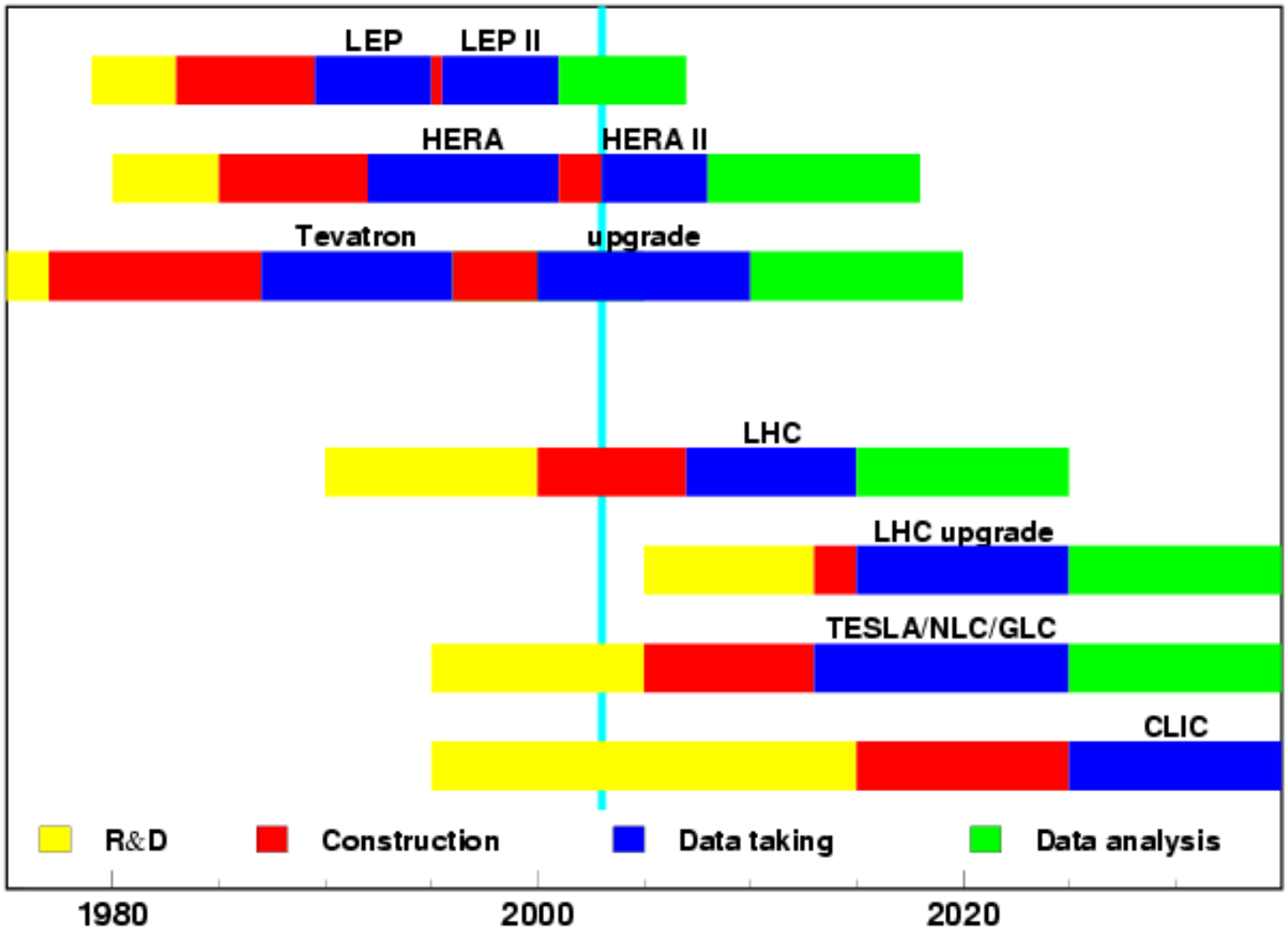
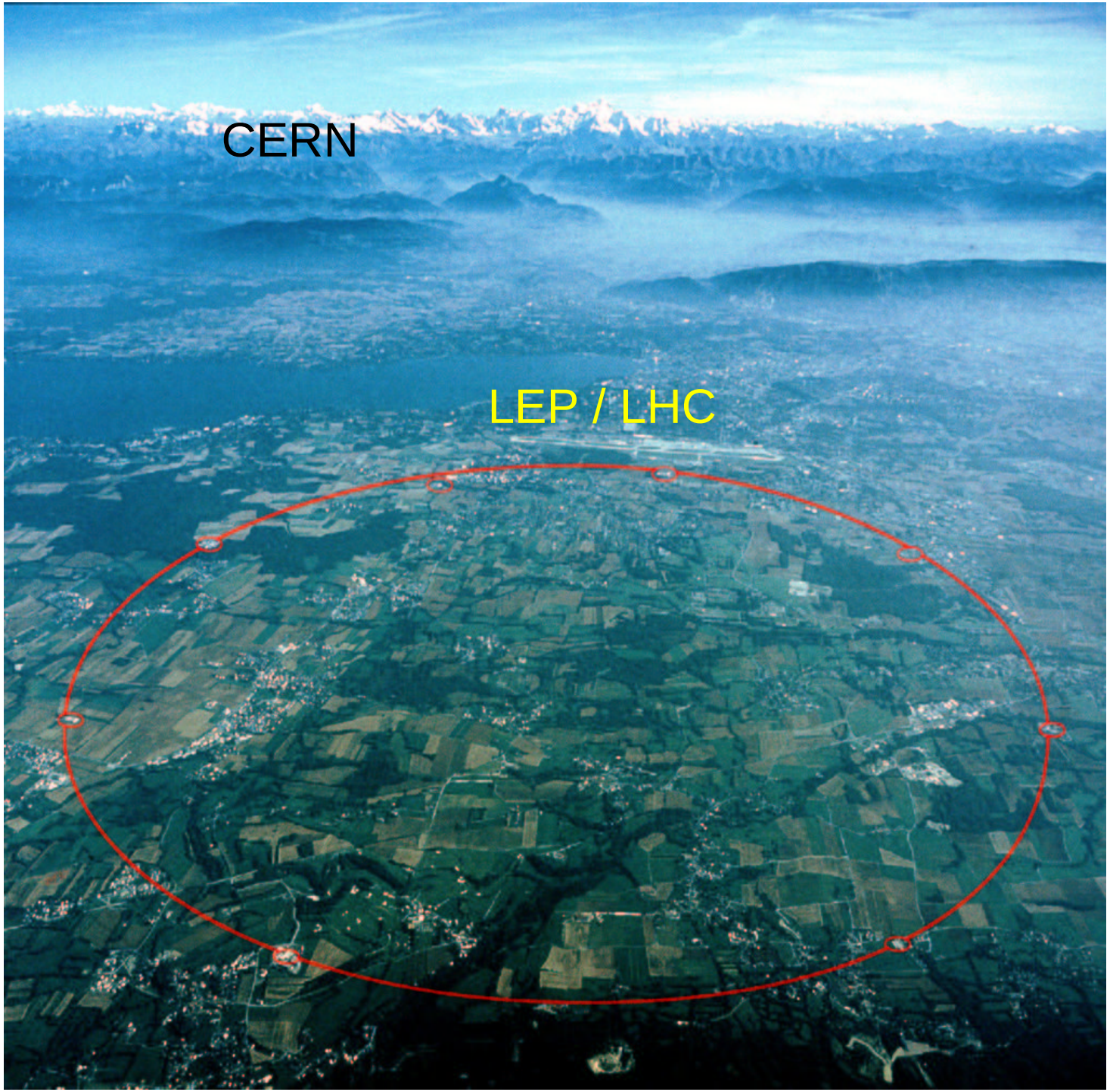
High Energy Physics Roadmap

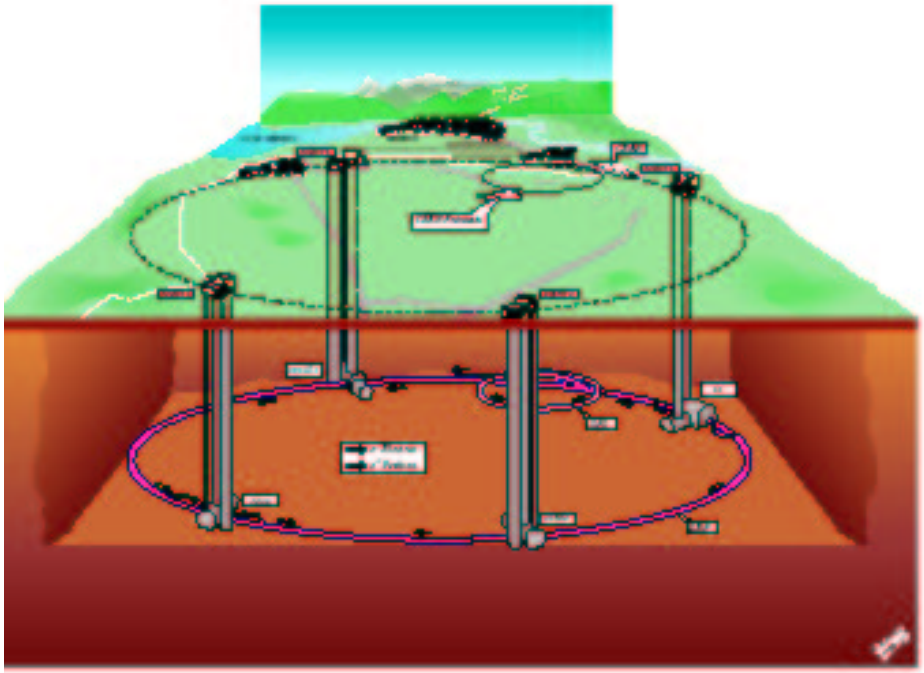


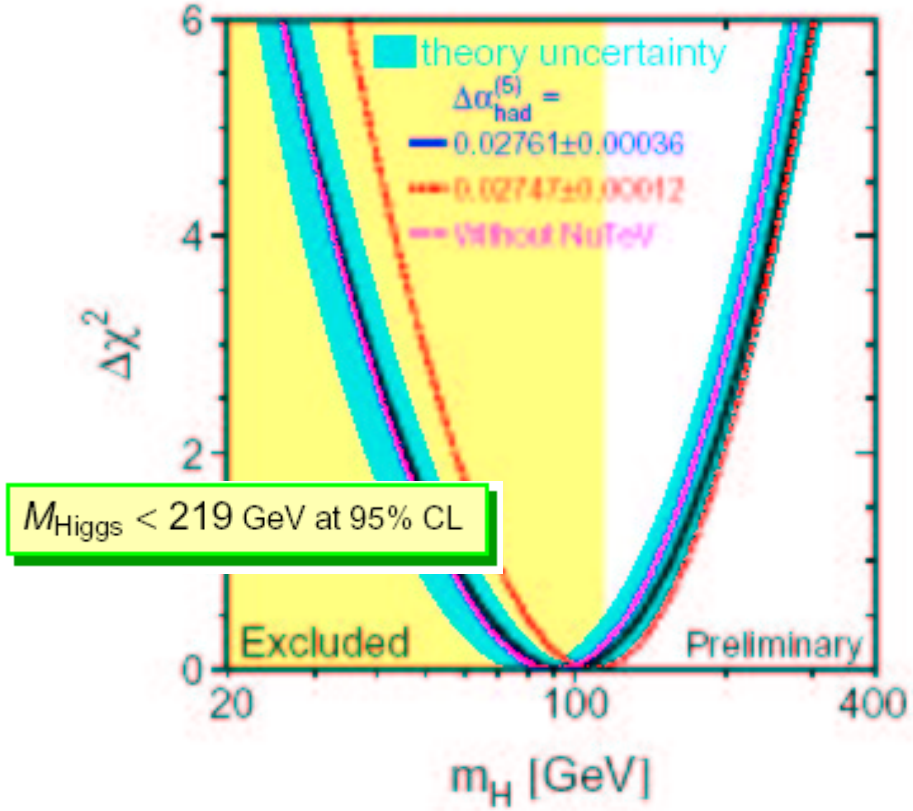

CERN
LEP / LHC

LEP / LEP2

- $e^+ e^-$ collider at CERN
- $\sqrt{s} = 91$ GeV (1989 - 1995)
  $\sqrt{s} \rightarrow 209$ GeV (1996 - 2000)
- Four experiments:
  ALEPH, DELPHI, L3, OPAL

Integrated luminosities in pb^{-1}					
	ALEPH	DELPHI	L3	OPAL	LEP
$\sqrt{s} \geq 189$ GeV	629	608	627	596	2461
$\sqrt{s} \geq 206$ GeV	130	138	139	129	536
$\sqrt{s} \geq 208$ GeV	7.5	8.8	8.3	7.9	32.5

