Belle Data Preservation status

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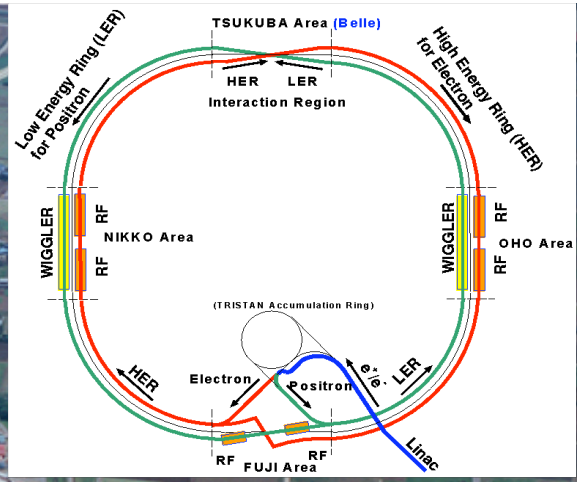
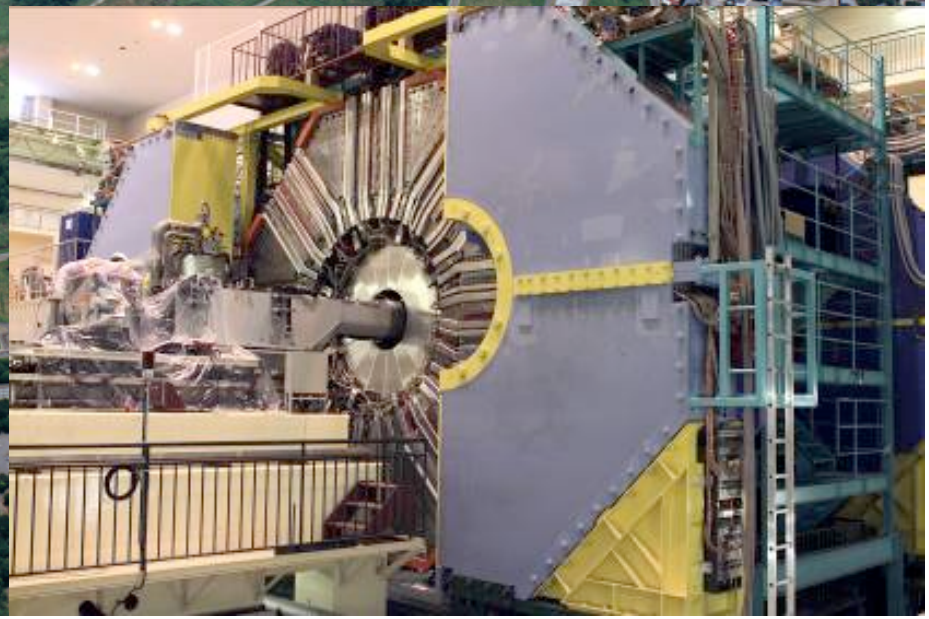
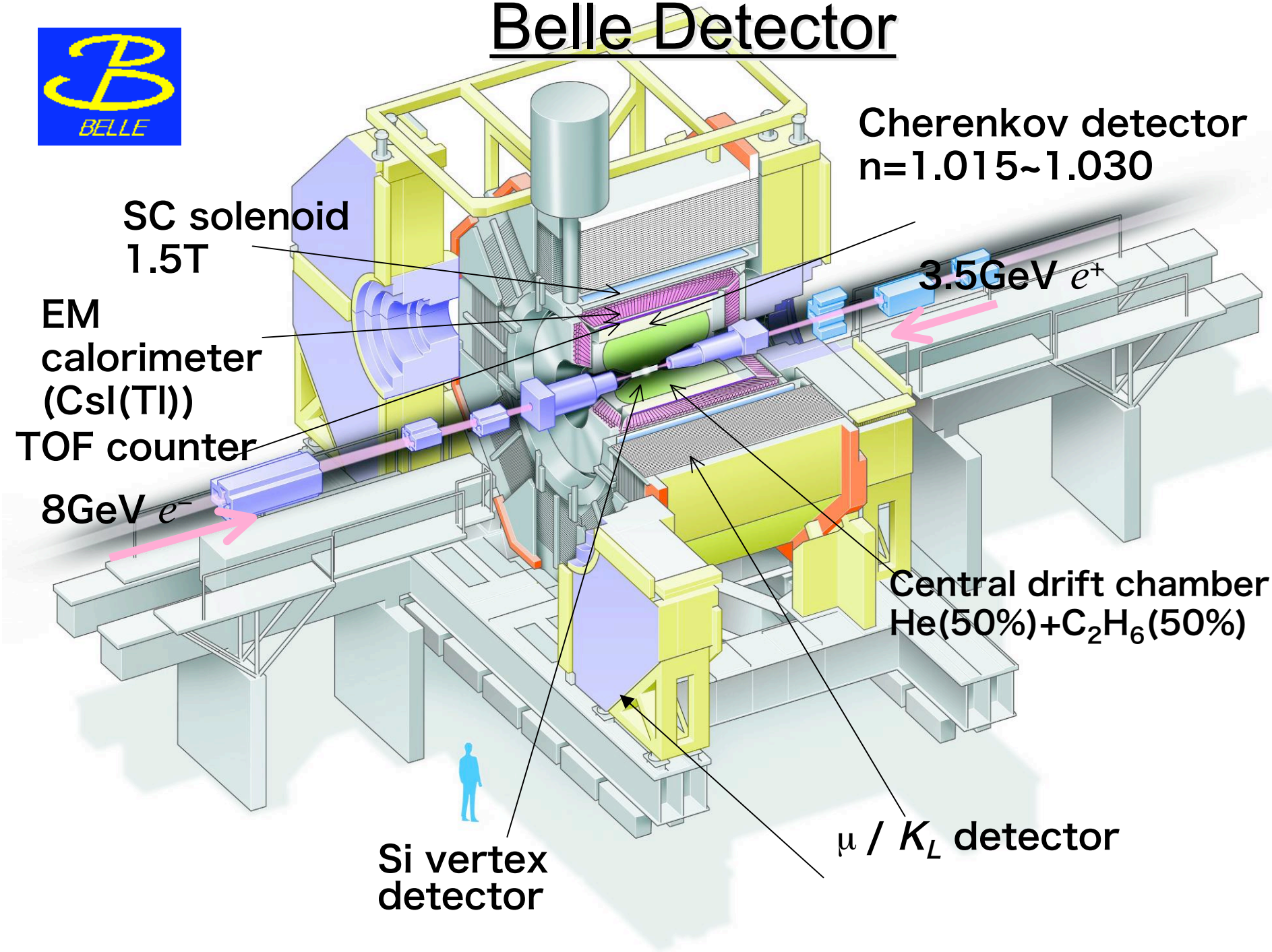
KEK
Jan. 26, 2008

