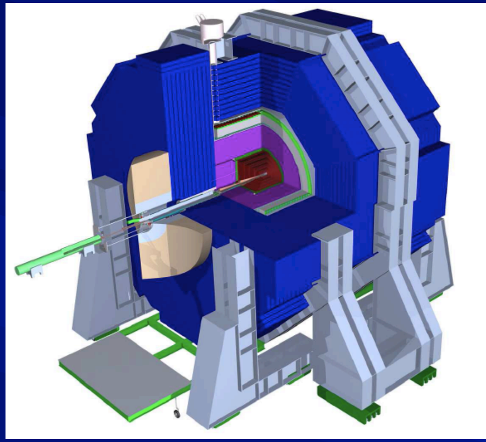
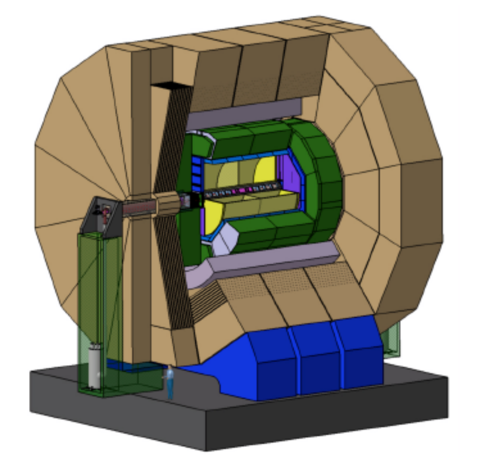
Introduction to TDAQ





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Fast Electronics and Detector Summer School,
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Thanks to Prof. Patrick Le Du for sharing slides

Questions

- How many people know TDAQ?
- How many people know Trigger?
- How many people know DAQ?
- What is trigger?
- What is DAQ?

Trigger/触发

- **WIKI:**
  - **trigger** - lever that activates the firing mechanism of a gun

- **Bing:**
  - a small device that releases a spring or catch and so sets off a mechanism, especially in order to fire a gun:

Trigger

Triggering: Find & Capture Signal of Interest
Powerful Measurement Leverage

Easy, Effective Ways to Monitor Environment for Signal
Look for Expected and Unexpected Signals
Avoid Measuring When No Signal Present
Monitor Other Frequency Bands?
Trigger on Other Activities
- External trigger from your circuit
- Oscilloscope or logic analyzer
- Consider all you know about signals, systems, transitions
- Take advantage of repeating signals, inter-signal timing, pos/neg delays

Triggering Can Enhance Measurement Performance
- Time or synchronous averaging
- Periodic trigger

Trigger a Time Capture

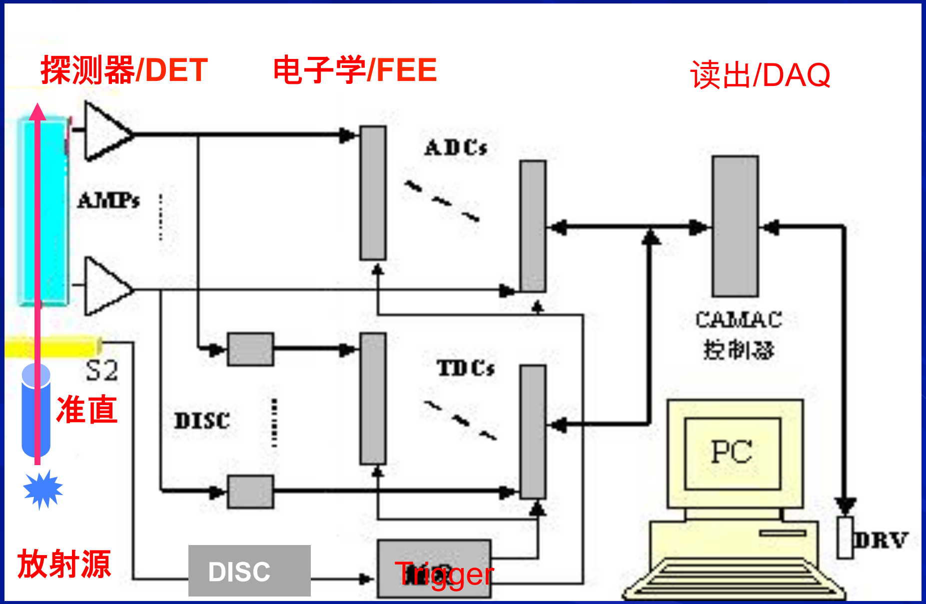
- Oscilloscope Trigger
  - The **trigger level** and **trigger slope** are the **two basic trigger controls on any oscilloscope whether digital or analogue.** The trigger level detects when a certain voltage level has been reached and at this point sets the time-base in operation to sweep across the screen.
  - 触发电平：被选定信号的幅度大于该电平时，被测信号的波形被抓取并显示在屏幕上。
- Digital Signal Analyzer
  - Triggering:Find & capture Signal of Interest(see left)
  - 触发模式：被选定串行信号满足一定的模式结构时，被测信号的结构被抓取并被显示在屏幕上。

What is DAQ

- Wikipedia: Data Acquisition
  - Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems, abbreviated by the acronyms DAS or DAQ, typically convert analog waveforms into digital values for processing.
- BING: What is DAQ?
  - DAQ is a broad term that includes a **suite of different tools and technologies that are designed to accumulate data**. DAQ systems generally consist of **DAQ software and hardware** along with sensors and actuators, and they generally require underlying network support for data communication between the data acquisition hardware and software.

Trigger/DAQ in Lab Exercise

- Radiation Source based
  - Radiation Intensity
  - Signal Amplitude
  - Discriminator Threshold
- Trigger
  - Providing Gate signal to ADC
  - Providing Common Start to TDC
- DAQ
  - Read data from ADC/TDC
  - Save onto the disk

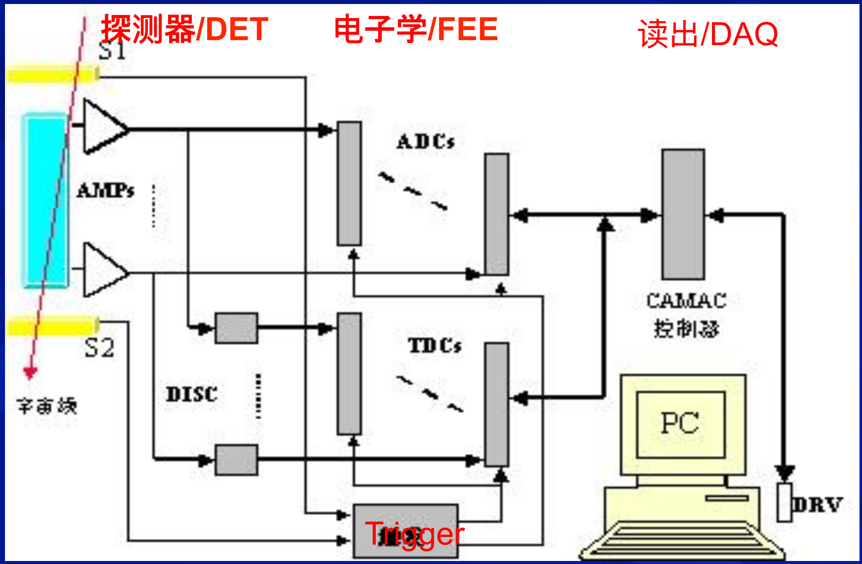


Outlook of this talk:
T/DAQ: Evolution of architectures, tools and techniques

- Basic about Trigger and DAQ
  - Common terms, T/DAQ in physics
  - Example with BESIII/BEPC
- Technologie for future experiments
  - LHC upgrade
  - FAIR-PANDA
  - ILC/FCC/CEPC
  - CEPC/SppC
  - What next in TDAQ
    - the 'Ultimate' Trigger concept -→ The Software trigger
- Summary

Cosmic Ray based Physics Experiment

- Lab Exercise with Cosmic Ray
  - 2 trigger detectors
  - Coverage of the detector volume under checking
- Can this setup search for J /Psi Resonance?
  - Why?
  - Particle ID
  - Efficiency
- Solution
  - Complex system
  - Accelerator based



Must: Accelerator based Spectrometer!

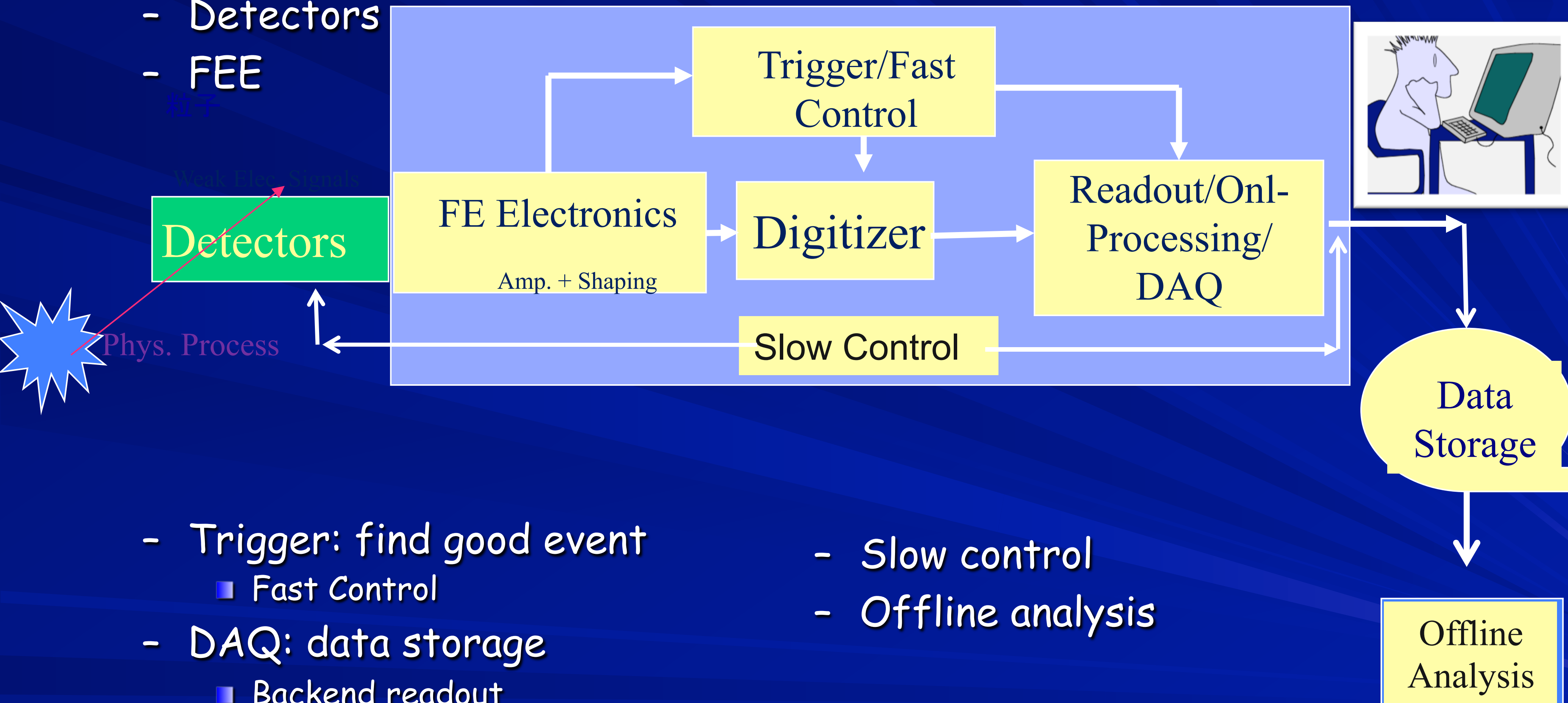
Accelerator based Experiment

- Advantages
  - Energy for Physics interested
  - Repeatable
  - High efficiency
  - Short time for resu
  - Target controllable
- Disadvantage
  - High background
  - Too many fake even
  - Tremendous data se
  - Analysis difficultie
- Solution
  - Complex trigger + DAQ

Good Event: find a needle in a Haystack

Trigger+DAQ in Large Physics Experiments

- Components of Experiment(Spectrometer)
  - Detectors
  - FEE



  - Trigger: find good event
    - Fast Control
  - DAQ: data storage
    - Backend readout
    - Online Monitoring
  - Slow control
  - Offline analysis

Terms, ideas, priciples in trigger and DAQ

Target of a Trigger+DAQ system design:

To accept all physics event interested(good event), no or fractional loss

To reject as many as possible sorts of backgrounds to the capacity of DAQ to process and save

Small dead time(in some percentages)

- Good event
  - Any event interested in
    - From collision
    - Cosmic ray
  - Defined by the experiment
    - BahBah events
    - Cosmic ray events
- Trigger Latency
  - Time from event produced until trigger decision is made
- Backgrounds (bad Event)
  - Any event not the experiment expecting
  - Cosmic ray
  - Lost beam particles(unfocused, de-accelerated, Toucheck effect)

Trigger Principle

- By timing
  - Time of flight, TOF
- Number of hitting: TOF,muon
- Tracking
  - Charged particle: DC, TPC, Silicon, muon,…
- Energy
  - Charged particle: EMC, Hcal
  - Neutral particle: EMC
- Corelation
  - Tracks, Clusters, JETs, …
- more

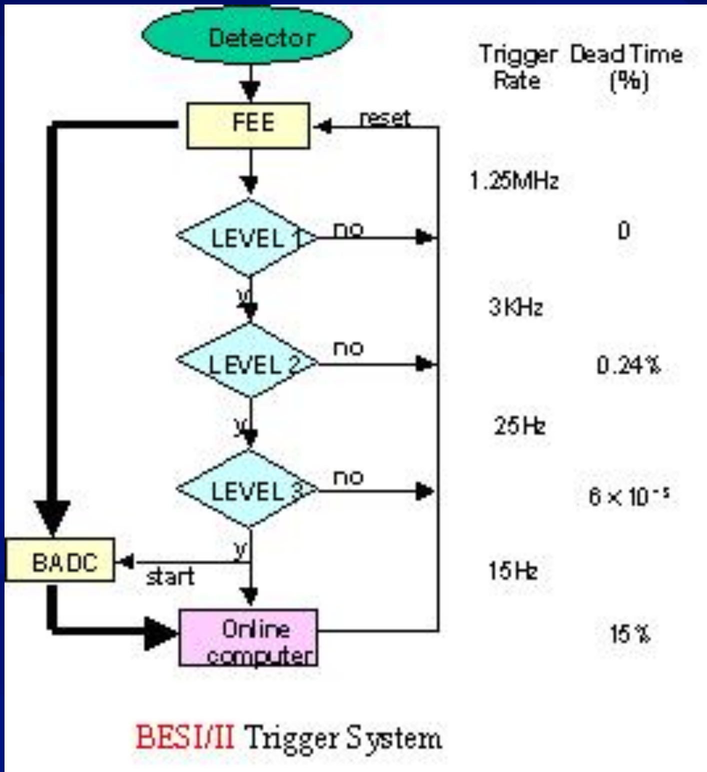
Multilevels trigger and DAQ

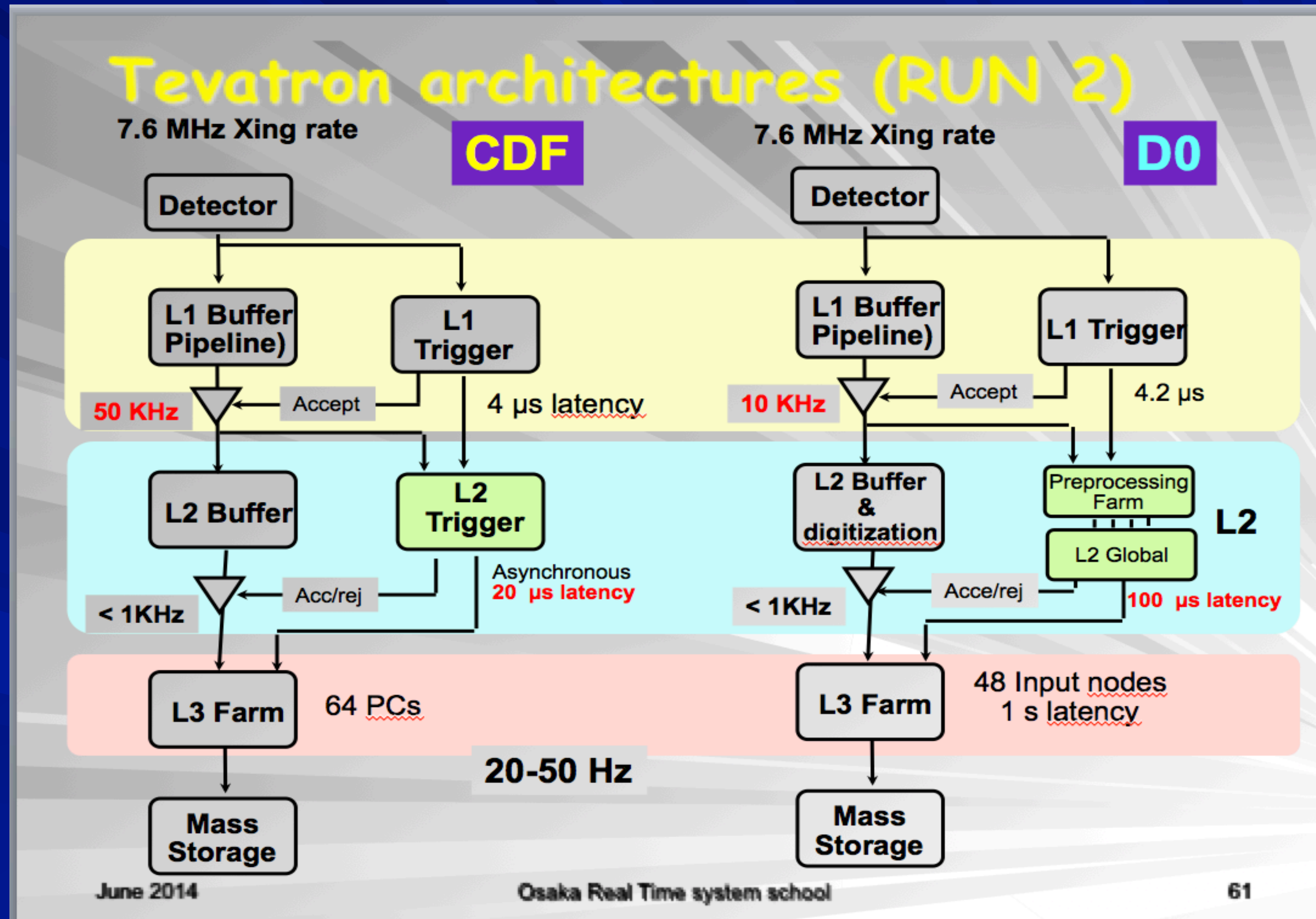
- Required rejection is orders of magnitude
- **Level 1 is hardware based**
  - Hardwired trigger system to make trigger decision with short latency.
  - Constant latency buffers in the front-ends
  - Crude signatures (hits and tracks, local energy deposit over threshold…)
  - Operates on reduced or coarse detector data
- **Level 2 is a composite**
  - Dedicated custom/DSP/FPGA processing or Processor based (standard CPU's or FIFO buffers with each event getting accept/reject in sequential order
- **Level 3 is a farm** → General Purpose CPUs

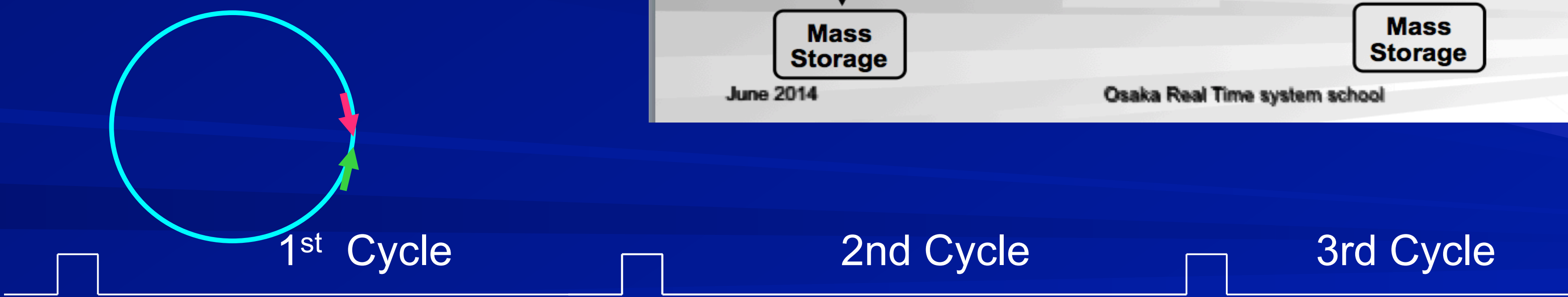
  hundreds – thousands

Almost every one uses this scheme.

