DAFNE upgrade

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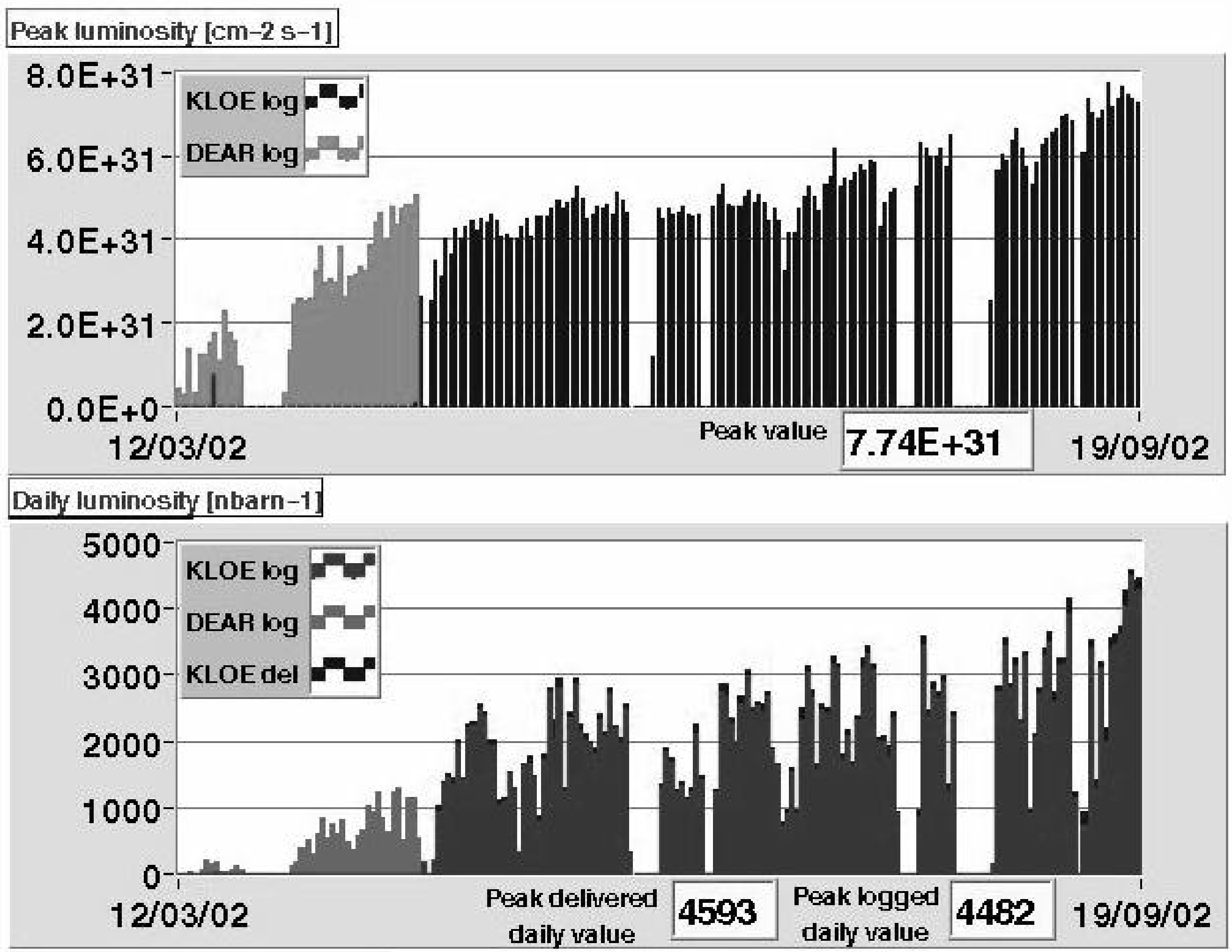
Present status of DAFNE

(end of september 02)



Present	next
• L_{max} = 0.8 10^{32} cm^{-2} sec^{-1}	1.5 10^{32}
• L_{int}/day = 4.5 $pbarn^{-1}$	8
• I^{+} = 1.2 A	2
• I^{-} = 0.9 A	2
• N bunches = 50	100

upgrades

- Higher L $> 10^{33}$ @ 510 + 510 MeV
- Higher E $\sim 10^{31}$ @ 1 + 1 GeV
- BOTH with the same machine ?

