Statistics, dead-time & free-running

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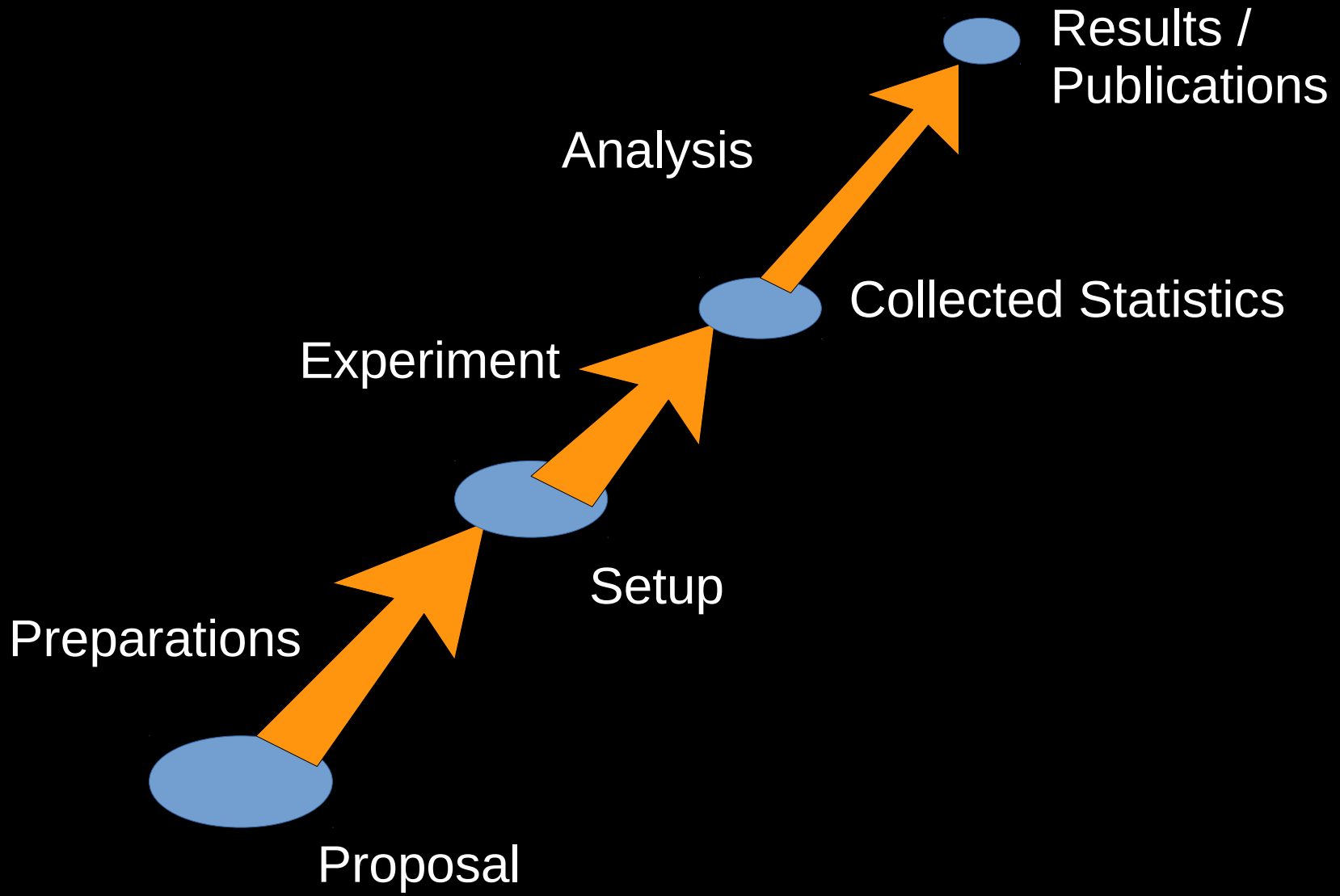
