SYSTEM CO-SIMULATION OF RADIO DIGITAL FRONT END

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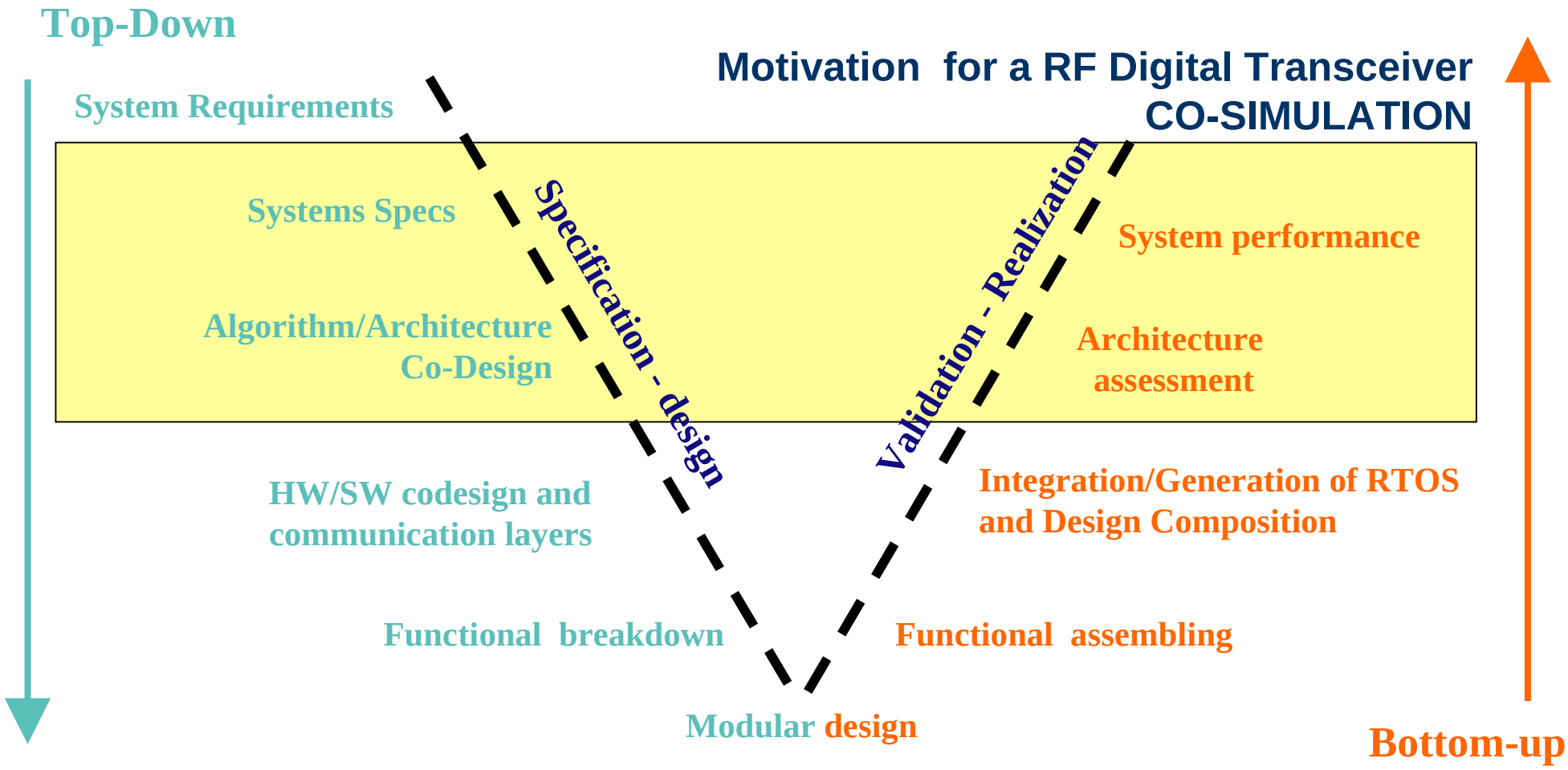
PRESENTATION PLAN

