

L2CAL Pulsar Upgrade Proposal in 24 minutes
An Executive Summary

Ted Liu

For the L2CAL upgrade team

Pisa/Purdue/Rockefeller/UC

/Madrid/Padova/Academica Sinica/

FNAL

Trigger Upgrade Review, July 27 2006



A brief history of time ...

- It has been a long way towards this proposal ... just like the Pulsar project history
 - Early 2001, 1st time Ted met Pacman while working with Monica on L2CAL commissioning... impressed with the simplicity of pacman's algorithm, worried about jet merging at higher luminosity ...
 - Year 2002, Pulsar was designed for general purposes (some CDF people hated it, yet many liked it): CDF/BABAR/CMS/ATLAS/TOTEM/ALICE/...compatible with L2CAL too
 - Sept. 23rd, 2004: Henry's email to Ted, asking if we can improve L2 clustering for taus and jets... I was really busy with L2 Pulsar upgrade back then.... Only answered Henry's email on March 23, 2005. The answer was: YES, but needs physics motivation....
 - Nov. 22nd, 2004 and Feb. 22, 2005: Viktor Veszpremi showed his study on L1MET and L2MET at exotics meeting, with higher resolution....
 - April 2005, Ted asked a few others to look for jet merging... lots of hall-way talking...
 - Early 2005: Ming&Mario mentioned the L2CAL upgrade idea at TDWG, a few people were very much pissed at them...:(
 - **June 18th, 2005: Mary showed a few event display with jet merging in ROF. Vadim and Ted confirmed Mary's finding, and showed the "phase transition"...**
 - However, it was really Paola Giannetti's full support that convinced Ted to go ahead and push this proposal forward ... Paola is willing to put her full team behind this upgrade!
 - Anwar/Mary/Gene developed L2Cone algorithm, Gene did extensive studies on it, and Laura significantly optimized the L2Cone algorithm speed in the spare L2 decision CPU...

