KLOE-2 Status Report

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for the KLOE-2 Collaboration

49 LNF SC, May 18 2015

Main progress in physics data analysis since last SC meeting

Paper	November 14	May 15
TFF of $\Phi \to \eta e^+e^-$	Submitted to PLB	Published
$e^+e^- \to Uh'$	Draft Paper	Submitted to PLB
Dalitz plot of $\eta\to\pi^+\pi^-\pi^0$	Almost completed	Draft Paper
$U \to e^+e^-$	Preliminary	Draft Paper
TFF of $\Phi \to \pi^0e^+e^-$		Preliminary

The table above shows that data analysis activity is progressing succesfully

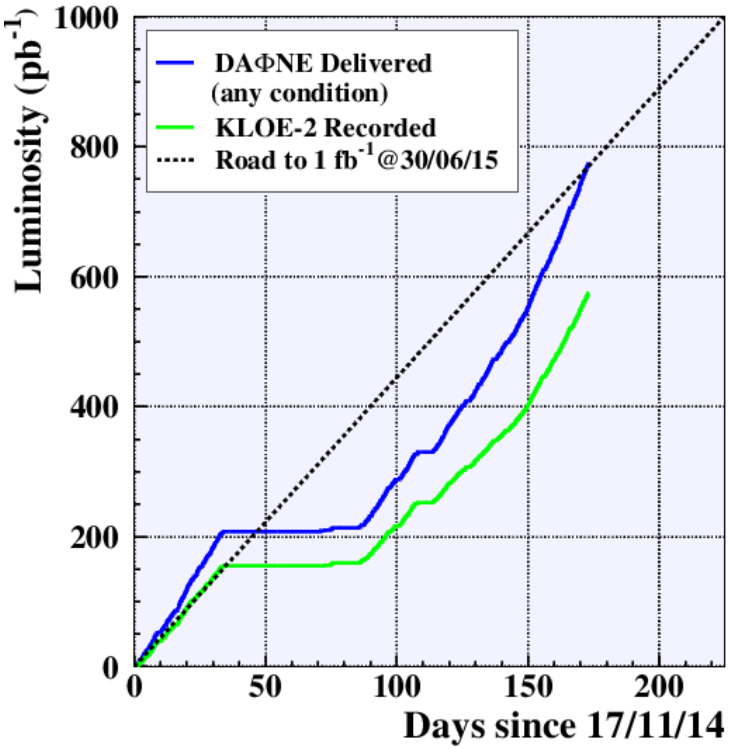
In the rest of the talk, however, I will concentrate on the status of the current data taking

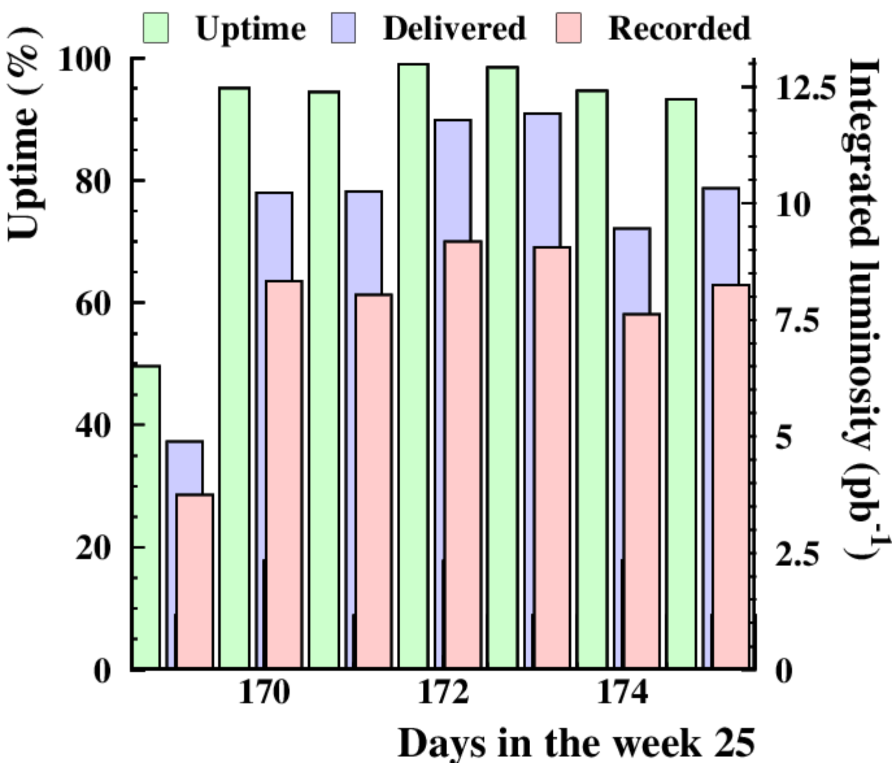
The KLOE-2 project, as originally proposed in 2009, was based on a total integrated luminosity of 20 fb^{-1}. In 2012 the project was re-defined on the basis of a minimum luminosity of 5 fb^{-1}, for which the following conditions were required (see S. Giovannella's presentation at the 44 LNF SC meeting)

- Minimum daily acquired luminosity of 12 pb^{-1}
- Background conditions similar to those of 2005
- Data throughput $\sim$4 times that of 2005, due to new detectors and higher luminosity

The current data taking period (started on November last year) is intended to prove whether this goal is reachabe in a reasonable amount of time, by identifying the milestone of integrating 1 fb^{-1} of «physics grade» data within July 2015

The presently measured performance have almost reached our requests in terms of delivered luminosity.





Although these results need to be consolidated over a few weeks, we believe that they represent a big step forward, for which we want to warmly congratulate all the DAΦNE team

However there are still reasons of concern, about which things require further improvements. They have to do with the quality of the operations in terms of

- Safe operation of the detector, in particular of the Inner Tracker
- High background level in the events, degrading the quality of the physics data
- Unexpectedly high data throughput, again mostly driven by backgrounds

Together with this, there are also issues connected to the long term reliability of the hardware of the detector as well as to the need of a substantial increase in manpower for KLOE-2 long term operations

I will briefly discuss all of this in the following

There are two main points connected to the machine operation which are relevant for the safety of the detector

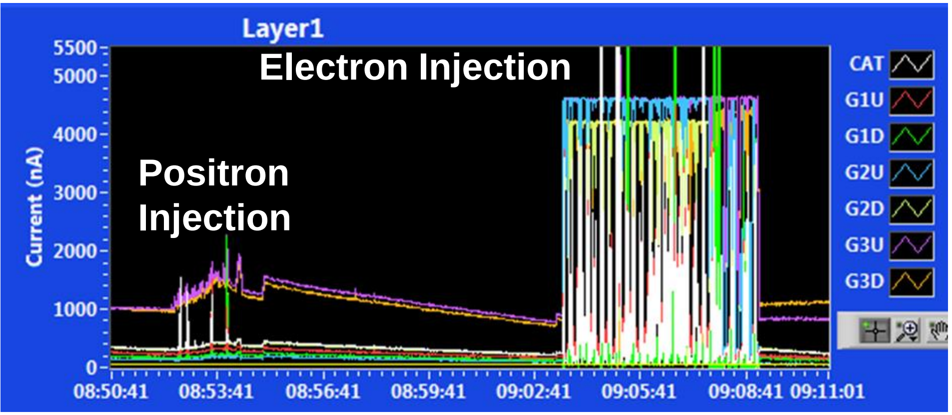
- Injections
- Beam losses

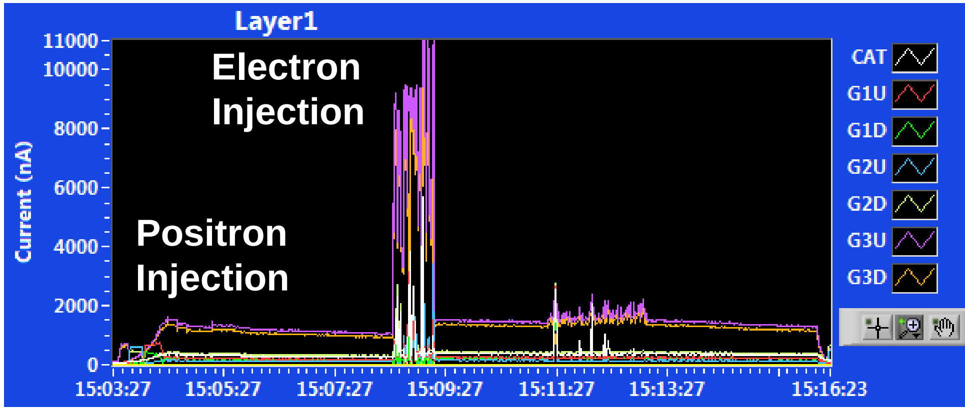
In both cases the high level of radiation increases the occurence of discharges in the tracking devices, which can cause permanent damages of the detectors

