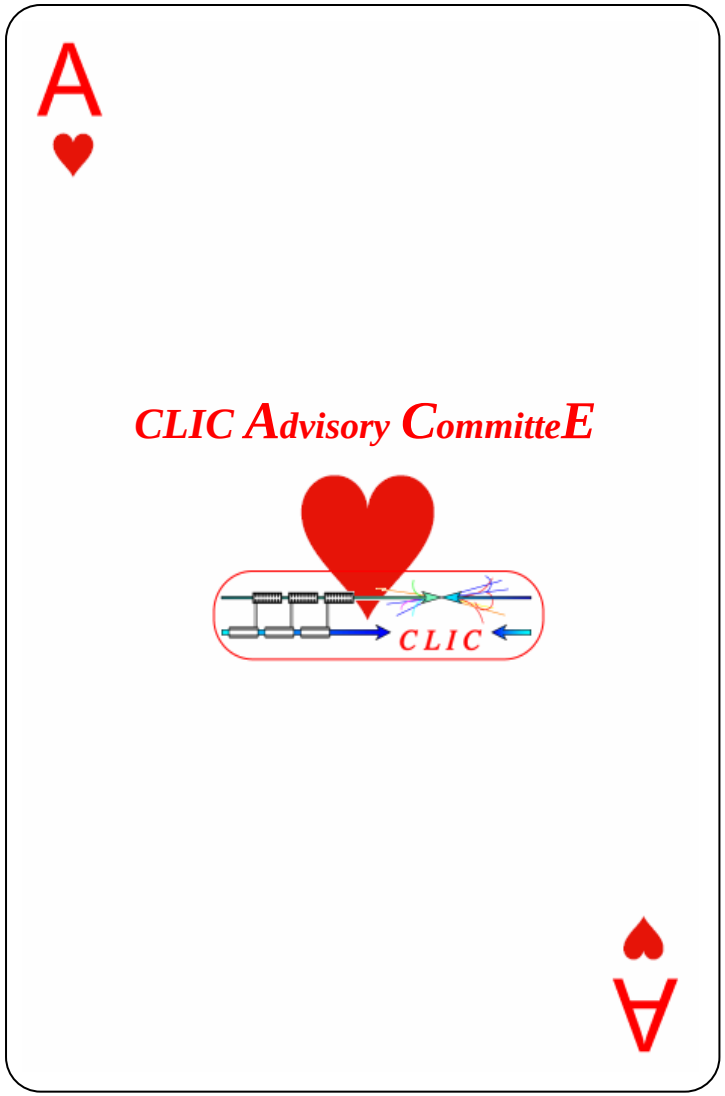
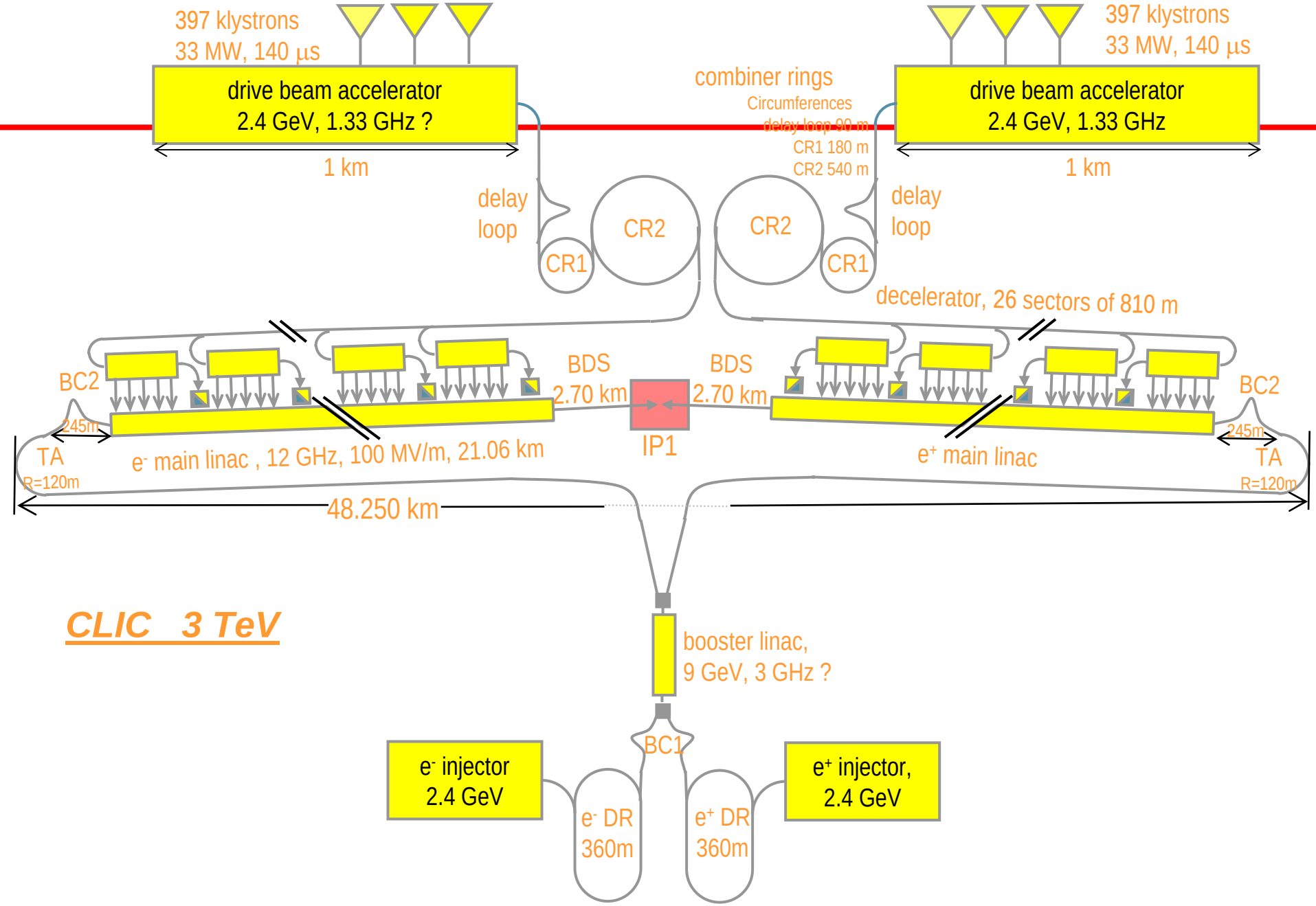
Follow-up of CLIC Advisory Committee (ACE) (20-22/06/07)



