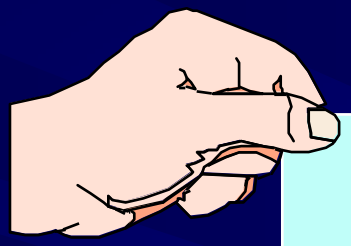
What next → Snowmass



Menu

By P. Le Dû

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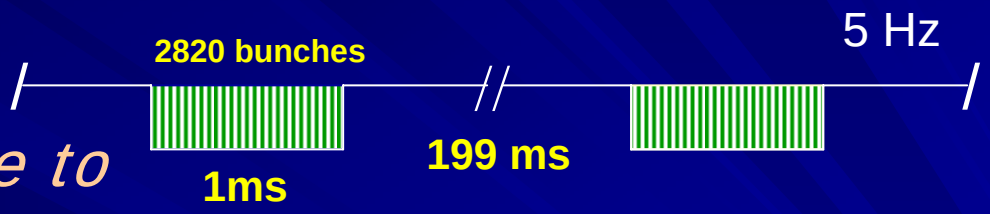
- Basic parameters and constraints
- Detector concepts
- Front end electronics and read out issues
- Data collection architecture model
- SoftwareTrigger concept
- Snowmass program → suggestions

LCWS05 Stanford

Conditions

Recent International decision: « cold » machine ' à la Tesla'



Machine parameters close to

- 2 x 16 km superconducting

Linear **independant** accelerators

- 2 interaction points

→ **2 detectors**

- Energy
  - nominale : 500 Gev
  - maximum : 1 Tev
- IP beam size ~ few μm
- L= 2. 10 ^{34} cm^{-1}s^{-1}

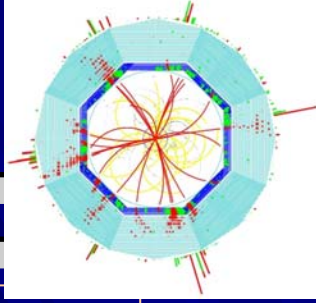
The LC is a pulsed machine

repetitian rate	5
bunches per train	**2820 → x 2 ?**
bunch separation	337 ns
train length	950 ns
train separation	199 ms

-> long time between trains

(short between pulses)

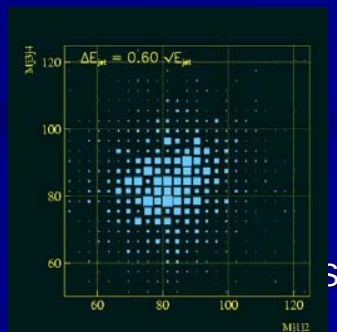
ILC vs LEP/SLD



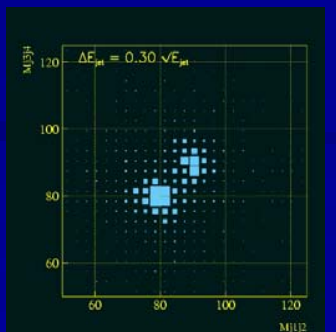
- Jets & leptons are the fundamental quanta at the ILC. They must be identified & measured well enough to discriminate between Z's, W's, H's, Top, and new states. **This requires improving jet resolution by a factor of two. Not trivial!**
- Charged Particle tracking must precisely measure 500 GeV/c (5 x LEP!) leptons for Higgs recoil studies. …. **This requires 10 x better momentum resolution than LEP/SLC detectors and 1/3 better on the Impact Paramater of SLD!**
- To catch multi-jet final states (e.g. t tbar H has 8 jets), need real 4π solid angle coverage with full detector capability. **Never been done such hermiticity & granularity!**

