VIRTUAL ASTRONOMICAL OBSERVATORY

Building and Analyzing SEDs

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The VAO is operated by the VAO, LLC.

Overview

- Software Development Model
- Requirements
- Baseline Components
- Design Overview
- Delivery Path
- Development Scoping efforts
- Conclusion

Software Development Model

- Development model borrows from several models and historic experience
- Waterfall Model
  - Defined project phases
    - Requirements, design, implementation, and test
  - Spend extra up-front time so early design considers final goal
    - Design data structures and libraries
    - Factor platform and runtime needs
    - Choose programming or scripting language
  - Diverge by not completing each phase before moving to next
- Spiral Model
  - Schedule series of requirement/design/implementation efforts
    - Test feedback loop of intermediate internal releases (or betas)
  - Assess risk (or liens) up front and along the way
    - External (hardware, science feedback) or internal (OTS upgrade)
- Historic experience
  - Based on years of processing and development experience
  - Follow community standards for compatibility with existing software
    - Leverage VAO efforts and define files to IVOA standards for compatibility

Requirements

- Provide Big Picture – R D'Abrusco/J McDowell
  - Develop project in steps with larger vision in hand
  - Year 1, Year 2 and Future development priorities identified
- Feedback to requirements
  - Team reviewing doc and working derived requirements
  - Science review and comment
    - Scientists from several disciplines
    - VAO Science Council / IVOA (Evanthia Hatziminaoglou)
  - Collecting use case
    - Soliciting practical threads that can be used as test cases
      - Year 1 and Overall
    - Use case doc on schedule for End Jan – *initial version*

SED Requirements Doc

High Level Requirements of the SED Tools

R. D'Abrusco, J. McDowell

December 6, 2010

1 Introduction

This document describes the scientific requirements for the SED builder and analysis tool. It is divided in three sections describing the 'SED building' (section 2, 'SED analysis' (section 3) and 'SED visualization' (section 4) capabilities of the tool respectively. Each section is split in multiple subsections, each one describing a distinct requirement of the tool. Each distinct requirement discussed in this document is associated to a label indicating the general section of the document (SED builder - SED analysis - SED visualization) where the requirement can be found, and a unique index (for example, **SED.an.3.1** for the first sub-requirement of the third requirement of the analysis section). These labels are used to provide a quick reference to the different parts of the requirements and provide a handle to the hierarchical structure of the document. The hierarchy of requirements is also shown in the tree-graph in figure 1, which is associated to the break-down scheme adopted throughout this document. The labels (in boldface in the document) are also used in tables 1, 2, 3 and 4.

2 SED builder

The overall goal of this section of the document is to outline the basic capabilities of the tool regarding the ability to read different data types, their conversion to VO formats and their combination to create the SED. The Spectral Energy Distribution (SED) of a source can be built by combining photometric points and spectroscopic segments; the basic definitions of these two different type of data given below:

1. Photometric points. A photometric point is specified, at a very basic but general level, by assigning three numbers $(s, f(s), t)$, namely a spectral coordinate s (either a wavelength, a frequency or an energy), a flux $f(s)$ (or flux density, or luminosity) measured at that spectral coordinate, and the time t of the observation. While the time coordinate associated to a photometric measurement is a fundamental information of its own, in the following the explicit dependence will be dropped for the sake of the simplicity. At the same time, the time t of the observation will be considered part of the metadata accompanying every measurement. In the ideal case, error estimates for these values are also given. Sometimes, upper limits on $f_u(s)$ are the only available data; in these cases, the points need to be labelled as such but otherwise handled as if they were detected values for this section (builder tool) of the software;