- 0 – SLD – System verification of digital radio front-end for base-band system
- 1 - CO-SIMULATION needs
- 2 - Existing ADS tool
- 3 - Advantages and drawbacks according to the needs
- 4 - Action plan, suggestions, open questions

Position in System Level Design



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1 - CO-SIMULATION needs

Digital Transceiver / RF Module
Wide band Transceiver

=> DTX-RF Co-simulation and Co-verification

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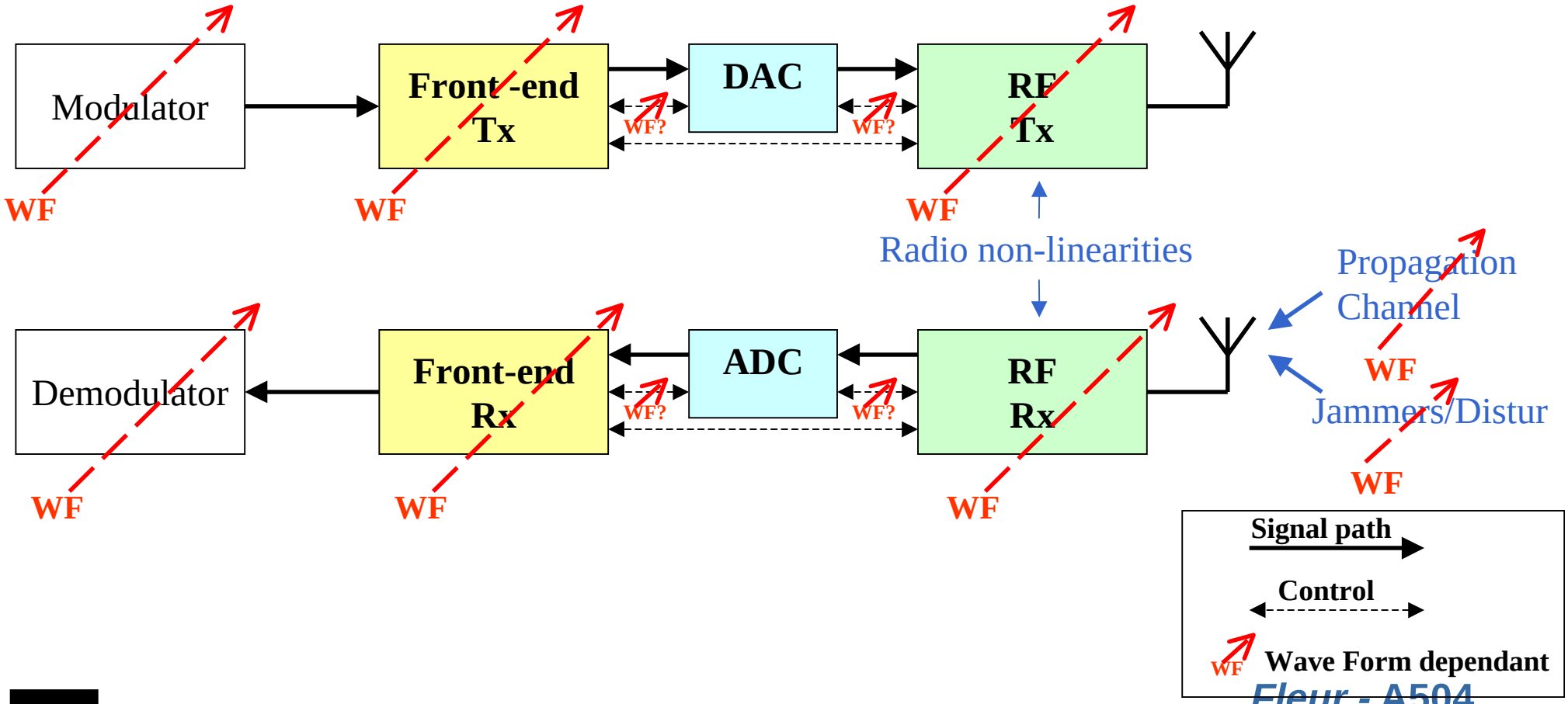
RCV & XMIT CHAINS TO SIMULATE



