

Bunch-to-Bucket (B2B) Transfer System for FAIR

Jiaoni Bai
Thibault Ferrand

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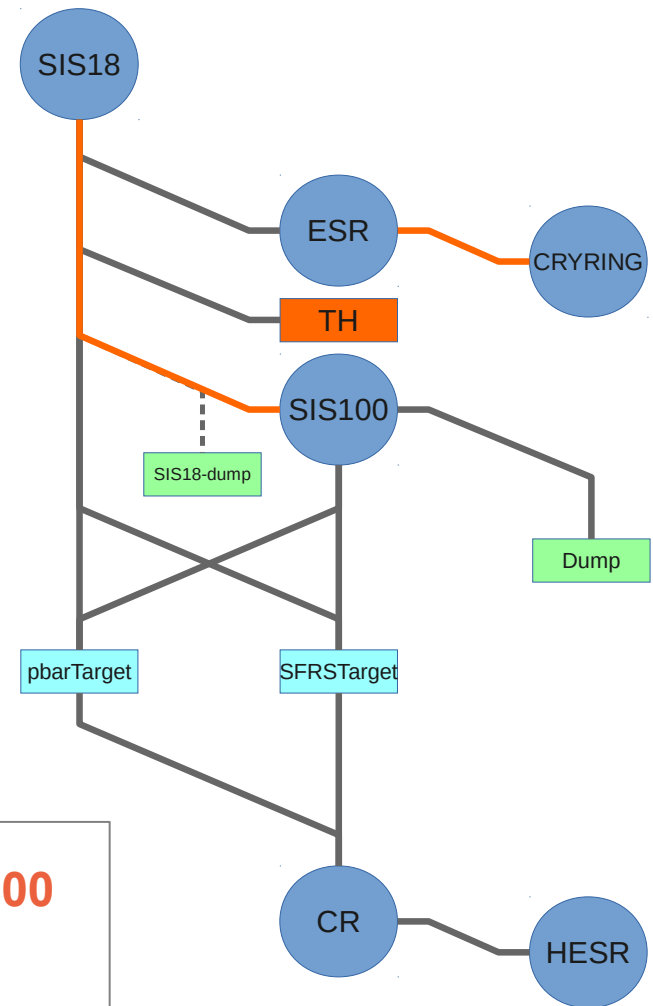
Outlines

- Introduction (Bai)
- Kicker and bucket pattern (Bai)
- B2B transfer procedure (Bai)
- Synchronization methods (Bai)
- Example: U²⁸⁺ B2B transfer from SIS18 to SIS100 (Bai)
- Functional implementation (Thibault)
- Task sharing (Thibault)
- Functional specification and requirements (Thibault)

Introduction

- Bucket : a bucket defines the potential well in (E_{kin}, t) - phase space, where the particles can be trapped.
- Bunch : a bunch defines the packet of particles gathered within a bucket.

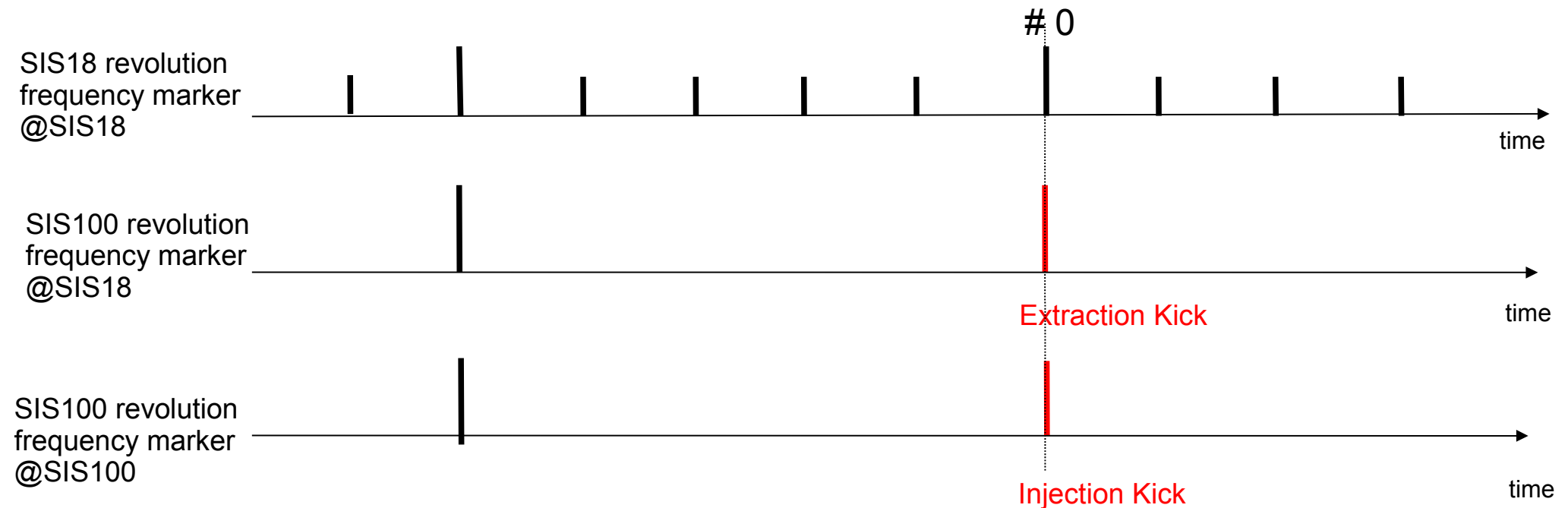
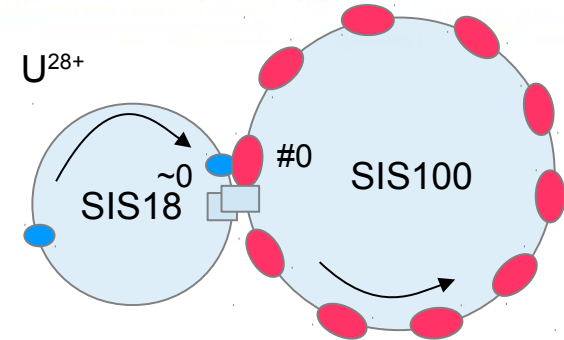
- **Focus mainly on the B2B transfer from SIS18 to SIS100**
- **Firstly tested in B2B transfer from ESR to CRYRING.**



Kicker & Bucket pattern

Assumption:

- Virtual cavity is located at the extraction/injection kicker position.
- There is no distance between two virtual cavities.
- Bucket #0 and #1

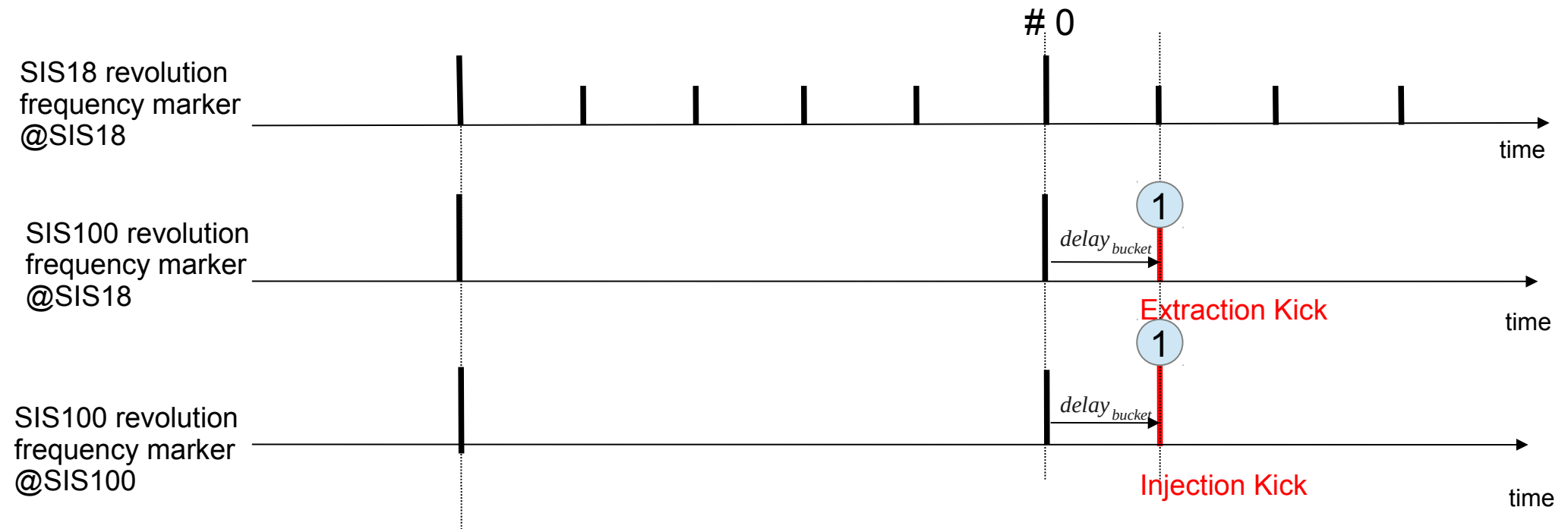
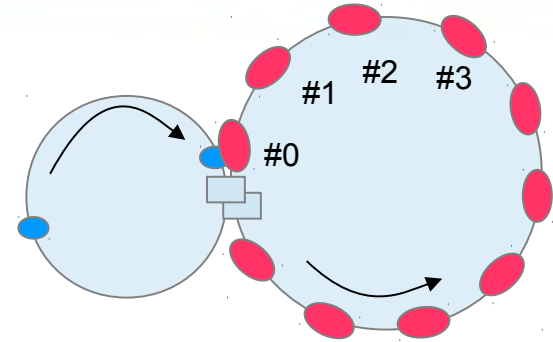


SR: Signal Reproduction module producing SIS100 revolution signal at SIS18, which labels bucket #0.

Kicker & Bucket pattern

Consideration:

1. Bucket pattern (#2 and #3)

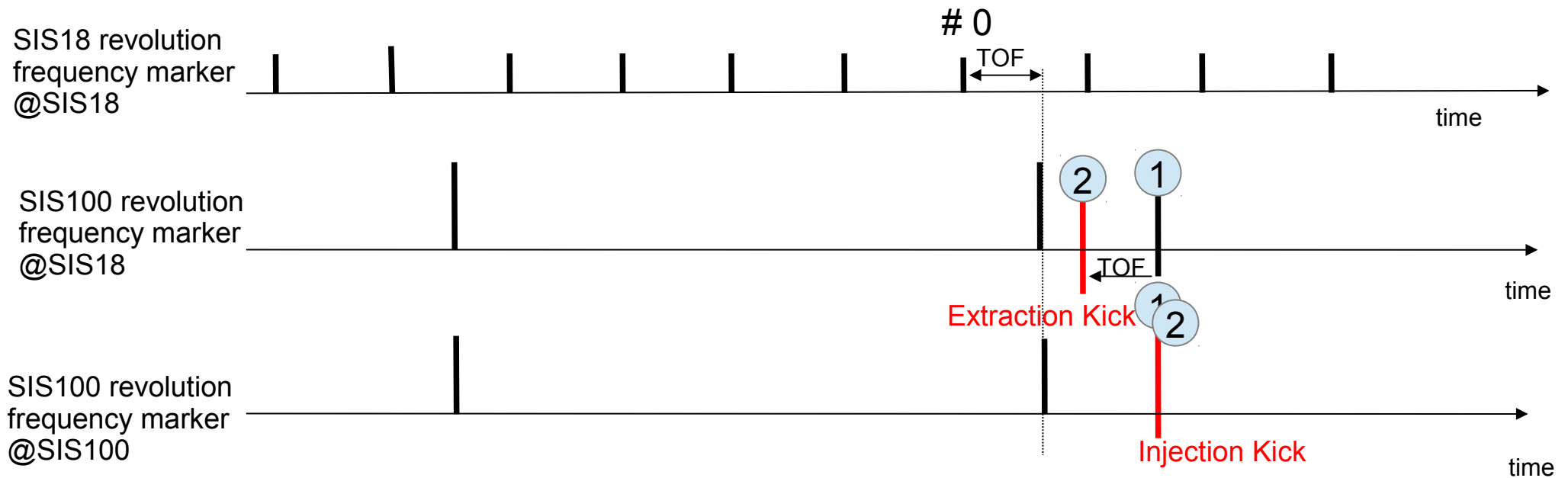
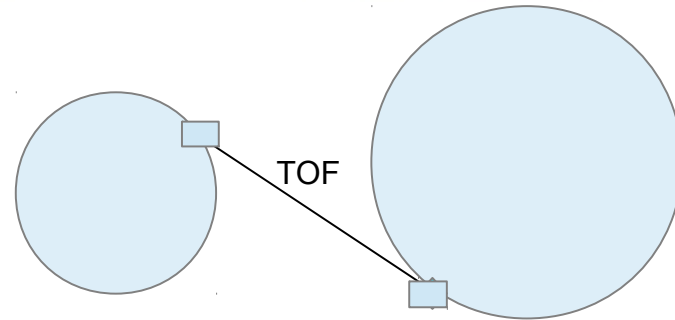


