Computing Resources for ILD

a report on work in progress

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with a help by Vincent, Mark, Junping, Frank

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Introduction

- Computing design and cost are not included in ILC TDR, because
  - difficult to estimate a reliable estimate now
  - development of computing technology in > 10 years will be enormous

- But there requests to evaluate the cost and the human power needed for ILC computing.
  - "HL-LHC needs a huge computing resource. How about ILC ?"
  - Funding agency would like to know the total cost.

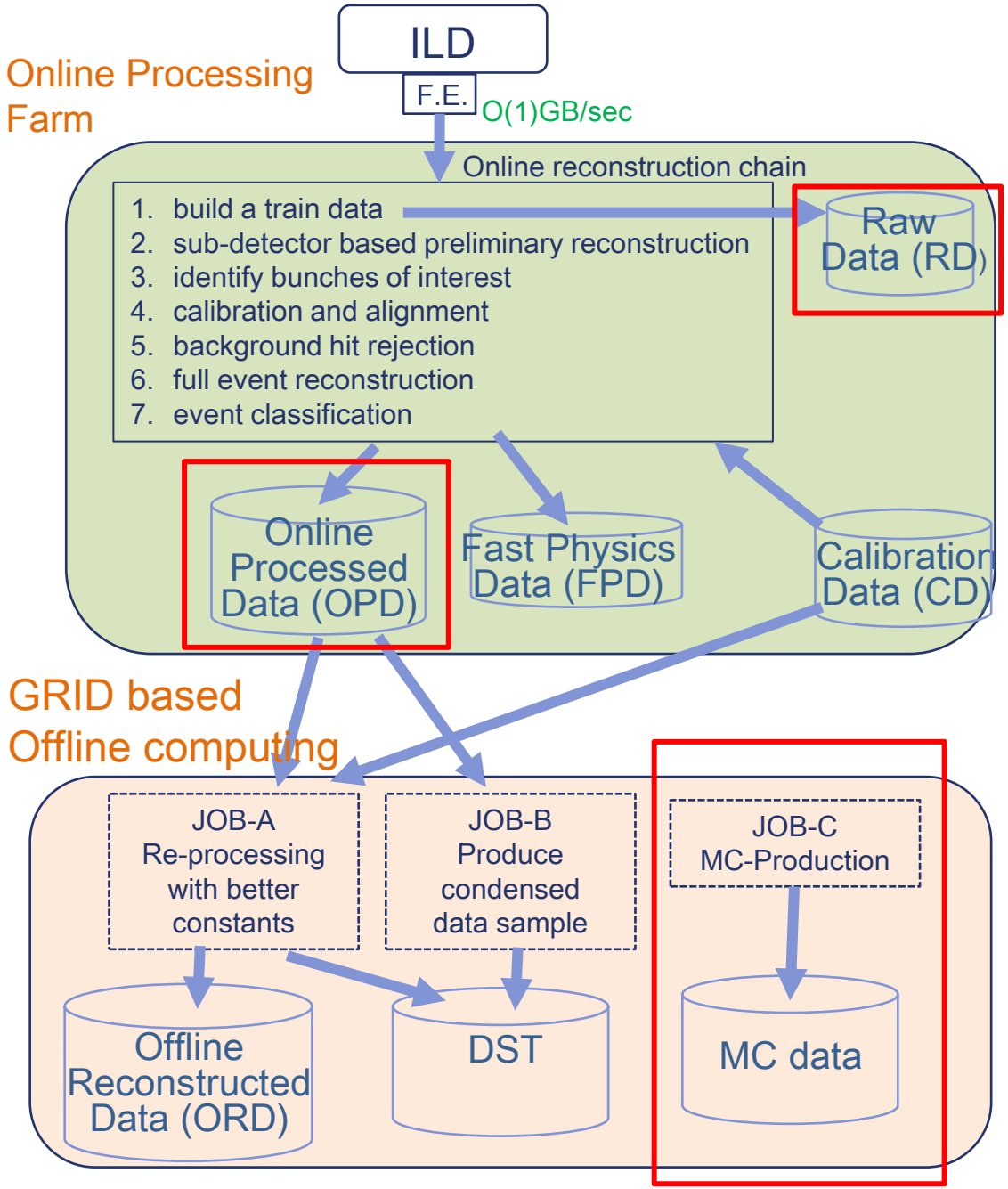
  ➔First discussion at AWLC14 Sim/Rec session.

