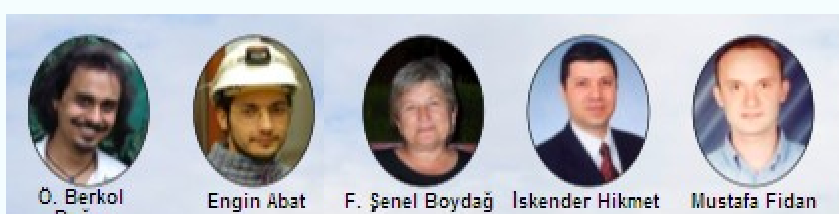
The Status of CLIC
the Compact Linear Collider
2nd International Conference on Particle Physics
in memoriam of Engin Arik and colleagues

Doğuş University, Istanbul
23rd June 2011

Ken Peach
(JAI, University of Oxford)



Contents

- Introduction
  - (Why) do we need a linear collider
- The technology challenges
  - Cold, warm or incandescent
- The Compact Linear Collider – CLIC
  - What is it
  - Status
- Summary

INTRODUCTION

Why do we need a linear collider?

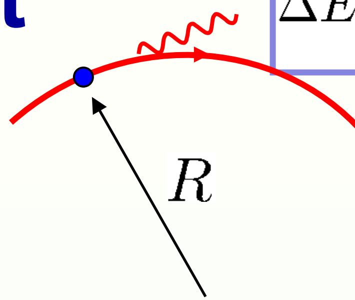
The European Strategy for Particle Physics

!. In order to be in the position to push the energy and luminosity frontier even further it is vital to strengthen the advanced accelerator R&D programme; *a coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.*

i. It is fundamental to complement the results of the LHC with measurements at a linear collider. In the energy range of 0.5 to 1 TeV, the ILC, based on superconducting technology, will provide a unique scientific opportunity at the precision frontier; *there should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.*

Why a linear collider?

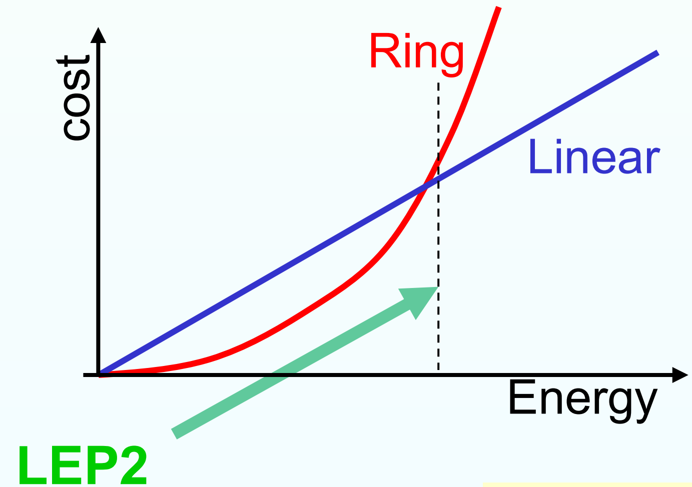
$$\Delta E \propto \frac{E^4}{m_e^4 R}$$



- **Ring colliders more efficient**
  - **Re-use the particles**
    - **Cost: RF $\propto E^4/R$; Ring $\propto$ R**
      - **Combined $\propto E^2$ ($+c_R$)**
- **Linear collider**
  - **Single pass**
    - **Cost: RF $\propto$ E ($+c_L$)**

so there must be a crossover

Breakpoint √s~200 GeV



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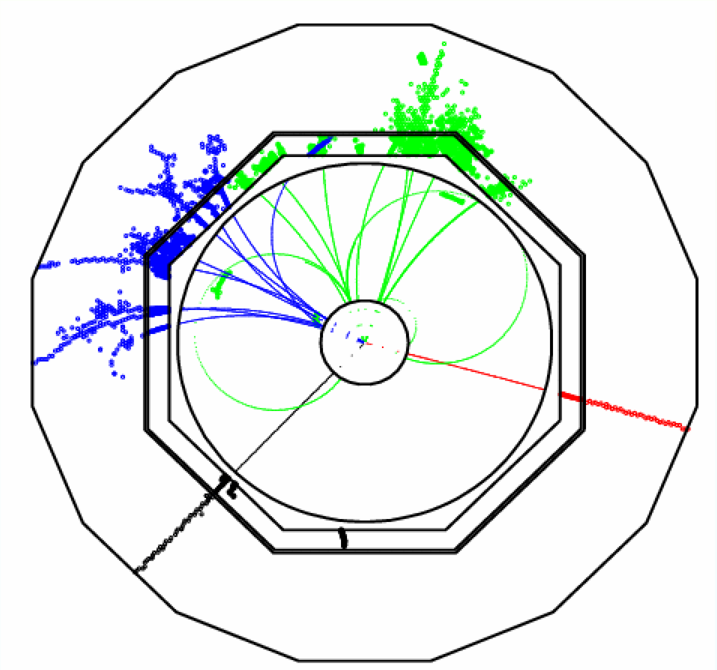
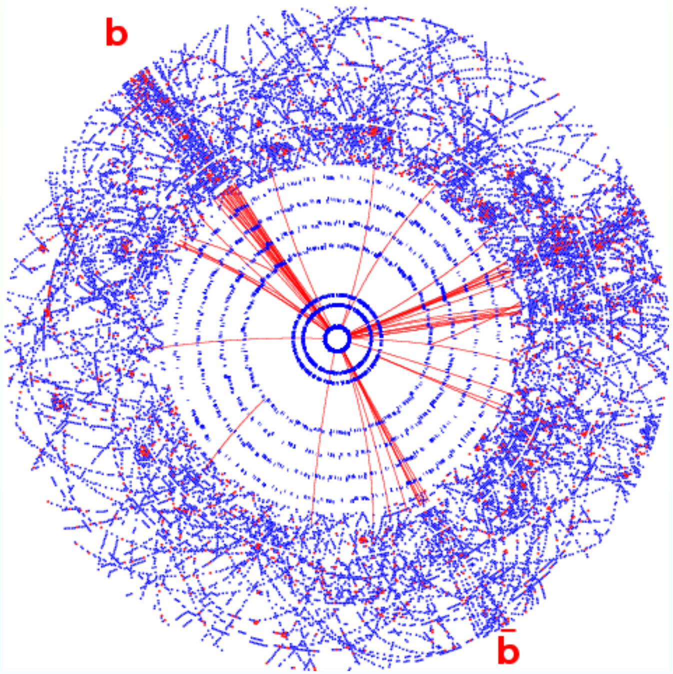
e^+e^- cleaner than LHC - precision

$e^+e^- \rightarrow HZ ; Z \rightarrow \mu\mu$

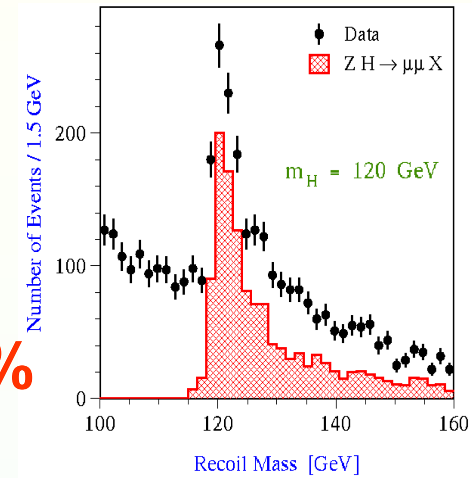
$pp \rightarrow H + X ; H \rightarrow bb$

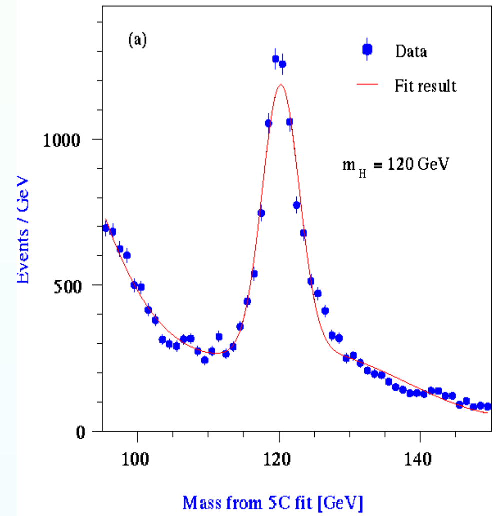




A LC is a Precision Instrument

- Clean initial state (e^+e^-)
  - Polarization, tunable $\sqrt{s}$ hard scattering
- Detailed study of the higgs sector
  - Mass 0.03% Couplings 1-3%
  - Spin & CP structure Total width 6%
  - Model-independent measurements
- Precision SUSY measurements
  - If it exists
  - Masses to 1% (if within reach)
  - SUSY space-time properties
- Precision top, W, TGC's etc
- New Physics ($W_L W_L$ scattering etc …)





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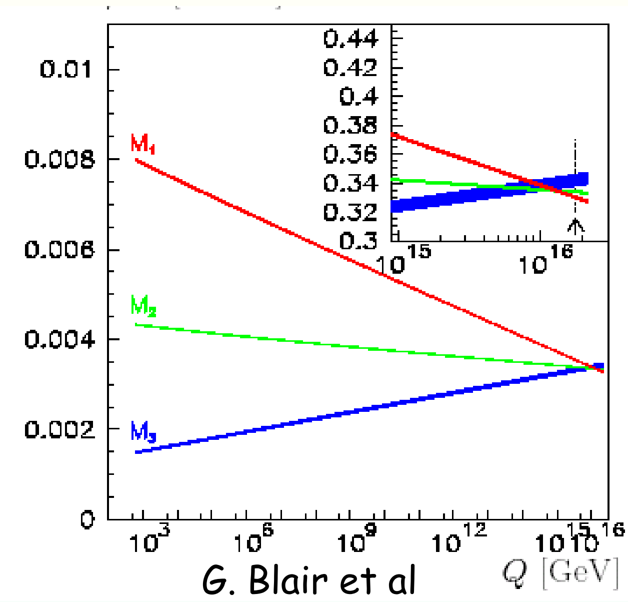
Physics goals

- **SUSY**
  - precision mass measurements



- **Dark Matter**
  - m_χ & couplings
    - Input to cosmology [$\Omega_{DM}h^2 \sim 3\%$]
      - Mismatch to WMAP/Planck – more DM
- **Quantum level consistency**
  - e.g. direct & indirect m_h

'WMAP'	7 %
LHC	~15 %
'Planck'	~2 %
LC	~3 %

F. Richard/SPS1a

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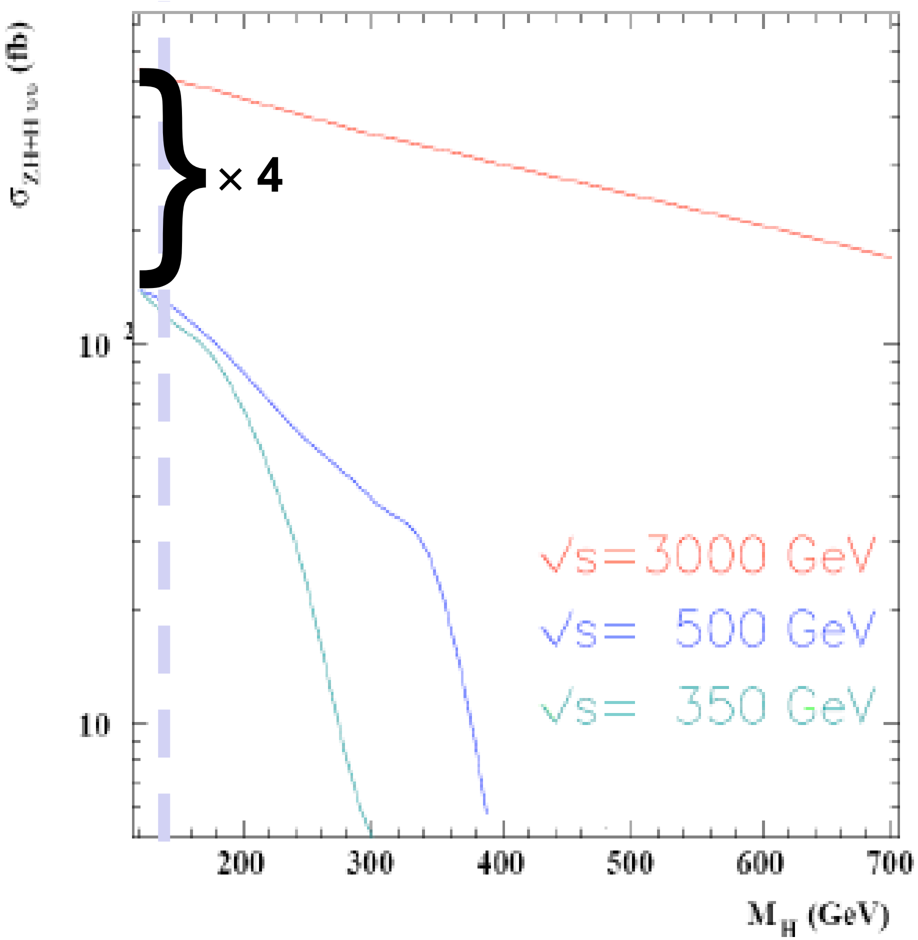
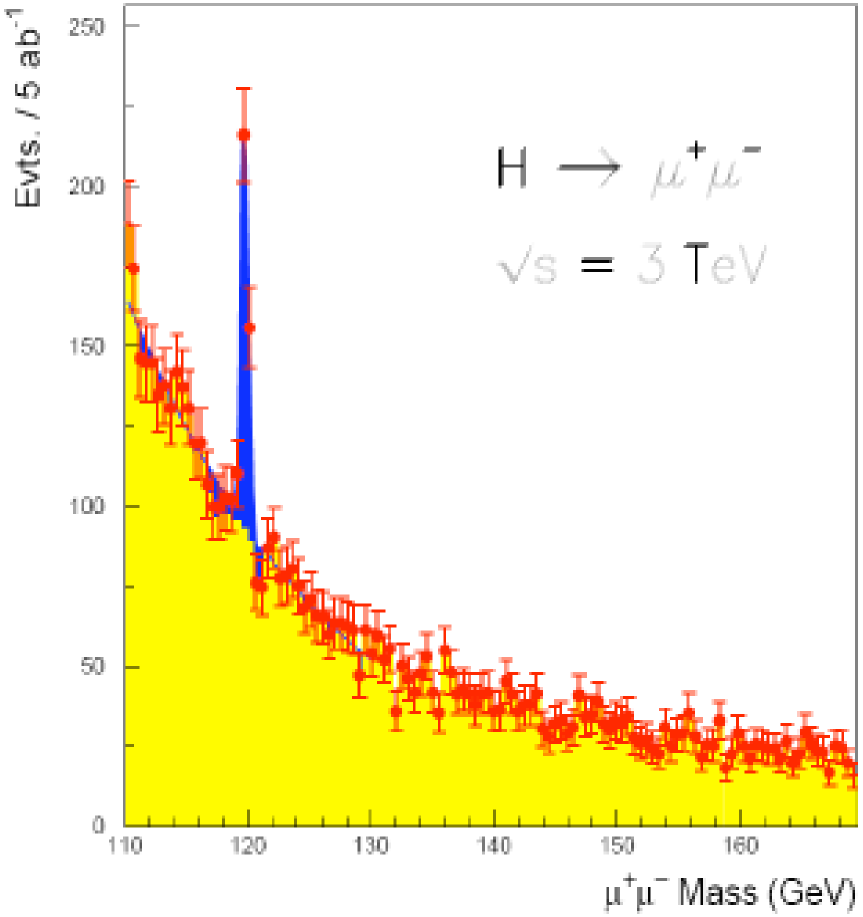
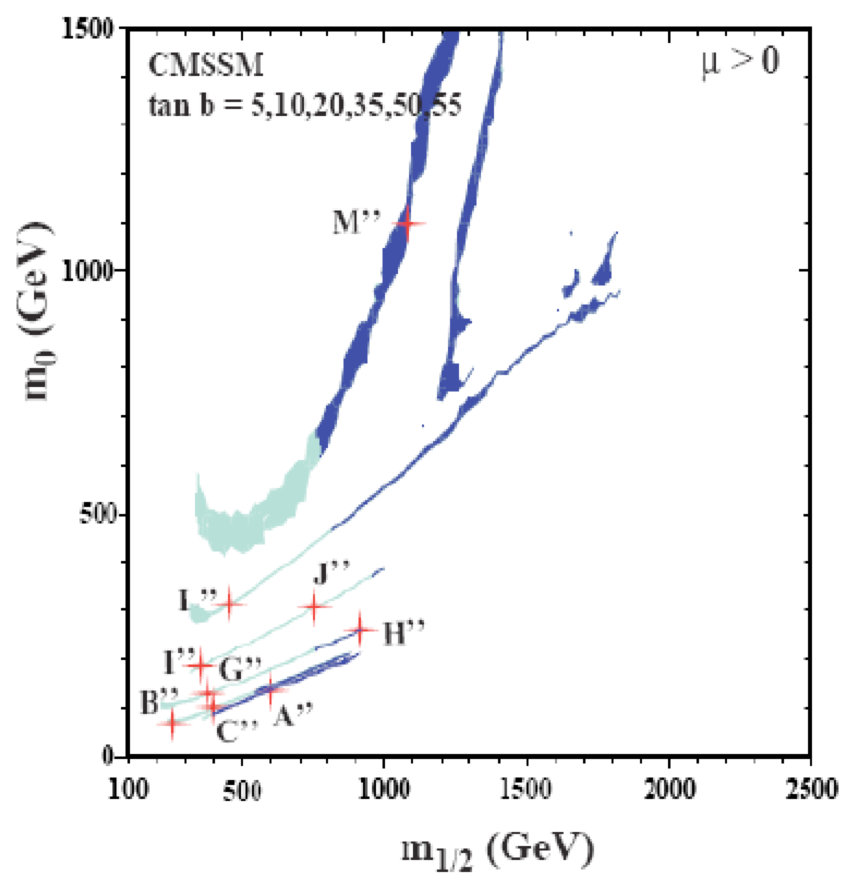
What Energy? Light Higgs (120 GeV)

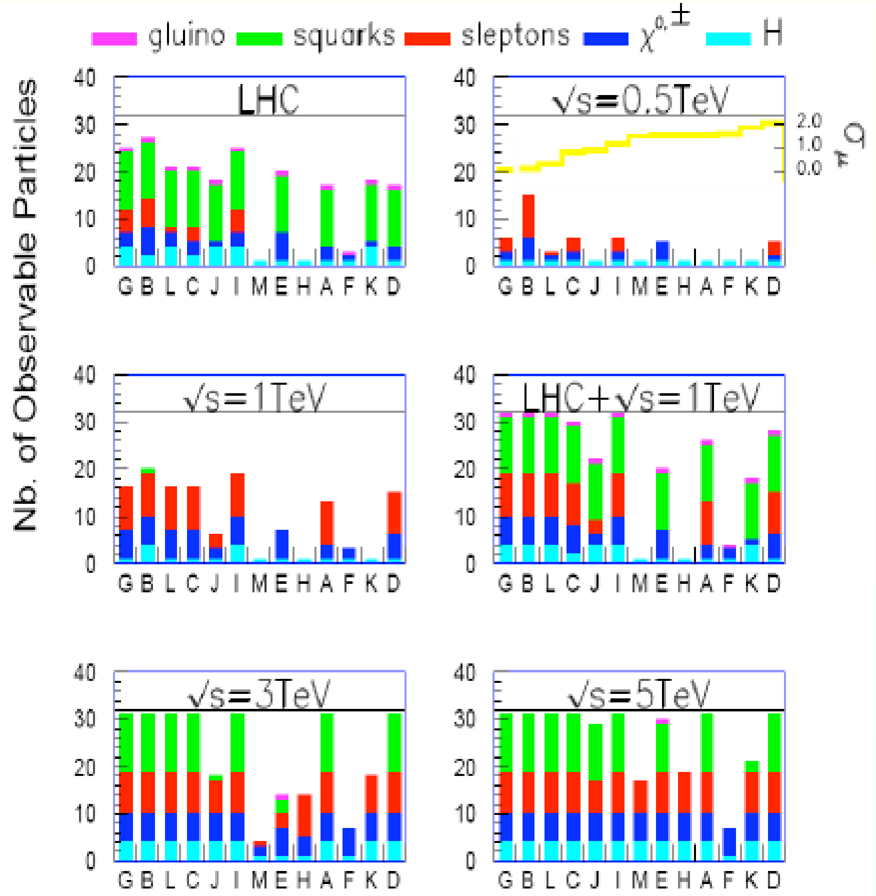




> 400k Higgs per year

Physics case: SUSY measurements





LC/LHC complementarity: precision measurements at ILC/CLIC

e.g. 1150 GeV smuon mass to O(1%)

Will a 0.5-1 TeV collider be enough?

