Design of the Online PC Farm for the High Level Trigger of the NA62 Experiment at CERN

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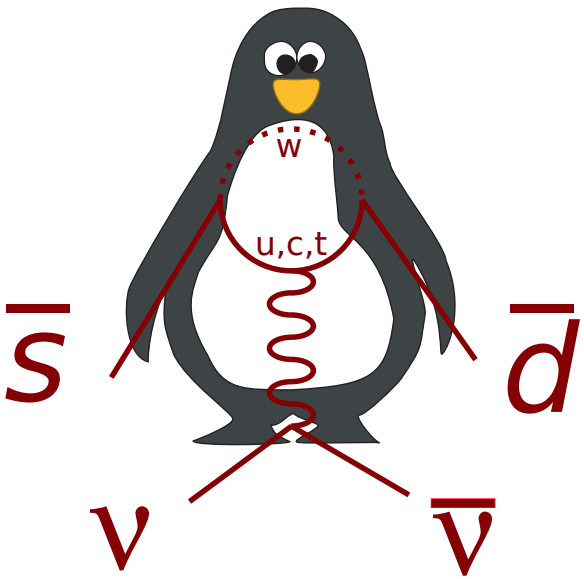


$K^+ \to \pi^+ \nu\bar{\nu} \Leftrightarrow V_{td}$ of CKM matrix

SM branching ratio: $(8.5 \pm 0.7) \cdot 10^{-11}$
Strong impact by new physcis

Measurement from BNL (Brookhaven)

The only experimental data so far (7 candidates) E787 and E949:
$BR(K^+ \to \pi^+ \nu\bar{\nu}) = (17.3^{+11.5}_{-10.5}) \cdot 10^{-11}$

