HEP experiments in Japan
- The Next Generation -

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KEK

TWEPP09, Paris, Sep.21 2009

BELLE

Outline

1. Introduction : Looking back past

2. J-PARC and T2K

3. KEKB+Belle to SuperKEKB+Belle II

4. Summary

1. Introduction

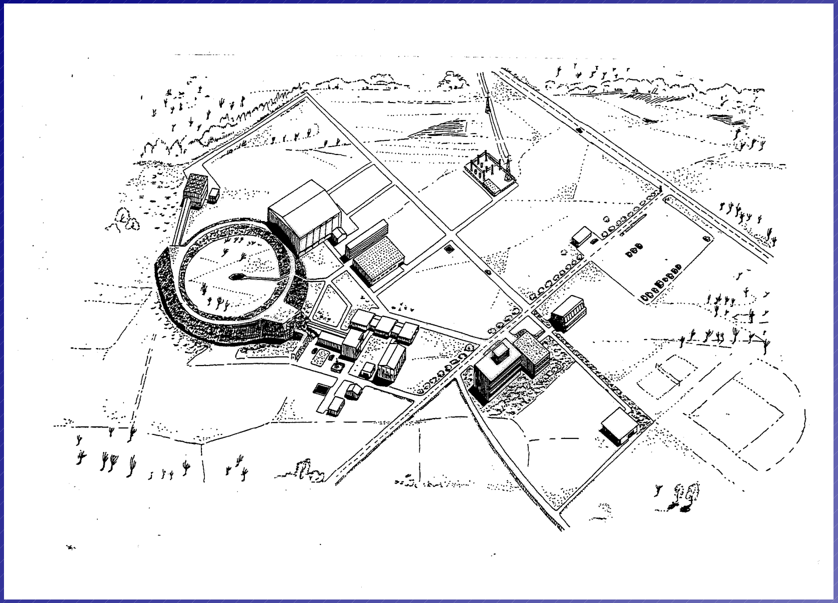
- Japan has a long history of the accelerator based HEP experiments.

  1956: INS: 1.3GeV Electron Synchrotron
  1970: KEK: 12GeV Proton Synchrotron(KEK PS)
  → Many experiments, and K2K from 1999
  1983: KEK: TRISTAN e^+e^- collider
  → Data taking started in 1986 by AMY, TOPAZ, VENUS and SHIP
  1995: KEK: KEKB B-factory
  → Data taking started in 1999 by Belle

- KEK PS stopped operation in 2005.

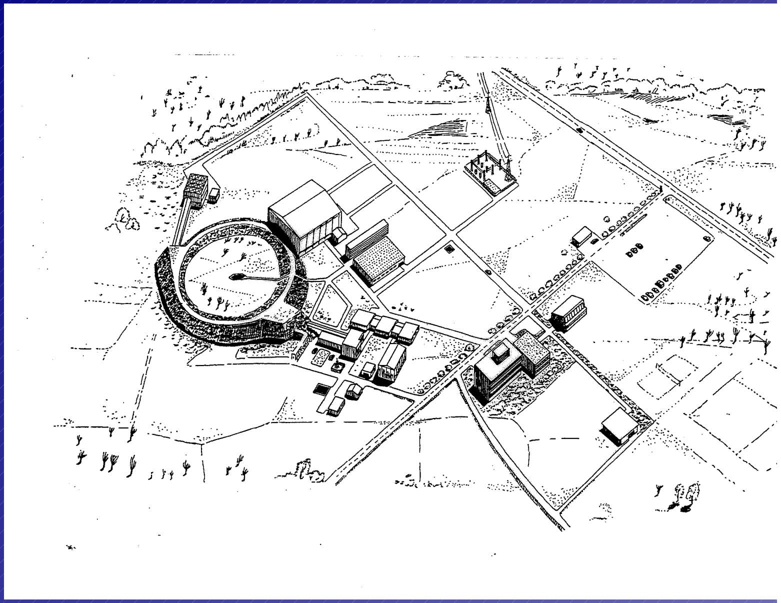
- KEKB is still running and data taking by Belle is going on.

KEK 12GeV PS



Original design in 1970

KEK 12GeV PS



Original design in 1970

Final configuration

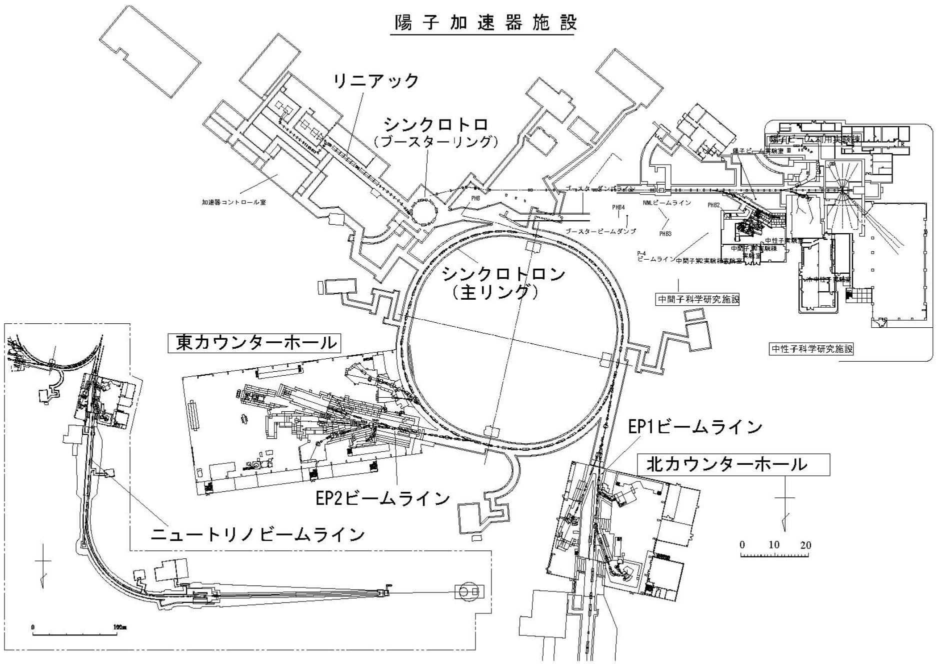
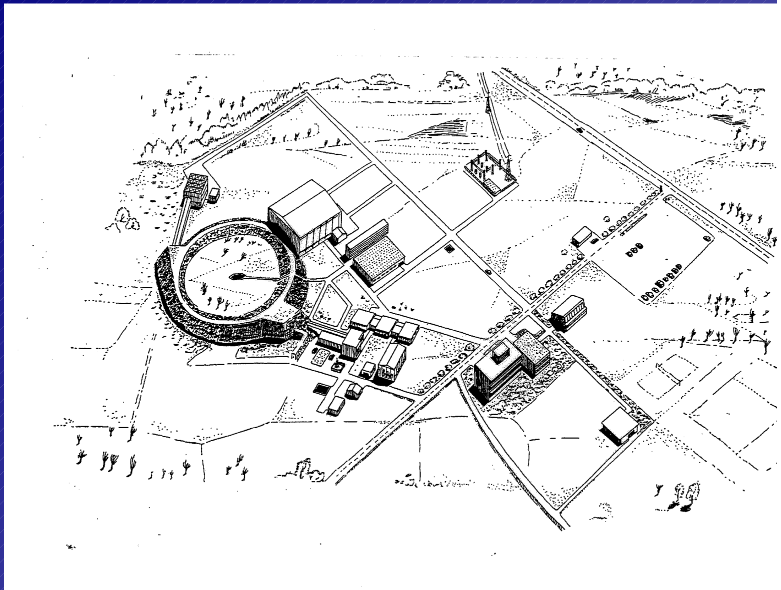