De Roeck et al, hep-ph/0508198

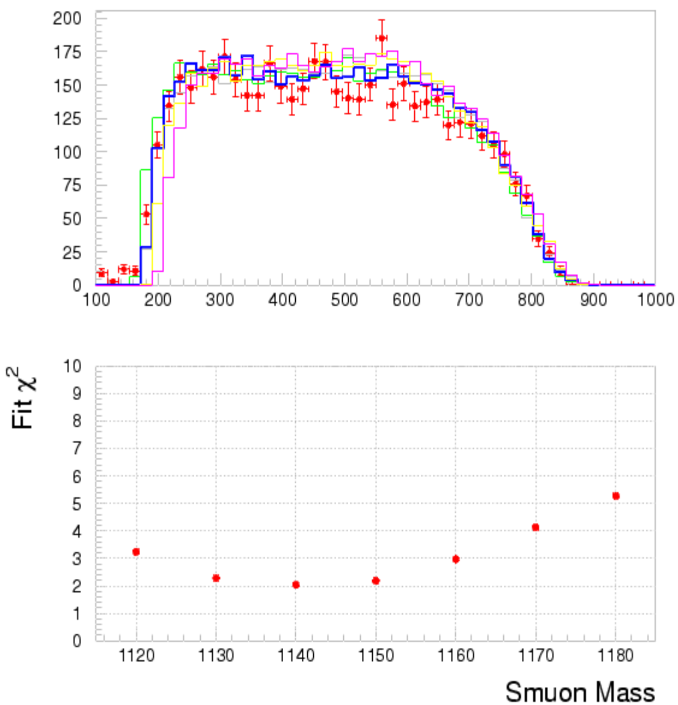
SUSY Mass Measurements

E.G. $m_{1/2} = 1500$ GeV, $m_0 = 420$ GeV, $\tan\beta = 20,\ A = 0$ GeV, $sign(\mu) > 0$ (mSUGRA) (point H)

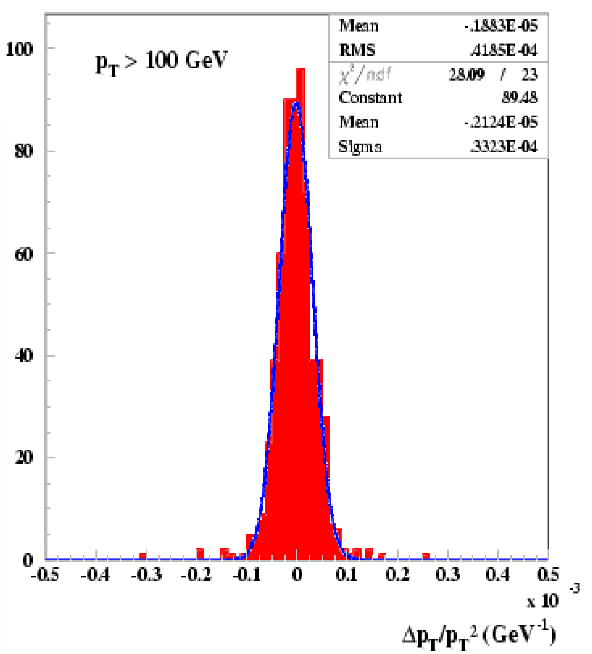
$\Rightarrow M_{\tilde{\mu}} = 1150$ GeV

Measure inclusive muon spectrum in $\tilde{\mu} \rightarrow \mu\chi^0$

$$\Rightarrow E_{max/min} = \frac{E_{beam}}{2}\left(1 - \frac{M^2_{\chi^0}}{M^2_{tilde\mu}}\right) \times \left(1 \pm \sqrt{1 - \frac{M^2_{\tilde{\mu}}}{E^2_{beam}}}\right)$$



Momentum resolution



$\delta p_t/p_t^2 \sim 10^{-4}$ GeV^{-1}

Mass measurements to O(1%)

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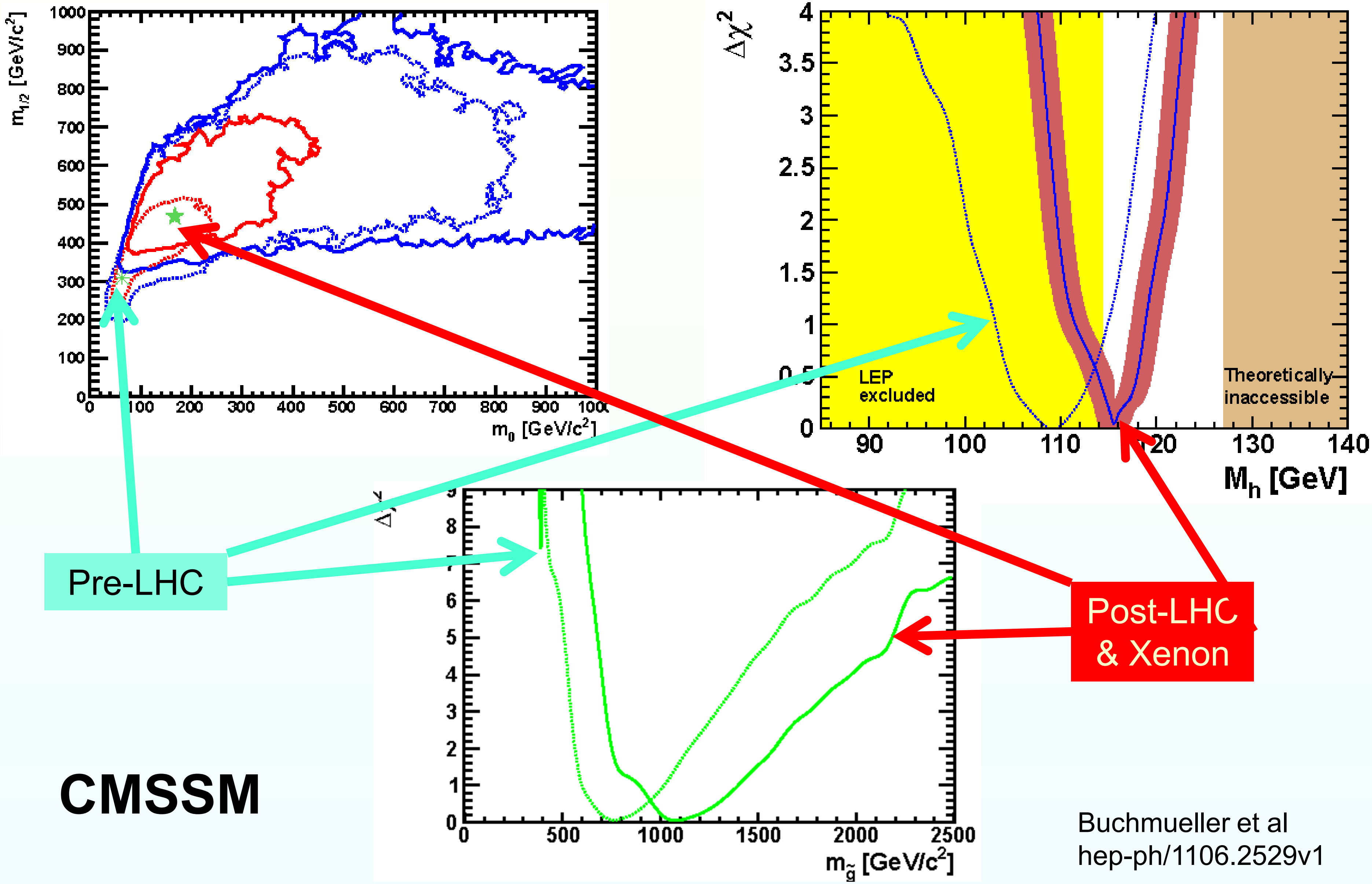
Implications of the LHC data 2010



CMSSM

Buchmueller et al
hep-ph/1106.2529v1

Latest parameters for 4 SUSY models

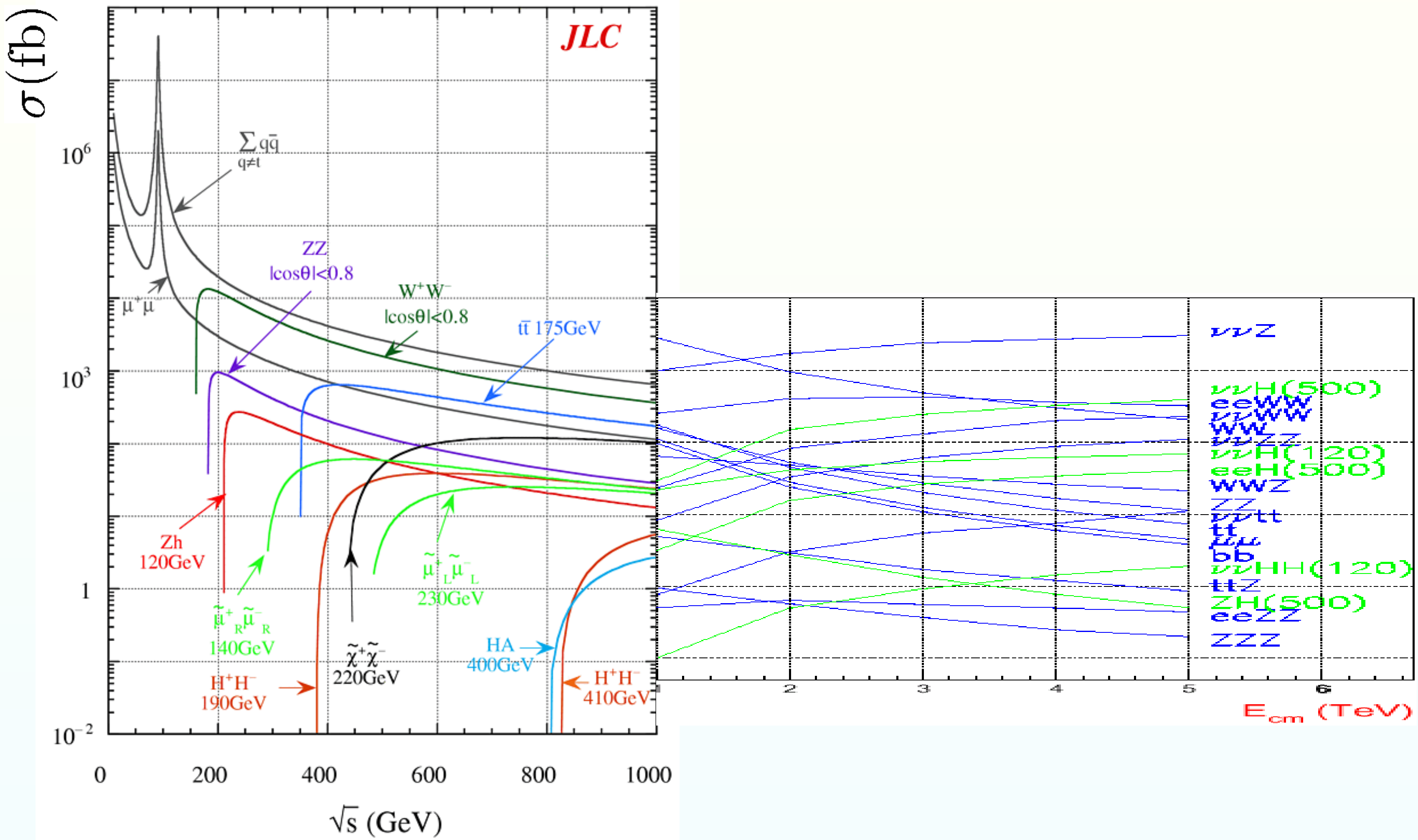
Model	Minimum χ^2/dof	Probability	$m_{1/2}$ (GeV)	m_0 (GeV)	A_0 (GeV)	$\tan\beta$	M_h (GeV) (no LEP)
CMSSM pre-LHC	22.5/19	26%	310^{+120}_{-50}	60^{+90}_{-10}	-60^{+410}_{-840}	10^{+10}_{-4}	108.6
post-2010-LHC	26.1/19	13%	470^{+140}_{-70}	170^{+330}_{-80}	-780^{+1410}_{-820}	22^{+27}_{-13}	115.7
post-Xenon (50 ± 14)	26.2/20	16%	470^{+140}_{-70}	170^{+330}_{-80}	-780^{+1410}_{-820}	22^{+27}_{-13}	115.7
NUHM1 pre-LHC	20.5/17	25%	240^{+150}_{-50}	100^{+70}_{-40}	920^{+360}_{-1260}	7^{+11}_{-2}	119.4
post-2010-LHC	24.1/18	15%	530^{+220}_{-90}	110^{+80}_{-20}	-370^{+1070}_{-1000}	27^{+24}_{-10}	117.9
post-Xenon (50 ± 14)	24.2/19	19%	530^{+220}_{-90}	110^{+80}_{-20}	-370^{+1070}_{-1000}	27^{+24}_{-10}	117.9
VCMSSM pre-LHC	22.6/20	31%	300^{+60}_{-40}	60^{+20}_{-10}	30^{+50}_{-30}	8^{+3}_{-1}	110.0
post-2010-LHC	27.9/20	11%	470^{+150}_{-80}	110^{+110}_{-30}	120^{+300}_{-190}	13^{+14}_{-8}	115.0
post-Xenon (50 ± 14)	28.1/21	14%	470^{+150}_{-80}	110^{+110}_{-30}	120^{+300}_{-190}	13^{+14}_{-8}	115.0
mSUGRA pre-LHC	29.4/19	6.0%	550^{+170}_{-90}	230^{+80}_{-40}	430^{+190}_{-90}	28^{+5}_{-2}	107.8
post-2010-LHC	30.2/20	6.7%	650^{+70}_{-130}	270^{+50}_{-50}	530^{+130}_{-130}	30^{+4}_{-3}	122.2
post-Xenon (50 ± 14)	30.3/21	8.6%	650^{+70}_{-130}	270^{+50}_{-50}	530^{+130}_{-130}	30^{+4}_{-3}	122.2

Table 1

Comparison of the best-fit points found in the pre-LHC analysis in the CMSSM, the NUHM1, the VCMSSM and the coannihilation region of mSUGRA [2, 6–8], and our latest results incorporating the CMS, ATLAS, LHCb, CDF, DØ and Xenon100 constraints. We also include the minimum value of χ^2 *and the fit probability in each scenario, as well as the predictions for* M_h *without imposing the LEP constraint.*

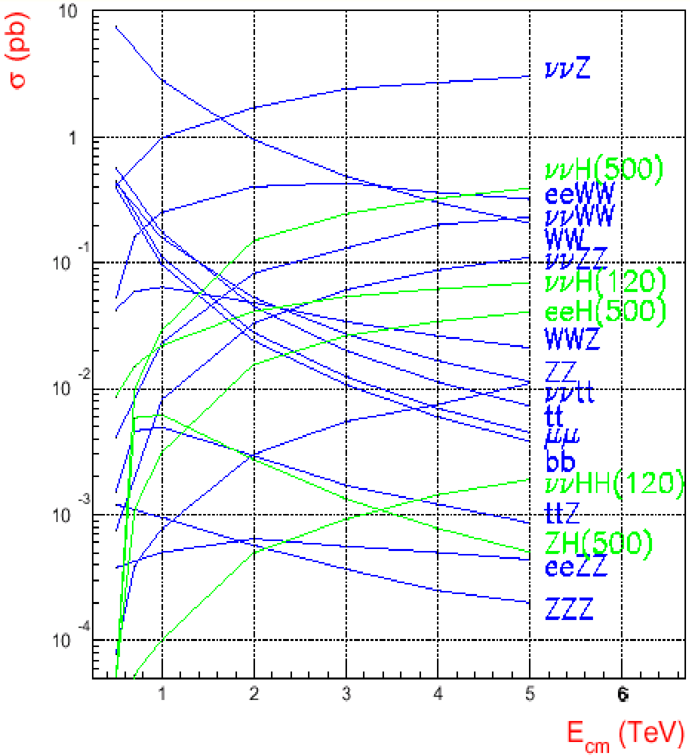
Buchmueller et al
hep-ph/1106.2529v1

ILC & CLIC



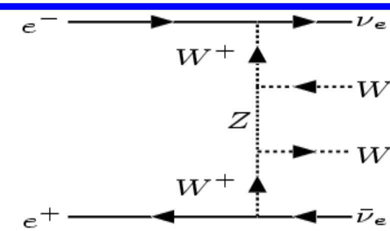
σ (fb)
JLC
$\sum_{q\neq t} q\bar{q}$
$\mu^+\mu^-$
ZZ
|cosθ|<0.8
W^+W^-
|cosθ|<0.8
$t\bar{t}$ 175GeV
Zh
120GeV
$\tilde{\mu}^+_R\tilde{\mu}^-_R$
140GeV
H^+H^-
190GeV
$\tilde{\chi}^+\tilde{\chi}^-$
220GeV
$\tilde{\mu}^+_L\tilde{\mu}^-_L$
230GeV
HA
400GeV
H^+H^-
410GeV
10^6
10^3
1
10^{-2}
0
200
400
600
800
1000
√s (GeV)
ννZ
ννH(500)
eeWW
ννWW
WW
ννZZ
ννH(120)
eeH(500)
WWZ
ZZ
ννtt
tt
μμ
bb
ννHH(120)
ttZ
ZH(500)
eeZZ
ZZZ
1
2
3
4
5
6
E_{cm} (TeV)

Cross Sections at CLIC



Event Rates/Year (1000 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

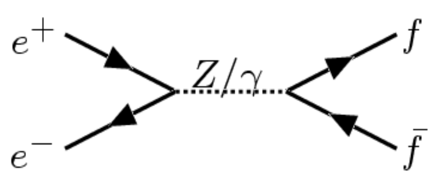
t-Channel Production



$\sigma \propto log(s)$

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

s-Channel Production



$\sigma \propto 1/s$

✧ Evolving from LEP-2 at $\sqrt{s} \leq 209$ GeV to CLIC $\sqrt{s} \simeq$ 3 TeV - 5 TeV implies reduction of σ(s-channel) cross-sections by $\simeq 15 - 25$ and σ(t-channel) $\simeq \sigma$(s-channel).

TECHNOLOGY CHALLENGES

Cold, warm or incandescent?

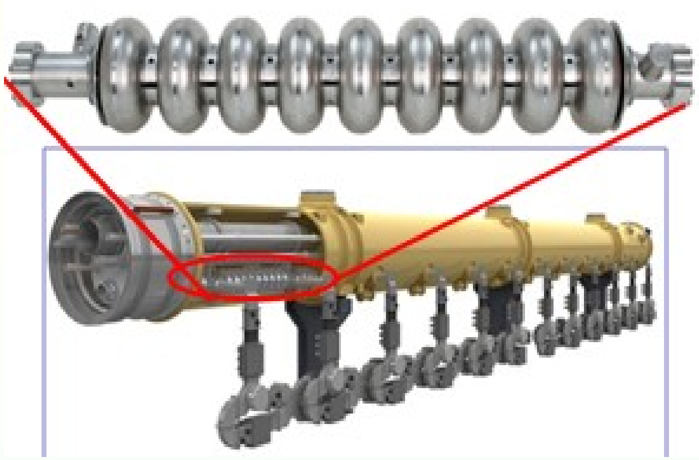
Three challenges

- **Energy**
  - Need to be well above LEP (200 GeV)
  - Preferably > 1TeV
    - Based on latest LHC results
- **Luminosity**
  - Falling s-channel cross-sections ($\propto 1/s$)
  - Increasing luminosity
    - Initial State Radiation broadens the peak
- **Reliability**
  - RF
  - Stability

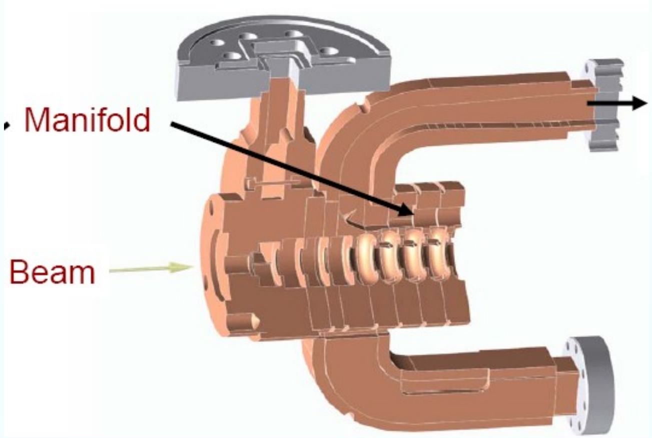
Energy

Conventional technologies

- **Superconducting cavities – ILC**
  - **35 MV/m**
    - **(limit ~55MV/m)**

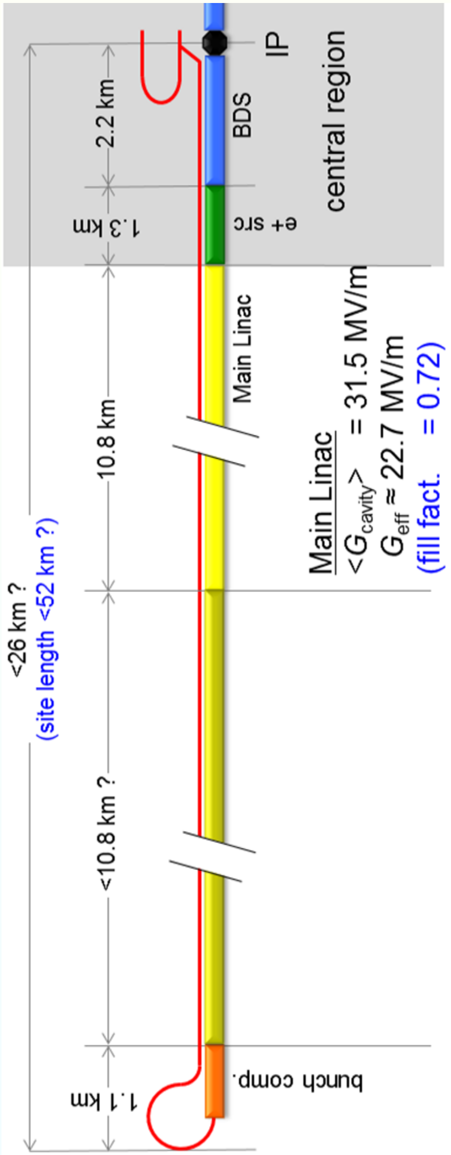


- **X-band**
  - **65MV/m**
    - **(loaded)**



- **Others (C-band, S-band)**

The ILC @ 1 TeV [new-ish]

