~~CP~~ with the LHCb detector

E. Graugés

Madrid 27/5/2008

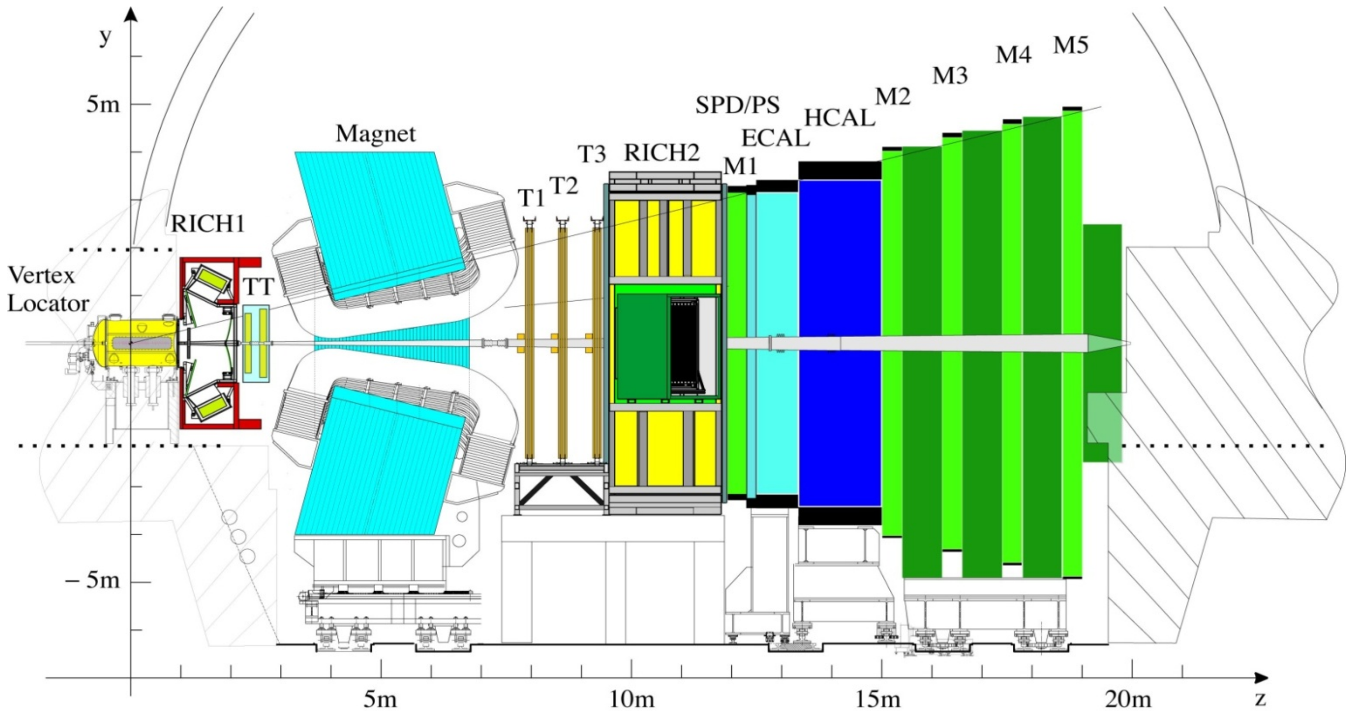
INDEX:

- Introduction
- Our contribution to the Detector (past, present & future)
- Physics Analysis related work
- People and institutions involved
- Budget and time schedule

Introduction

- σ_{bb} ~ 500μb in pp collisions at $\sqrt{s}$ = 14TeV
  - Luminosity limited to few $10^{32}cm^{-2}s^{-1}$
  - 10^{12} bb produced per year (10^7 s) at $2\times10^{32}cm^{-2}s^{-1}$
  - Interesting B decays have small branching ratios
    - Typically < 10^{-3} ⇨ O(10) Hz

⇨ Trigger is a key point



LHCb trigger

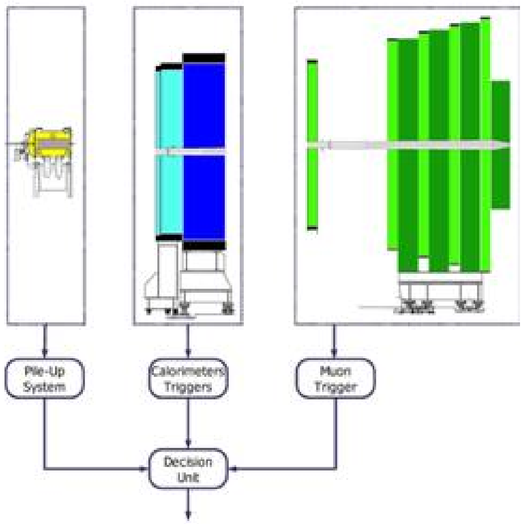
40 MHz

L0

1 MHz

HLT

2 KHz



“High p_T” e, γ, hadrons,
“High p_T” μ, μμ
pileup info

L0: on custom boards
hight pT candidates + not too busy
Uses **calo, muon system, 2 layers of VELO**

SPD (BCN contribution) separates electrons and photons, provides veto for complicated events

HLT: runs in a PC farm of 1000 16-core nodes
Full detector = full flexibility

Our group responsible of a (muon+track) line in the LHCb HLT

- **CP:** look for / constraint New Physics in B meson decays.
  Examples:

$\chi \cong$ **arg(V_{ts})-π** via **phase of B_s mixing, eg** $B_s \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$

$\gamma \cong$ **-arg(V_{ub}) from tree decays,** $B \to DK$, $B \to h^+h^-$

Flavour tagging: many CP analysis require to reconstruct the flavour of the B meson at production

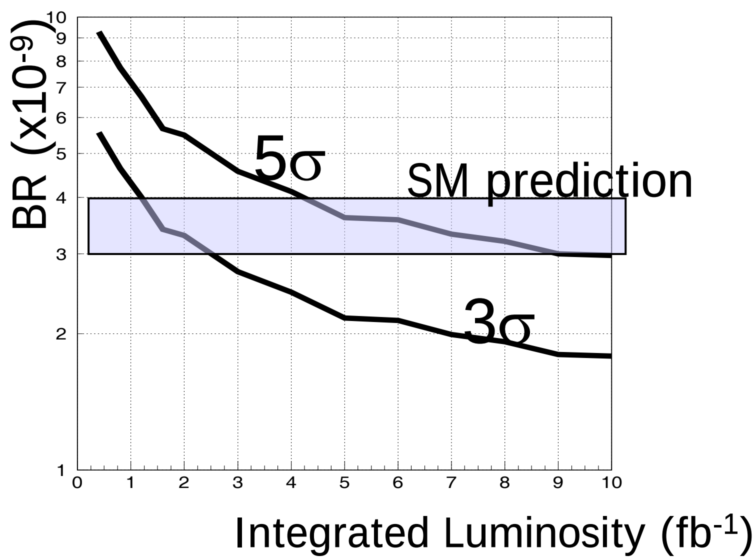
- **Strong involvement from our group in flavour tagging algorithms**

- Rare decays:
  - Via loops => small BR in SM => very sensitive to NP!
  - NP in angular distributions, eg $B^0 \to K^{*0}\mu^+\mu^-$
  - **Star measurement: BR of $B_s \to \mu^+\mu^-$**

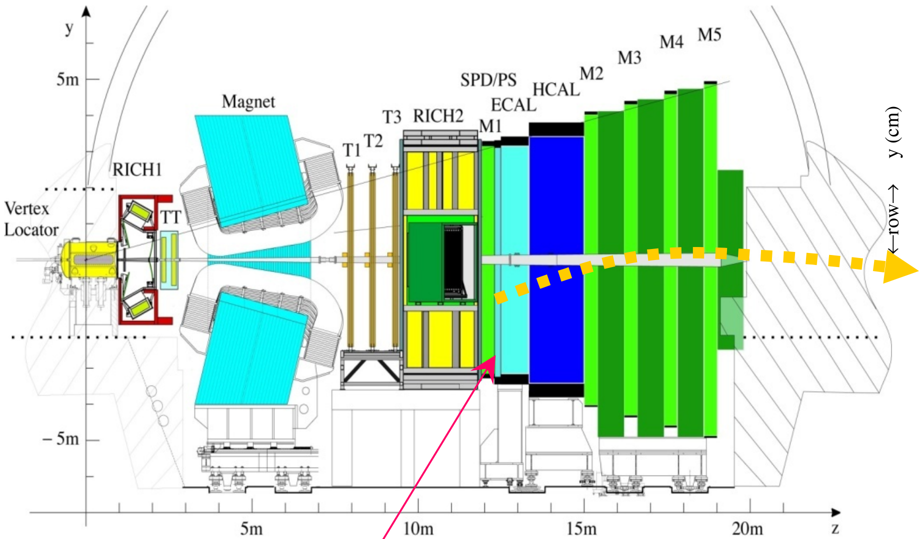
- Expected **Tevatron limit** 10x higher than SM!
- **LHCb:** with L=2fb-1, 3σ observation if SM value

Strong involvement from our group in the measurement

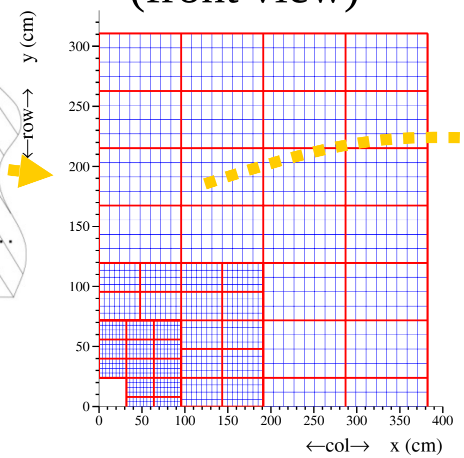
LHCb Sensitivity *(signal+bkg is observed)*



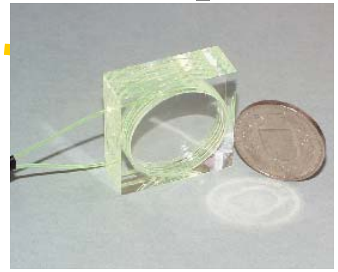
The SPD detector (our HW contribution)

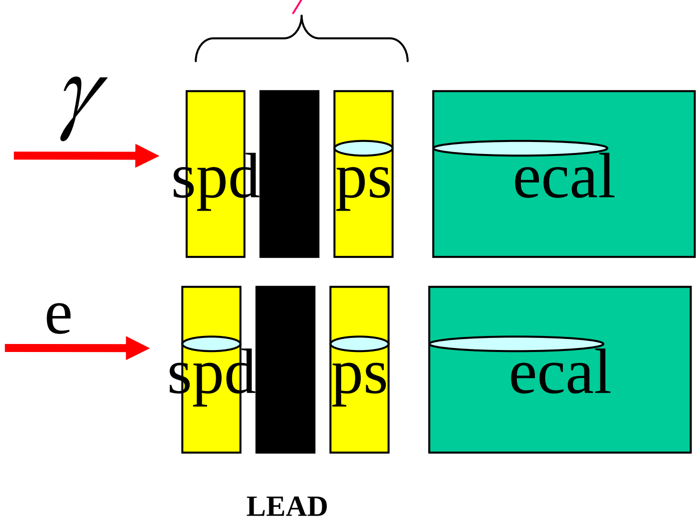


(front view)



- 6000 pieces



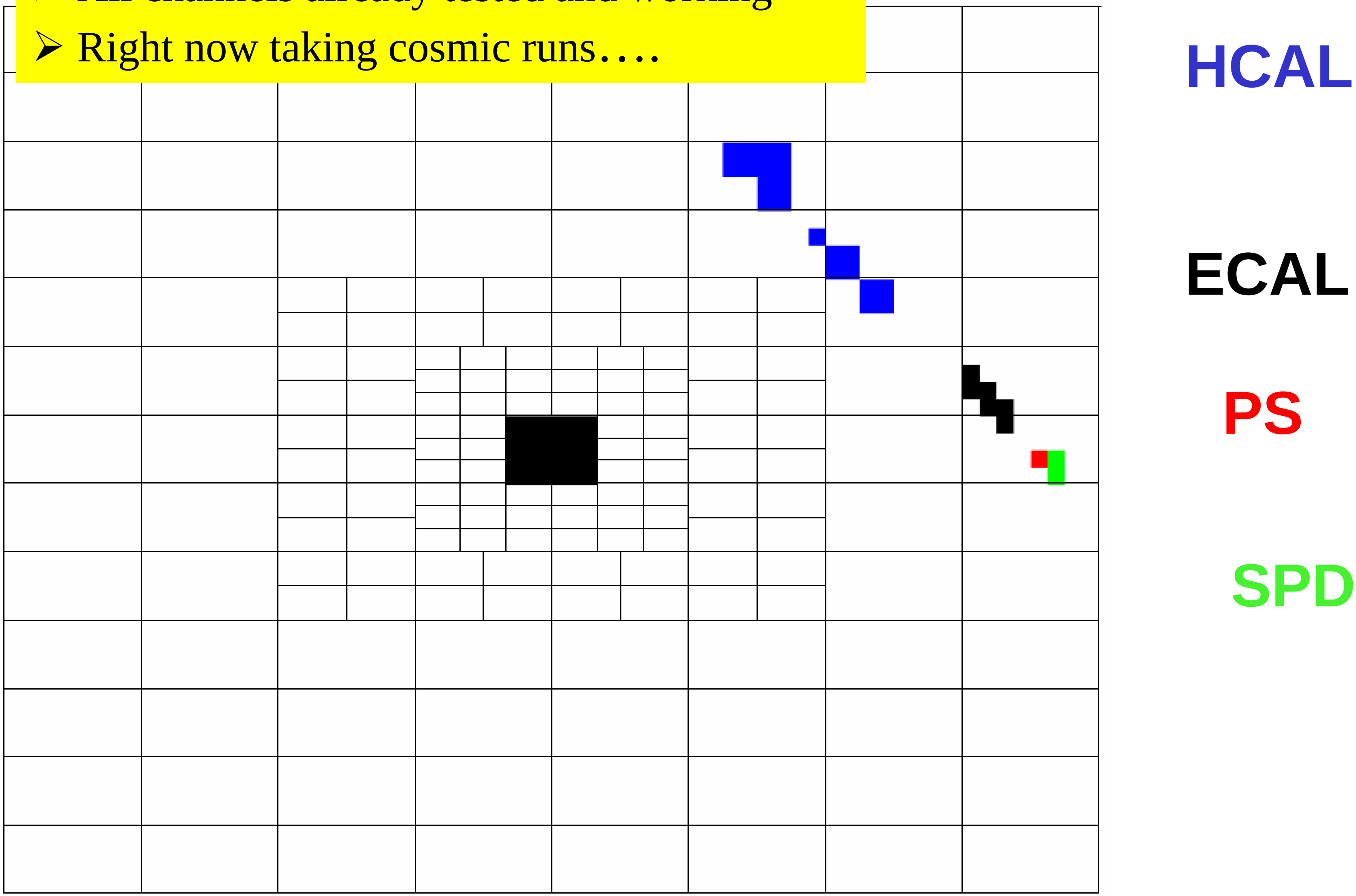


SPD/PS system determines the e/γ nature of energy deposited at L0 trigger level. Its multiplicity is used to veto complicated events

BCN responsibilities: ALL SPD electronics (from PMT to trigger boards), i.e.: design, test, production, test at lab, installation at CERN site, test on-site, commissioning, calibration, monitoring & maintenance, …. (full resposibility)

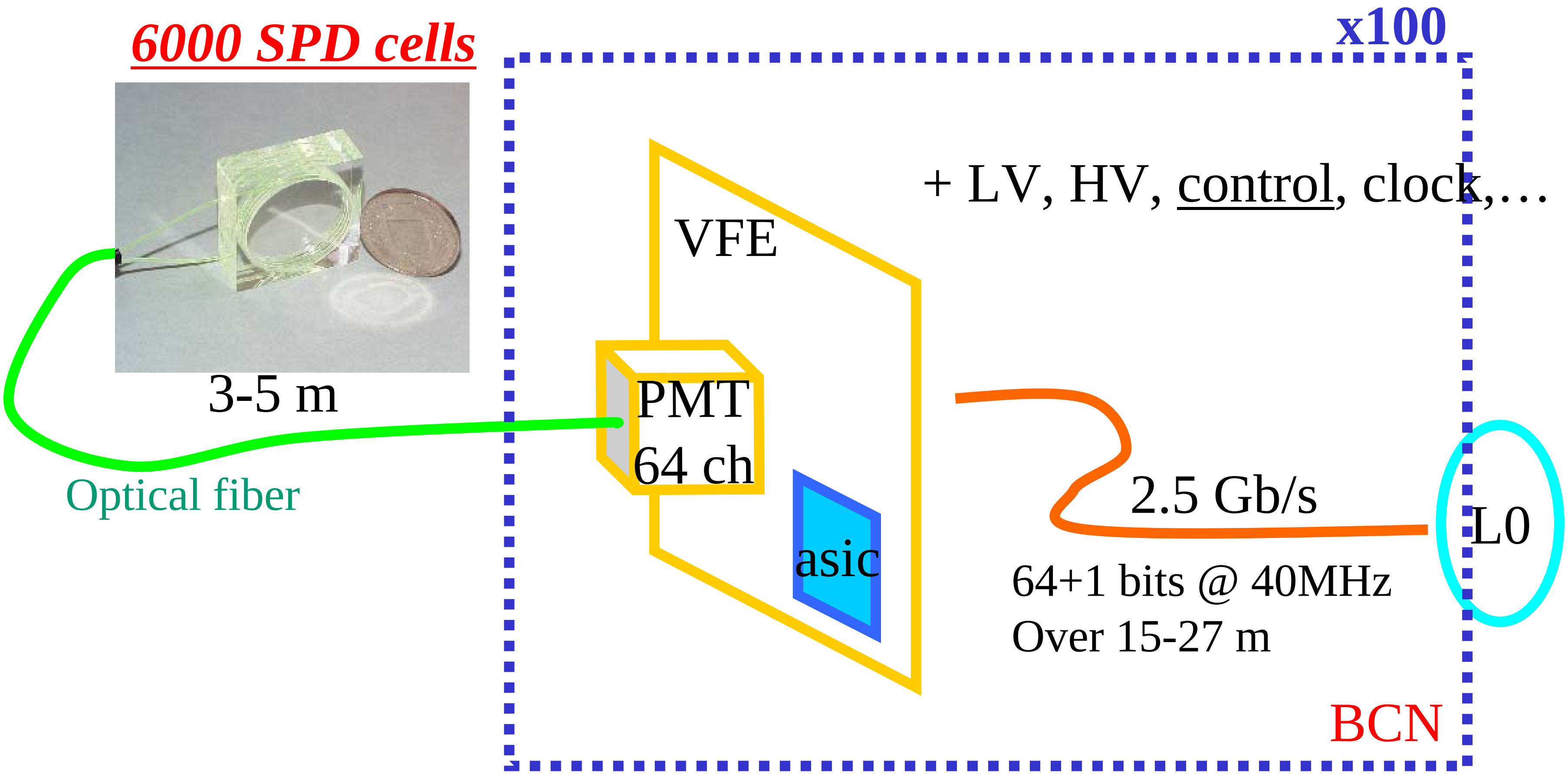
The SPD detector (today)

- Installed OCT-07.
- All channels already tested and working
- Right now taking cosmic runs….

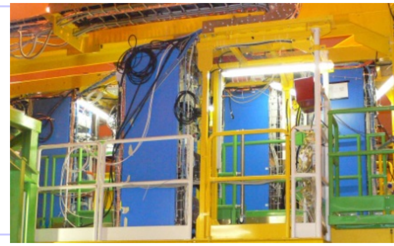


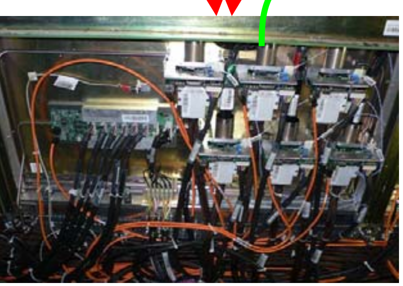
Hardware responsibilities

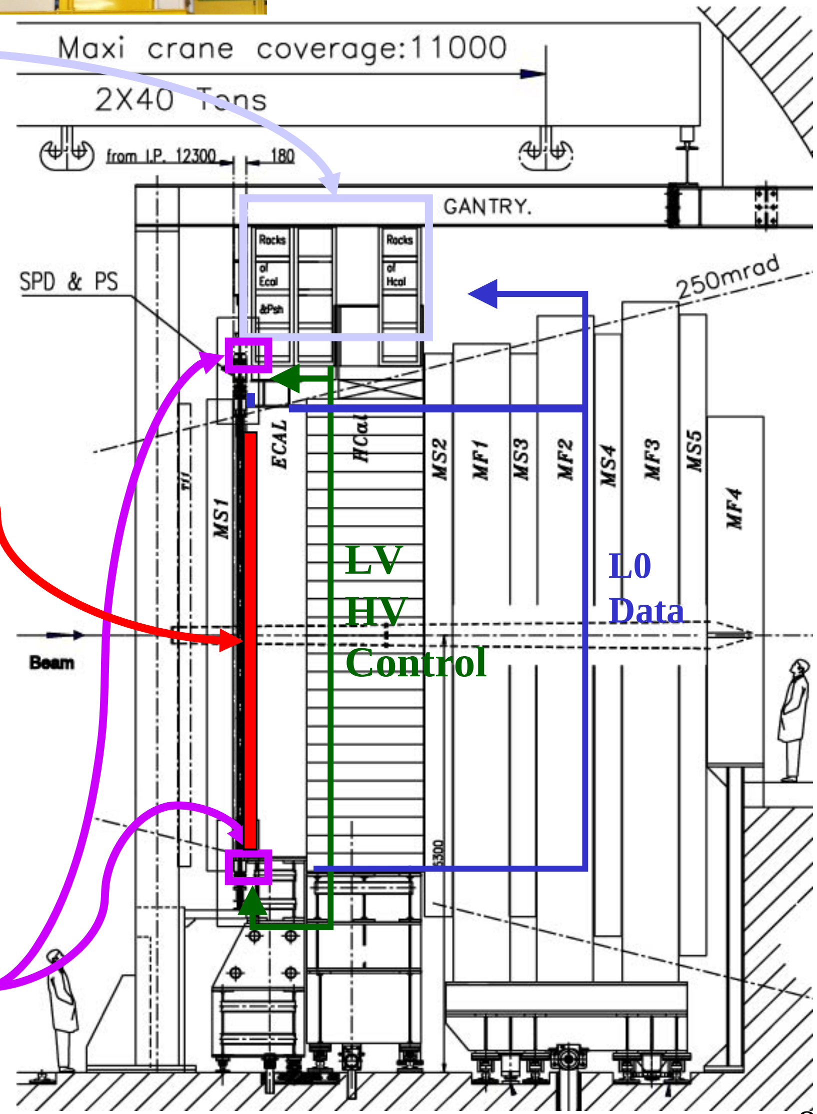
6000 SPD cells



Front-end Racks:
Front End boards (CB) & Power Supplies (HV and LV)







VFE PS & SPD

Metalic boxes: top and bottom ends of the detector

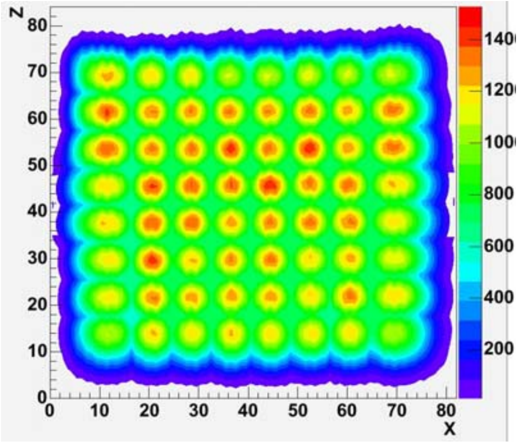
a) PMT
b) VFE units boards
c) LV regulation cards

HW Test Summary

- **MaPMT's (110)**

  Characterized, tested (Gain, Uniformity, Linearity & X-talk) and installed ⇒ All properties under specs (NIM paper)

64 ch signal output

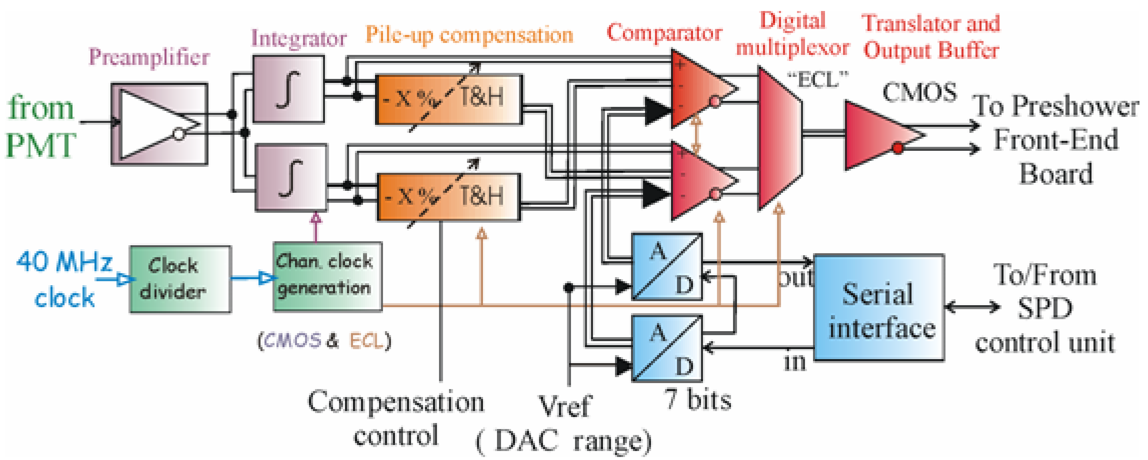


- **ASIC** (8 dual channel, analog + digital)