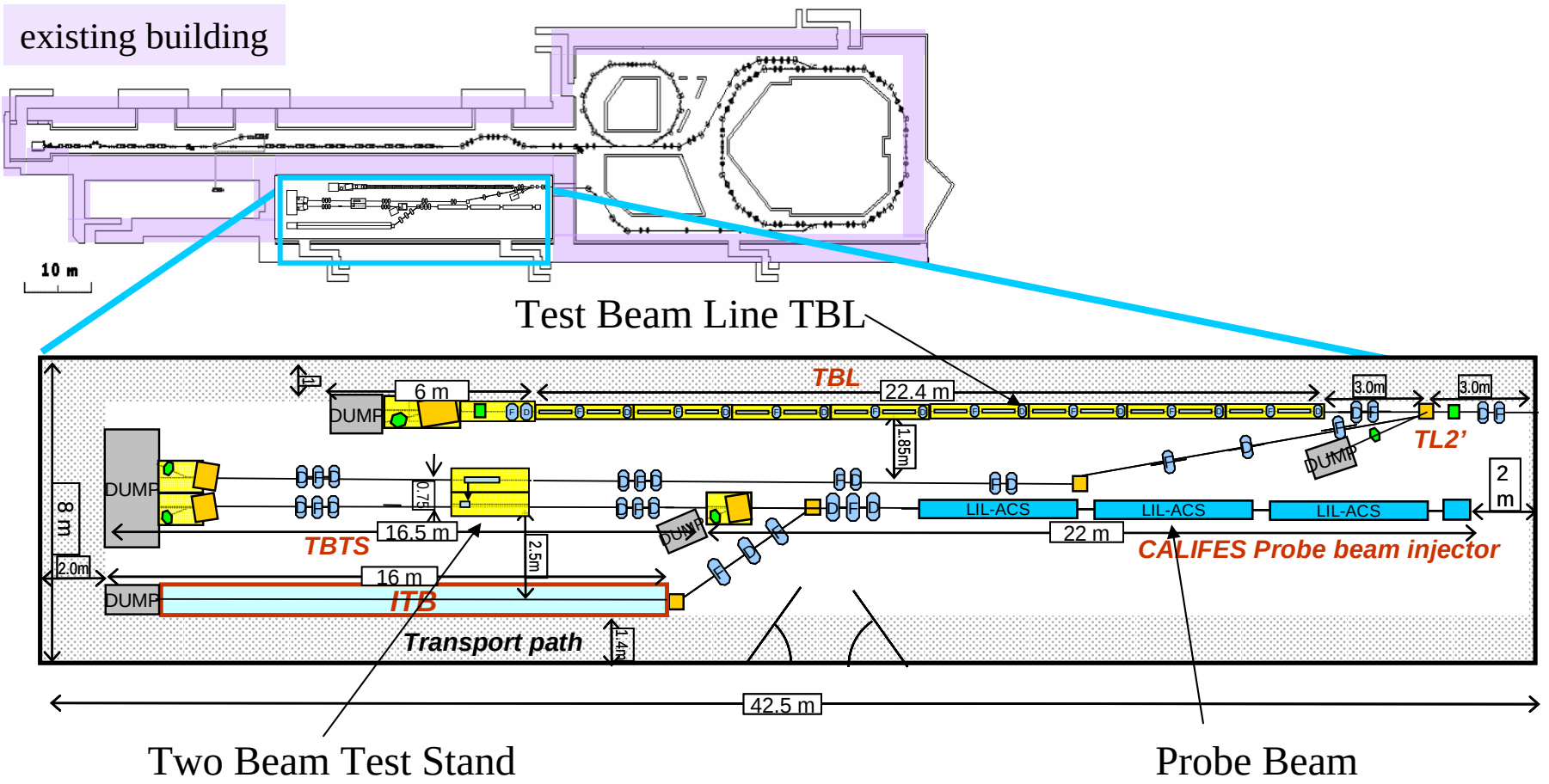
- General comments
- The ACE Committee
- Preparation in CLIC working groups
- Review of the ACE recommendations to the CLIC/CTF3 Collaboration Board and DG
- Action plan


397 klystrons
33 MW, 140 μs
drive beam accelerator
2.4 GeV, 1.33 GHz ?
1 km
combiner rings
Circumferences
delay loop 90 m
CR1 180 m
CR2 540 m
397 klystrons
33 MW, 140 μs
drive beam accelerator
2.4 GeV, 1.33 GHz
1 km
delay loop
CR2
CR2
CR1
CR1
delay loop
decelerator, 26 sectors of 810 m
BC2
245m
TA
R=120m
BDS
2.70 km
BDS
2.70 km
IP1
e- main linac , 12 GHz, 100 MV/m, 21.06 km
e+ main linac
BC2
245m
TA
R=120m
48.250 km
CLIC 3 TeV
booster linac,
9 GeV, 3 GHz ?
BC1
e- injector
2.4 GeV
e- DR
360m
e+ DR
360m
e+ injector,
2.4 GeV

CLIC parameters at 3, 1 and 0.5 TeV

Parameter	Symbol	3 TeV	1 TeV	0.5 TeV	ILC	Unit
Center of mass energy	E_{cm}	3000	1000	500	500	GeV
Main Linac RF Frequency	f_{RF}	12	12	12	1.3	GHz
Luminosity	**L**	**7**	**2.7**	**2.1**	**2**	**10^{34} cm^{-2} s^{-1}**
Luminosity (in 1% of energy)	$L_{99\%}$	2	1.5	1.4		10^{34} cm^{-2} s^{-1}
Linac repetition rate	f_{rep}	50	75	100	5	Hz
No. of particles / bunch	N_b	4.0	4.0	4.0	20	10^9
No. of bunches / pulse	k_b	311	311	311	2670	
No. of drive beam sectors / linac	N_{unit}	26	9	5	-	-
Overall two linac length	l_{linac}	41.7	14.4	8.0	22	km
Proposed site length	**l_{tot}**	**48.25**	**20.55**	**14.15**	**31**	**km**
DB Pulse length (total train)	τ_t	139	48	27	-	•s
Beam power / beam	P_b	15	5	5	10.8	MW
Total site AC power	**P_{tot}**	**388**	**~250**	**158**	**230**	**MW**

