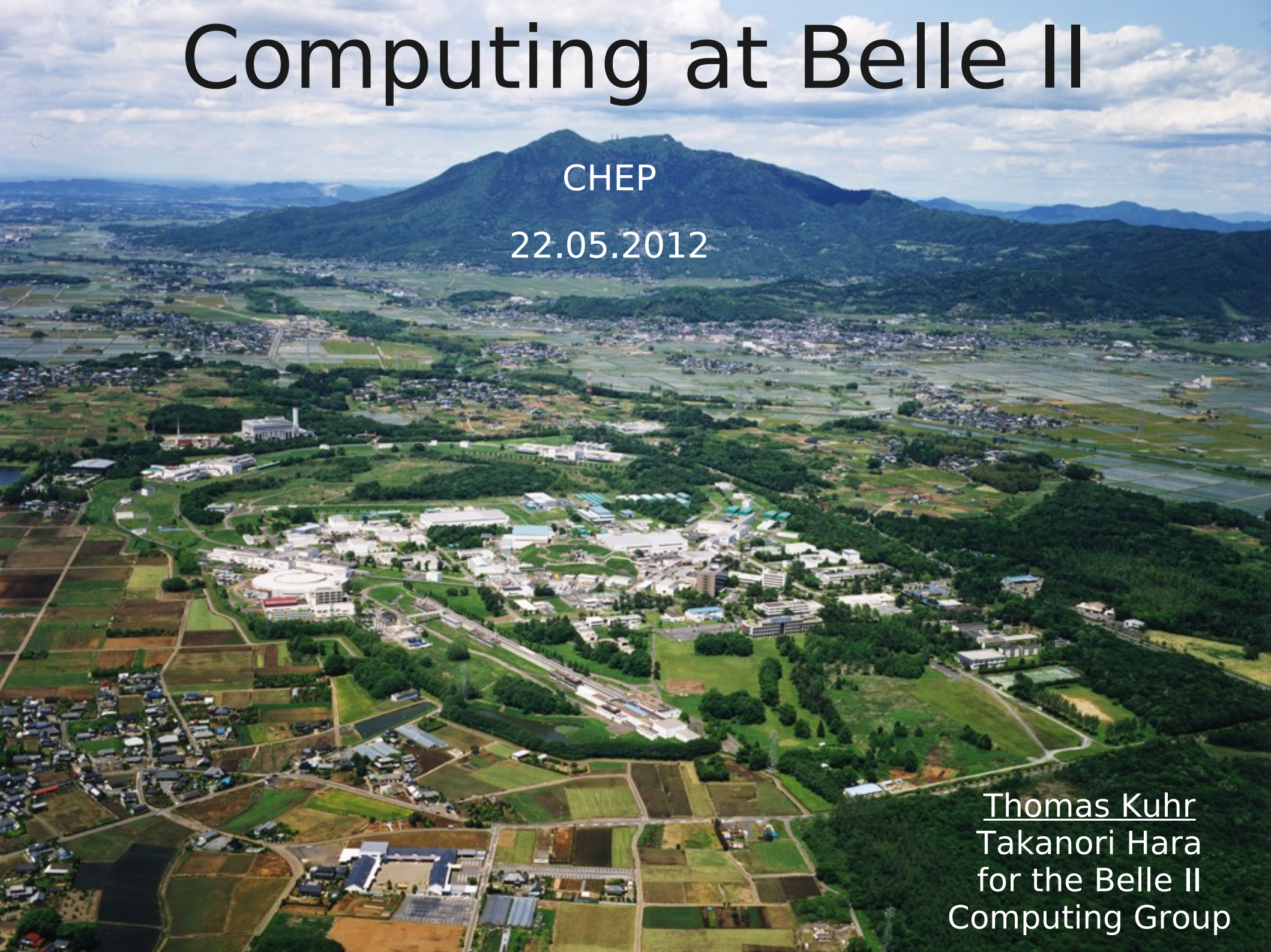
Computing at Belle II

CHEP

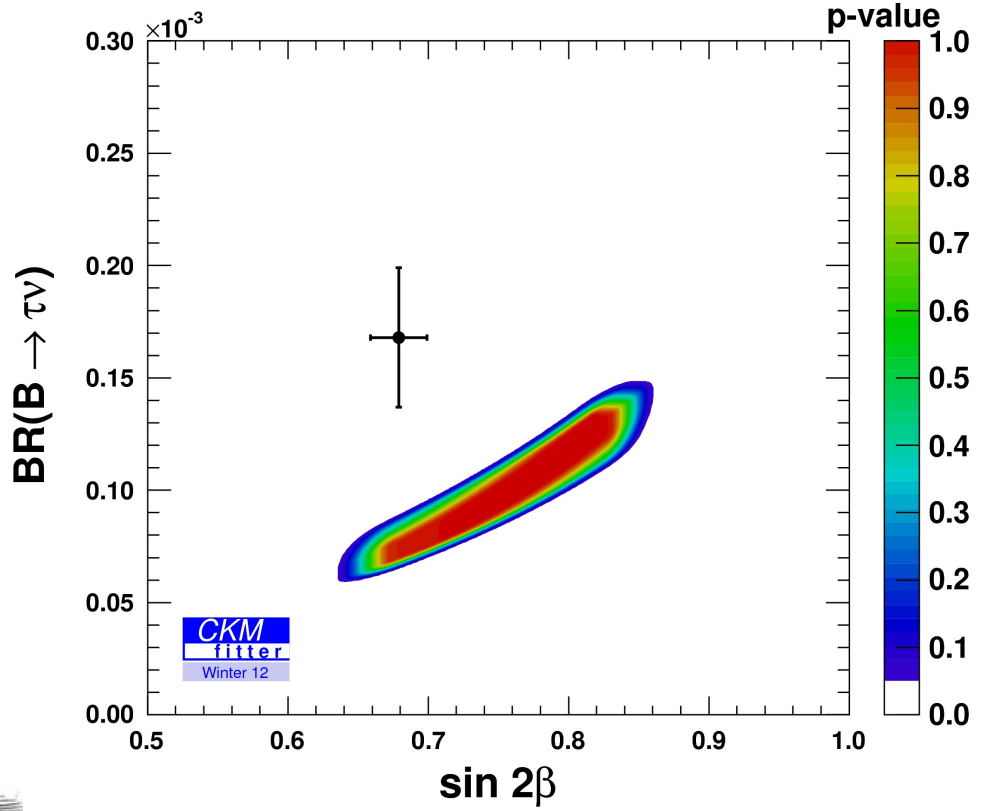
22.05.2012



Thomas Kuhr
Takanori Hara
for the Belle II
Computing Group

Physics Objective of Belle and Belle II

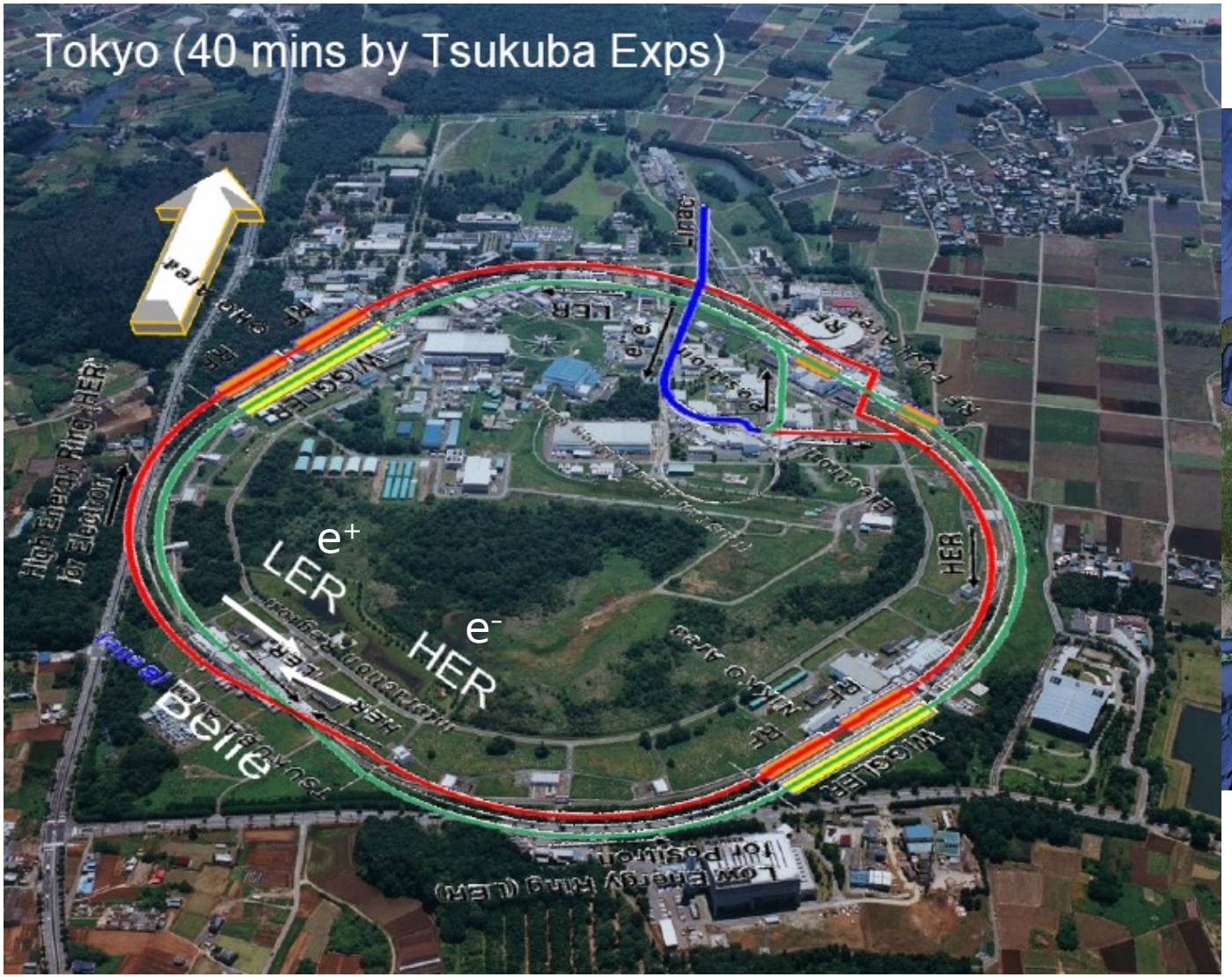
- ✔ Confirmation of KM mechanism of ~~CP~~ in the Standard Model
- ✗ ~~CP~~ in the SM too small
  (by many orders of magnitude)
  to generate observed baryon asymmetry in the universe
- ➔ Need sources of ~~CP~~ beyond the SM