KEKB and Belle





Belle Detector



International Collaboration: Belle

BINP
Chennai
Chiba U.
U. of Cincinnati
Fu-Jen Catholic U.
U. of Giessen
Gyeongsang Nat'l U.
Hanyang U.
U. of Hawaii
Hiroshima Tech.
IHEP, Beijing
IHEP, Moscow
HEPHY, Vienna
INFN-Torino
ITEP
Kanagawa U.
Karlsruhe
KEK
Korea U.
Krakow Inst. of Nucl. Phys.
Kyoto U.
Kyungpook Nat'l U.
EPF Lausanne
Jozef Stefan Inst. / U. of Ljubljana / U. of Maribor
U. of Melbourne
MPI Munich
Nagoya U.
Nara Women's U.
National Central U.
National Taiwan U.
National United U.
Nihon Dental College
Niigata U.
Nova Gorica
Osaka U.
Osaka City U.
Panjab U.
Peking U.
Princeton U.
Riken-BNL-Ilinois
Saga U.
USTC
Seoul National U.
Shinshu U.
Sungkyunkwan U.
U. of Sydney
Tata Institute
Toho U.
Tohoku U.
Tohoku Gakuin U.
U. of Tokyo
Tokyo Inst. of Tech.
Tokyo Metropolitan U.
Tokyo U. of Agri. and Tech.
Toyama Nat'l College
Tsukuba U.
VPI
Wayne
Yonsei U.

