Des diodes Schottky THz françaises pour l'astrophysique, la planétologie et l'étude de l'atmosphère : *gains récents en sensibilité et montée en fréquence*

Lina Gatilova[1&2], *A. Maestrini*[1], *J. Treuttel*[1] *D. Moro Melgar*[1], *T. Vacelet*[1], *Y. Jin*[2], *A. Cavanna*[2], *L. Couraud*[2], *A. Féret*[1], *G. Gay*[1], *S. Caroopen*[1], *J. Valentin*[1], *S. Mignoni*[1], *J-M. Krieg*[1], *C. Goldstein*[3]

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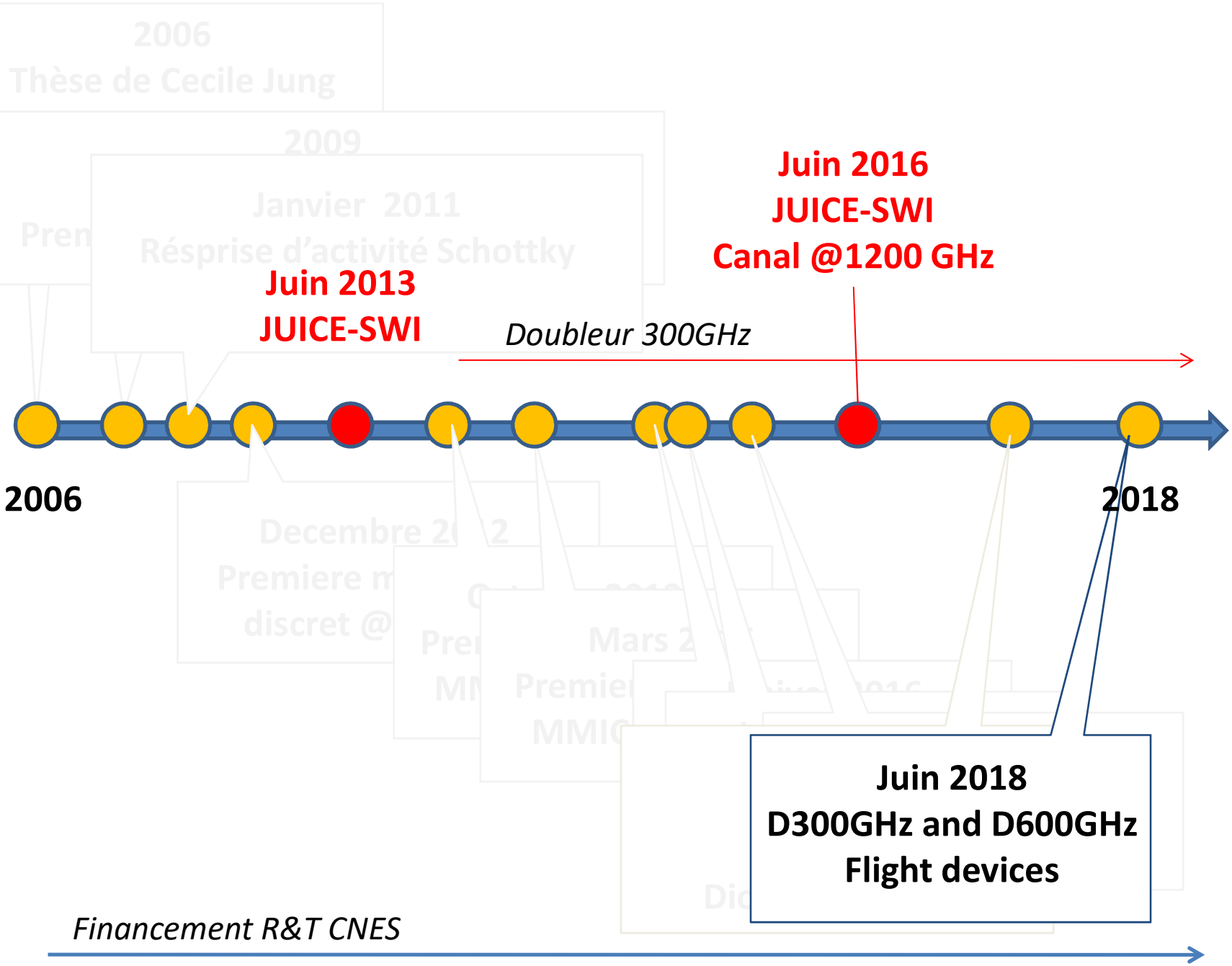
(2) C2N-CNRS Centre de Nanotechnologie et de Nanoscience, Palaiseau, France

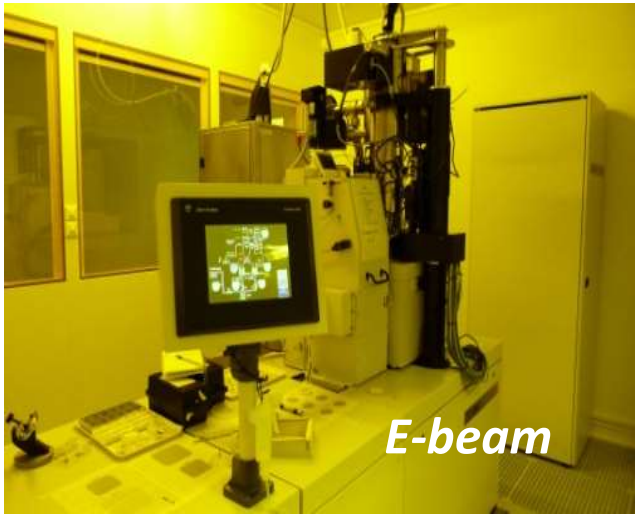
(3) Centre National d'Etudes Spatiales, 18 avenue Edouard Belin, F-31401 Toulouse cedex 9, France

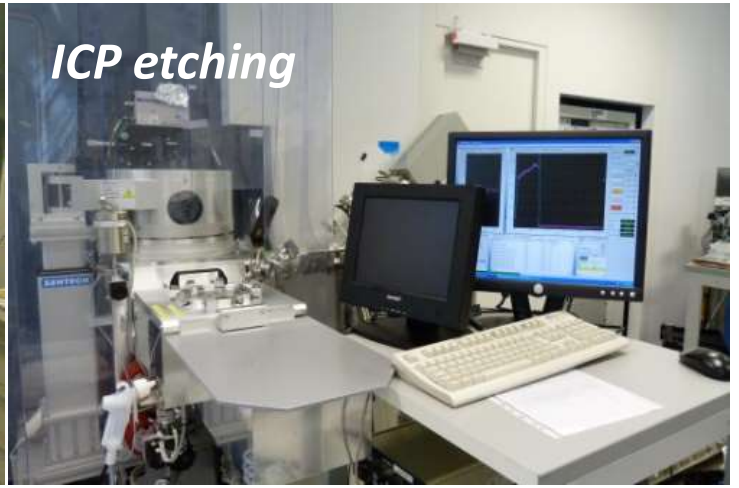

Juin 2016
JUICE-SWI
Canal @1200 GHz
Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Juin 2018
D300GHz and D600GHz
Flight devices
Financement R&T CNES

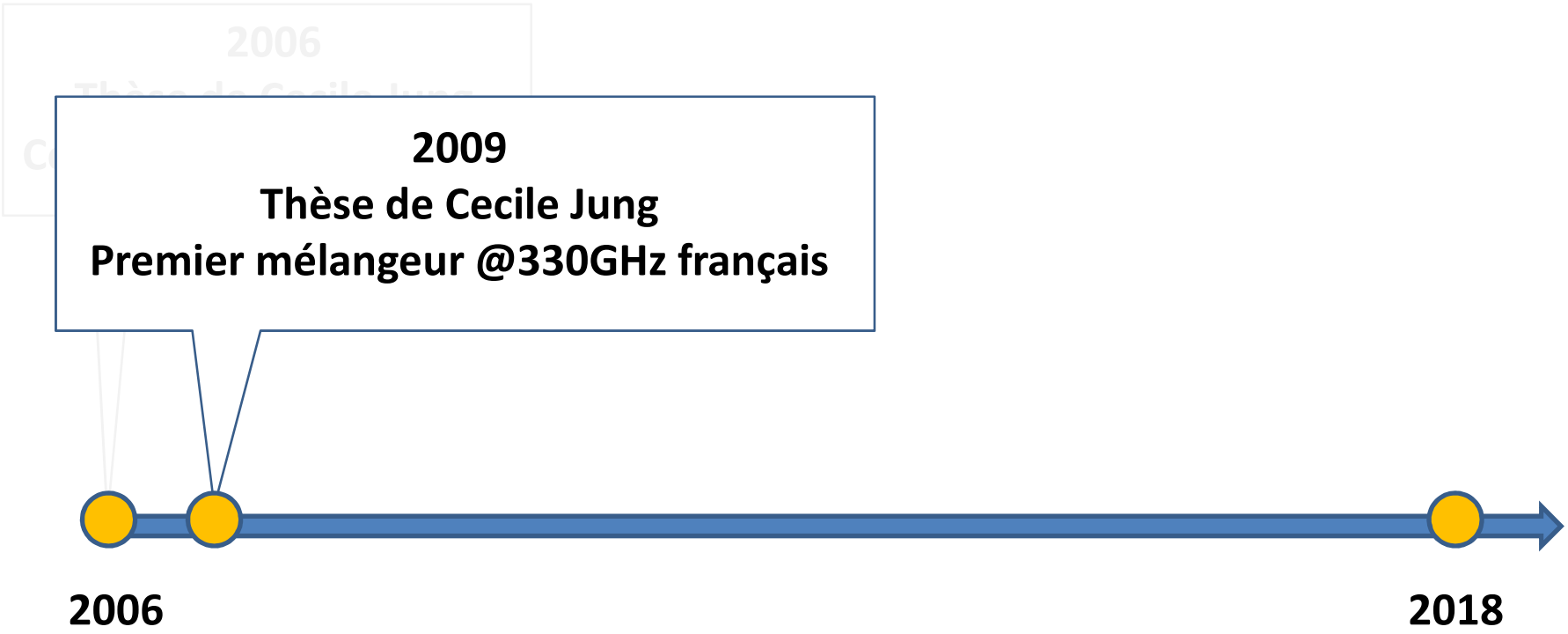
- Collaboration LERMA (A. Maestrini) – C2N (Y. Jin) – CNES (C. Goldstein)
- Financement CNES
- Dévéloppement de procédé de fabrication

C2N's Clean room Facilities

~ 1000 m² (ISO class 7, 5, 4)