Pipelined processing vs Latch-Process



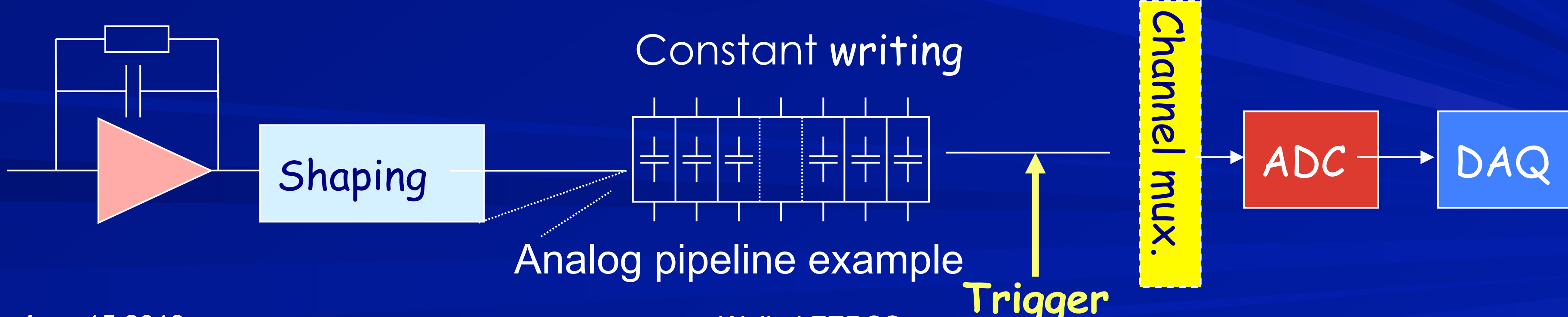




Terminology :buffer , pipeline & latency

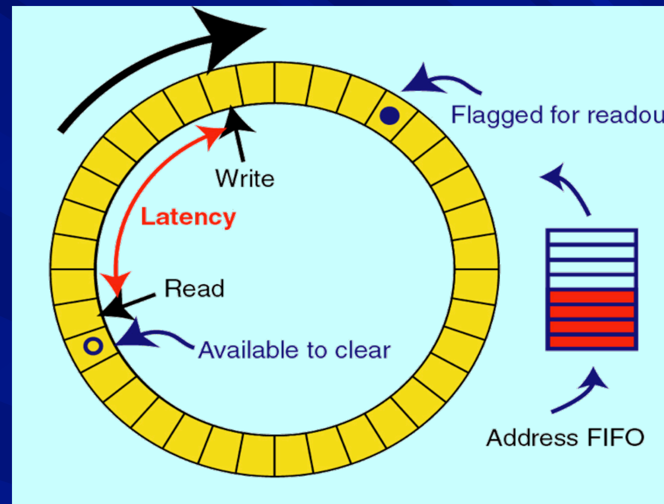
- Trigger processing requires some data transmission and processing time to make decision so front-ends must buffer data during this trigger latency time.
- For constant high rate experiments a "pipeline" buffer is needed in all front-end detector channels: (analog or digital) (e.g. circular buffer →

Analog Pipeline L1P before ADC

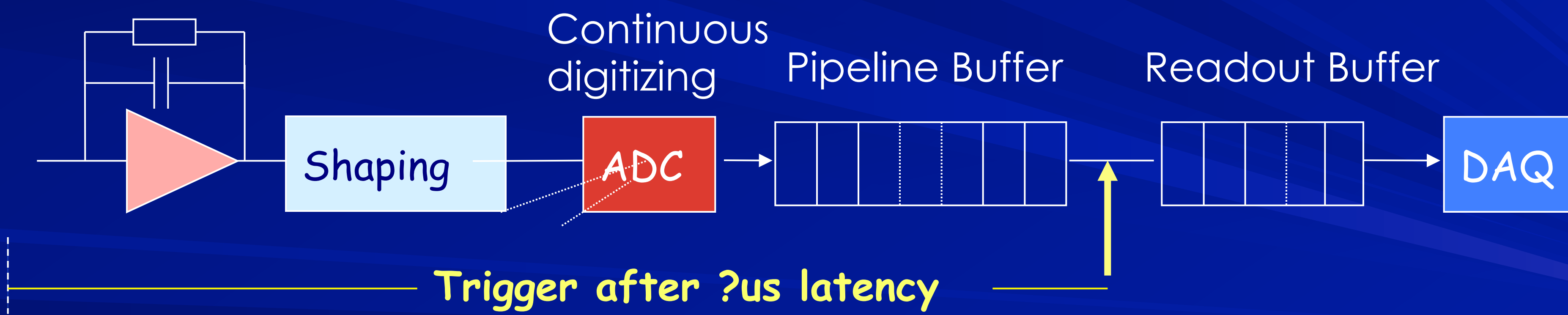


Terminology :buffer , pipeline & latency

- Digital Pipeline L1P after ADC but before Trigger Pass signal



Circular buffer

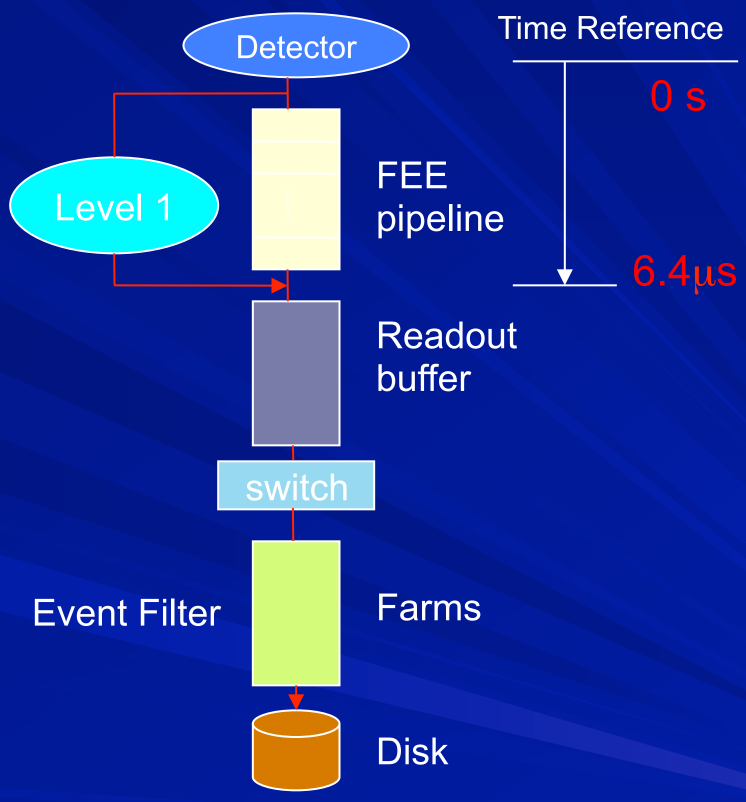


Digital pipeline example

BESIII Trigger System as example

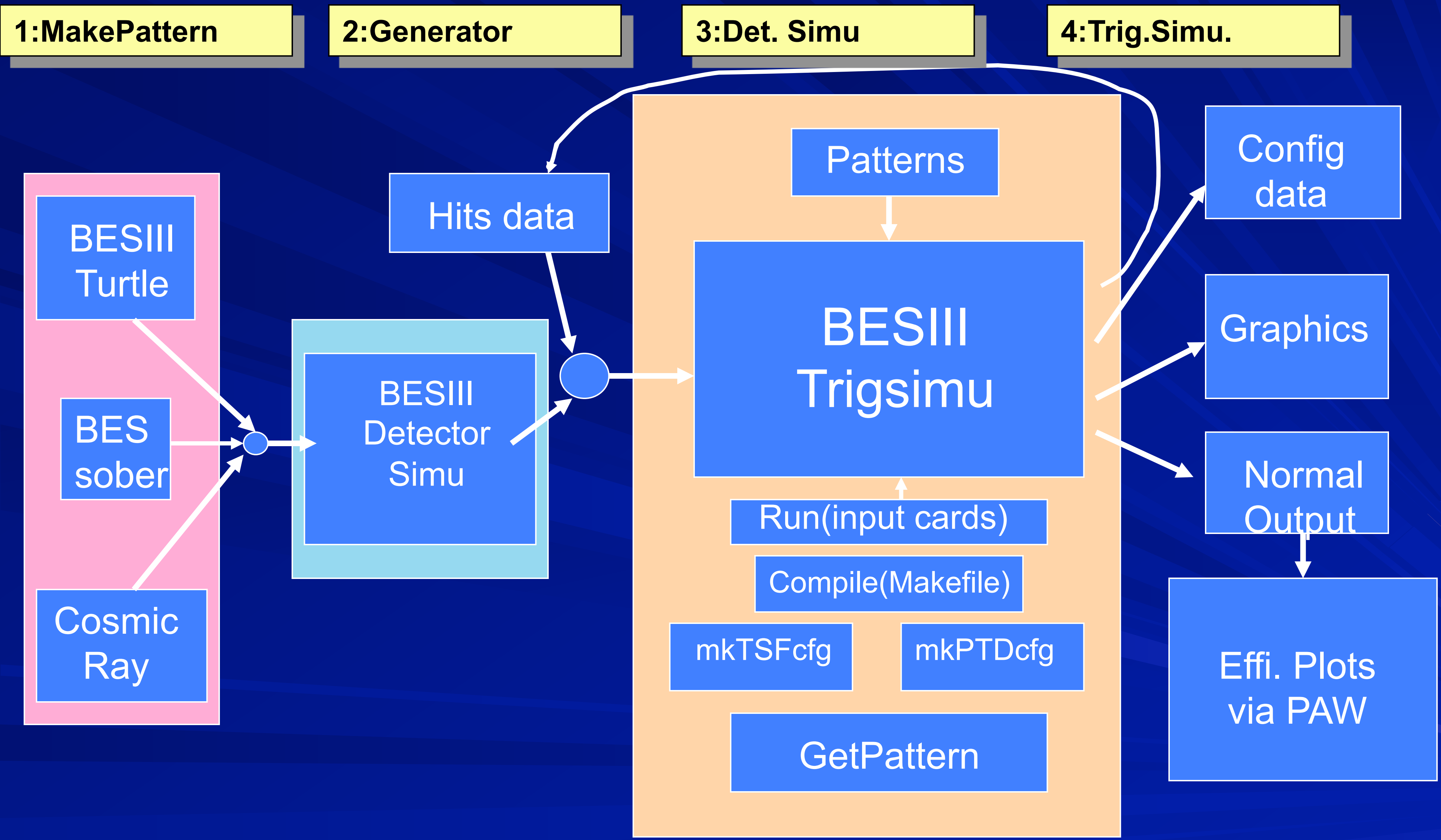
Requirement to trigger system

- Event Rate
  - Good Event Rate: ~ 2000Hz
  - Bhabha event Rate: ~800Hz
  - CosmicRay Rate:: <200Hz, rejection > 10:1
  - Beam Backgd Rate: <2000Hz, rejection > 10000:1
  - Total Trigger Rate: 4000 Hz
- Pipeline working mode
  - BEPCII Multibunch(93), Bunch spacing:8ns
- L1 Uncertainty: 0.4 μs
- Trigger Latency: 6.4 μs
- L1P is a data Index, not a time reference

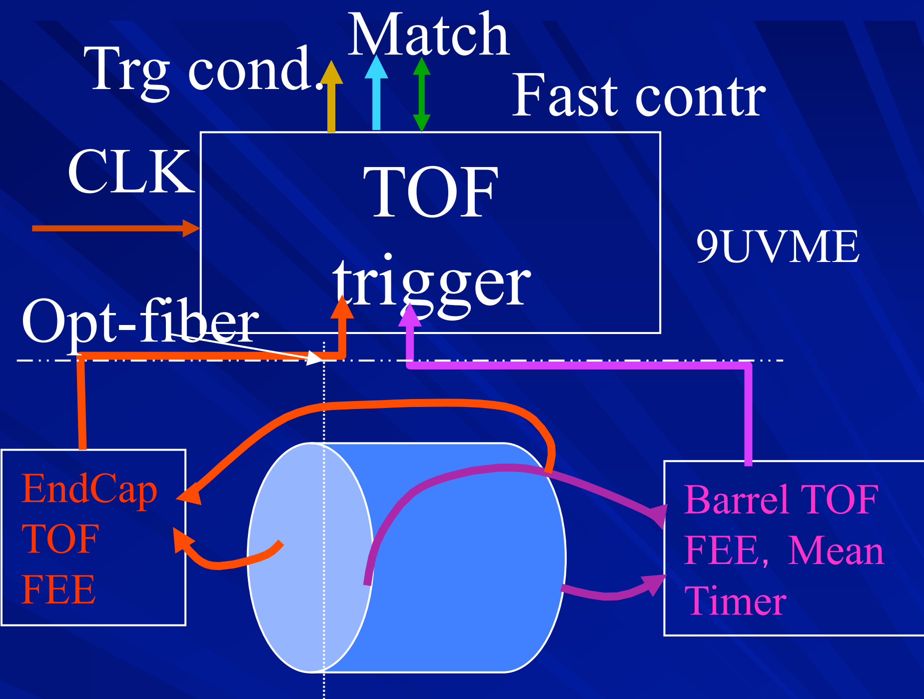


BESIII FEE pipeline and Data flow

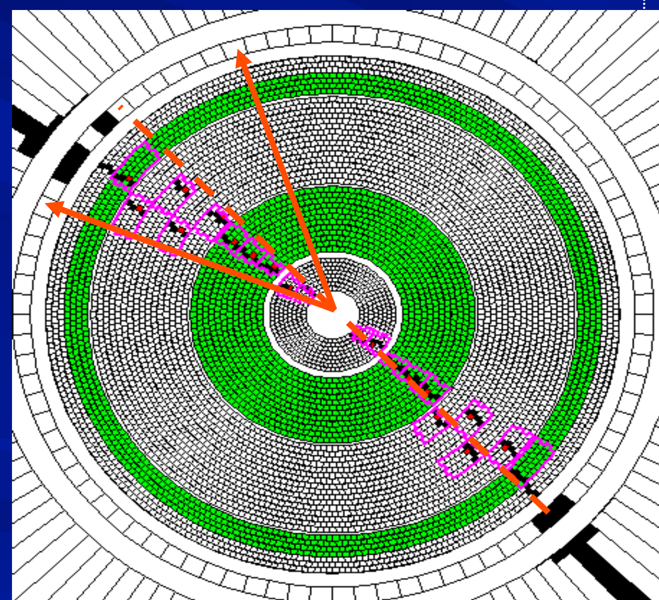
BESIII Trigger Scheme based on Simulation



TOF trigger Primitives



- Hitting numbers
  - NBtof>=1, NBtof>=2
  - Netof>=1,Netof>=2
- Topology in Barrel: TBB
  - Pt>837MeV
  - 12cells(3x2x2+1),53 °
- Topology in Endcap: ETBB
  - Pt>551MeV
  - 8cells(2x2x2+1),67 °
- Hitting position（TKM）:
  - TBhits(88), TEhits(48)

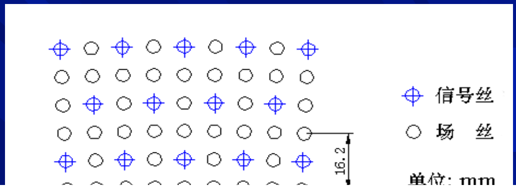


Barrel:88 Endcap:48

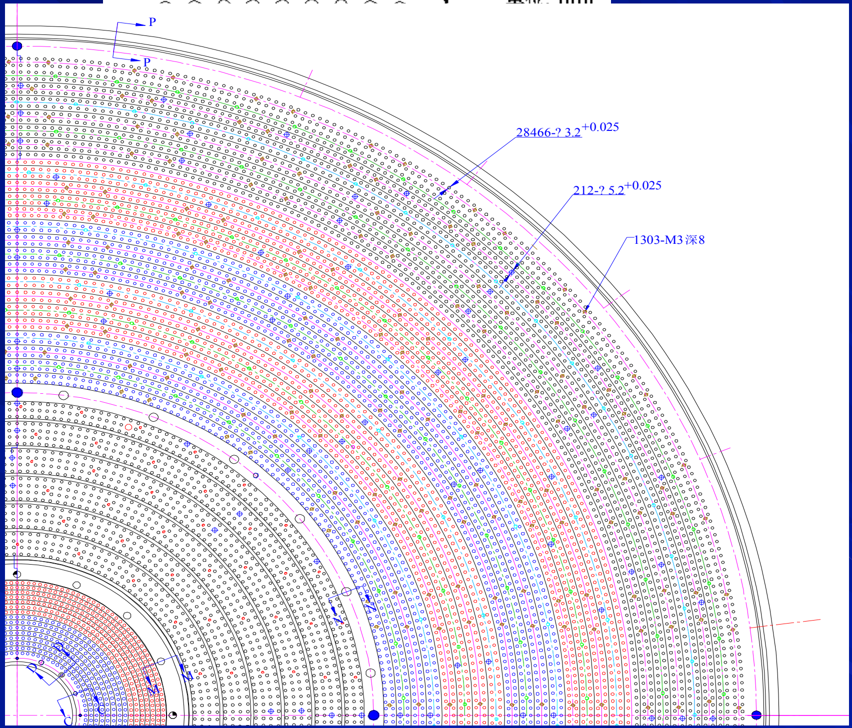
MDC subtrigger BESIII

Parameters of MDC trigger

Super Layer	Wire Layer	# of sig.				# of WL in SL	Pivot Layer	# of pivot cells SL
		L1	L2	L3	L4			
SL-1	ST-1/2/3/4	40	44	48	56	4	3	48
SL-2	ST-5/6/7/8	64	72	80	80	4	3	80
SL-3	AX-9/10/11/12	76	76	88	88	4	3	88
SL-4	AX-13/14/15/16	100	100	112	112	4	3	112
SL-5	AX-7/18/19/20	128	128	140	140	4	2	128
SL-6	ST-21/22/23/24	160	160	160	160	4	2	160
SL-7	ST-25/26/27/28	176	176	176	176	4	2	176
SL-8	ST-29/30/31/32	208	208	208	208	4	2	208
SL-9	ST-33/34/35/36	240	240	240	240	4	2	240
SL-10	AX-37/38/39/40	256	256	256	256	4	2	256
SL-11	AX-41/42/43	288	288	288	0	3	2	288
Total	43	6796				/	/	1784



Signal
Field



Inner layers
Pivotal layers
Axial layers
Not used layers

To simplify the hardware implementations, super layers 1st – 5th and 10th are used as MDC trigger sources

How the tracks are found in BESIII:
Track Segment Finding + Track Finding

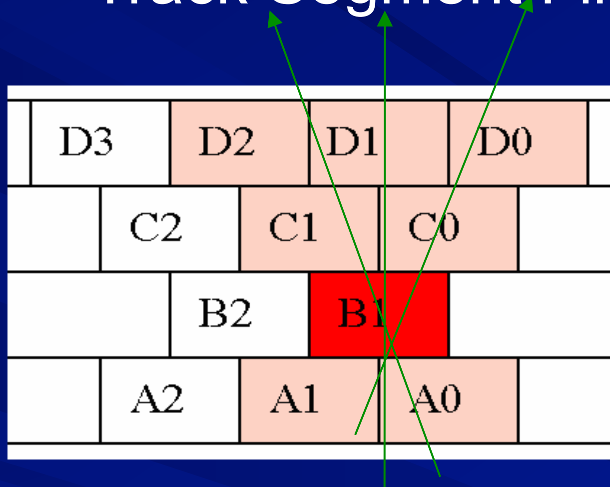
TSF

Layer D

Layer C

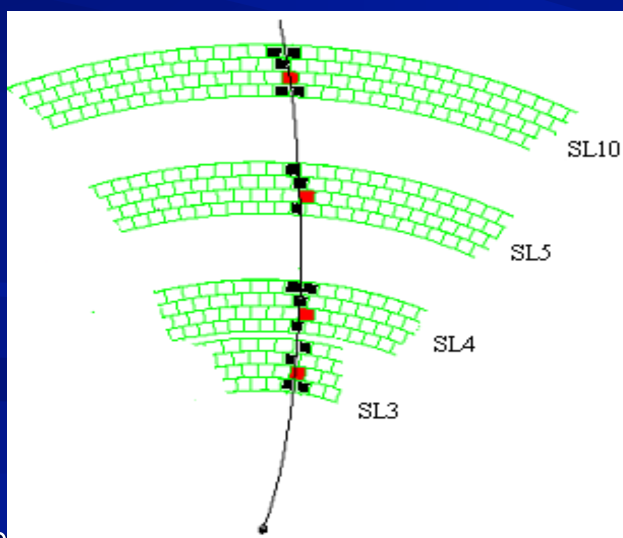
Layer B (PL)

