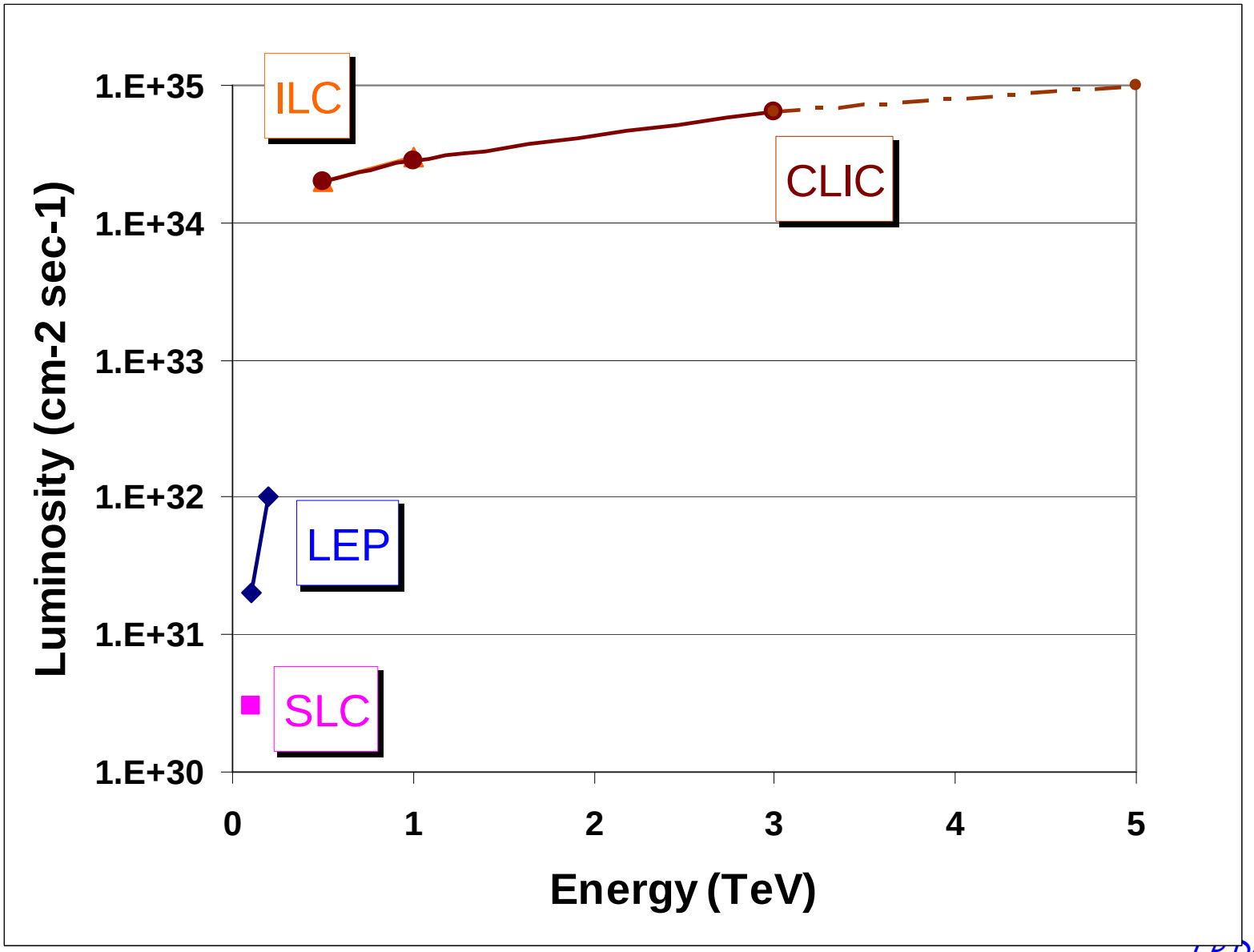
Multi-TeV Linear Collider (CLIC): Swiss in-kind contribution to the accelerator R&D

Lenny Rivkin, PSI & EPFL

- **Project evolution**
- **CTF3 Collaboration**
- **In-kind contribution from Switzerland**

Performances of Lepton Colliders



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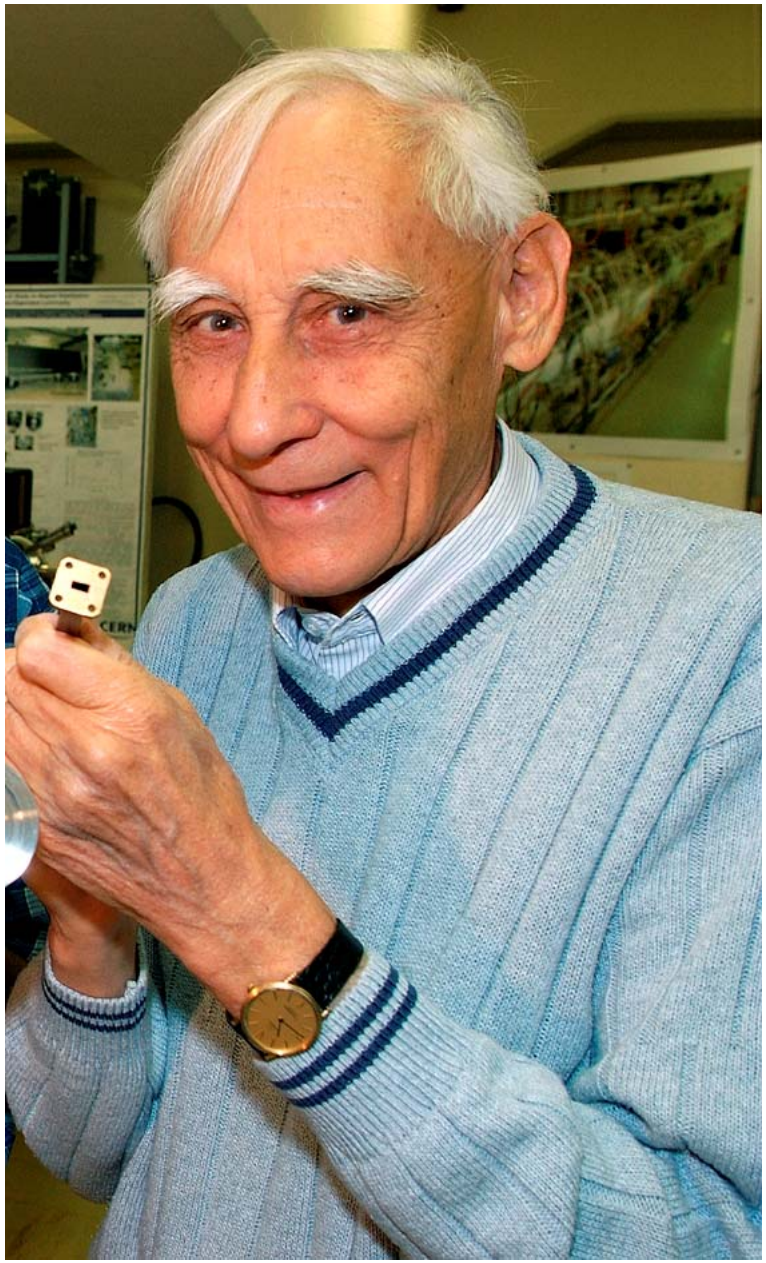
CERN