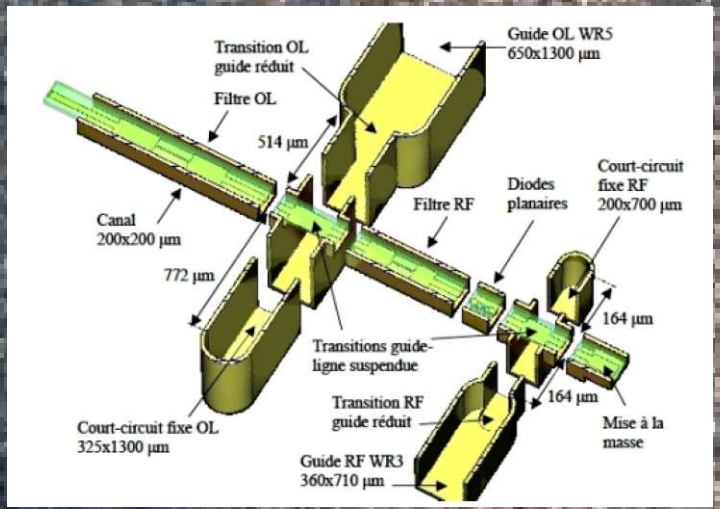


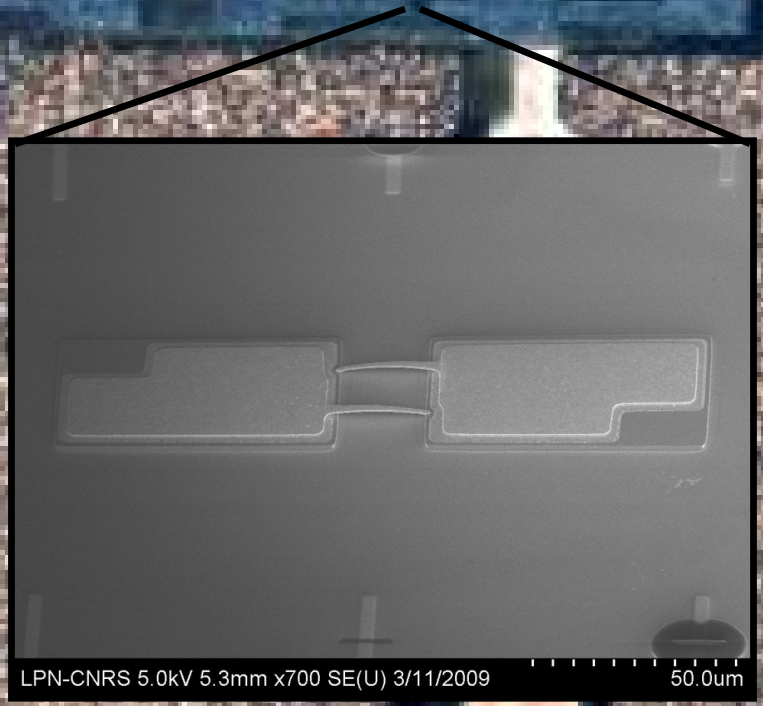



2009
Thèse de Cecile Jung
Premier mélangeur @330GHz français
2006
2018

Premières diodes discretes pour le mélangeur @330 GHz

@330GHz et 300 K
T_{mixer} = 2000 K
Conversion Loss = 10 dB



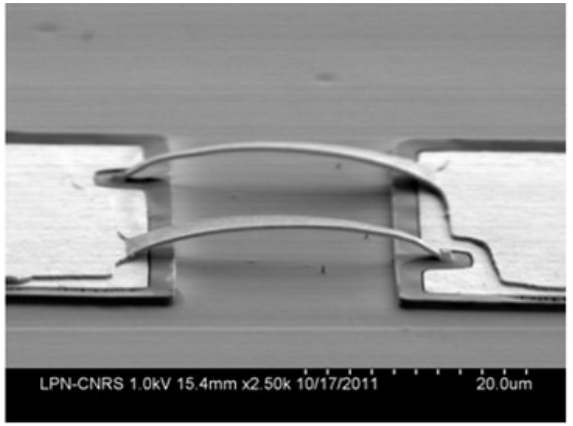


2006
Thèse de Cecile Jung

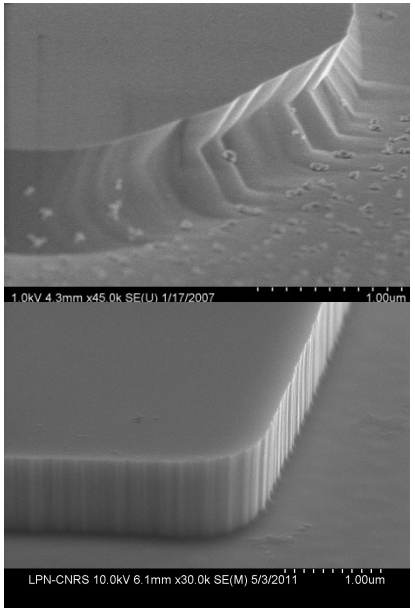
2009

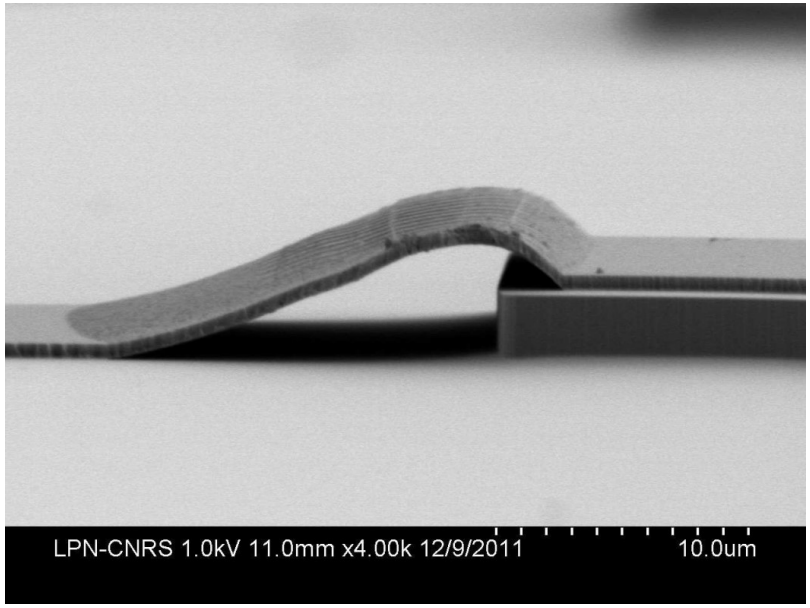
Premie

Janvier 2011
Reprise d'activité Schottky



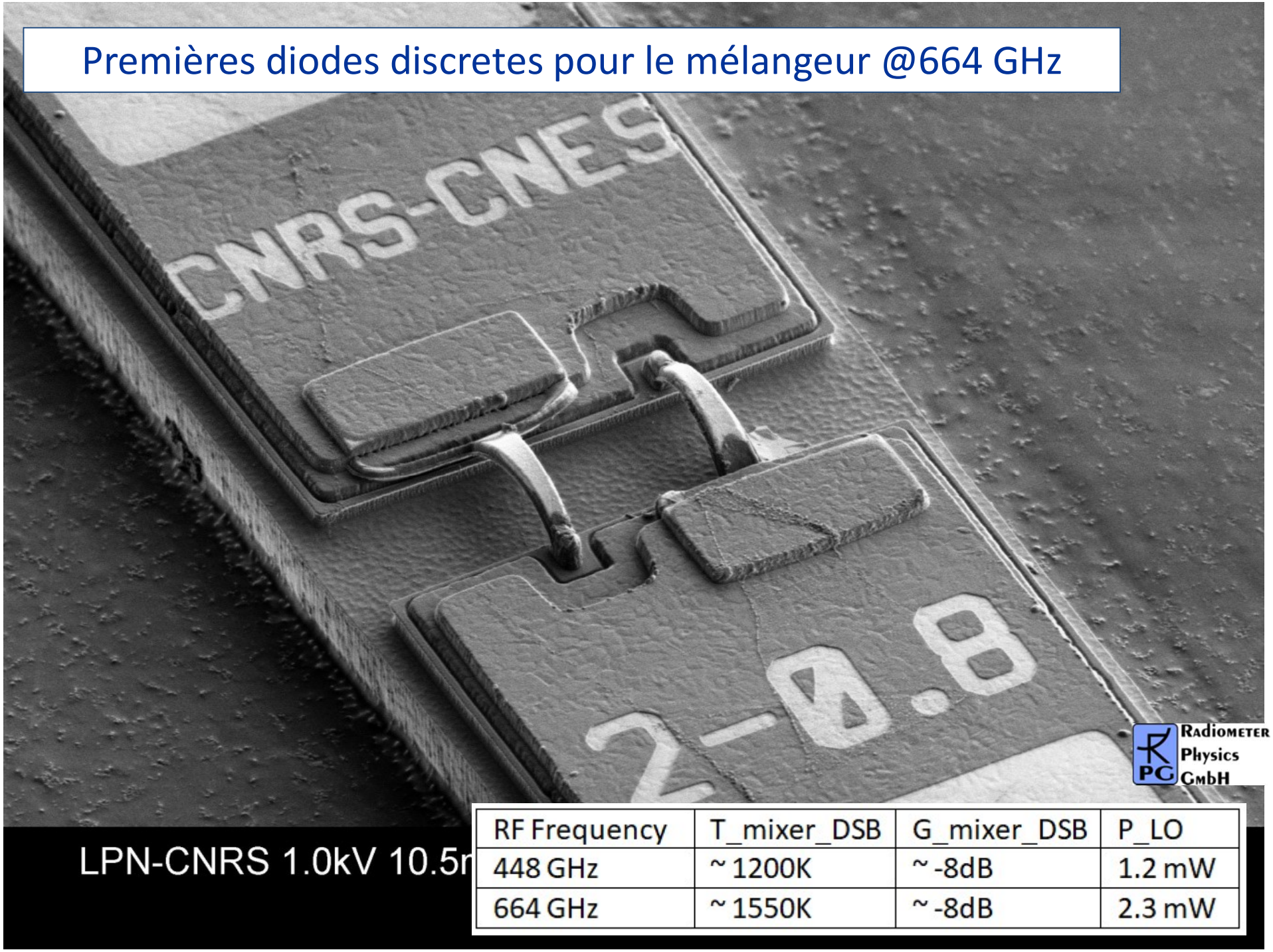
2006 **2018**






2006
Thèse de Cecile Jung
2009
Janvier 2011
Réprise d'activité Schottky
2006
2018
Décembre 2012
Première diodes discretes
pour le mélangeur @664 GHz

Premières diodes discretes pour le mélangeur @664 GHz



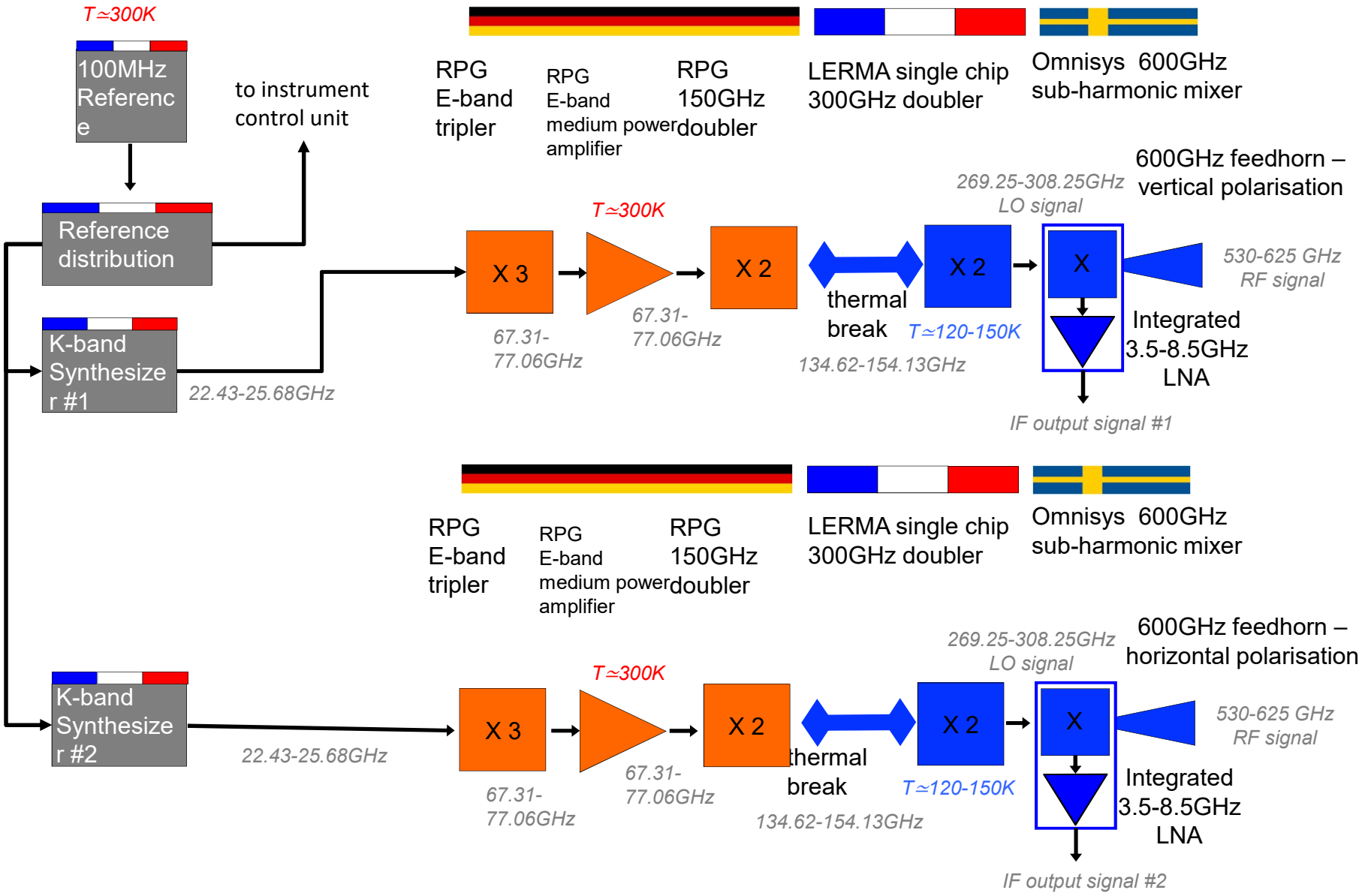
Radiometer Physics GmbH

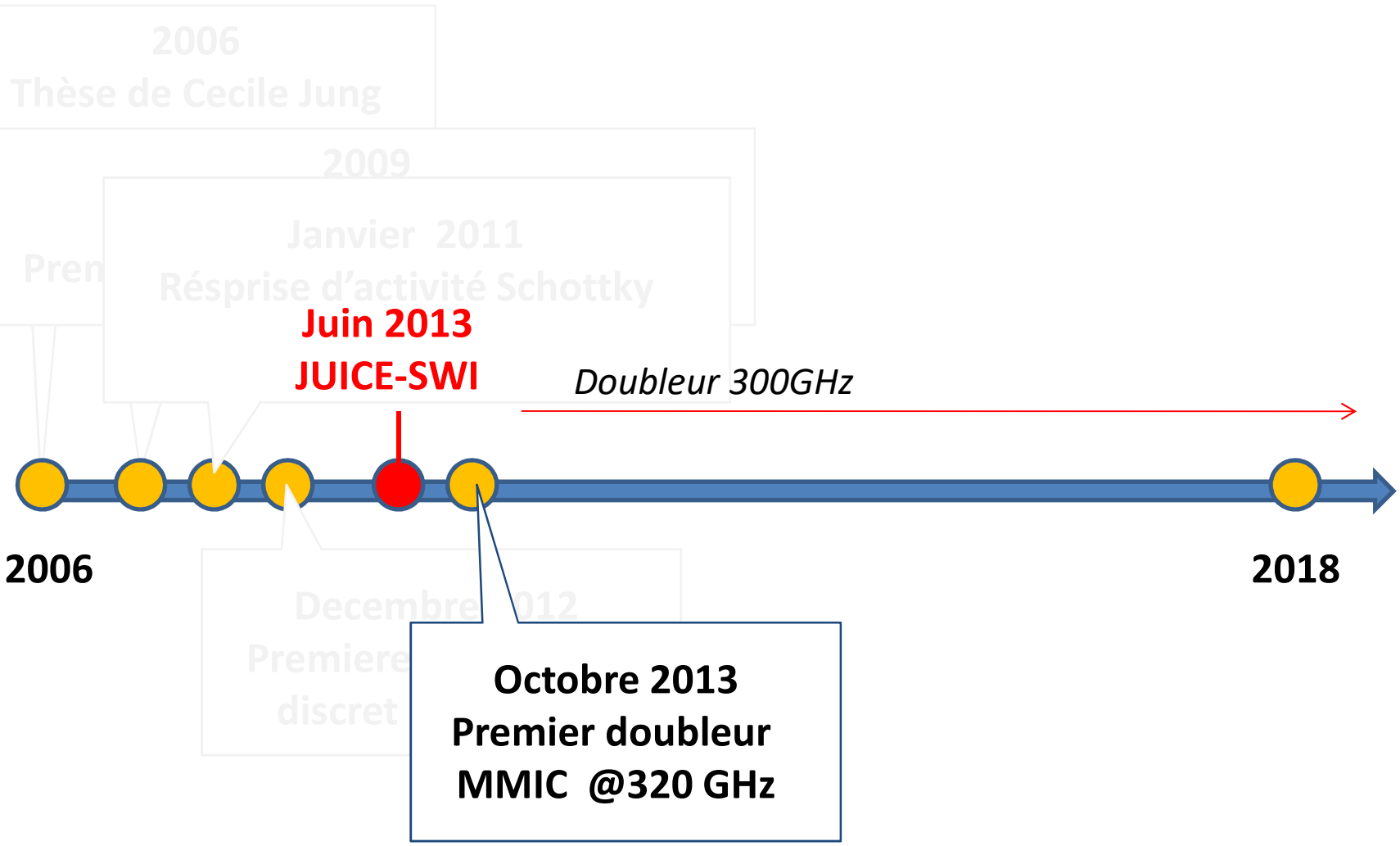
RF Frequency	T_mixer_DSB	G_mixer_DSB	P_LO
448 GHz	~ 1200K	~ -8dB	1.2 mW
664 GHz	~ 1550K	~ -8dB	2.3 mW