14 countries, 59 institutes, ~360 collaborators

Analysis within the Collaboration

- Working groups;
  - Indirect CPV
    - Charmonium
    - phi2
    - phi3
    - Double Charm
  - Rare/Direct CPV
  - CKM (b->u etc.)
  - Charm
  - tau
  - 2-photon
  - Others (1~5S)
- Some overlaps among them
- All groups are active
- ~30 shared skim/MC streams
- two analysis coordinators
  - convener for each sub group
    - micro groups
    - competing analyses for important topics

Data Analysis Model

- Two levels; DST and micro DST (MDST)
  - Physically they have the same format (panther)
  - Reconstruction jobs create DST and MDST is reduced from DST
  - micro DST has no hits information except for the vertex detector
- Levels of abstraction, common basis analysis
  - Charged tracks (helix parameters down to MDST),
    - four momentum at the primary vertex is generated in the users' analyses using standard library
  - Photons: four momentum and shape parameters in MDST
    - correction for the primary vertex is done in the users' analysis
  - pi0 and K shorts are reconstructed and stored in MDST
    - same correction as above
  - Weakly decaying particles (Dzeros~Bs) are combined in the users' code except for full reconstruction
  - Separate MDST are produced for full reconstruction events

Calibration/Data size

- Detector Calibration are done using raw data before production
  - Other calibration such as vertex profile, global momentum/energy correction are done after the processing and stored in database/code which are used to read/analyze the MDST
- Size of individual hadronic events
  - Raw data are 40~50 KB/events
  - DST upto 100KB/events
  - MDST, 25KB/events
  - MC-MDST 40KB/events
- So far 1PB raw data, >2PB for DST, 100TB hadron MDST, 700TB hadron MC

Software releases

- All software are in svn (moved from cvs in 2006)
- One major release per year or so
  - mainly for new hardware configuration/new data for summer conferences
    - belle-b20030807_1600-pl0-5.src.rpm
    - belle-b20040727_1143-pl0-5.src.rpm
    - belle-b20050311_0738-pl8-7.src.rpm
    - belle-b20060529_2127-r9767-8.src.rpm
    - belle-b20070528_1559-r10151-11.src.rpm
    - belle-b20080331_1823-r10486-13.src.rpm
    - belle-b20081107_1418-r10701-12.src.rpm
      - big software updates
  - at most few patches after the releases
- (S)RPMs and source.tar.gz are created
  - yum for distribution
  - doxygen for code browsing

Monte Carlo simulation strategy

- Geant3 based full simulation
  - Fast simulation not used
- MC mass production
  - For each real run, produce 10 times generic Bbbar and qqbar MC (files are in MDST format; hits are not kept)
  - Rare decay MC, tau MC are generated by sub groups
  - All other MC are done by individuals/micro groups
  - ~half of production are done at the collaborators' remote sites
- Storage and access
  - all generic MC are stored on disk
  - home grown simple protocol to access data
    - location are kept in postgres database
  - Production is now shifted to grid

