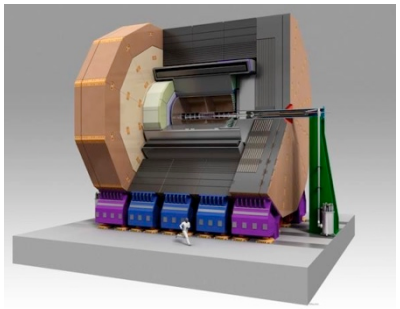
ILD
International Large Detector

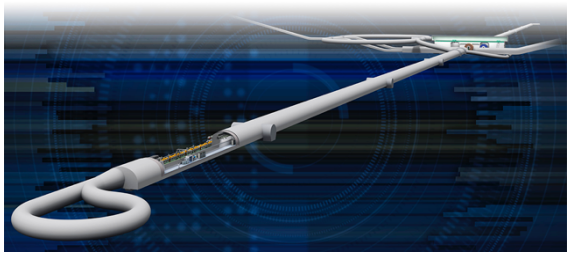
Kiyotomo Kawagoe / Kyushu University

on behalf of the ILD group

ECFA-LC Workshop

2nd June 2016, Santander

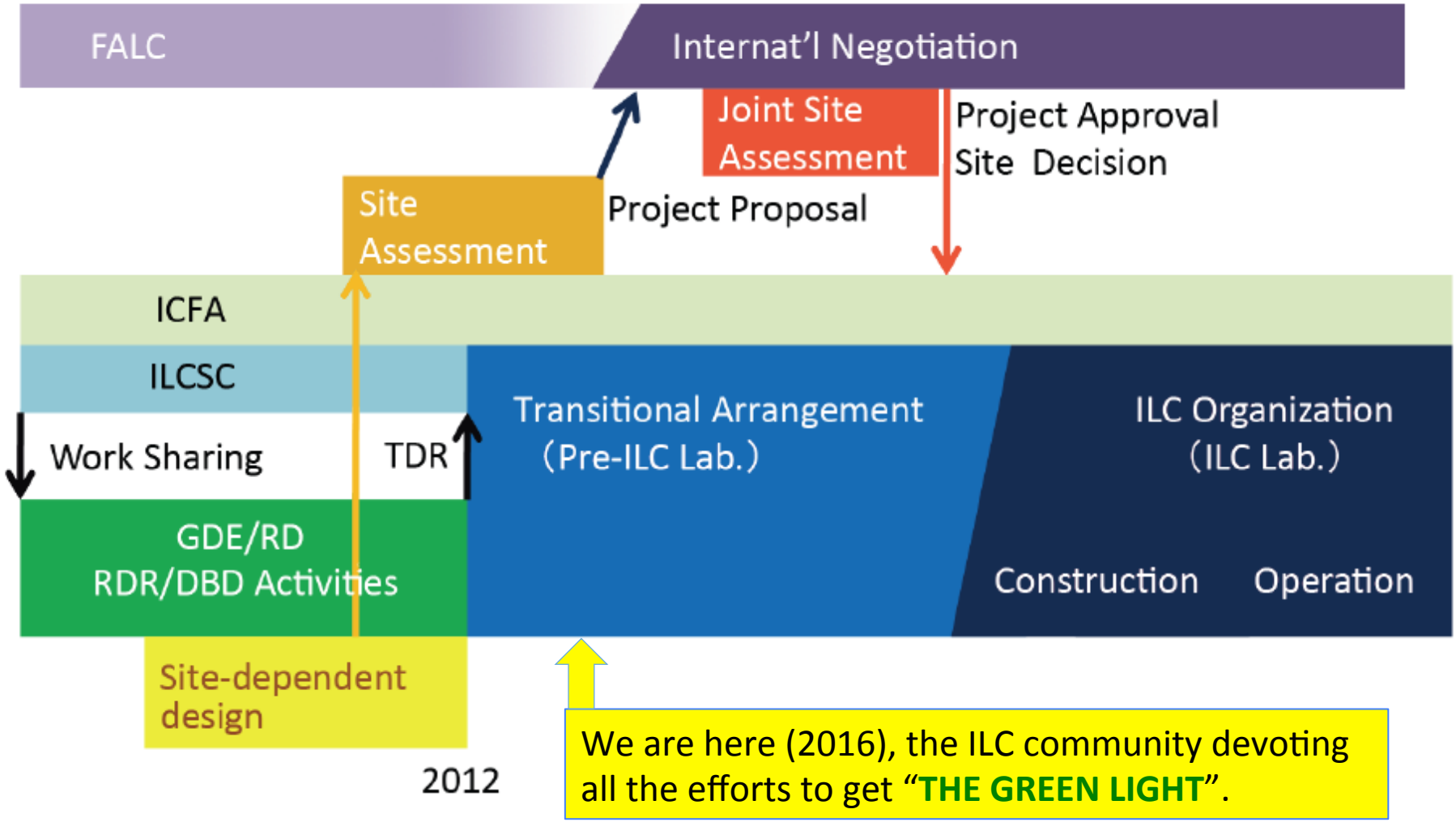




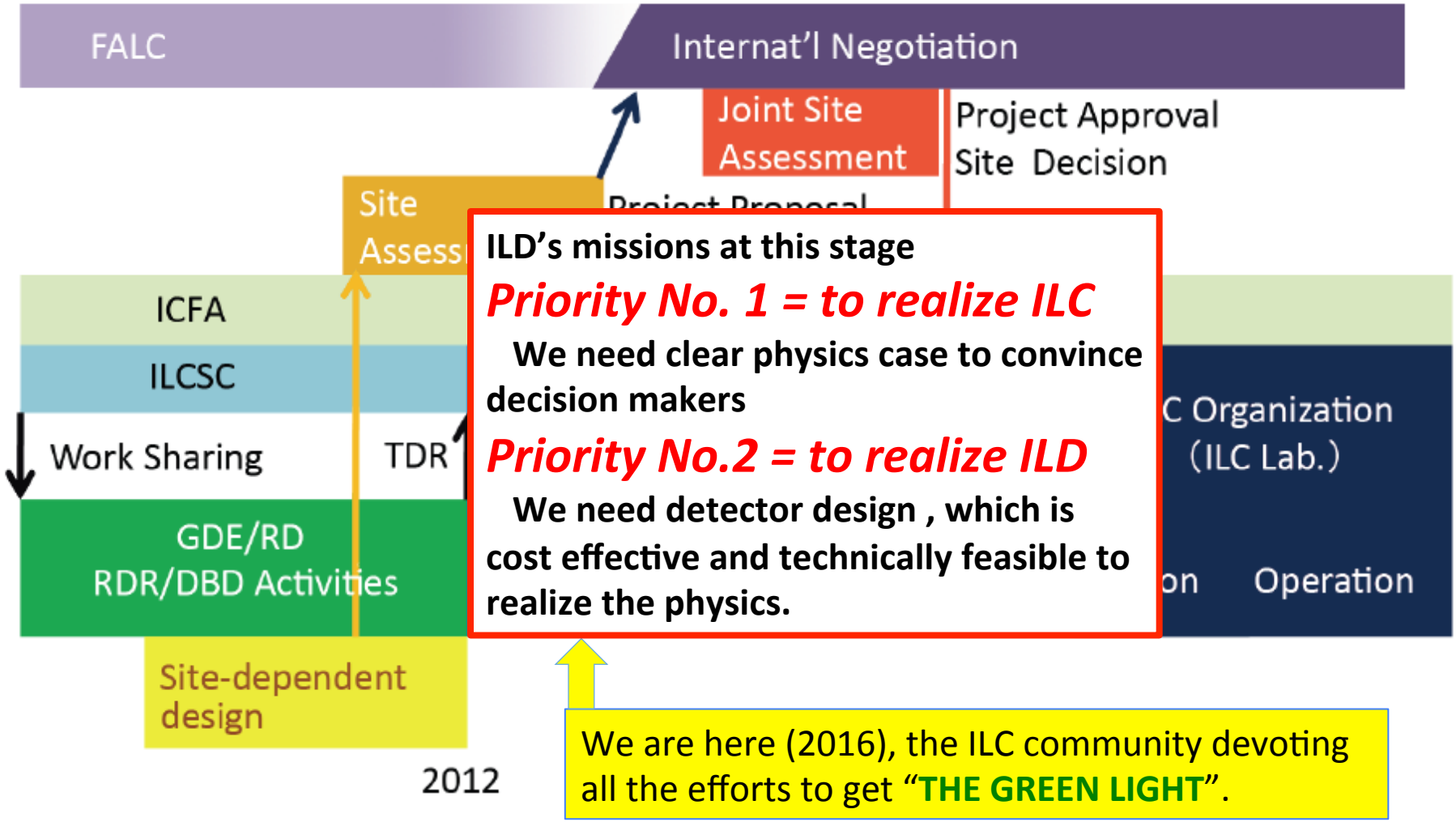
Kyushu University RCAPP

九州大学 KYUSHU UNIVERSITY

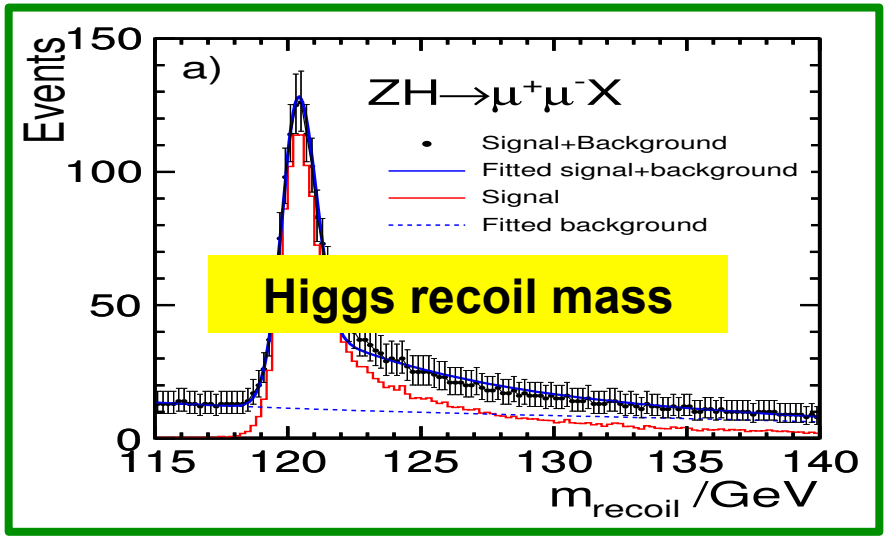
ILC Time Line

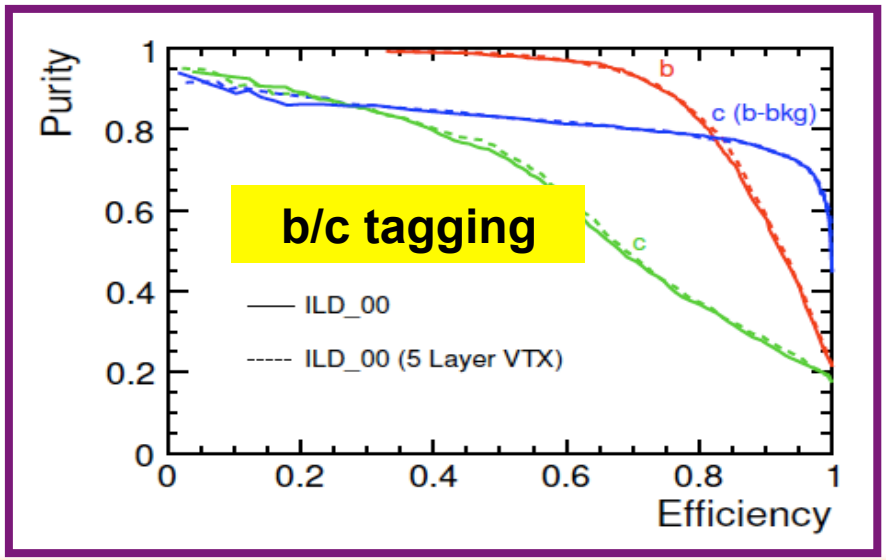


ILC Time Line



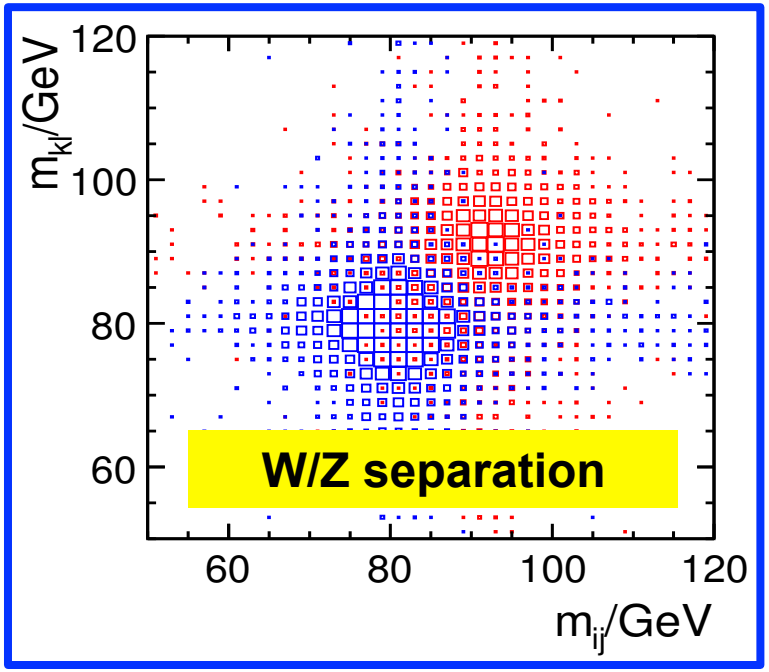
Requirements for ILC detectors





ILC detectors must have unprecedentedly

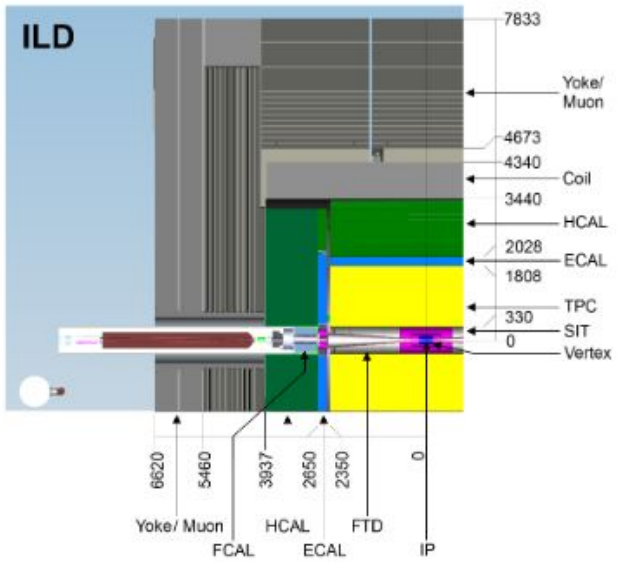
- **Good momentum resolution**
- **Good vertex resolution**
- **Good Jet energy resolution**
- **Good hermeticity for detection of missing particles**

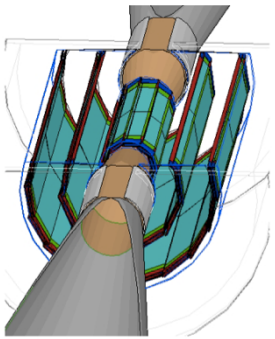


A “Particle Flow” Detector

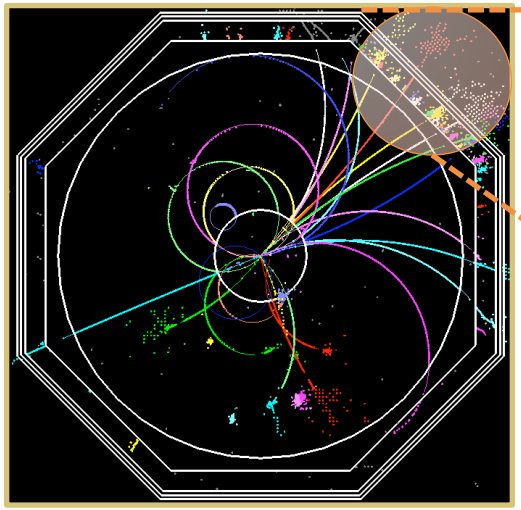
ILD is optimized for PFA with

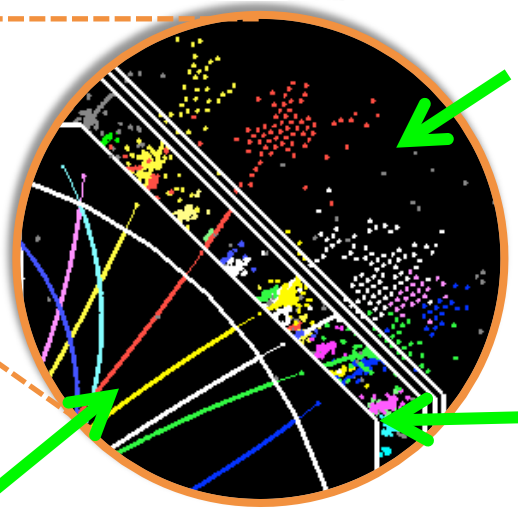
- “Large” TPC radius (ECAL inner radius) for good particle separation in jets (~1.8m in DBD)
- Pixel vertex detector for flavor tagging
- TPC + Si trackers for robust track reconstruction
- High granularity ECAL/HCAL in a solenoid
- Yoke/Muon detector, Very forward system





Vertex



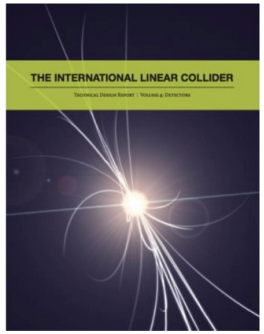


Our plans

