

ESO Garching, February 1-3, 2017



APEX Proposal Preparation tools and phase 2 Tutorial

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Getting Ready for ALMA Band 5 - Synergy with APEX/SEPIA

Introduction

- APEX in the last few years
- 5-year extension (2018-2022)
- APEX in 2017



Introduction

- APEX in the last few years
 - Facility instrumentation
 - LABOCA, SABOCA
 - SHeFI (APEX₁, APEX₂, APEX₃)
 - PI Instrumentation
 - FLASH+, CHAMP+ (MPIfR)
 - ArTéMiS (ESO)
 - Other visiting instruments



LABOCA
SHeFI
FLASH+
others...

2015

2016

2017

2018

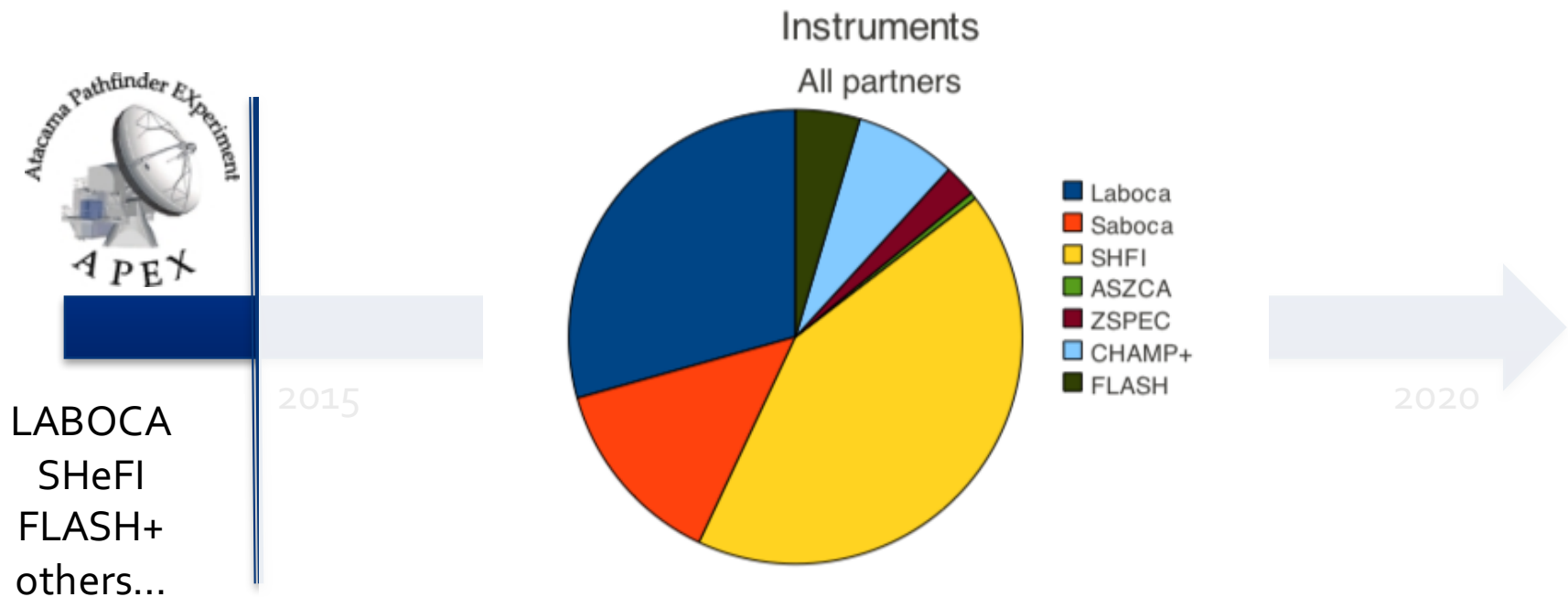
2019

2020

Introduction

■ APEX in the last few years

Proposal instrument requests statistics (2012-2014)



