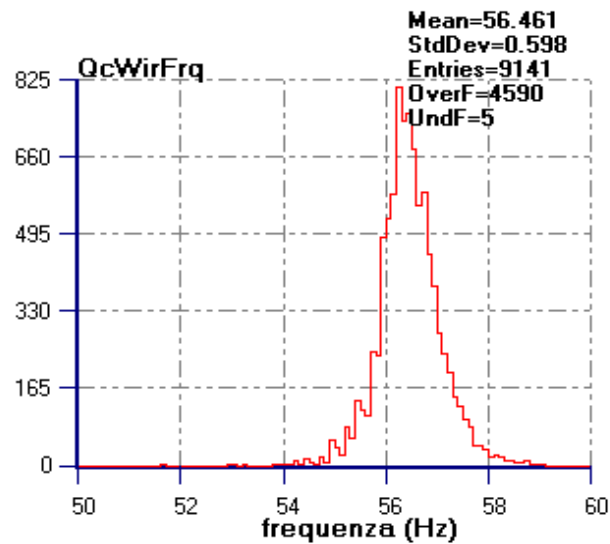
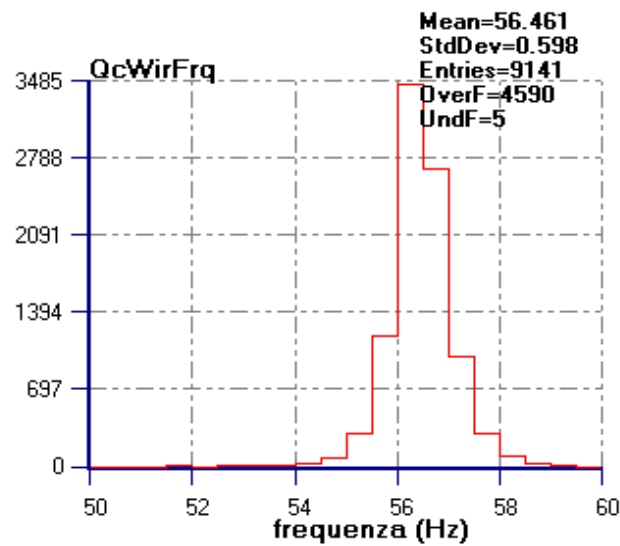
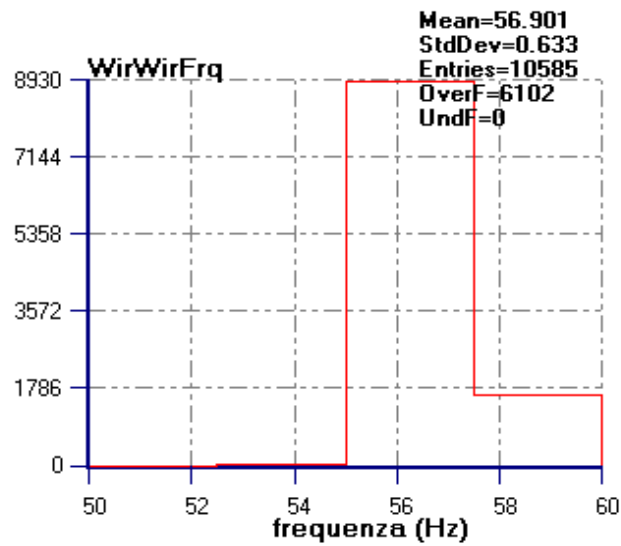



Istogramma misure stessa grandezza fisica con sensibilita' crescente





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The Time

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metrologia



elcome to the [Bureau International des Poids et Mesures \(BIPM\)](#).




The task of the BIPM is to ensure world-wide uniformity of measurements and their traceability to the [International System of Units \(SI\)](#).

It does this with the authority of the [Convention of the Metre](#), a diplomatic treaty between fifty-one nations, and it operates through a series of [Consultative Committees](#), whose members are the [national metrology laboratories](#) of the [Member States](#) of the Convention, and through its own [laboratory work](#).

The BIPM carries out measurement-related research. It takes part in, and organizes, [international comparisons](#) of national measurement standards, and it carries out [calibrations](#) for Member States.

Report of the study by KP

- [Potential Economic Impact of the CIPM Mutual Recognition Arrangement](#) This is the Report of a study carried out by KPMG Consulting on behalf of the BIPM. The study had three main goals: to study the economics of central coordination of multilateral relationships between individual national metrology institutes (NMIs); to study the MRA's potential impact on economic efficiency as a facilitator of reductions in technical barriers to trade; and to present a set of arguments that might be useful in ensuring that potential economic benefits associated directly with the MRA are actually realised.
- [Memorandum of Understanding between the CIPM and the ILAC](#) The Comité International des Poids et Mesures (CIPM) and the International Laboratory Accreditation Cooperation (ILAC), recognizing the need to strengthen the links between accreditation and metrology and to cooperate and to coordinate their actions in respect of their tasks related to national and international measurement infrastructure, signed a Memorandum of Understanding on 3 November 2001.
- The BIPM key comparison database and the Mutual Recognition Arrangement (MRA), see the [key comparisons section](#)
- [Resolutions adopted by the 21st CGPM](#)
- [Metrology search engine](#): This search engine is specially designed to search only the web pages of the **national metrology institutes of Member States of the Metre Convention** and Associates of the **CGPM** and of other designated institutes listed in the **MRA**



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The International System of Units (SI)

The 11th Conférence Générale des Poids et Mesures (1960) adopted the name *Système International d'Unités* (International System of Units, international abbreviation SI), for the recommended practical system of units of measurement.

The 11th CGPM laid down rules for the prefixes, the derived units, and other matters. The **base units** are a choice of seven well-defined units which by convention are regarded as dimensionally independent: the metre, the kilogram, the second, the ampere, the kelvin, the mole, and the candela. **Derived units** are those formed by combining base units according to the algebraic relations linking the corresponding quantities. The names and symbols of some of the units thus formed can be replaced by special names and symbols which can themselves be used to form expressions and symbols of other derived units.

The SI is not static but evolves to match the world's increasingly demanding requirements for measurement.

