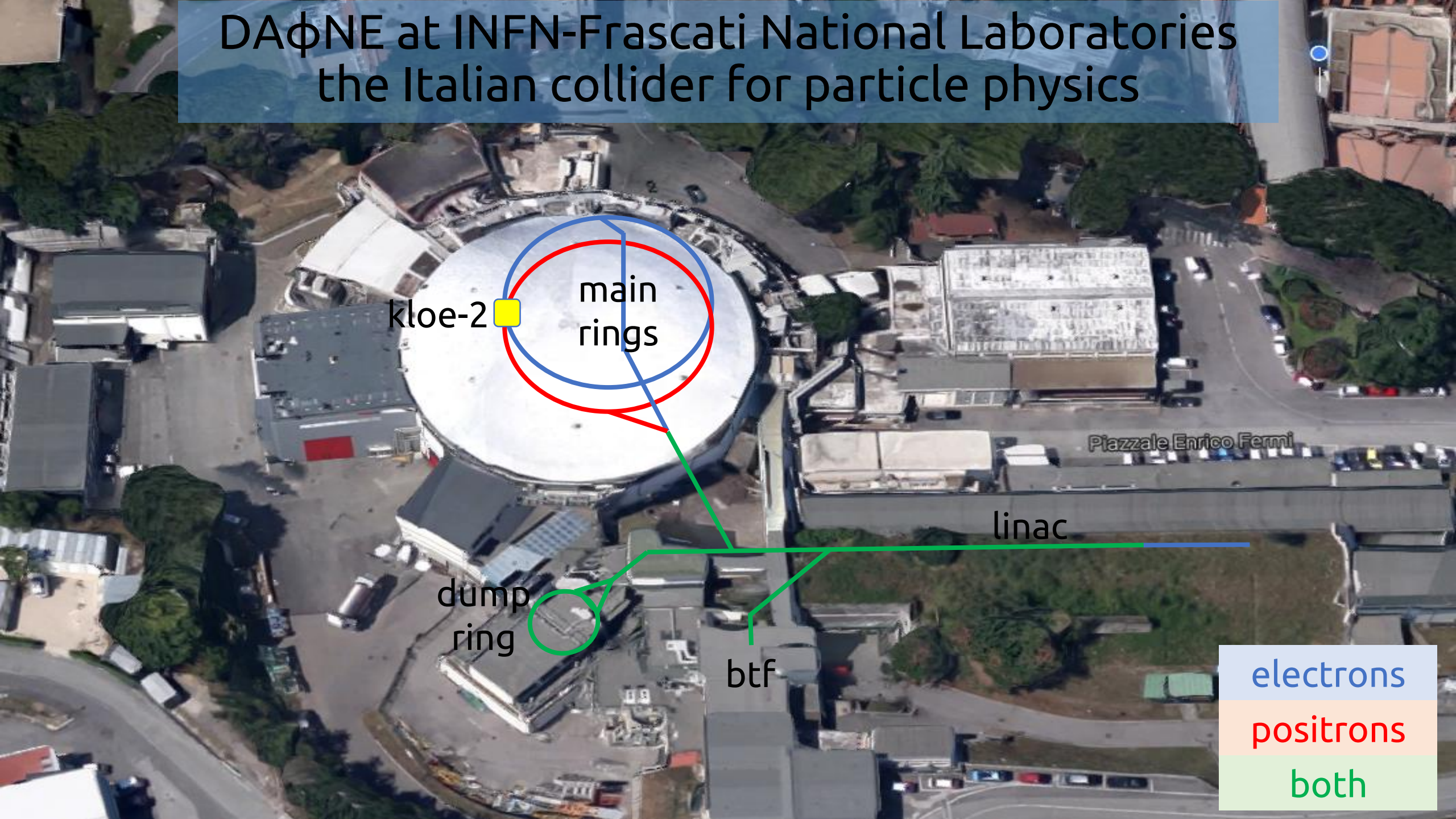
Status of the KLOE-2 experiment

INSTR17 - Instrumentation for Colliding Beam Physics

Danilo Domenici - LNF
on behalf of the KLOE-2 collaboration

DAϕNE at INFN-Frascati National Laboratories
the Italian collider for particle physics



1 GeV Physics History at Frascati

KLOE experiment has already taken data in 2001-2006:

- 2.5 fb^{-1} at 1.02 GeV
- 250 pb^{-1} at 1.00 GeV

DAFNE upgraded in 2008 with Crab-waist interaction scheme:

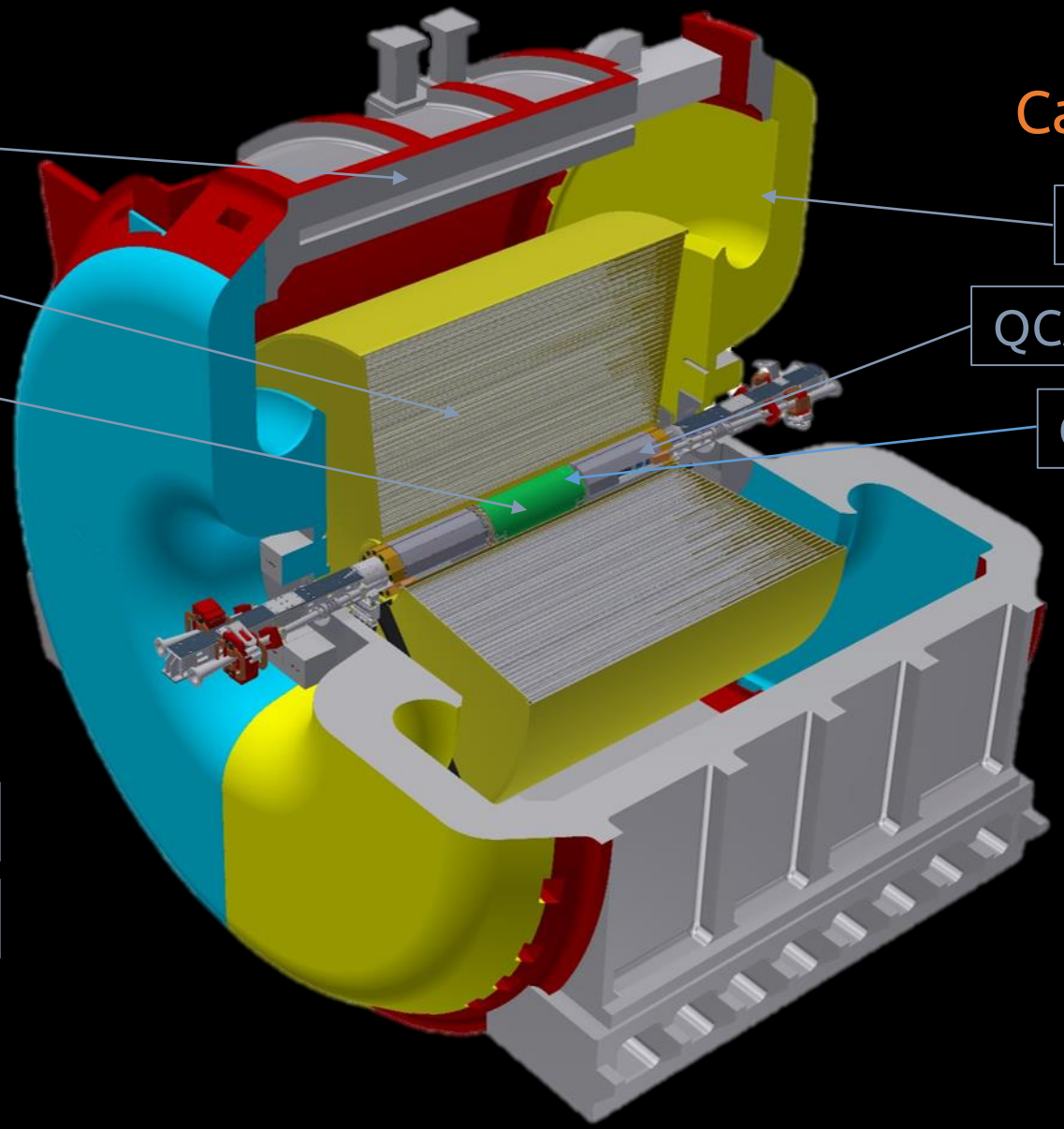
- Large Piwinski angle
- Compensating Sextupoles

New experiment KLOE-2 started in 2014 to integrate 5fb^{-1} in 3÷4 years

- CKM unitarity
- CPT invariance
- CP violation
- ChPT model of QCD
- Hadronic cross-section for muon g-2
- $\gamma\gamma$ physics
- Hidden sector searches

Tracking System

- Superconductive Magnet
- DC - Drift Chamber
- IT - Inner Tracker



Calorimeter System

- EMC - Calorimeter
- QCALT - Quadrupole Calo
- CCALT - Crystal Calo

Tagging System

- HET – High Energy Tagger
- LET – Low Energy Tagger

Drift Chamber

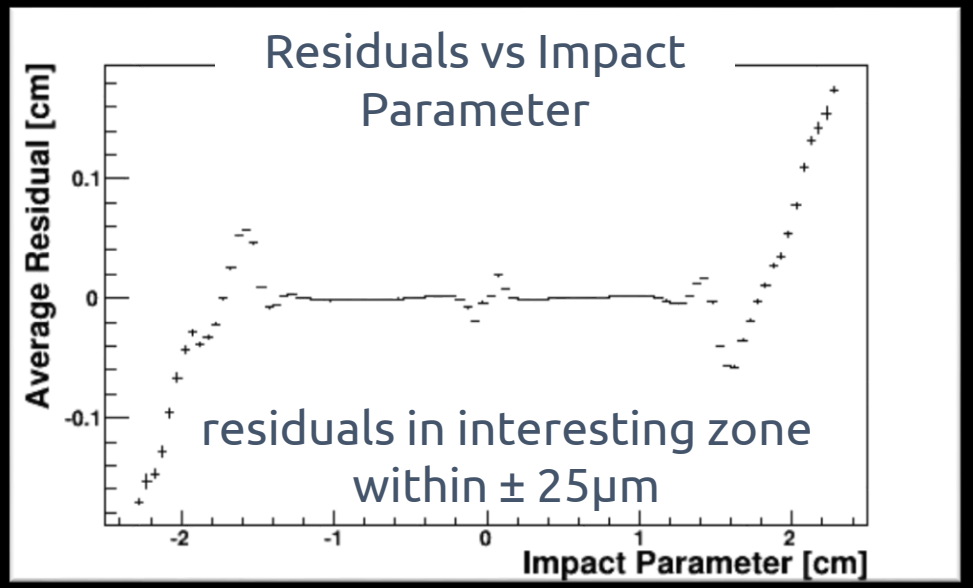
4m diameter - 3.7m length - 52k wires

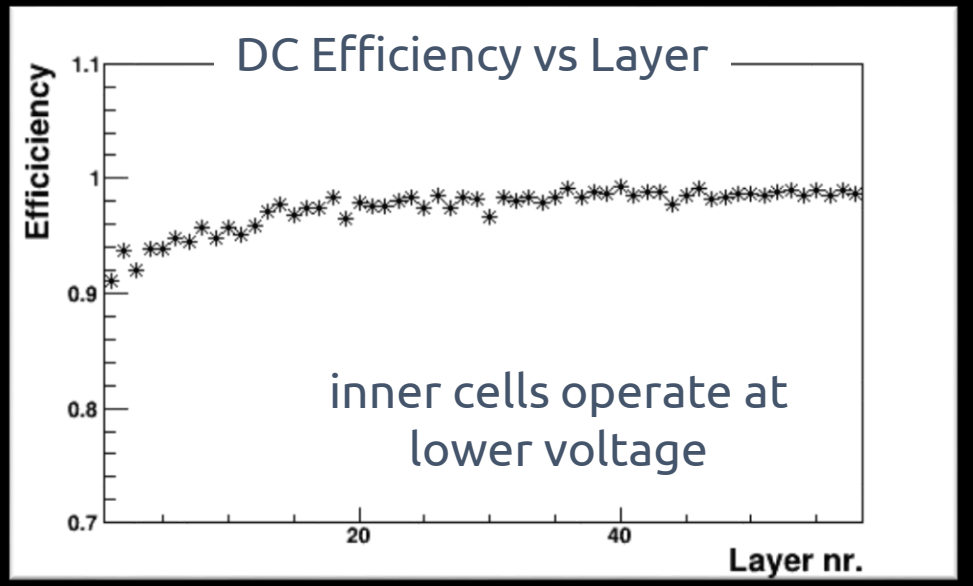
He:Iso=90:10 light gas mixture

σ_p/p = 0.4% (45° tracks)

