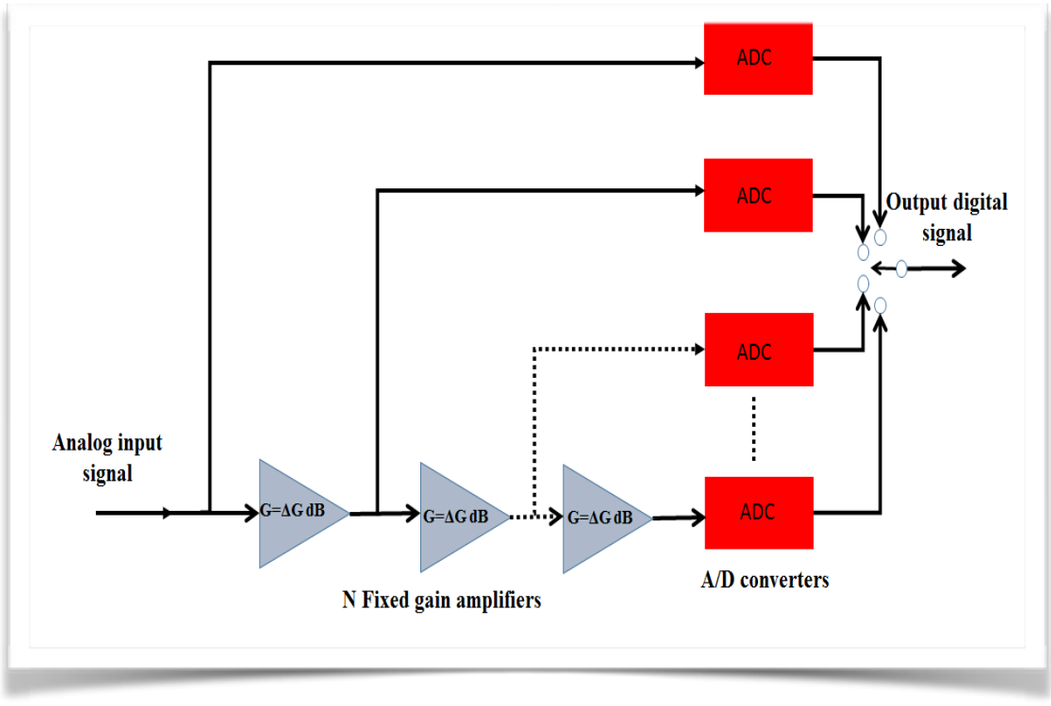
STAR, un nouveau récepteur radio miniaturisé pour la radio astronomie spatiale basse fréquence