We must be well prepared in case that the ILC will receive **THE GREEN LIGHT** in 2-3 years (or sooner).

Within O(2) years we are going to

- **Redefine our baseline detector**, based on
  1. significant studies with different models
     - close collaboration of physics, software/reconstruction, and technical groups
  2. progress of sub-detector technologies
     - close collaboration with detector R&D groups (LCTPC, CALICE, FCAL, etc)
     - follow technologies developed for other experiments (LHC upgrades etc.)
     - follow newly emerging technologies
  3. development of assembly/installation processes assuming a Japanese site
     - close collaboration with accelerator/MDI people
- Write a light-weight document that updates DBD



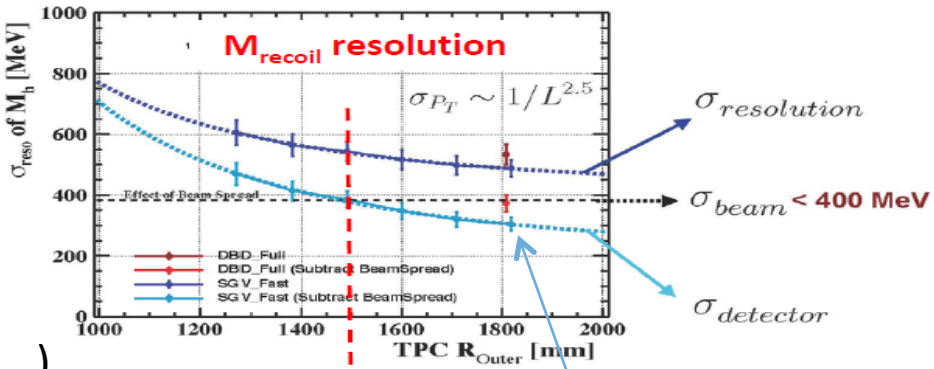
ILD DBD in ILC TDR
Volume 4 (June 2013)

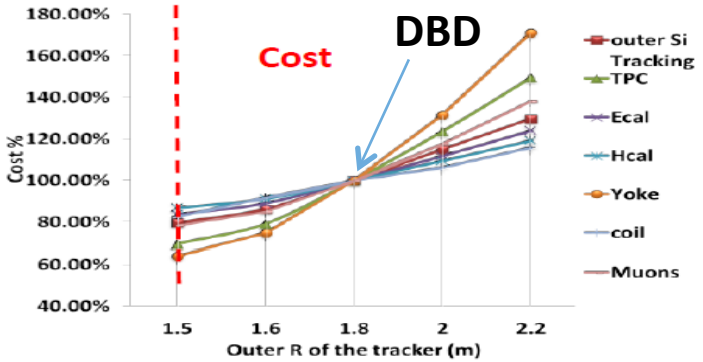
OPEN QUESTIONS

- **General optimization of the detector size**
  - ✓ cost vs performance ➔

- VTX layout: with/without endcaps ?
- Transition to forward tracking system
- TPC outer radius
  - ✓ Length and Radius for TPC
  - ✓ Performance for some issues (dE/dx …)
- ECAL inner radius and depth
- HCAL depth in Lambda
- Forward region layout

- Cost update
  - ✓ Sub-detector level
  - ✓ Global level
- Impact on running scenarios
  - ✓ Operation at 10Hz ?
- Calibration and alignment strategies
  - ✓ calibration run at Z^0 ?

