The CLIC programme 2020-2025

The CLIC Workshop 2018

Steinar Stapnes – CERN

A TDR for CLIC by 2025

- We have heard about the CLIC Project Implementation Plan being prepared for the 2019-20 European Strategy Update - the underlaying topic of most of the talks this afternoon
- Among the documents prepared are overviews of the collaboration’s plans for next period – the CLIC Preparation Phase 2020-2025
  - Such overviews are very important for the European Strategy Update and for planning at CERN
  - The collaborative partners plans in the same period are equally crucial – for making a coherent programme for developing “CLIC technologies”

- During 2020-2025 - Towards a CLIC Technical Design Report (TDR)
  - What is needed for a CLIC TDR ?
  - How can we optimize the programme linking to other technology related projects ?
  - What are the main unknowns ?
  - Summary

2013 - 2019 Development Phase

Development of a Project Plan for a staged CLIC implementation in line with LHC results; technical developments with industry, performance studies for accelerator parts and systems, detector technology demonstrators

2020 - 2025 Preparation Phase

Finalisation of implementation parameters, preparation for industrial procurement, Drive Beam Facility and other system verifications, Technical Proposal of the experiment, site authorisation

2026 - 2034 Construction Phase

Construction of the first CLIC accelerator stage compatible with implementation of further stages; construction of the experiment; hardware commissioning

2019 - 2020 Decisions

Update of the European Strategy for Particle Physics; decision towards a next CERN project at the energy frontier (e.g. CLIC, FCC)

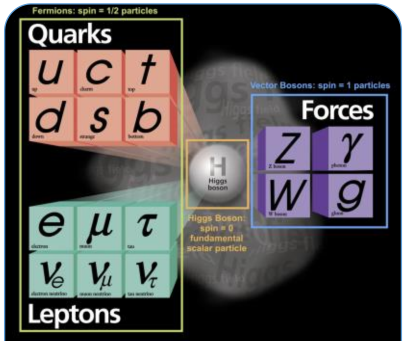
2025 Construction Start

Ready for construction; start of excavations

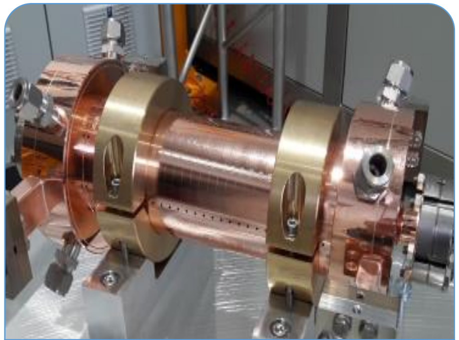
2035 First Beams

Getting ready for data taking by the time the LHC programme reaches completion

The CLIC project

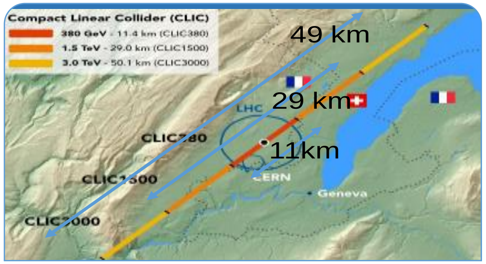


Physics case



Technical implementation and solutions

Organization and community



Industrial basis and future flexibility

So why are there no LCs around ?

- A: The cost and timescales/size involved

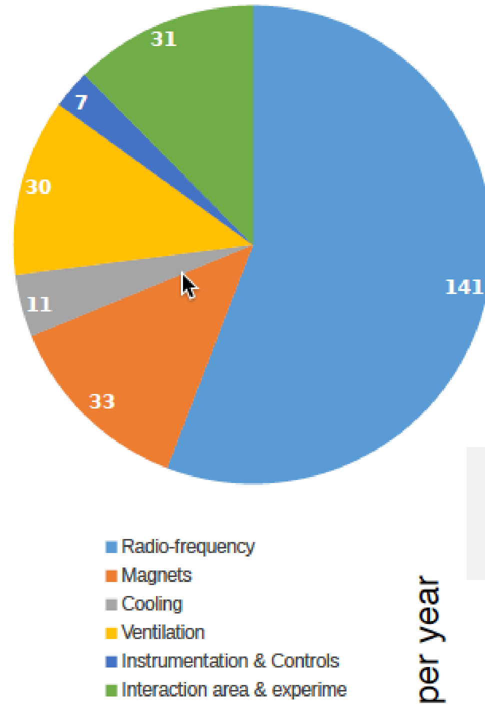
Key activities for a TDR in Preparation Phase will be:

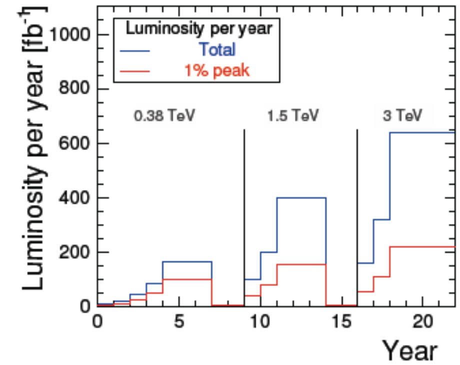
1. Reduce costs (including power and energy consumption)
2. Prepare technically for industrial production (examples for cost and power drivers below)
3. Finalize and verify design and performances, system-tests
4. Detector and Physics studies