Introduction

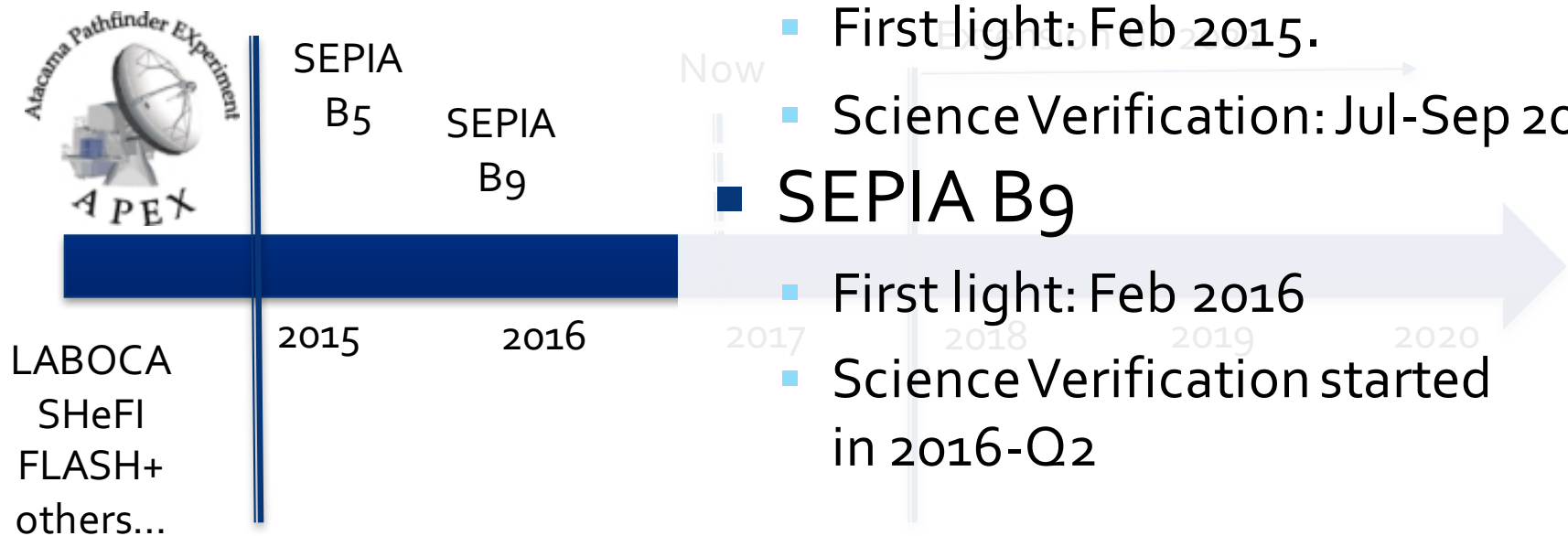
- New heterodyne receivers: SEPIA

- SEPIA B₅

- First light: Feb 2015.
- Science Verification: Jul-Sep 2015

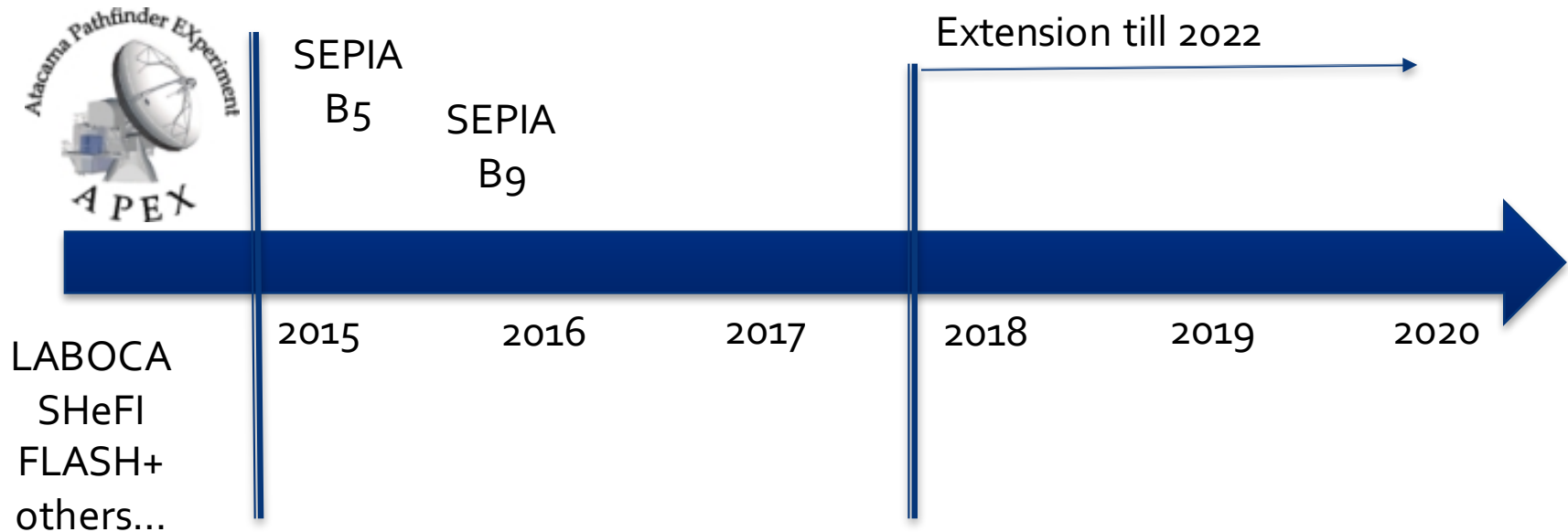
- SEPIA B₉

- First light: Feb 2016
- Science Verification started in 2016-Q2



Introduction

- 5-year extension (2018-2022)
- APEX in 2017

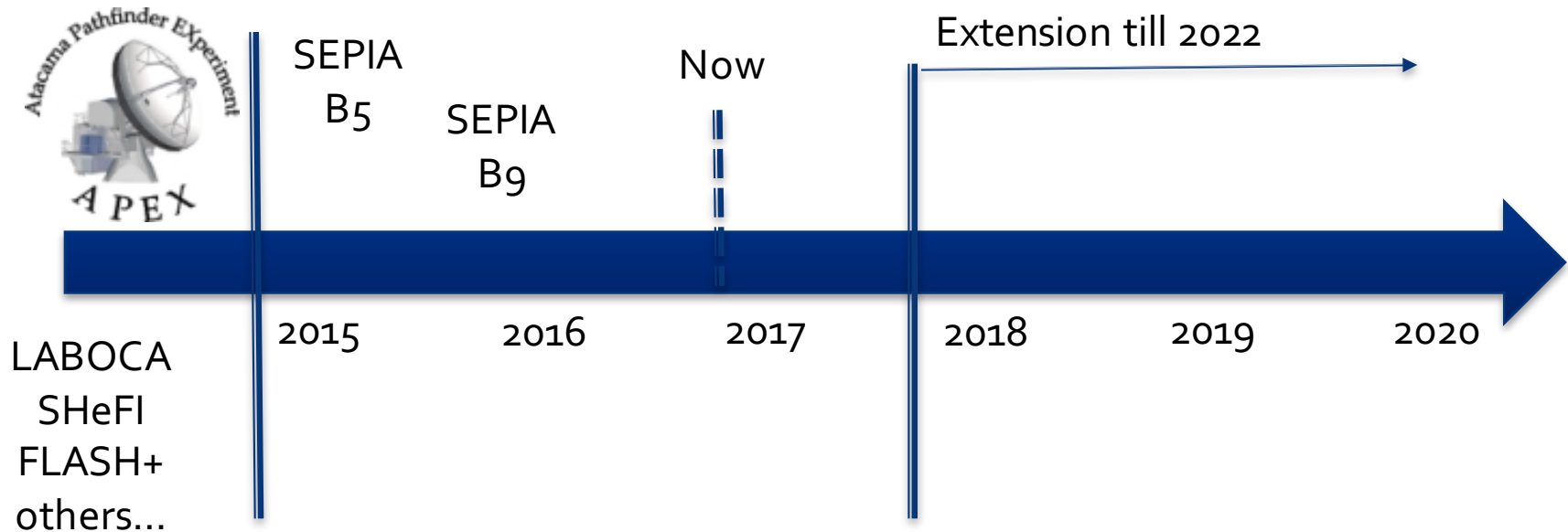


APEX 5-year extension

- New suite of facility instrumentation
- Improved heterodyne instruments (larger IF bandwidth, dual polarization, 2SB, some in common with ALMA: synergies)
- Improved (multicolour, kpixel) bolometer cameras
- Improvements in the antenna (power generation and cooling capacity)
- Sciops-R (remote operations)

APEX in 2017

- APEX in 2017



APEX in 2017

- Observing periods P99, P100
- Short year for science operations (Mar-Sep)
- Extended 2018 shutdown period (Oct-Mar 18)
- APEX community needs to **get used to work with new receivers**



Proposal preparation tutorial

- Have an interesting scientific project
- Select the proper tuning for your lines
- Get time estimates to achieve your goal
- Submit your proposal and get the time
- Prepare phase-2 submission
- Wrong practices to avoid
- Final considerations

Overview

- Atmospheric model
- On/Off time calculator
- OTF Simulator (mapping)
- OTF time calculator
- APEX phase 2 submission
- Your observations

Two demo cases

- SEPIA-B₅ OTF
 - CS(4-3) 195.95 GHz
 - OTF simulator

- SEPIA-B₉ On/Off
 - C₁₈O(6-5) 658.55 GHz
 - ¹³C₁₈O(6-5) 661.07 GHz
 - C₁₇O(6-5) 674.01 GHz

Chajnantor B5/B9 transmission



Atacama Pathfinder Experiment APEX Atmosphere at Chajnantor

[Home](#) > [APEX Sites](#) > [Chajnantor](#) > [Atmosphere at Chajnantor](#) > [Transmission calculator](#)

