

Luminosity measurements experience at DAFNE

G. Mazzitelli

on behalf of various people that during 13 years have worked on an high background/ luminosity accelerator...

G. Mazzitelli, F. Sannibale, F. Cervelli, T. Lomtadze, M. Serio, G. Vignola

M. Boscolo, F. Bossi, B. Buonomo, **G. Mazzitelli**, F. Murtas, P. Raimondi, G. Sensolini, M. Schioppa, F. Iacoangeli, P. Valente, N. Arnaud, D. Breton, L. Burmistrov, A. Stocchi, A. Variola, B. Viaud, P. Branchini







way a machine lumi monitor?



F. Sannibale DIPAC09

The Physics at DAFNE



FIG. 8

Coincidence with y@small angle



Fig. 11. Single and double Bremsstrahlung cross sections vs. energy threshold. Analytical result.



--> no possible to make coincidence with gamma physic at small angle

N (accidental) = 2 f1*f2/Dt Dt = 2.0 E-8 s



DAFNE RUN1 y monitor





Nuclear Instruments and Methods in Physics Research A 486 (2002) 568-589

Single Bremsstrahlung luminosity measurements at DAFNE

G. Mazzitelli^a, F. Sannibale^{a,*}, F. Cervelli^b, T. Lomtadze^b, M. Serio^a, G. Vignola^a ^a INFN Laboratori Nazionali di Frascati, C.P. 13,00044 Frascati, Italy ^b INFN Sezione di Pisa, C.P. 56010, San Piero a Grado (PI), Italy

Received 25 April 2001; received in revised form 1 November 2001; accepted 1 November 2001

Abstract

At DAFNE luminosity measurements are performed by detecting the photons from single Bremsstrahlung at the two interaction points. Set up and measurement method are presented with special emphasis on background subtraction schemes, error evaluation and machine related issues. r 2002 Elsevier Science B.V. All rights reserved

PACS: 41.85.Qg; 02.50.Ng; 29.40.Vj; 07.50.-e

Keywords: Luminosity measurement; Single Bremsstrahlung; Radiative Bhabha; DAFNE; DAFNE

1. Introduction

DAFNE, the Frascati phi-factory [1], is a 510+ 510 MeV electron-positron collider, tuned on the F meson resonance and mainly devoted to the study of CP violation in Kaon decay. In order to optimize the luminosity performance, the related machine parameters must be accurately set relying on a tuning process [2,3] based on the readout of a luminosity monitor. In designing such a monitor the following major requirements were pursued: (i) capability of performing very fast measurements to allow tuning machine parameters in real time, (ii) measurement stability with respect

to variations of the beam position and angle at the interaction point (IP), (iii) no interference with the experiments, to ensure independent luminosity measurements during the data taking and during the initial phase of the machine commissioning with no experiment installed in the two interaction regions (IR).

A direct way to measure luminosity consists in measuring the counting rate of a known electromagnetic process while the beams are colliding. Good candidates are small angle Bhabha scattering (BB), single Bremsstrahlung (SB) and double Bremsstrahlung (DB), Differential and integrated cross-sections for BB, DB and SB are reported in Refs. [5-7]; an interesting comparison among measurements with the three different processes can be found in Ref. [8]. At DAFNE SB was chosen because it better fulfills requirements (i) and (ii) [4] and ensures measurements at a few percent level when an efficient background subtraction method is used.

IP

splitter magnet charge particle cleaning effect



Lead/scintillating fibers calorimeters (KLOE-type) resolution 4.7%/√E(GeV)





DAFNE y monitor (con't)



Requirements for an accelerator lumi monitor

- fast (< 1 s) at very low luminosity (2/3 order of dynamic range)
- absolute
 - -day one
 - -MD
 - -Detector maintenance
- accurate (~ 10 %)
- wide range beam acceptance

vertical and horizontal crossing angle

- Ip displacement
- -vertical and horizontal angle

expected percentage of rate lost in the lumi monitor due to collimator beam acceptance and bem transverse displacement and vertical crossing angle



DAFNE Day 1 (flat machine)



Figure 8: a) Luminosity (circles with error bars) and product of bunch currents (solid line); b) Geometrical luminosity

A luminosity monitor based on the measurement of the photons from the single bremsstrahlung (SB) reaction is used. The SB high counting rate allows fast monitoring, which is very useful during machine tune-up. The contribution of the gas bremsstrahlung reaction is subtracted by measuring the counting rate with two non interacting bunches. The estimated error on the measurements is of the order of 20%.

When running at **low current** the effect of the incoming **beam trajectory** on the background is negligible as well as beam beam effect, etc.