  ➔Several suggestions for improvements

  - LCC infrastructure group's request from Yasuhiro
  - Ad hoc meeting within ILD in August with

    Vincent, Frank, Junping, Mark, Akiya

A model of ILD data processing



Type of Data

Raw Data(RD): train-based data.
3 Copies at ILC Site, US, EU

Calibration Data (CD):
- Data for calibration & alignments

Online Processed Data (OPD):
- Event based data after filtering
- Consists of raw data objects and reconstructed objects
- Replicated to GRID sites for sub-sequent processing

Fast Physics Data (FPD):
- DST of important physics events

Offline Reconstructed Data (ORD):
- Re-processed OPD. Produced after a few months later with new constants. Same events as OPD.

DST:
- DST from OPD or ORD. Several DSTs may be produced depending on physics

MC data:
- Monte Calro data

Bases of estimation: ILD raw data size in TDR (@500 GeV)

raw data size per train estimated @ 500 GeV

Sub-detector	Channels [10^6]	Beam induced [Hits/BX]	Noise [Hits/BX]	Data volume per train [MB]
VTX (CPS)	300	1700	1.2	< 100
VTX (FPCCD)	4200	1700	1200	135
TPC	2	216	2000	12
FTD	1	260	0.3	2
SIT	1	11	0.3	6
SET	5	1		1
ETD	4			7
SiECAL	100	444	29	3
ScECAL	10	44	40	
AHCAL	8	18000	640	1
SDHCAL	70	28000	70	
MUON	0.1		8	≤ 1
LumiCal	0.2			4
BeamCal	0.04			126**

VXD : ~ 100MB
BeamCal : 126 MB→
reduced to 5% = 6MB
Others < 40MB

Total data size : < 150MB/train = 750MB/sec ~ 6Gbps (bit per sec)

~ 7.5PB/1 year (10^7 sec) for ILD

Energy dependence of pair hits

- The number of SimTracker/SimCalorimeter hits/BX were obtained by reading 100 BX of pair simulation files.
- Many Muon hits seems inconsistent with the data size estimation in TDR.
- The ratio relative to 500 GeV was used to estimate the data size at different beam energy

	Hits/BX			Relative to 500GeV		
Energy	250	350	500	250	350	500
VXD	807.8	1047.2	1889.8	0.427	0.554	1
TPC	1273.9	1984.5	4048.0	0.315	0.490	1
FTD	84.4	117.4	250.9	0.337	0.468	1
SIT	10.5	14.4	17.6	0.597	0.816	1
SET	0.3	0.8	0.9	0.297	0.824	1
SiECAL	99.0	160.6	321.6	0.308	0.499	1
AHCAL	3419.0	5782.3	18145.6	0.188	0.319	1
Muon	59416.6	61949.2	145783.9	0.408	0.425	1
LumiCAL	104.8	133.6	323.8	0.324	0.412	1
BCAL	172922.7	275519.2	703877.8	0.246	0.391	1
LHCAL	199.2	337.2	1153.1	0.173	0.292	1

Energy dependence of pair hits - 2

Data size / Train

Beam induced hits are scaled.

	datasize MB/train (500 GeV)	Beam induced [Hits/BX]	Noise [Hits/BX]	byte/Hits	datasize(MB/Train) 250	350
VXD	135	1700	1200	35.13	89.7	99.7
TPC	12	216	2000	4.09	11.2	11.4
FTD	2	260	0.3	5.80	0.7	0.9
SIT	6	11	0.3	400.73	3.6	4.9
SET	1	1	0		0.3	0.8
ETD	7				0.0	0.0
SiECAL	3	444	29	4.79	1.1	1.6
AHCAL	1	18000	640	0.04	0.2	0.3
Muon	1	0	8		1.0	1.0
LumiCAL	4	1	0		1.3	1.6
BCAL	6.3	1	0		1.5	2.5
LHCAL						
Total	178.3	20634	3877.6		110.6	124.9

Data size / Year

CM Energy	GeV	250	350	500
Pulse rate	Ntrain/sec	5	5	5
Total data size	MB/Train	110.6	124.9	178.3
Data size/sec	MB/sec	553.07	624.26	891.50
Data size/year	PB/10^7 sec	5.53	6.24	8.92

Energy dependence of MC events

Procedure: 50~100 events of all type of Stdhep events were simulated by Mokka and estimated CPU time and data size.

