Assemblée Générale REFIMEVE 2014

02/06/2014

EXTRACTION D'UN SIGNAL MÉTROLOGIQUE SUR UN LIEN OPTIQUE FIBRÉ

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LPL - Laboratoire de Physique des Lasers - Equipe MMTF

SYRTE - Systèmes de Référence Temps Espace - Equipe FOP

PLAN

NETWORK ARCHITECTURE

FIRST SETUP

PHASE NOISE COMPENSATION MODEL

SECOND SETUP

CONCLUSION

Financement ANR (LIOM LPL/SYRTE), Labex First-TF, contrat Européen EMRP NEAT-FT et IFRAF-Conseil Régional Ile-de-France.

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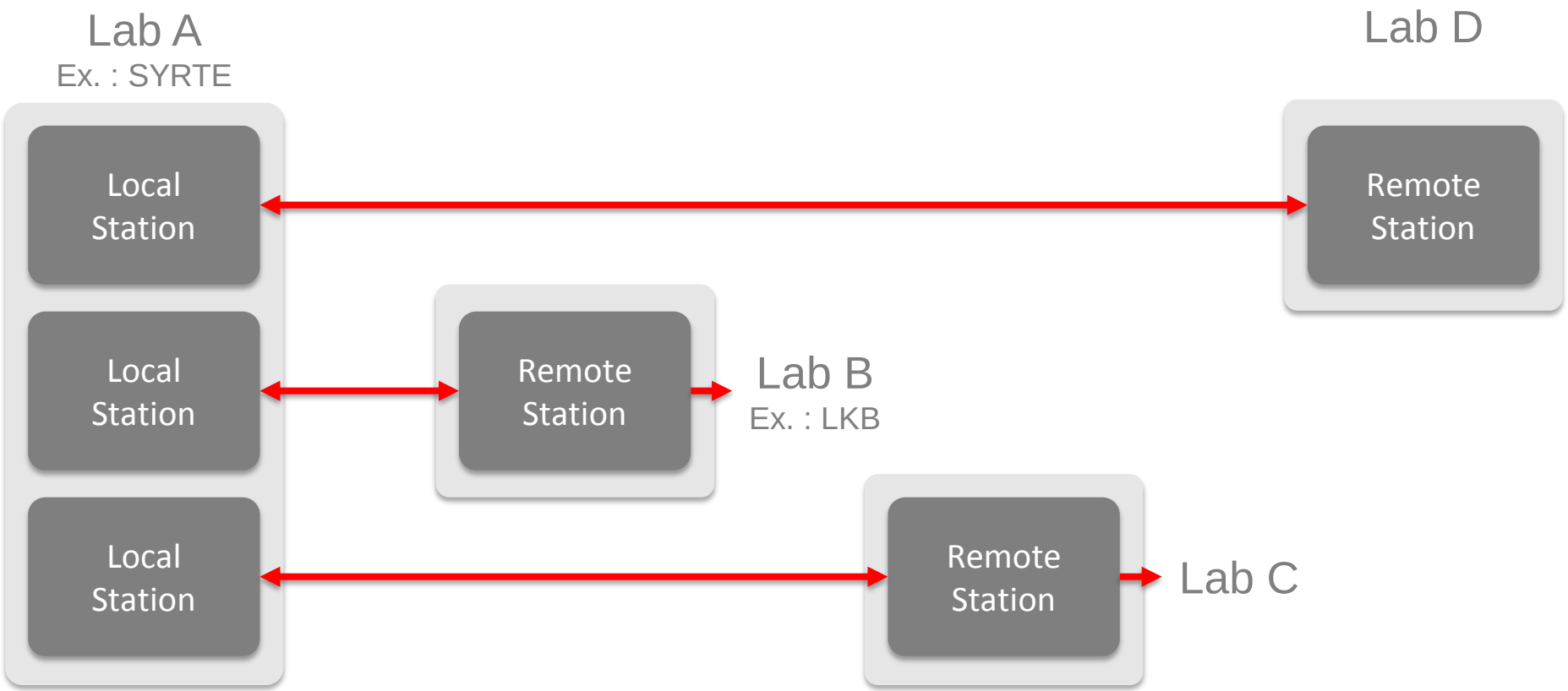
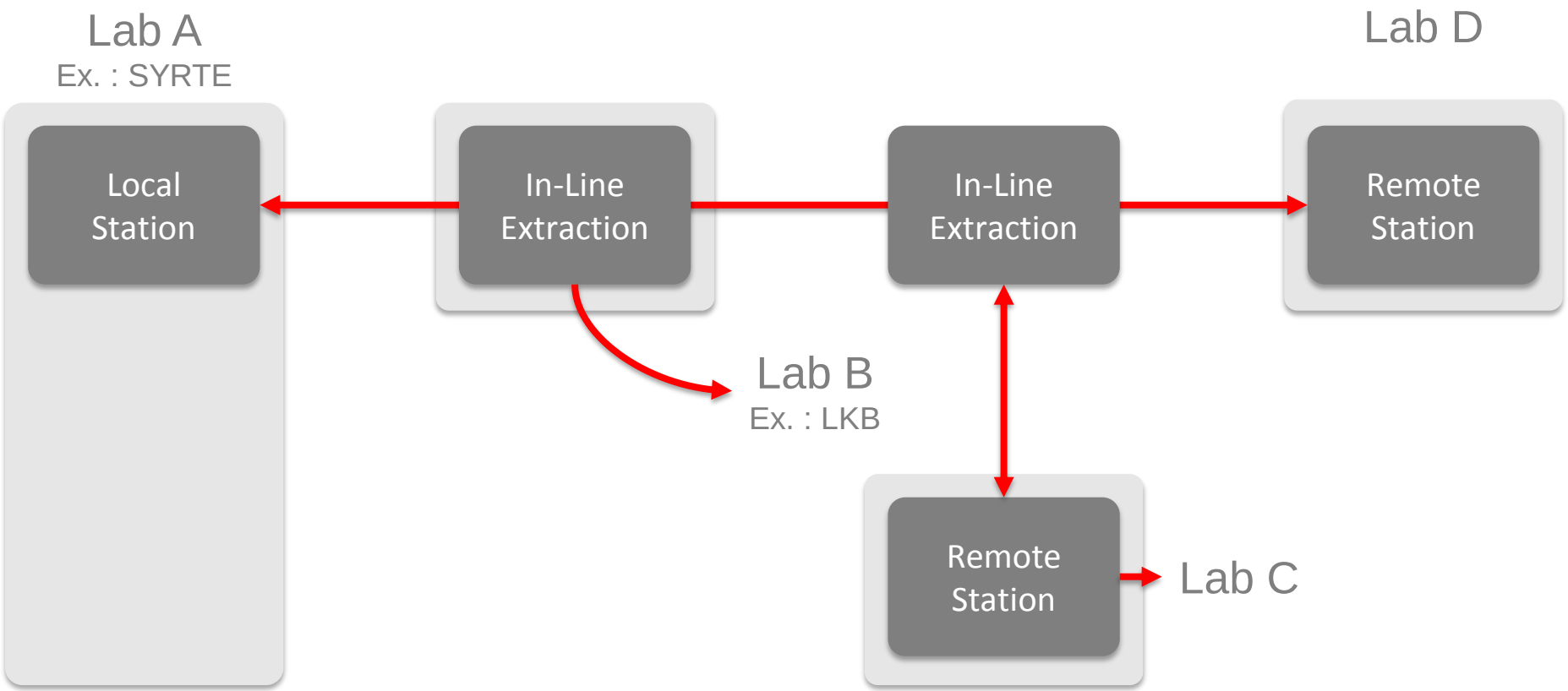
NETWORK ARCHITECTURE