LEP-like resolution

$60\%\sqrt{E}$



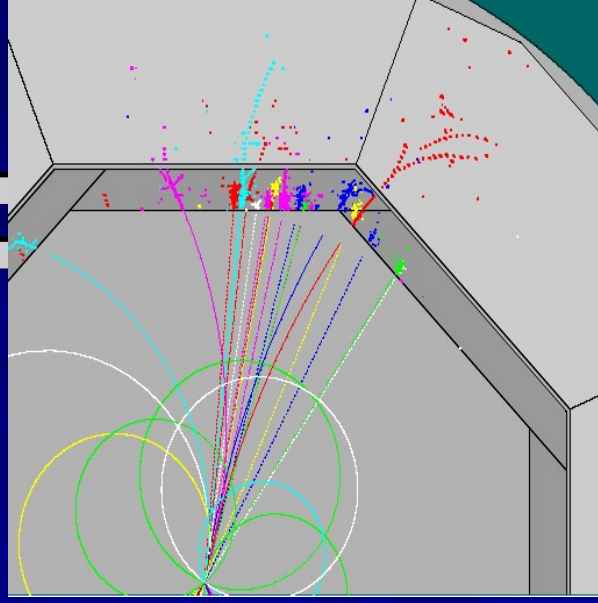
2 Jets separation



ILC goal

$30\%\sqrt{E}$

ILC vs LHC

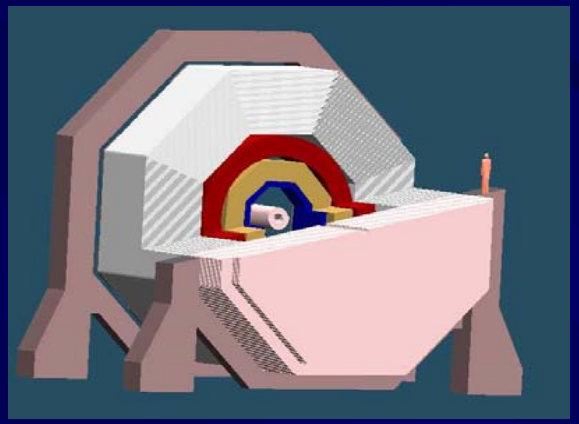


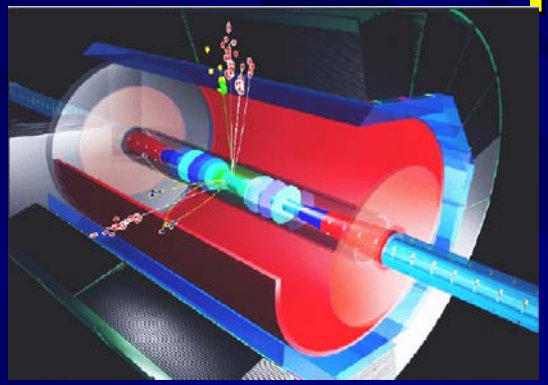
- **Less demanding ….**
  LC Detector doesn't have to cope with multiple minimum bias events per crossing,
  high rate triggering for needles in haystacks,
  radiation hardness…
  → hence many more technologies available, better performance is possible.

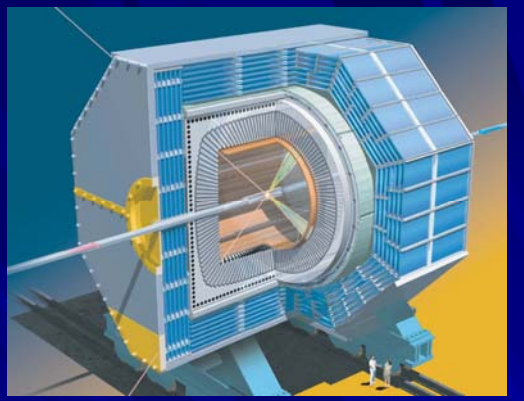
- **BUT →** LC Detector does have to cover full solid angle, record all the available CM energy, measure jets and charged tracks with unparalleled precision, measure beam energy and energy spread, differential luminosity, and polarization, and tag all vertices,…
  → hence better performance needed, more technology development needed.

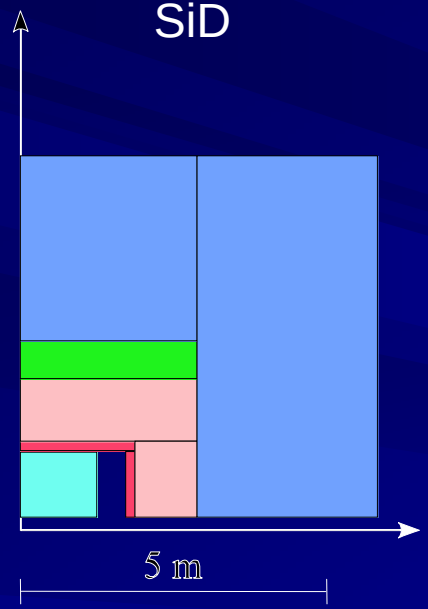
- **Complementarity with LHC → discovery vs precision**
  The 'Particle flow' paradigm in calorimeters !
  → LC should strive to do physics with ***all*** final states.
  Charged particles in jets more precisely measured in tracker
  Good separation of charged and neutrals