250GeV	250GeV/250fb^{-1},Pol(e-:-80%, e+:+30%)		
Process	k events	CPU days	Data size(GB)
1f	365541.4	36186.5	25259.6
2f	29055.9	5595.8	13267.6
3f	23087.4	2592.3	3405.4
4f	10213.4	2373.2	8614.5
aa_2f	165274.4	9879.9	13988.3
aa_minj	1818.1	435.1	741.5
ffh	79.9	22.4	100.7
Total	595070.4	57085.1	65377.6

2380kev/1fb^{-1}

350GeV	350GeV/350fb^{-1},Pol(e-:-80%, e+:+30%)		
Process	k events	CPU days	Data size(GB)
1f	355028.8	52965.0	33423.1
2f	18028.8	4693.1	9080.4
3f	32033.8	5045.6	5727.0
4f	7990.8	2386.4	6100.7
6f	39.4	16.8	58.3
aa_2f	256407.9	16480.1	22809.6
aa_4f	14.9	4.2	7.9
aa_minj	4765.6	1322.1	2174.7
ffh	65.4	22.0	74.6
mixed_5f	10.3	3.3	7.6
mixed_6f	3.3	0.6	1.6
mixed_aa_4f	14.9	4.2	7.0
mixed_aa_minijet	3.4	0.9	2.0
tt	206.8	88.2	342.1
Total	674613.9	83032.5	79816.6

500GeV	500GeV/500fb−1,Pol(e-:-80%, e+:+30%)		
Process	k events	CPU days	Data size(GB)
1f	446288.2	104310.4	48775.9
2f	6599.5	2313.4	4527.7
3f	66730.9	16202.0	13434.6
4f	8111.7	2824.9	5241.4
5f	35.8	18.2	28.4
6f	196.1	111.5	312.8
aa_2f	669274.0	50391.6	66076.9
aa_4f	52.4	22.9	29.8
aa_minj	21127.6	5990.6	10309.1
ffh	4.5	2.3	4.5
Total	1218420.9	182187.8	148741.2

Summary

Energy	250	350	500
kEvents/fb-1	2380.3	1927.5	2436.8
CPU days/fb-1	228.3	237.2	364.4
Data size (GB)/fb-1	261.5	228.0	297.5

note:
- high cross section events, such as bhabha and ee$\mu\mu$ not included.
- Marlin Rec. is not take into account yet.

Total storage and CPU : Assumptions for estimation

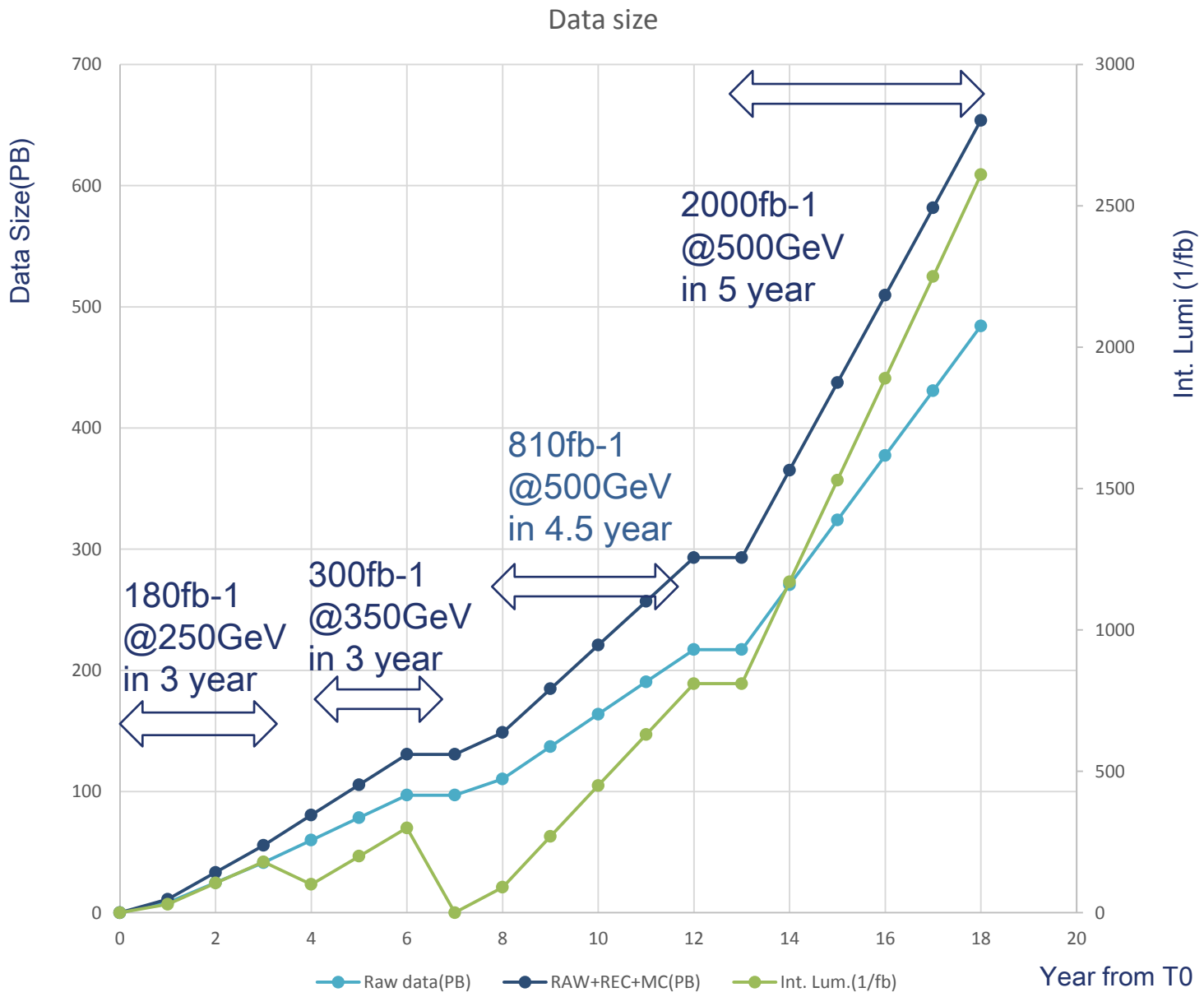
- Online Processed Data (OPD) = RDx0.02x2.03
  - 0.02: #signal and ECAL bhabha events <1% of BX
  - 2.03: from MC, (rec+dst)/sim ~ 2.03
- Offline Reconstructed Data = OPDx1.5 (~ RDx0.02x3)
- MC data :
  - x10 real data statistics
  - sim+rec+dst ~ 2.03xsim
  - x2 for bhabha+eemumu+…
- Data replication
  - Raw data : 3 copies at ILC site, EU and USA
  - OPD, ORD, MC DST at 10 major GRID sites
- CPU Time
  - MC data:
    - CPU time for 10 times more statistics than Raw Data
    - Another factor 2 for bhabha, eemumu, …
    - Marline CPU time = 0.2 x Mokka CPU time
  - Online Process Data:
    - CPU time/event = *0.2 x Mokka CPU time*
    - Nb. of events to be processed = 2xNb. of signal (2 for Bhabha, etc)
  - Offline Process Data:
    - Same as OPD
  - Computing efficiency: 90%

