Belle II

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on behalf of the Belle and Belle II Computing Group
http://belle2.kek.jp and http://belle2.kek.jp

The Team

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... with support from China (Wenjing Wu, Yan Liang Han [韩艳良]), Japan (Go Iwai [岩井剛]), Poland (Rafal Grzymkowski, Milosz Zydbal), Slovenia (Marko Bracko) USA (Leo Piilonen, David Asner, David Cowley, Brian Ermold, Michael Peterson) and all the people on the nextslide

•Thanks to Ruth Pordes (OSG VO creation), Brian Bockelman and Burt Holzman (EGI interoperability, getting things running), and Douglas Olsen (OSG security).

•Thanks to the DIRAC team, without whom this would not be possible.

... more of the team...

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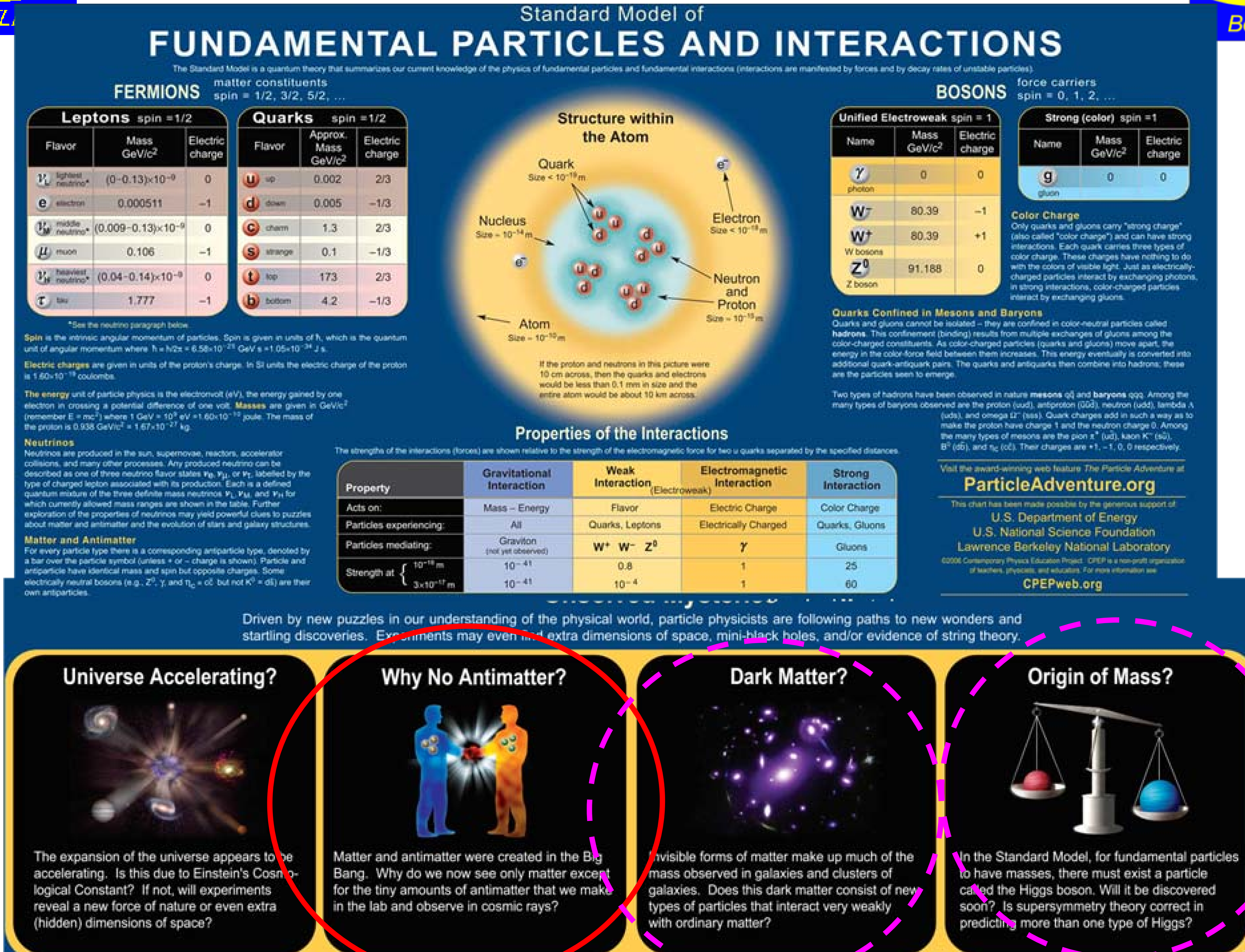
The Science


