



# Dynamic Control Room Interfaces

for Complex Particle Accelerator Systems

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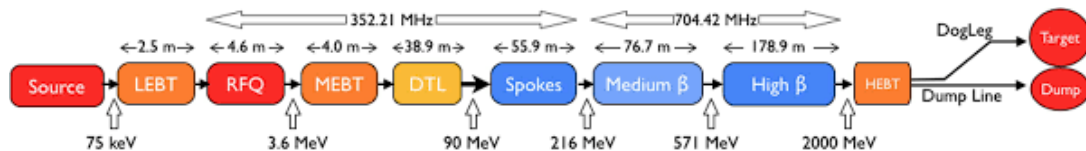
2023-10-10

# Challenge

## Large-scale particle accelerators



- Complex machinery = multiple challenges designing GUIs
- Many unique sub-systems
- Phoebus OPIs
  - XML-structured files
- Dynamic construction of OPIs
  - Input: Developer/user-provided
  - Dynamic construction based on input via scripts
  - Output: Ready OPI
    - Dynamically constructed
    - Static whilst being used
- Runtime-dynamic OPIs





# Dynamic construction of OPIs

## XML-files (.bob) generated via scripts

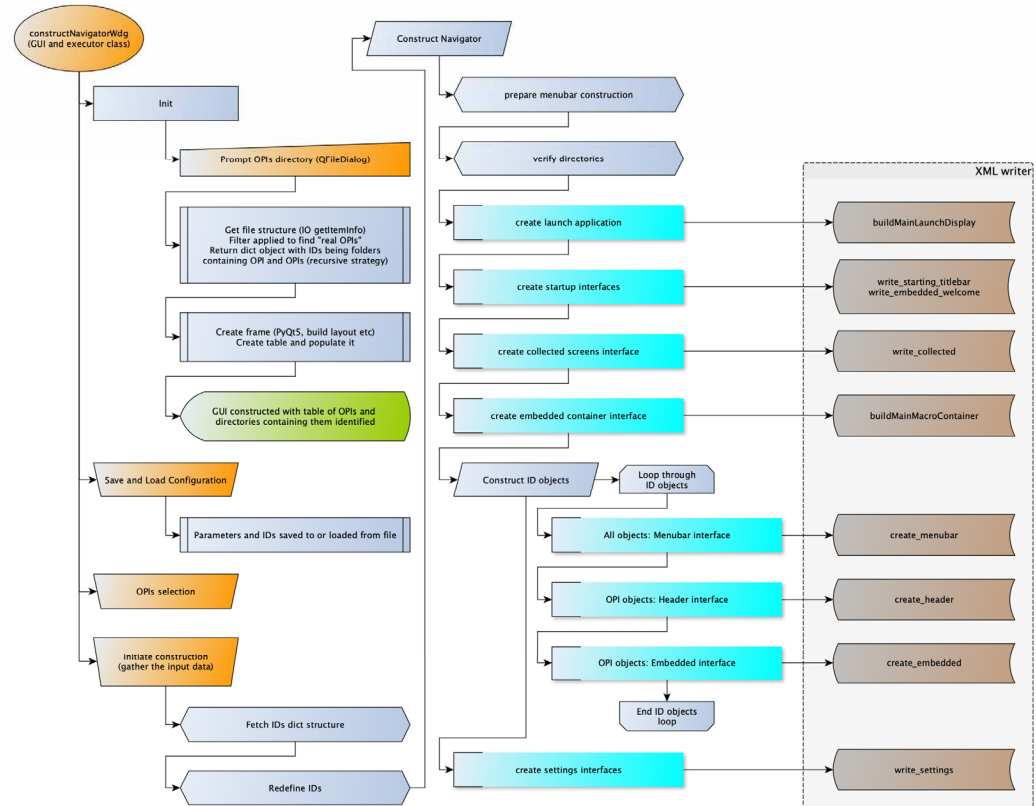
- Navigator OPI
  - Motivation

Category	Sub-category	Description	Stars	Last Update
A	ACC			17 icons, 0 lock, 1 refresh
>	A	A2T		1 icon, 0 lock, 1 refresh
>	B	BMD Beam Magnets and Deflector Systems OPIs		0 icons, 3 lock, 2 refresh
>	C	Cryo		0 icons, 2 lock, 2 refresh
>	D	DTL Drift Tube Linac		0 icons, 3 lock, 2 refresh
>	E	EMR Electro Magnetic Resonator OPIs		0 icons, 3 lock, 2 refresh
>	H	HEBT		3 icons, 0 lock, 1 refresh
>	I	ISrc-LEBT Ion Source and LEBT		0 icons, 3 lock, 3 refresh
>	M	MEBT Medium Energy Beam Transport OPIs		0 icons, 3 lock, 2 refresh
>	O	Ops Accelerator Operations		0 icons, 1 lock, 1 refresh
▼	P	PBI A group to manage EPICS OPIs for Proton Beam Instrumentation functions.		0 icons, 3 lock, 1 refresh
	E	Engineer EPICS OPIs for PBI system to be used for (very) low-level development and testing in the control room(s). Low-level...	★ 3	8 hours ago
	O	Operator For management of the EPICS OPIs used primarily by operators in the ESS control room(s) for PBI functions.	★ 1	10 months ago
	S	SystemExpert Collection of OPIs intended for use by PBI experts.	★ 2	5 months ago
▼	R	RF Container for RF OPIs to be used int control room.		0 icons, 3 lock, 2 refresh
