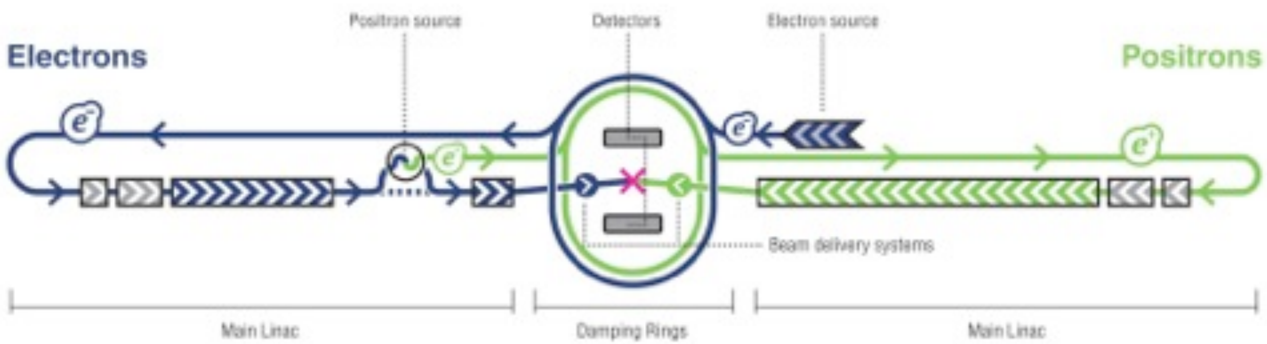
International Linear Collider – Status and Parameters

E.Elsen

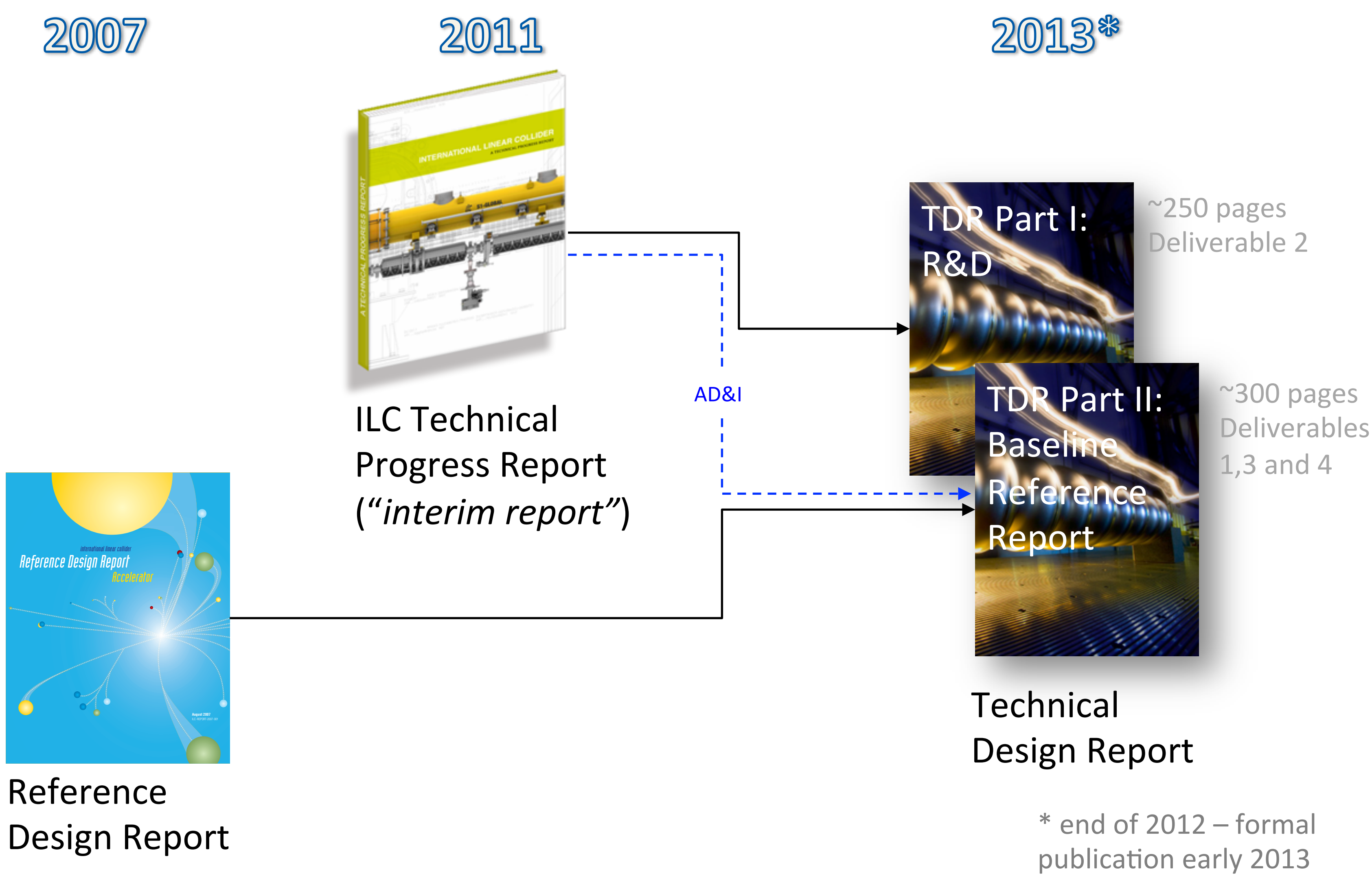


RDR version of the ILC

LC Forum, DESY, February 7-9, 2012

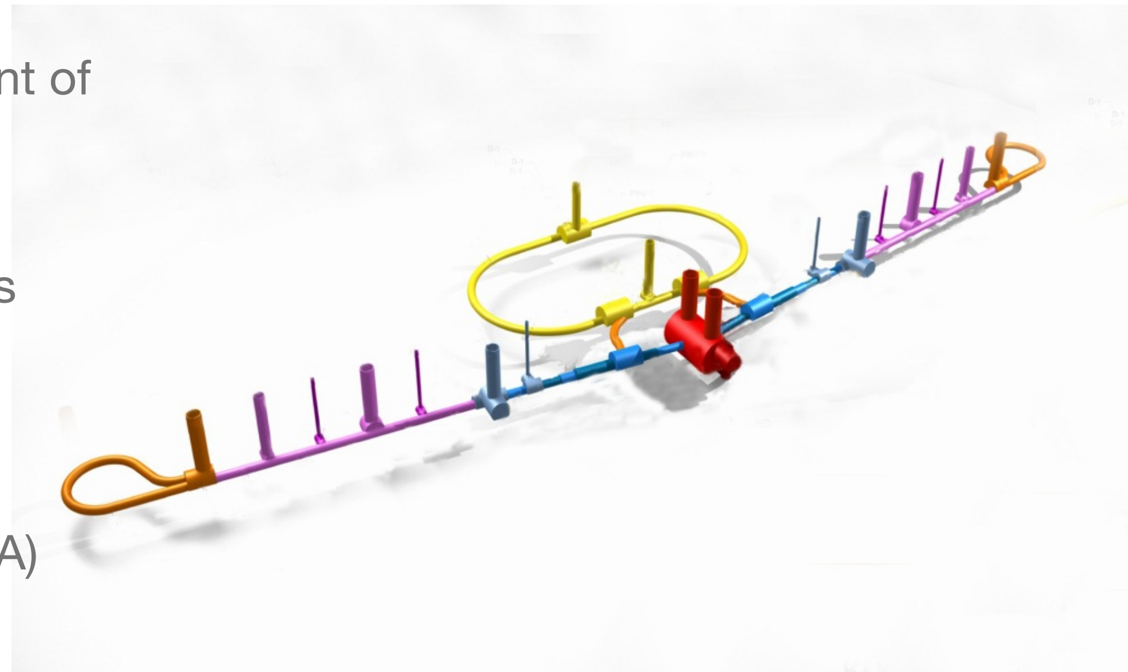
ILC - the Global Design Effort started in 2005…

