Crab waist @ DAFNE: The detector experience

Caterina Bloise on behalf of the KLOE-2 Collaboration

LNF-INFN, Italy

FCC-ee (TLEP) Joint Accelerator-Physics Vidyo meeting

June 29, 2015

Outline

- KLOE-2 detector and trigger
- Monitoring DAFNE performance
- Data taking conditions and comparison with data in year 2004-2005
- Conclusions

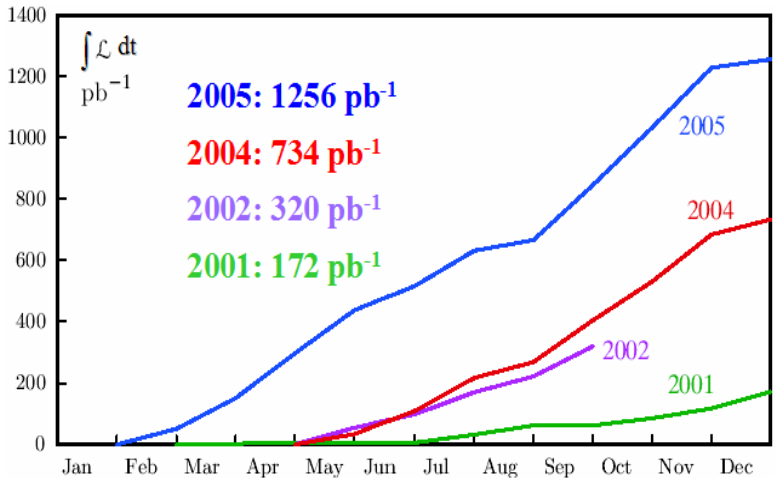
KLOE-2

The KLOE experiment, at the Dafne ϕ-factory took data in 2001-2002 and 2004-2006

2.5 fb^{-1} integrated at 1.02 GeV;
250 pb^{-1} at 1 GeV (off-peak data)

Excellent-quality data set for precision measurement on:

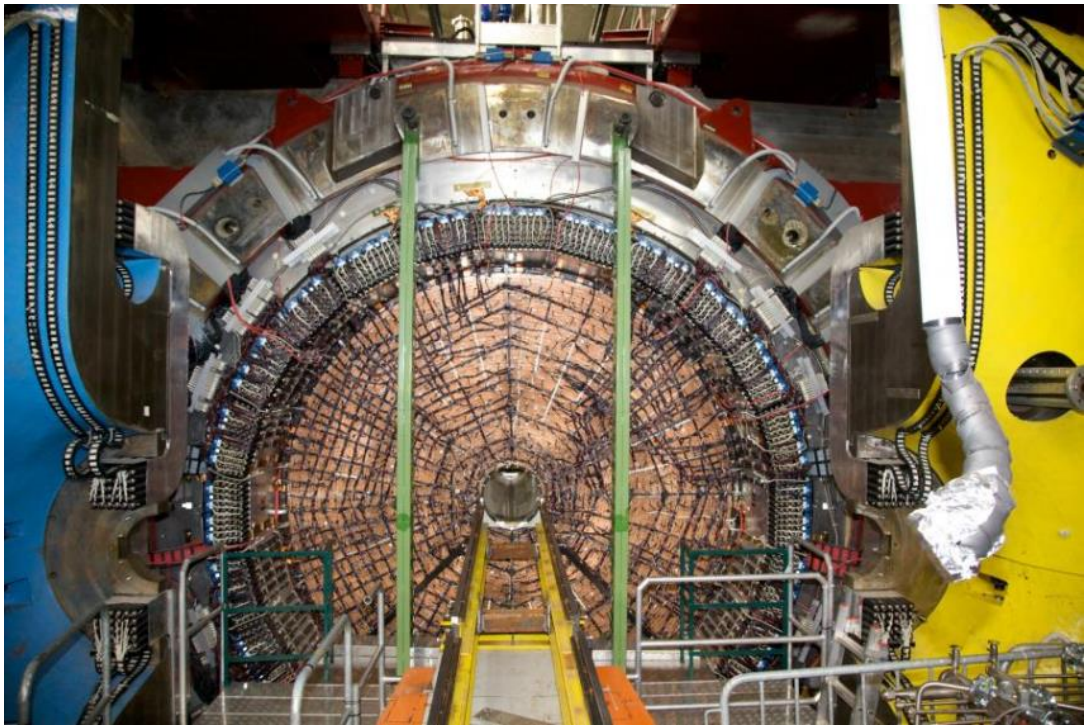
- CKM unitarity
- QM, and CPT invariance;
- CP in kaons;
- QCD models based on ChPT;
- isospin-violating decays for the measurement of the light quark masses ratio;
- hadronic cross section for the calculation of HVP
- $\gamma\gamma$ physics
- Dark photon searches



New data taking goal is to integrate 5 fb^{-1} during 2015-17 for the physics program in EPJ C68, 619

For the physics run the detector has been upgraded with taggers for $\gamma\gamma$ physics, the inner tracker and calorimeters at low polar angle

KLOE detector



Drift Chamber

$\sigma_p/p \cong 0.4$ %

(tracks with $\theta > 45°$)

$\sigma_x^{hit} \cong 150$ mm (xy), 2 mm (z)

$\sigma_x^{vertex} \sim 1$ mm

Calorimeter

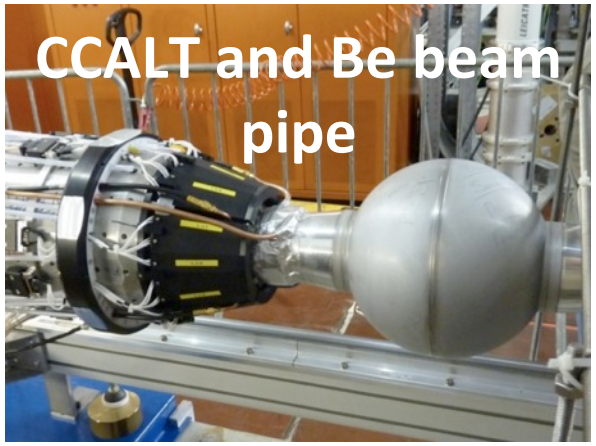
Both side read-out (PM)