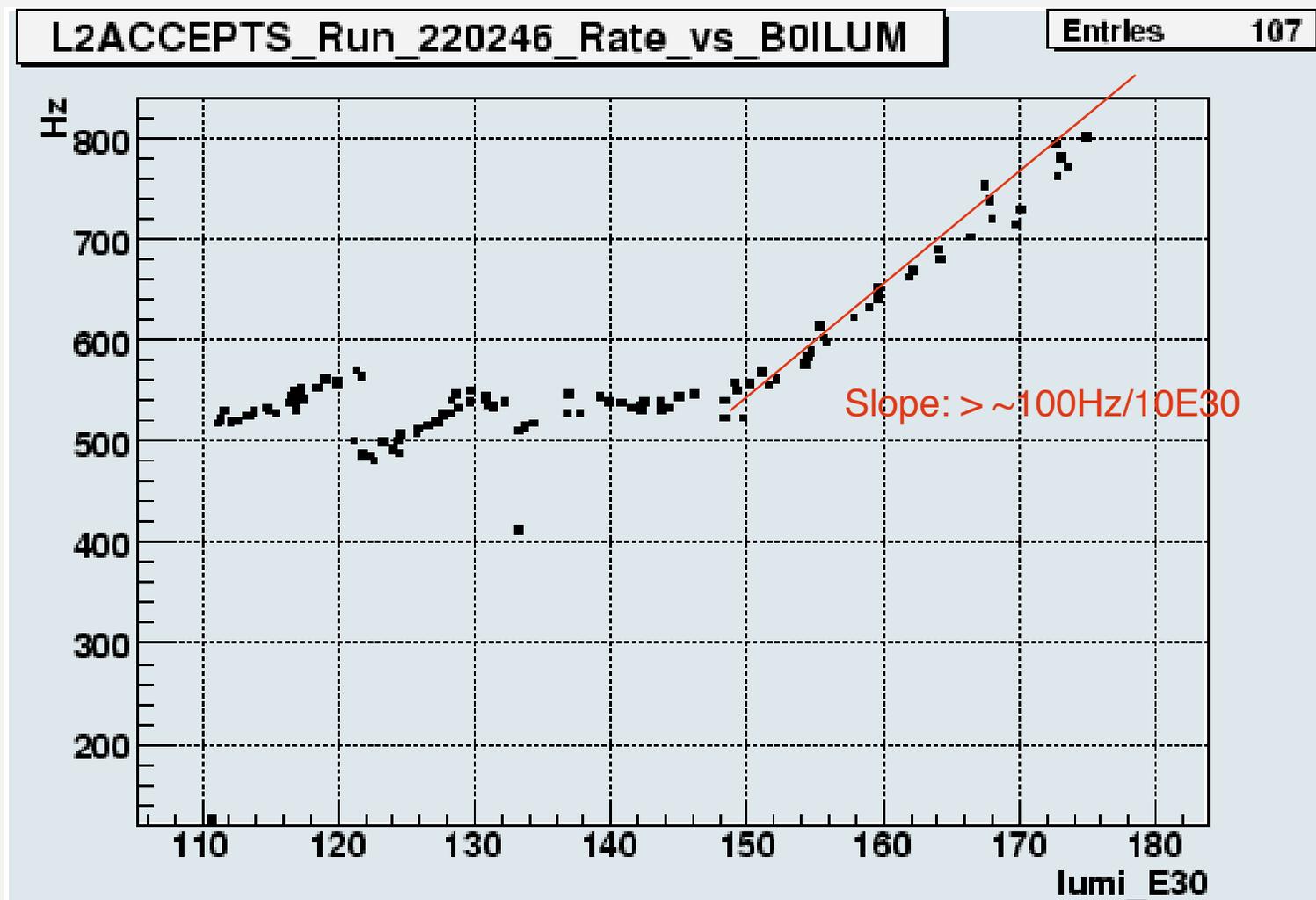


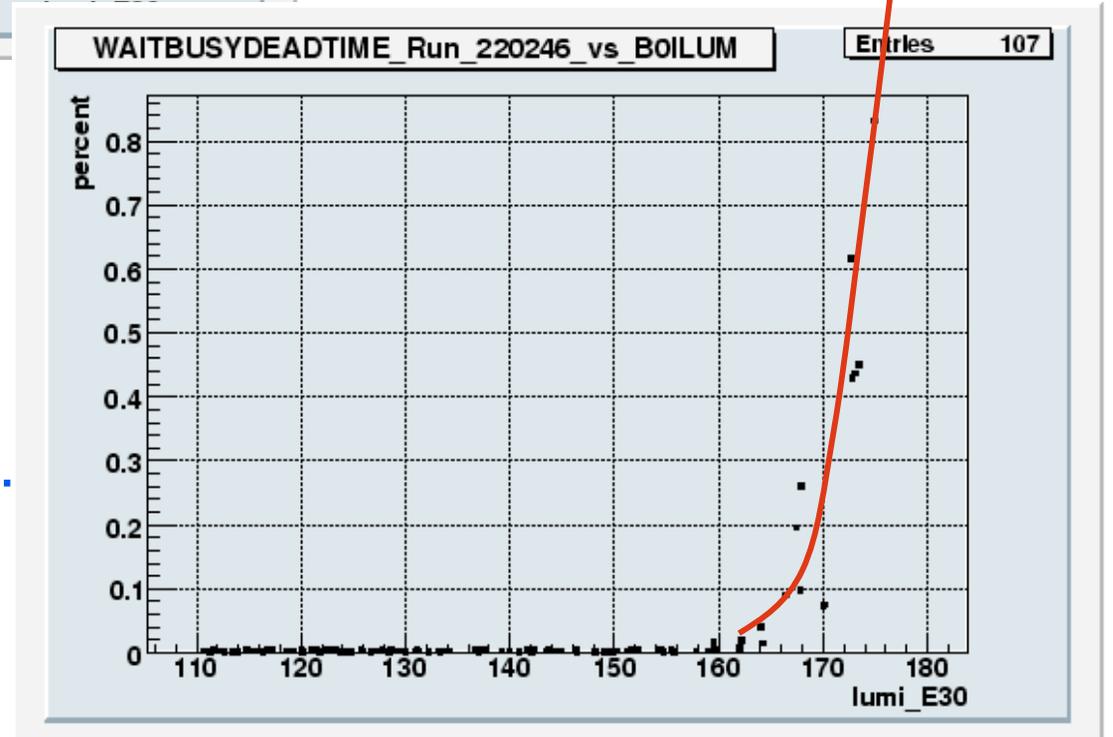
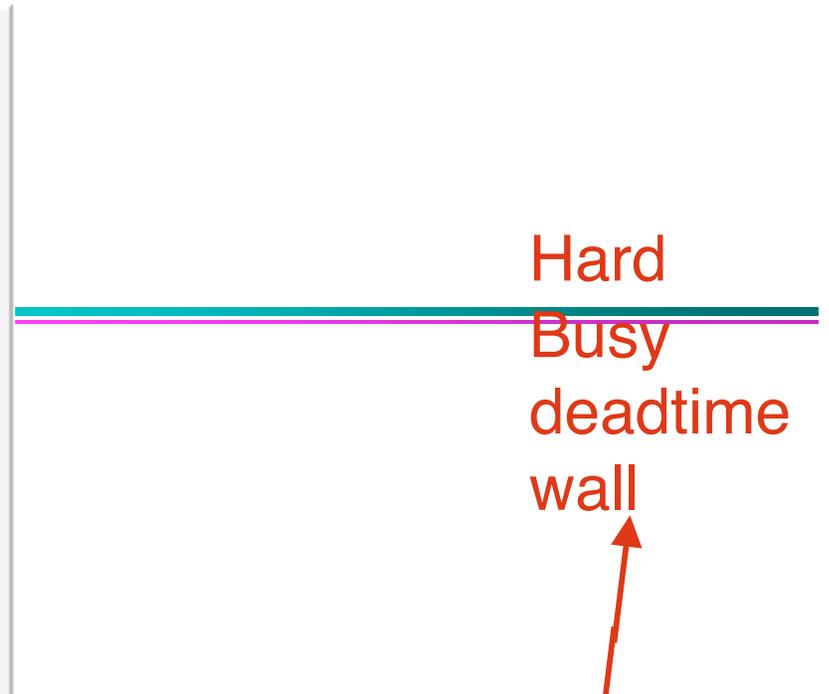
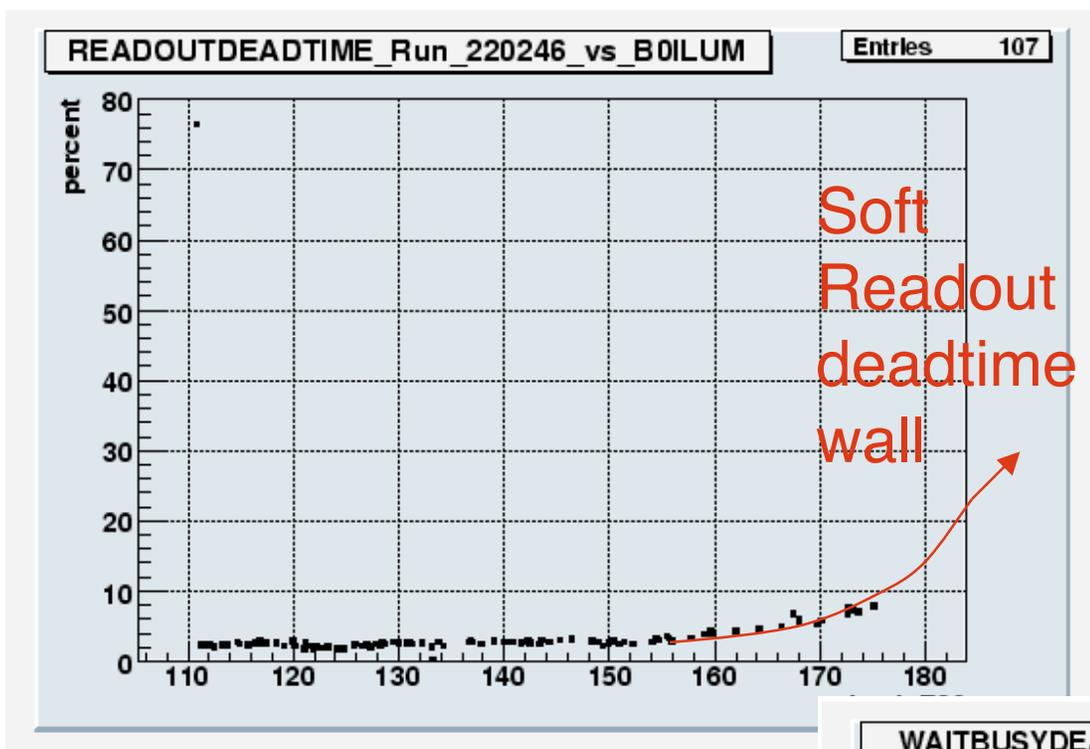
CDF Trigger Performance in 24 seconds...

- L1A bandwidth: $\sim 30\text{KHz}$, no longer a bottleneck for RunIIb
 - ↘ L2 Decision crate and SVT upgrade
 - ↘ XFT upgrade will also improve the L1 purity
- L2A bandwidth: $\sim 1\text{ KHz}$, not enough for RunIIb
 - ↘ Tons of work went into EVB/L3 upgrade, DAQ improvements ...
 - ↘ Significant improvements from $\sim 300\text{ Hz}$ to 1 KHz
 - ↘ Still not enough for RunIIb, L2A already at $\sim 800\text{Hz}$ at $\sim 180\text{E}30$
 - ↘ The problem: L2A cross section grows rapidly with luminosity
 - ↘ Why? Mostly JUNK
 - ↘ **L2 does not have enough information to control the background**



Most recent run (July 23, 2006)





The two great Walls competing for attention...



L2 triggers with high growth term: two types of L2 triggers gone wild...

