Nuove Tecnologie
Macchine, Rivelatori, Trigger & Software

Luca Lista
INFN Napoli
&
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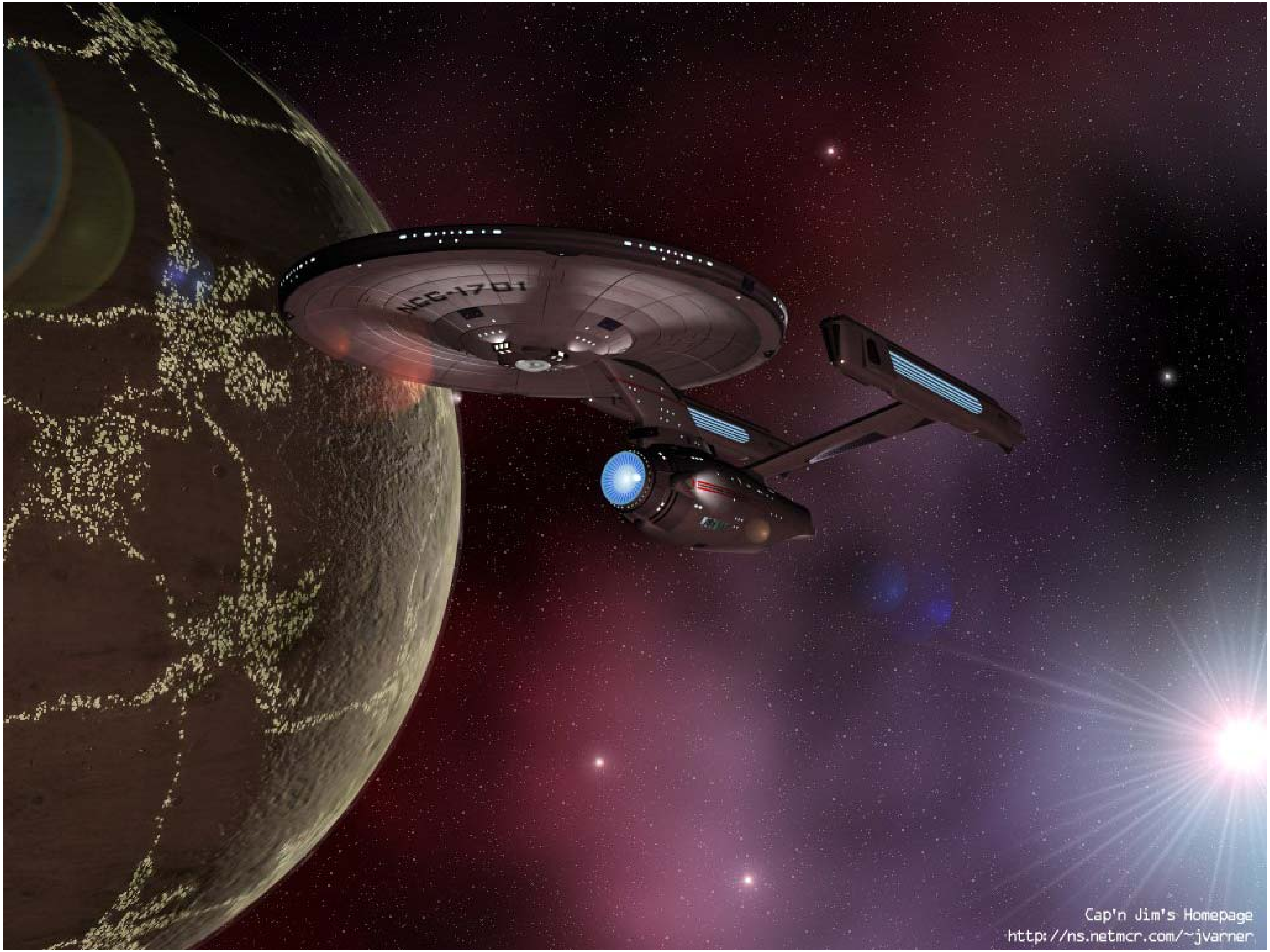
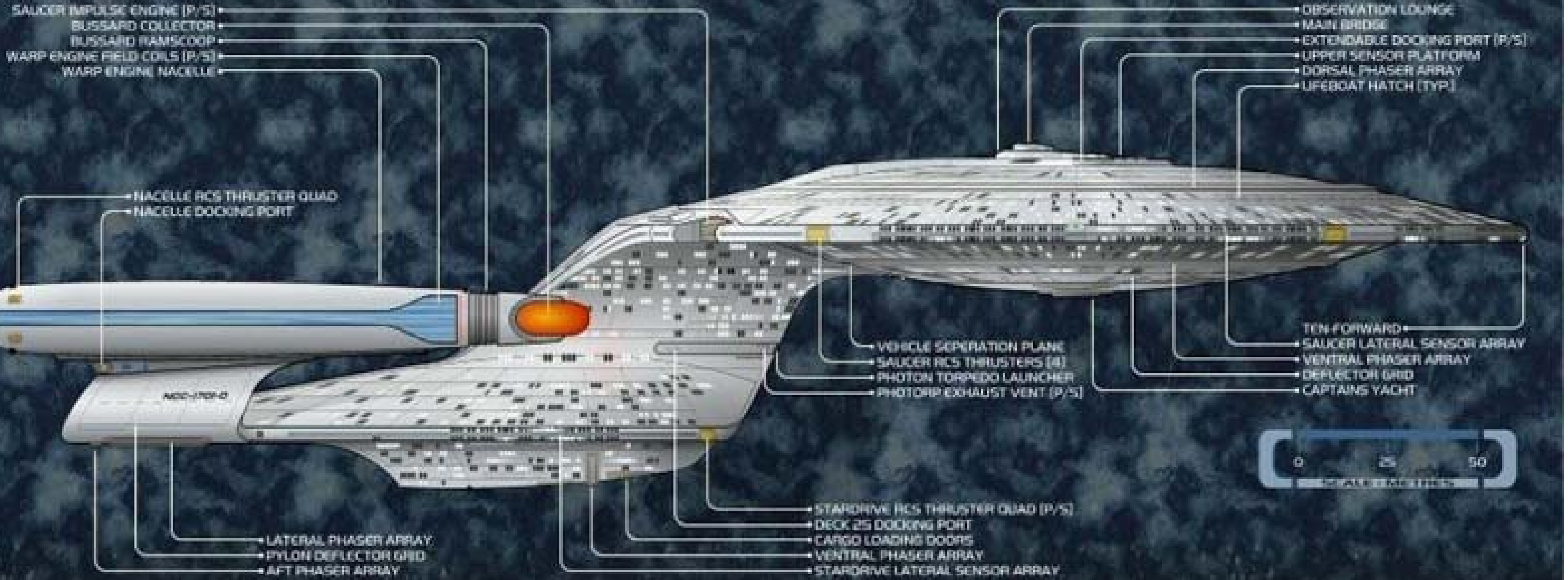