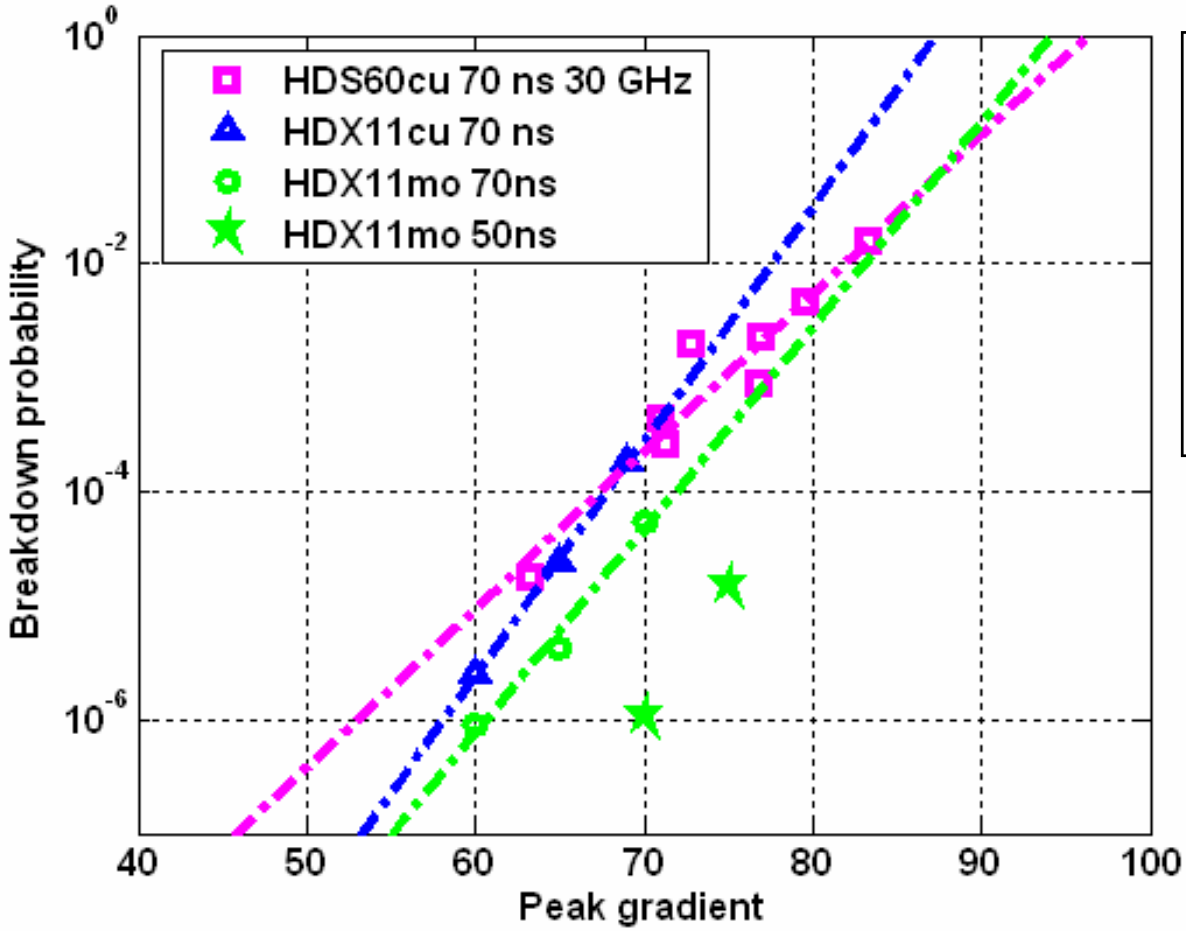
CTF3 status, commissioning and plans

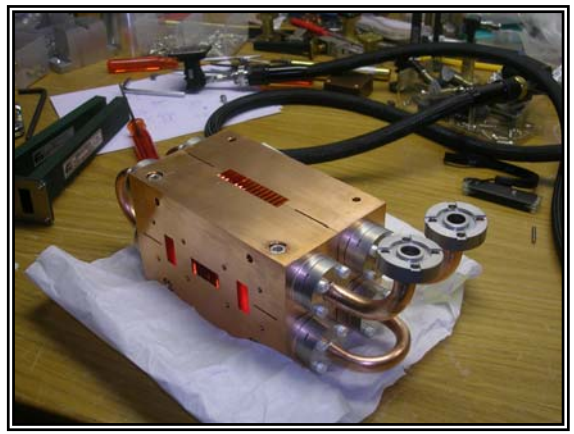


Construction during 2006/beg 2007
installation of equipment from
2007 - 2009

Beam in CLEX from 2008 onwards

Hybrid damped structures (HDX) at x-band
Frequency scaling



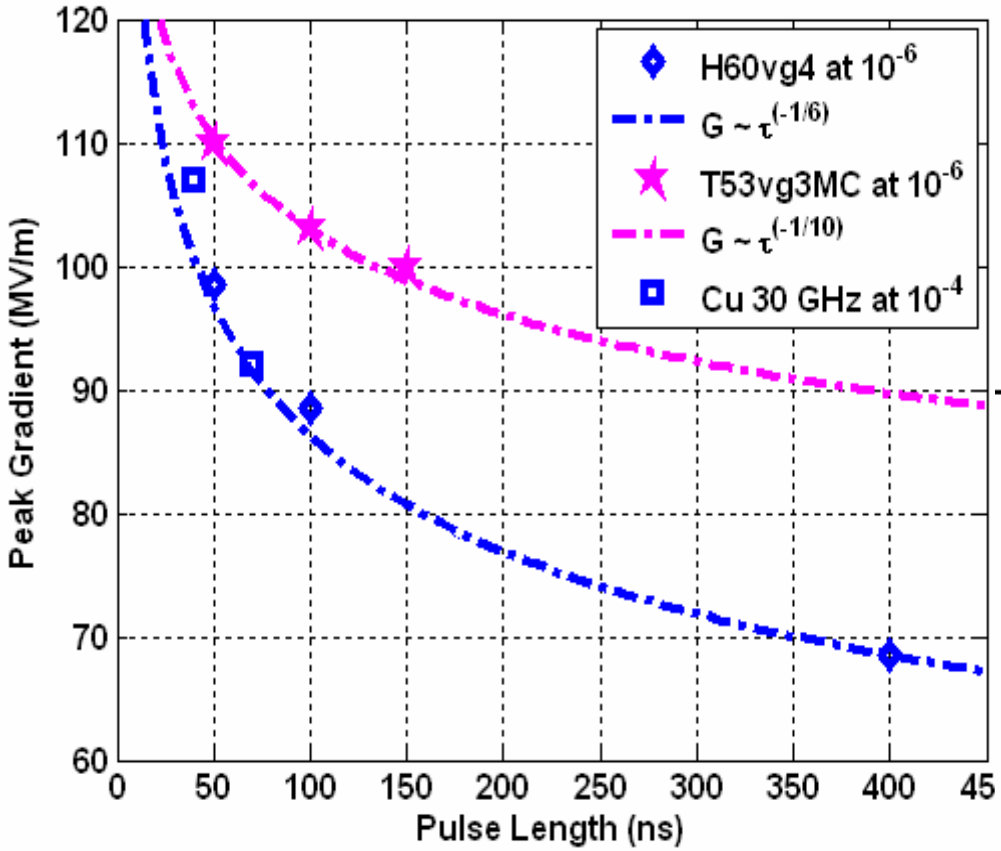


Scaled structures show very similar performance

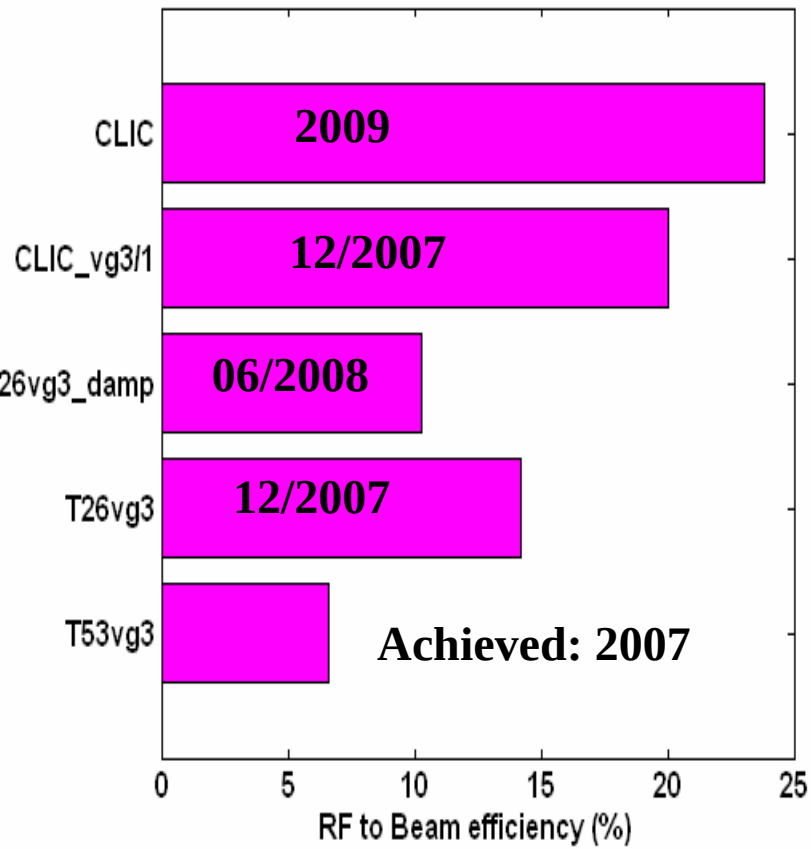
HDS-type structures show consistently limited performance

