



# Reconfigurable Architecture of Real-Time Data Processing for Laser-aided Electron Density Diagnostics on EAST Tokamak

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# Outlines

- **Introduction**
- **Primary Interferometers on EAST**
- **Reconfiguration Architecture Concept**
  - **Signal Processing System for SSI**
  - **Signal Processing System for CO<sub>2</sub>-DI**
  - **Configuration Modules**
- **Results of Real-Time Data Processing**
- **Summary and Outlook**



# Introduction

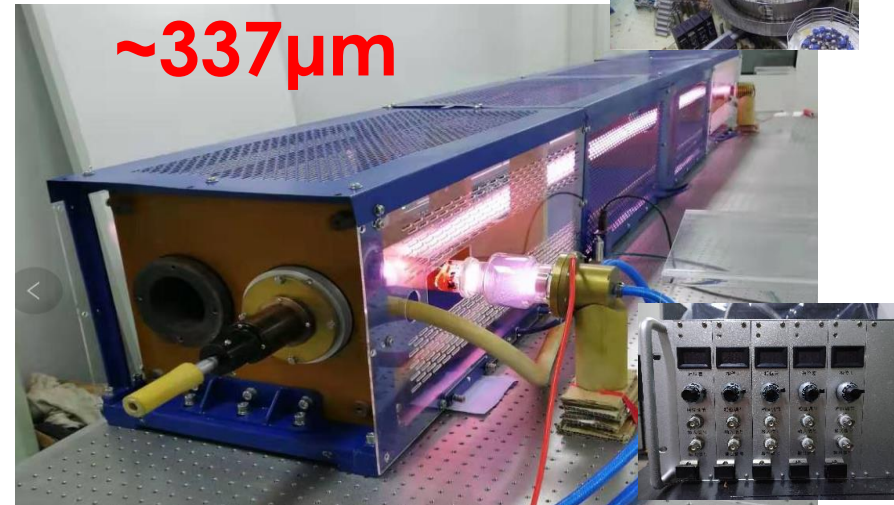
- Interferometers for electron density ( $n_e$ ) measurements are indispensable diagnostics on Tokamaks.
  - Different interferometers employ different DAQ system
    - requirements for future fusion devices: Real-time; integration,...
    - same principle/signal processing method for interferometers
    - different source of error; different synchronous signals
- ✓ *A unified real-time DAQ can be implemented to solve or simplify problems above. (Development of electronics)*
- ✓ *Rapidly implementing DAQ hardware for different interferometers.*



