

Scientific Program : Theory

The main aim is to study **experimentally** (at CERN facilities) and **theoretically**, the fundamental properties of channeling interactions for relativistic particles **in crystals** :

To study channeling and dechanneling processes and related phenomena:

- developing complete dechanneling theory for relativistic particles based on solution of Fokker-Planck equations for straight and bent crystals;
- developing radiation theory of relativistic particles channeled in various crystals and crystalline structures;
- studying of parametric radiation with protons and leptons (fundamental studies on particle-crystal interaction);
- developing special computer codes;
- calculating the spectra of radiation emitted by particles in crystals (fundamental studies on particle-crystal interaction)

Scientific Program : Experiment



The maintenance of detector installed in UA9

- Monitor and electronics spare construction

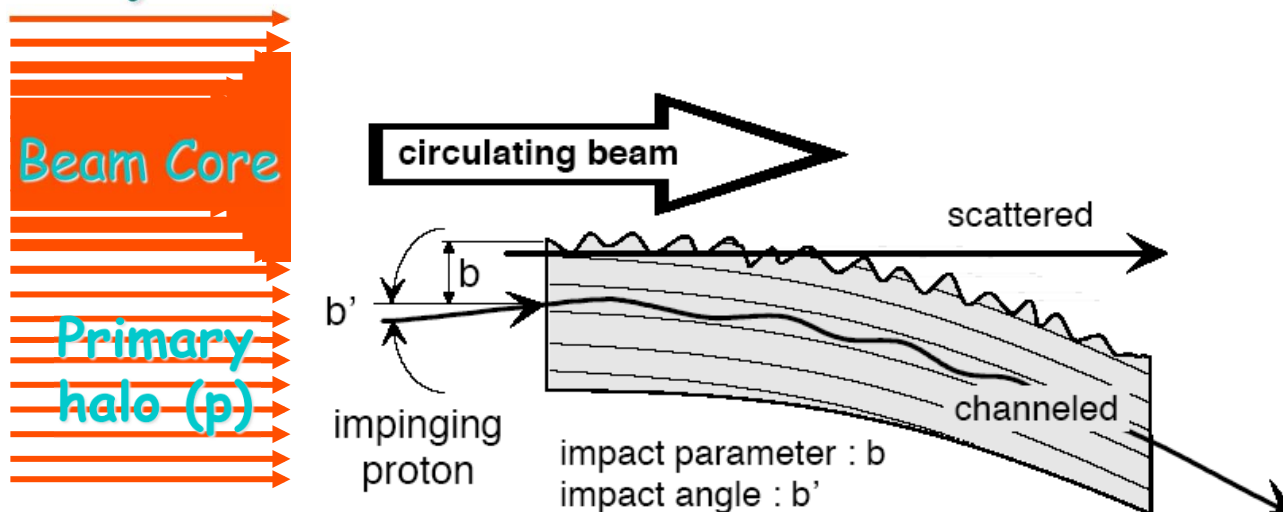
Contribution to Crystal testing facility at North Area H8:

- Construction of a compact TPC for extracted beam monitor (IMAGEM)
- Crystal characterization: diffraction technique and stress analysis;
 - X-ray testing facility within optical laboratory of LNF;
 - Design of a special system for alignment. (Synergy with microX)

Preliminary tests of the crystals for UA9 and H8:

- Tests at BTF and SPARC facilities
completion of the preparatory studies of multi-crystals
aiming at the demonstration of a suitable multi-crystal
for the SPS ring) ;

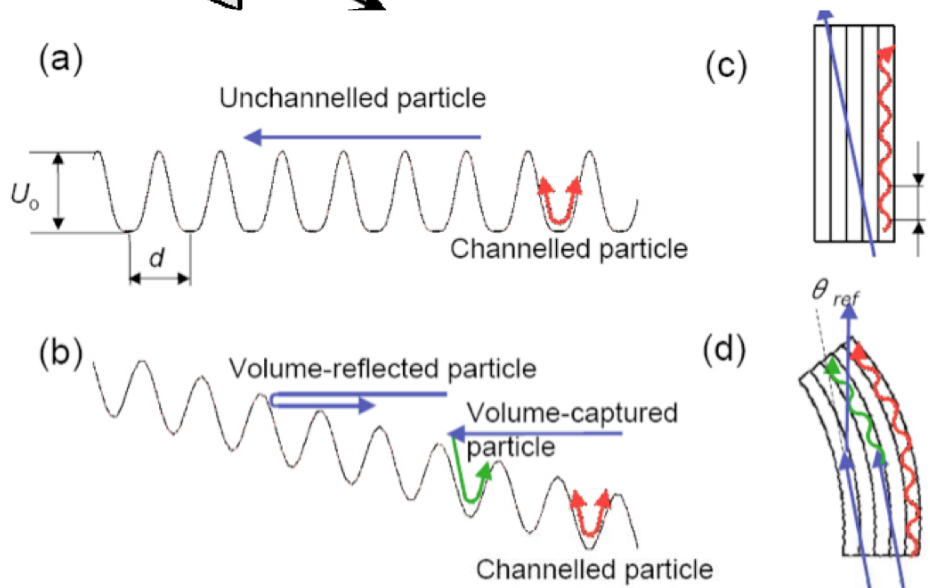
Crystal collimation



E. Tsyganov - 1975
 E. Tsyganov & R.A. Carrigan - 1976
 E. Tsyganov & A. Taratin - 1991

Possible processes:

- ◆ multiple scattering
 - ◆ **channeling**
 - ◆ **volume capture**
 - ◆ de-channeling
 - ◆ *volume reflection*
- ◆ **Primary halo directly extracted!**
 - ◆ **Much less secondary and tertiary halos!?**
 - ◆ *..but no enough data available to substantiate the idea..*

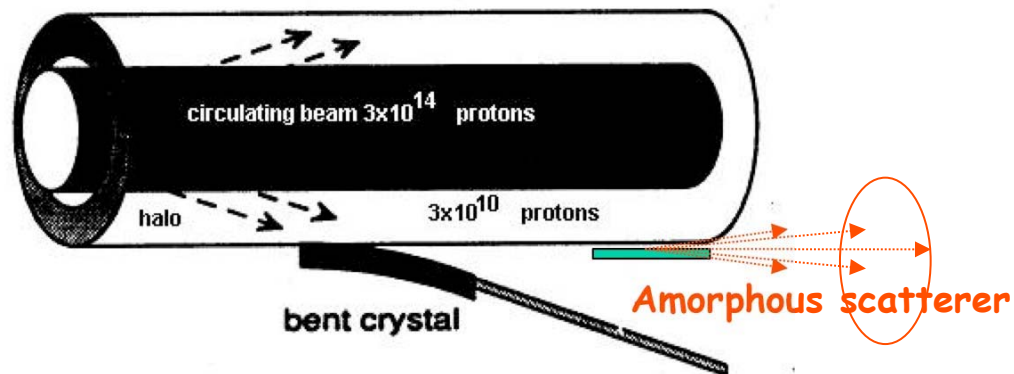


UA9: a channeling experiment at SPS



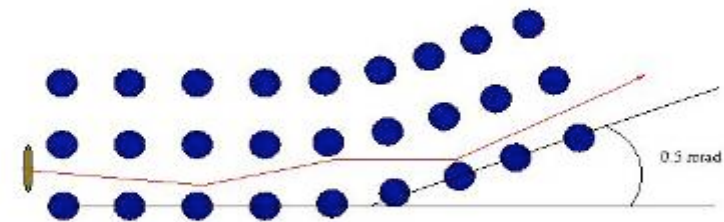
A bent crystal should efficiently deflect halo particles away from the beam core toward a downstream massive absorber

The **selective and coherent scattering** on atomic planes of an aligned Si-crystal replaces the **random scattering** process on single atoms of an amorphous target



Crystal Channeling

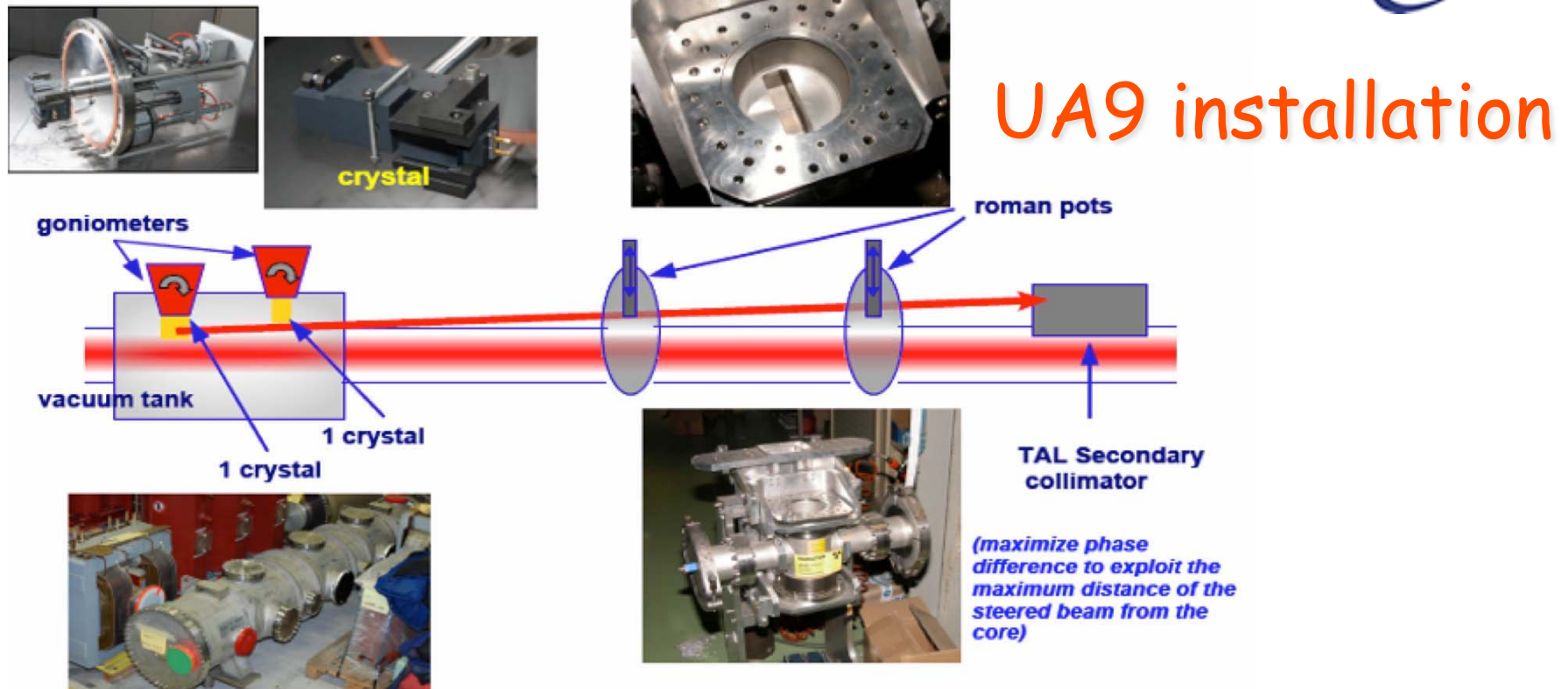
If ions enter a crystal at an appropriate angle, the scattering events are correlated, and the ion is channeled through the crystal planes.



