Crystals for Muon Collider

Laura Bandiera, Andrea Mazzolari
INFN Ferrara
bandiera@fe.infn.it
mazzolari@fe.infn.it

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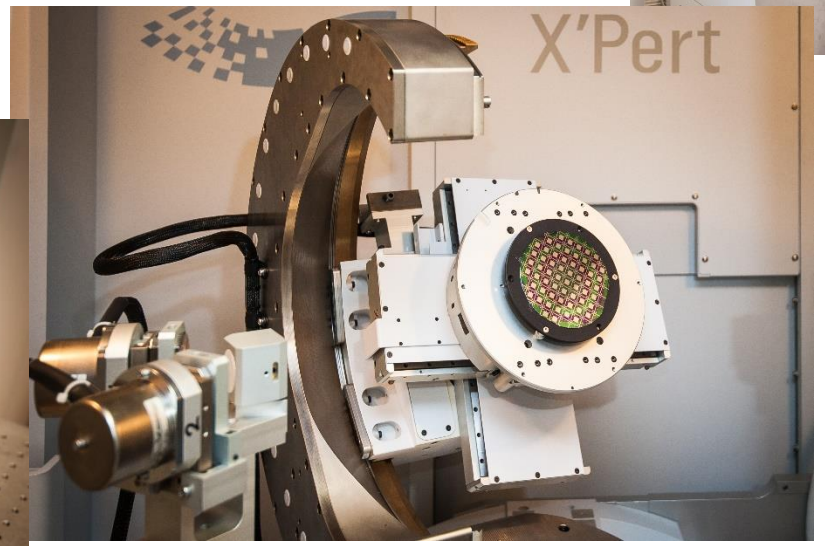
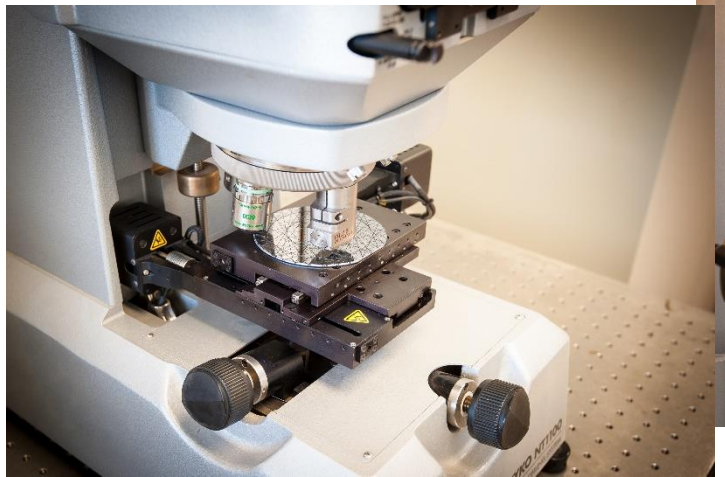
INFN-FERRARA INFRASTRUCTURE

Laboratory fully equipped for silicon micro and nanomachining
ISO4 certified clean room (130 m^2)