	E	Engineer Engineer use-case OPIs.	★ 0	3 weeks ago
	O	Operator Operator use-case OPIs	★ 0	2 weeks ago
	S	SystemExpert System expert use-case	★ 1	4 days ago

# Dynamic construction of OPIs

## XML-files (.bob) generated via scripts

- Navigator OPI
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  - Solution



# Dynamic construction of OPIs

XML-files (.bob) generated via scripts

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  - Solution
  - Results

**Navigator OPI - ACC > RF > overview**

Settings

Breakout

ACC

Ops

ISrc-LEBT

RFQ

MEBT

BIS

BMD

EMR

PBI

PSS1

**RF**

Cavinticks

Modulators

PowerStab

orchestrat

TS2

Global

**Orchestrations:**

NCL

Spk 01-06

Spk 07-13

MBL 01-03

MBL 04-06

MBL 07-09

HBL 01-03

HBL 04-06

HBL 07-09

HBL 10-12

HBL 13-15

HBL 16-18

HBL 19-21

System:	RFQ	MEBT1	MEBT2	MEBT3	DTL1	DTL2	DTL3	DTL4	
<b>C a v</b>	Average Field:	-0.00	-0.59	-0.27	-0.37	0.01	0.00	0.00	-0.00
	Max. Field:	5.09 kV	12.65 kV	9.24 kV	10.01 kV	0.15 MV/m	0.33 MV/m	0.37 MV/m	0.33 MV/m
<b>L L R F</b>	State:	RESETTING	INIT	INIT	INIT	INIT	INIT	INIT	
	Loop:	Closed	Open	Open	Open	Open	Open	Open	
	Pulse Gen:	Off	Off	Off	Off	Off	Off	Off	
	SP Ramp:	Off	Off	Off	Off	Off	Off	Off	
<b>T u n e</b>	State:		Off	ON	ON	SYSTEM OK	SYSTEM OK	SYSTEM OK	
	Freq. Detuning:	4479 Hz	0 Hz	0 Hz	8176 Hz	-726 Hz	-5475 Hz	-1885 Hz	-1163 Hz
	Timers Status:					T1 T2 T3	T1 T2 T3	T1 T2 T3	
<b>T i m</b>	Mode:	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	
	Rep. rate:	1.0 Hz	1.0 Hz	1.0 Hz	1.0 Hz	1.0 Hz	1.0 Hz	1.0 Hz	
	Width:	50.0 us	54.0 us	50.0 us	50.0 us	50.0 us	50.0 us	50.0 us	
<b>R F L P S</b>	FIM RFON:	●	●	●	●	●	●	●	
	SIM RFON:	●				●	●	●	
	Filament:	●				●	●	●	
<b>M o d</b>	State:	OFF				OFF	OFF	OFF	OFF
	Voltage:	0.00 kV				0.00 kV	0.00 kV	0.00 kV	0.00 kV
	Width:	3500 us				3500 us	3500 us	3500 us	3500 us
	Kly. output:	Disabled				Disabled	Disabled	Disabled	Disabled