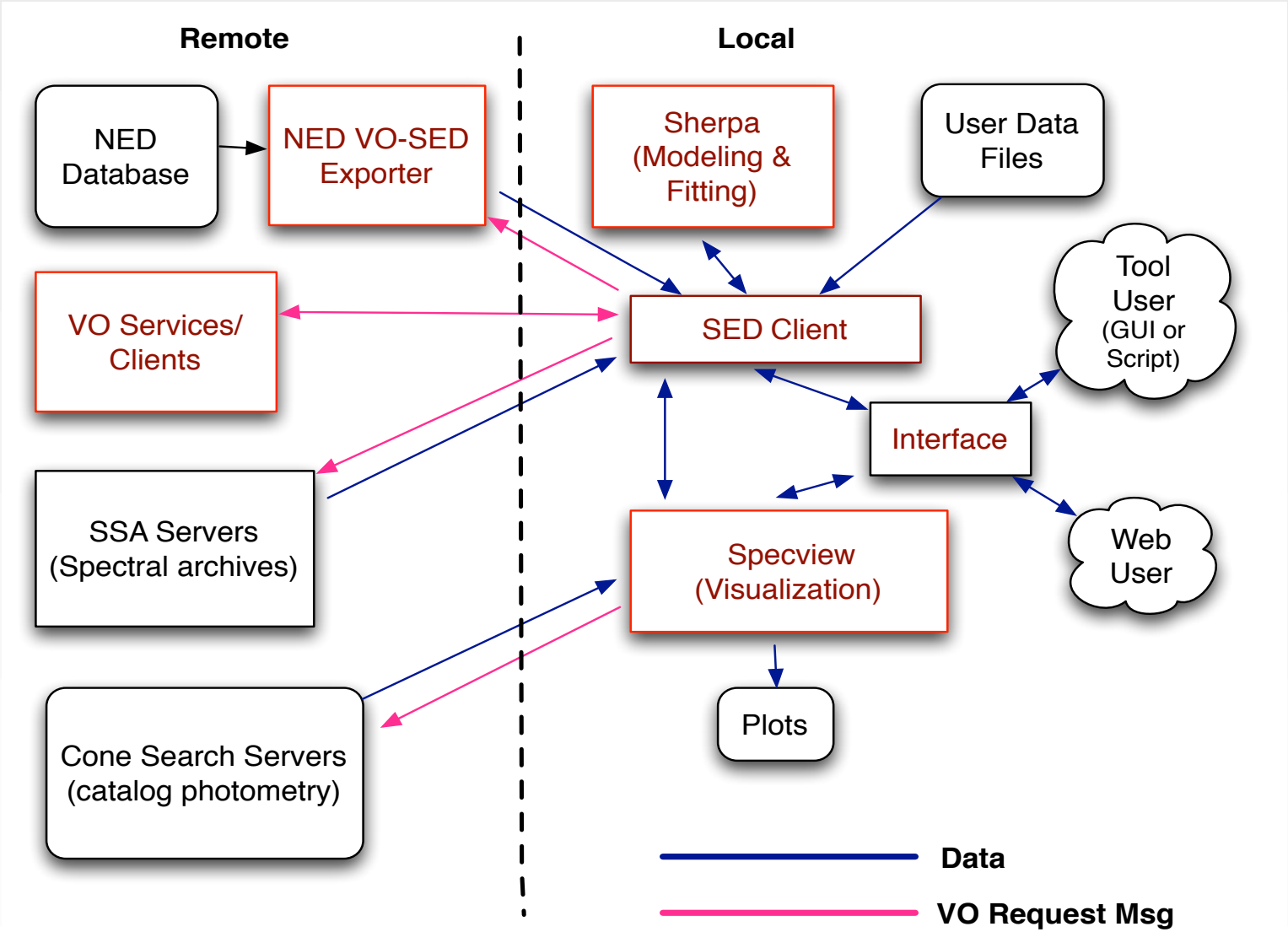
Table 3: Break-down of the requirements and proposed prioritization for the "SED analysis" section of the document.

Task	Sub-task	Sub-sub-task	Description	Year 1	Year 2	Later...
SED.an.1			Read/convert aggregate SED	X		
SED.an.2			Read rebinned SED		X	
SED.an.3			Convert from agg.to rebinn.		X	
↘	SED.an.3.1		Choose spectral coord. grid		X	
|	SED.an.3.2		Choose units of measure		X	
|	SED.an.3.3		Measure bin fluxes		X	
SED.an.4			Fitting of SEDs	X		
↘	SED.an.4.1		Fit aggregate SEDs	X		
|	SED.an.4.2		Fit rebinned SEDs		X	
|	SED.an.4.3		Library of template models	X		
|	SED.an.4.4		Composed models	X		
|	SED.an.4.5		Specify spectral interval	X		
|	SED.an.4.6		Estimate goodness-of-fit	X		
|	SED.an.4.7		Estimate confidence lev.	X		
|	SED.an.4.8		User-def. model funct.		X	
|	SED.an.4.9		User-def. tabular models		X	
|	SED.an.4.10		User-def. statistics			X
|	SED.an.4.11		Estimate integr. fluxes		X	
|	SED.an.4.12		Estimate fluxes in ref. filters			X
SED.an.5			Template fitting		X	
↘	SED.an.5.1		Routine interf. for libraries		X	
|	SED.an.5.2		Interf. to synthetic libraries			X
|	SED.an.5.3		Add comp. to libraries			X
|	SED.an.5.4		Spatial-spectral fit			X
|	SED.an.5.5		Spatial-spectral fit in interv.			X
|	SED.an.5.6		Evaluate aperture correct.			X
SED.an.6			Population analysis		X	
↘	SED.an.6.1		Evaluate pop. statistics		X	
|	SED.an.6.2		Eval. pop. statistics in interv.			X
|	SED.an.6.3		Eval. integrated quantities		X	
SED.an.7			SEDs classification			X
↘	SED.an.7.1		Clustering of SEDs			X
|	SED.an.7.2		Classification of SEDs			X
SED.an.8			Astrophysics and cosmology		X	
↘	SED.an.8.1		Apply extinction laws		X	
|	↘	SED.an.8.1.1	User-provided ext. laws		X	
|	|	SED.an.8.1.2	Libraries of ext. laws		X	
|	|	SED.an.8.1.3	Tabular descript. of ext. laws			X
|	|	SED.an.8.1.4	Redshift-depend. ext. laws			X
|	SED.an.8.2		Modify redshift of SED		X	
|	SED.an.8.3		Estimate bolometric flux		X	
|	SED.an.8.4		Bolometric lum. with distance		X	
SED.an.9			Convolution		X	

