XML in LHCb Detector Description Framework

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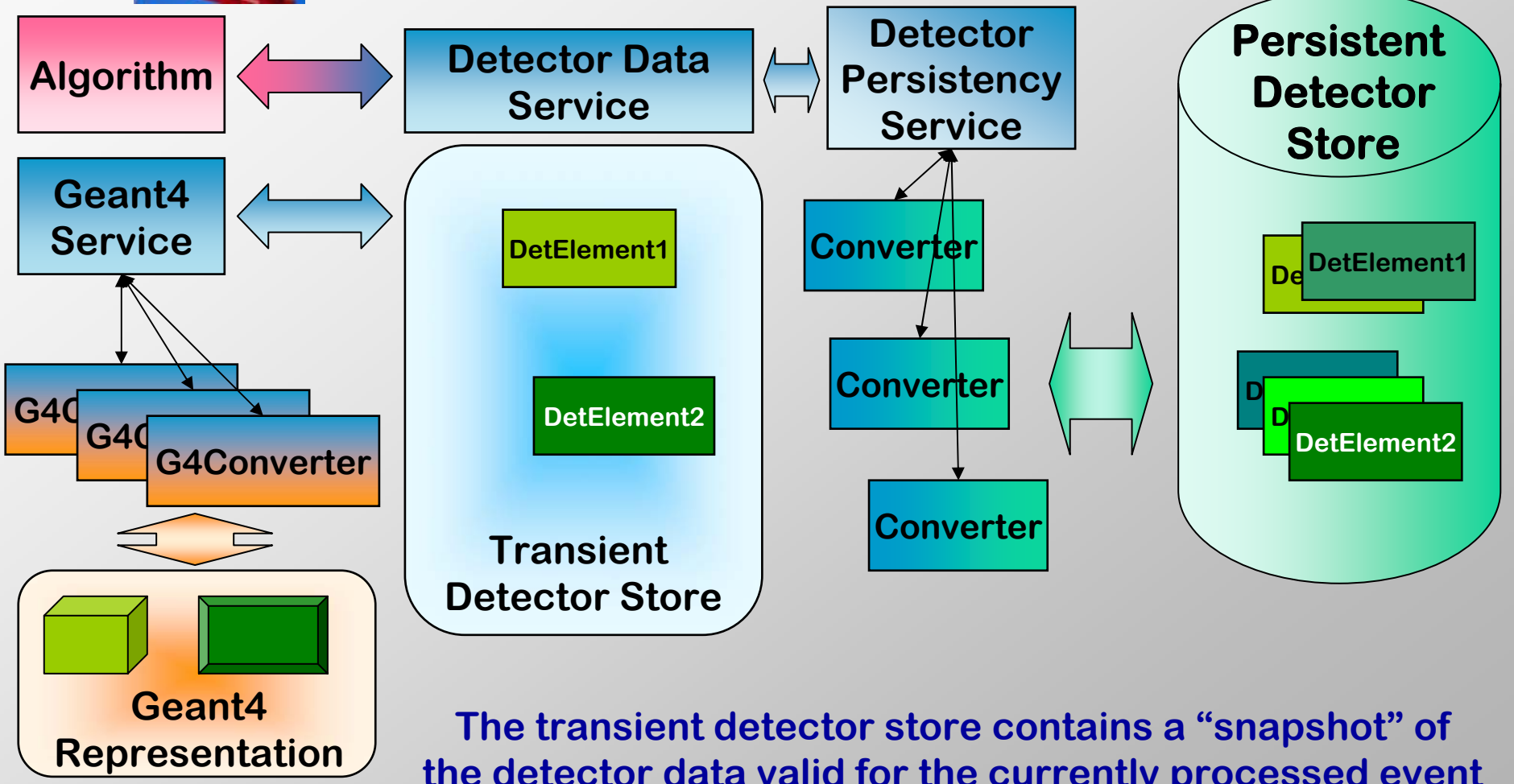
Detector Description Overview