Advantage: The angle of escape from the crystal is known, intercepting the ions now is easy!

The possible use of crystal for phase II collimation at LHC can be extensively tested at SPS now.

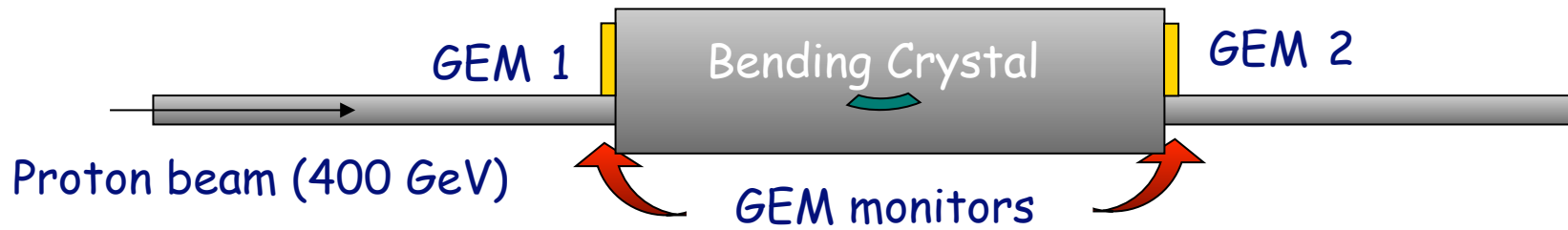
What can be done at CERN



The experiment needs crystals of better quality, perfectly characterized

- They can be provided within other R&D programmes
- A test facility in North Area H8 will be interest in the evaluation of crystal reflection probability and the other crystal properties

Installation on Crystal Tank at SPS



Front view

Side view



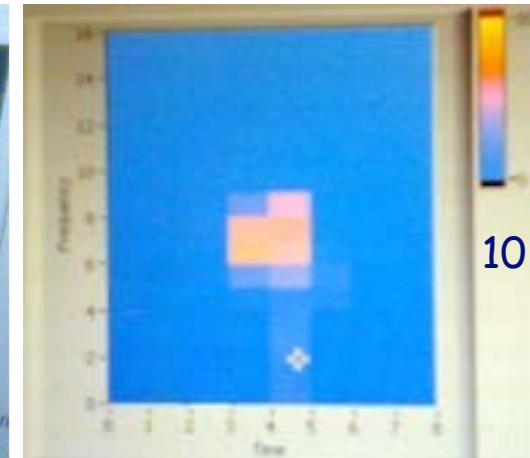
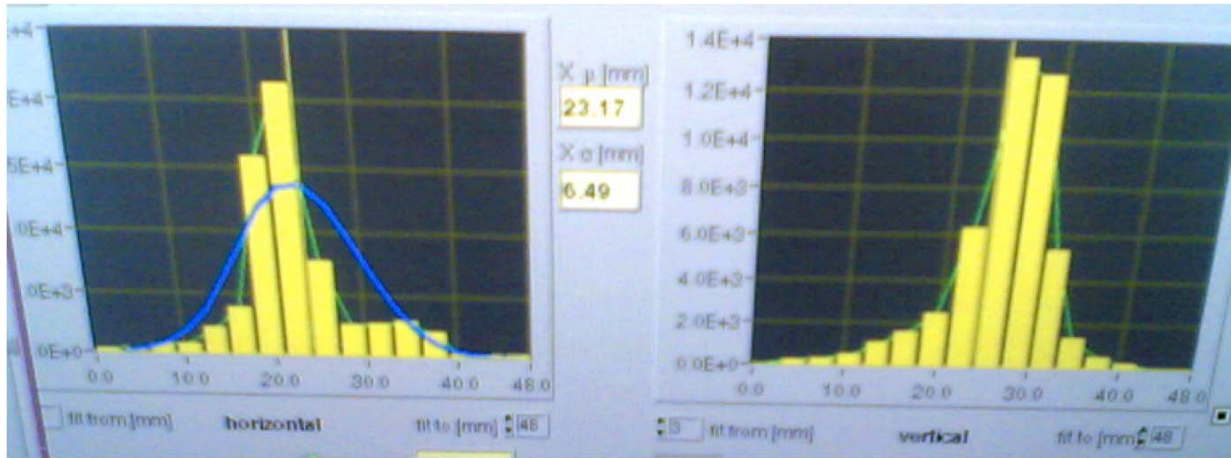
Contribution of Roma1 and Frascati (February 2009)

