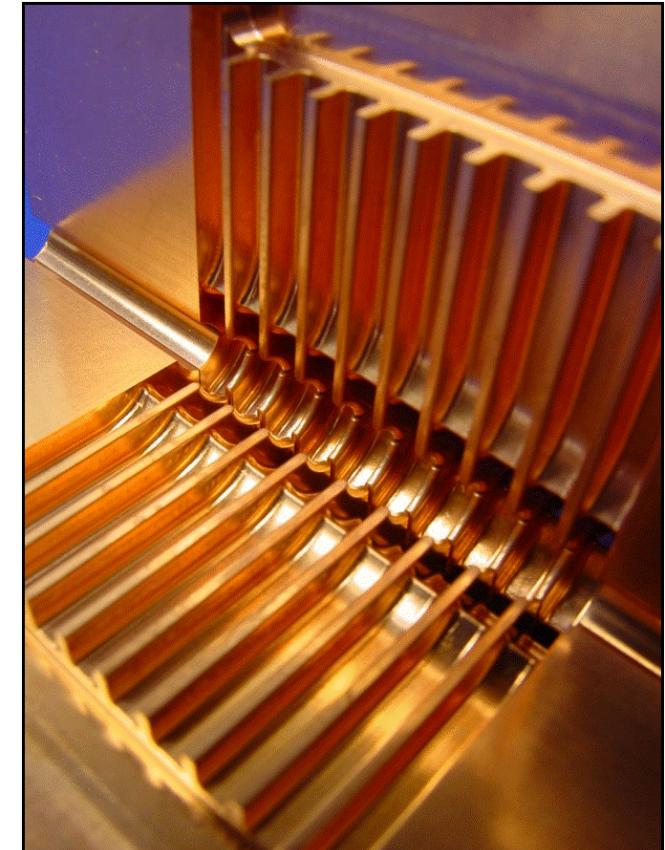


CLIC / CTF 3

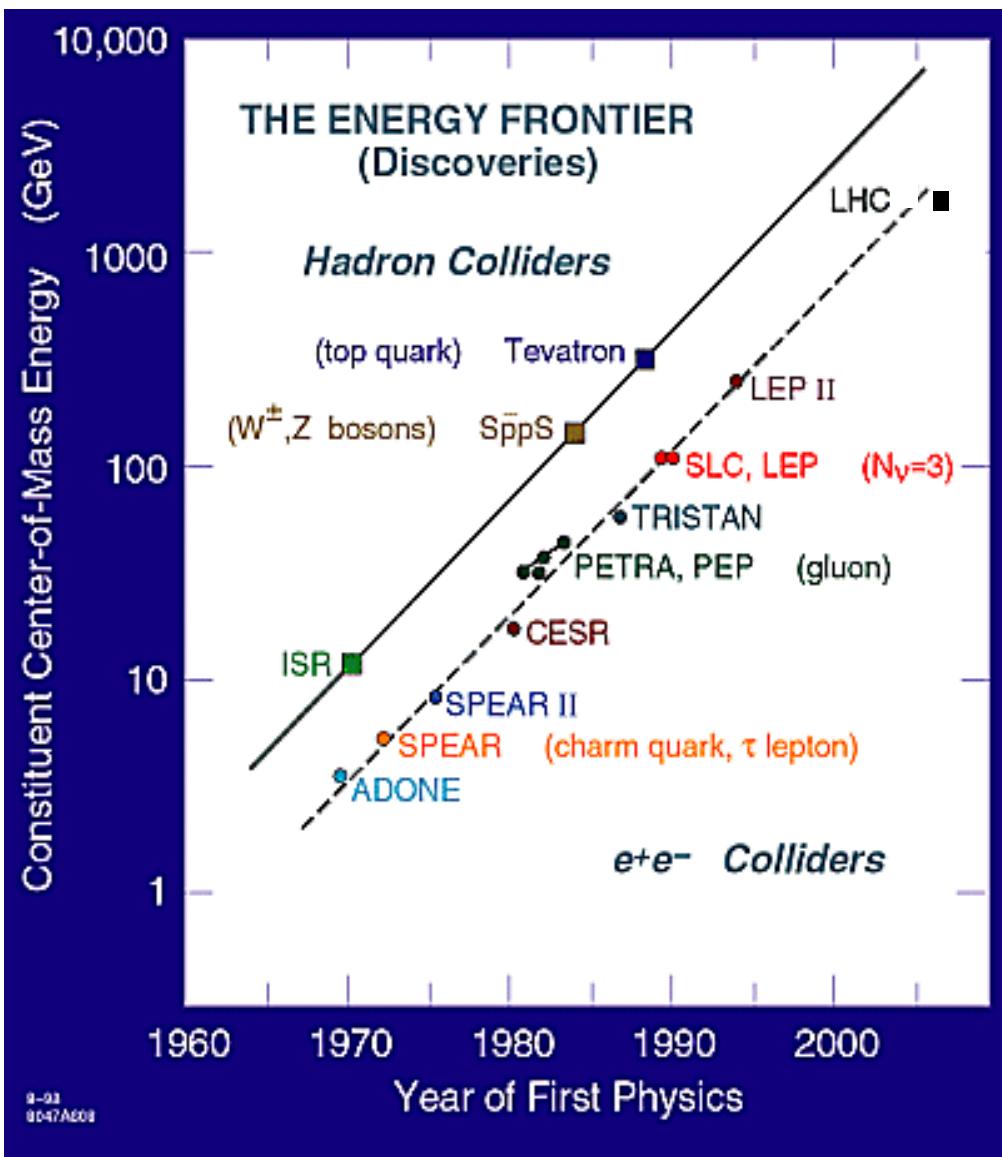


Frank Tecker - BE/OP

- Introduction CLIC / CTF 3
- Visit of CTF3



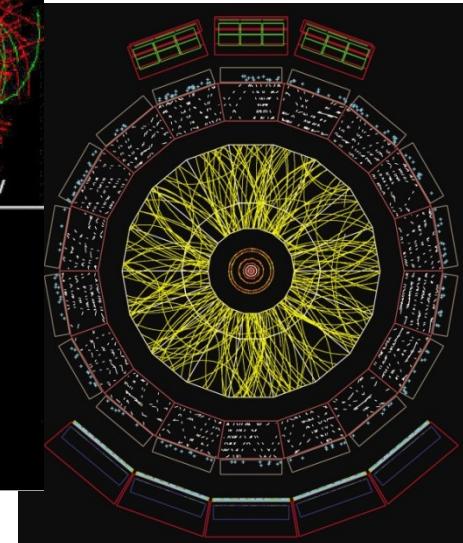
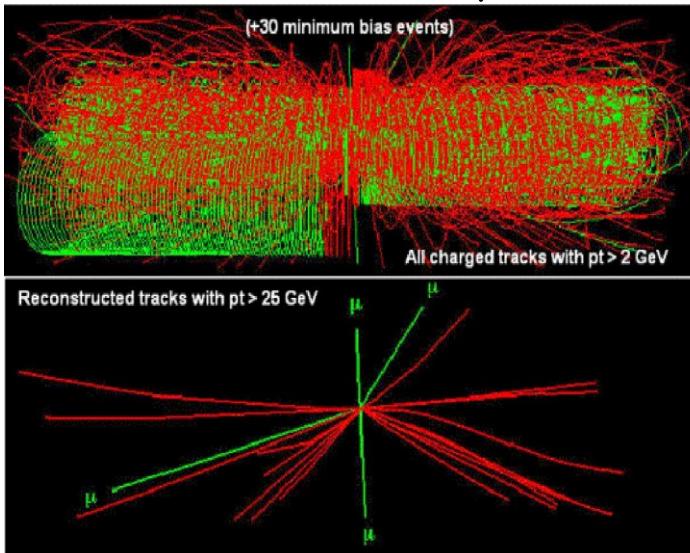
Path to higher energy



- History:
 - Energy constantly increasing with time
 - Hadron Collider at the energy frontier
 - Lepton Collider for precision physics
- LHC has just come online
- Consensus to build Lin. Collider with $E_{cm} > 500$ GeV to complement LHC physics (*European strategy for particle physics by CERN Council*)

LHC vs. Lepton Collisions

LHC: $H \rightarrow ZZ \rightarrow 4\mu$



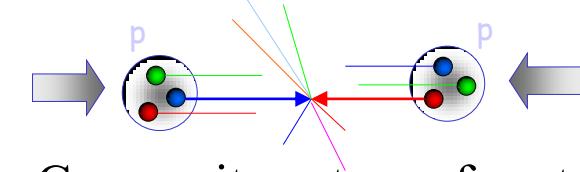
ALICE: Ion event



LEP event: $Z^0 \rightarrow 3 \text{ jets}$

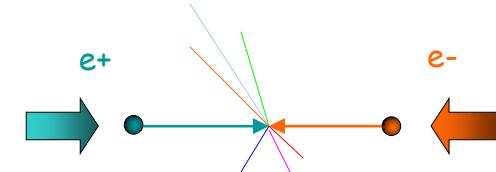
Much more **precise**
analysis with leptons
=> precision
measurements of
particle properties

- Hadron Collider (p , ions):



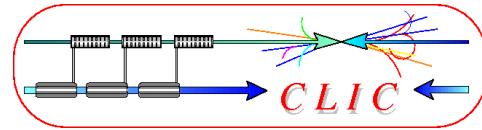
- Composite nature of protons
- Can only use p_t conservation
- Huge QCD background

- Lepton Collider:

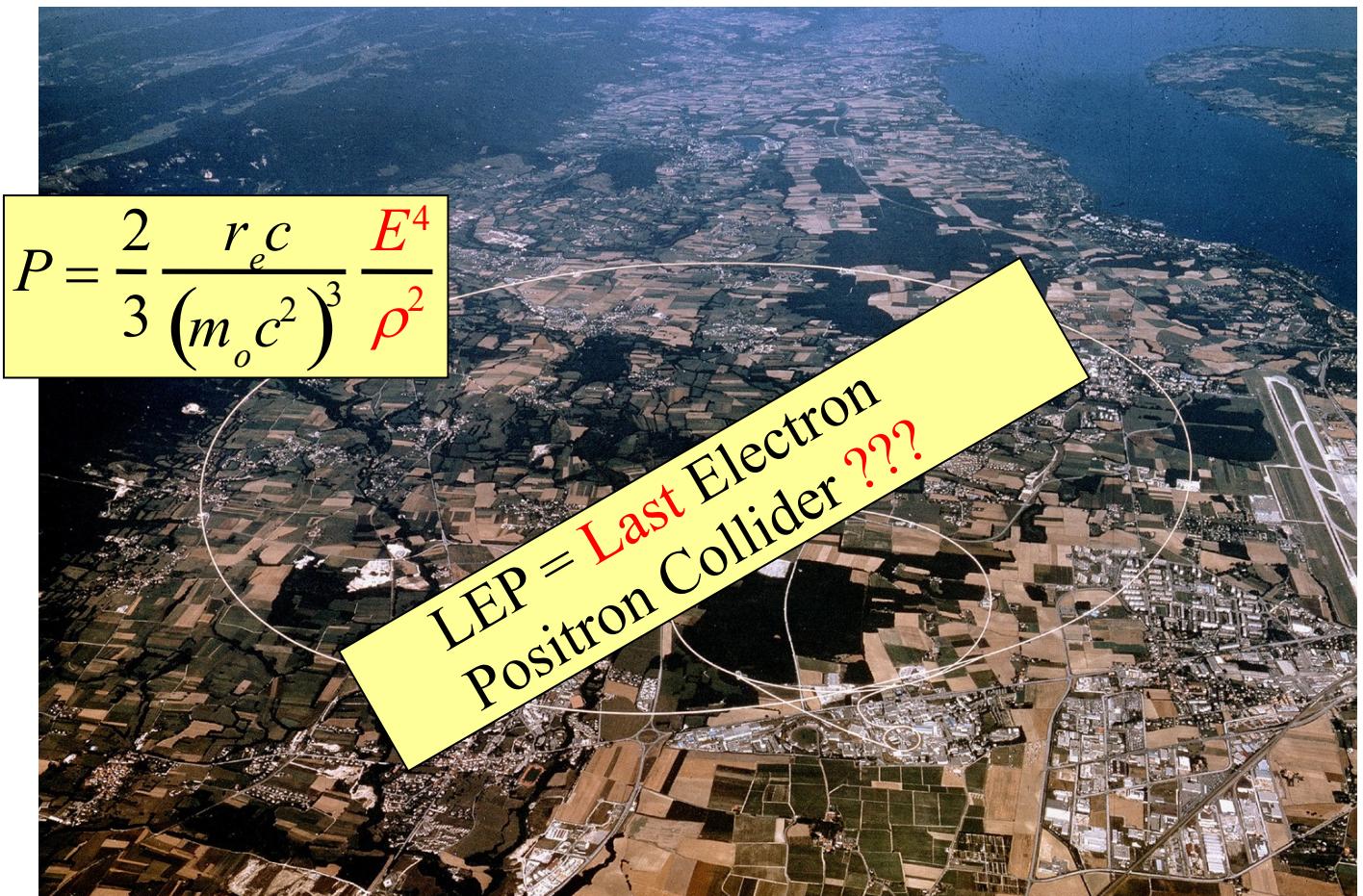


- Elementary particles
- Well defined initial state
- Beam polarization
- produces particles democratically
- Momentum conservation eases decay product analysis

