«ALOHA : General presentation of the project and current efforts» CHARA Workshop Nice

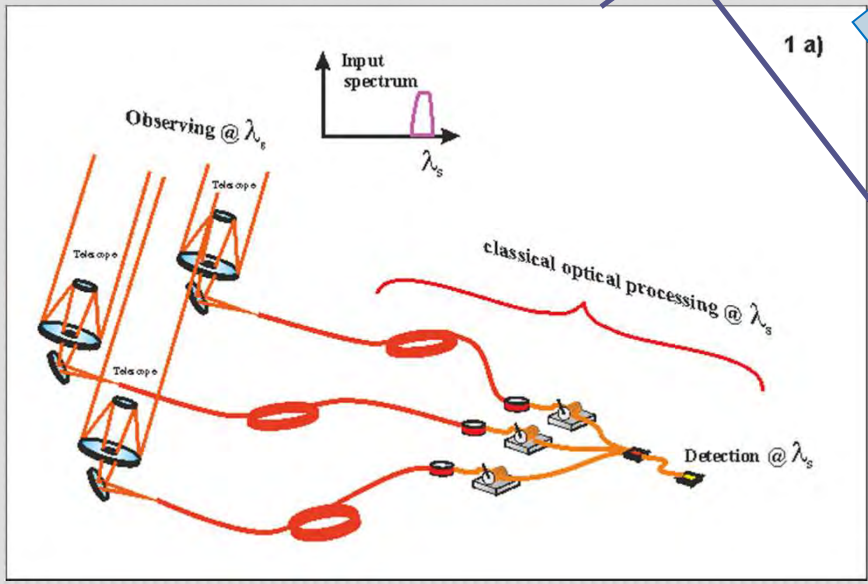
François Reynaud

XLIM / Dépt. Photonique IRO Limoges

P. Darré, L. Szemendera, H. Boulogne L. Delage, L. Grossard,
Collaboration with the CHARA team : T. Brummelaar J. Strumann. N. Scott ….

Why it's interesting to change the color of star light

Astro target >>> wavelength



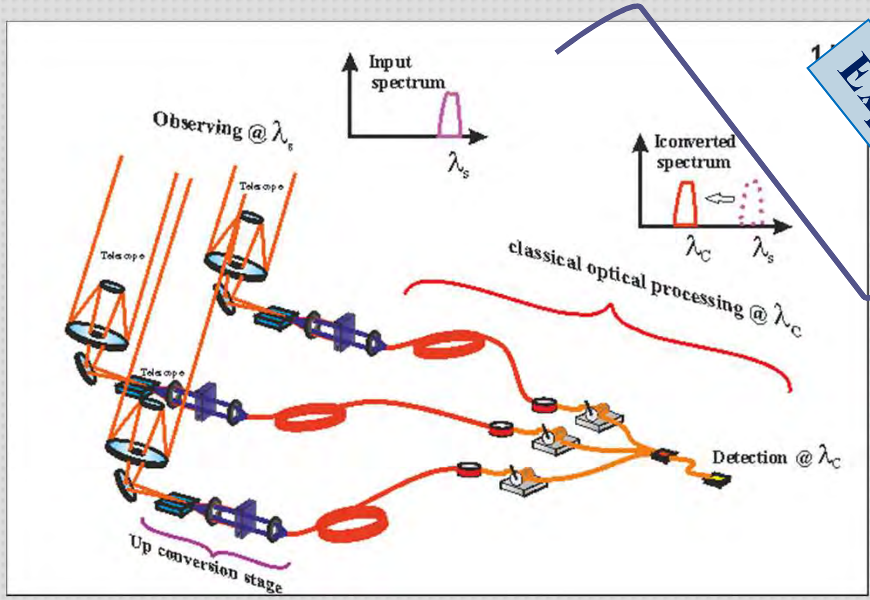
Experimental chain

Constraint for :
Transmission
Filtering
mixing
Detection…

Classical way :
All the experimental chain is design as function of the spectral domain of the source

Why it's interesting to change the color of star light

Astro target >>> wavelength



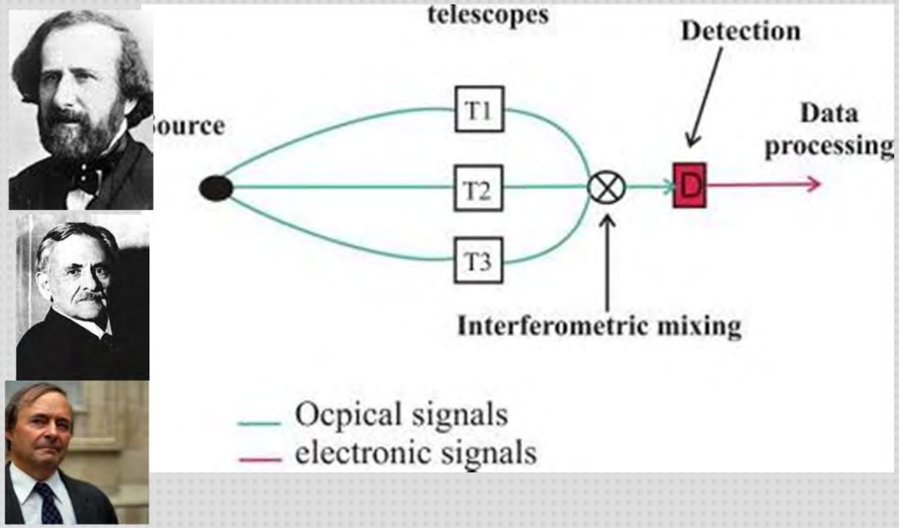
Experimental chain

Experimental chain optimized for :
Transmission
Filtering
mixing
Detection…

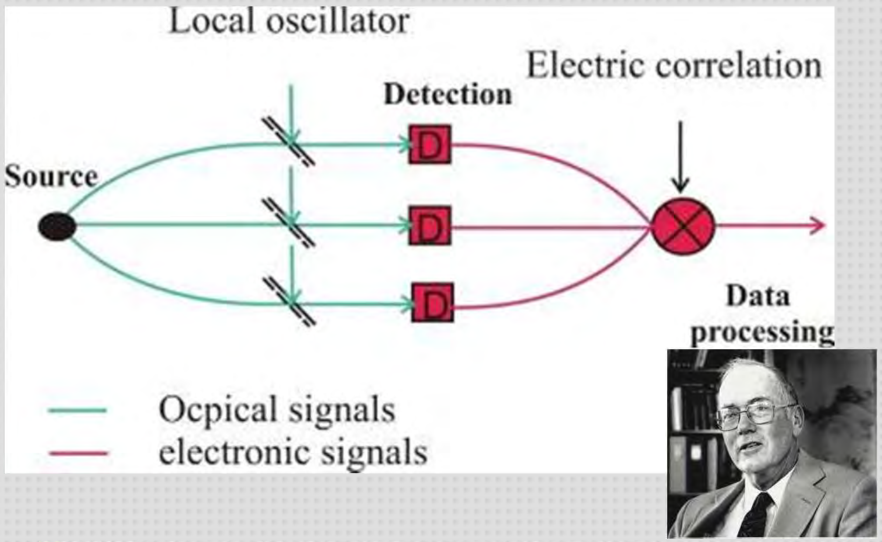
New way :

