CLIC programme 2013-2018

- Guidelines and overall goals
- Main activities as re-defined this summer
- Summary and conclusions

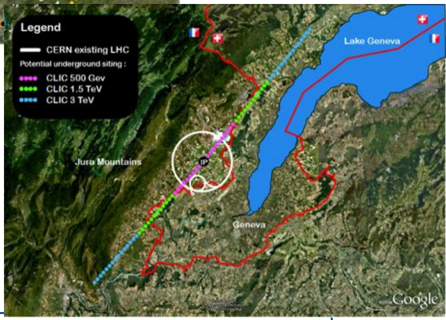
Strategy outcome

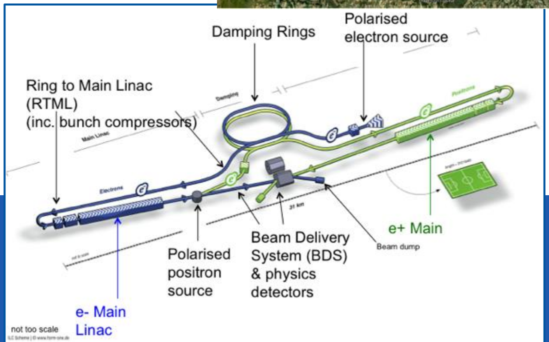
European Strategy priorities related to the Energy Frontier:

- LHC and LHC luminosity upgrades (until ~2030)
  - Higgs and Beyond the Standard Model physics in long term programme
- BSM – does it show up at LHC at 14 TeV, 2015 onwards ?
  - What are the best machines to access such physics directly post-LHC …. we don't know but we can prepare main options the next years towards next strategy update (~2018)
  - Two alternatives considered; higher energy hadrons (HE LHC or VHE LHC), or highest possible energy e+e- with CLIC
- ILC in Japan, a possibility for exploring the Higgs in detail, starting at 250 GeV
  - If implemented a comprehensive programme that can map out the Higgs sector in particular

At CERN: In accordance with this, pursue three connected LC activities in the period towards 2018 (when LHC results at nominal energy are becoming mature):

- CLIC as option for the energy frontier (accelerator, det&phys studies)
- ILC project development - towards a construction project
- Common activities wherever possible





CLIC for the energy frontier

Goal for the next European Strategy update (2018): Present a CLIC project that is a "credible" option for CERN beyond 2030:

- Physics studies updated taking into account LHC-14 TeV (assume the physics case will be there for an energy frontier machine – i.e. focus beyond the Higgs)
- Physics after LHC programme completion (2030 +)
- Initial costs and upgrade costs for 2nd and 3rd stage in reasonable agreement with one could hope based on "CERN resources with additional international help" – considering a 20-30 year perspective
- Common/combined or coordinated studies with various of high energy hadron rings (v)HiE LHC, in particular related to CE, conv.system, costs, power, schedules, resources, some technical studies, physics studies (very little done in the last decade – see fig. right from 2001)

Process	VLHC	CLIC	
	200 TeV	3 TeV	5 TeV
squarks	15	1.5	2.5
sleptons		1.5	2.5
Z'	30	20	30
q^*	70	3	5
l^*		3	5
Extra two dimensions	65	20 – 33	30 – 55
$W_L W_L$	30σ	70σ	90σ
TGC (95%)	0.0003	0.00013	0.00008
Λ compos.	130	300	400

Resource realities:

Overall CERN LC budget reduced wrt March 2012 planning by 10-15%, and overall distributed over one more year (includes 2018 to match next Strategy Update)

Profile adjusted such that project can carry out main hardware investments 2013-2015, and exploits and reduce long term commitments as we are getting closer to next Strategy Update – a natural development

Personnel also have a similar up to 10% reduction, partly implemented already for staff

Fellowship number decrease potentially more difficult, must work effectively with collaborators looking at associate possibilities and students (co-)financing

Main activities and goals for 2018

Design and Implementation studies:

- Baseline design and staging strategy
- Solid cost basis and more optimized power/energy (aim for 20% energy reduction)
- Proof of industry basis for key components/units, in particular those specific for CLIC
- Comprehensive reliability/robustness/uptime analysis
- Pursue increased use of X-band for other machines/applications (hard to set concrete goal)
- CDR status: not optimized except at 3 TeV and not adjusted for Higgs discovery, not optimized cost, first power/energy estimates without time for reductions, limited industrial costing, very limited reliability studies