The GEM monitors will measure **the beam halo** during the crystal insertion

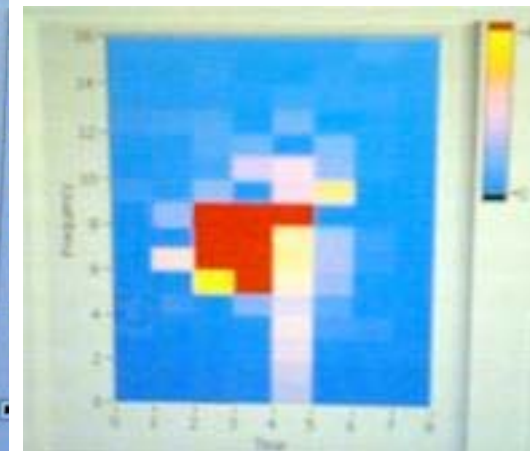
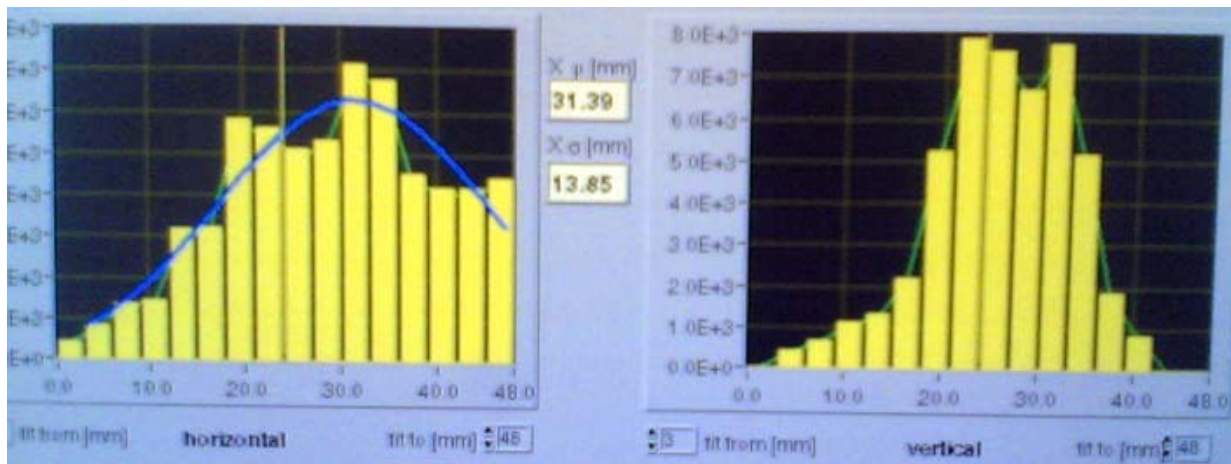
The 3GEM monitors at BTF Frascati