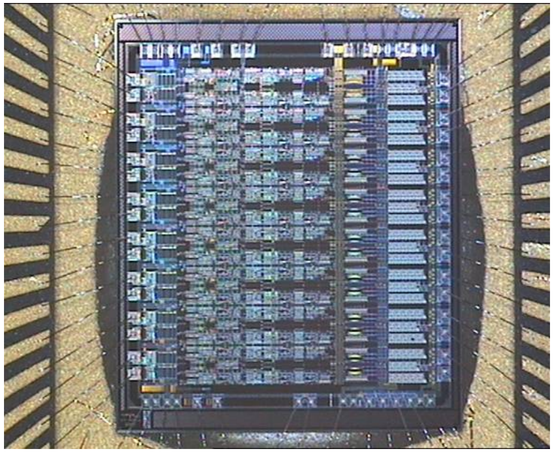
  After 4 designed prototypes, the RUN5 production resulted in

  1300 produced + 600 unpacked
  Needed 800+160 (tested & mounted)

- ***Radiation qualification (with krypton beam) @GANIL:***
  - ASIC, VFE board, and all the other components (NIM paper)

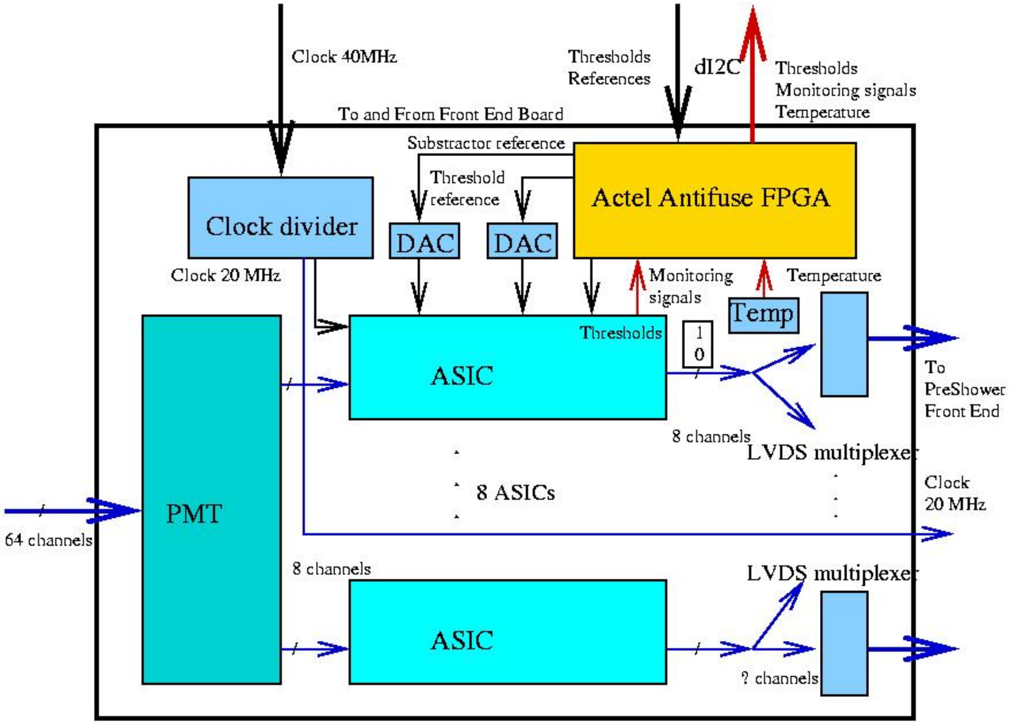


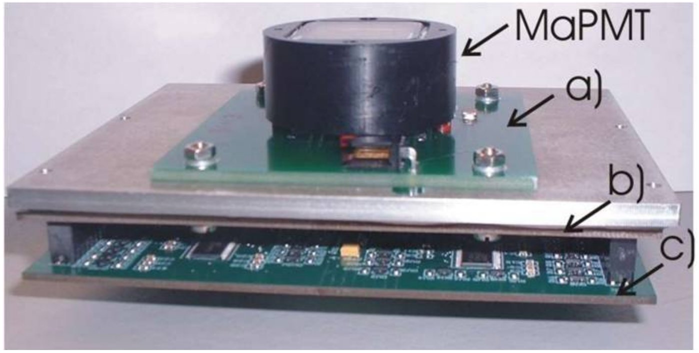
Rad-Hard design



AMS BiCMOS 0.8 μm – 30 mm^2

VFE board (100)





a) PMT base
b) 8-Asic board
c) Digital + Serializer

VFE board involves :

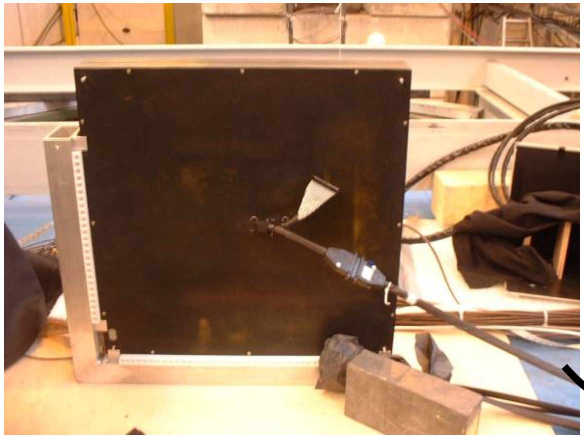
- **Binary output 0 or 1 to correspond with photon or electron**
- **Communication with Control Board** in FE crate in order to get the initial conditions from the ECS as programmable thresholds,

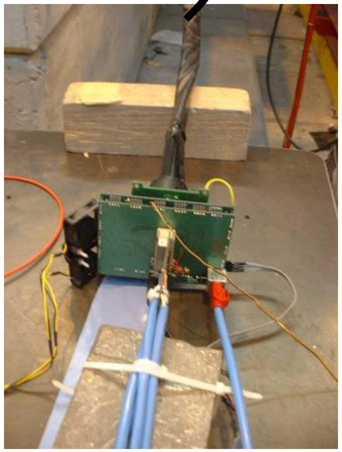
➢ *Burn-in Test:*

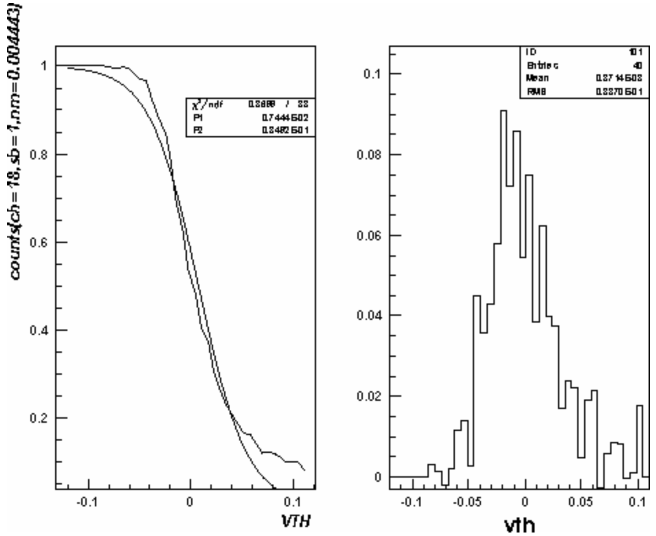
- Test against *infant mortality* of (semiconductor) all VFE components

VFE board test

Test beam:

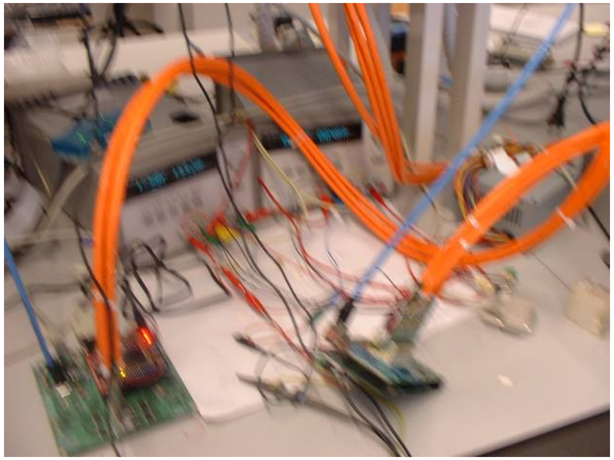


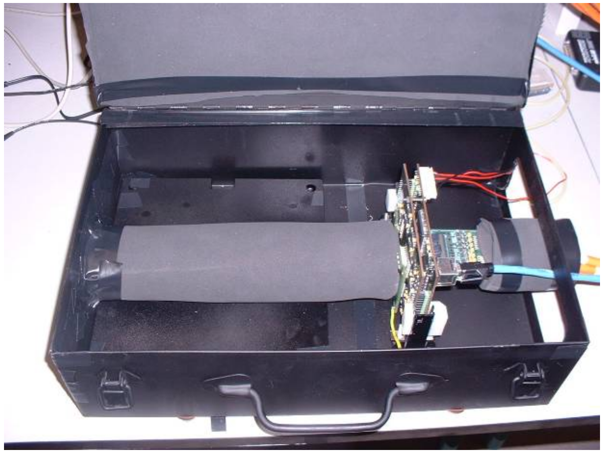




Lab test bench (x 120)
(without light)

with light



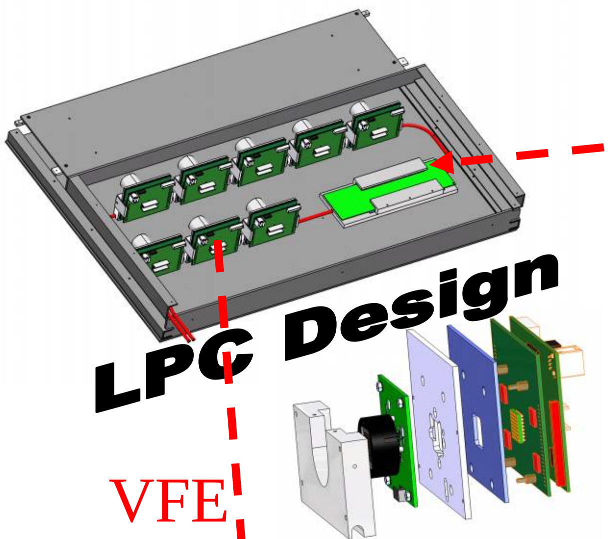


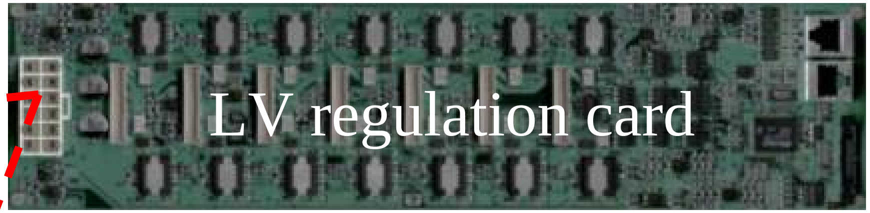
- **Performance of signal processing in agreement with ASIC performance.**
- **Crosstalk < 2%**
  (Contacts in PMT base-board)
- **Short term stability (12 h) < 2mV**

Re-tested at CERN during installation

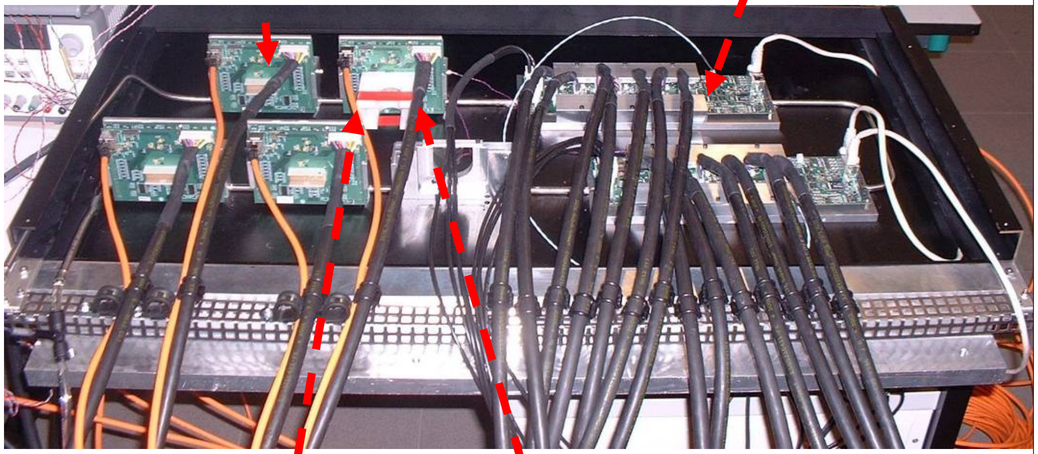
Electronics Box (16)

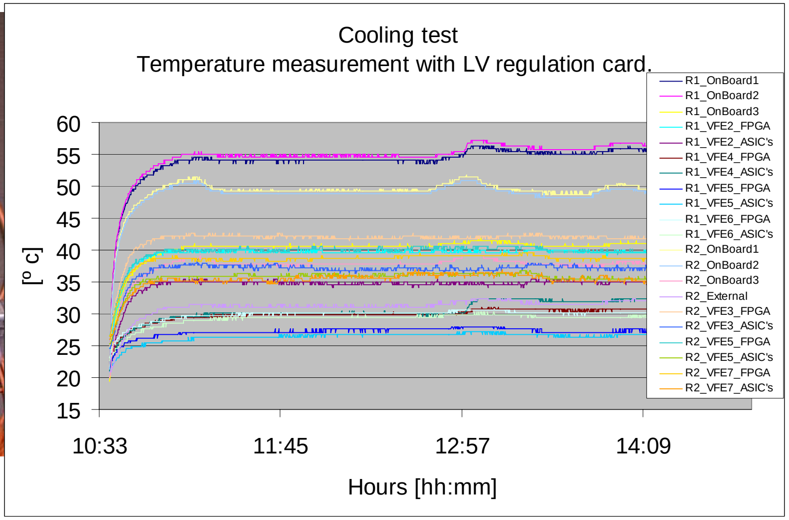
- A VFE box was fully equipped with VFE and LV regulator cards, cabled and tested.
- The VFE box incorporates a water cooling system that has also been tested with success.





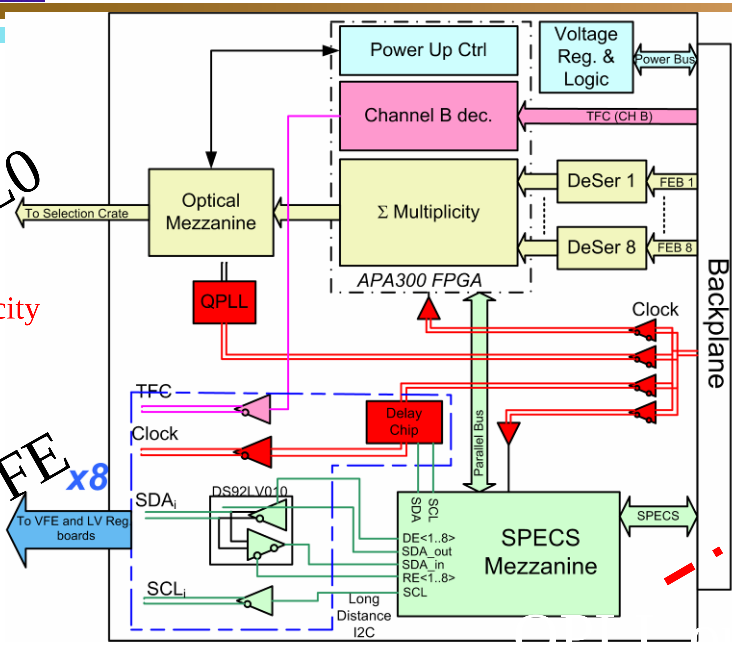
- Designed, produced, tested and installed by our group
- Monitoring: V, I and Temperature (on board, on VFE board and external).



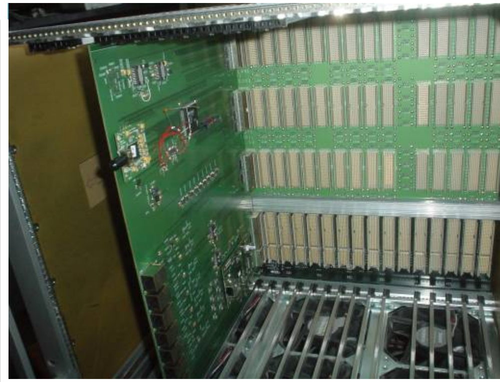


Control Board (16)

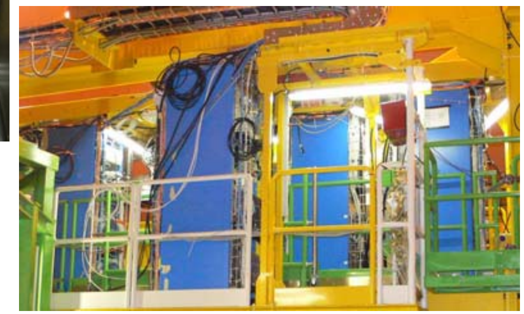
To L0
SPD multiplicity

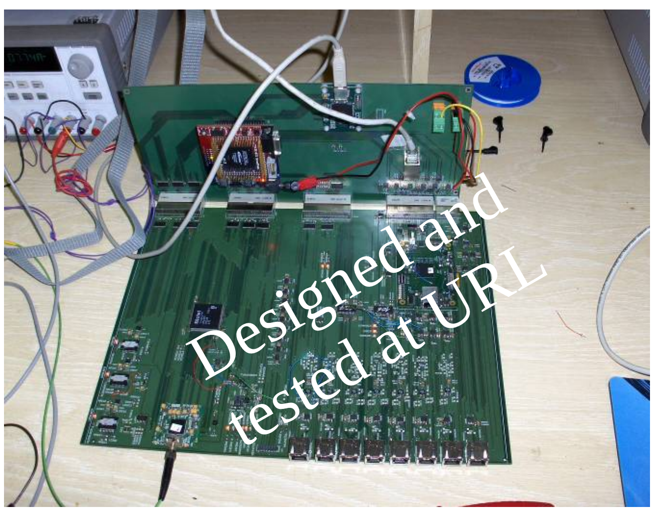


To VFE x8



Installed at the racks over the ECAL platform



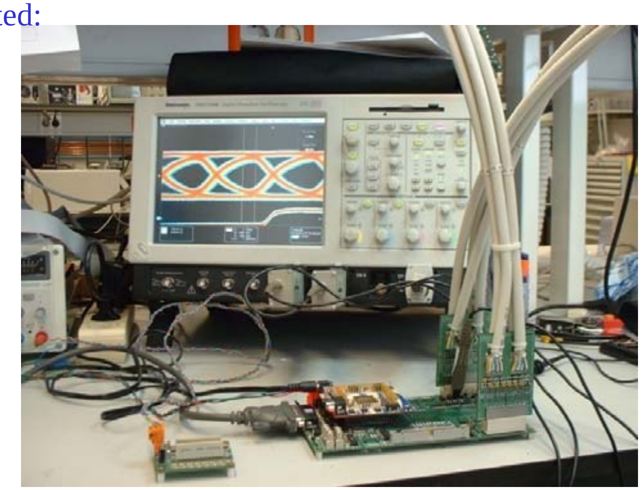


Cables (~500)

a) VFE board: SPD⇒PS **LVDS data link:** **2.5 Gb/s connection (30m long)**
- Bit Error Rate (BER) tested: BER<10^{-13}
- 120 links produced, tested and installed

b) LV & HV

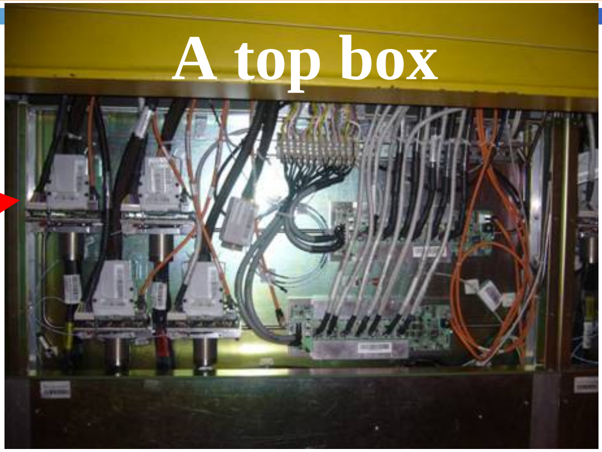
c) Control cables



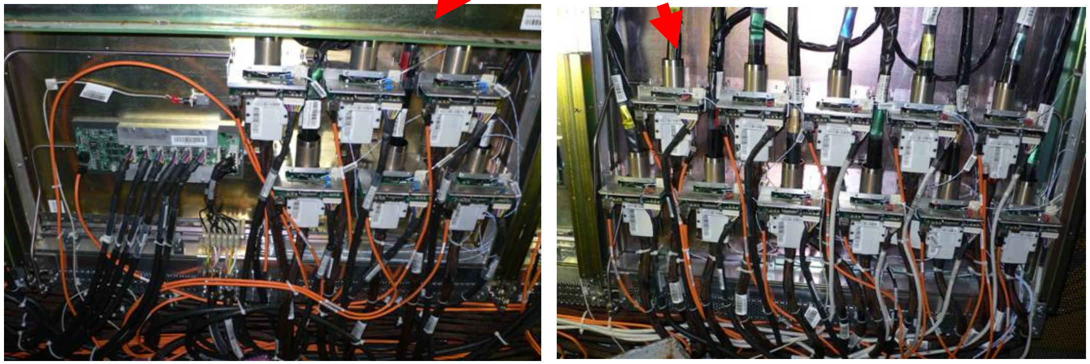
SPD End of 2005


Calorimeter system:
HCAL, ECAL, PS, SPD

SPD Electronics installation



A top box



2 bottom boxes

working at bottom

Present & Future work

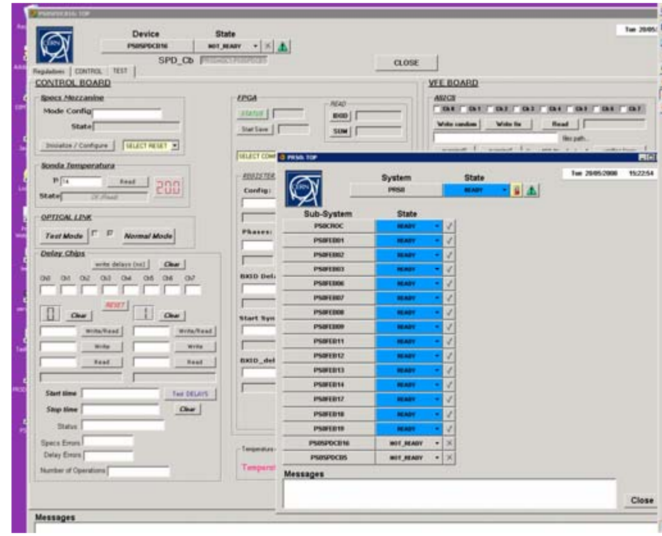
- Commissioning, Maintenance and Operation of the SPD (single responsible)
- LHCb detector contributions (service task, shifts, etc…)
- Physics Analysis
- R&D for possible LHCb upgrade

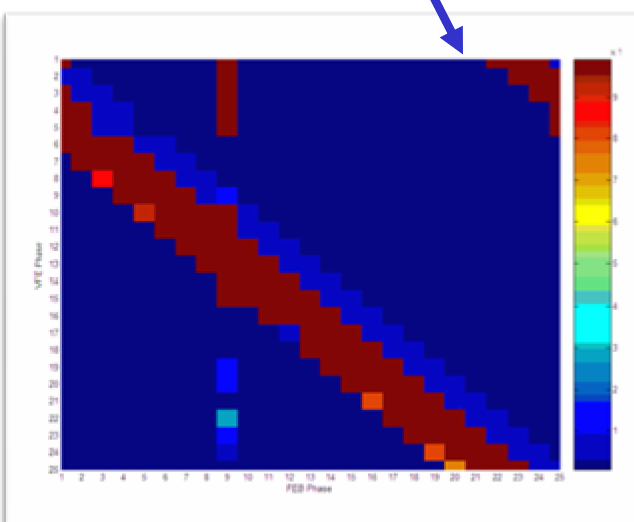
Commissioning Phase

LA SALLE ENGINYERIA I ARQUITECTURA Universitat Ramon Llull

UNIVERSITAT DE BARCELONA

- SPD integrated in experiment ECS
- SPD integrated in the DAQ & Trigger path
- Performing SPD time alignment





- SPD is regularly included in LHCb Global Commissioning Weeks
- Preparing SPD for calibration

The coordination of the Calorimeter Experiment Control System (ECS) falls under the responsibilities of our group (X. Vilasís)

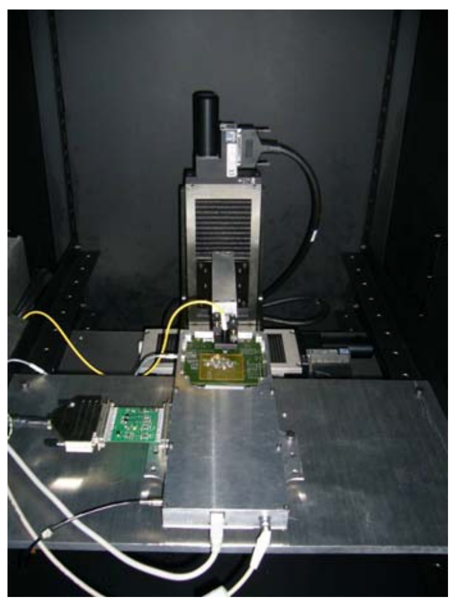
- EoI (LHCb upgrade)
  CERN/LHCC/2008-007
  LHCb 2008-019
- LHCb lumi. upgrade not related with SLHC

Proposed R&D topics are:

• All sub-detectors need to replace or adapt their FEE to the new 40MHz read-out scheme, and drive their data over the GBT link to the "New Read out Board".