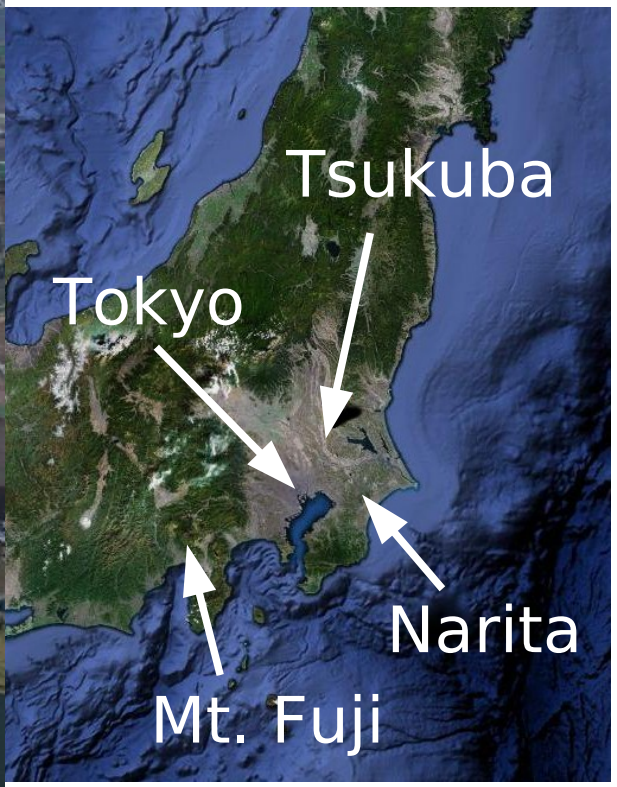


➔ Super B factory

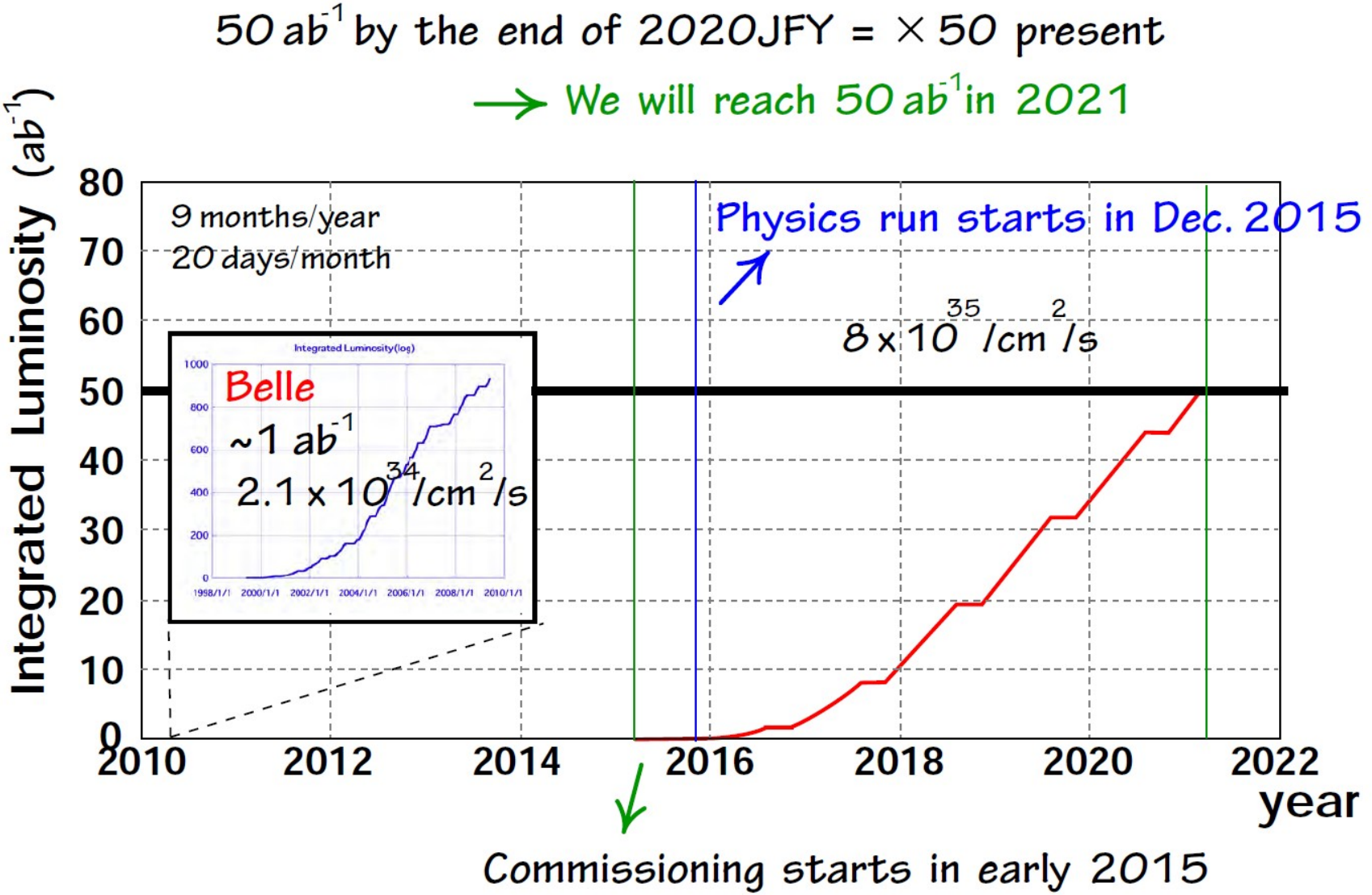
Complementary to LHCb

KEK Site


Tokyo (40 mins by Tsukuba Exps)
e+
LER
e-
HER
Belle


Tsukuba
Tokyo
Narita
Mt. Fuji

Projection of Luminosity at SuperKEKB



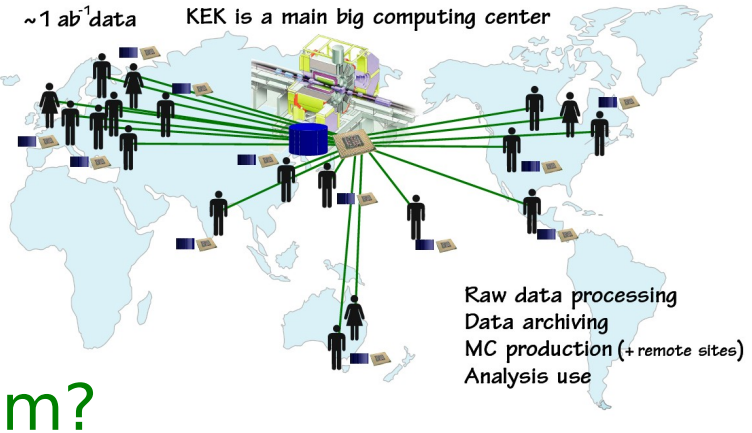
Estimated Data Rates

Experiment	Event Size [kB]	Rate [Hz]	Rate [MB/s]
High rate scenario for Belle II DAQ:			
Belle II	300	6,000	1,800
LCG TDR (2005):			
ALICE (HI)	12,500	100	1,250
ALICE (pp)	1,000	100	100
ATLAS	1,600	200	320
CMS	1,500	150	225
LHCb	25	2,000	50

Belle II Collaboration

→ Distributed collaboration

Considerations for Belle II Computing



Belle: Computing centralized at KEK

Belle II: ➔ 50 times more data, distributed collaboration

- Go for a distributed computing system?

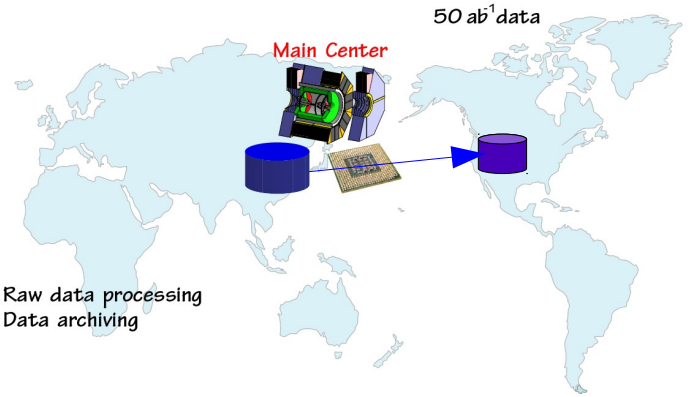
- *More complicated, requires more effort to set up and maintain*
- It allows the Belle II members to contribute via computing facilities in their country
- It provides redundancy
- The distributed infrastructure already exists
  - ➔ *Use existing grid sites and services (gLite, EMI, DIRAC)*

Grid Sites

Country	Sites	Belle VO	Comment
Australia	Tier2/3	Supported	Cloud system planned
Austria	Tier2		
China	Tier2		DIRAC server
Czech Republic	Tier2	Supported	
Germany	Tier1/2	Supported	
India	Tier2		New data center planned
Japan	KEK	Supported	
Korea	Tier2	Supported	
Poland	Tier2/3	Supported	Cloud system developed
Russia	Tier2		
Slovenia	Tier2	Supported	
Taiwan	Tier1/2		
USA	OSG	Supported	Site at PNNL is set up

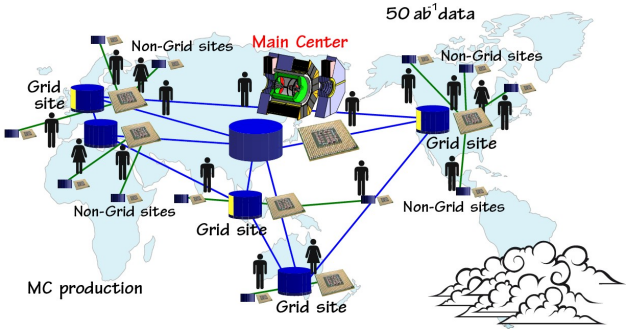
Poster Session 1, #159, M.Sevior

Computing Tasks



Raw data processing

- Tape as storage medium
- Store and process at KEK, replication to just one remote site
  - ➢ Simpler than LCG model



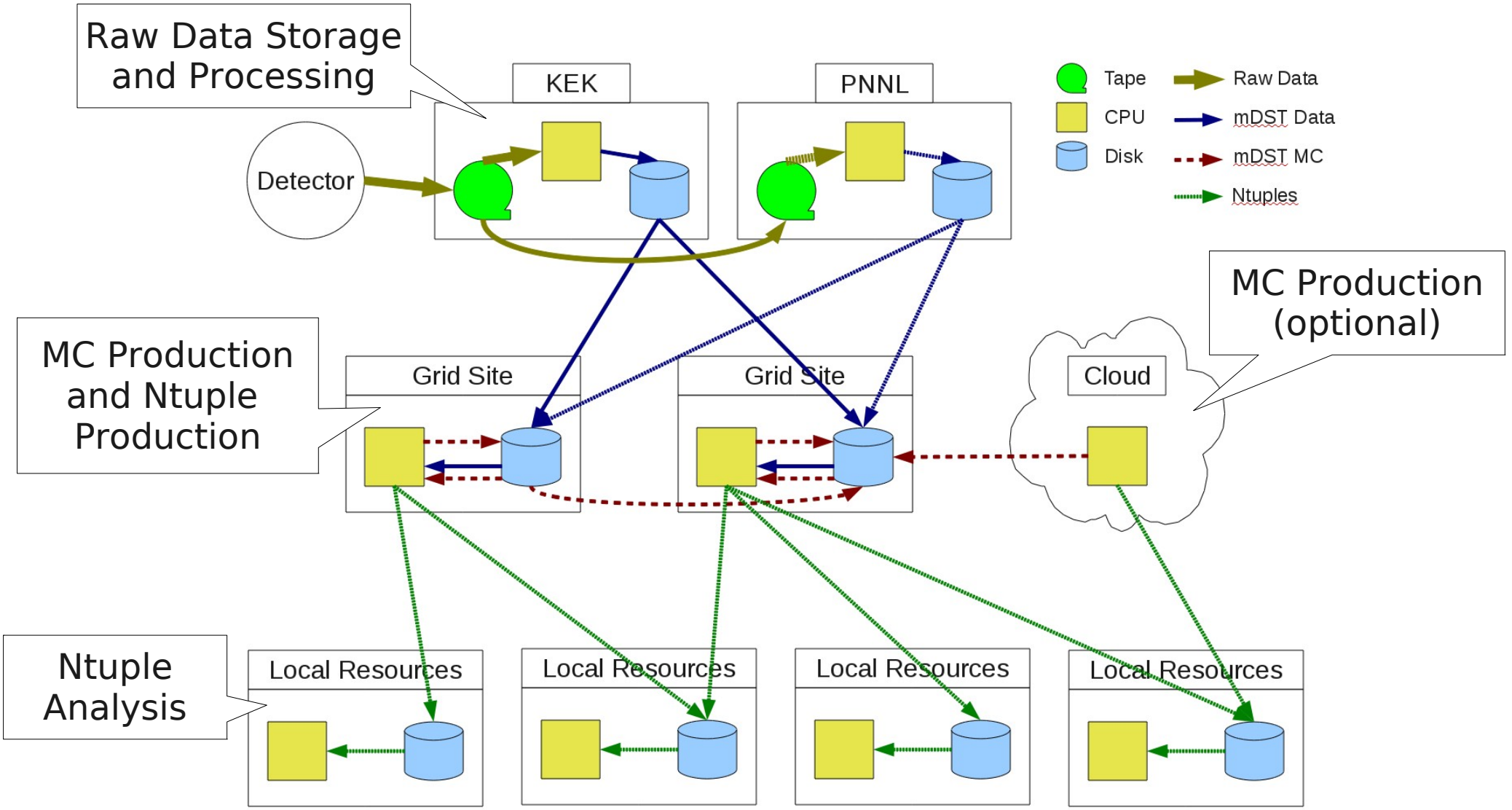
Monte Carlo Production

- 6 times the real data size
- Produced in managed way, (almost) no input data needed
  - ➔ Well suited for a distributed environment, including cloud