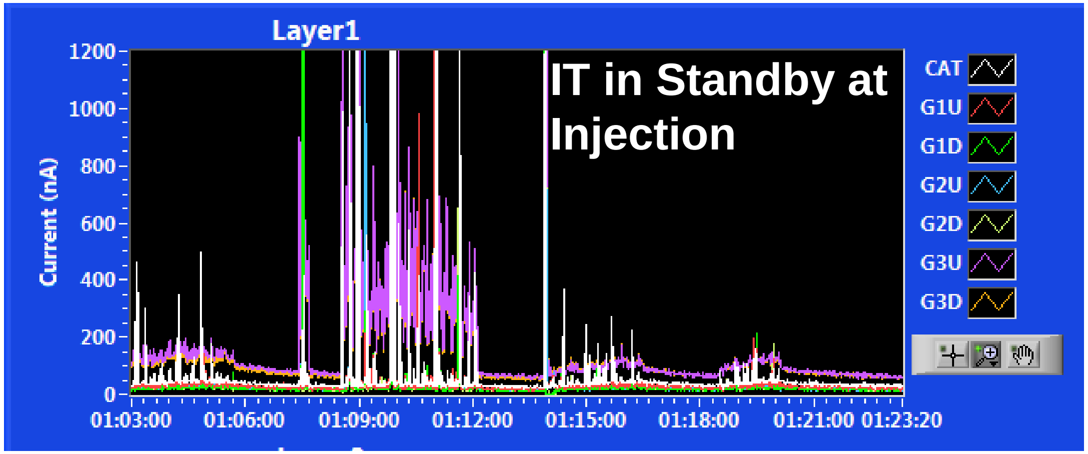
Under this respect, the most critical component of KLOE-2 is the Inner Tracker, because of the small distance between electrodes in GEM detectors. Moreover the probability of discharges increases exponentially with the gain and we are operating the IT at a relatively high gain (12 k) to maximise detection efficiency

We regularly observe high radiation levels at electrons injection, while for positrons the situation is much safer. Despite the relevant efforts of the DAΦNE team, this situation has not improved with time

IT Layer #1 Currents at Injection: discharges with values up to tens of microA

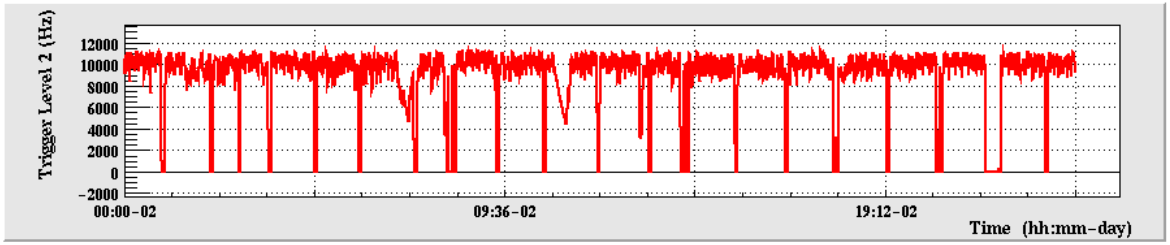


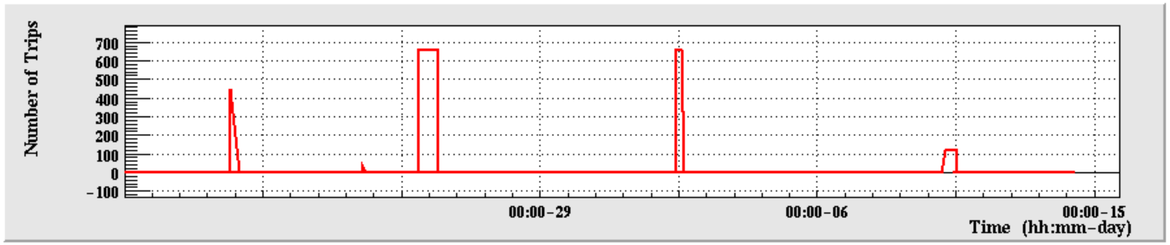




Also beam losses can produce high irradiation levels in the detector

On average, we observe three losses of beams (total or partial) per day which cause major DC trips (for which therefore we see that a relevant amount of charge is dumped inside KLOE-2)



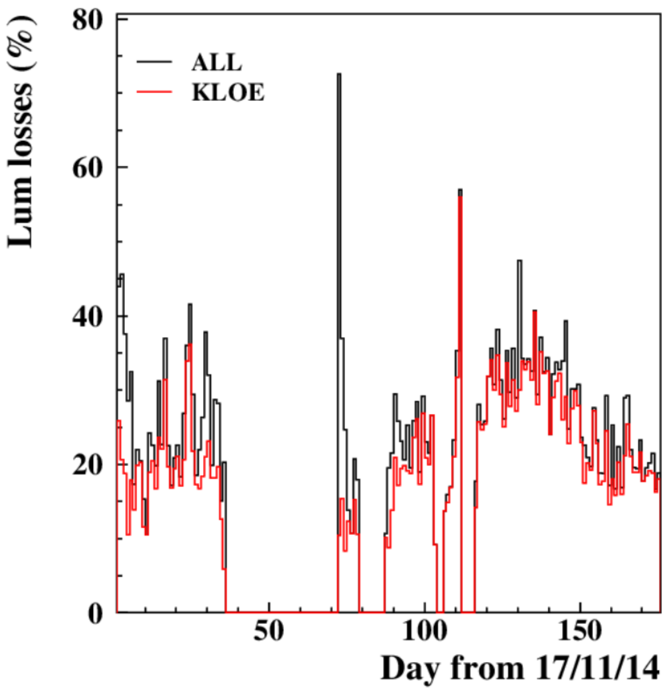


In one of these occasions, on April 10 («Tsunami event») we have lost HV sectors of the IT which translates in a further 5% of the dead strips of the IT in one shot!

At present we do not have an easy method to prevent the occurrence of these rare but potentially highly destructive events

Trips of the DC cause also a loss of acquired luminosity, since it takes time (in some cases up to 20 minutes) to recover from them and restore «normal» useful data taking conditions

This effect however explains only a small part of the observed difference between delivered and acquired luminosity that at present is of about 20% but has been higher in the past



The black curve corresponds to the daily percent loss of luminosity of KLOE-2. The red one corresponds to the same quantity referred to «good» operating conditions

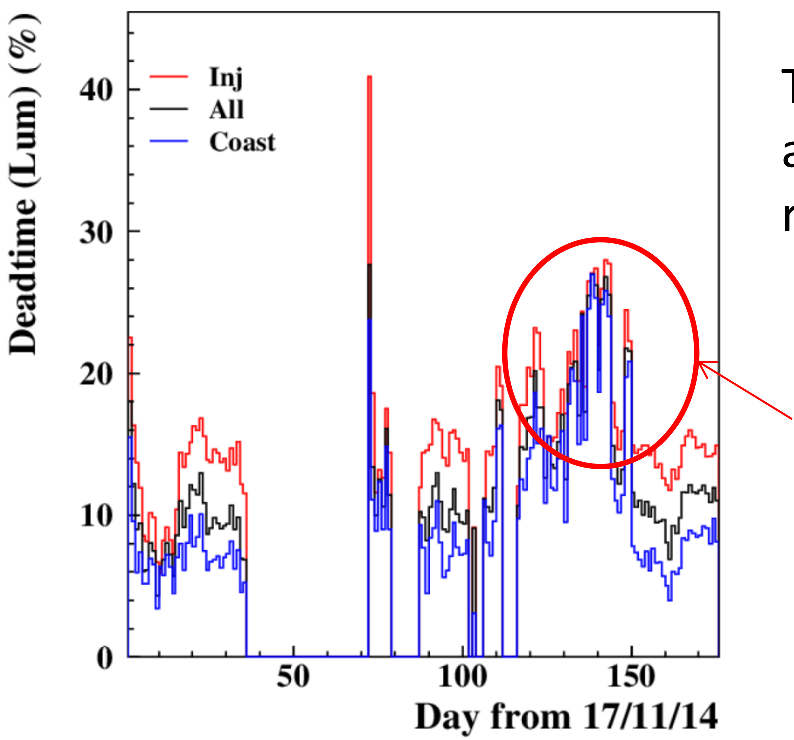
~ 4% of downtime is due to beam losses

~ 6% is due to run change operations. This is expected to improve now having we recently increased the run change prescription from 500 to 800 nb^{-1}

The remaining ~10% loss is due to dead-time.

This has a first intrinsic component which increases linearly with trigger rate, it is 4% at 10 kHz

A second component is related to injections, during which DAQ is vetoed for 10% of the time (more in terms of luminosity) to avoid high background events. About 40% of DAΦNE operations is injection

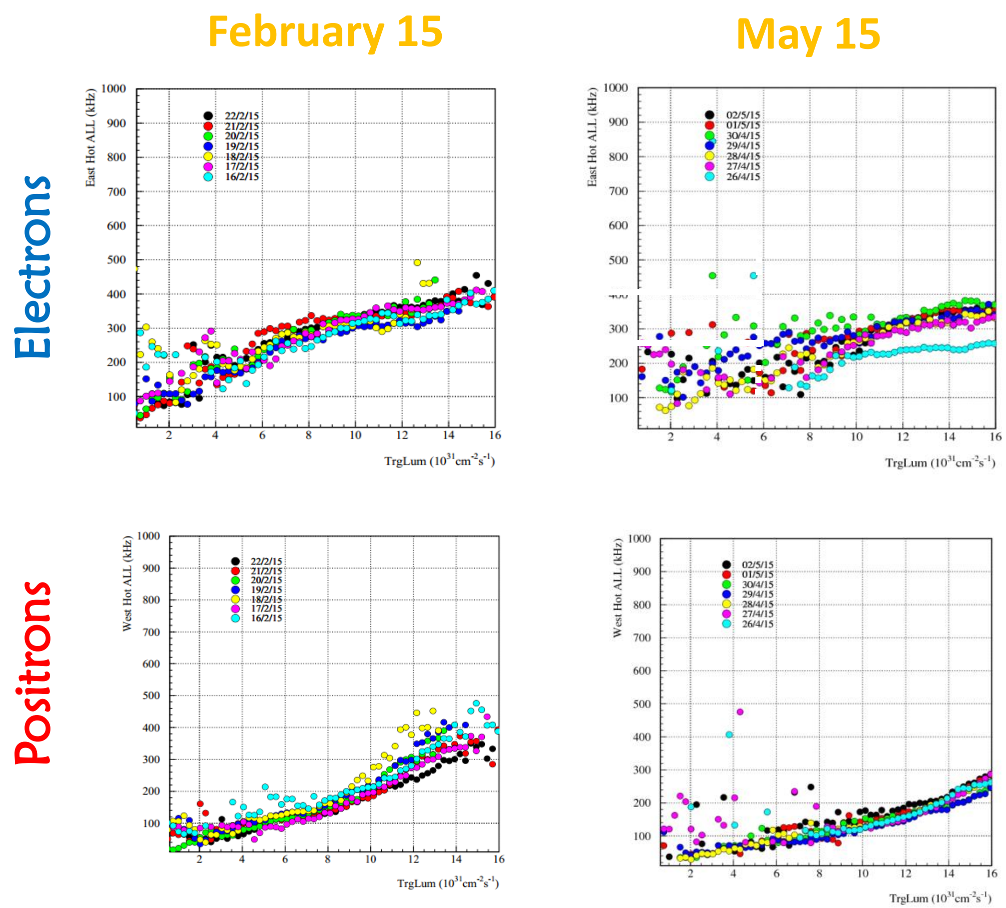


The rest is due to possible busy signals asserted by the DAQ system for various reasons

