

**Experimental tests of the trigger prototype
for the AMADEUS experiment
based on SciFi read by SiPM**

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On behalf of the AMADEUS Collaboration

NDIP2011, Lyon - France

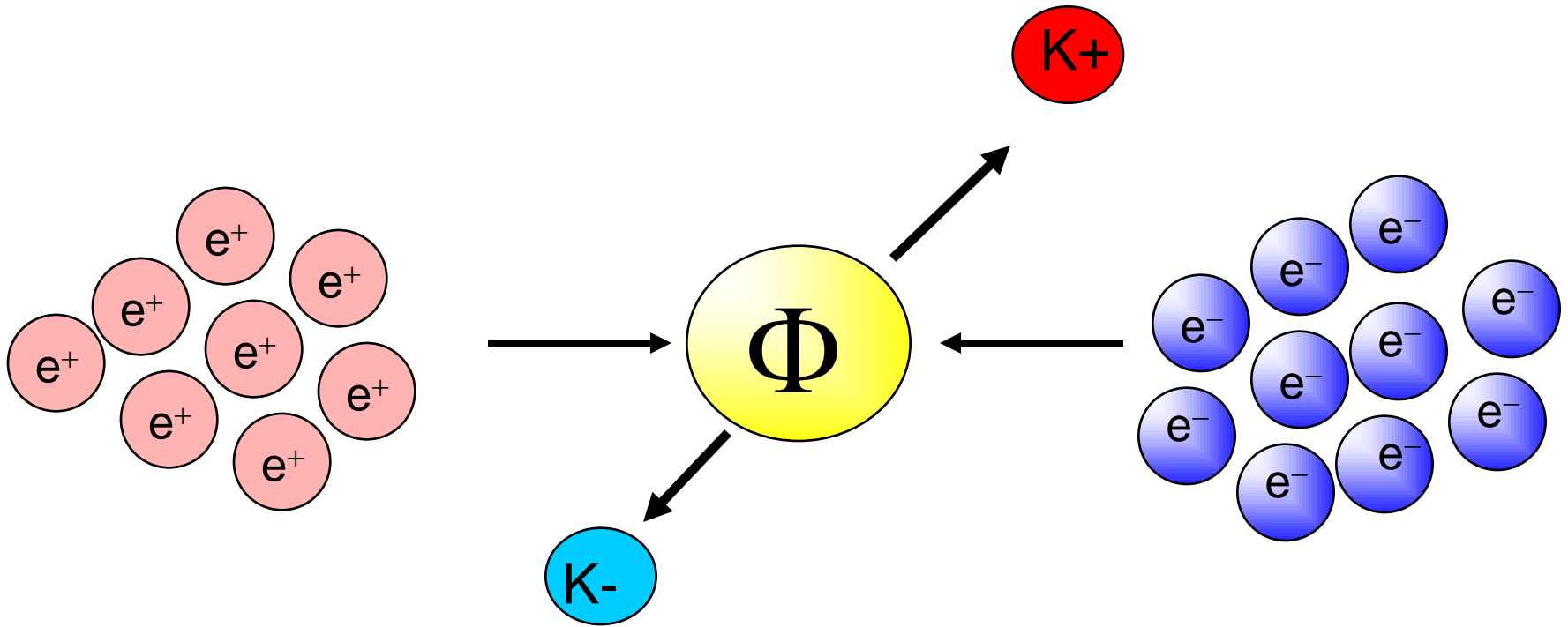
July 8, 2011

Contents

- The AMADEUS experiment at the DAΦNE collider
- The AMADEUS trigger
- SiPM characterization and lab tests
- First trigger prototype; tests at the DAΦNE beam
- Second prototype and tests at PSI beam
- Conclusions

The DAΦNE collider at LNF-INFN

The $DA\Phi NE$ working principle



Flux of produced kaons: about 1000/second

DAΦNE



DAFNE

$e^- e^+$ collider

- $\Phi \rightarrow K^- K^+$ (49.1%)
- Monochromatic low-energy K^- ($\sim 127\text{MeV}/c$)
- Less hadronic background due to the beam
(compare to hadron beam line : e.g. KEK /JPARC)

Suitable for low-energy kaon physics:
kaonic atoms
Kaon-nucleons/nuclei interaction
studies

AMADEUS

Antikaon Matter At DAΦNE: Experiments with Unraveling Spectroscopy

AMADEUS collaboration
116 scientists from 14 Countries and 34 Institutes

Inf.infn.it/esperimenti/siddharta

and

LNF-07/24(IR) Report on Inf.infn.it web-page (Library)

**AMADEUS started in 2005 and
was presented and discussed in all the LNF Scientific
Committees**

**EU Fundings FP7 – I3HP2:
Network WP9 – LEANNIS;
WP24 (SiPM JRA);
WP28 (GEM JRA)**



AMADEUS physics:

Antikaon Matter At DAΦNE: Experiments with Unraveling Spectroscopy

- Stopped kaons physics - ? Kaonic nuclear clusters (K-pp, K-ppn, K-pnn...) and interaction processes
- Low-energy kaon-nuclei interaction physics

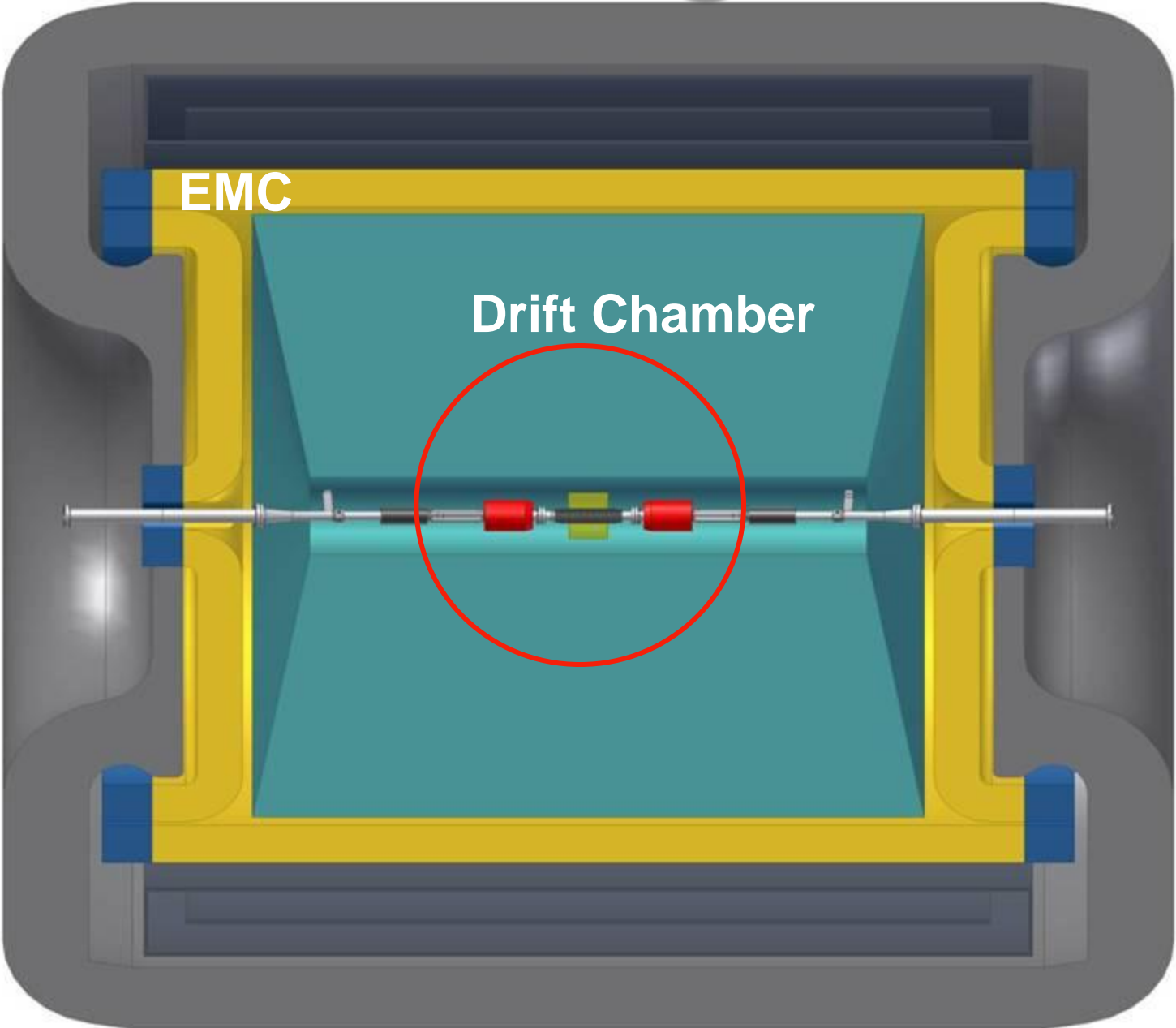
The scientific case of the so-called “deeply bound kaonic nuclear states” is hotter than ever both in the theoretical

Either situations: EXISTENCE or NON-EXISTENCE of the deeply bound kaonic nuclear clusters will have strong impact in kaon-nucleon/nuclei physics!!!

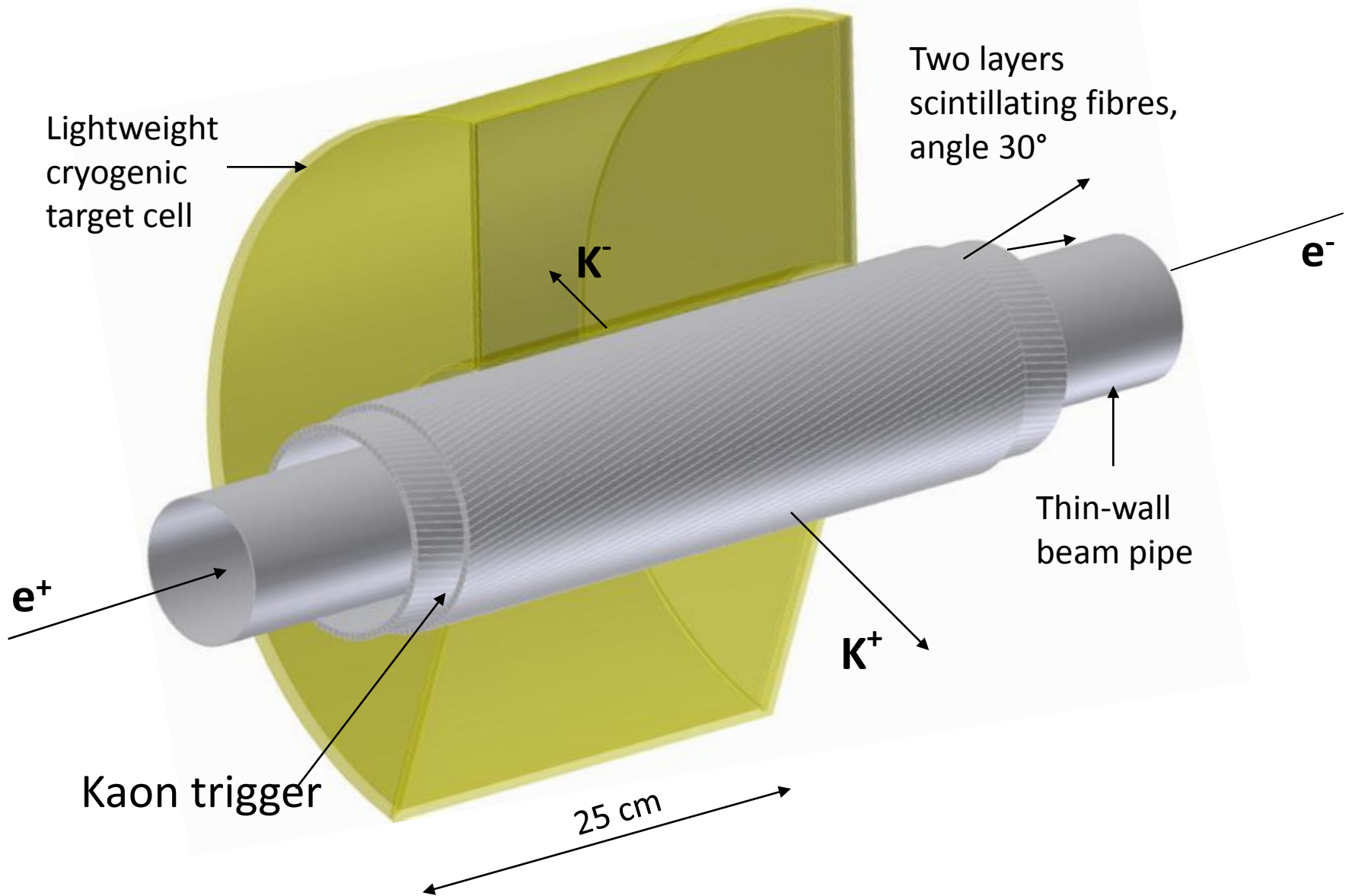
And even astrophysics (Strange stars?)