Juin 2013
JUICE-SWI

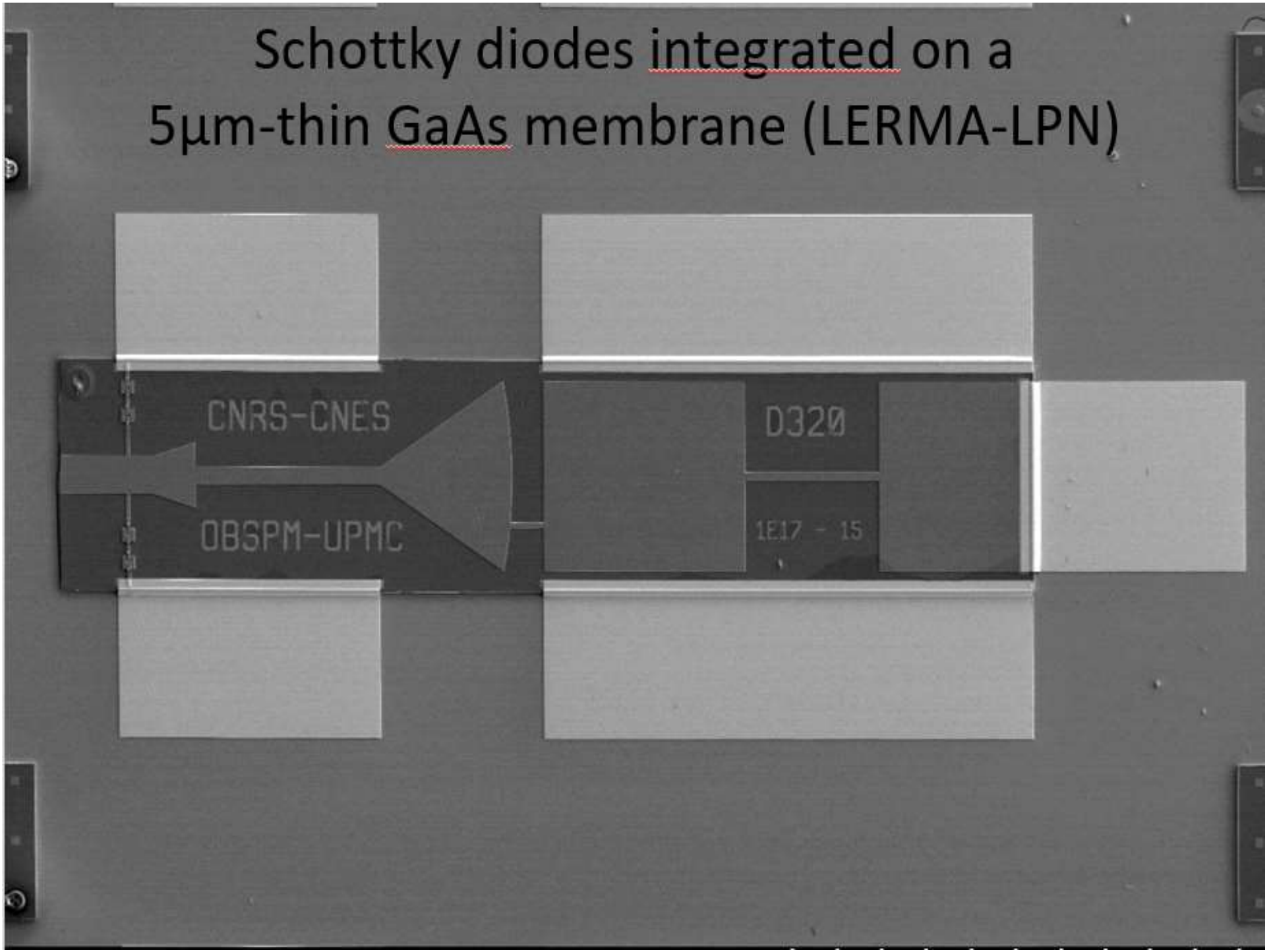
2006 **2018**

JUICE-SWI front-end configuration from June 2013 until June 2016



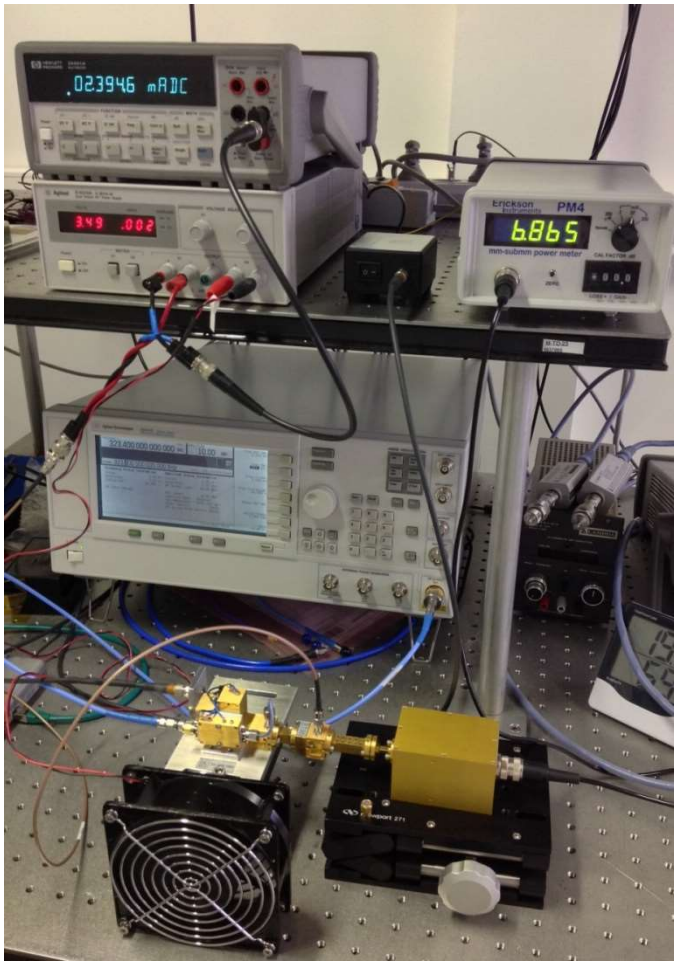

2006
Thèse de Cecile Jung
2009
Janvier 2011
Réprise d'activité Schottky
Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Octobre 2013
Premier doubleur
MMIC @320 GHz

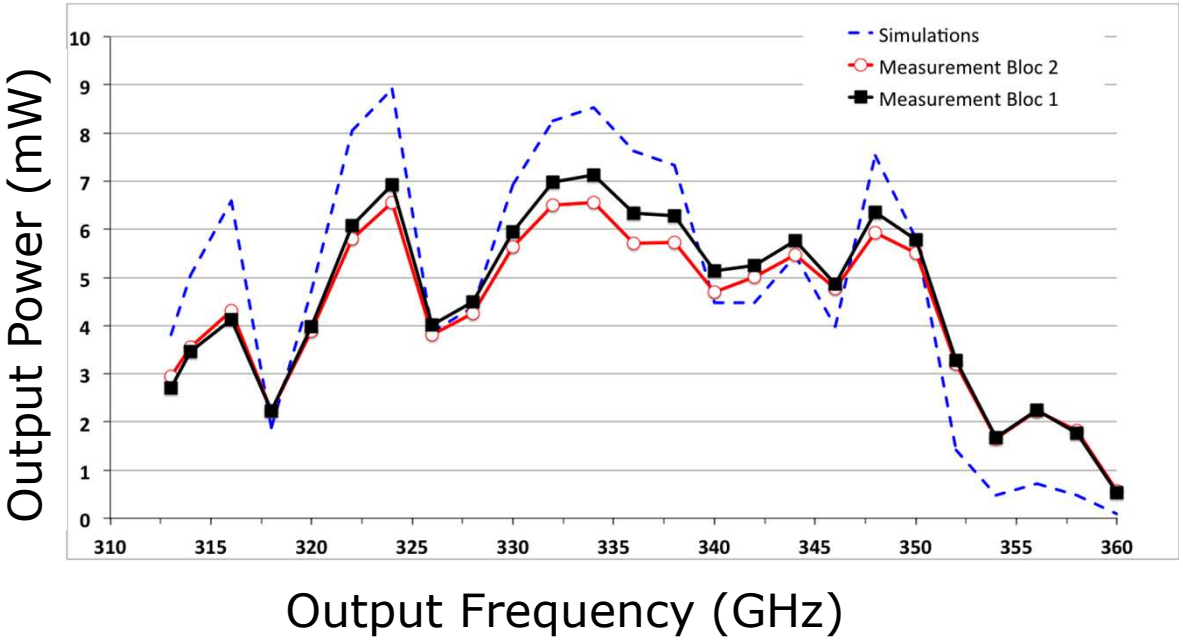
Schottky diodes integrated on a 5µm-thin GaAs membrane (LERMA-LPN)