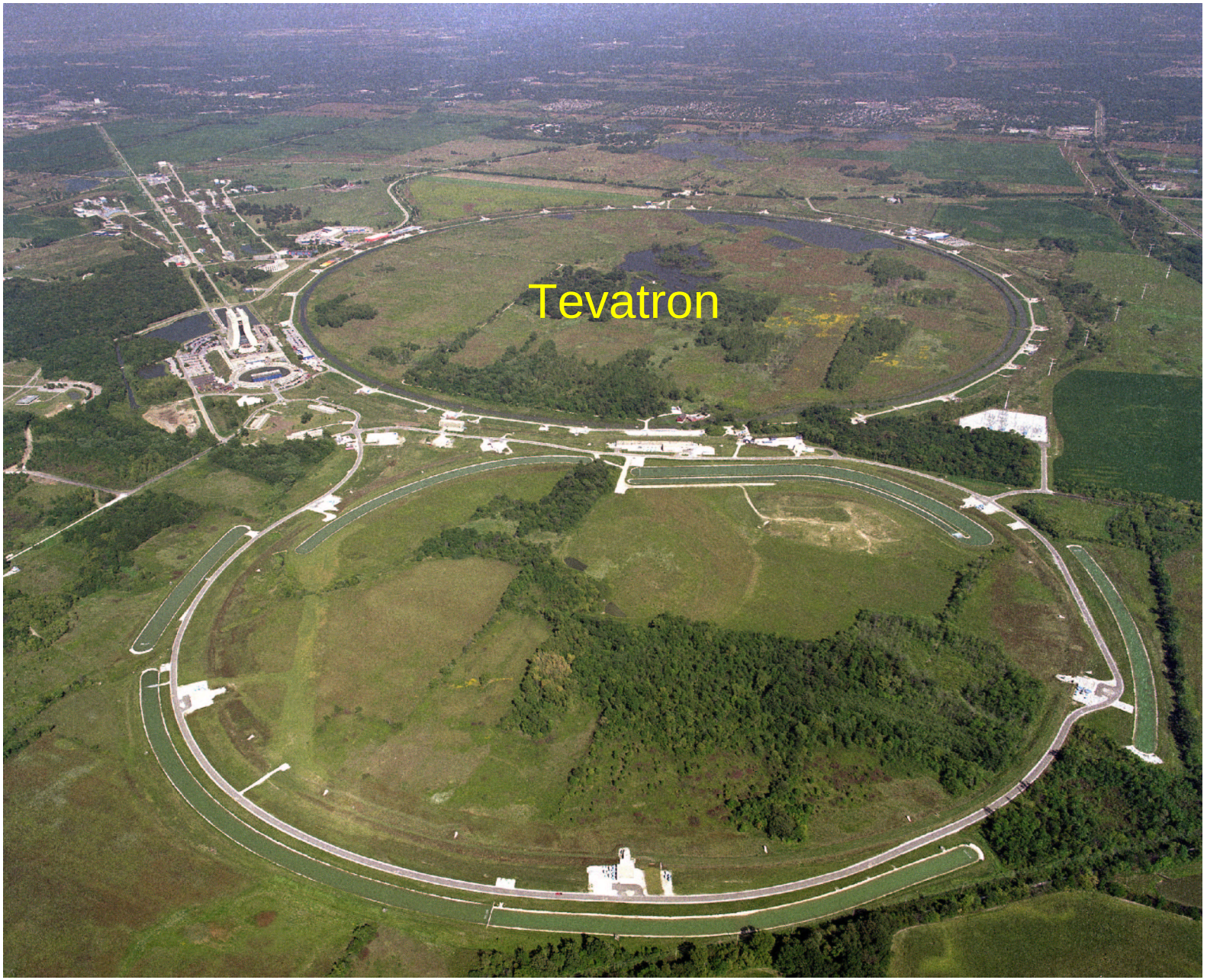




$M_{Higgs} < 219$ GeV at 95% CL

DESY Hamburg

Fermilab



W-Mass Tevatron Run I Result

? W Mass Tevatron Run I result (July 2002)

? DØ:

$$M_W = 80.483 \pm 0.084\ \text{GeV}$$

? CDF:

$$M_W = 80.433 \pm 0.079\ \text{GeV}$$

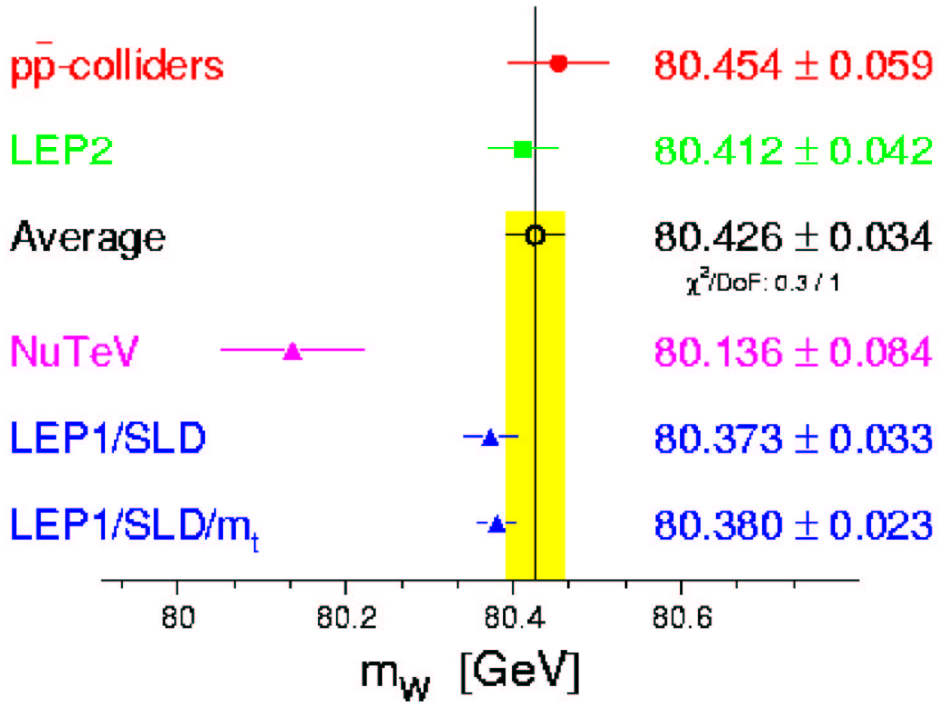
? Tevatron:

$$M_W = 80.456 \pm 0.059\ \text{GeV}$$

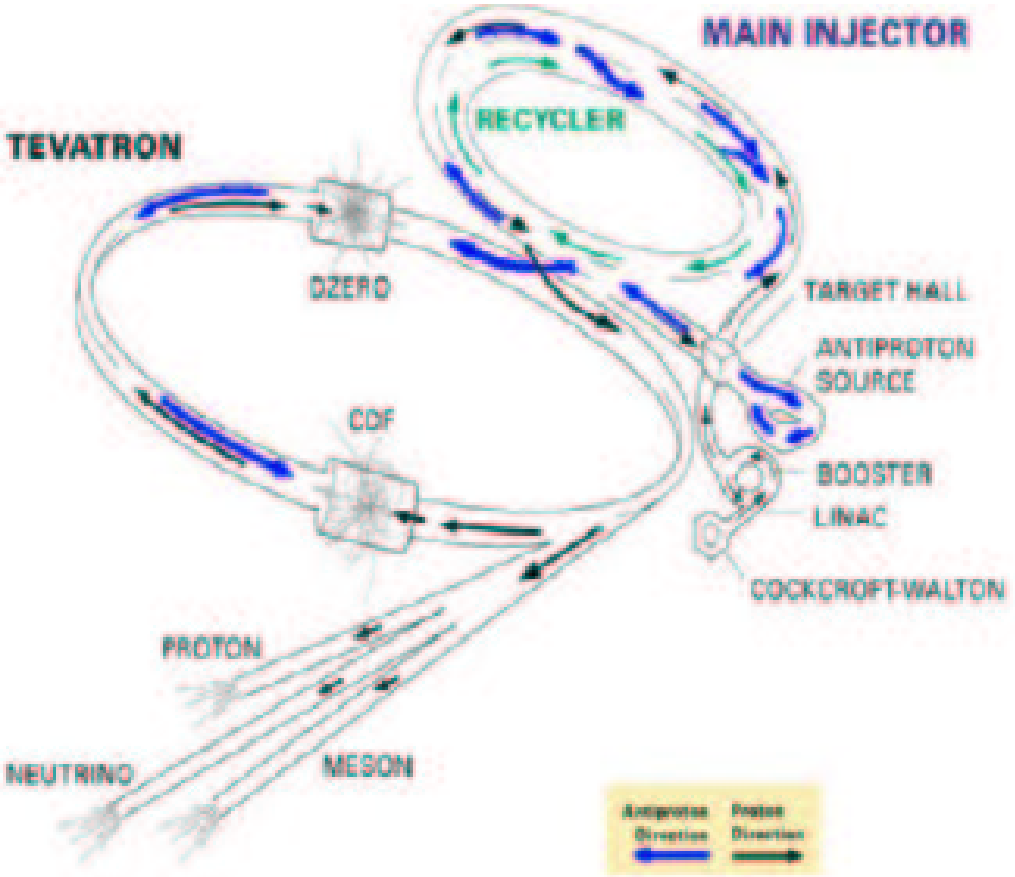
? World:

$$M_W = 80.426 \pm 0.034\ \text{GeV}$$

Run I



Tevatron upgrade



- Lum at RunI: 110 pb^{-1}
- 2003 Goals:
  - ~200 pb^{-1} for Fall
  - 10 pb^{-1}/week by the end of the year
- Achieved
  - ~9.2 pb^{-1} best week

Both detectors upgraded

Final goal: 30 fb^{-1} by 2010 (?)

- New Main Injector:
  - Improve p-bar production
- Recycler ring:
  - Reuse p-bars

