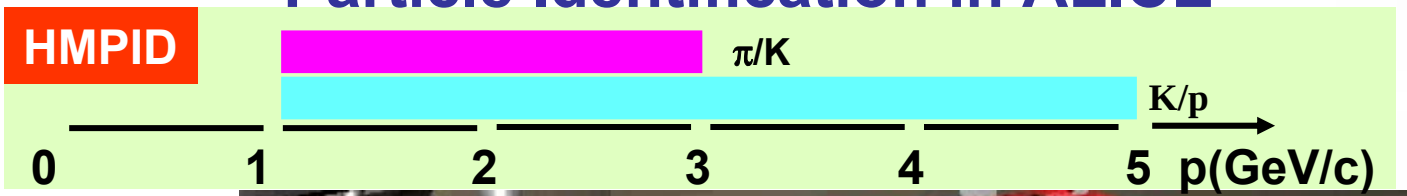
Trigger capabilities of the ALICE TOF for ultra-peripheral collisions

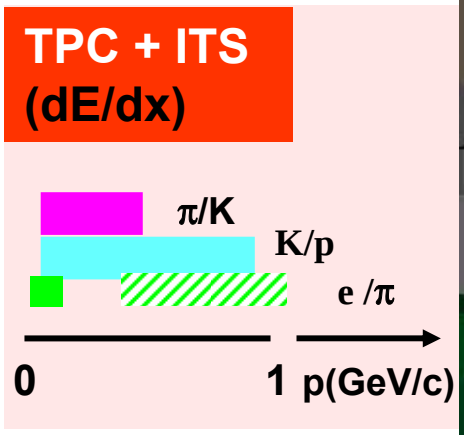
E. Scapparone (INFN – Bologna)
on behalf of the TOF(*) Group,
Jan 18, 2007

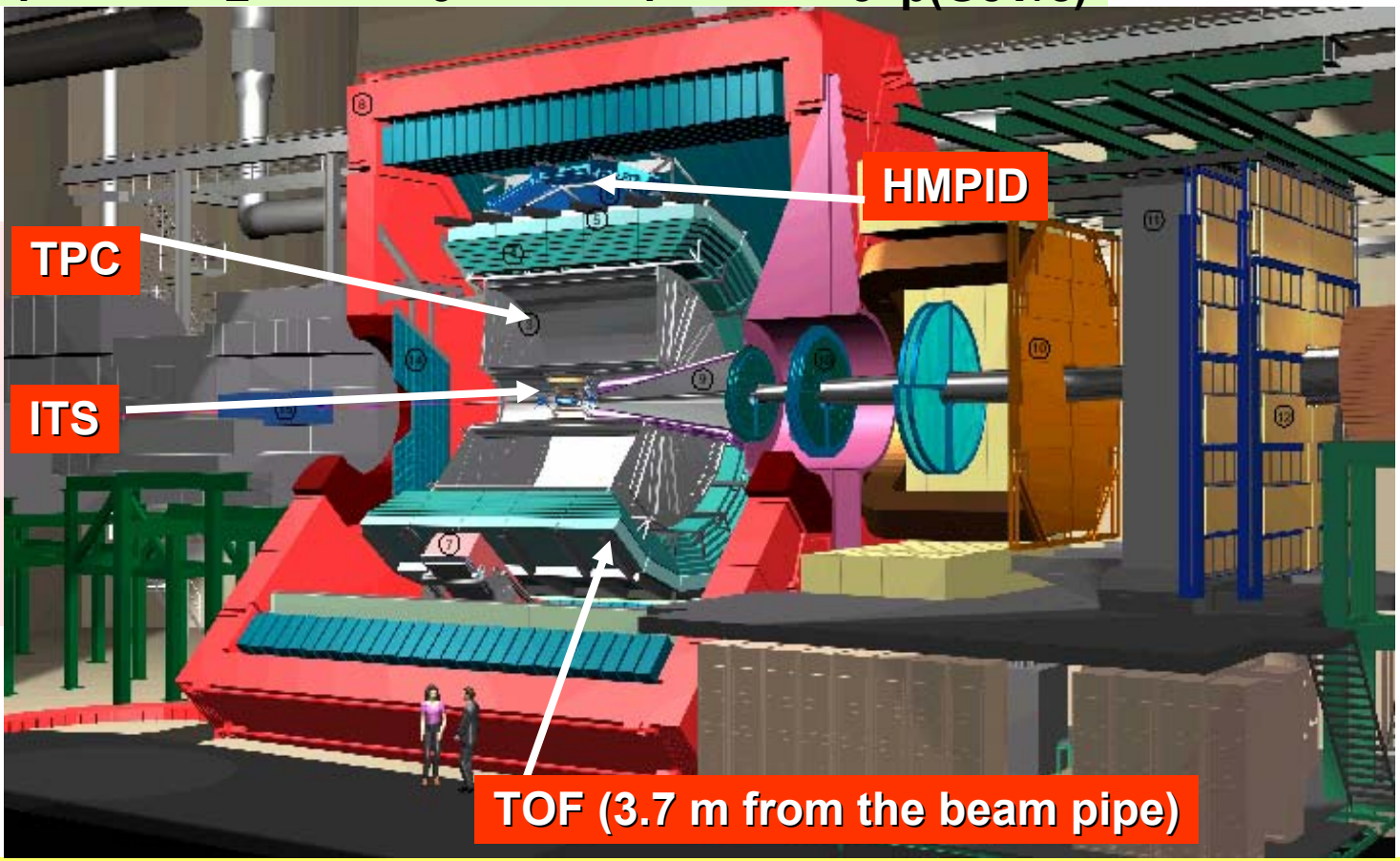
- The role of the TOF in ALICE;
- TOF for L0 trigger;
- The TOF trigger layout;
- Trigger construction;
- Triggering on UPC;
- Conclusions

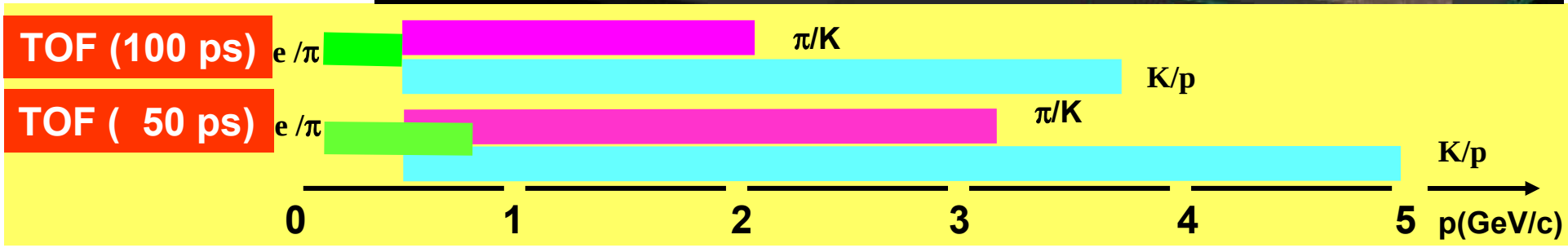
(*) INFN and University, Bologna (Italy) – INFN and University, Salerno (Italy) –
ITEP Moskow (Russia) - Kangnung University (South Korea)

Particle Identification in ALICE









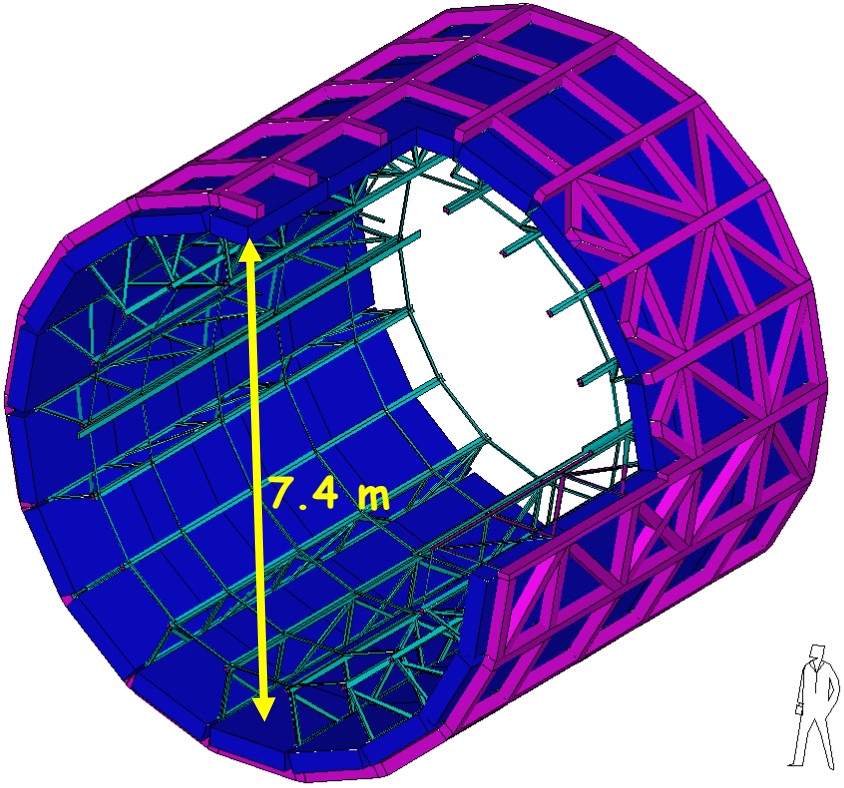
TOF requirements:

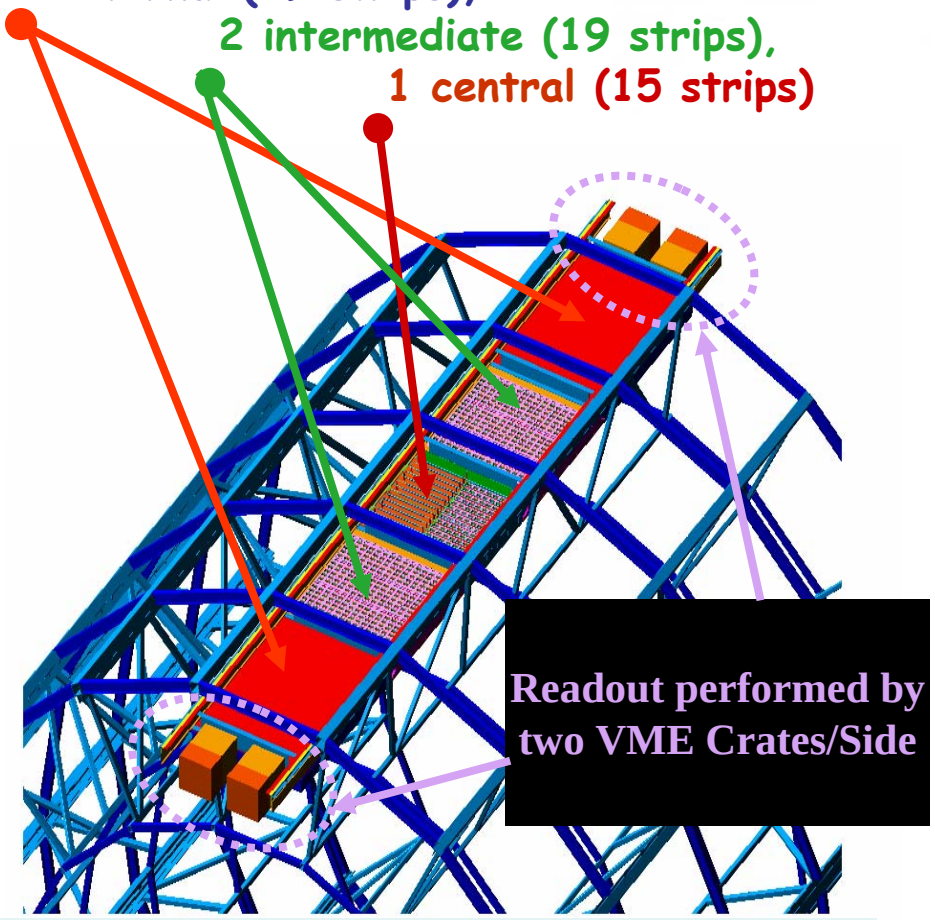
- Large array to cover the ALICE barrel (**~150 m²**)
- Time resolution **σ < 100 ps**
- High efficiency, **ε > 95%**
- High segmentation: few thousands of particles per unit of rapidity expected in Pb-Pb collision at $\sqrt{s}$ = 5.5 TeV/nucleon pair

ALICE choice: a detector based on MRPC, segmented in ~157,000 channels, (3.5 x 2.5) cm2 area