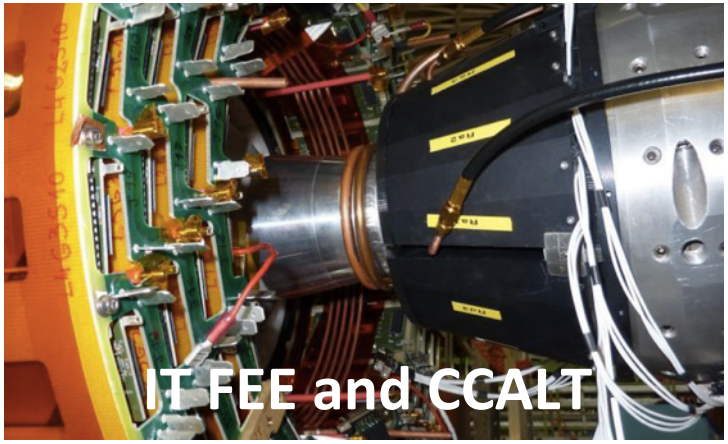
98% solid angle coverage

$\sigma_E/E \cong 5.7\% /\sqrt{E(GeV)}$

$\sigma_t \cong 54$ ps $/\sqrt{E(GeV)} \oplus 50$ ps

Detector upgrades

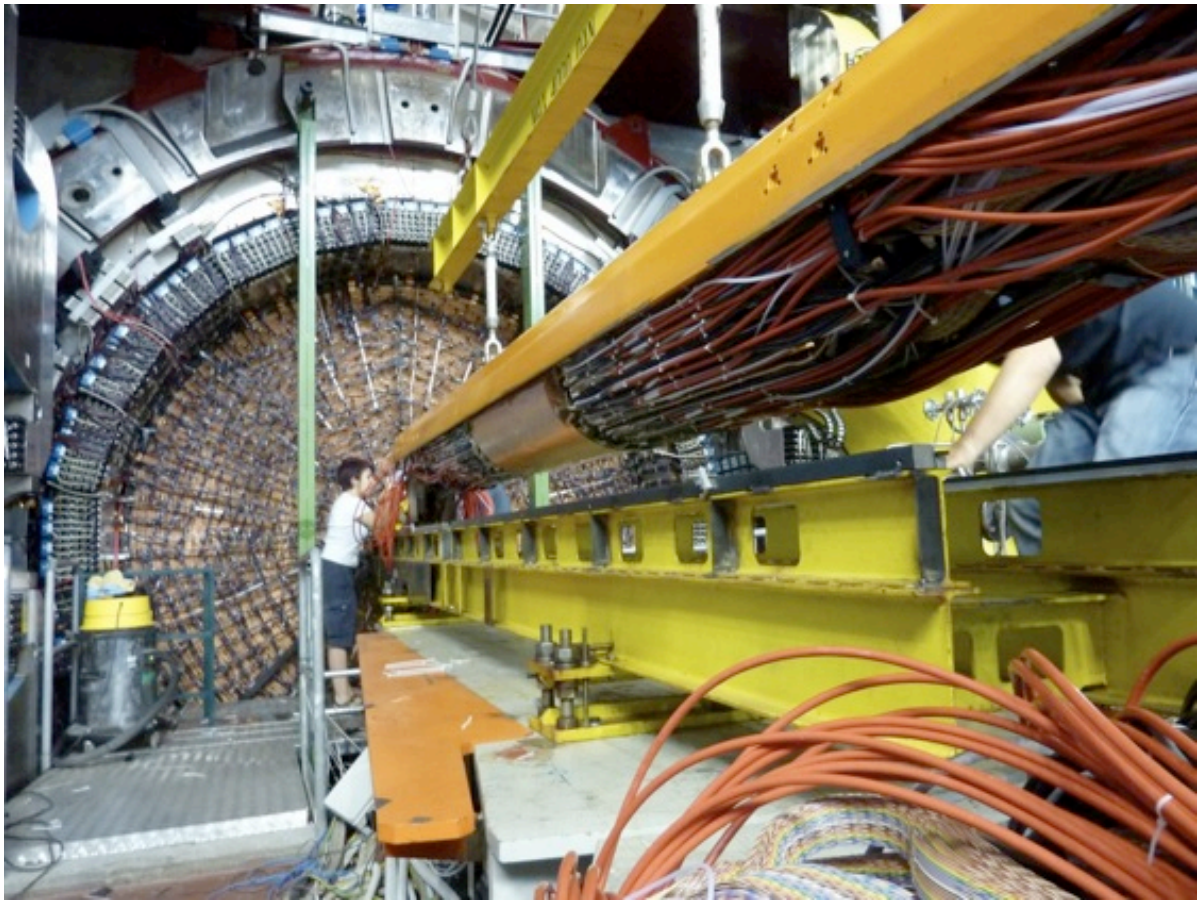




- 4 tagger stations with e^+/e^- detectors for $\gamma - \gamma$ physics
- The inner tracker, cylindrical 3-GEM, for improving vertex resolution near the IR
- The calorimeters, CCALT (lyso-crystals) and QCALT (scintillator tiles and fibers readout by SiPM), to improve the acceptance at low polar angle and to instrument the final focusing region

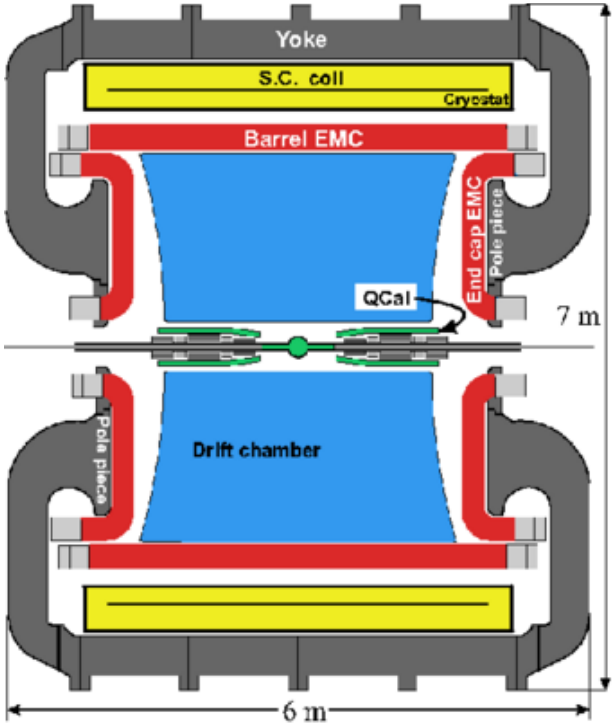
Detector upgrades

Integration and installation on the beam line successfully completed in 2013



- Global integration in progress
  - DAQ and Slow-control
  - MCarlo
  - Reconstruction

Event Time structure



Detector and trigger conditions for the acquisition of all of the collision final states

At 1.02 GeV from DAQ side the events are

- prompt : continuum, radiative ϕ decays, early decays of K_L ($K^{\pm}$)

- non-prompt : $\beta(K_L) = 0.2$ and the decays can be delayed of 40 ns

- DAFNE bunch crossings : every 2.7 ns

2005 Run conditions

Operation at DAFNE was very stable

injections every 15 min

DC operation smooth

Triggers from intra-bunch scattering < 0.5 kHz

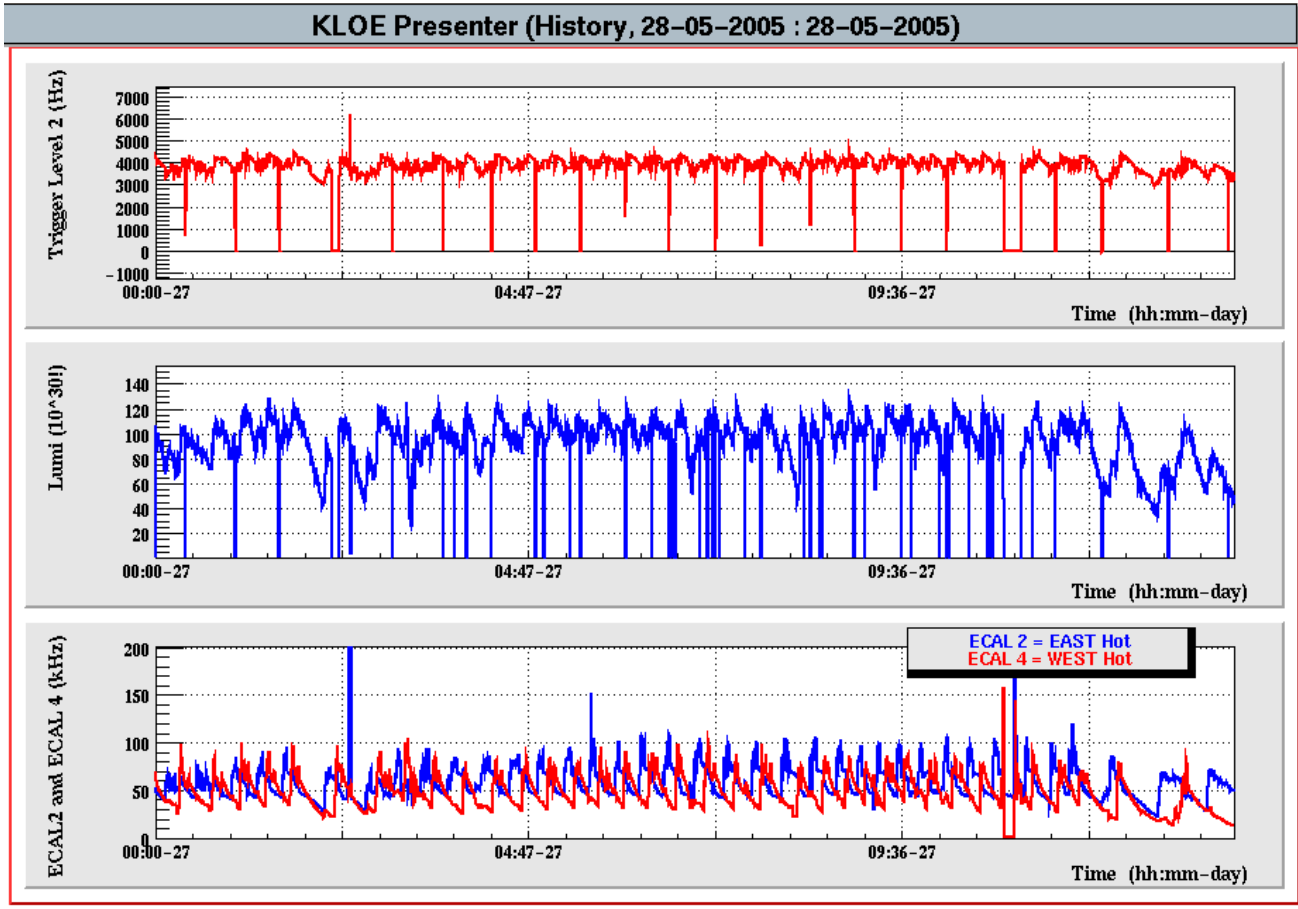
Typical Conditions:

T2 rate ~ 4 kHz,

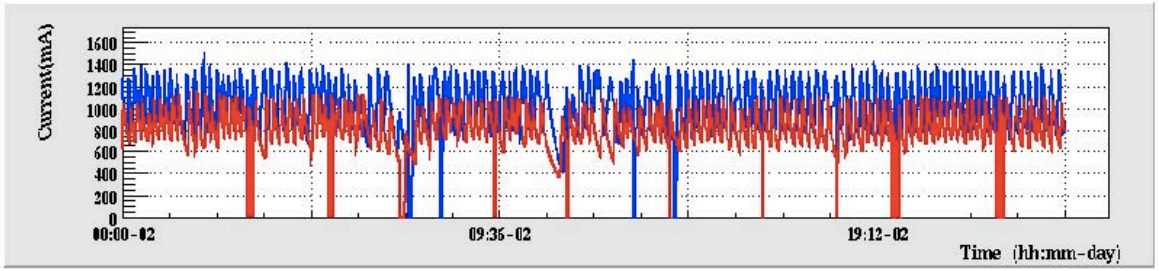
Lumi ~ 10^{32},

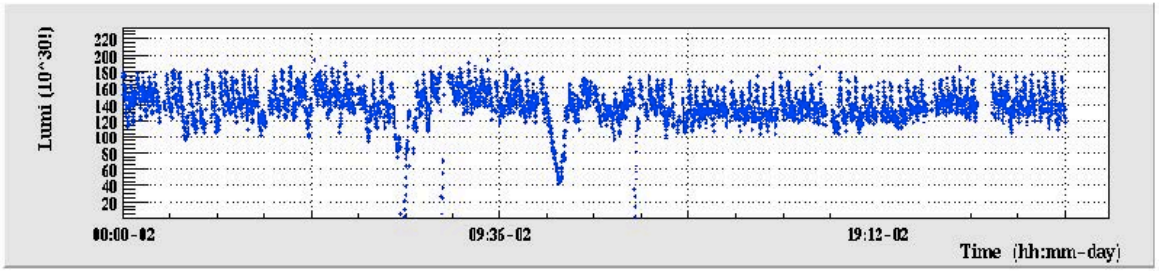
EndCap rates < 100 kHz

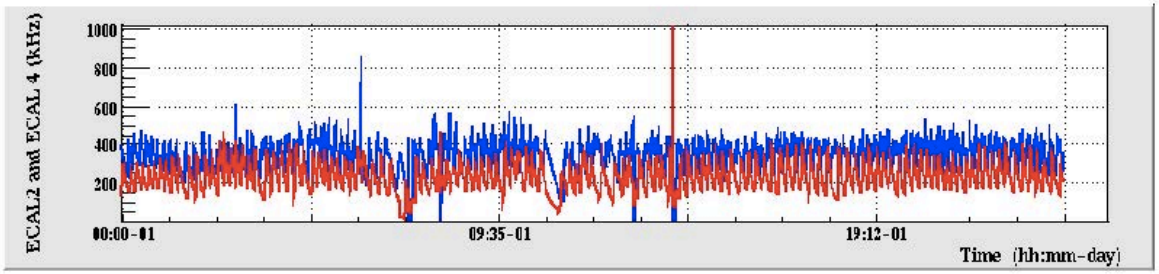
Overall, high quality data set



Run conditions in 2014-15







Data taking began in November, 2014

First of all, a feasibility test for a long physics run

Continuous efforts from DAFNE
- to reach and keep more than 10 pb^{-1} day of integrated luminosity
- to keep the background level at the operative threshold for KLOE (IT and DC on)