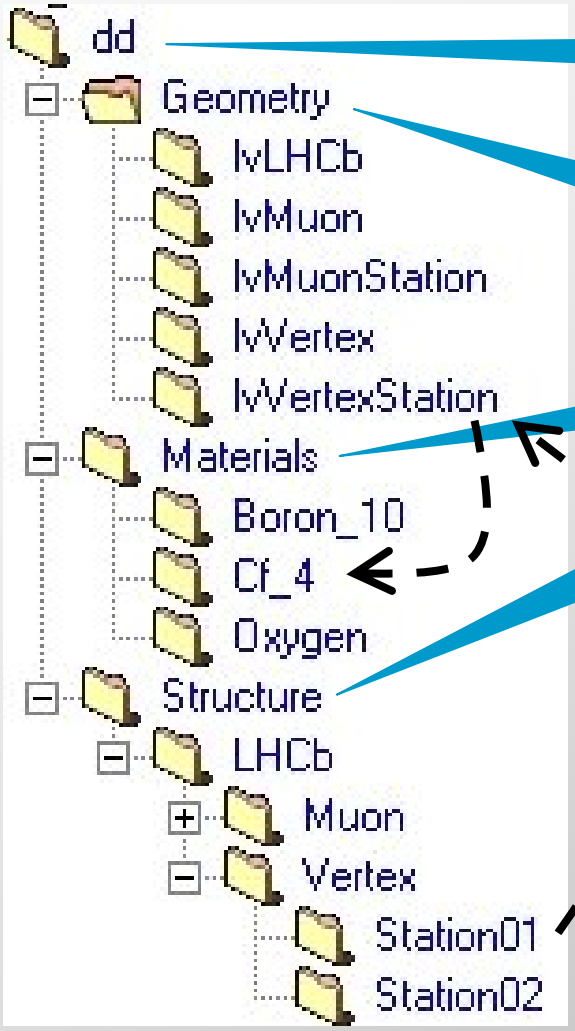
- Component of the Gaudi framework
- Inherits the Gaudi architecture decisions
- Detector description provides
  - Single source of detector data for all clients
    - simulation, reconstruction, analysis, test beam
  - It is not detector geometry only!
    - logical detector structure, geometry & positions, materials, mapping electronic channels to detector cells, detector control data needed for reconstruction, calibration and alignment data
  - Versioning of all detector data based on event time, run #, etc.
- Persistency of detector description in XML format
  - XML may be stored in files on disk , on the Web or in a DBMS

Detector Data Store



The transient detector store contains a "snapshot" of the detector data valid for the currently processed event