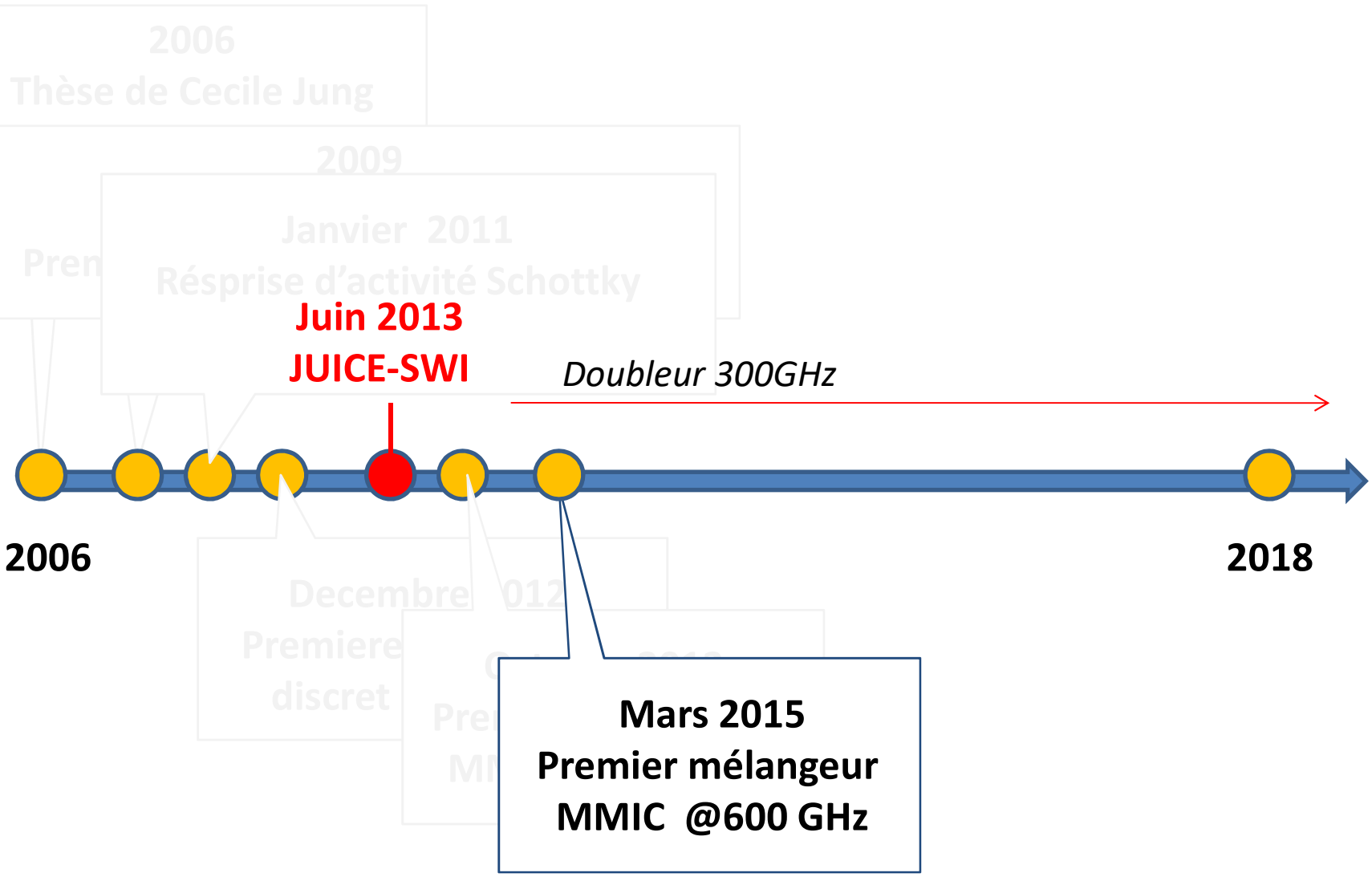


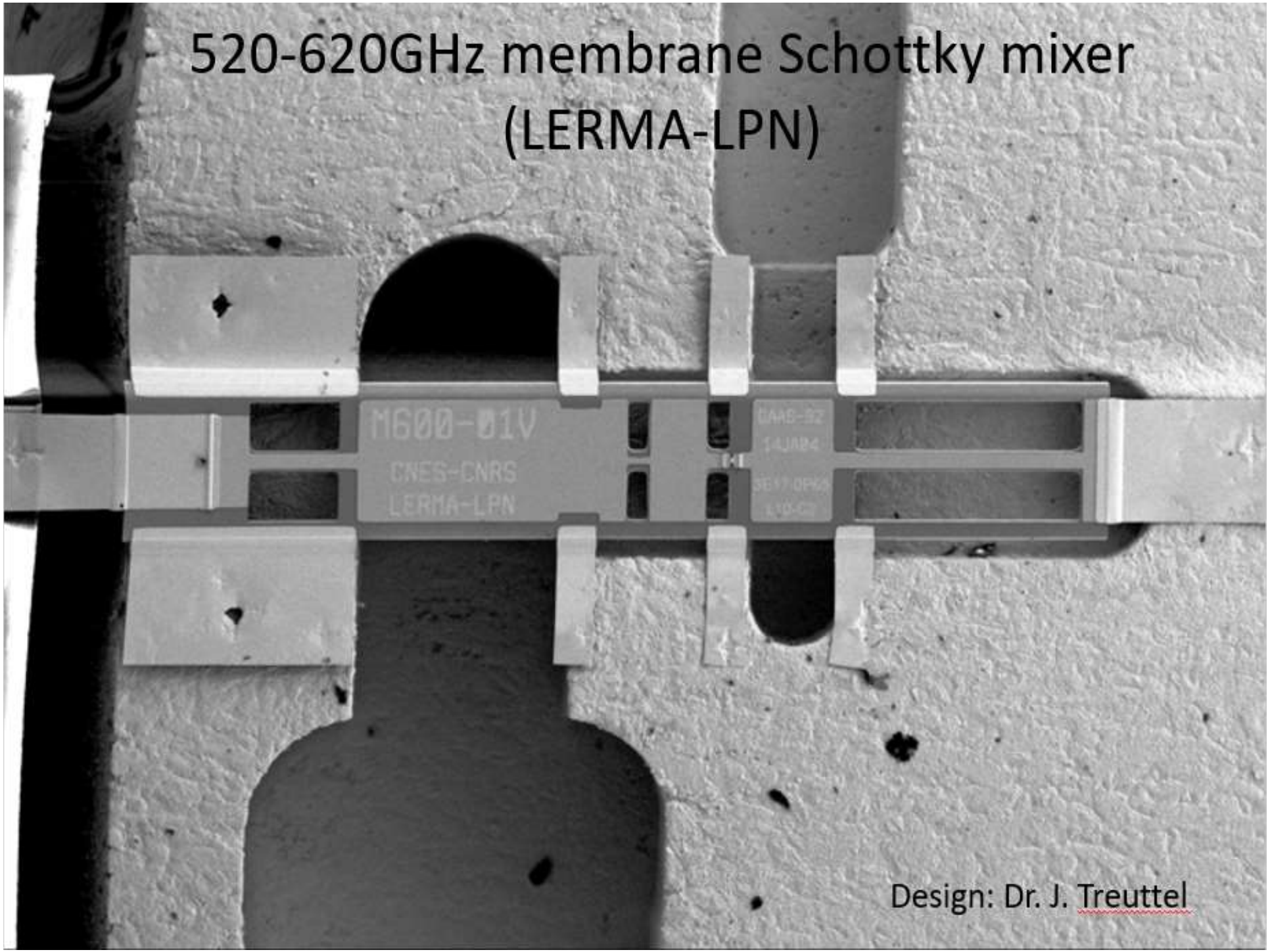
Doubler @300GHz : RF test

- Conversion efficiency ~ 15-22% @ 310-360GHz
- ~1600 hours of continuous operation at 45mW – no sign of aging



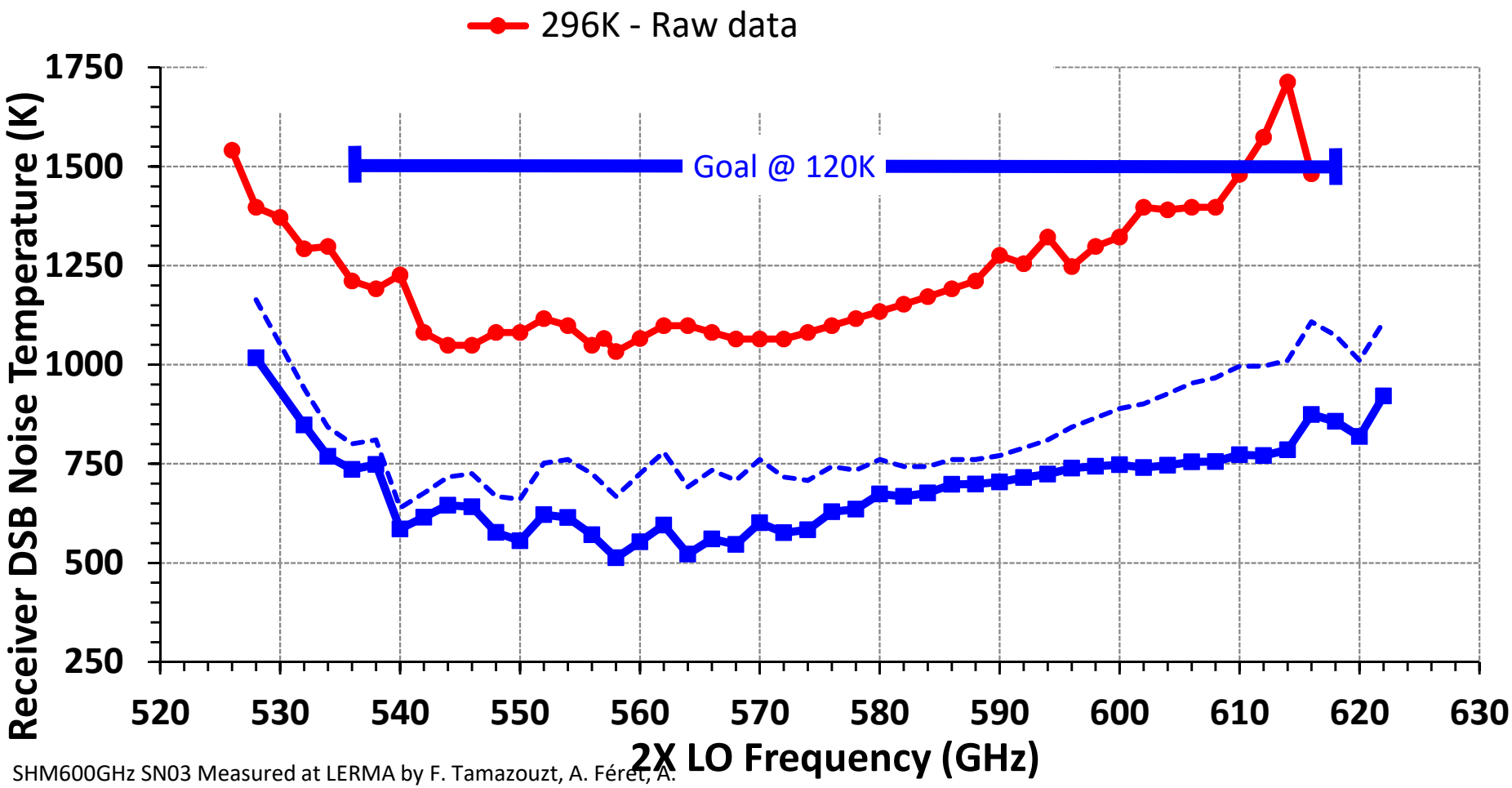



Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Mars 2015
Premier mélangeur
MMIC @600 GHz

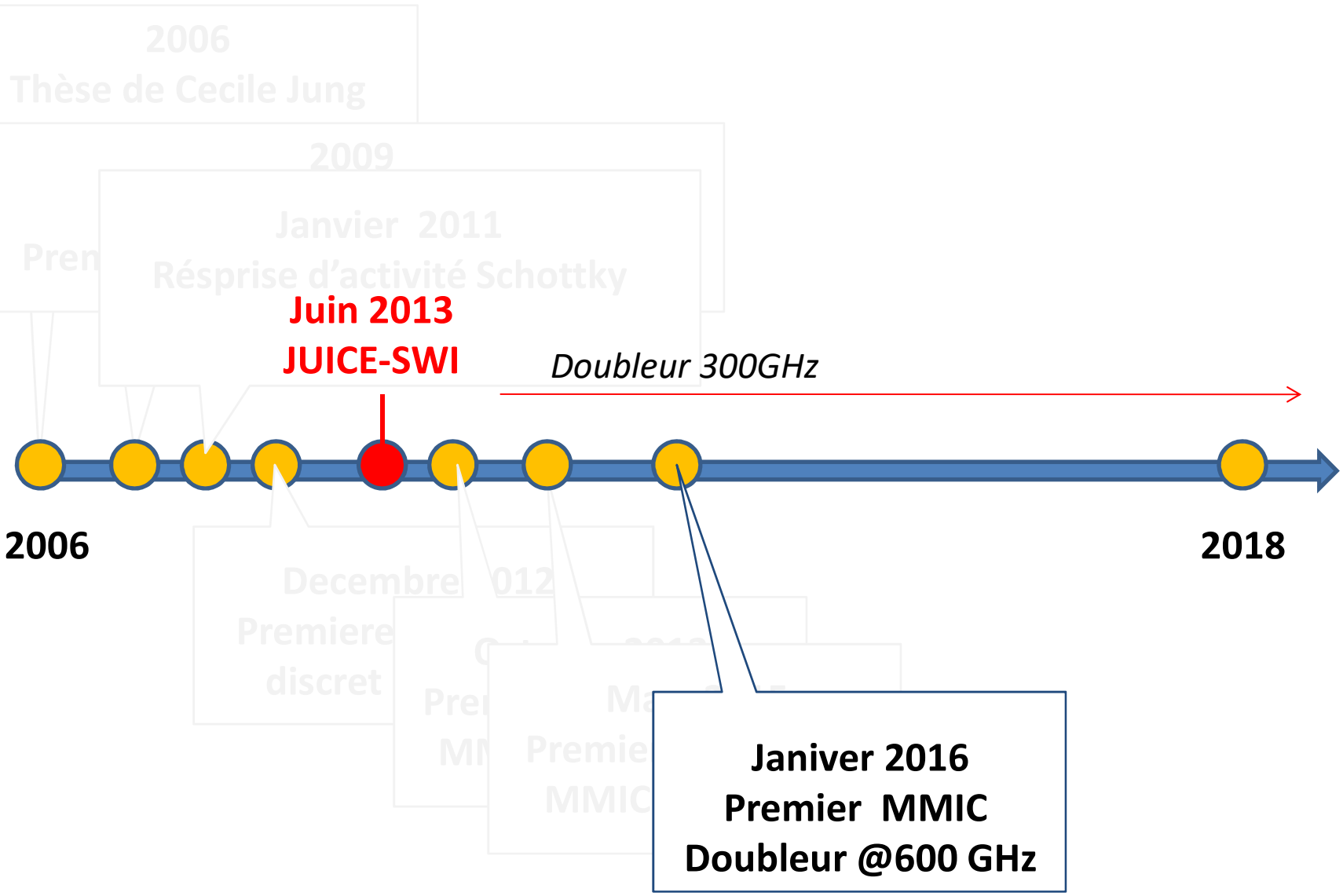

520-620GHz membrane Schottky mixer
(LERMA-LPN)
M600-01V
CNES-CNRS
LERMA-LPN
Design: Dr. J. Treuttel

LERMA 600GHz Receiver Sensitivy

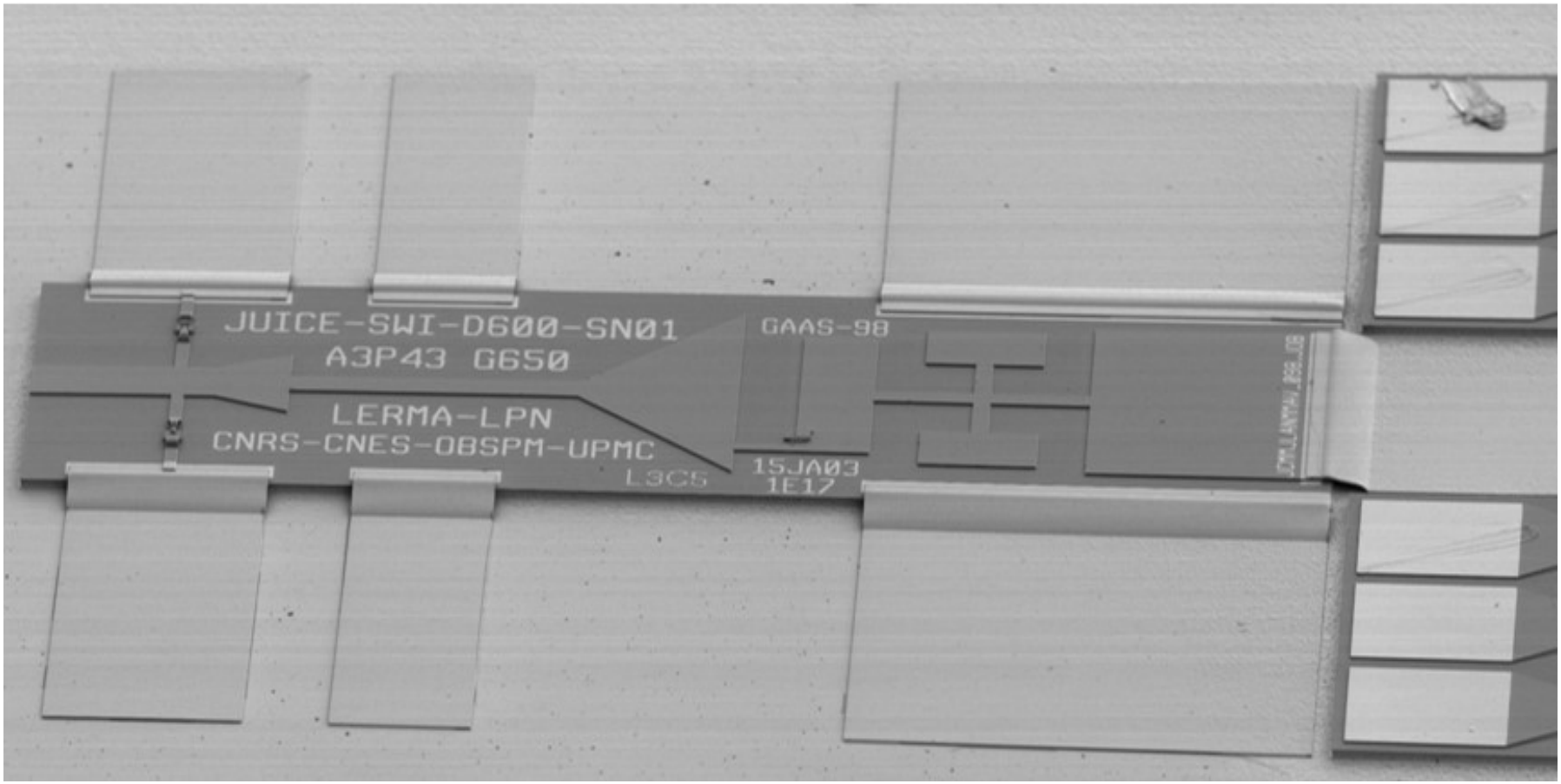
With Miteq 4-8GHz AFS4-0400 0800-07-10P (296K) / Low Noise Factory 1-12GHz LNF-LNC1_12A (134K) & 4.0-8.0GHz Intermediate Frequency Filter