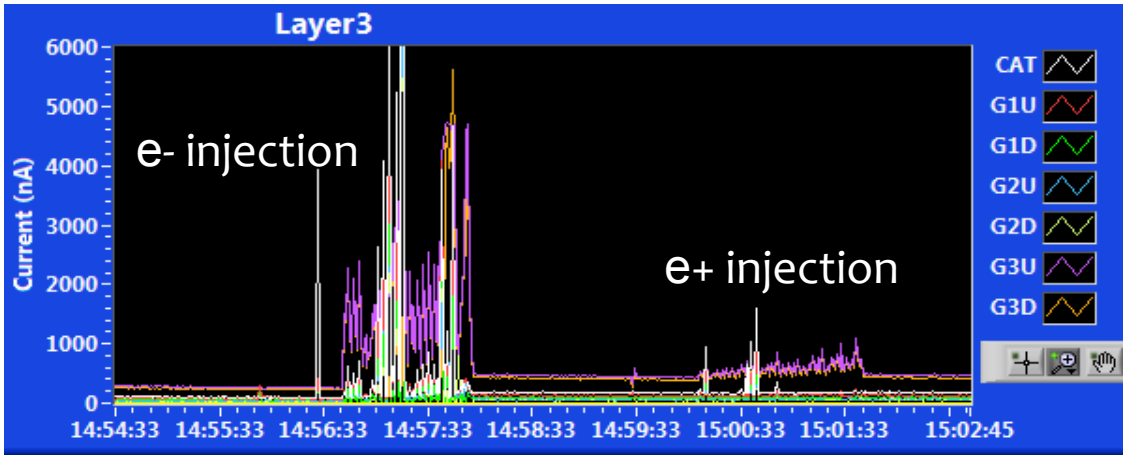
and KLOE
- to keep high data taking efficiency
- to lower recovering time after beam loss

Beam Injections

Beam Injections are an issue for the operation of both, Drift Chamber and Inner Tracker

Lot of attention and efforts to avoid beam losses

Long transfer line of the electrons in the DAFNE Hall makes the electron injection more difficult to take under control



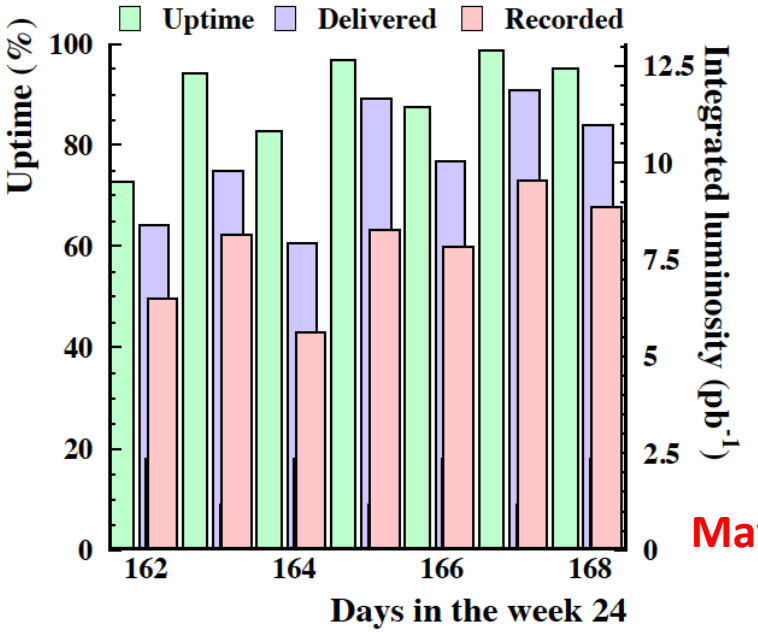
Run with dirty electron and good positron injections

Integrated luminosity

DAFNE and KLOE uptime was good

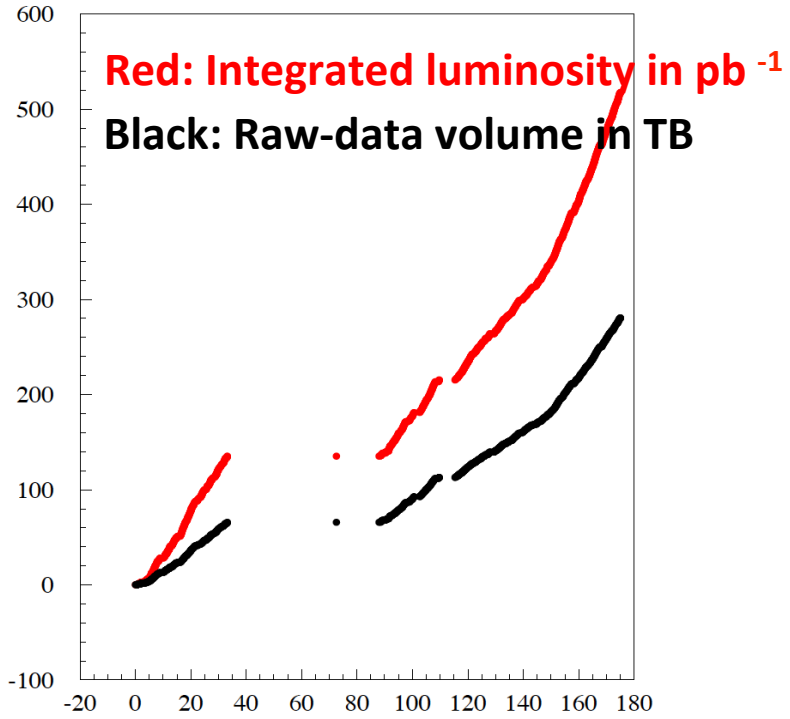
Peak luminosity ~1.5-2 10^{32} cm^{-2} s^{-1}

More than 10 pb^{-1} delivered per day



May 2015

May 2015

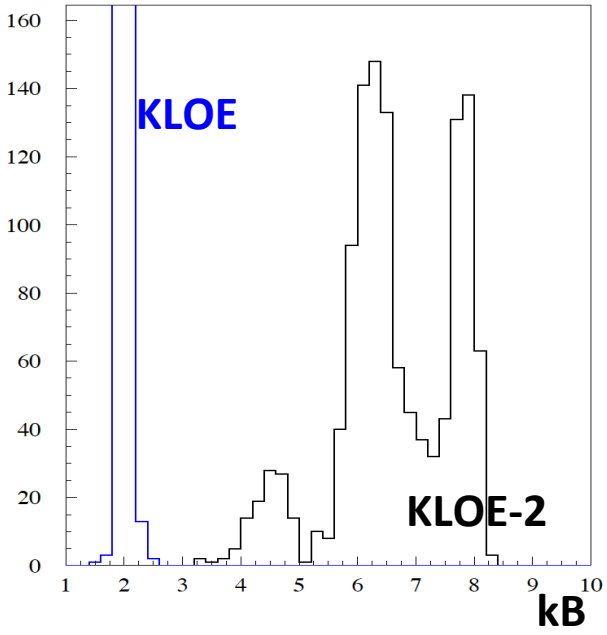


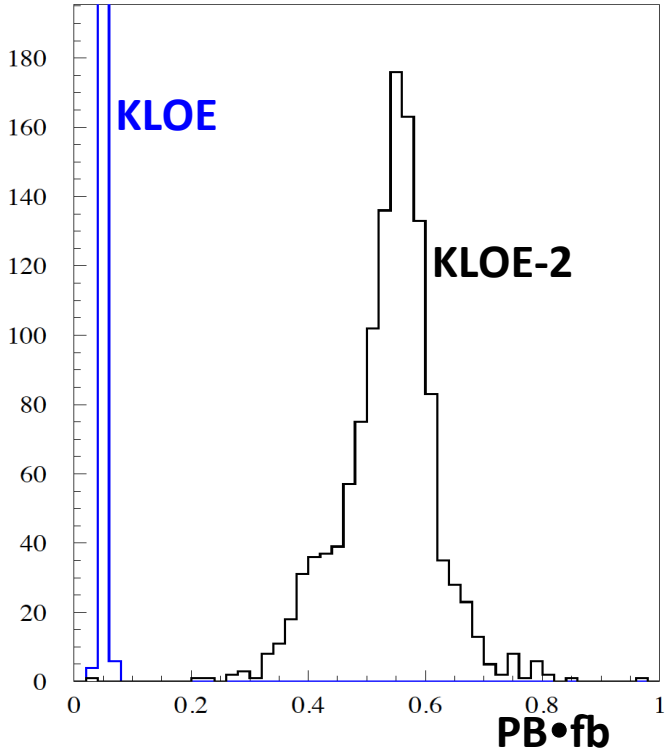
Data quality assessment ongoing

Data volume

Photons from em showers of Touschek particles are more frequent and of higher energy than in the past

