"Extreme Precision Radial Velocities and IVOA Standards"

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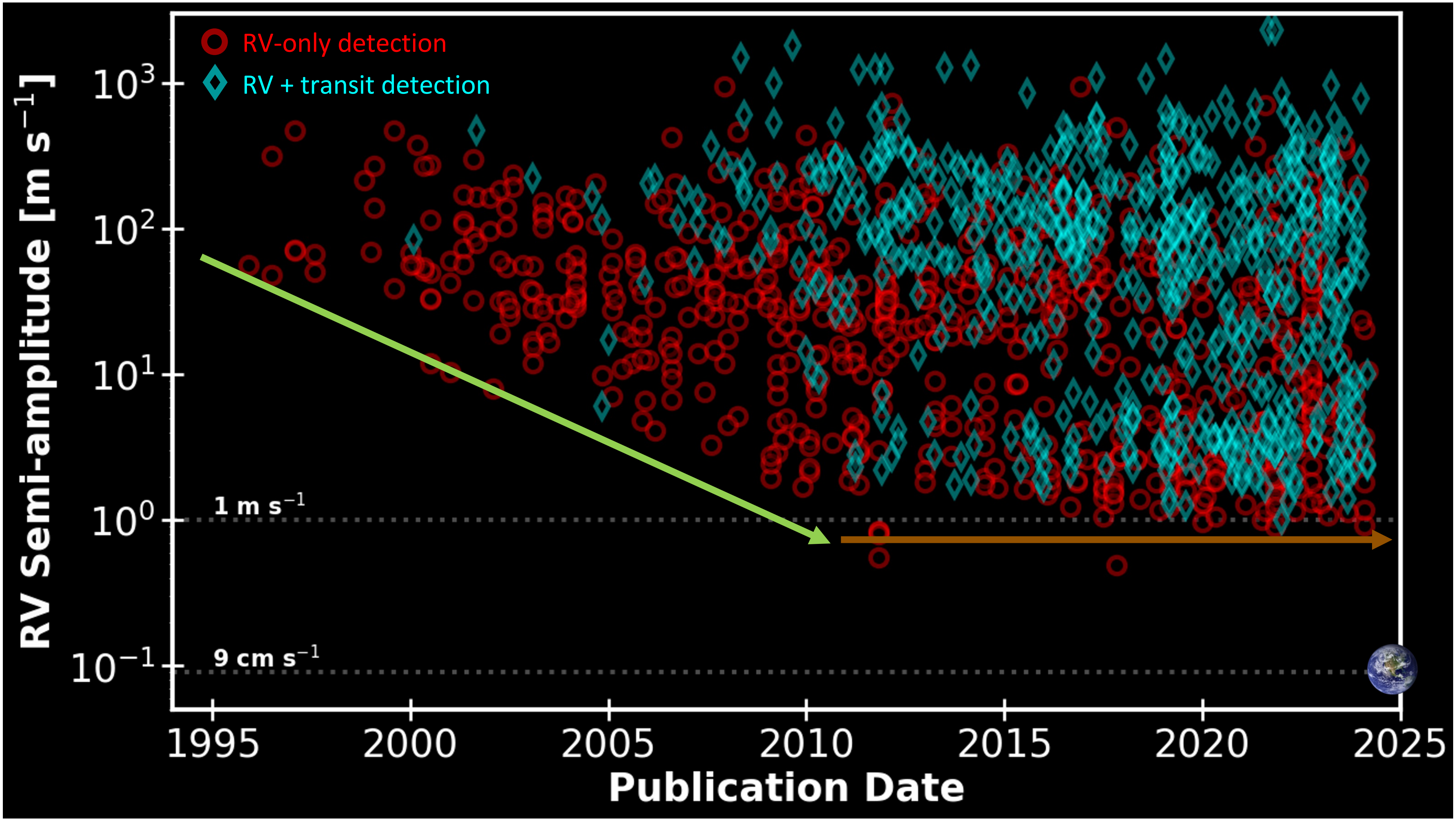
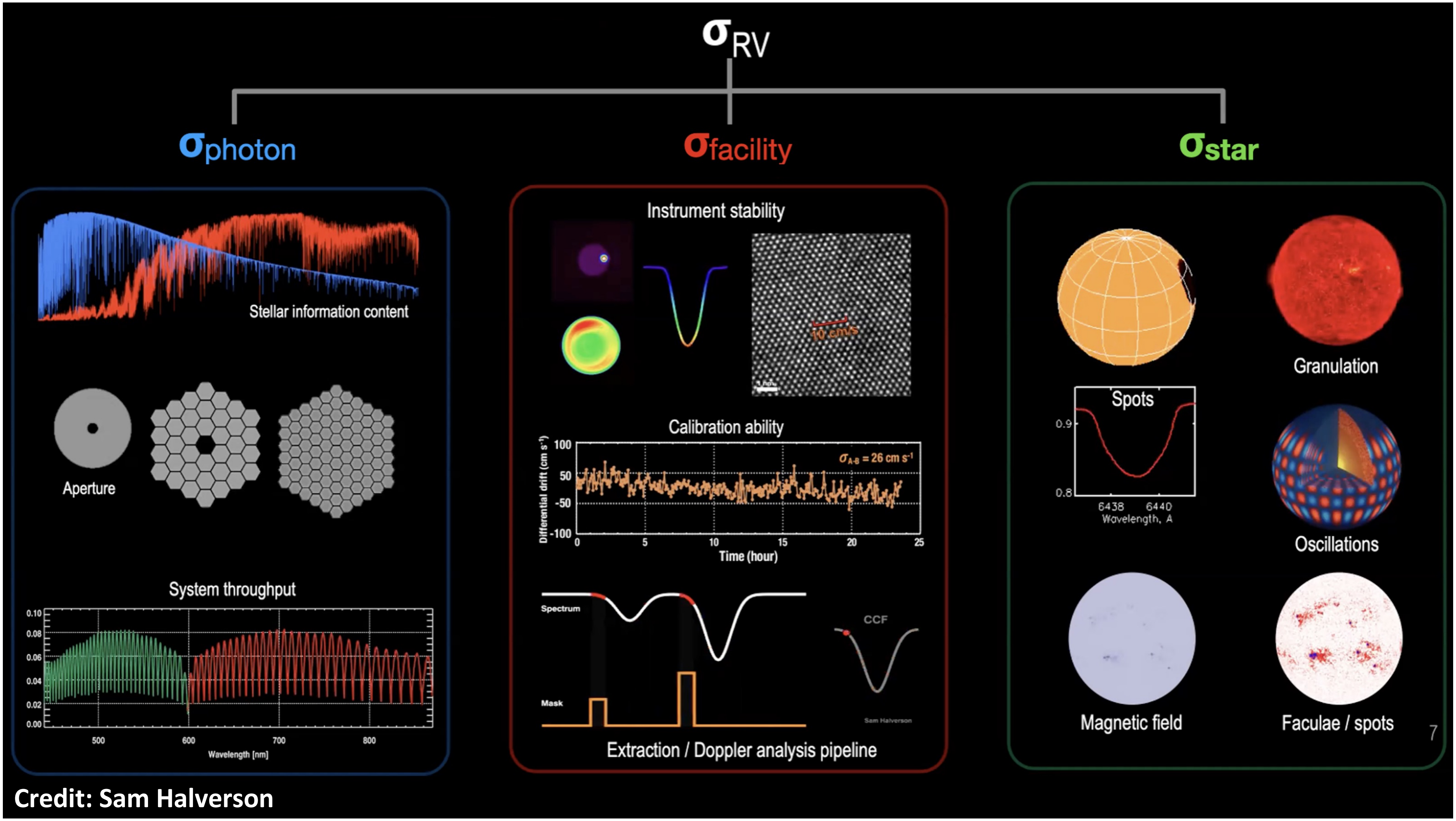
On behalf of:

The International EPRV Formatting Team

IVOA Interoperability Workshop, College Park, MD
June 2025.



RV-only detection
RV + transit detection
RV Semi-amplitude [m s^{-1}]
10^3
10^2
10^1
10^0
10^{-1}
1 m s^{-1}
9 cm s^{-1}
1995
2000
2005
2010
2015
2020
2025
Publication Date



σRV
σphoton
σfacility
σstar
Stellar information content
Aperture
System throughput
Wavelength [nm]
Instrument stability
10 cm/s
Calibration ability
Differential drift (cm s-1)
σA-B = 26 cm s-1
Time (hour)
Spectrum
Mask
CCF
Sam Halverson
Extraction / Doppler analysis pipeline
Granulation
Spots
Wavelength, A
Oscillations
Magnetic field
Faculae / spots
Credit: Sam Halverson

Recommendations from the NASA/NSF EPRV Working Group's Final Report (Crass et al. 2021):

Cross-Comparison of Near-Term Instrument Performance (Objective 2) : "*Perform detailed analyses (by both instrument teams and external groups to ensure independent analyses) of the final instrument performance so that the community can identify successes and lessons learned, and thereby make informed design choices for future EPRV instruments.*"

Develop Modular, Open-Source Pipeline for EPRV Science (Objective 5) : "*Establish a community-standard framework that allows researchers to experiment with new RV measurement and interpretation techniques and make meaningful comparisons between current practices and next-generation analysis tools… Make data publicly available at multiple levels and as standardized data products in standard formats*"

Community would benefit from an standardized FITS format for data products starting at the extracted, order-by-order spectrum level

NEID

HPF

carmenes

-CLEF

NASA Exoplanet Archive

Keck Planet Finder

espresso

W. M. KECK OBSERVATORY
Maunakea
Island of Hawai'i

ESO

iLocater

EXPRES
Search for 100 Earths

Planetary Search [HARPS
ESO
OHP
OBSERVATOIRE DE GENEVE
FONDE EN 1772
http://obswww.unige.ch

MAROON-X

NOIR Lab

Instrument	First Light	Bandpass [nm]	Resolution [λ / $\Delta\lambda$]	Wave. Cal. Source	Telescope & Aperture	Reference [m]
HARPS*	2003	380-690	115,000	Th-Ar/Etalon (LFC**)	La Silla 3.6m	Mayor et al. 2003
HARPS-N*	2012	380-690	115,000	Th-Ar/Etalon	TNG [3.6m]	Cosentino et al. 2014
SOPHIE+	2012	380-690	75,000	Th-Ar/Etalon	OHP 1.93m	Bouchy et al. 2013
APF	2014	500-620	110,000	Iodine	APF [2.4m]	Vogt et al. 2014
CARMENES	2016	520-1710	82,000	Th-Ne / U-Ne HCL	Calar Alto 3.5m	Quirrenbach et al. 2014
iSHELL	2016	2180-2470	80,000	$^{13}CH_4$ Cell	IRTF [3.2m]	Cale et al. 2019
IRD	2017	970-1750	70,000	LFC/Th-Ar	Subaru [8.2m]	Kotani et al. 2018
EXPRES*	2018	390-780	137,500	LFC/Etalon	LDT [4.3m]	Petersburg et al. 2020
HPF	2018	800-1270	50,000	LFC	HET [10m]	Mahadevan et al. 2014
PFS	2018	500-620	120,000	Iodine	Magellan Clay [6m]	Crane et al. 2010
ESPRESSO*	2019	380-790	140,000	Th-Ar/Etalon (LFC**)	VLT [8m]	Pepe et al. 2021
PARVI	2019	1145-1766	60,000	LFC	Hale [5m]	Cale et al. 2023
SPIRou	2019	980-2350	64,000	U-Ne HCL, Etalon	CFHT [3.6m]	Donati et al. 2020
MAROON-X*	2020	500-920	85,000	Etalon	Gemini-N [8m]	Seifahrt et al. 2020
NEID*	2021	380-930	115,000	LFC/Etalon	WIYN [3.4m]	Schwab et al. 2016
KPF*	2022	445-870	97,000	LFC/Etalon	Keck I [10m]	Gibson et al. 2024
PARAS-2	2022	380-690	107,000	U-Ar HCL	PRL [2.5m]	Chakraborty et al. 2024
NIRPS*	2023	970-1800	84,000	U-Ne HCL/Etalon (LFC**)	La Silla 3.6m	Artigau et al. 2024
HARPS3*	2025	380-690	115,000	Sim. Th-Ar, Etalon	INT [2.5]	Thompson et al. 2016
iLocater	2025	970-1310	190,000	Etalon	LBT [8.4m]	Crass et al. 2022
MARVEL	2025	380-950	135,000	Th-Ar, Etalon	Mercator Obs. [0.8m]	Pember et al. 2022
HISPEC	2026	980-2500	100,000	LFC/Etalon	Keck II [10m]	Konopacky et al. 2023
2ES	2027	370-890	120,000	TBD	ESO/MPG 2.2m	Stürmer et al. 2024
G-CLEF	2029	350-950	105,000	TBD	GMT [25m]	Szentgyorgyi et al. 2018

Future Instruments

*Spectrographs that have, or are soon adding, a solar feed to allow day time observations of the Sun.

**LFC spectra are available but the calibrator is not yet available to the community due to reliability issues.

†Instruments above the horizontal line are already in science operation at the time of publication of this article, those below the line are expected to begin science operations before the end of the decade.