* All the experimental chain is designed at a given wavelength to improve the global efficiency
* The astro light is spectrally shifted to reach this spectral domain

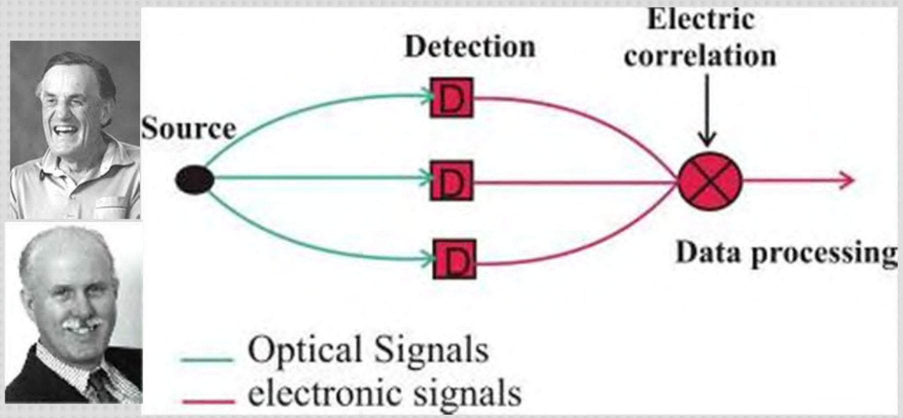
A new concept for high resolution imaging



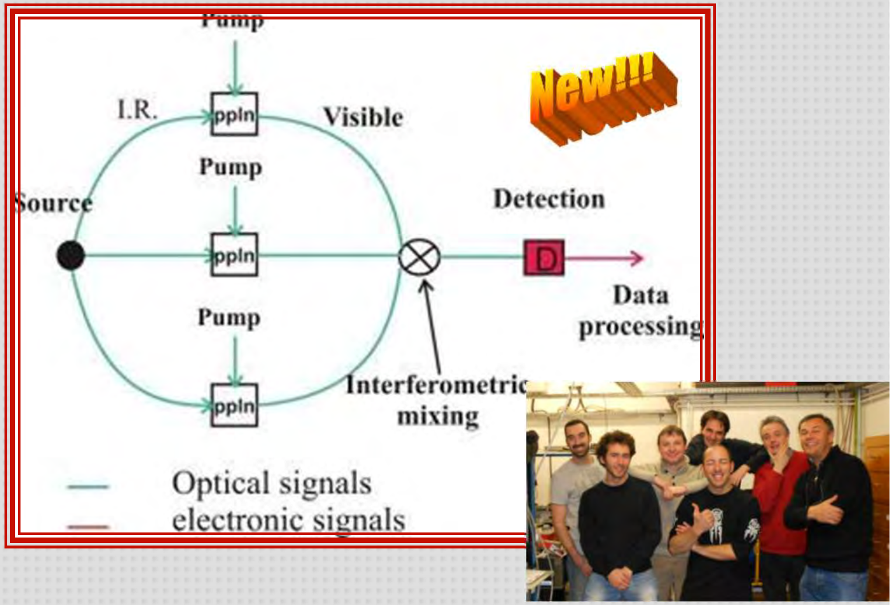
[4] : A. Michelson : *On the application of interference methods to astronomical measurements*. American journal of science, 02/1890.



[8] : M.A. Johnson, A.L. Betz, C.H. Townes : *10 µm Heterodyne stellar interferometer*. Physical Review Letters, vol. 33 (27), pp. 1617-1620.



[5] : R.H. Brown, G. Twiss : *Correlation between photons in two coherent beams of light*. Nature, vol. 177, pp. 27-29, 07/01/1956.



The nonlinear process

Astro target

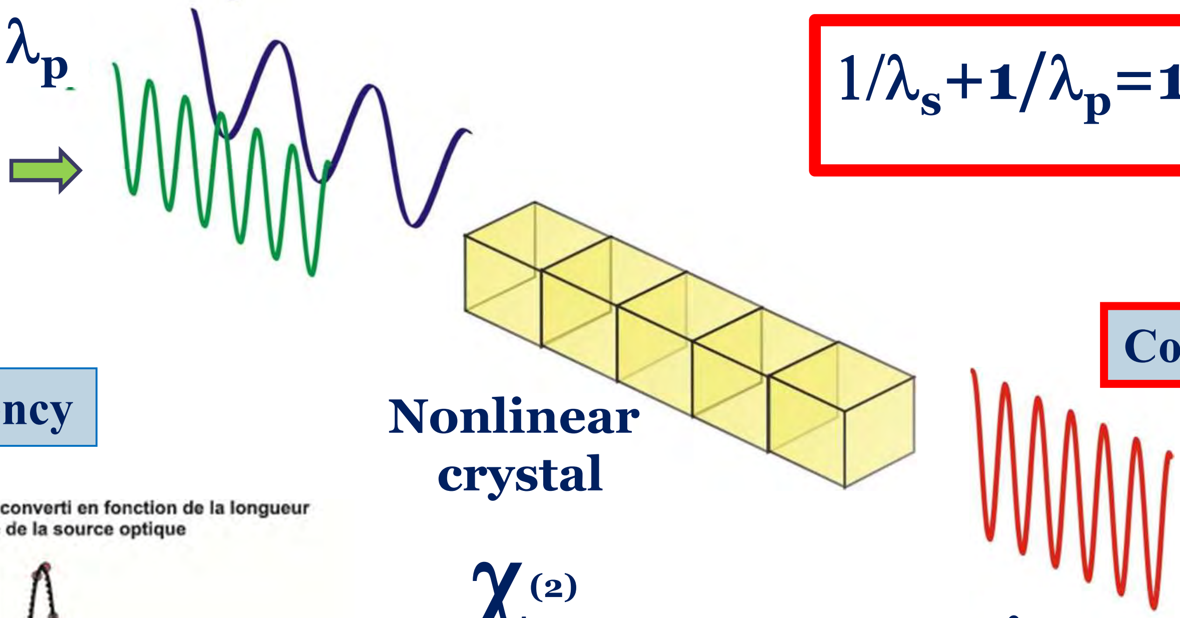
λ_s

Pump laser

λ_p

$\nu_s+\nu_p=\nu_c$

$1/\lambda_s+1/\lambda_p=1/\lambda_c$



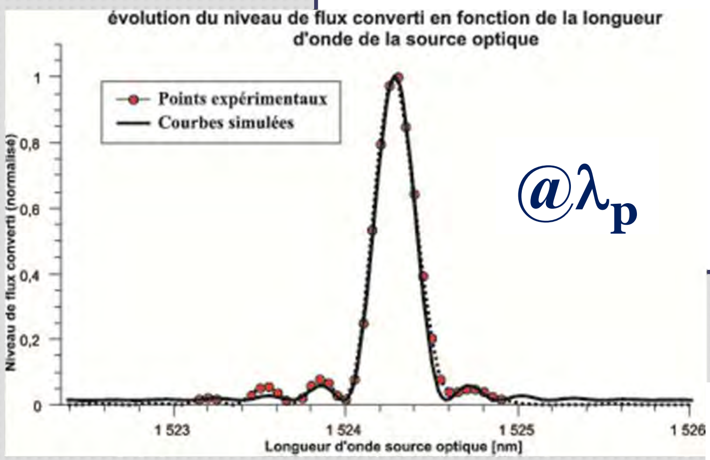
Nonlinear crystal

$\chi^{(2)}$

Converted signal

λ_c

Conversion efficiency



$@\lambda_p$

λ_s

Spectral resolution!

