Proposals for the Generation and Distribution of Safe LHC Parameters:

- Beam Energy
- Safe Beam Flags
- Beam Presence Flags

Functional Specification

DRAFT
GENERATION AND DISTRIBUTION OF SAFE LHC PARAMETERS

Abstract

For safe operation of the LHC, several parameters must be generated and distributed around the LHC with very high reliability.
The beam loss monitors system and the injection kickers require a parameter proportional to the energy: "SAFE LHC ENERGY".
When a flag, the "SAFE BEAM FLAG", is received by the interlock system, it will be possible to disable some of the interlocks. When the LHC is operating with beam parameters that exclude damage of equipment in case of uncontrolled beam loss, this flag is present.
For injection of high intensity beam from the SPS into the LHC, the BEAM PRESENCE FLAG must be set.

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Parameter #1: Safe LHC Energy

- Proportional to momentum of proton circulating in LHC, and to the B•ρ
  (B=magnetic field of main dipoles, ρ = bending radius).

- Produced in IR6 by an new highly reliable system made by AB/BT.
  Derived from current in main dipole magnets in sectors 5-6 and 6-7.
  Only one value is needed (identical for both beams).

- Required by BLM system and Injection Kickers,
  by Collimators (?) and Beam absorbers (?).

Parameter #2: Safe Beam Flags

- Permit "flexibility" by masking (of some) interlocks.
  Derived from LHC energy and from beam intensity:
  - Energy value coming from the ultra reliable energy tracking system
  - Intensity of beam 1 and beam 2 measured by the BCTs

If (Ibeam1 · Energy) < Threshold1 then SFB1 = PRESENT else SFB1 = NOT PRESENT
If (Ibeam2 · Energy) < Threshold2 then SFB2 = PRESENT else SFB2 = NOT PRESENT

- SAFE BEAM FLAGS could be generated in IR4 by a new system:
  - BCT measuring the beam currents are already installed in IR4.
  - SAFE LHC ENERGY has to be transmitted from IR6 to IR4.
  - Threshold values should normally be fixed.
    Must be possible to set them to different values after receiving authorisation (*to be defined*) and new values must be logged.
- Required by Beam Interlock Controllers, by SPS Extraction system.

Parameter #3: Beam Presence Flags

- Permit injection of high intensity beam from SPS into LHC.

  Derived from beam Intensity of beam 1 and beam 2 measured by the BCTs

If (Ibeam1 < MINIMUM_BEAM_INTENSITY1) then BPF1 = NOT PRESENT else BPF1 = PRESENT
If (Ibeam2 < MINIMUM_BEAM_INTENSITY2) then BPF2 = NOT PRESENT else BPF2 = PRESENT

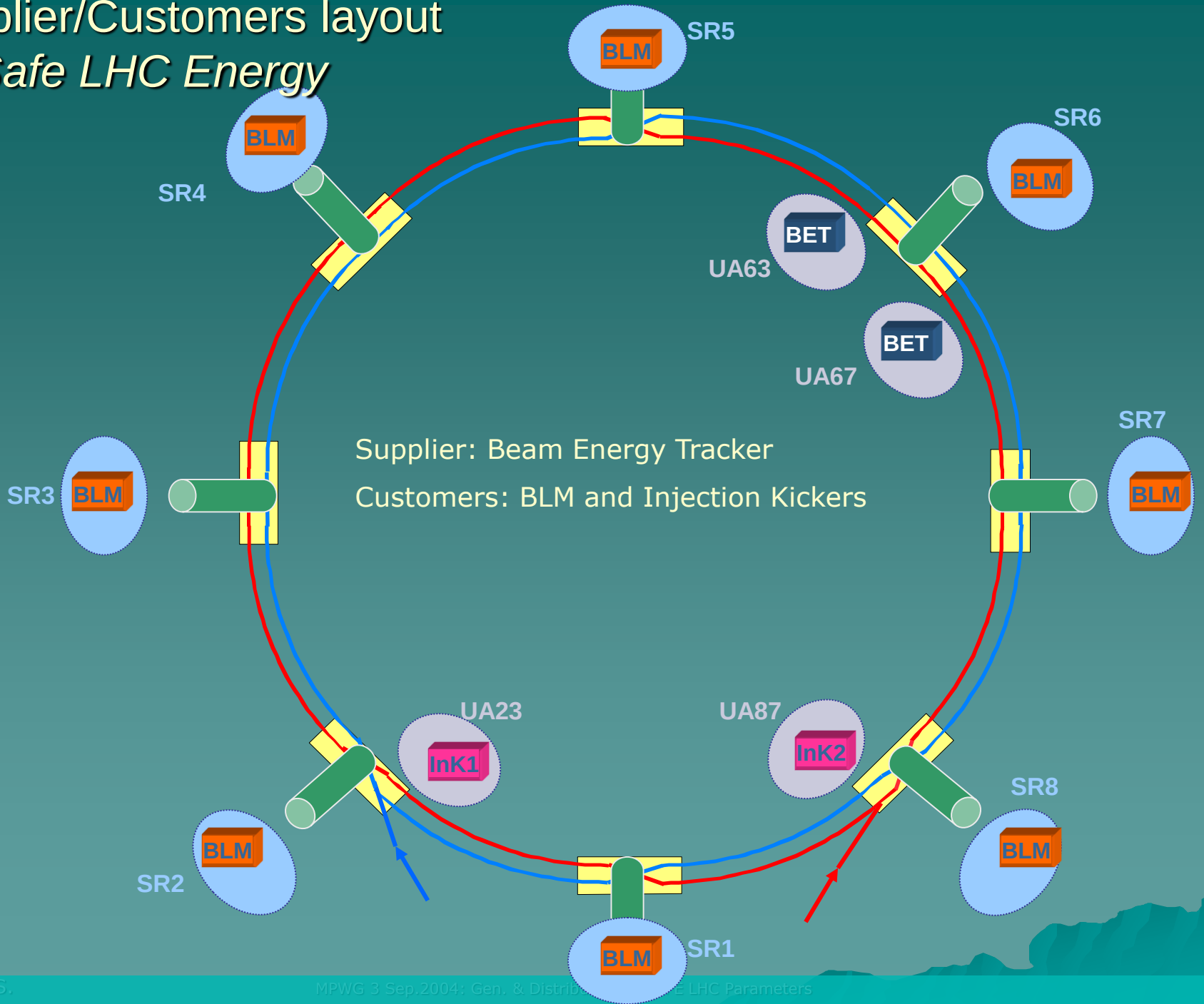
- BEAM PRESENCE FLAGS could be generated in IR4.