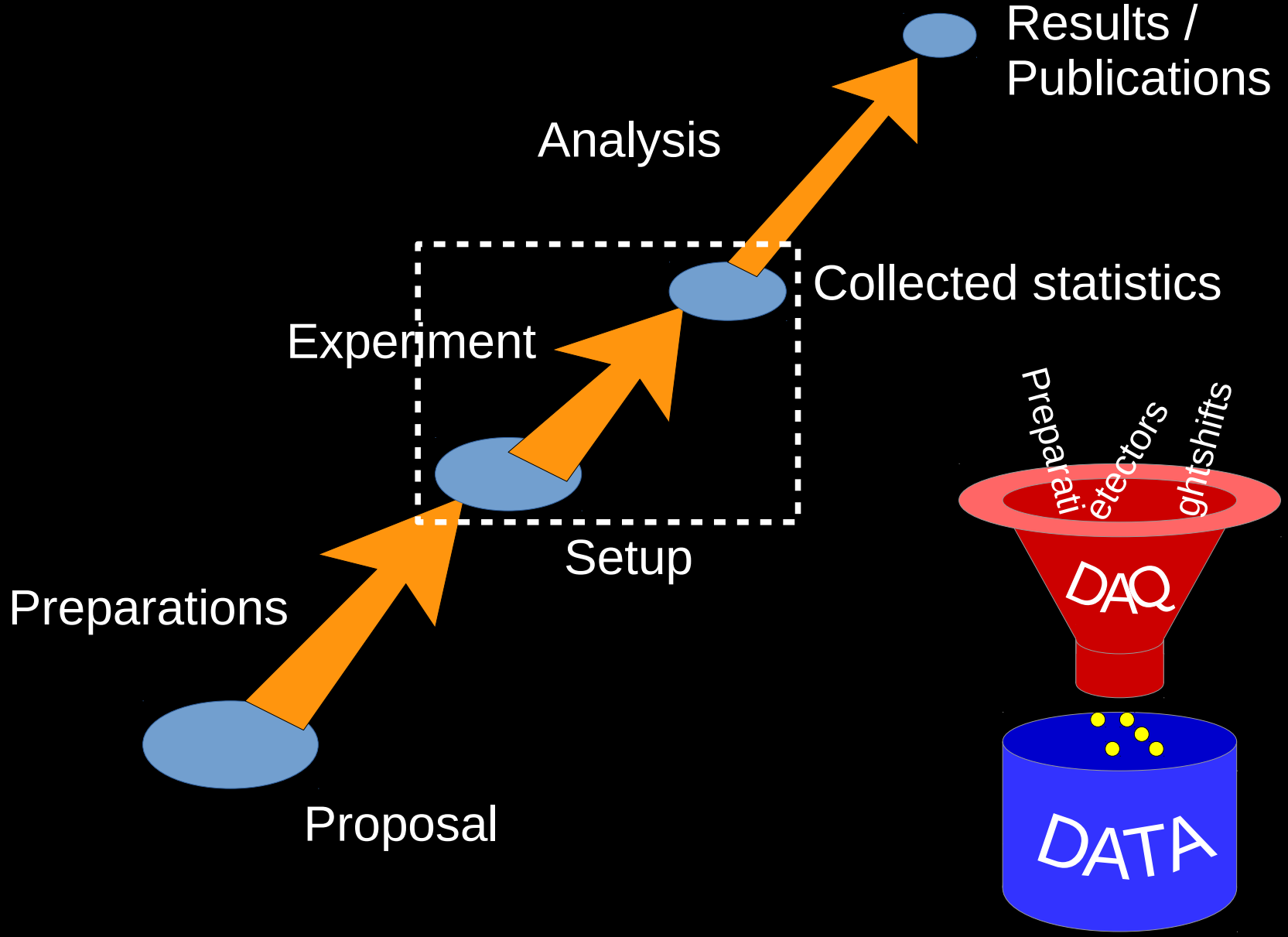
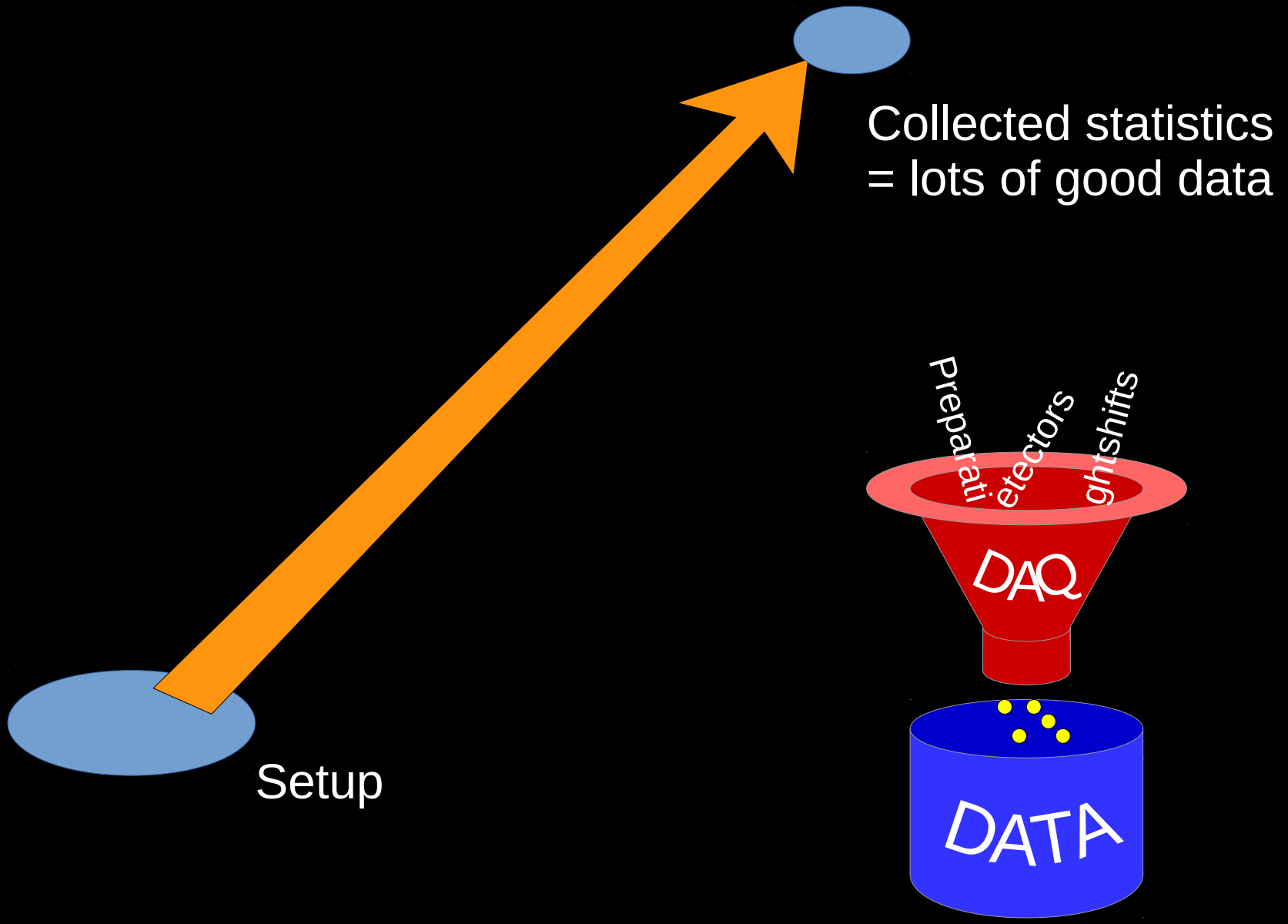
Experiment Lifecycle



