Introduction

Overview and perspectives of ICS compact X sources

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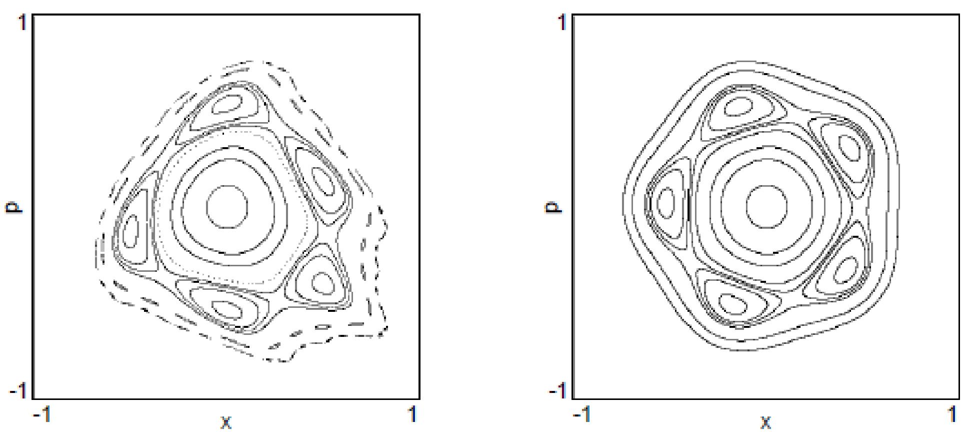
Beam Dynamics at DIFA
Inverse Compton X sources
The Bologna proposal

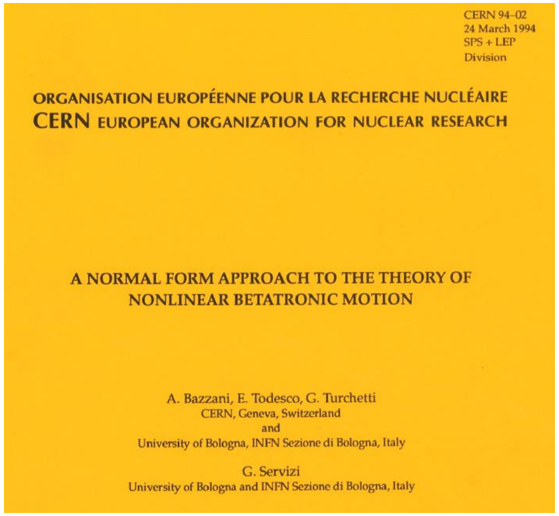
Beam Dynamics at DIFA.

Research activity on non linear beam dynamics started in 85 in collaboration with CERN. We extended to Courant-Sneider theory to non linear betatron motion with Birkhoff normal forms 88

Correction of multipolar errors and dynamic aperture



Symmetry recovery with normal forms



CERN 94–02
24 March 1994
SPS + LEP
Division

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

A NORMAL FORM APPROACH TO THE THEORY OF
NONLINEAR BETATRONIC MOTION

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CERN, Geneva, Switzerland
and
University of Bologna, INFN Sezione di Bologna, Italy