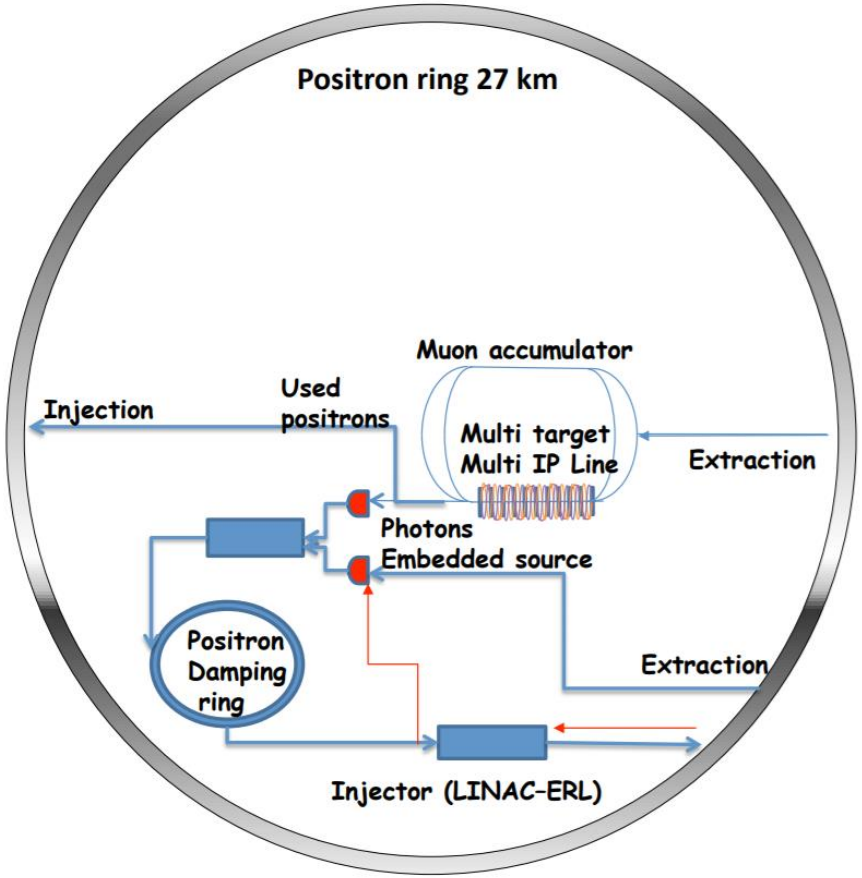
High-resolution x-ray diffraction
Dicing and polishing equipment
White light and Fizeau interferometers



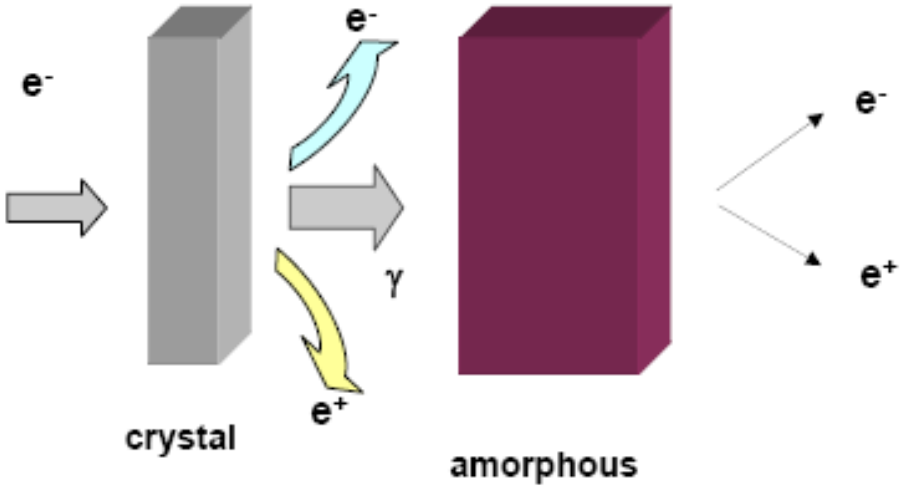


INNOVATIVE POSITRON SOURCE USING CHANNELING RADIATION IN CRYSTALS

LEMMA PROPOSAL (INFN)