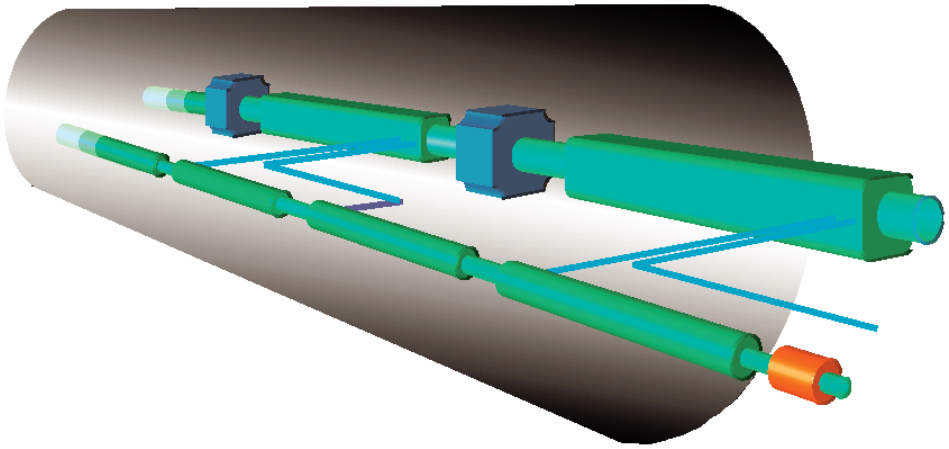
LInear

Collider



Wolfgang Schnell 1929–2006

THE COMPACT LINEAR COLLIDER (CLIC) STUDY



The CLIC study is a site independent feasibility study aiming at the development of a realistic technology at an affordable cost for an e± Linear Collider in the post-LHC era for Physics in the multi-TeV center of mass colliding beam energy range.

http://clic-study.web.cern.ch/CLIC-Study/

CERN 2000-008, CERN 2003-007, CERN 2004-005

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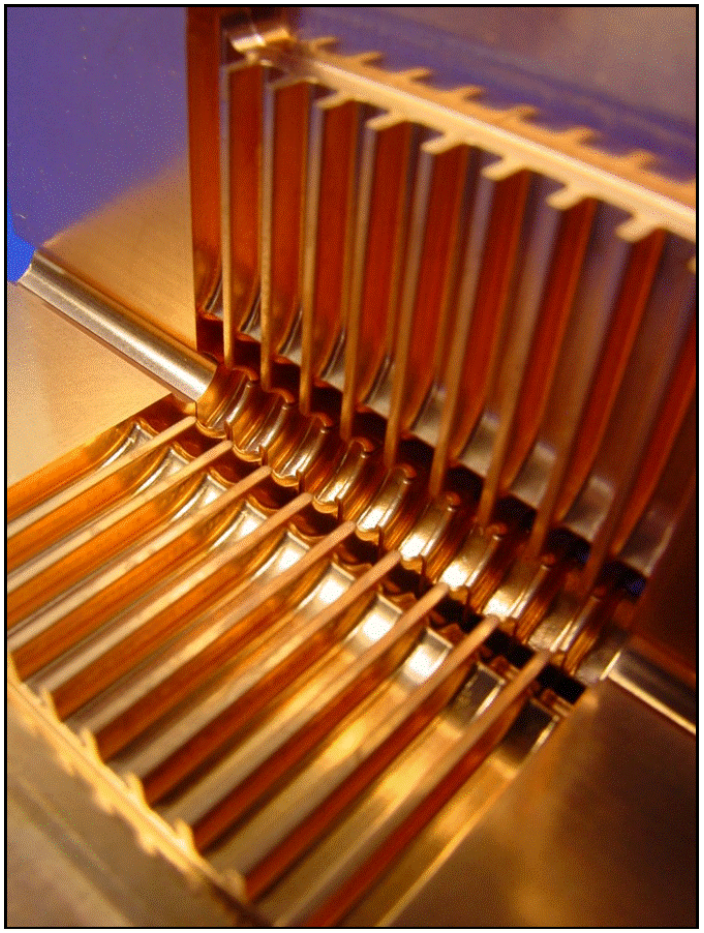
Technical Design for CLIC 2011 - 2016

