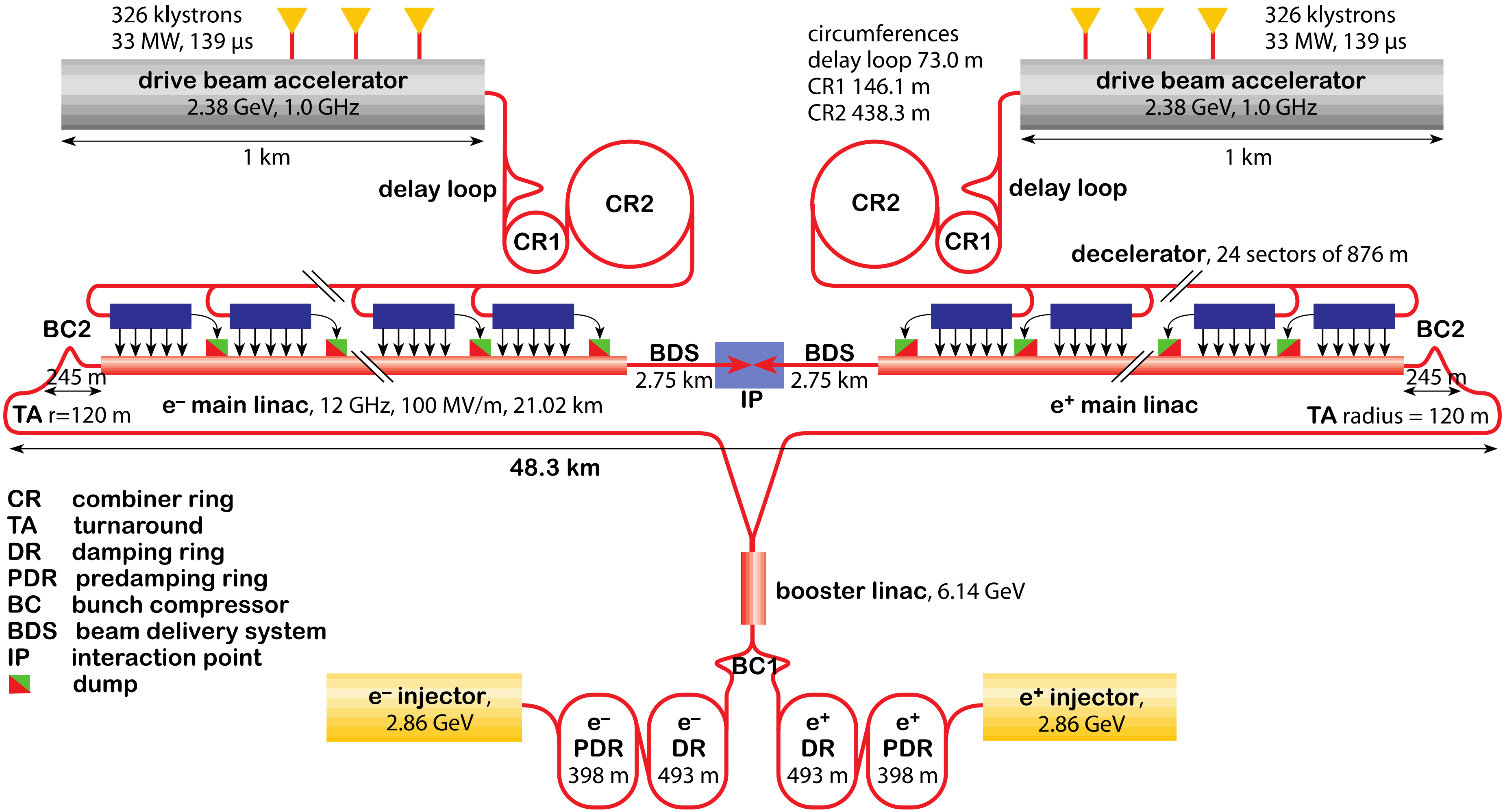
Global projects and local challenges

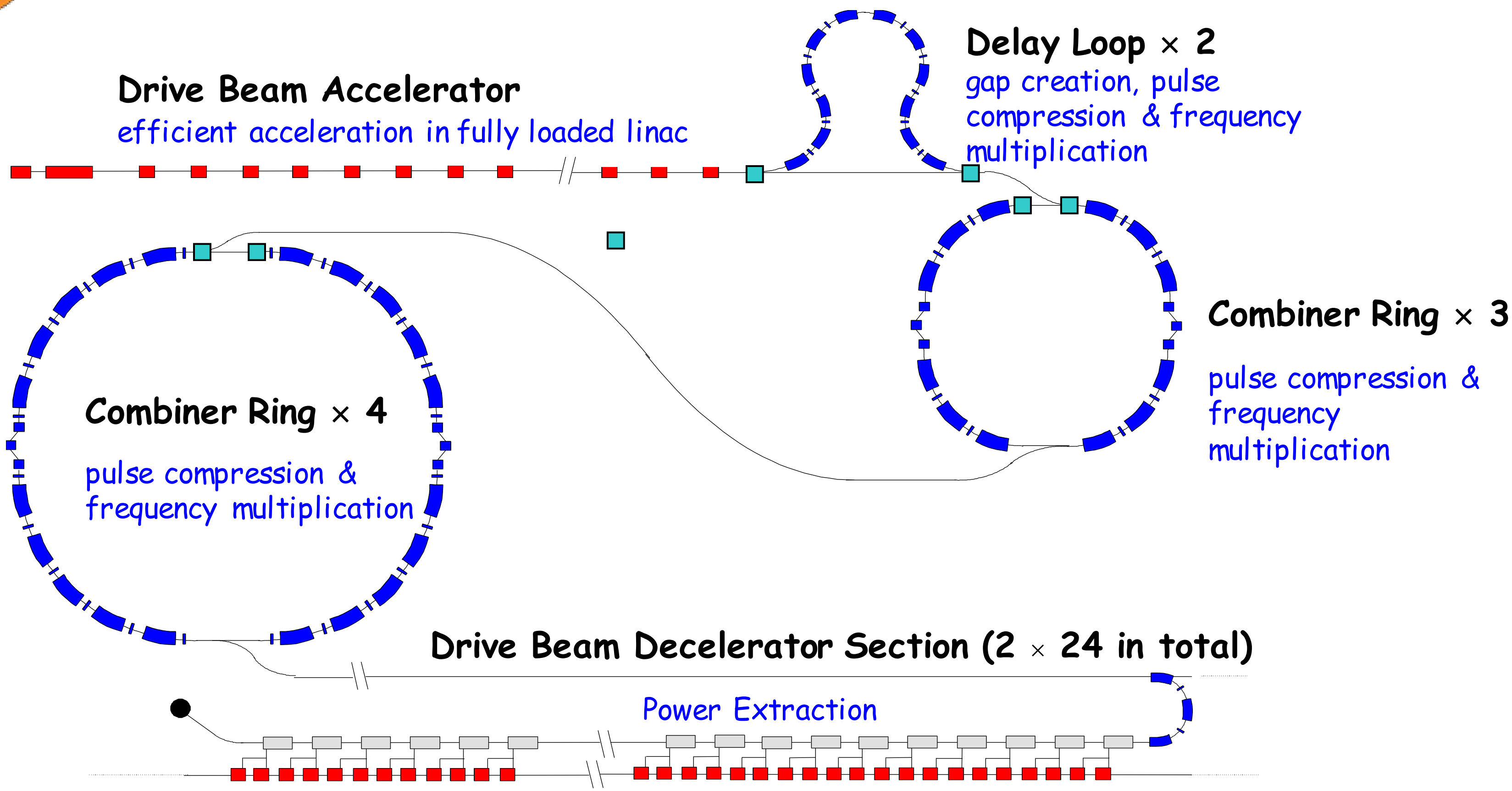
1. A future Linear Collider – CLIC
   - Feasibility and implementations
2. Global projects – Councils point of view, LC development
3. Local challenges (at CERN – and in a small member-state)

.... and the many roles of John

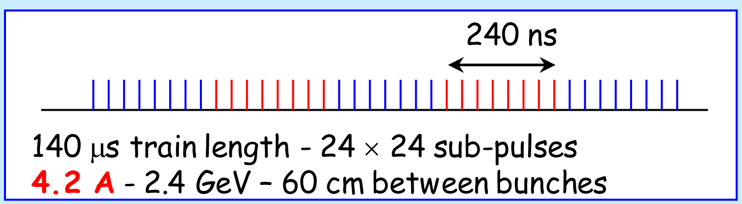
The CLIC Layout



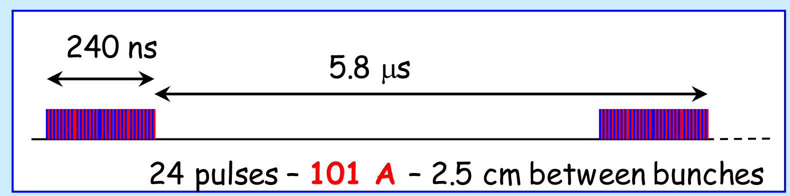
CLIC Power Source Concept



Drive beam time structure - initial



Drive beam time structure - final



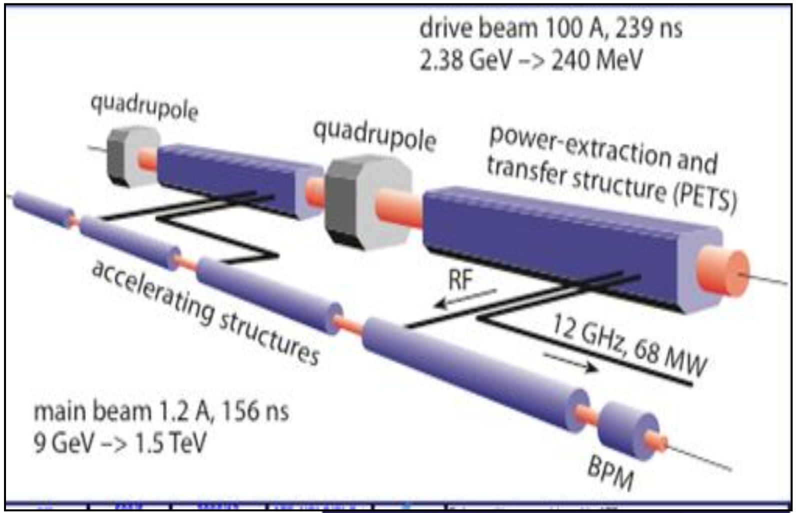
CLIC main parameters

parameter	symbol		
centre of mass energy	E_{cm} [GeV]	500	3000
luminosity	$\mathcal{L}$ $[10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}]$	2.3	5.9
luminosity in peak	$\mathcal{L}_{0.01}$ $[10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}]$	1.4	2
gradient	G [MV/m]	80	100
site length	[km]	13	48.3
charge per bunch	N $[10^9]$	6.8	3.72
bunch length	σ_z [μm]	70	44
IP beam size	σ_x/σ_y [nm]	200/2.26	40/1
norm. emittance	ϵ_x/ϵ_y [nm]	2400/25	660/20
bunches per pulse	n_b	354	312
distance between bunches	Δ_b [ns]	0.5	0.5
repetition rate	f_r [Hz]	50	50
est. power cons.	P_{wall} [MW]	240	560

Feasibility studies and the CDR

Feasibility issues (some examples in the following slides):

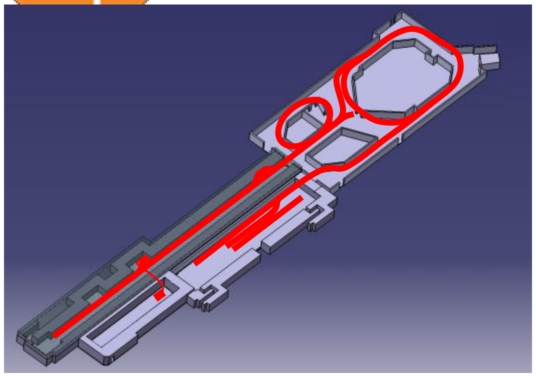
- Drive beam generation
- Beam driven RF power generation
- Accelerating Structures
- Two Beam Acceleration
- Ultra low emittances and beam sizes
- Alignment
- Vertical stabilization
- Operation and Machine Protection System

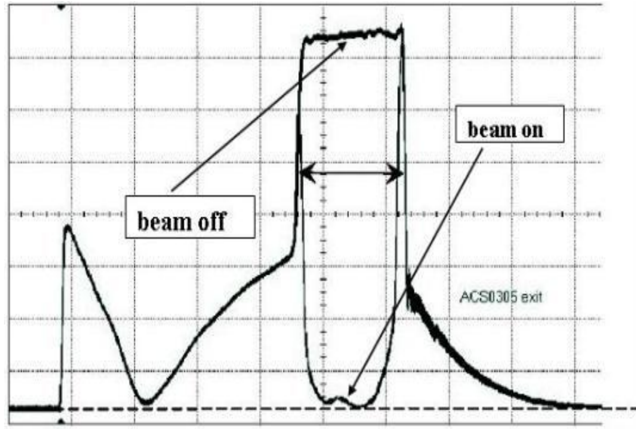


CDRs:

- Vol 1: The CLIC accelerator and site facilities (H.Schmickler)
  - CLIC concept with exploration over multi-TeV energy range up to 3 TeV
  - Feasibility study of CLIC parameters optimized at 3 TeV (most demanding)
  - Consider also 500 GeV, and intermediate energy ranges
- Vol 2: The CLIC physics and detectors (L.Linssen)
- Vol 3: CLIC study summary (S.Stapnes)
  - Summary and available for the European Strategy process, including possible implementation stages for a CLIC machine as well as costing and cost-drives
  - Proposing objectives and work plan of post CDR phase (2012-16)
- Timescales:
  - By end 2011: Vol 1 and 2 completed
  - Spring/mid 2012: Vol 3 ready for the European Strategy Open Meeting

Key CTF3 feasibility milestones: drive beam generation

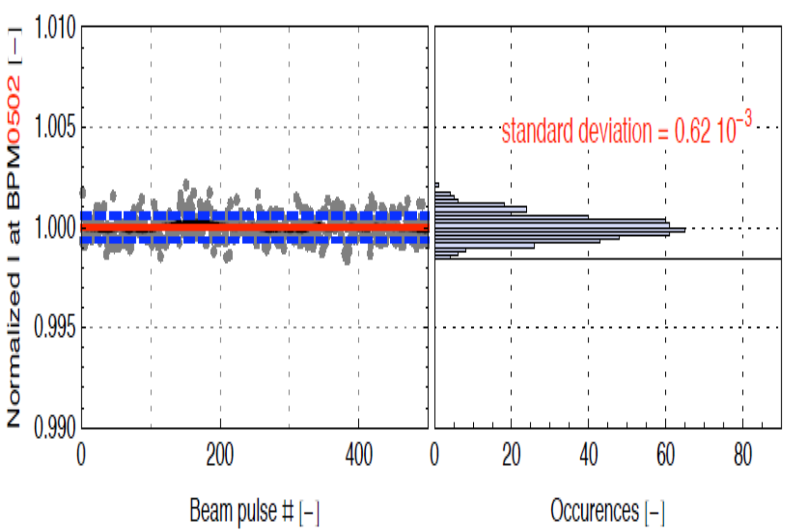




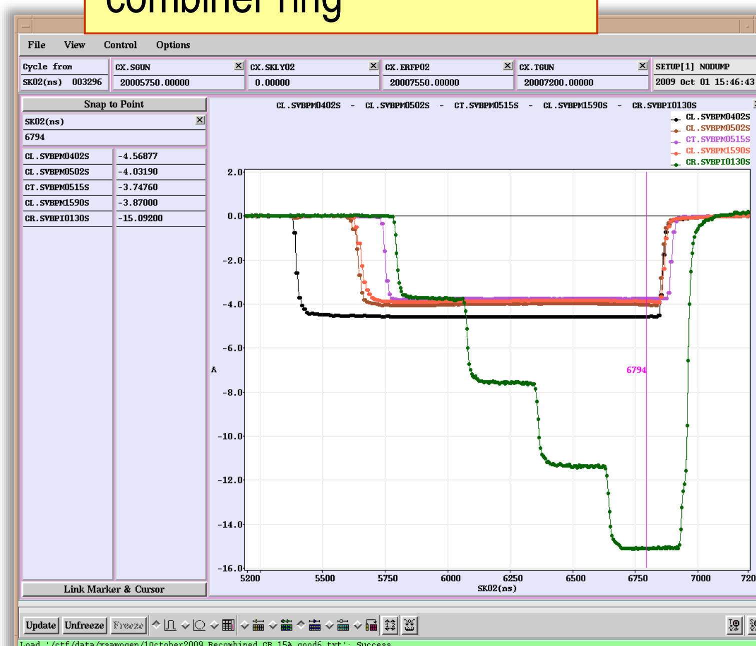
Fully loaded acceleration RF to beam transfer: 95.3 % measured.
No issues found with transverse wakes in structures. Operation is routinely with full loading

