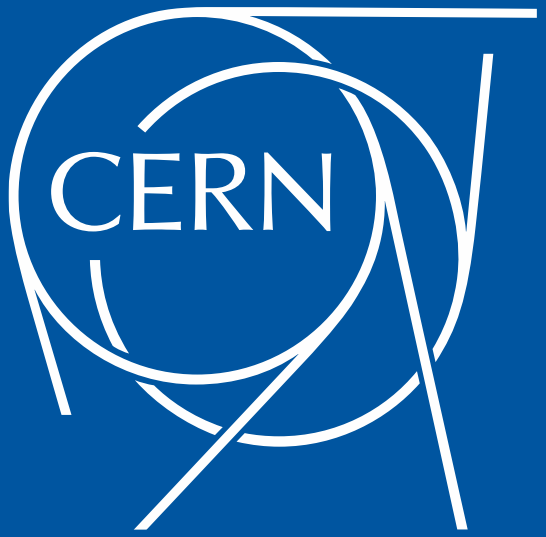

CERN

MPP meeting 19th July 2013 – A. Apollonio, V. Vatansever

Connection between LHC BIS and LBDS re-triggering system: dependability studies

Outline

- Overview and considerations of the connection between LHC BIS and LBDS re-triggering system
- Dependability studies on the Trigger Delay Unit
- Dependability studies on the Link between the BIS and the Trigger Delay Unit

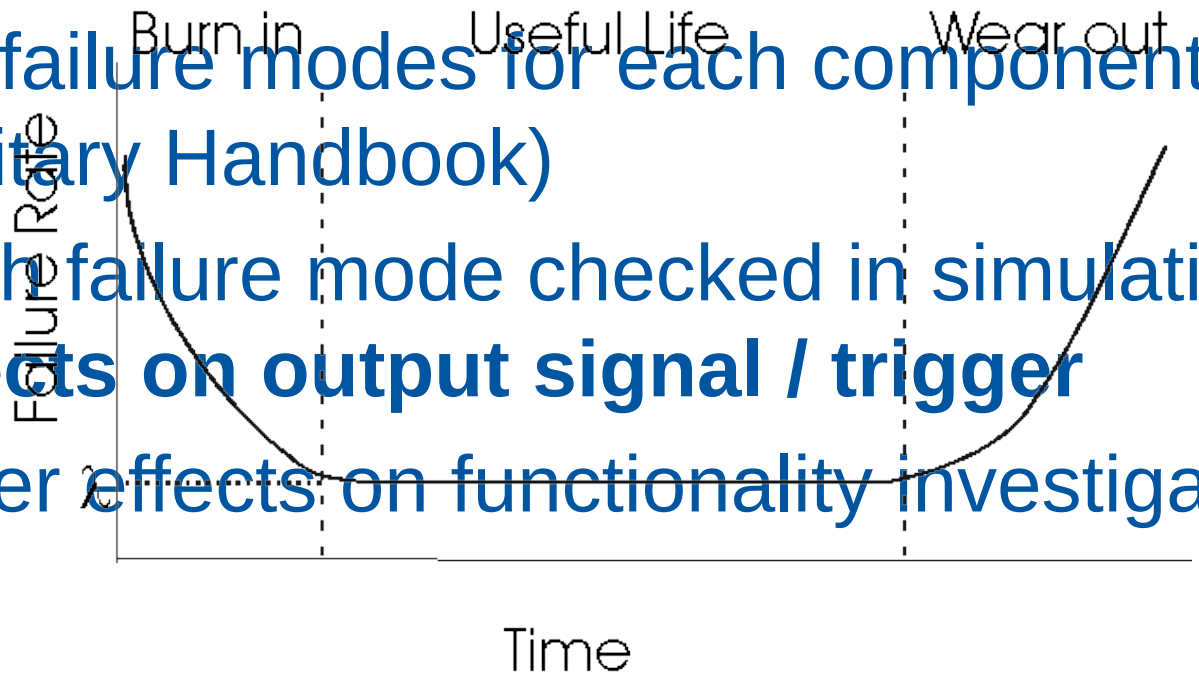
Technical considerations and goals

- Modify as little as possible the BIS
- Obtain SIL level
- Not more than 1 false asynchronous beam dump in 10 years
- Not more than 2 false synchronous beam dumps per year

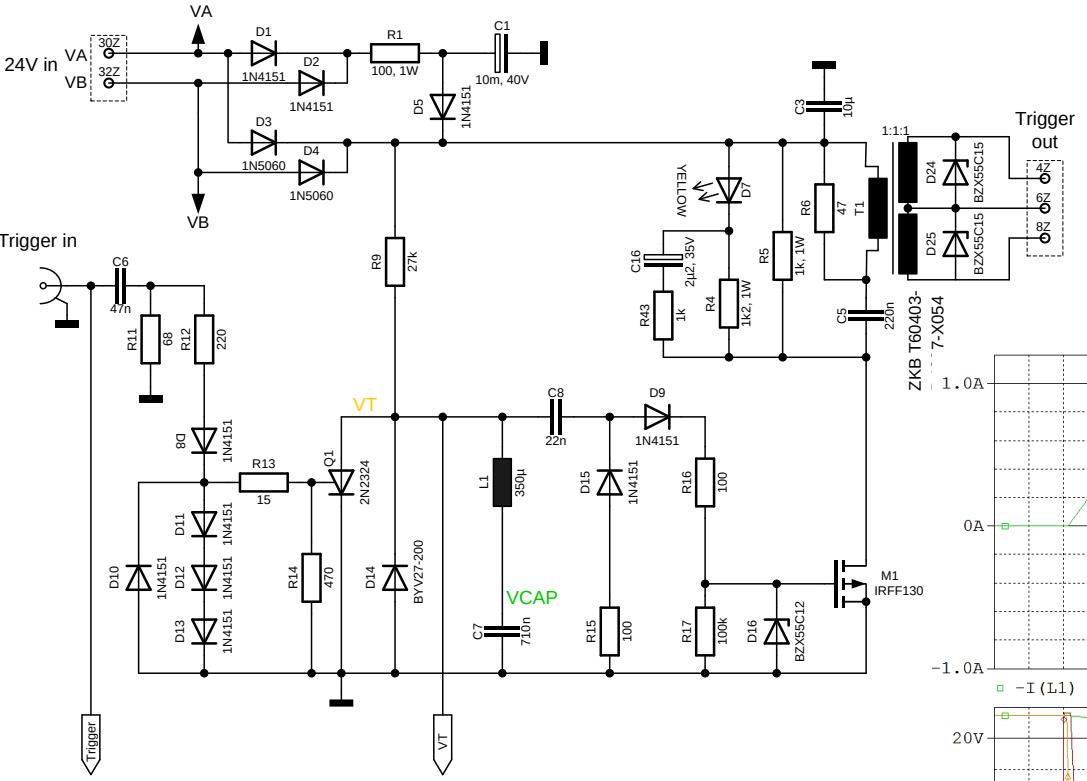
➔ Reliability analysis of Trigger Delay Unit and the Link