Suggested Data Level Definitions

L0: Raw Data

L1: Assembled detector image with some corrections (e.g. overscan & flatfield) applied

L2: Order-by-Order spectra, aimed primarily at subset of the EPRV community interested in improving instrument performance or data reduction pipelines

L3: Stitched spectrum, aimed primarily at non-EPRV experts interested in exoplanet follow up, stellar characterization, etc

L4: Derived data products, aimed primarily at subset of the EPRV community interested in exoplanet detection and stellar variability characterization

All EPRV Standard files share the same PRIMARY header

All Keyword headers must be present, those that are not “required” may be set to Null. Tho that are “required” must be populated with meaningful information

Keyword	Description	Units	Data type	Example Value	FITS required	Default	Population Required for EPRV Standard Compliance
ORGANIZA	Organization the data belongs to, for licensing purposes	N/A	String	'ESO' or 'CC-0'		CC-0	N
ORIGIN	Entity that created this file	N/A	String	"ESO" or "NOIRLab"		'	N
DATALVL	Data Product Base Level	N/A	String	"L0", "L1", "L2"		UNKNOWN	Y
OBSERVER	Observer	N/A	String	"Bender"	Y	UNKNOWN	Y
PROGRAM	Observing program name	N/A	String	Program ID		'	N*
PINAME	Program PI Name	N/A	String	"Bender"		'	N*
OBSTYPE	Observation type	N/A	String	‘Sci”, “Eng”, “Cal”, or “Tst”	Y	UNKNOWN	Y
OBSMODE	Observing mode	N/A	String	endent (e.g. HR, HE, etc.)		'	N
READMODE	Readout Mode	N/A	String	R", "FowlerN", "CDS", etc.		'	N
BINNING	Binning Mode	N/A	String	"1x1","2x2"		UNKNOWN	Y
NUMTRACE	Iterator for Number of Object related keywords	N/A	UInt	1		UNDEFINED	Y
NUMORDER	Number of Orders	N/A	Uint	172		UNDEFINED	Y
OBJECT	Primary Object Name	N/A	String	n Readable Object Name	Y	UNKNOWN	Y
ALIASES	user defined name(s) for the object, ; separated	N/A	String	n Readable Object Name	N	'	N
FILENAME	Name of the FITS file	N/A	String	YYYMMDDThhmmss.fits”	Y	UNKNOWN	Y
DATE	Last modification date/time of this file	UTC	String	018-04-26T15:53:13.456”	Y	UNKNOWN	Y
DATE-OBS	Date/time at start of exposure	UTC	String	018-04-26T15:53:13.456”	Y	UNKNOWN	Y
JD_UTC	Julian date of DATE-OBS	day	Double	e.g., 2450000.000000000		UNDEFINED	Y
EXPTIME	Exposure time	s	Float	e.g., 29.43664		UNDEFINED	Y
TRACE1 ... TRACE#	Type of object in trace 1 to #	N/A	String	., "SCI" or "CAL" or "SKY"		UNKNOWN	Y
CLSRC1 ... CLSRC#	Name of calibration source in trace 1 to # [if use	N/A	String	"LFC", "Etalon", 'UrNe"		UNKNOWN	Y
CSRC1 ... CSRC#	Catalog source for object in trace 1 to #	N/A	String	"GaiaDR2"		UNKNOWN	Y
CID1 ... CID#	Catalog name/designation for object in trace 1 to #		String	NNNNNNNNNNNNNNNN		UNKNOWN	Y
CRA1 ... CRA#	Catalog right ascension for object in trace 1 to #	sexagesimal	String	HH:MM:SS.sss		UNKNOWN	Y
CDEC1 ... CDEC#	Catalog declination for object in trace 1 to #	sexagesimal	String	DD.mm.ss.sss		UNKNOWN	Y
CEQNX1 ... CEQNX	Catalog equinox for object in trace 1 to #	yr	Float	2000		UNDEFINED	Y
CEPCH1 ... CEPCH	Catalog epoch for object in trace 1 to #	yr	Float	e.g., 2015.5		UNDEFINED	Y
CRV1 ... CRV#	Catalog Systemic RV for for object in trace 1 to #	km/s	Float	e.g. 45.654		UNDEFINED	Y
CPLX1 ... CPLX#	Catalog parallax for object in trace 1 to #	mas	Float	20.45		'	N
CPMR1 ... CPMR#	Catalog proper motion RA for object in trace 1 to	“/yr	Float	e.g. 0.0345		'	N
CPMD1 ... CPMD#	Catalog proper motion DEC for object in trace 1	“/yr	Float	e.g. 0.345		'	N
CZ1 ... CZ#	Catalog Z for for object in trace 1 to #	N/A	Float	e.g. 0.00000454		'	N
CCLRN1 ... CCLRN	Catalog color 1 - color 2 name for object in trace	N/A	String	e.g. "Gaia B-R"		'	N
CCLR1 ... CCLR#	Catalog color 1 - color 2 for object in trace 1 to #	mag	Float	e.g. 0.47		'	N
OBSERVAT	Observatory name	N/A	String	KPNO	Y	UNKNOWN	Y
TELESCOP	Telescope name	N/A	String	VLT UT1", "LBT SX + DX"	Y	UNKNOWN	Y
OBSLON	Observatory longitude	deg	Float	-111.600562		UNDEFINED	Y
OBSLAT	Observatory latitude	deg	Float	31.958092		UNDEFINED	Y
OBSALT	Observatory altitude	meters	Float	2091		UNDEFINED	Y
SEEING	Seeing at beginning of exposure	arcsec	Float	e.g. 1.2		'	N
AIRMASS	Airmass at center field at beginning of exposure	secZ	Float	e.g. 1.3		'	N