図1　高エネルギー加速器研究機構　陽子加速器施設全体図

KEK 12GeV PS



Original design in 1970

Final configuration

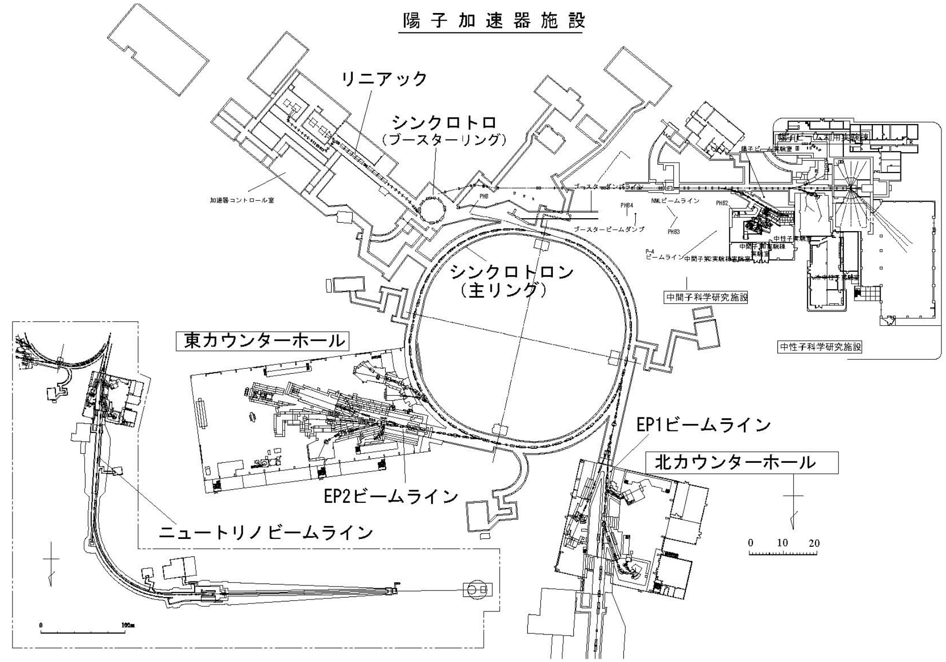
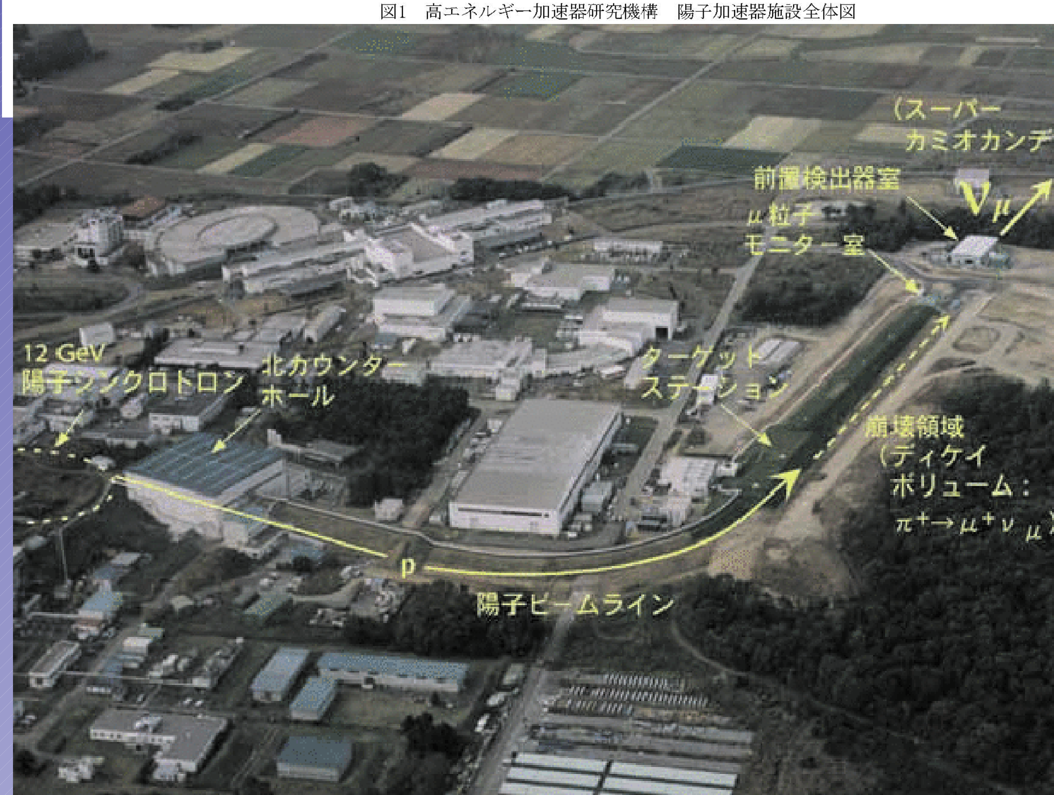


