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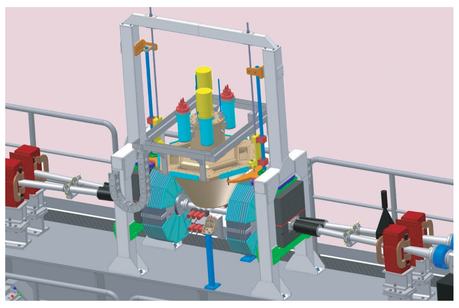
Detectors for Absolute Luminosity Measurement for Crabbed Waist Collisions at DAFNE Phi-factory

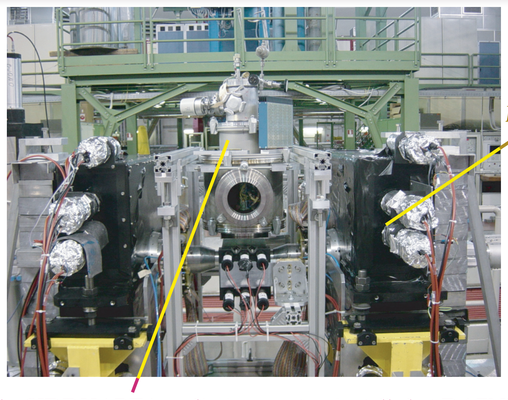


Three different processes are used to measure the DAFNE luminosity:

-The Bhabha elastic scattering e+ e- to e+ e-;
polar angle range covered by calorimeters 18-27 degrees,
expected rate (~440 Hz at a luminosity of 10^{32} cm-2 s-1)

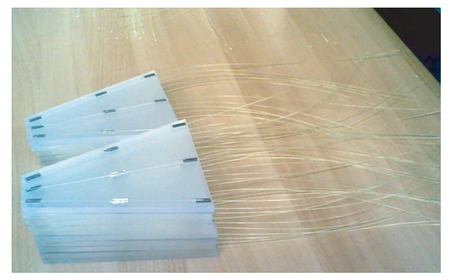
-The very high rate e+ e- to e+ e- g (radiative Bhabha process);
95% of the signal in contained in a cone of 1.7 mrad aperture,
but suffers heavily from beam losses due to interactions with
residual gas and from Touschek effect.

- e+e- to Φ to K+ K-, at a rate of about 25 Hz at 10^{32} is expected in the SIDDHARTA experiment monitor at ~90 degrees.



The SIDDHARTA preliminary setup installed at DAFNE.

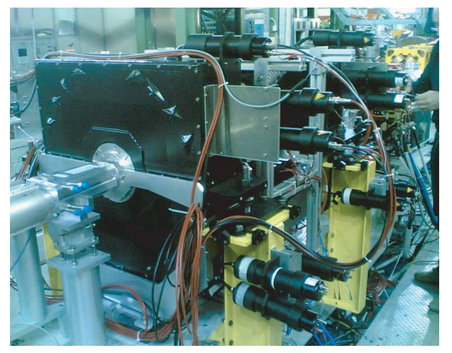
Bhabha calorimeters construction



1 cm scintillator tiles [Protvino], each read by 3 wavelength shifting fibers [Bicron, 1mm]
36 fibers/sector, 1 photomultiplier/sector

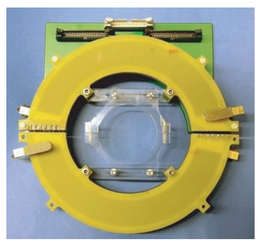
All tiles wrapped in a Tyvek foil

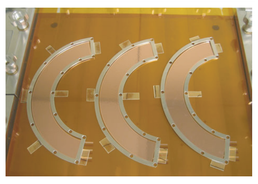
8 lead plates [5 mm thick] + 3 lead plates [1 cm]

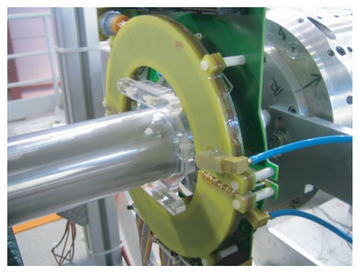


The four half-calorimeters installed around the DAFNE interaction region

Triple-GEM trackers

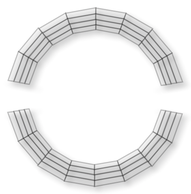






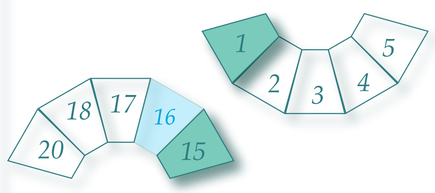
In front of each calorimeter, at a distance of 18.5cm from the IR, a ring of triple-GEM detectors is installed around the beam pipe. The two GEM trackers are divided in two units, with an half-moon shape; the top (bottom) half covers azimuthal angles [14,166] degrees ([194,346] degrees).