B. Cecconi[1], R. Mohellebi[1,2], P. Loumeau[2], et toute l'équipe STAR[1,2]

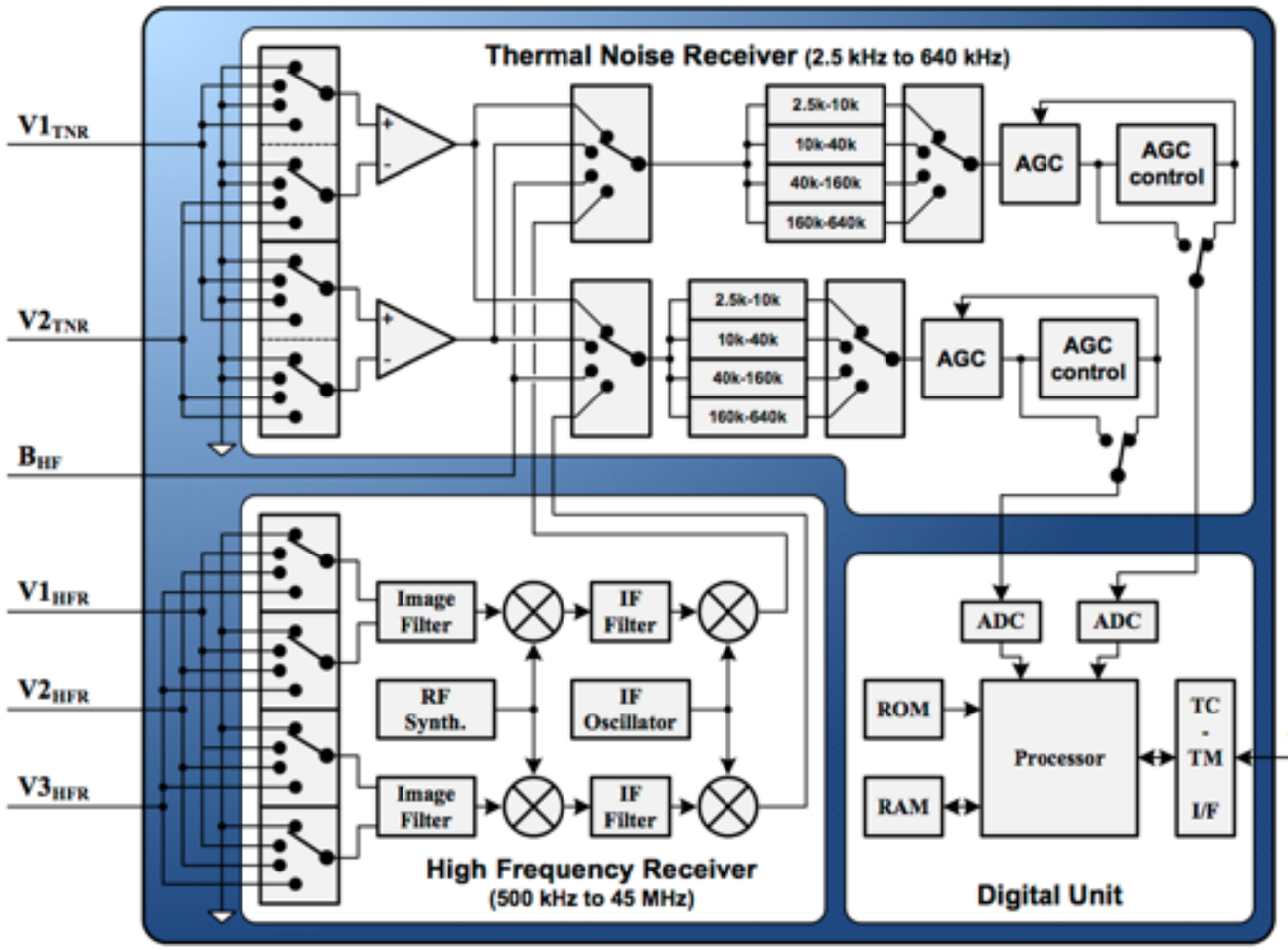
1. LESIA, Observatoire de Paris; 2. C2S, TelecomParis



Projet soutenu par le CNES (R&T + Thèse techno)
et par le LabEx ESEP (LESIA-PSL)

Etat de l’art avant STAR

- Cassini/RPWS
- STEREO/Waves
- BepiColombo/MMO/RPWI/Sorbet
- SolarOrbiter/RPW/THR