System-tests:

- Complete system-tests foreseen for next phase, and comprehensive documentation of the results at CERN (CTF3) and elsewhere
- Strategy for further system verification before construction (XFEL, connected to light-sources, further drive-beam verifications) or as part of initial machine strategy.
- CDR status: CTF3 results initial phase (as of early 2012), ATF and FACET very little, no convincing strategy for further system verification
- Demonstrator of drive beam FE and RF power unit based on industrial capacity – will open for larger facilities beyond 2018 if necessary
- CDR status: Nothing done beyond CTF3

X-band developments:

- Statistics for gradient and structure choice (energy reach) and other X-band elements
- CDR status: Single elements demonstrated – limited by test-capacity

Technology developments:

- Demonstration of critical elements and methods for the machine performance:
  - ✓ DR, main linac, BDS with associated instrumentation and correction methods (combination of design, simulation, system-tests and technologies)
  - ✓ Stability/alignment (locally and over distances)
  - ✓ Module including all parts
- CDR status: alignment/stability partly covered, BBA assumed, wakefield mon. perf. assumed, no complete module

Summary and Conclusions

Programme towards next Strategy Update is defined and optimized.

Can be executed according to CERN MTP resources 2013-18:

- Re-work list of critical items for the project, and re-prioritize accordingly
- Need to close down CTF3 end 2016 and reduce or cut short several activities
- Key points/changes: CTF3 programme and Drivebeam FE “transfer” clarified, module 1st and 2nd generation better defined, test-setup planning and structure prod. planning updated, PACMAN support included, bat 156 and space clarified, technology transfer including FEL WG, power/energy studies and UK-CERN beyond mid 2014 all accounted for
- We also have agreement about most urgent significant hardware purchases

There are several potential areas for common work with future hadron options (site/cost/power/schedules/WBS and general project development, possibly some technical studies, physics and detector technology) – to be developed and exploited

Other news

- Snowmass input:
  - Accelerators: http://arxiv.org/abs/1305.5766
  - Detector and Physics: http://arxiv.org/abs/1307.5288

- New CLIC collaborators
  - Earlier this year: Jerusalem, Belgrade, Alba, Tartu
  - Recently:
    - ✓ NCBJ Warsaw – drivebeam FE studies and structures
    - ✓ Shandong University – beam dymamics studies, in particular related to RTML
    - ✓ Ankara University Institute of Accelerator Technologies (IAT) – drive beam complex and feedback design/background

- Next major collaboration event: CLIC workshop 2014: https://indico.cern.ch/conferenceDisplay.py?confId=275412
- Project meeting Tuesday 17.12 PM, followed by Christmas drink

- Open days a great success – for CERN and also for us (around 5000 people visiting the CLEX and our improved showroom)

Organisation of CLIC detector and physics study

Collaboration-like structure, based on a “Memorandum on Cooperation”
Partners join on a “best-effort” basis
http://lcd.web.cern.ch/LCD/Home/MoC.html

Currently 19 participating institutes (~3 more under discussion)

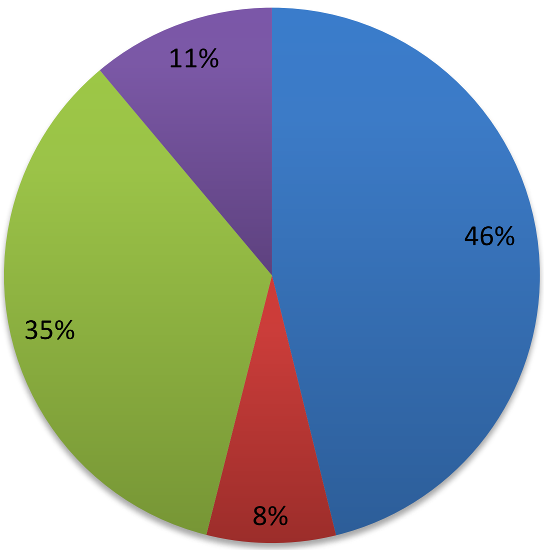
MoC partners

MoC participating institutes (19):