NETWORK ARCHITECTURE



First proposed by G Grosche, patent application DE 10.2008.062.139

Travail réalisé en collaboration avec S. Guellati du LKB

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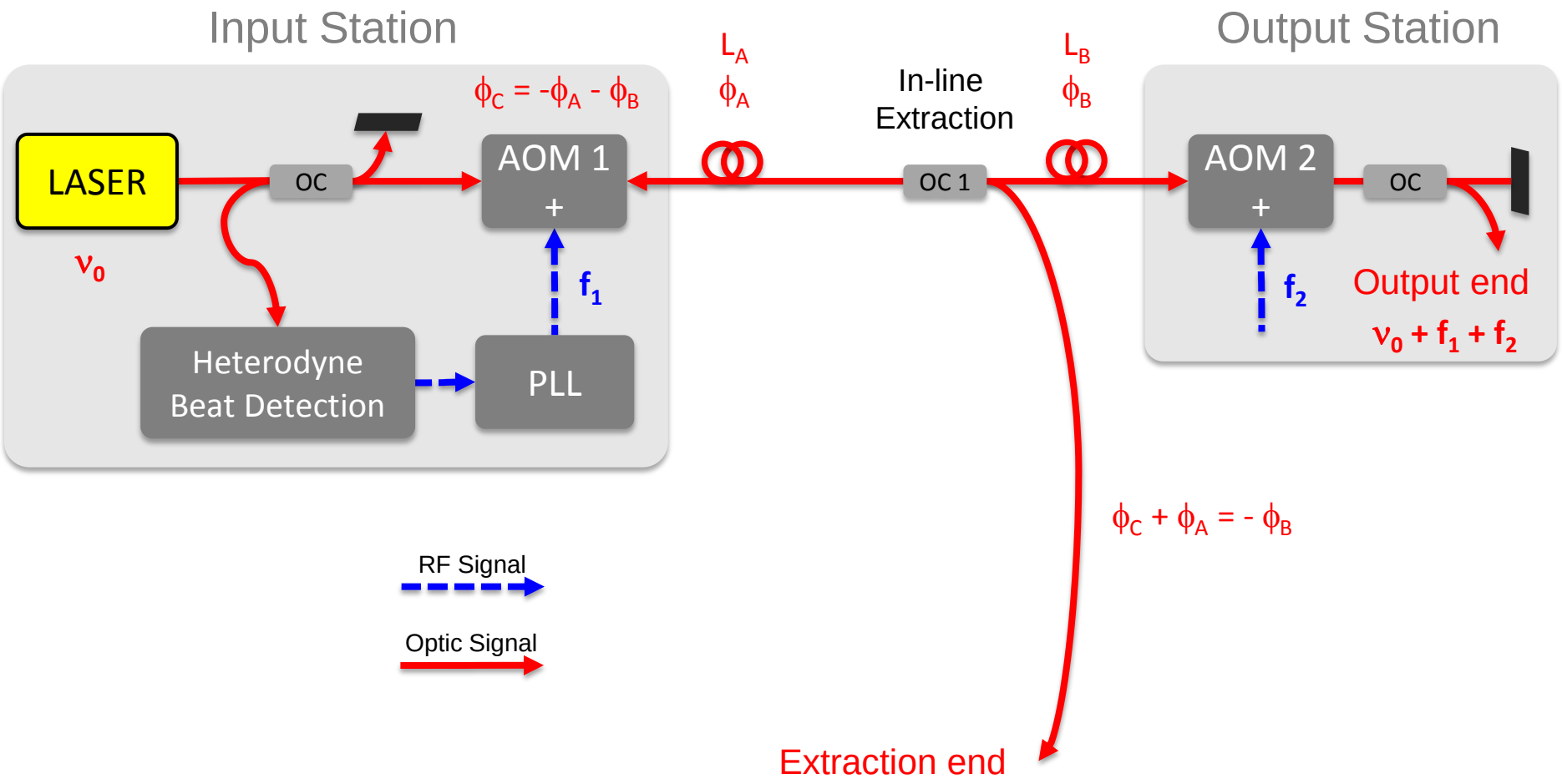
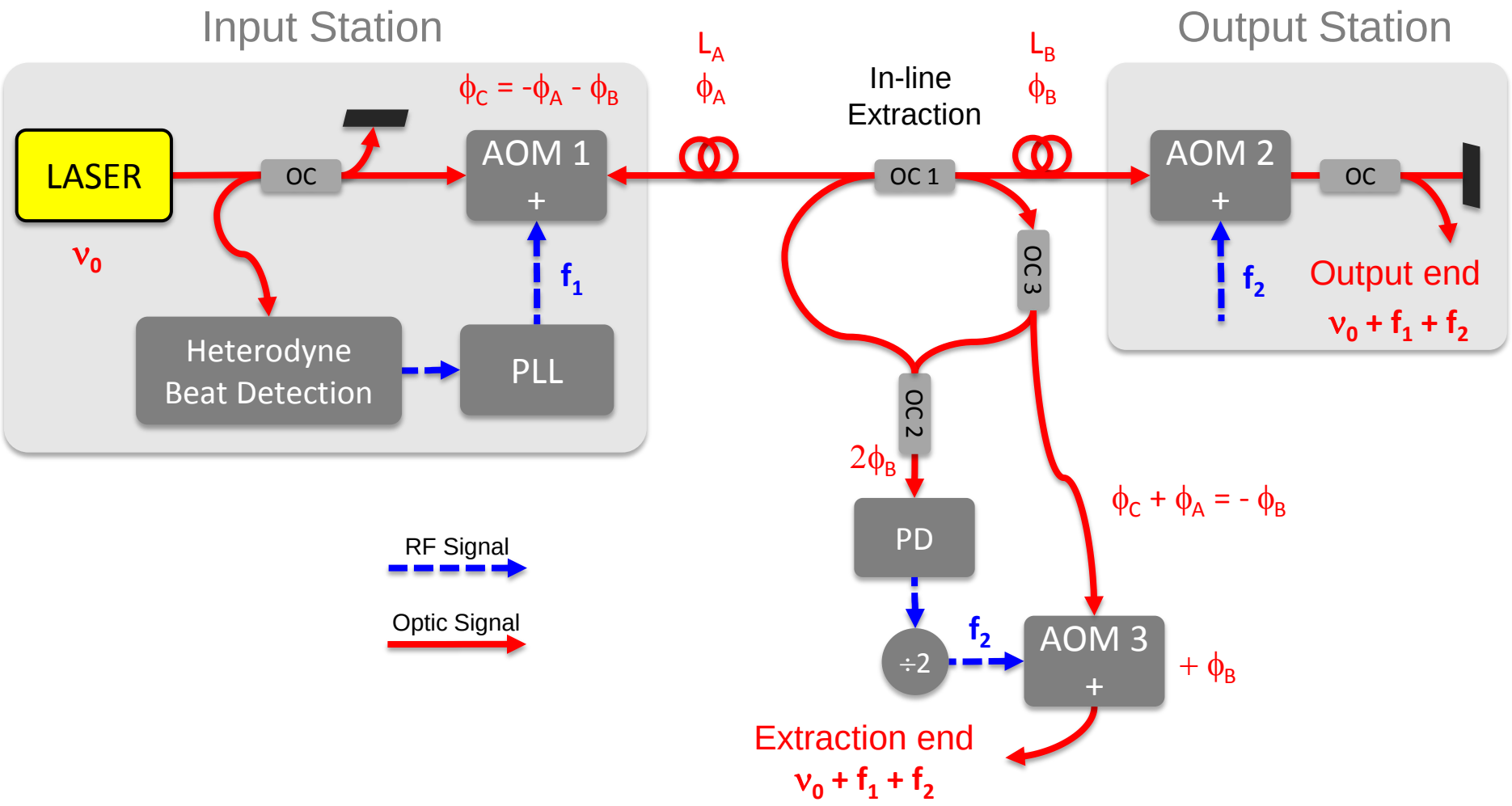
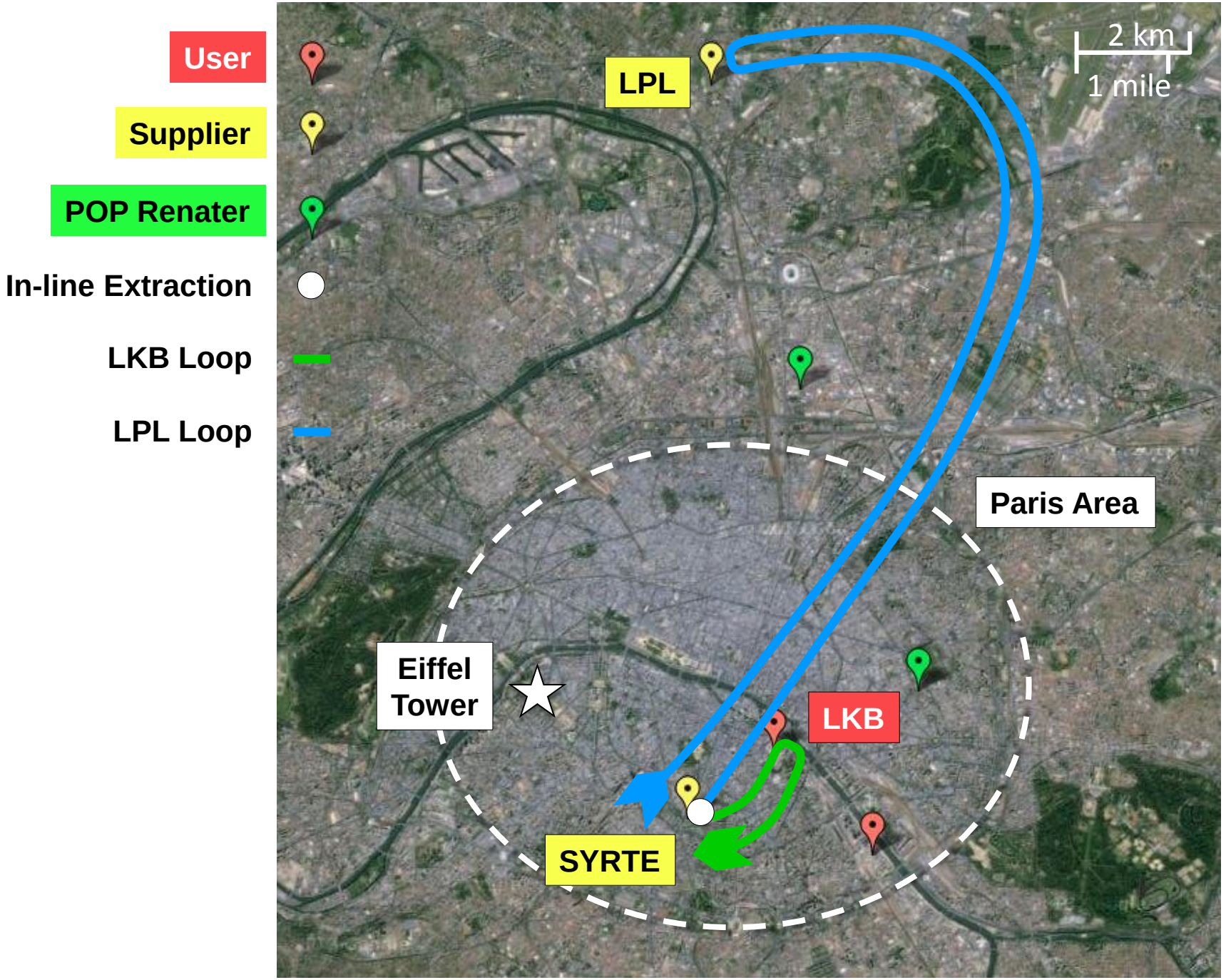
FIRST SETUP