Atmospheric transmission

Plot the transmission at the signal and image bands

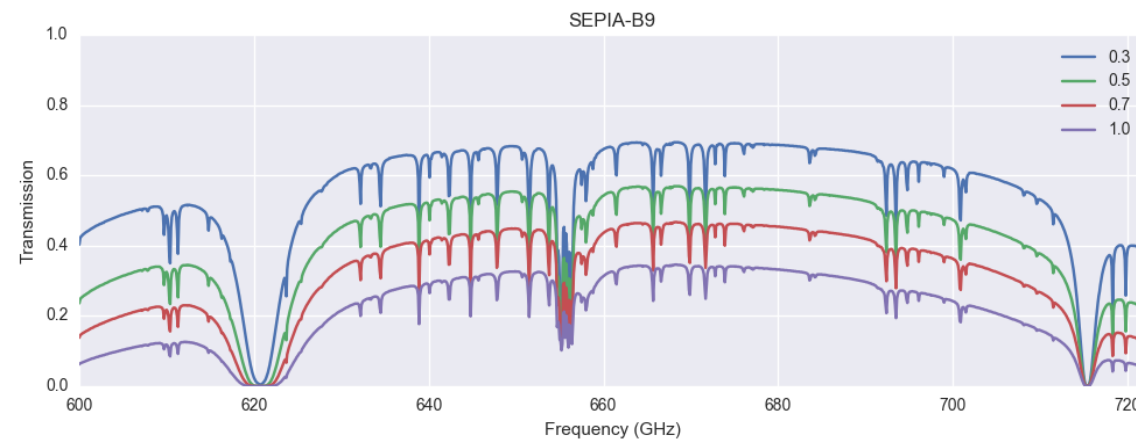
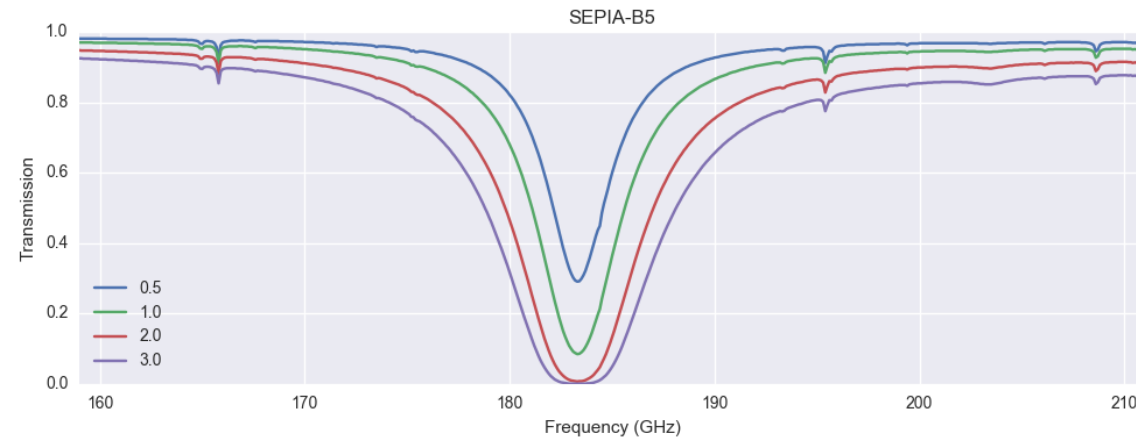
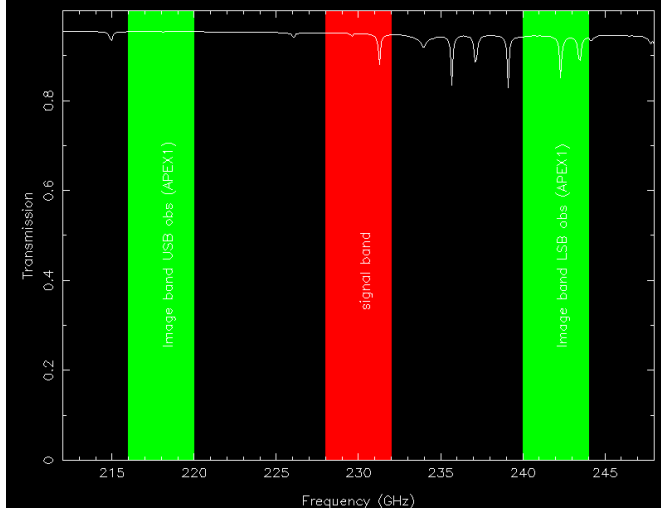
The calculator plots the zenith atmospheric transmission on Llano de Chajnantor, for a specified frequency, assuming the respective frequency separation between signal and image band, which is specific for each receiver. Care has to be taken when selecting LSB or USB, since atmospheric lines will have a negative impact on the signal, but they are not affected to the same extent. Common for both types of receivers it is important to avoid atmospheric absorption.

This [plot](#) shows the PWV as function of month as measured by the ALMA radiometer.

Center frequency GHz

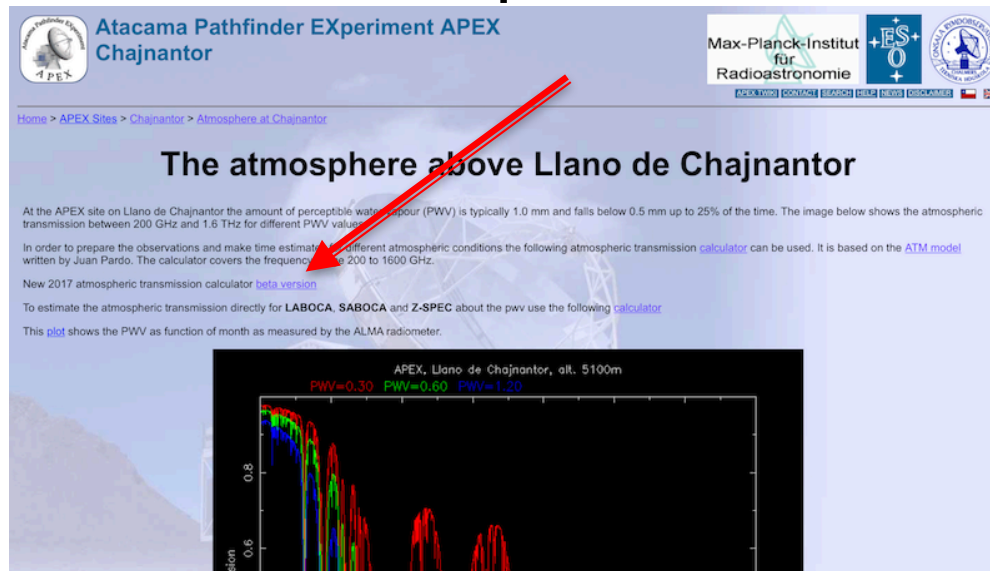
PWV value mm

APEX, Llano de Chajnantor, alt. 5109m, pww 1.00mm



“New” atmospheric calculator

- Uses the same tabulated data (ATM)
- Include our new instruments
 - Different parameters (SB separation, BW)
- Visualize science frequencies

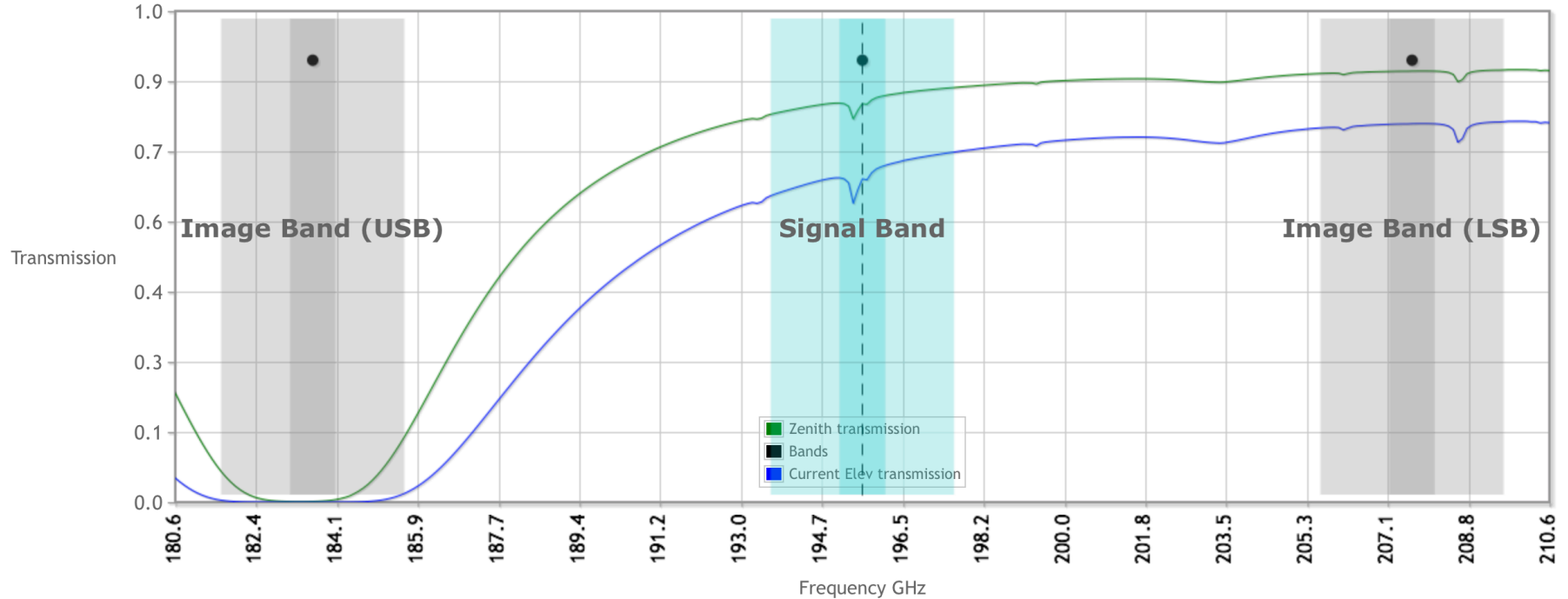


<http://www.apex-telescope.org/sites/chajnantor/atmosphere/>

SEPIA-B5

APEX Chajnantor atmospheric transmission

SEPIA-B5 195.6 USB Atmospheric transmission pwv = 3 mm



Heterodyne receiver:

SEPIA-B5 (2SB)

PWV [mm H2O]

3

Elevation [degree]

30

Tuning Frequency [GHz]

195.55

Refresh the plot

Select a Side Band to be used:

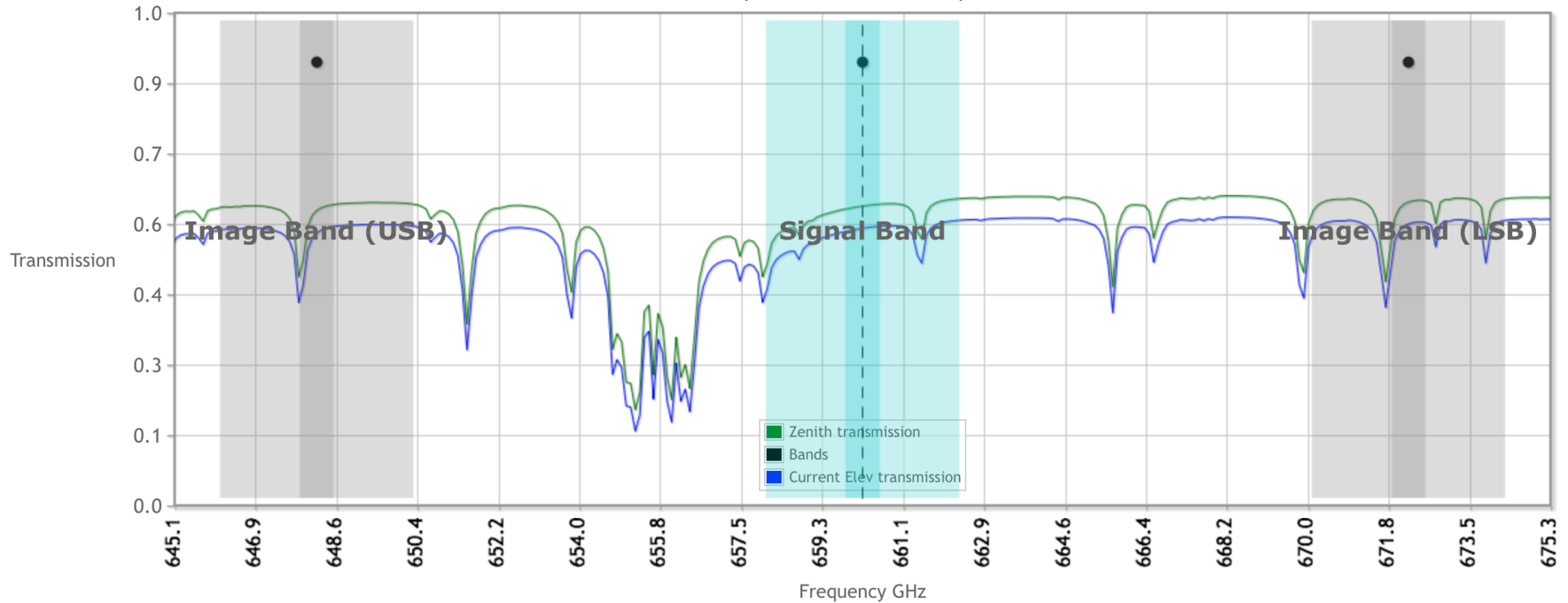
LSB

Open LSB plot

SEPIA-B9 #1

APEX Chajnantor atmospheric transmission

SEPIA-B9 660.2 USB Atmospheric transmission pwv = 0.5 mm



Heterodyne receiver:

SEPIA-B9 (DSB)

PWV [mm H₂O]

0.5

Elevation [degree]

60

Tuning Frequency [GHz]

660.2

Refresh the plot

Select a Side Band to be used:

LSB

Open LSB plot

SEPIA-B9 #2

Heterodyne Receiver SEPIA-B9

PWV [mm H₂O] 0.5

Elevation [deg] 60

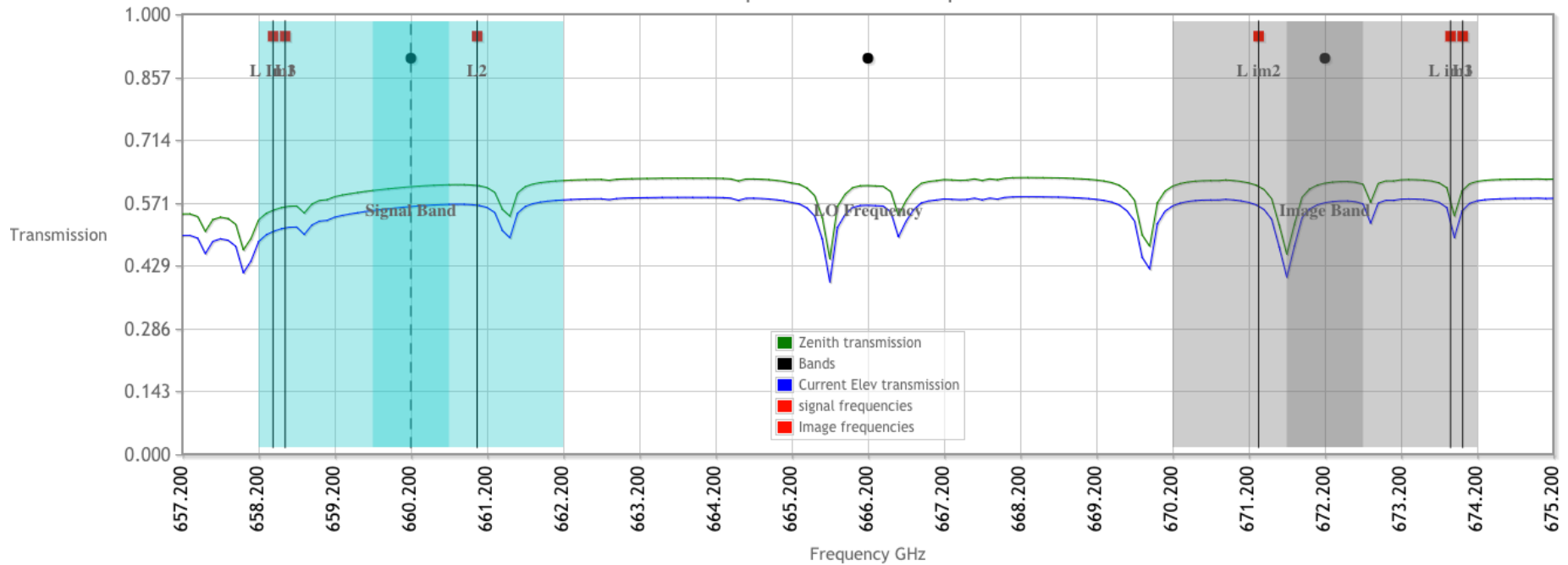
Sky Frequency [GHz] + 100 MHz - 100 MHz Refresh

Line 1 [GHz] 658.55

Line 2 [GHz] 661.07

Line 3 [GHz] 674.01

SEPIA-B9 660.2 LSB Atmospheric transmission pww = 0.5 mm





■ V6 available for the next CfP

ON/OFF Integration time estimator V6.0

Use this calculator for on-off observations. If you are planning on-the-fly mapping, you should instead use the dedicated [OTF Calculator](#)

The (average) elevation of the source, the receiver temperature, required σ (in K), and the spectral resolution, the on-source integration time can be estimated. Also the total time is calculated assuming $t_{\text{off}}=t_{\text{on}}$ and a system observing efficiency of 0.4, i.e. $t_{\text{total}}=(t_{\text{on}} + t_{\text{off}})/0.4$. The system efficiency takes into account both system and setup+calibration overheads. System overheads include telescope movements, software overheads, observing mode efficiency, etc. Setup + calibration overheads include source acquisition, pointing, focus, receiver tuning and calibration scans.