1.2 us drive beam pulse

Drive beam current stability at the end of the fully loaded linac : better than CLIC specification: 0.75 10^{-3}



Full commissioning of x 4 combiner ring



RF STRUCTURES AND COMPONENTS

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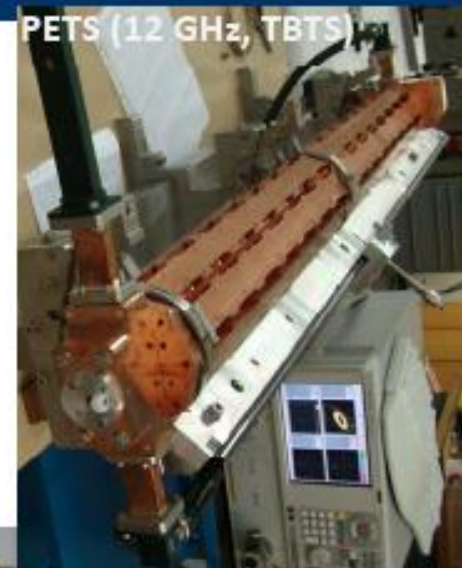
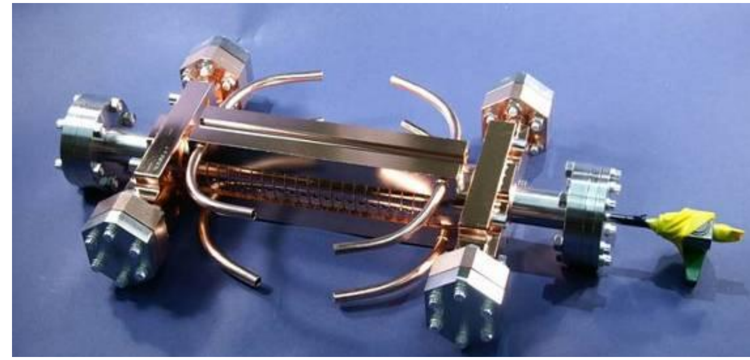
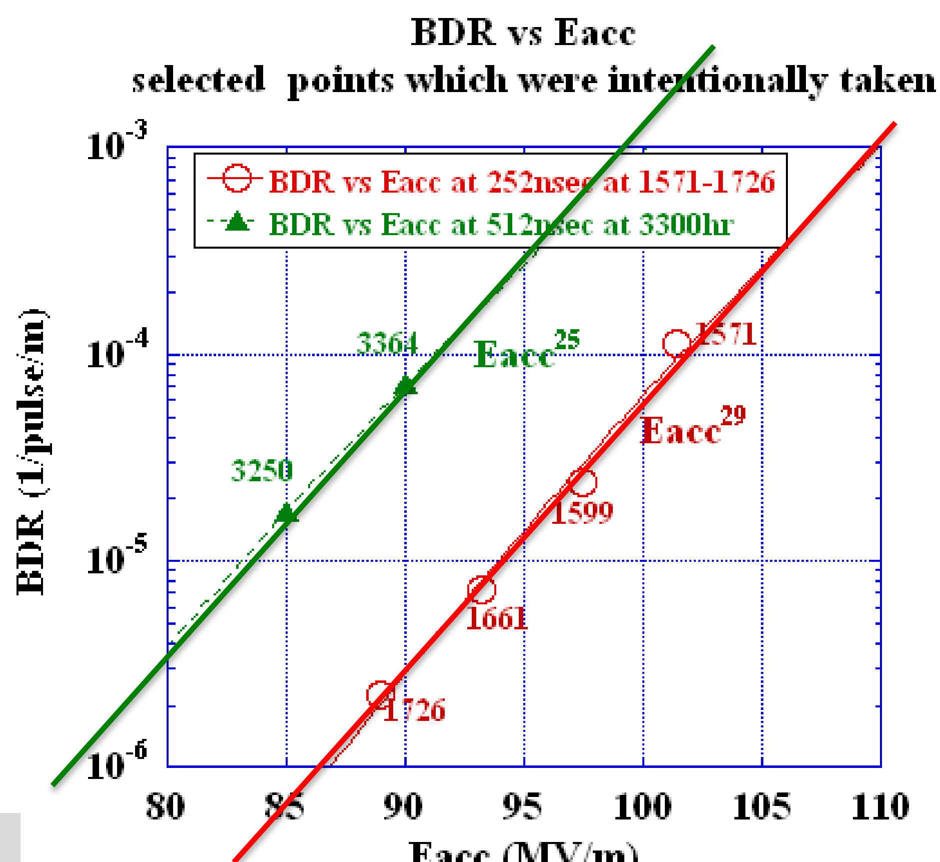


Accelerating Structure



- Require breakdown probability 1% per pulse
  - $p \leq 3x10^{-7} m^{-1} pulse^{-1}$



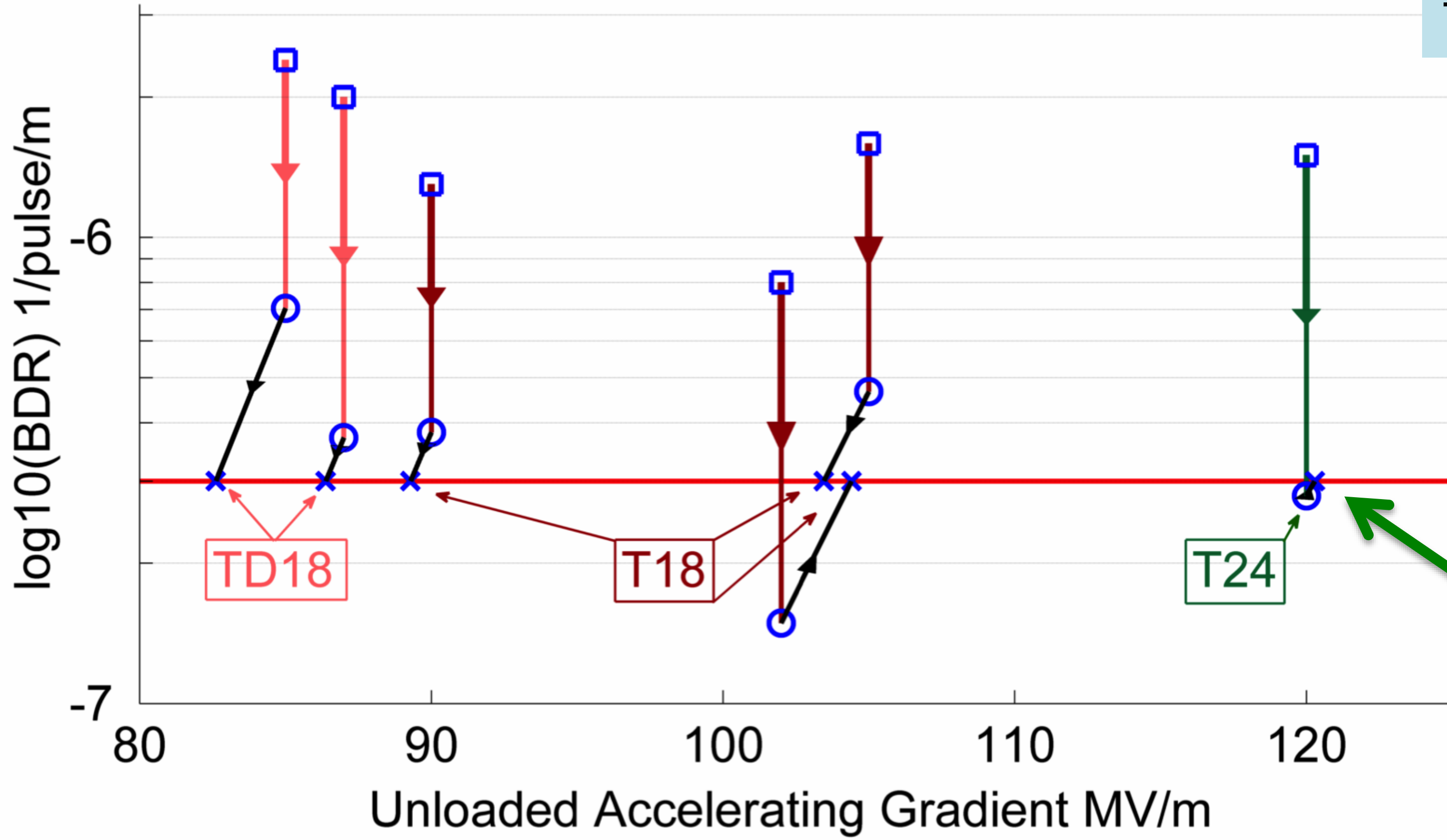
- Design based on empirical constraints
  - $E_{surf} < 260 MV/m$
  - $\Delta T < 56 K$
  - $P/(2\pi a)\tau^{1/3} < 18 MW/mm\ ns^{1/3}$

D. Schulte

W. Wuensch et al.

Achieved Gradient

Tests at KEK and SLAC



Measurements scaled according to

$$p \propto G^{30} \tau^{5}$$

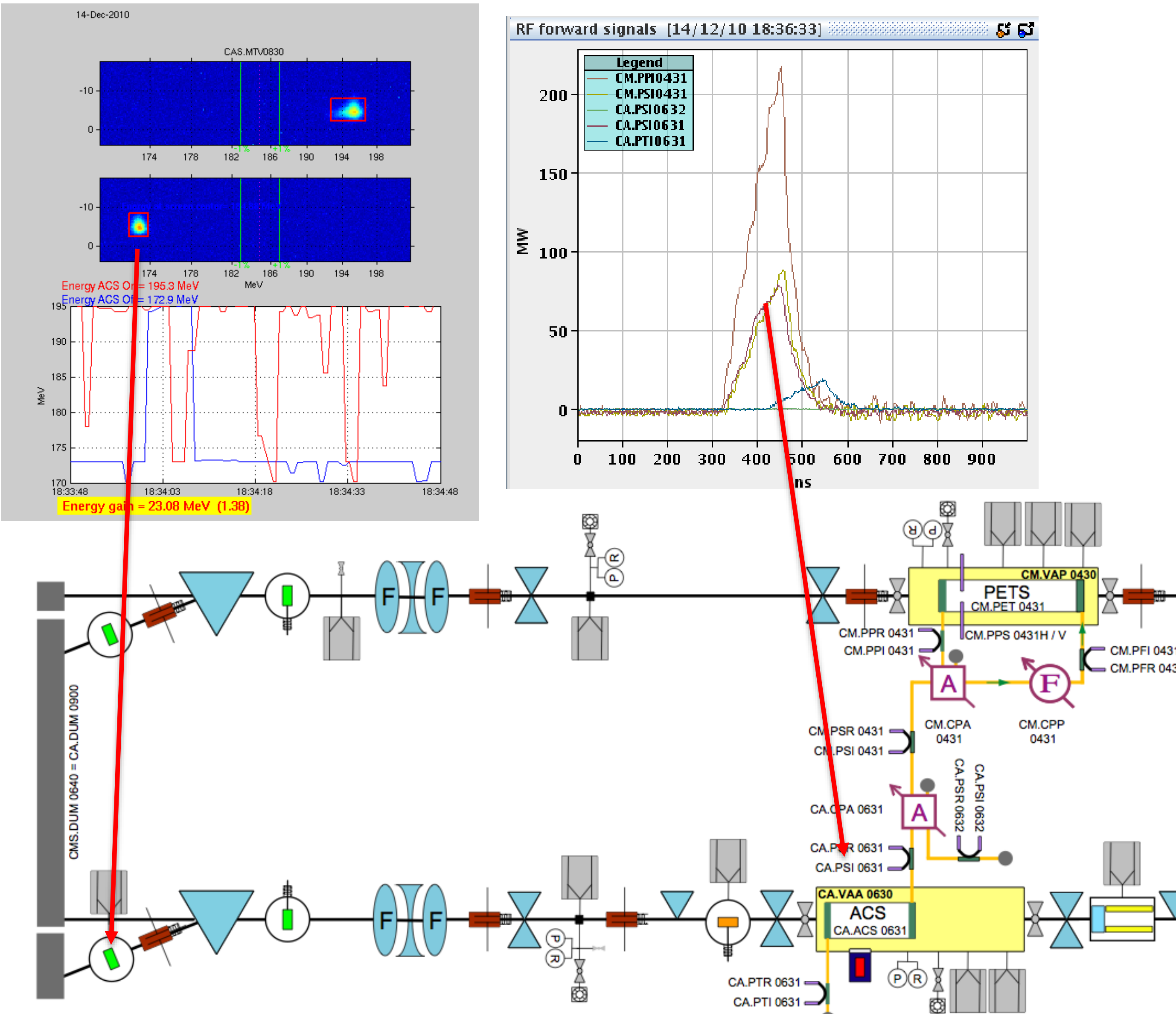
Same input power as 100MV/m loaded

	Simple early design to get started	More efficient fully optimised structure
No damping waveguides	T18	T24
Damping waveguides	TD18	TD24 = CLIC goal

CLIC RF team
N. Shipman

TD24: September 15th @ KEK
mid-November @ SLAC
Soon @ CERN

2010: Two-beam acceleration with a gradient of 106 MV/m



December 14, 2010:

Probe beam accelerated by 23 MV in a TD24 accelerating structure, corresponding to 106 MV/m, in a reproducible way.