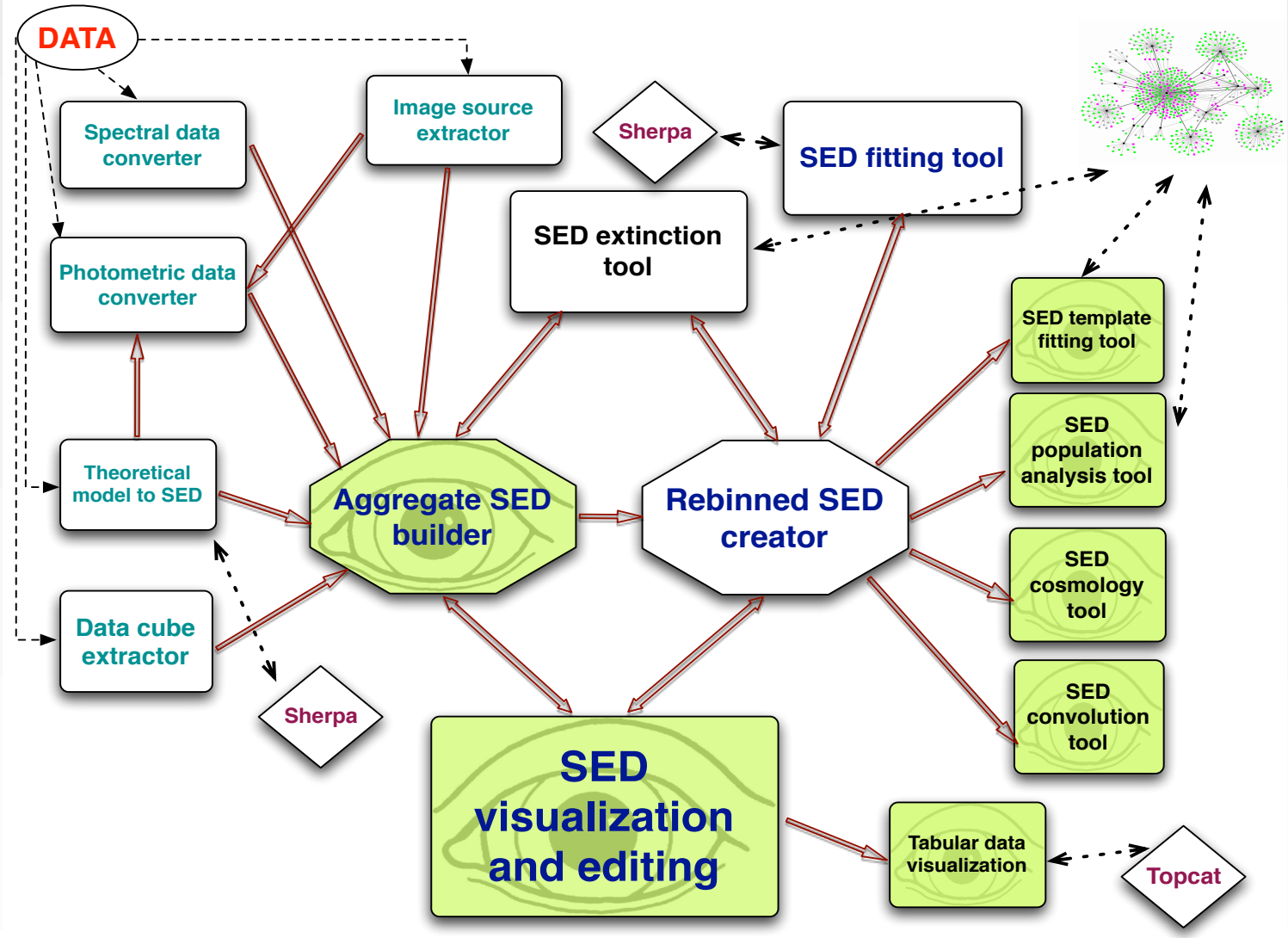
Baseline components

- SED DataModel library & toolkit (SAO)
  - Jonathan McDowell, Mark Cresitello-Dittmar, Joe Miller
- Generic SED Service in DALserver framework (NRAO)
  - Doug Tody
- NED SED Service (IPAC)
  - Joe Mazzarella, Rick Ebert, Olga Pevunova, Ashish Mahabal
- SpecView (STScI) – Visualization
  - Ivo Busko
- Sherpa (SAO) – Spectral Modeling and Fitting
  - Stephen Doe, Brian Refsdal, Dan Nguyen

Design Overview – Yr1



Design Overview – Yr 2+



Delivery Path

- IVOA Note Photometry and SED/DM
  - J. McDowell – Done
- Derived requirements for components (End Nov)
  - SED Library/SED Service Framework/NED/Specview/Sherpa
  - Overall and highlight year 1
  - Requirements buy-in by development team
  - Input for test case development
- Design (Early Jan)
  - SED Library/SED Service Framework/NED/Specview/Sherpa
  - High level for existing code; detailed for SED project

Delivery Path cont.