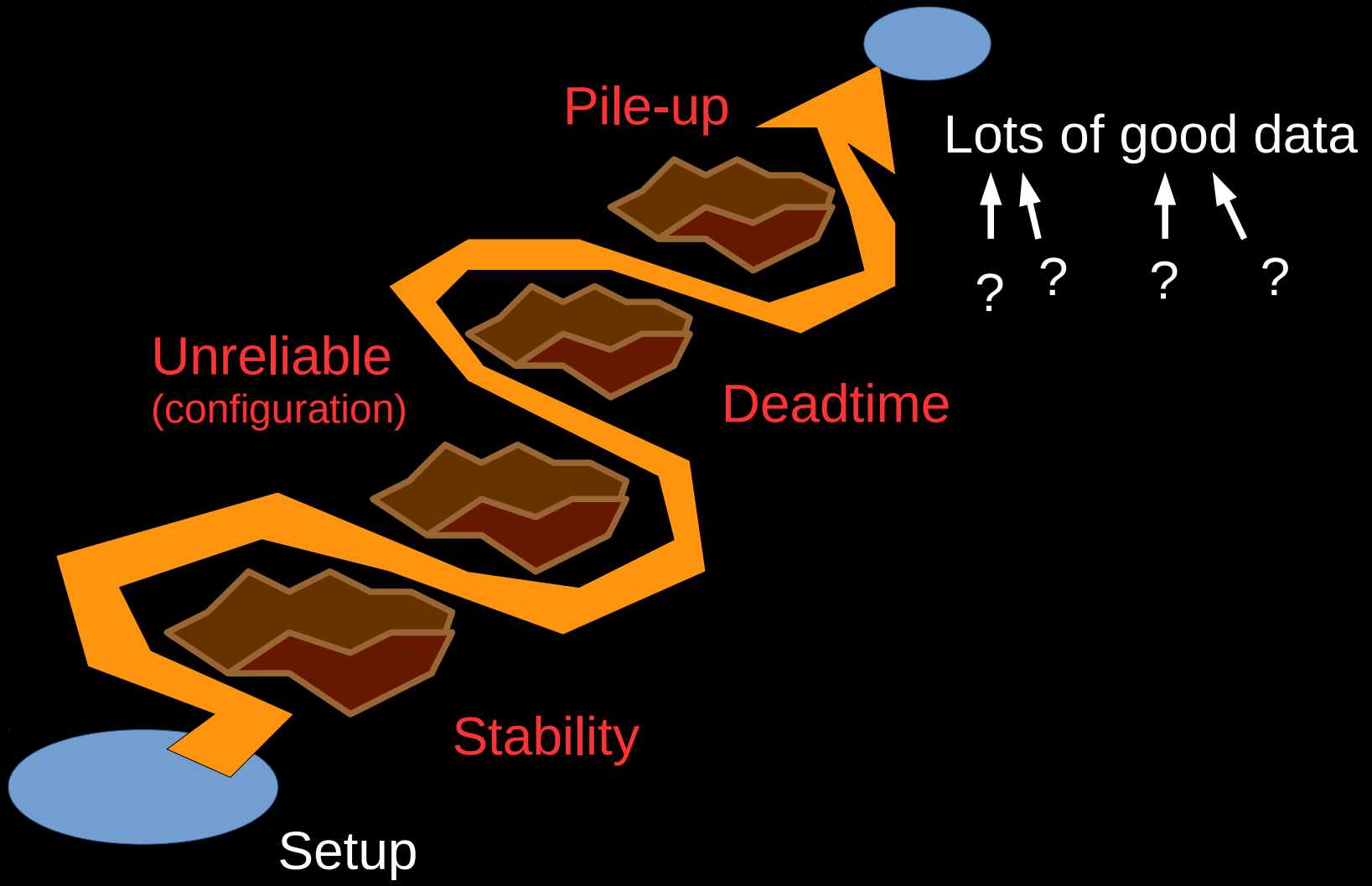
Experiment Lifecycle—Focus...



