

Beam Compression for the Neutrino Factory?

Preliminary, Exploratory and Tentative ...

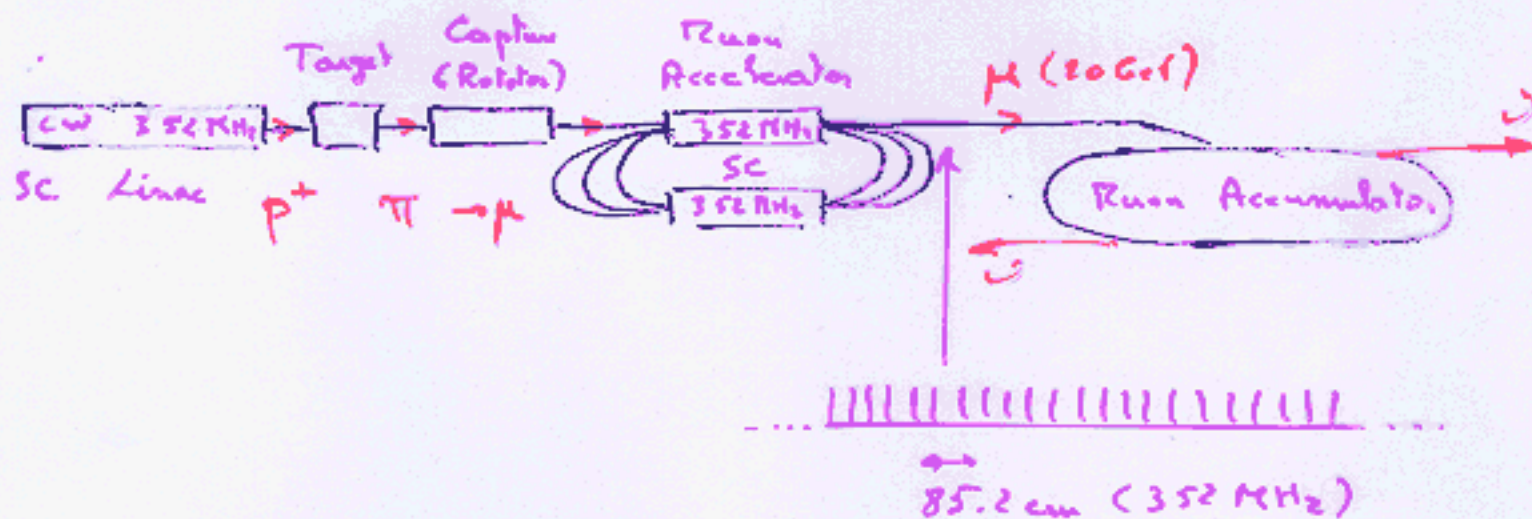
Assumptions:

Scheme as presented by B. Autin

Production of neutrinos by Accumulation of μ ons

μ ons created from pions generated in a target illuminated by C.W. 352 MHz Linac (few GeV)

as studied in PS report 98/063 and accelerated to 20 GeV by recirculation "à la CERN" by 352 MHz superconducting cavities



Problem:

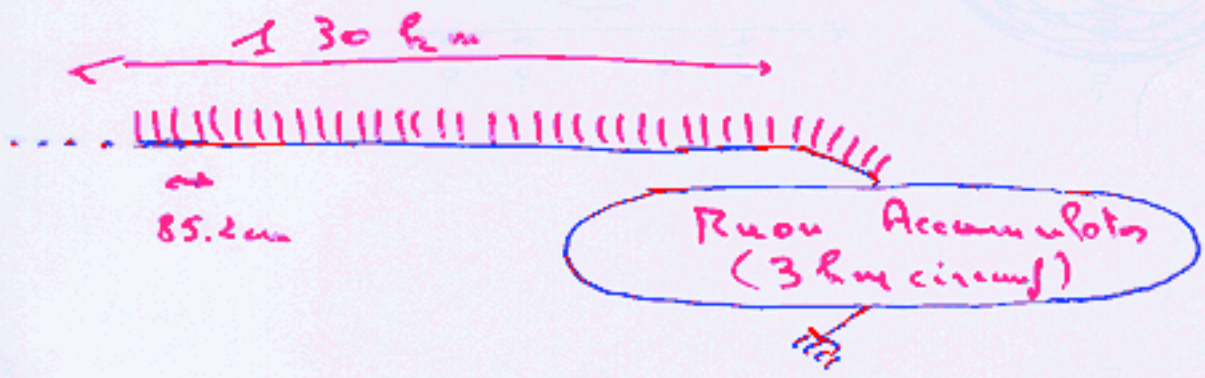
Lifetime of K_{uons} at $20 GeV =$

$2.2 \mu sec \times 200 = 440 \mu s (\approx 130 km)$

\Rightarrow Storage of K_{uons} for production of neutrinos in a ring of a few km (say 3 km)