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Kicker & Bucket pattern

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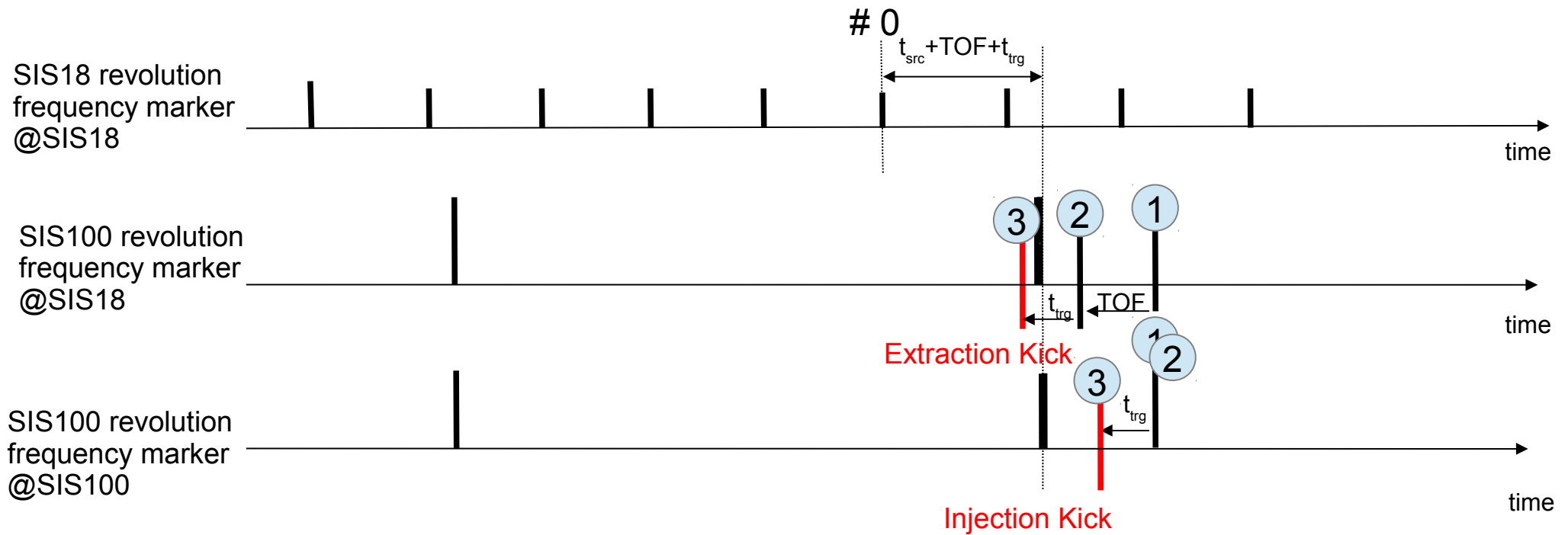
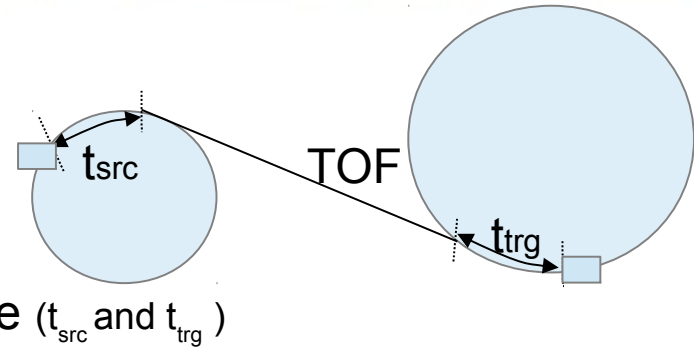
1. Bucket pattern (#2 and #3)
2. Time Of Flight (TOF)



Kicker & Bucket pattern

Consideration:

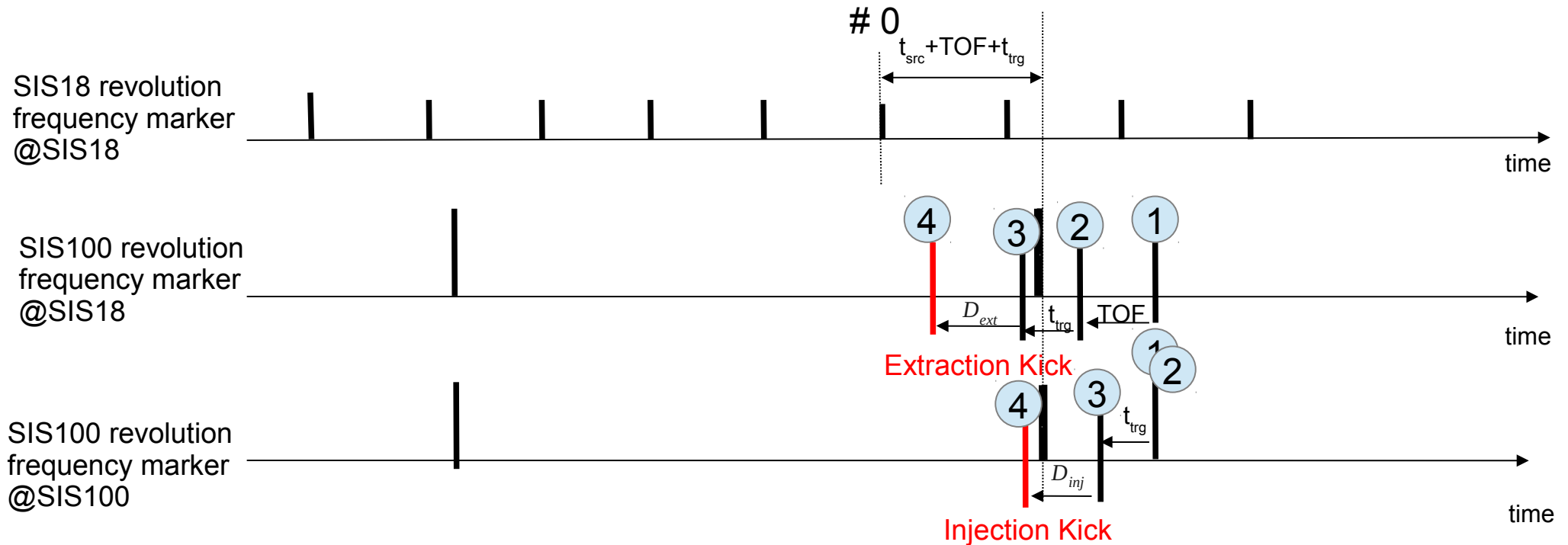
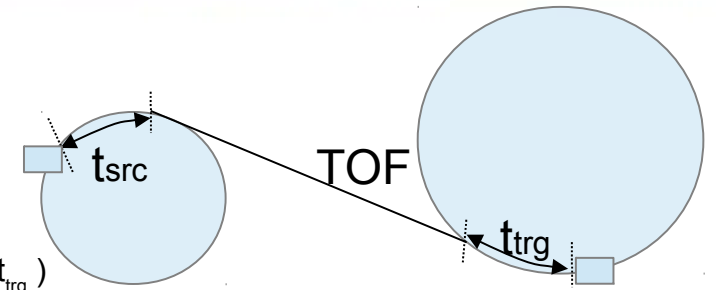
1. Bucket pattern (#2 and #3)
2. Time Of Flight (TOF)
3. Distance between virtual cavity and transport line (t_{src} and t_{trg})



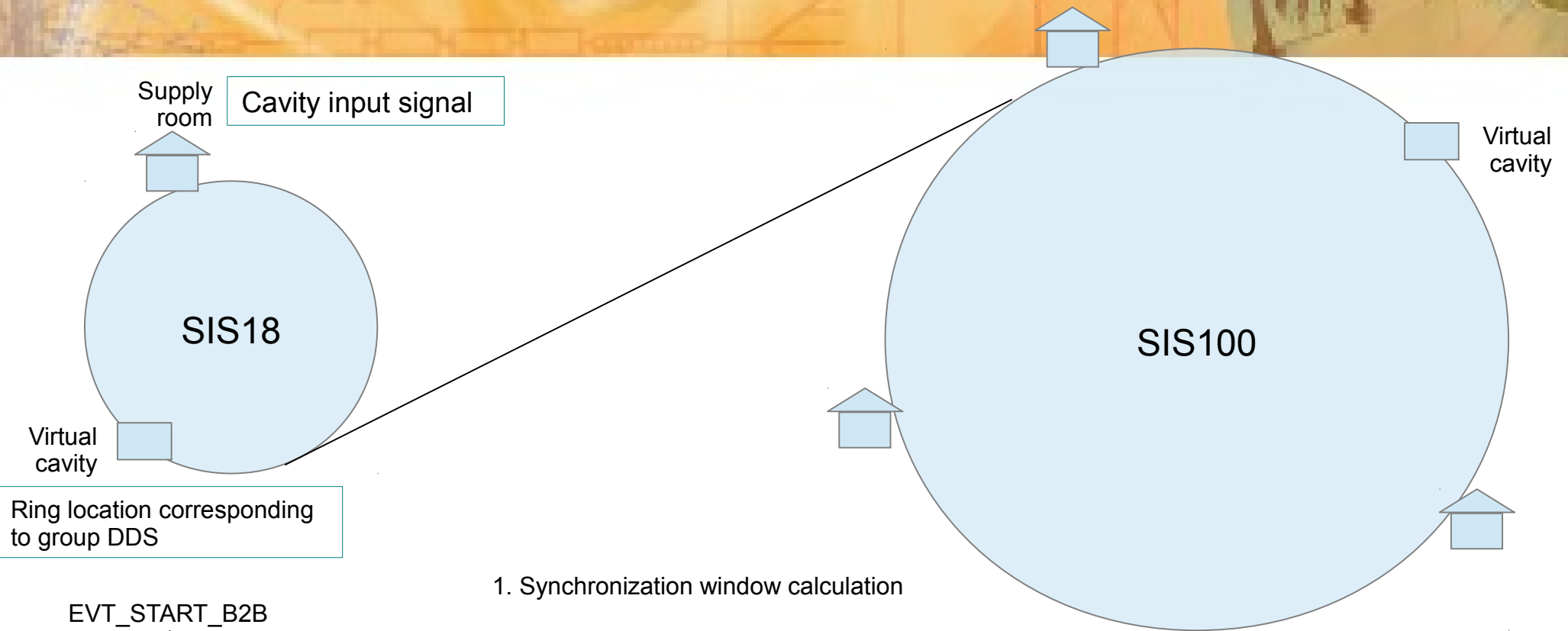
Kicker & Bucket pattern

Consideration:

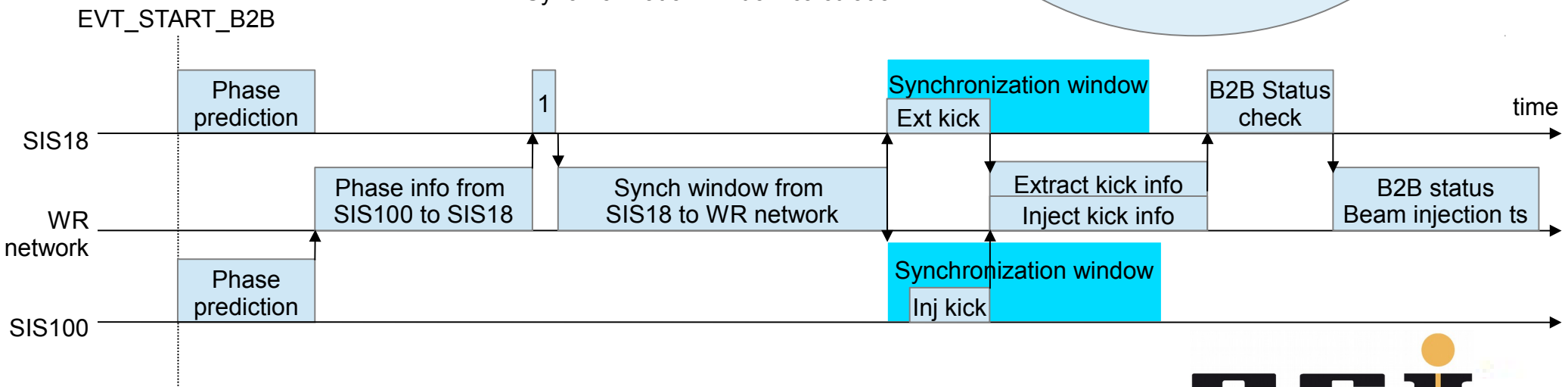
1. Bucket pattern (#2 and #3)
2. Time Of Flight (TOF)
3. Distance between virtual cavity and transport line (t_{src} and t_{trg})
4. Extraction and injection kicker delay (D_{ext} and D_{inj})



Procedure for the B2B transfer system

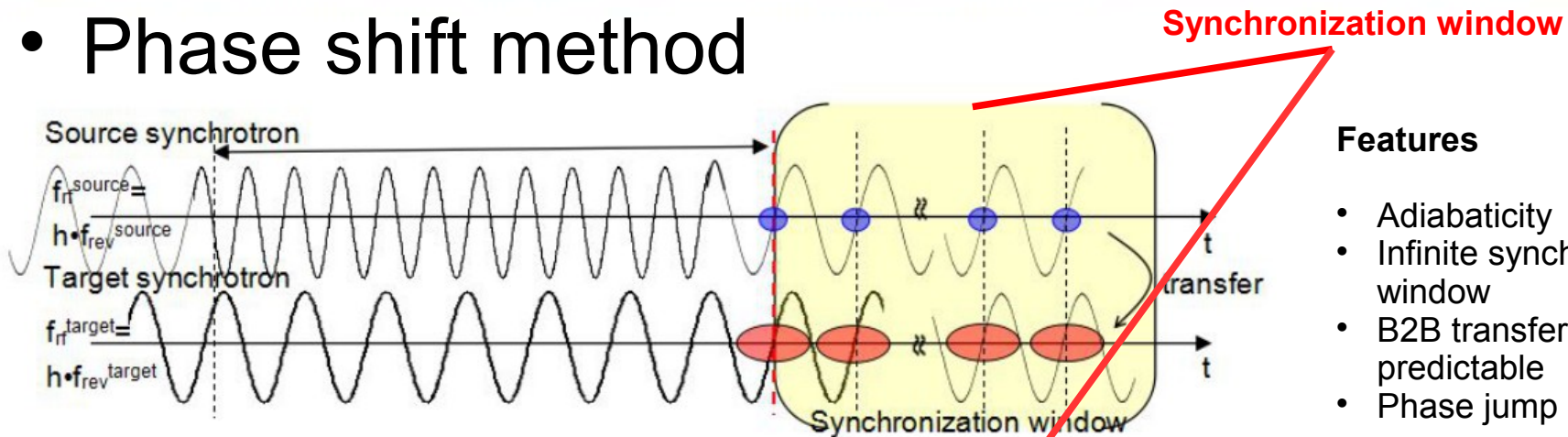


1. Synchronization window calculation



Synchronization methods

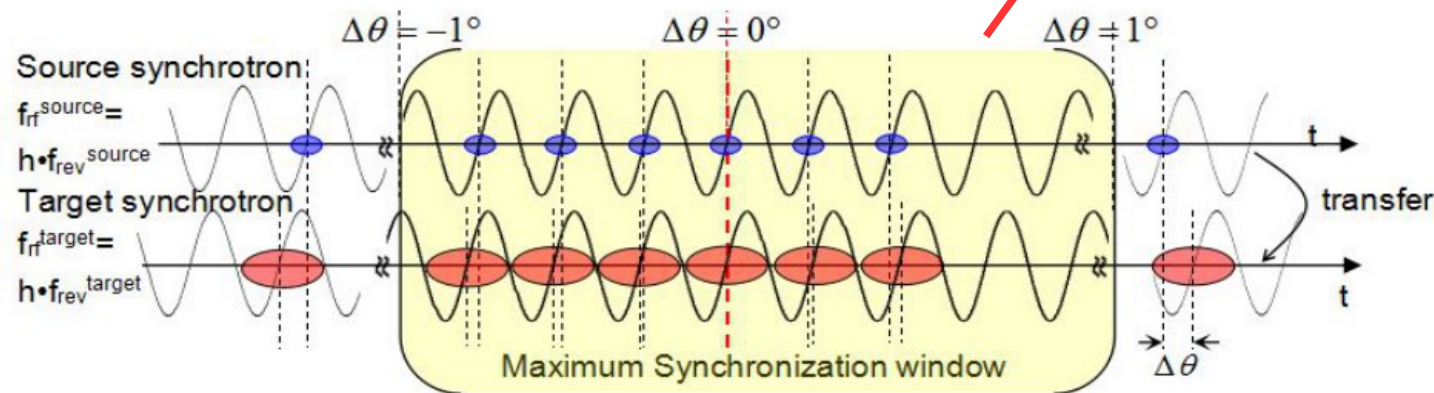
- Phase shift method



Features

- Adiabaticity
- Infinite synchronization window
- B2B transfer time is predictable
- Phase jump