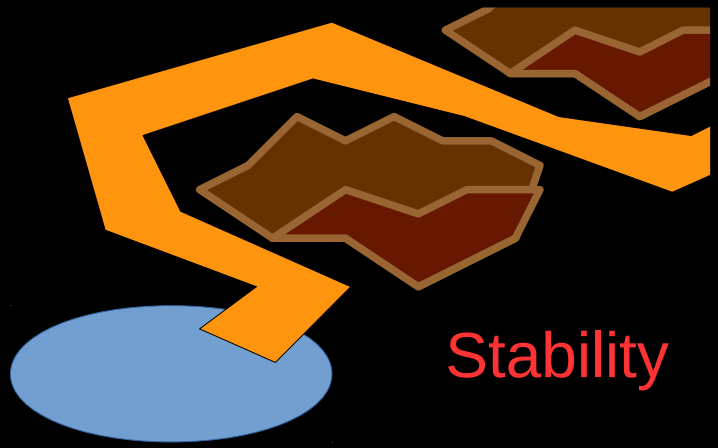
Experiment


Collected statistics
= lots of good data
Preparati
etectors
ghtshifts
DAQ
DATA
Setup

Experiment Hazards



Stability Hazard



S393: Aug 28 → Sep 12 (2010)
8 subsystems
→ 12 crashes/stuck (< 1/day)
(1 noted in elog)

Stability "level":
Users reported individual DAQ
error messages to operator!

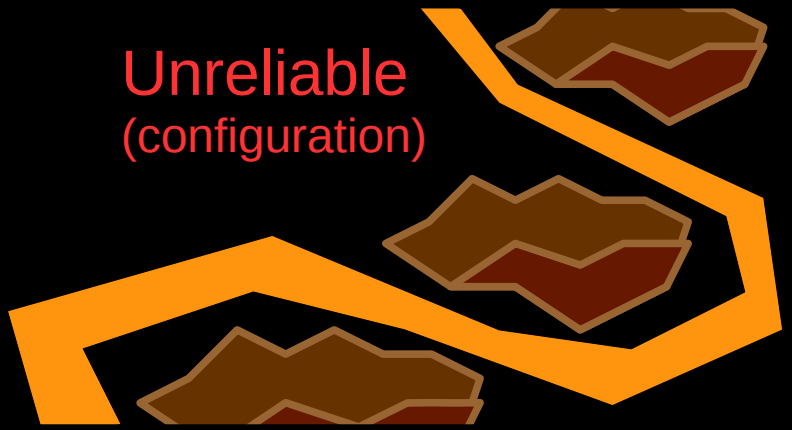
Diagnosis:
Hardware or software?
Likely: firmware issues!

Action:
Many components are involved...
Introduce checksums,
to pin-point *where* problems are.