  Threshold values should normally be fixed.

  Must be possible to set them to different values after receiving authorization *(to be defined)* and new values must be logged.

- Required by the SPS Extraction system.

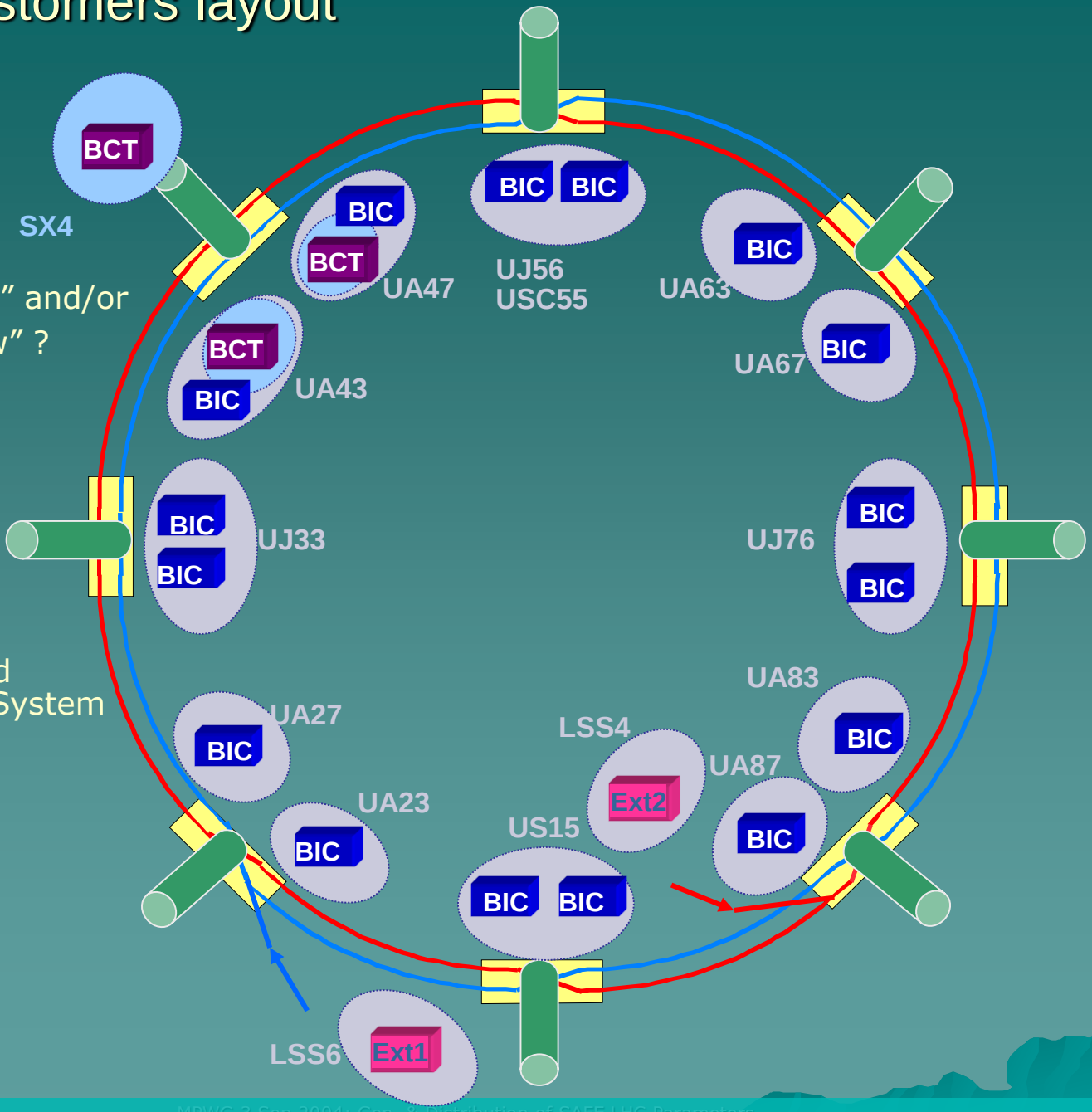
Supplier/Customers layout for *Safe LHC Energy*



