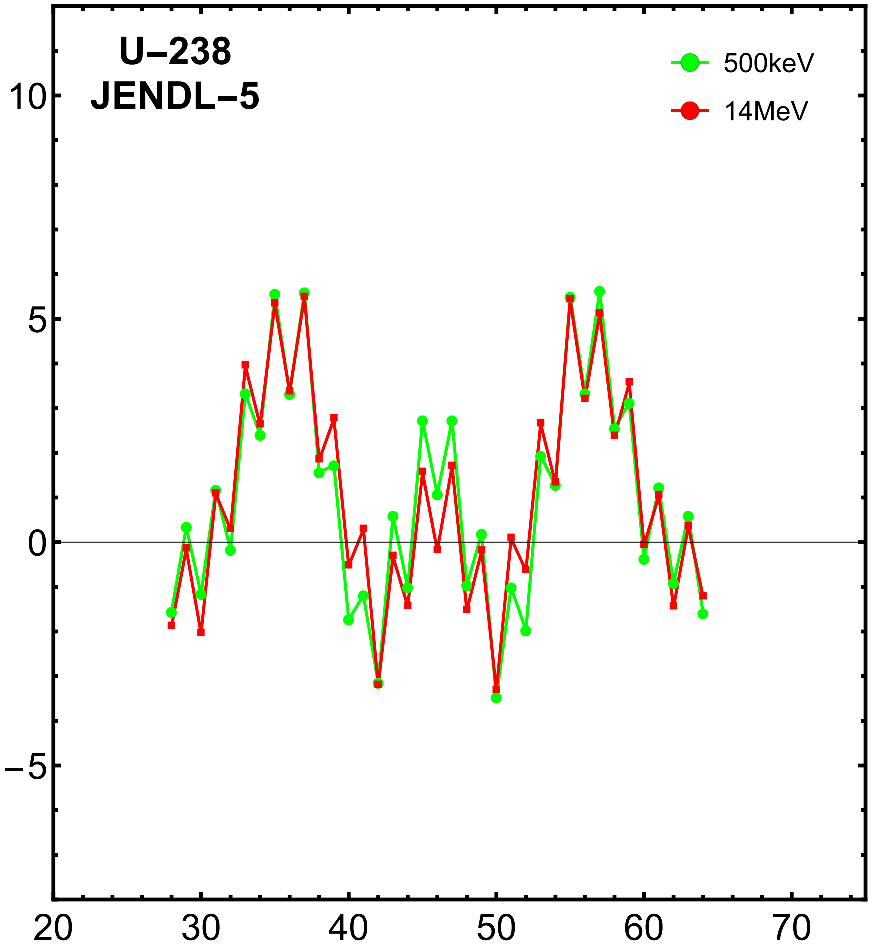
2. Analysis for Incident Neutron Energy: 500keV

```
{{28, -1.56169}, {29, 0.3376}, {30, -1.16065}, {31, 1.17071}, {32, -0.173082},
 {33, 3.33069}, {34, 2.40112}, {35, 5.5554}, {36, 3.32206}, {37, 5.58605}, {38, 1.56423},
 {39, 1.72106}, {40, -1.7341}, {41, -1.19027}, {42, -3.15629}, {43, 0.584982},
 {44, -1.01494}, {45, 2.72812}, {46, 1.06602}, {47, 2.72393}, {48, -0.969206},
 {49, 0.185465}, {50, -3.47541}, {51, -1.01448}, {52, -1.97286}, {53, 1.93248},
 {54, 1.27867}, {55, 5.49443}, {56, 3.32866}, {57, 5.62973}, {58, 2.5504}, {59, 3.11864},
 {60, -0.370704}, {61, 1.22311}, {62, -0.916085}, {63, 0.590737}, {64, -1.59301}}
```

