

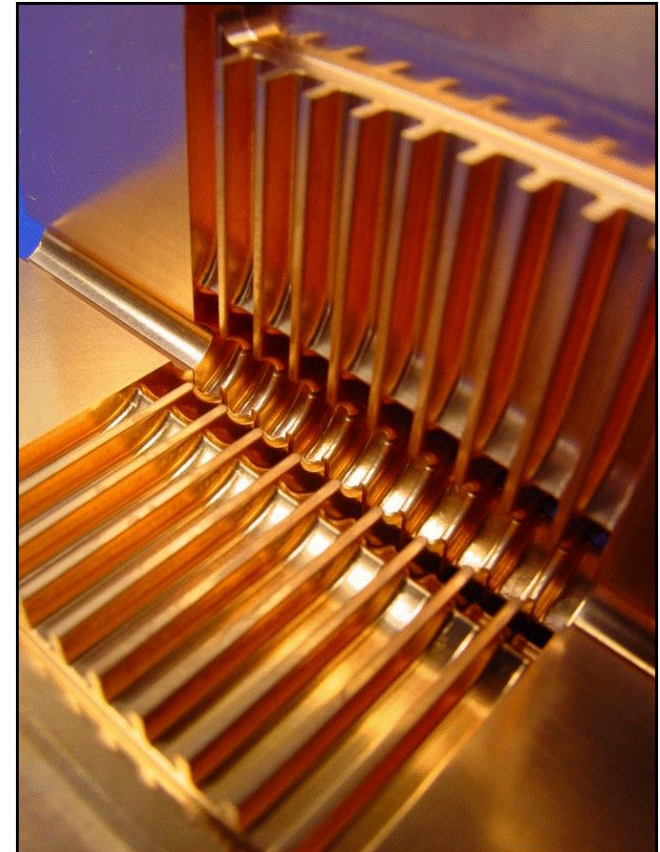


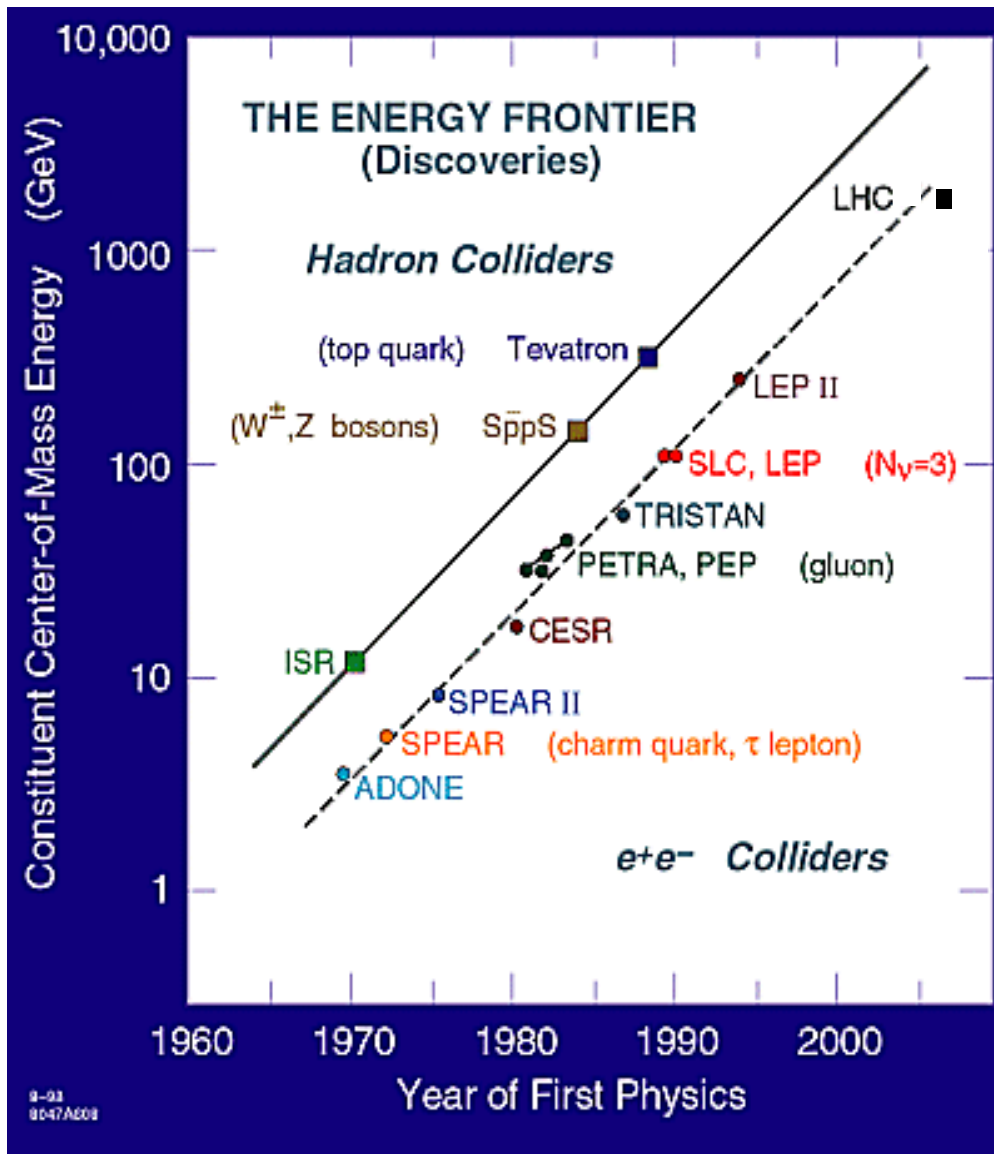
CLIC / CTF 3



Frank Tecker - BE/OP

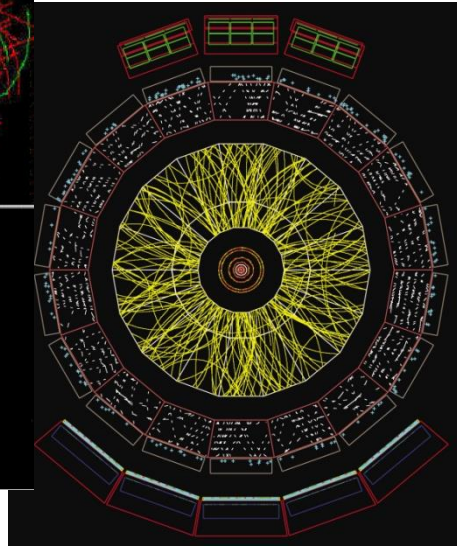
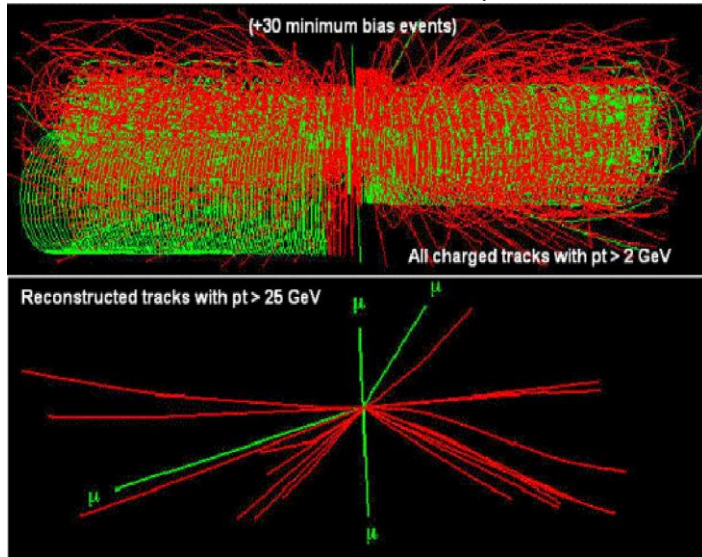
- Introduction CLIC / CTF 3
- Visit of CTF3





- History:
 - Energy constantly increasing with time
 - Hadron Colliders at the energy frontier
 - Lepton Colliders for precision physics
- LHC has found the Higgs with $m_H = 126 \text{ GeV}/c^2$
- A future Lepton Collider would complement LHC physics

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

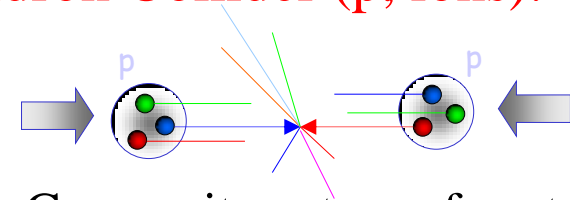


ALICE: Ion event



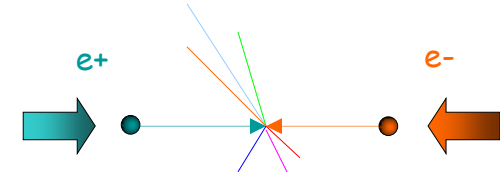
LEP event: $Z^0 \rightarrow 3 \text{ jets}$

● Hadron Collider (p, ions):



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

● Lepton Collider:

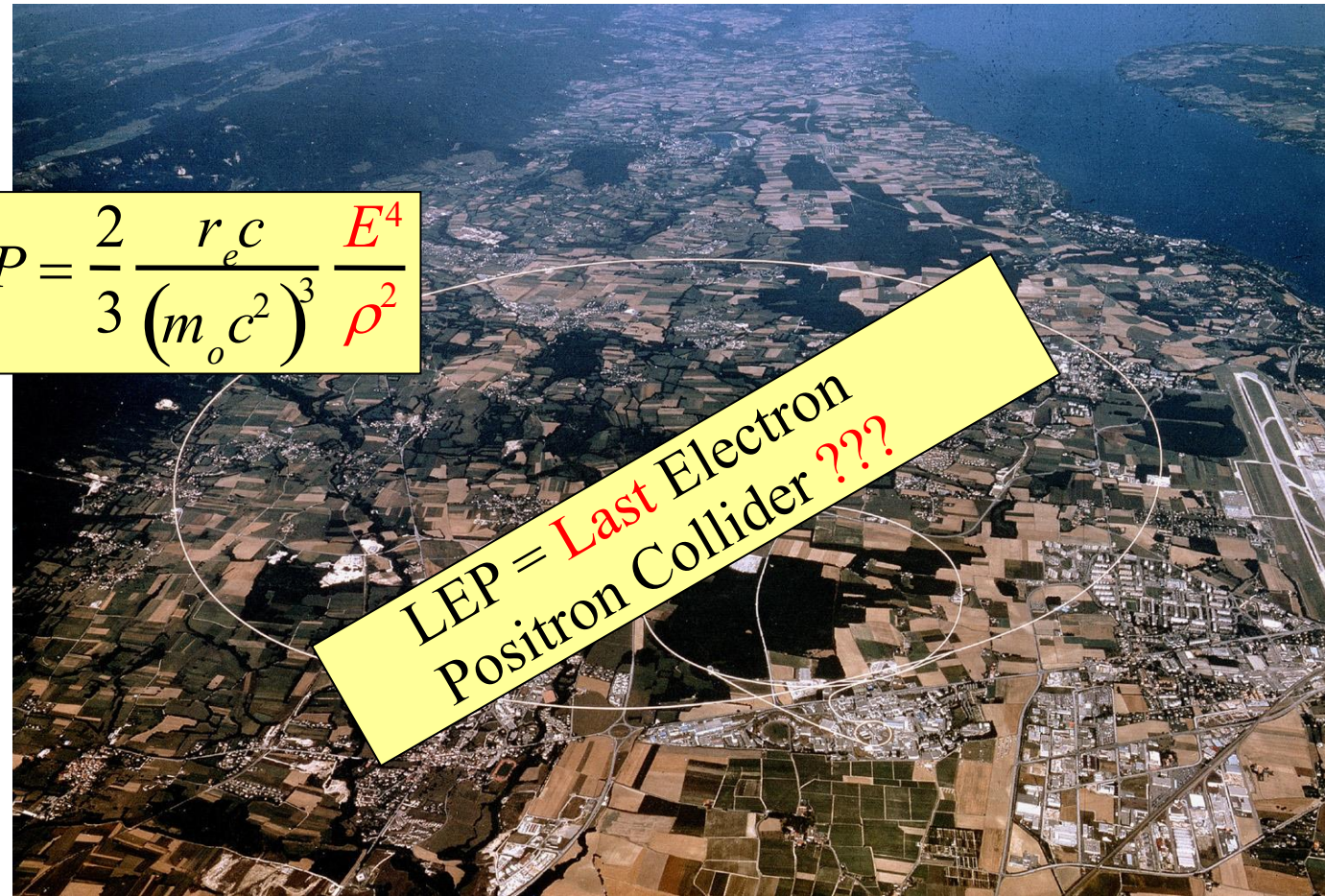


- Elementary particles
- Well defined initial state
- Beam polarization
- produces particles democratically
- Momentum conservation eases decay product analysis

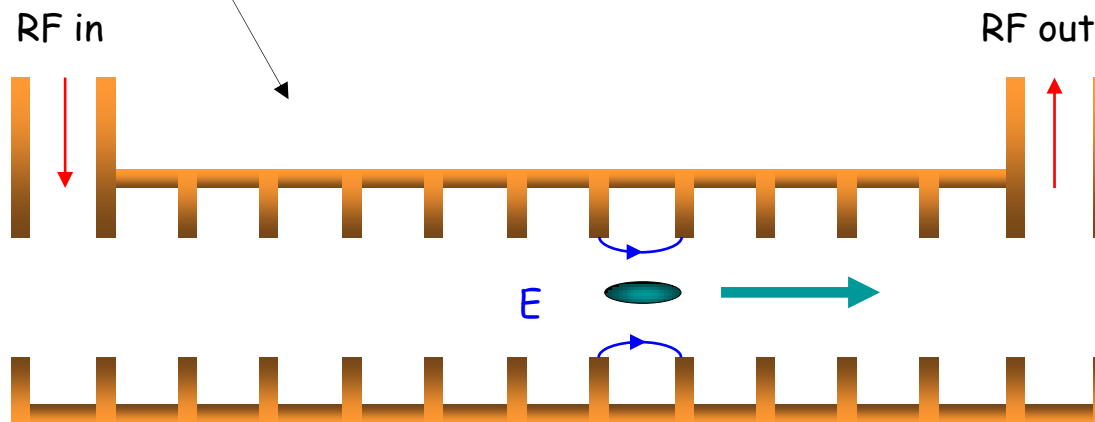
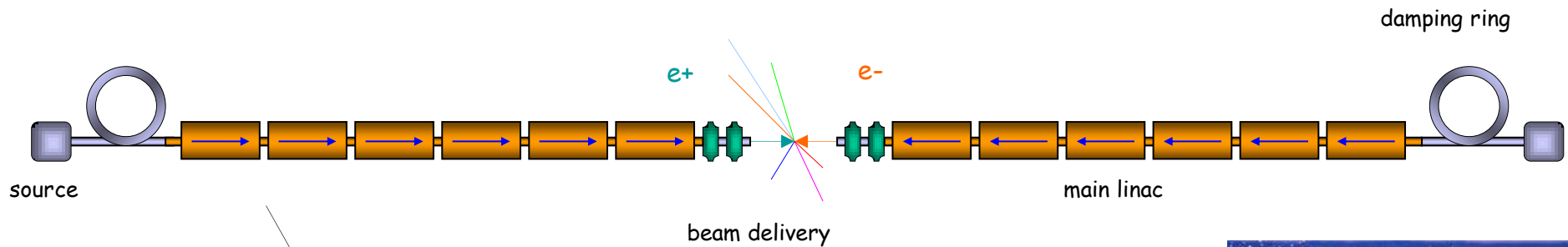
Much more **precise analysis** with **leptons**
 \Rightarrow **precision measurements** of particle properties

- LEP (Large Electron Positron collider) was installed in LHC tunnel
- $e^+ e^-$ circular collider (27 km) with $E_{\text{cm}}=200 \text{ GeV}$
- 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!

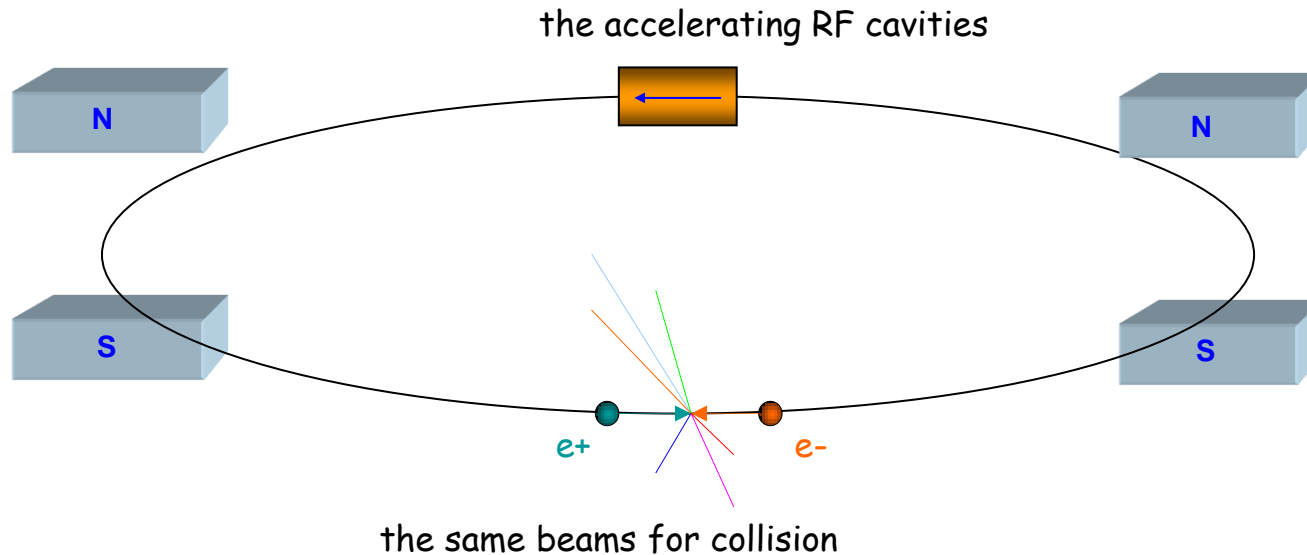
$$P = \frac{2}{3} \frac{r_e c}{(m_0 c^2)^3} \frac{E^4}{\rho^2}$$



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



particles "surf" the electromagnetic wave



• Storage rings:

- accelerate + collide every turn
- 're-use' RF + 're-use' particles
- => efficient

• Linear Collider:

- one-pass acceleration + collision
- => need
- high gradient (acceleration)
- small beam size
- to reach high event rate (Luminosity)

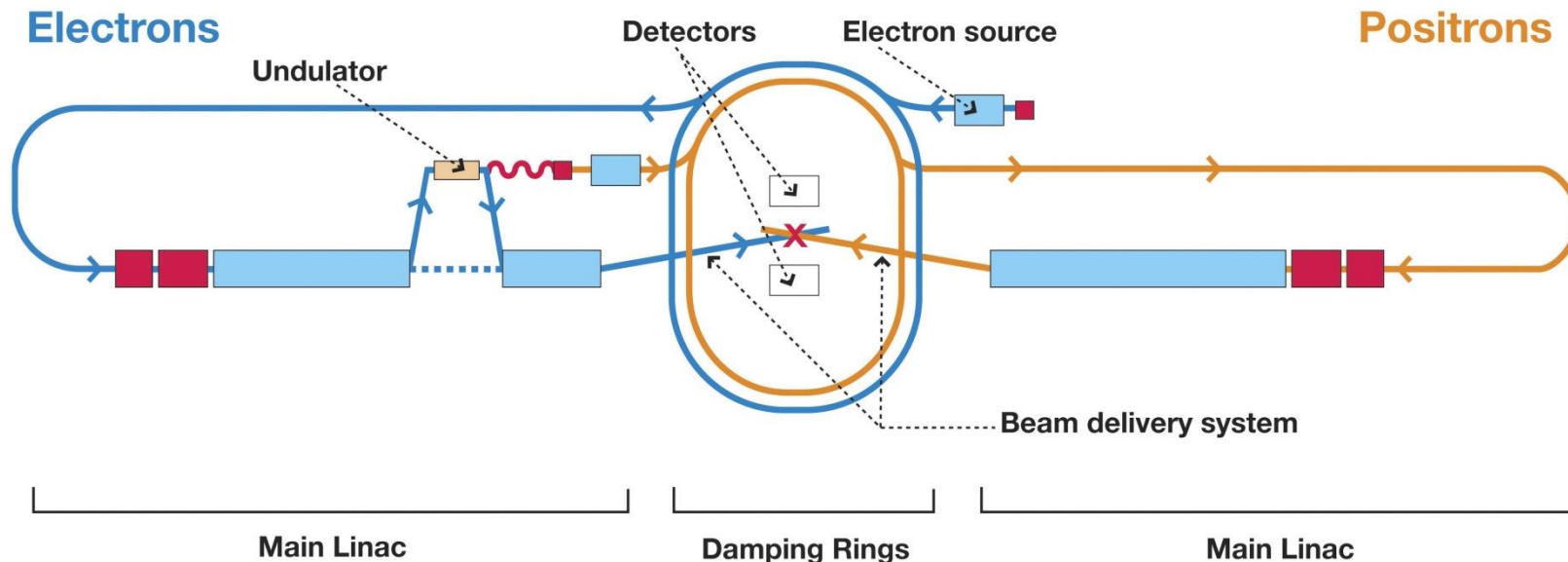
• ILC (International Linear Collider)