In fact we have experienced a period of sizeable dead-times, due to a very subtle malfunctioning of one DAQ farm which drove us nuts for a couple of weeks

As often reported in the past, background levels also during «safe and stable» operations are sizeably higher with respect to the old KLOE

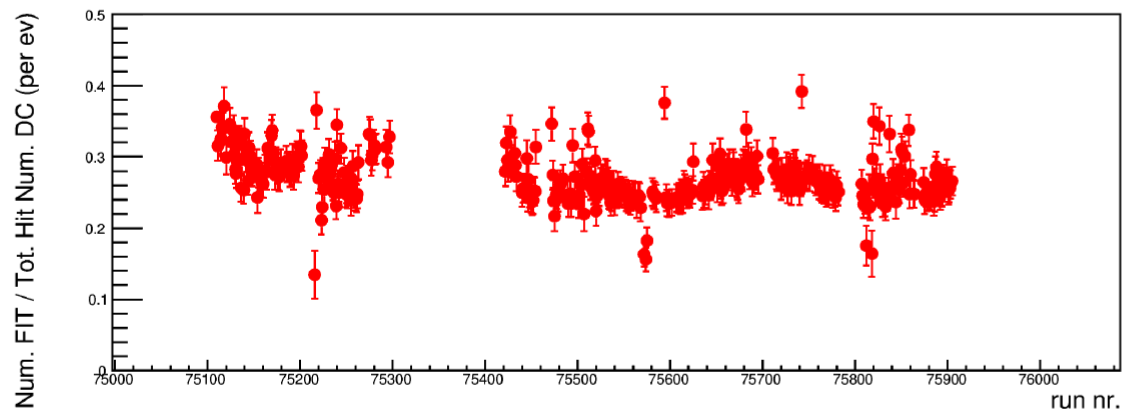
Thanks to a long and fruitful work in collaboration with the DAΦNE team, we have reached a compromise situation in which the machine is able to keep the backgrounds at an «acceptable» level while still delivering high luminosity collisions



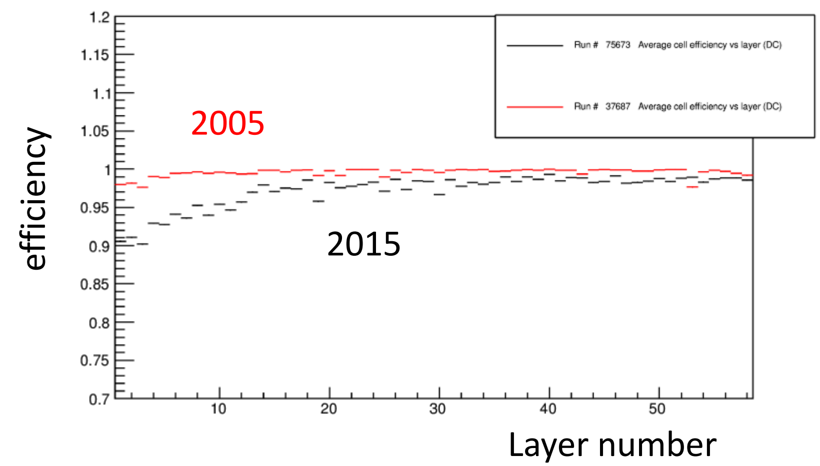
I would like to underline that this condition still corresponds to an increase of a factor at least 5-6 of the backgrounds with respect to 2005

This has obvious consequences on the quality of the data

For instance, the percentage of DC hits belonging to a track has substantially decreased with respect to 2005, where it was close to 90%

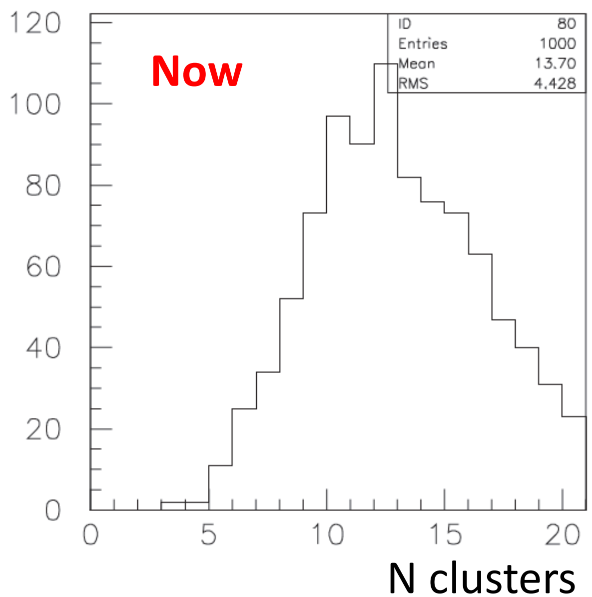


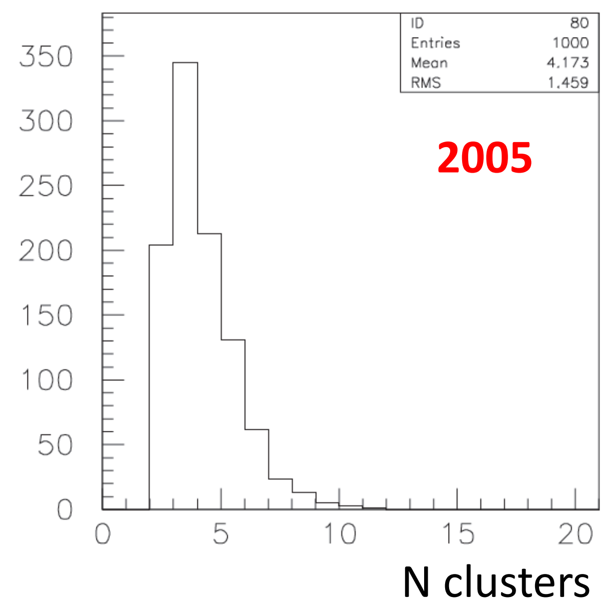
Also, we have decided to operate the DC at a lower voltage, which translates to a slightly lower efficiency, particularly for the innermost layers



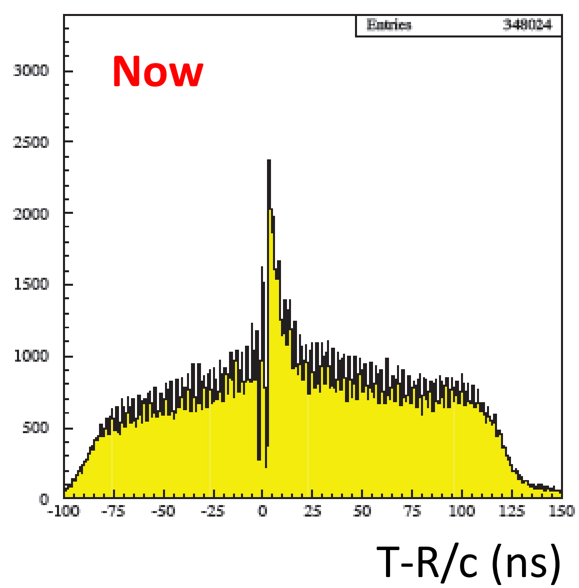
On the other hand, the «quality» of the tracks as measured by the averaged residuals on a run by run basis is at the level of 2005

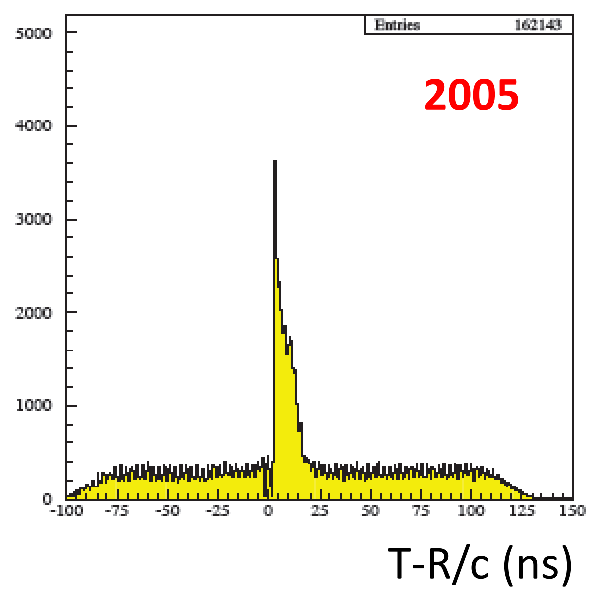
The effect on the calorimeter is clearly seen by studying Bhabha scattering events