A TOF SuperModule in the Space Frame

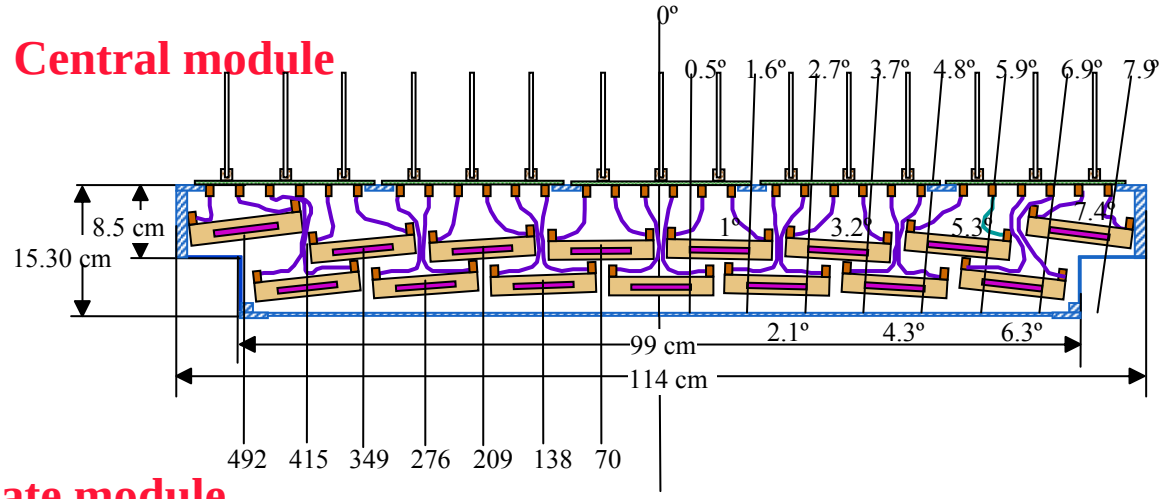
18 Supermodules, each made of 5 modules: 2 external (19 strips), 2 intermediate (19 strips), 1 central (15 strips)



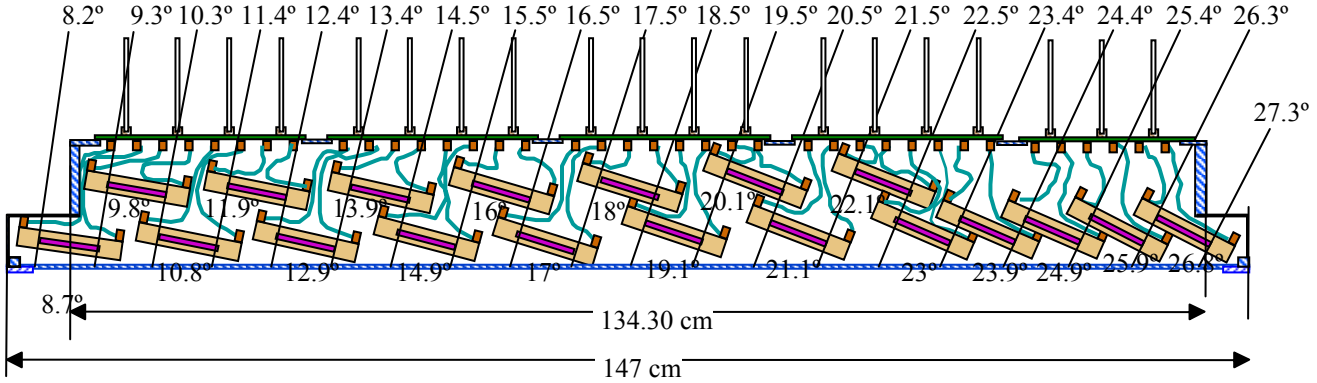


157248 pads, total sensitive area: ~150 m^2

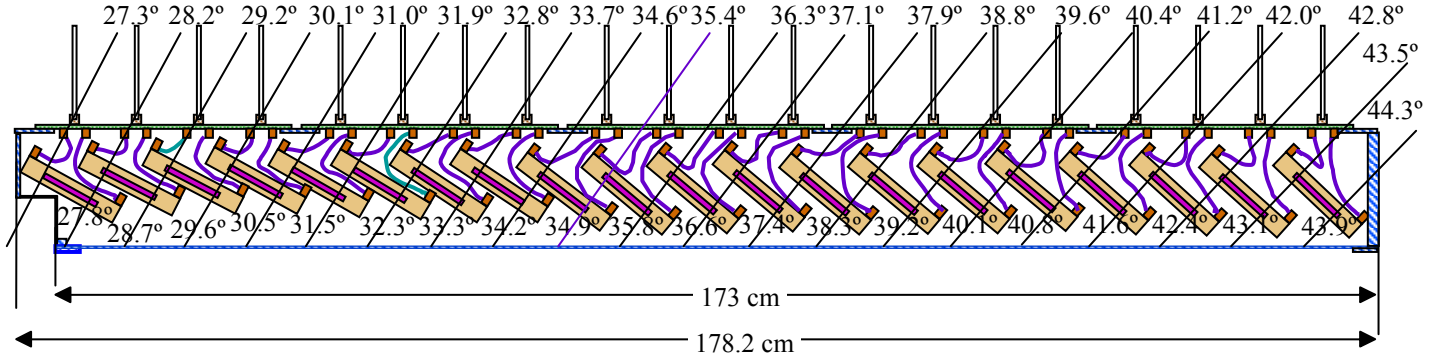
Central module



Intermediate module

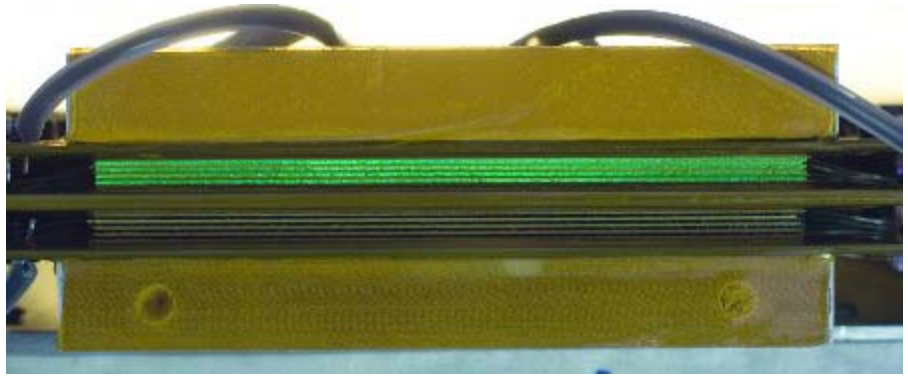


Outer module



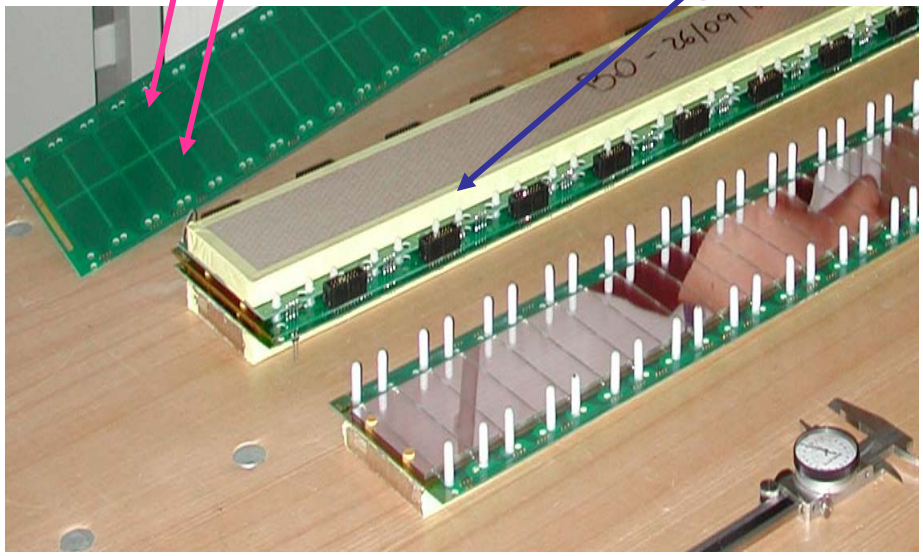
Cross section of a double-stack MRPC strip

10 gaps 250 μm

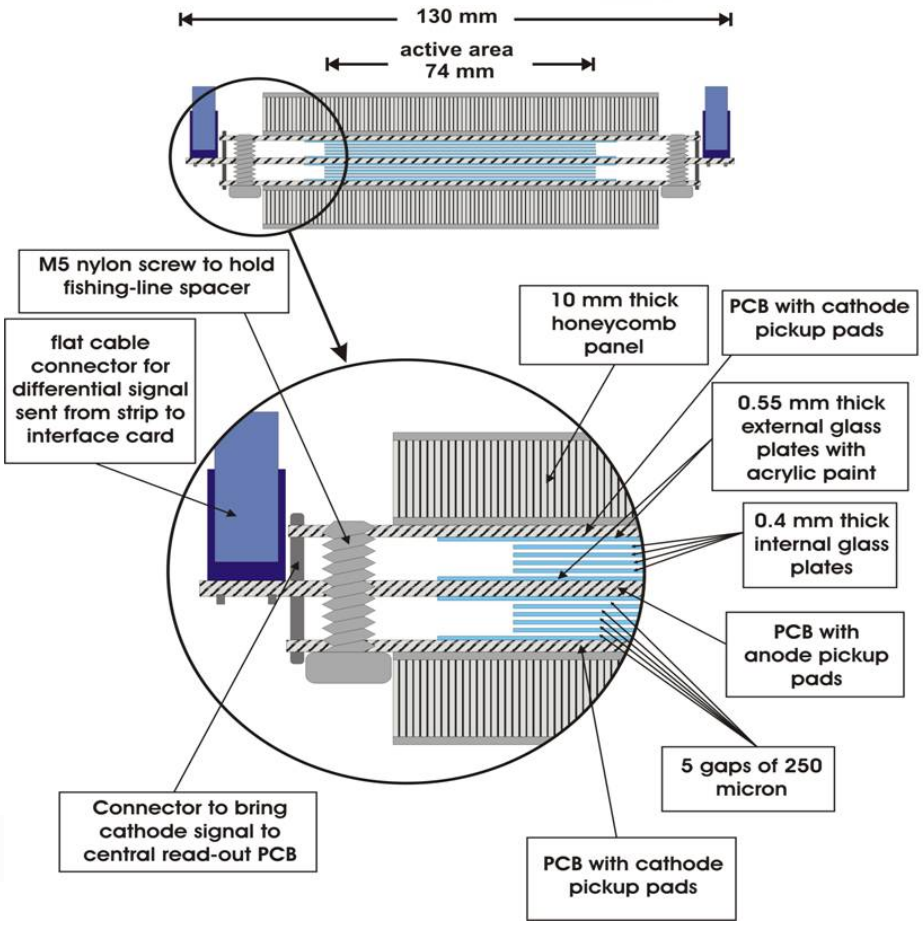


2 rows of 48 readout pads
(3.5 x 2.5 cm²)