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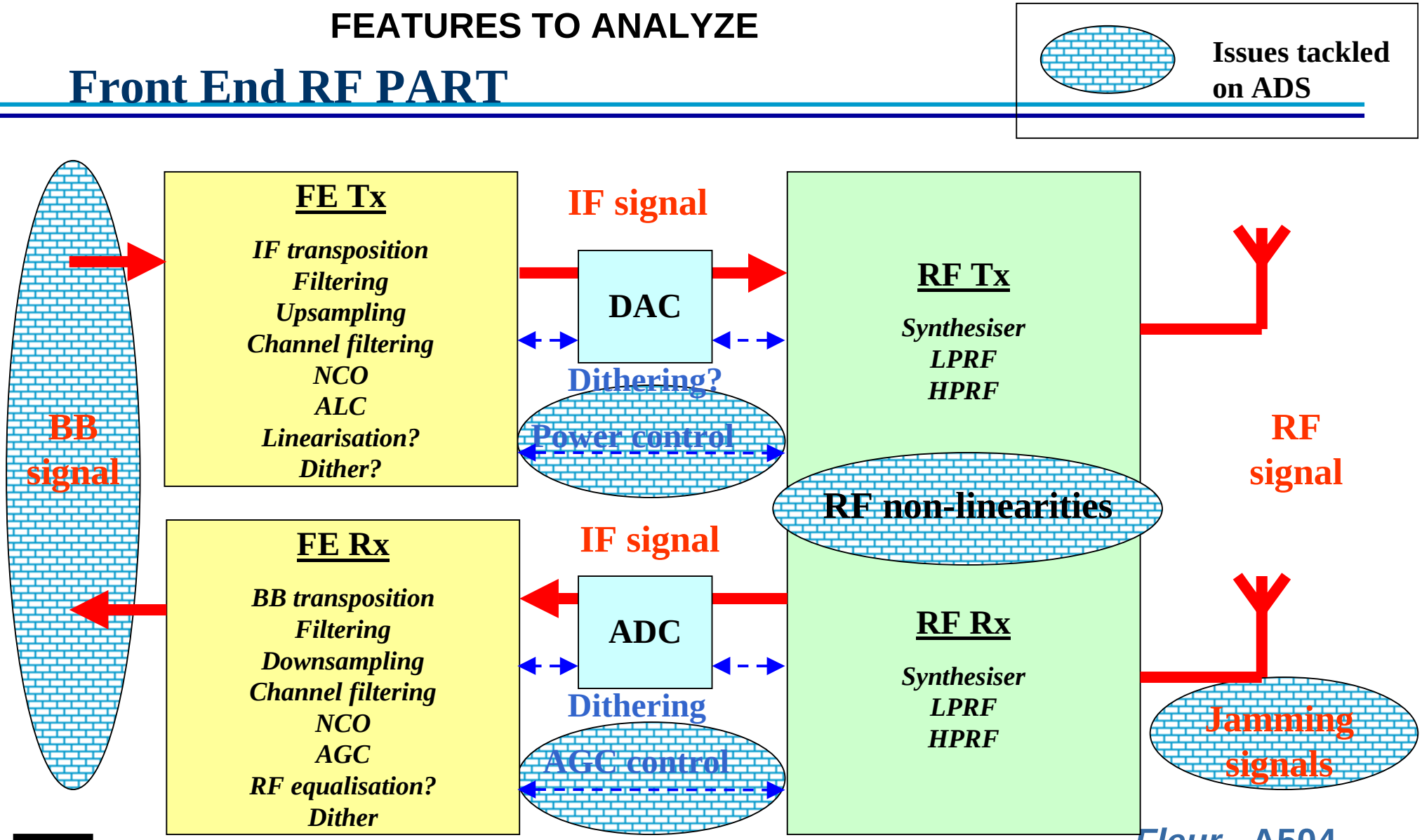
FEATURES TO ANALYZE