1- Event size increase





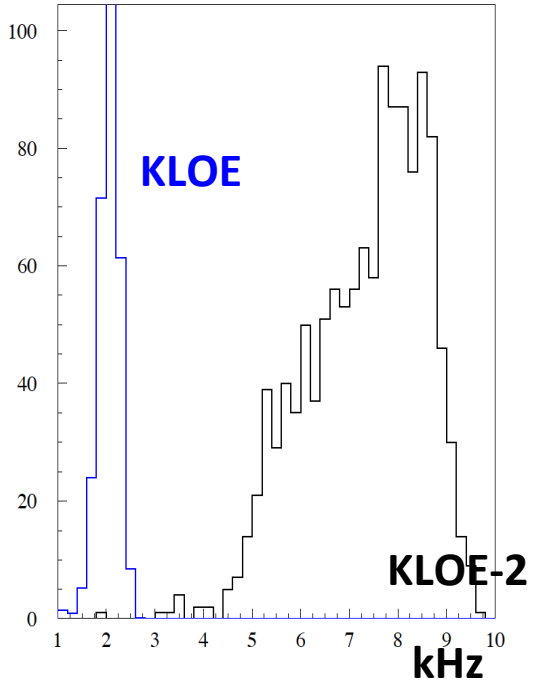
Increase in data volume:

1 fb^{-1} of raw-data

in 2005: 46 TB

in 2015: 550 TB

2- Trigger rate increase



Data reduction strategy

Data reduction

1- filtering ``empty" events

2- downscaling Bhabha

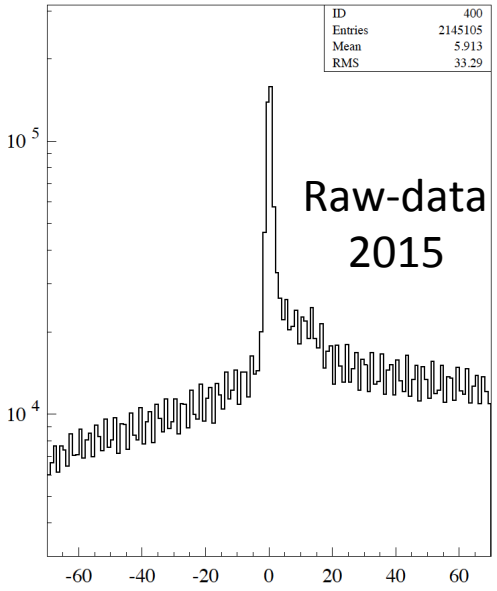
Event composition (approx)

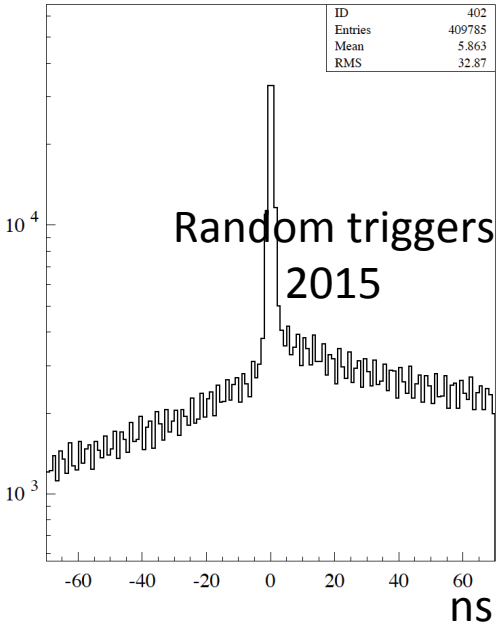
measured with out-of-collision beams

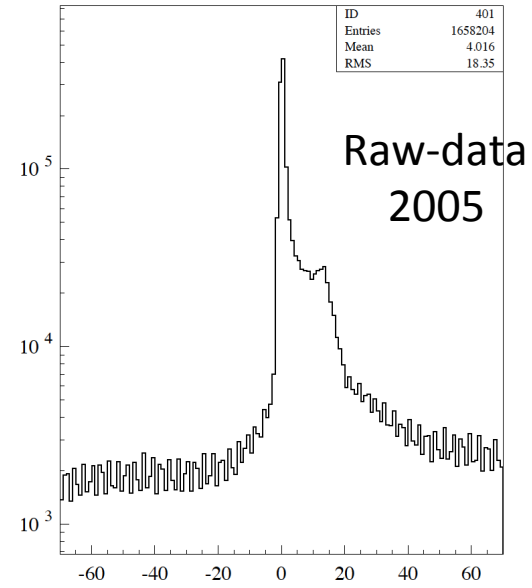
- **Intrabunch interactions (Touschek background) ~5.5 kHz**
- ϕ decays ~ 0.5 kHz
- Bhabha (Golden) ~ 1 kHz
- Cosmic muons ~ 0.5 kHz
- Bhabha (radiative, shower on the beam line,...) ~ 1 kHz

Data reduction: Exploiting calorimeter time resolution to associate energy to bunch crossing

Bunch crossing analysis – Cluster Time



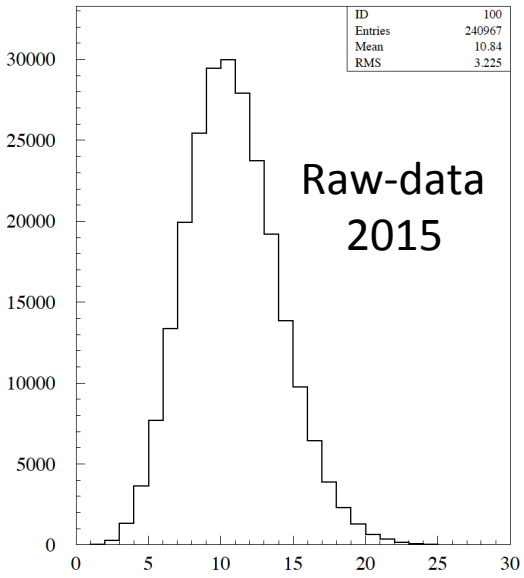


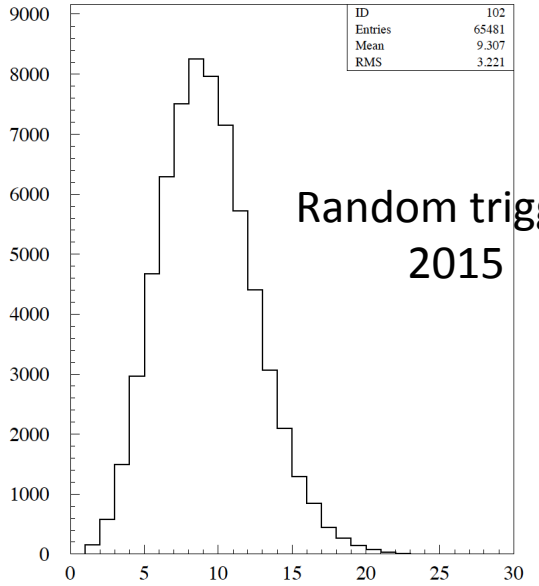


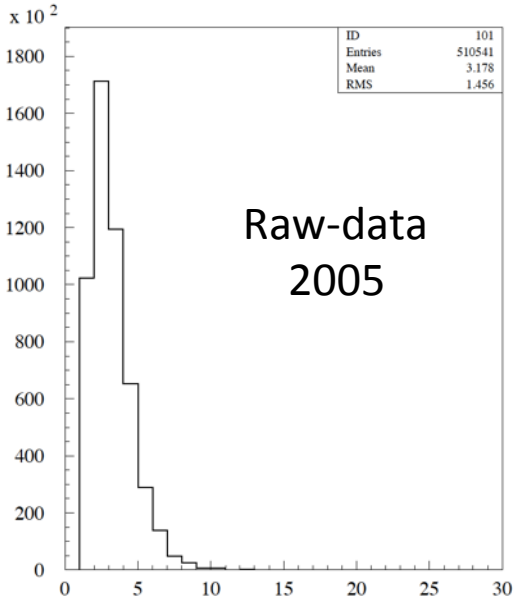
Random triggers at 20 Hz are routinely acquired for the background analysis and MC simulation