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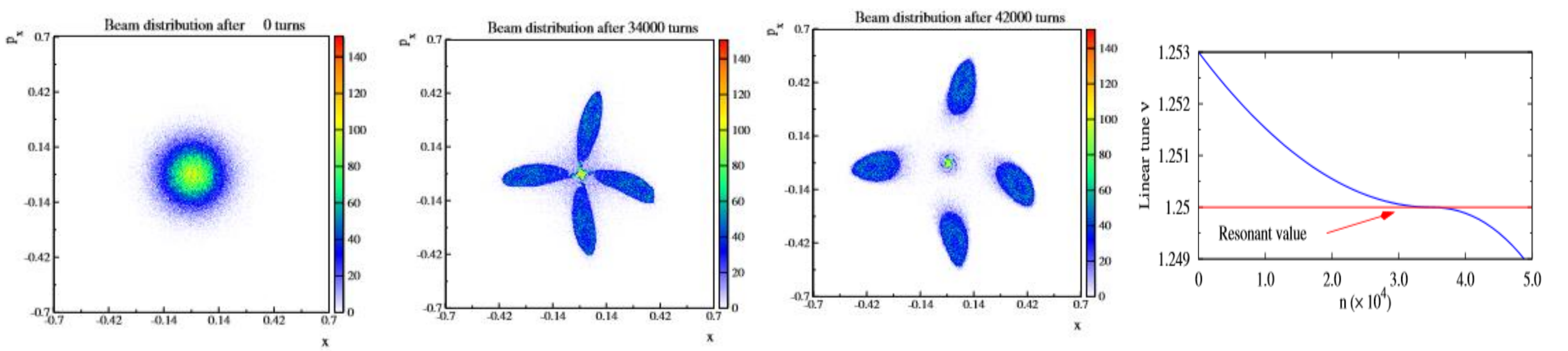
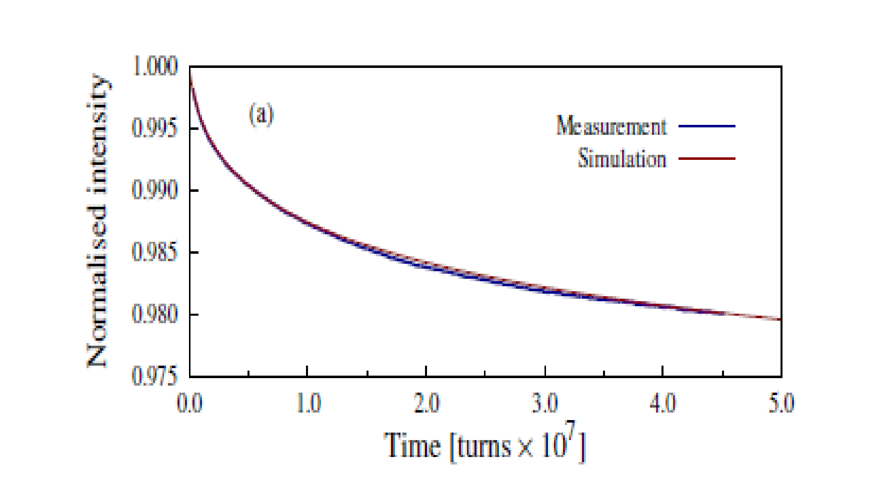
Current results of CERN collaboration

Change the tune to cross a a resonance. Resonant extraction works experimentally being controlled with normal forms and adiabatic theory



Dynamic aperture is related to the slow particles loss. A diffusion model with $D(J)= \exp(- J_*/ J)$ suggested by by Nekhoroshev estimates allows extrapolations



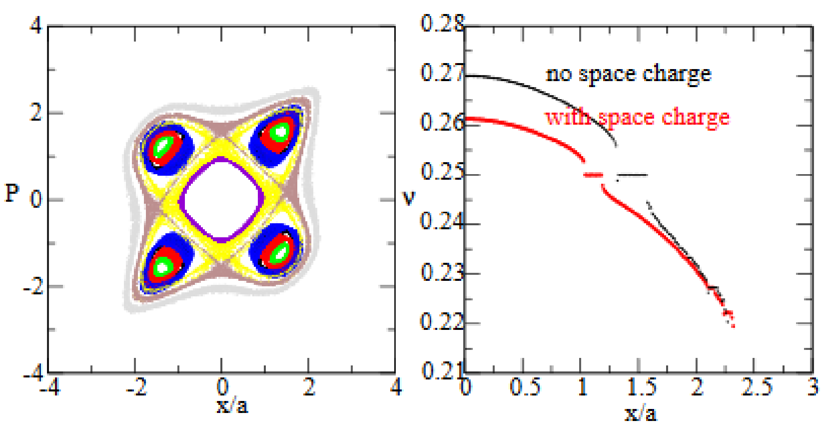
First EU network in beam dynamics

Nonlinear Problems in beam dynamics and transport (93-96).