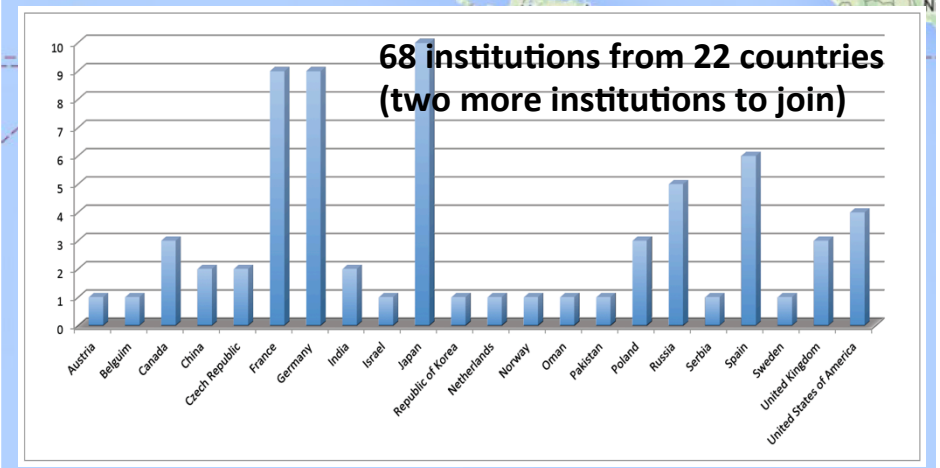


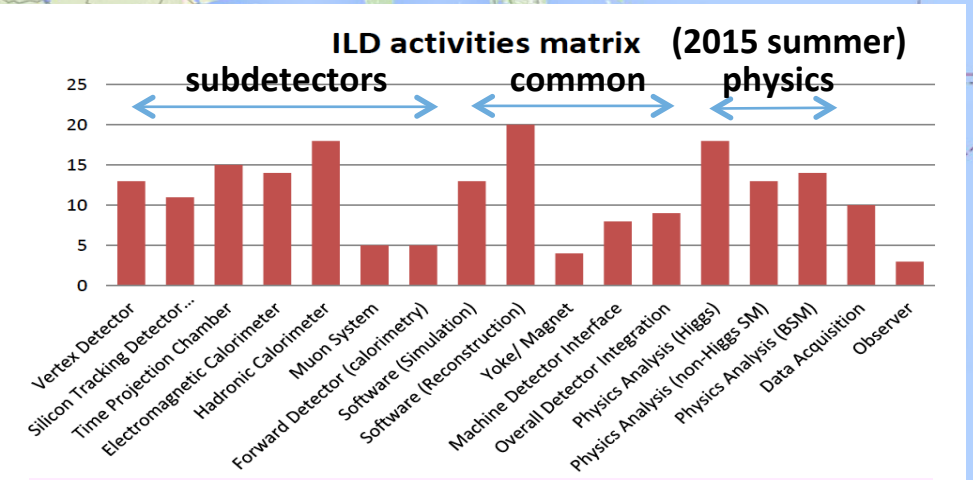


Many things to do !
The manpower and budget are limited.
We must work very efficiently.

ILD institutions

ILD institutions

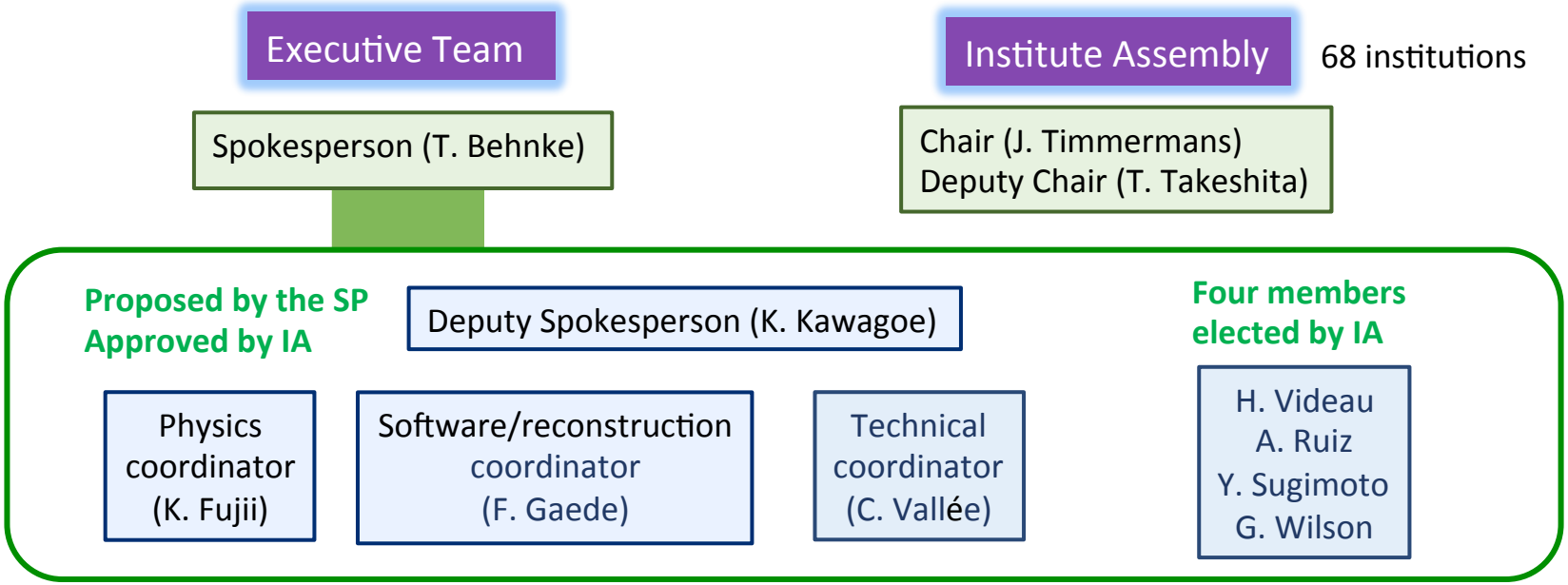




reasonably balanced, rooms for newcomers

New management
-- from a concept toward a real experiment --

- 2014 October: the Chair of the Institute Assembly was elected.
- 2015 April: the Spokesperson was elected by IA.
- 2015 November-December:
  - Deputy-chair of the IA, proposed by the Chair, was approved by IA.
  - Four members of the Executive Team, proposed by the Spokesperson, were approved by IA.
- 2016 January-March: Four members of the Executive Team were elected by the IA.
- 2016 April: Structure of Technical group was established.
- Now: Structures of "Physics" and "Software/reconstruction" groups are being established.



Physics group

Coordinated by K. Fujii + Deputy

Goals

1) to make compelling physics case for ILC that can convince decision makers that ILC is worth the investment,

> ILC Advisory Panel's Discussion to Date (August 2015, MEXT, Japan)
> Recommendation 1: " … a clear vision on the discovery potential of new particles as well as that of precision measurements of the Higgs boson and top quark has to be shown. …"
> Recommendation 2: "… it is necessary to closely monitor, analyze, examine the development of the LHC experiments. ..."

2) and to optimize ILD so as to realize (1)

Three subgroups are to be made, each having two conveners

a) Higgs/EW, b) Top/QCD, c) BSM/NP

Study of light Higgsinos

LHC already excluded large SUSY regions for which ΔM is large ($\Delta M = M_{NLSP} - M_{LSP}$)

Remaining region has compressed spectrum i.e. small ΔM

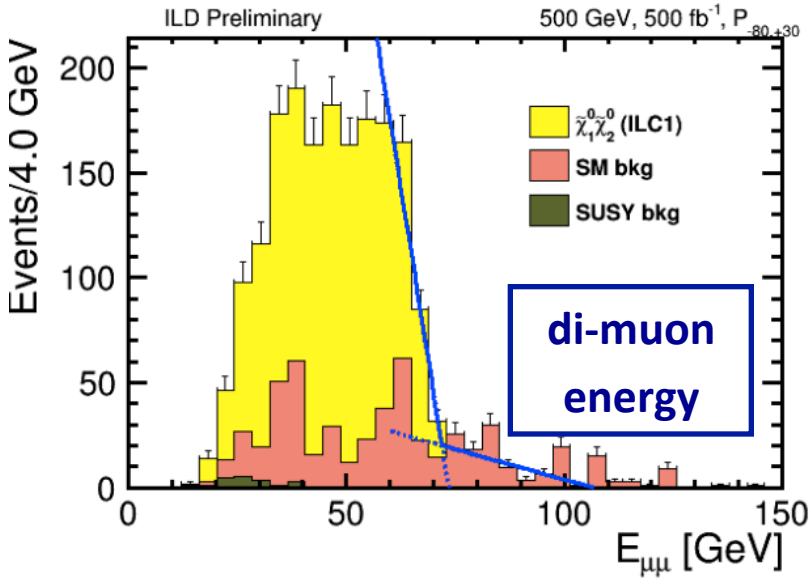
→ very small visible energy, nearly impossible to probe at LHC ➔ **ILC is essential !!**

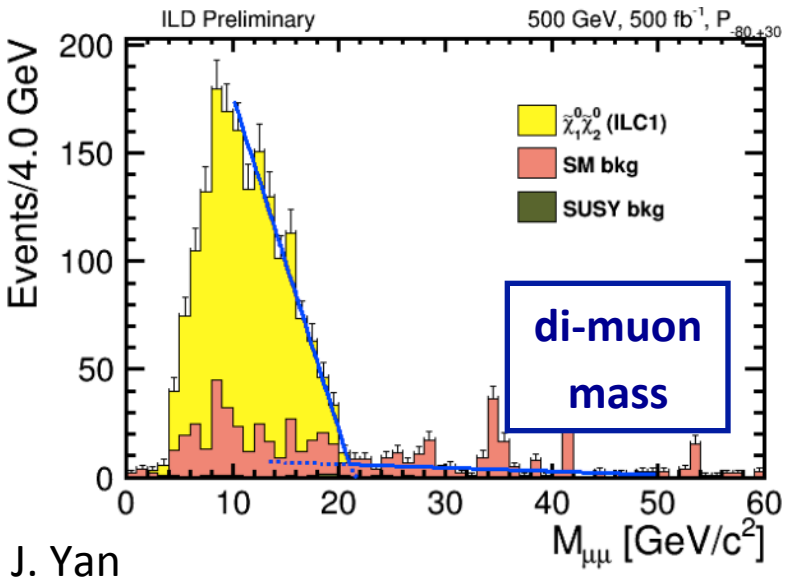
Study in the RNS (Radiatively-driven Natural SUSY) model
where **three Higgsinos are light** and other SUSY particles are too heavy to produce.