Positron source using a crystal

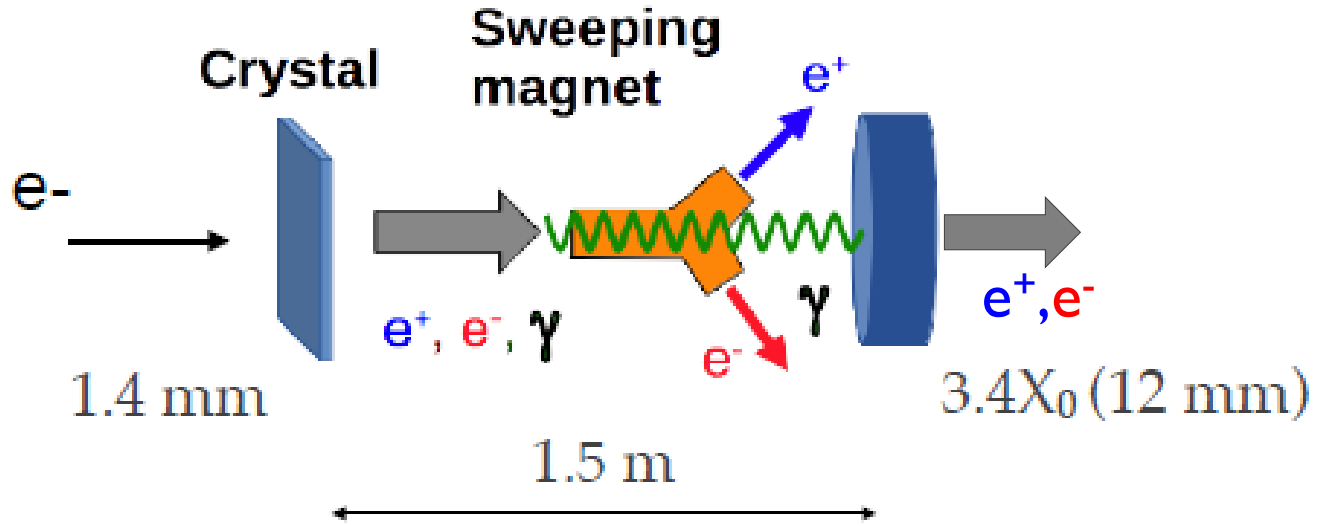


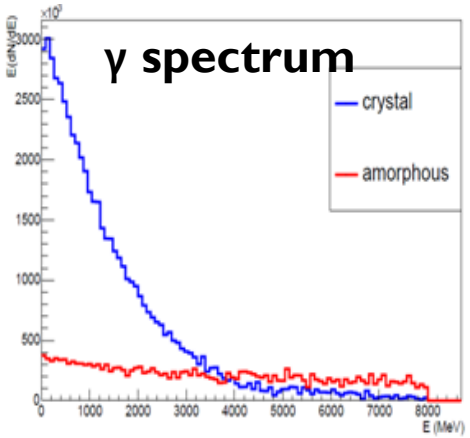
Idea of R. Chehab, V. Strakhovenko and A. Variola

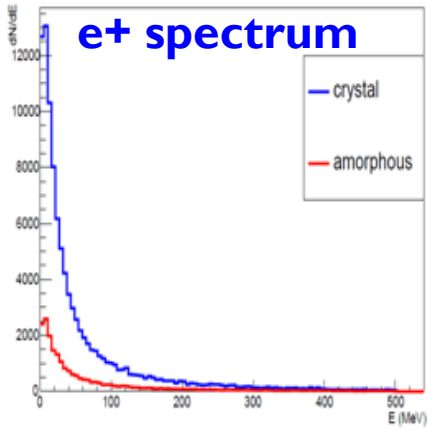
- Collaboration with I.Chaikovska (IJCL Orsay), leader of the FCC-ee and LEMMA positron sources groups;
- Joint efforts on Monte Carlo simulations and crystal tests on beam.