Standard Model of
FUNDAMENTAL PARTICLES AND INTERACTIONS
The Standard Model is a quantum theory that summarizes our current knowledge of the physics of fundamental particles and fundamental interactions (interactions are manifested by forces and by decay rates of unstable particles).
FERMIONS matter constituents spin = 1/2, 3/2, 5/2, ...
Leptons spin =1/2
Flavor | Mass GeV/c² | Electric charge
νL lightest neutrino* | (0–0.13)×10⁻⁹ | 0
e electron | 0.000511 | –1
νM middle neutrino* | (0.009–0.13)×10⁻⁹ | 0
μ muon | 0.106 | –1
νH heaviest neutrino* | (0.04–0.14)×10⁻⁹ | 0
τ tau | 1.777 | –1
Quarks spin =1/2
Flavor | Approx. Mass GeV/c² | Electric charge
u up | 0.002 | 2/3
d down | 0.005 | –1/3
c charm | 1.3 | 2/3
s strange | 0.1 | –1/3
t top | 173 | 2/3
b bottom | 4.2 | –1/3
*See the neutrino paragraph below.
Structure within the Atom
Quark Size < 10⁻¹⁹ m
Electron Size < 10⁻¹⁸ m
Nucleus Size ≈ 10⁻¹⁴ m
Neutron and Proton Size ≈ 10⁻¹⁵ m
Atom Size ≈ 10⁻¹⁰ m
If the proton and neutrons in this picture were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.
BOSONS force carriers spin = 0, 1, 2, ...
Unified Electroweak spin = 1
Name | Mass GeV/c² | Electric charge
γ photon | 0 | 0
W⁻ | 80.39 | –1
W⁺ W bosons | 80.39 | +1
Z⁰ Z boson | 91.188 | 0
Strong (color) spin =1
Name | Mass GeV/c² | Electric charge
g gluon | 0 | 0
Color Charge
Only quarks and gluons carry "strong charge" (also called "color charge") and can have strong interactions. Each quark carries three types of color charge. These charges have nothing to do with the colors of visible light. Just as electrically-charged particles interact by exchanging photons, in strong interactions, color-charged particles interact by exchanging gluons.
Quarks Confined in Mesons and Baryons
Quarks and gluons cannot be isolated – they are confined in color-neutral particles called hadrons. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs. The quarks and antiquarks then combine into hadrons; these are the particles seen to emerge.
Spin is the intrinsic angular momentum of particles. Spin is given in units of ħ, which is the quantum unit of angular momentum where ħ = h/2π = 6.58×10⁻²⁵ GeV s =1.05×10⁻³⁴ J s.
Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10⁻¹⁹ coulombs.
The energy unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. Masses are given in GeV/c² (remember E = mc²) where 1 GeV = 10⁹ eV =1.60×10⁻¹⁰ joule. The mass of the proton is 0.938 GeV/c² = 1.67×10⁻²⁷ kg.
Neutrinos
Neutrinos are produced in the sun, supernovae, reactors, accelerator collisions, and many other processes. Any produced neutrino can be described as one of three neutrino flavor states νe, νμ, or ντ, labelled by the type of charged lepton associated with its production. Each is a defined quantum mixture of the three definite mass neutrinos νL, νM, and νH for which currently allowed mass ranges are shown in the table. Further exploration of the properties of neutrinos may yield powerful clues to puzzles about matter and antimatter and the evolution of stars and galaxy structures.
Matter and Antimatter
For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or – charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z⁰, γ, and ηc = cc̄ but not K⁰ = ds̄) are their own antiparticles.
Properties of the Interactions
The strengths of the interactions (forces) are shown relative to the strength of the electromagnetic force for two u quarks separated by the specified distances.
Property | Gravitational Interaction | Weak Interaction (Electroweak) | Electromagnetic Interaction | Strong Interaction
Acts on: | Mass – Energy | Flavor | Electric Charge | Color Charge
Particles experiencing: | All | Quarks, Leptons | Electrically Charged | Quarks, Gluons
Particles mediating: | Graviton (not yet observed) | W⁺ W⁻ Z⁰ | γ | Gluons
Strength at 10⁻¹⁸ m | 10⁻⁴¹ | 0.8 | 1 | 25
Strength at 3×10⁻¹⁷ m | 10⁻⁴¹ | 10⁻⁴ | 1 | 60
Two types of hadrons have been observed in nature mesons qq̄ and baryons qqq. Among the many types of baryons observed are the proton (uud), antiproton (ūūd̄), neutron (udd), lambda Λ (uds), and omega Ω⁻ (sss). Quark charges add in such a way as to make the proton have charge 1 and the neutron charge 0. Among the many types of mesons are the pion π⁺ (ud̄), kaon K⁻ (sū), B⁰ (db̄), and ηc (cc̄). Their charges are +1, –1, 0, 0 respectively.
Visit the award-winning web feature The Particle Adventure at
ParticleAdventure.org
This chart has been made possible by the generous support of:
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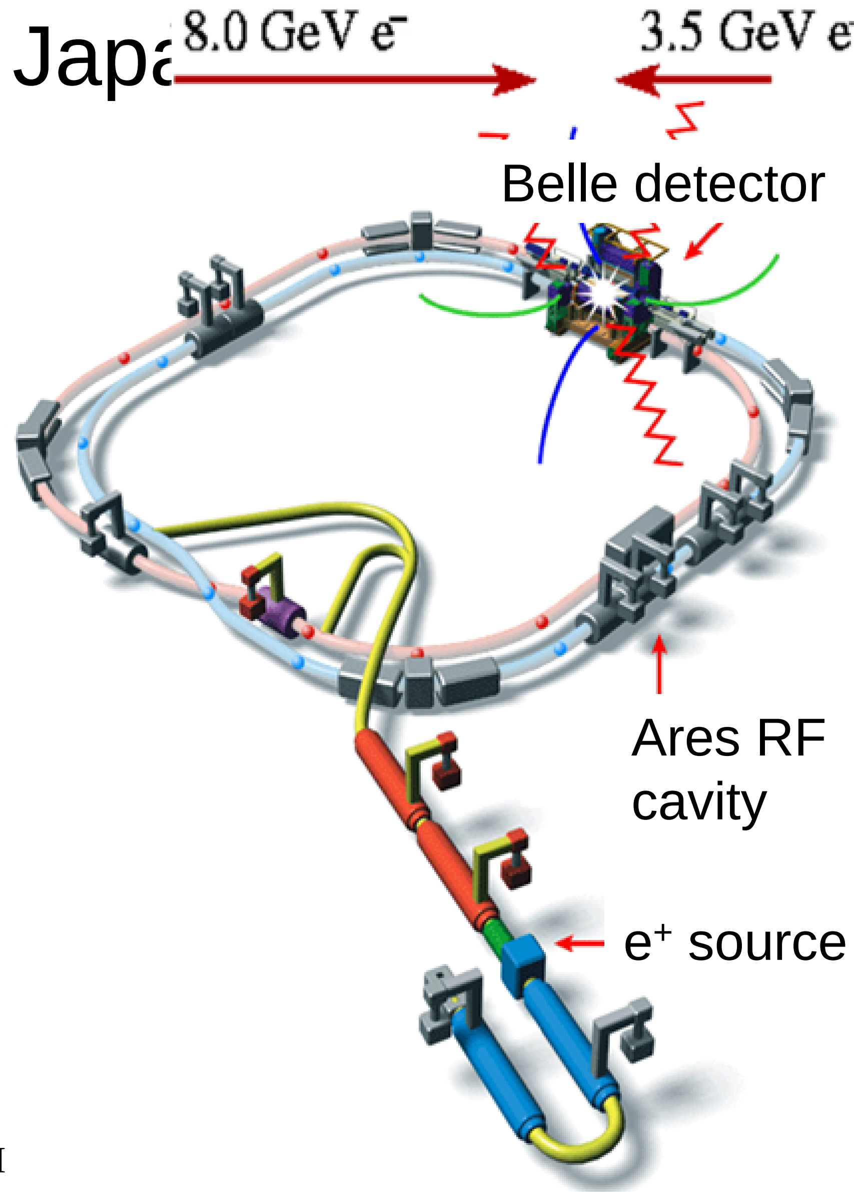
Driven by new puzzles in our understanding of the physical world, particle physicists are following paths to new wonders and startling discoveries. Experiments may even find extra dimensions of space, mini-black holes, and/or evidence of string theory.
Universe Accelerating?
The expansion of the universe appears to be accelerating. Is this due to Einstein's Cosmo-logical Constant? If not, will experiments reveal a new force of nature or even extra (hidden) dimensions of space?
Why No Antimatter?
Matter and antimatter were created in the Big Bang. Why do we now see only matter except for the tiny amounts of antimatter that we make in the lab and observe in cosmic rays?
Dark Matter?
Invisible forms of matter make up much of the mass observed in galaxies and clusters of galaxies. Does this dark matter consist of new types of particles that interact very weakly with ordinary matter?
Origin of Mass?
In the Standard Model, for fundamental particles to have masses, there must exist a particle called the Higgs boson. Will it be discovered soon? Is supersymmetry theory correct in predicting more than one type of Higgs?