The multiplicity of clusters of energy > 7 MeV associated to the event has increased by a factor of > 3



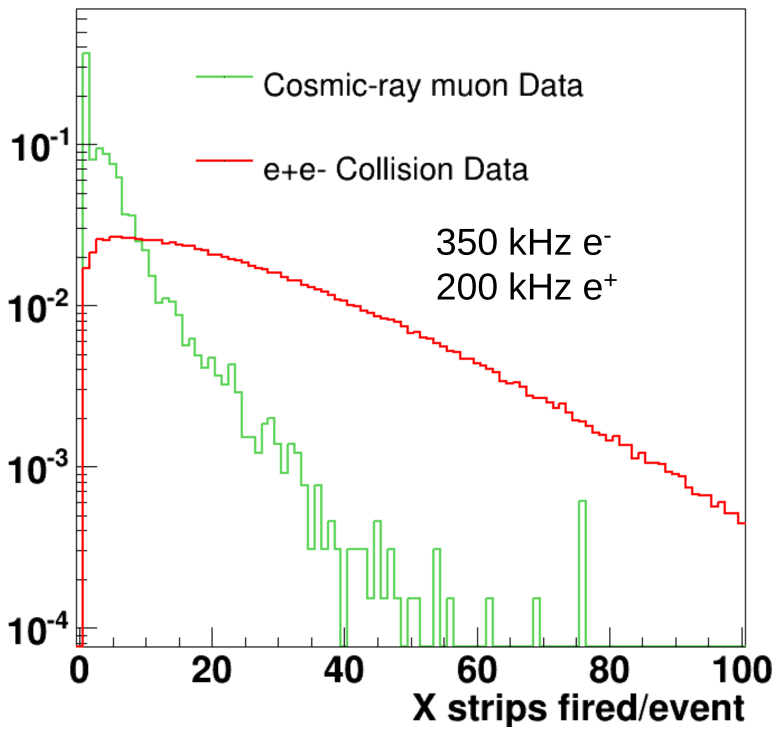


From out of time clusters, i.e. T-R/c = -20 ÷ -60 ns the fraction of accidentals in TW is

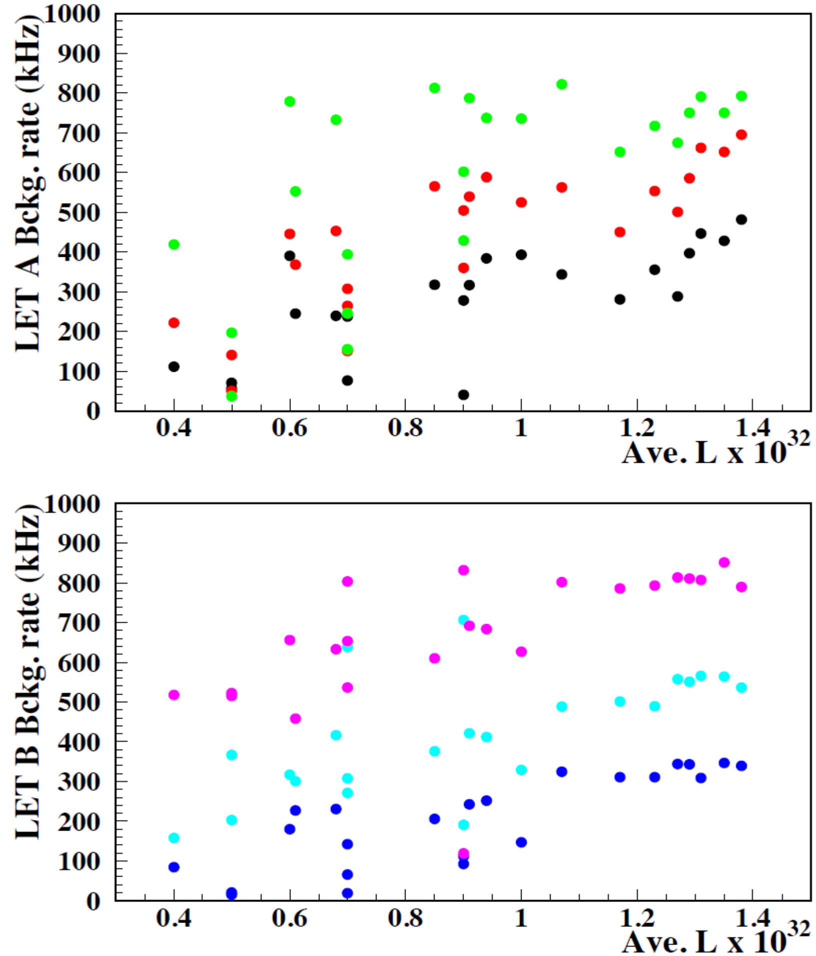
Acci(2005) = 10%
Acci(2014) = 120%

Also the new detectors are suffering of high backgrounds

Hit multiplicity of IT Layer 1



Counting rate for three crystals of LET A and B



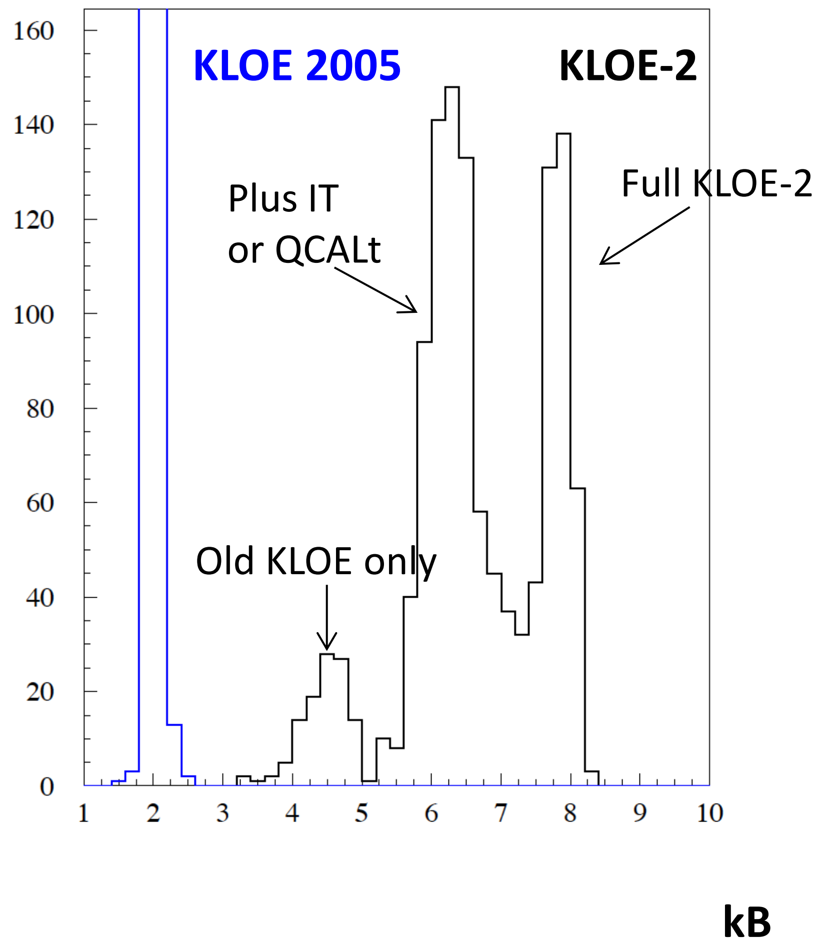
However the most worrying feature connected to the background issue is the fact that the data throughput has increased by a factor 13 with respect to the old KLOE

Backgrounds contribute to the increase of both the event size and of the trigger rate

Events size was 2.1 kB in 2005
It has become 8 kB in 2015

Trigger rate was 3 kHz in 2005
It has become 10 kHz in 2015

Data volume for 1 fb^{-1} was 46 TB
It has become 550 TB in 2015



We are considering different possible actions to be taken to cope with this problem

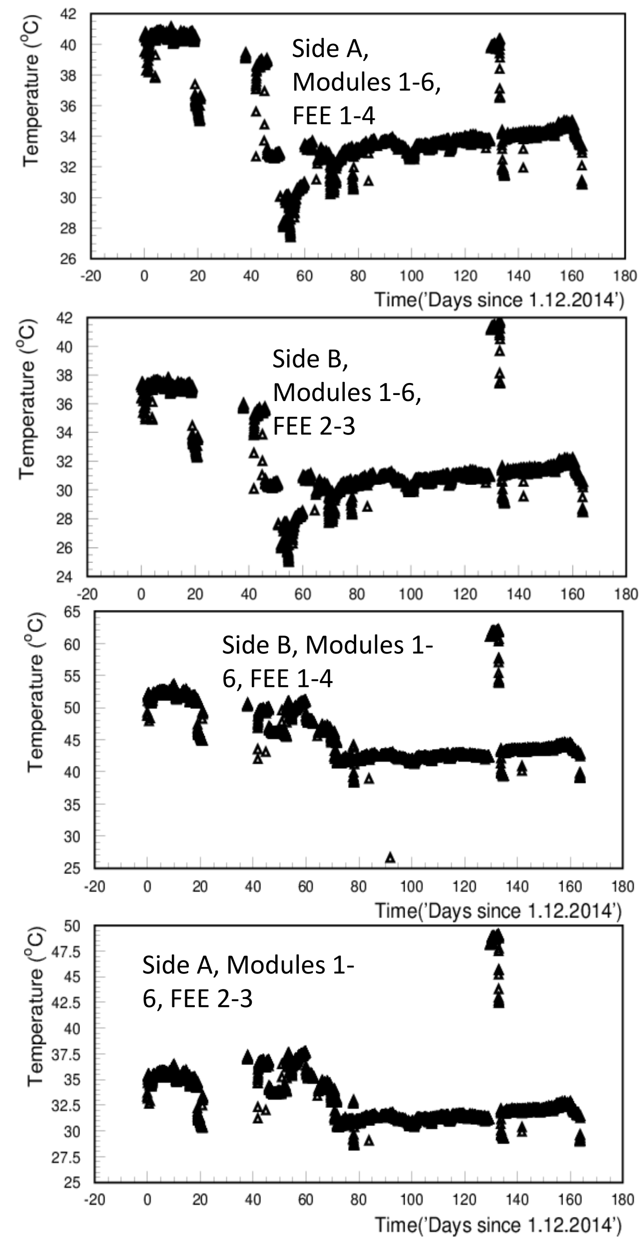
- Increase the zero suppression window of the EmC
- Increase the trigger thresholds, in particular in the forward region. If we trigger on barrel only we almost halve the trigger rate
- Search and reduce possible electronics noise
- Implement a real level 3 filter to try to reject software at least part of the machine background events