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Keyword	Description	Units	Data type	Example Value	FITS required	Default	Population Required for EPRV Standa Compliance
TTIME	TCS-data date/time	UTC	String	., “2018-04-26T15:53:13”		'	N
TEQNX	TCS equinox	yr	Float	J2000		'	N
TEPCH	TCS epoch	yr	Float	J2000		'	N
TLST1 ... TLST#	TCS local sidereal time for telescope 1 to #	sexagesimal	String	e.g. 14:23:43		'	N
TRA1 ... TRA#	TCS RA for telescope 1 to #	sexagesimal	String	e.g. 13:43:42.3456		'	N
TDEC1 ... TDEC#	TCS DEC for telescope 1 to #	sexagesimal	String	45:45:45		'	N
TEL1 ... TEL#	TCS elevation angle for telescope 1 to #	deg	Float	e.g. 43.5		'	N
TZA1 ... TZA#	TCS zenith angle for telescope 1 to #	deg	Float	e.g. 35.5435		'	N
TAZ1 ... TAZ#	TCS azimuth angle for telescope 1 to #	deg	Float	e.g 124.3		'	N
THA1 ... THA#	TCS hour angle for telescope 1 to #	sexagesimal	String	e.g. -2:34:43.3455		'	N
PARANG	Parallactic angle at exposure start	deg	Float	e.g. 175.2		'	N
PARANG2	Parallactic angle at exposure end	deg	Float	e.g. 180.7		'	N
ROTANG	Rotator angle	deg	Float			'	N
SUNEL	Sun Elevation Angle	deg	Float	e.g. -18.5		'	N
MOONANG	Target-Moon Angle	deg	Float	e.g. 34.56		'	N
MOONEL	Moon Elevation Angle	deg	Float	e.g. 26.8		'	N
MOONILLU	Moon illumination	%	Float	e.g. 23%		'	N
MOONRV	RV of reflected sunlight off moon	km/s	Float			'	N
INHUM	relative humidity inside dome	%	Float	e.g., 56.6000		'	N
INHUMT	INHUM timestamp	UTC	String	g. "2024-02-20T03:31:33"		'	N
OUTTMP	Outside temperature	deg C	Float	e.g., 0.0		'	N
OUTTMPT	OUTTMP timestamp	UTC	String	g. "2024-02-20T03:31:33"		'	N
OUTHUM	Outside relative humidity	%	Float	e.g., 56.6000		'	N
OUTHUMT	OUTHUM timestamp	UTC	String	g. "2024-02-20T03:31:33"		'	N
ENVWINDS	Wind speed	m/s	Float	e.g., 23.4000		'	N
ENVWINDD	Wind direction	angle	Float	e.g., 133.5000		'	N
DRPTAG	RV DRP version	N/A	String	e.g., v1.1.0		UNKNOWN	Y
EPRVTAG	Version of EPRV standard applied	N/A	String	e.g., v1.1.0		UNKNOWN	Y
VOCLASS	Version of EPRV standard applied	N/A	String	, EPRVSTANDARDv1.1.0		UNKNOWN	Y
DRPHASH	Git commit hash	N/A	String	def1234567890abcdef12"		'	N
INSTERA	Tag to track permanent changes to instrument	N/A	String	e.g. v2.3.0		UNKNOWN	Y
EXTRACT	Type of 1D extraction	N/A	String	., sum, flatrelativeoptimal		'	N
EXSNR1 ... EXSNR	Extracted signal-to-noise at EXSNRW1 to EXSN	SNR/1-D pix	FLOAT	e.g., 245.35		'	N
EXSNRW1 ... EXSN	Wavelength at which EXTSNR1 to EXTSNR# is	Angstroms	FLOAT	e.g., 5530.0		'	N
FULLCOMP	Is this file fully compliant with the RVSTAND EP	N/A	String	'Yes' or 'No'		UNKNOWN	Y
TELFLAG	Issues with observatory or telescope?	N/A	String	'Pass' , 'Fail', 'Warn'		'	N
INSTFLAG	Issues with instrument?	N/A	String	'Pass' , 'Fail', 'Warn'		'	N
DRPFLAG	Issues with pipeline?	N/A	String	'Pass' , 'Fail', 'Warn'		'	N
ADDFLAG	Additional team defined flag	N/A	String	'Pass' , 'Fail', 'Warn'		'	N
OBSFLAG	Observer pass/fail for exposure	N/A	String	'Pass' or 'Fail'		'	N
SUMMFLAG	Summary roll up of other flag keywords	N/A	String	'Pass' , 'Fail', 'Warn'		UNKNOWN	Y
DQLVL0	Quality check bitfield of N characters	N/A	UInt	0		UNDEFINED	Y