Not used yet

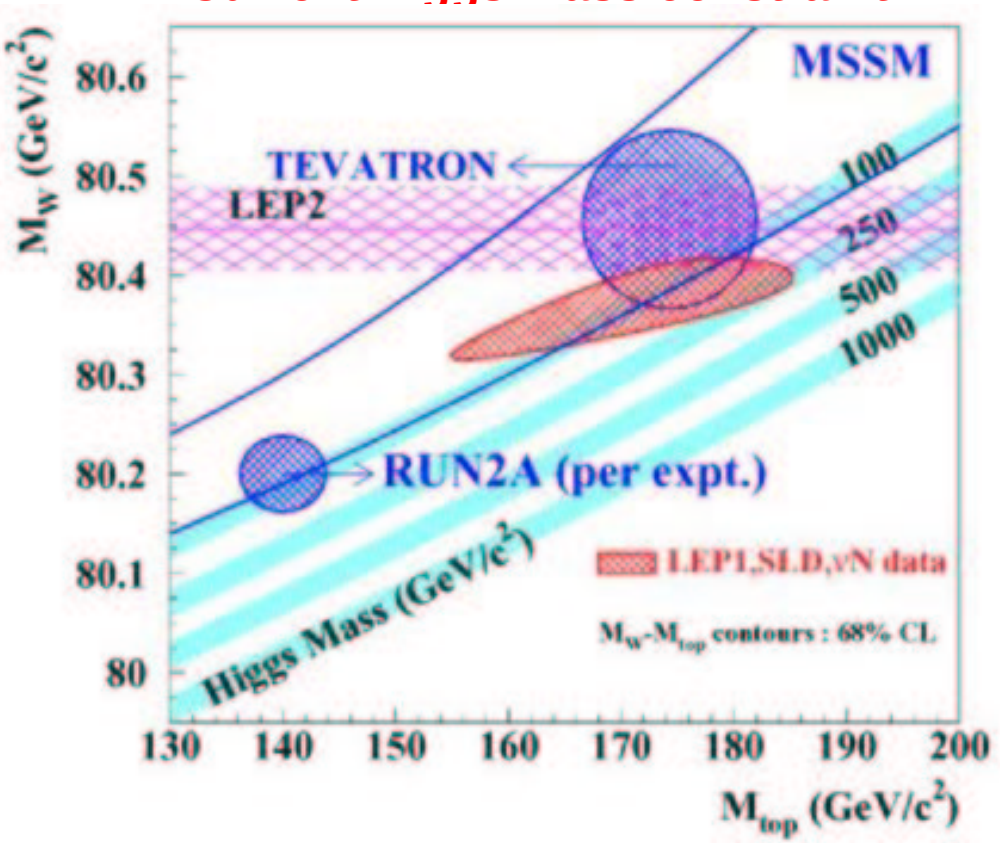
Goal of Run II

Top quark mass
~ 2 – 3 GeV

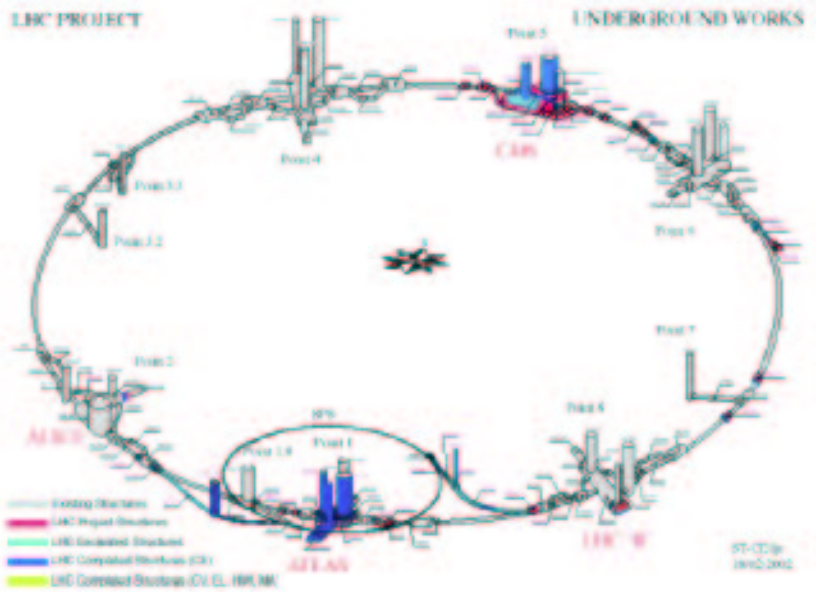
W boson mass
~ 30 – 40 MeV

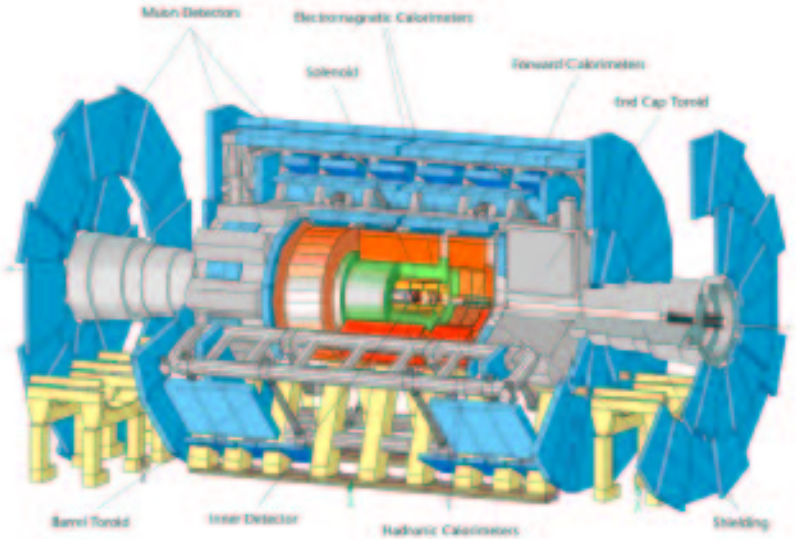
$\delta M_t / M_t \sim 35\%$

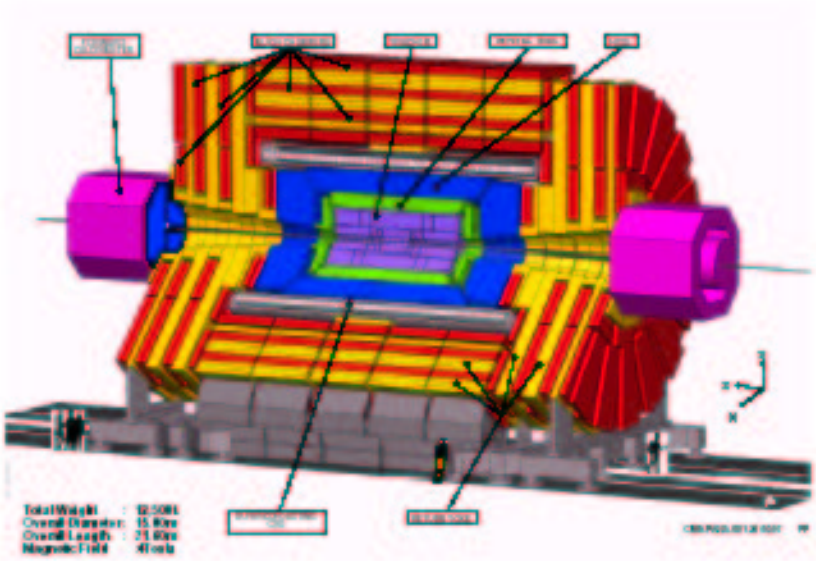
Current Higgs mass constraint



Higgs Searches at the LHC



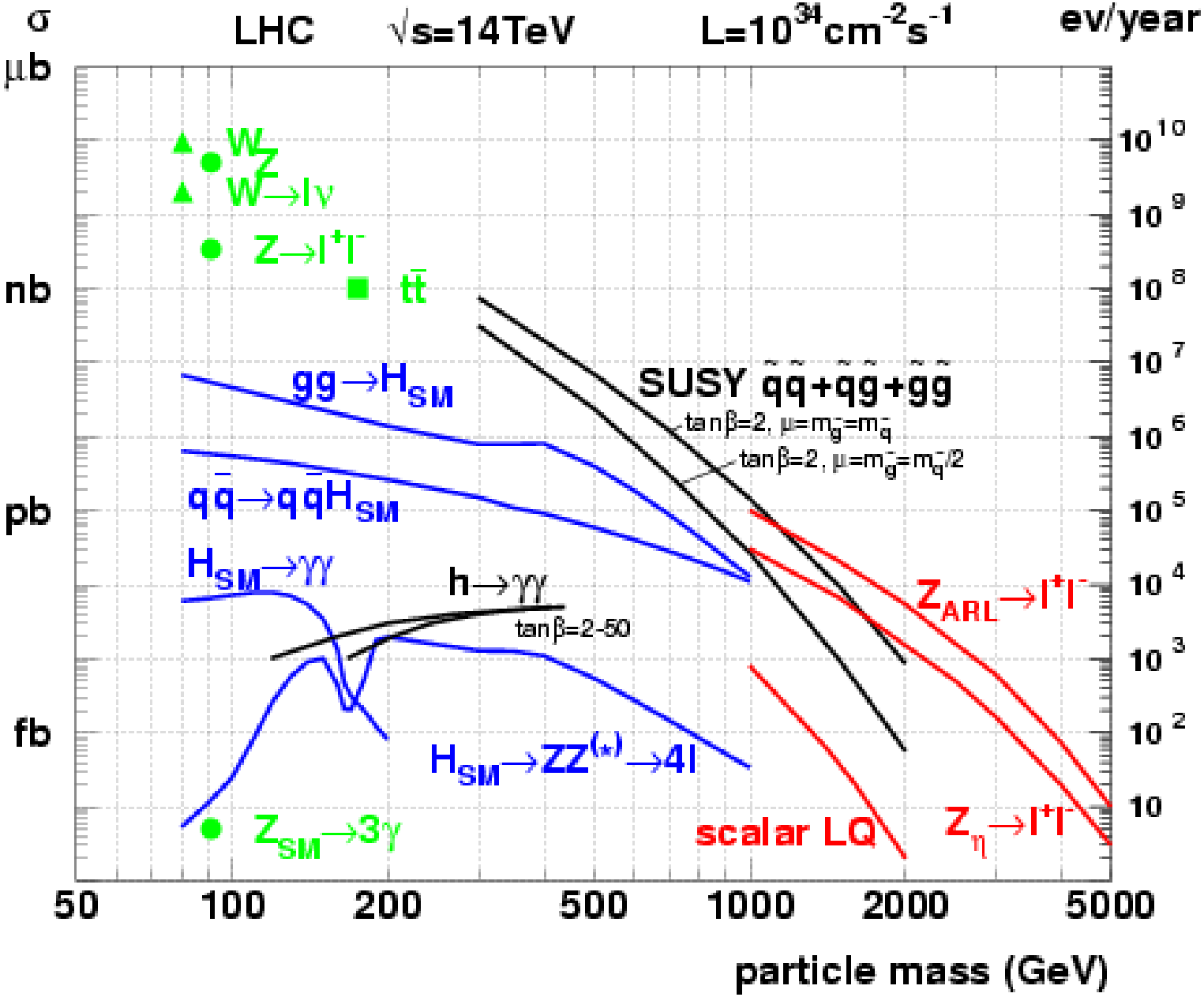




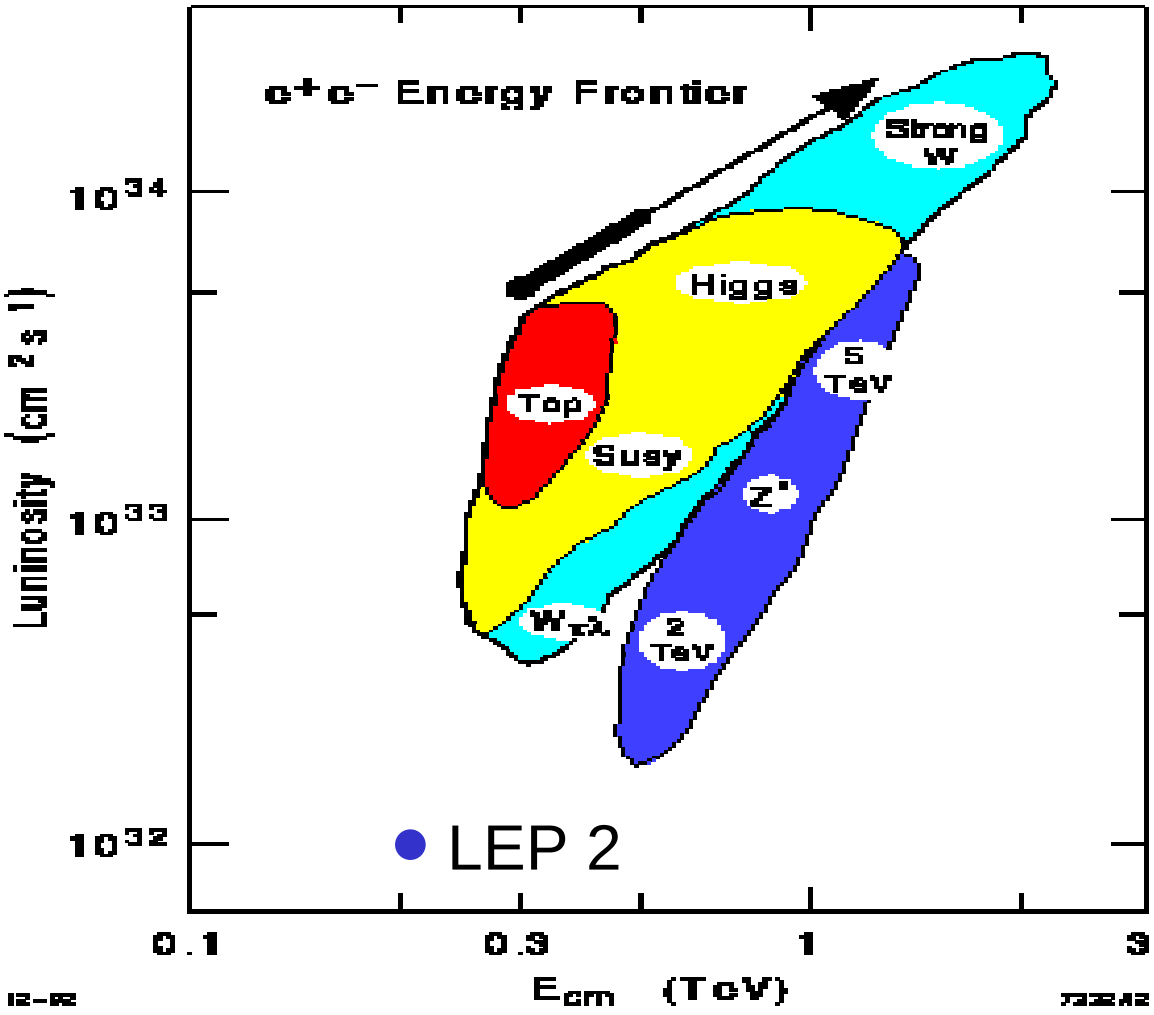
Start hopefully

2007

Very large background rates !!! e.g. $\sigma(pp \to b\bar{b}\, X) \approx 1$ mb



The energy and luminosity challenges for a future e+e- linear collider:



SLC ↓

"LEP 1000"

2 TeV in Center-of-Mass

Diameter ≈ 900 km

Linear Collider at 50 MeV/m

Length = 40 km →–←

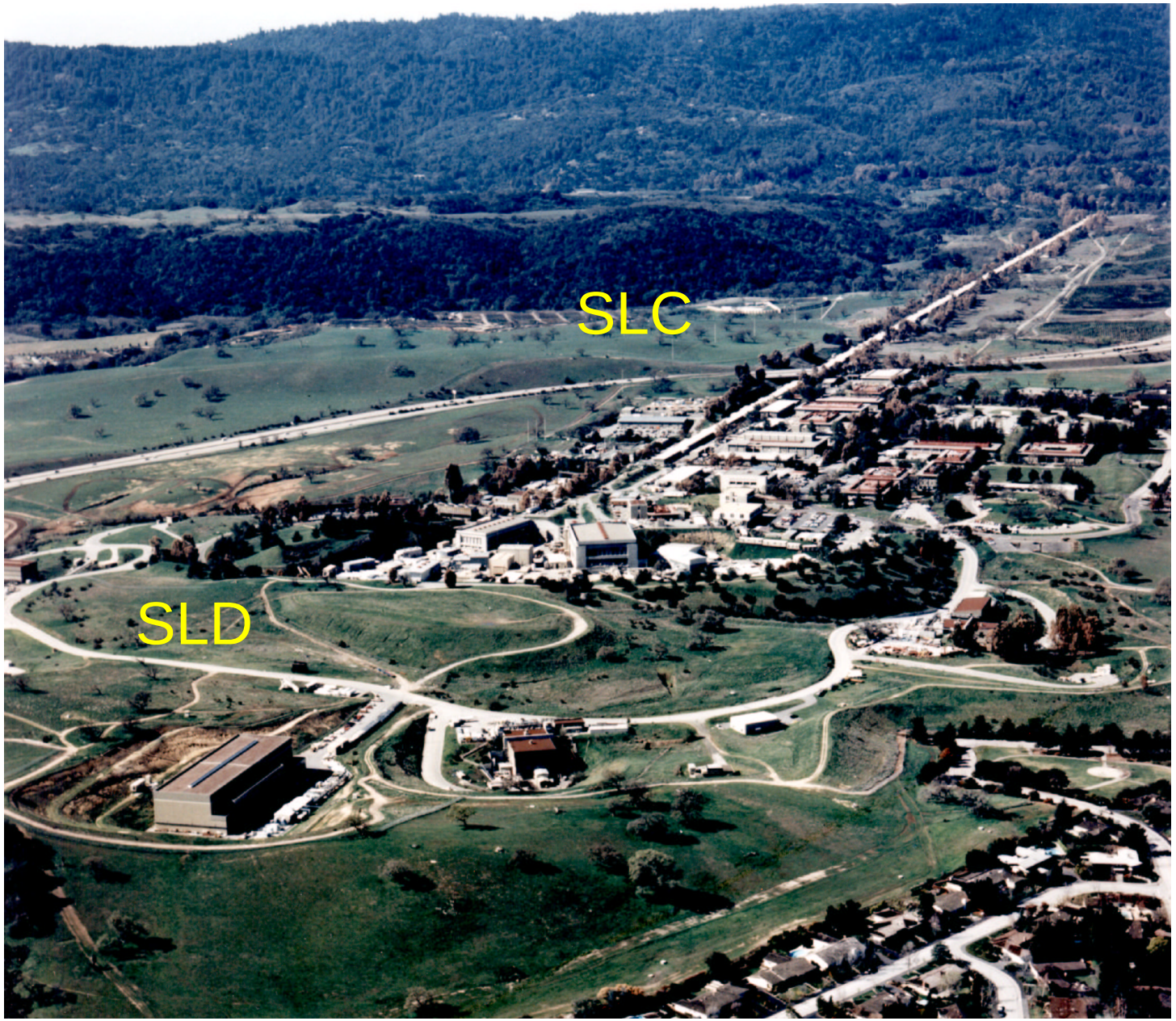
Why LEP 1000 gave way to the idea of linear colliders

