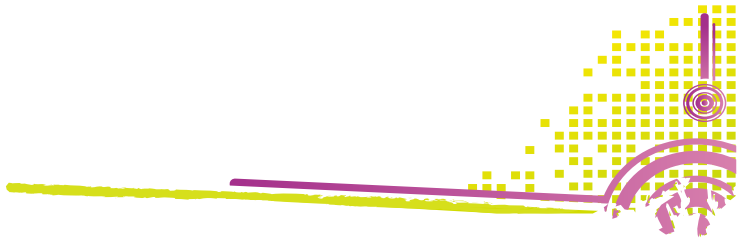
ACAT in Jaipur, 23 Feb. 2010



Computing at Belle II

Takanori Hara (KEK)
on behalf of Belle II Computing Group

B-Factories aimed for

KEKB+Belle

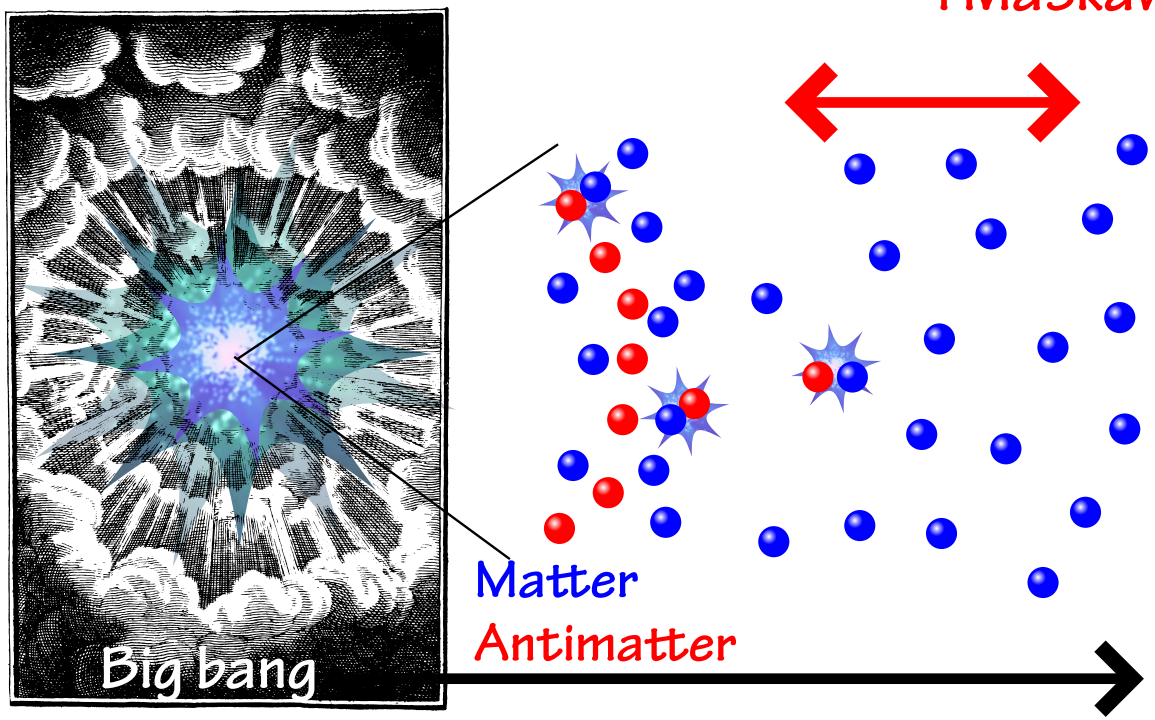
Kobayashi

+Maskawa

Matter excess of Universe

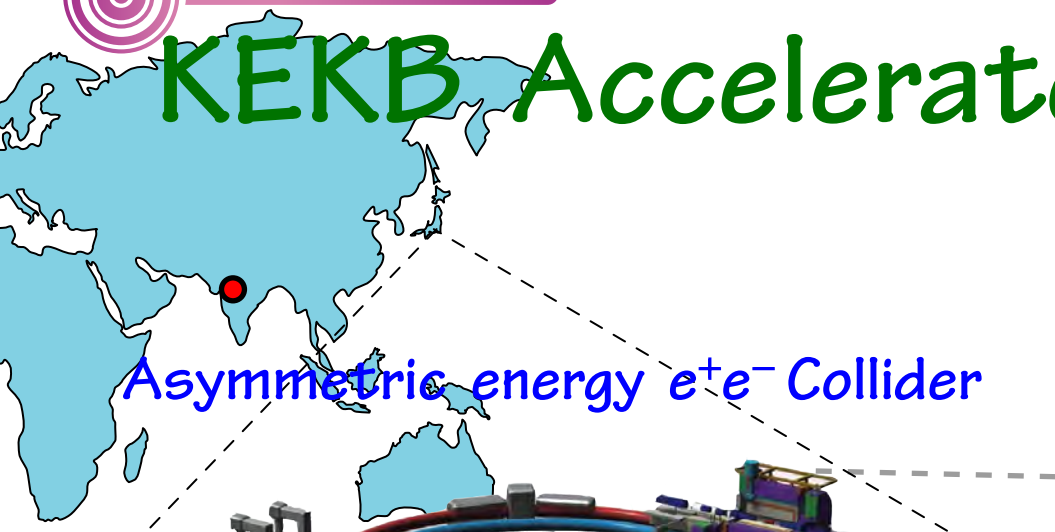
Dark matter

Origin of mass ...

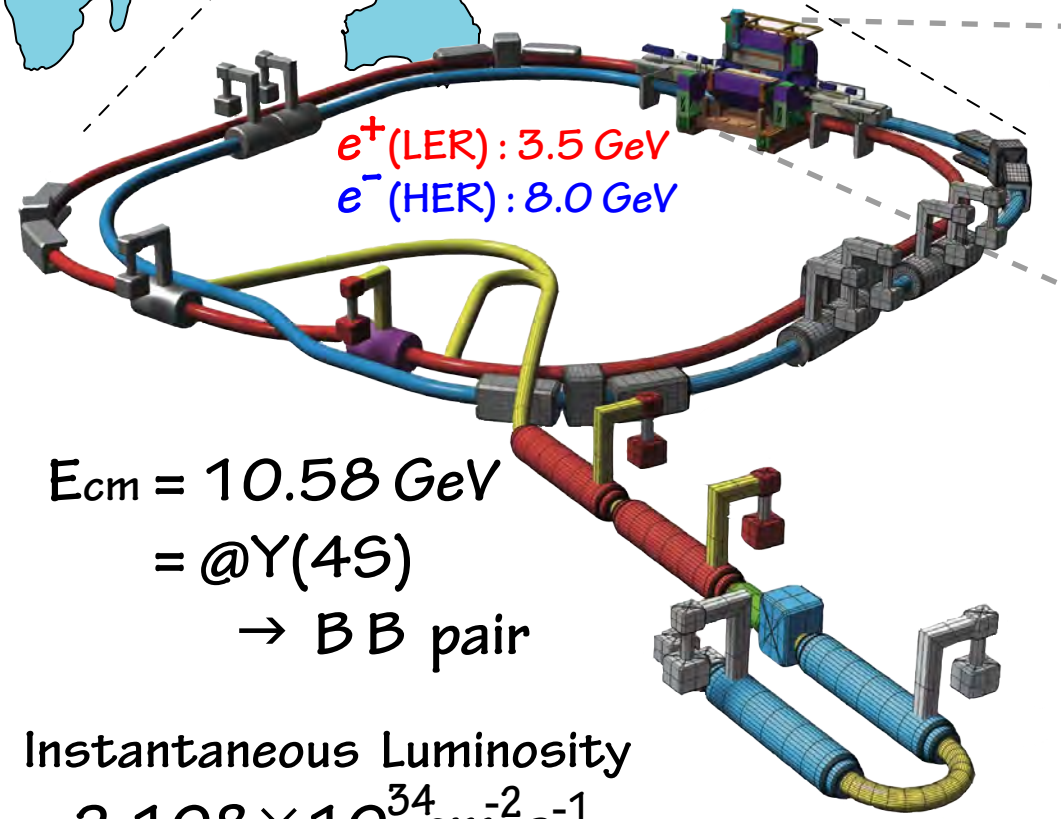


Now (a 13.7 billion years later)