Concerns @ DAFNE design

- High currents
- 120 bunches - feedbacks
- Impedance
- Vacuum
- Crossing angle - parasitic crossings
- Coupling - beam sizes

DAFNE experience

Not critical

- **Feedbacks: challenging but ok**
- **Crossing angle**
- **Coupling**
- **IP β^***

Critical

- **Damping time still long**
- **Non linearities**
- **2 IPs**
- **Beam lifetime and background: Touschek**
- **Parasitic crossings**

Every thing said from now on is

Very very preliminary

“Conservative” L upgrade

- **Add damping: sc wigglers and/or sc dipoles**
- **Increase crossing angle: increase rf frequency and n. of buckets -> bunches**
- **Increase V for lifetime**
- **Eliminate 2nd IP**
- **Minimize β* and bunch length**
- **Background estimation and shielding**
- **2 independent injection chains**

Increase the damping

Increase the energy

or

Decrease ρ = add wigglers and/or smaller dipoles

Damping

Radiated energy per turn $U_o \quad E^4 \; I_2 \qquad I_2 = \int \frac{ds}{\rho^2}$

Damping time:
few tens of ms

$$\frac{1}{\tau} \quad \frac{E^3 \; I_2}{T_o}$$

LEP: damping in less than 100 turn
DAFNE (now): damping in ~ 60.000 turns

Wigglers

NOW

4 wigglers/ring
ρ **= 0.94 m**
B = 1.8 T
L_{TOT} **= 8m**
$I_2 \sim 9\ m^{-1}$

--->

4 SC wigglers/ring
ρ **= 0.34 m**
B = 5 T
L_{TOT} **= 10m**
$I_2 \sim 90\ m^{-1}$

Damping increased by a factor 10...

Wigglers added to optimize L at lower energies

For example:

LEPP, Cornell University (Laboratory for Elementary-Particle Physics)

Optimization of luminosity performance of the 768 m circumference **e+e- collider CESR** at 1.9 GeV is a critical objective of the CESR-c conversion project. In order to achieve a reasonable damping rate at the low energy approximately **18 m of 2.1 Tesla peak field wigglers** will be installed. 90% of the synchrotron radiation power in the ring will be produced in the wigglers. The non-linear properties of the wigglers are a concern for high luminosity operation.