Compact

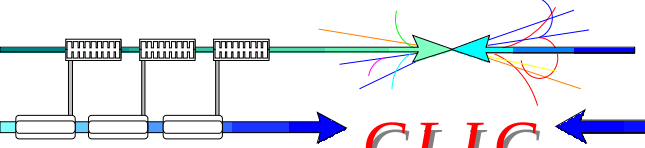
LInear

Collider

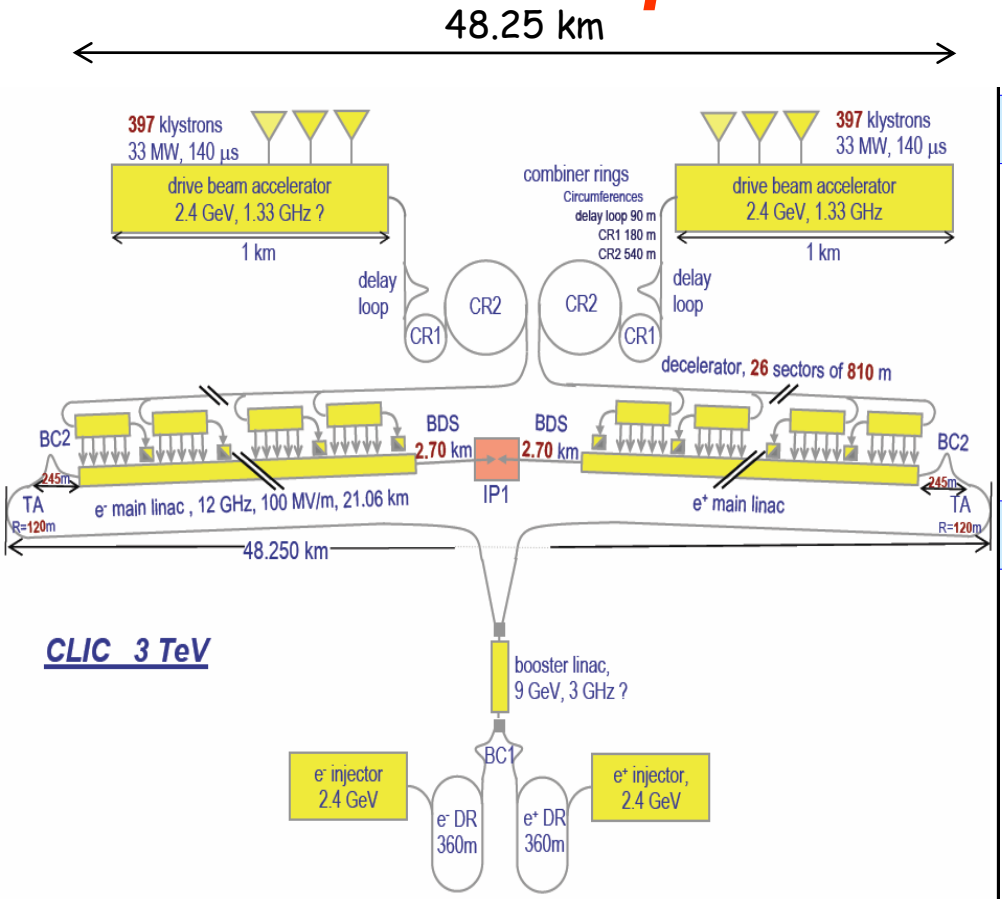


http://clic-study.web.cern.ch/CLIC-Study/

CLIC technology for Multi-TeV Linear Colliders



CLIC



Overall layout
Colliding energy of 3 TeV

- High acceleration gradient (100 MV/m)

- "Compact" collider-overall length≈48 km
  - Normal conducting accelerating structures
  - High acceleration frequency (12 GHz)

- Two-Beam Acceleration Scheme

  - RF power generation at high frequency
  - Cost-effective & efficient (~ 10% overall)
  - Simple tunnel, no active elements
  - "modular" design, can be built in stages
  - Easily expendable in energy

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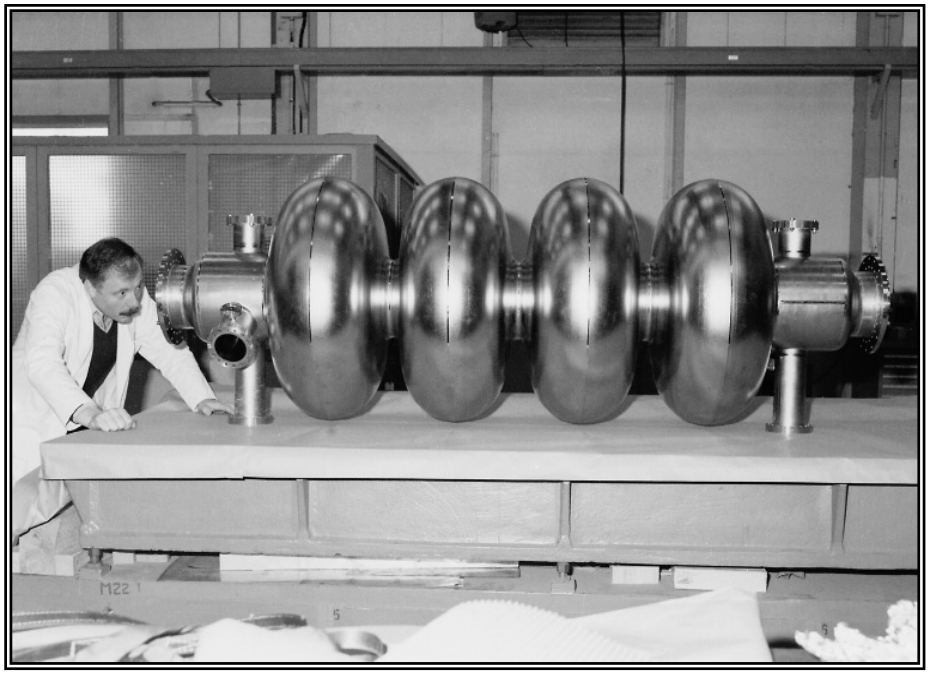
New CLIC Parameters (December 2006)

Main Linac RF frequency	**30 GHz ⇒ 12 GHz**
Accelerating field	**150 MV/m ⇒ 100 MV/m**
Overall length @ E_{CMS}= 3 TeV	**33.6 km ⇒ 48.2 km**

- **Substantial cost savings and performance improvements for 12 GHz / 100 MV/m indicated by parametric model (flat optimum in parameter range)**
- **Promising results already achieved with structures in test conditions close to LC requirements (low breakdown rate) but still to be demonstrated with long RF pulses and fully equipped structures with HOM damping.**
- **No strong frequency dependence of achieved accelerating gradients in copper structures for RF > 12 GHz**
- **Realistic feasibility demonstration by 2010**
- **Review in 2010 on optimum gradient and frequency based on experiments**