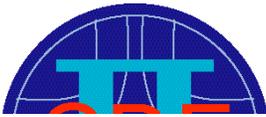
- Track/mu related:
e.g. CMX etc

L2CAL related:
e.g. MET+2JETs

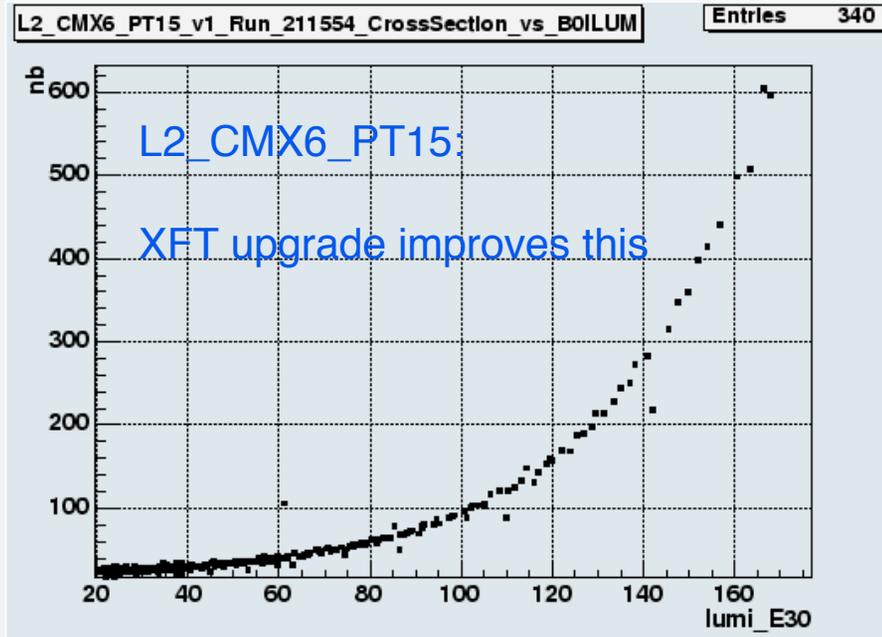
Why? Probably Bad names...

JET: **J**UNK **E**nhanced **T**rigger
MET: **M**ESS **E**nhanced **T**rigger

CMX: **C**ould **M**atch beam**X**



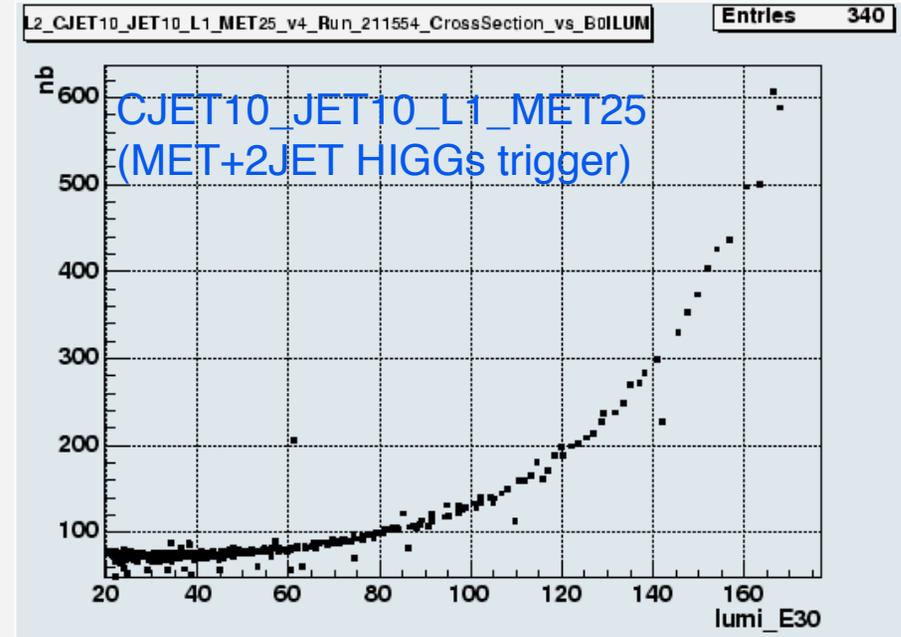
Examples of L2 triggers gone wild



600 nb @ 170E30: ~100 Hz

Bottom line:

Higgs/Top/QCD physics is at stake. Once bandwidth saturated, ALL physics triggers at stake...



Other examples of JET/MET related triggers will go wild in rate at higher luminosity:
MET35, Higgs high-Pt b-jet, Higgs multi-jets ...
JET40/60/90...

also go wild in inefficiency:

Triggers require multi-jets at L2, e.g.

Top_multi_jets (L2_FOUR_JET15_SUMET175) could go TOPLESS at higher luminosity due to jets merging...



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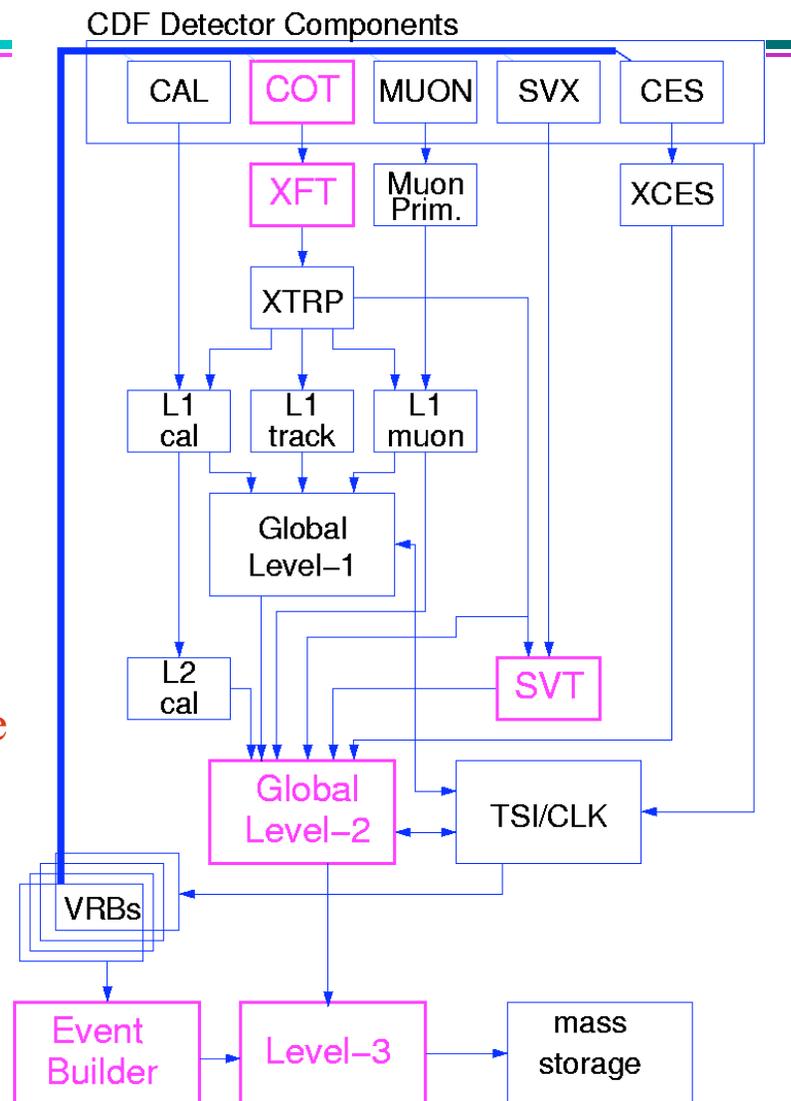
The most effective way to solve the L2A bandwidth problem is to:

improve the trigger purity at L2 ...