The spectral issues : photon counting detectors

pump laser (µm)			1,064		1,3		1,5		2	
Astro band (µm)										
H	1,50	1,80	0,62	0,67	0,70	0,75	0,75	0,82	0,86	0,95
K	2,00	2,50	0,69	0,75	0,79	0,86	0,86	0,94	1,00	1,11
L	3,20	3,90	0,80	0,84	0,92	0,98	1,02	1,08	1,23	1,32
M	4,50	5,00	0,86	0,88	1,01	1,03	1,13	1,15	1,38	1,43
N	8,00	13,00	0,94	0,98	1,12	1,18	1,26	1,34	1,60	1,73
Q	17,00	25,00	1,00	1,02	1,21	1,24	1,38	1,42	1,79	1,85

Ambient temperature photon counting detectors

Si APD detectors

In GaAs APD detectors

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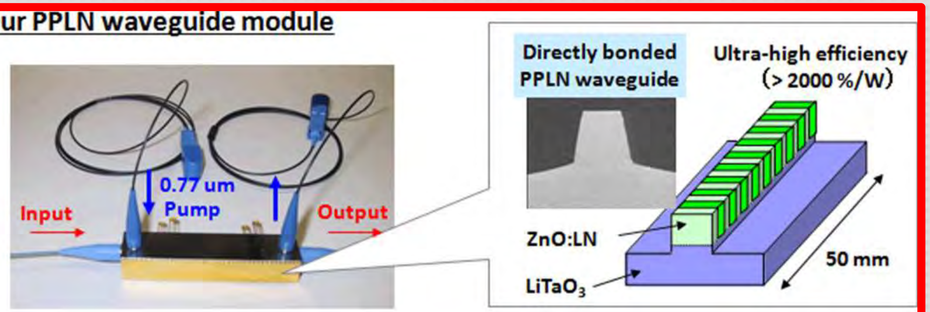
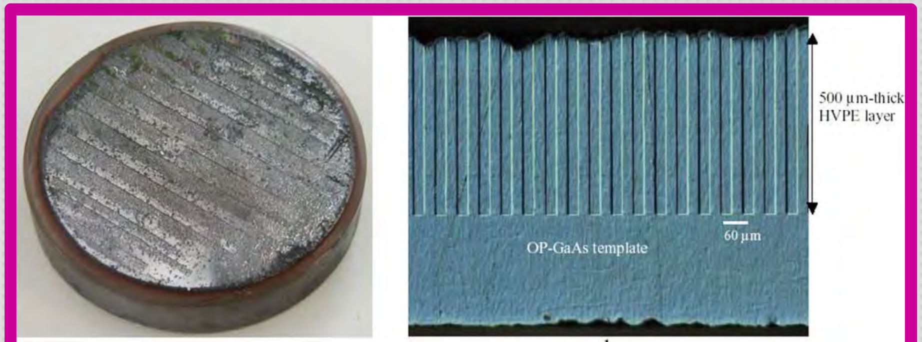
PPLN	0.5-4.5 µm
OP GaAs	1-18 µm

Our PPLN waveguide module



- the world's highest level conversion efficiency
- Highly robust against input power



a. b.

Strategy of the ALOA project

Pump laser → ALOHA
Crystal → ALOHA
Detector → ALOHA

ALOHA

Selection of:
- Available and reliable pump source
- Available and reliable crystal
- Commercial ambient detector

Current test

ALOHA @1.55 µm

H band >> 630 nm
Si APD detectors
PPLN
1.06 µm laser diode as pump

ALOHA @3.39 µm

L band >> 810 nm
Si APD detectors
PPLN
1.06 µm laser diode as pump

ALOHA @1.55 µm

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In laboratory experiment :

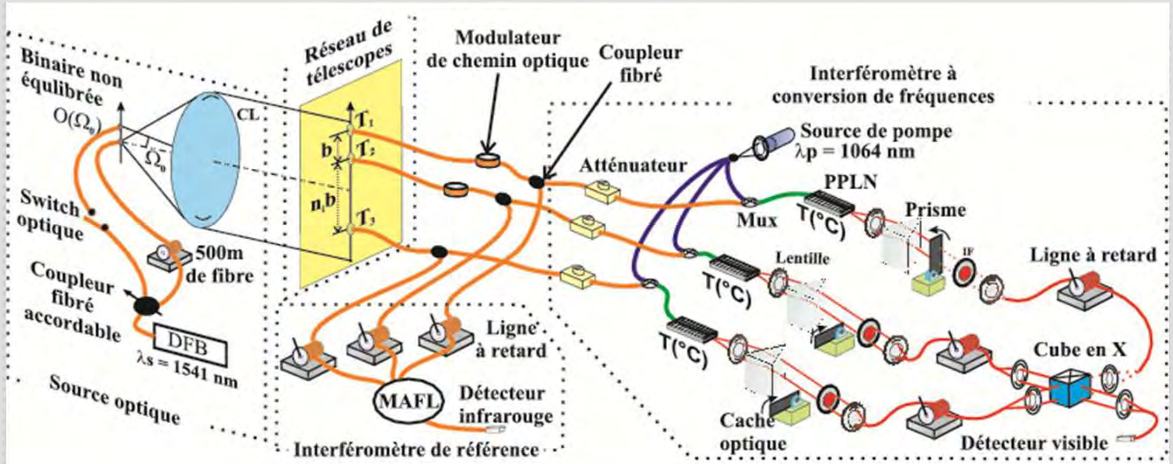
* Demonstration of the principle
* Spectral behavior
* Noise investigation