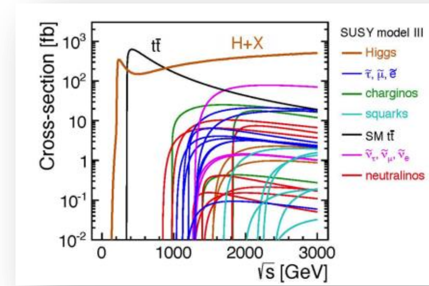
Australia:	ACAS;
Belarus:	NC PHEP Minsk;
Chile:	the Pontificia Universidad Católica de Chile, Santiago;
Czech Republic:	Academy of Sciences Prague;
Denmark:	Aarhus Univ.;
France:	LAPP, Annecy;
Germany:	MPI Munich;
Israel:	Tel Aviv Univ.;
Norway:	Bergen Univ.;
Poland:	Cracow AGH + Cracow Niewodniczanski Inst.
Romania:	Inst. of Space Science;
Serbia:	Vinca Inst. Belgrade;
Spain:	Spanish LC network;
UK:	Cambridge Univ. + Oxford Univ. + Birmingham Univ.;
USA:	Argonne lab;
CERN	

- More details in the next 4 slides

Design and Implementation (9% of overall resources)



- Design, Machine Prot, MDI - covers all areas of the machine, overall design and tools - and documentation, costs mainly students
- Civil Engineering & Services - central for layout, costs and power after rebaselining and final "report"
- Cost optimised module and component qualification of industries. Cost driver for project. Basis for ind. prod.
- Power/cost/schedules/WBS - basis for project implementation and documentation



Collaborators: CERN, Ankara, Australia, Novosibirsk, Cornell, Valencia, Frascati, IHEP, JAI, LAL, LAPP, Oslo, RHUL, SYMME, Catalonia, KIT, NIKHEF, EPFL, Aarhus, Shandong, Uppsala – to be completed

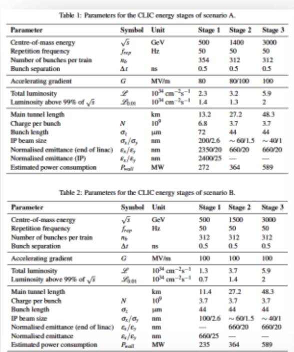
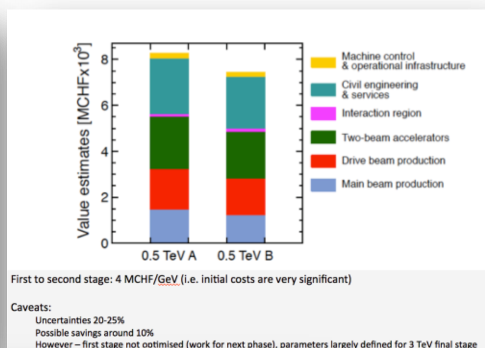


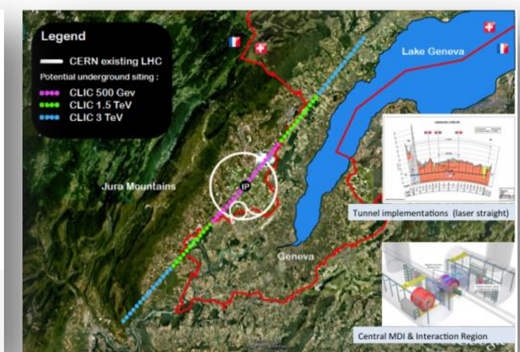
Table 1: Parameters for the CLIC energy stages of scenario A.

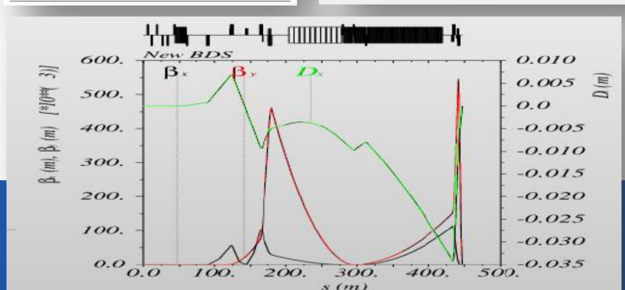
Parameter	Symbol	Unit	Stage 1	Stage 2	Stage 3
Centre-of-mass energy	$\sqrt{s}$	GeV	500	1400	3000
Repetition frequency	f_{rep}	Hz	50	50	50
Number of bunches per train	n_b		354	312	312
Bunch separation	Δt	ns	0.5	0.5	0.5
Accelerating gradient	G	MV/m	80	80/100	100
Total luminosity	$\mathscr{L}$	10^{34} cm^{-2}s^{-1}	2.3	3.2	5.9
Luminosity above 99% of $\sqrt{s}$	$\mathscr{L}_{0.01}$	10^{34} cm^{-2}s^{-1}	1.4	1.3	2
Main tunnel length		km	13.2	27.2	48.3
Charge per bunch	N	10^9	6.8	3.7	3.7
Bunch length	σ_z	µm	72	44	44
IP beam size	σ_x/σ_y	nm	200/2.6	~ 60/1.5	~ 40/1
Normalised emittance (end of linac)	ϵ_x/ϵ_y	nm	2350/20	660/20	660/20
Normalised emittance (IP)	ϵ_x/ϵ_y	nm	2400/25	—	—
Estimated power consumption	P_{wall}	MW	272	364	589

