**FLASH⁺ instrument - receiver capabilities**

- simultaneous observations at 870µm and 630µm atmospheric windows
- 2SB (sideband separating) state of the art SIS mixer devices [ALMA spin off]
- tuning range 262 – 374 and 374 – 516GHz
- 4-8GHz IF bandwidth per sideband [16GHz total processing bandwidth]
- fast tuning procedures
- full remote operation with no engineering support on site
FLASH⁺ sideband separating mixers

- sideband separating mixers, build up of different components:
  - RF coupler - signal & LO waveguide (!) input
  - 2 SIS DSB mixers
  - IF coupler - generating USB and LSB IF output
  - DC bias feed via IF port
- each sideband $f_c = 6$ GHz with $bw=4$GHz
- everything x2 (bias, IF processing, ..)

![Diagram of sideband separating mixers](image)
• mixer assemblies: containing mixer, optics, IF parts almost monolithically fabricated
• simplifies alignment, integration and maintenance
• 460GHz VDI LO low/high subbands
LO synthesizers controlled by APECS safety reasons --> 460L, 460H
FLASH+ IF scheme

- XIF processors input bandwidth 4-8GHz
- 4 IF sub-bands (345LSB + USB, 460LSB + USB)
- 1 TP detector per chain (continuum measurements: focus scans, pointings) detector bw 2.5GHz
- 2x 2.5GHz XFFTS for each sub-band (1GHz overlap)
- backend resolution 65k channels ($2^{16}$)
- backend resolution 32k channels ($2^{15}$)
FLASH+ IF processing specialty

- XFFTS input limitation 0-2.5GHz
- IF split into two XFFTS bands (1GHz overlap)
- requirement for processing the full band (CLASS) channels in overlap range need to be centered on each other
- μwave synthesizers with resolution in Hz regime expensive --> shift on 10MHz reference level
- generation of reference signals for 4 & 8GHz LO by Direct Digital Synthesizer (in-house design)

- full signal processing chain needs to be locked to one reference → also XFFTS!
FLASH+ control

- almost fully ethernet based infrastructure
- 100% remote operation
- flexible and modular hardware and software design

- fully integrated bias supply provides DC bias for one sideband

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APECS (Apex Control Software)  
Optics & Calibration Units  
Synth. 345  
Synth. 460

Apex Inst. Ethernet (10.0.2.x)

345 LO Power control  
Network Card 1  
Flash PC  
Network Card 2

Flash Ethernet (192.168.1.x)

Bias PC + DC Supplies  
460 LO control (ADAM 6024)  
Temp. & Vac. Monitoring  
Compressor Control

SIS mixer bias  
mixer B-Field  
mixer heater  
2 stage MMIC  
>120 pps/channel  
(IV + TP sweeps)
FLASH+ ‘distribution’
over the telescope

GUI
system electronics
frontend
XIF processors
Nasmyth receiver cabin A
LO driver synthesizers
instrument cabin
spectroscopy backend
He compressor
compressor level

APEX training 2014, CL

MPIfR – Division for Submm Technologies – Heterodyne Group

– CHAMP+ –
FLASH$^+$ system performance at APEX

- excellent Trx in both receiver channels
- good SSB rejection
- high instrument stability, Allan Variance Time of more than
  
  $>80$sec total power and $>150$sec in spectroscopy mode

![Graphs showing system performance](image-url)
CHAMP+

in mid 2013

• successful refurbishment of receiver control infrastructure
• changes on hardware and development of new control software
• goals:  - improve system stability (operational-wise)
  - add remote capabilities for diagnostics and maintenance
  - base for further upgrades
CHAMP+
OLD Control Architecture

- troubleshooter: VME computer running CHAMP server application

-> problems in handling massive IO paths to receiver sub-systems

APECS
CHAMP Client (GUI)

VME RACK

IF Server
CHAMP Server

IF Rack
Bias Rack
Cold Optics
Dewar Rotation
LOs
Cal. Unit
Temp.+Vac.

Mixer Bias
B-Field
HEMT Bias
Heaters
LF Diplex.
LF SSB
HF Diplex.
HF SSB
LCU (bias)
LF Synth.
HF Synth.
Cooler
H-C Chopper
C-S Mirror
Temp. Monitor 1
Temp. Monitor 2
Vac. Monitor
HE Compr.

Manual control
CHAMP+ NEW Control Architecture

- VME RACK
  - IF Server
  - CHAMP Server

- NEW CONTROL SYSTEM
  - CHAMP Server + GUI (New)

- IF Rack
  - Bias Rack
    - Mixer Bias
    - B-Field
    - HEMT Bias
    - Heaters
  - Cold Optics
    - LF Diplex.
    - LF SSB
    - HF Diplex.
    - HF SSB
  - Dewar Rotation
  - LOs
    - LCU (bias)
    - LF Synth.
    - HF Synth.
    - Cooler
  - Cal. Unit
    - H-C Chopper
    - C-S Mirror
  - Temp.+Vac.
    - Temp. Monitor 1
    - Temp. Monitor 2
    - Vac. Monitor
    - HE Compr.

- Manual control

• up-to-date, powerful, rugged, industrial PC hosting new CHAMP server
• ethernet based IO
Hardware Changes:

- New Ethernet-based internal system architecture (as used for FLASH+)
- VME PC replaced by a modern Industry Standard, Intel i5-based Rack PC (as used for FLASH+)
- VME Analog/Digital IO modules replaced by a National Instruments Ethernet based compact-DAQ system
- VME serial communication cards replaced by BrainBoxes multiport Ethernet to Serial converters
- New dewar rotation encoder (RS-compatible)

**NOTE:**
- *IF control not changed, IF rack still controlled over IF server on the VME PC!*
- *Front end bias control not changed, still set by hand or using the old Client/Server configuration!*

IF Rack

New Control PC

Existing VME Rack

Motor/LO Rack

Compact DAQ

RS Connections

Ethernet to RS Converters
Software Changes:

- Completely new LabView-based server software → ability to modify/debug almost “on-the-fly”
- Server and GUI in one single application
- Multitasking and multithreading operation for better performance → simultaneous execution of tasks on different subunits of the receiver, faster user interface response
- Comprehensive logging capabilities (separate logs for operations, APECS communication and errors) → easier debugging and thus faster improvements
- Implementation of a simple IF control based on the communication with the old IF server
- Testing and implementation of further functionality in progress
CHAMP+

LFA 625 – 720 GHz 4.6 – 7.4 GHz IF 16k Trx_ssb 400-500K
HFA 780 – 950 GHz 4.6 – 7.4 GHz IF 16k Trx_ssb 900 – 1800K

oscilloscope for tp and IV trace for one mixer
• things that should belong to the past:
  - checking the vitality of the 'chamsserver' task
  - power cycling of the VME computer in the B-cabin
  - error message in APECS: G2I too high!
    (old recommendation: repeat tuning
     change tuning to an adjacent frequency
     then return to the nominal frequency
     report the frequency)
    → should be eliminated due to a more sophisticated tuning algorithm

• tunings especially when switching LO bands (800 to 900 LO) take time!
  ramping down and up of the LOs, moving mirrors, setting diplexer and ssb filter......
  → please be patient, don`t cancel the tuning after a view seconds