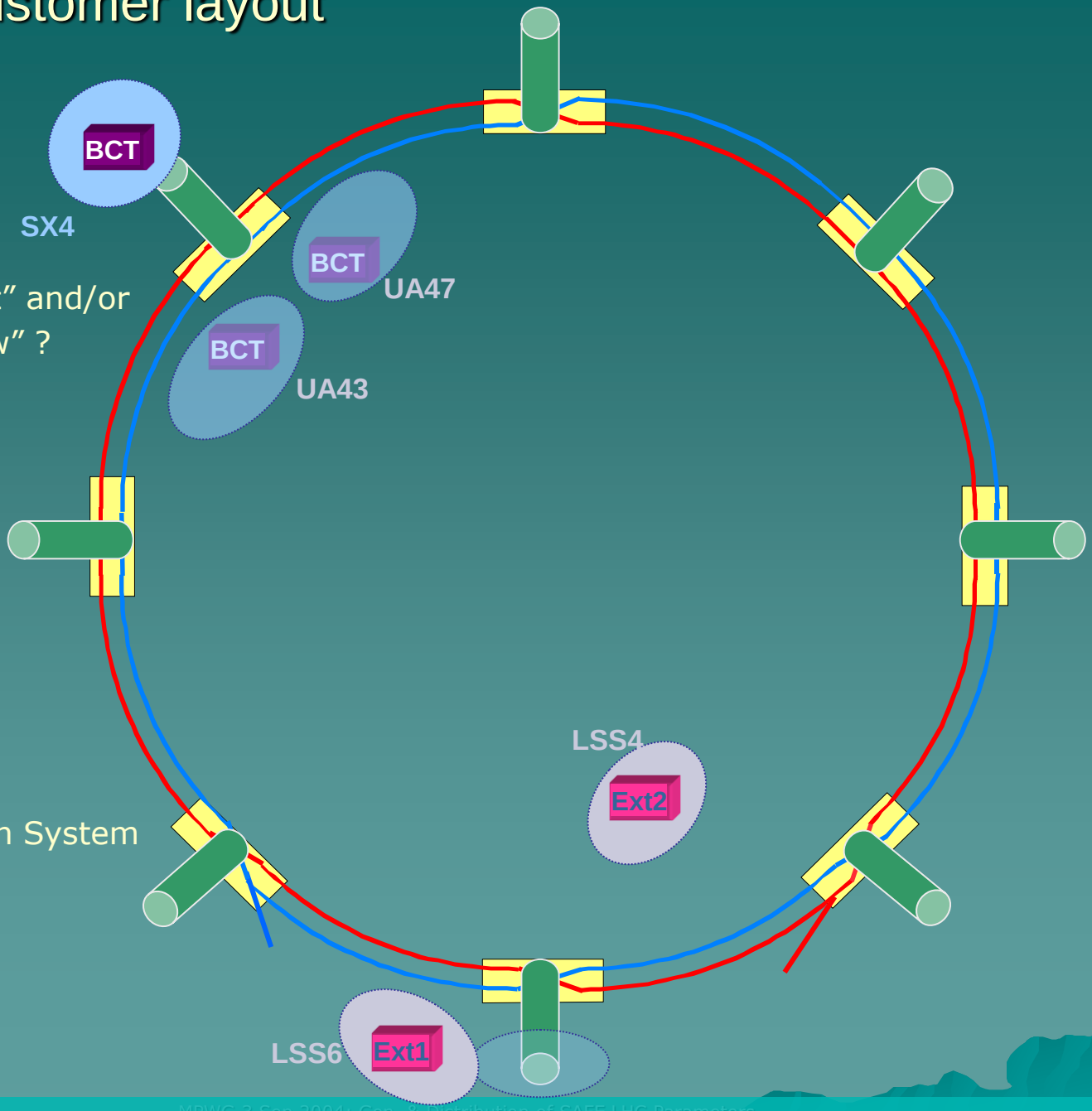
Supplier/Customers layout for *SBFs*

Supplier: BCT "Fast" and/or
BCT "Slow" ?

Customers: BIC and
SPS Extraction System



Supplier/Customer layout for *BPFs*



Supplier: BCT "Fast" and/or
BCT "Slow" ?