a second phase),

AMADEUS @ KLOE



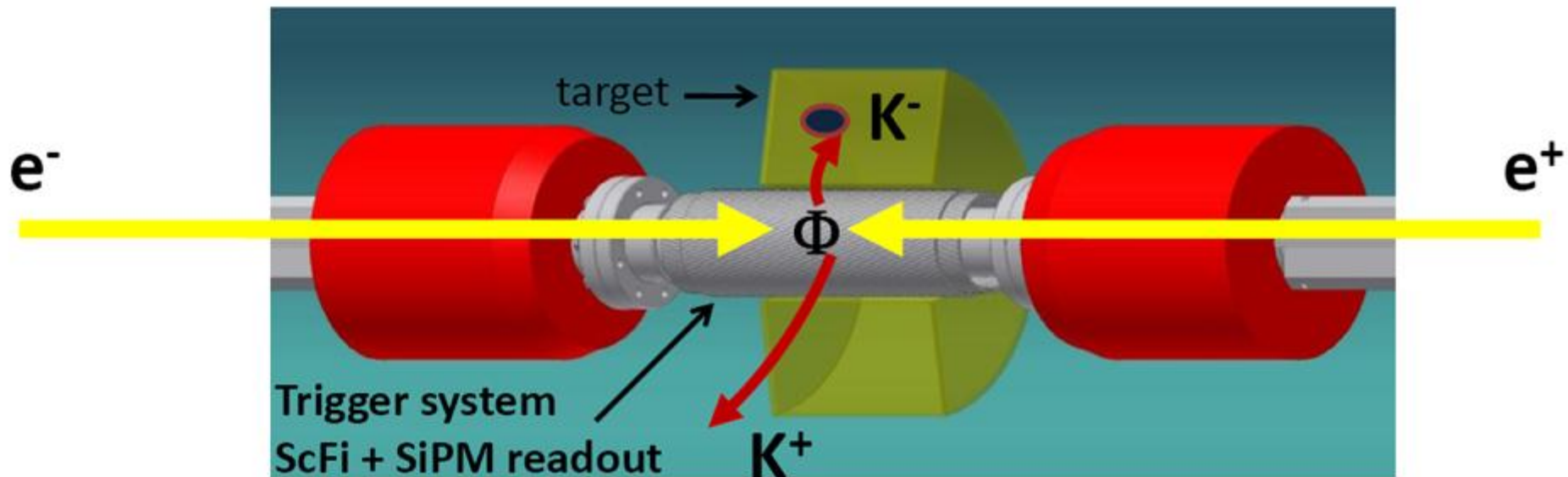
AMADEUS: stopped K-



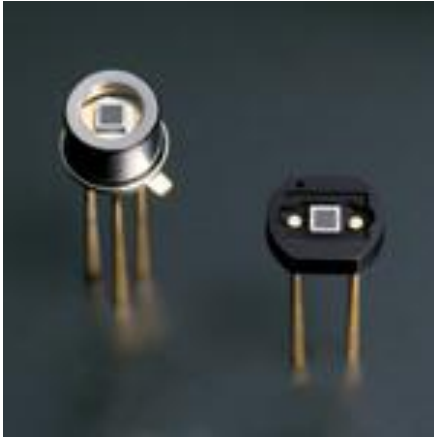
Trigger system requirements

Cylindrical layer(s) of scintillating fibers surrounding the beam pipe to trigger K^+/K^- in opposite directions

- Readout to be done by SiPM (Silicon Photo-Multipliers)
- Separation between Kaons and MIPs (time and Edep)
 - Very good timing resolution ($\sim 200\text{-}300$ ps)
 - High rates capability



SiPM tests



- Array of single Geiger Mode APD.
- Photon counting depending on the PIXEL size
- **Ideal for:**
 - **ScFi coupling**
 - **High granularity detector**
- **Time resolution below 1 ns**
- **Insensitive to strong magnetic fields**
- High gain ($>10^6$) and quantum efficiency

**Different options available in the market,
becoming a standard light readout system
(Hamamatsu, Photonique, etc)**

MPPC Hamamatsu S10362-11-050U

effective area 1mm²

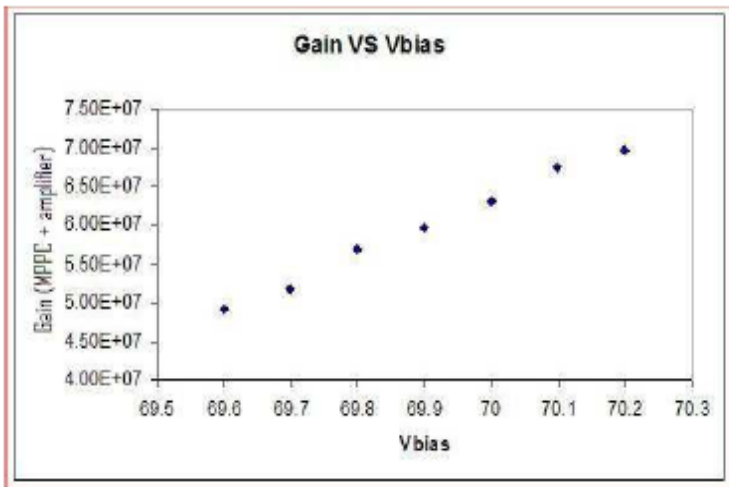
400 pixel

$\lambda = 270-900 \text{ nm}$

working biases $\sim 70 \text{ V}$.



SiPM tests: Readout electronics



- The Geiger mode of SiPM makes **gain extremely dependent of applied V_{bias}**
- A characterization of this dependency based on the peak distance of intrinsic noise:
- For a good behavior stability in the applied voltage with great precision is needed for every single detector.

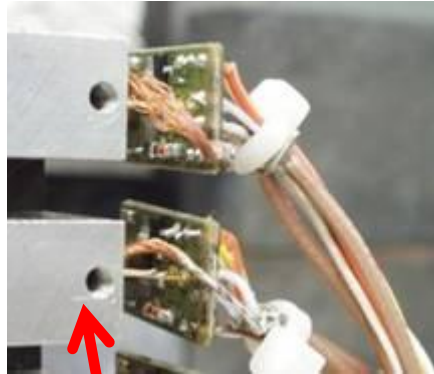
We developed new electronic modules providing:

- Variable V_{bias} with a **stability for nominal voltages below 10 mV**
- 2 output / channel:
 - Amplified (x50-x100) signal
 - Discriminated signal (variable threshold)



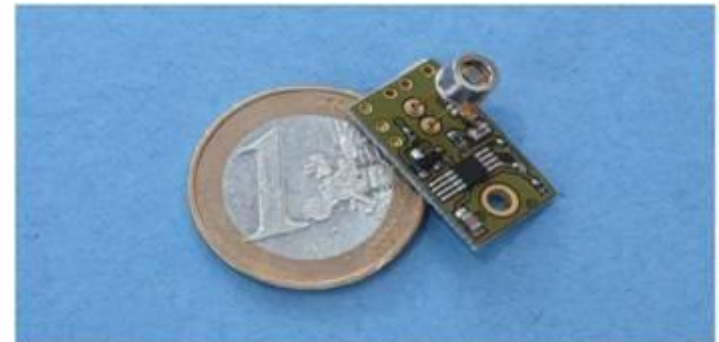
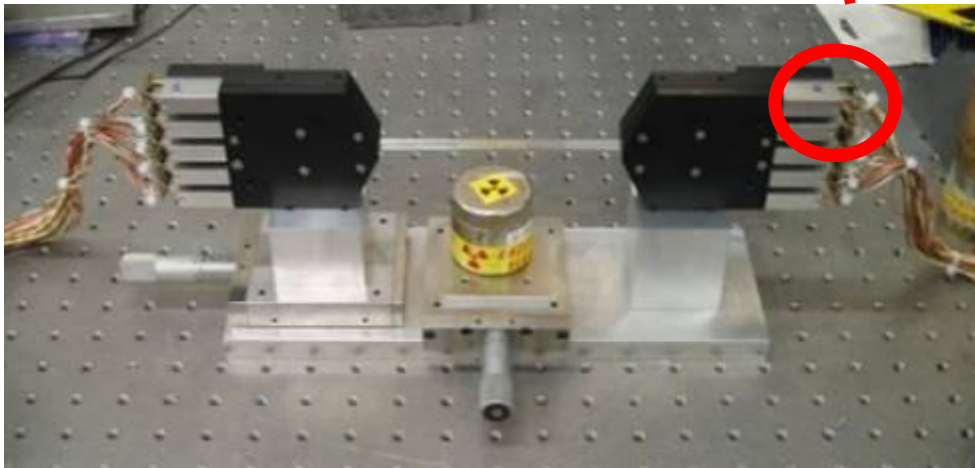
ScFi + SiPM tests

Prototype with
5 ScFi read from both sides
10 SiPM + readout card

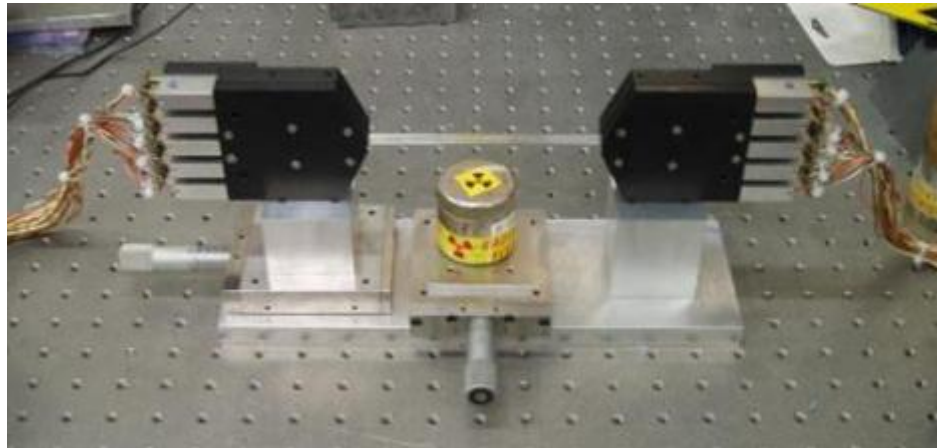
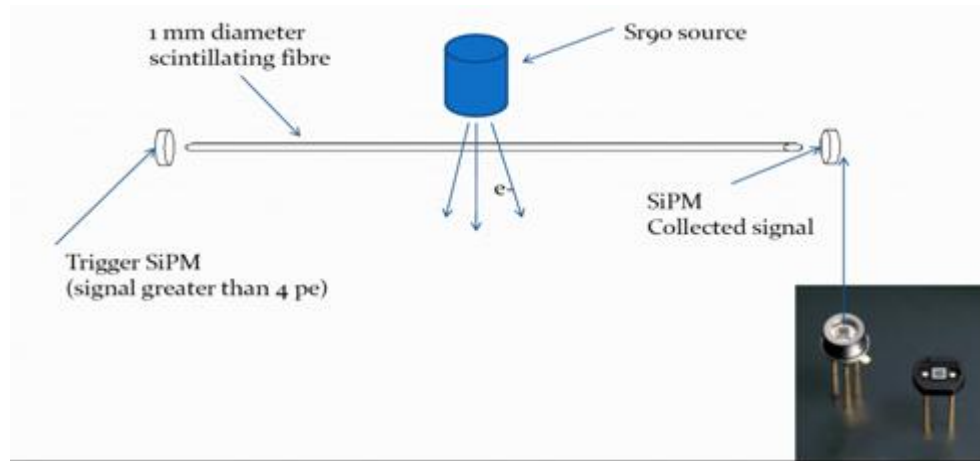


Instrumented fibers:

- Saint Gobain BCF- 10 single clad
- Emission peak 432 nm
- Decay time 2,7 ns
- 1/e 2.2 m
- 4000 ph./MeV



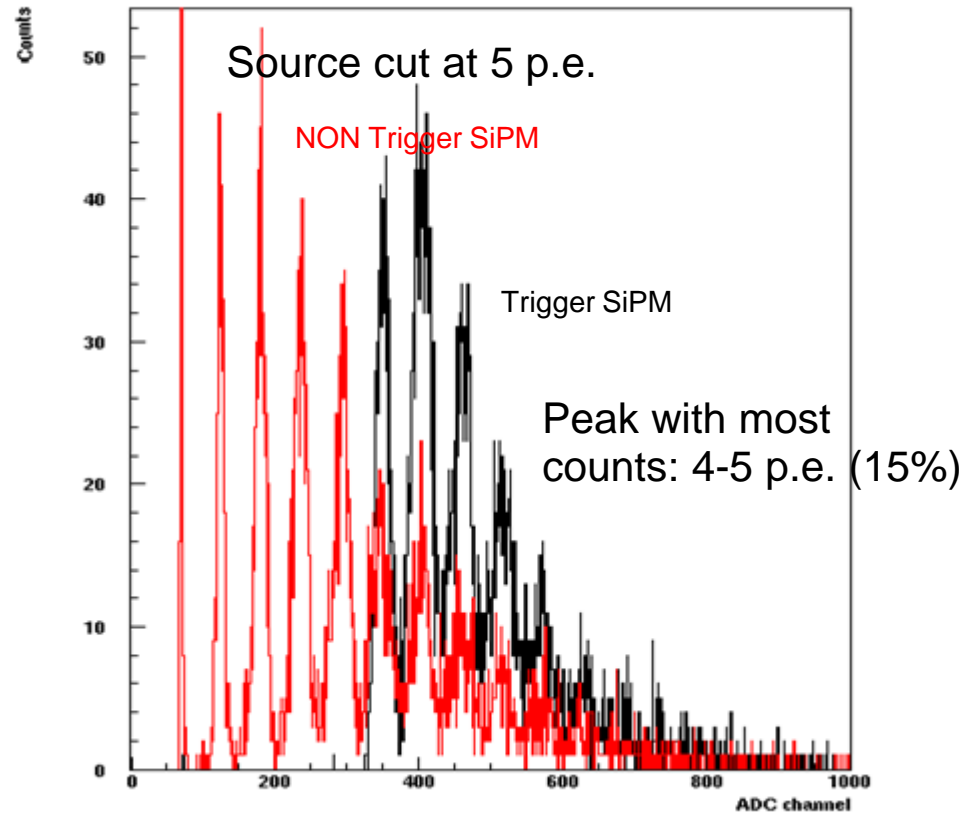
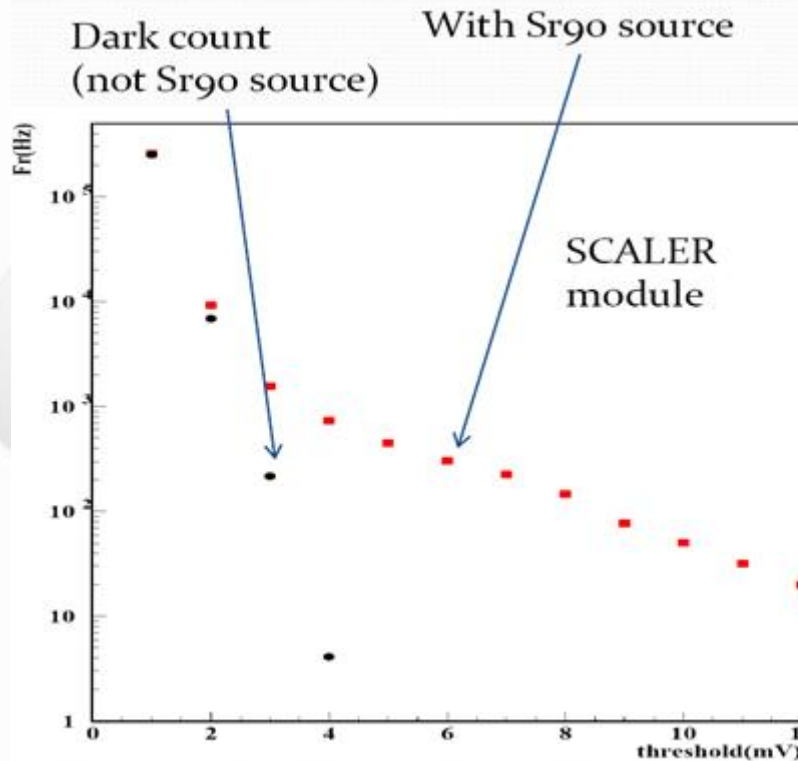
Tests in laboratory