L2: Order-by-order spectrum, variance, wavelength solution, and blaze function

Designed for users who intend to produce their own RVs and/or work on pipeline improvements

Level 2 FITS Extensions

HDU	Name	DataType	MinBetDepth	Multiplicity	Required	Description	Comments
0	PRIMARY	PrimaryHDU		False	True	EPRV Standard FITS HEADER (no data)	
1	INSTRUMENT_HEADER	ImageHDU		False	True	Inherited instrument header (no data)	If this L2 file was translated from an instrument's native data product then this header contains the original data
2	RECEIPT	BinTableHDU		False	True	Table of operations that have been performed on this file	
3	DRP_CONFIG	BinTableHDU		False	True	Pipeline details (settings etc) to go from native data to L2	
4	EXT_DESCRIPT	BinTableHDU		False	True	Table describing contents of each extension	
5	ORDER_TABLE	BinTableHDU		TRUE	TRUE	Table capturing the wavelength extent of each order	Required columns: physical echelle order; index echelle order; start wavelength [64bit]; end wavelength [64bit]
6	TRACE1_FLUX	ImageHDU		True	True	Flux in trace 1	
7	TRACE1_WAVE	ImageHDU	64	True	True	wavelength solution for trace 1	
8	TRACE1_VAR	ImageHDU		True	True	variance for trace 1	
9	TRACE1_BLAZE	ImageHDU		True	True	blaze for trace 1	
10	BARYCORR_KMS	ImageHDU		False	True	barycentric correction in km/s	Format should convey how this is applied to the wavelength solution – can be a single value in which case 1 cor
11	BARYCORR_Z	ImageHDU		False	True	barycentric correction in redshift	Format should convey how this is applied to the wavelength solution – can be a single value in which case 1 cor
12	BJD_TDB	ImageHDU	64	False	True	Photon weighted midpoint	Format should convey how this is applied to the wavelength solution – can be a single value in which case 1 cor
13	DRIFT	ImageHDU		False	False	Drift measurement map in delta lambda	Format should convey how this is applied to the wavelength solution – can be a single value in which case 1 cor
14	TRACE1_QUALITY	ImageHDU	UINT8	True	False	Quality of each pixel in trace 1	Format should match TRACE1_FLUX – recommend convention that 0 is the no flag value
15	EXPMETER	BinTableHDU		False	False	Table of exposure meter counts timeseries over the exposure	Table has # of columns equal to the number of wavelengths where the exposure counts are measured and numb
16	TELEMETRY	BinTableHDU		False	False	Table of telemetry collected during the exposure	Table has 4 columns: time stamp; sensor name; value; units
17	TRACE1_TELLURIC	ImageHDU		True	False	Telluric model for trace 1	Follows same format as TRACE1_FLUX HDU; generally used for Science Object traces
18	TRACE1_SKYMODEL	ImageHDU		True	False	Sky model for trace 1	Follows same format as TRACE1_FLUX HDU
19	ANCILLARY_SPECTRUM	ImageHDU		True	False	Extension(s) that store ancillary spectra	Options include Ca II H&K if separate spectrograph used
20	IMAGE	ImageHDU		True	False	Extension(s) that store useful support images	Options include guider cam or sky monitoring or pupil image
21	CUSTOM1_TRACE1_FLUX	ImageHDU		True	False	Additionally corrected flux in trace 1	Modified flux extension that includes additional corrections such as telluric or sky corrections – should have sar
22	CUSTOM1_TRACE1_WAVE	ImageHDU		True	False	Additionally corrected wavelength solution for trace 1	Wavelength solution corresponding to USTOM1_TRACE1_FLUX – should have same format as TRACE1_WAVE
23	CUSTOM1_TRACE1_VAR	ImageHDU		True	False	Additionally corrected variance for the flux in trace 1	Variance of the CUSTOM1_TRACE1_FLUX extension – should have same format as TRACE1_VAR above

