



# LHC Feedbacks – Reference Orbit Management and other external Services

**Kajetan Fuchsberger**  
LHC Feedback Review, 2013-05-07

**Many Thanks to:**

V. Baggiolini, G. Kruk, R. Steinhagen, L. Ponce,  
J. Wenninger

Introduction

Reference Settings

Optics Changes

Possible Improvements

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# Quick Reminder

Positions  $\vec{u} = \begin{pmatrix} u_1 \\ u_2 \\ \dots \\ u_{N_M} \end{pmatrix}$ , COD kicks  $\vec{\delta} = \begin{pmatrix} \delta_1 \\ \delta_2 \\ \dots \\ \delta_{N_C} \end{pmatrix}$

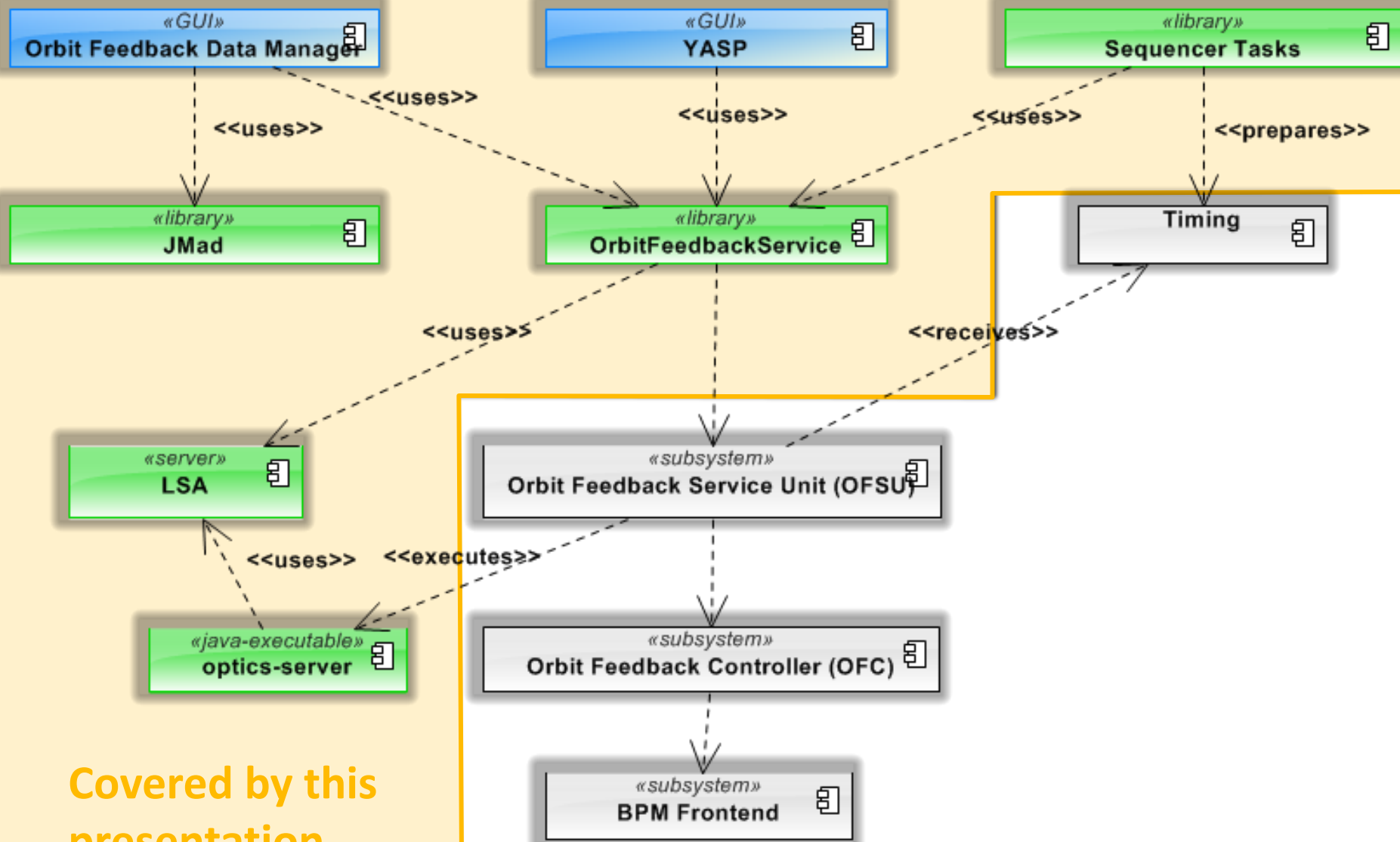
$\Delta \vec{u} = R \Delta \vec{\delta} \xrightarrow{\text{SVD}} \Delta \vec{\delta} = R^{-1} (\vec{u} - \vec{u}_{\text{ref}})$

Response Matrix (Calculated from Optics)

Pseudo-Inverse

Reference Orbit  
(= Desired Orbit)