- [● Brief history of the SI](#)
- [● Base units](#)
- [● Derived units](#)
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SI base units

Quantity	Unit	Symbol	Definition
Length	metre	m	The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.
Mass	kilogram	kg	The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.
Time	second	s	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.
Electric current	ampere	A	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.
Thermodynamic temperature	kelvin	K	The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.
Amount of substance	mole	mol	<ol style="list-style-type: none"> 1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12. 2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.
Luminous intensity	candela	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency

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Derived units

SI derived units with special names and symbols

Derived quantity	SI derived unit			
	Name		in terms of other SI units...	Expression in terms of SI base units
plane angle	radian (a)	rad		$\text{m}\cdot\text{m}^{-1} = 1$ (b)
solid angle	steradian (a)	sr (c)		$\text{m}^2\cdot\text{m}^{-2} = 1$ (b)
frequency	hertz	Hz		s^{-1}
force	newton	N		$\text{m}\cdot\text{kg}\cdot\text{s}^{-2}$
pressure, stress	pascal	Pa	N/m^2	$\text{m}^{-1}\cdot\text{kg}\cdot\text{s}^{-2}$
energy, work, quantity of heat	joule	J	$\text{N}\cdot\text{m}$	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-2}$
power, radiant flux	watt	W	J/s	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-3}$
electric charge, quantity of electricity	coulomb	C		$\text{s}\cdot\text{A}$
electric potential difference, electromotive force	volt	V	W/A	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-3}\cdot\text{A}^{-1}$
capacitance	farad	F	C/V	$\text{m}^{-2}\cdot\text{kg}^{-1}\cdot\text{s}^4\cdot\text{A}^2$
electric resistance	ohm	Ω	V/A	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-3}\cdot\text{A}^{-2}$
electric conductance	siemens	S	A/V	$\text{m}^{-2}\cdot\text{kg}^{-1}\cdot\text{s}^3\cdot\text{A}^2$
magnetic flux	weber	Wb	$\text{V}\cdot\text{s}$	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-2}\cdot\text{A}^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$\text{kg}\cdot\text{s}^{-2}\cdot\text{A}^{-1}$
inductance	henry	H	Wb/A	$\text{m}^2\cdot\text{kg}\cdot\text{s}^{-2}\cdot\text{A}^{-2}$
Celsius temperature	degree Celsius (d)	$^{\circ}\text{C}$		K

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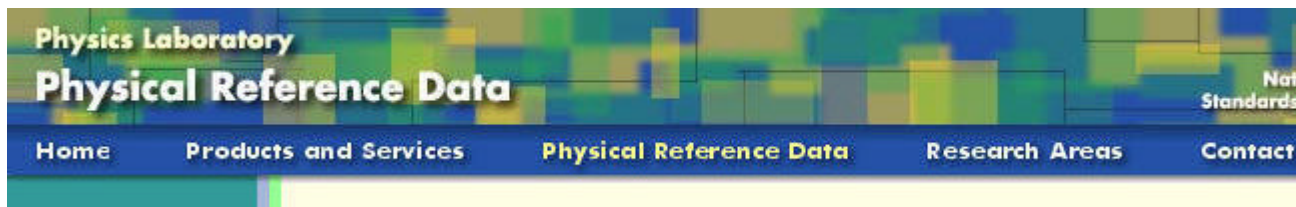
luminous flux	lumen	lm	cd·sr ^(c)	$m^2 \cdot m^{-2} \cdot cd = cd$
illuminance	lux	lx	lm/m ²	$m^2 \cdot m^{-4} \cdot cd = m^{-2} \cdot cd$
activity (referred to a radionuclide)	becquerel	Bq		s ⁻¹
absorbed dose, specific energy (imparted), kerma	gray	Gy	J/kg	m ² ·s ⁻²
dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent, organ dose equivalent	sievert	Sv	J/kg	m ² ·s ⁻²

- (a) The radian and steradian may be used with advantage in expressions for derived units to distinguish between quantities of different nature but the same dimension.
- (b) In practice, the symbols rad and sr are used where appropriate, but the derived unit "1" is generally omitted.
- (c) In photometry, the name steradian and the symbol sr are usually retained in expressions for units.
- (d) This unit may be used in combination with SI prefixes, e.g. millidegree Celsius, m°C.

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The NIST Reference on Constants, Units, and Uncertainty

Information at the foundation of modern science and technology from the [Physics Laboratory](#) of [NIST](#)

[Detailed contents](#)

Fundamental Physical Constants

[Values of the constants](#) and related information
[Searchable bibliography](#) on the constants

International System of Units (SI)

[In-depth information on the SI](#), the modern metric system

Uncertainty of Measurement Results

[Guidelines](#)
for the expression of uncertainty in measurement

[About this reference.](#) [Feedback.](#)

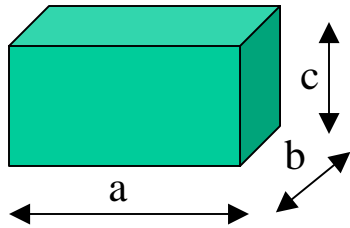


Online: February 1998 - Last update: October 2000
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Unita' di Misura

Lunghezza		
	inch	2.540×10^{-2} m
	foot	3.048×10^{-1} m
	yard	9.144×10^{-1} m
	miglio	$1.609 \times 10^{+3}$ m
	miglio marino	1.852×10^{-2} m
	Unita' Astronomica	$1.496 \times 10^{+11}$ m
	anno luce	$9.461 \times 10^{+15}$ m
	parsec	$3.086 \times 10^{+16}$ m
Area		
	ettaro	$1.000 \times 10^{+4}$ m ²
	square inch	6.452×10^{-4} m ²
	barn	1.000×10^{-28} m ²
Volume		
	square inch	$1.639 \times 10^{+1}$ m ³
	litro	1.000×10^{-3} m ³
	gallone (ingl.)	4.546×10^{-3} m ³
Forza		
	KgForza	9.807 N
	pound	4.448 N
Pressione		
	baria	0.1 Pa
	bar (10+6 barie)	$1.0 \times 10^{+5}$ Pa
	cm Hg	$1.333 \times 10^{+3}$ Pa
	atmosfera(76 cm Hg)	$1.013 \times 10^{+5}$ Pa
Energia		
	KgForzaxm	9.807 J
	caloria	4.187 J
	Btu	$1.055 \times 10^{+3}$ J
	litrixatmosfera	$1.013 \times 10^{+2}$ J
	kWora	$3.600 \times 10^{+6}$ J