NA62 aims $\sigma < 10\%$ with 100 events

$\approx 10^{13}$ K^+ decays in 2014-15

Inspired by Mr. Heuer: Finding the needle in the **needlestack**

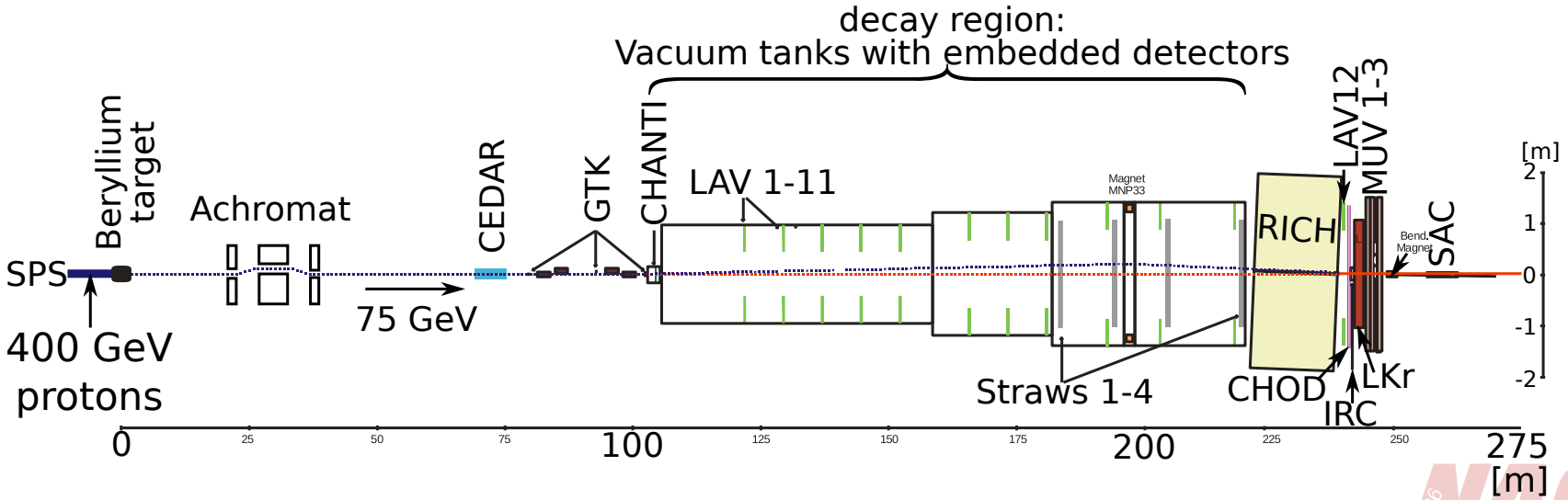
Experiment overview

K^+ production

400 GeV protons from SPS colliding with a beryllium target

Measurement

- 0.8 GHz particles crossing (6% kaons)