The (Calorimeter) FE-boards need to be replaced to accommodate the increase of full read-out from 1 to 40MHz.

- SPD is already readout at 40 MHz



R&D Plans:

Based on the SPD experience:

• Design CALO RO boards

• Study Si-PM as replacement photodetector for the RICH

- It is very important that experts continue in the project to participate in the SPD maintenance and the detector upgrade (SLHCb)

From UB:

- Edu Picatoste: Commissioning coordinator (MEC Tech.)
  1 year co-finance + 2 years 100%
- D. Gascon: Upgrade R&D effort coordinator (GC Tech.)
  3 year co-finance

From URL:

- X.Vilasís (ECS)
- Mar Roselló (CB)
- Carlos Abellán: Technician 3 year 100%

7 PhD's (UB + URL)

Eugeni Graugés

Xavier Vilasís

Lluís Garrido

Hugo Ruiz

Ricardo Graciani (LHCb GRID PI)

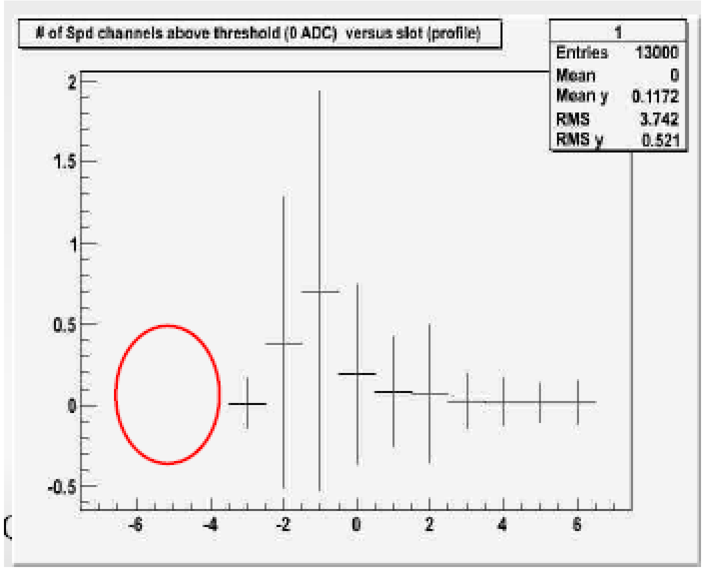
Post-doc (Marco Musy)

Míriam Calvo (J.d.C.)

7 Graduate Students	Subject
Ricard Vazquez	SPD cosmic analysis
Albert Puig	SPD monitoring, ECAL calibration.
Marc Grabalosa	SPD calibration and flavour tagging
Alessandro Camboni	SPD HV data base, Threshold set, jets
Elias López	Bs to hh as control channel to Bs to $\mu\mu$
Antonio Perez-Calero	New HLT trigger alley
Jordi Garra	Flavour Physics @ BaBar: CKM angles, D meson oscillation

SPD cosmic events analysis

Ricard Vàzquez, E. Picatoste, M. Calvo



- Cosmic Trigger: **HCAL** and **ECAL** coincidence using the full L0 trigger path of the experiment .
- Data acquisition feature: +/-7 previous/next bunch-crossing data can be stored.
- Data Analysis provide:
  - An initial **time alignment** between subdetectors.
  - Identification of problems such as:
    - Mapping issues: miscabling, mislabelling.
    - Identify working/non-working channels.

SPD Monitoring

Albert Puig, R.G.

Parameters to be monitorized on SPD:

- Efficiency on charged particles identification
- Occupancy (check pedestal stability, aging of the detector,...)
- Cross-talk
- Dead channels

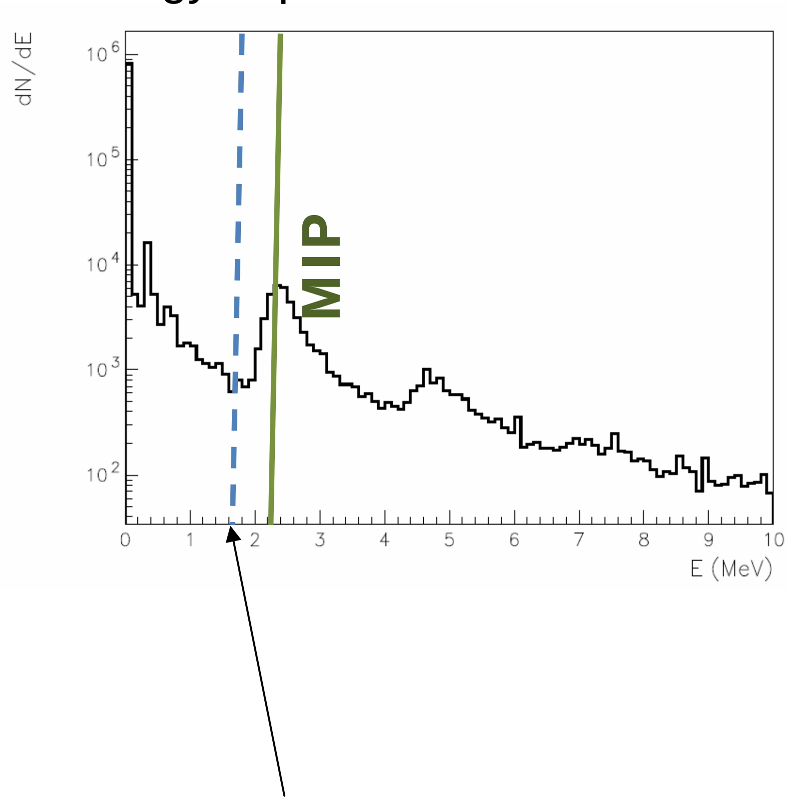
SPD Calibration

M. Grabalosa, A. Camboni
(E.G, E.P, H.R, L.G.)

SPD channel parameters:

- Noise offset:
  - Threshold scan without signal
  - Test with LED
- Threshold values: MIP calibration
  - Th-scan with particles
  - Calculate differential output and fit curve to MIP peak
  - To be done at start-up, after that, very scarcely
- Gain
- Nphe (obtained from MIP peak width)

Energy deposition in a CELL:

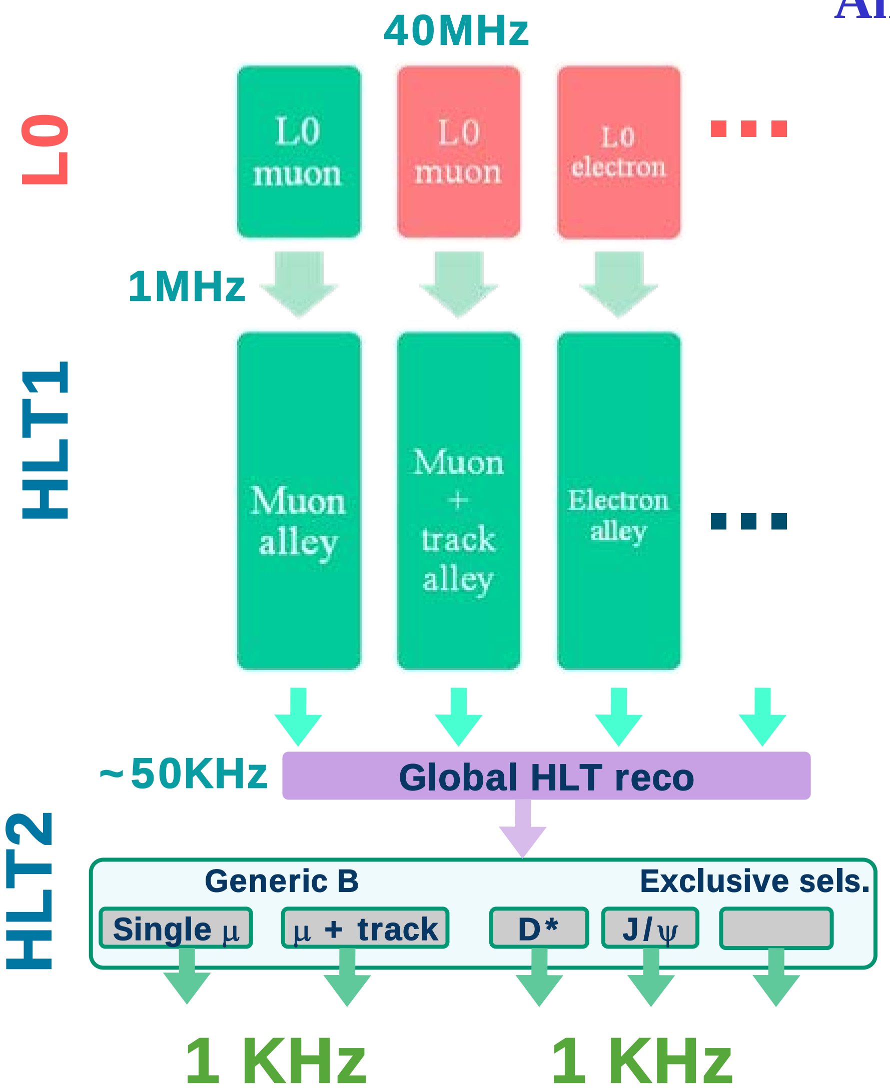


Threshold:
~0.7 MIPs

Trigger contribution

μ+track lines at HLT1 and HLT2

Antonio Pérez-Calero, H. Ruiz



At HLT1:

- **Principle:** start by L0-muon candidates, confirm them at T and VELO, and look for companion tracks that form good displaced vertex with the muon
- **Aim:** highest efficiency for semileptonic B decays, useful for CP studies, **calibration of tagging**.

At HLT2: very pure source of B-generic events (other B in the event "untouched")

$B_s \rightarrow \mu\mu$

Elías López, Alessandro Camboni, H.R, L.G, E.G, M.M.

B → hh (h=π,K) as control channel
(E. López)

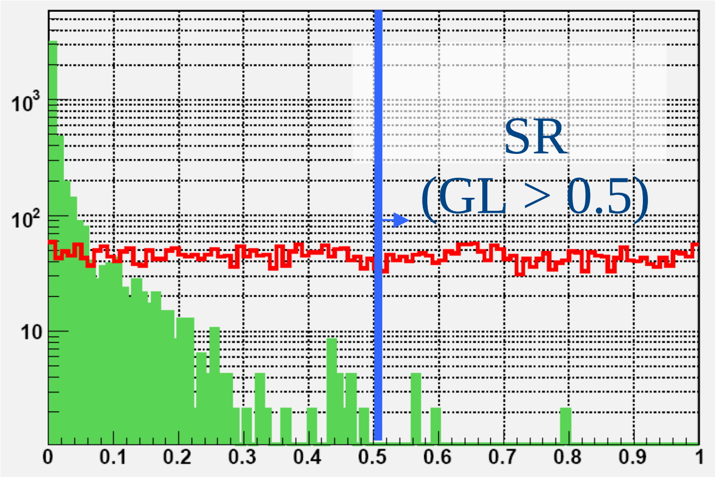
Same kinematics than signal channel
High event yield (~400 K/year)
Must account for diff. in trigger PID

* Useful to (among others):
- Calibrate invariant mass distribution
- Normalize the measurement

Optimization of the statistical method
(A. Camboni)

- Choice and optimization of MVA.
- Study of selection improvements based on isolation, etc... to optimize B/S

Same cuts than B → hh/CPV preselection



red line: signal
green filled: background

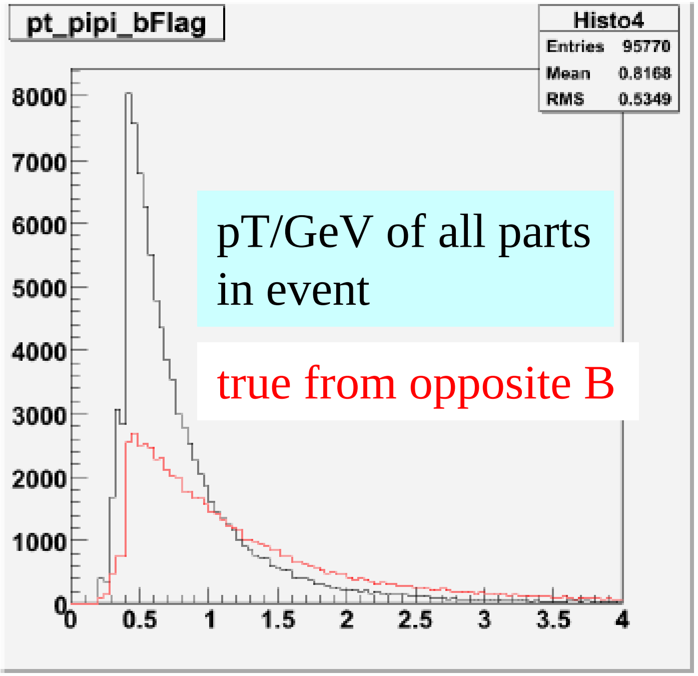
- Flavour Tagging Miriam Calvo, Marc Grabalosa, Marco Musy

Secondary vertex (SV) finding
Marc Grabalosa

1. Used in tagging for all decay modes, needs retuning for latest simulated data

2. Study of kinematical cuts by looking at typical distributions, and splitting for PID and track type.

3. Refine treatment of incl. SV as a tagger, assessing performance and correlations with other taggers



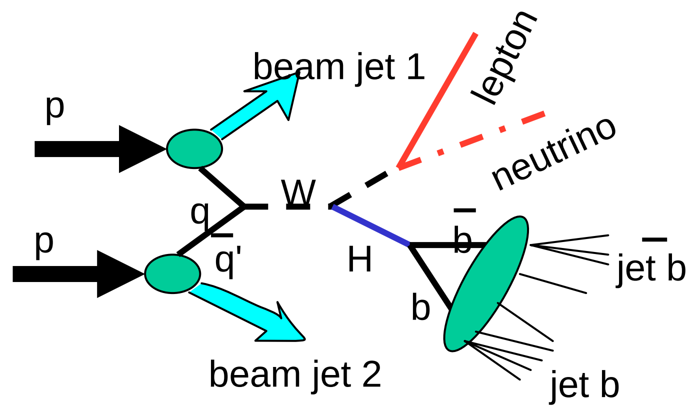
Study of same side tagging in $B_s \to D_s\pi$
Miriam Calvo

- Starting from study of offline selection, perform fit of oscillations to extract Δm_s along with ω as control for other channels

- **Flavour Tagging development and maintenance** **Marco Musy**

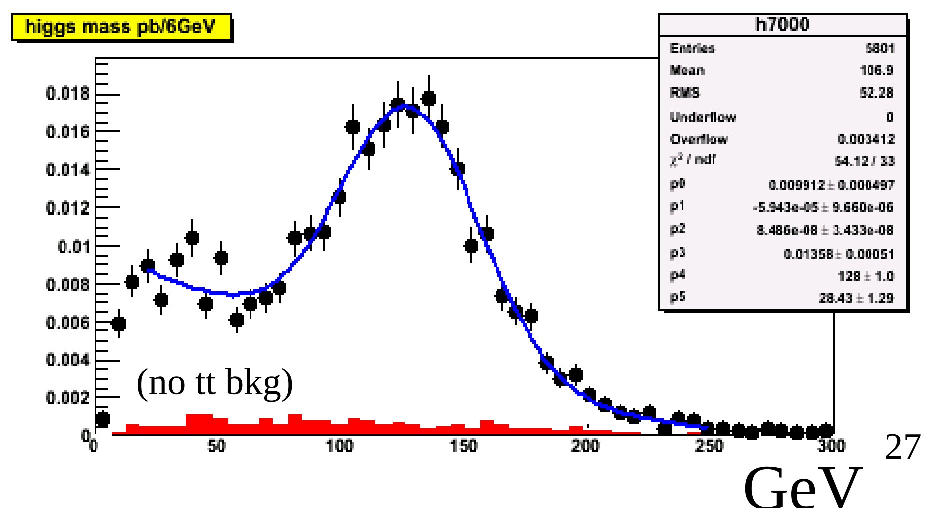
1. Implementation of tagging algorithms and study of performances
2. Development of monitoring tools for tagging. Tuning of sensitivity.
3. Fit of sin 2β in unified selections of J/ψ Ks with control channels

- **Jet Algorithms** A. Camboni, M. Musy



Retuning algorithm to account for Higgs event topology

- Make a jet energy calibration
- Study of Z–>bb events for data calibration



CKM angle γ

Jordi Garra, E. Graugés (& IFIC-UV)

D meson oscillation

Measurement of the CKM angle γ

- Not even part of the initial plan of the B-Factories
- Today one of the main milestones

- Use of interference between $B^- \to DK^-$ and $B^- \to$ anti-D K^- ; where D or anti-D decay into the same final state ($K_s\pi\pi$)

$$\mathcal{A}(D^0K^-) \propto \lambda^3$$

$$\mathcal{A}(\bar{D}^0K^-) \propto \lambda^3 \sqrt{\bar{\eta}^2+\bar{\rho}^2}\; e^{i(\delta_{B,DK}-\gamma)}$$

$$\mathcal{A}_{tot} = \mathcal{A} + \mathcal{A}$$

Search for D^0 mixing with $D^0 \to K_s h^+ h^-$ decay modes ($h = \pi, K$)

$$e^+e^- \to c\bar{c} \to D^{*+}X$$

$$D^{*+} \to D^0\pi_s^+$$

$$D^0 \to K_s h^+ h^-$$

- $\sigma(c\bar{c}) = 1.3$ nb;
- $BR(D^{*+} \to D^0\pi_s^+) \simeq 68\%$;
- $BR(D^0 \to K_s\pi^+\pi^-) \simeq 2.9\%$;
- $BR(K_s \to \pi^+\pi^-) \simeq 70\%$;
- π_s charge tags D^0 flavour;
- D^* decays inside the beam spot.

Expected yields on Run1-5:
Lumi (On+Off) = 385 fb-1
Reco efficiency~15%
$N_{Sig}(K_S\ \pi^+\pi^-) \sim 450K$
$N_{Sig}(K_S K^+K^-) \sim 1/6 N_{Sig}(K_S\ \pi^+\pi^-) \sim 80K$

People and Task Distribution (last 3 years)

People

ECM (UB)	Electrònica (UB)	EALS (URL)
R. Graciani(Grid)		**X. Vilasis**
E. Graugés		J.Riera
D. Gascon	A. Herms	M. Rosello
A. Comerma		S.Luengo
E. Picatoste		(becario)

Engineer/tec /postdoc.

students

M. Calvo (PhD 2006)
C. Gonzalez (PhD June 2008)
Jean Marc Fieschi
J. Garra (PhD 2009)

H. Ruiz (since May 2005)
L. Garrido.

- VFE/CB/firmware
- Physics/integration&commissioning
- Rest (ECS,..)

People (next years)

UB	URL
Eugeni Graugés (PI & coordinator)	**Xavier Vilasís (PI)**
Lluís Garrido	**Míriam Calvo**
Hugo Ruiz	**Mar Roselló**
Posdoc (M. Musy)	C. Abellán
Ricardo Graciani (LHCb Grid PI)	
Elias López	
Ricard Vazquez	
Albert Puig	**Physics**
Marc Grabalosa	*Physics Students*
Alessandro Camboni	
Jordi Garra	
Antonio Pérez-Calero	
E.Picatoste	**SPD HW experts & Upgrade**
D.Gascon	SPD Maintenance

* The group maintains the coll. with the UB electronic dpt. focused now on silicon detector for ILC

Budget

Objeto	Cantidad Solicitada (k€)		Fracción
	UB	URL	(%)
Personal	476,20	182,60	38,19
Complementos salariales	66,15	18,9	4,93
Viajes y estancias en el CERN	472,20	136,20	35,26
Otros: Peq. Equipamiento + Fungible + Varios	290,00	81,00	21,62
Subtotales	1304,55	418,70	
Total	1725,25		100,00

- Balanced budget : 70% UB vs 30% URL (same as personnel fraction)
- Major contributions:

1) **Personnel**: we should maintain the same level for commissioning and long term support and maintenance (1-2 years running: still some problems to understand/resolve)

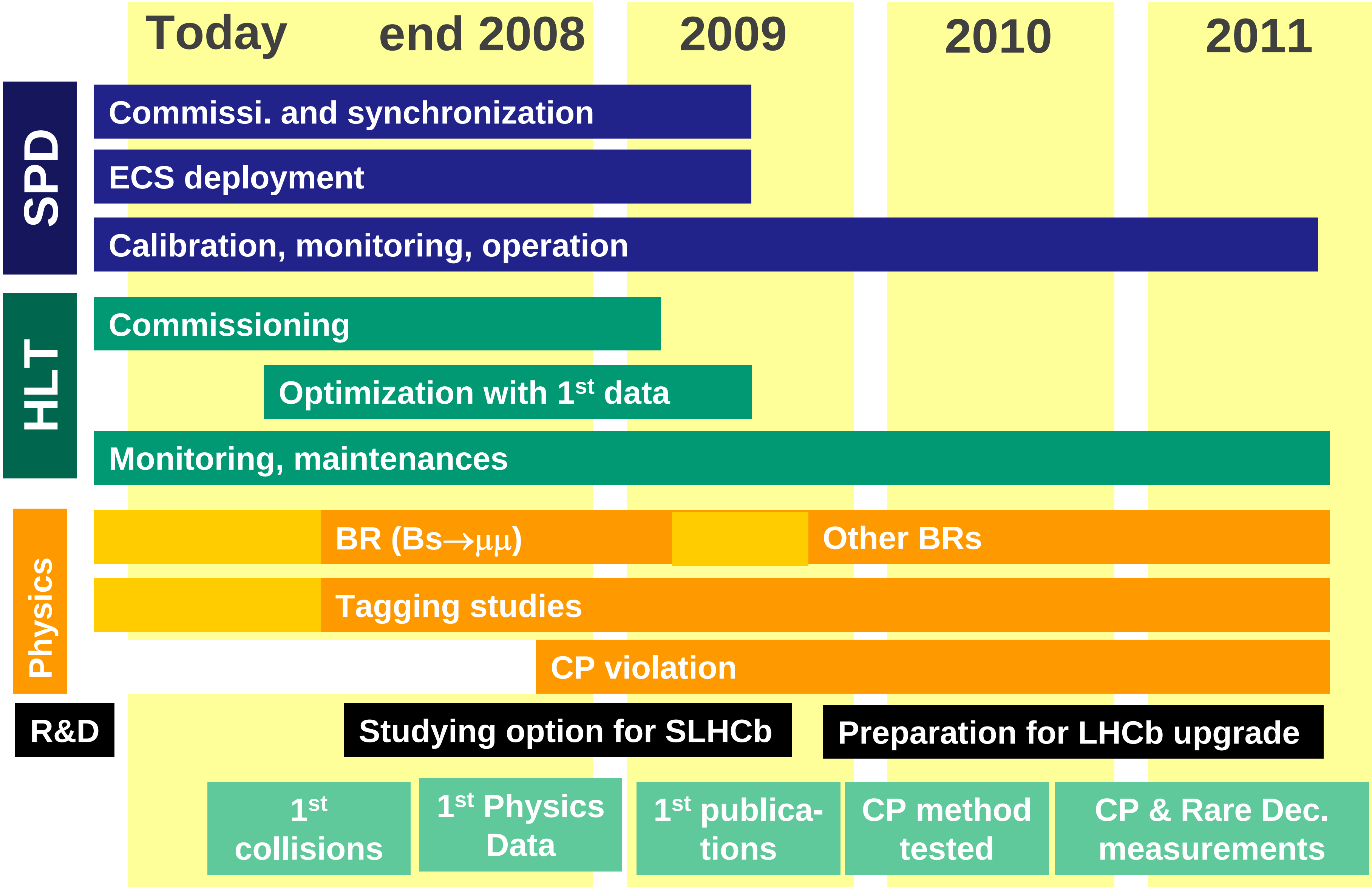
2) Travel: commissioning, data taking shifts, service tasks, maintenance, collaboration meetings…