- Frequency beating method



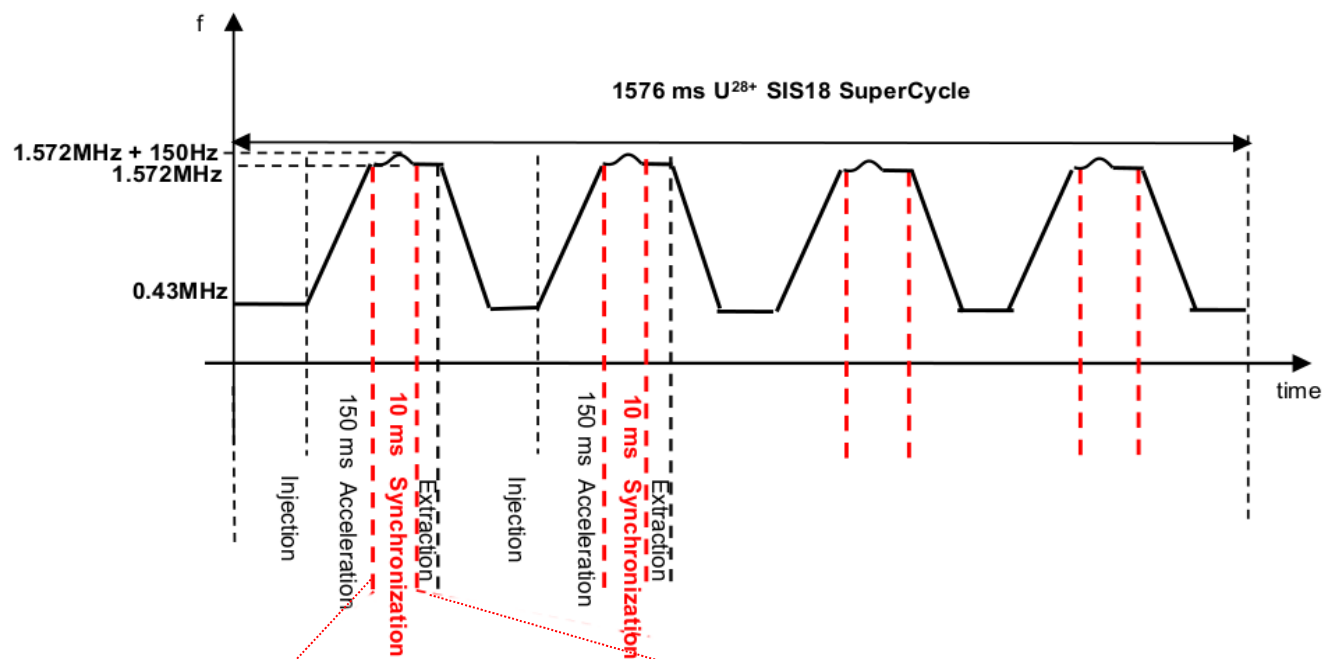
Features

- Bunch and bucket center Mismatch
- Mismatch within the synchronization window is better than 1°
- Only choice for some pair of machines
- Automatically beating

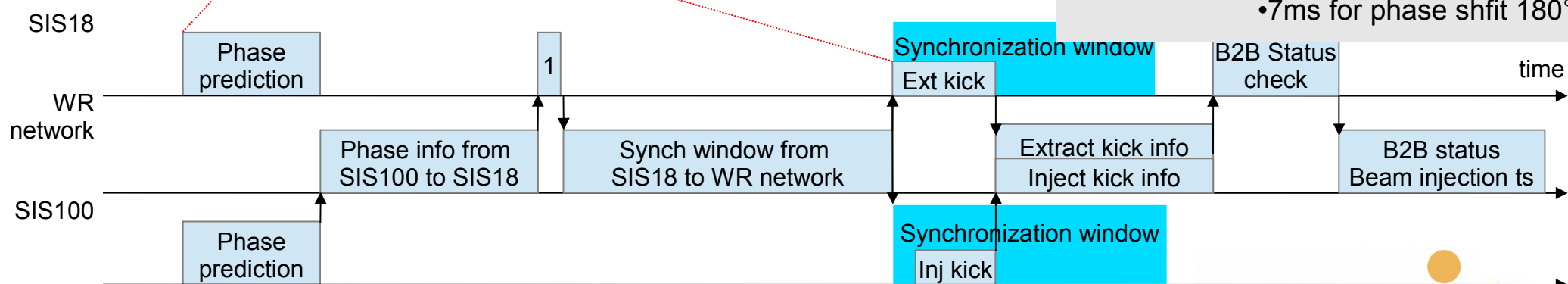
- Bunch
- Bucket

Example: U^{28+} B2B from SIS18 to SIS100 with the phase shift method

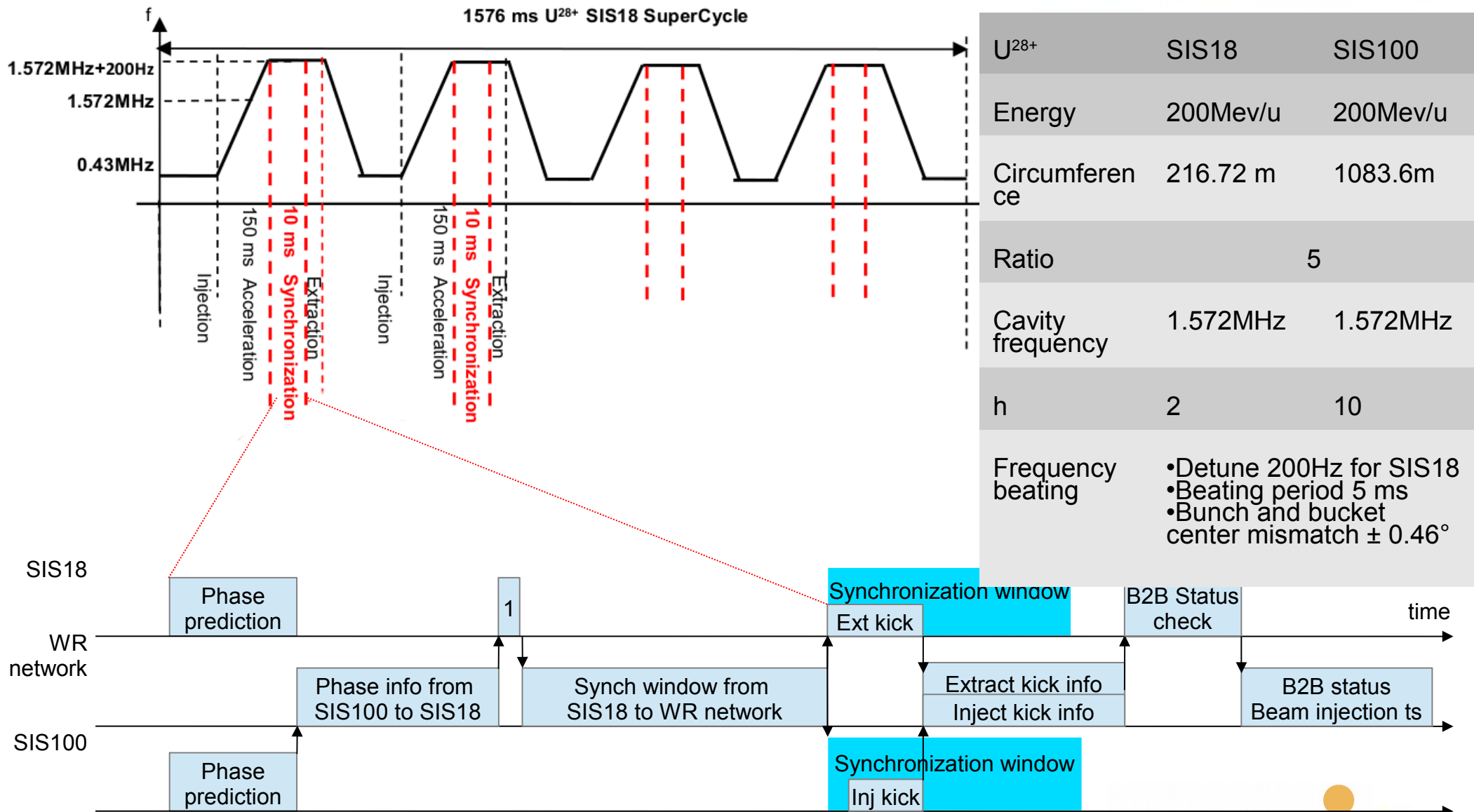
From SIS18, four batches of the U^{28+} at 200 MeV/u, each of two bunches, are injected into eight out of ten buckets of SIS100.



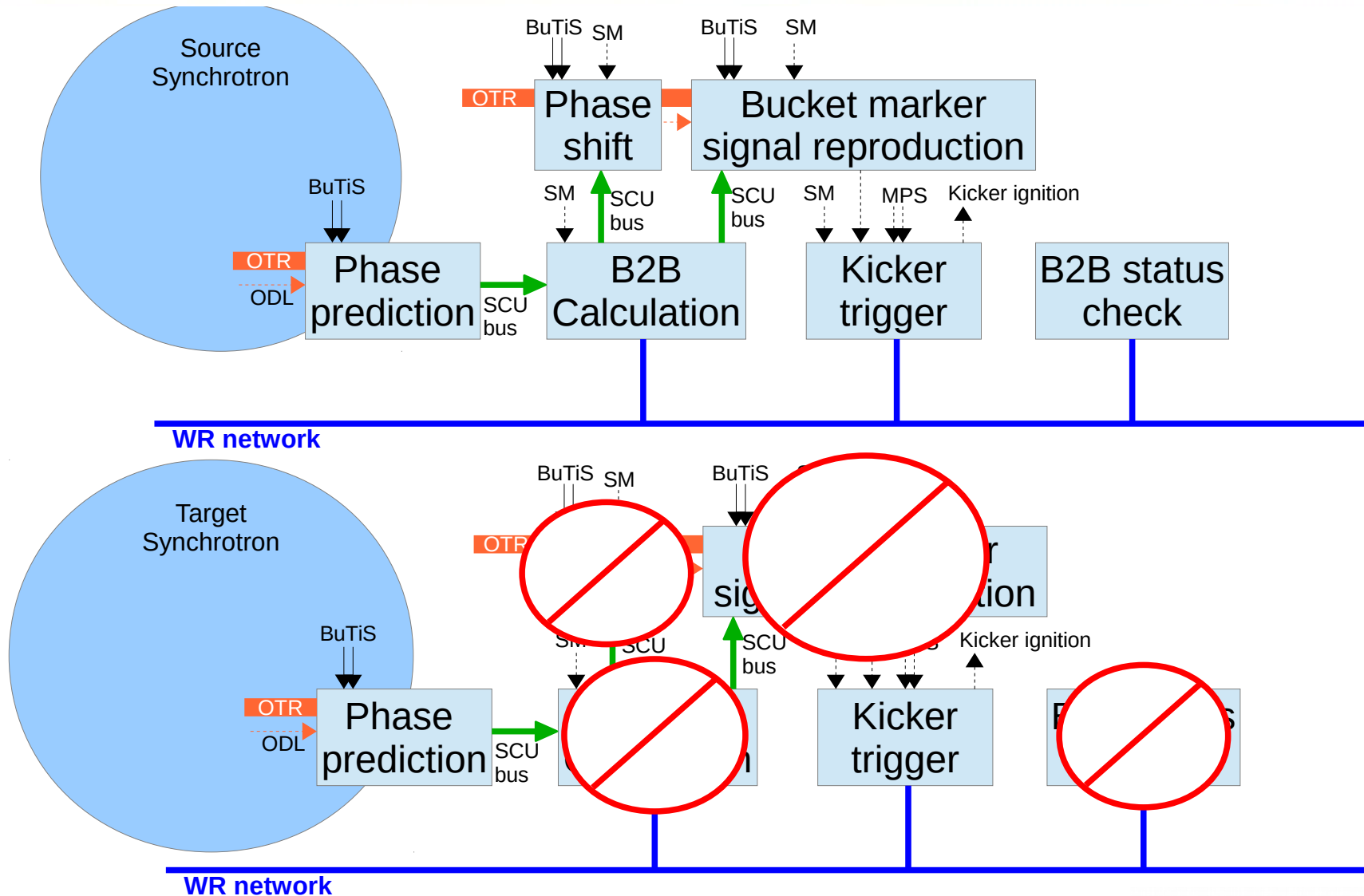
U^{28+}	SIS18	SIS100
Energy	200MeV/u	200MeV/u
Circumference	216.72 m	1083.6m
Ratio		5
Cavity frequency	1.572MHz	1.572MHz
h	2	10
Phase shift	<ul style="list-style-type: none"> •Parabola modulation for SIS18 •Max 64Hz/ms •Offset 150Hz •7ms for phase shift 180° 	