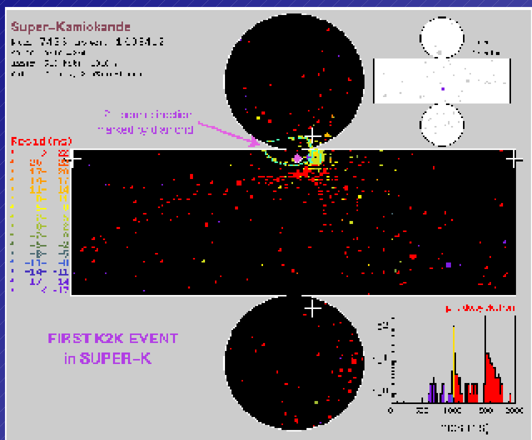
図1　高エネルギー加速器研究機構　陽子加速器施設全体図

Beamline for K2K

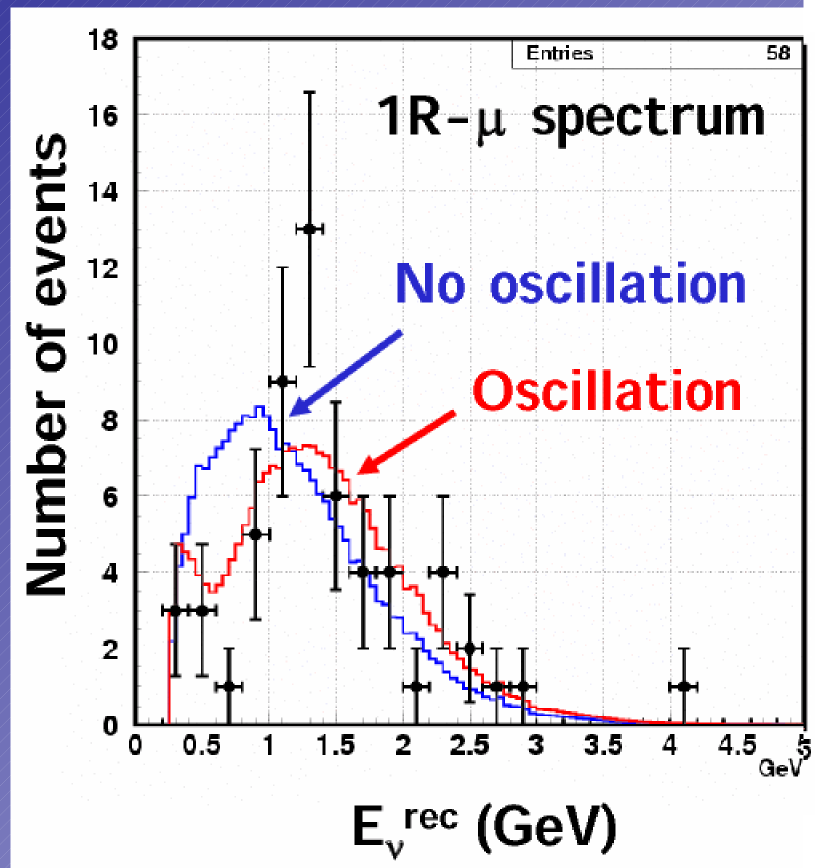


Physics outputs from KEK PS

- K2K
  * Long-baseline neutrino oscillation exp.



First event
on 6/19/99



Best fit value
(all region)
$\sin^2 2\theta = 1.19 \pm 0.23$
$\Delta m^2 = (2.55 \pm 0.40)\times10^{-3}\mathrm{eV}^2$
(in physical region)
$\sin^2 2\theta = 1.0$
$\Delta m^2 = (2.76 \pm 0.36)\times10^{-3}\mathrm{eV}^2$

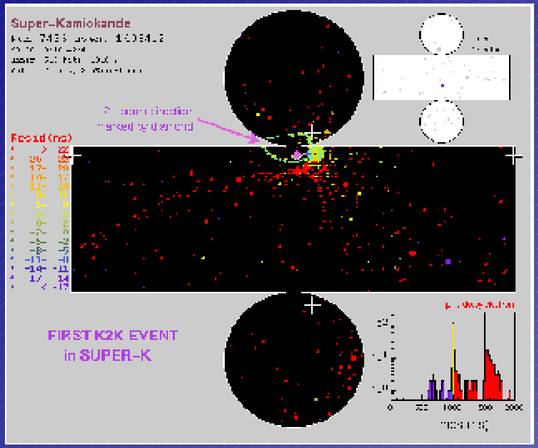
No oscillation prob.= 0.003% (4.2σ)
(for best fit in the phys. region)

$1.88\times10^{-3} \leq \Delta m^2 \leq 3.48\times10^{-3}$ eV^2
(90%CL) @ $\sin^2 2\theta=1$