All of this is technically feasible, the first two points even trivial. However the real point is to make a serious study on the consequences on physics that these action can have. We are aware of the importance of this item and are trying to set up a dedicated task force to efficiently and rapidly give us answers. However finding the necessary manpower is a big issue.

The first months of run have been largely devoted to the commissioning of the new subdetectors and to the solution of unexpected problems showing up during collision operations.

This has implied among other things:

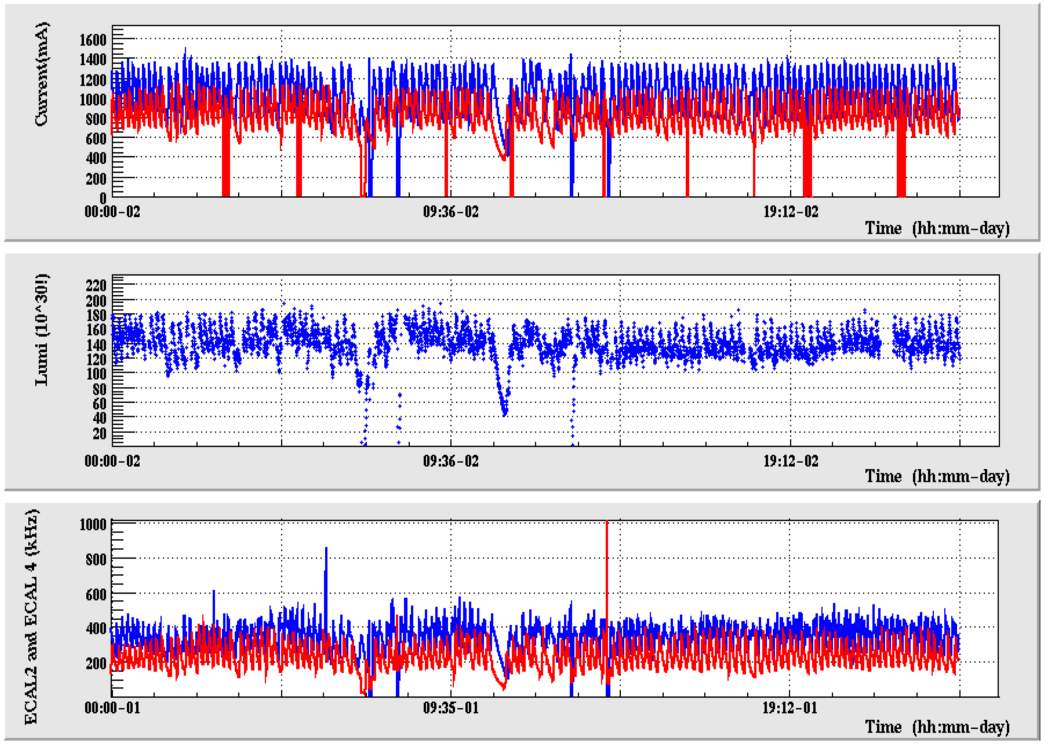
- Modification of some front-end firmware to prevent DAQ crashes due to big «splash» events
- Increase of the cooling power towards the innermost detectors to beat a temperature issue particularly relevant for QCALt
- Re-writing the calibration procedures to cope with the new background conditions
- Improvement of the automated control of the new subdetectors
- Definition of the optimal working point of the new subdetectors



Although many things need to be improved, we are now stably taking data with all subdetectors in since more than one month. In other words, KLOE-2 is fully operational. This is due to the dedicated efforts of a relatively small «crew» of of people to whom goes my biggest thank and appreciation

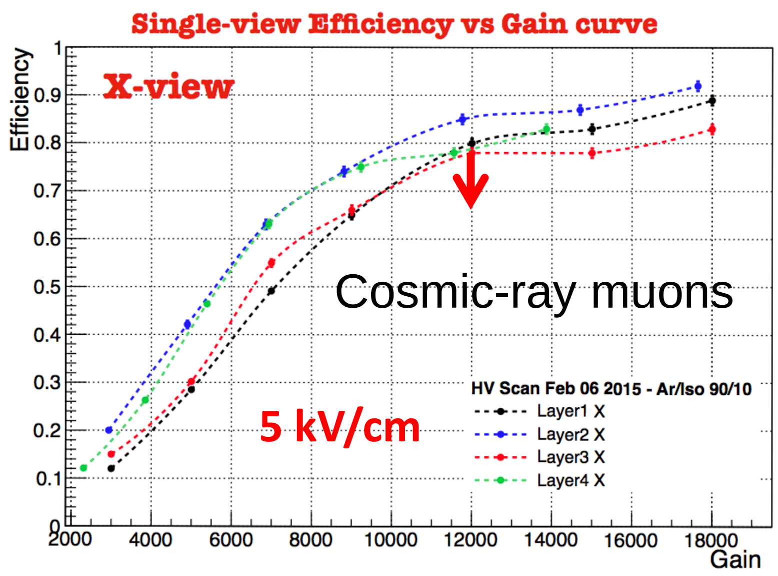
Best Day

2 May 2015
Delivered lumi: 12 pb^{-1}
Acquired lumi: 9.5 pb^{-1}
Peak lumi: 2 x 10^{32}



There are pending problems, though.

- Some old FEE component of the calorimeter and of the trigger have started showing their age. This is dangerous because a) we're running out of spares b) most of this hardware is now obsolete and difficult if not impossible to procure. We have started a campaign of «spare components recovery», we hope for the best still i'm very concerned
- An unexpected high rate of shorts occurrences in the IT is observed, mainly but not only triggered by high irradiation levels (see next slide)
- We are short in manpower to study and optimize detector's performance, to qualify data for physics, to develope reconstruction/simulation software required by the new data taking conditions (see later on)



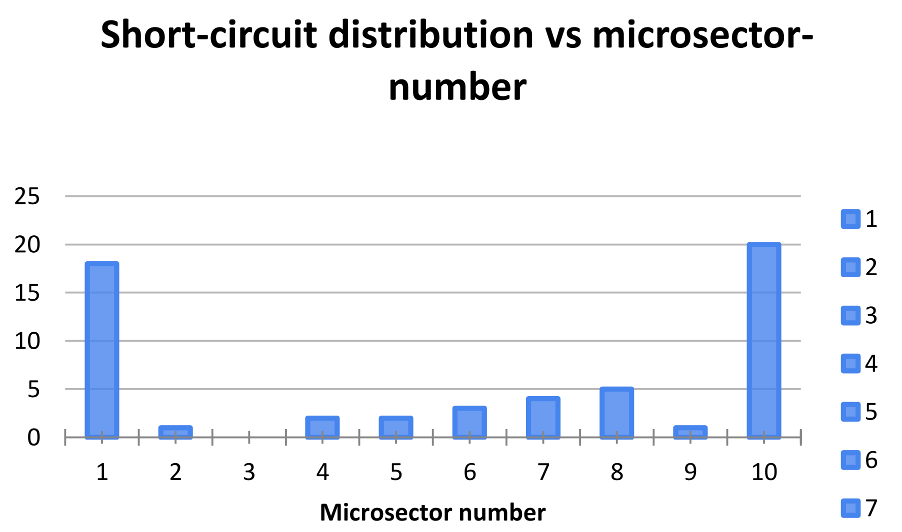
We initially operated the IT at a 12 k gain with 5 kV/cm induction field and an Ar-Isobutane 90-10% gas mixture

Now we work at 6 kV/cm, with the same bias voltages which has increased detection efficiency to 95% while keeping discharge probability at the same level as before

Each GEM foil is divided into 4 sectors each one divided into 10 microsectors

We observe an insofar unexplained accumulation of shorts at the edges

A change in the HV supply scheme is programmed to become safer with respect to this problem



Being able to take under control some basic physics quantities to monitor the quality of the data is obviously extremely important

We had to rearrange old KLOE tools to the new situation (new materials, different background conditions) to provide some of these essential counters

We provide regularly DAΦNE with basic informations such as the luminous point, the center-of-mass energy, as well as the luminosity of the collisions

Some physics counters connected, for instance, to Bhabha, $e^+e^- \rightarrow \gamma\gamma$ events are also regularly produced. However, we need still to understand their correct normalization

Based on what we have observed so far, what conclusion can be drawn? What are the perspectives and the concerns for a successful KLOE-2 run, fulfilling the minimum requests of 2012?