- 11 detectors triggered at 10 MHz



Data rates

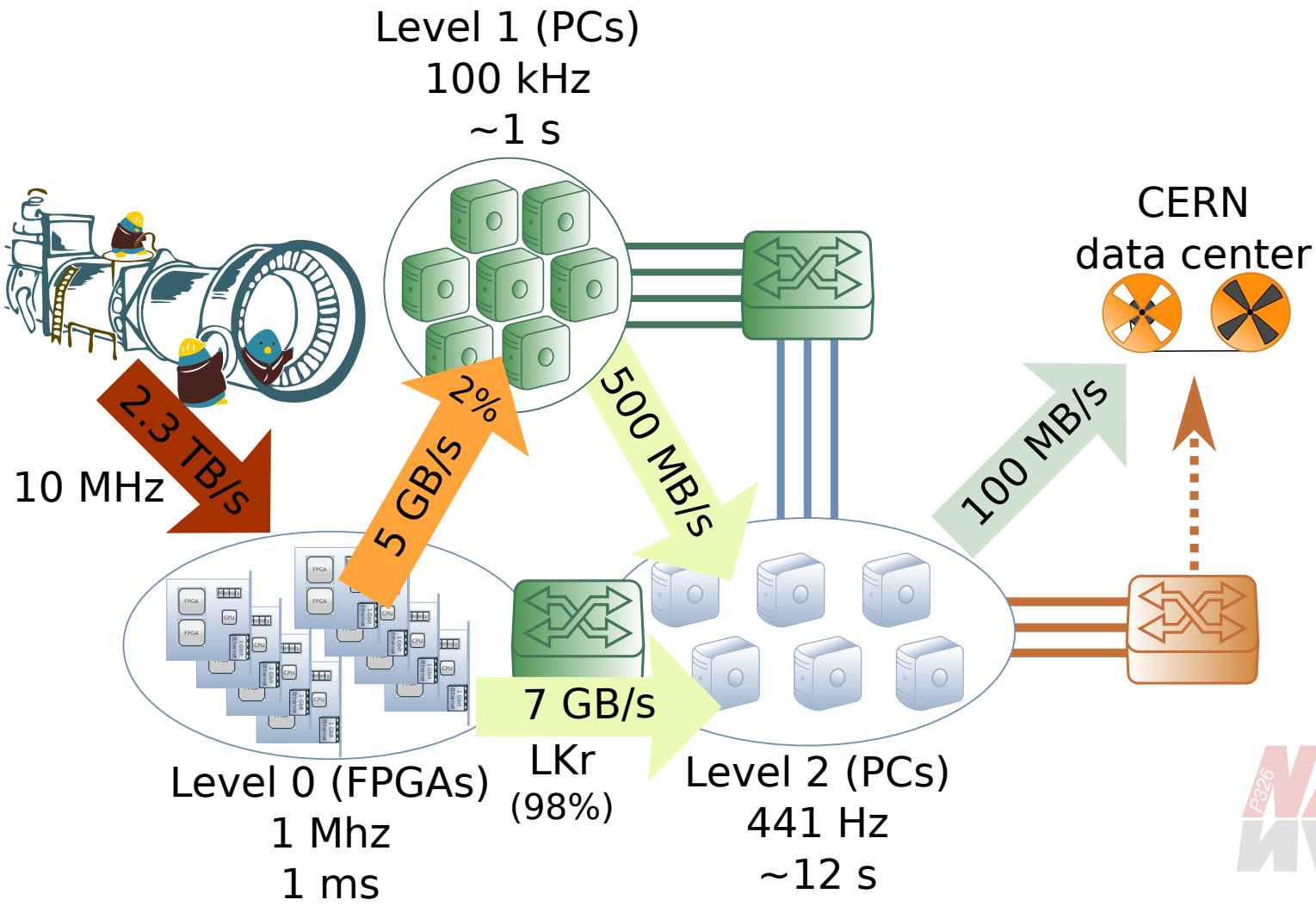
10 MHz unsteady K^+ decay rate

Detector	Event size [B]	Data rate [GBps]
CEDAR	216	2.16
GTK	2250	22.50
CHANTI	192	1.92
LAV	160	1.60
STRAW	768	7.68
RICH	160	1.60
CHOD	$\ll 1000$	$\ll 10$
MUV	768	7.68
IRC & SAC	576	5.76
LKR	**222 k**	**2220**
Sum	**$\approx$227 kB**	**$\approx$2.3 TBps**