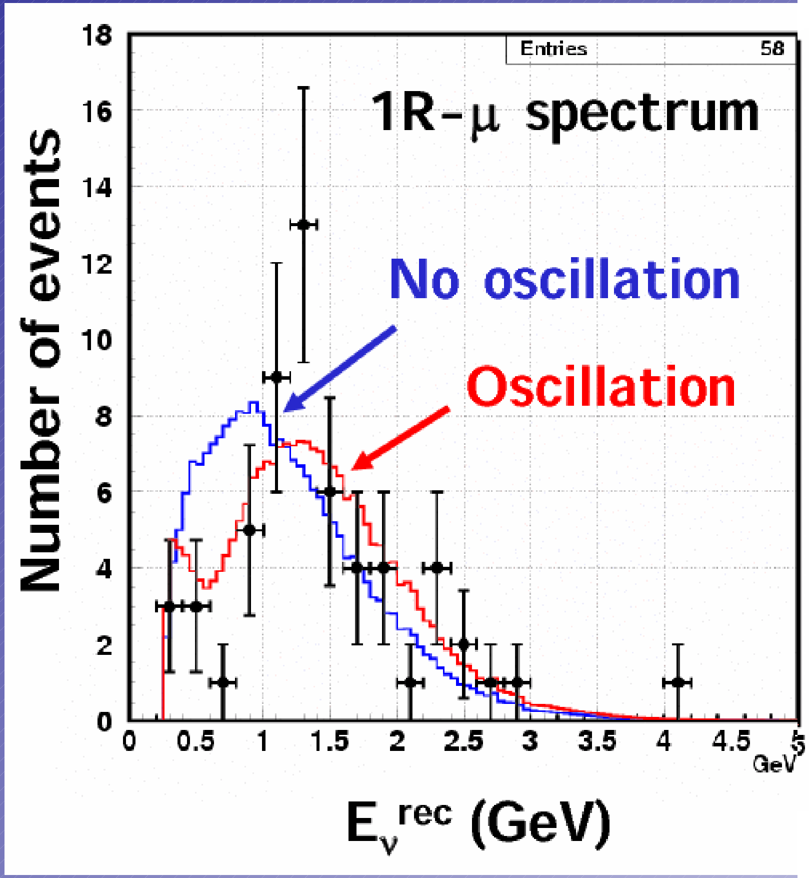
Confirmed atmospheric neutrino oscillation

Physics outputs from KEK PS

- K2K
  * Long-baseline neutrino oscillation exp.



First event on 6/19/99



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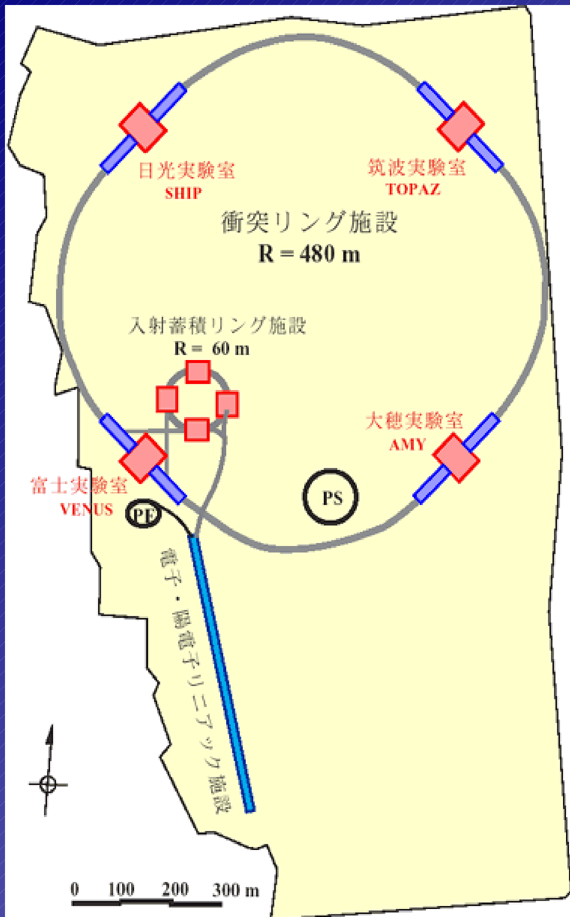
Confirmed atmospheric neutrino oscillation

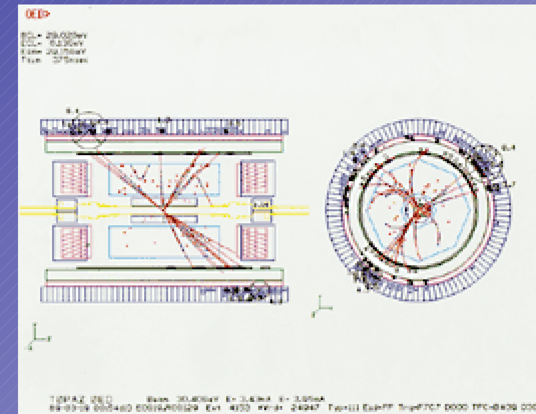
- E246: T-Violation in $K^+ \to \pi^0 \mu^+ \nu$