On sky demonstration

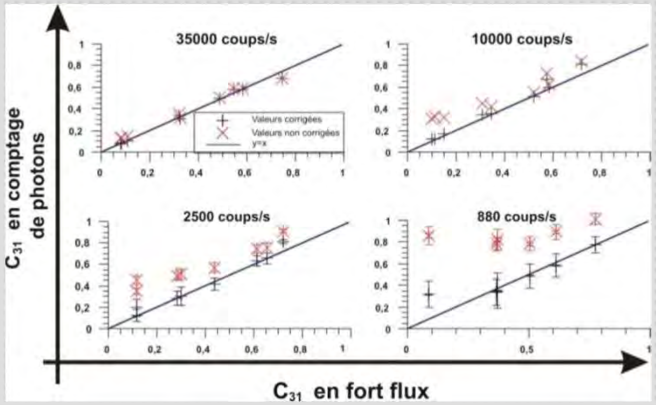
Photometry Mission 2014

First fringes Mission 2015

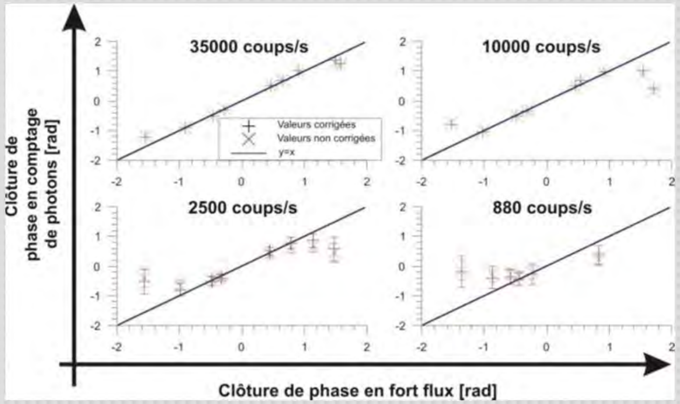
ALOHA @1.55 µm in lab test



Contrast measurement



Phase closure measurement



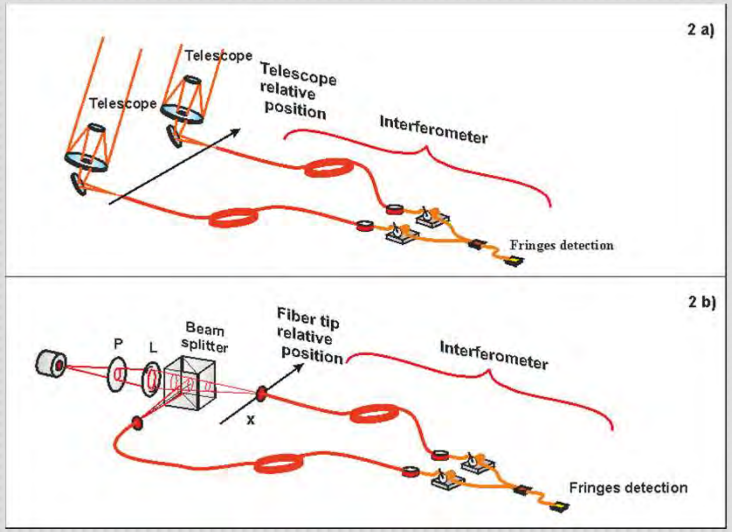
MNRAS 2013

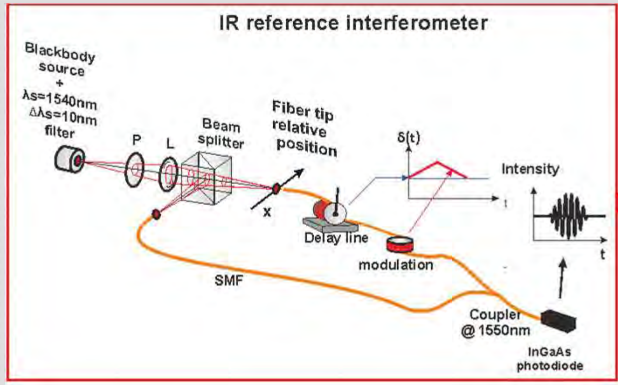
“Contrast and phase closure acquisitions in photon counting regime using a frequency upconversion interferometer for high angular resolution imaging ”

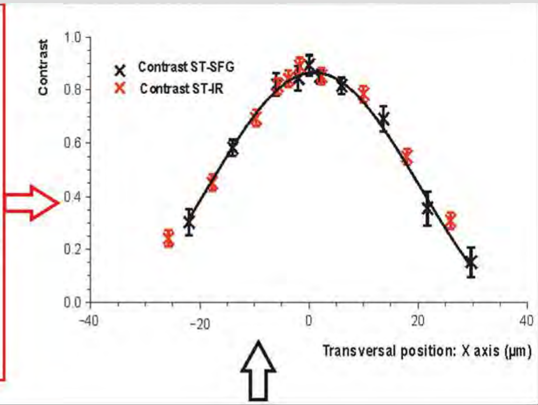
ALOHA @1.55 µm in lab test

source >>> blackbody

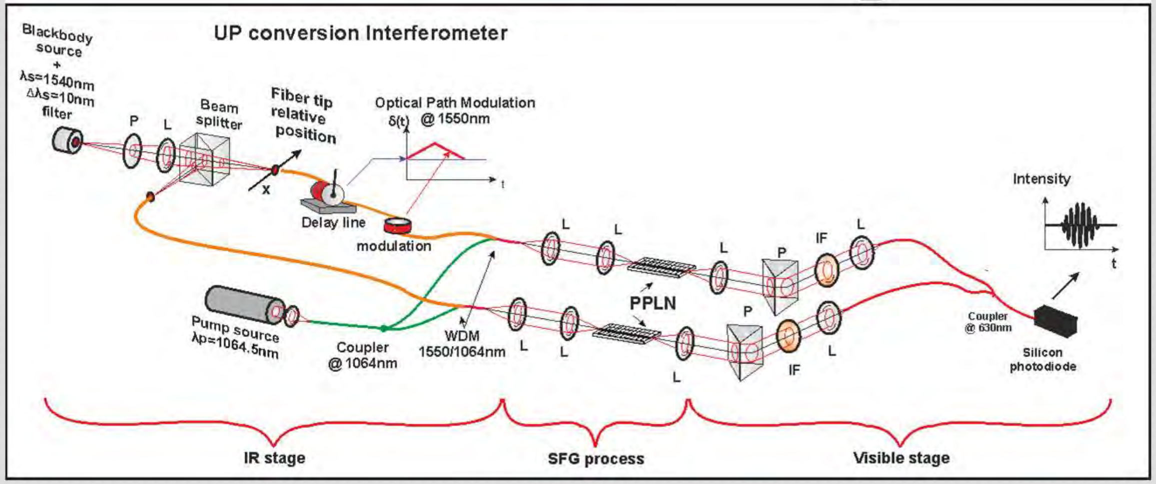
In lab experiment







Ultra fine servo control of the SFG



Laboratory Demonstration of Spatial-Coherence Analysis of a Blackbody through an Up-Conversion Interferometer PRL 112, 143904 (2014)