Example: U^{28+} B2B from SIS18 to SIS100 with the frequency beating method

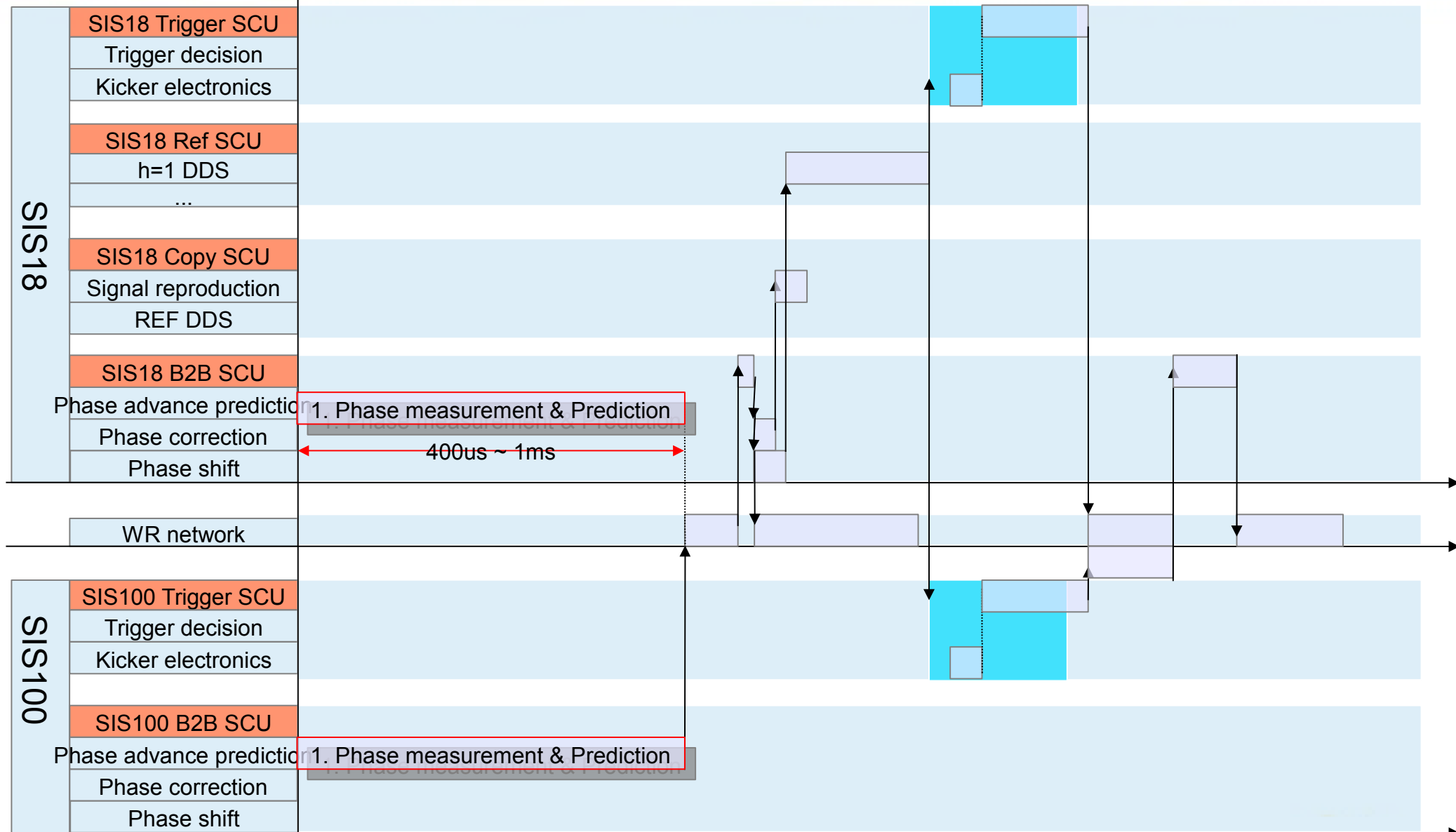


Functional specification and implementation

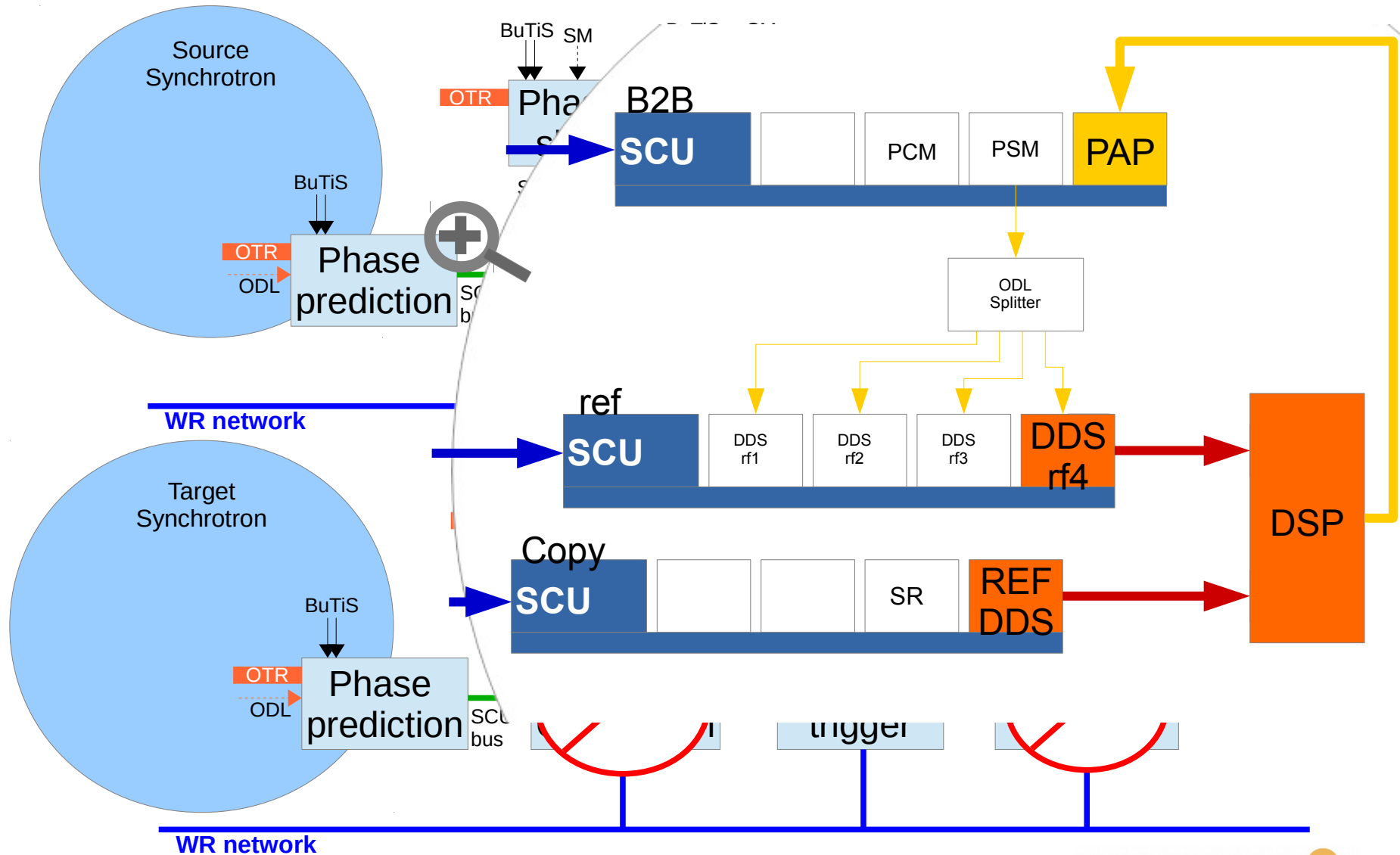


Functional specification and implementation

EVT_START_B2B

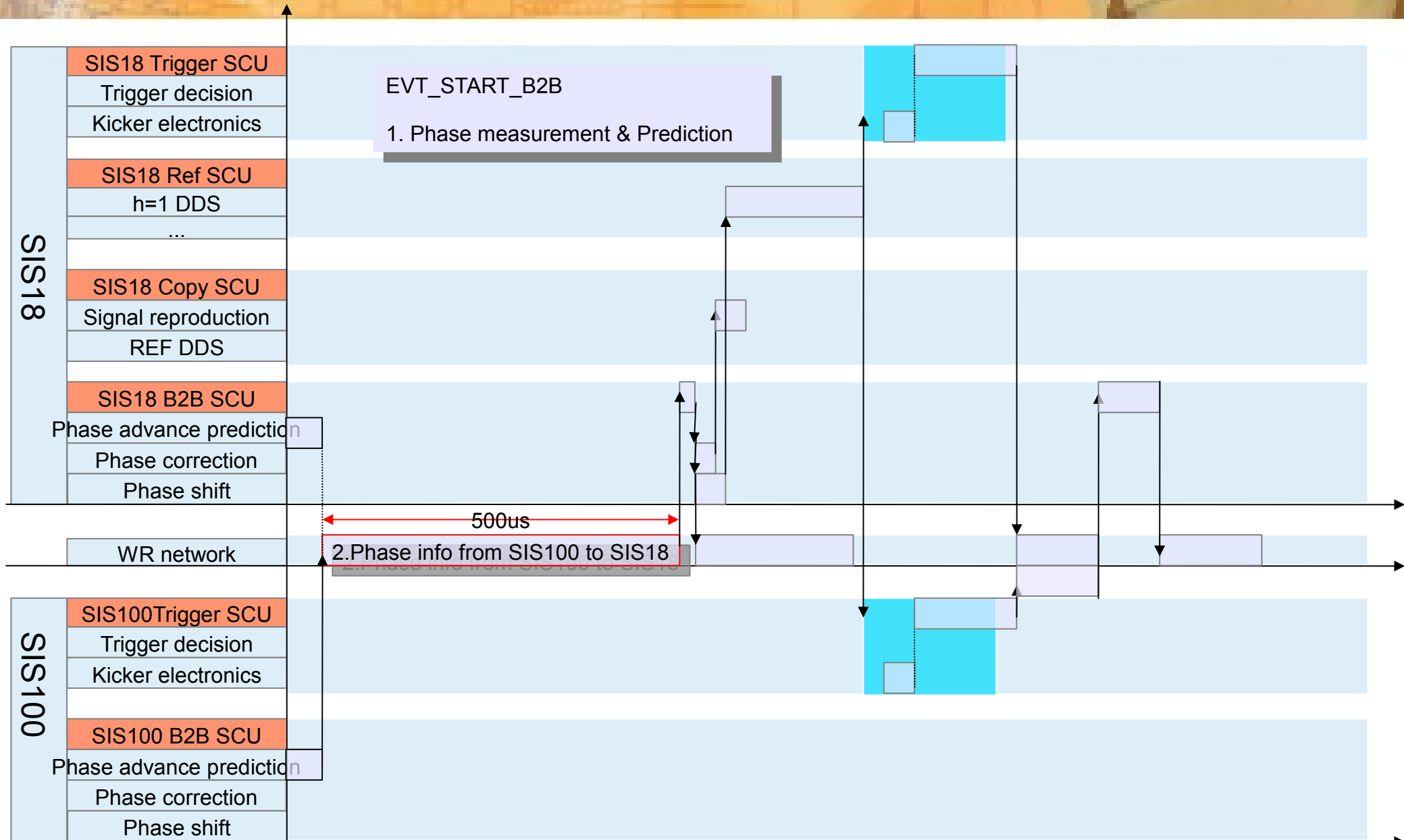


Functional specification and implementation