Heterodyne receiver:	SEPIA-B9
Tuning Freq:	660.2 [GHz]
Line Freq:	660.2 [GHz]
Side Band:	LSB
<input type="radio"/> Full resolution Δv [channels] :	0.0173 [km/s]
<input checked="" type="radio"/> Manual resolution Δv :	0.08 [km/s]
pwv :	0.5 [mm H ₂ O]
Source elevation:	50 [deg]
rms :	0.1 [K]

Process

Results

Tau (source elev 50 deg)	0.787
Trec [K]	160.7
Tsys [K] (source elev 50 deg)	1189.4
TsysImage [K] (source elev 50 deg)	870.5
Beam [arcsec]	9.5
Position Switching On time	1.080 [hr]
Total Position Switching time	4.429 [hr]
Beam Switching On time	1.080 [hr]
Total Beam Switching time	4.862 [hr]

RMS estimator

OTC

- Parameters that you need to know

- Tuning frequency and sideband
- Spectral resolution (km/s)
- RMS to achieve your goal (mK) at selected resolution
- Elevation
- PWV



Estimated time
(with/without overhead)

OTC

- Radiometer equation $\sigma_T \approx \frac{T_{sys}}{\sqrt{\Delta\nu \cdot \tau}}$
- Parameters from receiver
 - Receiver temperature
 - Image gain
 - Forward efficiency
 - Number of polarizations
- Parameters from sky
 - Opacity (El, pwv)
 - ATM model



OTC

- Overhead: calibrated with real datasets
 - Pointing, focus
 - Calibrations
 - Duty cycle (on/off or wobbler)
 - Tuning
 - Control system overhead





OTF

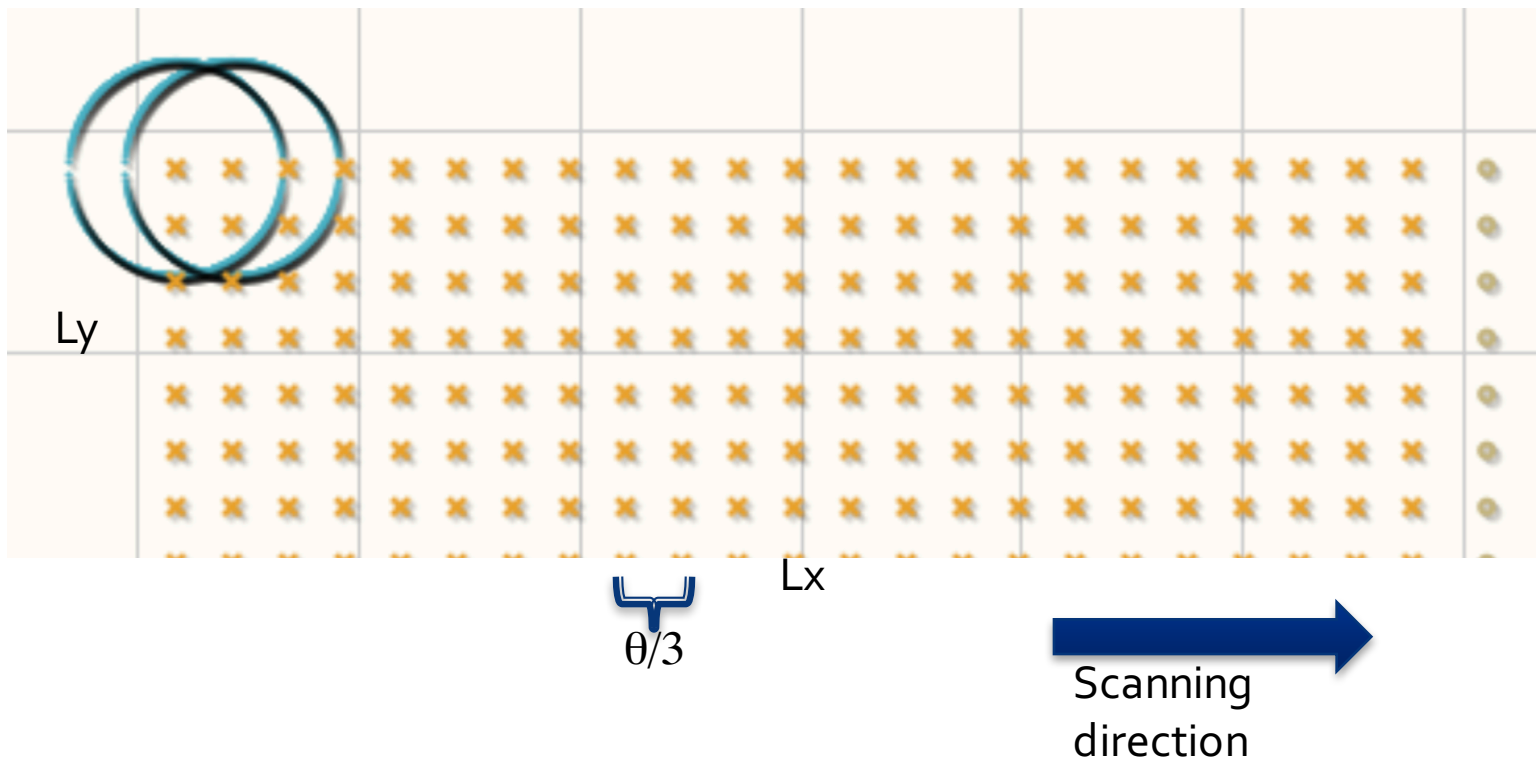
- Tools
 - Observing Time Estimator
 - Estimate the total time to reach a rms
 - OTF simulator
 - Setup a map to cover an area

OTF

- OTF time estimator

- Method

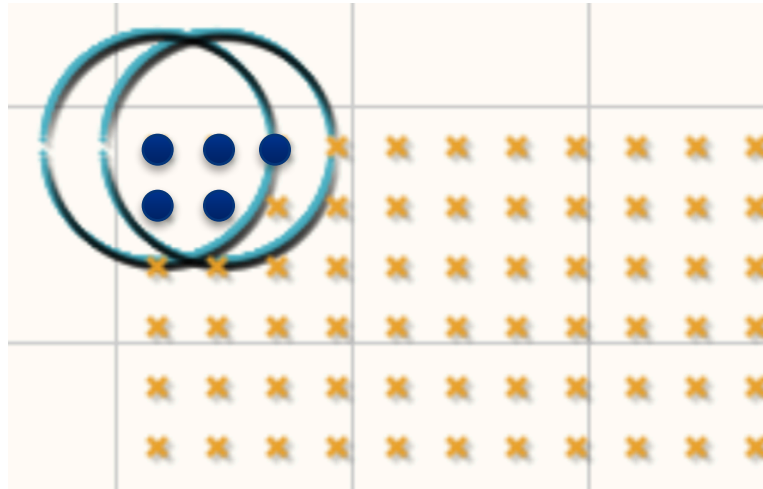
Estimate the rms



OTF

- OTF time estimator
 - The radiometer equation

$$\sigma = \frac{T_{sys}}{\sqrt{N_{pol} \cdot \Delta f}} \sqrt{\frac{1}{t_{on}} + \frac{1}{t_{off}}}$$