Each of the four GEM units is segmented into 32 pads:
eight cells in azimuth (covering 19 degrees) are arranged in four rings of equal radial extension.

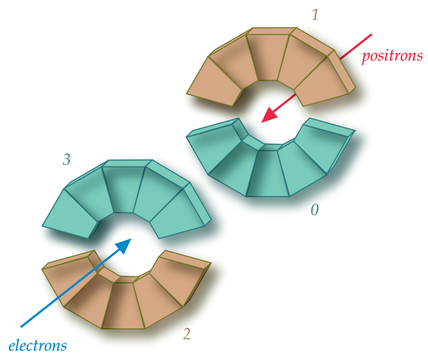


When a charged particle crosses the 3 mm drift gap, it generates electrons that will be multiplied by the three GEM foils separated by 2/1/2 mm.
Each of the GEM planes is made of a thin (50mm) kapton foil sandwiched between two copper clads and perforated by a dense set of holes (70mm diameter, 140 mm pitch).
As a high potential difference (about 400 kV) is applied between the copper sides, the holes act as multiplicating channels and the gain of each layer is about 20 (and hence roughly 8,000 in total).
The GEM trackers, are included into the main DAQ system.

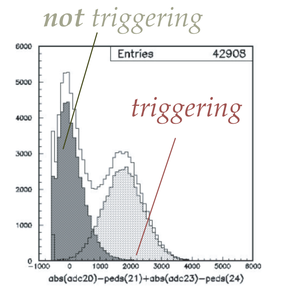
Trigger



Bhabha elastic scattering e+ e- to e+ e- has a very clean signature:
two energy deposits in two back-to-back s ectors.
At the trigger level, we require two energy deposits in the sum of the 5 sectors of a couple of back-to-back modules, with an equivalent threshold of ~200 MeV

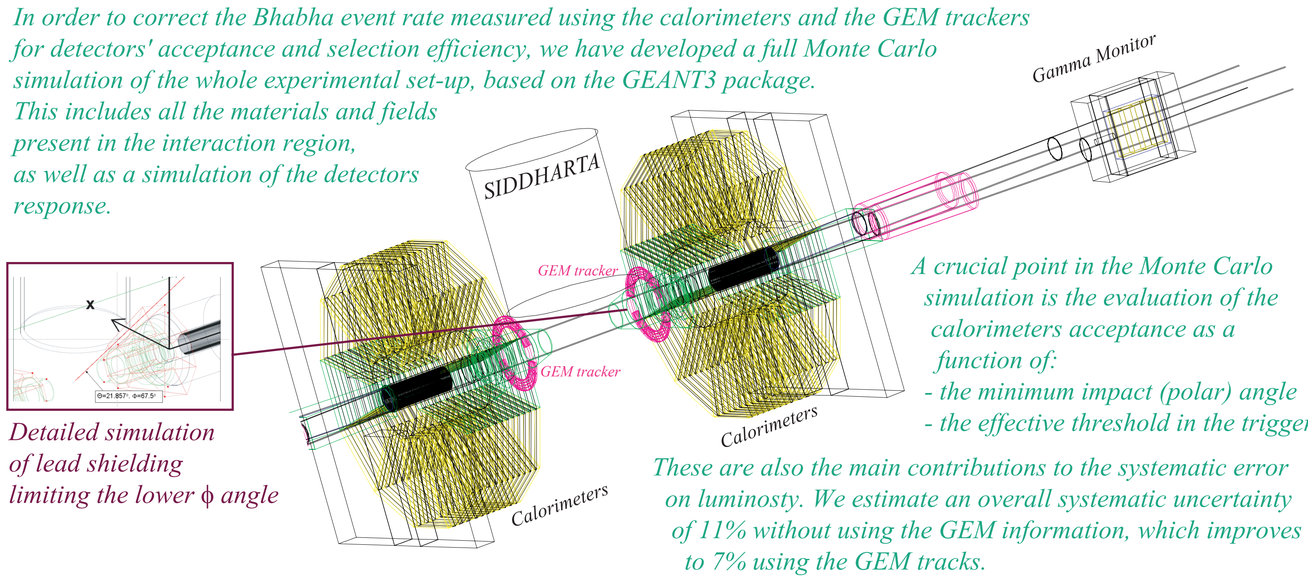


Trigger:
back-to-back coincidences of 2 modules [1 module=5 sectors]
*(**0** AND **3**) OR (**1** AND **2**)*