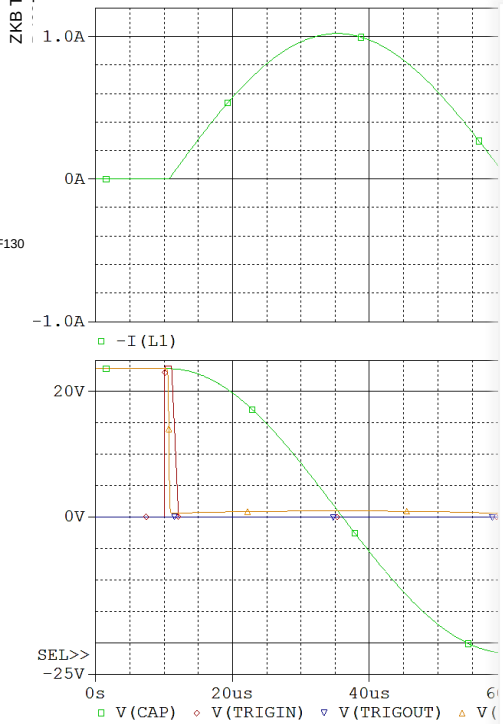
Reliability Analysis

- Failure rates for each component (Military Handbook, manufacturer data, assessment of lifetime statistics)
- 3-6 failure modes for each component (Military Handbook)
- Each failure mode checked in simulation for **effects on output signal / trigger**
- Other effects on functionality investigated



Trigger Delay Unit (TDU)



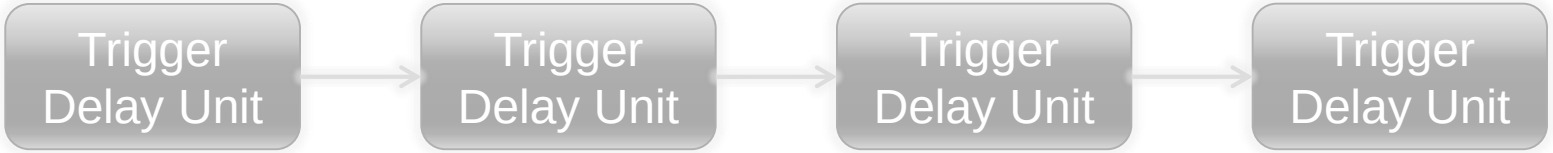


Main failure modes of the TDU

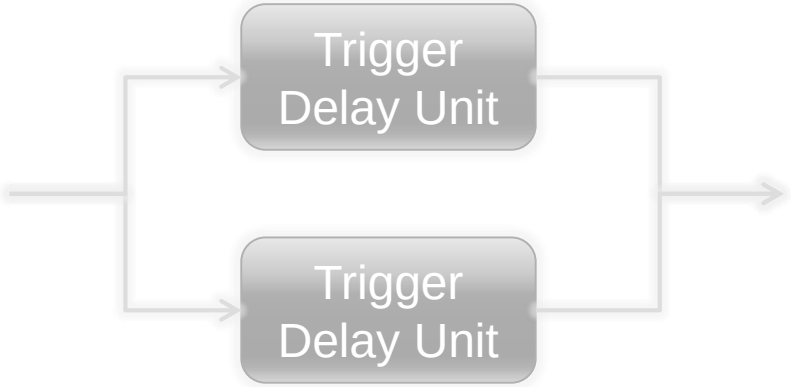
1. Asynchronous beam dump (unwanted)
   - TDU causes an asynchronous beam dump although the LBDS is working
2. System not available on demand
   - TDU cannot forward the trigger
3. Silent failures, failures w/o effect on output
   - Loss of redundancy
   - Loss of additional functions

