


X-Band Test Stands: Conditioning and Operational Algorithms

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NATIONAL INSTRUMENTS

Agenda

- System goal
- Software architecture
- Algorithm description
  - Tuning
  - Conditioning

System goal

Each accelerating structure needs a few thousand hours of high power RF conditioning

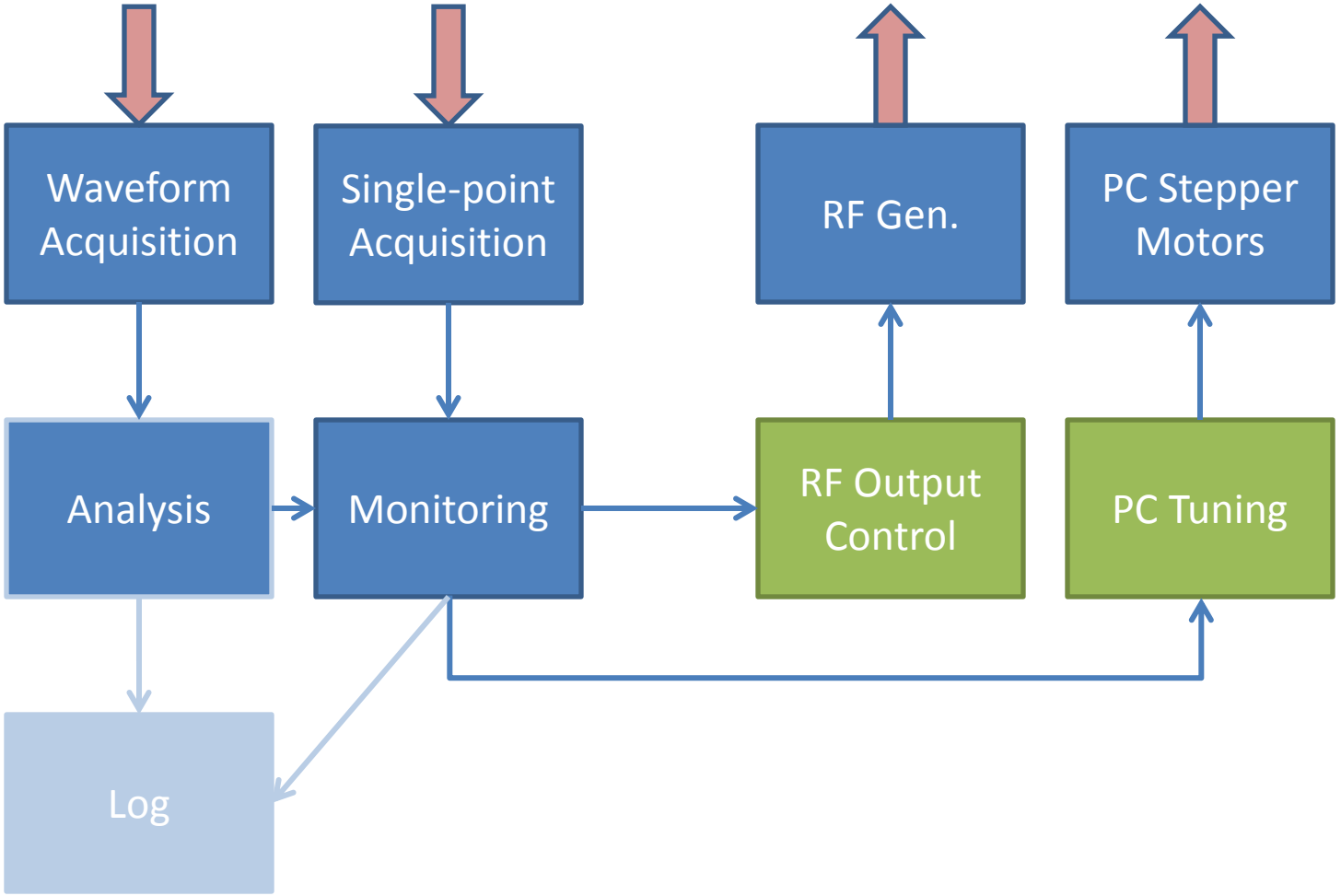
The purpose of the software is to automate the X-band test stands to run 24/7.