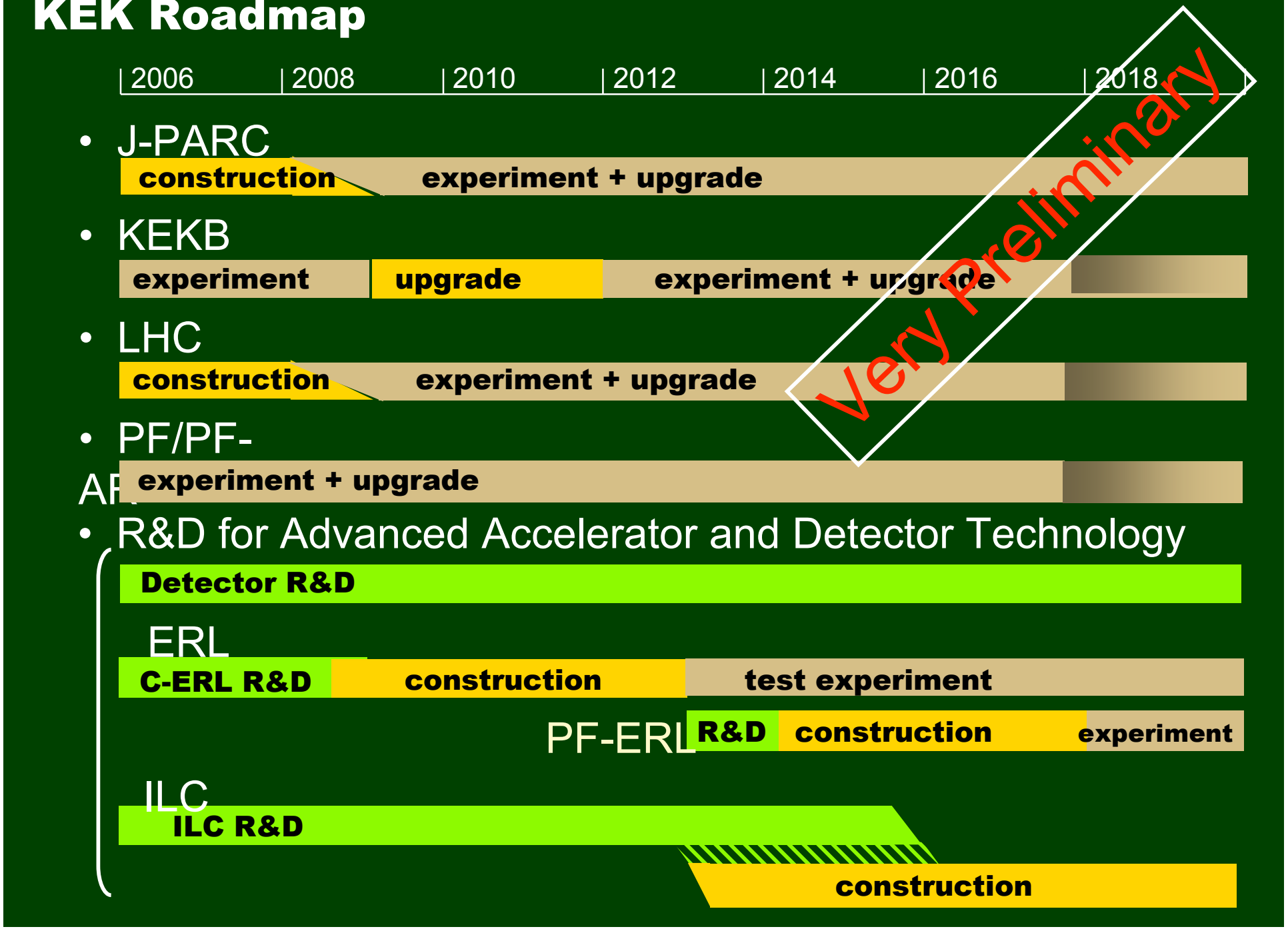
Data Conservation Prospects

- We store two copies of raw data in two different locations at KEK (in the tape libraries)
- We store two copies of MDST at KEK and at Nagoya University (+ in the tape library)
- We store two copies of generic MC at KEK; on disk and in the tape library
- Our software uses CERNLIB/GEANT3/FORTRAN
  - can compile/run with gfortran/gcc4
- We hope to keep using our data till Super KEKB
  - We hope the Super KEKB starts taking data in five years
  - We hope to keep data/software in tact at KEK until Super KEKB takes overwhelmingly large amount of data