\Rightarrow Replacement of K_{uons} after $440 \mu s$ ($\approx 130 km$ travelling time)

Needs beam compression by factor $\frac{130 km}{3 km} = 44$



Direct accumulation by multibunch transverse or momentum spreading not feasible without cooling

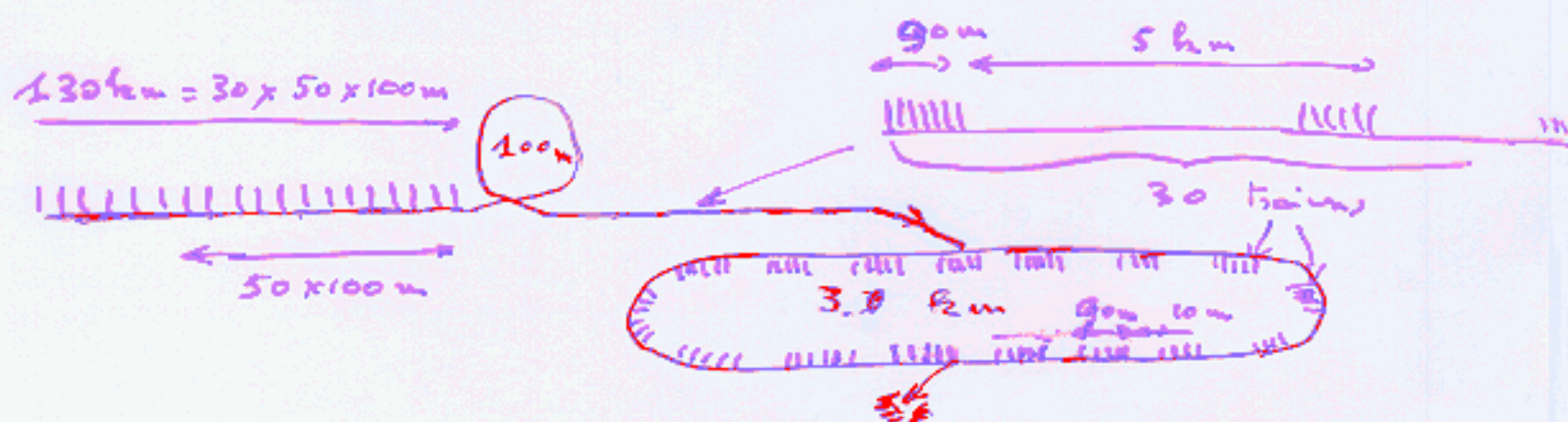
Continuous increase of transverse or longitudinal acceptance

No time for cooling

JPD 03

Intermediate Accumulation of Muons

* 50 turns injection into a small (100m) Accumulator Ring



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$\Rightarrow \sim 5000 \text{ m}$ beam accumulated during $16.7 \mu\text{sec}$

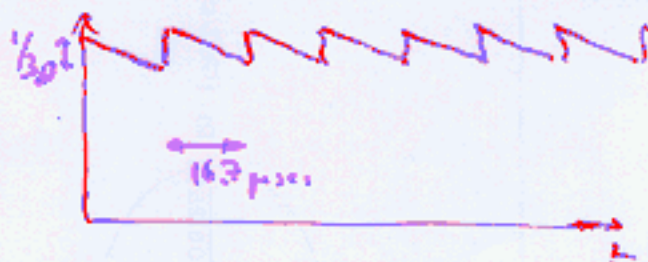
* Every $16.7 \mu\text{sec}$, extraction of one train of 200 m with 50 times more particles / bunch from intermediate acc.

* Extraction from Muon Accumulator of one of the 30 trains, having circulated for $30 \times 1.6 \mu\text{sec} = 480 \mu\text{sec}$