- Automatically increase power over time
- Tune pulse compressor (XBOX1)

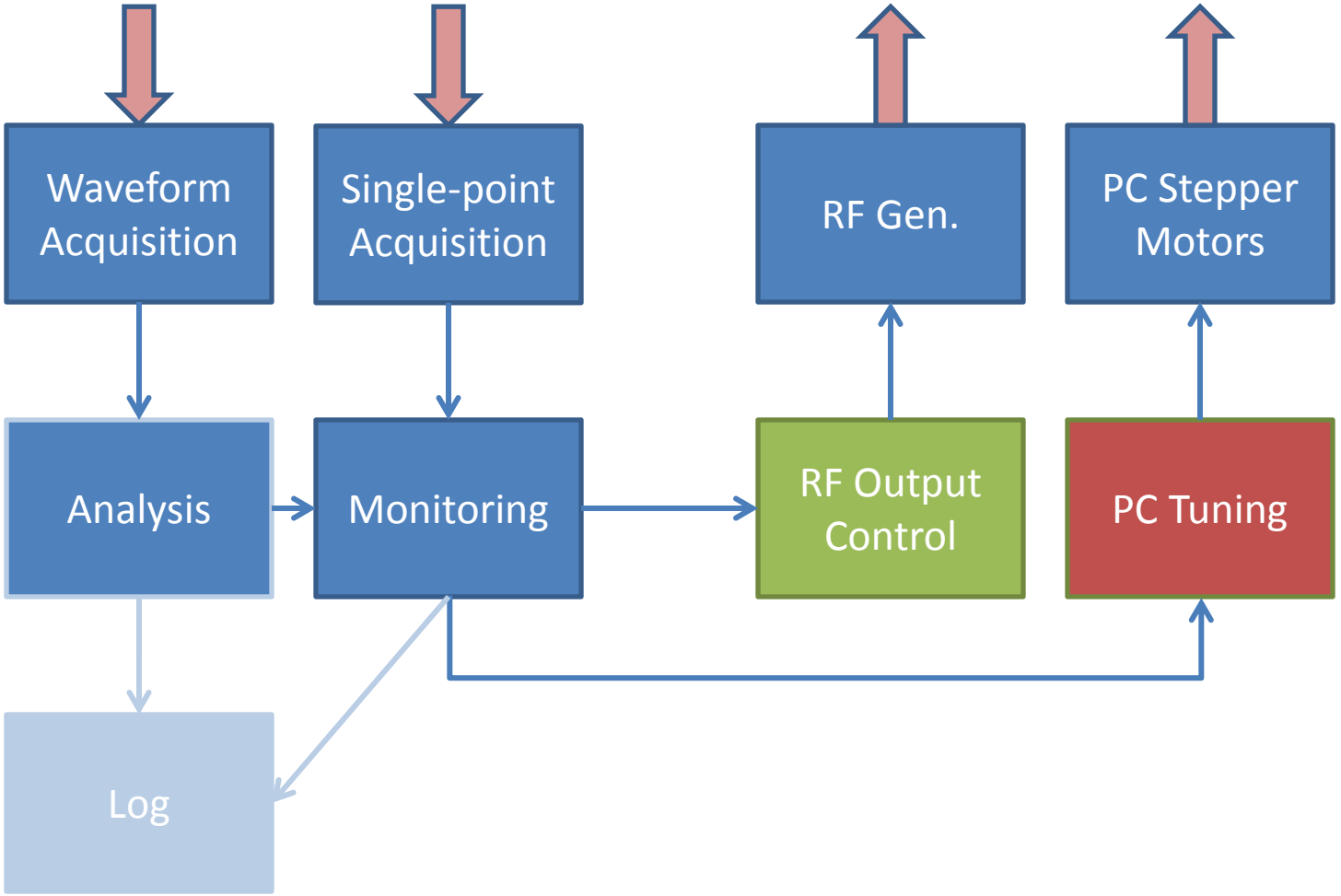
Software Versions

- XBOX1 software
  - TERA CBOX
  - CTF Dogleg
- XBOX2 software
  - SLAC XBOX
  - XBOX3
- Further external interest
  - CPI
  - TERA TULIP