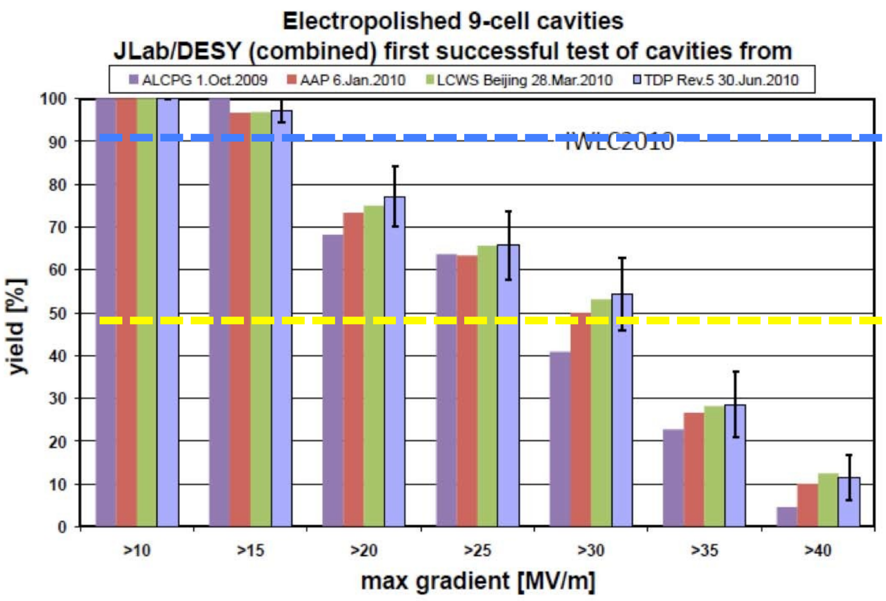


Collision rate	f_{rep}	4 Hz
Number of bunches	n_b	2625
Bunch population	N_-	2 $\times 10^{10}$
Bunch seperation	Δt_b	356 ns
Pulse current	I_{beam}	9.0 mA
RMS bunch length	σ_z	0.3 mm
RMS energy spread (e-, e+)	$\Delta p/p$	0.105, 0.038
Polarisation (e^-, e^+)	P_-	80, 22 %
Emittance (linac exit)	$\gamma\varepsilon_{x,y}$	10, 0.035 µm
IP beta function	$\beta_{x,y}$*	30, 0.3 mm
IP RMS beam size	$\sigma_{x,y}$*	554, 3.3 nm
Vertical disruption parameter	D_y	19.2
Luminosity	L	**2.70** $\times 10^{34}$ $cm^{-2}s^{-1}$
Fraction of luminosity in top 1%	$L_{0.01}/L$	63.5 %
Average energy loss	δE_{BS}	4.9 %
Number of pairs per bunch crossing	N_{pairs}	169
Total pair energy per bunch crossing	E_{pairs}	1084 TeV

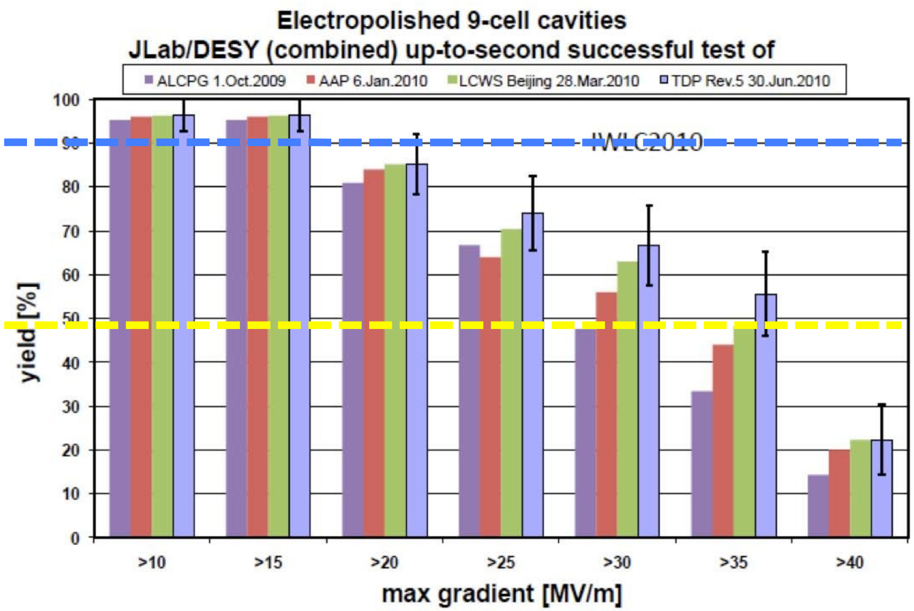
- **1 TeV, 2.7 × 10^{34} cm^2s^{-1}**
  - **Length <52km**
  - **Gradient 31.5 Mv/m (>50?)**
  - **AC power 352 MW**

Nick Walker, ALCPG11

Production Yield - Progress



1st pass



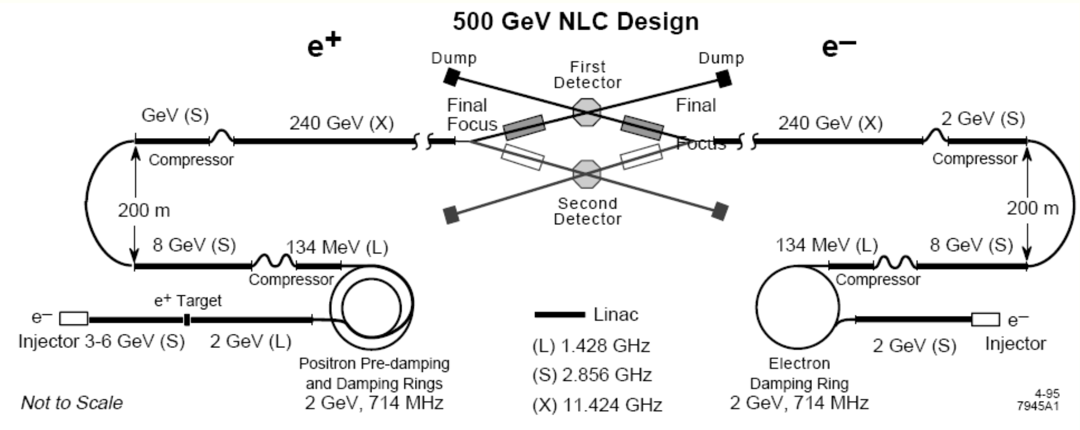
2st pass

Only contains: 2 vendors + 2 infrastructure (DESY, JLAB)

Next update:
Additional Japan vendor + 2 infrastructure (KEK, FNAL/ANL)

Nick Walker, ALCPG11

An example of an X-band design



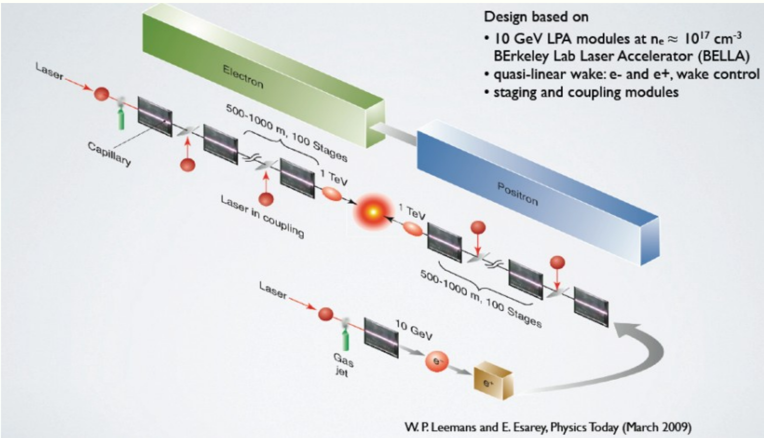
- **1 TeV, 1.45 × 10^{34} cm^{2}s^{-1}**
  - **25.5km**
  - **9456 klystrons**
  - **Klystron power 72 MW**
  - **AC power 202 MW**

CM Energy [TeV]	0.5	1.0	1.5
Luminosity [10^{33}]	7.1	14.5	16.1
Rep. Rate [Hz]	180	120	120
Bunch Charge [10^{10}]	0.7	1.1	1.1
Bunches/RF Pulse	90	75	75
Bunch Sep. [ns]	1.4	1.4	1.4
$\gamma\epsilon_x/\gamma\epsilon_y$ IP [10^{-8} m-rad]	500/5	500/5	500/5
β_x/β_y IP [mm]	10/0.1	25/0.1	37/0.15
σ_x/σ_y IP [nm]	320/3.2	360/2.3	360/2.3
σ_z IP [μm]	100	100	100
Upsilon	0.09	0.27	0.41
Pinch Enhancement	1.3	1.4	1.5
Beamstrahlung δ_B [%]	2.3	7	9
# Photons per e^-/e^+	0.8	1.1	1.1
Loaded Gradient [MV/m]	37	63	63
Active Linac Length [km]	14.2	17.0	25.5
Total Site Length [km]	20.0	25.5	36.2
# of Klystrons	3940	9456	7092
Klyst. Peak Pwr. [MW]	50	72	76
Pulse Comp. Gain	3.6	3.6	6.8
Power/Beam [MW]	4.2	7.9	11.9
AC Power [MW]	103	202	240

Raubenheimer et al, PAC 95

Incandescent – plasma acceleration

- **Laser-driven plasma**

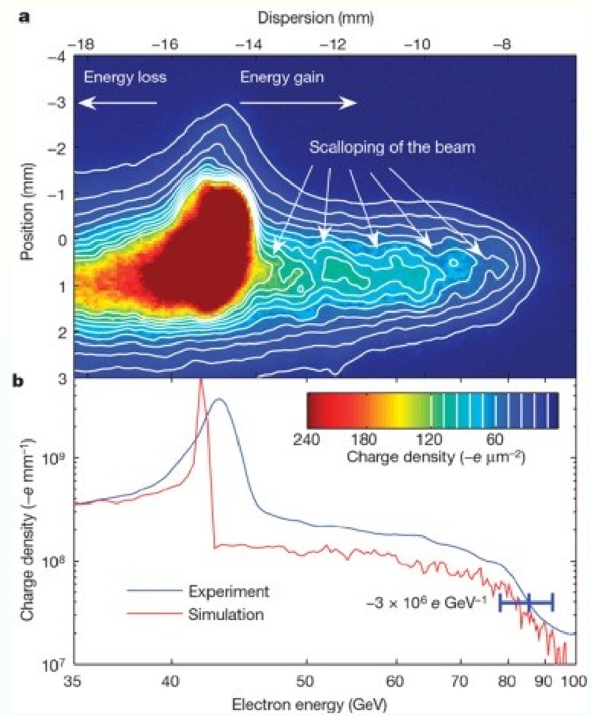


Achievement (2008)

Acceleration results	Gas cell
Peak energies	220 MeV
Energy fluctuations	± 2.5 %
Energy spread	> 2 % RMS
Peak charge	~ 10 pC
Charge fluctuations	±16 %
Divergence	0.9 mrad RMS
Pointing stability	1.4 mrad RMS
Injection	~ 100 %

In 15mm of plasma

- **Beam driven plasma**



- **42 GeV electron beam**
- **0.85m plasma**
- **42 GeV energy gain**

Nature 445, 741-744 (2007)

Luminosity

Luminosity

Efficiency

Beamstrahlung parameter

$$\delta \propto E_{CM} \frac{N^2}{\sigma_z \sigma_x^2}$$

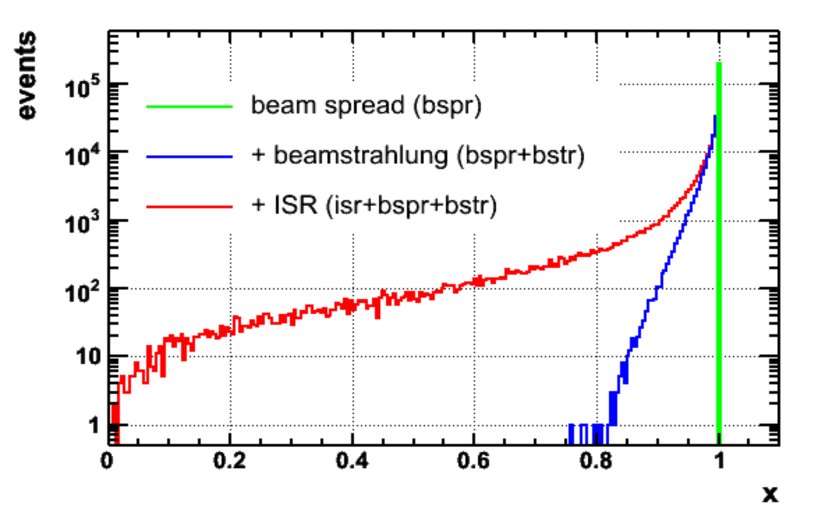
$$L = \frac{\eta P_{\text{electrical}}}{E_{CM}} \sqrt{\frac{\delta}{\varepsilon_{n,y}}} H_D$$

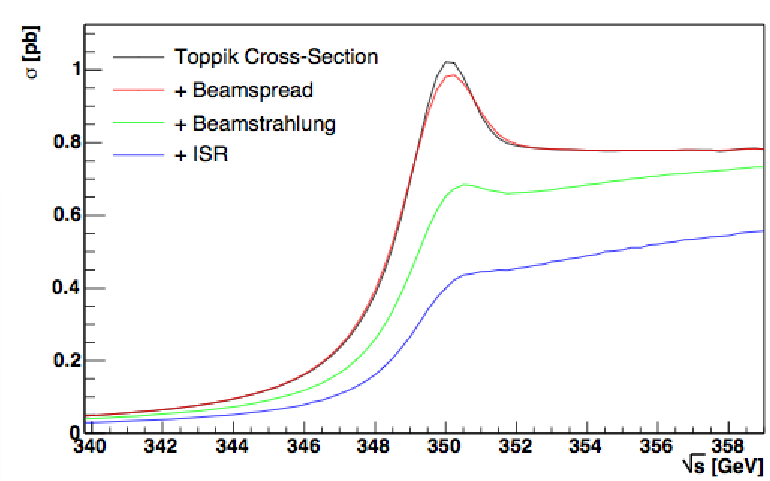
Disruption parameter

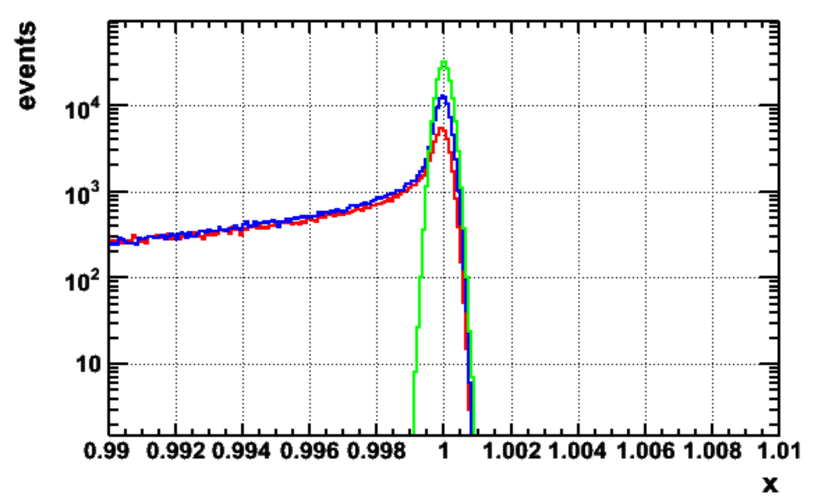
Trade-off between
- Luminosity
- beam energy precision (beamstrahlung δ)
- backgrounds (related to H_D)
- running cost

After Blair

ILC energy spectrum



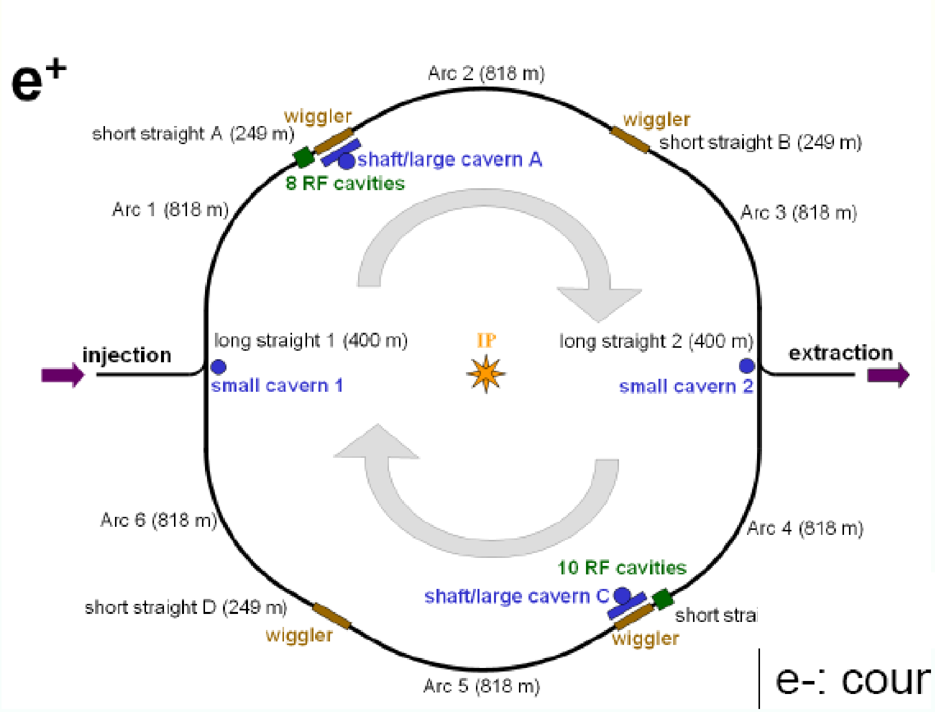


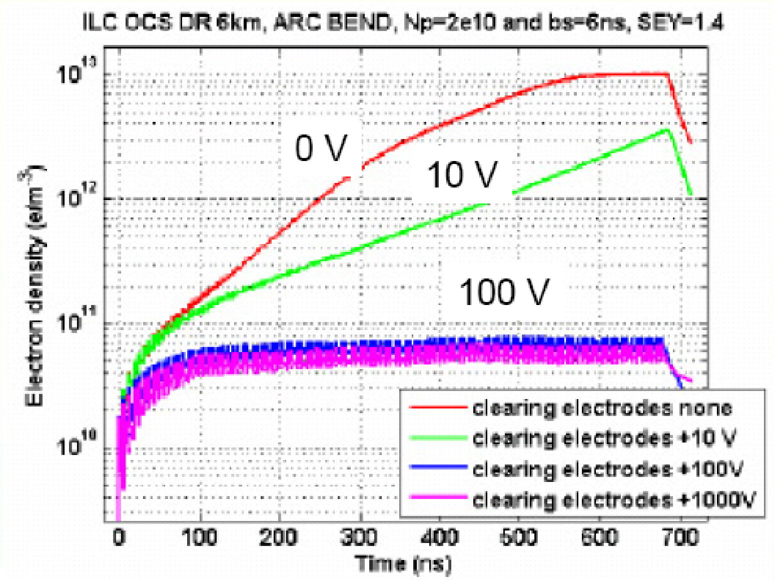


Need for:

- Energy measurement accuracy 10^{-4}
- Stability and ease of operation
- Minimal impact on physics data taking

DR Challenges





Electron cloud: suppression with clearing electrodes?

- Fast ion effects in electron DR:
  feedback, vacuum design (1nTorr), train gaps?
- Long-range wake fields can drive multi-bunch instabilities,
- Short-range wake fields can drive single-bunch instabilities
- Requires: Fast kicker: 5ns rise time, 30 ns fall time…
  (one train of 2625×369ns →290 km !)