# Dynamic construction of OPIs

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  - Results
- Accelerator Synoptics OPI
  - Motivation

The screenshot shows a web browser displaying a table of elements. The table has columns for 'sect', 'cell', 'slot', 'disc', 'elem', 'index', 'doorsid', 'model', 'esname', 'len[mm]', 'r[mm]', 's,sl[mm]', and 'BPS,s,x[mm]'. The data is organized into rows, with some rows grouped by 'sect' and 'cell' values. The 'esname' column contains various identifiers like 'BPS', 'LEBT-010-PBI-d\_z\_mm=160-001', 'LEBT-010-BMD-Sol-001', and 'LEBT-010-PBI-Iris-001'.

sect	cell	slot	disc	elem	index	doorsid	model	esname	len[mm]	r[mm]	s,sl[mm]	BPS,s,x[mm]
								BPS	0.0	0.0	0.0	0.0
iSrc	010			Drf	001				70.0	50.0	0.0	0.0
iSrc	010			Drf	002				184.1	75.0	70.0	0.0
iSrc	010			Drf	003				219.0	50.0	254.1	0.0
LEBT	010			Drf	001				45.0	50.0	473.1	0.0
LEBT	010		PBI	d_z_mm=160	001			LEBT-010-PBI-d_z_mm=160-001	0.0	50.0	678.1	0.0
LEBT	010		BMD	Sol	001			LEBT-010-BMD-Sol-001	320.0	50.0	518.1	0.0
LEBT	010			Drf	002				192.8	75.0	838.1	0.0
LEBT	010			Drf	003				46.0	75.0	1030.9	0.0
LEBT	010			Drf	004				15.0	40.0	1076.9	0.0
LEBT	010			Drf	005				42.5	75.0	1091.9	0.0
LEBT	010			Drf	006				15.0	37.0	1134.4	0.0
LEBT	010			Drf	007				5.0	75.0	1149.4	0.0
LEBT	010			Drf	008				15.0	37.0	1154.4	0.0
LEBT	010			Drf	009				11.5	75.0	1169.4	0.0
LEBT	010		PBI	Iris	001			LEBT-010-PBI-Iris-001	0.0	75.0	1180.9	0.0
LEBT	010			Drf	010				33.5	75.0	1180.9	0.0
LEBT	010			Drf	011				15.0	37.0	1214.4	0.0
LEBT	010			Drf	012				101.5	75.0	1229.4	0.0
LEBT	010			Drf	013				96.0	75.0	1330.9	0.0
LEBT	010			Drf	014				20.0	40.0	1426.9	0.0
LEBT	010			Drf	015				27.5	40.0	1446.9	0.0
LEBT	010		BMD	Chop	001			LEBT-010-BMD-Chop-001	0.0	40.0	1474.4	0.0
LEBT	010			Drf	016				27.5	40.0	1474.4	0.0
LEBT	010			Drf	017				20.0	40.0	1501.9	0.0
LEBT	010			Drf	018				79.9	75.0	1521.9	0.0