Reliability block diagrams TDU failure modes

Asynchronous beam dump

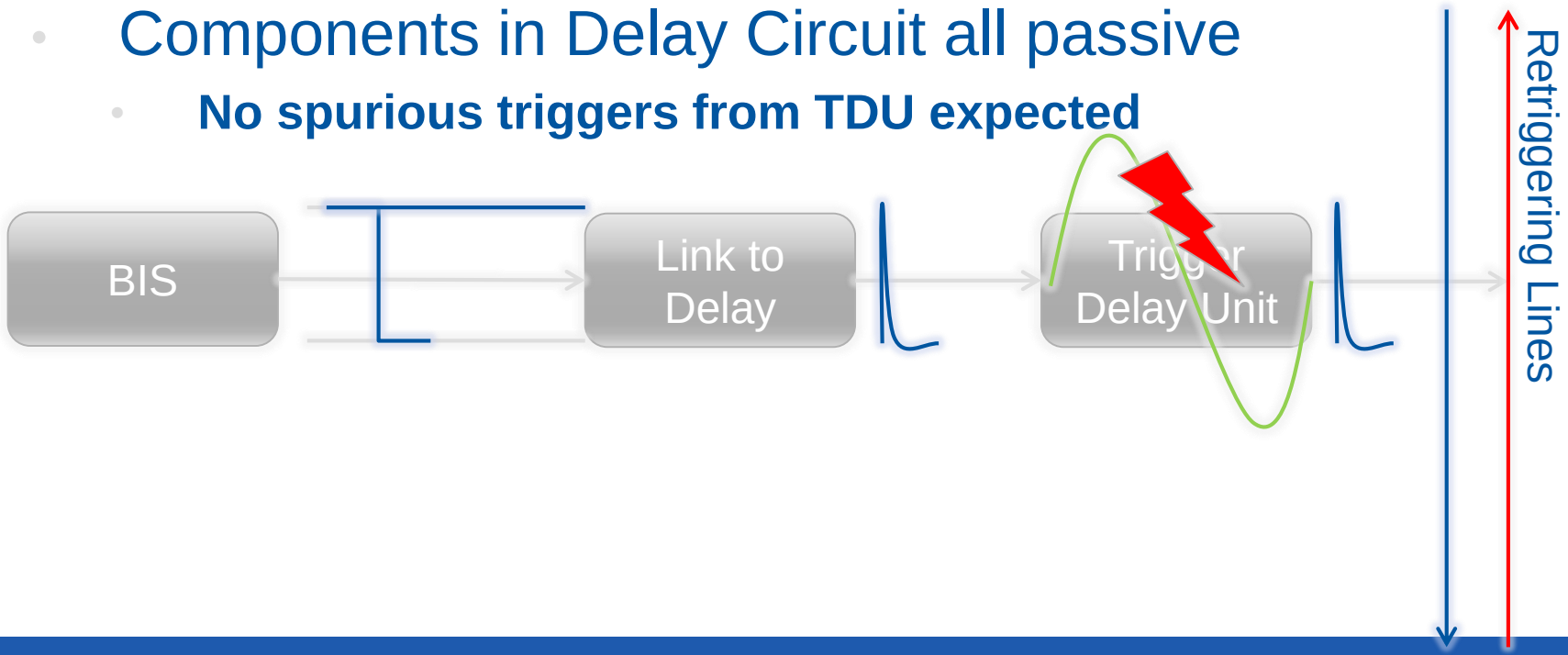


System not available on demand

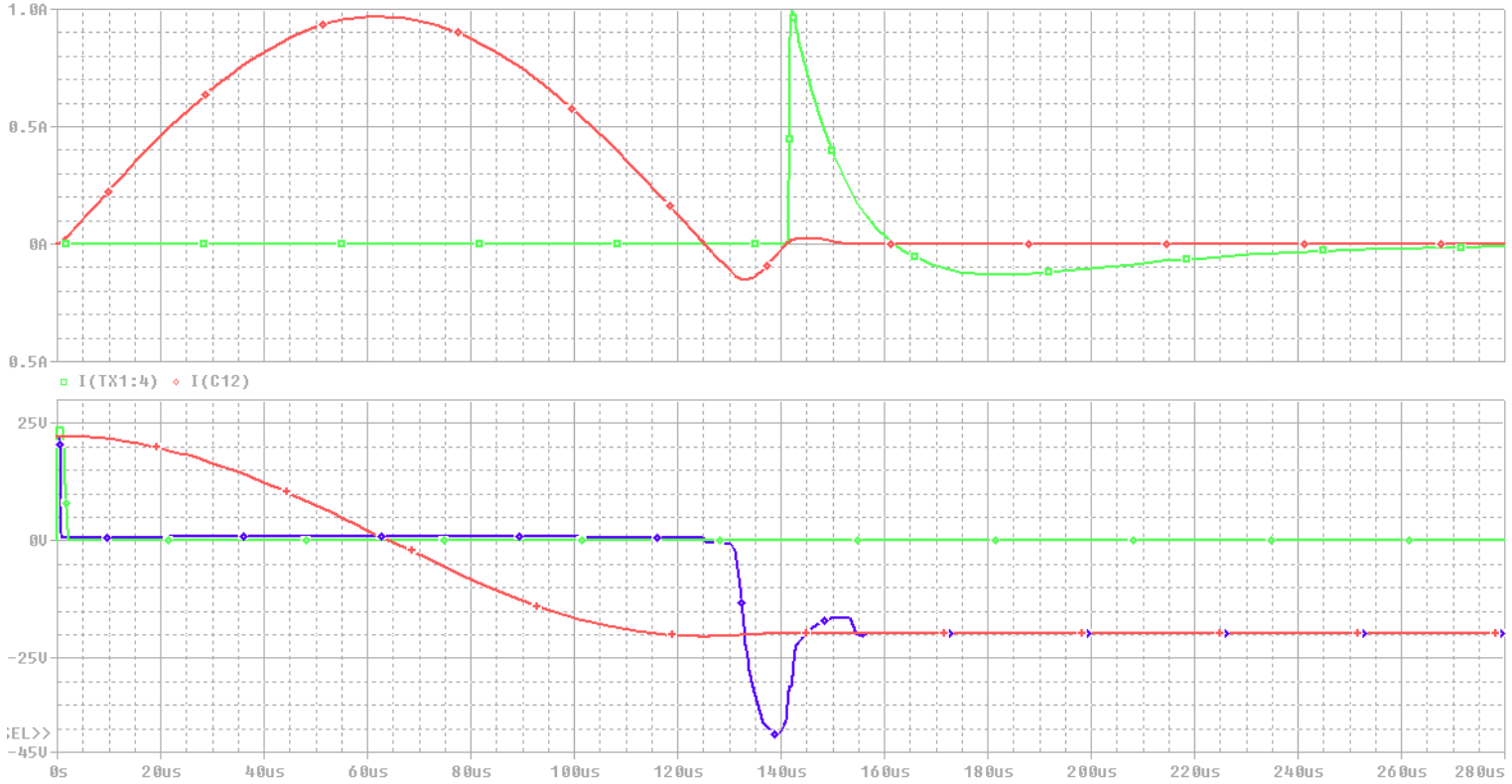


Asynchronous Beam Dumps

- Almost no asynchronous beam dumps expected
  - Asynchronous beam dumps only with trigger input
  - Just one diode and changes in LC parameters are contributing to this failure mode
- Components in Delay Circuit all passive
  - **No spurious triggers from TDU expected**