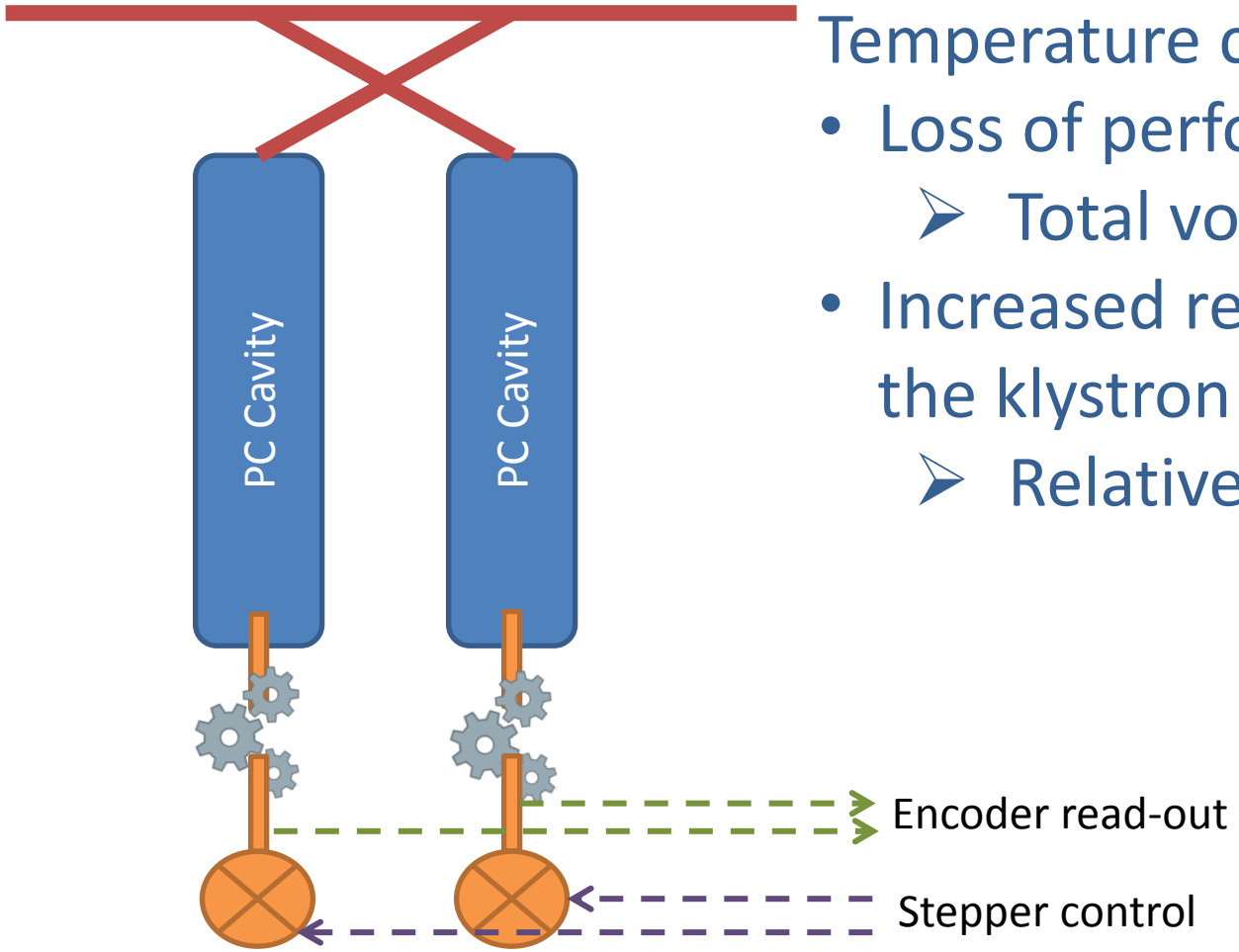
Software Architecture



Software Architecture



Pulse Compressor Tuning (XBOX1)