Not Included in the budget presented in the write-up application:

Category-B common fund (Maintenance and Operation):

- **8000 Euros/year**
- This amount not defined until recently (~ 3% of our contribution to the CALO system)

Project time-line



Conclusions

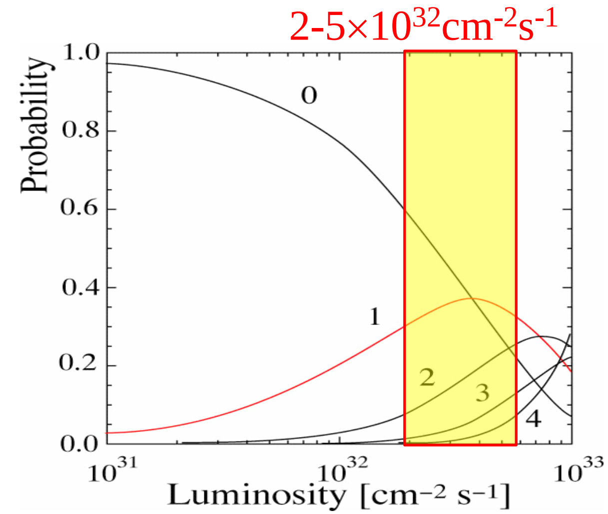
- **We have successfully fulfilled our detector commitments**
  - SPD electronics installed and commissioned
- **Our groups have:**
  - got actively involved in the preparation of some of the most important LHCb measurements
  - attract a high number of PhD students (6 with grant + 1)
- **We are ready to get the most of this extremely exciting period of 3 years in terms of:**
  - Scientific results
  - Education of Phd students and junior scientists
- **The proposed budget is the adequate to guarantee the exploitation of the work done up to now, in terms of scientific results, as well as the SPD maintenance and LHCb upgrade studies**

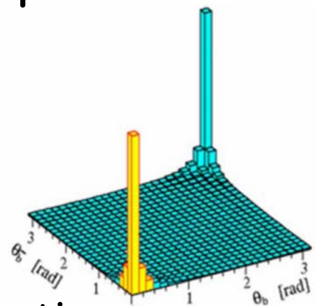
The End

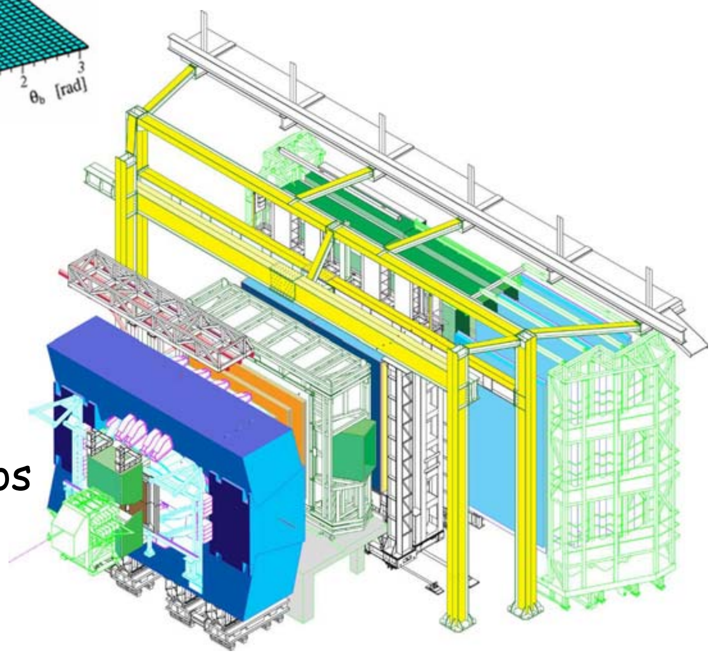
BACKUP

- σ_{bb} ~ 500μb in pp collisions at $\sqrt{s}$ = 14TeV
  - Luminosity limited to few $10^{32}cm^{-2}s^{-1}$
    - Maximizes probability of single interaction per crossing
  - 10^{12} bb produced per year (10^7 s) at $2\times10^{32}cm^{-2}s^{-1}$
- Forward peaked, correlated bb pair production
  - Single-arm forward spectrometer
    - $\theta \in$ 10–300mrad (4.9 > η > 1.9)
- Rates at $2\times10^{32}cm^{-2}s^{-1}$
  - Bunch crossing rate 40MHz
    - 30MHz with bunches from both directions
    - 10MHz of visible interactions
      (at least 2 tracks in the acceptance)
  - bb production ~ 100kHz (cc ~ 600kHz)
    - 15kHz with all the decay products
      of at least one B in the acceptance
    - Interesting B decays have small branching ratios
      - Typically < 10^{-3} ⇨ O(10) Hz

⇨ Trigger is a key point







LHCb overview

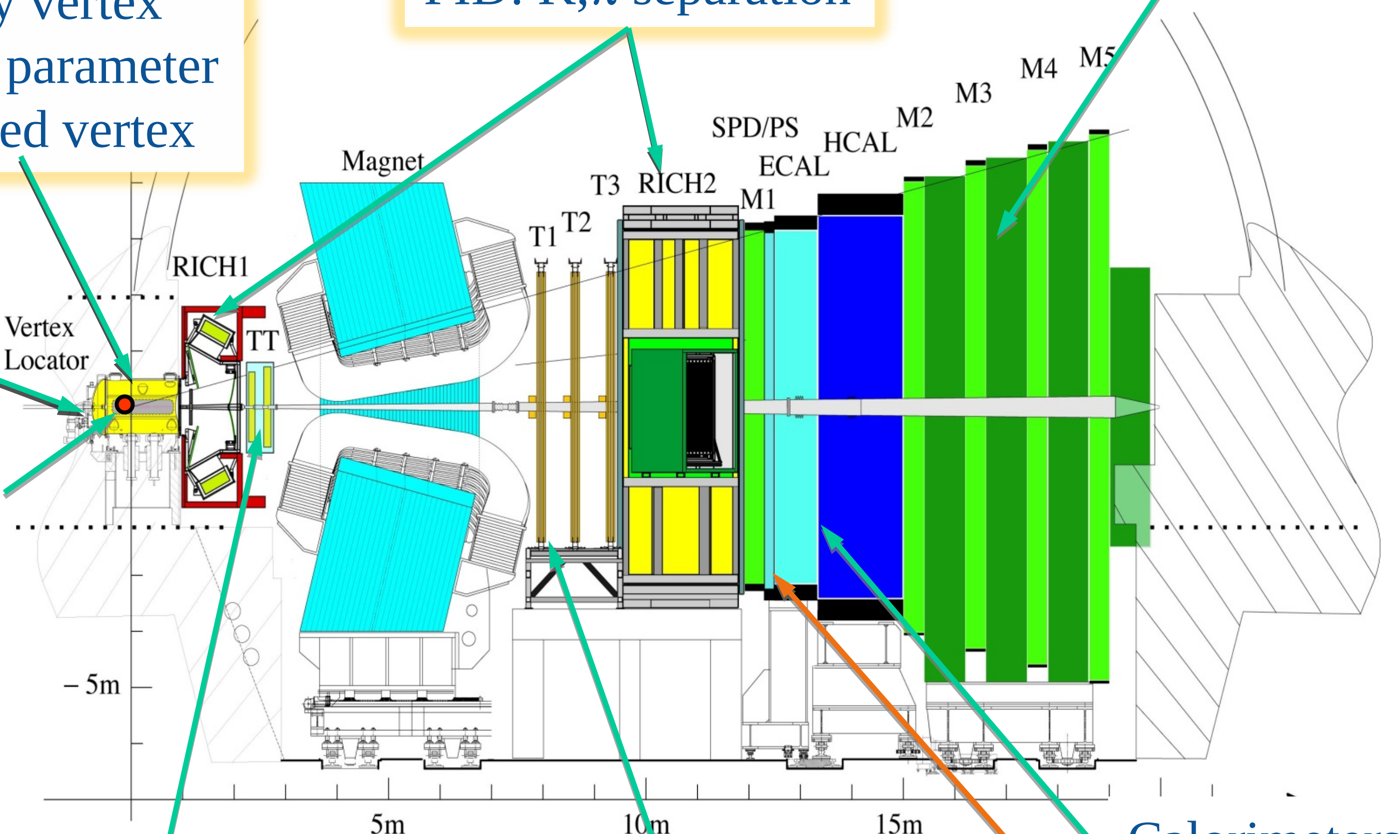
VELO:
primary vertex
impact parameter
displaced vertex

RICHES:
PID: K,π separation

Muon System

PileUp System

Interaction region

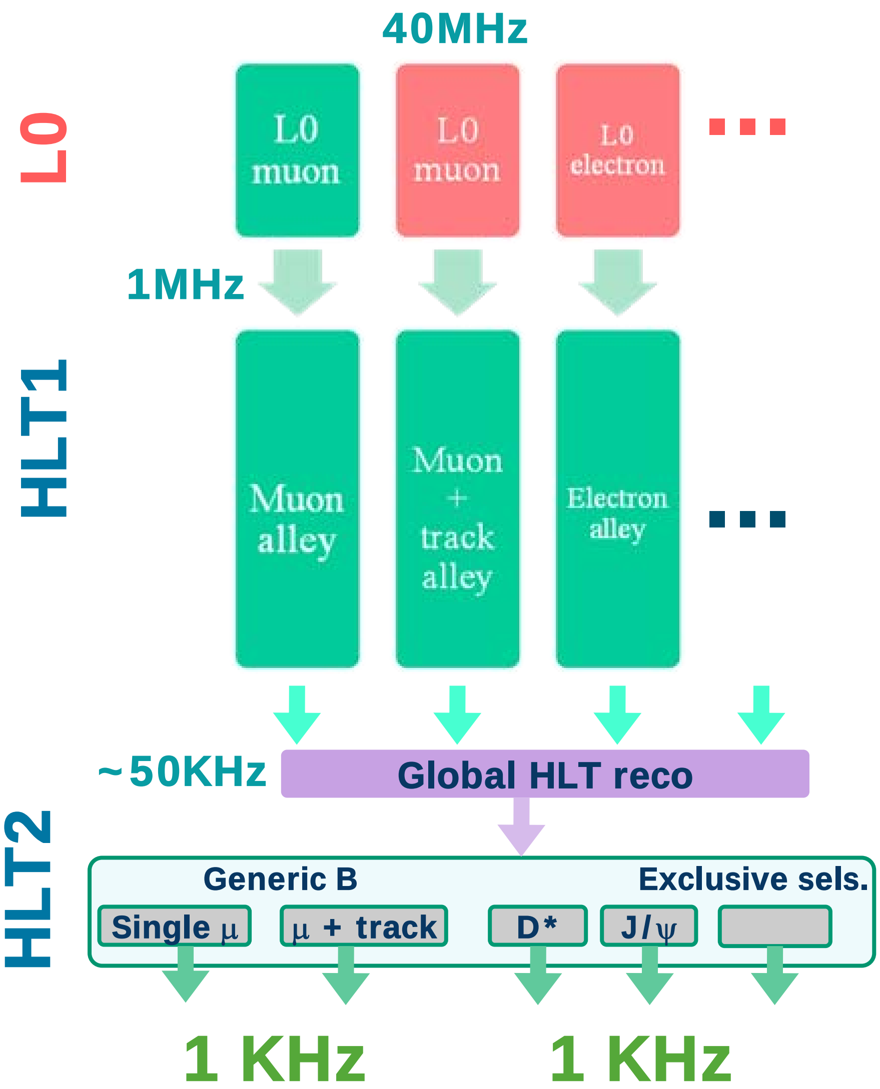


Trigger Tracker: p for trigger and K_s reco

Tracking Stations:
p of charged particles

Calorimeters:
PID: e,γ, π^0

SPD (Barcelona)

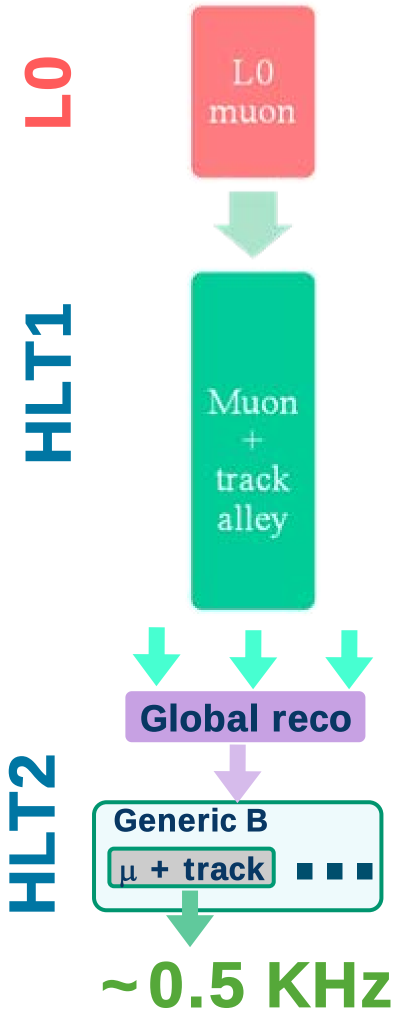


L0: on custom boards
hight pT candidates + not too busy
Uses **calo, muon system, 2 layers of VELO**
SPD separates electrons and photons, provides veto for complicated events

HLT: runs in a PC farm of 1000 16-core nodes
Full detector = full flexibility
•**HLT1** based on "regions of interest": confirm L0 candidate looking at the minimum detector information
•**HLT2** performs a global event reconstruction, then applies inclusive + exclusive selections
Our group responsible of muon+track lines in HLT1 and HLT2

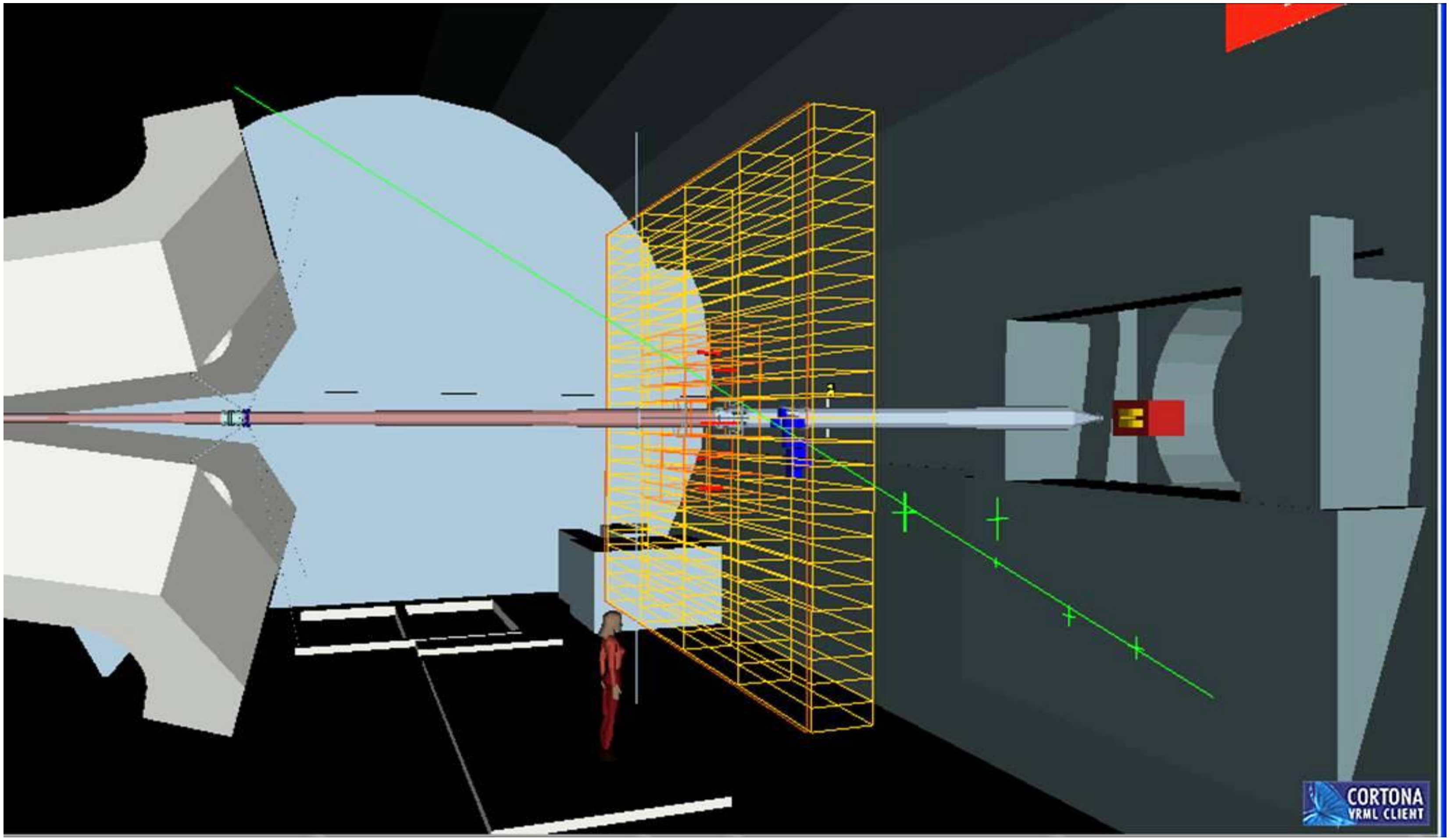
μ+track lines at HLT1 and HLT2

Antonio Pérez-Calero, H. Ruiz



- **At HLT1:**
  - **Principle:** start by L0-muon candidates, confirm them at T and VELO, and look for companion tracks that form good displaced vertex with the muon
  - **Aim:** highest efficiency for semileptonic B decays, useful for CP studies, **calibration of tagging**.
- **At HLT2:** very pure source of B-generic events (other B in the event "untouched"
- **Already optimized with MC:**
  - HLT1: 98% efficiency for a reduction to 12KHz
  - HLT2: fill ~600Hz of events with 70% B purity!
- **Next steps:**
  - Commission the trigger lines (and contribute to global HLT)
  - Provide and maintain monitoring tools
  - Optimize selections with 1st real data available
  - Maintain the trigger line under future LHCb conditions

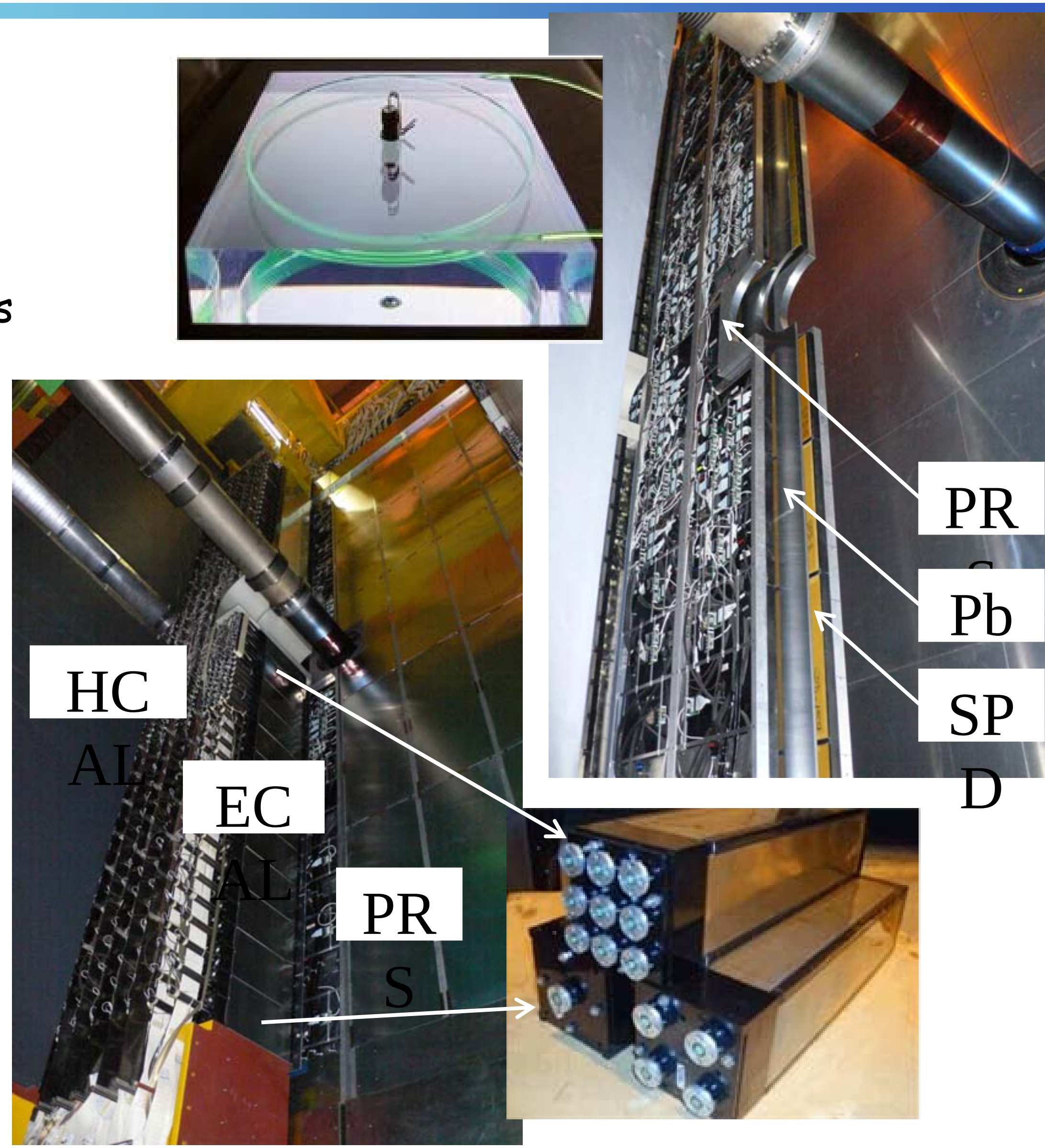
May'08



Cosmic ray seen by Muon and Calo systems

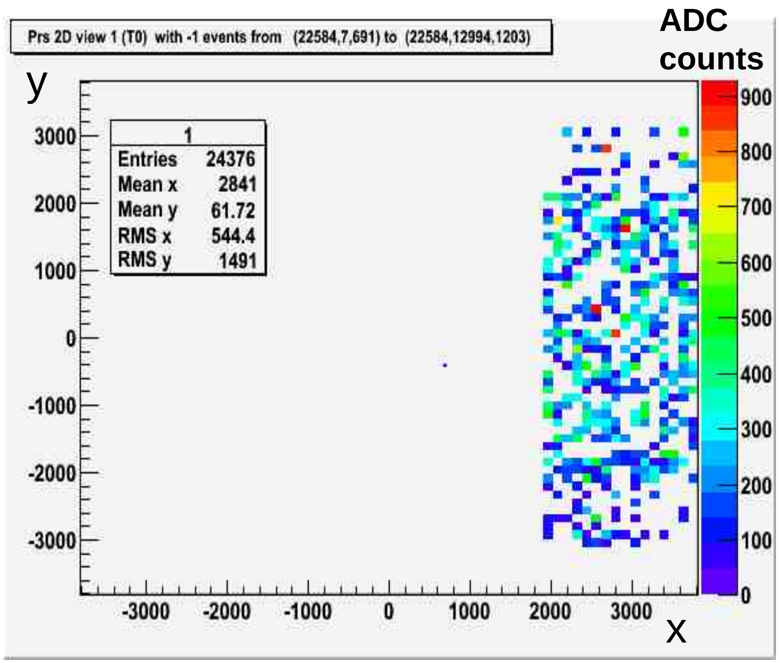
Calorimeter System

- Scintillator Pad Detector (SPD) & Preshower (PRS)
  - 15mm think scintillator pad
    - 20 to 30 pe/mip
  - Same transverse granularity as ECAL
    - 5952×2 readout channels
  - 2.5 X_0 Pb converter
- Shashlik EM Calorimeter
  - Pb/Scintillator, 25 X_0
    - $\sigma/E \sim 10\%/\sqrt{E} \oplus 1\%$
  - 5952 readout channels
    - 4×4, 6×6 and 12×12 cm^2 (~ 1 to 3 R_M)
- Tile Hadronic Calorimeter
  - Fe/Scintillator, 5.6 λ_0
    - $\sigma/E \sim 80\%/\sqrt{E} \oplus 10\%$
  - 1488 readout channels
    - 13×13 and 26×26 cm^2