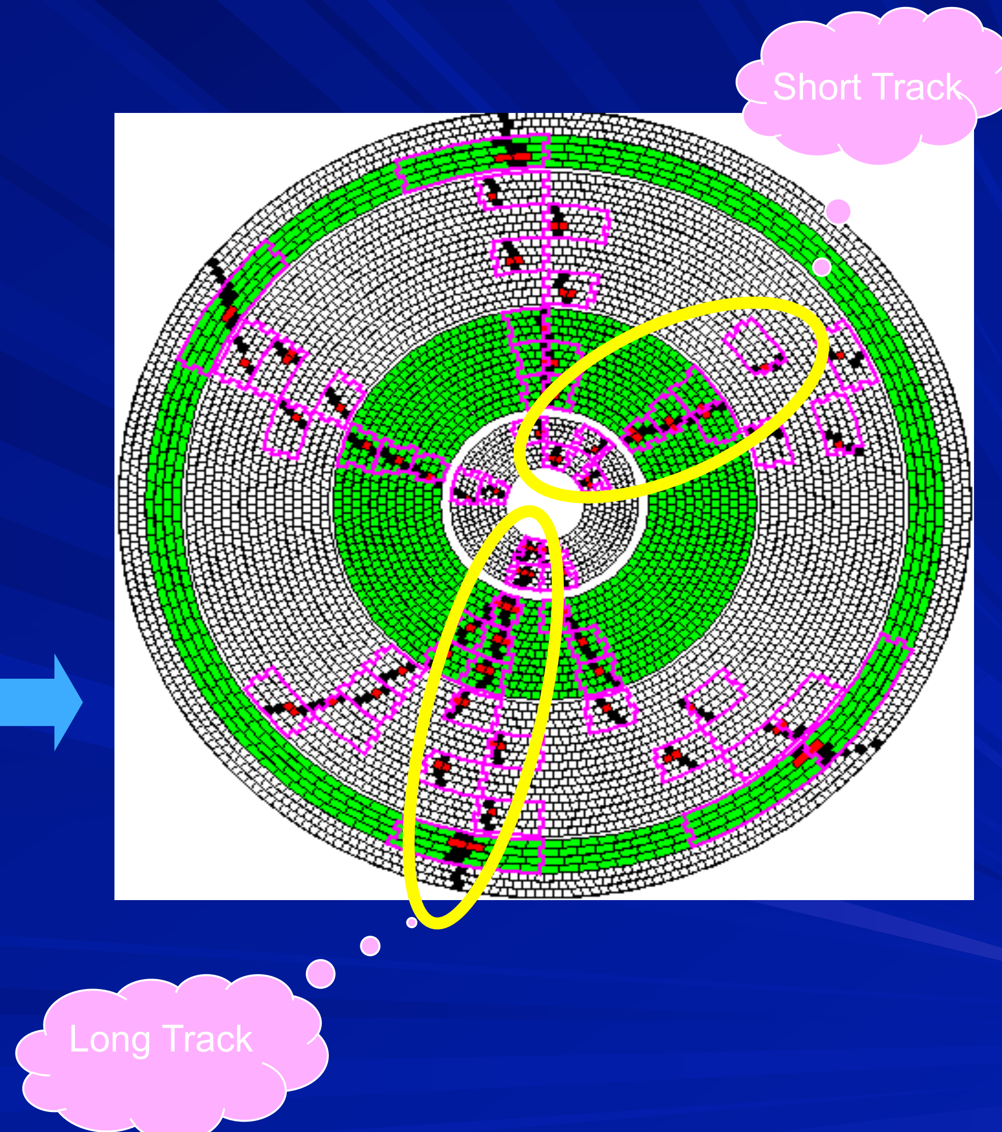
Layer A



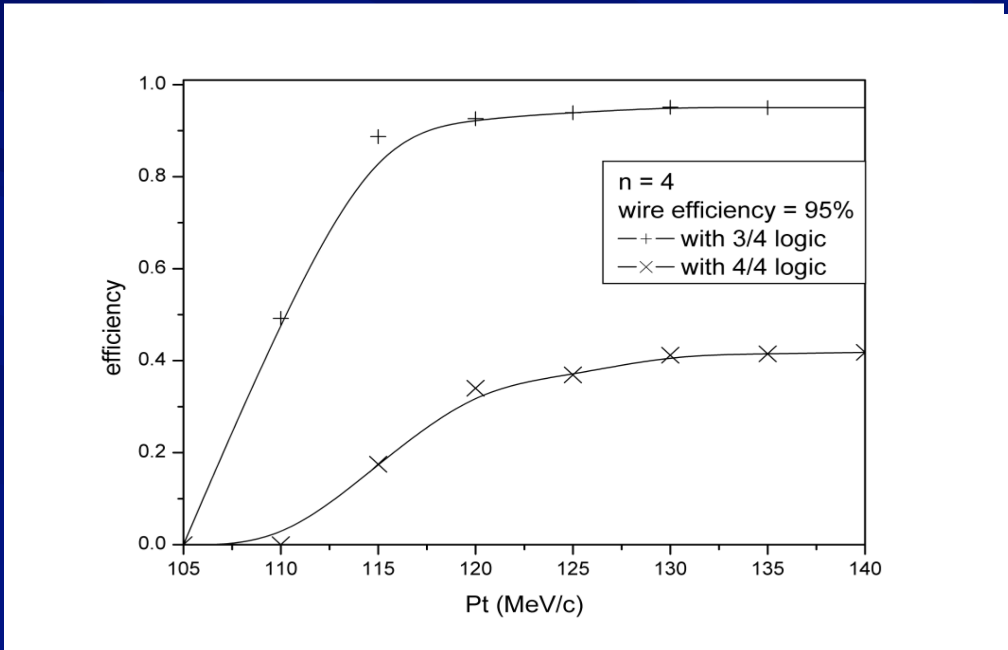
TF

Pivot SL

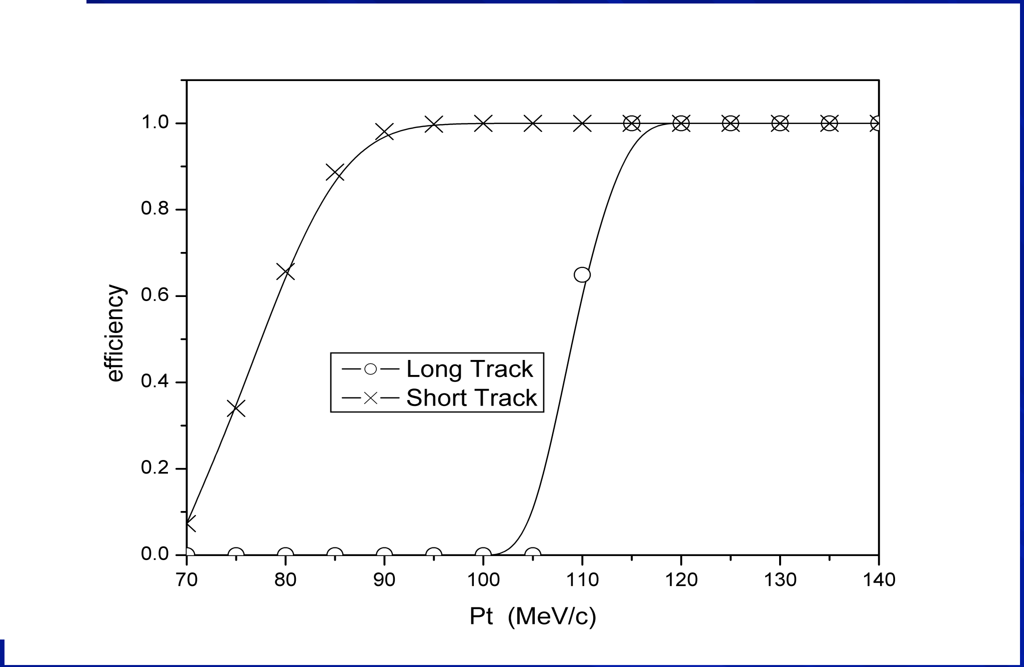




Some results of simulation



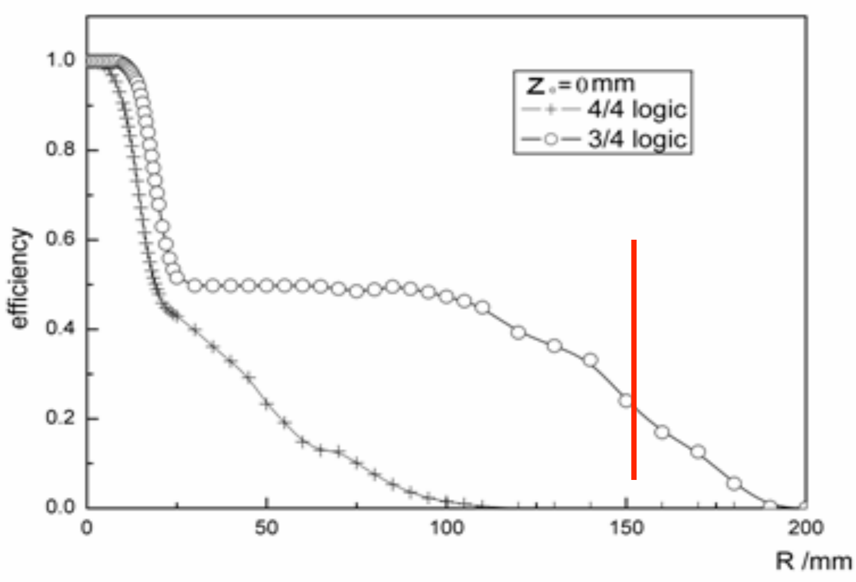
Relations between TSF efficiency and *pt*

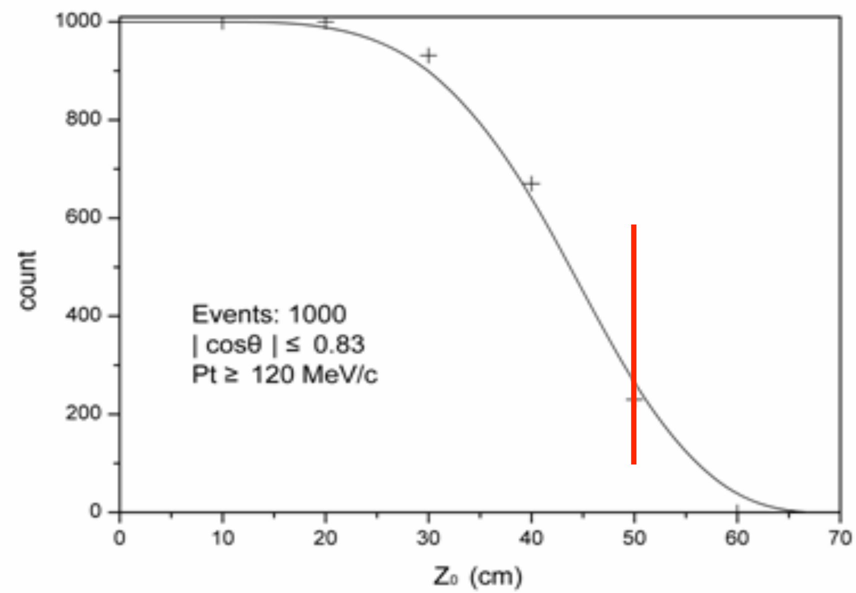


Relations between TF efficiency and *pt*

Some results of simulation (2)

- The track finding efficiencies in the r-ϕ plane and Z direction.
  - For a distance of 15 cm in the r-ϕ plane, the TF efficiency is about 30% for 3/4 TSF logic.
  - For a distance of 50 cm in the Z direction, TF efficiency is about 30%.





It is good to reject backgrounds far from the Interaction Point

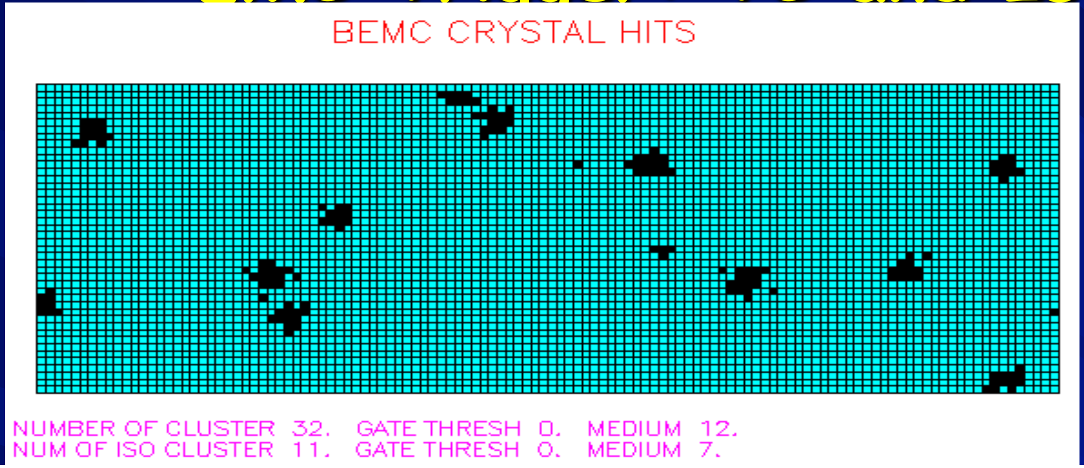
MDC Primitive

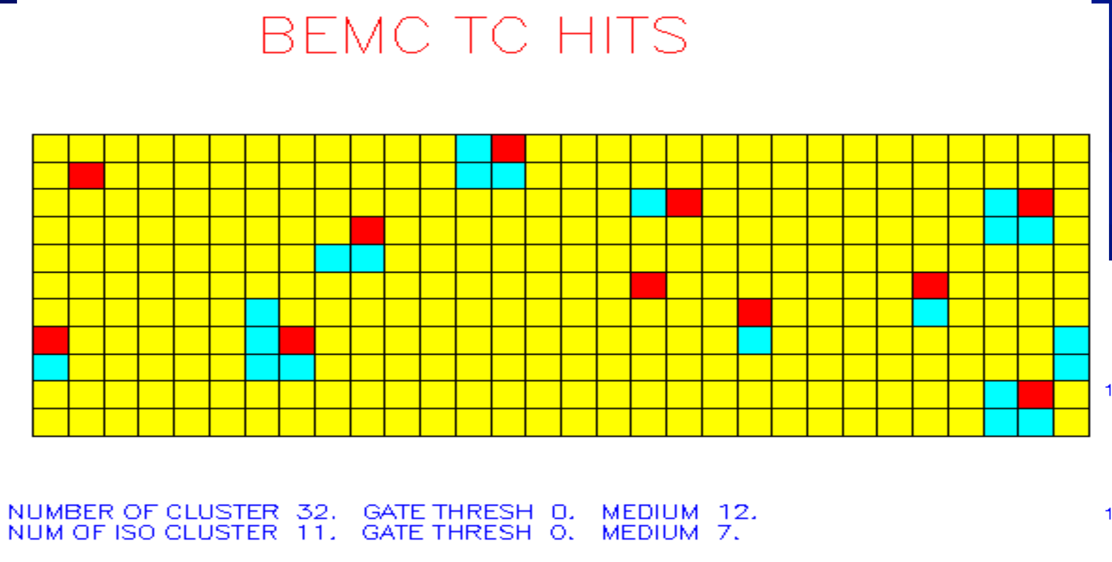
- 10 trigger conditions of the MDC trigger are used in BESIII trigger system
- 3 charged channels:
  - Charge1: NLtrk≥1 + Ntof≥1 (Number of Hits of TOF) + Etot-l (Low threshold of the whole EMC total energy, ~200MeV)
  - Charge2: NLtrk≥1 + NStrk≥2
  - Charge3: STrk-BB

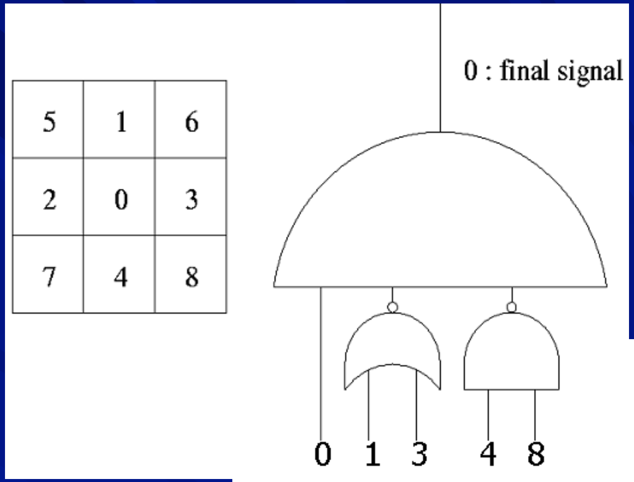
NLtrk⩾1	Number of long track ⩾1；
NLtrk⩾2	Number of long track ⩾2；
NLtrk⩾N	for MDC wires' hits of high voltage sudden discharge
NStrk⩾1	Number of short track ⩾1；
NStrk⩾2	Number of short track ⩾ 2；
NStrk⩾N	for MDC wires' hits of high voltage sudden discharge ；
STrk-BB	Short Tracks back to back ；
NItrk⩾1*	Number of the Track Segments of the SL1 and SL2 are equal to or greater than 1；
NItrk⩾2*	Number of the Track Segments of the SL1 and SL2 are equal to or greater than 2。

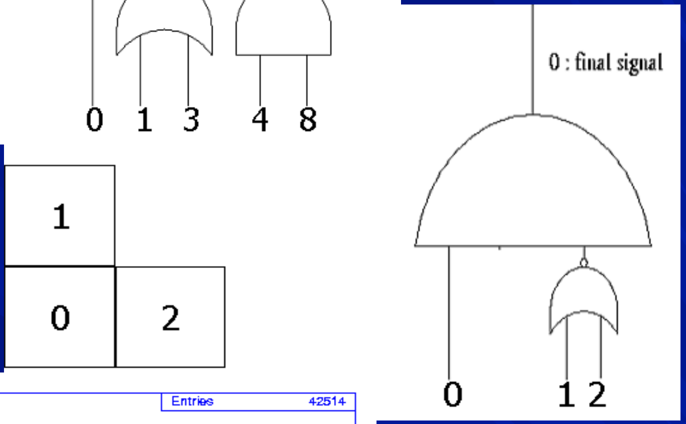
* NItrk >= 1 and NItrk >= 2 are for backups to reject beam-related backgrounds.

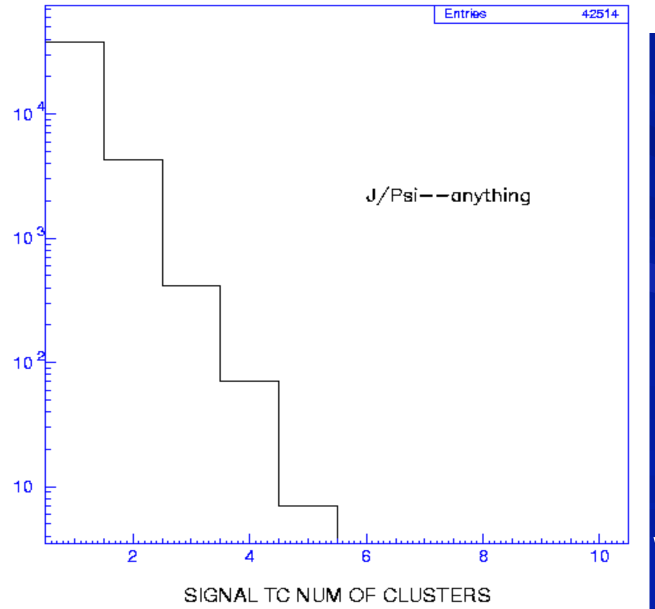
EMC Trigger: TC and Isolated Cluster finding