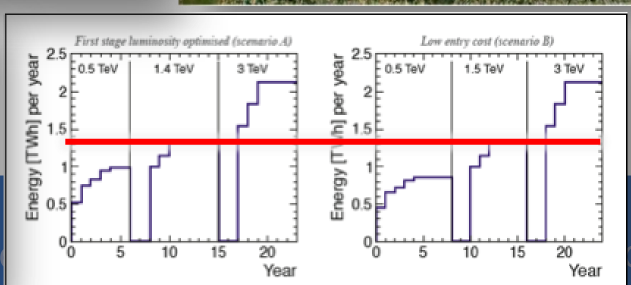
Table 2: Parameters for the CLIC energy stages of scenario B.

Parameter	Symbol	Unit	Stage 1	Stage 2	Stage 3
Centre-of-mass energy	$\sqrt{s}$	GeV	500	1500	3000
Repetition frequency	f_{rep}	Hz	50	50	50
Number of bunches per train	n_b		312	312	312
Bunch separation	Δt	ns	0.5	0.5	0.5
Accelerating gradient	G	MV/m	100	100	100
Total luminosity	$\mathscr{L}$	10^{34} cm^{-2}s^{-1}	1.3	3.7	5.9
Luminosity above 99% of $\sqrt{s}$	$\mathscr{L}_{0.01}$	10^{34} cm^{-2}s^{-1}	0.7	1.4	2
Main tunnel length		km	11.4	27.2	48.3
Charge per bunch	N	10^9	3.7	3.7	3.7
Bunch length	σ_z	µm	44	44	44
IP beam size	σ_x/σ_y	nm	100/2.6	~ 60/1.5	~ 40/1
Normalised emittance (end of linac)	ϵ_x/ϵ_y	nm	—	660/20	660/20
Normalised emittance	ϵ_x/ϵ_y	nm	660/25	—	—
Estimated power consumption	P_{wall}	MW	235	364	589