NCC-1701
Cap'n Jim's Homepage
http://ns.netmcr.com/~jvarner

STARSHIP U.S.S. ENTERPRISE NCC-1701-D

UNITED FEDERATION OF PLANETS
GALAXY CLASS

ORIENTATION:
SIDE ELEVATION



SUPPORT VEHICLES TYPE 15 - TYPE 15A - TYPE 16 - TYPE 6

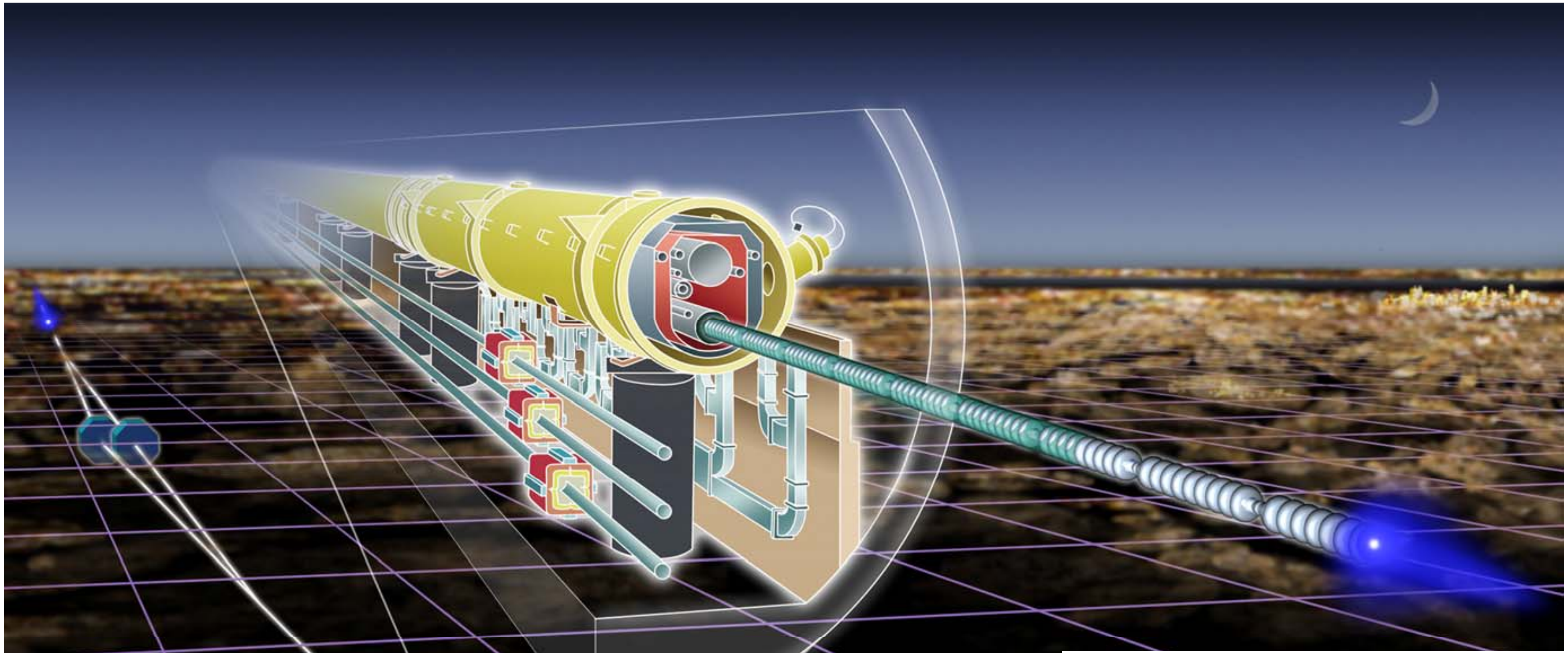
SPECIFICATIONS

LENGTH 641.0m
WIDTH 467.5m
HEIGHT 138.7m

SHIPS COMPLIMENT
OFFICERS 212
ENLISTED (CREW) 802

PERFORMANCE
CRUISING VELOCITY WARP 7
MAXIMUM VELOCITY WARP 9.6

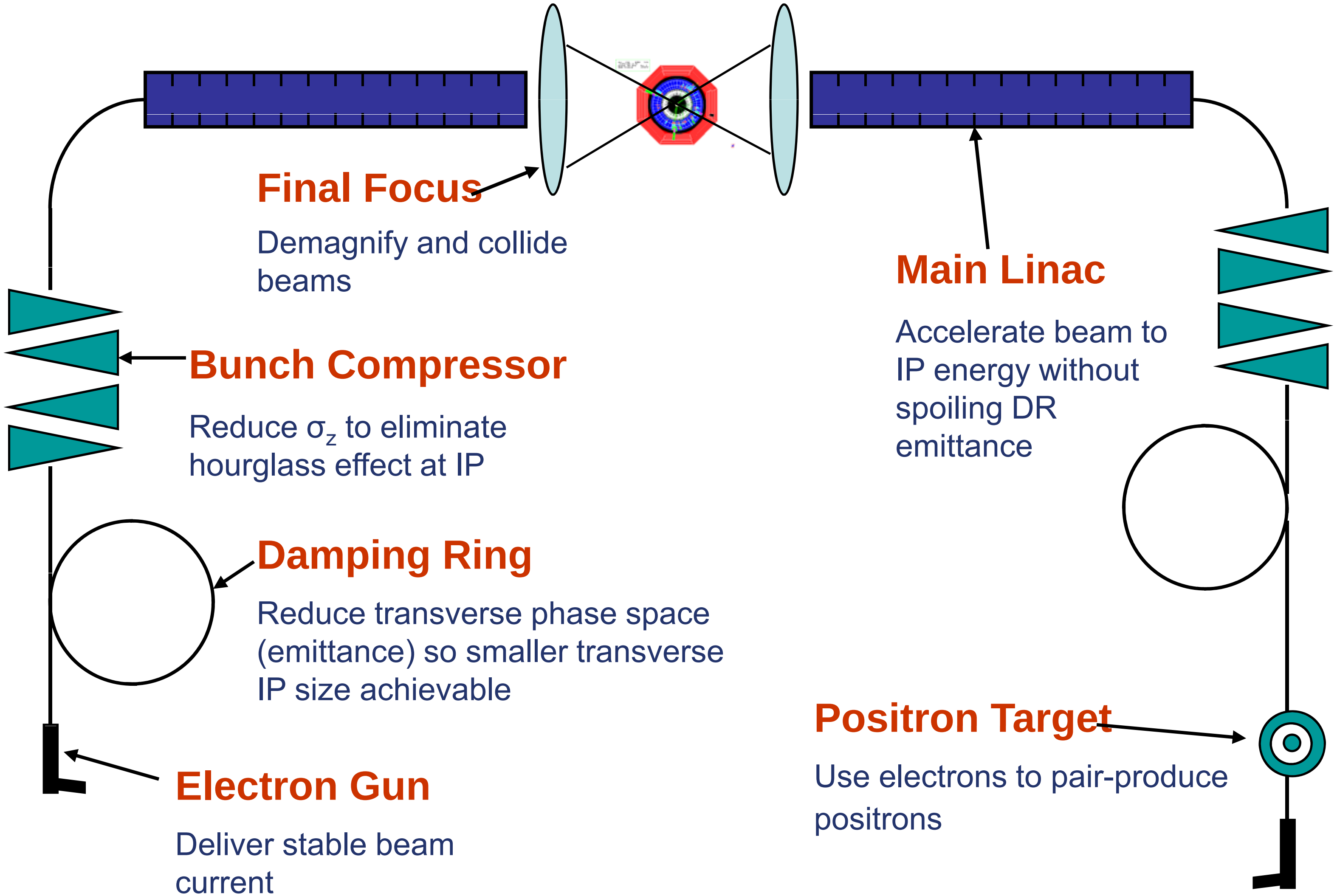
created by
TREKART



Daniele Sertore
INFN Milano - LASA

Serial TV - http://www.serialtv.it

LC conceptual scheme



Final Focus

Demagnify and collide beams

Bunch Compressor

Reduce σ_z to eliminate hourglass effect at IP

Damping Ring

Reduce transverse phase space (emittance) so smaller transverse IP size achievable

Electron Gun

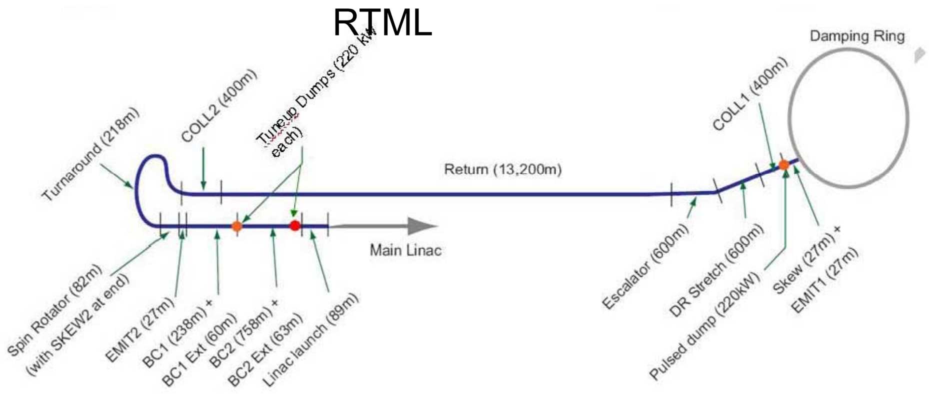
Deliver stable beam current

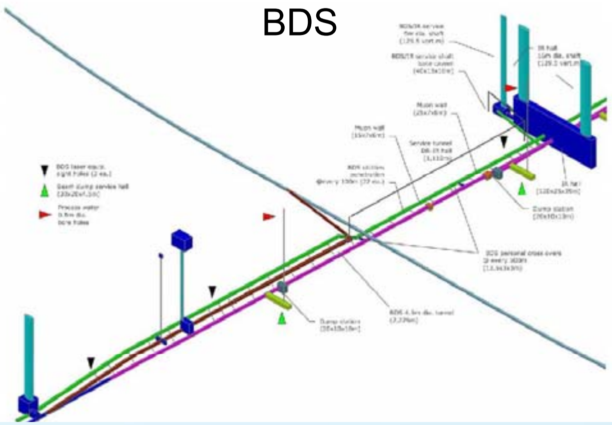
Main Linac

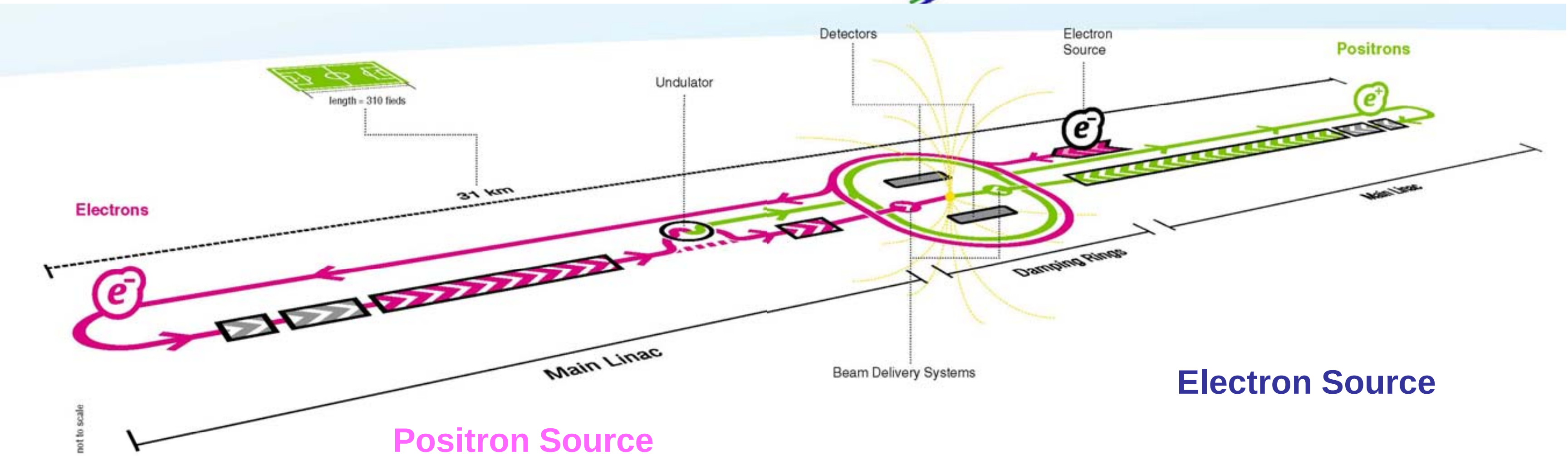
Accelerate beam to IP energy without spoiling DR emittance

Positron Target

Use electrons to pair-produce positrons

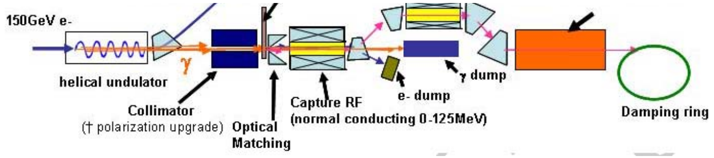






Electron Source

Positron Source



Il progetto attuale

Reference Design Report

Marzo 2007

RDR ILC Cost Estimate

- The reference design was "frozen" as of 1-Dec-06 for the purpose of producing the RDR, including cost.
- It is important to recognize this is a snapshot and the design will continue to evolve, due to results of the R&D, accelerator studies and value engineering.
- The value costs have already been reviewed twice
  - **3 days "internal review" in Dec 2006**
  - **ILCSC MAC review in Jan 2007**

From GDE-Status-2007 presented at Bejing by Barry Barish

Summary RDR "Value" Costs

Total Value Cost (FY07)

1 ILC Unit = 1 US 2007$ = 0.83 € = 117 Yen

4.87B Shared

\+

1.78B Site Specific

\+

13.0 k person-years

("explicit" labor = 22.2 M person hrs @1700 hrs/yr)

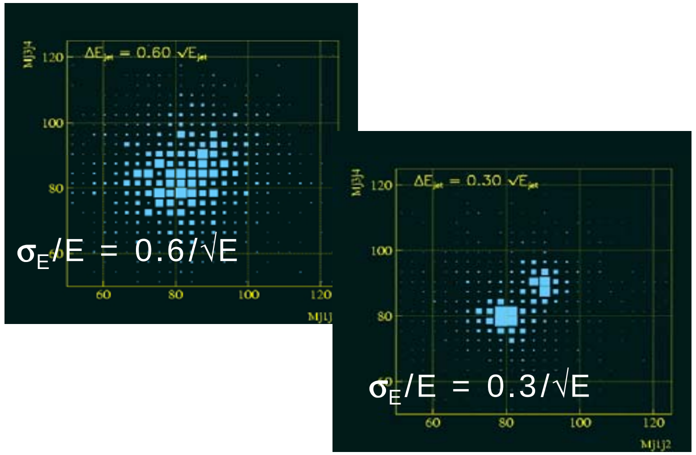
The Starting Point

The starting points (well known by now)

- Precision tracking
- Precision vertexing   Antonio **Bulgheroni**, Roma III
- Particle flow for overall event reconstruction   Anna **Mazzacane**
  Uni. Salento &INFN Lecce

???