Beam profile at btf in two configuration : narrow and wide



10 cm

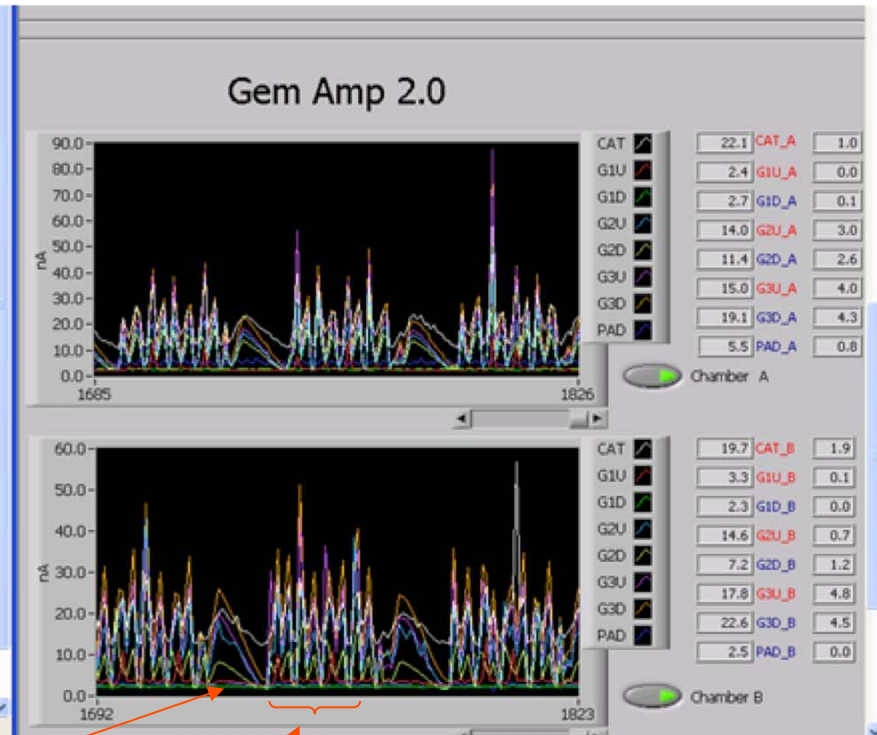
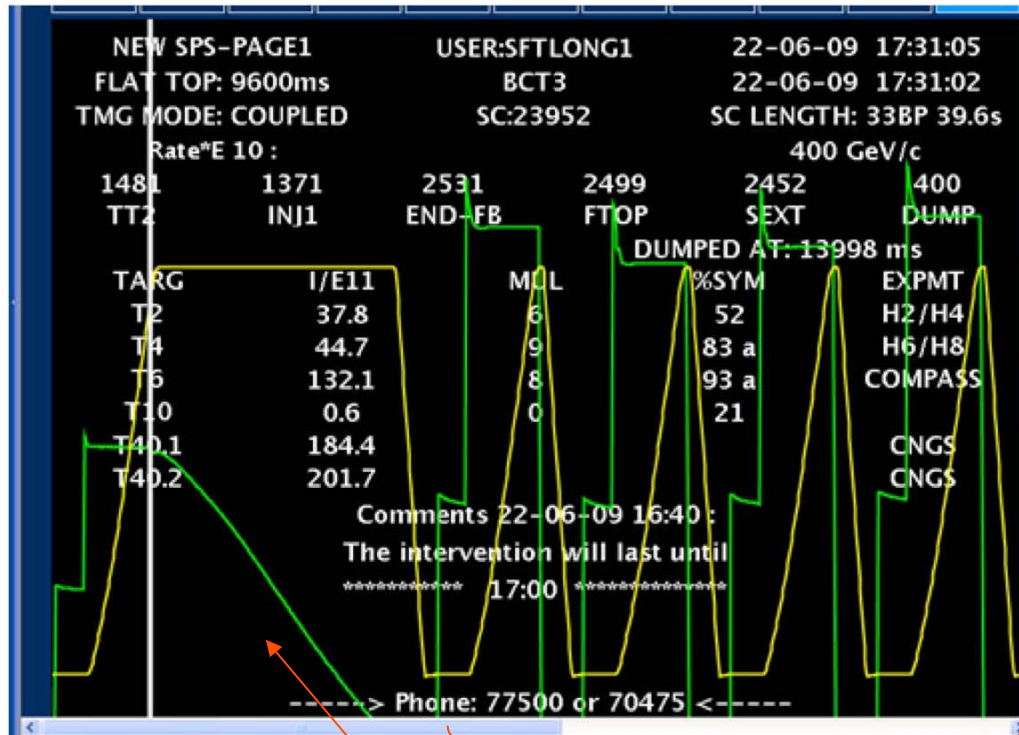


The monitors at SPS (23 June 2009)



Warming up !

GEM currents (both GEM1 and GEM2)

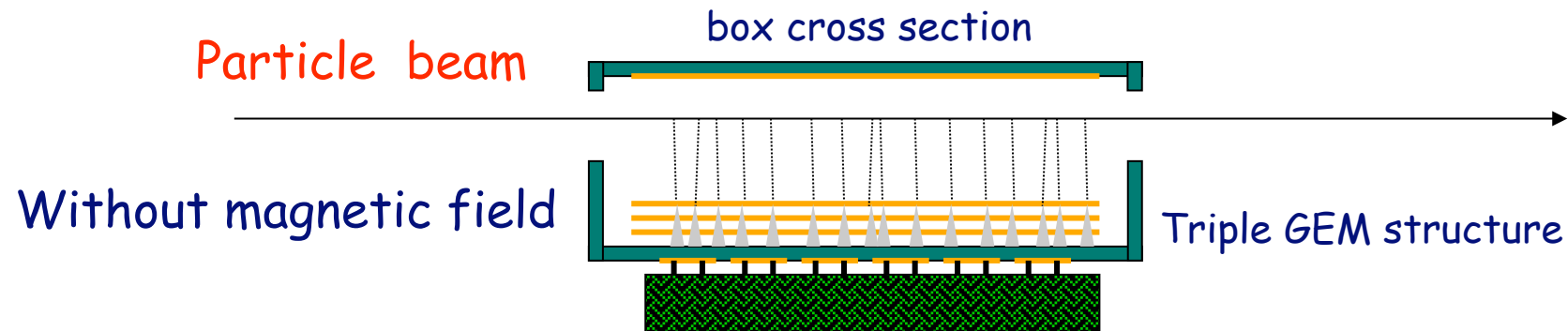


The spill for test areas

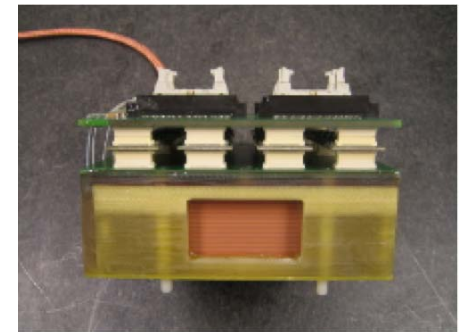
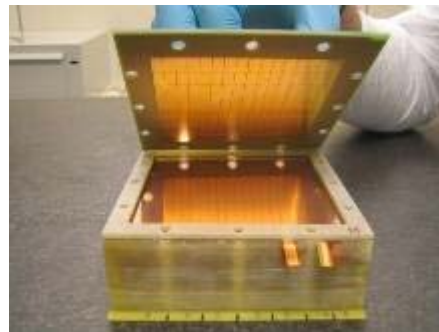
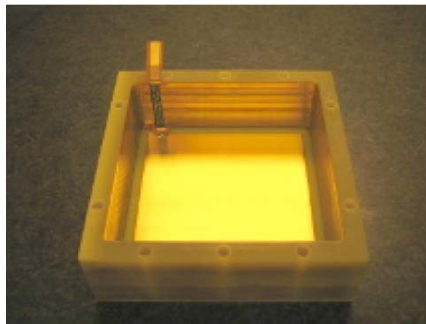
The four spills for CNGS