As as been shown by KLOE 1 run experience, the luminosity monitor is able to perform absolute and correct measurement only in low current condition where **background** and **instrumental effect** where negligible.



Luminosity Position Scans









calibrated vertical bump

$$L = f_R \frac{N_+ N_-}{2\pi \Sigma_x \Sigma_y}$$
$$\Sigma_w = \sqrt{\sigma_{w+}^2 + \sigma_{w-}^2} \quad w = x, y$$

Diagnostics (dispersion, electron cloud)



$$\Delta y_{\text{max}} = (4.8 \pm 0.4) \ \mu m \longrightarrow \Delta \eta_y^{IP} = (2.3 \pm 0.4) \ mm$$



PEPII photo electron cloud blowup effect on the bunch by bunch luminosity measurements





but... (KLOE run1)

collimator

front view

needle

- High current --> high background:
 - PM saturation;

-->

- Discriminator over rate;
- upgrade of readout system;
- Imitate rates with the same acceptance (mantain angular and beam position acceptance) filling of needle the collimator hole;
- use independent lumi estimator to validate data: slm lumi based, cross calibration with KLOE









Geometric Luminosity estimator





SLM beam characteristics (vertical and horizontal dimension)

- Beam overlap
- $\sigma_x = 2 \text{ mm } \sigma_y = \text{wid}/2$
- $\beta_y / \beta_y @SLM = 0.03 / 7.60 @ KLOE,$
- $\beta_y / \beta_y @SLM = 0.04 / 7.53 @ DEAR$
- SLM monitor resolution

SIDDHARTA run (the crab waist test)

- The crab waist, moreover the background, have introduced very important difficulties in the measures:
 - A) shorter beta minimum respect to beam dimension
 - B) vertical and horizontal rate maximization could not be equivalents to luminosity optimization
- These required:
 - a fast and absolute luminosity measurement not affected by background issue and new beam condition
 - maintaining all the γ monitor measurement characteristic, optimization futures, and integration in DAFNE control system













INACTIVE NATIONAL DE PHYSIQUE NUCLÉARE ET DE PRYSIQUE DES PARTICULES



Luminosity and background measurements at the e"e" DADNE collider upgraded with the crab waist scheme

M. Boscolo*, F. Bossi*, B. Buonomo*, G. Mazzitelli*, F. Murtas*, P. Raimondi*, G. Sensolini*, M. Schioppa⁸, F. Iaonangeli⁴, P. Valente⁴, N. Arnaud^{45,4}, D. Breton⁴, L. Burmistrov⁴, A. Stocchi^a, A. Variola^a, B. Viaud^a, P. Branchini^a

DEPETAT. Hard. Press division of American and American Grappe Gallegare (NPK Ha F Basel - 8700K Bends, CL Ind) (NPS Barna, For Aldo More S, Barna, Ind) ¹ Laboratori de Universita Labora, Università Anto-Sud. (NES-PAPE, 10498 Brogs, Annor ¹ NES Bong J, Va delle Vecco Nevale, 84 - 80348 Bong, 849

8-factories [1,2] requires improvements up to two orders of

magnitude above the performances of the PEP-8 [4] and KEK-8 [5]

e's' colliders. Among the ideas currently being developed to

achieve this ambitious physics-driven goal, the crab waist compensation scheme associated with large Piwinski angle and

low vertical beta function [6] is very promining, furnimenties as high as 10^m cm⁻² s⁻¹ could be mached with beam currents

similar to those operated routinely in today's accelerators, which

would also help keeping the background under control. In

addition to being based on existing technologies, this scheme

would significantly limit the power (and hence the cost) needed

Francati (INFN), is optimized for the production of & mesons

1,7 - 1020 MeV) at a high rate. Since 2000 it has been delivering

158-90525 see lossi nariter i 3010 Elsevier K.K.All rights reserved.

e'e' collisions to three experiments KLOE [7], FINUDA [8] and

The DHMNE accelerator, located in the National Laboratory of

ARTICLE INFO ABITBACT

strick binese Rearised to pay 2008 Bearing in strengt form Accepted 11 April 2018 Available online (m. April (1976) Report D

Laminority Depth Cub main: California and Making scattering

1. Introduction

to ran such a new machine.

2008-2009 runs: the gain in laminosity is consistent with the predictions while the backgroun remains sustainable. Among the various inputs used by the DMME accelerator team to meet this new machine and improve its performances, key online information, absolute luminosity and background level measurements, has been provided by the (2M) detectors: a Blabba calorimeter and two gamma terminishing proportional counters. This paper focuses on the results achieved with this experimental using, described is details in another article. 2010 Elsevier BV, All rights reserved.