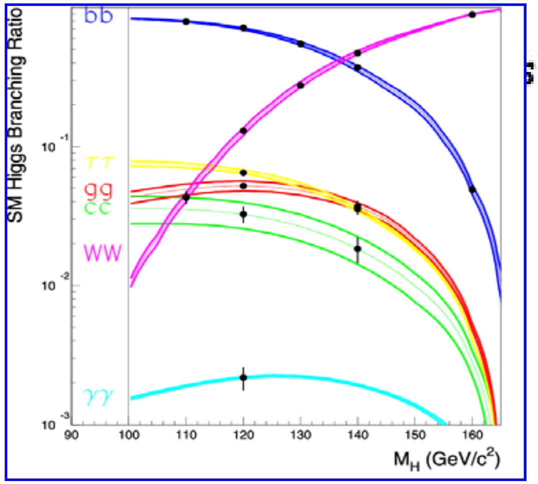
WW-ZZ separation



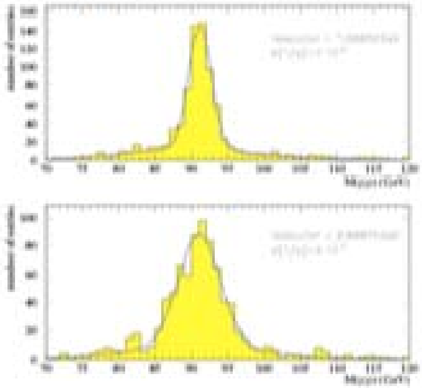
$\sigma_E/E = 0.6/\sqrt{E}$

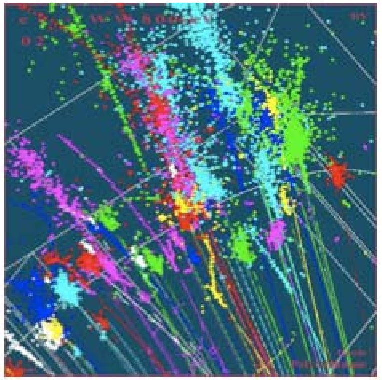
$\sigma_E/E = 0.3/\sqrt{E}$

Higgs couplings



Higgs recoil mass





Sulla Calorimetria a ILC

- **TESLA TDR resolution ($Z \rightarrow uds$ at rest) : $\sim 0.30\sqrt{E_{jet}}$**

Component	Detector	Frac. of jet energy	Particle Resolution	Jet Energy Resolution
Charged Particles($X^{\pm}$)	Tracker	0.6	10^{-4} E_X	neg.
Photons(γ)	ECAL	0.3	$0.11\sqrt{E_\gamma}$	$0.06\sqrt{E_{jet}}$
Neutral Hadrons(h^0)	HCAL	0.1	$0.4\sqrt{E_h}$	$0.13\sqrt{E_{jet}}$

- **Energy resolution gives $0.14\sqrt{E_{jet}}$ (dominated by HCAL)**
- **In addition, have contributions to jet energy resolution due to "confusion", i.e. assigning energy deposits to wrong reconstructed particles (double-counting etc.)**

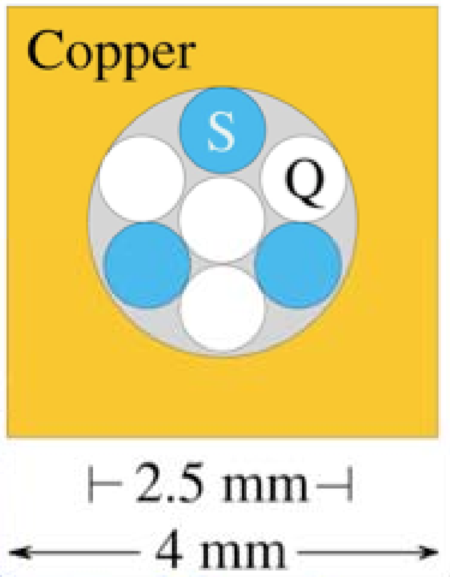
$$\sigma_{jet}^2 = \sigma_{x^{\pm}}^2 + \sigma_{\gamma}^2 + \sigma_{h^0}^2 + \sigma_{confusion}^2 + \sigma_{threshold}^2$$

- **Single particle resolutions not the dominant contribution to jet energy resolution !**

granularity more important than energy resolution

Dual REAdout Module (DREAM)

http://www.phys.ttu.edu/dream/



Unit cell

Back end of 2-meter deep module

Physical channel structure

The C/S method

- Hadronic calorimeter response (C,S) can be expressed with f_{em} and *e/h*

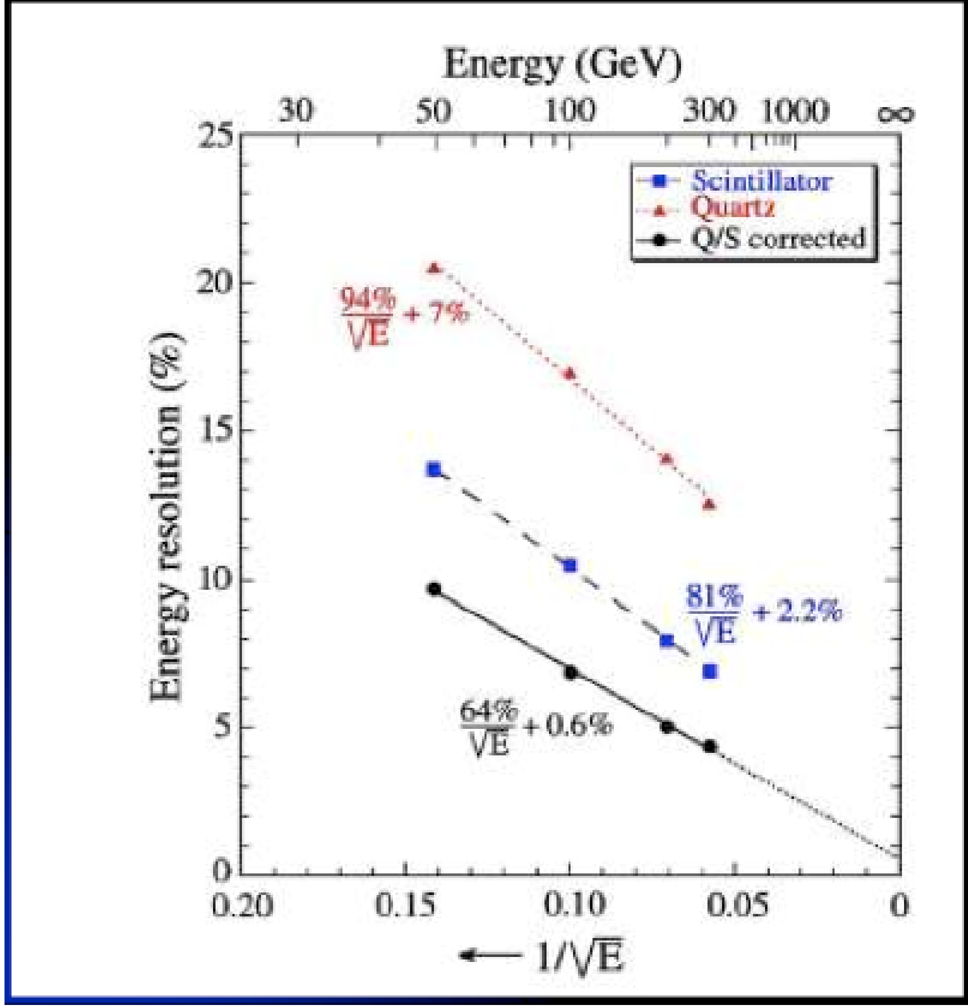
$$R(f_{em}) = f_{em} + \frac{1}{e/h}\left(1 - f_{em}\right)$$

- e/h depends on: active & passive calorimeter media and sampling fraction

  $(e/h)_C = \eta_C \sim 5$ for copper/quartz fiber
  $(e/h)_S = \eta_S \sim 1.4$ for copper/plastic-scintillator
- Asymmetry, non-gaussian & non-linear response are due to fem fluctuation..
- Measurement f_{em} event by event is the key to improve hadronic calorimeter response

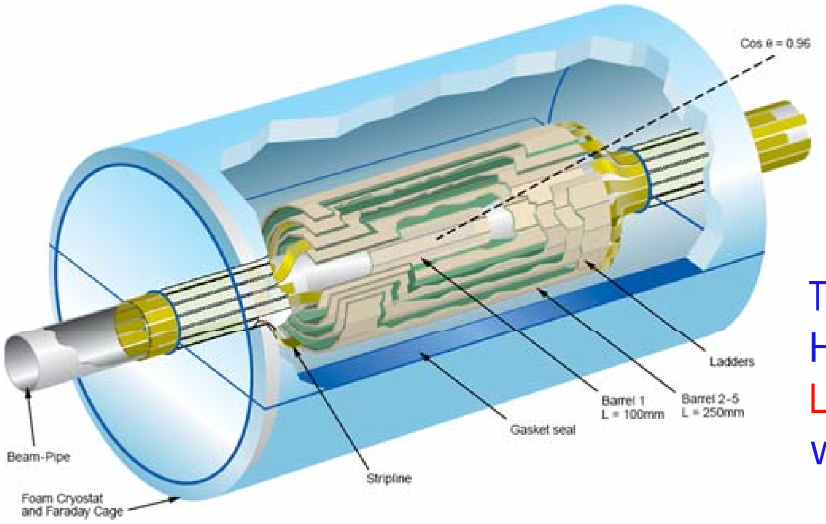
$$\frac{C}{S} = \frac{f_{em} + 0.20\left(1 - f_{em}\right)}{f_{em} + 0.71\left(1 - f_{em}\right)}$$

Corrected Calorimeter Response



$$E_{HCAL} = \frac{\eta_S \cdot E_S \cdot (\eta_C - 1) - \eta_C \cdot E_C \cdot (\eta_S - 1)}{\eta_C - \eta_S}$$

- High multiplicity jets



Sulla misura di vertici secondari a ILC

The ongoing R&D in position sensitive Si sensors for HEP (and beyond) is driven by the International Linear Collider, requiring complementary figures with respect to the LHC:

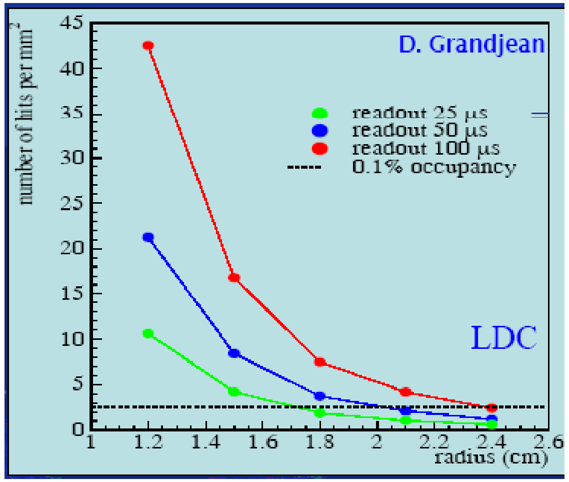
- ❖ high granularity (at the 20 μm level)
- ❖ low material (0.1% X_0)
- ❖ low power dissipation (a few Watts)
- ❖ tolerance against background hits

Risoluzioni
&
spessori

R_{in} = 15 mm
R_{out} = 60 mm
$\sigma_{ip} = [5 \oplus 10/p \sin^{3/2}\theta]\ \mu m$

⇨

- σ_{point} ~ 2.5μm
- spessore ~ 0.1%X_0/layer (~100 μm)



Densita' di hit di background
&
Tempo di lettura

Technology and architecture R&D

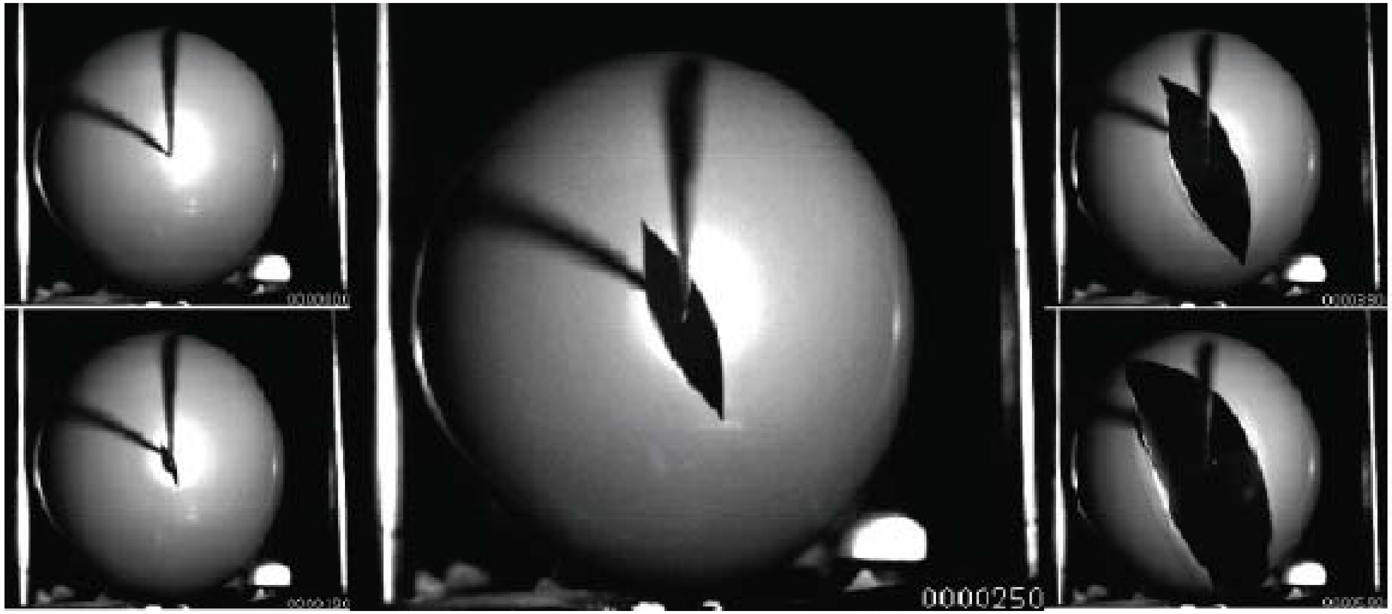
- There are several teams working on different (monolithic) detector technologies trying to implement architectures suitable for the ILC environment