L3: Single, blaze-corrected spectrum created by stitching together individual orders

Designed for non-EPRV science accomplished with high resolution spectra. Examples include exoplanet atmospheres or stellar astrophysics.

Level 3 FITS Extensions

HDU	Name	DataType	Multiplicity	Required	Description
0	PRIMARY	PrimaryHDU	False	True	EPRV Standard FITS HEADER (no data)
1	INSTRUMENT_HEADER	ImageHDU	False	True	Inherited instrument header (no data)
2	RECEIPT	BinTableHDU	False	True	Table of operations that have been performed on this file
3	DRP_CONFIG	BinTableHDU	False	True	Pipeline details (settings etc) to go from native data to L2
4	ORDER_TABLE	BinTableHDU	TRUE	TRUE	Table capturing the wavelength extent of each order
5	STITCHED_CORR_TRACE1_FLUX	ImageHDU	True	True	Order stitched blaze-corrected flux in trace 1
6	STITCHED_CORR_TRACE1_WAVE	ImageHDU	True	True	Order stitched BC- and drift-corrected wavelength solution for trace 1
7	STITCHED_CORR_TRACE1_VAR	ImageHDU	True	True	Order stitched variance for the flux in STITCHED_CORR_TRACE1_FLUX
8	COMBINED_STITCHED_CORR_FLUX	ImageHDU	True	True	Order stitched and blaze-corrected flux co-added across all traces
9	COMBINED_STITCHED_CORR_WAVE	ImageHDU	True	True	Order stitched BC- and drift-corrected wavelength solution
10	COMBINED_STITCHED_CORR_VAR	ImageHDU	True	True	Order stitched variance for the combined flux in COMBINED_STITCHED_COR
11	STITCHED_CUSTOMCORR1_TRACE1_FLUX	ImageHDU	True	False	Additional corrections made to STITCHED_CORR_TRACE1_FLUX
12	STITCHED_CUSTOMCORR1_TRACE1_WAVE	ImageHDU	True	False	Wavelength solution corresponding to STITCHED_CUSTOMCORR1_TRACE1_
13	STITCHED_CUSTOMCORR1_TRACE1_VAR	ImageHDU	True	False	Variance corresponding to STITCHED_CUSTOMCORR1_TRACE1_FLUX
14	COMBINED_STITCHED_CUSTOMCORR1_FLUX	ImageHDU	True	False	Additional corrections made to COMBINED_STITCHED_CORR_FLUX
15	COMBINED_STITCHED_CUSTOMCORR1_WAVE	ImageHDU	True	False	Wavelength solution corresponding to COMBINED_STITCHED_CORR_WAVE
16	COMBINED_STITCHED_CUSTOMCORR1_VAR	ImageHDU	True	False	Variance corresponding to COMBINED_STITCHED_CORR_VAR

L4: derived data products such as RV measurements, CCFs and associated metrics and stellar activity indicators.