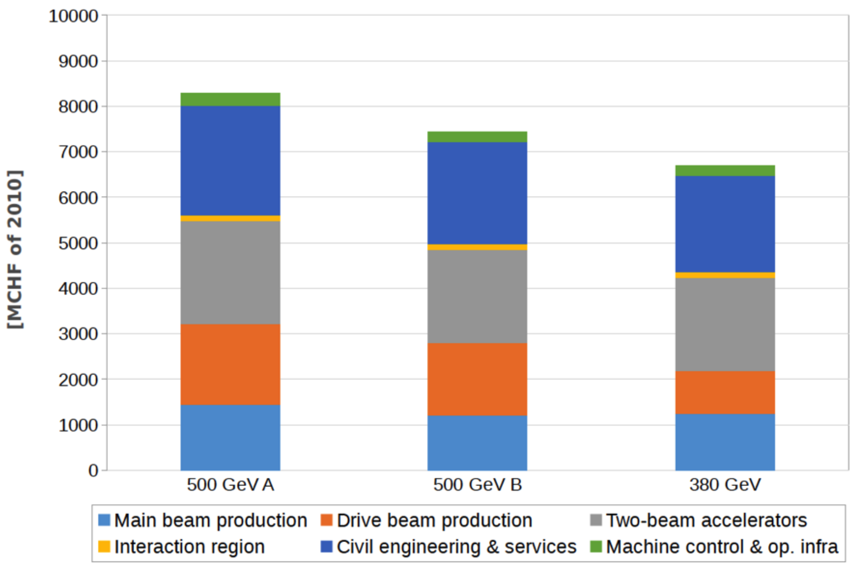
1 - Cost and Power

Table 11: Value estimate of CLIC at 380 GeV centre-of-mass energy.

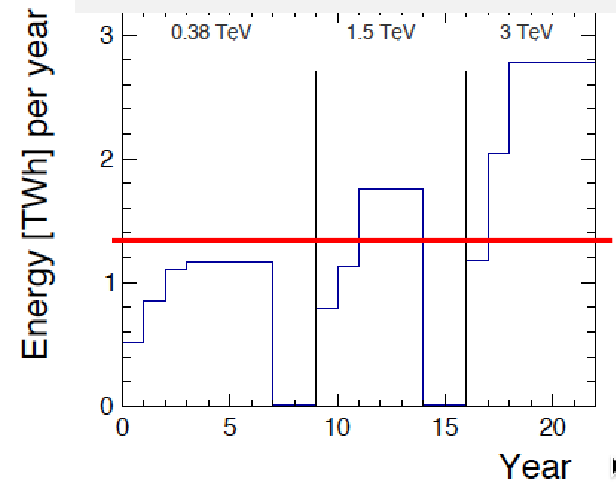
	Value [MCHF of December 2010]
Main beam production	1245
Drive beam production	974
Two-beam accelerators	2038
Interaction region	132
Civil engineering & services	2112
Accelerator control & operational infrastructure	216
Total	6690







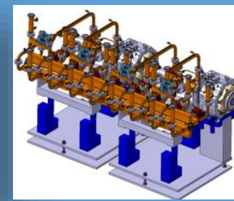
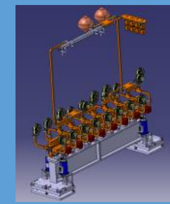
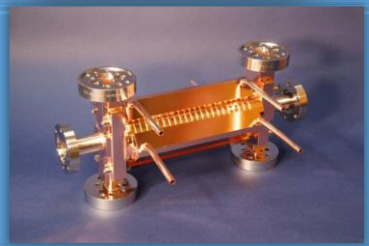
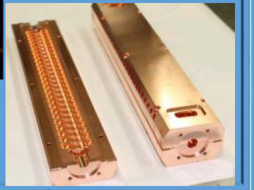
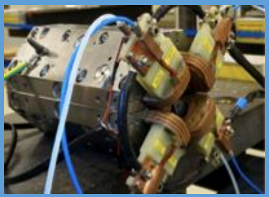
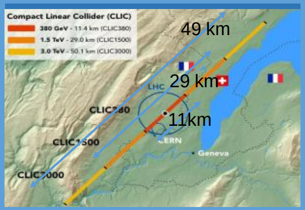
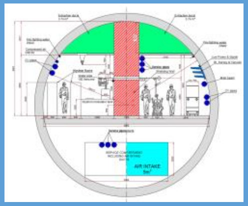
CERN energy consumption 2012: 1.35 TWh



A cost of ~6 BCHF and power ~200 MW are "reasonable" values

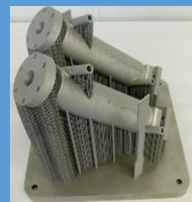
→ Focus TDR work on modules, RF and CE for costs; for power RF and magnets