- E391a: Measurement of $K_L \to \pi^0 \nu\nu \to$ Unitarity triangle

TRISTAN



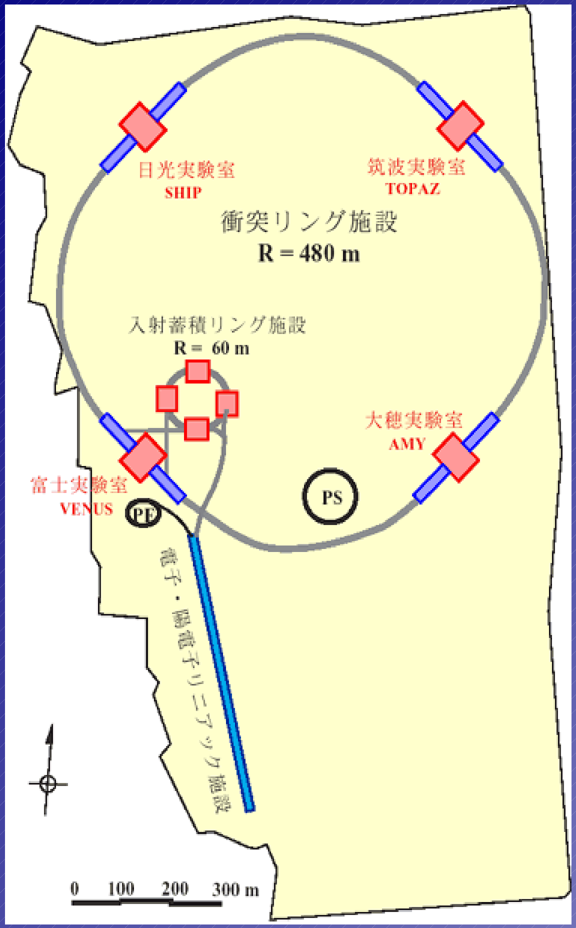
TOPAZ-TPC



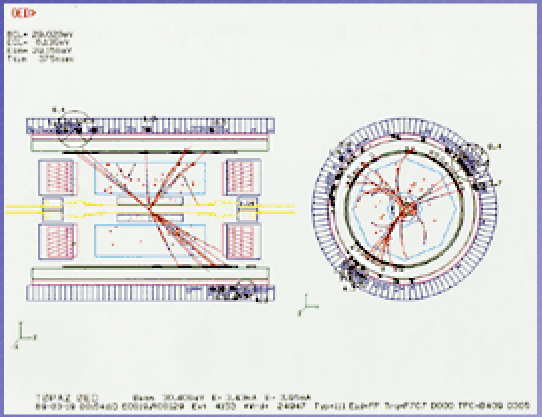
3-jet event

* e^+e^- collider at √s=52-61.4 GeV
* 4 experiments:
  AMY, TOPAZ, VENUS and SHIP

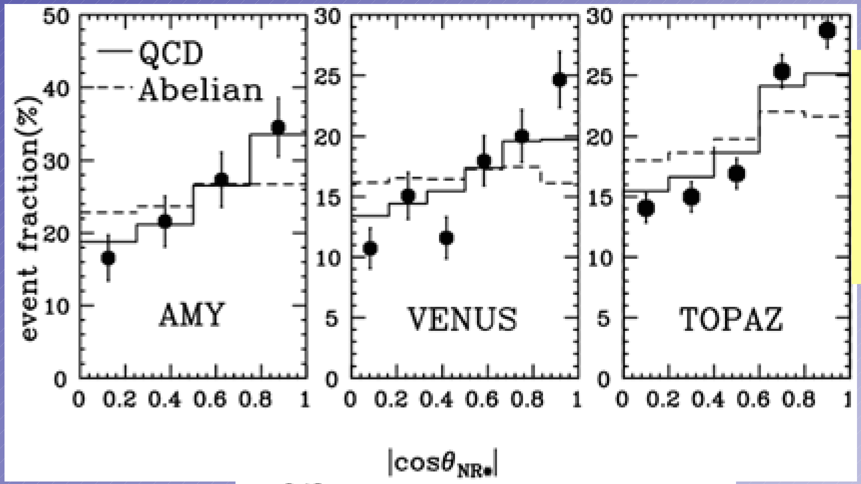
TRISTAN



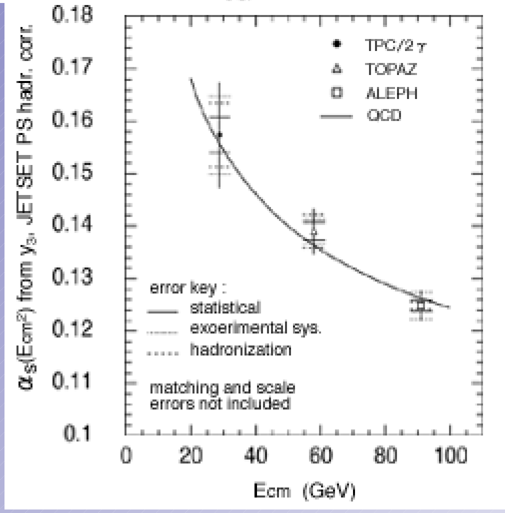
TOPAZ-TPC



3-jet event



First observation of Triple gluon coupling



α_s measurement at $\sqrt{s}$ = 58GeV

* e^+e^- collider at $\sqrt{s}$=52-61.4 GeV
* 4 experiments: AMY, TOPAZ, VENUS and SHIP

What's next?

- KEK PS stopped operation in 2005
  => taken over by J-PARC
  * Higher intensity : MW class
    - High intensity neutrino beam for T2K
    - Many hadron experiments

- KEKB is still running.
  * But more than 50 times higher luminosity is required for the precision study of rare decays of B mesons to search for New Physics in the loop diagram.
    => Upgrade is being planned :SuperKEKB