Detector concepts

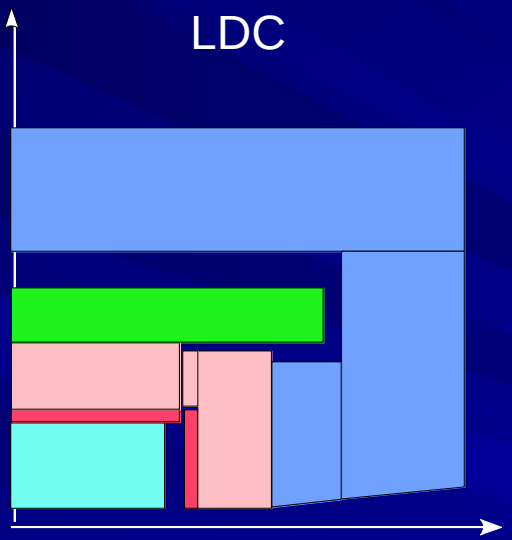




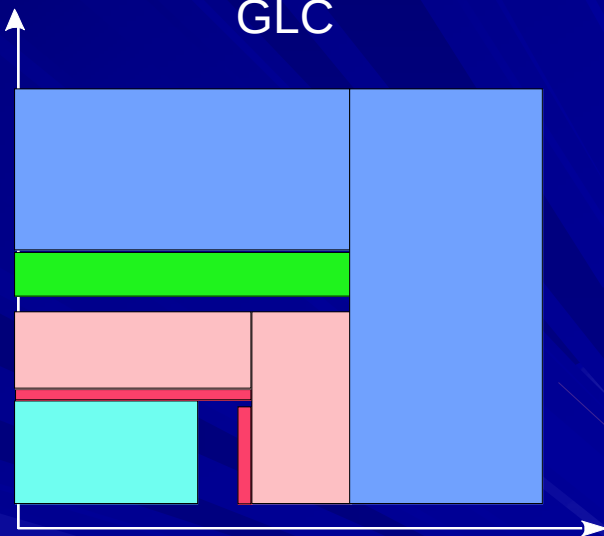




- Si Strips
- SiW EM
- 5 Tesla



- Large gaseous central tracking device (TPC)
- High granularity calorimeters
- High precision microvertex
- All inside 4 T magnetic field



- Large Gazeous Tracker → JET,TPC
- W/Scint EM calor.
- 3 Teslas solenoid

Evolution of basic parameters

Exp. *Year*	Collision rate	Channel count	L1A rate	Event building	Processing. Power	Sociology
UA's *1980*	3 μsec	-	-	-	5-10 MIPS	150-200
LEP *1989*	10-20 μsec	250 - 500K	-	10 Mbit/sec	100 MIPS	300-500
BaBar *1999*	4 ns	150K	2 KHz	400 Mbit/s	1000 MIPS	400
Tevatron *2002*	396 ns	~ 800 K	10 - 50 KHz	4-10 Gbit/sec	5.10^4 MIPS	500
LHC *2007*	25 ns	200 M*	100 KHz	20-500 Gbit/s	$>10^6$ MIPS	2000
ILC *2015 ?*	330 ns	900 M*	3 KHz	10 Gbit/s	$\sim 10^5$ MIPS	> 2000 ?

** including pixels*

Sub-Detector	LHC	ILC
Pixel	150 M	800 M
Microstrips	~ 10 M	~30 M
Fine grain trackers	~ 400 K	1,5 M
Calorimeters	200 K	30 M
Muon	~1 M	

Summary of present thinking

The ILC environment poses new challenges & opportunities which will need new technical advances in VFE and RO electronics → **NOT LEP/SLD, NOT LHC !**

- Basic scheme: The FEE integrates everything
  - →From signal processing & digitizer to the RO BUFFER …
- Very large number of channels to manage (Trakers & EM)
  - →should exploit power pulsing to cut power usage during interburst
- New System aspects (boundaries ..→ GDN !)
- Interface between detector and machine is fundamental
  - →optimize the luminosity → consequence on the DAQ
- Burst mode allows a fully software trigger !
  - →Looks like the Ultimate Trigger: Take EVERYTHING & sort later !

