COBALD - An Inverse Compton Back-Scattering (CBS) Source at Daresbury

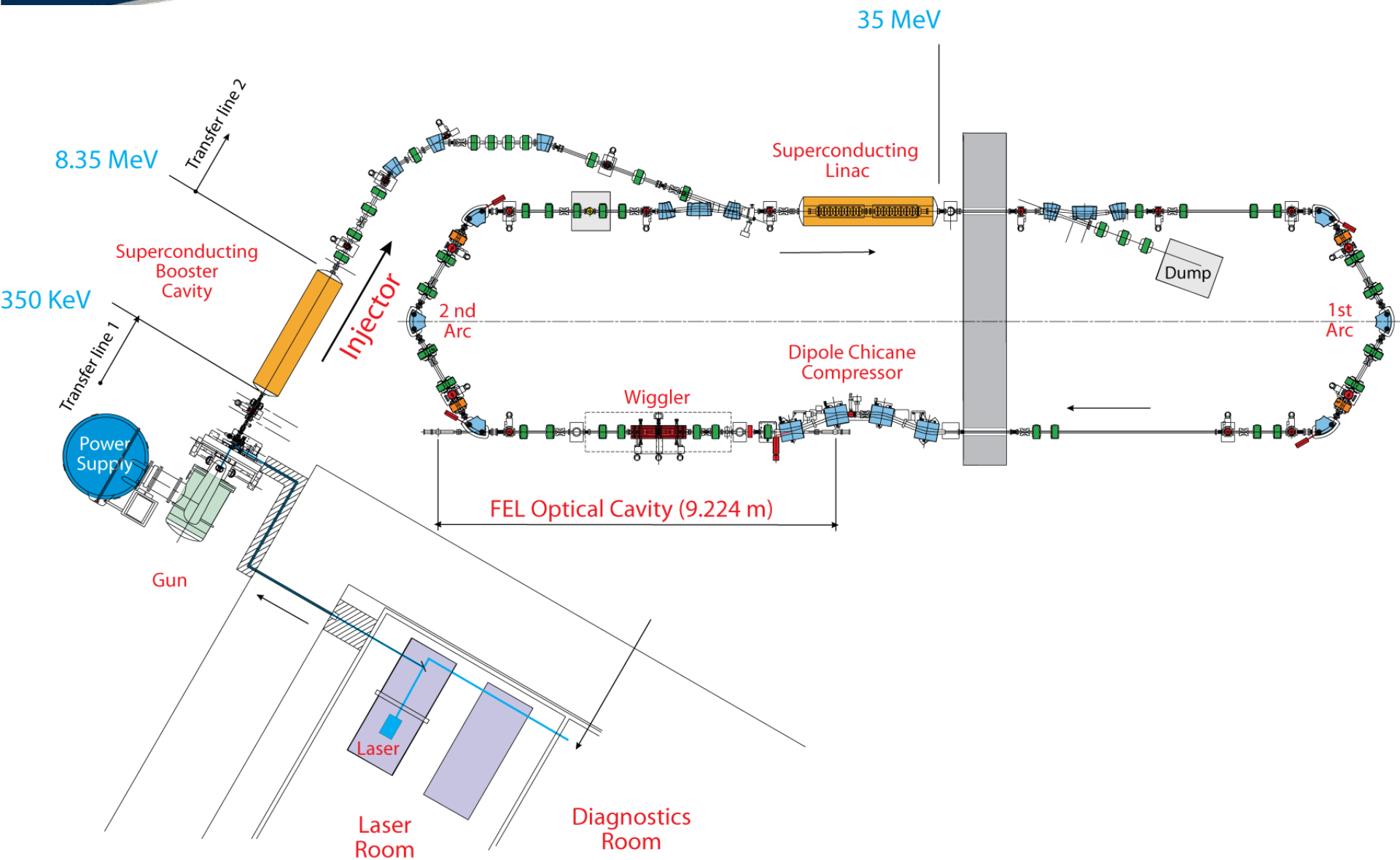
Introduction to ALICE

ALICE (Accelerators and Lasers In Combined Experiments) - known formerly as ERLP:

- High-voltage DC photoemission electron gun;
- Superconducting linacs operating in energy recovery mode;
- A mid-IR free-electron laser (FEL);
- PLUS a source of ultrashort x-ray pulses produced by inverse Compton scattering of multi-terawatt 100 fs laser pulses by the electron beam.