S444/S473/S454
10-16 subsystems in main DAQ
5 night hours: **9 subsystem hickups**
(autorecovered)

(S473, elog #597)

Reliable configuration Hazard



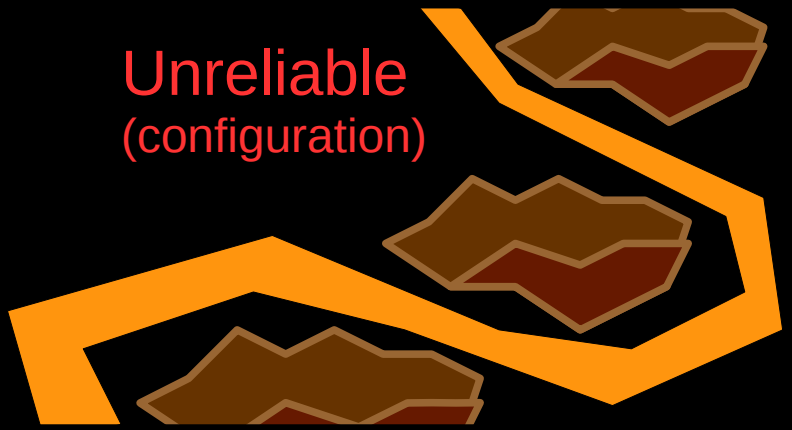
Special concern:
- CALIFA
  - S444, elog #252
  - S454, elog #159, #274

CALIFA FEBEX firmware **fails to meet timing by 8%!** (worst propagation delay vs. clock period)

Diagnosis:
Readback mismatch set values...
Firmware!

Action:
(Debug) & fix!

Reliable configuration Hazard



In many signal paths!
With many cards, not unlikely to manifest in reality...
When? Depends on which card, temperature, 'unlucky' clock cycle...

Diagnosis:
Readback mismatch set values...
Firmware!

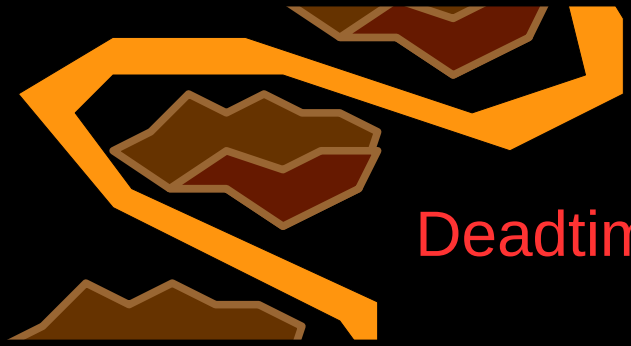
CALIFA FEBEX firmware
fails to meet timing by 8%!
(worst propagation delay vs. clock period)

Action:

(Debug) & fix!

The firmware can—as written—not be reliably run on the given FPGA (family).