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

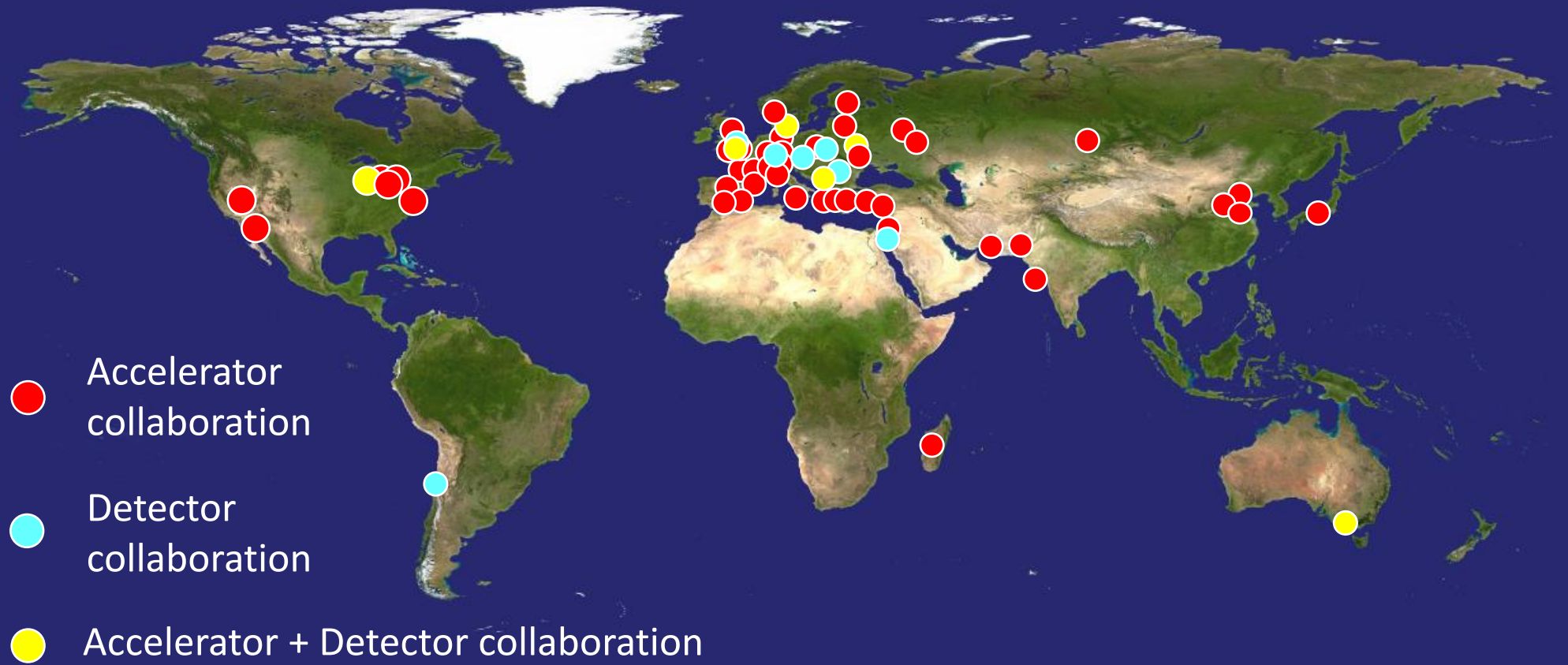
• CLIC (Compact Linear Collider)

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

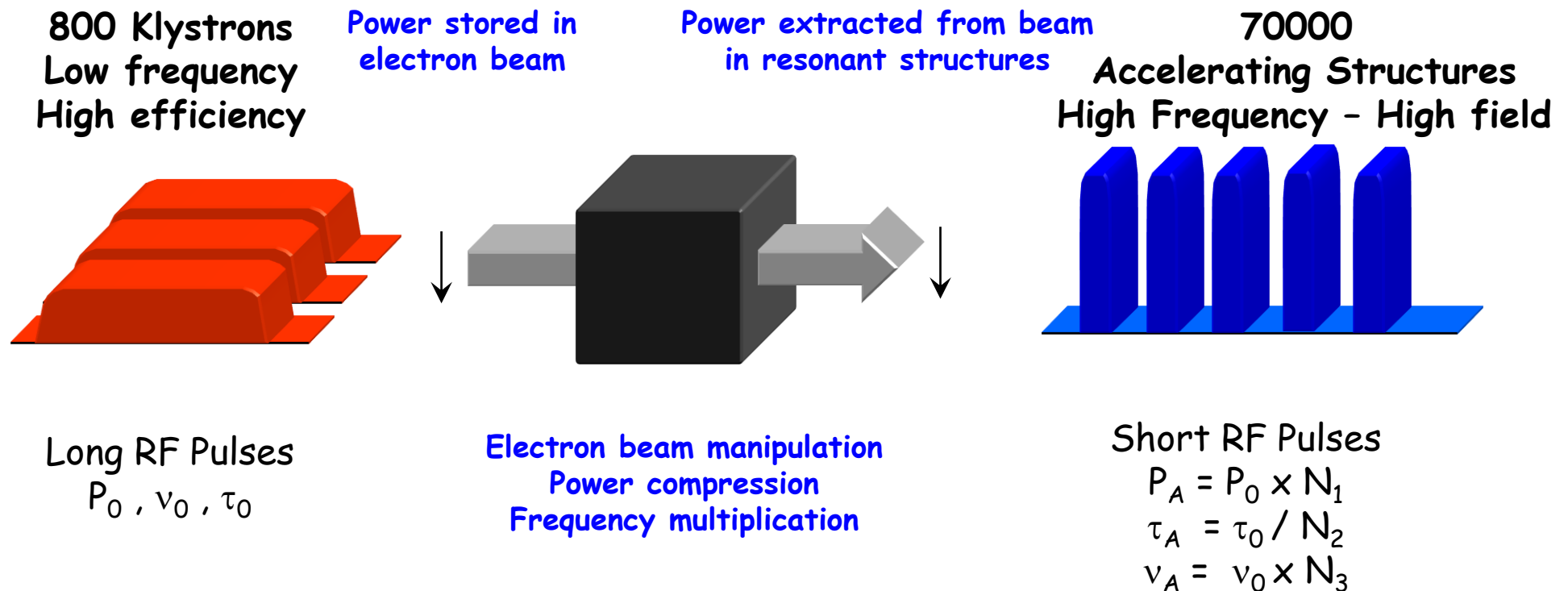
~35 km total length



CLIC Collaboration: 31 Countries – over 70 Institutes

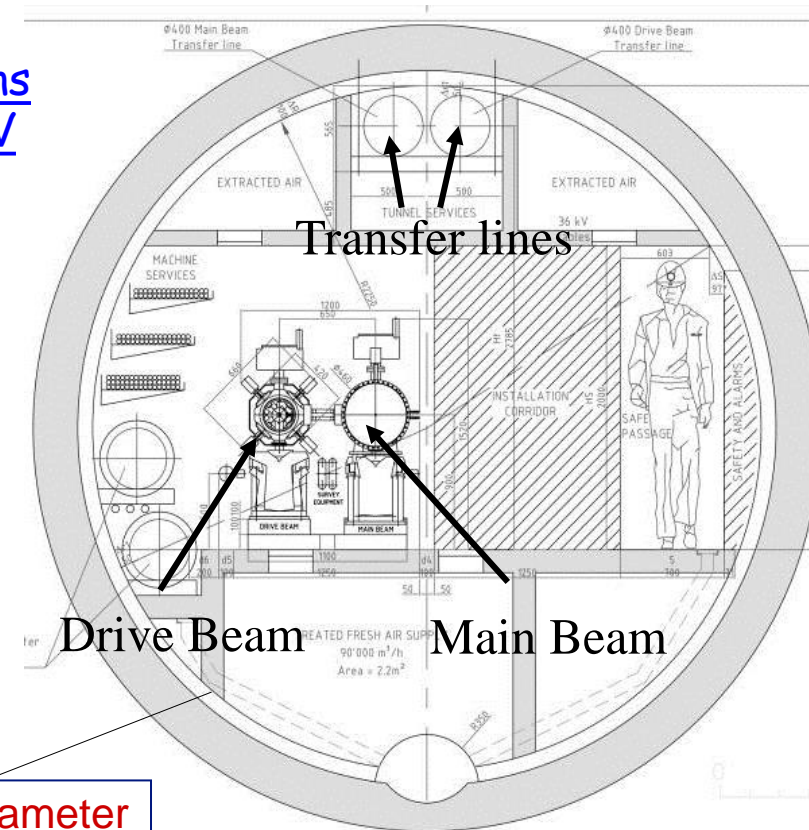
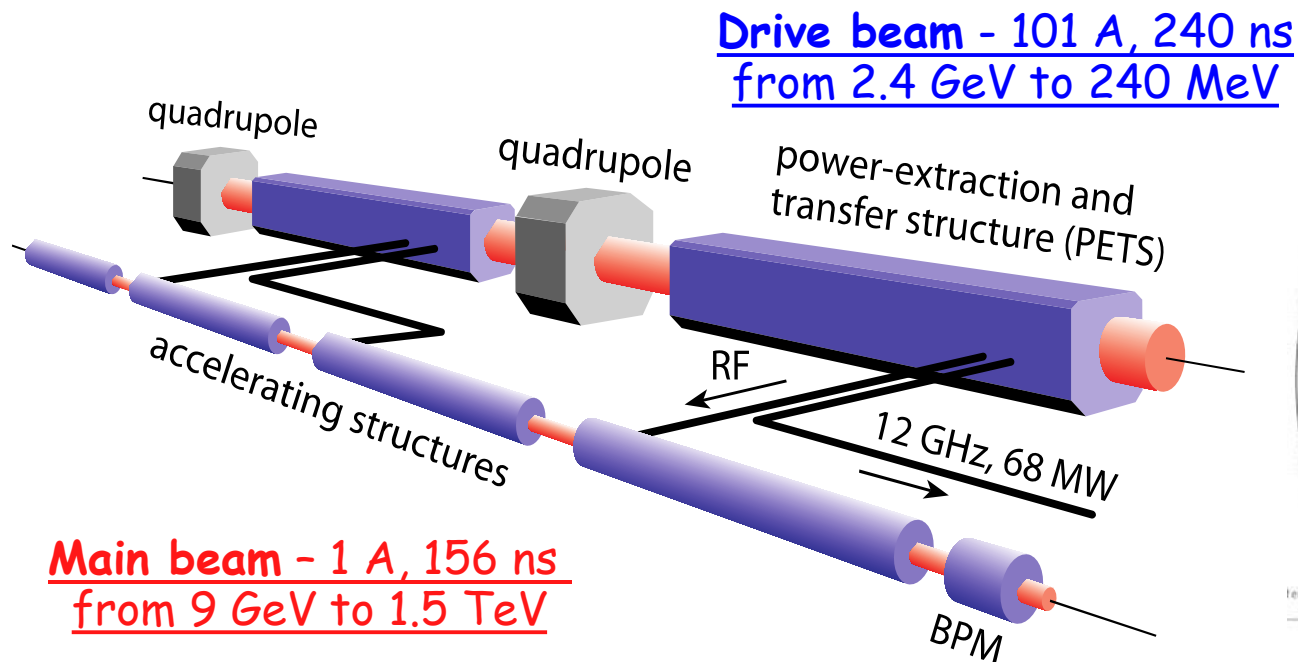