The LEP collider

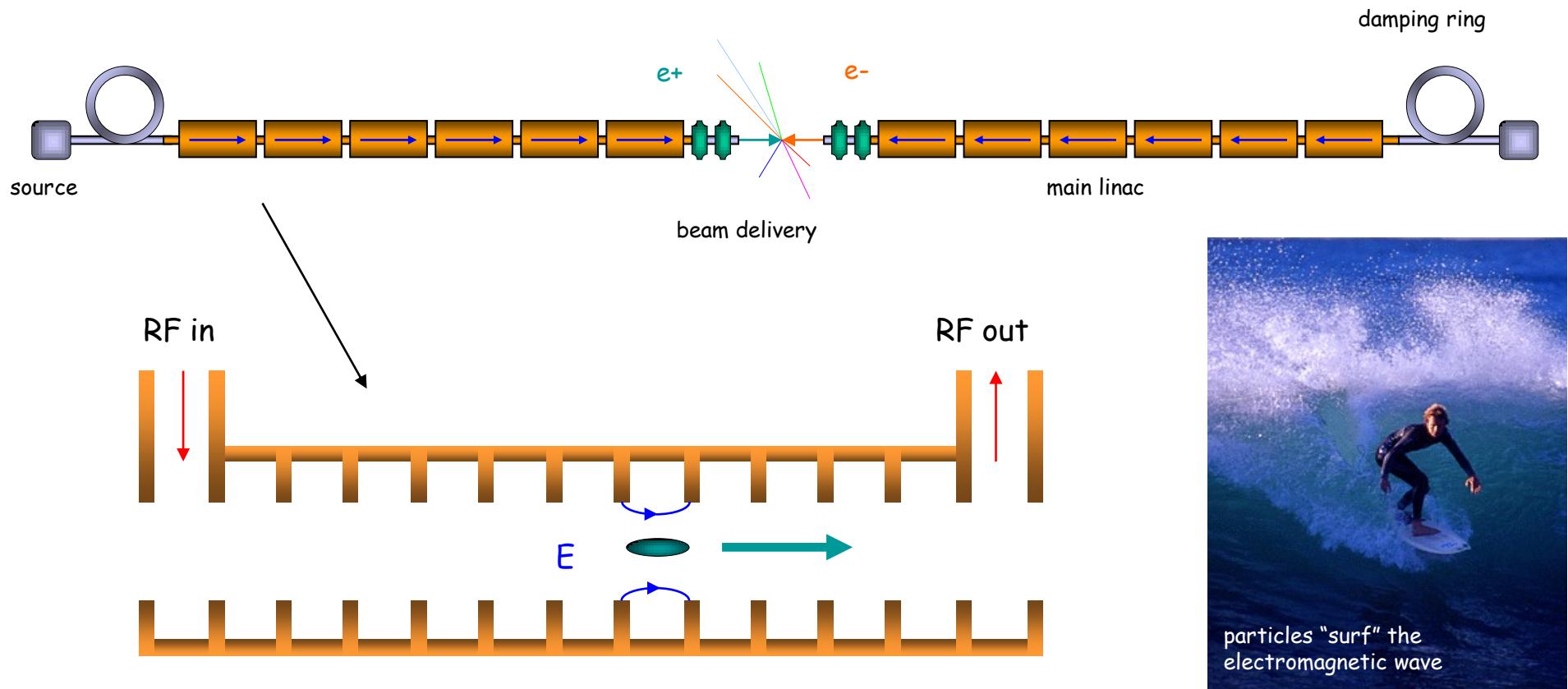


- LEP (Large Electron Positron collider) was installed in LHC tunnel
- e+ e- circular collider (27 km) with $E_{cm}=200$ GeV
- Problem for any ring:
Synchrotron radiation
- Emitted power:
scales with E^4 !!
and $1/m_0^3$ (much less
for heavy particles)
- This energy loss
must be replaced
by the RF system !!
- particles lost 3% of
their energy each turn!

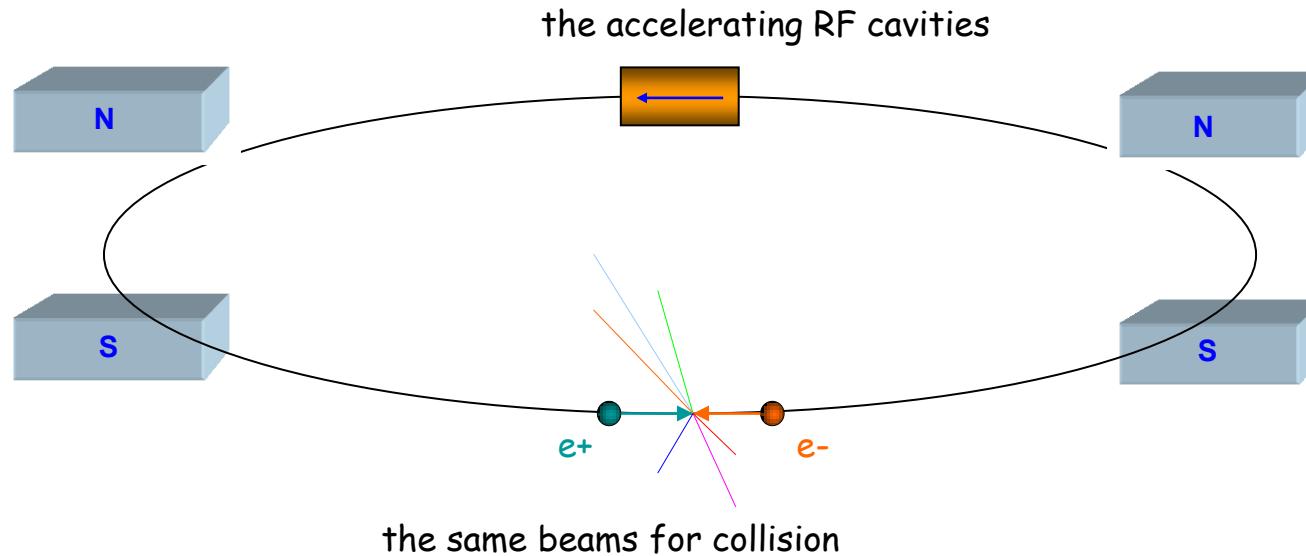


The next lepton collider

- Solution: LINEAR COLLIDER
- avoid synchrotron radiation
- no bending magnets, huge amount of cavities and RF



Linear Collider vs. Ring



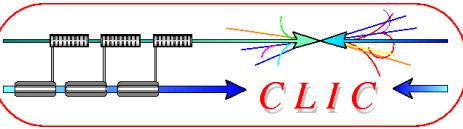
- **Storage rings:**

- accelerate + collide every turn
- ‘re-use’ RF + ‘re-use’ particles
- \Rightarrow efficient

- **Linear Collider:**

- one-pass acceleration + collision
 \Rightarrow need
 - **high gradient (acceleration)**
 - **small beam size**
- to reach high event rate (Luminosity)

Linear Collider projects



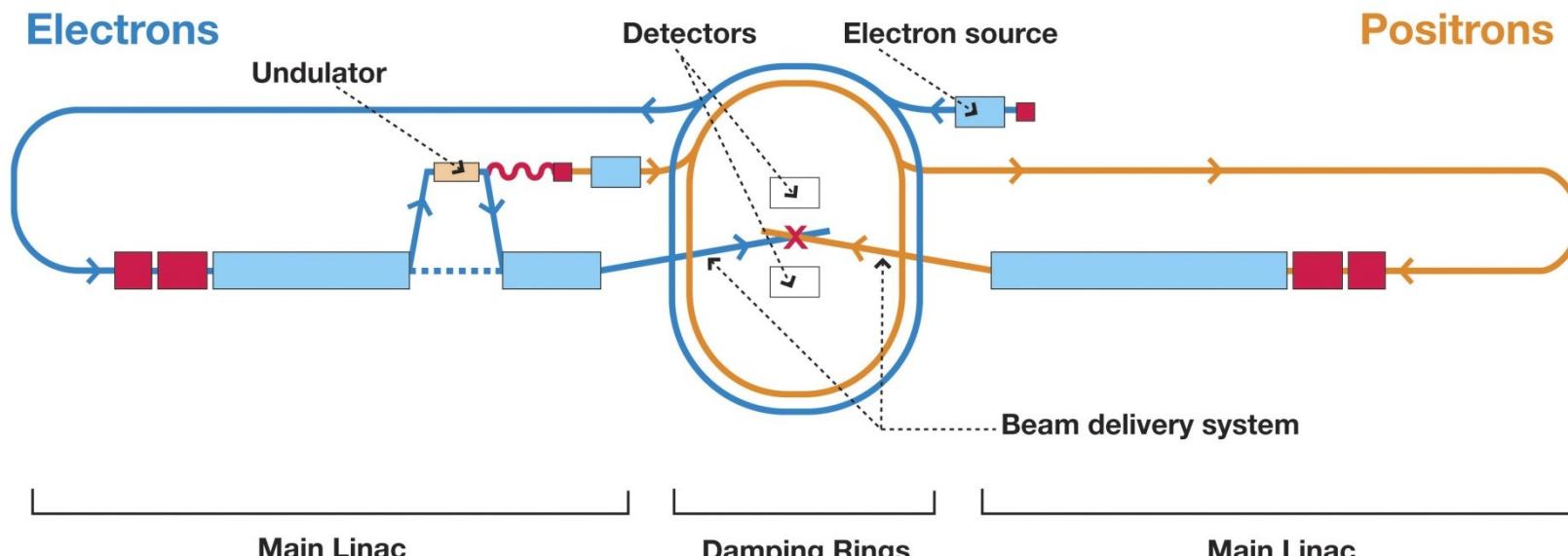
- ILC (International Linear Collider)

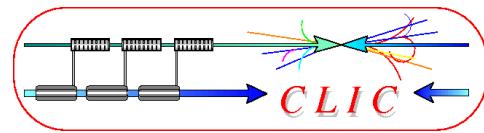
- Technology decision Aug 2004
- Superconducting technology
- 1.3 GHz RF frequency
- ~ 31 MV/m accelerating gradient
- 500 GeV centre-of-mass energy
- upgrade to 1 TeV possible

- CLIC (Compact Linear Collider)

- normalconducting technology
- multi-TeV energy range (nom. 3 TeV)

~ 35 km total length

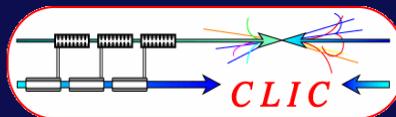




CLIC-CTF3 Collaboration



WORLD WIDE CLIC &
CTF3 COLLABORATION



Ankara University (Turkey)
Berlin Tech. Univ. (Germany)
BINP (Russia)
CERN
CIEMAT (Spain)
DAPNIA/Saclay (France)

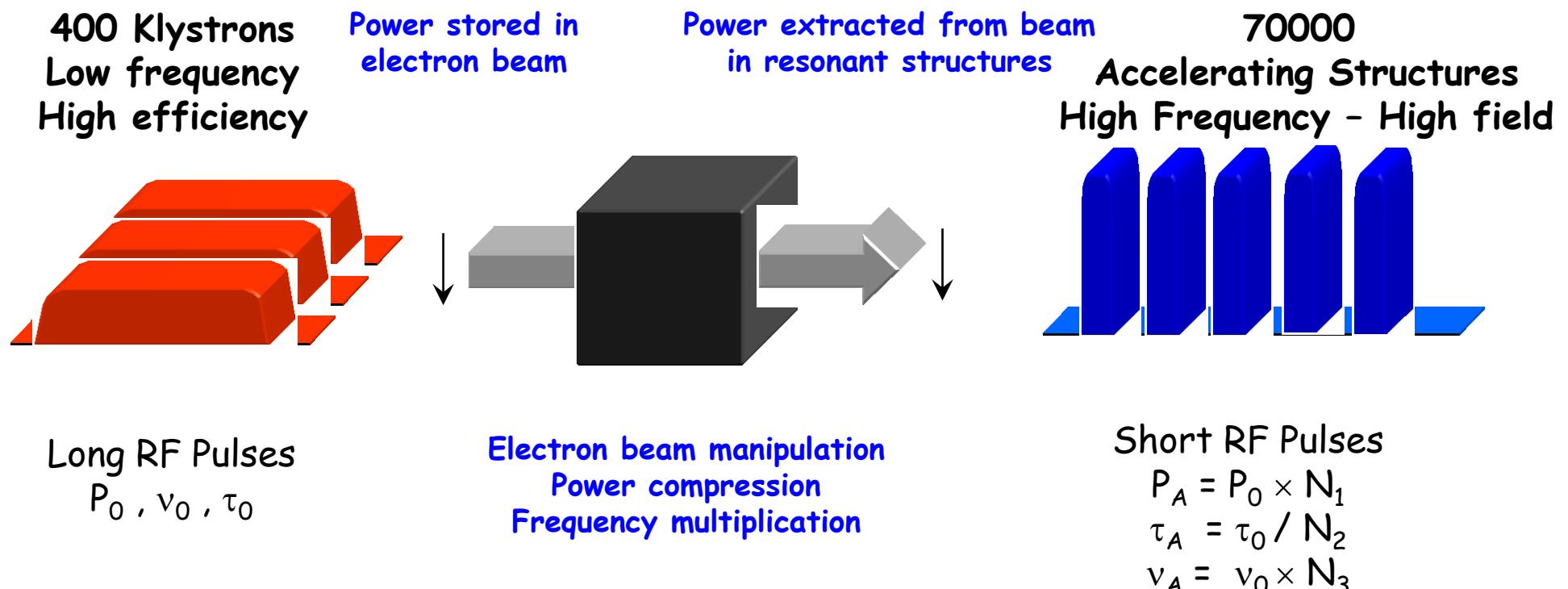
RRCAT-Indore (India)
Finnish Industry (Finland)
Gazi Universities (Turkey)
Helsinki Institute of Physics (Finland)
IAP (Russia)
Instituto de Fisica Corpuscular (Spain)
INFN / LNF (Italy)

JASRI (Japan)
JINR (Russia)
KEK (Japan)
LAL/Orsay (France)
LAPP/ESIA (France)
LLBL/LBL (USA)
NCP (Pakistan)

PSI (Switzerland),
North-West. Univ. Illinois (USA)
Polytech. University of Catalonia (Spain)
John Adams Institute (England)
SLAC (USA)
Svedberg Laboratory (Sweden)
Uppsala University (Sweden)

