US National Virtual Observatory

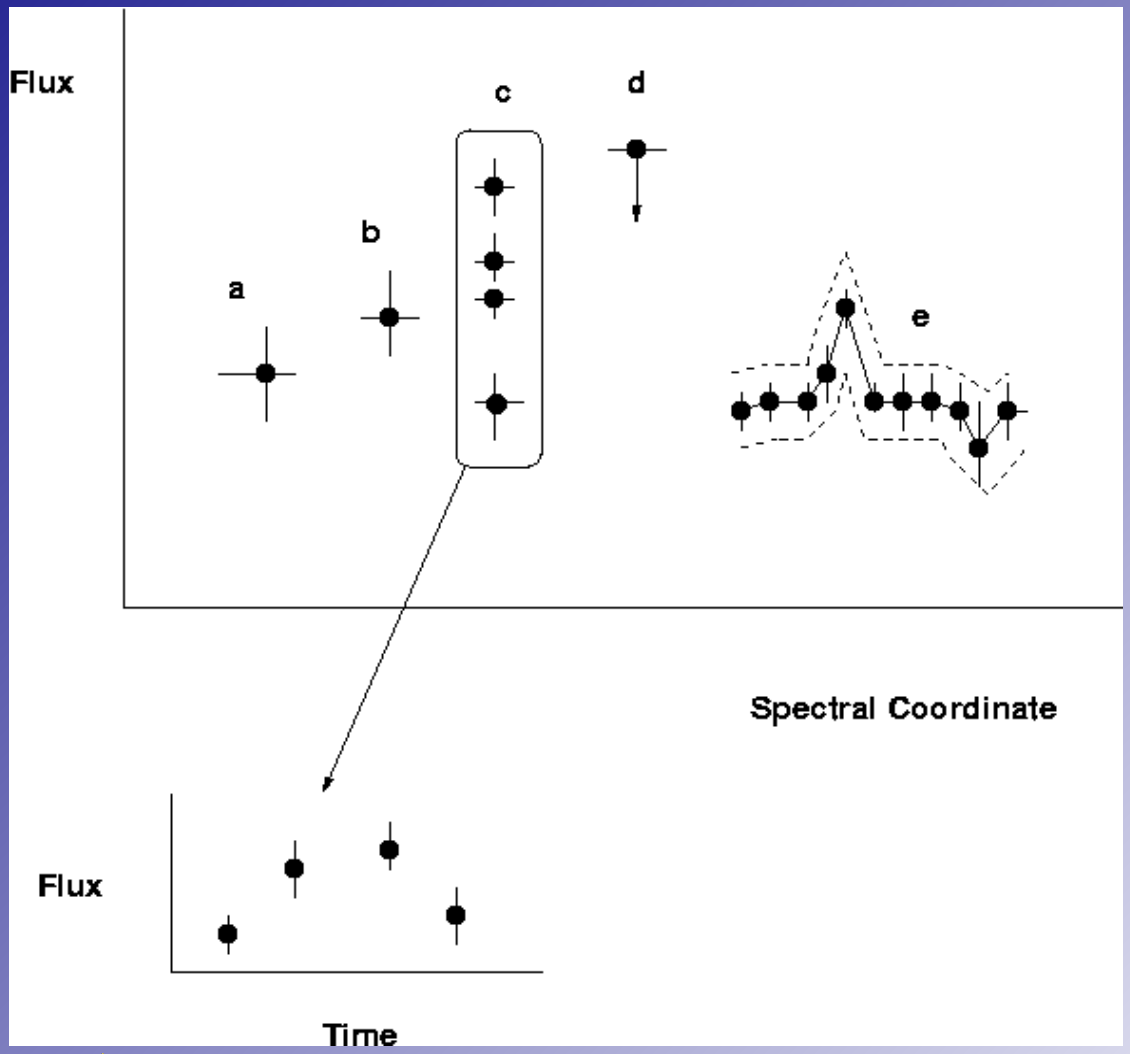
Spectrum Data Model

Jonathan McDowell
CfA

Short term Spectral DM

- Spectral Energy Distribution (SED)
- Collection of 'segments'
- Each segment is a photometry point, a spectrum or a time series
- Defined metadata for bandpass, aperture, spectral coordinates
- Interim for SSAP pending full Observation model