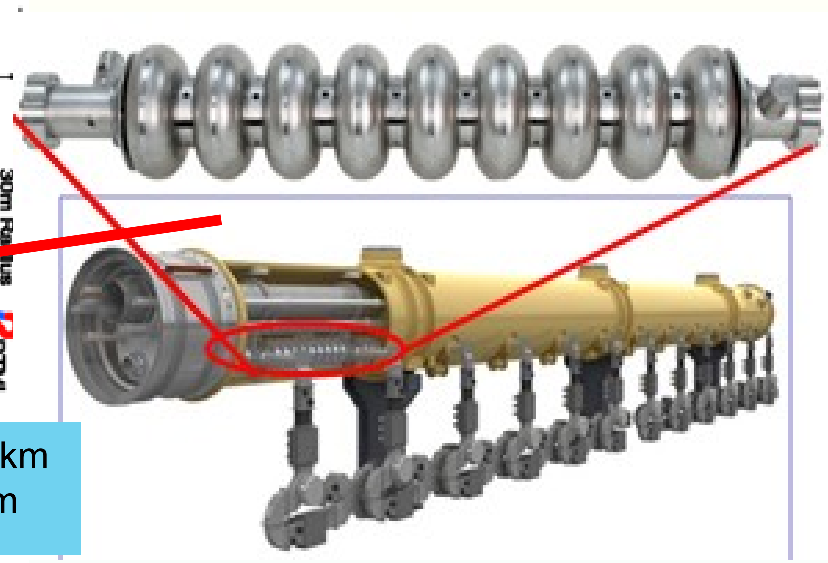
"The DR have more accelerator physics than the rest of the accelerator…"

After Blair

Reliability

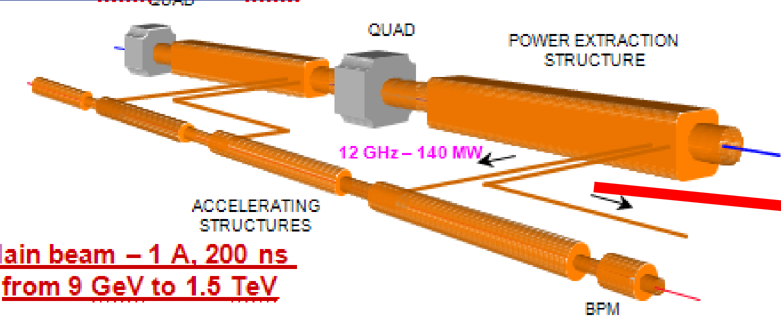
Linear Collider layouts

http://www.linearcollider.org/cms   http://clic-study.web.cern.ch/CLIC-Study/

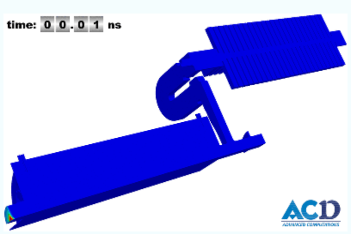


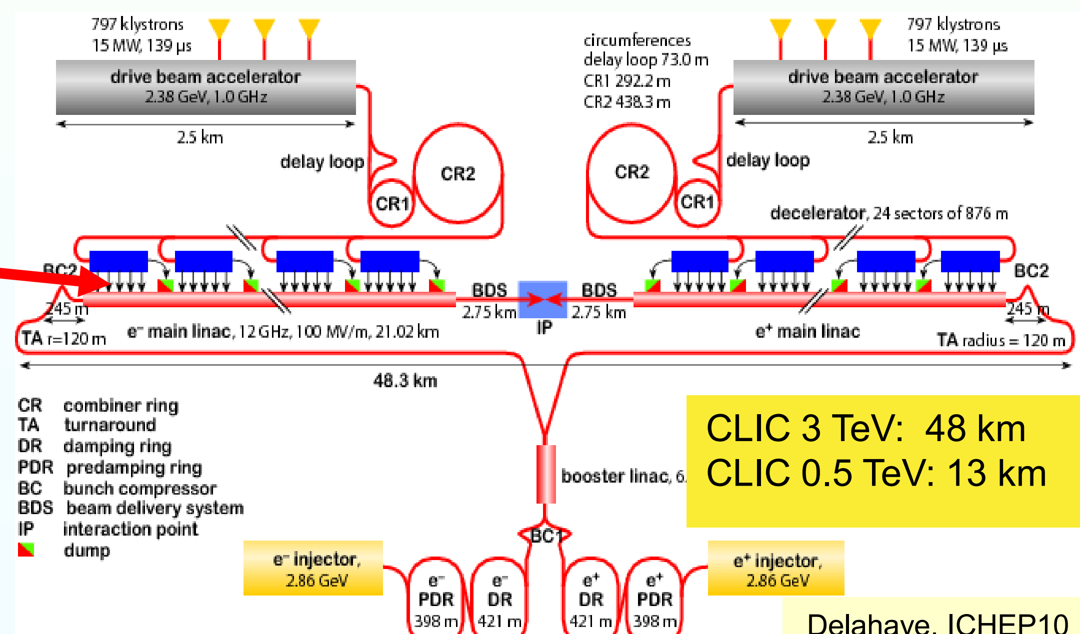
ILC 0.5 TeV – 30 km
ILC 1 TeV – 50 km

Drive beam - 95 A, 300 ns
from 2.4 GeV to 240 MeV



Main beam – 1 A, 200 ns
from 9 GeV to 1.5 TeV



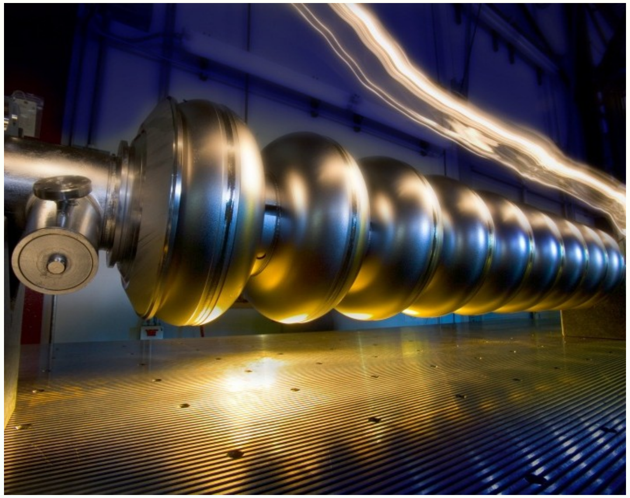


CLIC 3 TeV: 48 km
CLIC 0.5 TeV: 13 km

Delahaye, ICHEP10

Today: ILC & CLIC

ILC



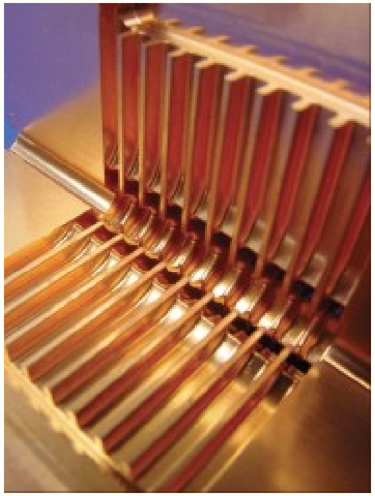
Based on SC RF Cavities

Gradient: 32 MV/m

Energy 500 GeV (upgradable to 1 TeV)

Detector studies mostly 500 GeV

CLIC



Based on 2 beam acceleration scheme

Gradient: 100 MV/m

Energy 3 TeV (staging likely)

Detector studies mostly 3 TeV

Renewed impetus on CERN Compact Linear Collider:

- **CLIC CDR due late Summer 2011: Accelerator + Detector/Physics**
- **could be the long term future of CERN**
- **but very challenging accelerator (R&D at least 5 years behind ILC)**
- **also very challenging detector environment**

COMPACT LINEAR COLLIDER
CLIC

What is it?

The CLIC Collaboration
4 institutes, 21 countries & growing

Delahaye

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)
Gazi Universities (Turkey)

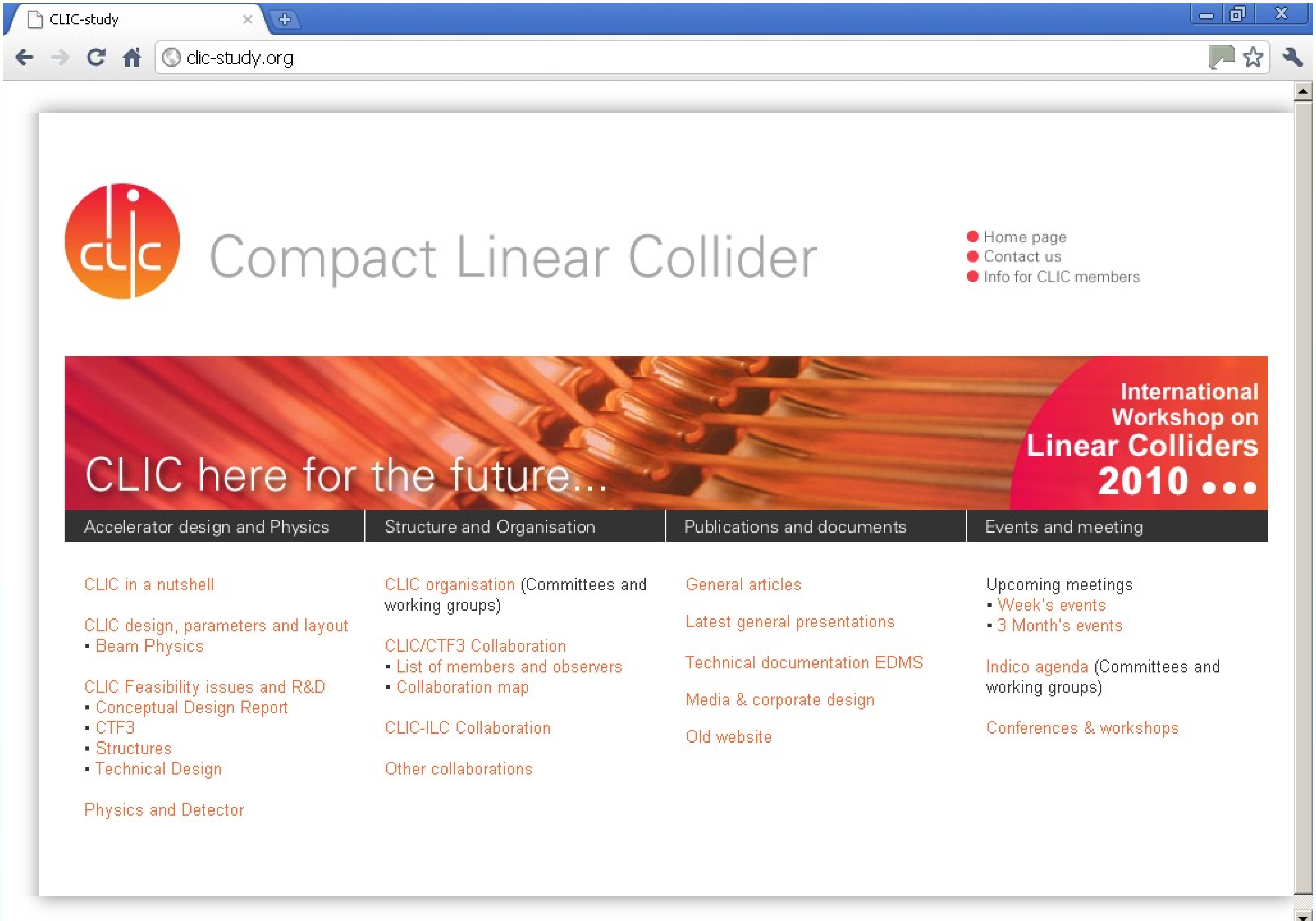
Fermilab

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)
NIKHEF/Amsterdam (Netherland)
NCP (Pakistan)
North-West. Univ. Illinois (USA)
Patras University (Greece)

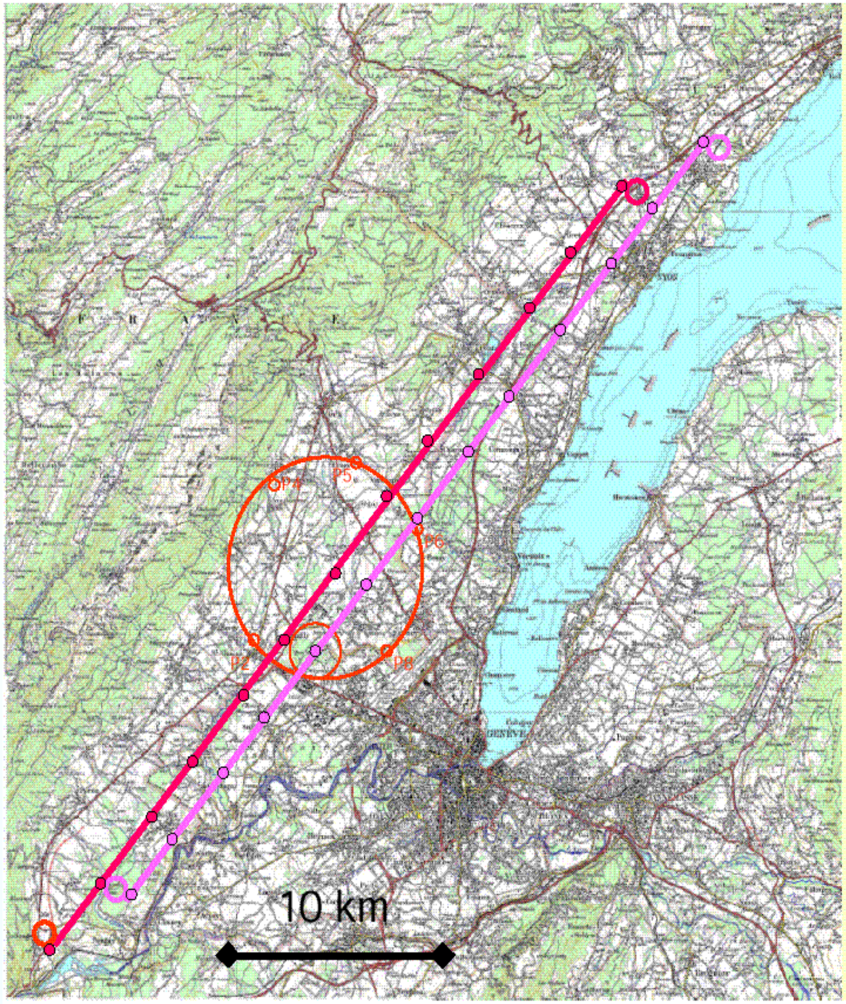
Polytech. University of Catalonia (Spain)
PSI (Switzerland)
RAL (UK)
RRCAT / Indore (India)
SLAC (USA)
Thrace University (Greece)
Tsinghua University (China)
University of Oslo (Norway)
Uppsala University (Sweden)
UCSC SCIPP (USA)

CLIC website: http://clic-study.org/

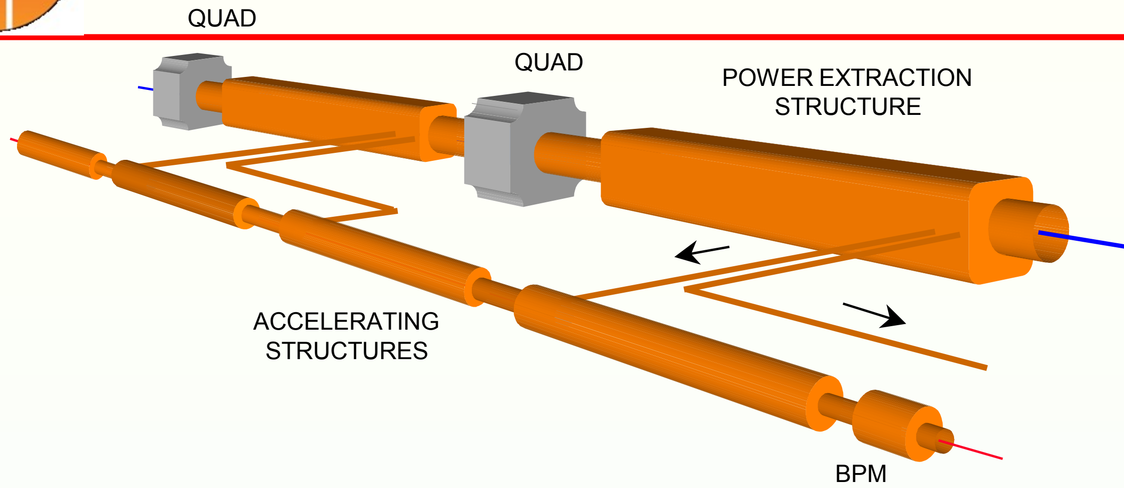


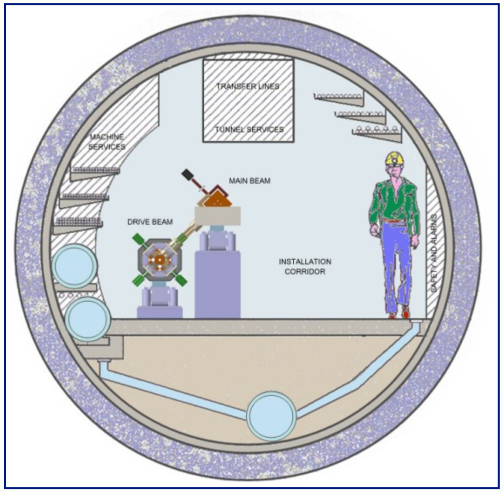
Building CLIC at CERN?

- **40 km continuous available**
- **Good geology**
- **Parallel to Jura & lake**
  - **also ILC?**