2 - Technical developments

Modules (drive-beam, klystron type)	  	Final modules, from revised designs to industrial modules
Optimized structures	  	Use existing test-stands for testing, increase manufacturability, brazed, halves, conditioning
Klystrons and Modulators	  	Efficiency and costs, significant gains possible for efficiency, industrial cost-models and optimisation
Magnets	   	Permanent magnets, industrial capabilities
Civil engineering, infrastructure	  	Detailed site layout and CE/infrastructure designs

2 - Industrial considerations
(example)

Bodycote (FR)
Reuter (DE)
TMD (UK)



SWISSto12 (CH)
3T RPD (UK)
Concept Laser (DE)
INITIAL (FR)
Protoshop (DE)

VDL (NL)
LT-Ultra (DE)
Yvon Boyer (FR)
DMP (ES)
Morikawa (JP)
KERN (DE))

Thermocompact (FR)
BACMI (FR)
Multivalent (NL)

CINEL (IT)
VDL (NL)
BACMI (FR)
CECOM(IT)
Reuter (DE)
Nihon (JP)
COMEB (IT)
Viztrotech (KR)

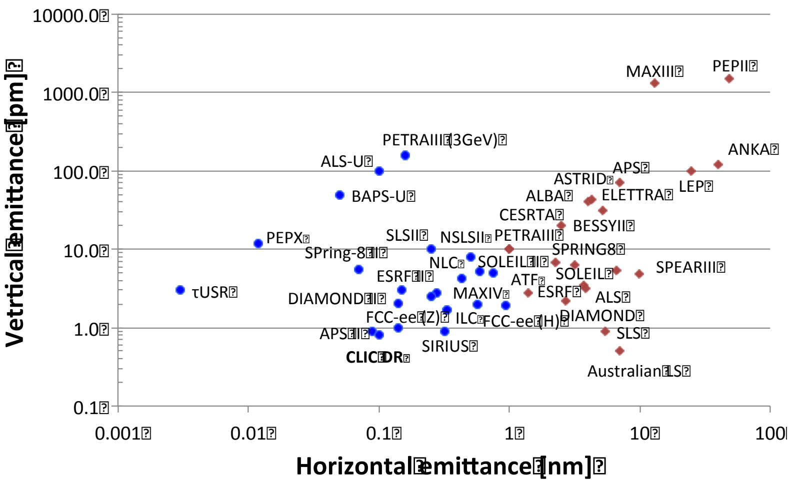
Thales (FR)
CPI(US)
Toshiba (JP)

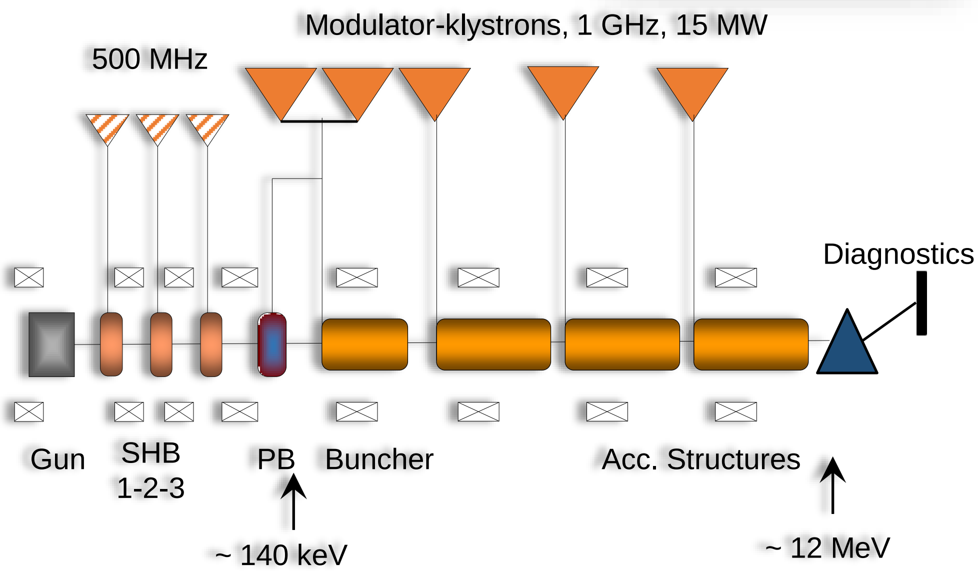
Scandinova (SE)
Jema (ES)
Picatron (CH)

Needed by the time of the TDR:
Qualified companies, technical and commercial documentation,
reliable costs (i.e. not first prototype), ideally (small) part of larger marked

3 - System tests

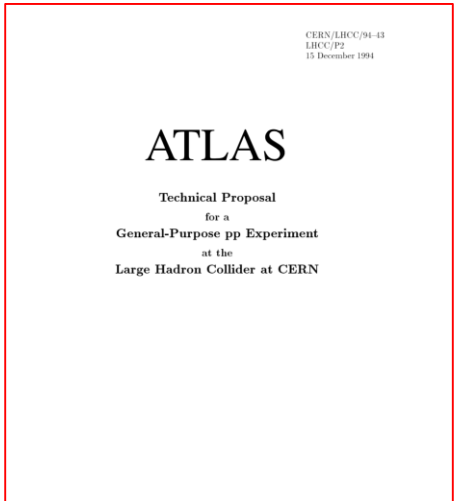
- Light sources, FACET/FELs for emittance conservation, Final Focus studies (ATF2), Drive-beam Front End facility at CERN
- Two examples:





4 - Detector TP and TDR

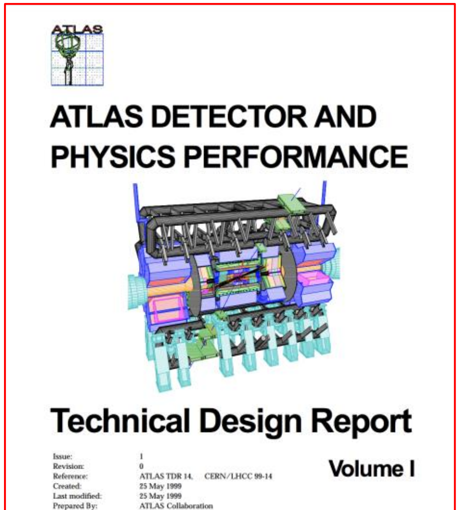
- The steps from Detector R&D and models to Technical Proposal (TP) and Technical Design Reports (TDRs) well established by LHC
- Key activities: Technical R&D → prototypes → small series, Detector layout and optimization, Physics and performance studies, Software and simulation frameworks
- Also in this area – linking to other detector developments as HiLumi can be very beneficial


CERN/LHCC/94–43
LHCC/P2
15 December 1994

ATLAS

Technical Proposal
for a
General-Purpose pp Experiment
at the
Large Hadron Collider at CERN

1994


ATLAS

ATLAS DETECTOR AND PHYSICS PERFORMANCE

Technical Design Report

Volume I

Issue:	1
Revision:	0
Reference:	ATLAS TDR 14, CERN/LHCC 99-14
Created:	25 May 1999
Last modified:	25 May 1999
Prepared By:	ATLAS Collaboration

1999

Resources and Collaboration

- So all this is possible – what is the problem ?

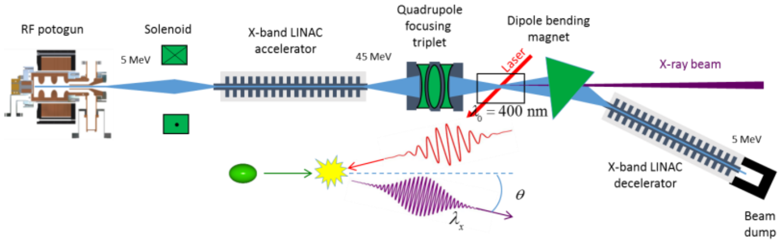
  Resources: A total of ~30 MCHF/year foreseen in the CERN MTP (Medium Term Plan) 2020 onwards for energy frontier developments

- What is (part of) the solution ?

  Collaboration and increasing use of X-band technologies in other projects

  Additionally: Medical applications (proton and very high energy electron therapy)

INFN Frascati advanced acceleration facility EuPARXIA@SPARC_LAB



Eindhoven University led SMART*LIGHT Compton Source

X-band technology

CERN	XBox-1 test stand	50 MW	Operational, connection to CLEAR planned
	Xbox-2 test stand	50 MW	Operational
	XBox-3 test stand	4x6 MW	Operational
Trieste	Linearizer for Fermi	50 MW	Operational
PSI	Linearizer for SwissFEL	50 MW	Operational
	Deflector for SwissFEL	50 MW	Design and procurement
DESY	Deflector for FLASHforward	6 MW	Design and procurement
	Deflector for FLASH2	6 MW	Design and procurement
	Deflector for Sinbad	tbd	Planning
Tsinghua	Deflector for Compton source	50 MW	Commissioning
	Linearizer for Compton source	6 MW	Planning
SINAP	Linearizer for soft X-ray FEL	6 MW	Operational
	Deflectors for soft X-ray FEL	3x50 MW	Procurement

Australia	Test stand	2x6 MW	Proposal submission
Eindhoven	Compact Compton source, 100 MeV	6 MW	Design and procurement
Valencia	S-band test stand	2x10 MW	Installation and commissioning
KEK	NEXTEF test stand	2x50 MW	Operational
SLAC	Design of high-efficiency X-band klystron	60 MW	In progress
Daresbury	Linearizer	6 MW	Design and procurement
	Deflector	tbd	Planning
	Accelerator	tbd	Planning
Frascati	XFEL, plasma accelerator, 1 GeV	4(8)x50 MW	CDR
	Test stand	50 MW	Design and procurement
Groningen	1.4 GEV XFEL Accelerator, 1.4 GeV	tbd	NL roadmap, CDR

Above: EU Design Study for X-Band FELs 2018-2020: http://compact-light.web.cern.ch

Beyond being a collaboration for CLIC, many groups have their own X-band facilities and components (see overview on the left)

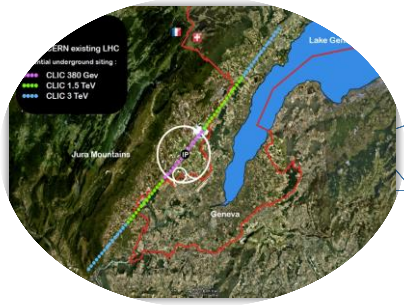
In the CLIC preparation phase:
Take advantage of the widespread use of electron linacs, and rapidly increasing use of X-band → **increase collaboration**