Transient Detector Store

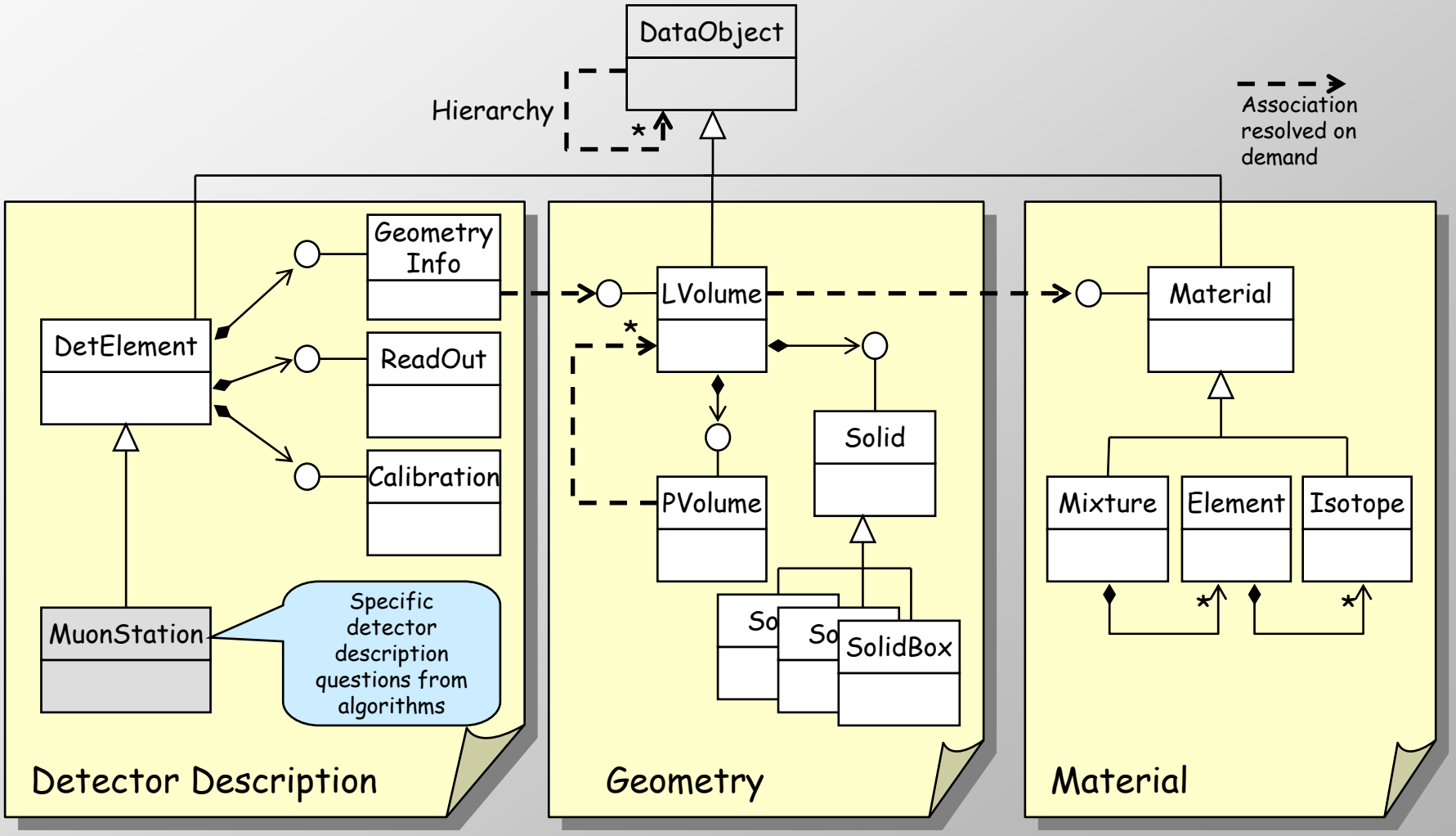


Root of the store

Top level catalogues

- Tree-like structure
- Items identified by a logical name
- Updated on demand
- Automatic update when a new event is loaded

Loading on demand



Choices made for XML

- XML DOM is not used
  - memory expensive
  - we don't write data back to XML (yet)
  - we have already the transient hierarchical object model in Gaudi
- SAX is the choice for implementation
  - easy to implement and extend
  - we loose structure of XML documents
- IBM XML4C parser

Numerical Expressions Parser

- Simple parser for evaluation of expressions
- Expressions can be composed of
  - integer and floating point numbers
    - 100 | 100. | .05 | 0.1| 1.34-e12|-23
  - operations: +, -, *, /, unary +|-, exponent ^
  - parenthesized expressions: 1.4 * (23.4-e12 / 1.8)
- Result is always evaluated to double value
- Operator precedence from left to right:
  - [()] [unary +|-] [^] [*|/] [+|-]
- By default checks for units in expressions

CLHEP Units Compatibility

- DTD for XML detector description defines units a la CLHEP
- Units MUST be used where required
  - XML converters assume the use of units
  - In case the units are missing processing stops and an exception is thrown.
- Use expressions parser where needed with check for units enabled
- Examples
  - 23*&cm; | 12*&volt; | 23.6*&g;/&cm3;

C++ to XML

C++	XML
Class	XML Element
Primitive class data members	Element attributes
Complex class data members	Element embedded in Content Model
Reference	Element reference with hyperlink and class ID of a target object

DDDB Tag

```
<!ENTITY % elems "detelem | logvol | material">
<!ELEMENT DDDB (catalog | catalogref | %elems;)+>
<!ATTLIST DDDB version CDATA "3.0">
```

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE DDDB SYSTEM "xmldb.dtd">
<DDDB>
  <catalog name="dd">
    <catalogref href="structure.xml#Structure"/>
    <catalogref href="materials/materials.xml#Materials"/>
    <catalogref href="geometry.xml#Geometry"/>
  </catalog>
</DDDB>
```

Detector Element Tag

```
<!ENTITY % detelemdata "author?,version,geometryinfo">
<!ENTITY % nmclid "name ID #REQUIRED classID CDATA #REQUIRED">
<!ELEMENT detelem (%detelemdata;, detelemref*, specific?)>
<!ATTLIST detelem %nmclid;>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE DDDB SYSTEM "../xmldb.dtd">
<DDDB>
  <detelem classID="2" name="LHCb">
    <author>RCH</author>
    <version>0.1</version>
    <geometryinfo>
      <lvname name="/dd/Geometry/LHCb/lvLHCb"/>
    </geometryinfo>
    <detelemref classID="9999" href="VertexRich1/Vertex/structure.xml#Vertex"/>
    <detelemref classID="2" href="VertexRich1/Rich1/structure.xml#Rich1"/>
    <detelemref classID="2" href="TrackerRich2/Tracker/structure.xml#Tracker"/>
    <detelemref classID="2" href="TrackerRich2/Rich2/structure.xml#RICH2"/>
    <detelemref classID="8900" href="CaloMuon/Calo/structure.xml#Ecal"/>
    <detelemref classID="2" href="CaloMuon/Muon/structure.xml#Muon"/>
  </detelem>
</DDDB>
```

Inheritance in XML