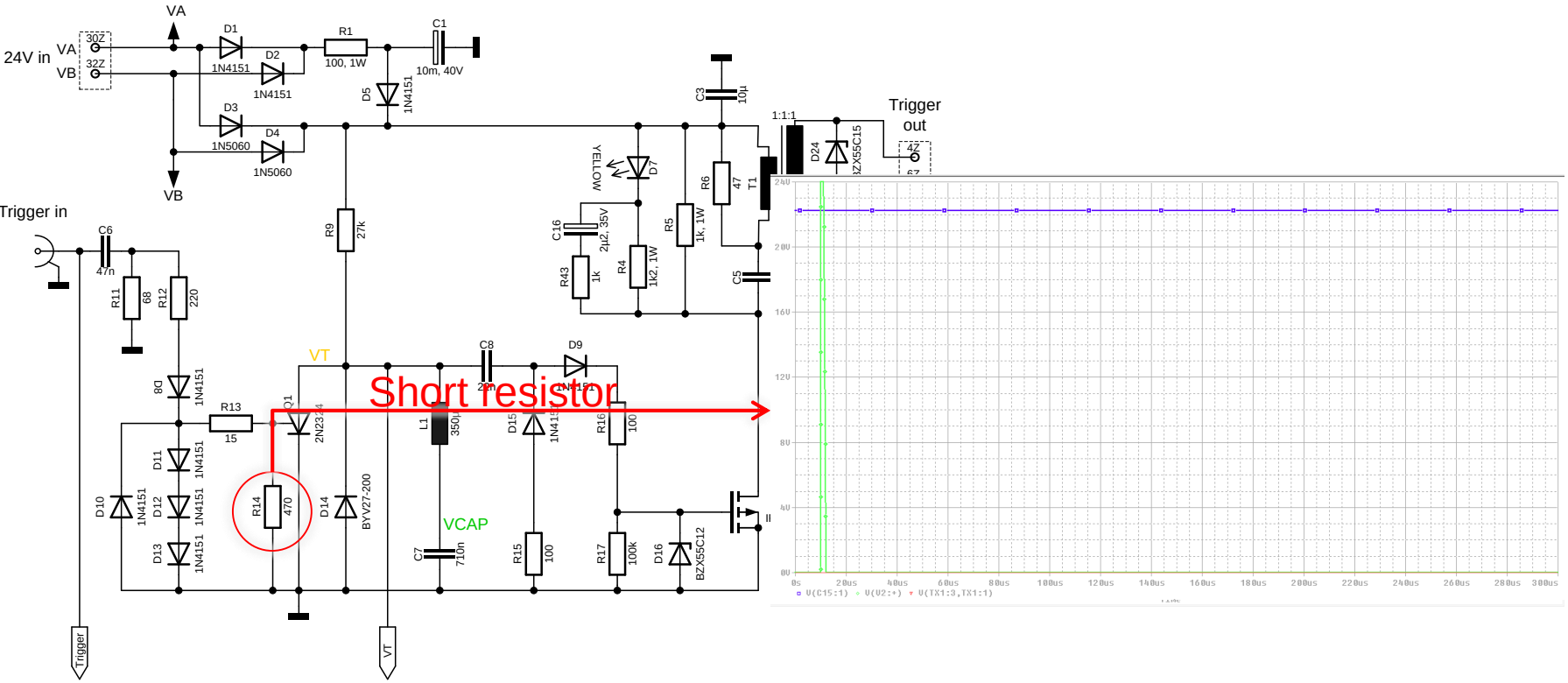


Open Diode BYV27-200



TDU not available on demand

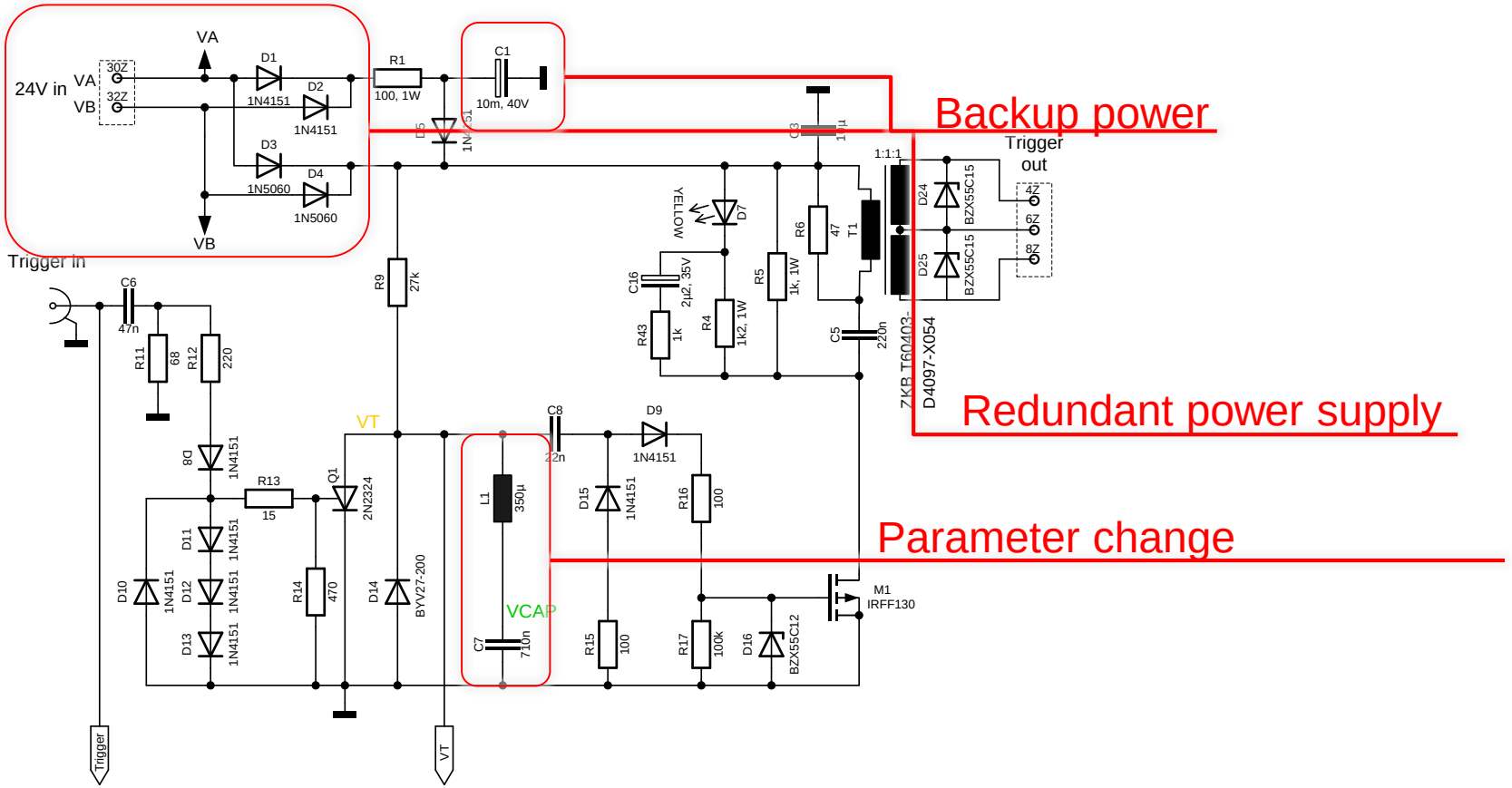
- 21 components contribute
- Effect: TDU cannot forward trigger