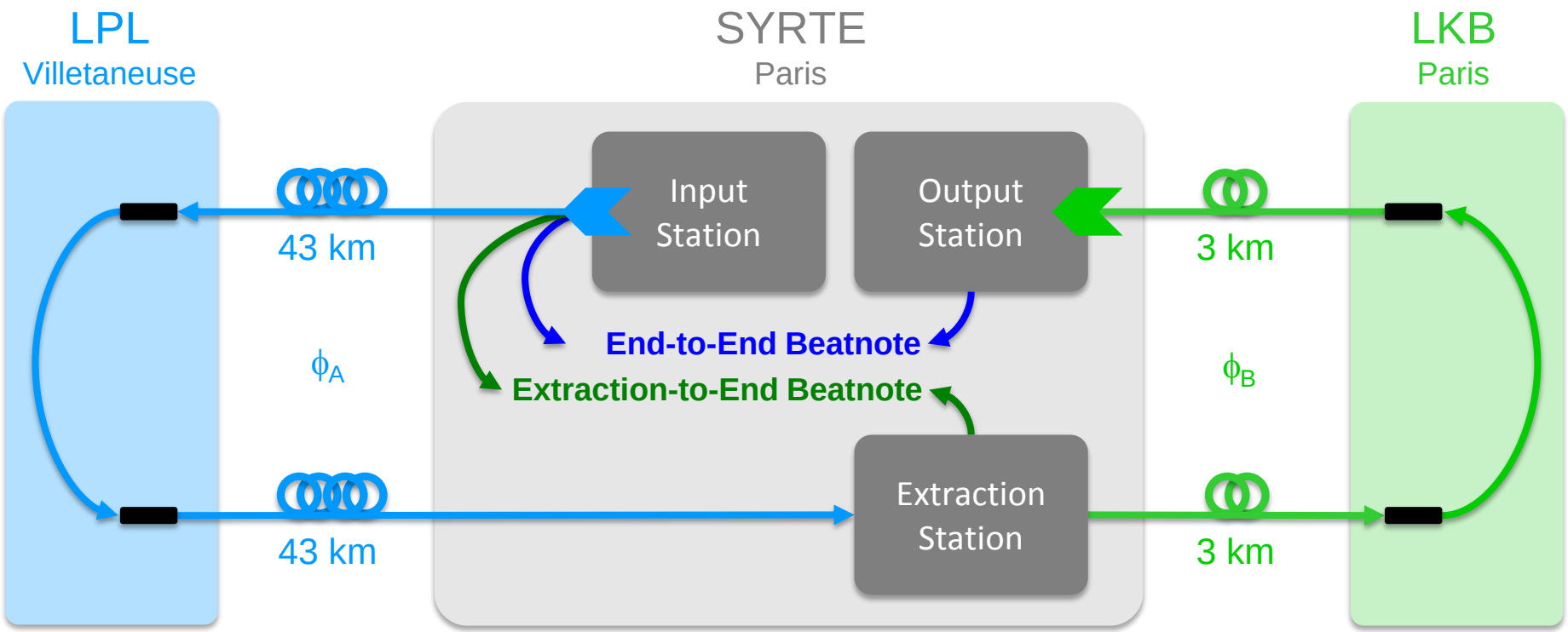

Input Station
Output Station
LASER
OC
AOM 1
+
AOM 2
+
OC
OC 1
In-line
Extraction
Heterodyne
Beat Detection
PLL
ν_0
f_1
f_2
$\phi_C = -\phi_A - \phi_B$
L_A
ϕ_A
L_B
ϕ_B
Output end
$\nu_0 + f_1 + f_2$
$\phi_C + \phi_A = -\phi_B$
RF Signal
Optic Signal
Extraction end