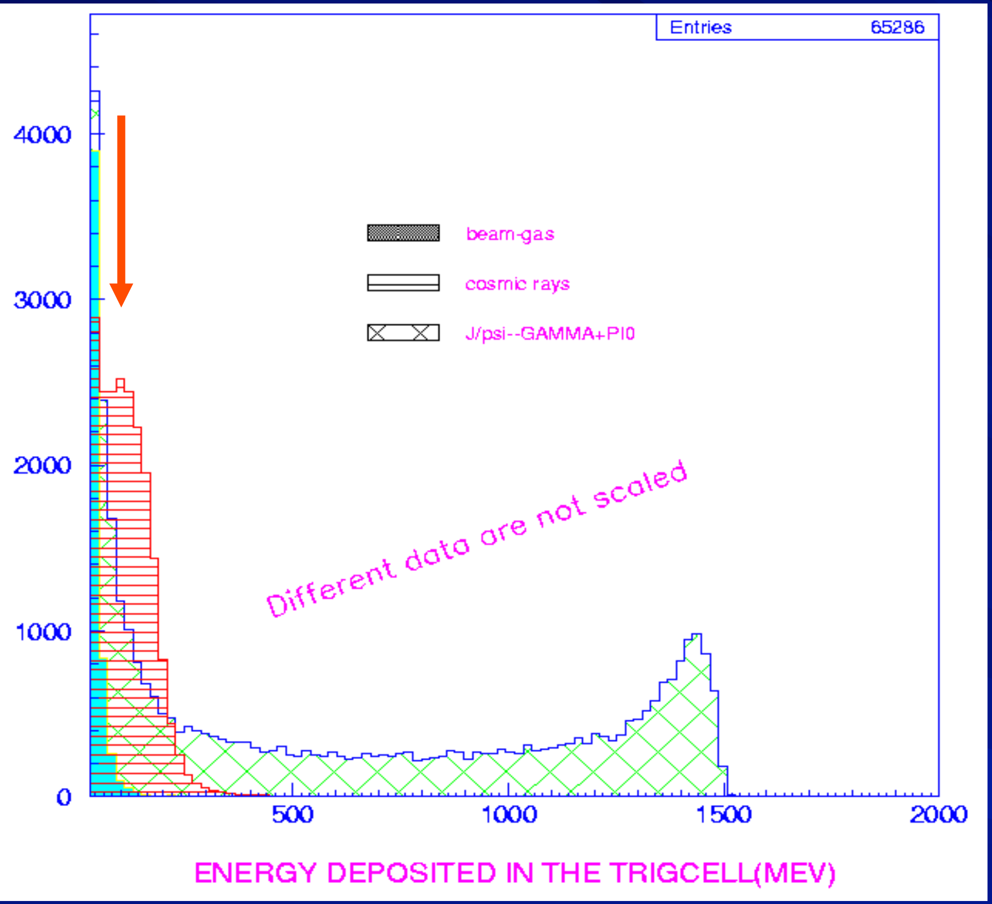


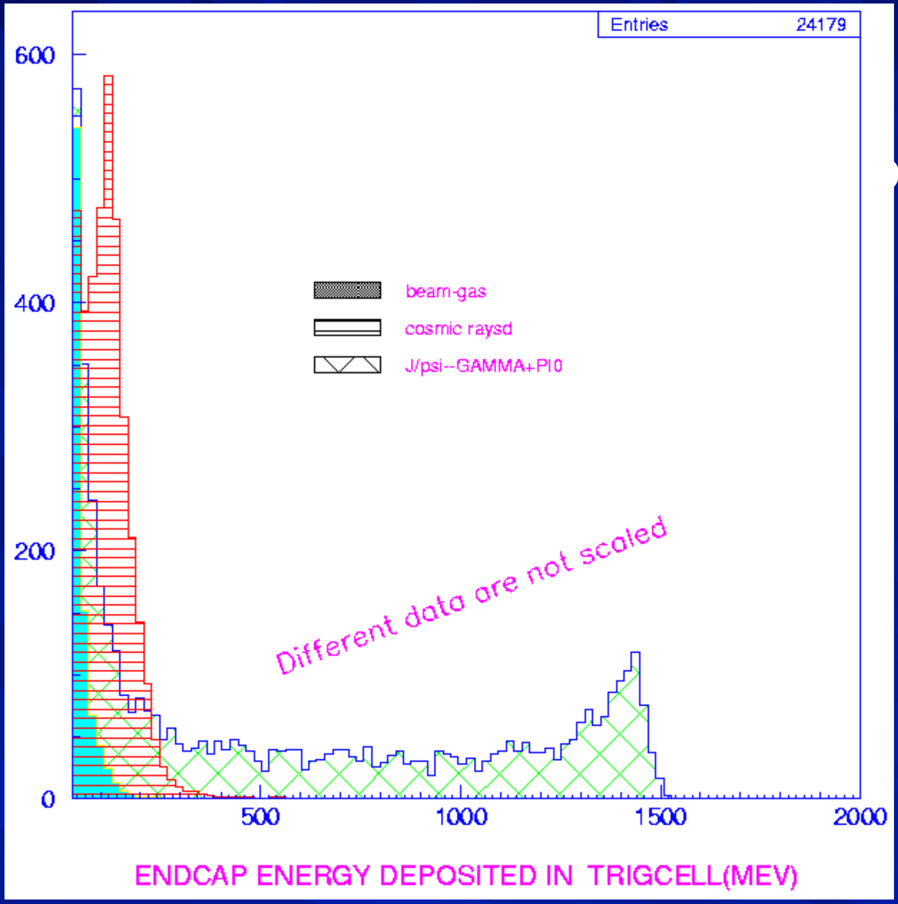




- Crystals: 120 x 44
- Trigger Cell(TC): 30 x 11
- TC Energy
- Total Energy

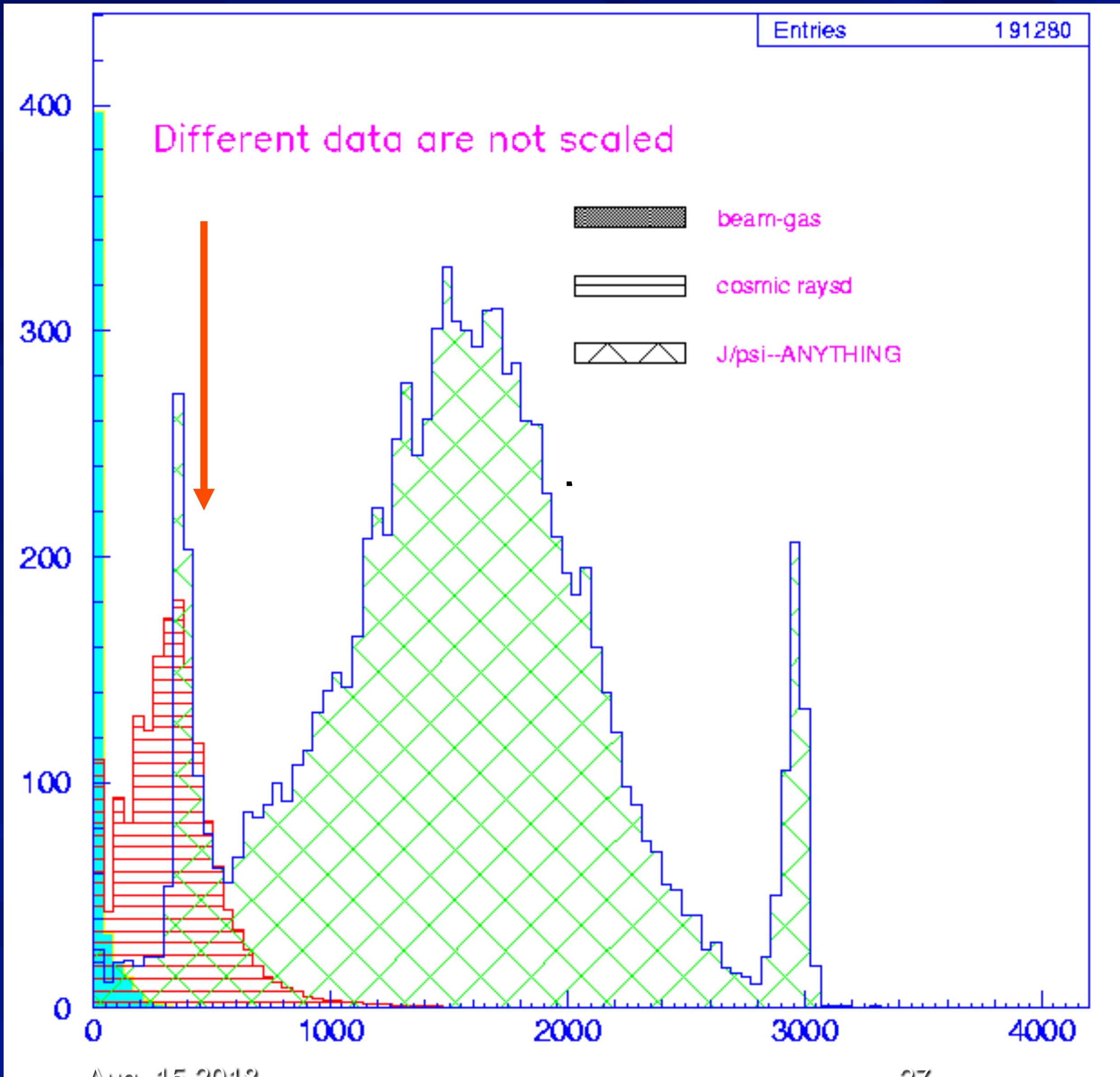
TC Energy Threshold





- Taking the pileup and baseline flucturation into account, the TC threshold is utilized as 60—80Mev.
- Beam gase background in low energy, so a 60—80Mev threshold can remove most of the BG backgrounds

Total energy



- Etot-L (~200MeV)
  Threshold for background events
- Etot-M (~800MeV)
  Threshold for neutral events
- Etot-H (~2.5GeV)
  Threshold for bhabha event

EMC 触发条件

NClus>=1	Cluster number (>=1 for EMC timming)
NClus>=2	
BclusBB	Back to back cluster
EclusBB	
Clus_PHI	Cluster balance at φ
Clus_Z	One cluser at each half of EMC
Diff_B	Energy difference between each B half
Diff_E	Energy difference between each E half
BL_BEMC	Energy Balance between half BEMC
BL_BLK	Energy Balance of barrel blocks
BL_EEMC	Energy Balance between half EEMC
BL_Z	Z energy balance (B+E)
Etot_L	Total Energy >Thre-l
Etot_M	Total Energy >Thre-m
BEtot_H	Total energy of Barrel EMC
EEtot_H	Total energy of Endcap EMC

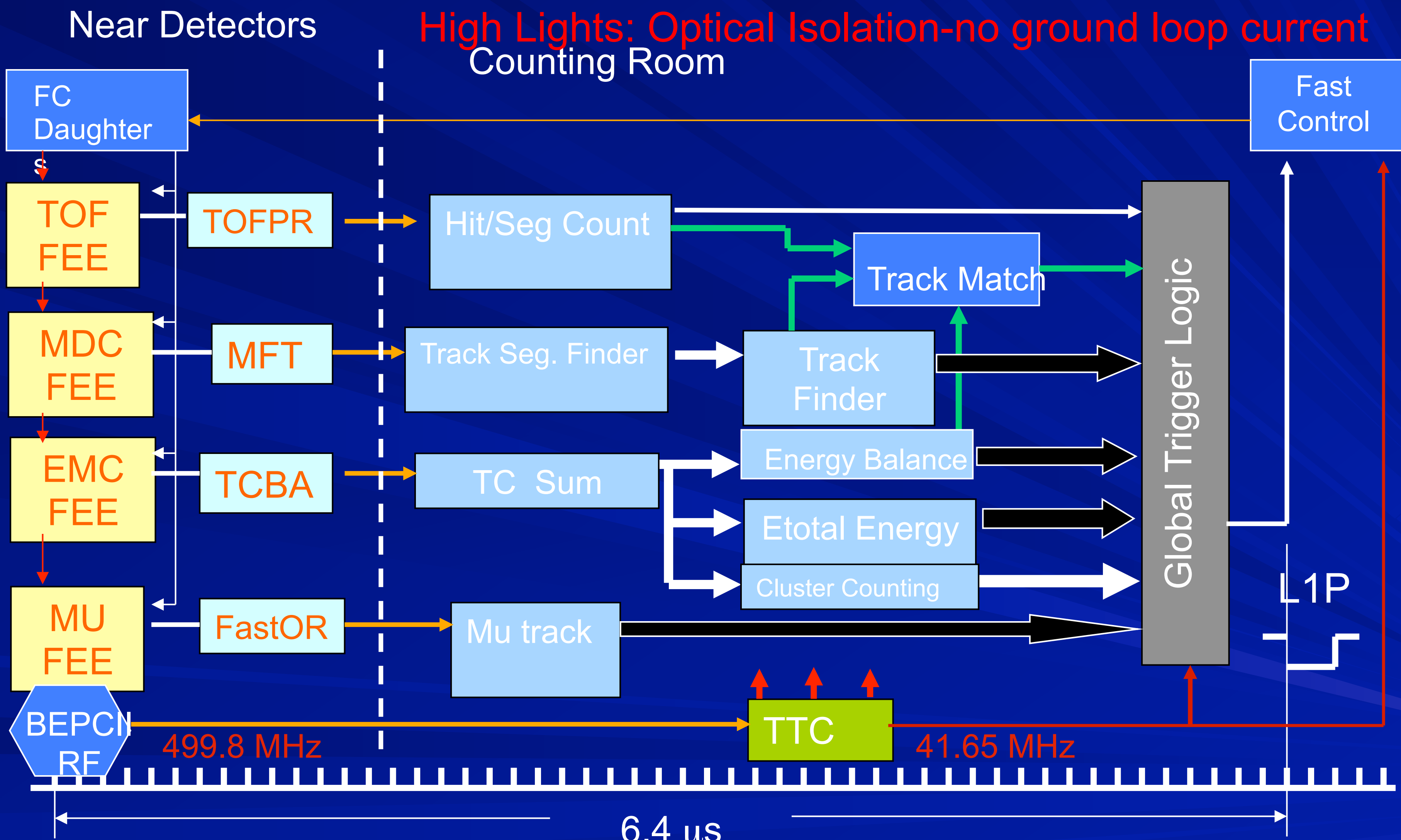
- To TKM:
  - Bemc(40),Eemc(48)

Trigger Table

Detector	Trigger Condition	bits	**Comments**
TOF	Ntof≥1 Ntof≥2 TBB	3	TOF hits number (TOF timming) Back to back hits
ETOF	Netof≥1 Netof≥2 ETBB	3	(ETOF timming)
MDC	NLtrk>=1 NLtrk>=2 LTrk-BB NLtrk>=N NStrk>=1 NStrk>=2 STrk-BB NStrk>=N NItrk>=1 NITRK>=2	10	Full Track number Back to back tracks Many tracks Short Tracks number With Inner DC hit
EMC	NClus>=1 NClus>=2 BclusBB EclusBB Clus_PHI Clus_Z Diff_B, Diff_E, BL_BEMC, BL_BLK BL_EEMC BL_Z Etot_L, Etot_M BEtot_H EEtot_H	16	Cluster number(EMC timming) Back to back cluster Cluster balance at φ One cluser at each half of EMC Energy difference between each B half Energy difference between each E half Energy Balance between half BEMC Energy Balance of barrel blocks Energy Balance between half EEMC Z energy balance (B+E) Tatol Energy >Thre-l Tatol Energy >Thre-m Tatol energy of Barral EMC Tatol energy of Endcap EMC
MATCH	NAtrk≥1 NAtrk≥2 ATRK-BB NBtrk≥1 NBtrk≥2 BTRK-BB NCtrk≥1 NCtrk≥2 CTRK-BB	9	Atrk=MDC Full track+TOF hit OR MDC Full track+TOF hit+ EMC Cluser Btrk= ETOF hit + EEMC Cluster OR ETOF hit + EEMC Cluster +MDC Short Track Ctrk=MDC Track+Inner MDC hit
		41	

- Function
  - TOF
    - Timing and trigger for Charged particles
    - Background rejection
  - MDC
    - Tracking
    - Background rejection
  - EMC
    - Trigger for neutral (+charged) particles
  - Match
    - Track/Cluster matching to further background rejection

BESIII L1 trigger block diagram



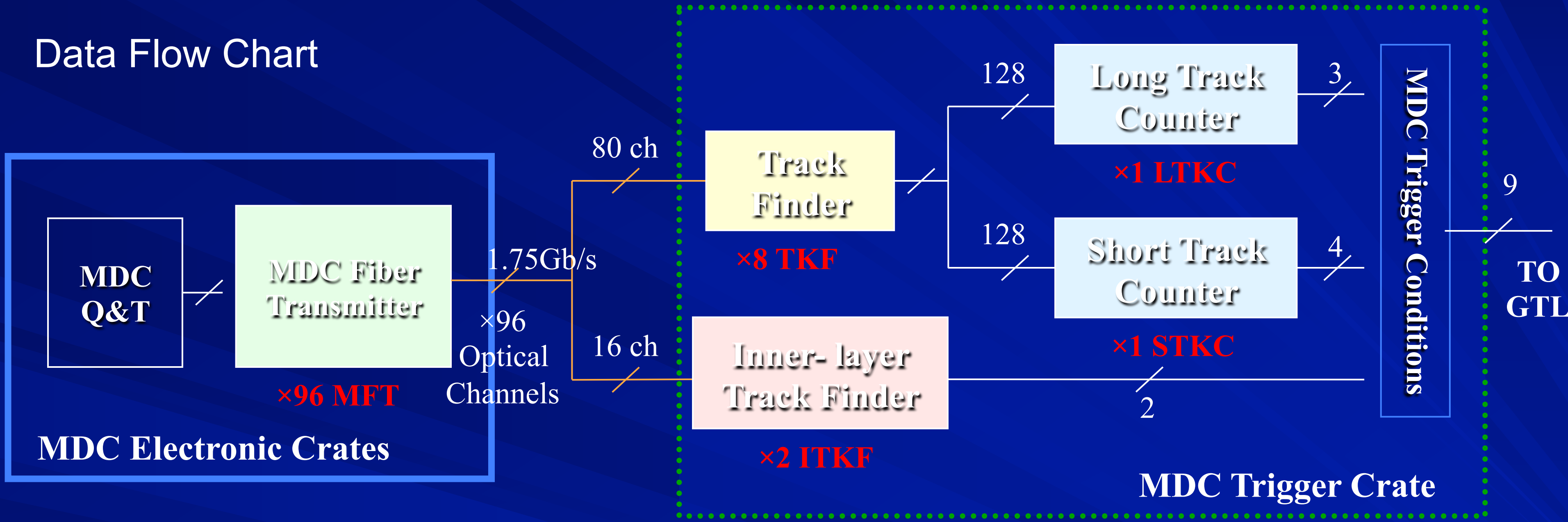
Trigger efficiency from Simulation

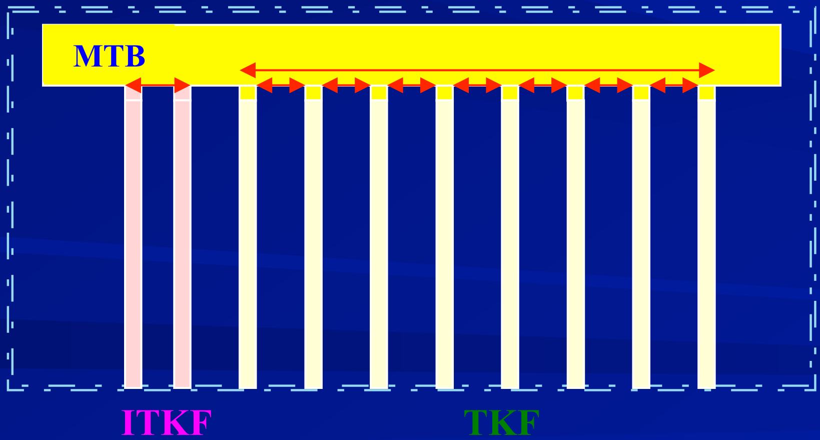
Events generated and simulated with Geant	Trigger efficiency(%)/background rate
Bhabha @3.097Gev	100
Radiative BB(3.097GeV)	100
$J/\psi \to \gamma\ \eta \to 3\gamma$	99.99
$J/\psi \to \omega\ \eta \to 5\gamma$	99.99
$J/\psi \to K^+K^-\pi^0$	99.69
$J/\psi \to$ P Pbar	99.91
$J/\psi \to$ anything	99.80
J/ψ (2S)$\to$anything	99.50
J/ψ (3770)$\to$anything	99.90
Lost beam backgrounds	1.85kHz
Cosmic-ray backgrounds	86Hz

- Showed good results

Hardware Implimentation (MDC as example)

Data Flow Chart





	Type of PCB	Board name	# of boards	FPGA firmware
MDC Fiber Transmitter	1	MFT	96	1
TracK Finder	1	ITKF	2	2
		TKF	8	8
TracK Counter	1	LTKC	1	1
		STKC	1	1
MDC Trigger Backplane	1	MTB	1	
Total	4		109	13