- Beta1 release
  - SED Library/SED Service Framework (Mid Feb)
  - NED/Specview/Sherpa (Early Mar)
  - Internal test and Informal Science Evaluation (Apr 1)
- Beta2 release
  - SED Library/SED Service Framework (Early May)
  - NED/Specview/Sherpa (Mid May)
  - Internal & VAO project level test and evaluation (Early Jun)
- Yr 1 release (End Jul)
  - Includes unit and regression tests
  - Packaging and project turnover
  - Internal & VAO project level test and evaluation

Schedule Overview

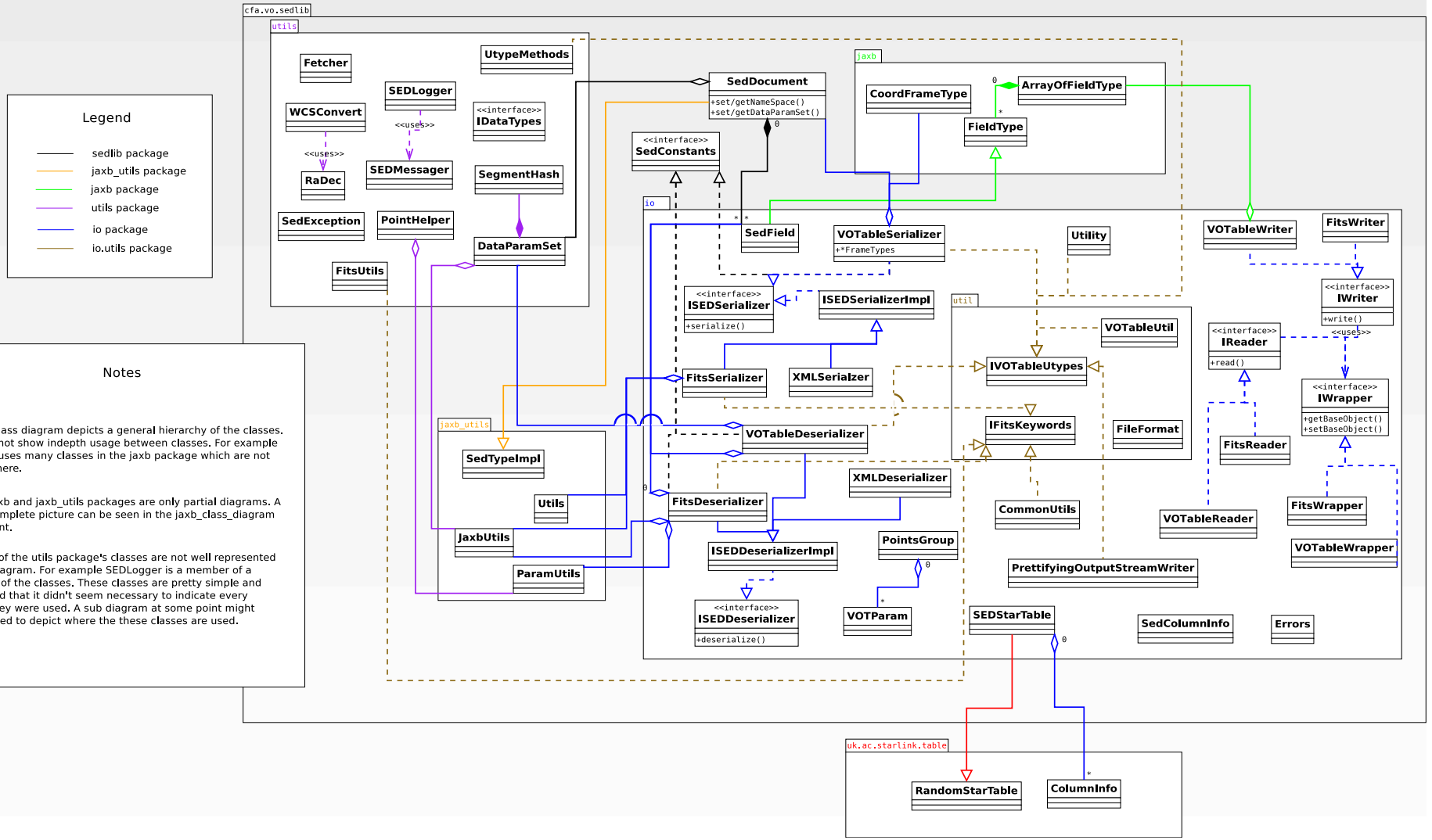
	A	B	C	D	E	F	G	H	I
1	**TAG**	**INSTITUTION**	**TASK**	**DESCRIPTION**	**START DATE**	**END DATE**	**LIEN**	**Actual END**	*Edit Notes*
2									
3	REQ	ALL	REQ Review	Internal Requirements Review & Feedback	Early Sep	22-Oct	None		
4	REQ	SAO/Raffaele	Requirements Update	Requirements Update based on feedback; Id Year 1 development	22-Oct	4-Nov	RR		
5									
6	**REQ**	**SAO/JDE**	**SED Requirements 1.0**	**Post Requirements; Get VAO project sign-off**	4-Nov	**End Nov**			
7	REQ	SAO/Raffaele	Solicit Input on Science Use Cases	Create separate doc outlining SED Sciece use cases; will use for testing SED app	Mid Nov	End Jan			
8	**REQ**	**STDS/DTody**	**IVOA Note**	**SED/DM specification doc; cover DM and access protocol;** help from JCM/MCD	Mid Nov	**7-Dec-10**	**None**		
9	REQ	IPAC/JMazz	Data Provider SED/DM Req	IPAC input on API specifications for toolkit; built on DM/Lib	Early Nov	Early Dec			
10	**REQ**	IPAC/JM	SED Visualization evaluation (SVE)	Evaluation of web-based and desktop-based applications best suited for SED visualization, editing, and fitting and analysis tools; to provide requirements for Specview modifications	Mid Nov	Mid Feb			
11	REQ	SAO/RD	SED Requirements update (1.1)	SED Req update based on SVE report	End Nov	End Feb	SVE		
12	**REQ**	**SAO/RD**	**SED Use Case Doc 1.0**	**Outline Science Use cases**	**End Nov**	**End Feb**	**Solicit Science Use Cases**		
13	**REQ**	**STDS/DTody**	**IVOA Note update**	**IVOA note update after mtg**	7-Dec-10	**End Feb**	**IVOA Note**		New(11/23)
14									
15	*****DM*****								
16	DM	SAO/MCD	SED/DM Lib Requirements	SED/DM requirements doc derived from IVOA Note + Data Provider SED/DM Req; *Overall and Highlight Yr1*	Early Oct	Mid Dec	SED Req 1.0, IVOA Note,Data Provider SED/DM Req		
17	**DM**	**ALL**	**Req Review**				**SED/DM Lib Req**		
18	DM	SAO/MCD	SED/DM Lib Design	**High level existing; details for SED proj**	Early Oct	Early Jan	SED Req 1.0, IVOA Note, Data Provider SED/DM Req; SED Lib Req, Req Rev		
19	**DM**	**ALL**	**Design Review**				**SED/DM Lib Design**		