LoI submitted to Snowmass21

THE HYBRID POSITRON SOURCE USING CHANNELING: A PROMISING DEVICE FOR FUTURE COLLIDERS





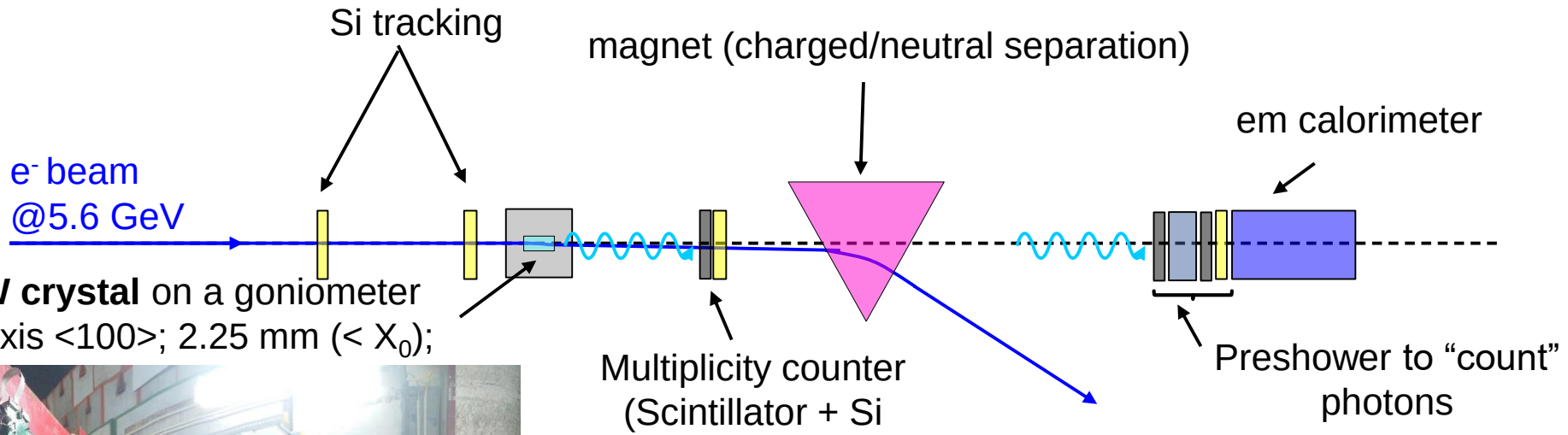


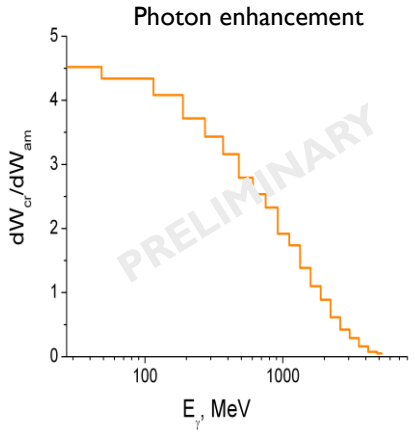
- **Main advantages**
  - **Enhancement of photon generation in crystals in channeling conditions ➔ enhancement of pair production in the converter target**
  - **Reduction of the *Peak Energy Deposition Density* (PEDD) in the target material** compared to conventional sources (more than 1 order of mag. less)

Sinergy with the FCC-ee positron study but the LEMMA positron source has is own challenges (e.g. the very high-intensity, possibility of embedded source..)

TESTS ON BEAM

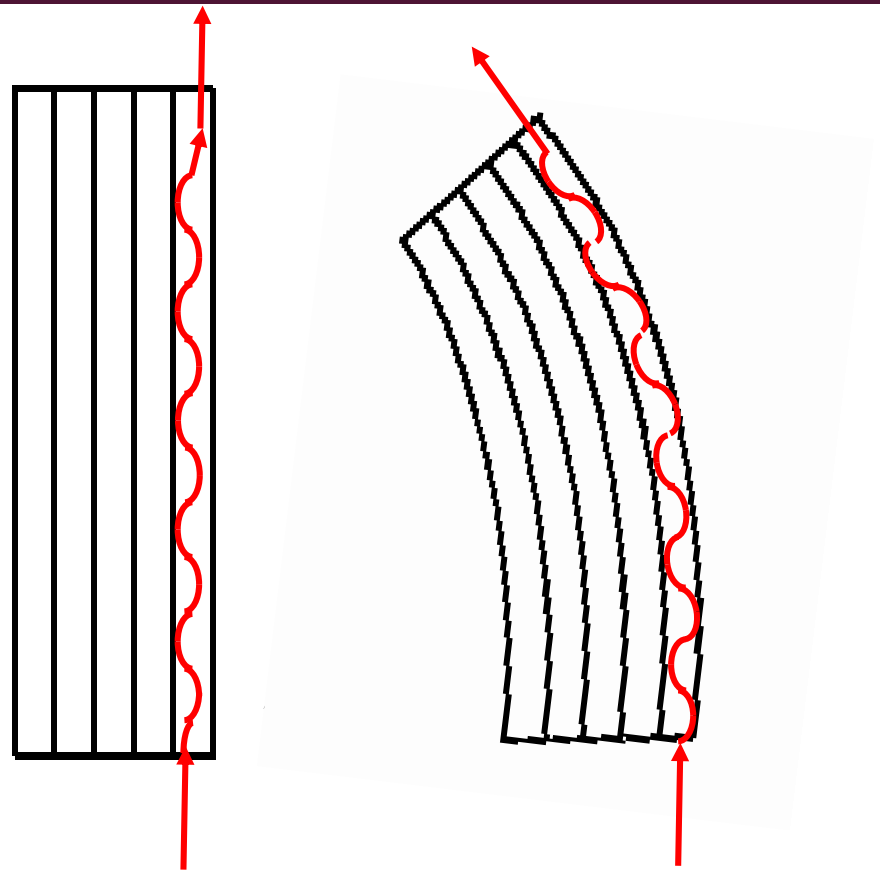
To check our Monte Carlo simulation for positron source we carried out a test beam @DESY TB in 2019