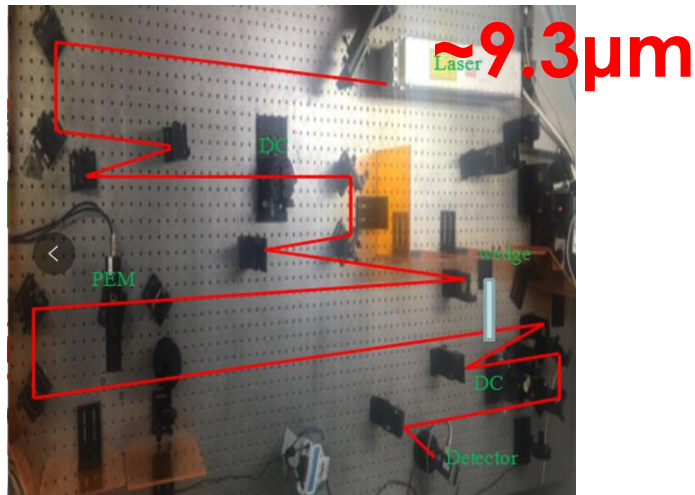
# Primary Interferometers on EAST



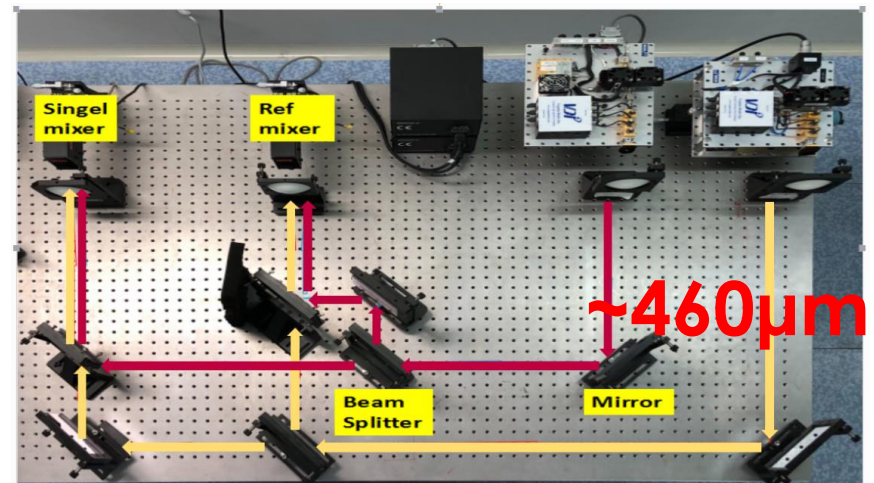
□ **P**Olarimeter-**I**NTERferometer



□ **H**CN interferometer



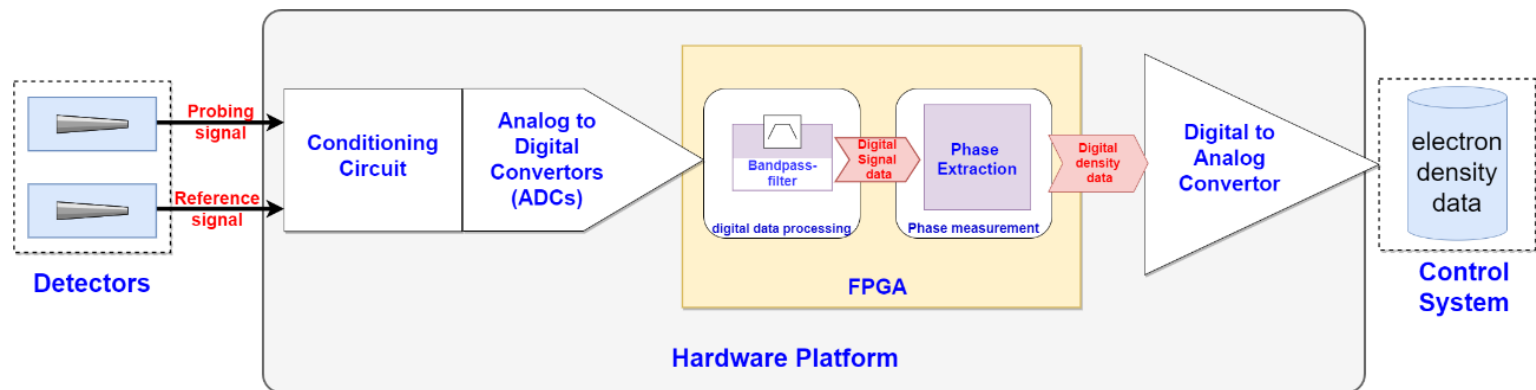
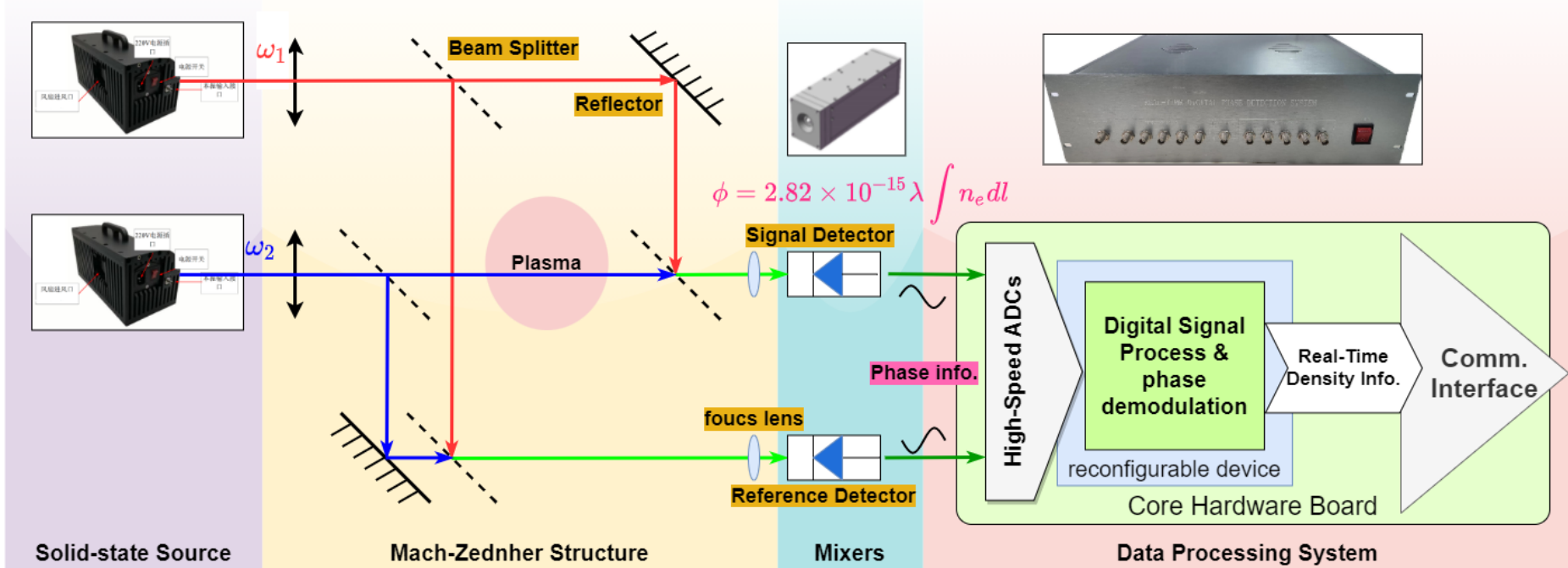
□ **C**O<sub>2</sub> **D**ispersion **I**nterferometer