Arch/Tech	Parallel Column	In situ storage	Sparse data scan
CCD	LCFI (UK)	★ LCFI-ISIS	-
CMOS	★ IRES (Strasbourg)	RAL-FAPS	★ Not impossible
DEPFET	★ MPI-Bonn et al	-	-
3D / SOI	★ MIT / INFN & Hamamatsu	Possible	Possible

Credits slide at the end…

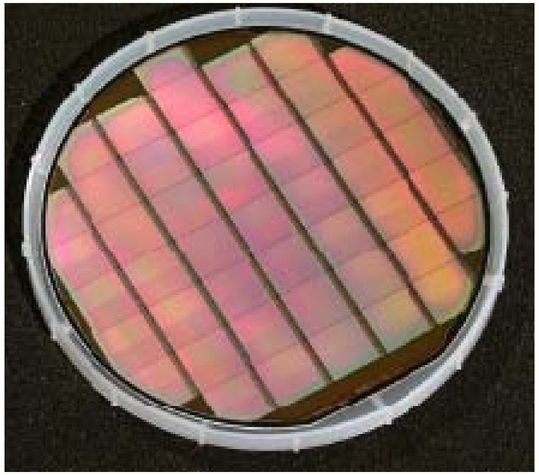
In-situ Storage Imager Sensor

- Signal production and collection in solid state detector is a very process
- The long lasting procedure is the signal readout
- So, store the signals in the sensor and transfer of all them afterward



- **2003: Dart bursting a balloon: 100 consecutive frames at 1M frame/sec**

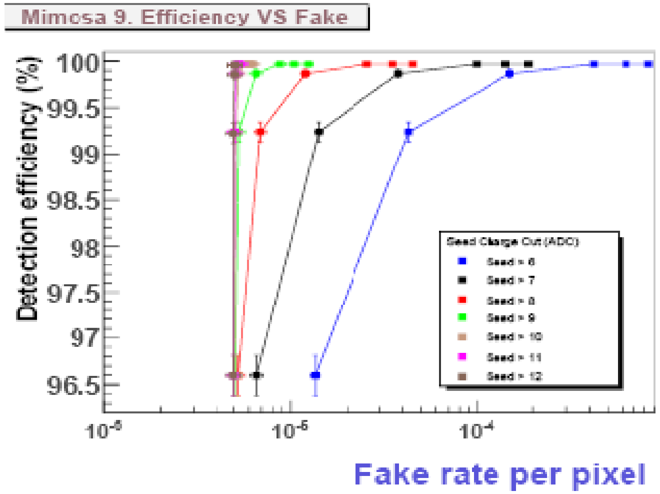
“Standard” CMOS: the Mimosa family



- CMOS for particle detection was firstly used at Strasbourg with the Mimosa 1 chip. Currently designers are working on Mimosa 22
- Already tested many different technologies and architectures with well established performances

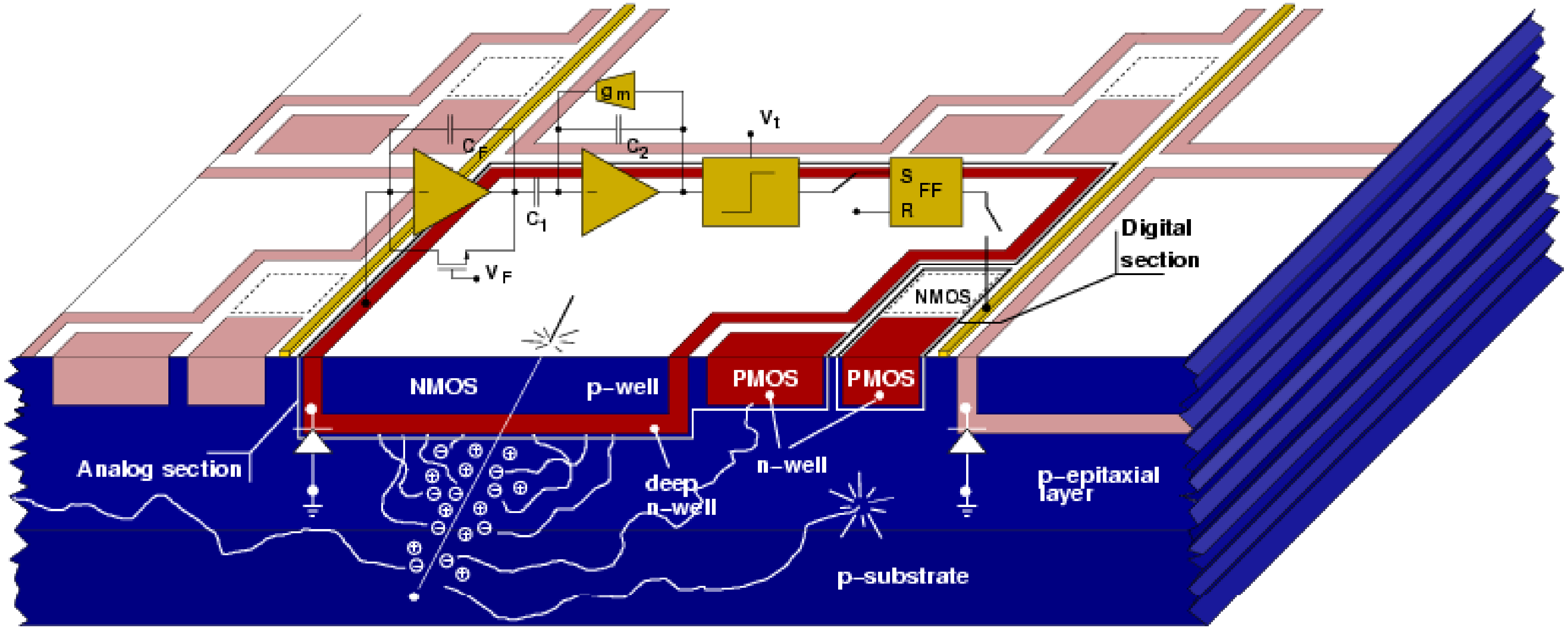
SUMMARY

- **Best performing technology:** AMS 0.35 opto
- **Noise:** 10 e^-
- **SNR for a MIP**: 20 – 30 (MPV)
- **Detection efficiency:** 99.5%
- **Operating temperature:** up to 40º
- **Single point resolution:** down to 1.5 µm



Exotic CMOS development

- CMOS MAPS with hybrid-pixel-like analogue readout electronics in a 130 nm triple well process (INFN – PV + PI)
- Overcoming the only n-MOS limitation

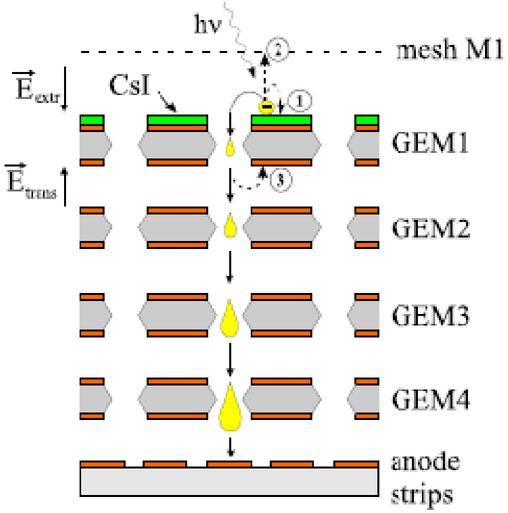


Alessandro Cardini (INFN Cagliari): GEM, Stato dell’arte

- una personale selezione di alcuni degli argomenti riguardanti i rivelatori a GEM presentati recentemente a Conferenze Internazionali ed a Workshop dedicati
- Ringrazio quindi tutti gli autori per il materiale messo a disposizione

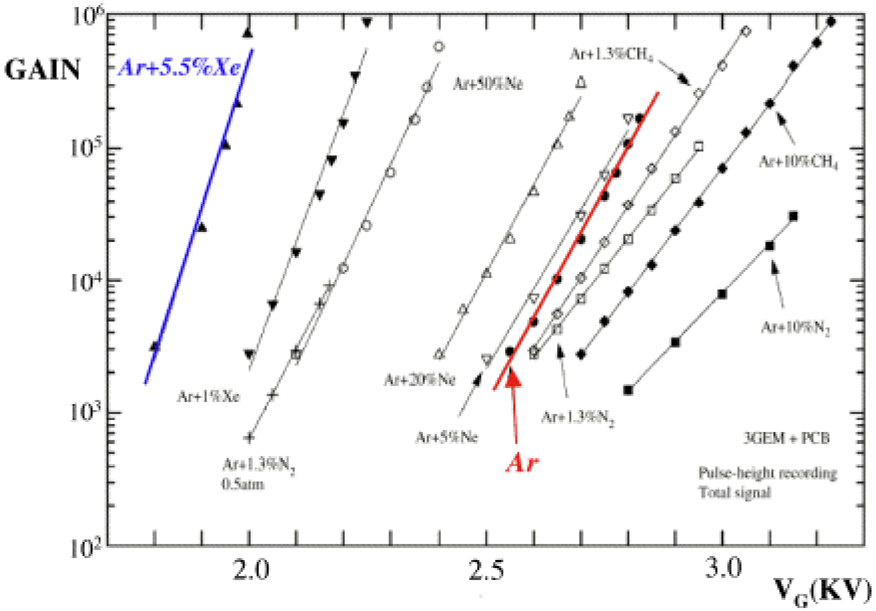
Fotomoltiplicatori a GEM

- La particolare struttura della GEM, con canali di moltiplicazione stretti ed indipendenti, e l’opacita’ della GEM ai fotoni e al feedback ionico permette di raggiungere elevati guadagni in gas nobili puri o loro miscele



- Strutture multi-gem che utilizzano fino a 4 GEM in cascata sono state studiate al CERN, al Weizemann e a Novosibirsk