FIRST SETUP

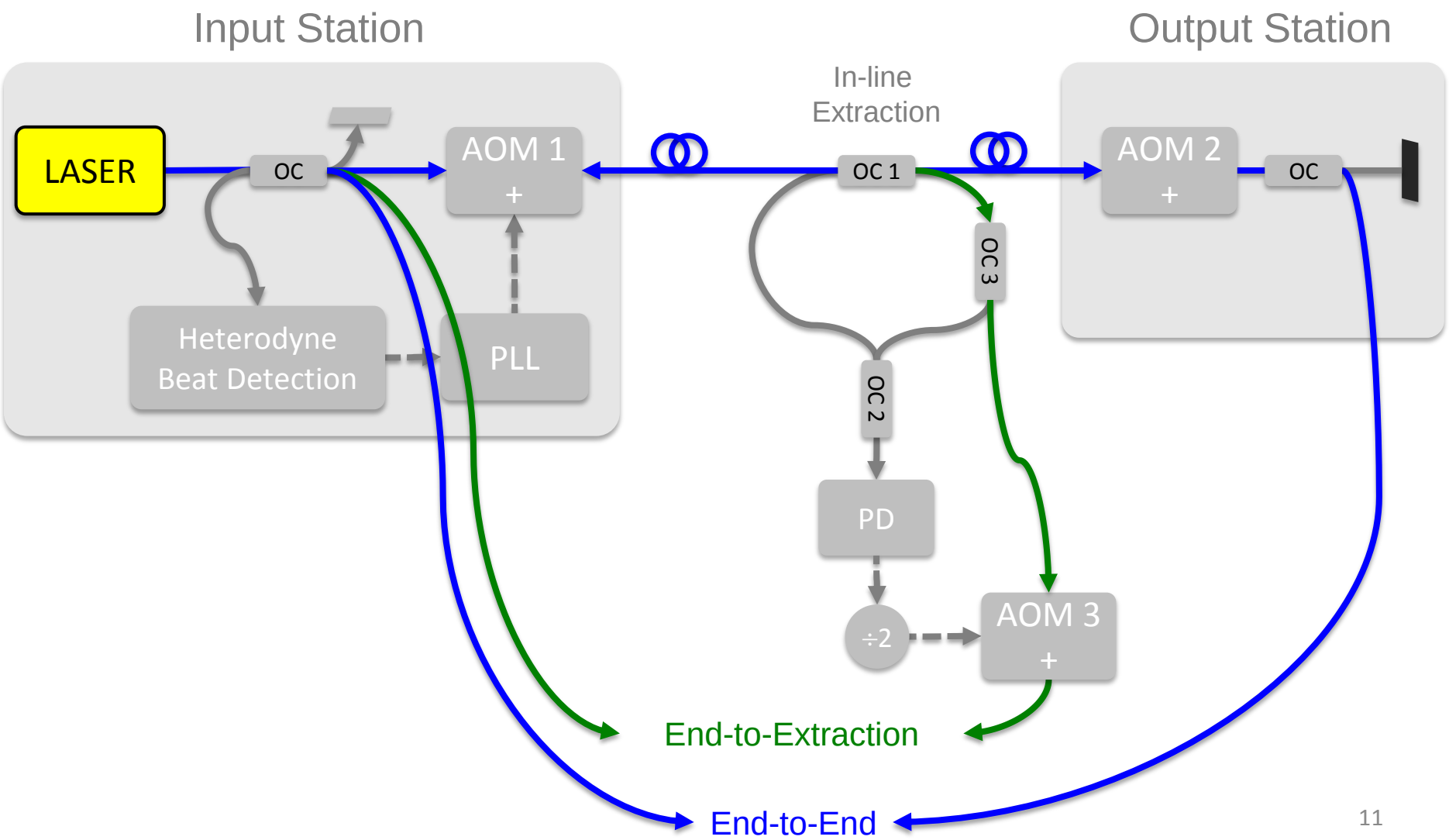

Input Station
Output Station
L_A
ϕ_A
L_B
ϕ_B
In-line
Extraction
$\phi_C = -\phi_A - \phi_B$
LASER
ν_0
OC
AOM 1
+
f_1
Heterodyne
Beat Detection
PLL
OC 1
OC 3
OC 2
$2\phi_B$
PD
÷2
f_2
AOM 2
+
OC
f_2
Output end
$\nu_0 + f_1 + f_2$
$\phi_C + \phi_A = -\phi_B$
AOM 3
+
$+\phi_B$
Extraction end
$\nu_0 + f_1 + f_2$
RF Signal
Optic Signal


User
Supplier
POP Renater
In-line Extraction
LKB Loop
LPL Loop
LPL
2 km
1 mile
Paris Area
Eiffel Tower
LKB
SYRTE