ALOHA CHARA @1.55 µm on sky missions

Road map

Photometric tests 2014

↓

In lab development

↓

Interferometric tests 2015

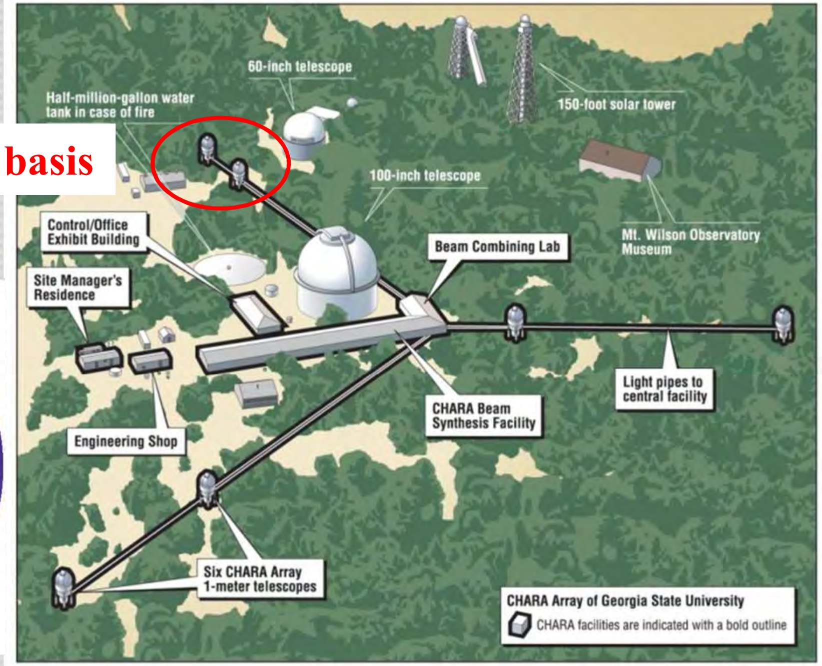
↓

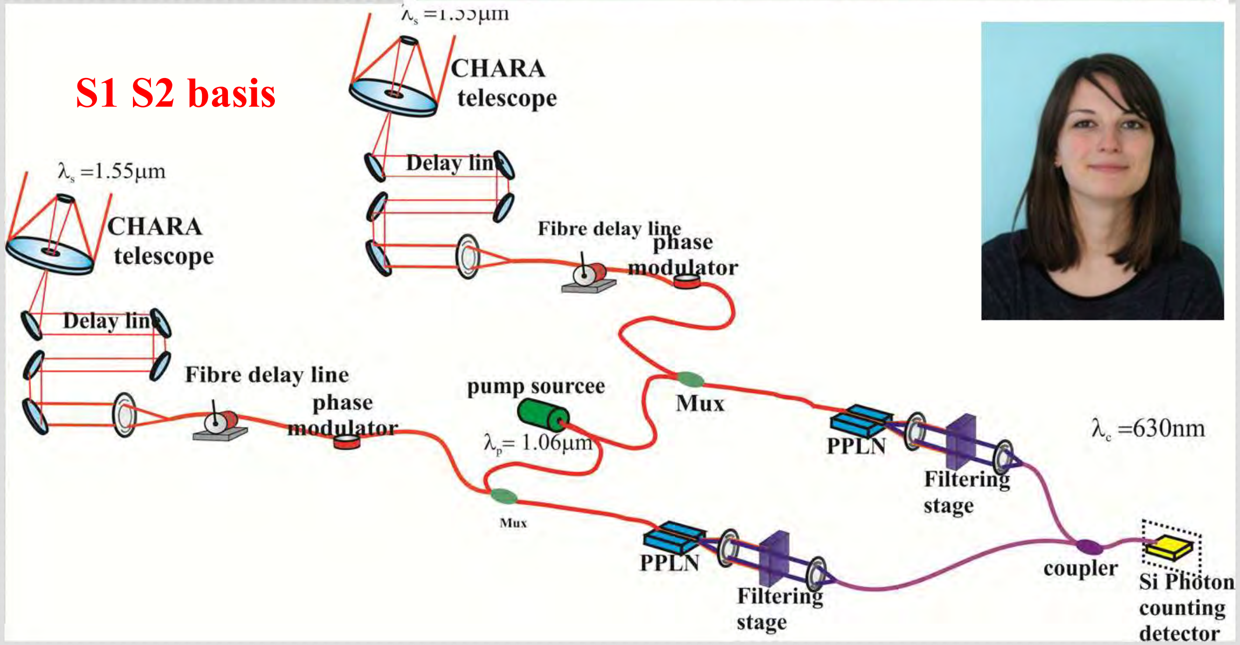
In lab development

↓

C calib and spectro 2016

S1 S2 basis





ALOHA @3.39 µm

pump laser (µm)			1,064		1,3		1,5		2	
Astro band (µm)										
H	1,50	1,80	0,62	0,67	0,70	0,75	0,75	0,82	0,86	0,95
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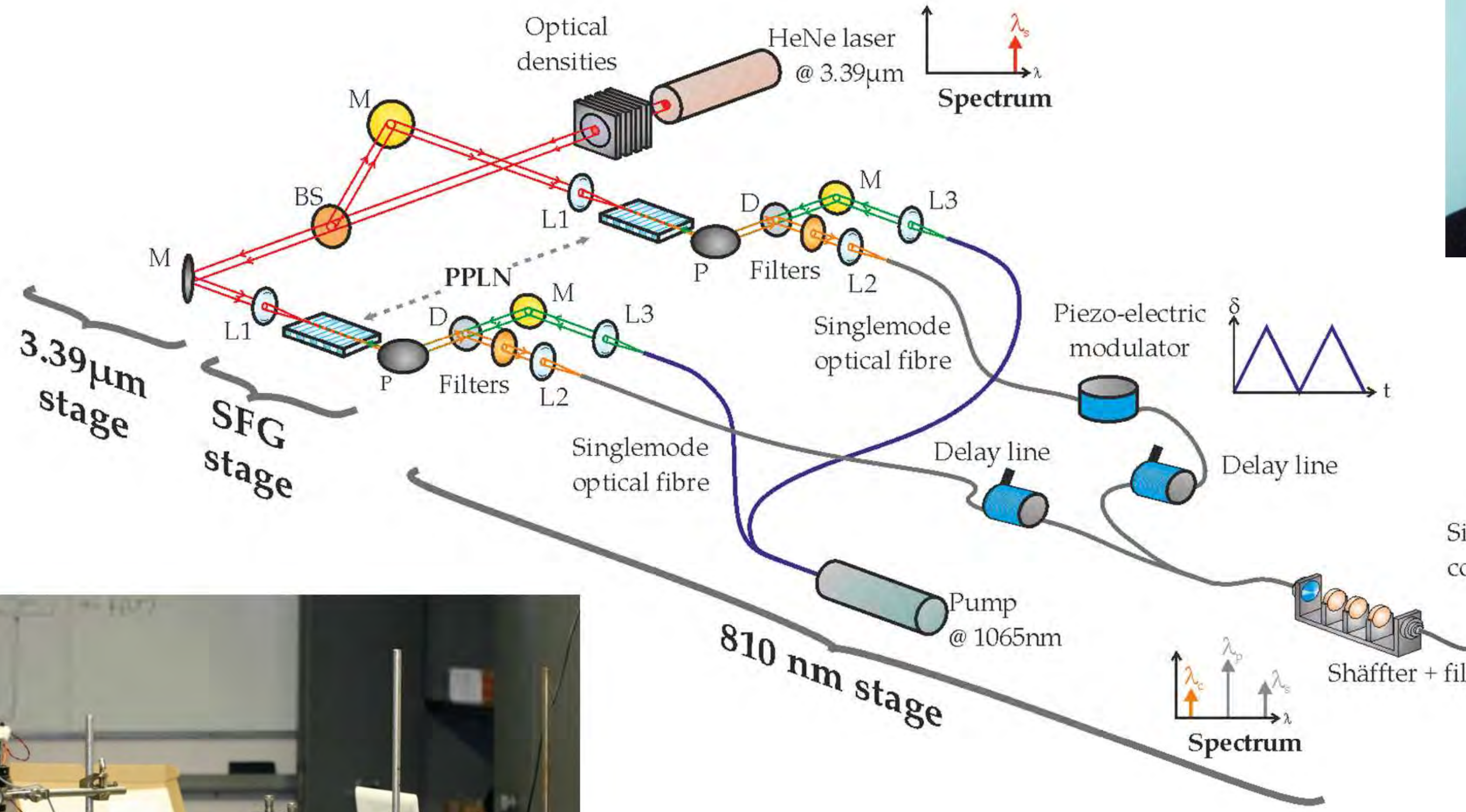
In laboratory experiment :