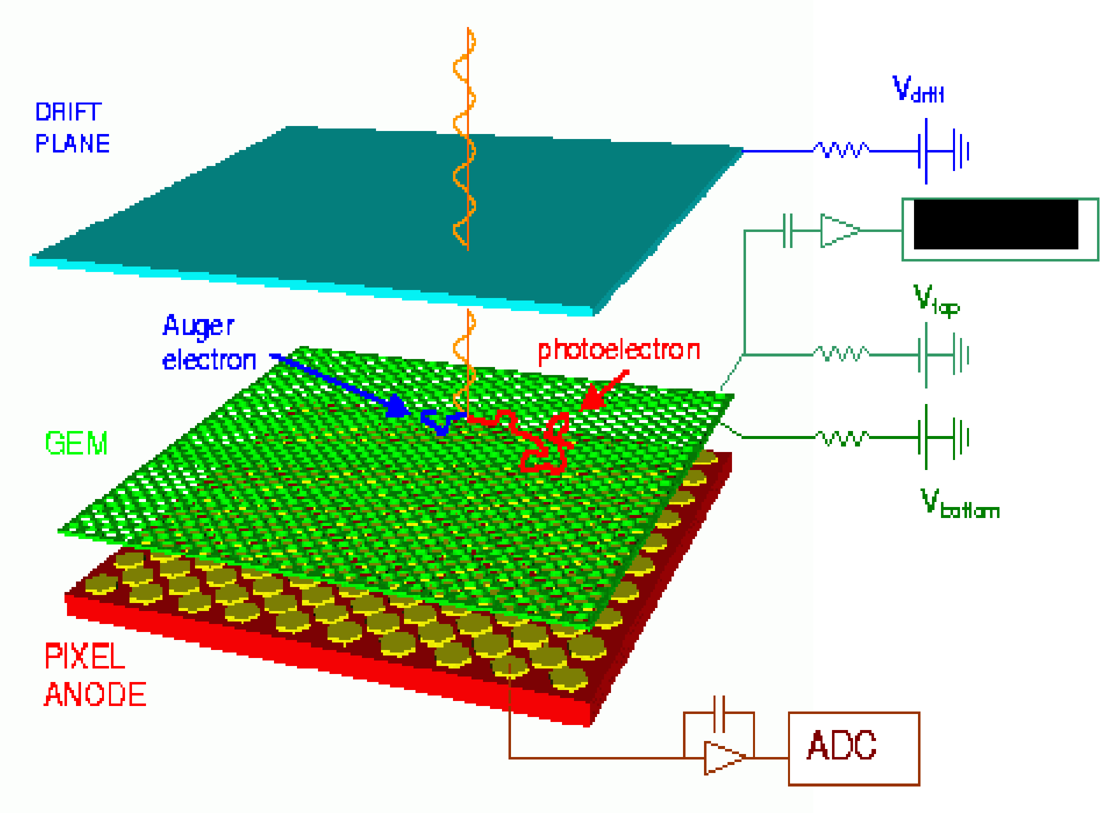
- In particolare sono stati studiati fotocatodi in trasparenza o in riflessione – in questo ultimo caso il fotocatodo e’ depositato sulla prima GEM



Readout con ASIC

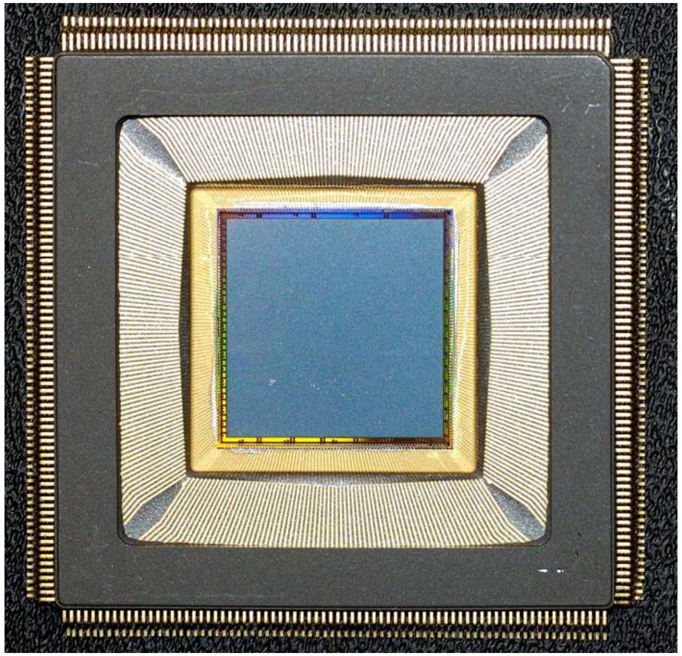
"Ultimate grnularity"

Un rivelatore a singola GEM con lettura a micro-PAD ha una buona efficienza di rivelazione di raggi X morbidi attraverso la rivelazione del fotoelettrone e la misura dell'angolo medio di emissione



R. Bellazzini et al., NIM A435 (2004) 477

ASIC readout chip
105600 canali
470 pixel/mm^2
15 mm x 15 mm active area



Cesare Bini

Sapienza Università di Roma e INFN Roma

DAFNE2:
prospettive di fisica e^+e^- a Frascati

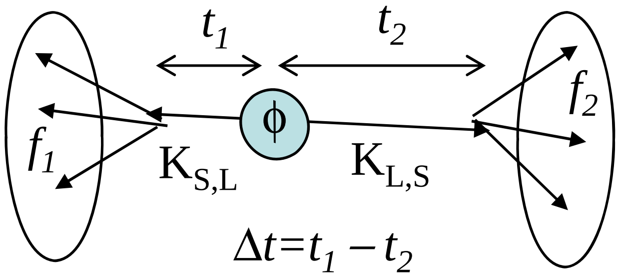
Macchina e^+e^- con

- **$1 < \sqrt{s} < 2.5$ GeV**,
- luminosità fino a **10^{33} $cm^{-2}s^{-1}$** (a 1 GeV) e **$> 10^{32} cm^{-2}s^{-1}$** (alle altre energie);

Programma di Fisica:

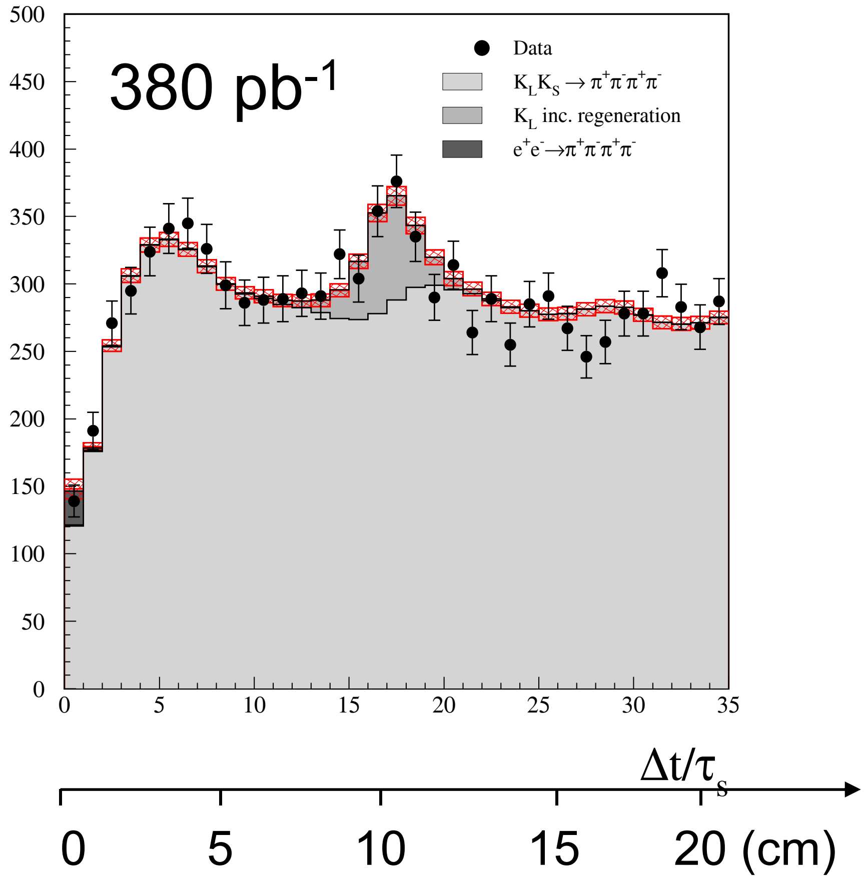
1. Fisica dei mesoni K alla ϕ: matrice CKM, simmetrie CP e CPT, universalità leptonica, teorie chirali;
2. Struttura dei mesoni leggeri: η, η', $f_0(980)$, $a_0(980)$, σ (+ spettroscopia di mesoni $1 < m < 2.5$ GeV);
3. Sezione d'urto adronica da $2m_\pi$ a 2.5 GeV: calcolo correzioni adroniche a g-2 e a α_{em} running ;
4. Fattori di forma time-like dei barioni (p, n, Λ, Σ): misura delle fasi dalla polarizzazione;
5. Esistenza di nuclei kaonici fortemente legati e sistematica interazioni KN;

Esempio: $\phi \to K_S K_L \to \pi^+\pi^- \pi^+\pi^-$,test di coerenza quantistica



KLOE ha già migliorato i limiti precedenti.

(*KLOE coll. Phys.Lett.B642 (2006) 315*)



Differenza di tempo tra i 2 vertici:

→ Effetti di decoerenza (ζ)

→ Violazione di CPT indotta da effetti di gravità quantistica (ω)

$$|i\rangle \propto (K_S K_L - K_L K_S) + \boxed{\omega}(K_S K_S - K_L K_L)$$

$$|\omega|^2 = O\left(\frac{E^2/M_{PLANCK}}{\Delta\Gamma}\right) \approx 10^{-5} \Rightarrow |\omega| \sim 10^{-3}$$

(vedi ▪ www.roma1.infn.it/people/didomenico /roadmap/kaoninterferometry.html)

Questioni sperimentali:

- ottima ***risoluzione di vertice***, no ***materiale*** nei primi 10 ÷15 cm,…

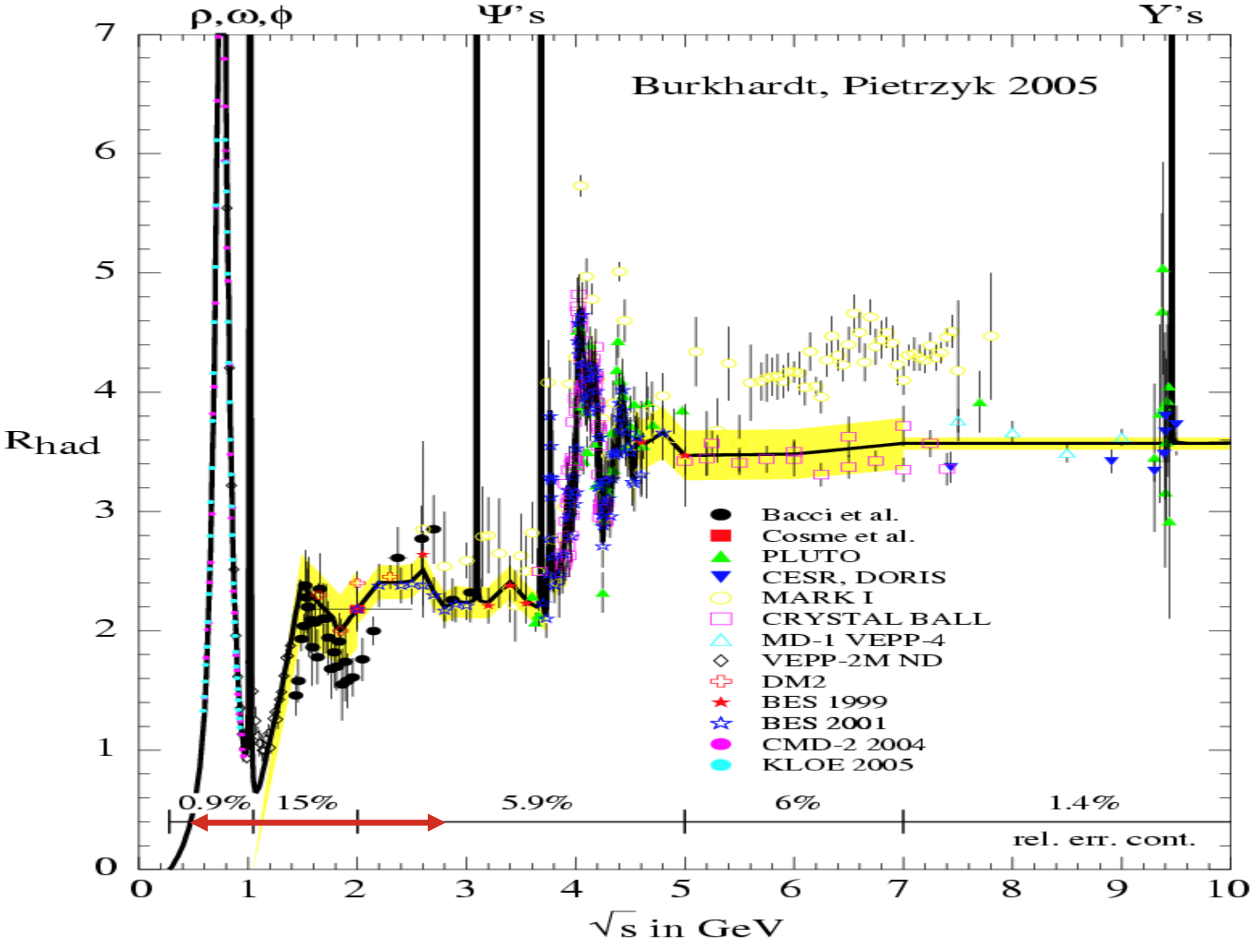
Misura della sezione d’urto e^+e^- in adroni