30 GHz: an overshoot?

LEP-Cavity 350 MHz

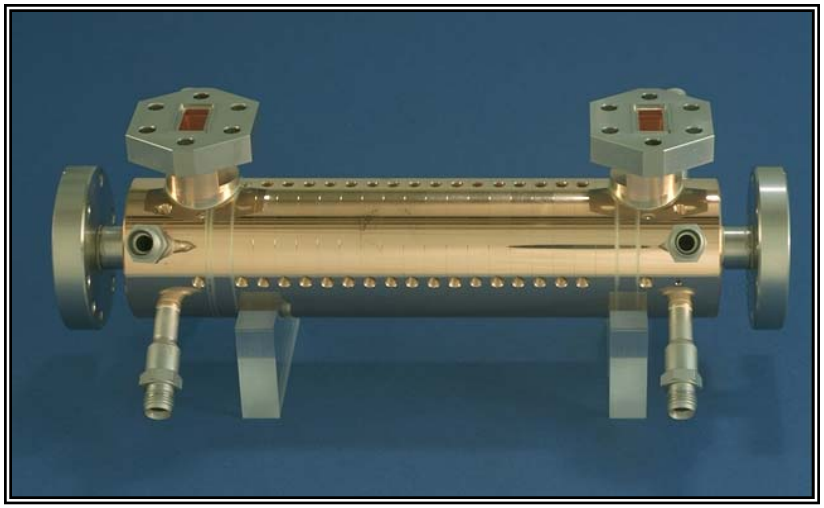


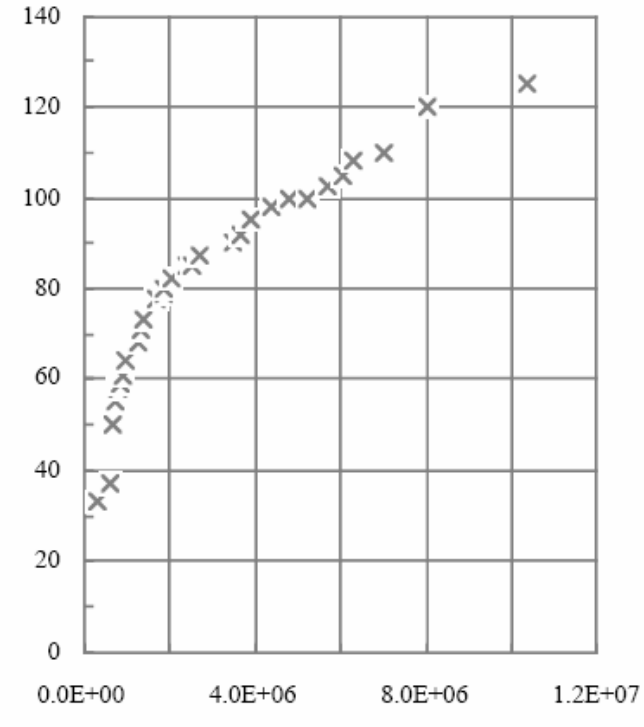
CLIC-Cavity 30 GHz

First CLIC x-band structure

One tested at KEK and one tested at SLAC

Beam hole radius	3 mm
Disk thickness	2 mm
Effective length (26+2cells)	.2449 m
Group velocity, v_g/c	1.1% *
Impedance, r/Q	16.0 [kΩ/m]
Shunt impedance, r	106.8 [MΩ/m]
Q	6680*
Attenuation parameter	1.61 [neper/m]*
Filling time, t_f	58 [ns]*
Surface/Accelerating field	1.9