Preparation Phase planning

- The main activities needed for a TDR are quite clear, keywords: costs/power R&D, industrial activities, final parameters, site preparation, detector and physics studies
  - Concerns: Drive-beam facility, ATF2 or similar, resources
  - The way forward depends very strongly on the collaboration – for each item/study needed for the TDR: Combine CERN resources, collaboration activities, industrial interests and educational programmes

- Examples:
  - Klystron modules – if done for FEL projects outside CERN the CERN efforts can be less
  - Permanent magnets – if industry interested (for use outside CLIC), or other projects for use on a short timescale, we need to participate and not carry such a programme
  - If a country would like to establish a training or exchange programme with CERN for electron linacs/X-band we will put into the planning matching funds
  - Network of X-band testing facilities – rely strongly on activities outside CERN

  \- need to be creative -



The CLIC studies are CERN hosted

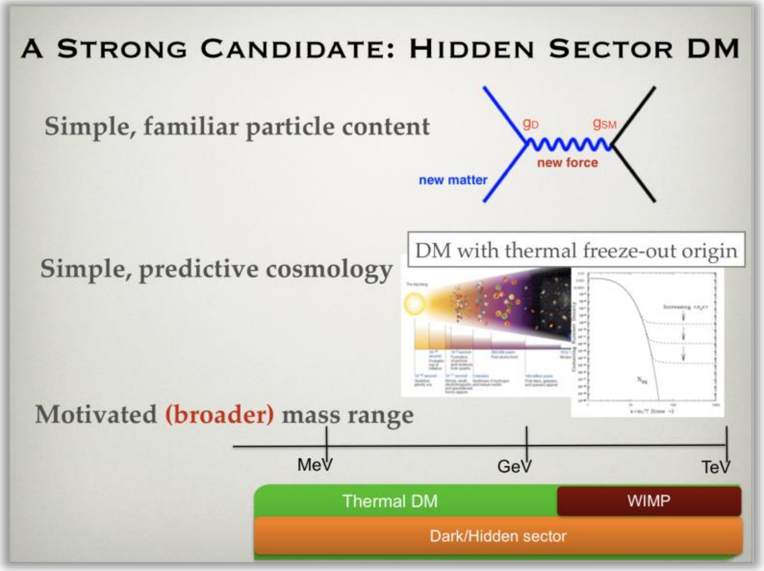
MoU annexes or similar (with MS and NMS collaborators)

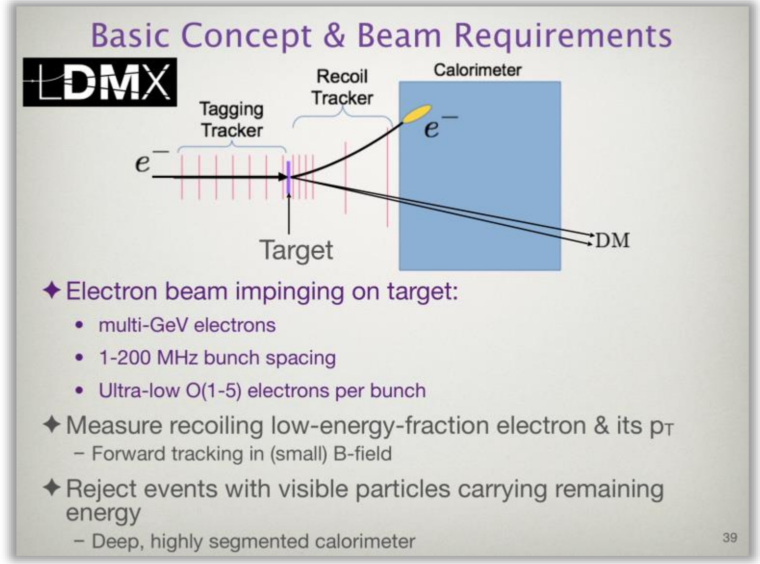
R&D contracts

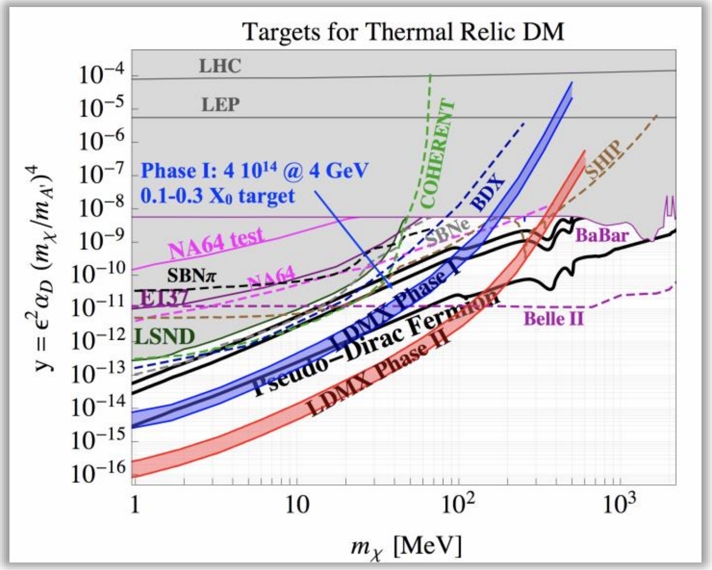
Technology Transfer agreements, EU projects.