CLIC scheme

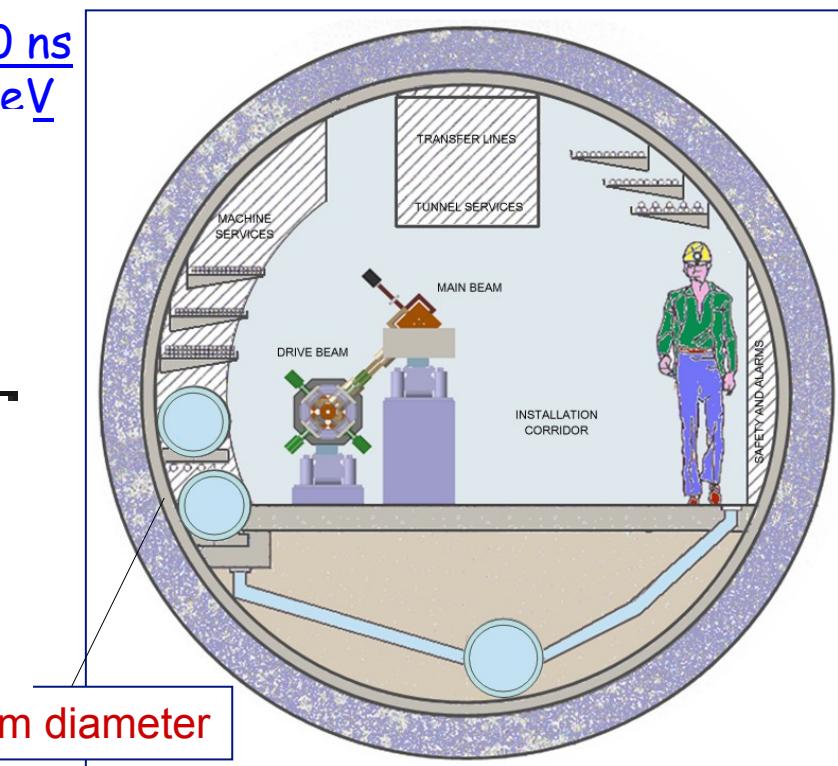
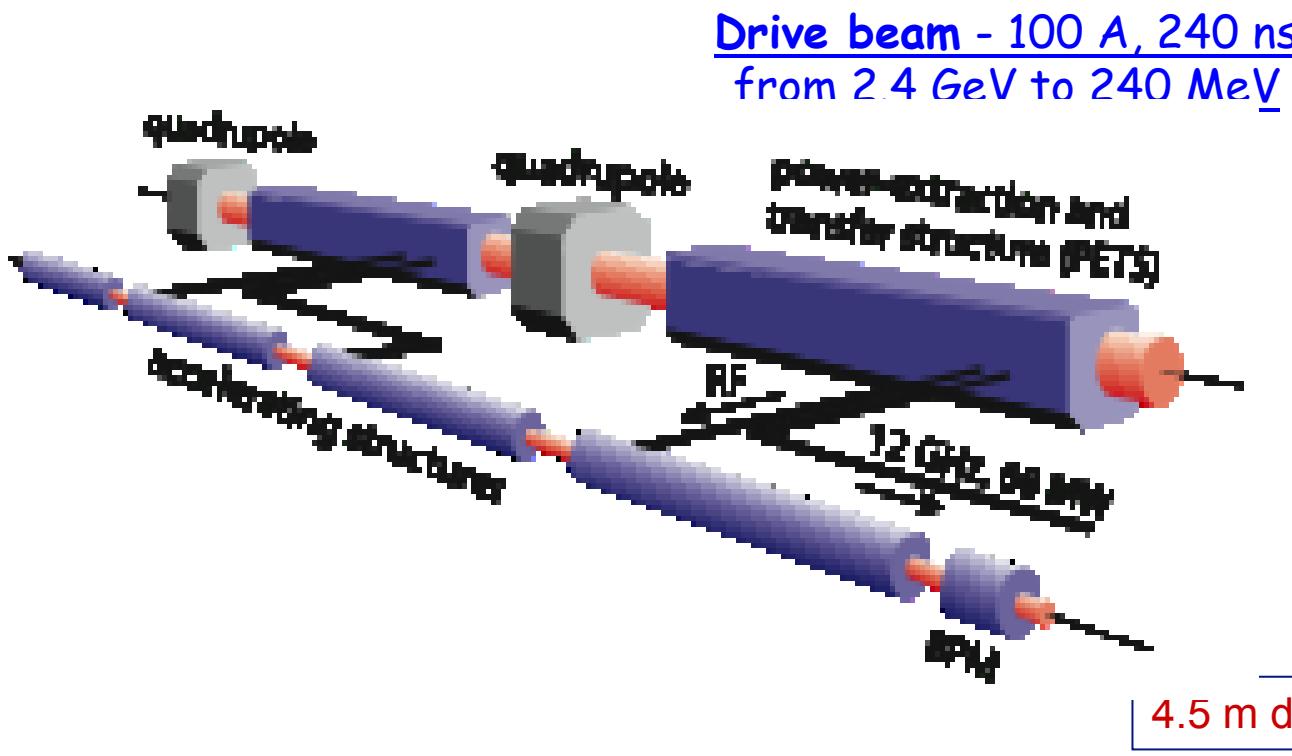
- Very high gradients possible with NC accelerating structures at high RF frequencies ($12 \rightarrow 30$ GHz)
- Extract RF power from an intense electron “drive beam”
- Generate efficiently long pulse and compress it (in power + frequency)

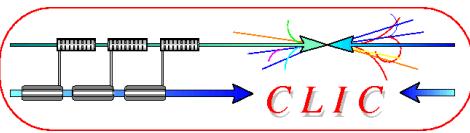


CLIC two beam scheme

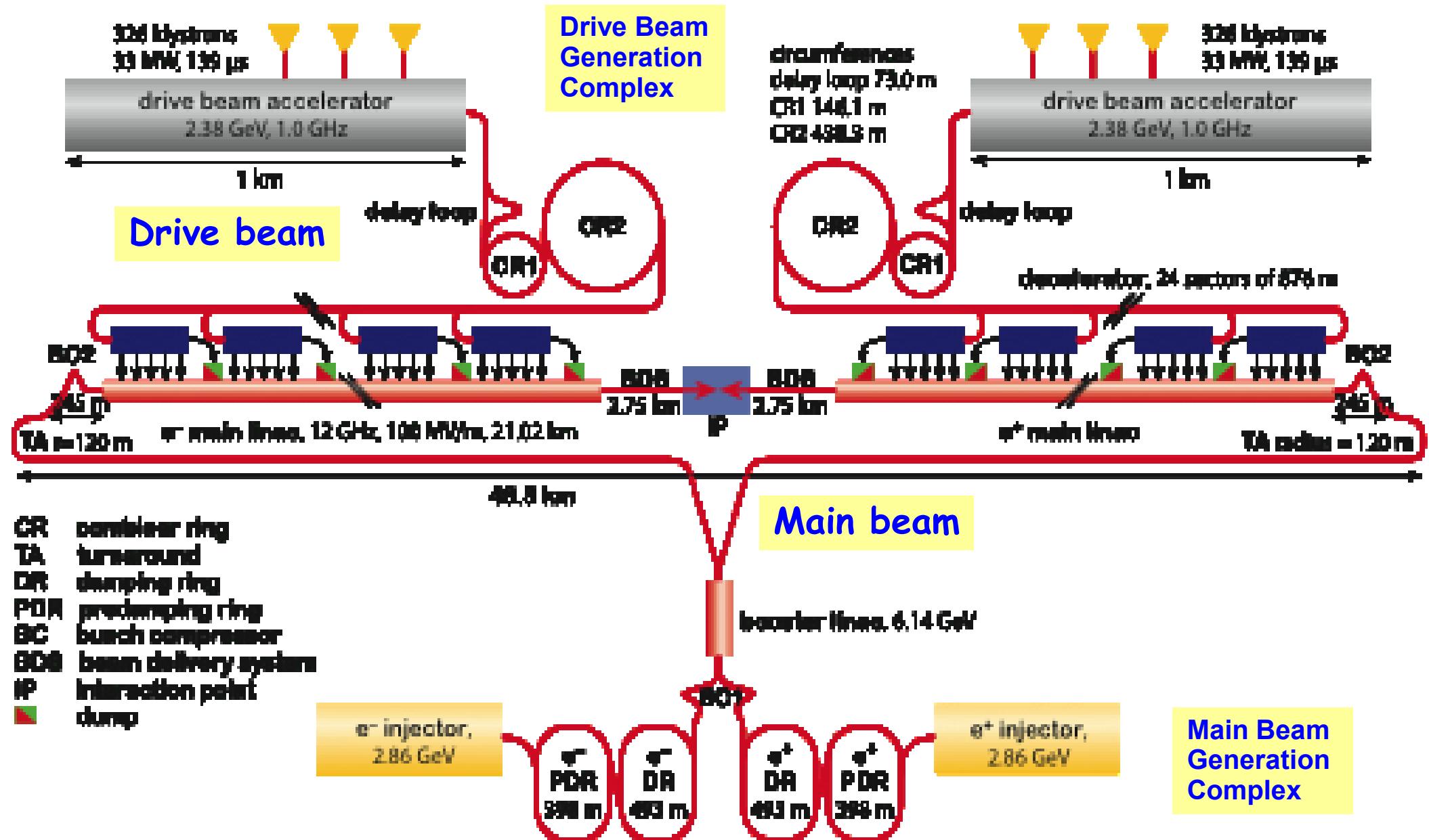
- Two beam acceleration scheme:
 - High charge **Drive Beam** (low energy)
 - Low charge **Main Beam** (high collision energy)
- High power for high gradient of $>100 \text{ MV/m}$

CLIC TUNNEL CROSS-SECTION





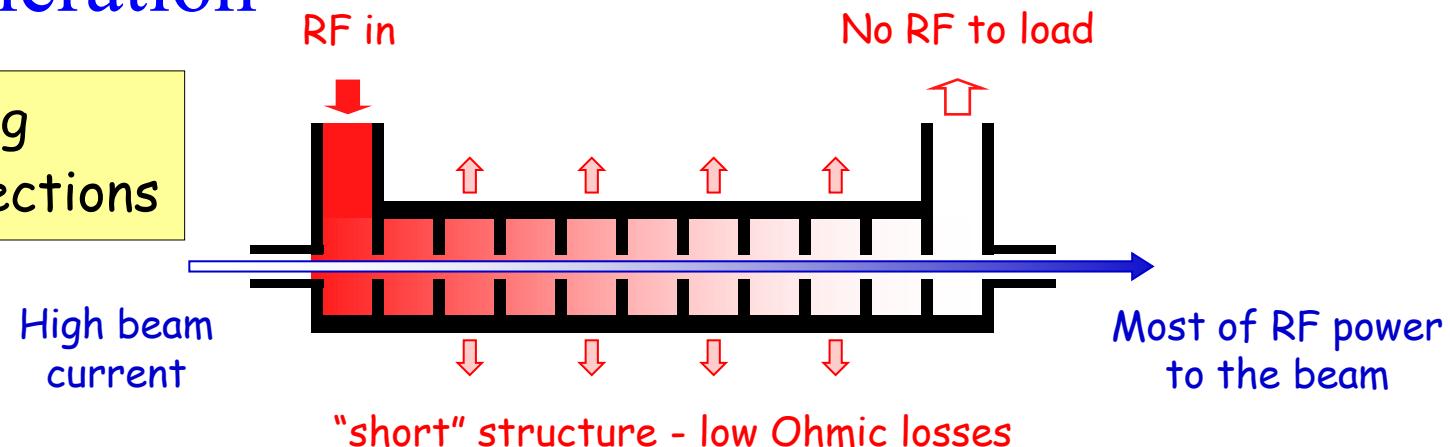
CLIC – overall layout – 3 TeV



Drive beam generation basics

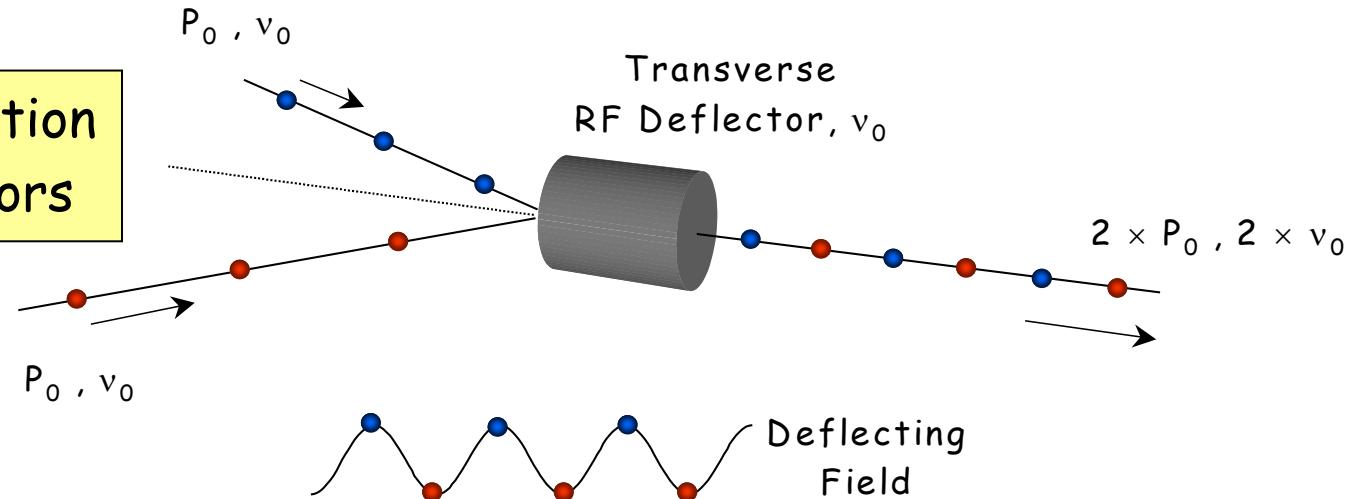
- Efficient acceleration

Full beam-loading
acceleration in TW sections

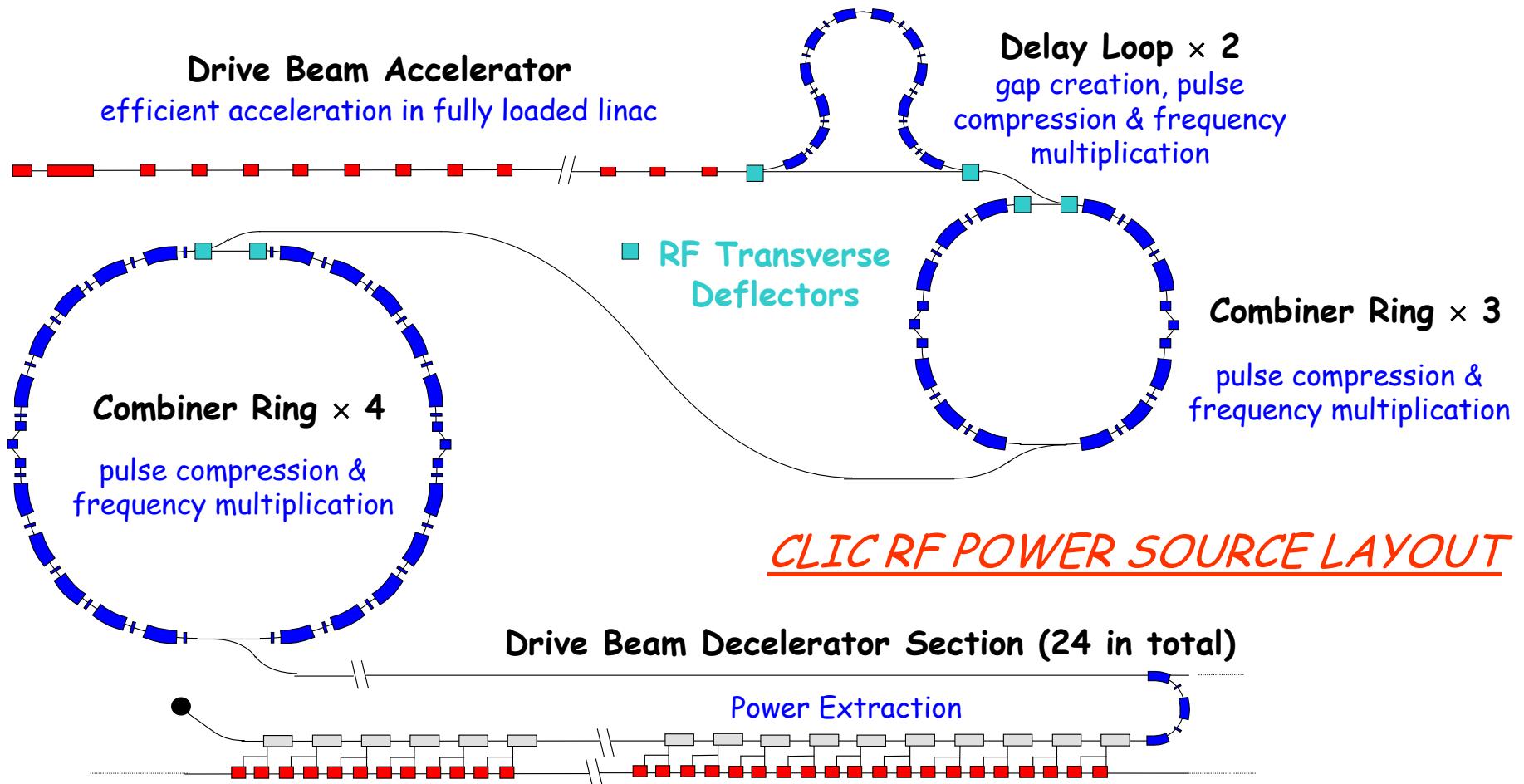


- Frequency multiplication

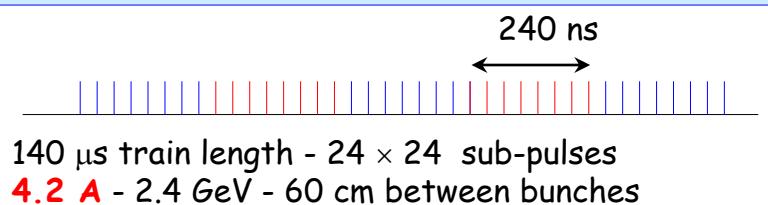
Beam combination/separation
by transverse RF deflectors