KEKB Accelerator + Belle Detector



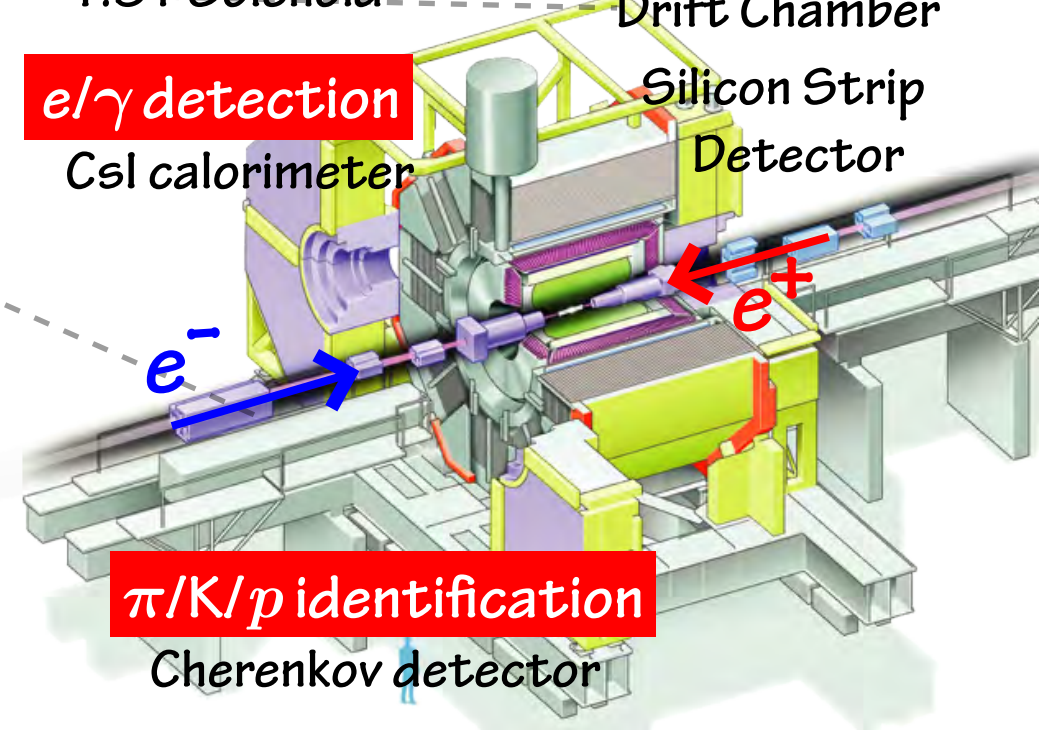
Asymmetric energy e^+e^- Collider



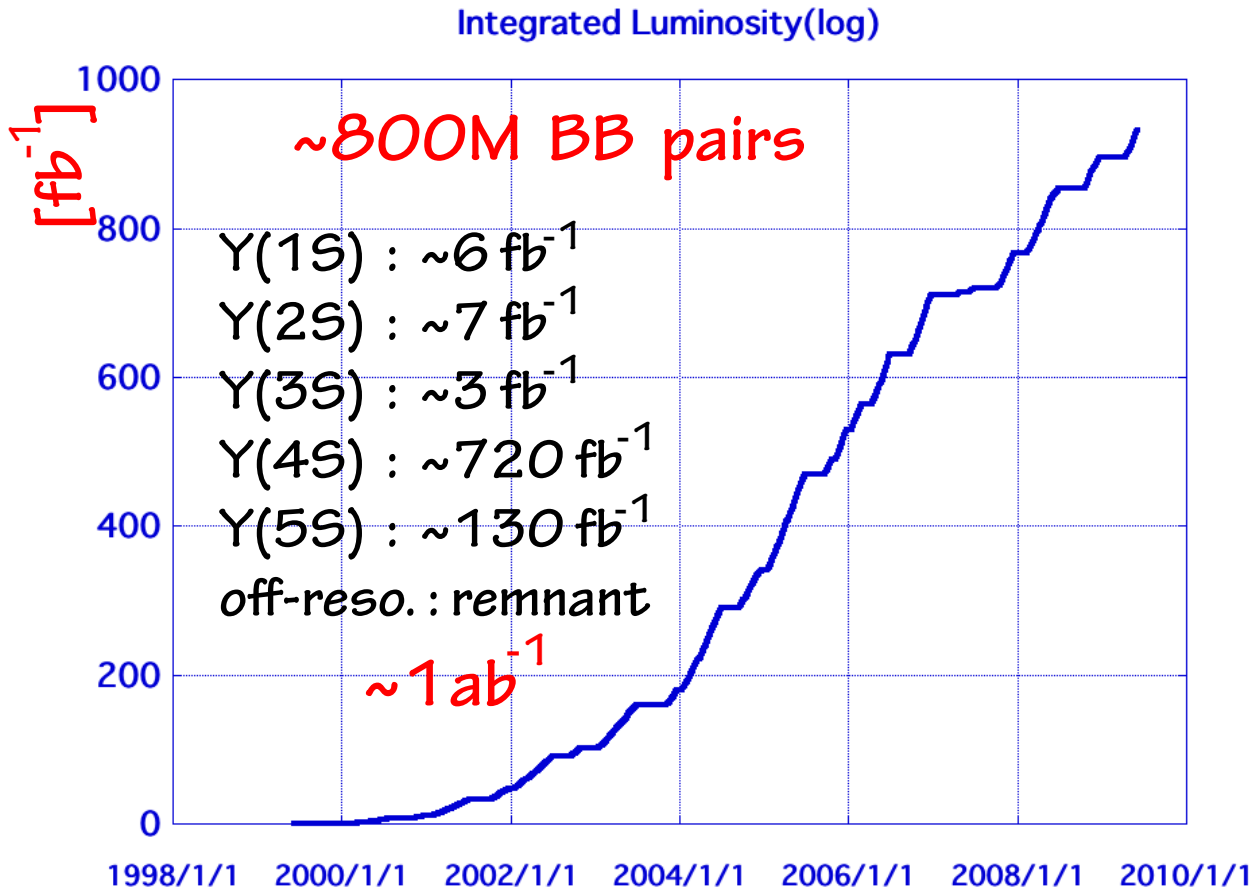
E_{cm} = 10.58 GeV
= @Y(4S)
→ B B pair

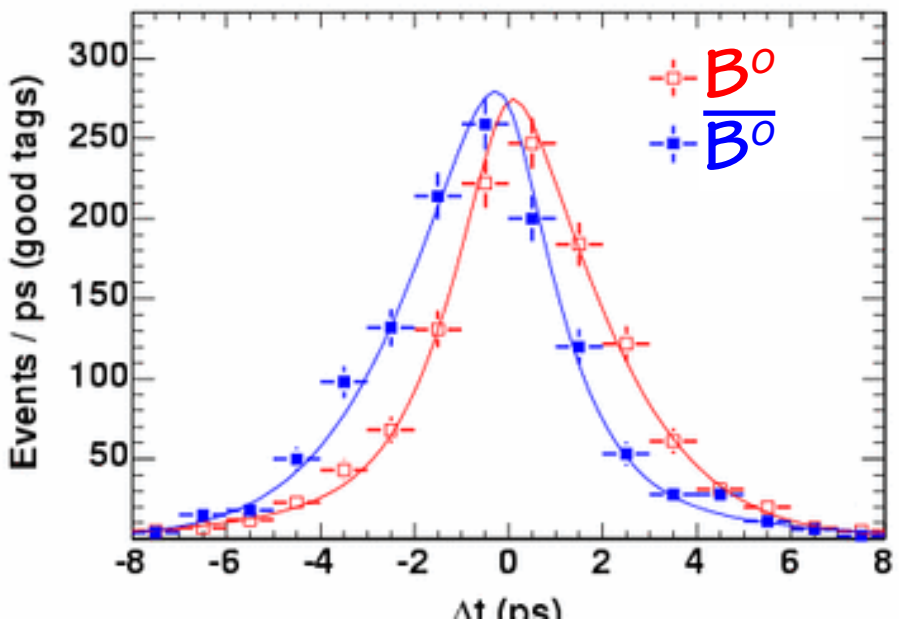
Instantaneous Luminosity
$2.108 \times 10^{34} cm^{-2} s^{-1}$
(twice of the design value)

Large-solid-angle magnetic spectrometer



Super B-Factories aimed for



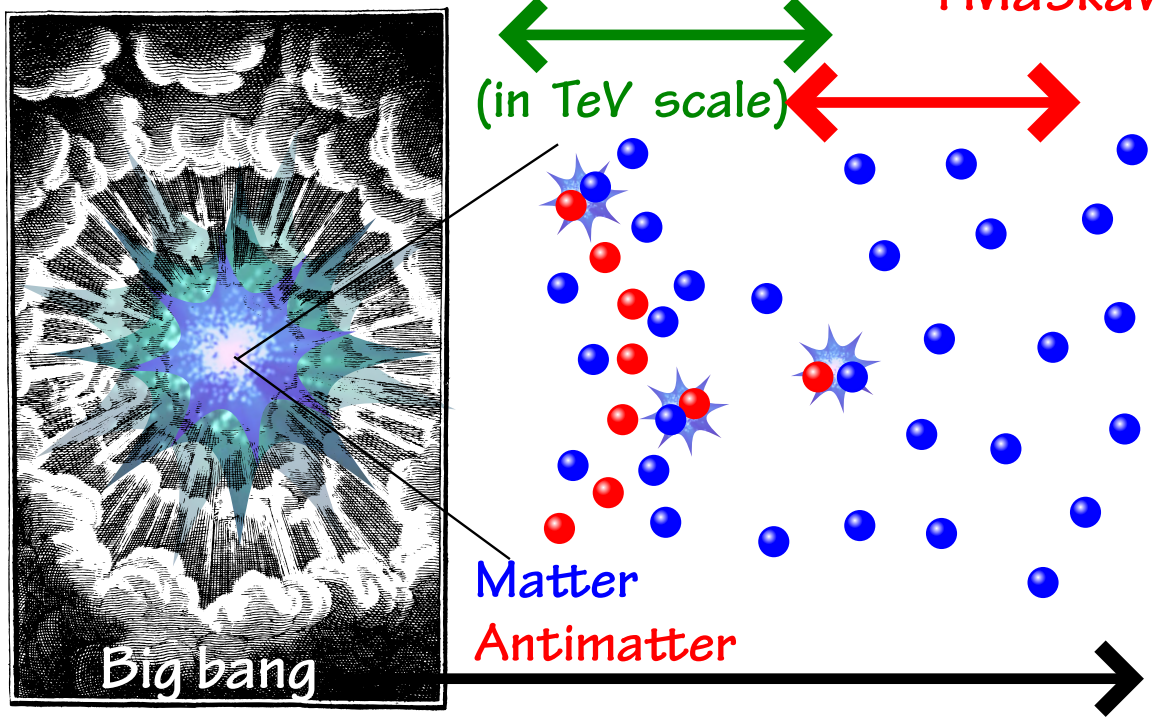


Kobayashi-Maskawa theory is confirmed.

But this is not enough to explain the Universe

Other source of CP violation is implied ...