Setting the threshold for the SiPM used as trigger, most part of dark count is eliminated.

In this way spectra due only to the source can be observed

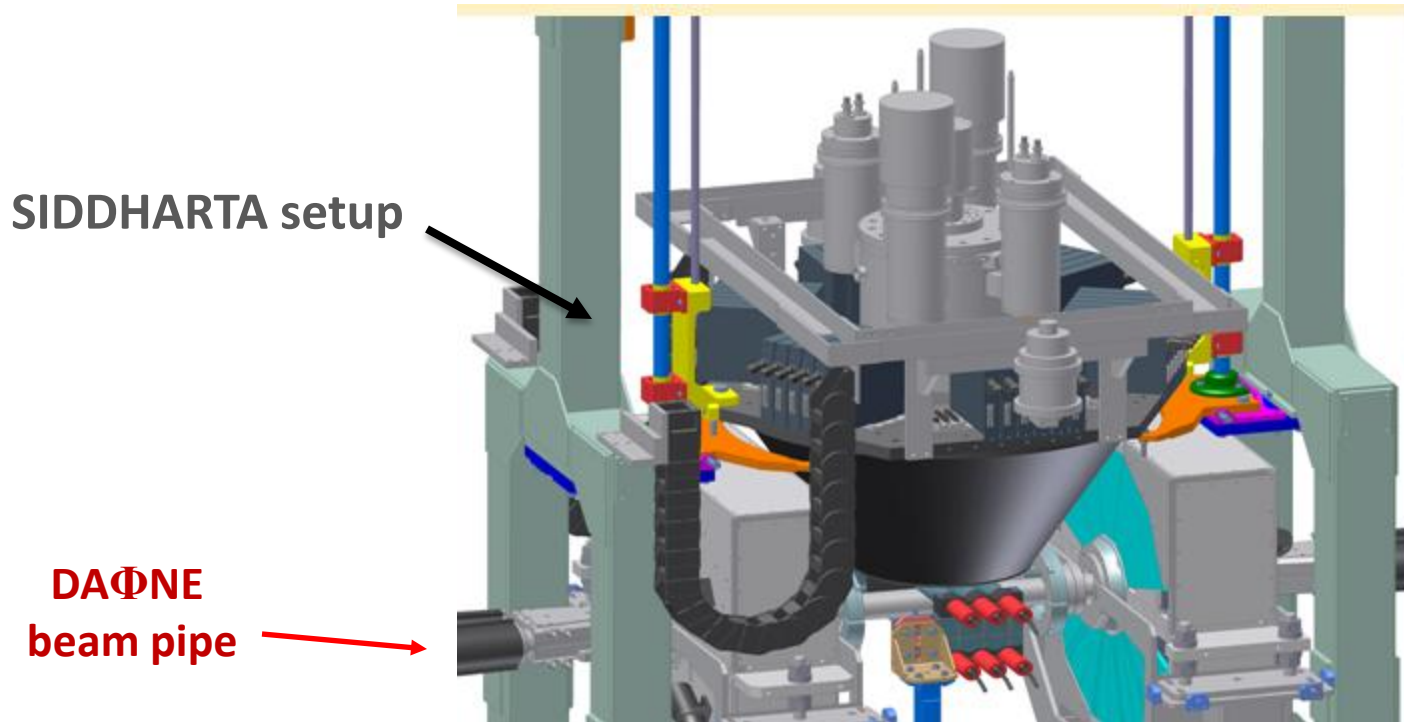
Dark count at room temperature



Studying rates with and without the beta source, it turned out that starting from the 4th p.e. Peak, dark count contribute is negligible

This means that no cooling is needed in our case (Kaons are expected to give ~ 50 ph signal)!!!!

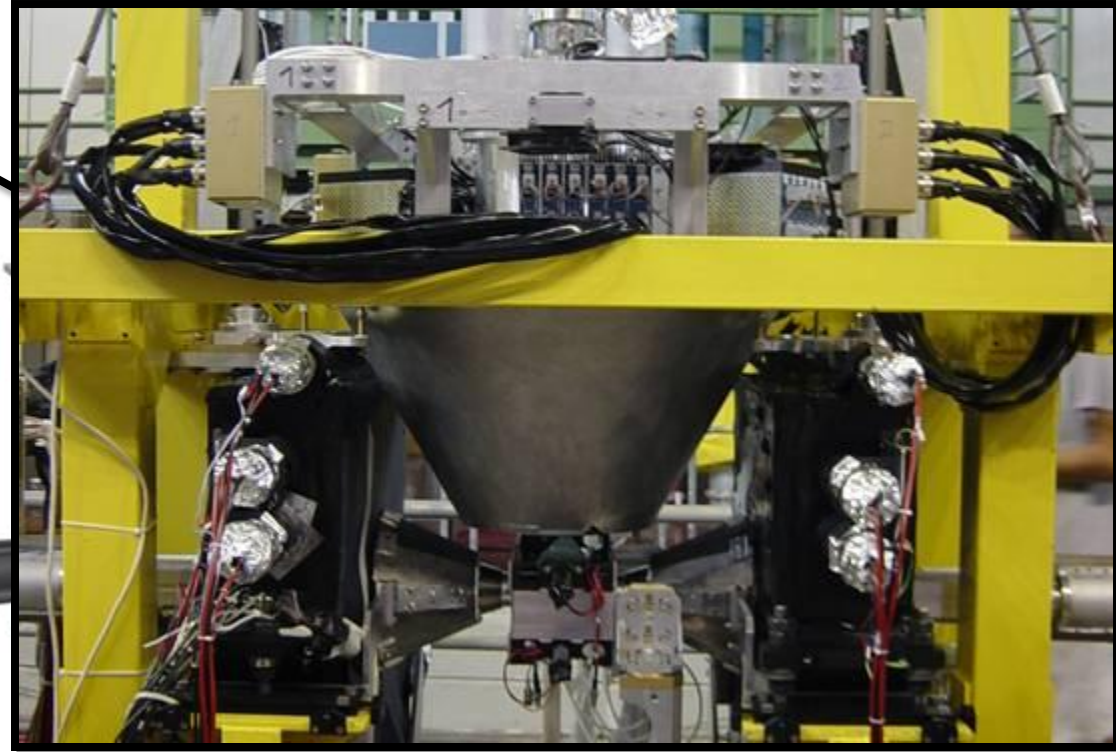
Trigger system tests: installation at DAΦNE



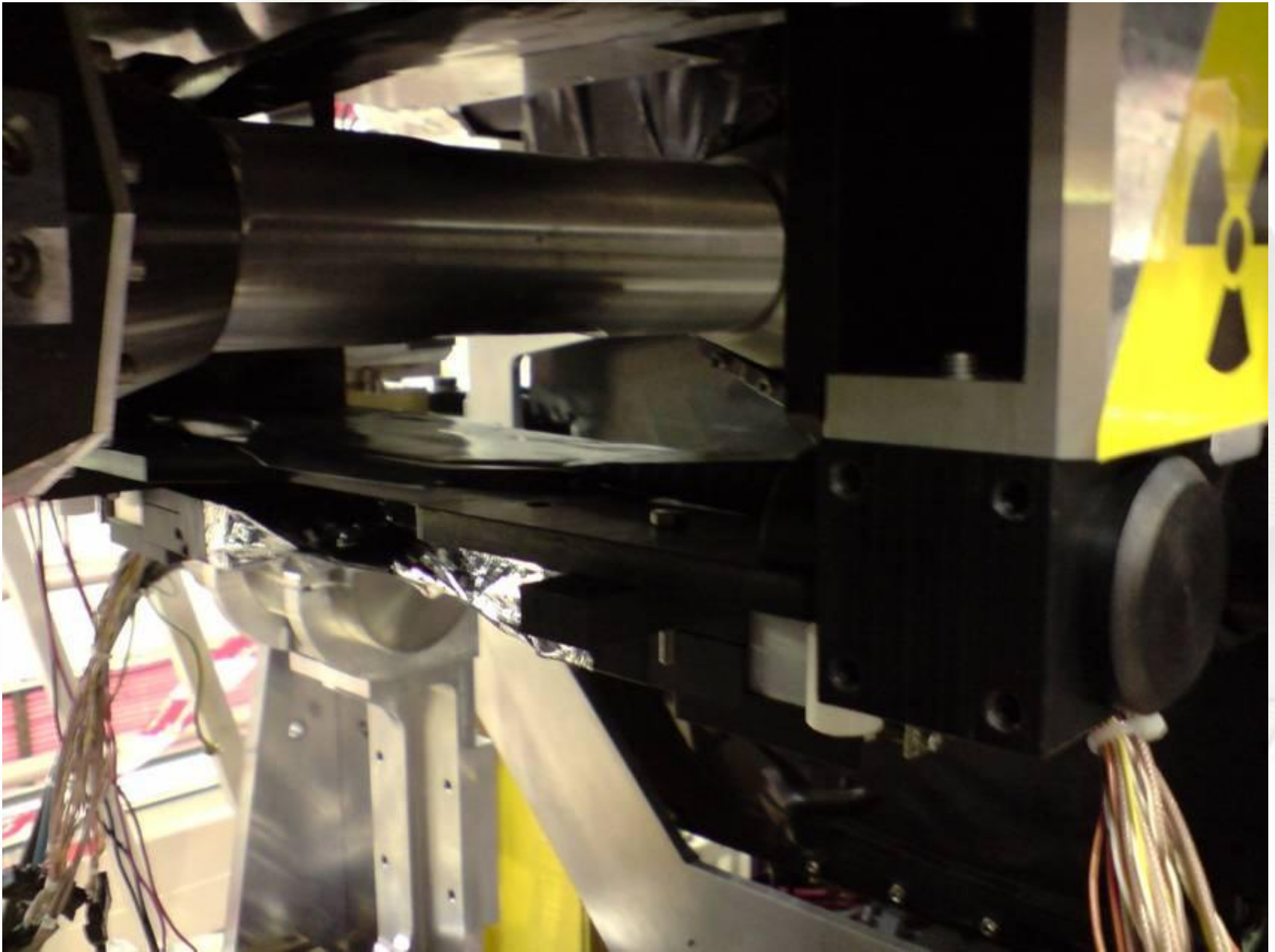
Trigger system tests: installation at DAΦNE