□ **S**olid-**s**tate **S**ource **I**nterferometer



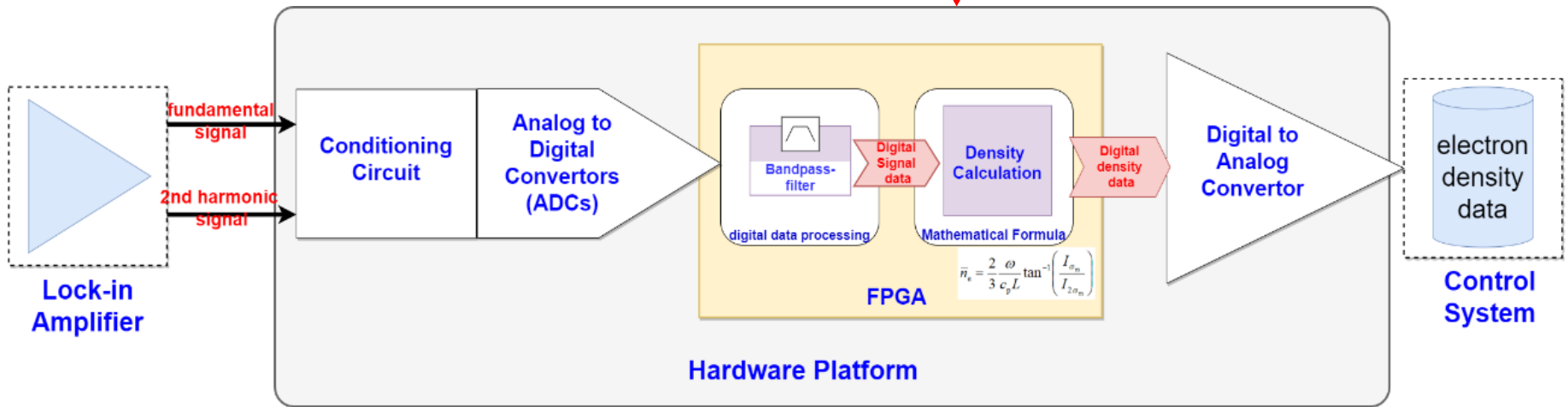
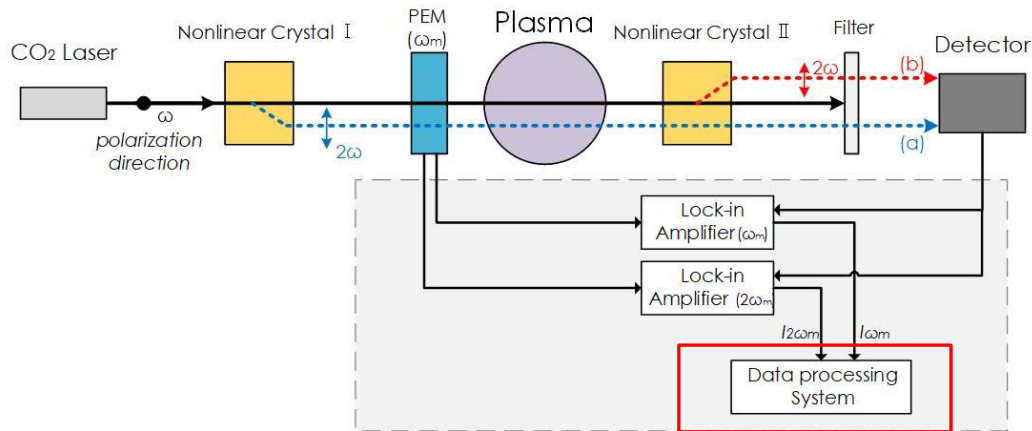
# Signal processing system for SSI/HCN