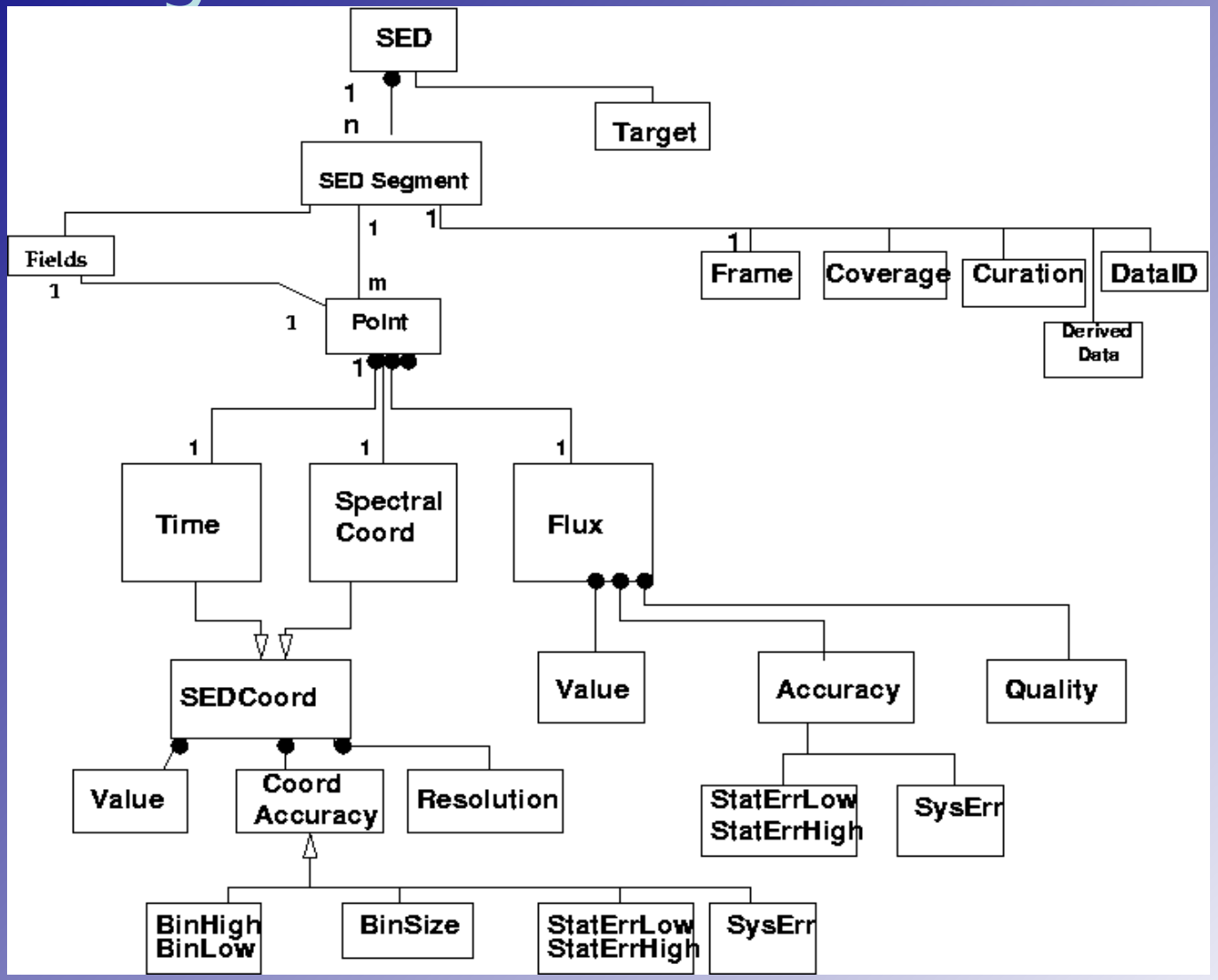
SED Segments



Compromises

- Keep it simple: first cut, don't solve all problems
- Explicit listing of (lambda, flux) or (lambda1, lambda2, flux) for each point
- No detailed space-time coords description
- Only supports 1-D extracted spectral data - no support for raw spectra on 2-D imagers etc.
- Do we need support for (count spectrum + sensitivity curve)? Not

UML diagram


SED
1
n
Target
SED Segment
1
1
Fields
1
1
m
1
Point
1
Frame
Coverage
Curation
DataID
Derived Data
1
1
1
Time
Spectral Coord
Flux
SEDCoord
Value
Accuracy
Quality
Value
Coord Accuracy
Resolution
StatErrLow
StatErrHigh
SysErr
BinHigh
BinLow
BinSize
StatErrLow
StatErrHigh
SysErr

SED Issues

- For `science-grade' analysis need extra metadata
- Each segment has 'associated metadata'
- Each point has bandpass, systematic and statistical errors
- Time series and spectra closely related, allow both

Main changes since Boston

- Rearranged to make an explicit array of 'points'
- Added detailed VOTable and object-XML instances and XML schema
- Added UTYPEs in VOTable