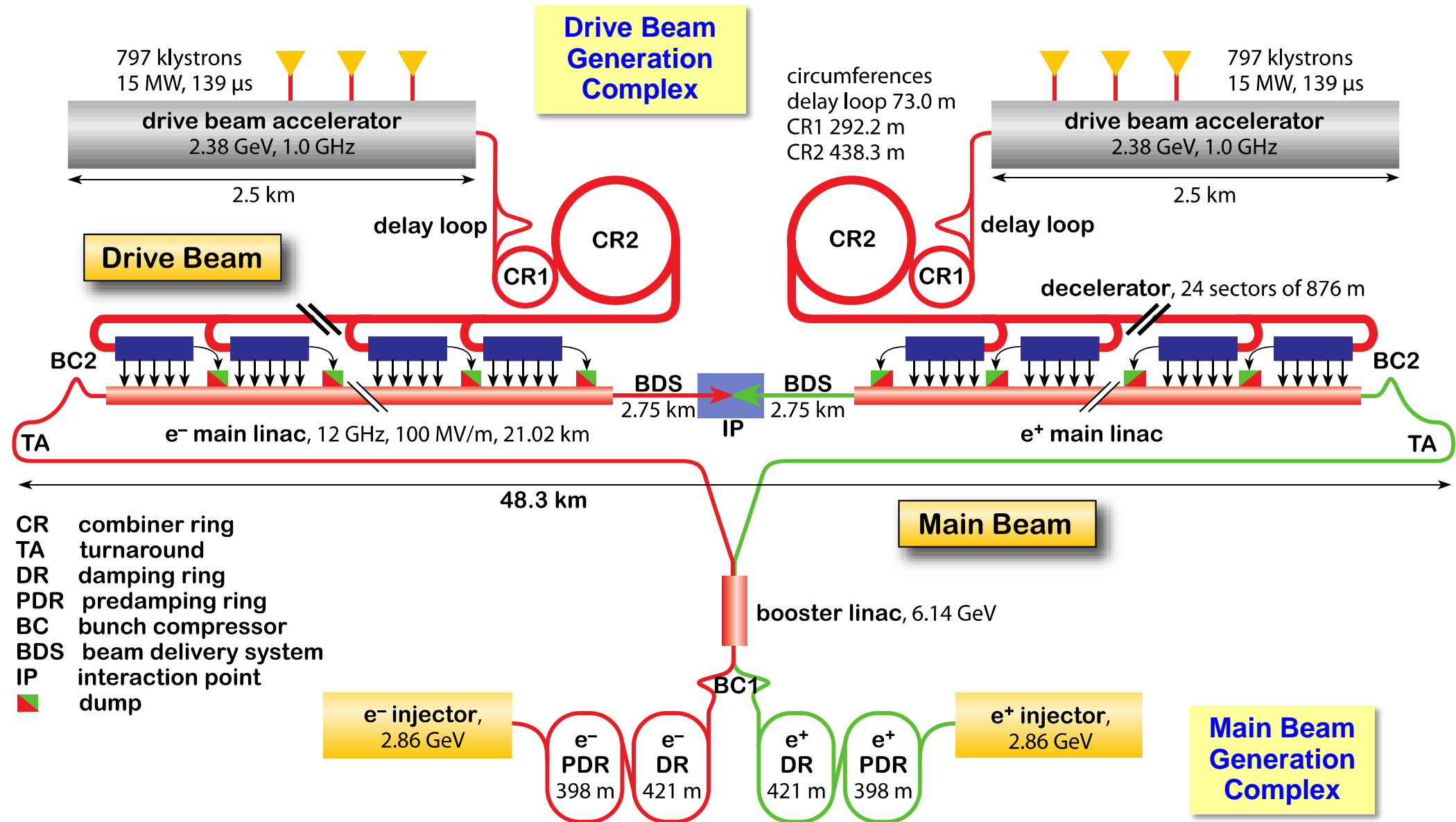
- **Very high gradients** possible with NC accelerating structures at high RF frequencies (**12 → 30 GHz**) for **short RF pulses**
- Extract RF power from an **intense** electron “**drive beam**”
- Generate **efficiently** long pulse and compress it (in power + frequency)



- High charge **Drive Beam** (low energy)
- Low charge **Main Beam** (high collision energy)
- => Simple tunnel, no active elements
- => Modular, easy energy upgrade in stages