**Two main parameters.**  
(Both might change over time!)

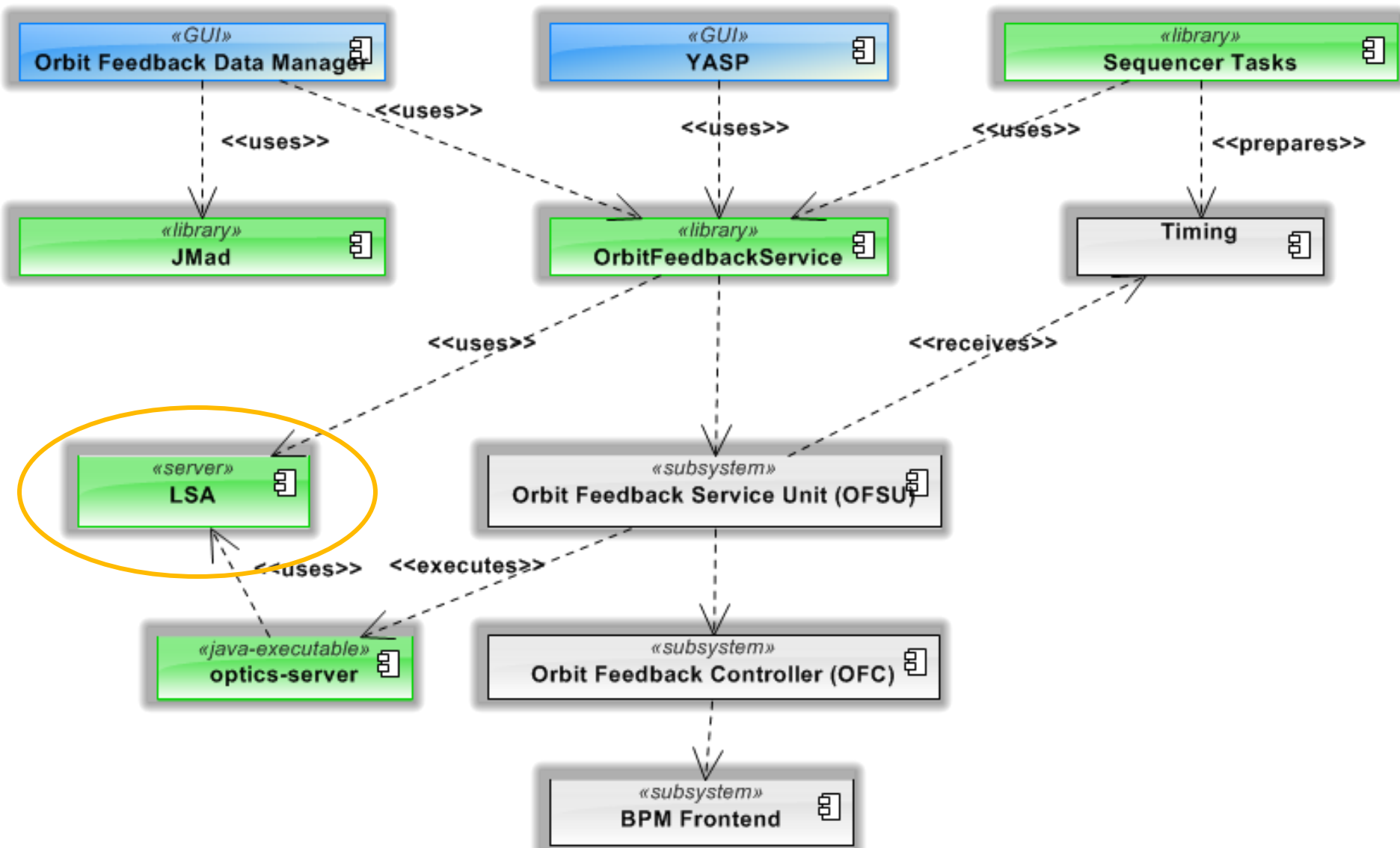


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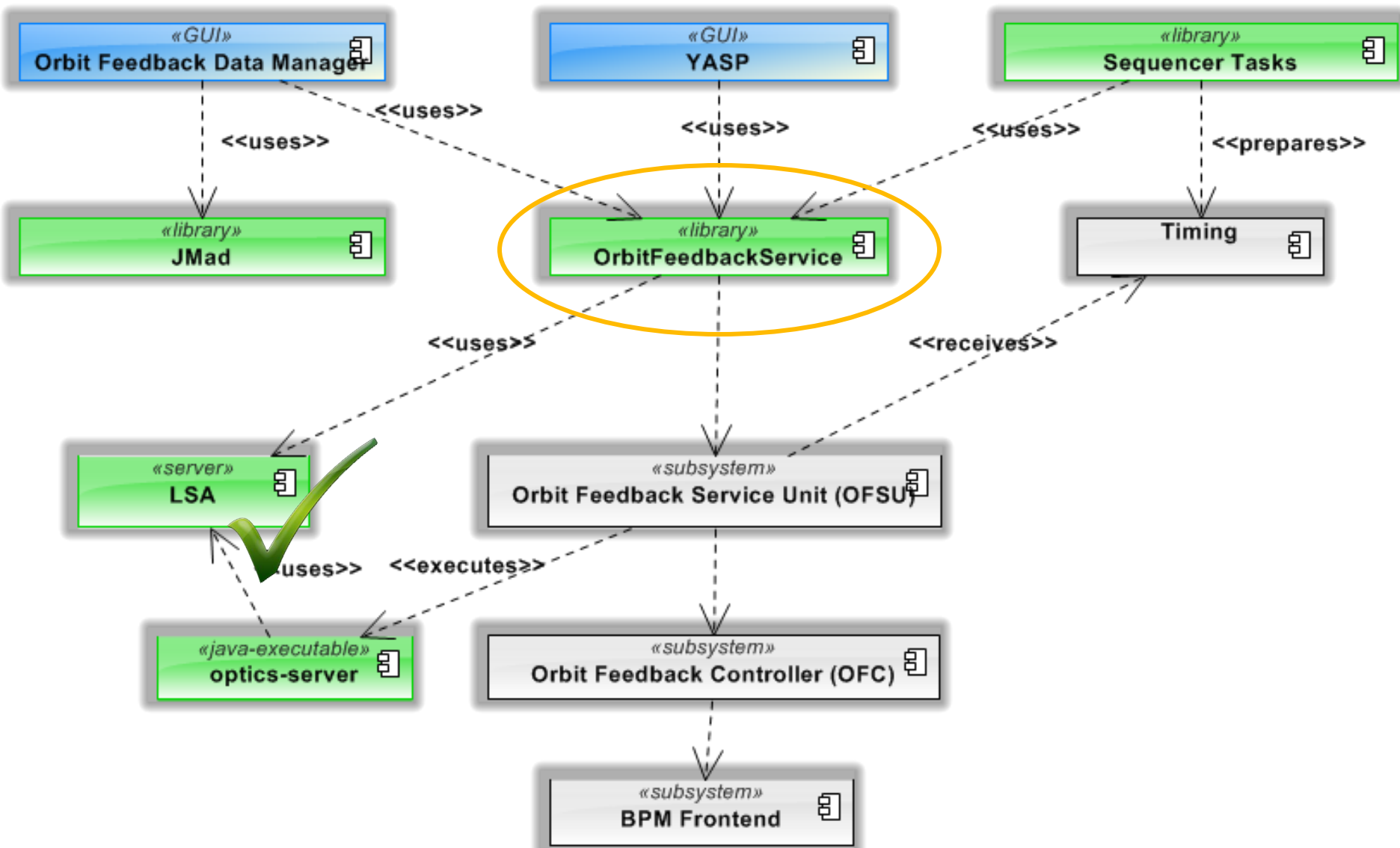
Possible Improvements



- Wrt Reference Orbits:  
Mainly used for Storage
- Dedicated tables in LSA Db
- Dedicated finder/persister methods in  
ClientOpticsController







# Orbit Feedback Service

➤ Java library that encapsulates communication with DB & OFSU.

➤ Used by:

➤ Orbitfeedback Data Manager

➤ Yasp

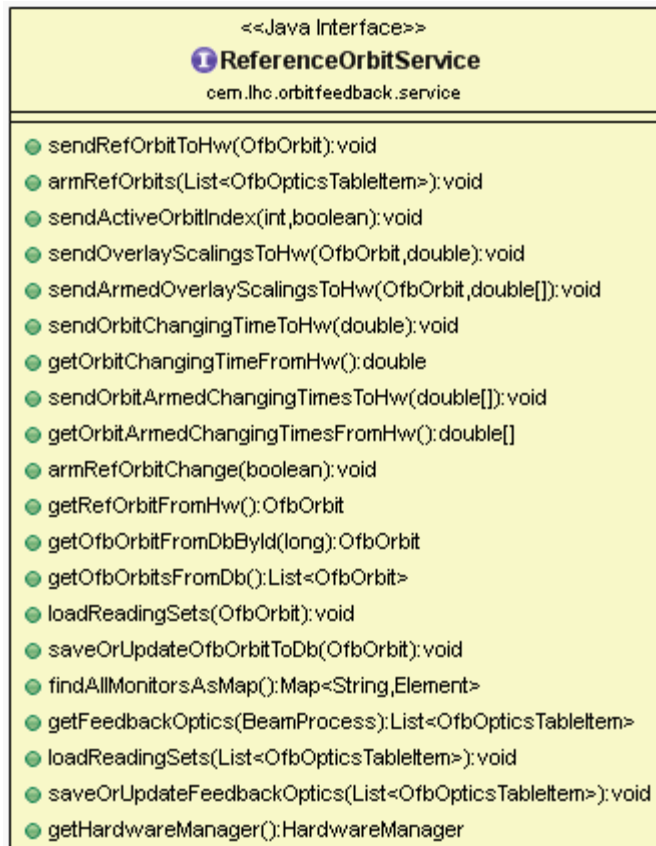
➤ Sequencer Tasks

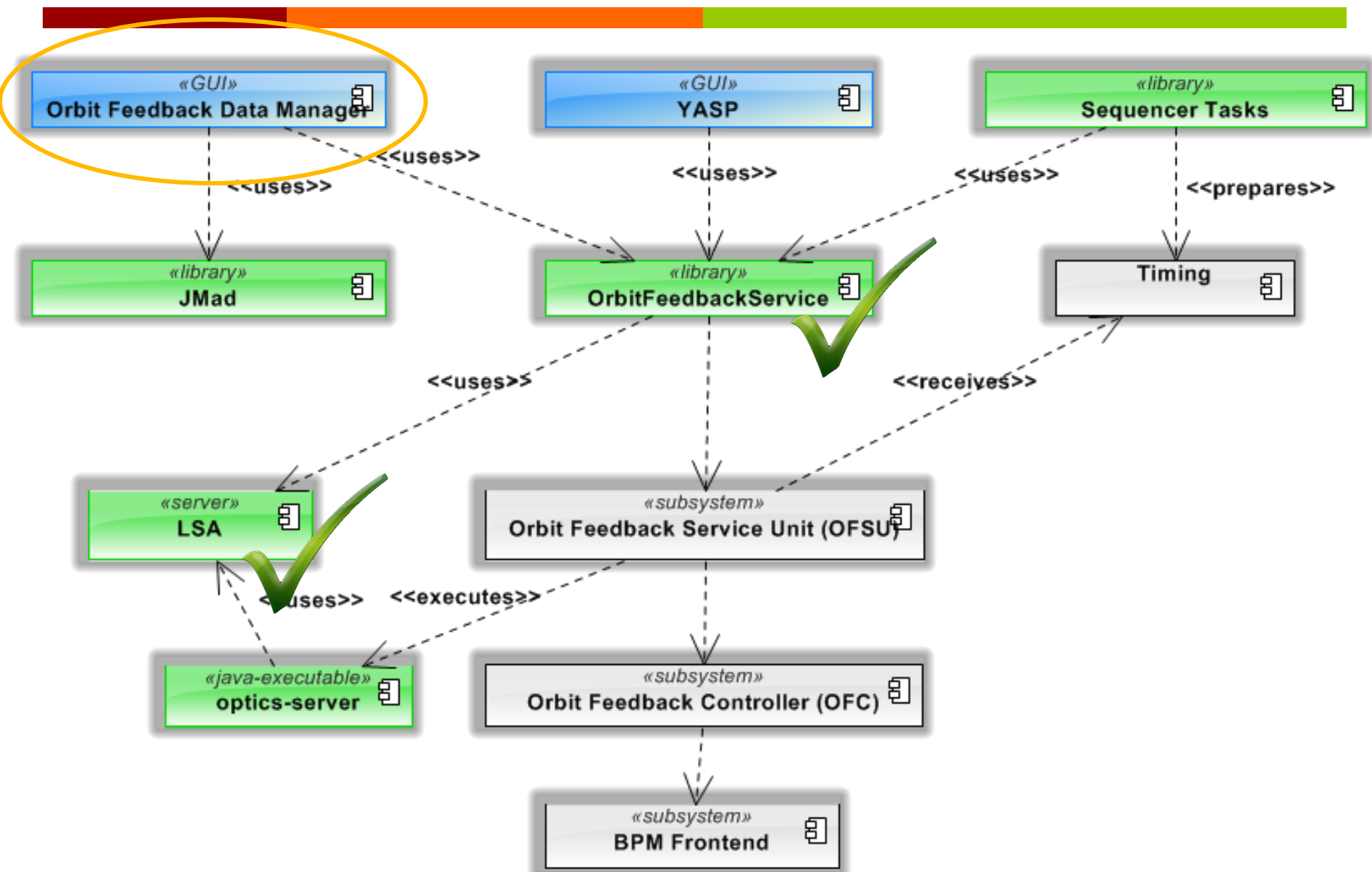
➤ Aperture Meter

➤ Possible Other use cases:

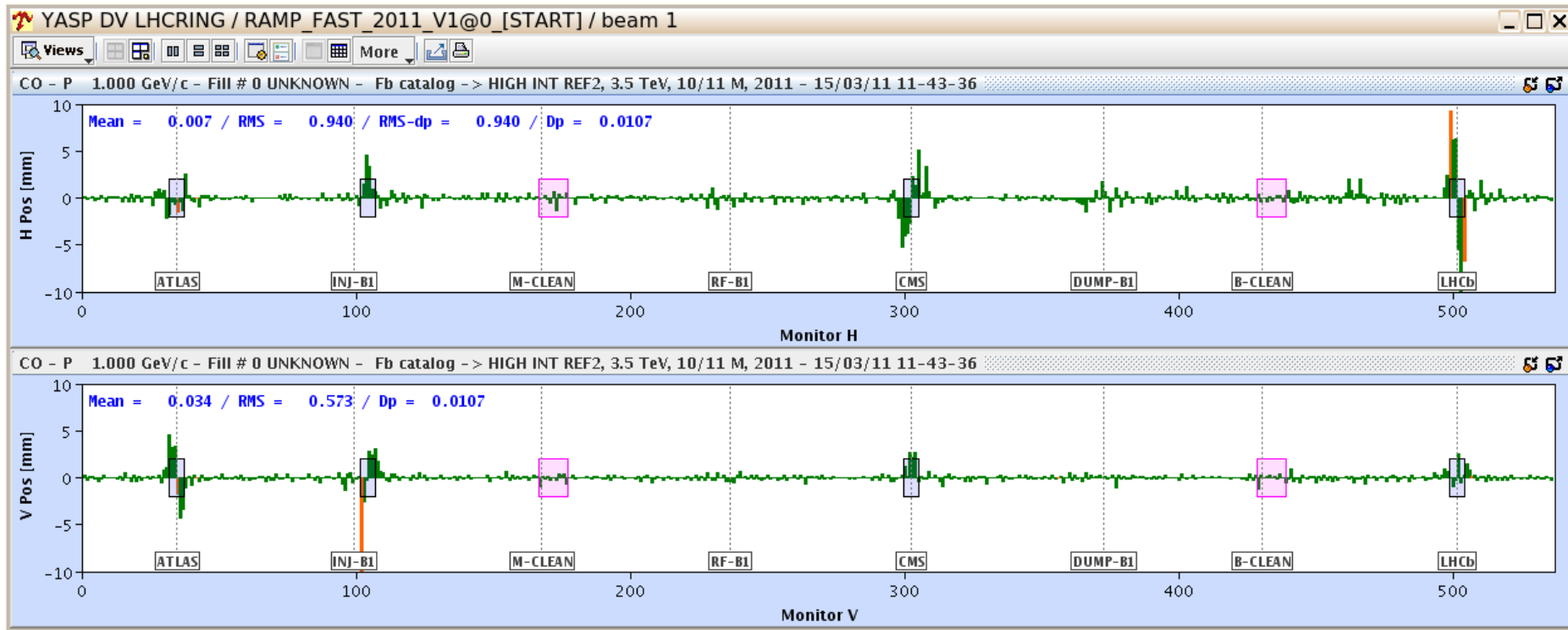
➤ Orbit subscriptions from other apps.