VOTable approach - 1

```
<?xml version="1.0" encoding="UTF-8"?>
<VOTABLE version="1.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation="http://www.ivoa.net/xml/VOTable/v1.1"
  xmlns:sed="http://www.ivoa.net/xml/SedModel/v1.0"  >
<RESOURCE utype="sed:SED">
<TABLE utype="sed:SED">
<PARAM name="Date" utype="sed:Date" value="2004-05-10"/>
<PARAM name="Nseg" utype="sed:NSegments" ucd="meta.number" value="1"/>
<GROUP utype="sed:Target">
 <PARAM name="Target" utype="sed:Target.Name" value="Arp 220"/>
 <PARAM name="TargetPos" utype="sed:Target.pos" unit="deg" value="233.737917 23.503330"/>
 <PARAM name="z" utype="sed:Target.redshift" value="0.0018"/>
</GROUP>
</TABLE>

<TABLE utype="sed:Spectrum">
<-- SegmentType can be Photometry, TimeSeries or Spectrum -->
<PARAM name="Segtype" utype="sed:SegmentType"  value="Photometry" ucd="meta.code"/>
<GROUP name="Frame" utype="sed:Frame">
 <GROUP utype="sed:Frame.Sky">
   <PARAM name="Equinox" utype="sed:Equinox" ucd="time.equinox;pos.eq" value="2000.0" />
   <PARAM name="System" utype="sed:System" ucd="frame.pos.system" value="ICRS"/>
 </GROUP>
 <GROUP utype="sed:Frame.Time">
  <PARAM name="TimeFrame" utype="sed:Type" ucd="frame.time.scale" value="UTC"/>
  <PARAM name="TimeZero" utype="sed:Zero" ucd="frame.time.zero" value="0.0"/>
 </GROUP>
 <GROUP utype="sed:Frame.SpectralCoord">
  <PARAM name="SpectralFrame" utype="sed:Frame.SpectralCoord.System"  ucd="frame.em.system" value="Barycent"/>
 </GROUP>
</GROUP>
<GROUP utype="sed:Coverage">
 <GROUP utype="sed:Coverage.Location">
  <PARAM name="SkyPos" utype="sed:Coverage.Location.Sky" ucd="pos.eq" unit="deg" value="132.4210 12.1232">
  <PARAM name="TimeObs" utype="sed:Coverage.Location.Time" ucd="time.obs" value="52148.3252"/>
 </GROUP>
 <GROUP utype="sed:Coverage.Extent">
  <PARAM name="SkyExtent" utype="sed:Coverage.Extent.Sky" ucd="pos.region.diameter" unit="arcsec" value="20"/>
  <PARAM name="TimeExtent" utype="sed:Coverage.Extent.Time" ucd="time.expo;phot.spectrum" unit="s" value="1500.0" />
  <PARAM name="SpectralExtent" utype="sed:Coverage.Extent.Spectral" ucd="instr.bandwidth" unit="Angstrom" value="3000.0"/>
 </GROUP>
</GROUP>
```

VOTable approach - 2

```
 <PARAM name="SNR" utype="sed:SNR" value="3.0"/>
</GROUP>

<GROUP utype="sed:SpectralCoord">
 <FIELDref ref="Coord"/>

 <GROUP utype="sed:SpectralCoord.Accuracy">
  <FIELDref ref="BinLow"/>
  <FIELDref ref="BinHigh"/>
 </GROUP>
<-- In this case Resolution is demoted from Field to Param since it is constant -->
 <PARAM name="Resolution" utype="sed:SpectralCoord.Resolution" unit="Angstrom" value="14.2"/>
</GROUP>

<GROUP utype="sed:Flux">
 <FIELDref ref="Flux"/>
 <GROUP utype="sed:Flux.Accuracy">
  <FIELDref ref="ErrorLow"/>
  <FIELDref ref="ErrorHigh"/>
  <PARAM name="SysErr" utype="sed:SysErr" unit="" value="0.05"/>
 </GROUP>
 <FIELDref ref="Quality"/>
</GROUP>

<FIELD name="Coord" utype="sed:SpectralCoord.Value" ucd="em.wavelength" unit="Angstrom"/>
<FIELD name="BinLow" utype="sed:BinLow" ucd="stat.min;em.wavelength" unit="Angstrom"/>
<FIELD name="BinHigh" utype="sed:BinHigh" ucd="stat.max;em.wavelength" unit="Angstrom"/>
<FIELD name="Flux" utype="sed:Flux.Value" ucd="phot.flux;em.wavelength" unit="erg cm^-2 s^-1 Angstrom^-1"/>
<FIELD name="ErrorLow" utype="sed:StatErrLow"  unit="erg cm^-2 s^-1 Angstrom^-1"/>
<FIELD name="ErrorHigh" utype="sedStatErrHigh" unit="erg cm^-2 s^-1 Angstrom^-1"/>
<FIELD name="Quality" utype="sed:Flux.Quality">

<DATA>
<TABLEDATA>
<-- Note slightly nonlinear wavelength solution -->
<-- Second row is upper limit -->
<-- Third row has quality mask set -->
<TR><TD>3200.0<TD>3195.0<TD>3205.0<TD>1.38E-12<TD>5.2E-14<TD>6.2E-14 <TD>0</TR>
<TR><TD>3210.5<TD>3205.0<TD>3216.0<TD>1.12E-12<TD>1.12E-12<TD>0<TD>0</TR>
<TR><TD>3222.0<TD>3216.0<TD>3228.0<TD>1.42E-12<TD>1.3E-14<TD>0.2E-14<TD>3</TR>
</TABLEDATA>
</DATA>
</TABLE>
</RESOURCE>
</VOTABLE>
```