Increase rf frequency

Present: 369 MHz
$C = 98$ m $h = n_{max} = 120$

Distance between bunches:
$D = 0.8$ m

Going to 500 MHz
$C = 100$ m $h = n_{max} = 160$

$D = 0.6$ m

↓

Decrease bunch length

↓

Increase f_{coll}

2nd IP

Strong beam-beam interaction only once per turn because

Beams “see” each other on 2nd IP, even when separated.
Easier with a single IP

DAFNE is usually operated with one single experiment

Minimize β* and bunch length together

Particle per bunch

$$L = \frac{N^{e^+} N^{e^-}}{\Sigma_x \Sigma_y} f_{collision}$$

Beam sizes at IP

Hour glass effect:
Going to β smaller than bunch length does not increase L

Background estimation and shielding

One of the biggest concerns for experiments is background

Beam lifetime shorter than foreseen because of coupling

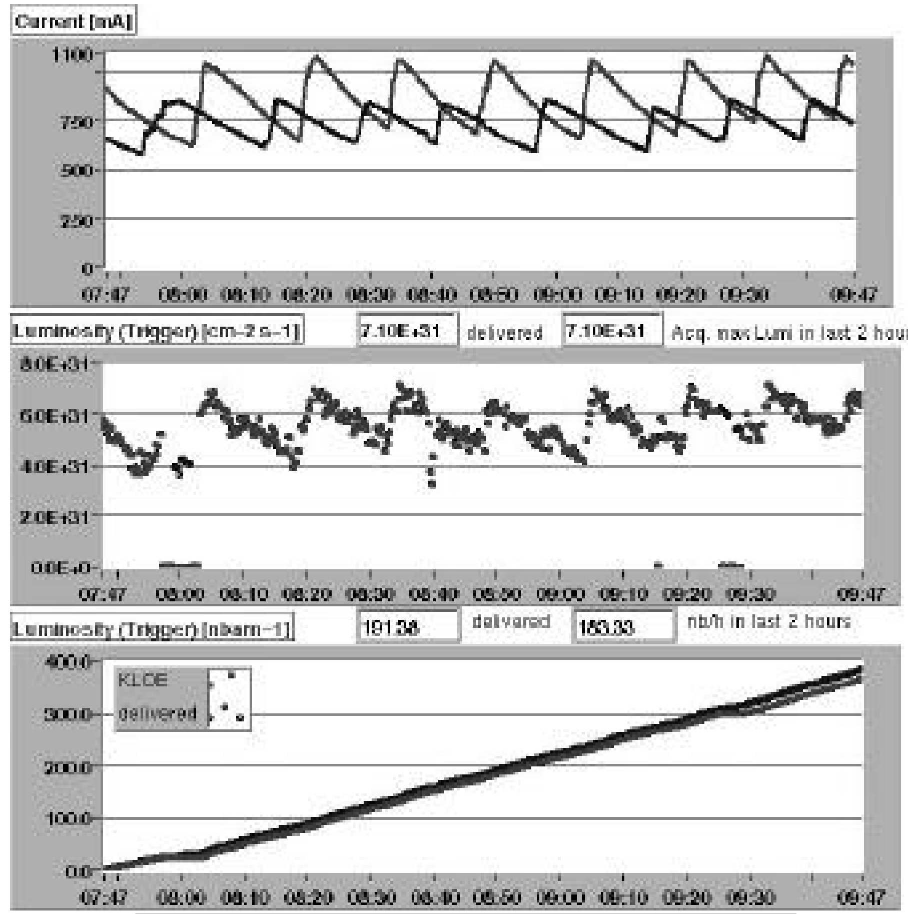
Experiments must be designed with powerful shieldings

Higher L = Higher currents = shorter lifetime

2 independent injection chains

Ratio between integrated and peak luminosity depends on:

- **Beam lifetime**
- **Injection efficiency**



Two hours KLOE run

… ideas for higher L

- **Round beam (Novosibirsk style)**
- **Round beam + 2 IPs (H / V)**
- **AWM**

Round beam (Novosibirsk style)

1.7 ϕ−фабрика

В проекте ϕ−фабрики для достижения высокой светимости предполагается использовать столкновение так называемых "круглых пучков".

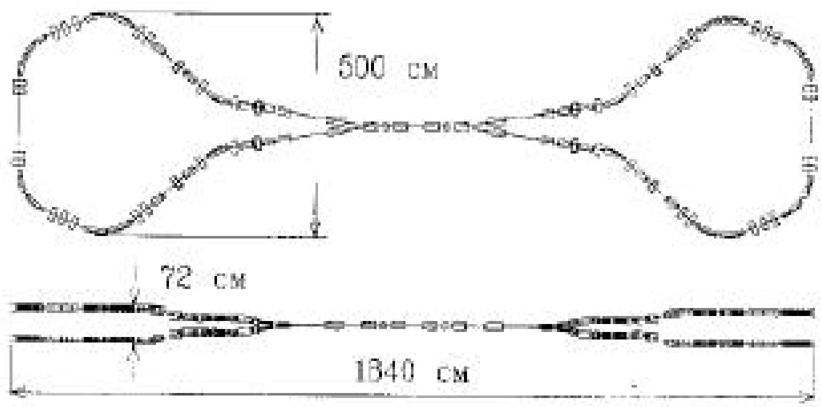


Рис. 1.2: ϕ−фабрика.

Ruggiero – Zimmermann (*CERN*)
2 Ips – H/V

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Luminosity optimization near the beam-beam limit by increasing bunch length or crossing angle

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(Received 21 February 2002; published 18 June 2002)

We discuss the choice of bunch length and crossing angle near the beam-beam limit in a storage-ring collider. First, we derive expressions for the tune shifts of either bunched or continuous round beams which are induced by a single collision with arbitrary crossing angle and bunch length and for the associated luminosities. Then, considering two collision points with alternating planes of crossing, we demonstrate that, if the total beam-beam tune shift is held constant, the collider luminosity increases as a function of bunch length and crossing angle. This implies a corresponding increase in the bunch intensity. As an illustration, we present numerical examples for a Large Hadron Collider upgrade and for the Very Large Hadron Collider.