Front End RF PART



SYSTEM SIMULATION NEEDS AT SYSTEM LEVEL

- **Simulation of feedback loops**
  - Rx : AGC
  - Tx : Power Control (ALC)
- **Simulation of the whole radio chain**
  - Rx, Tx
  - Tx + Propagation channel + Rx ➔ BER (if necessary)
- **Simulation in a jammer context**
- **Simulation including the RF non-linearities**

2 - ADS tools

ADS TOOLS FOR CO-SIMULATION

- **Digital domain : Agilent Ptolemy**
  - signal processing simulations
- **Analogue domain : Circuit Envelope or High-Frequency SPICE (Transient) simulators**
  - analogue/RF simulations
- **Co-simulation : Agilent Ptolemy**
  - “master” for global co-simulations

MAIN ISSUES

- **HW/DSP/HW co-design**
  - RF implementation
  - Digital Signal processing algorithm
  - VHDL implementation
- **Validation of very closed functionality which strongly impact the global characteristics of the complete chain**
- **Architecture assessment regarding system requirements**

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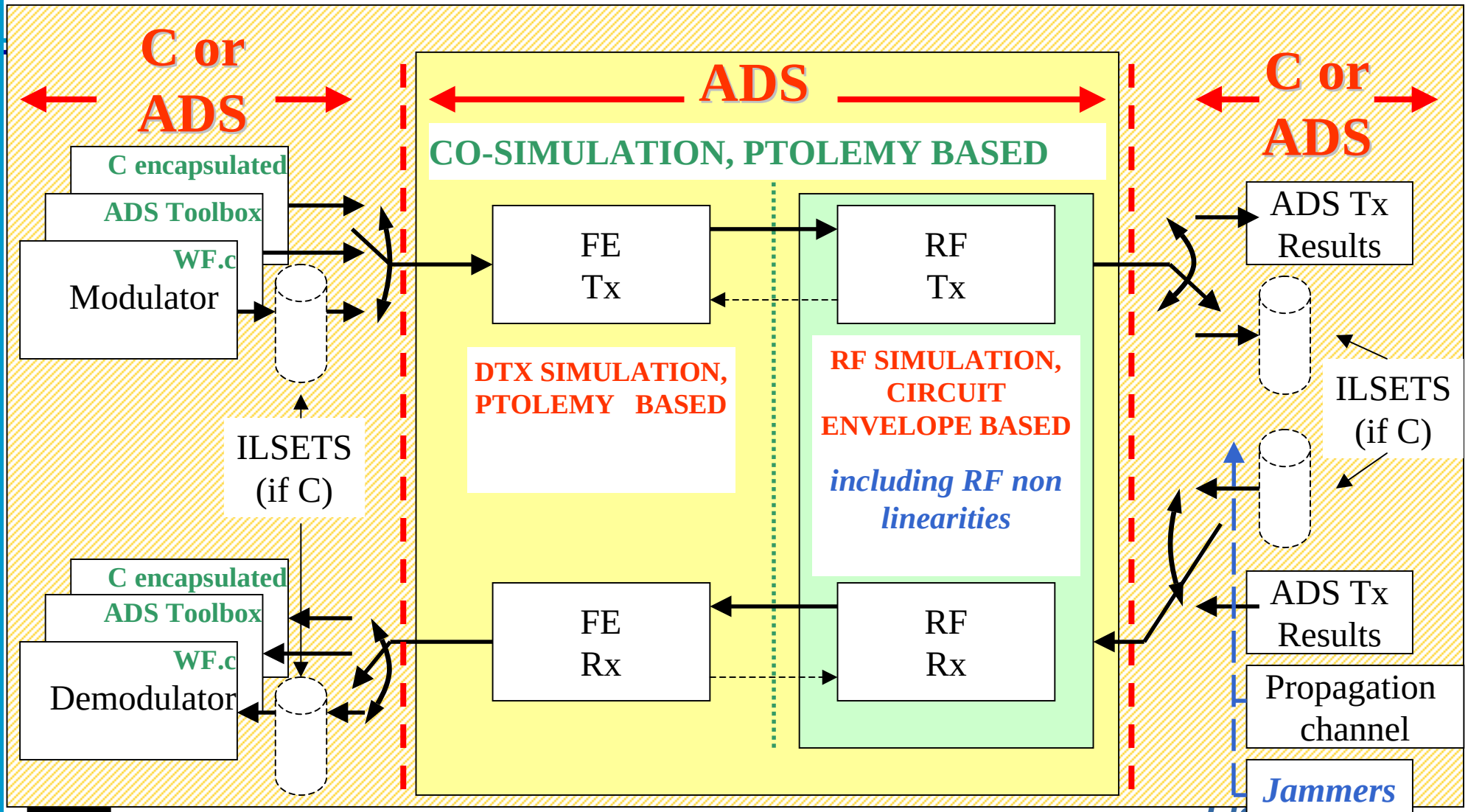
OVERVIEW OF THE ENVIRONMENT