Science & Technology Facilities Council

ALICE Layout



Nominal ALICE Parameters

Gun Energy	350keV
Injector Energy	8.35 MeV
Circulating Beam Energy	35 MeV
Linac RF Frequency	1.3 GHz
Bunch Repetition Rate	81.25 MHz
Nominal Bunch Charge	80 pC
Average Current	13 μA

Construction status

- Gun commissioned into test line - ready for HV conditioning mid-July 2008;
- Beam transport system complete;
- Both linacs and cryosystem ready to go;
- RF systems to be ready for ER in October;
- Installation of FEL, CBS, EO and THz beamlines underway.

Compton Back-Scattering

- Compton scattering of photons off a high-brightness electron beam:
  - A collision between a photon and an electron;
  - Or the electromagnetic field of the laser beam acts as a very short period undulator;
- Produces ultra-short pulse x-ray radiation from low-energy e^- beam;
- Collision geometry determines flux and energy.

COBALD

COmpton BAckscattering x-ray source driven by the multi-10 TW Laser installed at Daresbury

	kHz-Laser	TW-Laser
wavelength	*798 nm*	*802 nm*
bandwidth	*30 nm*	*13 nm*
energy before compression	*2.8 mJ*	*1500 mJ*
energy after compression	*2.2 mJ*	*860 mJ*
pulse width	*35 fs*	*98 fs / 35 fs*
strahl ratio		*0.6 - 0.8*
M^2	*01.2 x; 1.11 y*	*1.38 x; 1.45 y*