SIDDHARTA setup

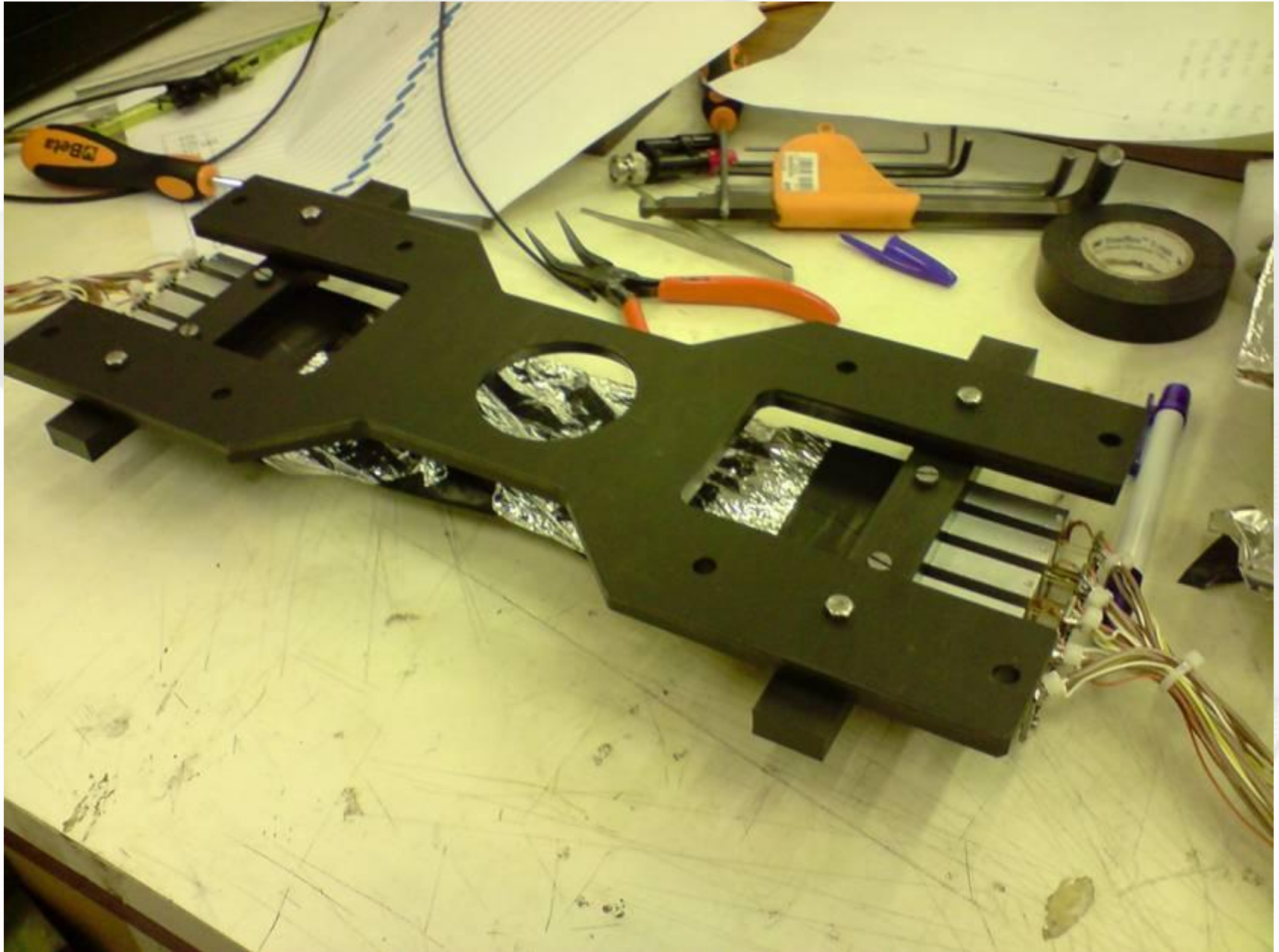
DAΦNE
beam pipe



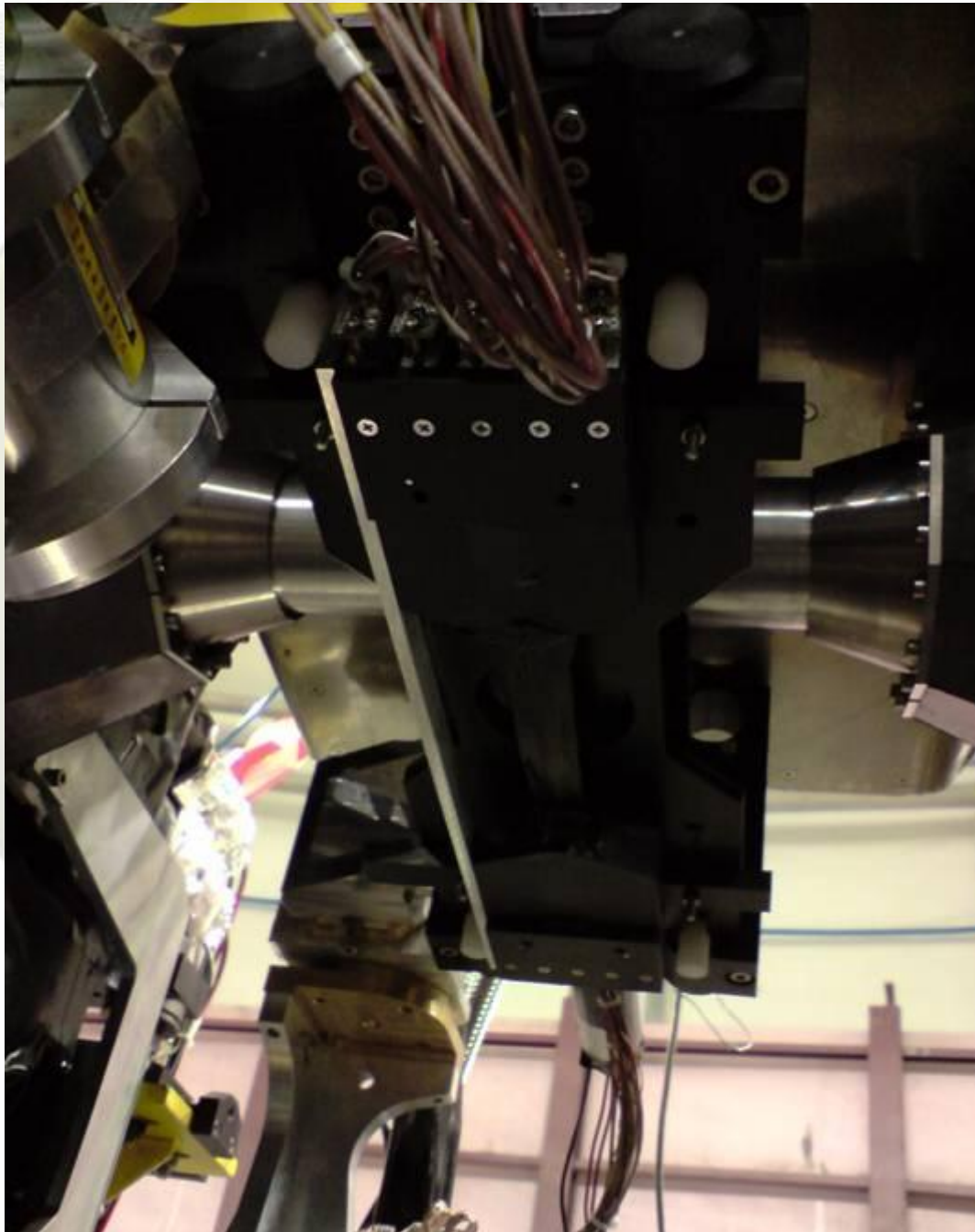
First Kaons detection in DAΦNE



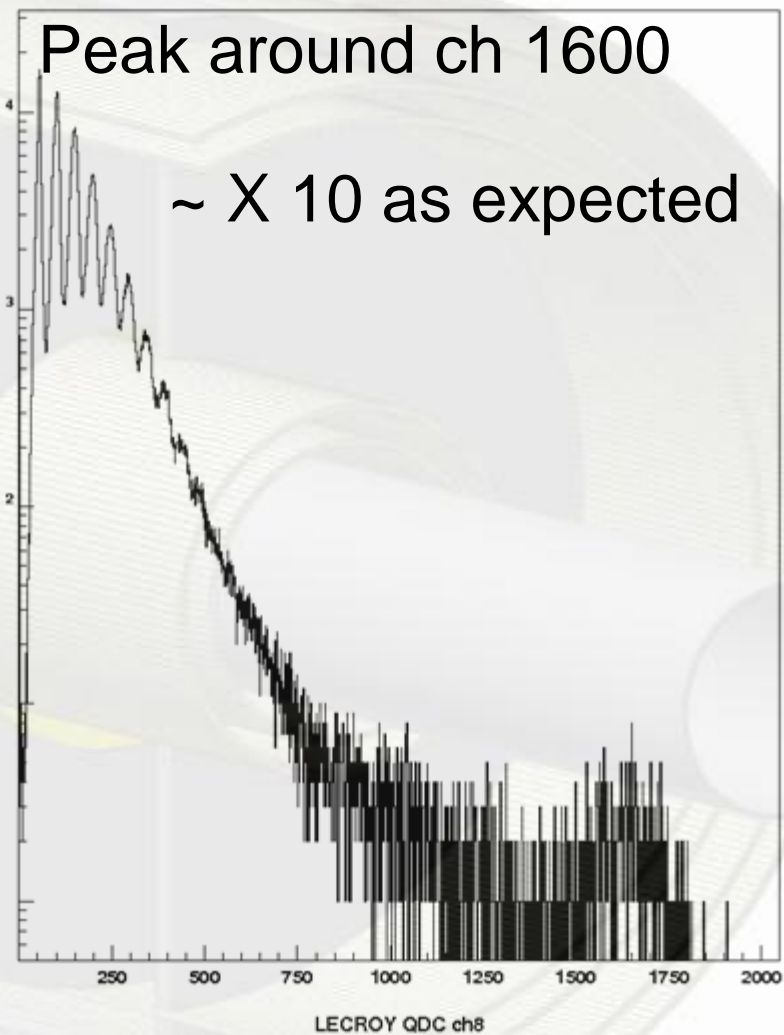
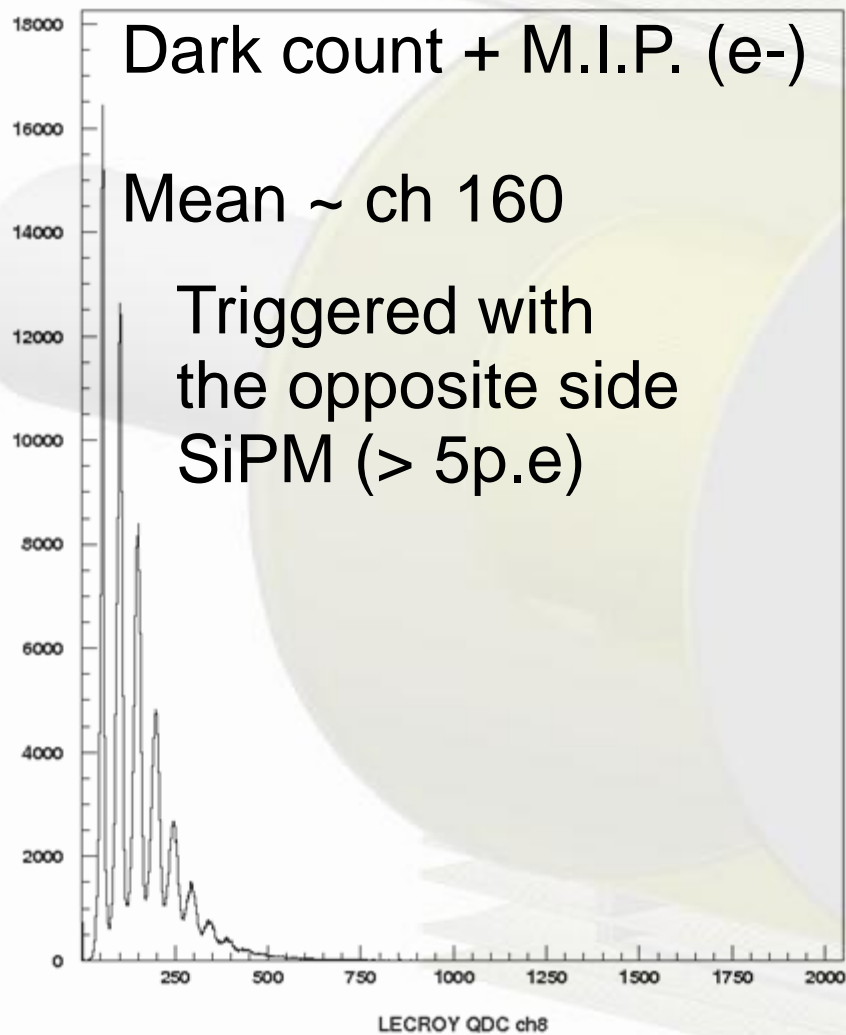
First Kaons detection in DAΦNE



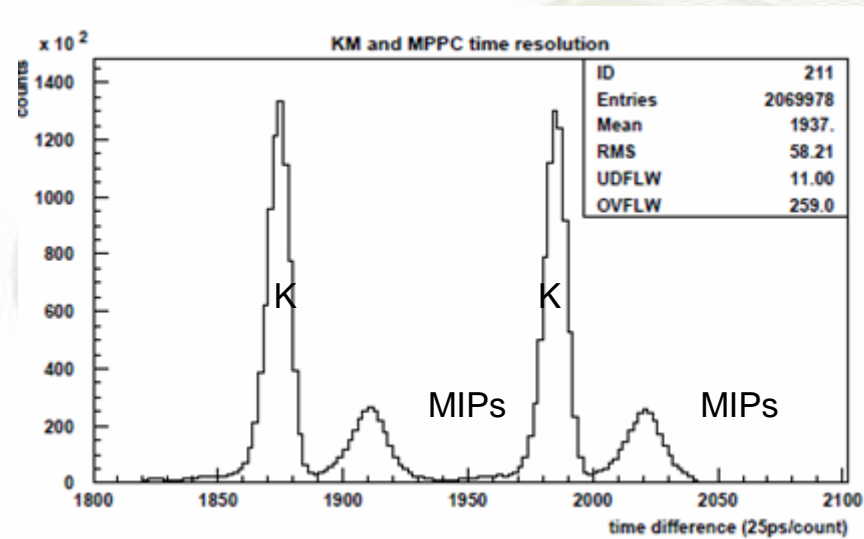
First Kaons detection in DAΦNE



First Kaons detection in DAΦNE



First Kaons detection in DAΦNE

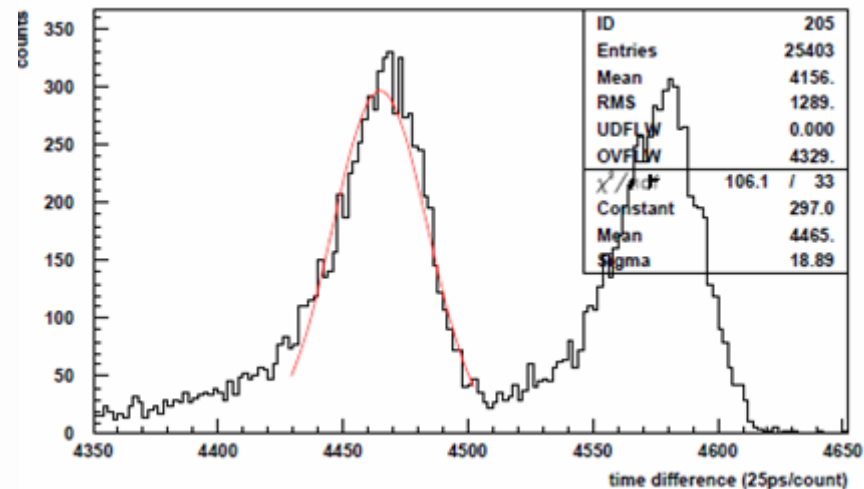


Kaon Monitor TDC (upper/lower coincidence)