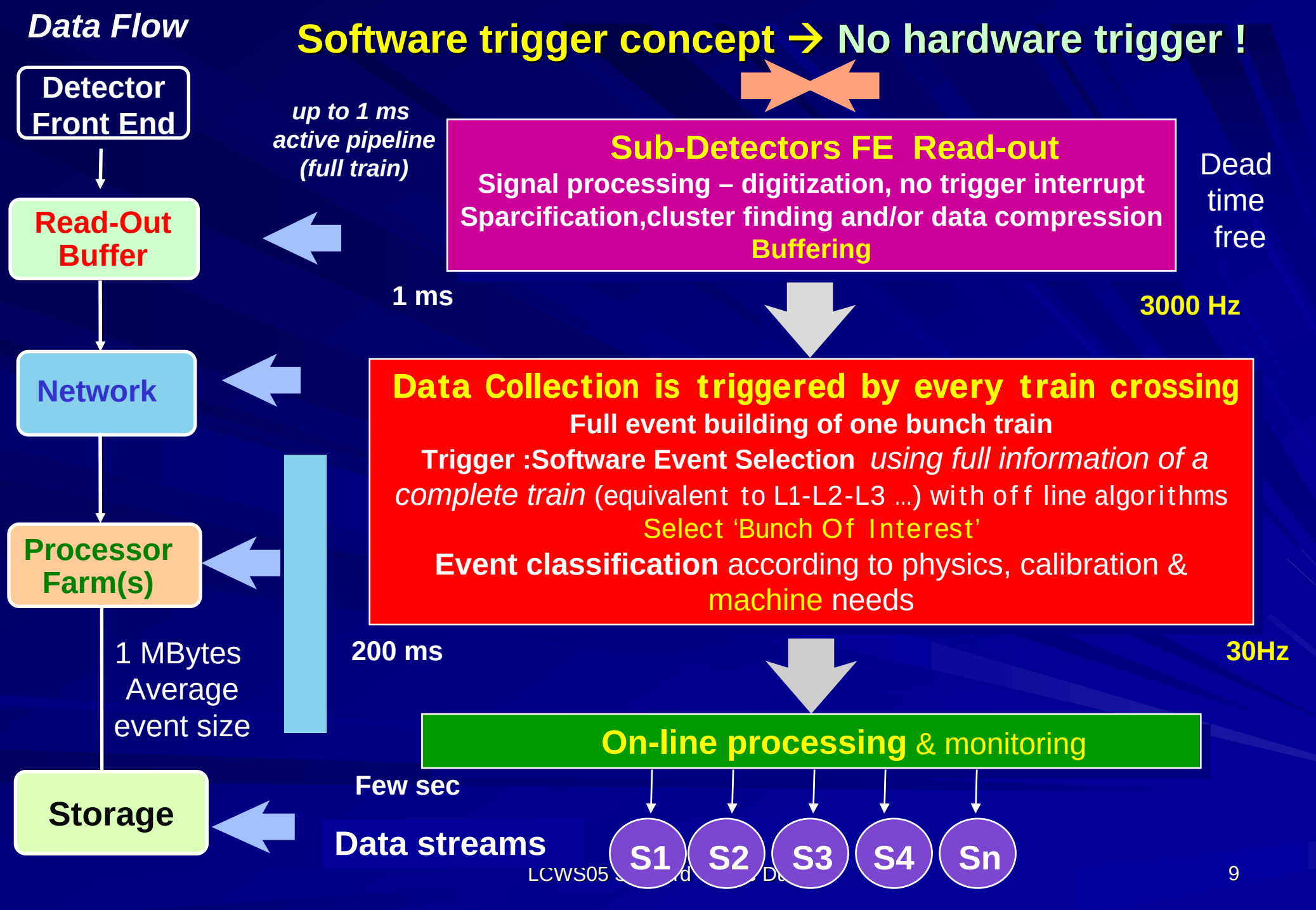
→ GREAT! A sociological simplification!

Technology forecast (2005-2015)

- **FPGA for signal processing and buffering**
  - Integrates receiver links, PPC, DSPs and memory ….
- **Processors and memories**
  - Continuous increasing of the computing power
    - More's law still true until 2010! Expect x 64 by 2015!
- **Memory size quasi illimited !**
    - Today : 256 MB
    - 2010 : > 1 GB … then ?
- **Links & Networks:**
  - Commercial telecom/computer standards
  - 10 -30- 100 GBEthernet !

Systematic use of COTS products

⇨ make decision at T0 minus 2-3 years!


Data Flow
Software trigger concept → No hardware trigger !
Detector Front End
Read-Out Buffer
Network
Processor Farm(s)
1 MBytes Average event size
Storage
up to 1 ms active pipeline (full train)
Sub-Detectors FE Read-out
Signal processing – digitization, no trigger interrupt
Sparcification,cluster finding and/or data compression
Buffering
Dead time free
1 ms
3000 Hz
Data Collection is triggered by every train crossing
Full event building of one bunch train
Trigger :Software Event Selection using full information of a complete train (equivalent to L1-L2-L3 …) with off line algorithms
Select 'Bunch Of Interest'
Event classification according to physics, calibration & machine needs
200 ms
30Hz
On-line processing & monitoring
Few sec
Data streams
S1
S2
S3
S4
Sn