σ_{hit} = 150μm in XY and 2mm in Z

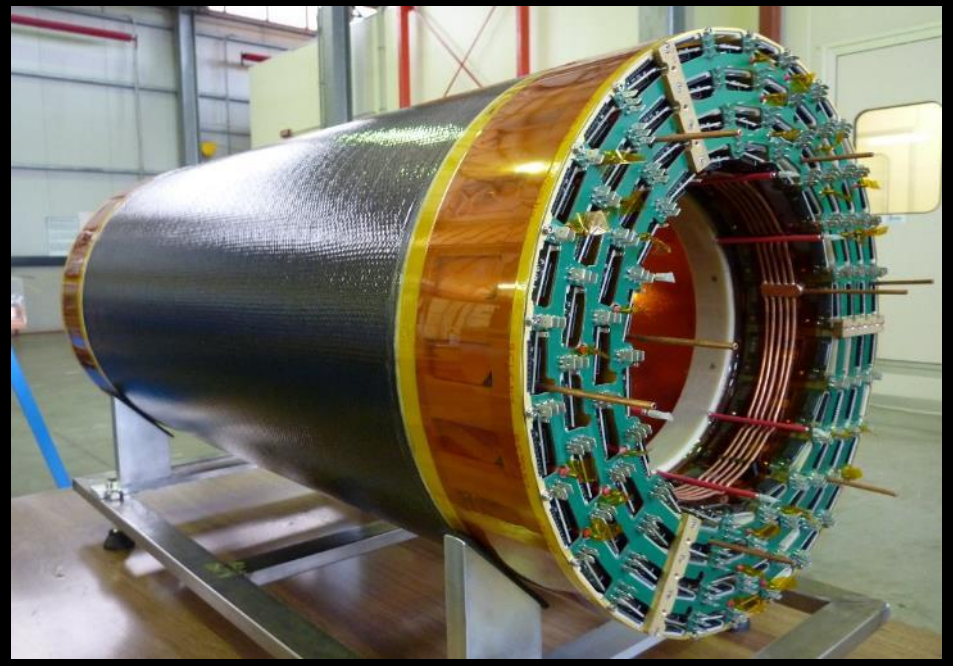
σ_{vertex} = 1mm



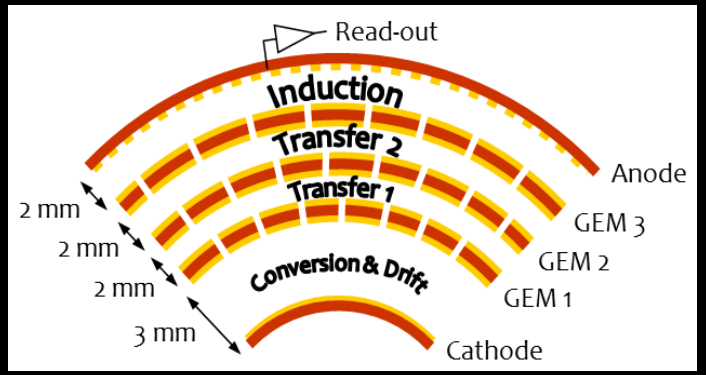


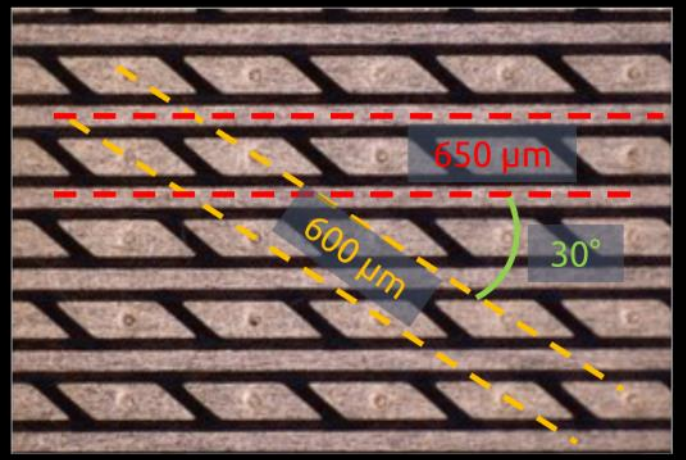
dedicated talk
Thursday morning

Inner Tracker



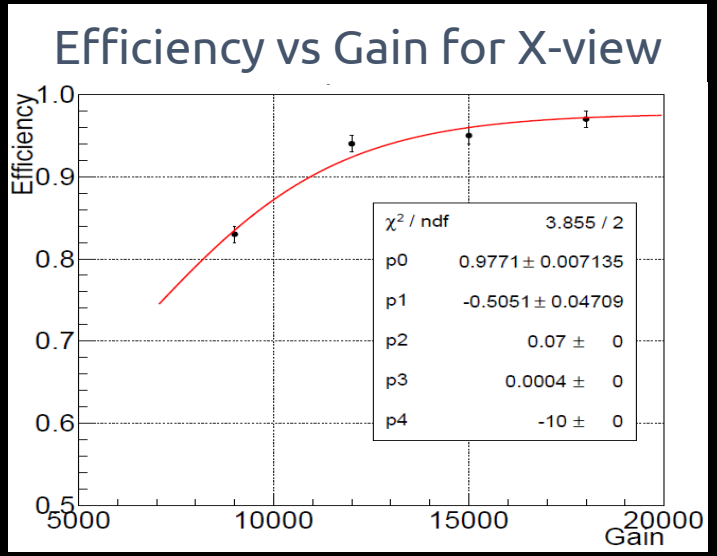
First cylidrical triple-GEM detector ever built

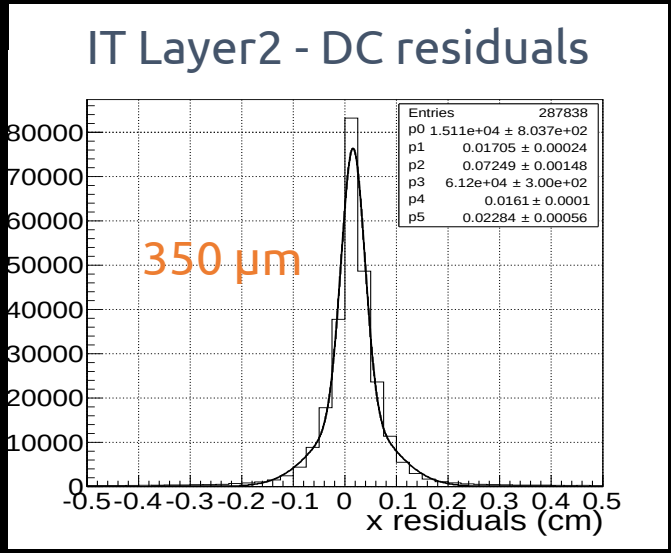




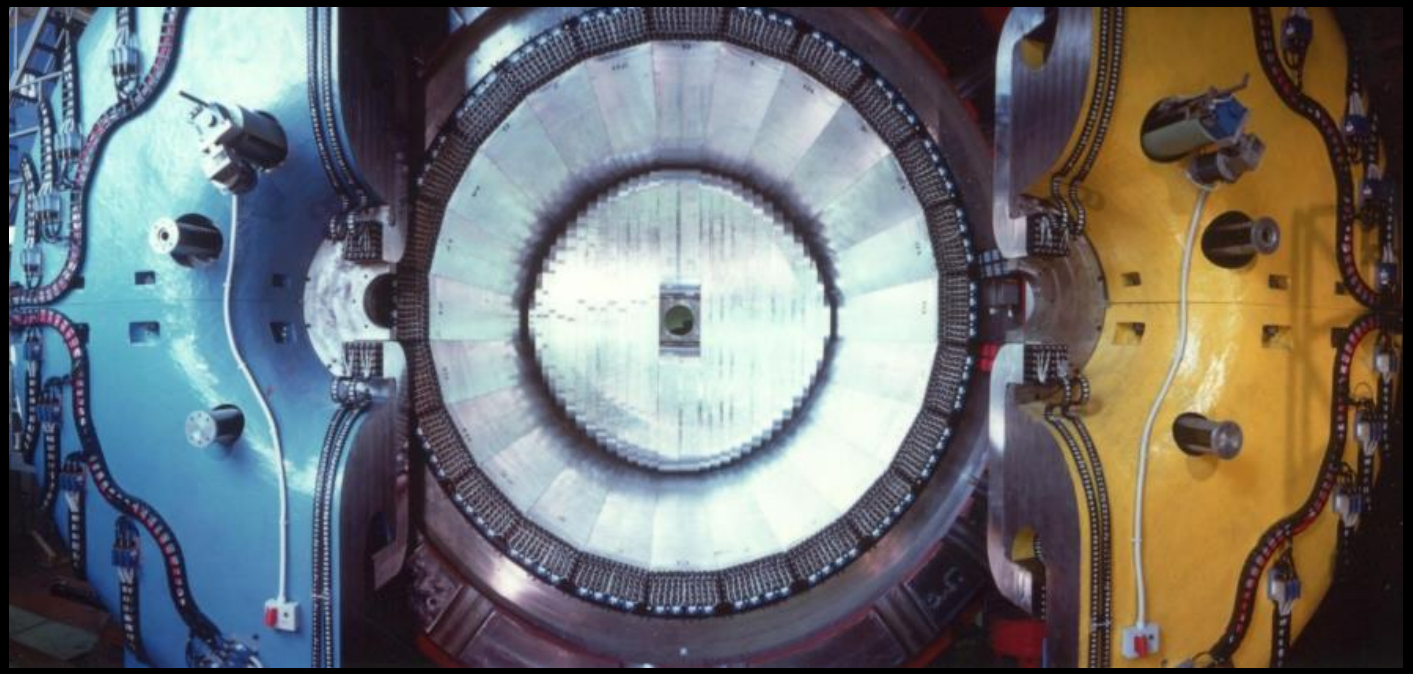
X strips and V pads readout

4 tracking layers
70cm active length
13cm – 20cm inner and outer diameters
Ar:Iso=90:10 gas mixture
2% X_0 thickness
1.6k HV channels and 30k FEE channels

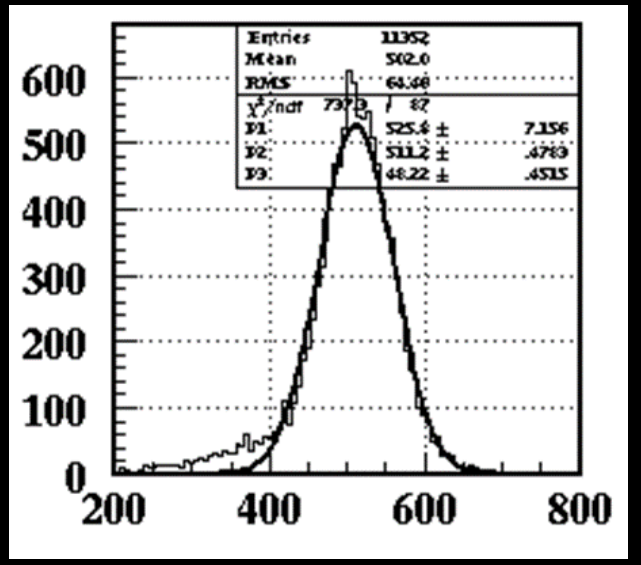




Central Calorimeter

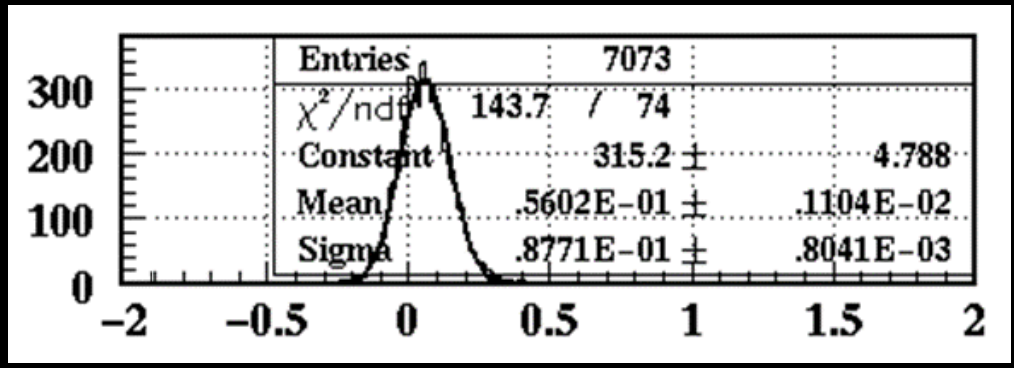


σ_E = 45 MeV
for 510 MeV photons

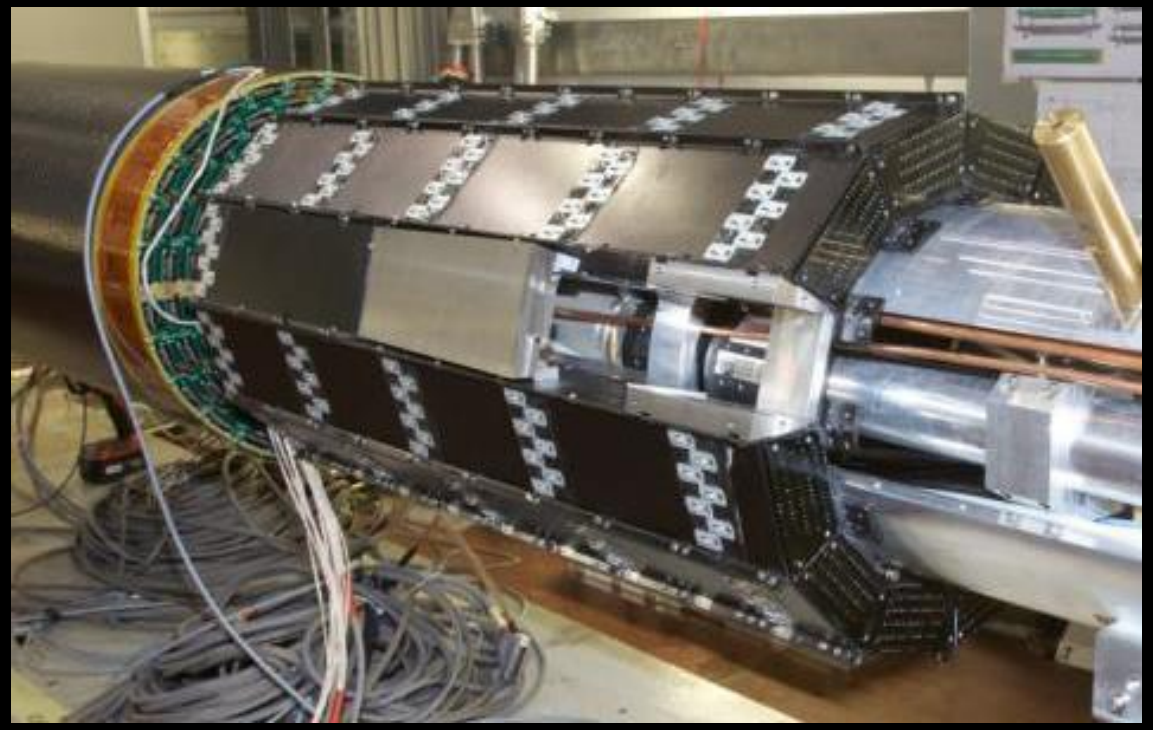


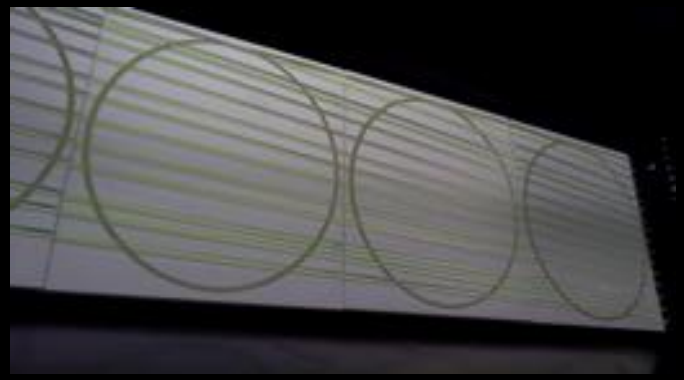
Barrel + 2 endcaps: 98% solid angle coverage
Pb+SciFi sampling – $15X_0$ thickness
$\sigma_E/E = 5.7\% / \sqrt{E}$
$\sigma_T = 54ps / \sqrt{E} \oplus 50ps$
PID capabilities using TOF

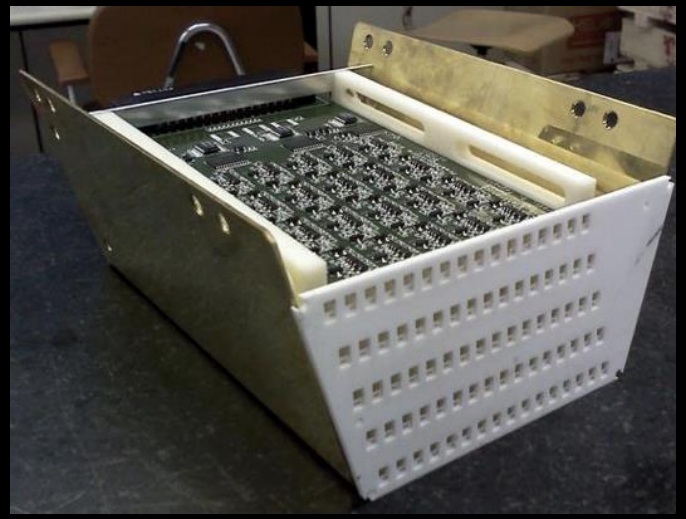
intrinsic σ_t < 90 ps
for 510 MeV γγ events