# Dynamic construction of OPIs

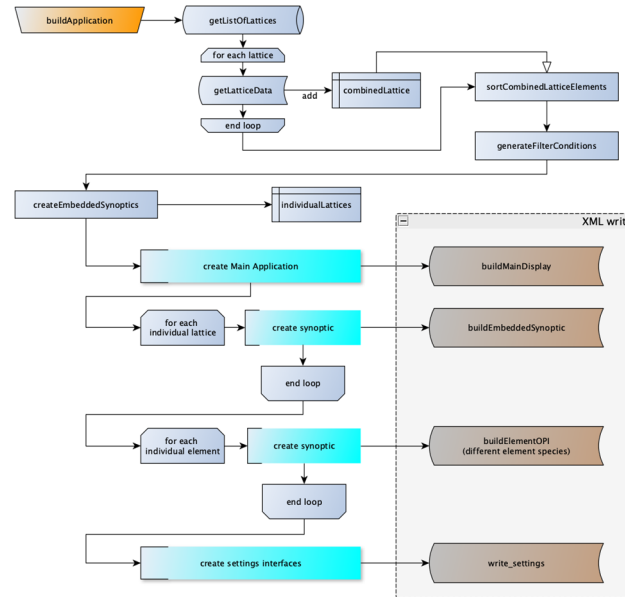
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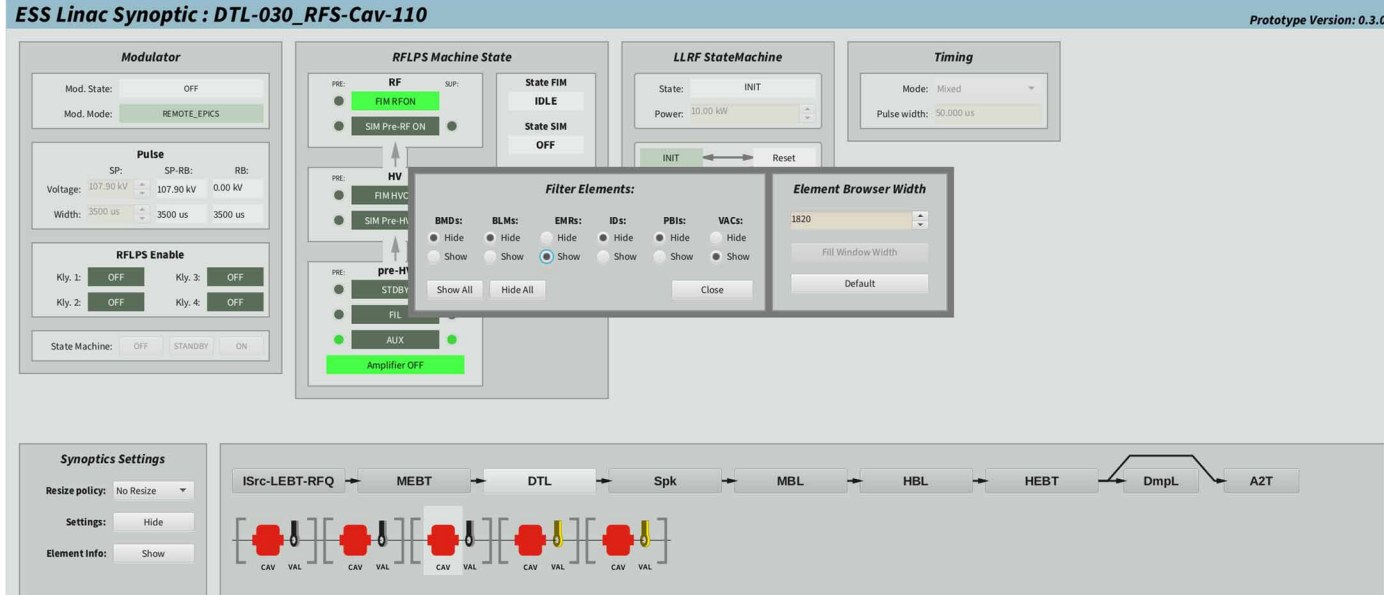


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**ESS Linac Synoptic : DTL-030\_RFS-Cav-110** Prototype Version: 0.3.0



The interface displays several control panels:

- Modulator:** Mod. State: OFF, Mod. Mode: REMOTE\_EPICS
- Pulse:** SP: 107.90 kV, SP-RB: 107.90 kV, RB: 0.00 kV; Width: 3500 us
- RFLPS Enable:** Kly. 1-4: OFF
- RFLPS Machine State:** PRE: RF (FIM RFLON, SIM Pre-RFLON), HV (FIM HVC, SIM Pre-H), pre-H (STDBY, FIL, AUX), Amplifier OFF
- LLRF StateMachine:** State: INIT, Power: 10.00 kW
- Timing:** Mode: Mixed, Pulse width: 50.000 us
- Filter Elements:** BMDs, BLMs, EMRs, IDs, PBIs, VACs (Hide/Show options)
- Element Browser Width:** 1820
- Synoptics Settings:** Resize policy: No Resize, Settings: Hide, Element Info: Show
- Beamline Diagram:** ISrc-LEBT-RFQ → MEBT → DTL → Spk → MBL → HBL → HEBT → DmpL → A2T





# Runtime-dynamic OPIs

## Dynamic configuration / setup

- Issues
  - A lot of OPIs needed open at the same time

File Browser X | RF Systems X | MBL-080 K2 - LLRF System X | File Browser X | Timing System - Basic View - DTL-1 X

## RF Systems

RFQ | MEBT | DTL | Spoke | MBL | HBL

010 | 020 | 030 | 040 | 050

### DTL-1

System Overview | Section Overview

**Interlocks**

- LPS Detailed
- Signal Conditioning
- Electron Pickup
- Pin Diode

**LLRF**

- LLRF
- Local Oscillator

**Amplifiers**

- Preamp
- Solenoid

### DTL-010 - SP Ramping

Pulse generation

Enable

Cavity Field A: 1.00 MV/m

Filling time: 0.150 ms

Tao: 0.015 ms

Delay: 0.000 ms

Fall Time: 0.000 ms

Phase: -150.000 deg

**Pulse Configuration**

Power Level P: 10.000 ADC Cou

Fill Ratio: 1.000

Filling Time: 0.000 ms

Rise Time: 0.005 ms

Fall Time: 0.005 ms

Phase: -20.000

**Frequency tracking**

Enable

Detuning Source: Decay

Update Interval: 1 second

Frequency Offset: 0.0 Hz

Detuning Value: 0 Hz

**Static FeedForward Co**

Enable

Increase Signal

Magnitude:

Angle: 0.1000 deg

**Beam Detection**

Beam Start Detected

Start: 0.000000000000 ms

End: 0.000000000000 ms

**Automatic**

Enable

K Parameter: 0.000000000000

X Parameter: 0.000000000000

MAG [ADC Co

DTL-010 X | CS-Studio | 75% | RUNNING | Connected | Connected | Connected

## RF Local Protection System

DTL-010

System Overview | SIM Transitions | FIM Transitions | Diagnostics

FIM Reset: FIM Reset | SIM OP Modet: Normal | Actual State: SIM: OFF | FIM: IDLE | SIM lcks status: WARNING | SIM reset lcks

**CIRCULATOR + ISOLATION LOAD**

- Circulator Arc
- Isolation Load Arc
- Isolation Load power forward: 3.06 kW

**RF SHUTTER**

RF Shutter 1: RF PASS

**Cooling monitoring**

- Oil Water Temp: 34.98 C
- Water Supp Press. CW# 1: 3.34 Bar
- Water Supp Press. CW# 2: 3.86 Bar

**Indicators**

- RF Indicator
- HV Indicator
- STDBY Indicator

**Klystron Output**

- Klystron Arc
- PWR Amplifier power forward: 2.64 kW

### DTL-010 - LLRF System

General Information

- Open Loop
- Adaptive FF
- Beam Start Detected
- RFLPS Status: IDLE

Digitiser-1

State: INIT

Pulse Count: 0

Digitiser-3

State: INIT

Pulse Count: 0

Digitiser-2

State: INIT

Pulse Count: 0

**DTL-010 - Digitiser 1 Configuration**

State Machine | AI Channel Setup | Internal Channels | Calibration | Input Stage | Filters | PI Controller | Out