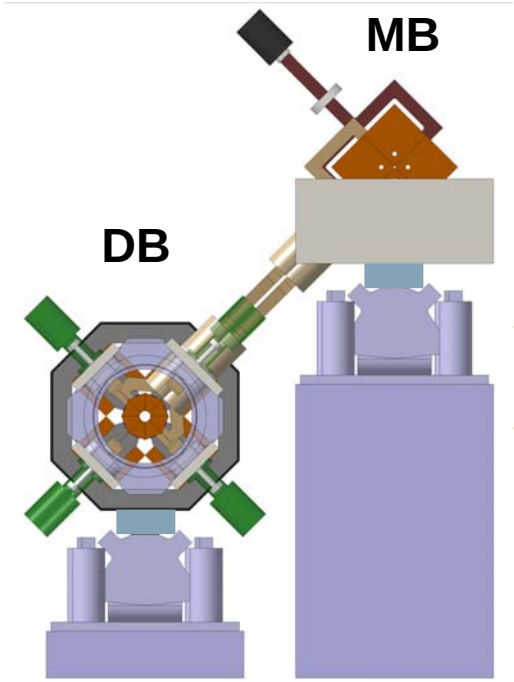
CLIC Accelerating Structures

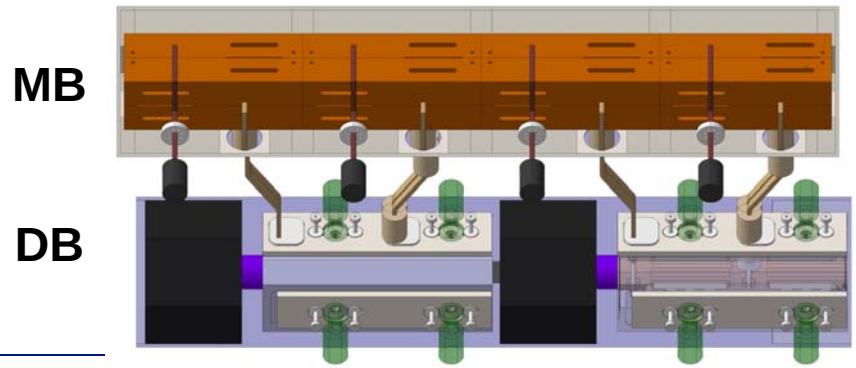
Structure Tests

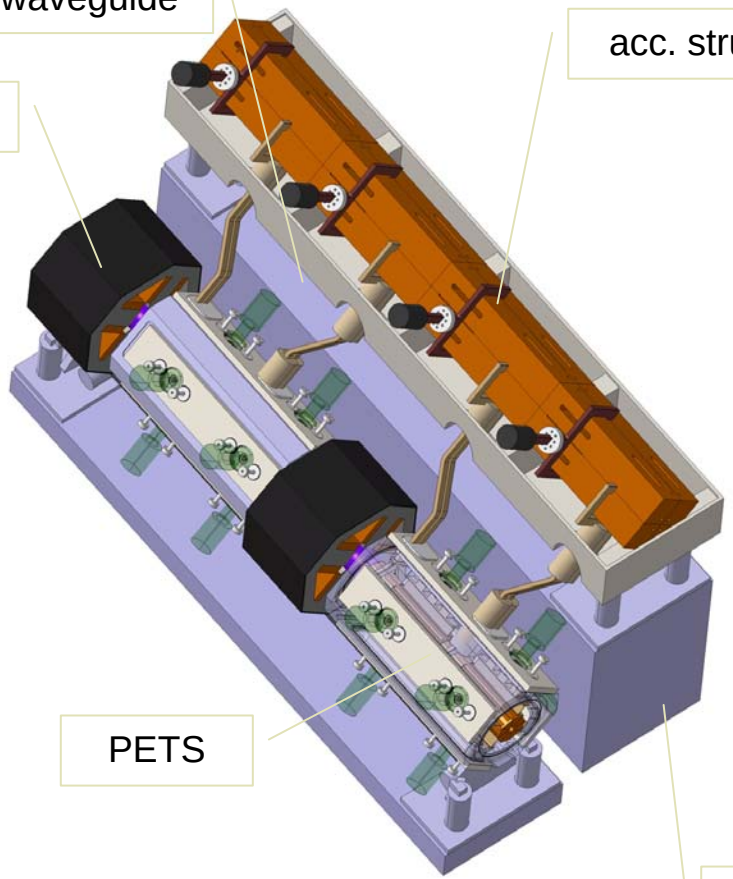


Efficiency milestones









girder

cradle

waveguide

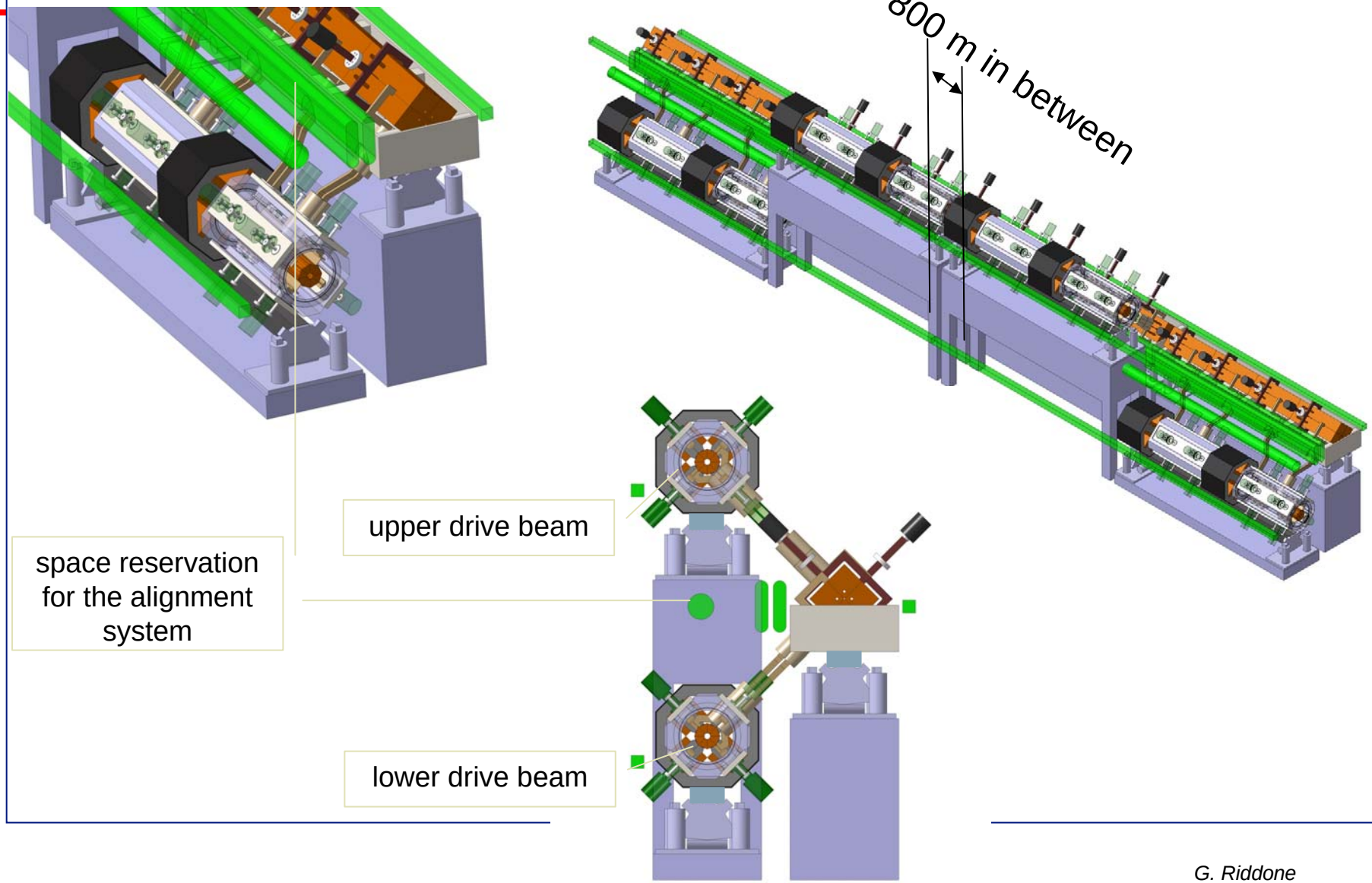
DB Quad

acc. structure

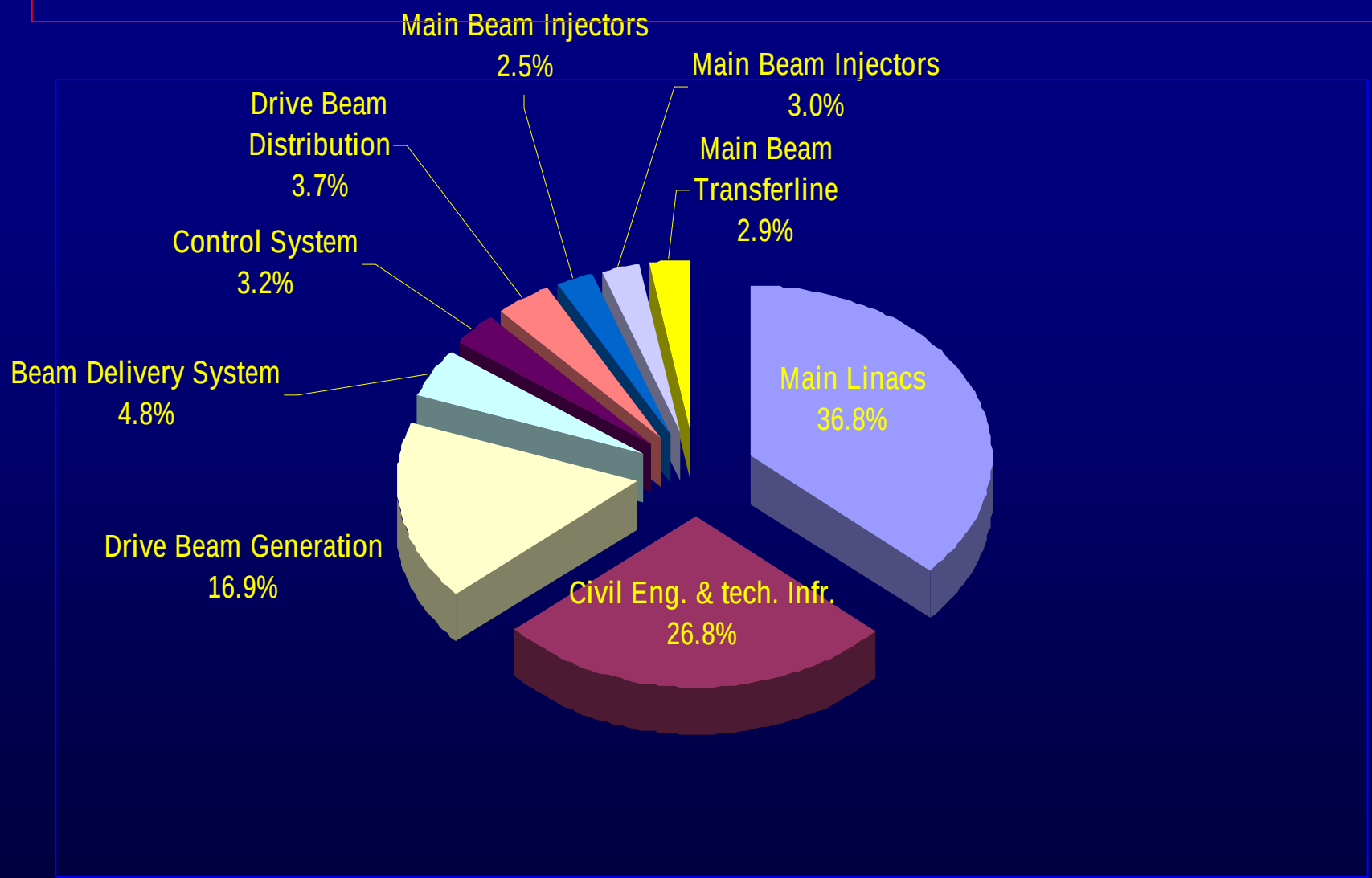
PETS

supports

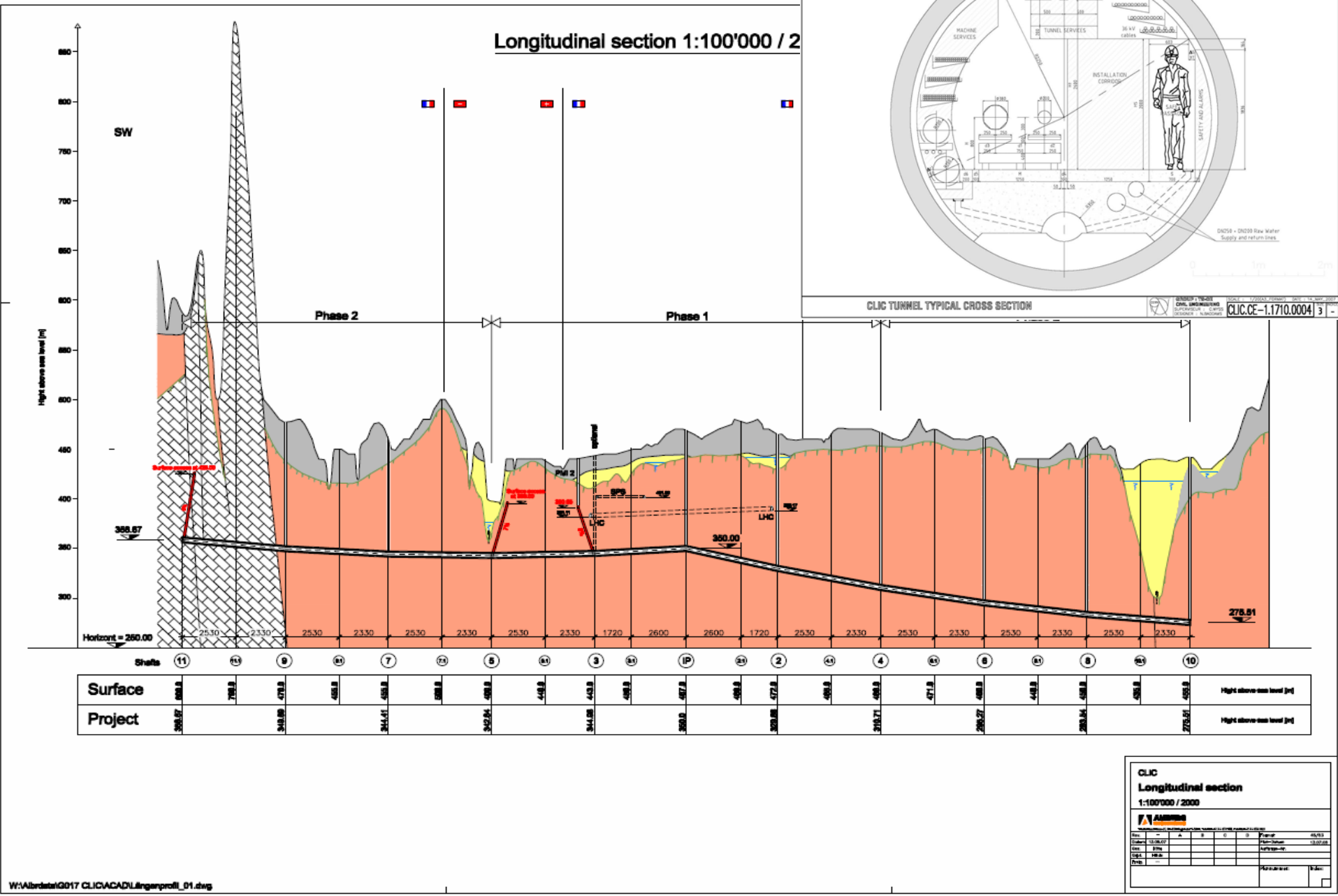
PETS on-off mechanism


~ 800 m in between
upper drive beam
space reservation for the alignment system
lower drive beam

CLIC cost (relative figures)



CLIC 3TeV


Longitudinal section 1:100'000 / 2
SW
Phase 2
Phase 1
358.67
350.00
278.51
Horizont = 260.00
Shafts
Surface
Project
CLIC TUNNEL TYPICAL CROSS SECTION
CLIC.CE-1.1710.0004
CLIC
Longitudinal section
1:100'000 / 2000

General comments

- Excellent preparation (Thanks to the working groups)
- Excellent presentations (Thanks to speakers)
- Excellent atmosphere (Thanks to ACE)
- Very constructive discussion and comments (Thanks to all)
- Excellent organisation (Thanks Sonia)
- Very useful comments of the Committee
- Strong CLIC support to Collaboration Board and to the DG
- ACE members to be enlarged (number and expertise)

Final ACE Comments

- **Very impressed with CLIC effort**
  - Large amount of progress over the last decade
  - Has the potential to offer a real path to multi-TeV e+/e- LC
- **CTF3 will demonstrate most of the critical issues**
  - Potential to create an 800 MeV test linac using CTF3 TBL
    - Clearly needed for TDR but likely possible well before
- **Like to have the next meeting focused on the structure and PETS development program**
  - Dates TBD but probably January
- **Excellent presentations**
  - Thanks to all participants (extra thanks to Sonia!)