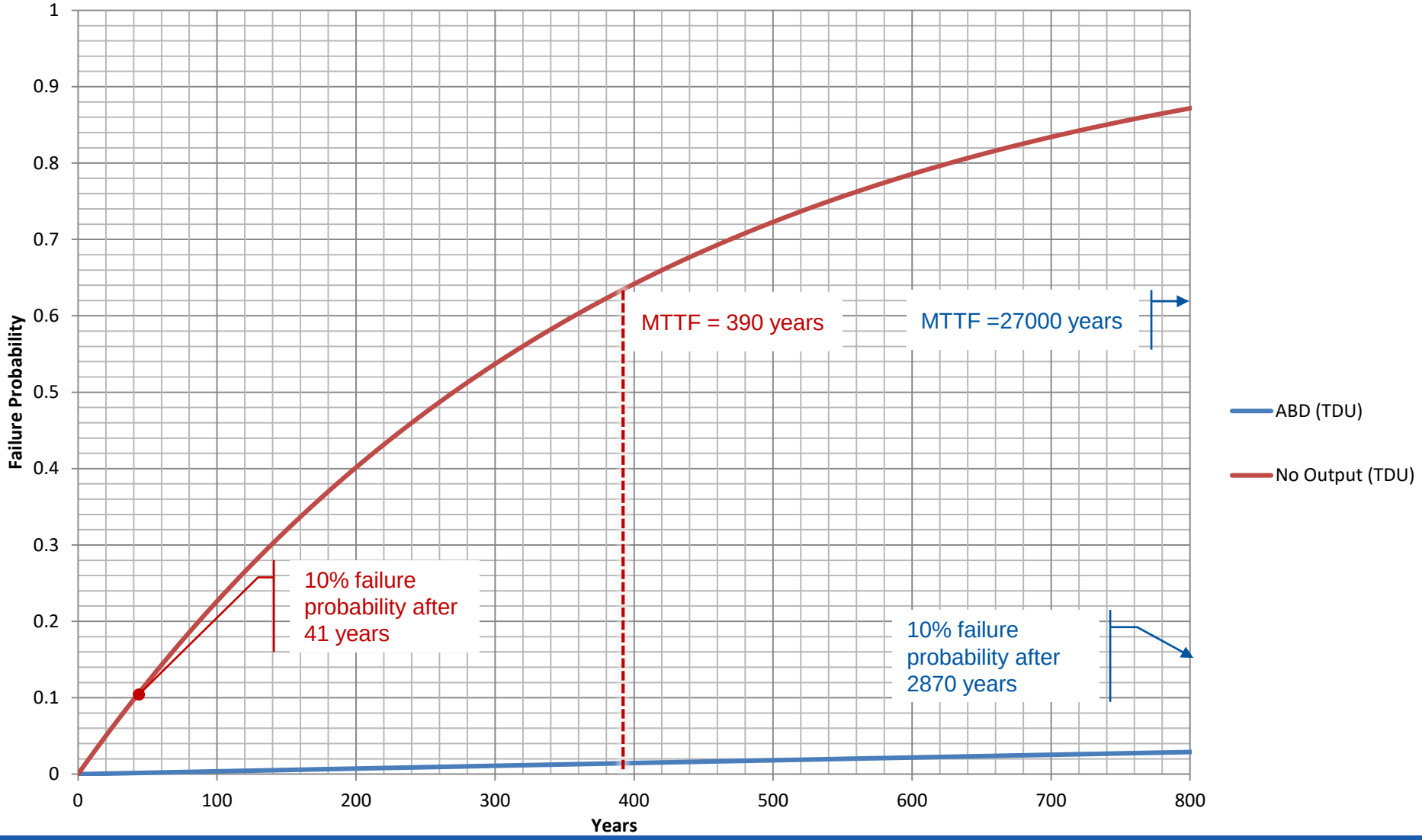
Other failures TDU

- 337 FIT w/o effect on output pulse
  - Redundant components
  - Detectable failures (changes in delay time)
  - Other failures with no effect on trigger delay

Other failures



Failure Probabilities TDU



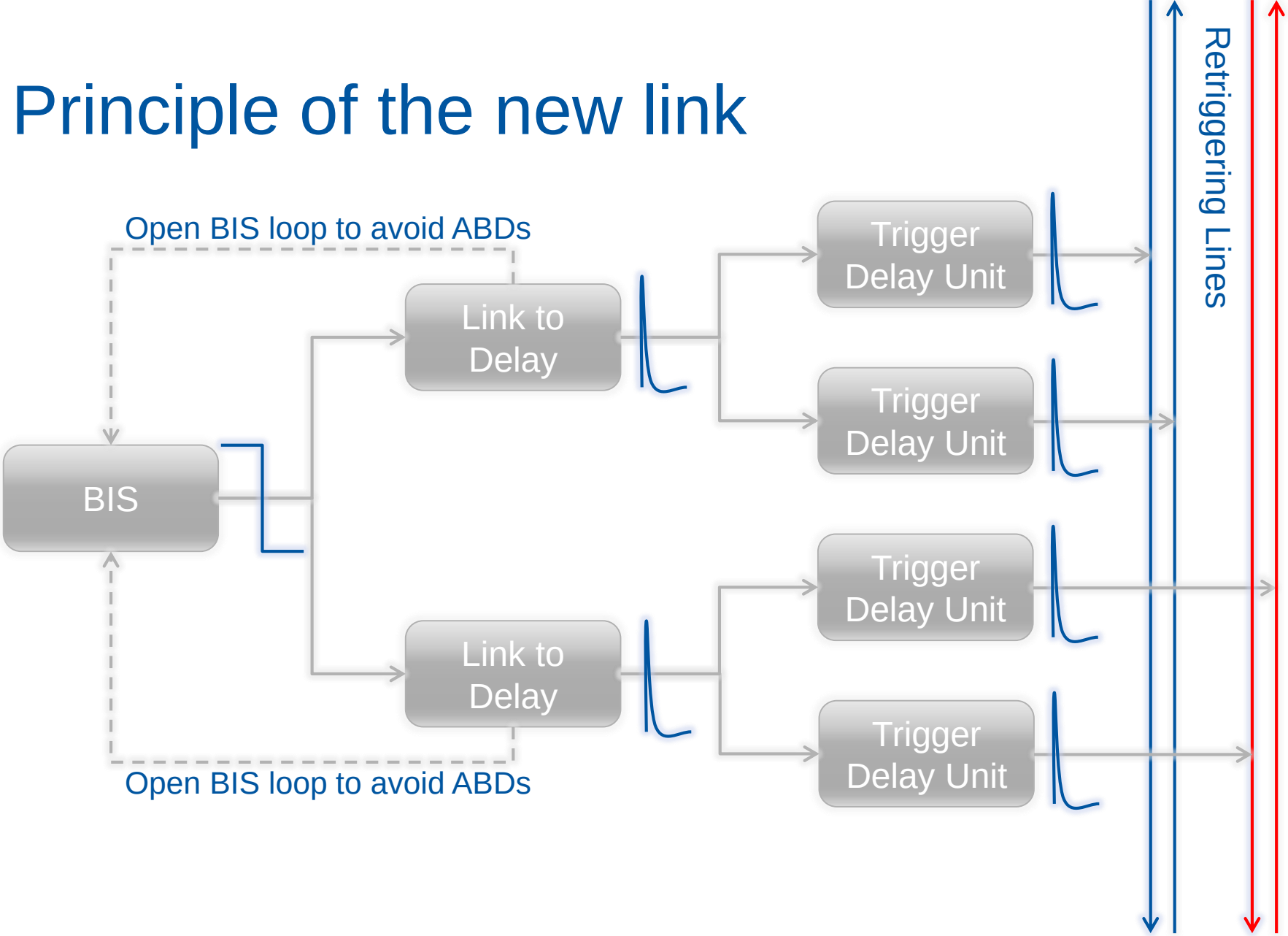
Summary TDU reliability

- High reliability
- Almost no asynchronous beam dumps expected
- Most frequent failure: Not available on demand (MTTF=390 years)
- No back link to BIS loop necessary (regarding the TDU)

Link to TDU: status of analysis

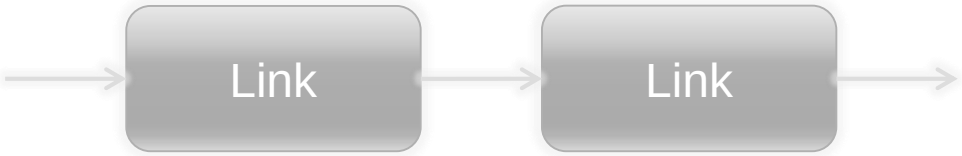
- reliability analysis is in early state
- different designs regarded
  - Analogic / digital
  - Redundant paths in the link
  - Combining the output signals to trigger both retriggering lines at the same time
  - Backlink opening the BIS to prevent spurious triggers causing an ABD