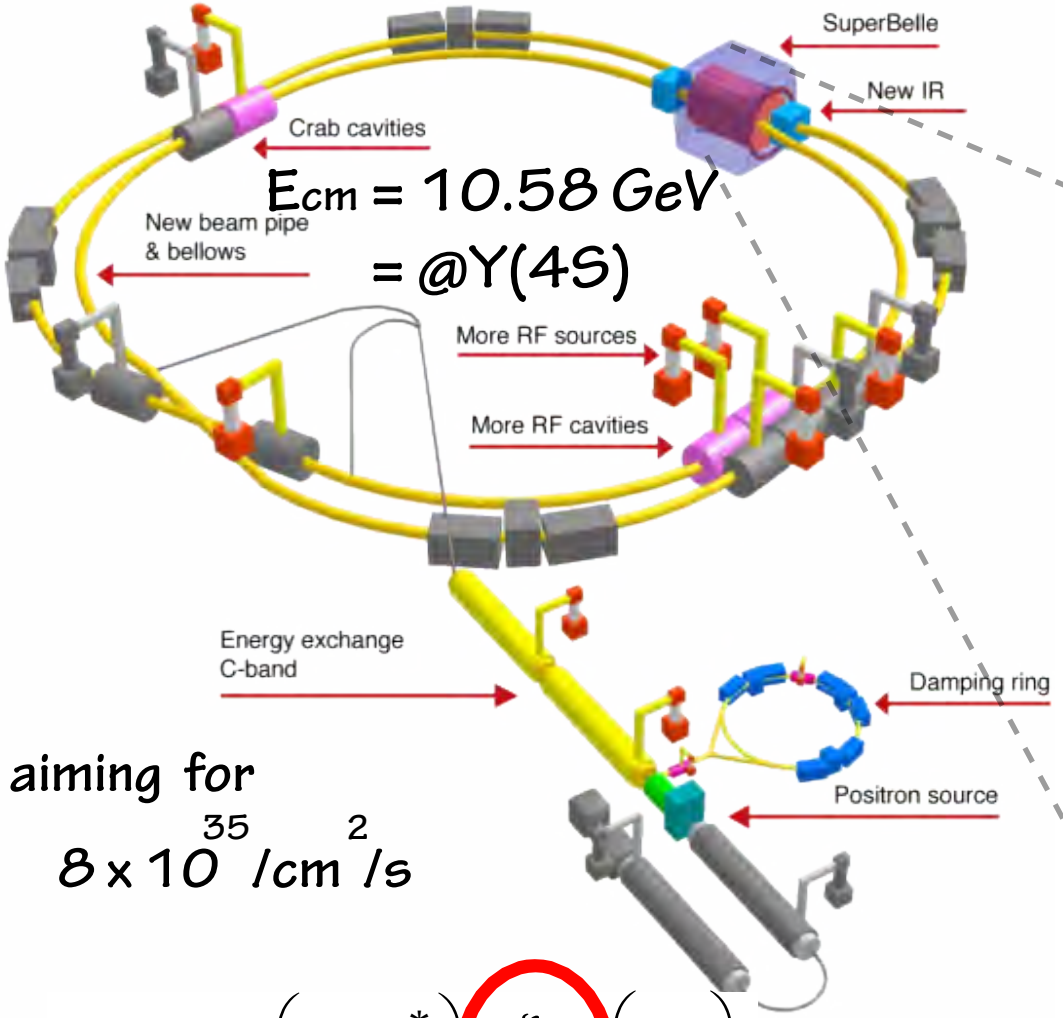
Super B-Factories aimed for



Matter excess of Universe
Dark matter
Origin of mass ...

Now (a 13.7 billion years later)

SuperKEKB + Belle II



Ecm = 10.58 GeV
= @Y(4S)

aiming for
8×10^{35} /cm^2/s

$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

tracking/vertexing

small-cell Drift Chamber

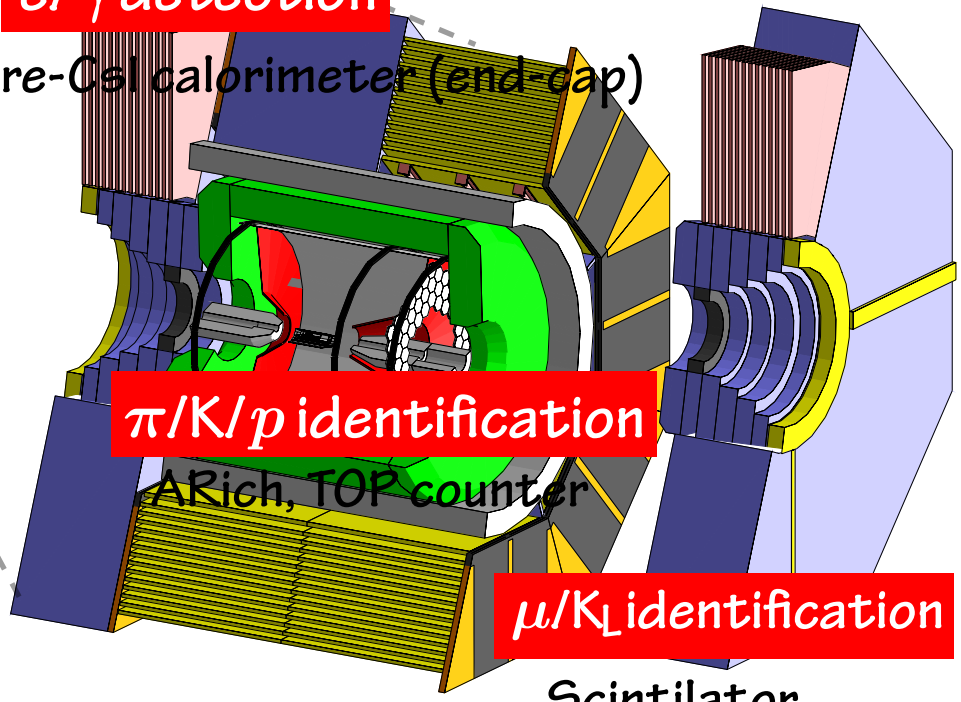
Silicon Strip det.

longer lever arm

Pixel detector

e/γ detection

pure-CsI calorimeter (end-cap)



π/K/p identification

ARich, TOP counter

μ/K$_L$ identification

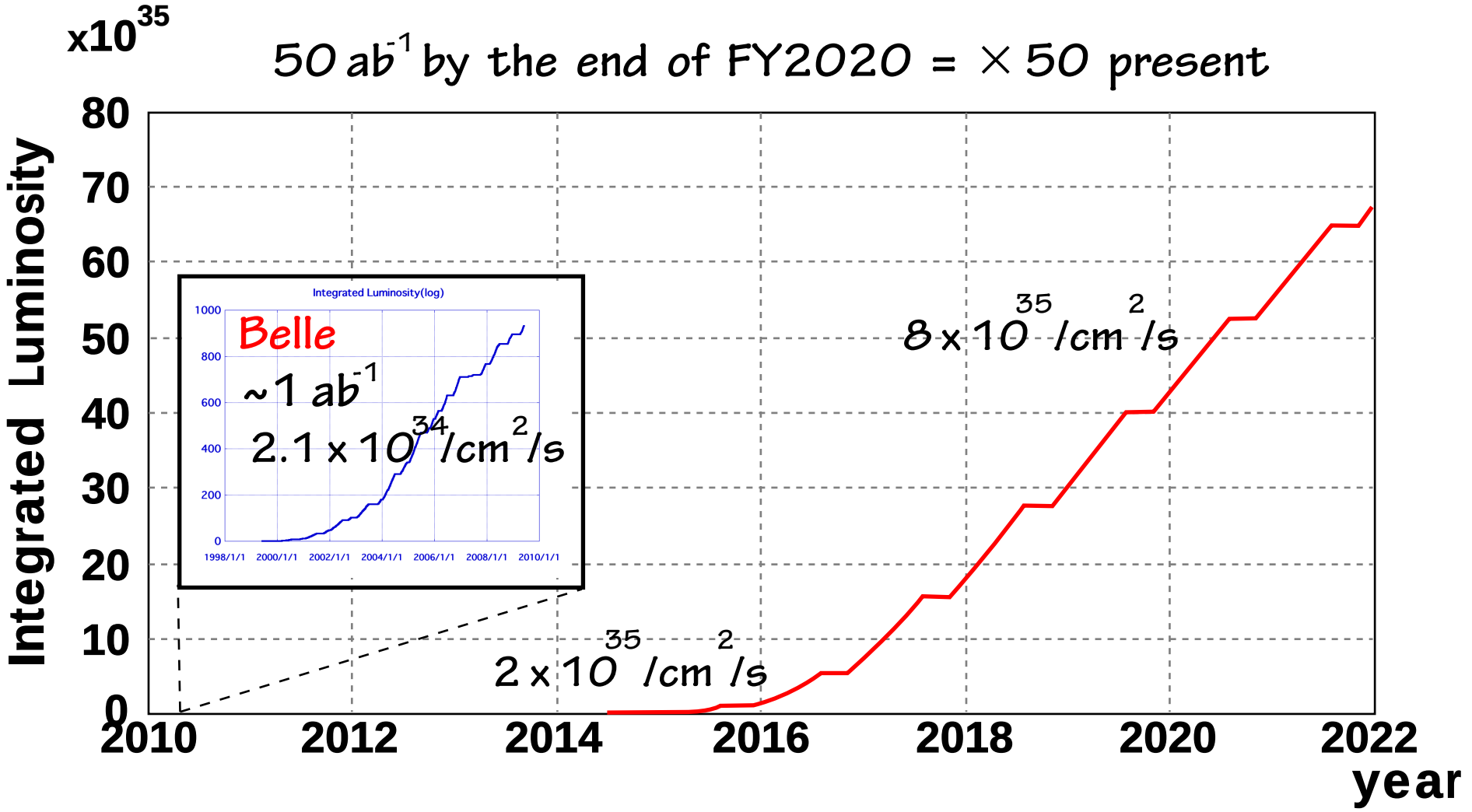
Scintilator

Belle II collaboration

13 countries/regions, 44 institutes

~300 members

Luminosity Prospect



Expected Event Rate + Size

- Expected event rate

L1 trigger rate : 20kHz @ $2\times10^{35}/cm^2/s$

1/2

after HLT : 10 kHz @ $2\times10^{35}/cm^2/s$ → to storage

1/4

after phys-trig. : 2.5 kHz @ $2\times10^{35}/cm^2/s$

expected reduction factor

Here, bb = ~1nb = 0.2kHz @ $2\times10^{35}/cm^2/s$

(continuum ~3nb, tau ~1nb : total phys event :> ~1kHz)

assumed to be 5kHz after phys-trigger for estimation (BG ???)

9.6E+10 events/yr @ $2\times10^{35}/cm^2/s$

cf. Atlas : 2E+09 events/yr

- Expected event size

SVD	40
CDC	6
TOP	8
ARICH	6
ECL	12
KLM	5

(kB/event)

total raw data size is assumed to be 300kB/event

(~1,000 kB/event is expected for PXD, though...)