ILC – Evolution of the Reference Design Report



International Linear Collider ILC

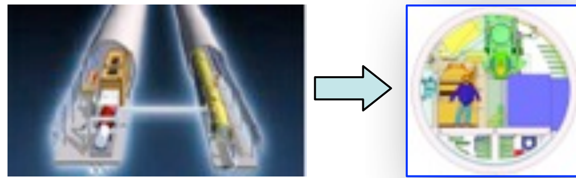
- Approaching end of Global Design Effort
  - Accelerating gradient of 31.5 MV/m
  - Damping ring issues (e-could etc.)
  - Test facilities (FLASH, ATF, CesrTA)
  - Cost optimization
- TDR to be issue by end of 2012



Machine prepared for construction decision

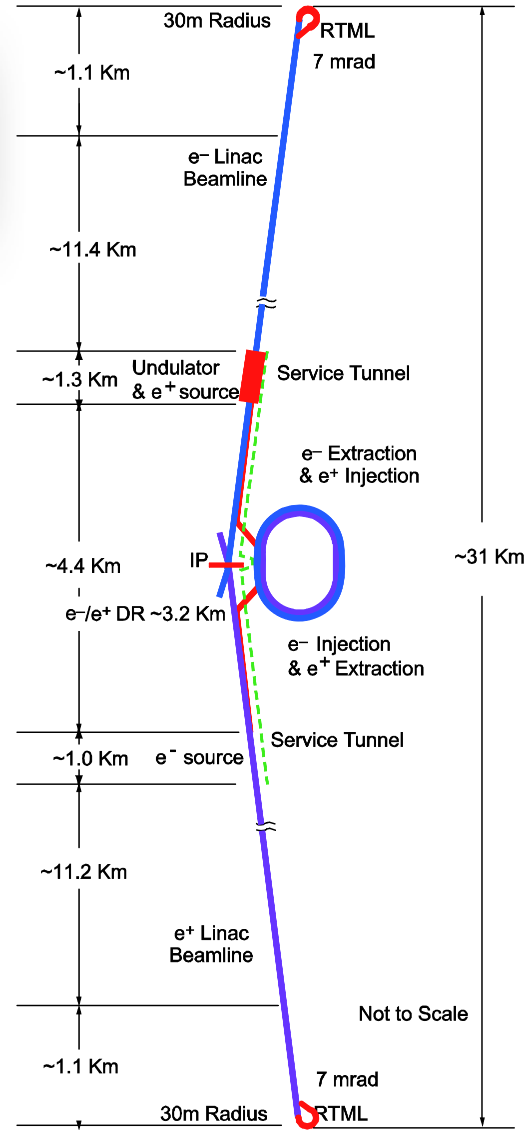
Design changes proposed in 2009

- Single accelerator tunnel

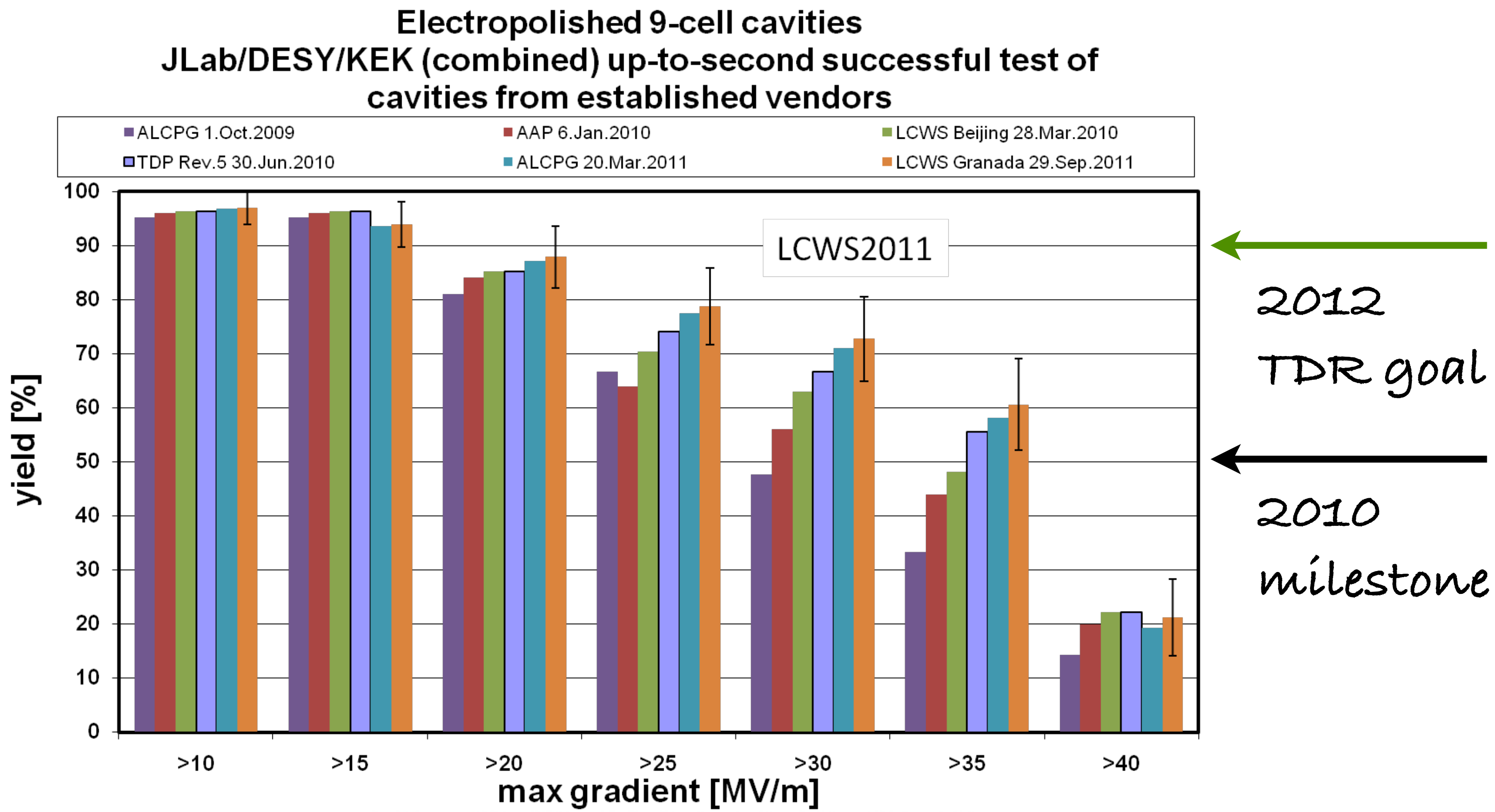


- smaller damping ring
- relocation of e⁺-source to end of linac
- SCRF gradient spread: 31.5 MV/m ± 20%