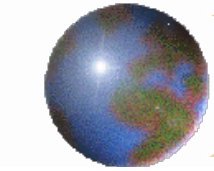
Collaboration prospects

- KEKB/Belle will end in one year or two
  - in order to start super KEKB/Belle
- We hope to keep writing papers for several more years using Belle data
- Most of Belle members will continue to work on Super Belle
- We are in fact growing
  - Many new groups joined in 2008 in anticipation for the Super KEKB/Belle prospects
  - We can rework software/data with increased human resources
    - We are reprocessing our data right now!
- As far as data/software is concerned smooth transition to Super Belle is now being considered
- Some portion of data (in four momentum) are now open and being used by high school students

KEK Roadmap


2006
2008
2010
2012
2014
2016
2018
Very Preliminary
J-PARC
construction
experiment + upgrade
KEKB
experiment
upgrade
experiment + upgrade
LHC
construction
experiment + upgrade
PF/PF-
AR
experiment + upgrade
R&D for Advanced Accelerator and Detector Technology
Detector R&D
ERL
C-ERL R&D
construction
test experiment
PF-ERL
R&D
construction
experiment
ILC
ILC R&D
construction

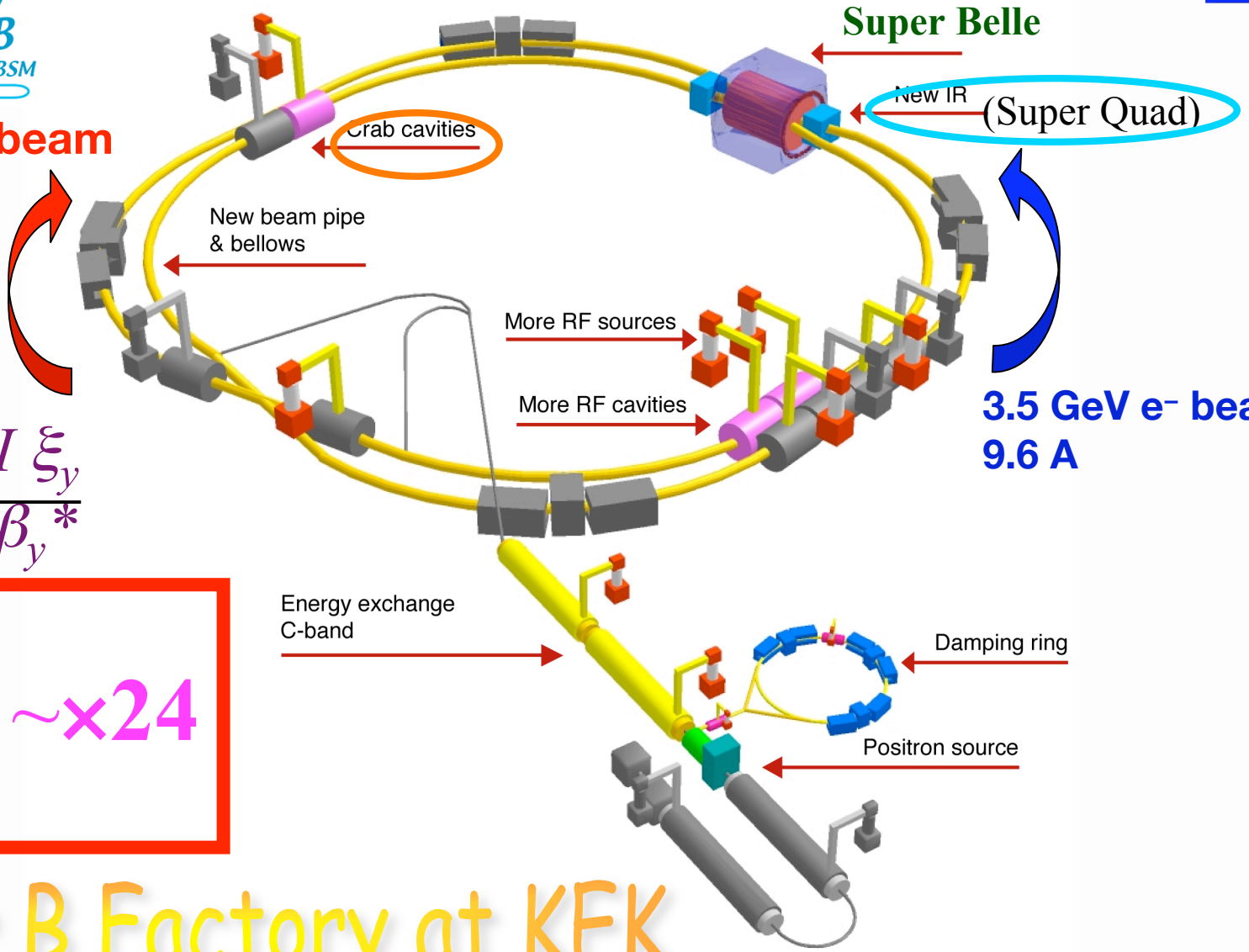
SuperKEKB: schematics



Super KEKB
uest for BSM

Belle

8 GeV e⁺ beam
4.1 A



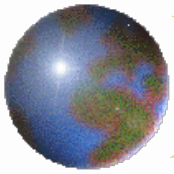
3.5 GeV e⁻ beam
9.6 A

$$L \propto \frac{I\,\xi_y}{\beta_y^*}$$

$$\frac{4 \times 3}{0.5} \sim \times 24$$

Super B Factory at KEK

The rest of the slides are shown at CHEP 2004

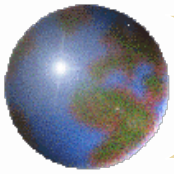


Collaborating institutions

- Collaborators
  - Major labs/universities from Russia, China, India
  - Major universities from Japan, Korea, Taiwan, Australia…
  - Universities from US and Europe
- KEK dominates in one sense
  - 30~40 staffs work on Belle exclusively
  - Most of construction and operating costs are paid by KEK
- Universities dominates in another sense
  - Young students to stay at KEK, help operations, do physics analysis
- Human resource issue
  - Always lacking man power

Core Software

- OS/C++
  - Solaris 7 on sparc and RedHat 6/7/9/RHEL3,4 on PCs
  - gcc 2.95.3/3.0.4/3.2.2/3.3/4 (code compiles with SunCC)
- No commercial software except for batch queuing system and hierarchical storage management system
  - QQ, EvtGen, GEANT3, CERNLIB (2001/2003), CLHEP(~1.5), postgres 7
- Legacy FORTRAN code
  - GSIM/GEANT3/ and old calibration/reconstruction code)
- I/O:home-grown stream IO package + zlib
  - The only data format for all stages (from DAQ to final user analysis skim files)
  - Index file (pointer to events in data files) are used for final physics analysis