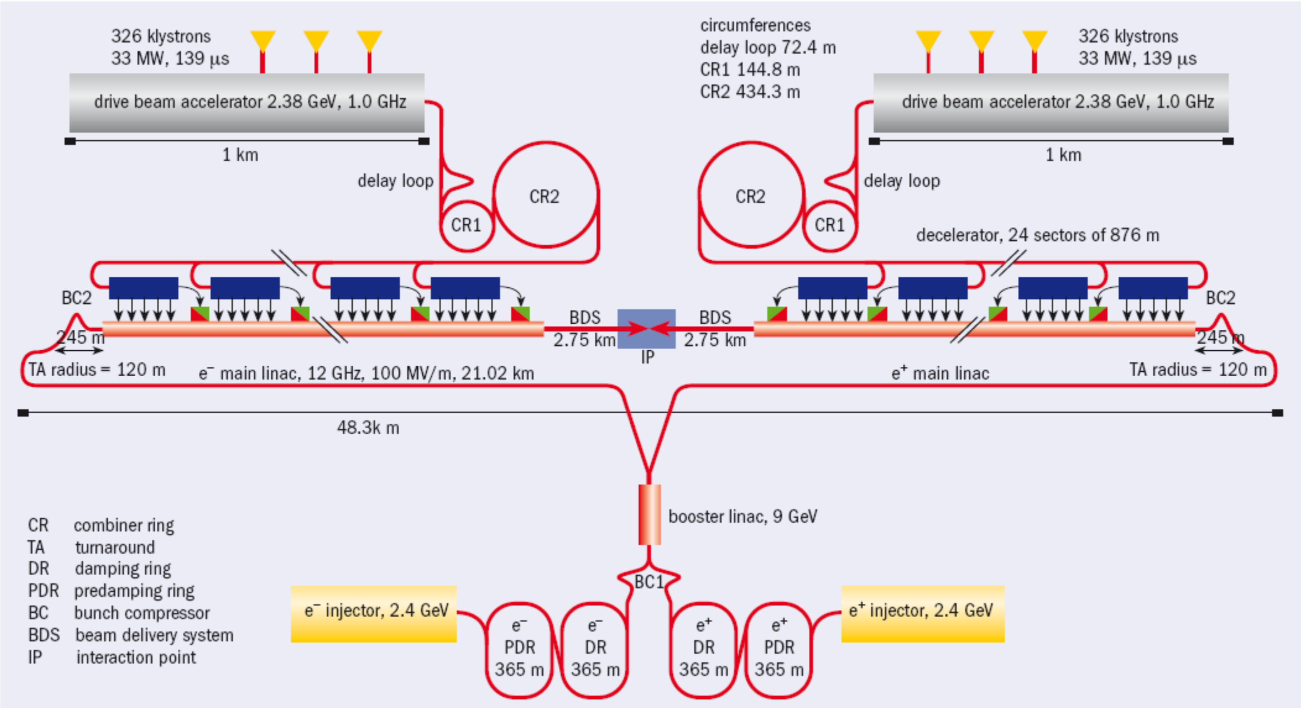


it won't be easy…





Drive Beam Generation Complex



Main Beam Generation Complex

COMPACT LINEAR COLLIDER
CLIC

Status

Main CLIC parameters

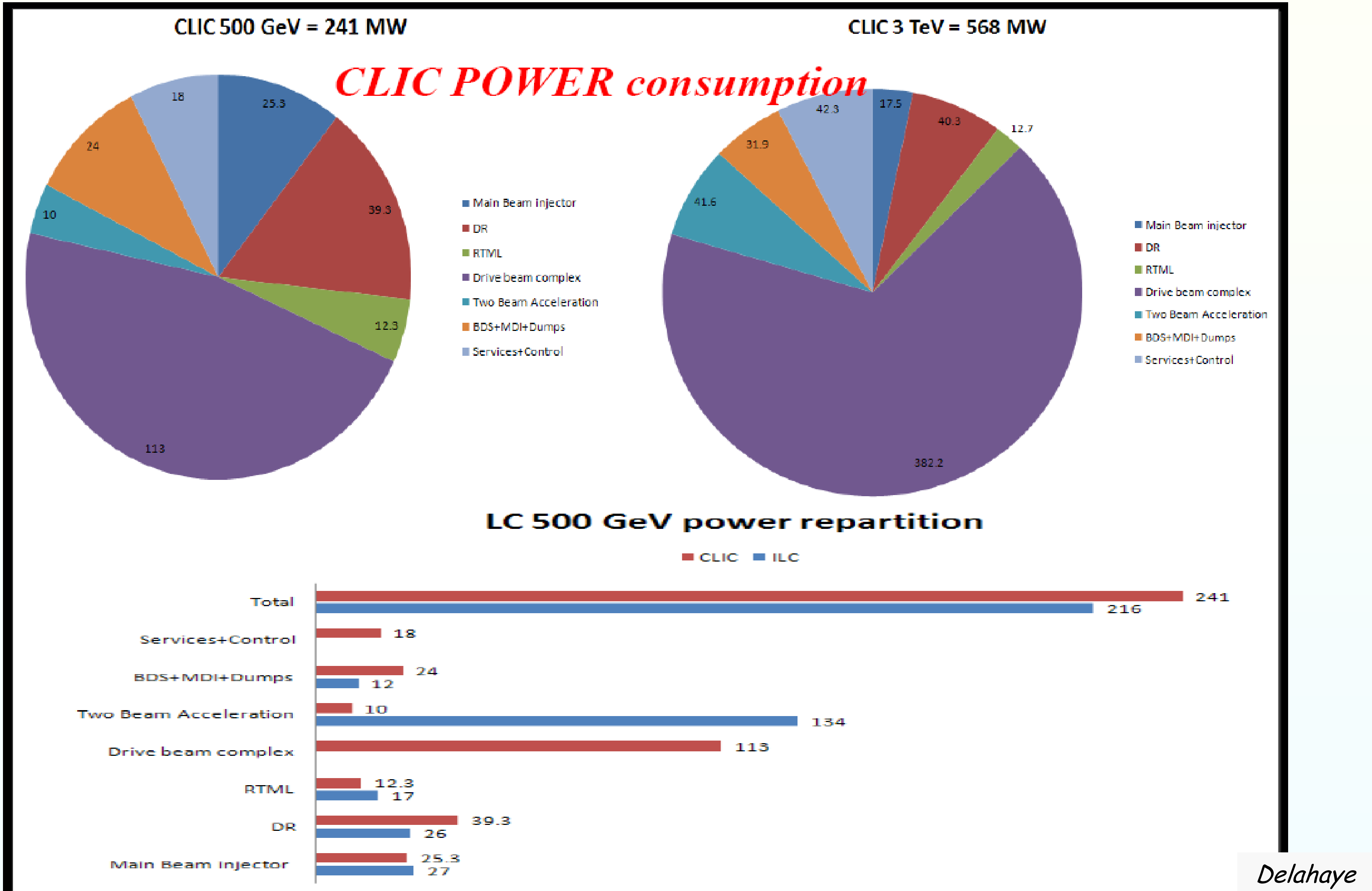
Centre-of-mass energy	CLIC 500 GeV		CLIC 3 TeV	
Beam parameters	Relaxed	Nominal	Relaxed	Nominal
Accelerating structure	502		G	
Total (Peak 1%) luminosity	$8.8(5.8)\cdot10^{33}$	$2.3(1.4)\cdot10^{34}$	$7.3(3.5)\cdot10^{33}$	$5.9(2.0)\cdot10^{34}$
Repetition rate (Hz)	50			
Loaded accel. gradient MV/m	80		100	
Main linac RF frequency GHz	12			
Bunch charge10^9	6.8		3.72	
Bunch separation (ns)	0.5			
Beam pulse duration (ns)	177		156	
Beam power/beam MWatts	4.9		14	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	7.5/40	4.8/25	7.5/40	0.66/20
Hor/Vert FF focusing (mm)	4/0.4	4 / 0.1	4/0.4	4 / 0.1
Hor./vert. IP beam size (nm)	248 / 5.7	202 / 2.3	101/3.3	40 / 1
Hadronic events/crossing at IP	0.07	0.19	0.28	2.7
Coherent pairs at IP	10	100	$2.5\ 10^7$	$3.8\ 10^8$
BDS length (km)	1.87		2.75	
Total site length km	13.0		48.3	
Wall plug to beam transfert eff	7.5%		6.8%	
Total power consumption MW	129.4		415	

CLIC Feasibility status

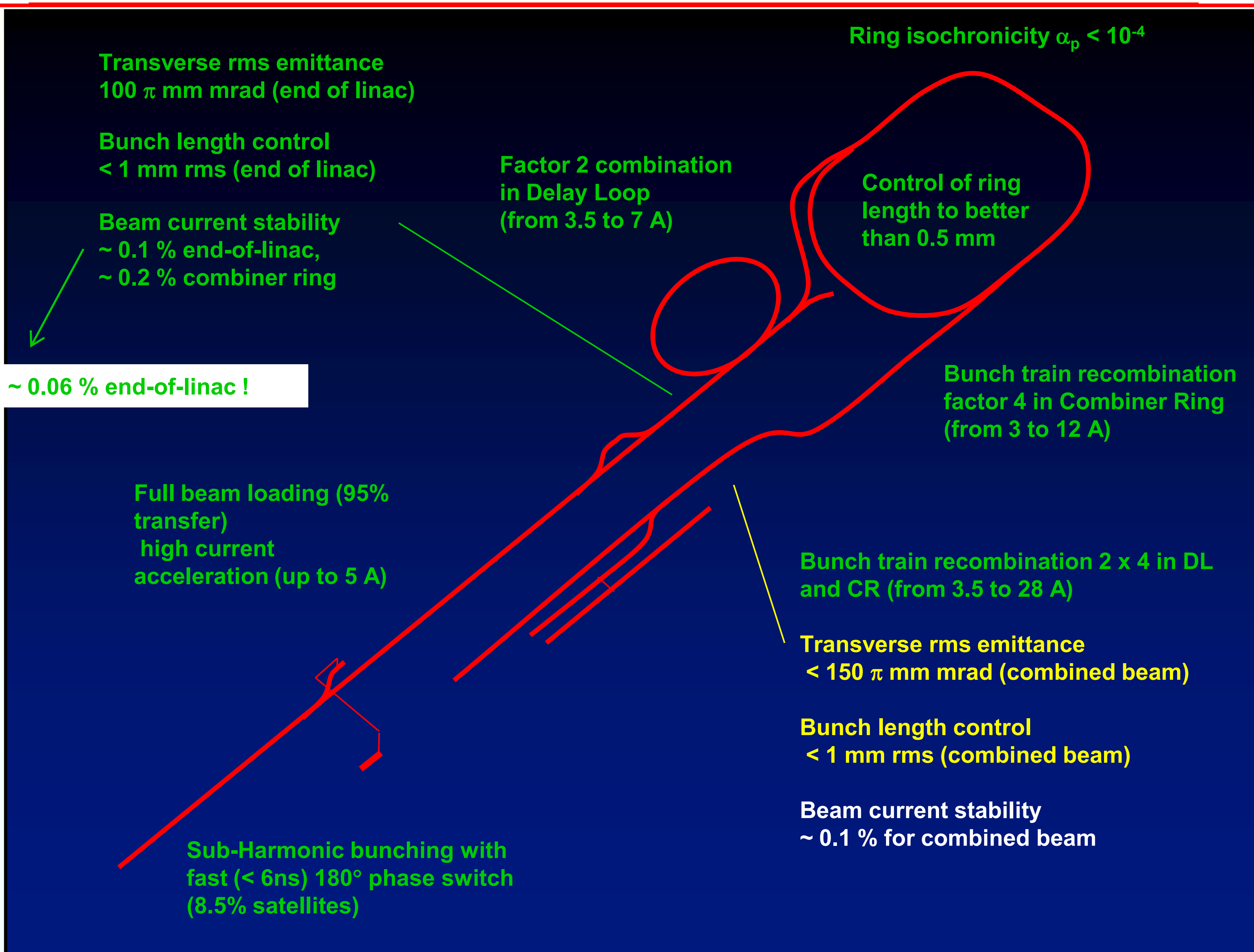
Delahaye

System	Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibilit
Two Beam Acceleration	Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓
		Freq&Current multipl	-	2*3*4	2*4	CTF3	✓
		Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓
		Combined pulse length (12 GHz)	ns	240	140	CTF3	✓
		Intensity stability	1.E-03	0.75	< 0.6	CTF3	2011
		Drive beam linac RF phase	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓
	Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓
		PETS Pulse length	ns	170	>170	TBTS/SLAC	✓
		PETS Breakdown rate	/m	< 1·10-7	≤ 2.4 10-7	TBTS/SLAC	✓
		PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011
		Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012
		RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012
	Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	✓
		Structure Flat Top Pulse length	ns	170	170		✓
		Structure Breakdown rate	/m	< 3·10-7	5·10-5(D)		2011
		Rf to beam transfer efficiency	%	27	15		2011
	Two Beam Acceleration	Power producton and probe beam acceleration in Two beam	MV/m - ns	100 - 170	106 - <130	TBTS	2011
		Drive to main beam timing	psec	0.05	-	CTF3	2012
		Main to main beam timing	psec	0.07	-	XFEL	2012
Ultra low beam emittance & sizes	Ultra low Emittances & Beam Sizes	Norm. Emitttance generation	H/V (nm)	500/5	3000/12	ATF, NSLS/SLS	✓
		Emittance preservation: Blow-up	H/V (nm)	160/15	160/15	+ simulation	2011-12
		Strong focusing: β*eff /L* from IP	mm/m	0.1/3.5	2.0/1.0	ATF2	2011-12
		Nanometer beam sizes at IP	H/V (nm)	40/1	70 300	FFTB ATF2+simul.	2011-12
	Alignment	Main Linac components	µm	10	10 (princ.)	Align. & Mod. Test Bench	2011
		Final-Doublet tolerance	µm	10			
	Vertical stabilisation	Quad Main Linac	nm>1 Hz	1.5	0.13 (principle)	Stabilisation Test Bench	2011-12
		Final Doublet (with feedbacks)	nm>4 Hz	0.2			
Operation and Machine Protection System (MPS)		72MW@2.4GeV				CTF3 simulations	2011-12
		13MW@1.5TeV					

CLIC Power Consumption

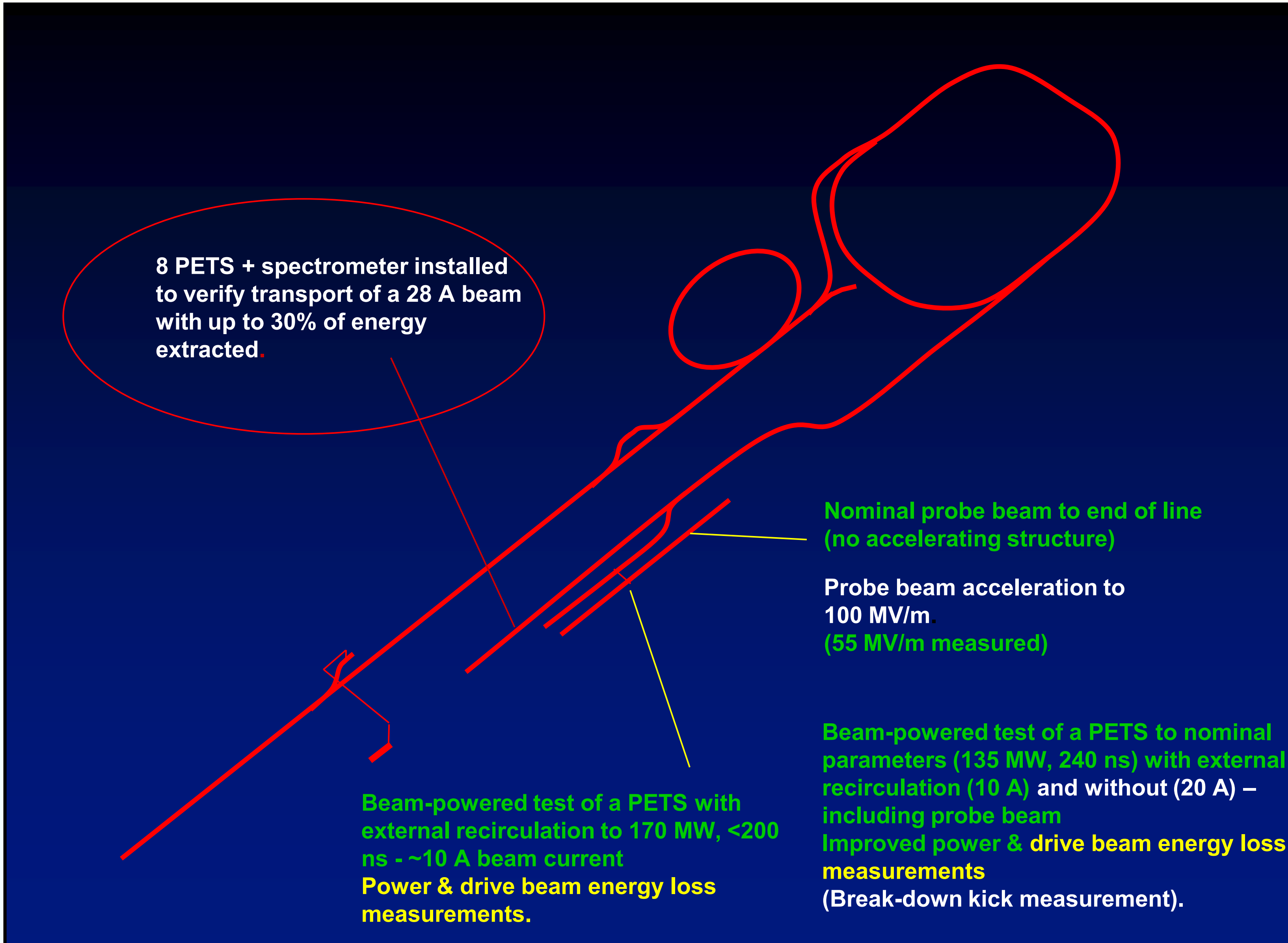


Drive Beam Generation



Corsini

CTF3 Achievements



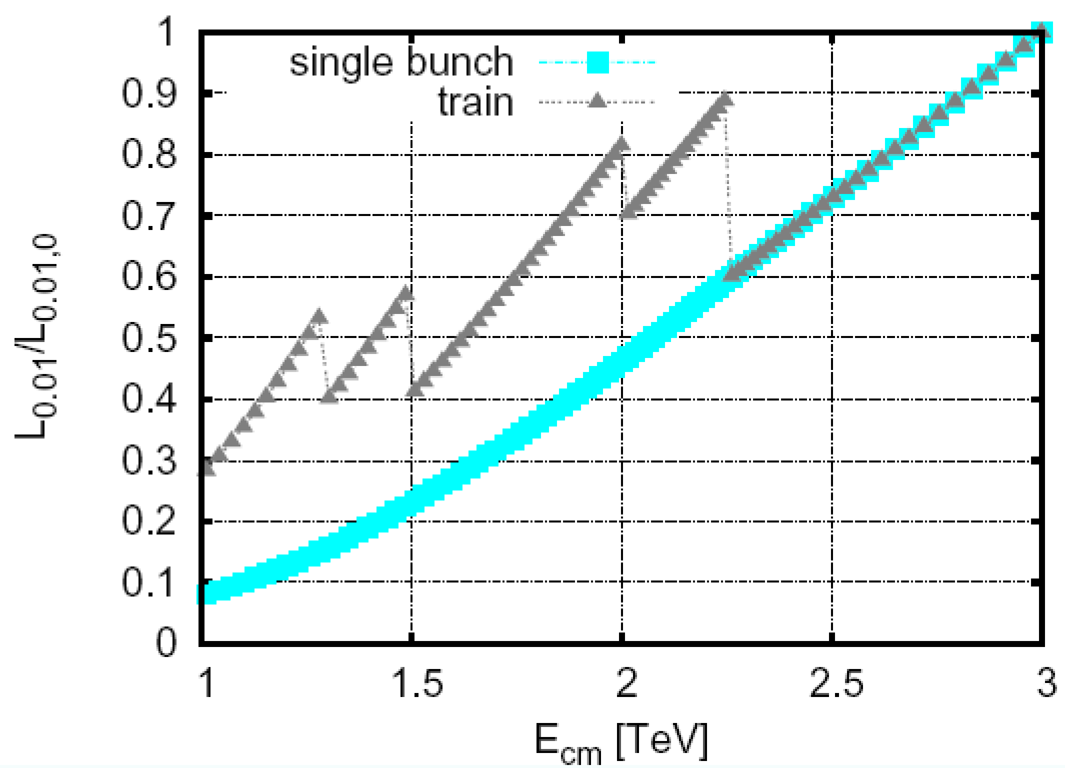
Corsini

Progress-1: Energy scanning

- **The issue**
  - **Small (10%) scans can always be done**
    - **Tune magnets, detune RF**
  - **Optimise the machine for one energy**
    - **Running at much lower (or higher) energy**
      - **Compromised luminosity**
      - **Needs a machine reconfiguration**
      - **Cannot be done quickly (within a few hours)**
        - » **Can it be done at all?**

Progress-1: Energy scanning-2

- **Compensate partially for loss of (useful) luminosity from *decreasing* the RF gradient by *increasing* the pulse length**

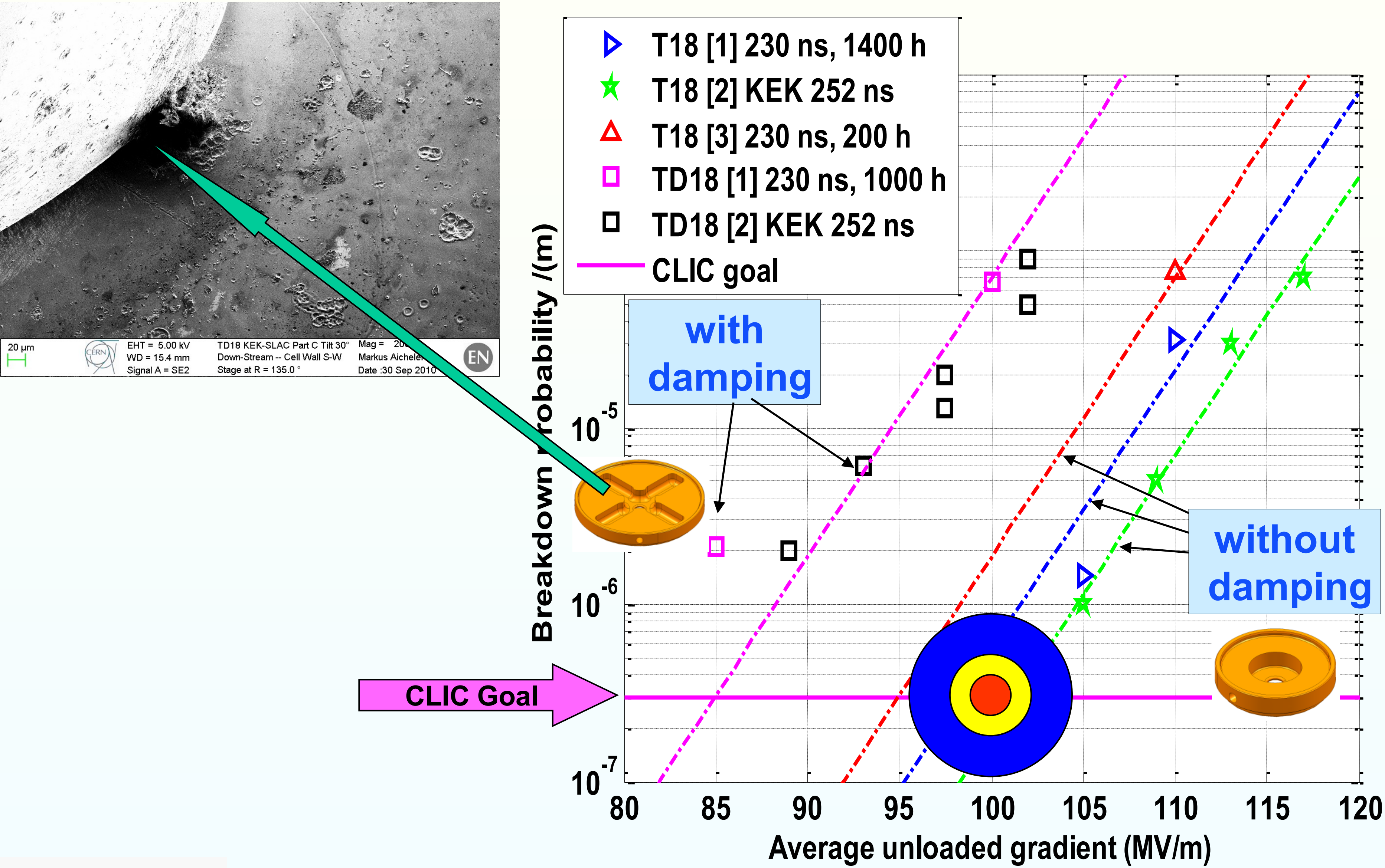


E/E_0	n_b	$n_{\mathcal{L}}$	$Q_p/Q_{p,0}$
1.0	312	1.0	1.0
0.75	472	1.5	1.12
0.667	552	1.77	1.18
0.5	792	2.54	1.27
0.375	1112	3.56	1.34
(0.333)	(1272)	(4.08)	(1.36)