```
<!DOCTYPE DDDB SYSTEM "xmldb.dtd" [
<!--Number of stations in Vertex detector-->
    <!ELEMENT SiTankRadius EMPTY>
    <!ATTLIST SiTankRadius n CDATA #REQUIRED>
    <!ELEMENT DiodePitch EMPTY>
    <!ATTLIST PiodePitch n CDATA #REQUIRED>
    <!ELEMENT ReadoutPitch EMPTY>
    <!ATTLIST ReadoutPitch n CDATA #REQUIRED>
]>
<DDDB>
  <detelem classID="9999" name="Vertex">
    ...
    <geometryinfo>
      <lvname  name="/dd/Geometry/lvVertex" />
      <support name="/dd/Structure/LHCb"> <npath value="pvVertex_0" /> </s
    </geometryinfo>
    <detelemref classID="2" href="#VStation01"/>
    <detelemref classID="2" href="#VStation02"/>
    <specific>
      <SiTankRadius n='17' /> <DiodePitch n='0.0025' /> <ReadoutPitch n='0.0050' />
    </specific>
  </detelem>
</DDDB>
```

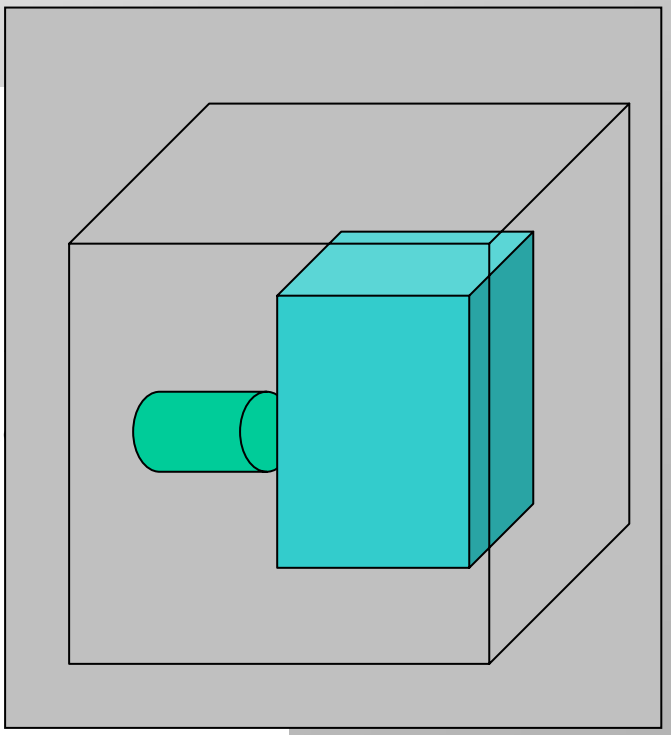
Definition of the user XML tags

Detector specific data

Logical Volume Tag

```
<!ENTITY % solid "(box | cons | sphere | tubs | trd |
                   union | subtraction | intersection)">
<!ELEMENT logvol (%solid;, (physvol | paramphysvol)*)>
<!ATTLIST logvol name ID #REQUIRED
                 material CDATA #REQUIRED
                 classID CDATA #FIXED "1100">
```

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE DDDB SYSTEM "../../xmldb.dtd">
<DDDB>
  <logvol name="lvVertexRich1" material="Vacuum">
    <box name="VertexRich1Box"
         sizeX="5000*&mm;" sizeY="5000*&mm;" sizeZ="
    <physvol name="pvVertex"
             logvol="/dd/Geometry/LHCb/Vertex/lvVert
      <posXYZ x="0*&mm;" y="0*&mm;" z="-1000*&mm;"/>
    </physvol>
    <physvol name="pvRich1"
             logvol="/dd/Geometry/LHCb/Rich1/lvRich1
      <posXYZ x="0*&mm;" y="0*&mm;" z="2000*&mm;"/>
    </physvol>
  </logvol>
</DDDB>
```