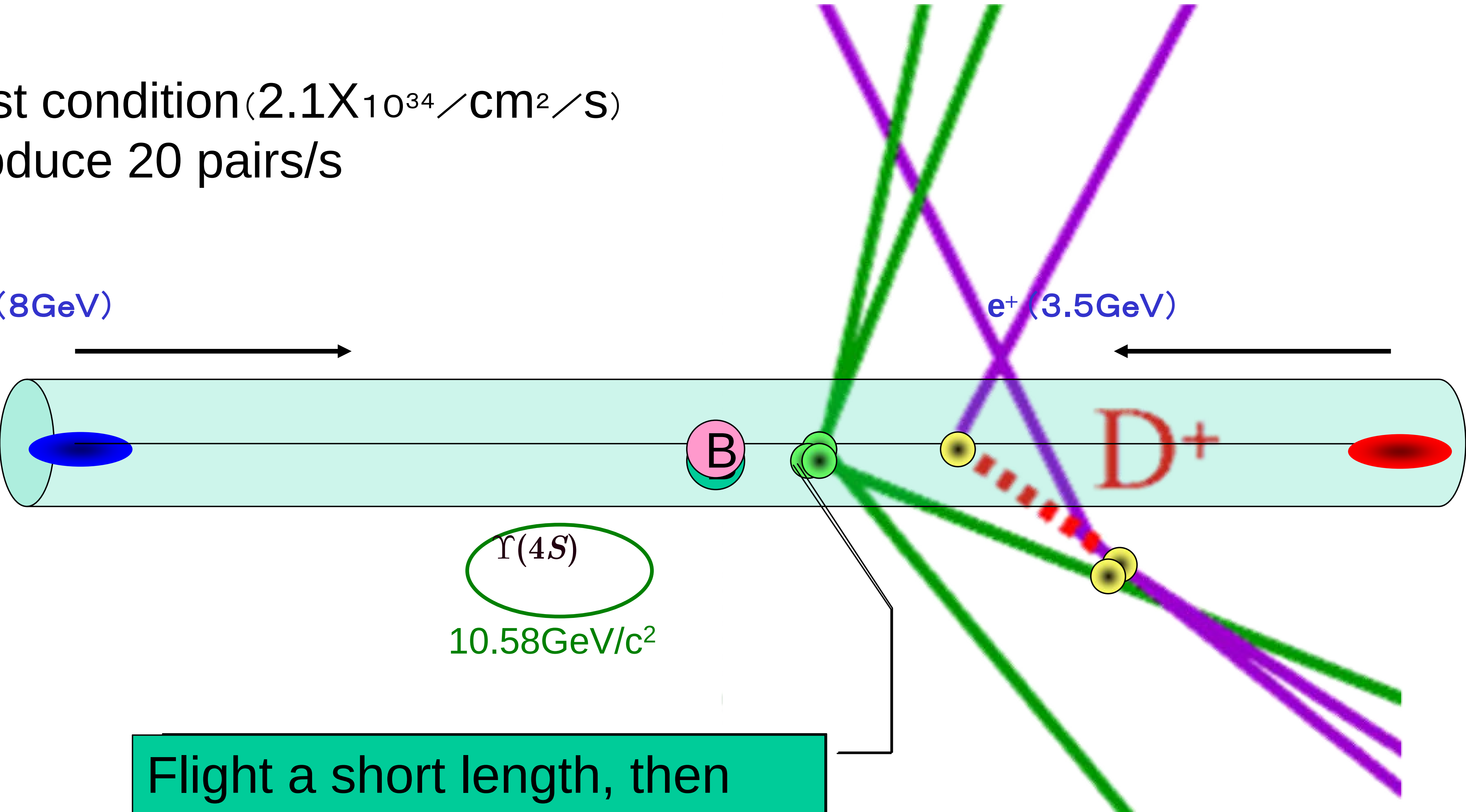
The Belle Experiment

- KEK: the High Energy Accelerator Research Organisation, Tsukuba, Japa



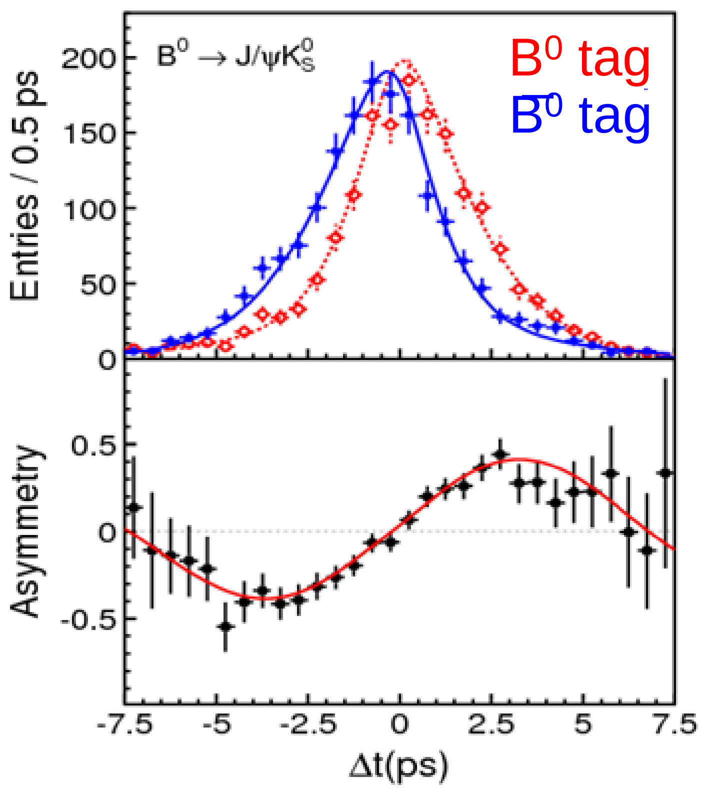
Production/Decay of B-meson

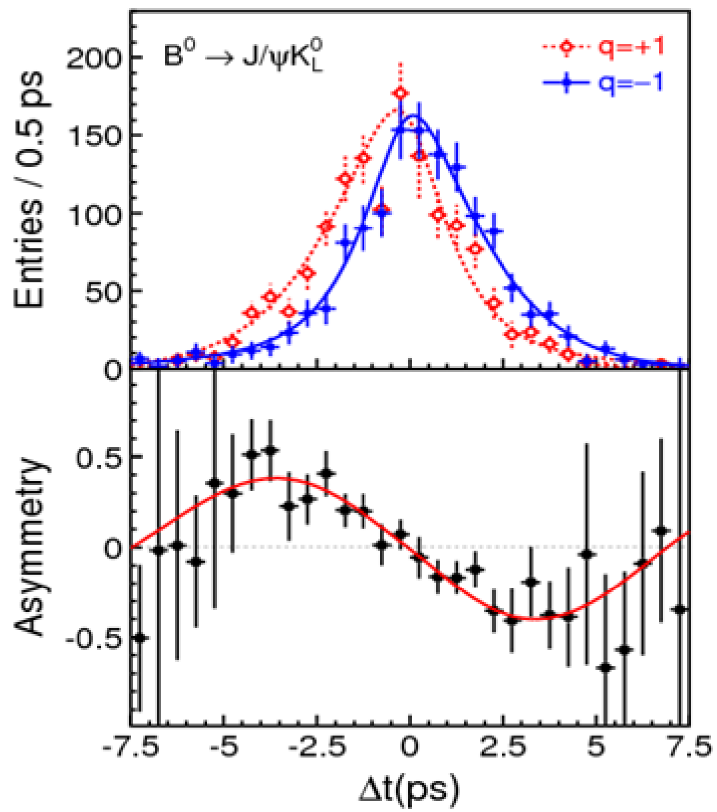
st condition（2.1X10^{34}／cm^2／s）