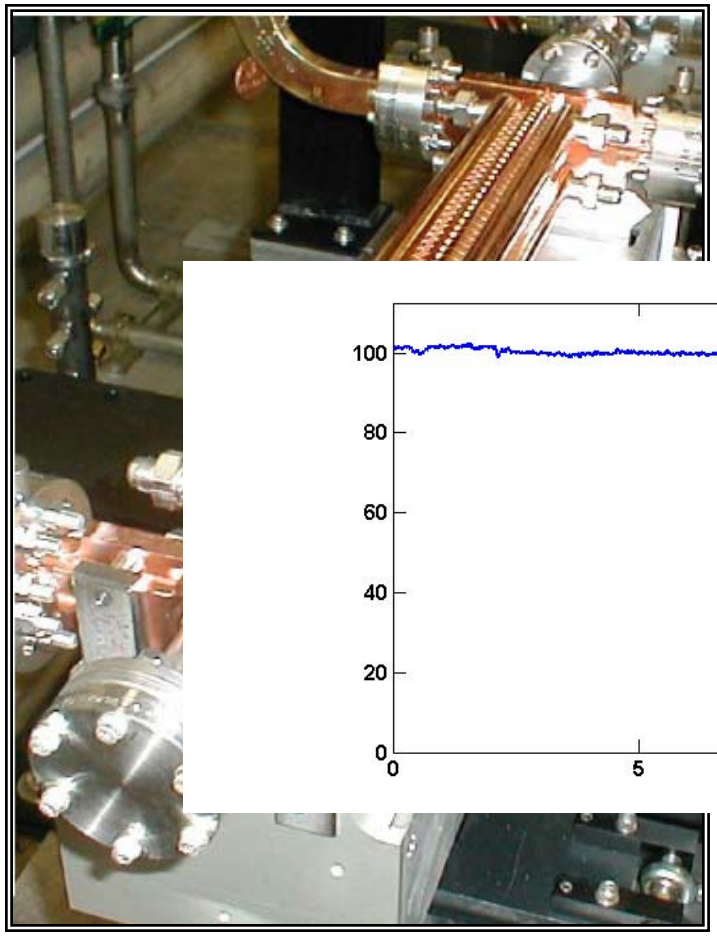


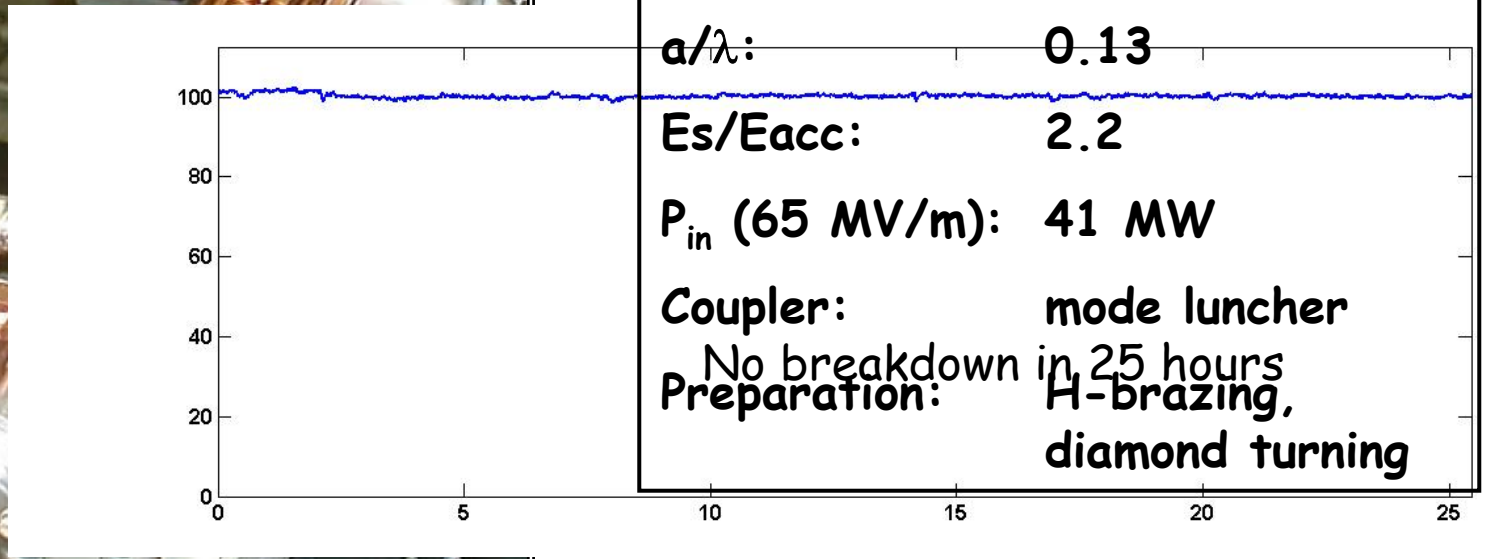
150 MV/m peak, 125 MV/m avg

150 ns pulse length

No breakdown monitoring

A reference structure for CLIC from NLC

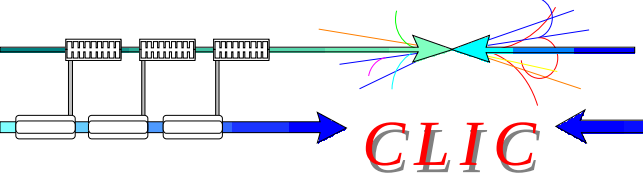




Length:	53 cm
Phase advance:	120 deg
Group velocity:	3 %
a/λ:	0.13
Es/Eacc:	2.2
P_{in} (65 MV/m):	41 MW
Coupler:	mode luncher
Preparation:	H-brazing, diamond turning

T53vg3, 50ns, 100MV/m

No breakdown in 25 hours



CTF3 multi-lateral Collaboration

16 members

21 institutes involving 15 funding agencies from 10 countries

MoU with addenda describing specific contribution

Countries	Funding Agencies	Laboratory
CERN	CERN	CERN
FINLAND		Helsinki Inst of Phys (HIP)
FRANCE	CEA/DSM-Saclay	DAPNIA
	CNRS/IN2P3	LAL - LURE
		LAPP
INDIA*	Indian DAE	RRCAT, Indore
ITALY	INFN	LNF
RUSSIA		Budker Inst (BINP)
		IAP
	Dubna	JINR
SPAIN	Ministry of Education & Science (MEC)	CIEMAT, UPC, IFIC
SWEDEN	Swedish Research Council	Uppsala Univ and Svedberg Lab (TSL)
	Wallenberg Foundation	
SWITZERLAND		Paul Scherrer Inst (PSI)
TURKEY		Ankara Univ Group 1 & 2
USA	DOE	Northwestern Univ Illinois (NWU)
		SLAC

* India participating through a special agreement with CERN for the development of novel accelerator technologies

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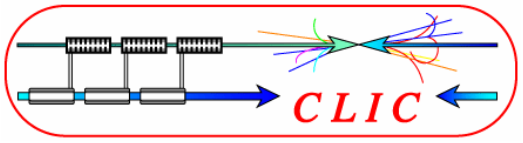
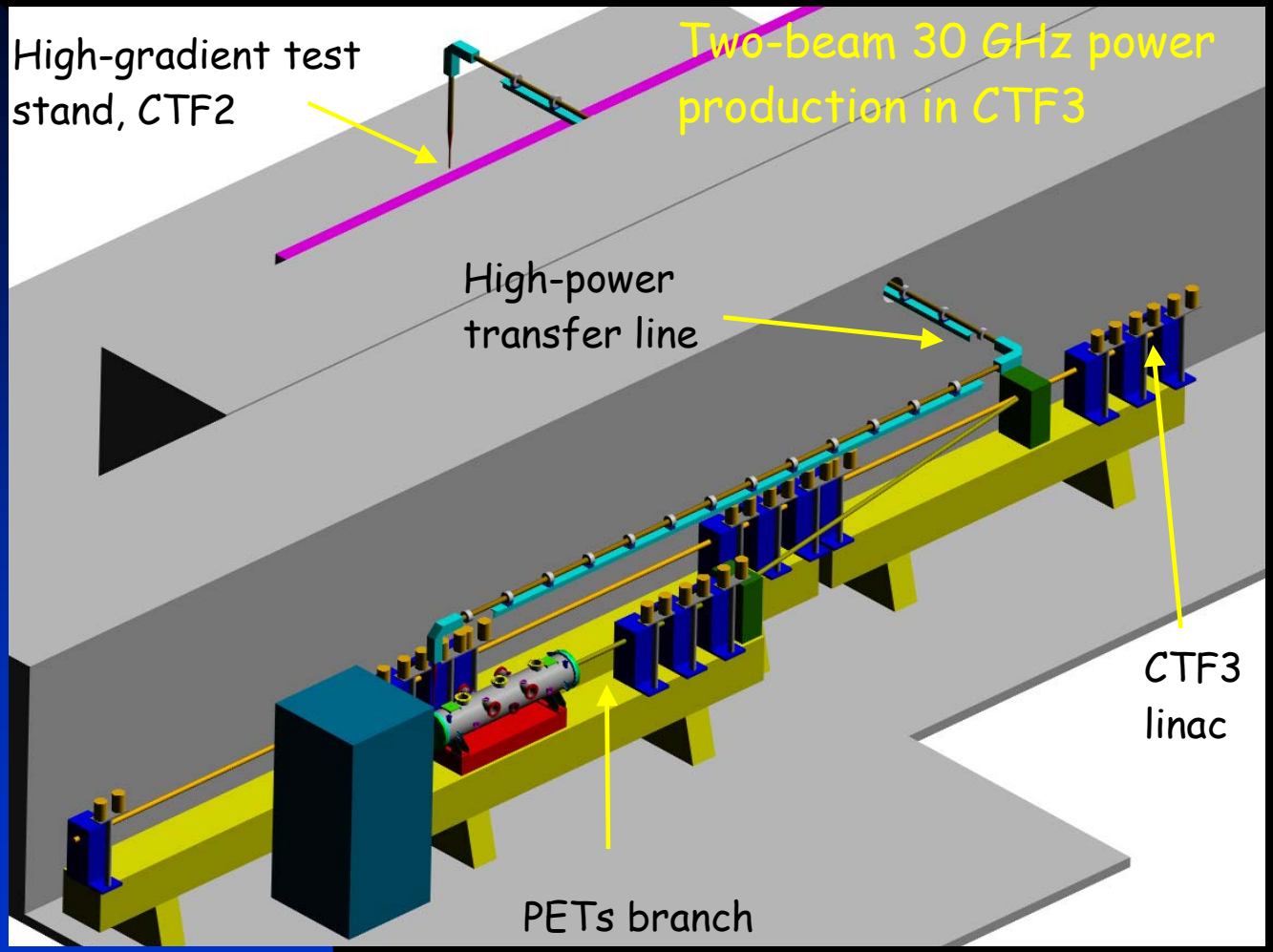