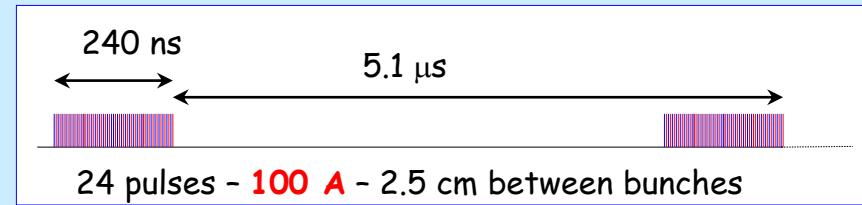
CLIC Drive Beam generation



Drive beam time structure - initial

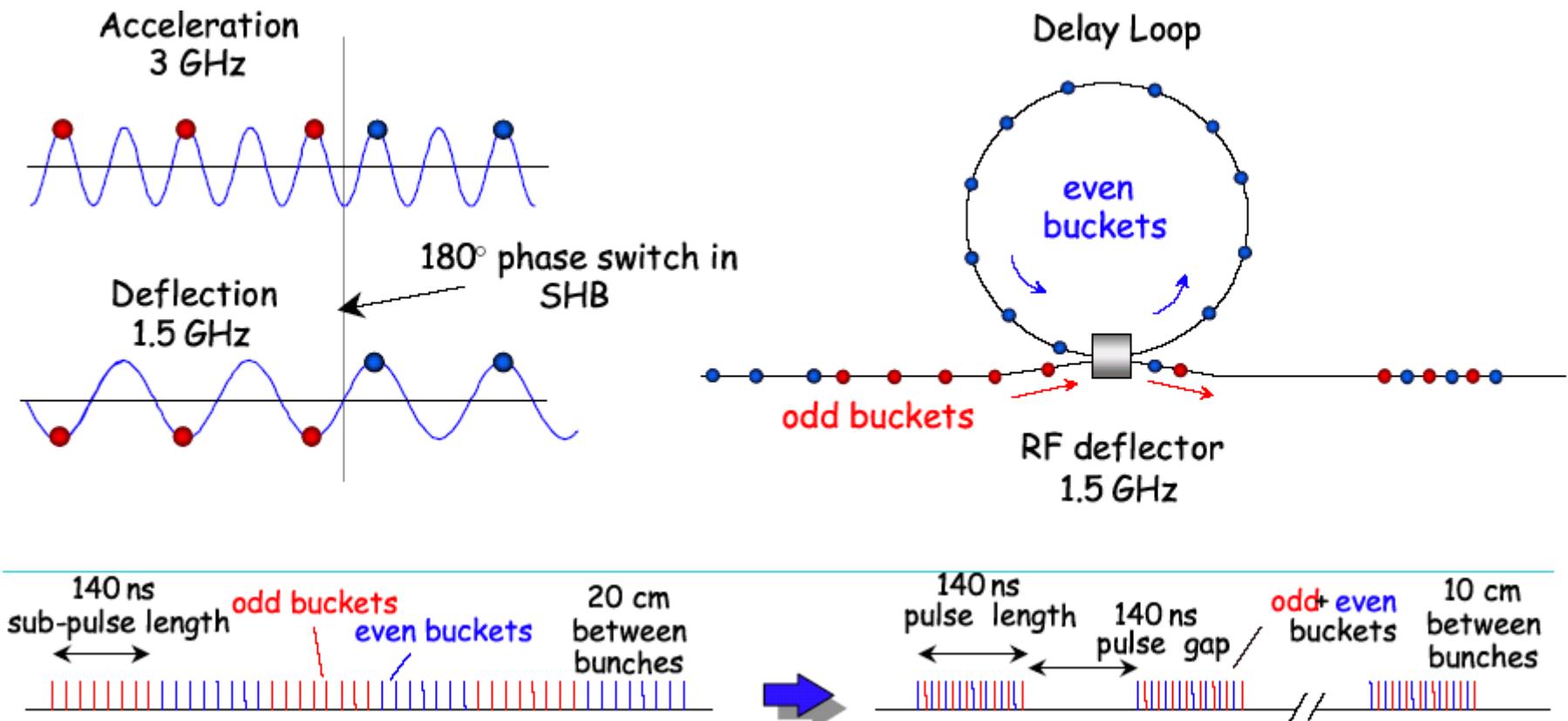


Drive beam time structure - final



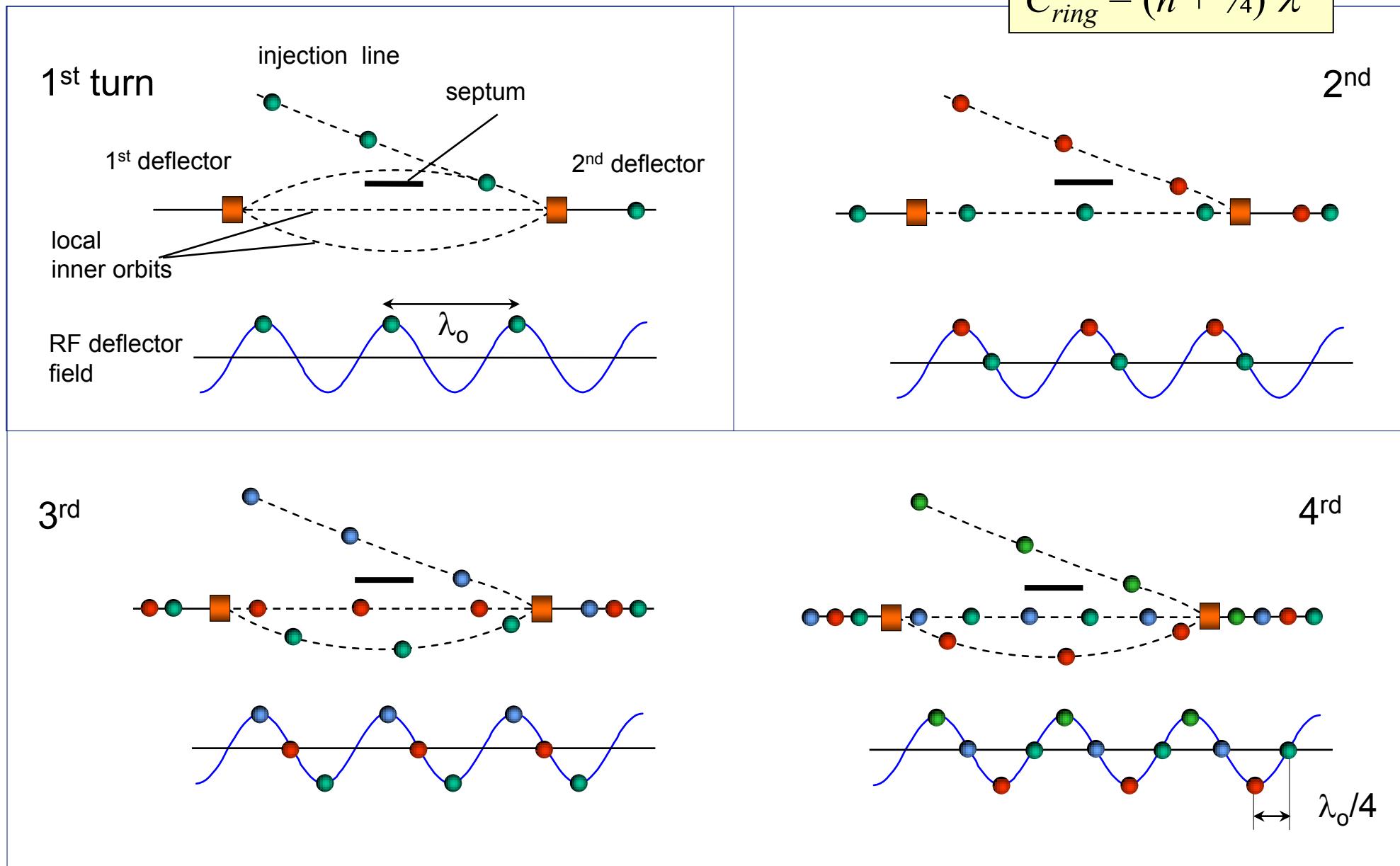
Delay Loop Principle

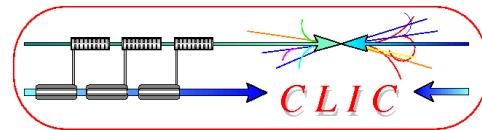
- double repetition frequency and current
- parts of bunch train delayed in loop
- RF deflector combines the bunches



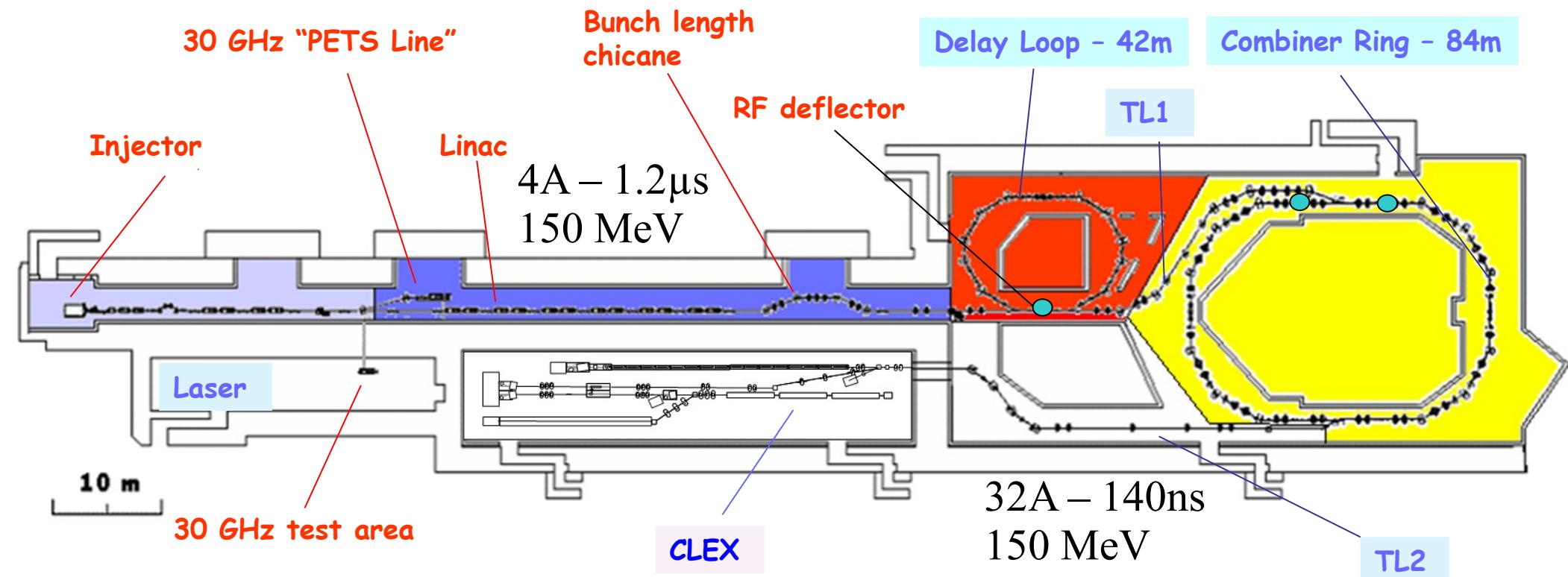
RF injection in combiner ring

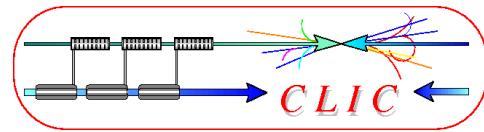
- combination factors up to 5 reachable in a ring





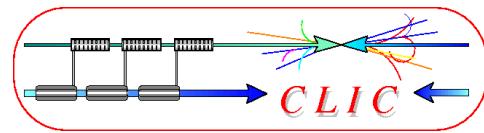
- demonstrate remaining CLIC feasibility issues, in particular:
 - Drive Beam generation (fully loaded acceleration, bunch frequency multiplication)
 - CLIC accelerating structures
 - CLIC power production structures (PETS)