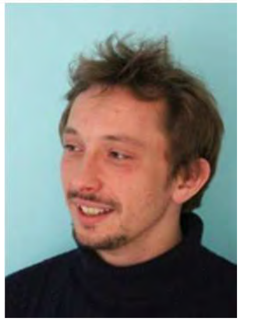
* Demonstration of the principle
* Spectral behavior
* Noise investigation
* Photon counting regime
* Blackbody source

On sky demonstration…..

ALOHA @3.39 μm

In laboratory experiment





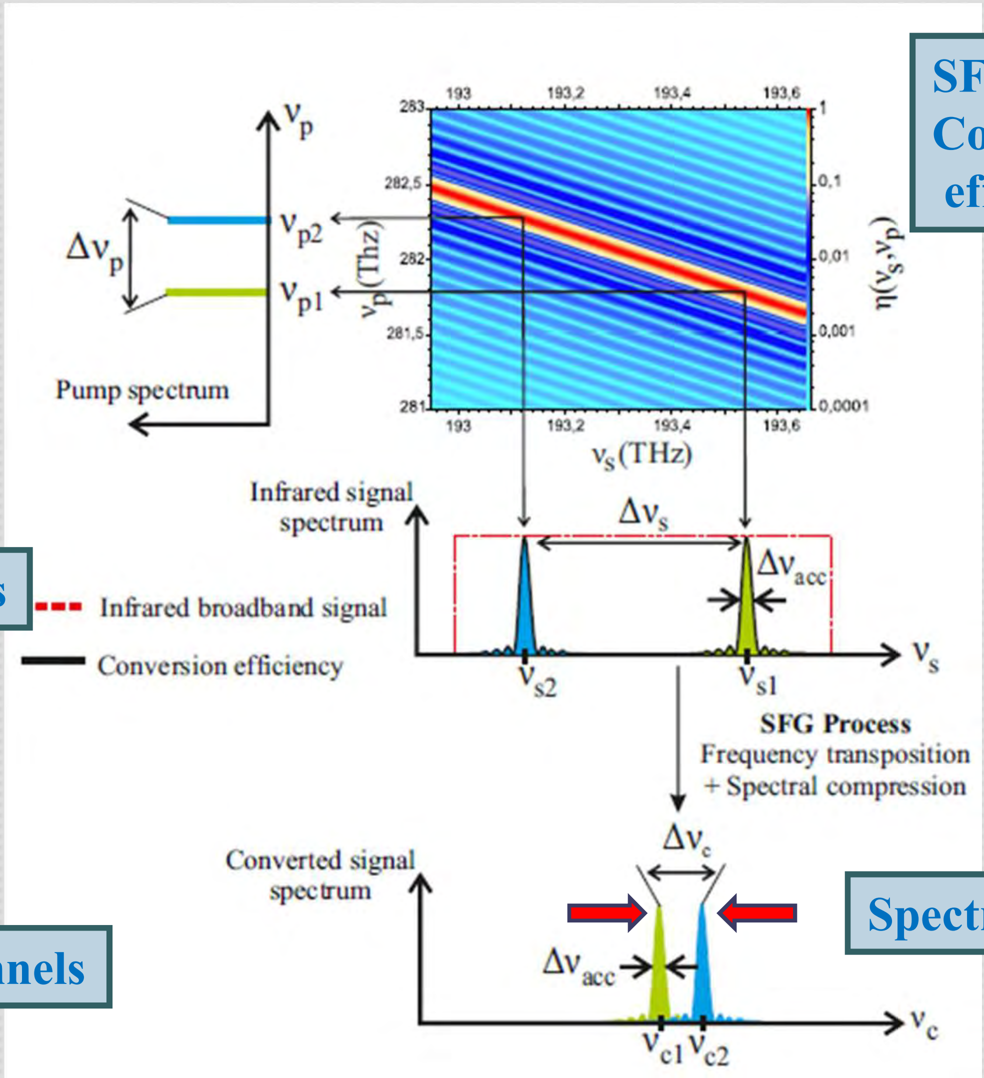
Current development: increasing the spectral bandwidth

Use of multi line laser ;
Preliminary study in H band with two CW laser lines as pump source