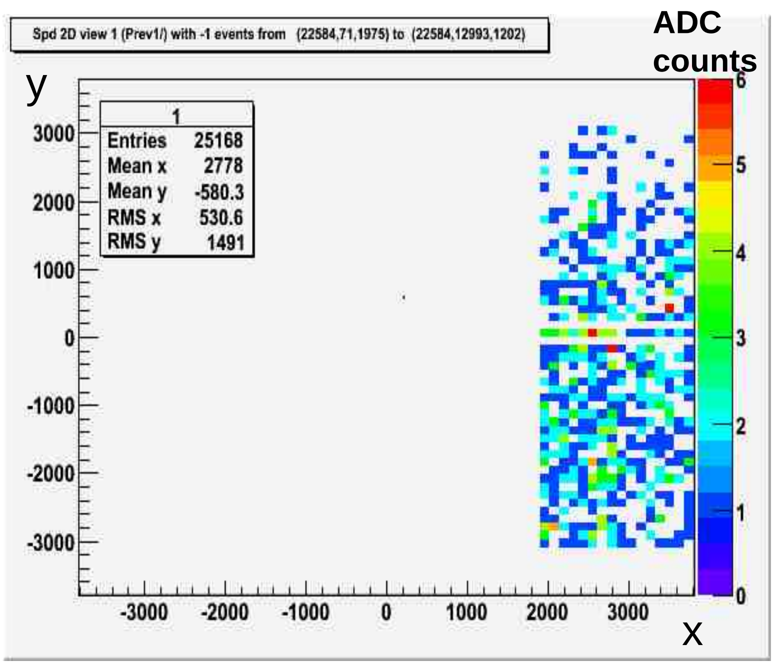


- Cosmics accumulated signal on some of the outer part:

PS



SPD



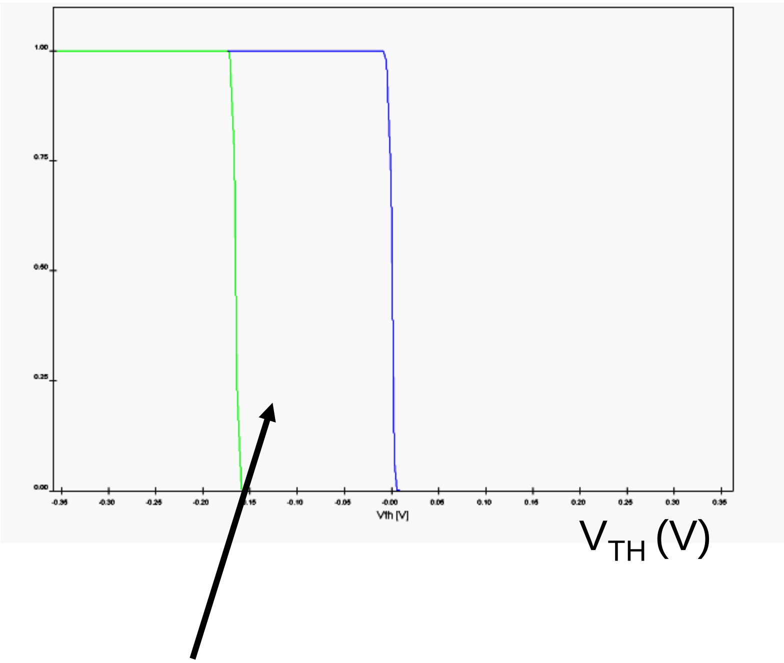
SPD Calibration

Alessandro Camboni, E. Picatoste

SPD threshold scan:

- SPD is a binary detector:
  - Output = 0/1 if signal below/over programmed threshold
- Input signal measurement is not direct, need to make a scan:
  - Obtain output data for different threshold values
  - For each threshold, take N events and normalize
  - Signal value is on transition from 1 to 0
- The scan is useful to measure:
  - Channel offset values
  - LED signal
  - Find MIP peak

Threshold sweep for one SPD channel:

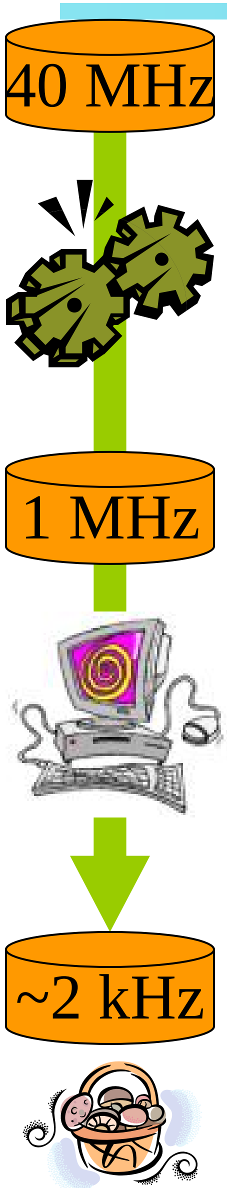


Each VFE channel is composed of 2 subchannels.

Trigger Strategy

- Large output bandwidth of 2kHz
- Exclusive selections: 200Hz
  - Specific final states: exclusive B candidates
    - $B_s \to D_s h$, $B_s \to \phi\phi$, $B^0 \to J/\psi K_S$, $B^0 \to D^* \pi$, $B_{(s)} \to h^+ h^-$, $B^0 \to K^* \mu^+ \mu^-$, $B^0 \to D^0 K^*$, $B_s \to \mu^+ \mu^-$, $B_s \to J/\psi \phi$…
      - Some include neutrals: $B^0 \to \pi^+ \pi^- \pi^0$, $B^0 \to K^* \gamma$, $B_s \to \phi\gamma$, $B_s \to J/\psi \eta$ …
- Inclusive selections: 1800Hz
  - Inclusive single-muon sample: 900Hz
    - Unbiased on the signal side
      - Trigger efficiencies
      - Data mining
  - High mass di-muon sample [J/Ψ, $b \to J/\Psi X$…]: 600Hz
    - Selected without lifetime information
      - Proper time resolution using prompt J/Ψ events
    - Clean mass peaks for alignment, momentum (B field) calibration
  - Inclusive D* sample [clean $D^{*+} \to D^0 (K^- \pi^+) \pi^+$ signal]: 300Hz
    - Selected without RICH information
      - Measure PID performance as a function of momentum
    - Charm physics

Two-level Trigger



Level 0

Custom Electronics

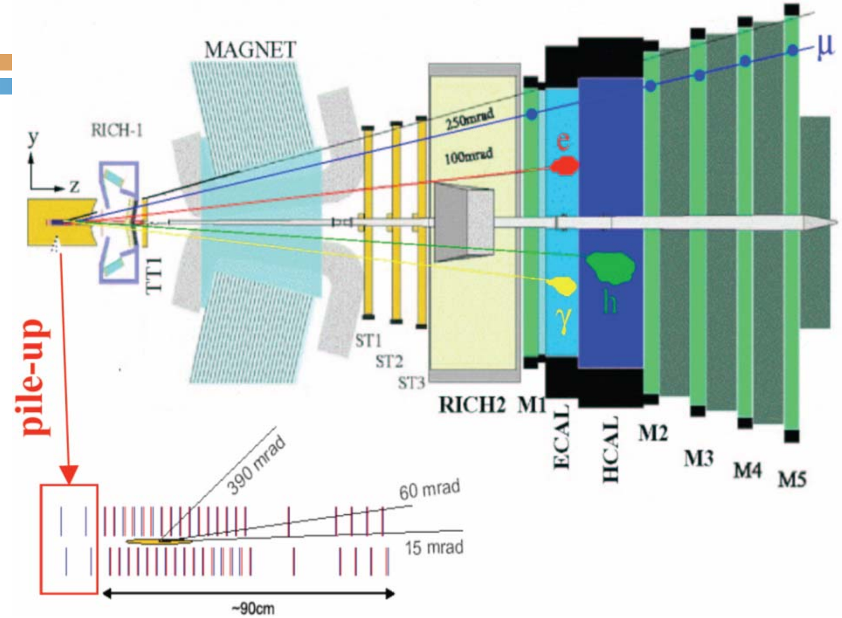
- ✓Fully synchronous (40MHz)
- ✓4 μs fixed latency
- ➢ Pile-up veto ⊕ **High p_T candidates**
- ✓from Calorimeter (e, γ, π^0, hadron)
- ✓and Muon system (μ, μμ)

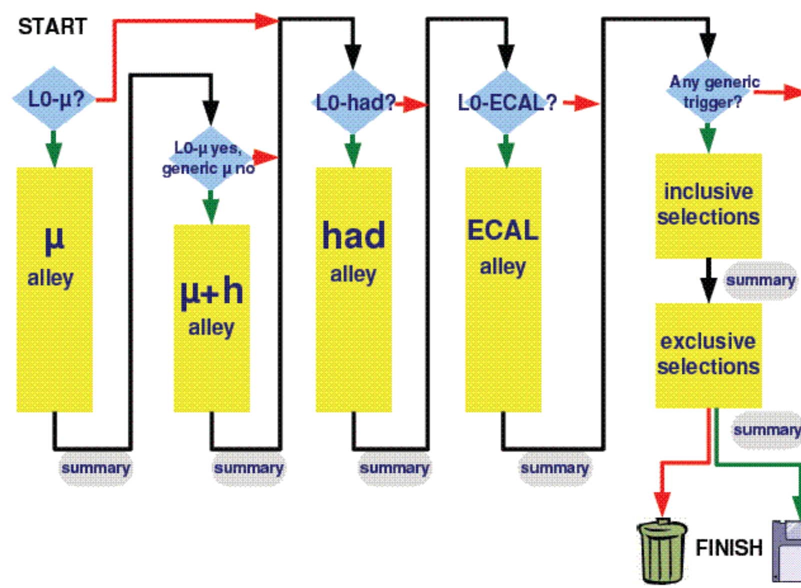
High Level Trigger

PC farm of ~2000 CPUs

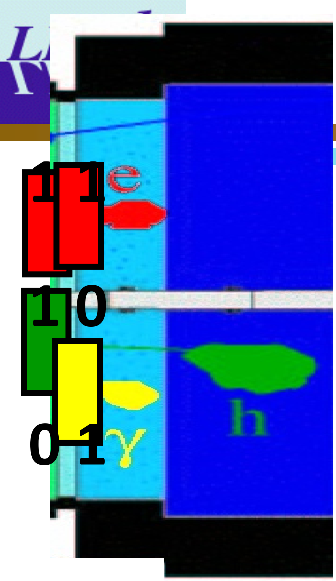
- ✓Full detector information available
- ✓Only limit is CPU time
- ➢ First uses tracking information to **confirm L0 decision** ⊕ **High IP**
- ✓4 alleys: rate reduced to **~30kHz**
- ➢ Then build **Inclusive** and **exclusive** selections: full event reconstruction

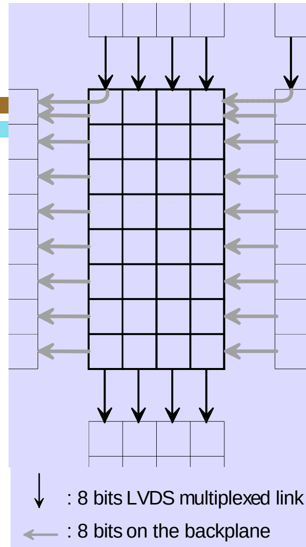
Storage: event size ~35kB

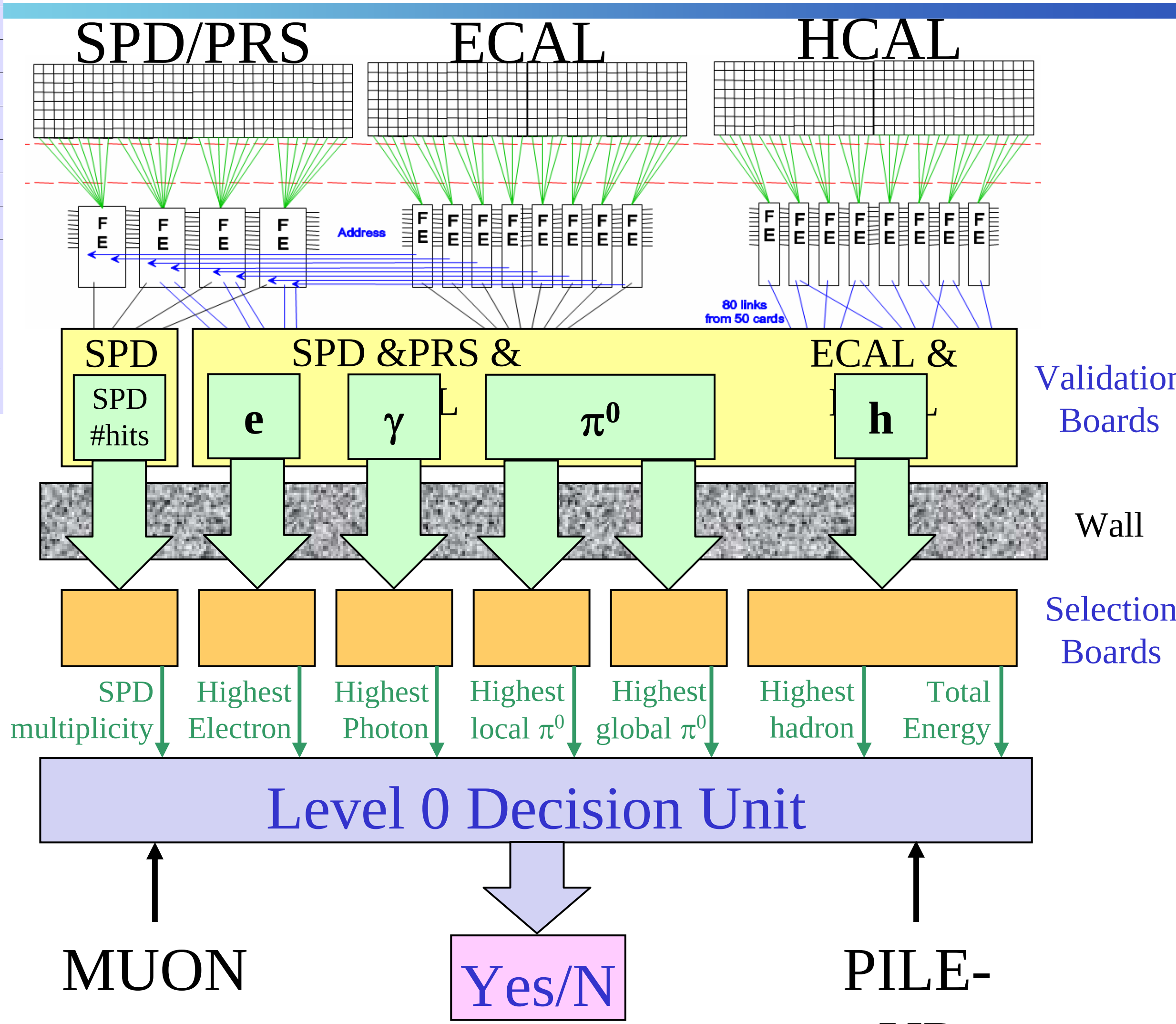




Level 0 Calo Trigger







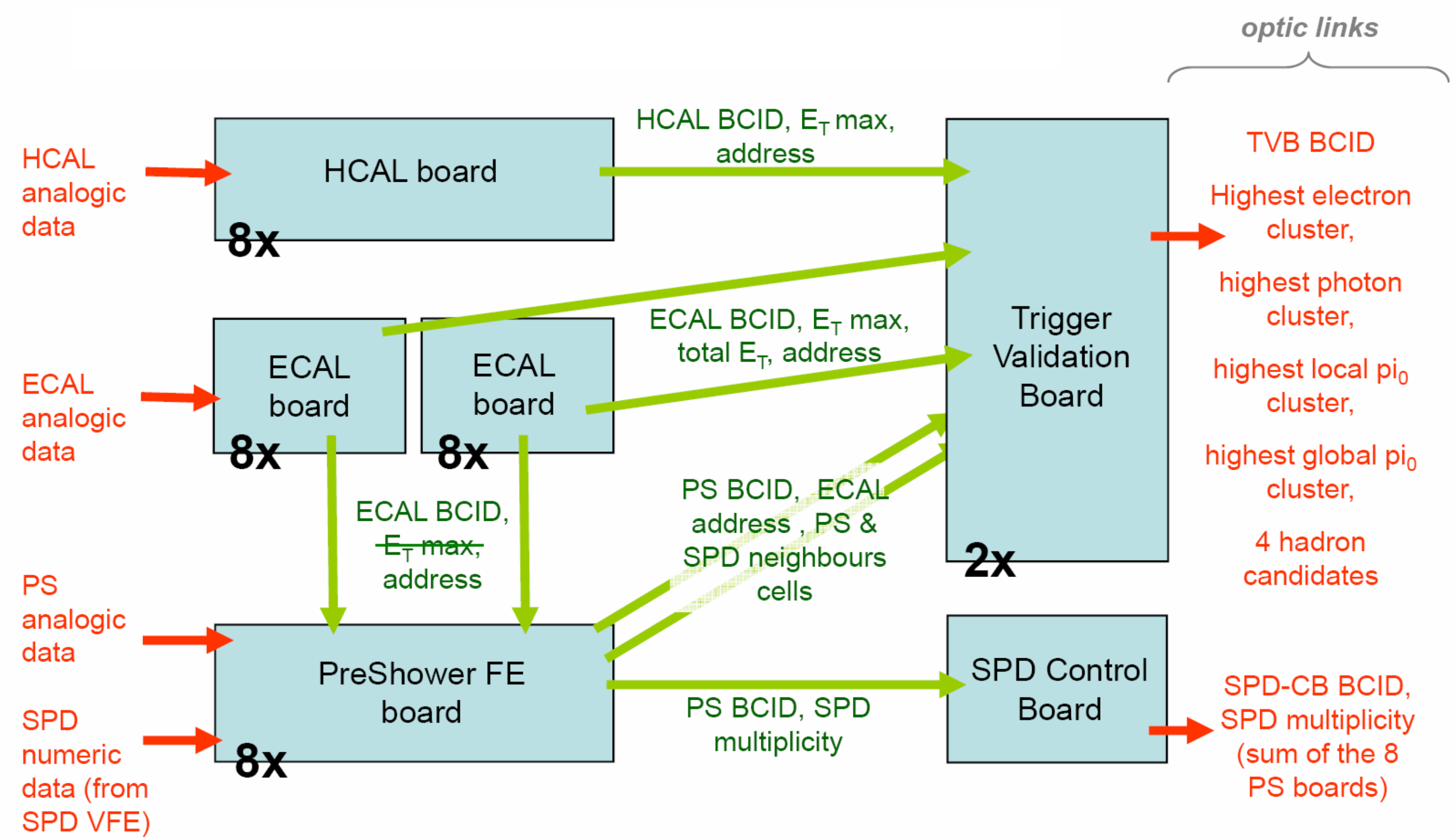
- Form all 2×2 pads ECAL and HCAL clusters
- Identify electron, γ, π^0 and hadron with highest E_T
  - SPD: charged vs. neutral
  - PRS: EM shower vs. Hadronic shower
- SPD hits multiplicity
  - Veto pile-up / busy events
- Total HCAL Energy
  - Veto muon halo events

⇨ Latency of L0 calorimeter Trigger ~ 1 μs

LA SALLE ENGINYERIA I ARQUITECTURA Universitat Ramon Llull

UNIVERSITAT DE BARCELONA

Located on a platform on top of the



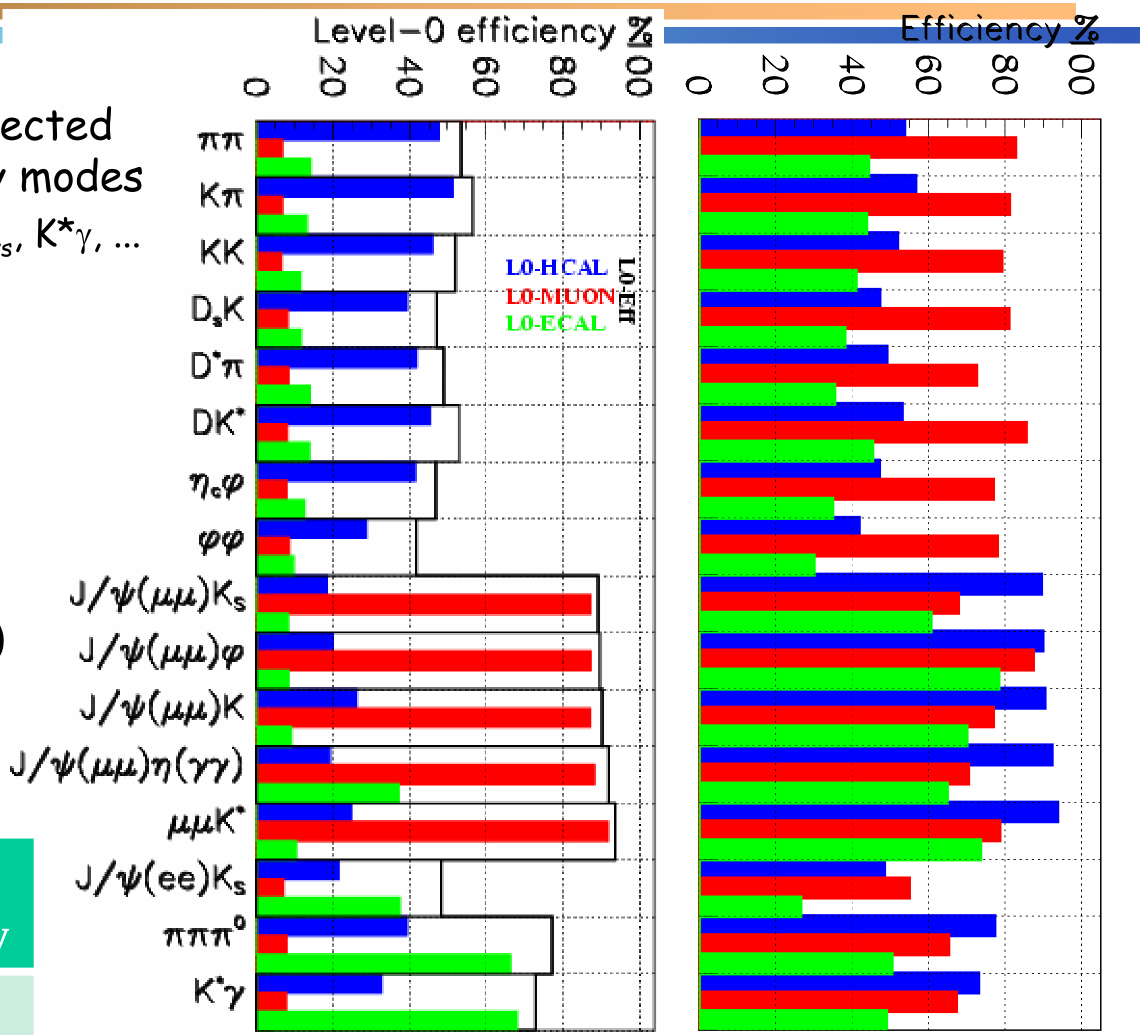
Trigger performance

- Level 0 Thresholds
  - Tuned to maximize offline selected yields of some typical B decay modes
    - $\pi\pi$, $J/\Psi(\mu\mu)K_s$, $J/\Psi(ee)K_s$, $K^*\gamma$, …
  - Hadron $E_T > 3.6$ GeV
    - 700kHz
  - e, γ, π^0 $E_T > 2.5$ to 4.5 GeV
    - 300kHz
  - Muon $p_T > 1.1$ GeV/c
    - 160kHz

  NB: 1MHz in total (some overlap)

- Typical Efficiencies

Channel type	L0 Efficiency	HLT Efficiency
Hadronic	50%	80%
Radiative	70%	70%
Muonic	90%	75%