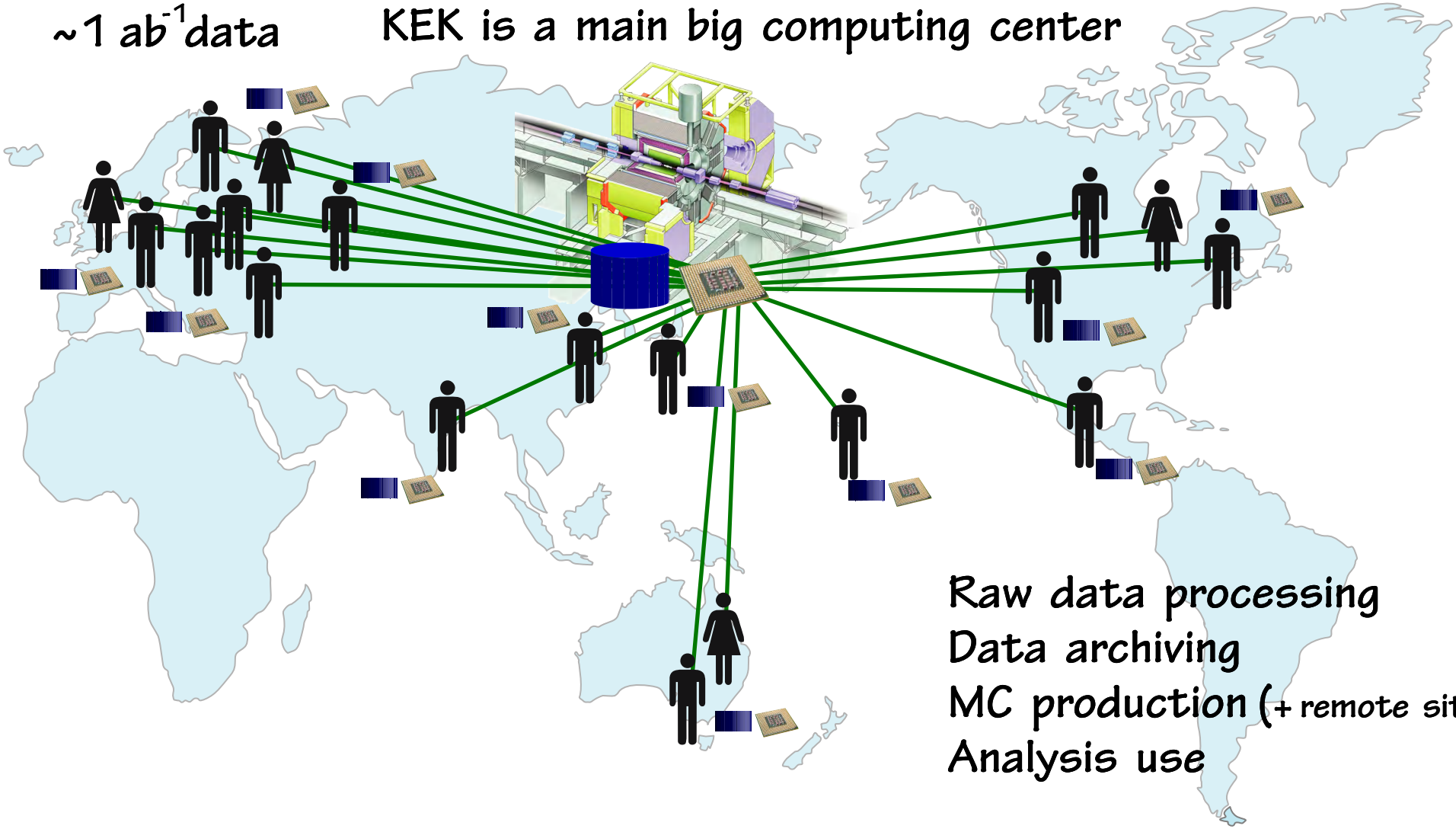
cf. Atlas : 1,600 kB/event

Belle II Computing

Belle : Centralised computing

~1 ab^{-1} data

KEK is a main big computing center

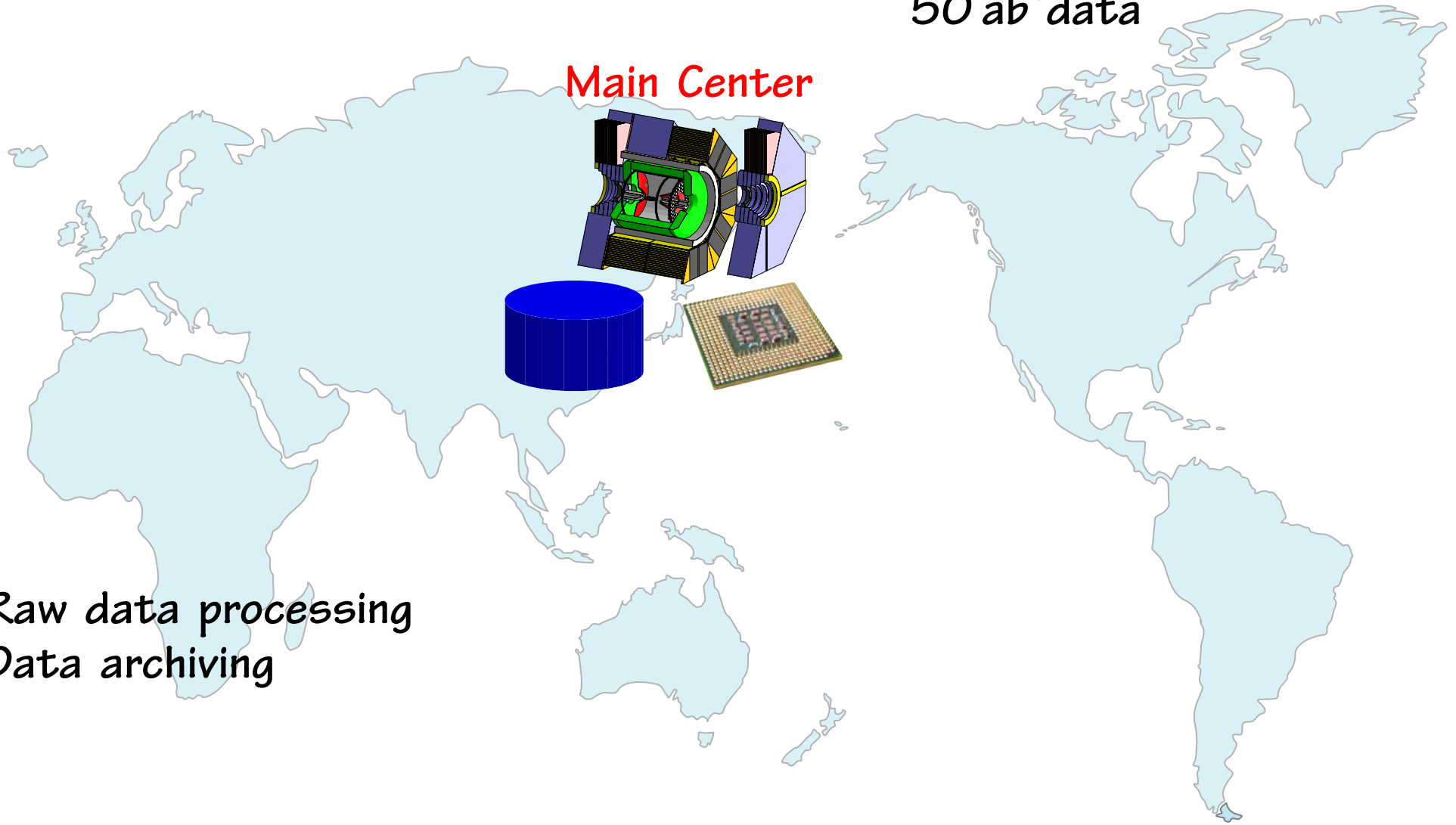


Raw data processing
Data archiving
MC production (+ remote sites)
Analysis use

Belle II Computing

Belle : Centralised computing → Belle II : Distributed computing

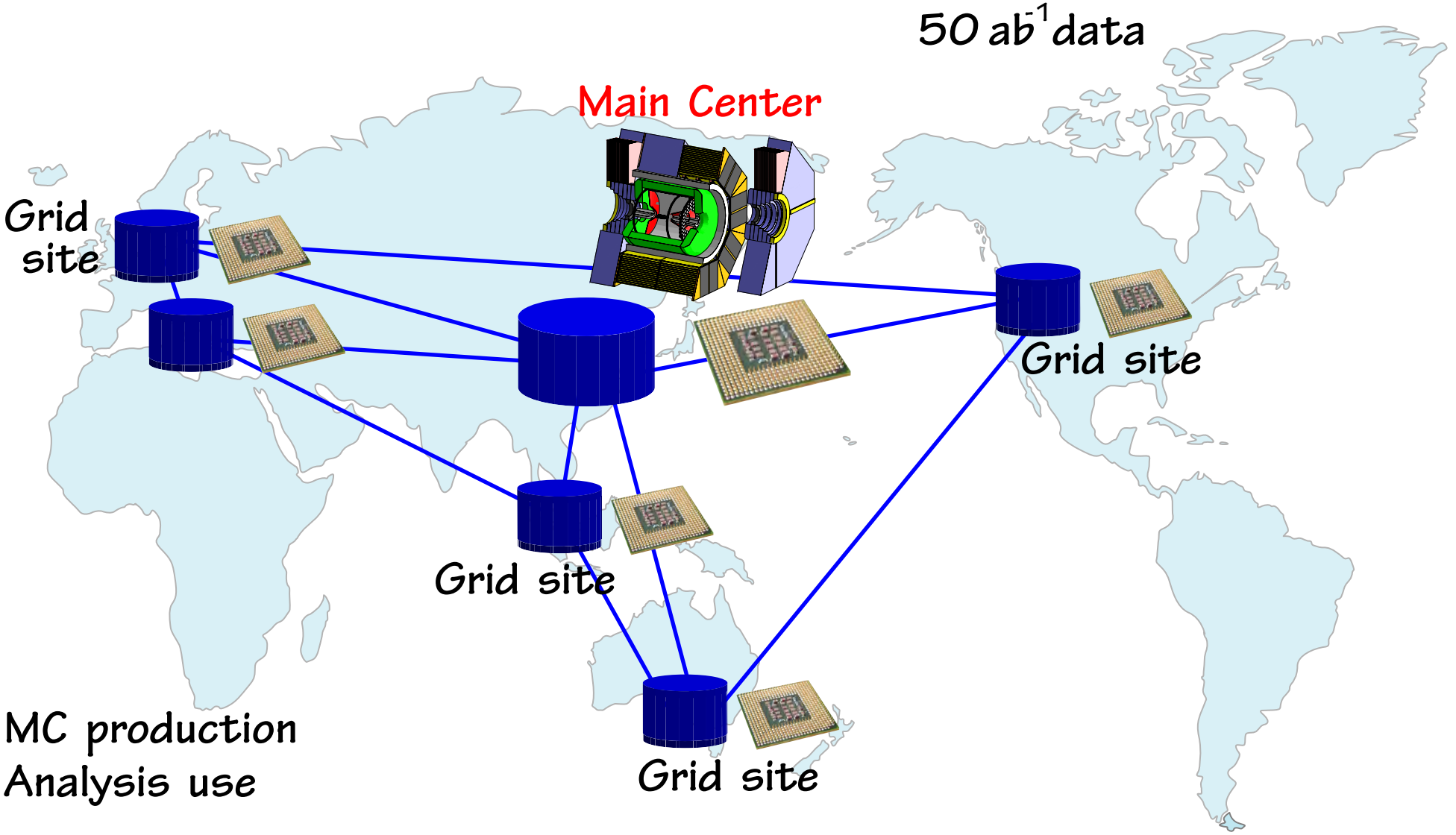
50 ab^{-1} data



Raw data processing
Data archiving

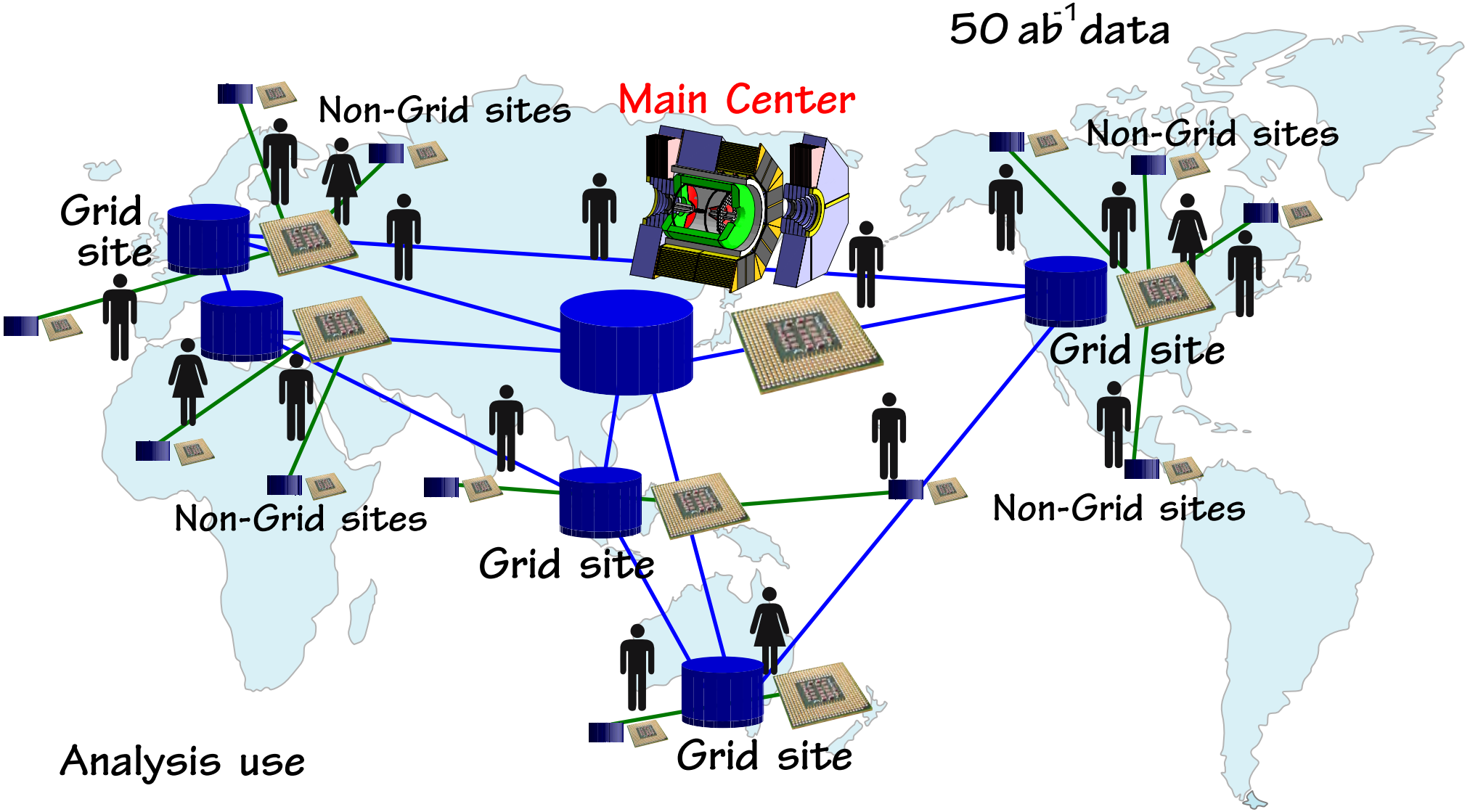
Belle II Computing

Belle : Centralised computing → Belle II : Distributed computing



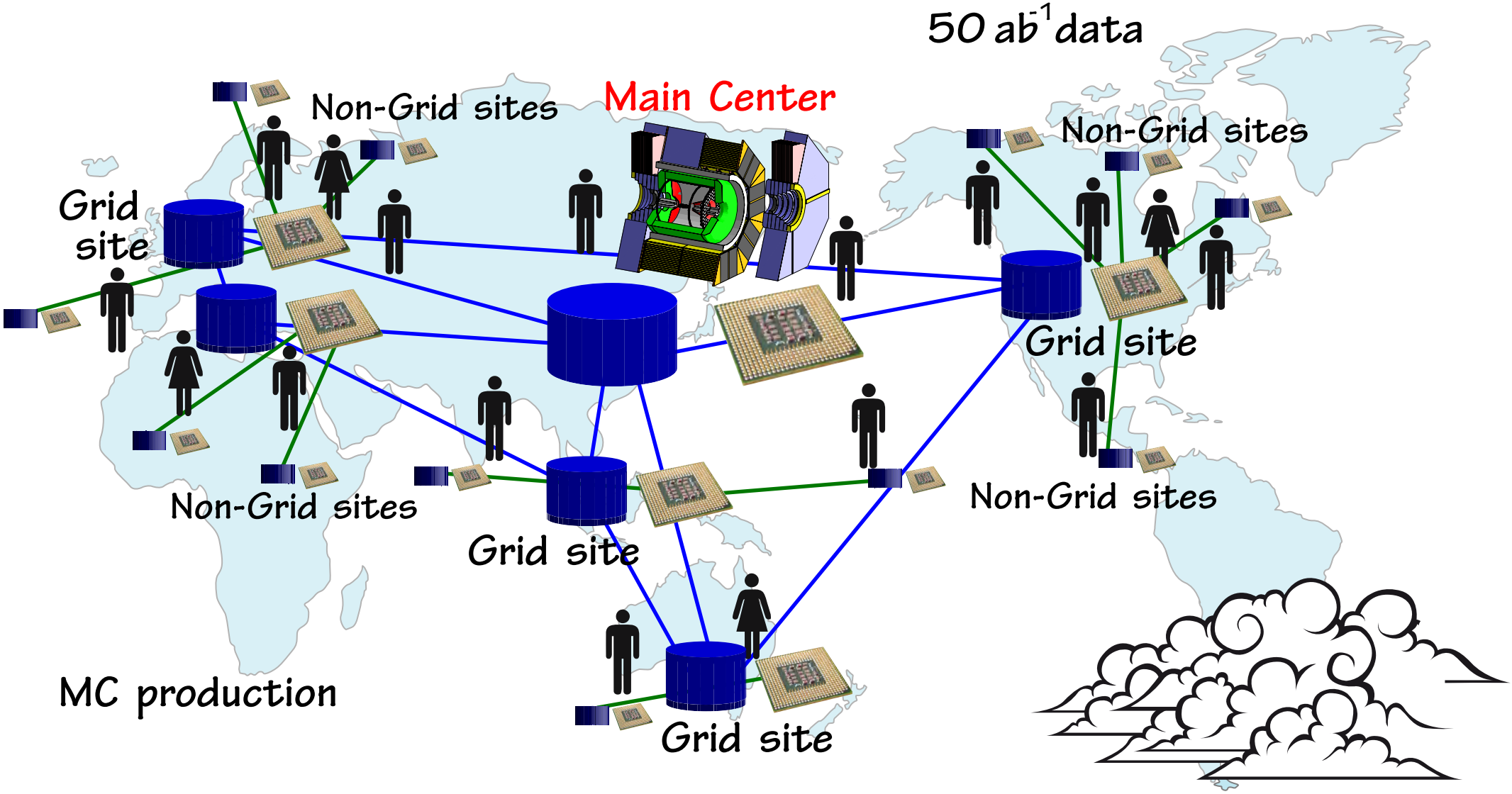
Belle II Computing

Belle : Centralised computing → Belle II : Distributed computing



Belle II Computing

Belle : Centralised computing → Belle II : Distributed computing



Tasks of computing facilities

KEK : Host institute of Belle II
= Main center + Grid site

Non-grid Sites	Grid Sites	KEK	
		Storage and Processing of Raw Data	Main Center
	Experiment-specific Services	Experiment-specific Services	
	Monte-Carlo Production	Monte-Carlo Production	Grid Resources
	Data Analysis	Data Analysis	
Ntuple-level Analysis	Ntuple-level Analysis	Ntuple-level Analysis	Local Resources
User Interface	User Interface	User Interface	

Distributed Computing

Basic concept is

keeping the system as simple as possible

utlizing existence grid services as much as possible

the gLite middleware used by the LHC experiments	the metadata and project structure from DO and CDF experiments