CTF3 Delay Loop

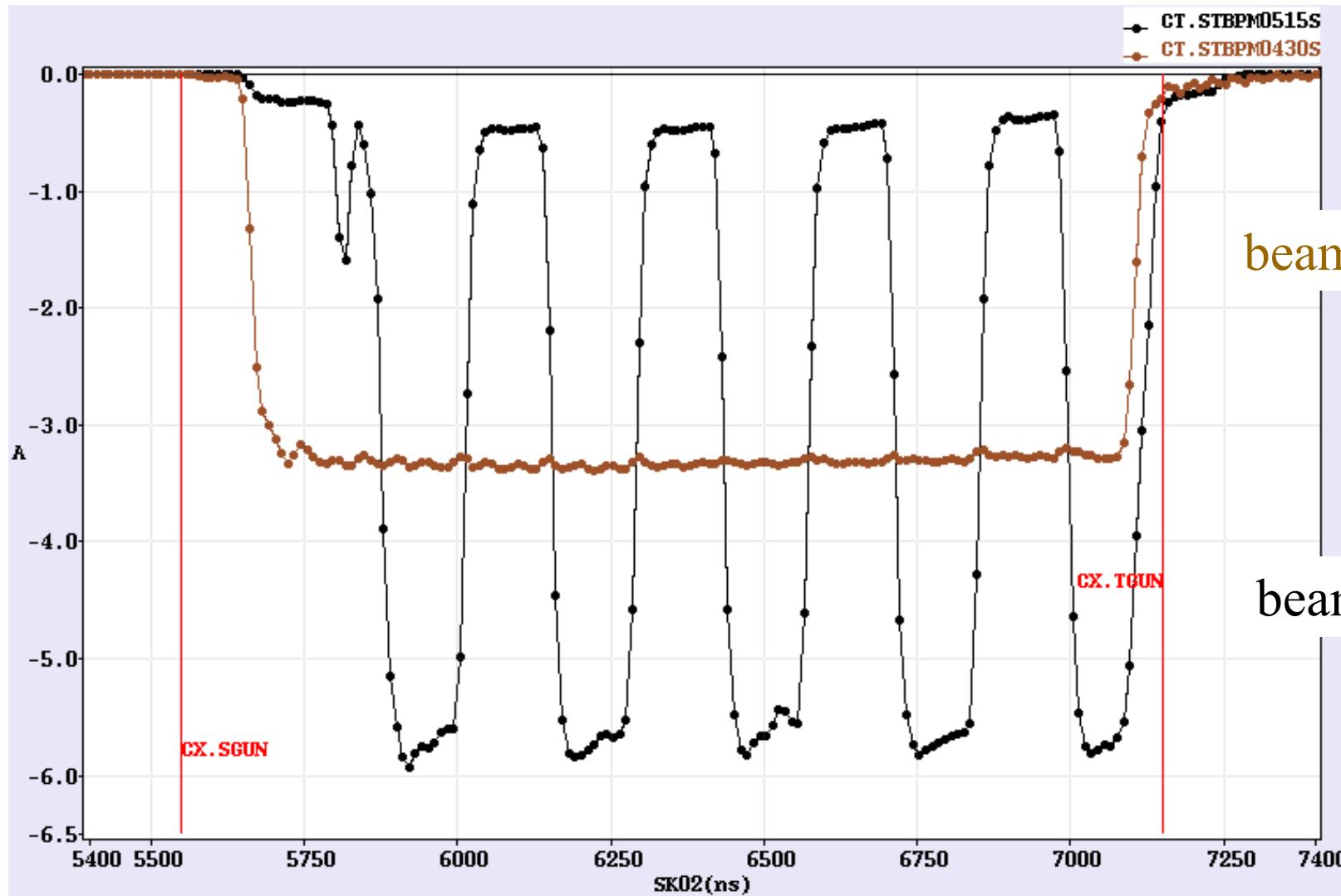
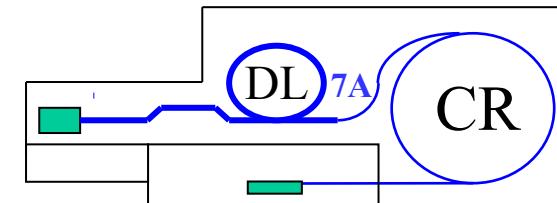




Delay Loop – full recombination



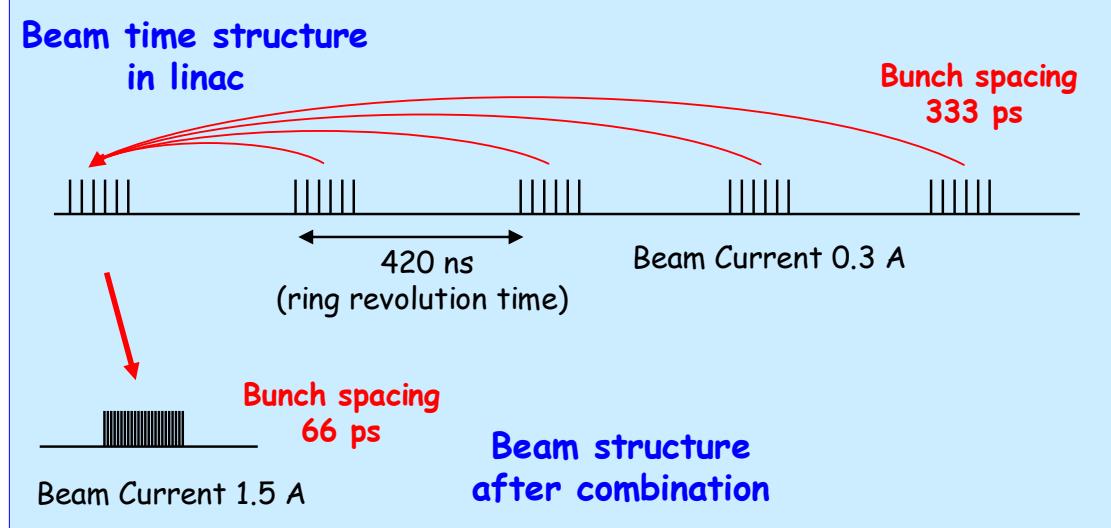
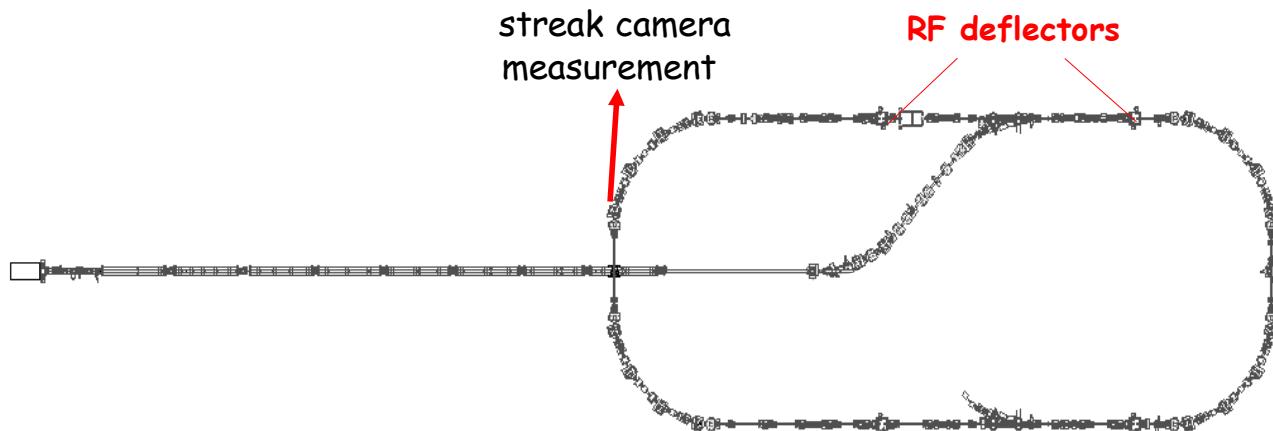
- 3.3 A after chicane =>
< 6 A after combination (satellites)



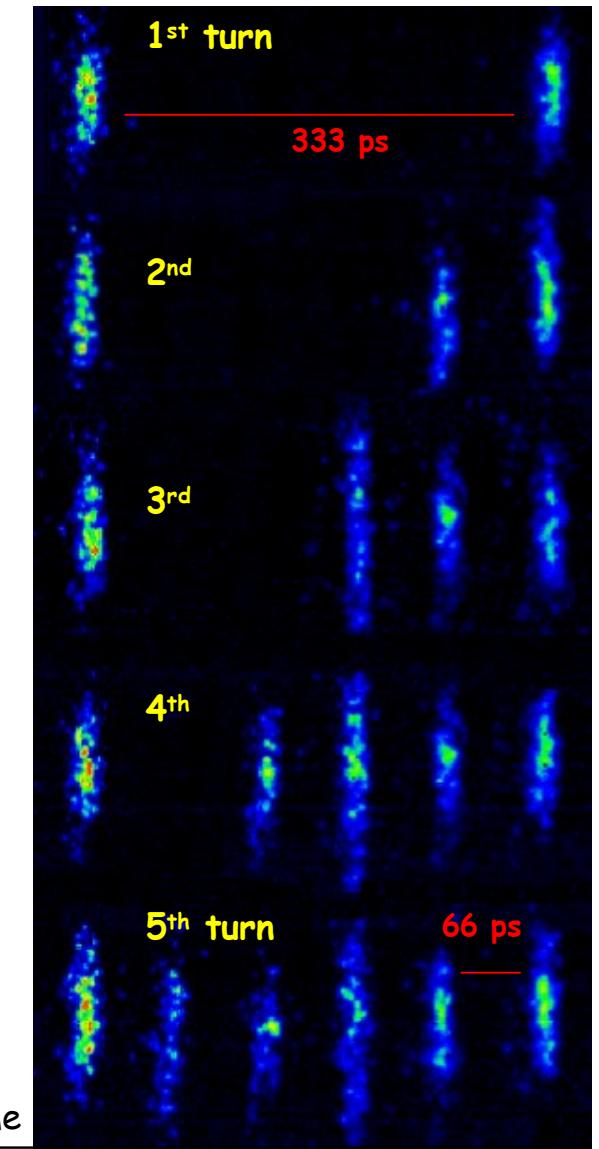
Demonstration of RF recombination

CTF3 - PRELIMINARY PHASE

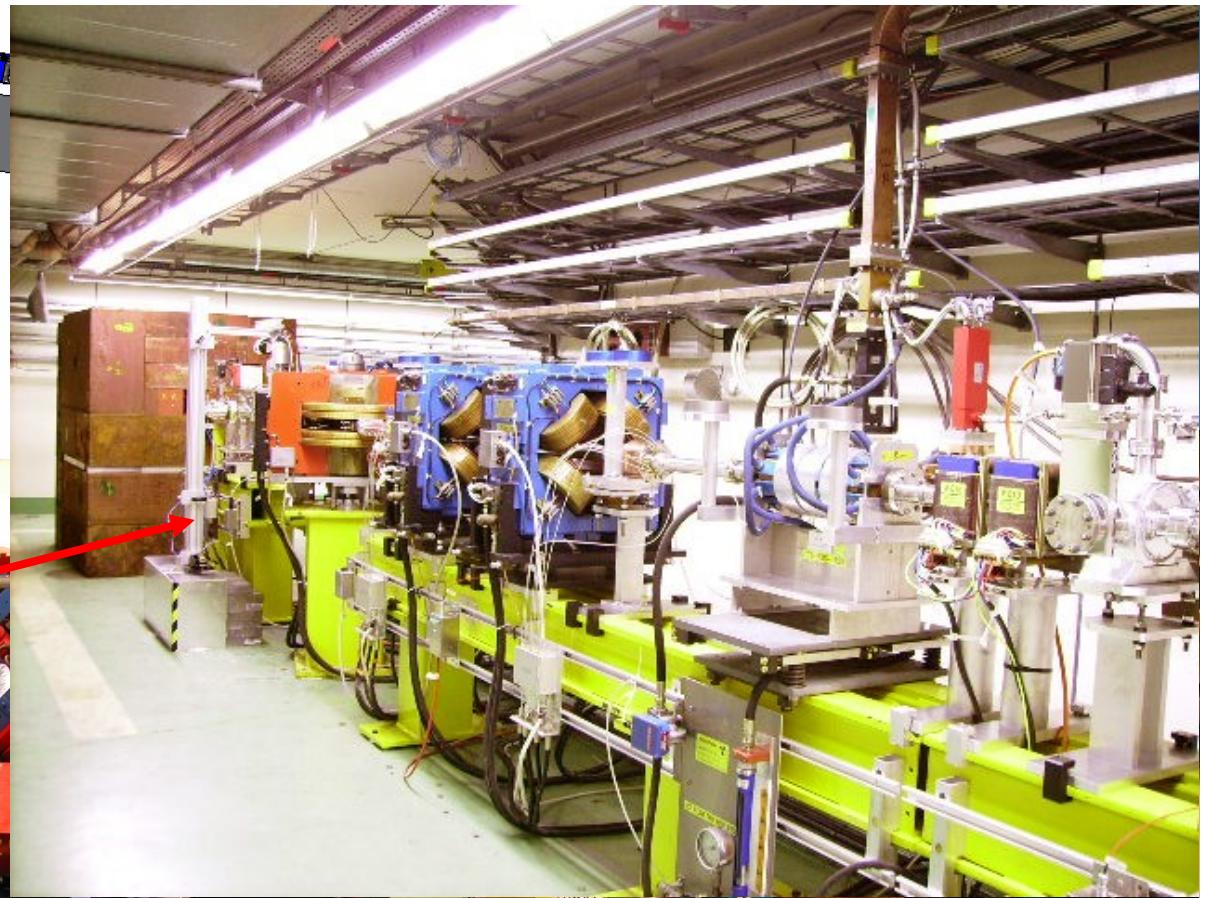
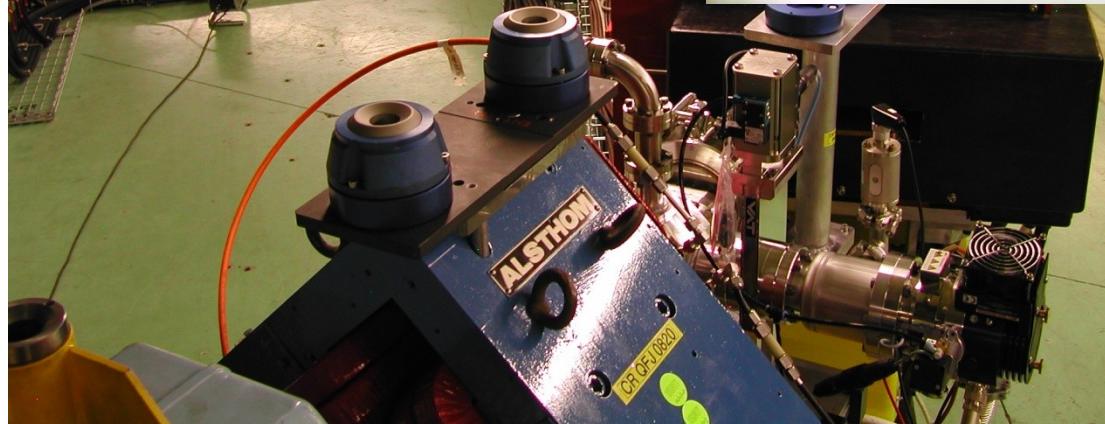
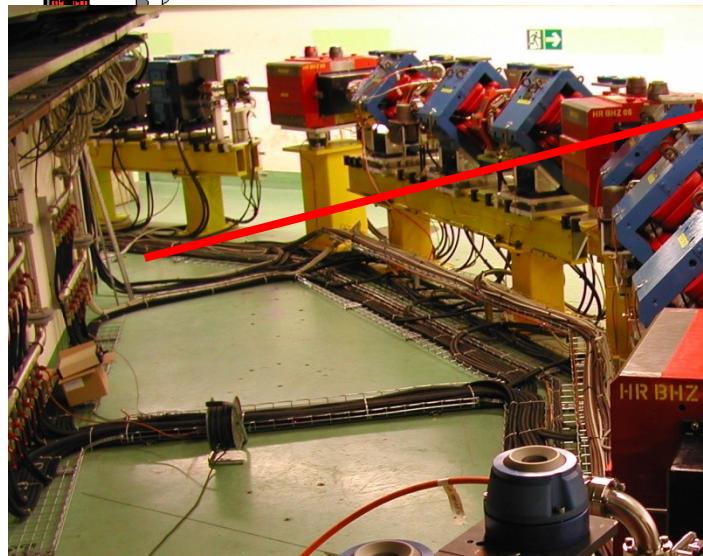
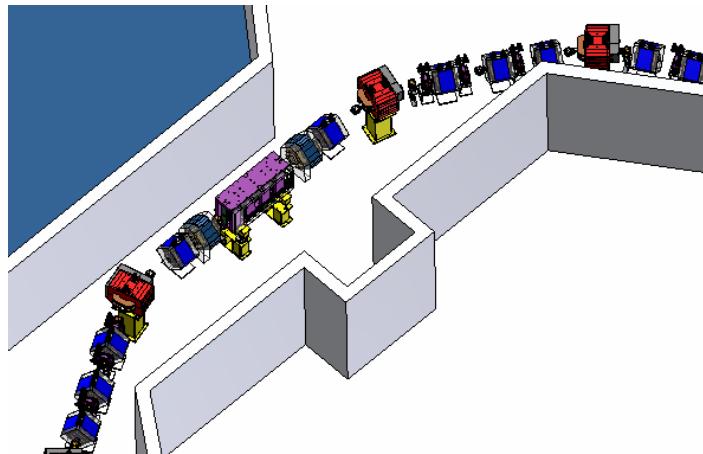
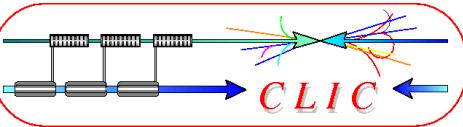
Successful low-charge demonstration of electron pulse combination and bunch frequency multiplication by up to factor 5