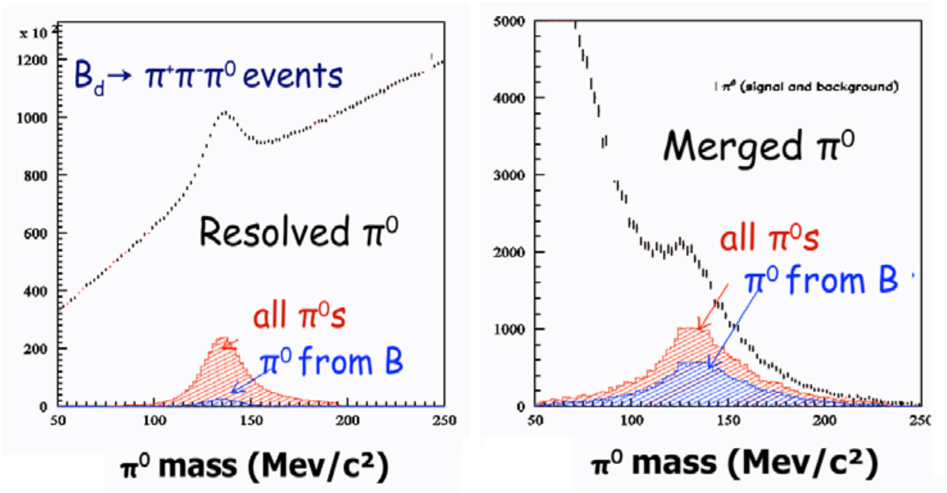


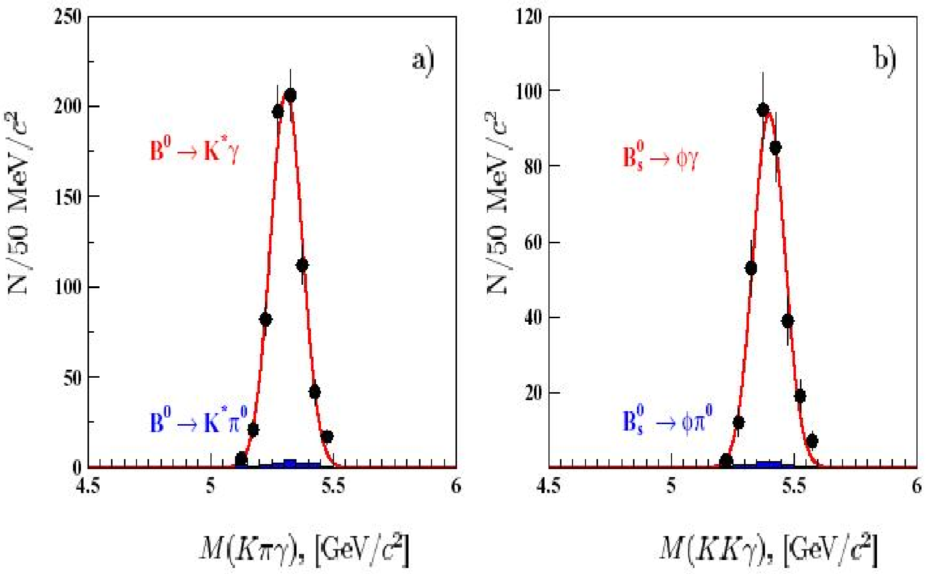
L0-HCAL
L0-MUON
L0-ECAL

L0
HLT
L0×HLT

Illustration: physics with neutral

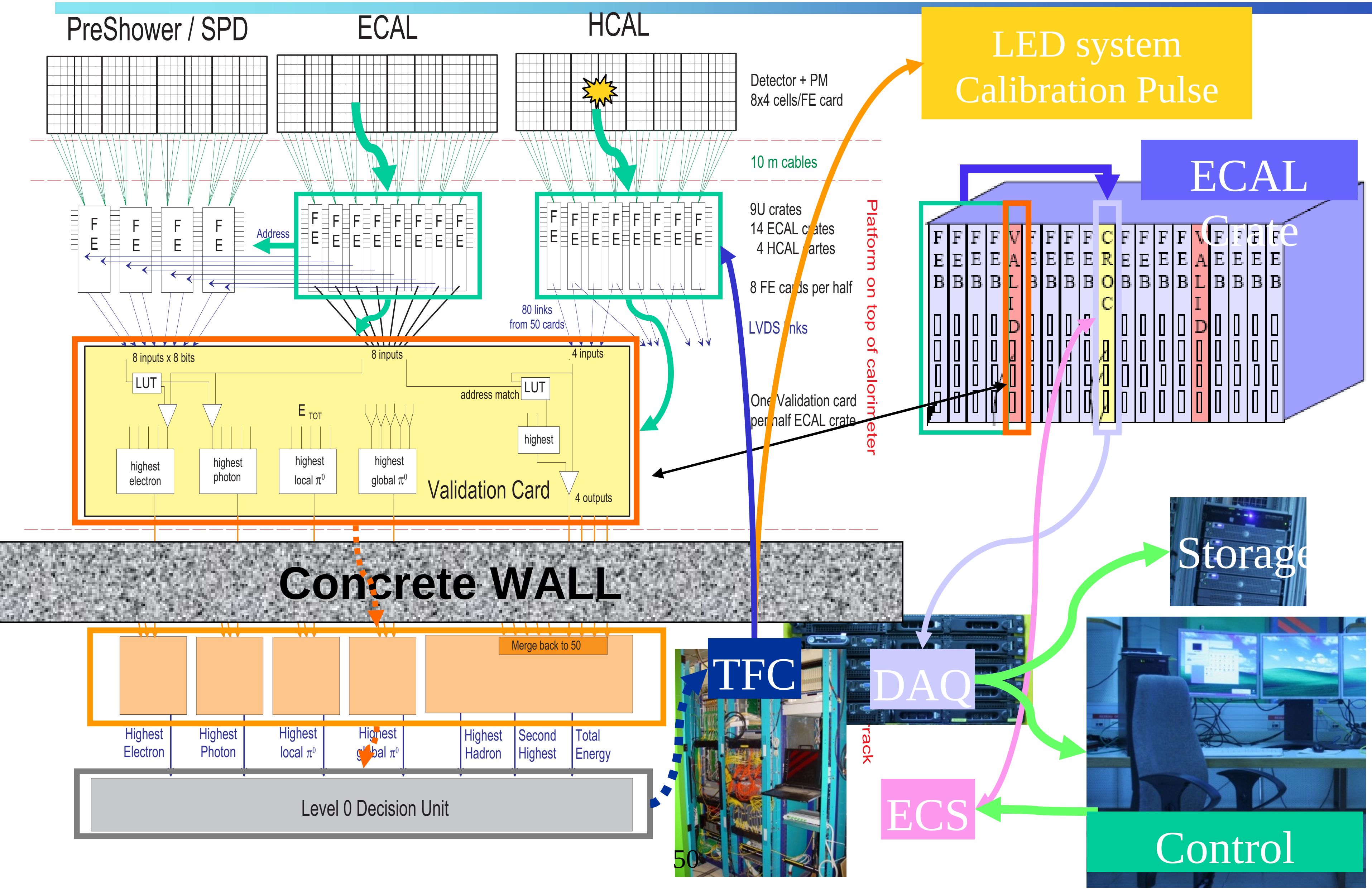
- π^0 recontruction
  - Use calorimeter clusters not associated to tracks
  - π^0 reconstructed from two separate clusters (resolved) or single merged cluster (use cluster shape)
  - Reconstruction efficiency ~ 50% for $B^0 \to \pi^+\pi^-\pi^0$
    - Mass resolution ~ 10 (15) MeV/c² for resolved (merged) π^0
    - Time dependent Dalitz plot analysis a la Snyder & Quinn for $B^0 \to \rho\pi \to \pi^+\pi^-\pi^0$ leads to $\sigma(\alpha)$ ~ 10° with 2fb^{-1}
- Radiative B decays
  - $B_d \to K^*\gamma$ (BR = $2.9 \cdot 10^{-5}$)
    - $35 \cdot 10^3$ selected events per year with B/S < 0.7
  - $B_s \to \phi\gamma$ (BR = $4.3 \cdot 10^{-5}$)
    - $9 \cdot 10^3$ selected events per year with B/S < 2.4





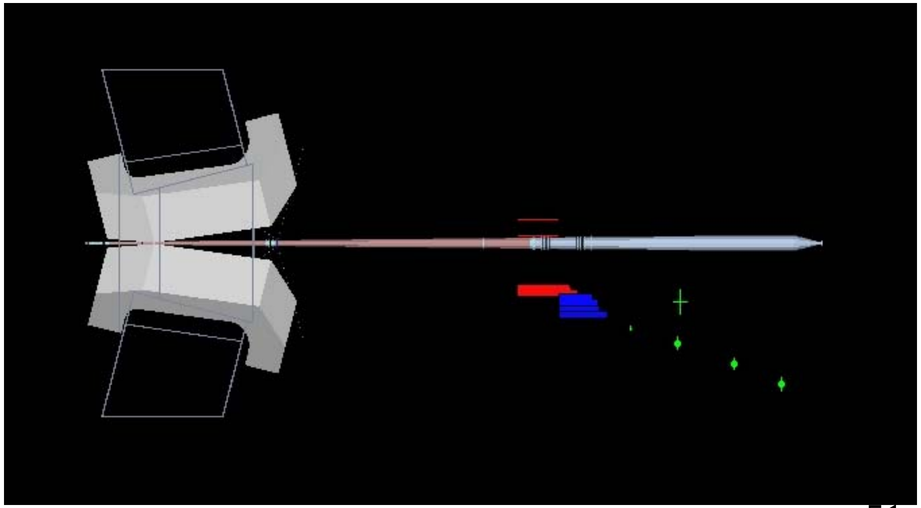
$\sigma(M_B)$ ~ 65 MeV/c²

Full System Test (May 2007)

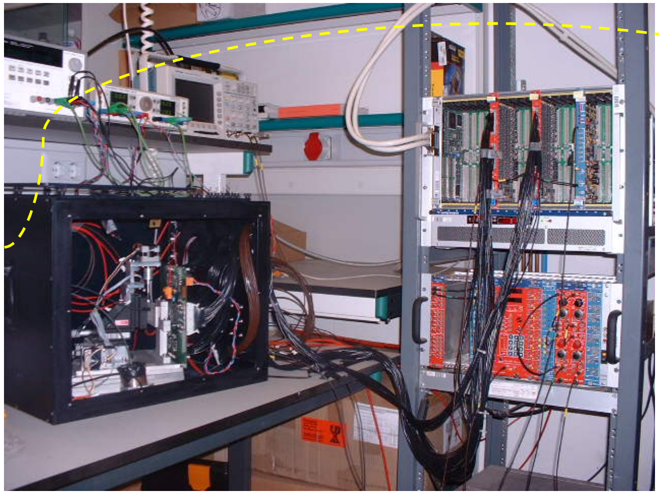


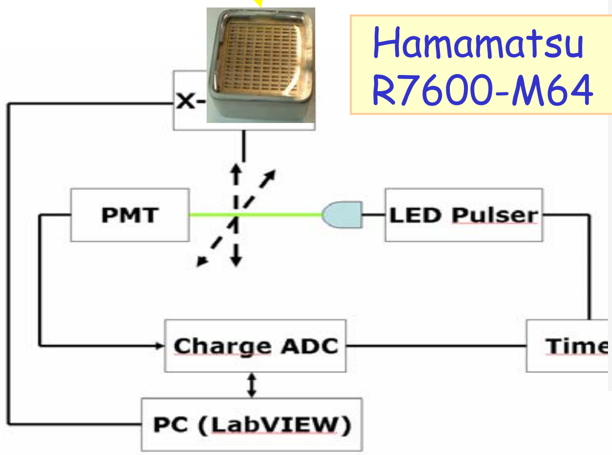
Cosmic Trigger

- Calorimeter cosmic trigger available since end of December 2007
  - Special HV settings to trigger on mip
  - Coincidence between ECAL and HCAL
    - Trigger rate ~ 4 Hz
- Proof of principle but not only
  - Very useful for timing
  - Helpful to finish setting up SPD and PRS
- Also have a muon cosmic trigger since April 2008



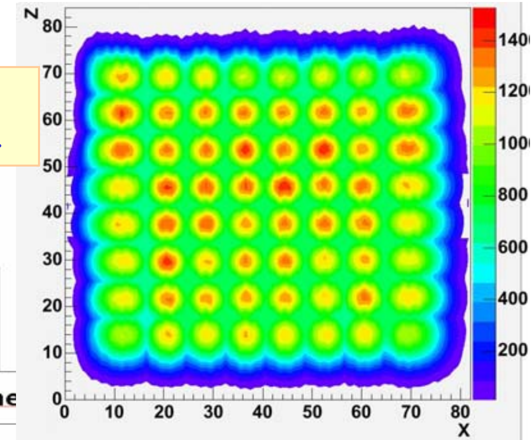
MaPMT Test (x 110)





Hamamatsu R7600-M64

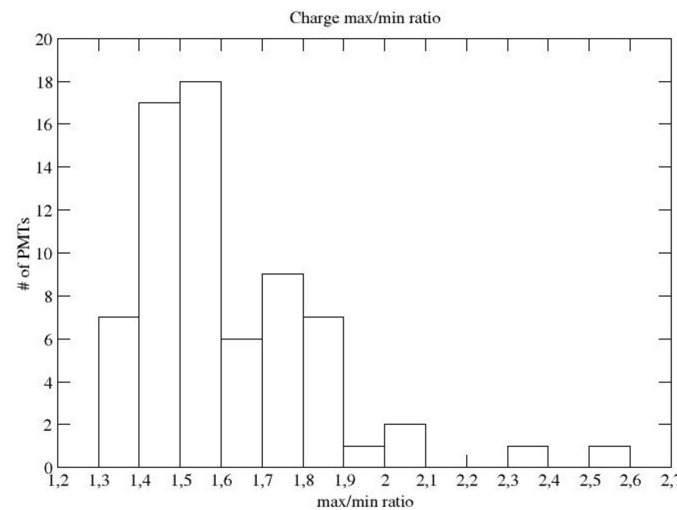
64 ch signal output



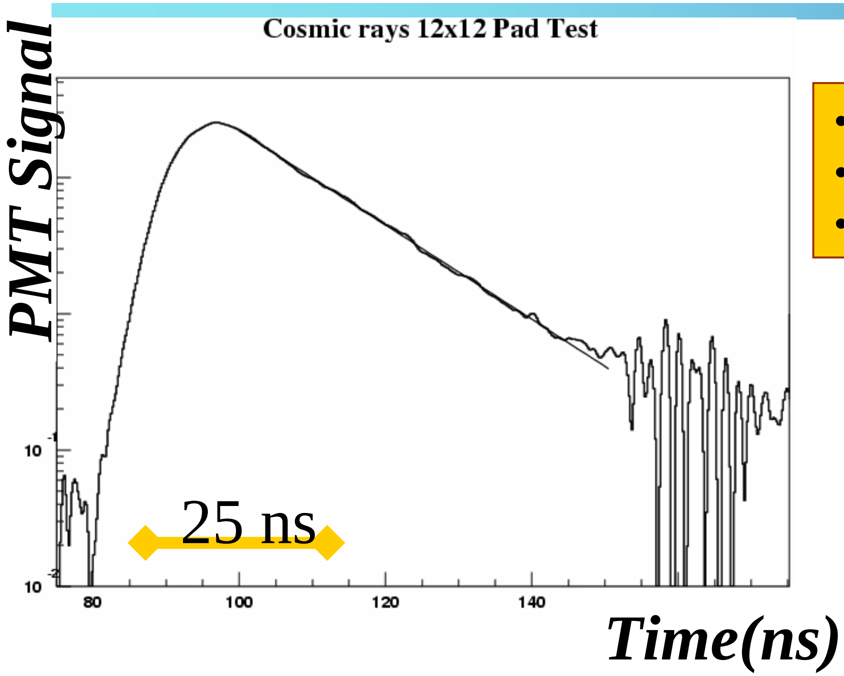
110 PMT received, tested and installed:

1. Gain test. All under specification
2. Linearity test: deviation below 5 %
3. Fine scan: uniformities below factor 3.
4. High crosstalk in 10 %.

Uniformity

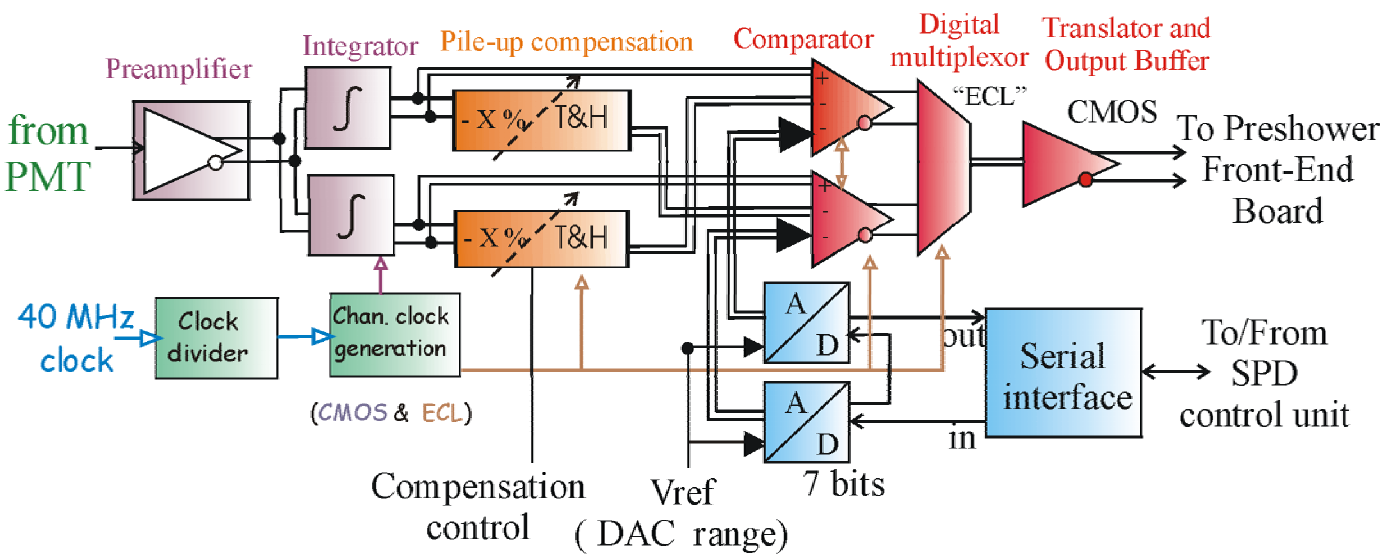


Signal processing



- Only ~80 % of signal in 25 ns (depends on the pad size)
- No dead time on integration
- Different channels gain (1-4) on the same PMT

we need
- ***Dual channel***
- ***Programmable threshold for each subchannel.***
- ***Programmable subtractor***



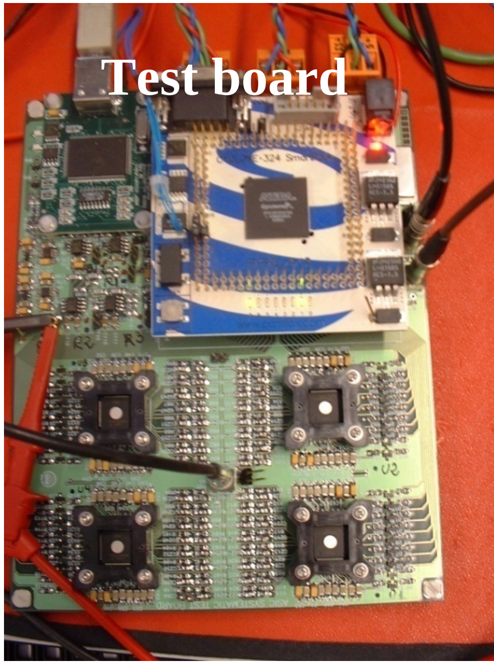
The ASIC (App. Specific Integrated Circuit)

Designed in collaboration with the electronics department (UB)

- *Analog Processing + Digital Control*
- *Signal range: 1 pC* (1 V)
  (1 MIP ~ 30-100 fC)
- *Electronics resolution 2 fc*
- *Radiation tolerant design*
  - Guard rings for SEL prevention
  - Triple Voting Register (TVR) for SEU.

8 dual channels

AMS BiCMOS 0.8μm – 30mm²



1300 produced + 600 unpacked
Needed 800+160 (tested & mounted)

1)digital and bias test

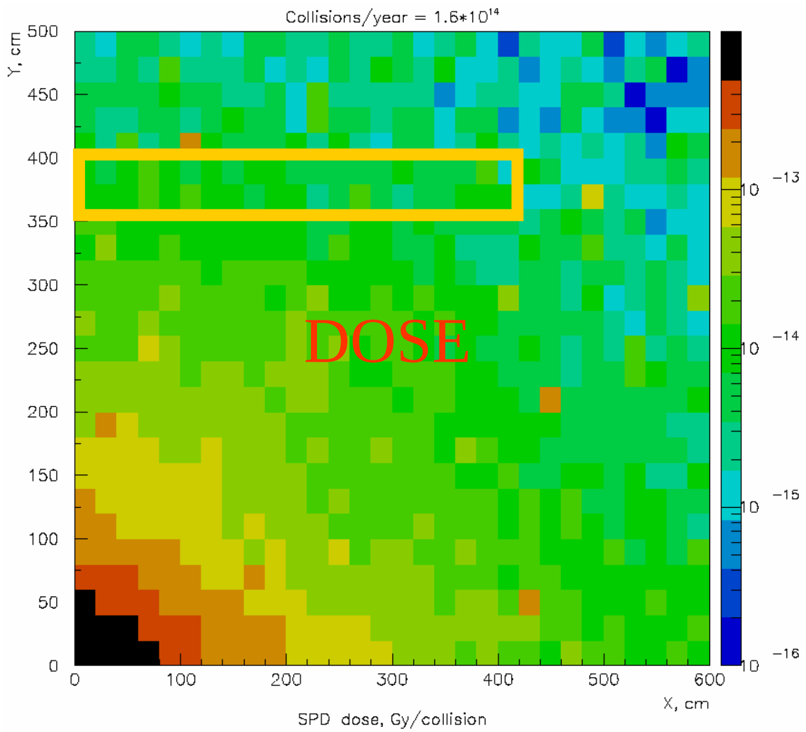
Yield over 88,5%

Total	1311	
Pass	1161	88,56%
Digital Error	112	8,54%
Bias problem	38	2,90%

2)analog part: noise, linearity, pile-up correction

Yield 90%

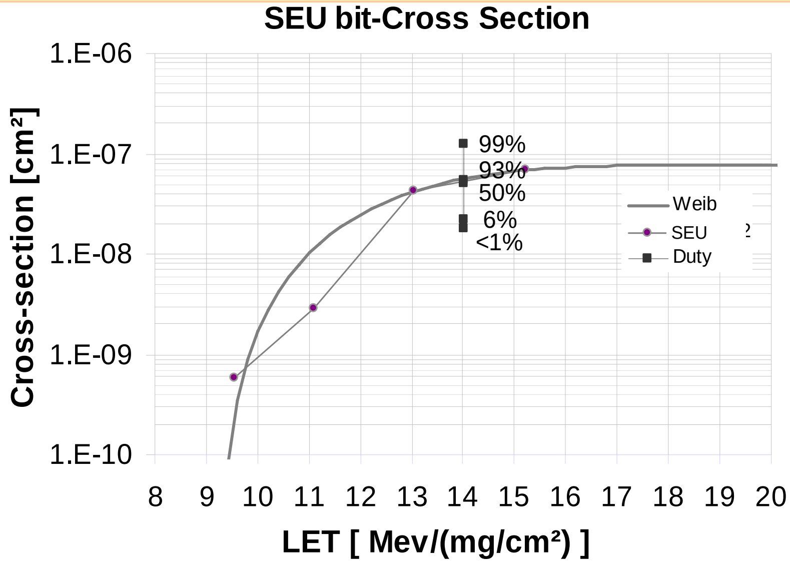
Radiation qualification



Radiation qualification:

Using a krypton beam we have qualified this ASIC

- Expected total dose (tested up to 200 Gy = 20krad)
- The rate of SEU is acceptable
- No SEL



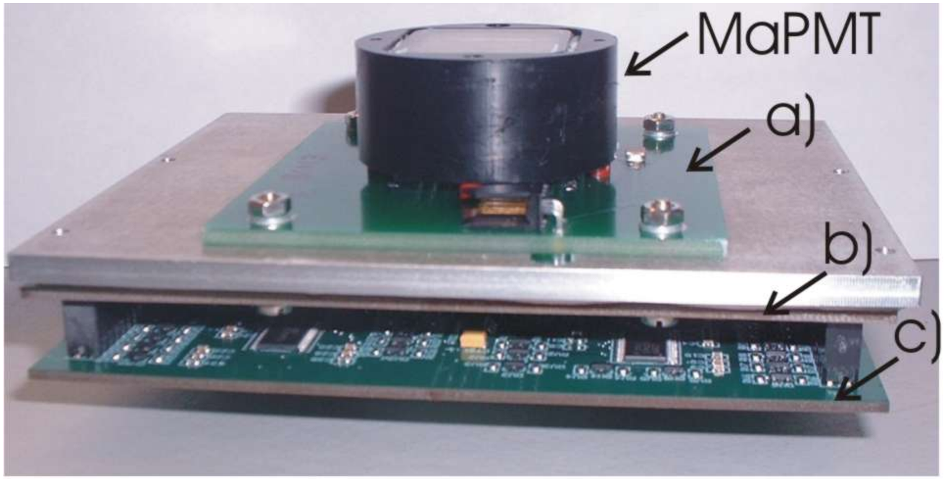
Radiation during 10 years
(in the VFE electronics)*