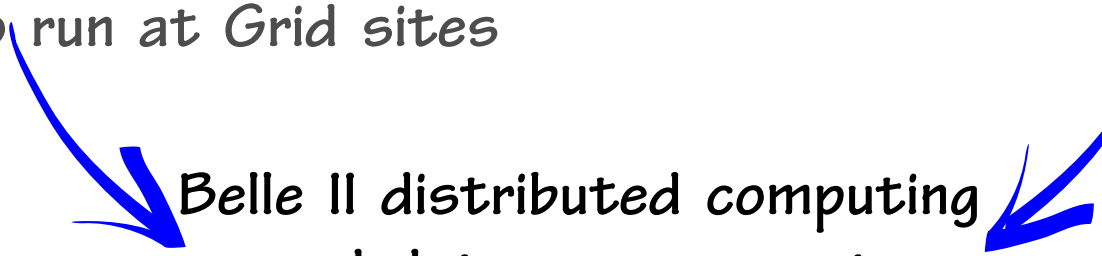
enables data and CPU resources to be located in the world

enables the movement of data between storage resources

allows jobs to run at Grid sites

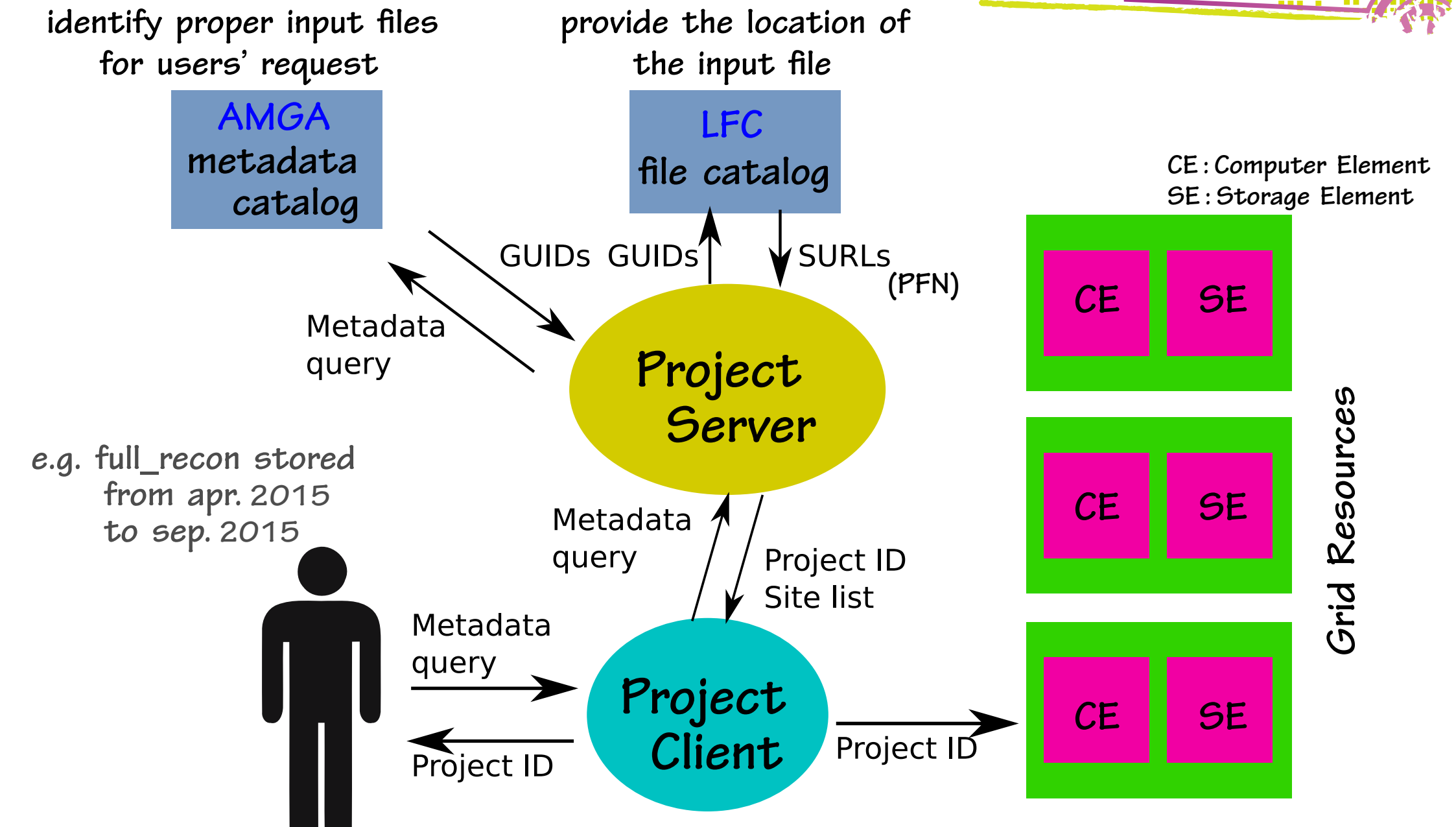
steers tasks amongst the distributed computer and data resources

bookkeeping service with using metadata catalog

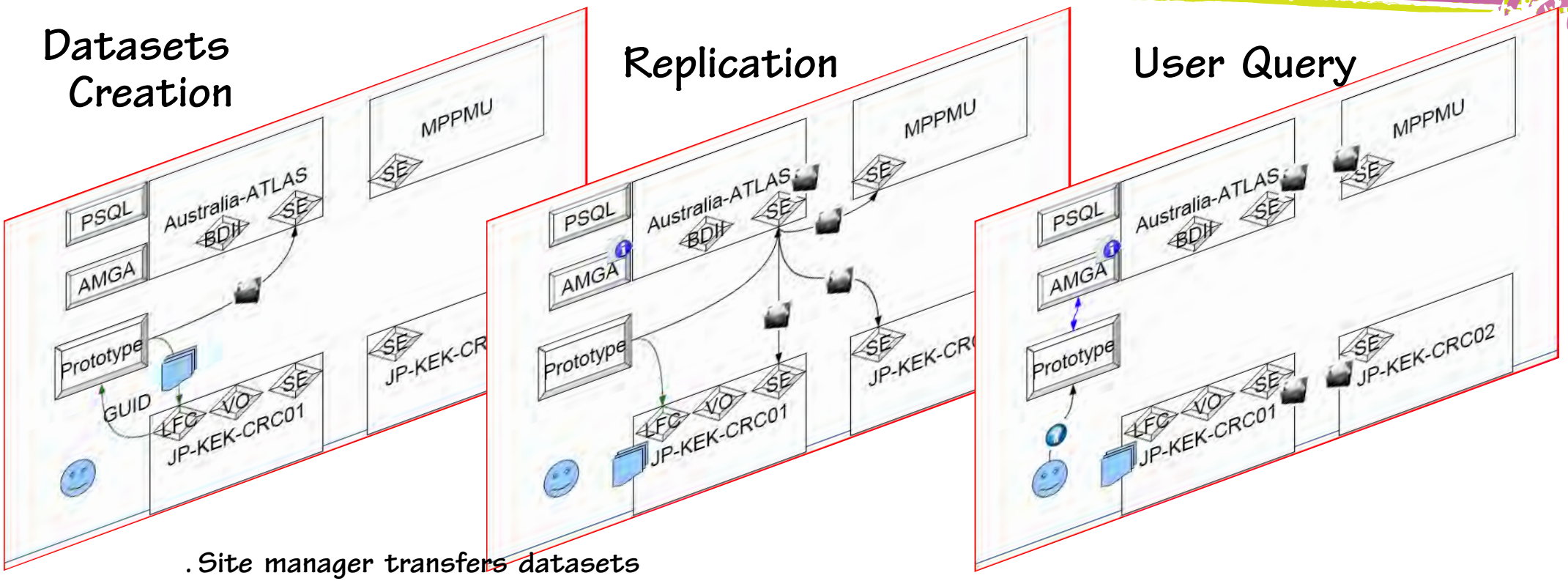


Belle II distributed computing and data management

Analysis model : Project Structure



Analysis model : Prototype test



. Site manager transfers datasets
. User starts project
using metadata query

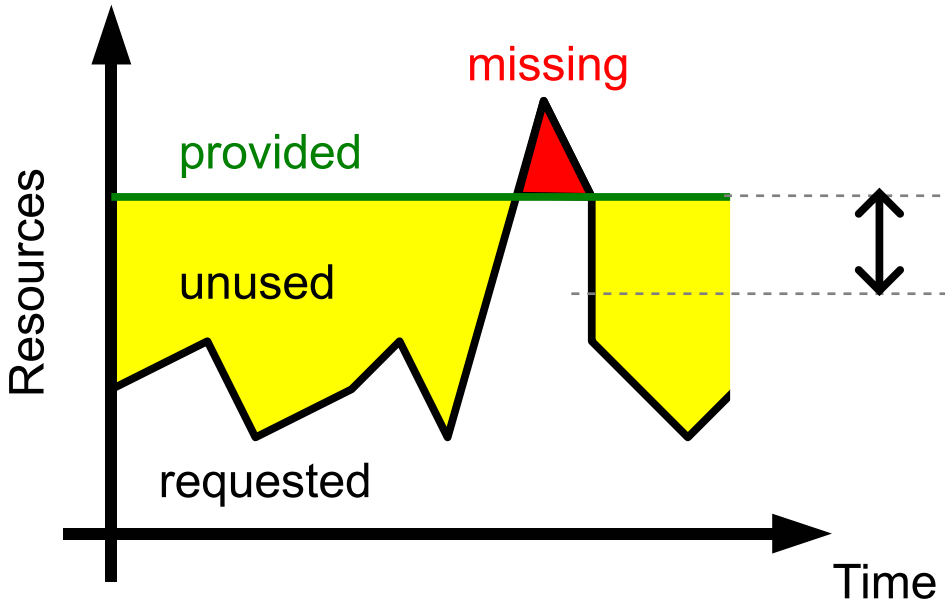
. User submits jobs to sites
where the data is
. Job asks for the next file
. Project server returns
next PFN (Physical File Name)
. Output stored
at local SE

We need a large-scale test
with a huge amount of Belle MC data files

(planned in the next fiscal year
: KEK - KISTI - Melbourne - Krakow - ...)