TDC working in Common Start (RF/2)

Single peak resolution~ 100 ps

MIP/K separation ~ 1 ns



SiPM spectraTDC

working in Common Stop (RF/2)

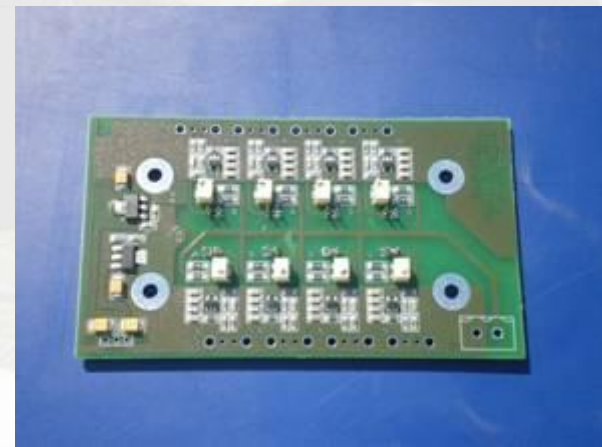
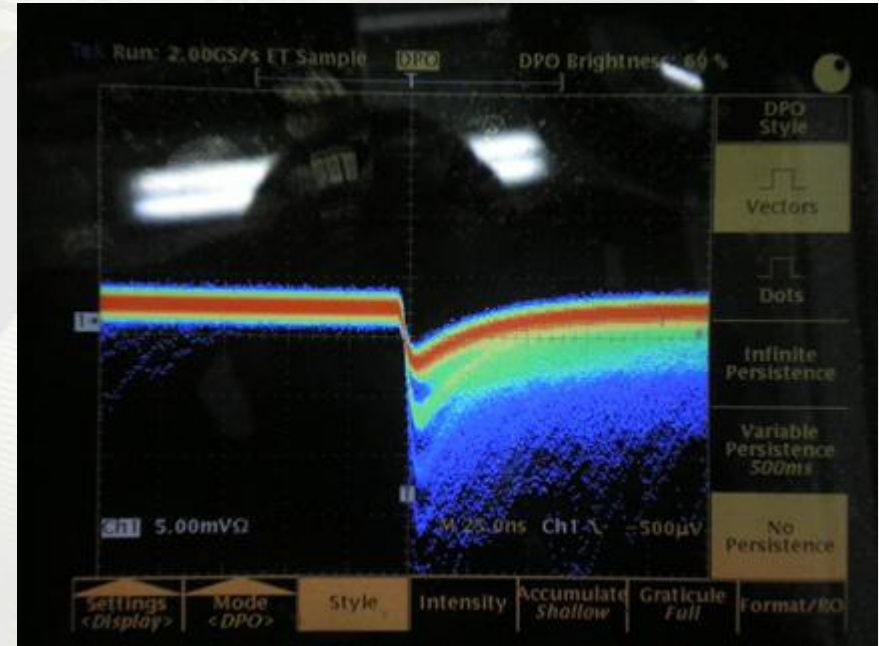
Single peak resolution~ 300 ps

New electronics: Preamplifier board

- A dedicated preamplifier board has been developed for the experimental set-up. Main Characteristics are:

- 8 SiPM channels
- Independent and 10% tunable HV supply for each channel
- LV stability below 0.1%
- Dual output signal per channel
- Transimpedance amplifier

(Gain = 1KOhm)



New electronics: Constant Fraction Discriminators

A constant fraction discriminator has been designed and realized for a large number of channels.

Main characteristics are:

- 64 input channels (50 Ω terminated)
- Negative input
- Selectable threshold 10-1000mV
- Differential ECL output
- Minimum input amplitude signal 10mV
- Minimum input pulse width 10ns
- Jitter skew below 10ps
- 5 OR outputs (NIM) with adj, width

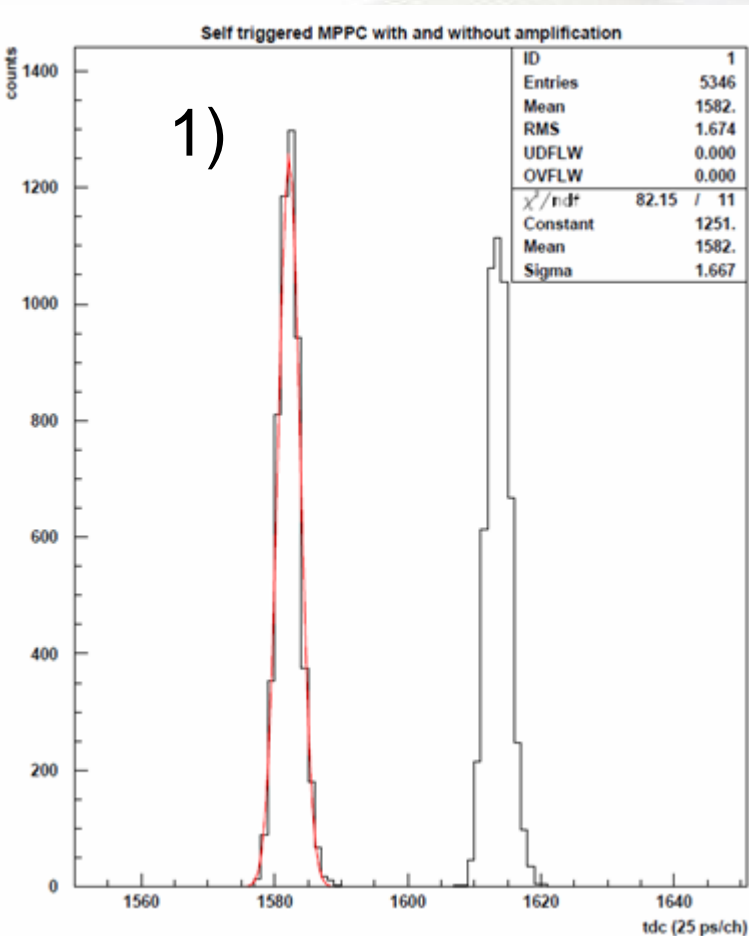


New electronics: Timing Characterization

Very high precision laser used to test new electronics behaviour at ROMA 3 University

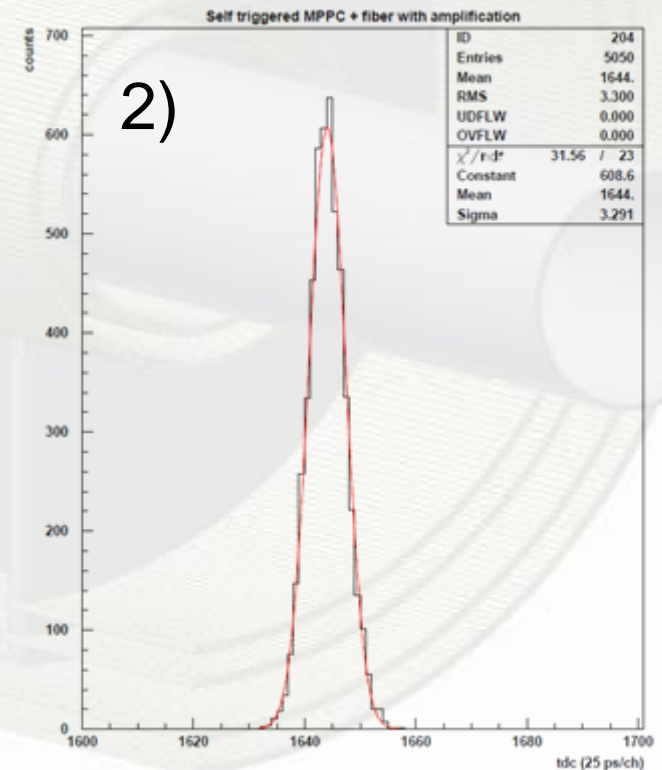
1) Amplifier test: Sigma with and without amplification measured (no fiber coupling, just direct hit on SiPM)

2) Test with scintillating fiber coupling



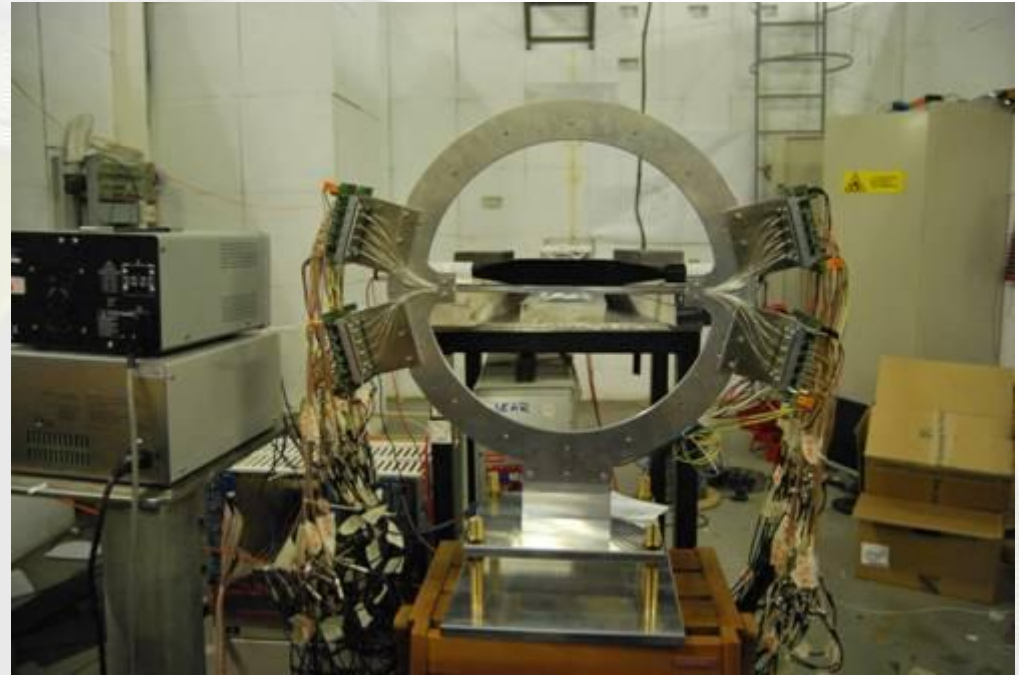
1) Amplificator doesn't worse time resolution; $\sigma \sim 40$ ps

2) Scintillating fibers causes a little loss in time resolution ; $\sigma \sim 80$ ps



New prototype with 64 channels

A second prototype has been developed for “on beam” tests; it has been designed for efficiency, timing, and optical cross talk studies



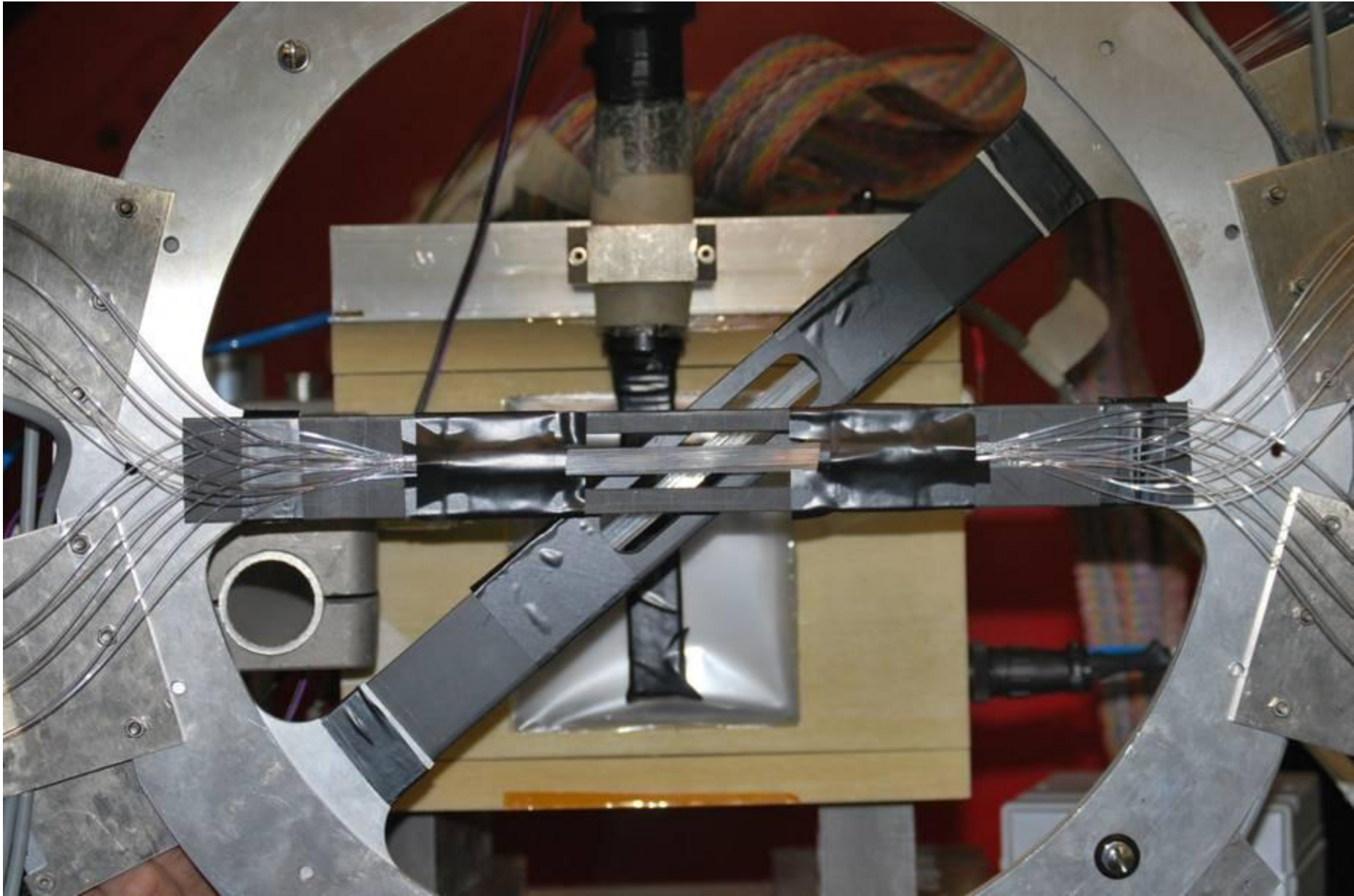
New mechanical setup:

- 2 separate rings for 16 fibers each
- Fibers organized in full efficiency layers
- 64 SiPM with own CFD
- Different orientation of rings
- 8 Amplifier boards

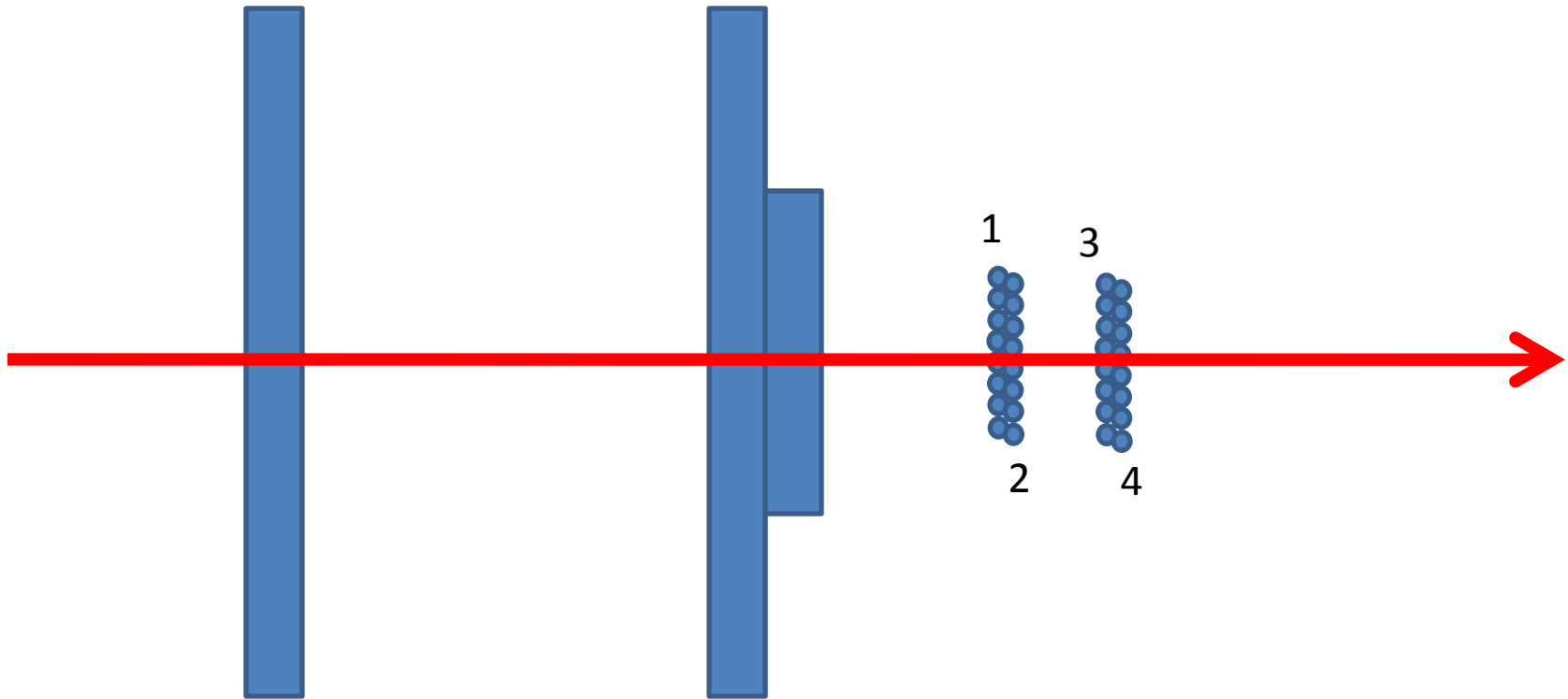
New prototype with 64 channels



Setup - detail



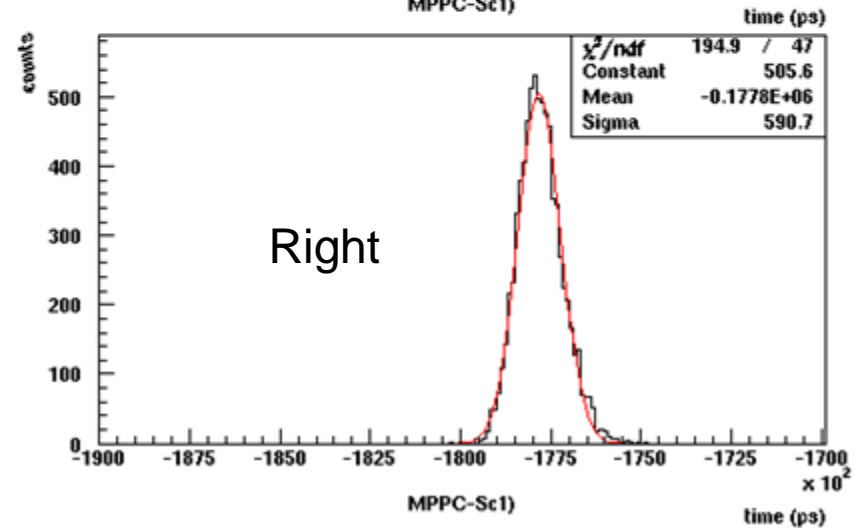
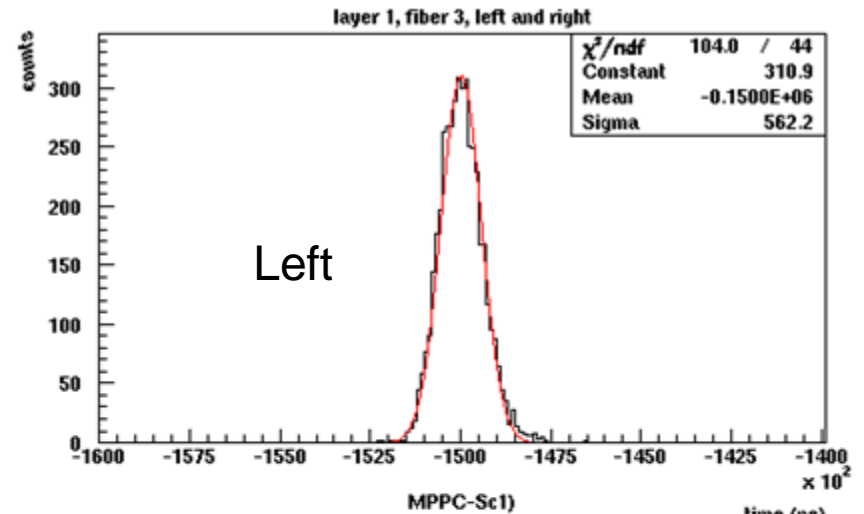
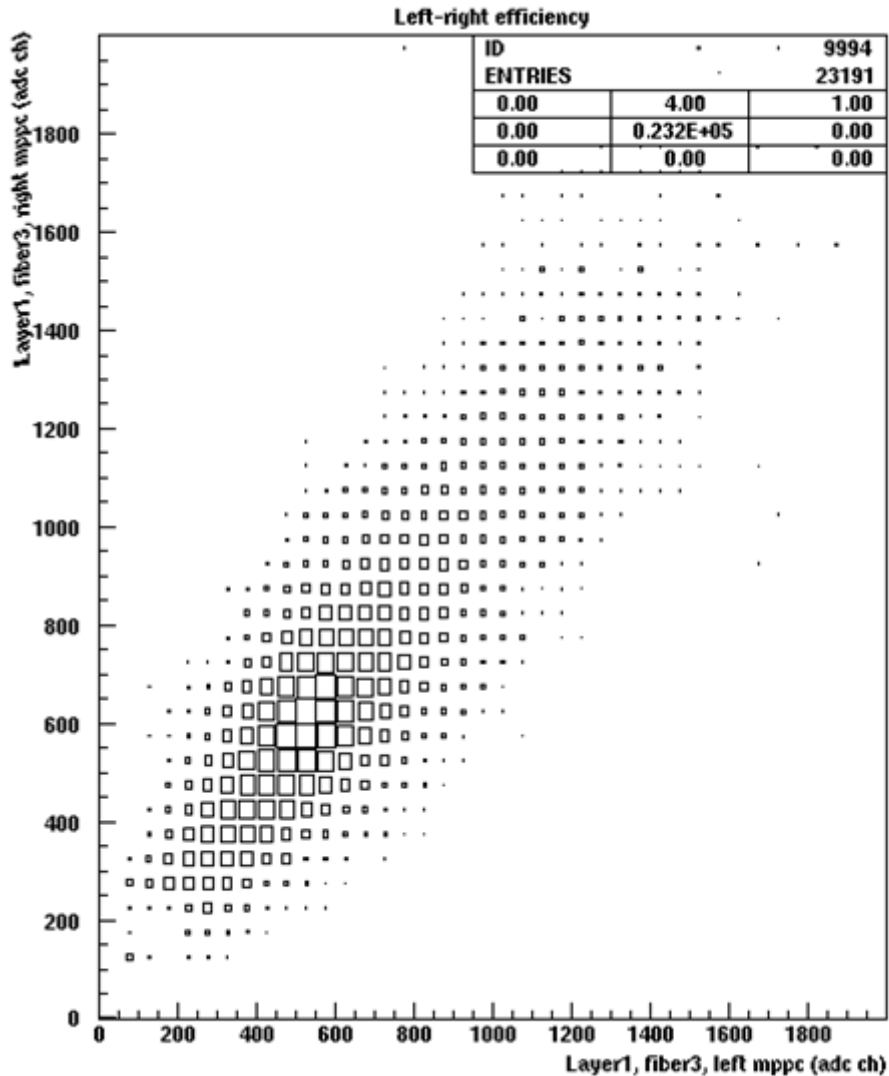
Setup



Scintillator 2

Scintillator 1&3
(DAQ trig)