SHM600GHz SN03 Measured at LERMA by F. Tamazouzt, A. Féret, A. Maestrini, Diego Moro Melgar & Raffaello Ferone - April-September 2015


Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Janiver 2016
Premier MMIC
Doubleur @600 GHz

Doubler @600GHz

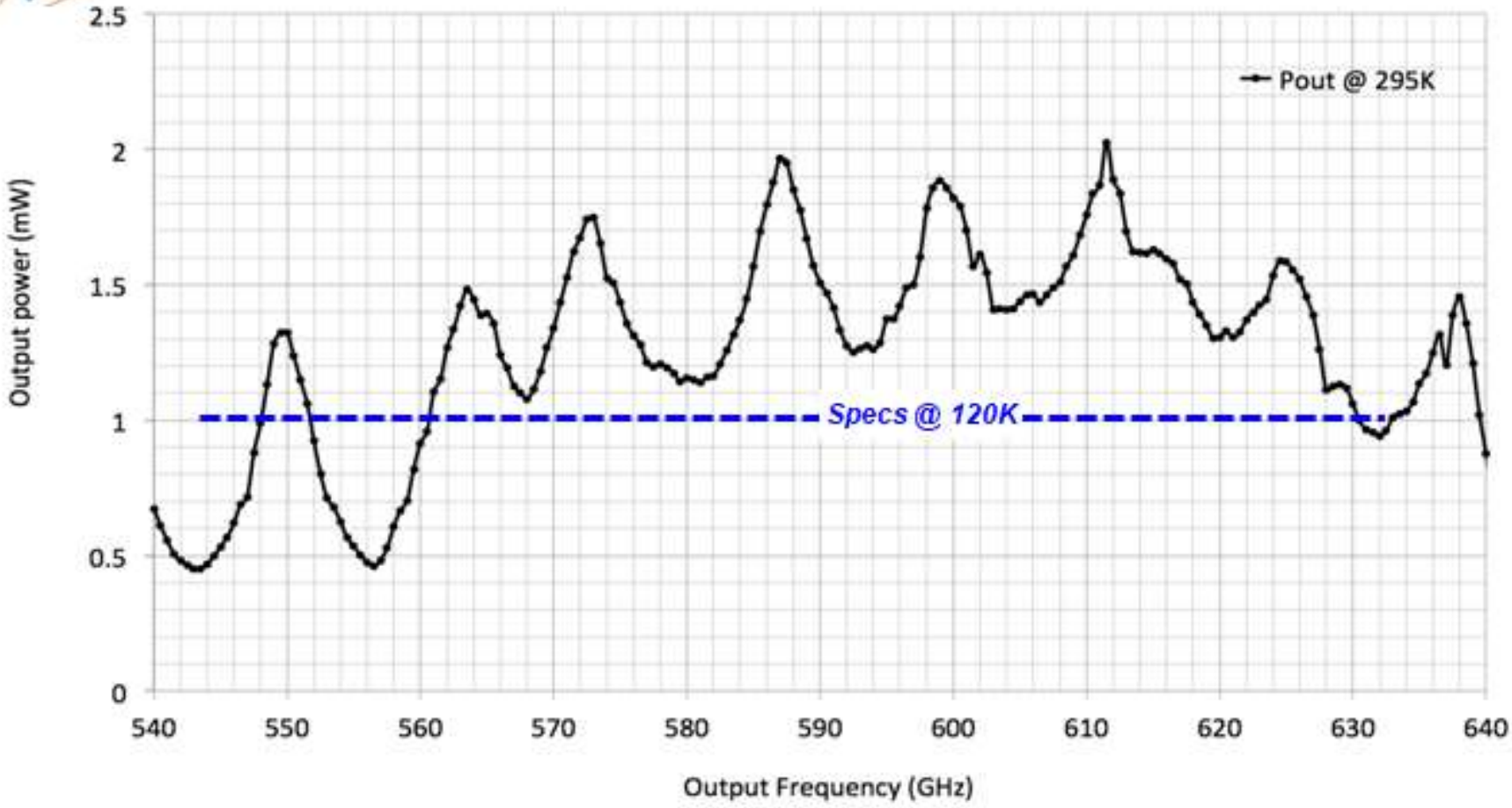


LERMA - OBSERVATOIRE DE PARIS

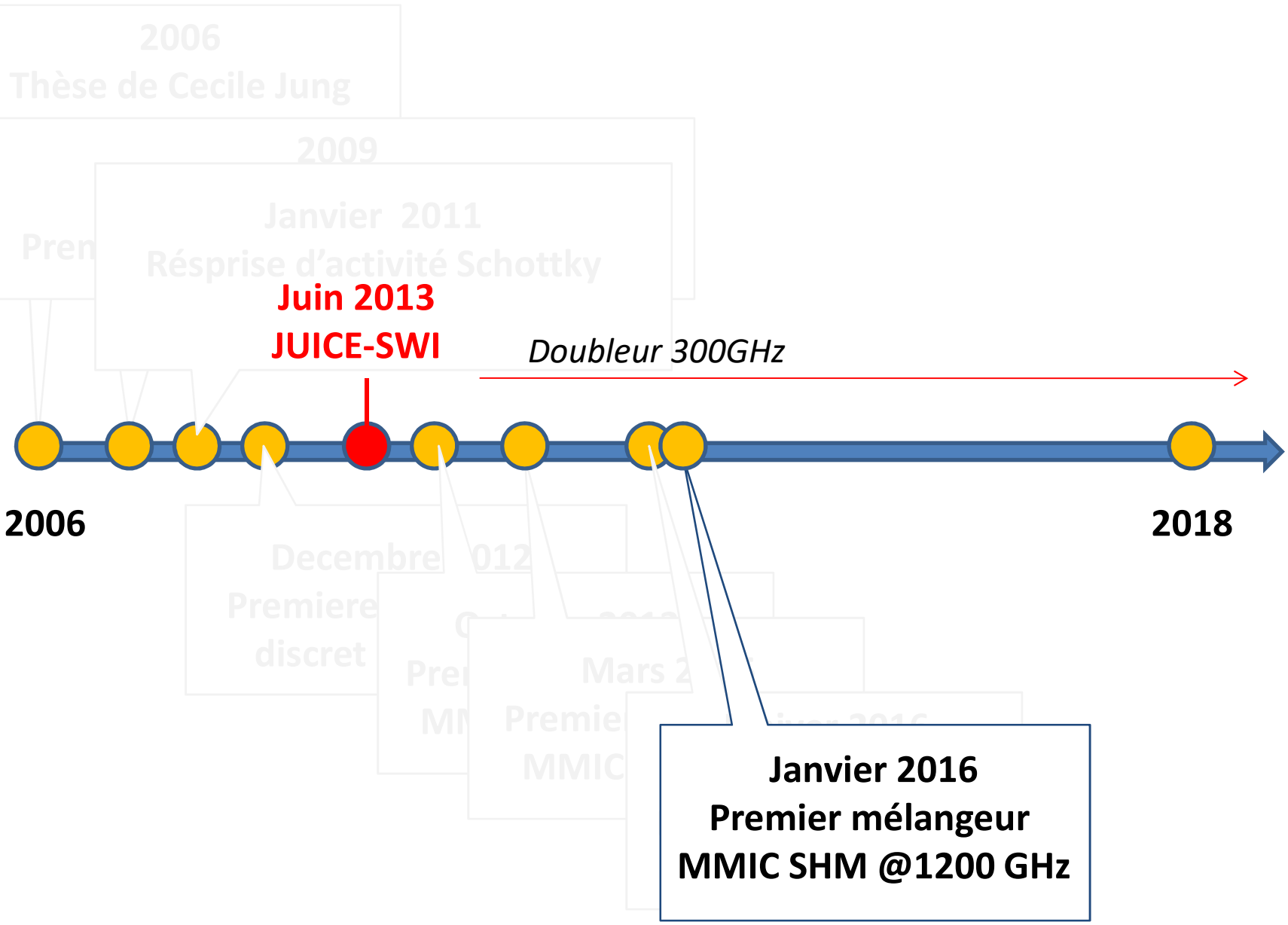
JUICE-SWI DM 600 GHz Doubler SN01 with RPG DM driver chain

Tested @ LERMA on 11-08 2016 by A. Féret, D. Moro Melgar & A. Maestrini - Troom=21-22°C

Power measurements with VDI-Erickson PM5+WR10 to WR1.9 wgd adapter - Cal Factor=+0.3dB



Measured at LERMA May-November 2016

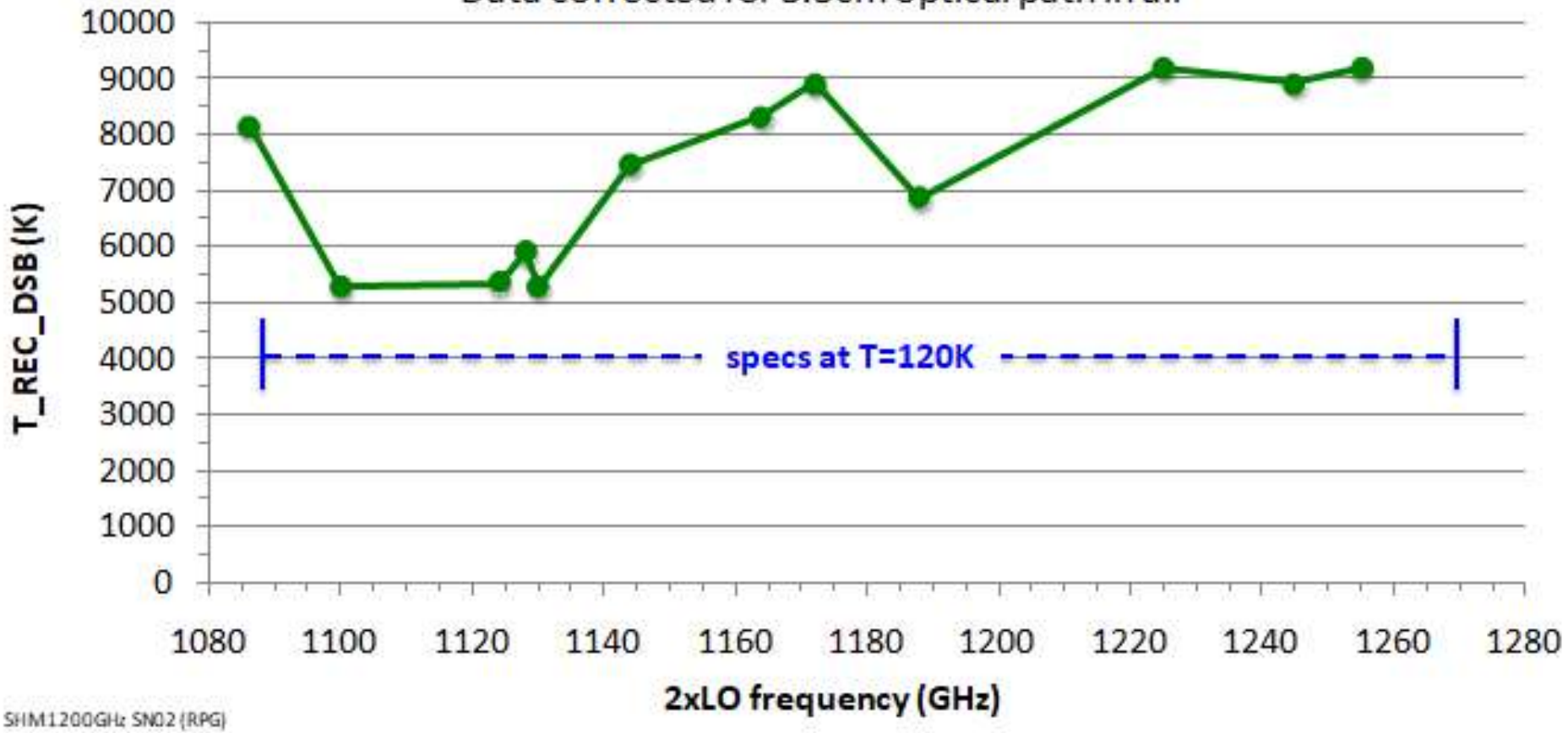

Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Janvier 2016
Premier mélangeur
MMIC SHM @1200 GHz

LERMA 1200GHz Schottky Receiver
Preliminary RF Results **at Room Temperature in Air**