Neutralino mixed production with leptonic decay

$$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ell^+ \ell^-$$

Signal: low energy lepton pair + missing
Kinematic edges can determine the mass spectrum

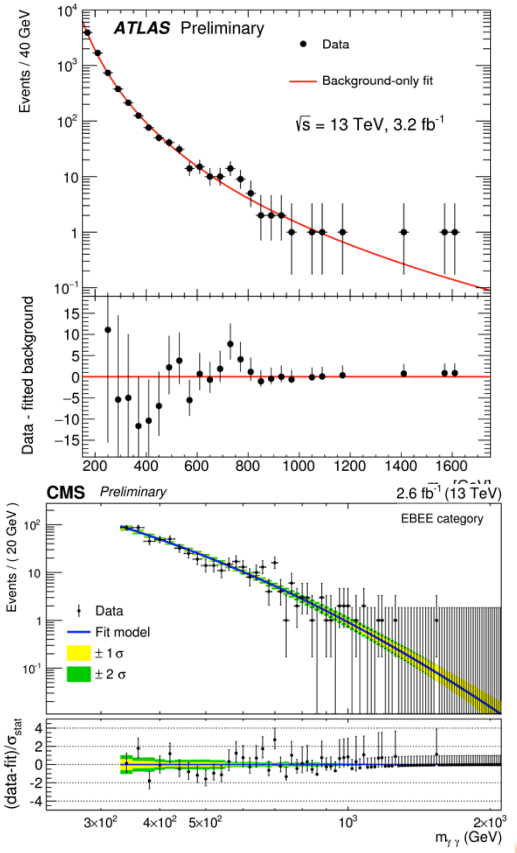




J. Yan

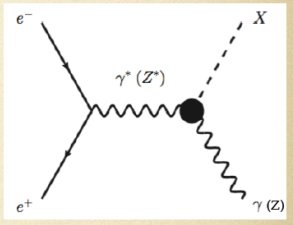
X(750) at the ILC

The bump observed in the LHC 13 TeV run has an enormous impact on the ILC project, if it is confirmed to be “TRUE”.



X(750) search @ e+e- collider

- since Γ(X—>γγ) is large —-> photon collider
- if X couples to ee —> single X production

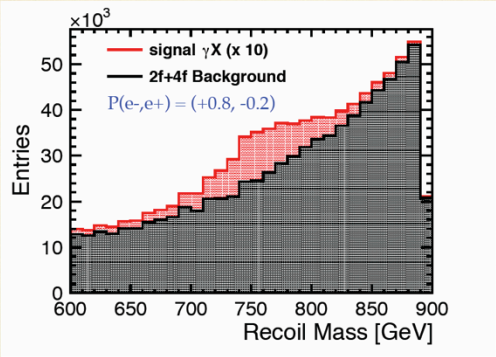


our strategy:

- X(750) can be directly produced via e+e- —>γX
- if X(750) couples to $SU(2)_L$ or $U(1)_Y$ fields, it implies Γ(X—>γZ/ZZ) —> production channel e+e- —>ZX

reconstructed recoil mass (inclusive)

$e^+ + e^- \to \gamma X$ @ 1 TeV $\int L = 2\text{ab}^{-1}$



significance ~ 10σ

without looking at decay

J. Tian

Study of the strategy to determine X(750)’s

- mass, spin, parity
- total width, couplings

See also talks of F. Richard, K. Hamaguchi at physics session

Very active physics analyses

47 Physics analyses

+

9 det. opt. analyses

+

29 analyses on tools

Many contributions to this workshop !!

ILD Physics and Detector Optimisation Studies										
Analysis Contact	**email**	**supervisor/collaborator**	**institute**	**Topic**	**EOM**	**Full / Fast**	**Status**	**last presen.**	**Asian meeting**	**Comment**
Physics Analyses										
Abhinav Dubey	abhinav@epx.phys.tohoku.ac.jp		Tohoku	Heavy Higgs search (Neutral)	500/1000	Full Sim	abandonned	Jan-07	Feb-06	e+e- ? HA ? 4b
Akimasa Ishikawa	akimasa@epx.phys.tohoku.ac.jp		Tohoku	H->Invisible	250 /350 / 500	Full Sim	almost done	Nov-19		almost done
Alexey Drutskoy	Drutskoy@itep.ru		ITEP	H->tautau CP	?	?	planned			
Ali Ebrahimi	aliakbar.ebrahimi@desy.de	JL	DESY	Higgs mass from H->bb	500	Full Sim	just started			
Brian van Doren			Kansas U	?						
Claude Duerig	claude.duerig@desy.de	JL						Nov-26		Kinfit, ME, Jet Finding
Daniel Jeans	jeans@icepp.s.u-tokyo.ac.jp								Dec 12	Kinfit, angular reco
Davide Mellini		Marcel Vos / LAL								currently working on ttH at ATLAS
Emi Kou		Francois LeDiberder								Whizard / Madgraph interface…?
Felix Mueller	felix.johannes.mueller@desy.de	JL						Nov-26		
Graham Wilson										
Hale Sert	hale.sert@desy.de	JL						Oct 22		has to hand-in thesis in early 2015
Hiroaki Ono	ono@ngt.ndu.ac.jp	Akiya								H->bb,cc,gg & H->WW*, updating with mH=125GeV
Jacqueline Yan	rinrin84@gmail.com	Daniel Jeans							Mar 13	comparison with 250 GeV, next focus on mass
Junping Tian	tianjp@post.kek.jp	Keisuke/Claude/Jenny						Feb-18	Feb-20	need be updated to mH=125GeV, being considered as one early publication
Junping Tian	tianjp@post.kek.jp	Keisuke								For total width study, only full hadronic decay of ZZ* remains to be done
Junping Tian	tianjp@post.kek.jp	Keisuke								For total width study, only full hadronic decay of ZZ* remains to be done
Junping Tian	tianjp@post.kek.jp	Keisuke								H->bb done, going to explore anomalous HZZ coupling, particularly CP violation effect
Koya Tauchimoto	tauchimoto@azusa.shinshu-u.ac.jp	Katsuhige						Jan-21	Feb-27	motivated by impact of ScECAL on JER, going to be a master project
Madalina Chera	madalina.chera@desy.de	JL						Feb-18		Comparison LoI, DBD, SGV
Marca Boronat		Marcel Vos / LAL								new method, ~ 6 months
Marcel Vos										Jet finding
Mark Thomson	thomson@hep.phy.cam.ac.uk									
Mark Thomson	thomson@hep.phy.cam.ac.uk							Oahu		publication in prep
Martin Perelló		Marcel Vos / LAL								take over from Nacho
Masakazu Kurata	kurata@icepp.s.u-tokyo.ac.jp								Feb-27	PID, jet pairing, kin fit
Mikael Berggren	mikael.berggren@desy.de							Dec 10		incl. selectrons from S.Calasza
Morite Habermehl	morite.habermehl@desy.de	JL						Nov-19		Taking over from A.Chaus, focus on systematics
Nacho Garcia		Marcel Vos / LAL						Dec 10		arXiv
PhD MPI										
Postdoc MPI										
Rashid Mehdiyev	Rashid.Mehdiyev@carleton.ca	Alain Bellerive								
Shin-ichi Kawada	s-kawada@huhep.org	Taikan / Tomohiko						Nov-19	Feb-06	updating with mH=125 GeV
Shun Watanuki	watanuki@epx.phys.tohoku.ac.jp	Jan						Nov-05		Fitting techniques, systematic error of mass, CP
Shun Watanuki	watanuki@epx.phys.tohoku.ac.jp	Jan						Nov-05		Fitting techniques, systematic error of mass, CP
Svatoslav Bilokin	bilokin@lal.in2p3.fr	Roman Poeschl, Dirk Zerwas								title of thesis: "Top quark production at the ILC and optimisation of Particle Flow Algorithm
Takuaki Mori	takuaki@icepp.s.u-tokyo.ac.jp	Tomohiko								Input for gaugino mass unification plot
Tatsuhiko Tomita	tomita@epp.phys.kyushu-u.ac.jp	Taikan						Mar 4		ISR tagging, cut opt for model independency / LEAVING?
Tino Calancha	calancha@post.kek.jp	Akiya							Feb-20	now mainly on H->2gam gam at 250 GeV, and H->mumu at 250 and 500 GeV
Tomohiko Tanabe	tomohiko@icepp.s.u-tokyo.ac.jp									need scan points
Tomohisa Ogawa	ogawat@post.kek.jp	Junping / Keisuke								PhD project
Tomohisa Ogawa	ogawat@post.kek.jp	Junping / Keisuke							Mar 13	PhD project
Yorgos Voutsinas	georgios.voutsinas@desy.de	JL/PG								Taking over from Hale, focusing on VXD requirements
Yuji Sudo	sudo@phys.kyushu-u.ac.jp	Taikan								looking at systematics, cut opt / MVA
Yuka Shinzaki	shinzaki@epx.phys.tohoku.ac.jp	Jan / Akimasa							Jan-15	e+e- ? WH ? W(WZ) / GONE TO INDUSTRY
Trong Hieu	trong.hieu.tran@llr.in2p3.fr	Vincent Boudry								
Imad Laktineh	imad.laktineh@cern.ch									SDHCal
Imad Laktineh	imad.baptiste.laktineh@cern.ch									SDHCal
Detector Optimisation										
Benjamin Bolteille	benjamin.bolteille@desy.de	IM Gregor								Physics benchmark: H->ccbar
Dan Yu	dan.yu@llr.in2p3.fr	Vincent Boudry								
Hiroki Sumida		Taikan	Kyushu	Ecal Layer Opt		Full Sim	ongoing	Jan-14		
Mikael Berggren	mikael.berggren@desy.de	JL	DESY	Tracker optimisation		SGV	ongoing	Feb-11		
Sergei Schuwalow			DESY	FCal Opt				Jan-07		
Steven Green		Mark Thomson	Cambridge	HCal optimisation		Full/Sim	ongoing	Jan-14		
Tino Calancha	calancha@post.kek.jp	Akiya	KEK	photon energy resolution, momentum resolution	500/1000	Full Sim	ongoing			Physics benchmark: H->gammagamma, H->mumu
Tomohisa Ogawa	ogawat@post.kek.jp	Junping / Keisuke	KEK	SiW vs SciW ECAL, TPC radius	250/350	Full Sim / SGV	almost done	Nov-12		Physics benchmark: H->invisible, leptonic recoil with various TPC radius (SGV): continue
Yorgos Voutsinas	georgios.voutsinas@desy.de	JL/PG	DESY	VXD time/point res optimisation	500	Full/Sim	starting			Physics benchmark: light Higgsinos
Reconstruction & Analysis Tools										
Bo LI										
Brian van Doren										eg Higgs mass reco
Dan Yu	dan.yu@llr.in2p3.fr									
Daniel Jeans	jeans@icepp.s.u-tokyo.ac.jp									
Daniel Jeans	jeans@icepp.s.u-tokyo.ac.jp									
Daniel Jeans	jeans@icepp.s.u-tokyo.ac.jp									
Eldwan Brianne	eldwan.brianne@desy.de									to Calice testbeam
Frank Gaede										
Hale Sert	hale.sert@desy.de									-in thesis in early 2015
Junping Tian	tianjp@post.kek.jp	Keisuke	KEK	matrix element package (physsm)		Full Sim	ongoing			implement major LCFIPlus class in SM, support anomalous coupling, more development on
Junping Tian	tianjp@post.kek.jp	Keisuke	KEK	overlay removal, seed based	1 TeV	Full Sim	ongoing		Feb-06	for nunuHH at 1TeV
Junping Tian	tianjp@post.kek.jp	Keisuke	KEK	realistic color singlet jet clustering		Full Sim	ongoing			Mini-jet based, incorporating new Geogl Algorithm
Marcel Vos	marcel.vos@cern.ch		IFIC	systematic uncertainties			just started	Feb-11		
Mark Thomson		NN? Masakazu???	Cambridge	Pandora PFA		Full/Sim	maintenance			
Masakazu Kurata	kurata@icepp.s.u-tokyo.ac.jp		Tokyo	dE/dx and Calo PID	500	Full/Sim	ongoing	Oct 1		physics benchmark:ZHH
Masakazu Kurata	kurata@icepp.s.u-tokyo.ac.jp	Tomohiko/ Taikan / Jan	Tokyo	LCFI			ongoing			
Masakazu Kurata	kurata@icepp.s.u-tokyo.ac.jp		Tokyo	vertex charge, pi0 attach	500	Full/Sim	ongoing			physics benchmark:ZHH, tt
Mikael Berggren	mikael.berggren@desy.de		DESY	Colour Singlet Truth Jet Finder			done	Oct 1		will be in next release. physics appl: ZHH ADAPT TO HIGGS SAMPLES
Mikael Berggren	mikael.berggren@desy.de		DESY	SGV Maintenance		SGV	stable			several improvements in pipeline
Morite Habermehl	morite.habermehl@desy.de	MB	DESY	Whizard 2 comlisioning			ongoing			new GuineaPig interface, physics appl: WIMPs
Nacho Garcia		Marcel Vos / LAL	IFIC	Jet reconstruction	500	Full/Sim	ongoing			application: top couplings
Shaojun Lu		Tino Calancha	DESY/KEK	MC Production				Feb-04		
Svatoslav Bilokin	bilokin@lal.in2p3.fr	Roman Poeschl, Dirk Zerwas	LAL	b jet charge	500	Full/Sim	ongoing	Feb-11		application: top couplings
Svatoslav Bilokin	bilokin@lal.in2p3.fr	Roman Poeschl, Dirk Zerwas	LAL	Matrix element method	500	Full/Sim	plan			application: top couplings
Svatoslav Bilokin	bilokin@lal.in2p3.fr	Roman Poeschl, Dirk Zerwas	LAL	PFA development		Full/Sim	plan			improving PandoraPFA
Taikan Suehara	suehara@phys.kyushu-u.ac.jp	Shin-ichi	Kyushu	tau finder	250/500	Full Sim	almost			optimization
Tino Calancha	calancha@post.kek.jp	Akiya	KEK	Covarince matrix of four momentum, event by event mass resolution		Full Sim	ongoing			done for charged track in H->mumu, can start for H->gam gam
Yorgos Voutsinas	georgios.voutsinas@desy.de	PG	DESY	mini-vector tracking in VDX/SIT		Full/Sim	nearly done			
Yorgos Voutsinas	georgios.voutsinas@desy.de	PG	DESY	ILD Performance		Full/Sim	ongoing	Feb-18		
	PFA -" write email to Mark									