DAQ and trigger system

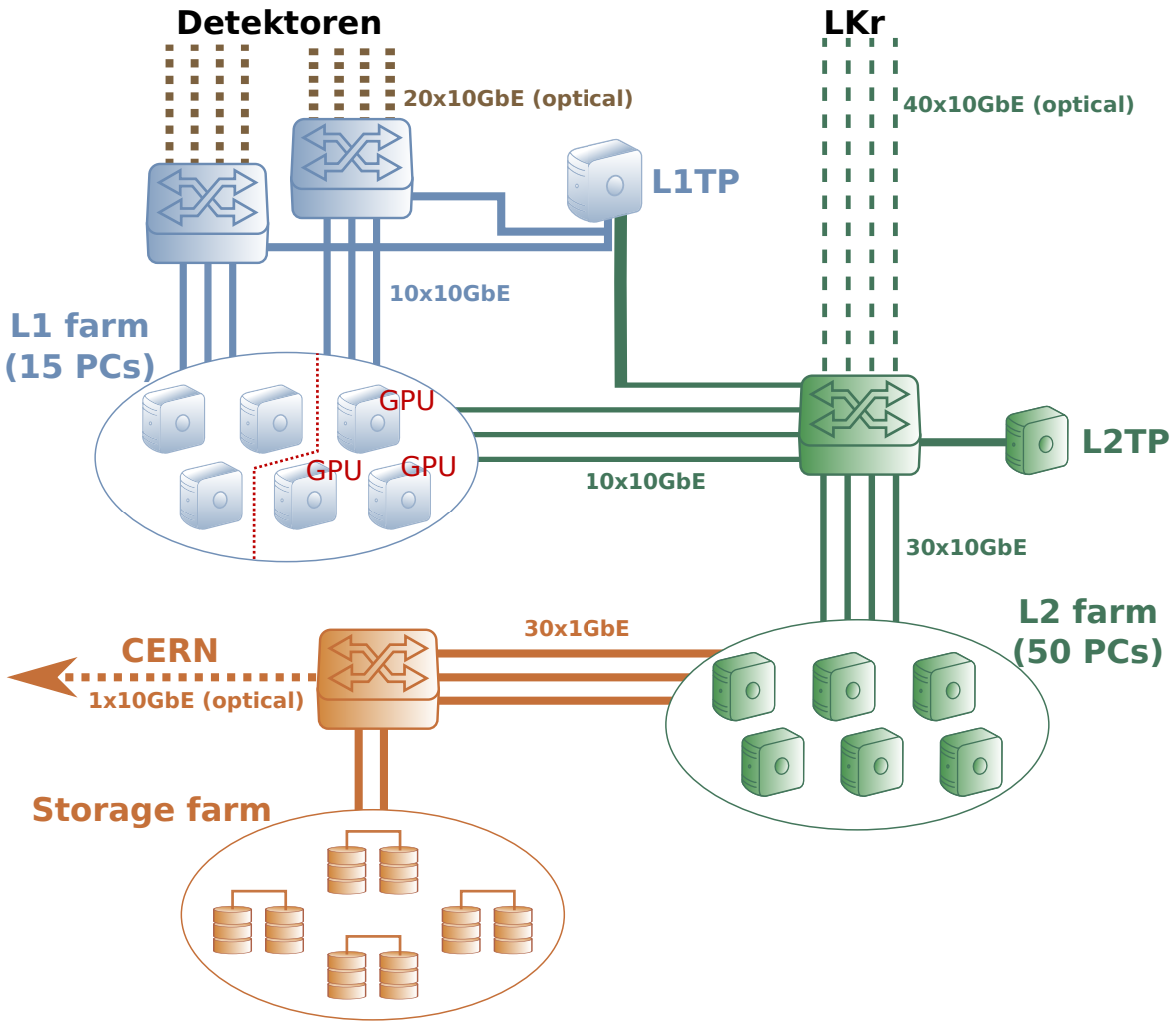
Three levels to filter data

FPGA based L0 and software based L1 and L2 triggers:



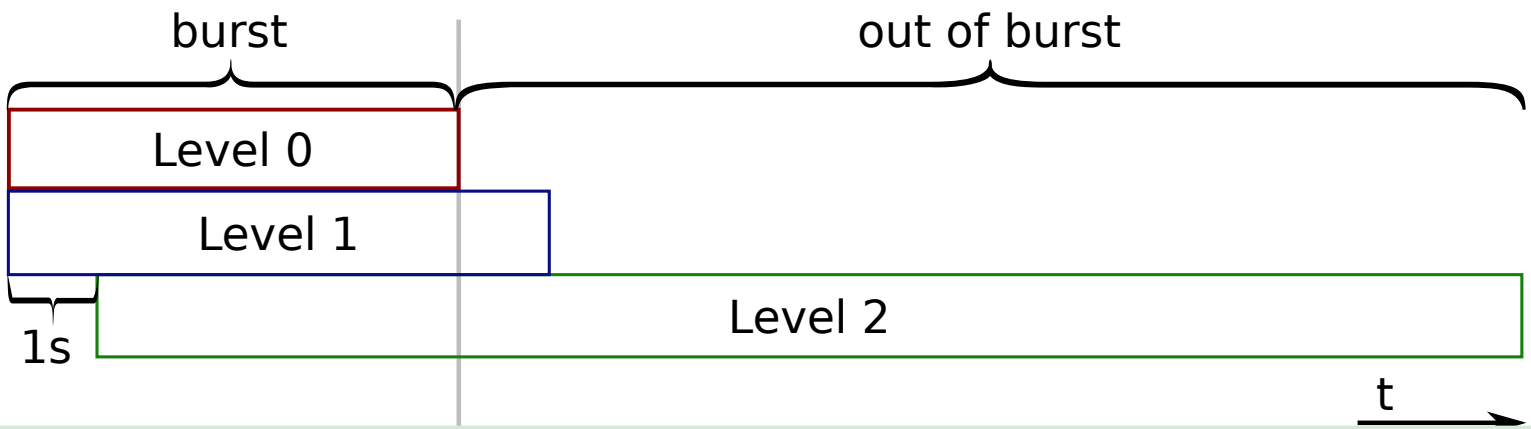
First topology proposal

Original concept:



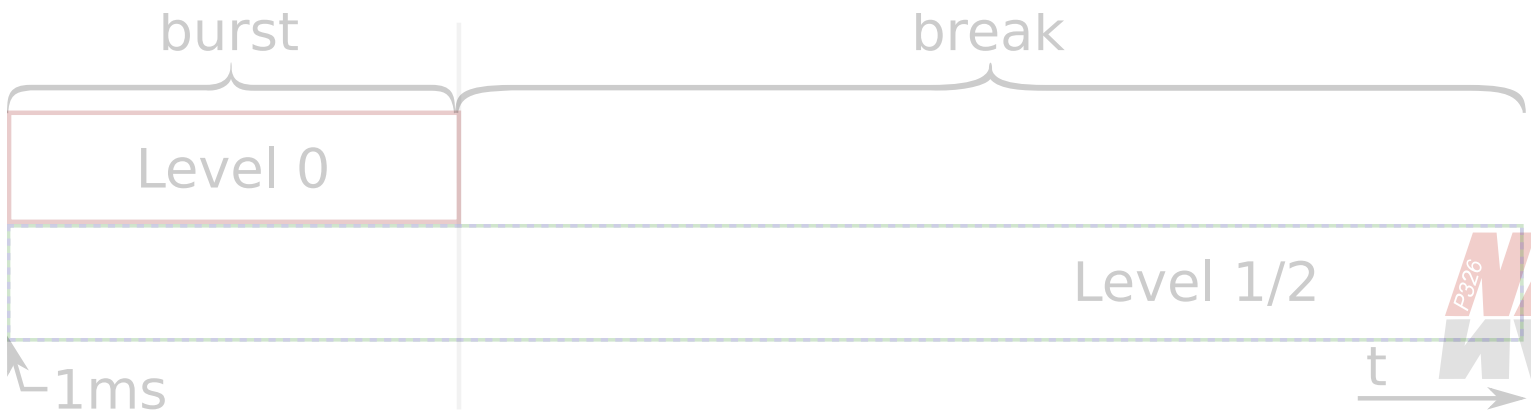
Burst time

Only approximately 5 s proton burst and 12 s break



My proposal to use resources more efficiently

Combine L1 and L2 to one farm



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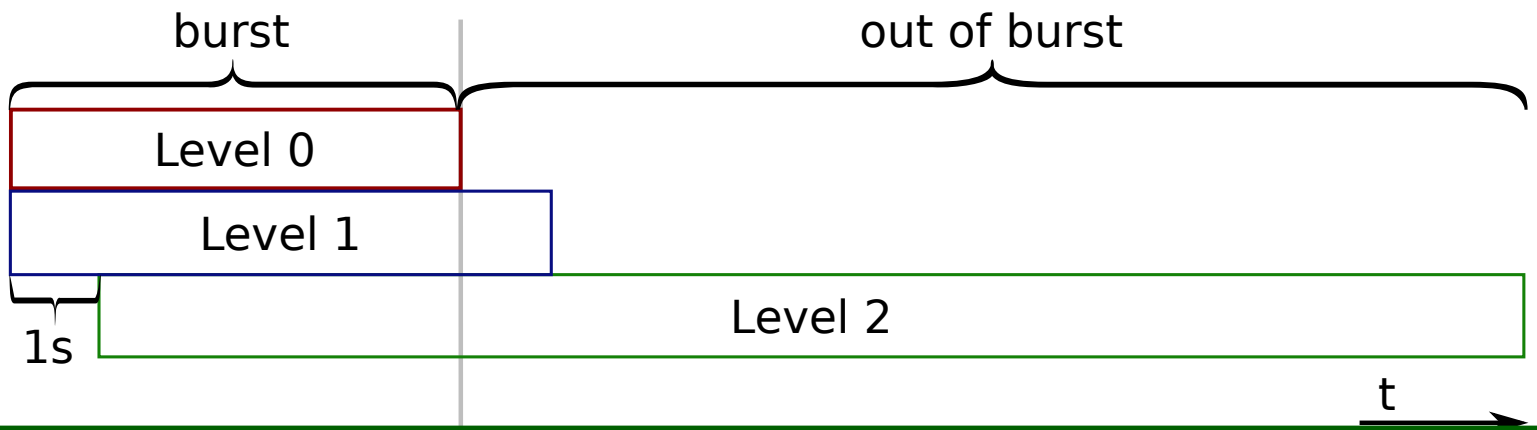