Mixer is unbiased - Estimated LO power : 1.2-1.7mW

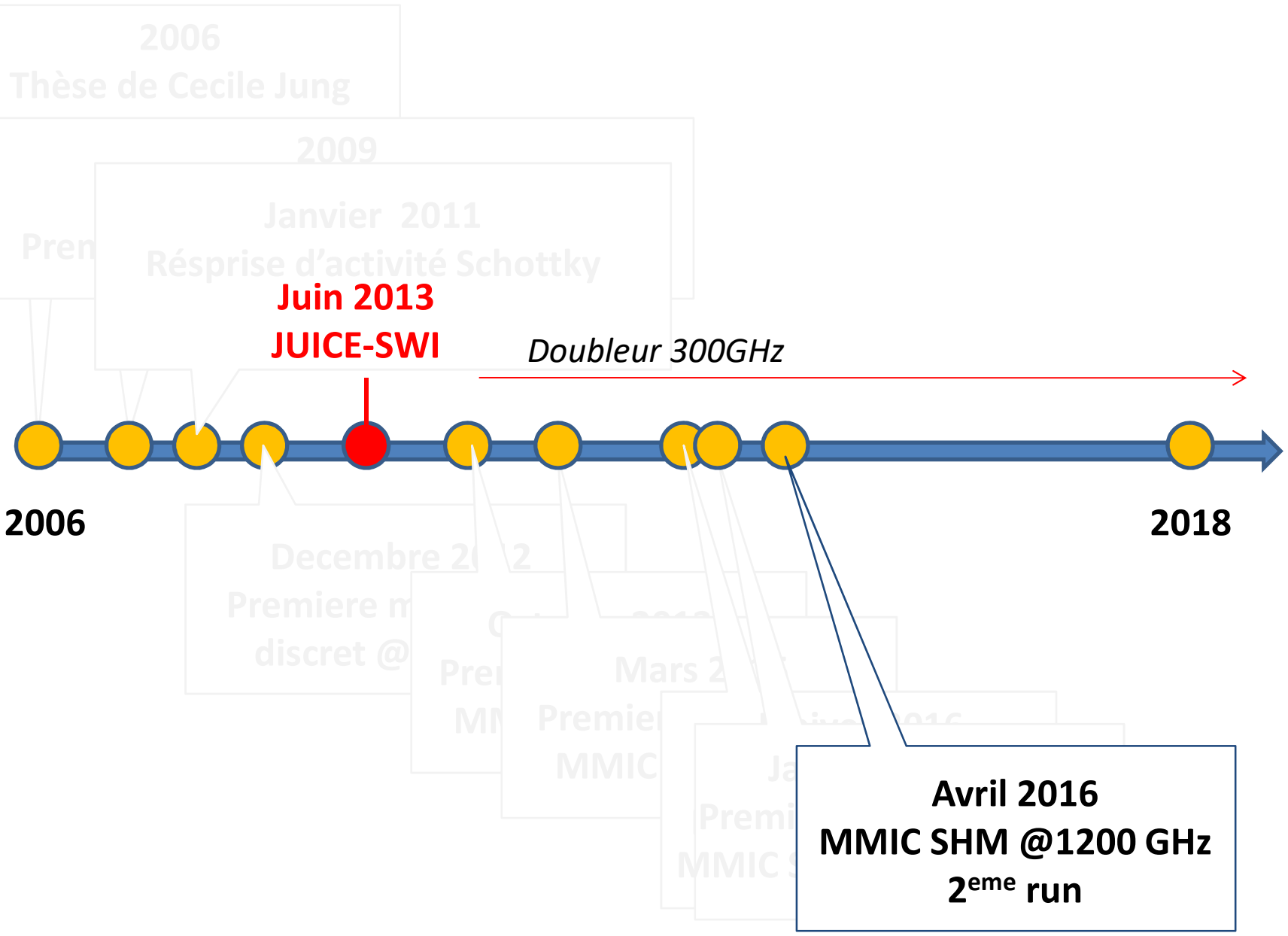
4-8GHz Miteq LNA (NF≤0.7dB)

Data corrected for 3.5cm optical path in air



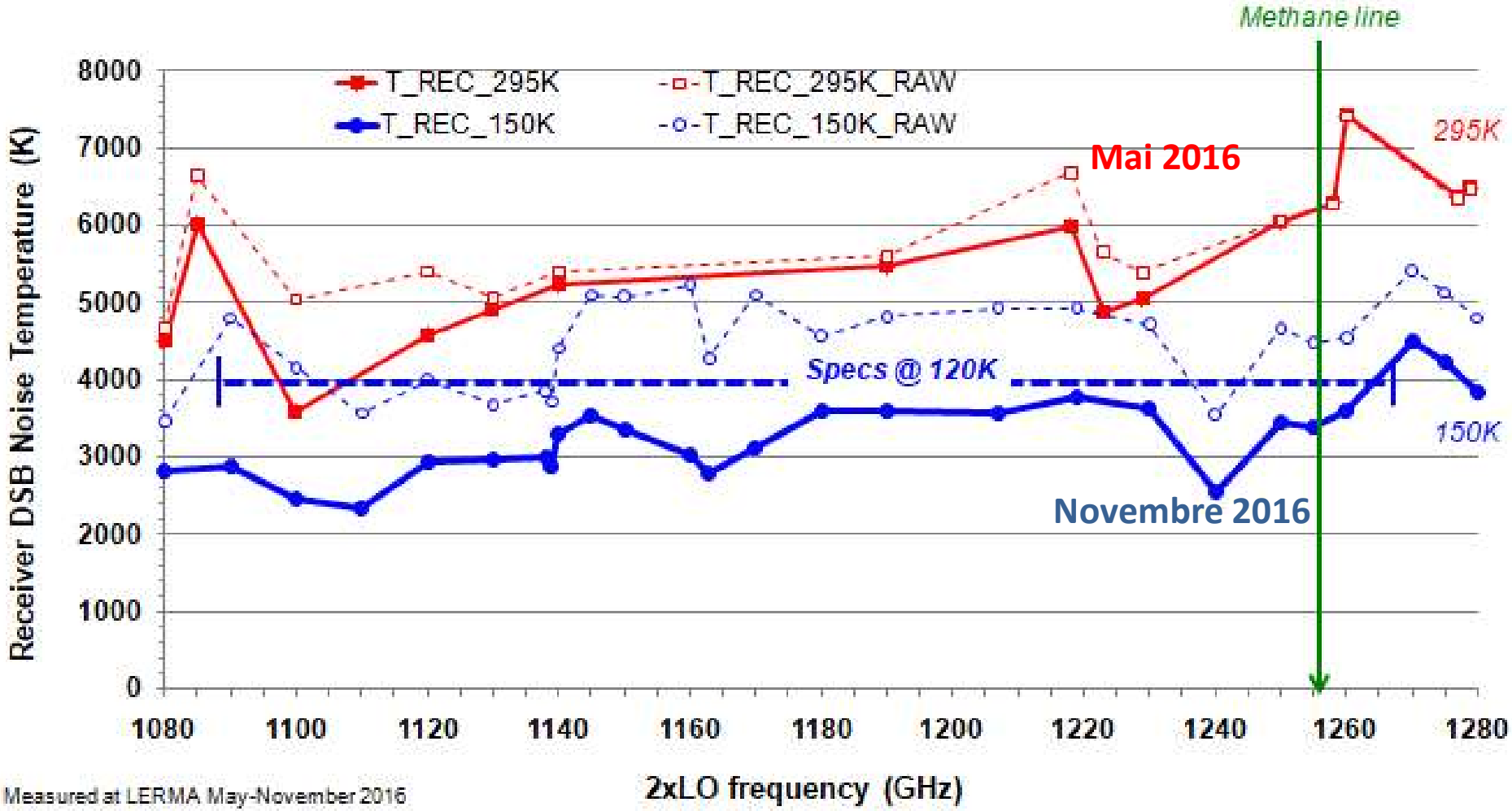
SHM1200GHz SN02 (RPG)

Tests at LERMA on 16-March-2016 by F. Tamazouzt, A. Féret & A. Maestrini

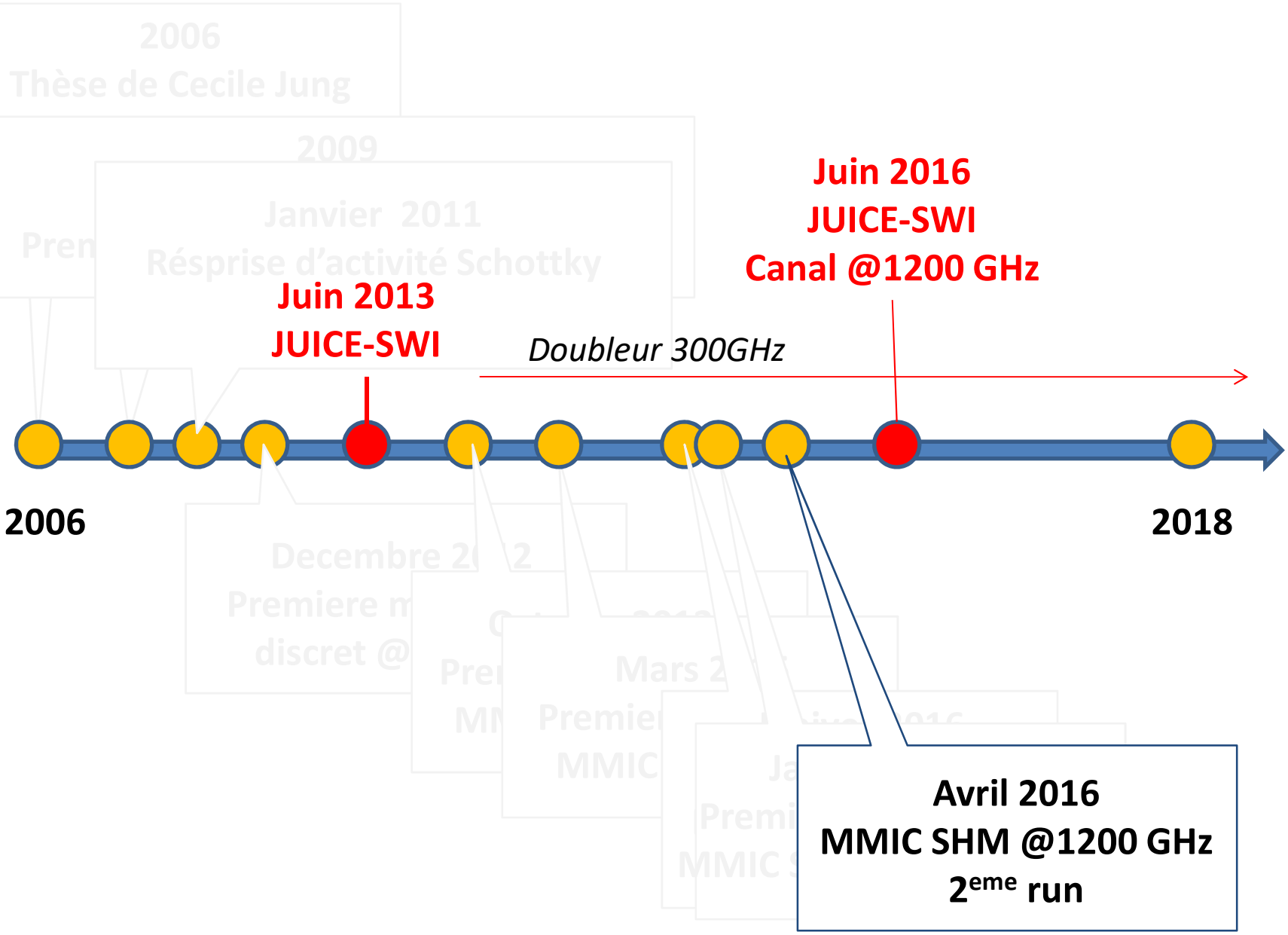

Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Avril 2016
MMIC SHM @1200 GHz
2eme run

JUICE-SWI 1200GHz receiver sensitivity

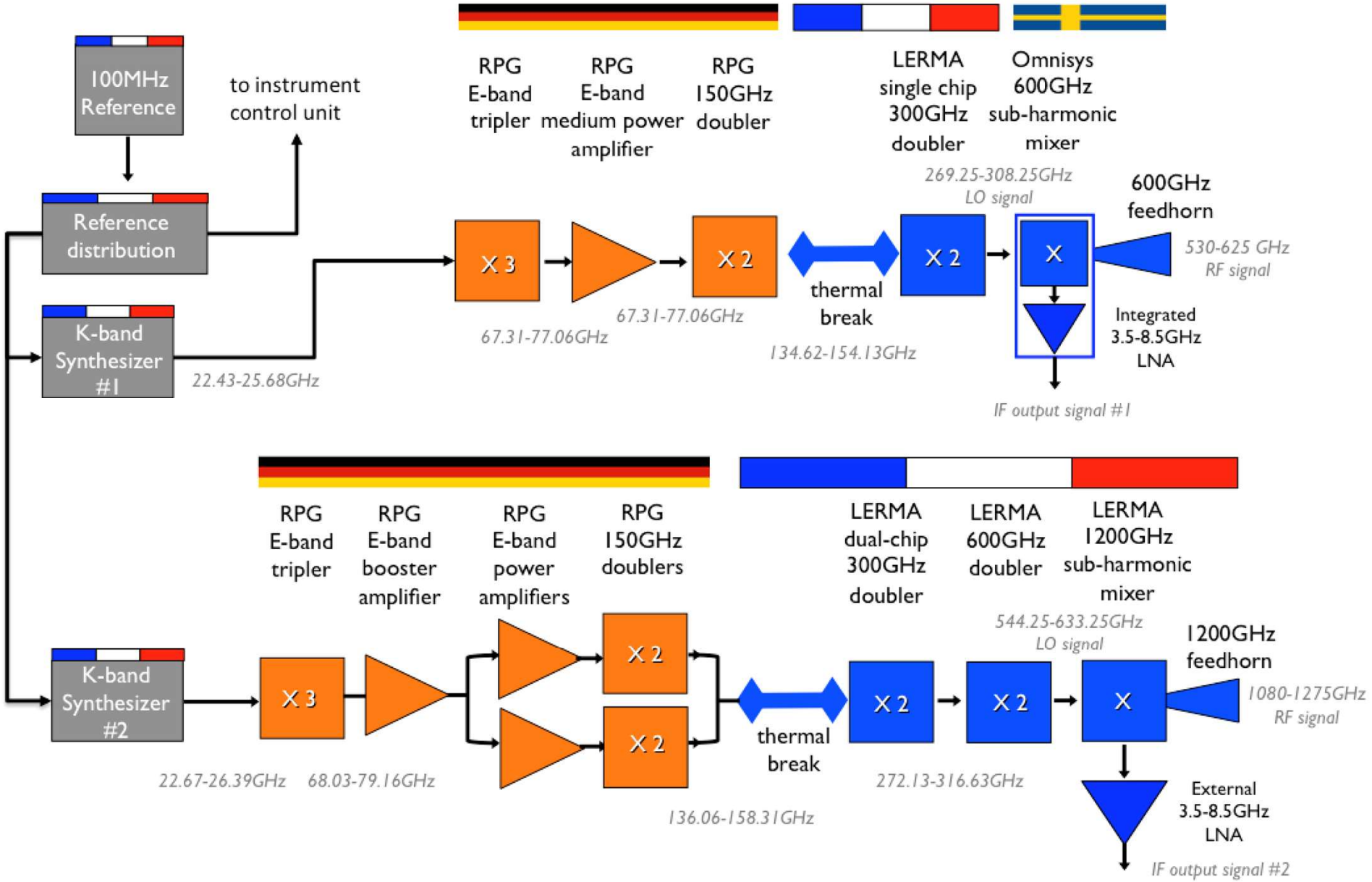
for cryogenic measurements a 2.040mm HDPE with Eps=2.32 / Loss_Tan=1.54E-3 was used
Data corrected for atmospheric absorption and cryostat window losses