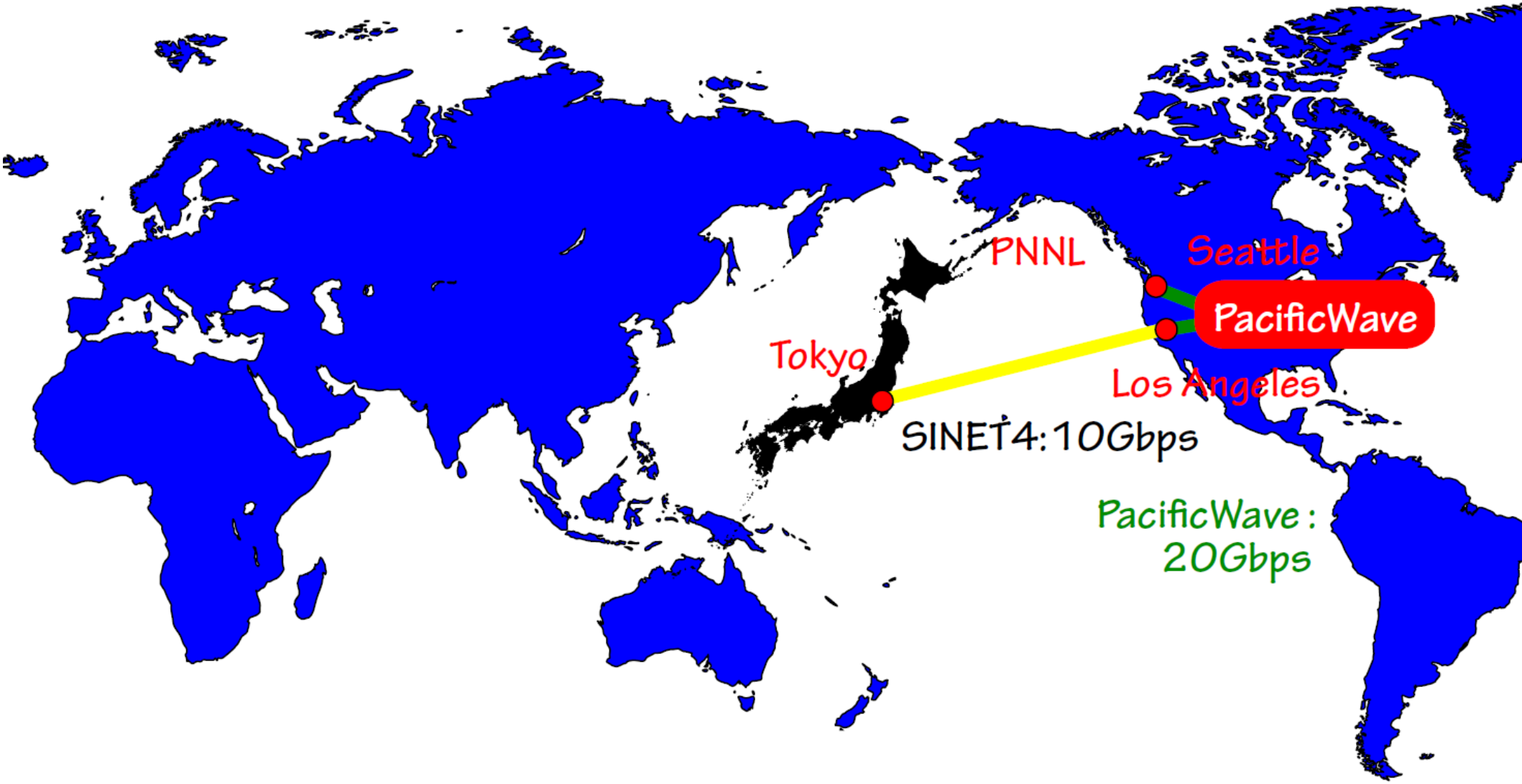
Physics Analysis

- Random, uncoordinated access → Store input data on disk
  - ➢ Ntuple analysis on local resources for fast turn-around

Computing Model



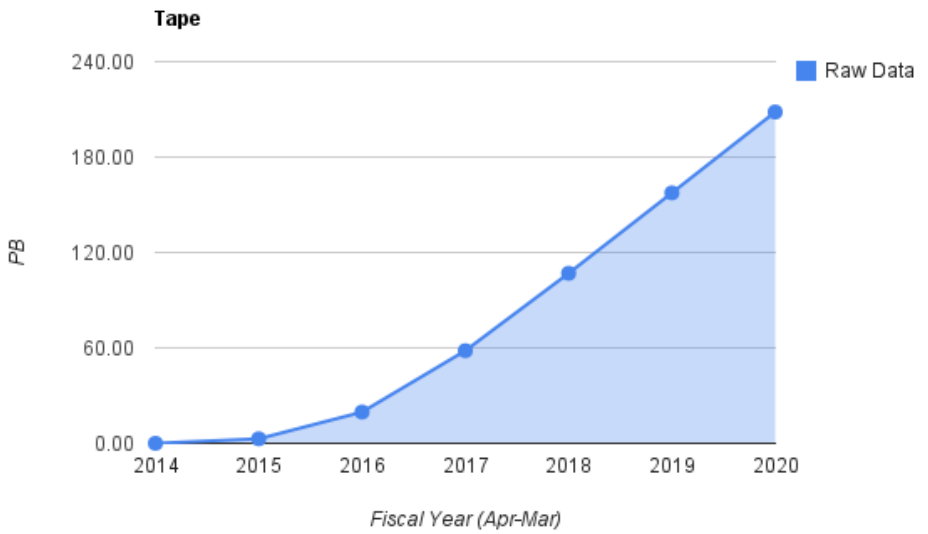
Network Connections

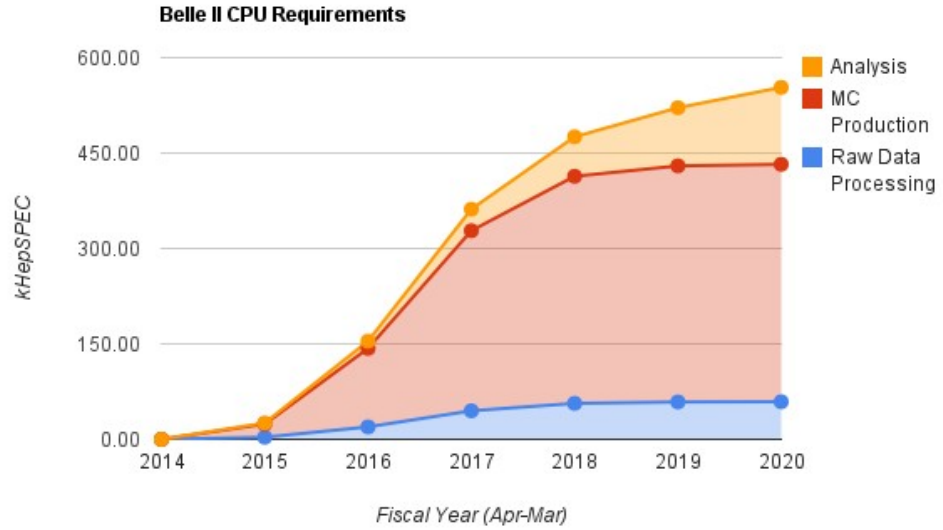


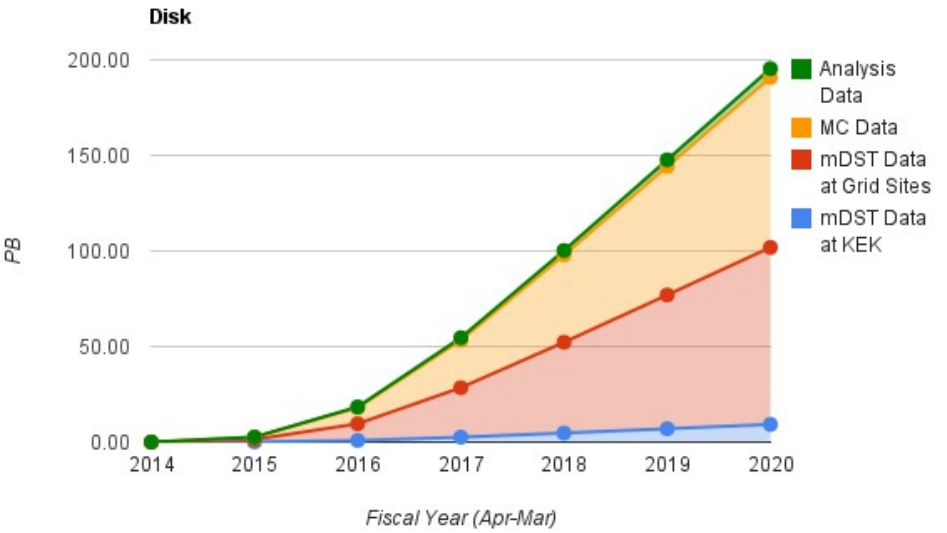
Resource Estimates

Estimates depend on
several unknown parameters:

- Accelerator performance
- Event data size
- Simulation/reconstruction code performance
- Analysis requirements