* Replacement by the new train freshly produced

* Continuous operation of train replacement one by one

\Rightarrow Variation of Neutrino production with time



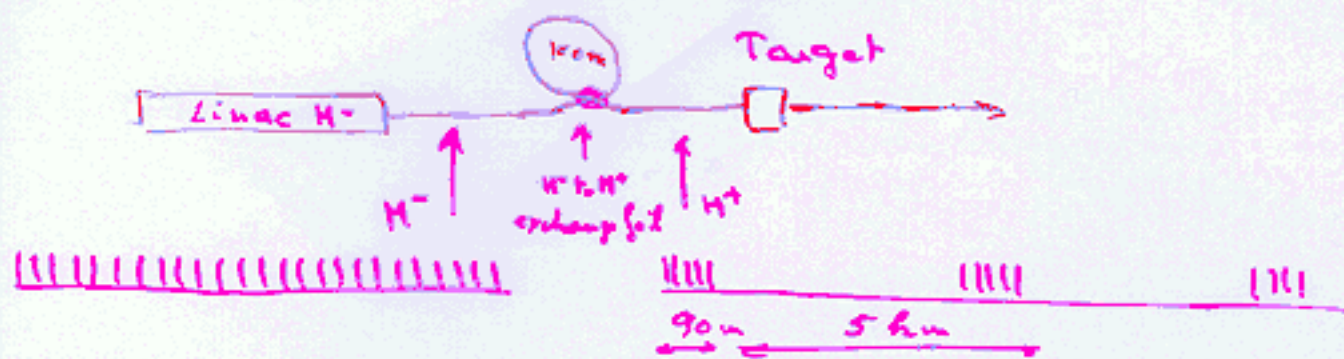
\Rightarrow Injection / Extraction repetition rate : 60 kHz

Not realistic scheme because of too large beam transverse emittances (multi-turn injection)

$$E = \frac{6 \cdot 10^{-3} \text{ rad m} \leftarrow E_{\perp}}{200 \text{ m} \leftarrow \gamma} \times (50 \times 10^6) = 3 \cdot 10^{-3} \text{ rad m}$$

$$\sigma = \sqrt{E_{\perp} \beta} \underset{\leftarrow 10 \text{ m}}{=} 35 \text{ cm}$$

Intermediate Accumulation of Protons:



- * Same as before but with H^- multibunch injection (50 bunches) with exchange of charge
- \Rightarrow no transverse blow-up at injection
- \Rightarrow distribution shaping of particles

But:

- ? Behaviour of foil for exchange of charge at injection with high power H^- beams?
- ? Limitation of charge per bunch in the H^+ accumulator
 (50 times charge per bunch in Linac)
 $50 \times 2 \cdot 10^8 H^+ = 10^{10} H^+ / \text{bunch} \Rightarrow I_p = 2.6 nC \times 5520 H^+ / \text{nb} = 9 \text{ Amp}$
- ? Pulsed operation of the target
 (peak power during time = 50 times average)

Possible scheme?

Should be studied in detail.



JED 05 Beam Compression by funneling as in CLIC

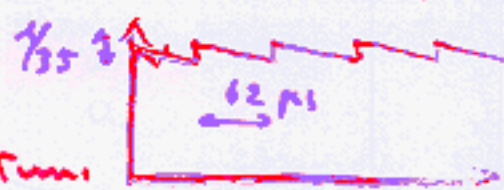
- * Principle
- * Possible compression in time by a factor up to 6 directly in the neutrino factory without any increase of beam emittance and of the charge per bunch.
- * Possible compression in time by a factor up to 6^m with m intermediate accumulator rings
Ex: $m = 2 \Rightarrow$ compression $\times 36$
- * 35 trains of $\sim 100m$ circulating in a 3.5 km neutrino factory.
- * Replacement of each train every 12 ps after $\sim 35 \times 12 \mu s = 420 \mu s$ travelling time.
- * Technique will be tested in CTF3 (if approved)

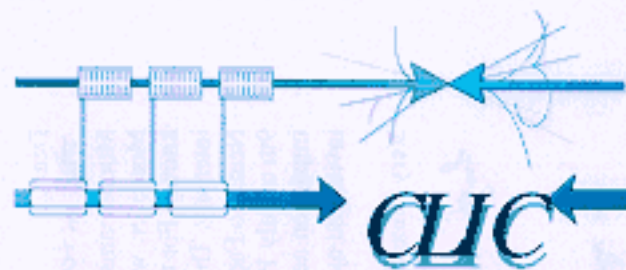
But

- * Variation of Neutrino Production with time
- * High rep rate of injection/extraction (500 kHz - 83 kHz)
- * Limitation of transverse acceptance by 2.1 GHz deflectors
- * Limitation of bunch length acceptance by funneling:

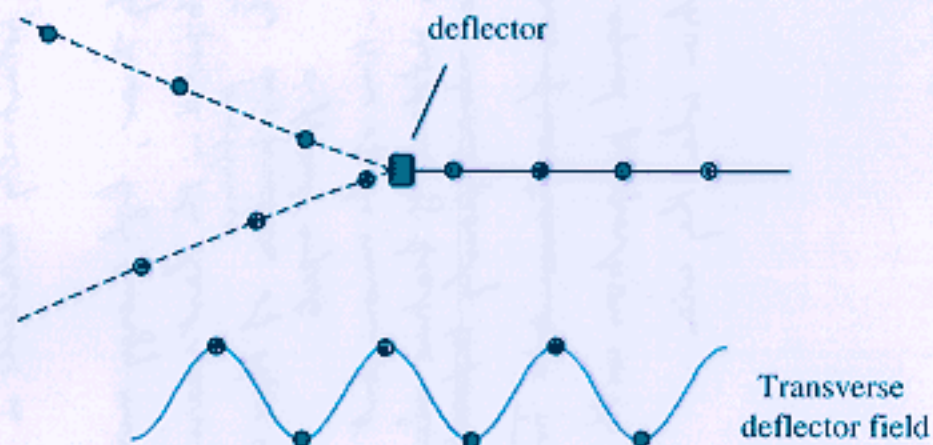
$$\frac{1}{12} \lambda_{2.1 \text{ GHz}} = \frac{14.3 \text{ cm}}{12} \approx 1 \text{ cm}$$

??? Possible scheme ???