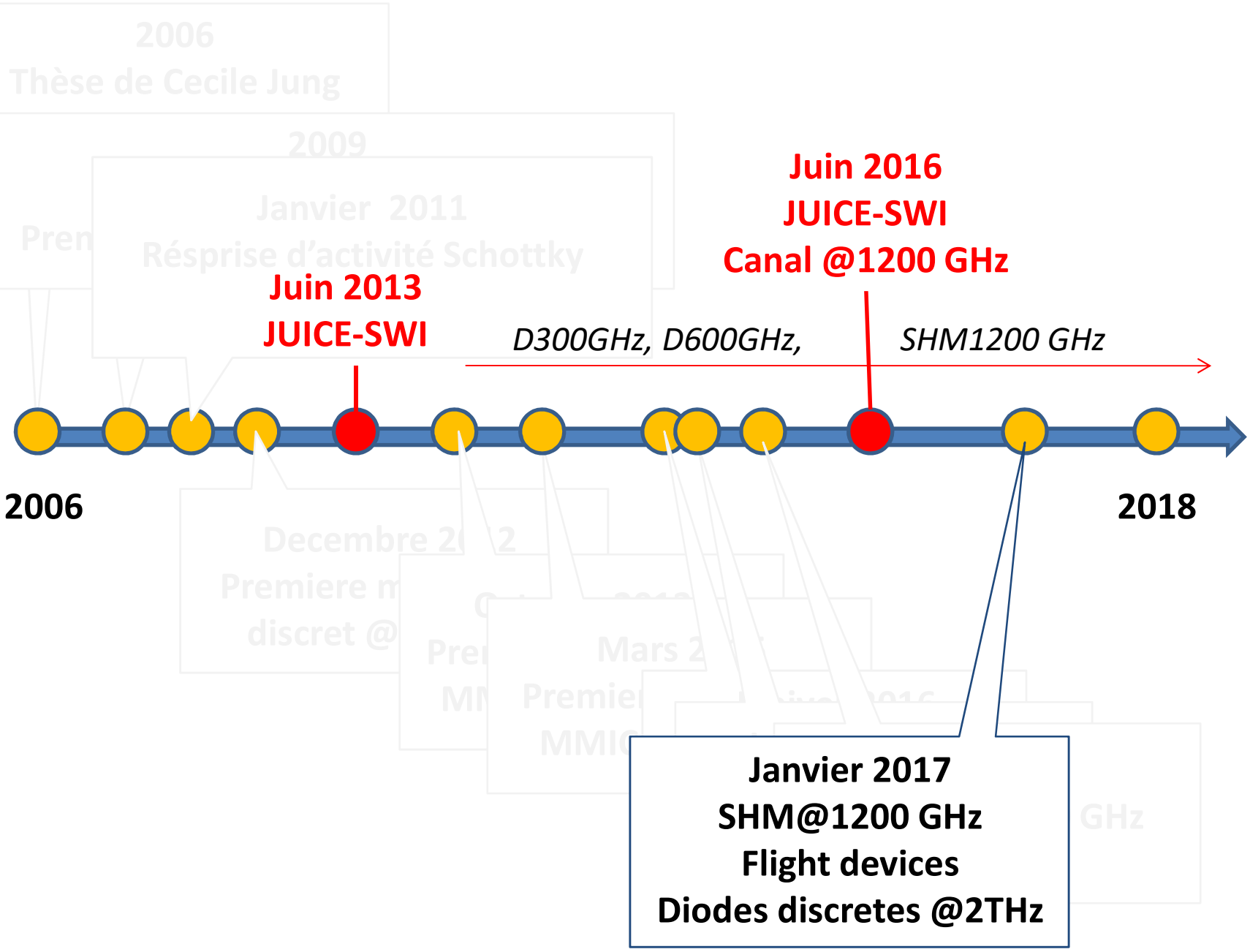


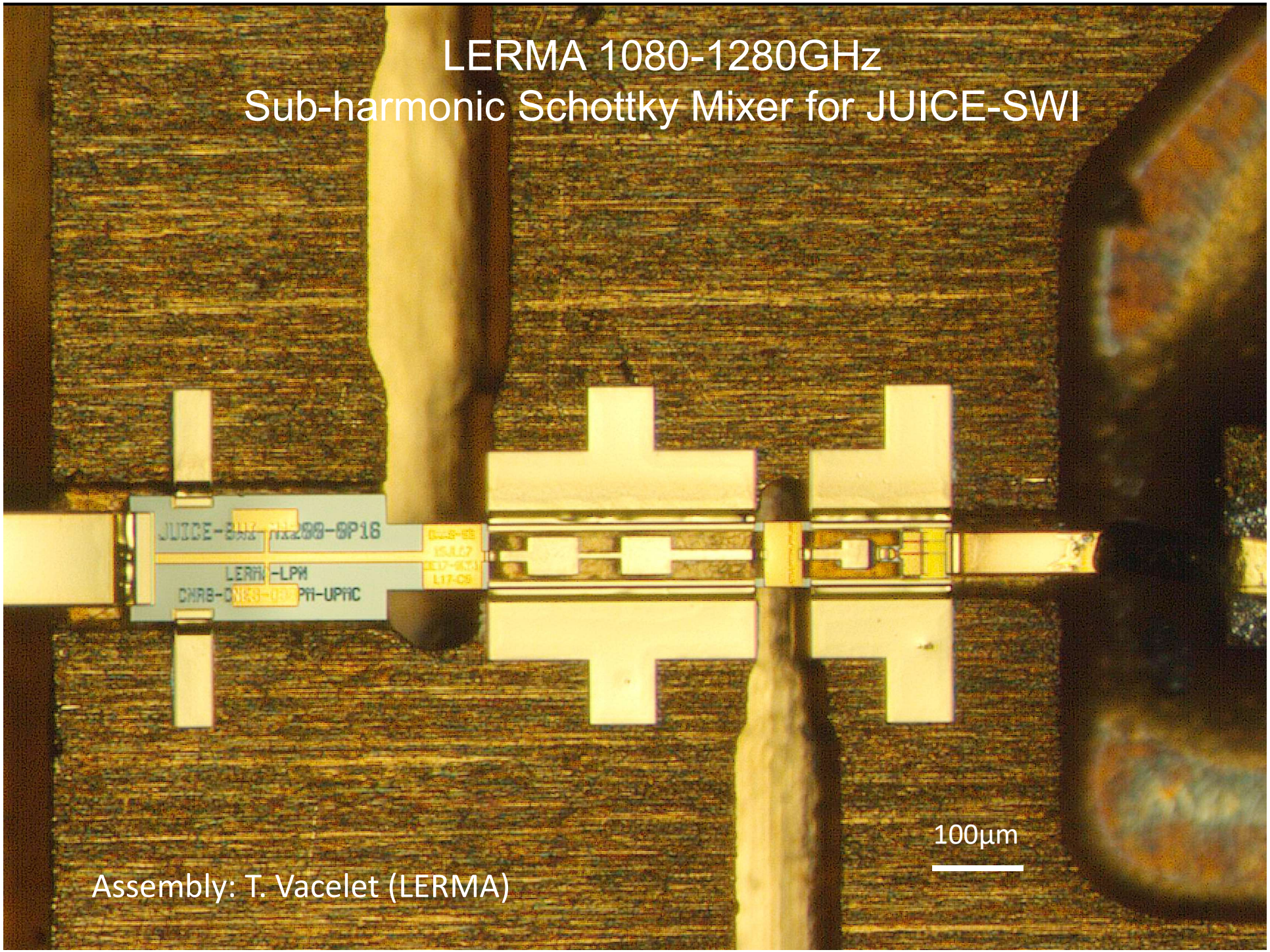
Measured at LERMA May-November 2016


Juin 2016
JUICE-SWI
Canal @1200 GHz
Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Avril 2016
MMIC SHM @1200 GHz
2eme run

JUICE-SWI front-end configuration on 2016-06-21

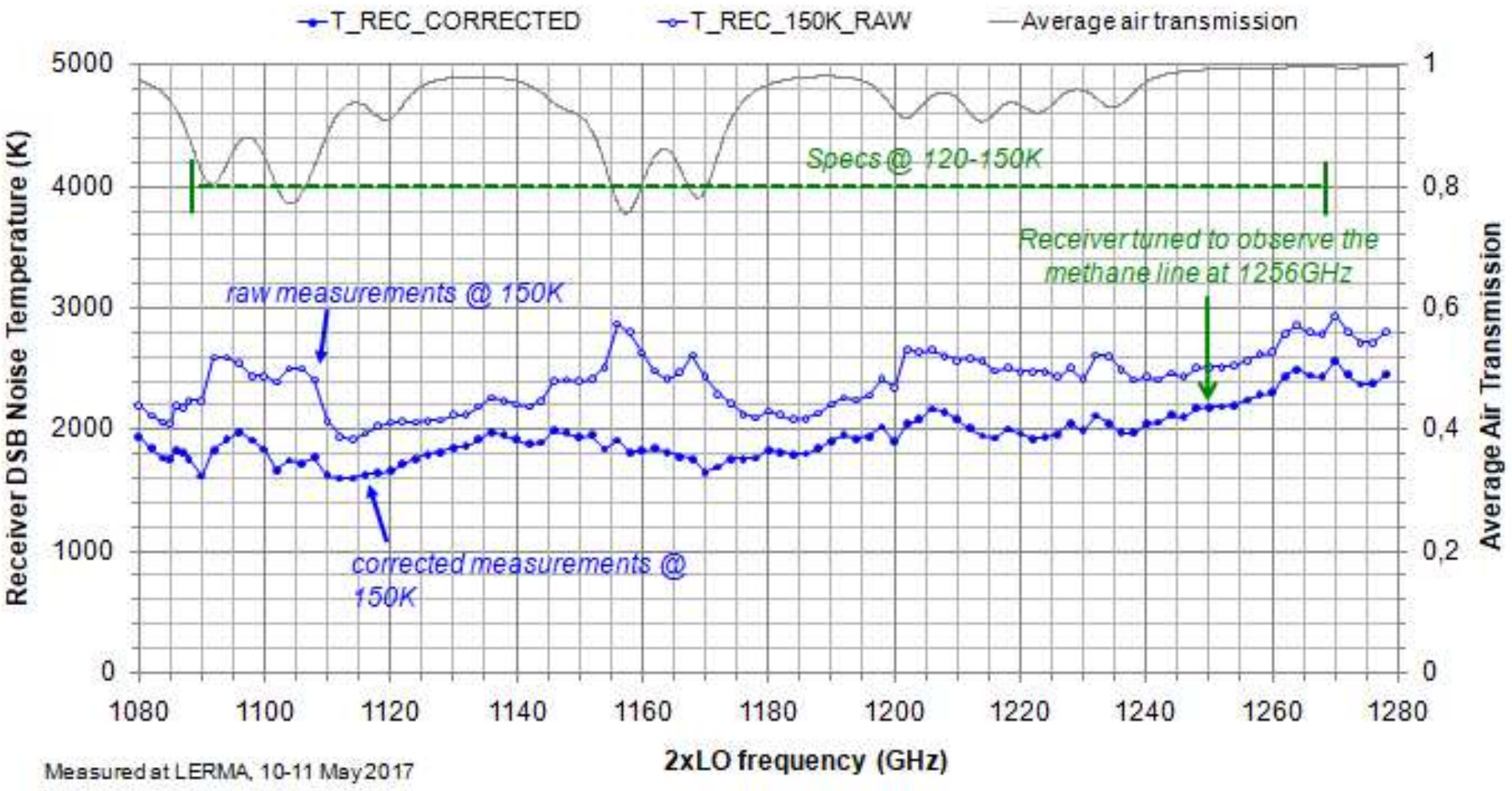



Juin 2016
JUICE-SWI
Canal @1200 GHz
Juin 2013
JUICE-SWI
D300GHz, D600GHz,
SHM1200 GHz
2006
2018
Janvier 2017
SHM@1200 GHz
Flight devices
Diodes discretes @2THz


LERMA 1080-1280GHz
Sub-harmonic Schottky Mixer for JUICE-SWI
100µm
Assembly: T. Vacelet (LERMA)

JUICE-SWI 1200GHz receiver sensitivity with baselined 150GHz LO chain and biased mixer

SHM1200-V1-RPG-SN01 with GaAs109-L6C4-A device
Data corrected for atmospheric absorption and cryostat window loss integrated for a 4.0-8.0GHz IF