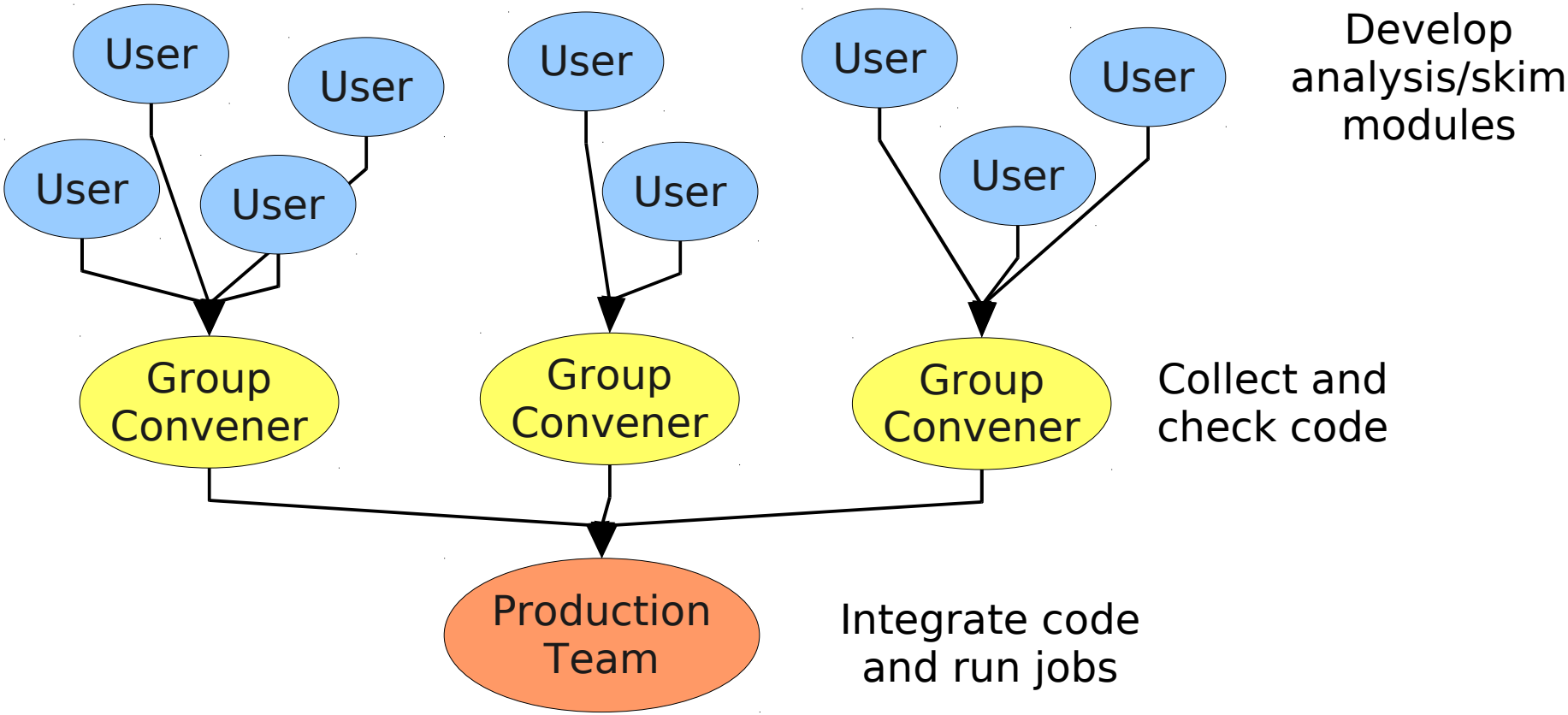






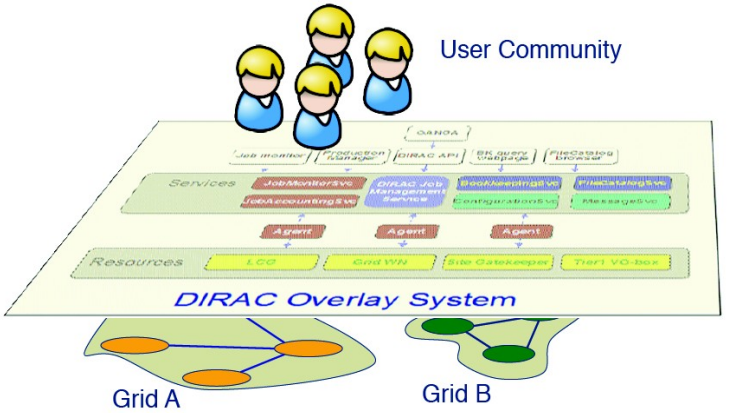
Organized Analysis

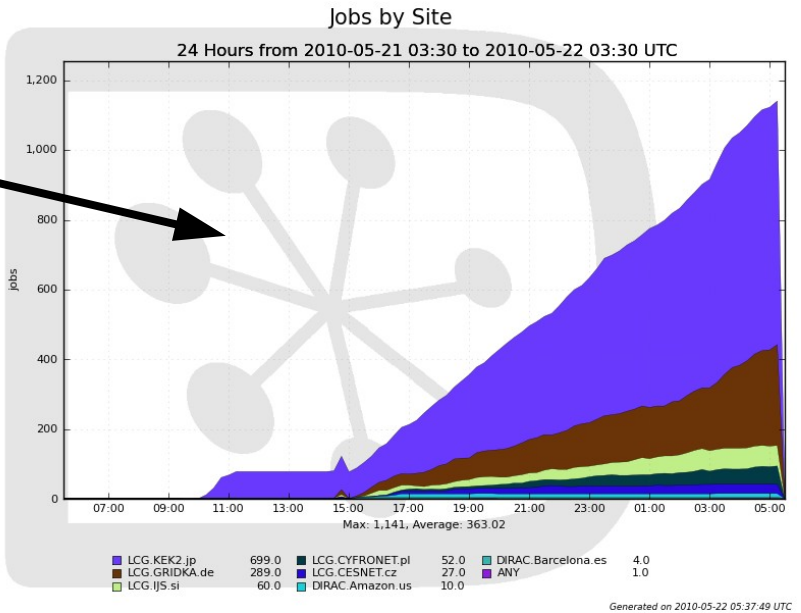
- Problem: inefficient resource usage by many users
- ➔ Limit resources per user, but maintain free access to data
- ➢ Offer high-performance organized analysis as a service



Distributed Computing System

- DIRAC (developed by LHCb)
  - Pilot jobs
  - VO centric
  - Extendible
  - Belle MC production on grid sites, local clusters, and Amazon EC2