➤ As java proxy for orbit subscriptions?

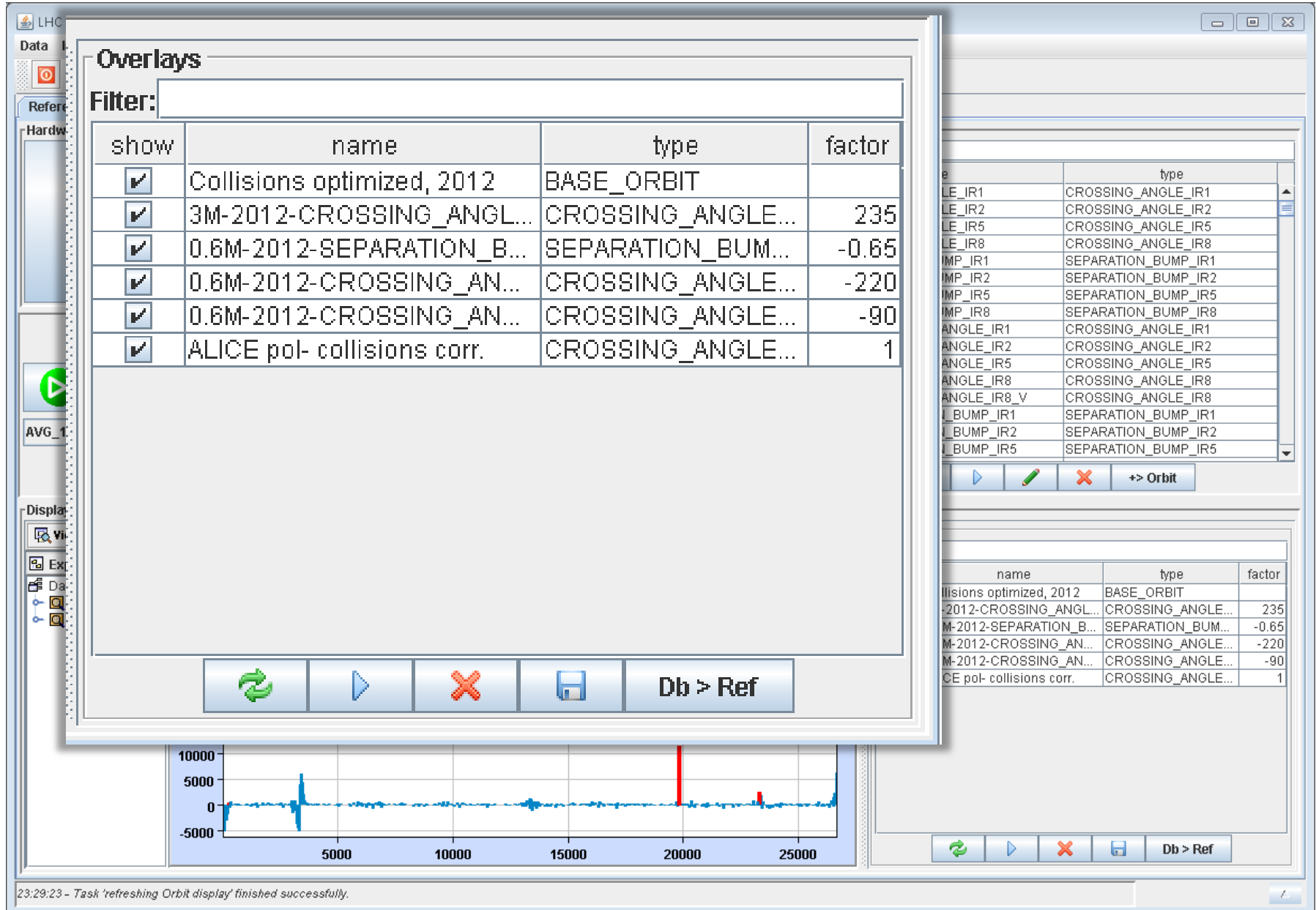




# Base Orbit and overlays



1 Base-Orbit (!)  
+ Overlays  
= Reference Orbit



**OFB Reference Orbit Catalog**

Filter: 2011 OFSU: LHC.OFSU

id	name
353	HIGH INT REF1, 450 GeV, 2011
354	HIGH INT REF2, 3.5 TeV, 10/11 M, 2011
362	HIGH INT REF3, 3.5 TeV, 7/6 M, 2011
363	HIGH INT REF4, 3.5 TeV, 3.5 M, 2011
364	HIGH INT REF5, 3.5 TeV, 1.5 M, 2011
365	HIGH INT REF6, 3.5 TeV, Collisions, 2011
384	HIGH INT REF7, 3.5 TeV, Coll. opt., 2011

**Overlays**

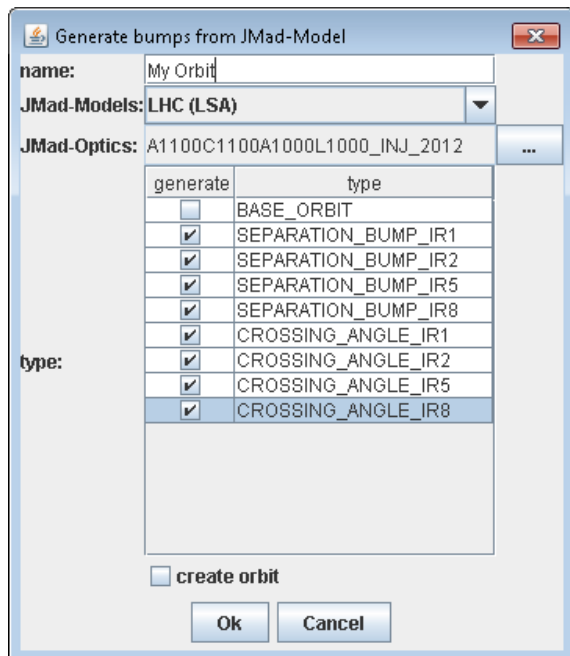
☐ Custom Scalings ☒ Use base orbit Global Overlays Factor: 1.00