The beam-beam effect between the horizontal and the vertical crossing is compensated

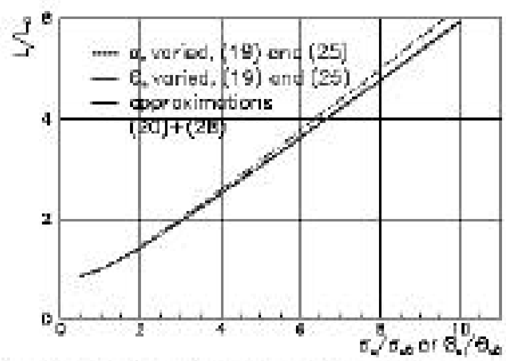
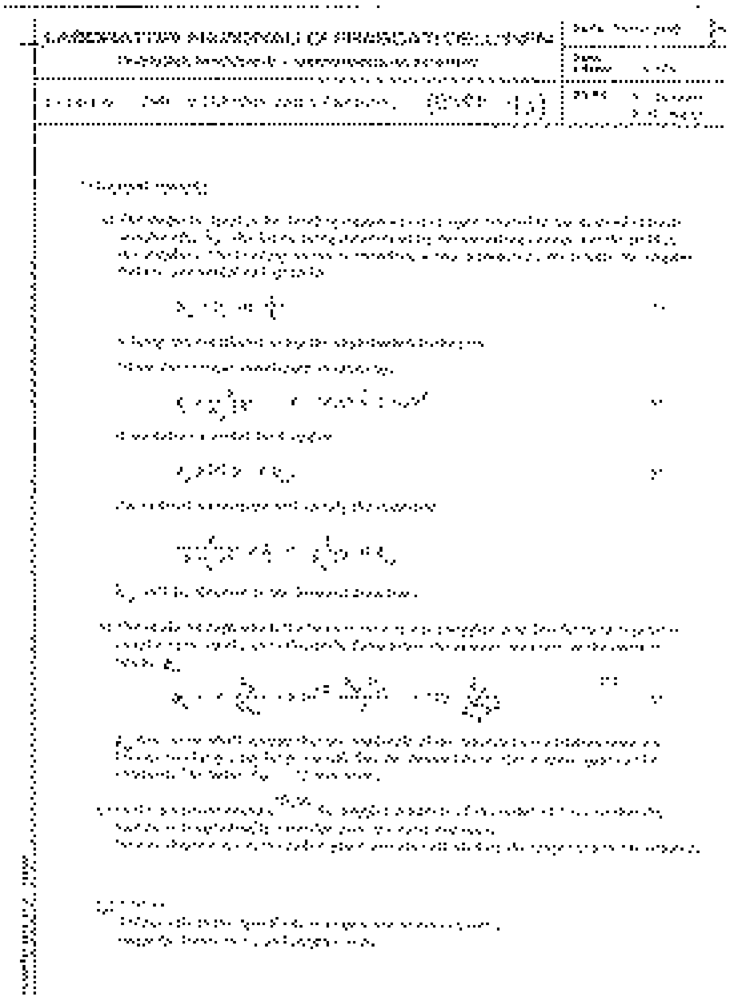
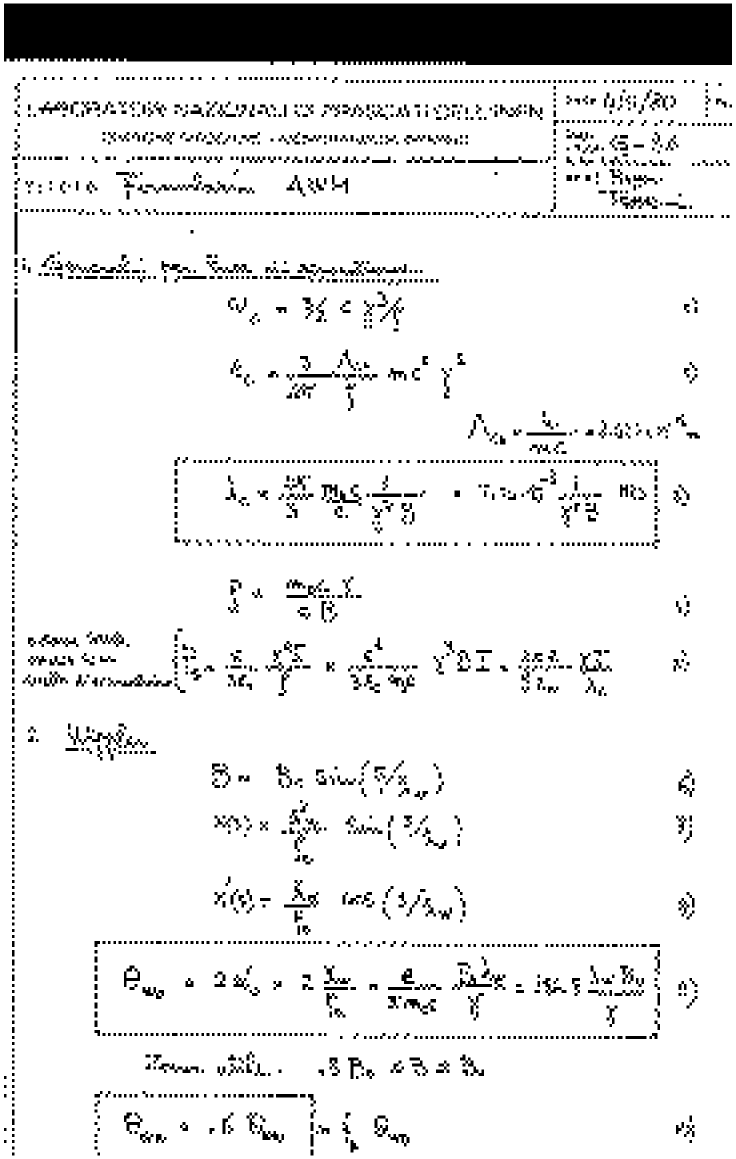


