

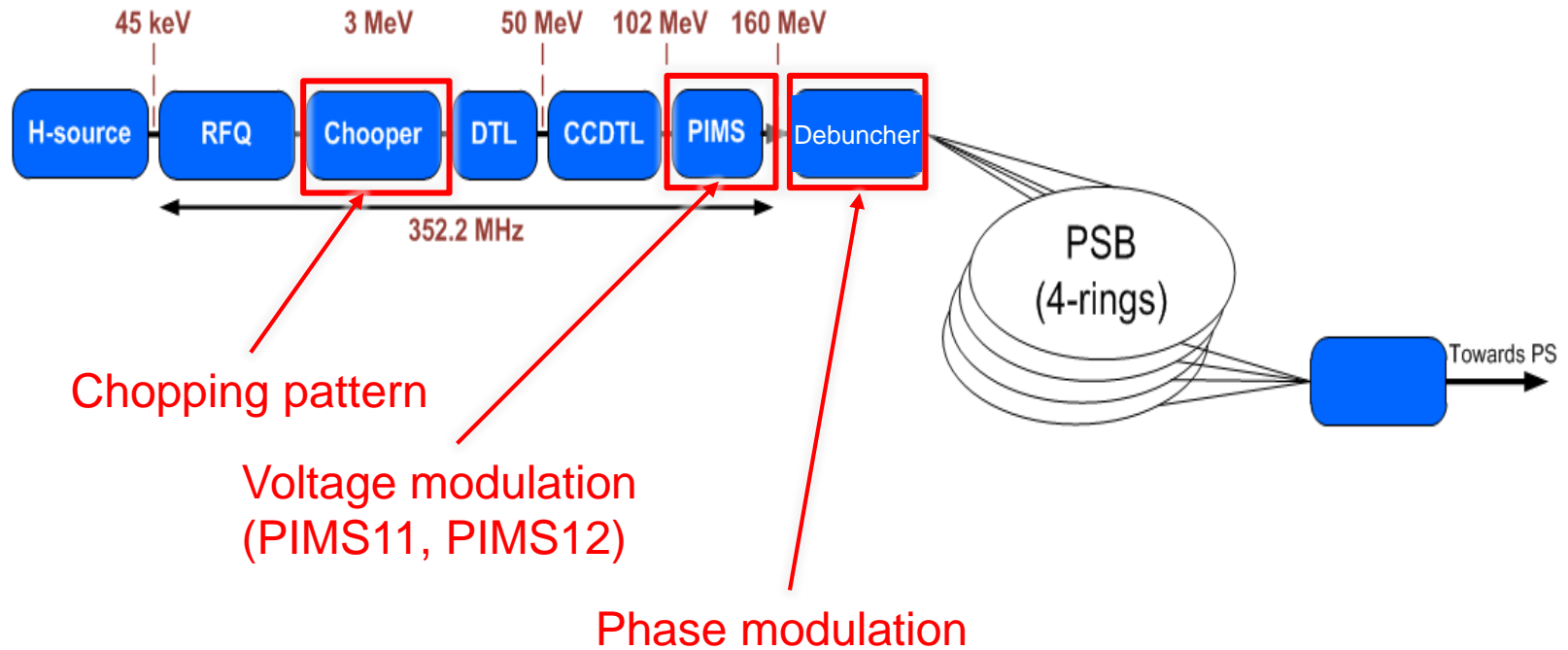
# Linac4 LowLevel RF

Longitudinal painting : Chopper-PIMS-Debuncher

Grégoire Hagmann, Philippe Baudrenghien

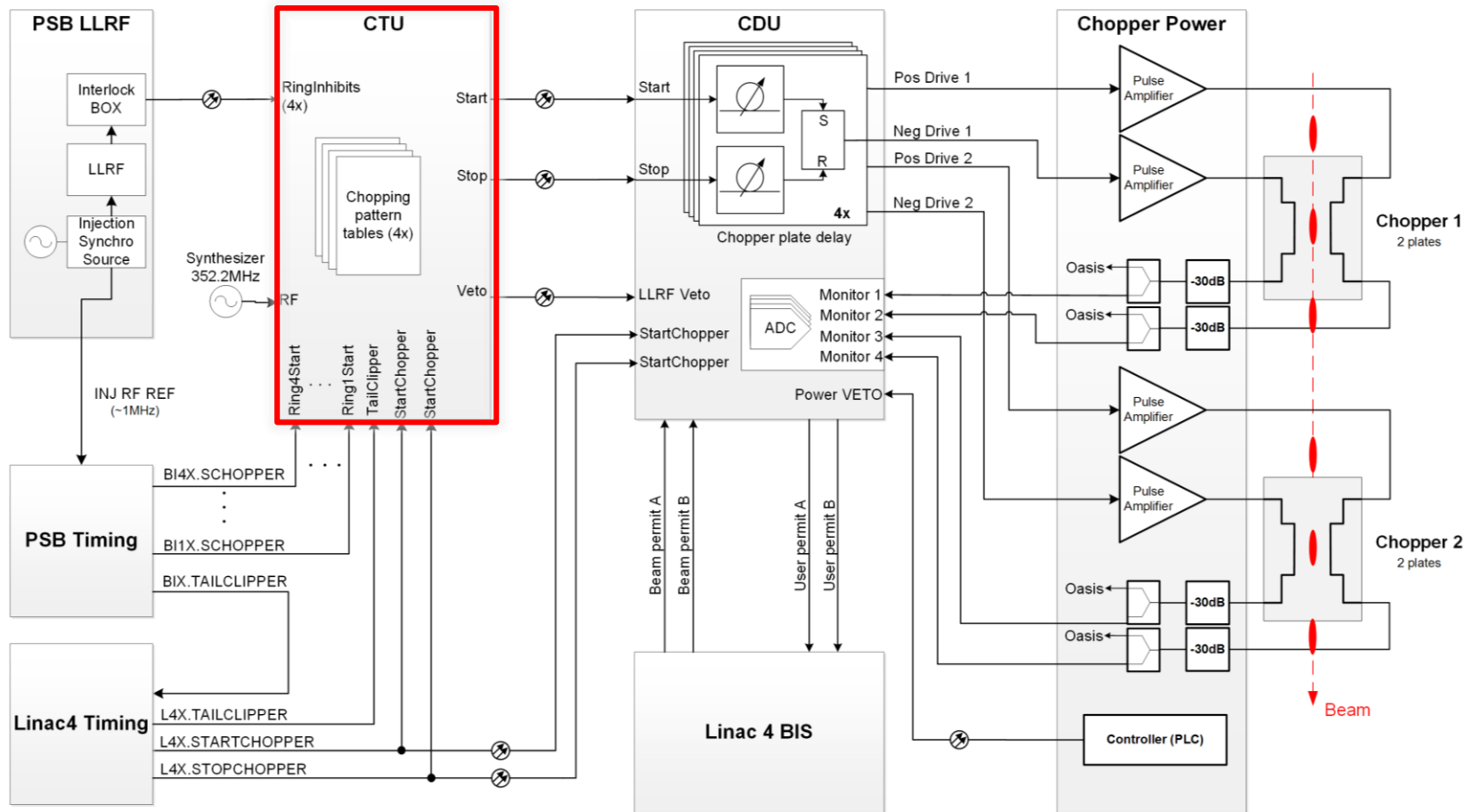
# Linac4 LowLevel RF

*Longitudinal painting "actors"*



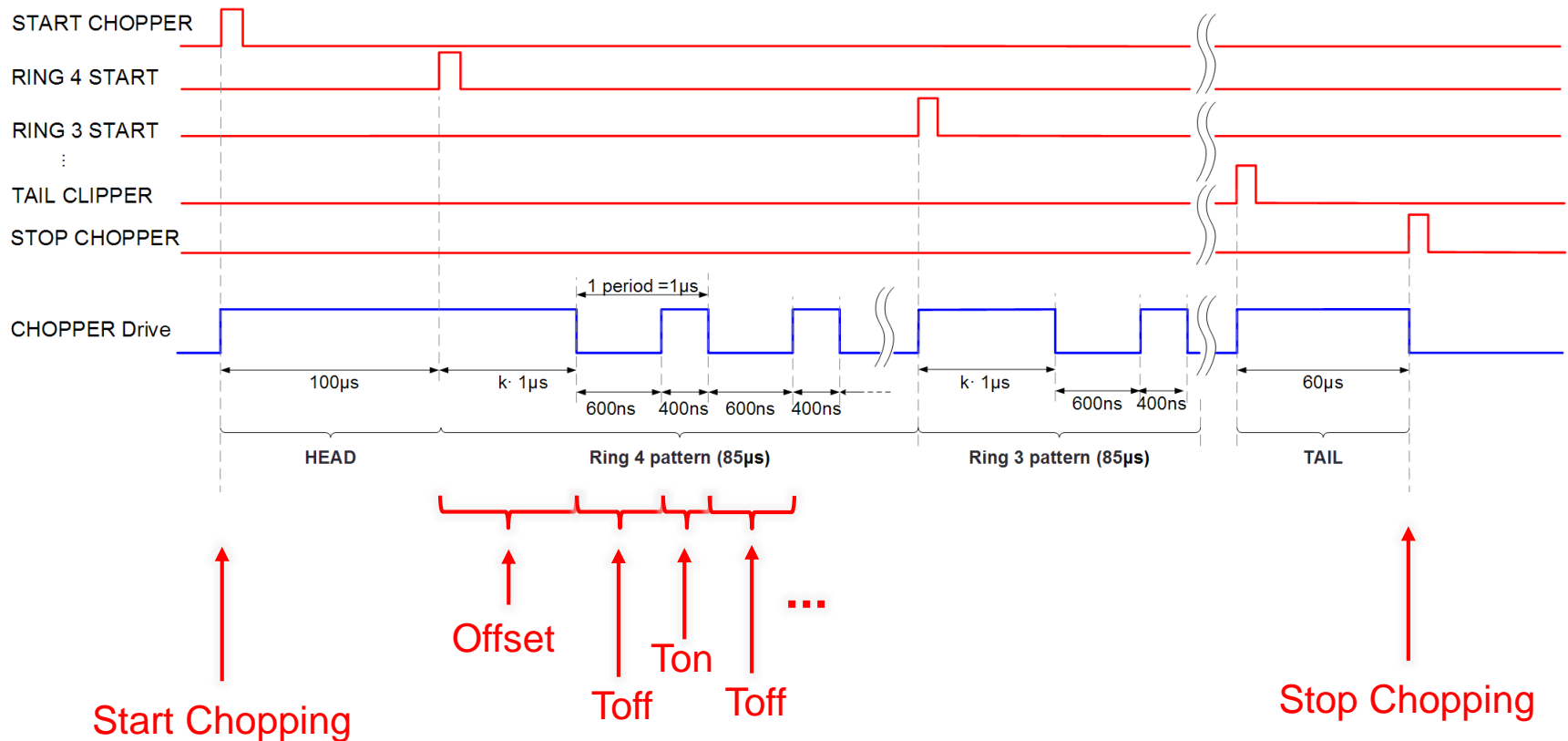
# Linac4 Chopper – CTU

## “Chopper Trigger Unit”



# Linac4 Chopper – CTU

## Simple chopping pattern algorithm (periodic)



# Linac4 Chopper – CTU

## Simple chopping pattern algorithm

- *LN4:CHOPPER* Working set (Chopping pattern)

Chopping pattern →