TPG for beam diagnostic

It's essentially a small TPC with a 4 cm drift and readout with triple GEM
 In this way also high current beam can be monitored in position



The material budget crossed by a particle is only two kapton foils ($<0.2\%X_0$) used for the field cage necessary for the drift field uniformity



As a beam monitor at H8 for **high intensity beams**

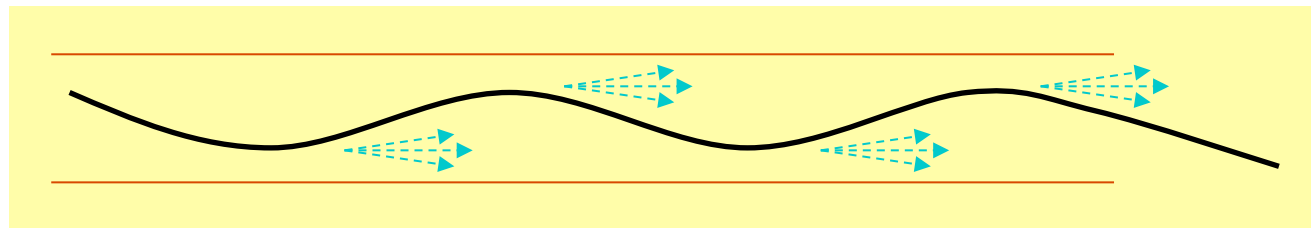
I - Our experience: CUP

CUP project studies the positron channeling for the development of undulator for e^+ and represents the first step of a project that investigates the possibility to create new, powerful sources of high-frequency monochromatic electromagnetic radiation: crystalline undulator and γ -laser, based on crystal undulator. The physical phenomena to investigate are essentially two:

- spontaneous undulator radiation by channeling of relativistic positrons
- the stimulated emission in periodically bent crystals

@ Channeling Radiation:

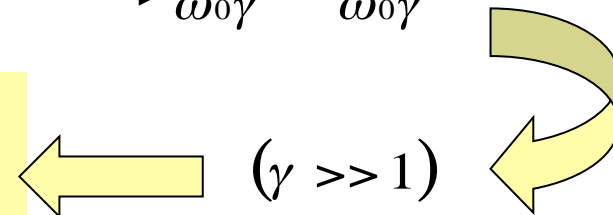
$$\omega = \omega(\theta) = \frac{\omega_{fi}}{1 - \beta_{\parallel} \cos \theta}$$



ω_{fi} - optical frequency \longrightarrow Doppler effect $\longrightarrow \omega_0 \gamma^{3/2} \omega_0 \gamma^2$

Powerful radiation source of X-rays and γ -rays:

- polarized
- Tunable (keV - MeV)
- narrow forwarded



II- Estimations: intense radiation

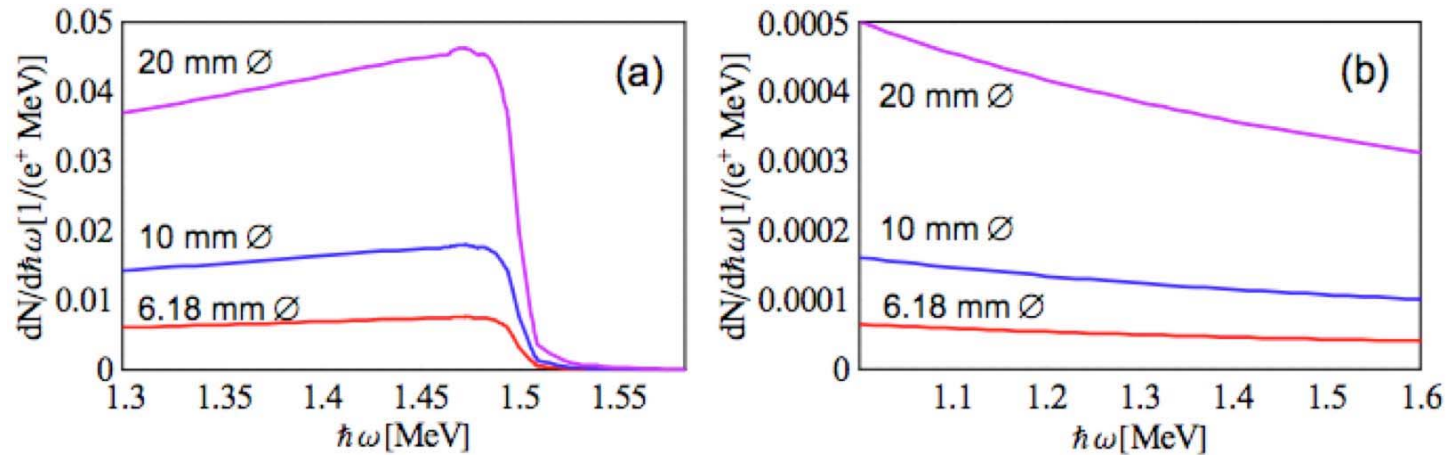
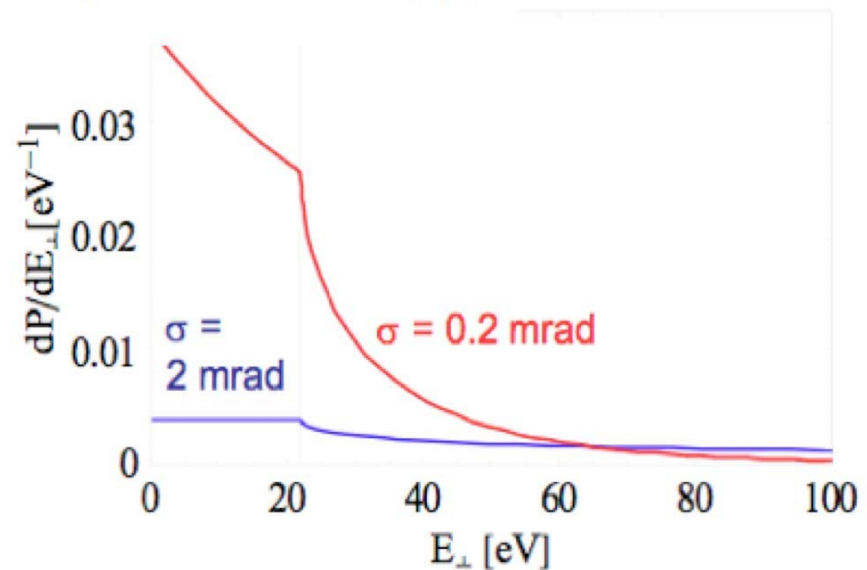
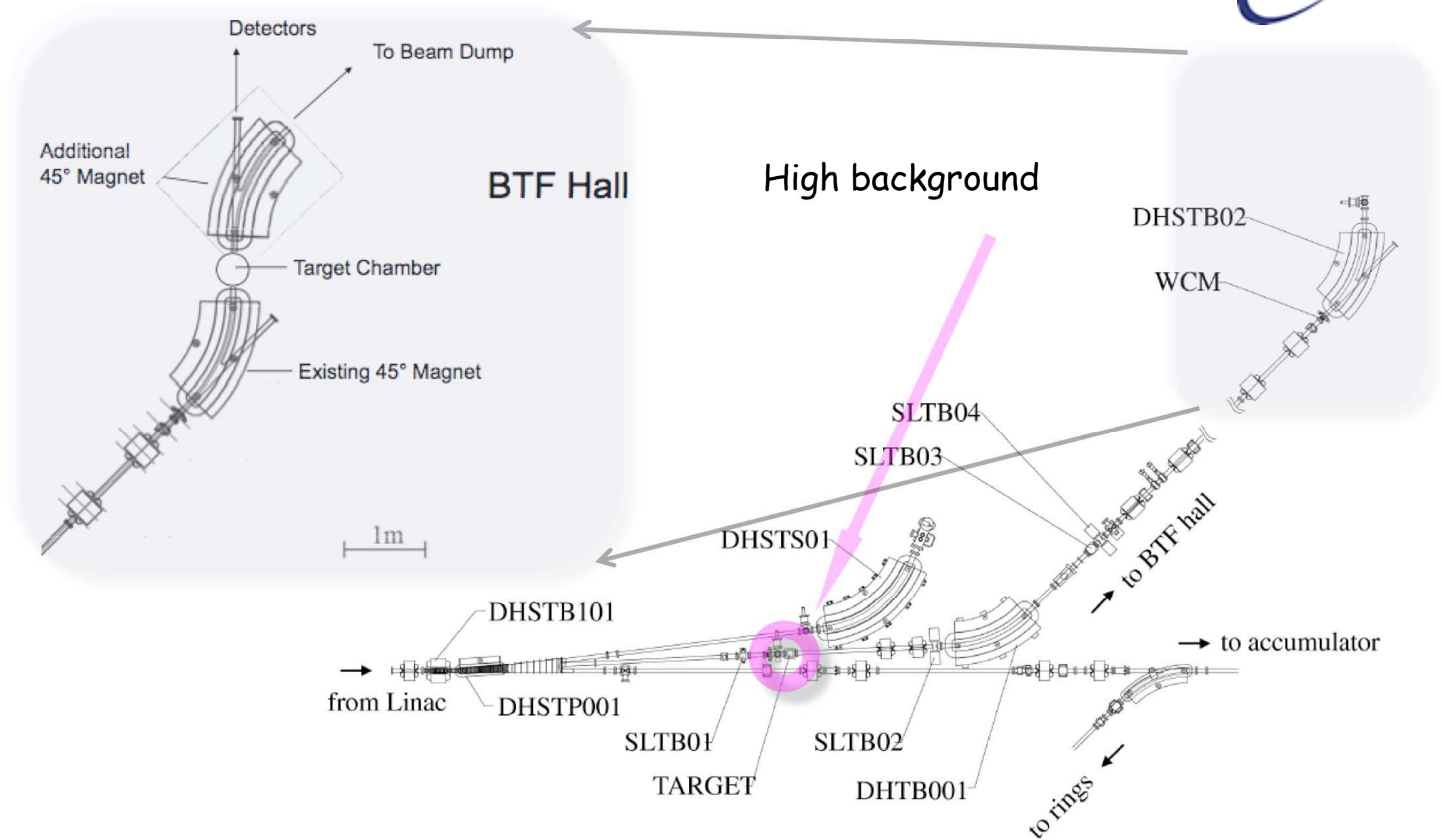