Misura di densita'



$$a=1.8\pm 0.05 \text{ cm}$$

$$b=1.2\pm 0.05 \text{ cm}$$

$$a=1.5\pm 0.05 \text{ cm}$$

$$m=24.6\pm 0.1 \text{ g}$$

$$\rho = \frac{m}{a \cdot b \cdot c}$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c} = 1.44 \cdot 10^{-2}$$

$$\Delta\rho = 0.11 \text{ g/cm}^3$$

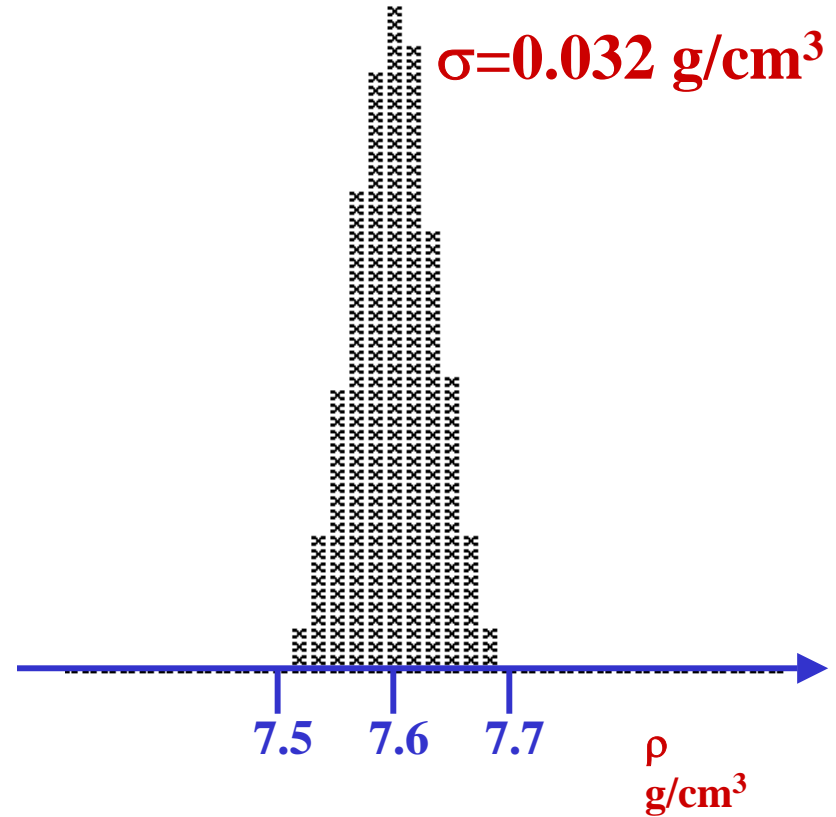
$$\sigma_m = \frac{\Delta m}{\sqrt{3}}; \quad \sigma_a = \frac{\Delta a}{\sqrt{3}}; \dots$$

$$\frac{\sigma_\rho}{\rho} = \sqrt{\left(\frac{\sigma_m}{m}\right)^2 + \left(\frac{\sigma_a}{a}\right)^2 + \left(\frac{\sigma_b}{b}\right)^2 + \left(\frac{\sigma_c}{c}\right)^2} = 4.2 \cdot 10^{-3}$$

$$\sigma_\rho = 0.032 \text{ g/cm}^3$$

$$\rho = 7.590 \text{ g/cm}^3$$

$$\sigma = 0.032 \text{ g/cm}^3$$



RAPPRESENTAZIONE GRAFICA DEI DATI

DIFFERENTE A SECONDA DEL TIPO DI PROBLEMA

◆ STUDIO ANDAMENTI FUNZIONALI DI DUE VARIABILI CORRELATE:

$$y_i \pm \Delta y_i \quad \text{vs} \quad x_i \pm \Delta x_i$$

◆ STUDIO DI CORRELAZIONI FRA 2 (3) VARIABILI (SCATTER PLOT)

◆ ISTOGRAMMI DI FREQUENZA DI 1 VARIABILE

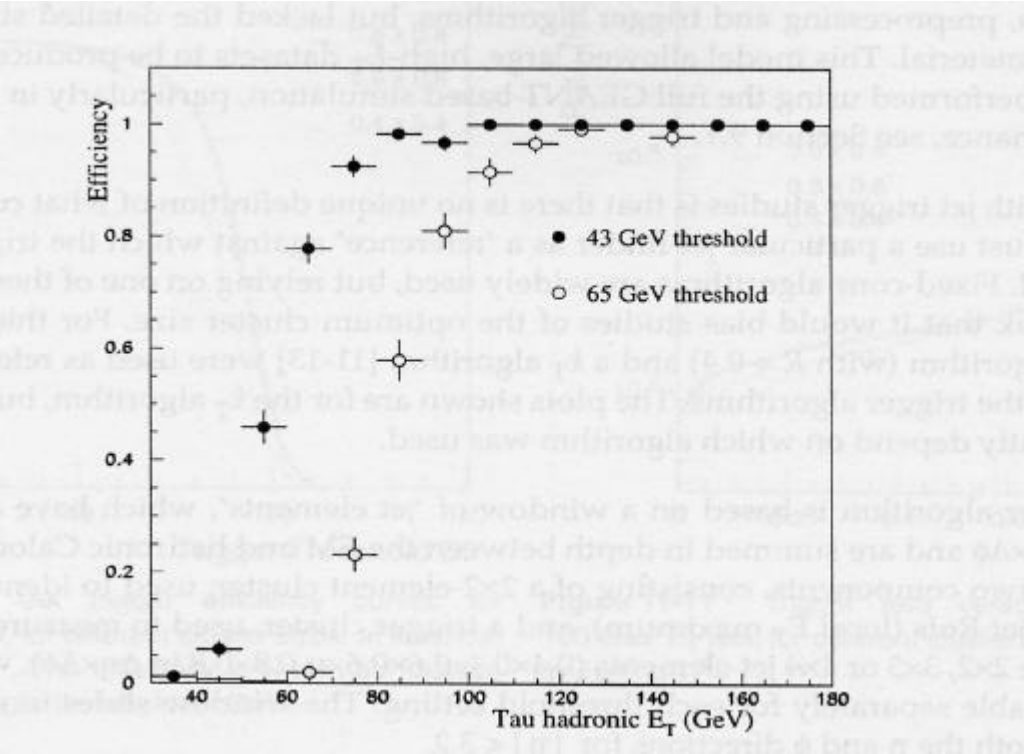
◆ ISTOGRAMMI DI FREQUENZA DI 2 VARIABILI (“LEGO” PLOT)