Streak camera image of beam time structure evolution

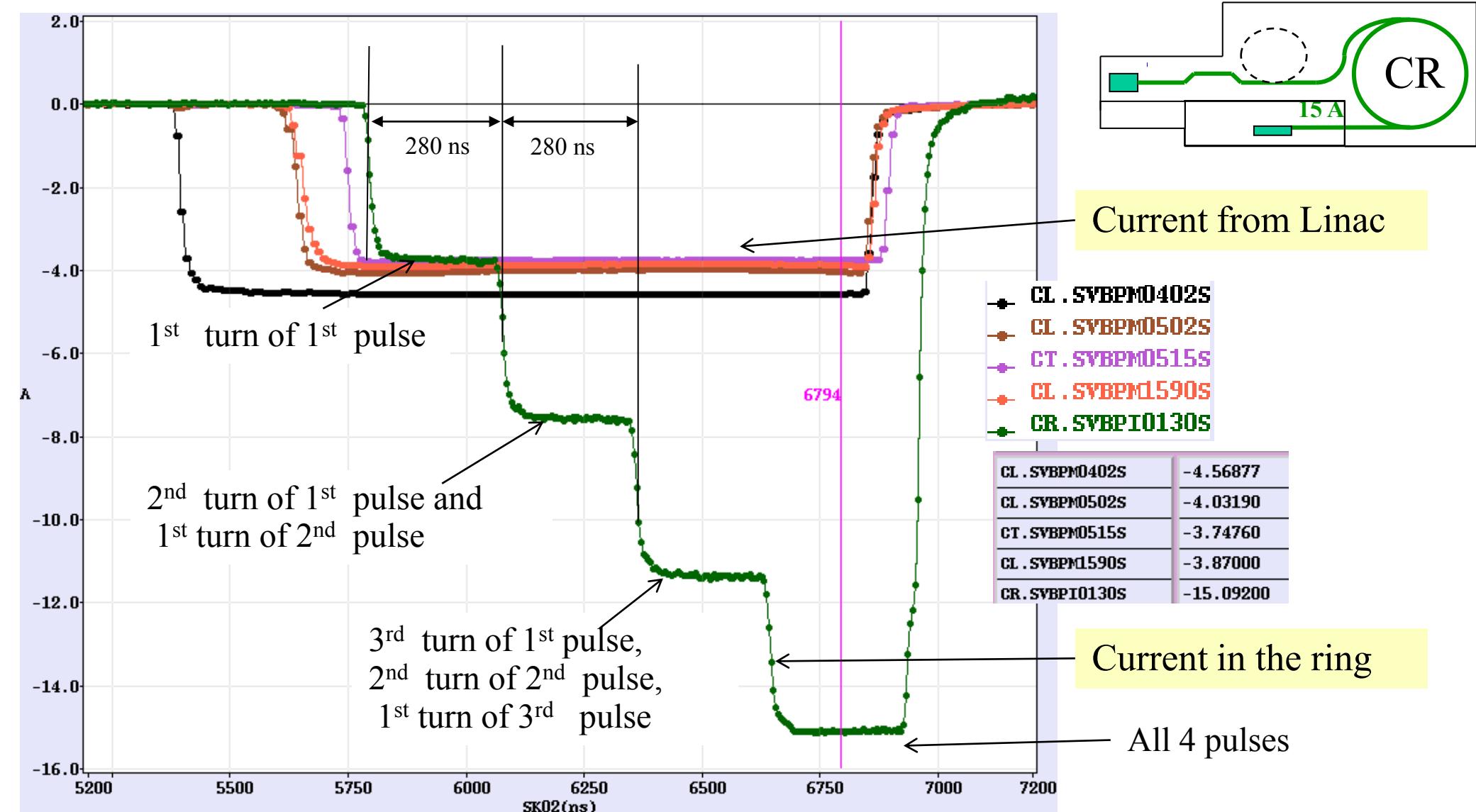


CTF3 combiner ring



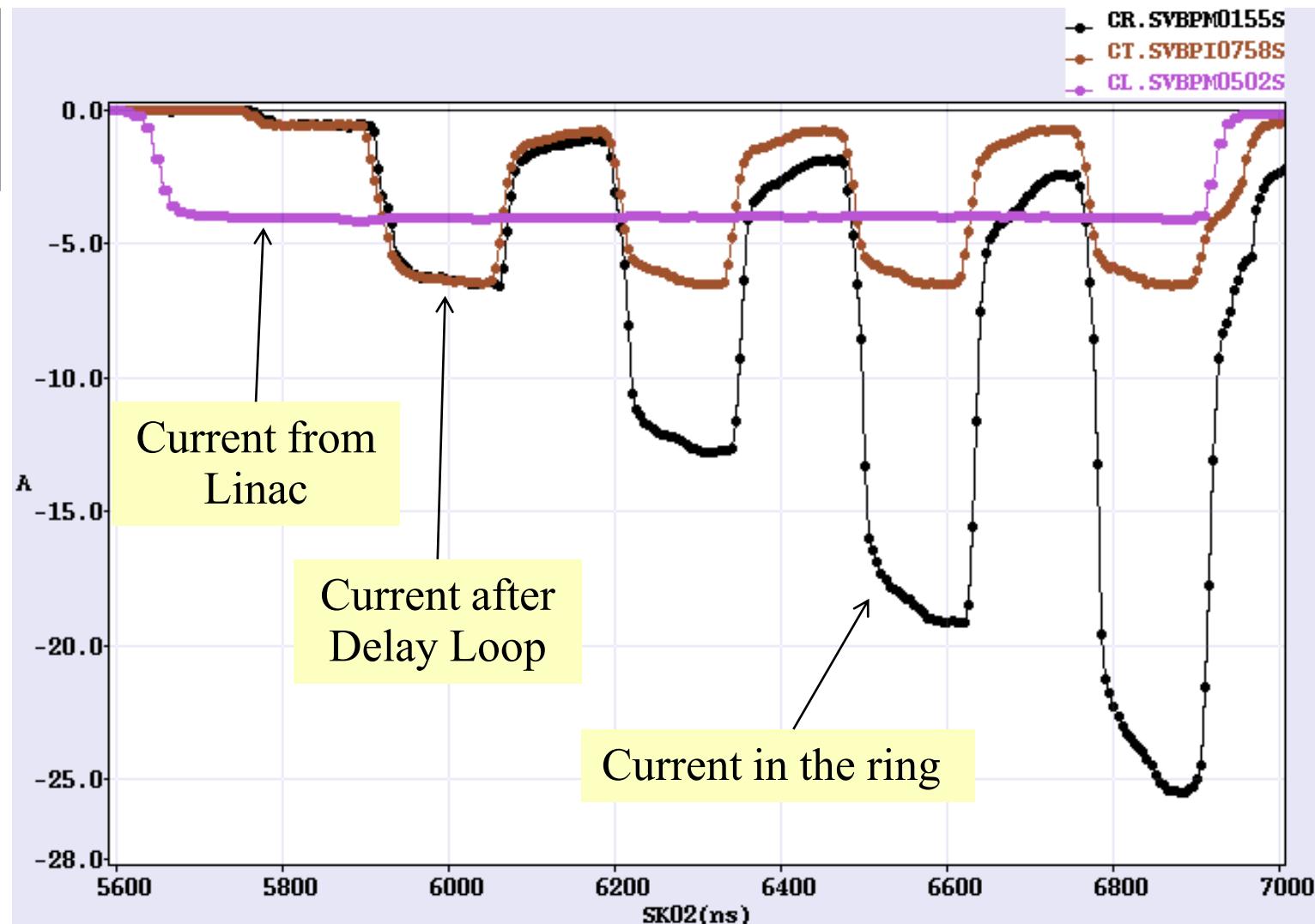
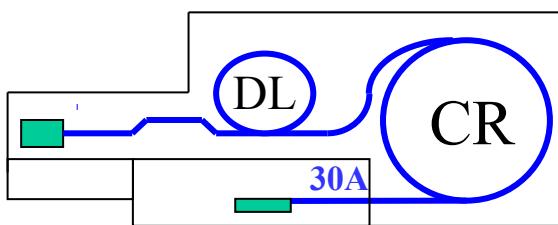
Combiner ring status

- factor 4 combination achieved with 15 A, 280 ns (without Delay Loop)



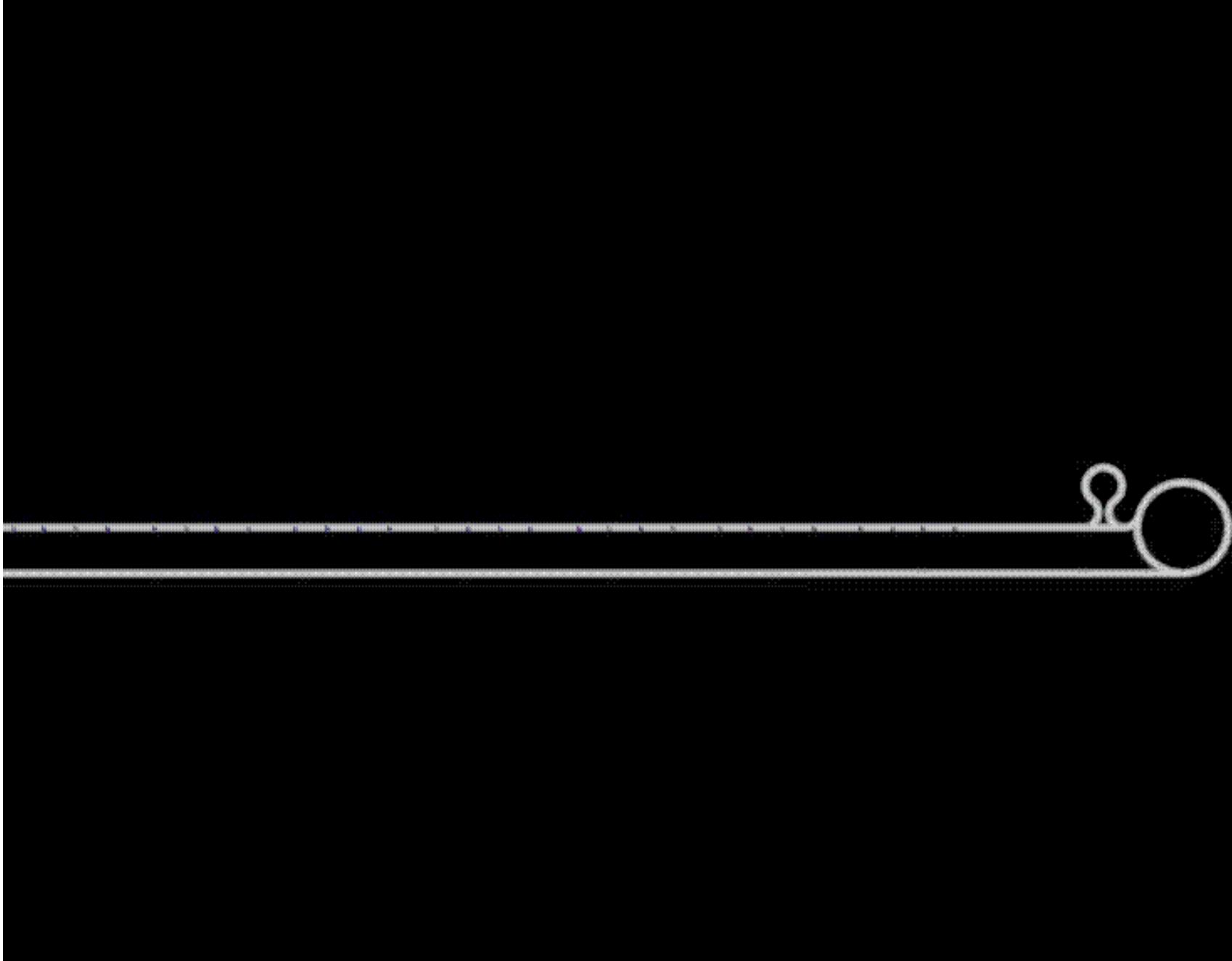
Factor 8 combination (DL+CR)