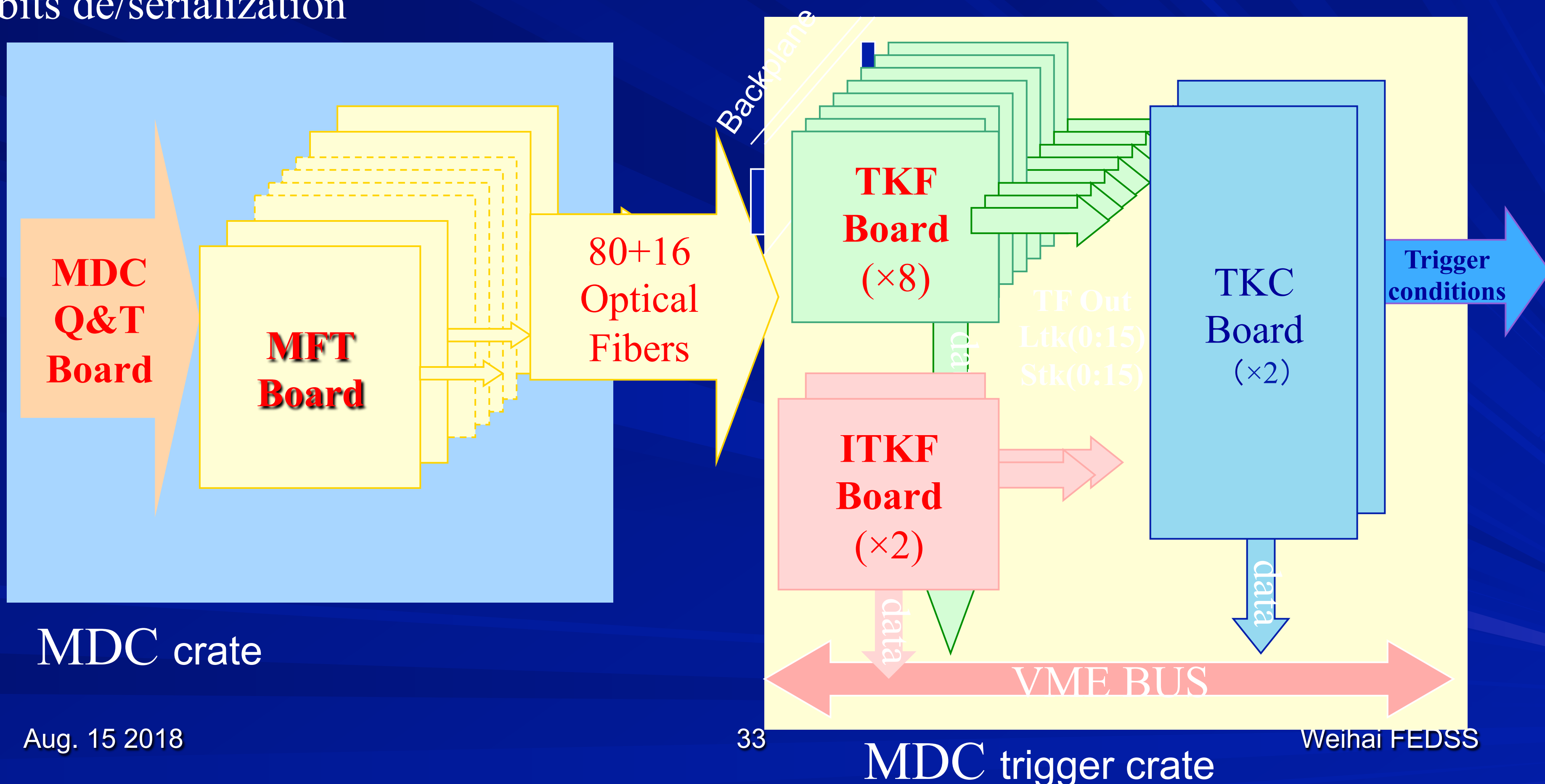
Processing boards allocation

- Xilinx VirtexII Pro
- RocketIO 1.6Gbps
- 32bits de/serialization

MFT: one fiber per board

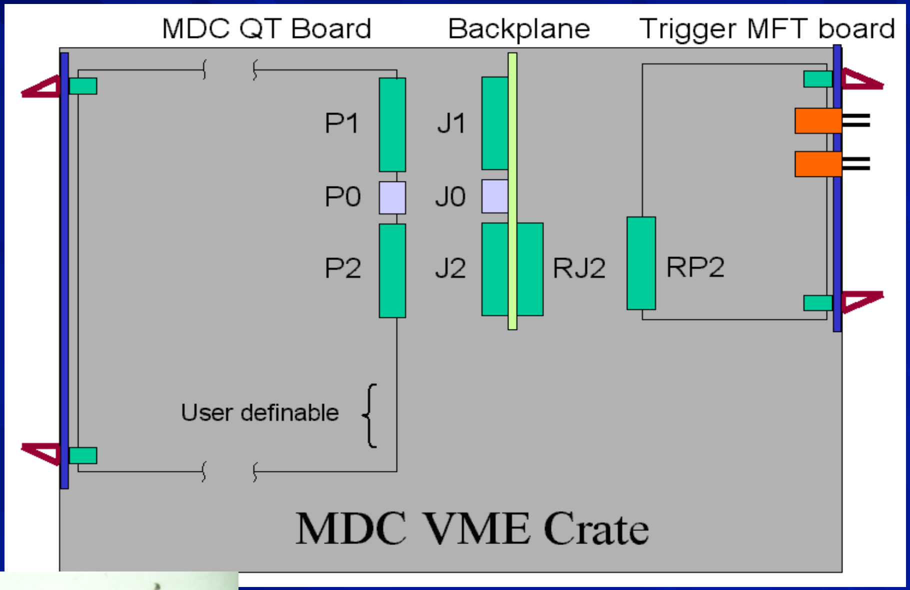
TKF: 8 boards hardware same

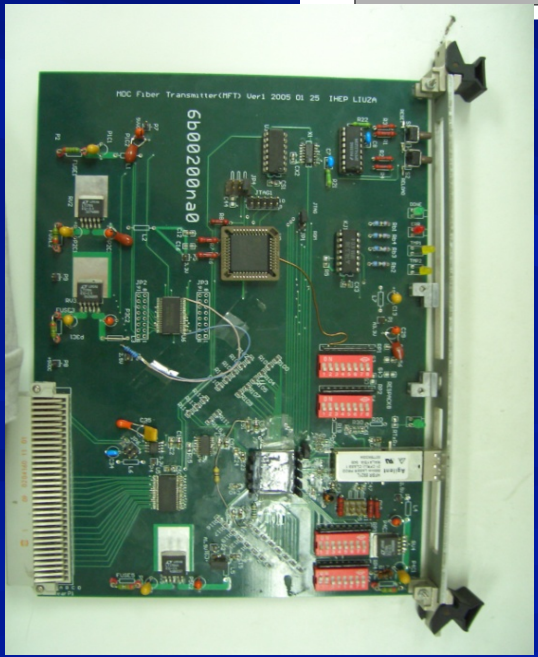
FPGA software similar

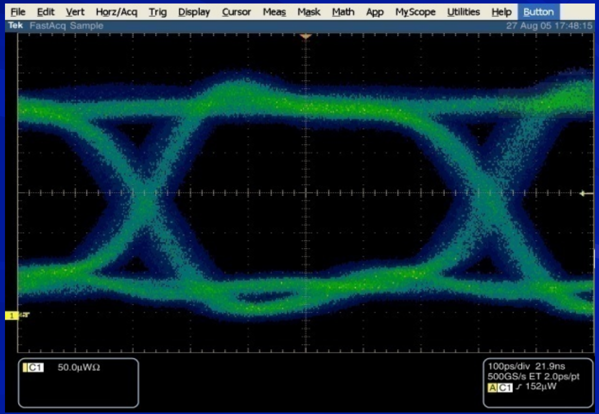


MFT (MDC Fiber Transmitter)

- 2796 hits signals from MDC QT boards are collected in MFT, 32 channels per MFT
- Optical fibers are used between MFT and TKF(ITKF) to eliminate common-ground noises
- Virtex-II Pro FPGA: XC2VP2
- 8 layers PCB







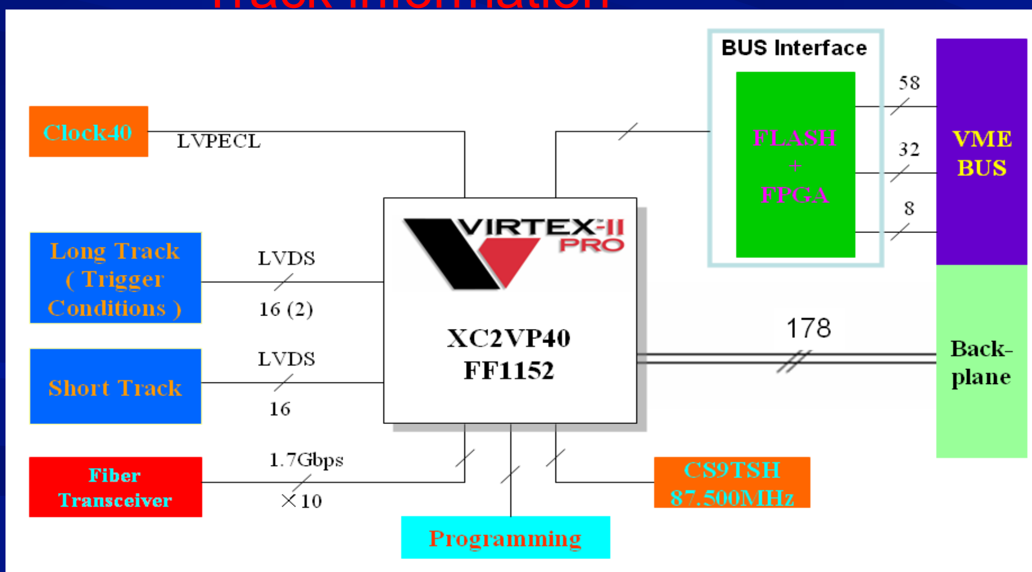
TKF (TracK Finder)寻迹板

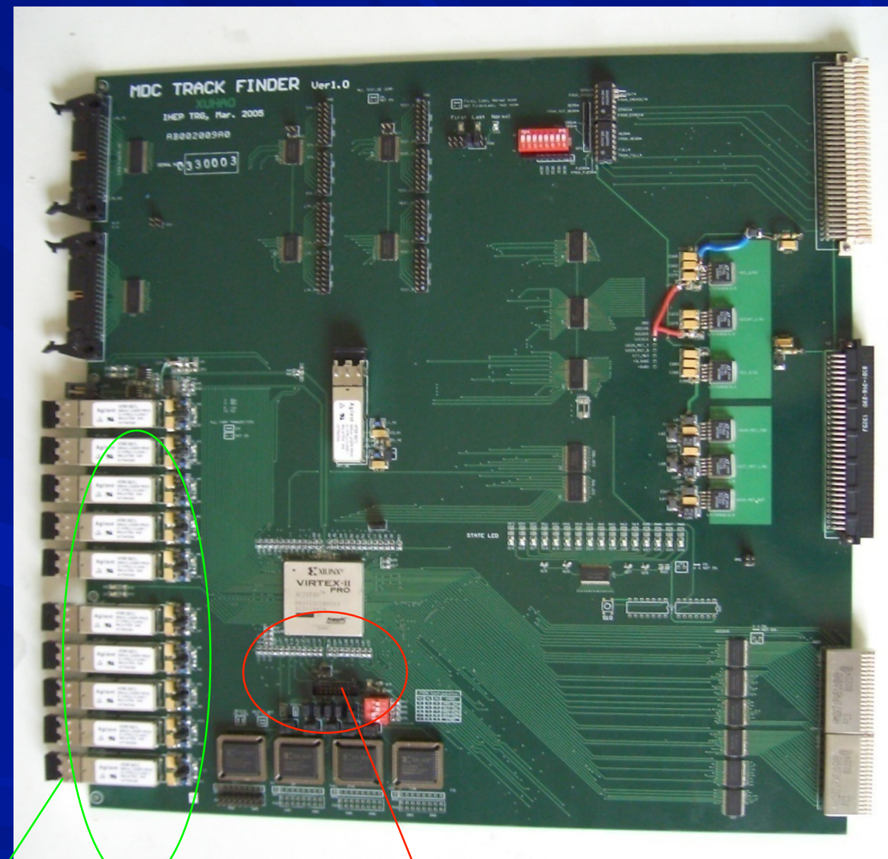
XC2VP40： FF1152, 804 user IOs, 43,632 logic cells, 3,456Kbit BRAM, 12 RocketIOs, 2 PowerPCs, 192 multiplier blocks

10 layers 9UVME PCB

Functions:

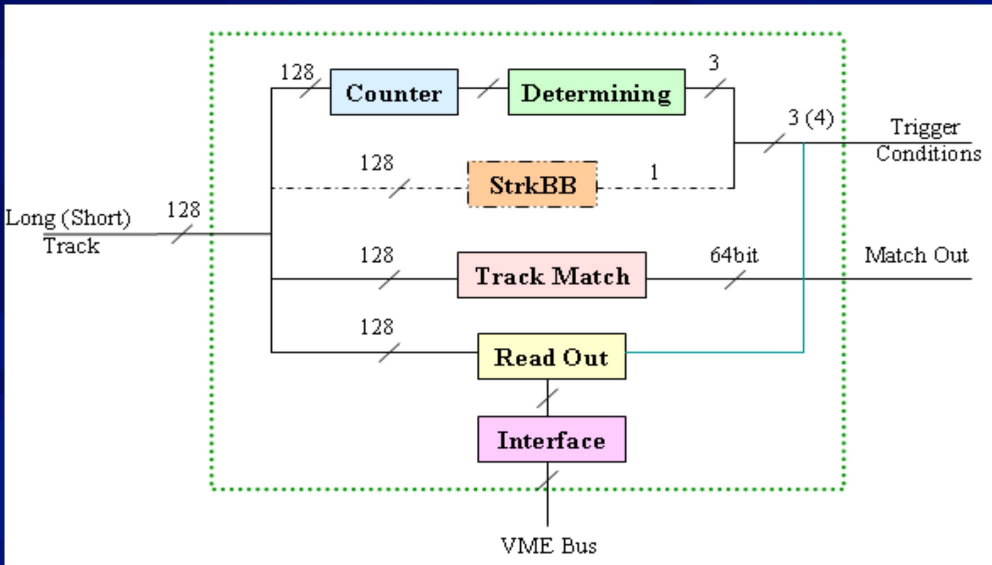
- TSF
- TF
- Track information



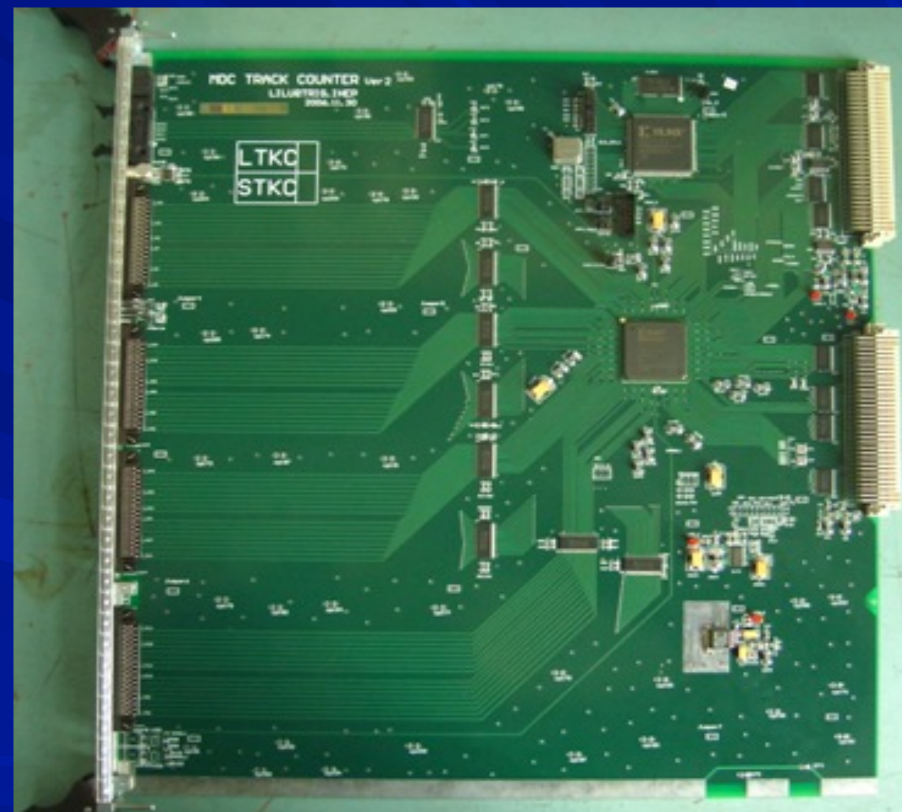


HFBR5921L XC2VP40

TKC (TracK Counter)径迹计数板



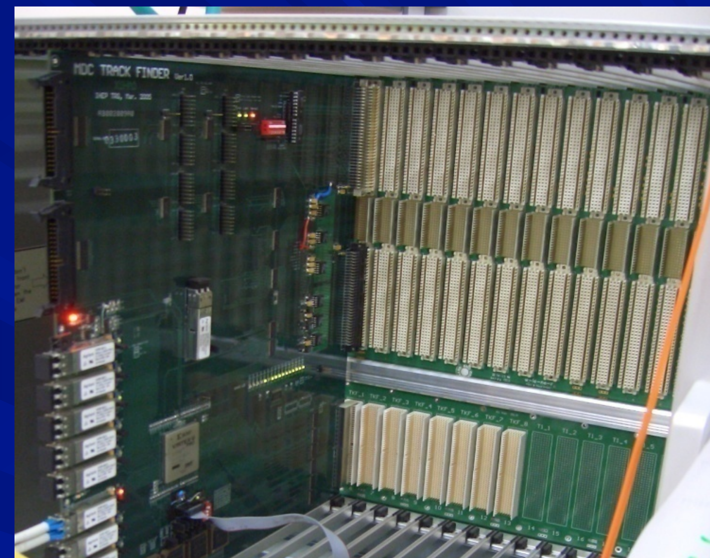
- LTKC（Long TracK Counter）receives the number of long tracks from TKF and sends the trigger conditions to global trigger
- STKC （Short TracK Counter） receives the number of short tracks from TKF and sends the trigger conditions to global trigger
- 8 layers PCB

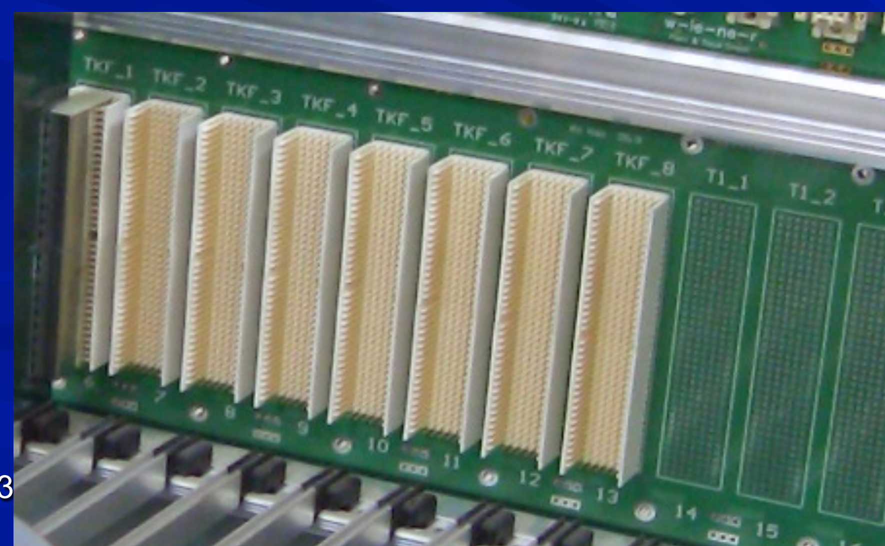


MTB (MDC Trigger Backplane)

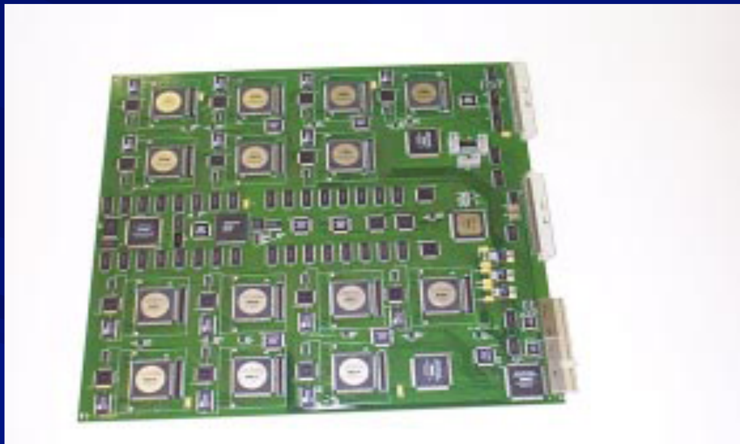
- Limited Bandwidth
- Inter-link neighbor boards, to reduce the cables.
- 12 layers PCB
- SI & EMC

- The experience in solving the difficulties met at BESIII Trigger Design, lead to collaborate for the new xTCA standard after VME.