IMPORTANTE SCELTA DELLE SCALE:

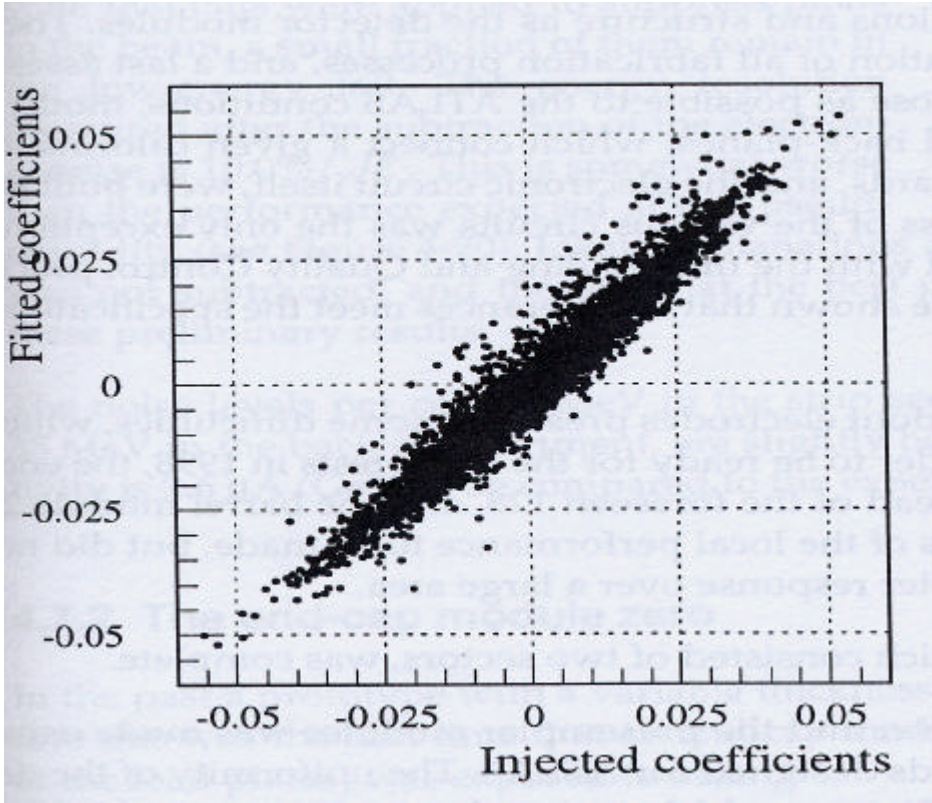
–“FACILI” (SPECIALMENTE SE SI USA CARTA MILLIMETRATA)