3. Analysis for Incident Neutron Energy: 14MeV

```
{{28, -1.88673}, {29, -0.155585}, {30, -2.04149}, {31, 1.084}, {32, 0.282822},
 {33, 3.94455}, {34, 2.61983}, {35, 5.33736}, {36, 3.36444}, {37, 5.48282}, {38, 1.83721},
 {39, 2.75763}, {40, -0.52659}, {41, 0.287263}, {42, -3.20195}, {43, -0.324308},
 {44, -1.43479}, {45, 1.5575}, {46, -0.189}, {47, 1.69964}, {48, -1.52909},
 {49, -0.194718}, {50, -3.31533}, {51, 0.0821332}, {52, -0.635475}, {53, 2.64598},
 {54, 1.32209}, {55, 5.42411}, {56, 3.19929}, {57, 5.10801}, {58, 2.36284}, {59, 3.56416},
 {60, -0.0738606}, {61, 1.03851}, {62, -1.45224}, {63, 0.350391}, {64, -1.22285}}
```

```
--------------------------------------------------------------------------------

 Systematic Analysis Results of Fermi Energy Ex

 Using Optimized Effective Fission Distance Reff
```



```
2. Analysis for Incident Neutron Energy: 500keV

Secondary Fragment: rubidium(Z=37); Yield: 5.58605 MeV

Primary Fragment: cesium(Z=55); Yield: 5.49443 MeV

Average Peak Yield: 5.54024 MeV

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3. Analysis for Incident Neutron Energy: 14MeV

Secondary Fragment: rubidium(Z=37); Yield: 5.48282 MeV

Primary Fragment: cesium(Z=55); Yield: 5.42411 MeV

Average Peak Yield: 5.45346 MeV

--------------------------------------------------------------------------------
```
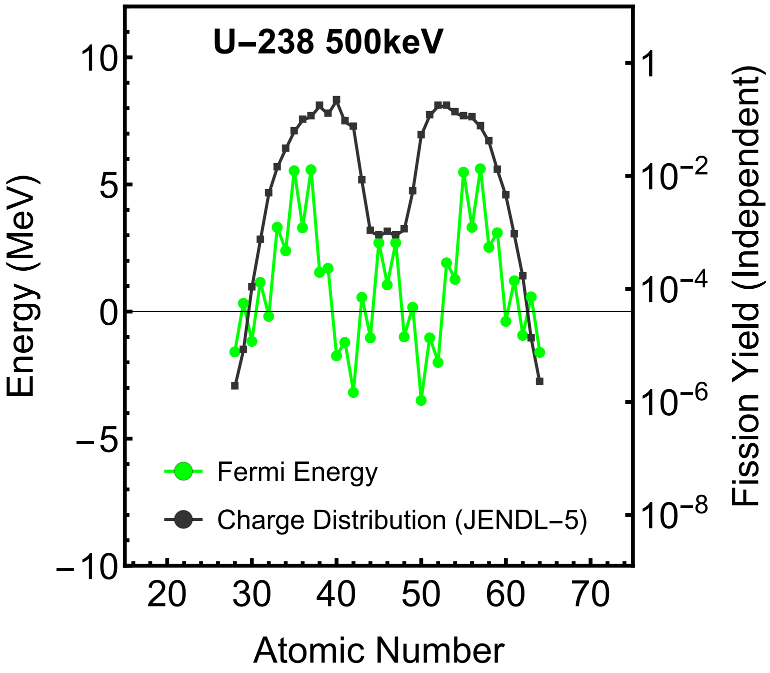
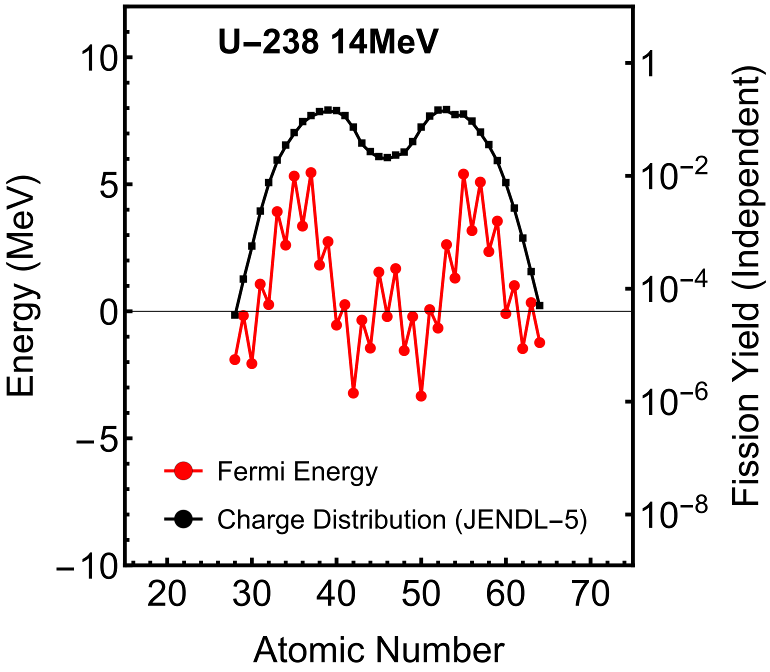


U–238 500keV
Energy (MeV)
10
5
0
−5
−10
Fission Yield (Independent)
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}
Fermi Energy
Charge Distribution (JENDL–5)
20
30
40
50
60
70
Atomic Number


U–238 14MeV
Energy (MeV)
10
5
0
−5
−10
Fission Yield (Independent)
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}
Fermi Energy
Charge Distribution (JENDL–5)
20
30
40
50
60
70
Atomic Number