oduce 20 pairs/s



Flight a short length, then decay into light stable particles

Measurement of $\sin(2\Phi_1)$



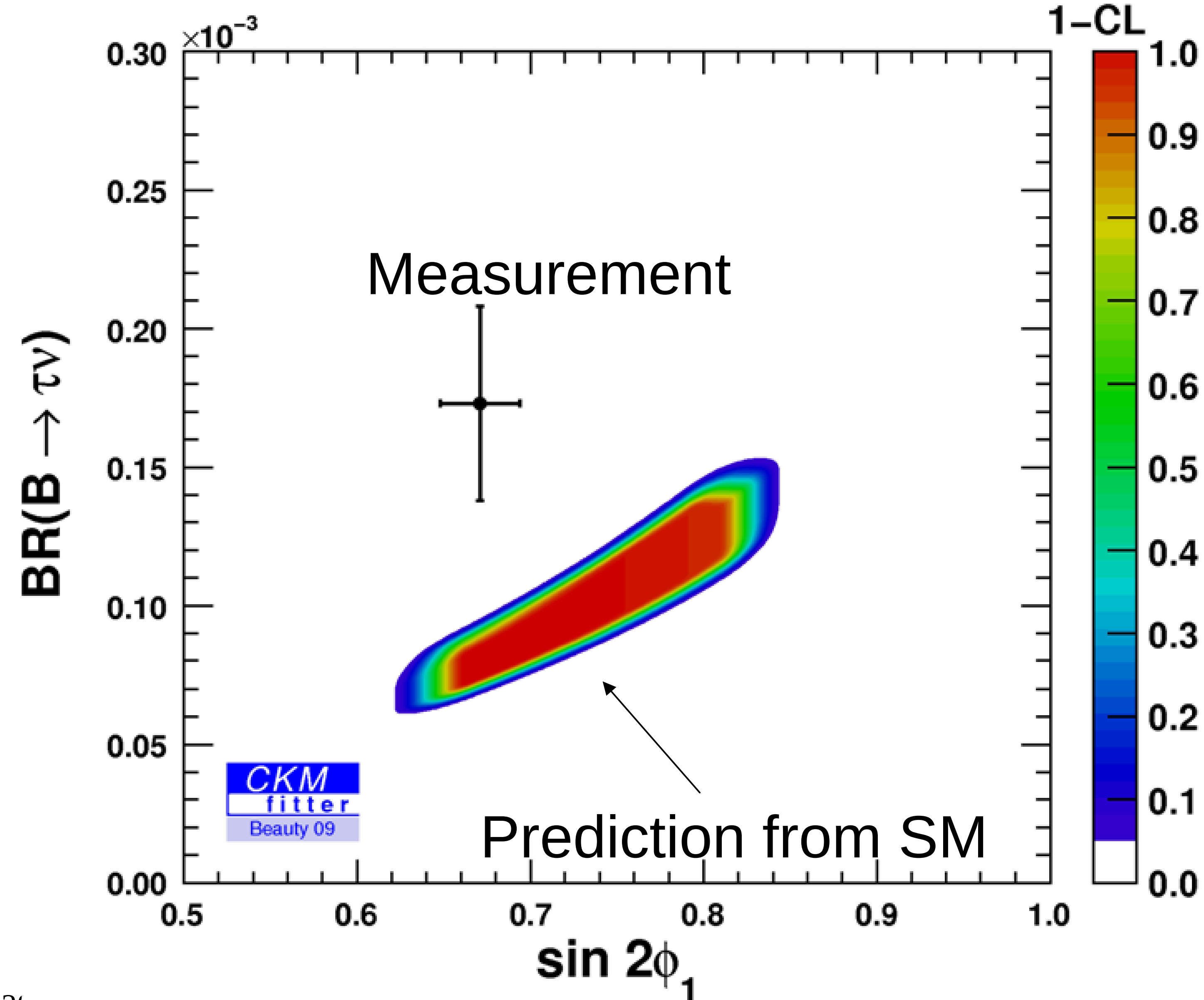


Beautiful measurement of Matter-Antimatter asymmetry

But…

Too small for Observed Universal Matter-Antimatter difference!