Chopper timings →

Obsolete timings →

ALL4CTURING	Time Offset	Time On	Time Off	Inhibit Forc...	Inhibit Forc...	Inhibit Opti...	Inhibited	
L4L.CTU.CHOPCAGE.RING1	1000	1000	98000	false	true	true	true	
L4L.CTU.CHOPCAGE.RING2	10000	10000	80000	false	true	true	true	
L4L.CTU.CHOPCAGE.RING3	1000	1000	98000	true	false	true	false	
L4L.CTU.CHOPCAGE.RING4	10000	10000	80000	false	true	true	true	
LTIM	Pulse	Event	Start	Delay	Clock Str.	AqnUTC	AqnC	AqnNano
L4X.WCHOPPER		Enable	BIX.W10-CT	98000	10MHz	1467386789	274	274800000
L4X.STARTCHOPPER	Enable		BIX.W10-CT	98500	10MHz	1467386789	274	274850000
L4X.SR4CHOPPER		Enable	BIX.W10-CT	100000	10MHz	1467386789	275	275000000
L4X.SR3CHOPPER		Enable	L4X.R4NT-SUM	100000	10MHz	1467386789	275	275100000
L4X.SR2CHOPPER		Enable	L4X.R3NT-SUM	100000	10MHz	1467386789	275	275200000
L4X.SR1CHOPPER		Enable	L4X.R2NT-SUM	100000	10MHz	1467386789	275	275300000
L4X.STOPCHOPPER	Enable		BIX.W10-CT	104500	10MHz	1467386789	275	275450000
LTIM	Pulse	Start	Delay	Clock Str.	AqnUTC	AqnC	AqnNano	
L4X.CHOP-TRIG	Enable	BIX.W10-CT	10	1KHz	1467386789	275	275000000	
L4X.CHOPOFF_CHALL								
L4X.CHOPON_CHALL								