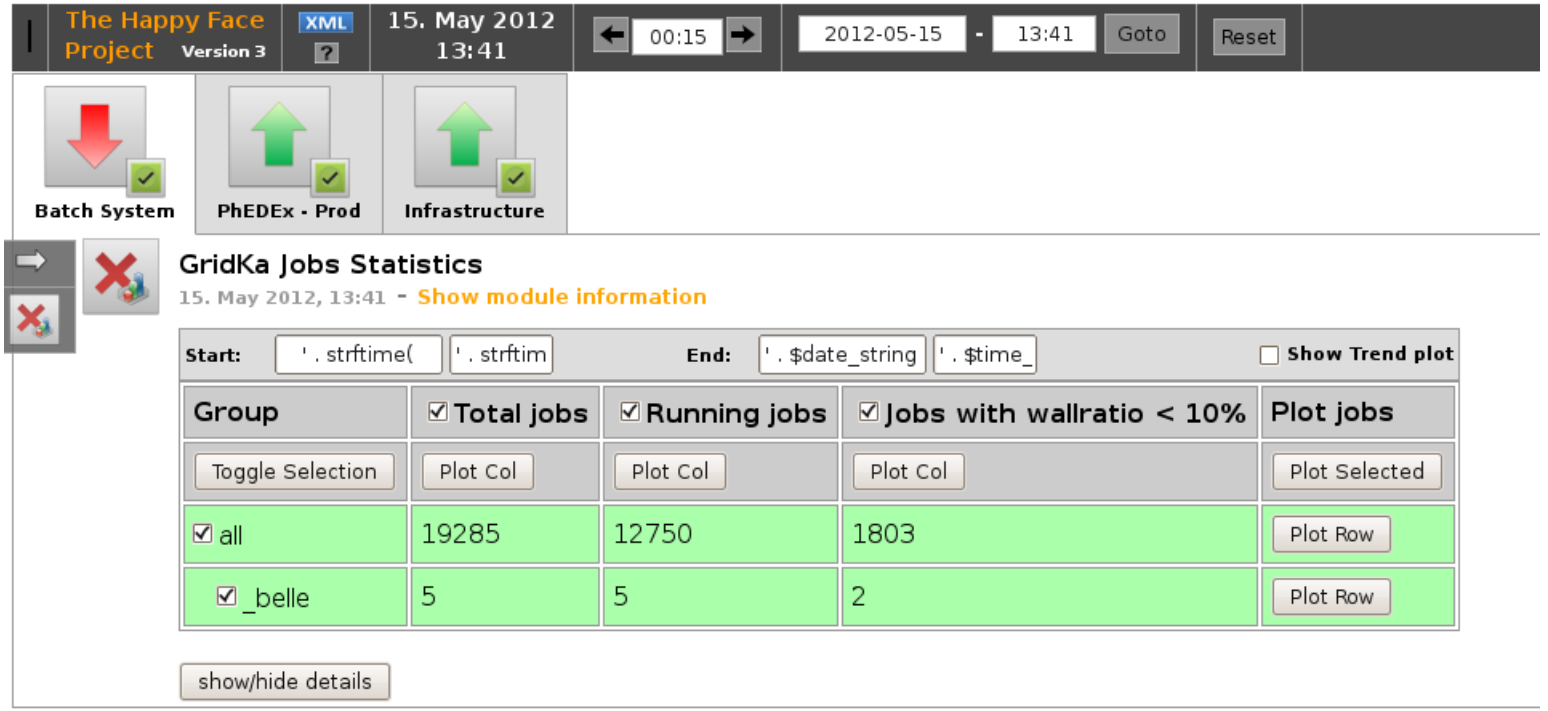


- AMGA
  - Metadata of files and datasets

Poster Session 2, #58, K.Cho

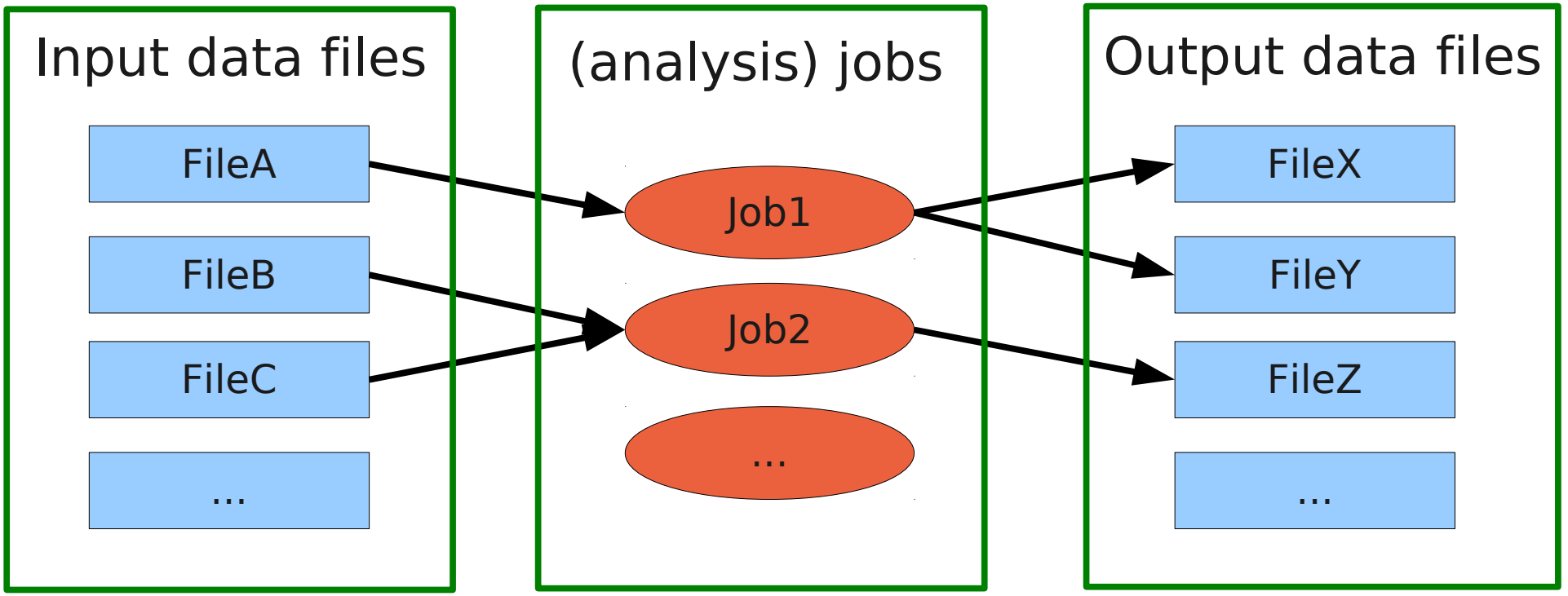
Distributed Computing System

- Happyface (developed by CMS)
  - ➔ Monitoring of grid sites



- CVMFS
  - ➔ Software distribution

Workflow Abstraction



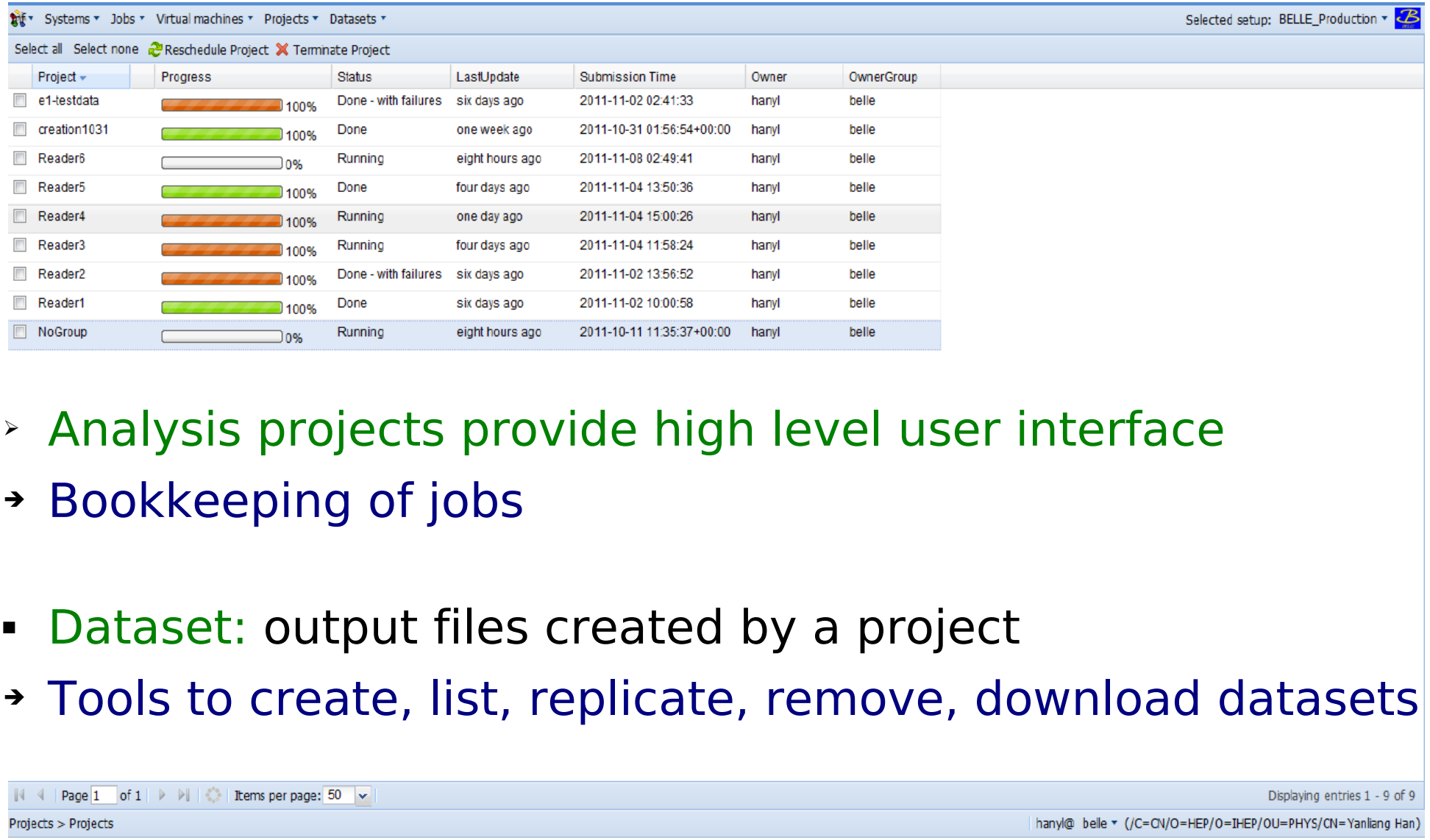
Input dataset

Project

Output dataset

- Don't deal with single files and jobs, but with datasets and projects

Analysis Projects



- Analysis projects provide high level user interface
  - Bookkeeping of jobs

- Dataset: output files created by a project
  - Tools to create, list, replicate, remove, download datasets

User Interface: gbasf2

Basf2 Steering File options

The default configuration option for gBasf2 is to set a number of variables in your normal basf2 steering file:

```
############################
# gBasf2 configuration     #
############################
#Name for project
project='e055-test'
# (optional) Job priority [0-10]
priority='1'
#Experiments (comma separated list)
experiments='13,57'
#Metadata query
query='id > 10 and id < 15'
#Type of Data ('data' or 'MC')
type='data'
#estimated Average Events per Minute (eg Mcprod = 40)
evtpermin='45'
# (optional) Files to be sent with the job
inputsandboxfiles = 'file1.txt,file2.txt'
# (optional) max events - the maximum number of events to use
maxevents ='100000'
```

You can then invoke gBasf2 using the steering file and it will do the rest:

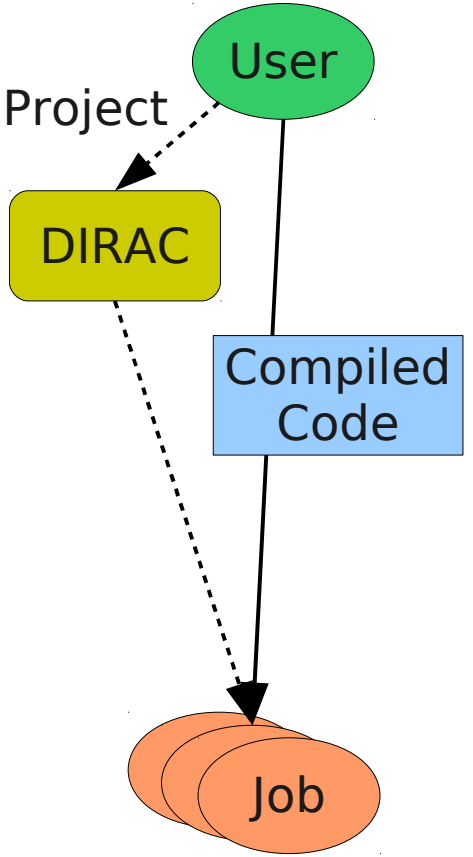
```
./gbasf2.py -s steering_file.py
```

Same python steering file as for offline basf2 job, but with additional parameters for the grid job

Analysis Code Submission with gbasf2

Three options planned:

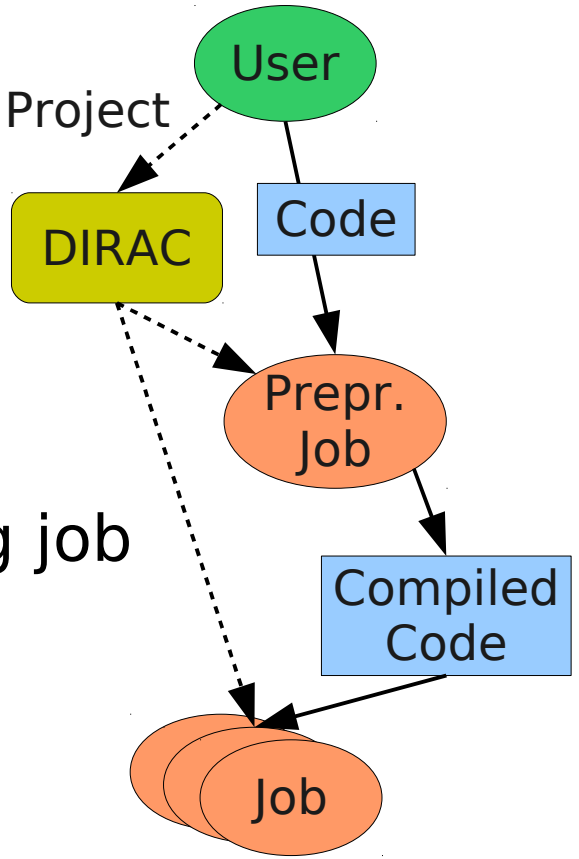
- Locally compiled code
  - ➔ Requires SL5 compatible system



Analysis Code Submission with gbasf2

Three options planned:

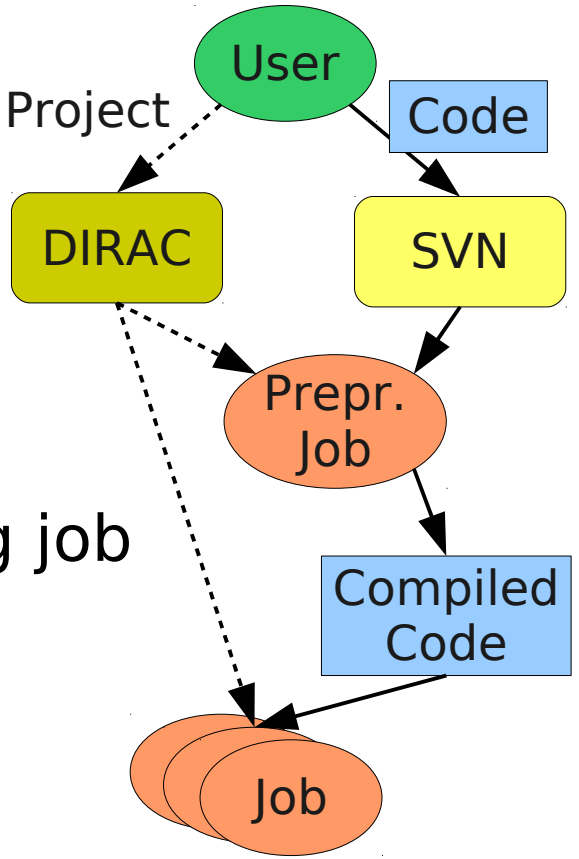
- Locally compiled code
  - ➔ Requires SL5 compatible system
- Local source code
  - ➔ Automatic compilation in preprocessing job



Analysis Code Submission with gbasf2

Three options planned:

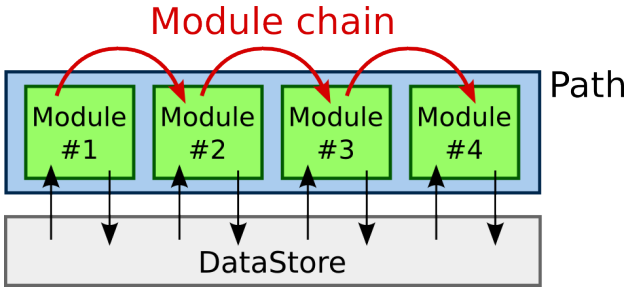
- Locally compiled code
  - ➔ Requires SL5 compatible system
- Local source code
  - ➔ Automatic compilation in preprocessing job
- Source code committed to svn repository
  - ➔ Automatic commit of local code
  - ➔ Automatic compilation in preprocessing job
  - ➔ Code version stored in metadata of output dataset
  - ➢ Documentation which code was used to produce a file



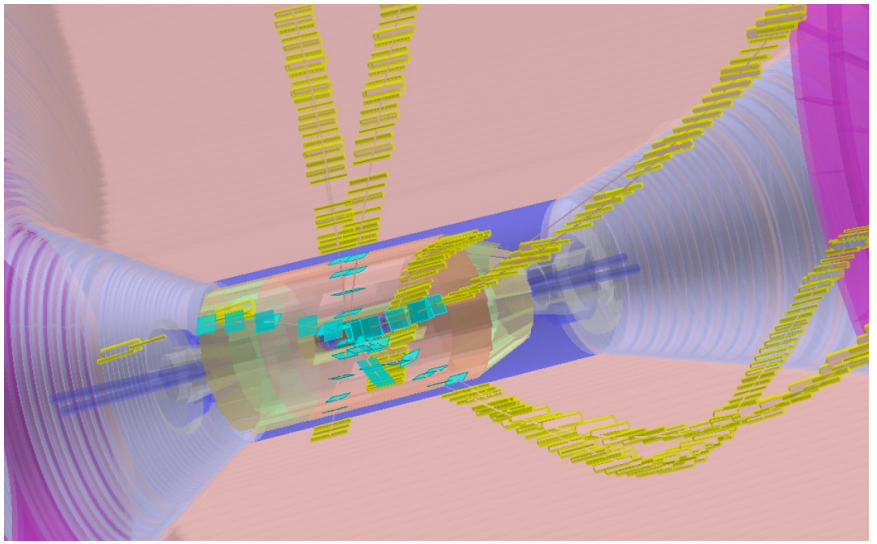
Software Framework: basf2

- Inspired by frameworks of Belle (basf) + other experiments
- ✔ Used for simulation, reconstruction, analysis, and DAQ

- ✔ ROOT I/O as data format
- ✔ Software bus with dynamically loaded modules
- ✔ Python steering
- ✔ Parallel processing



Poster Session 2, #155, R.Itoh



- Simulation: Geant4
- Tracking: GenFit

Event Processing, Thu 15:10, M.Nadler

Poster Session 2, #74, J.Lettenbichler

Code Management

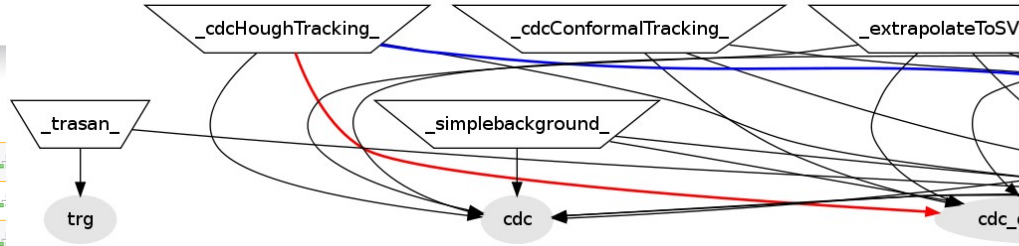
- Developer with different level of experience, distributed around the world