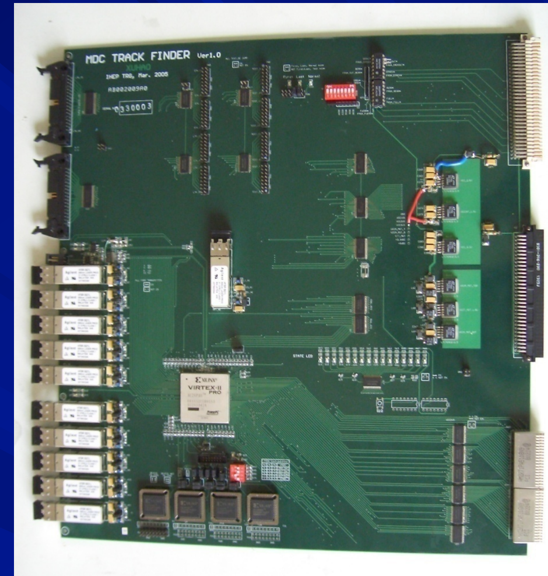




Example of evolution



Demonstrator at
the end of the 90's

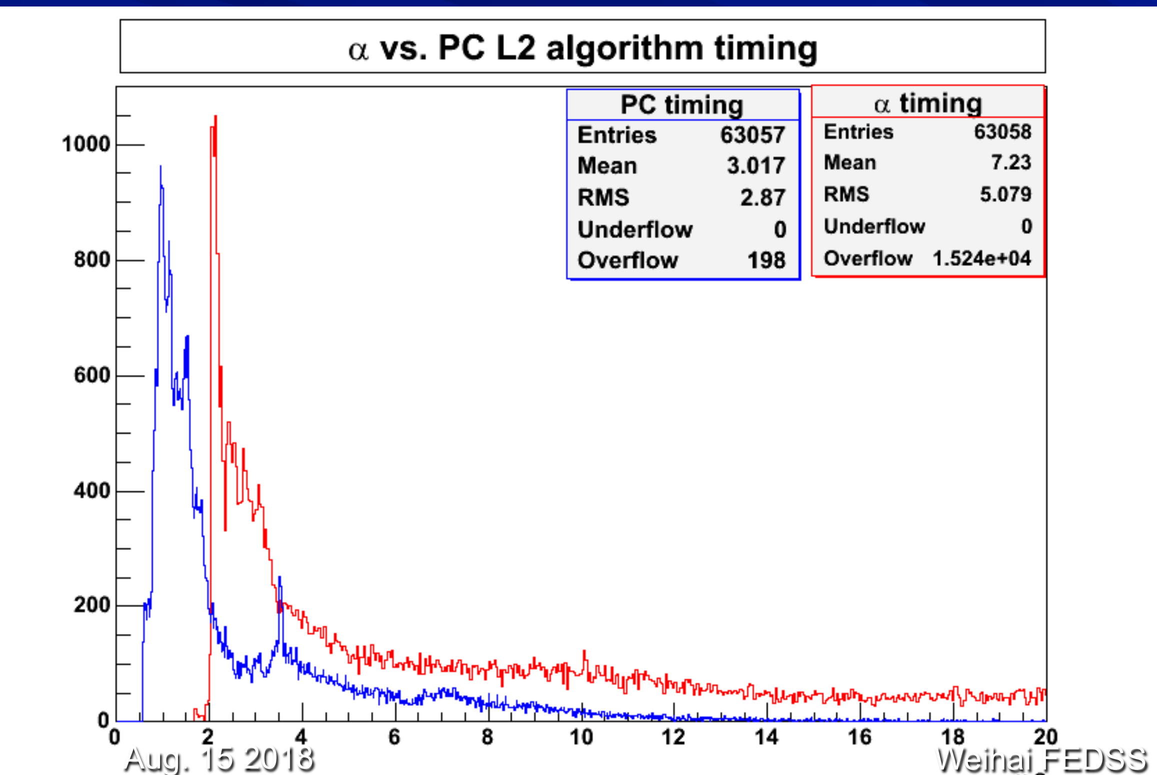


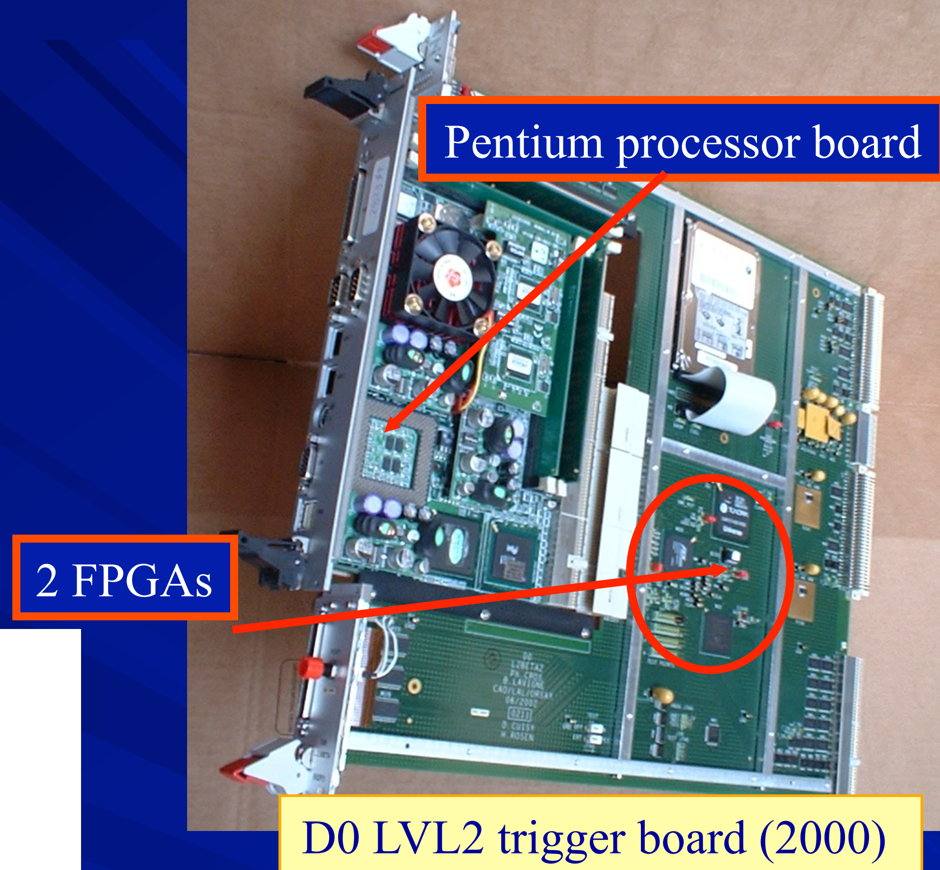
Final version
installed

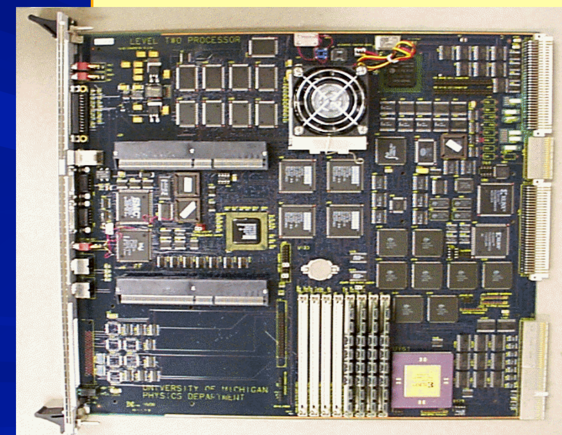
- Muon trigger board for ATLAS
  - Handles 13 input links, each of them receiving 32-bit every 25ns
  - ~17 Gb/s processed
- MDC Trigger board for BESIII(right)

LVL2 examples

- Alpha = many years of efforts ….hardware and software
- PC (Commercial): few months to implement! No hardware !







Alpha Processor board

Specification of BESIII DAQ requirement (Thanks to Prof. Kejun Zhu for DAQ Infor)

- Trigger Rate: 4KHz
- Event Length: 12KB
- Data Bandwidth: 48MB/s
- Dead Time < 5%

Sub-Detector	Channels
MDC (T+Q)	6796+6796
EMC	6240
TOF (T+Q)	448+448
MUC	9088
Total	~ 30K

1000 * BESII DAQ

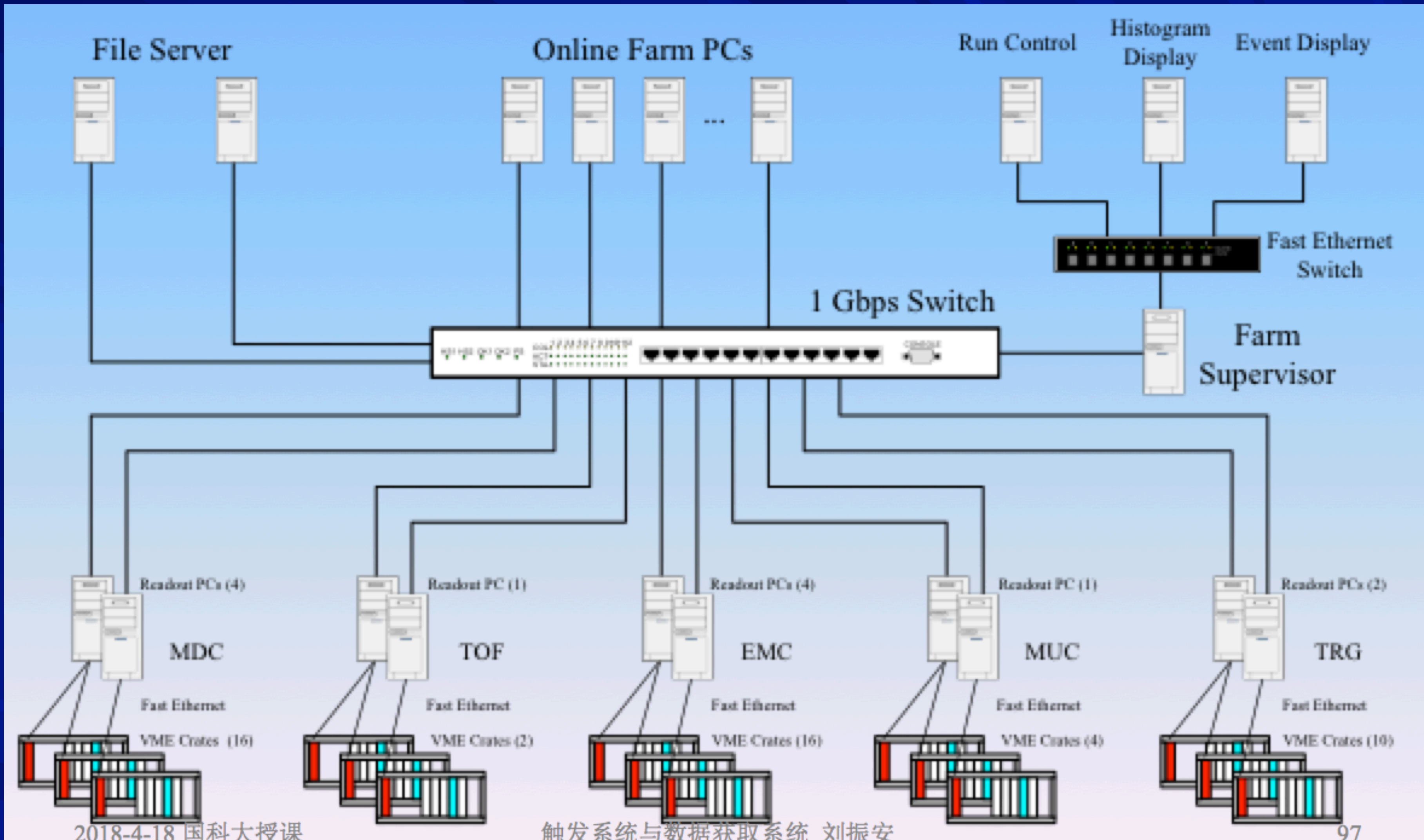
Function of BESIII DAQ

- Data acquisition including readout, packing and online filter数据获取，包括数据读出、组装和在线过滤等
- Data storage数据存储
- Run Control运行控制
- Monitoring数据监测，如单事例、直方图显示
- DataBase Configuration配置数据库
- Error reporting报错和容错

Techniques技术措施

- Distributed Parallel Computing, Layered architecture分布式并行计算、层次结构
- Multithread and Object Oriented多线程技术、面向对象
- Based on Network Exchanging基于网络交换技术
  - A multi-processor distributed environment
  - Parallel data streams working independently and concurrently
- Multi Layer Data Buffer多级数据缓存
- Upgradability and Expendability易升级和扩展
- Reliable and Stable系统可靠、稳定

Structure of BESIII DAQ

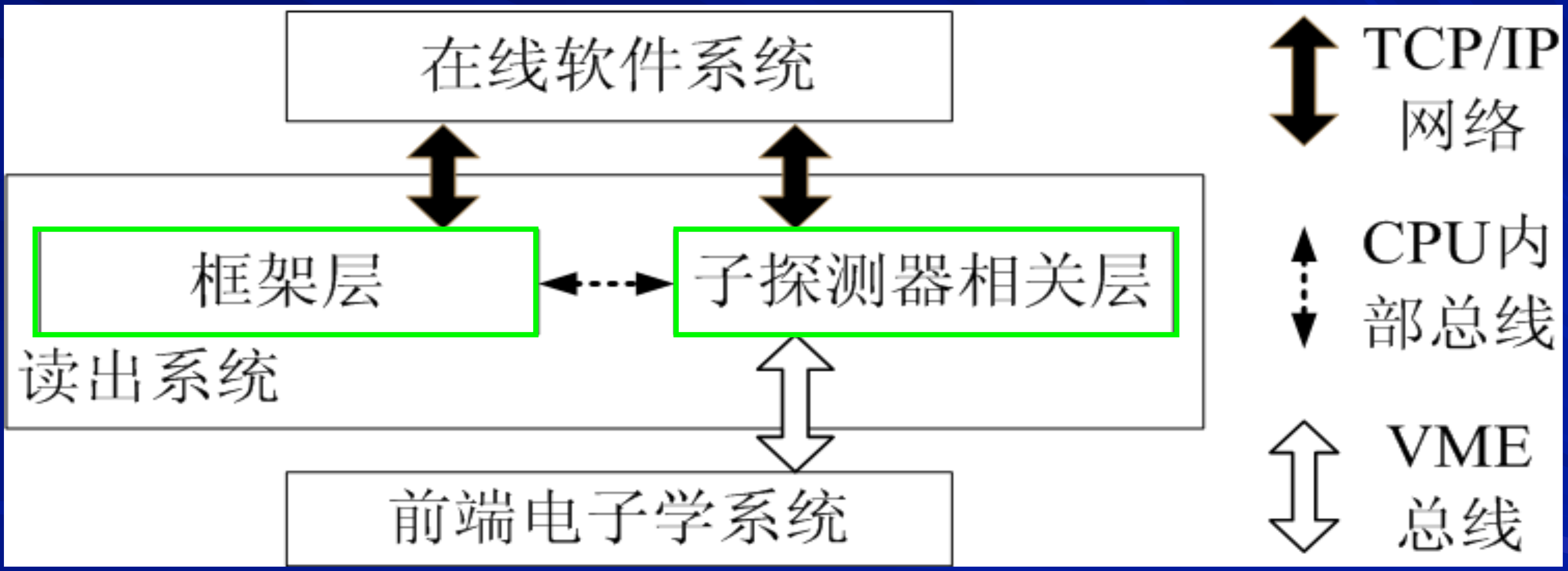


DAQ系统组成

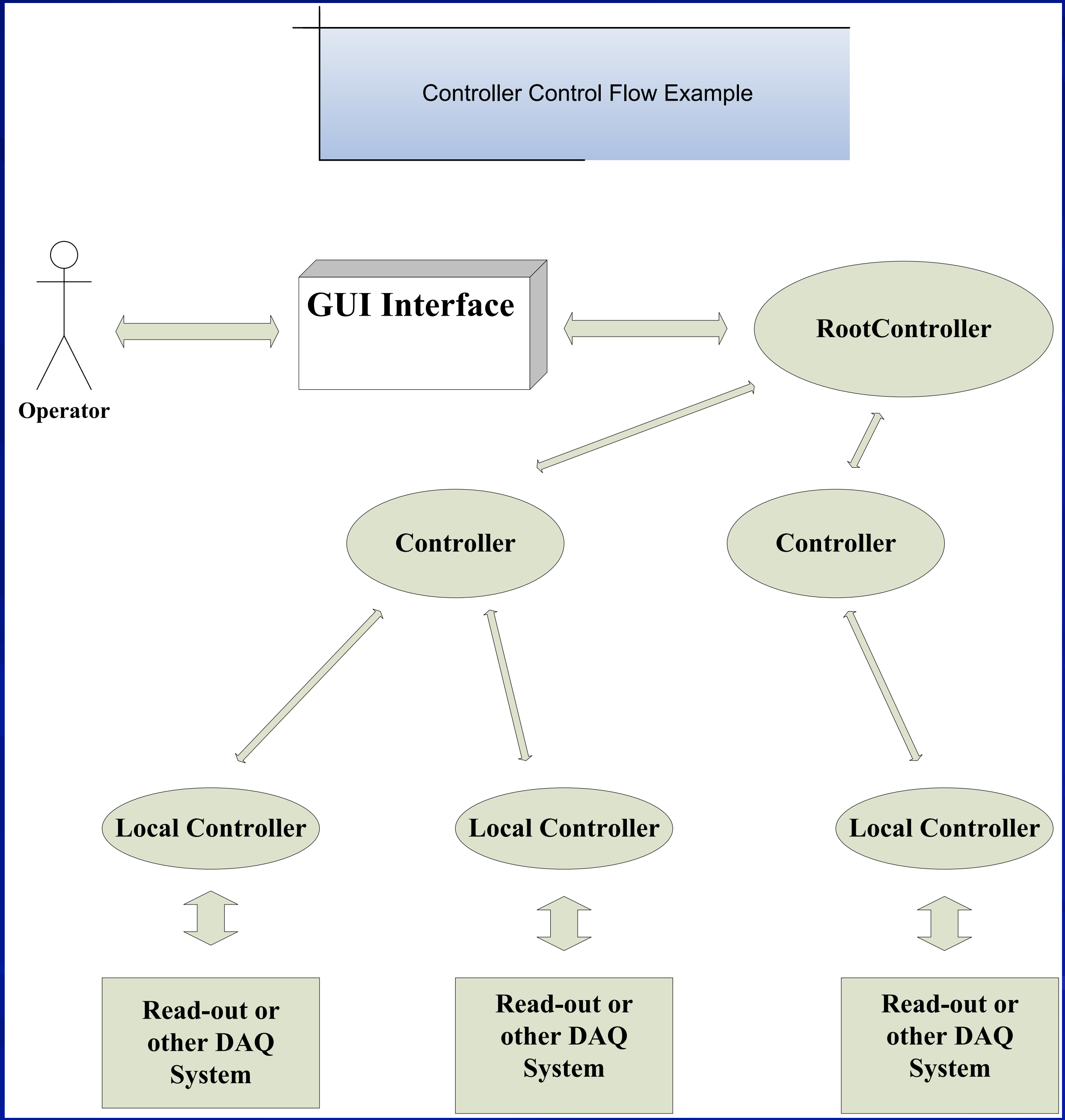
- 前端电子学读出：通过VME总线由PowerPC读出插件中的数据
  - 采用CBLT (Chained Block Transfer) DMA数据读出方案
  - 采用多事例读出方案
- 数据流：负责探测器数据通过网络传送
  - 插件→PowerPC→读出PC→在线机群→服务器→计算中心
- 在线软件：负责取数、测试和刻度运行过程中的控制和管理，还提供报错、运行参数管理、直方图和实时监测等功能
- 采用ATLAS TDAQ软件作为BESIII数据获取系统的基本框架