Total energy deposited in module

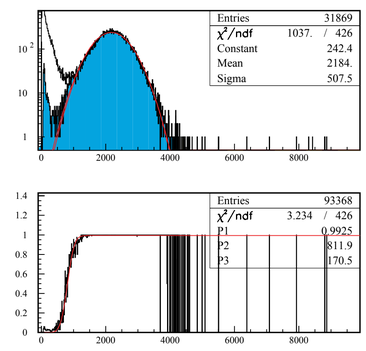
In order to correct the Bhabha event rate measured using the calorimeters and the GEM trackers for detectors' acceptance and selection efficiency, we have developed a full Monte Carlo simulation of the whole experimental set-up, based on the GEANT3 package.
This includes all the materials and fields present in the interaction region, as well as a simulation of the detectors response.



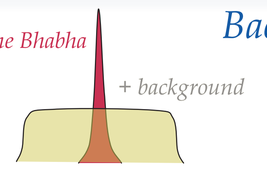
Detailed simulation of lead shielding limiting the lower ϕ angle

A crucial point in the Monte Carlo simulation is the evaluation of the calorimeters acceptance as a function of:
- the minimum impact (polar) angle
- the effective threshold in the trigger

These are also the main contributions to the systematic error on luminosty. We estimate an overall systematic uncertainty of 11% without using the GEM information, which improves to 7% using the GEM tracks.

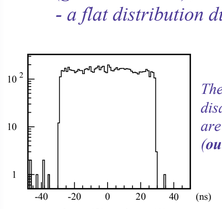


Background subtraction

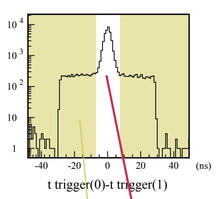


A filtering process has been implemented in the DAQ system, for on-line correction of the rate by subtracting the percentage of background events.

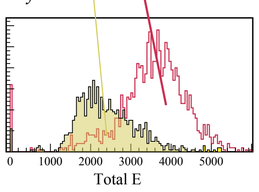
The correction is estimated analyzing blocks of events (typically 1000 ~ 1s at 1 kHz), and by performing a cut on the distribution of the time of the two triggering modules.
In the difference of the arrival time of Bhabha candidates (for a couple of triggering modules) we can see two contributions:
*- a Gaussian distribution peaked at Δt=0 (**good Bhabha's**);*
*- a flat distribution due to **background**.*



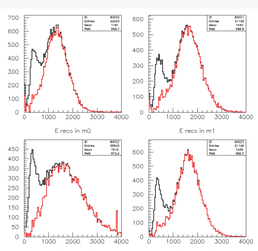
*The narrow peak completely disappears when the beams are longitudinally separated (**out of collisions**)*



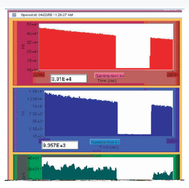
out of time *in time*



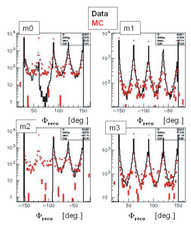
*The total energy deposited in the calorimeters is consistent with two 510 MeV particles for **in-time** events (consistent with Bhabha events), while is peaked at half this value for **out-of-time** events (consistent with background).*



Bhabha spectra after background subtraction



Beams out of collisions (180 degrees phase-shift)



Data vs. Monte Carlo rate vs. azimuthal angle

Acceptance & threshold

*Determine **acceptance** from **Monte Carlo**, after having measured the **effective threshold** using data, taking the ratio of triggering/all events*
Energy scale nicely set by the Bhabha peak (510 MeV).