E maximum centre-of-mass energy for operation mode

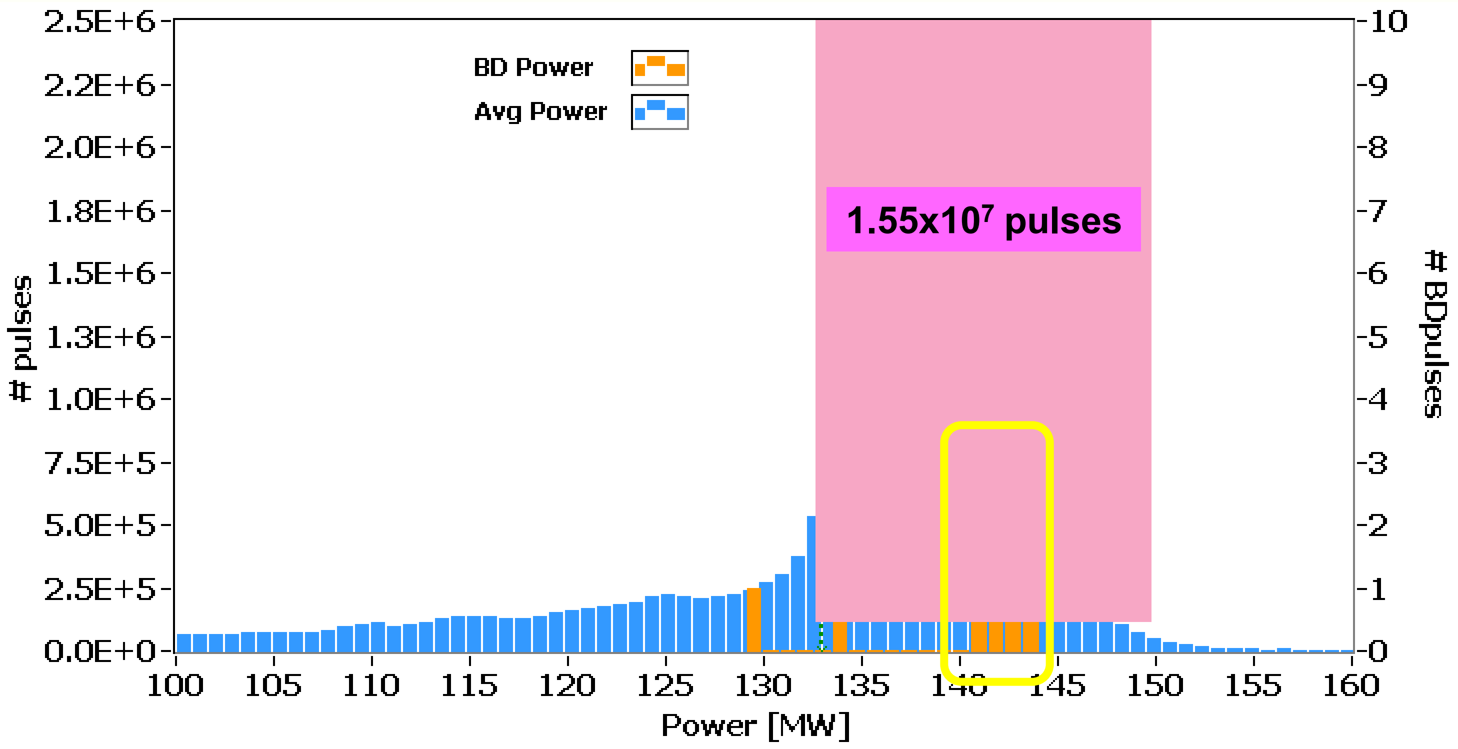
Schulte

Progress-2: Accelerating Structures



Wuensch *Delahaye*

Progress-2: PETS

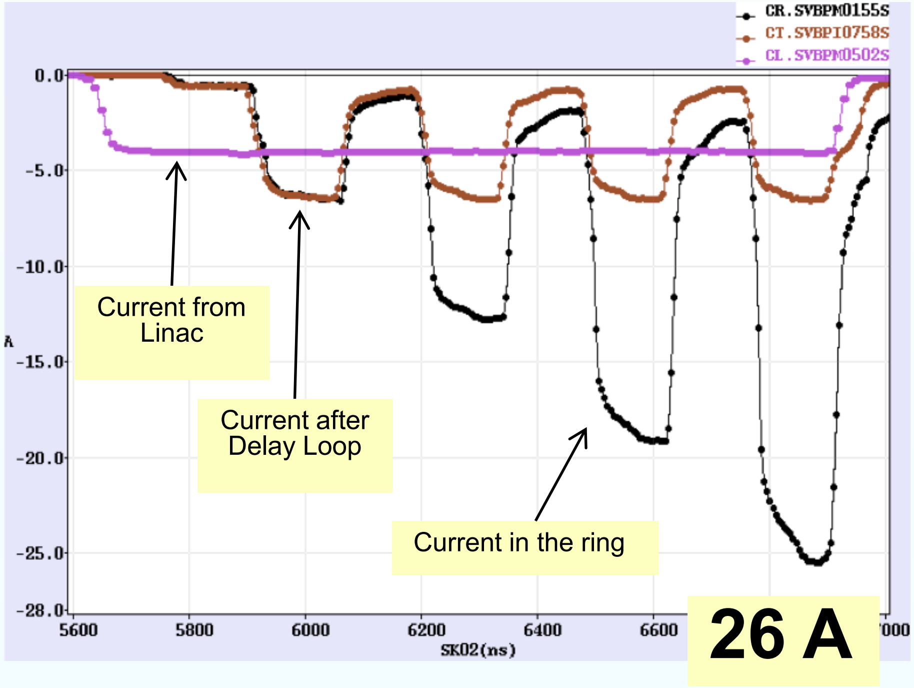


- 8 PETS breakdown events in 1.55 $\times 10^{7}$ pulses (125 hours)
  - Breakdown rate 5.3 $\times 10^{-7}$/pulse [CLIC Goal <2 $\times 10^{-7}$/pulse]
    - (excluding the 8 in the cluster – 1.3 $\times 10^{-7}$/pulse)
  - In 80 hours no breakdowns were registered
    - BDR <1.2x10^{-7}/pulse

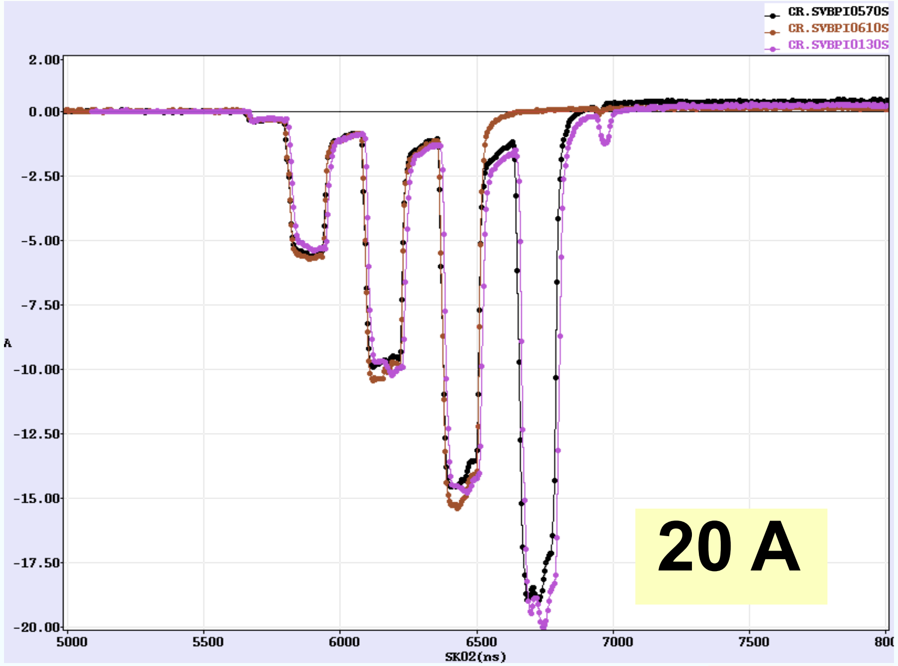
Wuensch

- **4 x combination**
  - **Lower current ←→ Missing klystron**
  - **But back in operation – continue work**

2009



2010

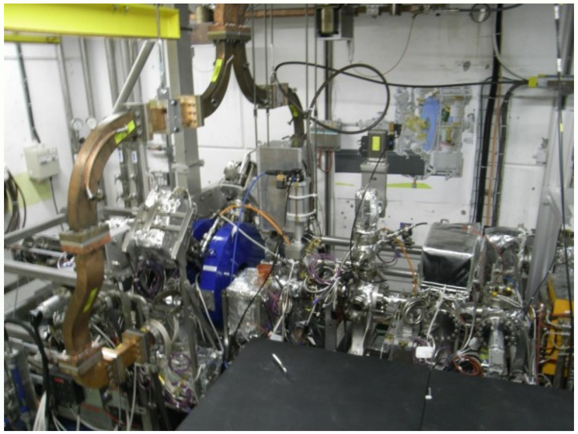


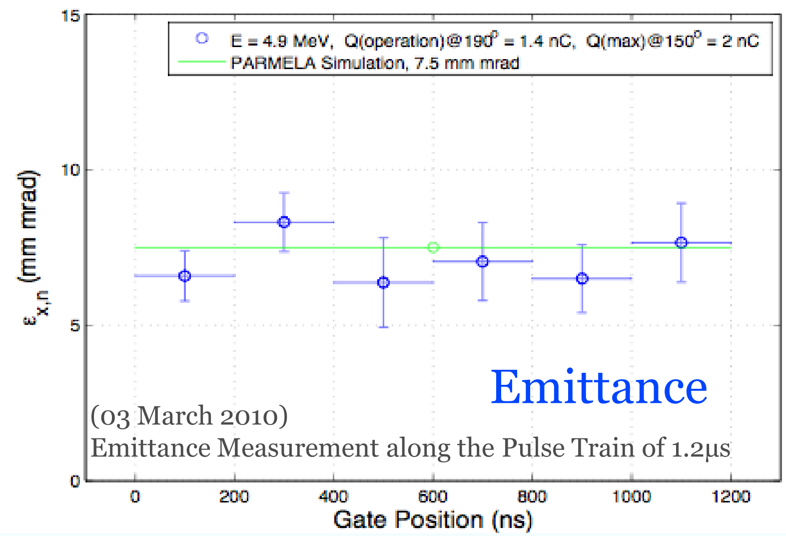
Tecker

PHIN

See Oznur Mete, Friday 17:00

- **specifications successfully demonstrated during the June run**
- **measurements along pulse train**





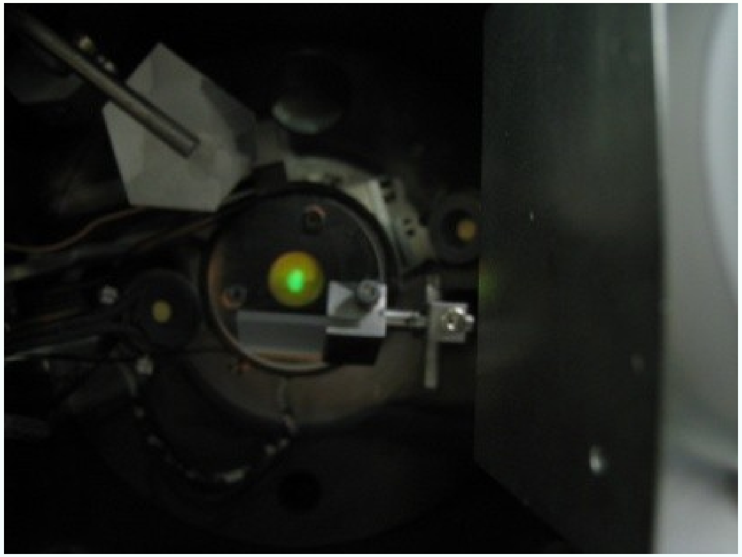
Parameter	Specification	Achieved	
Charge per Bunch (nC)	2.33	4.4	✓
Charge per Train (nC)	4446	>4446	✓
Train Length (ns)	1273	1300	✓
Current (A)	3.5	~3.4	✓
Normalized Emittance (mm mrad)	<25	14	✓
Energy Spread (%)	<1	0.7	✓
Energy (MeV)	5.5	5.5	✓
UV Laser Pulse Energy (nJ)	370	400	✓
Charge Stability (%)	<0.25 rms	1-2	✗
Cathode	Cs_2Te	Cs_2Te	✓
Quantum Efficiency (%)	3	18 (peak)	✓
RF Gradient (MV/m)	85	85	✓
RF Frequency (GHz)	2.99855	2.99855	✓
Micropulse Repetition Rate (GHz)	1.5	1.5	✓
Macropulse Repetition Rate (Hz)	1-5	1-5	✓

Tecker

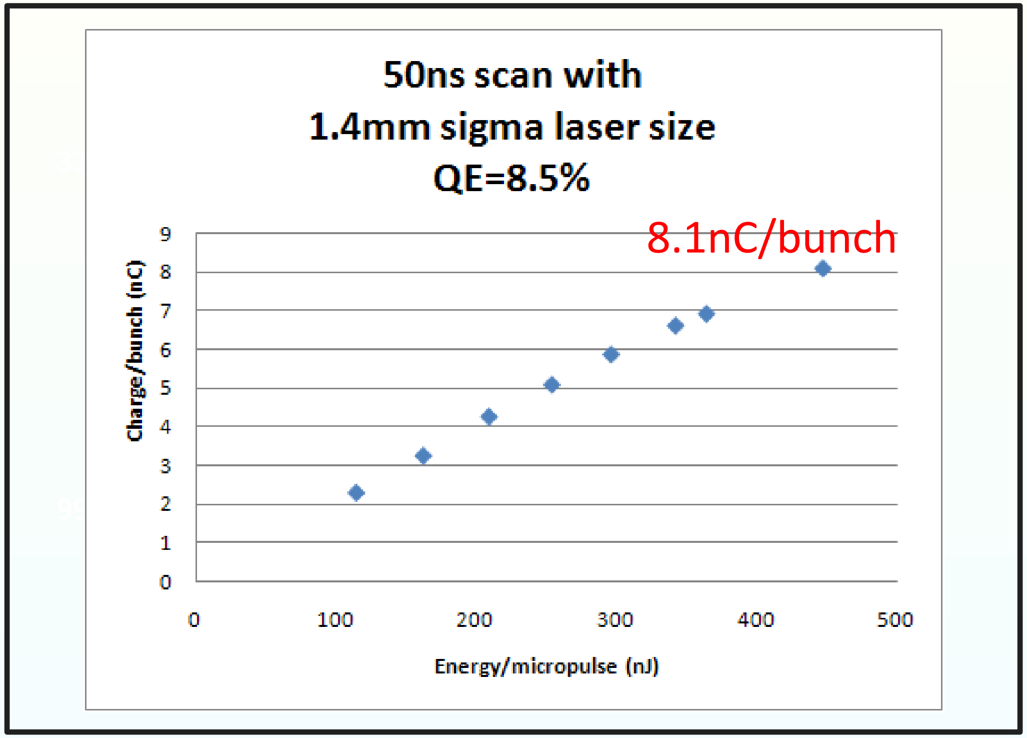
High charge & cathode tests - PHIN

Marta Csatari

- New green responsive cathode tested in UV Cs3Sb
- Cathode lifetime measurements

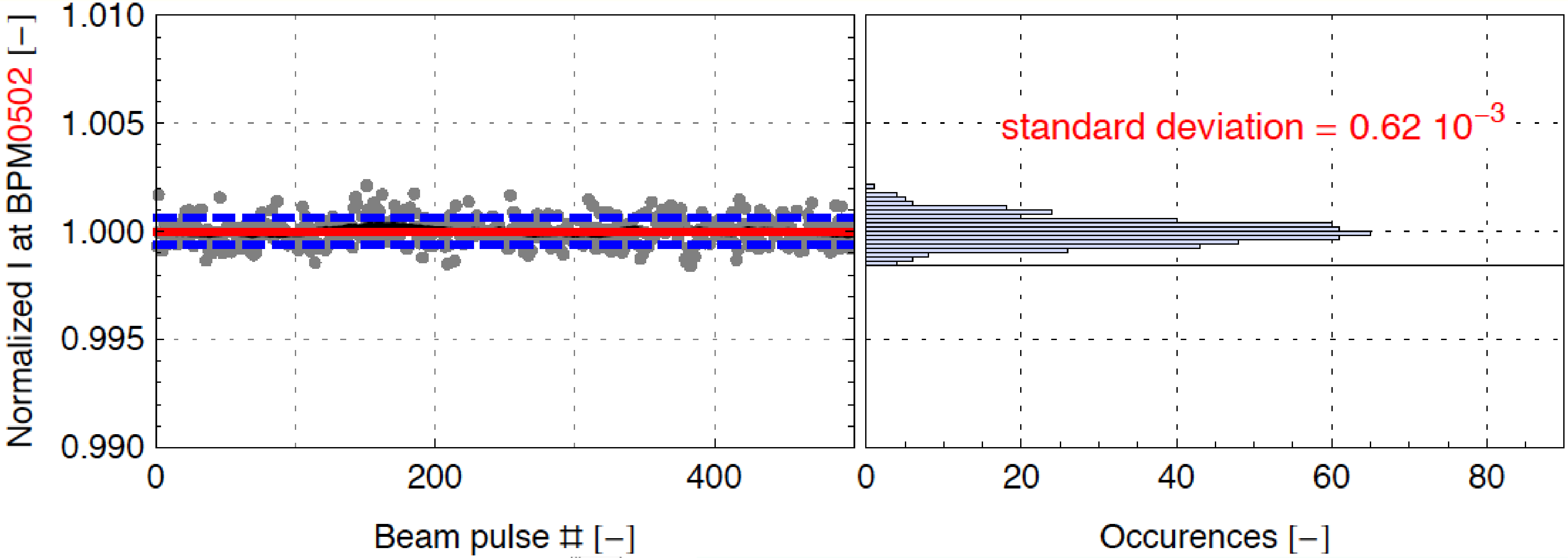


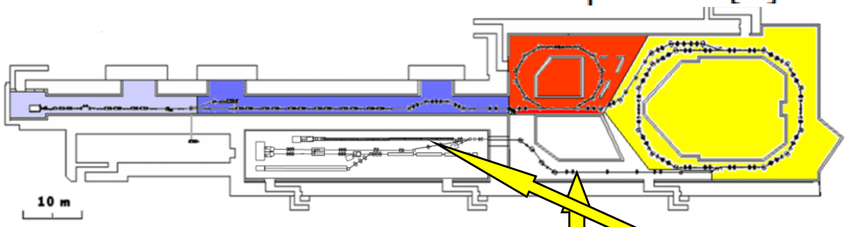
Maximum charge extracted with 75 bunches