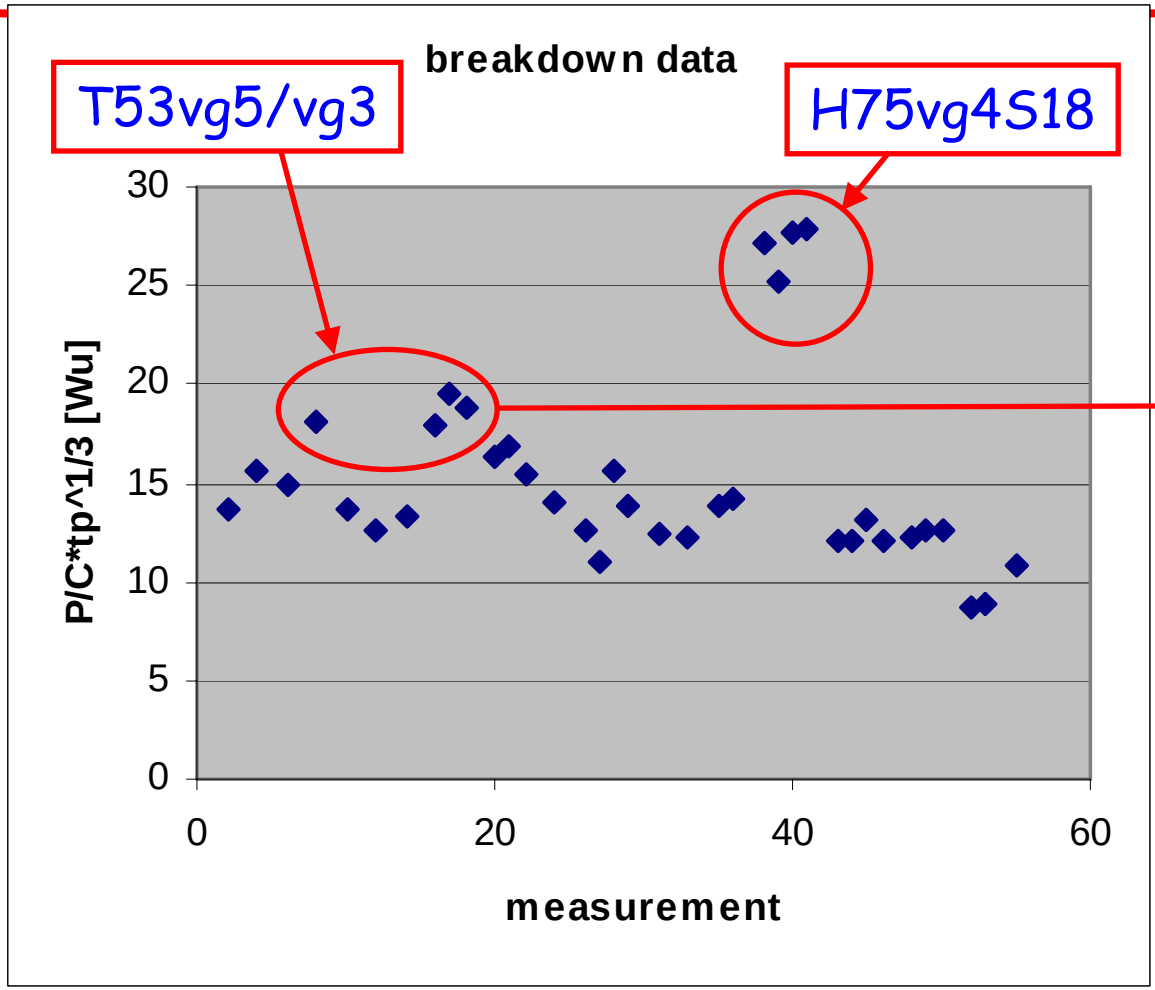
Summary of Committee recommendations about structures: (Action Structure WG)

- **Additional tests to benchmark P/c scaling law**
  - Tests pieces of CLIC structures
- **Do not mix fabrication, damping & gradient issues**
  - Test of quadrant separate from gradient
  - Develop tests (separate from gradient issues) to validate choices
- **Consider zero crossing detuning for additional damping**
- **Develop a detailed structure development & test program**
  - Fabrication and testing schedule with milestones and decision points
  - Focus on separate issues (gradient, damping. Cost)
- **Maximise the tests facilities**
  - Take advantage as much as possible of SLAC and KEK existing facilities - invite FNAL to participate
  - Strong support to 12 GHz power test stand
- **Evolve from R&D towards project management**

Additional note about Structures

- **Review of breakdown rate (BR) specification (10^-6) with short structures and low gradient (Action: Hans)**
- **Validation of P/C scaling with frequency**
  - Graph of all scaled (BR= 10^-6) to all tested structures (X band & 30 GHz) **(Action: Alexej)**

X-band data @ BDR=10^{-6}



$P_{in} t_p^{1/3} / C_{in} = 18 Wu$

Summary of Committee recommendations about PETS

- **Develop a PETS test program (including Petsonof) similar to the one on structures (Action: Igor)**
- **Consider using TBL to power additional structures**
  - Consider reduce to 8 PETS and add accelerating structures

  (Action?: Steffen)
- **Consider fully integrated modules in CLEX**
  - Beam acceleration to 800 MeV ?
  - Motivation?

  (After 2010? But reserve space?: Action Steffen)

Summary of Committee recommendations about parameters (Action: Parameters WG)

- **Strong support to change of parameters**
  - 100 MV/m and 12 GHz
  - Coherent set of parameters
  - Concerned with long RF pulse, tight tolerances and low emittances
- **Second iteration of coherent set of parameters**
  - Adapt optimum structure to low charge and wake field
  - Aim for short(er) RF pulse length
- **Suggest staged approach to 3 TeV**
  - Low energy (500 GeV? 1 TeV?) with ATF emittances and NLC tolerances
  - Range of performances with more challenging parameters