20	DM	SAO/MCD	SED DM Library Beta1 (DMB1)	Provide a java library to (create,read, interpret, modify) SED data objects; include design for review & unit tests; some legacy code from NVO with review/update	Early Oct	Mid Jan	SED/Lib Design, Design Rev		
21	**DM**	**ALL**	**Test & Eval Beta 1**	**Internal Unit test/Science Evaluation**	**Mid Jan**	**Mid Feb**	**SED DM Lib Beta1**		
22	DM	SAO/MCD	SED DM toolkit Beta1 (SDM)	Access toolkit - High Level User Interface (HLUI); build on SED/DM library	Mid Jan	Mid Feb	SED/Lib Design		
23	**DM**	**ALL**	**Test & Eval toolkit Beta1**	**Internal Unit test/Science Evaluation**	**Mid Feb**	**End Feb**	**SED DM toolkit Beta1**		
24									
25	DM	SAO/MCD	SED DM Lib & Toolkit Beta2	Updates based on Beta1 feedback - support Beta2 application turnovers	Mid Feb	Mid Apr	SED/Lib Design, Test & Eval Beta1		
26	**ALL**	**SAO/JDE**	**Test & Eval Beta 2**	**Internal/Project level review; Evaluation & feedback**	**Mid Apr**	**Early May**	**SED DM Lib & Toolkit Beta2**		
27	**ALL**	**SAO/JDE**	**FINAL Code Freeze**	**Integrated SED App**	**Mid Apr**	**Mid Jun**	**Test & Eval Beta2**		
28									
29	*****S&P*****								New Section(11/23)
30	S&P	S&P/Dtody	SED Service Support in DALServer Framework Requirements	Derived requiremets - *Overall and Highlight Yr 1*	Early Nov	Mid Dec	SED Req 1.0		
31	**ALL**	**SAO/JDE**	**Req Review**				**SED Service Req**		
32	NED	S&P/Dtody	SED Service Support in DALServer framework design	High level existing; details for SED proj	End Nov	Early Jan	SED Service Req, SED Req 1.0, Req Review		
33	**ALL**	**SAO/JDE**	**Design Review**				**SED Service Design**		
34	S&P	S&P/Dtody	SED Service Support in DALServer Framework Beta1	Provide a generic, ready to use SED service implementation which takes care of all the details of the protocol and data model (as used for metadata in the query response).	Early Jan	Mid Feb	SED Service Design; SED DM Lib		
35	**ALL**	**SAO/JDE**	**Test & Eval Beta 1**	**Internal Unit test/Science Evaluation**	**Mid Feb**	**Mid Mar**	**SED Servie Bundle Beta1**		
36	NED	S&P/DTody	SED Service Support in DALServer Framework Beta2	Beta1 feedback / add'l features	Mid Feb	Mid Apr	SED Service Design; Test & Eval Beta1		
37	**ALL**	**SAO/JDE**	**Test & Eval Beta 2**	**Internal/Project level review; Evaluation & feedback**	**Mid Apr**	**Early May**	**SED Service Bundle**		
38	**ALL**	**SAO/JDE**	**FINAL Code Freeze**	**Integrated SED App**	**Mid Apr**	**Mid-Jun**	**Test & Eval Beta2**		
39									
40	*****NED*****								
41	NED	IPAC/JMazz	NED SED Service Requirements	Derived requiremets - *Overall and Highlight Yr 1*	Early Nov	Early Dec	SED Req 1.0		END DATE change (11/23) - prev=End_Nov
42	**ALL**	**SAO/JDE**	**Req Review**				**NED/SED Service Req**		

Schedule Overview cont.