Preliminary results for protons



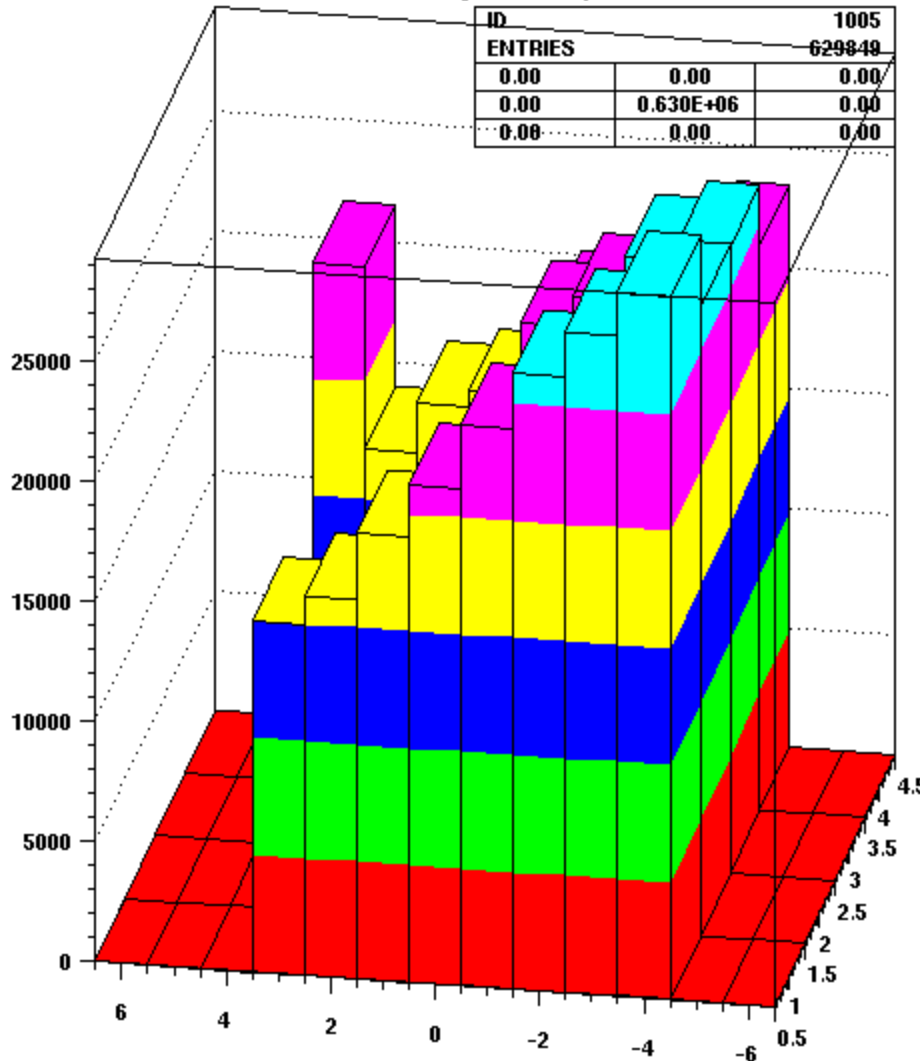
Sc1 is used as reference

Beam profile

Protons

Left-right efficiency

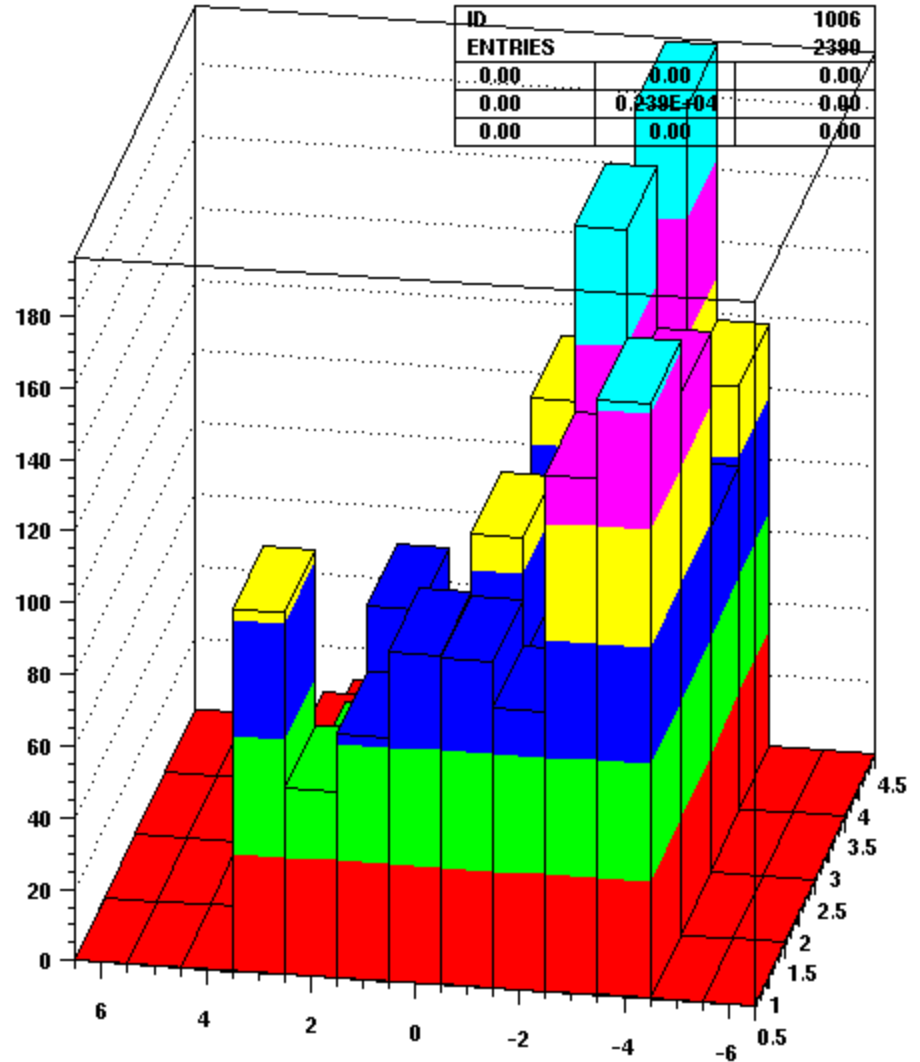
ID	1005	
ENTRIES	629848	
0.00	0.00	0.00
0.00	0.630E+06	0.00
0.00	0.00	0.00



MIPs

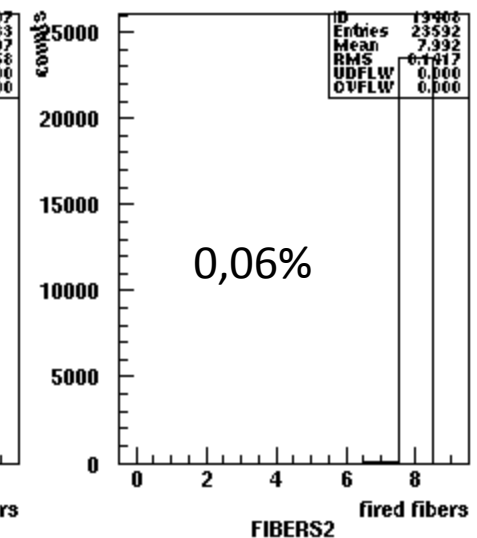
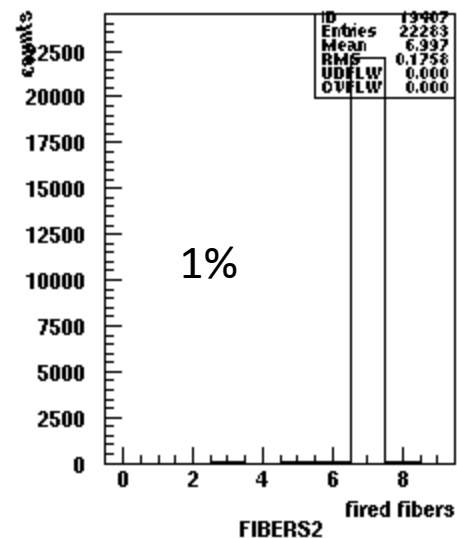
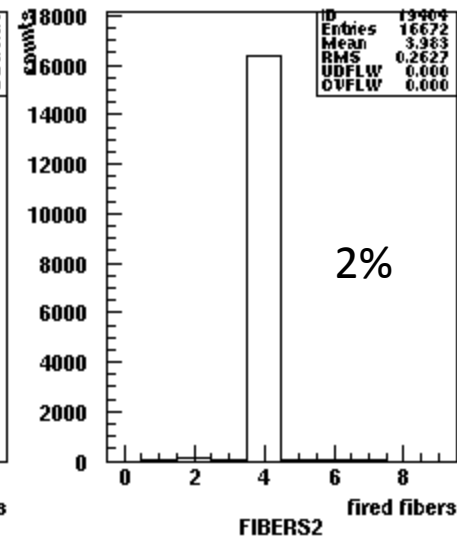
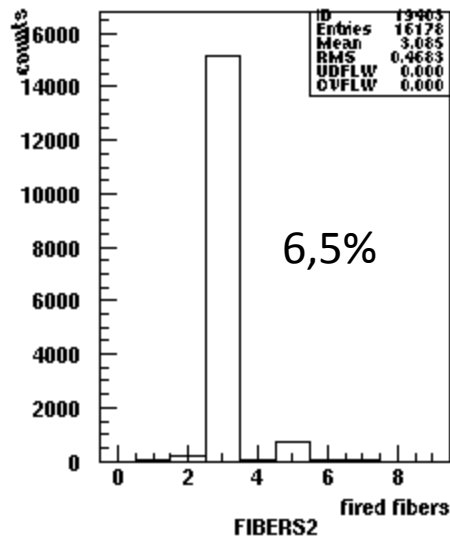
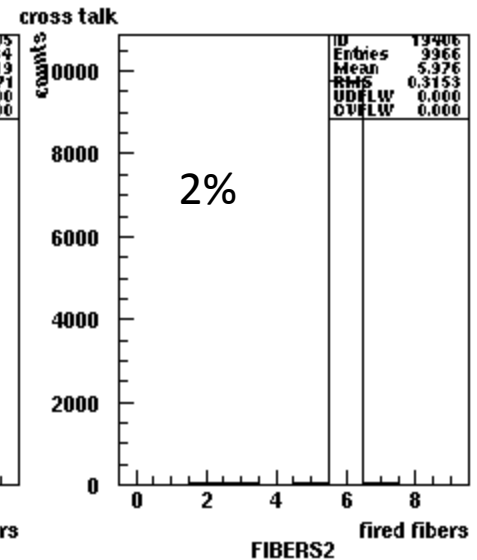
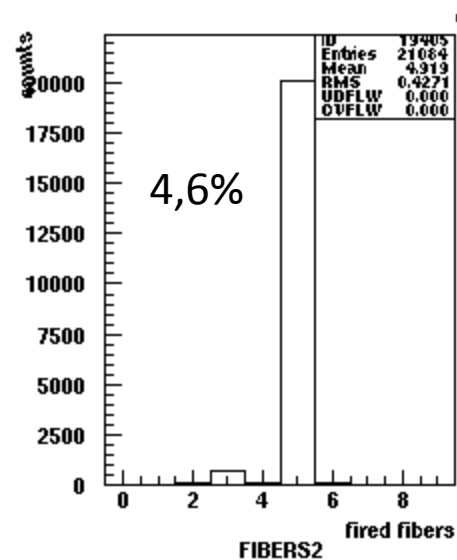
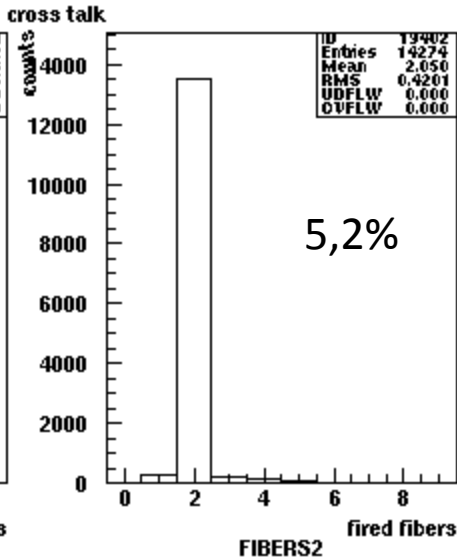
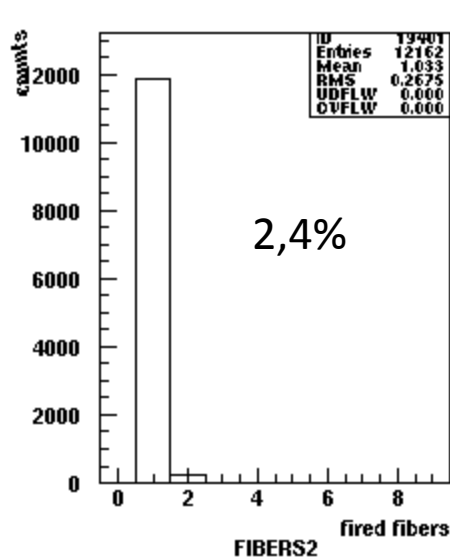
Left-right efficiency

ID	1006	
ENTRIES	2390	
0.00	0.00	0.00
0.00	0.239E+04	0.00
0.00	0.00	0.00



Cross talk (layer 4)

19400 + i -> fired fibers of layer 4 if fiber i of layer 4 is fired



Conclusions



- Trigger is a crucial for AMADEUS and preliminary positive tests were performed at DAFNE with a 5 fibers prototype
- Achieved best single peak resolution around 300 ps
- Bigger ptototype (64 channels) with new electronics was built and testes (PSI) – under analyses
- MCarlo simulations are as well undergoing

AMADEUS is for low-energy QCD:



AMADEUS goes from u and d sector:

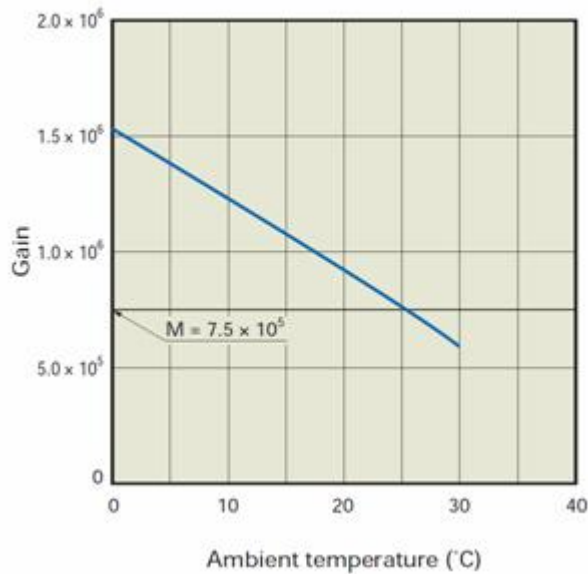


AMADEUS goes to u, d and s sector:



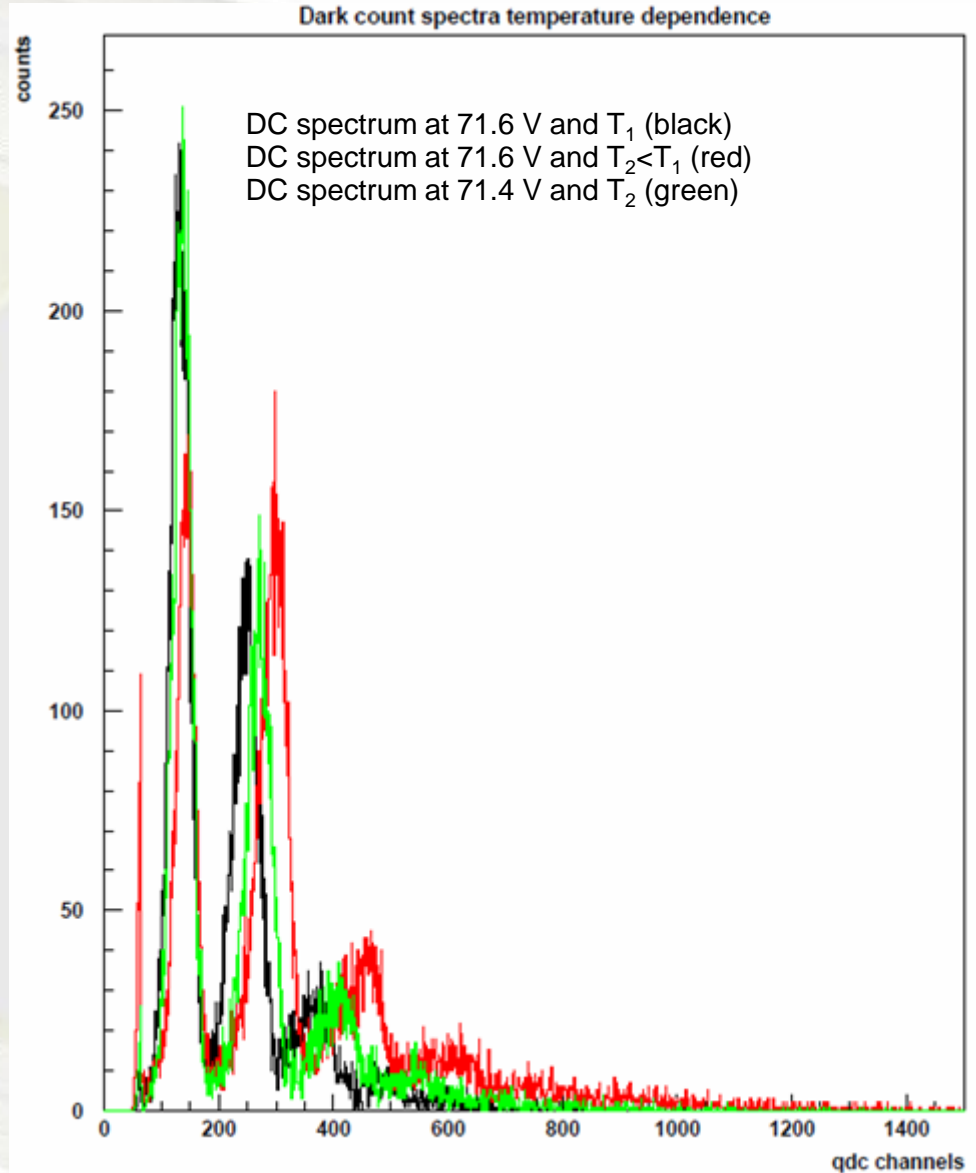
Temperature dependence and stabilization

(b) S10362-11-050U/C



A small variation of the temperature causes a gain variation of the detector.

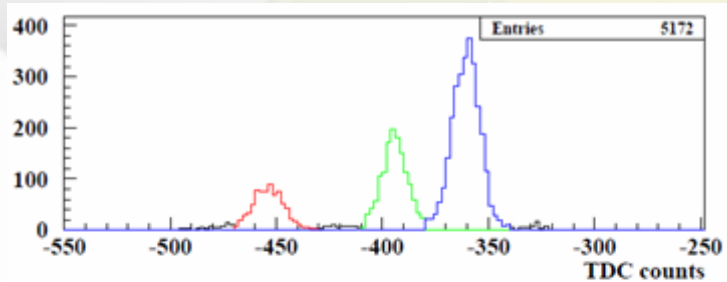
In order to have best performances, gain has to be stabilized.



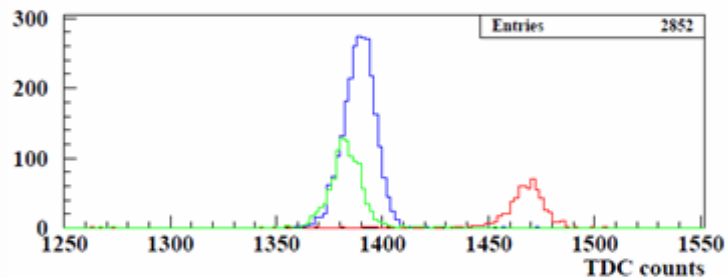
PSI beam test for timing resolution



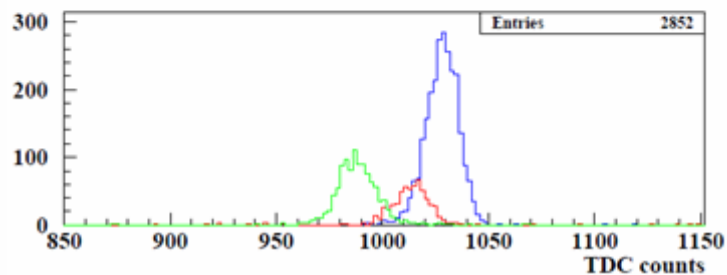
PSI beam provides p,m,e- bunches with a frequency of 50 MHz, which means repeated windows of 20 ns.



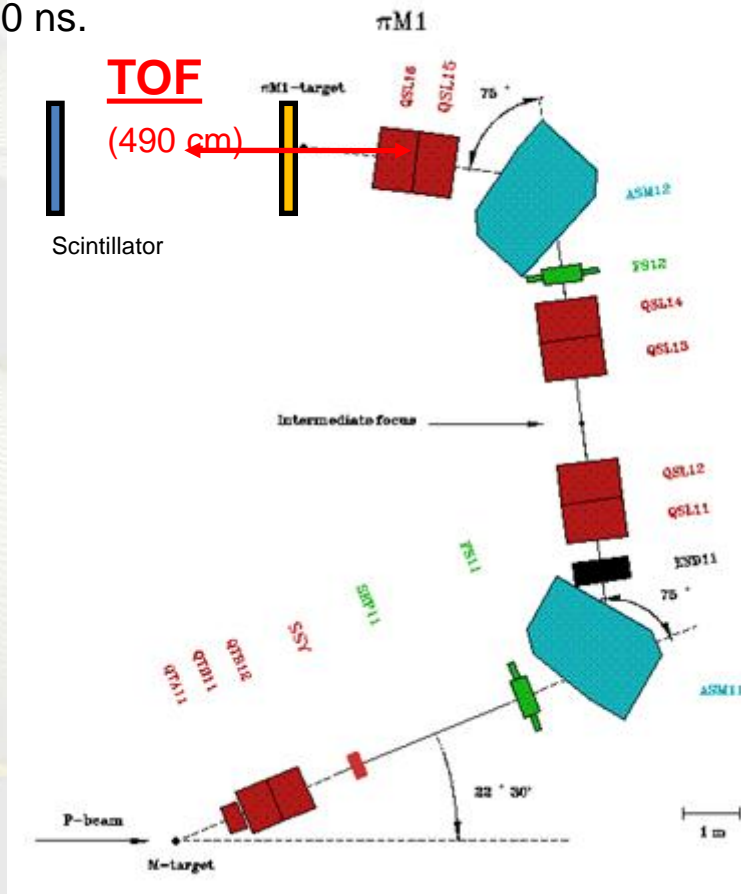
Scintillator TDC with respect to the RF signal of PSI beam



SiPM TDC with respect to the RF signal of PSI beam

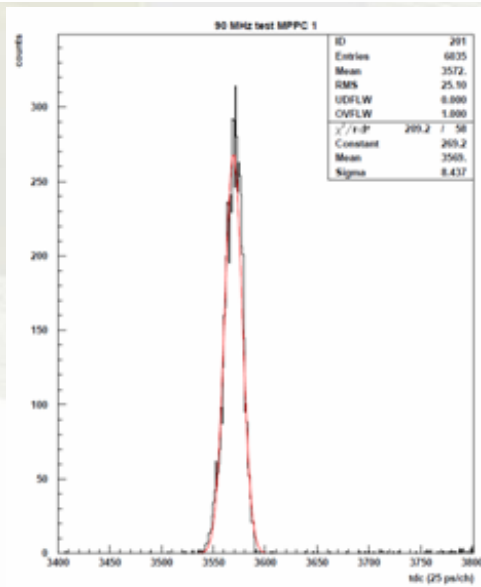
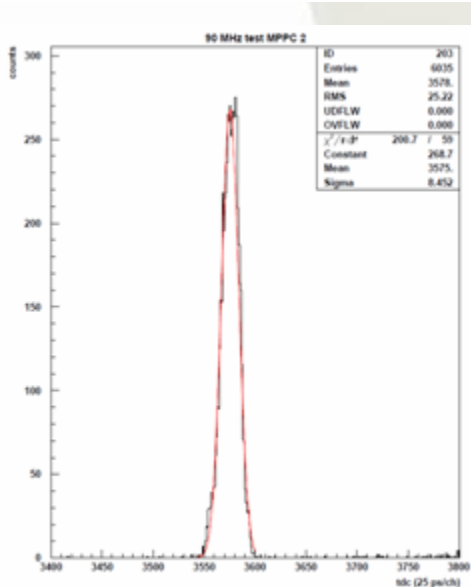
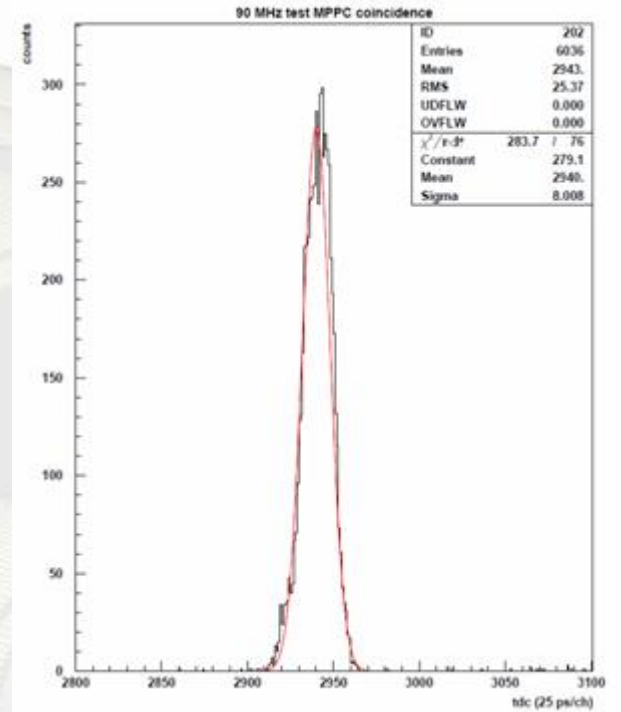
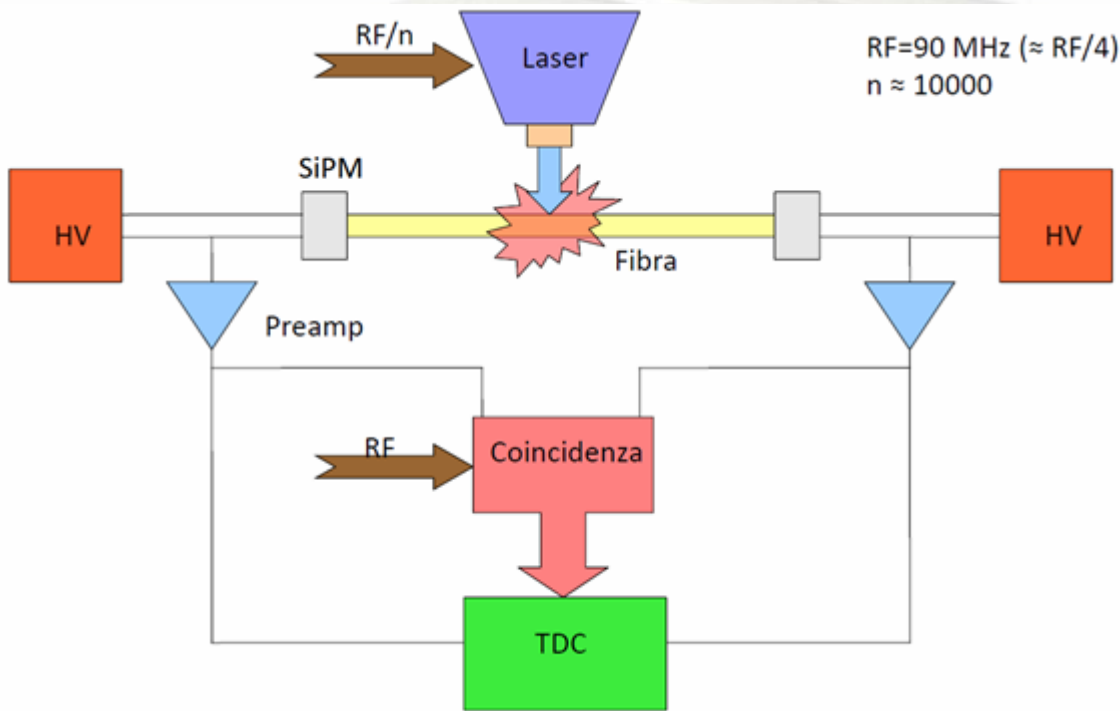


SiPM TDC with respect to the scintillator signal



Time resolution ($\sigma \sim 500$ ps) is compatible with the one of the scintillator.

New electronics: Timing Characterization



Good time resolution for ($\approx 200\text{ ps}$)