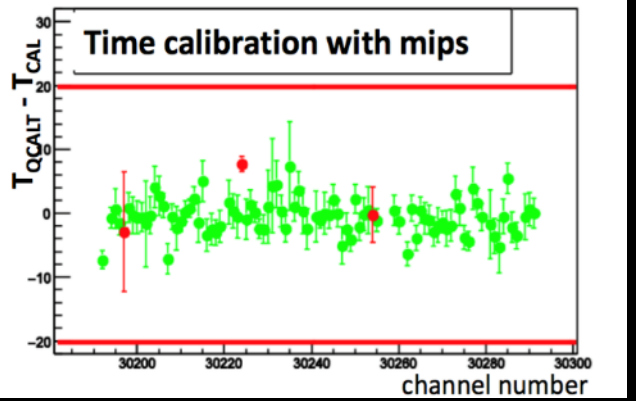
QCALT – Quadrupole CALorimeter with Tiles





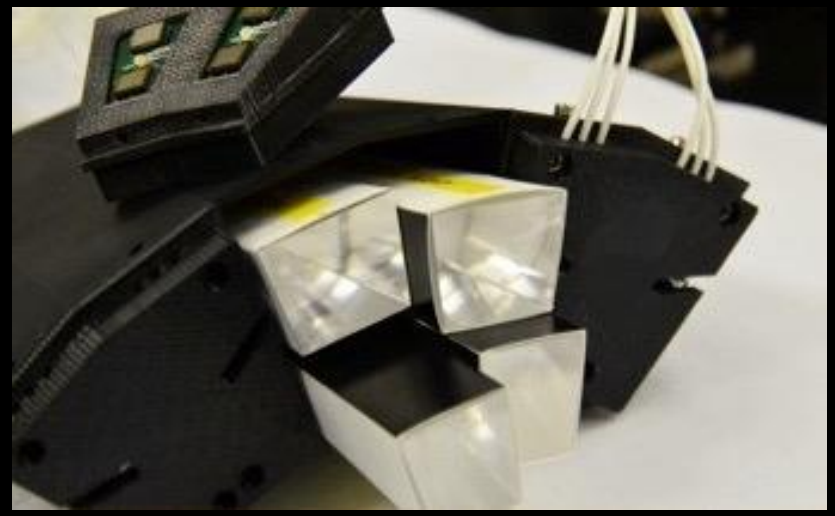


$\sigma_t \approx 1$ ns for cosmic muons



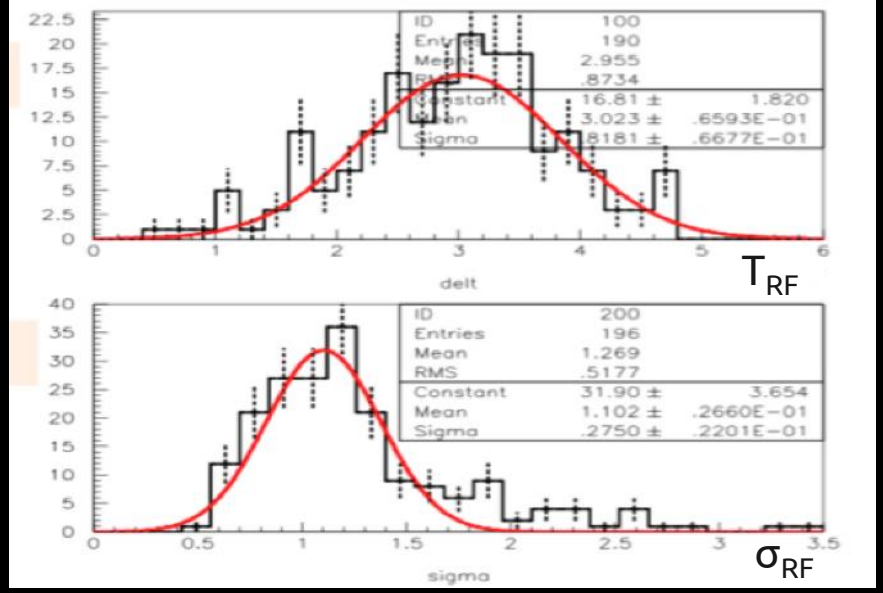
2 structures aside of IT
12 towers surrounding beam-pipe
Tungsten+Scintillating tiles+WLS
SiPM readout
increase hermeticity for K_L neutral decays

CCALT – Crystal Calorimeter withTiming capabilities



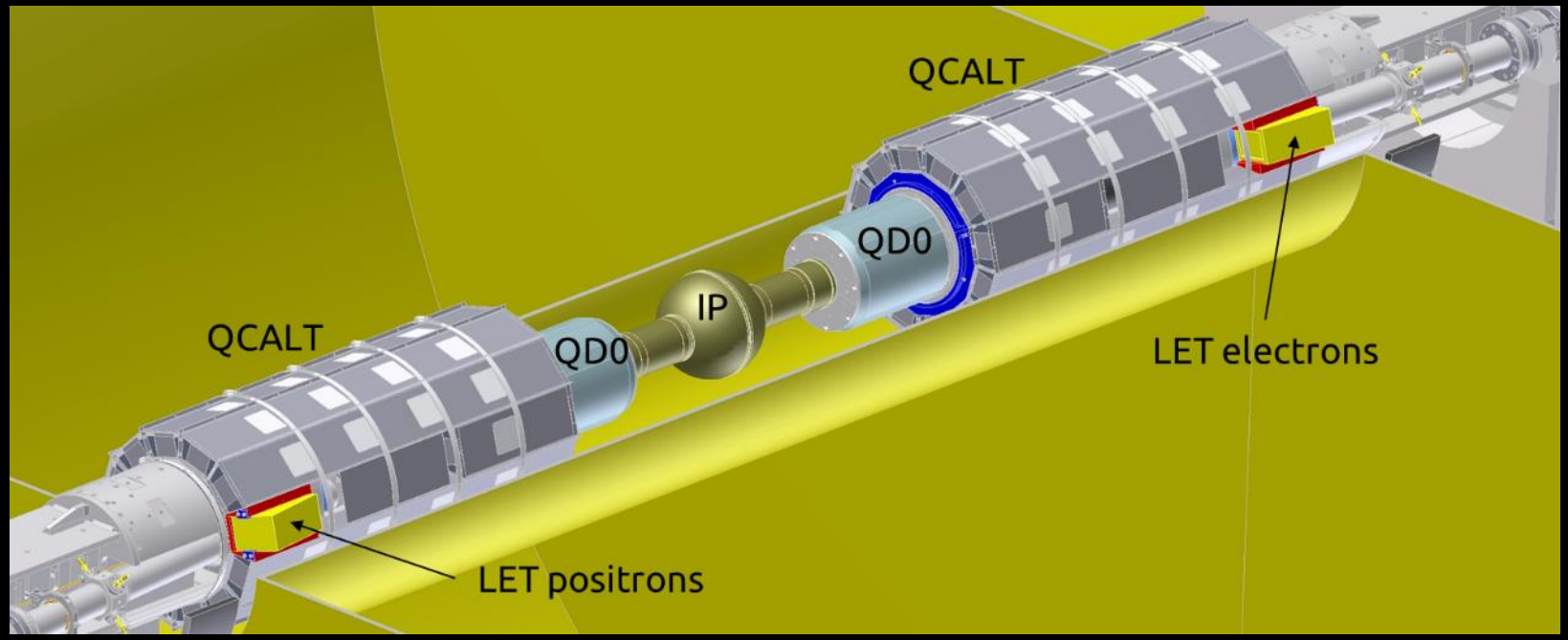
2 structures aside of IP
96 LYSO crystals customarily shaped
SiPM readout
extend photon acceptance down to 11°
used as luminosity monitor

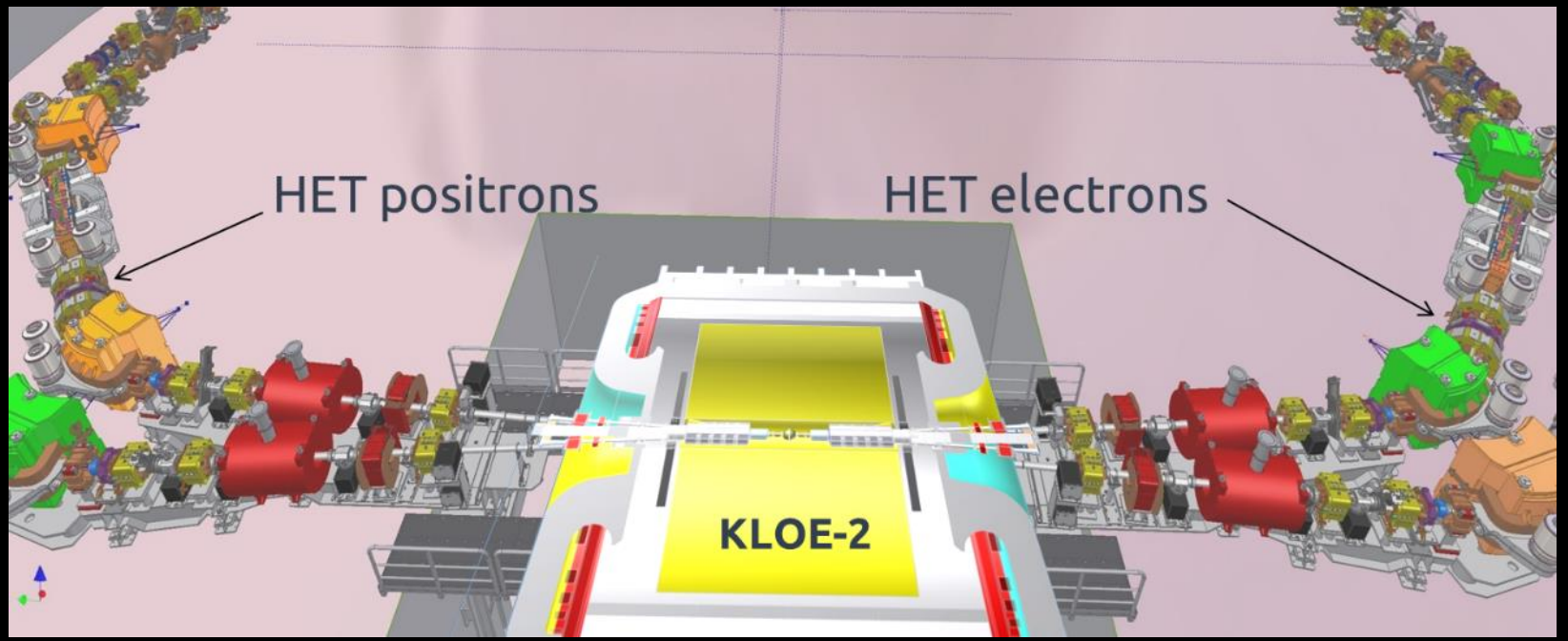
RF period reconstrucion with $\sigma_t \approx 1$ ns



Tagging System

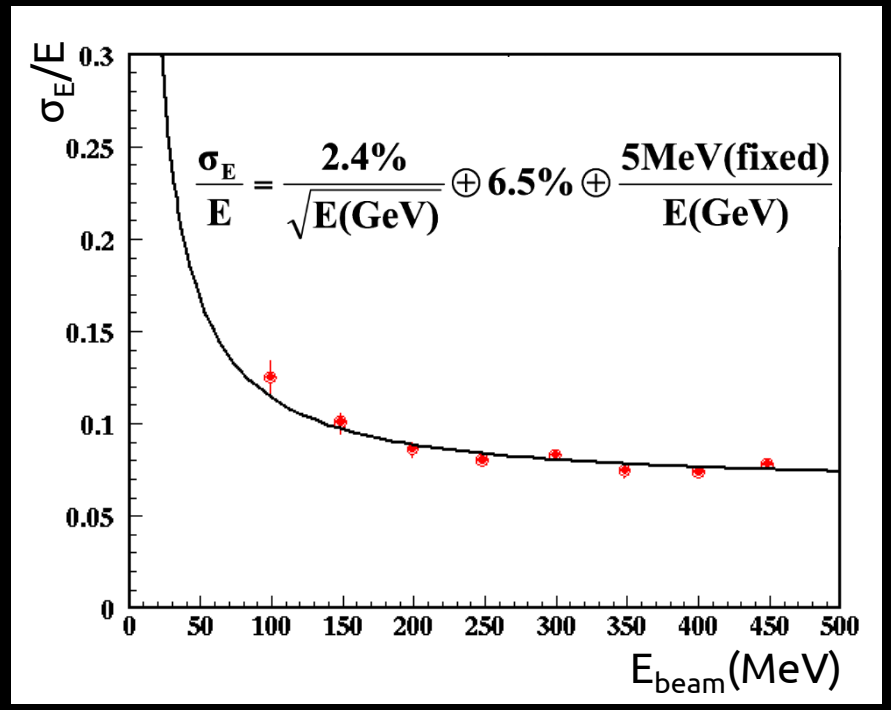
- HET – High Energy Tagger
- LET – Low Energy Tagger





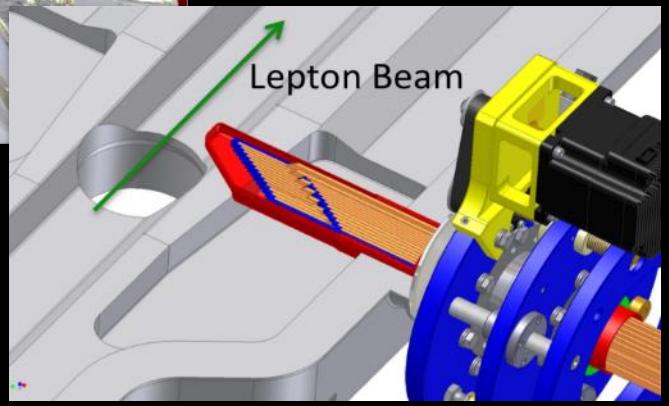
Low Energy Taggers

2 stations inside the QCALT at ± 1m from IP
20 LYSO cristals + SiPM readout
σ_E/E = 10% for E > 150 MeV
150 ÷ 400 MeV energy range
essential for $2\pi^0$ resonance search