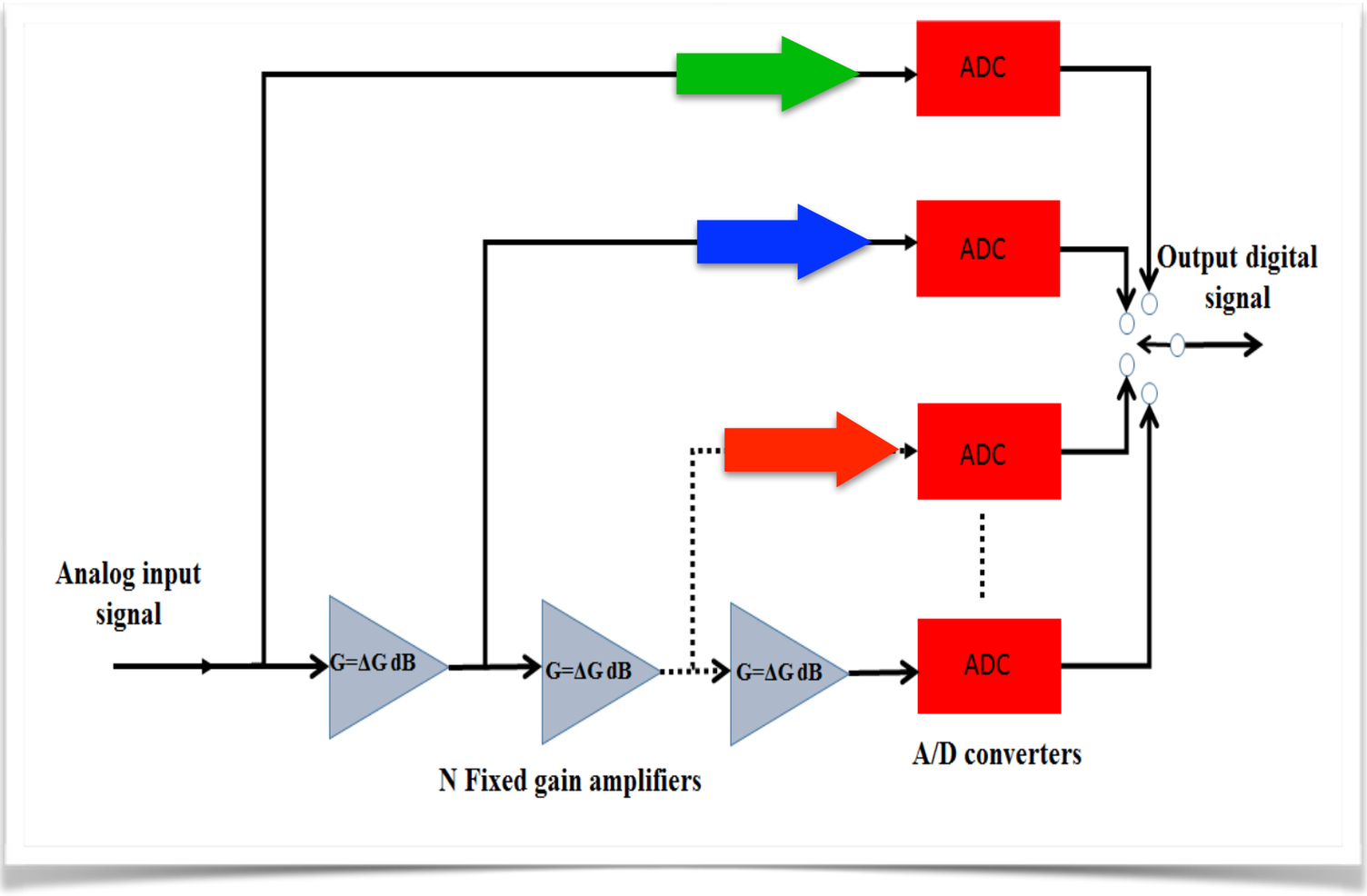
Numérisation directe < 500 kHz
SuperHétérodyne > 500 kHz