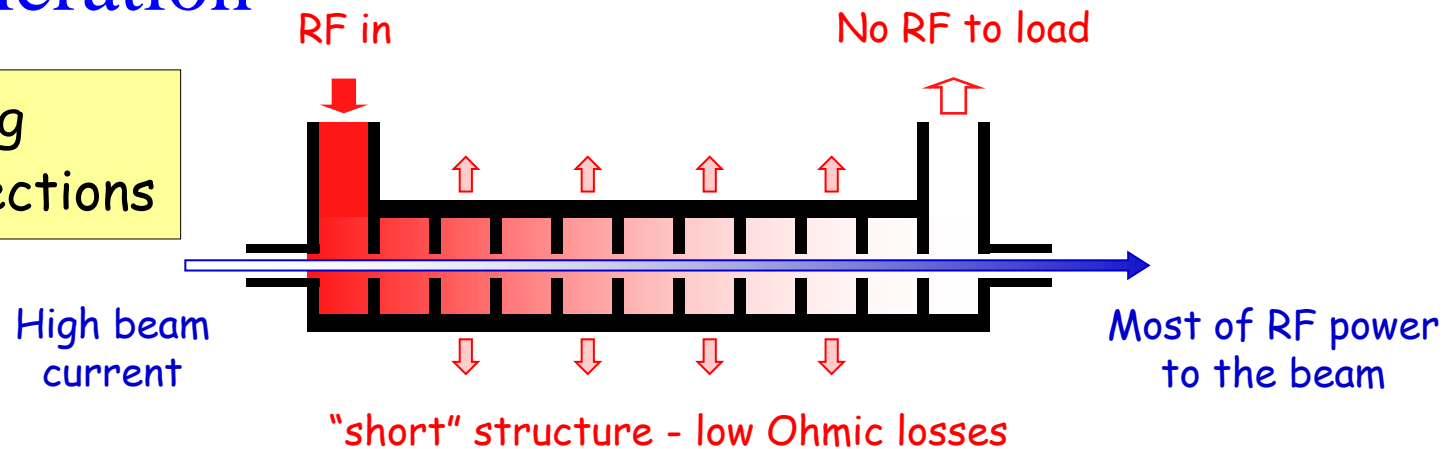
CLIC TUNNEL CROSS-SECTION





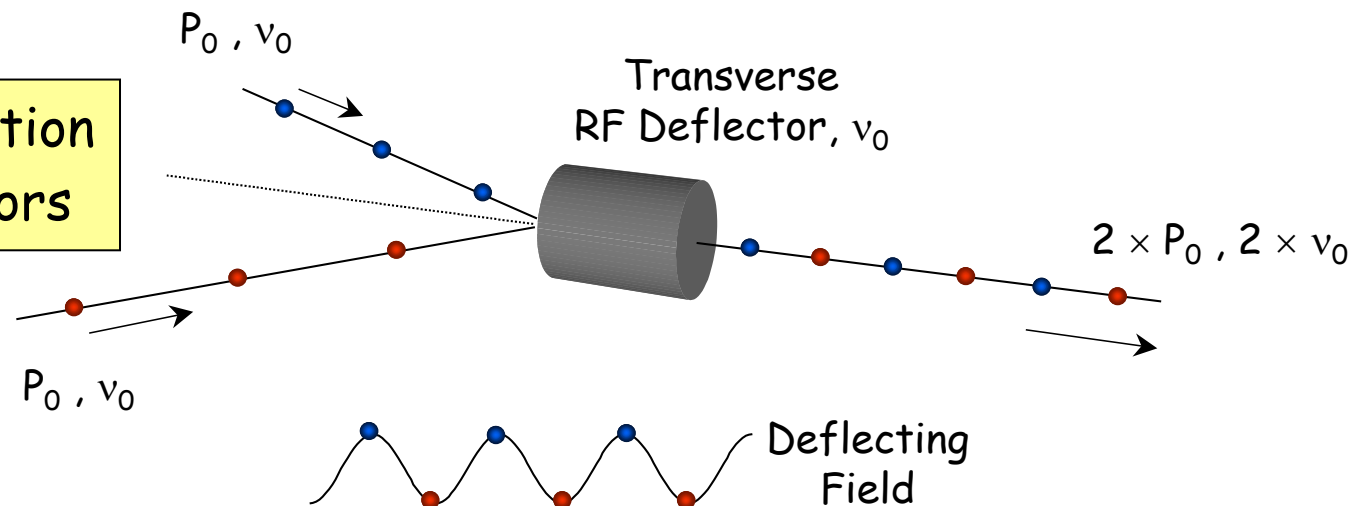
Efficient acceleration

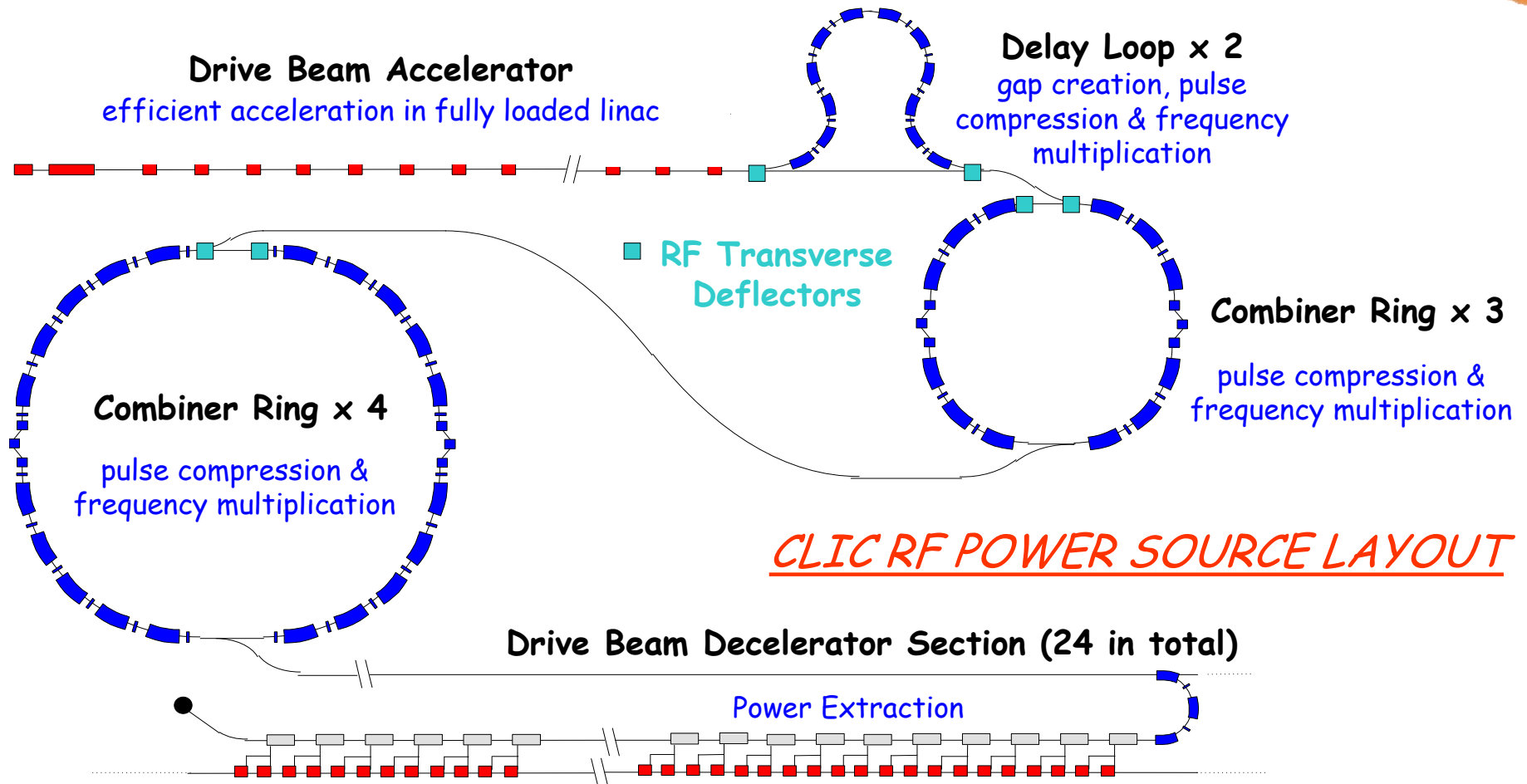
Full beam-loading
acceleration in TW sections



Frequency multiplication

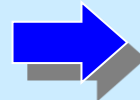
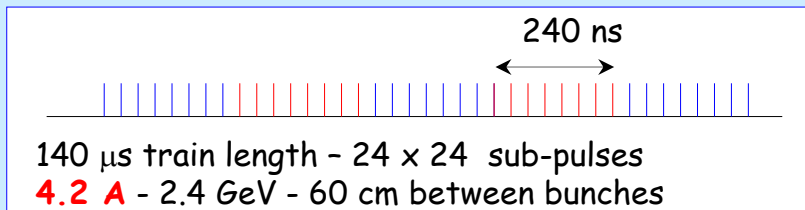
Beam combination/separation
by transverse RF deflectors



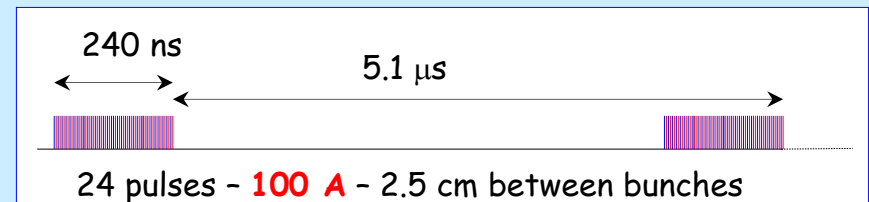


CLIC RF POWER SOURCE LAYOUT

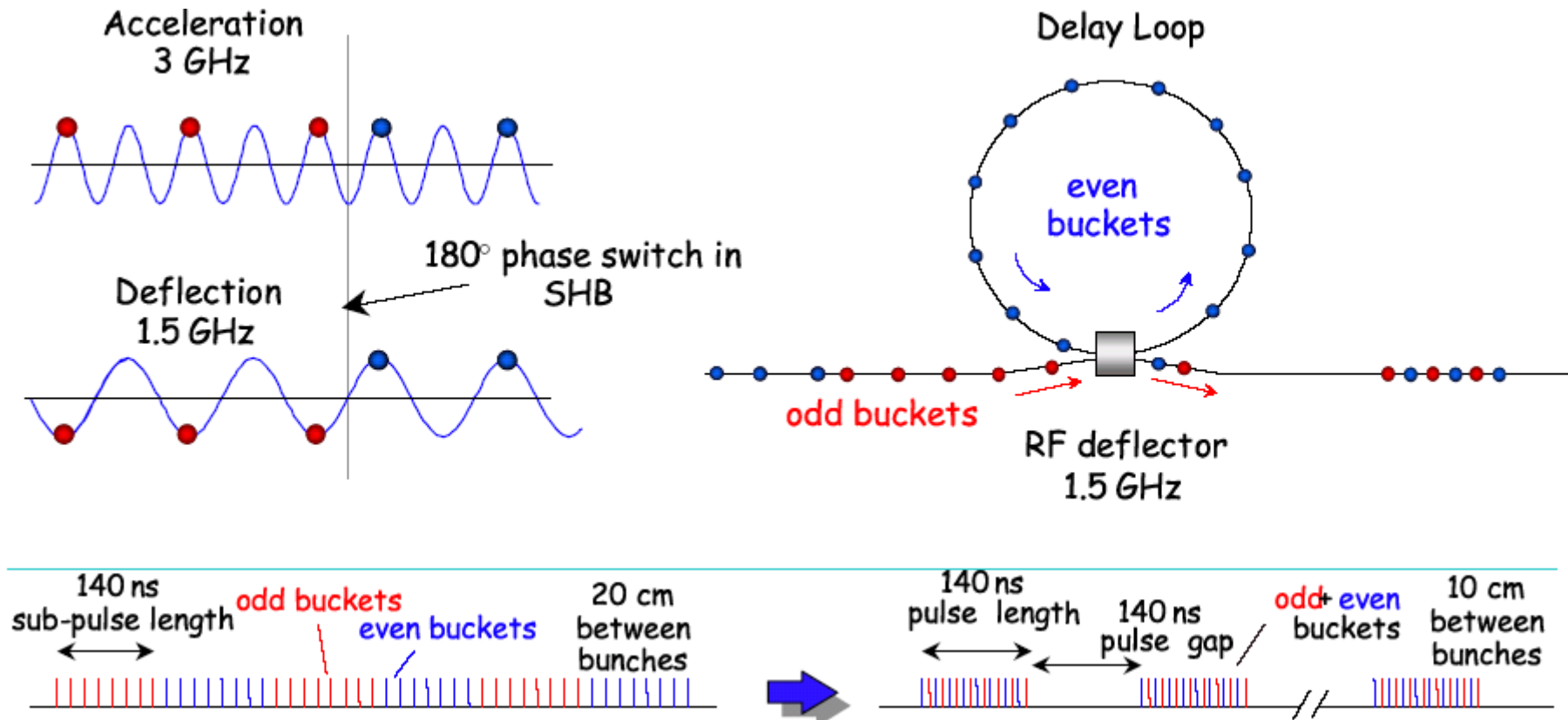
Drive beam time structure - initial



Drive beam time structure - final



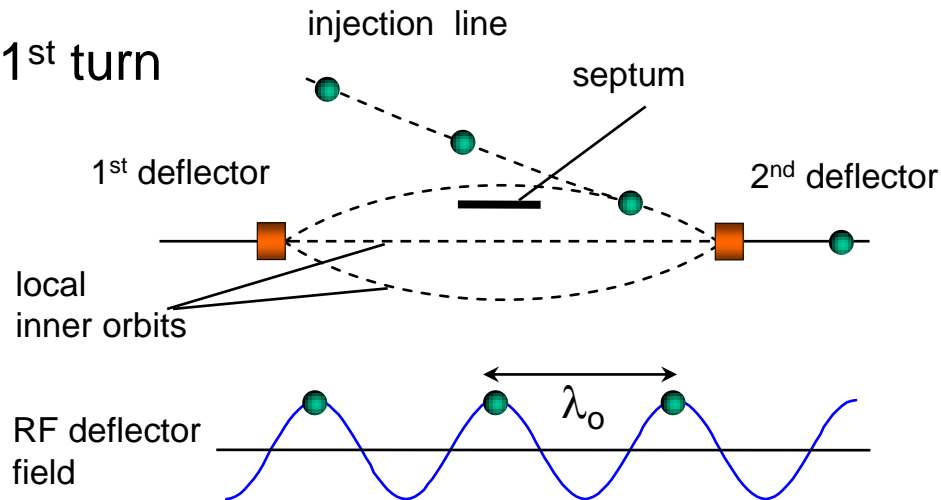
- double repetition frequency and current
- parts of bunch train delayed in loop
- RF deflector combines the bunches