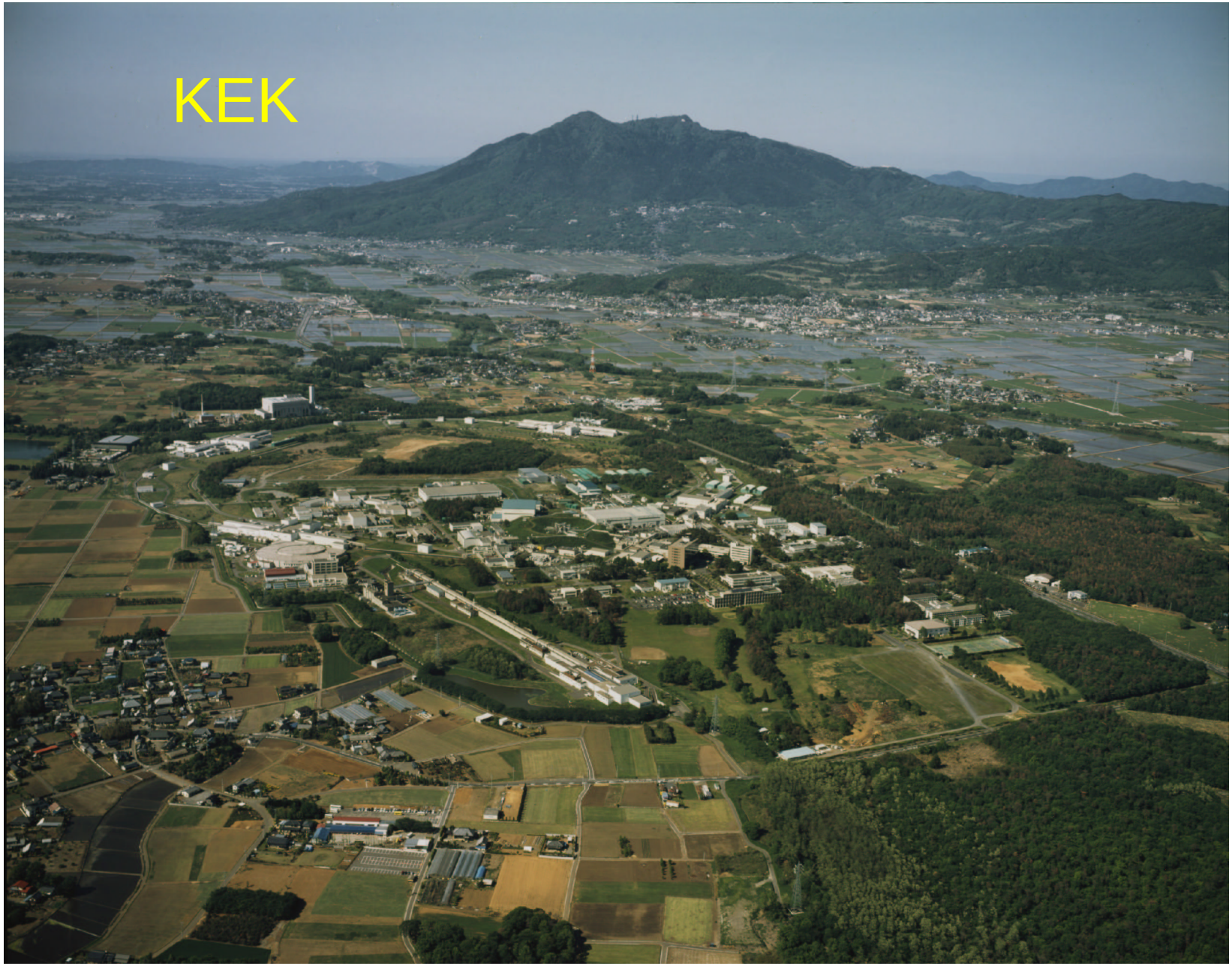
Linear Collider Parameter Overview

	NLC/JLC	**TESLA**	**CLIC**	SLC
f / GHz	11.4	1.3	30	2.9
E-cms / GeV	500 – 1000	500 – 800	3000 – 5000	100
g / MV/m	50	23 – 35	150	~20
Lumi / 10^{34}	2 – 3	3.4 – 5.8	~10	.0003
Power p. beam / MW	6.9 – 13.8	11.2 – 17	~15	0.04
σ_y at IP / nm	2.7 – 2.1	5 – 2.8	1	500
Beamstrahlung δB / %	3.2 – 4.3	3.4 – 7.5	21	<0.1
Site length / km	30	33	~35	3.5
Site power / MW	195 – 350	140 – 200	~400	
Cost[§] (stage-I)	~3.5B$	3.14B€+7k p.y.		?

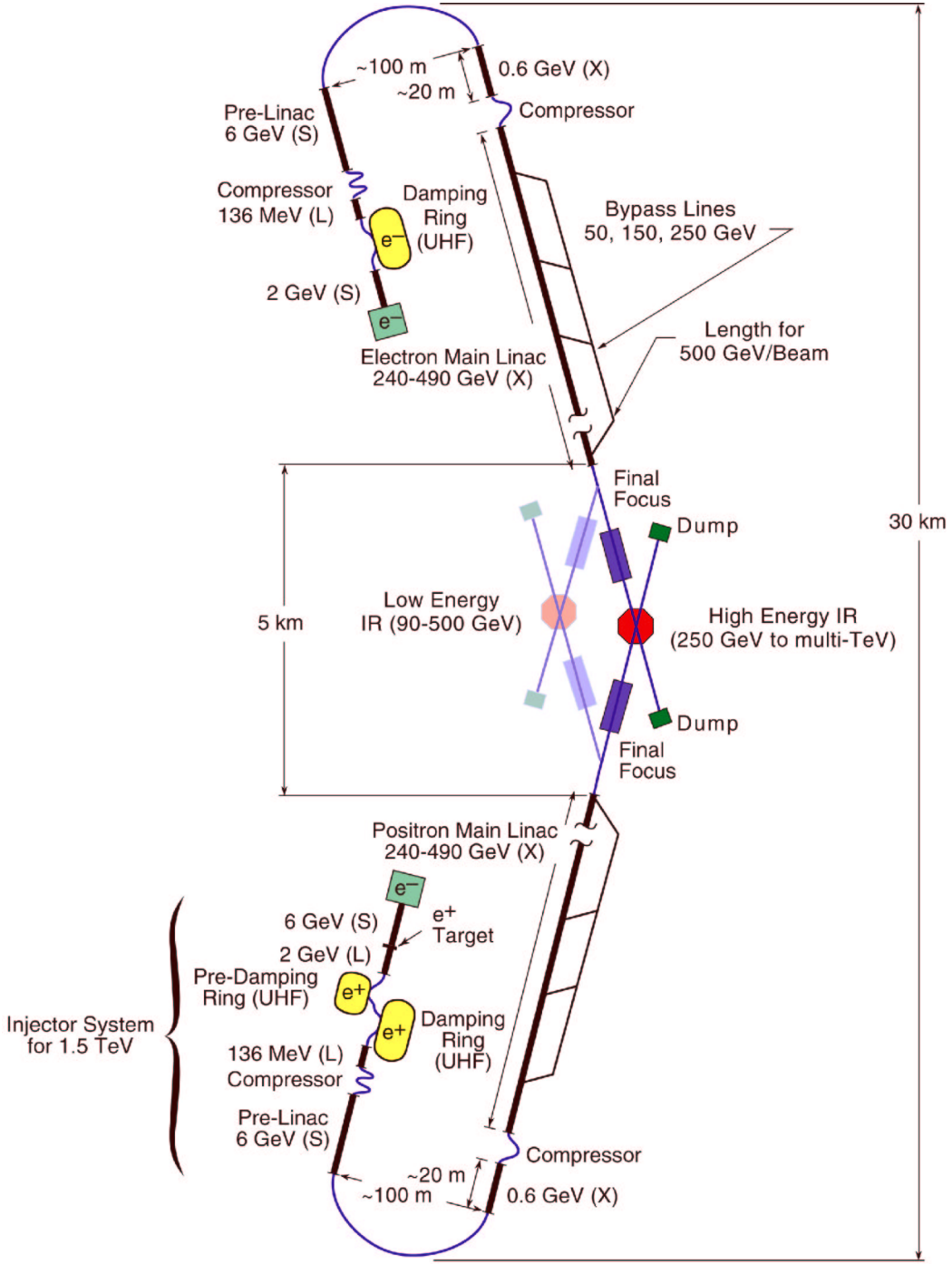
§ numbers quoted at Snowmass 2001, no pre-operation, escalation and contingency included