J. Tian @LCWS15

Software/reconstruction

Coordinated by F. Gaede + Deputy

Missions

- develop, maintain and provide the software tools that are needed for ILD detector and physics studies
- produce and provide the necessary Monte Carlo samples
- do this in close collaboration and with the support from the technical and physics groups
- continue the collaboration on software tools with the other LC detector concept groups as well as other HEP groups

Four subgroups are to be made, each having two conveners

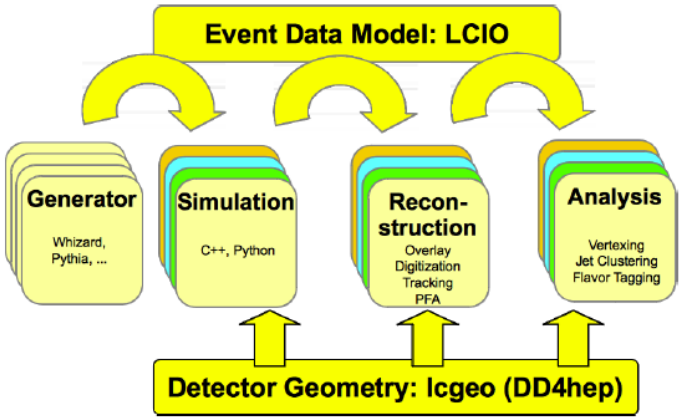
a) Generator
b) Simulation
c) Reconstruction
d) MC production

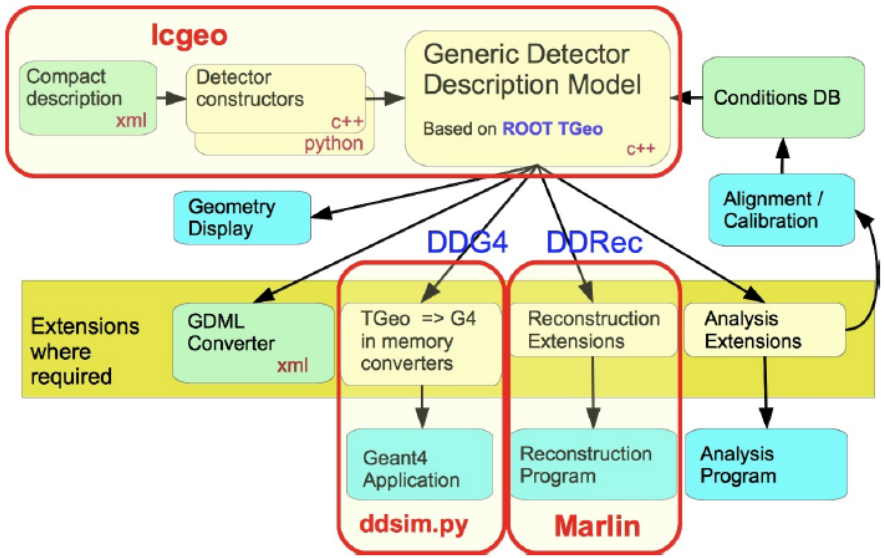
Need strong communication and collaboration of all sub-groups

New ILD software

- LC community is moving towards more common software tools
- ILD decided to use the DD4hep geometry description and DDG4 for simulation
- DDRec is the interface for reconstruction
  - note: same tools used by CLIC and maybe SiD

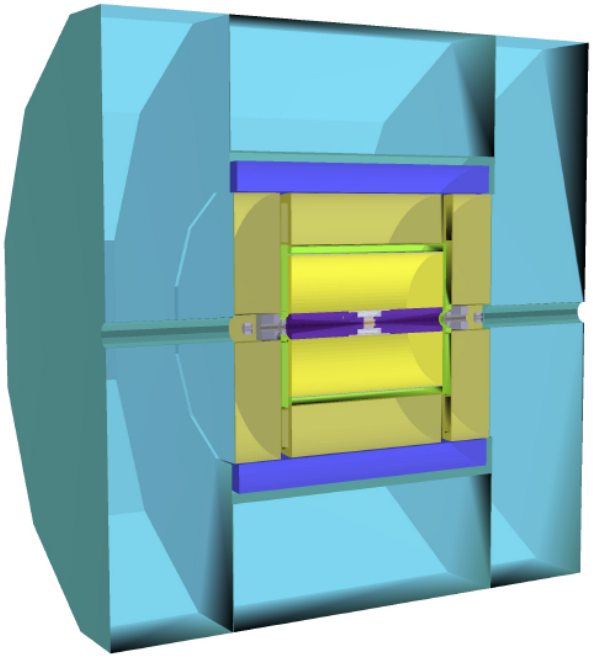
DDRec to replace GEAR

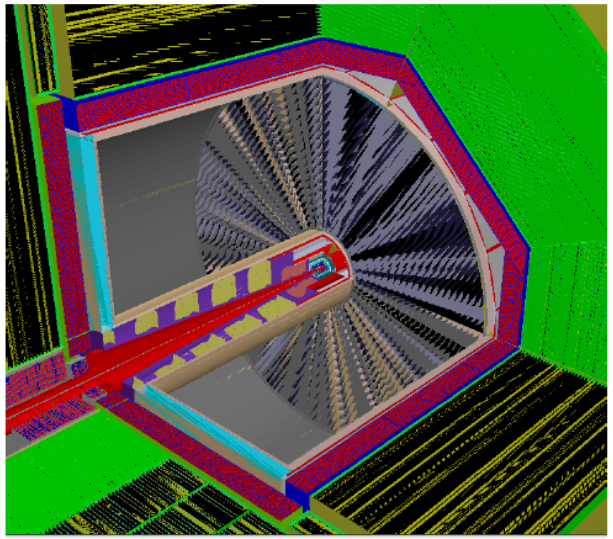




DD=Detector Description

ILD simulation model in lcgeo (DD4hep)





- ILD_o1_v05 Mokka model ported one-to-one to DD4hep
- introduced mandatory envelope volumes
  - validation and scaling behaviour
- model is fully functional and ready for detailed validation
- ddsim python simmulation tool in place

Reconstruction tools (1)

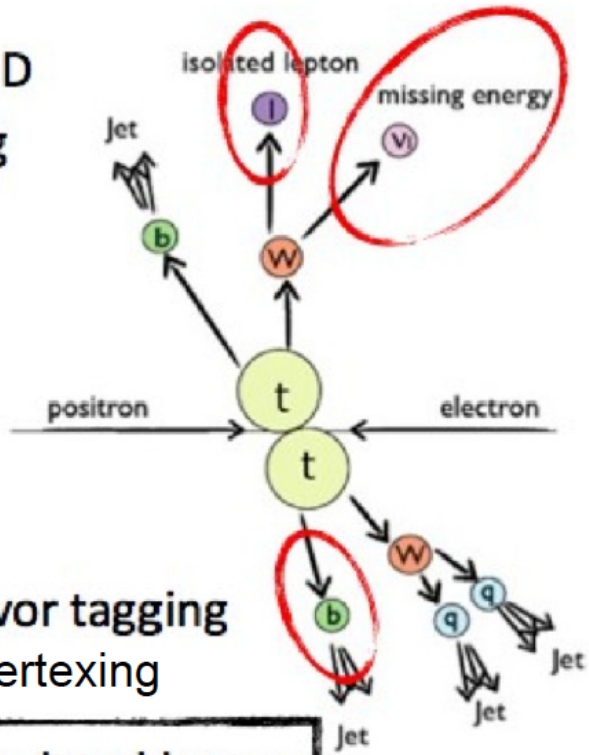
The tools are compatible with DD4hep.