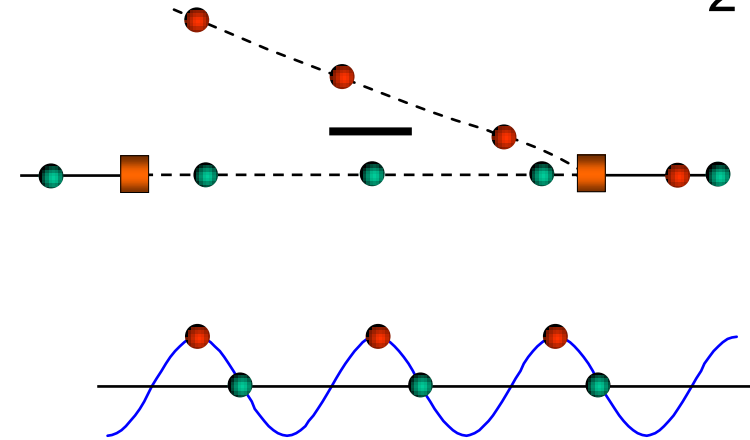
- combination factors up to 5 reachable in a ring

$$C_{ring} = (n + 1/4) \lambda$$

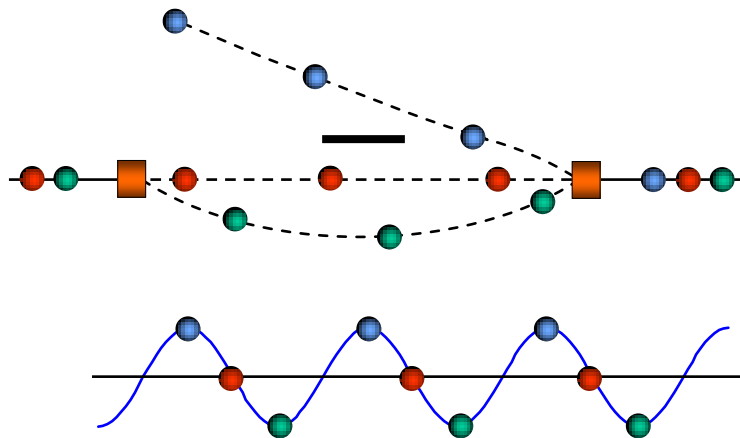
1st turn



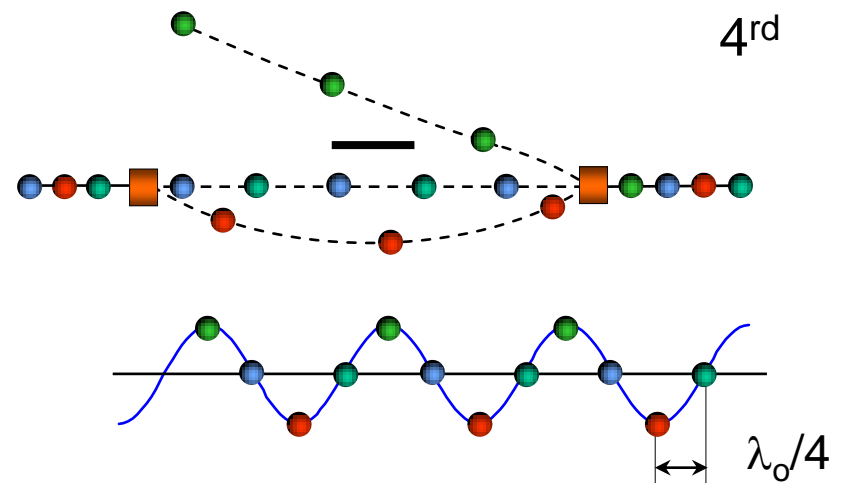
2nd



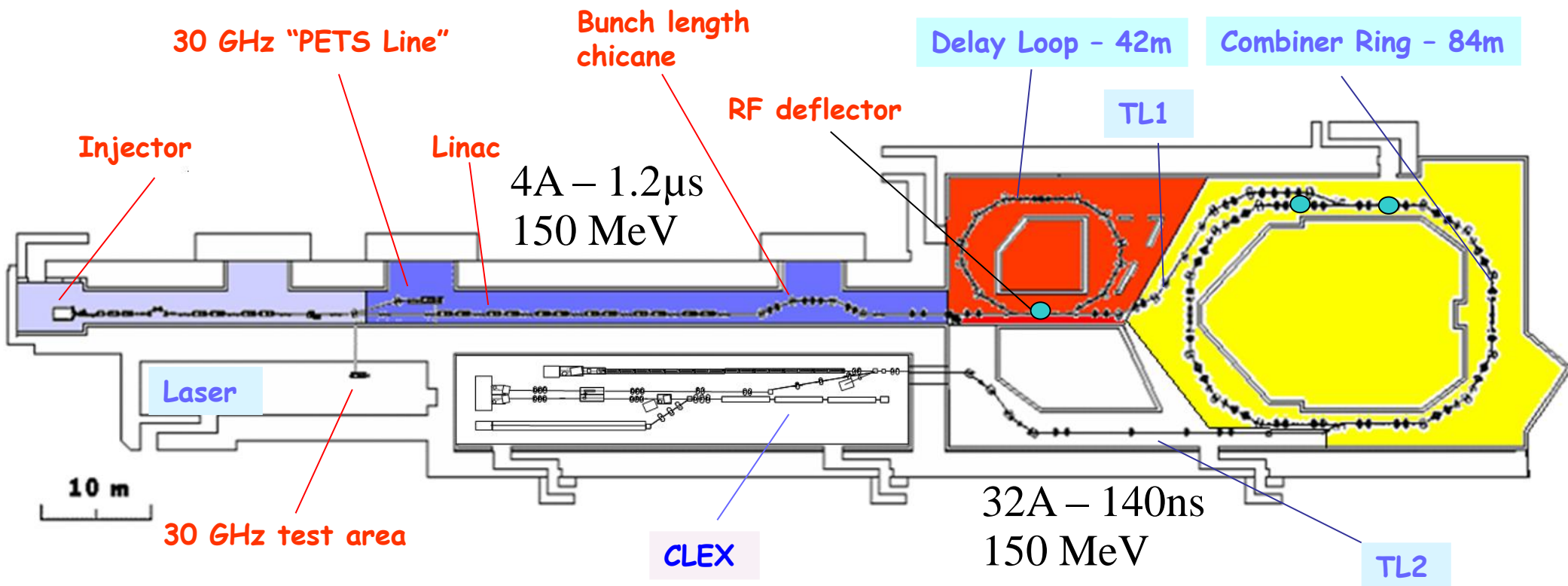
3rd



4rd



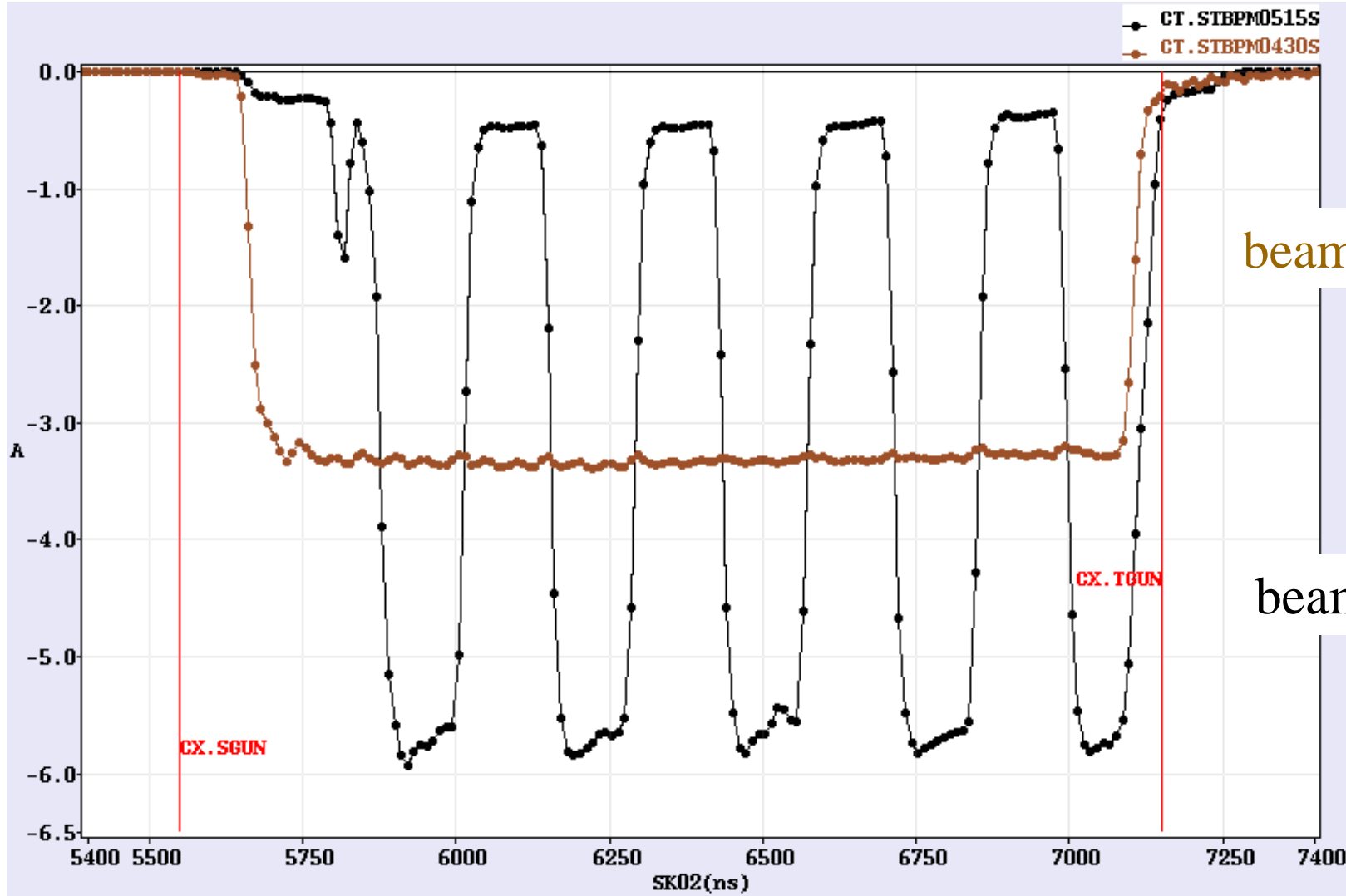
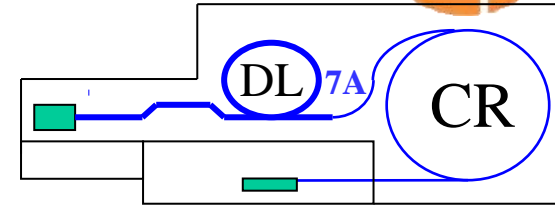
- demonstrate remaining **CLIC feasibility** issues, in particular:
 - **Drive Beam generation** (fully loaded acceleration, bunch frequency multiplication)
 - **CLIC accelerating structures**
 - **CLIC power production structures (PETS)**