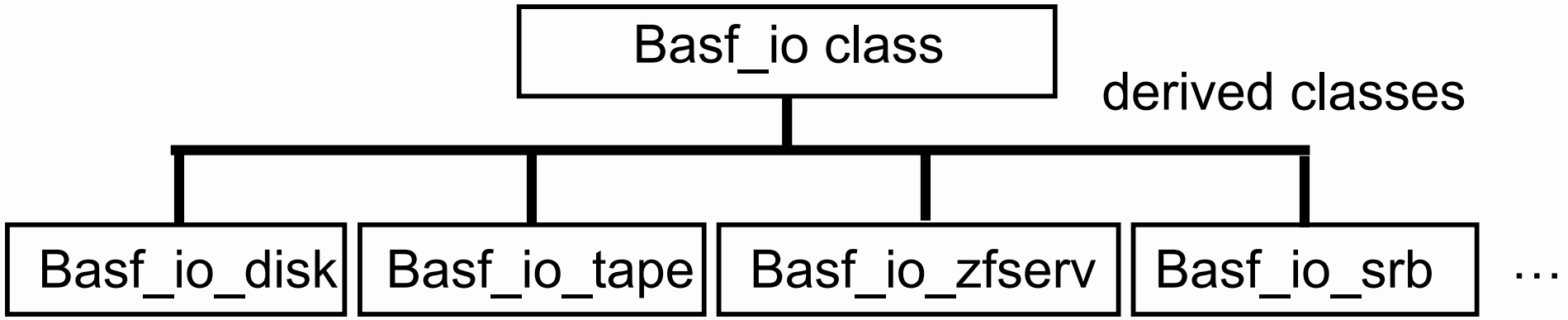


Framework (BASF)

- Event parallelism on SMP (1995~)
  - Using fork (for legacy Fortran common blocks)
- Event parallelism on multi-compute servers (dbasf, 2001~, V2, 2004)
- Users' code/reconstruction code are dynamically loaded
- The only framework for all processing stages (from DAQ to final analysis)

Data access methods

- The original design of our framework, BASF, allowed to have an appropriate IO package loaded at run time
  - Our (single) IO package grew to handle more and more possible ways of IOs (disk, tape, etc.) and was extended to deal with special situations and became spaghetti-ball like code
- This summer we were faced again to extend it to handle new HSM and for tests with new software
  - We finally rewrote our big IO package into small pieces, making it possible to simply add one derived class for one IO method

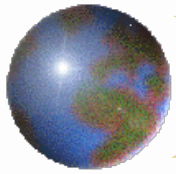


IO objects are dynamically loaded upon request

Reconstruction software

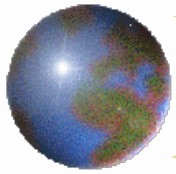
- 30~40 people have contributed in the last several years
- For many parts of reconstruction software, we only have one package. Very little competition
  - Good and bad
- Identify weak points and ask someone to improve them
  - Mostly organized within the sub detector groups
  - Physics motivated, though
- Systematic effort to improve tracking software but very slow progress
  - For example, 1 year to get down tracking systematic error from 2% to less than 1%
  - Small Z bias for either forward/backward or positive/negative charged tracks

    ⇒When the problem is solved we will reprocess all data again



Analysis software

- Several ~ tens of people have contributed
  - Kinematical and vertex fitter
  - Flavor tagging
  - Vertexing
  - Particle ID (Likelihood)
  - Event shape
  - Likelihood/Fisher analysis
- People tend to use standard packages but…
  - System is not well organized/documented
  - Have started a task force (consisting of young Belle members)