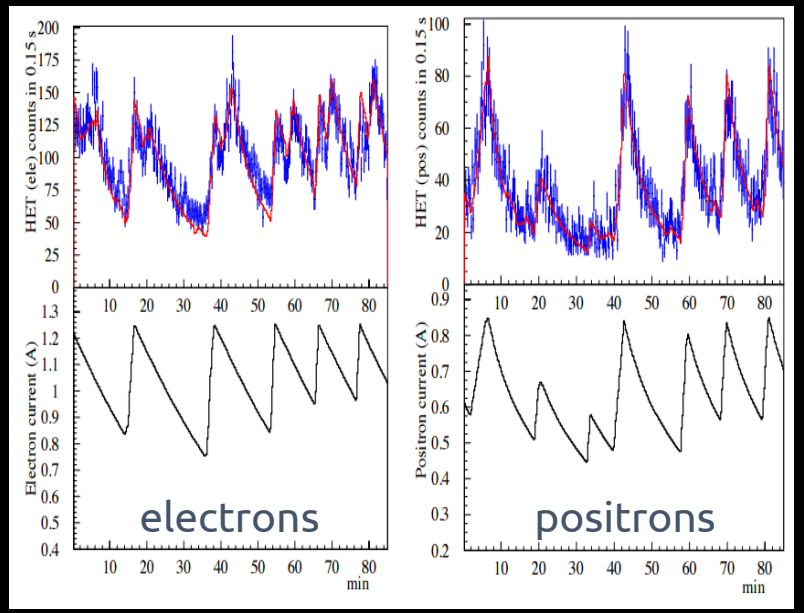


dedicated talk
Monday afternoon

High Energy Taggers



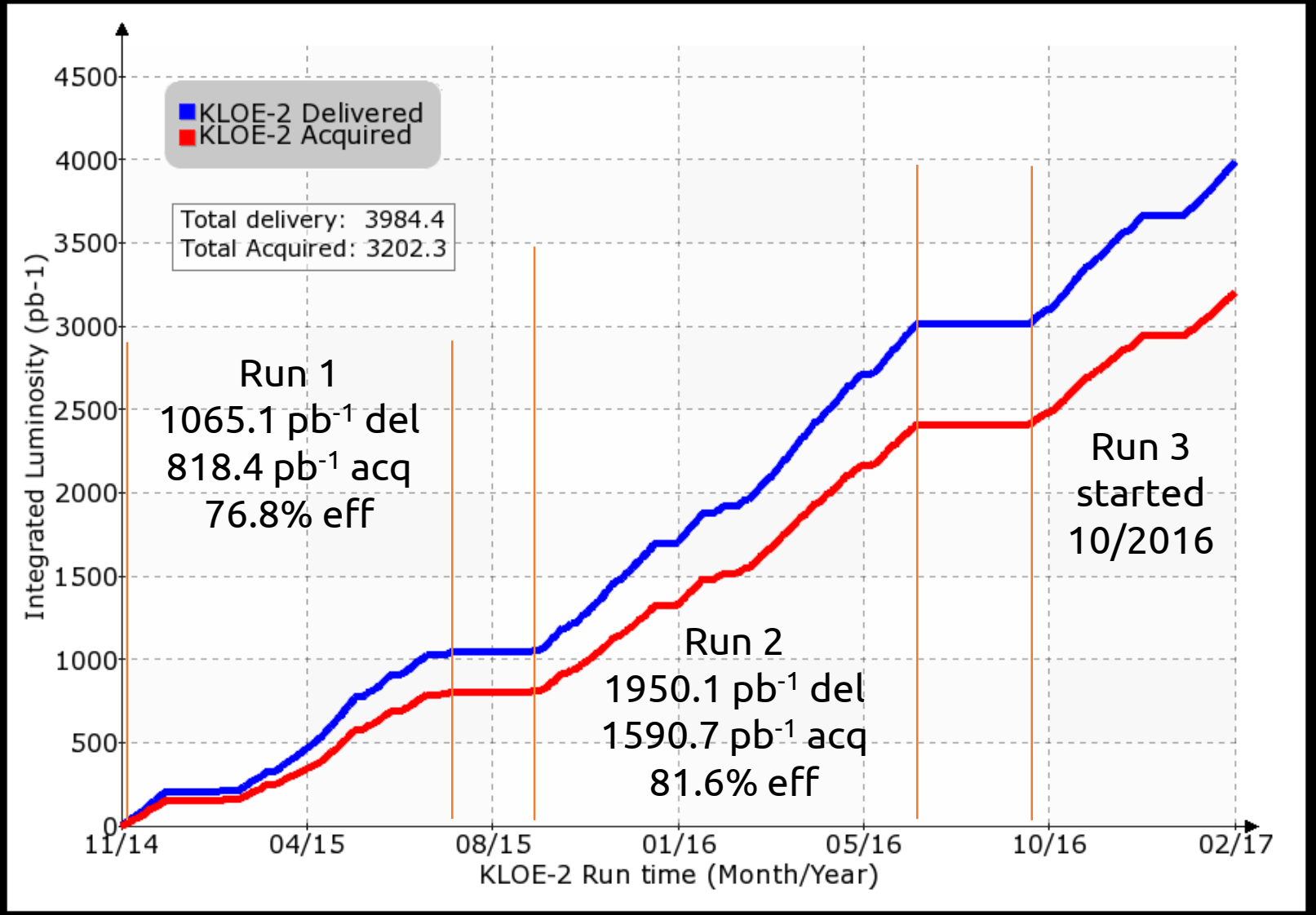
2 stations after the dipoles at ± 11m from IP
Plastic scintillator hodoscope + PMT readout
σ_E = 2.5 MeV - σ_t = 200 ps
> 400 MeV energy range
essential for π^0 resonance search



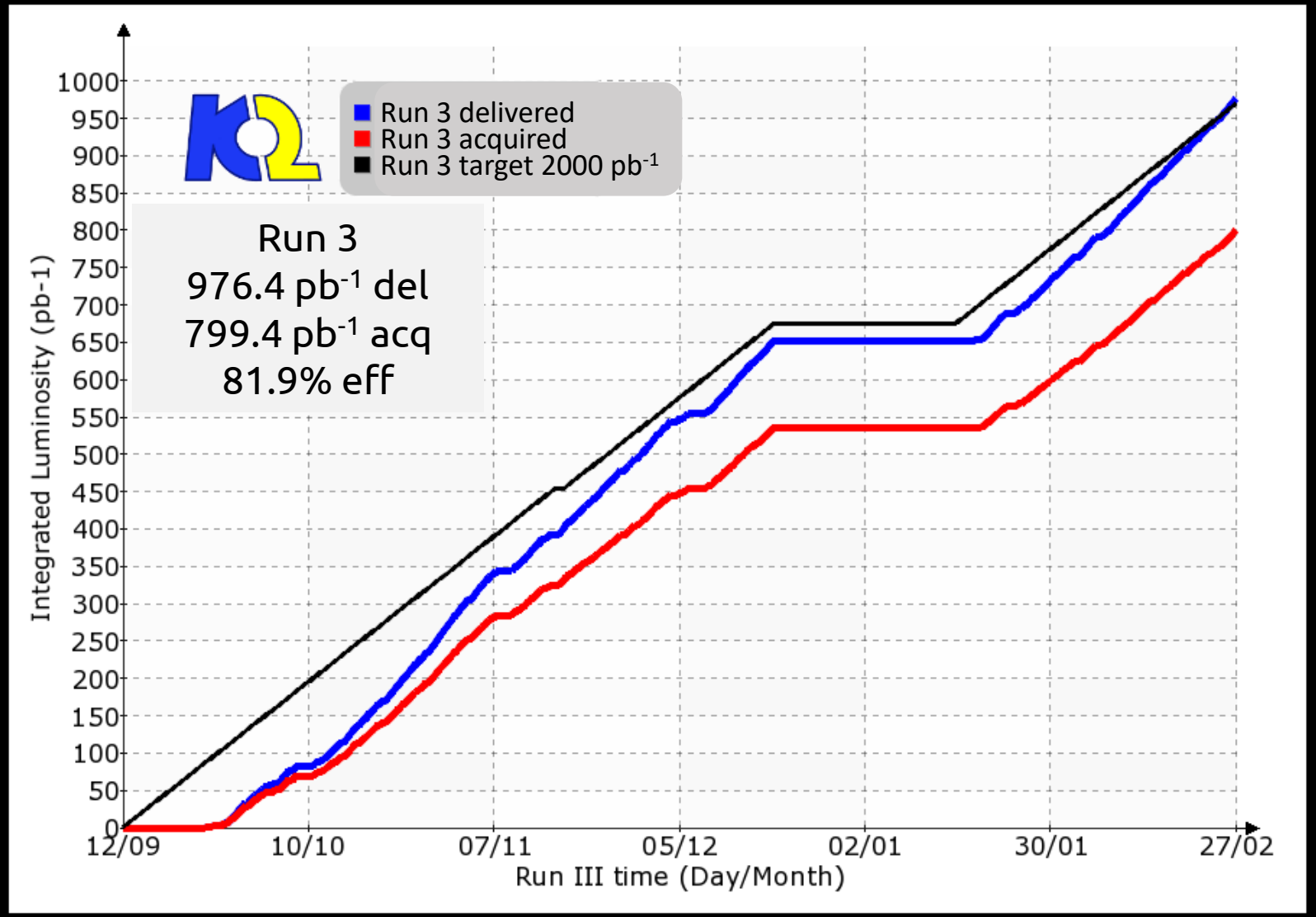
HET counting for
no-collisions runs

Background at DAFNE
mostly due to
Touschek particles

KLOE-2 data-taking: Summary



KLOE-2 data-taking: Run 3

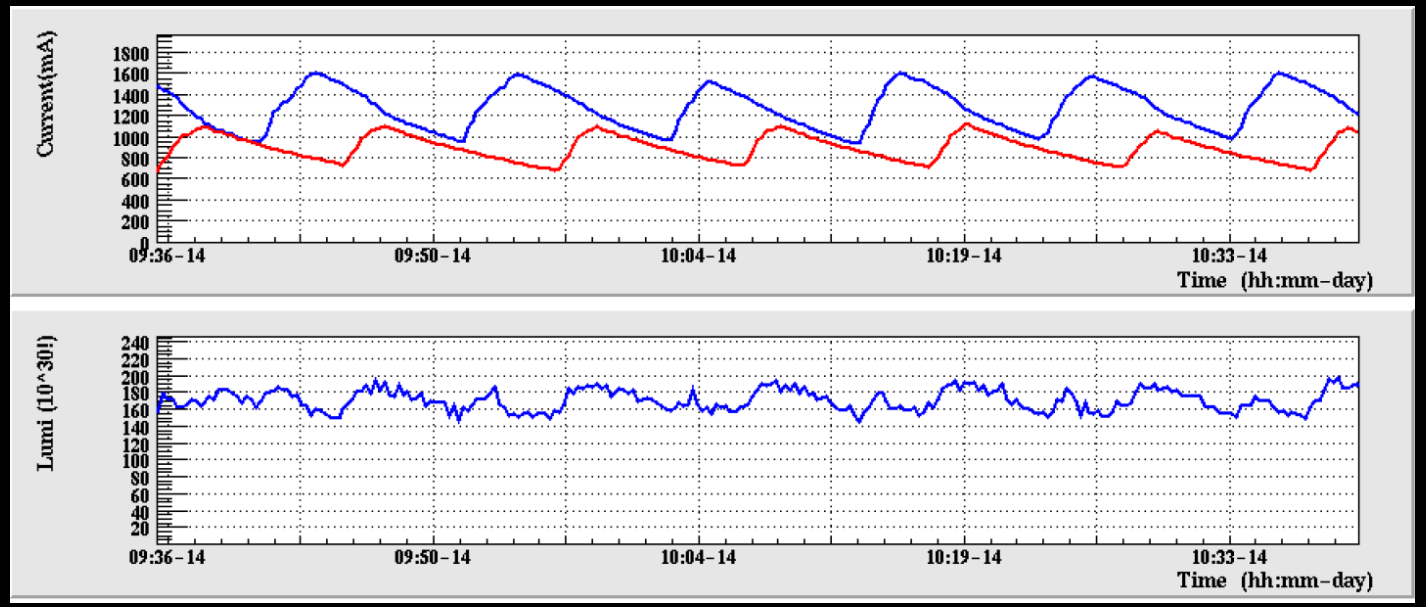


DAFNE performance

DAFNE complex consolidated in 2013 to improve up-time
Main characteristics:

- Typical beam currents 1.4A (e^-) and 1A (e^+)
- 105 bunches stored with 2.7 ns spacing
- Top-up injections of e^- and e^+ beams every 10 min
- Average up-time 80%

good hour of operation



Best Luminosity achievements in KLOE-2 Data-taking

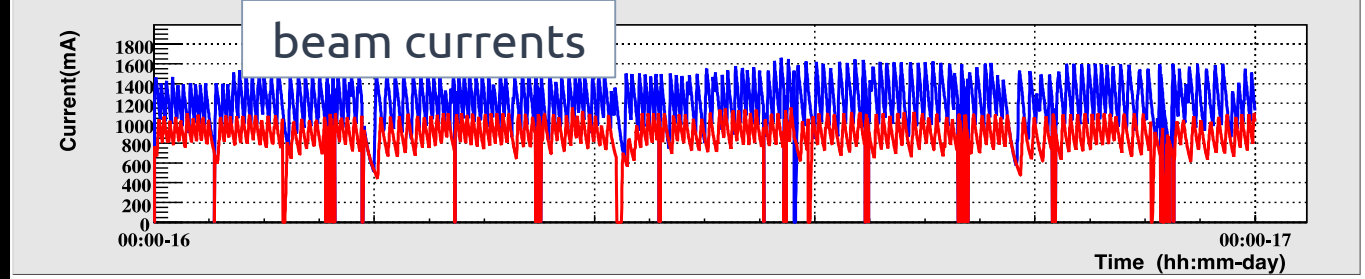
Max instantaneous: $2.21 \times 10^{32} cm^{-2} s^{-1}$
Max hourly: 651.0 nb^{-1}
Max daily delivery: 13.4 pb^{-1}
Max weekly delivered: 76.3 pb^{-1}

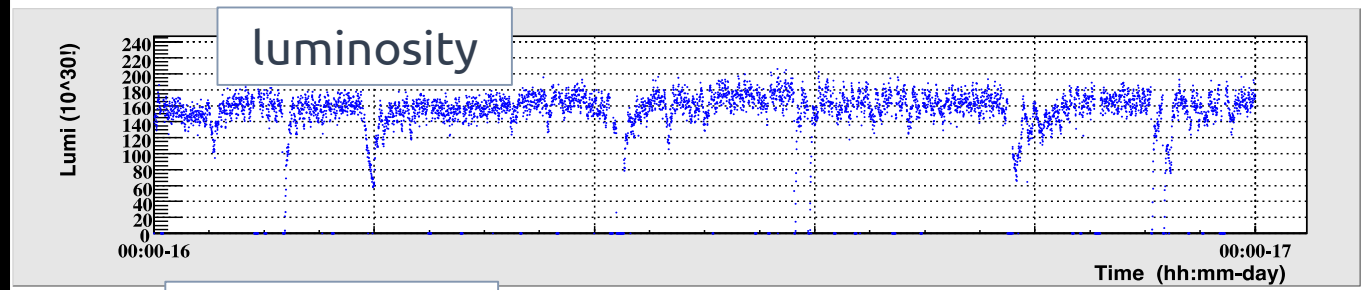
Typical Day

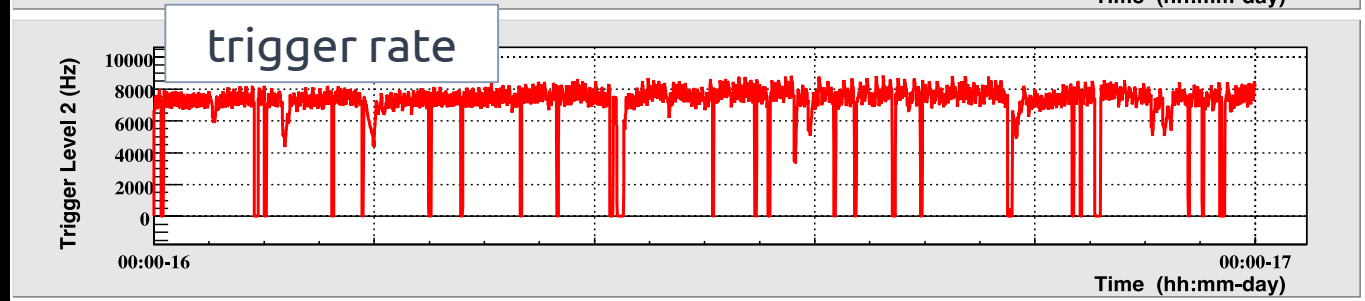
top-up injection results in a uniform instantaneous luminosity