name	type	fact
DEFAULT-SEPARATION_BUMP_IR1	SEPARATION_BUMP_IR1	-2
DEFAULT-SEPARATION_BUMP_IR2	SEPARATION_BUMP_IR2	2
DEFAULT-SEPARATION_BUMP_IR5	SEPARATION_BUMP_IR5	2
DEFAULT-SEPARATION_BUMP_IR8	SEPARATION_BUMP_IR8	-2
DEFAULT-CROSSING_ANGLE_IR1	CROSSING_ANGLE_IR1	-170
DEFAULT-CROSSING_ANGLE_IR2	CROSSING_ANGLE_IR2	170
DEFAULT-CROSSING_ANGLE_IR5	CROSSING_ANGLE_IR5	170
DEFAULT-CROSSING_ANGLE_IR8	CROSSING_ANGLE_IR8	-170
1.5M-SEPARATION_BUMP_IR1	SEPARATION_BUMP_IR1	0
1.5M-SEPARATION_BUMP_IR2	SEPARATION_BUMP_IR2	0
1.5M-SEPARATION_BUMP_IR5	SEPARATION_BUMP_IR5	0
1.5M-SEPARATION_BUMP_IR8	SEPARATION_BUMP_IR8	0
1.5M-CROSSING_ANGLE_IR1	CROSSING_ANGLE_IR1	0
1.5M-CROSSING_ANGLE_IR2	CROSSING_ANGLE_IR2	0
1.5M-CROSSING_ANGLE_IR5	CROSSING_ANGLE_IR5	0
1.5M-CROSSING_ANGLE_IR8	CROSSING_ANGLE_IR8	0
7-7-10-6 M-SEPARATION_BUMP_IR1	SEPARATION_BUMP_IR1	0
7-7-10-6 M-SEPARATION_BUMP_IR2	SEPARATION_BUMP_IR2	0
7-7-10-6 M-SEPARATION_BUMP_IR5	SEPARATION_BUMP_IR5	0
7-7-10-6 M-SEPARATION_BUMP_IR8	SEPARATION_BUMP_IR8	0
7-7-10-6 M-CROSSING_ANGLE_IR1	CROSSING_ANGLE_IR1	0
7-7-10-6 M-CROSSING_ANGLE_IR2	CROSSING_ANGLE_IR2	0
7-7-10-6 M-CROSSING_ANGLE_IR5	CROSSING_ANGLE_IR5	0
7-7-10-6 M-CROSSING_ANGLE_IR8	CROSSING_ANGLE_IR8	0
3.5M-SEPARATION_BUMP_IR1	SEPARATION_BUMP_IR1	0
3.5M-SEPARATION_BUMP_IR2	SEPARATION_BUMP_IR2	0
3.5M-SEPARATION_BUMP_IR5	SEPARATION_BUMP_IR5	0
3.5M-SEPARATION_BUMP_IR8	SEPARATION_BUMP_IR8	0
3.5M-CROSSING_ANGLE_IR1	CROSSING_ANGLE_IR1	0
3.5M-CROSSING_ANGLE_IR2	CROSSING_ANGLE_IR2	0
3.5M-CROSSING_ANGLE_IR5	CROSSING_ANGLE_IR5	0
3.5M-CROSSING_ANGLE_IR8	CROSSING_ANGLE_IR8	0

Db Refresh New Entry Load Entry Load as reference Add to active Send to OFSU Send scalings Load from OFSU

Dedicated panel,  
to import/export  
reference orbits  
from/to YASP.

# Overlay Calculations



➤ Currently:

➤ Done in OFB-Datamanager using JMad.  
(with some hardcoded strengths, which define the knobs for crossing angles & separation)

➤ Could/Should it be more dynamic?

➤ Incorporation of Lumi Knobs are needed for colliding squeeze and beta\* levelling.

➤ More Flexibility might be needed  
(Partly already done in aperture-meter)

# Base Orbit & Overlays - Remarks

- Very useful functionality on Java level (+Db)
- OFC has the same concept (Base+Overlays+Factors)
  - Some redundant functionality
  - Current way of treatment:
    - Sending Base with all ZEROS
    - One overlay represents the full orbit at one point in time
    - Exactly one overlay factor = 1; all others = 0;
    - On Db level nothing changed (ofb-service does the conversion)
  - Possibly OFC – Functionality could be simplified?



# Orbit Assignment

LHC orbit-feedback datamanager

Data Import Options

RBA: kfuchsbe

Reference Orbits Feedback Optics

StandAloneBeamProcess

Filter:

time	id	name	used by ofb	reference orbit
0	1829	A1100C1100A1000L1000_INJ_2012	<input checked="" type="checkbox"/>	Nom 4TeV, 11m 2012
19	1828	A1100C1100A1000L1000_2012	<input type="checkbox"/>	Nom 4TeV, 11m 2012
169	1831	A900C900A900_0.00915L750_0.0093...	<input type="checkbox"/>	
262	1830	A700C700A750_0.00897L600_0.0090...	<input type="checkbox"/>	Nom 4TeV, 7m 2012
348	1874	A400C400A600_0.00889L500_0.0090...	<input type="checkbox"/>	
396	1873	A300C300A500_0.00889L375_0.0088...	<input type="checkbox"/>	Nom 4TeV, 3m 2012
425	1872	A250C250A450_0.00889L350_0.0088...	<input type="checkbox"/>	
455	1871	A200C200A400_0.00889L325_0.0087...	<input type="checkbox"/>	Nom 4TeV, 2m 2012
491	1870	A160C160A350_0.00889L300_0.0087...	<input type="checkbox"/>	
529	1869	A150C150A300_0.00889L300_0.0087...	<input type="checkbox"/>	Nom 4TeV, 1.5m 2012
563	1868	A120C120A300_0.00889L300_0.0087...	<input type="checkbox"/>	
602	1867	A100C100A300_0.00889L300_0.0087...	<input type="checkbox"/>	Nom 4TeV, 1m 2012
634	1880	A90C90A300_0.00889L300_0.00875...	<input type="checkbox"/>	Nom 4TeV, 1m 2012
696	1879	A80C80A300_0.00889L300_0.00875...	<input type="checkbox"/>	Nom 4TeV, 0.6m 2012
840	1878	A70C70A300_0.00889L300_0.00875...	<input type="checkbox"/>	Nom 4TeV, 0.6m 2012
925	1876	A60C60A300_0.00889L300_0.00875...	<input checked="" type="checkbox"/>	Nom 4TeV, 0.6m 2012

Filter:

RAMP\_4TeV\_MCS\_2012\_V1  
RAMP\_4TeV\_MCS\_2012\_V1@0\_[START]  
RAMP\_4TeV\_SPOOLS\_V1@0\_[START]  
RAMP\_4TeV\_SPOOL\_clone  
RAMP\_4TeV\_SPOOL\_clone@0\_[START]  
SQUEEZE\_1.38TeV\_V1  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@0\_[START]  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@175  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@19  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@273  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@370  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@431  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@499  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@578  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@629  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@649  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@715  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@773  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@810  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_V1@874\_[END]  
SQUEEZE\_4TeV\_IP1+IP5+IP2\_0.8m\_IONS\_simulation\_with\_bumps  
SQUEEZE\_4TeV\_LONG\_2012\_V1  
SQUEEZE\_4TeV\_LONG\_2012\_V1@19  
SQUEEZE\_4TeV\_LONG\_2012\_V1@262  
SQUEEZE\_4TeV\_LONG\_2012\_V1@396  
SQUEEZE\_4TeV\_LONG\_2012\_V1@40  
SQUEEZE\_4TeV\_LONG\_2012\_V1@455  
SQUEEZE\_4TeV\_LONG\_2012\_V1@602  
SQUEEZE\_4TeV\_LONG\_2012\_V1@634  
SQUEEZE\_4TeV\_LONG\_2012\_V1@696  
SQUEEZE\_4TeV\_LONG\_2012\_V1@840  
SQUEEZE\_4TeV\_LONG\_2012\_V1@925\_[END]  
SQUEEZE\_4TeV\_LONG\_2012\_V1\_Aug\_ALICEplus