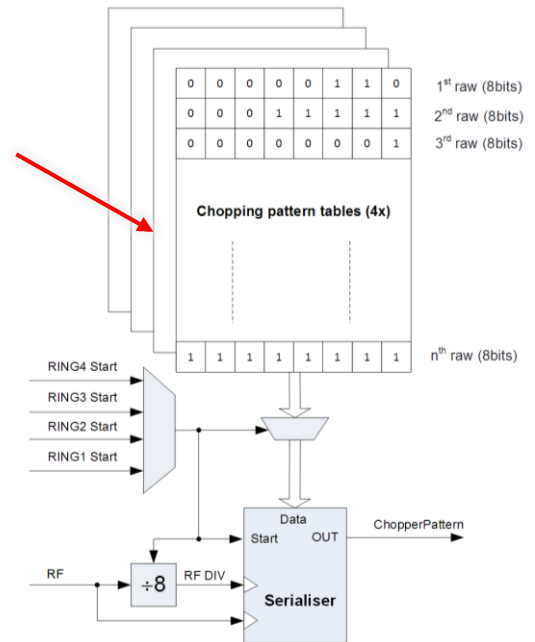
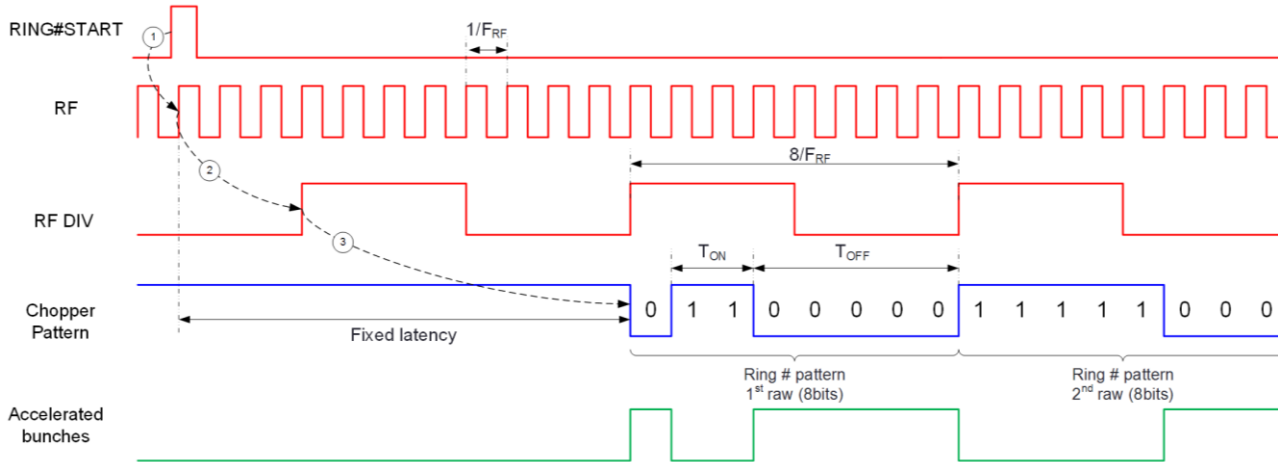
⇒ Simple chopping pattern algorithm (working set)

# Linac4 Chopper – CTU

## Complex chopping pattern algorithm

- Direct access to the Chopping pattern tables (FESA class property)
- Need higher level application to compute the chopping pattern
- Resolution: 1bits = 1/352.2MHz
- LSB first
- Last bit shall bit '1'

Chopping pattern tables (4x)



# Linac4 Chopper – CTU

## Complex chopping pattern algorithm

- FESA class spec on EDMS (doc n° 1729215)
- FESA class ALLL4CTURing
- 4 devices (1 per ring)

Mode → Custom

Navigation Tool 2016-SEPTFS(v3.0.140)

ALLL4CTURING version 1.2.1

ALLL4CTURING1.2.1 Global

Device Selection

- ALLL4CTU\_DU.ctv-400-allchopage
  - L4L.CTU.CHOPCAGE.RING2
  - GD.L4L.CTU.CHOPCAGE.RING
  - L4L.CTU.CHOPCAGE.RING3
  - L4L.CTU.CHOPCAGE.RING4
  - L4L.CTU.CHOPCAGE.RING1

Cycle Selection

- LN4.USER.LHC.SU\_A
- LN4.USER.LHC.SU\_B
- LN4.USER.MD1
- LN4.USER.MD2
- LN4.USER.MD3
- LN4.USER.MD4
- LN4.USER.MD5
- LN4.USER.MD6

Property Selection (db1-ck = new)

- Acquisition
- AlarmDetails
- Alarm
- DiagnosticSetting
- Inhibit
- PatternCustom
- PatternGenerated
- PatternMode

Class ALLL4CTURING  
Version 1.2.1  
FEC ALLL4CTU\_DU.ctv-400-allchopage  
Device L4L.CTU.CHOPCAGE.RING1  
Cycle LN4.USER.MD1  
Property PatternCustom

RBA: no token

L4L.CTU.CHOPCAGERING1 MD1 L4L.CTU.CHOPCAGERING1 MD1

PatternMode

Property Value

cycleName

mode

Generated

Generated

Custom

Viewers

All -viewers- Global tab

Get Get Next Published Set Subscribe

There are no active viewers

No help available

history



# Linac4 Chopper – CTU

## Complex chopping pattern algorithm

- FESA class spec on EDMS (doc n°...)
- FESA class ALLL4CTURing
- 4 devices (1 per ring)

Integer array  
(4096 x 16bits)

Max ring length 186us

The screenshot shows the Navigation Tool 2016-SEPTIS (v3.0.140) interface. The main window displays the configuration for the ALLL4CTURing class (version 1.2.1). The interface is divided into several sections:

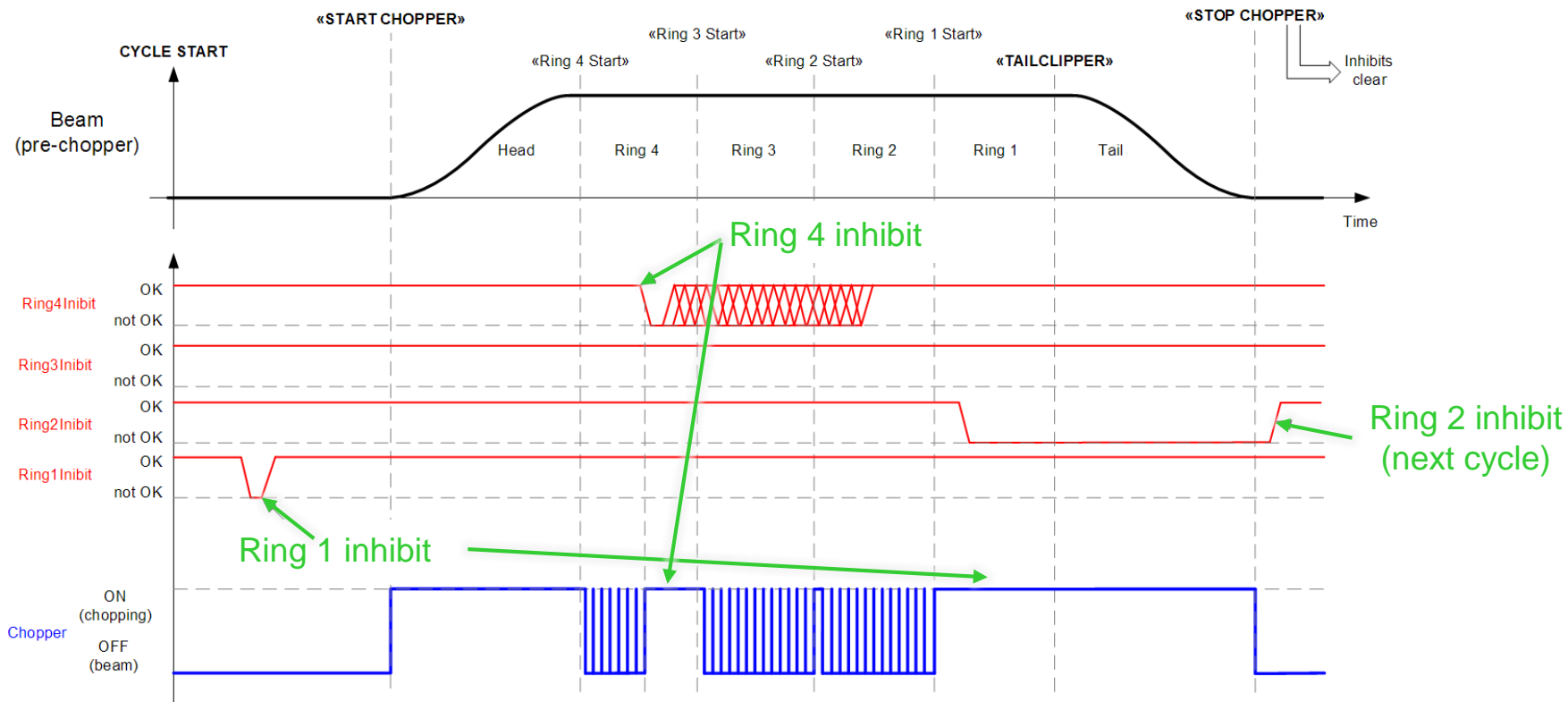
- Device Selection:** A tree view showing the hierarchy of devices, including L4L CTU.CHOPCAGERING1 through RING4.
- Cycle Selection:** A list of cycles, including LN4.USER.LHC\_SU\_A, LN4.USER.LHC\_SU\_B, LN4.USER.MD1 through MD5.
- Property Selection (dbf-dk = new):** A list of properties, including Acquisition, AlarmDetails, Alarm, DiagnosticSetting, Inhibit, PatternCustom, and PatternGenerated.
- Class Information:** A summary of the class configuration, including the class name (ALLL4CTURing), version (1.2.1), FEC (ALLL4CTU\_DU.cfv-400-allchopage), device (L4L.CTU.CHOPCAGERING1), cycle (LN4.USER.MD1), and property (PatternCustom).
- Property Value (8,204 b) - Wed Oct 26 17:32:41 CEST 2016:** A section showing the current value of the selected property, including a cycleName (LN4.USER.MD1) and a table (array-int16\_t).
- Viewers:** A section with buttons for Get, Get Next Published, Set, and Subscribe.
- Table view on L4L.CTU.CHOPCAGERING1@LN4.USER.MD1:PatternCustomtable (sequential=true):** A table showing the values of the PatternCustom property for each index (0 to 10).