Principle of the new link



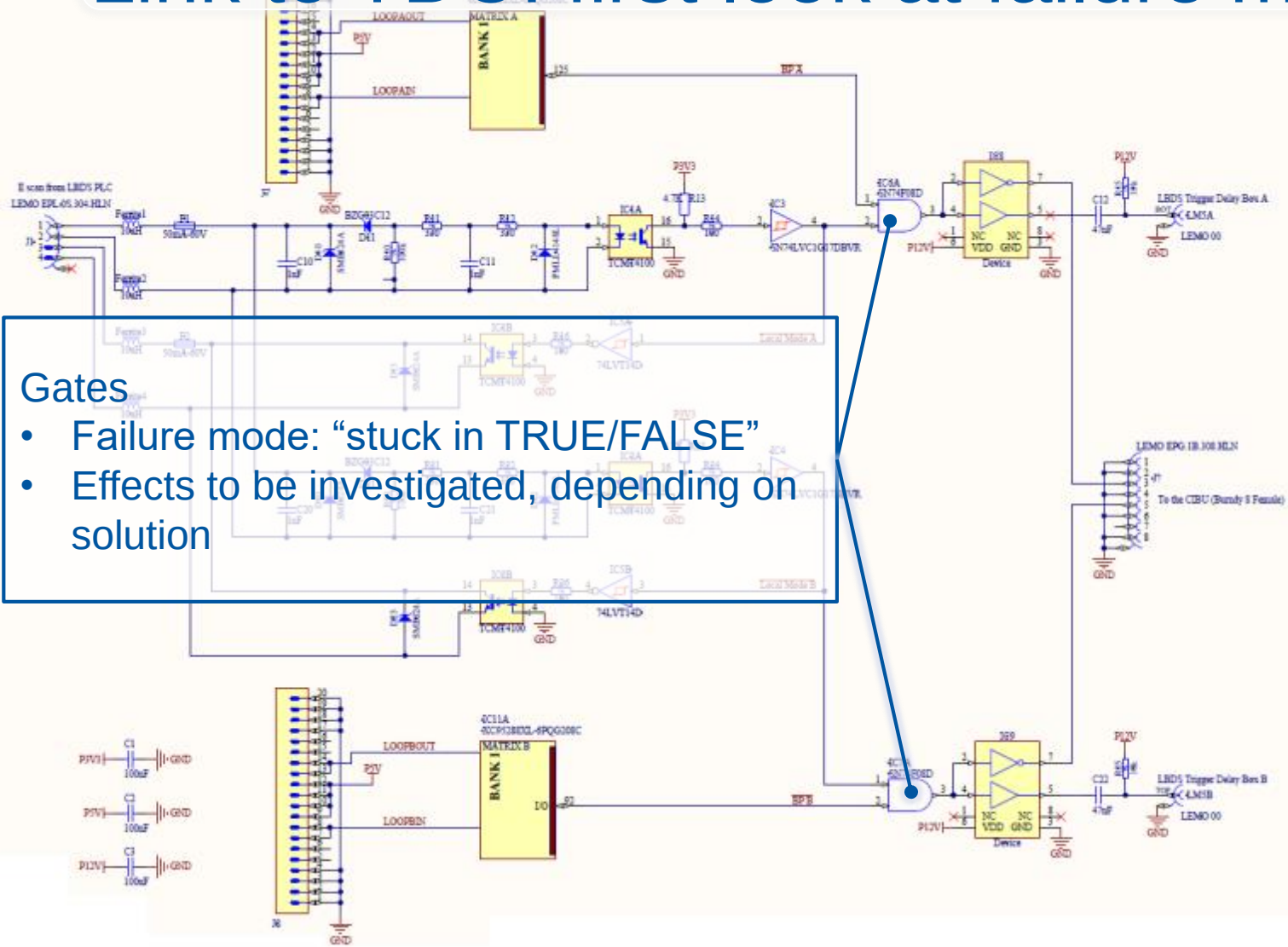
Reliability block diagrams Link failure modes

Asynchronous beam dump



System not available on demand (1 beam)

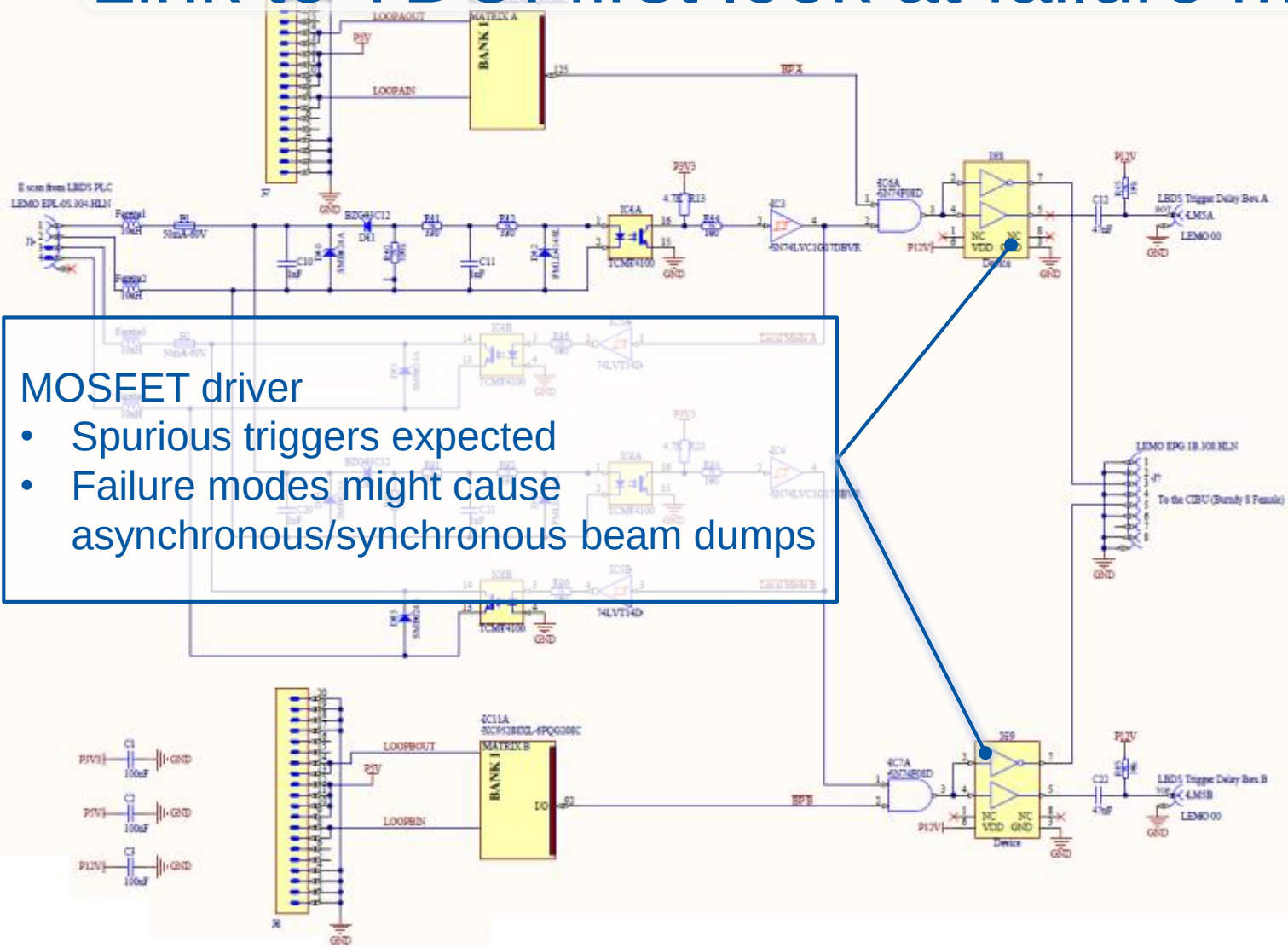
Link to TDU: first look at failure modes