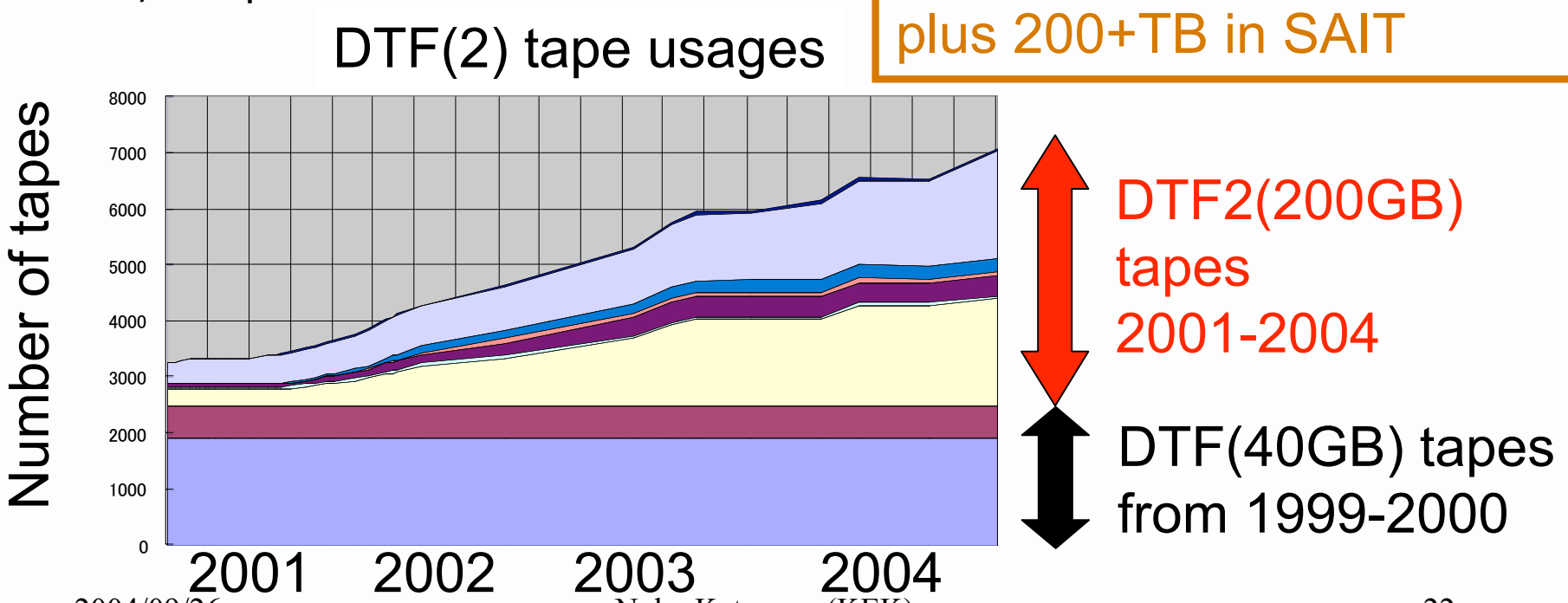
Postgresql database system

- The only database system Belle uses
  - other than simple UNIX files and directories
  - A few years ago, we were afraid that nobody uses postgresql but it seems postgresql is now widely used and well maintained
- One master, several copies at KEK, many copies at institutions/on personal PCs
  - ~120,000 records (4.3GB on disk)
  - IP (Interaction point) profile is the largest/most popular
- It is working quite well although consistency among many database copies is the problem

Data size so far

- Raw data
  - 400TB written since Jan. 2001 for 230 fb^{-1} of data on 2000 tapes
- DST data
  - 700TB written since Jan. 2001 for 230 fb^{-1} of data on 4000 tapes, compressed with zlib
- MDST data (four vectors, verteces and PID)
  - 15TB for 287 fb^{-1} of hadronic events (BBbar and continuum), compressed with zlib
  - τ, two photon: add 9TB for 287 fb^{-1}

Total ~1PB in DTF(2) tapes plus 200+TB in SAIT



generic MC production

- Mainly used for physics background study
- 400GHz Pentium III~2.5fb^{-1}/day
- 80~100GB/fb^{-1} data in the compressed format
- No intermediate (GEANT3 hits/raw) hits are kept.
  - When a new release of the library comes, we try to produce new generic MC sample
- For every real data taking run, we try to generate 3 times as many events as in the real run, taking
  - Run dependence
  - Detector background are taken from random trigger events of the run being simulated

  into account
- At KEK, if we use all CPUs we can keep up with the raw data taking (×3) MC production
  - We ask remote institutions to generate most of MC events
  - We have generated more than 2 ×10^9 events so far using qq
- 100TB for 3×300 fb^{-1} of real data
  - Would like to keep on disk

M events produced since Apr. 2004