**State Machine**

Placeholder: INIT

Init | Reset

On | ERROR

Pulse Count: 0

**Firmware State Machine**

- Interlock
- RF-LPS Interlock

State: INIT

Interlock Cause: No Interlock

RF Off Cause: Normal Pulse Sequence

DAQ End Cause: Normal DAQ Termination

Enable

- Max RF Length: 0.000000
- Max DAQ Length: 0.000000
- LPS Lock Dead Time: 65.000000
- LPS Lock Detection: ON

Detected | Position Cyc

- Beam Start: 0 cycles
- Beam End: 0 cycles
- RF Off: 0 cycles
- Interlock: 0 cycles

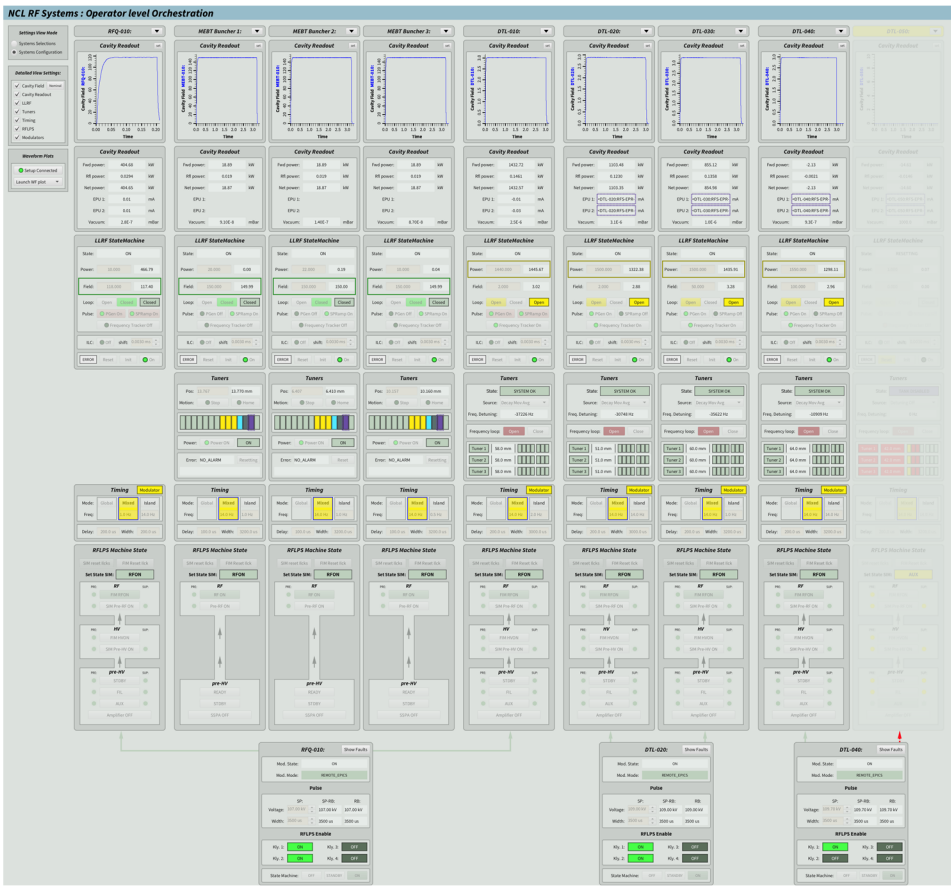
Reference

Pulse generation | Detune Cavity | Adaptive FF | FF Auto Calib | SP Ra

# Runtime-dynamic OPIs

## Dynamic configuration / setup

- Issues
  - A lot of OPIs needed open at the same time
  - Jungle to navigate between OPIs
- Solution
  - Extract needed controls and information
  - Still too much!
  - Configurable by end-user
  - Collapsible elements
  - Unused: Collapse



# Runtime-dynamic OPIs

## Dynamic configuration / setup

### ■ Issues

- A lot of OPIs needed open at the same time
- Jungle to navigate between OPIs

### ■ Solution

- Extract needed controls and information
  - Still too much!
- Configurable by end-user
- Collapsible elements
  - Unused: Collapse
  - Used/needed: Expand
- Virtual signals (loc-PVs)