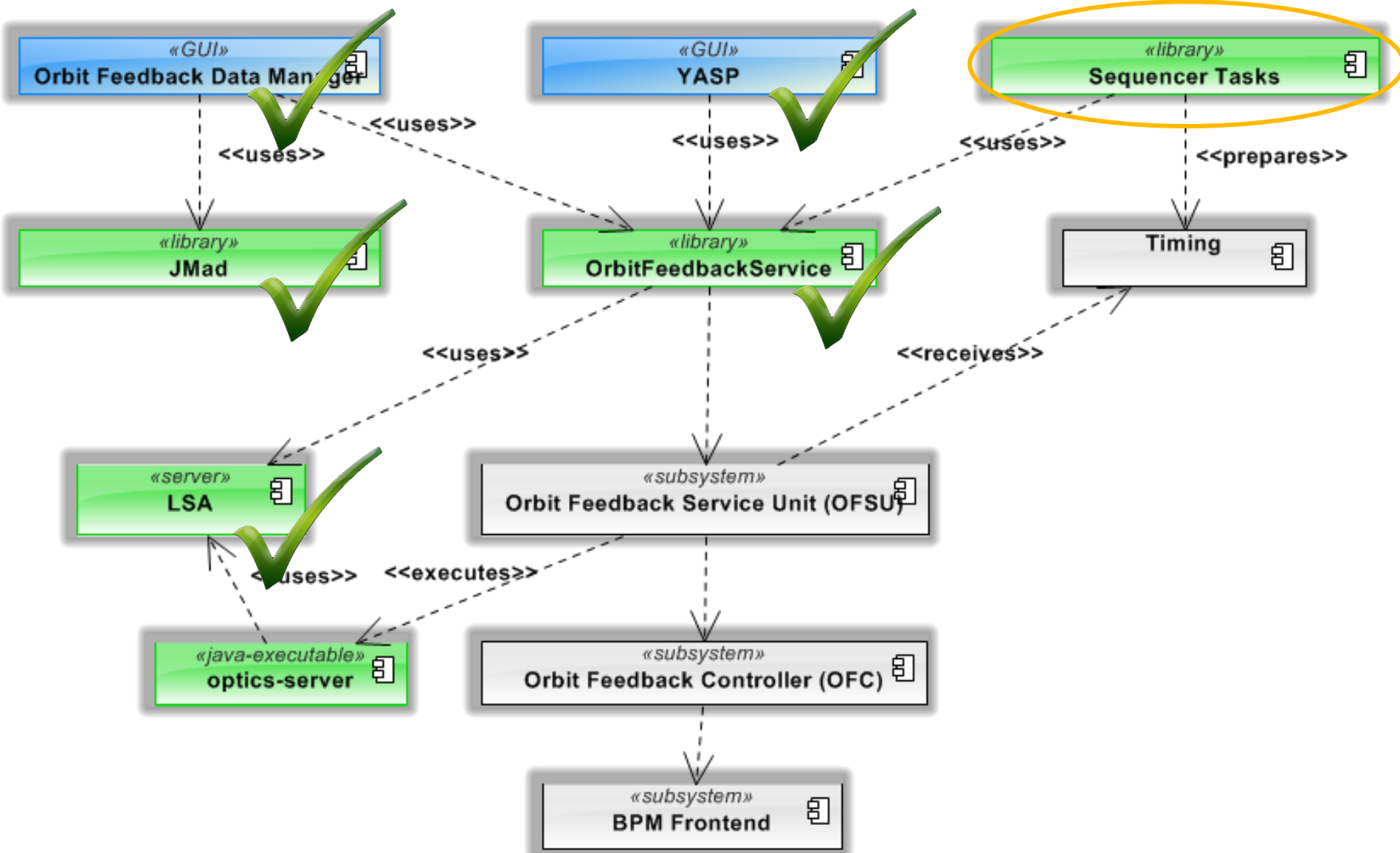
OPERATIONAL

23:33:45 - New subject is set!

Stored in LSA Optics table per BP Type. (Not a ,real' Setting)

# Tune Settings

- Much simpler (4 Values per point in time)
- Stored as Settings in LSA
  - Set via LSA command
- Changing mechanisms similar to Orbit changes  
(See Laurettes Presentation)



# Orbit Changes during Ramp/Squeeze

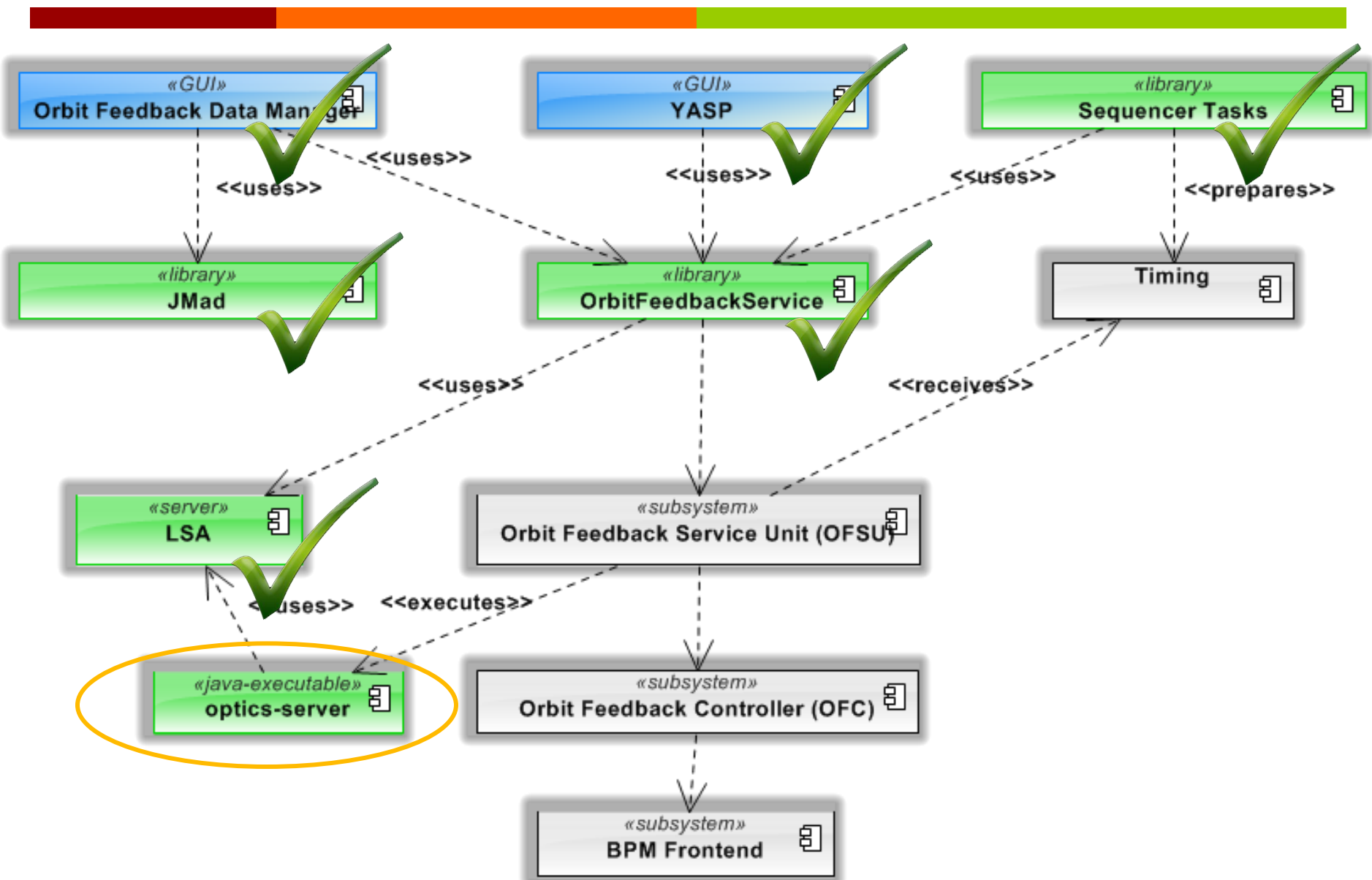
- Preparation: Set fields in OFSU RefOrbit Property:
  - Set Base Orbit + Array of Overlay Shapes
  - Set Array of Changing Times
  - Set (2D)Array of Overlay factors
- OFSU receives one timing event per change.
  - Array Index(!) in payload.
  - Sends Changing time and factors for index to OFC.
  - Timing table constructed by Sequencer task.  
(Has to be consistent with changing times!)
- Could be simpler (Similar to functions in PC):
  - Array of Orbits + Array of points in time
  - One timing event (e.g. „START\_RAMP“)