How to improve L2 purity? send more information into L2 CPU

- We are already doing it !
 - Send XFT stereo information from L1 Segment Finders to L2 CPU via Pulsars, to improve CMX etc trigger purity ...
 - The information is made available by designing the new stereo Finder boards ...
- Today, we are proposing the same thing for JET/MET related triggers (L2CAL path)
 - Send all 10-bit trigger tower information from L1 DIRACs to L2 CPU via Pulsars, to improve JET/MET trigger purity...
 - The information has already been there in the system, and we have not made use of them!
 - This is a natural thing to do...
 - Will take some real work for sure ...





Wait a second! Do we really have to do this? (I)

- Are you sure the machine luminosity will ever go beyond $200E30$?
 - ↘ We have every reason to believe that it will (past year experience!)
 - ↘ True, every single machine I know is a moving target
 - ↘ We are not 100% for sure it will ever reach $300E30$
 - ↘ We cannot even say for sure it will not go beyond $300E30$
(CESR&PEP-II&KEKB all went way beyond design luminosity at the end)

It does not matter:

One may hope for the worst (to minimize the work), we will have to prepare for the best. Otherwise, why waste our life in the CDF trailer?



Wait a second!

Do we really have to do this? (II)

- OK, let's assume the luminosity will reach $300E30$, but there must be other easy&simple&cheap&lazy way to deal with this!
 - ↘ Sure. The simplest way is to DPS all high rate L2 triggers, and call it the final RunIIb trigger table
 - ↘ It will only take a few hours work for TDWG. We have been practicing this technique a lot in the past few years, mostly to charm and beauty triggers
 - ↘ We have been pretty good at this already. Quite a few Higgs high-Pt or multi-jets triggers are already DPSed in the default trigger table
 - ↘ This would minimize the work load for ALL of us ...:)

Is this really what you want?

The simplest idea of all: beg the machine folks to keep the luminosity low...

It may reduce their work load as well...

Want more discussions on luminosity leveling?



Wait a second!

Do we really have to do this? (III)

- OK, But what if one could improve the L2A bandwidth to, say, ~ 5 KHz? Do we still need to do the L2CAL upgrade? Or, what if one could improve the L1MET at L1 with higher resolution, to reduce the MET+2JET rate?
 - ↘ If we had much more L2A bandwidth, much less work online for sure!
 - ↘ Jet90, MET35, Jet40/60 etc could be saved this way ...
 - ↘ However, still much more work offline....
 - ↘ Top_multi_jets efficiency is inst. luminosity dependent due to jet merging
 - ↘ MET+2JETs efficiency is inst. luminosity dependent due to jet merging
 - ↘ The same is true for any trigger requiring multi-jets...
 - ↘ Offline analysis on systematic could be a lot of fun, making many heroes...
 - ↘ It doesn't really minimize the work for ALL of us



Wait a second!

Do we really have to do this? (cont.)

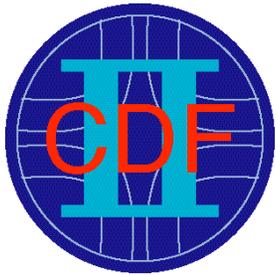
- OK, I got it. This L2CAL upgrade thing is all about survival then: to improve the purity of Jet/Met related triggers so that we have extra bandwidth for other triggers...
 - No, it is not just about survival, it is really about how to live gracefully...
 - L2Cone algorithm is much less sensitive to luminosity... the trigger efficiency is more robust against inst. Luminosity... much easier life offline...
 - Finer resolution MET sharpens the turn-on curve: possibility to lower the threshold.
 - L2CAL upgrade allows more sophisticated algorithms to be implemented in software... JET/MET can be made nearly equivalent to offline quality
 - Many new opportunities for additional improvements in trigger purity and performance, most notably for Higgs and exotics triggers, with such information available at L2 as dijet mass, delta-Phi between jets or between a jet and MET, sum Et of the cluster, better jet-SVT matching for b-jets, improvements in tau triggers
 - With the L2CAL Pulsar upgrade, we could really push the Higgs/exotics search sensitivity beyond the baseline ... to make sure we have the best shot for discovery
 - Keep in mind: we are not alone in the Tevatron Universe ... D0 has just upgraded its L1CAL with more sophisticated capability at L1...

“We need to have trigger datasets with broad bandwidth for discovery”
--- Jaco Konigsberg, the CDF spoke, has spoken



Wait another second, Do we have enough man/woman power to do this?

- For long, I have heard horrible stories that nowadays it is very hard to find people to even take care of the CDF operation ...
- This is so not true with the L2CAL Pulsar upgrade
- There are people who HATE the L2CAL upgrade, for whatever reasons
- Still, there are MANY brave people who are highly motivated to work on this upgrade
- It has been a “phase transition” in the past few months around the trigger workshop on May 12th... all started from hall-way talking ... no single bottle of beer was even involved
- Pisa, Rockefeller, Purdue, UC, Academia Sinica, Madrid, Padova, Frascati ...
- I am **TOTALLY** impressed that there is still **SO MUCH** energy within CDF. All it takes is to inspire them...



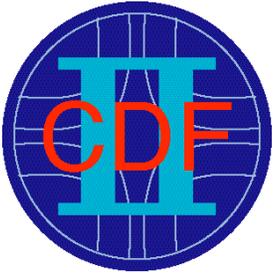
The man/woman power: only people with > 20% time shown

- Engineers:
 - ↘ Marco Piendibene (50%): Pisa (Pulsar firmware expert)
 - ↘ Lucas Rogondino (100%): Pisa engineer student
 - ↘ Mircea Bogdan or Fukun tang, Harold Sanders (part time): UC engineers, Pulsar hardware experts
 - ↘ Richard Northrop (part time): UC mechanical engineer for cabling
 - ↘ Davis Pantano (30%): Padoca technician
- Physicists: postdocs
 - ↘ **Laura Satori (100%): pisa**
 - ↘ **Gene Flanagan (100%): Purdue**
 - ↘ Giorgio Cortiana (100%): Padova, available soon
 - ↘ New Padova postdoc (100%): available end of year
 - ↘ New U. Chicago postdoc from Henry (100%): end of year
- Physicists: Ph.D students
 - ↘ Miguel Vidal (100%): Madrid, available Sept. 2006
 - ↘ Michael Schmidt (30%): U. Chicago (Y.K. Kim), available Sept. 2006



So how much it would cost?

- **No Pain, No Gain....** As we all learned. We are not cheap...
 - ↘ In order to interface with L1 DIRAC, we need to design a new mezzanine card, and we need 72 of them (i.e. build ~100 of them). **The total cost is about \$50K.**
 - ↘ We already have 92 Pulsar boards for CDF: 36 for SVT+9 for L2D + 6 for XFT = 51. Still 41 left. However, L2CAL upgrade takes 24 Pulsars... so only 17 Pulsars left.
 - ↘ This is clearly not enough, given all the test stand needs for the official projects at different places, and the unofficial XFT project needs, hot spares for operation ... etc
 - ↘ Also depends on how many other upgrade proposals will be approved...
 - ↘ The last thing we want to see is to run out of Pulsar boards.
 - ↘ I would strongly suggest that we order ~25 Pulsar boards if the L2CAL upgrade is approved...
 - ↘ **This would cost 25 x \$4K ~ \$100 K**, bring the total to \$150K
 - ↘ Plus ~30% contingency: \$50K + \$150K ~ \$200K. This is the price tag for doing the dirty work for CDF...