Active strip length = 120 cm

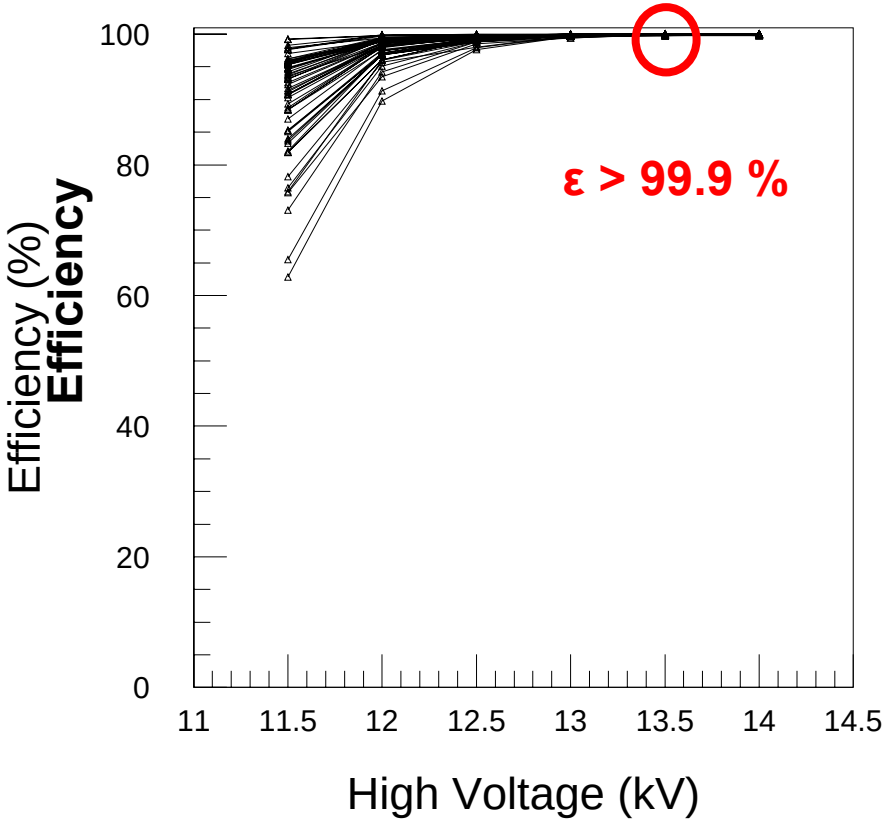


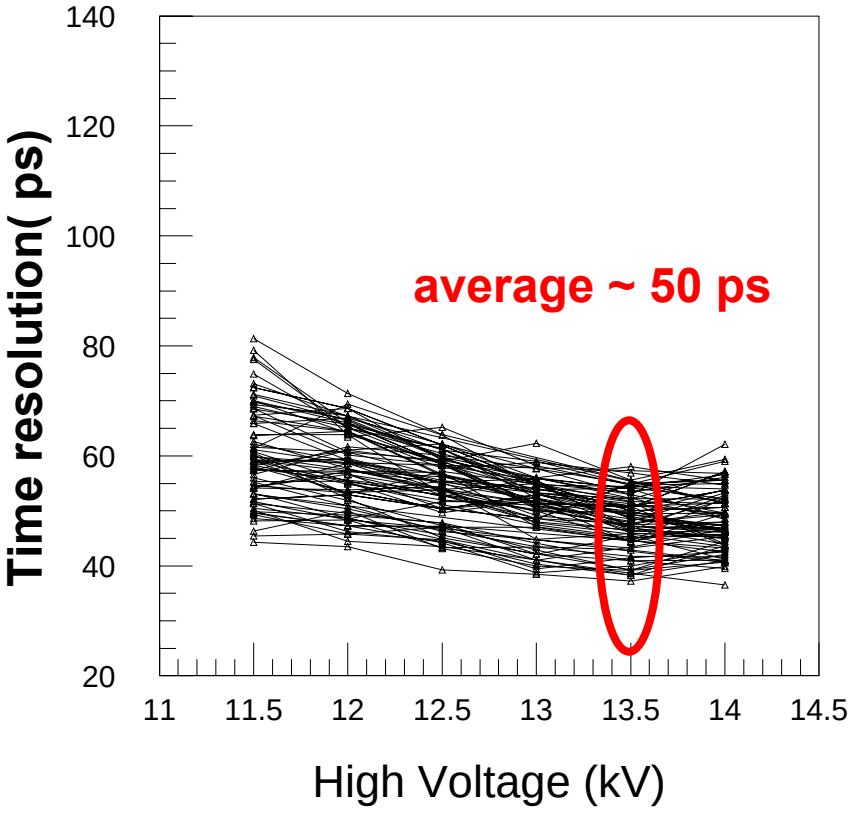
Differential signal to FEA card



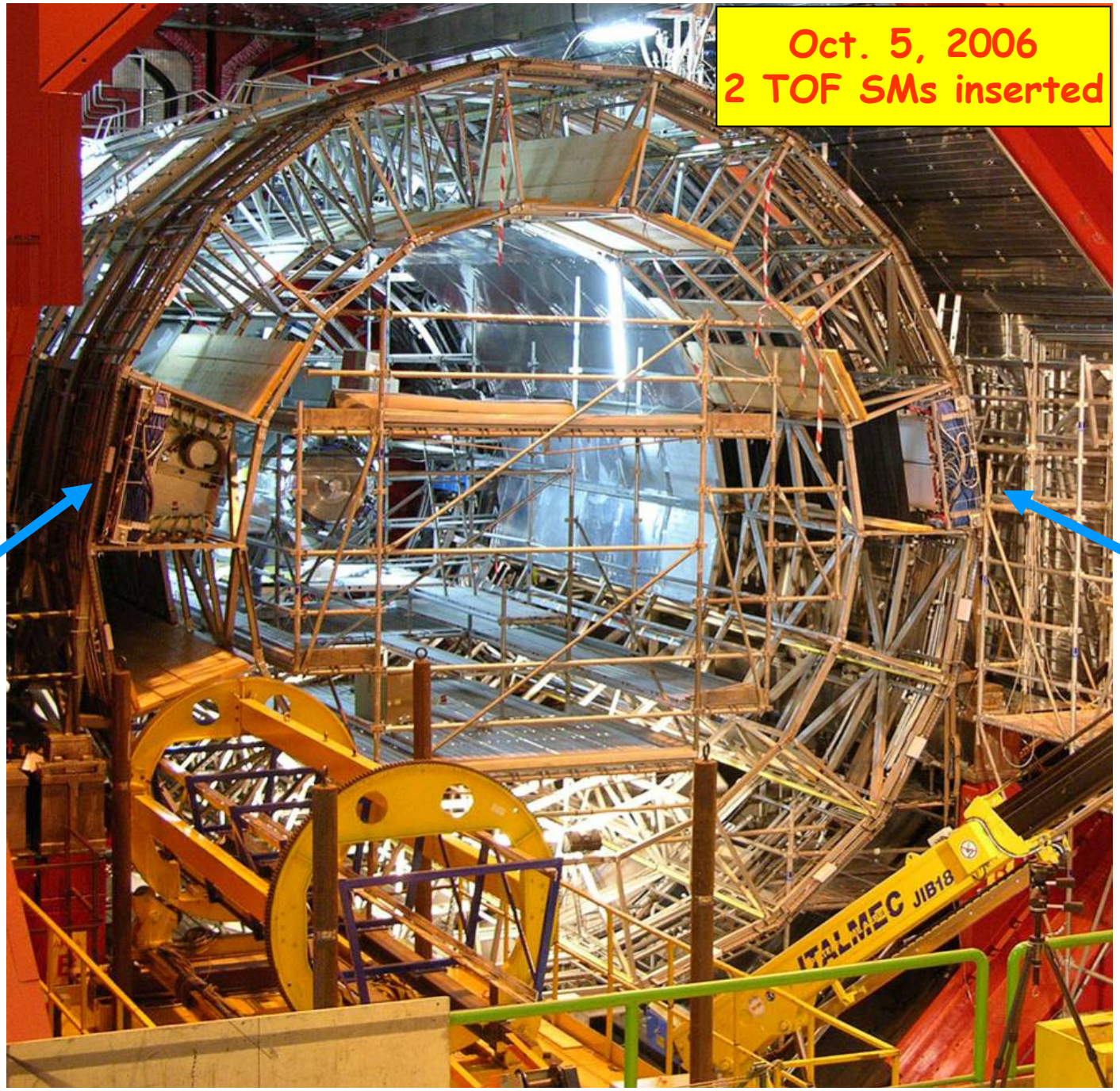
Test beam of single strips

Gas mixture: $C_2F_4H_2$(90%) – SF_6 (5%) – C_4H_{10}(5%)





Excellent time resolution detector → well suited for PID
high efficiency, high segmentation, Very fast → can be used for LO triggering


Oct. 5, 2006
2 TOF SMs inserted

TOF TRIGGER steps…

- Generation of LVDS signal on the FEA cards ;

- Signal handling by 72 Local Trigger Module (LTM) boards;

- Data Transmission using 72 , 60 m long cables (25 pairs);

- Final trigger decision taken by the Cosmic and Topology Trigger Module (CTTM)

- Data sent to the ALICE Central Trigger Processor (CTP)

…and goals

- Cosmics (commissioning , μ physics);

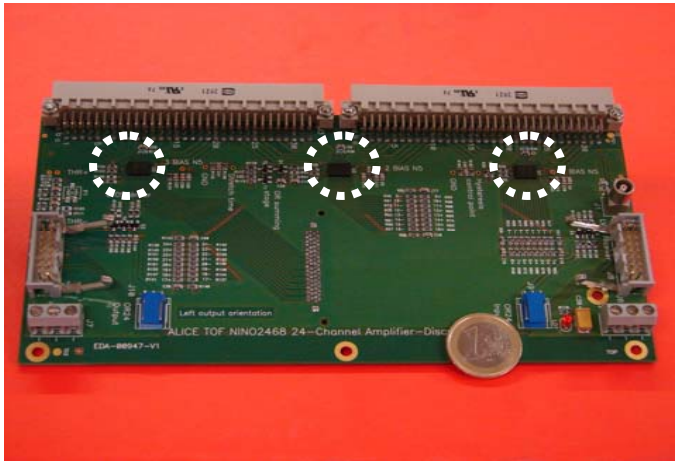
- Minimum bias study;

- UPC selection;

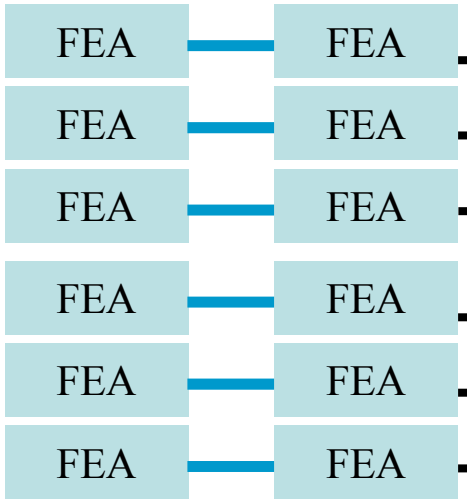
- High multiplicity events;

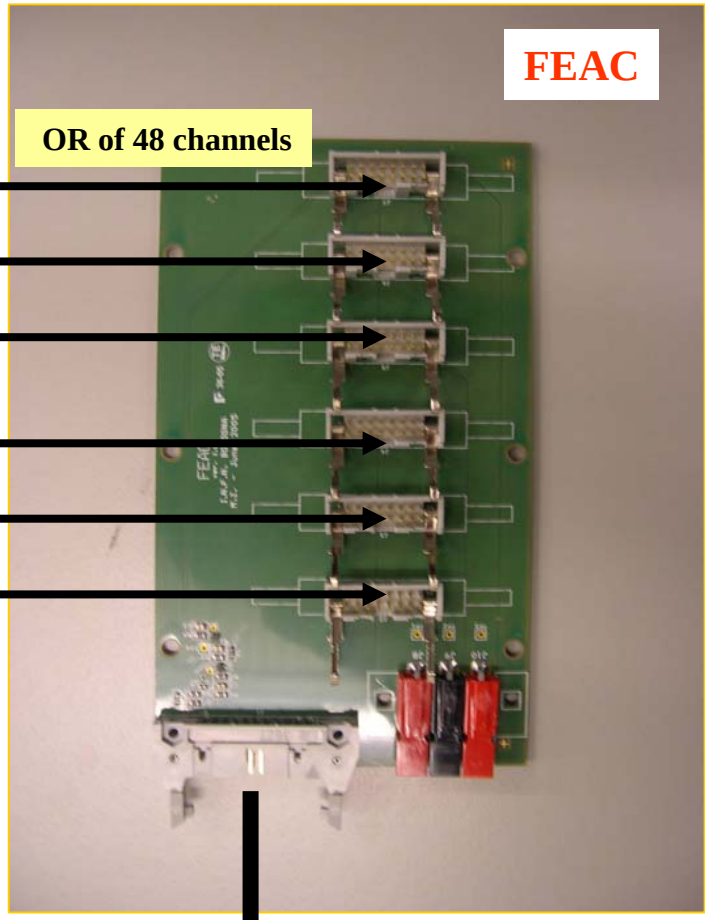
- Jet search in p-p collisions (L1);