Stanford

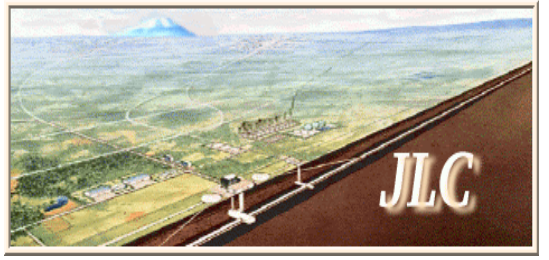



KEK

NLC proposal

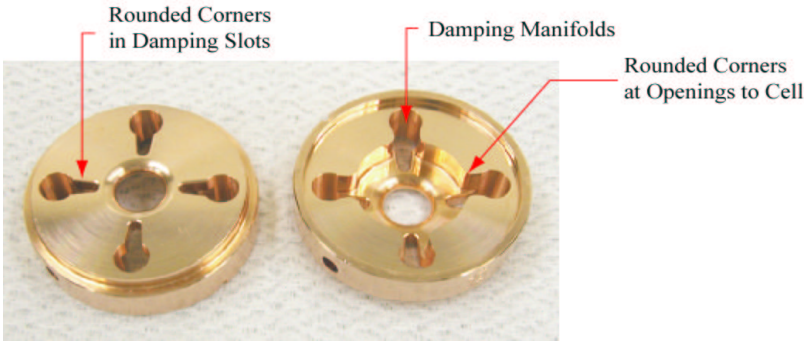


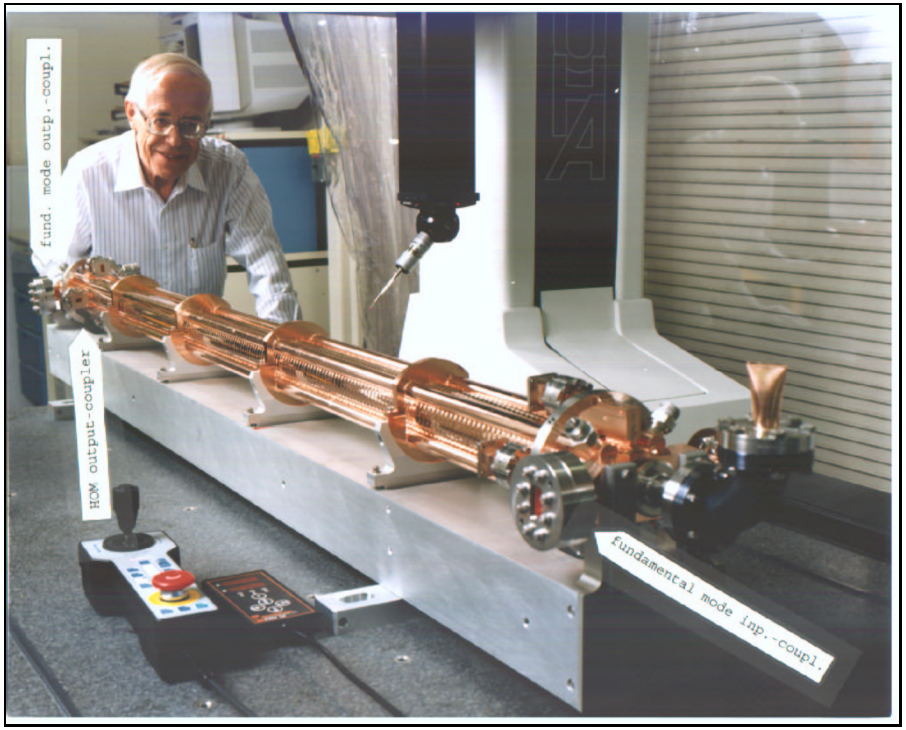
NLC



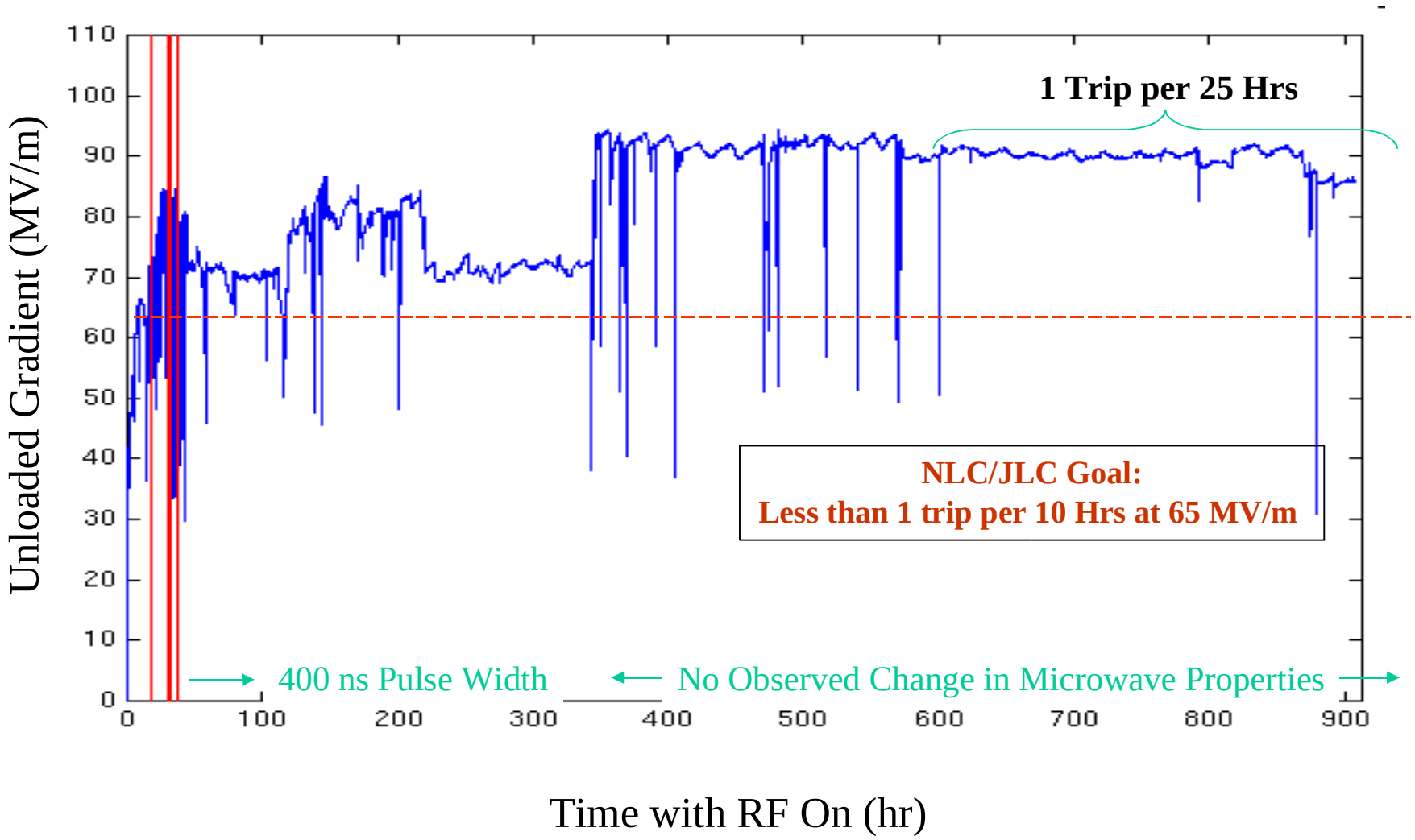
X-band technology (SLAC/KEK & coll. Inst.)

SLC-like 20MV/m, 3 GHz → 50MV/m (65 unloaded), 11.4GHz





Test Structure Run History
(T-Series 2003, not final version for linac)



500 (800) GeV e+e- Linear Collider

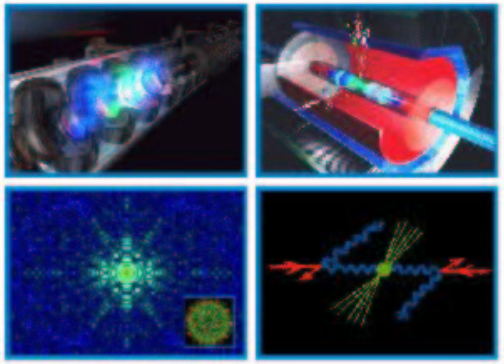
Based on superconducting linac technology

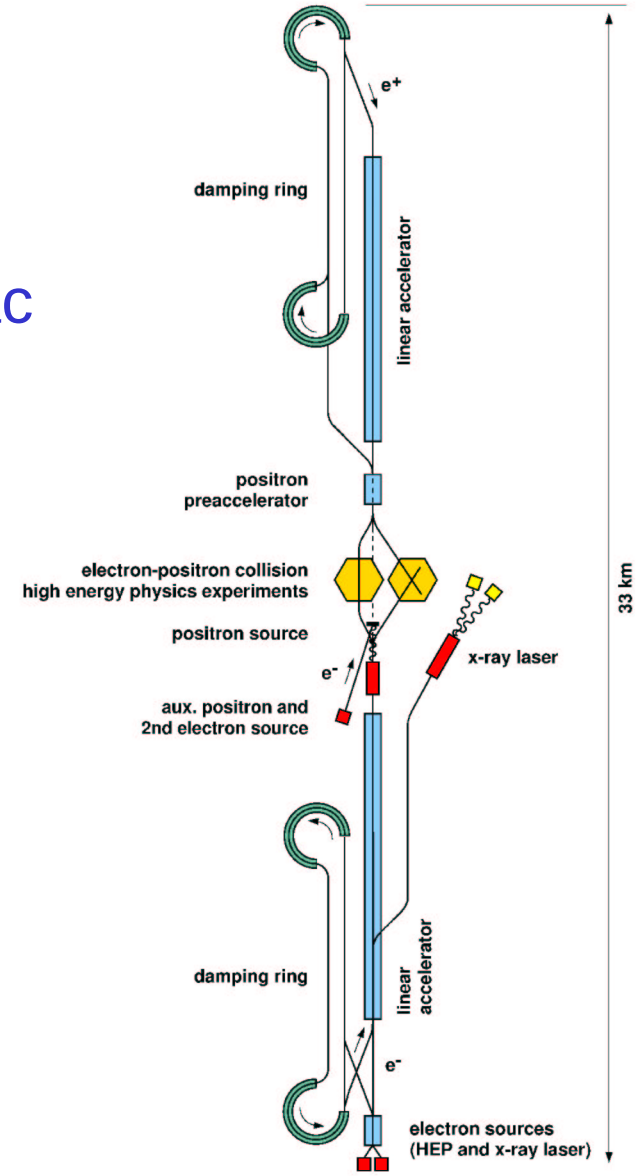
TESLA

The Superconducting Electron-Positron Linear Collider

with an Integrated X-Ray Laser Laboratory

Technical Design Report



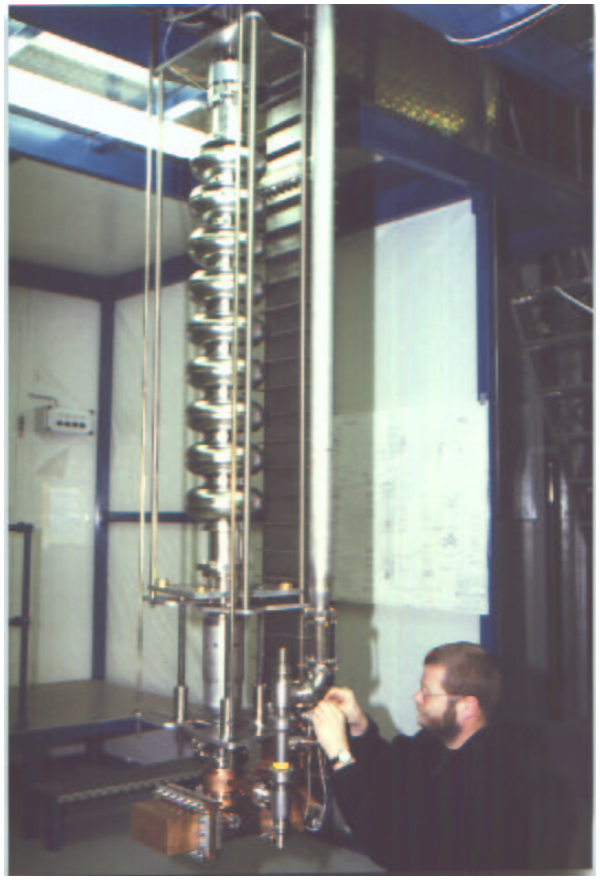


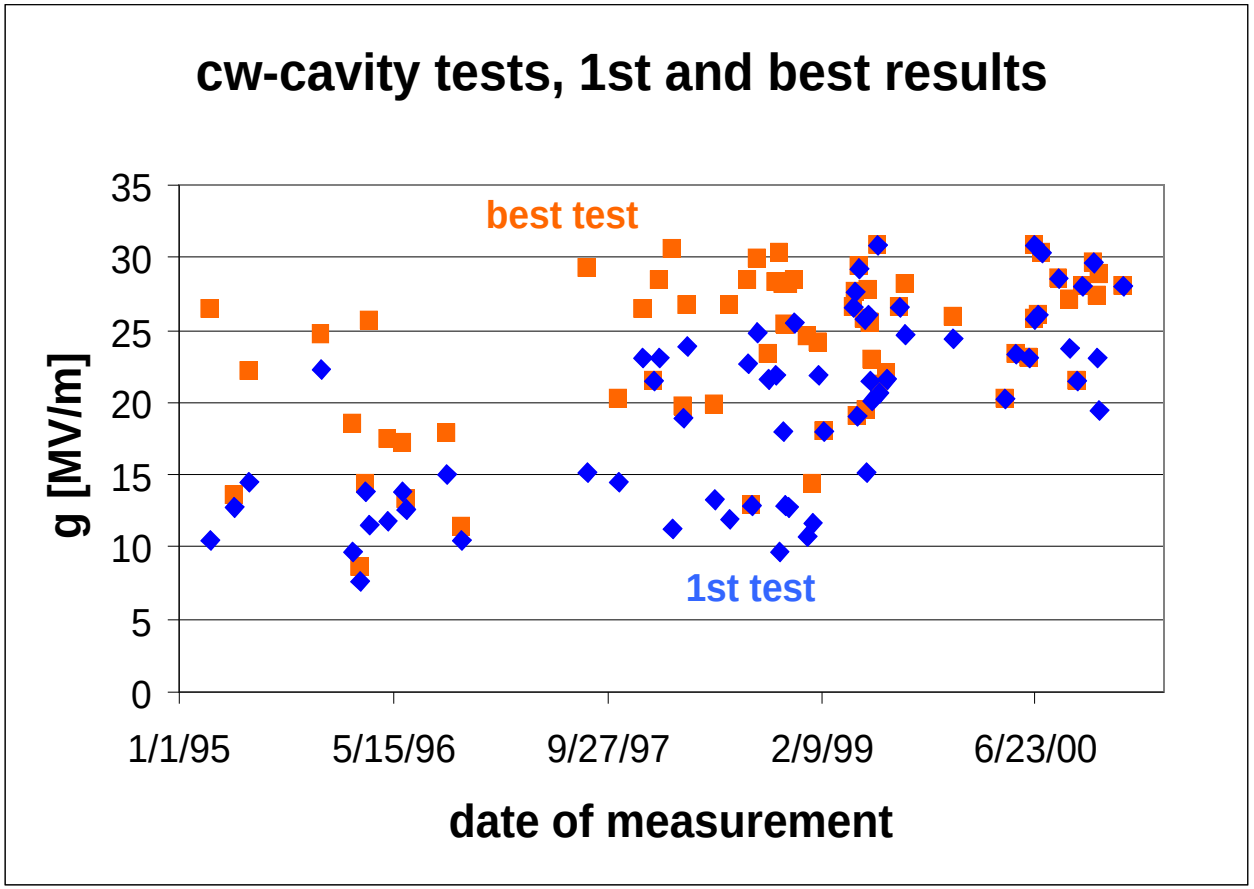
H.Weise 3/2000

Why superconducting?

- High efficiency ACBeam (>20%, ~10% normal c.)
- Low frequency:
  - Long pulses with low RF peak power
  - Small beam perturbations from wakefields
  - Intra-train feedback on beam orbit, energy, luminosity…
- First proposed in 1960s (M. Tigner)… show stopper was too low acc. Gradient, too high cost

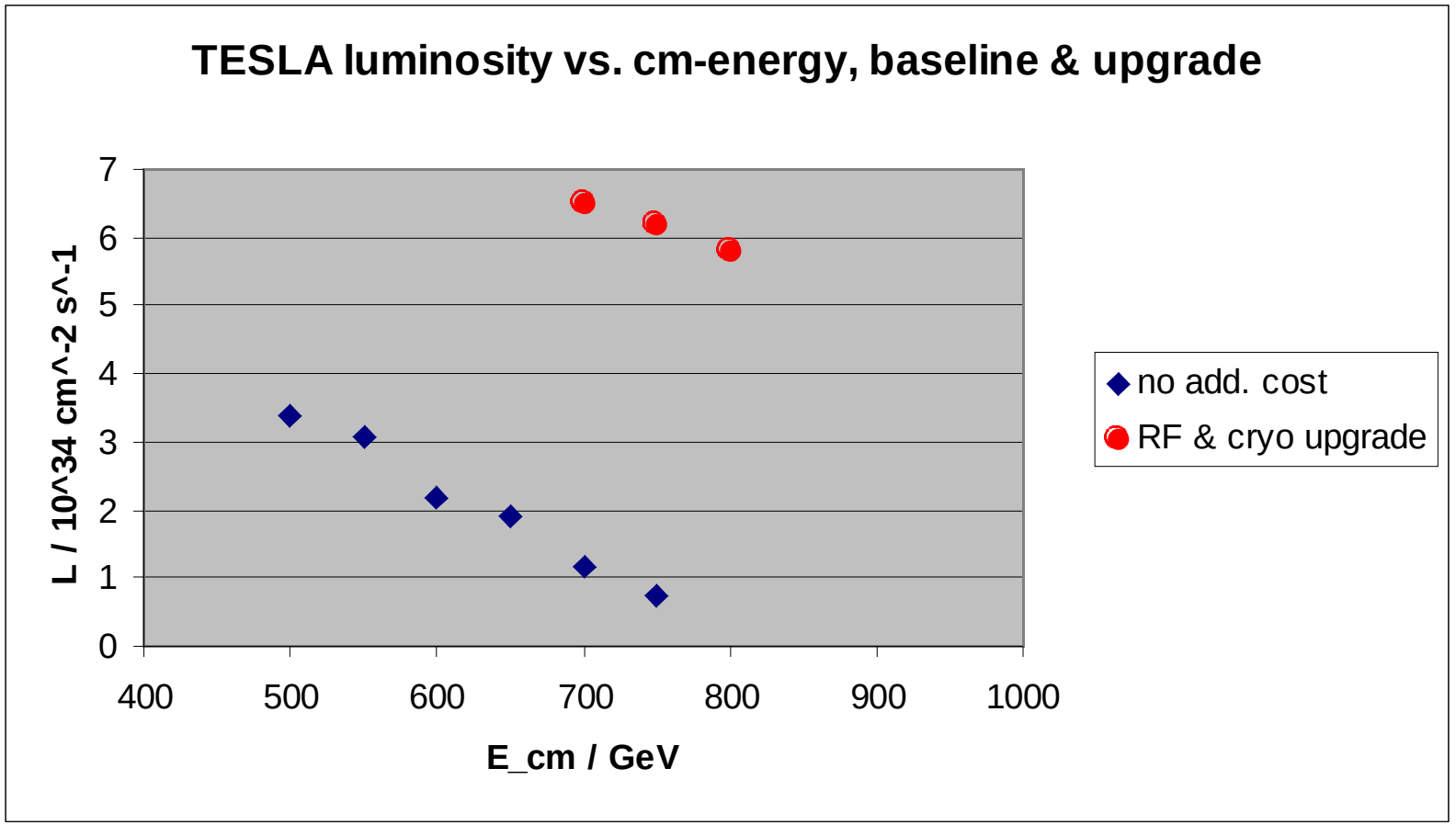
Accelerating gradient on test stand reached 25 MV/m ***on average*** for 1999/2000 cavity production