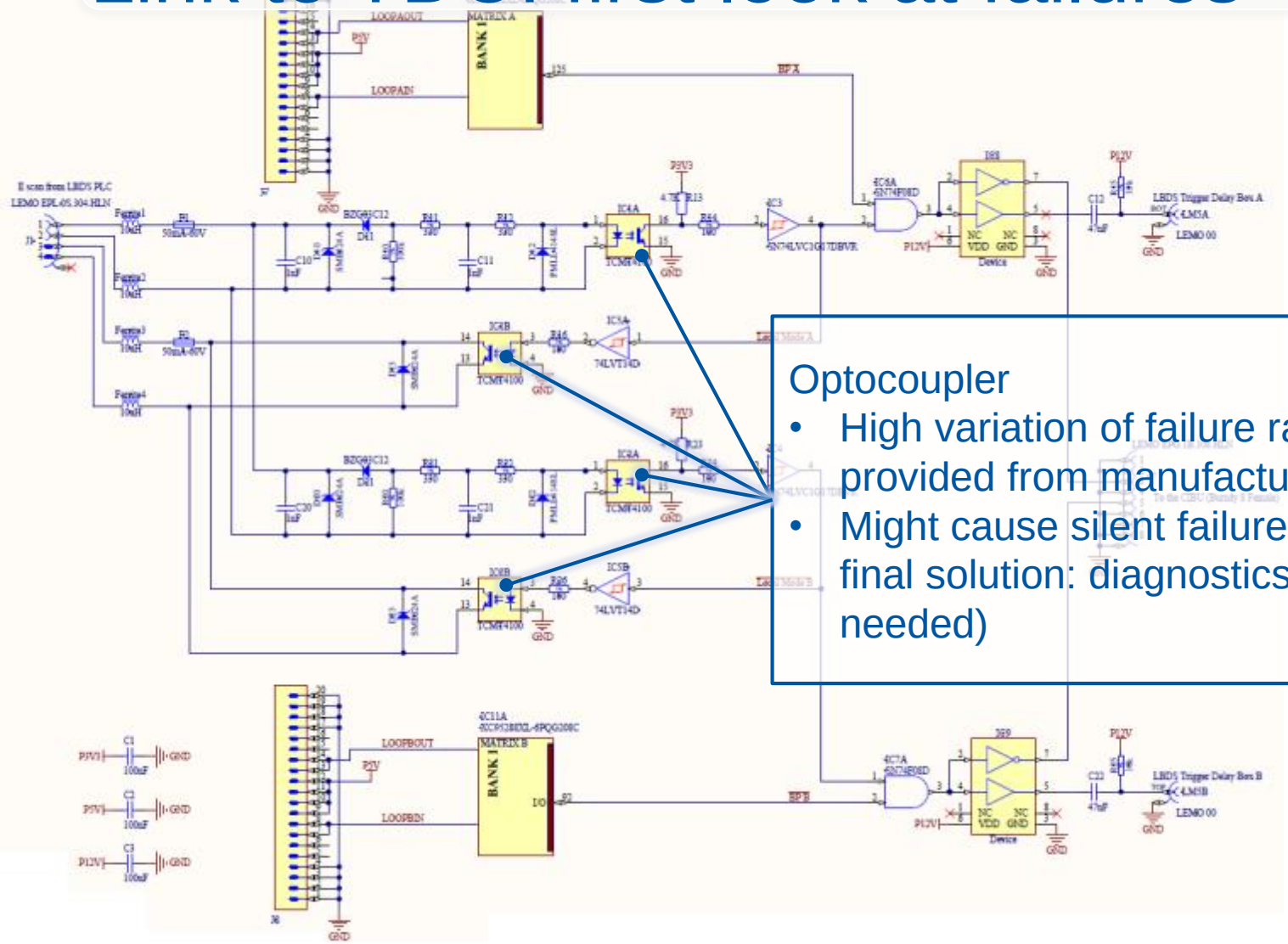
Gates

- Failure mode: “stuck in TRUE/FALSE”
- Effects to be investigated, depending on solution