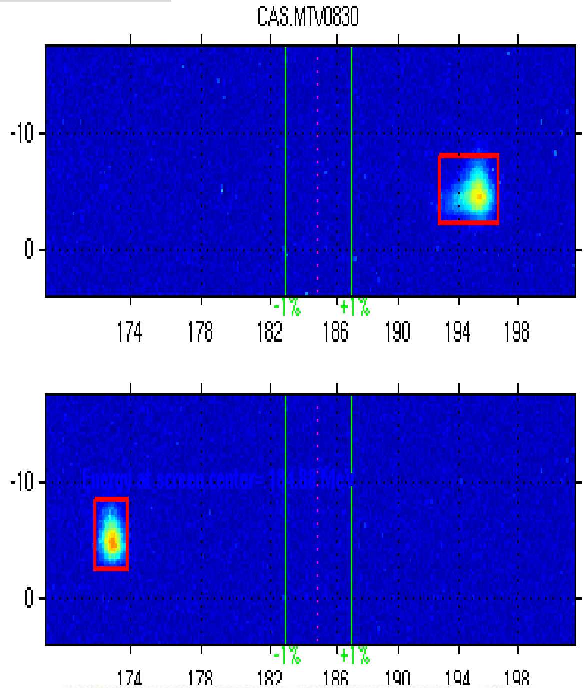
Meas. PETS power input to structure ~ 80 MW (~200 MW in the resonant loop)

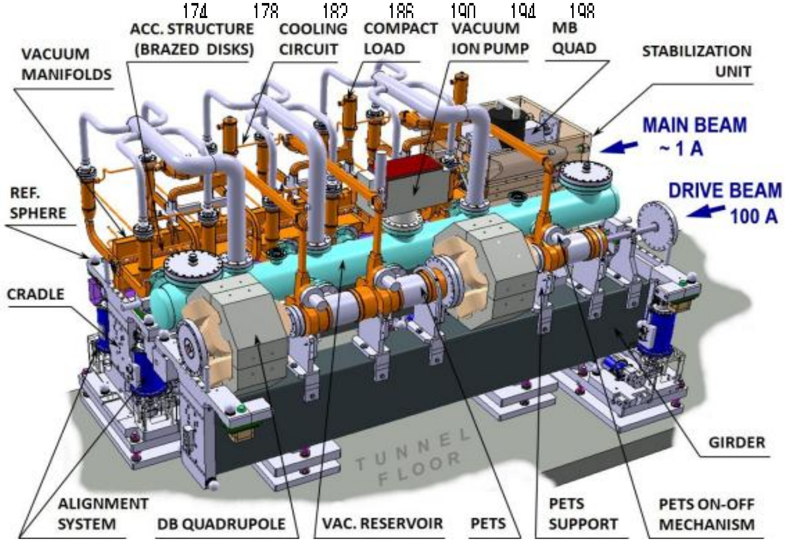
Drive beam: 12.5 A, 113 MV, 12 GHz in CLEX (1.5 GHz beam combined factor 8), 140 ns pulse length

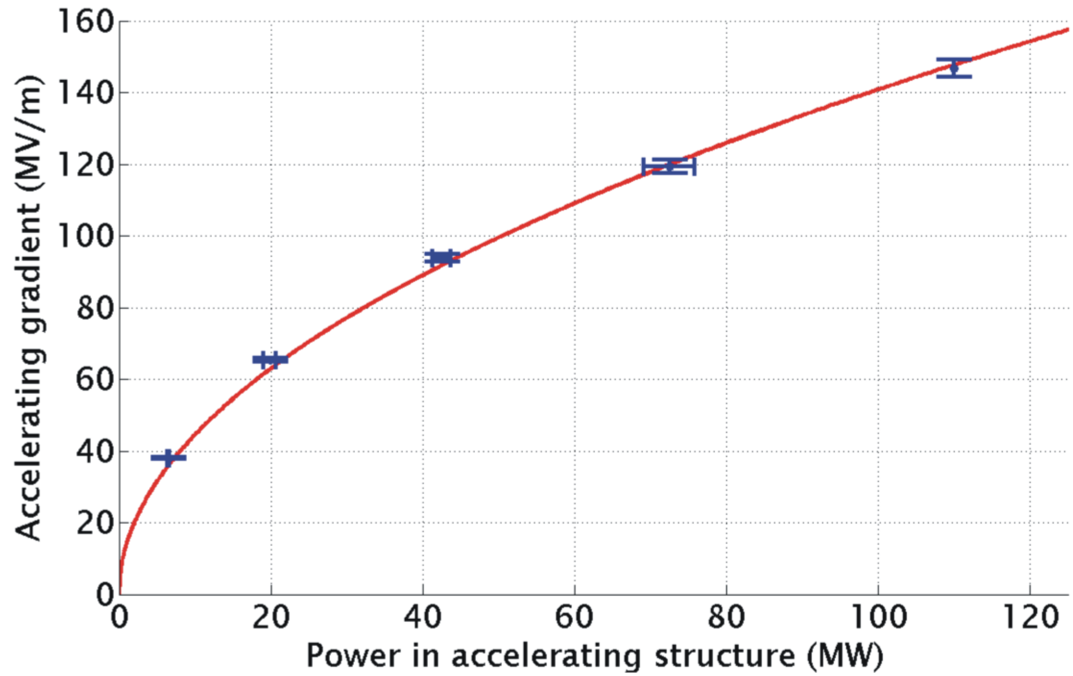
Probe beam: 0.08 A, 173 MV, 1.5 GHz, 8 ns pulse length

TBTS: Two Beam Acceleration

CTF3 team





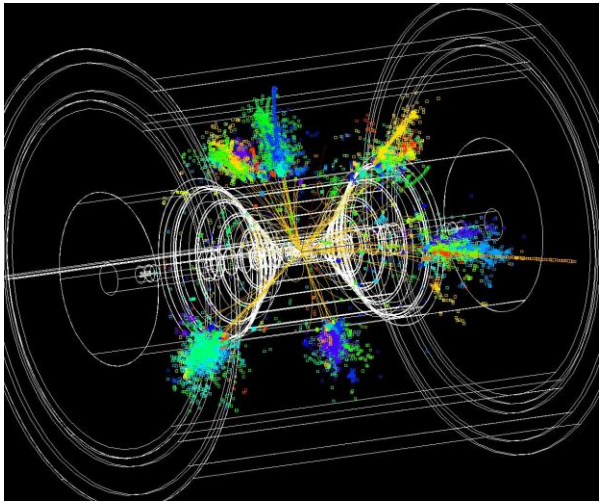


Maximum gradient
145 MV/m

Consistency between
- produced power
- drive beam current
- test beam acceleration

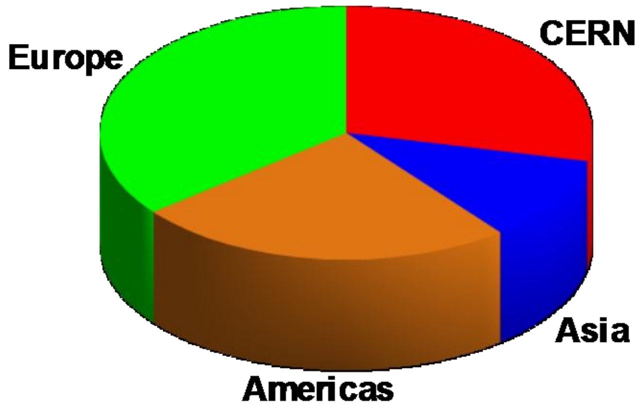
CLIC Detector Issues

- Detector requirements are close to those for ILC detectors
  - First studies indicate that ILC performances are sufficient in many cases
  - Adapt ILD and SID concepts for CLIC
  - Close collaboration with validated ILC designs and work
- Differences to ILC
  - Larger beam energy loss
  - Time structure (0.5 ns vs. 738 ns)
  - Higher background due to:
    - Higher energy
    - Smaller bunch spacing
  - Other parameters are slightly modified
    - Crossing angle of 20 mradian (ILC: 14 mradian)
  - Larger beam pipe radius in CLIC (30mm)
  - Denser and deeper calorimetry
- Linear Collider Detector study has been established at CERN beginning of 2009 (see http://www.cern.ch/lcd)



Linear Collider Detector project @ CERN

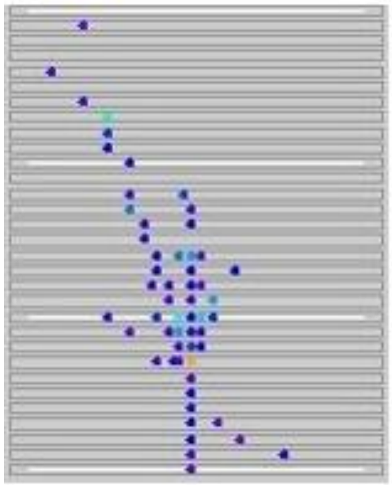
LCD: addressing physics and detectors at CLIC and ILC



Affiliation of CLIC CDR editors

Current focus:
Preparation of conceptual design report for CLIC detectors => developed into a truly international effort in 2010

Experimental issues for a CLIC experiment now well understood, and detector geometries for the CLIC benchmark studies were fixed



← Beam test with a tungsten-based HCAL for linear collider, CALICE collaboration →

The CLIC Collaboration

41 Institutes from 21 countries

ACAS (Australia)
Aarhus University (Denmark)
Ankara University (Turkey)
Argonne National Laboratory (USA)
Athens University (Greece)
BINP (Russia)
CERN
CIEMAT (Spain)
Cockcroft Institute (UK)
ETHZurich (Switzerland)
FERMILAB

Gazi Universities (Turkey)
Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
IHEP (China)
INFN / LNF (Italy)
Instituto de Fisica Corpuscular (Spain)
IRFU / Saclay (France)
Jefferson Lab (USA)
John Adams Institute/Oxford (UK)

John Adams Institute/RHUL (UK)
JINR (Russia)
Karlsruhe University (Germany)
KEK (Japan)
LAL / Orsay (France)
LAPP / ESIA (France)
NCP (Pakistan)
NIKHEF/Amsterdam (Netherlands)
North-West. Univ. Illinois (USA)
Patras University (Greece)

Polytech. University of Catalonia (Spain)
PSI (Switzerland)
RAL (UK)
RRCAT / Indore (India)
SLAC (USA)
Thrace University (Greece)
Tsinghua University (China)
University of Oslo (Norway)
Uppsala University (Sweden)
UCSC SCIPP (USA)

CLIC/CTF3 Collab. Board

CB: Every 6 months, links to WP update and status to provide active feedback/discussion basis to collaborators

From WIKIPEDIA: John Ellis has been a strong supporter of the CLIC option for a future high-energy e+e− linear collider; this option is pursued most strongly at CERN. He was convenor of the CLIC Physics Study Group that produced the main report on this option, in 2004.
He is a member of the extended CLIC (Compact Linear Collider) Steering Committee.

CLIC Steering Committee

Repr. from accelerator and detector/physics management structures

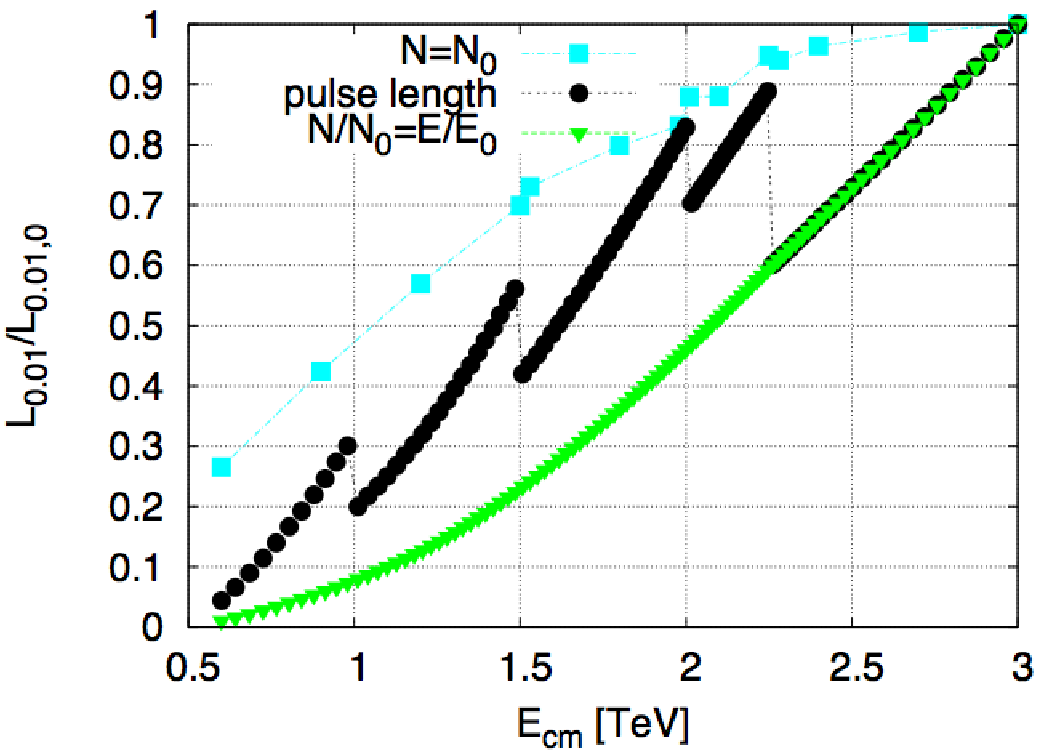
CLIC accelerator activities and management

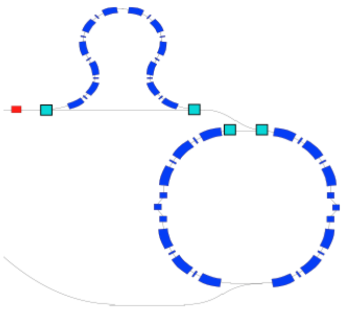
Detector/Physics activities and management

CLIC energy scans (for a single stage)

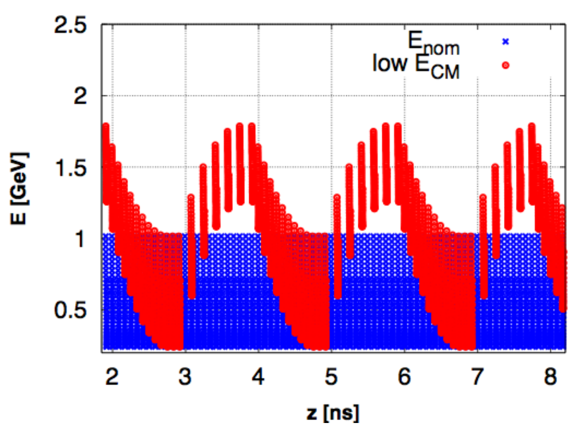
Requirement from physics : vary the c.m. energy for a given CLIC machine. Main options :

- Early extraction lines : significant hardware modifications needed
- Reduce gradient : disadvantage: need to scale down bunch charge linearly with gradient for stability, leading to a significant luminosity loss (green)
- CLIC drive beam scheme: gradient can be reduced while increasing pulse length. A large fraction of the luminosity loss is recovered (black). Modifications to drive beam generation are minimal.