Signal generation



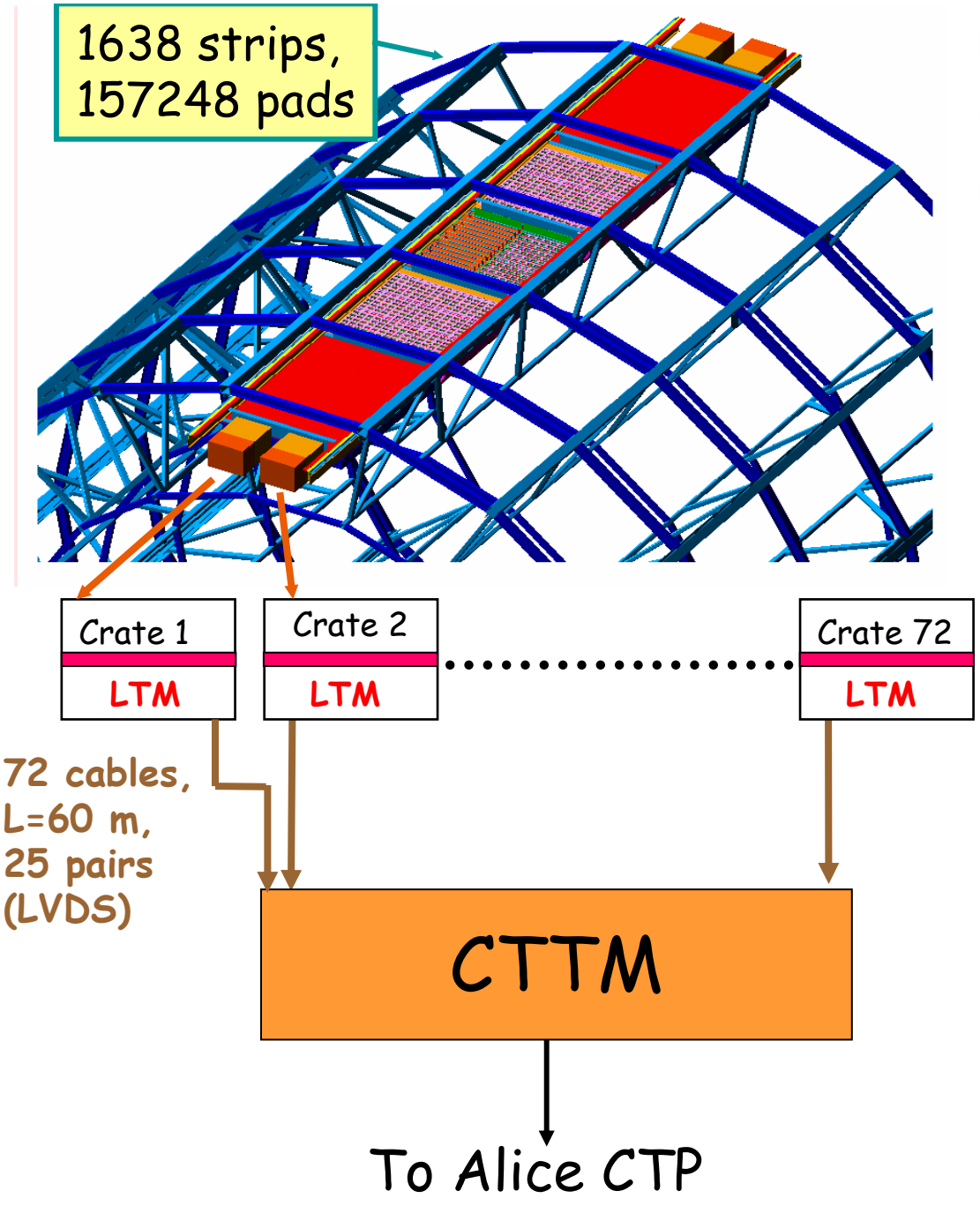
Daisy chain



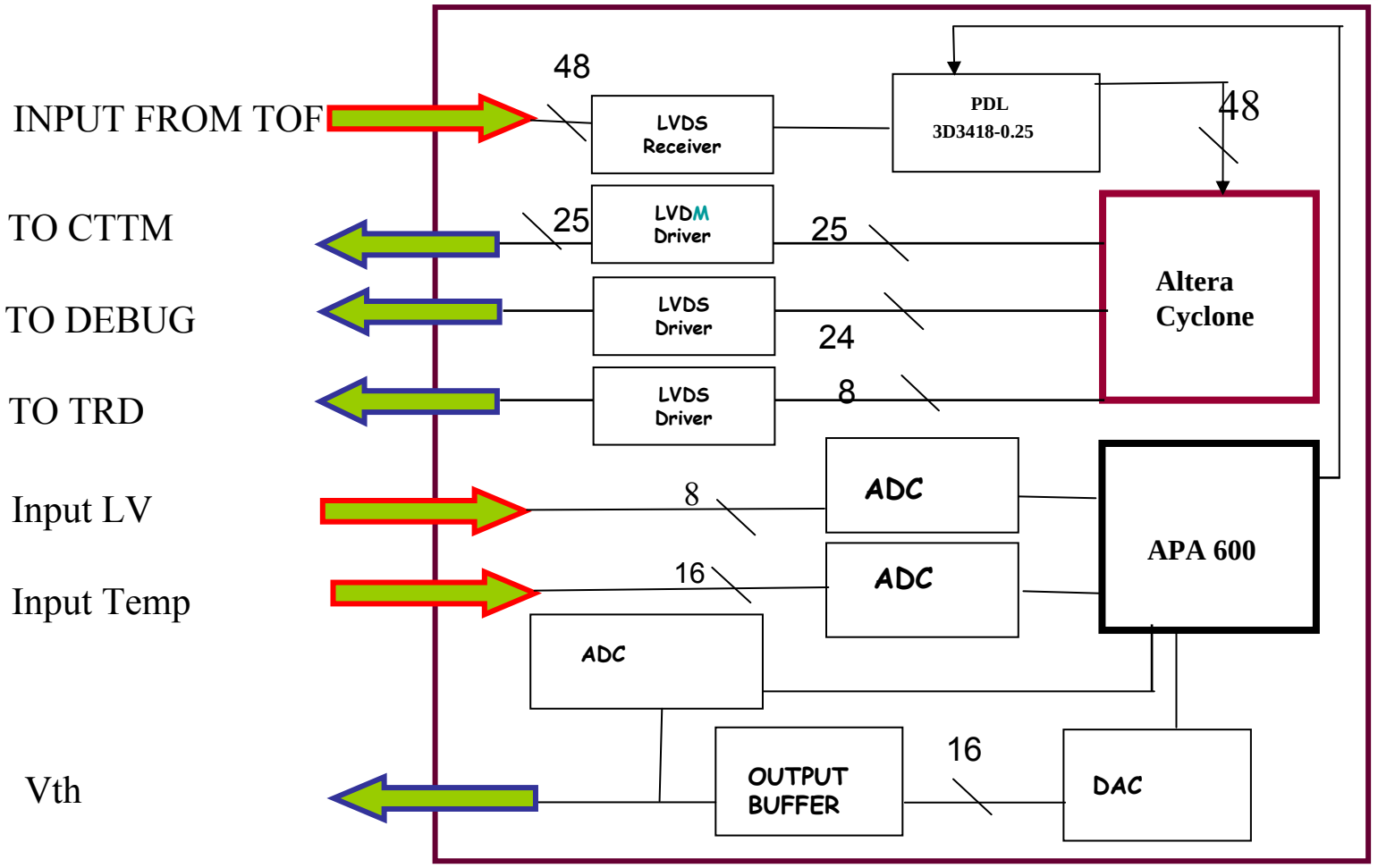


Each FEA is in daisy chain with another FEA.
Each ASIC produces a OR signal (1 FEA = 3 ASICs).
48 channels (24 +24) are OR-ed and sent to the LTM.
→ 1 OR ~ 500 cm2.
Each LTM receives 48 ORs (8 FEACs)

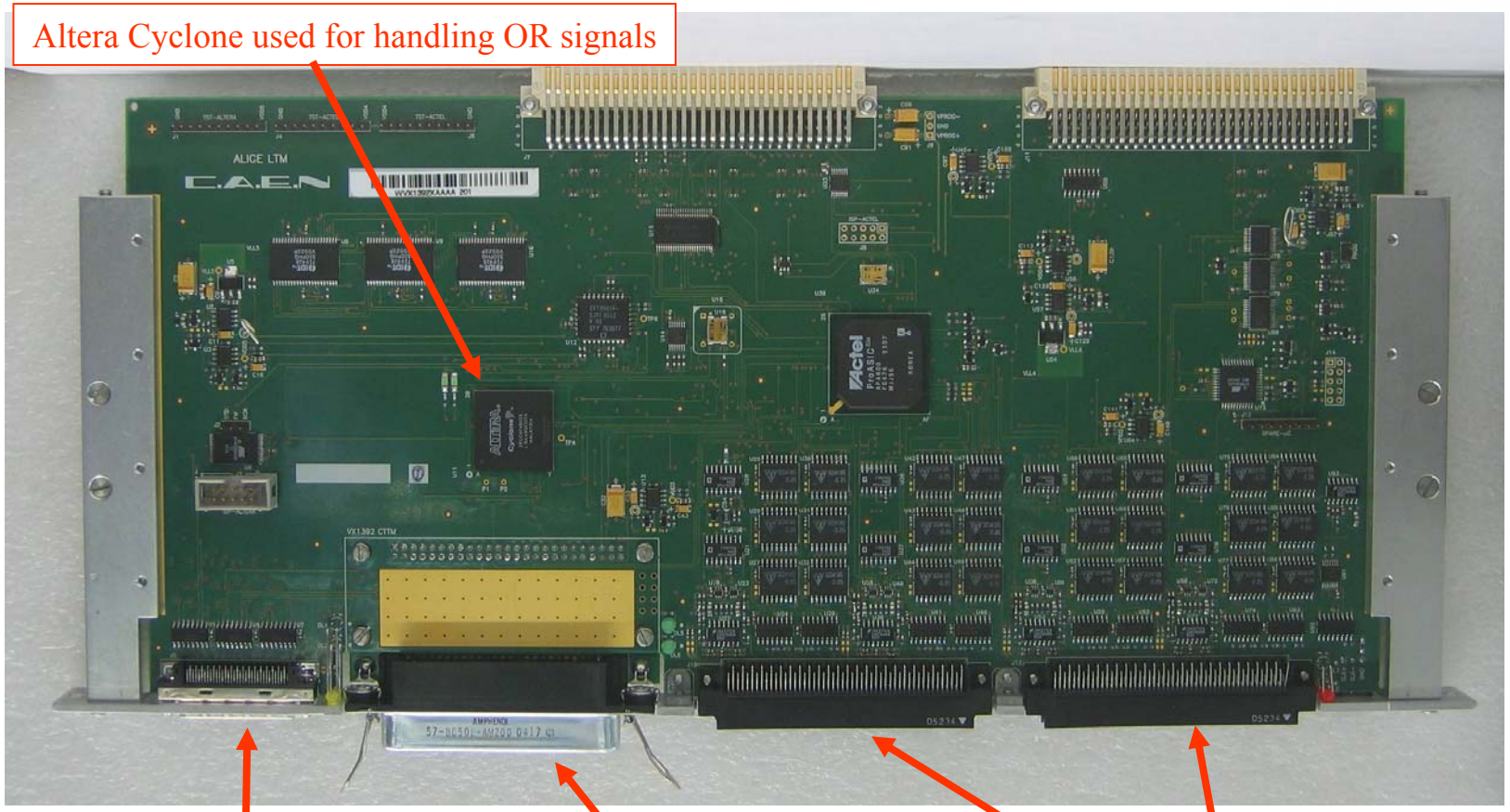
TO LTM


1638 strips,
157248 pads
Crate 1
LTM
Crate 2
LTM
Crate 72
LTM
72 cables,
L=60 m,
25 pairs
(LVDS)
CTTM
To Alice CTP

