

US National Virtual Observatory

Spectrum Data Model

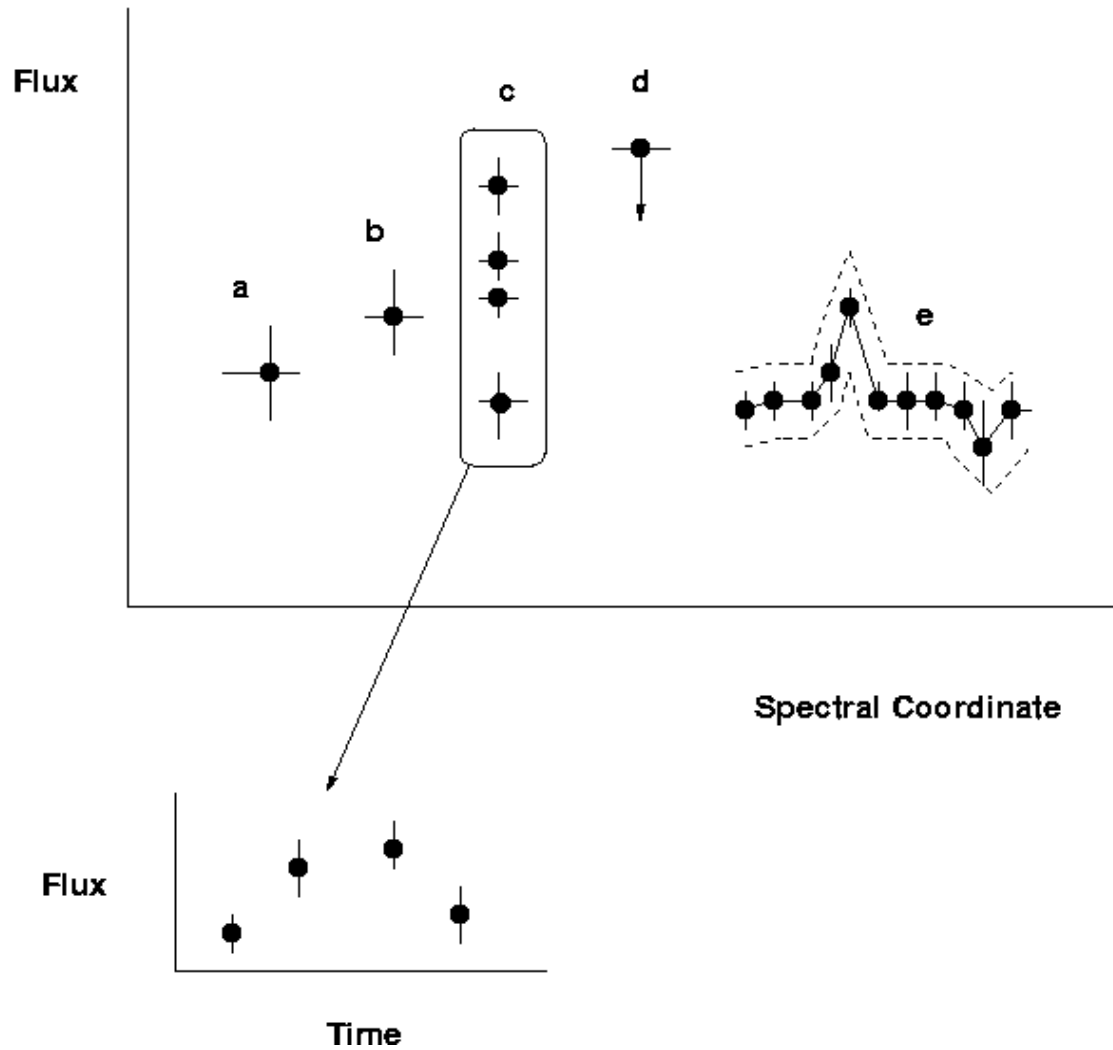
Jonathan McDowell
CfA



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

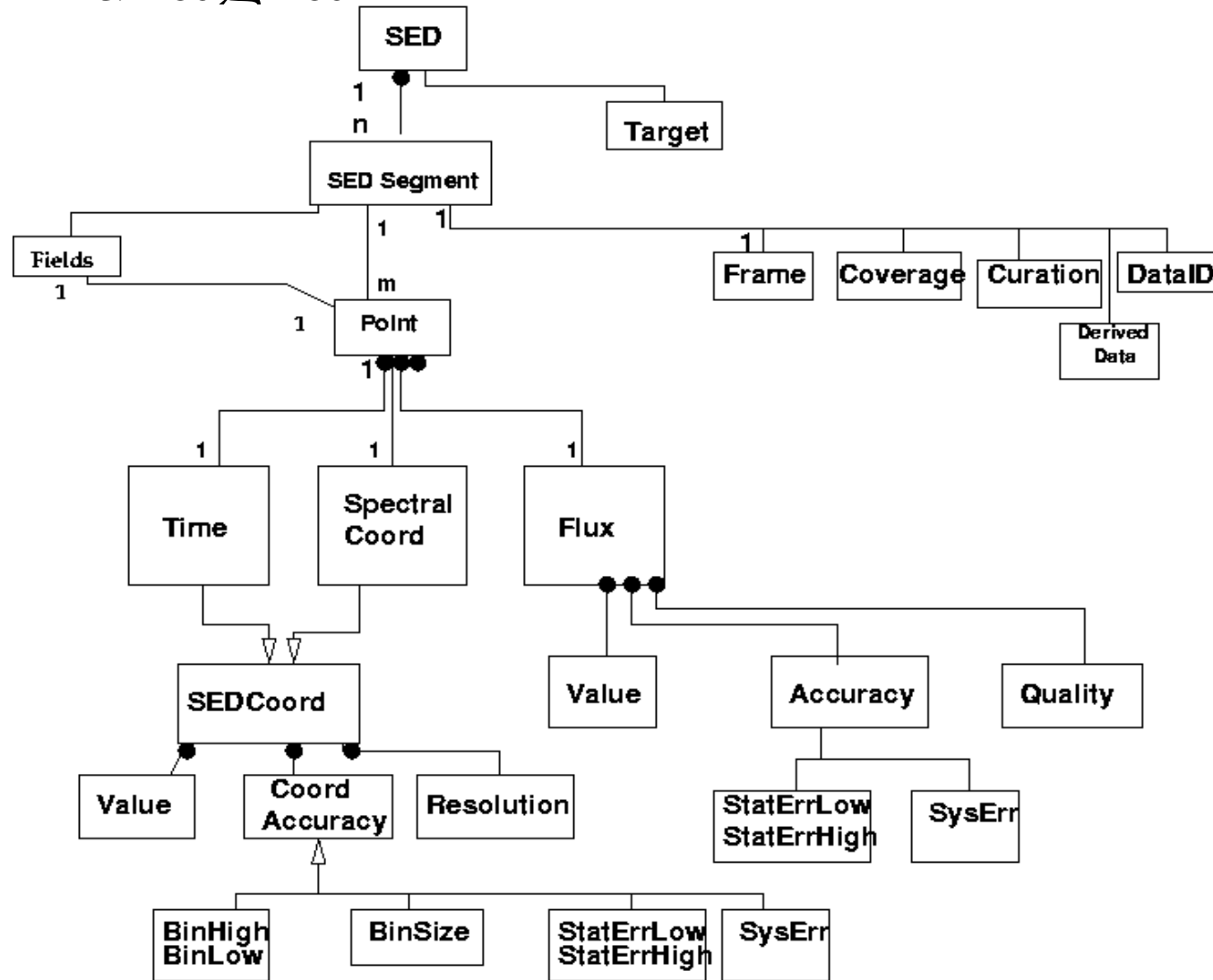
SED Segments



Compromises

- Keep it simple: first cut, don't solve all problems
- Explicit listing of (λ , flux) or (λ_1 , λ_2 , 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 there right now

UML diagram



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="sed:StatErrHigh" 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>
  </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>
```