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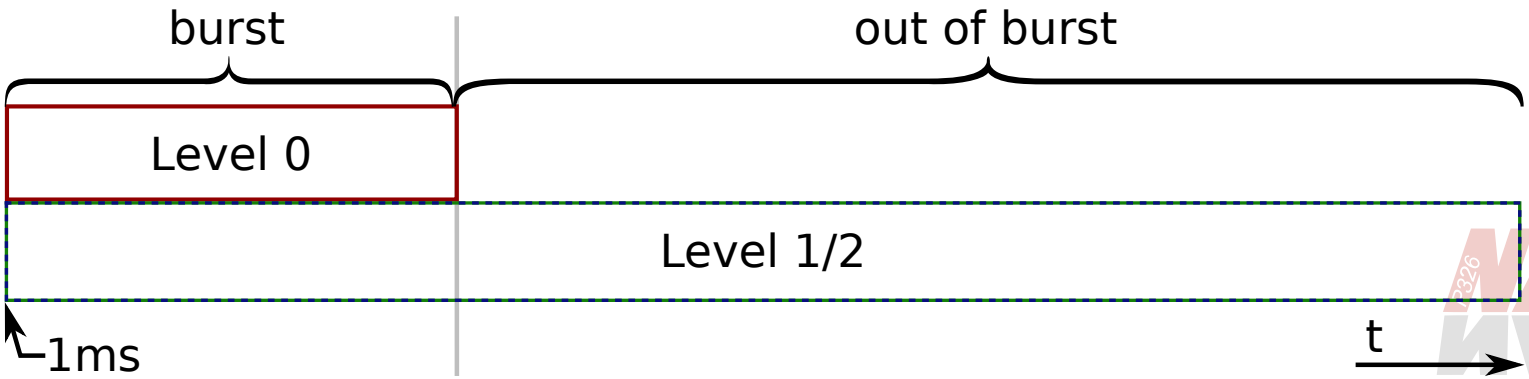
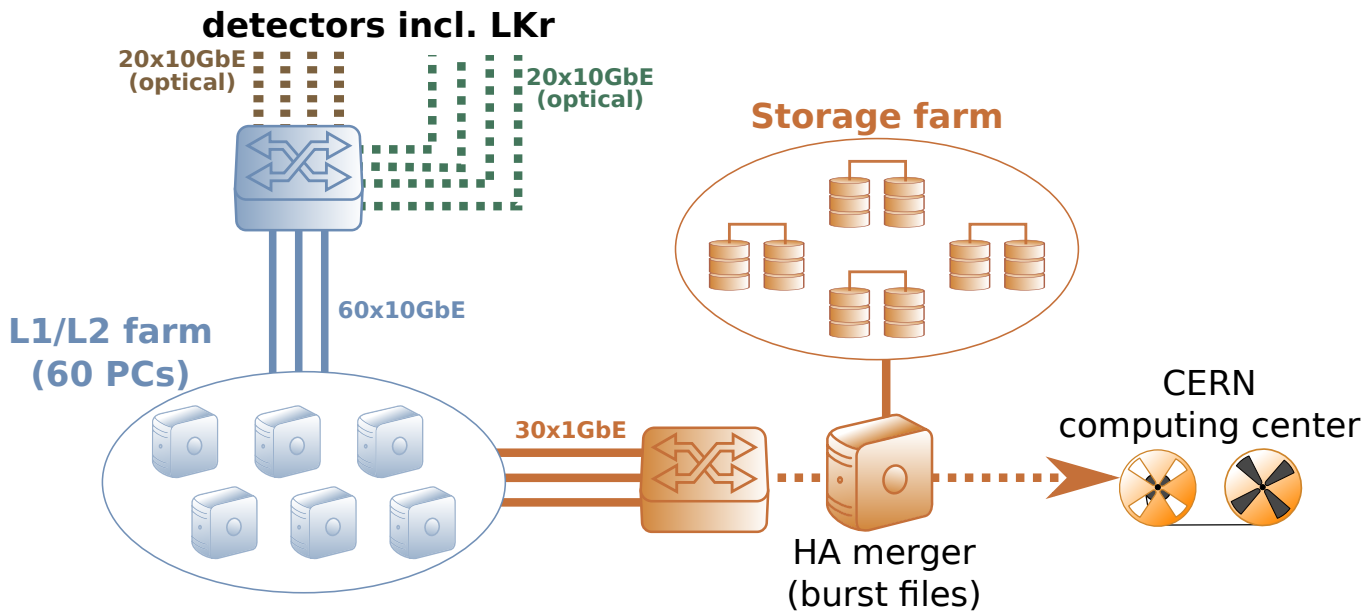