Index	Value
[0]	0
[1]	0
[2]	0
[3]	0
[4]	0
[5]	0
[6]	0
[7]	0
[8]	0
[9]	0
[10]	0

# Linac4 Chopper – CTU

## Ring Inhibit

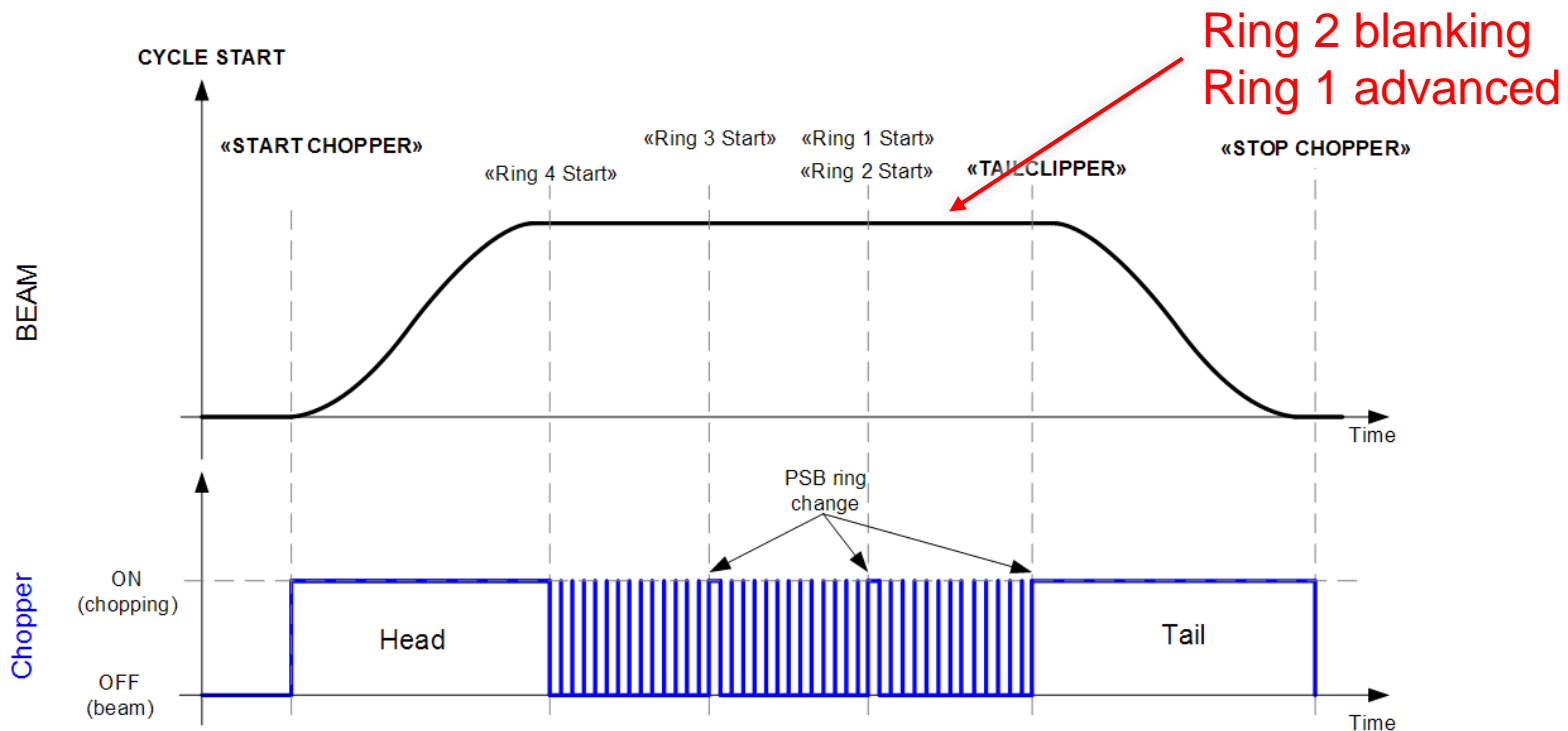
- 1 asynchronous interlock per PSB ring (optical fiber)
- Ring sequence not affected