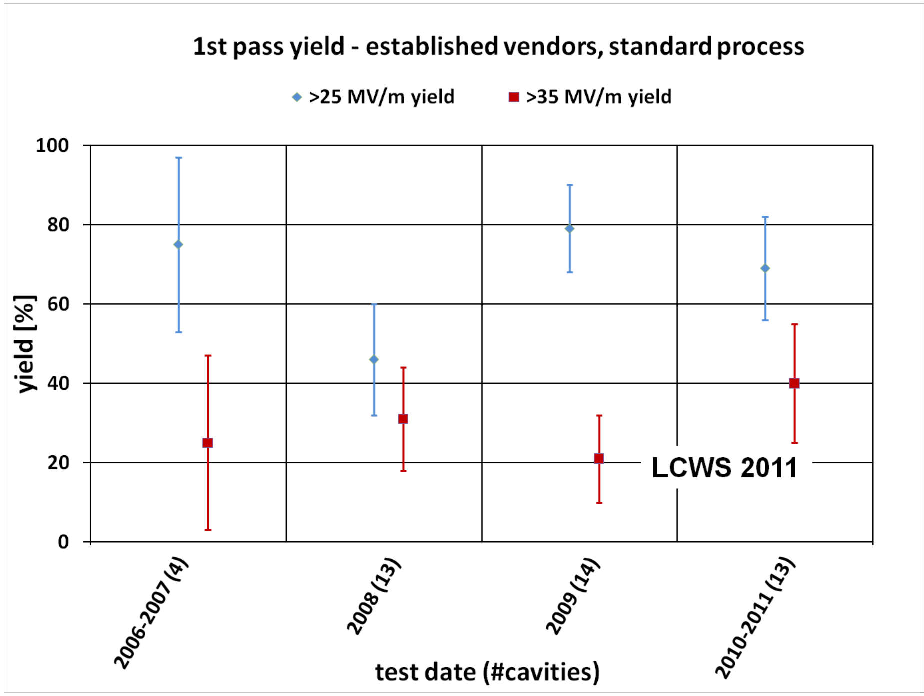
- HLRF:
  Klystron cluster scheme (KCS) and
  Distributed RF system (DRFS) with
  RDR RF unit as backup

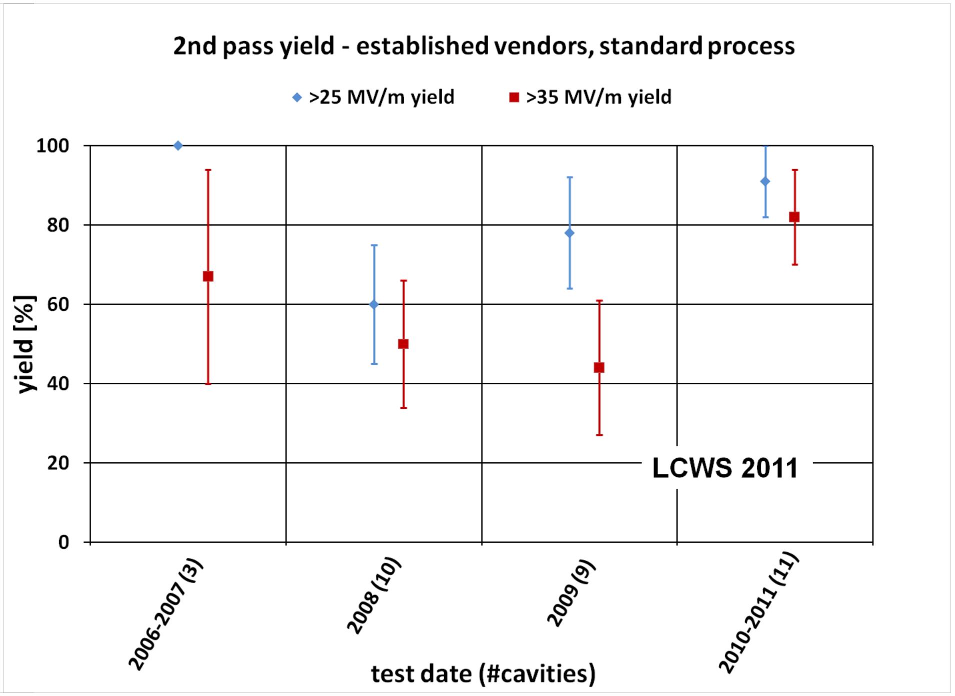


Cavity Gradient Milestone 2010 achieved



Differential yield





A two-pass electro-polishing process tends to achieve the yield goal.

Recent SRF progress

- Americas
  FNAL mechanical polishing improved 9-cell cavity ACC15 gradient from 19 MV/m to 35 MV/m
  JLAB started processing and testing DESY seamless 9-cell cavity built from DESY 3-cell seamless units
  6 of AES 3rd production & 4 Niowave-Roark 1st production received by FNAL

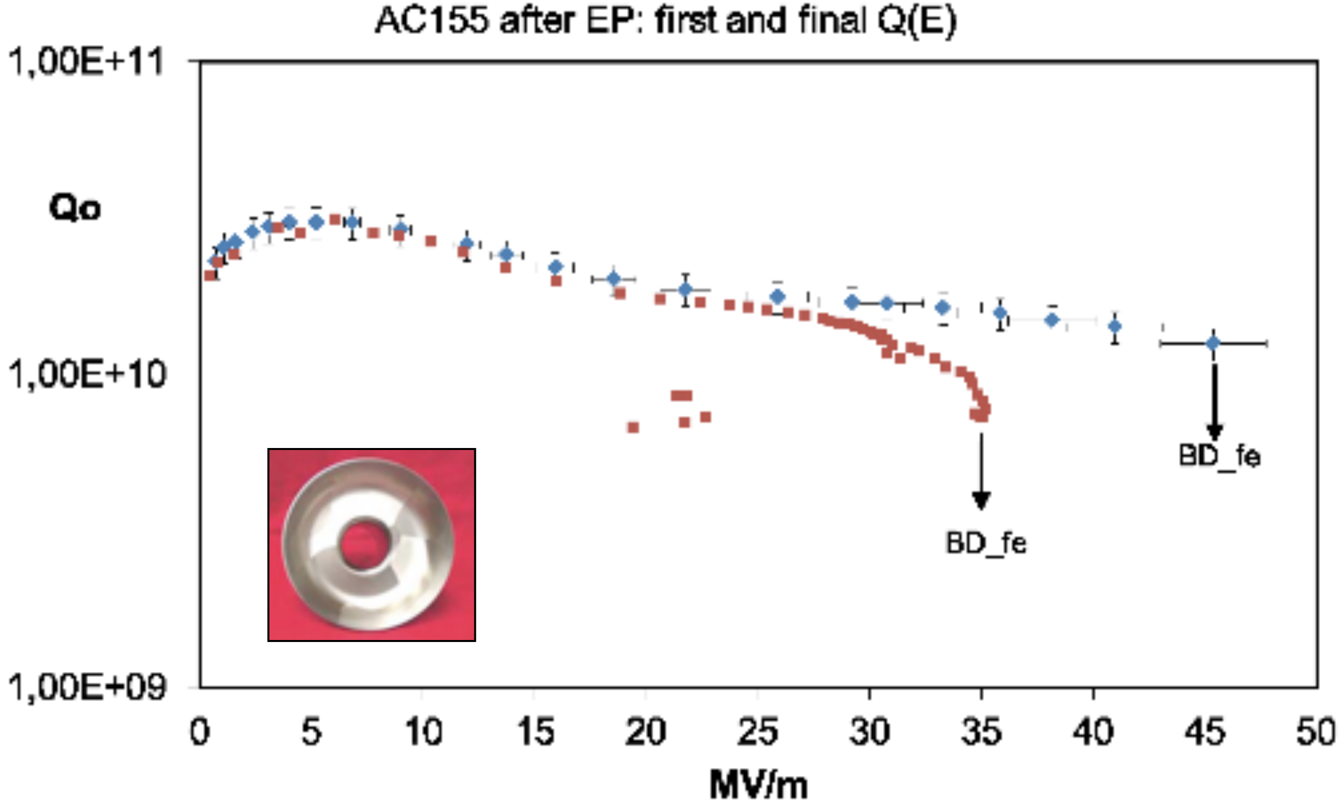
- Asia
  PKU-JLab reached 28.6 MV/m
  KEK MHI-12 exceeds 40 MV/m at $Q_0=6.2\times10^9$
  KEK-JLAB: ACD shape cavity ICHIRO7 reached 40 MV/m at $Q_0=8\times10^9$