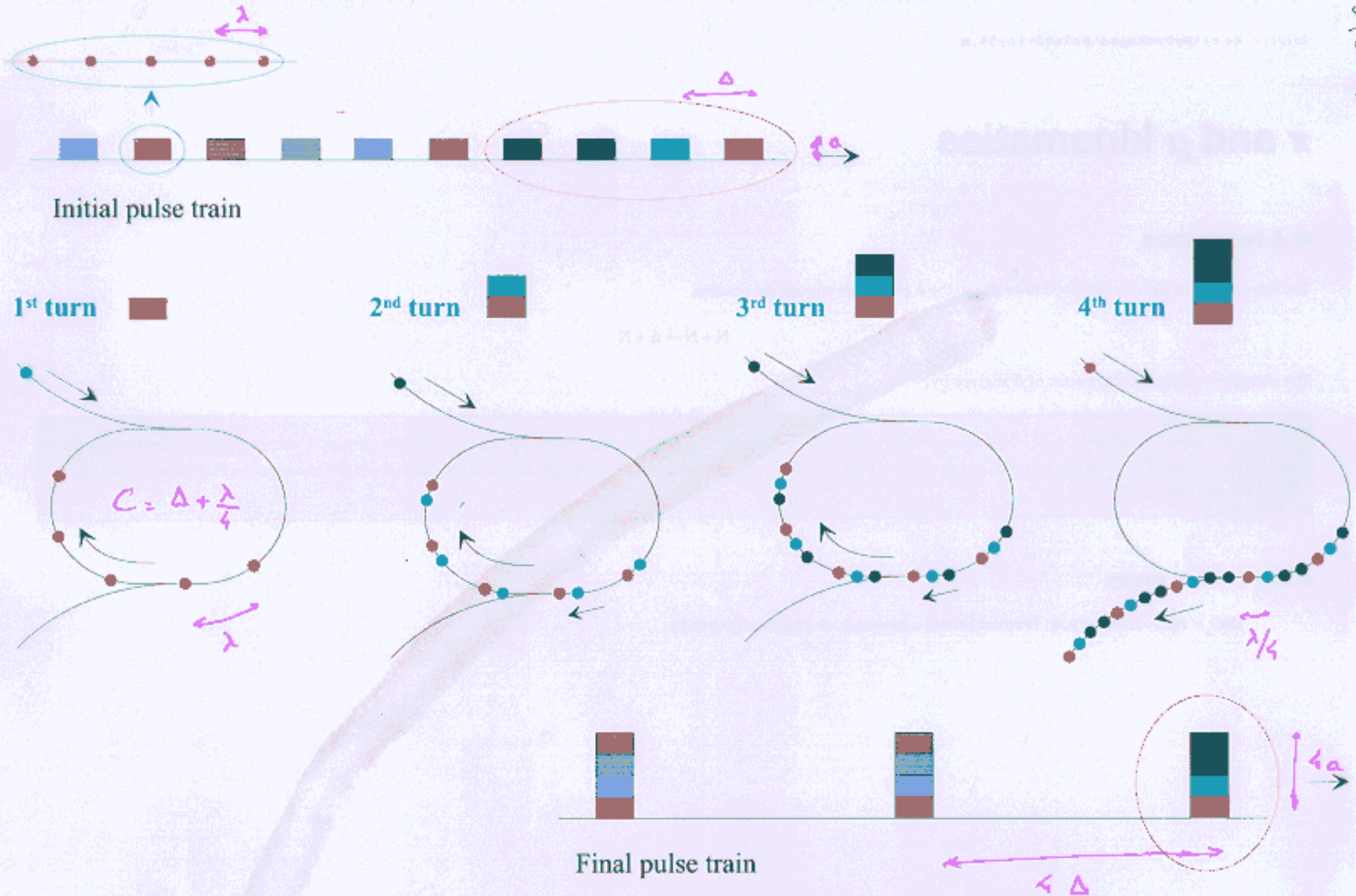




Beam Compression by fanning

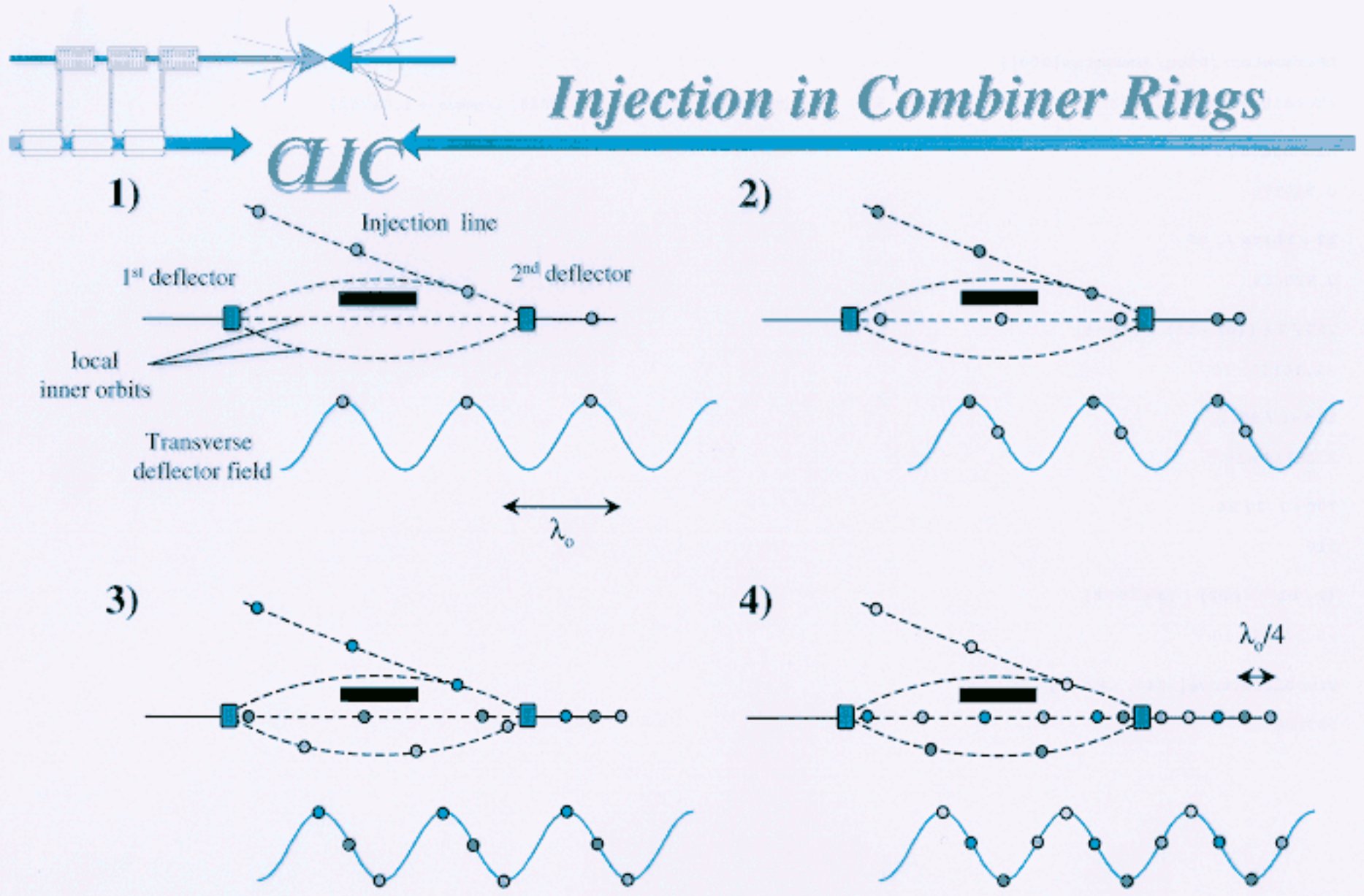


X4 PULSE COMPRESSION AND FREQUENCY MULTIPLICATION USING A COMBINER RING