2 pumps

2 signal channels

2 converted channels

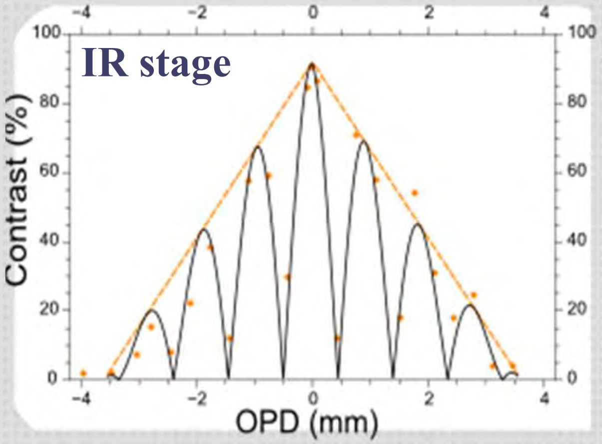


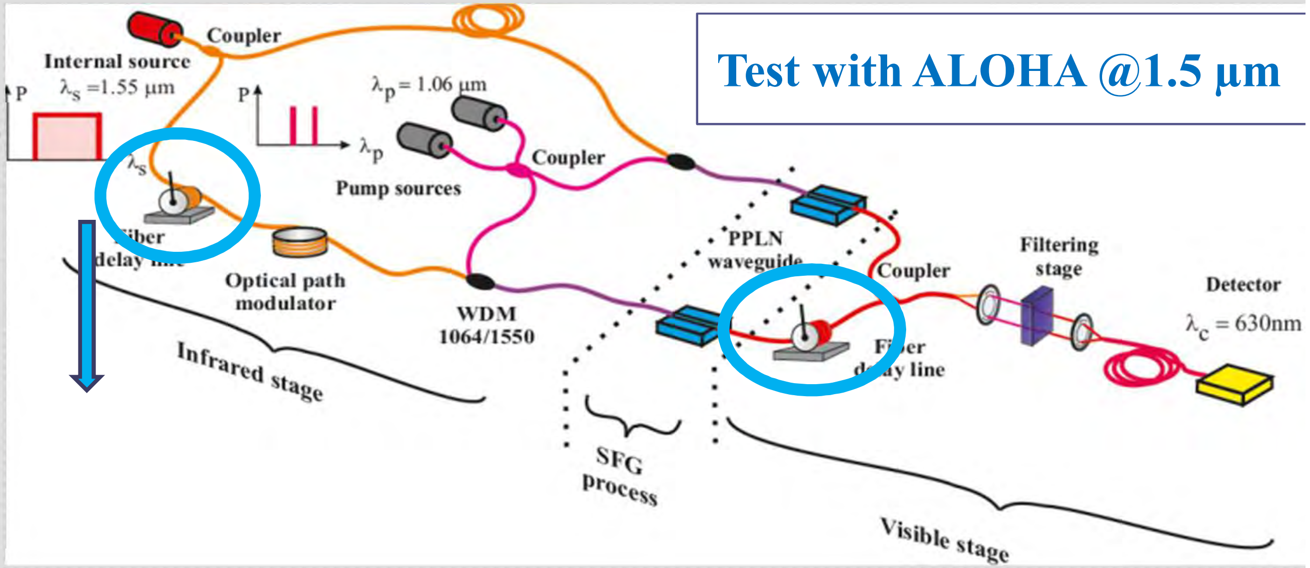
SFG Conversion efficiency

Spectral compression

Current development: increasing the spectral bandwidth

Test with ALOHA @1.5 µm

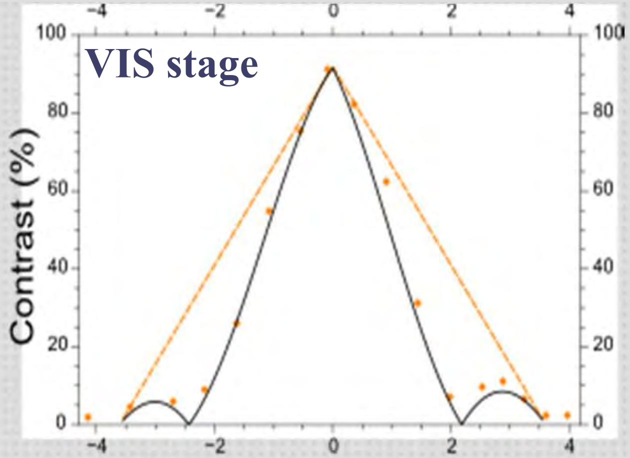




Spectral compression

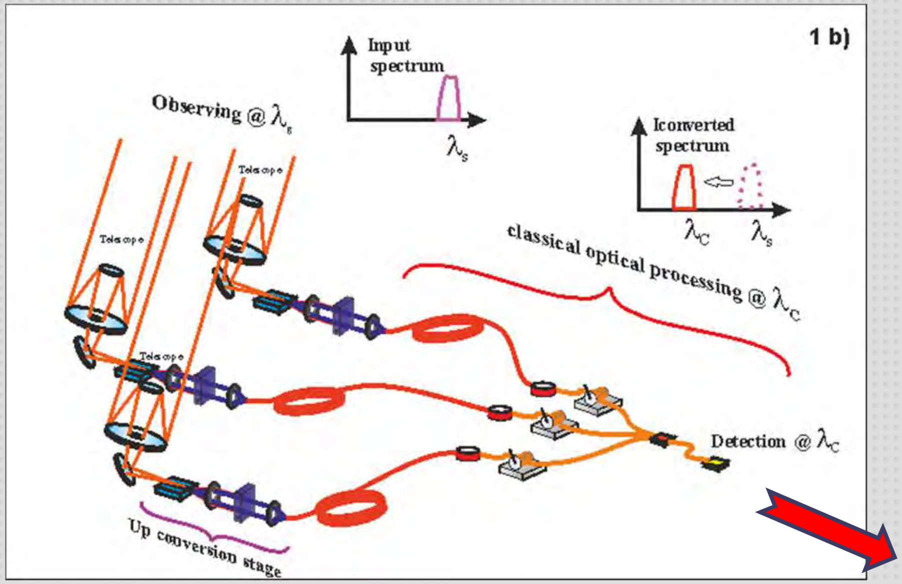
(Darré & al., 2015)

Coherence pattern expansion



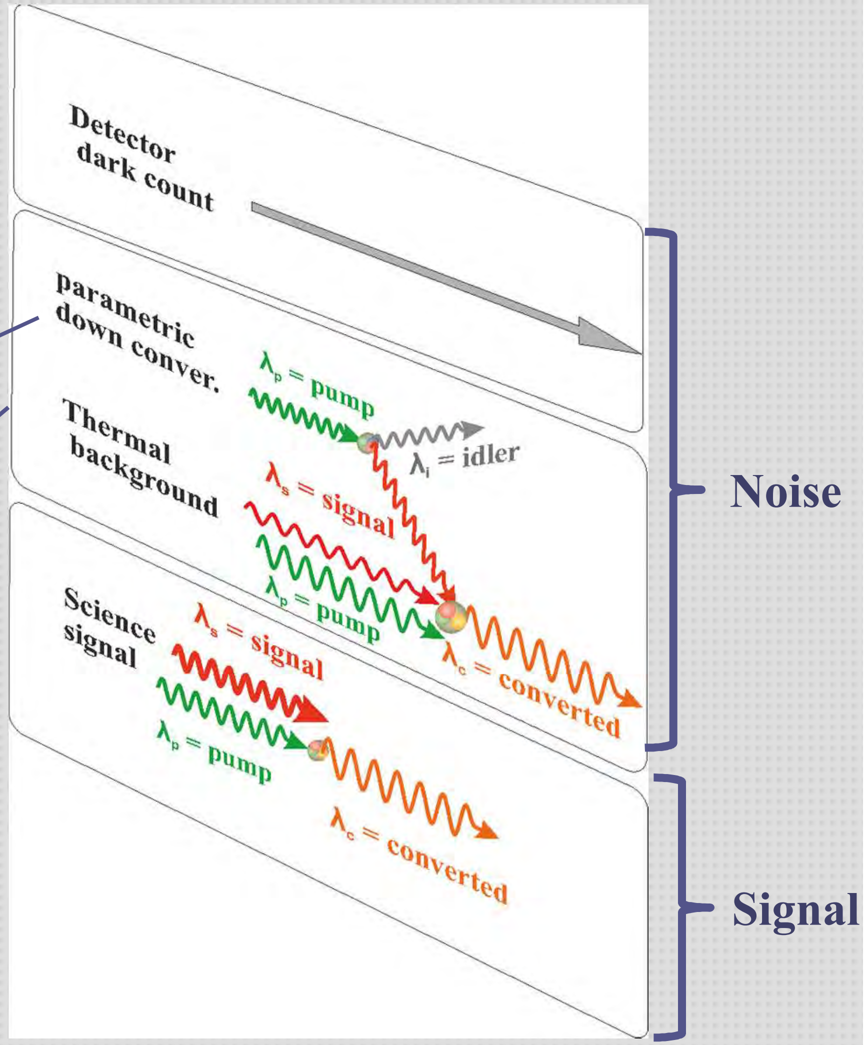
Spectral behavior:
*** Spectral selection >> Intrinsic spectrometry**
*** Spectral compression >> Fiber delay lines**