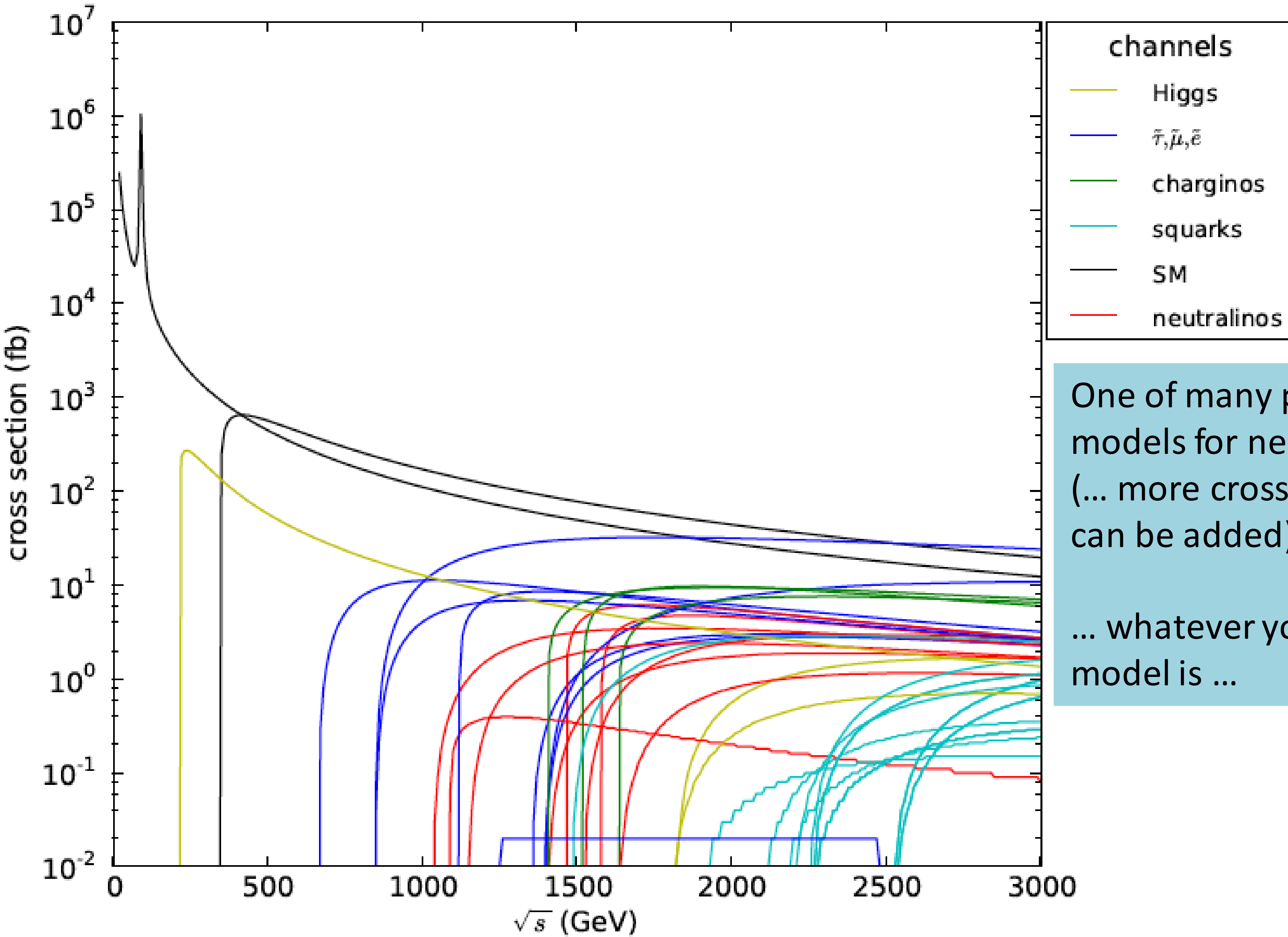


Lower gradient can be achieved by switching of phase of incoming drive beam bunches :



Drive beam energy after extraction

What is the physics ?
- some production cross-sections -



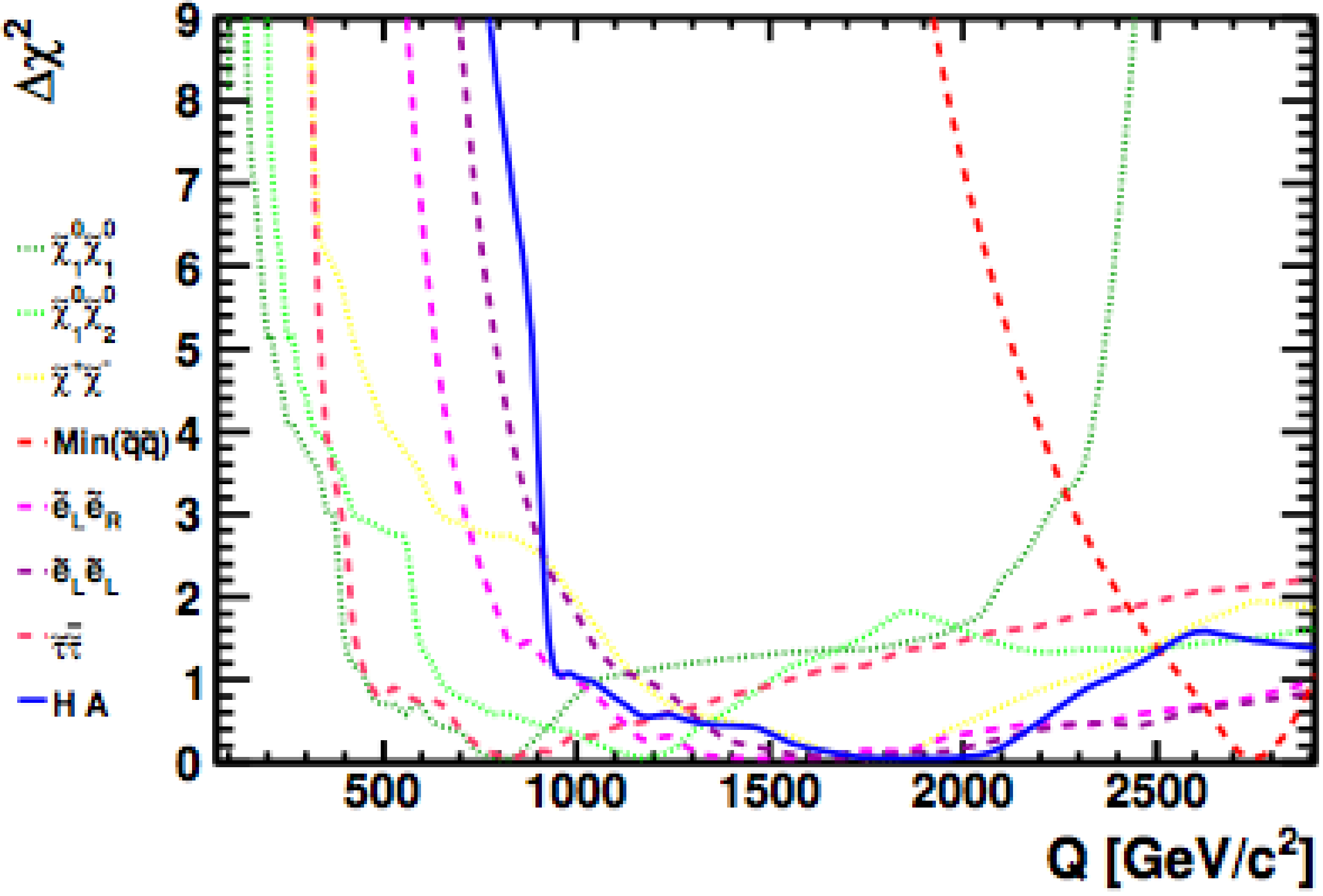
One of many possible models for new physics (… more cross-sections can be added)

… whatever your favorite model is …

Likelihoods for sparticle thresholds

Preliminary

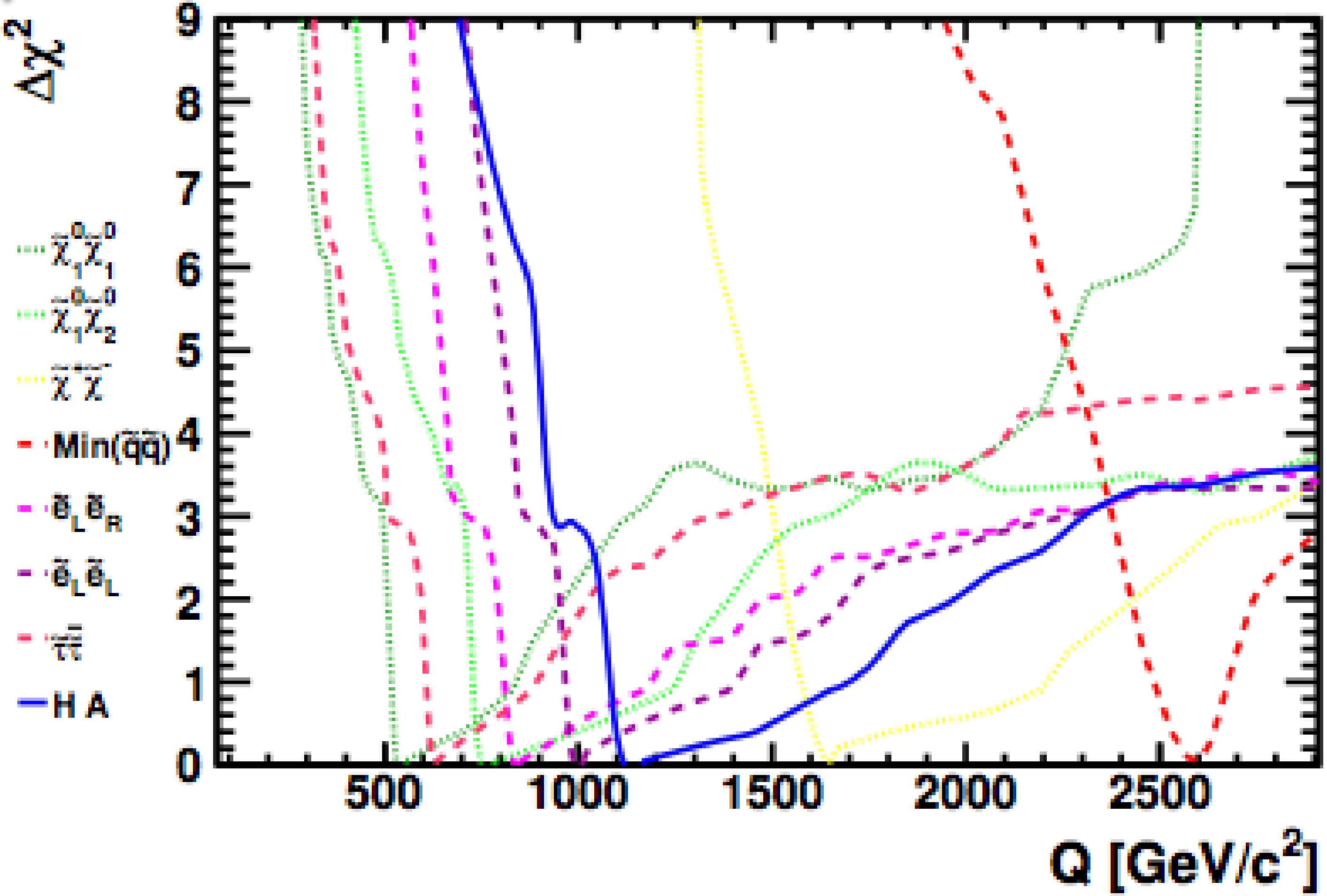
CMSSM



Likelihoods for sparticle thresholds

Preliminary

NUHM1

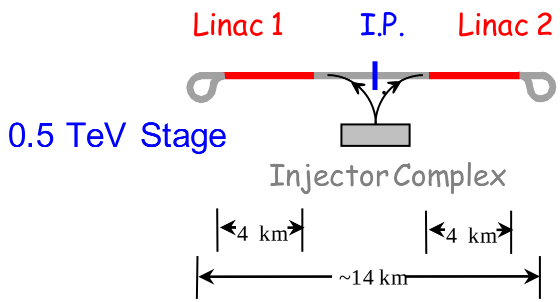


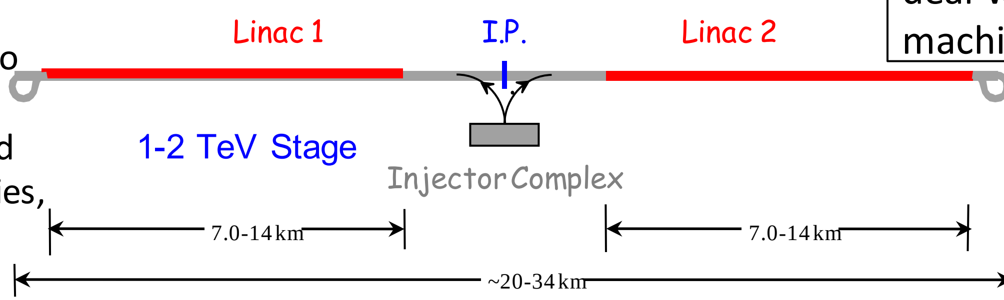
CLIC energy staging

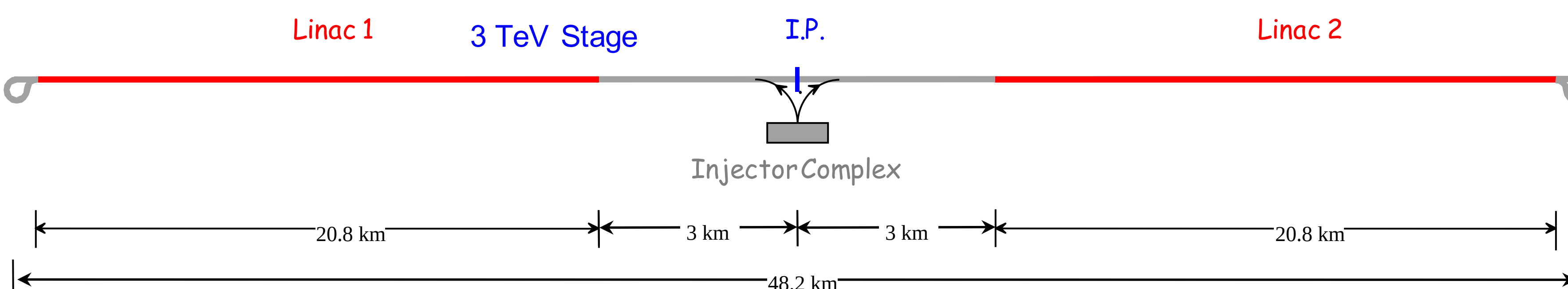
CLIC two-beam scheme compatible with energy staging to provide the optimal machine for a large energy range

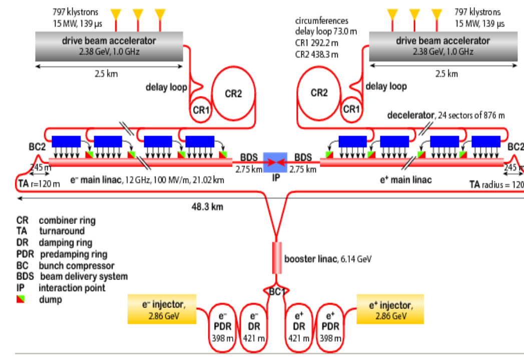
Lower energy machine can run most of the time during the construction of the next stage. Physics results will determine the energies of the stages

Optimization need to take into many account many others parameters: performance and luminosities at various energies, costs, construction and commissioning times, manufacturing/re-use/move of components, etc