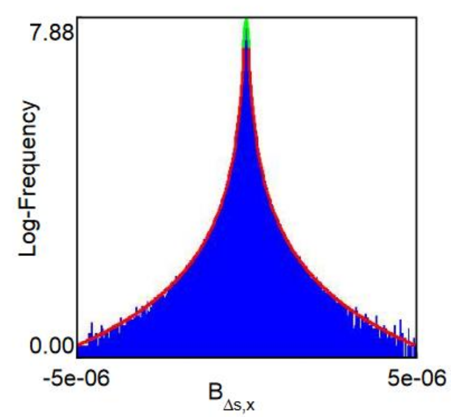
Collective effects for intense beams (99-07)

Halo formation and collisional relaxation in collaborations with GSI

(PIC and N body codes)



octupole+space charge

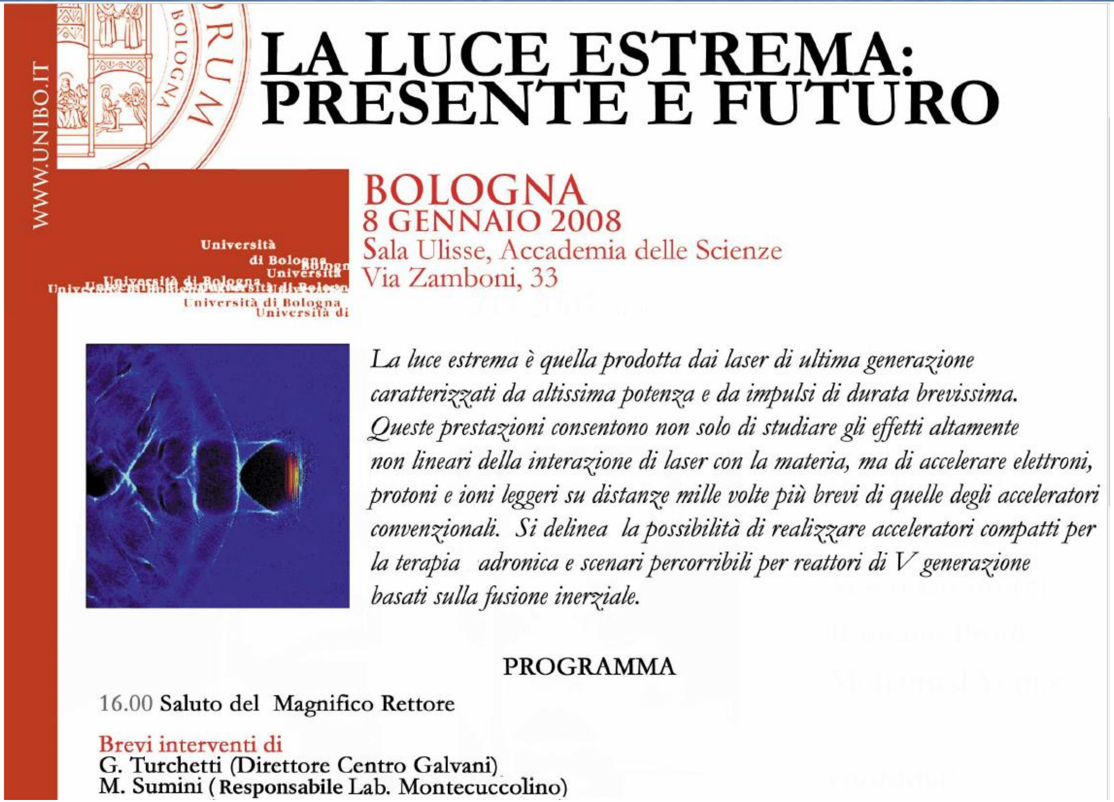


long tails

Laser acceleration (08-016)

Since 08 we turned to laser plasma acceleration, which seemed promising for medical applications.

Simulation of proton and electron acceleration with our PIC code Aladyn in collaboration with LNF (Frascati) and ILIL (Pisa).