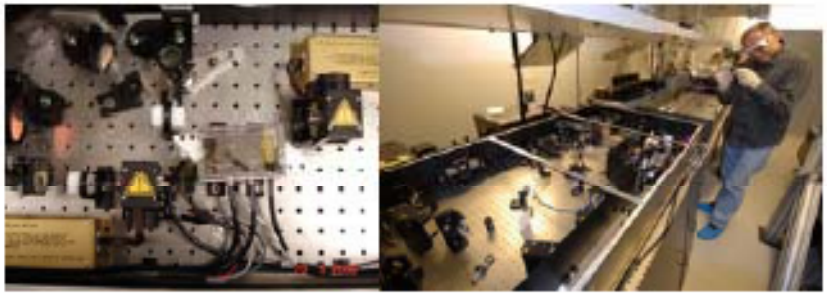
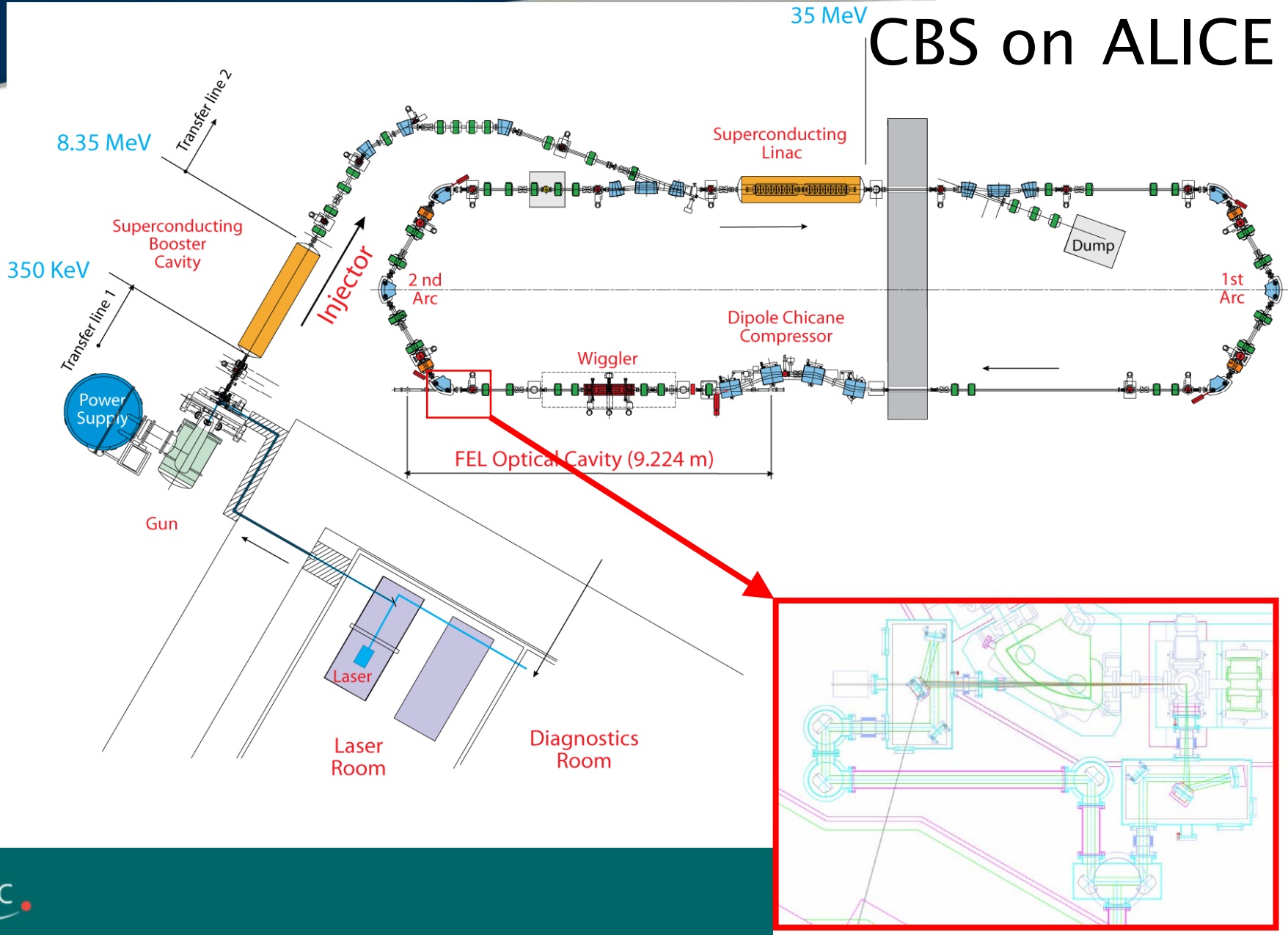


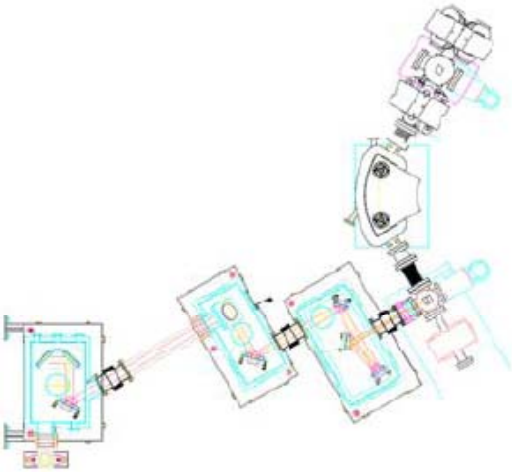
Fig. 2. Installation of the regenerative amplifier front end including pulse-picker and kHz compressor.