2. J-PARC and T2K

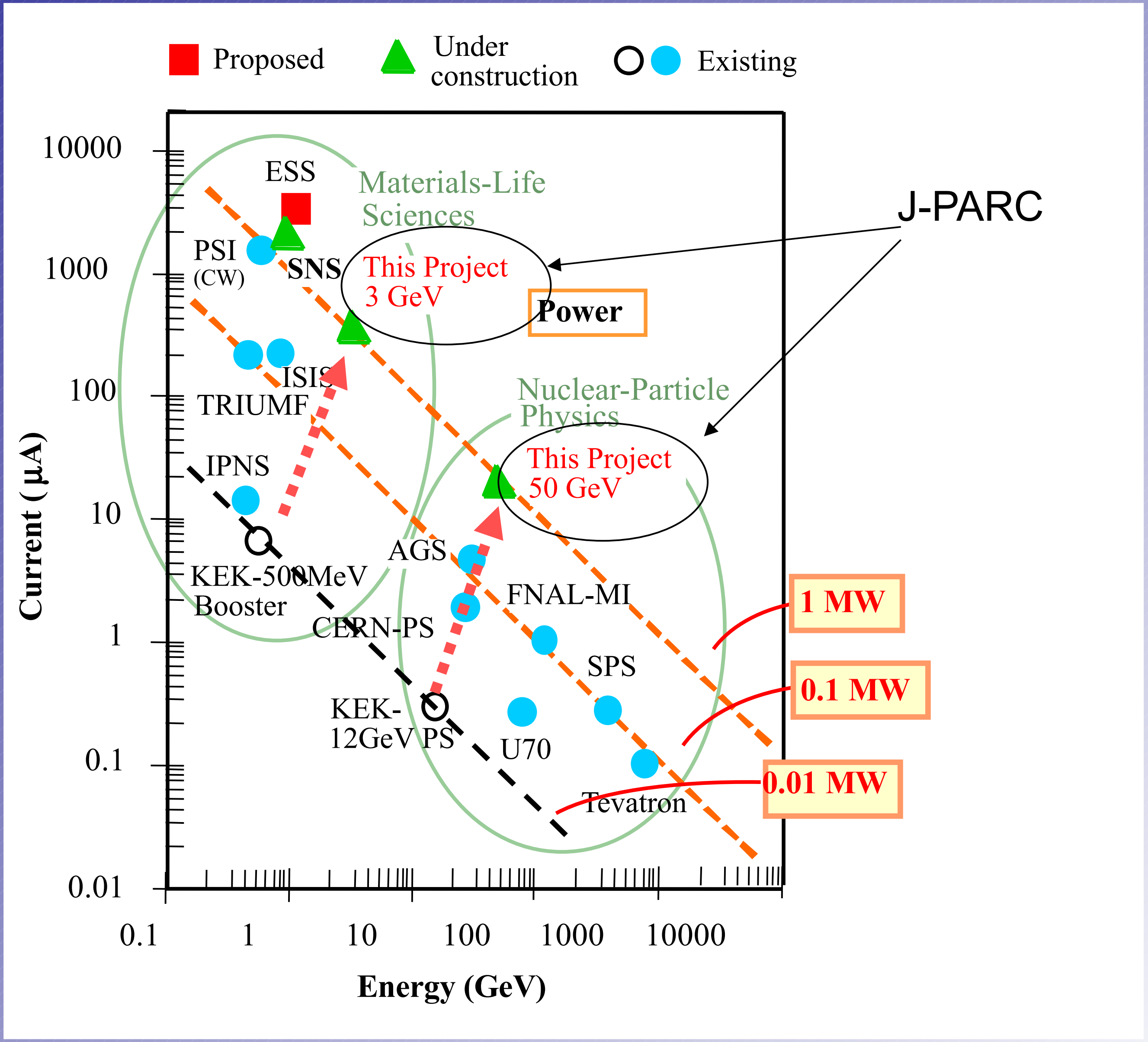
Bird's eye photo in January of 2008

J-PARC : Power frontier proton accelerator

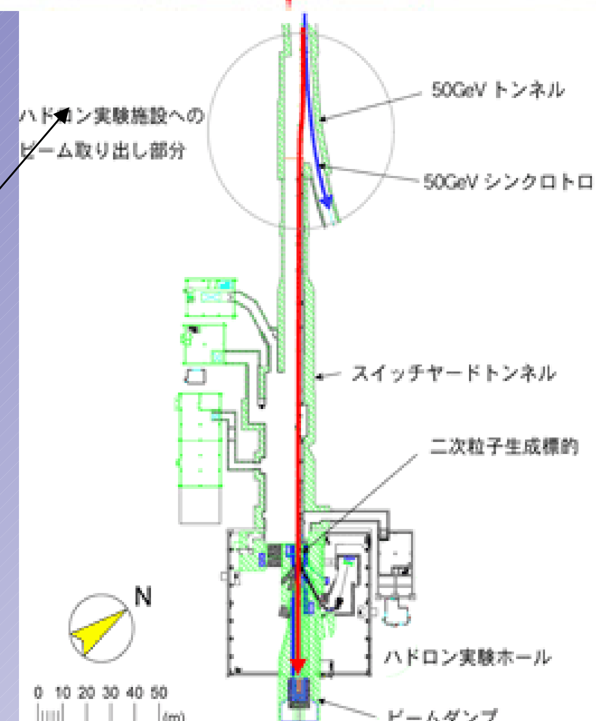
10-100 times higher power than that of existing accelerators