2008

Injection in Combiner Rings



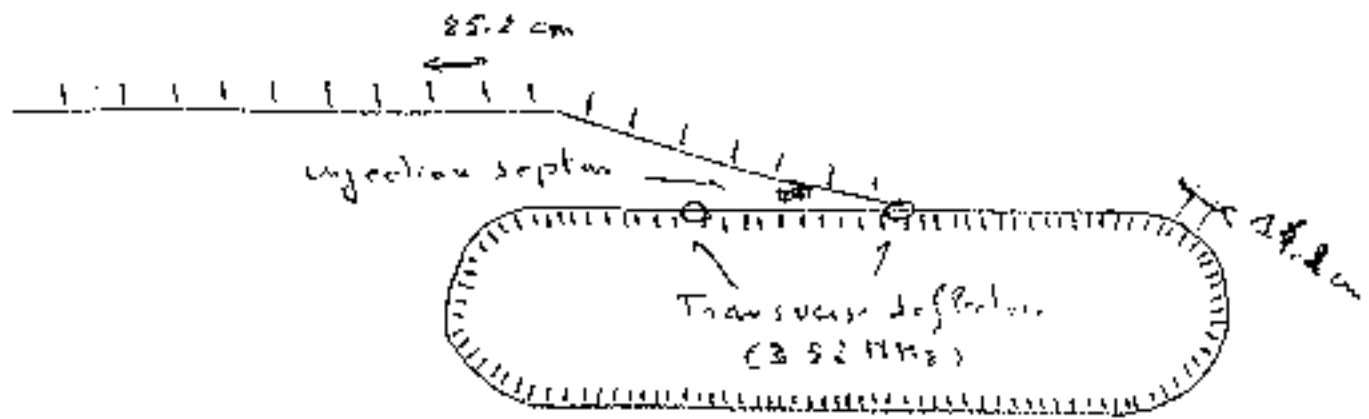


Fig 3. Layout of an accumulator with a 22 km circumference after a factor 6 beam compression by sunneling