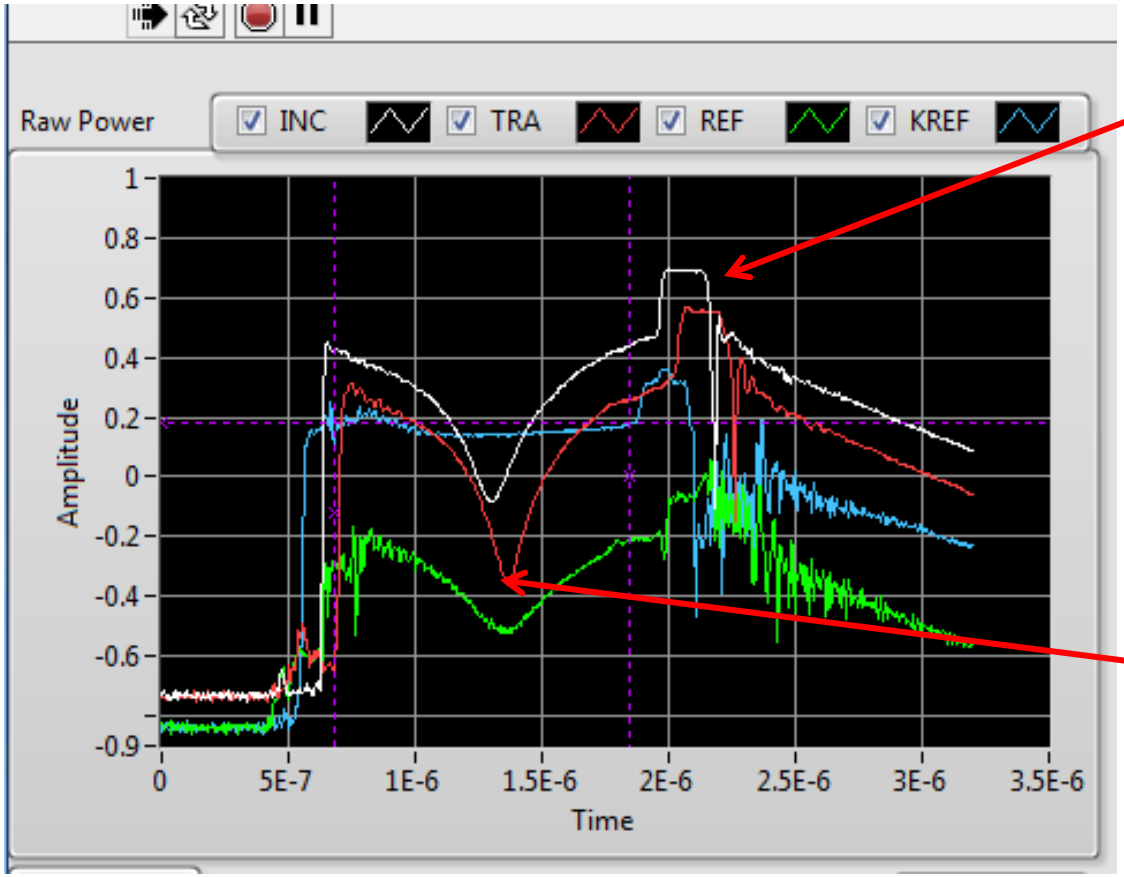


Temperature changes lead to:

- Loss of performance
  - ➢ Total volume offset
- Increased reflection back to the klystron
  - ➢ Relative volume offset

Photo by Ben Woolley

Tuning Indicators



Slope of flat top

Position of dip

PC Tuning Algorithm Loop (XBOX1)

