Hierarchy for storing particle and decay data

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Generalized Nuclear Data (GND): designed to replace ENDF-6 for storing reaction data

- Translate ENDF into GND (and back)
- Nuclear structure data shows up in many places in both ENDF and GND:
 - Masses and excited levels affect Q-values, reaction thresholds, energy balance...
- Unfortunately, current ENDF files often contain discrepant nuclear structure data!
- One goal of WPEC Subgroup #38 is to improve how structure data are stored in reaction databases



Why is LLNL interested in formats for nuclear structure data?

 Evaluated nuclear structure data impacts reaction evaluations, but the pipeline is slow:



 Multiple databases and formats, all representing the same physics! Can we design a unified hierarchy to handle all of them?



Format change requires lots of effort, but in our experience there are clear benefits:

- Using modern tools makes work more attractive to young scientists.
- Adding new data types to card-based format is hard (ENSDF ends up storing data in comments instead), but adding a new layer in a nested hierarchy is simple.
- Searching, checking and fixing data becomes easier.
- Translating (especially round-trip translation) between formats helps reveal problems in data.
- Leverage existing XML tools (schema provides format checking, XSLT for web display, multiple tools for parsing XML).



Progress at LLNL so far:

- ARRA + internal funds used for translating ENDF and to help start WPEC SG38.
- Before ARRA funds were used up, they helped us start handling nuclear structure information
- We would like to continue this effort.
 - With USNDP support, we could work with ENSDF, RIPL and ENDF communities to create a prototype hierarchy to meet the needs of all three.





LLNL has recent experience with translating ENDF and RIPL-formatted data into a modern hierarchy.

- Reaction databases include some nuclear structure information:
 - ENDF reaction evaluations include masses, level schemes, gamma decay
 - ENDF decay sub-library adds much more decay info
 - RIPL 'levels' database has partial level schemes translated from ENSDF
 - These can now be partially converted into a structured hierarchy and stored in XML



```
<?xml version='1.0' encoding='UTF-8'?>
<!-- created by Nidhi R. Patel -->
<!-- created on 201010 -->
<!-- last modified on 201301 -->
<pop version="0.0.0">
   <particle symbol="Mn" name="Manganese" genre="atomicNucleus">
      <mass reference="AME2003">
            <atomicMass valueIs="evaluated">54938045.141e-6 +/- 0.729e-6 amu</atomicMass>
            <massExcess valueIs="evaluated">-57710.580 +/- 0.680 keV</massExcess>
            <bindingEnergyPerA valueIs="evaluated">8764.988 +/- 0.012 keV</bindingEnergyPerA>
            <betaDecayEnergy valueIs="evaluated">-231.212 +/- 0.184 keV</betaDecayEnergy>
         </mass>
         <nuclearLevels maxCompleteUpTo="e92" uniqueSpinParityUpTo="e2" neutronSeparationEnergy="10.226401 MeV"</pre>
                        protonSeparationEnergy="8.067 MeV" reference="RIPL-3">
            <nuclearLevel index="e0">
               <energy>0 MeV</energy>
               <spin spinEstimationMethodFlag="u" originalENSDFspins="5/2-">2.5</spin>
               <parity>-1</parity>
               <halfLife>-1 s</halfLife>
            </nuclearLevel>
            <nuclearLevel index="e1">
               <energy>0.125949 MeV</energy>
               <spin spinEstimationMethodFlag="u" originalENSDFspins="7/2-">3.5</spin>
               <parity>-1</parity>
               <halfLife>2.59e-10 s</halfLife>
               <decayModes>
                  <electromagnetic branchingRatio="1">
                     <qamma>
                        <energy>0.126 MeV</energy>
                        <finalState>e0</finalState>
                        <gammaProbability>0.9829</gammaProbability>
                        <electromagneticProbability>1</electromagneticProbability>
                        <internalConversionCoefficient>0.0174</internalConversionCoefficient>
                     </gamma>
                  </electromagnetic>
               </decayModes>
            </nuclearLevel>
            . . .
         </nuclearLevels>
      </atomicNucleus>
   </particle>
</pop>
```

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