Physical Volume Tags

```
<!ELEMENT physvol ((posXYZ|posRPhiZ|posRThPhi),(rotXYZ|rotAxis)?)>
<!ATTLIST physvol name ID #REQUIRED logvol CDATA #REQUIRED>

<!ELEMENT paramphysvol (physvol,(posXYZ|posRPhiZ|posRThPhi)
<!ATTLIST paramphysvol    number CDATA #REQUIRED>

  <logvol name="lvPVStation" material="Vacuum">
    <tubs name="pvStationTubsPV" sizeZ="0.15*&mm;"
          outerRadius="60*&degree;" innerRad
          startPhiAngle="-1.5*&degree
    <paramphysvol number="6">
      <physvol name="waferPV" logvol="
        <posXYZ x="0*&mm;" y="0*&mm
        <rotXYZ rotX="0*&degree
      </physvol>
      <posXYZ x="0*&mm;" y="0*&mm;" z="0*&m
      <rotXYZ rotX="0*&degree;" rotY="0*
    </paramphysvol>
    <physvol name="pvwaferStrange" logvol="/dd/Geometry/LHCb/Vertex/lvWafer">
      <posXYZ x="0*&mm;" y="0*&mm;" z="-1.5*&mm;"/>
      <rotXYZ rotX="0*&degree;" rotY="0*&degree;" rotZ="0*&degree;"/>
    </physvol>
  </logvol>
```

Simple physical volume

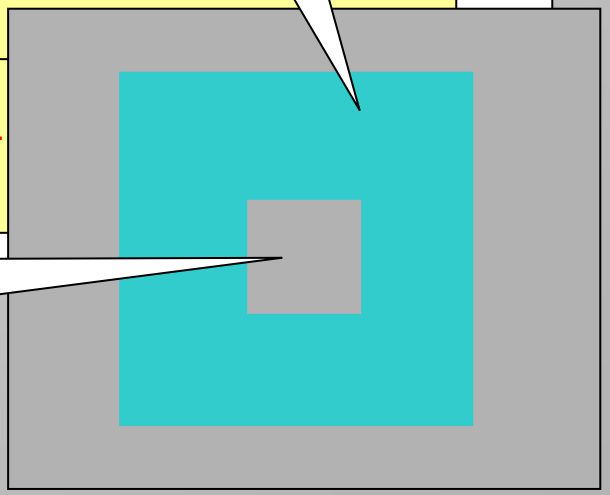
Solid Tags

```
<!ENTITY % simplesolid "(box | cons | sphere | tubs | trd)">
<!ELEMENT box ((posXYZ | posRPhiZ | posRThPhi), (rotXYZ | rotAxis)?)?>
<!ATTLIST box name ID #REQUIRED
          sizeX CDATA #REQUIRED sizeY CDATA #REQUIRED sizeZ CDATA #REQUIRED>
<!ELEMENT union (%simplesolid;)+>
<!ATTLIST union name ID #REQUIRED>
```

```
<logvol material="Vacuum" name="lvEcalOuter"
 <subtraction name="boxEcalOuter">
  <box name="boxEOMain"
       sizeZ="432*&mm;" sizeX="7933.44*&mm;" sizeY="6445.92*&mm;">
    <posXYZ z="0*&mm;" y="0*&mm;" x="0*&mm;"/>
  </box>
  <box name="boxEOSubtracted"
       sizeZ="432*&mm;" sizeX="2479.20*&mm;" si
   <posXYZ z="0*&mm;" y="0*&mm;" x="0*&mm;"/>
  </box>
 </subtraction>
</logvol>
```

Main or reference solid

Subtracted solid placed relative to the main solid



Position Tags

Cartesian coordinate system

```
<!ELEMENT posXYZ EMPTY>
<!ATTLIST posXYZ x CDATA #REQUIRED y CDATA #REQUIRED z CDATA #REQUIRED>
```

Cylindrical coordinate system

```
<!ELEMENT posRPhiZ EMPTY>
<!ATTLIST posRPhiZ r CDATA #REQUIRED phi CDATA #REQUIRED z CDATA #REQUIRED>
```

Spherical coordinate system

```
<!ELEMENT posRThPhi EMPTY>
<!ATTLIST posRThPhi r CDATA #REQUIRED theta CDATA #REQUIRED phi CDATA #REQUIRED>
```

Rotation Tags

Rotation around the axes X,Y and Z

```
<!ELEMENT rotXYZ EMPTY>
<!ATTLIST rotXYZ rotX CDATA #REQUIRED rotY CDATA #REQUIRED rotZ CDATA #REQUIRED>
```