Calorimeter information from ~ 100 bunch crossings
~25 are used to trigger

Bunch crossing analysis - Multiplicity



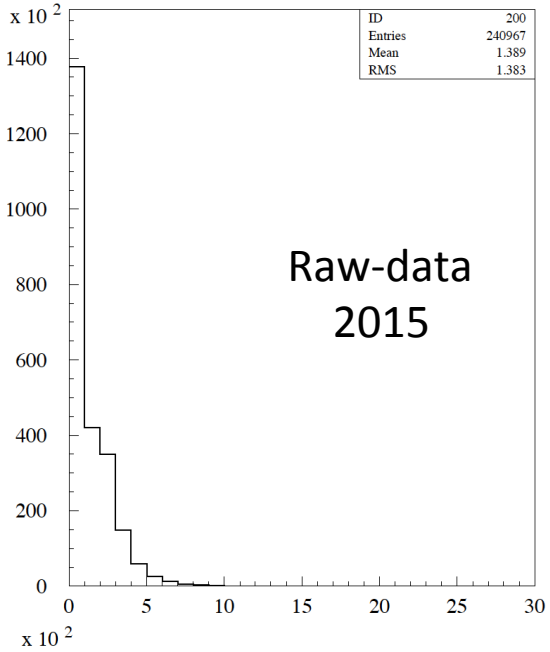


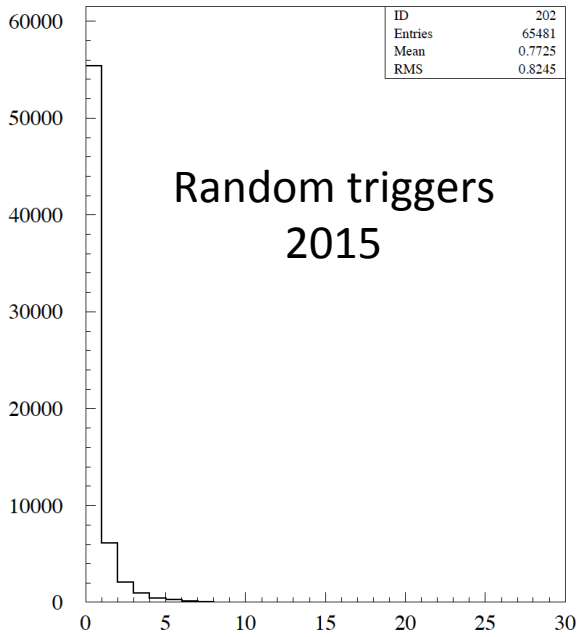


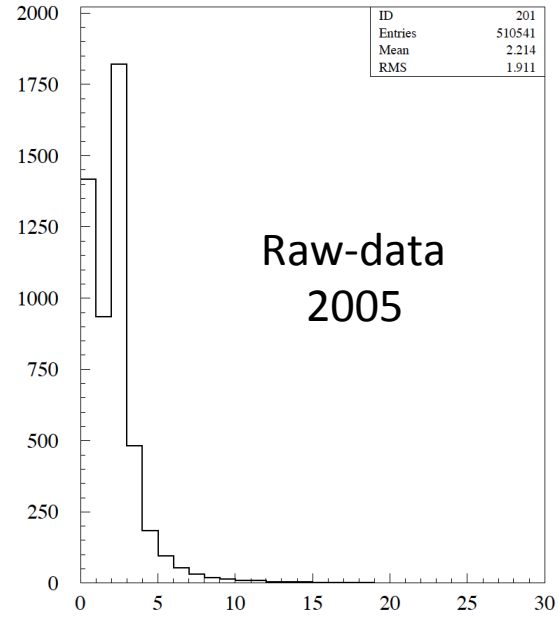
Clusters in the calorimeter were associated to 3 bunch crossings (ave) in 2005, now to 10

Touschek- generated clusters are associated to 9 bunch crossings per event

Bunch crossing analysis – Tracks

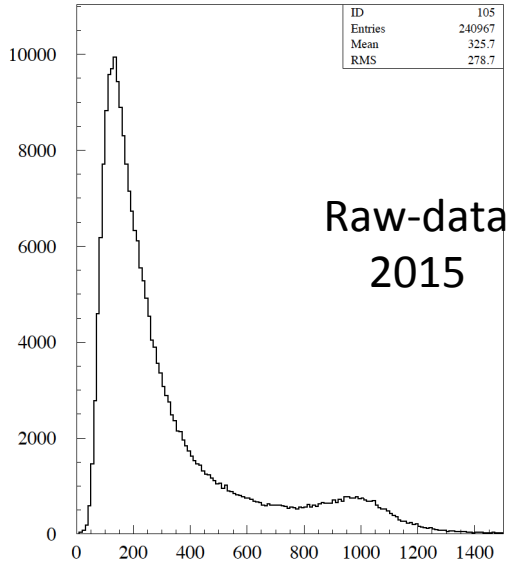




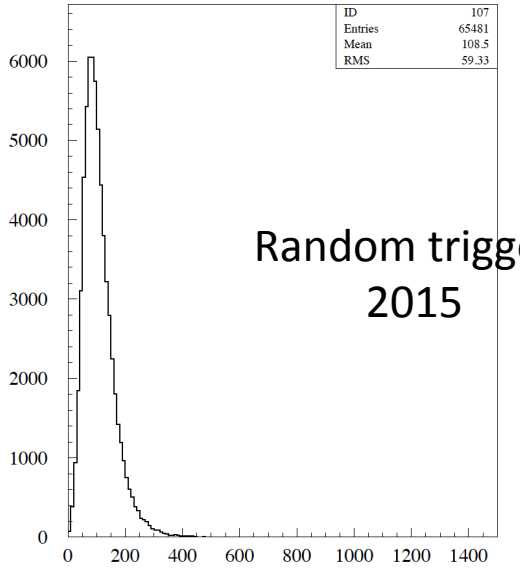


Background mostly from photons

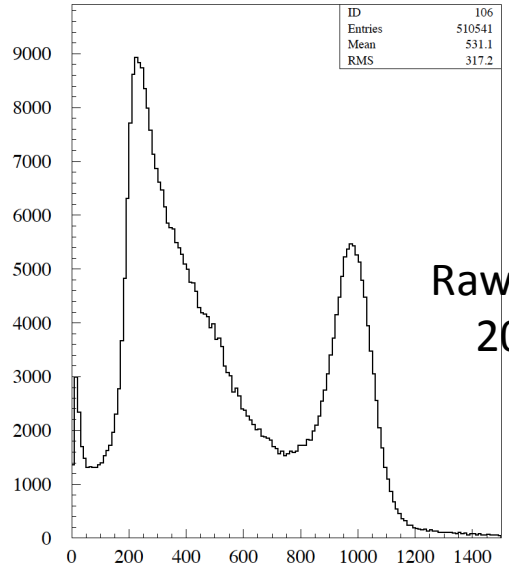
Bunch crossing analysis - Energy



Raw-data 2015



Random triggers 2015



Raw-data 2005

Raw data are completely dominated by triggers from machine background

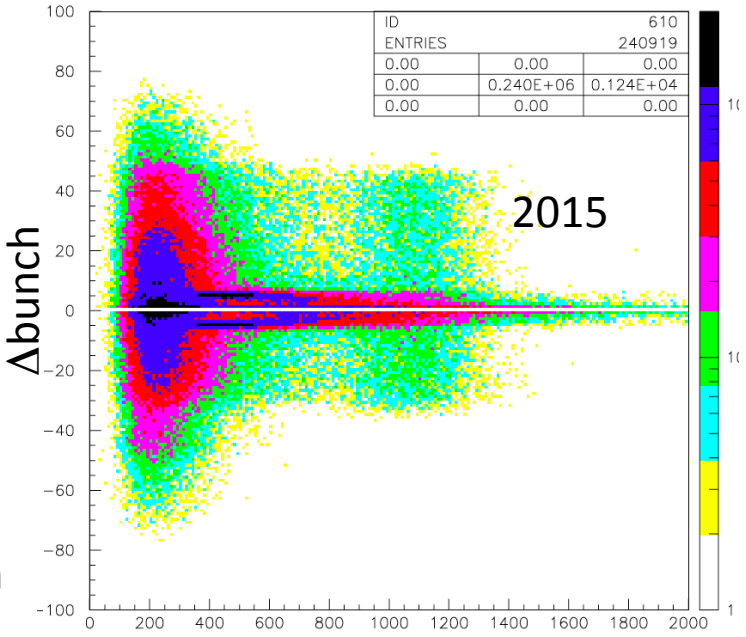
Bunch crossing analysis –Δbunch vs ΣEnergy

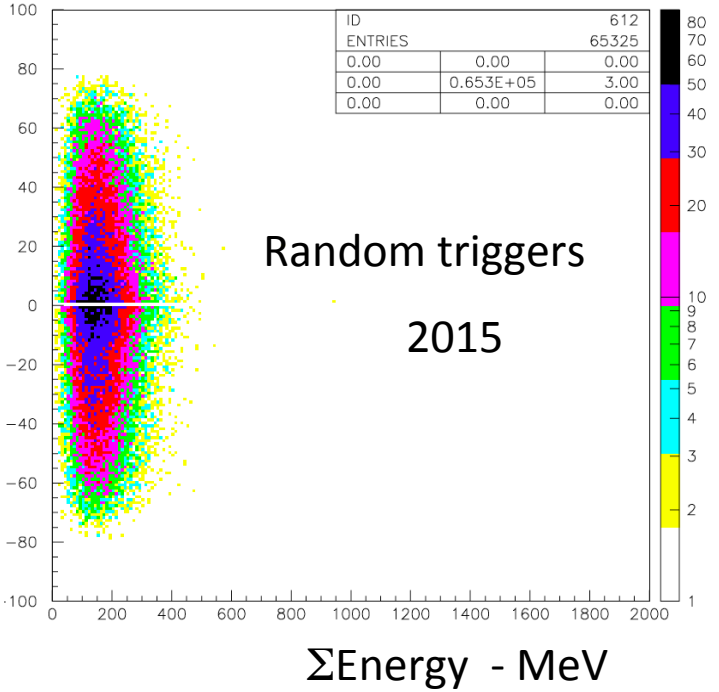
Data reduction – effectiveness

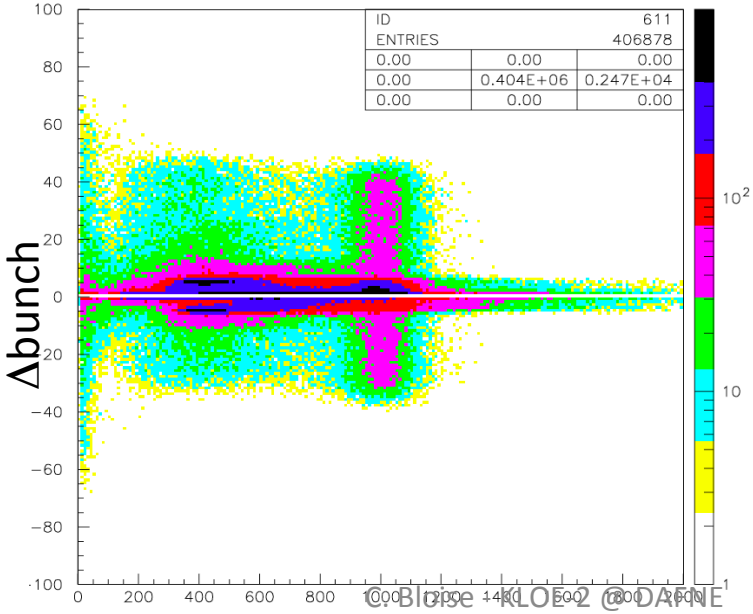
Raw data reduction factor: 35% of the events – **3 kHz**
To compare with maximal reduction factor, measured with out-of-collision beam of 5.5 kHz