Advantages → all

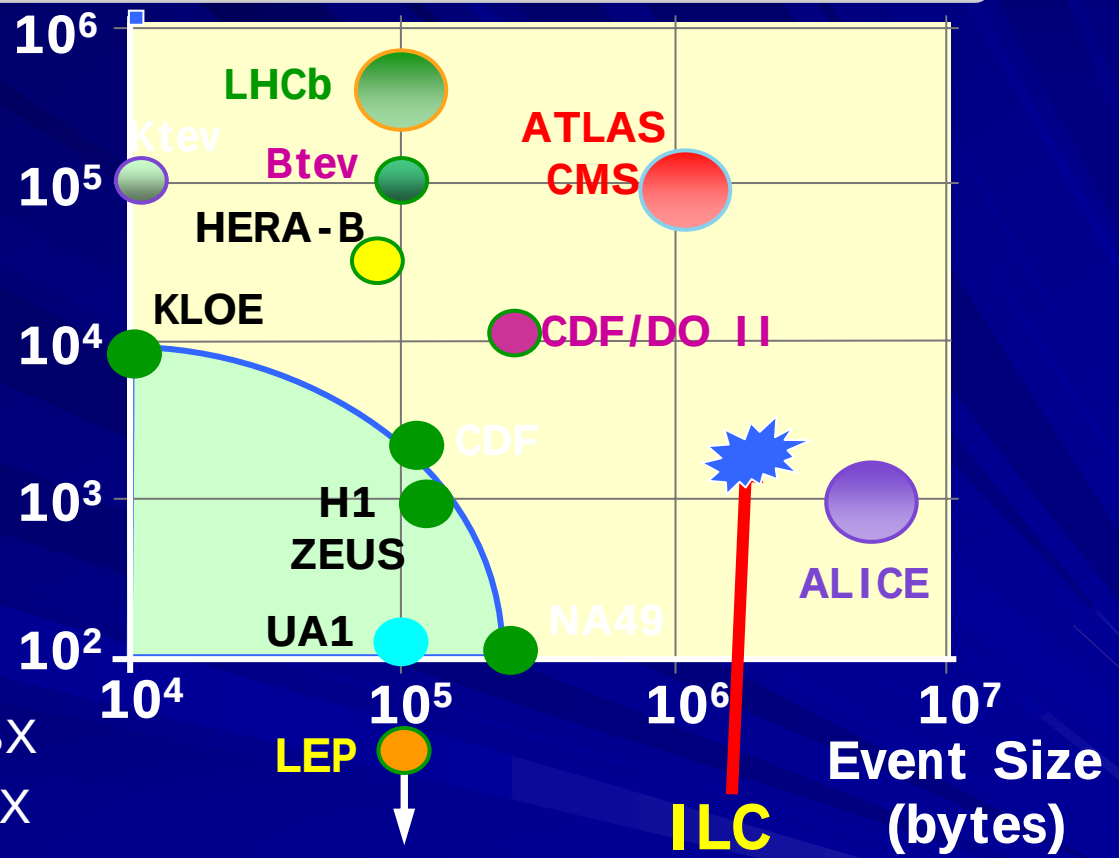
- **Flexible**
  - fully programmable
  - unforeseen backgrounds and physics rates easily accomodated
  - Machine people can adjust the beam using background events
- **Easy maintenance and cost effective**
  - Commodity products : Off The Shelf products (Links, memory,switches, processors)
  - Commonly OS and high level languages
  - on-line computing ressources usable for « off-line »
- **Scalable :**
  - modular system

Looks like the ‘ ultimate trigger ’