Also relevant for the CLIC preparation phase: Potential use of CLIC technology for e-beams as part of non-collider physics programme at CERN – **use of ~3 GeV e-linac**

Physics with e-beams, example LDMX

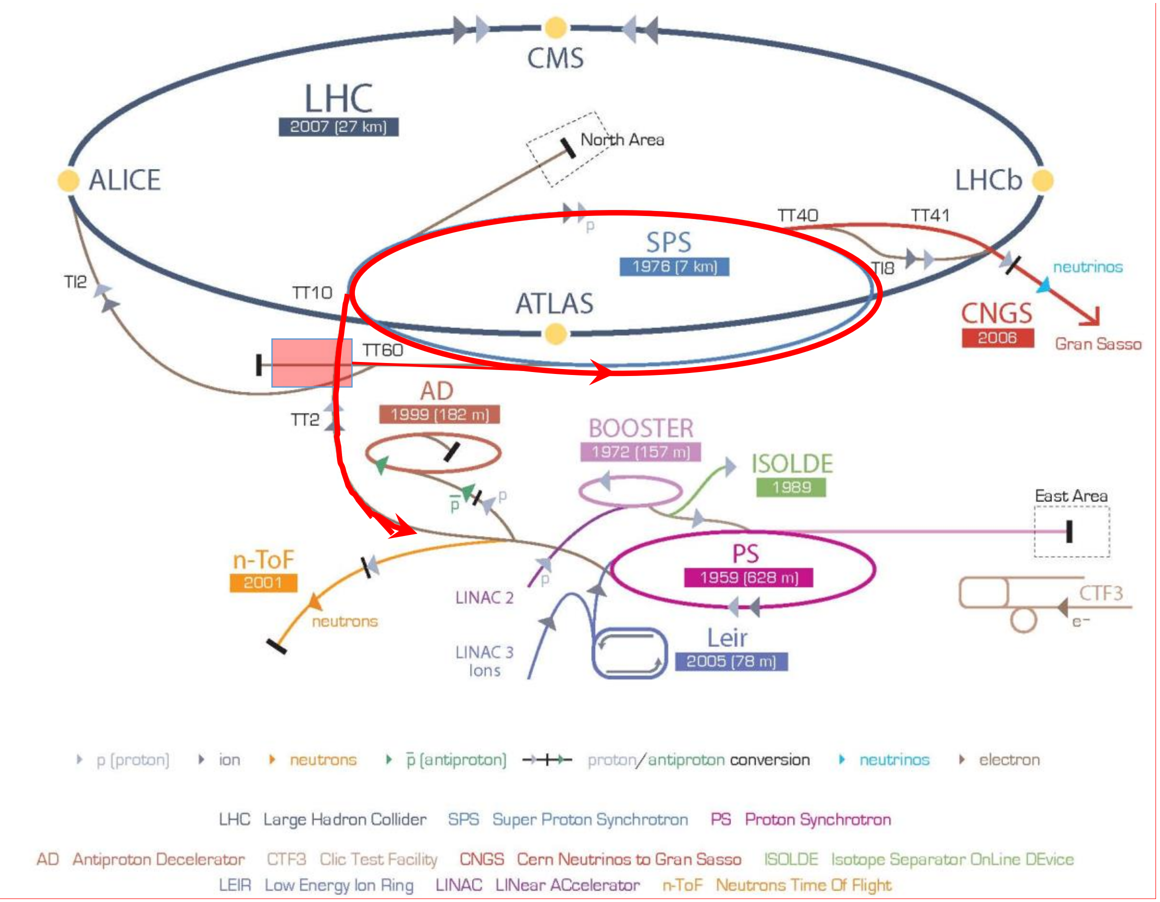






Talk by P. Schuster
"Physics Beyond Colliders" Nov 21, 2017

An e-beam facility at CERN

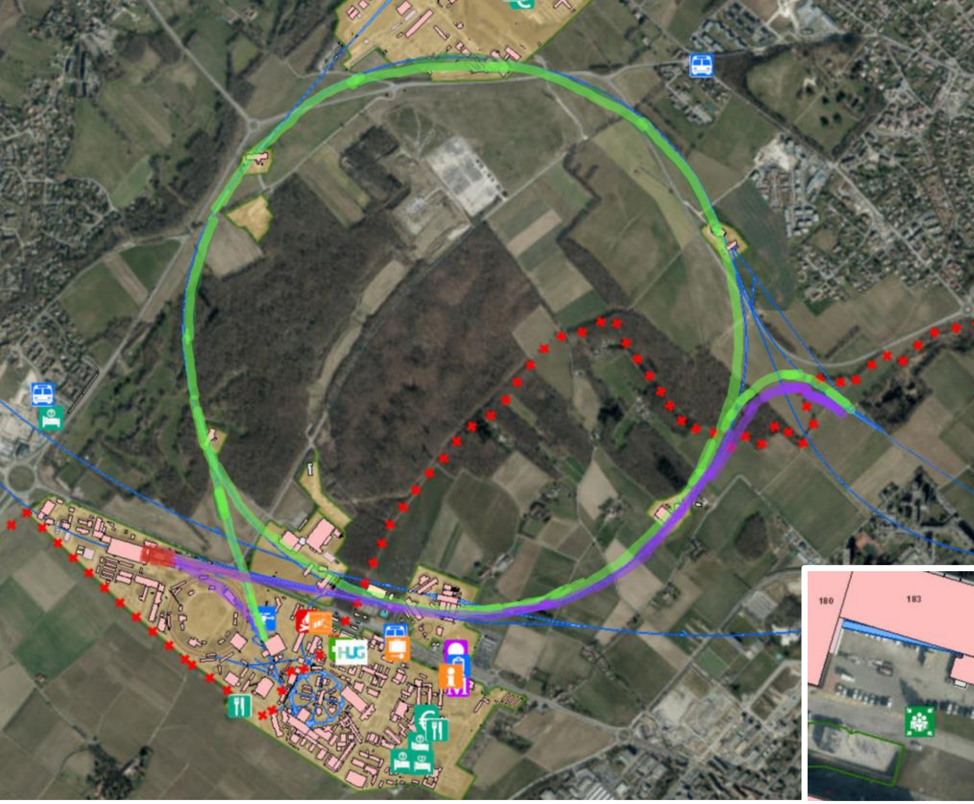


Accelerator implementation at CERN of LDMX type of beam

X-band based 60m LINAC to 3 GeV in TT4-5.

- Fill the SPS in 2s (bunches 5ns apart) via TT60