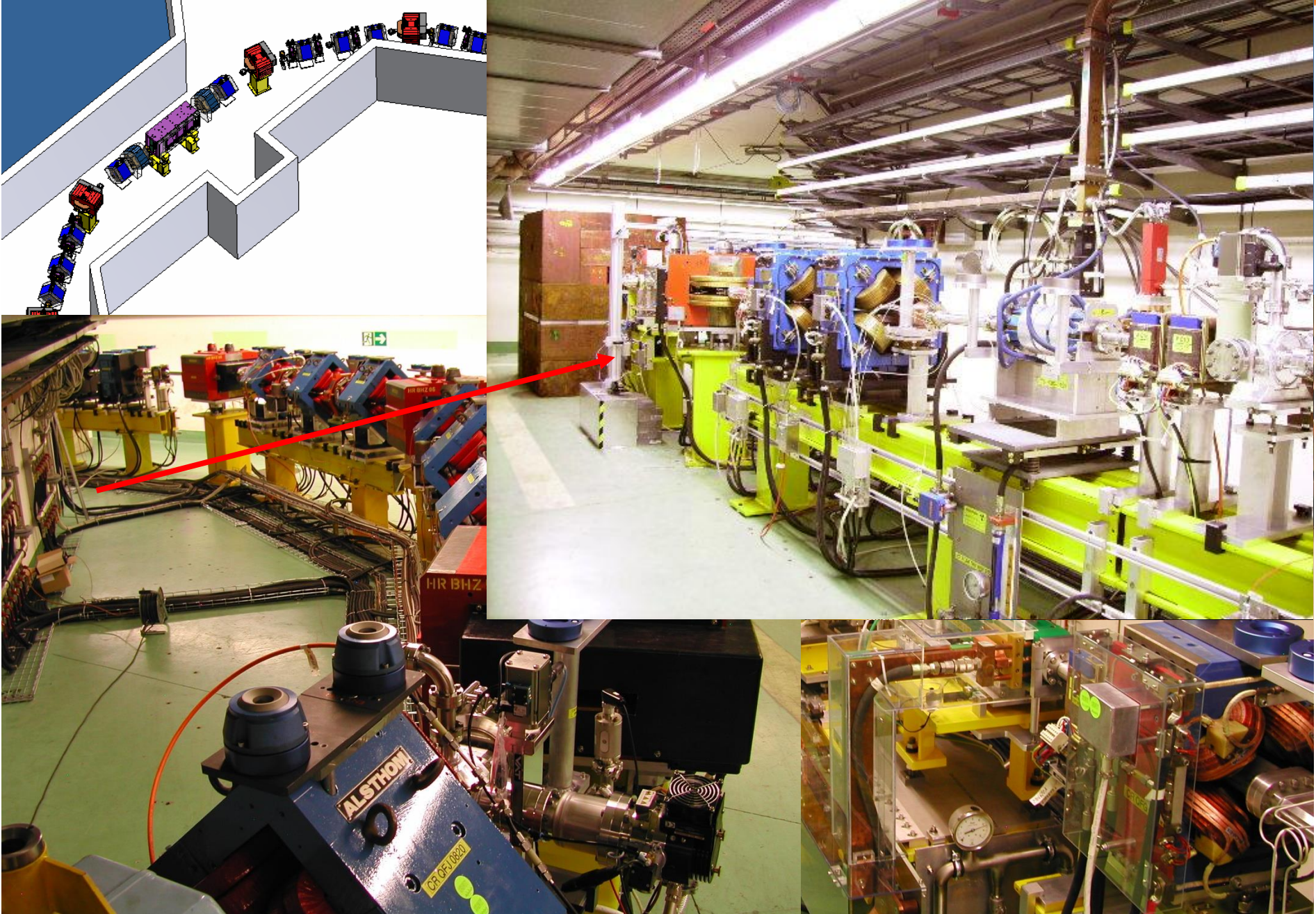




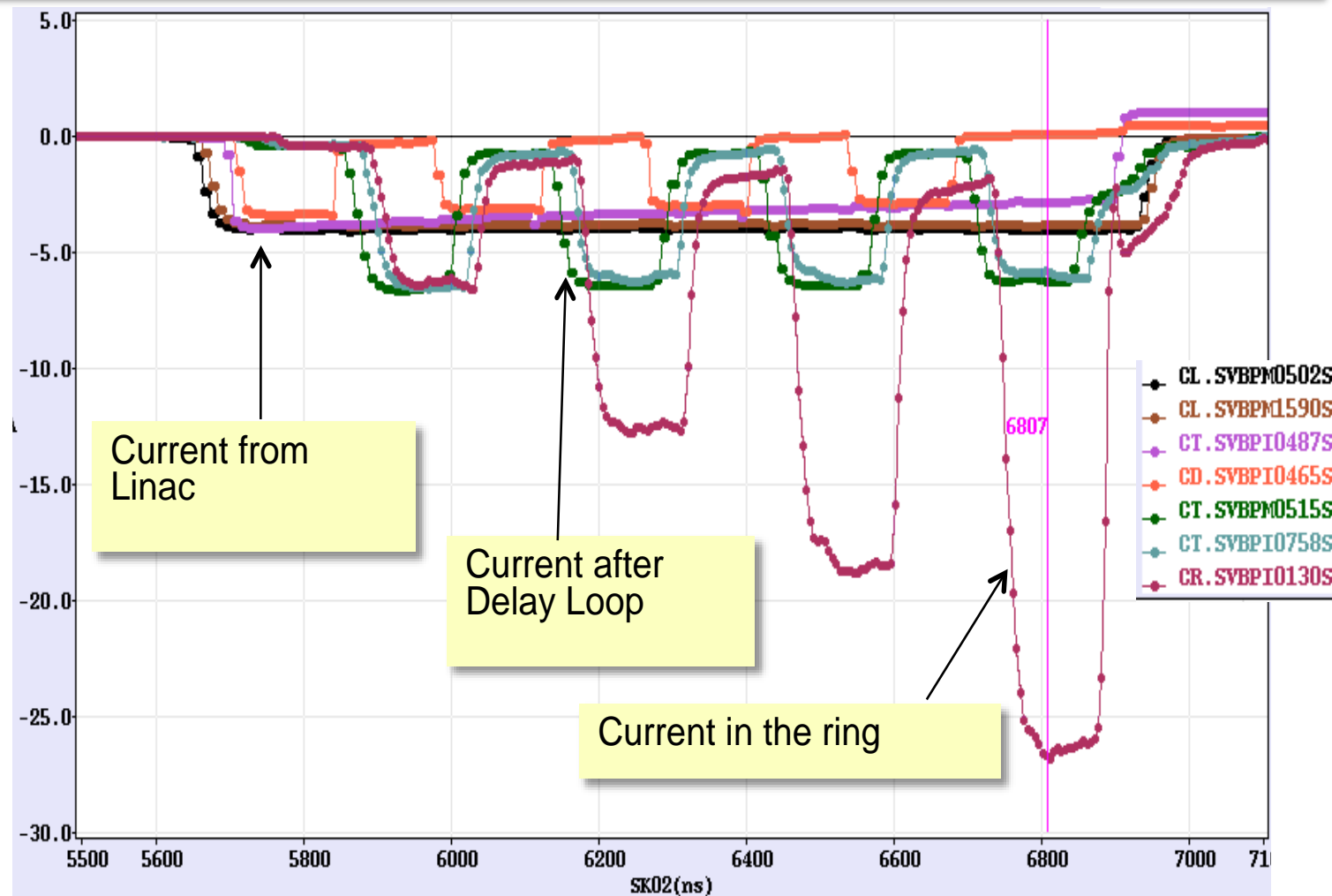
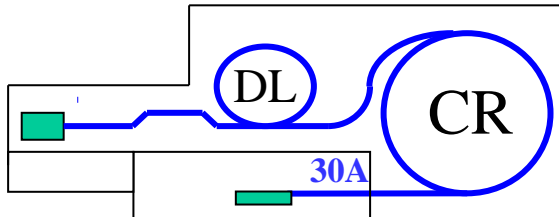
Delay Loop – full recombination