Deadtime Measurements

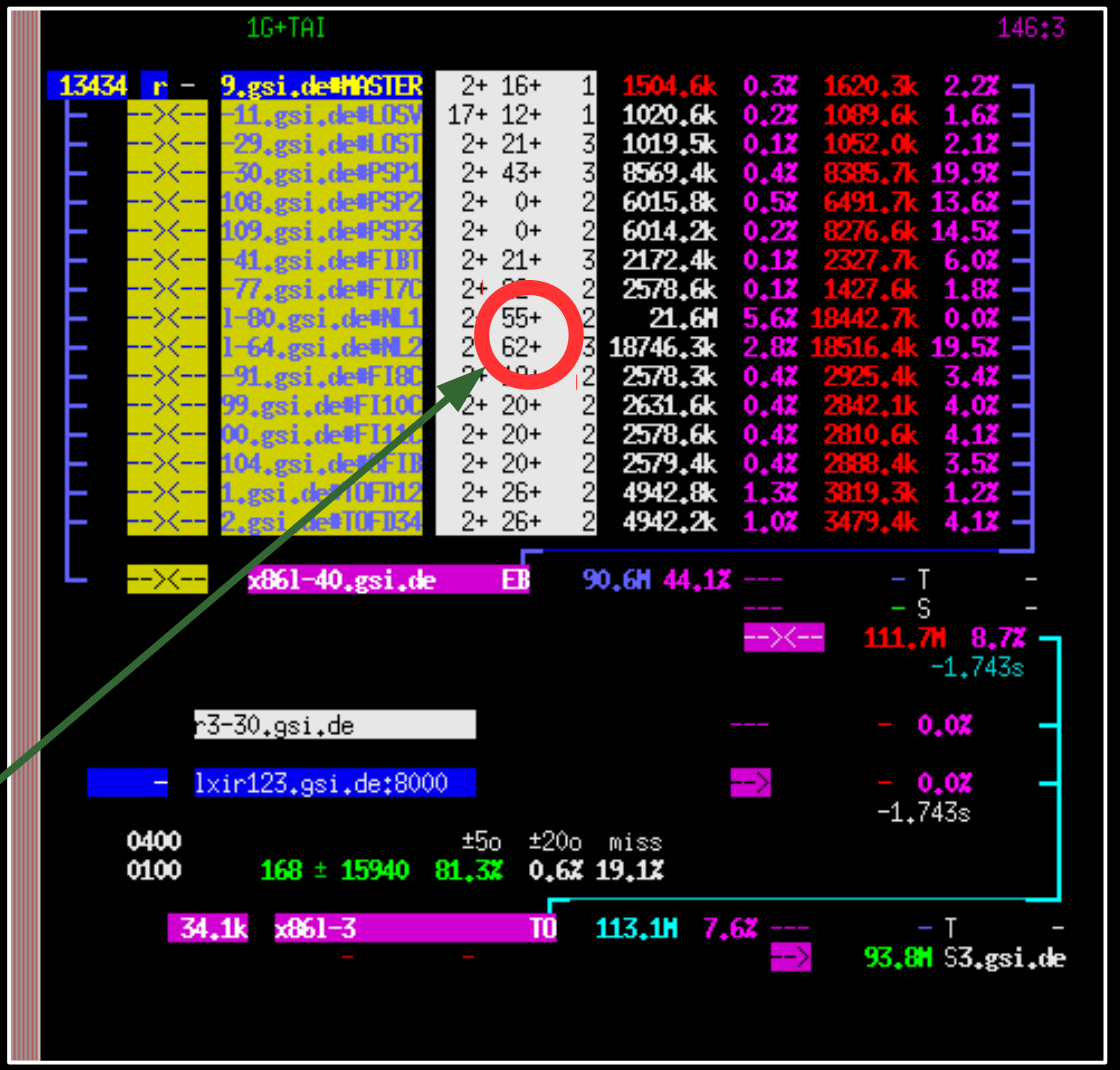


Diagnosis:

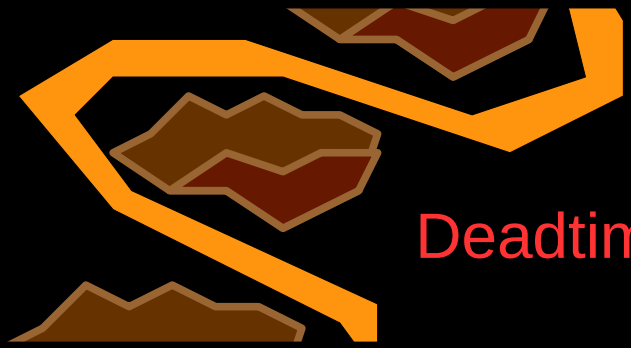
Measure individual subsystems (introduced S473, elog #568)

Action:

Deal with **slowest systems**, (one at a time...)



Deadtime Limitations



Make sure early DT-release can be used reliably for all systems.

Investigate PC-internal (PCIe) communication overhead between CPU ↔ PEXOR/KINPEX.

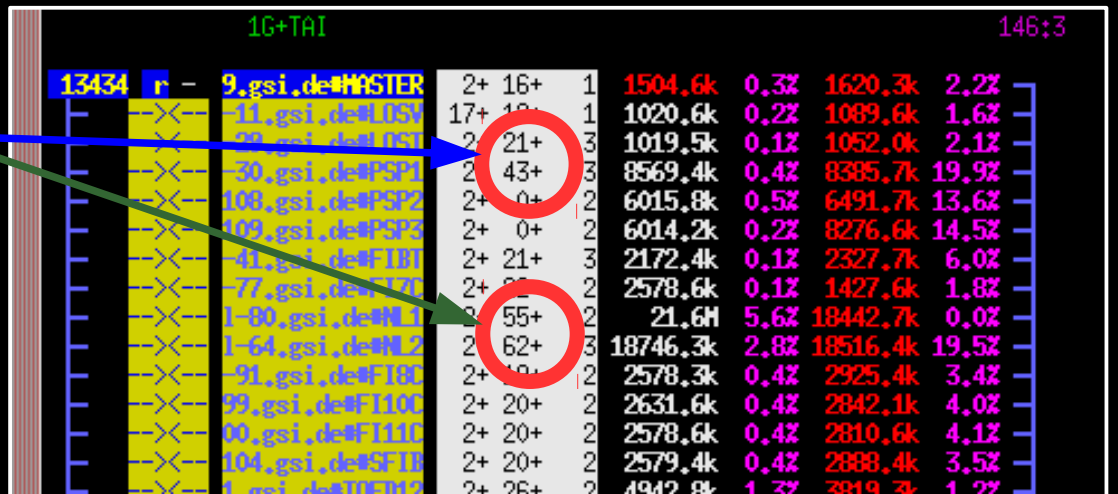
(2.5 us/read, 0.5 us/write)
[fewer possible?, // over SFPs]