Reconstruction algorithms

Various Lepton finders → lepton ID

CluPaTra → tracking
Forward Tracking
SiTracking
FullLDCTracking
ConformalTracking
ExtrapolateCASeed

LCFIPlus → flavor tagging +vertexing



Particle flow mainly within Pandora toolkit

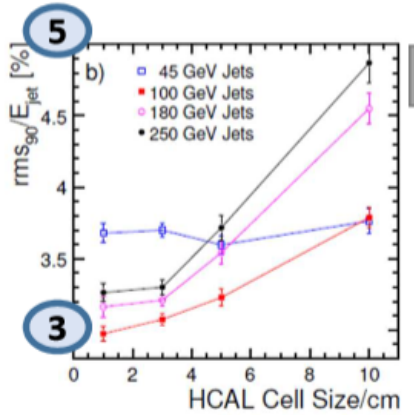
- Calorimeter clusterisation
- Separation of charged and neutral particles
- Output are Particle Flow Objects, i.e. Individual Particles

- Alternative is ARBOR

Jet algorithms:
- Mainly Durham but also anti-kt

Reconstruction tools (2)

We need high-level reconstruction tools **NOW**
to investigate the ILC physics case and to optimize the detector.

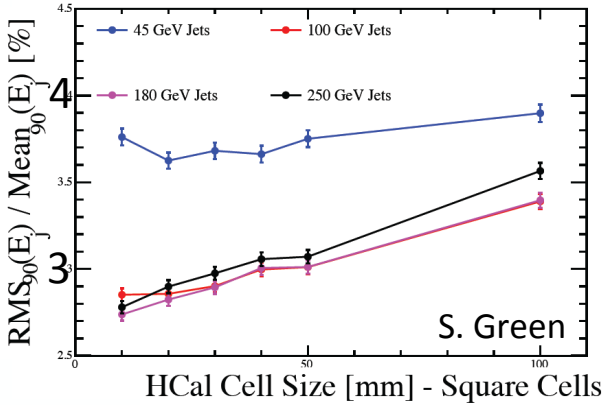


OLD ⟷ NEW

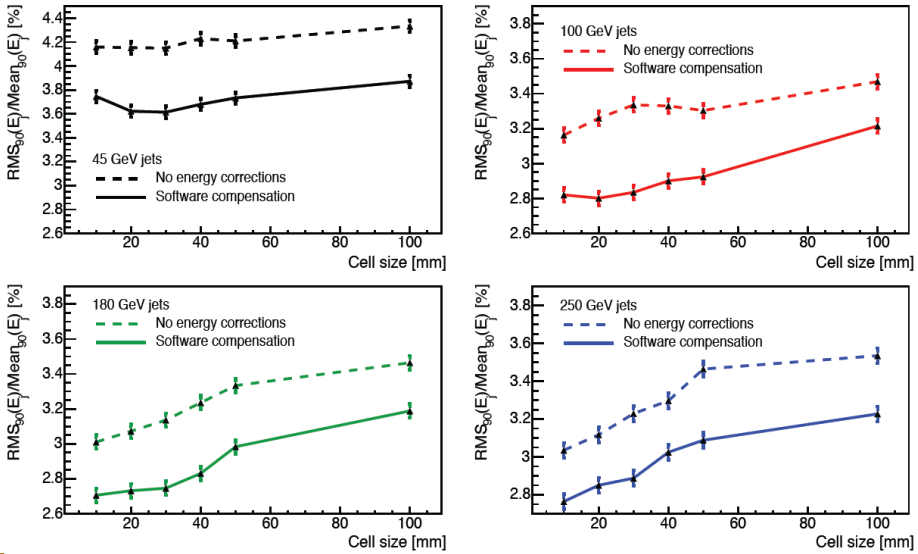
PandraPFA

Changes

- Pandora version
- Timing cuts
- Digitizers
- Hadronic E truncations
- Calibration



H. L. Tran

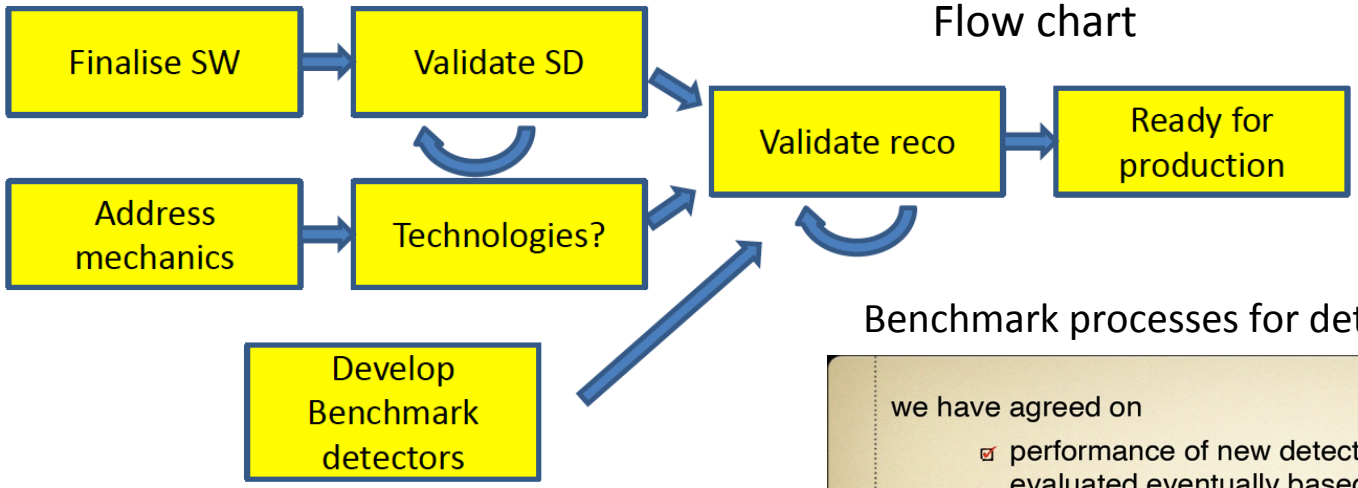


An example: Dependence of jet energy resolution on the HCAL cell size

- Improvement of PandraPFA has been changing the dependence significantly.
- Proper software compensation may change the dependence further.

Toward a large MC production

Flow chart



Planning a large MC production early next year

- Finalize and validate the new software suite
- Agree on some number of benchmark detectors
  - need to agree on mechanics
  - need to agree on how to use different technologies in sub-detectors

Benchmark processes for detector performance

we have agreed on

- performance of new detector models will be evaluated eventually based on physics performance

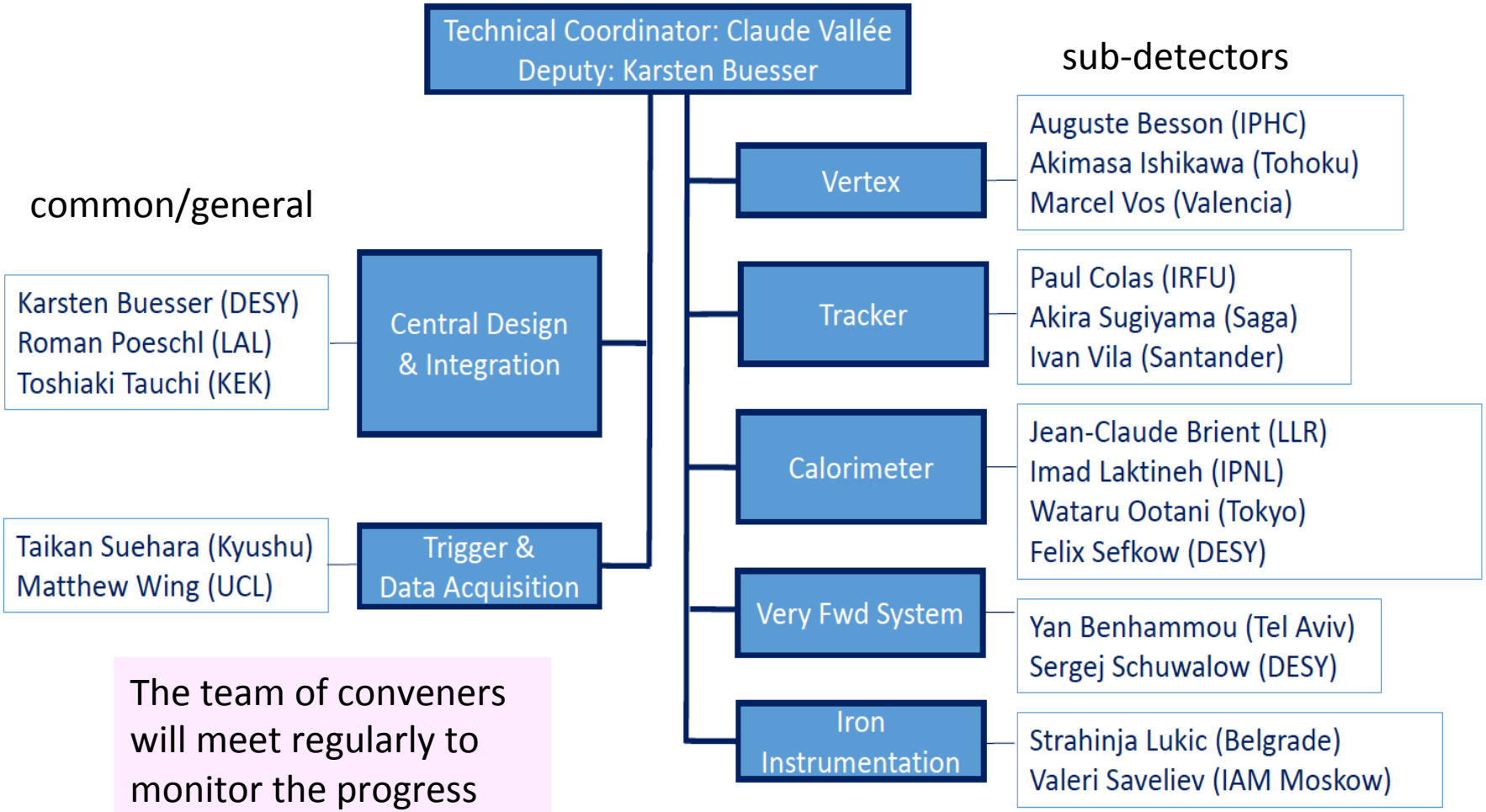
process	physics	detector performance	Ecm
H—>cc	BR	c-tag, JER	any
H—>μμ	BR	high P tracking	500 GeV
H—>ττ	BR, CP	τ recon., PID, track separation	250 GeV
H—>bb	M_H, BR	JES, JER, b-tag	500 GeV
H—>invisible Z—>qq	Higgs Portal	JER	250 GeV
evW—>evqq	M_W, TGC	JES, JER	500 GeV
tt-bar—>6-jet	top coupling, A_{FB}	b-tag, jet charge	500 GeV
$\chi_1^+\chi_1^-$, $\chi_2^0\chi_1^0$ near degenerated	natural SUSY	low P tracking, PID	500 GeV
γXX	WIMPs	Photon ER & ES, Hermiticity	500 GeV

**this is just a minimum list

2

Shown by J. Tian, Software/Optimization workshop at DESY, 2016 Feb.