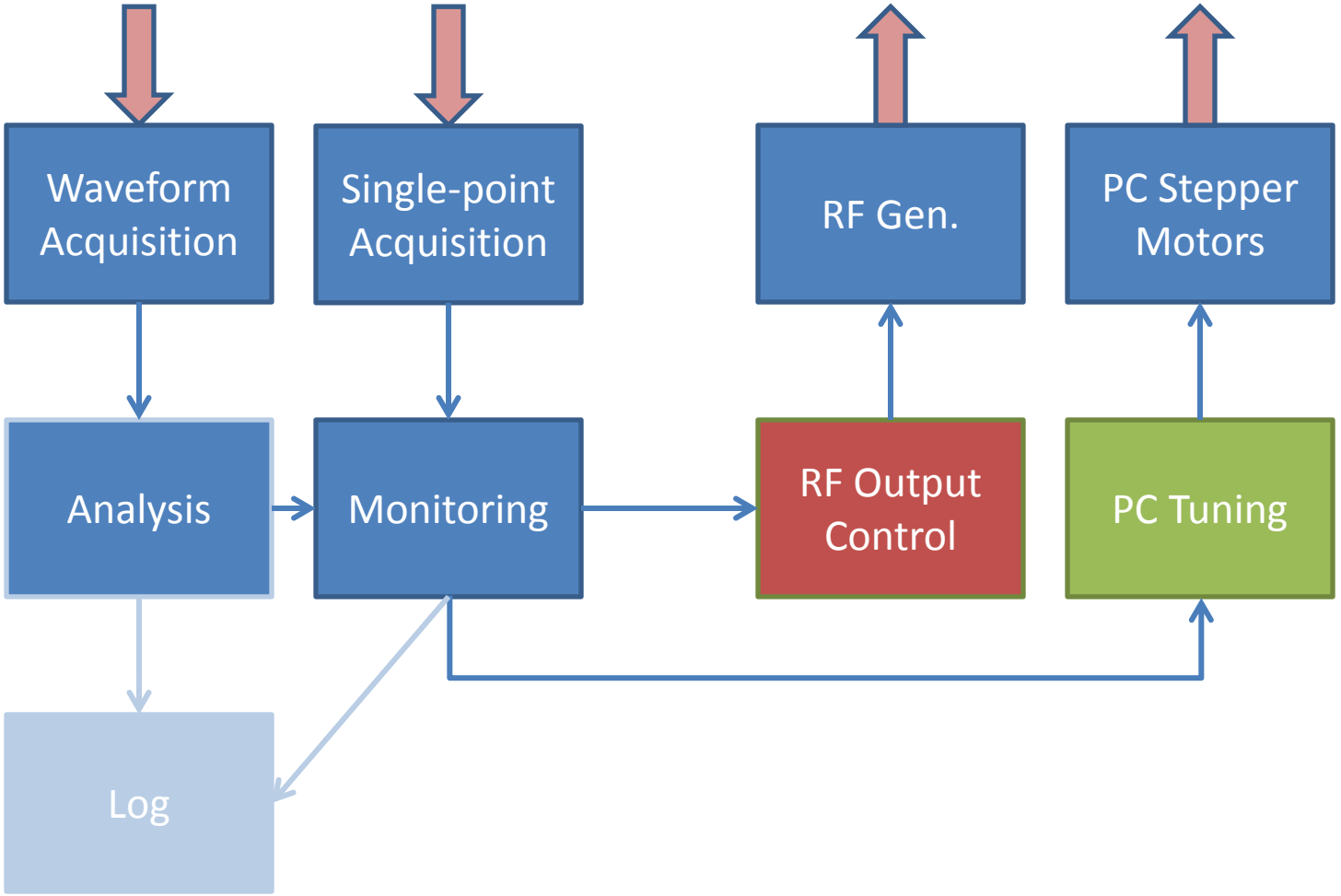
```
if reflected_dip > limit:
        change one cavity volume
        if things get worse:
                inverse direction of change
else:
        if slope good:
                work on power amplitude PID
        else:
                change volume of both cavities
                if things get worse:
                        inverse direction of change
```

Pulse Compressor Tuning (XBOX2)

- Water-cooled PC cavities
- Programmable chiller units maintain temperature
- No further automatic control at this time