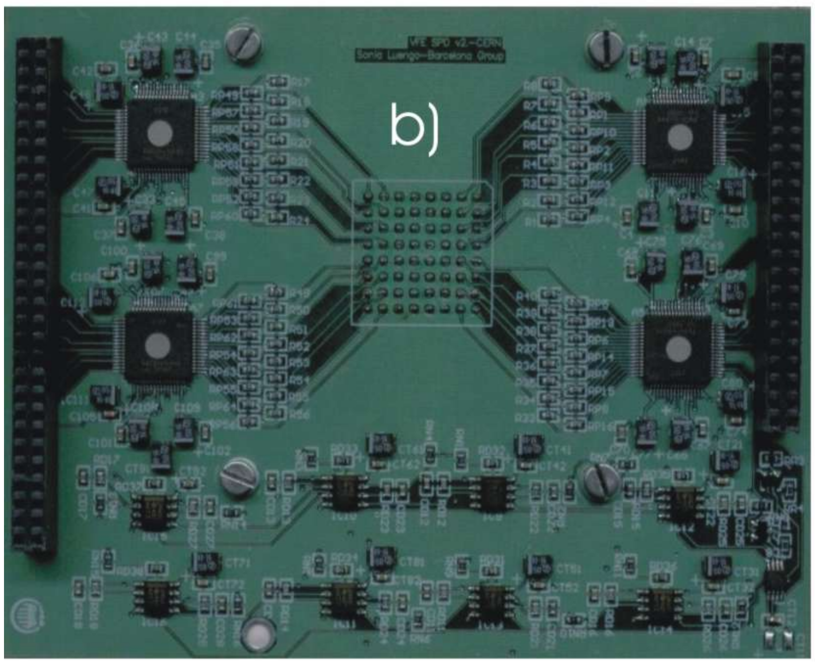
Total dose (Rad)	1 Mev Neutron eq.	Hadrons > 20 Mev
5.8*10**3	9.3*10**11	4.8*10**10

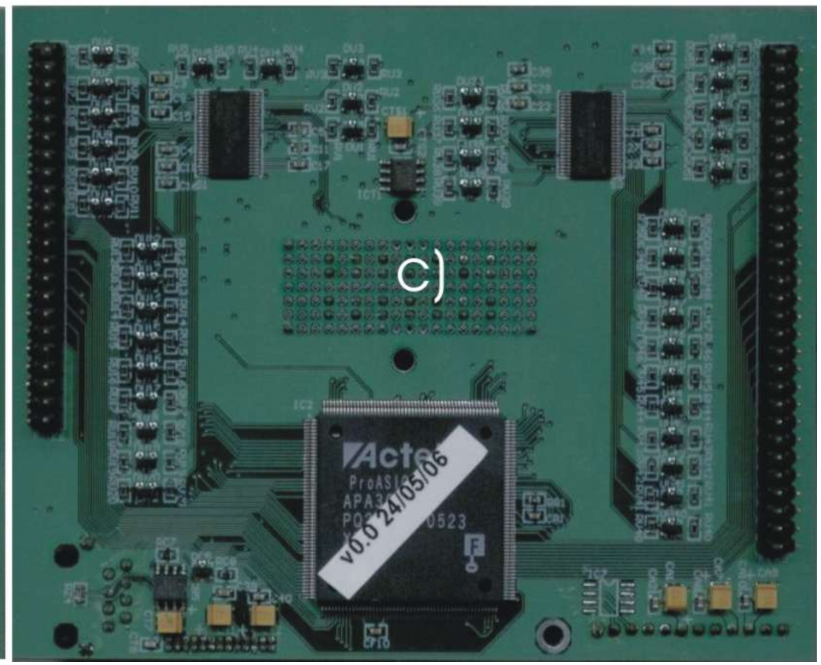
NIM xxxxxxx

(*) including safety factors

VFE board: Implementation

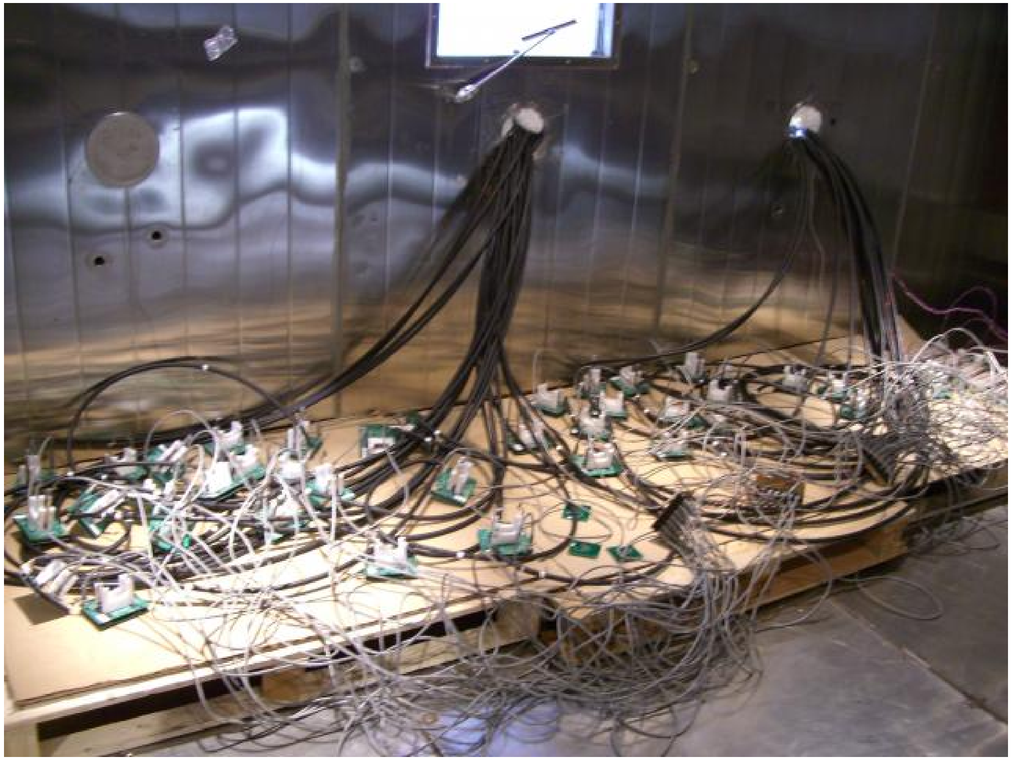






Additional test …..

Burn in againts infant mortality

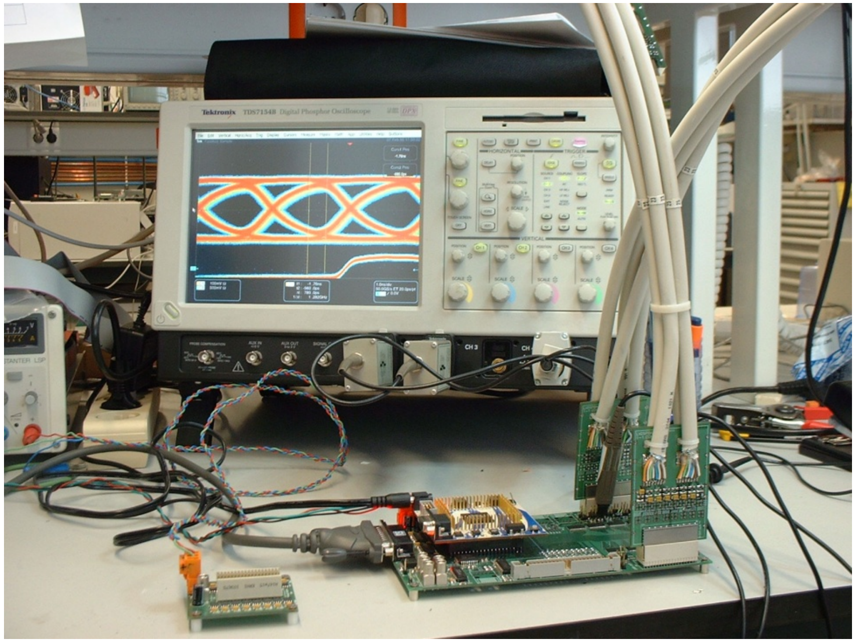


One characteristic of modern semiconductor electronic equipment is something called infant mortality. The failure rate of new electronic equipment is generally very low. However, if the equipment is going to fail, it is likely to do so within the first few hundred hours of operation.

Stressing the components with thermal-cycling allows the detections of such components that will fail very early, avoiding its installation and later replacement.

Cables

VFE board: SPD⇒PS **LVDS data link**



2.5 Gb/s connection (30m long)

- Std LAN cable of 4 twisted pairs (cat 7- STP).
- DS90CR215/216 Chipset multiplexes 7 bits into LVDS data pair.
- Cable Equalization
- Bit Error Rate (BER) has been tested: BER<10^{-13}

•120 links produced, tested and installed

Power distribution

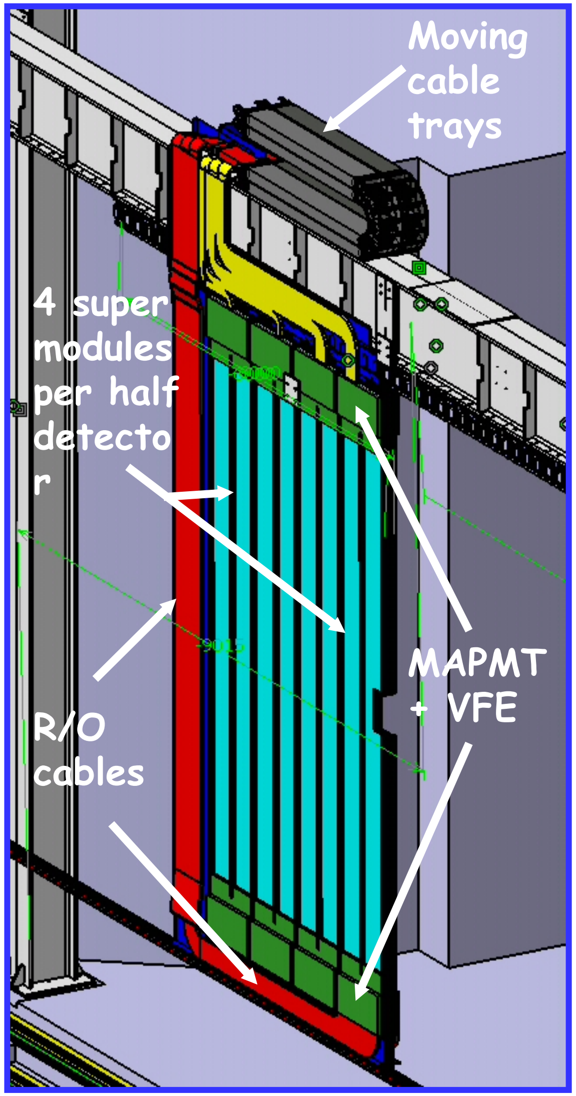
3 pairs of conductors (4 mm^2)

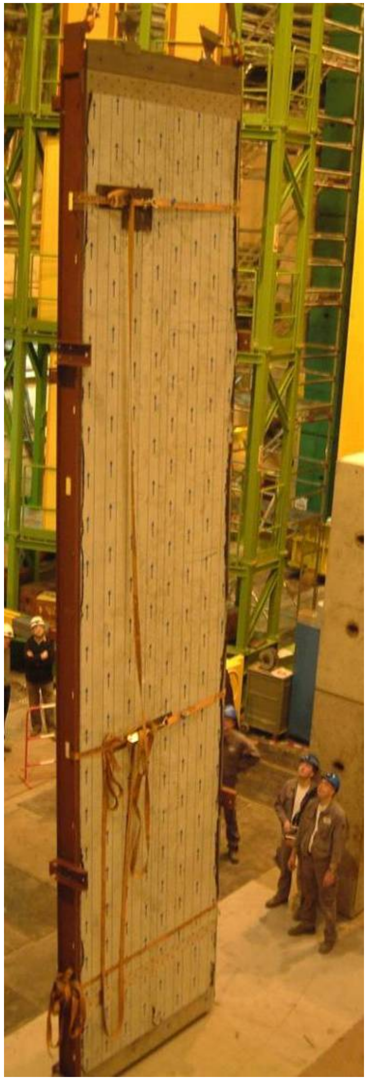
6 pairs of conductors (0.5 mm^2)

- Twisted pair of tinned copper
- Screened to the ensemble with braid of tinned copper and
- Insulation type: polyolefin Z1 halogen free

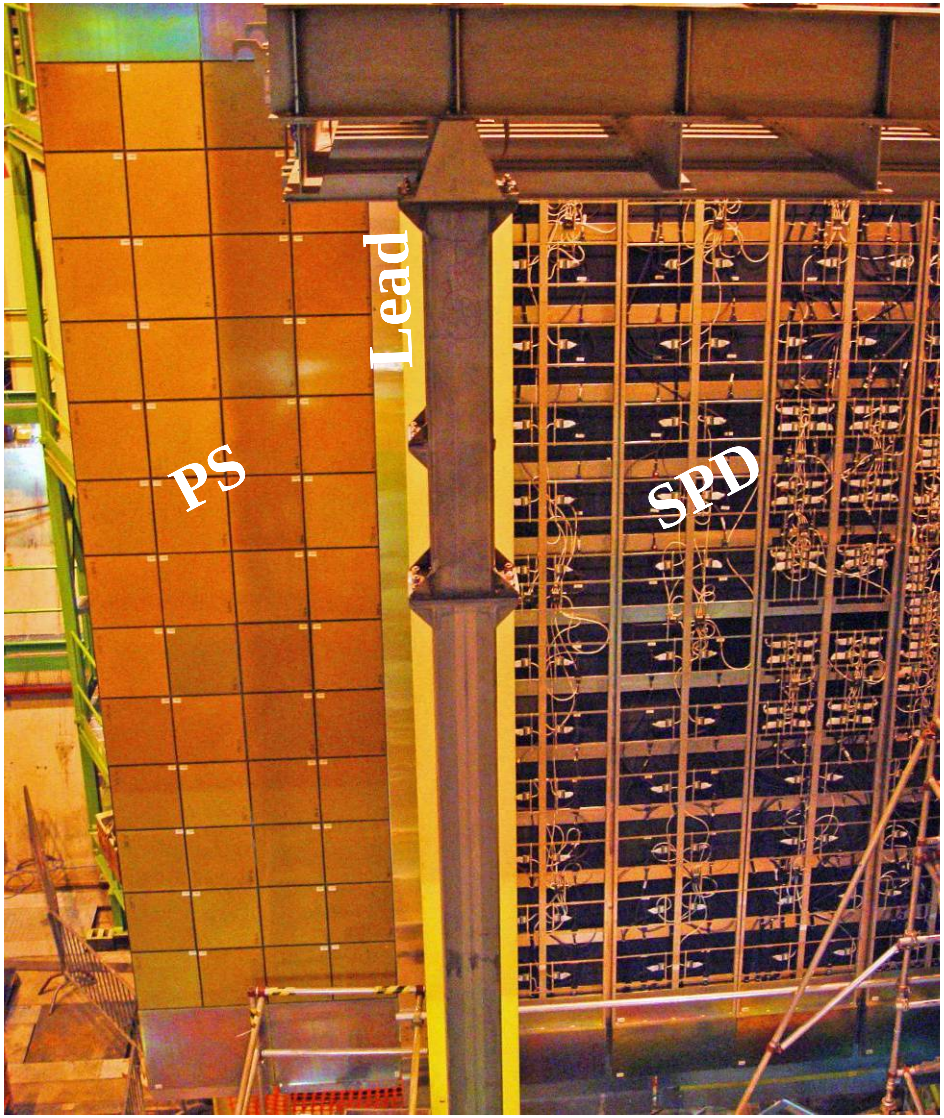
+….. others

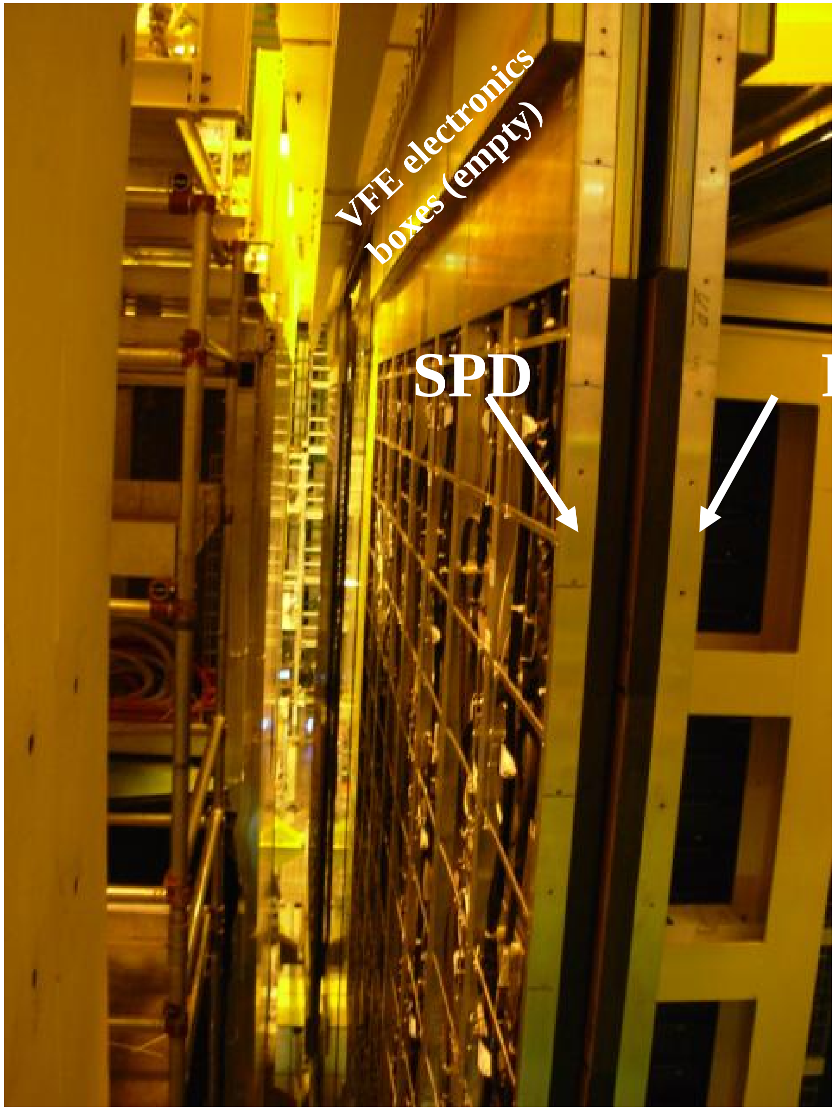
Lead panel installation A super module





Summer 2006



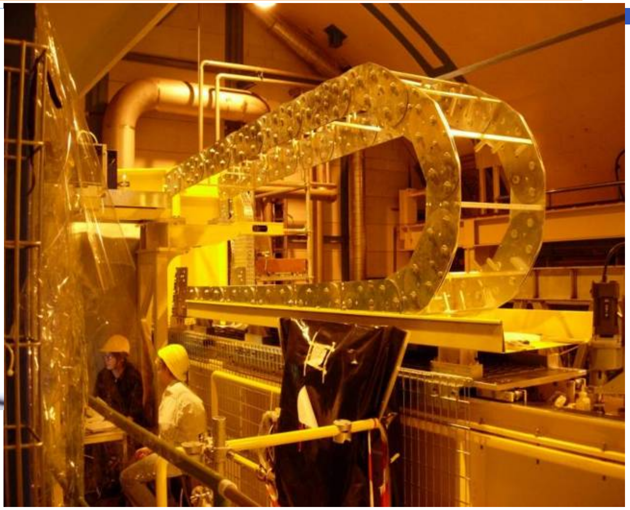


2007: transporting cables to CERN...

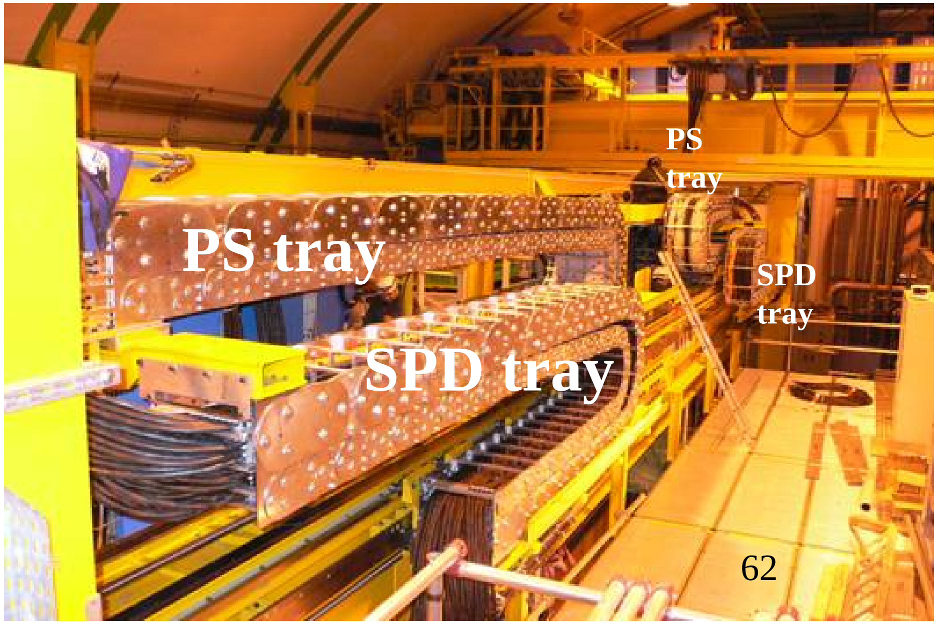
Cable installation

From VFE at bottom to the XCAL platform at top

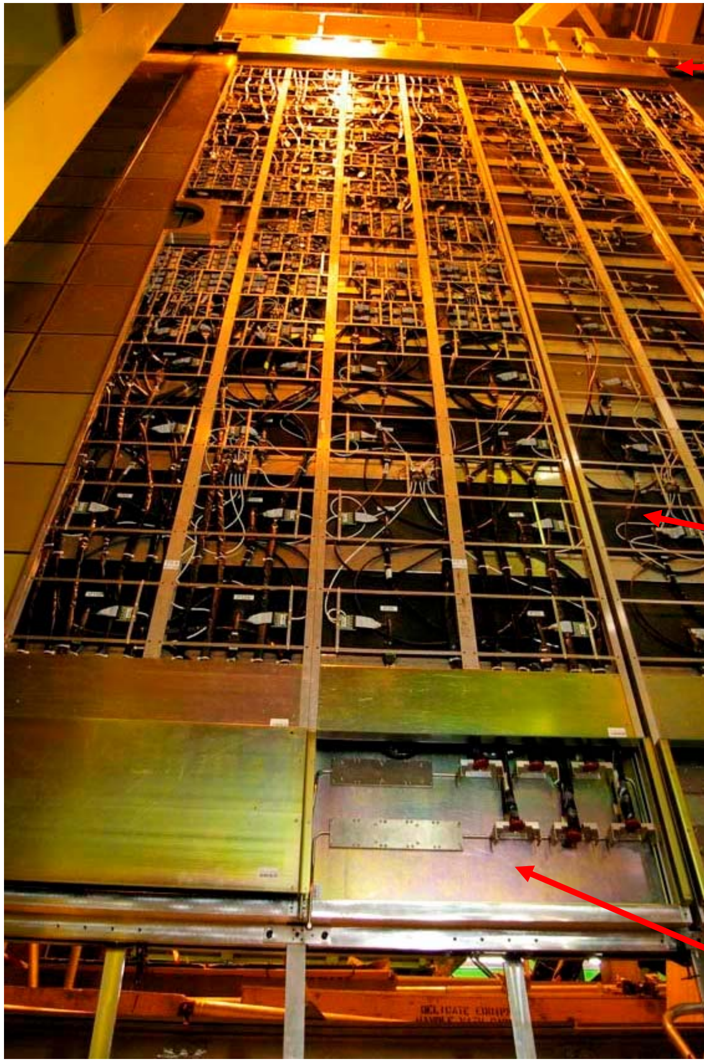
From VFE at top to the XCAL platform at top