- Europe
  DESY large-grain 9-cell cavity AC155 reached 45 MV/m at $Q_0 > 10^{10}$

Mass production of cavities for European XFEL just beginning

DESY Large-Grain Cavity AC155

- **Re-test after 300 K:** Final $Q_0(E_{acc})$ at 2K: **45 MV/m @ > 10^{10}** ; some FE



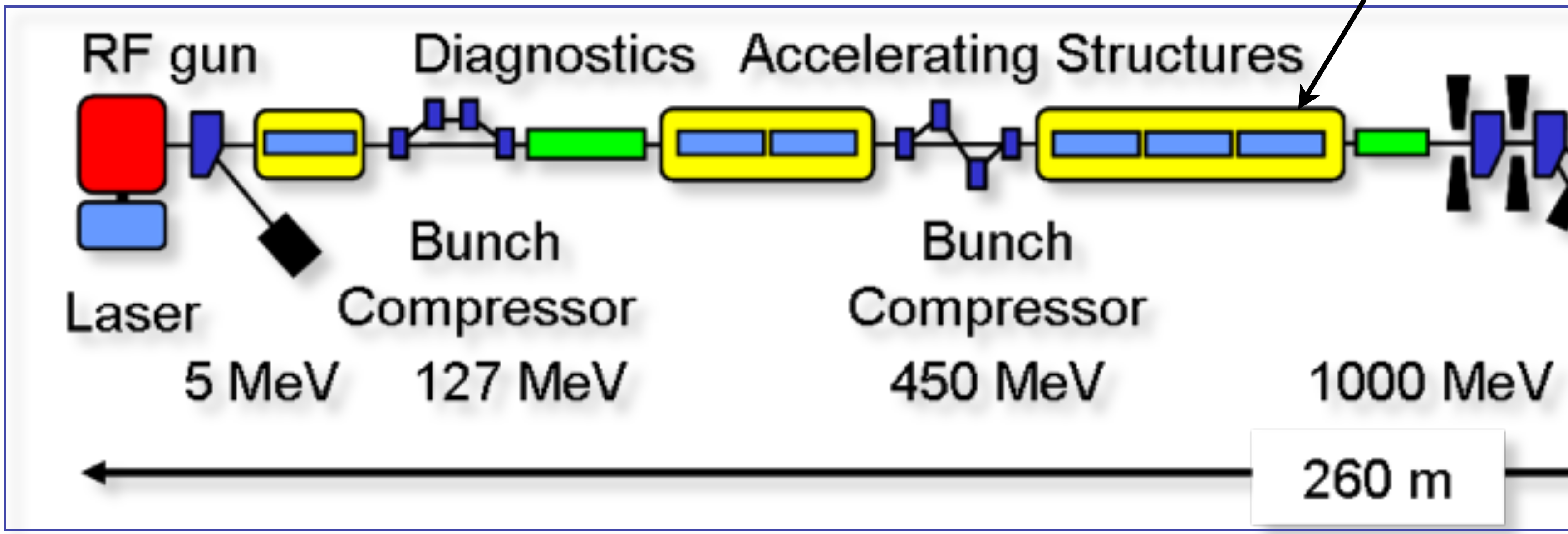
- Final mode measurements: 47 – 51 MV/m

- Second Sound done

High gradient requirement of 45 MV/m foreseen for 1 TeV extension

9 mA Experiments in TTF/FLASH

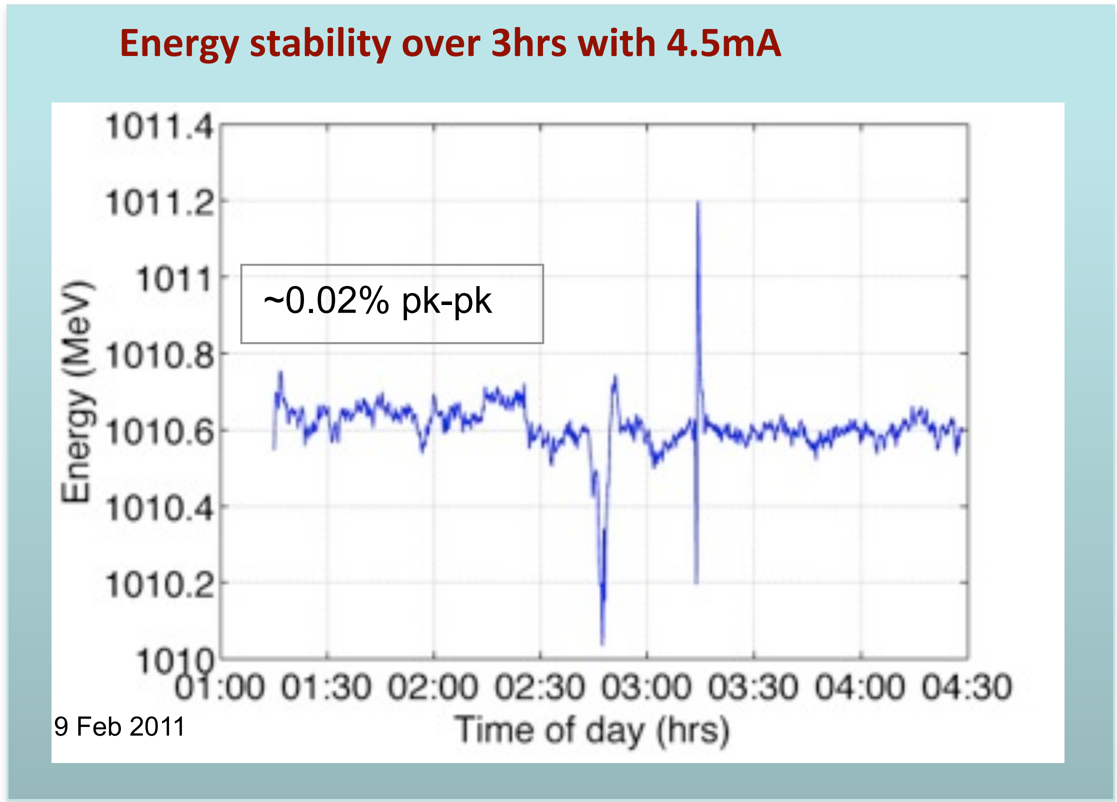
ILC like RF-configuration



		XFEL X-Ray Free-Electron Laser	ilc	FLASH design	FLASH experiment
Bunch charge	nC	1	3.2	1	3
# bunches		3250*	2625	7200*	2400
Pulse length	µs	650	970	800	800
Current	mA	5	9	9	9