Rotation using vector and angle

```
<!ELEMENT rotAxis EMPTY>
<!ATTLIST rotAxis axTheta CDATA #REQUIRED axPhi CDATA #REQUIRED
          angle CDATA #REQUIRED>
```

Material Tag

```
<!ENTITY % materialdata "a?,z?,n?,density,x0?,lambda?">
<!ELEMENT fraction (atoms | mass)>
<!ELEMENT atoms EMPTY>
<!ATTLIST atoms n CDATA #REQUIRED>
<!ELEMENT mass EMPTY>
<!ATTLIST mass n CDATA #REQUIRED>
<!ELEMENT material (%materialdata;, (materialref)*)>
<!ATTLIST material
        %nmclid;
        form (isotope | element | mixture) #IMPLIED
        temperature CDATA #IMPLIED
        pressure CDATA #IMPLIED
        state (solid | liquid | gas) #IMPLIED
>
<!ELEMENT a (#PCDATA)>
<!ELEMENT z (#PCDATA)>
<!ELEMENT n (#PCDATA)>
<!ELEMENT density (#PCDATA)>
<!ELEMENT x0 (#PCDATA)>
<!ELEMENT lambda (#PCDATA)>
```

Material Tag

```
<material name="Bor_10" classID="&isotope;">
  <a>10.000*&g;/&mole;</a>
  <z>5.000</z>
  <density>2.3400*&g;/&cm3;</density>
  <x0>0.0000e+00*&cm;</x0>
  <lambda>0.0000e+00*&cm;</lambda>
</material>
```

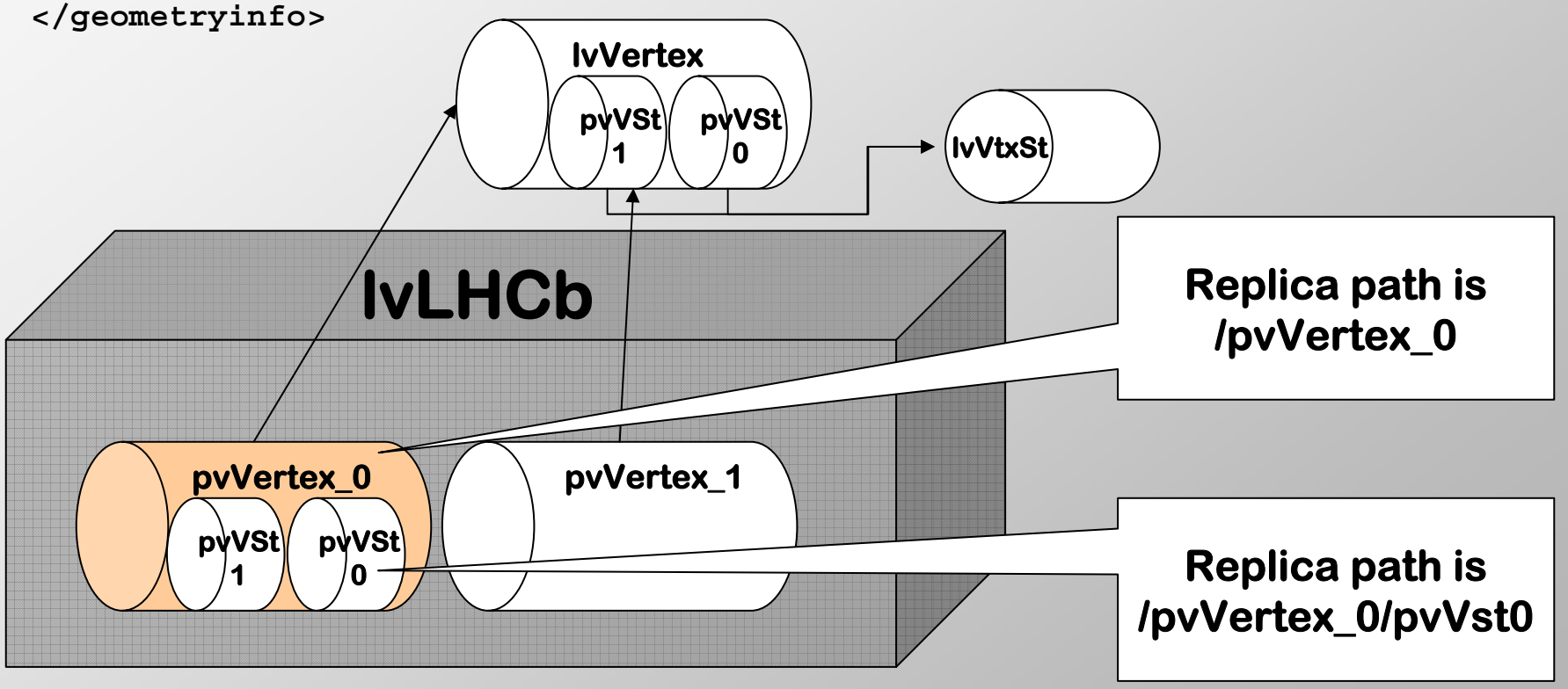
```
<material name="Water" classID="&mixture;">
  <density>1.0000*&g;/&cm3;</density>
  <materialref classID="&element;" href="elements.xml#Hydrogen">
    <fraction>
      <atoms n="2"/>
    </fraction>
  </materialref>
  <materialref classID="&element;" href="elements.xml#Oxygen">
    <fraction>
      <atoms n="1"/>
    </fraction>
  </materialref>
</material>
```