Customers:
SPS Extraction System

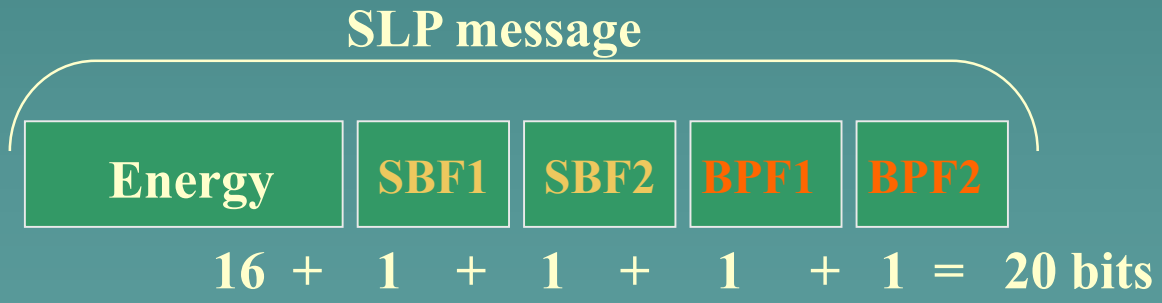
1st Proposition: Use a new dedicated system

- Because a high level of Reliability is expected
- Control network and Timing system do not fulfil requirements
- Have to define:
  - How to collect the needed information
  - How to generate it
  - How to transmit
  - How to receive
  - How to check it
  - What to do in case of error or failure.
- System will be supplied AB/CO through a collaboration with AB/BT and AB/BDI groups.

2nd Proposition:
all *Safe LHC Parameters* merged in one message

3 parameters in 1 message:

- Unique link => Reduce transmission cost
- Put Reliability effort on only 1 system instead of 3
- Despite clients are different (BIC for SBF, BLM for Energy parameter)



3rd Proposition:
Use Timing electronics to generate & receive messages

- Reliable and improved transmission system
- Fast speed is not required: 512Kbits and 1ms rate could be enough
- Easy to re-use Generator and Receptor electronics (VHDL recovering)
- Multi-bytes format: possible extension for additional parameters

typical "Timing" message:

Starting Seq.	1st byte	P	2nd byte	P	3rd byte	P	4th byte	P	Ending Seq.

4th proposition:
a *SLP* Generator in a VME crate installed in IR4*

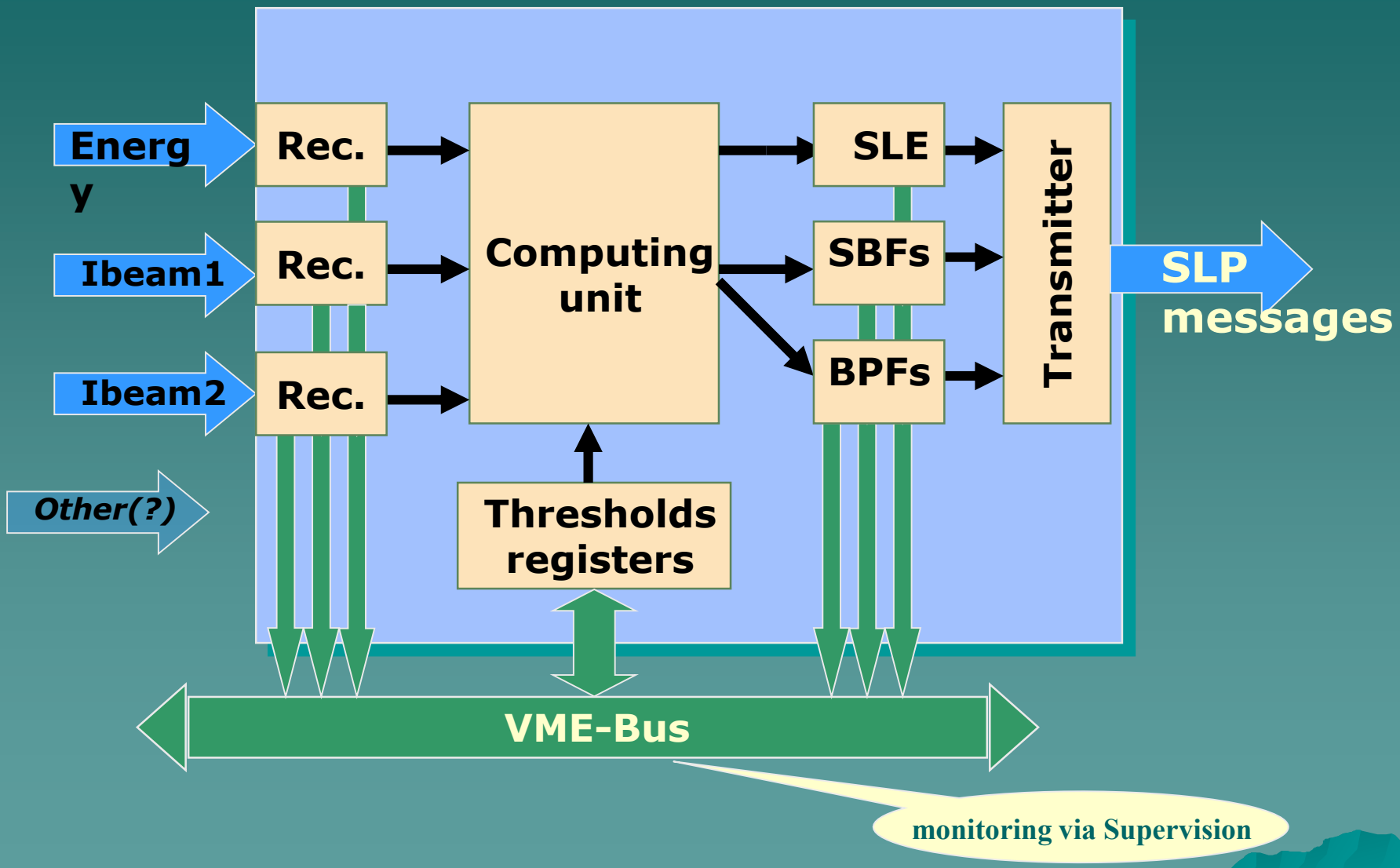
- *SLP* Generator in IR4 because*:*
  - *SBFs* + *BPFs* made in IR4*
  - *SLE* produced in IR 6
  - Energy parameter needed in IR4 to produce the *SBFs*:
    => transmit *SLE* from 6 to 4