	A	B	C	D	E	F	G	H	I
43	NED	IPAC/JMazz	NED SED Service design	High level existing; details for SED proj	End Nov	End Jan	NED/SED Service Req, SED Req 1.0, Req Review, SED DM Lib design		END DATE change (11/23) - prev=Early Jan
44	**ALL**	**SAO/JDE**	**Design Review**				**NED/SED Service Design**		
45	NED	IPAC/JMazz	SED sample files	Sample files for Specview/Sherpa development	Mid Jan	End Jan	IVOA Note, SED DM Lib Beta1		
46	NED	IPAC/JMazz	NED SED Service Beta1	Serve up NED SEDs ;; TBD whether to implement with SED/DM Java lib	Early Jan	Early Mar	NED/SED Service Design		
47	**ALL**	**SAO/JDE**	**Test & Eval Beta 1**	**Internal Unit test/Science Evaluation**	**Early Mar**	**1-Apr-11**	**NED/SED Service Beta1**		
48	NED	IPAC/JMazz	NED/SED Service Beta2	Beta1 feedback; add'l features	1-Apr	Mid May	NED/SED Service Design; Test & Eval Beta1		
49	**ALL**	**SAO/JDE**	**Test & Eval Beta 2**	**Internal/Project level review; Evaluation & feedback**	**Mid May**	**Early Jun**	**NED/SED Service Beta2**		
50	**ALL**	**SAO/JDE**	**FINAL Code Freeze**	**Integrated SED App**	**Mid May**	**Mid-Jun**	**Test & Eval Beta2**		
51									
52	***Sherpa***								
53	Sherpa	SAO/SDoe	Sherpa Requirements	Derived requirements - Overall and Highlight Year 1	Early Nov	End Nov	SED Req 1.0		
54	**ALL**	**SAO/JDE**	**Req Review**				**Sherpa Req**		
55	Sherpa	SAO/SDoe	Sherpa design	Sherpa design / API to Specview/others; web/tool packaging	End Nov	Early Jan	Sherpa Req, SED Req 1.0		
56	**ALL**	**SAO/JDE**	**Design Review**	**High level existing; details for SED proj**			**Sherpa design**		
57	Sherpa	SAO/SDoe	Sherpa Fitting Beta1	SED enabled fitting; Integrated build with Specview - coordinate integrated Web app	Early Jan	Early Mar	Sherpa design, Design Review		
58	**ALL**	**SAO/JDE**	**Test & Eval Beta 1**	**Internal Unit test/Science Evaluation**	**Early Mar**	**1-Apr-11**	**Sherpa Fitting Beta1**		
59	Sherpa	SAO/SDoe	Sherpa Fitting Beta2	Beta1 feedback; add'l features; web & tool base support	Early Mar	Mid May	Sherpa design; Test & Eval Beta1		
60	**ALL**	**SAO/JDE**	**Test & Eval Beta 2**	**Internal/Project level review/evaluation & feedback**	**Mid May**	**Early Jun**	**Sherpa Fitting Beta2**		
61	**ALL**	**SAO/JDE**	**FINAL Code Freeze**	**Integrated SED App**	**Mid May**	**Mid-Jun**	**Test & Eval Beta2**		
62									
63									
64	***Specview***								
65	Specview	ST/Ivo	Specview Derived requirements	Overall and Highlight Yr 1	Early Nov	End Nov	SED Req 1.0		
66	**ALL**	**SAO/JDE**	**Req Review**				**Specview Req**		
67	Specview	ST/Ivo	Specview design	Specview design / API to Sherpa / baseline design & enhancements	End Nov	Early Jan	Specview Req, SED Req 1.0		
68	**ALL**	**SAO/JDE**	**Design Review**	**High level existing; details for SED proj**			**Specview Design**		
69	Specview	STScI/Ivo	Specview Beta1	Integrated build with Sherpa	Early Jan	Early Mar	Specview Design, Design Review		
70	**ALL**	**SAO/JDE**	**Test & Eval Beta 1**	**Internal Unit test/Science Evaluation**	**Early Mar**	**1-Apr-11**	**Specview Beta1**		
71	Specview	STScI/Ivo	Specview Beta2	Beta1 feedback; add'l features; web & tool base support	Early Mar	Mid May	Specview design; Test & Eval Beta1		
72	**ALL**	**SAO/JDE**	**Test & Eval Beta 2**	**Internal/Project level review/evaluation & feedback**	**Mid May**	**Early Jun**	**Specview Beta1**		
73	**ALL**	**SAO/JDE**	**FINAL Code Freeze**	**Integrated SED App**	**Mid May**	**Mid-Jun**	**Test & Eval Beta2**		
74									
75									
76	*** Wrap Up***								
77	**ALL**	**SAO/JD**	**Packaging/Test Turnover**	**Web/Tool - Docs/Unit/reg tests/Project repository**	**Early Apr**	**End-Jun**	**NED,Sherpa,Specview Beta1**		
78									
79	***ALL***	***Margin***	***Project overrun***	***1 month***	***End Jun***	***End Jul***	***Buffer for schedule above***		
80		**ALL**	**SED RELEASE 1.0**	**Integrated SED release - DM/SED data/Fitting/Viz; includes unit and regression tests**		**SED Release1 (End Jul)**	**Integrate/test success**		
81									
82									
83									
84	***#####***	***#####***	***#####***	***#####***	***#####***	***#####***	***#####***		Sent JM email/what to do with section (11/24)
85	***#####***		**from IPAC SOW; Yr 1 or Post Yr 1??**	***#####***	***#####***	***#####***	***#####***		
86	***#####***	***#####***	***#####***	***#####***	***#####***	***#####***	***#####***		
87									
88		IPAC/JM	GAL/AGN compare	Deploy capability to compare SEDs of galaxies and AGNs			from SOW		
89		IPAC/JM	URI	Deliver a Uniform Resource Identifier (URI) to the VAO Registry that provides an SED for the requested source (Galaxy & AGN) following the IVOA/SED Data Model			from SOW		
90		IPAC/JM	GAL/FIT	Deploy capability to compare and fit SEDs with a library of galaxy model templates			from SOW		