OTF

- OTF estimator

- On time

- Area Map

$$A_{map} = L_x \cdot L_y$$

- Area Beam

- Number Beams in the map

$$N_{beams} = \frac{A_{map}}{A_{beam}}$$

OTF

- OTF estimator

- Number of dump in map

$$N_{dump}^{map} = \left(\frac{L_x}{\Delta x}\right) \cdot \left(\frac{L_y}{\Delta y} + 1\right)$$

- Number of dump per beam

$$N_{dump}^{beam} = \frac{N_{dump}^{map}}{N_{beams}}$$

- On time per beam

$$t_{on}^{beam} = N_{dump}^{beam} \cdot t_{dump}$$

OTF

- OTF estimator

- Off time

- Time off

$$t_{off} = \alpha t_{on} \quad \alpha = \frac{\text{beam}}{\frac{\text{beam}}{3}} \sqrt{\frac{\frac{\text{beam}}{3} n_{dump}}{\text{beam}}} \sqrt{n_{on2off}} = \sqrt{3 n_{dump} n_{on2off}}$$

- RMS reached after only one cover

$$\sigma^1 = \frac{T_{sys}}{\sqrt{N_{pol} \cdot \Delta f \cdot t_{on}^{beam}}} \sqrt{1 + \frac{1}{\sqrt{3 \cdot N_{dump}^{subMap}}}}$$

- Number of covers to reach final RMS

OTF

- OTF estimator
 - Number of coverages

$$N_{cover} = \left(\frac{\sigma^1}{\sigma} \right)^2$$

- Final RMS

$$\sigma = \frac{T_{sys}}{\sqrt{N_{pol} \cdot \Delta f \cdot N_{cover} \cdot t_{on}^{beam}}} \sqrt{1 + \frac{1}{\sqrt{3 \cdot N_{dump}^{subMap}}}}$$

OTF

- OTF estimator
 - Example
 - `177.82 +41.0 1.46 1`
 - `otf(xlen=120,xstep=12,ylen=100,ystep=12,time=1.0,direction=x, angle=0.0)`

OTF

■ OTF time estimator (V8.o)

OTF time estimator V8.0 [How to use](#)

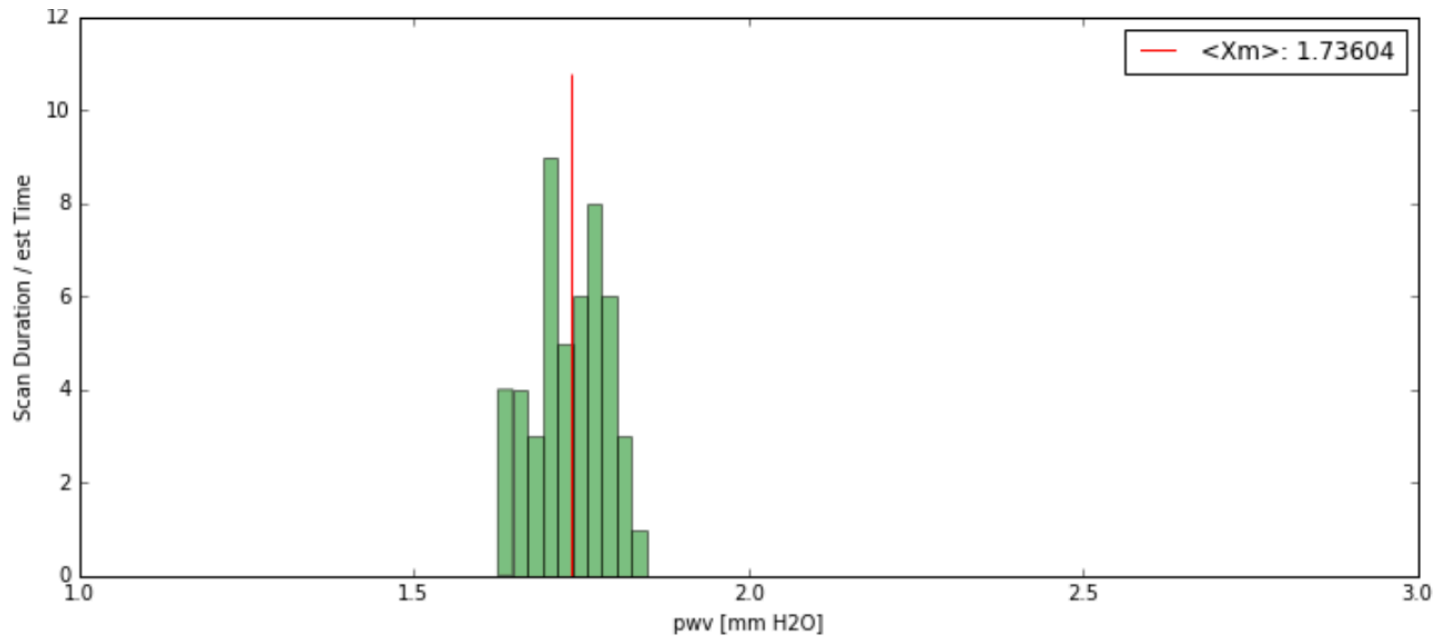
Heterodyne receiver:	SEPIA-B5		Time per sub map [sec]	112.8
Side Band:	USB		Number of calibration per coverage	1
Frequency:	177.82	[GHz]	Total map area covered [arcsec ²]	12000
Line Freq:	177.82	[GHz]	Number of submaps	1
Resolution Δv :	1	[km/s]	Tau (source elev 41 deg)	0.395
pwv :	1.5	[mm H ₂ O]	Trec [K]	60
Source elevation:	41	[deg]	Tsys [K] (source elev 41 deg)	244.956
Length axis in scanning direction:	120	[arcsec]	HPBW () [arcsec]	35.1
Length in the orthogonal axis:	100	[arcsec]	Beam solid angle [arcsec ²]	1548.8
Dumptime (0.1 <= dt <= 4 [s]):	1	[sec]	Num of row per Off position (reference pos.)	11
rms or sigma requested:	0.167	[K]	Scanning speed [arsec/ s]	11.7
			Number of coverages	1
			sigma reached after 1 coverage [K]	0.121
			sigma reached after 1 coverage(s) [K]	0.121
			On source time [min,hr]	1.88 0.03
			Off source time [min,hr]	0.31 0.01
			Calibration time [min,hr]	0.5 0.01
			Telescope time [min,hr]	5.25 0.1

Process Data

ON/OFF OTC Calculator

OTF

- OTF estimator
 - Estimated time versus scan duration SEPIA-B₅



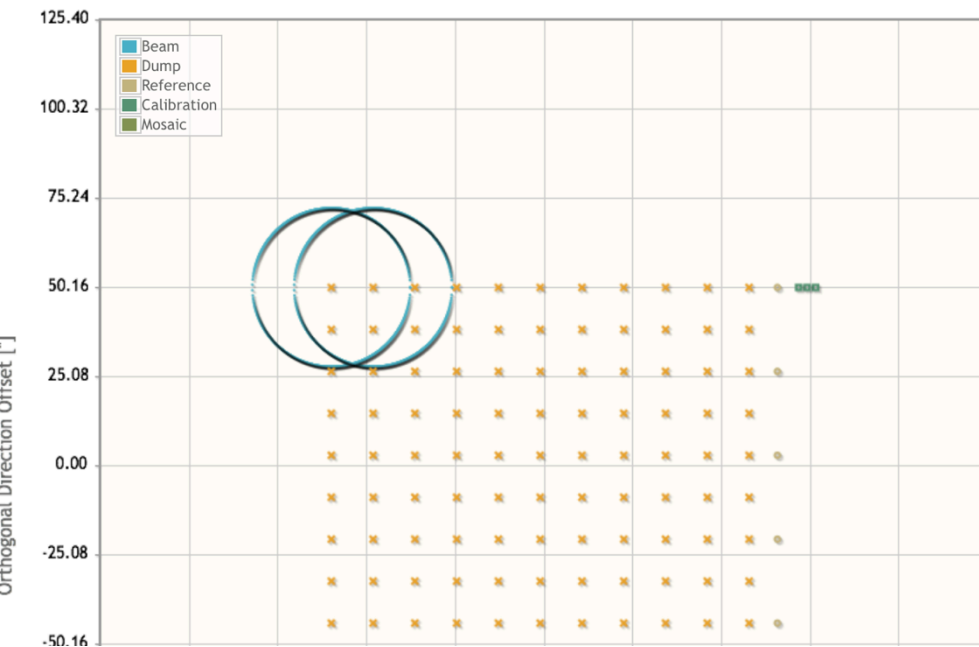
OTF

- OTF map simulator
 - Important parameters
 - Duration
 - On2Off
 - On2Cal

OTF

■ OTF map simulator

On The Fly Map Simulator



Basic OTF Parameters		Map dimension	
Frequency	177	x _{len}	120
Reference (on2off)	2	x _{step}	11.8
Calibration (on2cal)	0	y _{len}	100
		y _{step}	11.8
		angle	0
		t _{dump}	1