Random trigger reduction: 75%

Same criteria on 2005 raw data sample: 9% reduction



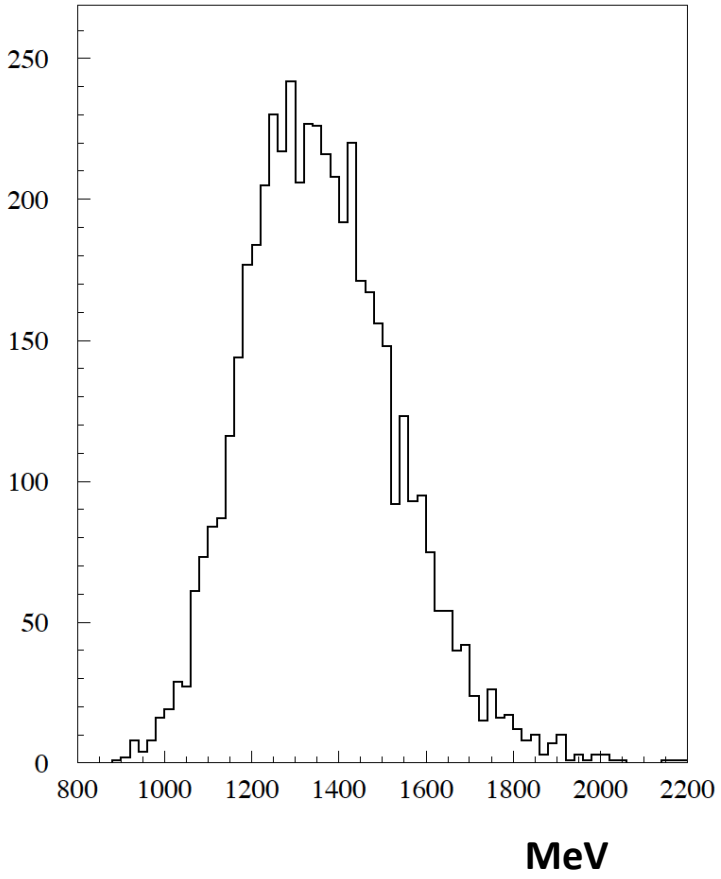




Bunch crossings with highest energy (2)

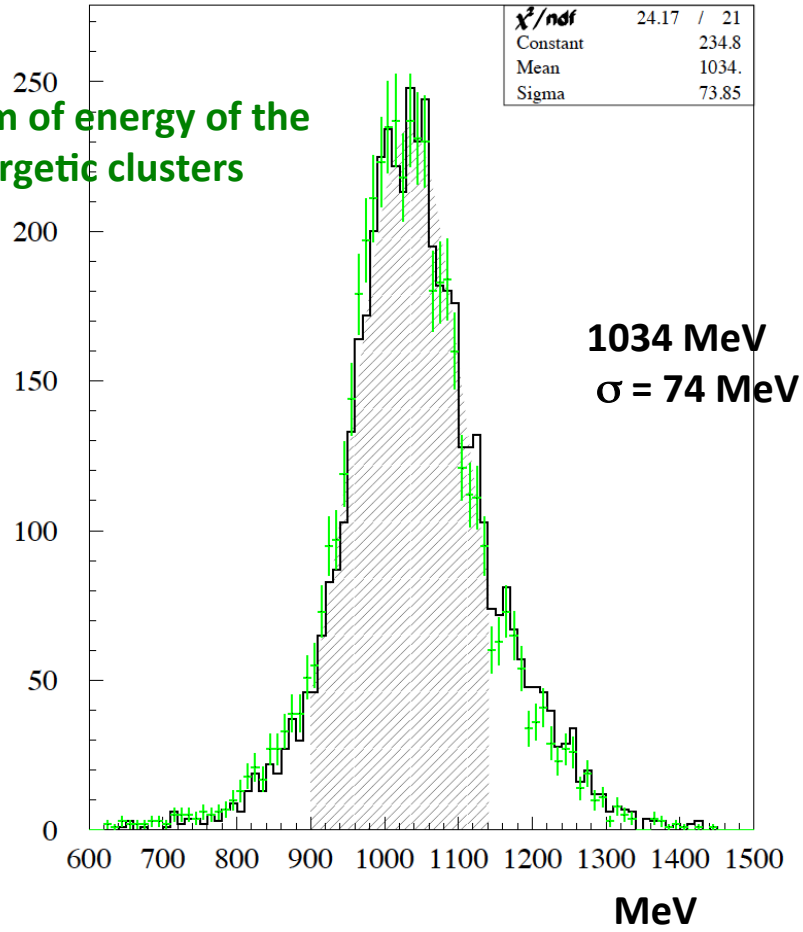
Large angle γγ

Energy distribution in the event



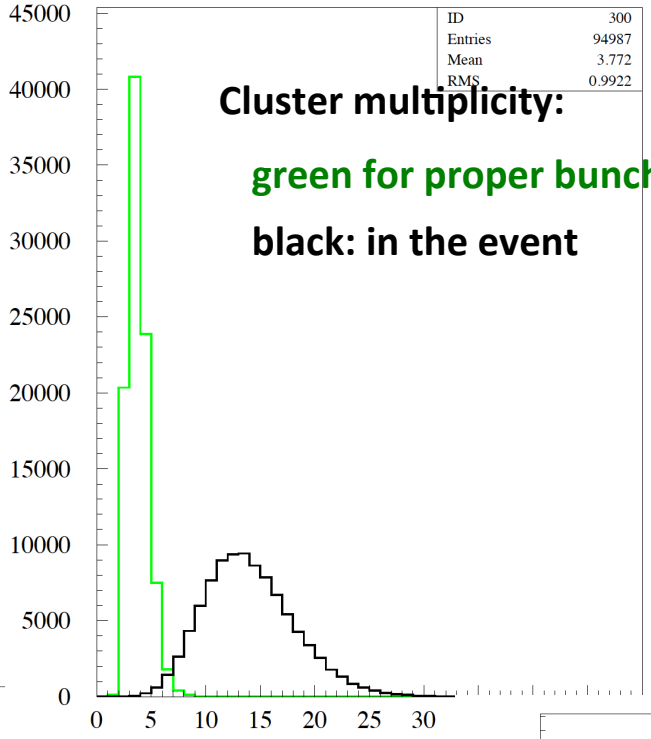
Energy distribution in proper bunch crossing

green sum of energy of the most energetic clusters



1034 MeV
σ = 74 MeV

Golden Bhabha



Cluster multiplicity:

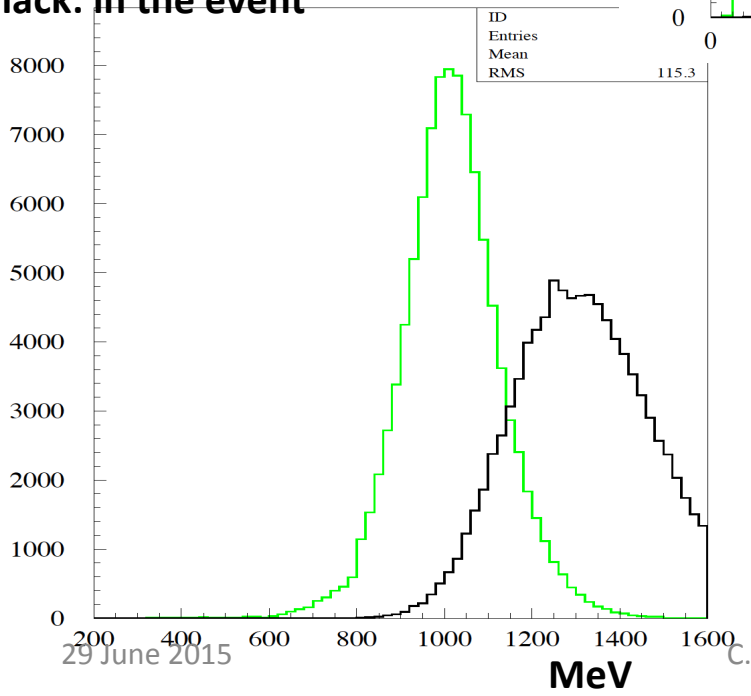
green for proper bunch crossing

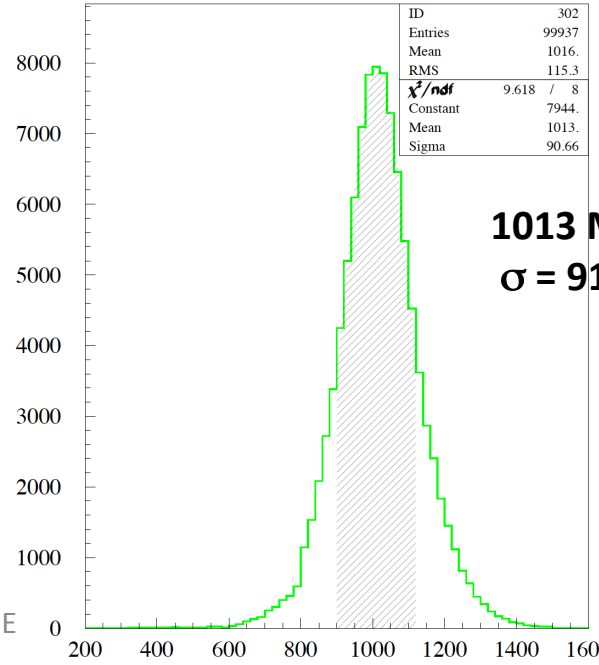
black: in the event

Energy:

green for proper bunch crossing

black: in the event



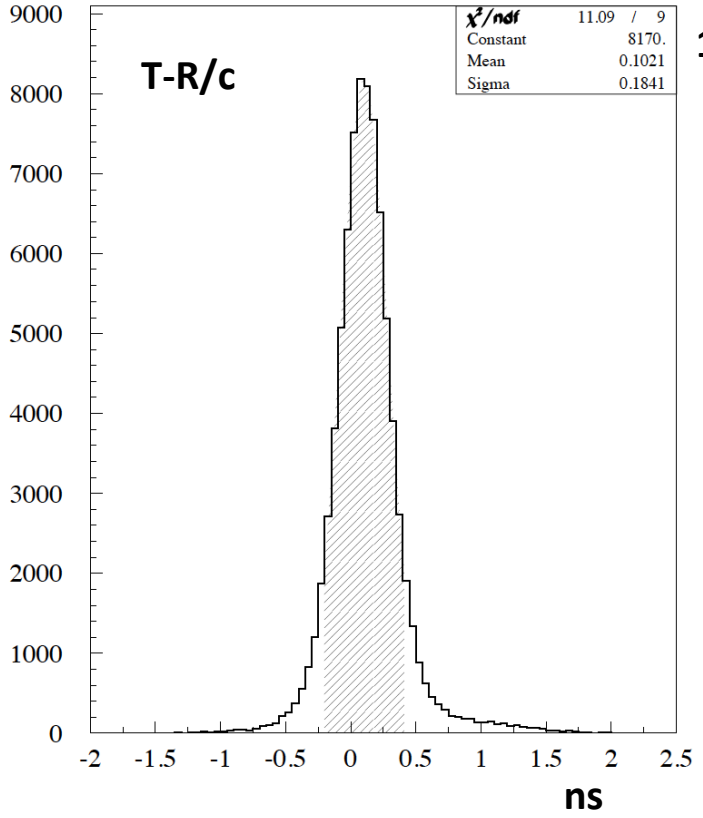


1013 MeV

σ = 91 MeV

Golden Bhabha (barrel and endcap)

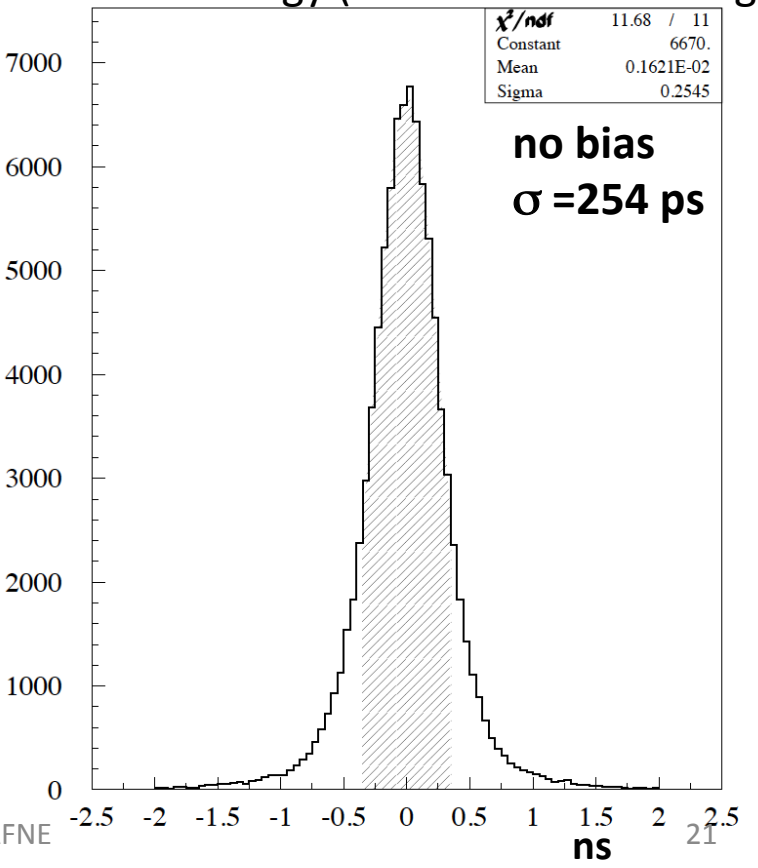
Distribution for clusters of maximal energy



102 ps bias due to curvature

σ =184 ps

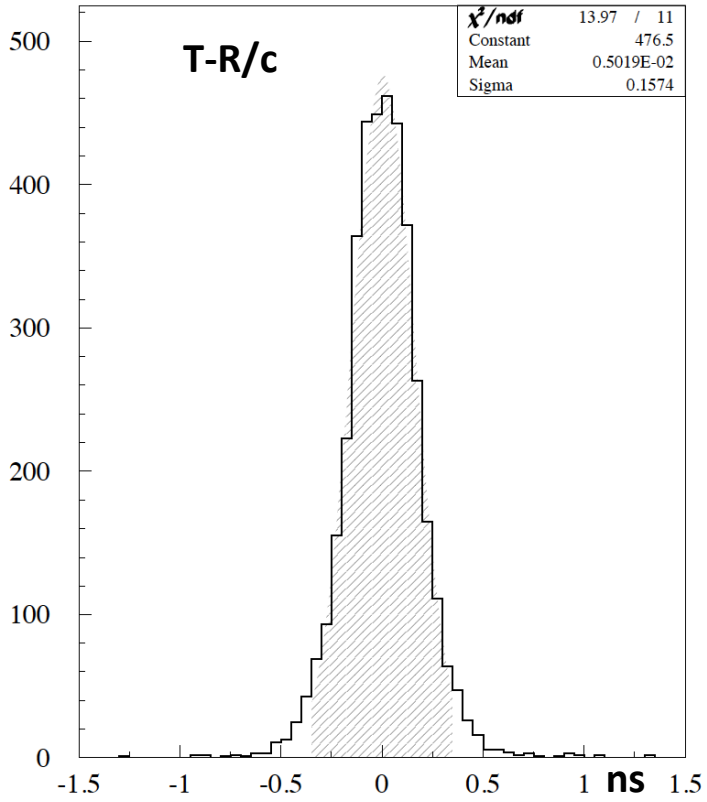
Distribution for the two clusters of maximal energy (same bunch crossing)



Cluster with Emax: **13%** of the events have T0 from another cluster

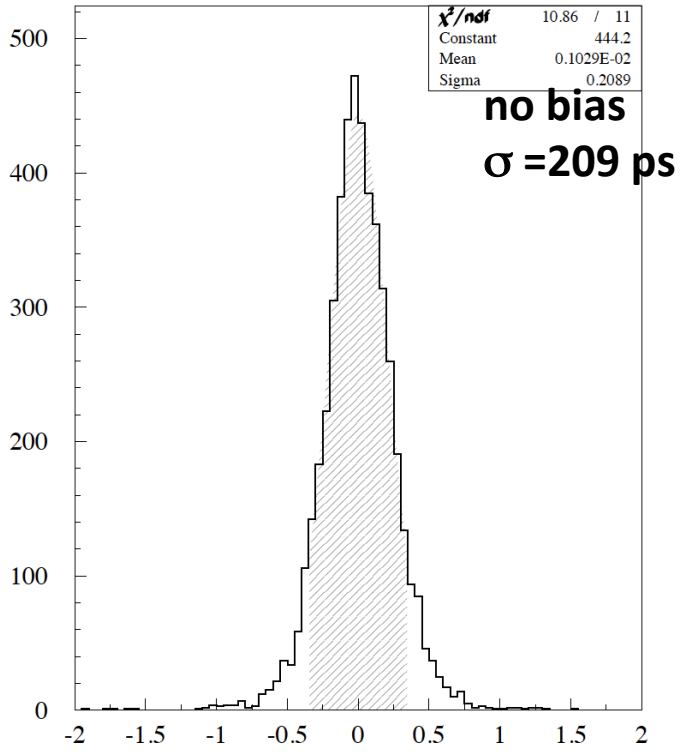
γγ at large angle

Distribution for clusters of maximal energy



no bias
σ =157 ps

Distribution for the two clusters of maximal energy (same bunch crossing)



Conclusions

KLOE-2 data taking started in November 2014 after the installation of the detector upgrades and the consolidation works at DAFNE following the long shutdown for the upgrade of the interaction region.

The specific goal was to integrate at least 1 fb^{-1} within June 2015, monitoring DAFNE and KLOE performance: efficiency, uptime, and data quality.

The conclusions for this first phase are quite satisfactory although data quality assessment is still in progress.

In particular, raw data volume is a factor 3-4 higher than expected, with 550 TB acquired per fb^{-1}. Data reduction criteria are being evaluated

The analysis of the energy in the calorimeter associated to each bunch crossing is now needed to obtain the quality, and even improve on old KLOE data

A report on this first experience of data taking is in preparation

Backup slides

KLOE-2 with 5-10 fb^{-1}

The KLOE-2 physics program as originally proposed and published in year 2009, is based on 20 fb^{-1}, feasible starting with a data delivering of ~20 pb^{-1} per day.