(jusqu’à 10-16 MHz)

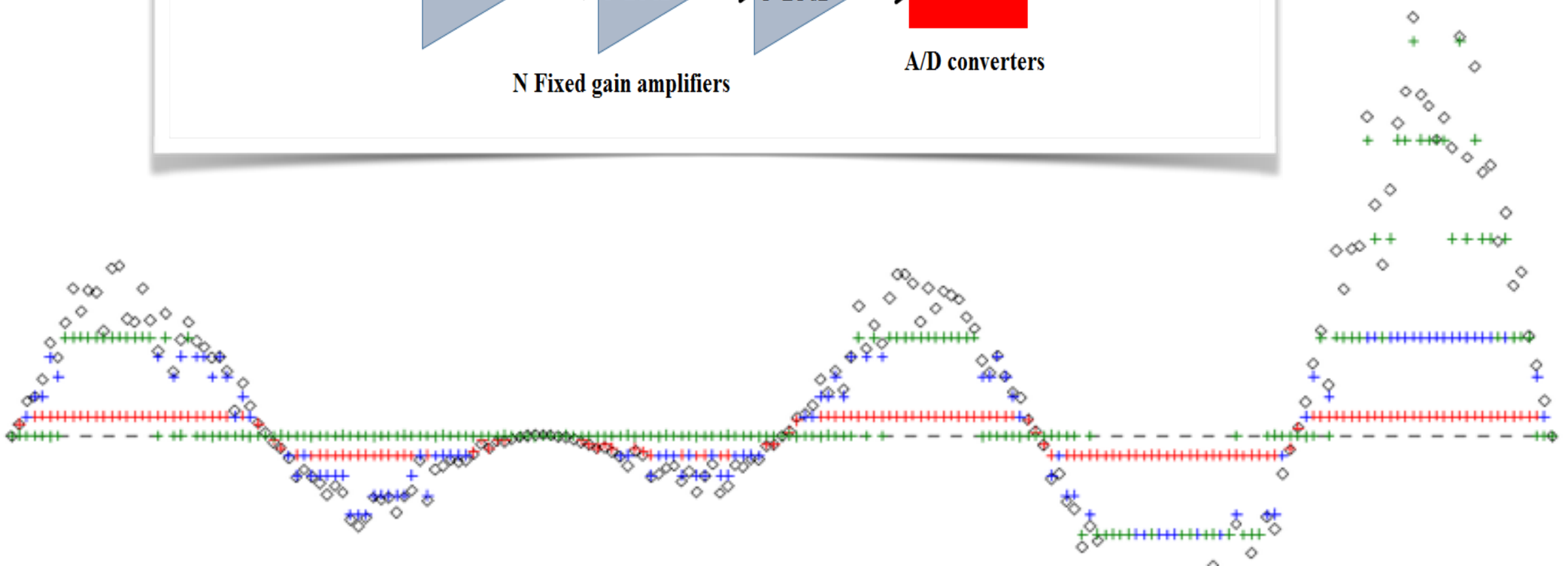
Contrôle Automatique de Gain
=> Grande dynamique