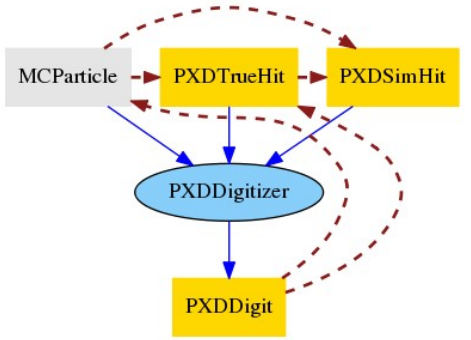
➔ Need reliable, user-friendly, well-maintainable code

  - Tools: Central code repository (svn), code browser, doxygen, style formatting tool, issue tracker, twiki, continuous integration system (buildbot), mailing lists

Package details

Package	Librarian	Build Result	Intel Build Result	Test Result	Geometry	Code Documentation	Dependencies	
arich	Luka Santelj	OK	Remarks: 416	None	OK	Missing: 12	Extra: 1	
bklm	Leo Piilonen	OK	Remarks: 310	None	OK	OK	OK	
cdc	Guofu Cao, Makoto Uchida	Warnings: 2	Remarks: 537	None	OK	Missing: 52	Extra: 1	
daq	Ryosuke Itoh	Warnings: 5	Warnings: 9 Remarks: 467	None	OK	Missing: 260	Missing: 7	Graph | Package graph
data	Takanori Hara	OK	OK	None	OK	OK	OK	
data_handling	Junghyun Kim	OK	OK	None	OK	OK	OK	
ecl	Poyuan Chen, Takanori Hara	OK	Warnings: 3 Remarks: 421	None	OK	Missing: 133	OK	Graph | Package graph
eklm	Timofey Valerevich Uglov, Kirill Chilikin	OK	Remarks: 660	None	OK	Missing: 9	Missing: 1	Graph | Package graph
examples	Susanne Koblitz	OK	Remarks: 41	None	OK	OK	Missing: 3 Extra: 3	Graph | Package graph
framework	Martin Heck	OK	Warnings: 2 Remarks: 1316	0/14, 0/2	OK	Missing: 141	Extra: 1	Graph | Package graph

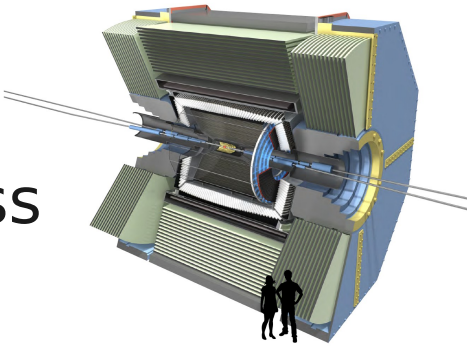




Summary

- Belle II at the SuperKEKB accelerator will search for New Physics with O(50) times more data than current B factories

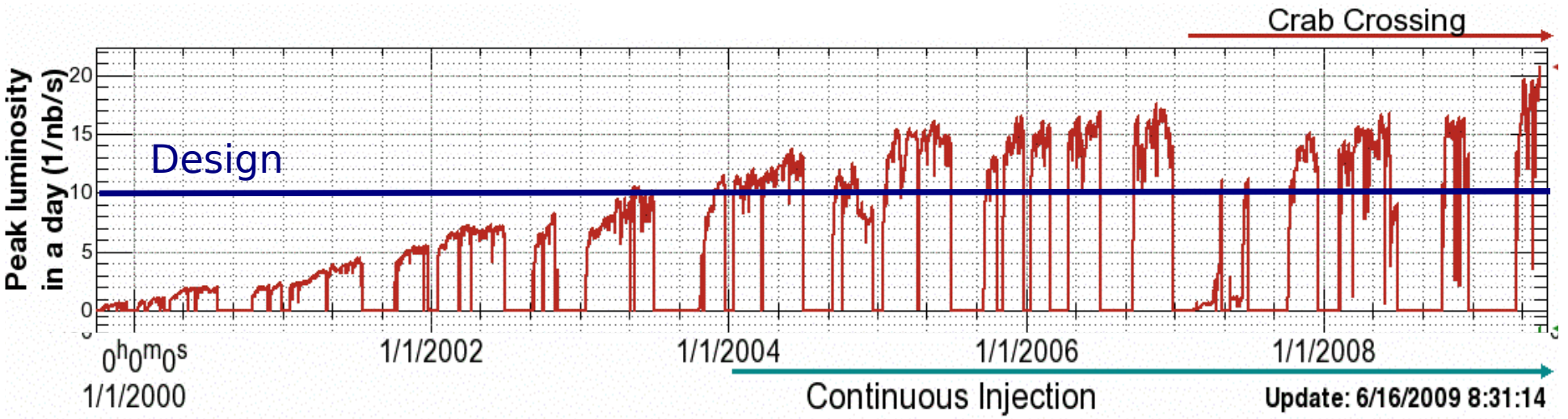
- Huge data volume is a challenge for the computing
  - Distributed computing system based on existing technologies and infrastructures
  - Formation of grid sites federation in progress



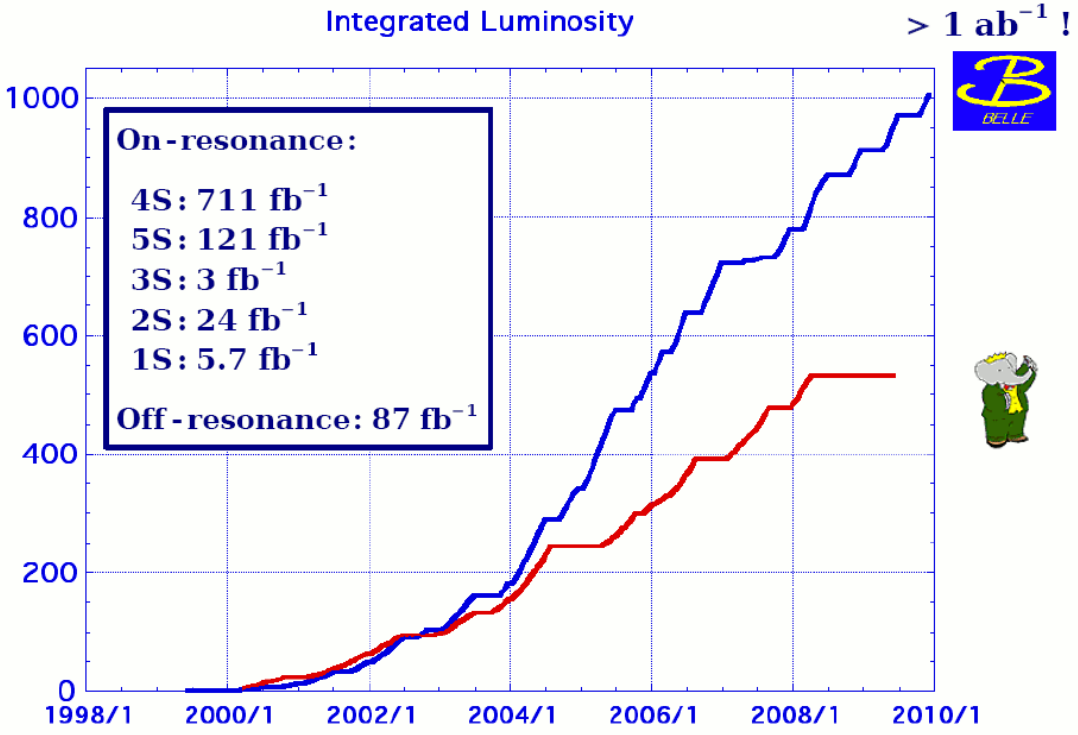
- Distributed computing user interface: gbasf2
  - Workflow abstraction with projects and datasets
- Easy transition from offline software framework: basf2
- *Upgrade of accelerator and detector to be complemented by upgrade of software and computing system*

Backup

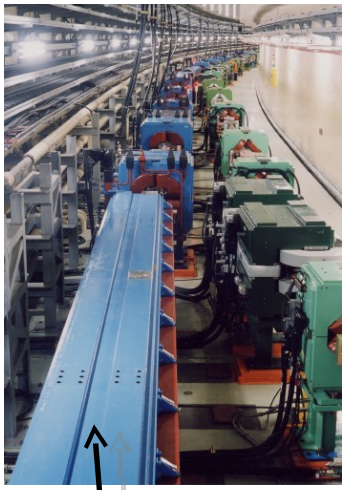
KEKB Performance

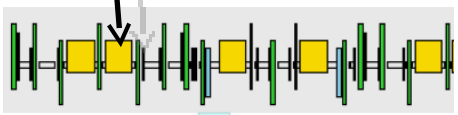


- World record luminosity:
  2.1×10^{34} cm^{-2}s^{-1}
  → Twice design
- 1 ab^{-1} of integrated luminosity

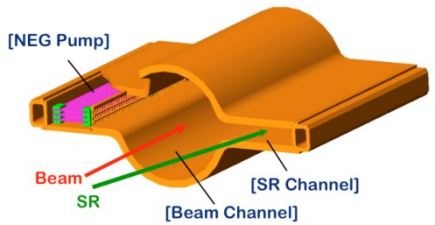


SuperKEKB Upgrade: Nano Beam Scheme





Replace long TRISTAN dipoles with shorter ones (HER).