–UTILIZZO OTTIMALE AREA DISPONIBILE

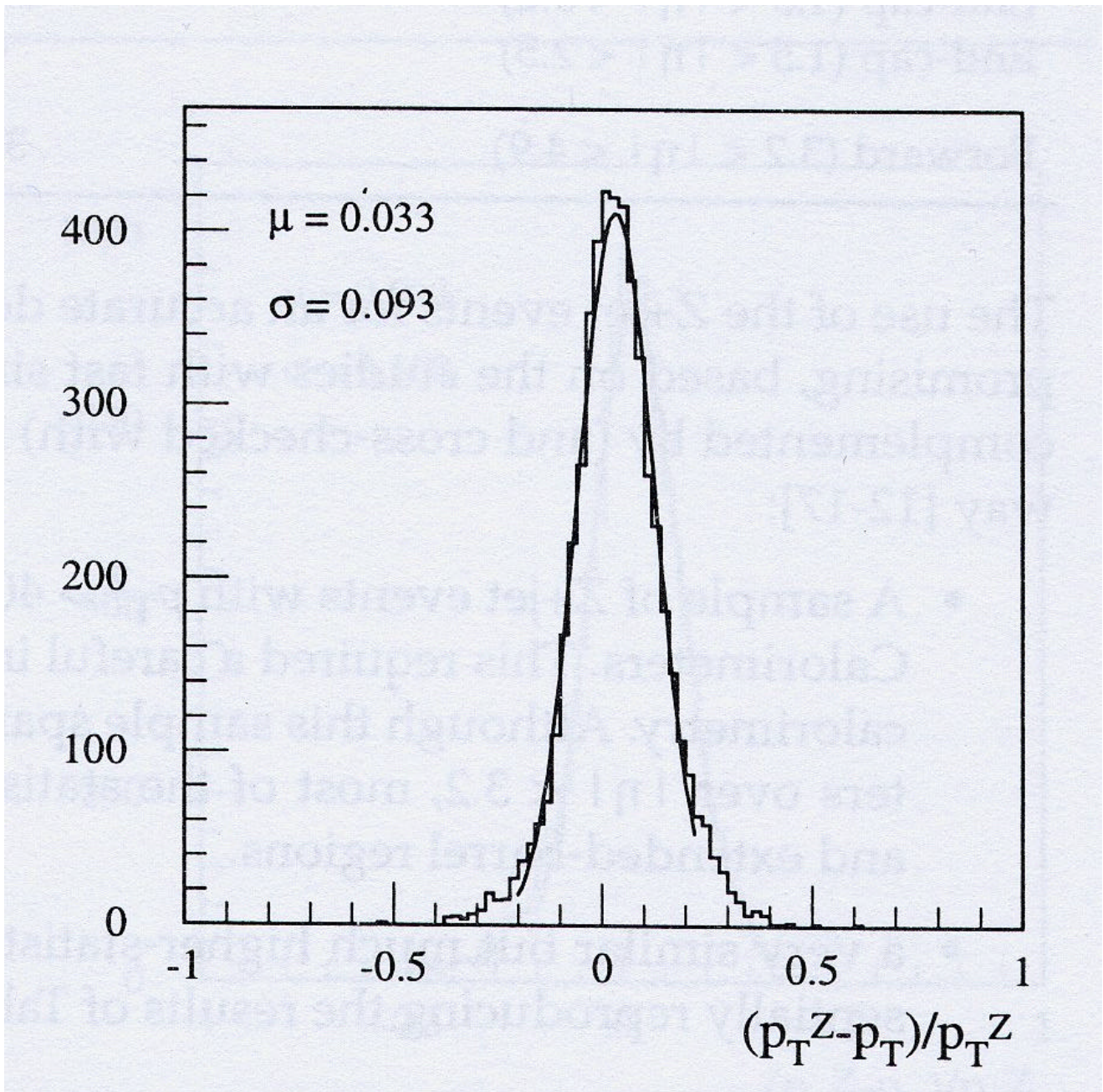
Andamenti funzionali y vs x



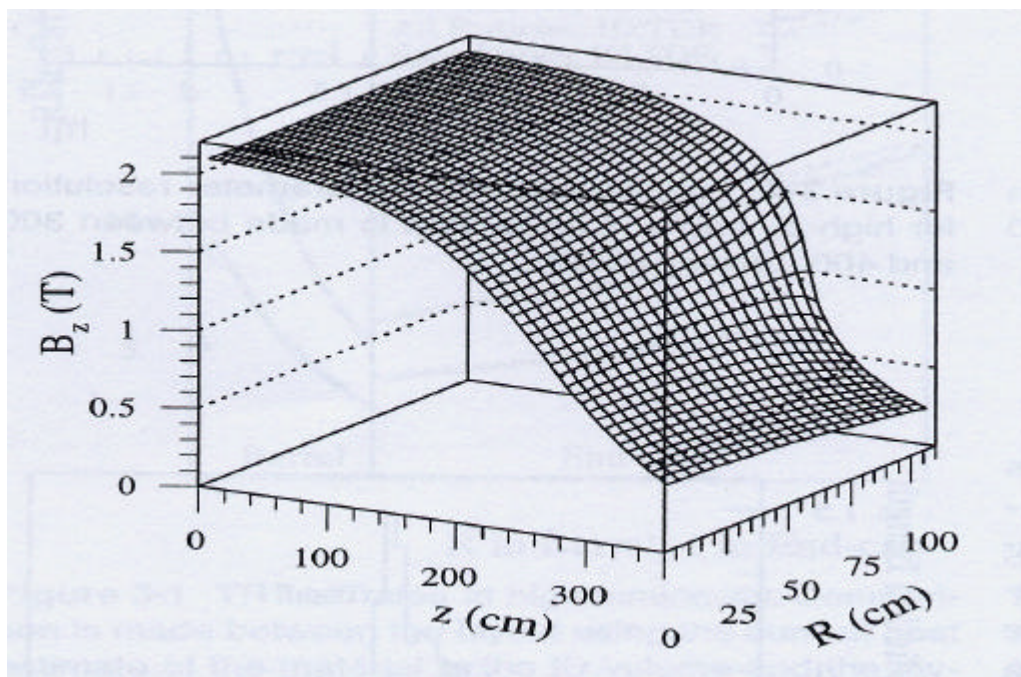
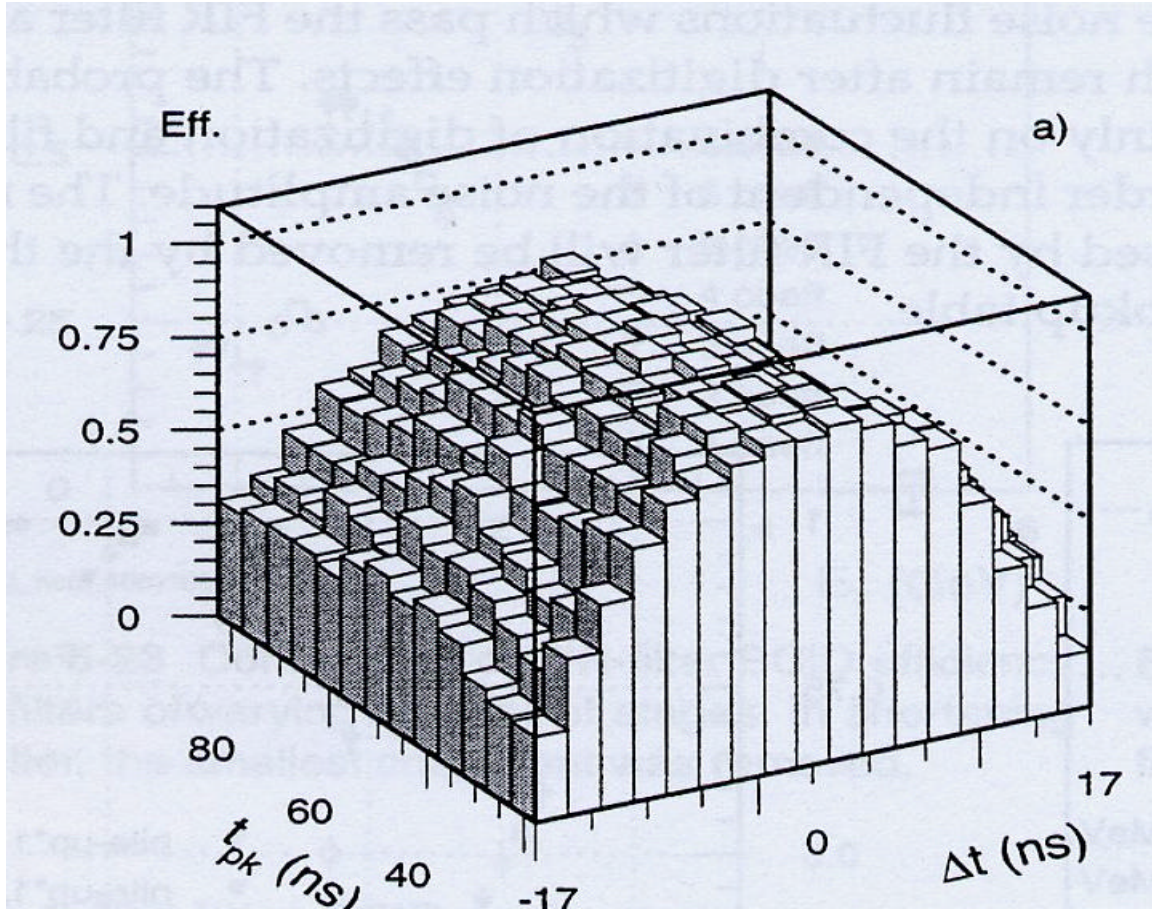
Correlazioni y vs x



Istogrammi di frequenza



Isogrammi di frequenza (bidimensionali)