# Linac4 Chopper – CTU

## Ring Blanking (nb turns=0)

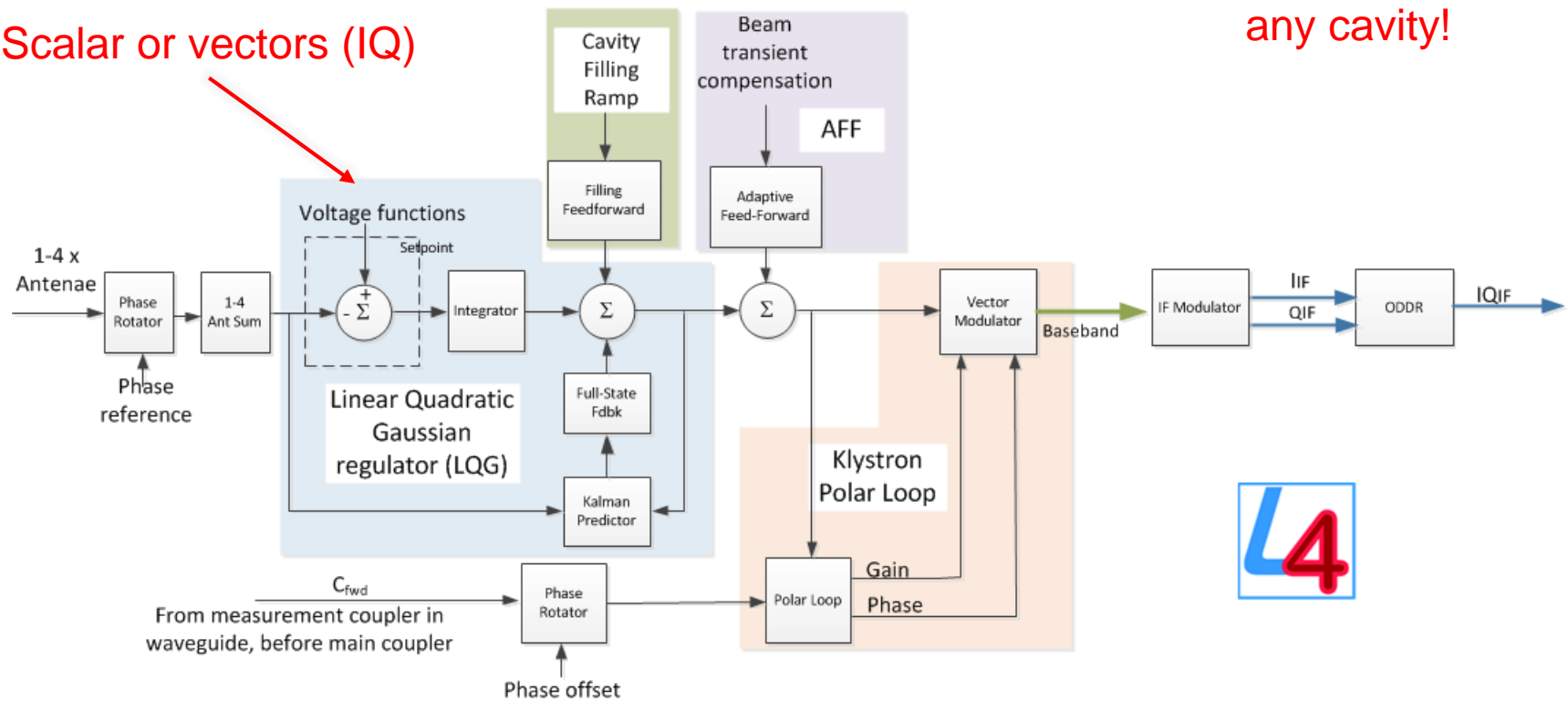
- From timing
- Ring sequence affected
- Timing prioritization: TailClipper → Ring 1 Start → Ring 2 Start → Ring 3 Start → Ring 4 Start



# Linac4 Cavity controller

## Voltage modulation (CavityLoops)

Scalar or vectors (IQ)

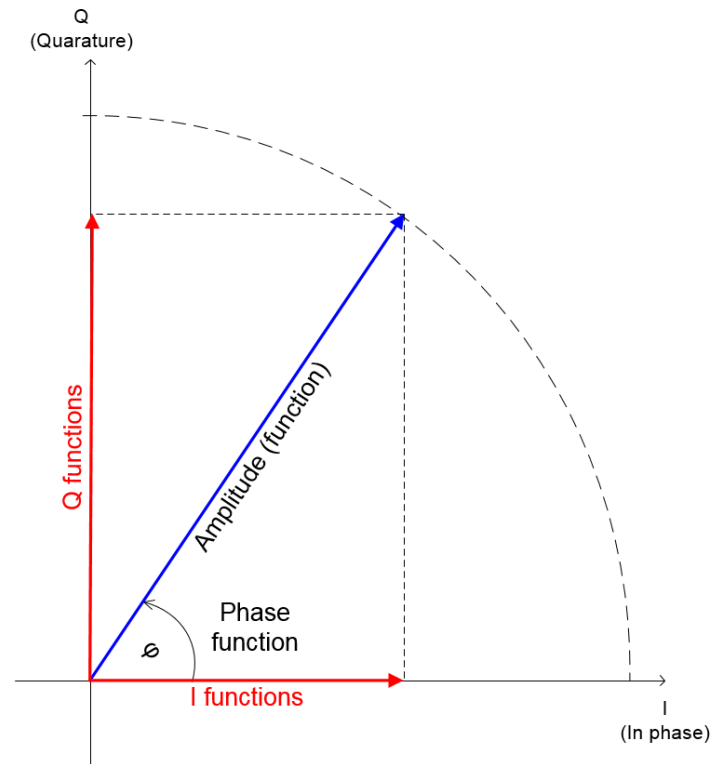


Will be available for any cavity!