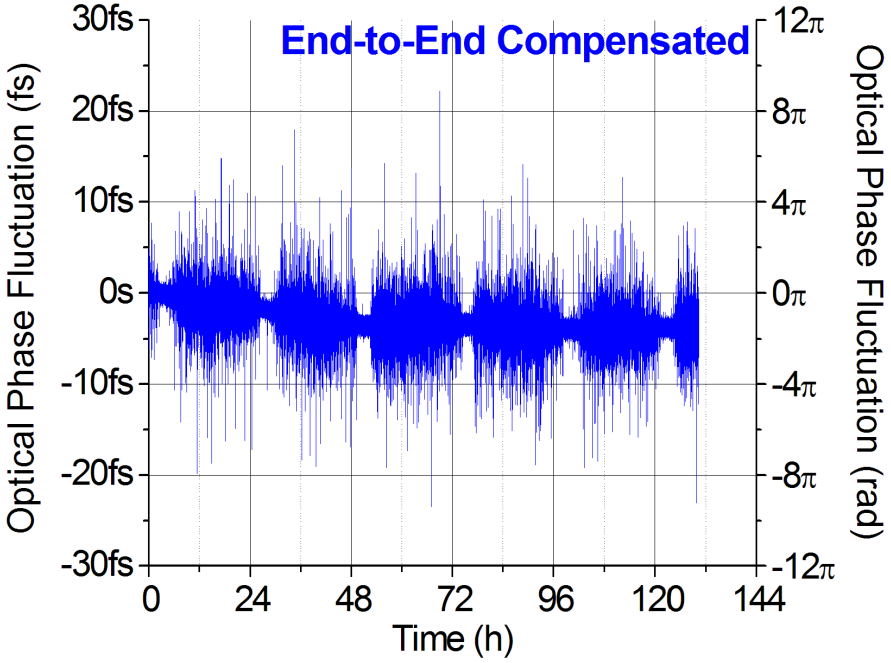
EXPERIMENTAL SETUP

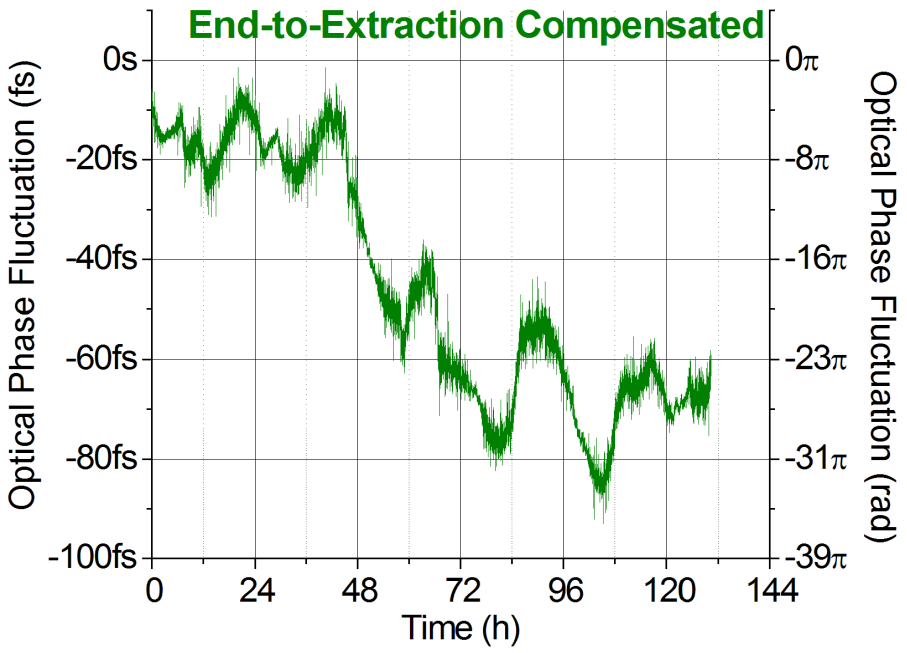


FIRST SETUP

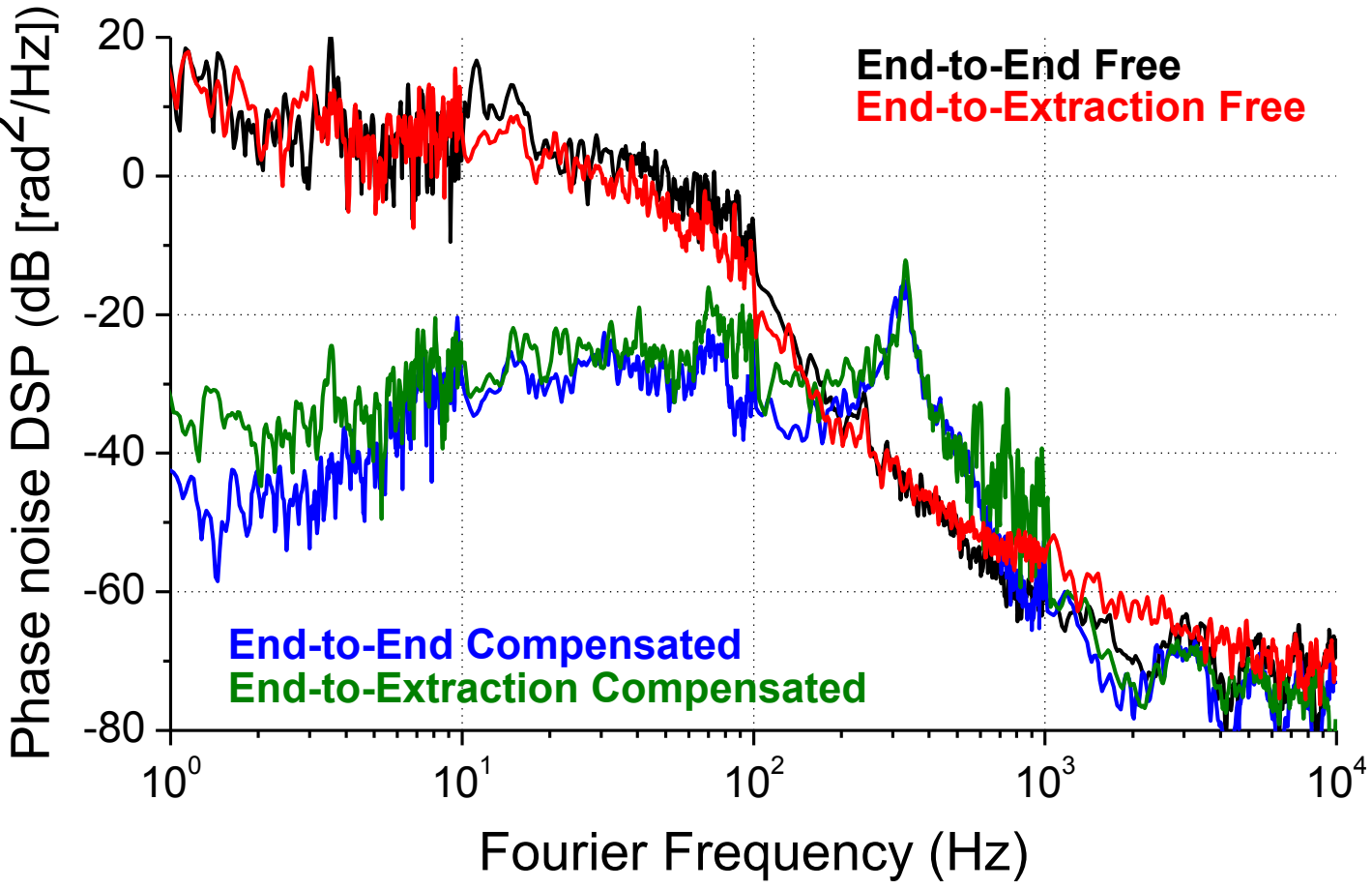

Input Station
Output Station
In-line
Extraction
LASER
OC
AOM 1
+
Heterodyne
Beat Detection
PLL
OC 1
OC 3
OC 2
PD
÷2
AOM 3
+
AOM 2
+
OC
End-to-Extraction
End-to-End

PHASE


End-to-End Compensated
Optical Phase Fluctuation (fs)
30fs
20fs
10fs
0s
-10fs
-20fs
-30fs
Optical Phase Fluctuation (rad)
12π
8π
4π
0π
-4π
-8π
-12π
0
24
48
72
96