XML instance example

```
<?xml version="1.0" encoding="UTF-8"?>
<-- xml instance example -->
<SED>
 <Date>2004-05-10</Date>
 <NSegments ucd="meta.number">1</NSegments>
 <Target>
  <name>Arp 220 </name>
  <pos>233.737917 23.503330</pos>
  <redshift>0.0018</redshift>
 </Target>
 <Segment>
  <SegmentType ucd="meta.code">Photometry</SegmentType>
  <Frame>
   <Sky>
    <Equinox ucd="time.equinox;pos.eq">2000.0</Equinox>
    <System ucd="frame.pos.system">ICRS</System>
   </Sky>
   <Time>
     <TimeFrame ucd="frame.time.scale">UTC</TimeFrame>
     <TimeZero ucd="frame.time.zero">0.0 </TimeZero>
   </Time>
   <SpectralCoord>
     <SpectralFrame ucd="frame.em.system">Barycent</SpectralFrame>
   </SpectralCoord>
  </Frame>
  <Coverage>
   <Location>
    <Sky ucd="pos.eq" unit="deg">132.4210 12.1232</Sky>
    <Time ucd="time.obs" unit="d">52148.3252</Time>
   </Location>
   <Extent>
     <Sky ucd="pos.region.diameter" unit="arcsec">20</Sky>
     <Time ucd="time.expo;phot.spectrum" unit="s">1500.0</Time>
     <Spectral ucd="instr.bandwidth" unit="Angstrom">3000.0</Spectral>
   </Extent>
  </Coverage>
  <Curation>
   <Publisher ucd="meta.organization;meta.curation">SAO</Publisher>
   <PubID ucd="meta.curation.pubid">ivoa://cfa.harvard.edu</PubID>
   <Logo ucd=meta.curation.logo">http://cfa-www.harvard.edu/nvo/cfalogo.jpg</Logo>
   <Contact>
     <Name ucd="meta.human;meta.curation">Jonathan McDowell</Name>
     <Email ucd="meta.email">jcm@cfa.harvard.edu</Email>
```

XML instance example (2)

```
<-- Define table structure -->
<Fields>
  <SpectralCoord>
   <Value ucd="em.wavelength" unit="Angstrom"/>
   <Accuracy>
    <BinLow ucd="stat.min;em.wavelength" unit="Angstrom"/>
    <BinHigh ucd="stat.max;em.wavelength" unit="Angstrom"/>
   </Accuracy>
 </SpectralCoord>
 <Flux>
   <Value ucd="phot.flux;em.wavelength" unit="erg cm^-2 s^-1 Angstrom^-1"/>
   <Accuracy>
     <StatErrLow  unit="erg cm^-2 s^-1 Angstrom^-1"/>
     <StatErrHigh unit="erg cm^-2 s^-1 Angstrom^-1"/>
     <SysErr>0.05</SysErr>
   </Accuracy>
   </Quality>
 </Flux>
</Fields>
<-- Use table structure -->
<Points>
 <Point>
  <SpectralCoord>
   <Value>3200.0</Value>
   <Accuracy><BinLow>3195.0</BinLow><BinHigh>3205.0</BinHigh></Accuracy>
  </SpectralCoord>
  <Flux>
    <Value>1.38E-12</Value>
    <Accuracy><StatErrLow>5.2E-14</StatErrLow><StatErrHigh>6.2E-14</StatErrHigh></Accuracy>
    <Quality>0</Quality>
  </Flux>
 </Point>

 <Point>
  <SpectralCoord>
   <Value>3210.5</Value>
   <Accuracy><BinLow>3205.0</BinLow><BinHigh>3216.0</BinHigh></Accuracy>
  </SpectralCoord>
  <Flux>
    <Value>1.12E-12</Value>
    <Accuracy><StatErrLow>1.12E-12</StatErrLow><StatErrHigh>0</StatErrHigh></Accuracy>
    <Quality>0</Quality>
  </Flux>
 </Point>

<Point>
```