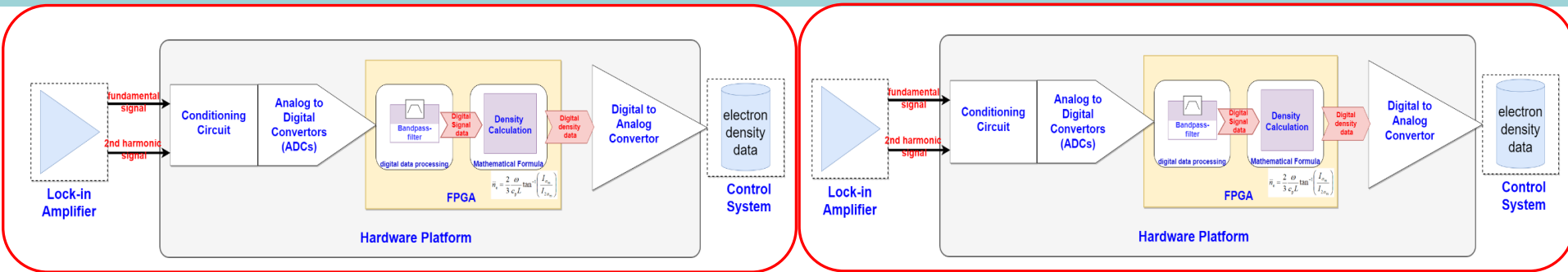
Similar one for HCN interferometer



# Signal processing system for CO<sub>2</sub>-DI

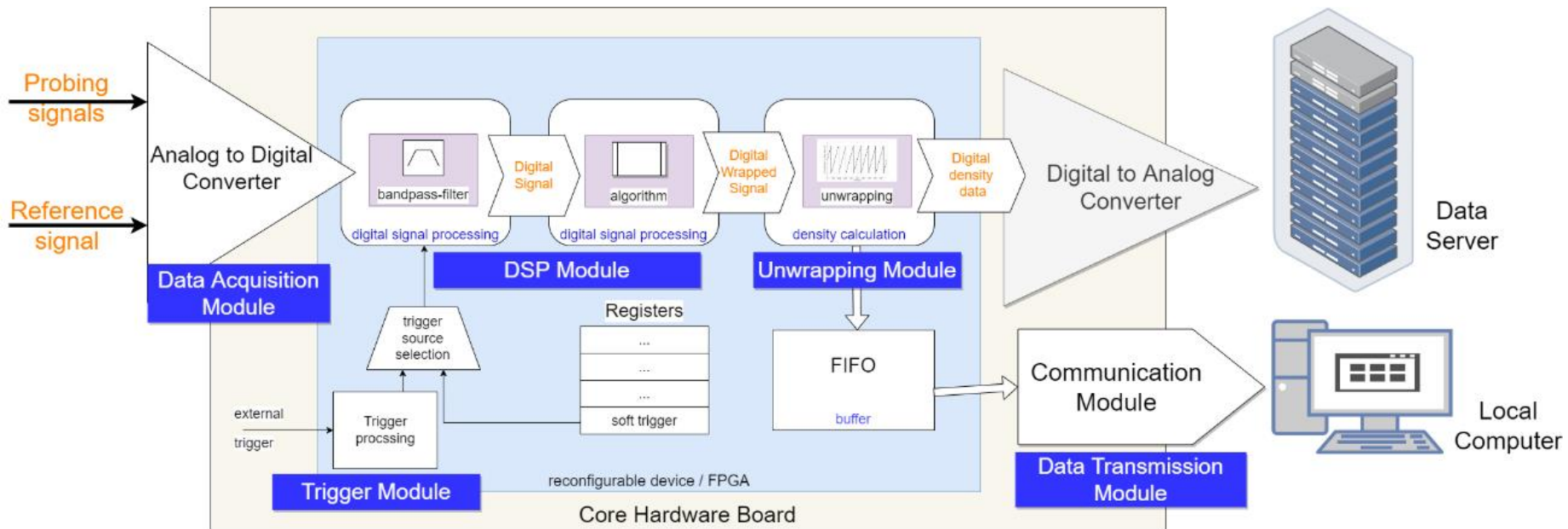


# Signal processing systems' architectures



DAQ system for HCN/POINT/SSI

DAQ system for CO2-DI



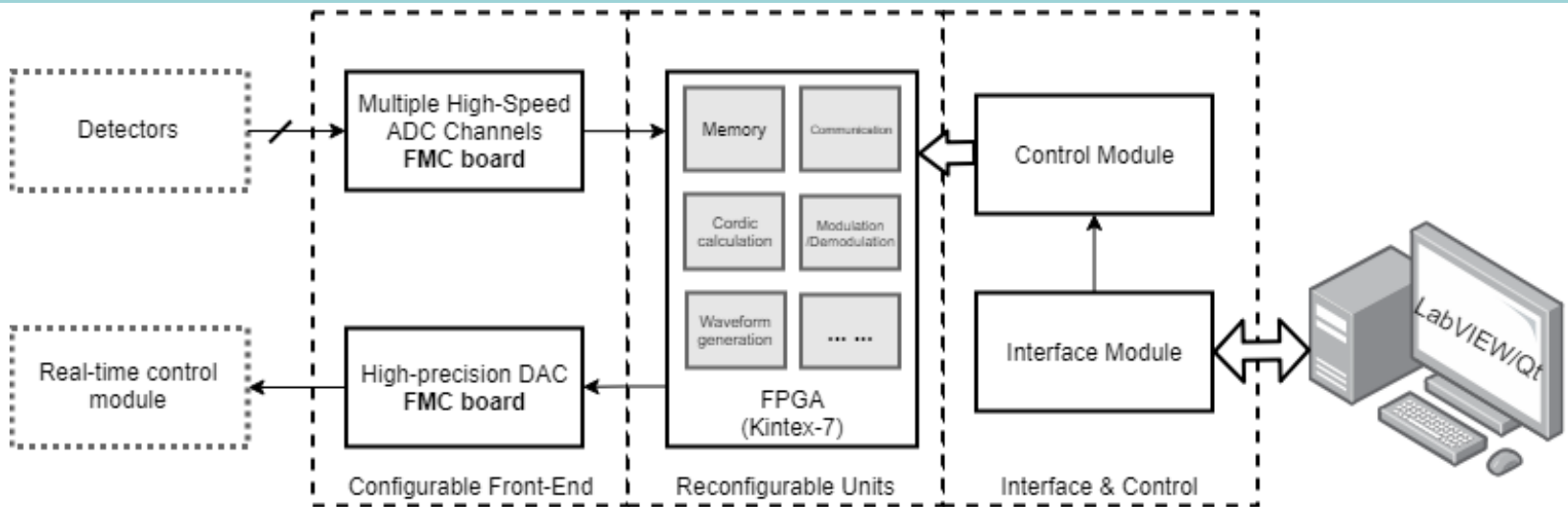
# Reconfiguration Concept

**Reconfiguration is a computer architecture, combining some of the flexibility of software/firmware, with the high performance of hardware by processing with very flexible high speed computing fabrics like field-programmable gate arrays (FPGAs).**