Current development: noise behavior

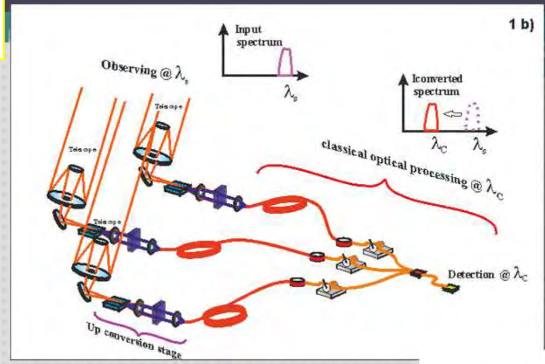


Evolution of the noise source vs spectra band

	Parametric noise	Thermal noise
@1.5 µm	~100%	#0
@3.4 µm	~50%	~50%
@10 µm	#0 ?	~100% ?



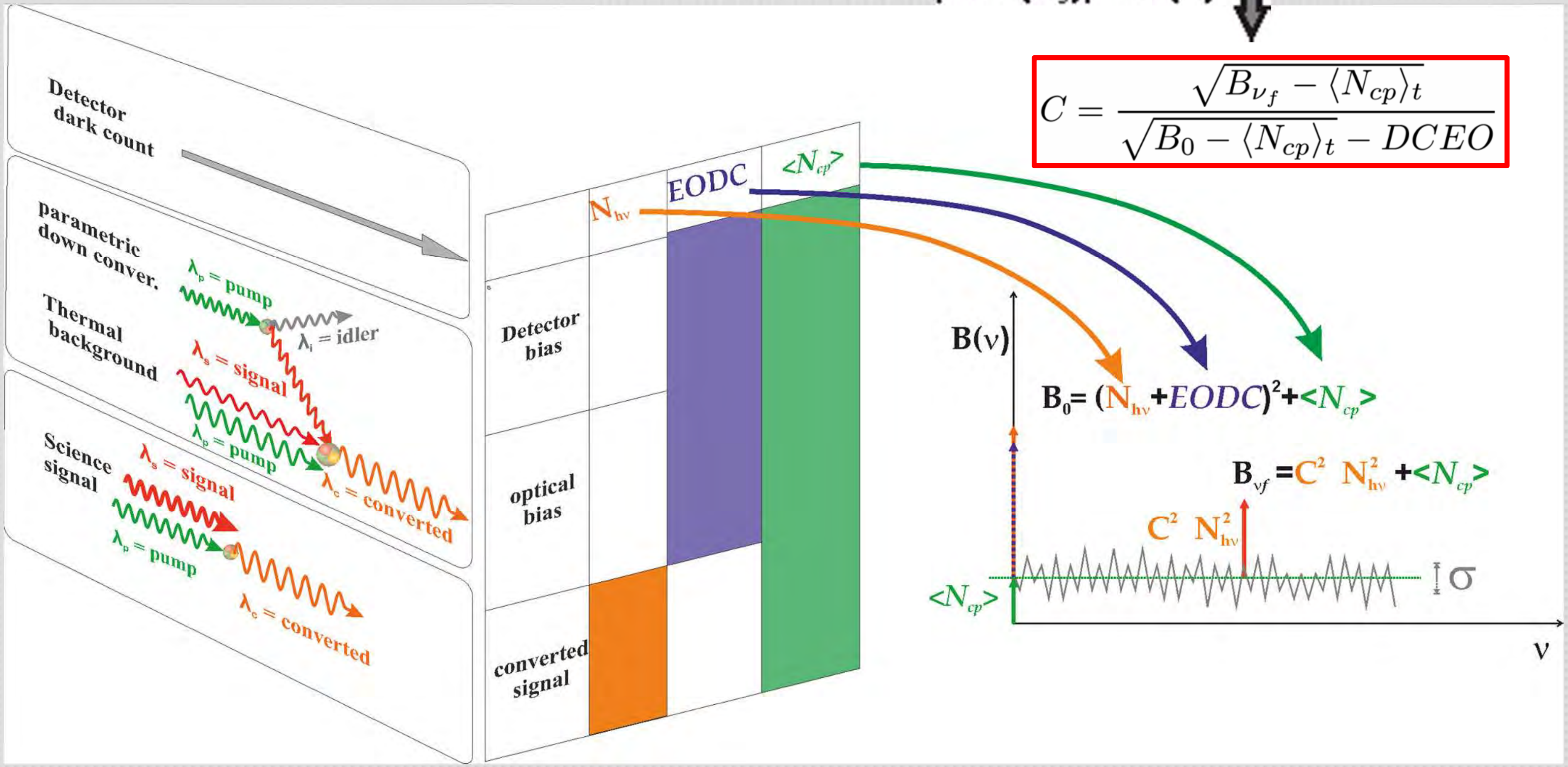
ALOHA noise behavior



Optimization of the data processing

$$|FFT(P_s)|^2 = B(\nu)$$

$$C = \frac{\sqrt{B_{\nu_f} - \langle N_{cp} \rangle_t}}{\sqrt{B_0 - \langle N_{cp} \rangle_t} - DCEO}$$



ALOHA conclusion and perspective

ALOHA @1.5 µm

Spectral comb pump
Mission CARA 2016
ALOHA > Spectrometrer

ALOHA @3.4 µm

Noise investigation
Acquisition with a blackbody source
New crystals

ALOHA @ 10 µm

Starting with OP GaAs
Investigation of noise
Global investigation on potential crystals
Possibility to design a N band instrument

cnes
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ThalesAlenia Space
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UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft
femto-st SCIENCES & TECHNOLOGIES
femto engineering
NÉEL Institut
THALES RESEARCH & TECHNOLOGY