TTF/FLASH – 9 mA experiment

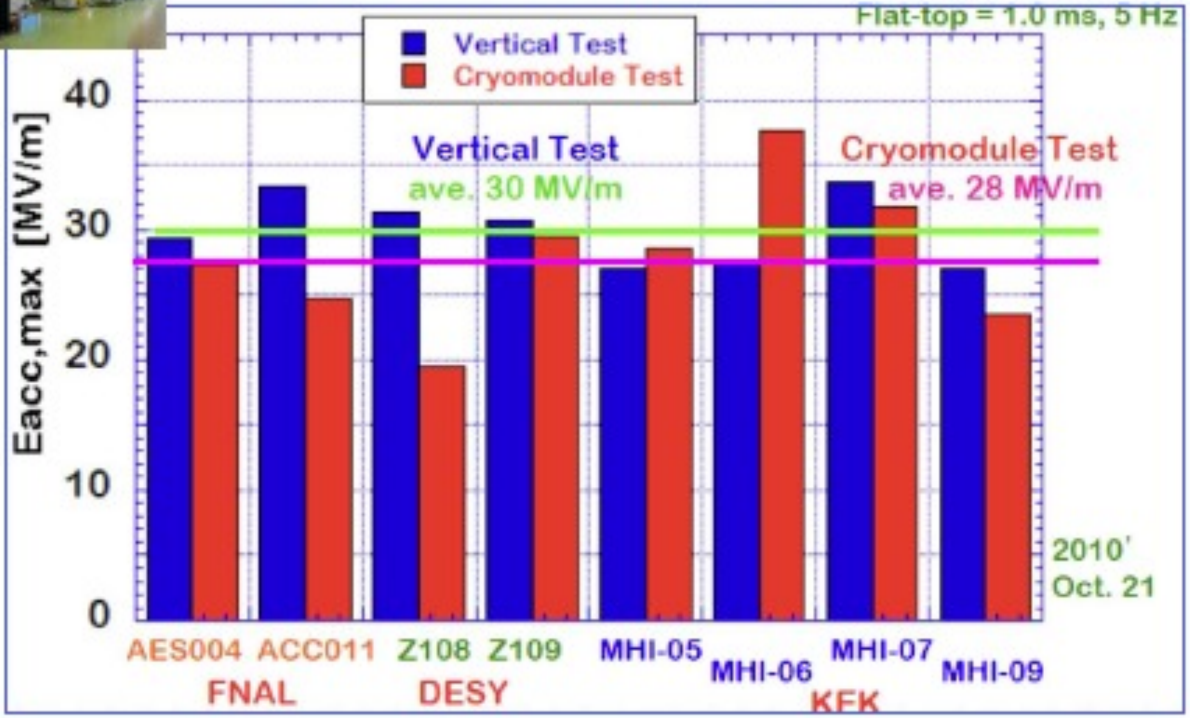
- 15 consecutive studies shifts (120 h) and with no downtime
- Time to restore 400 μs bunch-trains after beam-off studies: ~10 mins
- Energy stability with beam loading over periods of hours: ~0.02%
- Individual cavity “tilts” equally stable



2200 bunches @ 3 nC (3 MHz) for short periods achieved

S1-Global Cryomodule Test in Progress

DESY, FNAL, INFN, KEK, SLAC cooperation and IHEP participation



<u>Vertical cavity test</u>

- CW low power test reached:

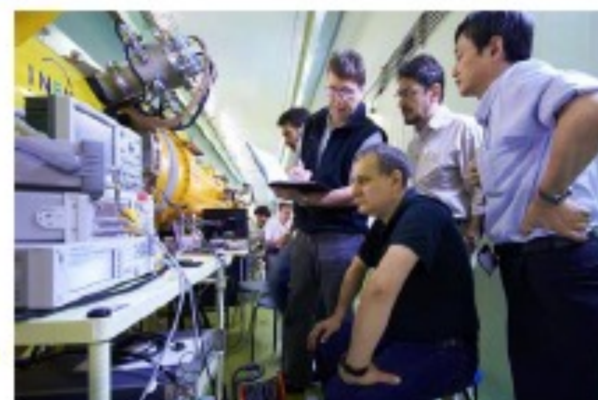
  < 30 MV/m >

<u>S1-Global cryomodule</u>

- 1ms, 5 Hz pulse
  Individual test reaching:

  < 28 MV/m >

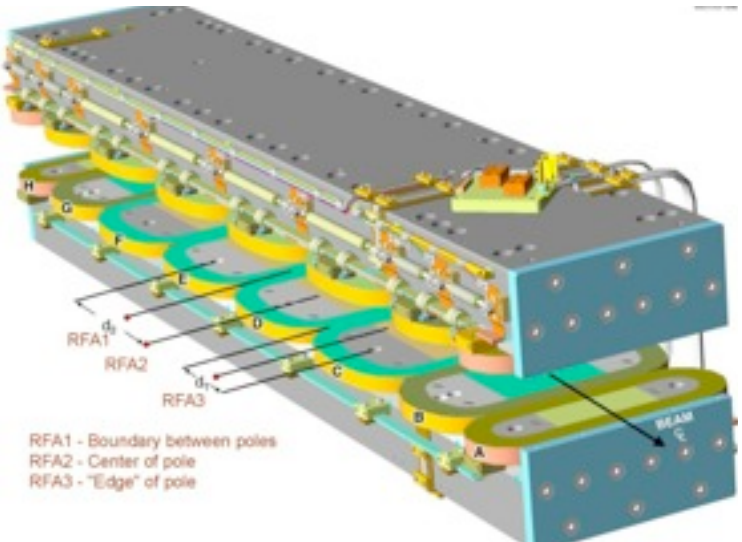
{as of Oct. 22, 2010}

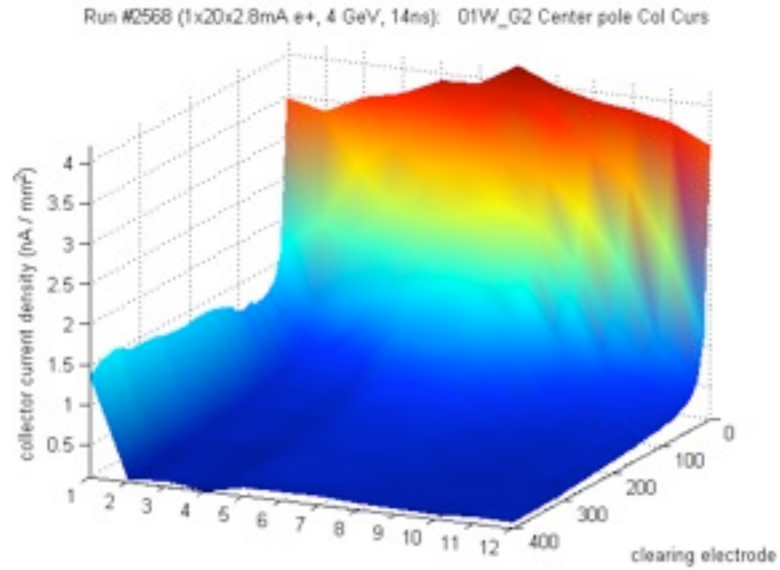


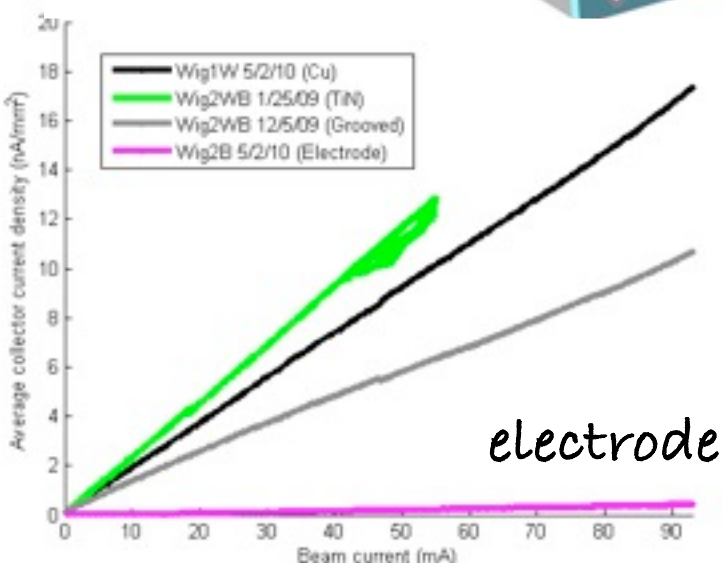
ATF2 – Beam size/stability and kicker tests