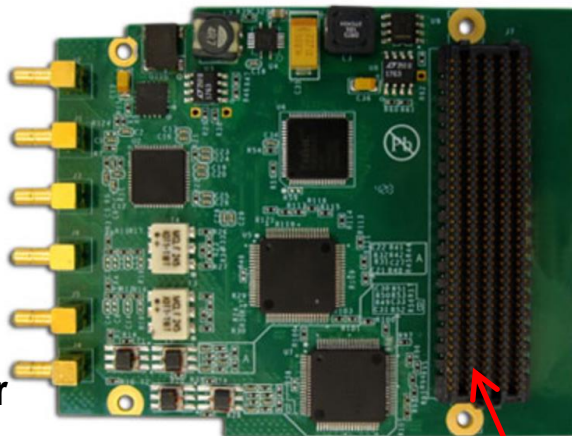


# Framework of a Reconfigurable system

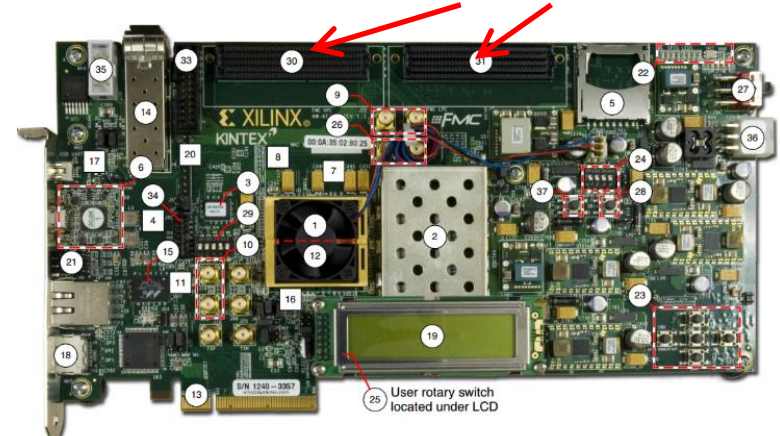


**FMC Connector**

- AD Channel 1
- AD Channel 2
- DA Channel 1
- DA Channel 2
- External Clock
- External Trigger



**FMC Connector**



**KC705(with Kintex-7 Chip) Development Board**



# Calculation Modules

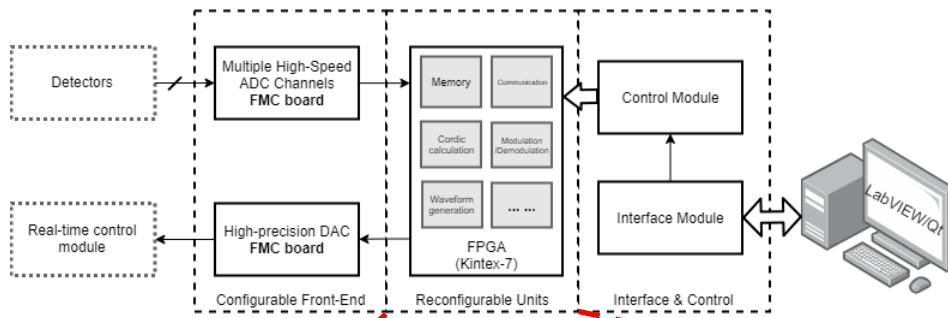
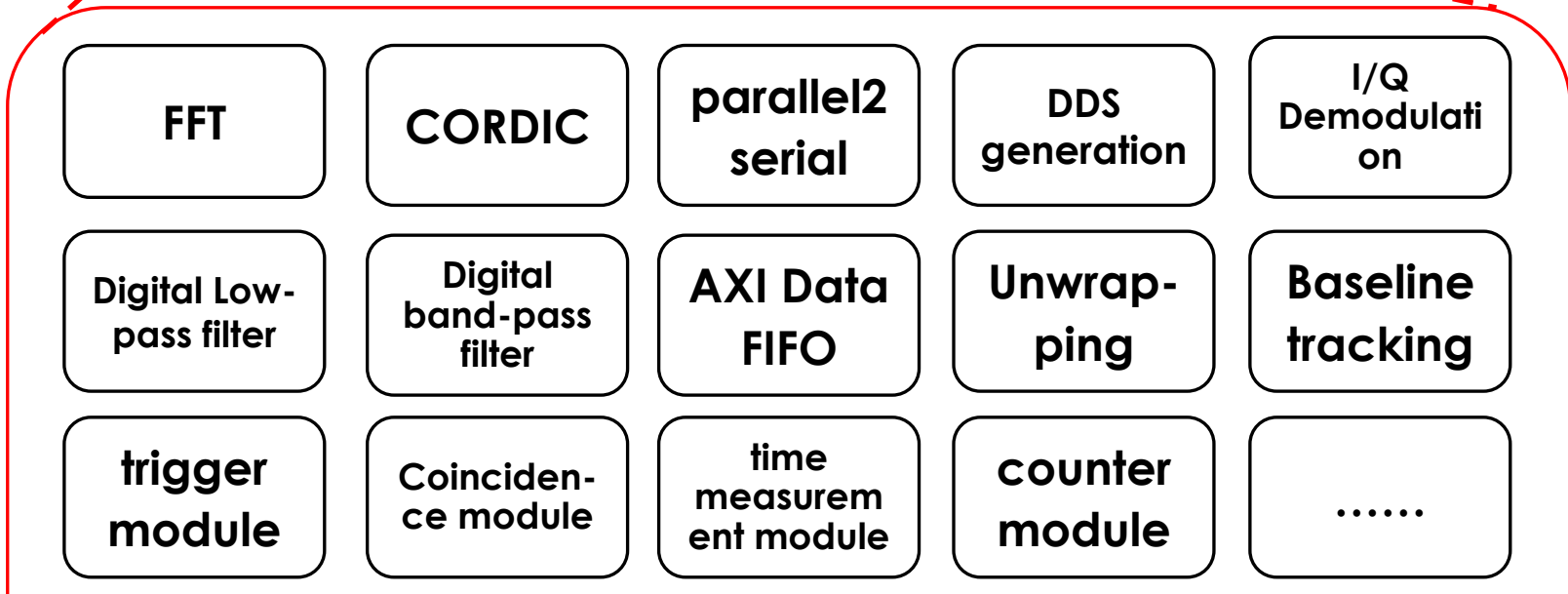