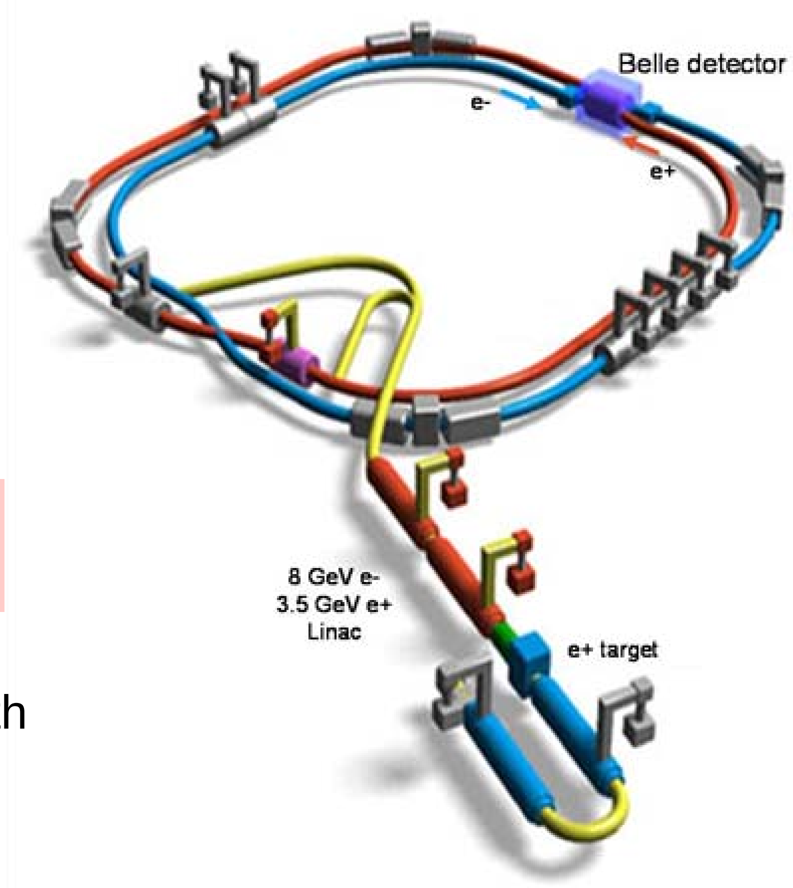
Hints of New Physics in Belle data



Belle II – Upgrade

New experiment to increase the intensity of the accelerator by a factor 50!

Start up 2014-2015



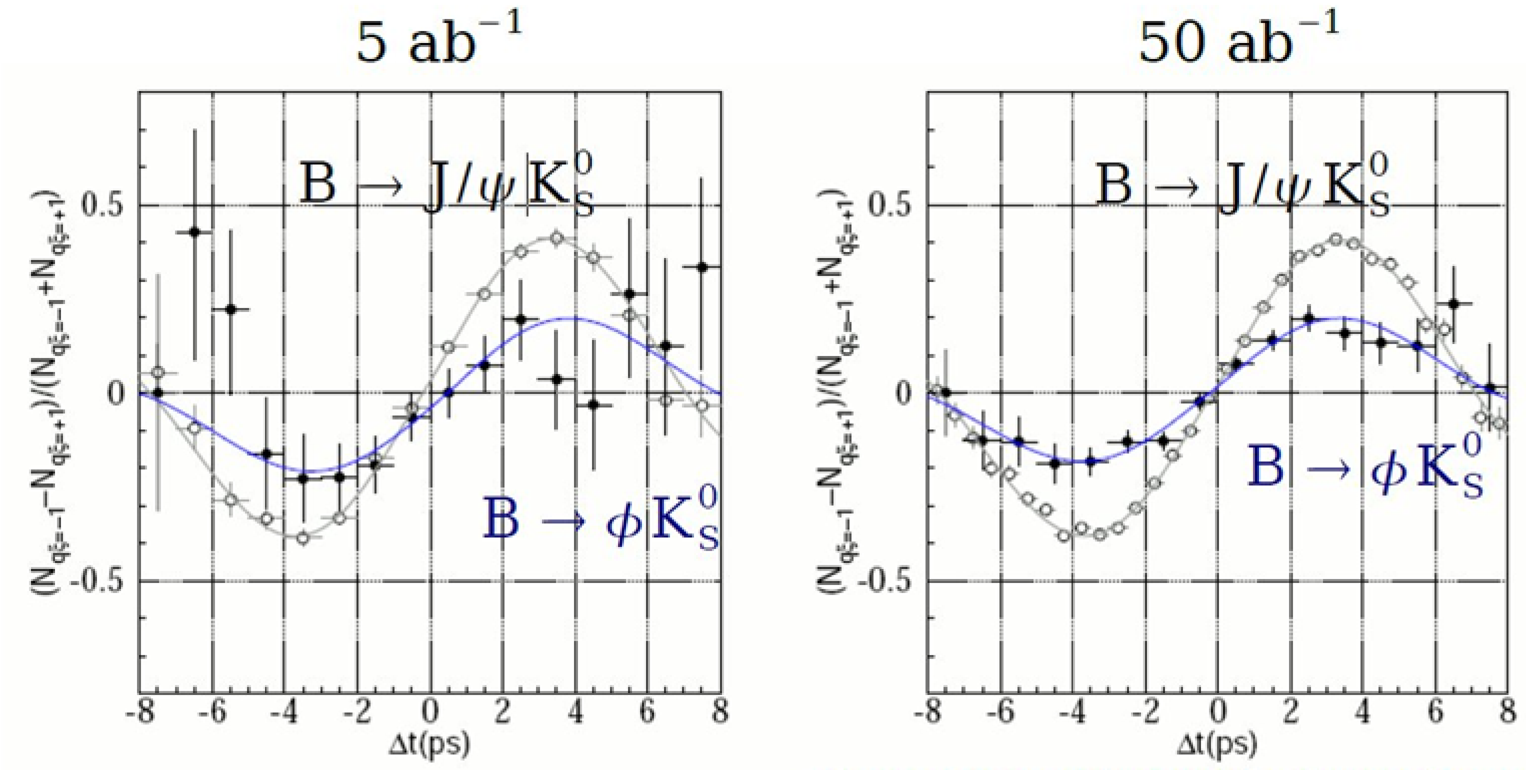
will collect 50x more data

Search for Physics beyond the Standard Model with Precision measurements

3 PB data (KEK, PNNL) => 150 PB data (GRID, gLite, OSG)

$B \to \phi K_S^0$ t-dependent CPV

(input values $S_{\phi K_S^0} = +0.39$, $A_{\phi K_S^0} = 0$)