Summary of data size and CPU of ~1 year(10^7sec) of running

EM Energy	250	350	500	GeV
Int Lumi for 10^7	75	100	180	fb^-1
Nb. of Signal + Bhabha / BX	0.53%	0.47%	0.82%	%
Data size (for one set)				
Raw Data (RD)	5.5	6.2	8.9	PB
Online Processed Data (OPD)	0.2	0.3	0.4	PB
Offline Reconstructed Data (ORD)	0.3	0.4	0.5	PB
MC Data (Sim+REC+DST)	0.8	0.9	2.2	PB
Sub Total	6.9	7.8	12.0	PB
Data size (incl. replication)				
Raw Data (RD)	16.5	18.6	26.7	PB
Online Processed Data (OPD)	2.2	2.5	3.6	PB
Offline Reconstructed Data (ORD)	3.3	3.8	5.4	PB
MC Data	0.9	1.1	2.5	PB
Sub Total	23.0	26.0	38.2	PB
Total Data size	22.2	25.0	36.1	PB
CPU				
MC CPU days for 10xLumi	410.9	569.3	1574.2	CPU daysx1k core
Online Process Data(*)	6.8	9.5	26.2	CPU daysx1k core
Offline Process Data	6.8	9.5	26.2	CPU daysx1k core
Total CPU days	417.8	578.8	1600.4	CPU daysx1k core
# of cores to process in 90 days	5.2	7.1	19.8	k cores

preliminary

Evolution of storage capacity based on a sample running scenario



Summary

- A preliminary result on computing resources necessary for ILD is presented.
- Numbers used for the estimation are very preliminary and subject to change Needs to be improved or confirmed. For examples,
  - Efficiency of non-signal event filtering
  - CPU time of online data processing, incl. calibration, alignment, filtering, ...
  - Consistency of raw data size in TDR and pair background simulation
  - How many MC events do we produce ?
  - How many reprocessing do we need ?
  - size of disk storage ?
  - resources during the construction ?
  - … more
- Independent estimation by SiD will help
- Comments/suggestions/thoughts are highly welcomed.

SiD's task(s)

- (From what I understand) the main purpose of this effort is to understand the spending profile for (all aspects of) the ILC campus
- ILD also has prepared man power estimates
  - SiD should come up with their own estimates, then we compare
- Some things will be shared with ILD, others will be taken care of the detector collaborations
  - We have some catching up to do before we can compare numbers with ILD
  - There are a few things we can / should discuss together, but we also need to put in some work to understand the details, e.g. event filtering
- Akiya did basically all of this by himself – we should try to split up tasks to catch up faster