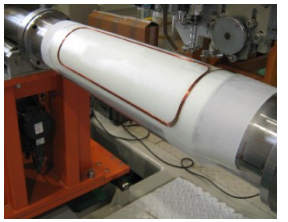


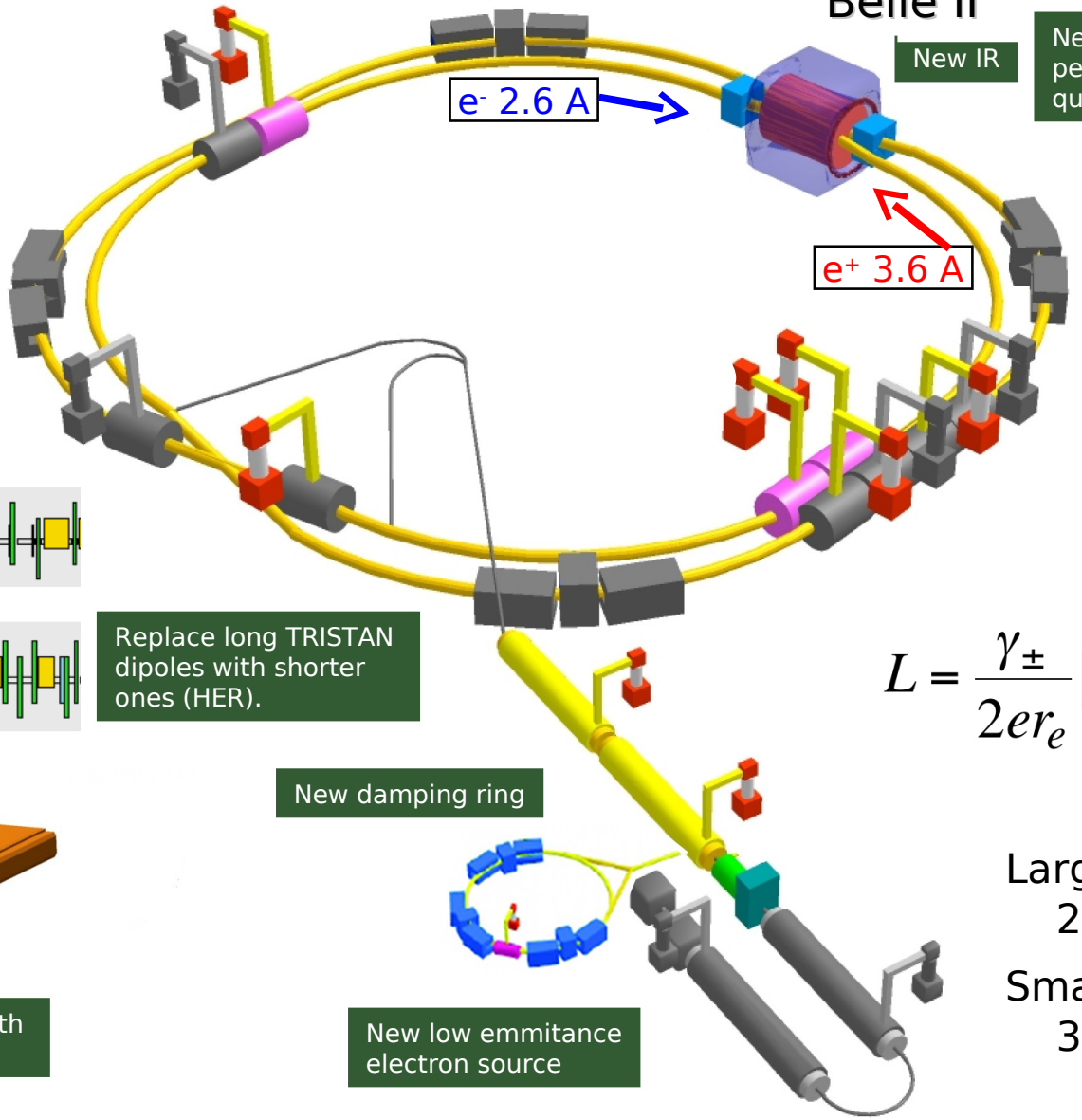
TiN coated beam pipe with antechambers

Belle II

New IR

New Superconducting / permanent final focusing quads near the IP





New damping ring

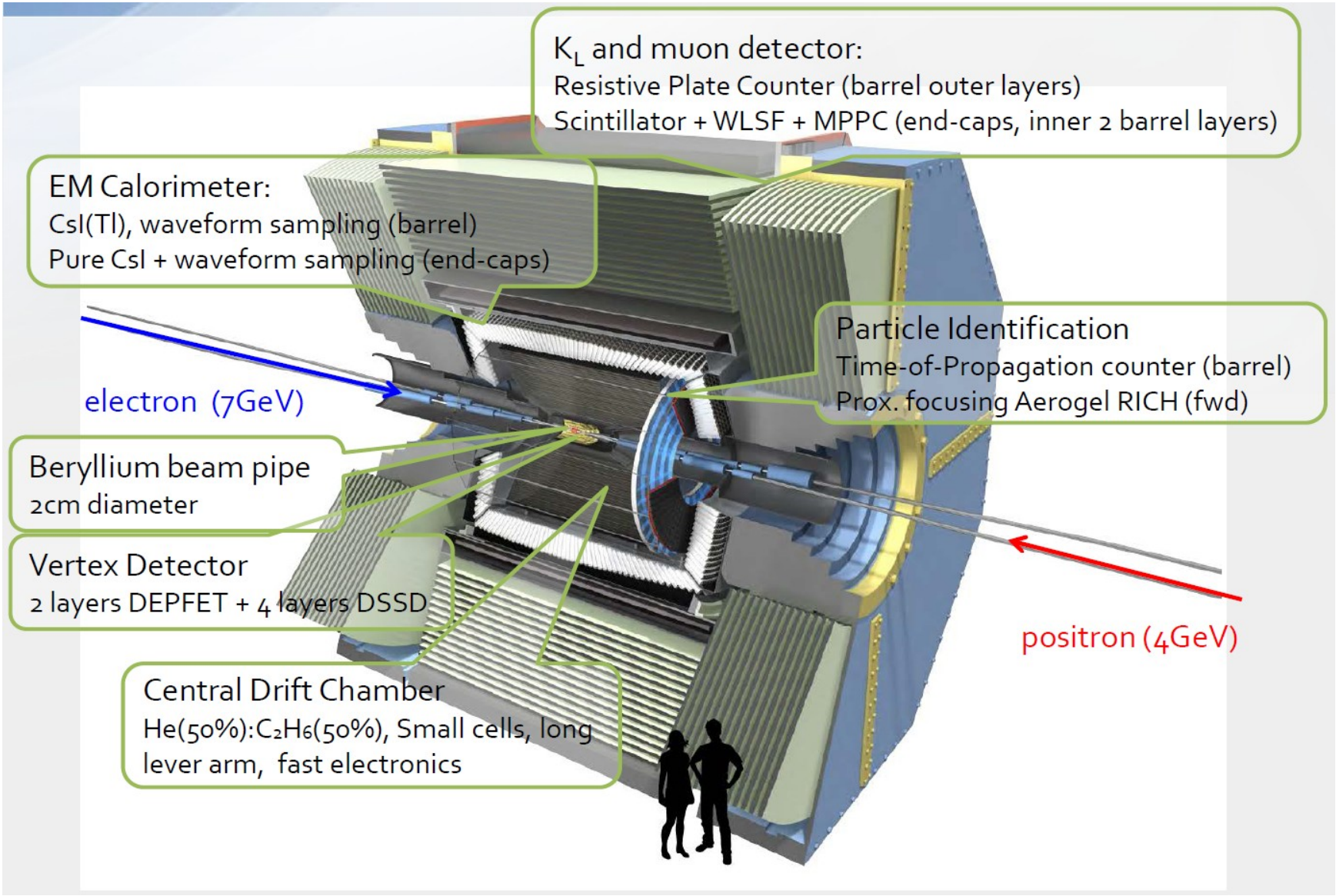
New low emmitance electron source

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

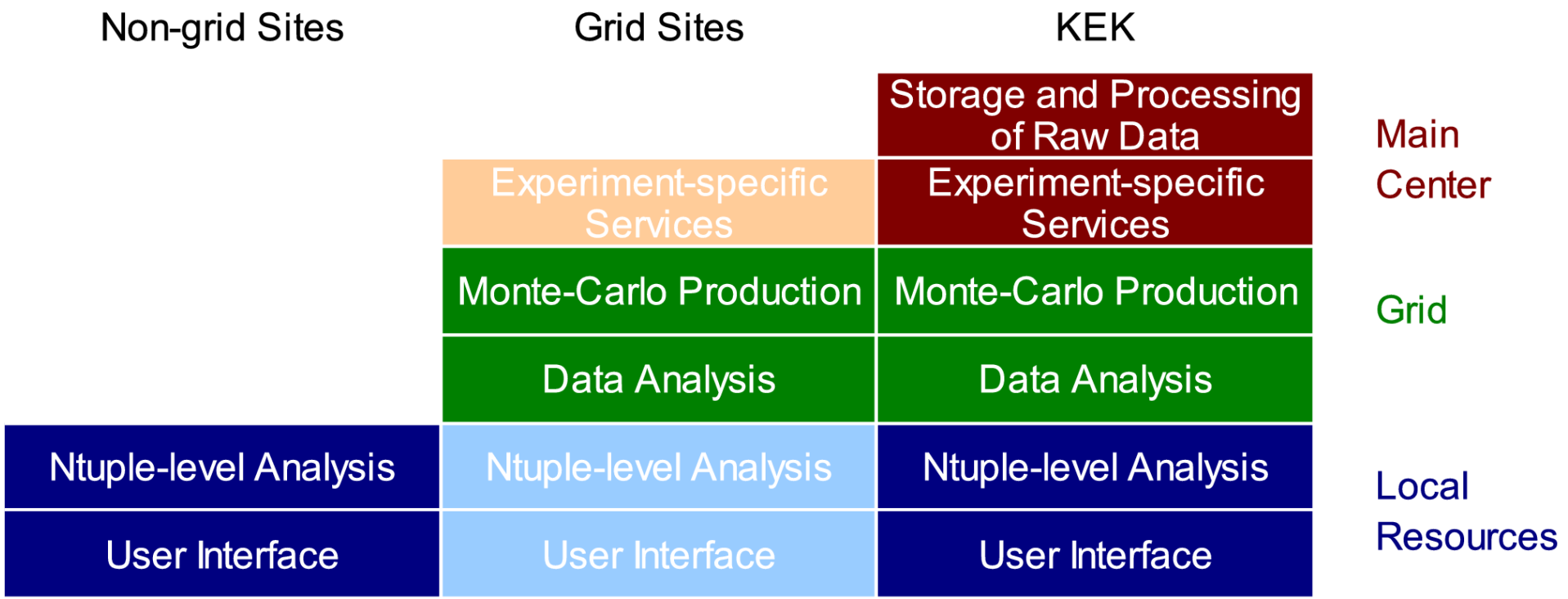
Larger crossing angle
$2\phi = 22$ mrad $\rightarrow$ 83 mrad