Collaboration

PSI on 12.12.06

Ankara University (Turkey):	CTF3 beam studies & operation
Berlin Tech. University (Germany):	Structure simulations GdfidL
BINP (Russia):	CTF3 magnets development & construction, DR wiggler & beam dynamics
CERN:	Study coordination, structures devel., CTF3 construction/commissioning
CIEMAT (Spain):	CTF3 septa and kickers, correctors, power extraction structures
DAPNIA/Saclay (France):	CTF3 probe beam injector
EU	Financing of RF photo injector (FP6 JRA)
Finnish Industry (Finland):	Sponsorship of mechanical engineer
INFN / LNF (Italy):	CTF3 delay loop, transfer lines & RF deflectors, ring vacuum chambers
JINR & IAP (Russia):	Surface heating tests of 30 GHz structures
KEK (Japan):	Low emittance beams in ATF
LAL/Orsay (France):	Electron guns and pre-buncher cavities for CTF3
LAPP/ESIA (France):	Stabilization studies, CTF3 beam position monitors
LLBL/LBL (USA):	Laser-wire studies
North-West. Univ. Illinois (USA):	Various CTF3 Beam diagnostics & CTF3 equipment
RAL (England):	Lasers for CTF3 and CLIC photo-injectors
SLAC (USA):	High Gradient Structure testing, structure design, CTF3 injector design
Uppsala University (Sweden):	Beam monitoring systems for CTF3

Present two beam 30 GHz test facility



Erk Jensen, Gerry McMonagle

White Paper

- Extra funding request for 2008 – 2010
  1. Physics potential LHC (103 MCHF, 246 FTEs)
  2. Injector complex (55 MCHF, 185 FTEs)
  3. Accelerator R&D (68 MCHF, 287 FTEs)

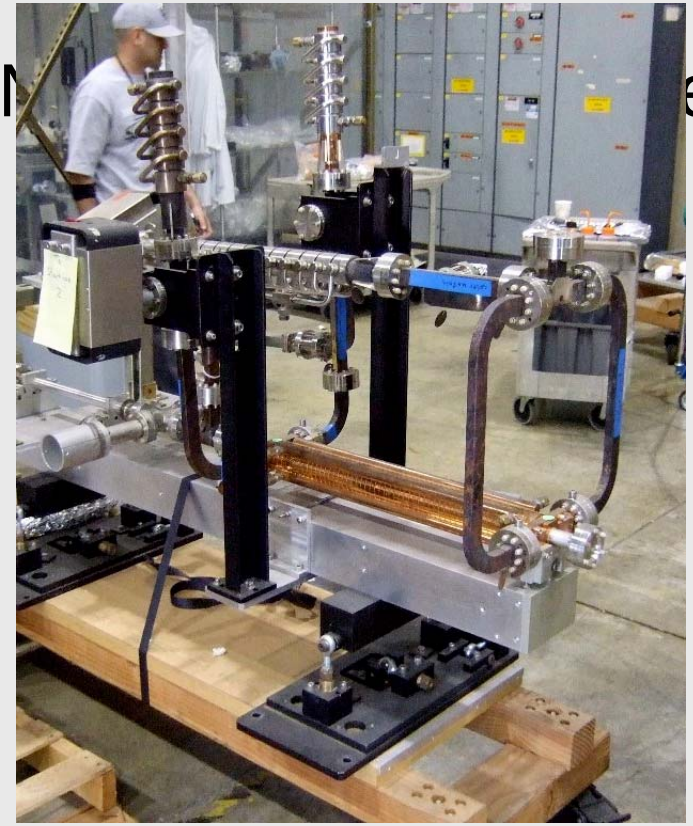
- CLIC R&D request: 12 MCHF, 60 FTEs

- EPFL/PSI „in-kind“ contribution ~ 4 M
  Technology of interest to PSI-XFEL, EPFL Laboratory of Ultrafast Spectroscopy, …

Accelerating gradient **100** MeV/m

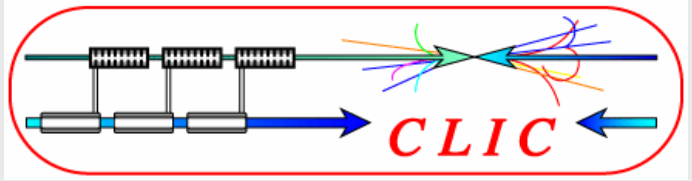
klystrons exist at 12 GHz

N est



X-Band accelerating structure at SLAC (~100 MeV)