Cloud computing

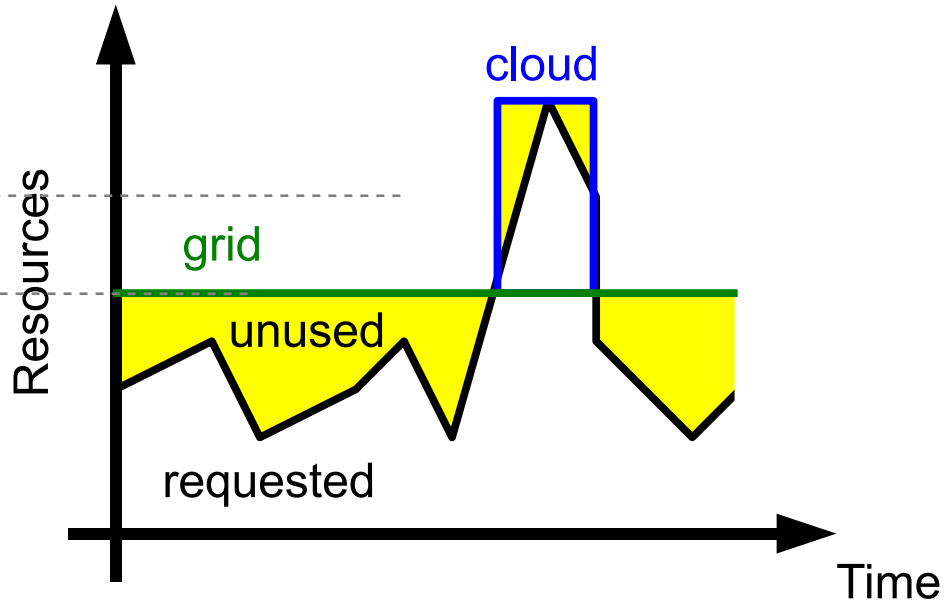
Classical design



maintain unused CPUs

risk of a resource shortage

System utilizing could resources



risk of a vendor lock-in

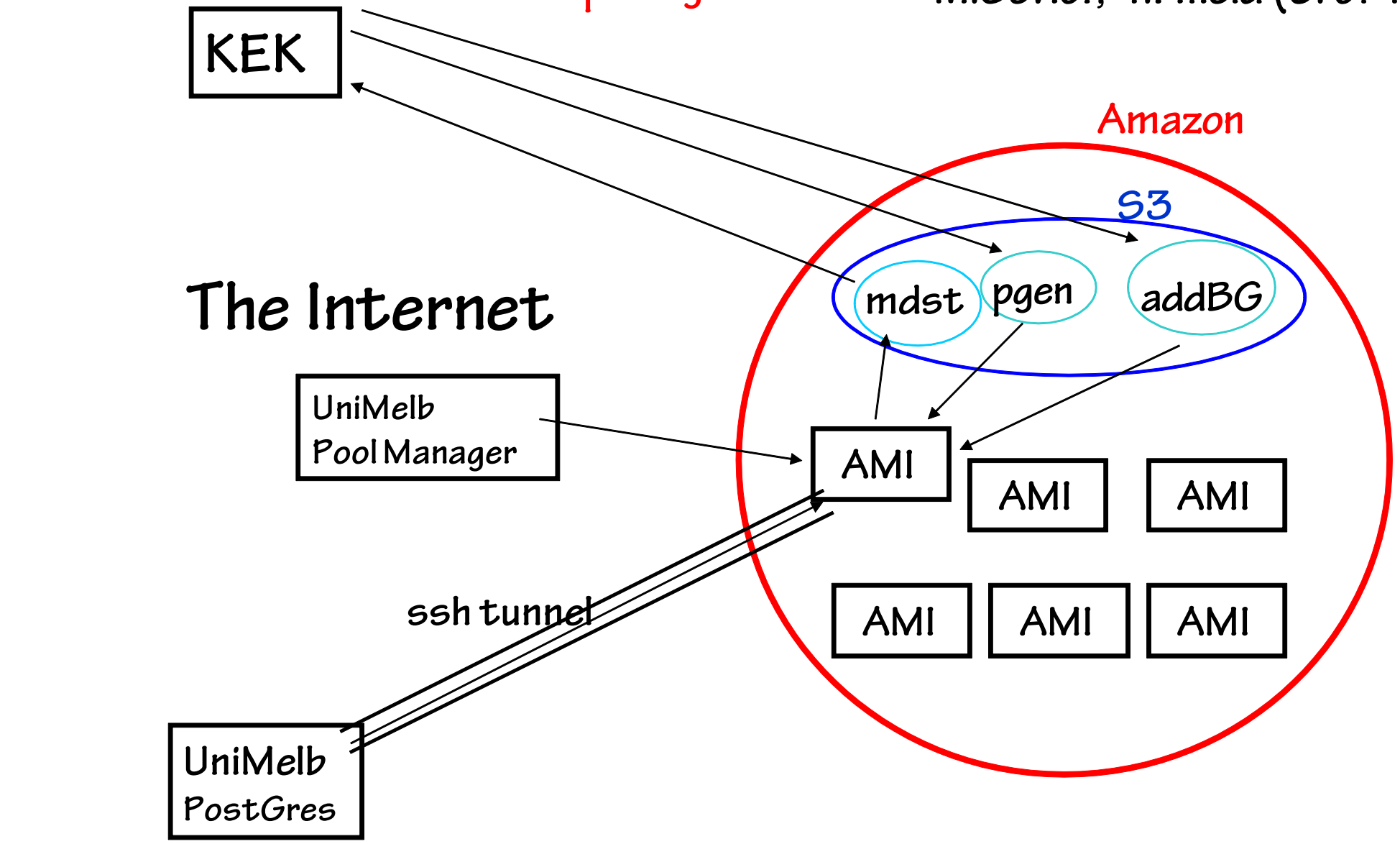
# of Events	CPU Cost	Cost of 10^4 events
752k	~$80	$1.16
1473k	~$110	$0.78
10000k	~$725	$0.76

An option for peak demands in MC production and/or physics analysis

Cloud computing

EC2 = Amazon Elastic Computing Cloud

M.Sevior, T.Fifield (U. of Melboulne)