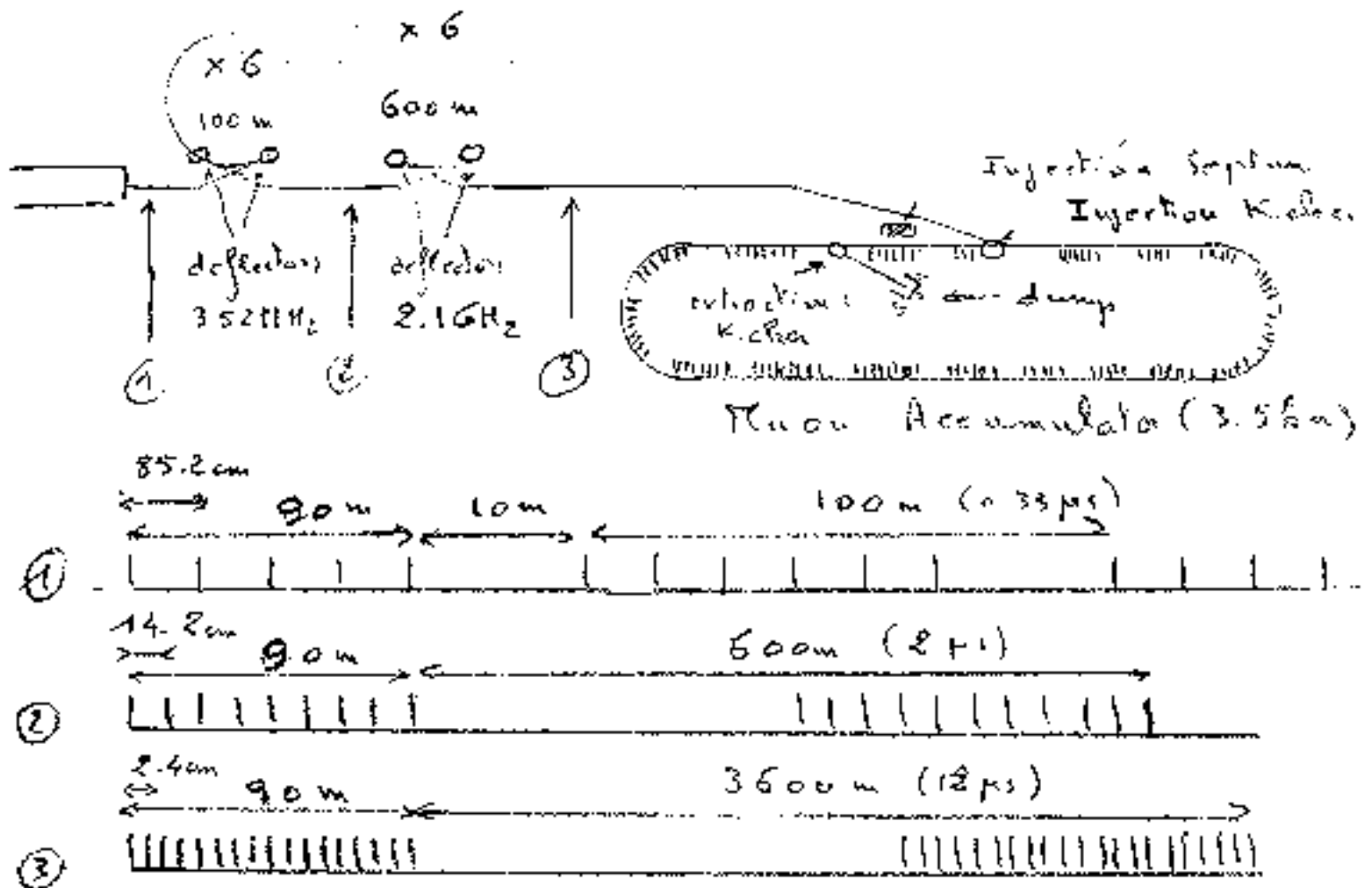
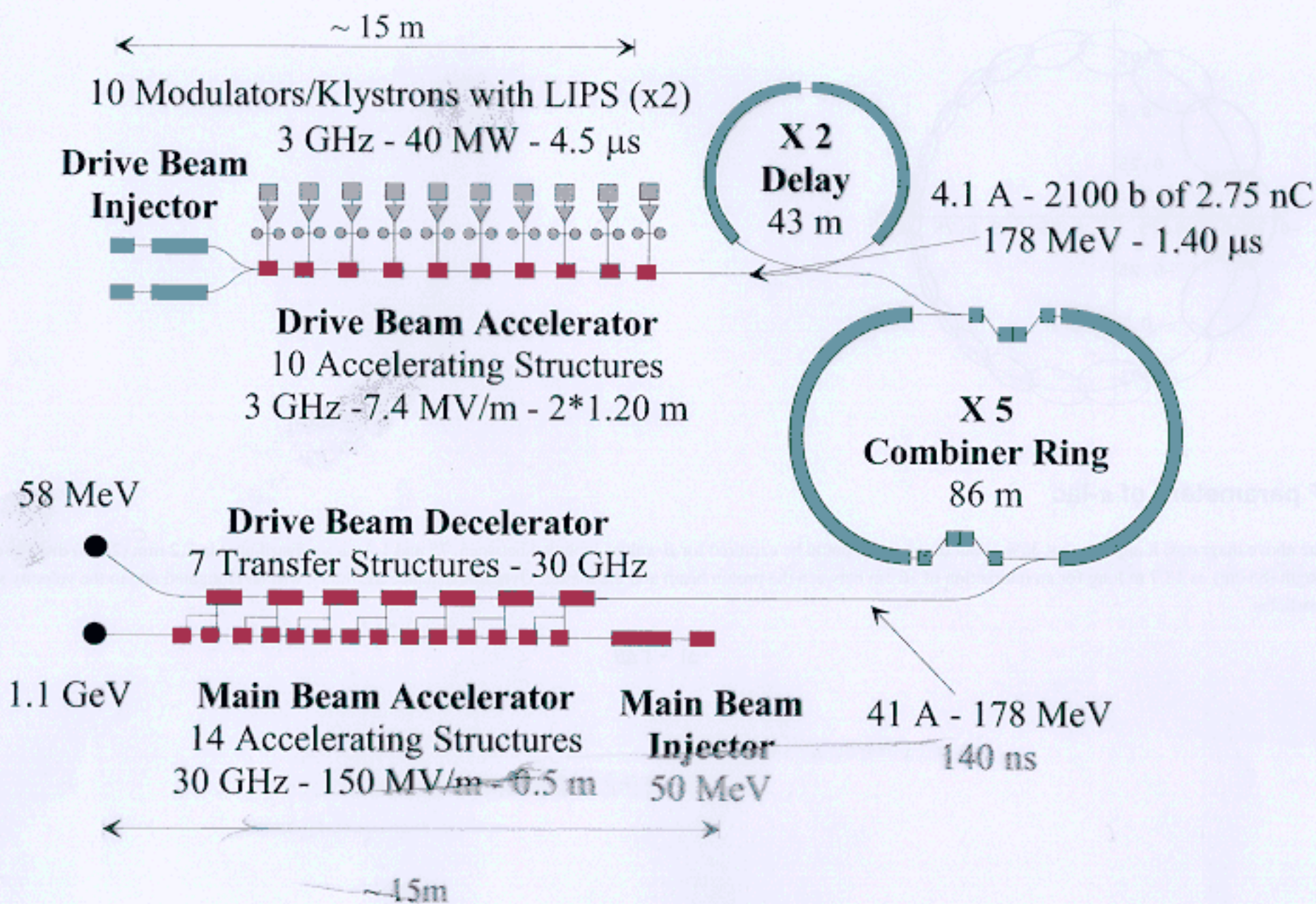


Fig 4: Layout of accumulator with a 35 km circumference after a factor 36 beam compression in two stages.