IR4* means
SR4 or
UA43 or
UA47 or ?

- *VME* is one the possible choice for an embedded card:
  - Easy to interface to Control infrastructure
  - Re-use VHDL code for VME-bus interface

Simplified block diagram for the SLP Generator

(SLP = Safe LHC Parameters)

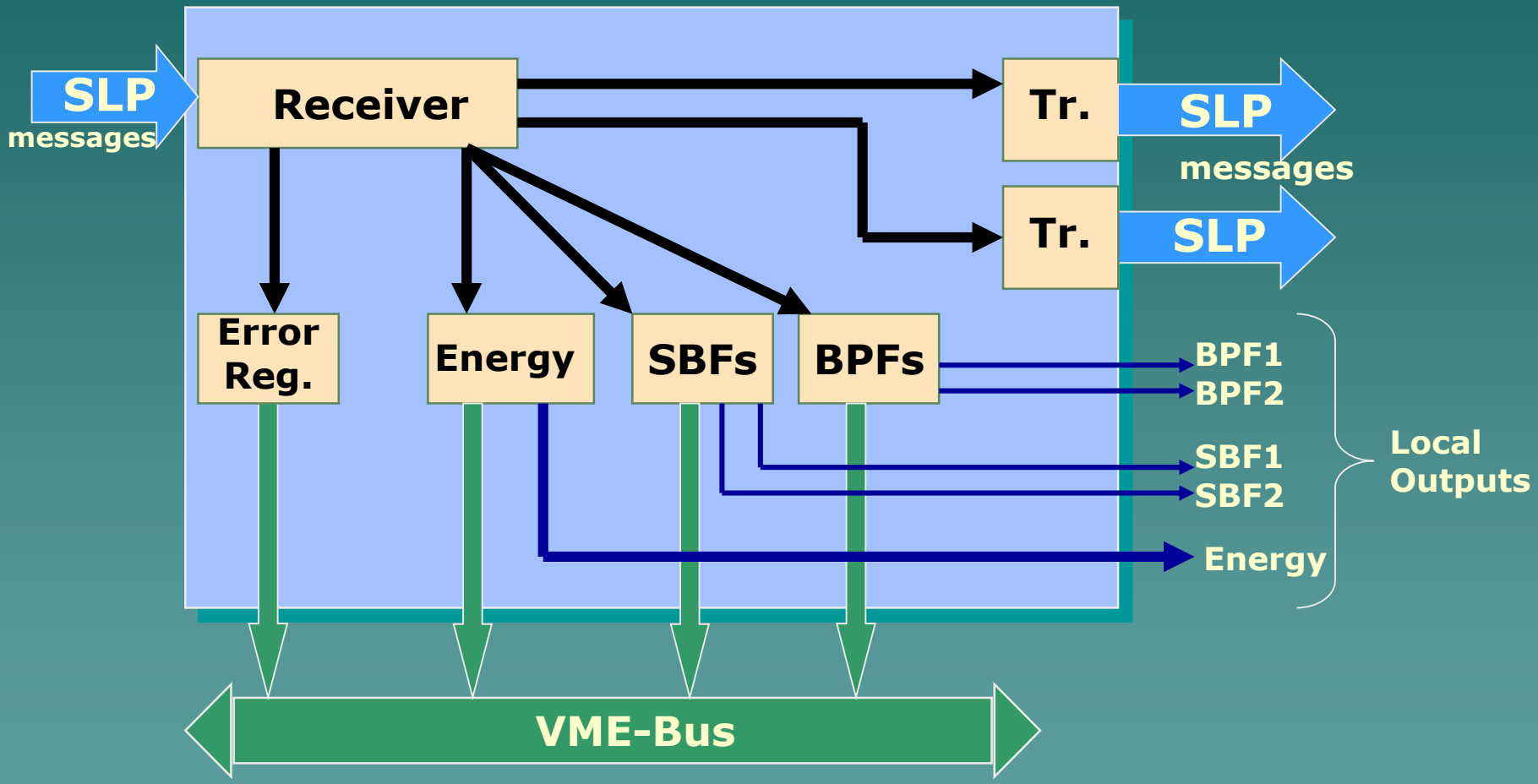


5th proposition: *SLP* User board in a VME standard

- *VME* platform already chosen by BLM and BIC systems:
  - Free slot needed to insert the board into an existing system.

- Features of the SLP User Board:
  - Receives, decodes the SLP messages.
  - Gives local information via 3 different outputs.
  - VME-bus interface for monitoring purpose.
  - Retransmits the SLP messages to the next User board.

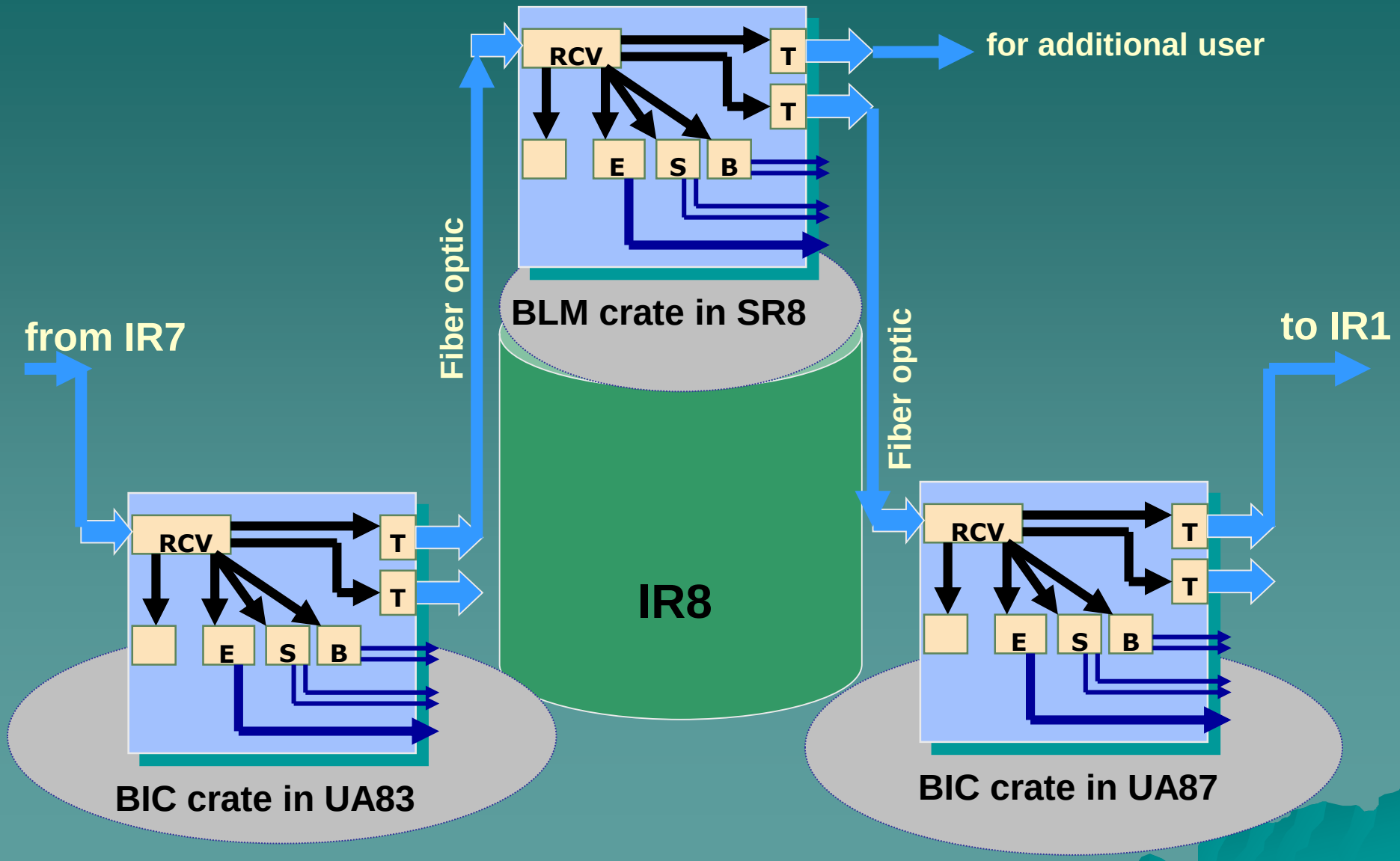
Simplified block diagram for the SLP User Board