FrontEnd Readout Software前端VME数据读出框架

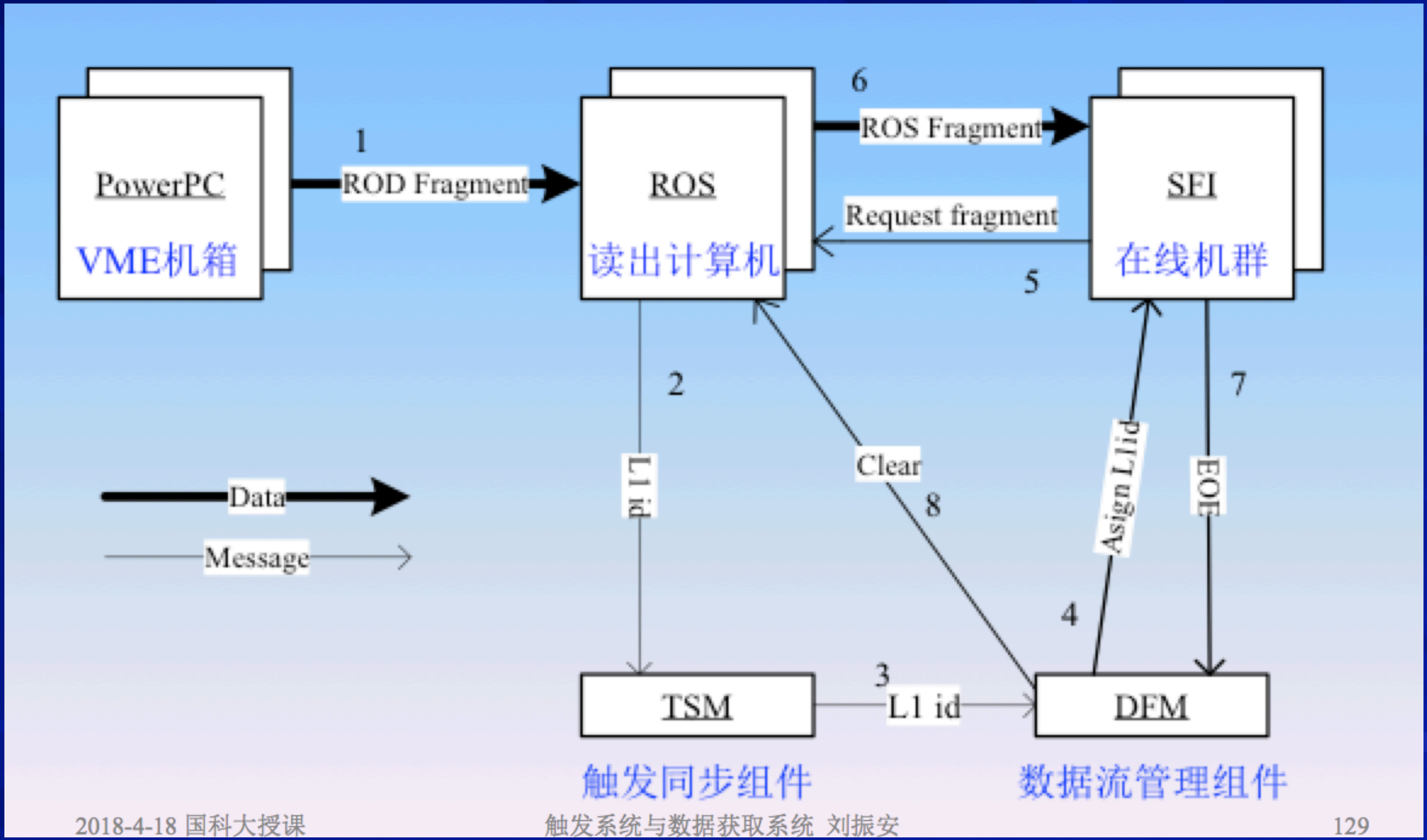
结构



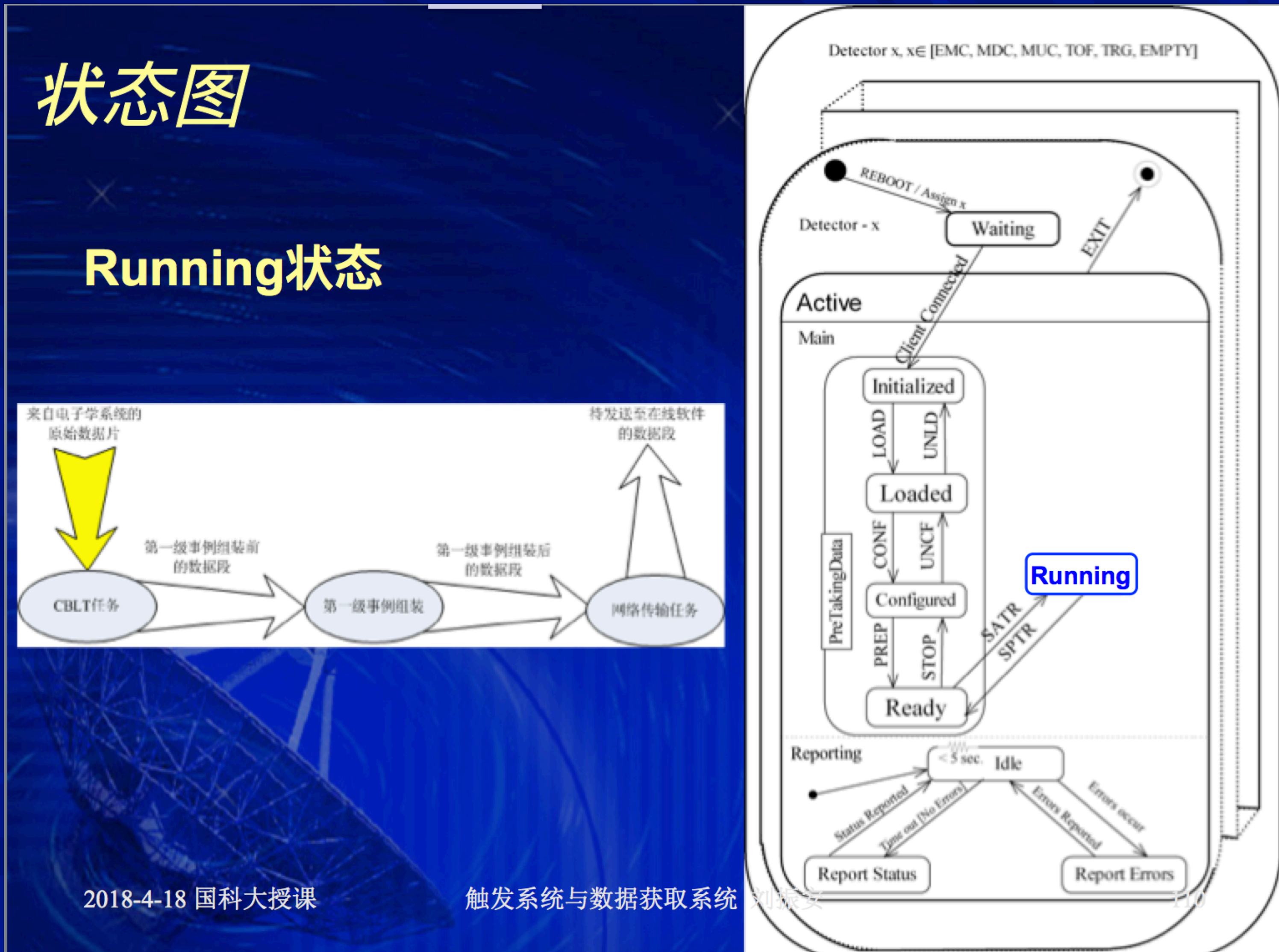
RUN Control


Controller Control Flow Example
Operator
GUI Interface
RootController
Controller
Controller
Local Controller
Local Controller
Local Controller
Read-out or other DAQ System
Read-out or other DAQ System
Read-out or other DAQ System

Control and Data Stream



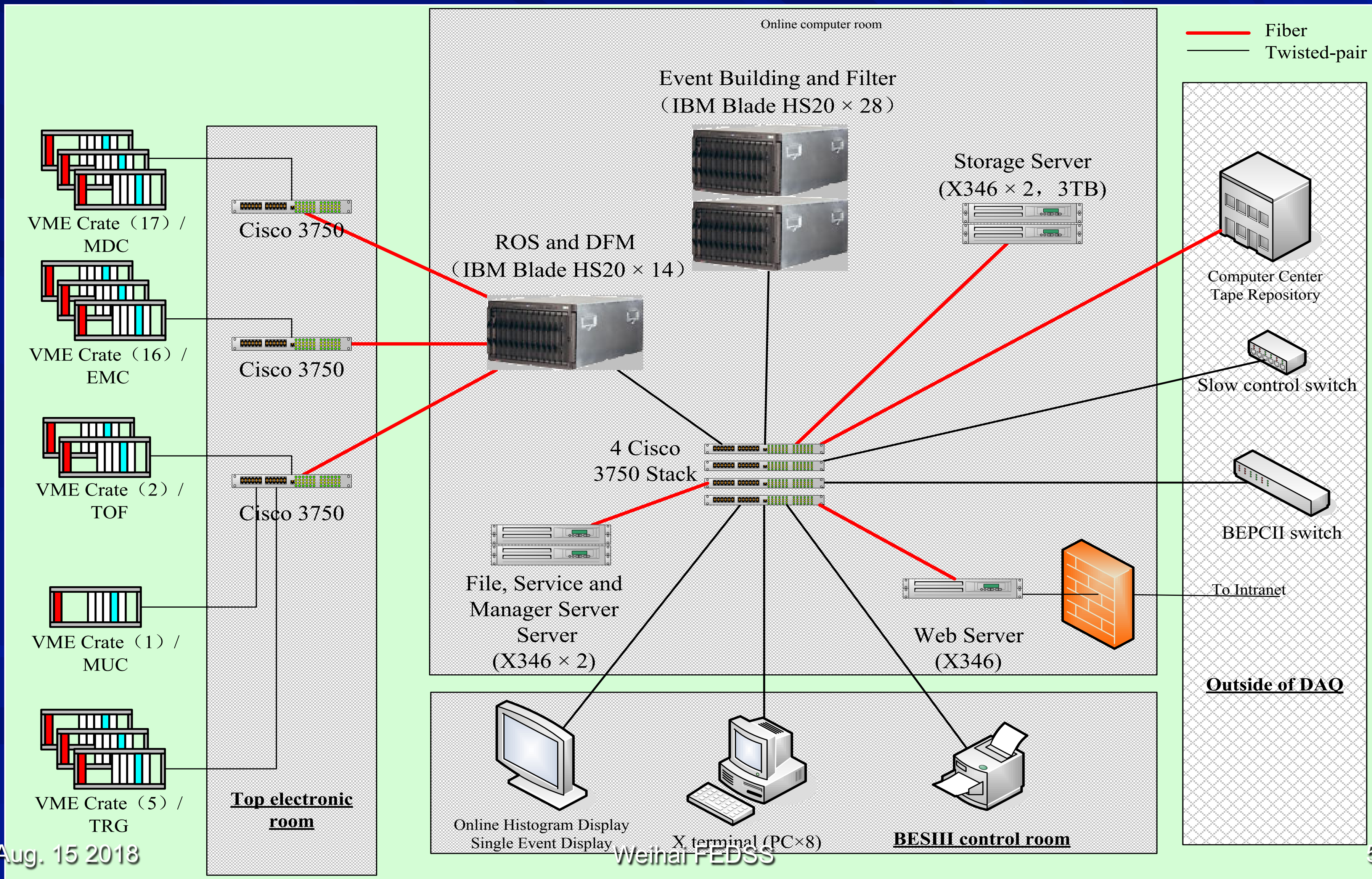
Run States


状态图
Running状态
来自电子学系统的
原始数据片
待发送至在线软件
的数据段
第一级事例组装前
的数据段
第一级事例组装后
的数据段
CBLT任务
第一级事例组装
网络传输任务
2018-4-18 国科大授课
触发系统与数据获取系统
Detector x, x∈ [EMC, MDC, MUC, TOF, TRG, EMPTY]
REBOOT / Assign x
Detector - x
Waiting
EXIT
Client Connected
Active
Main
Initialized
LOAD
UNLD
Loaded
CONF
UNCF
Configured
PREP
STOP
Ready
PreTakingData
SATR
SPTR
Running
Reporting
< 5 sec.
Idle
Status Reported
Time out (No Errors)
Errors Reported
Errors occur
Report Status
Report Errors

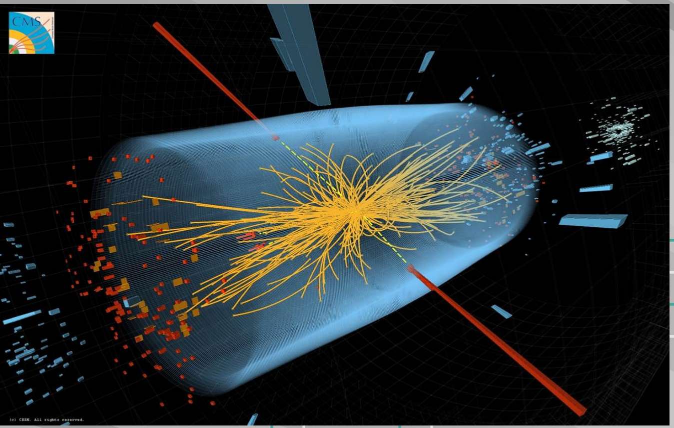
More on Hardware

- Ethernet Switch以太网交换机
  - 9 x Catalyst 3750 24 10/100/1000 + 4 SFP
- IBM服务器
  - 2个IBM刀片中心: 2 x 3.2GHz处理器 + 2 GB内存
  - 1个IBM刀片中心: 2 x 3.2GHz处理器 + 2 GB内存+ 1块千兆光纤网卡
  - 5台IBM x346服务器: 2 x 3.2GHz处理器 + 2 GB内存 + 1块千兆光纤网卡 + 1.5TB磁盘

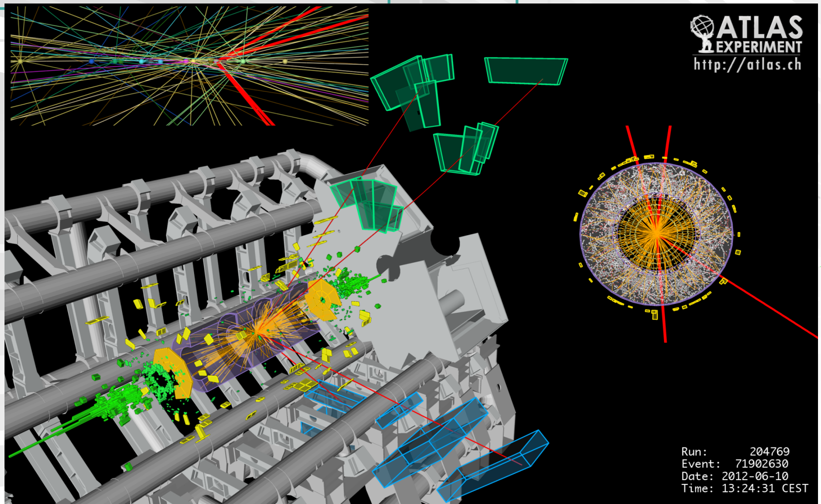
DAQ系统部署



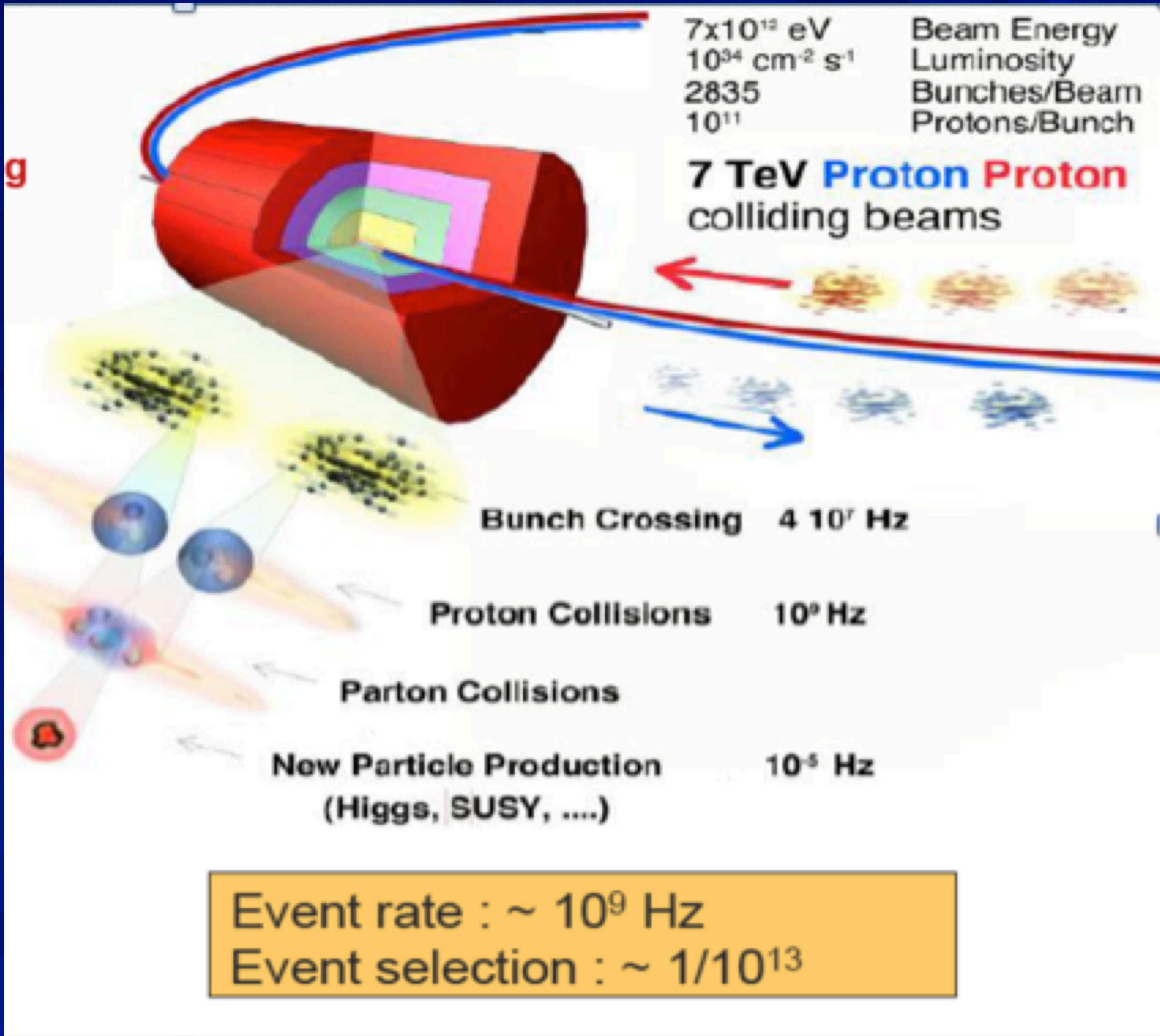
Online computer room
Fiber
Twisted-pair
Event Building and Filter
（IBM Blade HS20 × 28）
Storage Server
(X346 × 2，3TB)
ROS and DFM
（IBM Blade HS20 × 14）
VME Crate（17）/
MDC
VME Crate（16）/
EMC
VME Crate（2）/
TOF
VME Crate（1）/
MUC
VME Crate（5）/
TRG
Cisco 3750
Cisco 3750
Cisco 3750
4 Cisco
3750 Stack
Computer Center
Tape Repository
Slow control switch
BEPCII switch
To Intranet
File, Service and
Manager Server
Server
(X346 × 2)
Web Server
(X346)
Outside of DAQ
Top electronic
room
Online Histogram Display
Single Event Display
X terminal (PC×8)
BESIII control room