2010年 10月 19日 火曜日

CesrTA - wiggler observations



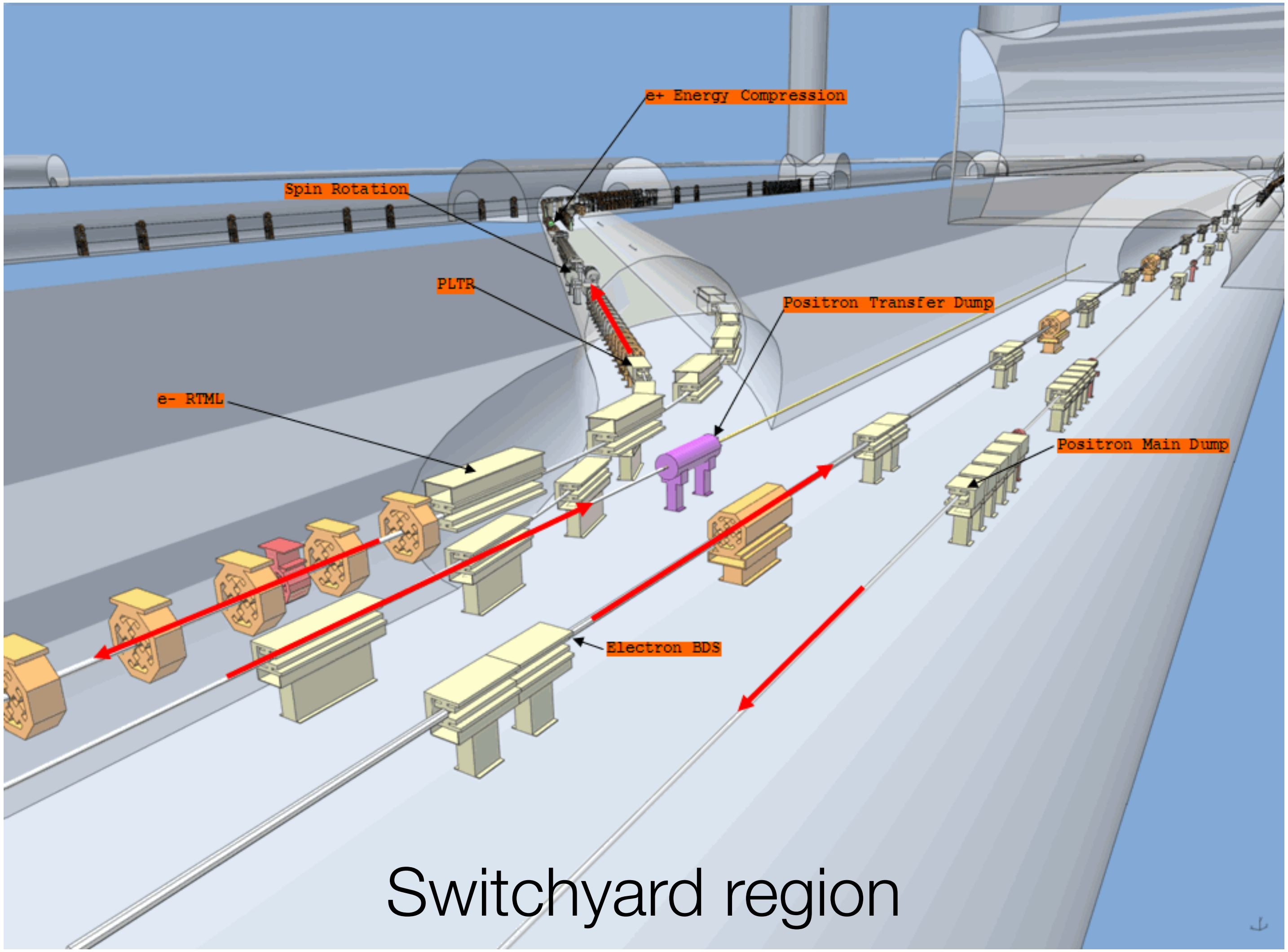




ILC – ecloud mitigation schemes

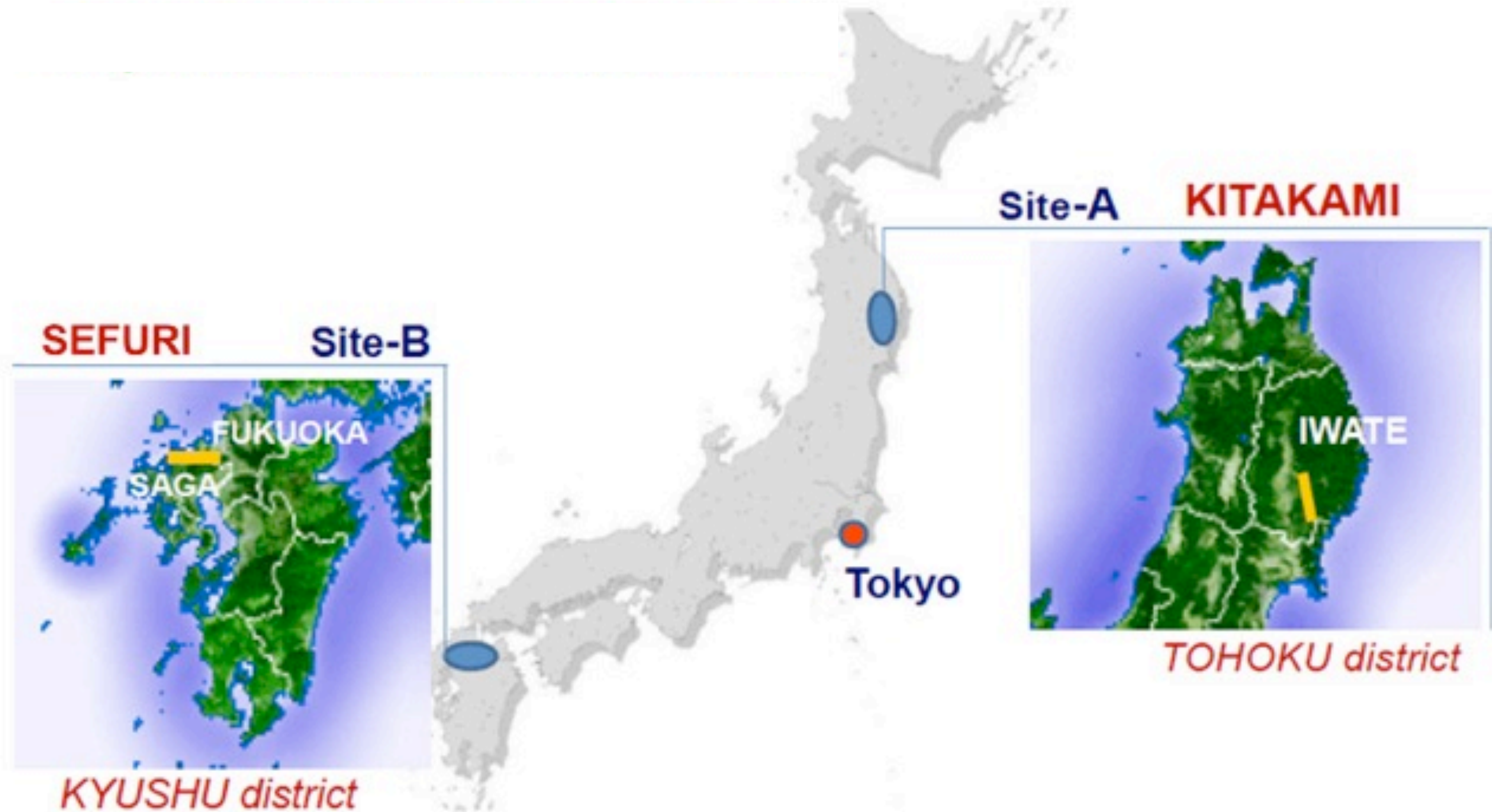
Field Region	Baseline Mitigation Recommendation		Alternatives for Further Investigation
Drift*	TiN Coating	Solenoid Windings	NEG Coating
Dipole	Grooves with TiN Coating	Antechambers for power loads and photoelectron control	R&D into the use of clearing electrodes.
Quadrupole*	TiN Coating		R&D into the use of clearing electrodes or grooves with TiN coating
Wiggler	Clearing Electrodes	Antechambers for power loads and photoelectron control	Grooves with TiN Coating

Detailed views of tunnel layouts available



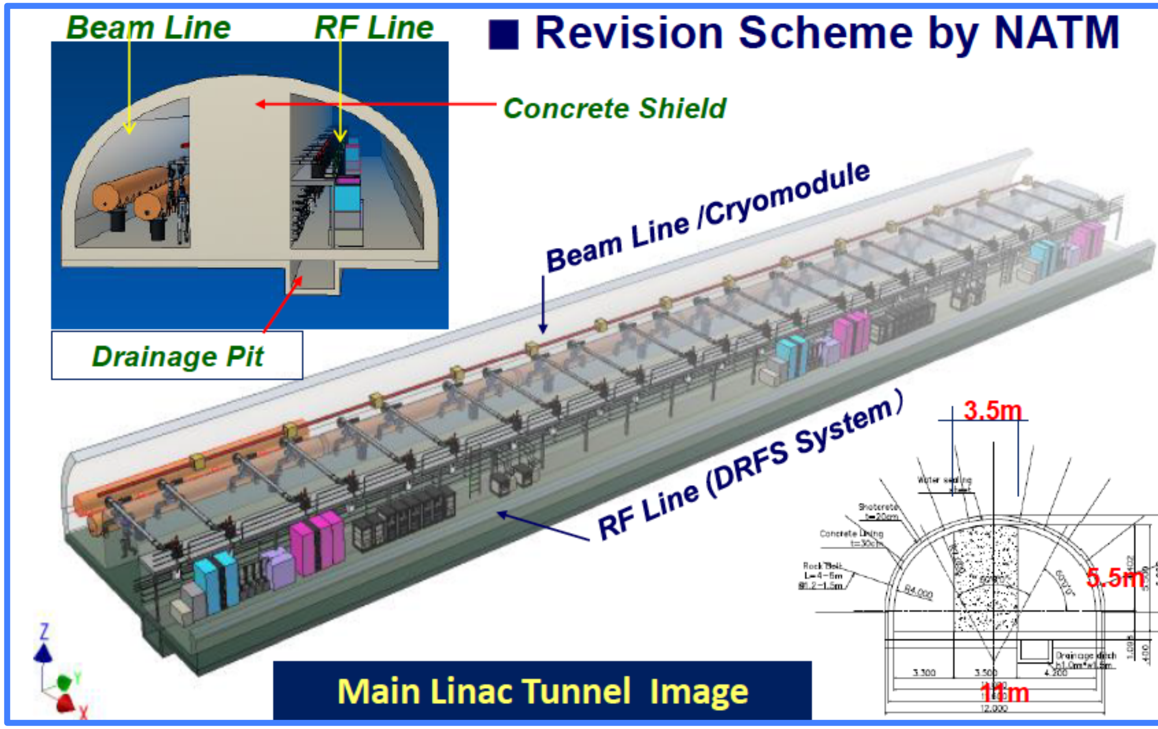
Switchyard region

Japanese candidate sites



Single tunnel layout in granite area

- Broad base (17 m) and 5 m height with refitted 3.5 m concrete wall is cost effective
    - preferred over single circular tunnel
    - Kamaboko tunnel
- Broad tunnel enables use of RDR like HLRF power distribution
    - 10 MW klystron for 26 cavities



recent development

"granite stability test" aired on NHK 19.1.2012

Beyond ILC TDR

ICFA LC parameters subcommittee (2003-2006)

The strong likelihood that there will be new physics in the 500 – 1000 GeV range means that the upgradeability of the LC to about 1 TeV is the highest priority step beyond the baseline.

- The energy of the machine should be upgradeable to approximately 1 TeV.
- The luminosity and reliability of the machine should allow the collection of order of 1 ab^{-1} (equivalent at 1 TeV) in about 3 to 4 years.
- The machine should have the capability for running at any energy value for continuum measurements and for threshold scans up to the maximum energy with the design luminosity ($\sqrt{s}$ scaling assumed).
- Beam energy stability and accuracy should be as stated for the baseline machine.