Studio delle dipendenze funzionali
per via grafica

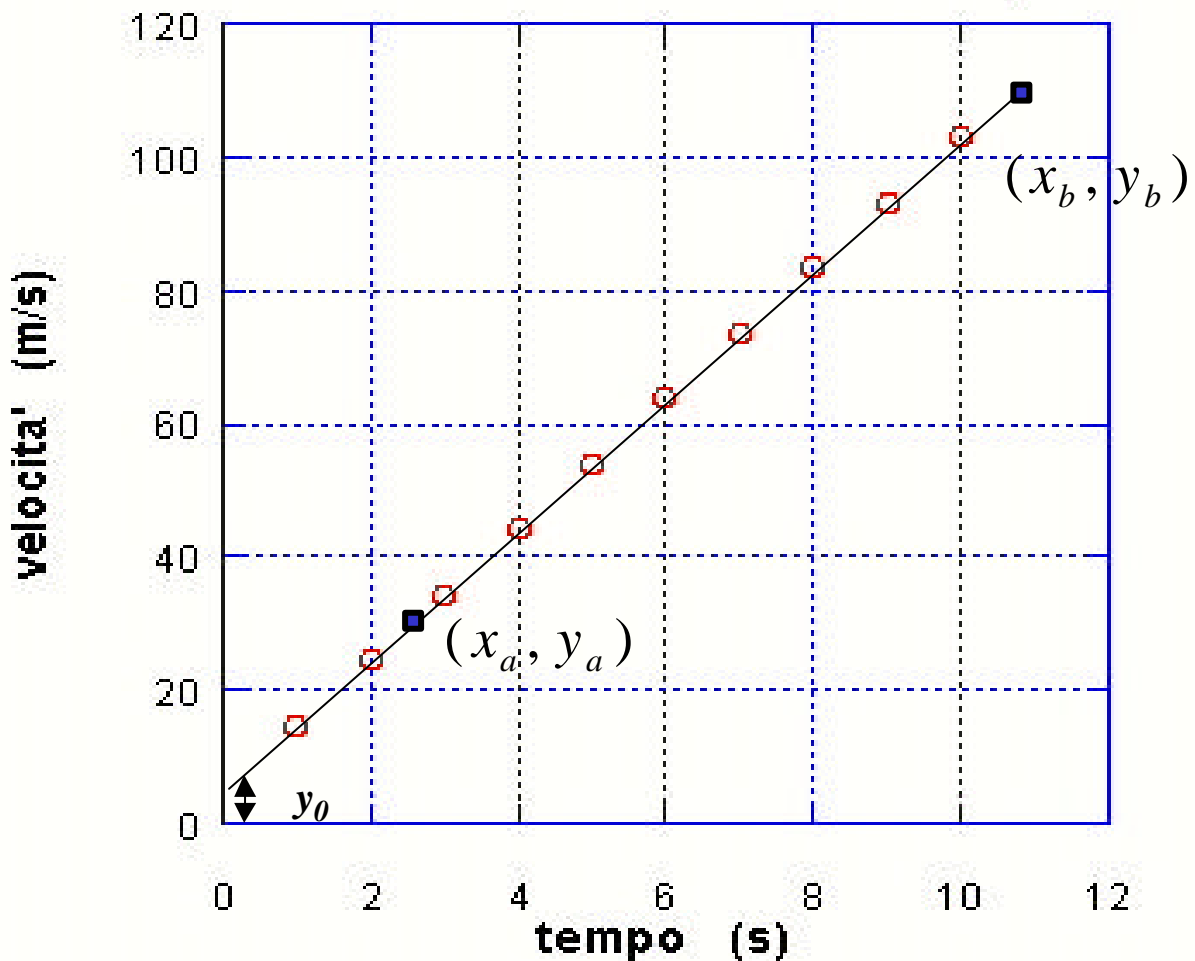
$$y = a \cdot x + b$$

Date n coppie di determinazioni (x_i, y_i) come ricavare a e b per via grafica?