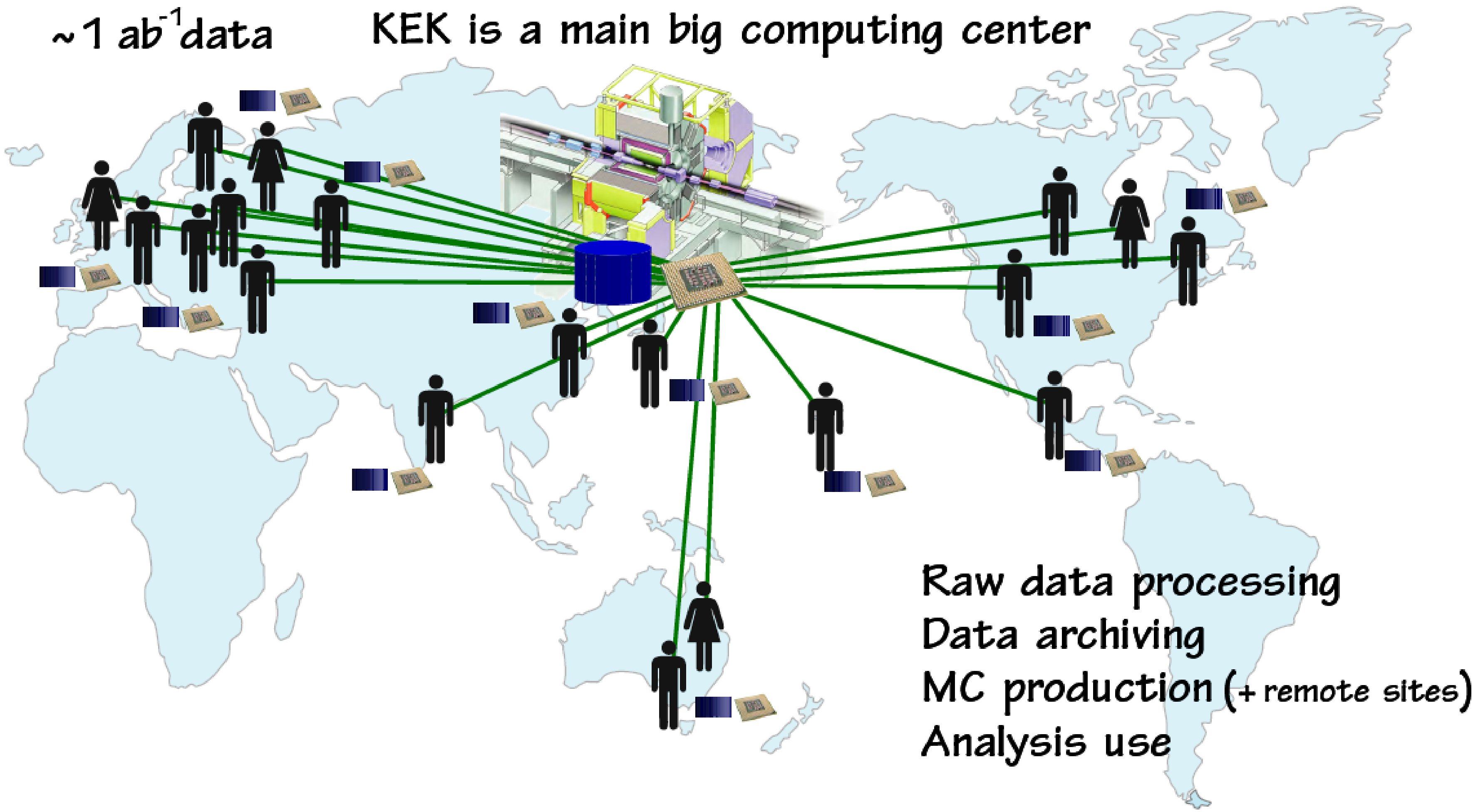


clear distinction with the reference mode

Discrepancy with reference => New Physics
(Complementary to LHC searches)

Belle Computing prior to Earth Quake

Belle Computing: Centralized at KEK



Post Earthquake

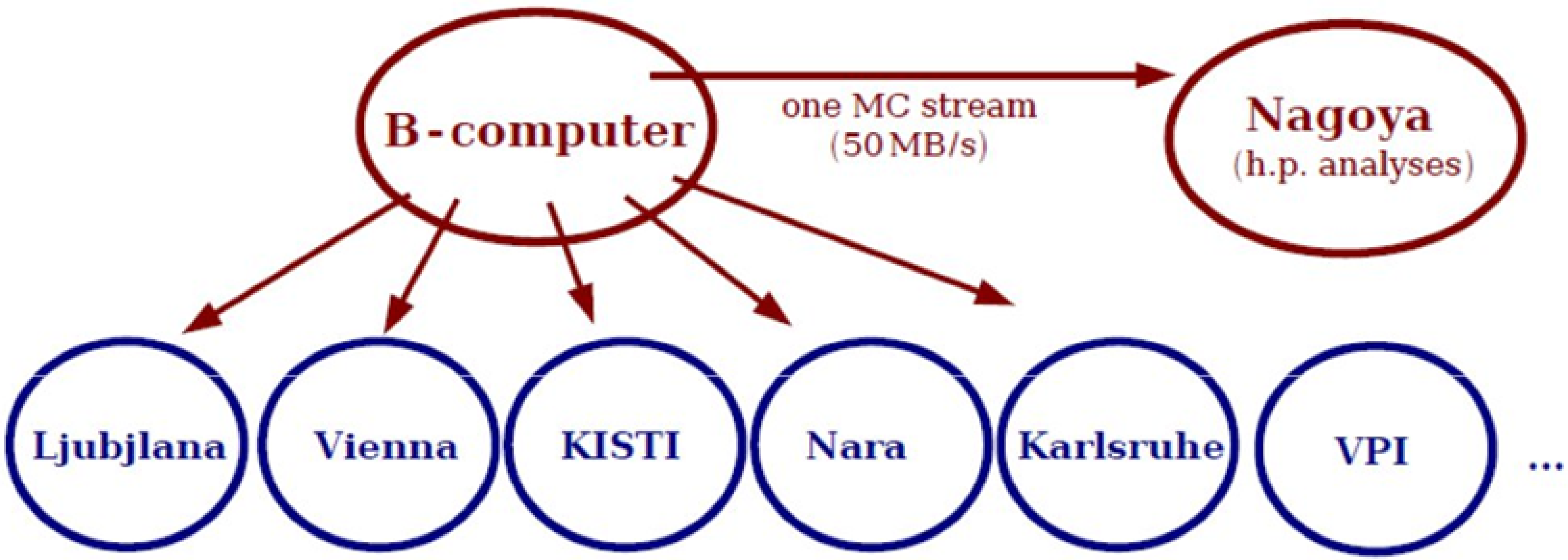
Substantial reduction in Electricity supply to KEK
Decentralize Data analysis

Skimmin center (SC):

- > PB capacity
- data/MC (few streams) mdst
- h.p. users (PhD students, summer)
- high maintenance (stability)
- produced organized skims

Local center (LC):

- > 10 TB capacity
- 3-10 users (library, paw/root, CPUs)
- users can produce and store signal MC
- users can read some skims brought from SC (~TB)



(almost as opposite of the MC production skim)
(LC: not only available for local users, accept outside users)

Belle Computing at PNNL : Status 7/5/11

- Proposal to DOE funded till June 2012
- Proposal to DOE for continued funding in preparation
- BASF installed on NW-ICE cluster
- 7 racks of 27 compute nodes (8 cores)
- Priority use of ½ of 1512 cores
- Validated MC produced for Exp43, Exp45
- 140 TB disk / 1 PB tape storage for
- Belle data/MC populated via FTP

Approval for Belle computing to occupy new Computer Science Facility (CSF)