3GeV RCS
333µA
1MW

50GeV Ring
15µA
0.75MW



J-PARC status

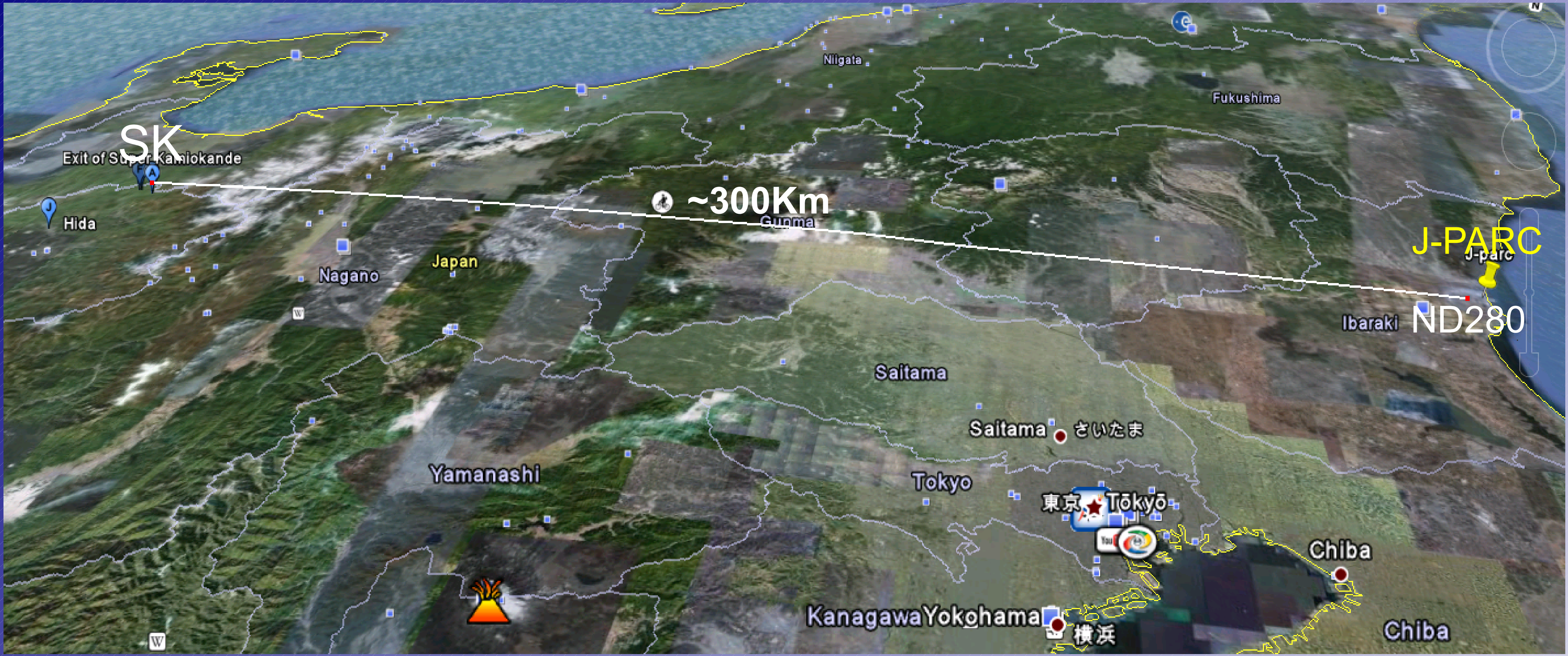


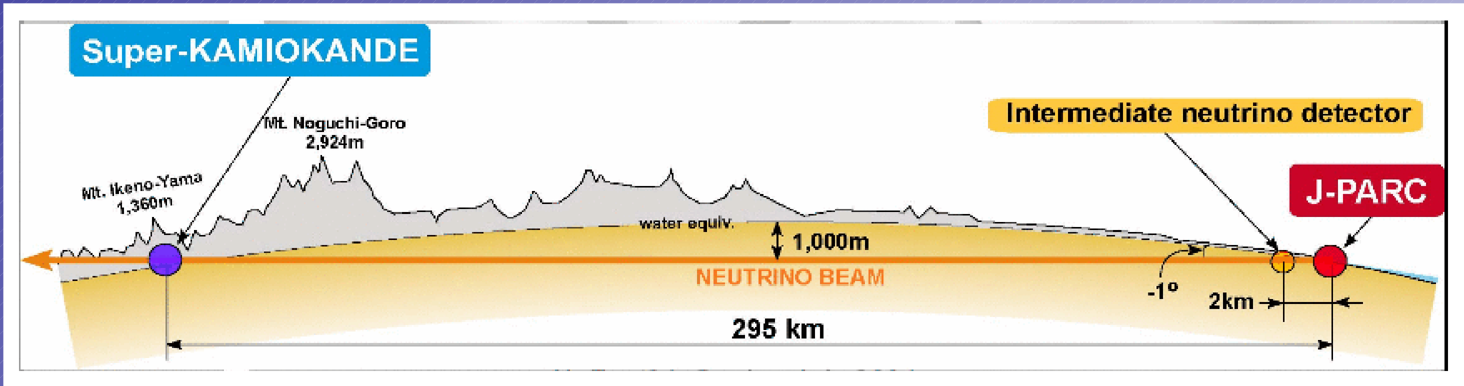
Recent milestones:

- December 23, 2008:
  - 30 GeV beam acceleration and fast extraction to the beam abort dump
  - MLF user run (20kW)
- January 27, 2009:
  - Beam extraction to the Hadron Experimental hall using slow beam extraction system
- February 19, 2009:
  - Government inspection for radiation safety