- DAΦNE can deliver something around 60 pb^{-1}/week of data, of which KLOE-2 is able to use ~50 pb^{-1}
- This points to the need of running order 2.5-3 solar years to reach the milestone of minimum 5 fb^{-1}
- Running conditions are more difficult than originally, and maybe too naively, thought at the beginning of KLOE-2
- All of this implies a huge human effort for which the present KLOE-2 manpower resources are barely sufficient now and are critical on a longer term

As of today, KLOE-2 is a Collaboration of 60 people (it was 72 in 2010), with the typical distribution of competences and dedication to the experiment

Actually we can count about 20 people who, besides taking shift, participate effectively to the data taking effort in different ways, being heavily present in the control room

Of these, during the last six months, 2 postdocs working on the new subdetectors have moved (or are moving) to other experiments while a third one, DAQ expert, will move to the AD soon. A fourth very important person is presently funded with «TARI» money who will not be available anymore starting from next summer

TARI has been a very important source of financial resources for travel for our foreign collaborators. Although all of these Institutions will be able to use internal resources for the purpose in the future, it is clear that we will have less manpower availability «in situ»

In a few words, we need more people to spend a consistent part of their time devoted to detector’s operations

On the basis of a preliminary but rather detailed internal discussion these «positions» amount to about 10 people

Only a minor part of them can be found inside the Collaboration. We need an injection of new blood which we ask the Laboratory to help us finding

It is important to note that some of these positions require rather high skills in crucial areas. We need at least

- One or two DAQ experts to follow the data taking and improve on the automated operations
- Two software experts to (finally) start the migration of our software towards new platforms. This operation was recommended repeatedly by our CSN1 referees, and delayed because of the uncertainties of the plans
- A few postdocs to closely follow the detector’s performance and the data quality

Conclusions:

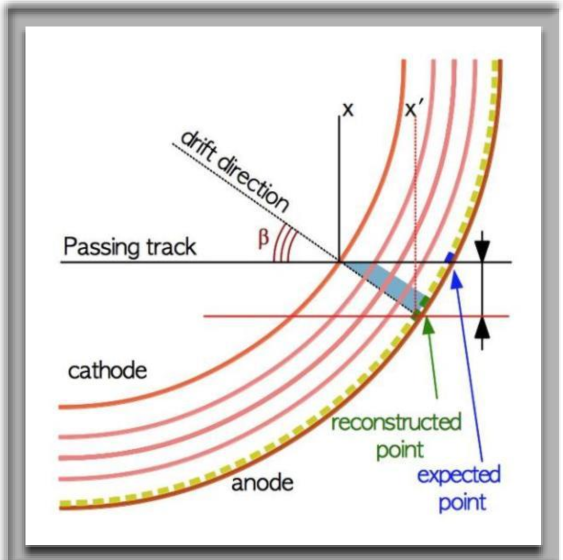
- We would like to congratulate once more our DAΦNE colleagues for the big progress achieved in terms of delivered luminosity and stability of operation of the machine
- Thanks to a long period of hard work, KLOE-2 is now stably taking data with all the subdetectors in
- Still there is a lot of work to be done in order to cope with the current running conditions, which are very challenging, and to be able to extract «physics» from the data
- Assuming the present luminosity performance, the road towards the minimum KLOE-2 milestone implies three years of hard work and full dedication to data taking issues
- We therefore have the absolute need of strengthening our manpower availability and ask the Laboratory and INFN to help us finding it

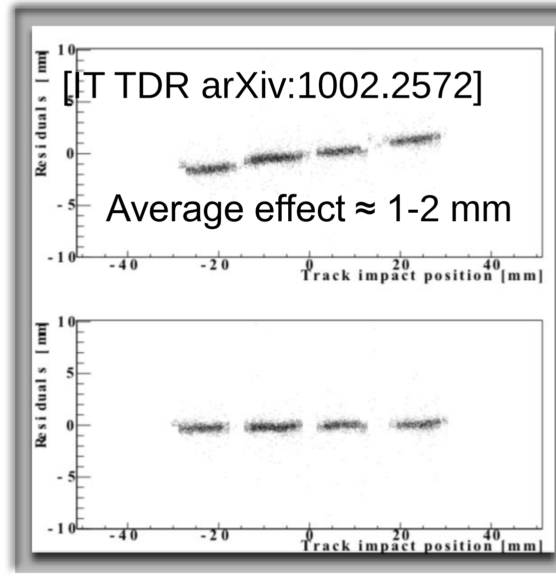
Spares

IT Alignment & Calibration (I)

1. NON-RADIAL TRACKS

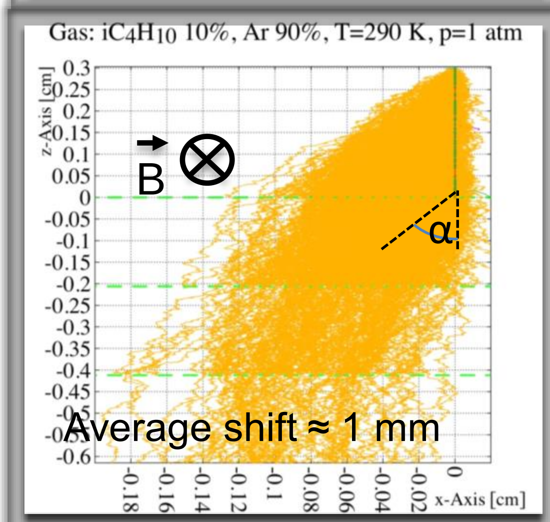
The angle formed by a track and the orthogonal to the cathode influences the reconstruction at two levels: **shift & spread**

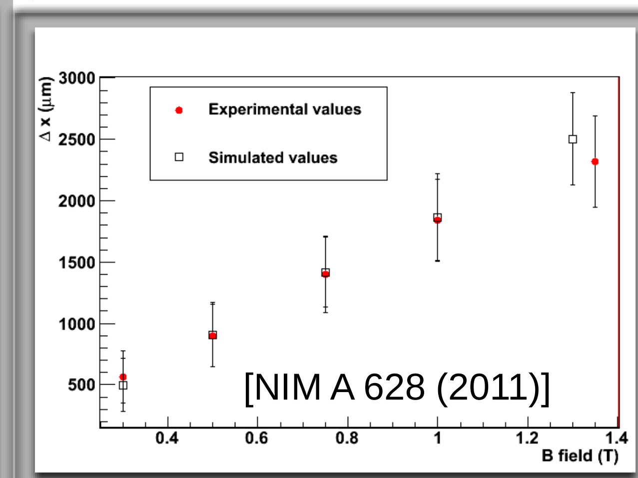




2. MAGNETIC FIELD

KLOE-2 0.52 T magnetic field is orthogonal to the electric fields of the triple-GEMs, introducing two effects: a **shift** $\Delta x(\alpha_L)$ and consequently a **larger spread of the electron cloud.**





- Cosmic-ray muons, w/wout B-field & Bhabha scattering to evaluate two effects
- Reconstruction Software integration within official framework

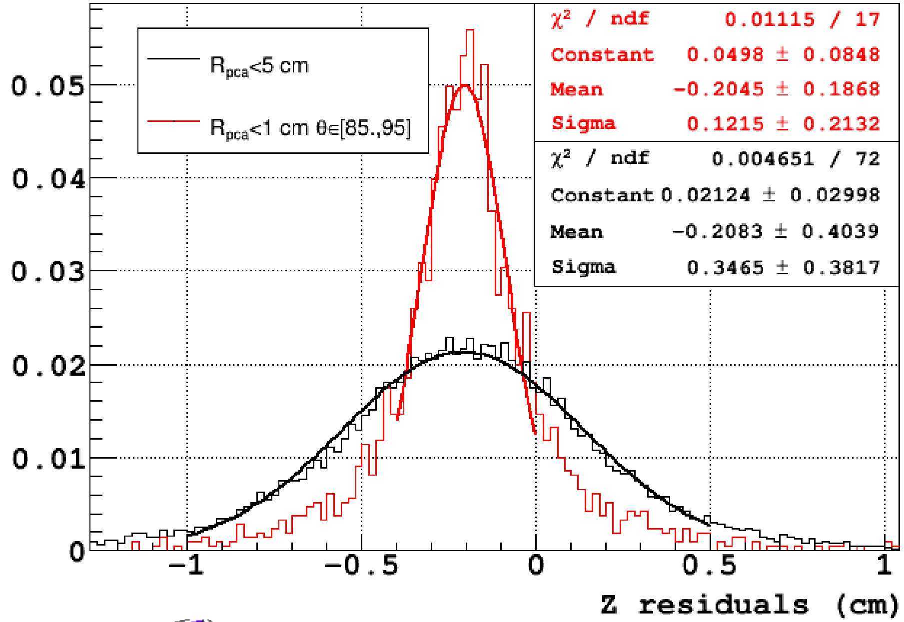
IT Alignment & Calibration (II)

1. COSMIC-RAY MUONS (B=0)

Tracks from DC with R_{PCA} < 5 cm.
Preliminary results on improvement on z residuals by applying a selection for radial tracks (R_{PCA} < 1 cm & θ in [85°, 95°]) :