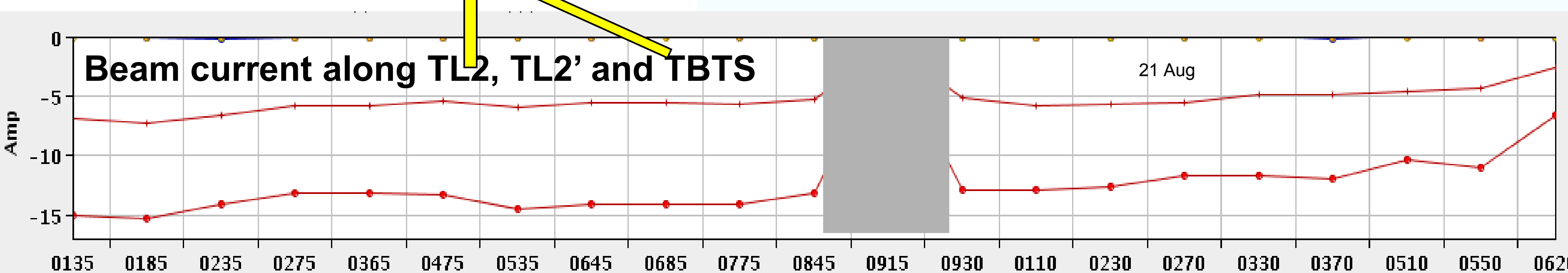


HIGHEST charge extracted from PHIN to date

Beam Stability

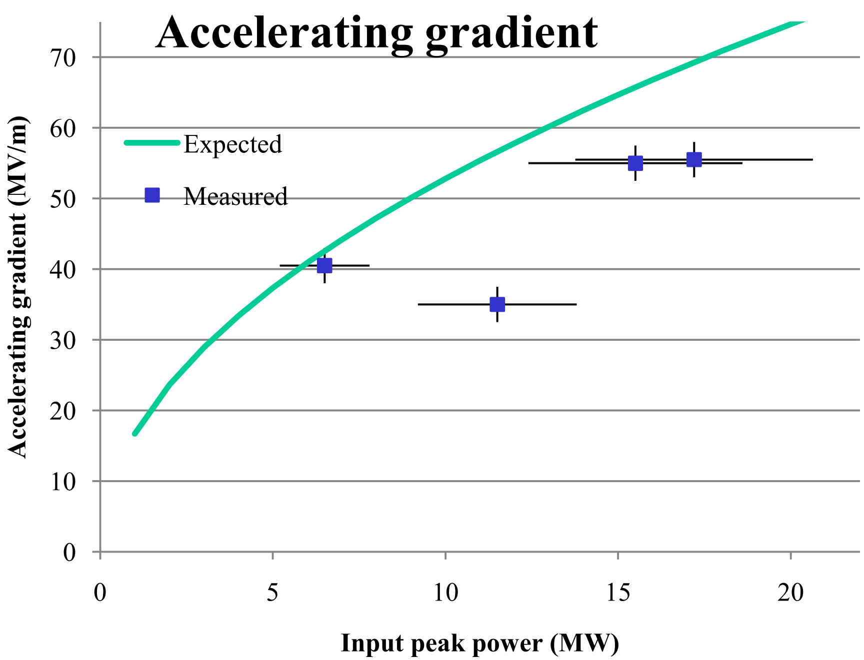


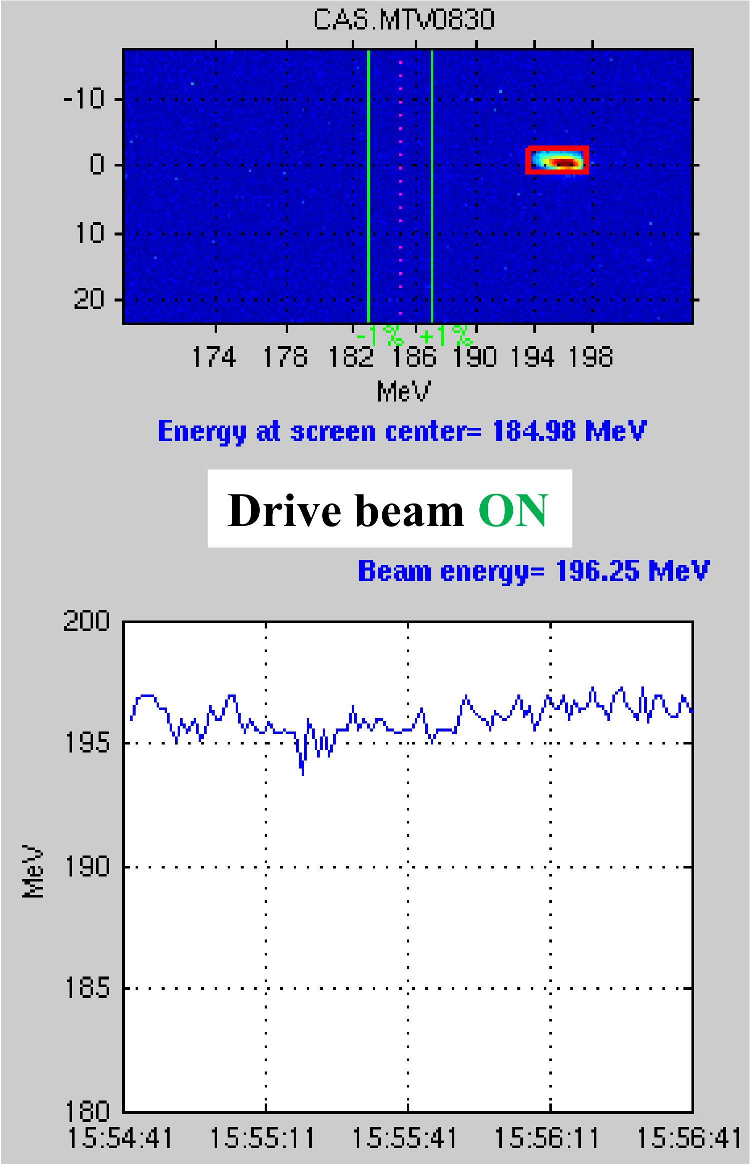




Two-beam acceleration in CTF3

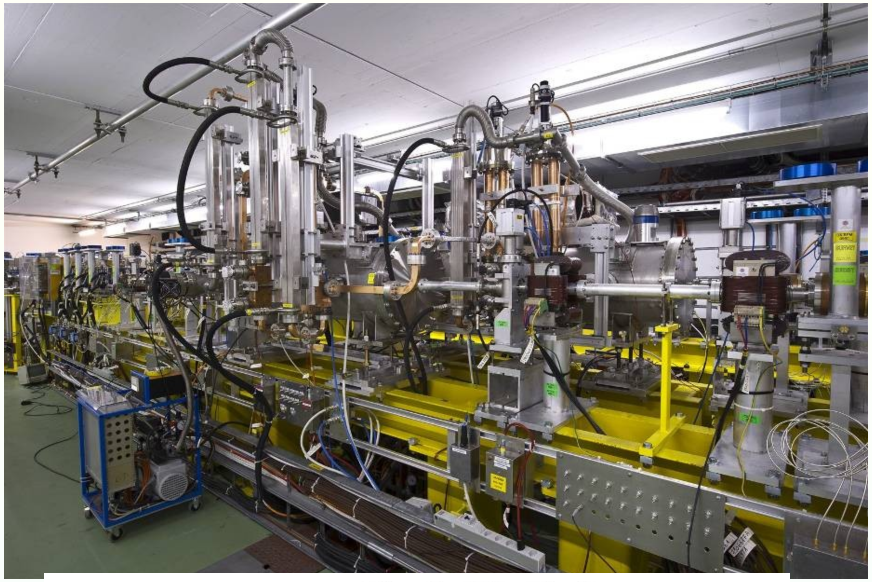
- maximum probe beam acceleration of 11 MeV measured
- => **gradient ~55 MV/m**
- RF calibrations to be verified

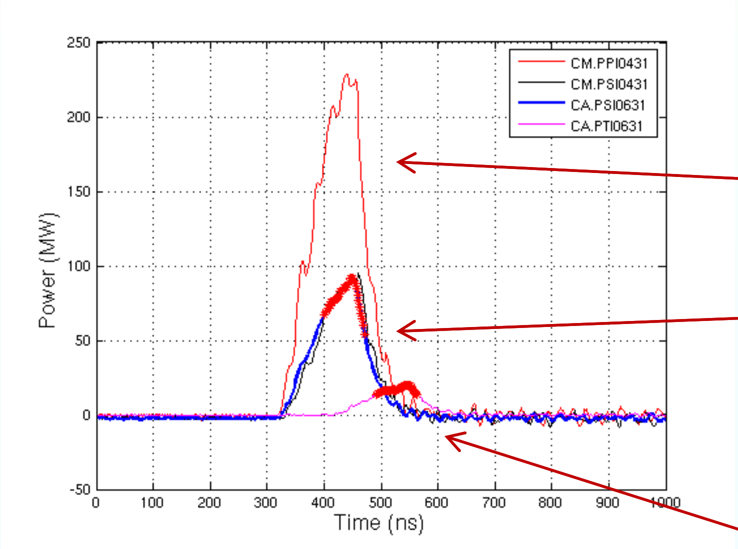




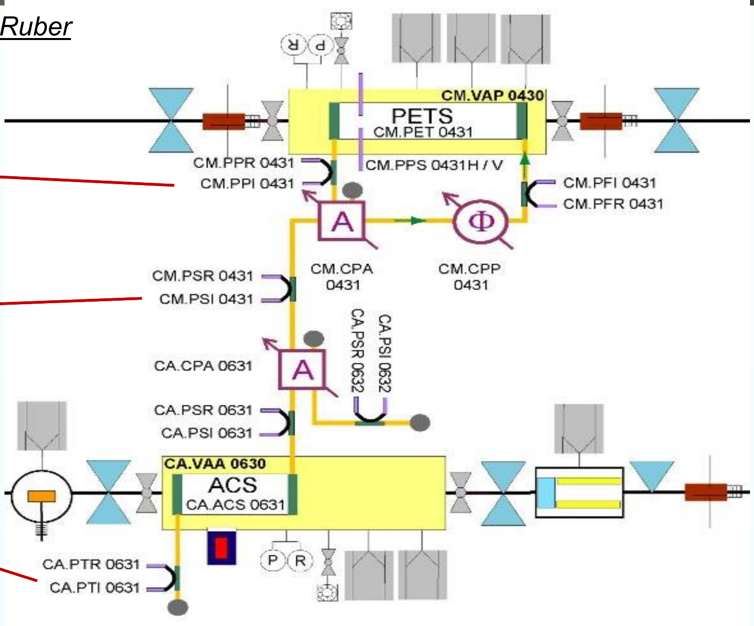
RF Power Production - PETS

- **>200 MW peak RF power**
  - **~ 3x10^5 pulses (rapid)**
  - **Record level**
- **reliable pulses**
  - **~100 MW in accelerating structure**
  - **~ twice power neded for 100 MV/m**
    - **two beam experiment**
    - **TD24_vg1.8_disk structure.**





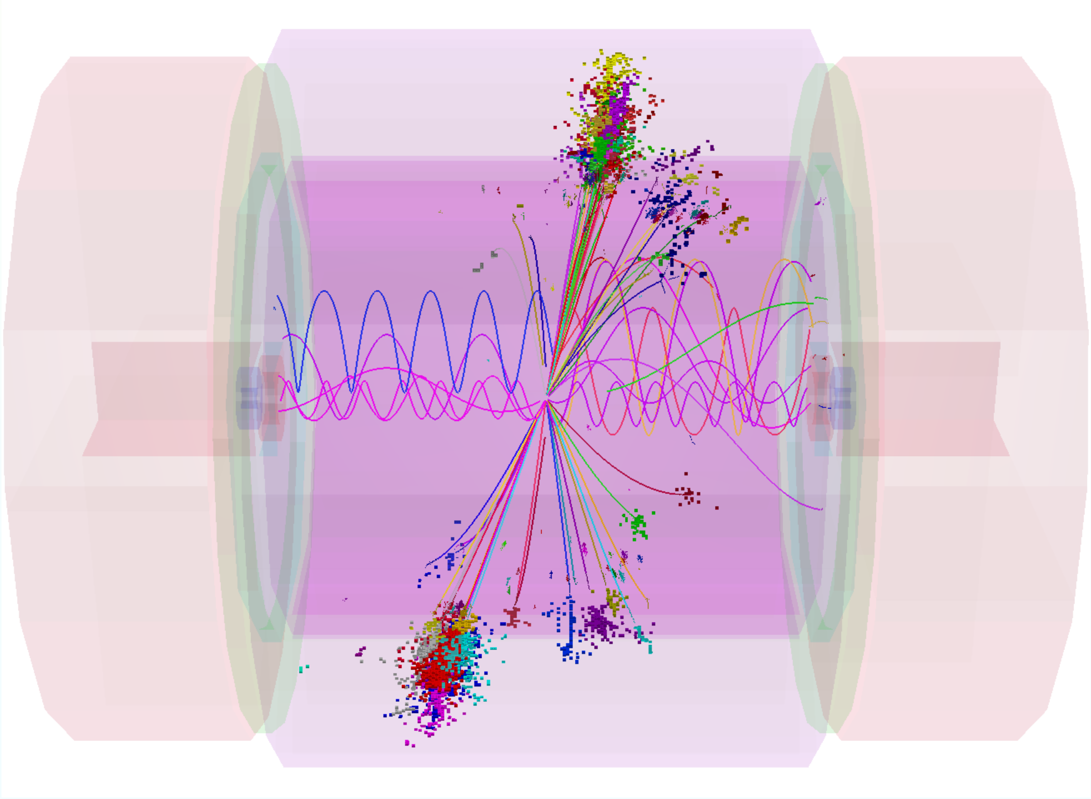
Roger Ruber



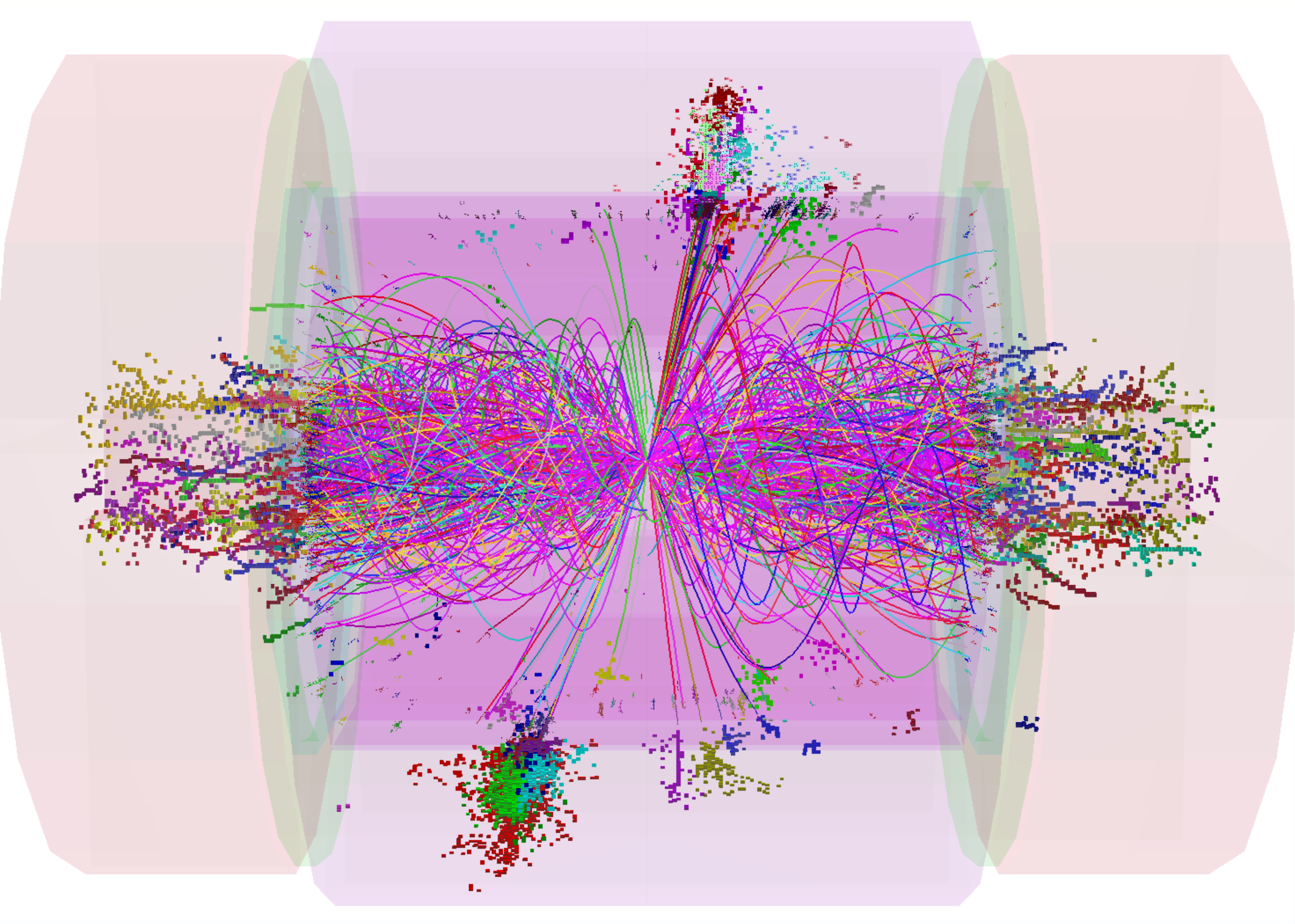
Detectors

CLIC Detector Concepts

- **Modified ILC detector concepts**
  - **Vertex detector further out (r_{min} = 30 mm)**
  - **Thicker HCAL (8 λ_I)**
    - **HCAL inside solenoid – need to keep "thin" (Tungsten?) Full Geant4 simulations of ILD and SiD for CLIC**

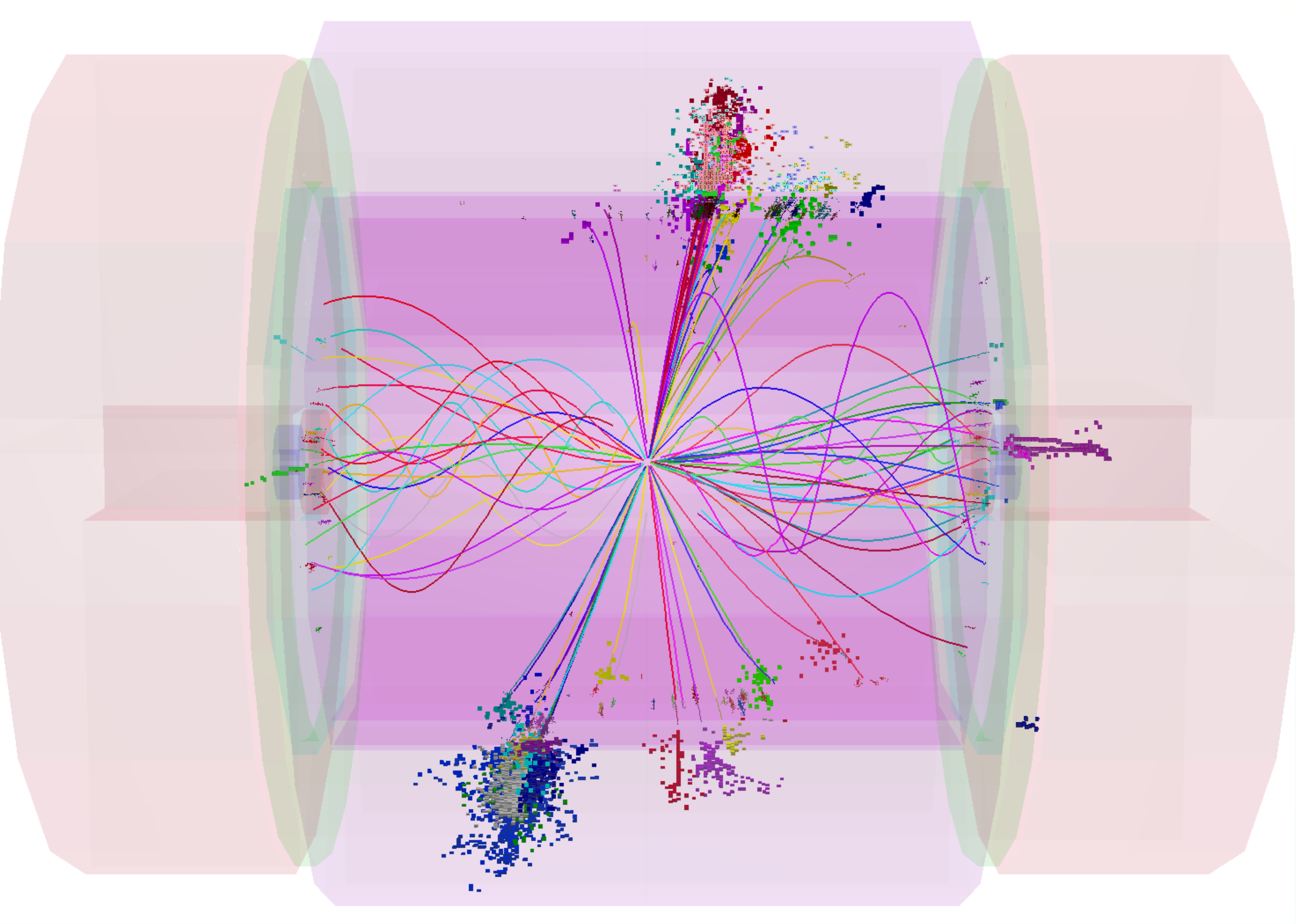


Reconstructed CLIC event with "pile-up"