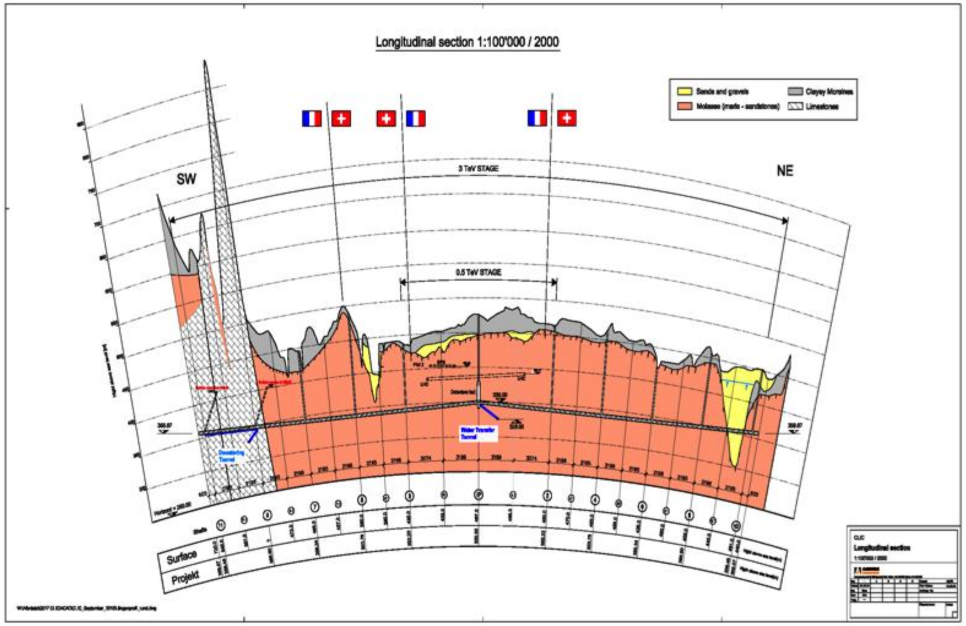
The drive beam setups can deal with various stages of the machine

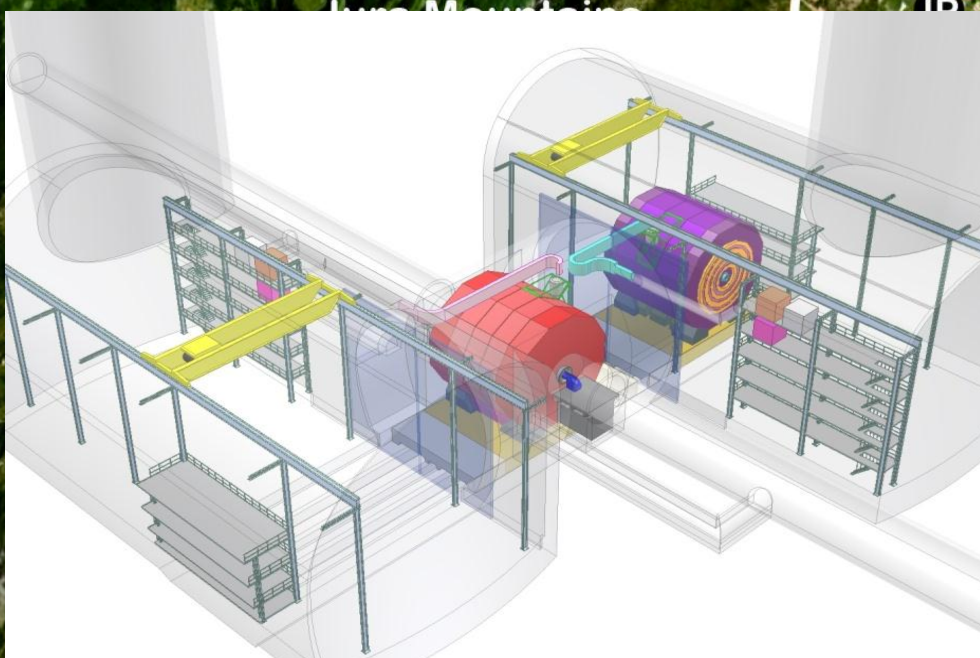
CLIC implementation questions

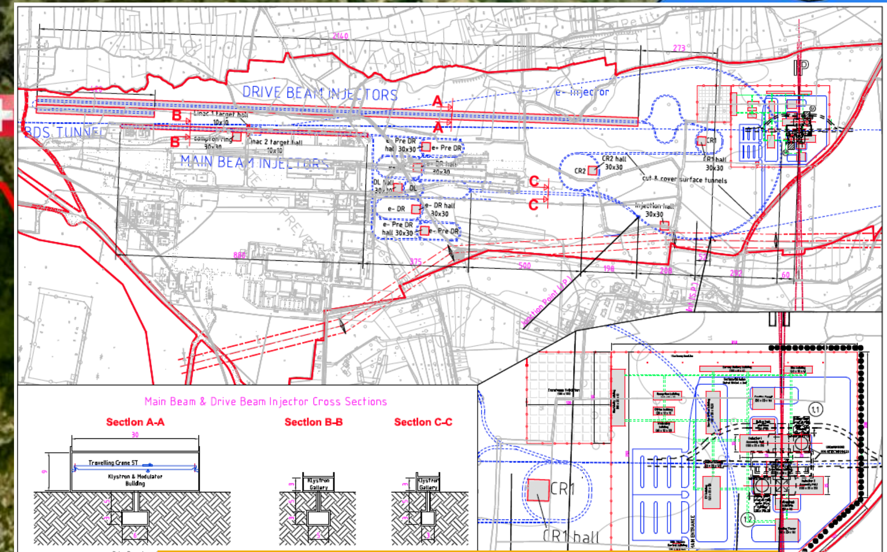
- Many questions:
  - Waiting for physics guidance: Current trend are increasing limits on squark/gluino masses (but loop holes exist) – and currently no information about other SUSY particles (can be much lighter in some models) or Higgs (Standard Model or several)
    - Some of you might know more …
    - Benefits of running close to thresholds versus at highest energy, and distribution of luminosities as function of energy ?
    - We assume that we have to be sensitive from a light Higgs threshold (~200 GeV) to multi-TeV, in several stages
  - What are the integrated luminosities needed and what it is the flexibility needed within a stage
    - Interested in looking in more detail for at least one model in order to make sure the machine implementation plan can cope with whatever will be needed
    - Complementarity with LHC a key
  - What are reasonable commissioning and luminosity ramp up times ?
    - LHC will need 3 years to get to 50 fb^{-1} and collects ~50 fb-1/year at 10^{34} (roughly)
  - How would we in practice do the tunneling and productions/installation of parts in a multistage approach
    - Cheapest (overall) to do in one go but we don't know final energy needed, and it is likely that we can make significant technical process before we get to stage 3 (or even 2?)
    - Timescales for getting into operation, and getting from one stage to another

- Answers are possible but must be found based on all available information at the time the project is launched

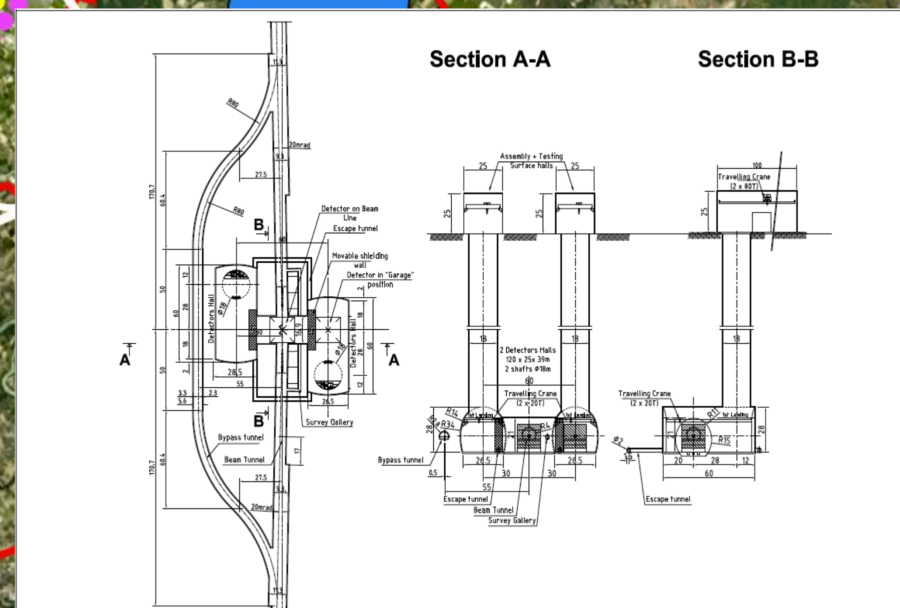
Tunnel implementations (laser straight)







Central Injector complex



Central MDI & Interaction Region

"Global accelerator projects and their Governance"
Council Working Group
on the
Scientific and Geographical Enlargement of CERN

A discussion of CERN's potential role and willingness to engage in a future Global Project, and possible Governance Models:

- In many implementation models a Project Governing Board could be created and mandated to monitor the project
- As for the actual management of the project, the most suitable model would seem to be that of the Scientific Collaboration.

Composition of the Preparatory Group (December 2009):

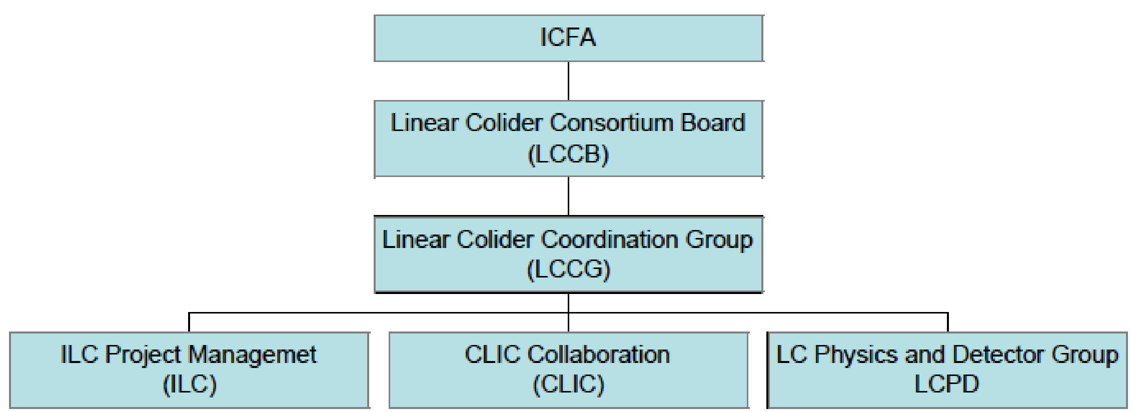
- Co-chairs: Prof. Felicitas Pauss, Coordinator for External Relations
- Prof. Steinar Stapnes, Scientific Secretary of the European Strategy Session of Council
- Members: Prof. John Ellis, Advisor for Relations with Non-Member States
- Prof. Enrique Fernandez, Chairman of the SPC
- Ex-officio: Prof. Rolf-Dieter Heuer, Director-General
- Prof. Torsten Åkesson, President of Council
- Legal advice: Dr. Eva-Maria Gröniger-Voss, Head of the Legal Service
- Mr. Maarten Wilbers, Deputy Head of the Legal Service

A common organisation for future LC work (ILC and CLIC)

- From discussions in ILCSC and ICFA in Mumbai in August (figure from European Input – T.Nakada)
- Details being worked out but concept agreed

Framework for the Linear Collider Work

Linear Collicer Management Structure



CLIC next phases

European Strategy
for Particle Physics
@ CERN Council

Final CLIC CDR and
feasibility established

	2010	2011	2012	2013	2014	2015	2016	2017	....
Feasibility issues (Accelerator&Detector)									
Conceptual design & preliminary cost estimation									
Engineering, industrialisation & cost optimisation									?
Project Preparation									
Project Implementation									?

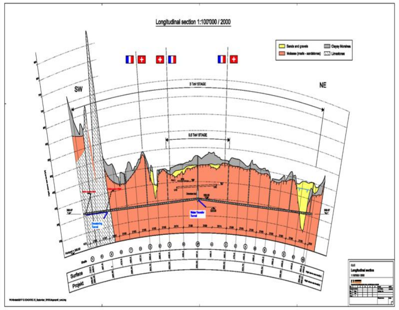
After 2016 – Project Implementation phase:

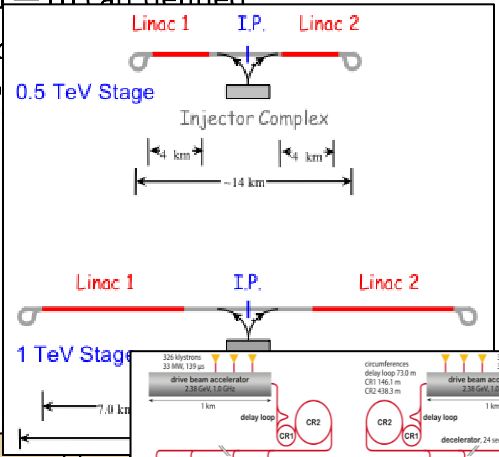
- Including an initial project to lay the grounds for full construction (CLIC 0 – a significant part of the drive beam facility)
- Finalization of the CLIC technical design, taking into accoun the results of technical studies done in the previous phase, and final energy staging scenario based on the LHC Physics results, which should be fully available by the time
- Further industrialization and pre-series production of large series components with validation facilities

The next steps – focusing points

In order to achieve the overall goal for 2016 the follow four primary objectives for 2011—16 can defined:

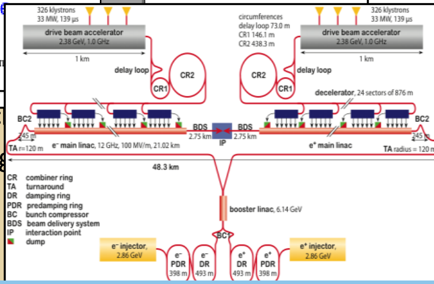
These are to be addressed by activities (studies, working groups, task forces) or work-pac developments, prototyping and tests of single components or larger systems at various p





Define the scope, strategy and cost of the project implementation.
Main input:

- The evolution of the physics findings at LHC and other relevant d
- Findings from the CDR and further studies, in particular concerni implementation.
- A Governance Model as developed with partners.

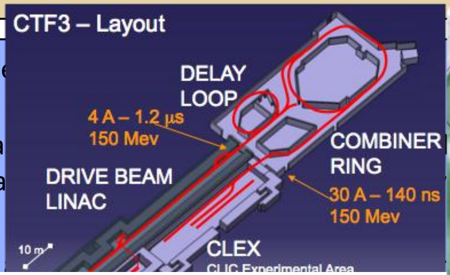


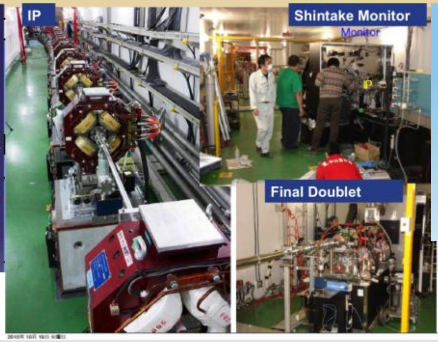
Define and keep an up-to-date optimized overall baseline design that can achieve the scope within a reasonable sc

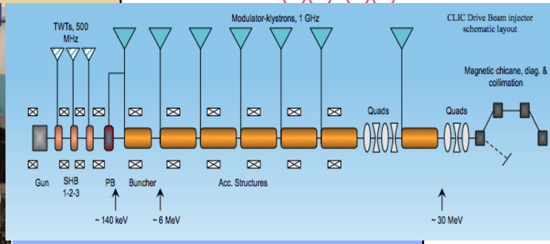
- Beyond beam line design, the energy and luminosity of the machine, key studies will address stability and alig phasing, stray fields and dynamic vacuum including collective effects.
- Other studies will address failure modes and operation issues.

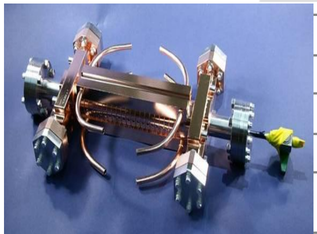
Indentify and carry out system te the project implementation.