σ_z = **3.4 mm => 1.2 mm**

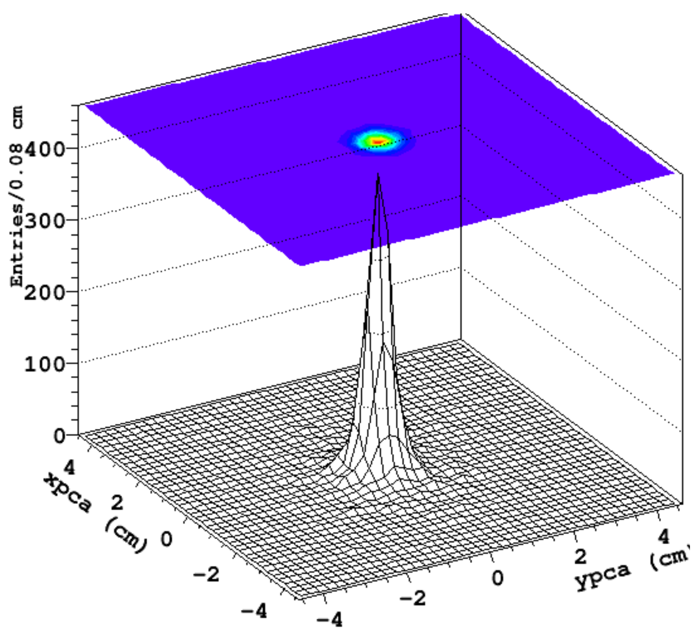
without alignment correction and calibration for B-field & non-radial tracks

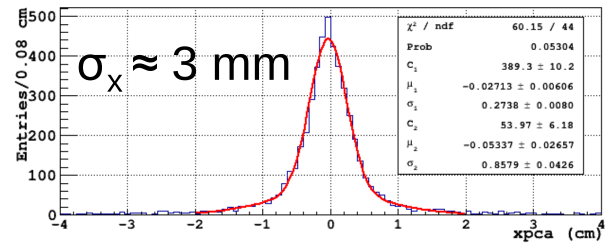


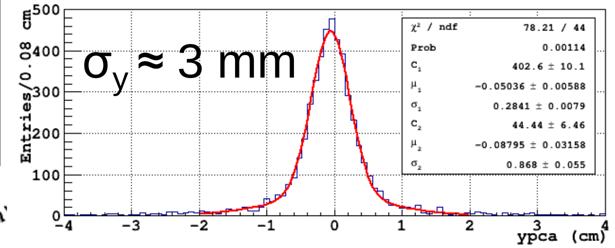
2. BHABHA SCATTERING

Preliminary Point of Closest Approach (PCA) of the track to beam-line

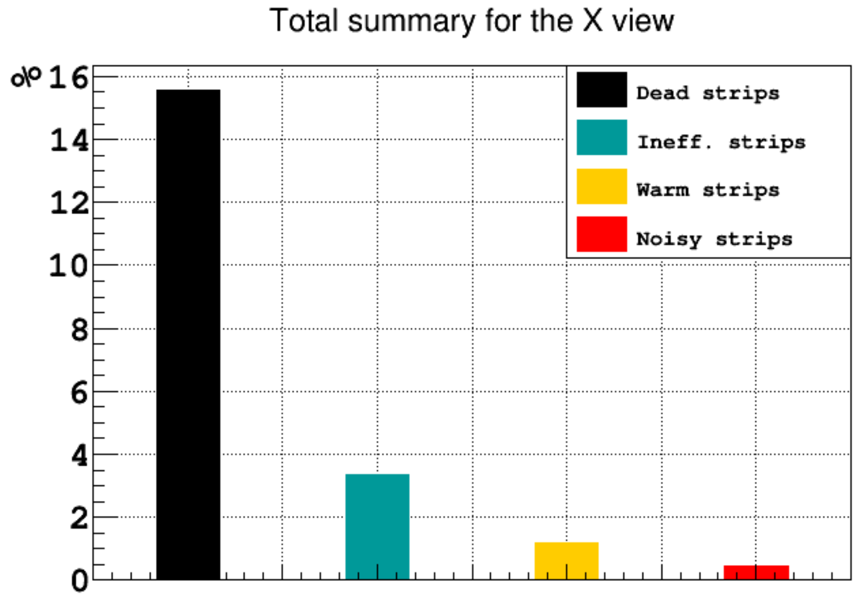
without alignment correction and calibration for B-field & non-radial tracks

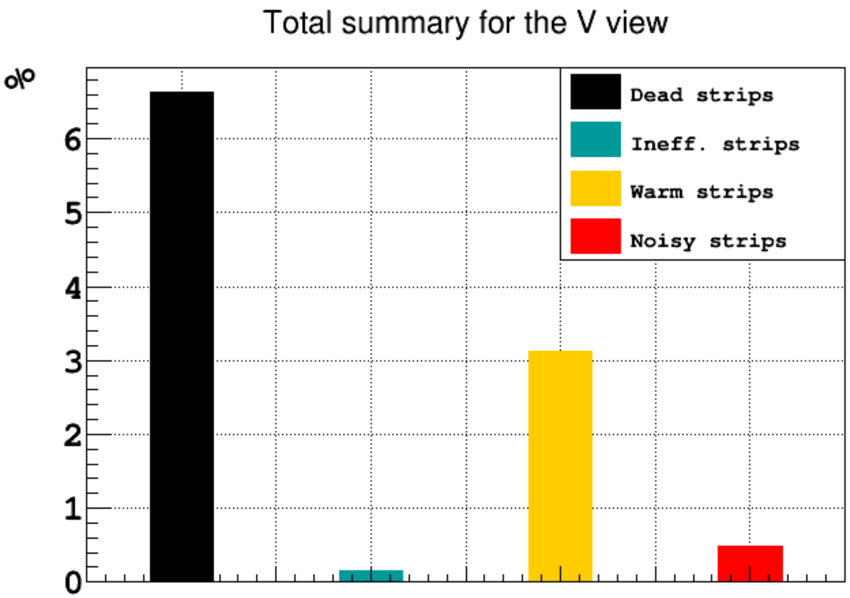






IT Detector Status (I)





1. Overall status also accounting for broken cables & FEE boards

2. **Single event beam loss "Tsunami" on April 10th caused 30% more dead strips:**