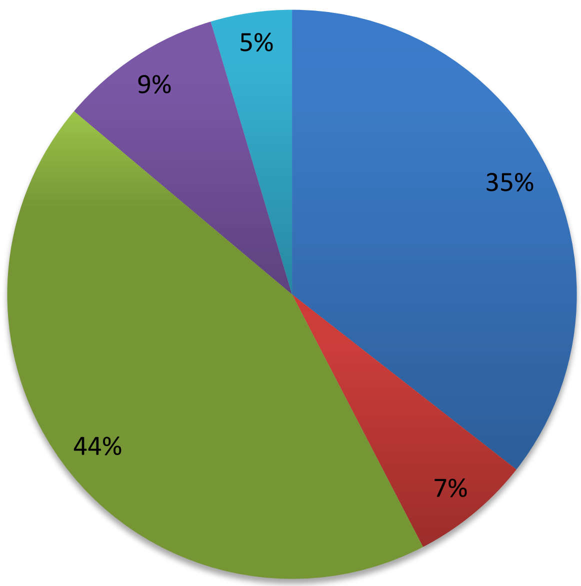






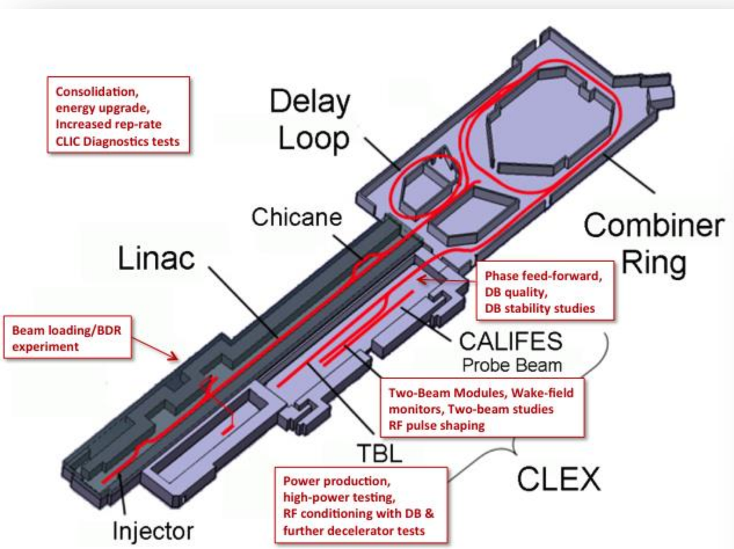


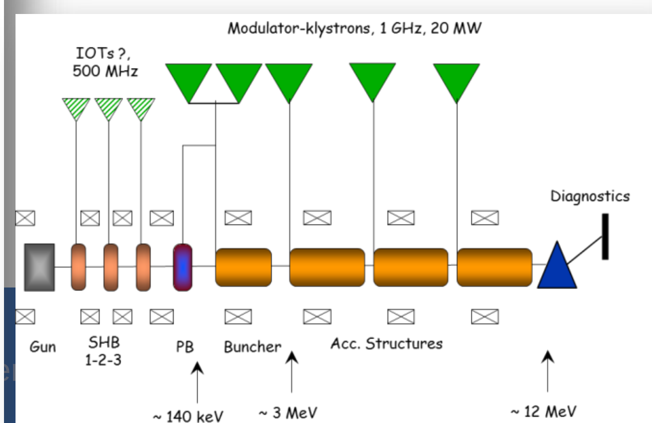
System-tests at CERN and outside (27% of overall)

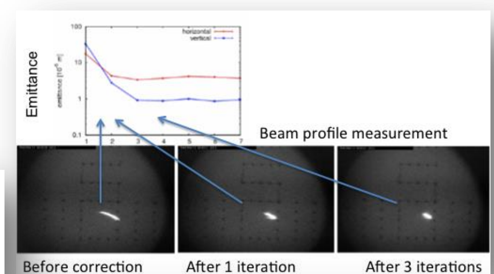


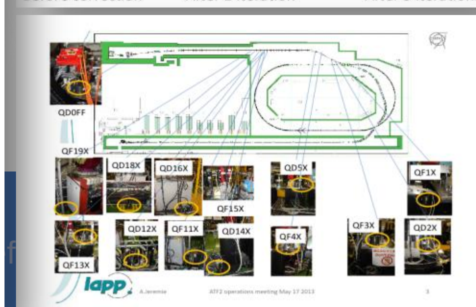
- CTF3 Consolidation & Operation (stop planned end 2016) for the next period, studies of re-use of equip. and site
- Drive Beam performance and feedback/forwards, drive beam decelaration and power prod., two beam mudule tests, instr. tests
- Drive-beam front end including injector studies (critcal parts of the first part of drive beam complex and power units)
- Modulator development, magnet converters, also to become part of Drivebeam FE system
- Accelerator Beam System Tests (Low emittance ring test, ATF, FACET,…)

Collaborators: IAP-Russia, Valencia, Frascati, IPM, JAI, Oslo, Uppsala, CEA, LAL, CIEMAT, RRCAT, LAPP, RHUL, SLAC, NCBJ - to be completed