Development Scoping Efforts

SedLib Class Diagram



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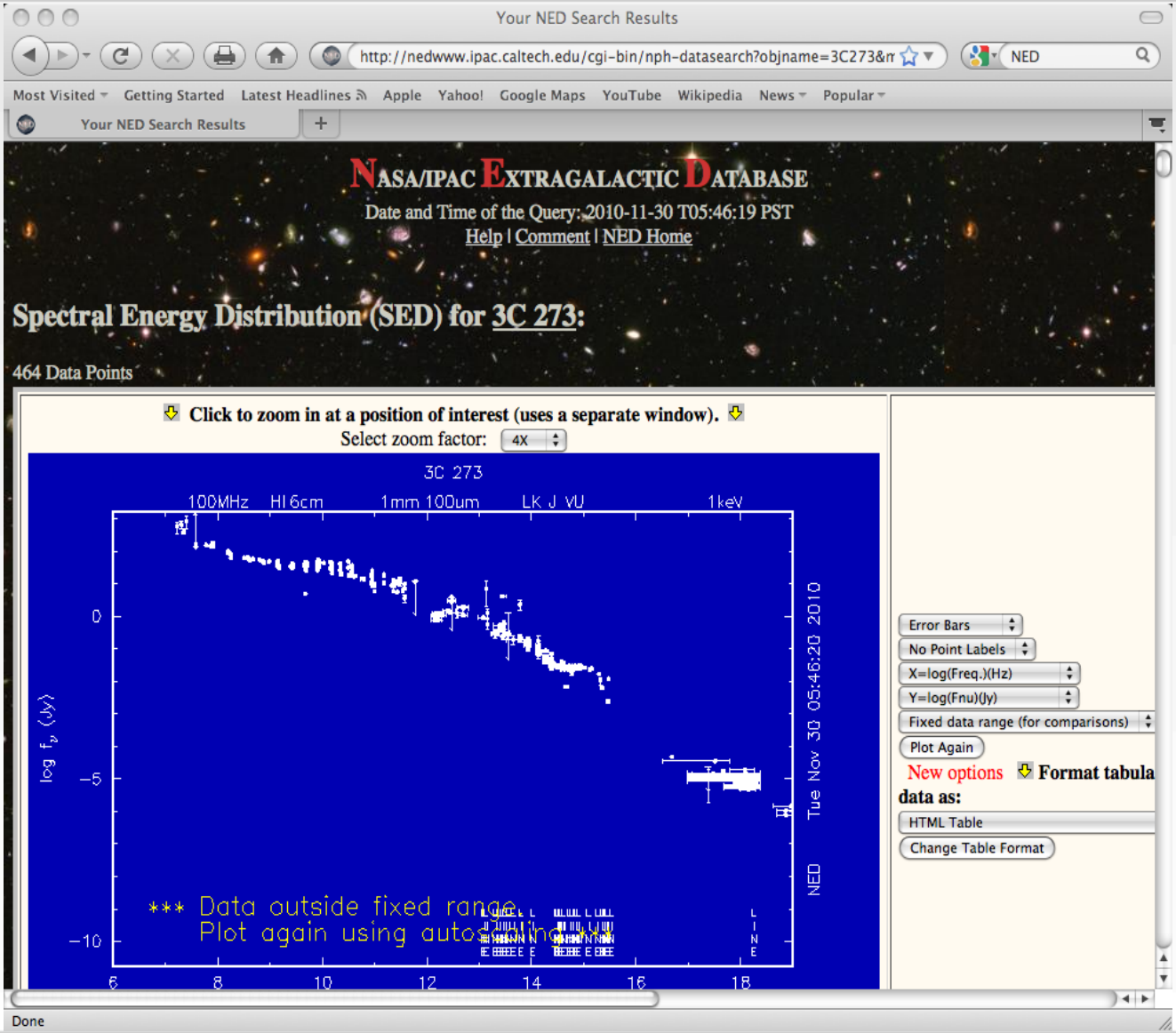
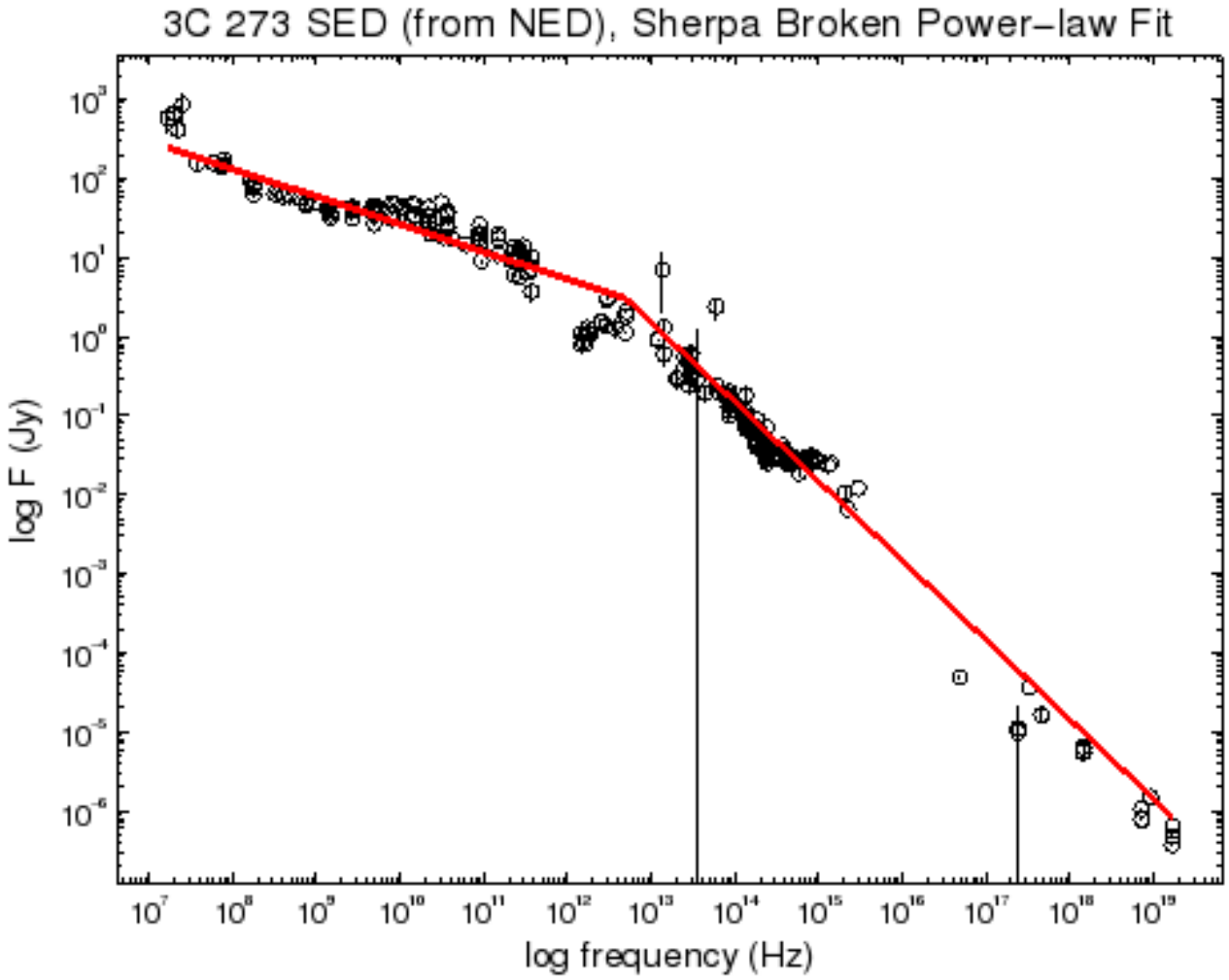


Development Scoping Efforts



Conclusions

- Feedback to requirements
  - http://dev.usvao.org/vao/attachment/wiki/Projects2010/SEDAccessAnalysisPDD/SED_HLR_Dec06.pdf
  - Email to <rdabrusco@cfa.harvard.edu>
- Interested scientists to review beta releases
  - Dedicated user support effort at CfA lined up for testing
  - If you are interested - Email to janet@cfa.harvard.edu
- SED Service Framework
  - Email to <dtody@nrao.edu>