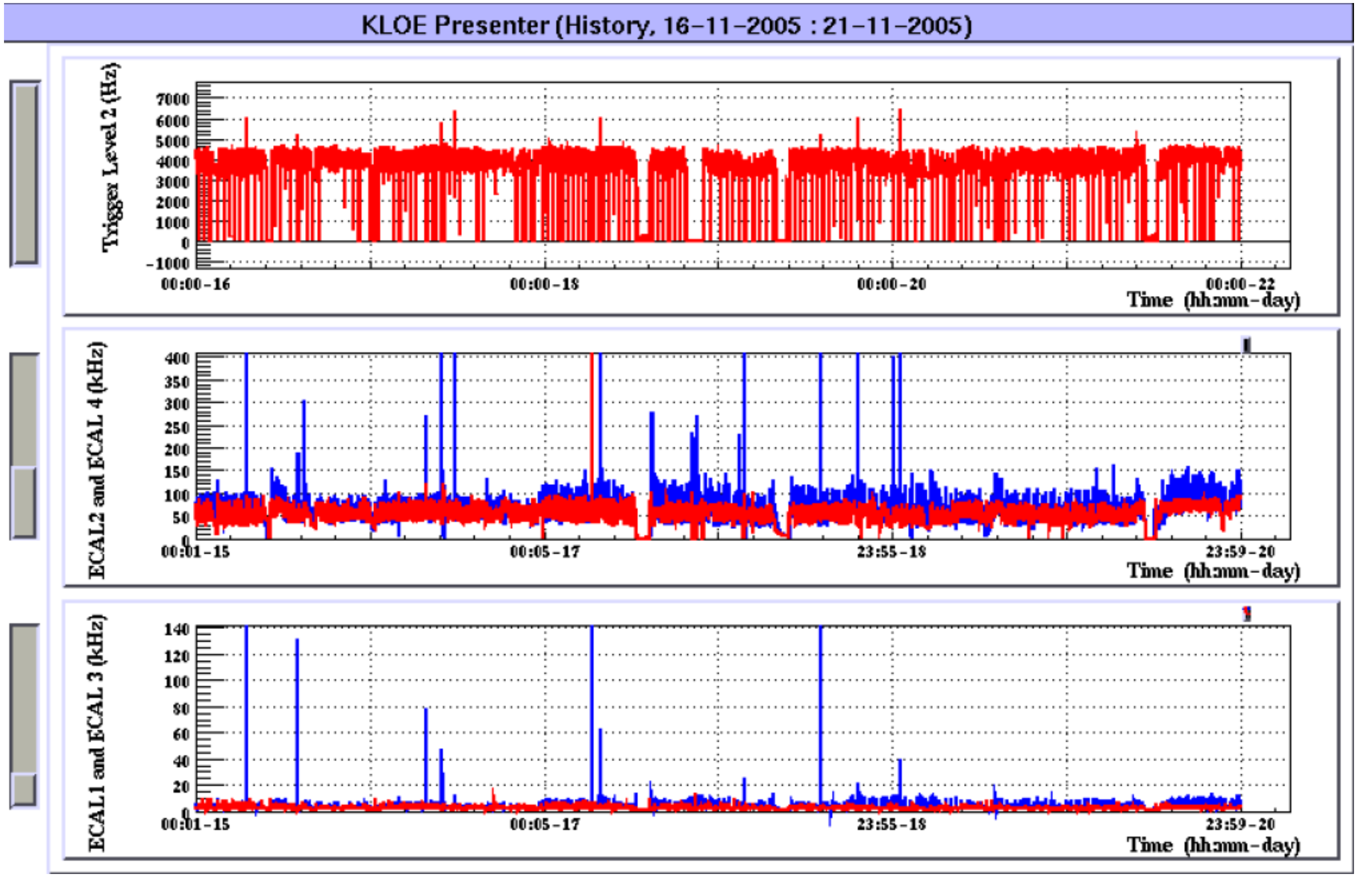
   Dead X Strips from 11% to 15.5%

   Dead V Strips from 6% to 6.5%

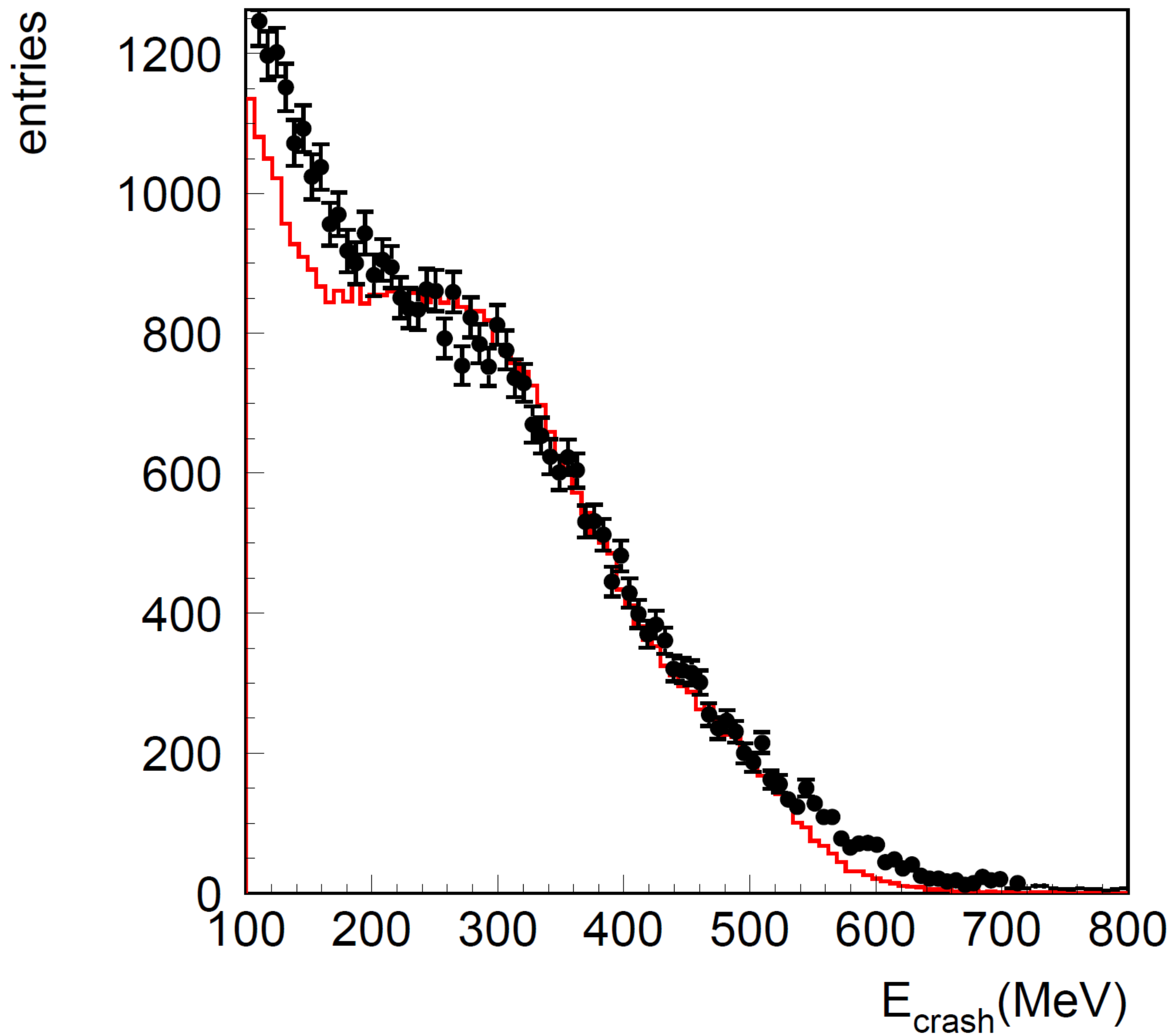
3. **5% of Total HV Sectors are presently disconnected**

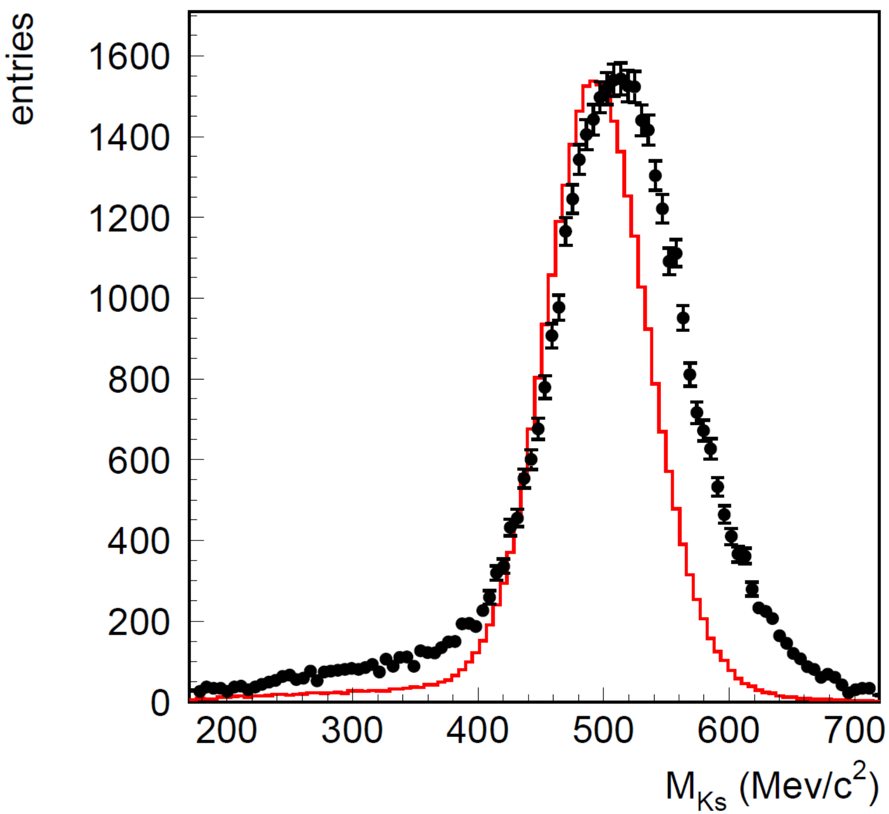
   53 micro-sectors/1140 (*)

(*) not accounting for 1/3 part of Layer #3 disconnected since the beginning



KLOE Presenter (History, 16-11-2005 : 21-11-2005)
Trigger Level 2 (Hz)
7000
6000
5000
4000
3000
2000
1000
0
-1000
00:00-16
00:00-18
00:00-20
00:00-22
Time (hh:mm-day)
ECAL2 and ECAL 4 (kHz)
400
350
300
250
200
150
100
50
0
00:01-15
00:05-17
23:55-18
23:59-20
Time (hh:mm-day)
ECAL1 and ECAL 3 (kHz)
140
120
100
80
60
40
20
0
00:01-15
00:05-17
23:55-18
23:59-20
Time (hh:mm-day)


entries
1200
1000
800
600
400
200
0
100
200
300
400
500
600
700
800
E_{crash}(MeV)

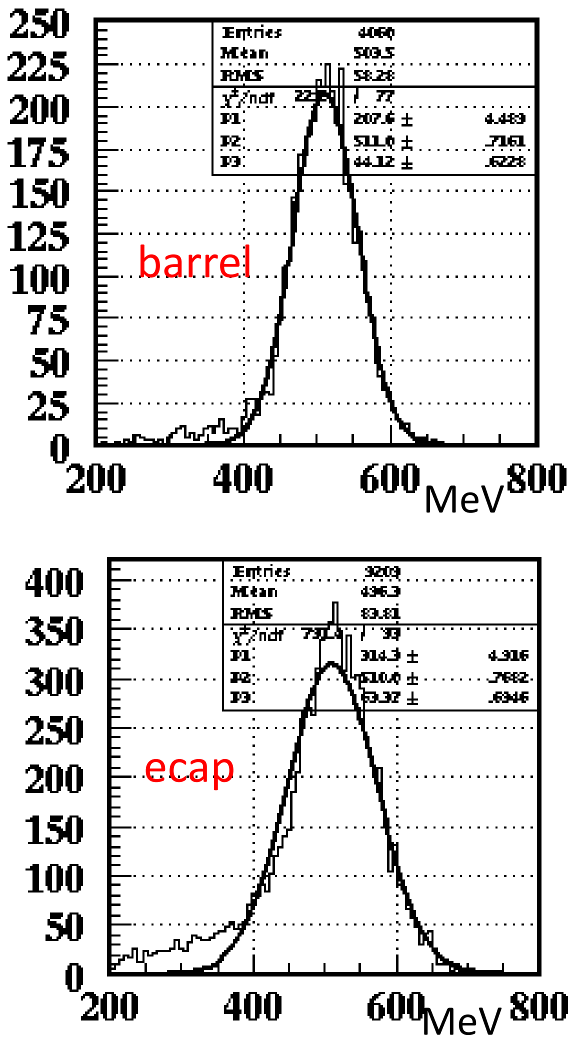


entries
1600
1400
1200
1000
800
600
400
200
0
200
300
400
500
600
700
M_Ks (Mev/c^2)

Calorimeter calibration (γγ events)

Despite the higher background level the calibration accuracy is at the level of KLOE1.

510 MeV photon energy



$T_\gamma - R_\gamma/c$