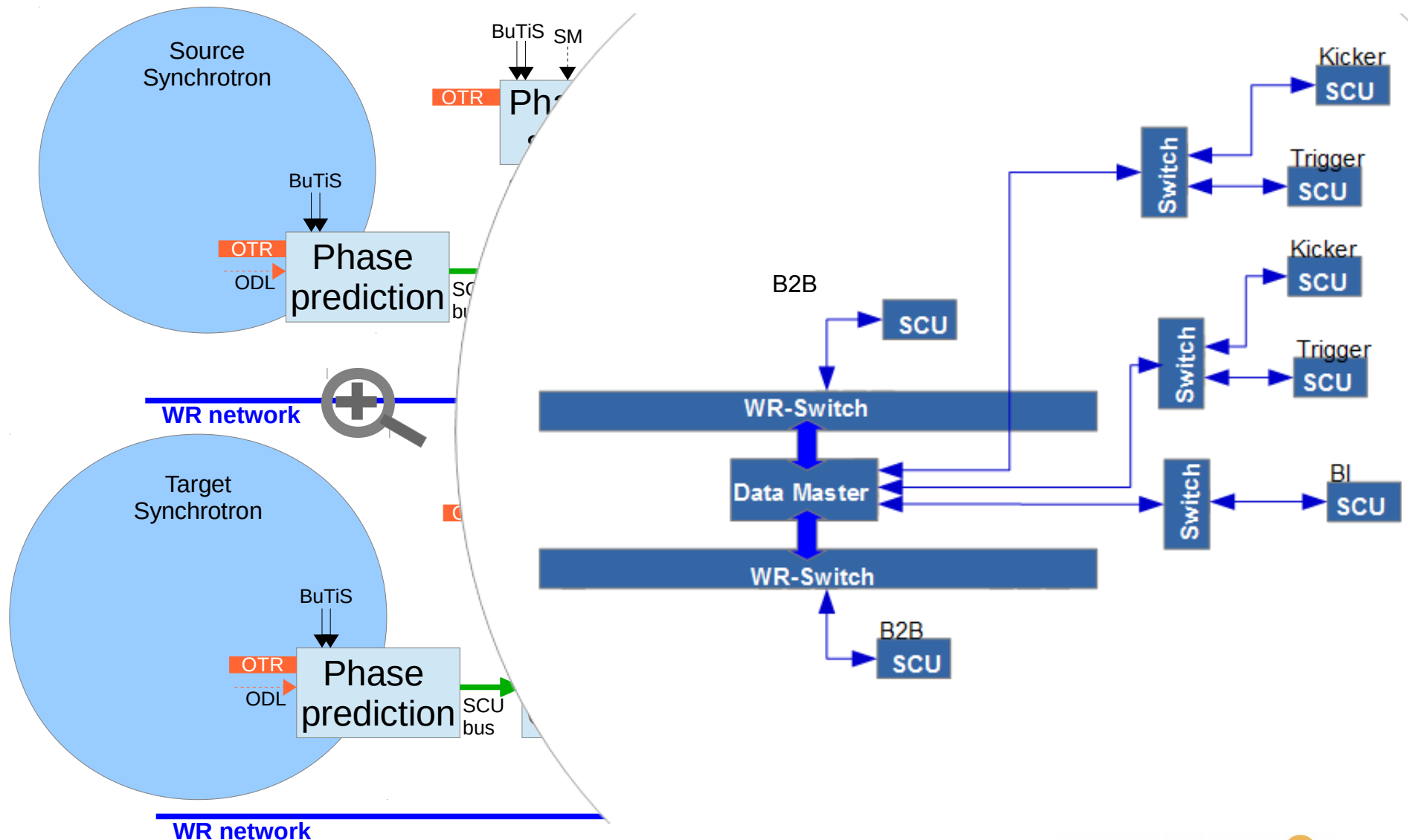


Functional specification and implementation

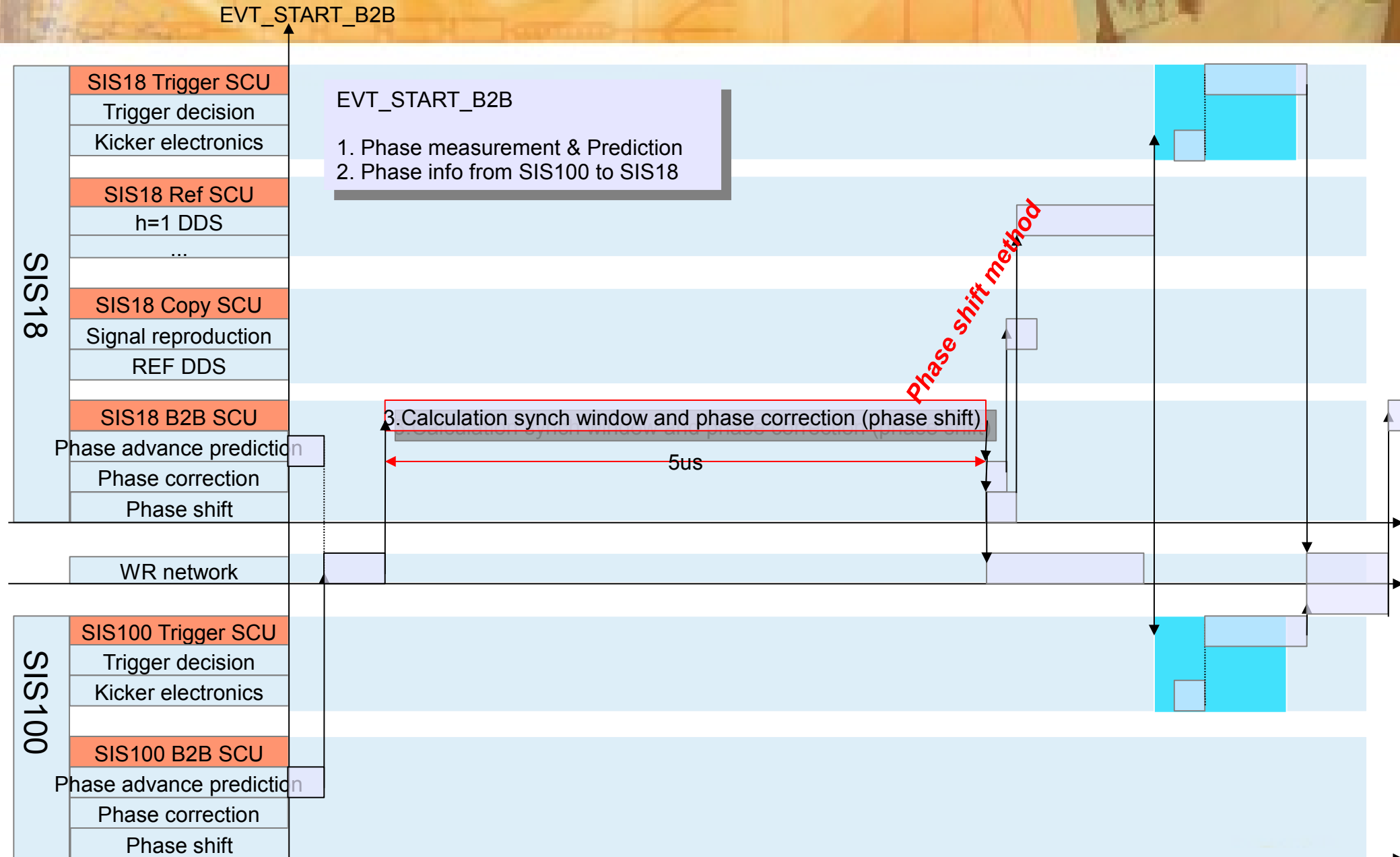
EVT_START_B2B



Functional specification and implementation

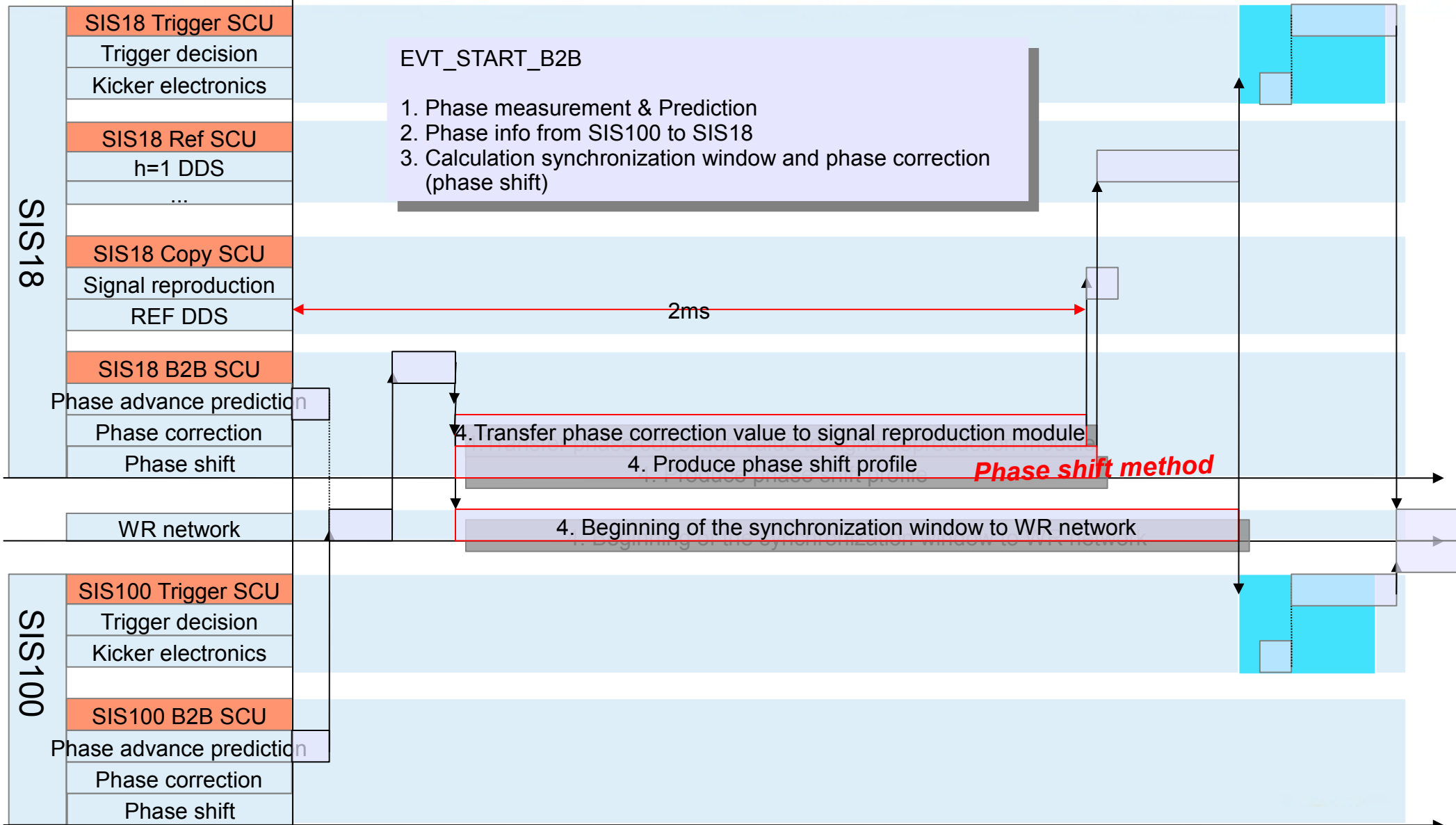


Functional specification and implementation



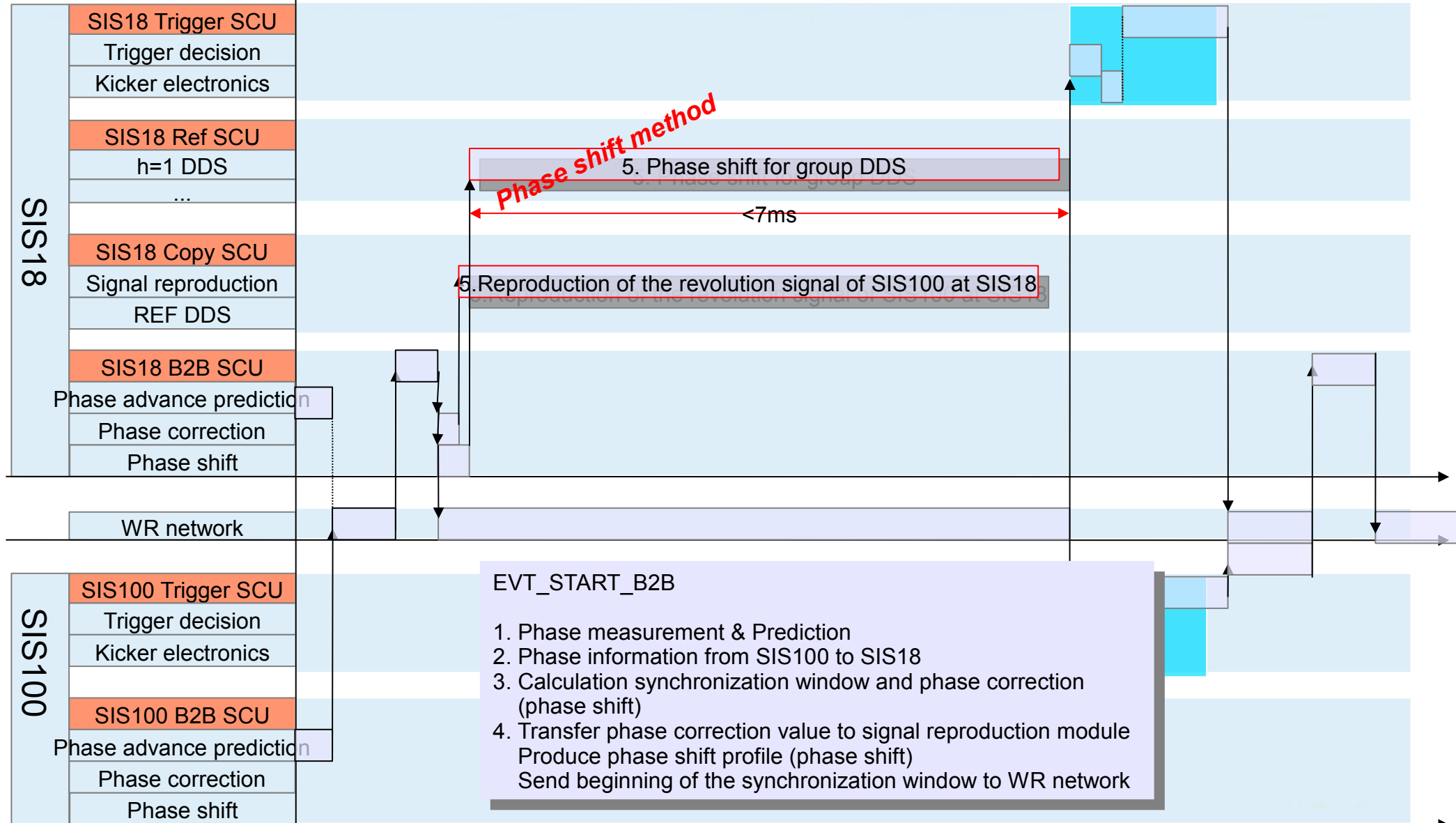
Functional specification and implementation