Designed for users who want to focus on fitting exoplanet and/or stellar activity models

Level 4 FITS Extensions

HDU	Name	DataType	Multiplicity	Required	Description
0	PRIMARY	PrimaryHDU	FALSE	TRUE	EPRV Standard FITS HEADER (no data)
1	INSTRUMENT_HEADER	ImageHDU	FALSE	TRUE	Inherited instrument header (no data)
2	RECEIPT	BinTableHDU	FALSE	TRUE	Table of operations that have been performed on this file
3	DRP_CONFIG	BinTableHDU	FALSE	TRUE	Pipeline details (settings etc) to go from native data to L2
4	RV1…N	BinTableHDU	TRUE	TRUE	Derived Radial Velocity Measurement
5	CCF1…N	ImageHDU	TRUE	FALSE	Array with same dimensionality of RV1…N, that contains the CCF that produced each RV1…N
6	DIAGNOSTICS1…J	BinTableHDU	TRUE	FALSE	Activity indicators, CCF metrics, etc
7	CUSTOM_CCF1…N	ImageHDU	TRUE	FALSE	Additional CCFs from (e.g.) different masks
8	CUSTOM_RV1…N	BinTableHDU	TRUE	FALSE	Derived Radial Velocity Measurement from CUSTOM_CCF1…N

- No request for instrument teams / observatories to change native instrument pipeline – but can provide useful starting point for new pipelines
- Development of “translators” – python scripts that take in native data from an instrument and reformat it to match EPRV Data Standard
- Each team shown above is making their own translator which will be posted to the project’s Github repo

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EPRV Implementation Status

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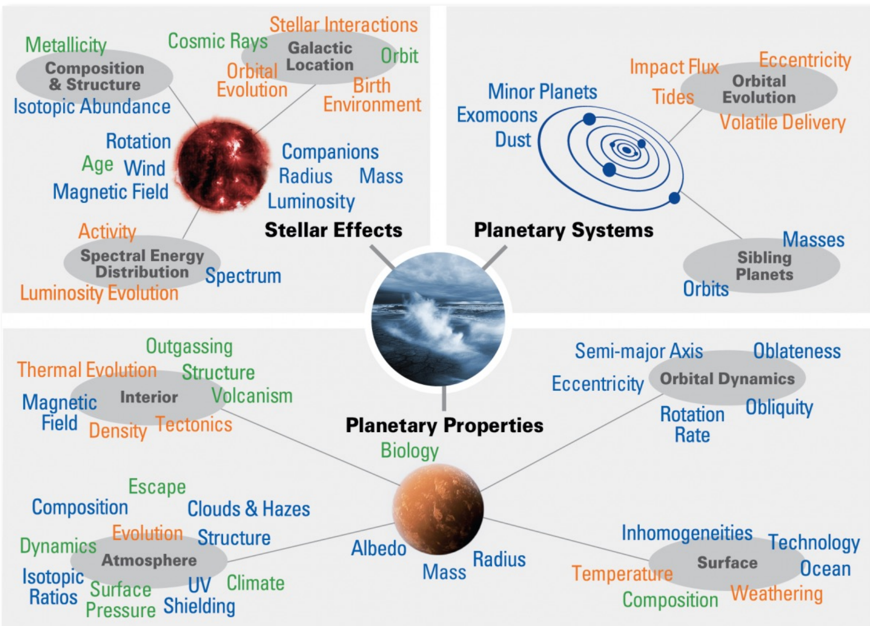
EPRV Implementation Status

- Some archives (e.g., NExScI) are planning to add in-line translation capabilities that users can choose when downloading data [estimate is ~2 seconds / file]
- Development of tutorials on how to work with each data standard product are underway
- Instituting Change Control Board once v.1.0.0 of the standard is rolled out, to oversee future modifications

Next Step: The VO!



Visualization of the many factors that influence the formation, evolution, and modern-day characteristics of a planet (credit: Meadows & Barnes).

Characterization of exoplanets requires investigation of the exoplanet itself, its companions and the host star

→ Data discovery → **VO!**

Use Cases for the VO

- Enable efficient and effective identification of existing data, ensuring that planet characterization efforts leverage as much information about the system as possible. Discover and access:
  - EPRV data sets for a specified star or set of targets through a common interface.
  - Additional data related to the host star, e.g. additional spectra or photometric time series, that can be used to quantify the star’s mass, radius, rotation period, chemical composition, and other physical characteristics that impact our interpretation of both stellar variability and planetary signals.
  - EPRV data of the sun generated by the growing population of small, solar telescopes that feed EPRV spectrographs during the daytime hours.

Bedtime Reading

- Read the docs: https://eprv-data-standard.readthedocs.io/en/develop
- Github: https://github.com/EPRV-RCN/RVData
- IVOA note in prep: “Extreme Precision Radio Velocity (EPRV) Astronomy and the IVOA.”
- Jenn’s SPIE talk (2024). https://doi.org/10.1117/12.3018595