$$a = \frac{(y_B - y_A)}{(x_B - x_A)}$$

$$b = y_0 \quad (x_a, y_a)$$

Velocita' di caduta vs tempo

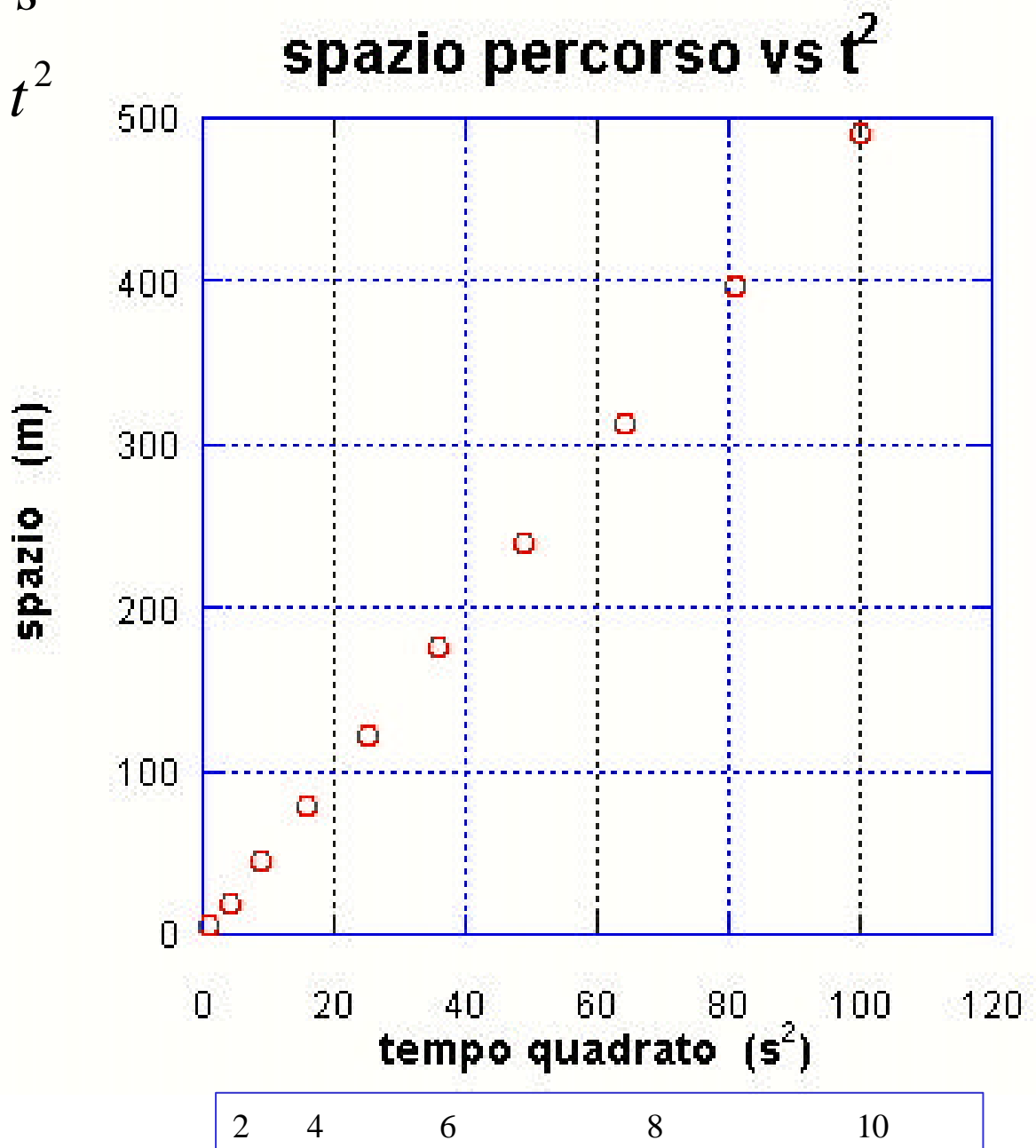


Con opportuno cambio di variabile e' spesso possibile linearizzare la dipendenza funzionale:

$$s = \frac{1}{2} \cdot a \cdot t^2$$

$$y = s$$

$$x = t^2$$



SCALE LOGARITMICHE

$$x = a^{\lg_a x} = b^{\lg_b x}$$

$$\lg_a(x) = \lg_a(a)^{\lg_a x} = \lg_a(b)^{\lg_b x}$$

$$\lg_a(x) = \lg_a x \cdot \lg_a(a) = \lg_b x \cdot \lg_a(b)$$

$$\lg_a(x) = K \cdot \lg_b(x)$$

CAMBIMENTO DI BASE \Rightarrow FATTORE MOLTIPLICATIVO

SCALA LOGARITMICA:

SCALA SU CUI SONO RIPORATI SEGMENTI PROPORZIONALI
AI LOGARITMI DEI NUMERI IN BASE QUALSIASI

$$1 \quad \lg_a(1) = 0$$

$$2 \quad \lg_a(2) = l_2$$

$$3 \quad \lg_a(3) = l_3$$

$$4 \quad \lg_a(2)^2 = 2 \cdot l_2 = l_4$$

$$5 \quad \lg_a(5) = l_5$$

⋮

$$10 \quad \lg_a(2 \cdot 5) = \lg_a(2) + \lg_a(5) = l_2 + l_5 = l_{10}$$

⋮

$$30 \quad \lg_a(3 \cdot 10) = \lg_a(3) + \lg_a(10) = l_3 + l_{10}$$

$$100 \quad \lg_a(10)^2 = 2 \lg_a(10) = 2 l_{10}$$

⋮

$$0.1 \quad \lg_a(10)^{-1} = -1 \lg_a(10) = -l_{10}$$

$$0.01 \quad \lg_a(10)^{-2} = -2 \lg_a(10) = -2 \cdot l_{10}$$

USO DELLE SCALE LOGARITMICHE:

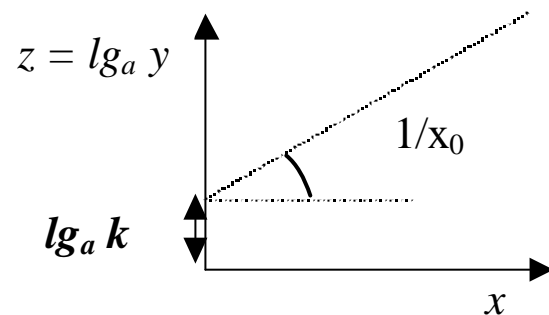
- $y = k \cdot a^{x/x_0}$

RICAVARE: k e x_0

$$\lg_a y = \lg_a k + \frac{x}{x_0} \lg_a a$$

$$\underbrace{\lg_a y}_z = \frac{1}{\underbrace{x_0}_k} x + \underbrace{\lg_a k}_b$$

$z = kx + b \Rightarrow$ RETTA NEL GRAFICO



ERRORE SU z : $\Delta z = \frac{dz}{dy} \cdot \Delta y = \lg_a e \cdot \frac{\Delta y}{y}$