- ~26 A combination achieved, nominal 140 ns pulse length
- detailed studies still to be done

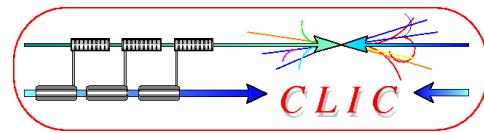




Lemmings Drive Beam



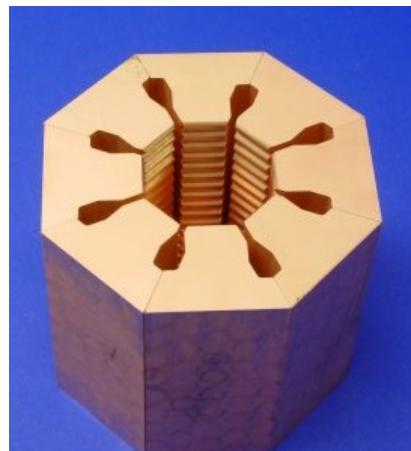
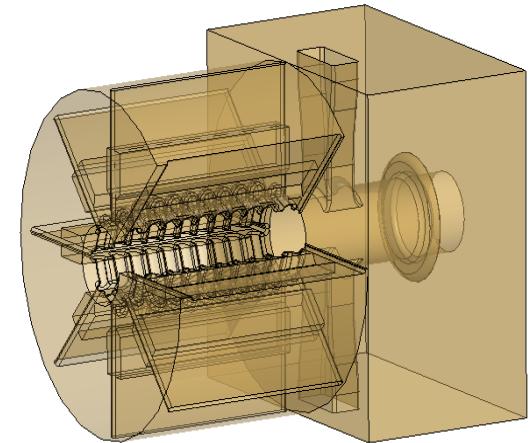
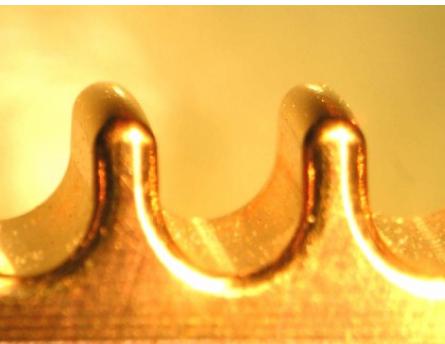
Alexandra
Andersson



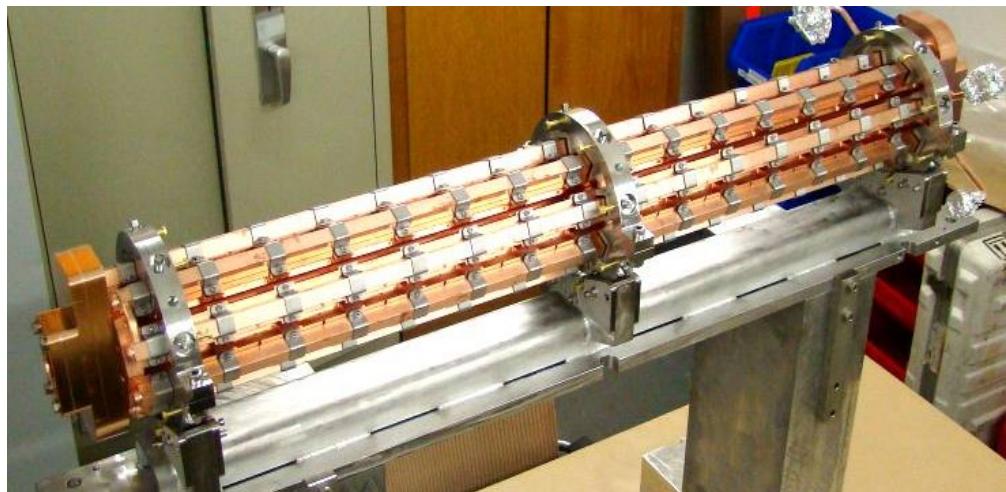
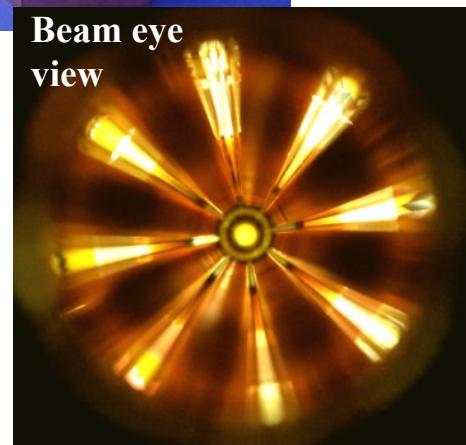
Power extraction structure PETS



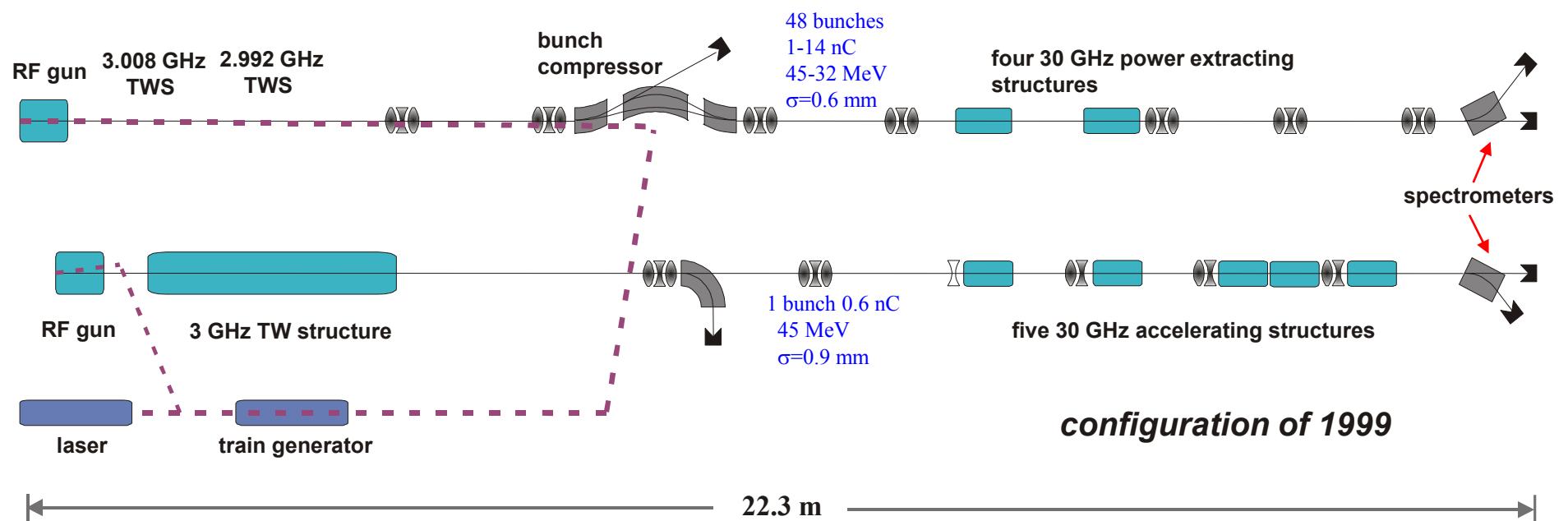
- must extract efficiently several 100 MW power from high current drive beam
- periodically corrugated structure with low impedance (big a/λ)
- ON/OFF mechanism



Beam eye view



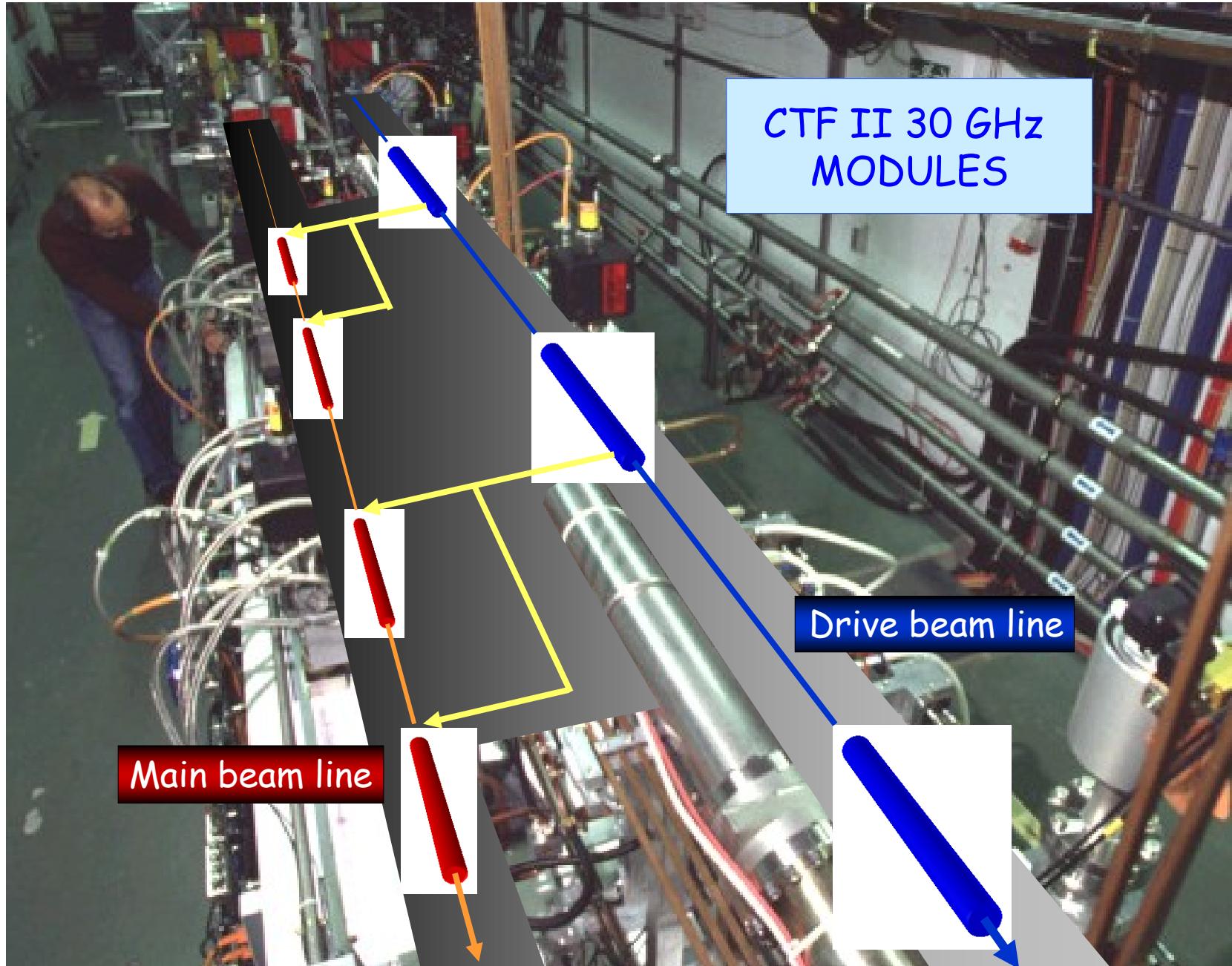
CLIC Test Facility CTF II

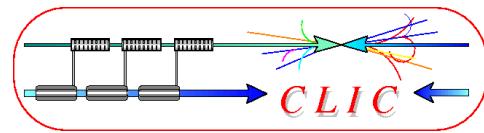


Dismantled in 2002, after having achieved its goals :

- Demonstrate feasibility of a two-beam acceleration scheme
- Provide high power 30 GHz RF source for high gradient testing (280 MW, 16 ns pulses)
- Study generation of short, intense e-bunches using photocathode RF guns
- Demonstrate operability of μ -precision active-alignment system in accelerator environment
- Provide a test bed to develop and test accelerator diagnostic equipment