X-Band klystron at SLAC



12 GHz high gradient test facility at CERN

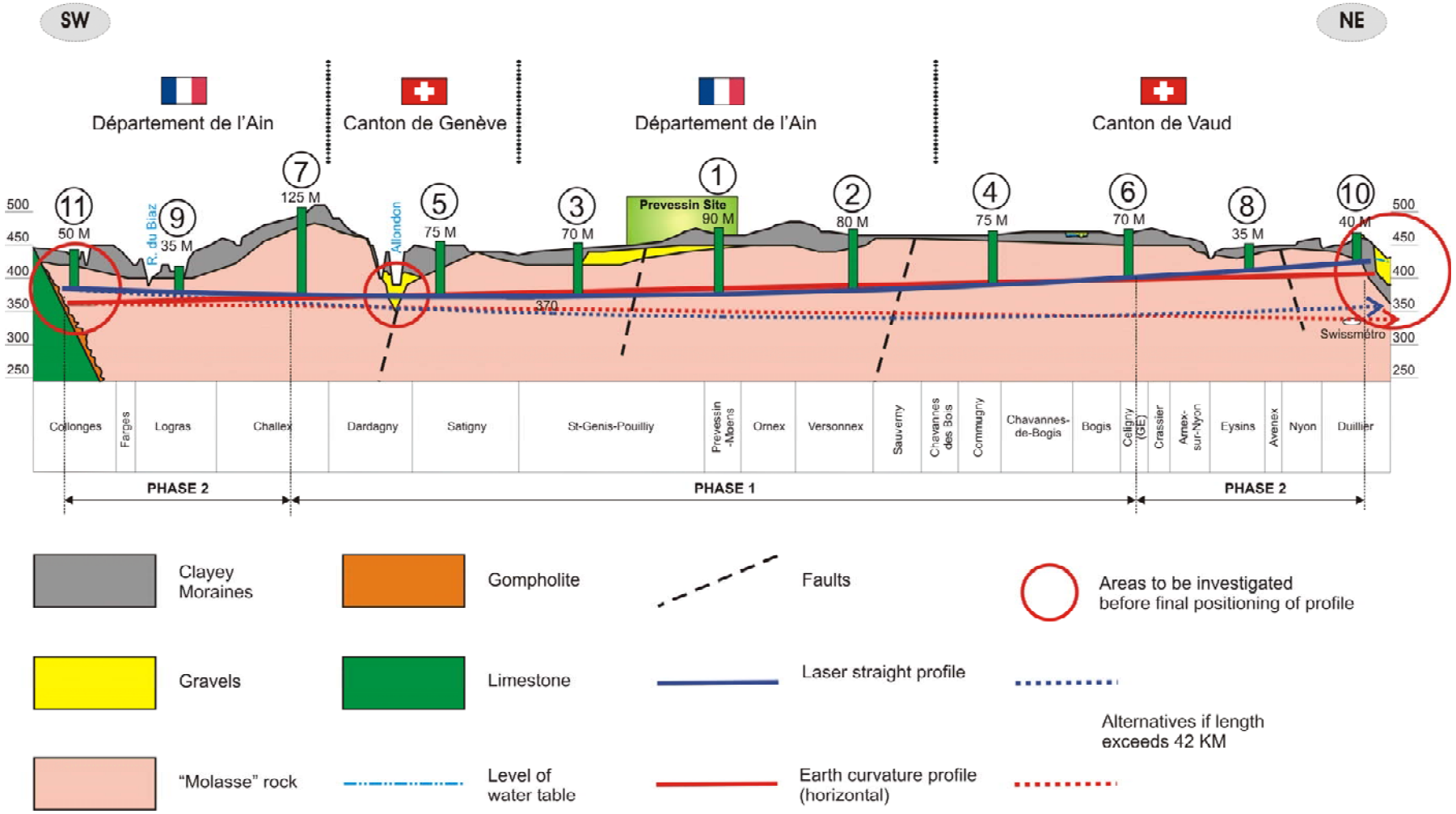
- Stand alone RF power source + paraphernalia
- 12 GHz signal aquisition system (LHEP)

Host country in-kind contribution to the advanced accelerator R&D at CERN over the period of 2008 – 2010

Third party financing of personnel at IPEP/LPAP matched in part by long term commitments from the EPFL towards accelerator R&D