Difficile de réduire masse et consommation
Volonté de monter en fréquence (45 MHz voire 100 MHz)

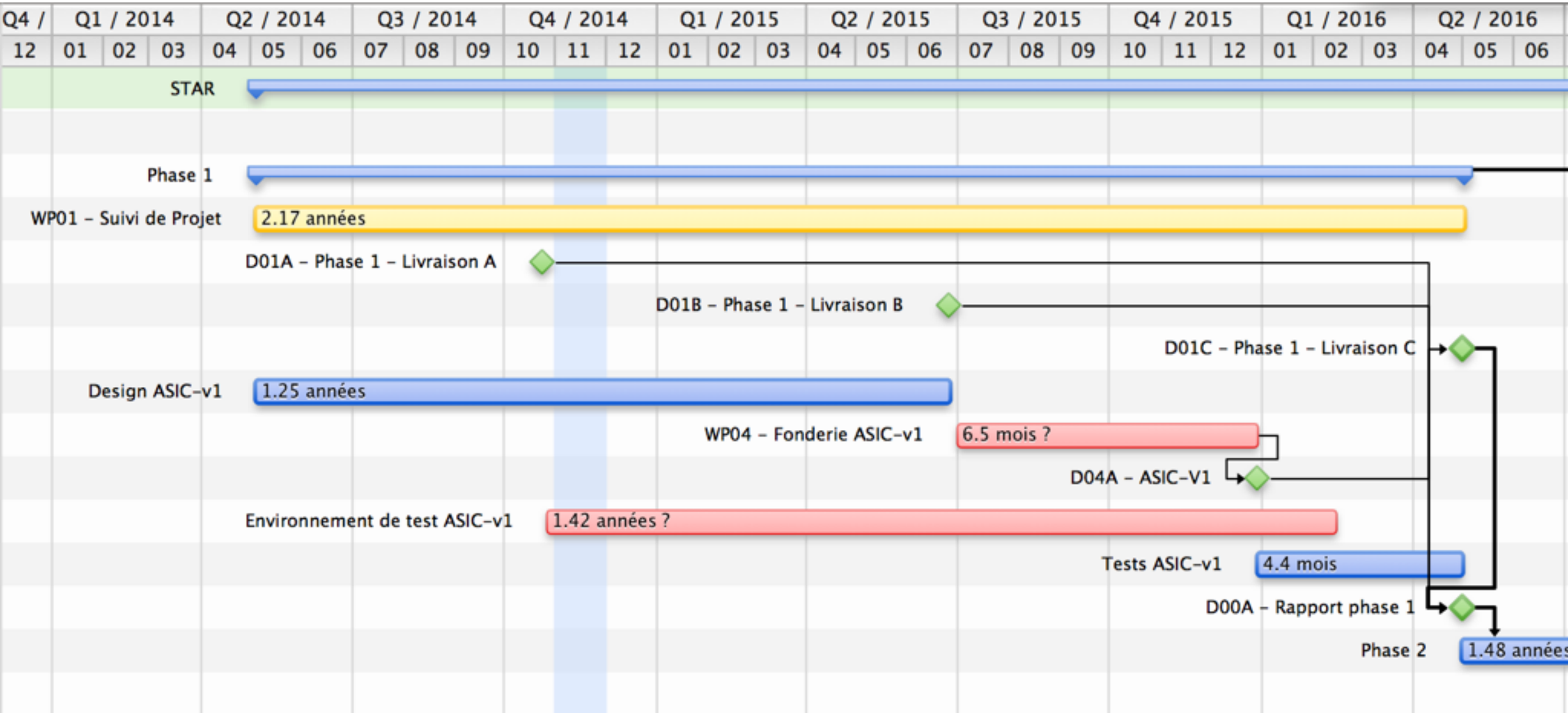
Pas embarqué sur JUNO, JUICE ou SolarProbePlus (manque de RH projet)