XCAL platform at top with empty tray



SPD installed on-site

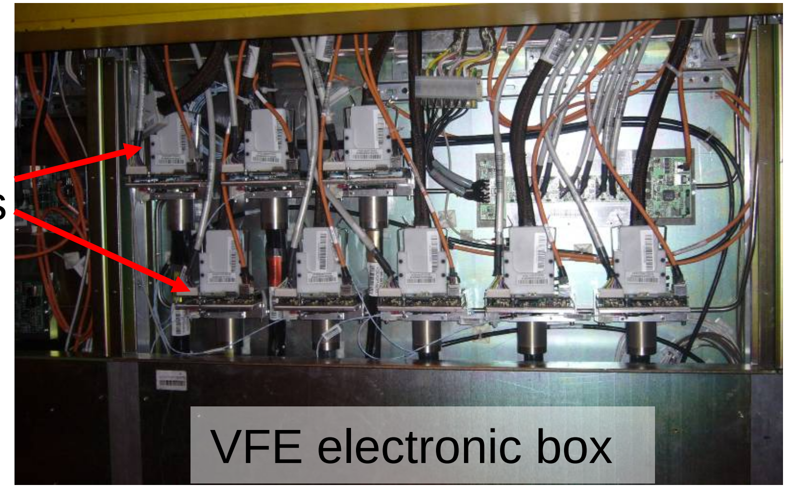


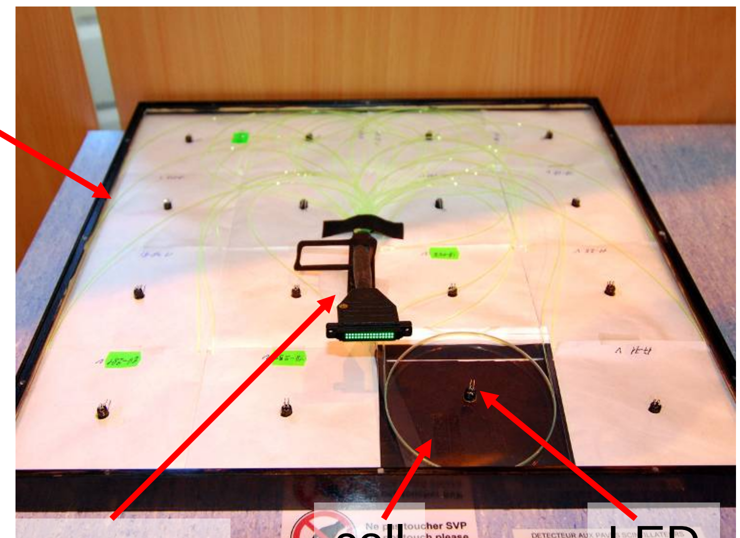
VFE electronic boxes

Detector cells

VFE electronic boxes

VFEs



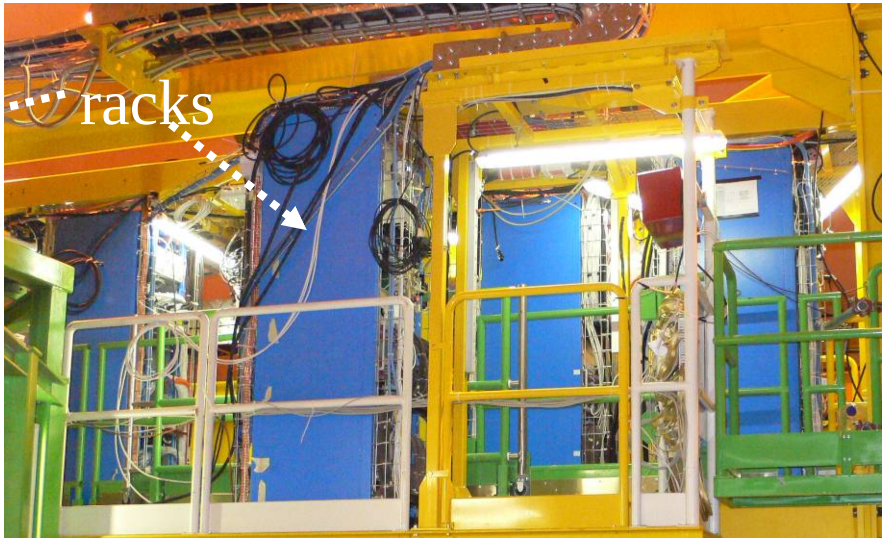


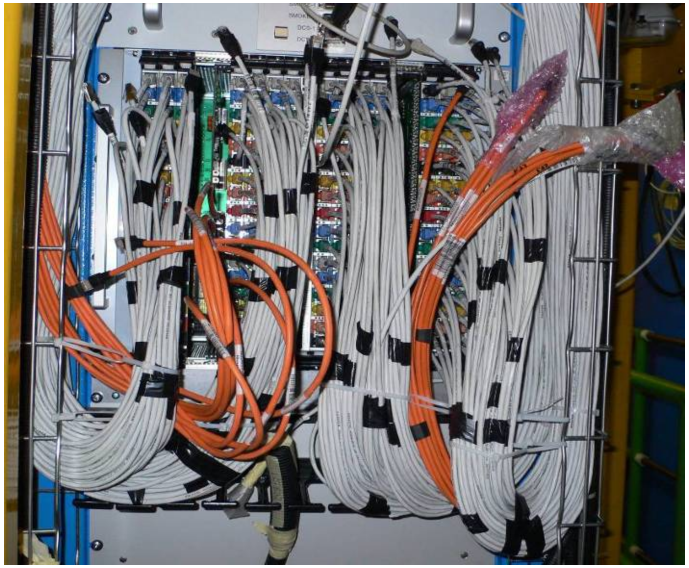
Optical fibers

cell

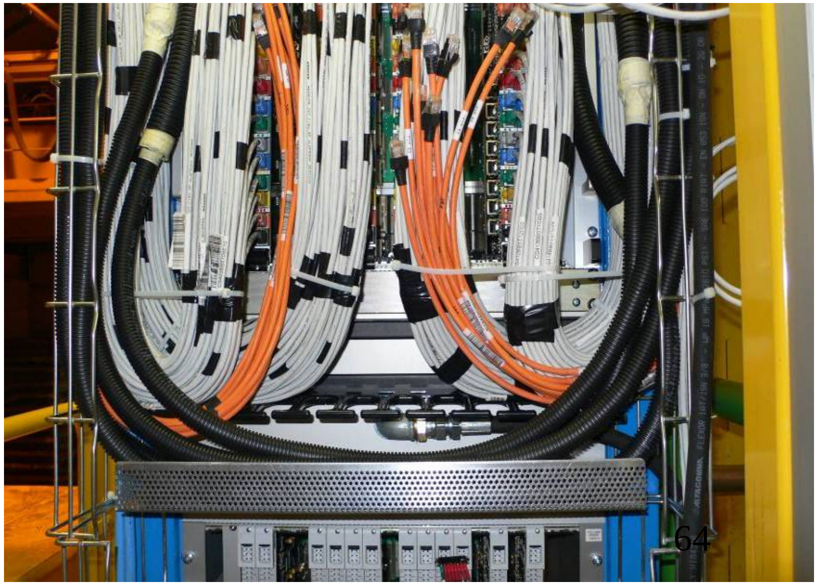
LED

Electronics installation at XCAL platform ……



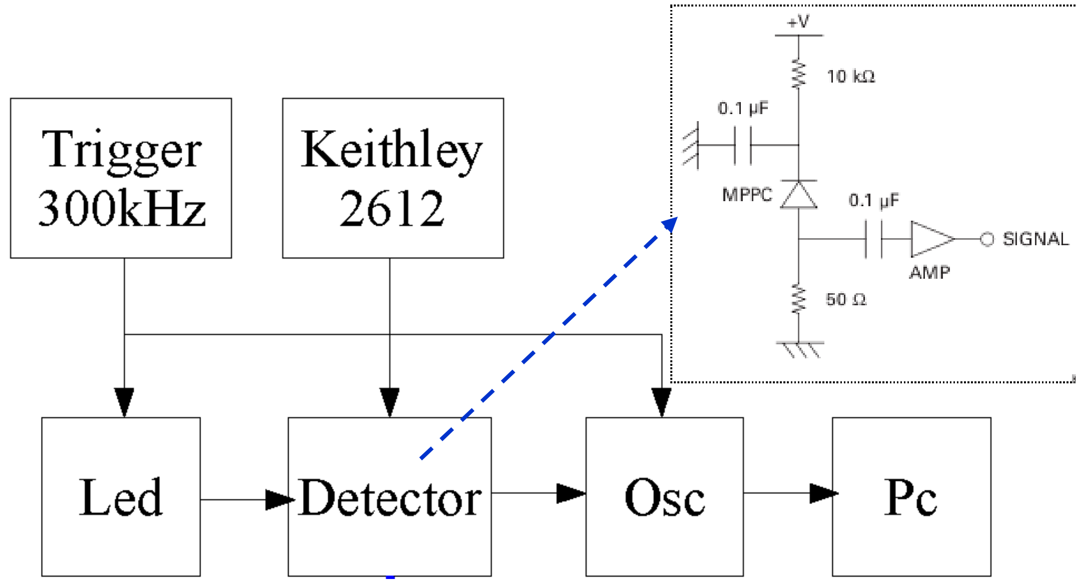


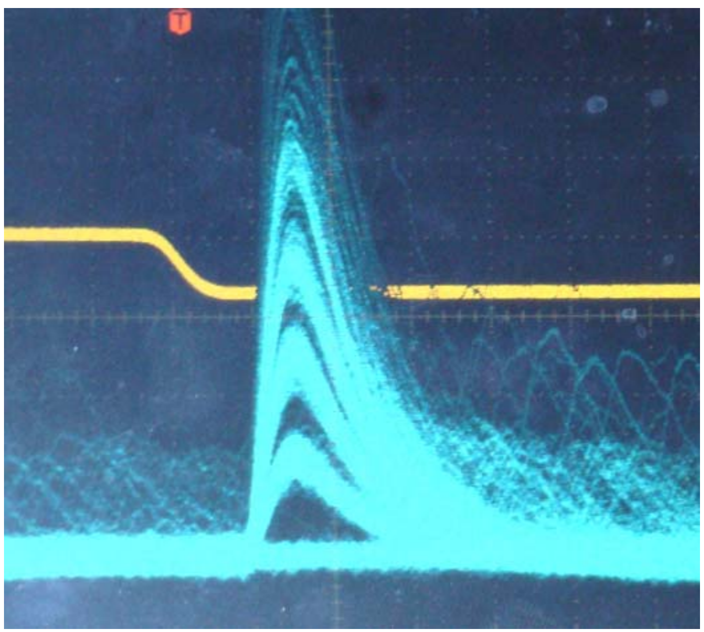
Boards on racks (and cables from VFE)

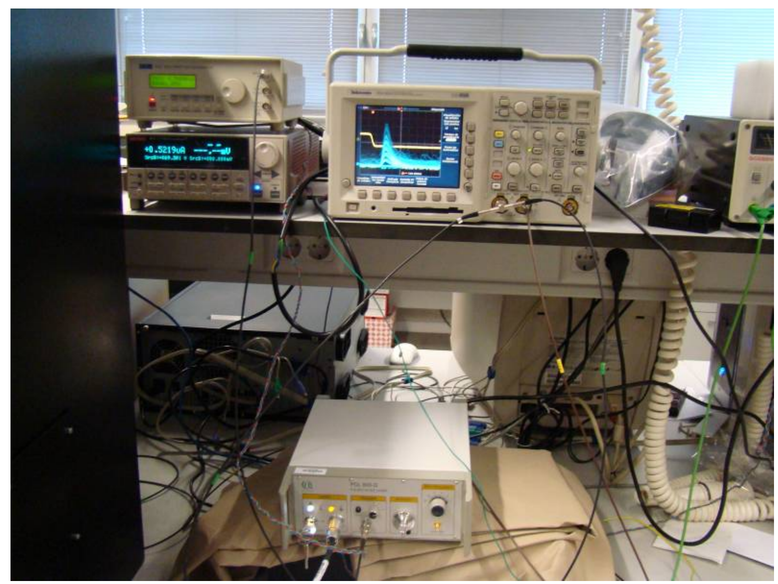


II. Current status

- Source/meter 2612 to trace IV curves
- Light sources:
  - 450 nm LED (500 ps FWHM)
  - 650 nm LASER (50 ps FWHM)
- Amplifier bandwidth to be improved.
- First tests: MPPC 100 μm cell
- Other sensors are welcome

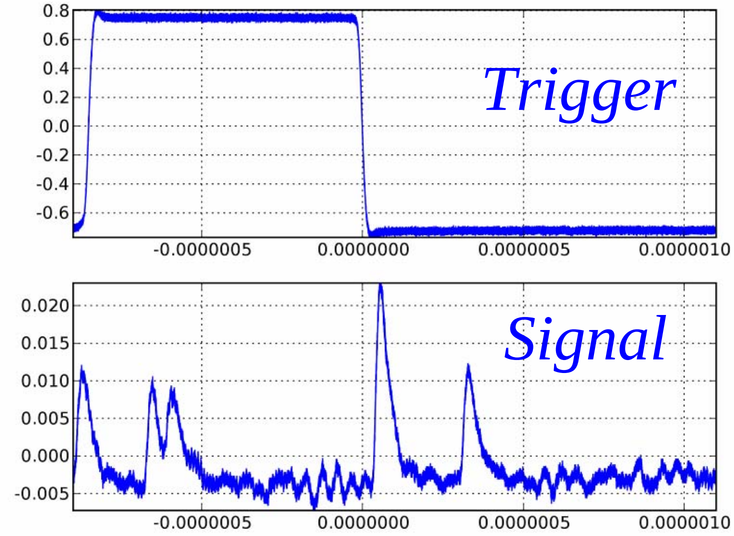




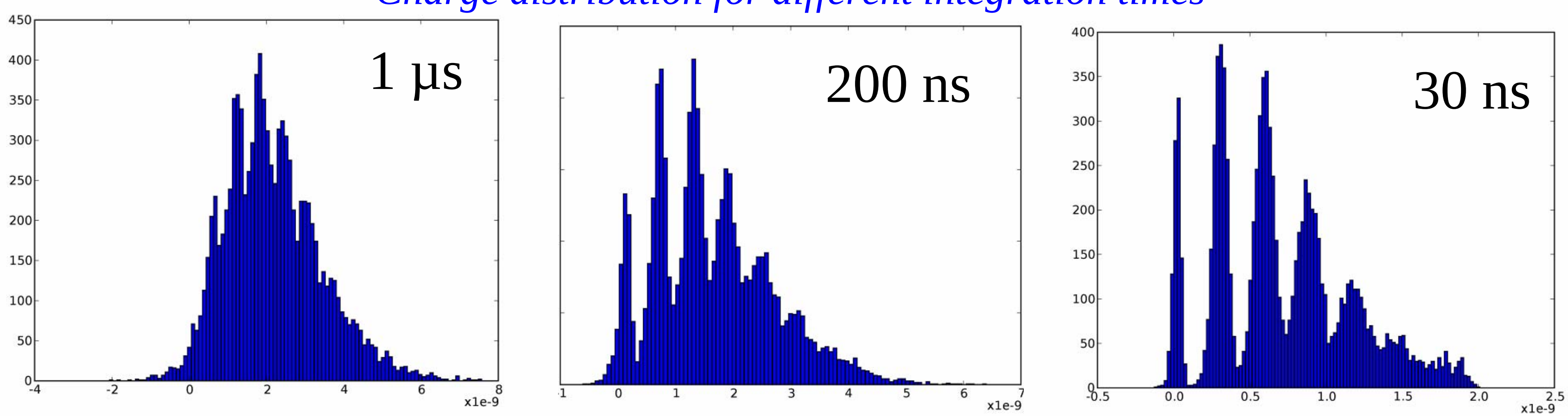


II. Current status

- Software to analyze data (ongoing)
- Time domain:
  - Time constant (capacitance)
  - Timming resolution
- Spectrum (needs xtalk correction):
  - Gain
  - Resolution
- Combined:
  - Dark count
  - Afterpulsing

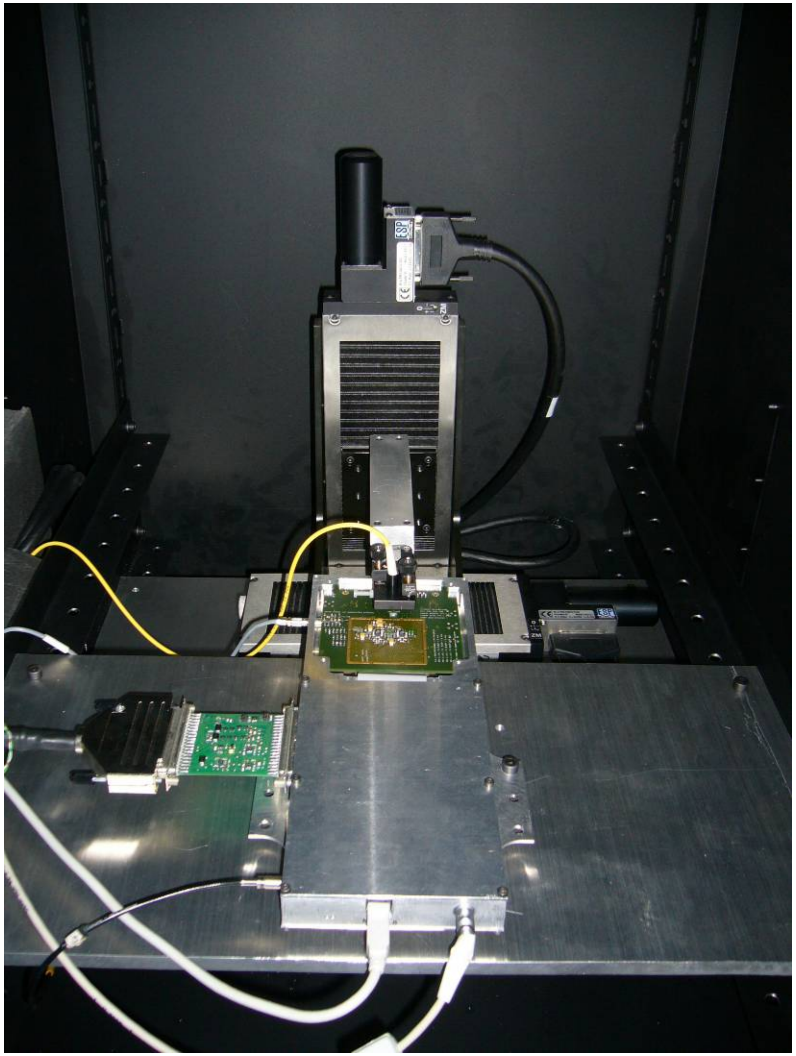


Charge distribution for different integration times

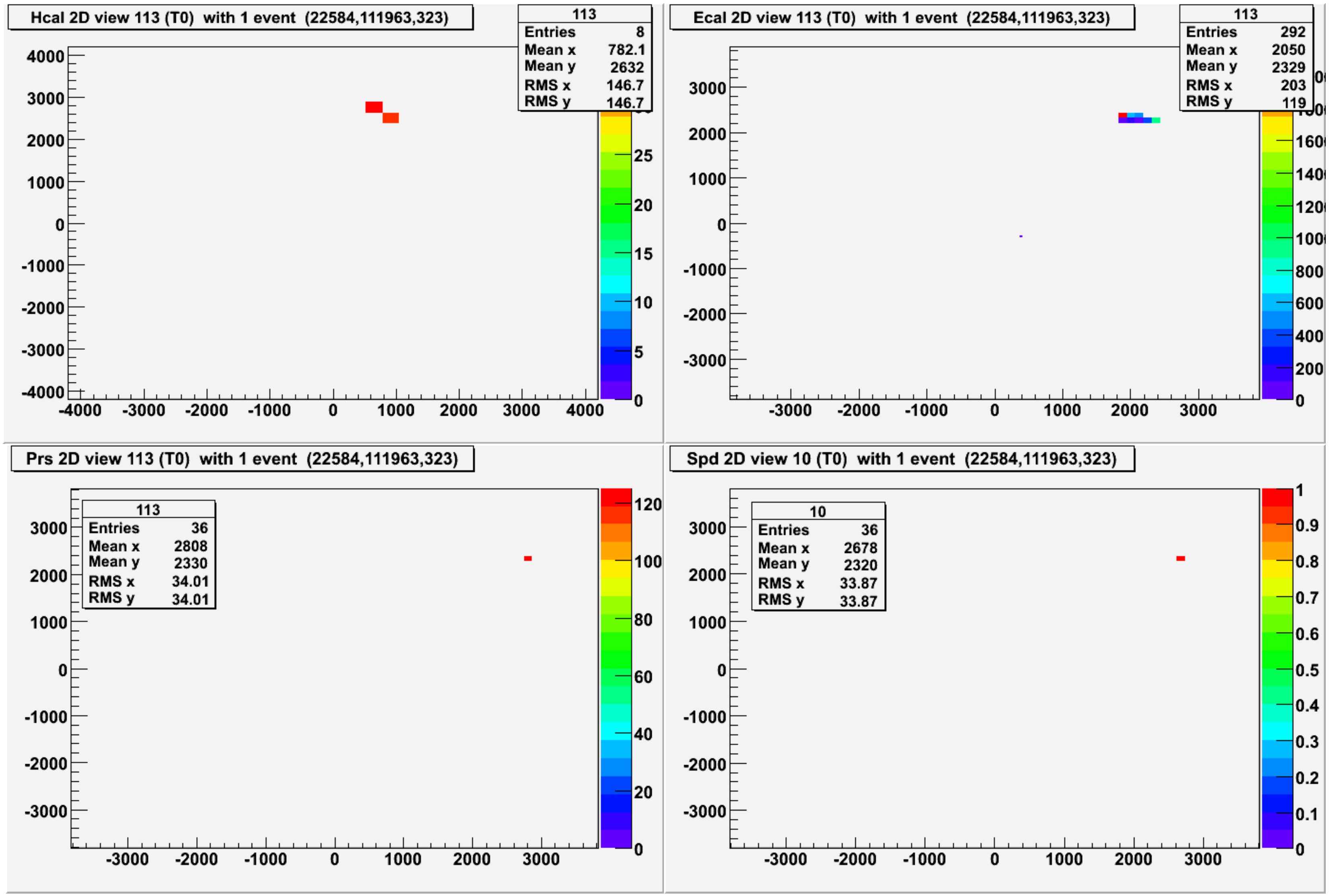


III. Short term plans

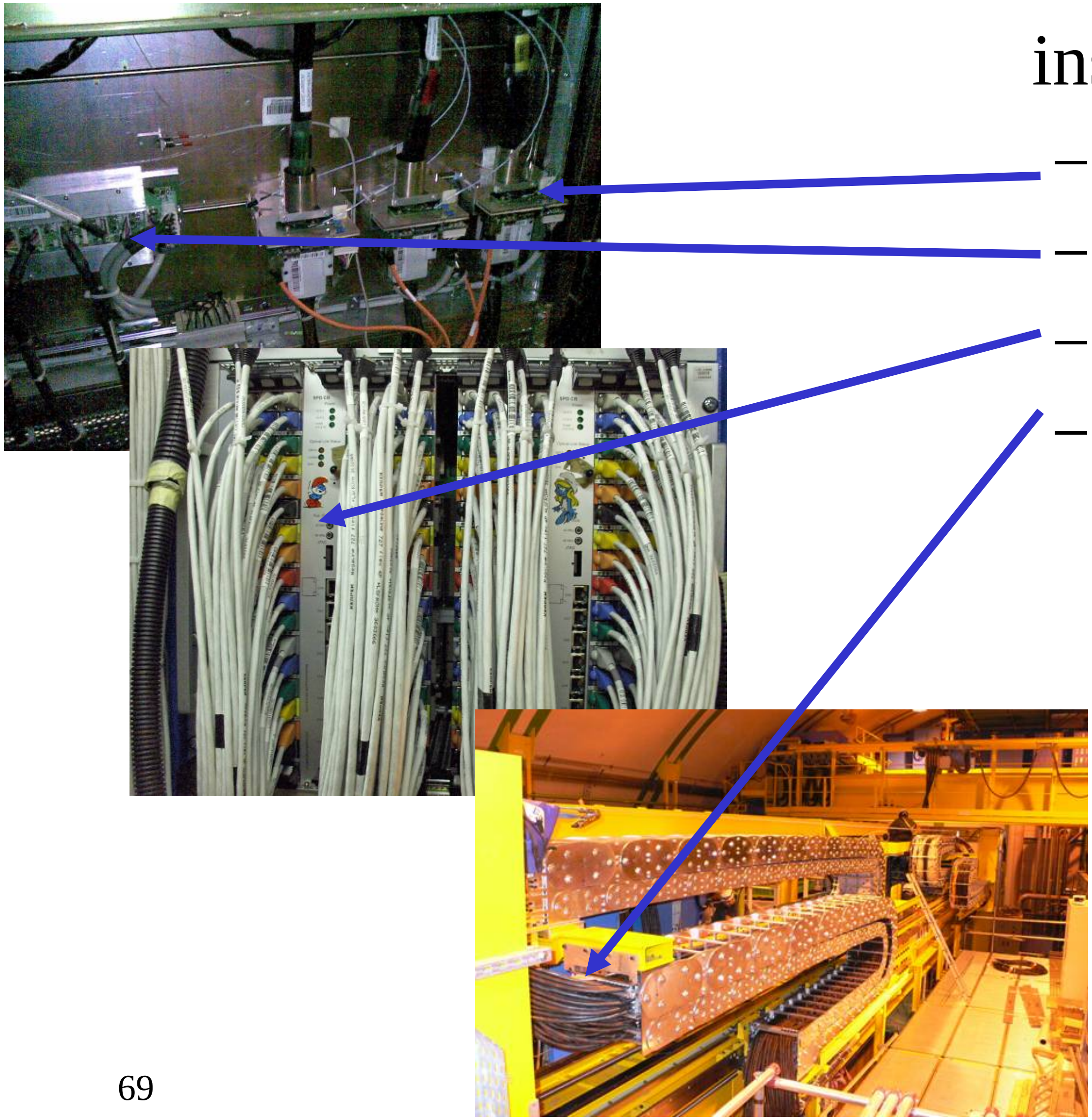
- Surface scan measurements:
  - Micro-cell structure
    - Fill factor
    - Sensitivity
  - Crosstalk
- Motorized XYZ stage: 100 mm travel, 100 nm resolution, 2 µm accuracy (just received)
- Laser + focus: 10 to 5 µm spot
- Install, align, software …



Cosmic Ray seen in the CALO system



At present : commissionig phase



- Electronics is fully installed and tested
  - VFE boards
  - LV Regulator Boards
  - SPD control board
  - Cables