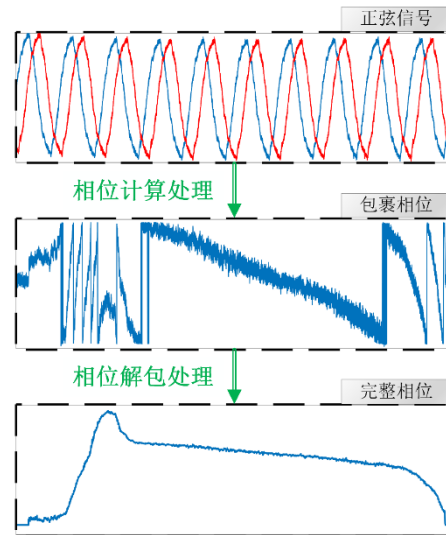
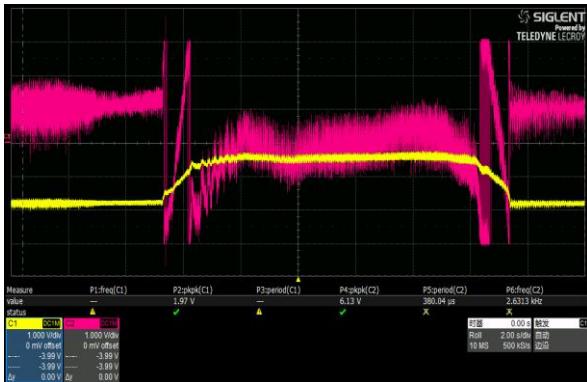
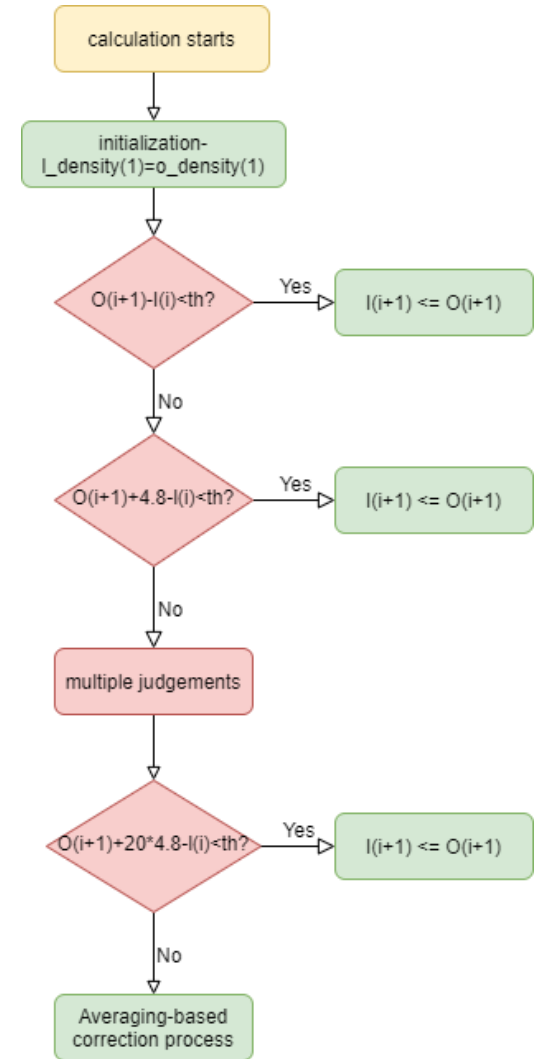
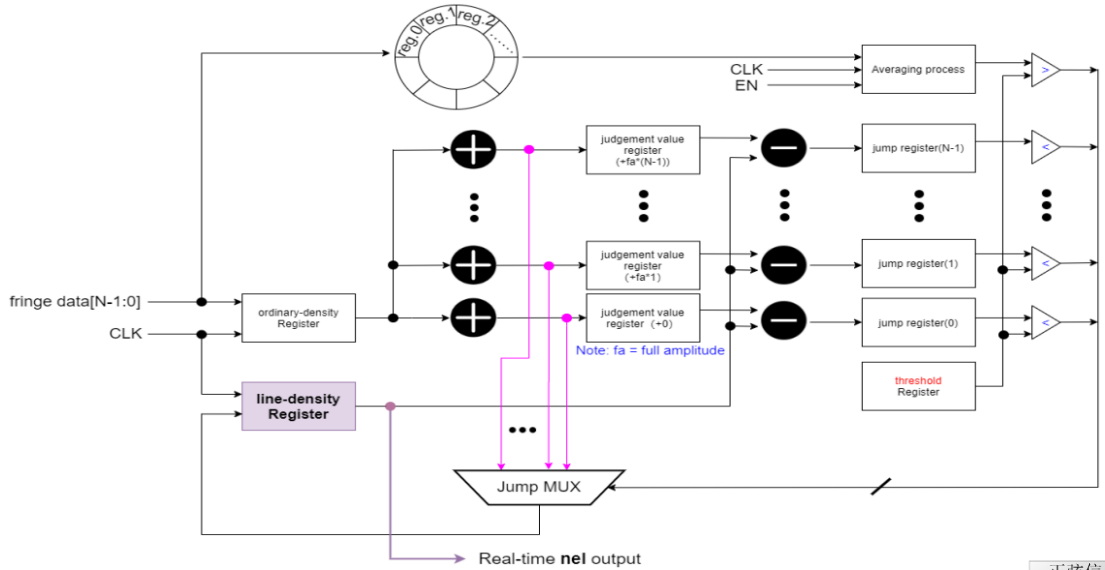
Fig. 1. Framework of reconfigurable digital phasemeter