FIG. 2. (Color) Relative increase in LHC luminosity as a function of the relative increase of the product of rms bunch length and crossing angle, $(\sigma_z\theta)$, starting from a nominal bunch length $\sigma_z = 7.7$ cm and crossing angle $\theta = 300$ μrad [11], and maintaining a constant total beam-beam tune shift for two collisions with alternating crossing. The transverse rms beam size is $\sigma^* = 16$ μm and the interaction-point beta function $\beta^* = 0.5$ m. The subindex "0" refers to the nominal initial parameters listed above.

The luminosity increases with crossing angle and bunch length

AWM: All Wiggler Machine


LABORATORI NAZIONALI DI FRASCATI DELL'INFN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AWM

Higher Energy : 2 GeV (1+1)

Easier luminosity

Naturally increase radiation damping and lifetime

But

hardware, costs, injection

Ring for two energies

Energy (GeV)	0.5	1.0
$B\rho$ (T m)	1.7	3.3
Dipoles	ρ_o	ρ_o
Wigglers	ρ_w	$2\ \rho_w$
Energy lost per turn	$U_{oD} - U_{oW}$	$16\ U_{oD} - 4U_{oW}$
Damping time	$\tau_{oD} - \tau_{ow}$	$\tau_{oD} / 8 - \tau_{ow} / 2$

ρ constant
B ramping

B constant

$$\frac{1}{\tau} \quad \frac{E^3\ I_2}{T_o}$$

Present reusable hardware

- Buildings
- 40% Vacuum
- 70% magnets , power supplies
- Diagnostics
- Feedbacks

New hardware

- Dipoles
- Wigglers
- 60% Vacuum
- 30% magnets , power supplies
- Diagnostic
- IRs

VVP

Combination: L + E

Very preliminary studies

Optimize L at low energy

Boost magnets and powers for high energy

When?

Present schedule:

2002 : KLOE + DEAR

2003 : shutdown **for FINUDA, KLOE , 3rd harmonic cavity,..**

FINUDA + KLOE runs

2004: FINUDA + KLOE runs

2005 - on