Trigger and Data Acquisition for LHC experiments



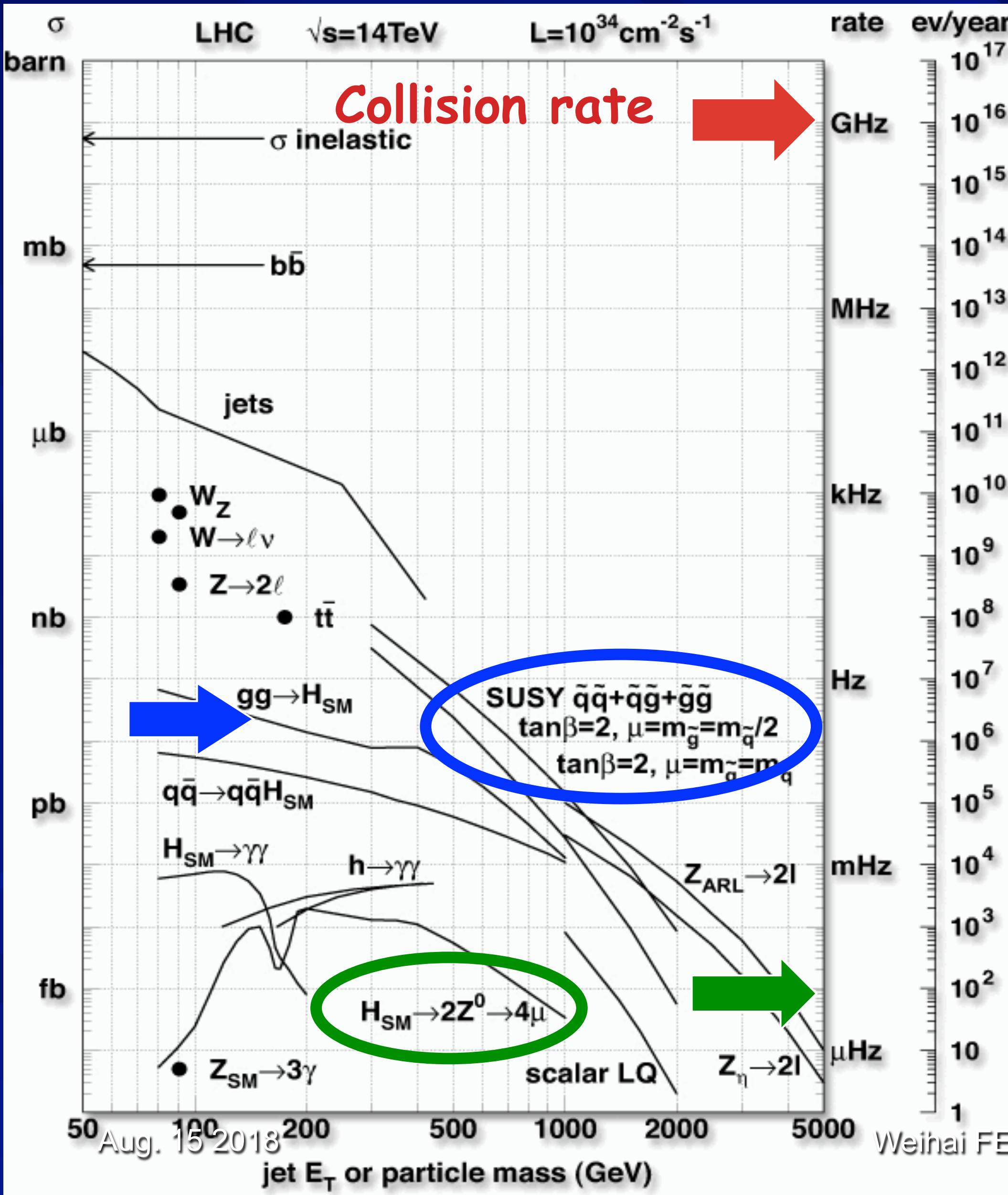
Challenging :The LHC T/DAQ



Collision
Every 25 ns

Quarks

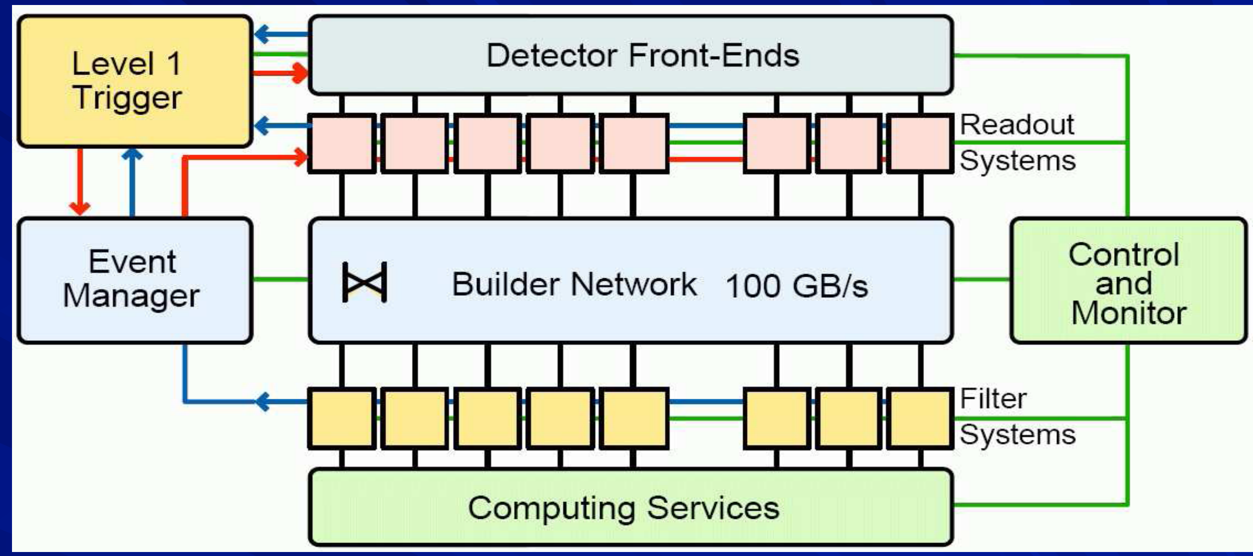
The LHC challenge

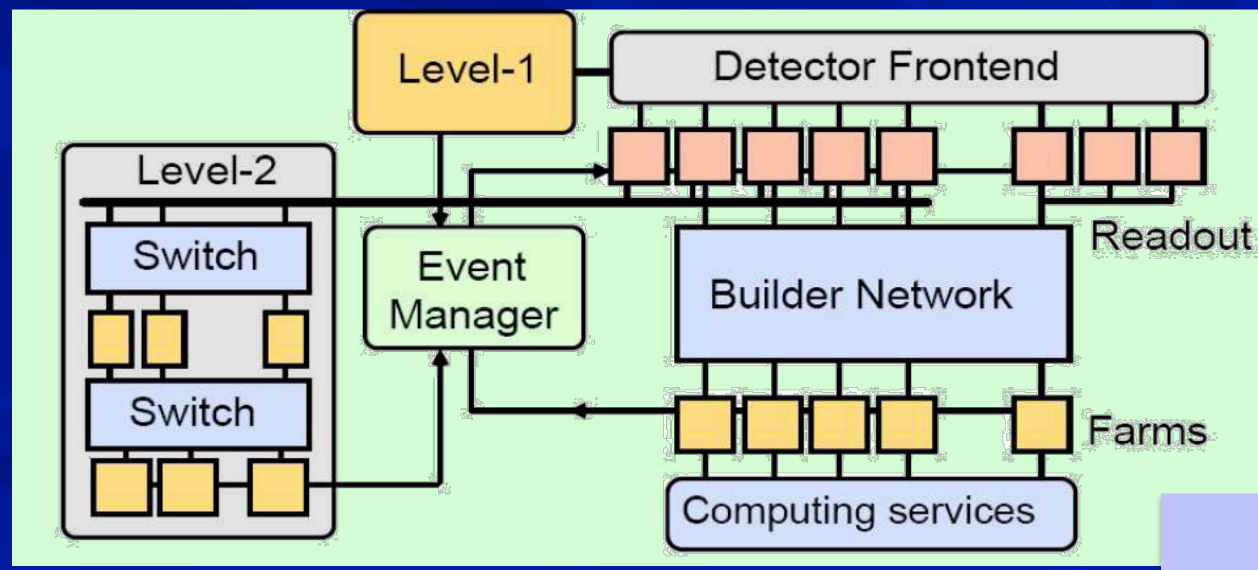


- "Interesting" physics is about 6-8 orders of magnitude below (EWK & Top)
- "Exciting" physics involving new particles/discoveries is ≥ 9 orders of magnitude below σ_{tot}
- We *just* ☺ need to efficiently identify these rare processes from the background before reading out & storing the whole event
- **Conclusion: Need to watch out for high transverse momentum electrons, jets or muons**

After L1 → Two philosophies

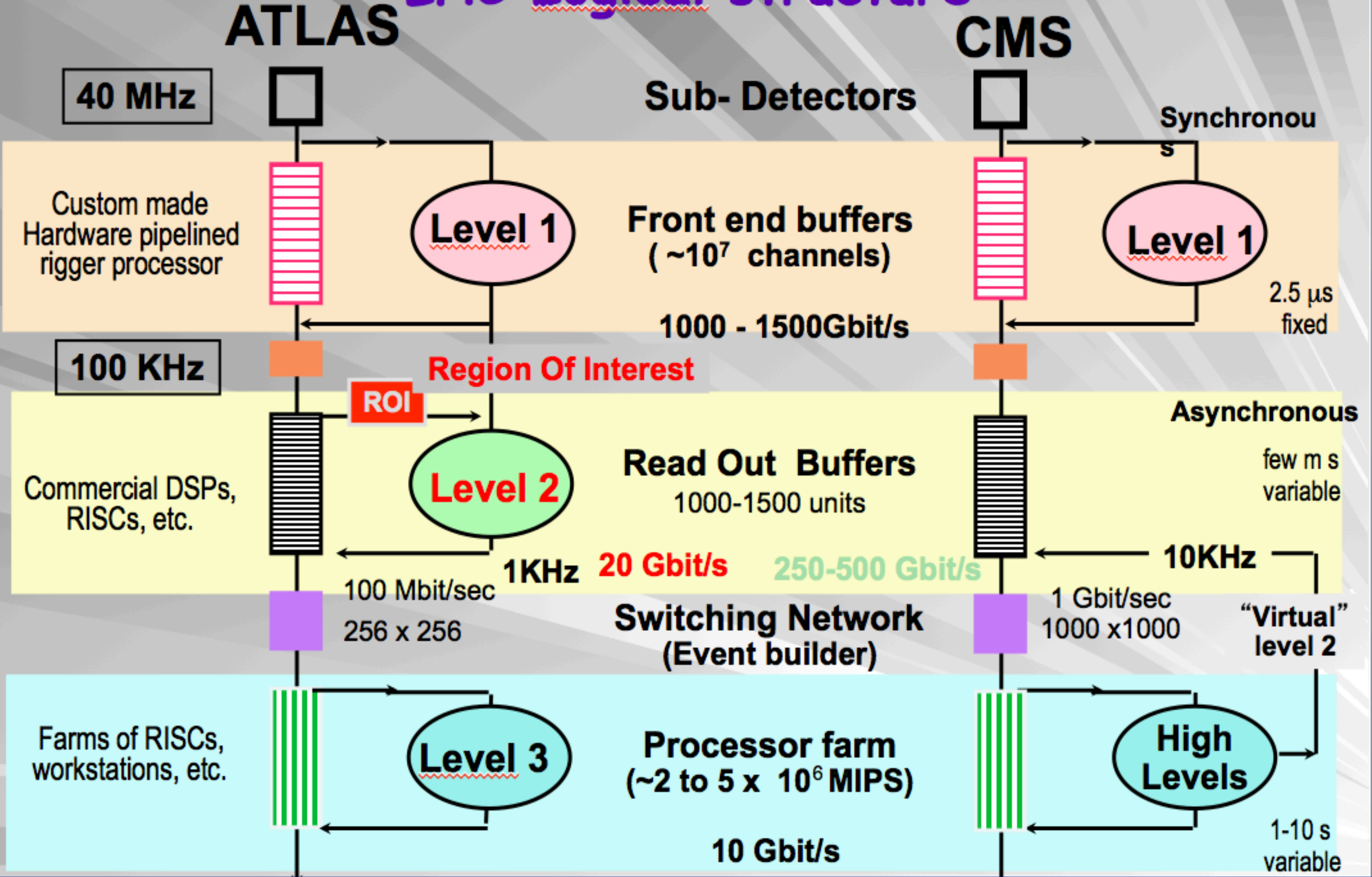
- Send everything, ask questions later (ALICE, CMS, LHCb)
- Send a part first, get better question
  Send everything only if interesting (ATLAS)





Push vs. Pull
That is the question?

LHC Logical structure



"Logical Strategy" for event selection

MHz → **collision rate**

Logical steps

L1 — Coarse dedicated data

Prompt Trigger
"Identification of objects"

Local identification of
- Energy cluster
- Track segment
- Missing energy

Few µsec — **> KHz** → Objects

L2 — Final Digitized data *optimised code*

High Level Trigger Selection
"L 1 objects " confirm
Particle signature
Global Topology
Trigger Menu

- Refine Et and Pt cut
- Detector matching
- Mass calculation
- VTX & Impact parameters ...

Few msec — **> Hz** → **Classification of Physics/calibration Process**

L3 — Partial to full event *"Off-line" code type*

Event Filter
On-line processing

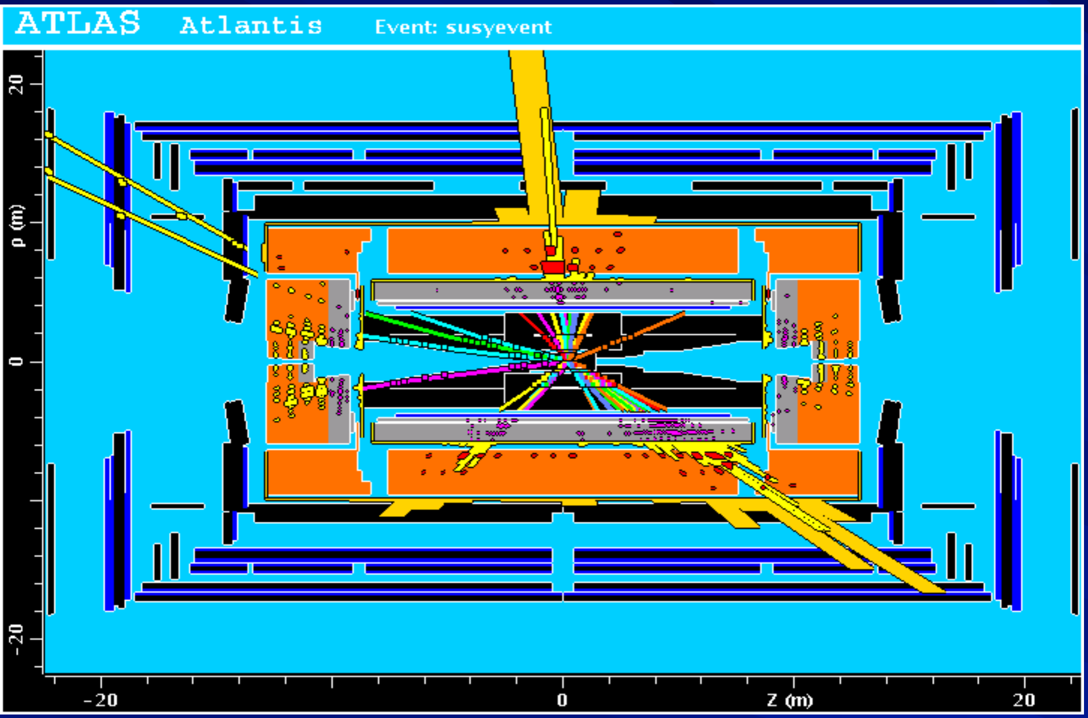
- Full or partial reconstruction
- Calibration & monitoring
- "Hot stream" physics
- "Gold platted "events
- Final formatting etc ...

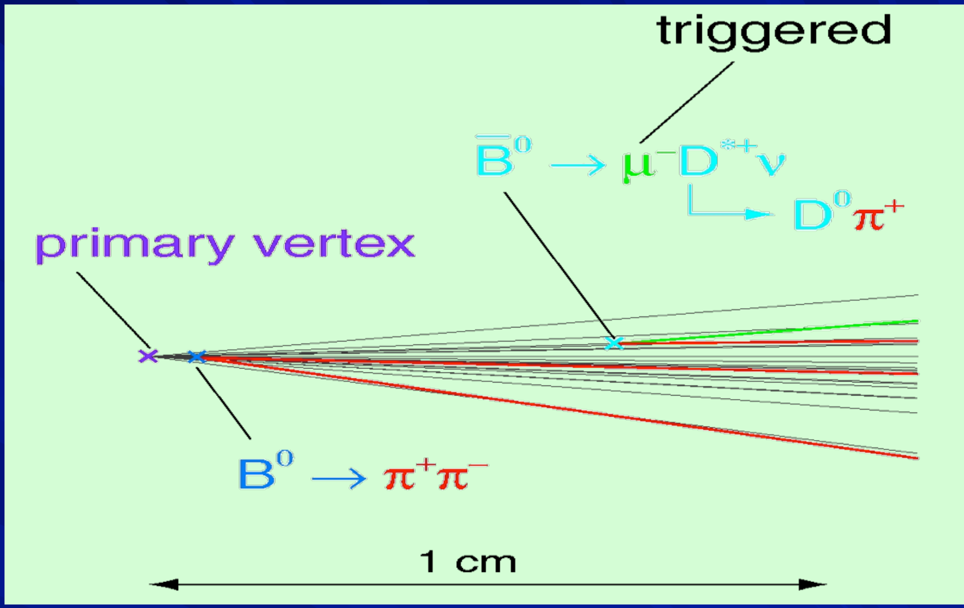
Few sec — **Data streams**

S1 S2 S3 S4 Sn → Storage& analys

"off-line"

High Level Triggers





Complicated Event structure with hadronic jets (ATLAS) or secondary vertices require full detector information

Methods and algorithms are the same as for offline reconstruction

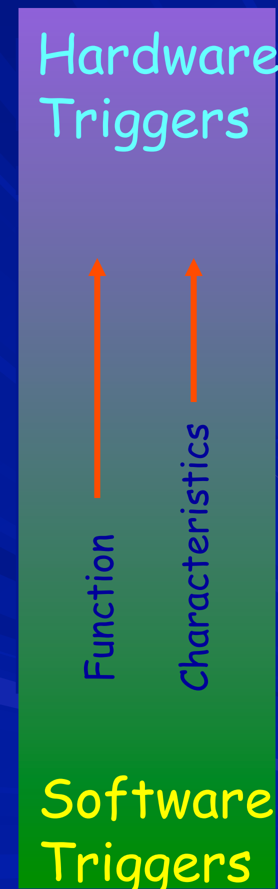
On-Off line boundaries

- Detectors are becoming more stable and less faulty
  - High efficiency, Low failure rate
  - Powerfull "on-line" diagnostics and error recovery (expert systems)
- On-line computing is increasing and not doing only "data collection": More complex analysis is moving on-line
  - "Off-line" type algorithms early in the selection chain (b tag ..)
  - Selection of "data streams" --> Important role of the "Filter"
  - Precise alignment needed for triggering
  - Detector calibration using Physics process available
  - On-line calibration and correction of data possible
- Common aspect →
  - Algorithms, Processing farms, Databases…
  - use similar hw/sw components (PC farms..)

Boundaries become flexible

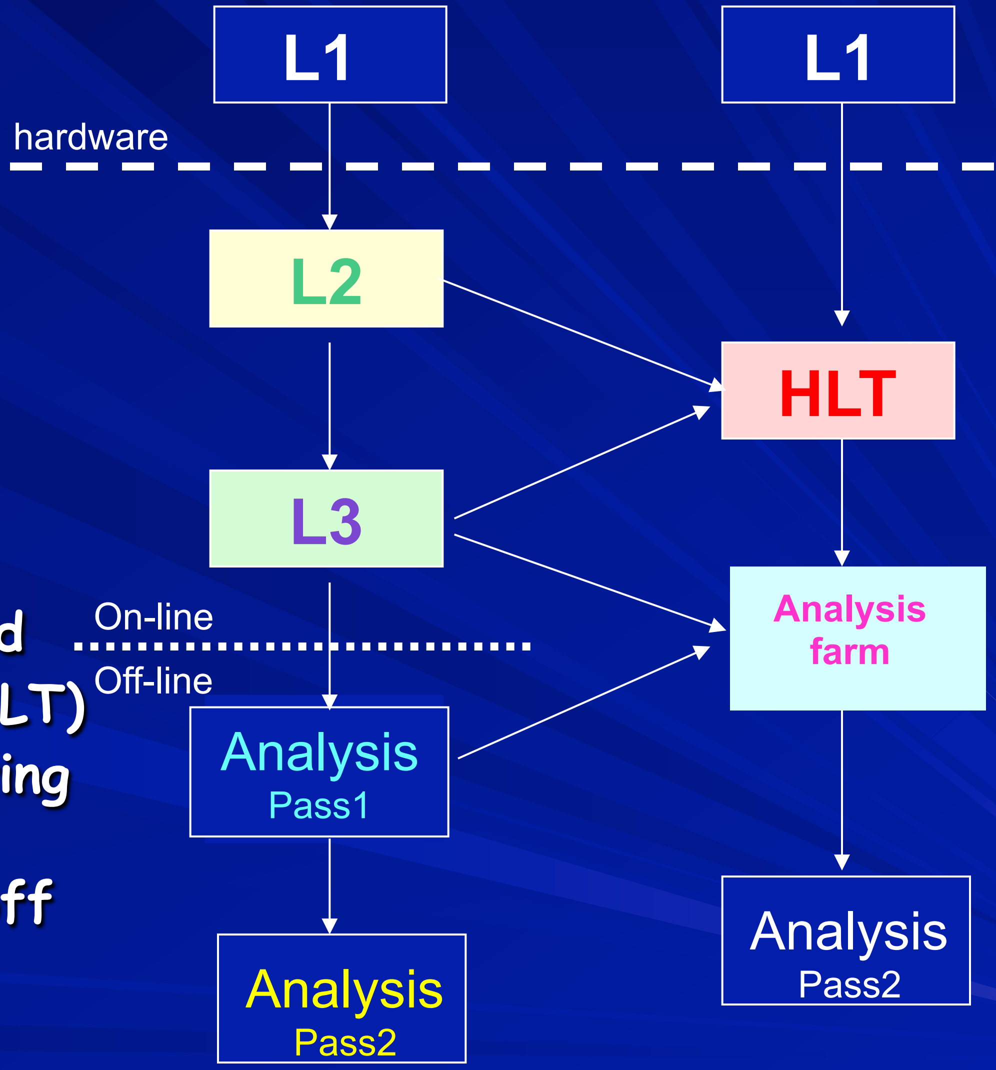
Present evolution (SLHC …)

- Higher level trigger decisions are migrating to the lower levels → Software Migration is following functional migration
  - Correlations that used to be done at Level 2 or Level 3 in are now done at Level 1.
  - More complex trigger (impact parameter!) decisions at earlier times (HLT) → Less bandwith out of detector?
- Boundaries
  - L2 and L3 are merging into High Levels Triggers
  - DAQ and trigger data flow are merging
  - On-line and off-line boundaries are flexible
- Recent Developments in Electronics
  - Line between software and hardware is blurring
  - Complex Algorithms in hardware (FPGAs)
  - Possible to have logic designs change after board layout
  - Fully commercial components for high levels.



Summary of T/DAQ architecture evolution

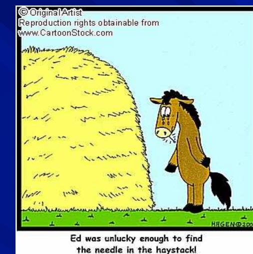
- Today
  - Tree structure and partitions
  - Processing farms at very highest levels
  - Trigger and DAQ dataflow are merging
- Near future
  - Data and control networks merged
  - Processing farm already at L2 (HLT)
  - More complex algorithms are moving on line
  - Boundaries between on-line and off-line are flexible
  - Comodity components at HLT



Backups

实验物理中Trigger/触发的困难

大海捞针：find a needle in a Haystack



1.怎么办哪？？
无从下手！！

2.苦干加
实干不
信找不
到！！

4.有没有
可能？？？

5.愁死
啦！！！

3.不行啊，
哪天能
找到
啊！！

6.别愁啦，快找
触发组啊！！

实验物理中的Trigger/触发

加速器物理实验中的触发判选

本底事例

好事例

- 设计高效的触发判选
  - 定义好事例（缝衣针）和本底（麦秸）的特征
  - 找出不同（界限）
  - 节省资源
  - 高效
  - 实时

本底事例

找到的好事例