120
144
Time (h)

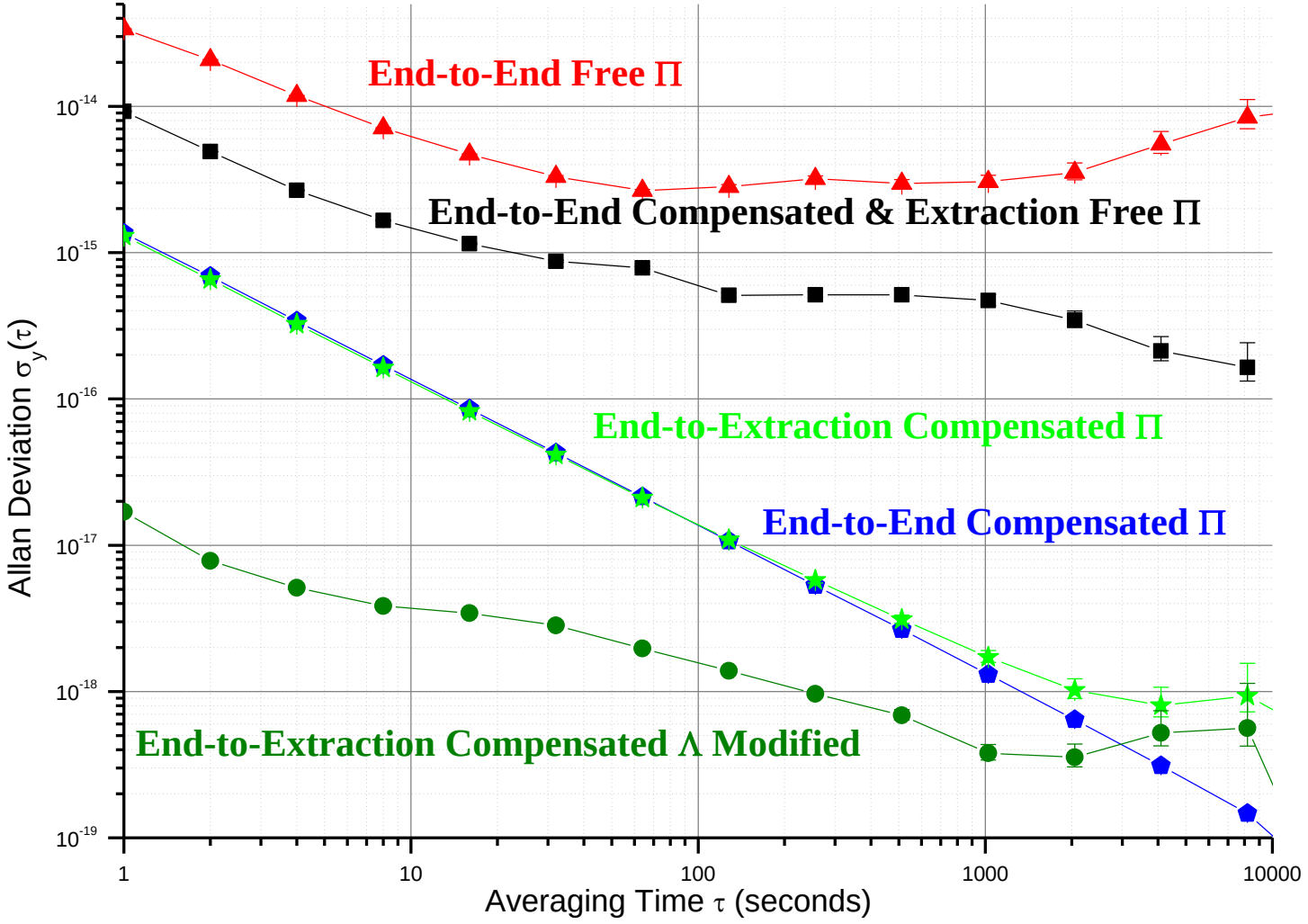

End-to-Extraction Compensated
Optical Phase Fluctuation (fs)
0s
-20fs
-40fs
-60fs
-80fs
-100fs
Optical Phase Fluctuation (rad)
0π
-8π
-16π
-23π
-31π
-39π
0
24
48
72
96
120
144
Time (h)

PHASE NOISE

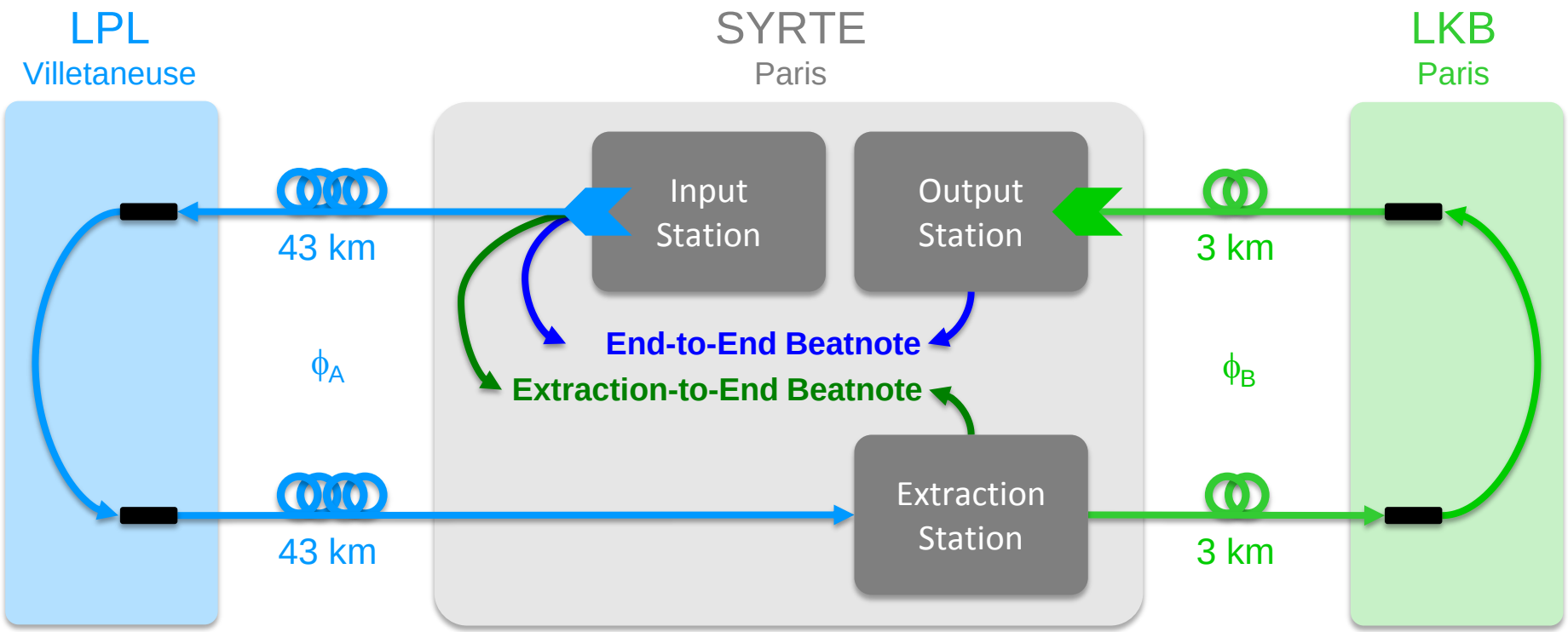

Phase noise DSP (dB [rad^2/Hz])
20
0
-20
-40
-60
-80
10^0
10^1
10^2
10^3
10^4
Fourier Frequency (Hz)
End-to-End Free
End-to-Extraction Free
End-to-End Compensated
End-to-Extraction Compensated