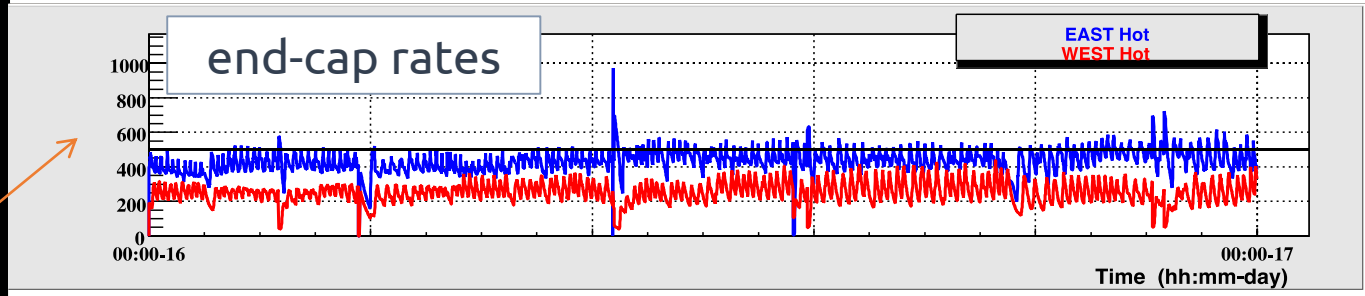
L2 trigger rate is about 7 kHz
500 Hz from Φ physics
3 kHz from cosmic muons
2.5 kHz from Bhabha events
the rest is background
(mostly Touschek scattered particles)

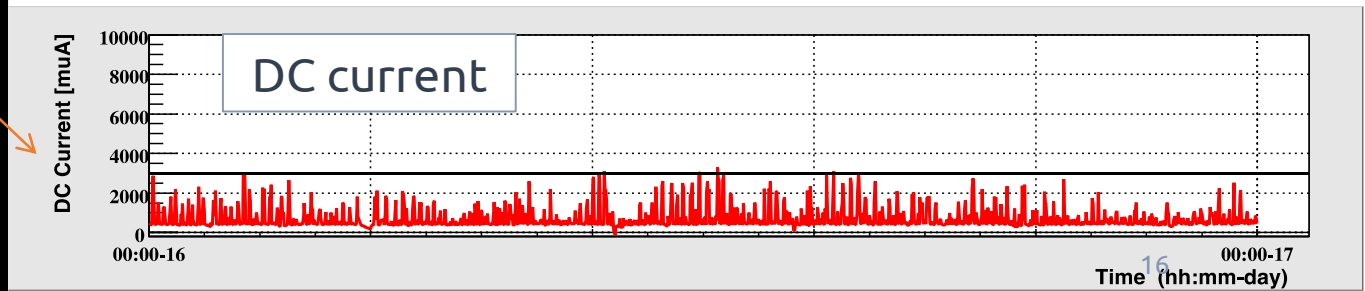
Calorimeter end-caps counters and total current in Drift Chamber are used as benchmarks for evaluating the machine induced background



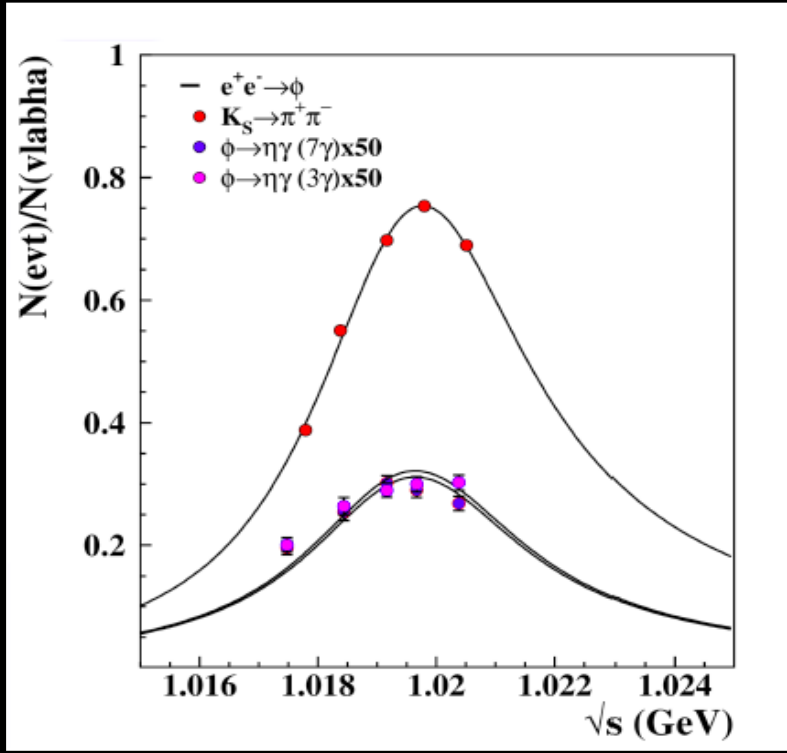








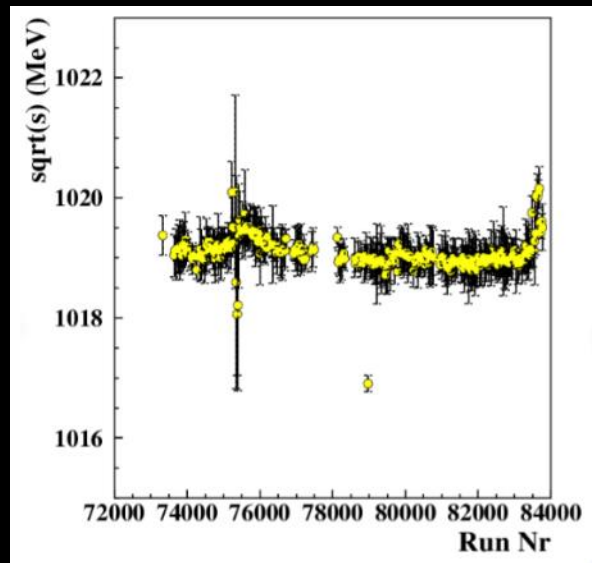
Beam parameters Monitor



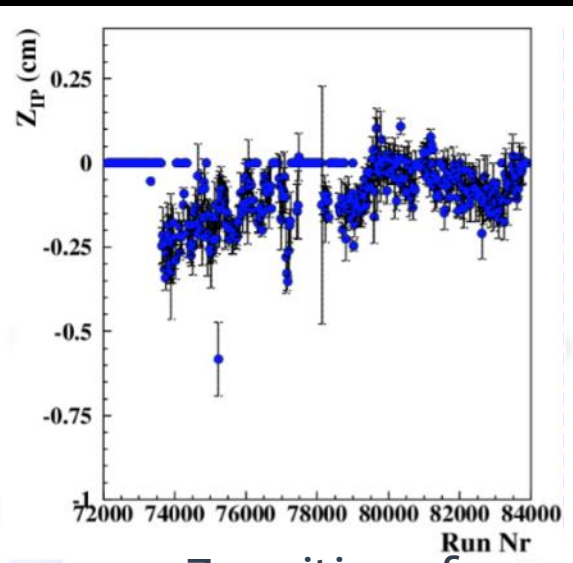
DAFNE RF scan (550 keV steps) to precisely set the beam energy to Φ peak

√s = 1019.5 MeV

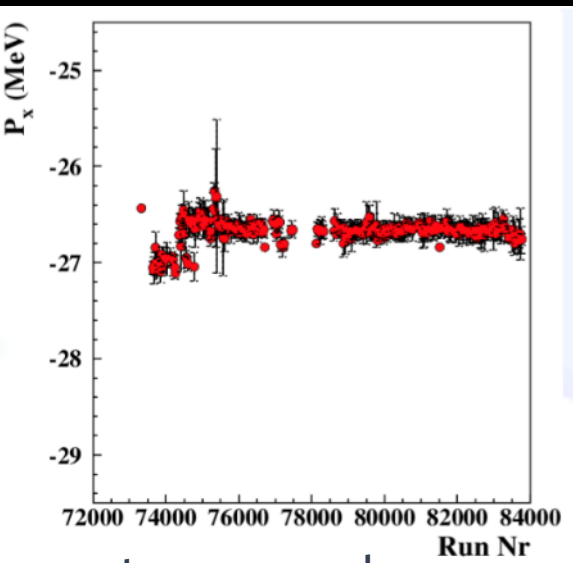
Beam parameters are precisely measured by KLOE and used also as feedback to DAFNE



center of mass energy



Z position of interaction point



transverse beams momentum

Data Quality Monitor Benchmark Analysis

K_S lifetime with $K_S \to \pi^+\pi^-$ (fully charged channel)

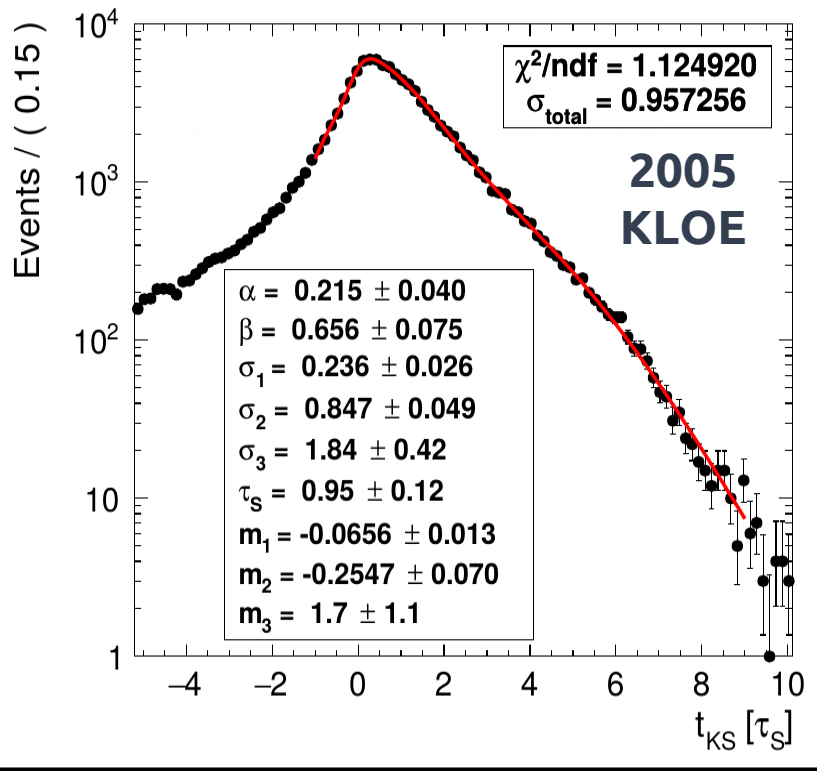
$\Phi \to \eta\gamma$ with $\eta \to 3\pi^0$ (fully neutral channel)

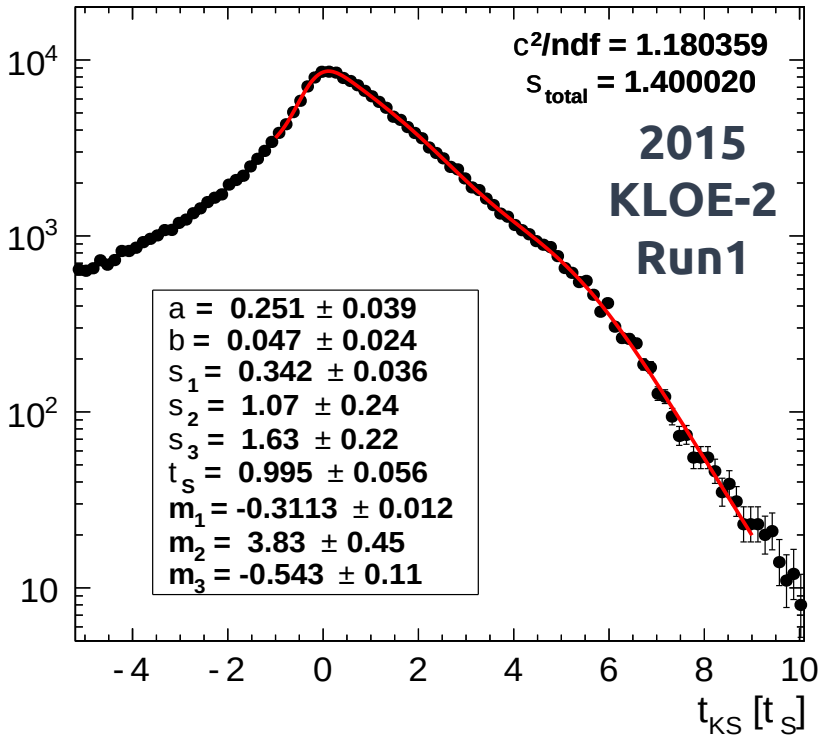
$K_L \to \pi^+\pi^-$ (fully charged channel)

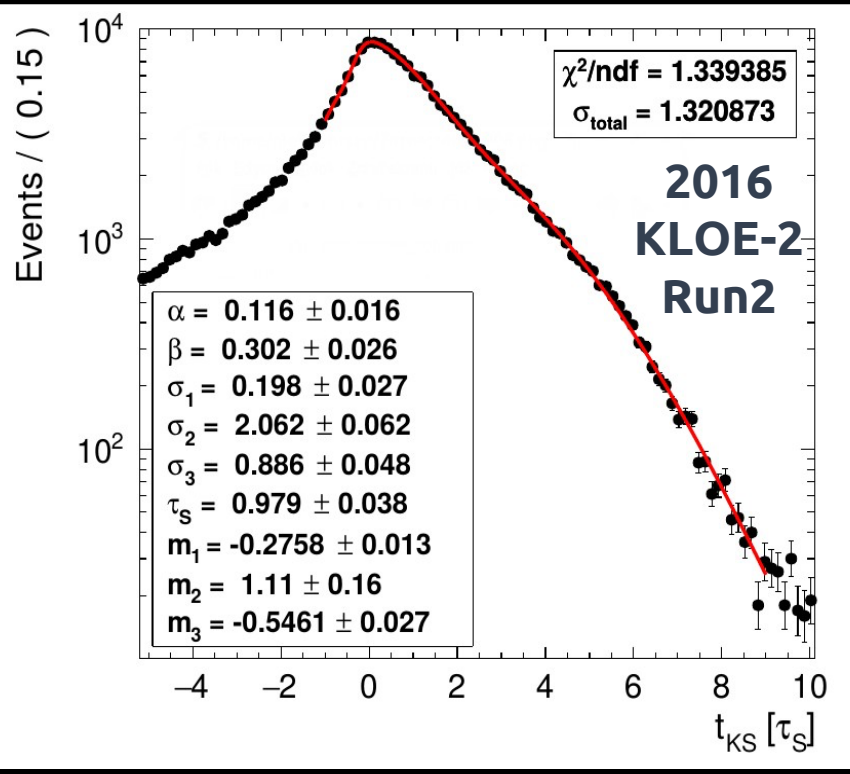
$\Phi \to \eta\gamma$ with $\eta \to \gamma\gamma$ (fully neutral channel)