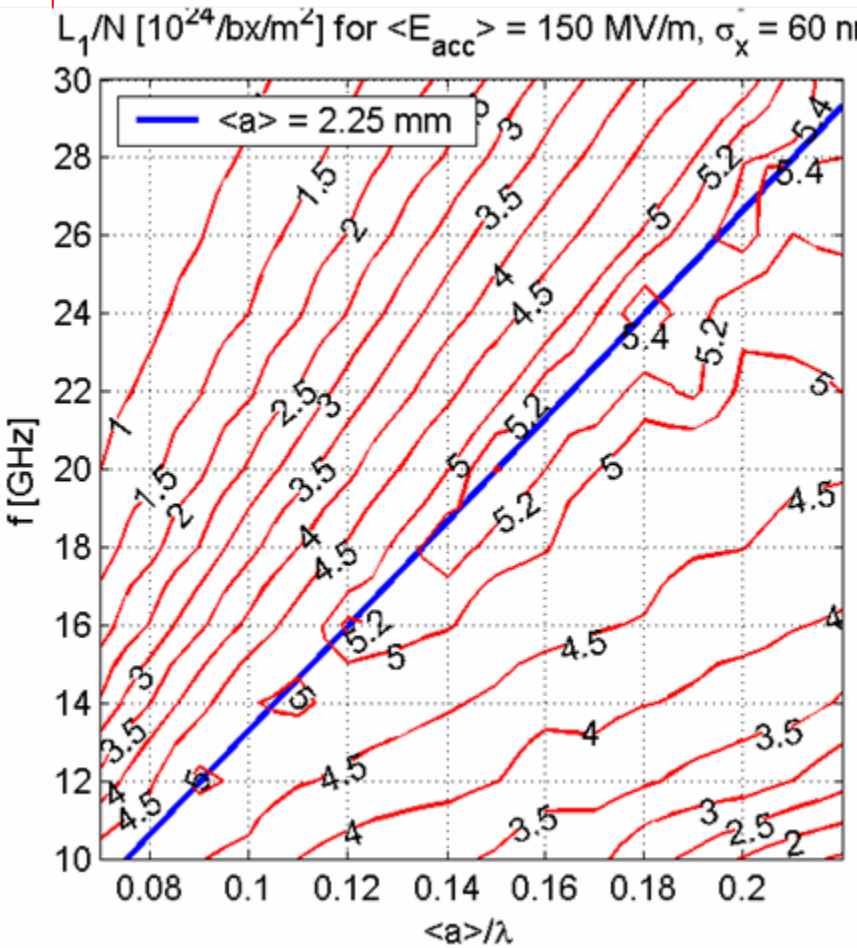
Additional note about Parameters

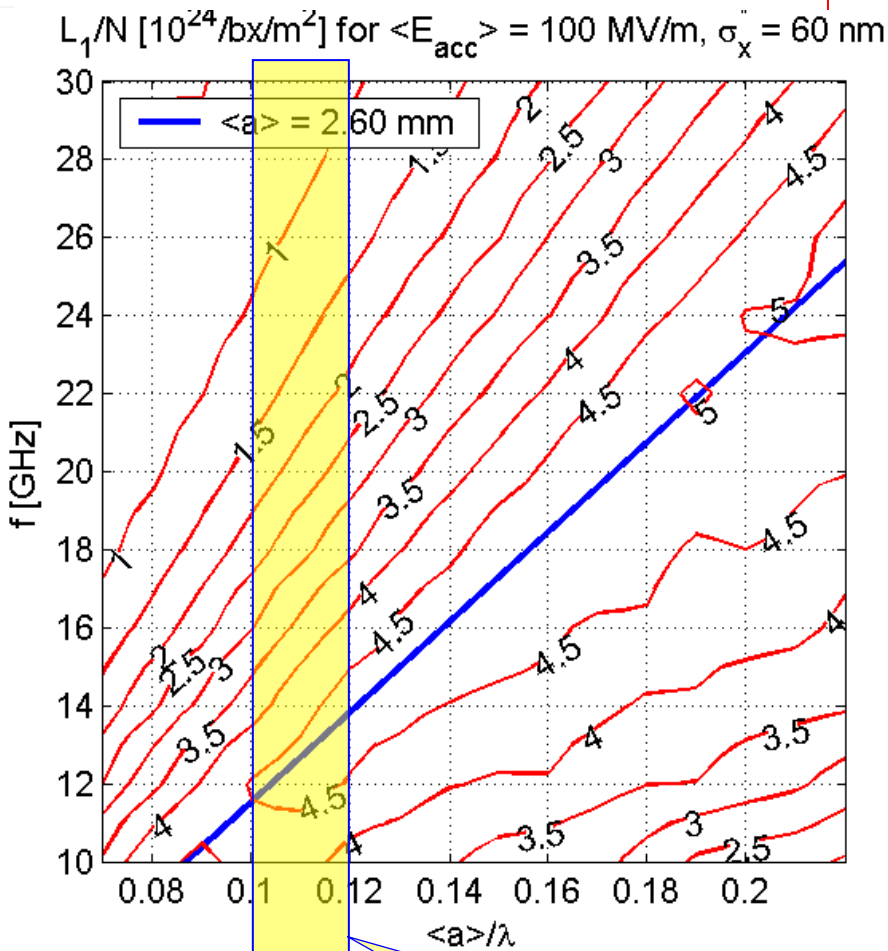
- **With present pulse length (300 ns), length of second Compressor ring (too?) long (540m) (Action: Roberto)**
  - consider 2*2*4=16 instead of 2*3*3=18 multiplication factor?
  - 2 Delay loops + CR = 360m, Frf drive linac = 1.5 GHz
- **Motivation for 20 mrad crossing angle (ILC = 14)?**

(Action? Daniel &Rogelio?)

- **Why tight(er) tolerances in CLIC than NLC when wakefield effect similar? (Action: Daniel)**
- **Add NLC in comparison table at 500 GeV (Action: Frank)**
- **Beam dynamics optimisation (Lb/N as function of a/lambda and Frf) with lower energy and bunch charge? (Action: Daniel)**

L_{bx}/N for different gradients





Why X-band ? A simplistic explanation:

Crossing gives the optimum frequency

Determined by RF constraints

Summary of Committee recommendations about Cost (Action Hans & Carlo)

- **CLIC cost mandatory for CLIC concept acceptance in 2010**
- **Need to show CLIC cost scaling with energy**
- **Develop international cost model**
- **Use ILC estimates wherever possible**
- **Limit CLIC unique aspects to when absolutely necessary**

Additional note about Cost (Action: Hans & Carlo)

- **CLIC cost to make coherent with parameters optimisation (electricity, etc…)**
- **CLIC 6kms too long at 3 TeV?**
  - Different and deeper site than NLC at 1 TeV (when effective gradient 4 times larger in CLIC!)
- **Compare CLIC, ILC and NLC costs for each system**
  - In absolute value and %
  - at the same energy and variation of % with energy in CLIC

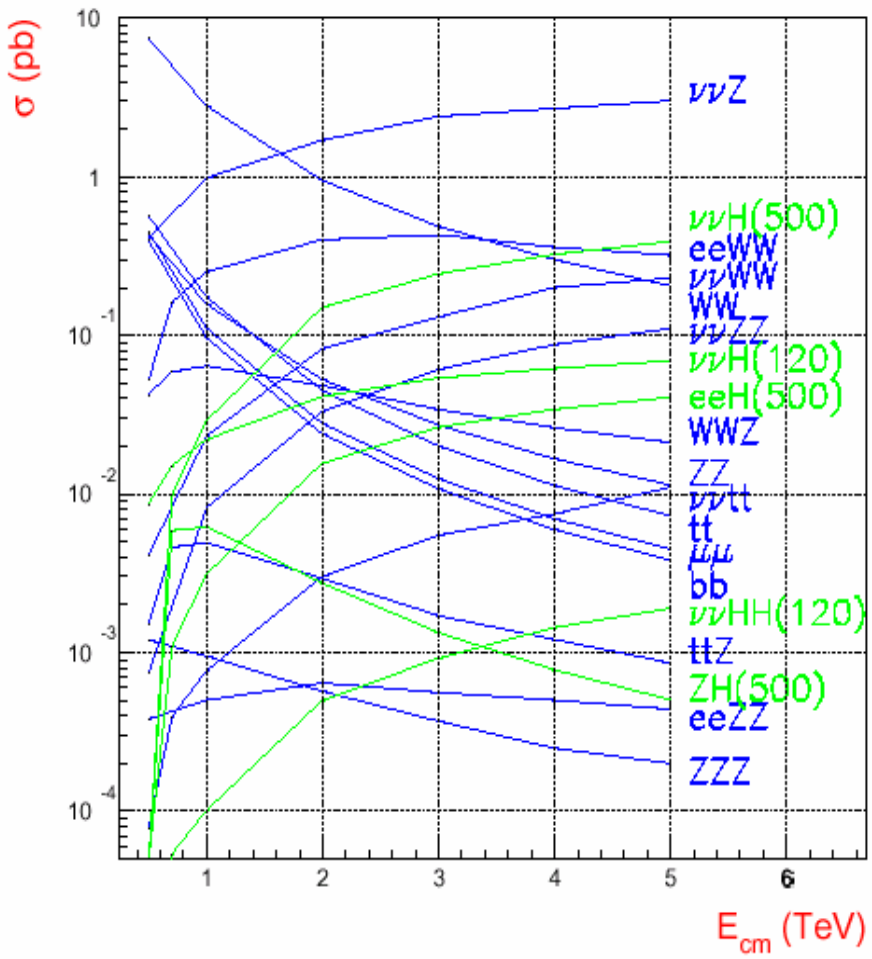
Additional note about Physics

- **Cross section increasing with energy for some events**
  - Constant luminosity in the multi-TeV energy range
- **Need to develop a 500 GeV to 1 TeV design**
  - Relaxed parameters?
  - Optimum gradient?
  - Optimum structure?