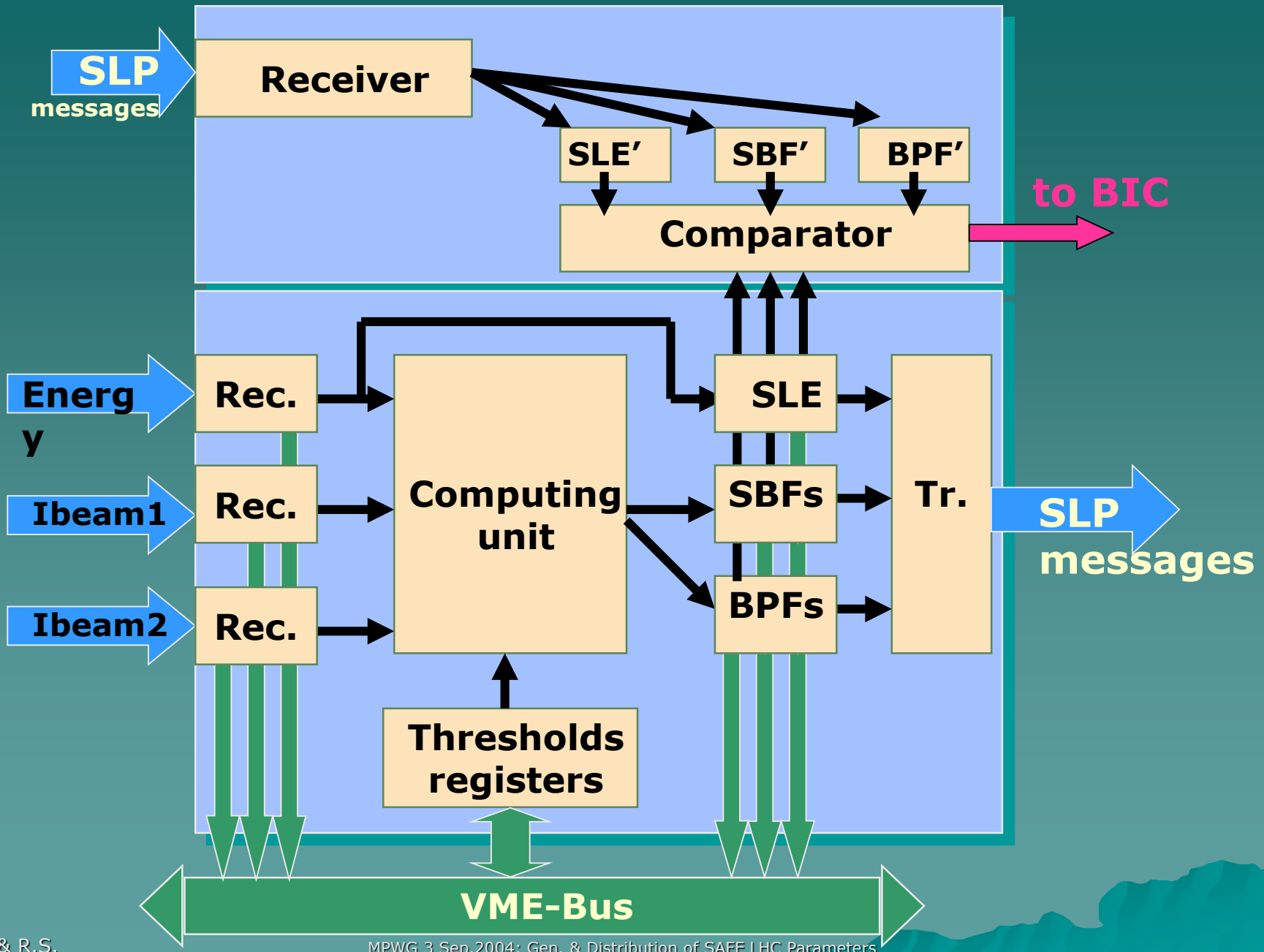
6th proposition: Use Fiber Optic loop

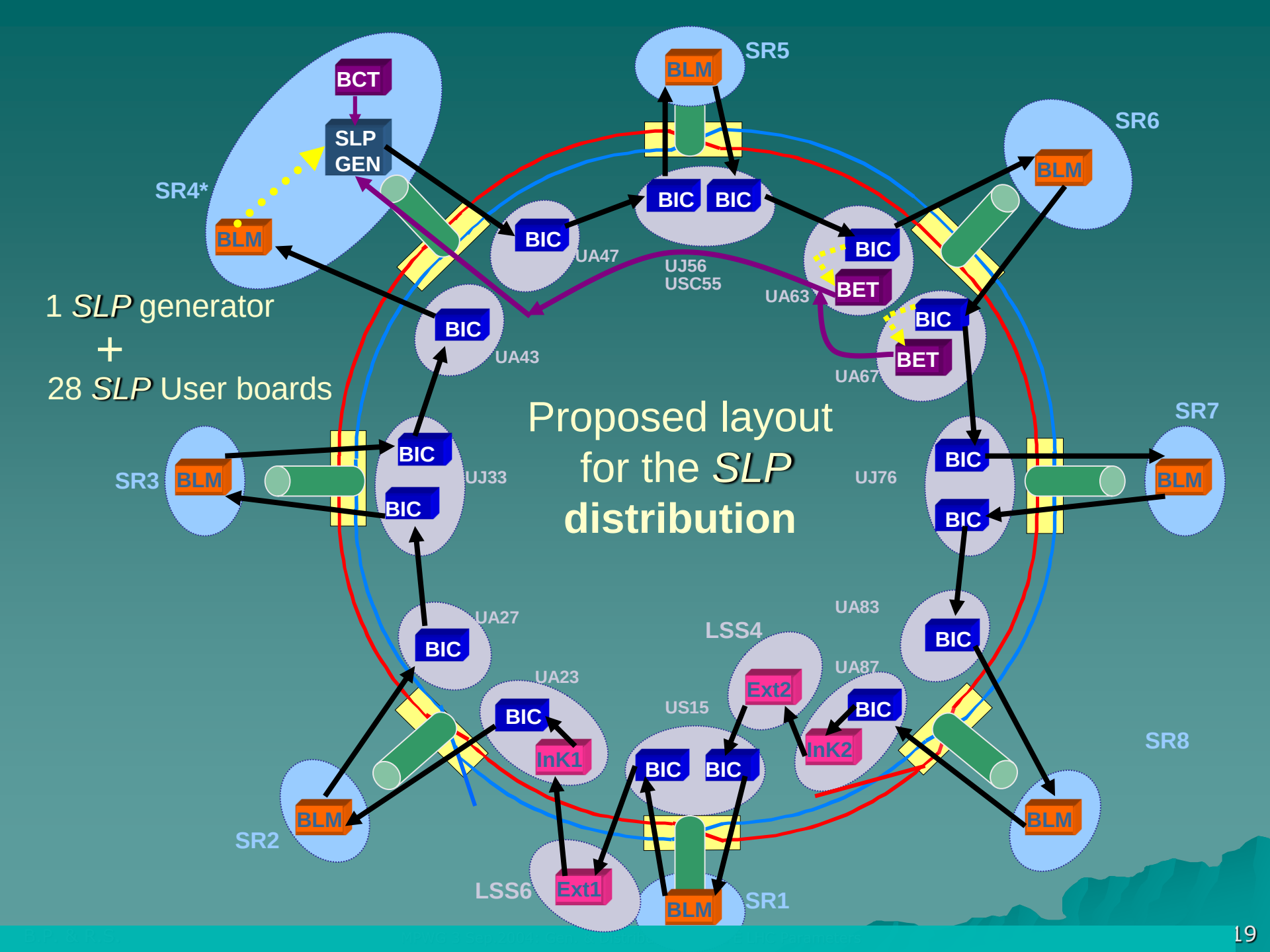
- Fail safe transmission support
- A loop ensures that SLP clients receive the same information
- Give possibility for adding new SLP clients:
  - Make a second transmitter output
  - Mix Ring (major clients) and Star distribution (see layout on next slide)
- Check the transmitted messages at the end of the loop
  - If ERROR then activate a Beam Dump Request to BIC

Two Outputs for Ring and Star Distribution



New simplified block diagram for the SLP Generator




1 SLP generator
+
28 SLP User boards
Proposed layout for the SLP distribution
SR1
SR2
SR3
SR4*
SR5
SR6
SR7
SR8
LSS4
LSS6
BCT
SLP GEN
BLM
BIC
BET
Ext1
Ext2
InK1
InK2
UA23
UA27
UA43
UA47
UA63
UA67
UA83
UA87
UJ33
UJ56
USC55
UJ76
US15

Recap

- New highly reliable system must be supplied
- All parameters in one message
- Use a.f.a.p. existing electronics and improved solutions
- Message speed 512kb/s with 1 KHz rate
- 2 types of modules:
  - Unique generator to built and broadcast the messages
  - R/T User board to get local outputs
- Use Optical Fibers to transmit all around LHC areas
- Chain all (main) User boards in one loop
- Check at the end of the loop and Generate Beam Dump request if Error
- Process 100% made by Hw (but Sw Monitoring via Supervision)

Pending Questions

- How to transmit Energy from IR6 to IR4?
- How to transmit Intensity from BCTs to the SLP Generator?
- How to give local parameters values:
  - Energy in serial? or in //?
  - Flags with TTL level? Which type of connectors?

- 2 bytes to define the Energy parameter: is it enough?
- SLP required for other systems?
- Which extra parameters could be added?

Conclusions

- Need comments and approval before starting the study

- Need additional analyze to increase the reliability:
  - Bring in a redundant "computing unit" to built parameters?
  - Transmit parameters across two loops?
  - Append UTC time in the message?
  - Perform Cross check for received parameters with another source?
  - How to avoid crossing over the Flags cables? SBF1<>SBF2, BPF1 <>BPF2