Future possible tests also @CERN

BENT CRYSTALS FOR MUON BEAM MANIPULATION



E. Tsyganov, 1976

Channeling of a charged particle beam in a bent crystal results in steering of its trajectory

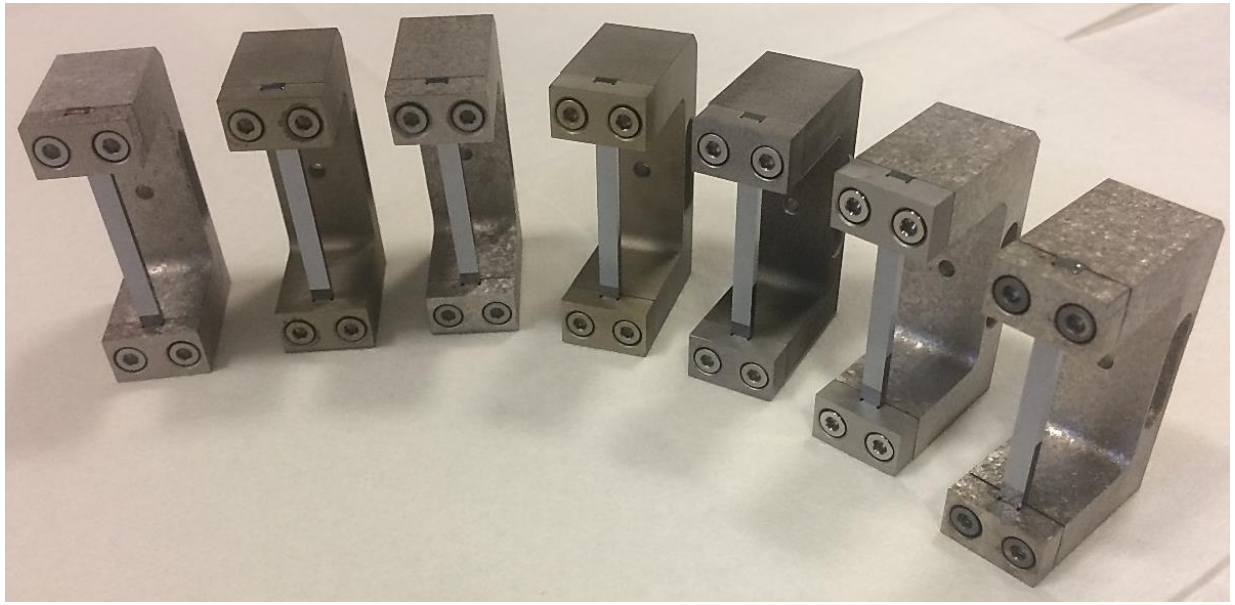
Bent crystals can be used in particle accelerators as collimating or extraction element

CRYSTALS FOR COLLIMATION

A set of 6 crystals for collimation of the LHC ions circulating beam is underway

Solid experience from manufacturing of crystals for collimation of the LHC circulating beam.

A possible usage of bent crystal in the muon collider collimation system*



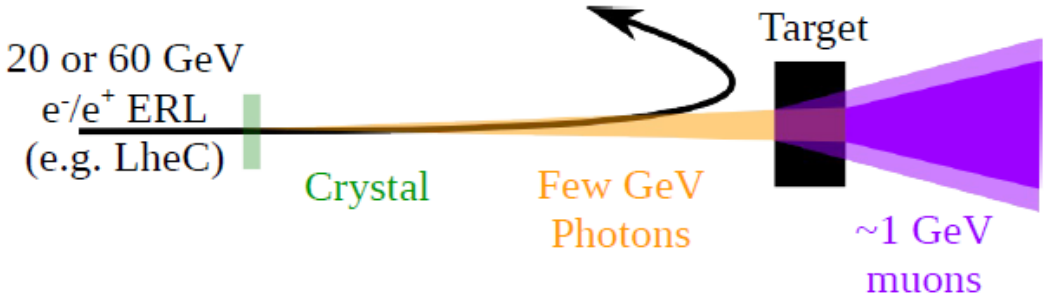
*D, Schulte et. al, *Muon Collider. A Path to the Future?* POS 2019