EVT_START_B2B

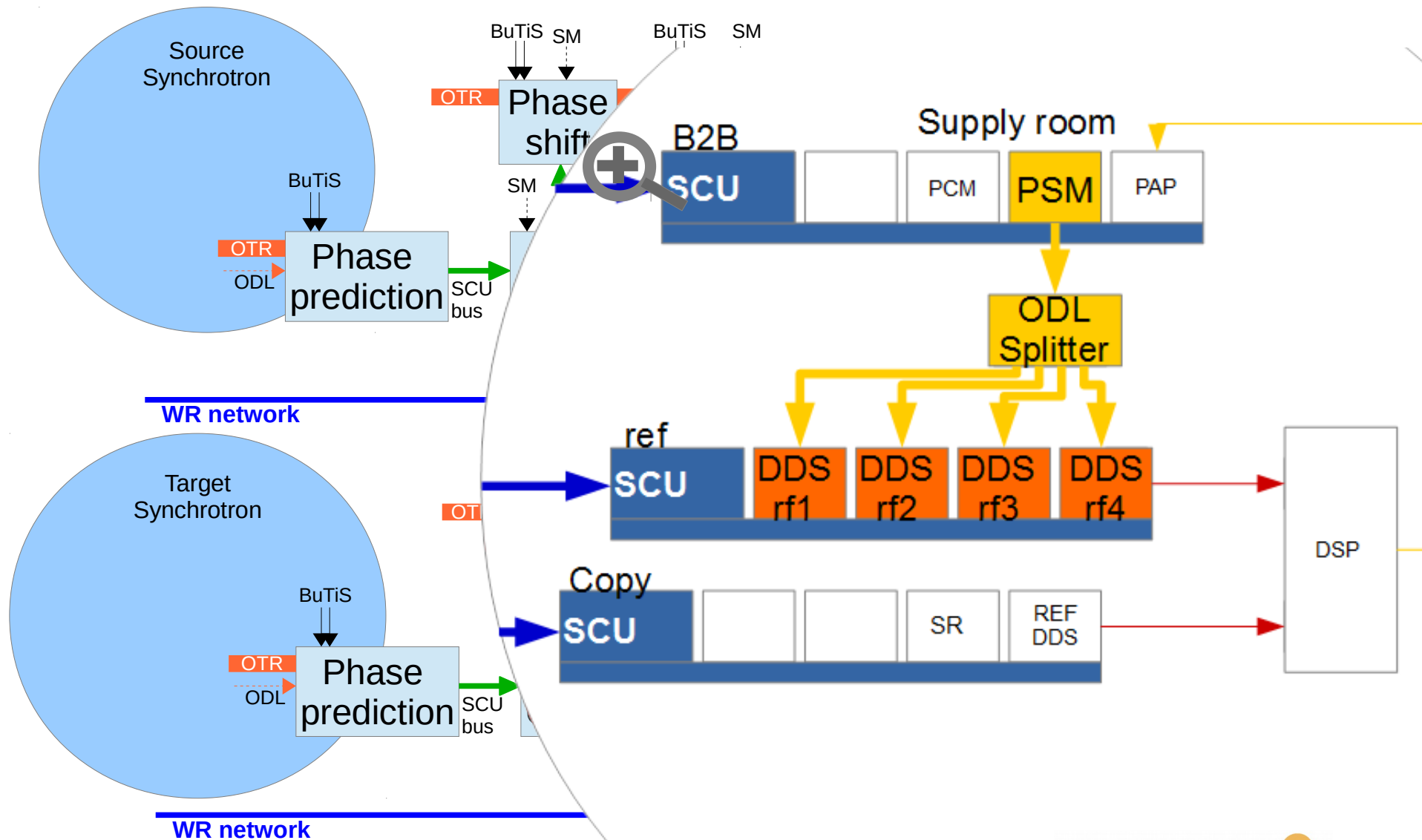


Functional specification and implementation

EVT_START_B2B

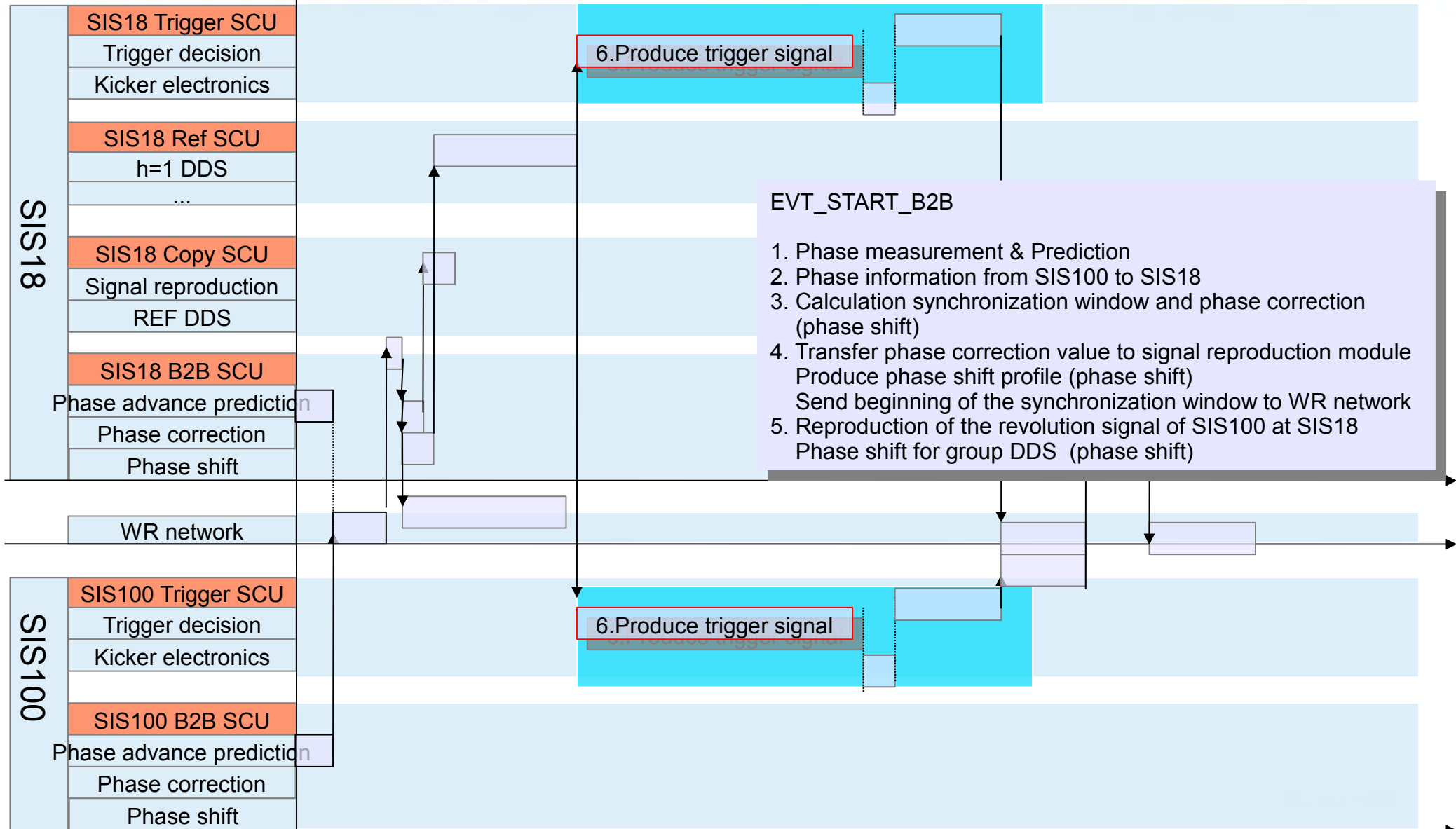


Functional specification and implementation



Functional specification and implementation

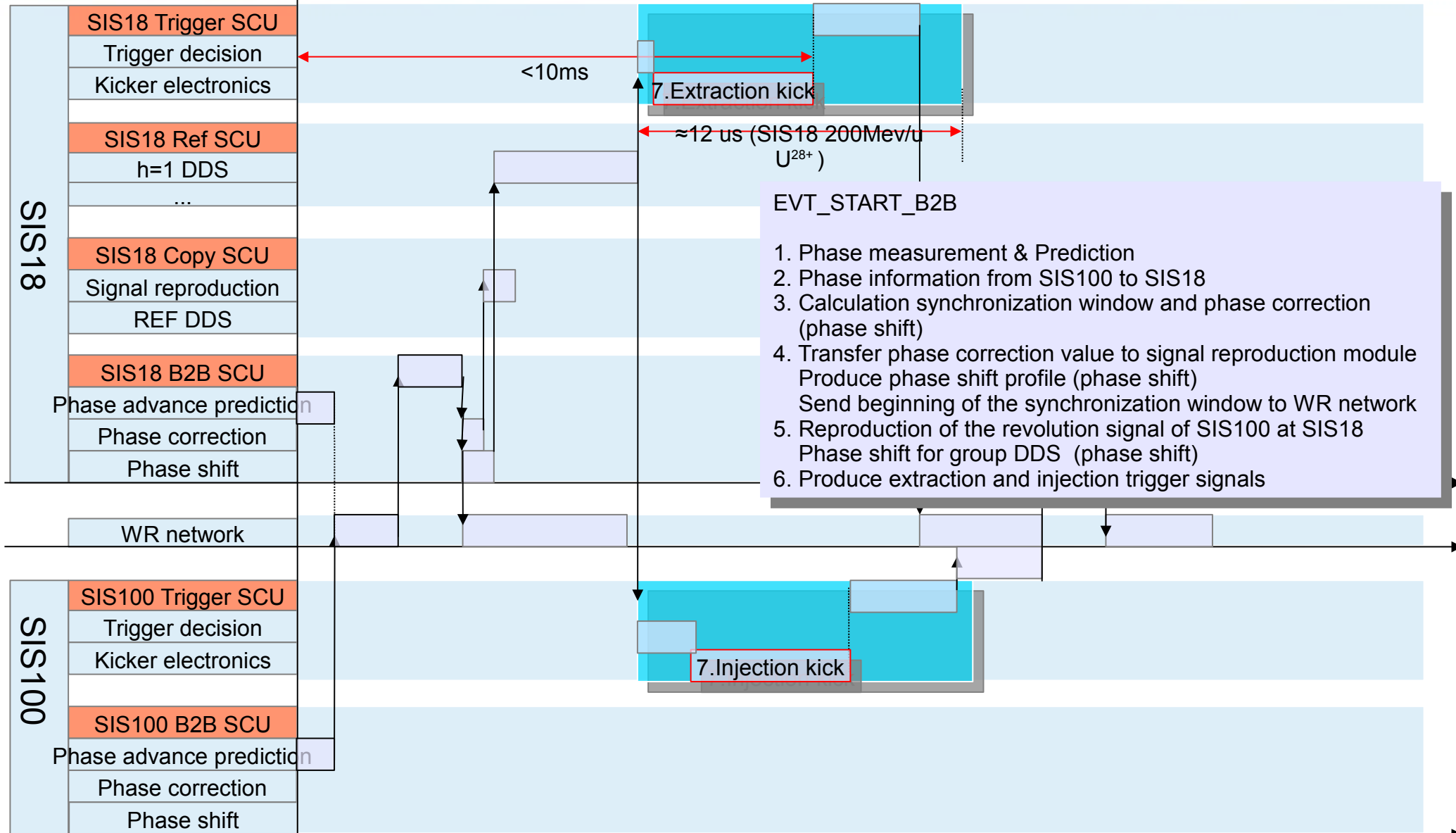
EVT_START_B2B



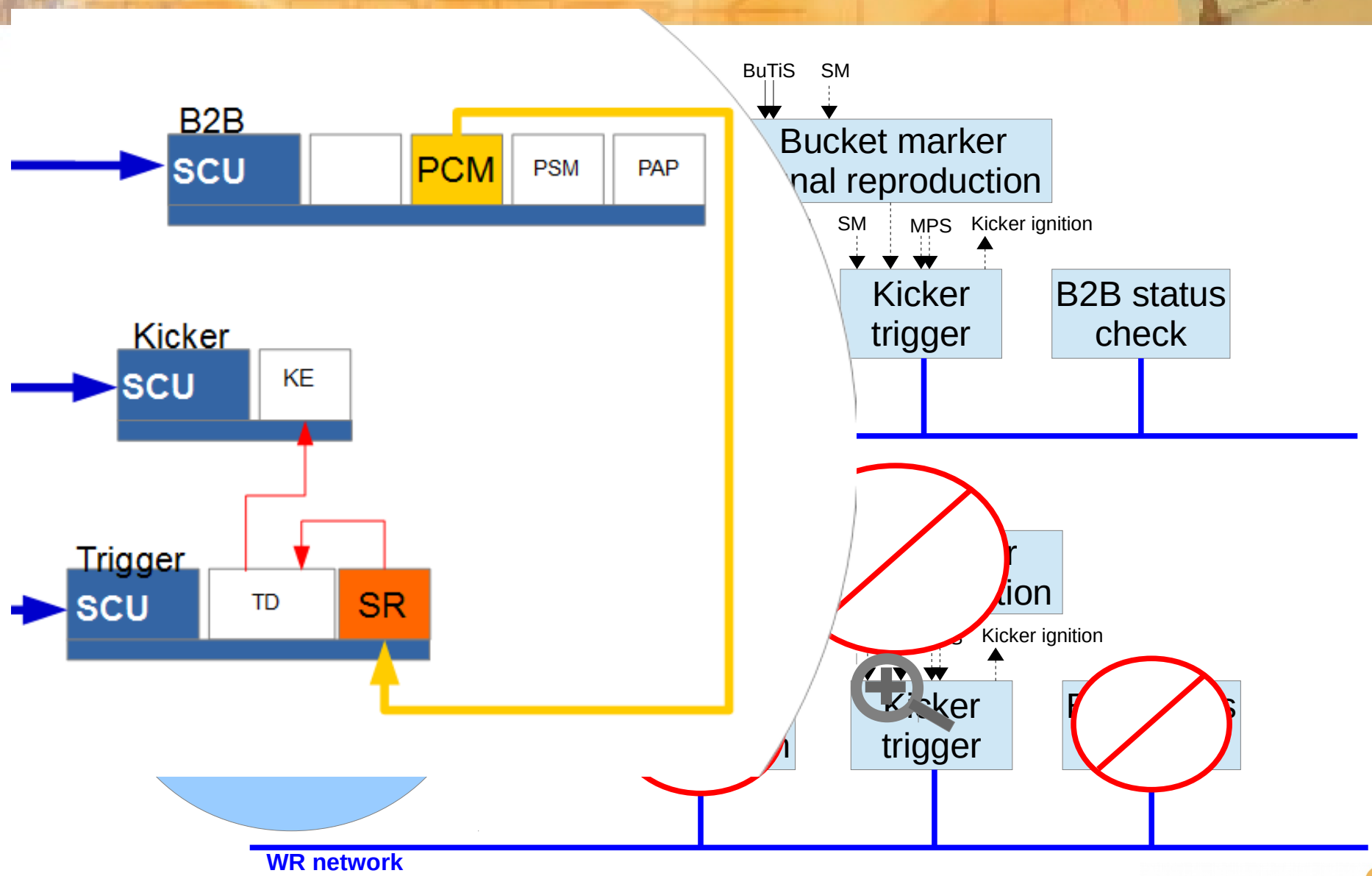
Functional specification and implementation