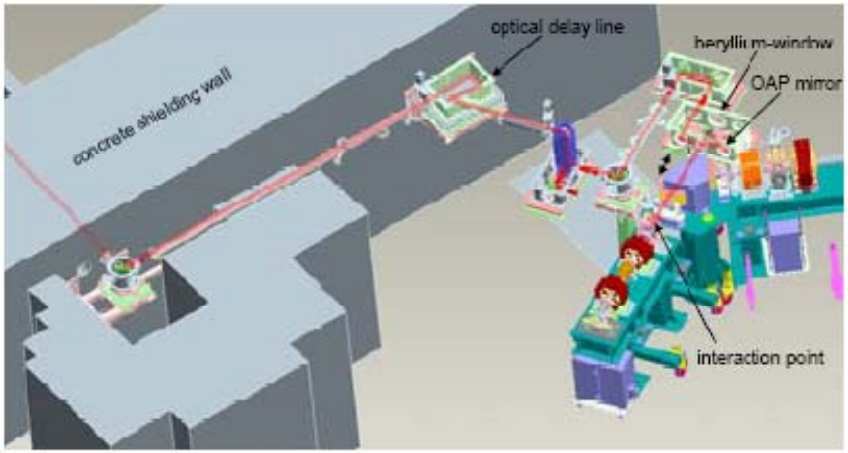
Fig. 3. Installation of the multi-pass power amplifier (left) and the chirped pulse compressor (right).

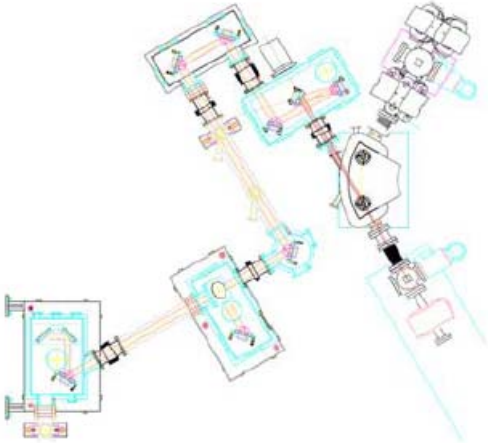
CBS on ALICE


35 MeV
8.35 MeV
Transfer line 2
Superconducting Linac
Superconducting Booster Cavity
350 KeV
Transfer line 1
Injector
Dump
2 nd Arc
1st Arc
Dipole Chicane Compressor
Wiggler
Power Supply
FEL Optical Cavity (9.224 m)
Gun
Laser
Laser Room
Diagnostics Room

Optics for both possible interaction angles:
180° “head-on” and 90° “sideways-on”