Device Source Summary (XC7K325T-2FFG900C)	
Logic resource	Avail.
No. of Regs	407,600
No. of LUT	203,800
No. of DSP48E1s	840

## 3 main libraries



# Diagram & Algorithm of unwrapping module



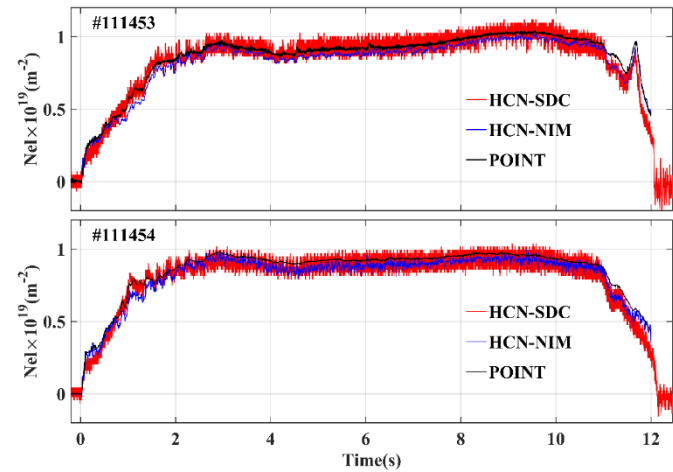
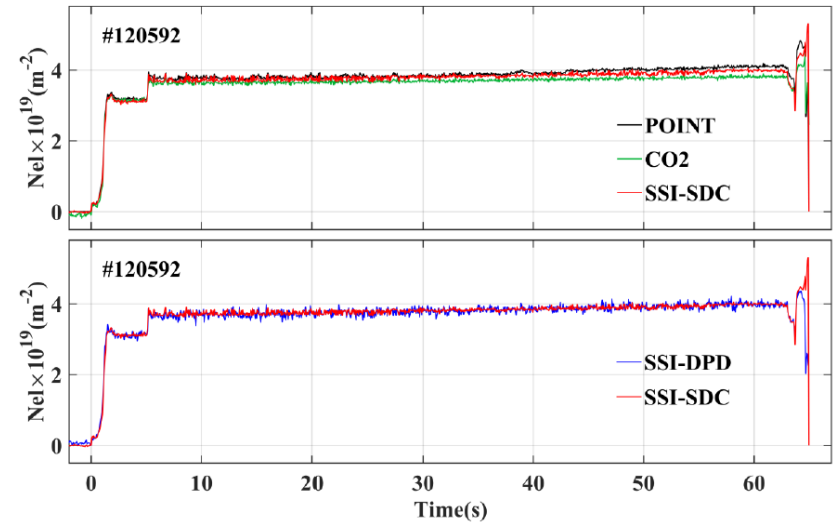
# Results of real-time data processing system



Bench test of the system



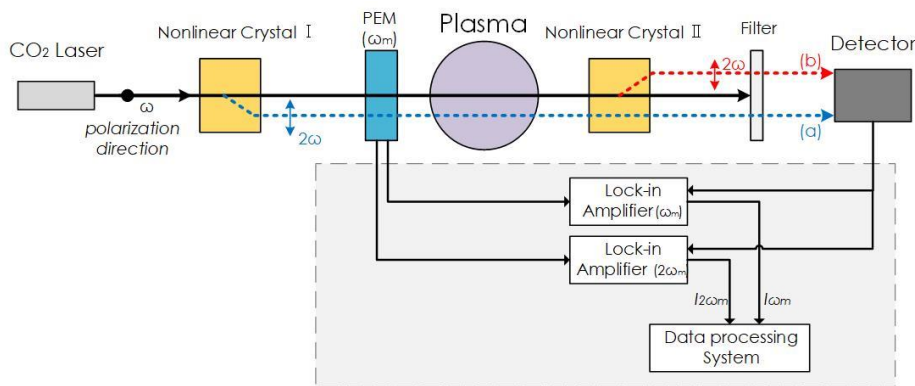
System for Solid-state interferometer Setup on EAST