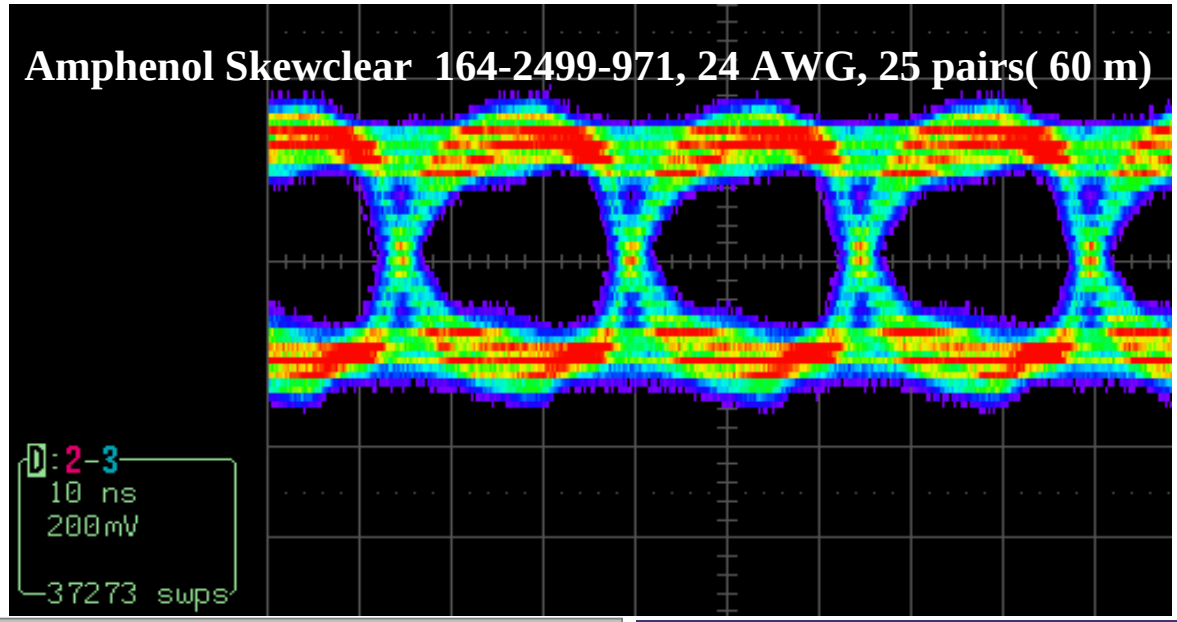
LTM board

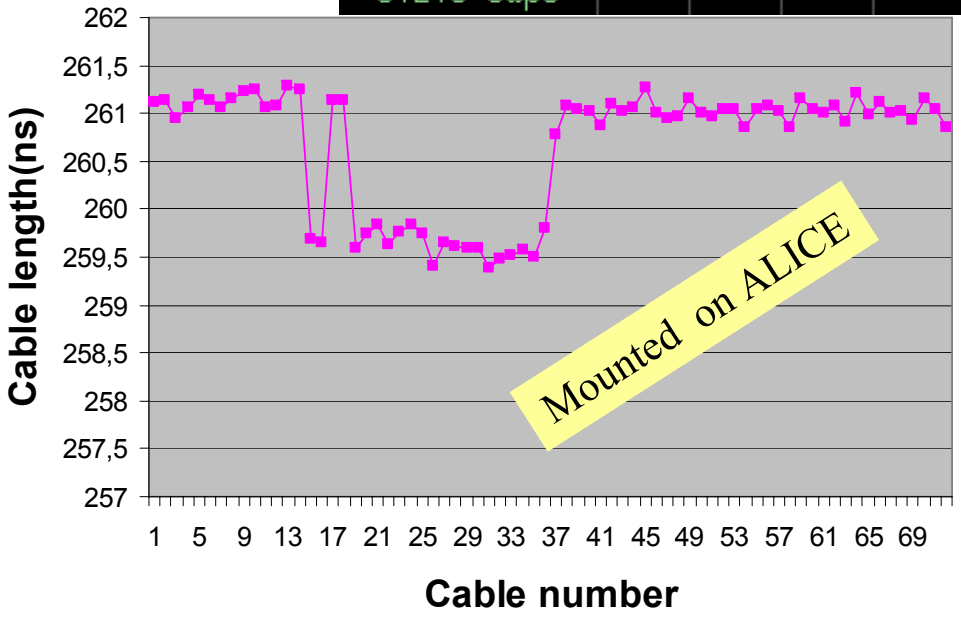

INPUT FROM TOF
TO CTTM
TO DEBUG
TO TRD
Input LV
Input Temp
Vth
48
LVDS Receiver
PDL 3D3418-0.25
48
25
LVDM Driver
25
LVDS Driver
24
LVDS Driver
8
Altera Cyclone
8
ADC
16
ADC
ADC
APA 600
OUTPUT BUFFER
16
DAC

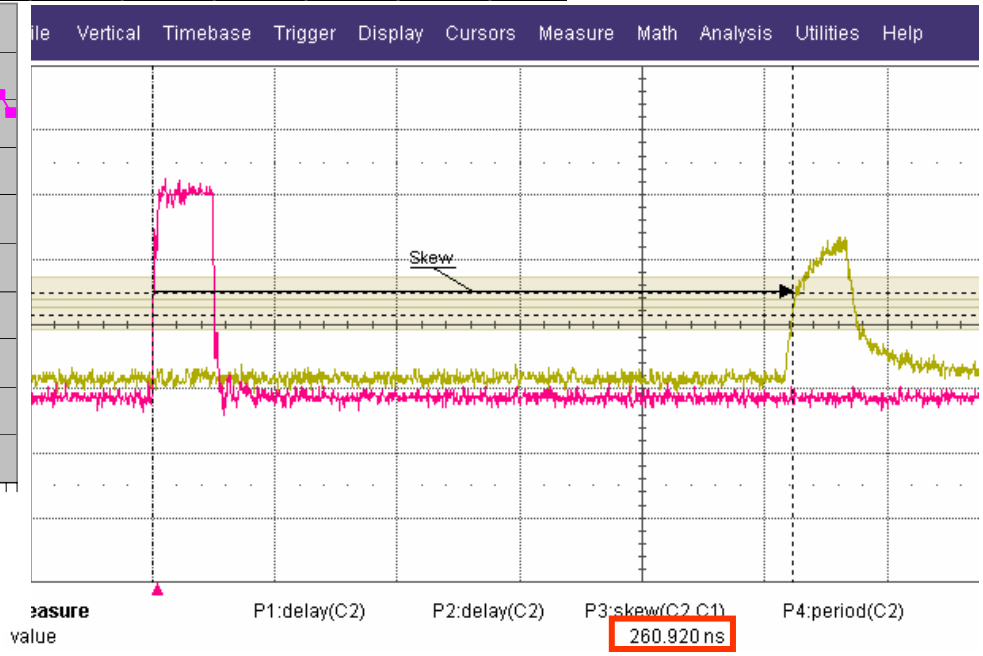
LTM (Local Trigger Module)

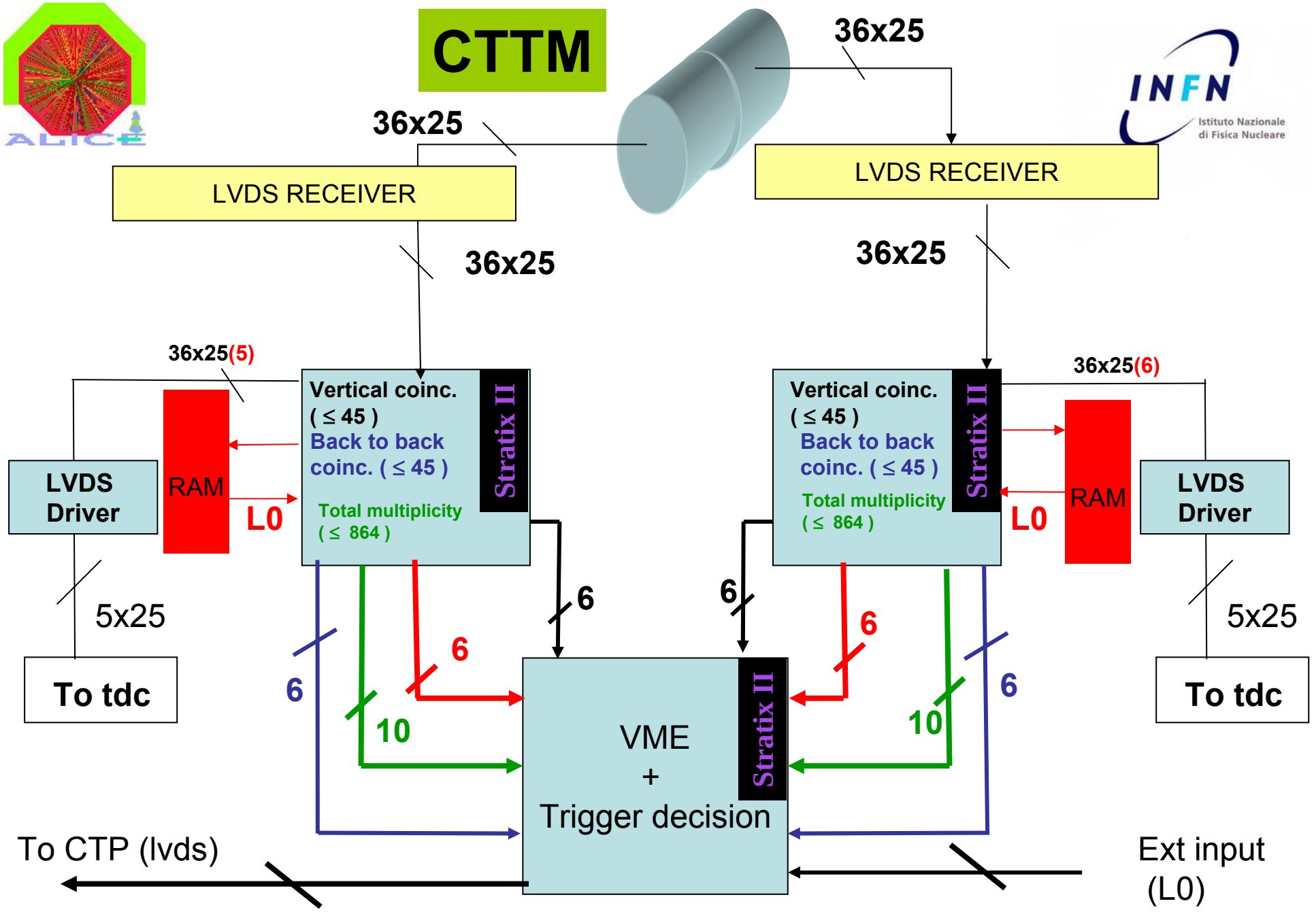


Data Transmission through 72 cables (25 LVDS pairs), 60 m long.