FREQUENCY STABILITY

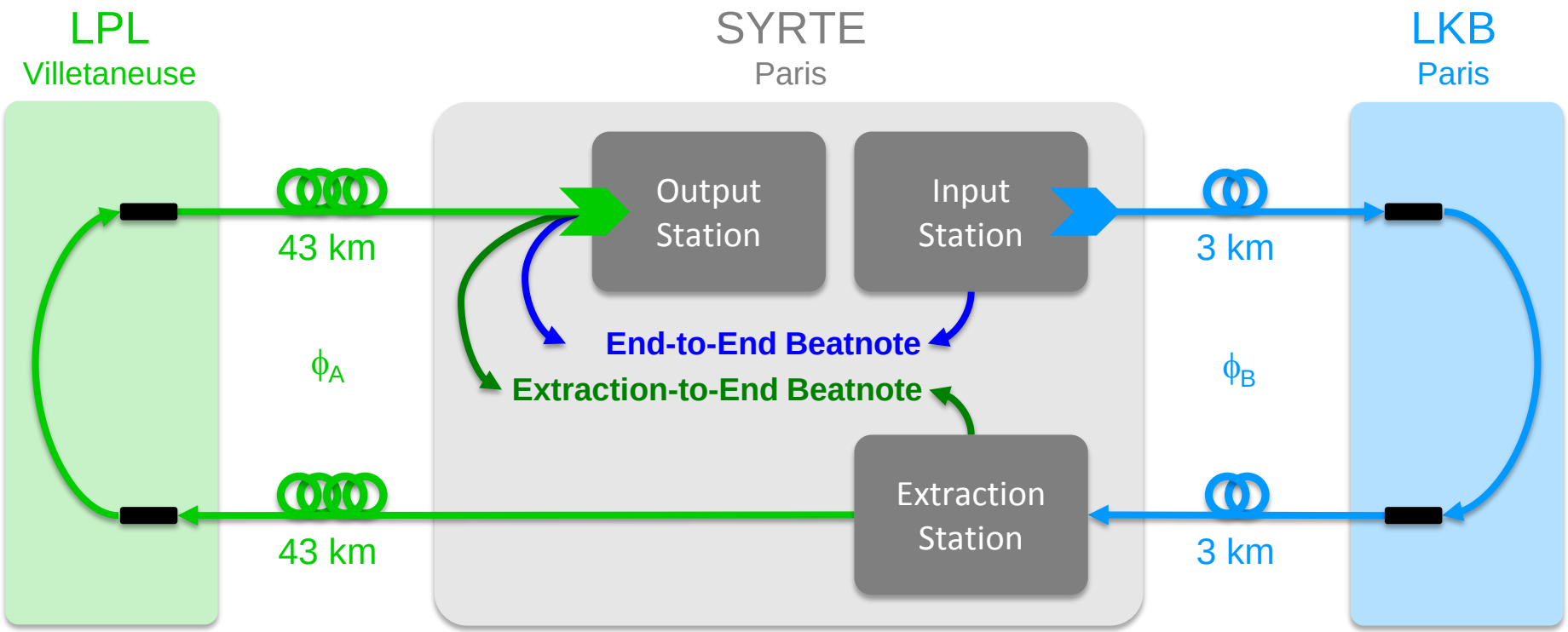
In-line Extraction @ 86 km



EXPERIMENTAL SETUP

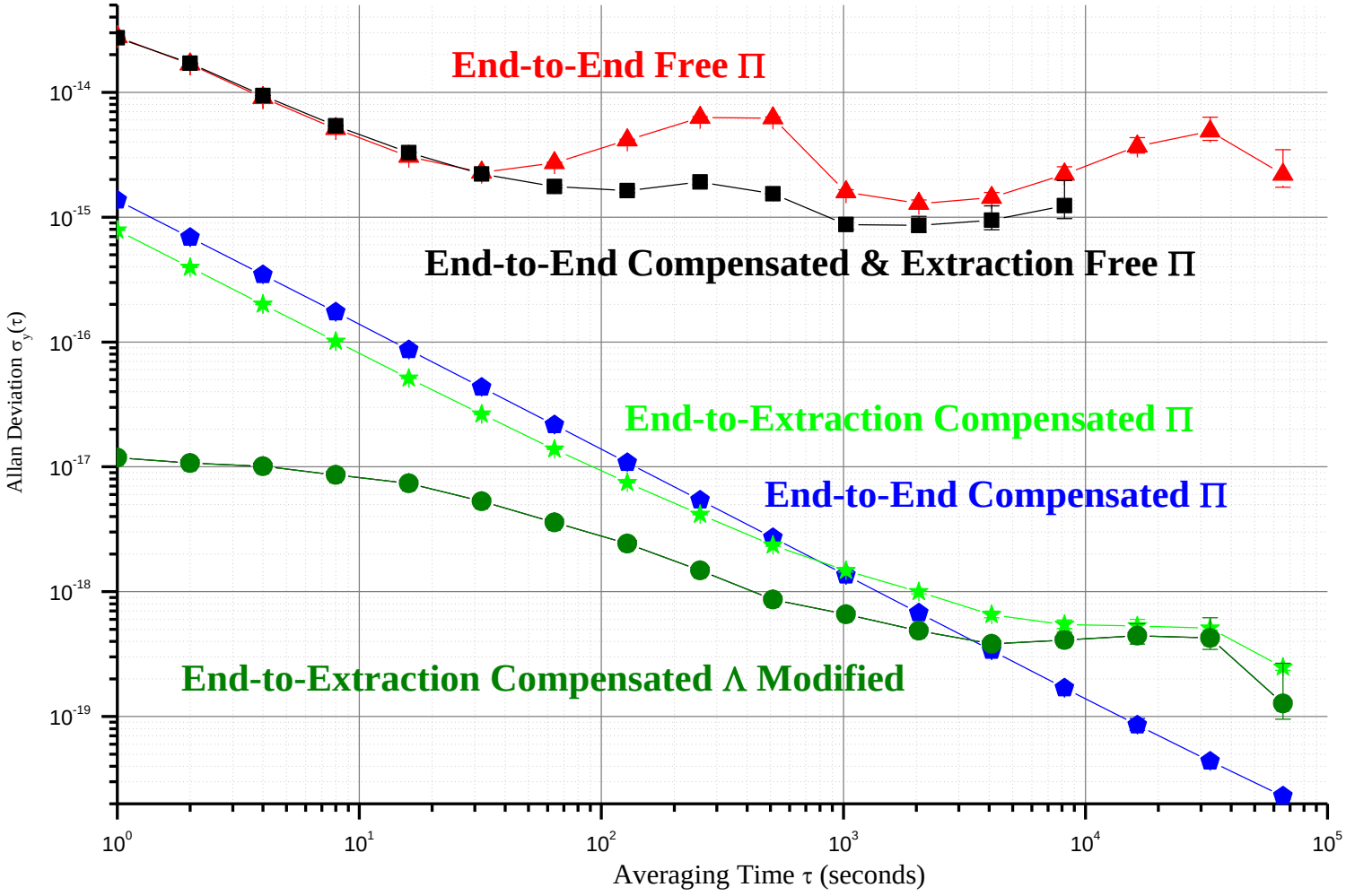


EXPERIMENTAL SETUP



FREQUENCY STABILITY

In-line Extraction @ 6 km



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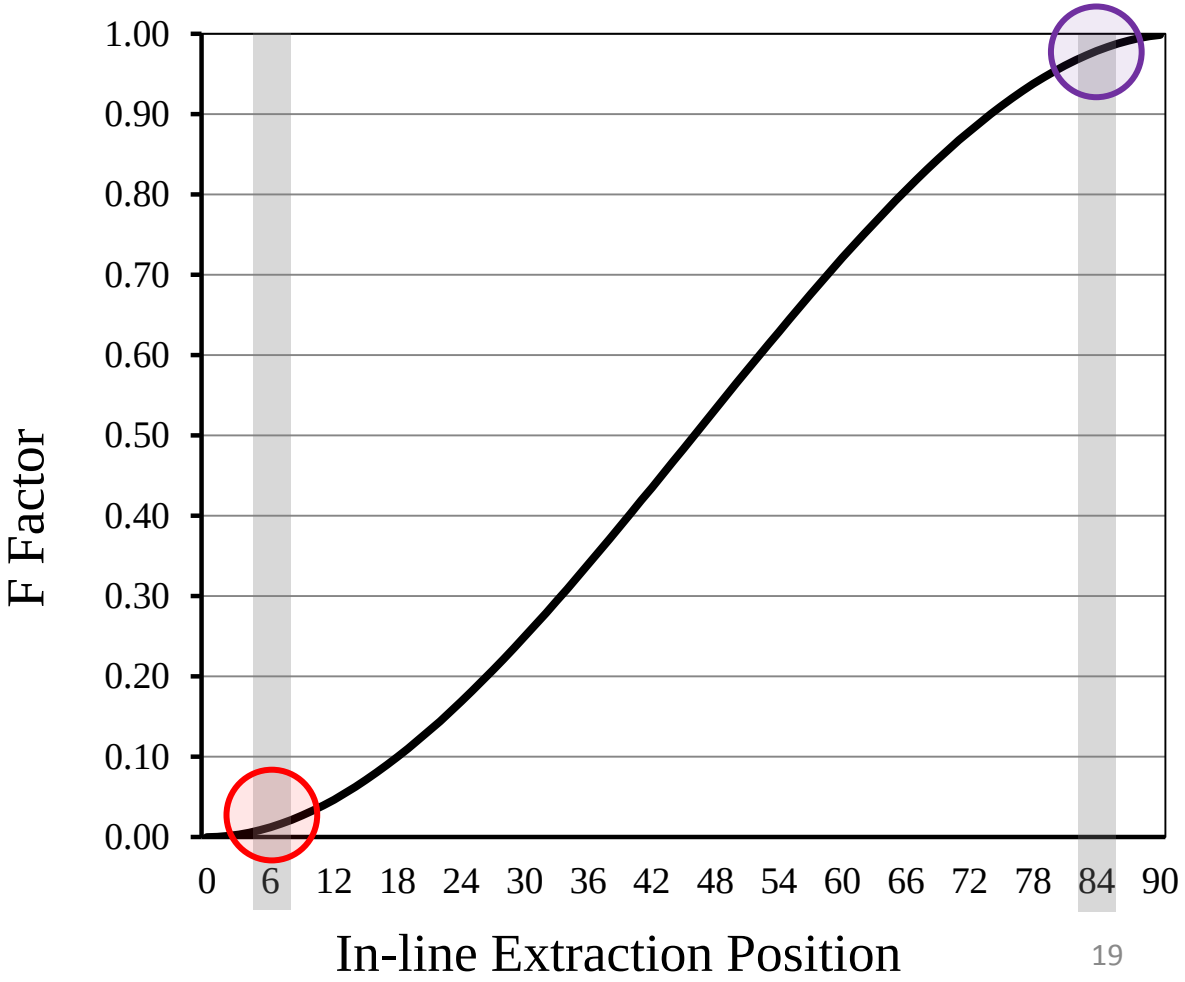
FACTEUR DE GAIN SUR LA COMPENSATION DU BRUIT