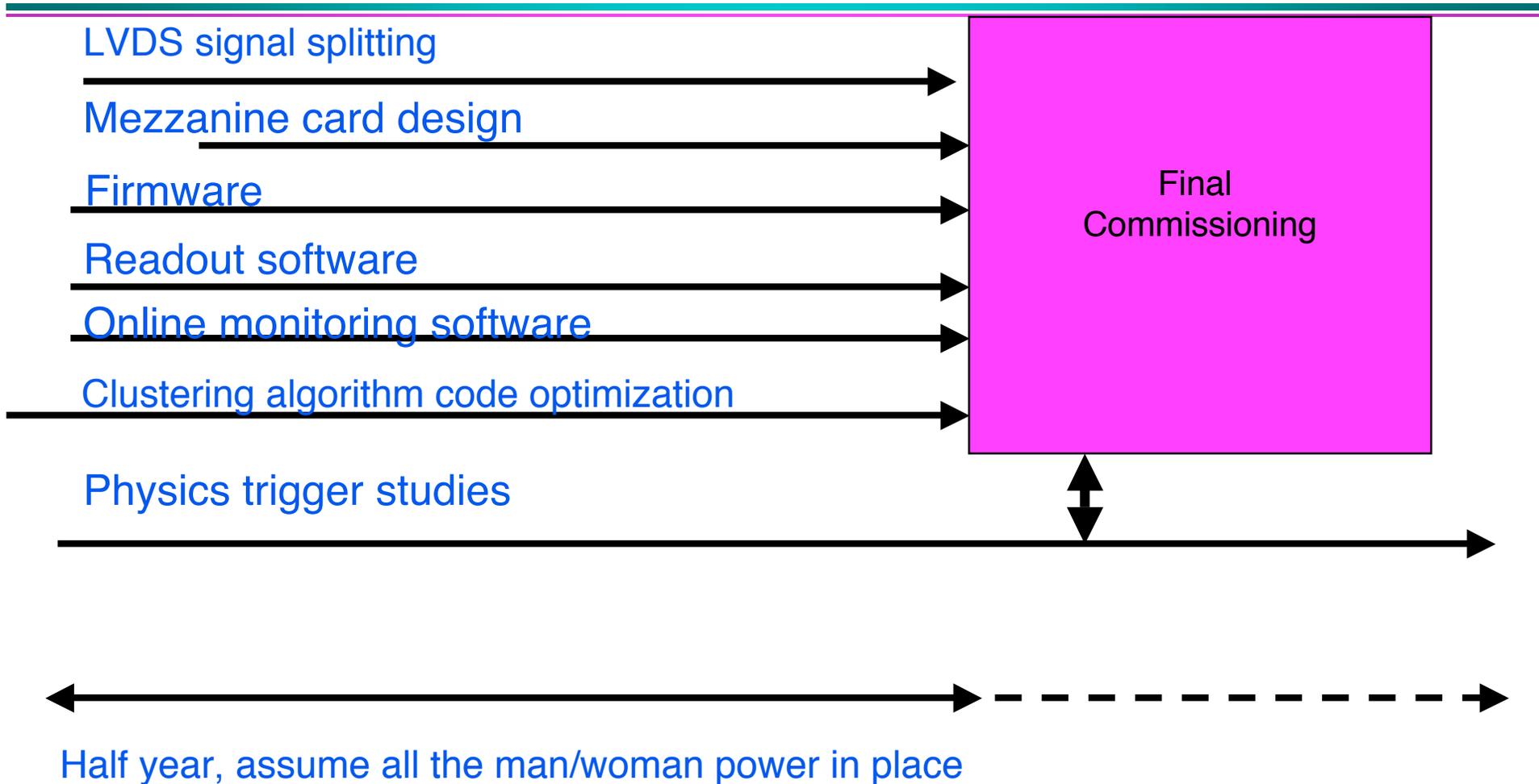


So how long it would take?

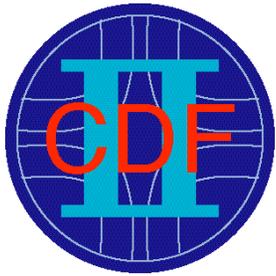
- Strongly depends on the people involved
 - ↘ It could take > 1 year to just change a simple firmware...
 - ↘ We have the best people on the case... with excellent track-record
 - ↘ With good people involved, strong leadership is the key....
 - ↘ Laura will be in charge of the technical aspects
 - ↘ Gene will be in charge of the physics trigger aspects
 - ↘ Paola/Henry/Mary/Matthew/Ted/etc will help
 - ↘ We expect ~ 6 months to finish the hardware installation. It typically takes another few months to fully make use of the new L2CAL trigger capabilities in the official trigger table, based on past experiences.
 - ↘ However, we will seek ways to shorten this time, by parallel processing...



Tasks involved



We are familiar with all the tasks...