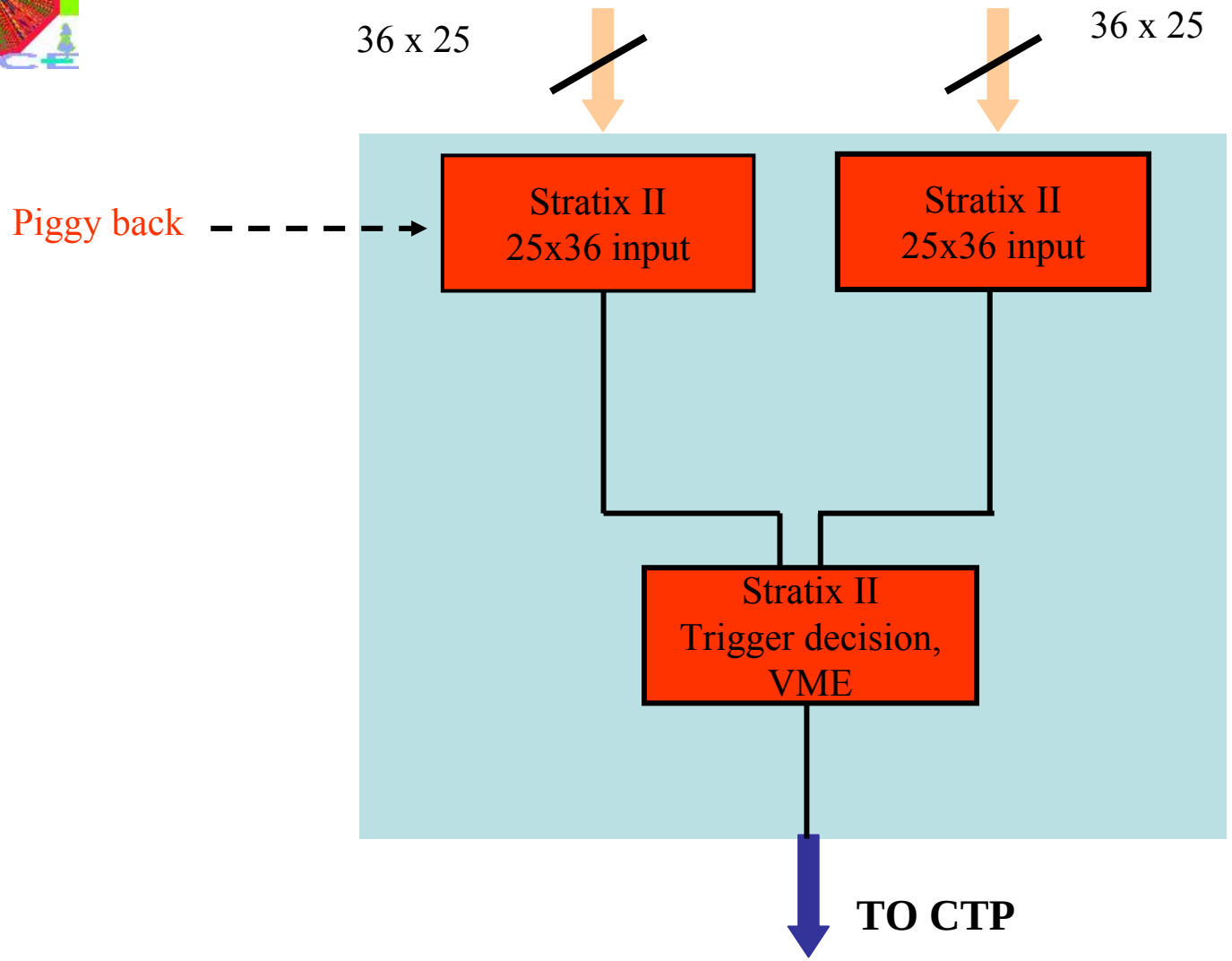




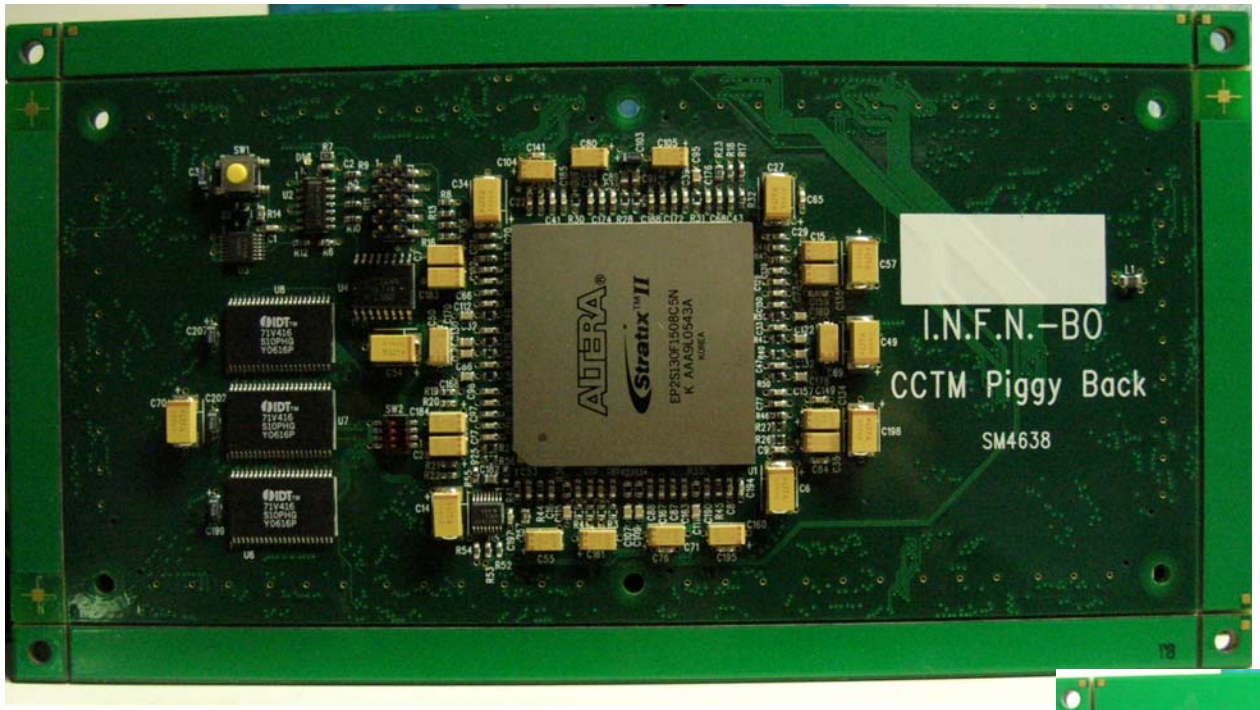



CTTM
36x25
36x25
LVDS RECEIVER
LVDS RECEIVER
36x25
36x25
36x25(5)
36x25(6)
Vertical coinc.
(≤ 45)
Back to back
coinc. (≤ 45)
Total multiplicity
(≤ 864)
Stratix II
Vertical coinc.
(≤ 45)
Back to back
coinc. (≤ 45)
Total multiplicity
(≤ 864)
Stratix II
LVDS
Driver
RAM
L0
L0
RAM
LVDS
Driver
5x25
5x25
To tdc
To tdc
6
6
6
6
6
6
10
10
VME
+
Trigger decision
Stratix II
To CTP (lvds)
Ext input
(L0)

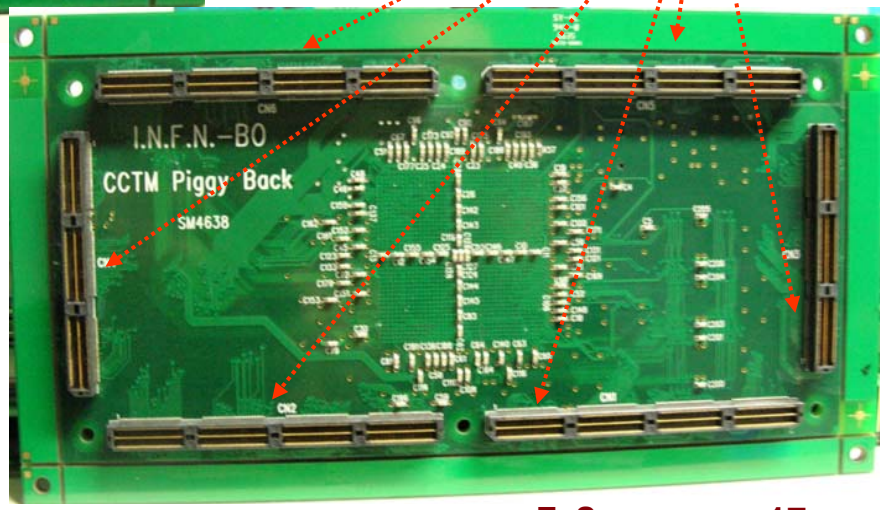
The CTTM is organized in a mother board + 3 piggy back boards



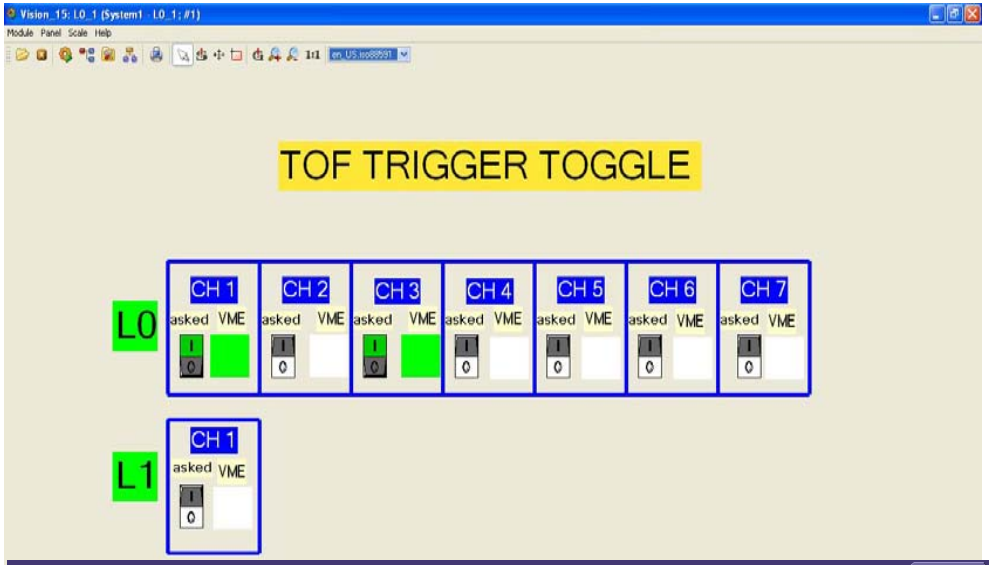
First PIGGY BACK produced , presently under test

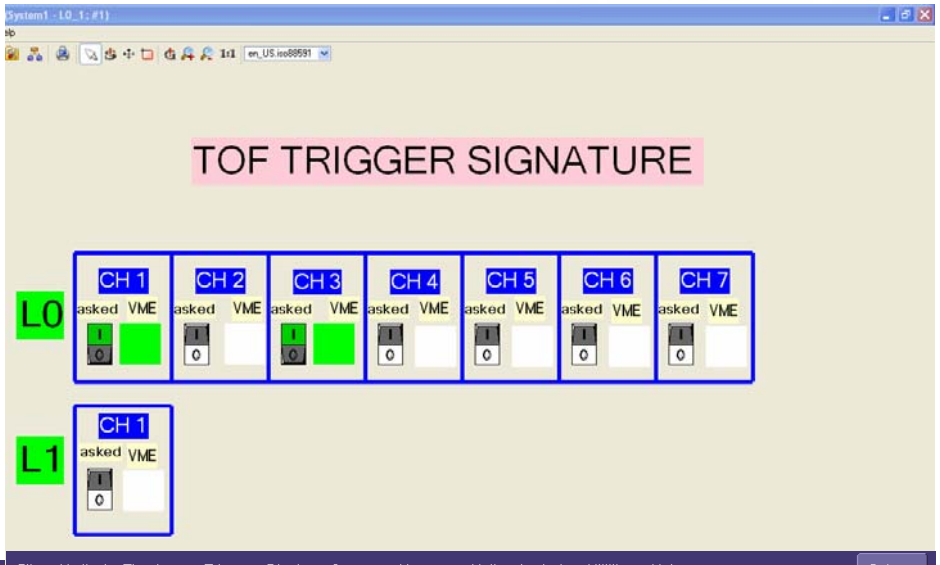


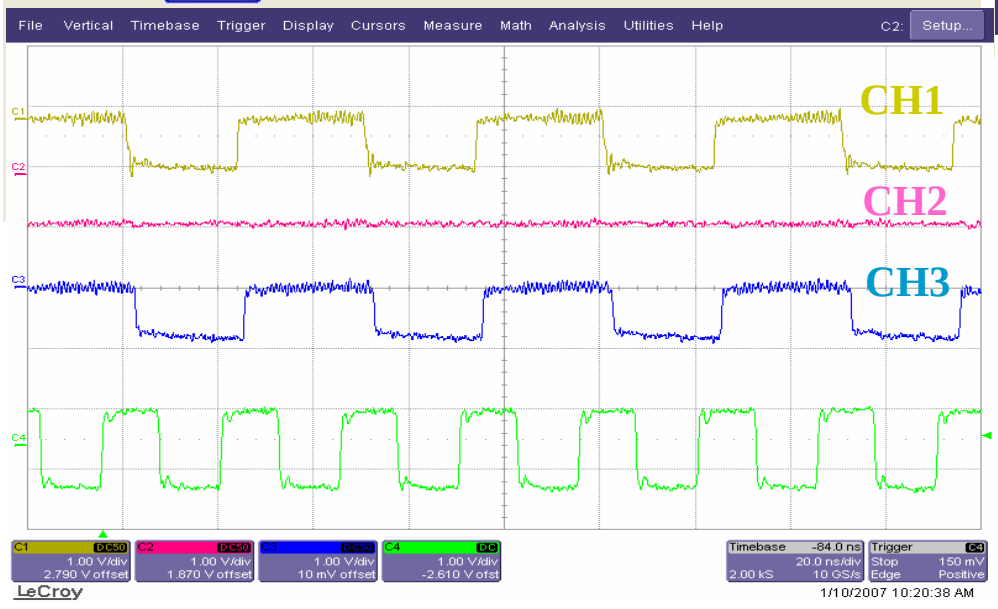
1121 I/O pins

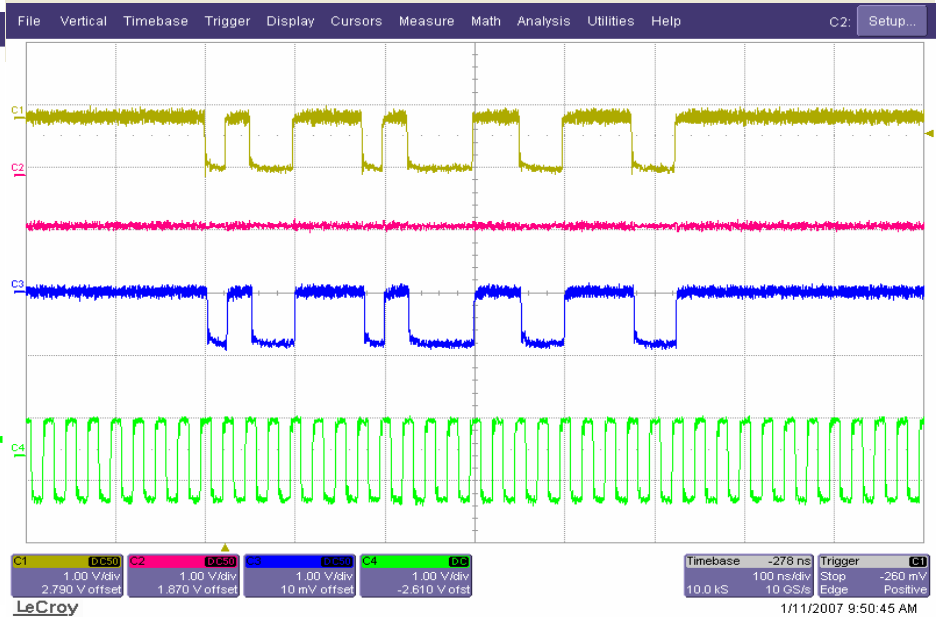


Remote Trigger control through PVSS/DIM interface









Triggering on UPC at L0

The L0 trigger must reach the ALICE Central Trigger Processor (CTP) within 800 ns after the interaction takes place.