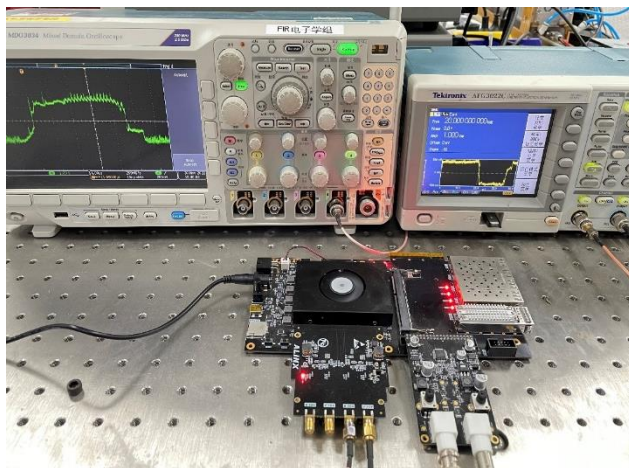
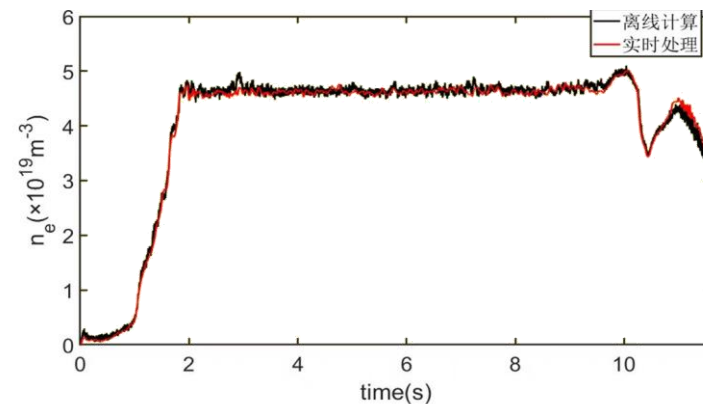
Comparison of our system and POINT



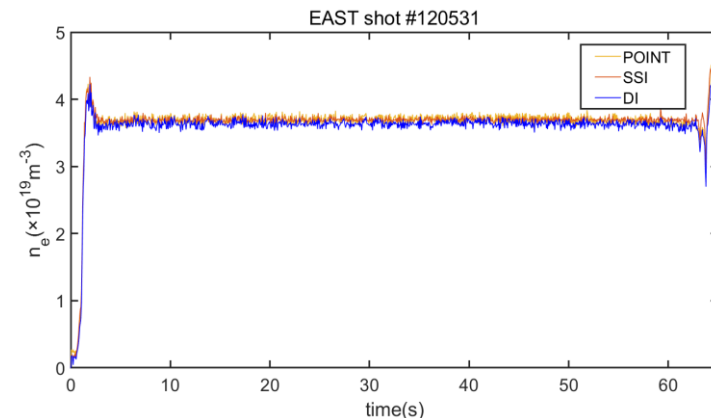
# Results of real time data processing system for CO<sub>2</sub>-DI



Principle of CO<sub>2</sub> dispersion interferometer



Bench test of the system



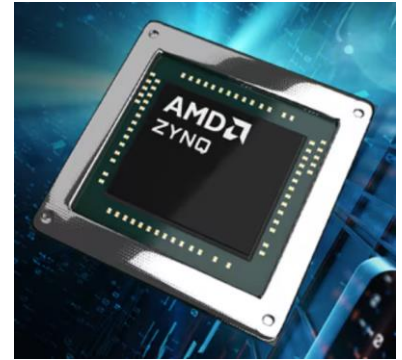
Comparison of our system and POINT



# Summary and Outlook

## SUMMARY

- ❑ The framework of the reconfigurable system has been established
  - ❑ Development board + FMC front-end board
  - ❑ 3 main libraries
- ❑ Basic arithmetic modules have been designed
  - ❑ FFT, CORDIC, I/Q Modulation, Series2Parallel ...
  - ❑ Communication modules
  - ❑ front-end readout
- ❑ Electronic Bench-test have been finished.
- ❑ The data processing system has been setup on SSI and CO<sub>2</sub>-DI (HCN before) and tested in latest discharging campaigns.



## OUTLOOK:

- ❑ More modules, especially Arithmetic modules will be designed and added into core Library
- ❑ New devices (High-speed, Multi-channel, .etc) will be used for diagnostics.



The background of the image is a complex, futuristic architectural structure. It features a central, large cylindrical column with a grid-like pattern of small, square openings. This central column is surrounded by several other cylindrical and spherical components, some of which have a similar grid pattern. The overall color scheme is light gray and white, with a subtle orange glow on the left side. The text "Thanks for your attention." is overlaid in a bold, red, sans-serif font, centered on the main cylindrical structure.

**Thanks for your  
attention.**

# POINT Data Processing System