→ satisfy everybody : no loss and fully programmable

Estimates Rates and data volume

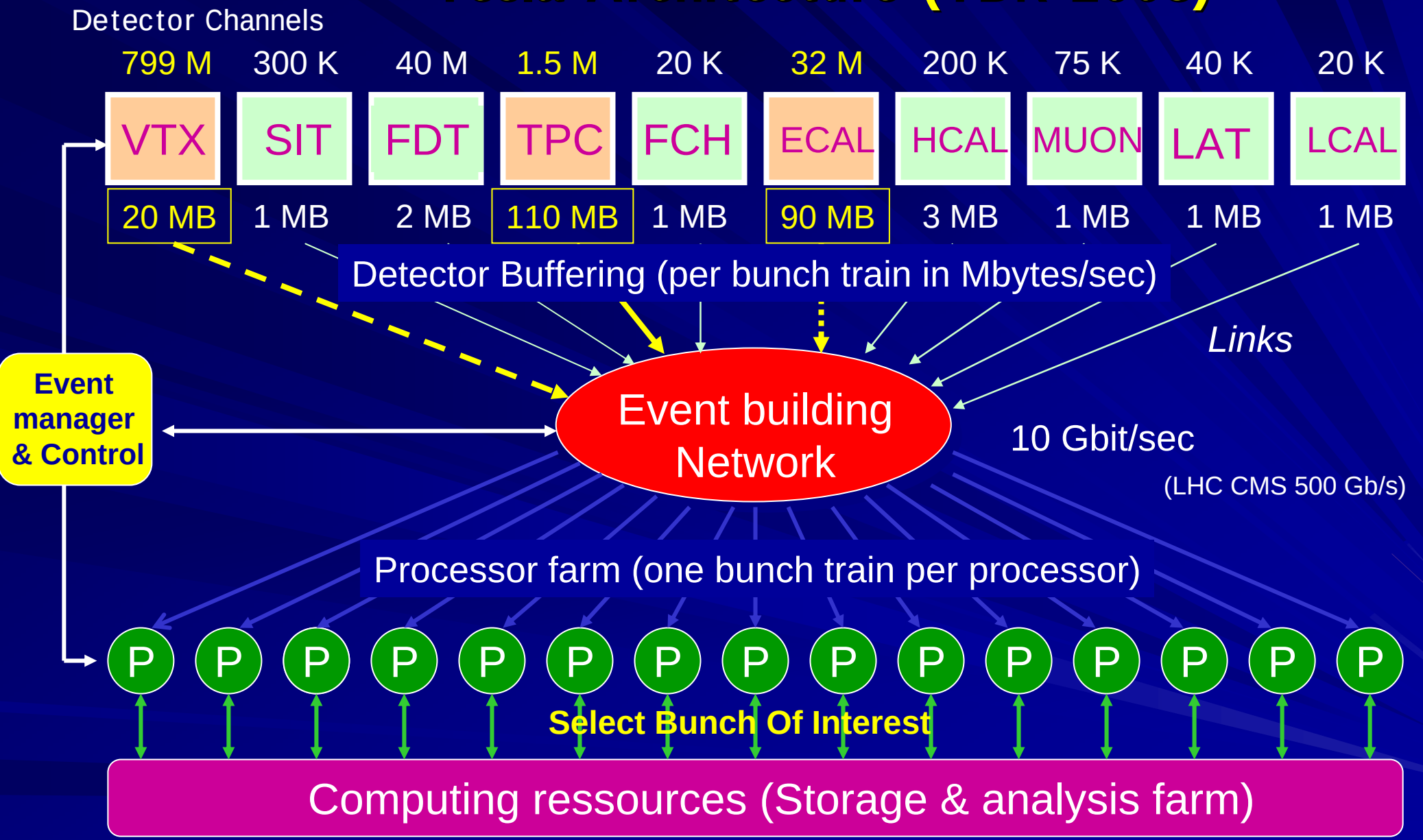
High Level-1 Trigger
(1 MHz)



- *Physics Rate :*
  - e+ e- → X 0.0002/BX
  - e+ e- → e+ e- X 0.7/BX
- *e+ e- pair background :*
  - VXD inner layer 1000 hits/BX
  - TPC 15tracks/BX

-> Background is dominating the rates !

Tesla Architecture (TDR 2003)



30 Mbytes/sec → 300TBytes/year

About systems boundaries …..moving due to !
→ evolution of technologies,sociology ……

NEW !

Machine
Synchronization
Detector feedback
Beam BT adjustment

Subdetectors FE Read out
Signal processing
Local FE Buffer

Uniform interface

Full Integration of Machine DAQ In the data collection system

Read out Node
Partitionning (physical and logical)