Fig. 2: (a) Calculated positron spectra for various detector apertures as indicated, (b) corresponding bremsstrahlung spectrum.

Need for small divergence!



III - Possible performance



IV - Theory: phenomenology & simulations



S.B. Dabagov, and N.K. Zhevago, "On radiation by relativistic electrons and positrons channeled in crystals" (invited review), *La Rivista del Nuovo Cimento* **31** (9) (2008) 491-529.

S.B. Dabagov, "Channeling of Neutral Particles in Micro- and Nanocapillaries" (Reviews of Topical Problems), *Physics Uspekhi* **46** (10) (2003) 1053-1075.

A. Babaev, and S.B. Dabagov, "Dynamics of Bound State Populations for Channeled Electrons/Positrons", *Preprint LNF-09/7 (IR)*, June 25, 2009, 16 pp.

A. Babaev, O.V. Bogdanov, V.I. Efremov, K.B. Korotchenko, Yu.P. Kunashenko, Yu.L. Pivovarov, and S.B. Dabagov, "On Crystal Assisted Processes by Means of 20-800 MeV e^-/e^+ LNF Beams", *Preprint LNF-08/22 (IR)*, October 2, 2008, 42 pp.

S.B. Dabagov, M. Ferrario, L. Palumbo, and L. Serafini, "Channeling projects at LNF: From crystal undulators to capillary waveguides", in the book *The Physics and Applications of High Brightness Electron Beams*, L. Palumbo, J. Rosenzweig, L. Serafini, Eds., World Scientific Publishing, 2007, pp. 602-631, see also *Intern. Journal of Modern Physics A22* (23) (2007) 4280-4309.

L. Quintieri, B. Buonomo, S.B. Dabagov, G. Mazzitelli, and P. Valente, "Channeling Experiments at DAFNE BTF for the Development of a Crystal Undulator for Positrons", *Proc. SPIE* **6634** (2007) 66340U1-7.

A. Babaev, and S.B. Dabagov, "On possibility of spin manifestation in channeling radiation", *Preprint LNF-07/23 (IR)*, November 5, 2007, 7 pp.

N. Nasonov, V.A. Likhachev, and S.B. Dabagov, "Modification of Radiation by Relativistic Particles in Thin Targets Due to Transition Radiation", *Preprint LNF-06/09(P)*, 1 March 2006.

S. Bellucci, S. Bini, V. Biryukov, Yu. Chesnokov, S. Dabagov, etc. "Experimental Study for the Feasibility of a Crystalline Undulator", *Phys. Rev. Lett.* **90**, 034801 (2003).

V - Conferences & Workshops



Instituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati

Channeling 2004

Workshop on Charged and Neutral Particles Channeling Phenomena
Frascati (Rome) Italy - November 2 - 6, 2004

Topics for discussion

- Radiation of relativistic charged particles in periodic structures
- Coherent scattering of electrons and positrons in crystals
- Channeling radiation of electrons and positrons in crystals
- Channeling of X-rays and neutrons in capillary systems (micro- and nano-channeling)
- Novel types of sources for electromagnetic radiation (FEL, powerful X-ray sources)
- Applications of channeling phenomena (novel radiation sources, X-ray waveguides, capillary/polycapillary optics)

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"Channeling 2006"

International Conference on Charged and Neutral Particles Channeling Phenomena
INFN - Laboratori Nazionali di Frascati
July 3-7, 2006 Frascati (Rome), Italy

Topics

- Coherent scattering of relativistic charged particles in matter;
- Radiation of relativistic charged particles in periodic structures (coherent bremsstrahlung, channeling radiation, resonant transition radiation, diffraction radiation, parametric X-ray radiation, LPM effect);
- Crystal channeling, volume capture and crystal reflection of positive ions; theory and experiments; crystal assisted collimation in hadron colliders: proposals and experimental observations;
- Channeling of radiations in capillary systems (micro- and nano-channeling, nanotubes, nanoporous);
- Novel types of sources for electromagnetic radiation (FEL, Thomson & Compton scattering, laser plasma acceleration);
- Applications of channeling phenomena (bending of the beams, positron sources, ion channeling applications, powerful radiation sources, X-ray waveguides, capillary/polycapillary optics, novel X-ray table-top instruments).

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Channeling 2008

The 51st Workshop of the INFN ELOISATRON Project
Charged and Neutral Particles Channeling Phenomena
25 October - 1 November 2008
Erice (Trapani), Italy

ETTORE MAJORANA FOUNDATION AND CENTRE FOR SCIENTIFIC CULTURE

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Prof. A. Zichichi

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