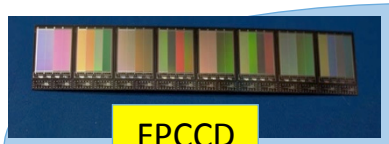
Technical working groups



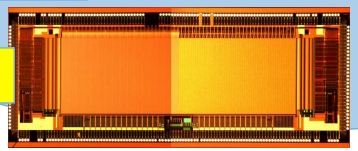
The team of conveners will meet regularly to monitor the progress

Subdetectors

Vertex



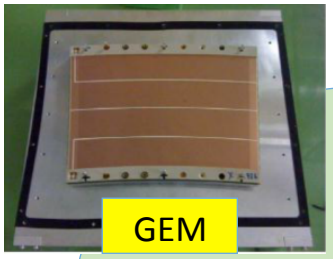
FPCCD



CMOS

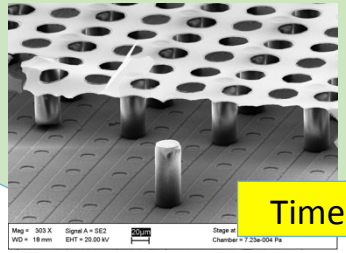
DEPFET

TPC



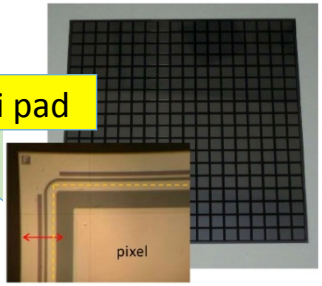
GEM

Micromegas

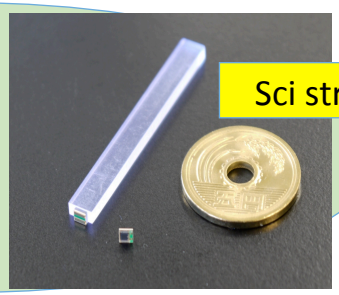


TimePix

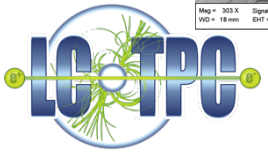
ECAL



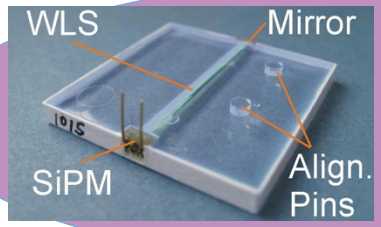
Si pad



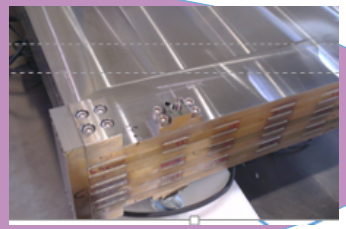
Sci strip



HCAL

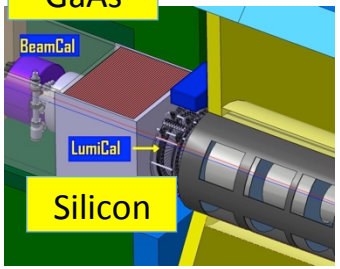


Analog (Sci)



Semi-digital (RPC)

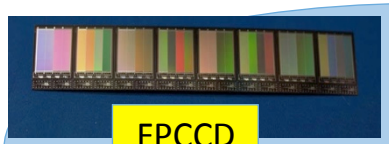
GaAs



FCAL

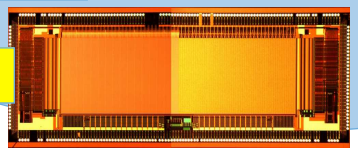
Subdetectors

Vertex



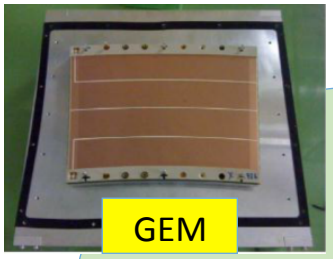
FPCCD

DEPFET



CMOS

TPC



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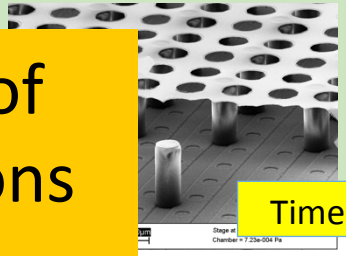


TimePix

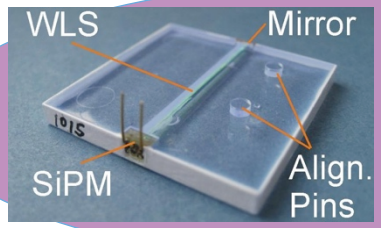
ILD maintains a number of different technology options for sub-detectors.

ECAL

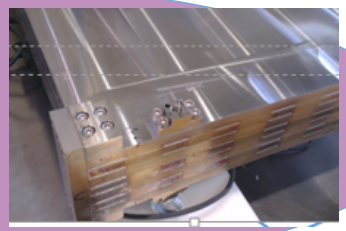
Si pad

CALICE

HCAL

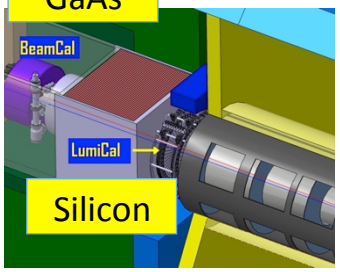


Analog (Sci)



Semi-digital (RPC)

GaAs



Silicon

FCAL Collaboration
High precision design

FCAL

Technology choice

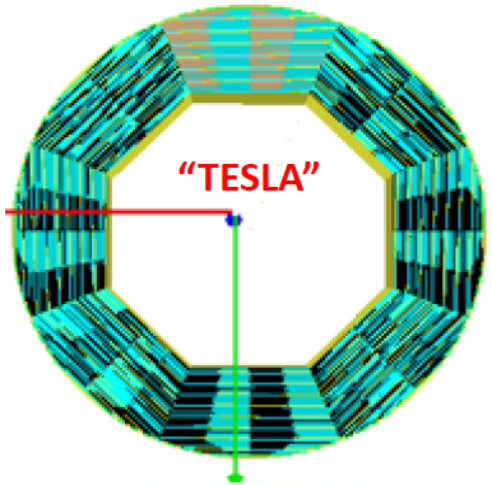
Strategy for moving toward a technology choice:

- We do not intend to make a technology choice soon.
- We intend to make technologies comparable within ILD.

Missions of sub-detector groups are (currently)

- follow progress on engineering prototypes developed by the R&D Collaborations or implemented in future projects like LHC upgrades.
- follow also emergence of possibly new promising technologies.
- for each technology option: gather information on services, infrastructure etc… relevant for its integration in the global ILD detector.
- for each technology option: provide realistic and validated simulation and digitization code within the overall ILD software environment.

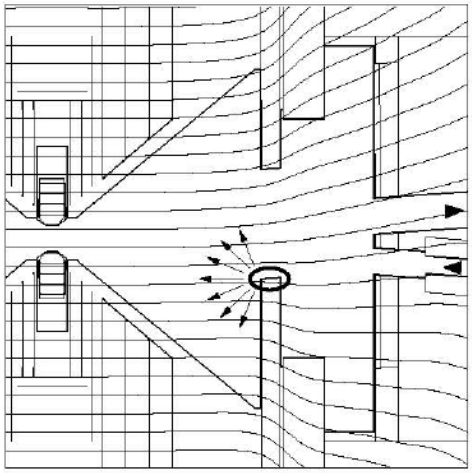
General options: Two TASK FORCEs



In addition to the WGs, we set up

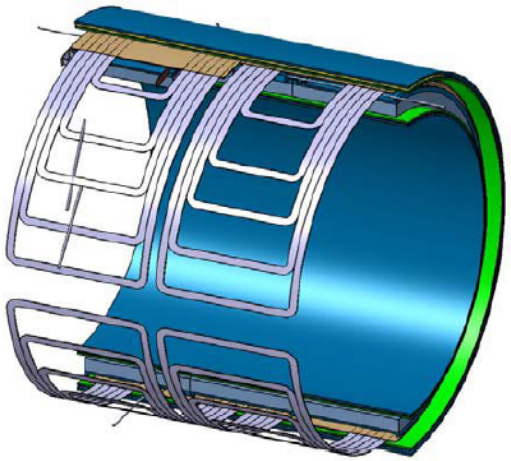
"VT" TASK FORCE investigates the two proposed HCAL mechanical options

Initial members: CDI and CALO conveners (to be completed with specific experts)



"ANTI-DID" TASK FORCE investigates need and feasibility of an ANTI-DID

Initial members: CDI and VFS conveners+ 1 VTX & 1 TRK representatives (to be completed with specific experts)



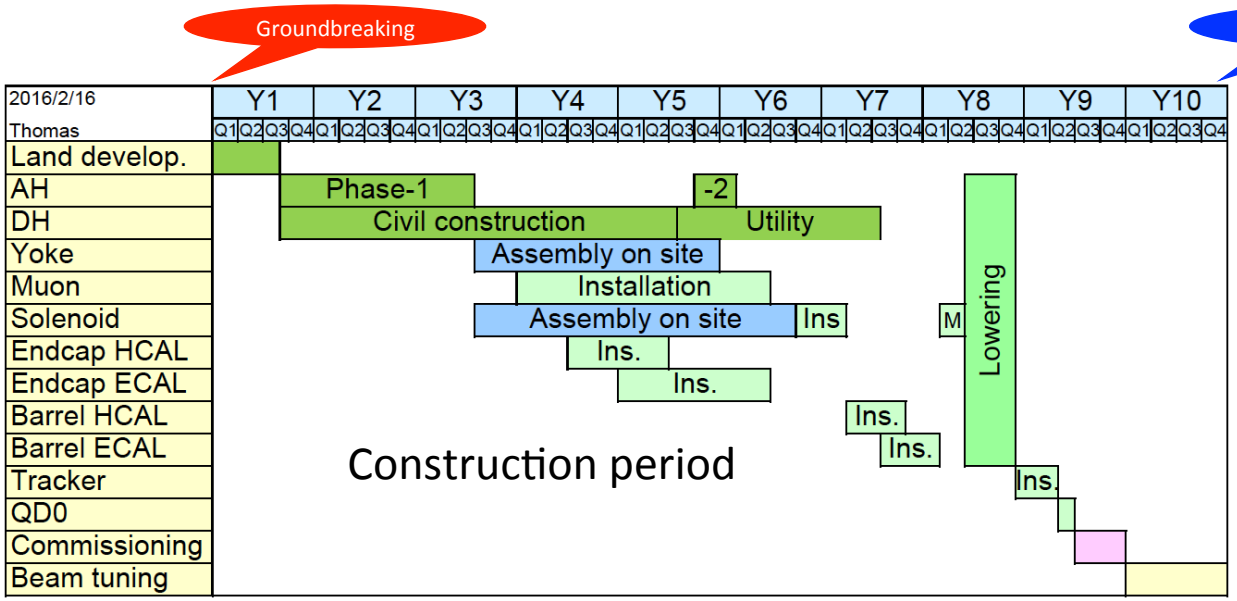
Expect conclusions by End 2016, that are for the baseline configuration for high statistics simulation samples.