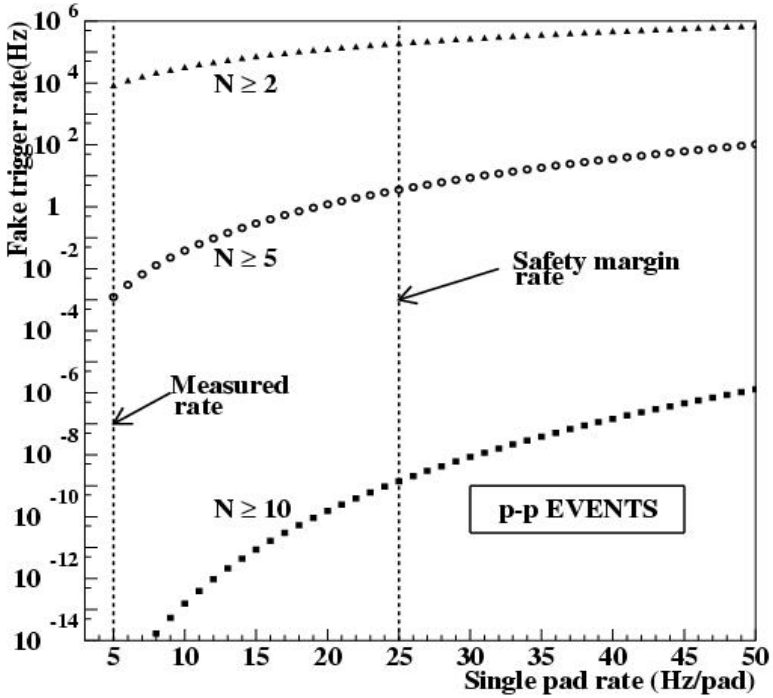
TOF is a natural candidate to trigger the UPC at L0:

- **Based on a very fast detector;**
- **Large area;**
- **$|\eta| < 1$;**
- **High segmentation;**

The most important parameter to face is the fake trigger rate (FTR), coming from combinatorial background: measurements at PS-T10 gives ~0.5 Hz/cm^2 . The situation could be worst in ALICE, due to neutron produced in beam-gas collision and neutron produced in Pb-Pb collisions: safety margin 2.5 Hz/cm^2

UPC selection require triggering on events with very low multiplicity

Selecting events with $N_{cell} \geq 5$, gives FTR ~ 1 Hz
$N_{cell} \geq 2$, gives FTR ~ 200 kHz

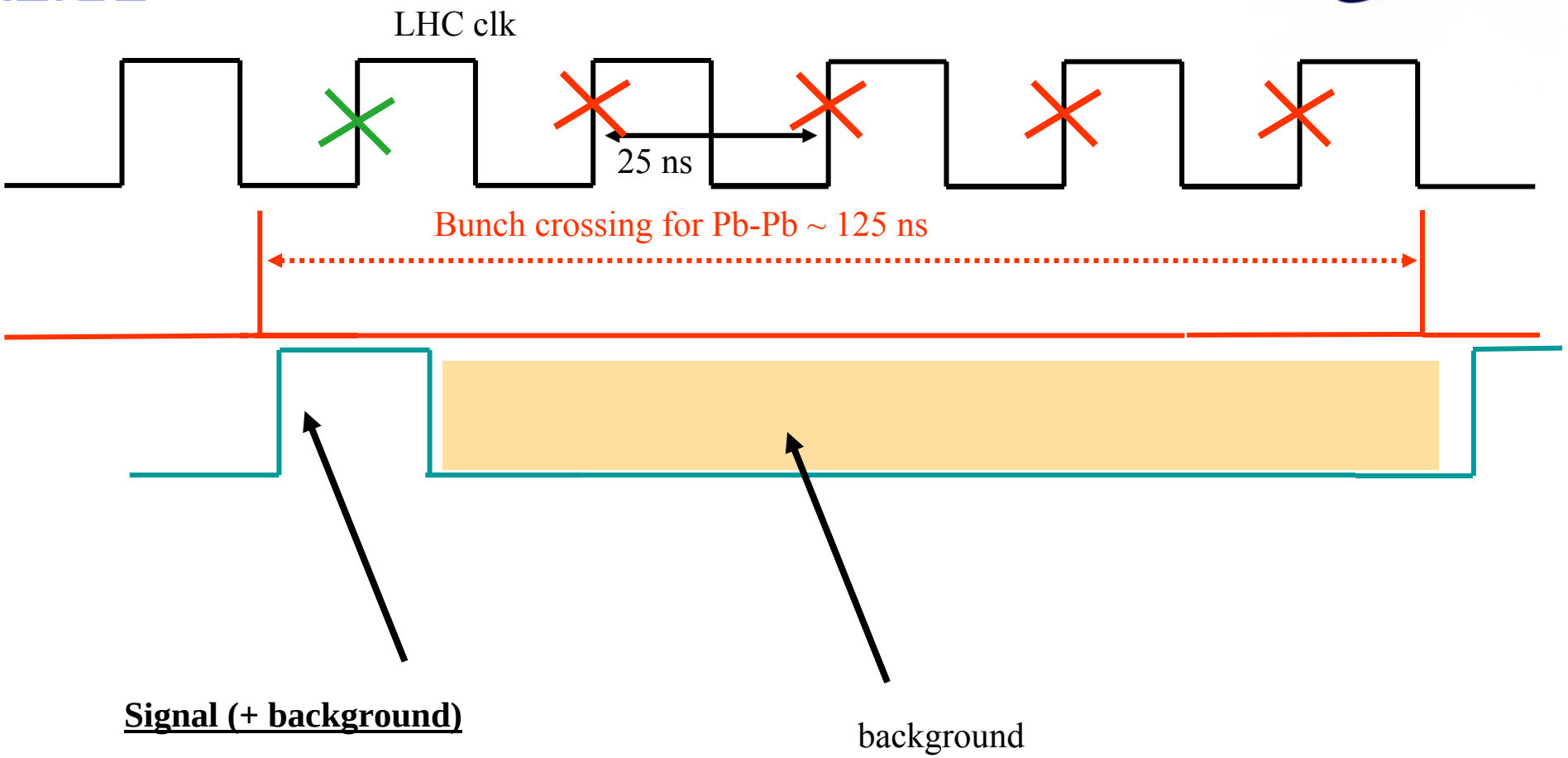


1 pad ~ 10 cm^2

Not manageable at L0, but can be reduced by using vector meson topology:

We performed a simulation based on the "starlight" Monte Carlo code. Particles are then traced in a empty cylinder with B = 0.5 T (full Aliroot simulation in progress)

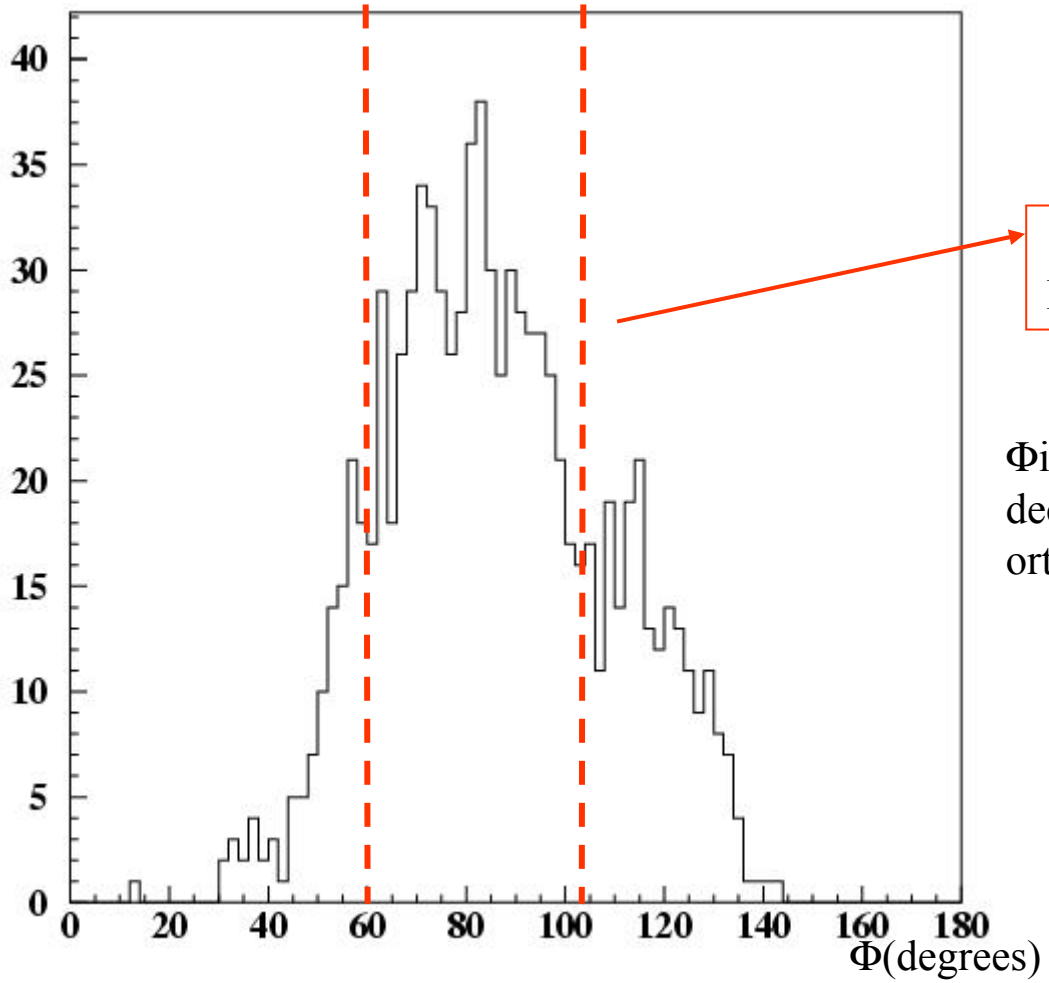
Background reduction



Factor 5 reduction → factor 25 for a pair

$\rho \rightarrow \pi\,\pi$

The efficiency for containing both the decay products is $\varepsilon^{cont} = 8.3\ \%$