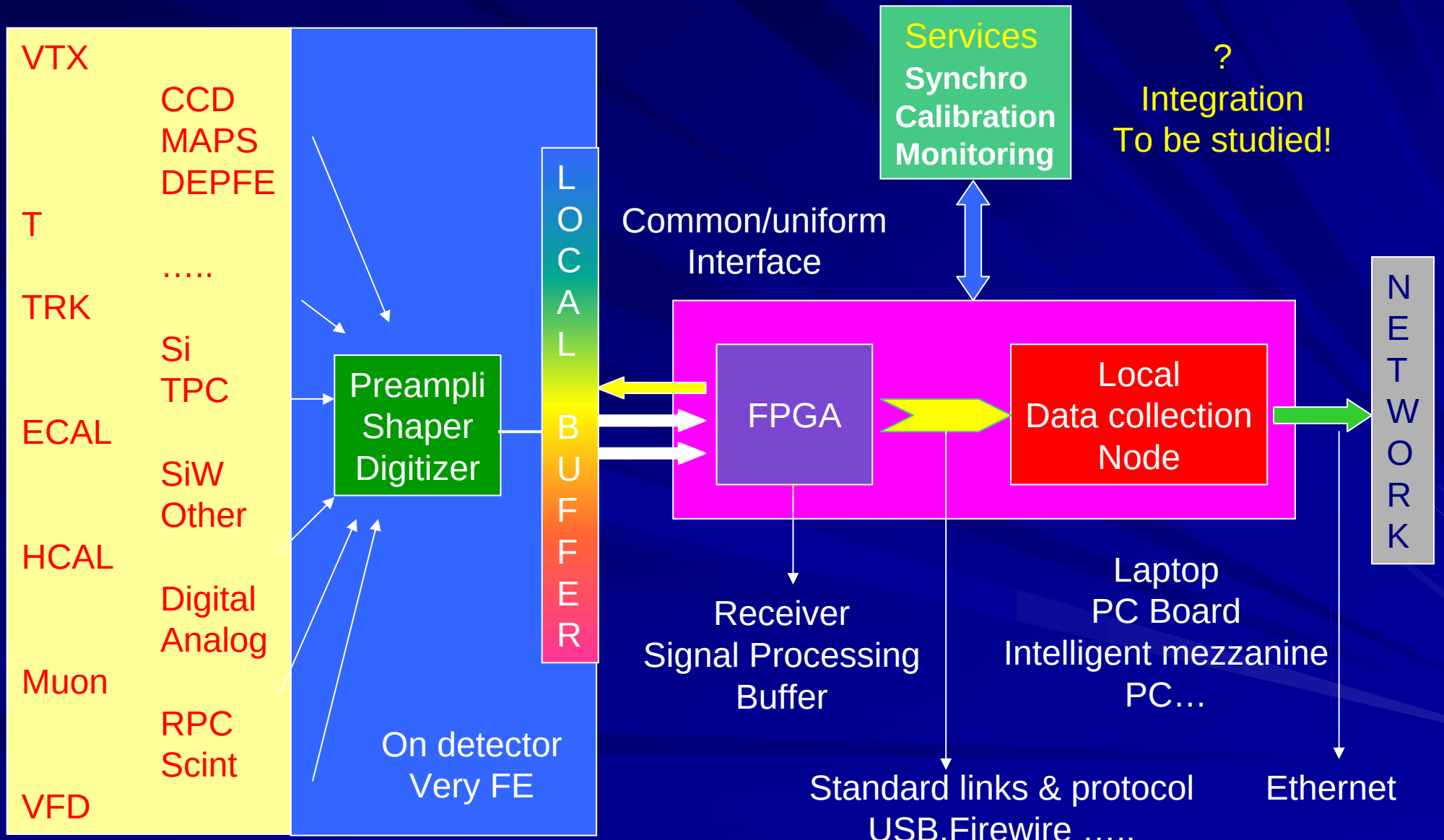
Global Detector Nerwork (worlwide)

- Detector Integration
- Remote Control Rooms (3)
  - Running modes
    - Local stand alone
    - Test
    - Global RUN
  - Remote shifts
    - Slow control
    - Detector Monitoring
- Physics & data analysis (ex On- Off line)
  - Farms
  - GRID …
- Final Data storage