Introduction

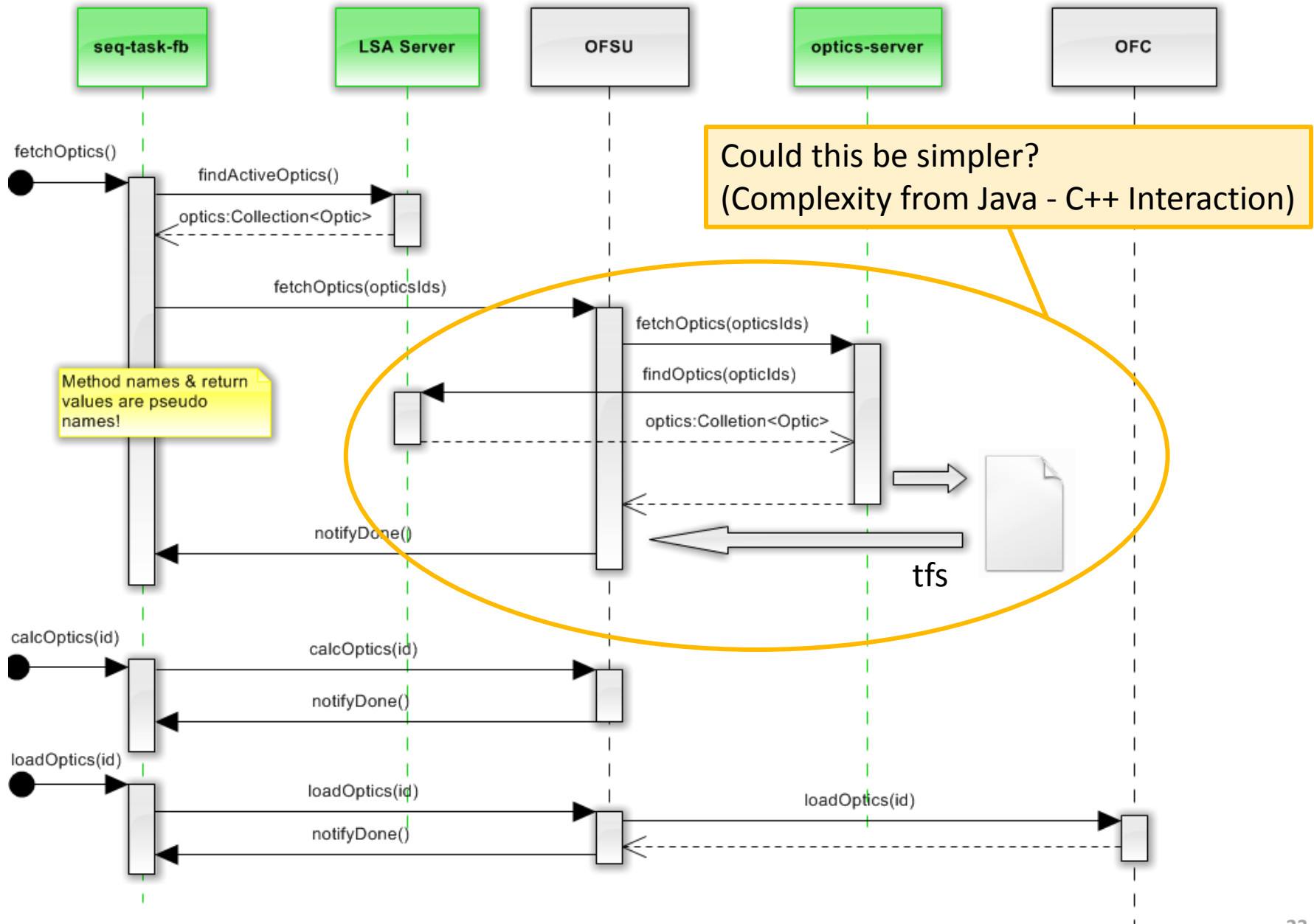
Reference Settings

Optics Changes

Possible Improvements



# Optics Loading



# Optics Loading & Change - Remarks

- Never used operationally!?
  - Crashes the OFSU
- Optics Change (Currently similar to Orbit):
  - One timing event per change.
  - Timing table constructed by sequencer task
- Could it be simpler?
  - Directly Set Response Matrix from Java layer?
  - Table with optics & times
  - One timing event (e.g. „START\_SQUEEZE“)



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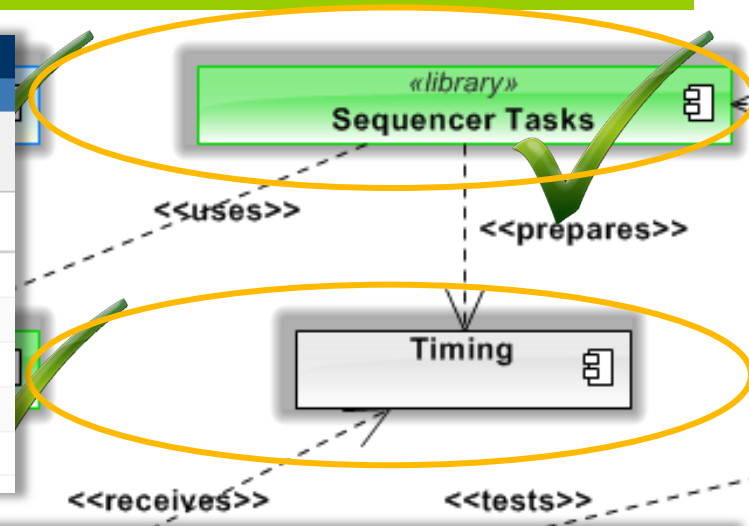
Optics Changes

Possible Improvements

**BAMBOO**  
Dashboard Authors Reports

### LHC feedbacks

Plan	Build	Completed	Tests	Reason
lhc-feedback-ofsu-test	❗ #1787	8 hours ago	4 of 6 failed	Dependant of LHCFB-SEQTASK-80
lhc-feedbacks-seq-task-fb-test	🕒 #378	7 months ago	10 of 18 failed	Scheduled build
lhc-orbitfeedback-datamanager	✅ #30	8 hours ago	1 passed	Dependant of LHCFB-LHCFB-41
lhc-orbitfeedback-service	✅ #41	8 hours ago	46 passed	Updated by Kajetan Fuchsberger
seq-task-fb	✅ #80	8 hours ago	2 passed	Dependant of LHCFB-LHCFB-41



- Status:
  - Only very few (!) High-Level Tests
  - Not very reproducible (depends partly on beam presence)
  - Test of behaviour (e.g. algorithm) currently impossible
- Putting in place better tests should not be too difficult!?
  - Controls Testbed isolated network + sending of timing events.
  - Small java server which simulates LHC behaviour?