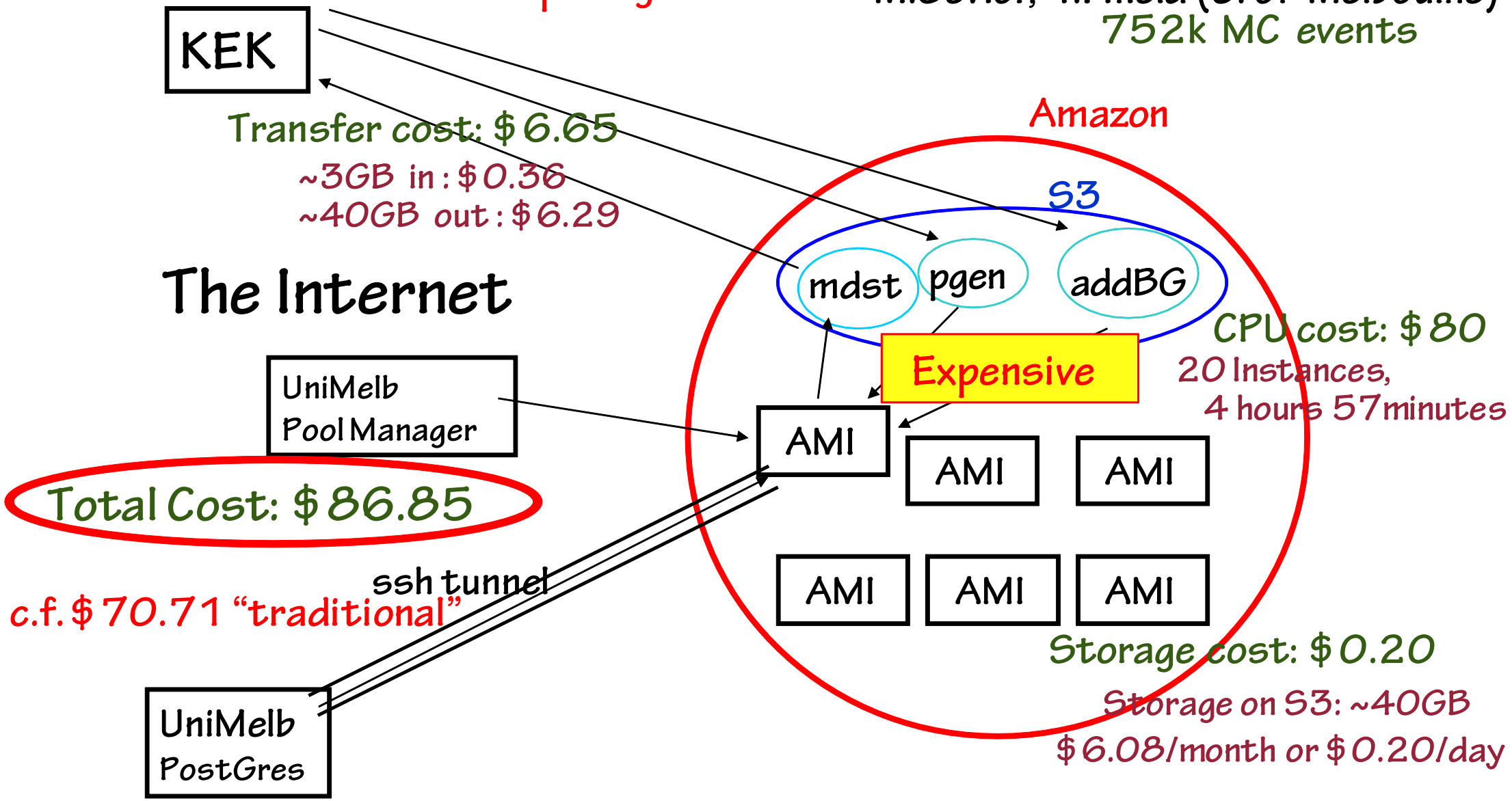


Cloud computing

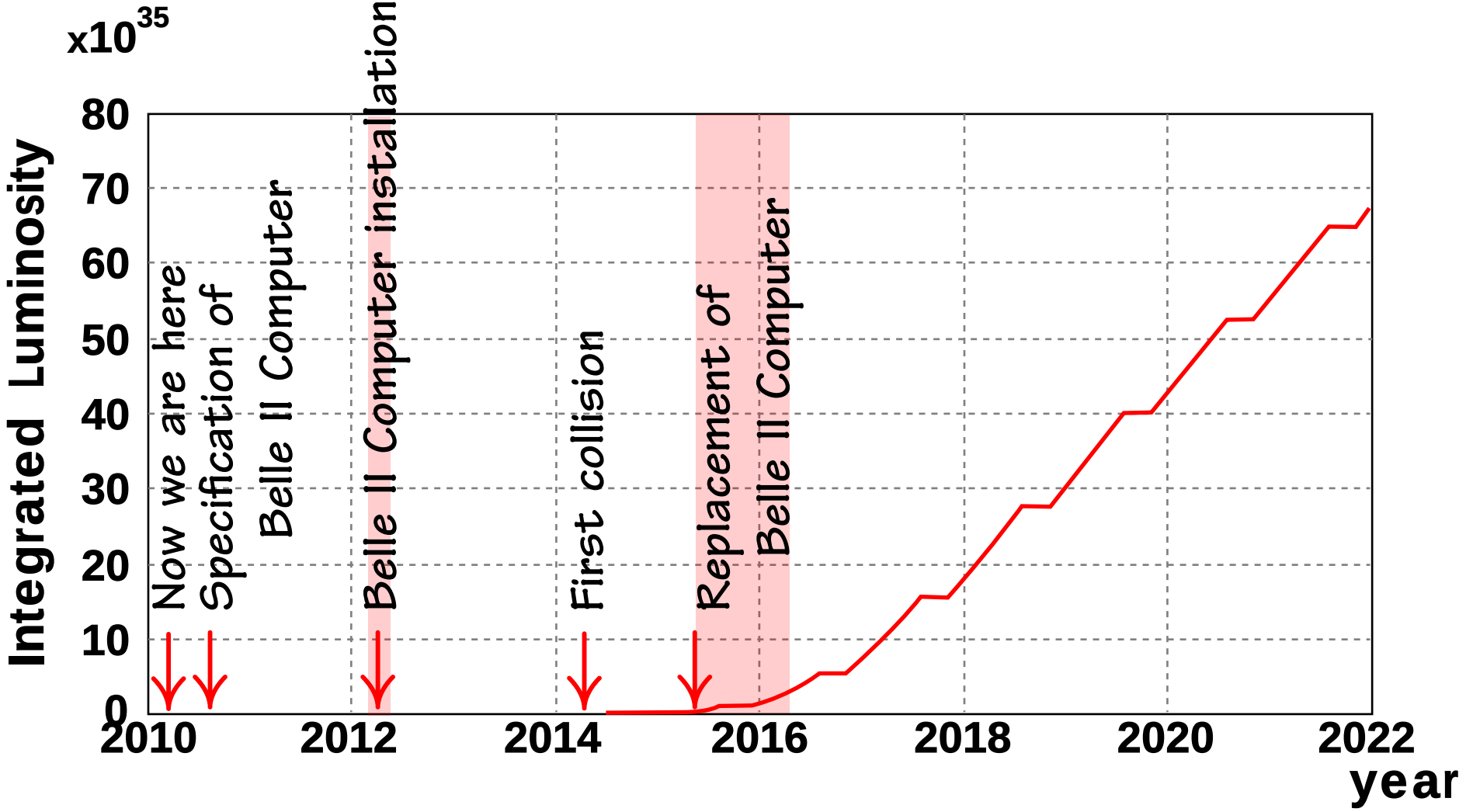
EC2 = Amazon Elastic Computing Cloud

M.Sevior, T.Fifield (U. of Melboulne)

752k MC events

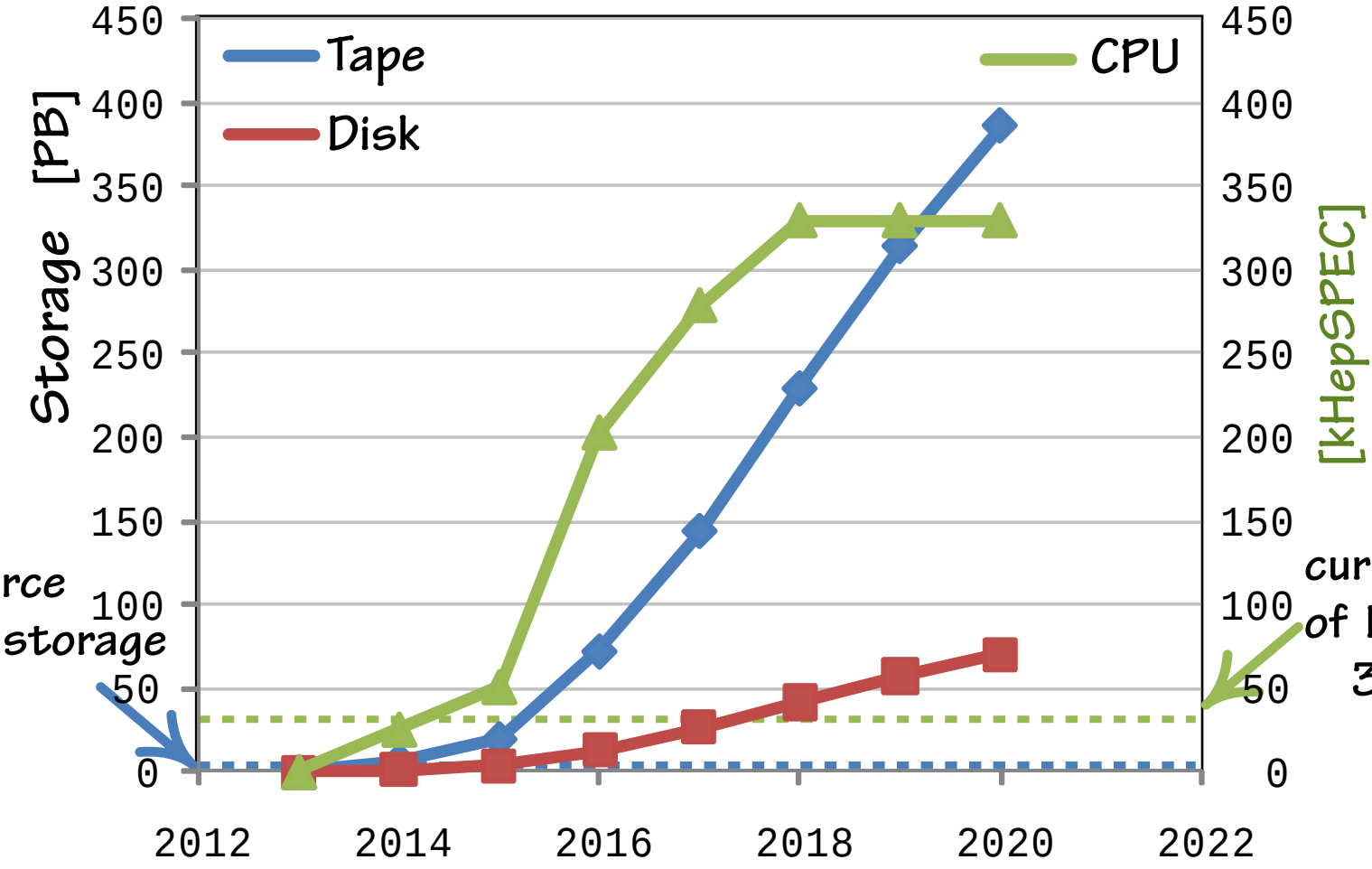


Milestone for computing



Resource requirement for KEK

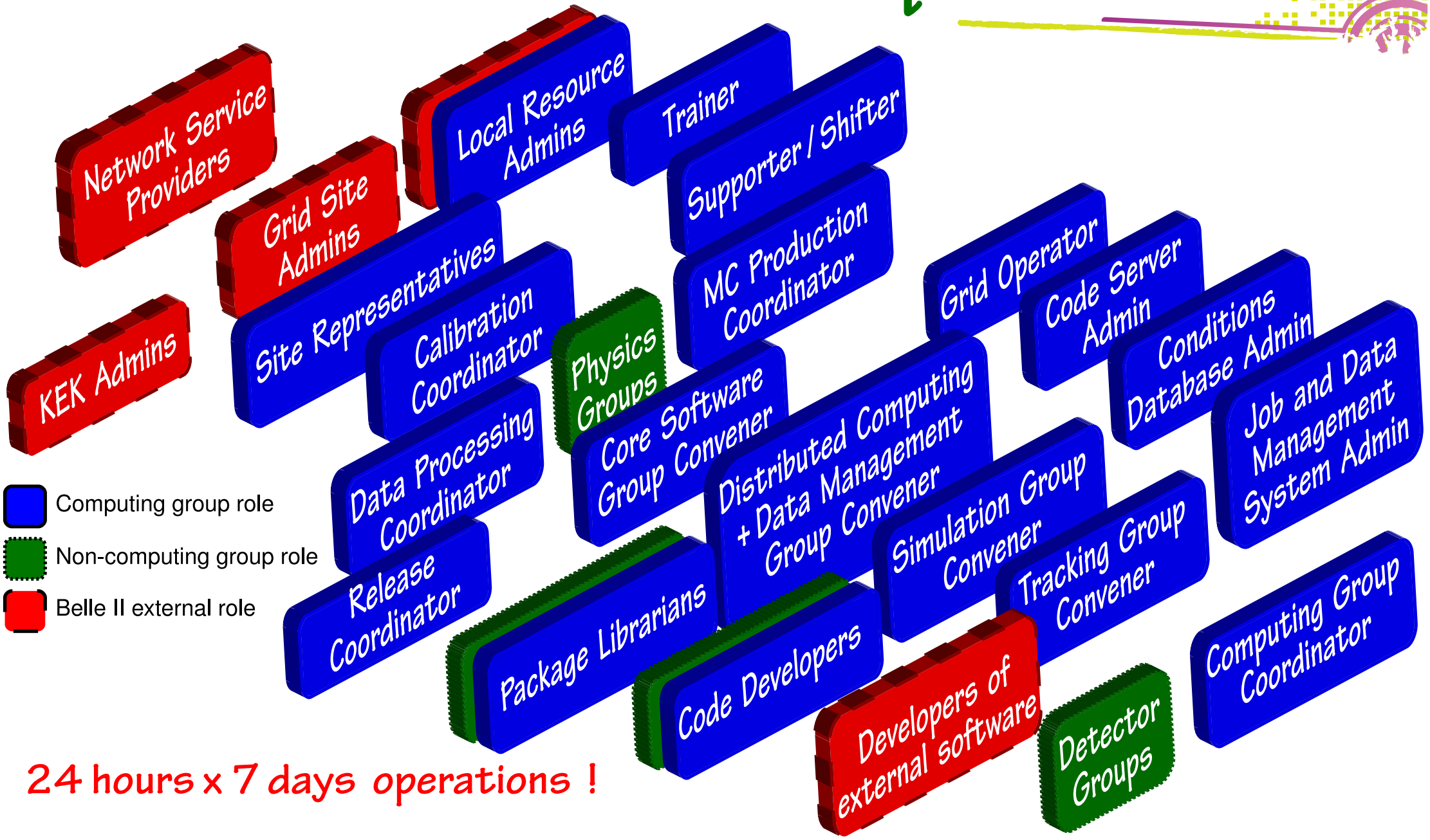
All raw data is processed (in 5 months : beam-off period)
30% of MC is produced (in 5 months)
All raw data, mDST and 30% of MC are archived



current resource
of Belle Tape storage
3.5 PB
(disk : 1.5PB)

current resource
of Belle CPU
35kHepSPEC

Human resource requirement



24 hours x 7 days operations !

Summary

We decided to employ a world-wide distributed computing system and a tiered structure based on the Grid technologies.

Cloud technology has a high potential, but this will be an option for peak demands in MC production or physics analysis.

A test of our analysis model prototype is in progress, and we plan a large-scale test in the next fiscal year.

Technological/budgetary limitation to handle and archive the order of 100PB data must be cleared.

We need to increase human resources so that we can develop, maintain and operate the proposed distributed computing system.