The Lockyer's committee -- it is now in your hands

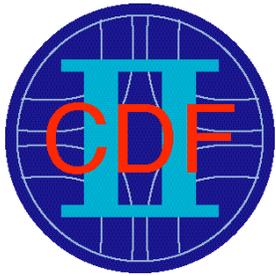


A BOLD BLUFF



Backup slides

- A few on hardware configuration



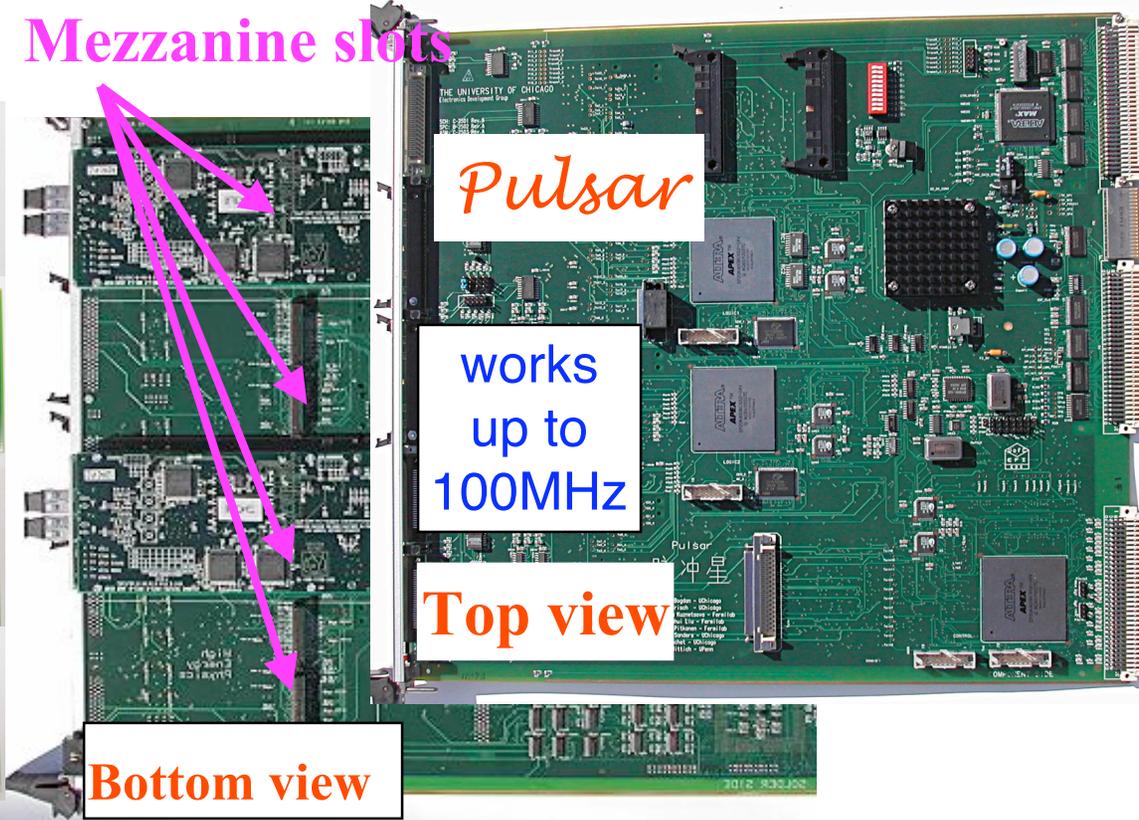
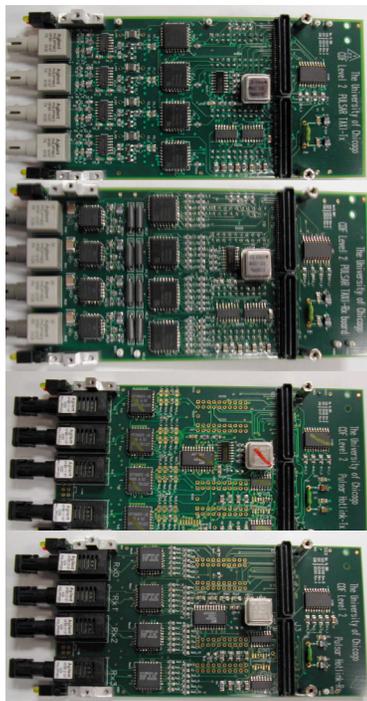
Pulsar Design

→ modular/universal/self-testable

Custom
mezzanine

Mezzanine slots

AUX card

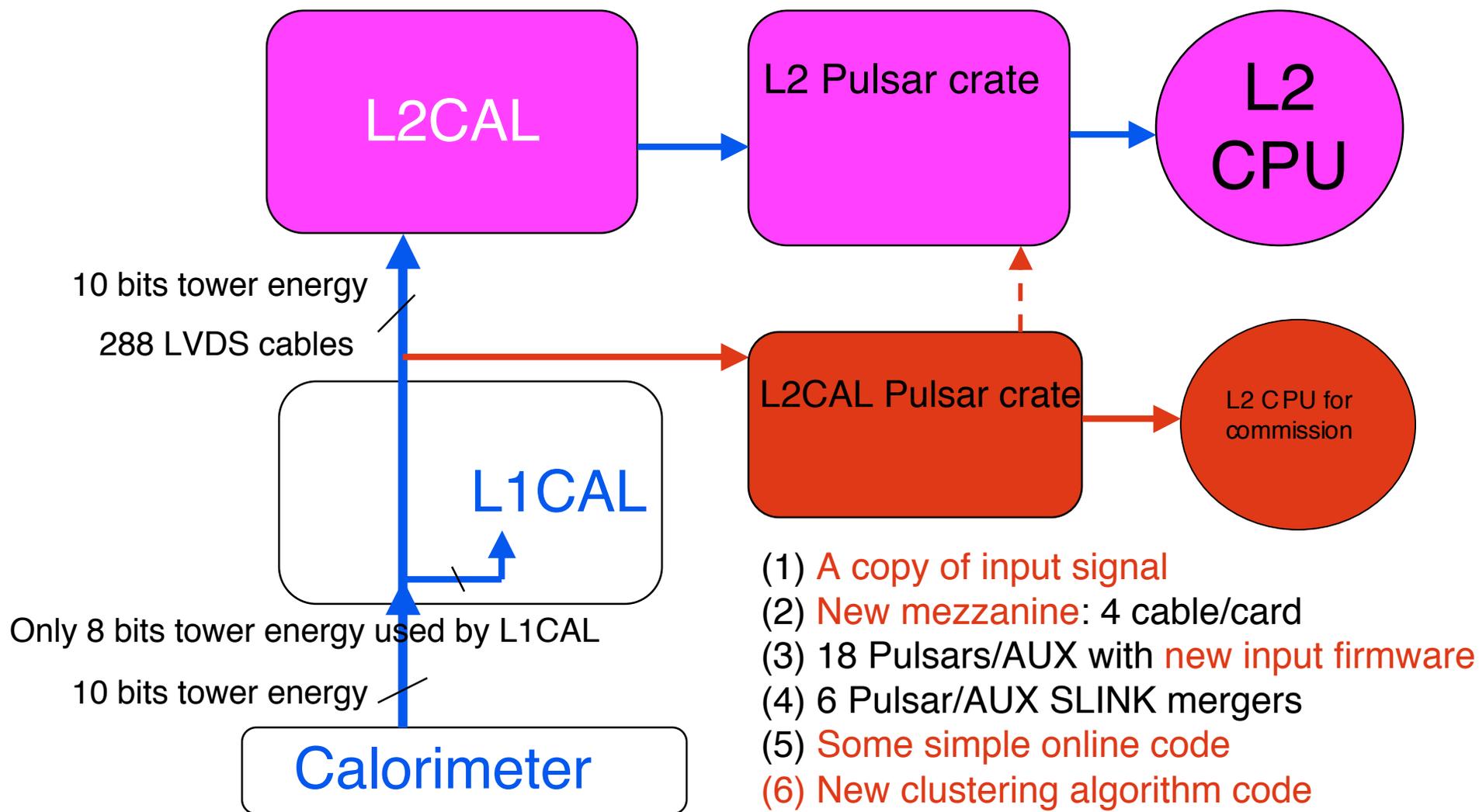


*Since most of the upgrade proposals are using Pulsar boards,
This slide is a backup slide.*



What's involved?