Principe de STAR





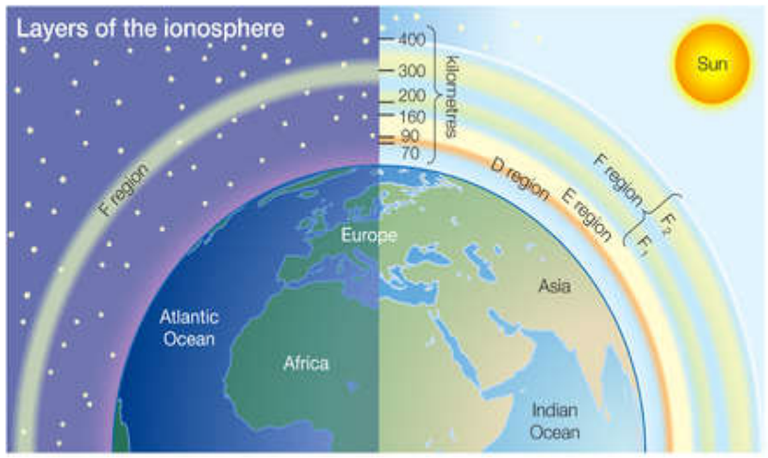
Première Phase

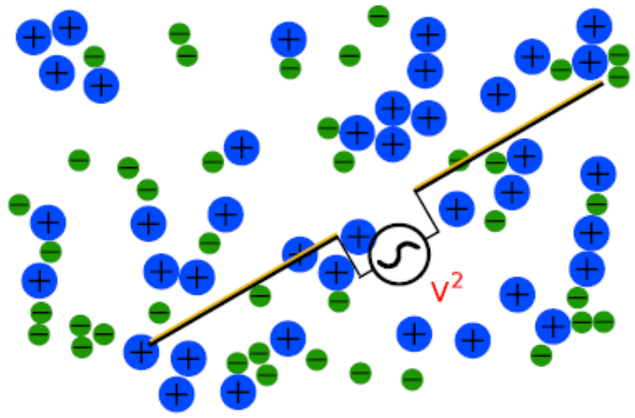


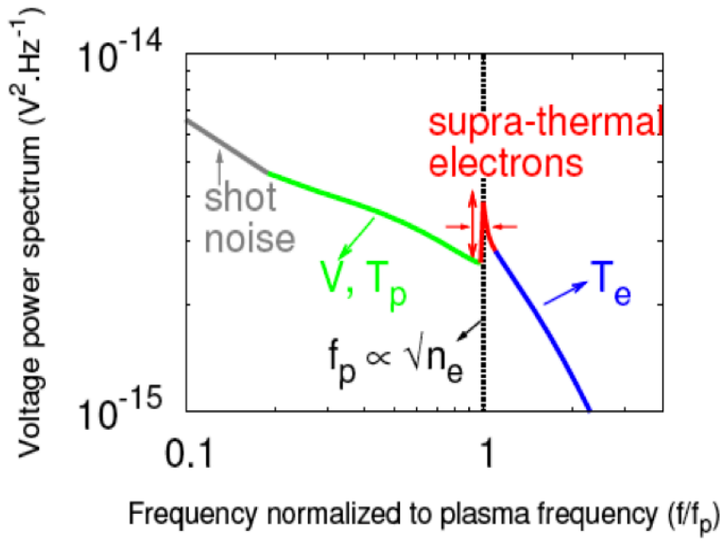
Spatialisation de STAR

Characterizing the Ionosphere with a Radio receiver on a CUbe Sat

A. Zaslavsky, D. Tiphene, et al.







- In-situ study of the ionospheric plasma with high temporal resolution (<1ms), using the thermal noise spectroscopy technique (provides measurements of local electron density and temperature)
- In-situ study of the ionospheric plasma turbulence, and non-thermal electromagnetic activity (waves).
- CubeSat with polar orbit, 300-600 km altitude.
- Typical plasma parameters : n_e 10^6 cm^{-3} et T_e 1300 K
- Plasma frequency f_p 5-10 MHz : necessity for a receiver with a frequency range from a few kHz – 100 MHz
- Debye length : L_D 1 mm (necessity for thin antennas : diameter smaller than 2-3 Ld)

Projets futurs

Proposé sur
- ESA-M4: Alfvén, **THOR**, Uranus, Farside
- ESA-S2: DSL

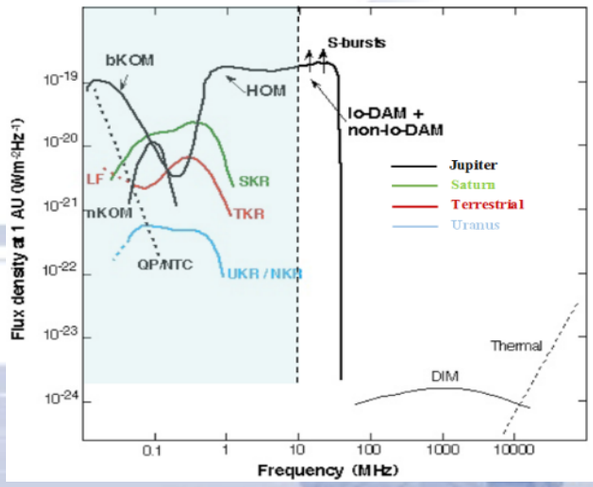
Suivants: projets de radioastronomie spatiale

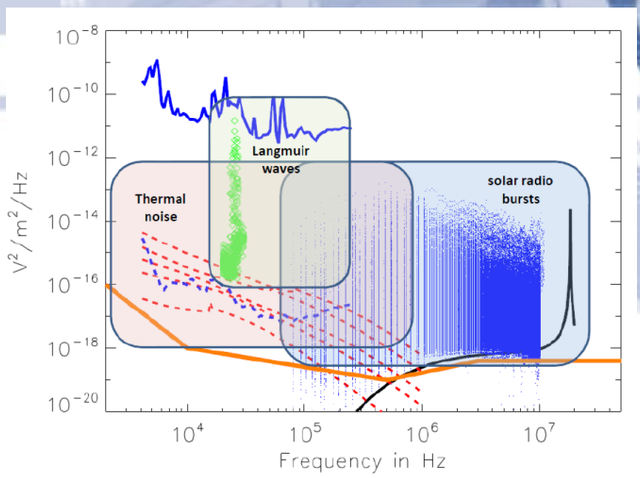
Avantages:
- Design innovant, consommation réduite (1/10)
- Compatible nanosat