$K_L \to \pi^+\pi^-$ (fully charged channel)

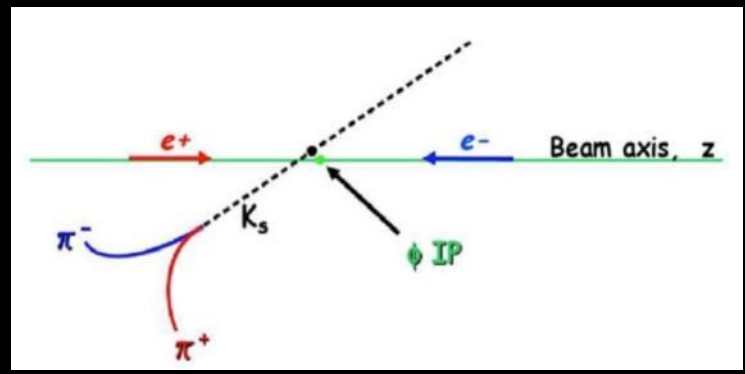
K_S lifetime with $K_S \to \pi^+\pi^-$



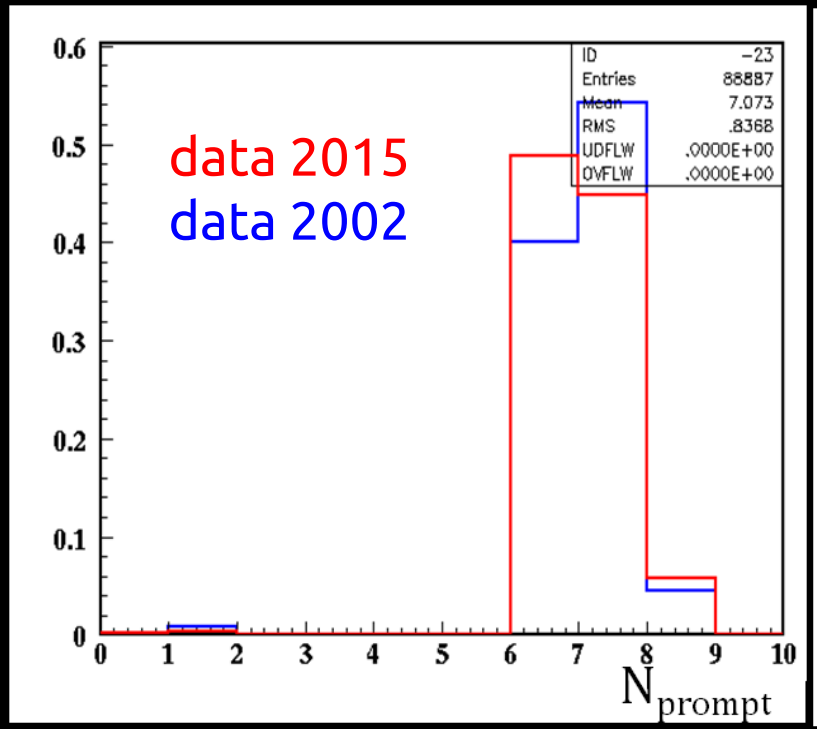


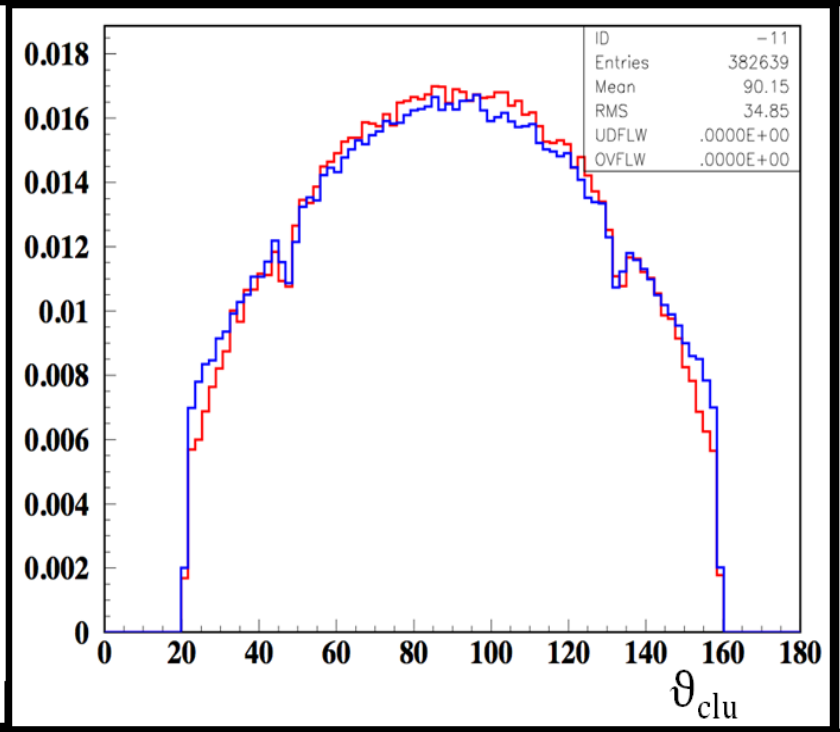


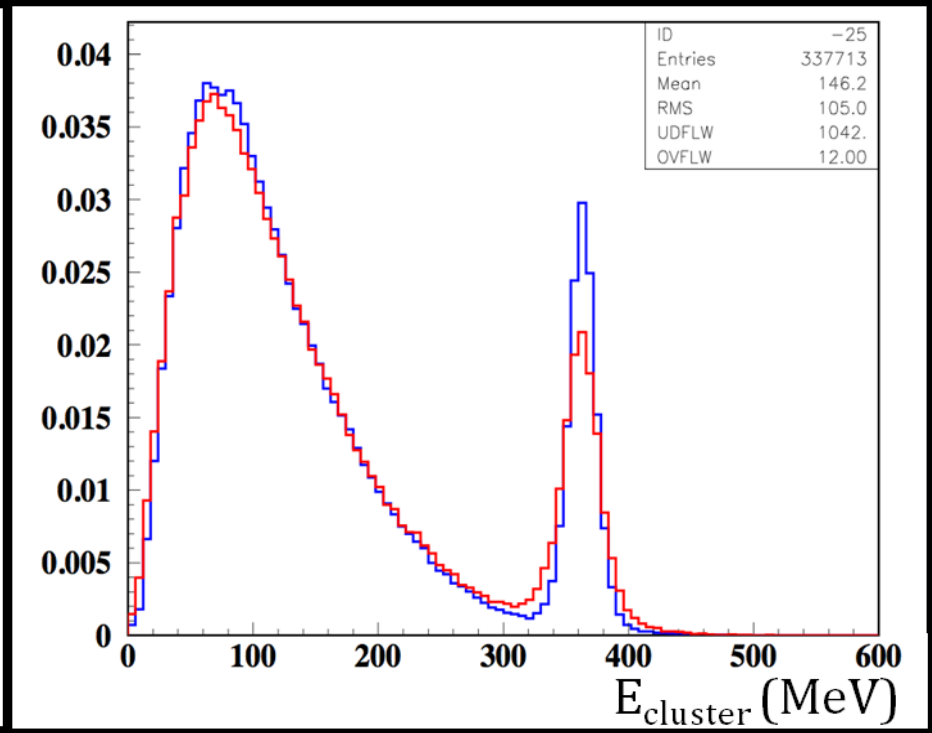
- Exponential function folded with a triple gaussian
- Time calculated from the projection of the decay length on the K_S momentum direction (negative tail due to resolution)
- Still space for improvement fully exploiting IT tracking



$\Phi \rightarrow \eta\gamma$ with $\eta \rightarrow 3\pi^0$







- Search for neutral rad with $N_{prompt} > 5$ clusters
- Background contribution to cluster distribution wrt 2002
- Select $\Phi \rightarrow \eta\gamma$ with $\eta \rightarrow 3\pi^0$ (clean 363 MeV recoil γ)

DAFNE Time Horizon

	2014				2015				2016				2017				2018				2019			
	I quad	II quad	III quad	IV quad	I quad	II quad	III quad	IV quad	I quad	II quad	III quad	IV quad	I quad	II quad	III quad	IV quad	I quad	II quad	III quad	IV quad	I quad	II quad	III quad	IV quad
KLOE-2																								
PADME																								
SIDDHARTA-2																								

- KLOE-2 will end data-taking 31 March 2018
  - Luminosity goal: 5 fb^{-1} acquired on disk
- PADME will take data (with only LINAC) from 1 April 2018 to end 2018
  - Statistics goal: 10^{13} positrons on target
- SIDDHARTA-2 will take data from January to July 2019
  - Luminosity goal: 800 pb^{-1} acquired on disk

several possible re-use of the DAFNE complex are under evaluation, spanning from a world-class accelerator physics test bed to single beam electron or positron facility

The PADME experiment

DAFNE LINAC characteristics

Length: 50 m

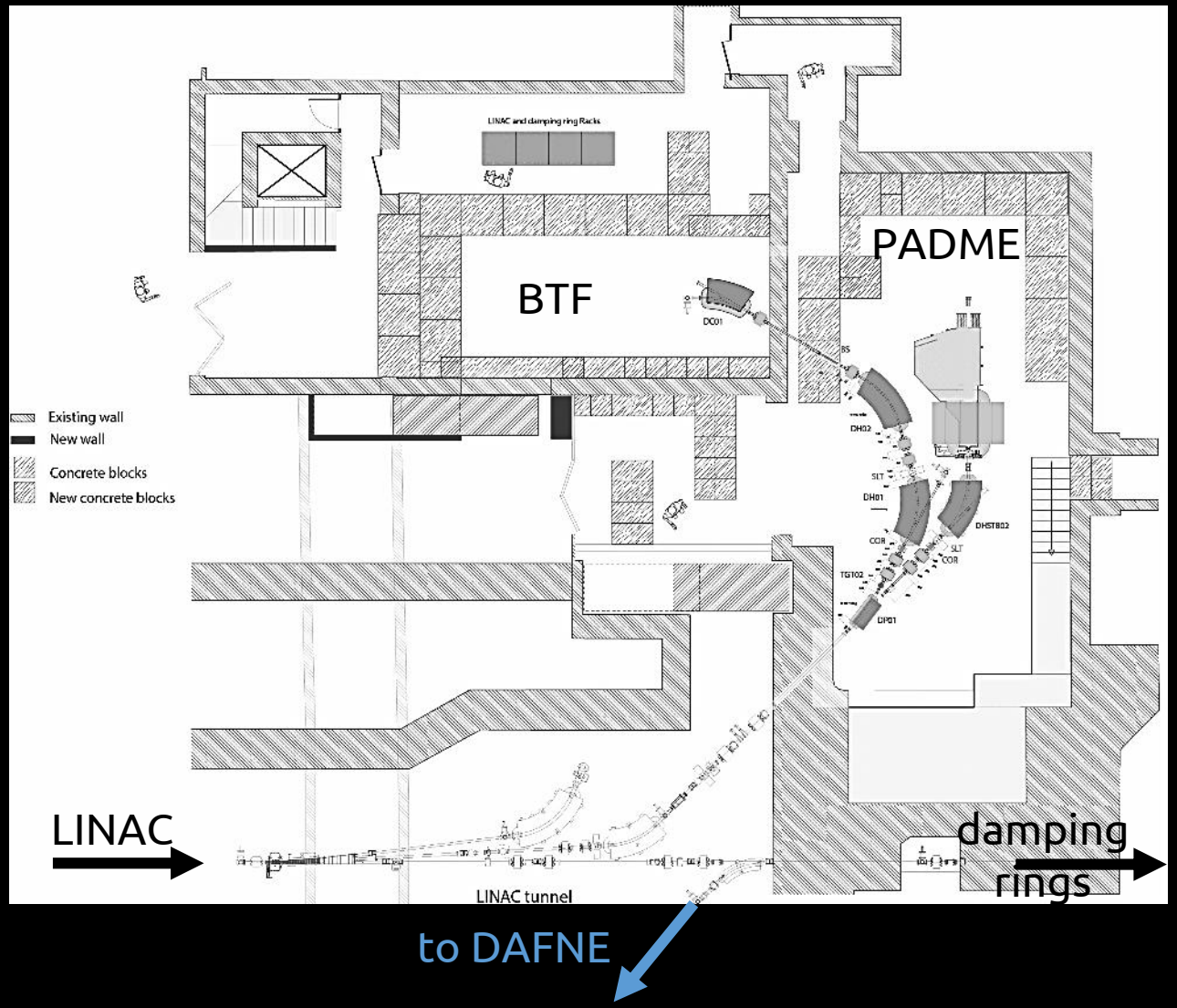
Particles: electrons or positrons

Max energy: 730 MeV (e^-), 530 MeV (e^+)