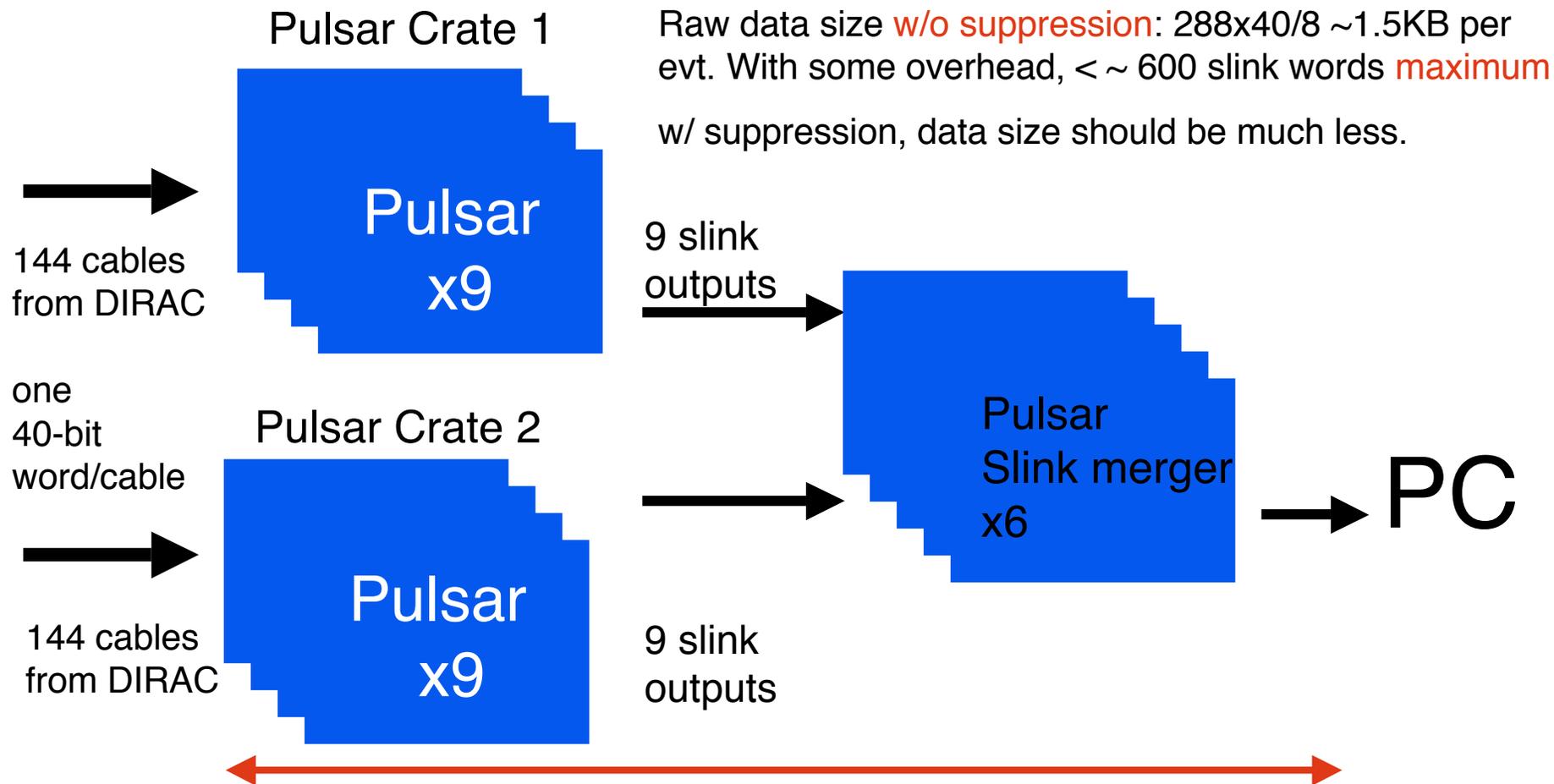
-- only CAL related shown: concept





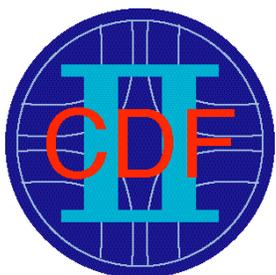
Pulsar Cluster

(1 Pulsar: 4 mezzanine x 4 cable = 16) x 18 = 288 input cables total

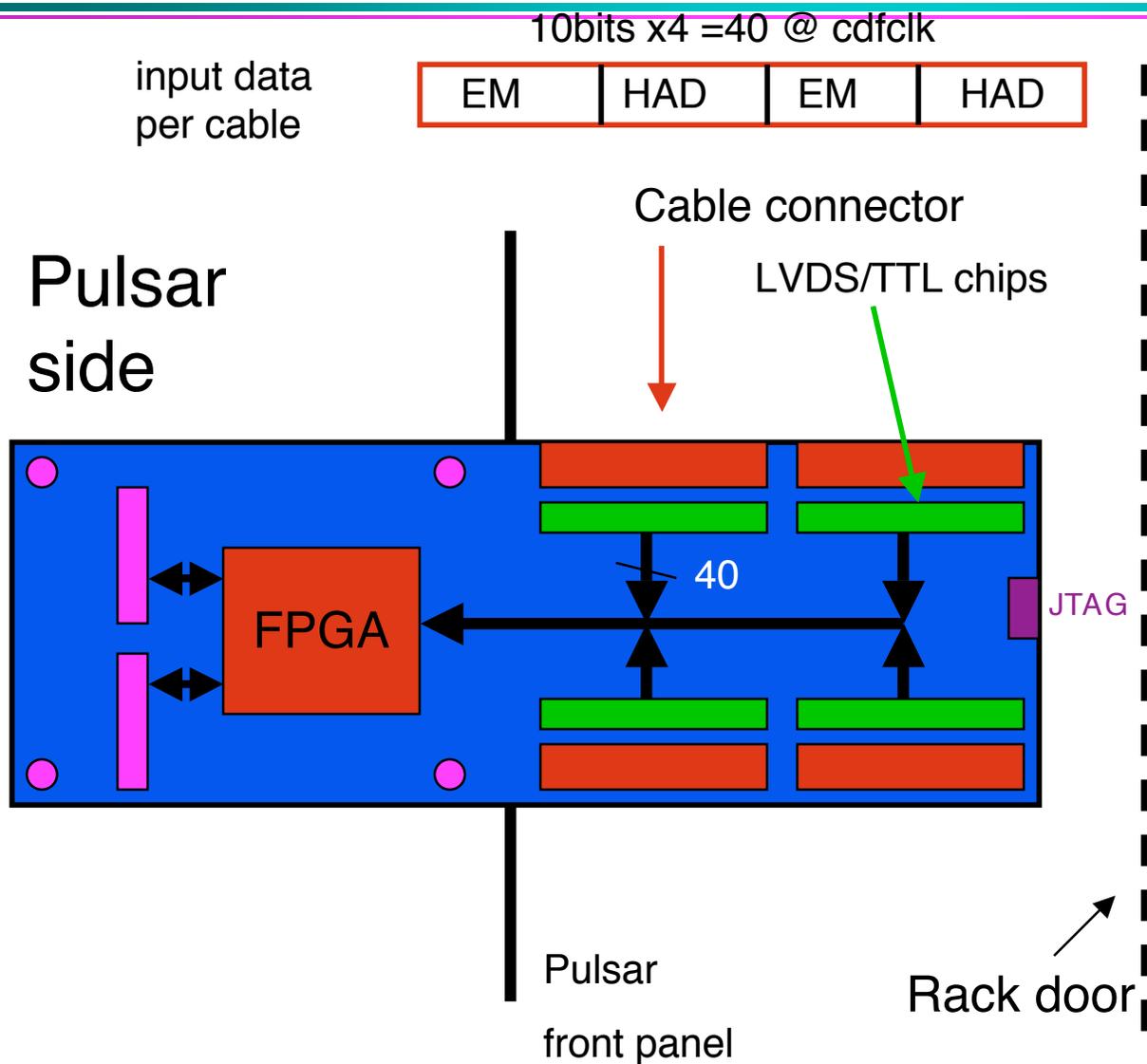


Raw data size **w/o suppression**: $288 \times 40 / 8 \sim 1.5\text{KB}$ per evt. With some overhead, $< \sim 600$ slink words **maximum**
w/ suppression, data size should be much less.