DAFNE2 ==> da 2 m_π a 2.5 GeV

➔ Spettroscopia dei mesoni vettori

➔Correzioni adroniche a **g-2** e a α_{em}

N.B. “competizione” con B-factories ISR e con VEPP-2000



(1) $2m_\pi \div 1$ GeV

ritorno radiativo

cruciale per **g-2**

(vedi *hep-ph/0703049*)

(2) $1 \div 2.5$ GeV

scan in energia

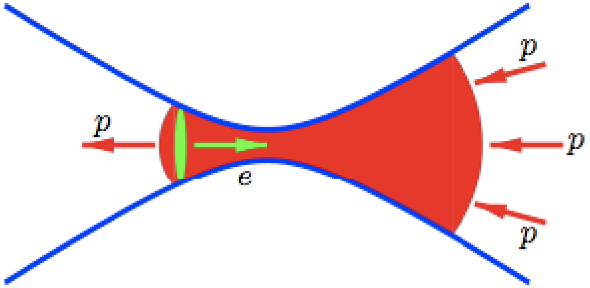
cruciale per α_{em}

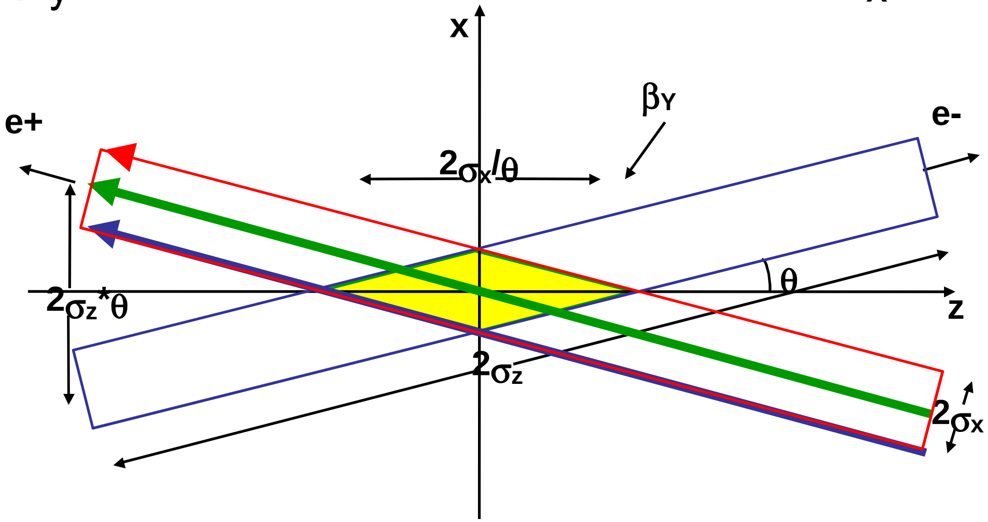
(vedi *hep-ph/0608329*)

Idee per aumentare la luminosità di DAFNE (*P.Raimondi*)

(vedi *D.Alesini et al., LNF-06/33 (IR)*)

(1) Collisioni ad angolo θ + riduzione di σ_x per evitare l'effetto "hourglass" (clessidra):
β_y può essere ridotto fino a $2\sigma_x/\theta$



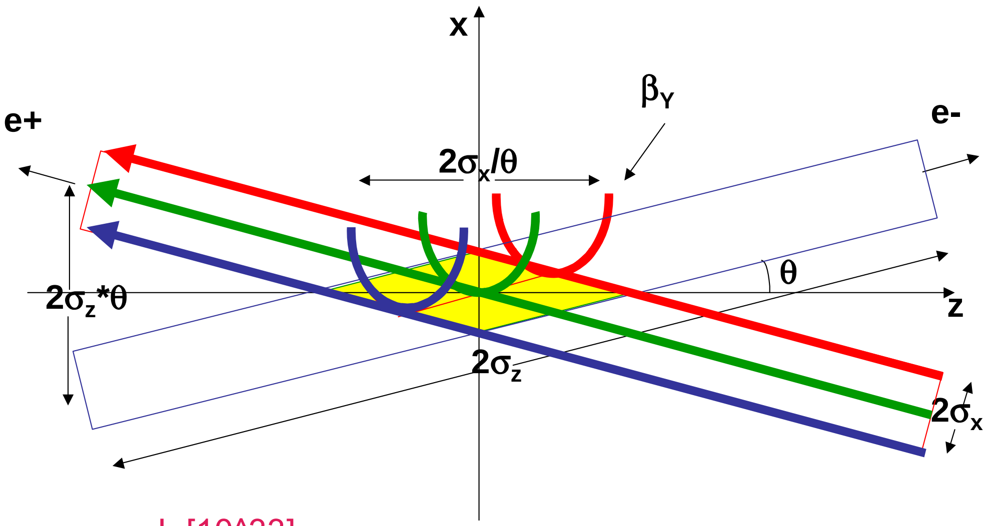


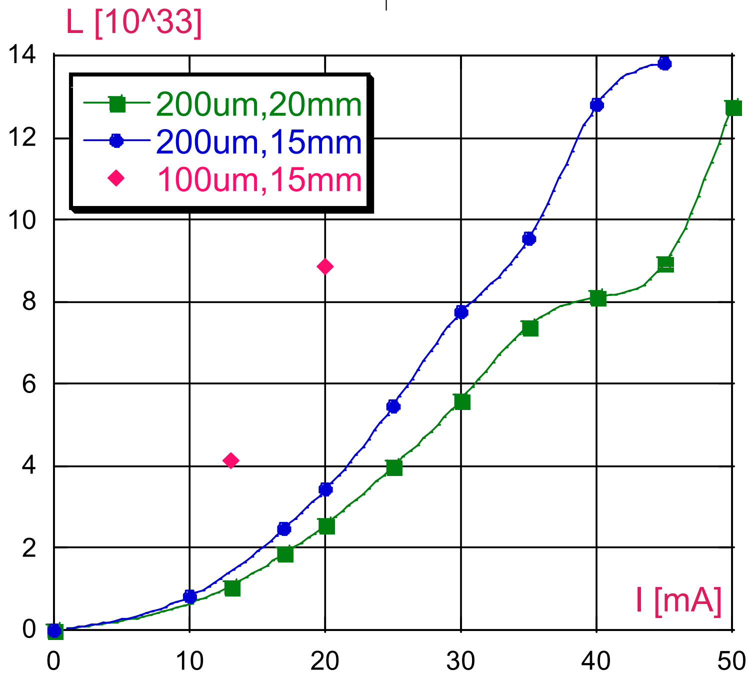
Nuovo set di parametri:

θ	2x17	→ 2x24 mrad
• β_x	1.5	→ 0.2 m
• β_y	18	→ 6 mm
• σ_x	700	→ 200 μm
• σ_y	15	→ 2.4 μm
• σ_z	25	→ 20 mm

A parità di correnti (13 mA / bunch x 110 bunches)
→ **$7 \div 8 \times 10^{32}$ cm^{-2} s^{-1}**

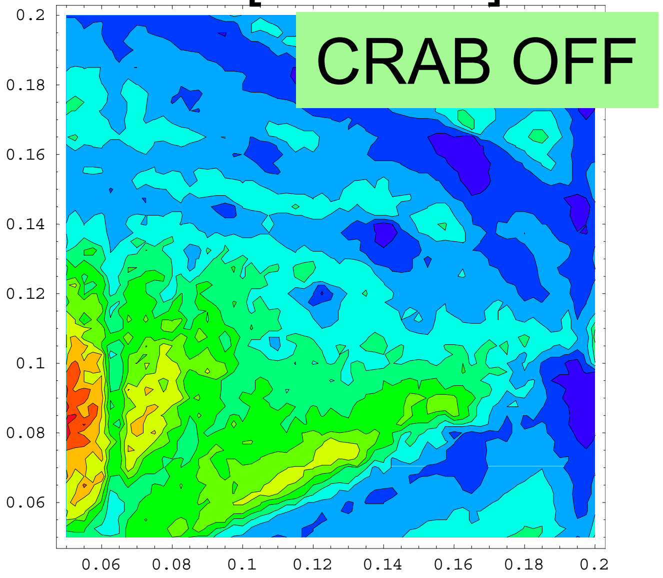
(2) “Crabbed waist”: diversi profili di β_y per diversi x: L aumenta

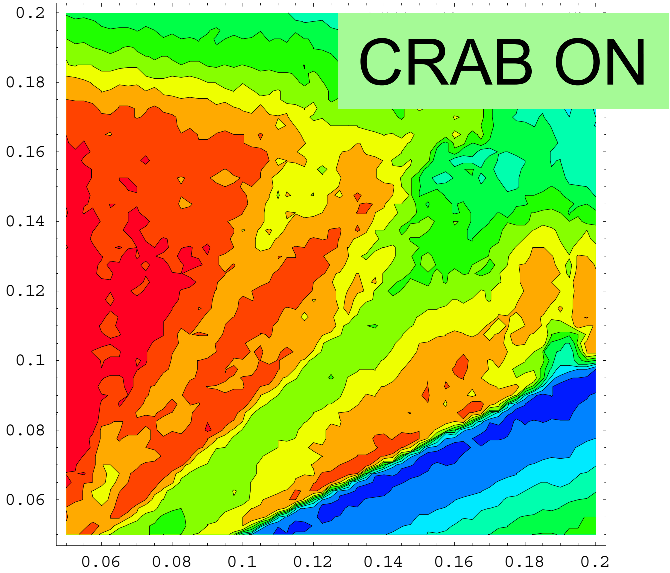




==> **$L \rightarrow 1. \times 10^{33}\ \mathrm{cm^{-2}s^{-1}}$** (I DAFNE)

==> ampia regione di stabilità [*LNF-07/003*]





Last but not least:

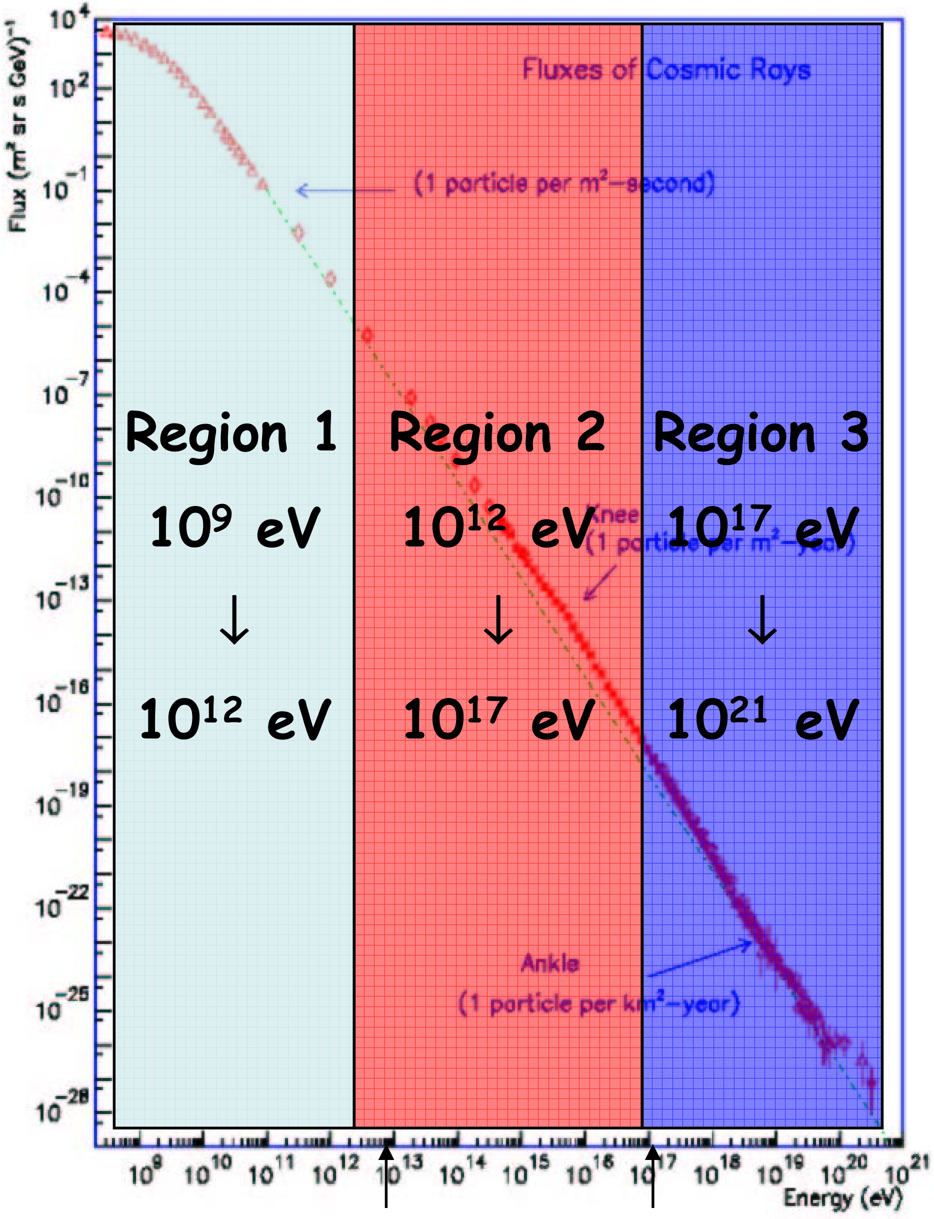
Oscar Adriani
Uni. Firenze & INFN FI

Primary cosmic rays

$$\Phi \propto E^{-2.7}$$

Deviations from this power law
- knee (4.10^{15} eV)
- ankle (5.10^{18} eV)

Very different techniques are necessary to cover these huge differences of:
- Fluxes
- Energies

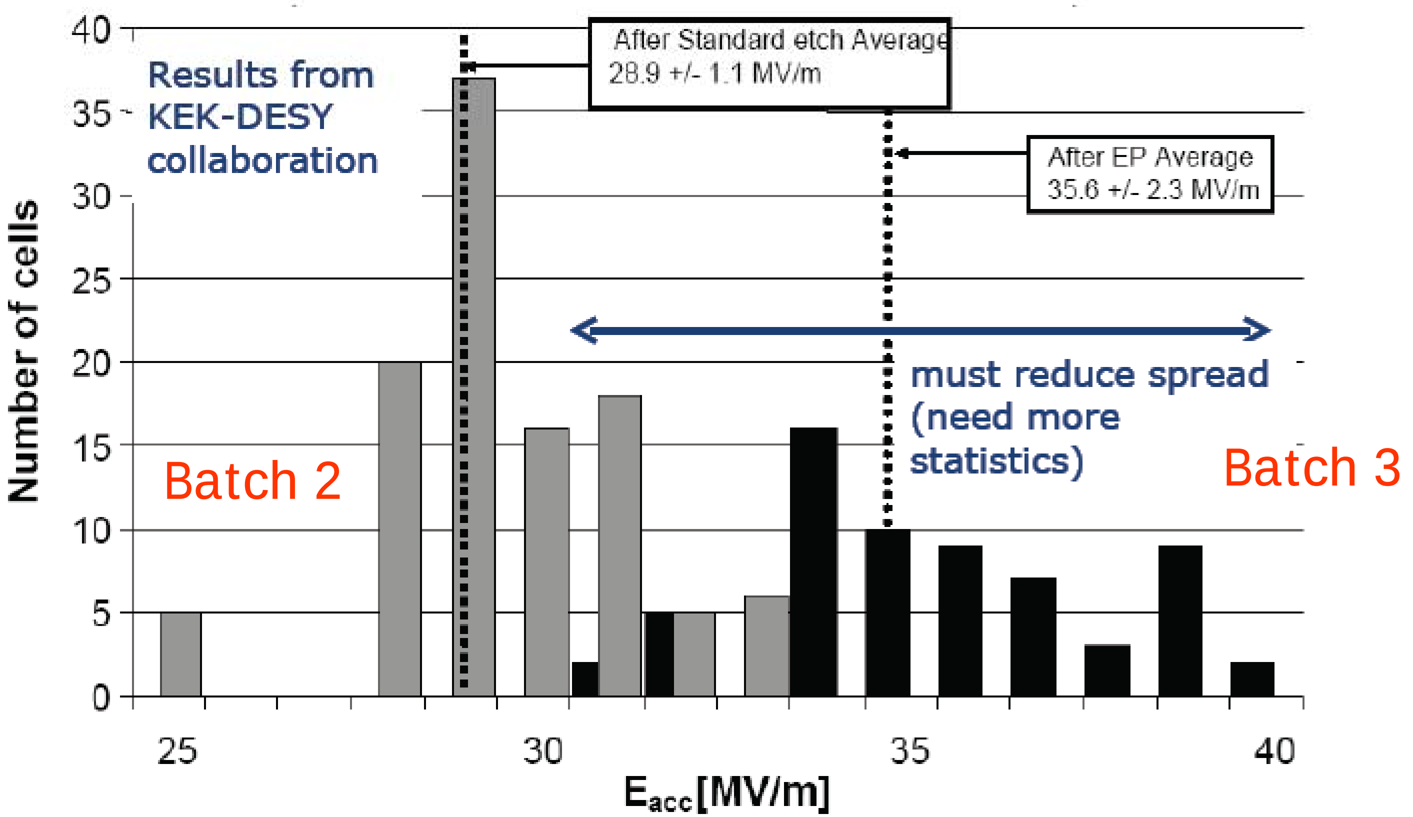


Region 1	Region 2	Region 3
10^{9} eV	10^{12} eV	10^{17} eV
↓	↓	↓
10^{12} eV	10^{17} eV	10^{21} eV

LHC Beam Energy **LHC CM Energy**

Backup slides!

Gradient: State of the Art



Results from KEK-DESY collaboration

After Standard etch Average 28.9 +/- 1.1 MV/m

After EP Average 35.6 +/- 2.3 MV/m

must reduce spread (need more statistics)