END

Tunnel for ILC or CLIC at CERN – Longitudinal section

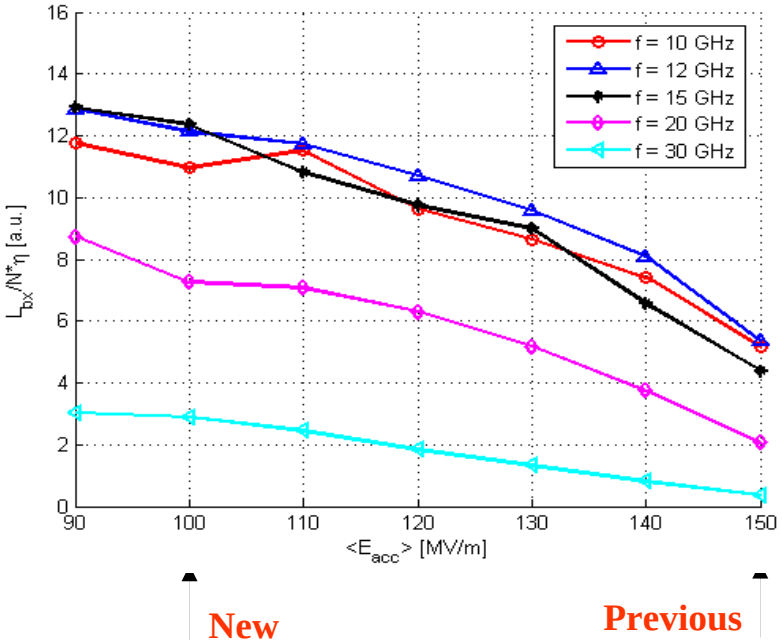


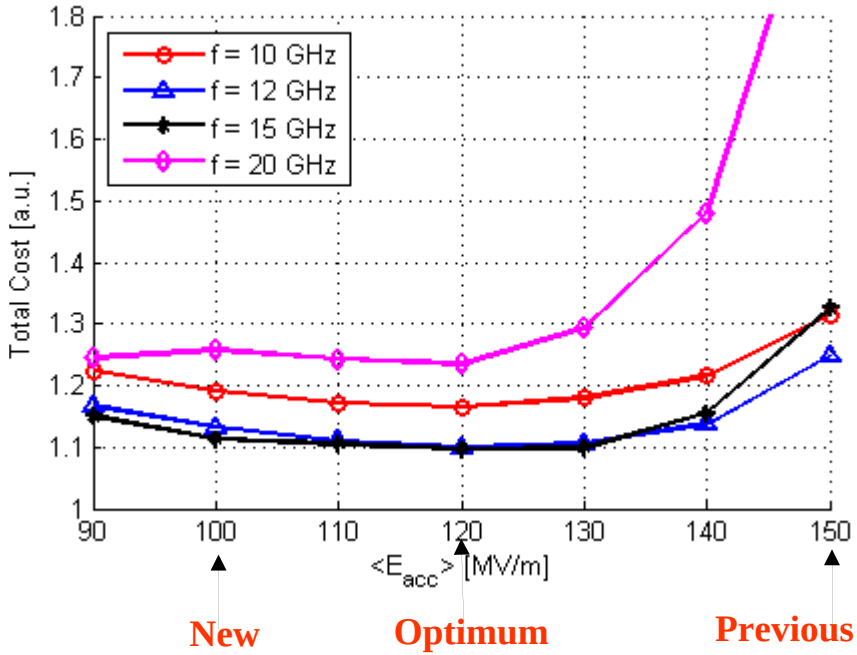
Study for 42 km tunnel.
New CLIC baseline is L_{total}=33.4 km

CLIC performances (FoM) and cost (relative) variation as a function of the accelerating gradient

E_{cms} = 3 TeV $L_{(1\%)}$ = 2.0 10^{34} $cm^{-2}s^{-1}$

(A.Grudiev)





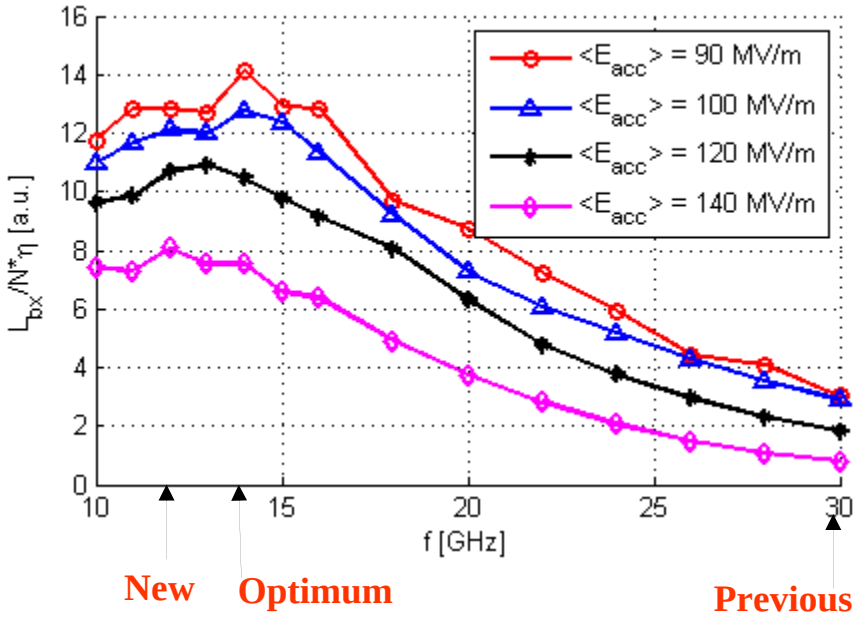
- **Performances increasing with lower accelerating gradient (mainly due to higher efficiency)**
- **Flat cost variation in 100 to 130 MV/m with a minimum around 120 MV/m**

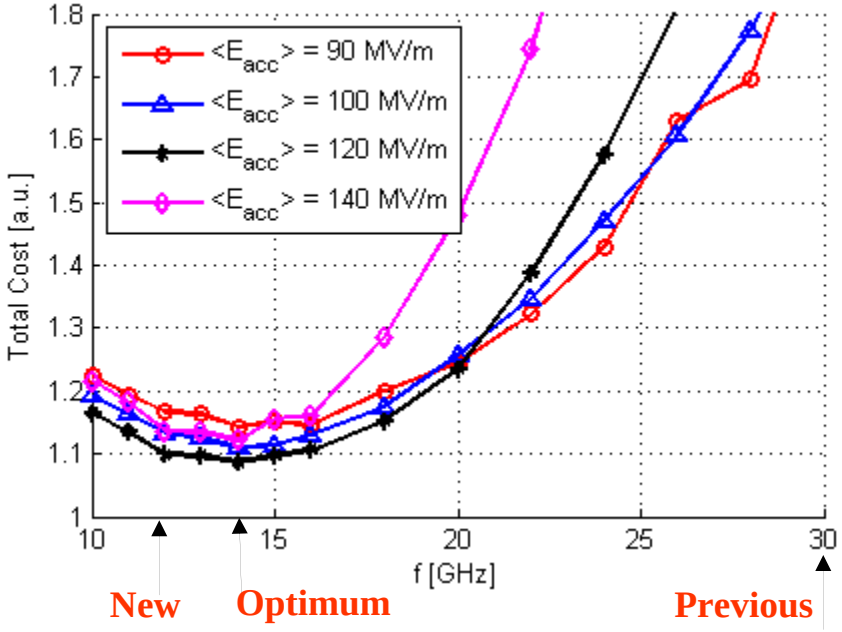
CLIC performances (FoM) and cost optimisation as function of RF frequency

CLIC

E_{cms} = 3 TeV $L_{(1\%)}$ = 2.0 10^{34} $cm^{-2}s^{-1}$

(A.Grudiev)





- **Maximum Performance around 14 GHz**
- **Flat cost variation in 10 to 16 GHz frequency range with a minimum around 14 GHz**