EVT_START_B2B

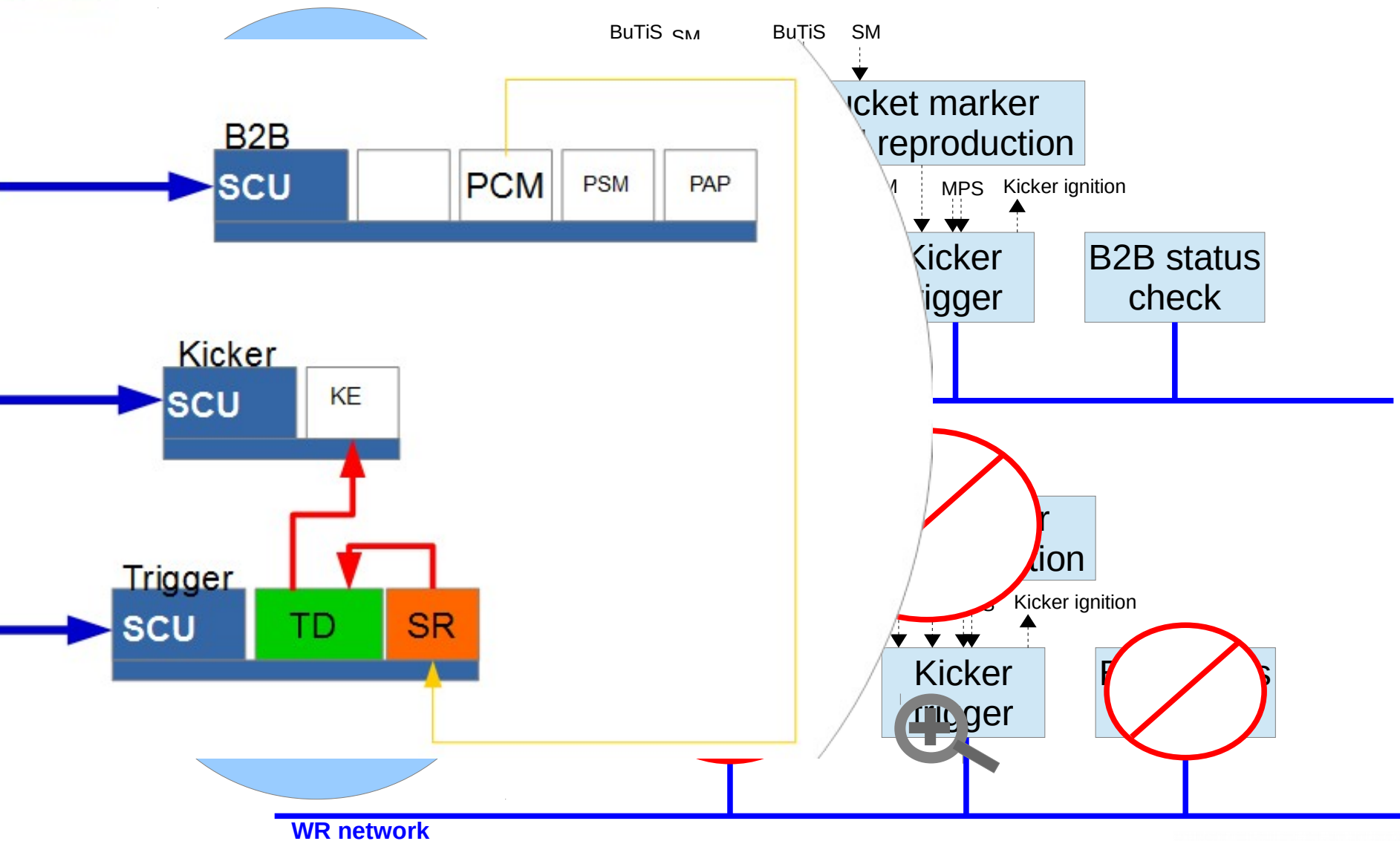
Synchronization window



Functional specification and implementation

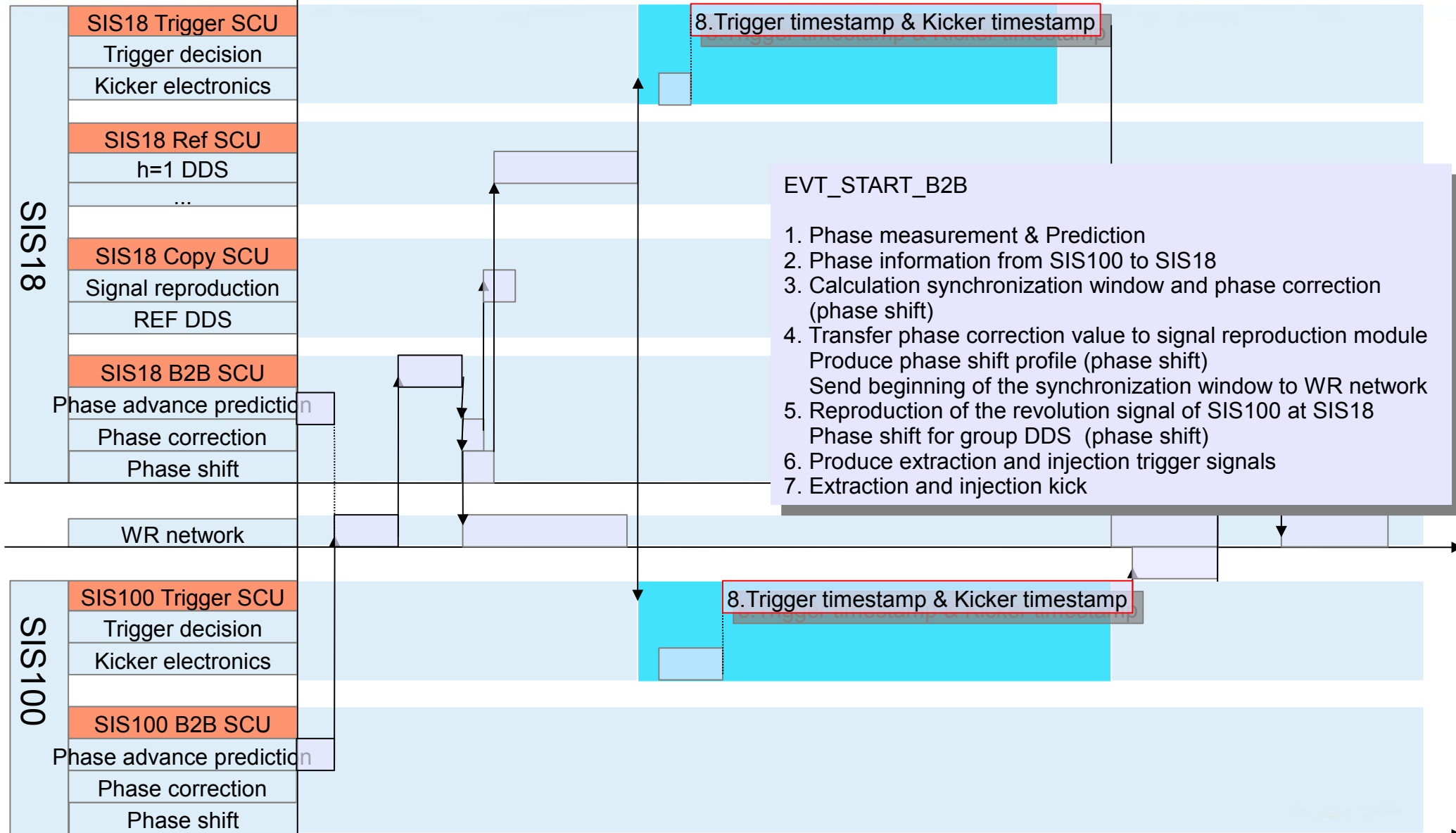


Functional specification and implementation



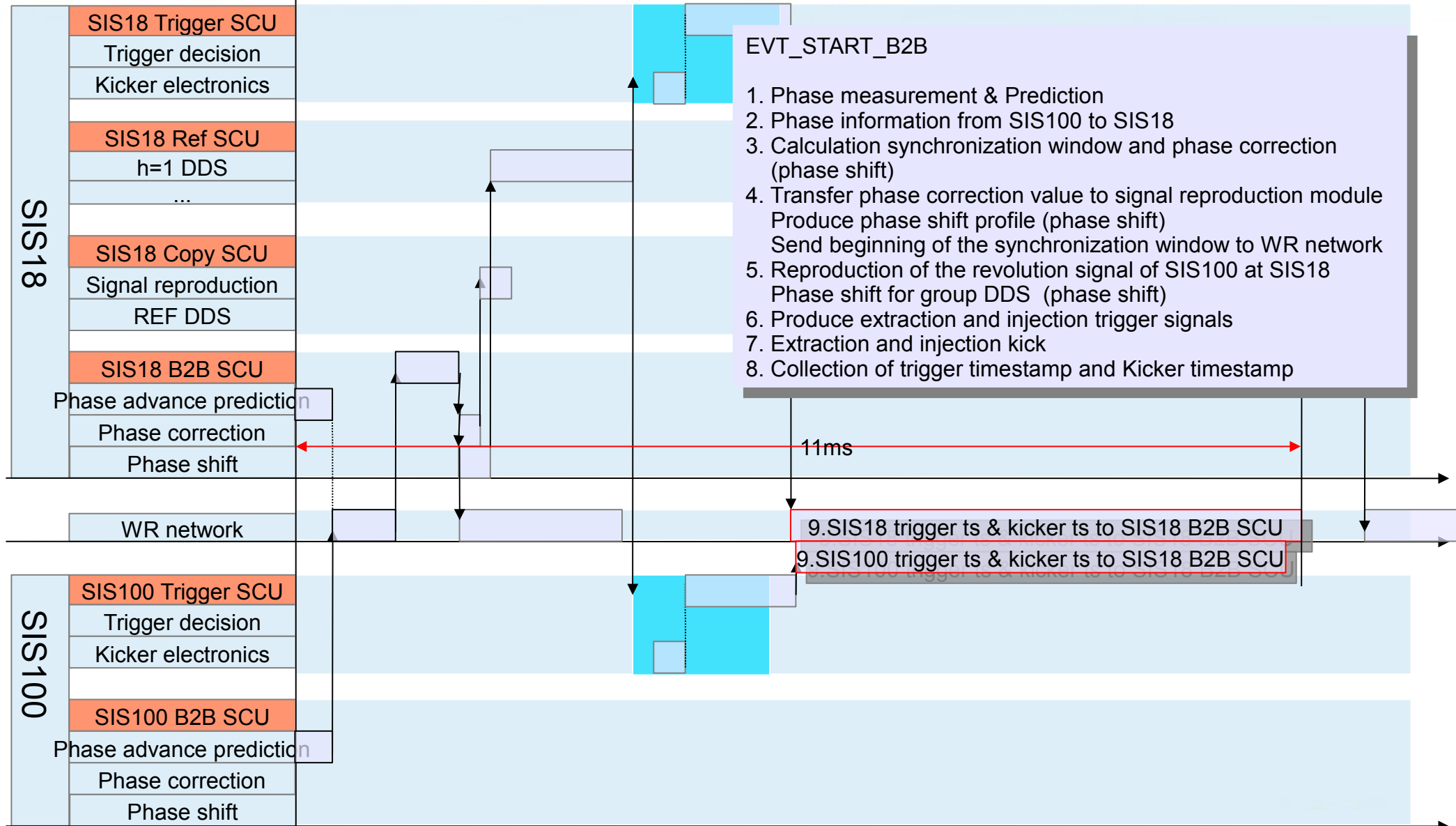
Functional specification and implementation

EVT_START_B2B



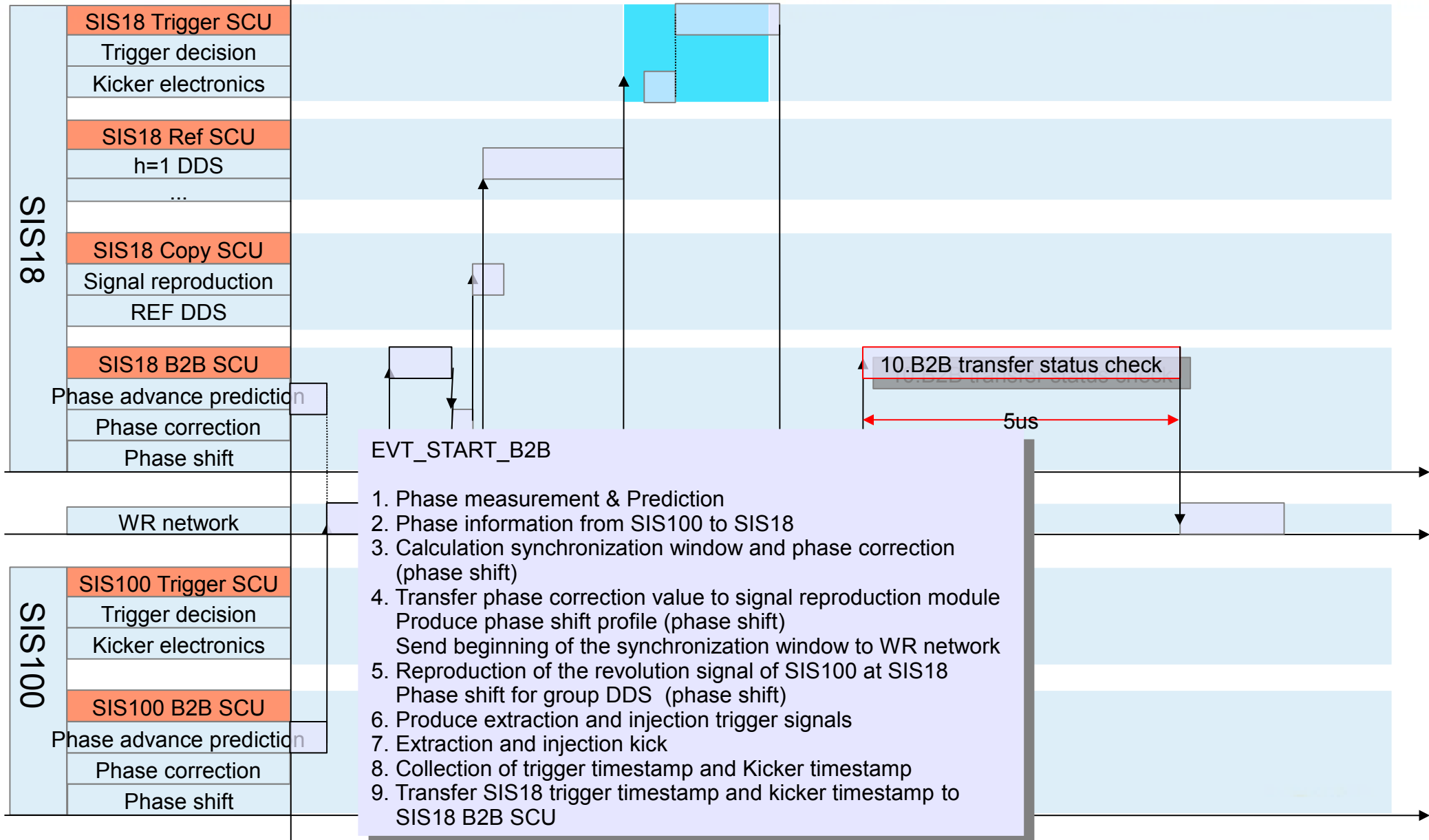
Functional specification and implementation

EVT_START_B2B



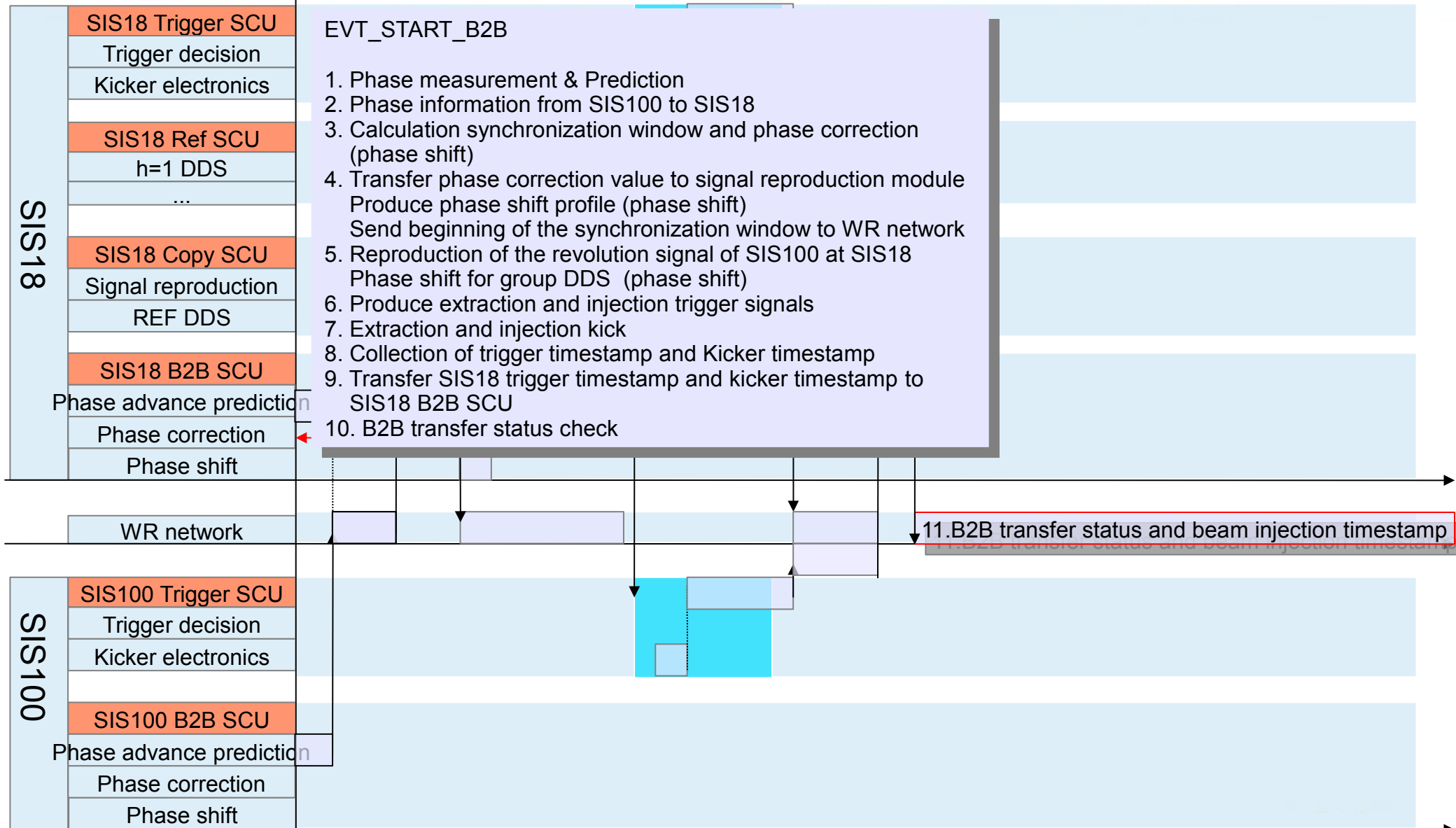
Functional specification and implementation