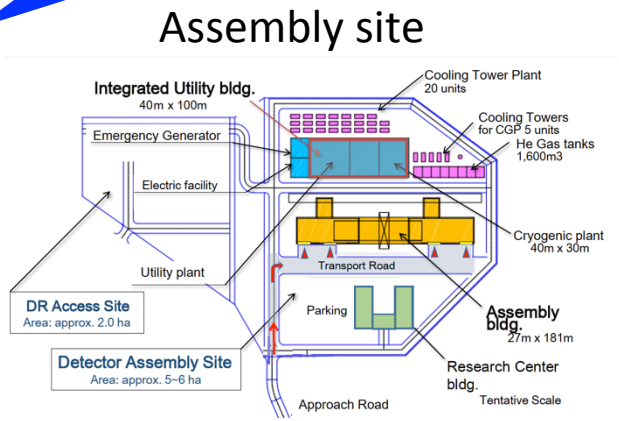
Detector Assembly/Integration

Two−day workshop at KEK (15-16) March (+ one-day candidate-site visit in Kitakami) with people from CFS/MDI/ILD/SiD http://agenda.linearcollider.org/event/6910/

- Requirements of the campus (space, facility, manpower)
- Study of assembly/fabrication/installation procedures
- Study of beam backgrounds, seismic behavior, …

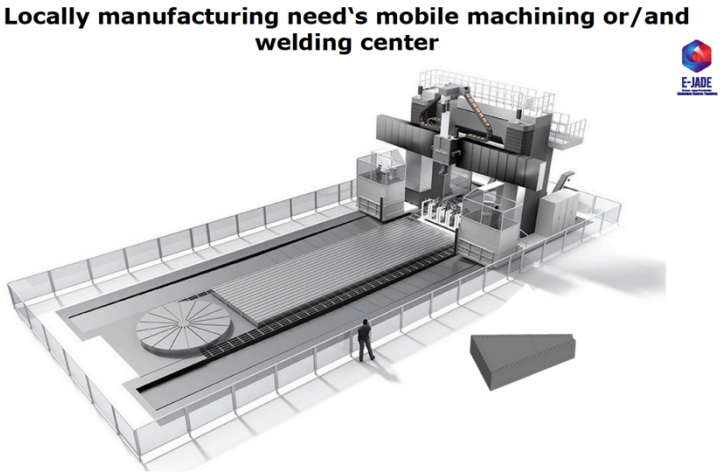
Assuming a possible Japanese site.

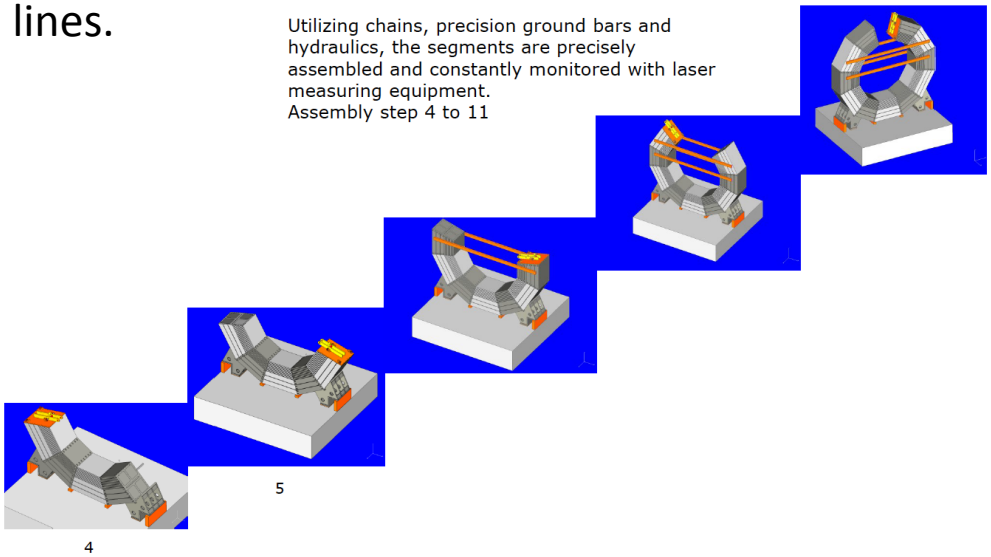


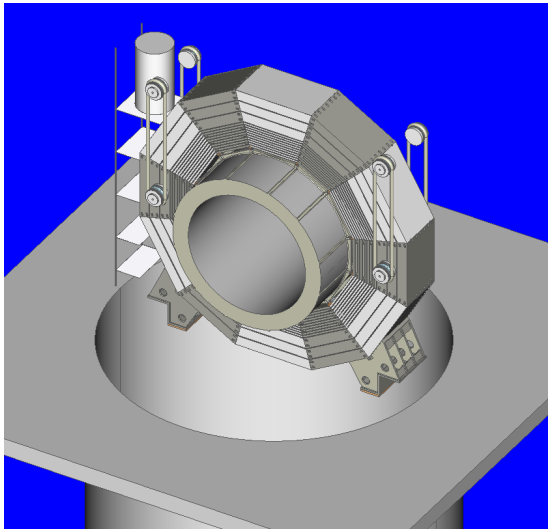


Study of york assembly procedure

- Presented by D. Stromhagen
- Transport in Japan limits 25 tones / part
- Module assembly on site
  - Plates are fixed by welding or screwing
  - Local machining and/or welding center needed.
- ~ 2 years for module assembly (~ 1 year with two assembly lines)
- In addition additional ~1.5 years for yoke fabrication and assembly, assuming two lines.







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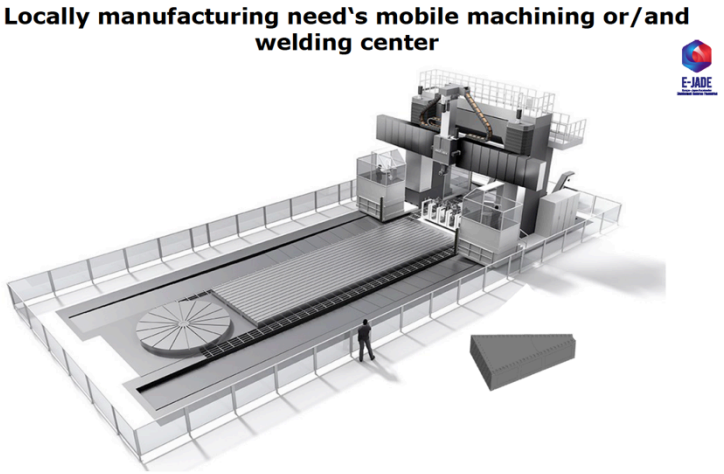
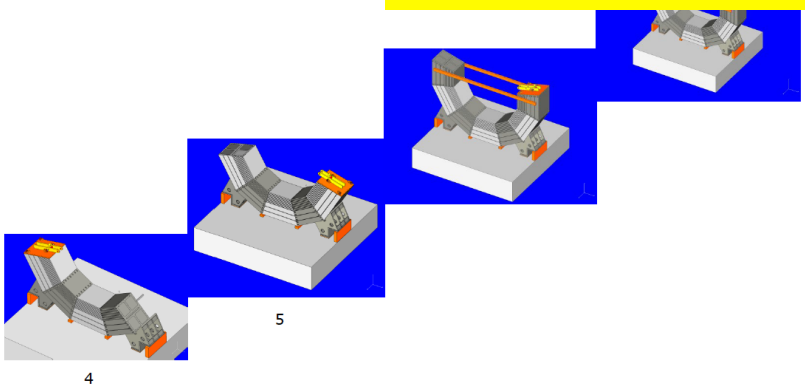
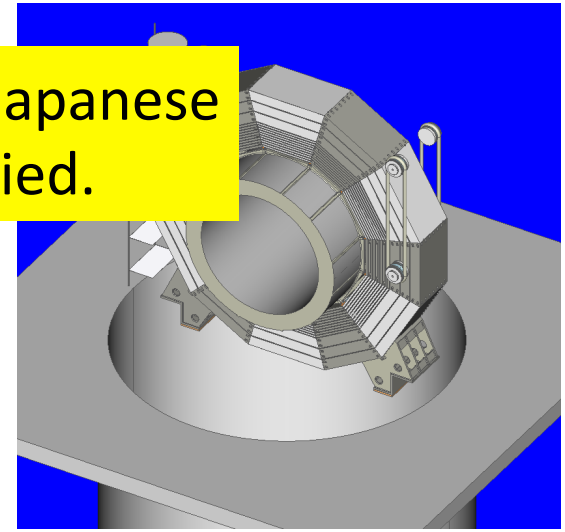


Realistic procedures at the Japanese site are seriously being studied.





Summary

- The ILD detector group is very active and moving forward from a “concept” to a “real experiment”.
- The new management team has been organized.
- The new structure is nearly complete.
  - Physics WGs
  - Software/reconstruction WGs
  - Technical WGs
- With the new organization, we redefine the baseline detector and write a new document that updates DBD in O(2) years to prepare for “**THE GREEN LIGHT**” for the ILC project we will see.
- Cooperation/collaboration with detector R&D groups, other detector concept groups, and the accelerator/MDI/CFS teams are essential for us to move forward.

Invitation to ILD meeting

ILD meeting in Santander starts tomorrow (2.5 days)

June 3 (Fri)	**AM**	**Joint Physics session (ILD/SiD/CLICdp)**
	PM	**ILD Status**
		Central Design & Integration
	Eve.	**IA meeting**
		ILD dinner
June 4 (Sat)	**AM**	**Subdetectors**
	PM	**Optimization**
June 5 (Sun)	**AM**	**Optimization, Discussion**

Please join !