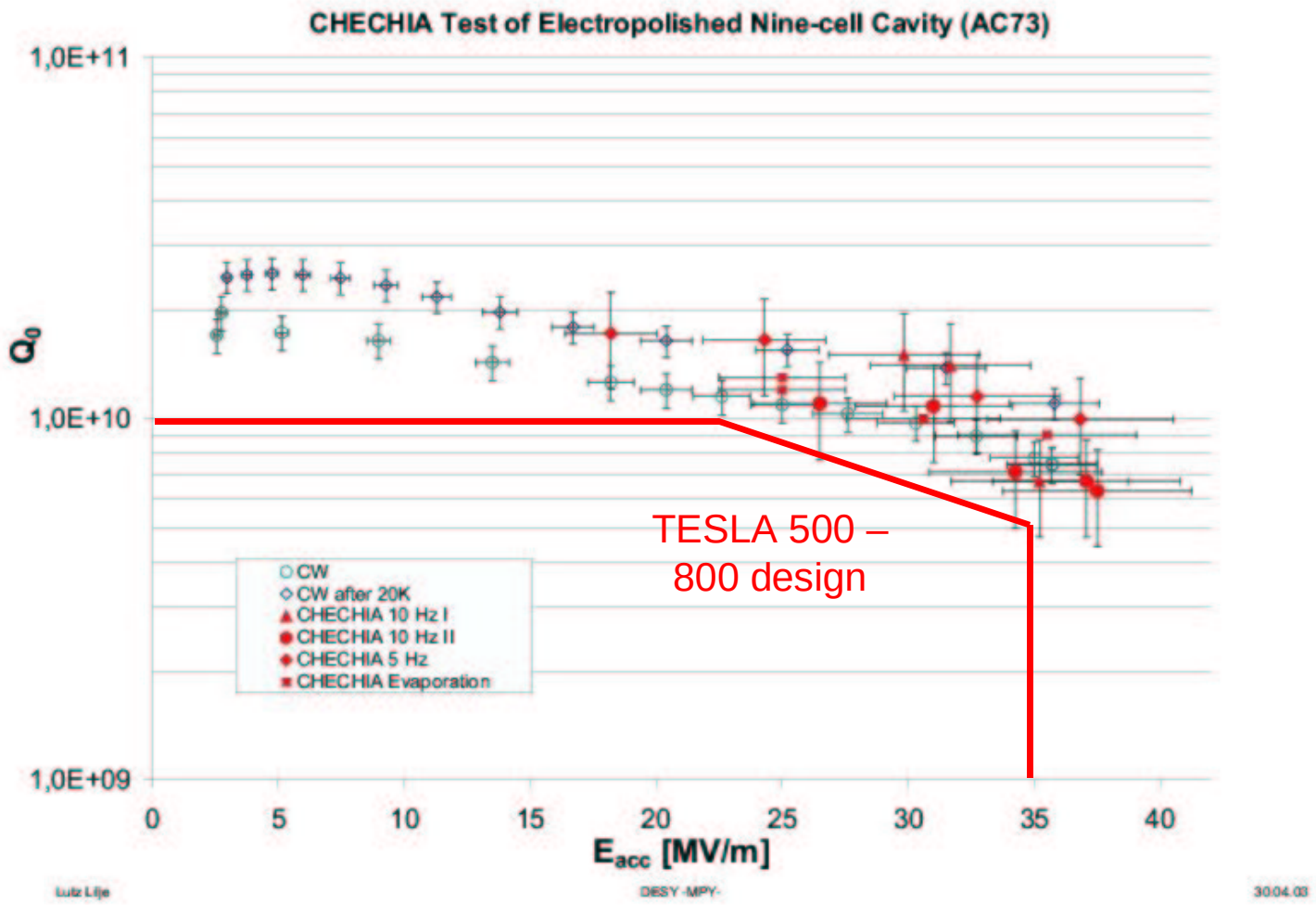


Higher performance cavities: energy reach ≥800 GeV

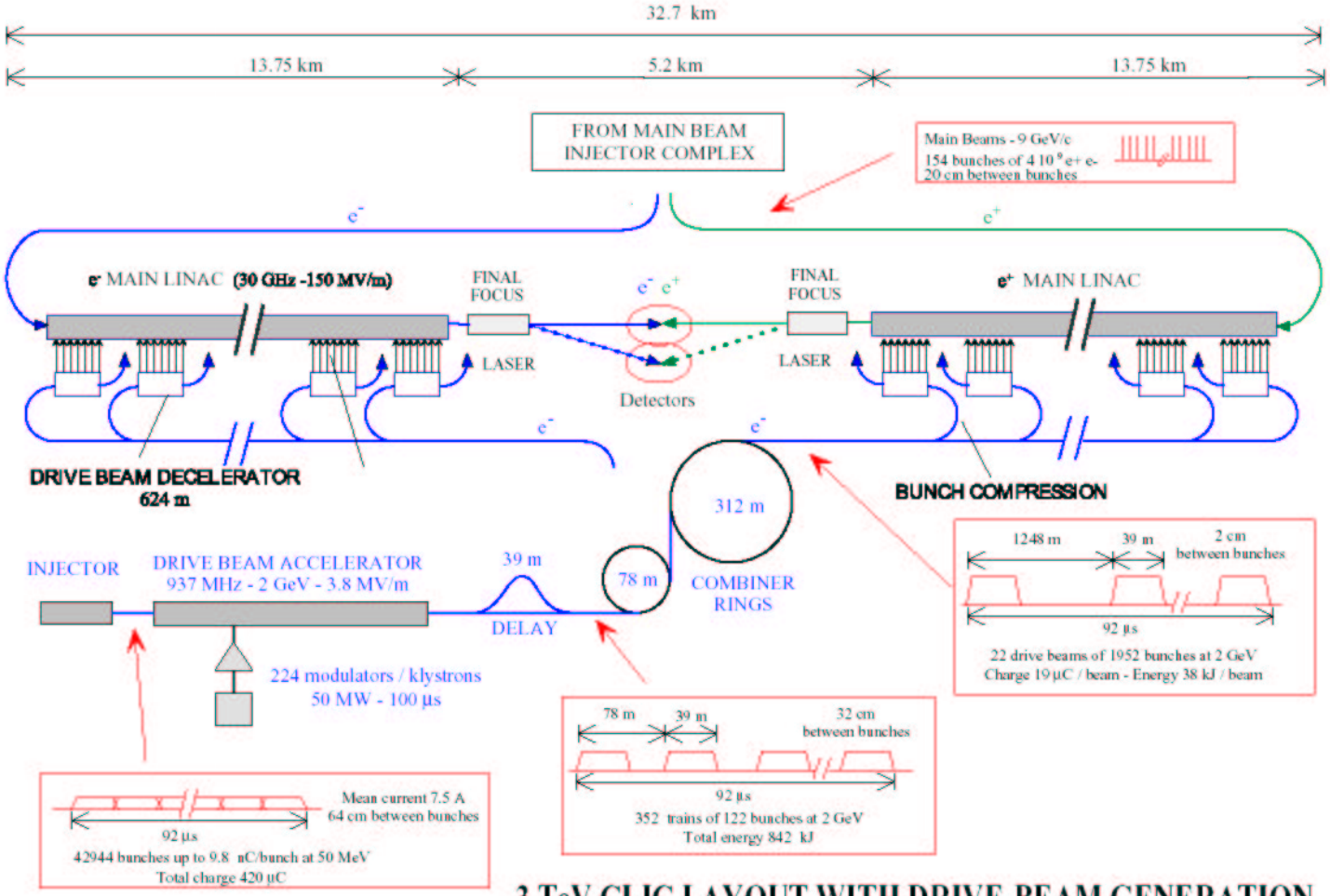
1st step: no add. investment, 2nd step: add cryo+RF power