Photo by Ben Woolley

Software Architecture



Power/Conditioning Control

- **Fast** – second
  - PID loop on the incident power to the structure
- **Medium** – minutes
  - increase power by 10kW every few minutes if no BD
  - reduce power by 10kW if successive BDs too close in time
- **Slow** – hours
  - BDR measurement and stop power increase if it is too high
  - Moving average of 1M pulses

Conditioning on Vacuum

- When outgassing is the limiting factor
- Replace medium-term algorithm to stabilize at a specified pressure

Allows conditioning of any high-power RF device

CTF Dogleg Amplitude Control

- Requires 2 setpoints:
  - With beam present
  - Without beam present
- Increase power when beam detected
- React to beam loss by immediately reducing power output to pre-beam levels

Dogleg Beam Loading

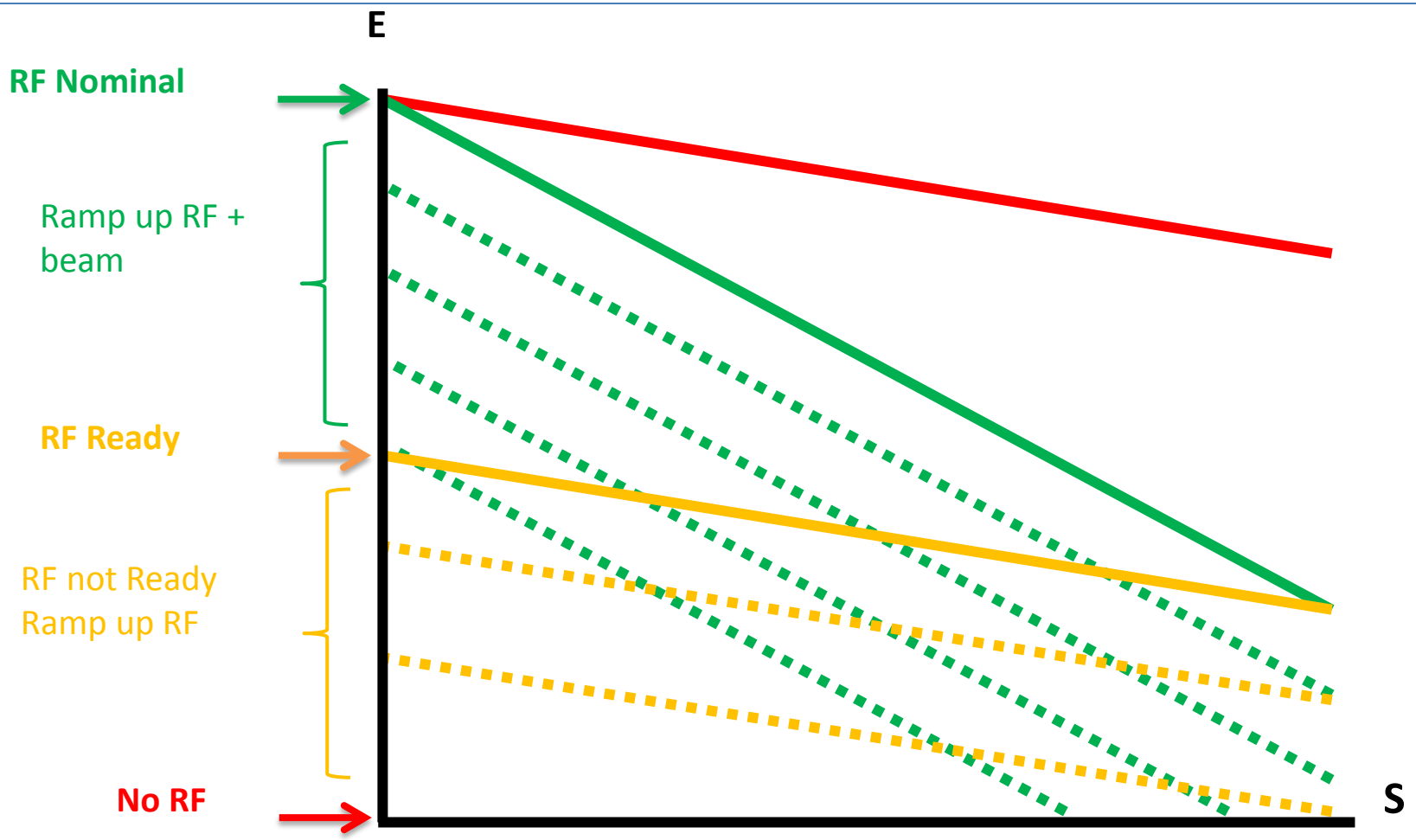


Image by Luis Navarro

Phase Control (XBOX2)