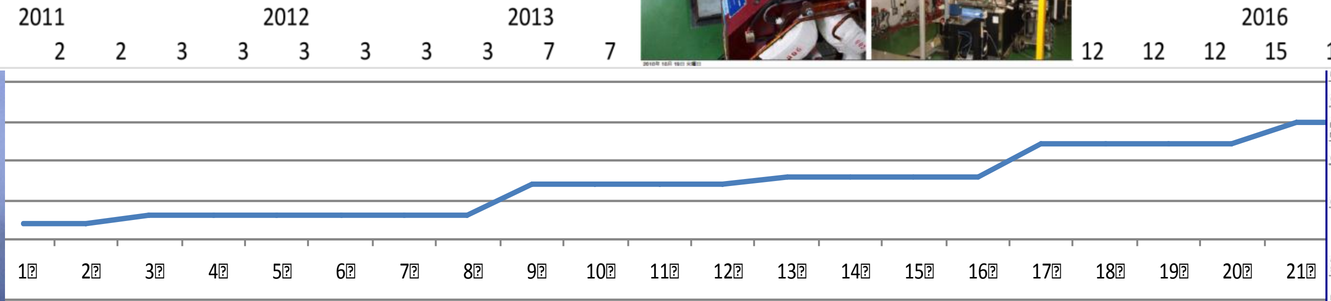
- The priorities are the mea stability, RF power genera (other system tests to be (technical work-packages

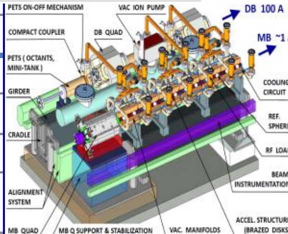












CLIC Project Meeting

Managers: Stapnes, S.; Tecker, F.

December 2011

09 Dec CLIC Project Meeting #5

October 2011

28 Oct CLIC Project Meeting #4

21 Oct CLIC Project Meeting #4

September 2011

02 Sep CLIC Project Meeting #3

July 2011

08 Jul CLIC Project Meeting #2

June 2011

01 Jun CLIC Project Meeting #1

http://indico.cern.ch/categoryDisplay.py?categId=3589

Friday 08 July 2011

09:00 - 09:45 General News and Issues

09:00 **Minutes** *10'*
Material: Minutes

09:10 **Actions and Critical Issues** *10'*

09:20 **News and updates** *20'*
- General news
- WP planning
- CDR update
Material: Slides

09:45 - 10:00 Detector/Physics report
Convener: Lucie Linssen (CERN)
Material: slides

10:05 - 10:40 Recent developments
Conveners: Roberto Corsini (CERN), Dr. Hermann Schmickler (CERN), Daniel Schulte (CERN)

10:05 **CTF3 status and next steps** *07'*
Speaker: Steffen Doebert (CERN)
Material: Slides

10:15 **Technical systems - news** *07'*
Material: Slides

10:25 **Beam dynamic** *07'*
Material: Slides

10:40 - 12:40 RF structures and test-facilities

10:40 **Structure programme and the need for test facilities** *15'*
RF structure test-programme.
Critically review the capabilities to produce the number and variety of structures proposed, identify follow up points
Introduce about the test capacity needed: Covering KEK-SLAC, "traditional" X-band facilities at CERN and other collaborators, multitube systems at CERN and outside CERN introduce, justify the needs
Speaker: Walter Wuensch (CERN)
Material: Slides

11:05 **Coffee Break** *25'*

11:35 **Experiences with and status of the X-band testing facility at CERN** *15'*
- Experiences with current klystron and options ahead
- CPI order and purchase options
- Plans for 2-3 such systems at CERN

Followed by a discussion including collaborators that could aim to install such systems
Speaker: Gerard McMonagle (CERN)
Material: Slides

12:15 **Multitube power systems** *15'*
Technical implementation of a cluster of tubes/systems
Discussion of next steps towards agreeing on specifications and verification test needed.

Followed by a discussion of the programme for such systems, next steps
Speaker: Igor Syratchev (CERN)
Material: Slides

12:45 - 13:00 Wrap up, next meeting, AOB
Material: slides

CLIC&CTF3 Collaboration

41 Institutes from 21 countries

ACAS (Australia)
Aarhus University (Denmark)
Ankara University (Turkey)
Argonne National Laboratory (USA)
Athens University (Greece)
BINP (Russia)
CERN
CIEMAT (Spain)
Cockcroft Institute (UK)
ETHZurich (Switzerland)
FERMILAB
Gazi Universities (Turkey)
Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
IHEP (China)
INFN / LNF (Italy)
Instituto de Fisica Corpuscular (Spain)
IRFU / Saclay (France)
Jefferson Lab (USA)
John Adams Institute/Oxford (UK)
John Adams Institute/RHUL (UK)
JINR (Russia)
Karlsruhe University (Germany)
KEK (Japan)
LAL / Orsay (France)
LAPP / ESIA (France)
NCP (Pakistan)
NIKHEF/Amsterdam (Netherlands)
North-West. Univ. Illinois (USA)
Patras University (Greece)
Polytech. University of Catalonia (Spain)
PSI (Switzerland)
RAL (UK)
RRCAT / Indore (India)
SLAC (USA)
Thrace University (Greece)
Tsinghua University (China)
University of Oslo (Norway)
Uppsala University (Sweden)
UCSC SCIPP (USA)

The Norwegian CERN programme

- During the last two programme periods of the Norwegian CERN related research (8+6 years) we have profited from the knowledge and guidance of a panel of three international experts, with John Ellis as the central member of the team
  - Provides feedback and an independent view (yearly review)
- Also recently as the Particle Physicist being being member of an international review team of Norwegian Physics
  - The particle physicist activities were very highly rated – presumably due to qualities, but it does not hurt to have a reviewer of John's standing when one physics branch is held up against another
- Many thanks from the Norwegian CERN community John !

Summary

- Exiting times – all fingers crossed for LHC results and new physics
- Major choices also ahead for international particle physics – and CERN

- John Ellis has been a central part of this organization for decades, providing input at many many levels – as you have seen and heard repeatedly today, and as I have also tried to show
- Thanks John, and we look forward to having you involved for many more years, even though the institute association changes

Thanks to the CLIC collaboration in general. Thanks in particular to:

D. Schulte (IPAC talk)

N. Shipman, I Syratchev, A. Grudiev, W. Wuensch, G. Riddone

M. Csatari

T. Persson, G. Sterbini, P. Skowronski, F. Tecker, R. Corsini,
S. Doebert, A. Dubrovski, W. Farabolini, R. Ruber

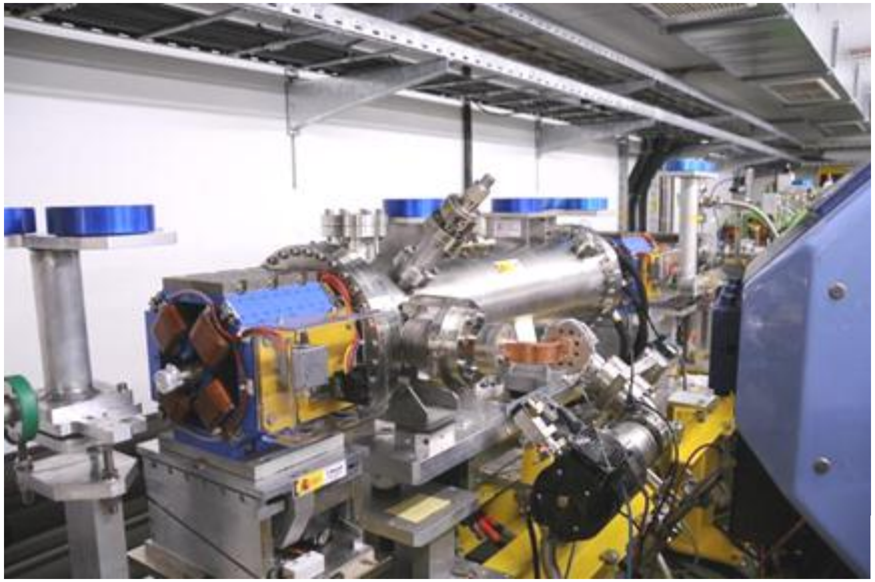
H. Meinaud Durand, K. Artoos, J. Snuverink, J. Pfingstner,

R. Tomas, Y. Papaphilippou, A. Latina, B. Dalena, B. Jeanneret

J.-P. Delahaye, L. Linssen – and J.Ellis

and others …

TBL: Drive Beam Deceleration



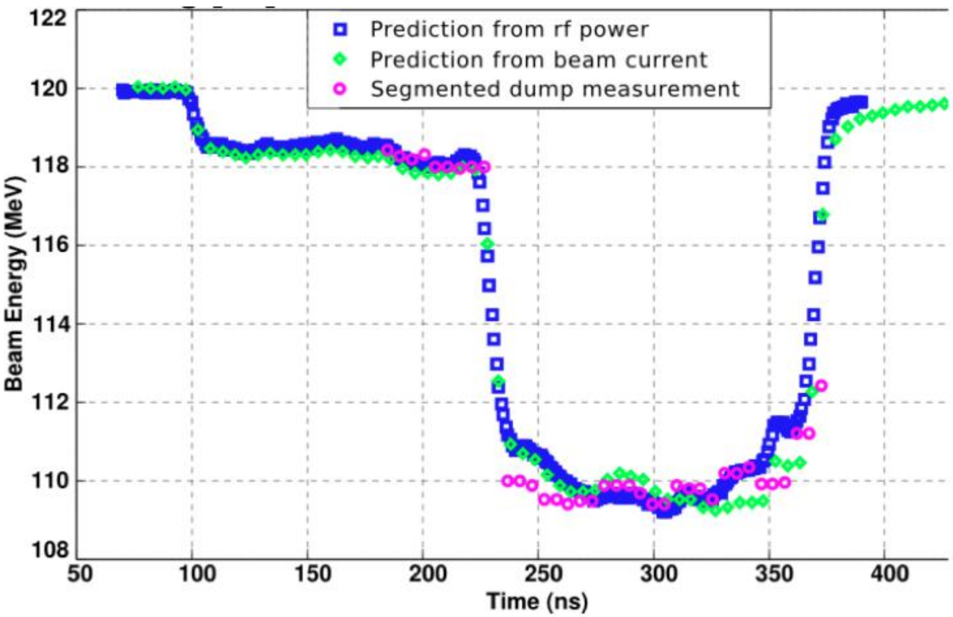
Goal is 50% deceleration

16 PETS maximum

4 PETS installed
4 to come in September
More next year

Up to 19A current
- optics understood
- no losses in TBL

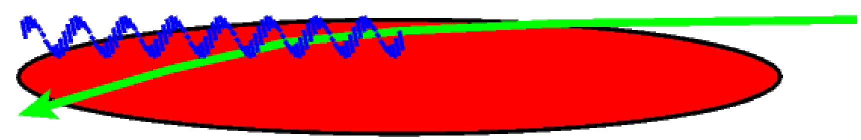
Good agreement
- power production
- beam current
- beam deceleration



S. Doebert et al.

Main Beam Emittances

	ϵ_x [nm]	ϵ_y [nm]
Damping ring exit	500	5
RTML exit	600	10
main linac exit	660	20



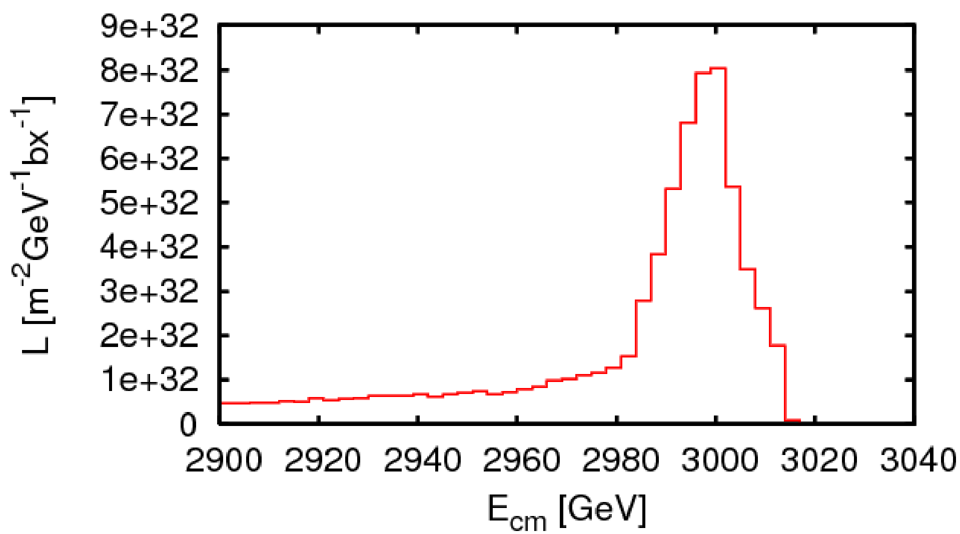
$$\mathcal{L} = H_D \frac{N^2}{4\pi\sigma_x\sigma_y} n_b f_r$$

$$\mathcal{L} \propto H_D \frac{N}{\sigma_x} N n_b f_r \frac{1}{\sigma_y}$$

Beam power

Luminosity spectrum

Beam Quality (+bunch length)



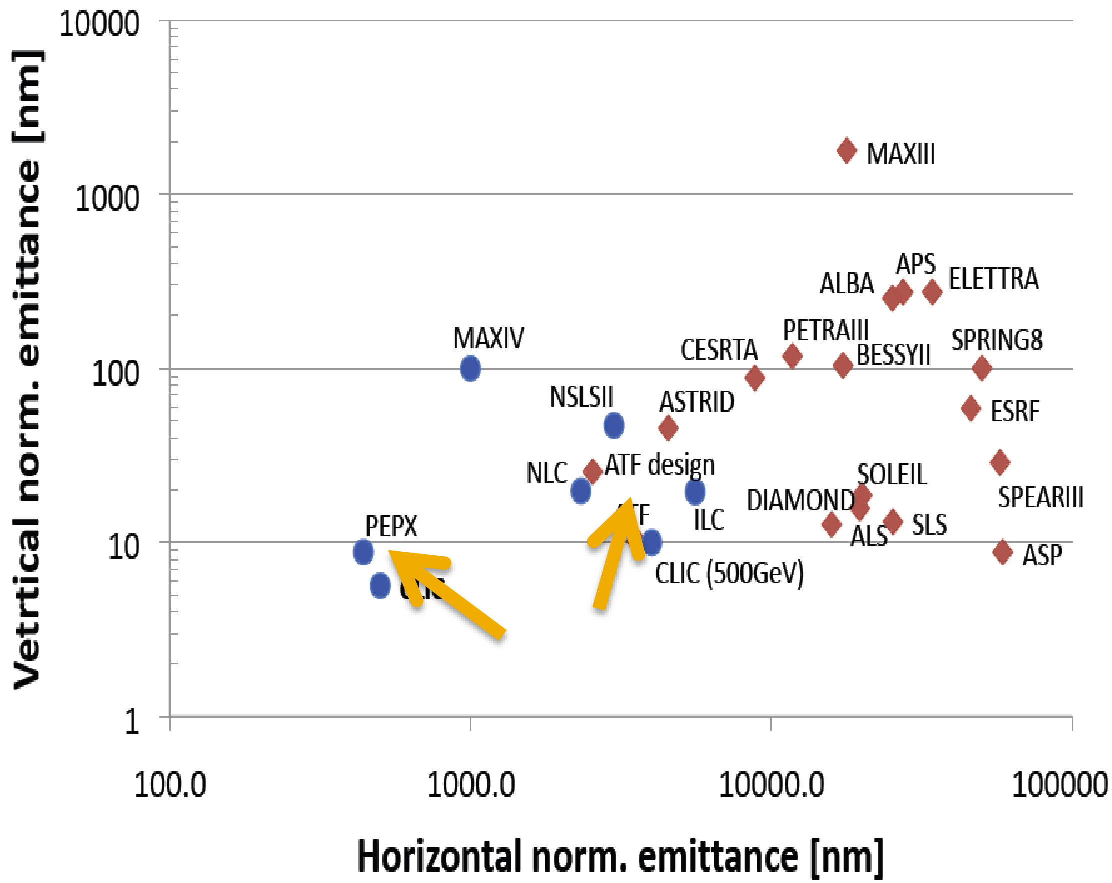
Emittance Generation

Damping ring design is consistent with target performance

Many design issues addressed
- lattice design
- dynamic aperture
- tolerances
- intra-beam scattering
- space charge
- wigglers
- RF system
- vacuum
- electron cloud
- kickers