DEAR [9], steadily improving performances in terms of luminosity, beam lifetimes and background. The best peak luminosity was ~ 1.5 = 10¹⁰ cm⁻² s⁻¹ with typical daily integrated luminosities Proposals of future flavor factories [1-3] emphasize the need of very high luminosity. For instance, the new generation of

of - 8 plo 1 during the KLOE run. in 2007, the DABAE interaction point 1 (IP) has been modified to test the crub waist sextupole compensation scheme [6]. According to calculations, this upgrade should increase the luminosity by a factor between 3 and 5. To test this prediction and to measure the associated background, various detectors have here built around the IP by the LUMI collaboration: a Bhabha calorimeter, a GEM [10] tracker and two gamma monitors. By providing accurate information to the DAMNE operators in real time, they aim at allowing them to steer the collides, to monitor its performances and to get direct feedback when performing optimization studies. There is some redundancy between their measurements which helps fighting transient hackgrounds which could impact strongly a particular detector. It should be noted that the SIDDROBERS experiment [11], installed at the same location, can in principle provide a luminosity measurement By counting kaon pairs produced by the well-known decay $\phi = K^+K^-$. However, this method suffers from a few practical limitations. The main ones are: a low rate for the K'K' production: a difficult event rate to huminosity convey due to the dependence of the 4-resonance lineshape on the exact

Ŧ



Description and performances of luminosity and background detectors at the upgraded e*e- DAΦNE collider

M. Boscolo", F. Bossi", B. Buonomo", G. Mazzitelli", F. Murtas", P. Raimondi", G. Sensolini", M. Schioppa^b, F. Iacoangeli¹, P. Valente¹, N. Arnaud^{4,*}, D. Breton⁴, L. Burmistrov⁴, A. Stocchi^d, A. Variola^d, B. Viaud^d, P. Branchini^{*}

¹ HERQUE Hard, Americ 40 Millell, Francesh, HM, Hady ² Cragger Collegers (HER, Vec.7, Barris - 87408; Breds, CJ, Indo ³ HER Americ, File Alab Mere 2, Barris, Eulp. ¹ Information de Ottenbilisteur (Induite, Université Paris-Ind. (2002)/02/12 (2008) Orașa, France ² (2017) Roma (1. Ville alube France, Roman, 84 - 2019) Roma, Ropp.

ARTICLE INFO ABSTRACT

Annale Annaly Received & December 2008 Roomed in encod famility April 2010 Normational 18 April 2010 Recallables onlines 34 April 2010 Kenneda . and services Dedeal Coll-mani Collectoreter Blable collect

finding the new coll-waist collision scheme at the erivy. Francat DARNE accelerator complex requires a lost and accurate measurement of the desilute luminosity, as well as a full characterization of the background conditions. To fulfill these sequencess, deficiented detectors have been half by the 3/ME Collaboration and operated during the 2008 and 2009 DAMM runs, providing valuable inputs for the accriterator team. This article motivates their design, describes their installation in the resulties' interaction region and persons they performances. Roother article in the same issue become on the really achieved using these detectors

a 2010 Charles &V. All rights reserved

1. Introduction

The DMMNE accelerator, located in the National Laboratory of Francati (ININ) and optimized for the production of q-mesons 1,/3 = 1020 MeV) at a high rate, has been modified in 2007. The new design of the interaction point 1 (3P) is based on the crabwaist sextupole compensation scheme [1], a promising idea to increase the collider haminesity while keeping the background under control-in this scheme, the beam currents are similar to those operated by the current generation of 8-Factories [2.3]. This test is motivated by the fact that future flavor factories [4-4] will clearly have to integrate much more luminosity than the current experiments in order to achieve their ambitious physics goals. After completion of the IP upgrade, sperations restarted at DifdHE during minter 2007-2008 for about two years

The expected huminosity increase, a factor 3-5 [1], is significant. Quantifying the improvement requires a measurement procise at the 10% level, in addition, that time and accurate information about itenity and backgrounds is manulatory to tune the new collider and improve its performances, forme redundance between measuremeets is also suitable in order to maintain an accurate monitoring of the machine conditions regardless of transient effects such as localized background bursts impacting severely a particular probe. Therefore, surfaces independent and luminosity-oriented detector have been built by the LUMI collaboration around the DABAE IP and put in operation beginning of February 2008 with a threefold goal: to guarantee an accurate measurement of the abookura luminosity, to number the background levels and to provide powerful and fast diagrantics to help steering the new machine.