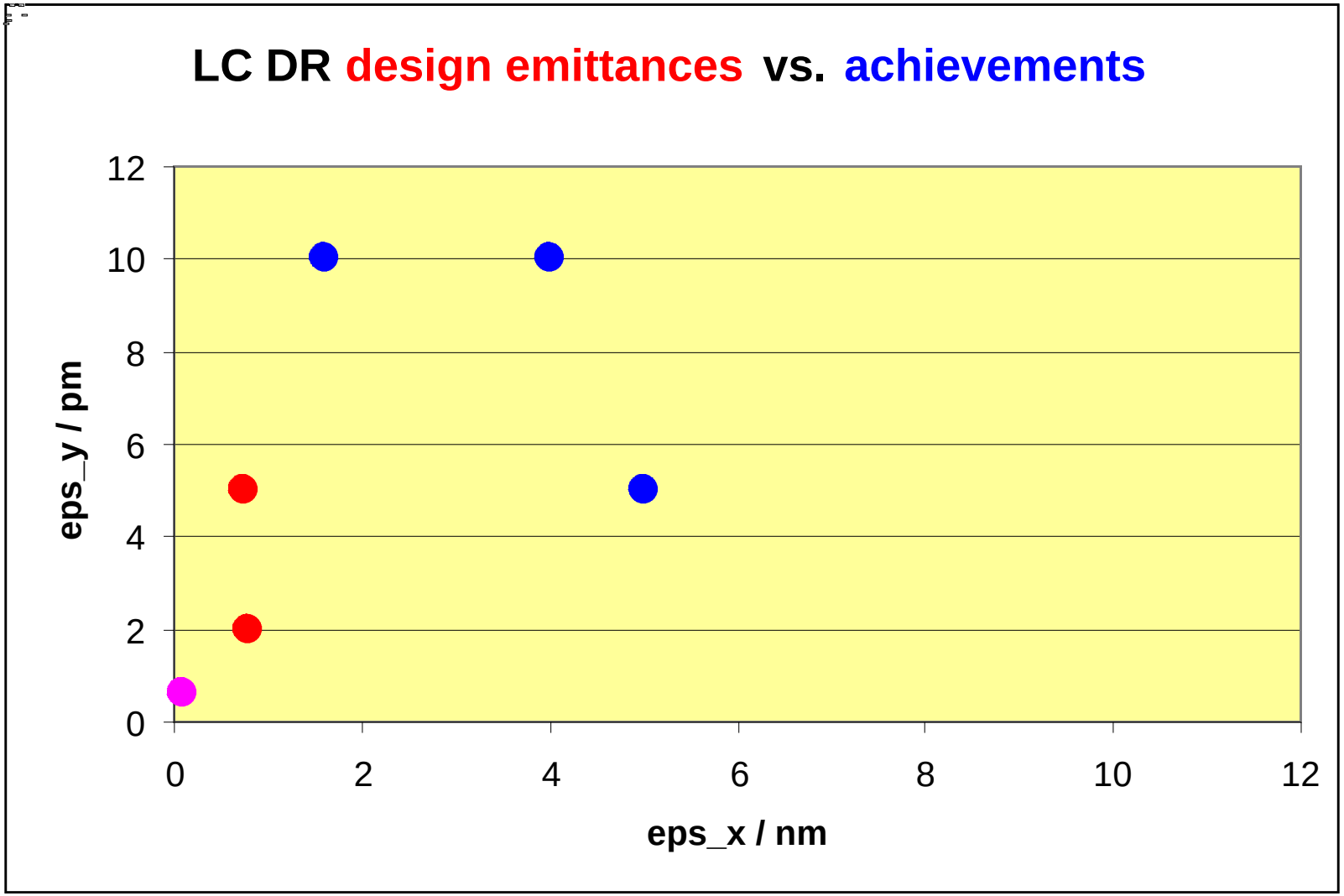
CHECHIA test in pulsed mode



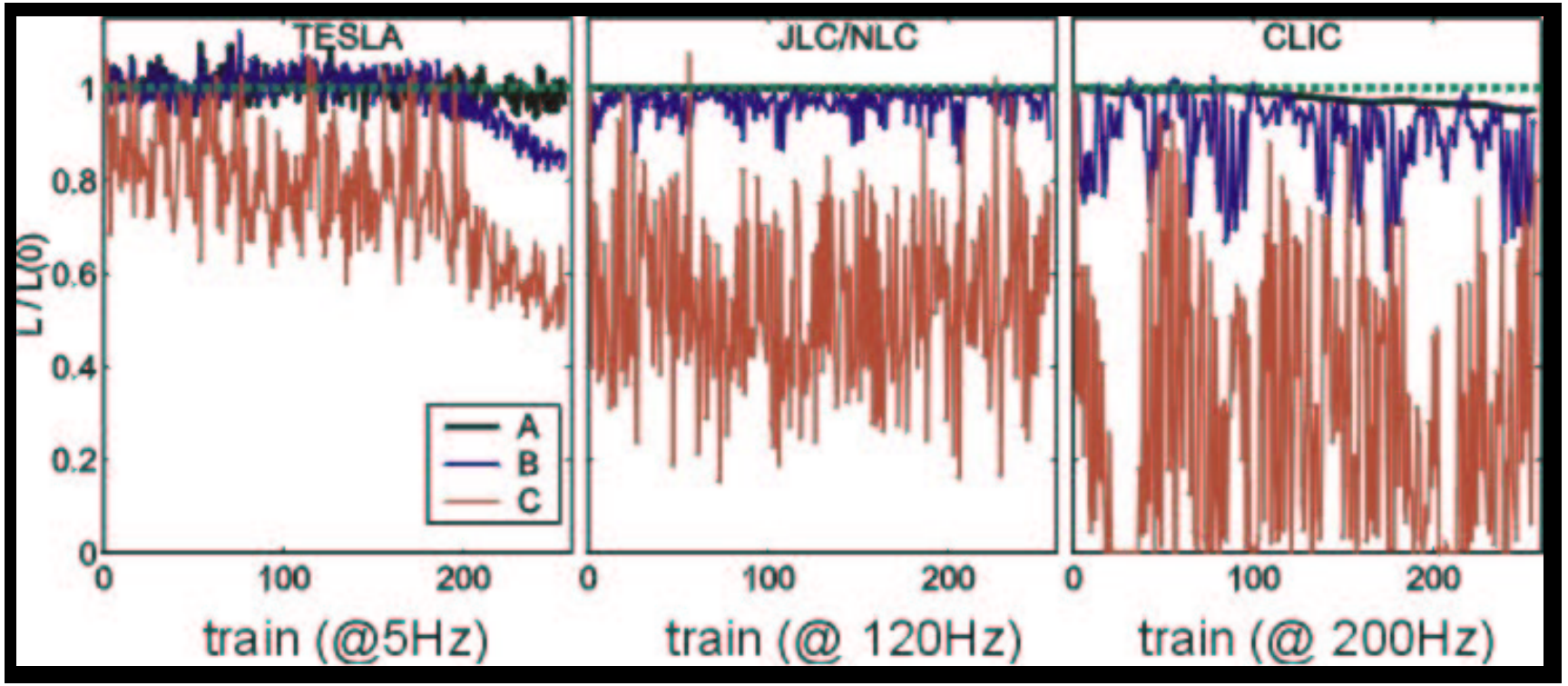
CLIC two-beam accelerator approach
CERN & coll. Inst.



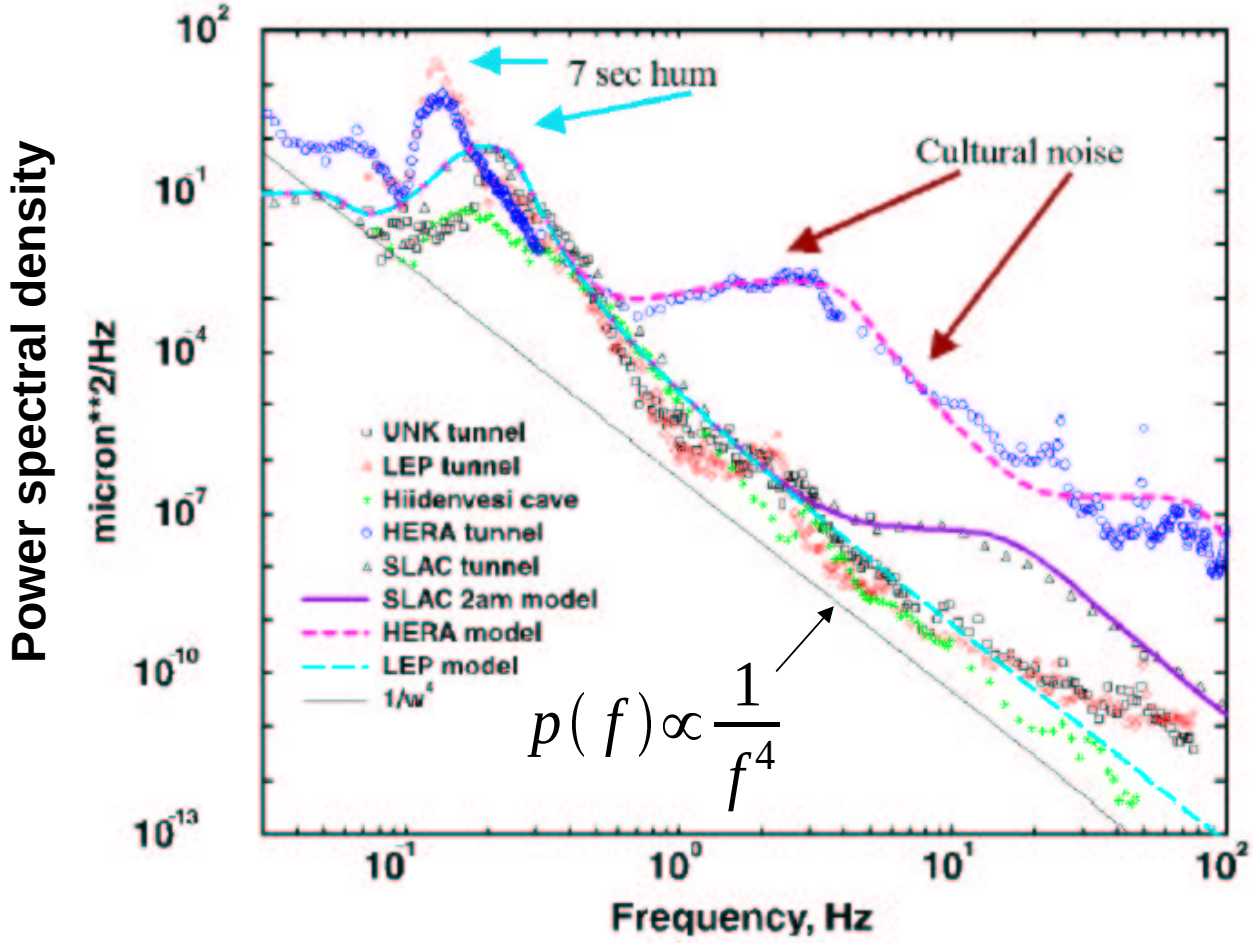
3 TeV CLIC LAYOUT WITH DRIVE-BEAM GENERATION


LC DR design emittances vs. achievements
eps_y / pm
eps_x / nm
0
2
4
6
8
10
12

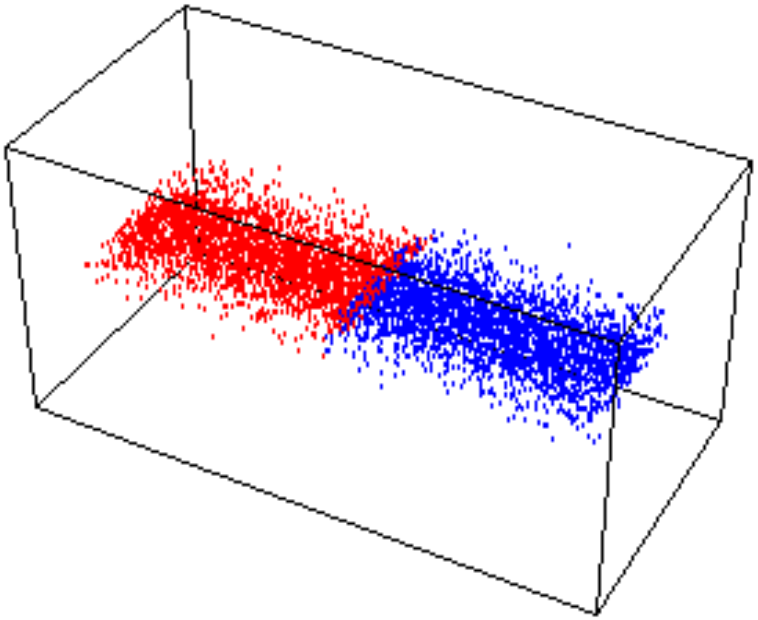
Luminosity stability: “Start-to-end” simulations, including ground motion

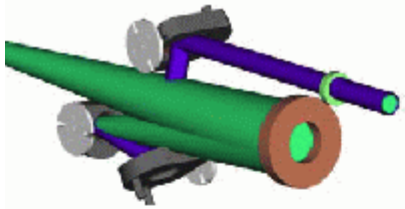


Ground motion: varies form “quiet” (model A) to “noisy” (model C), depending on site

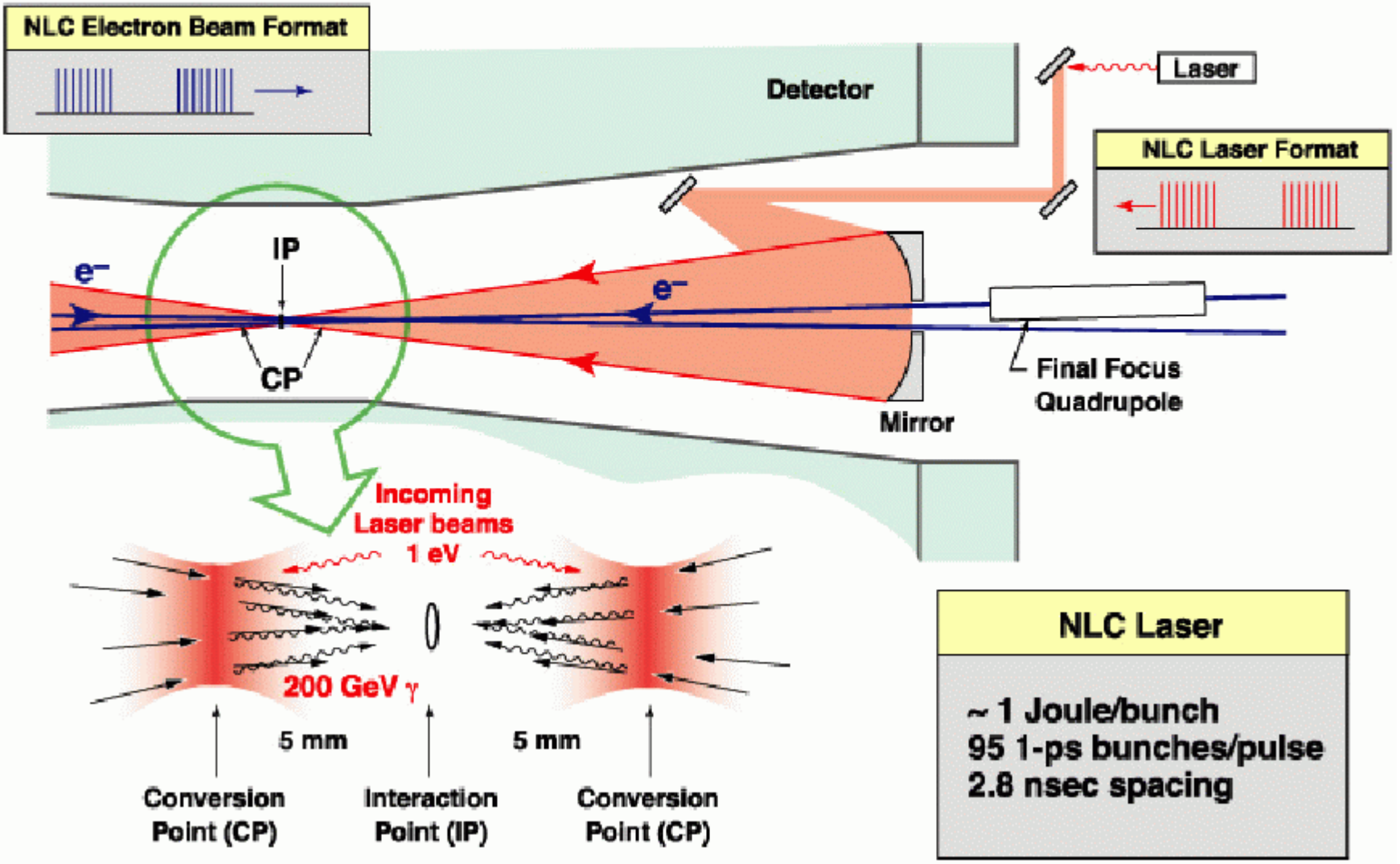


There are a number of subtle effects in LC beam dynamics… e.g. the ***banana effect*** (amplification of bunch deformations during collision): (TESLA beam-beam simulation)