- Accelerate to ~10 GeV in the SPS
- Slow extraction to experiment in 10s as part of the SPS super-cycle
- Experiment(s) considered in UA2 area or – better - bring beam back on Meyrin site using TT10

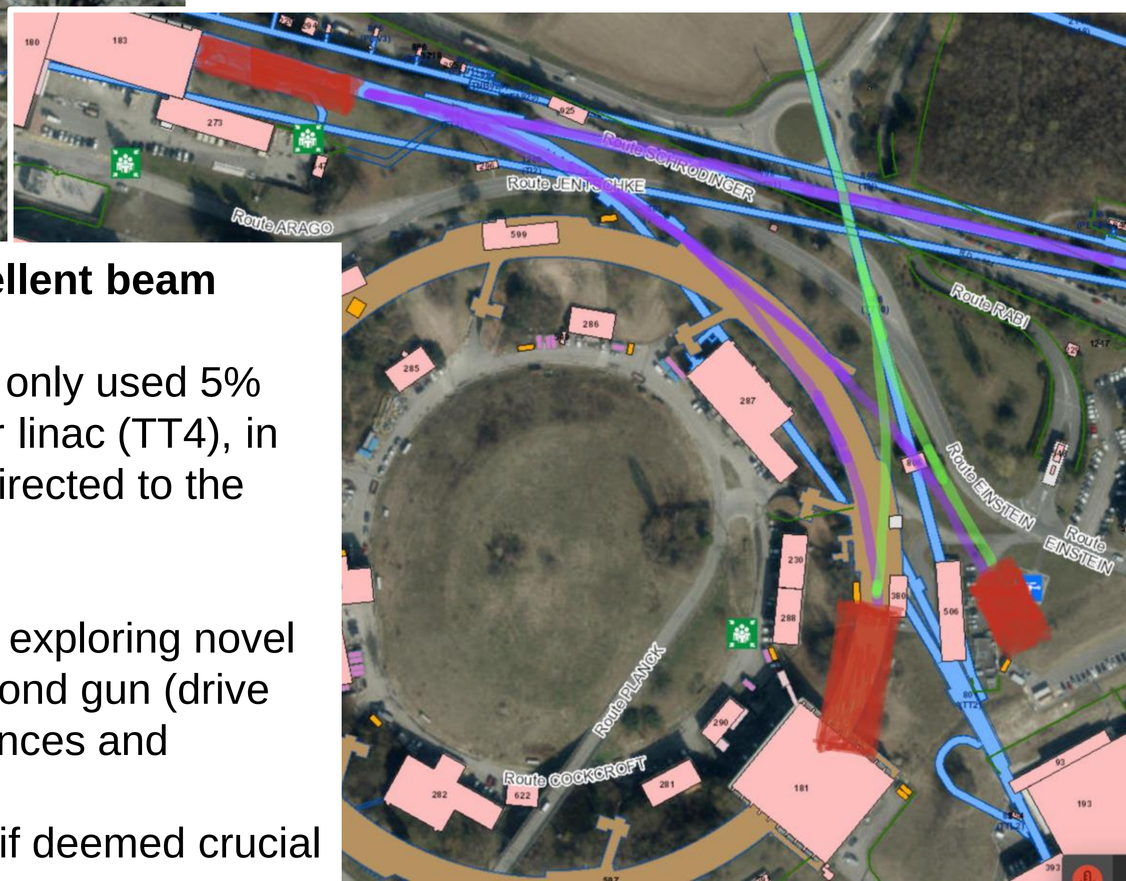
Beyond LDMX type of beam:
Other physics experiments can be considered (for example heavy photon searches)
Several other possible uses of linac and SPS beams for R&D



GREEN: ~10+ GeV electron beam in SPS

Acc. in SPS, can also be a damped small emittance beam. Long bunches.