Introduction

General requirements of radioastronomy receivers

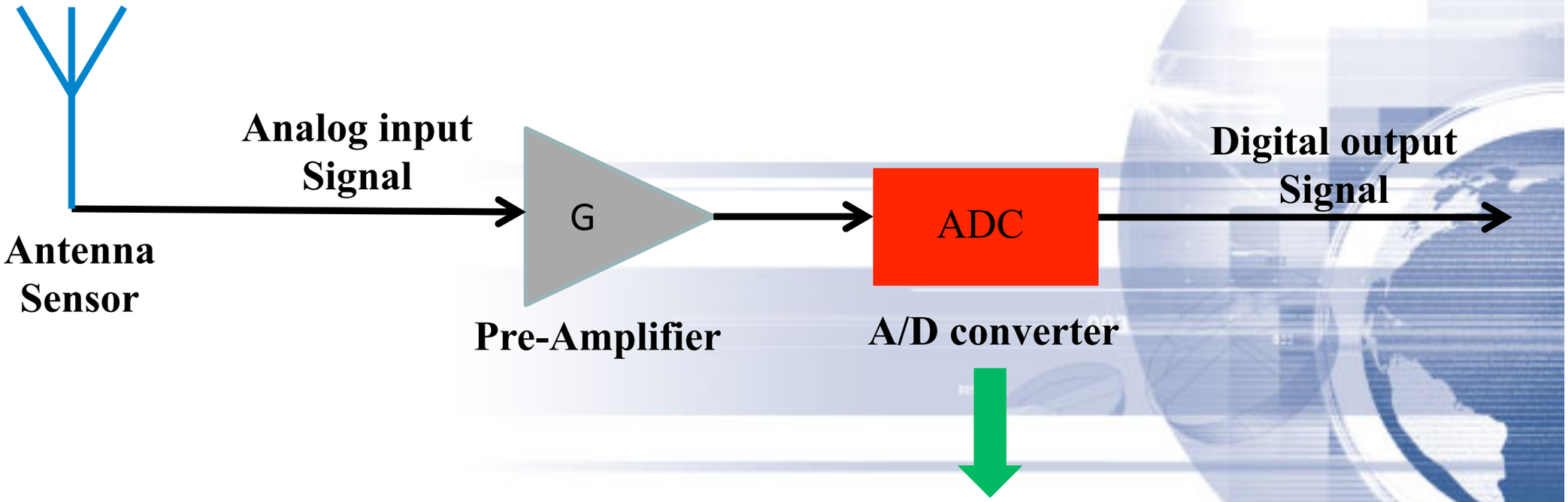
- ✓ High dynamic range ~ 120 dB
- ✓ Bandwidth : 100 MHz
- ✓ Frequency resolution : ~5% (1% for the tracking of local plasma frequency)
- ✓ Temporal resolution : < 1s





Introduction

Ideal radio receiver :

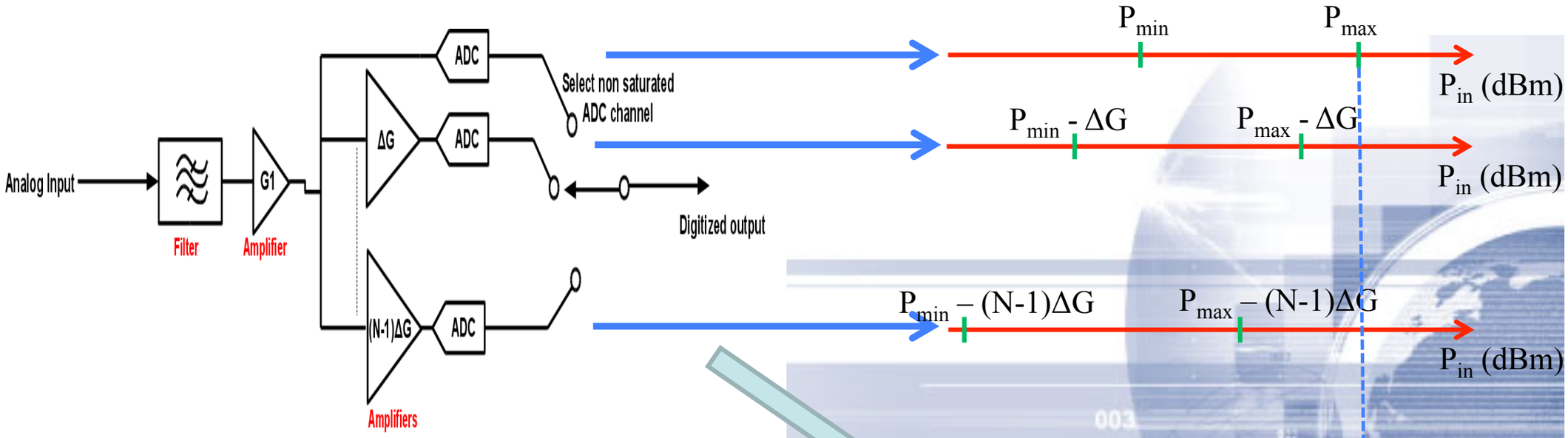


120 dB of dynamic range → Resolution : Minimum of 20 bits!!!