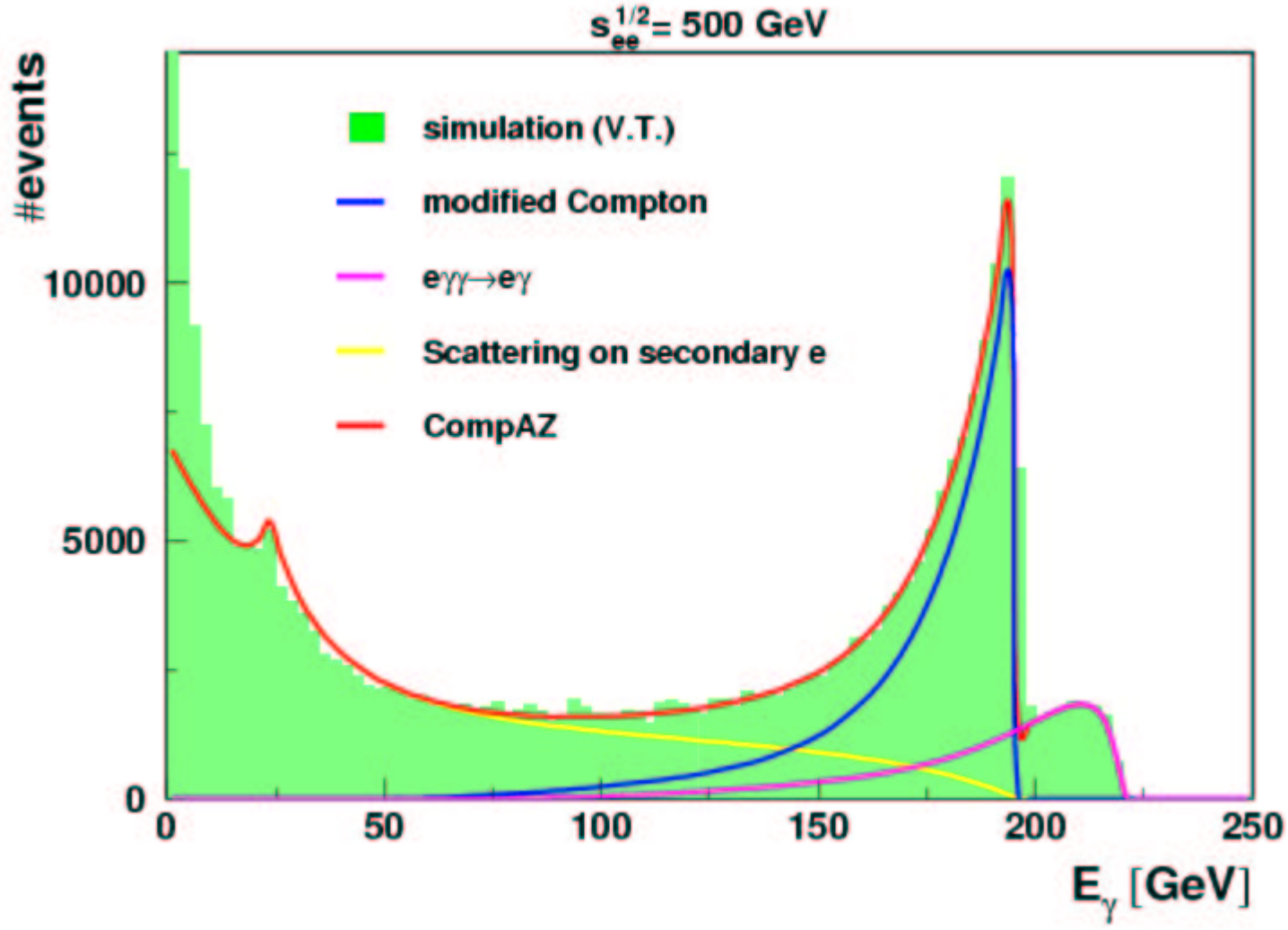


Photon Colliders – The marriage of lasers and electron linear colliders

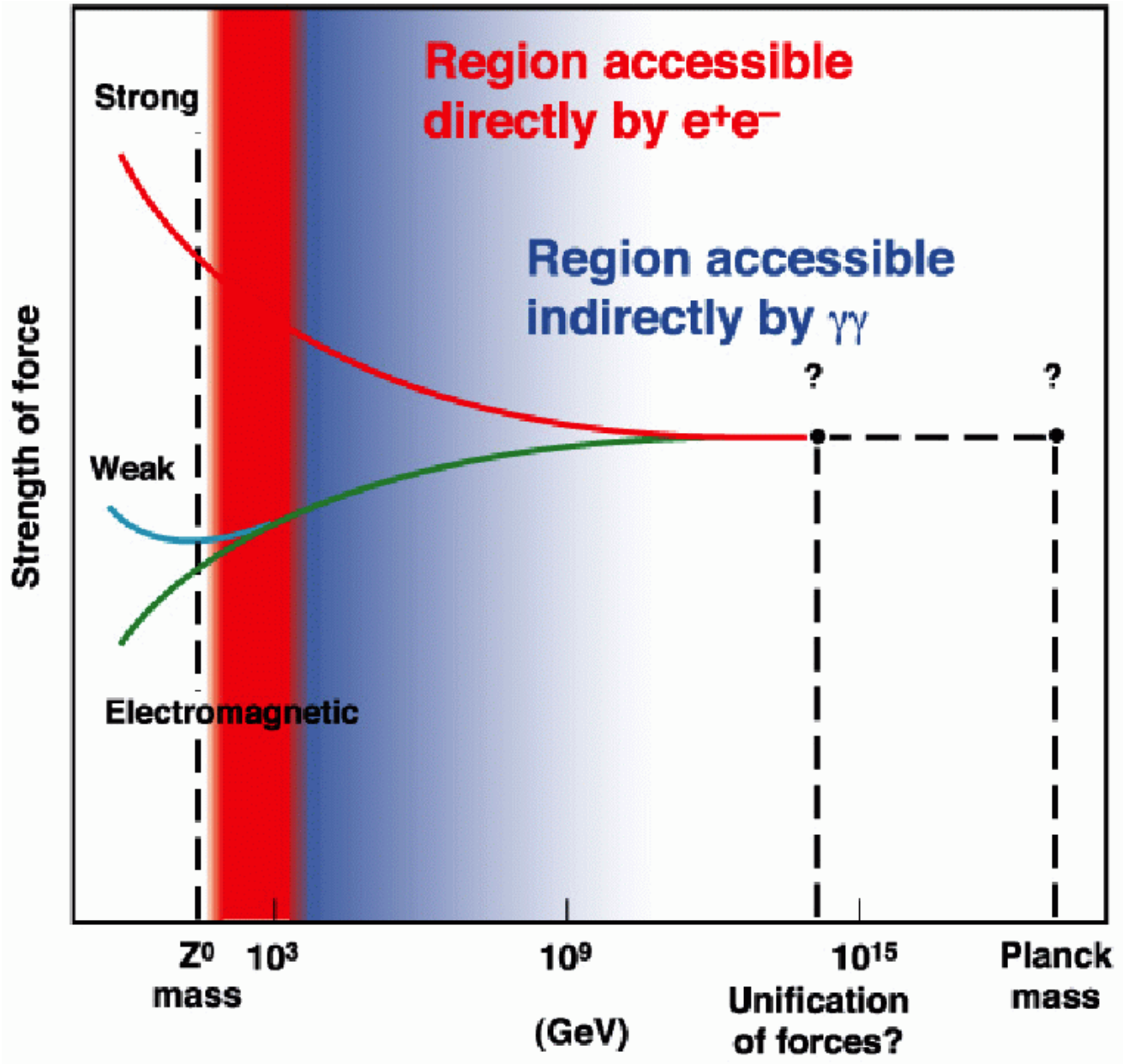


Photon Collider at TESLA

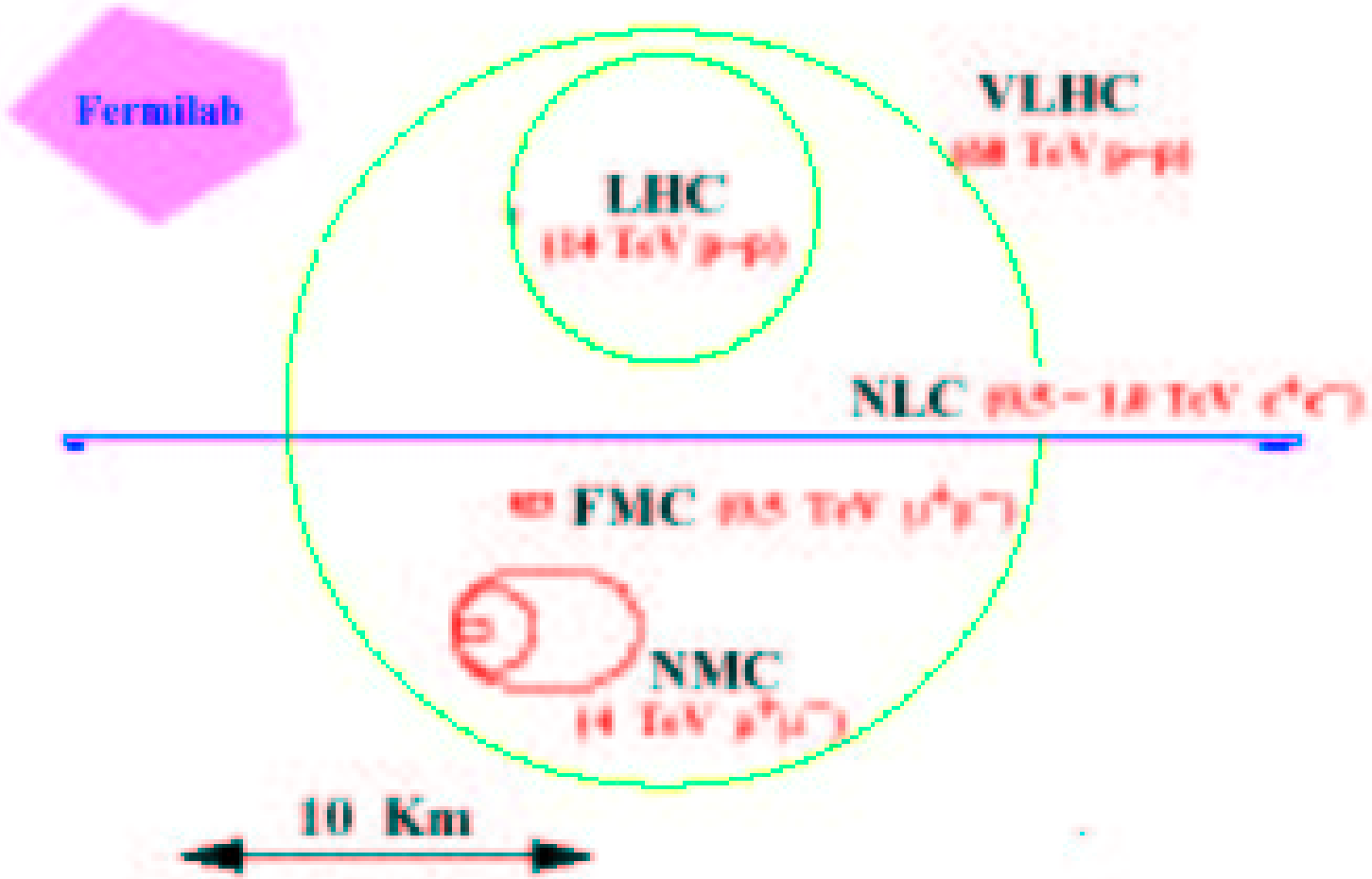
Photon beam energy spectra

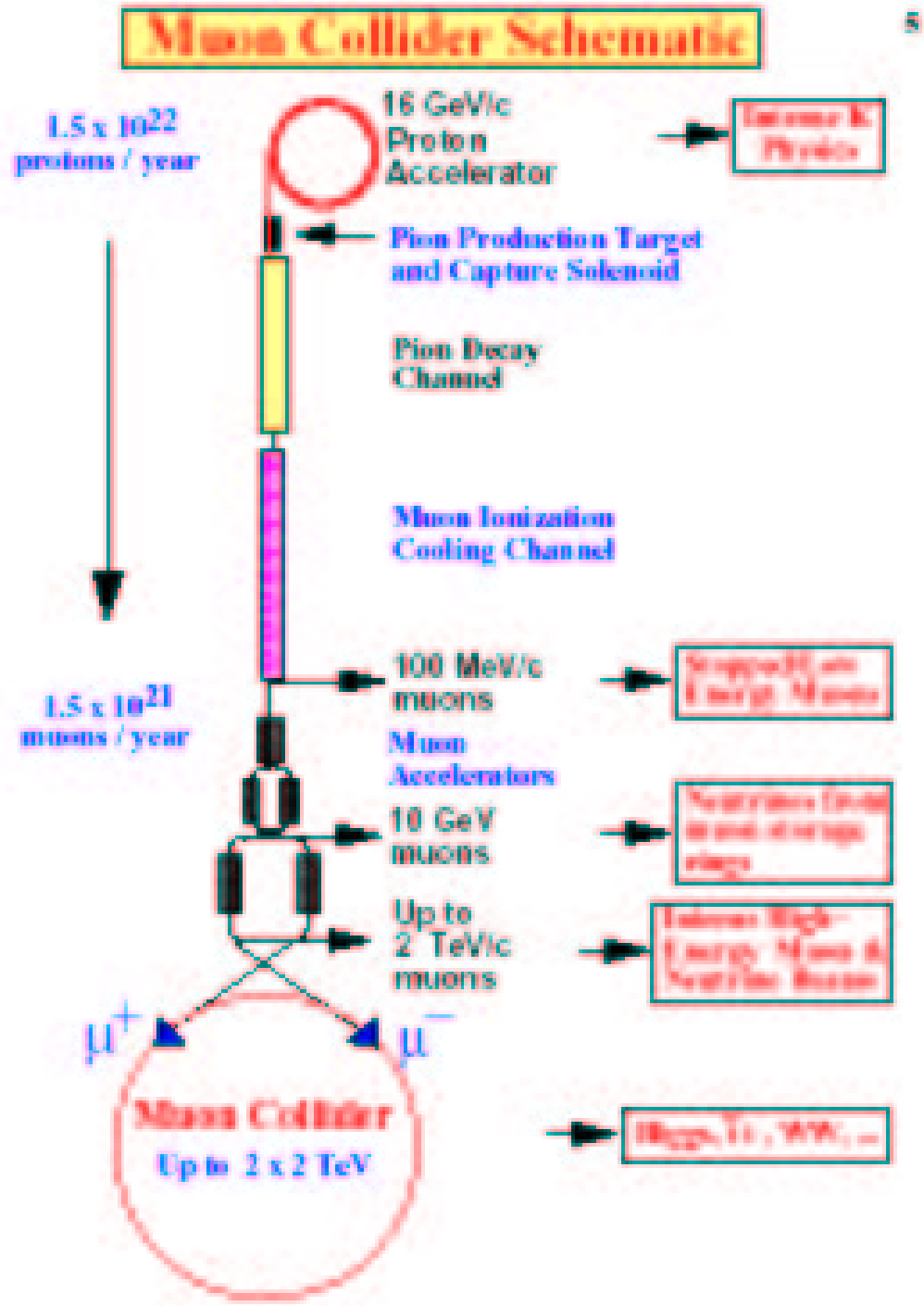


Photon Collider mass reach:



μ+μ- collider project:





Main problem:

luminosity