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

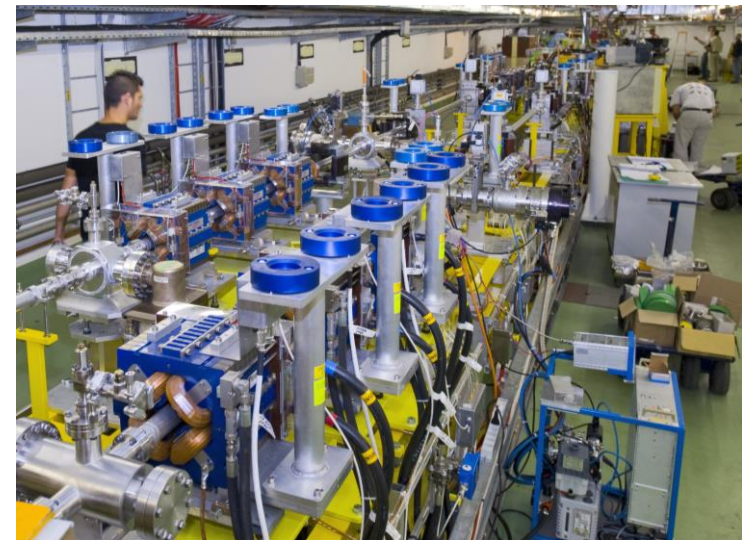
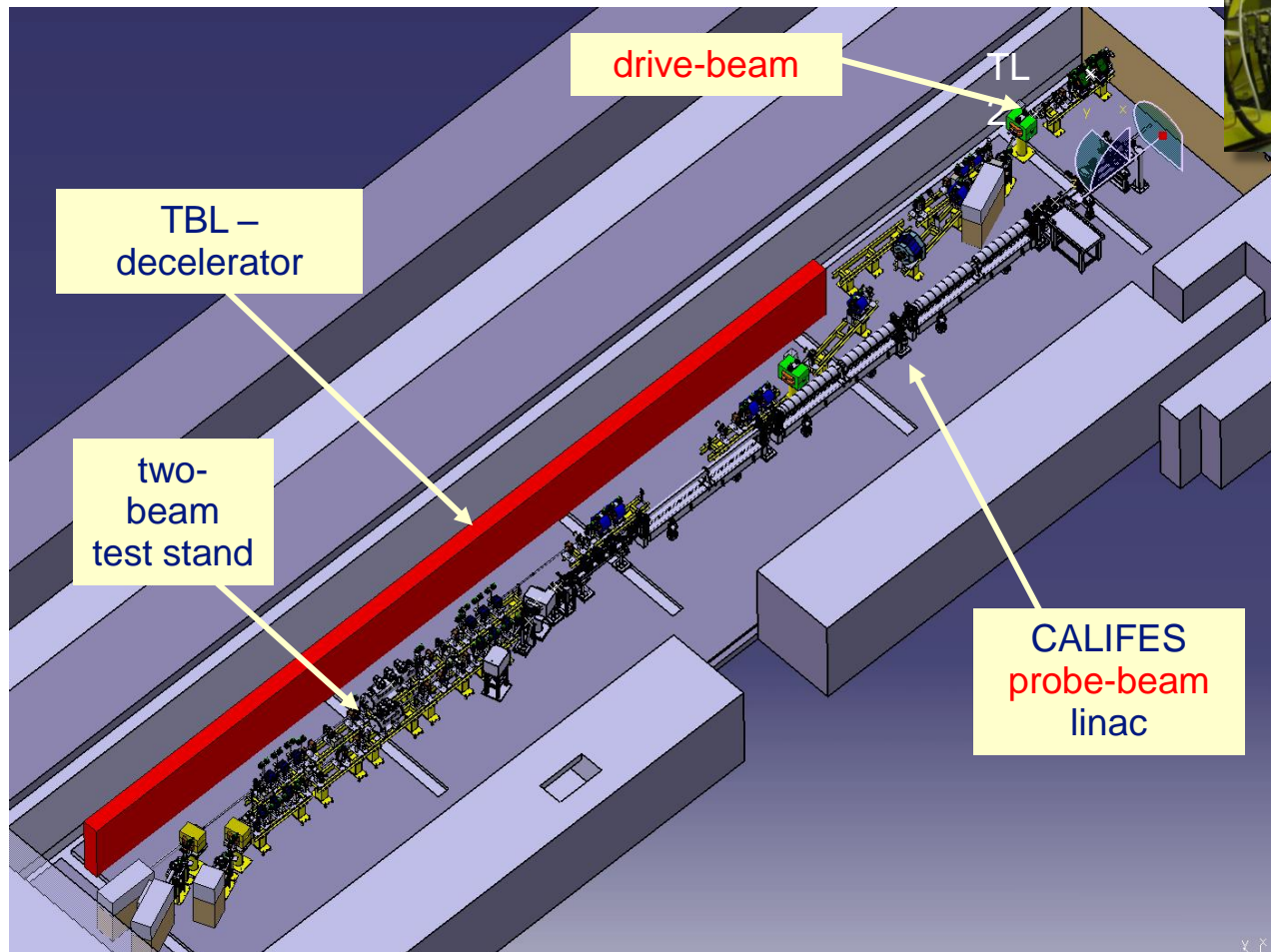
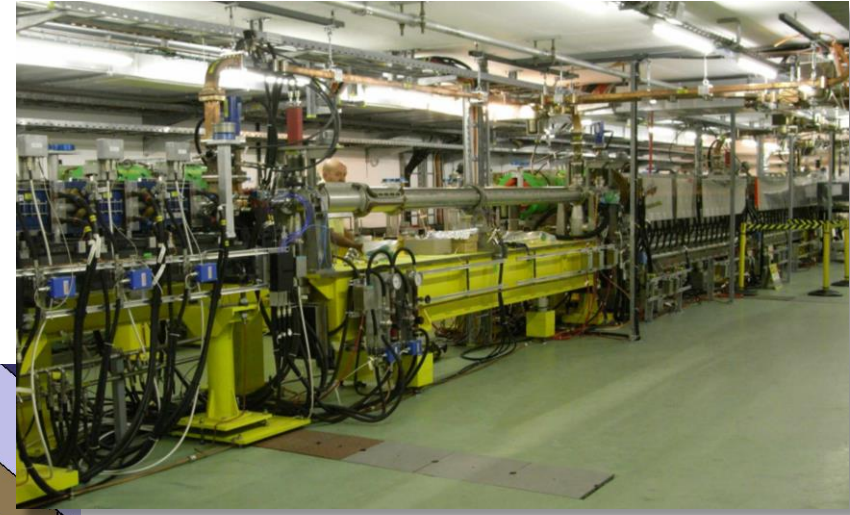




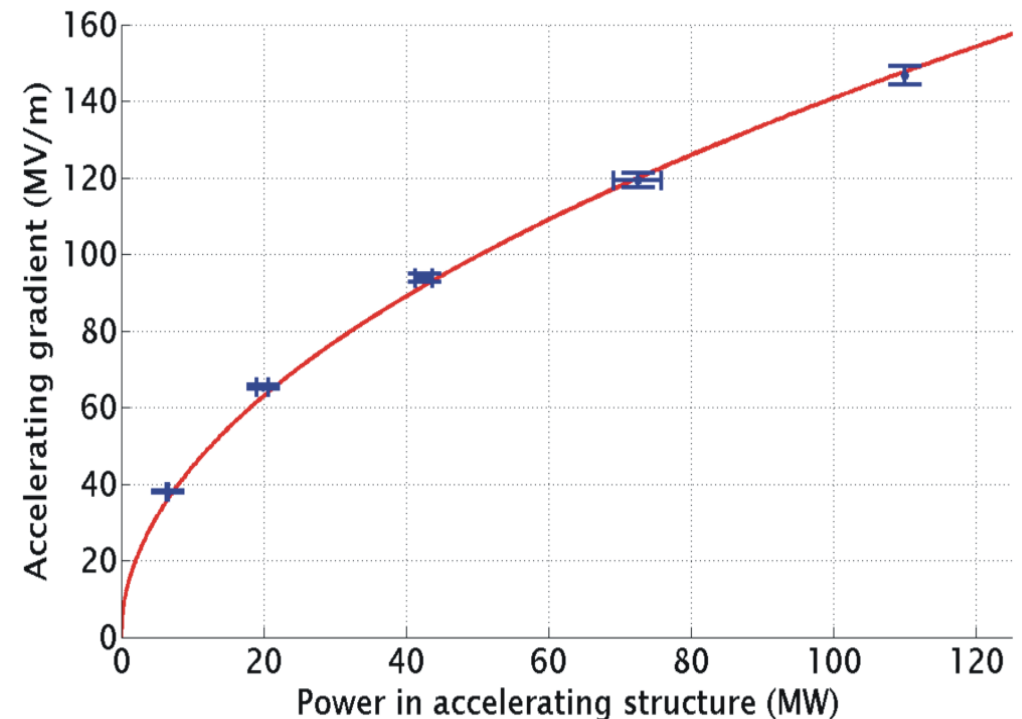
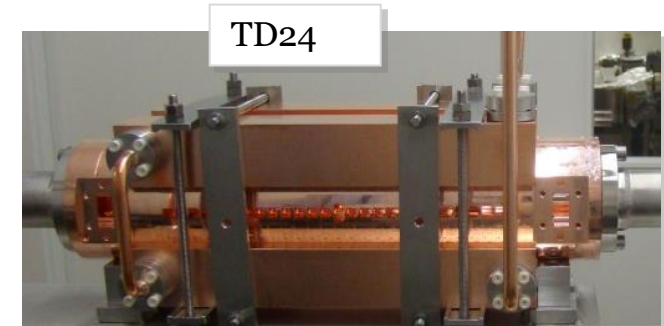
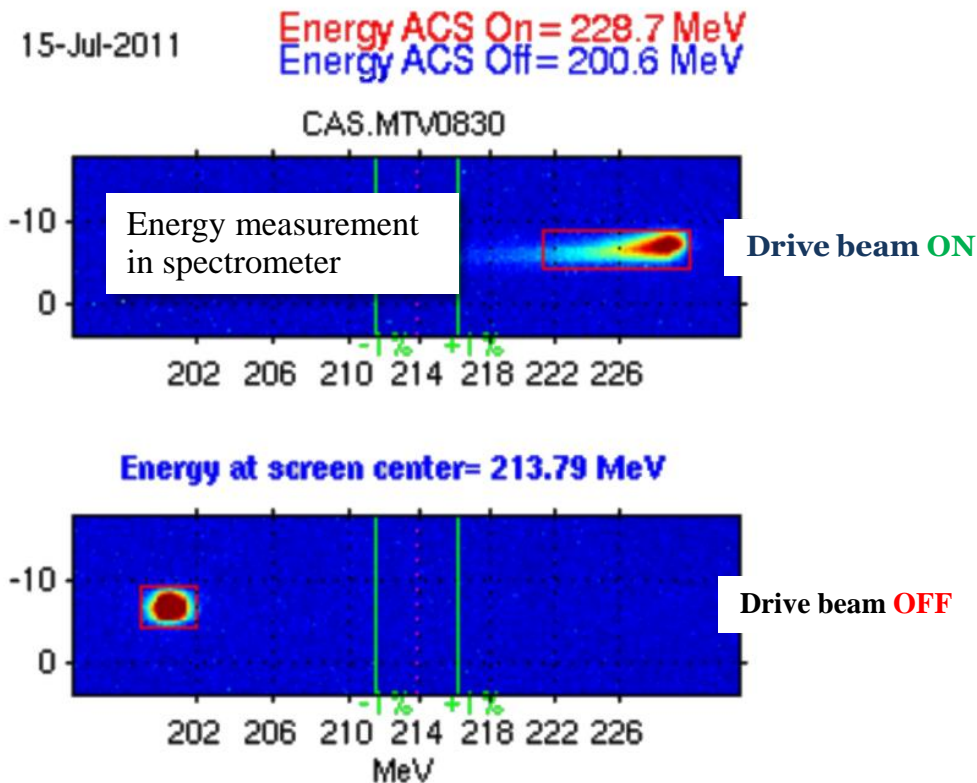
- combined operation of Delay Loop and Combiner Ring (factor 8 combination)
- ~ 26 A combination reached, nominal 140 ns pulse length
- => **Full drive beam generation, main goal of 2009, achieved**



- Deceleration and two-beam tests
- High power tests of **PETS** and accelerating structures



- Maximum probe beam acceleration measured: **31 MeV**
 - Corresponding to a gradient of **145 MV/m**



- CTF3 has shown the CLIC feasibility
 - stable Drive Beam generation
 - high gradient RF performance
 - many **important results** obtained **so far**
 - some issues still to finalize
 - challenging but very interesting
-
- next: the visit