CLIC TEST FACILITY - CTF 3 - Nominal

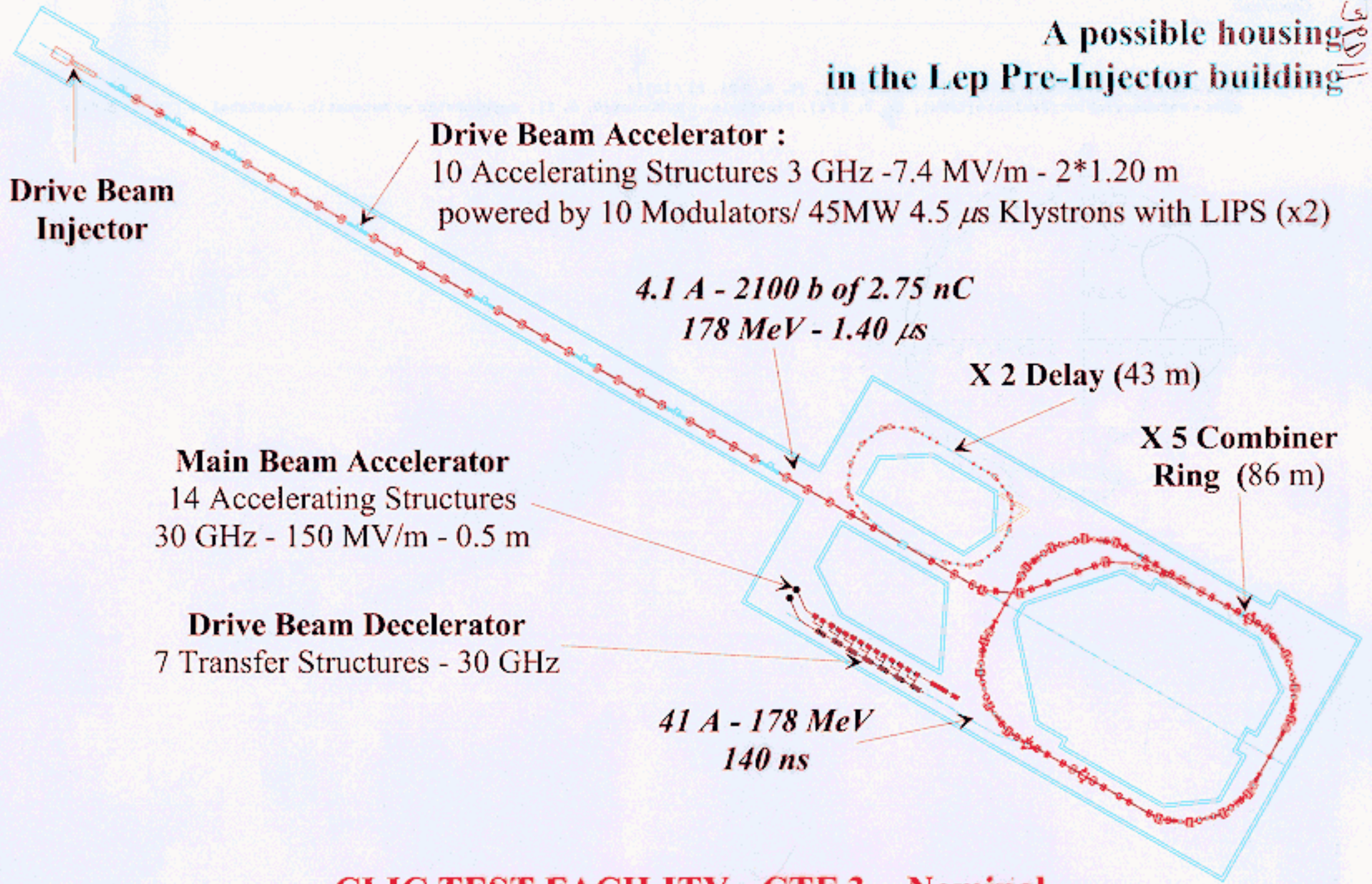
Test of Drive Beam Generation, Acceleration & RF Multiplication by a factor 10

18010



300116

A possible housing in the Lep Pre-Injector building



CLIC TEST FACILITY - CTF 3 - Nominal

Test of the Drive Beam Generation, Acceleration & RF Multiplication by a factor 10