Combine L1 and L2 to one farm

Data transmission via ordinary 10 gigabit ethernet and **UDP/IP**:

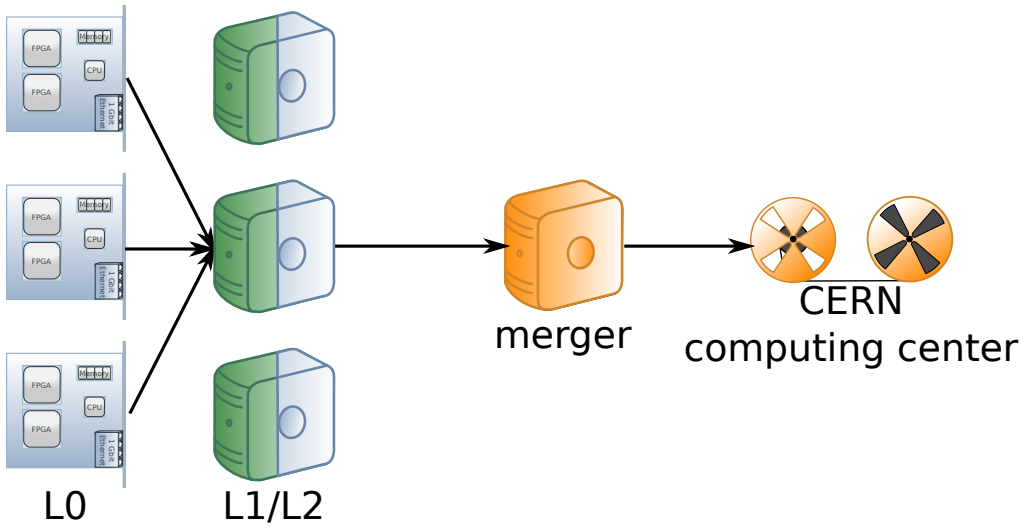


We save about 30% hardware ($\gtrsim$100 k€)

- No L1 PCs anymore
- Less switches, less network cards

New proposal

Event building @ L1



Every subdetector sends data of one event to the same PC

- **More physics at earlier state**
- No broadcast of a L1 decision needed anymore
- Easier to implement load balancing (self-sustaining PCs)

The implemented framework

A software framework has been implemented (5k lines C++):

- Receive UDP packets from electronics
- Consistency checks
- Event building(s)
- Execution of trigger algorithms (L1 and L2)
- Sending data to storage

pf_ring - new type of network socket

Bad performance with standard Kernel sockets

Interrupt based transmission causes packet loss ($\approx 10^{-5}$)

Special socket: pf_ring DNA by ntop

- Direct access to the NIC memory (avoids system calls)
- \+ Only ≈40% CPU @ full speed 10G receiving 1kB packets
- \+ No packet loss at all
- − Need to implement Ethernet, IP, UDP, ARP...

⇒ 270kHz Eventbuilding rate with only about 3 cores
⇒ much processing power left for L1 and L2 trigger

Conclusion

- NA62@CERN: search for new physics in $K^+ \to \pi^+ \nu\bar{\nu}$
- High precision (BR $< 10^{-10}$) $\Rightarrow$ high data rate
- A homogeneous PC farm saves money and work
- Using ordinary 10G ethernet saves money but lossless communication only feasible with special software like pf_ring DNA


The End