  (Action: Parameter WG)

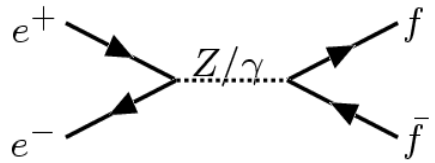
Cross Sections at CLIC

Event Rates/Year ($1000\ \text{fb}^{-1}$)	3 TeV 10^3 events	5 TeV 10^3 events
$e^+e^- \to t\bar{t}$	20	7.3
$e^+e^- \to b\bar{b}$	11	3.8
$e^+e^- \to ZZ$	27	11
$e^+e^- \to WW$	490	205
$e^+e^- \to hZ/h\nu\nu$ (120 GeV)	1.4/530	0.5/690
$e^+e^- \to H^+H^-$(1 TeV)	1.5	0.95
$e^+e^- \to \tilde{\mu}^+\tilde{\mu}^-$ (1 TeV)	1.3	1.0



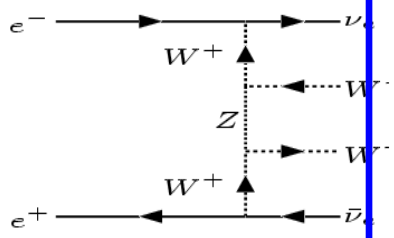
✧ Main production mechanisms in e^+e^- collisions at $s = 4 \times E^2_{beam}$:

s-Channel Production



$\sigma \propto 1/s$

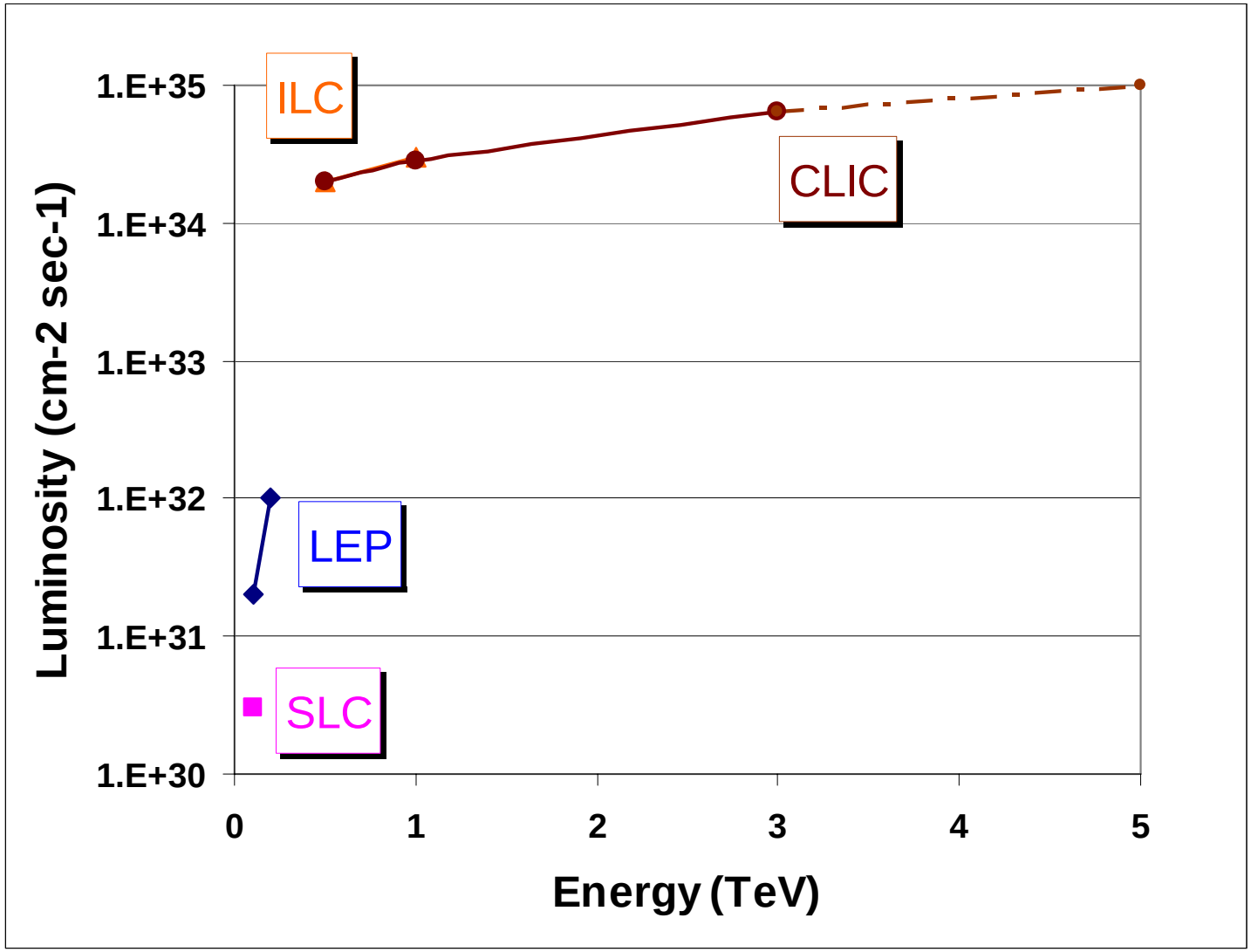
t-Channel Production



$\sigma \propto log(s)$

✧ Evolving from LEP-2 at $\sqrt{s} \leq 209$ GeV to CLIC $\sqrt{s} \simeq 3$ TeV – 5 TeV implies reduction of

Performances of Lepton Colliders



Summary of Committee's recommendations about other Critical Tests

- **Vibration suppression**
  - Important to demonstrate but explore if it is necessary to test as part of CTF3 – perhaps stand-alone test is sufficient
- **Instrumentation**
  - Take advantage of ATF and ILC programs
  - Demonstration of structure alignment important
- **Emittance transport (structure and quadrupole alignment)**
  - Explore studies at CTF3 to demonstrate main beam transport and emittance preservation (could this be part of a test linac built using the TBL??)
- **Beam phase stabilization**
  - Synergy with FEL and ERL programs ??

Summary of Committee's recommendations about CDR

- **A CLIC CDR by 2010 is a huge undertaking**
  - Excellent group but …
- **Clearly very limited by resources**
  - Resources may be better directed towards demonstrations
  - CTF3 demonstration addresses major technical issues
- **Important to develop resource loaded schedule**
  - Evolution from R&D group to more project orientated
- **Focus on elements that are unique to CLIC concept**
  - Two-Beam-Accelerator concept
  - High gradient accelerator
  - Adopt more established parameters in other areas with a staged approach to 3 TeV

CLIC Conceptual Design Report

- **Development of a full CDR will be a large undertaking**
  - Resources may be better directed towards demonstrations
  - CTF3 demonstration addresses major technical issues
- **Focus on elements that are unique to CLIC concept**
  - Two-Beam-Accelerator concept
  - High gradient accelerator
  - Adopt more established parameters in other areas with a staged approach to 3 TeV
- **Develop international cost model – Important for acceptance of CLIC concept**
  - Need to show cost scaling with energy
  - Use ILC estimates wherever possible
    - Participate in ILC engineering where common (civil, rf power, magnets, …)

Next meeting(s)

- **Focused on structures**
- **Advisory Committee: 16-18(am)/01/08**
  - Report to Extended CSC (and DG?) on 18/01 pm
- **CTF3 technical meeting: 21-23/01/08**
- **CTF3 collaboration board: 23 (pm) or 24/01/08 (am)**