The average data transfer latency after L1A~ expected within in $\sim 10\ \mu\text{s}$
Note: unlike other L2 paths, CAL data already available at L2 input upon L1A



Mezzanine card design concept



Cost estimate:

72 needed ~ 100

< \$300 per card

(dominated by FPGA)

< \$30K for mezzanine

~2 weeks engineer time

25 AUX cards

+ long cables

Total cost of the project:

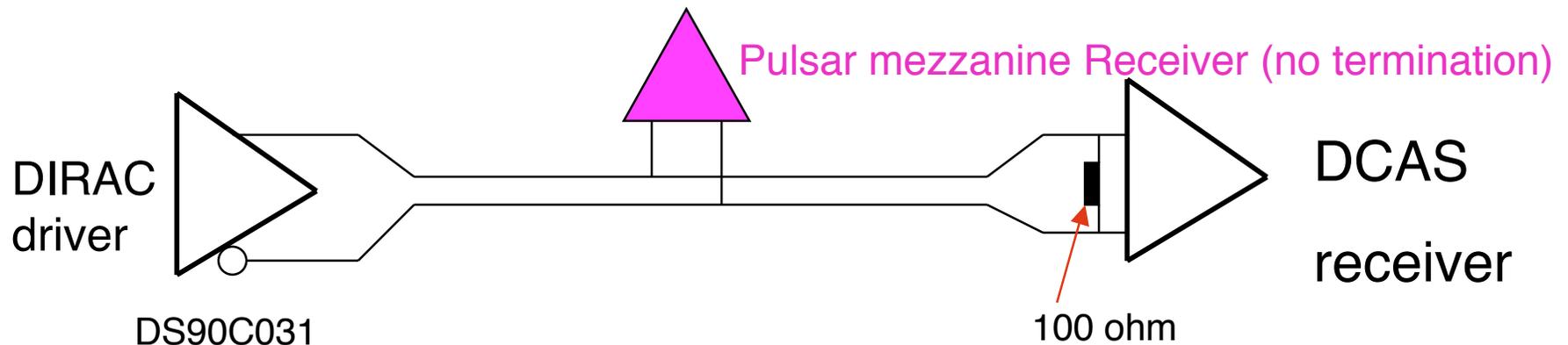
< ~ \$50K

Have just enough spare Pulsars to do this job



How to copy the input signal? -- for parasitic running, crucial for commissioning

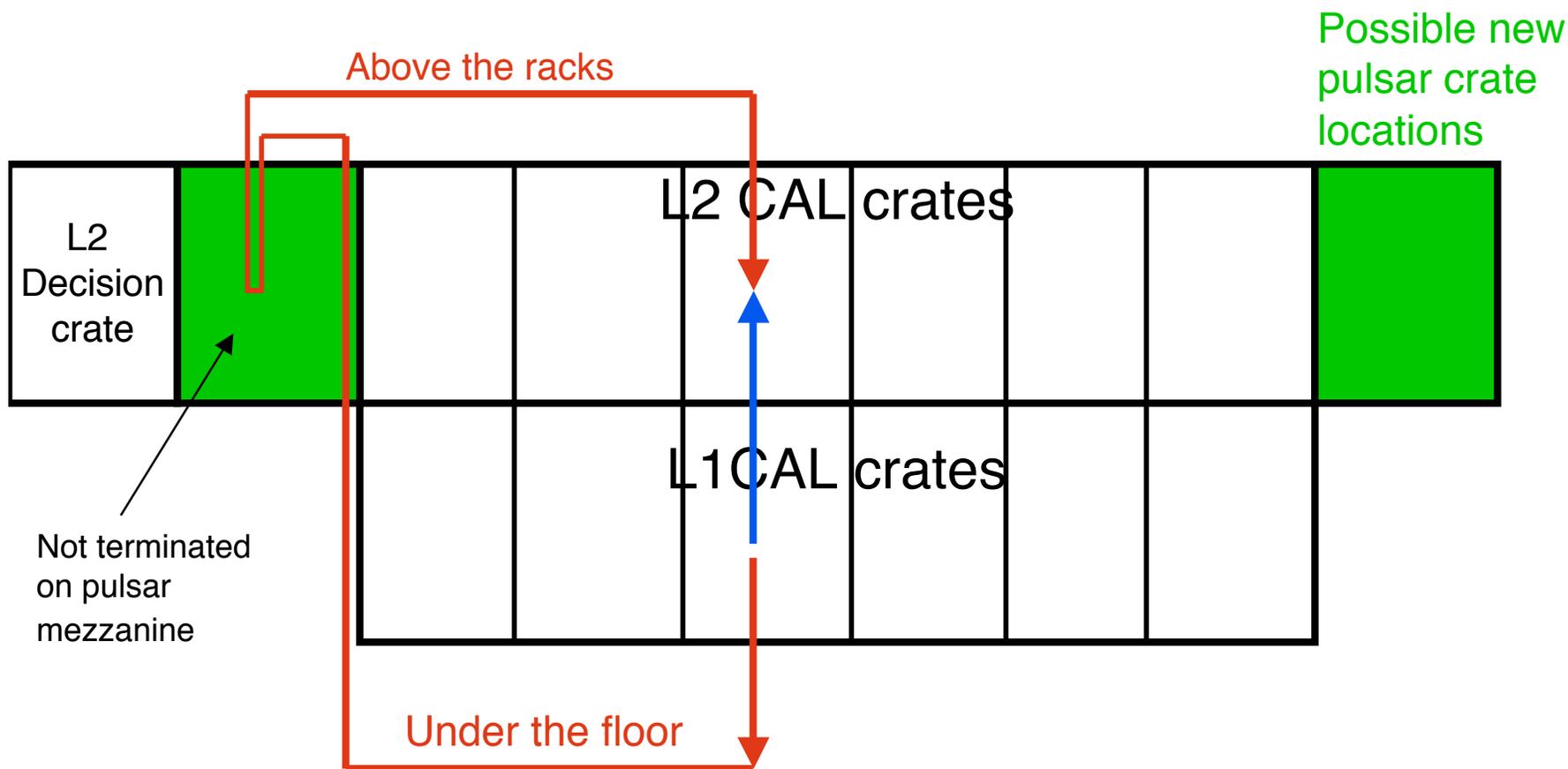
- In principle, one could design a special splitter board.
- Or can use LVDS multi-drop property to get a copy:



Need to make longer LVDS cables
Actual cabling needs to be clean:
with help from JDL



New Cabling at trigger room



Commissioning can be done **in pure parasitic mode**, using the spare decision CPU, along with a copy of all other L2 data paths information