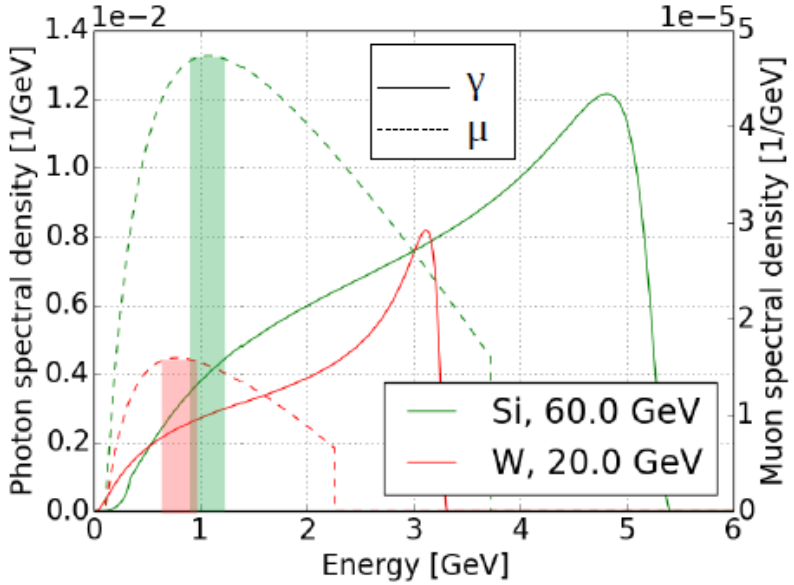
INFN FERRARA INTERESTS

- CRYSTALLINE TARGETS FOR POSITRON SOURCE:
  - Design of high-Z crystalline target for the LEMMA positron source
  - Irradiation tests with intense beams (electrons, protons) to evalutate the resistance of crystalline structure
  - Beam tests on positron production
- BENT CRYSTALS:
  - Design of bent crystals for muon beam manipulation
  - Beam tests on muon steering
- OTHER POSSIBLE APPLICATIONS (e.g., muon pair production based on channeling radiation, muon beam extraction and focusing, muon cooling..)

BACK UP

Muon pair production based on channeling radiation





- First estimates suggest that muon rates in the order of 10^{12}/s within a bandwidth of ±10% can be achieved which is compatible with collider application
  - The emittance is dominated by the target length and may likely be optimised (Here with a 5 cm tungsten target ε_n=0.3 mm)
  - The dechannelling model seem optimistic for electrons due to an underestimation of multiple scattering on the nuclei
    - → Possibly favors the usage of positrons rather than electrons
    - → Requires detailed modeling of the dechanneling process
- Achieving the required longitudinal structure needs to be worked out (ERL design with large bunch charge, bunch trains with an accumulator ring, …)

Courtesy of Xavier Buffat

	SLC	CLIC (380 GeV)	ILC (250 GeV)	LHeC (pulsed)	LHeC (ERL)	LEMMA	FCC-ee
e- beam energy(GeV)	45.6	380	250	140	60	45 (e+)	45.6
Norm. hor. emitt. (mm.mrad)	30	0.92	5	100	50	18	24.1
Norm. vert. emitt. (mm.mrad)	2	0.02	0.035	100	50	18	89
Bunches/macropulse	1	352	1312	10^5			2
Repetition Rate	120	50	5	10	CW		200 (Inj)
Bunches/second	120	17600	6560	10^6	20×10^6		16640
e+/second (10^{14})	0.08	1.1	1.3	18	440	100	0.06@Inj
Polarization	No	No/Yes	Yes	Yes	Yes	No	No

Courtesy of I. Chaikovska