CLIC Test Facility CTF II

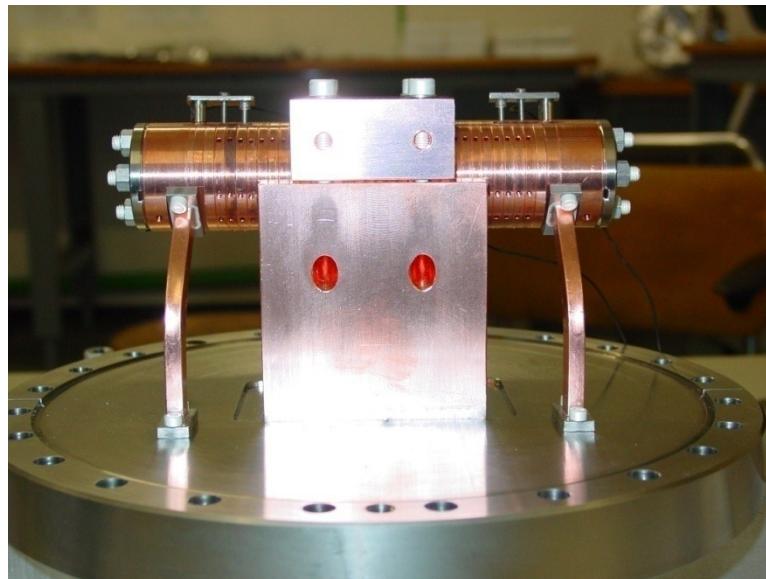




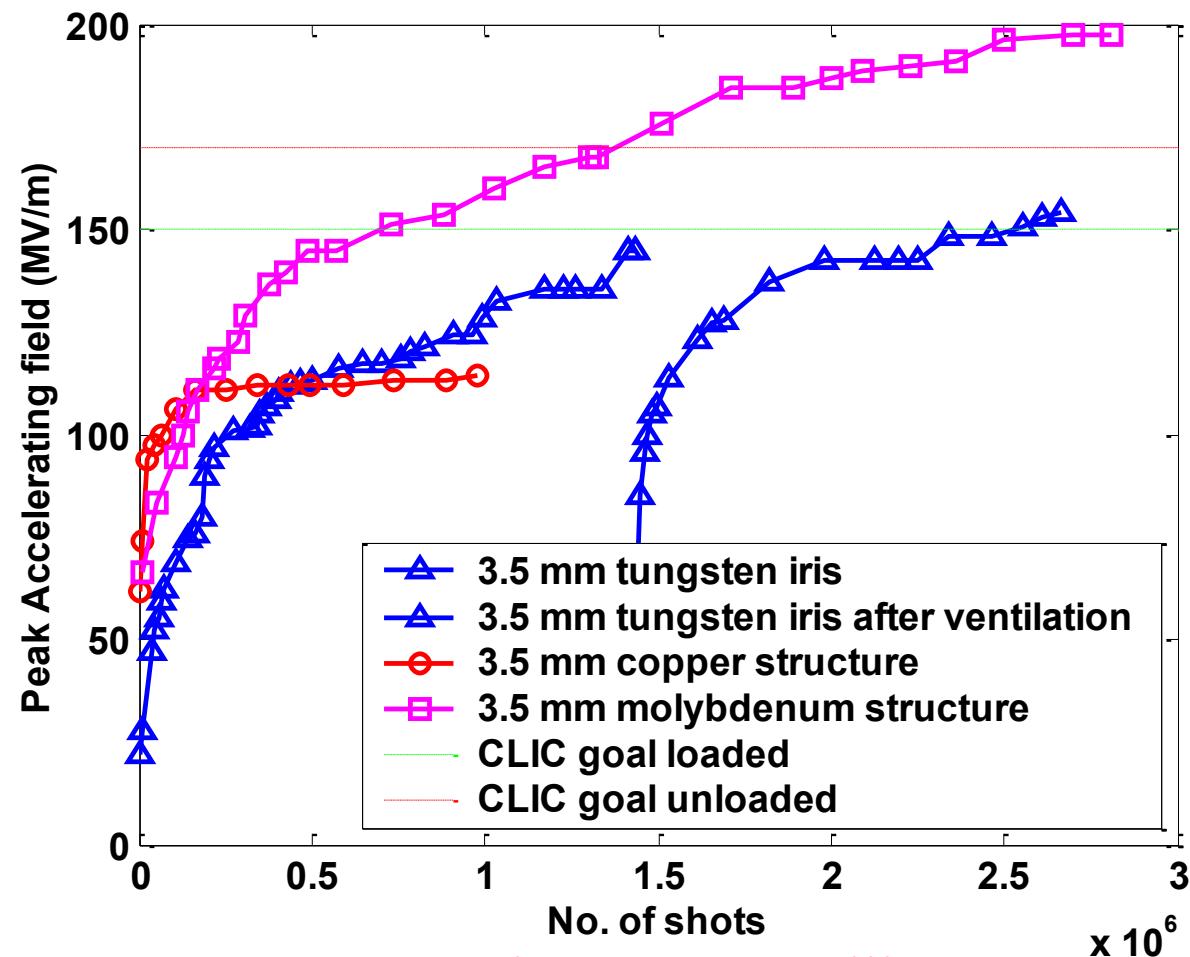
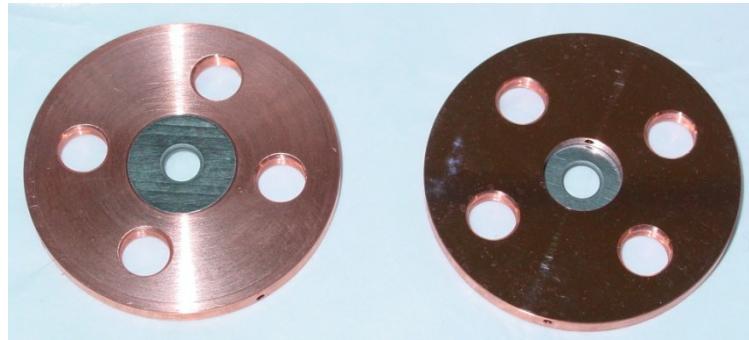
Achieved accelerating fields in CTF2



High gradient tests of 30 GHz structures with molybdenum irises reached **190 MV/m** peak accelerating gradient **without any damage** well above the nominal CLIC accelerating field of **150 MV/m** but with RF pulse length of **16 ns** only (nominal **160 ns**)



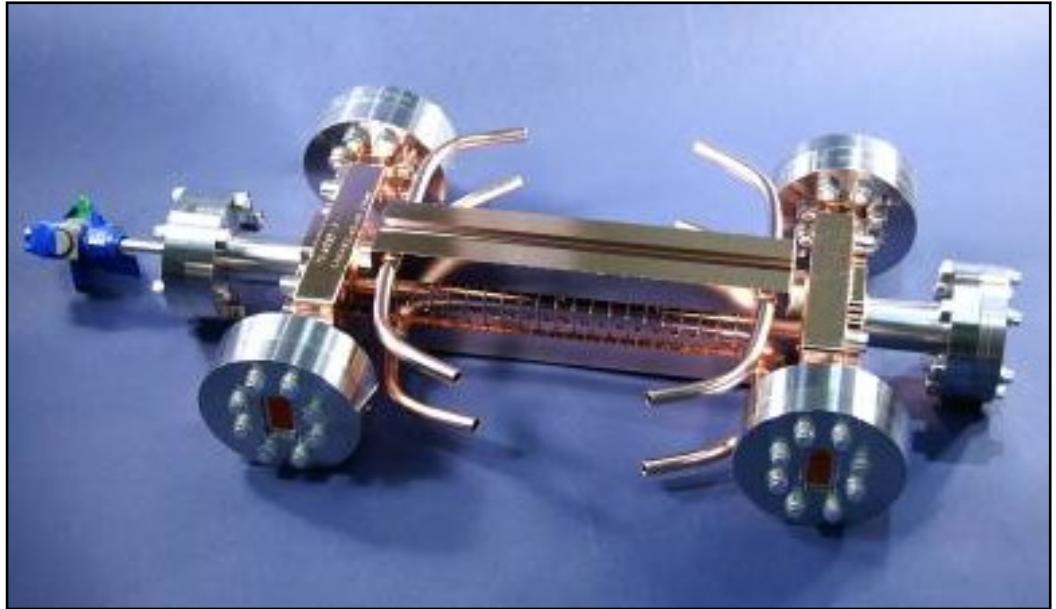
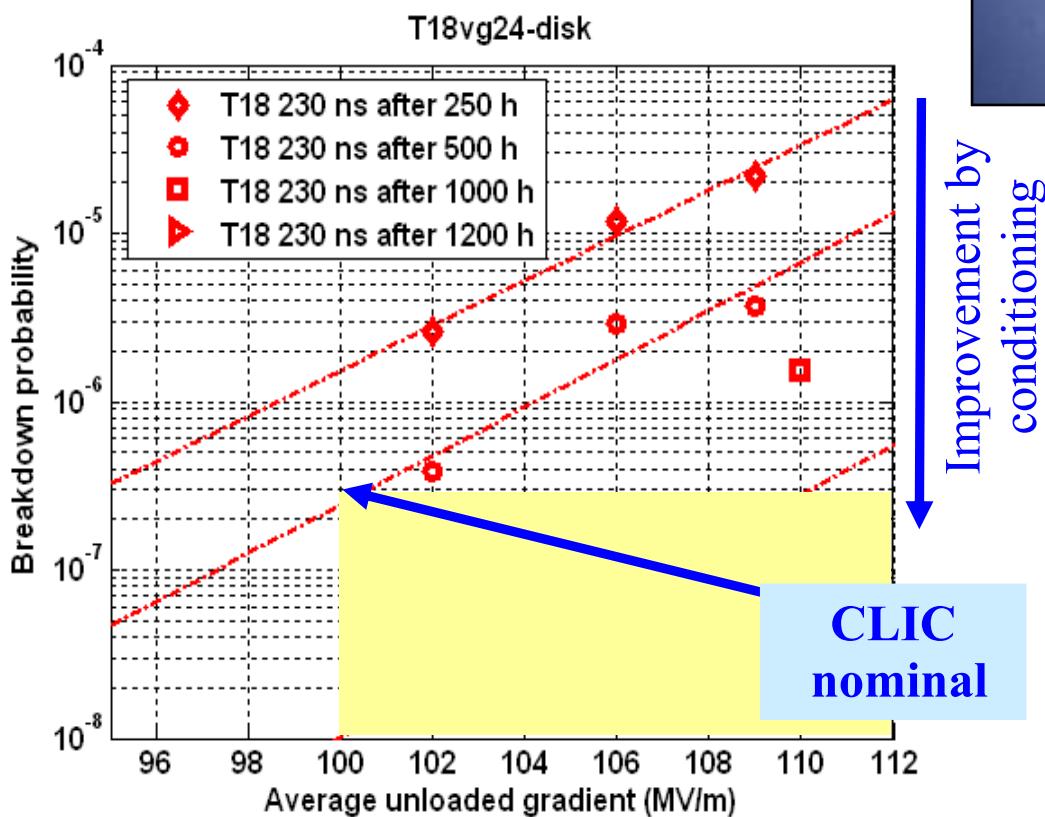
30 cell clamped tungsten-iris structure



A world record !!!

Present best structure performance

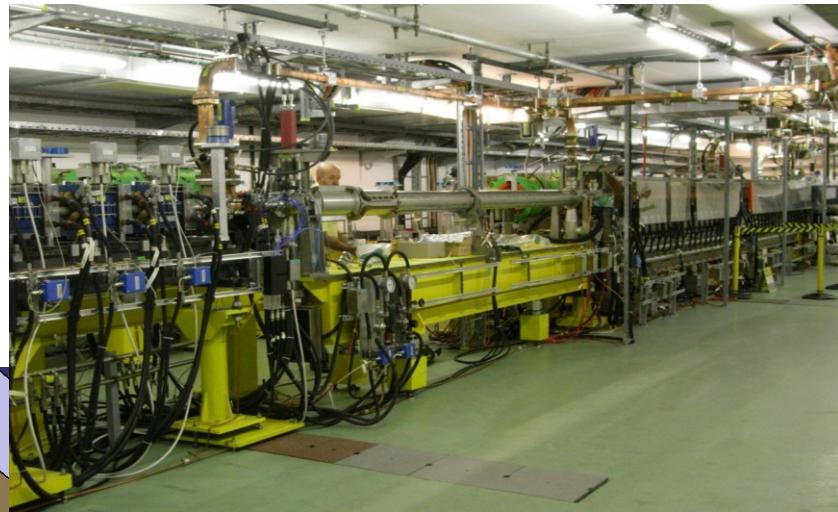
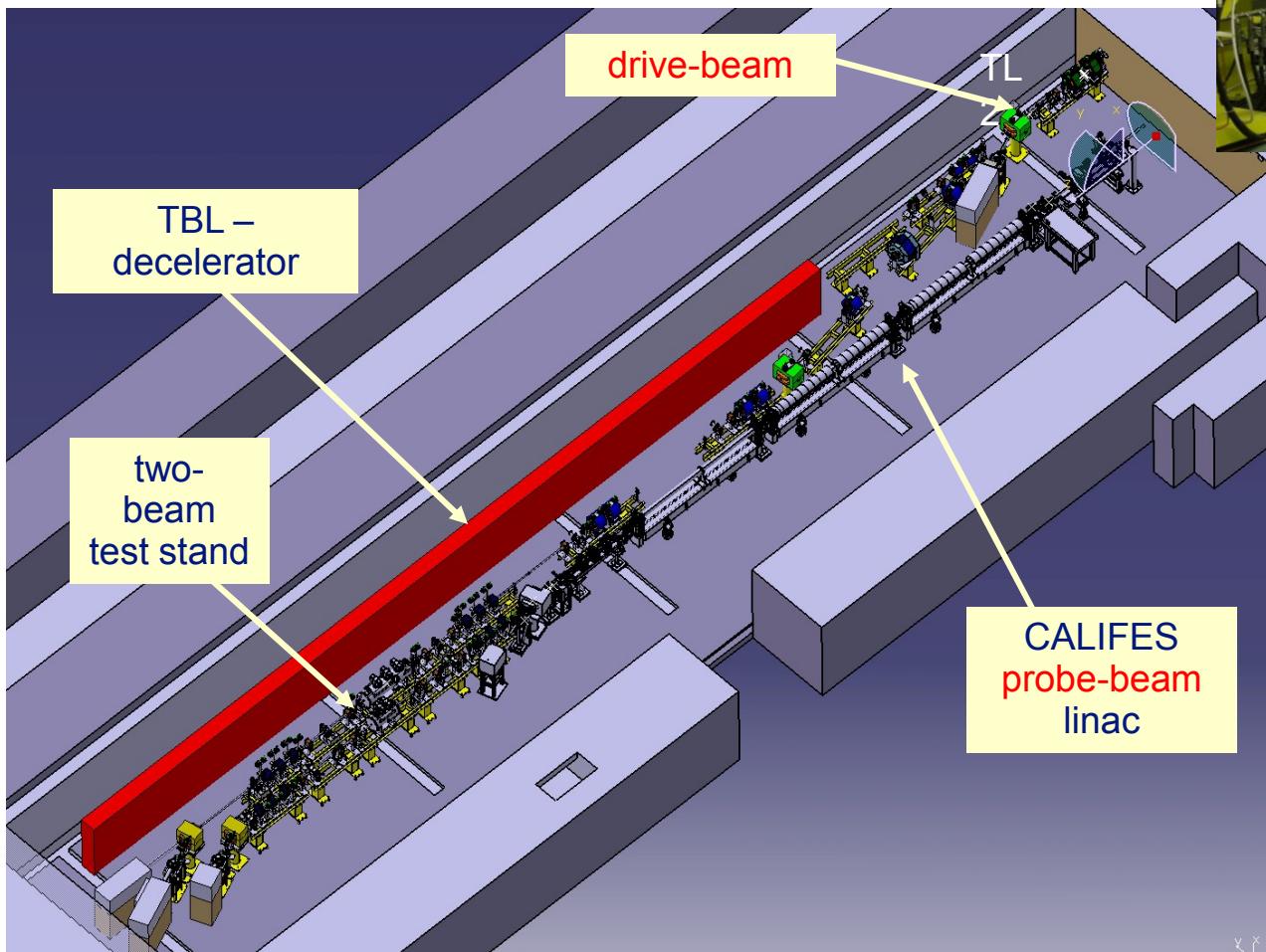
- Exceeded 100 MV/m at nominal CLIC pulse length and breakdown rate



Frequency:	11.424 GHz
Cells:	18+2 matching cells
Filling Time:	36 ns
Length: active acceleration	18 cm
Iris Dia. a/λ	0.155~0.10
Group Velocity: vg/c	2.6-1.0 %
Phase Advance Per Cell	$2\pi/3$
Power for $\langle E_a \rangle = 100 \text{ MV/m}$	55.5 MW
Unloaded $E_a(\text{out})/E_a(\text{in})$	1.55
E_s/E_a	2

CLEX test area

- Deceleration and two-beam tests
- High power tests of PETs and accelerating structures



Conclusions

- CTF3 is to show the CLIC feasibility until 2010
 - stable Drive Beam generation
 - high gradient RF performance
- many **important results** obtained **so far**
- key issues still to demonstrate
- challenging but very interesting
- next: the visit