- Extracted to Meyrin side for LDMX like experiment.
- Can also – possibly – be guided to AWAKE.
- Other uses, either extracted or circulating to be worked out.



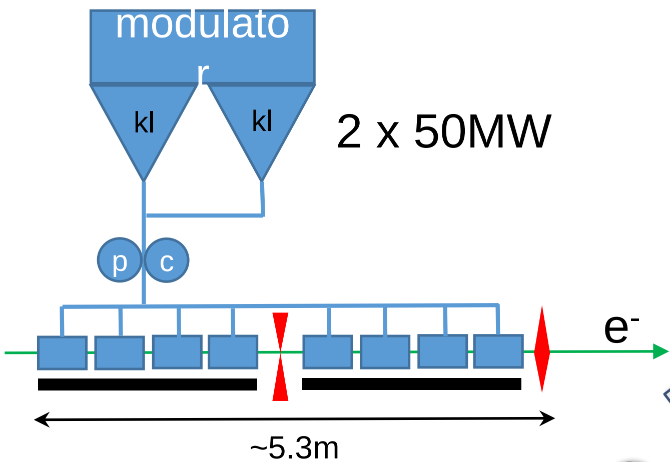
PURPLE: 3 GeV x-band linac with excellent beam quality

Short bunch electrons from X-band linac, only used 5% for filling the SPS. Can be used right after linac (TT4), in new experimental area, and/or possibly directed to the current AWAKE area.

- CLEAR type of research progamme.
- Electrons for drive and/or probe beam exploring novel accelerating techniques, including second gun (drive and probe bunches with variable distances and charges).
- Longer term possibilities for positrons if deemed crucial

X-band linac layout

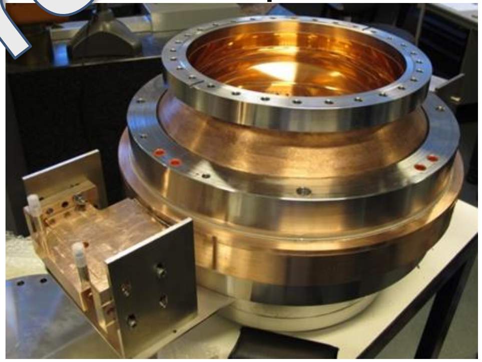
Make use of study recently made for LNF ~1.0 GeV X-band linac
“CLIC-like” RF unit: 2*(klystron+modulator) + pulse compressor + 8 accelerating structures



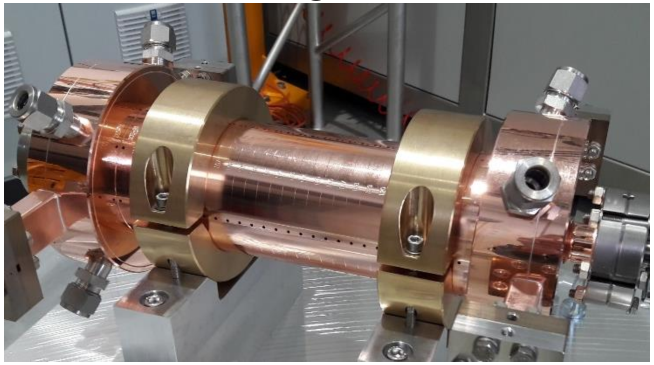
Klystron

Modulator

Pulse compressor



Accelerating structure



- One “CLIC-like” type RF unit accelerates 20[illegible] bunch train up to [illegible] MeV*
- 11 RF units to get to 2.9 GeV in ~60 m

* (lower than for Frascati single bunch operation: 336 MeV/unit)

Obvious interesting link with a CLIC preparation phase

Main known unknowns

- New physics
  - CLIC have energy flexibility (reach) to ~3 TeV
  - Working Group on New Accelerator Technology set up
  - Low energy studies – a CLIC type short linac can open opportunities

- ILC moves ahead
  - Two e+e- machines for SM/Higgs precision physics not reasonable
  - High gradient (in a wide sense) R&D will still be a priority

Summary

- The CLIC programme in the Preparation Phase 2020-25 is quite straight-forward but detailed work needed to make coherent with "related" projects and studies
  - Resources available a serious constraint
  - Collaboration partners outside CERN – with the significant X-band projects now happening – can cover important parts of work needed
  - Our goal is to present a complete overview for next phase by end 2018

- A 3 GeV linac for non-collider e-beams at CERN will cover a significant part of what is needed for a CLIC TDR phase – plus interesting physics (the main motivation) and accelerator R&D

- LHC physics developments can have large impact
- ILC moving ahead will change the next phase programme

- Initial ideas are on behalf of my CLIC collaborators -