Diagnosis:

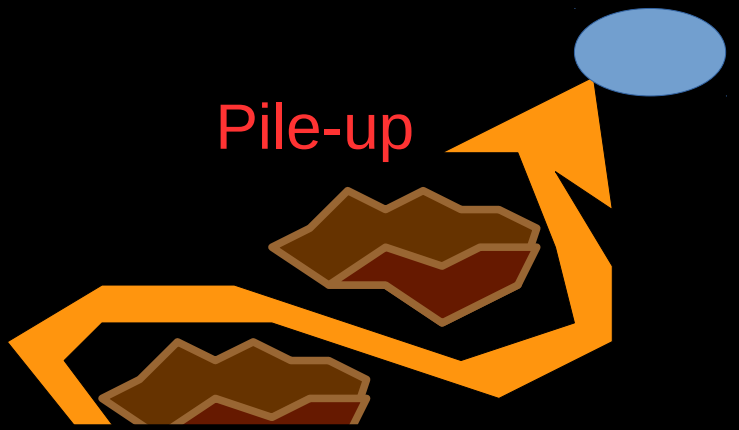
Measure individual subsystems (introduced S473, elog #568)

Action:

Deal with **slowest systems**, one at a time...



Reaching the pile-up limit ?



Accelerator beam spills:
micro-structure in ejection → pile-up

Detectors can handle
(< 1 us pile-up) S473, elog #718

Single-event DAQ not so easily...

Diagnosis I:

Much DAQ grief is caused by
trying to fight single-event deadtime

Diagnosis II:

Front-ends are free-running
But readout is event-oriented...

Action:

Dump all digitised data
→ software trigger

Use hardware to the limit...

Summary

- 4 x firmware:
  - Stability → firmware?
  - Reliability → firmware!
  - Deadtime → firmwares
  - Free-running → firmware…

(and software)

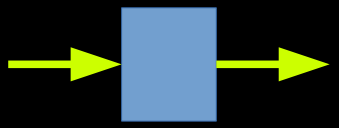
- Next talk…:

→ firmware… :-)

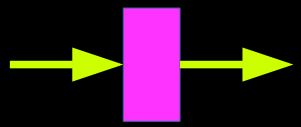
Backup...

Signal propagation delay in FPGA is due to:

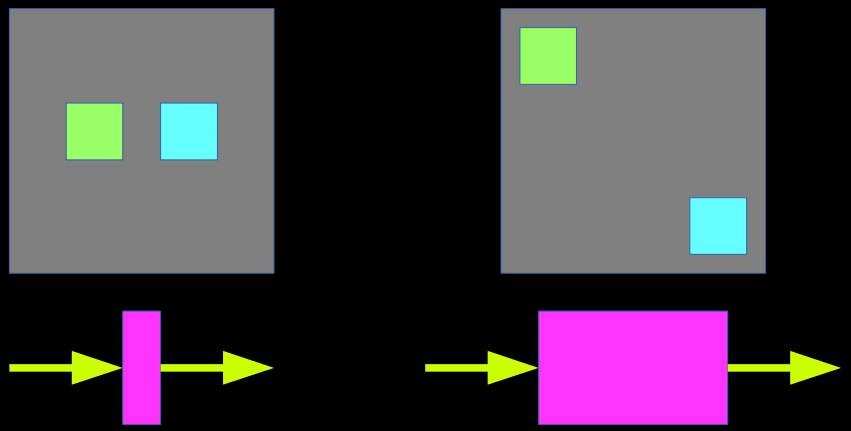
- Logic (LUTs):



- Routing:

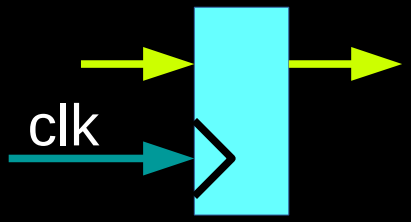


Routing delays generally depend on how far apart on the chip the source and destination are!