State of the art ADC@100 MHz → SNDR~(60-70)dB → Dynamic range enhancement techniques

High dynamic range receivers

3rt solution : Stacked ADC architecture

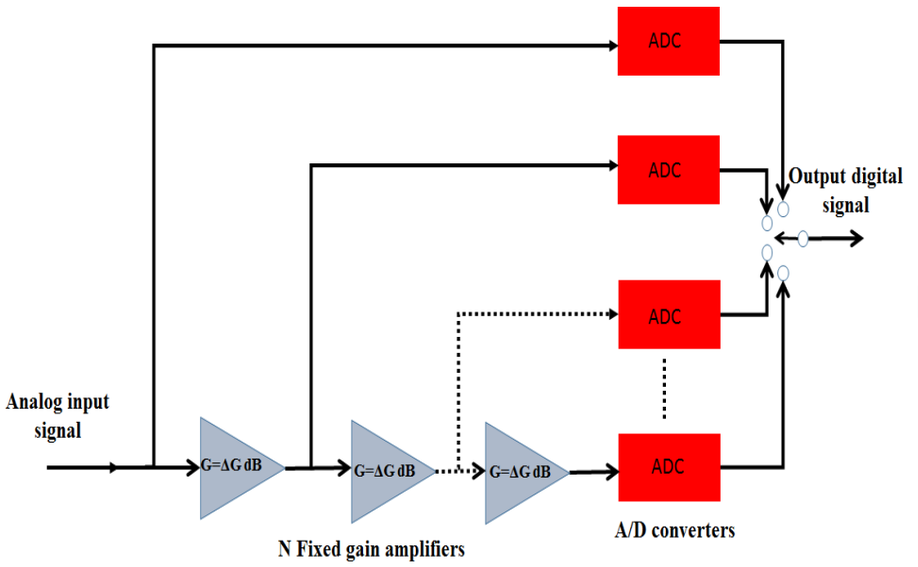


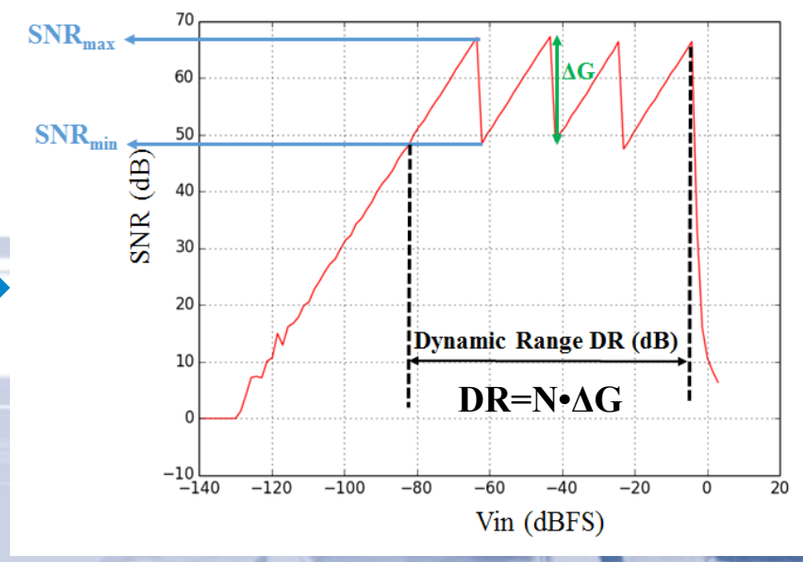
Dynamic range enhancement : (N-1)ΔG

Stacked ADC as defined by S. Duncan and al[2005] → Severe constraints on the gain and noise figure for the amplifiers

STacked A/D converters Receiver (STAR)

Stacked ADC modified architecture





- ✓ Less gain is needed for the amplifiers
- ✓ High noise requirements only for the first amplifier

Power consumption of the STAR receiver : $P= N \bullet P_{adc} + (N-1) \bullet P_{amp}$