As this is not the case, the reach of the experiment with 5-10 fb^{-1} is the present goal

QM, CPT- and Lorentz-invariance tests with neutral Kaons, sensitive to effects at the Planck scale (10^{19} GeV)

cited by (th.): EPJ C72(2012)1956; arXiv:1201.3045; arXiv:1102.3612; AIP Conf.Proc.1327(2011)118-127

SM test with **precision measurements of the V_{us}** element of the CKM mixing matrix

Rev. Mod. Phys.84(2012)399; arXiv:1112.1984

Low-energy QCD with radiative kaon, η, and η' decays and **low-mass scalars** with the study of scalar-KK coupling

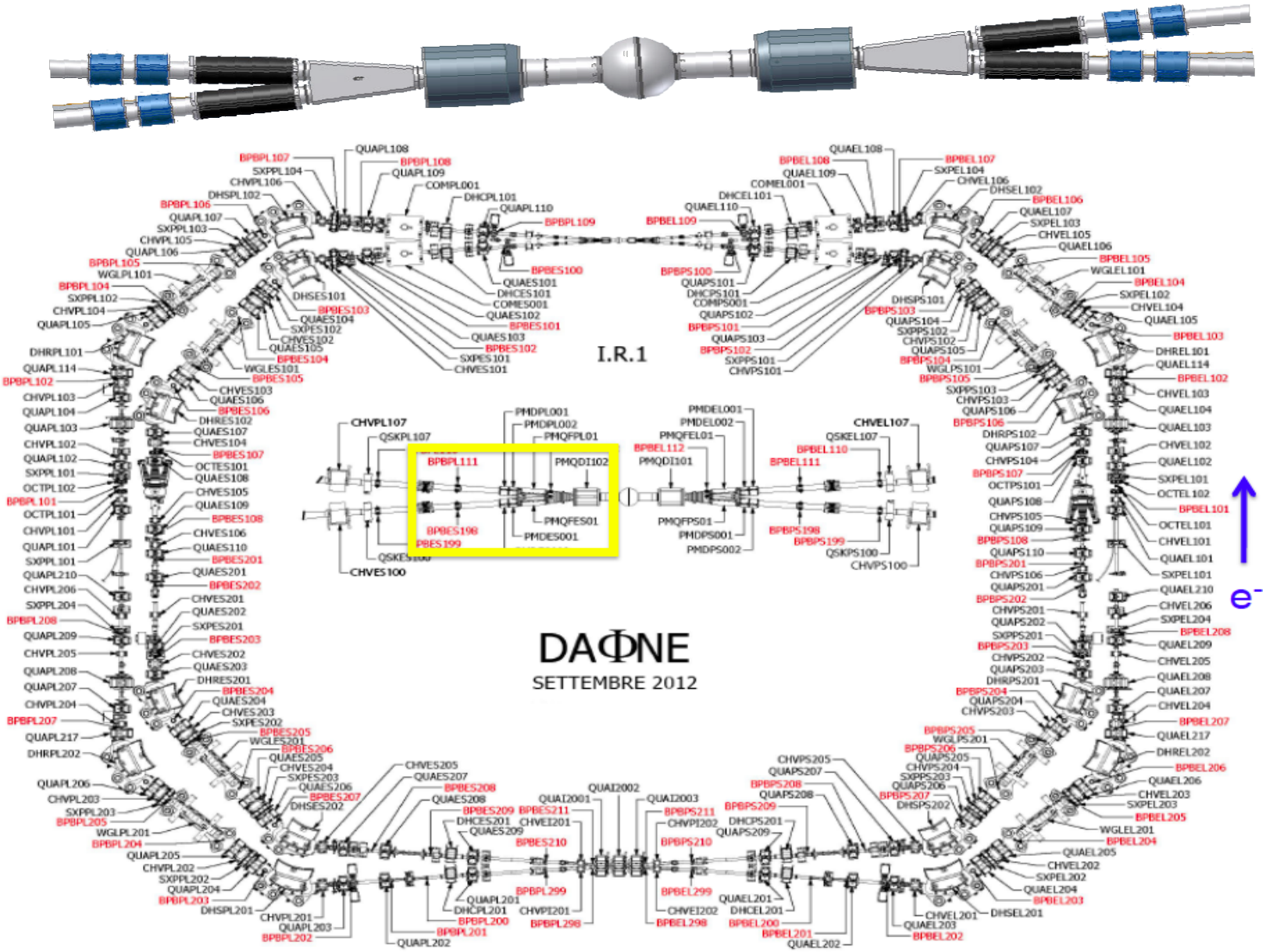
EPJA47(2011)148; PRD85(2012)054018; NPB860(2012)245-266; arXiv:1112.4384; arXiv:1109.3754; JHEP 1102(2011)028; arXiv:1007.4479 EPJ C71(2011)1814

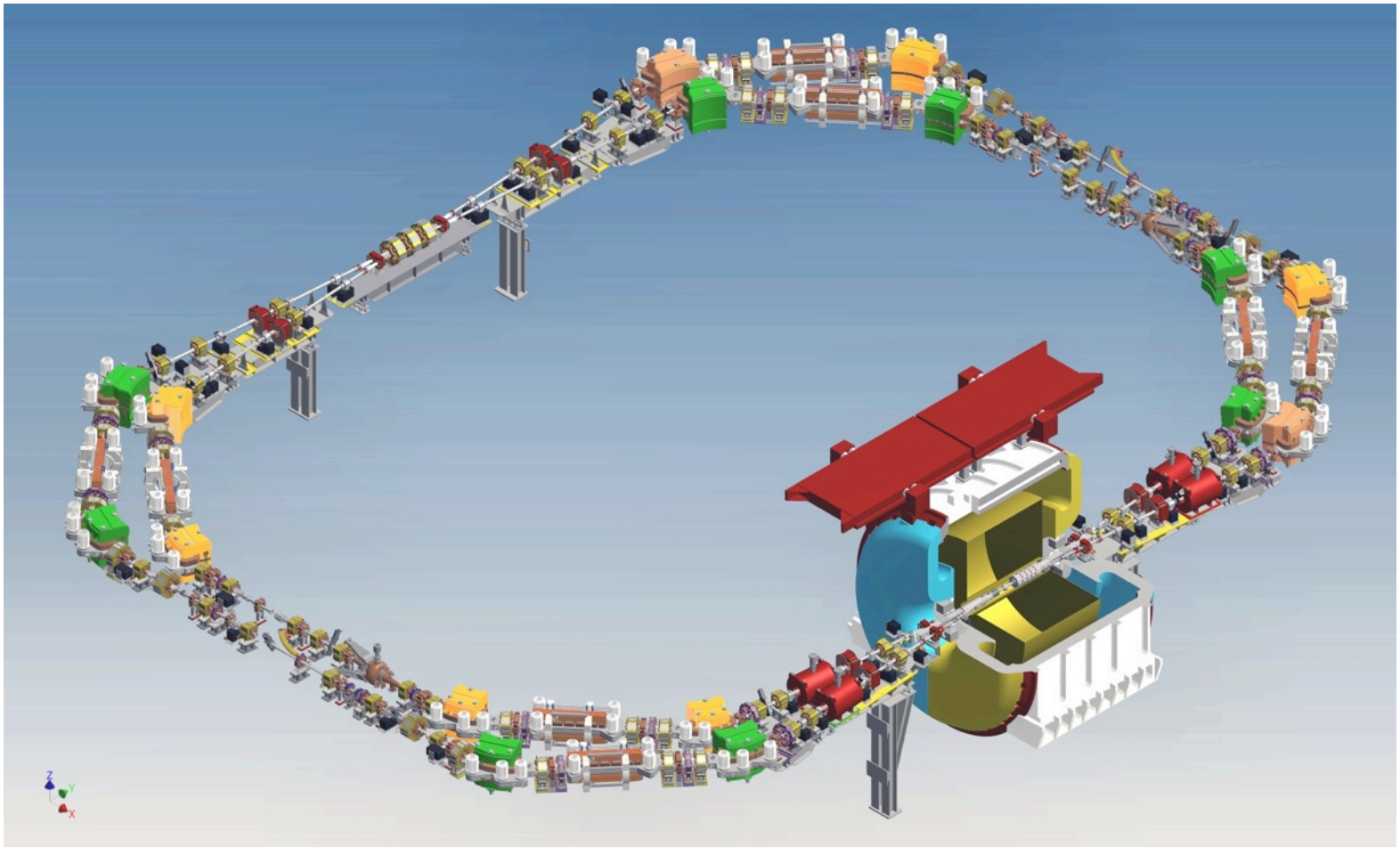
$\gamma\gamma$ physics with the measurements of the π^0 width and $\pi^0 \rightarrow \gamma\gamma^*$ transition form factor in the space-like region

EPJ C72(2012)1917;arXiv:1202.1171; AIP Conf.Proc.1257(2010)27-36; arXiv:0905.2017

Search for the U-boson from dark sector

EPJ C71(2011)1680; JHEP 110(2011)087; JHEP 1102(2011)087; arXiv:1103.0799; arXiv:1011.3082; arXiv:1004.0691


I.R.1
DAΦNE
SETTEMBRE 2012
e-



DAFNE in year 2015

Bunches	103
Bunch spacing	2.7 ns
Particle/bunch	$2.0\ 10^{10}$
Energy	510 MeV
Emittance (rms; x,y)	0.002 μm
Momentum spread (rms)	$5.5\ 10^{-4}$
Bunch length (rms)	1.6 cm
β@IP	0.84 cm

Raw Data – Cluster distribution