Extending the reach of the ILC

- Upgrade option for study:
  - Power < 300 MW AC
  - New linac gradient 45 MV/m
  - $Q_0 = 2\times10^{10}$
- Post-TDR program:
  - Improve cavity gradient
  - increase positron yield
  - Cost effective production
- Flexibility: higher or lower energy, as informed by LHC results

Strawman TeV parameters

		500GeV Reference		Straw-man TeV	
		no TF	TF	300MW 5% BS	300MW 10% BS
Ecm	GeV	500	500	1000	1000
gamma		4.89E+05	4.89E+05	9.78E+05	9.78E+05
N	e10	2.0	2.0	2.0	2.0
frep	Hz	5.0	5.0	4.0	4.0
Nb		1312	1312	2280	2280
PB	MW	10.5	10.5	29.2	29.2
sigz	mm	0.3	0.3	0.25	0.15
enx	m	1.0E-05	1.0E-05	1.0E-05	1.0E-05
eny	m	3.5E-08	3.5E-08	3.0E-08	3.0E-08
betax	mm	11.00	11.00	30.00	18.00
betay	mm	0.48	0.20	0.25	0.15
sigx	nm	474.2	474.2	553.7	428.9
sigy	nm	5.9	3.8	2.8	2.1
theta_x	ur	43.1	43.1	18.5	23.8
theta_y	ur	12.2	18.9	11.1	14.3
Dx		0.3	0.3	0.1	0.1
Dy		24.6	38.2	18.7	18.7
Upsilon		0.1	0.1	0.1	0.3
Ngamma		1.7	1.7	1.4	1.7
deltaB		4%	4%	5%	11%
HDx		1.1	1.1	1.0	1.0
HDy		6.1	2.8	3.5	3.5
HDy		2.0	1.5	1.5	1.5
Δp/p e+	%	0.087	0.087	0.033	0.048
Δp/p e-	%	0.22	0.22	0.20	0.20
P e+	%	22	22	30	30
P e-	%	80	80	80	80
L				1.55E+34	2.58E+34
Lgeo		7.51E+33	1.16E+34	1.89E+34	3.16E+34
L (formula)		**1.47E+34**	**1.75E+34**	**2.89E+34**	**4.82E+34**
Simulation (noTF)					
Ngamma				1.443	1.753
deltaB(%)		4.30		5.284	9.823
L		1.49E+34		2.825E+34	4.76E+34
L(1%)		62.5		62.1	50.2
Simulation (TF)					
Ngamma				1.444	1.759
deltaB(%)			4.33	5.258	9.826
L			2.05E+34	3.375E+34	5.639E+43
L(1%)			60.8	60.7	48.5
L(TR)/L(no)				1.19	1.18

ILC Parameter table

- Low power option $L=1.5\times10^{34}\ cm^{-2}s^{-1}$ upgrade $L=3.0\times10^{34}\ cm^{-2}s^{-1}$
- Low energy operation at 10 Hz (interleaved) and $L=0.5\times10^{34}\ cm^{-2}s^{-1}$
- 1 TeV upgrade $L=2.7\times10^{34}\ cm^{-2}s^{-1}$ upgrade $L=4.3\times10^{34}\ cm^{-2}s^{-1}$

Version as of linearcollider.org

	IP and General Parameters			TF = Traveling Focus					L Upgrade	E_{cm} Upgrade	
	Centre-of-mass energy	E_{cm}	GeV	200	230	250	350	500	500	1000	1000
										A1	B1b
	Beam energy	E_{beam}	GeV	100	115	125	175	250	500	500	500
	Lorentz factor			#######	#######	#######	#######	#######	#######	9,78E+05	9,78E+05
	Collision rate	f_{rep}	Hz	5	5	5	5	5	5	4	4
	Electron linac rate	f_{linac}	Hz	10	10	10	5	5	5	4	4
	Number of bunches	n_b		1312	1312	1312	1312	1312	2625	2450	2450
	Electron bunch population	N_-	$\times10^{10}$	2,0	2,0	2,0	2,0	2,0	2,0	1,74	1,74
	Positron bunch population	N_+	$\times10^{10}$	2,0	2,0	2,0	2,0	2,0	2,0	1,74	1,74
	Bunch separation	t_b	ns	554	554	554	554	554	366	366	366
	Bunch separation $\times f_{RF}$	$t_b\,f_{RF}$		720	720	720	720	720	476	476	476
	Pulse current	I_{beam}	mA	5,8	5,8	5,8	5,8	5,8	8,8	7,6	7,6
	RMS bunch length	$_z$	mm	0,3	0,3	0,3	0,3	0,3	0,3	0,250	0,225
	Electron RMS energy spread	p/p	%	0,206	0,194	0,190	0,158	0,125	0,125	0,083	0,085
	Positron RMS energy spread	p/p	%	0,187	0,163	0,150	0,100	0,070	0,070	0,043	0,047
	Electron polarisation	P_-	%	80	80	80	80	80	80	80	80
	Positron polarisation	P_+	%	31	31	30	30	30	30	20	20
	Horizontal emittance	$_x$	m	10	10	10	10	10	10	10	10
	Vertical emittance	$_y$	nm	35	35	35	35	35	35	30	30
	IP horizontal beta function	$_x^*$	mm	16	16	12	15	11	11	22,6	11,0
	IP vertical beta function (no TF)	$_y^*$	mm	0,48	0,48	0,48	0,48	0,48	0,48	0,25	0,23
	IP RMS horizontal beam size	$_x^*$	nm	904	843	700	662	474	474	481	335
	IP RMS veritcal beam size (no TF)	$_y^*$	nm	9,3	8,6	8,3	7,0	5,9	5,9	2,8	2,7
analytical estimate	Horizontal distruption parameter	D_x		0,2	0,2	0,3	0,2	0,3	0,3	0,1	0,2
	Vertical disruption parameter	D_y		20,7	20,7	23,8	21,3	24,9	24,9	18,9	25,4
	Horizontal enhancement factor	H_{Dx}		1,1	1,1	1,1	1,1	1,2	1,2	1,0	1,0
	Vertical enhancement factor	H_{Dy}		5,7	5,7	6,0	5,8	6,1	6,1	3,6	4,1
	Total enhancement factor	H_D		1,8	1,8	1,9	1,8	2,0	2,0	1,5	1,6
	Geometric luminosity	L_{geom}	$\times10^{34}\ cm^{-2}s^{-1}$	0,25	0,29	0,36	0,45	0,75	1,50	1,77	2,64
	Luminosity	**L**	$\times10^{34}\ cm^{-2}s^{-1}$	**0,46**	**0,52**	**0,69**	**0,83**	**1,47**	**2,95**	**2,71**	**4,33**
	Average beamstrahlung parameter	$_{av}$		0,013	0,016	0,021	0,032	0,063	0,063	0,130	0,207
	Maximum beamstrahlung paramete	$_{max}$		0,032	0,039	0,051	0,075	0,150	0,150	0,312	0,495
	Average number of photons / partic	n		0,96	1,02	1,22	1,28	1,74	1,74	1,44	1,99
	Average energy loss	E_{BS}	%	0,53	0,68	1,04	1,55	3,76	3,76	5,48	10,46
simulation	Luminosity	L	$\times10^{34}\ cm^{-2}s^{-1}$	0,468	0,548	0,708	0,858	1,49	2,98	3,23	4,31
	Coherent waist shift	W_y	m	250	250	250	250	250	250	190	190
	Luminosity (inc. waist shift)	**L**	$\times10^{34}\ cm^{-2}s^{-1}$	**0,5**	**0,6**	**0,8**	**0,9**	**1,8**	**3,6**	**3,6**	**4,9**
	Fraction of luminosity in top 1%	$L_{0.01}/L$		92,2%	89,8%	84,1%	79,3%	62,5%	62,5%	60,2%	45,5%
	Average energy loss	E_{BS}		0,61%	0,78%	1,23%	1,75%	4,30%	4,3%	5,3%	9,9%
	Number of pairs per bunch crossing	N_{pairs}	$\times10^3$	40,9	50,1	70,5	89,1	139,0	139,0	200,5	382,6

Conclusion

- ILC is well on track to deliver the TDR by end of 2012
  - 500 GeV machine with capability for scan $200 < \sqrt{s} < 500$ GeV
  - upgrade option for 1 TeV included with $P < 300$ MW
- Beyond TDR: research on
  - higher gradient
  - efficient e^+-production (luminosity limitation)
  - cost
  - power efficiency