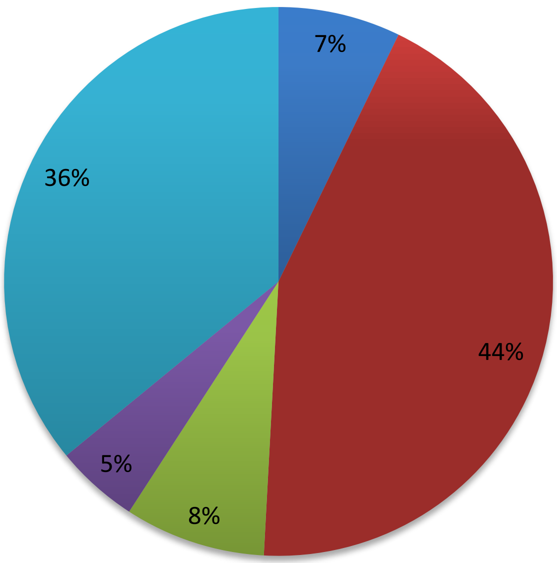




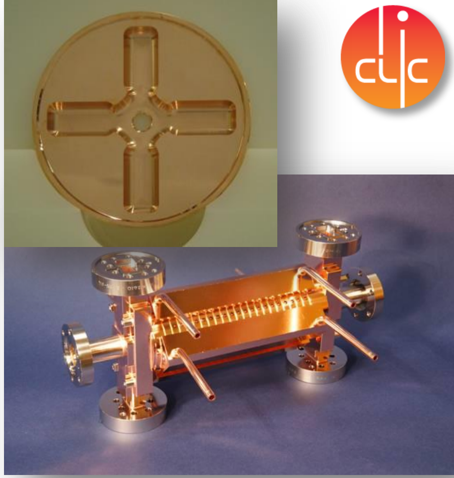




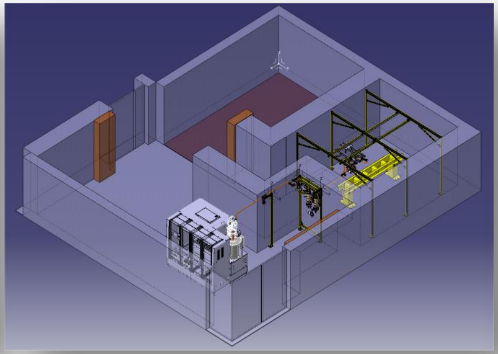
X-band activities (25% of overall)

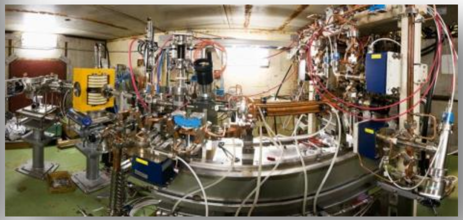


- X-band Rf structure Design and basis High Grad R&D
- X-band Rf structure Production (development and statistics)
- X-band Rf structure High Power Testing, including KEK and SLAC
- Novel RF unit developments, R&D for future, link to other R&D projects
- Creation and Operation of x-band High power Testing Facilities, core of programme

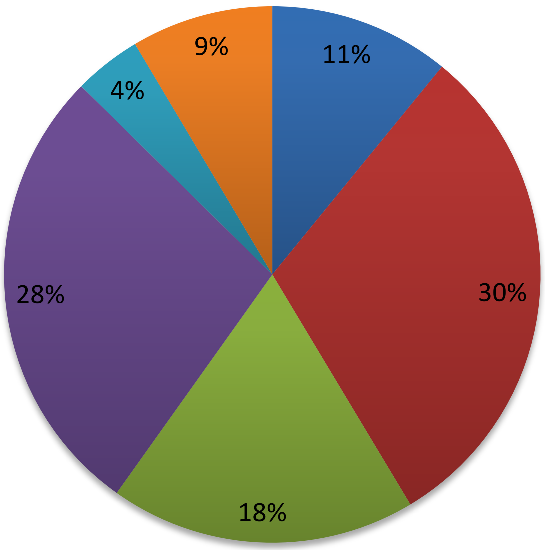


Collaborators: CEA, Helsinki, Valencia, IHEP, KEK, SLAC, Lancaster, Manchester, Oslo, PSI, Trieste, Tsinghua, Uppsala, Dubna,Tartu, Groningen, Jerusalem, EPFL, METAS, SACLAY, Sandia, Shanghai, TERA - to be completed





Technology developments (24% of overall)



- Pulsed, SC and warm magnets: Damping Rings Superconducting Wiggler and Kicker Development
- Survey & Alignment, Stability, Magnet development, including PACMAN hardware
- Beam Instrumentation and Control
- Two-Beam module development, for lab and CTF3 measurements
- Vacuum systems and studies (and finalise minor collimator studies)
- Creation of a "CLIC technology center@CERN" - bat 156

Collaborators: Brussels, CEA, CIEMAT, Dundee, Helsinki, Frascati, JAI, KIT, LAPP, LNBL, NTUA, PSI, SLAC, Cornell, Daresbury, Symme, Dubna, Minsk - to be completed