Plot >>

Times without overhead

Beam = 35.3
t_{on} = 1.4 [min]
t_{off} = 0.6 [min]
t_{cal} = 0.5 [min]

Total Time = 2.5 [min]

The OTF command produced with the input parameters
otf(xlen=120, xstep=11.8, ylen=100, ystep=11.8, time=1, direction = "x", on2cal=0, angle = 0)

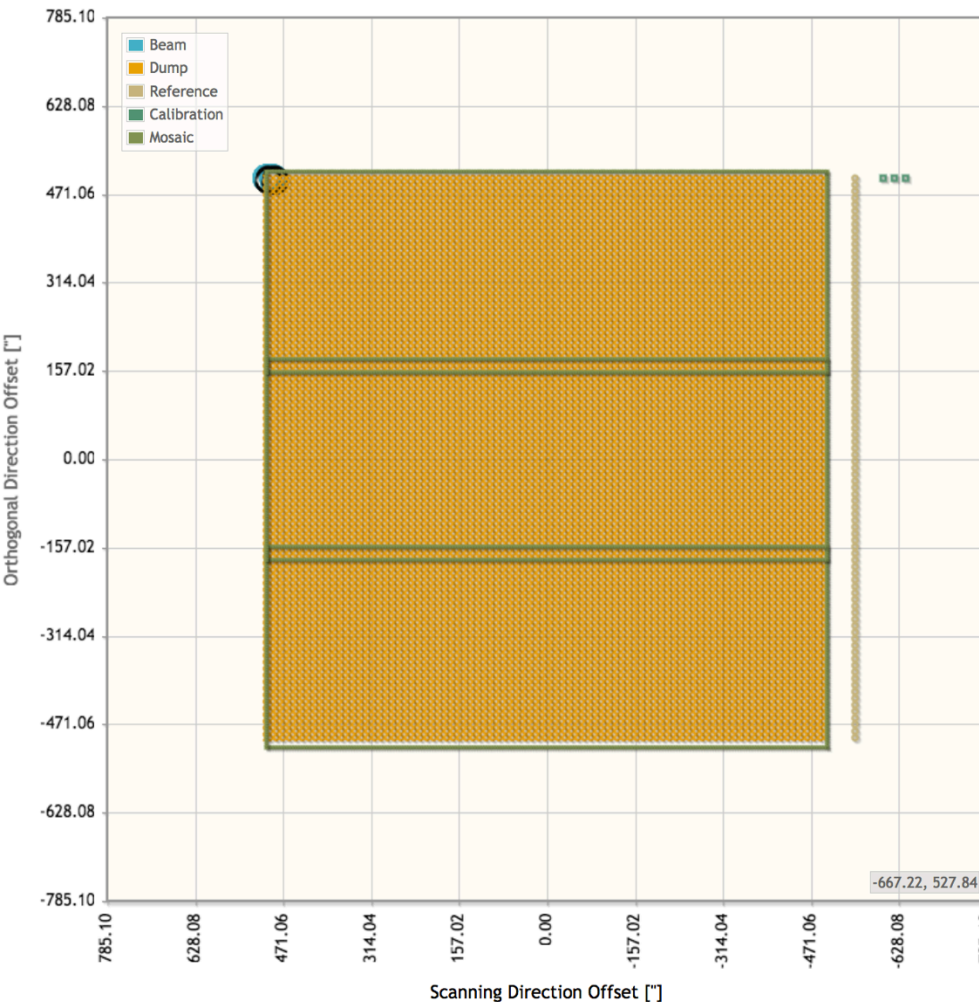
OTF

- OTF map simulator
 - Example

<i>Basic OTF Parameters</i>		<i>Map dimension</i>	
<i>Frequency</i>	<input type="text" value="177"/>	<i>X_{len}</i>	<input type="text" value="1000"/>
<i>Reference(on2off)</i>	<input type="text" value="2"/>	<i>X_{step}</i>	<input type="text" value="11.8"/>
<i>Calibration (on2cal)</i>	<input type="text" value="0"/>	<i>Y_{len}</i>	<input type="text" value="1000"/>
		<i>Y_{step}</i>	<input type="text" value="11.8"/>
		<i>angle</i>	<input type="text" value="0"/>
		<i>t_{dump}</i>	<input type="text" value="1"/>

OTF

On The Fly Map Simulator



Basic OTF Parameters		Map dimension	
Frequency	177.8	xlen	1000
Reference(on2off)	1	xstep	11.7
Calibration (on2cal)	0	ylen	1000
		ystep	11.7
		angle	0
		t _{dump}	1

Plot >>

Times without overhead

Beam = 35.1
 t_{on} = 121.8 [min]
 t_{off} = 22.8 [min]
 t_{cal} = 0.5 [min]

Total Time = 145.1 [min]

The OTF command produced with the input parameters

otf(xlen=1000, xstep=11.7, ylen=1000, ystep=11.7, time=1, direction = "x", on2cal =0, angle = 0)

The map need to be done in mosaic mode ...

Number of mosaic = 3

Mosaic number 1

New map dimension = (1000,356.7)

Offset = (0,-333.33)

otf(xlen=1000, xstep=11.7, ylen=356.7, ystep=11.7, time=1, direction = "x", on2cal =0, angle = 0)

#-----

Mosaic number 2

New map dimension = (1000,356.7)

Offset = (0,0)

otf(xlen=1000, xstep=11.7, ylen=356.7, ystep=11.7, time=1, direction = "x", on2cal =0, angle = 0)

#-----

Mosaic number 3

New map dimension = (1000,356.7)

Offset = (0,333.33)

otf(xlen=1000, xstep=11.7, ylen=356.7, ystep=11.7, time=1, direction = "x", on2cal =0, angle = 0)

#-----



Overview

- Introduction
- Sections on APEX phase 2 submission
- Tutorial

Front of the observing form



Atacama Pathfinder EXperiment APEX Preparing an observing run

Max-Planck-Institut
für
Radioastronomie



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[Home](#) > [Observing with APEX](#) > [Preparing an observing run](#) > [Phase 2 project submission](#)

If you have registered your project already, please go directly to the Project login section below.

Project registration

Before you can use the APEX phase 2 project submission system, you have to register your project. Please fill in the fields below. If your email has changed since your proposal submission, please contact your APEX partner's project scientist before continuing.

Please note that only accepted projects can register and submit their information (should be needless to say...).

APEX Partner [?]: Project ID (Proposal No) [?] [?]:

PI Full Name: PI Email:

Choose a password:

Retype password:

Project login

APEX Project ID [?]: Password [?]: (Please read these [phase 2 hints](#) before you log in!)