Energy spread: 0.5%

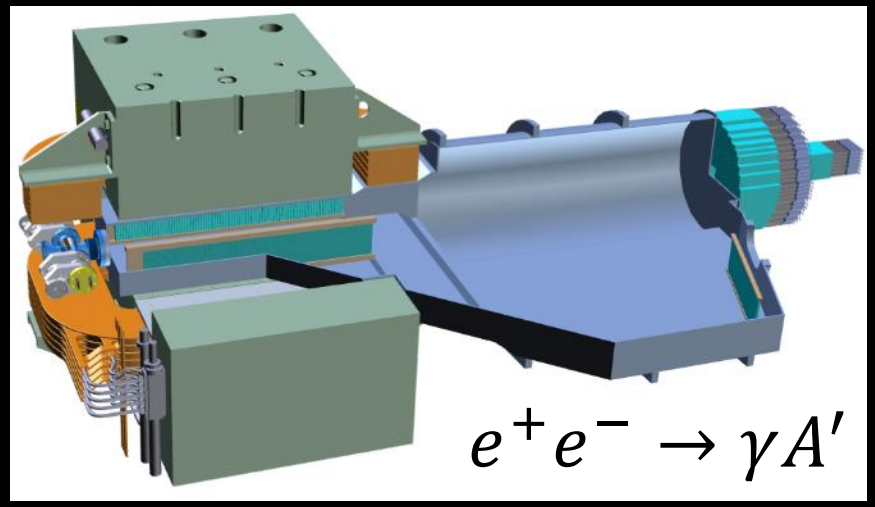
Bunch rate: 1 to 50 Hz

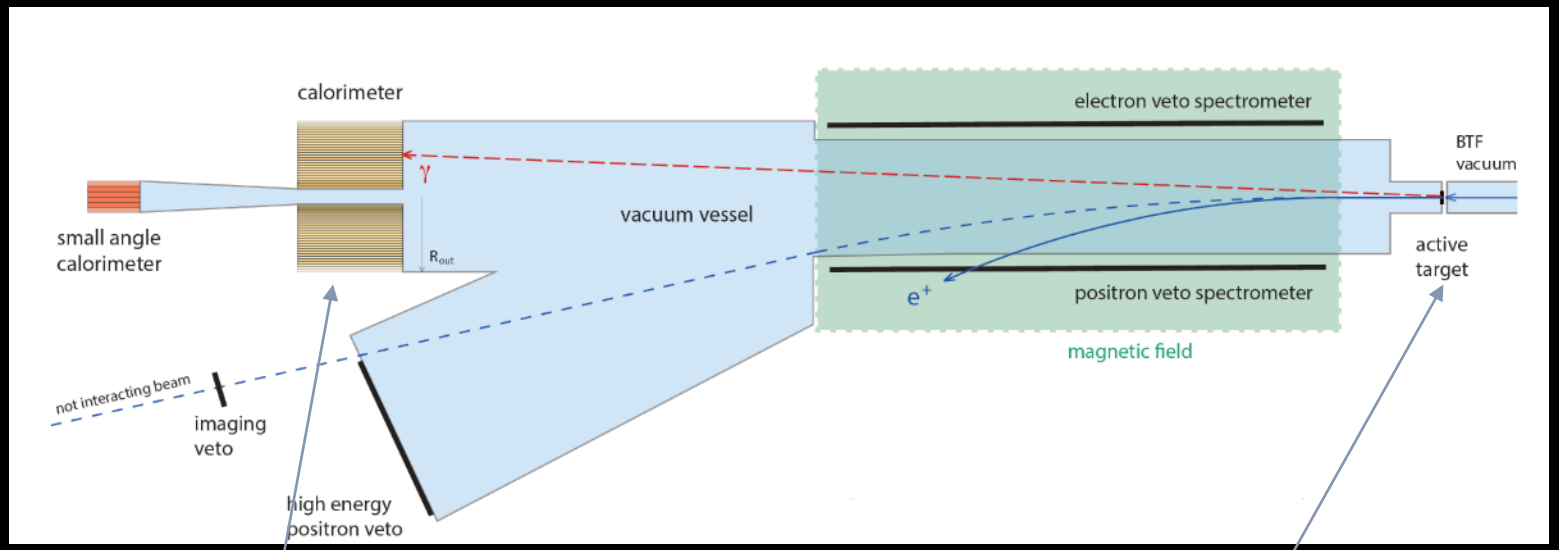
Intensity: up to 3 x 10^{10} part/bunch



The PADME experiment

Positron Annihilation into Dark Mediator Experiment



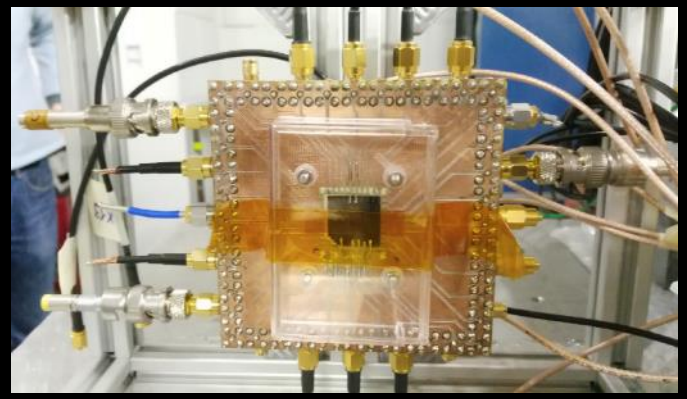


Signal: single photon in calorimeter

Background: bremsstrahlung, multiple photons

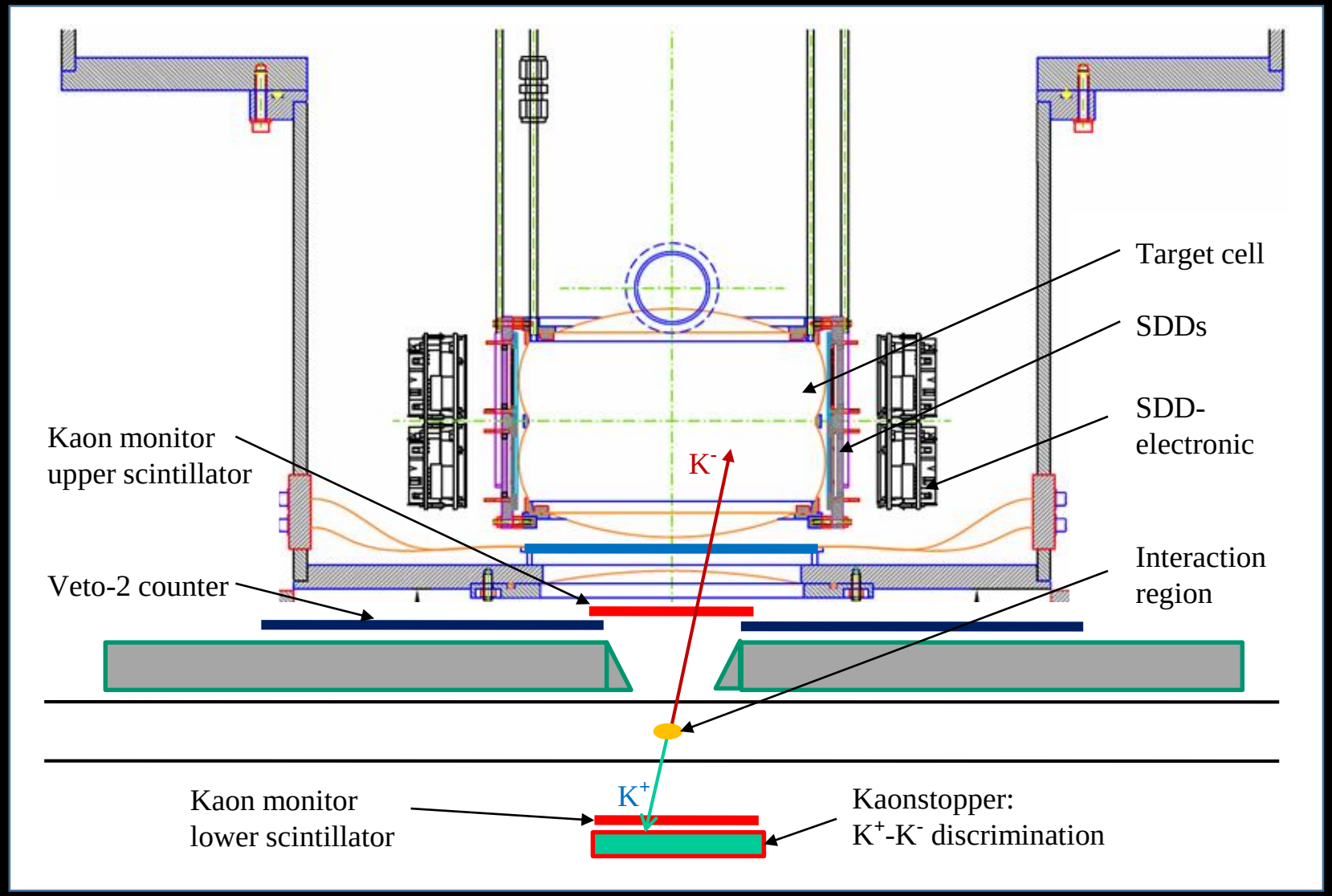
BGO crystals from L3 endcaps reshaped in 21x21 mm^2 220 mm long bars

diamond sensor 20x20x0.05 mm^3



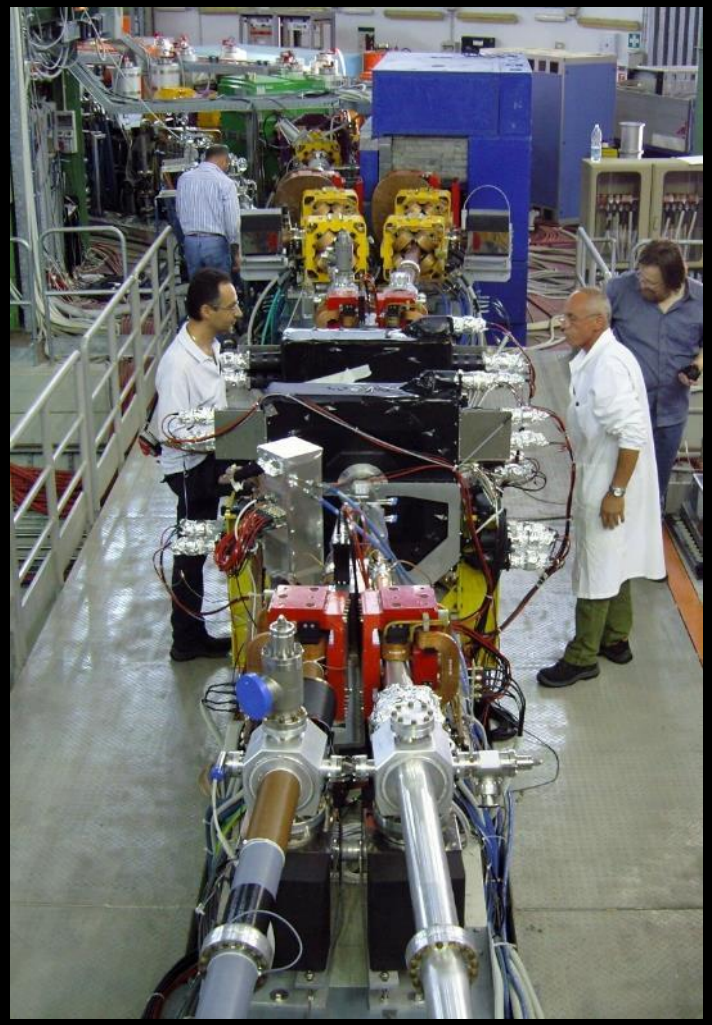
The SIDDHARTA-2 experiment

SIlicon Drift Detector for Hadronic Atom Research by Timing Applications

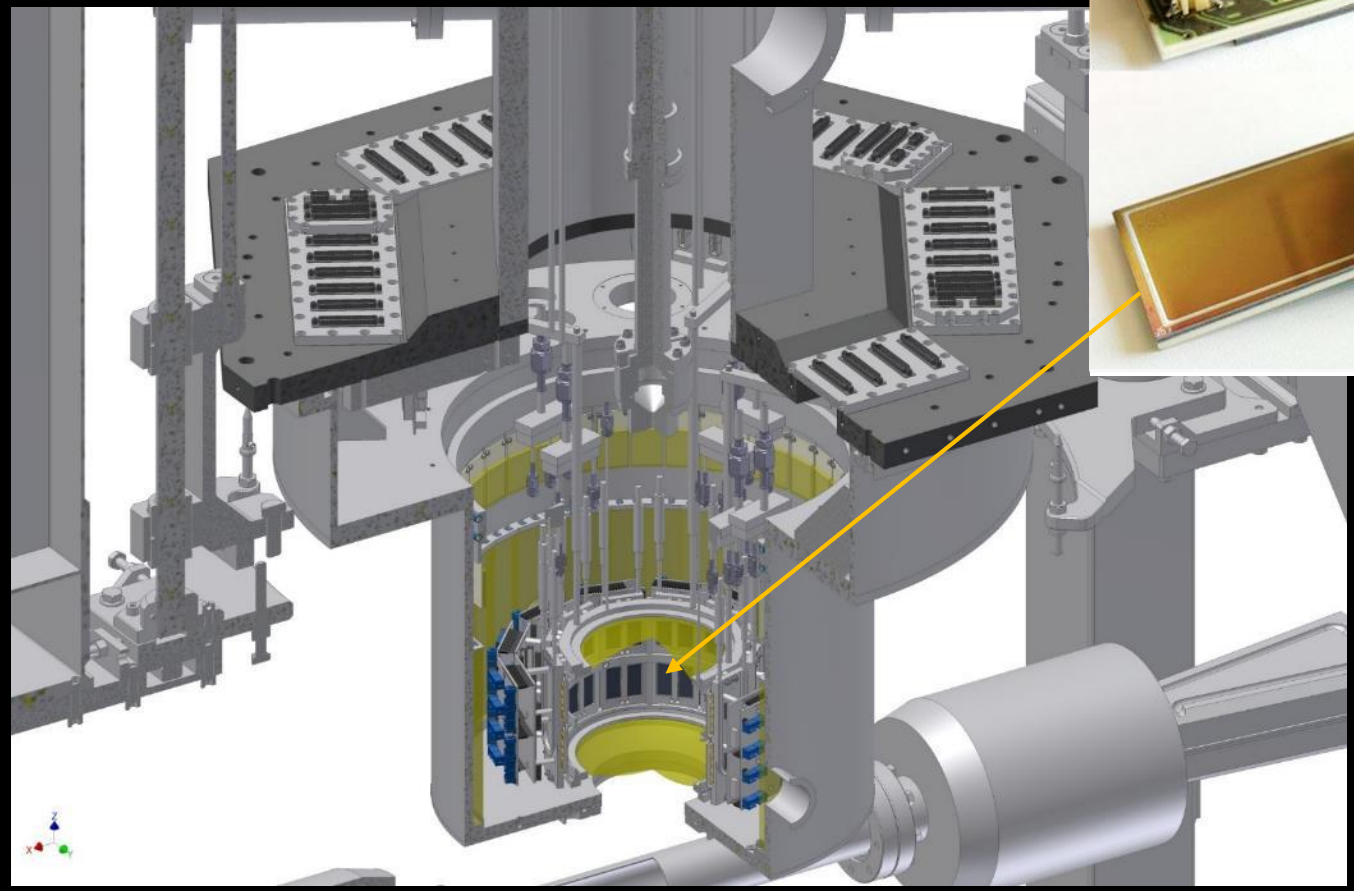


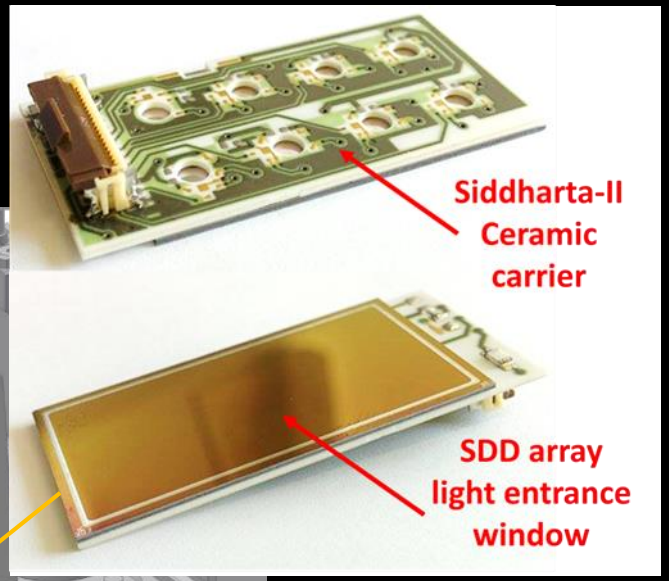
The SIDDHARTA-2 experiment

SIDDHARTA has already run at DAFNE in 2009 measuring the 1S level of kaonic Hydrogen
SIDDHARTA-2 will be upgraded and has the goal to measure for the first time the kaonic deuterium



new SDD
array of 8 sensors 8x8 mm^2





Conclusions

The upgraded KLOE-2 detector is fully operational and running since 2014, heading to collect 5 fb^{-1} for the end of data-taking scheduled in March 2018