Parallel to the upgrade of the DMMR interaction point 1 (IP). the SECONNEXA experiment (Micros Drift Detector for Hadronic Atom Research by Timing Application) [7] aiming at analying kaonic hydrogen and kaonic deuterium has been installed at the same location. The presence of this additional detector, whose operation requires a very good shielding against machine hackground, has consequences on the design and on the performances of the main luminometer. These are discussed in the following sections of this article. In principle, SZDROHTI can also provide a uminosity measurement based on the counting of charged kaon pairs produced by the well-known decay q-+K*K*. However, this method suffers from a low limitations (4).

This paper focuses on the design, the construction and the operation of the SOME detectors: a Bhabha calorimeter, a GDM teacher [19] (which could not really be used due to space conflicts with the SIDEVEARTA shielding) and two gamma bremestrahlung proportional counters, referred to an arrange monitors in the



Layout and Luminosity Monitors





Gamma monitor



PbWO₄ crystals





detector segmentation

•



- 2 calorimeters PbWO₄ crystals, 13 X₀ total depth
- Readout by Hamamatsu R7600
- High-statistics, very fast counter, main tool for luminosity optimization...
- ...but affected by background [not absolute luminosity measurement]

collimator



Kaon Monitor (SIDDHARTA)

PM: Hamamatsu R4998

Scintillators: BC420

Dimensions: 200 x 50 x 2.0 mm

Triple-GEM tracker



Triple-GEM tracker

Triple-GEM trackers













Final luminometers with Carioca FEE

Bhabha calorimeter design





• Longitudinal segmentation has been optimized keeping in mind that the total available depth is only the length of the quadrupole ≈ 20 cm

- 11 absorber plates + 12 samplings:
 - 8×0.5 cm + 3×1 cm lead \approx **12.5** X₀ should ensure sufficient shower containment
 - 12×1 cm scintillator
 - 2:1 active:passive ratio should ensure ≈15%/√E(GeV) resolution

• Lateral segmentation dictated by the need of keeping a reasonable number of channels and to have some degree of freedom in defining the acceptance

We decided to equip only 10 out of 12 sectors, keeping out the ϕ =0°-180° plane, since we expect larger backgrounds from there

CaloLumi construction





December '07 – January '08

CaloLumi installation











DAQ and Trigger

Offline and Online measurements (i.e. trigger rate)



- Re-use KLOE's DAQ
 - KLOE's SDS boards to split, discriminate and sum the signal to assert a trigger ;
 - DAQ software also KLOEbased running on Motorola CPU MVM-E6100



June 9th, 2008

Performance



Time resolution good enough to subtract backgrounds from Trigger Rate



Background





We can have energy deposits over threshold in another module, in addition to the couple of triggering modules: this gives us the "triples"



We expect a similar level of events with no Bhabha, but with **two** "spurious" deposits, giving a fake coincidence

Background topology

Cross check looking at runs with only 1 beam





run 1392, e- 350 mA, 100 bunch

Collaboration





Background subtraction (timing rejection procedure)



Online timing filter effect





Soyuz





Soyuz simulation results effect





Sputnik

Since May 29th, 2008







Sputnik

Simulation





A full simulation has been essential tool for understanding not only the real acceptance and normalization but also how to optimize detector performance

Today (very bad condition)

- no space available
- final focusing quadrupoles are covering the gamma exit line, and the quantity of material intercepted is depending by orbit path
- very high background condition
- trajectory effect, and overlap complicated by experiment magnetic field
- It's not possible calibrate the lumi monitor





auto-calibration procedure based on running average online luminosity KLOE data

Conclusion

- Have a fast, absolute, background free luminosity monitor on DAFNE has been always a not easy task.
- The **crab waist** scheme introduced many issue due to:

physic (significance) measurements;

background.

- In the very simple layout, like SIDDHARTA one, a **tracker** system (GEM) was not usable alone or a gamma monitor at zero angle, and a large angle calorimeter needed an accurate data analysis.
- To be completely background free we have to use also timing information and strongly increase the shielding detector protection.

The combinatin of **energy**, **position and timing** information looks to be fundamental to avoid background of an accelerators running with the crab waist scheme, as well as accurate selection of the lumi detector **acceptance** (shielding)

In the same time, the introducion of crab waist, and the consequent complication in the understanding the beam interaction behavior make fundamental have a machine accelerator luminosity detector with the above characteristics.

Conclusion (cont)

- the luminosity monitor is a fundamental instrument for accelerator measurement parameters and operation optimization
- the physic, in terms of signal, background and beam-beam behavior in the detector(s) must be very well known and understood (full simulation)
- the detector characteristic and design must be based on the accelerator quantity to be measured and background condition of operation