Smaller asymmetry
3.5 / 8 GeV $\rightarrow$ 4 / 7 Gev

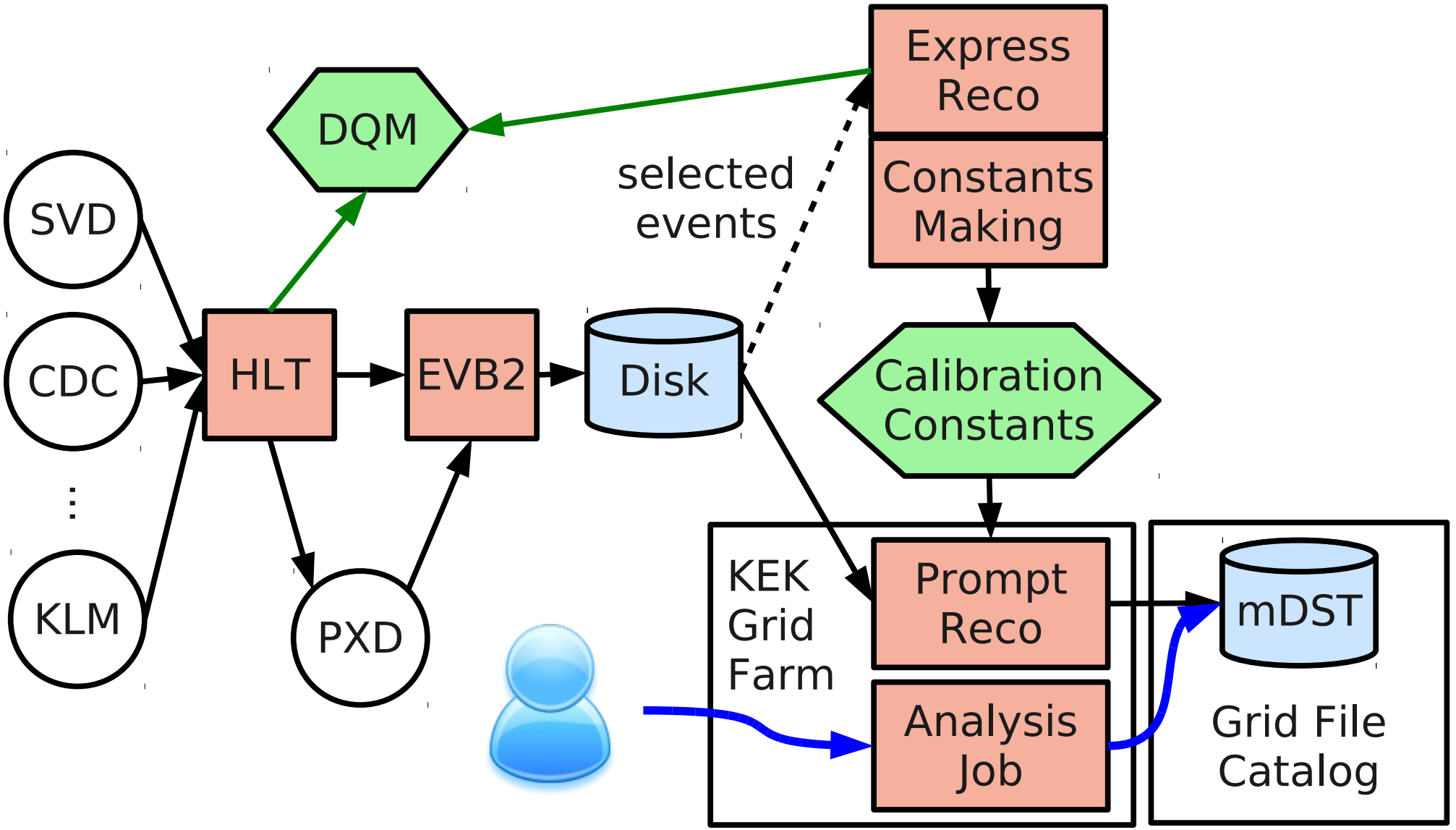
Belle II Detector



Tasks of Computing Facilities



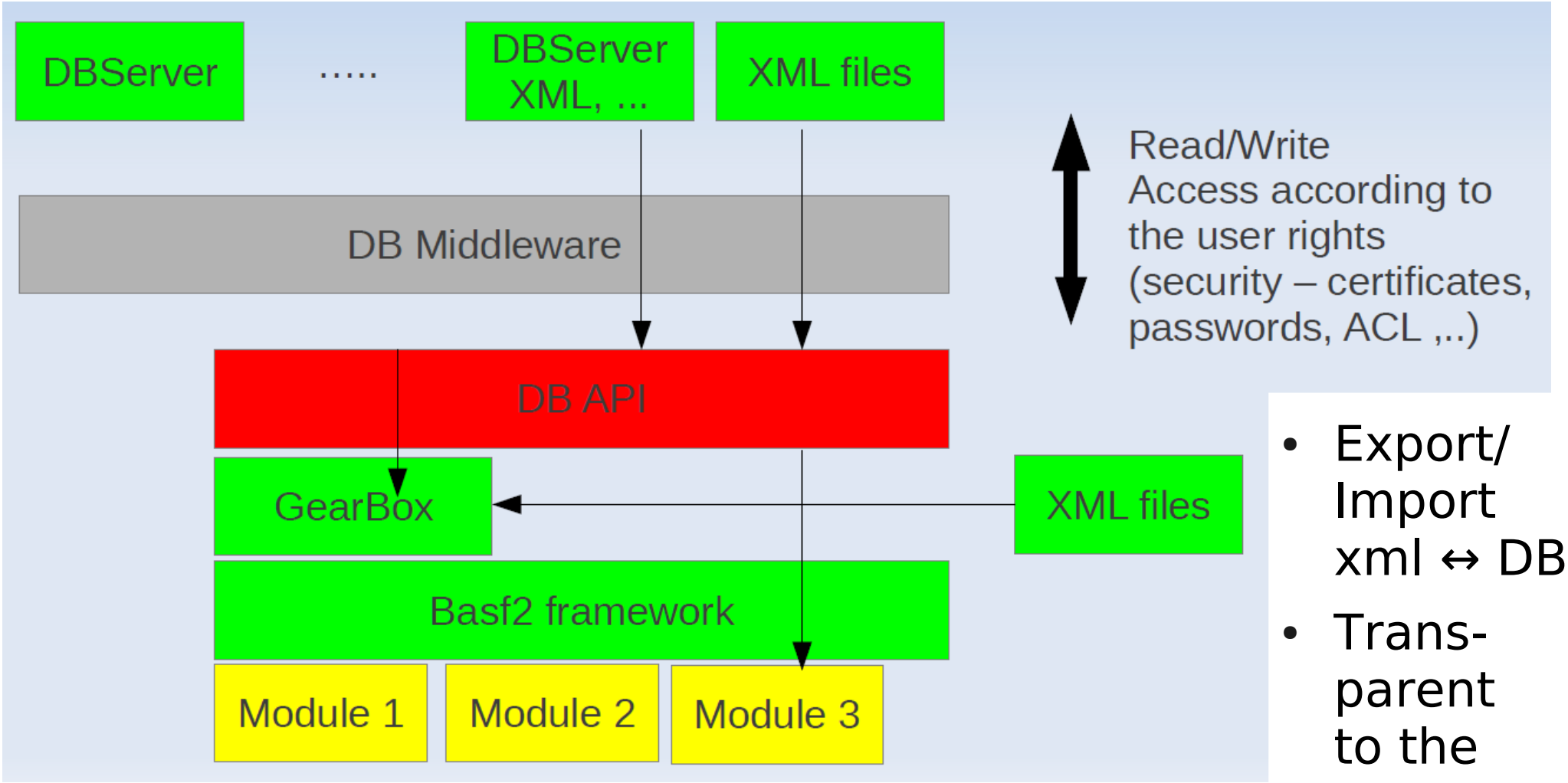
Prompt Reconstruction



Python Steering Example

```
import os
from basf2 import *

#Register modules
gearbox = register_module("Gearbox")

#Set parameters
gearbox.param("InputFileXML",os.path.join(basf2dir,"Belle2.xml"))
gearbox.param("SaveToROOT", True)
gearbox.param("OutputFileROOT", "Belle2.root")

#Create paths
main = create_path()

#Add modules to paths
main.add_module(gearbox)

#Process events
process(main,1)
```

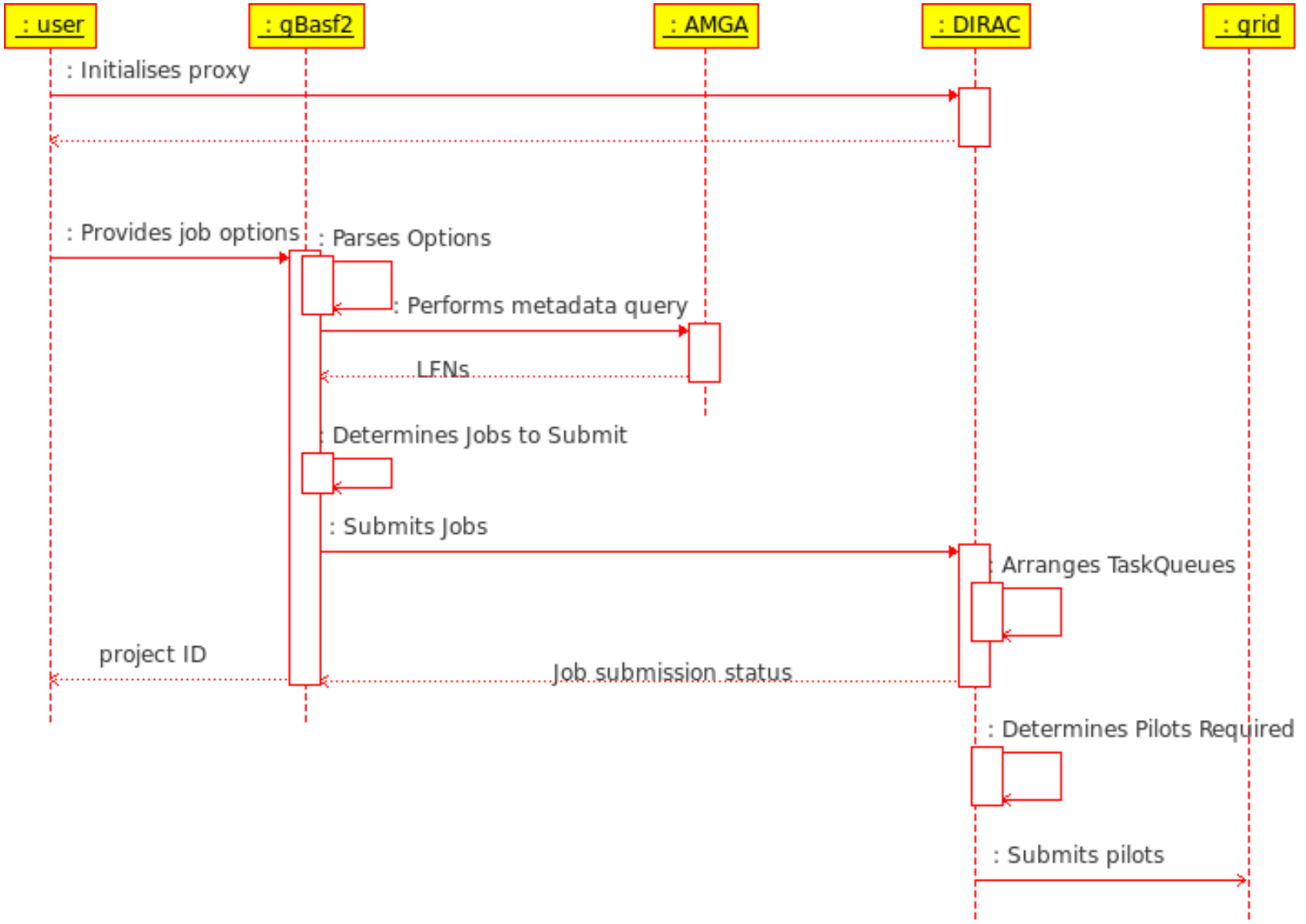
Database



- Export/ Import xml ↔ DB
- Trans-parent to the user

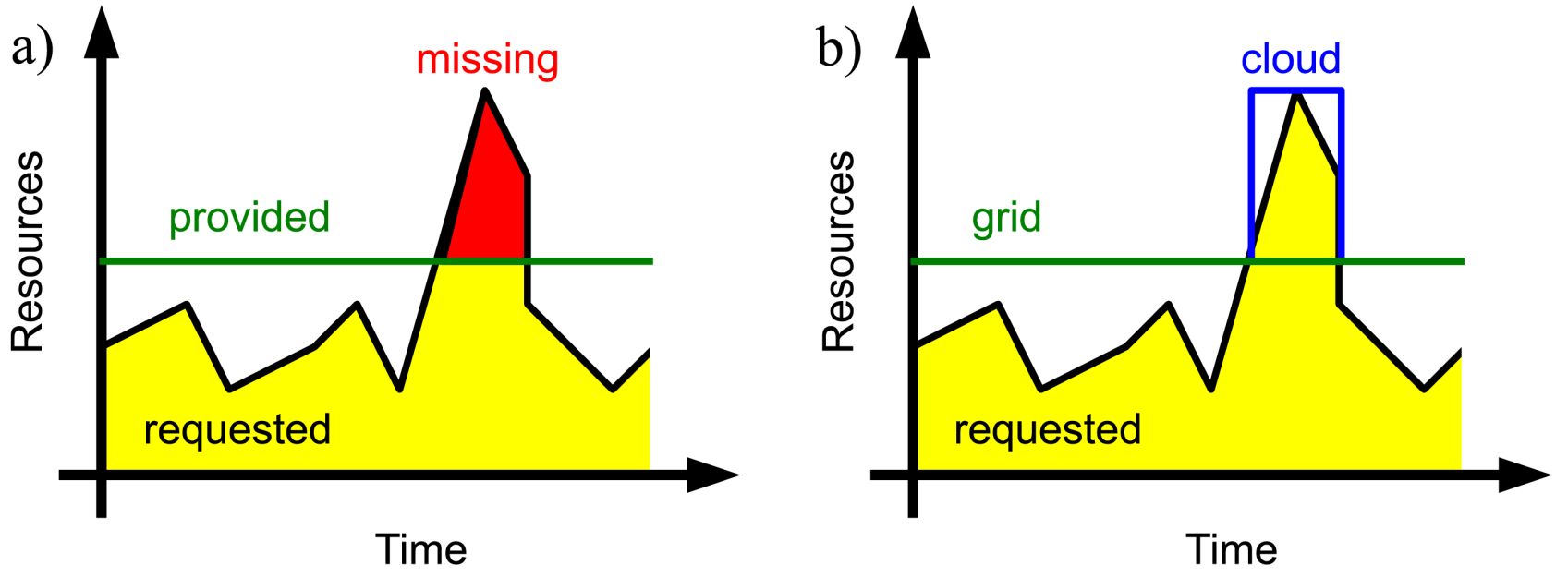
➔ Distribution via Frontier

gbasf2


: user
: gBasf2
: AMGA
: DIRAC
: grid
: Initialises proxy
: Provides job options
: Parses Options
: Performs metadata query
LFNs
: Determines Jobs to Submit
: Submits Jobs
: Arranges TaskQueues
project ID
Job submission status
: Determines Pilots Required
: Submits pilots

(Commercial) Cloud Computing

- Resource demands vary with time
- Fair-share can solve this issue only to some extent
- → Cloud computing allows to buy resources on demand
  - ➢ Well suited to absorb peaks in varying resource demand



Cloud Computing in Belle II

- Risk: vendor lock-in
  - ➔ No permanent data storage on the cloud
  - ➔ Much less critical for CPU resources
- Large data transfer / storage not cost efficient (now)
  - ➔ Use cloud primarily for MC production
  - ➔ No data processing
  - ➔ Maybe physics analysis
- Accounting issues

➢ Baseline of computing resources provided by the grid

➢ Cloud computing is option for peak demands