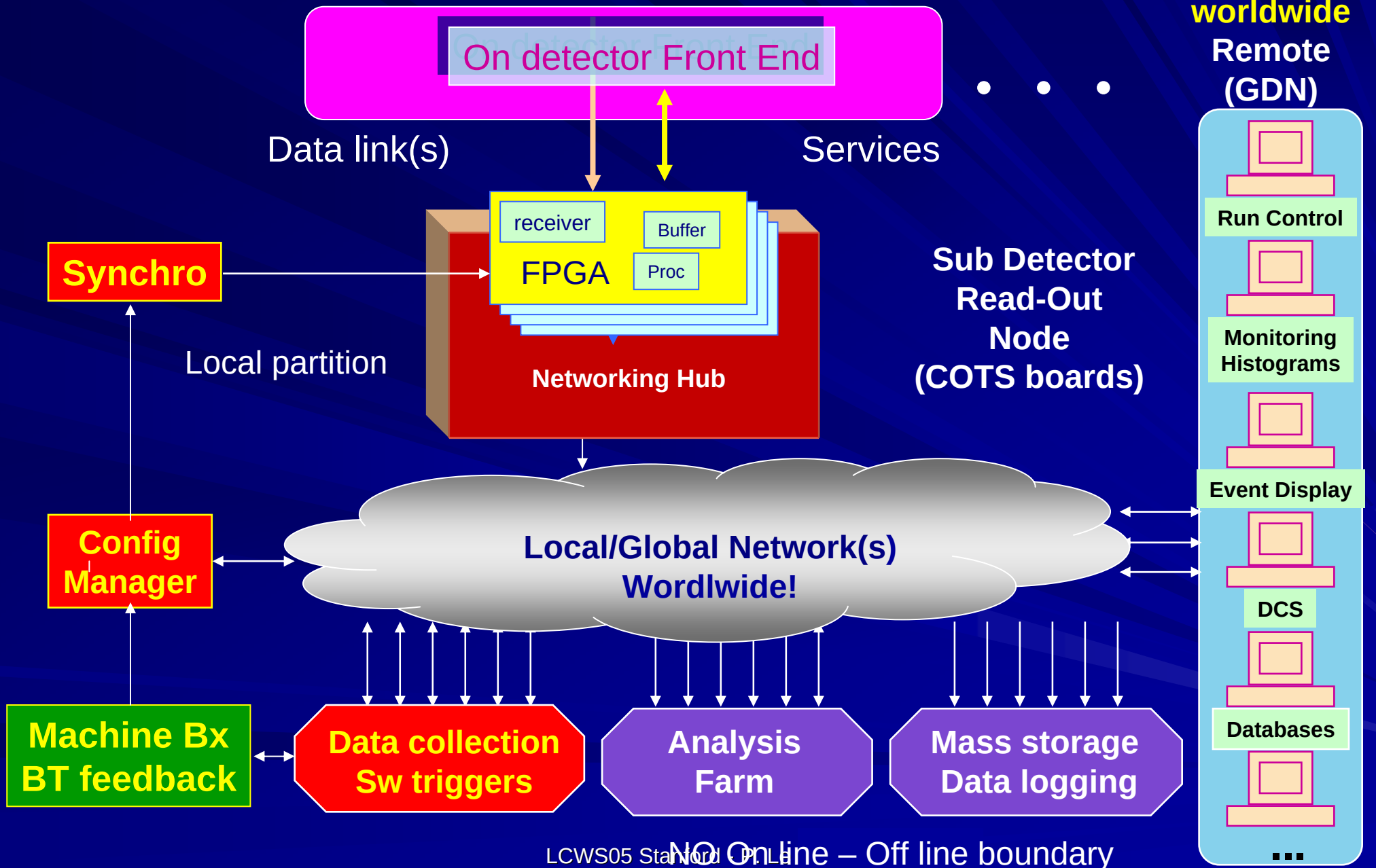
Data Collection (ex T/DAQ)
Bunch Train Buffer RO
Event Building
Control - supervisor
On line Processing
SW trigger & algorithms
Global calibration ,monitoring and physics
Local (temporary) Data logging (Disks)

Possible common RO architecture model

Detectors technology



ILC 'today' Data Collection Network model



What next (1) ? → Snowmass

- **Understanding in details Detectors Read out schemes**
  - Data Collection (DAQ) is starting at the Detector level
  - By Subdetectors → Independently of detector concepts
  - Detector concepts SiD,LDC,GLD → what are the particularities?
  - Propose a common architecture (VTX,TRACK, CALORs,Muon …)
  - Do not forget the Very Forward !
  - Influence of technical aspects → Power cycling & beam RF pick-up ….
- **Refine the s/w trigger concept → ILC T/DAQ model**
  - Special triggers (Calibration,Tests,cosmics …)
  - Hardware Preprocesing ?
- **Interface with machine**
  - Which infos are needed?
  - Integration of Beam Train feedback
- **Define clearly the 'boundaries' → functional block diagram**
  - Integration of GDN
  - 'Slow controls' and monitoring
  - Synchronization
  - Partitionning …..

What next (2) → Snowmass

- **Milestone for 2005 (CDR) → Baseline ILC document**
  - Define a list of technical issues and challenges to be addressed
  - Which prototyping is needed?
  - Practicing state of the art technologies (FPGAs, Bussless,wireless?,networking hubs …)

- **Toward a realistic costing model for the CDR (end 2005)**
  - Global to the 3 detectors concepts
  - Table of parameters: Estimate number of channels, bandwidth ….
  - Estimate quantity of hardware (interfaces, processors, links …), software ? and manpower (is LHC a good model?)
  - Cost effective, upgradable, modular …..

- **Build a wordwide 'international 'long term' strong team**
  - Seniors with LEP/SLD,Hera/LHC/Tevatron,Babar/Belle/KEK experience
  - Younger with enthousiasm!
  - Europ,North America and Asia → common meetings
  - Include long term sociology → NOT reinventing the wheel!
    - Build ONLY what is needed ! Not competing with industry!....

Others

- Modelling using ‘simple tools’ ?
  - Quantitative evaluation of the size of the system
- Trigger criteria & algorithms → trigger scenarios
- What about GRID ??? LHC experience