$\varepsilon^{\rho} = 60\ \%$
Back. reduction = 88.9 %

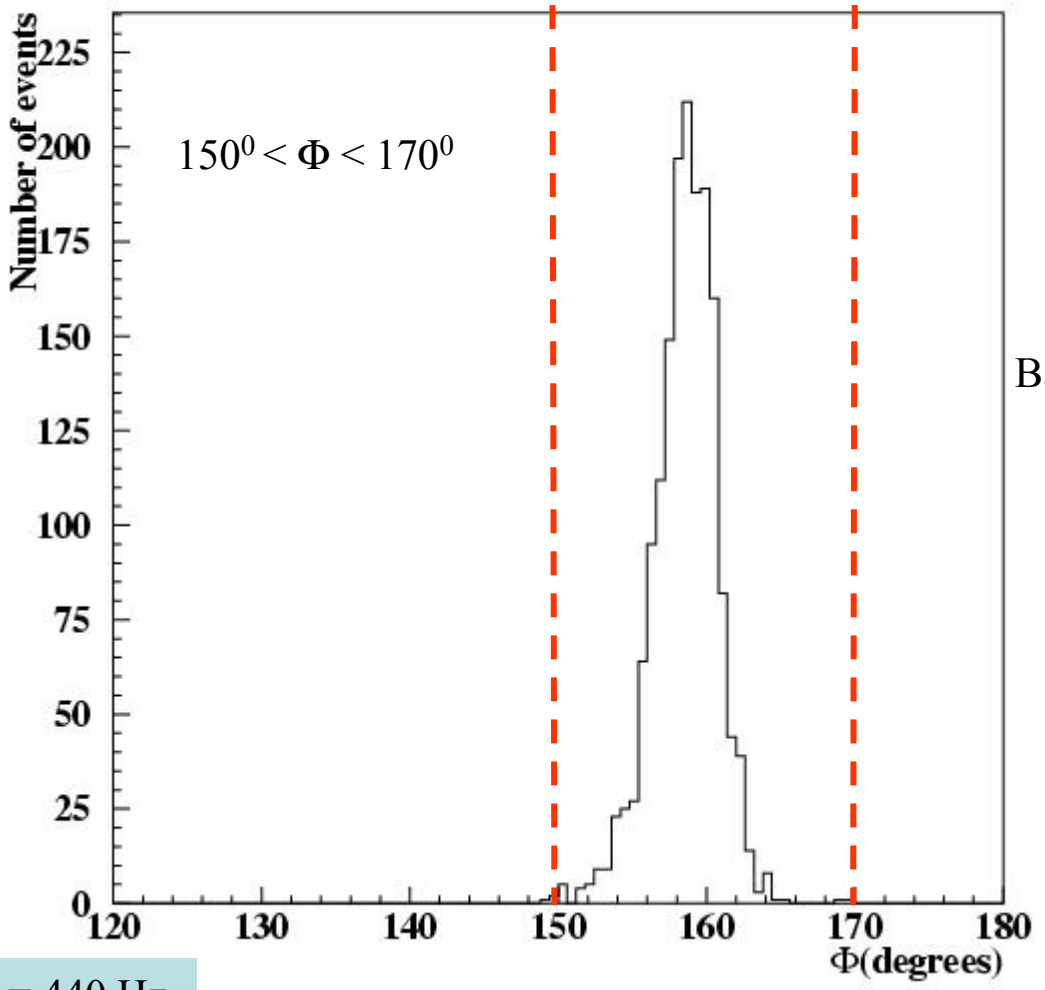
Φis the angle between the decay product in the plane orthogonal to the beam axis

FTR < 200 kHz/9/25 = 880 Hz

Rate $^{\rho\rightarrow\pi\,\pi} = \mathscr{L} \cdot \sigma \cdot \varepsilon^{cont} \cdot \varepsilon^{\rho} = 5 \cdot 10^{26} \cdot 5200\ mb \cdot 0.083 \cdot 0.6 = 120\ Hz$

$J/\Psi \rightarrow \ell + \ell$

The efficiency for detecting both the decay product is $\varepsilon^{cont} = 16.7\ \%$



$\varepsilon^{J/\Psi} \sim 100\ \%$

Back red. = 94.4 %

FTR < 200 kHz/18/25 = 440 Hz

$$\text{Rate}^{J/\Psi \rightarrow ll} = \mathscr{L} \cdot \sigma \cdot \varepsilon^{cont} \cdot \varepsilon^{J/\Psi} = 5 \cdot 10^{26} \cdot 32\ \text{mb} \cdot 0.176 \cdot 0.12 = 0.32\ \text{Hz}$$

CONCLUSIONS

-TOF can be used to trigger at L0 in ALICE;

- Fully programmable trigger → configuration can be improved at any moment. Max. Flexibility ensured;

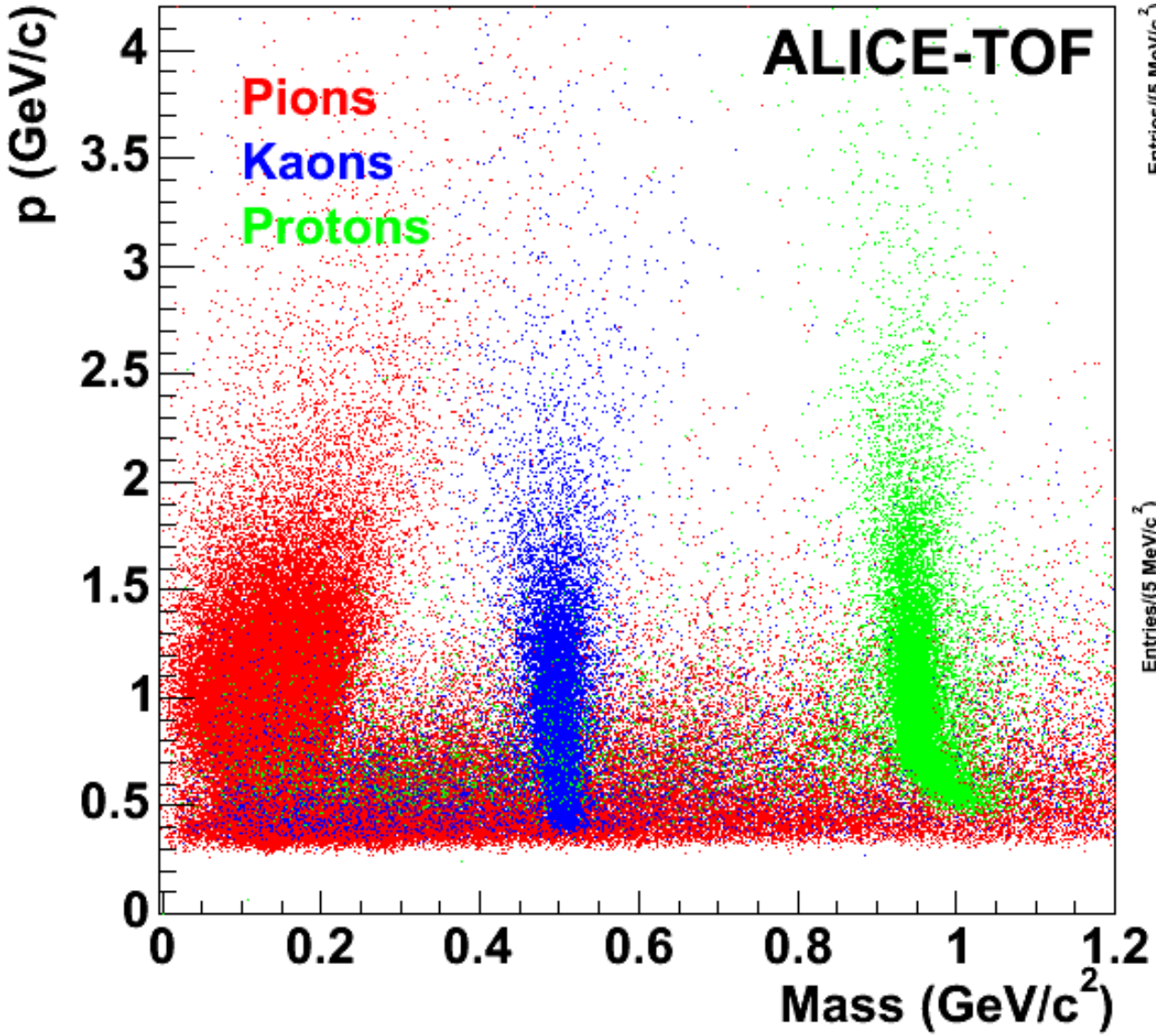
- Trigger construction and fw/sw development well advanced;

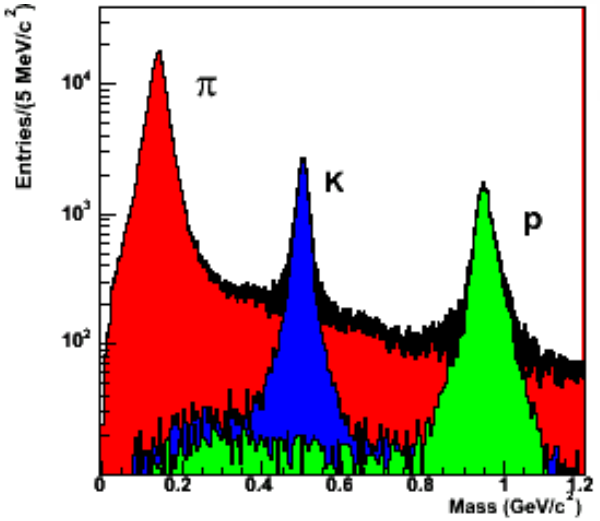
- Full study of the UPC triggering in progress.

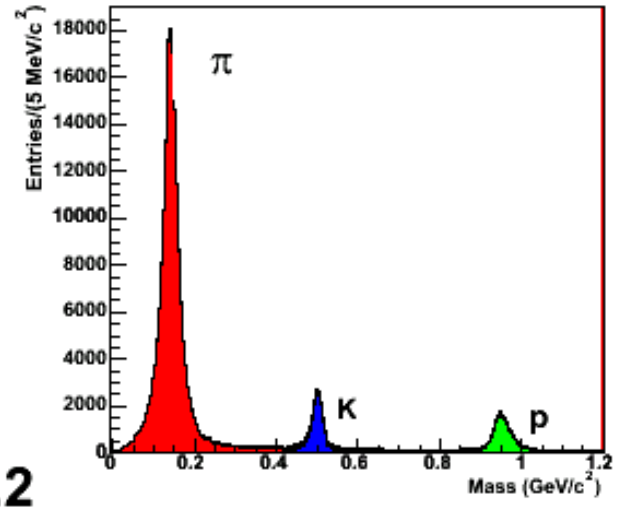
RISERVE

$M = p\,((t2\ c2\ /L2\ )-1)1/2$

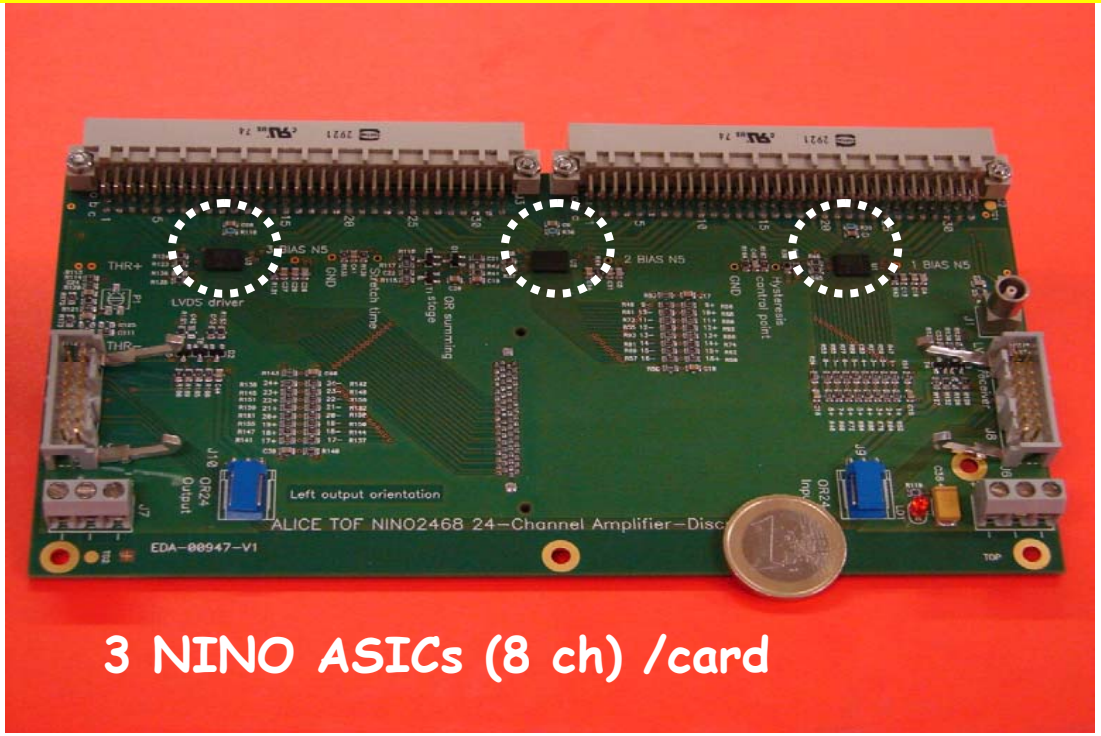
σ_{TOF} = 80 ps ; B = 0.5 T







TOF front end electronics: 6552 FEA cards



3 NINO ASICs (8 ch) /card

The benefit of the ASIC:

- Input stage (and following) fully differential;
- Adjustable input resistance (30 Ohm – 100 Ohm);
- Power: 40 mW/channels (to be compared with 400 mW/channels of the COTS amplifier);
- Nice matching with detector capacitance (30 pf);
- LVDS Output signal, compatible with HPTDC input