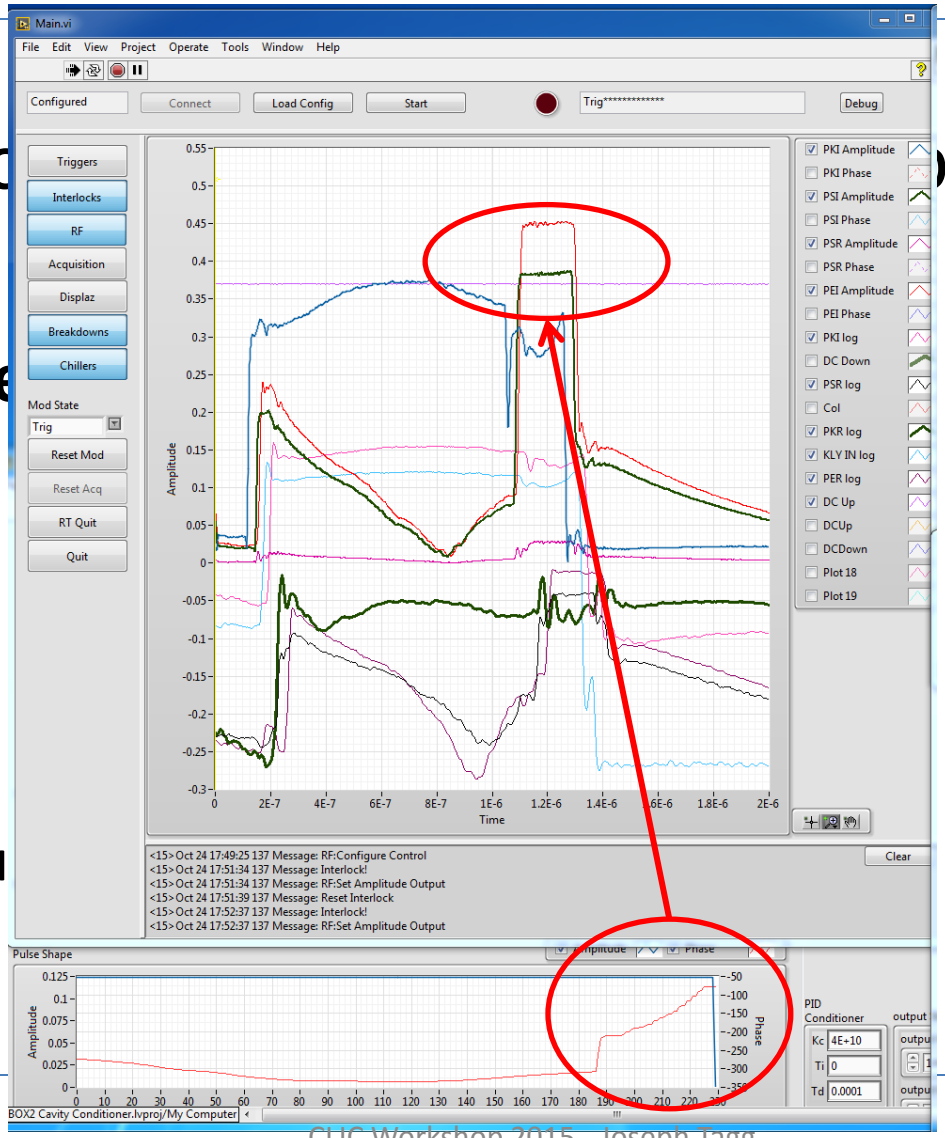
Phase is c … of the pulse

A_se

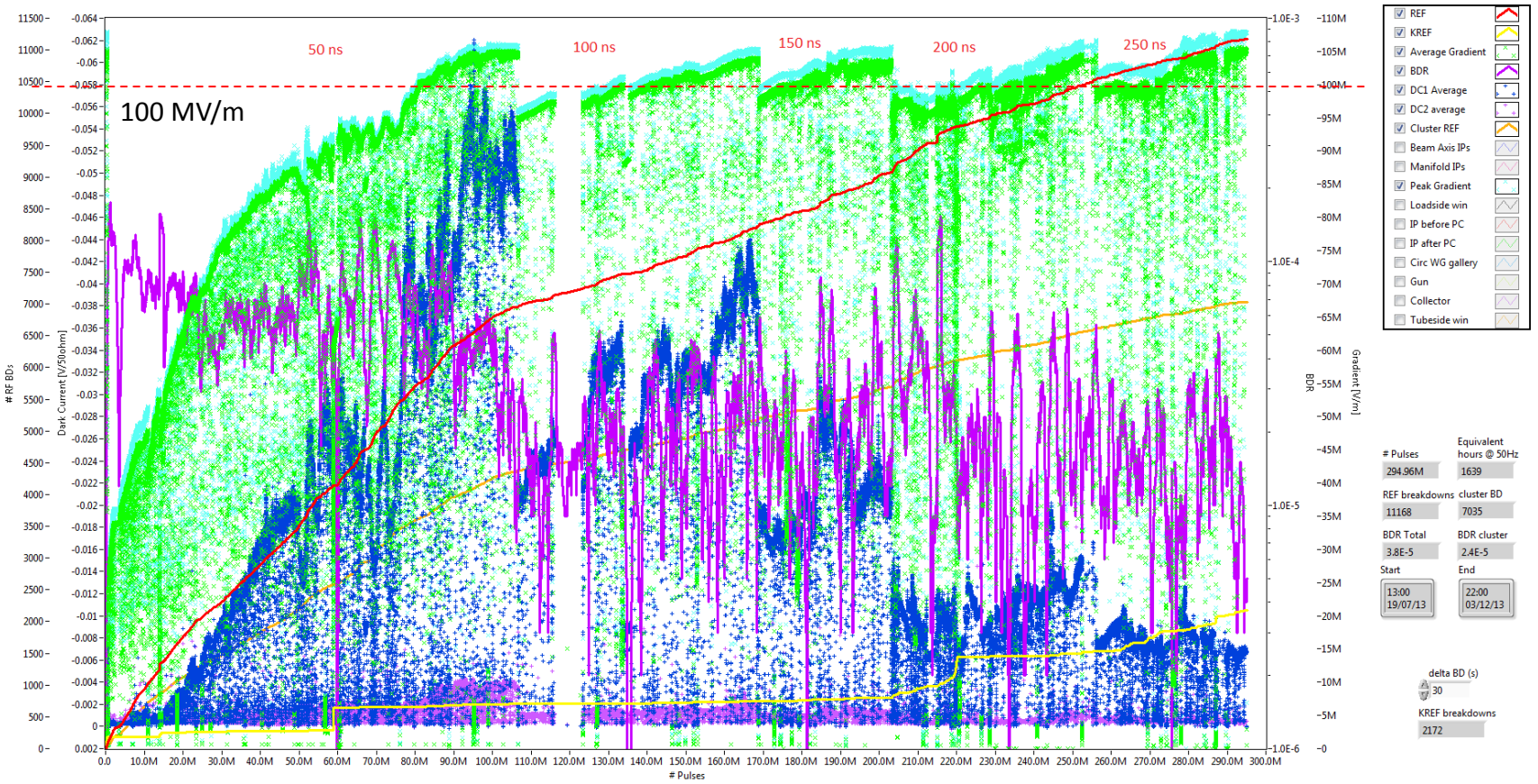
A

rate

ϕ_{ou} … * rate



XBOX1 Results



Thank you for your attention.

Questions?