Conclusions

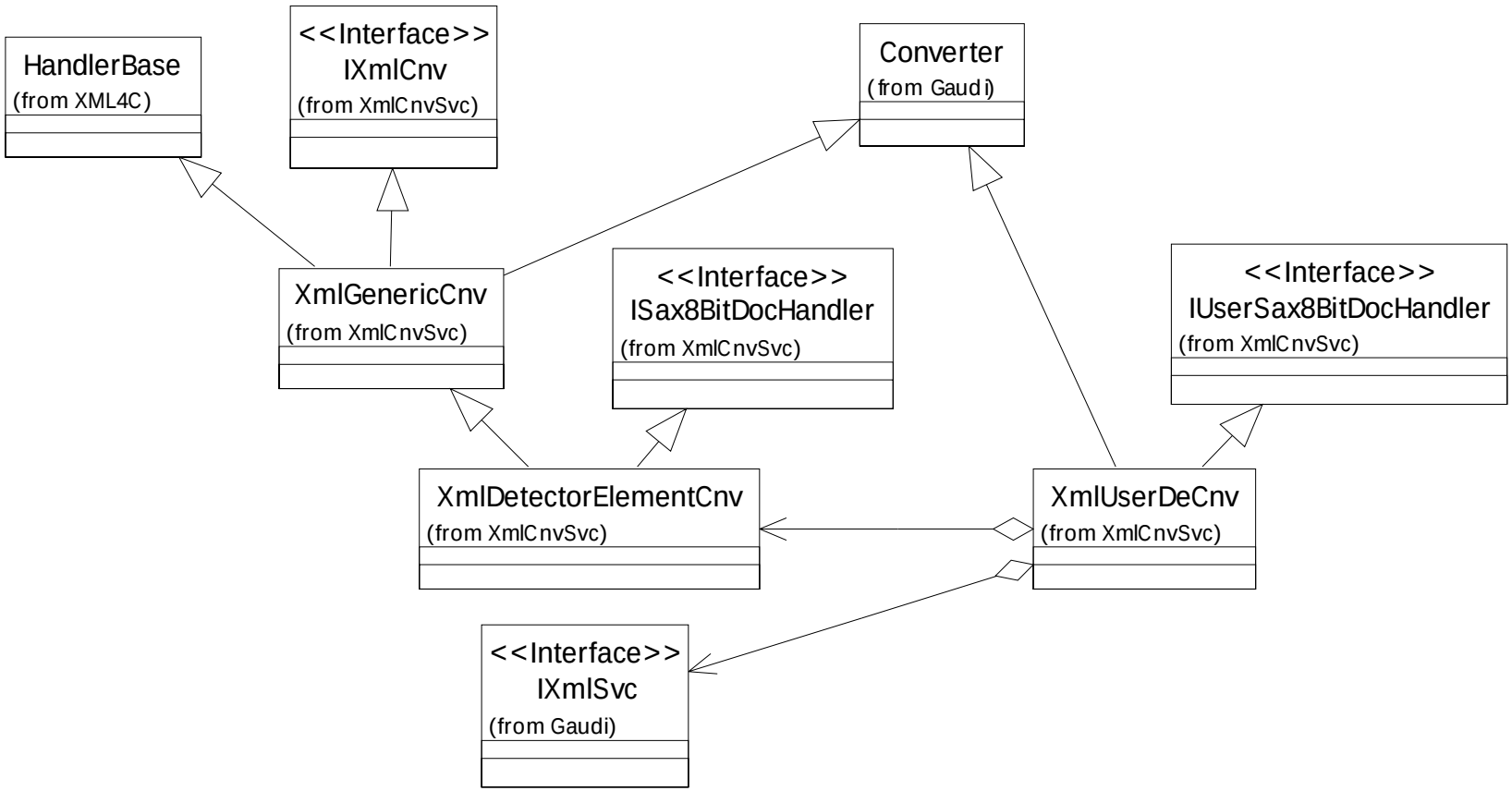
- Status
  - XML based det. descr. is the integral part of Gaudi
    - Working on NT, Linux
- Future steps
  - Versioning
  - Population of the XML DDDB from the LHCb detector description based on Geant3
  - Define the XML format for conditions
    - calibration, alignment, channel maps, slow control, …
  - Implement the XML DDDB in the conjunction with a “real” DB (RD45 Conditions/DB, Oracle, …)