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LA LUCE ESTREMA:
PRESENTE E FUTURO

Università di Bologna

BOLOGNA
8 GENNAIO 2008
Sala Ulisse, Accademia delle Scienze
Via Zamboni, 33

La luce estrema è quella prodotta dai laser di ultima generazione caratterizzati da altissima potenza e da impulsi di durata brevissima. Queste prestazioni consentono non solo di studiare gli effetti altamente non lineari della interazione di laser con la materia, ma di accelerare elettroni, protoni e ioni leggeri su distanze mille volte più brevi di quelle degli acceleratori convenzionali. Si delinea la possibilità di realizzare acceleratori compatti per la terapia adronica e scenari percorribili per reattori di V generazione basati sulla fusione inerziale.

PROGRAMMA

16.00 Saluto del Magnifico Rettore

Brevi interventi di
G. Turchetti (Direttore Centro Galvani)
M. Sumini (Responsabile Lab. Montecuccolino)

Synchrotron light imaging

Monochromaticity, space-time coherence, high brilliance allow to develop new techniques to obtain high quality images.

Images are obtained by absorption or by retrival of information on the phase variations. The X refraction index is

$$n = 1 + \alpha + i\,\beta$$

Imaginary part decreases faster with energy

In the 30-60 KeV range $\beta = 10^{-3}\,\alpha$

E = 30 keV	α	β
Adipose tissue	0.24 E-06	0.92 E-10
Soft tissue	0.27 E-06	0.13 E-09
Breast tissue	0.26 E-06	0.11 E-09

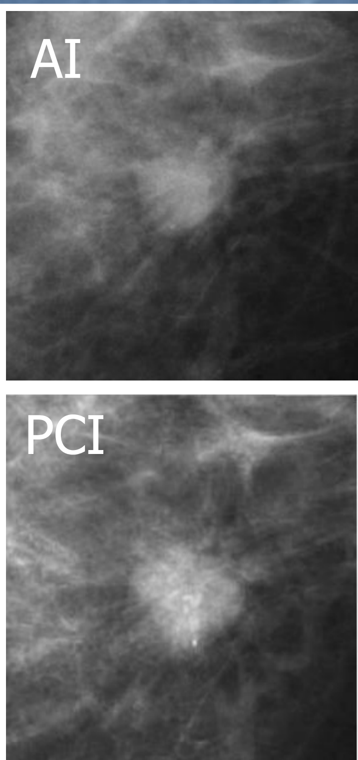
Comparison with X ray tubes

Synchroron light: space coherence + monochromaticity allow to detect interfaces and density variations in soft tissues.

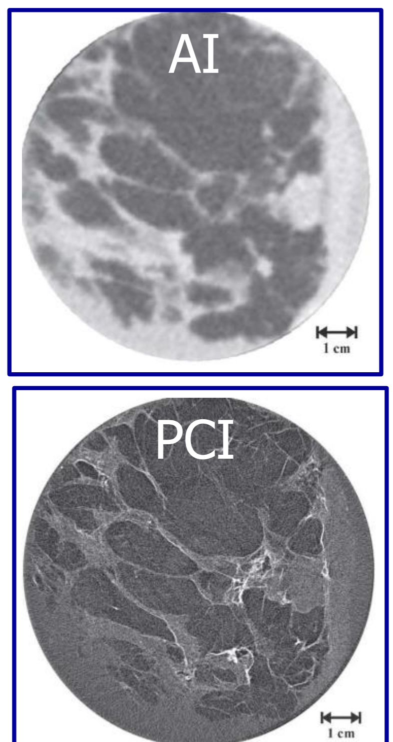
Clinical targets: oncology, orthopedy, neurology.

Microfocus: almost pointlike source, wide energy spectrum. Phase contrast possible: lower quality, higher dose.