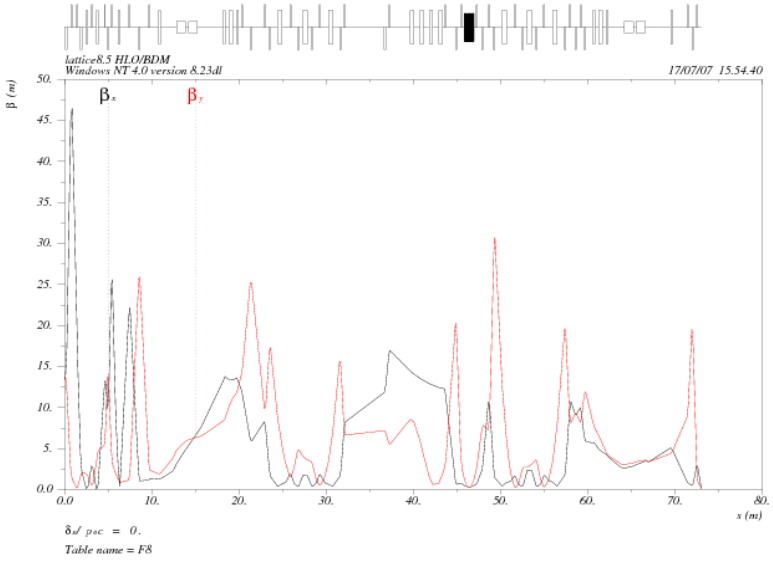


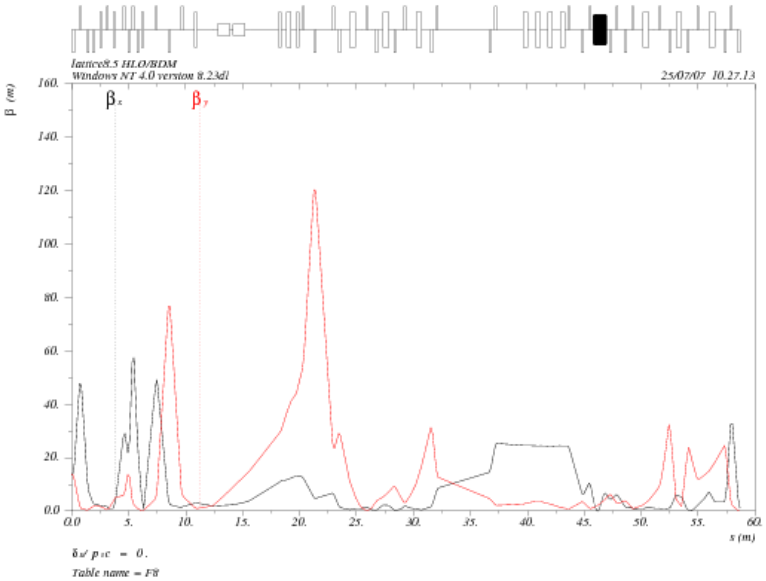


Constraints on lattice optimisation

- FEL wiggler to remain in place (∴no extra quadrupoles);
- Smallest possible transverse electron beam size at interaction point;
- After photon-electron interaction most of e^- beam must make it round the second arc;
- Quadrupole gradients must be within existing power supply range;
- Beam size constrained by existing vessel;
- ELEGANT used, result:
  - Beam waist 21.5 × 39 μm ($\sigma_x \times \sigma_y$);
  - 99% of the electrons make it to the pop-in dump.

Before and after (MAD)



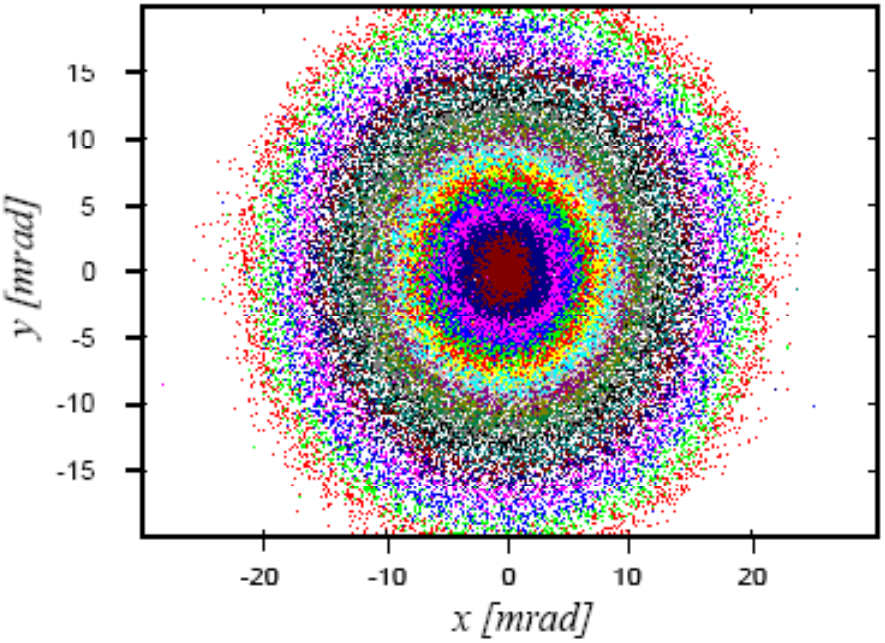


ALICE and CBS parameters

Parameter	Value	Units
Energy at interaction point	35	MeV
Train repetition rate	10	Hz
Bunches per train	1	
Bunch charge	80	pC
Electrons per bunch	5×10^{8}	
Average current	0.8	nA
Peak current	6.5	mA

Parameter	Value	Units
Brightness	$>10^{20}$	photons/mm^2/mrad^2/ s/0.1% bandwidth
Peak x-ray energy	30	keV (head-on geometry)
	15	keV (sideways-on)
X-ray pulse length (rms)	350	fs (head-on geometry)
	100	fs (sideways-on)
X-ray source size (FWHM)	20 × 35	μm

X-ray output



The angular distribution of the x-rays for head-on collision geometry collision; each colour is a 1 keV energy band with 20-21 keV on outside and 30-31 keV at centre