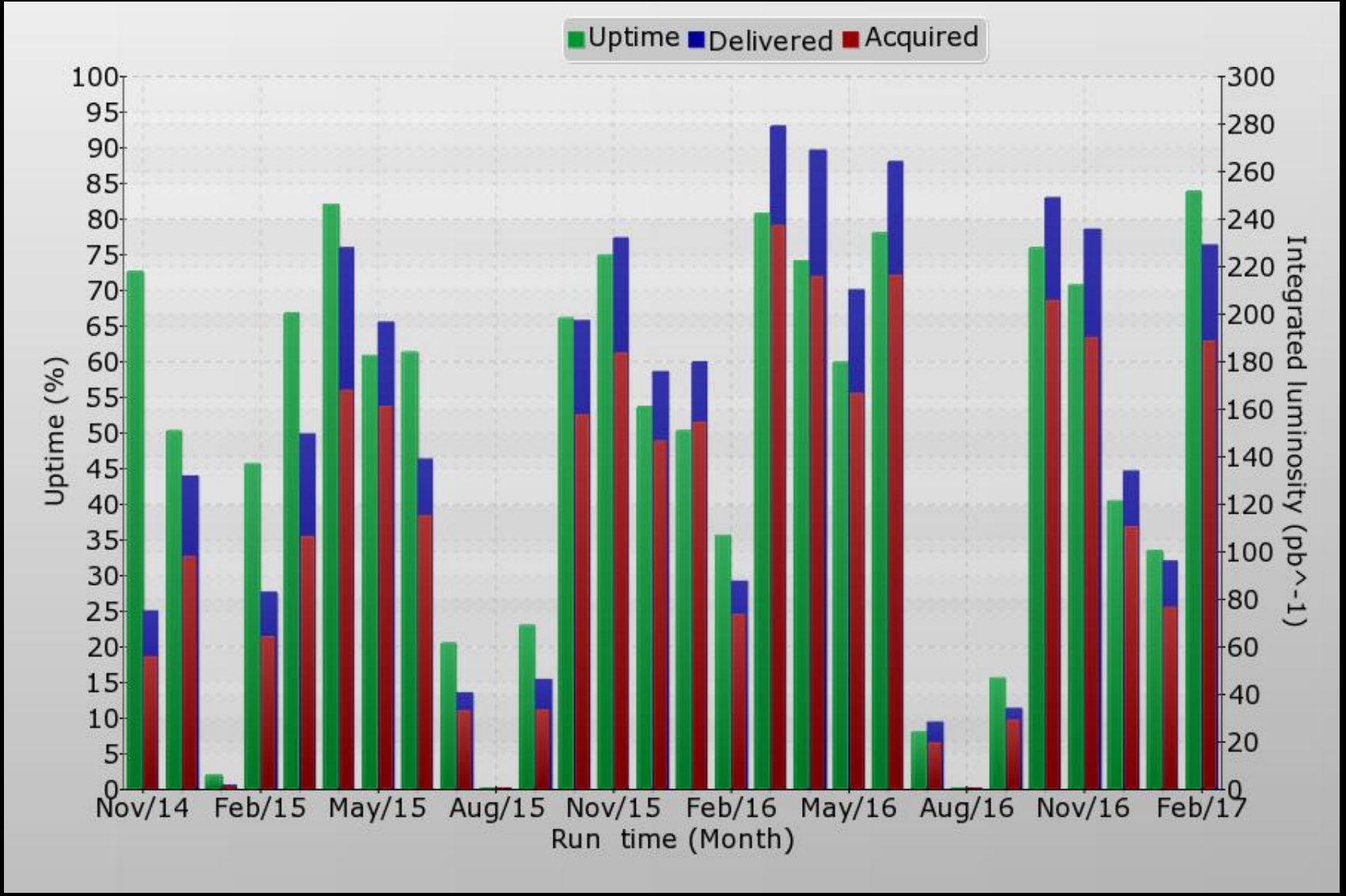
DAFNE is steadily delivering luminosity at an average of 10 pb^{-1}/day with tolerable background level and stable beam parameters

Quality of KLOE-2 data is monitored with benchmark channels and found in good agreement with the past

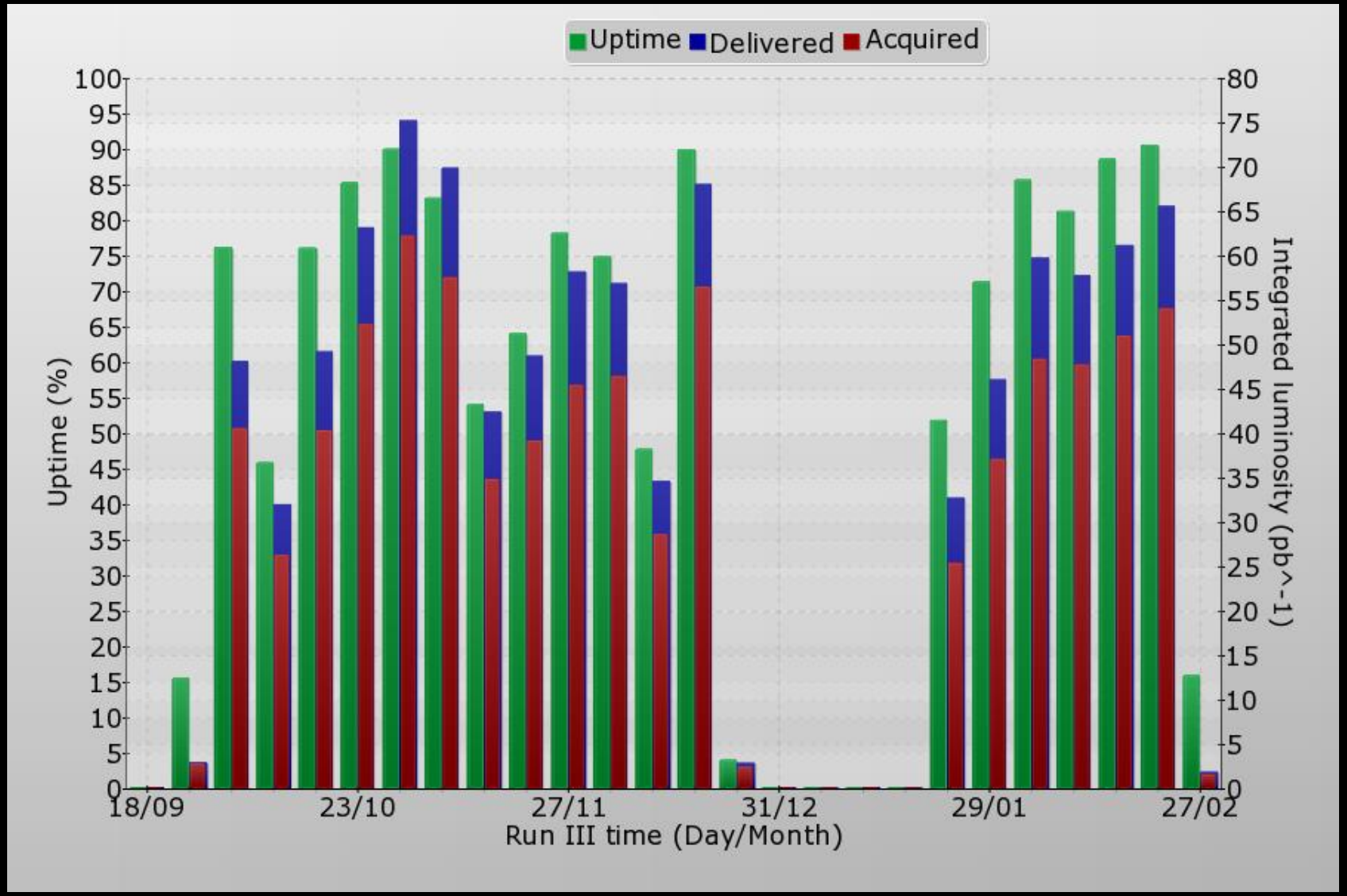
The DAFNE complex will operate until 2019 providing beams for PADME and SIDDHARTA-2 experiment

SPARES

KLOE-2 data-taking: Monthly detail

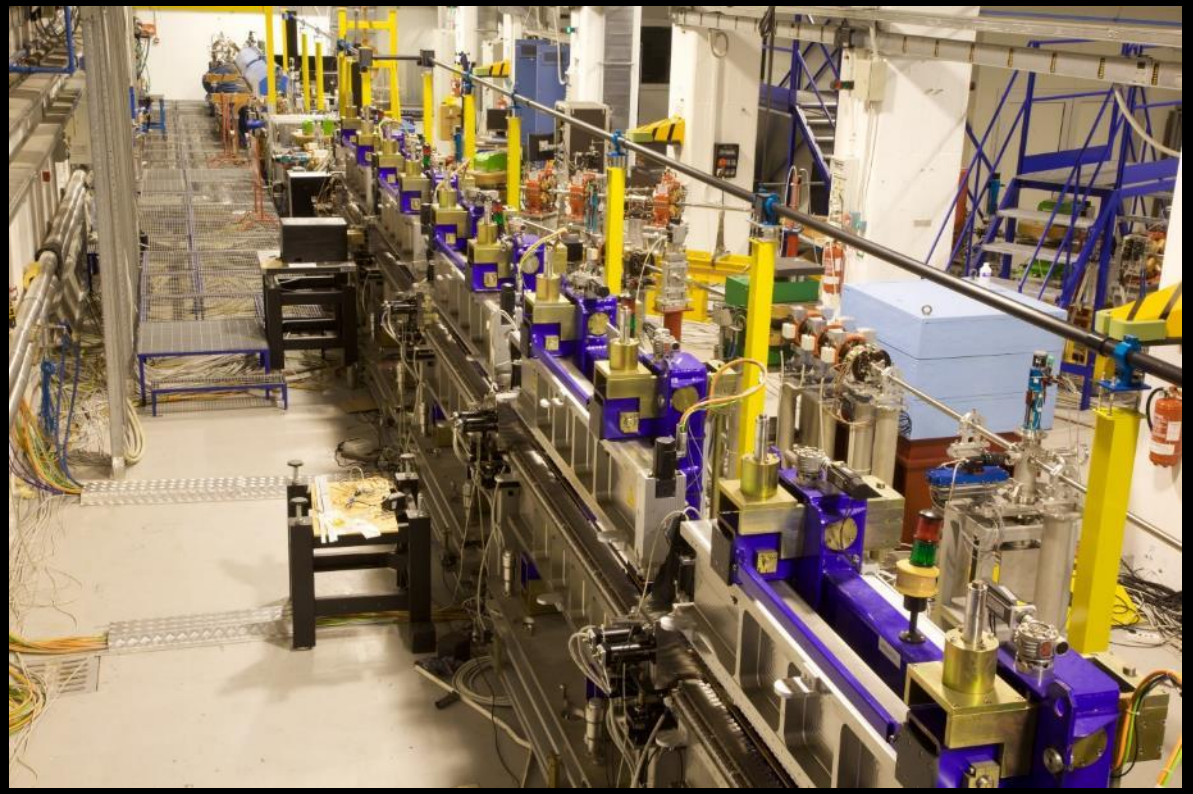


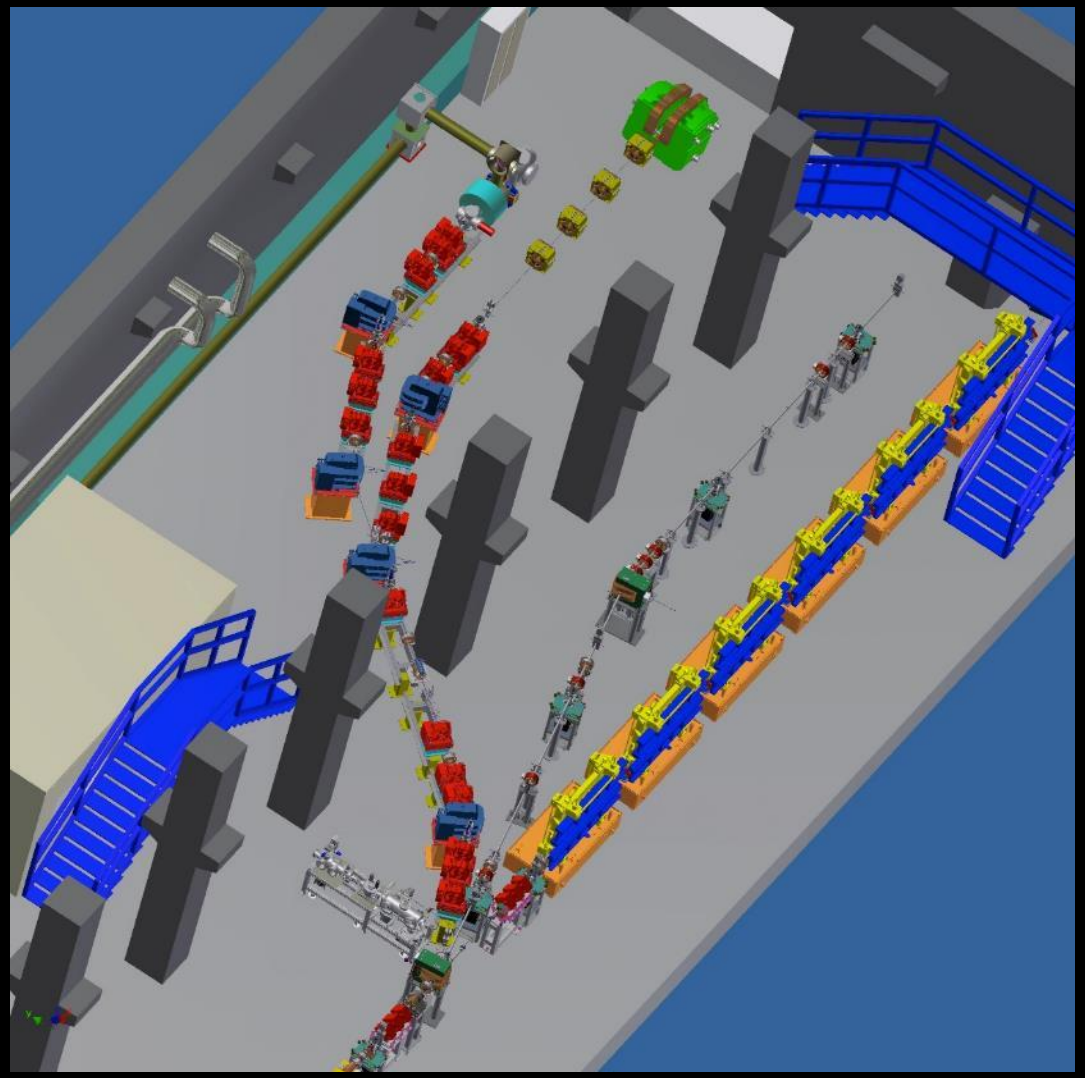
KLOE-2 data-taking: Run 3 weekly detail



SPARC_LAB

Sources for Plasma Accelerators and Radiation Compton with Lasers And Beams





FEL + High Power Laser

Research on new acceleration techniques using plasma wakefield both laser and beam driven