Batch 2

Batch 3

Electropolishing the way to (reproducible) high gradients

3 batch di cavita: b1, b2, b3

$\Delta t_{b1-b2} = 10$ anni

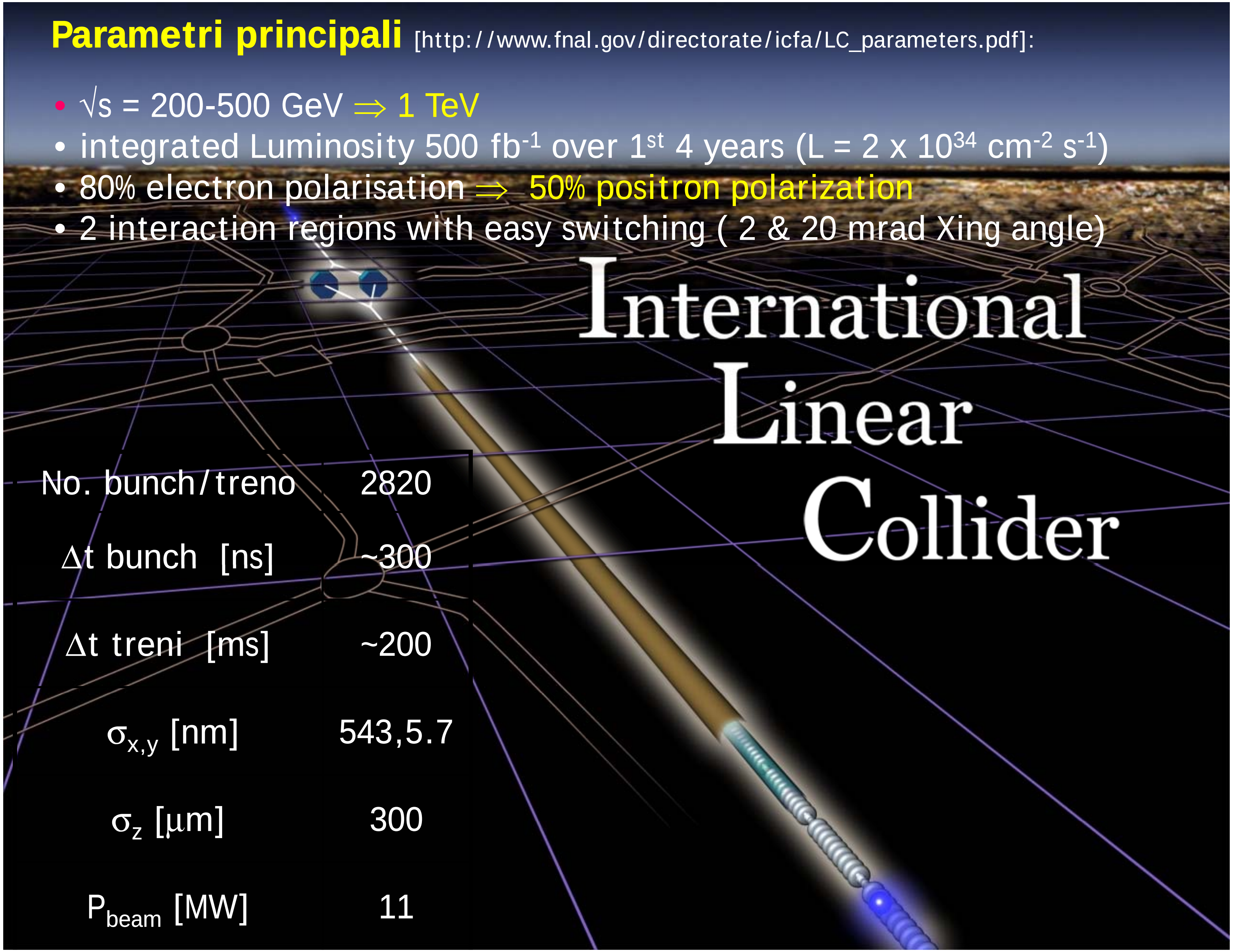
Δgradiente $_{b1-b3} \sim 3$

$\Delta t_{b2-b3} = 5$ anni

Δcosto $_{b1-b3} \sim 1/4$

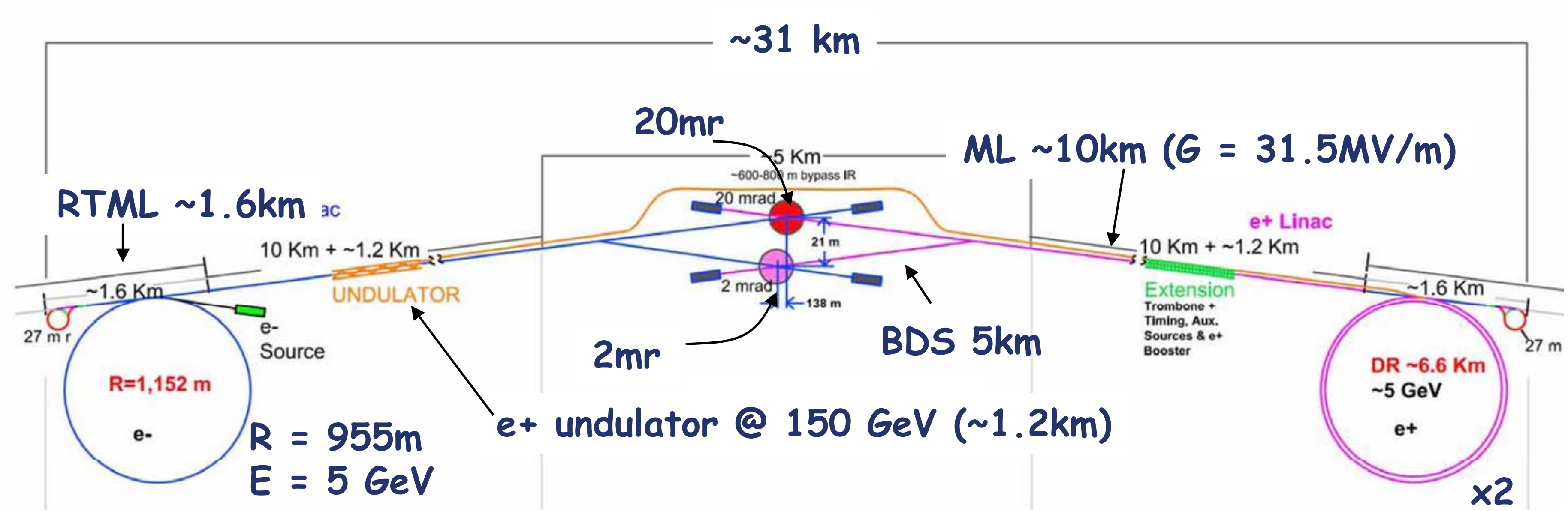
Parametri principali [http://www.fnal.gov/directorate/icfa/LC_parameters.pdf]:

- $\sqrt{s}$ = 200-500 GeV ⇒ 1 TeV
- integrated Luminosity 500 fb^{-1} over 1st 4 years ($L = 2 \times 10^{34}\ cm^{-2}\ s^{-1}$)
- 80% electron polarisation ⇒ 50% positron polarization
- 2 interaction regions with easy switching (2 & 20 mrad Xing angle)



No. bunch/treno	2820
Δt bunch [ns]	~300
Δt treni [ms]	~200
$\sigma_{x,y}$ [nm]	543,5.7
σ_z [μm]	300
P_{beam} [MW]	11

The Baseline Machine (fine 2005)



~31 km

20mr

ML ~10km (G = 31.5MV/m)

RTML ~1.6km

2mr

BDS 5km

R = 955m
E = 5 GeV

e+ undulator @ 150 GeV (~1.2km)

x2

A structured electronic document

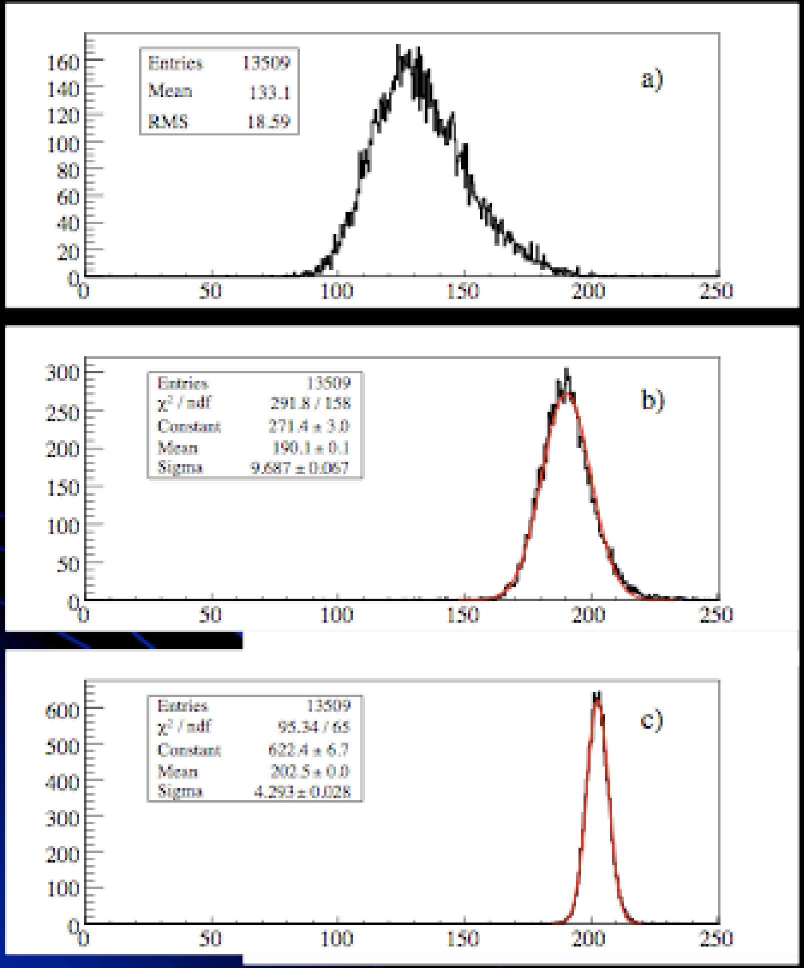
Documentation (reports, drawings etc)

Technical specs.

Parameter tables

http://www.linearcollider.org/wiki/doku.php?id=bcd:bcd_home

DREAM data 200 GeV π^-: Energy response



Scintillating fibers

Scint + Cerenkov

$f_{EM} \propto (C/E_{shower} - 1/\eta_C)$

(4% leakage fluctuations)

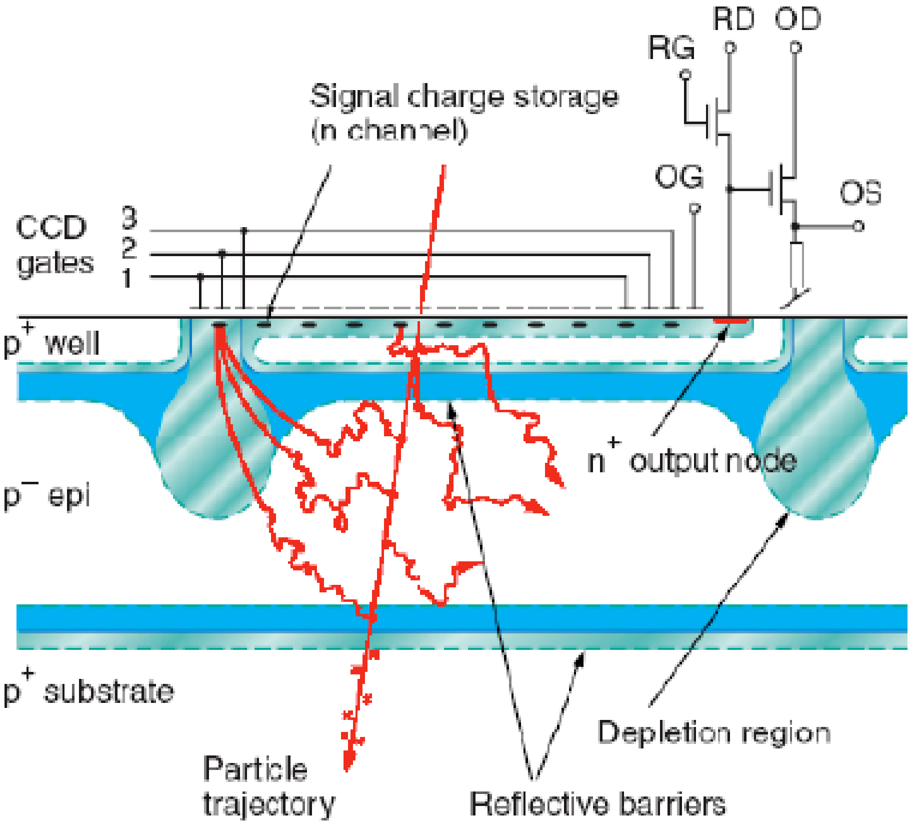
Scint + Cerenkov

$f_{EM} \propto (C/E_{beam} - 1/\eta_C)$

(suppresses leakage)

Data NIM A537 (2005) 537.

ISIS: In situ storage CCD



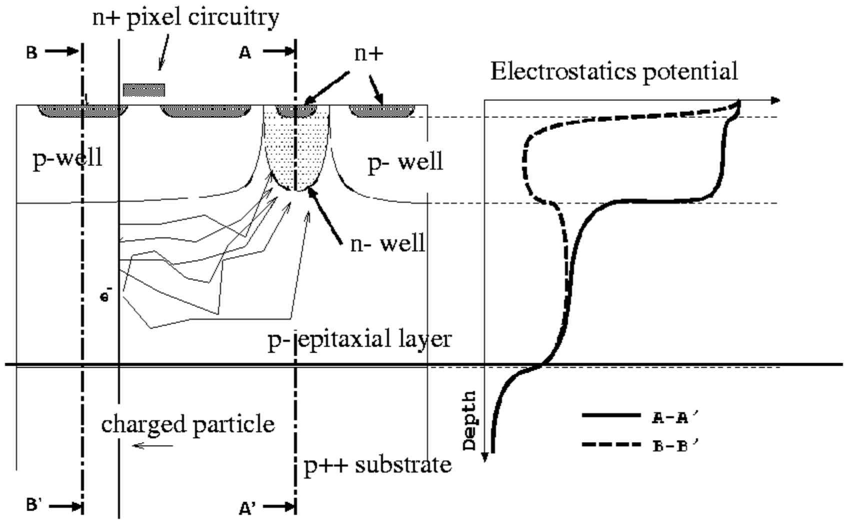
Beam-related RF pickup is a concern for all sensors converting charge into voltage during the bunch train

Charge collection to photo gate from ~20μm as in conventional CCD

Signal charge shifted into the storage register during the bunch

Readout of the storage register in the inter train time

Several technologies are being addressed, and a plurality of architectures for each technology. But all of the proposals have a common feature: sensors should be **MONOLITHIC!**



CMOS sensors for particle detection

- ❖ Pioneered in LEPSI Strasbourg in the late 90's
- ❖ Main drive from digital cameras
- ❖ Addressed HERE since a dedicated development pursued within the framework of the EC project SUCIMA lead to the IMAGING results shown in the following

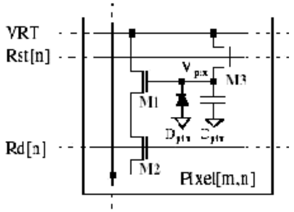
NON STANDARD SENSORS:

- based on the charge carrier generated in the epitaxial layer [2-14 µm thick, depending on the technology Þ SMALL signal (~80 coppie e-h/ µm)]

- diffusion detector vs [standard] drift sensors (the sensitive volume is NOT depleted Þ charge cluster spread over ~ 50 µm [10 µm] AND collection over ~ 150 ns [10 ns])

NEVERTHELESS OFFERING SEVERAL ADVANTAGES:

- very simple baseline architecture (3Transistors: reset, collecting diode, addressing key)



- standard, well established industrial fabrication process, granting a cost-effective access to state-of-the-art technologies

Generalita’

- La GEM (F. Sauli, 1997) e’ un sottile foglio di poliammide (Kapton) ramato su entrambi i lati e forato chimicamente con una densita’ di buchi di di 50-100 mm^{-2}

- Parametri standard:
  - Spessore poliammide 50 μm
  - Spessore rame 5 μm
  - $\varnothing$ buco 70 μm
  - Passo 140 μm

- Applicando una differenza di potenziale tra i due lati del foglio si creano all’interno dei buchi dei campi sufficienti a realizzare una moltiplicazione degli elettroni a valanga