900 TB disk acquired/deployed for Belle 1

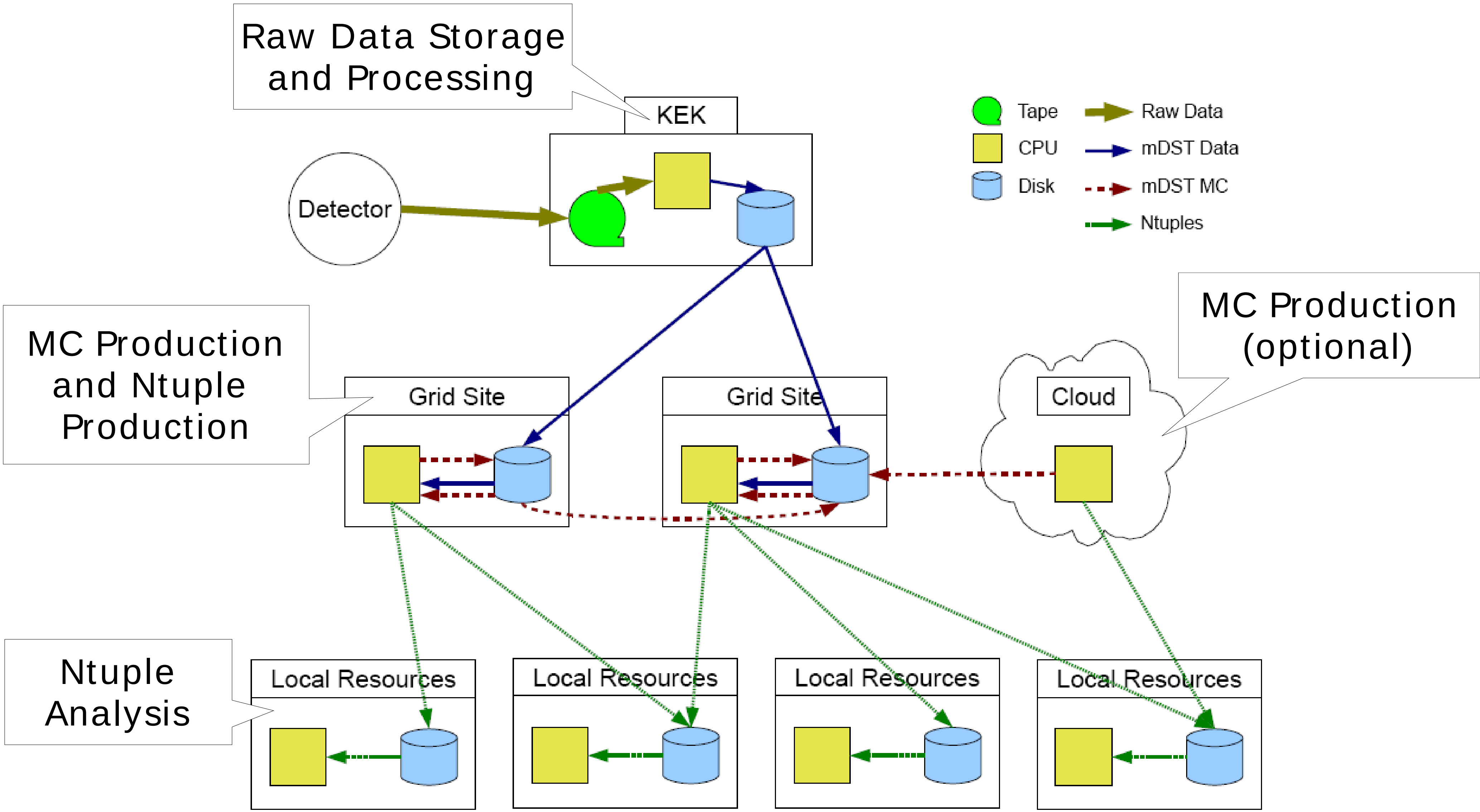
Future:

Additional servers (up to 400 cores)
Large data transfer from Japan

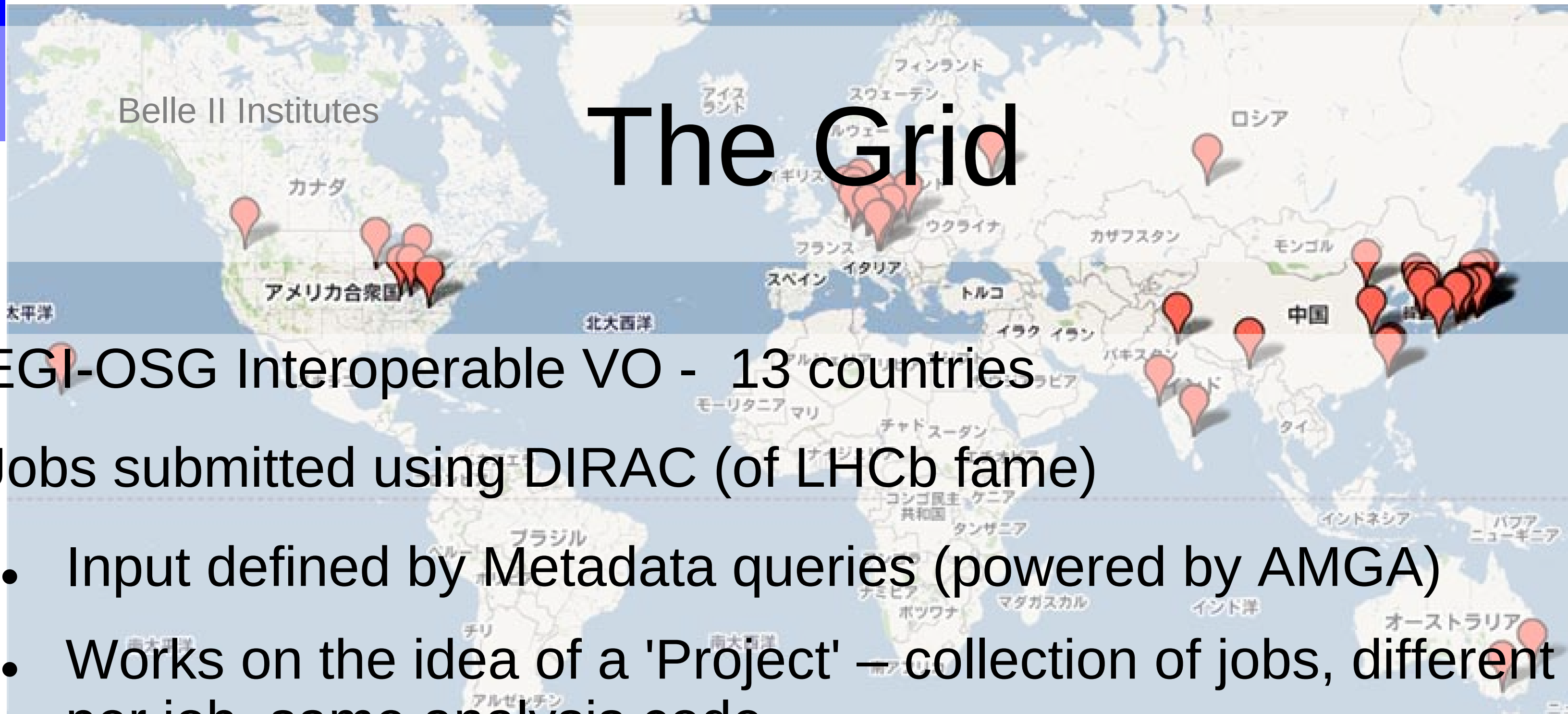
Intention to become OSG Grid Site

- 10,000 Square feet
- Up to 10 MegaWatts
- Geothermal Cooling

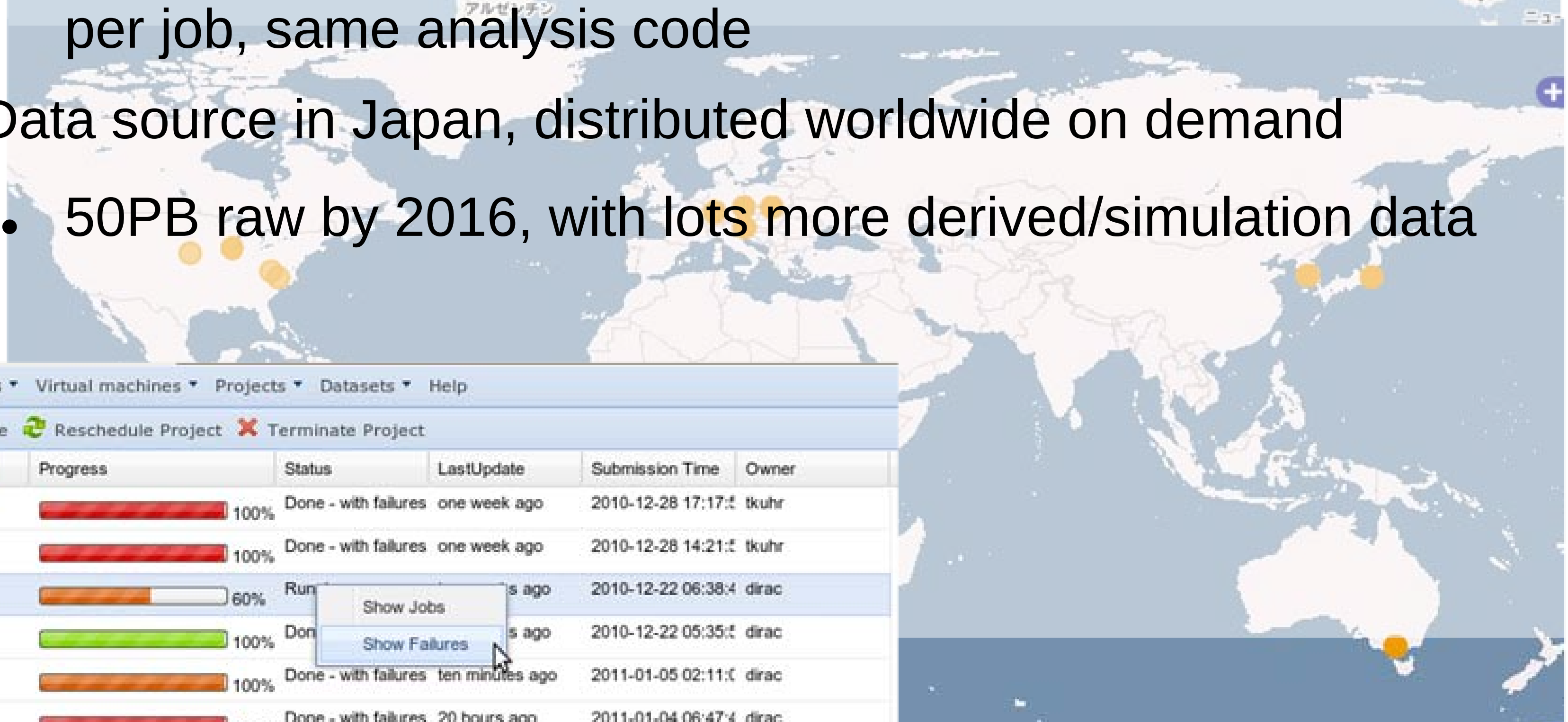
Belle II Computing Model



The Grid



- EGI-OSG Interoperable VO - 13 countries
- Jobs submitted using DIRAC (of LHCb fame)
  - Input defined by Metadata queries (powered by AMGA)
  - Works on the idea of a 'Project' – collection of jobs, different data per job, same analysis code
- Data source in Japan, distributed worldwide on demand
  - 50PB raw by 2016, with lots more derived/simulation data



Systems ▾ Jobs ▾ Virtual machines ▾ Projects ▾ Datasets ▾ Help

Select all Select none Reschedule Project Terminate Project

Project	Progress	Status	LastUpdate	Submission Time	Owner
test3	100%	Done - with failures	one week ago	2010-12-28 17:17:5	tkuhr
test1	100%	Done - with failures	one week ago	2010-12-28 14:21:5	tkuhr
loadstorm-kek2	60%	Run...	...s ago	2010-12-22 06:38:4	dirac
loadstorm-all	100%	Don...	...s ago	2010-12-22 05:35:5	dirac
installation	100%	Done - with failures	ten minutes ago	2011-01-05 02:11:0	dirac
e055-test	100%	Done - with failures	20 hours ago	2011-01-04 06:47:4	dirac
NoGroup	100%	Done	two weeks ago	2010-12-22 05:50:3	dirac

Show Jobs

Show Failures

...f Melbourne

Current Belle VO

Belle II Status

Japan remains committed to Belle II

Official groundbreaking ceremony Nov. 18^{th}, 2011

(Many dignitaries from around the world in attendance)

Data expected in 2015

Outlook to 2012

- Great Japan EarthQuake (March, 2011)
- Still looking for help!
  - Finding grid-skilled people is a challenge
  - (Tom Fifield 90% => 10%)
- Building experiment-specific software
- Busy arranging resources, signing MoUs
  - ~60 institutes to organise
- 1st delivery of equipment for our “Tier 0” Q1 2012
  - 5PB storage (+5PB for original Belle)
  - As many cores as budget will allow
- Virginia Tech incorporated into OSG
- Pacific NorthWest National Lab starts process to join OSG
- Belle data “liberated” => plan for deployment late 2011
- Look to develop grid/OSG and analysis tools for Belle by early 2012

Thank You