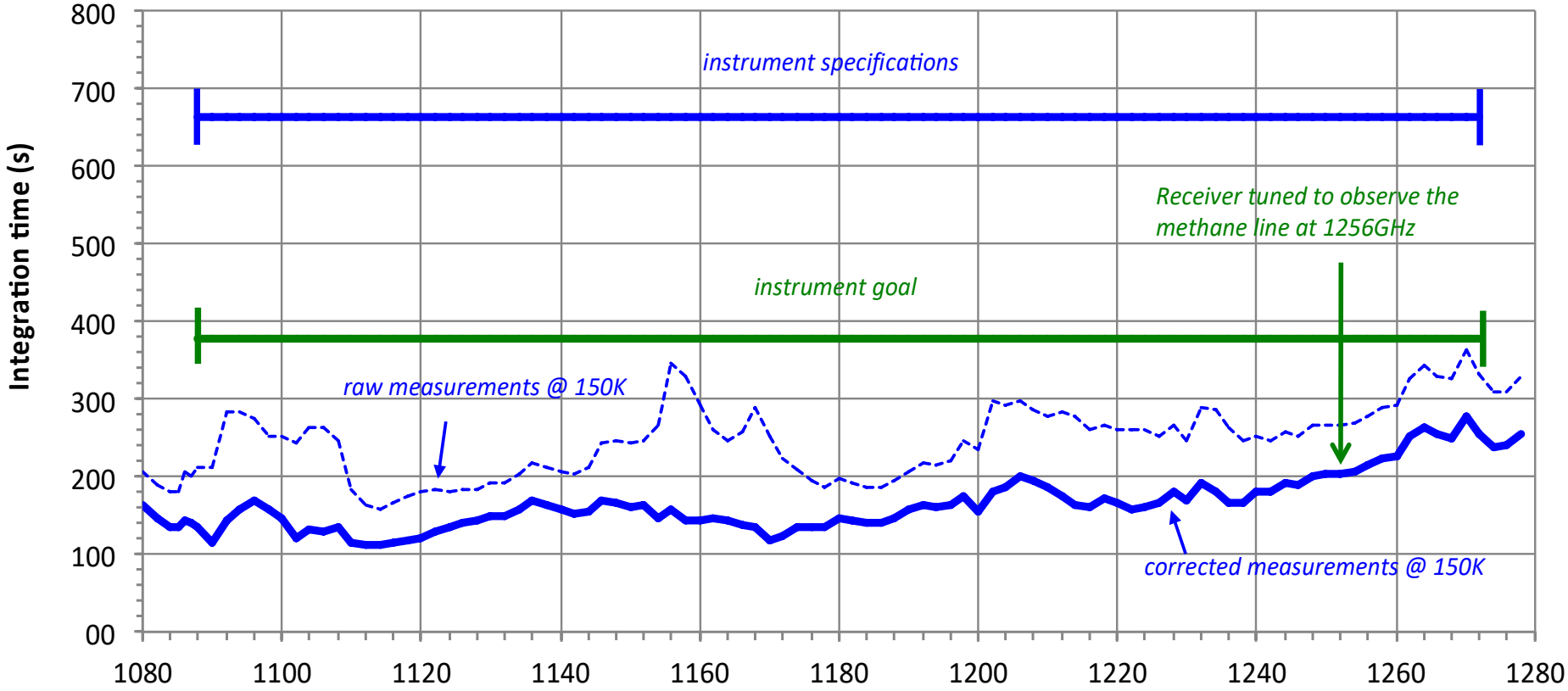


Measured at LERMA, 10-11 May 2017

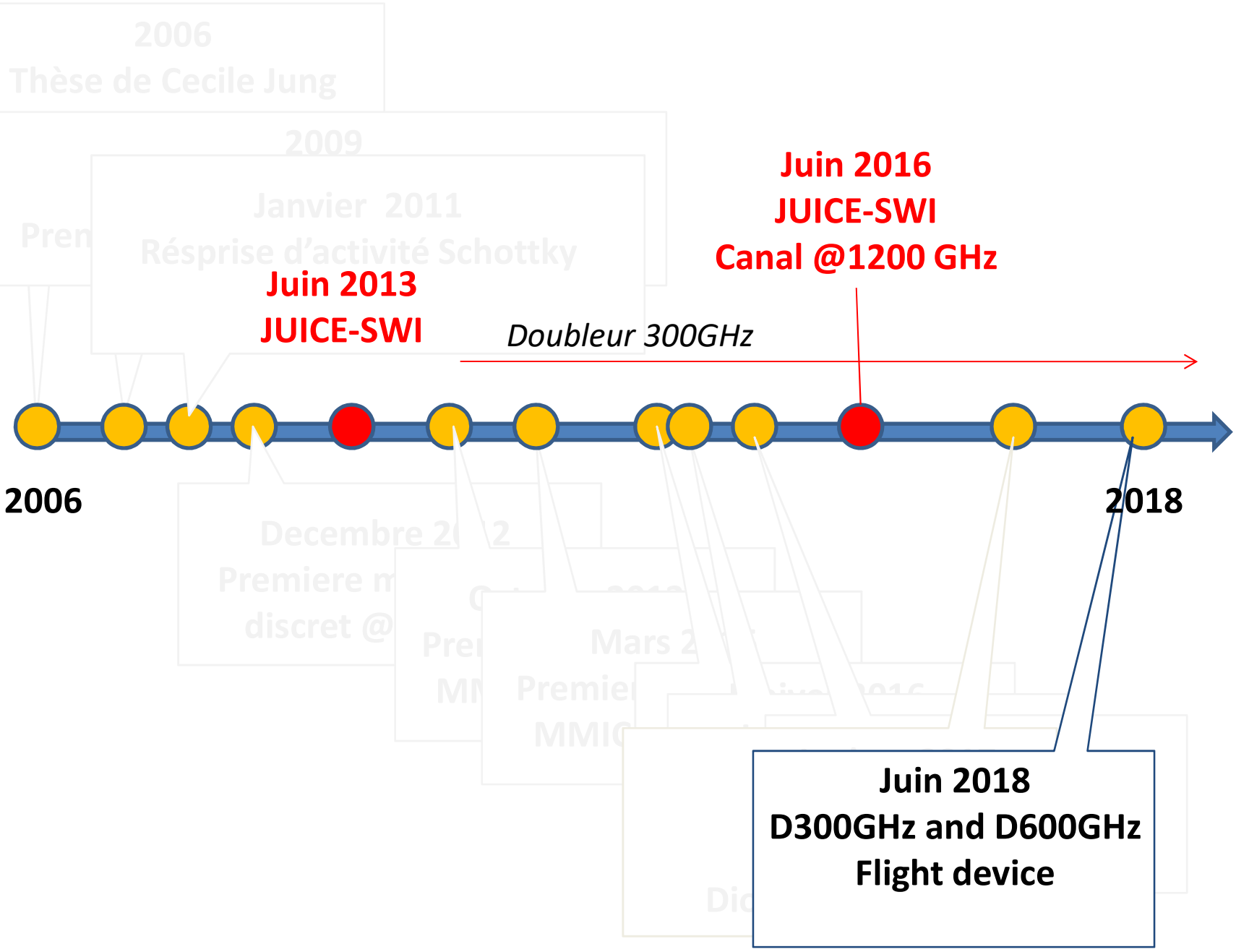
JUICE-SWI 1200GHz receiver

Estimated integration time for SSB observations with 100kHz resolution and 1K noise

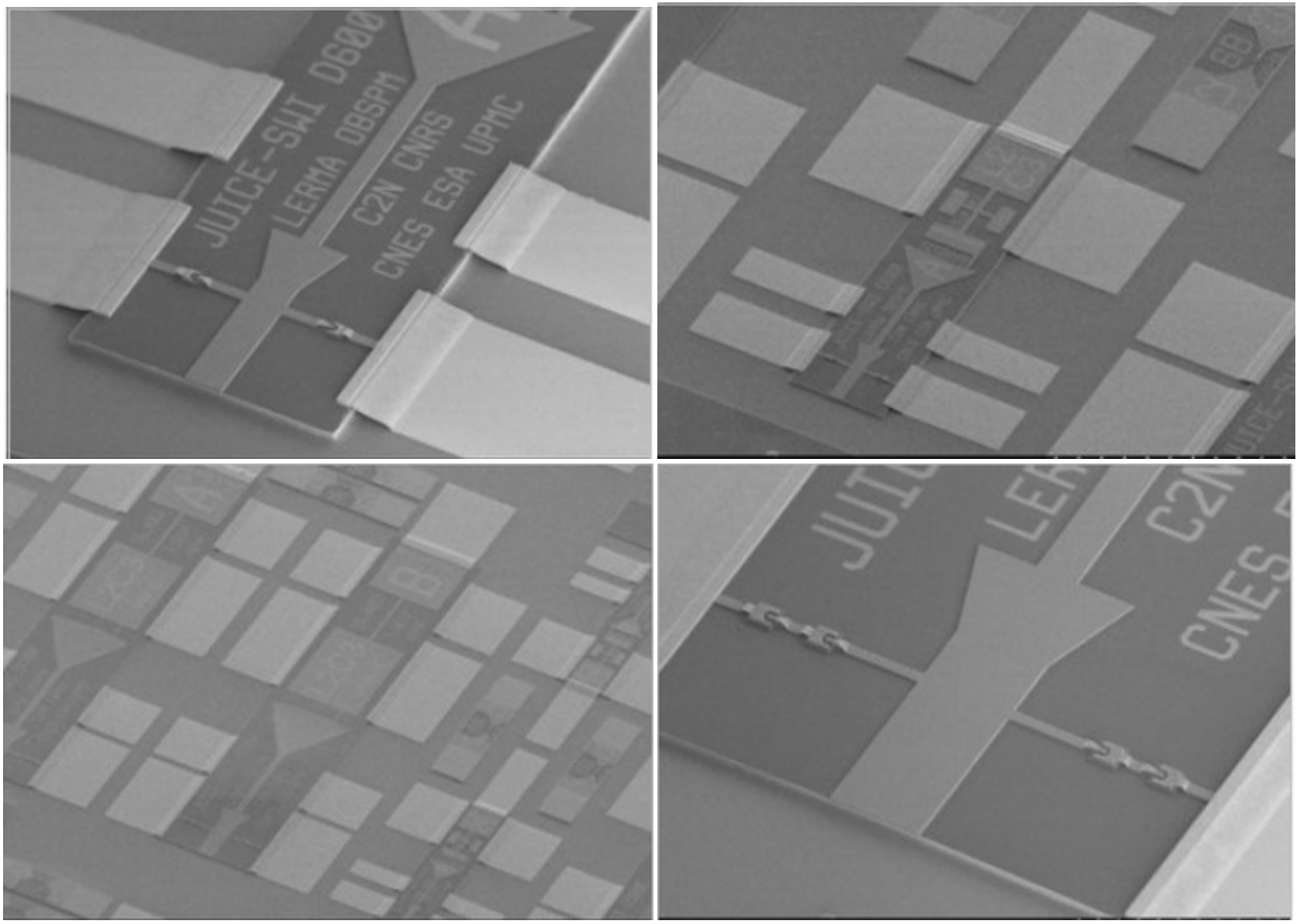
SHM1200-V1-RPG-SN01 with GaAs109-L6C4-A device
Data corrected for atmospheric absorption and cryostat window loss integrated for a 4.0-8.0GHz IF
(4.0cm air path with 40%-60% humidity - 250µm thcik Zitex IR filter + 3.0mm thick coated quartz vacuum window from QMC)



Measured at LERMA, 10-11 May 2017

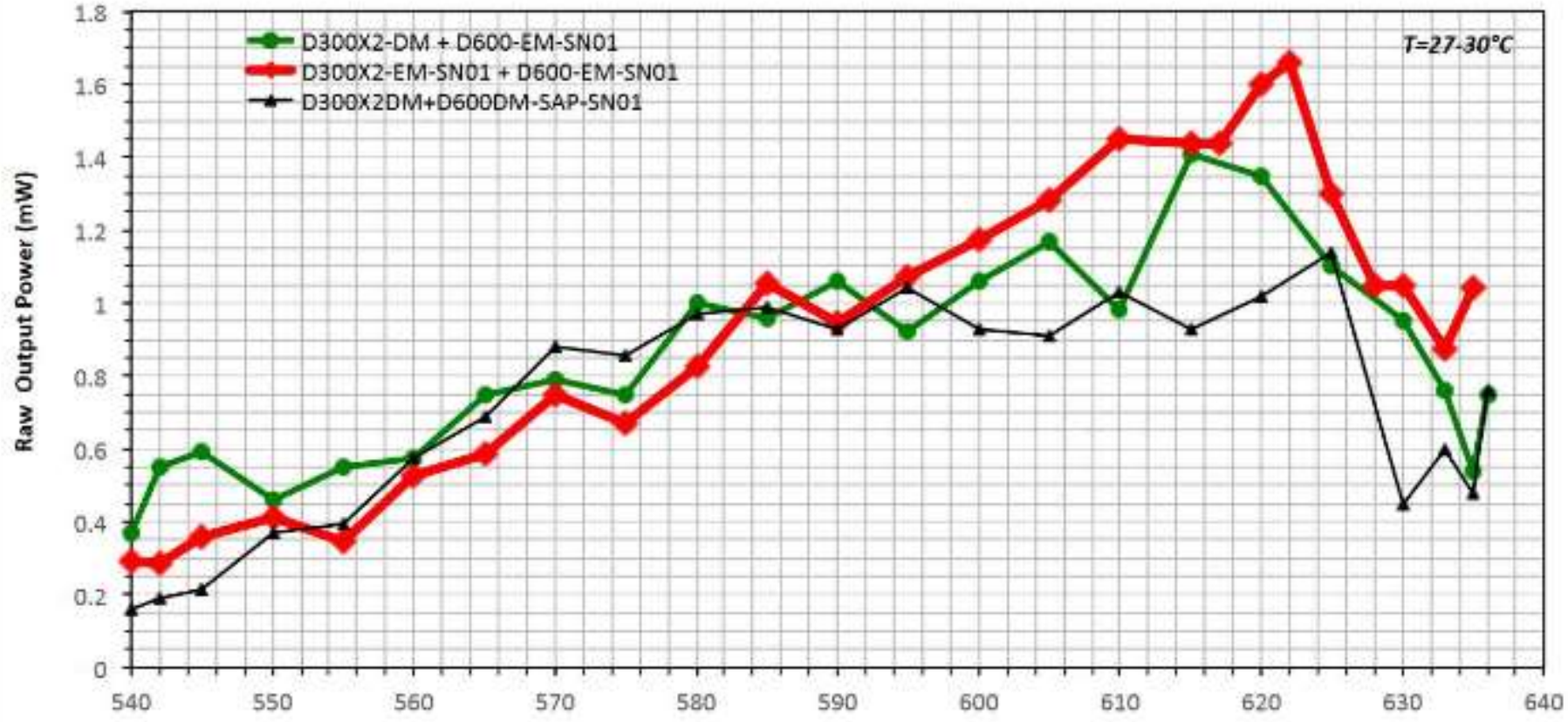

Juin 2016
JUICE-SWI
Canal @1200 GHz
Juin 2013
JUICE-SWI
Doubleur 300GHz
2006
2018
Juin 2018
D300GHz and D600GHz
Flight device

Juin 2018 - Flight devices D300 and D600



Comparision of RF response of different 600GHz LO Chain

RPG 150GHz Medium Power DM LO Chain
PM5 Cal Factor=100% (no correction for waveguide transition loss)



09/09/2018

Conclusions

- 12 ans de travail productif
- La technologie de fabrication développée au LERMA-LPN permet de réaliser les diodes Schottky très performantes!
- MMIC Doubleurs de fréquence @300GHz et @600GHz ont montrés des performances supérieures aux spécifications demandées et sont selectionnées pour le JUICE-SWI
- MMIC Mélangeur de fréquence @600 GHz avec faible température de bruit – record mondial!
- MMIC Mélangeur de fréquence @1200 GHz permet d'augementer la sensibilité de l'instrument et diminuer le temps d'acquisition