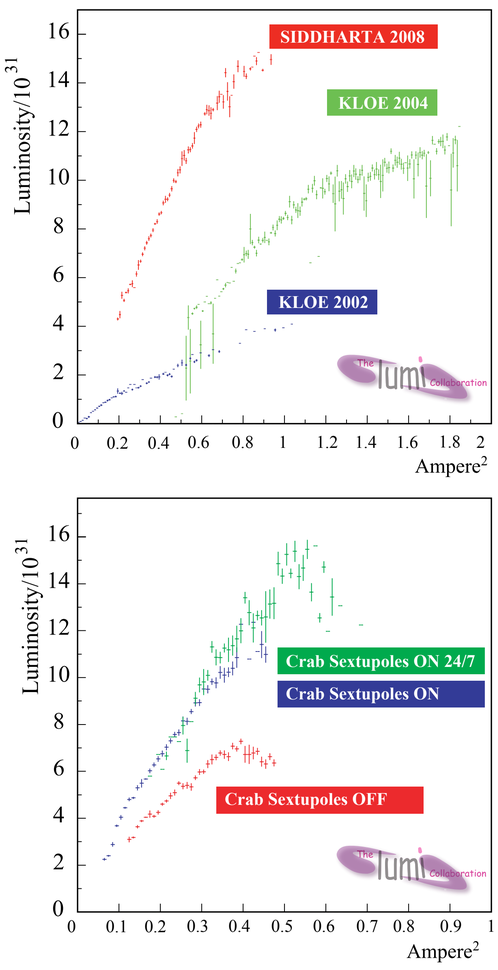
Sources	σ_{syst}
Calo	4%
Soyuz	8%
Siddharta	2%
Threshold	5%
BKG Accidentals	3%
BKG	0.1%
Total (Σ_{quad})	11%

Systematic error

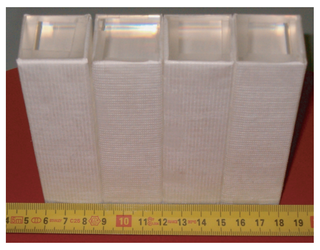
Sources	σ_{syst}
Calo	**2** %
Soyuz	**6** %
Siddharta	**0** %
Threshold	**1** %
BKG Accidentals	**0** %
BKG	**0** %
Total (Σ_{quad})	**~7** %

Adding GEM tracking

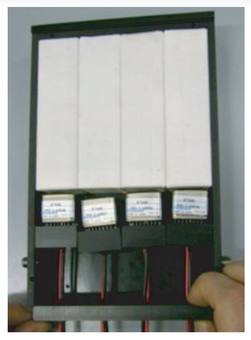
The diagnostics installed on the new DAFNE IR in order to measure luminosity for the test of the new crab waist scheme, started to operate at the beginning of February 2008 and has collectied encouraging results from the machine.



Radiative Bhabha monitors

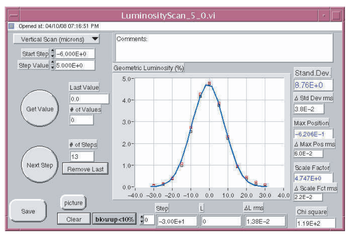


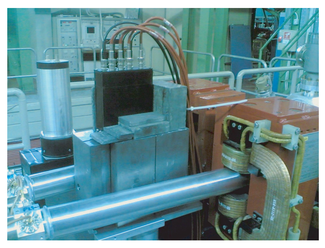
$PbWO_4$ crystals



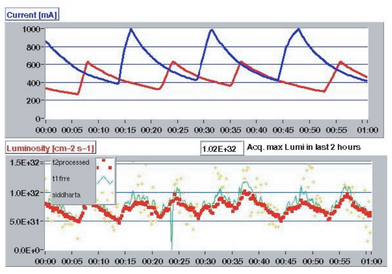
*Two gamma monitor detectors are located 170 cm away from the IR, collecting **photons radiated by electron or positron beam**.*
*Each counter is made by **4 PbWO crystals** (squared section, 30mm×30mm, and 110mm height) assembled together along z: the 30 mm face towards the photon beam, with a total depth of 120 mm corresponding to about **13X0**.*
Each crystal is readout by a Hamamatsu R7600 compact photomultiplier.
Prompt estimate of the luminosity is provided on-line by the DAFNE control system in order to perform machine optimization and characterization.

An on-line vertical beam-beam scan performed by acquiring the relative luminosity estimate of the crystal gamma monitor.





Both raw and filtered data are stored by DAFNE slow control system with a sampling time of 15 s, and are available for offline analysis and on the word wide web for online performance presentation.



Online luminosity display