Link to TDU: first look at failure modes



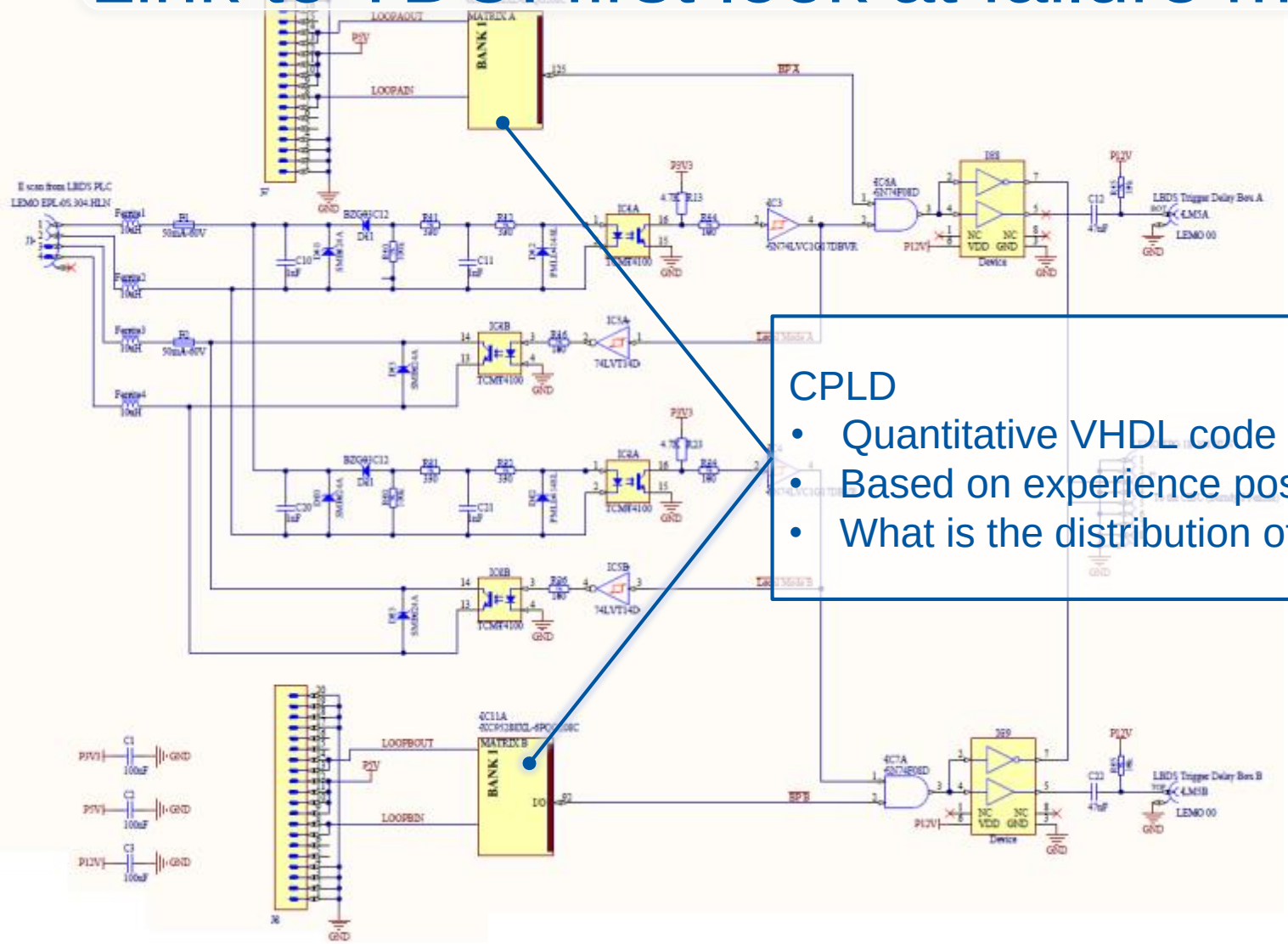
Link to TDU: first look at failures



Optocoupler

- High variation of failure rates calculated / provided from manufacturer
- Might cause silent failures (depending on final solution: diagnostics might be needed)

Link to TDU: first look at failure modes



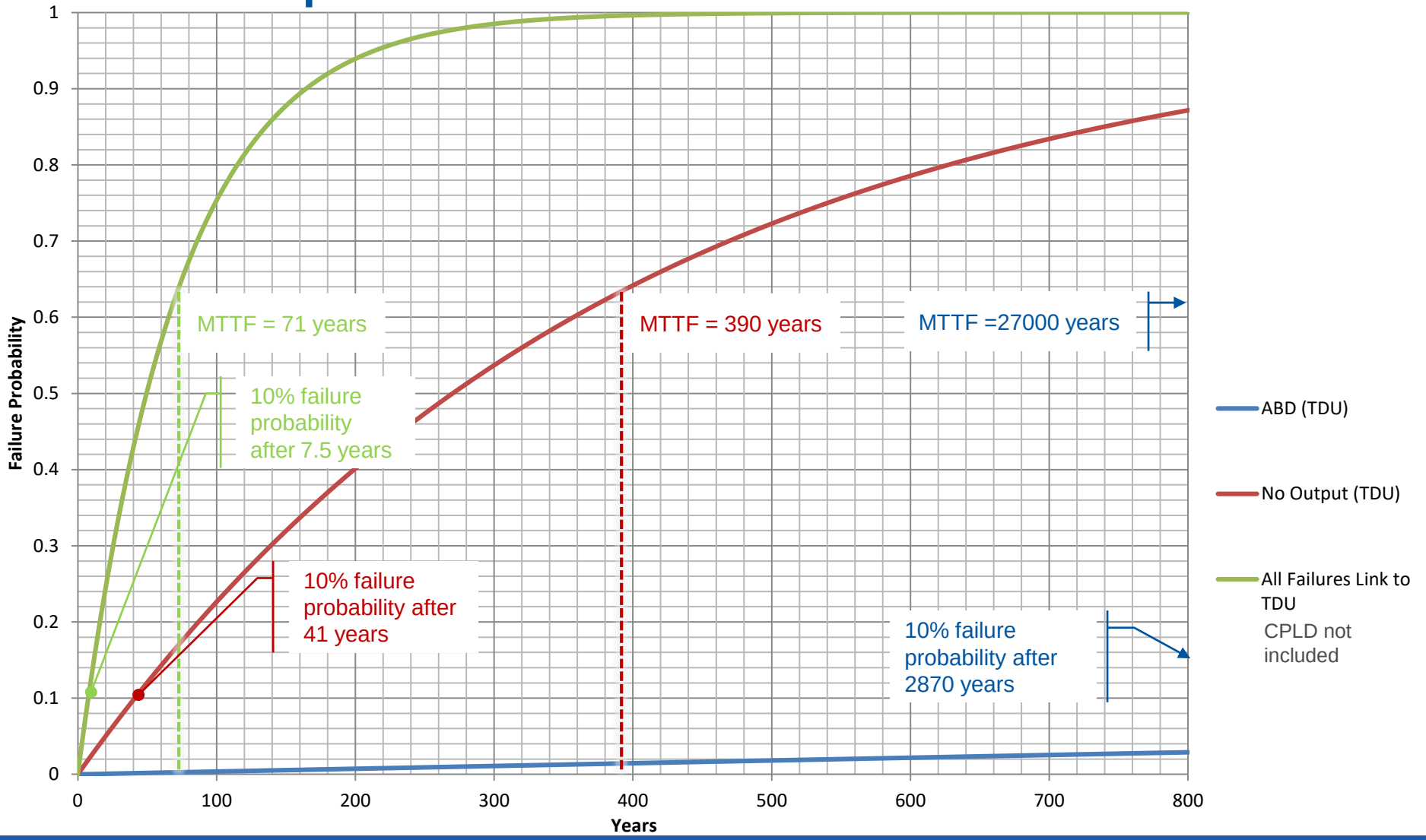
CPLD

- Quantitative VHDL code reliability difficult
- Based on experience possible?
- What is the distribution of failure modes?

Component failure rates (preliminary)

Component	Total failure rate [FIT]	Source
Schmitt-Trigger Buffer	2	Manufacturer
Inductors	3	MIL-217
MOSFET Driver	4	Manufacturer
Optocoupler	8	Manufacturer
Hex Schmitt-Trigger Inverter	10	Manufacturer
Gates	12	Manufacturer
Connectors	36	MIL-217
Fuses	40	MIL-217
Capacitors	135	MIL-217
Diodes	151	MIL-217
Resistors	210	MIL-217
CPLD	?	?

Failure probabilities Link and TDU



Different solutions investigated:

- One path for LBDS local mode
  + fewer components, less failures
  - single point of failure: logic gate
- Connection to the CIBU
  + spurious triggers wont cause an asynchronous beam dump
- - more connectors, more synchronous beam dumps?
- Combining the signals to trigger both retriggering lines at the same time after a dump request
  + shortens time to dump
  - new failure modes, single points of failures possible, post analysis difficult, silent failures possible

Summary Link reliability

- Reliability analysis is in early state
- Sum component failure rate: 611+ FIT
- Failure modes effects will be investigated on output signal and other effects on the link
- More critical failures expected than in the TDU
- More asynchronous beam dumps expected
- Impact on machine availability due to possible false synchronous beam dumps

Thank you!