1.4 TeV of background !

After timing cuts at cluster level

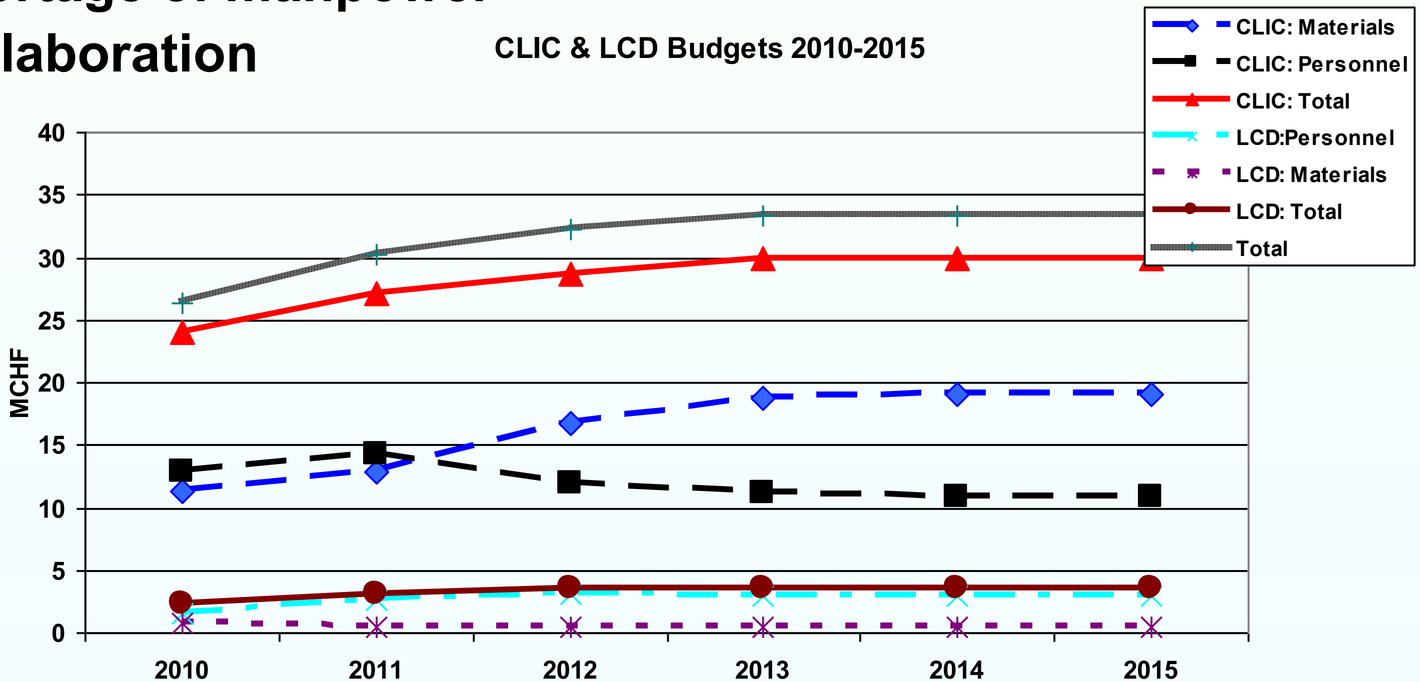


0.1 TeV of background

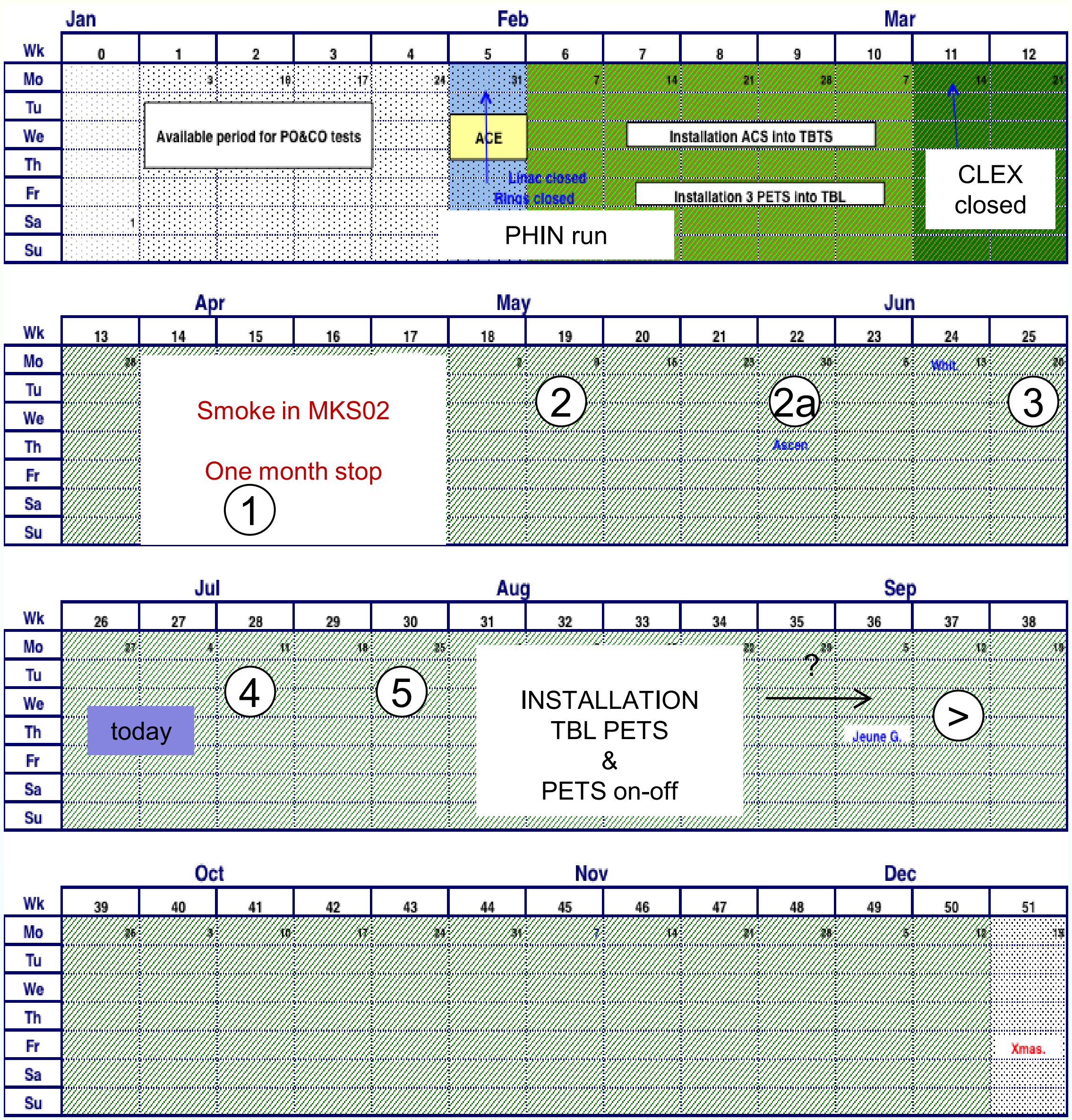
NEXT STEPS

"Lehman" impact

- **Increase in resources for CLIC**
  - Materials 11.9→19.0MCHF
  - Personnel 12.8→10.9MCHF
    - Overall increase ~60%
  - but
    - Shortage of manpower
    - Collaboration



Planning 2011



1. 3 GHz beam setup to CR
   initial beam to CLEX
   CALIFES setup

2. CR x 4 combination
   emittance studies
   combined beam to CLEX

2a. 1.5 GHz beam setup
   x 8 combination
   (if TWT is available – only 1 operational)

3. 100 MV/m acceleration
   breakdown kicks
   TBL deceleration
   (1-2 days for DB beam studies)

4. ε < 150 mm mrad
   longitudinal studies
   stability x 8 combination
   (night running for BDR)

5. breakdown rate measurements
   PETS / ACS

> Test of new PETS on-off scheme
   TBL deceleration up to 8 PETS

Beam phase
rep. rate / losses
supervision

CSR
night

CLIC Feasibility status

Delahaye

System	Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibilit
Two Beam Acceleration	Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓
		Freq&Current multipl	-	2*3*4	2*4	CTF3	✓
		Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓
		Combined pulse length (12 GHz)	ns	240	140	CTF3	✓
		Intensity stability		1.E-03	0.75	< 0.6	CTF3	2011
		Drive beam linac RF phase	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓
	Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓
		PETS Pulse length	ns	170	>170	TBTS/SLAC	✓
		PETS Breakdown rate	/m	< 1·10-7	≤ 2.4 10-7	TBTS/SLAC	✓
		PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011
		Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012
		RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012
	Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	✓
		Structure Flat Top Pulse length	ns	170	170		✓
		Structure Breakdown rate	/m	< 3·10-7	5·10-5(D)		2011
		Rf to beam transfer efficiency	%	27	15		2011
	Two Beam Acceleration	Power producton and probe beam acceleration in Two beam	MV/m - ns	100 - 170	106 - <130	TBTS	2011
		Drive to main beam timing	psec	0.05	-	CTF3	2012
		Main to main beam timing	psec	0.07	-	XFEL	2012
Ultra low beam emittance & sizes	Ultra low Emittances & Beam Sizes	Norm. Emitttance generation	H/V (nm)	500/5	3000/12	ATF, NSLS/SLS + simulation	✓
		Emittance preservation: Blow-up	H/V (nm)	160/15	160/15		2011-12
		Strong focusing: β*eff /L* from IP	mm/m	0.1/3.5	2.0/1.0	ATF2	2011-12
		Nanometer beam sizes at IP	H/V (nm)	40/1	70 300	FFTB ATF2+simul.	2011-12
	Alignment	Main Linac components	µm	10	10 (princ.)	Align. & Mod. Test Bench	2011
		Final-Doublet tolerance	µm	10			
	Vertical stabilisation	Quad Main Linac	nm>1 Hz	1.5	0.13 (principle)	Stabilisation Test Bench	2011-12
		Final Doublet (with feedbacks)	nm>4 Hz	0.2			
Operation and Machine Protection System (MPS)		72MW@2.4GeV 13MW@1.5TeV				CTF3 simulations	2011-12

CLIC Tentative Schedule

Final CLIC CDR and proposal next phase @ CERN Council

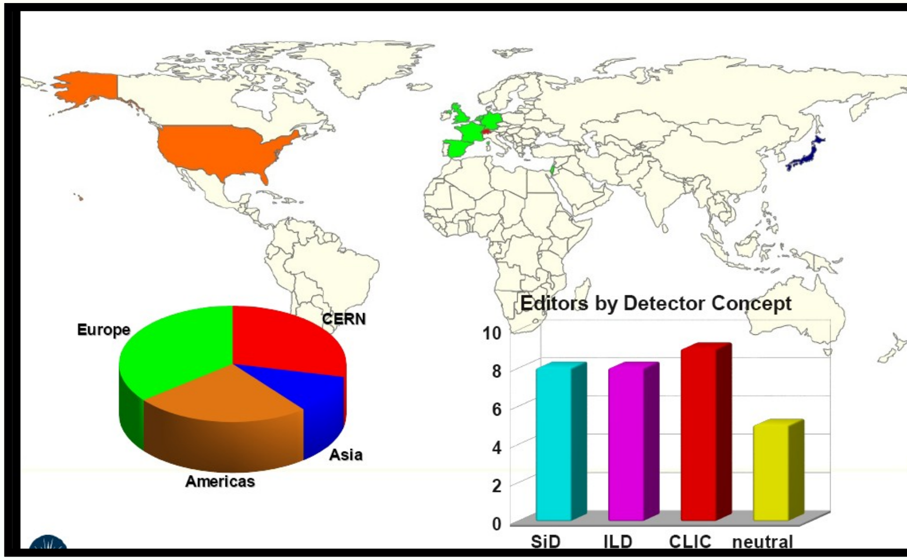
European Strategy for Particle Physics @ CERN Council

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Feasibility issues (Accelerator&Detector)									
Conceptual design & preliminary cost estimation									
Engineering, industrialisation & cost optimisation									?
Project Preparation									
Project Implementation									?

Draft Conceptual Design Report (CDR)

Project Implementation Plan (PIP) and proposal for next phase

CLIC CDR: P&D Editorial Team



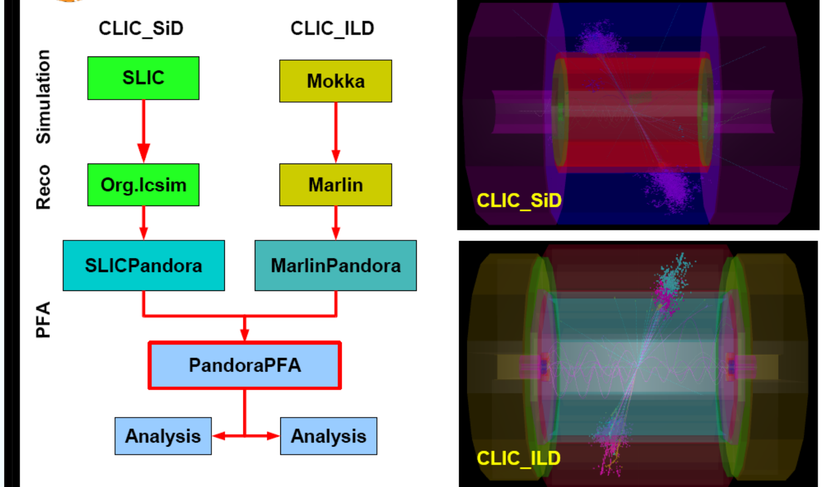
Main Editors

- **Physics Potential** – G. Giudice (CERN), J. Wells (CERN)
- **Performance requirements** – M. Battaglia(UCSC,CERN), M. Thomson(Cambridge)
- **CLIC Detector concepts** – J. Brau (Oregon), D. Schlatter (CERN), F. Simon (MPI), G. Wilson (Kansas)
- **Vertex Detectors** – S. Worm (RAL)
- **Tracking** – M. Demarteau (FNAL), C. Lacasta (Valencia), T. Matsuda (KEK), T. Nelson (SLAC), J. Timmermans(NIKHEF)
- **Calorimetry** – F. Sefkow (DESY), T. Takeshita (Shinshu U), A. White (UTA)
- **Solenoids** – A. Gaddi (CERN), Y. Makida (KEK)
- **Muon system** – B.Schmidt (CERN)
- **Forward** – H. Abramowicz (Tel Aviv), W. Lohmann (DESY)
- **Detector Integration** – H, Gerwig (CERN), M. Oriunno (SLAC)
- **Benchmarking** – J.J. Blaising (Annecy), J. Strube (RAL), F. Teubert (CERN)
- **Costing** – M. Breidenbach (SLAC), C. Clerc (LLR), M. Nordberg (CERN)

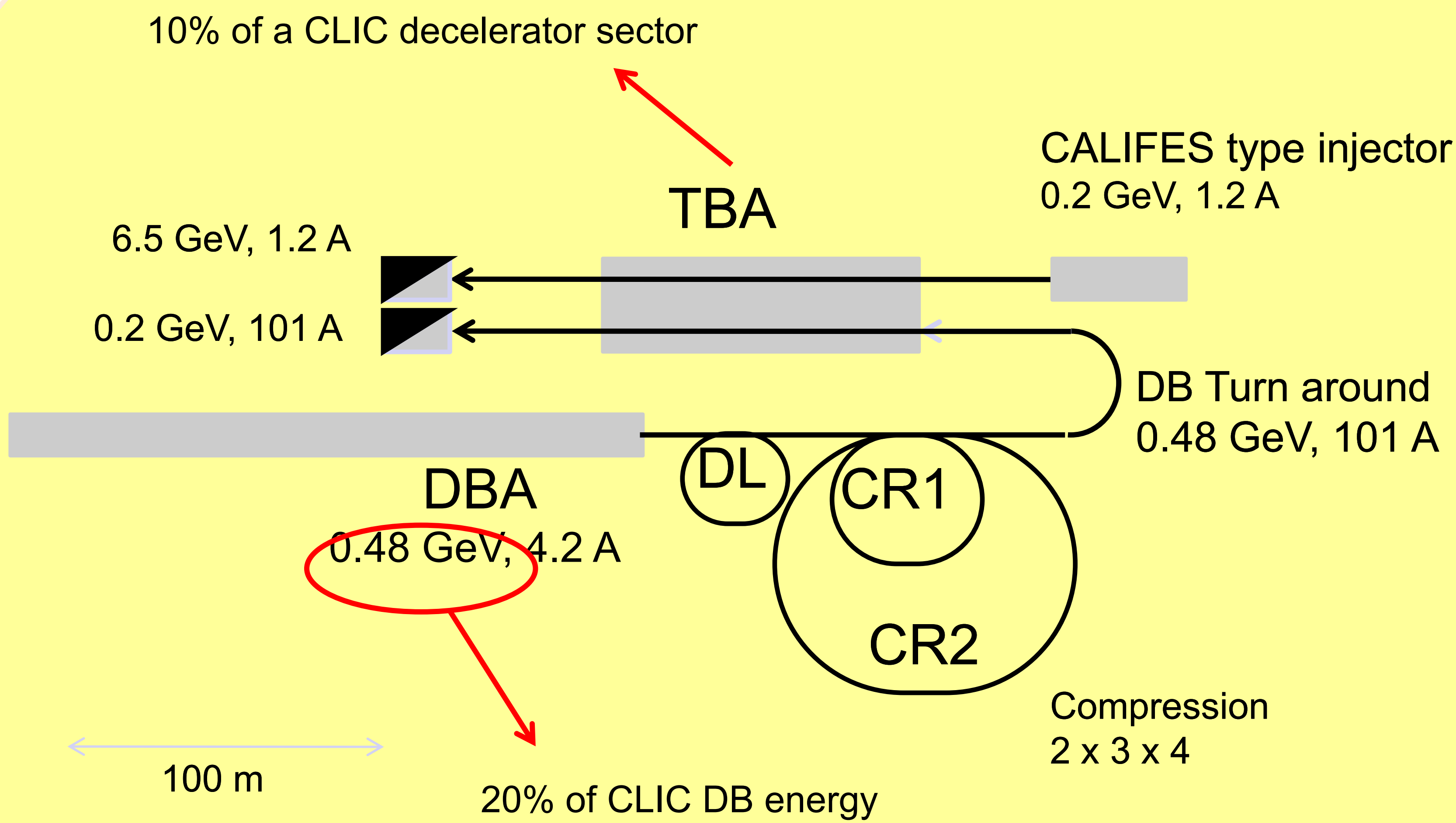
	CLIC_SiD	CLIC_ILD
Vertex detector	inner radius 2.7 cm 5 single barrel layers 6 single layer forward disks	inner radius 3.1 cm 3 double layers 3 double layer pixel forward disks
Tracker	Si, unchanged	TPC, unchanged
ECAL	unchanged	unchanged
HCAL Barrel	W+Scintillator, 3x3 cm tiles 7.5 Λ_i 1 cm plates W+RPC, 1x1 cm tiles 7.5 Λ_i 1 cm plates	W+Scintillator, 3x3 cm tiles 7.5 Λ_i 1 cm plates
HCAL Endcap	Fe+Scintillator, 3x3 cm tiles 7.5 Λ_i 2 cm plates Fe+RPC, 1x1 cm tiles, 7.5 Λ_i 2 cm plates	Fe+Scintillator, 3x3 cm 7.5 Λ_i 2 cm plates
Coil	5T, Radius=2.68 m	4T, Radius=3.35 m

Stanitski

Two detectors, one PFA



Do we need CLIC0? (Project after 2016?)



Corsini

CLIC-ILC WG on General Issues

2010

STATEMENT OF COMMON INTENT

by the CLIC Collaboration Board and the ILC Steering Committee

Recognising the need for an electron-positron linear collider to explore the physics that will be revealed by the LHC,

Considering the synergies that exist and the opportunities for collaboration that arise between the ILC Global Design Effort and the CLIC collaboration, as well as between the ILC and CLIC physics and detector studies, and

Building upon the CLIC/ILC joint statements,[1]

The two parties **agree** to promote and develop scientific and technical preparations for a linear collider, and to exploit wherever possible synergies between ILC and CLIC, including accelerator, detector and physics topics, so the designs are prepared efficiently in the best interest of high-energy physics.

The ILC Steering Committee and the CLIC Collaboration Board will foster this cooperation by agreeing, reviewing and updating a list of topics of common interest. This includes, but is not limited to, the topics listed in the Addendum to this agreement, which already form the subjects of joint ILC-CLIC Working Groups.

Signed Jonathan Bagger	Signed K. J. Peach
Date January 11th 2010	Date January 11th 2010
(Jonathan Bagger)	(Ken Peach)
on behalf of the ILC Steering Committee	on behalf of the CLIC Collaboration Board

CLIC-ILC WG on General Issues

- **Membership:**
  - CLIC: Ph. Lebrun (co-chair), K. Peach, D. Schulte
  - ILC: E. Elsen, M. Harrison (co-chair), K. Yokoya
- **Mandate**
  - Promoting the Linear Collider
  - Identifying synergies
  - Discussing detailed plans for the ILC and CLIC effort & project planning.
  - Discussing issues that will be part of each project implementation plan
  - Identifying points of comparison between the two approaches
- **Reporting line**
  - Creported to the ILCSC and CLIC Collaboration Board
  - Amin to produce a joint document.
- **Working method**
  - Approximately monthly meetings by teleconference
  - Four face-to-face meetings

NOT OFFICIALLY APPROVED!

Accelerator Inspired Working Groups

Current technical working groups are

- Beam delivery system & machine-detector interface
- Civil engineering and conventional facilities
- Positron generation
- Damping rings
- Beam dynamics
- Cost & schedule

- **Opportunities for further work**
  - Conventional RF?
  - Surface science?
  - …

Decision point for the LC

- 2½ key facts are needed
  1. Is there a light (<200 GeV/c^2) Higgs?
  2. Is there New Physics (below 1 TeV)?
     - ½ If yes, what is the energy range?
- Note:
  - It does not matter much from the point of view of defining the *decision point* what the answers to these questions are – only that we know them!
  - The 1st question may be answered by end 2012
  - The 2nd question may be answered by end 2011
    - The ½ question may not be clear for some time
  - We need to define criteria for making a "fact"
    - Is 3σ enough for evidence?
    - Is 98% enough to exclude?

- **Reach of LC wrt HE-LHC or HL-LHC?**

Comments and proposals

- **Do we need the answers to both to proceed?**
  - **(KJP) yes (politically)**

- **Is the European Strategy update a constraint?**
  - **(KJP) yes**
    - **If either is question are answered before Strategy workshop**
      - **Encourage the Americas & Asia to update their strategies**
      - **Organise input to these discussions**
    - **If there is no reliable information by March 2012**
      - **Be prepared to organise a quick workshop between March and the Strategy update workshop if evidence emerges**
      - **Plan for a "community workshop" in 2013 to review the situation**
      - **[this will either define the LC parameters or address the crisis]**

Summary

- **Excellent technical progress to the CDR**
  - Delayed ~6 months by the fire
  - Address remaining feasibility issues
  - On track for CDR by end 2011
- **Plans developed for the post-CDR phase**
  - Disrupted by the financial crisis
    - But a revised plan emerging
- **Opportunities for greater collaboration**
  - Prepare for the post 2012 landscape
    - New connections ILC←→CLIC?
    - New organisational structures?
- **Wait for "good news" from the LHC**

Thank you