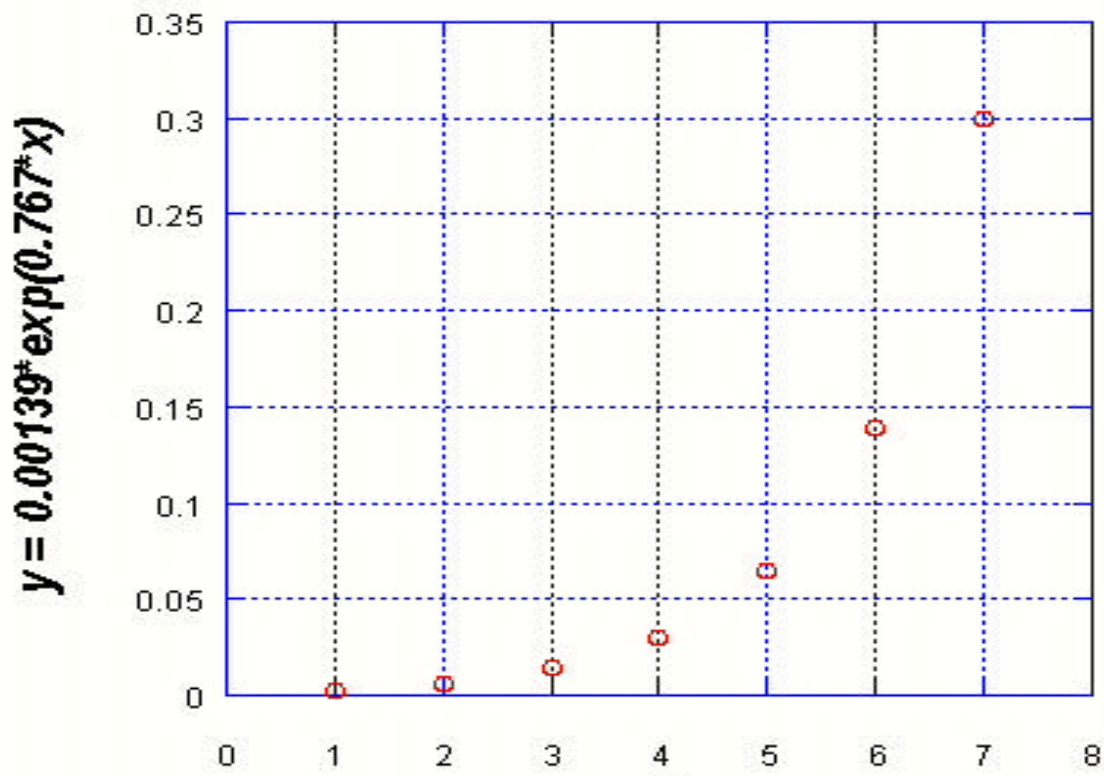
- $y = k \cdot x^n$

RICAVARE: k e n

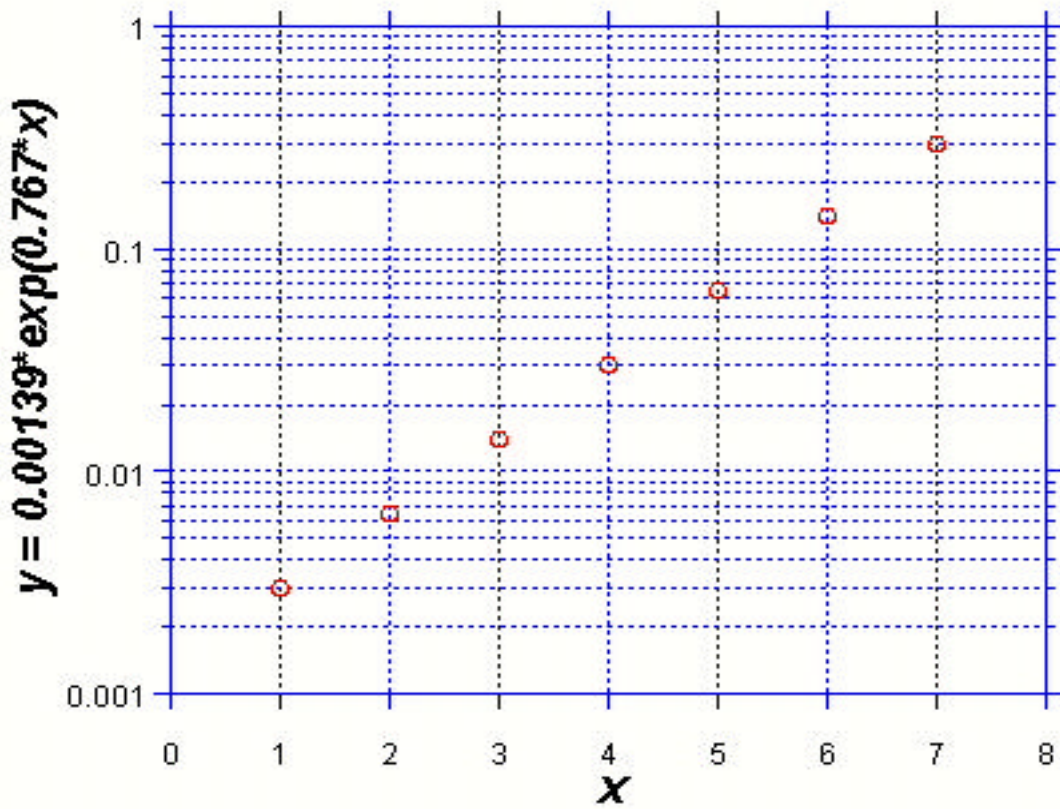
$$\underbrace{\lg_a y}_z = \underbrace{\lg_a k}_b + \underbrace{n}_k \cdot \underbrace{\lg_a x}_x$$

$z = k \xi + b \Rightarrow$ RETTA SU GRAFICO DOPPIO LOG

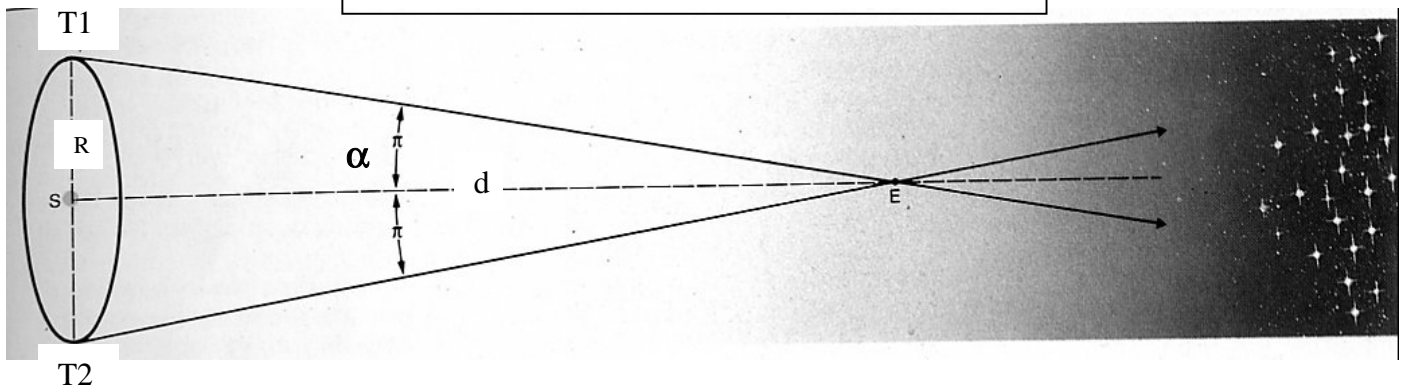
Scala lineare



Scala semilogaritmica



Misura distanze stellari



$R = 149.6 \cdot 10^6 \text{ Km} = 1 \text{ u.a.}$ (distanza media terra-sole)

α : parallasse

$d = R / \alpha = (\text{per } \alpha = 1'') = 149.6 \cdot 10^6 \times 206265 \text{ Km} = 3.086 \cdot 10^{13} \text{ Km} = 1 \text{ parsec}$

1 parsec = 3.26 anni-luce