# Open Questions



- Would it be a really bad idea, to have a FESA class directly on the OFC?
  - Would avoid proprietary protocol.
  - OFSUs main job seems to be transporting information.
- Could some jobs be done on the java layer?
  - Optics recalculation
  - Orbit-Subscription proxy

# Or even more in Java?



- Java can subscribe to timing events
- Java can well handle UDP packets
- Java can easily communicate with LSA
- Standard JVM can do soft real time ...
- Specialized JVMs can do hard real time! (JamaicaVM, Zing, ...)

[http://en.wikipedia.org/wiki/Real time Java](http://en.wikipedia.org/wiki/Real_time_Java)

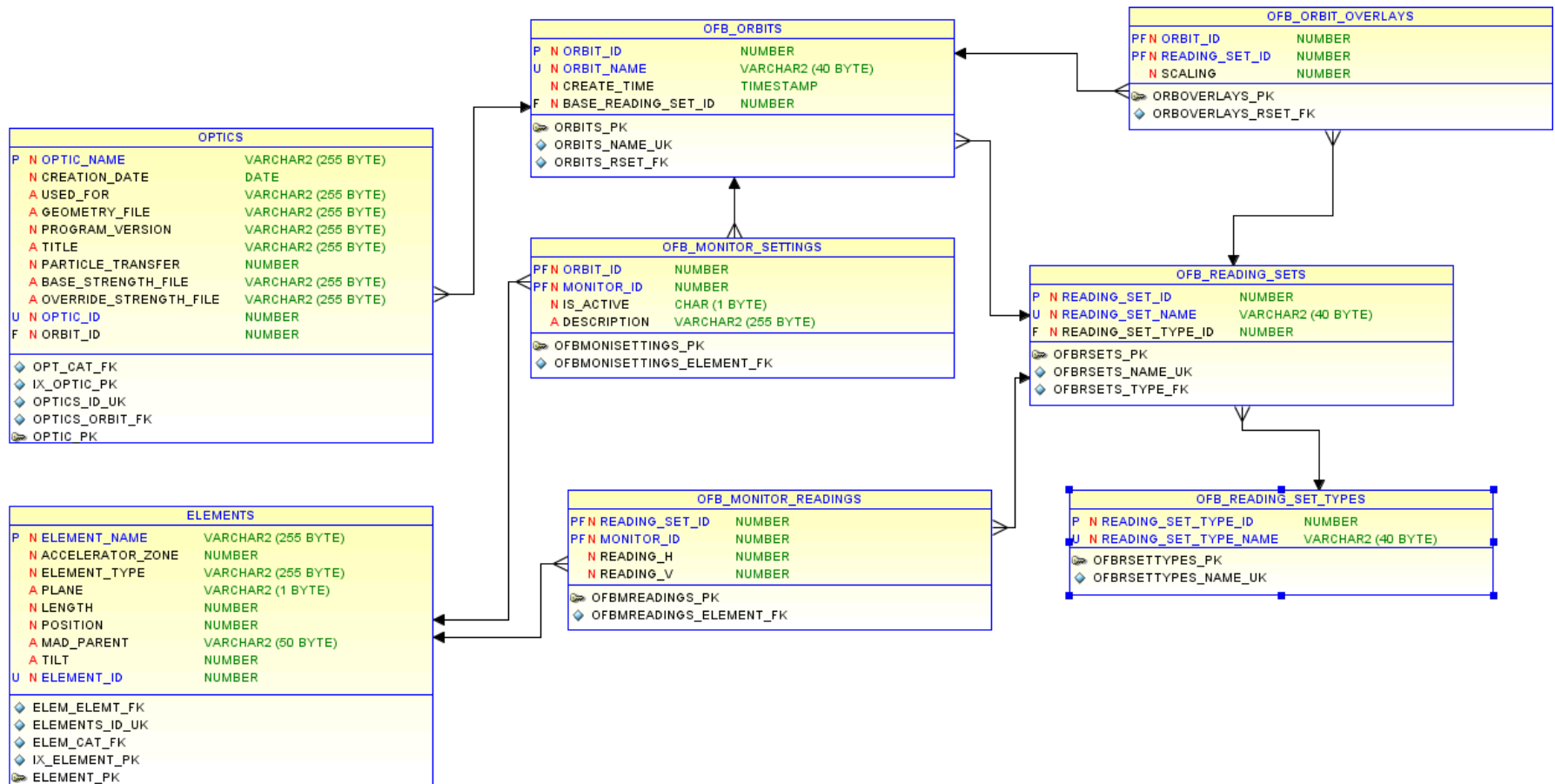


# Thank you for your Attention!



## Questions?

# LSA Db Tables



# Sequencer Tasks

task name	java method name
DISARM OFB	disarmOFB
LOAD SQUEEZE PC TABLE	loadPcTable
LOAD SQUEEZE OPTICS ORBIT CHANGE TABLE	loadSqueezeOpticsOrbitChangeTable
LOAD COLLISIONS OPTICS ORBIT CHANGE TABLE	loadCollisionsOpticsOrbitChangeTable
LOAD RAMP OPTICS ORBIT CHANGE TABLE	loadRampOpticsOrbitChangeTable
SET FEEDBACK PARAMETERS	setFeedbackParameters
FETCH ALL OPTICS	fetchAllOptics
CALC ALL OPTICS	calcAllOptics
CALC SQUEEZE OPTICS	calcSqueezeOptics
SET ACTIVE BEAM PROCESS OPTIC	setActiveBeamProcessOptic
SET ACTIVE OPTIC BY ID	setActiveOpticById
CALC ACTIVE BEAM PROCESS OPTIC	calcActiveBeamProcessOptic
SET BPM TEMP OP MASK BY REGEX	setBpmTempOpMaskByRegex
ARM REF ORBITS BY USER	armRefOrbitsByUser
CHECK REF ORBITS BY USER	checkRefOrbitsByUser
SET ACTIVE ORBIT INDEX	setActiveOrbitIndex
SWITCH FEEDBACK STATE	switchFeedbackState
CHECK FEEDBACK STATE	checkFeedbackState
RESET FEEDBACK	resetFeedback
SET OPTICS OPERATION MODE	setOpticsOperationMode
USE MEASURED ORBIT AS REFERENCE	useMeasuredOrbitAsReference
SET SQUEEZE PARAMETERS	setSqueezeParameters
SET SQUEEZE END USER	setSqueezeEndUser
LOAD OPTICS ORBIT CHANGE TABLE	loadOpticsOrbitChangeTable
SET LOADABLE OPTICS	setLoadableOptics
REGENERATE SQUEEZE ACTUAL BP	regenerateActualBeamProcess
MAKE RESIDENT SQUEEZE ACTUAL BP	makeLhcUserResident
LOAD FEEDBACK SETTINGS	loadFeedbackSettings
LOAD ARMED FEEDBACK SETTINGS	loadArmedFeedbackSettings
ARM TUNE FEEDBACK CHANGE	armFeedbacksController
LOAD TUNE FITTER SETTINGS	loadTuneFitterSettings
LOAD ARMED TUNE FITTER SETTINGS	loadArmedTuneFitterSettings

# Squeeze (in one step)