# Linac4 Cavity controller

## Cartesians or polar coordinates



Inca in polar  
(Amplitude/phase)

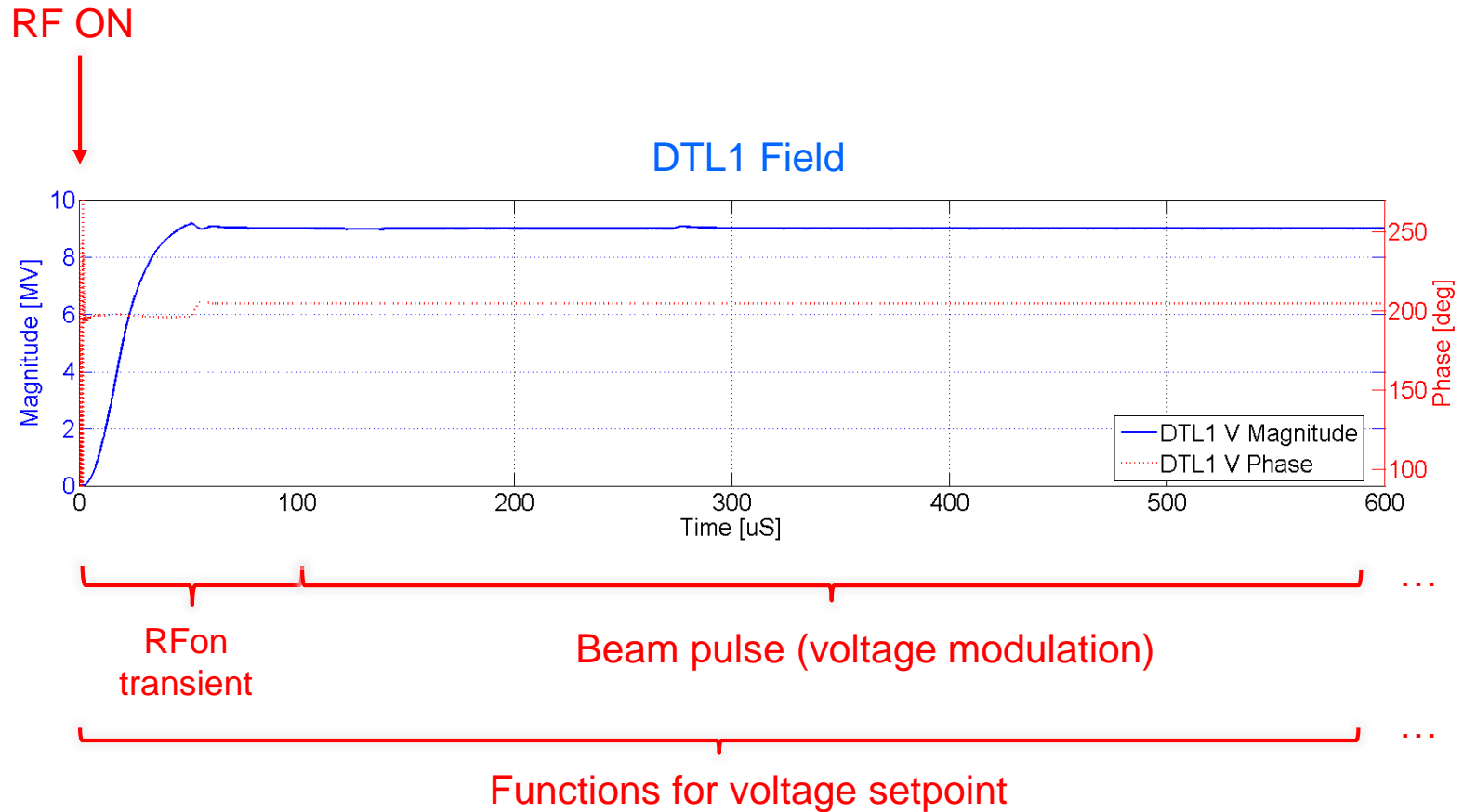
# Linac4 Cavity controller

## Voltage modulation (amplitude or phase)

- Functions (IQ) for Voltage Setpoint (fesa)
- Functions (amplitude/phase) in INCA
  - To be driven by higher level application
  - Make rule needed to convert from amplitude/phase to IQ
- RF feedback will make the cavity field follow these functions
- Playback at RF on (100us before BIX.W10-CT)
- 2048 cells arrays (one for I, one for Q)
  - Sampling rate  $RF/4 = 88.05\text{MHz}$
  - Interpolation by 64  $\Rightarrow$  function resolution =  $256/RF = \sim 727\text{ns}$  (1.37MHz)
  - Function length  $\sim 1.5\text{ms}$  (OK?)
- Boolean (in INCA) to select scalars or functions

# Linac4 Cavity controller

## RF on – Beam pulse



# Linac4 Summary

- 4 functions for chopping pattern (1 per ring)
  - Start playback at PSB Ring start timings
  - Resolution:  $1/RF$
- 2 functions per cavity for voltage set points (amplitude/phase)
  - Start playback at RF ON timing (currently 100us before BIX.W10-CT)
  - Resolution:  $256/RF$





# Reference

[1] C. Carli, et Al., SYNCHRONIZATION BETWEEN LINAC4 AND THE PS BOOSTER, CERN 2010