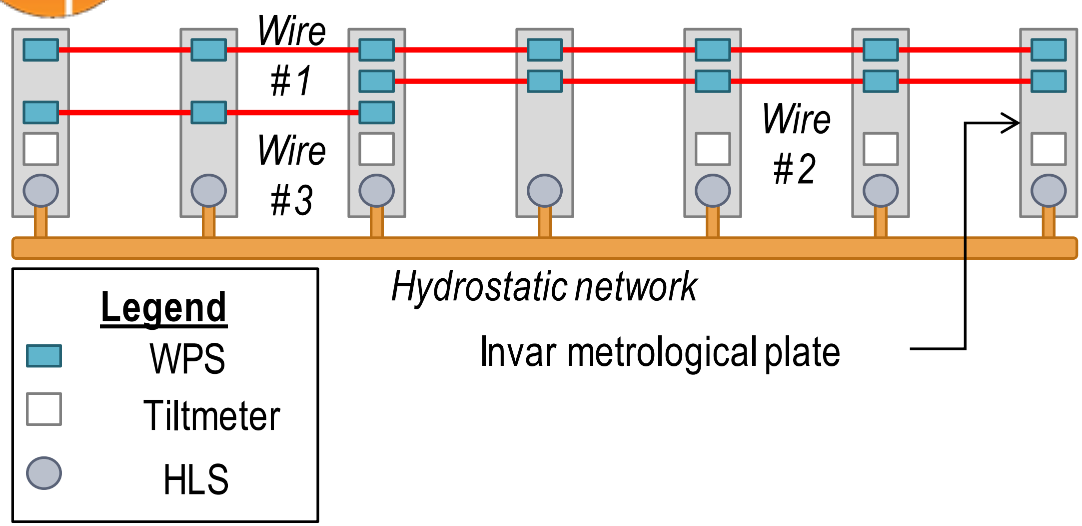
CLIC @3 TeV would achieve 40% of luminosity with ATF performance (3800nm/15nm@4e9)

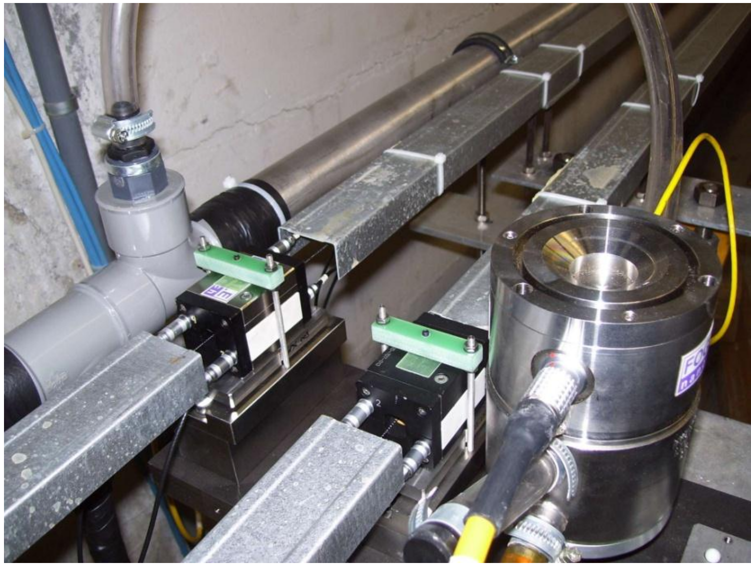
Y. Papaphilippou et al.



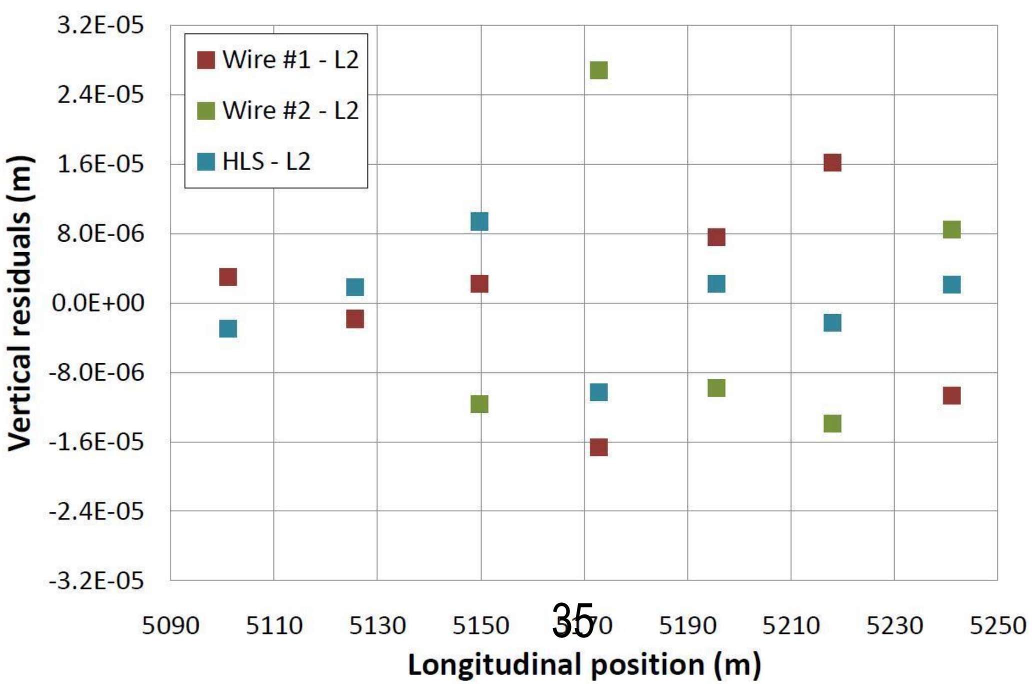
ICFA Beam Dynamics Mini Workshop on Low Emittance Rings 2011
3-5 October 2011

TT1 Alignment Results





- RMS error of 11μm found
  - accuracy is approx. 13.5μm
  - Target is 10μm
- More work remains to be done
  - Found two bad points due to mechanical problem
  - Stake-out error needs to be determined



D. Schulte

Th. Touze et al.

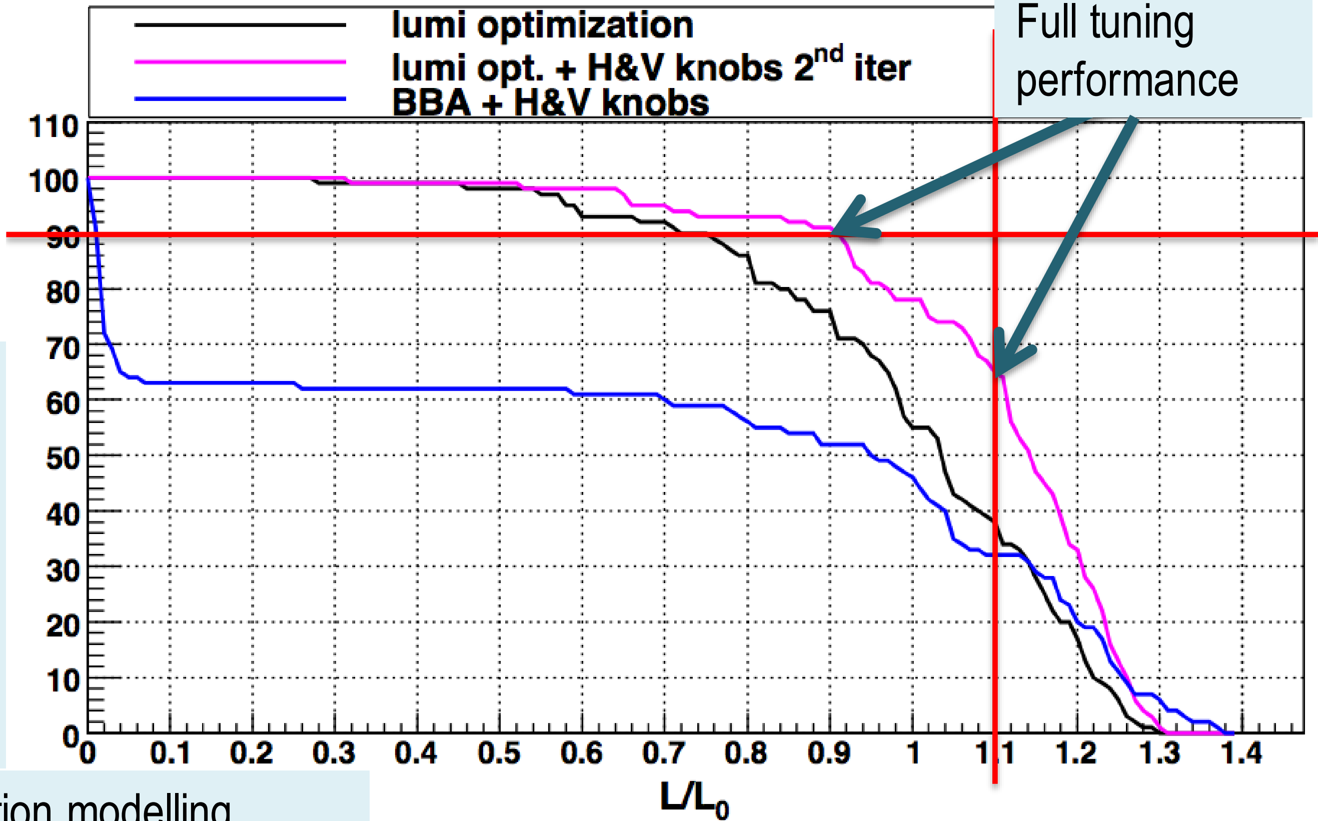
BDS Design and Alignment

Main design issues
- chromaticity
- non-linear effects
- synchrotron radiation
- tuning
- stability

Static imperfections:
- Goal is L ≥ 110% L_0
- with probability of 90%

Convergence is slow
- faster method is being developed

Including 10μm RMS misalignments



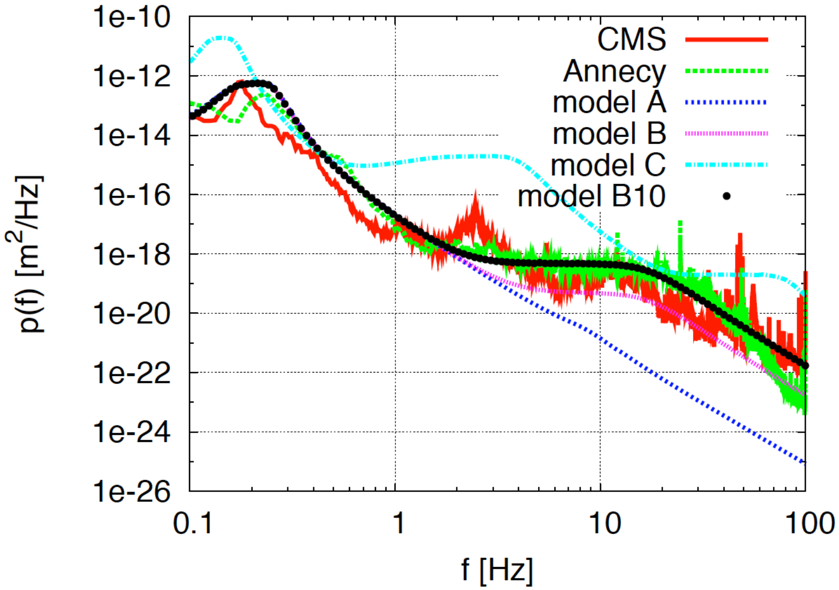
Full tuning performance

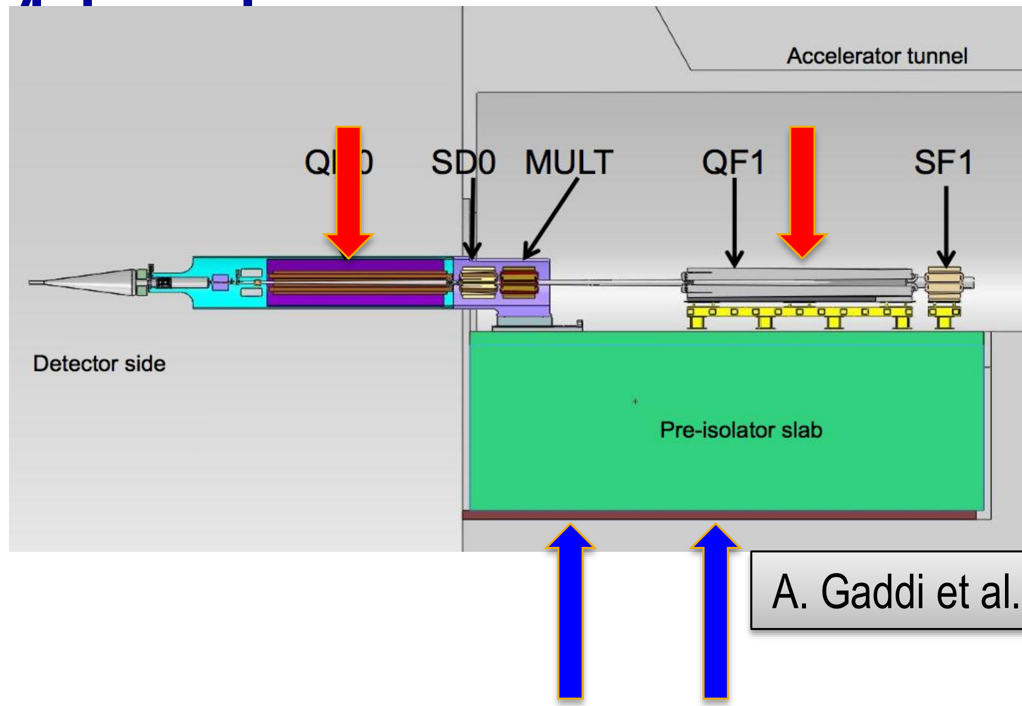
Need more complete imperfection modelling
- independent sides
- field errors
- dynamic imperfections during tuning
- realistic signals