EVT_START_B2B



Functional specification and implementation

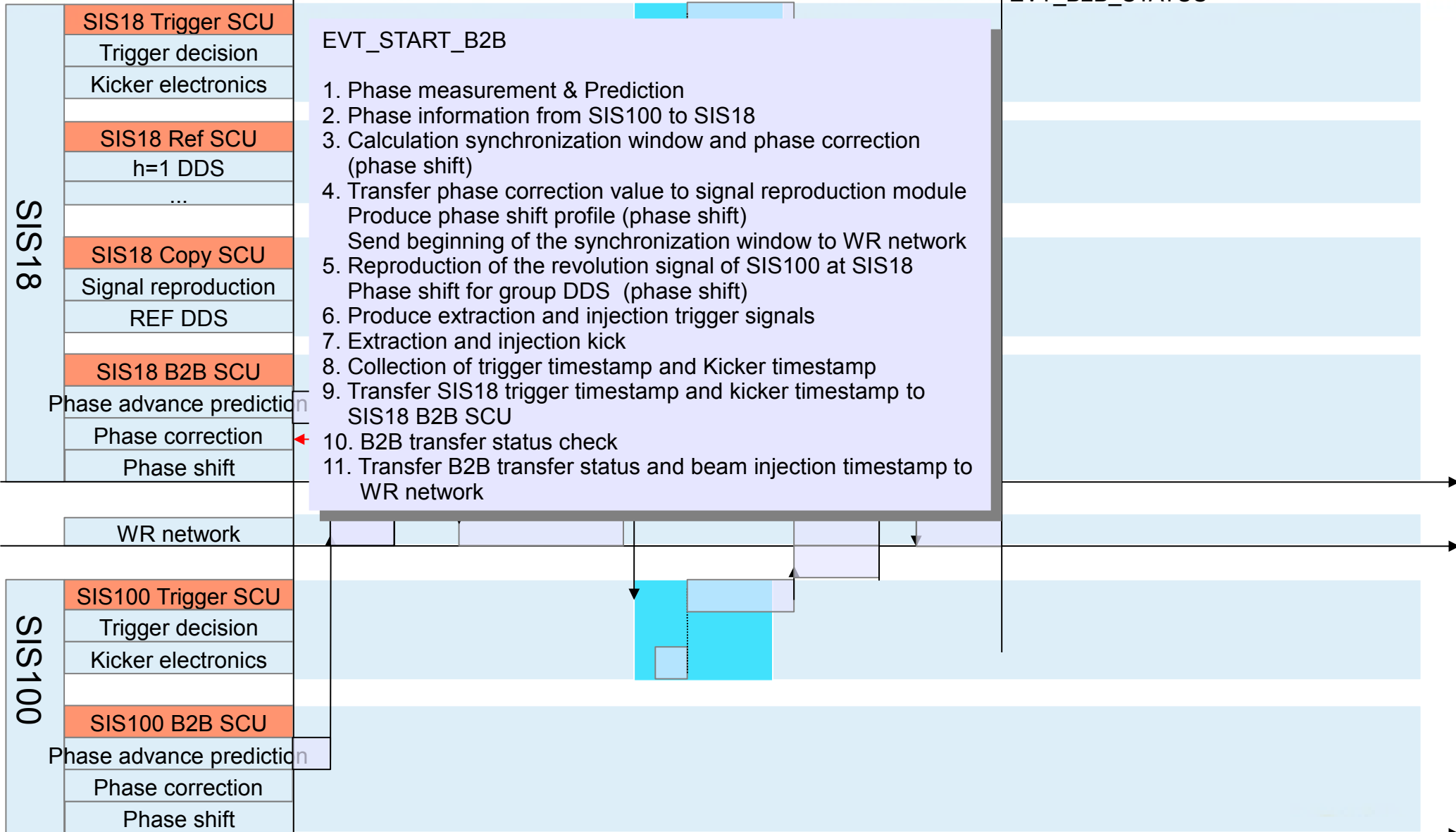
EVT_START_B2B



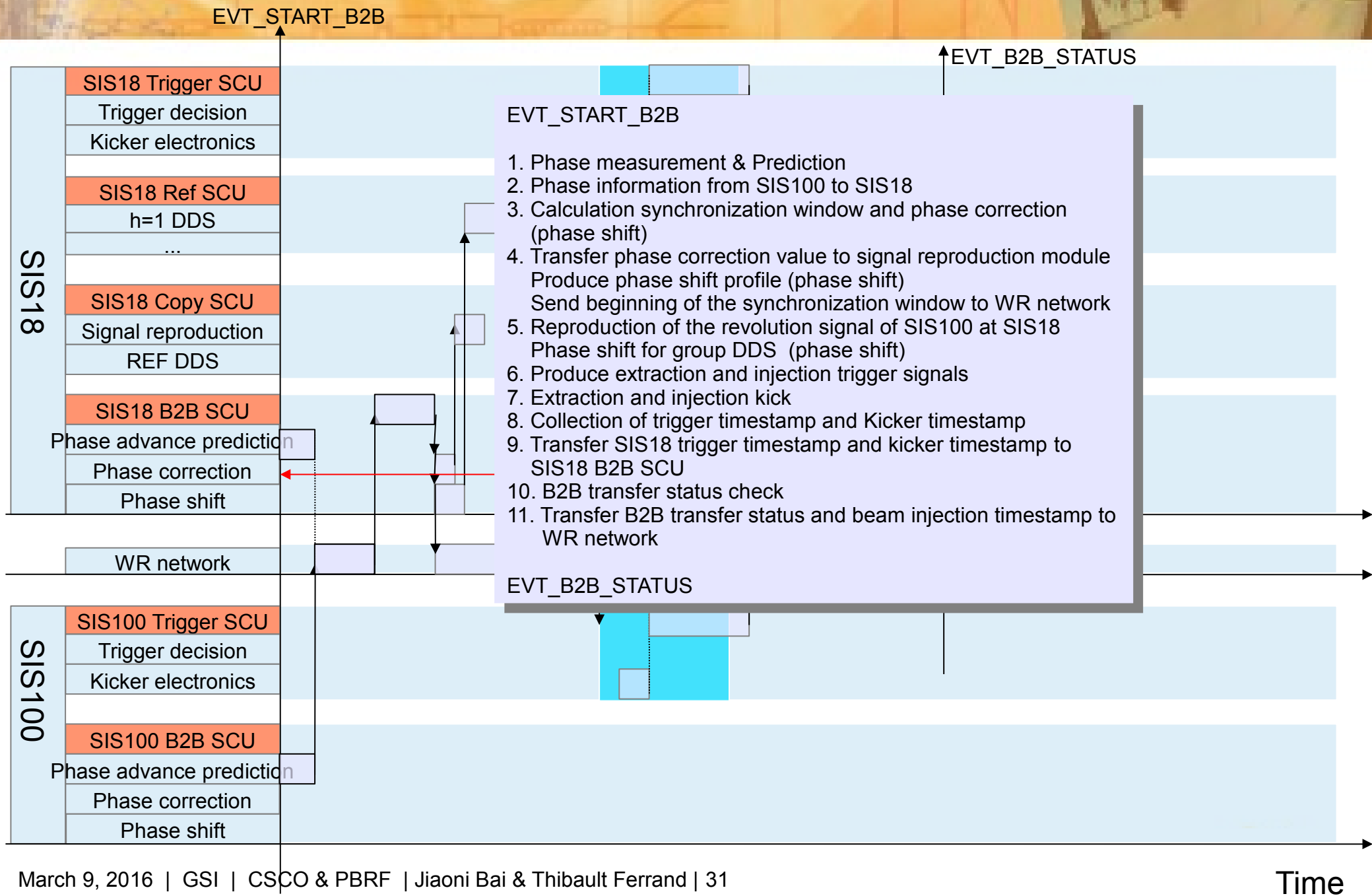
Functional specification and implementation

EVT_START_B2B

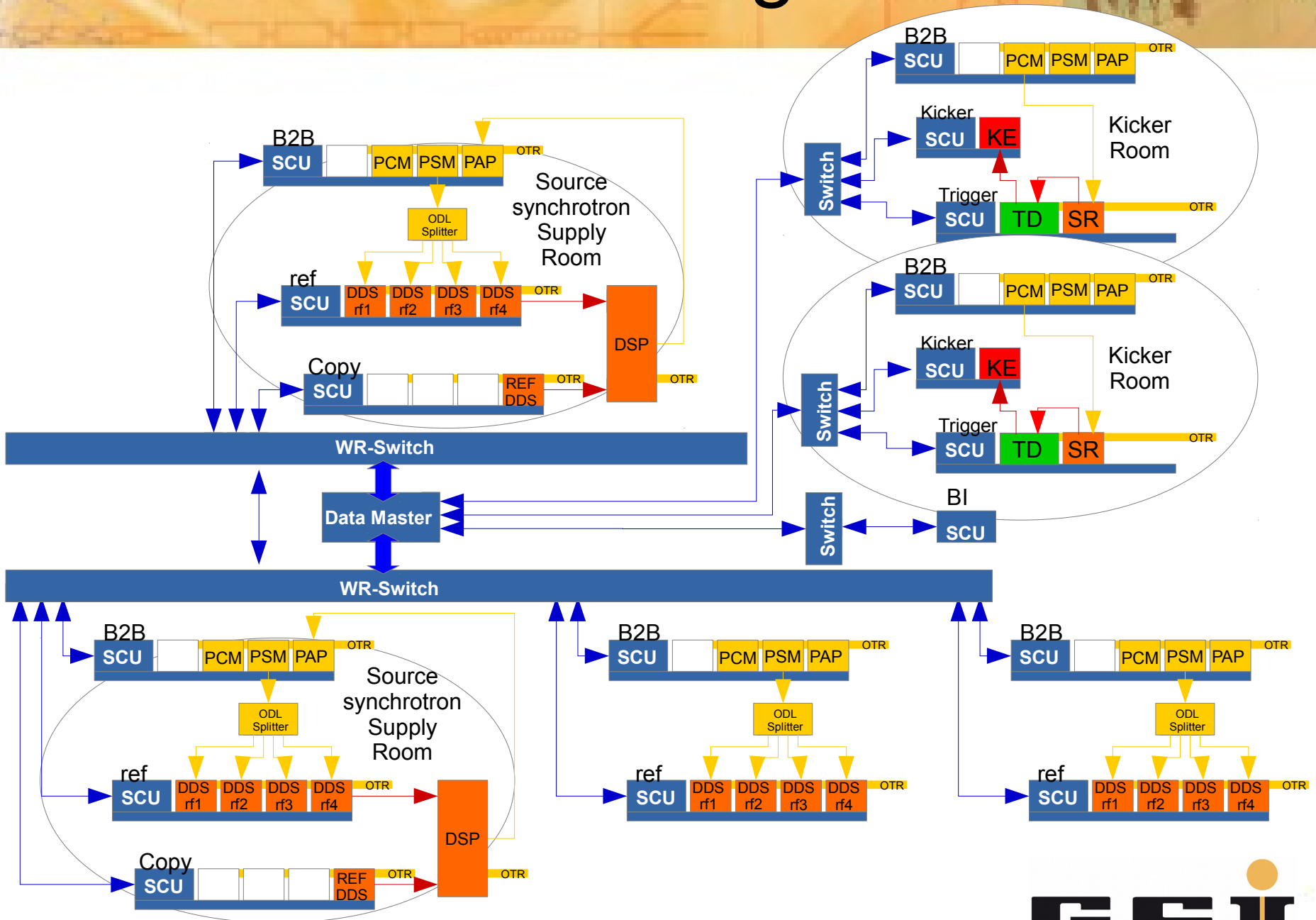
EVT_B2B_STATUS



Functional specification and implementation



Block diagram



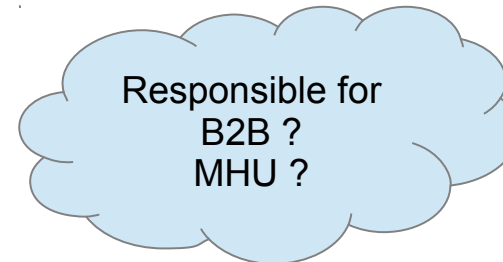
Task sharing

Hardware VIEW

- SCU CSCO (Hardware)
- MHU PBRF
- WR network CSCO (Timing group)
- DM CSCO (Timing group)
- Infrastructure (LM32, VHDL code) CSCO (Timing group)
- DDS PBRF

Software VIEW

- Synchronization window calculation (B)
- Phase shift and correction calculation (B)
- B2B status check (B)
- Send/receive to/from WR network (B)
- B2B FESA configuration (B)
- Phase shift profile and phase shift (T)
- Signal reproduction (T)
- Phase advance measurement and prediction (T)



Functional Requirements

- All B2B transfers for FAIR
- Phase shift and frequency beating method
- Maximum synchronization time. E.g. 10 ms for U²⁸⁺ from SIS18 to SIS100
- Bunch to bucket center mismatch less than 1°.
- Timing messages for beam instrumentation (BI)
- Inhibit and emergency extraction signals from the Machine Protection System (MPS)
- B2B transfer status back to the DM
- Flexible bucket filling pattern



Thank you for your attention !