PSD Bruit de Phase en extraction

$$S_E(f) = F \times S_O(f)$$

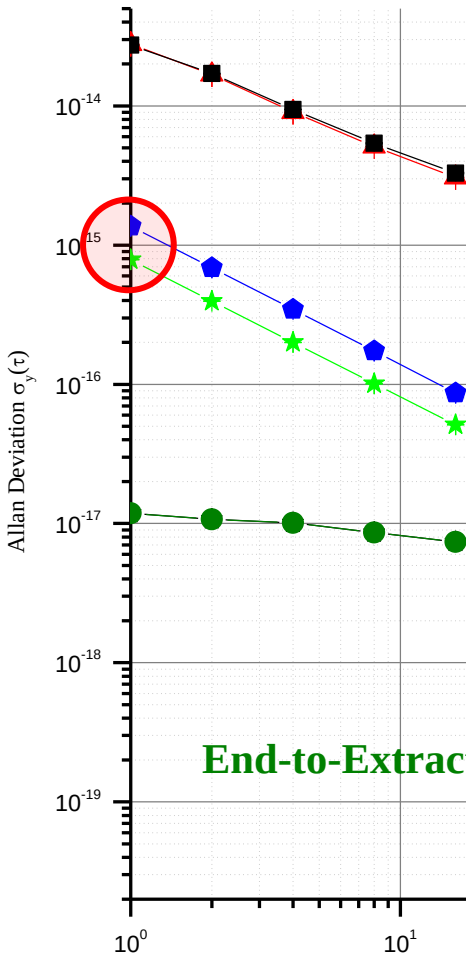
PSD Bruit de Phase en extrémité du lien

$$F = \left(\frac{L_A}{L}\right)^2 \left(3 - 2\frac{L_A}{L}\right)$$

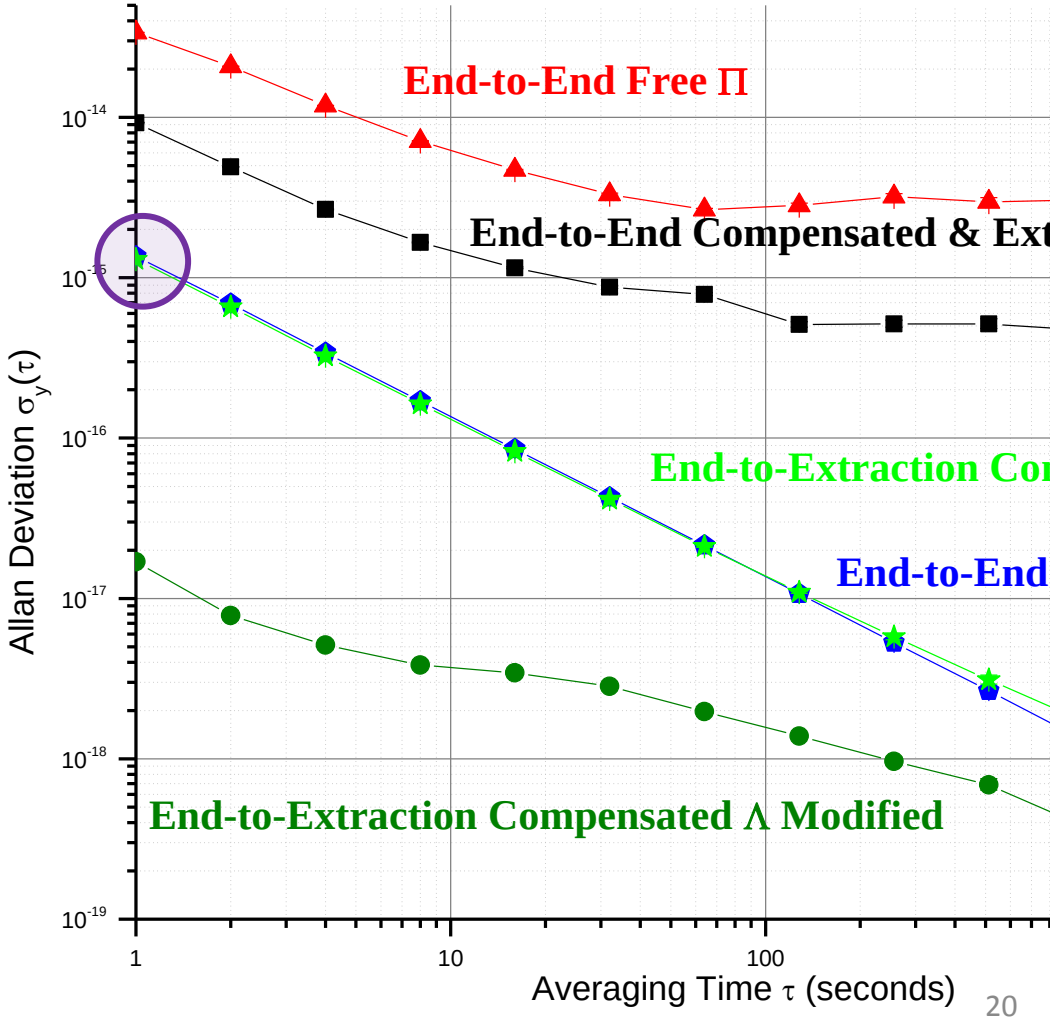


FREQUENCY STABILITY

In-line Extraction @ 6 km



In-line Extraction @ 86 km



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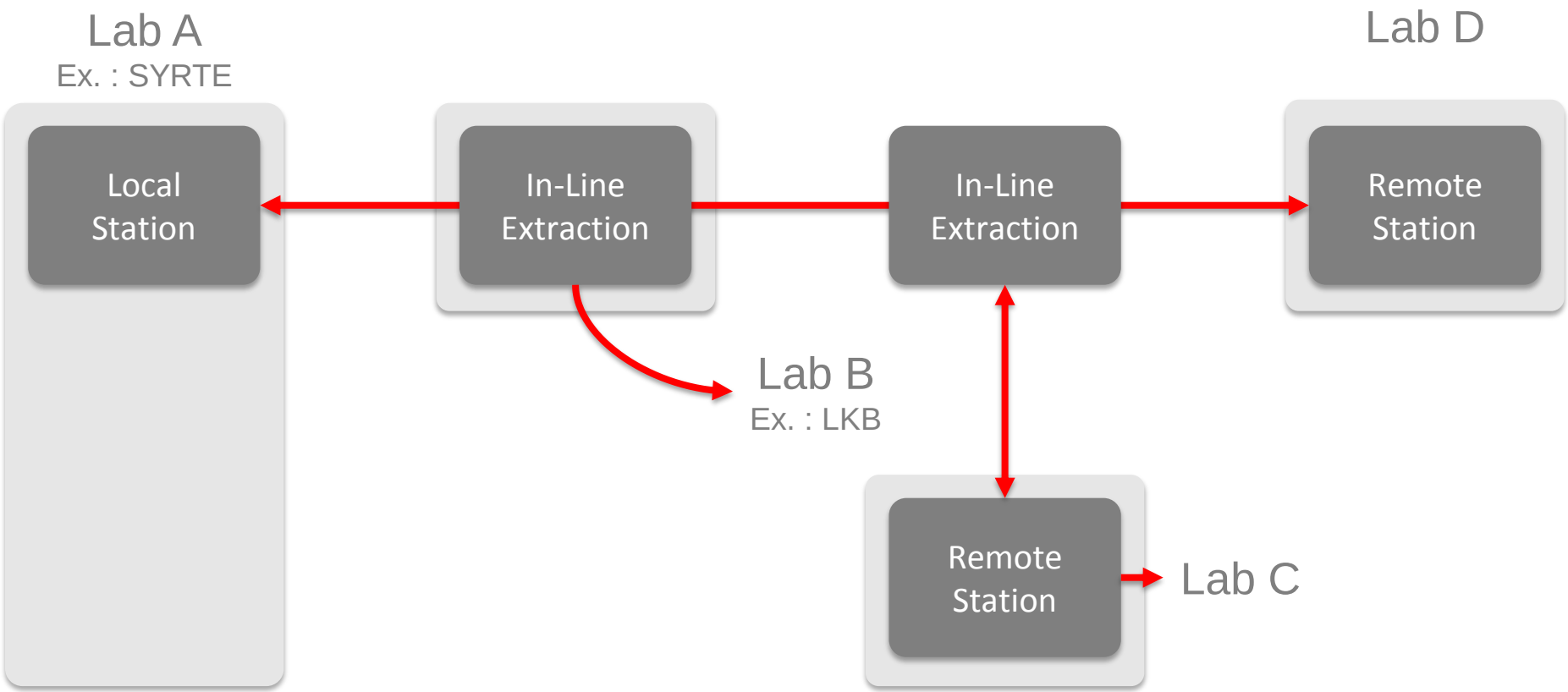

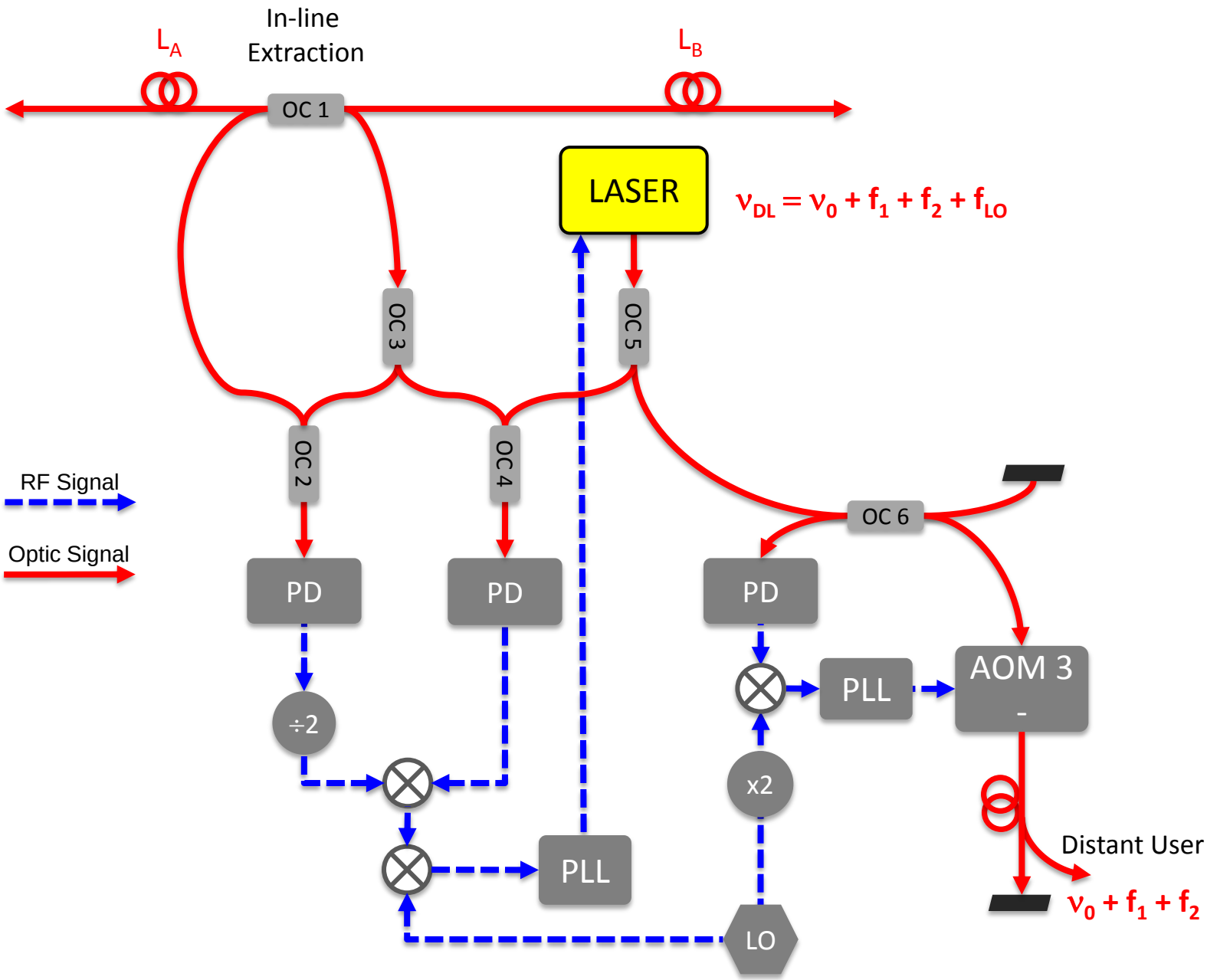
In-line
Extraction
L_A
L_B
OC 1
LASER
$\nu_{DL} = \nu_0 + f_1 + f_2 + f_{LO}$
OC 3
OC 5
OC 2
OC 4
OC 6
RF Signal
Optic Signal
PD
PD
PD
÷2
PLL
AOM 3
-
x2
PLL
LO
Distant User
$\nu_0 + f_1 + f_2$

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DEMONSTRATION OF SIMPLE AND EFFICIENT EXTRACTION SETUP (Bercy et al, JosaB 2014)

ALSO RF/OPTICAL EXTRACTION **on fiber spools** (Grosche, OL 2014, Gao et al, OL 2012 et Bai et al, OL 2013) **and RF link** (Krehlik et al I3E UFFC 2013)

IN PROGRESS

Length adjustment
Fibers length adjusted in extraction interferometry

Thermal box
To stabilize the reference arm of the interferometry

Automatic re-lock

Diode laser
To disseminate a frequency with more optical power

Secondary link
To disseminate a frequency far away