R. Tomas,
B. Dalena et al.

Tests programme at ATF2 at KEK

Ground Motion and Its

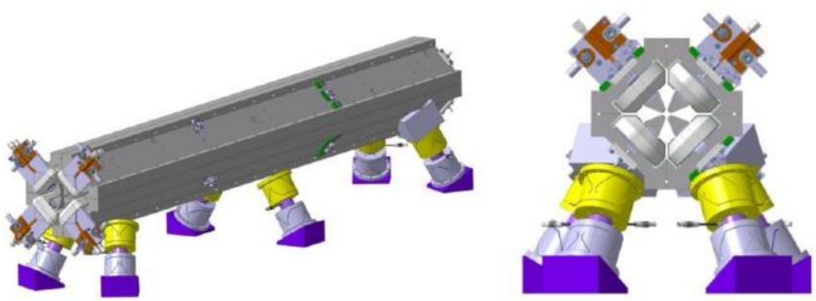




A. Gaddi et al.

Natural ground motion can impact the luminosity
- typical quadrupole jitter tolerance O(1nm) in main linac and O(0.1nm) in final doublet

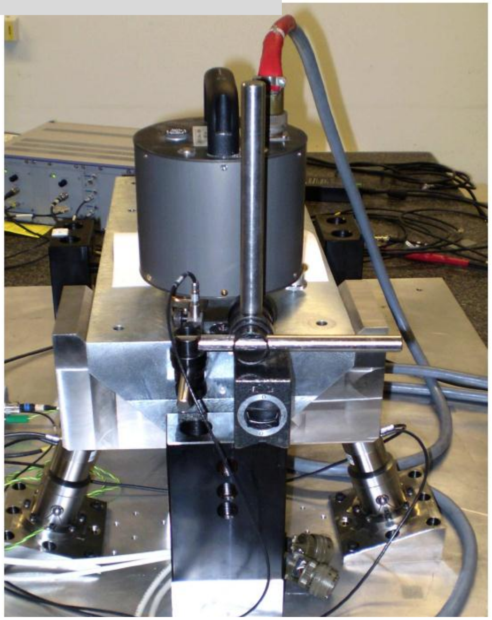
-> develop stabilisation for beam guiding magnets

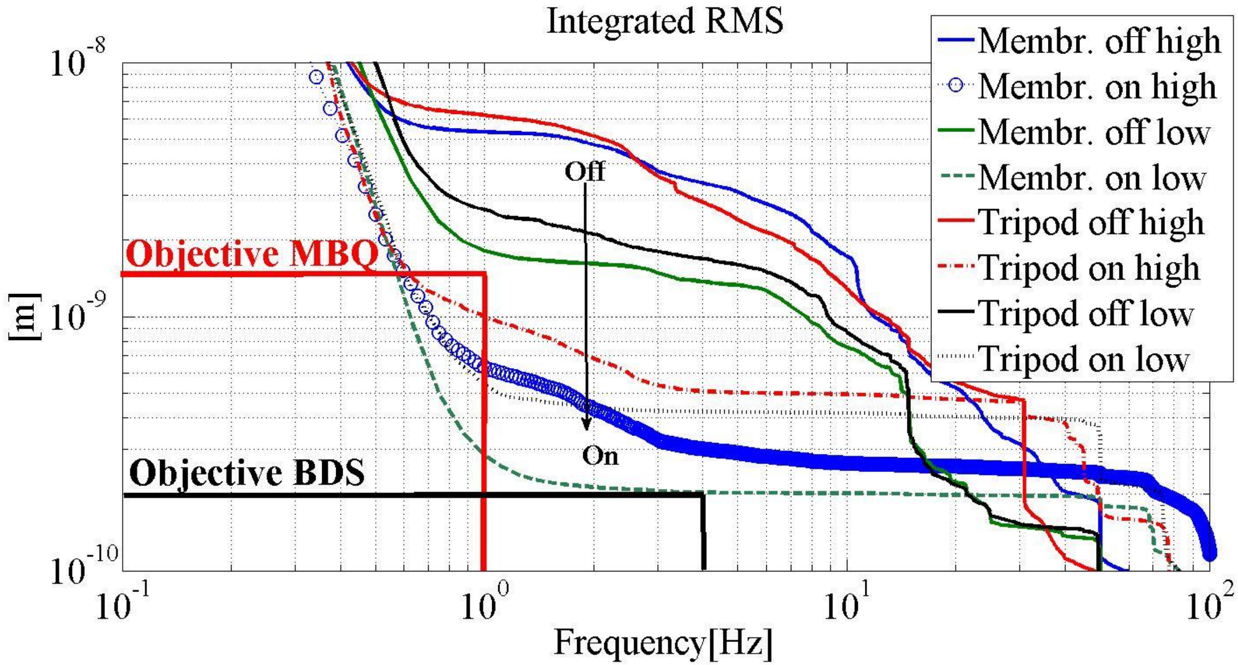


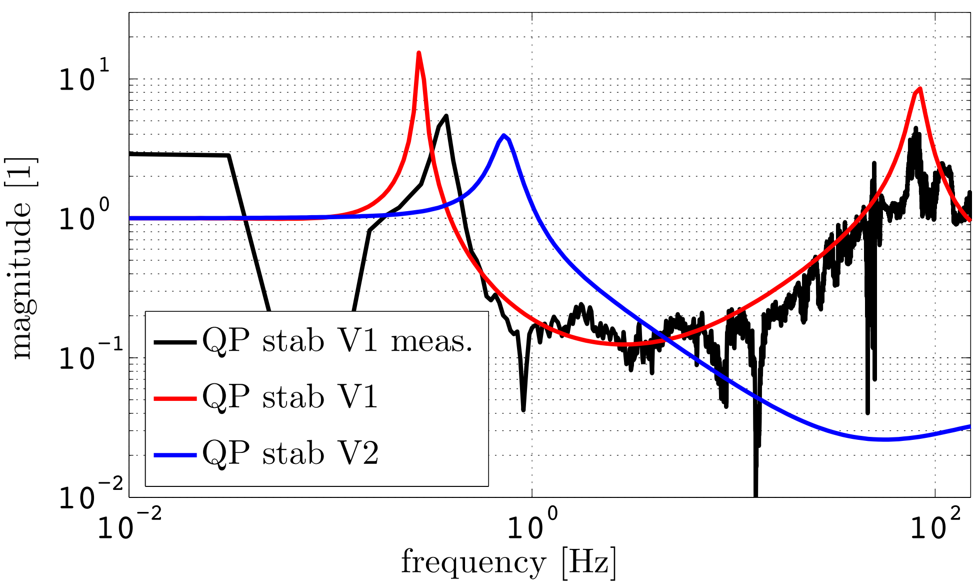
K. Artoos et al.

Active Stabilisation Results

K. Artoos et al.







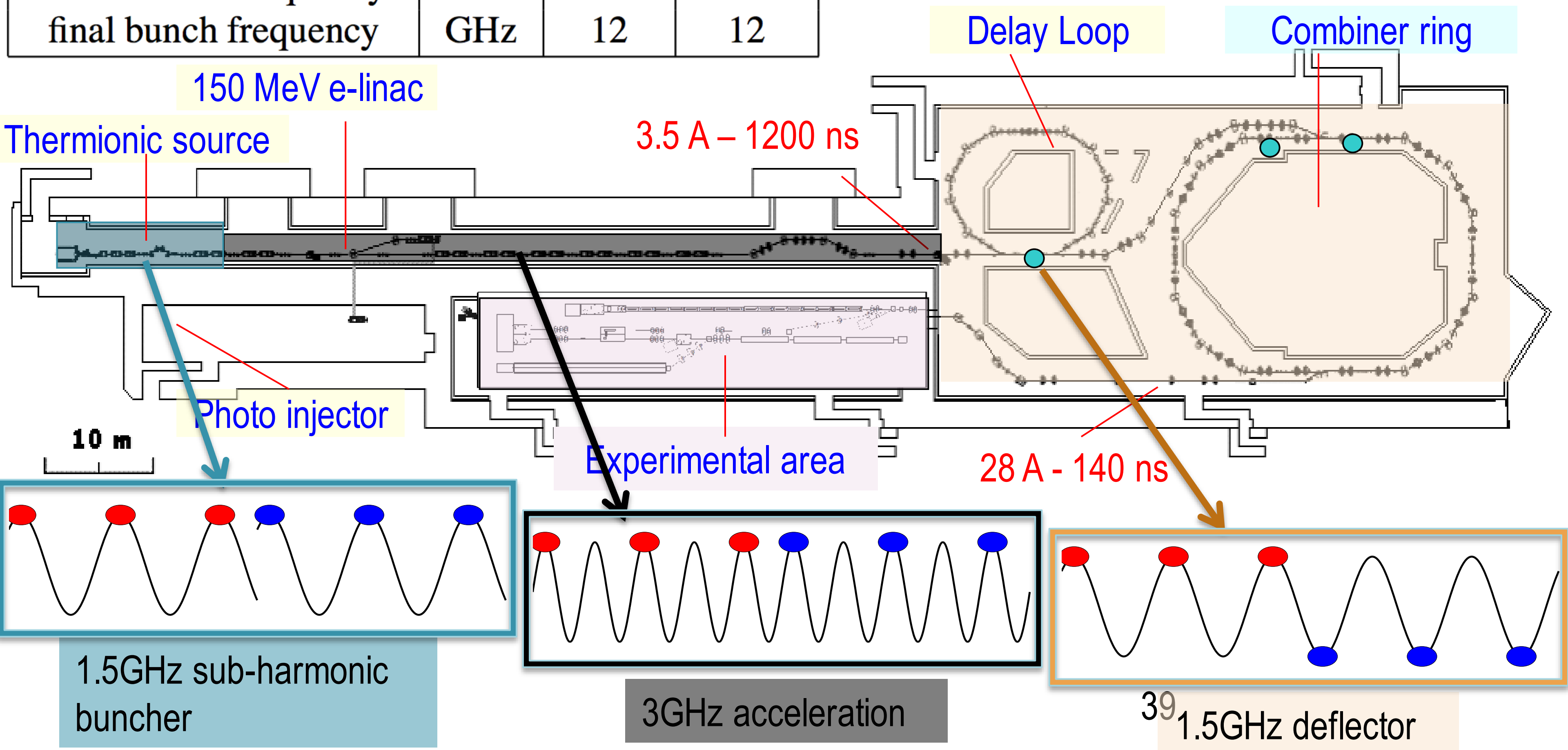
Luminosity achieved/lost [%]		
	A	B10
No stab.	119%/2%	53%/68%
Current stab.	116%/5%	108%/13%
Future stab.		118%/3%

J. Snuverink, J. Pfingstner

CLIC Test Facility (CTF3)

parameter	unit	CLIC	CTF3
accelerated current	A	4.2	3.5
combined current	A	101	28
final energy	MeV	2400	≈ 120
accelerated pulse length	μs	140	1.2
final pulse length	ns	240	140
acceleration frequency	GHz	1	3
final bunch frequency	GHz	12	12

Recycled infrastructure
- made it affordable
- causes lots of headache



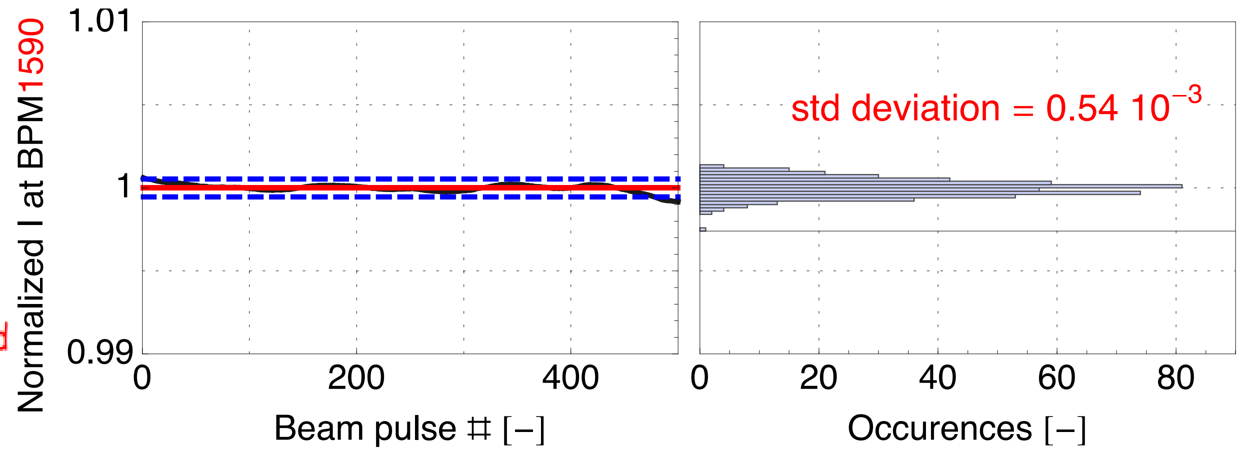
Drive Beam Linac

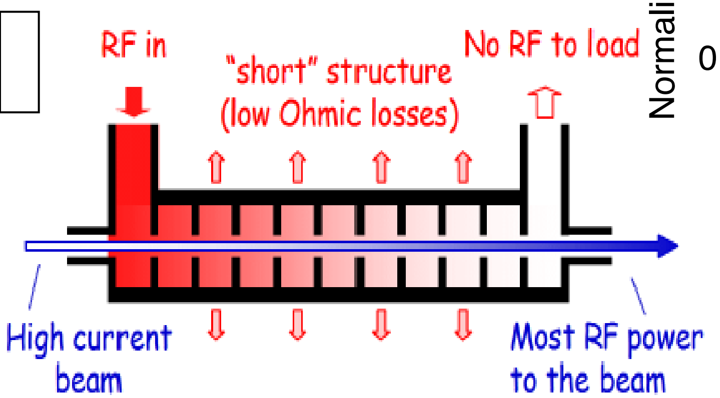
CTF3 team

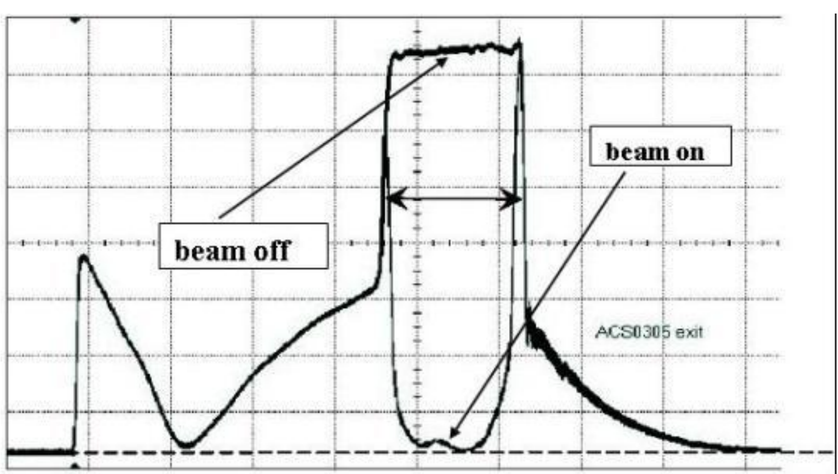
95.3% RF to beam efficiency

No instabilities

Phase switch works OK







Parameter	CLIC goal	CTF3 routine at end of linac
Transverse emittance	100µm	50-60µm
Pulse current	7.5e-4	5.4e-4

G. Sterbini, T. Persson

Drive Beam Efficiency

- Power on grid
  - ↓ 89%*70%
- 1GHz RF power
  - ↓ 97%*92%
- Drive beam
  - ↓ 81%
- 12GHz RF power
  - ↓ 25%
- Beam power

11% with other systems included 6.3%

Low frequency long pulse klystrons and modulators are more efficient

Power compression is similar

RF to beam efficiency is the same

- Power on grid
  - ↓ 70%*55%
- 12GHz RF power
  - ↓ 70%*92%
- Compressed RF
  - ↓ 25%
- Beam power

Target 6.2%, with cooling 5.5%