Geometry Info Tag

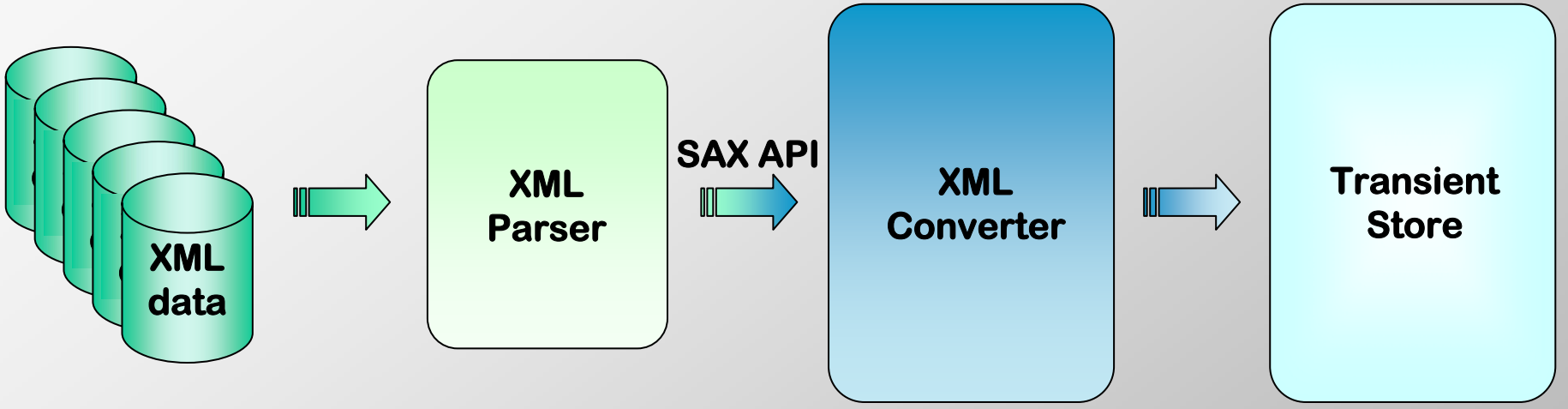
```
<geometryinfo>
  <lvname  name="/dd/Geometry/lvVertex" />
  <support name="/dd/Structure/LHCb"> <npath value="pvVertex_0" /> </support>
</geometryinfo>
```



XML Converters Model



XML Conversion



- It can be any XML parser supporting SAX API for C++
- SAX - Simple API for XML

XML Briefly

- XML is the
  - W3C Recommendation
    - XML 1.0
  - subset of SGML
    - 20% complexity
    - 80% flexibility of SGML
  - Application independent data interchange format
- Safe investment in data and manpower
  - increasing support for XML in the industry
  - maintained outside CERN
- XML features
  - User defined tags
  - Data self described
  - Hyperlinks
  - Properly nested tags forming a tree structure
  - Data separated from behavior
- Problems with XML
  - C++ to XML mapping
  - Inheritance
  - Performance
  - Data Management

Persistent Detector Store

- The Gaudi architecture shields end users from a persistent technology
  - Allows co-existence of different persistency technologies
    - technology specific code only on well defined places
      - →services and converters
  - We don't know which technologies will be available in 2005
- We use XML as our persistent data format
  - XML can be stored in files, WWW, database