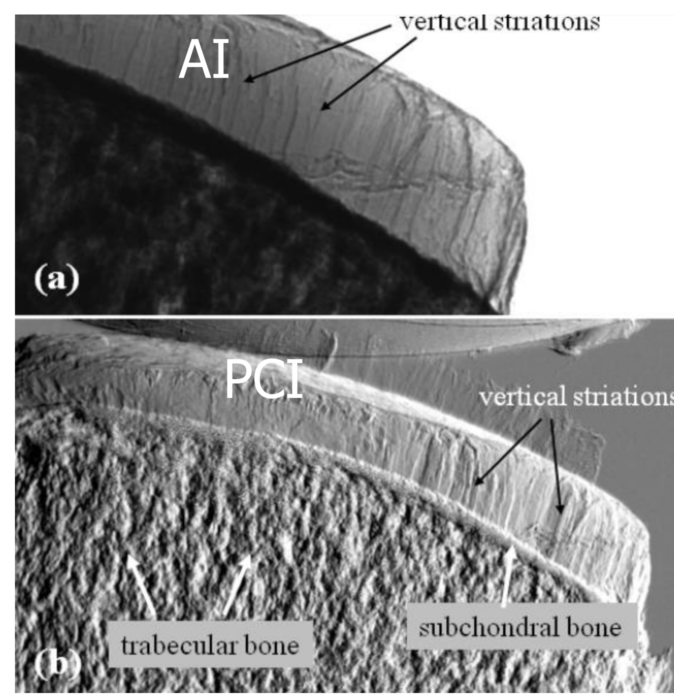
mammography



breast sample



Joint cartilage



Inverse Compton X Sources

The basic idea is to transfer energy from electron beam to a photon beam, transforming light rays into hard X rays.

Electrons oscillate in the light beam as in a wiggler or undulator. Wavelength is 10^4 times smaller ($1\mu m$ vs 1 cm)

X photons energy proportional to electrons energy square

Same X energy obtained with electron energy 1/100

$$E_X^u \sim hc\frac{\gamma^2}{\lambda_u} \quad \textit{(undulator)} \qquad\qquad E_X^{ICS} \sim 4hc\frac{\gamma^2}{\lambda_{ph}} \quad \textit{(ICS)}$$

For head on collisions with λ_{ph}=1 μm X energy of ICS

$$E_X(KeV) = 0.019\ E_e^2(MeV)$$

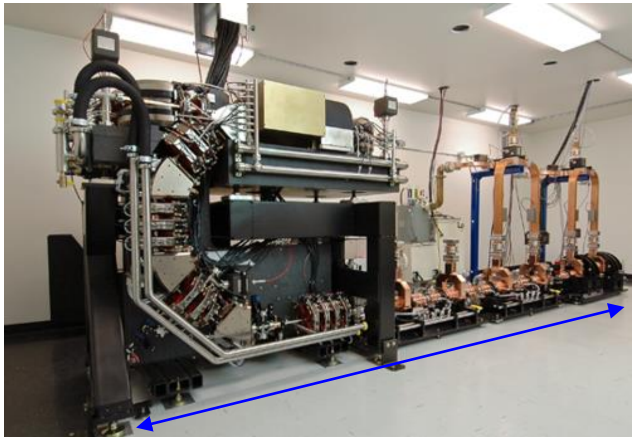
The beam divergence is a few mrad, to be compared with the smaller divergence of a SR source $\theta = 1/\gamma$.

ICS	E_e= 65 MeV	E_X= 80 KeV	θ= 5 mrad
ESRF	E_e= 6 GeV	E_X= 60 KeV	θ= 0.1 mrad

ESRF

270 m

CLS



5 m

The Bologna proposal

To develop a compact system to produce high quality X rays

$E_{el} \leq 80$ MeV $E_X \leq 120$ KeV $\phi = 2\ 10^{10}$ ph/s

$E_X \leq 240$ KeV $\phi = 5\ 10^{9}$ ph/s second harmonic

Main Target

Preclinical and clinical imaging

Secondary targets

Materials structure and detectors development

Non destructive analysis of mechanical samples

Characterizaton of cultural heritage samples

Road map

Conceptual design ready

Take off a few months after funding

Photoinjector + laser available on market

S band cavities 25 MV/m similar to STAR

Tranport line (technical designed and machining)

X ray detectors and monitors (available)

Optimization for medical imaging

Thank you for participating

to this workshop