[Send comments to APEX Web Team \(apex@apex-telescope.org\)](#)

Last update: August 6th, 2015



Sections on APEX phase 2

- Section 1

General project information

APEX Partner [?]: Project ID (Proposal No) [?]:

APEX Project ID:

Project Title:

Contact information

Please give here any information which can help us to contact you in case of problems with your project.

Principal investigator: Full name: Email:

Additional information (e.g. phone number, alternative email, 2nd PI, ...):

Sections on APEX phase 2

■ Section 2

Target – catalogues – Receiver

Target sources

For your target sources, you need to specify the source name, the coordinates, and the velocity.

For equatorial coordinates (which is usually the case), note that you **MUST** give your coordinates in J2000.0! The APEX staff will not calculate your coordinates from B1950.0 or whatever! Use the [NED Coordinate Transformator](#) if you don't have your coordinates in J2000.0.

For high-redshift sources, you should give a velocity of "0.0" and enter the redshifted frequency in the "Line information" section further below.

There are two ways of submitting source information. You can either prepare a source catalog offline, following the [syntax rules for APEX source catalogs](#), and upload it through this web form, or enter the source parameters online. For more than 10 target sources, you must prepare the source catalog offline.

- I will enter the source parameters online (only possible for up to 10 targets).
- I will prepare a catalog offline and upload it.

Please select the number of targets. The form will dynamically change to accommodate more than one target, if necessary.

Number of targets:

Fill out the following fields for all your targets. The "Comment" field is optional.

Format for coordinates: hh:mm:ss.s for RA and dd:mm:ss.s for Dec (i.e. colon as separator), e.g. 2:29:15.312, -26:05:55.71

Source name	RA(2000)	Dec(2000)	v(LSR)[km/s]	Comment (e.g. priority, required S/N, ...)
#1 <input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Receiver usage

Please check all receivers which will be used for your project. Please note that you can **not** submit heterodyne and bolometer setups together. If you have been granted time for both types of observation within one project, you have to submit them separately using different Run-IDs:

- | | | |
|---|--|--|
| <input type="checkbox"/> APEX-1 (230GHz) | <input type="checkbox"/> FLASH+ (345/460) | <input type="checkbox"/> LABOCA (870 μ m) |
| <input type="checkbox"/> APEX-2 (345GHz) | <input type="checkbox"/> CHAMP+ (690/810) | <input type="checkbox"/> SABOCA (350 μ m) |
| <input type="checkbox"/> APEX-3 (460GHz) | <input type="checkbox"/> SEPIA Band 5 (180GHz) | <input type="checkbox"/> ARTEMIS (450 μ m) |
| <input type="checkbox"/> APEX-T2 (1.3THz) | <input type="checkbox"/> SEPIA Band 9 (660GHz) | |

Sections on APEX phase 2

■ Section 3

Additional information

Please enter in the following field any additional information you might have for the APEX staff concerning preparation or observation of your project.

Support material

You can upload support material to make it available to the APEX staff. This can be images, which may clarify some map sizes/orientations/offsets, or other support documents. The upload is restricted to images (jpg/gif/png) or portable documents (pdf). Word or Excel documents will be rejected by the system, as well as files larger than 1Mb. Please do NOT upload your proposal (We have it already!) or published articles which are easily available anyway.

- No, thanks, my instructions are clear enough.
- Yes, I want to upload something.

Before getting started

- ✓ Less than 10 sources – More than 10 sources
- ✓ Less than 8 spectral setup – More than 8 spectral setups
 - ✓ Source Names and Tuning names characters have limits in MBFITS (30) and CLASS (12) e.g **NO** HCN(2-1)_apexBand5
 - ✓ Careful to introduce bad characters (minus/hyphens)
- ✓ Sources at high redshift
- ✓ Please add supplementary material (maps, reference positions, check atmospheric transmission)
- ✓ Always you can save your info. This does not mean that you are submitting.

Example 1

- Example Project ID: **E-097.F-0000A-2016**
password: **apex4guests**

- Band 5 / OTF

- **Syntax for target**

```
ORION-KLEQ 2000 05:35:14.46 -05:22:30.6 LSR +8.0  
IRC+10216 EQ 2000 09:47:57.41 +13:16:43.6 LSR -25.0  
ETA_CAR EQ 2000 10:45:03.59 -59:41:04.3 LSR -25.0
```

- **Syntax for line catalog**

Tuning at 195.95GHz (LSB) .

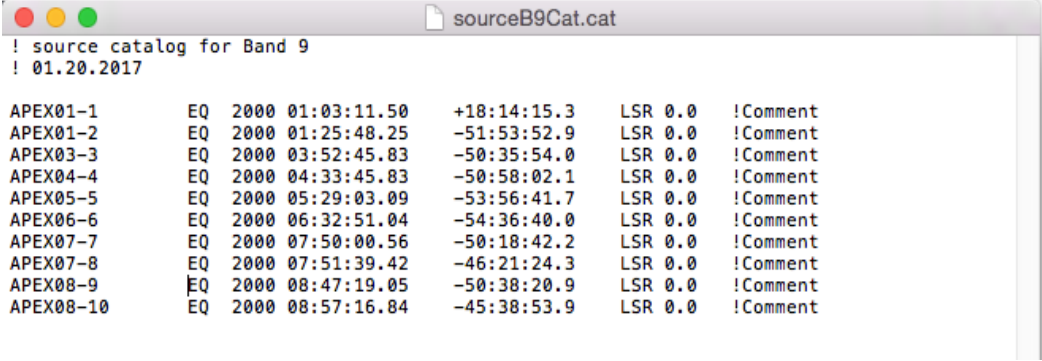
```
CS(4-3) 195.959421 GHz LSB !comment
```

<http://www.apex-telescope.org/observing/phase2/login.php>

Example 2

- Example Project ID: **E-097.F-0000A-2016**
password: **apex4guests**

- Band 9 / ON-OFF
 - Syntax for target / More than 10 sources.
 - Upload a catalog.



```
! source catalog for Band 9
! 01.20.2017

APEX01-1      EQ  2000 01:03:11.50  +18:14:15.3  LSR 0.0  !Comment
APEX01-2      EQ  2000 01:25:48.25  -51:53:52.9  LSR 0.0  !Comment
APEX03-3      EQ  2000 03:52:45.83  -50:35:54.0  LSR 0.0  !Comment
APEX04-4      EQ  2000 04:33:45.83  -50:58:02.1  LSR 0.0  !Comment
APEX05-5      EQ  2000 05:29:03.09  -53:56:41.7  LSR 0.0  !Comment
APEX06-6      EQ  2000 06:32:51.04  -54:36:40.0  LSR 0.0  !Comment
APEX07-7      EQ  2000 07:50:00.56  -50:18:42.2  LSR 0.0  !Comment
APEX07-8      EQ  2000 07:51:39.42  -46:21:24.3  LSR 0.0  !Comment
APEX08-9      EQ  2000 08:47:19.05  -50:38:20.9  LSR 0.0  !Comment
APEX08-10     EQ  2000 08:57:16.84  -45:38:53.9  LSR 0.0  !Comment
```

- Syntax for line catalog
Tuning at 660.2GHz (LSB) .

```
C18O(6-5)    658.553600 GHz LSB !comment
13CO(6-5)    661.0681   GHz LSB !comment
C17O(6-5)    674.0093   GHz LSB !comment
CO_isotop    660.2000   GHz LSB !comment
```

<http://www.apex-telescope.org/observing/phase2/login.php>

Your observations

- Pointing
 - SEPIA-B5: Planets, HCN, SiO masers
 - SEPIA-B9: Planets, CO, H₂O maser (challenging)
- Focus
- Calibration spectra (as for facility rx)
 - IRC+10216, OMC1, SgrB2 ...
- Calibration
 - Online calibration done per 2.5GHz baseband
 - Offline channel by channel (or chunk) calibration?
- Aliasing at band edges
 - Flag 100Mhz (4%) in the overlap region
- Send us an email: apex-astro@apex-telescope.org