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FIRST SIMULATIONS

- **First step: independent simulations of both digital and RF chains**
  - Simulation of the analogue chain (with circuit envelope): RF and IF parts
    - simulates: amplifiers, mixers, oscillators, feedback loops… in the presence of modulated and transient high frequency signals
    - speed, efficiency and realistic details
    - includes: adjacent channels, harmonics, noise, …
  - Simulation of the digital chain (with Ptolemy): IF and BB parts
    - good performances
    - includes: ADC, digital filters, harmonics, ...

ADVANCED SIMULATIONS

- **Second step: co-simulation of digital and RF chains (plus propagation channel)**
  - The real added value is for feedback loops (Rx: AGC, Tx: Power control) between both worlds and simulations at different time scale levels with associated models:
    - RF: characterisation of non-linearities, …
    - IF: AGC transient analysis
    - BB: long BER computations (see remark next slide), false alarm probability

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3 - Advantages and drawbacks according to the needs

ADVANTAGES

- **Co-simulation between RF part and Digital Signal processing module**
- **Simulation of feedback loops**
  - Rx : AGC (ex digital filtering)
  - Tx : Power Control (ex linear PA for EDGE or UMTS)
- **Integration of the global environment**
  - non-linearities
  - jammer
  - Channel characteristics

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DRAWBACKS/LIMITS OF ADS

- **Extreme frequencies**
  - If we consider a co-simulation with the RF in the UHF band (225-400MHz) and if we want to simulate the effects of a closed interferer (for example at 25kHz of the useful signal), then the ratio between the extreme frequencies is 16000 (400MHz/25kHz) and ADS cannot perform the simulation in such conditions.
- **Not suitable for BER simulation**
  - Too long 10^{-5} = days , 1 ms = 4 days
- **ADS Models**
  - Different ADS blocks + noise
  - Not yet validated

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4 - Current status

Current status

- **ADS is powerful but**
  - the simulation of the entire chain may be very long,
  - And expensive
- **Solution is applicable in small runs to validate particular concepts (eg: AGC, ALC…with transient issues)**
- **Classical approach seems more suitable for characterisation**
  - in C language or Matlab for instance
- **Both approaches are complementary**
- **Generation of VHDL test vectors to be assessed**

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