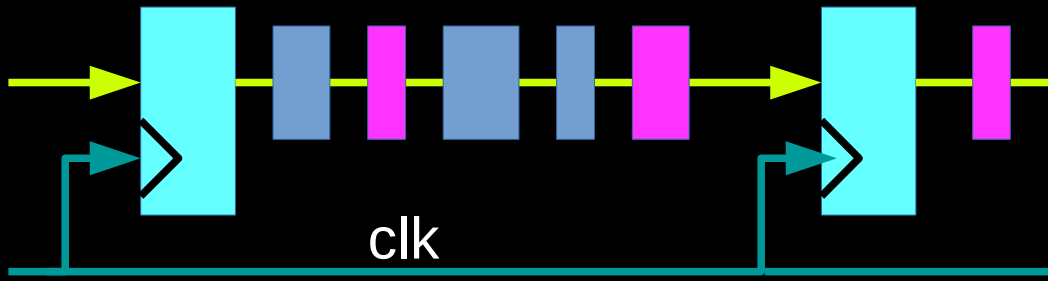


Place & route has to locate components such that **all** routes **meet timing**! (e.g. clock periods)

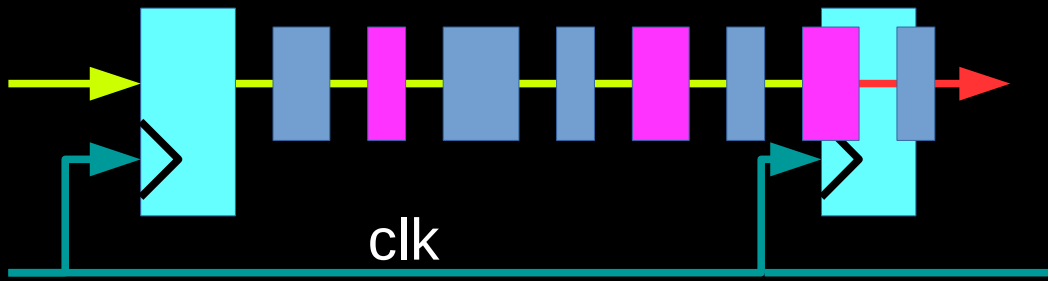
Flip-flops latch on the clock signal



Expressions are between flip-flops:



For expressions that have longer propagation than clock period, ...

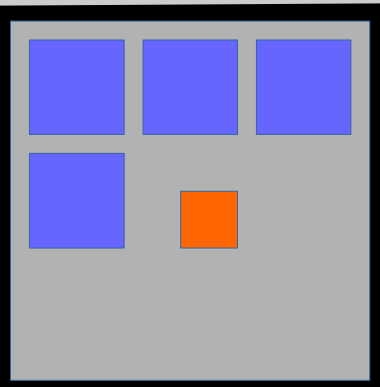


...results **unpredictable!**
(unless you have a time machine!)

BROKEN!

(not so) Preliminary analysis of why CALIFA FEBEX firmware fails to meet timing constraints

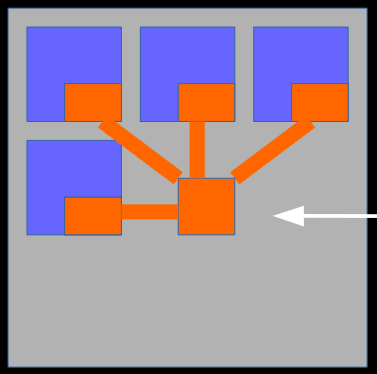
One PSA core (4 channels) uses ~10 % of FPGA resources



With 4 cores (16 channels) FPGA is not full.
(actual: 50%)

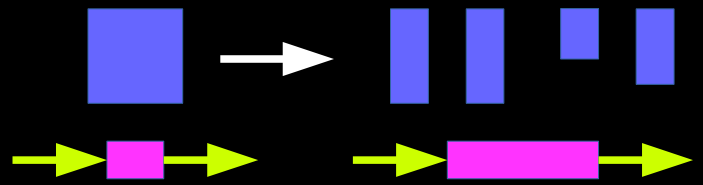
There is also the GOSIP core, However, not in itself large.

Cannot be viewed separately!
PSA and GOSIP tie together...



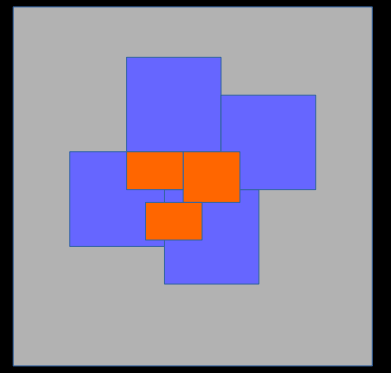
Here GOSIP is spread over large area...

However…
Both PSA and GOSIP seem to 'just' meet timing:
If spread over larger areas, Routing delays break timing.



Place & route **cannot solve**…
(more components requires it to place some things further apart)
So does the best it can do...
(reduce the worst timing failure).

(Also causes long compile times.)



NeuLAND readout times