30 GeV / 0.1MW operation in 2009-2010

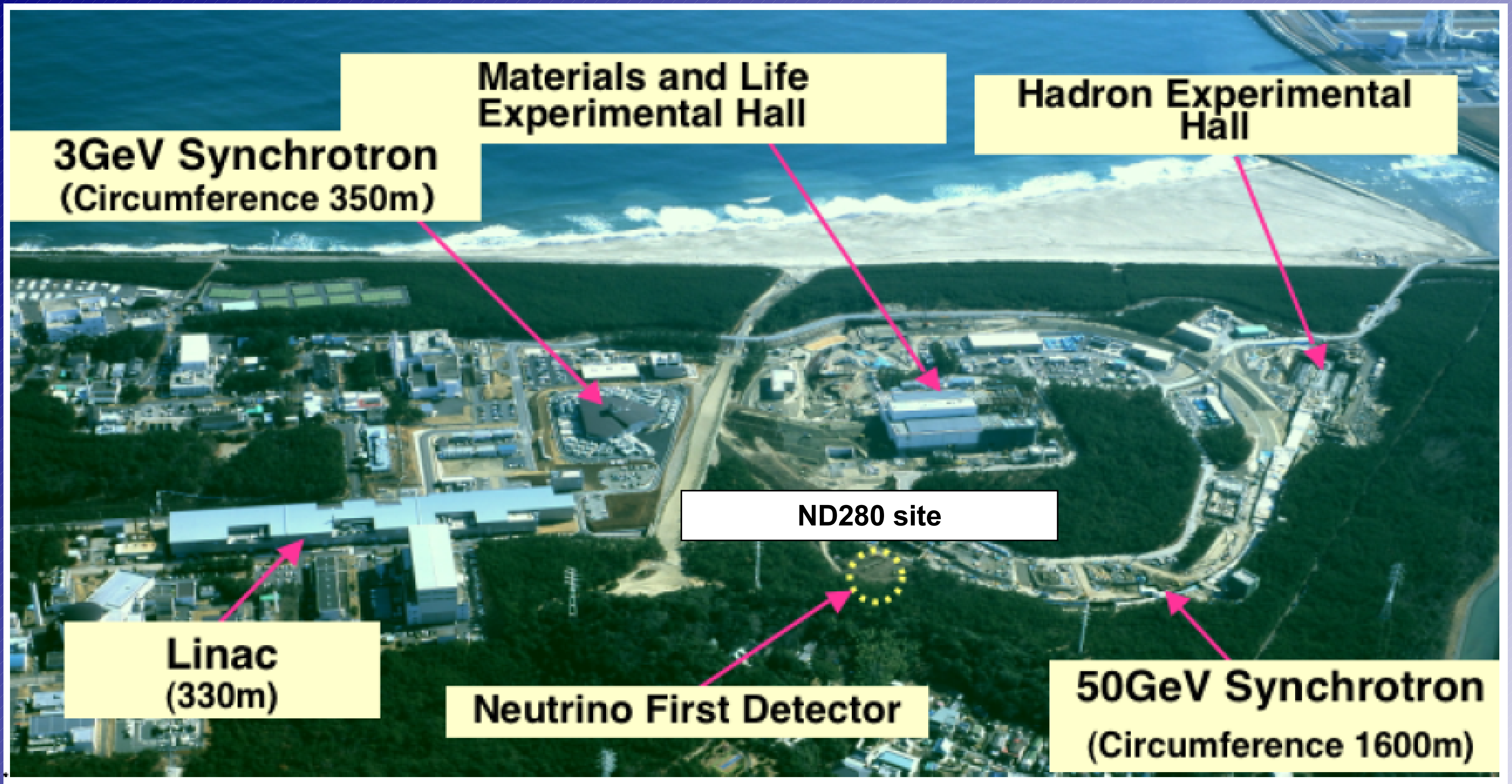
T2K: Tokai to Kamioka



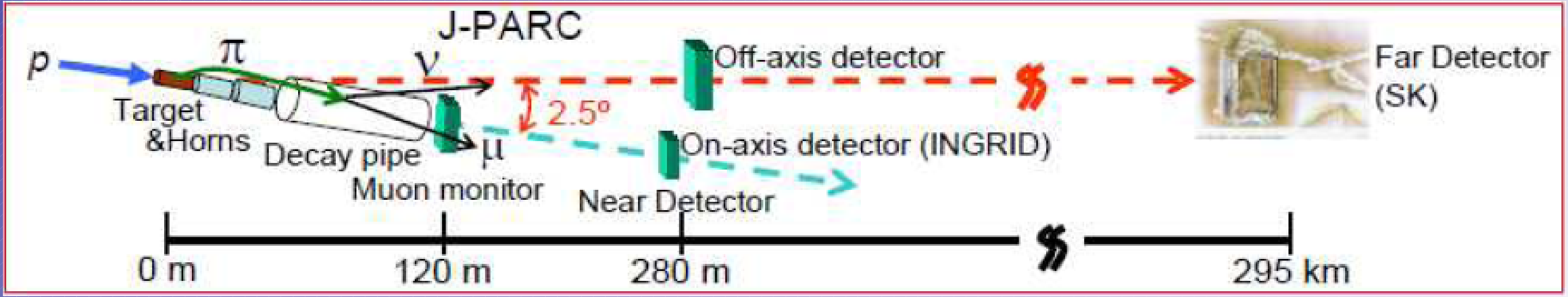


Goals of the T2K project

- ν_μ disappearance
  $\times$ 10 more precise $\theta_{23}, \Delta m^2_{23}$
- $\nu_\mu \to \nu_e$ appearance
  θ_{13} discovery
- $\nu_\mu \to \nu_e$ vs. $\bar{\nu}_\mu \to \bar{\nu}_e$
  δ_{CP} discovery



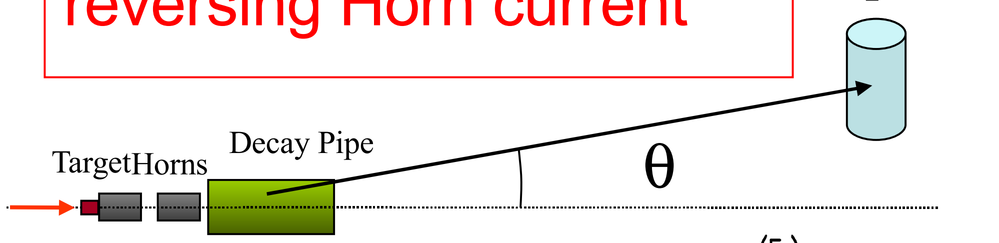
Materials and Life Experimental Hall
Hadron Experimental Hall
3GeV Synchrotron
(Circumference 350m)
ND280 site
Linac
(330m)
Neutrino First Detector
50GeV Synchrotron
(Circumference 1600m)



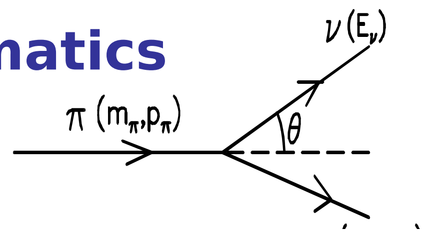
J-PARC
p
π
ν
Target
&Horns
Decay pipe
μ
Muon monitor
2.5°
Off-axis detector
On-axis detector (INGRID)
Near Detector
Far Detector
(SK)
0 m
120 m
280 m
295 km

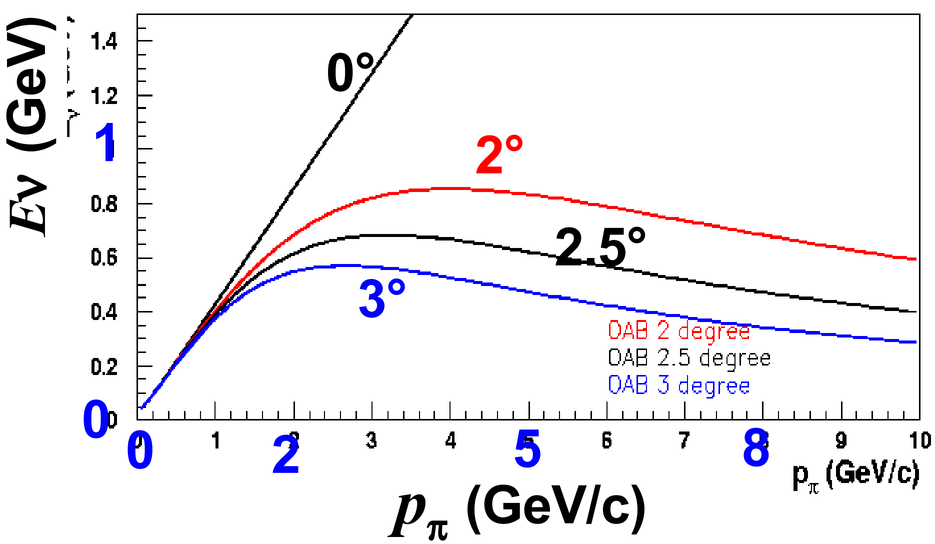
Off-axis beam

Anti-neutrinos by reversing Horn current

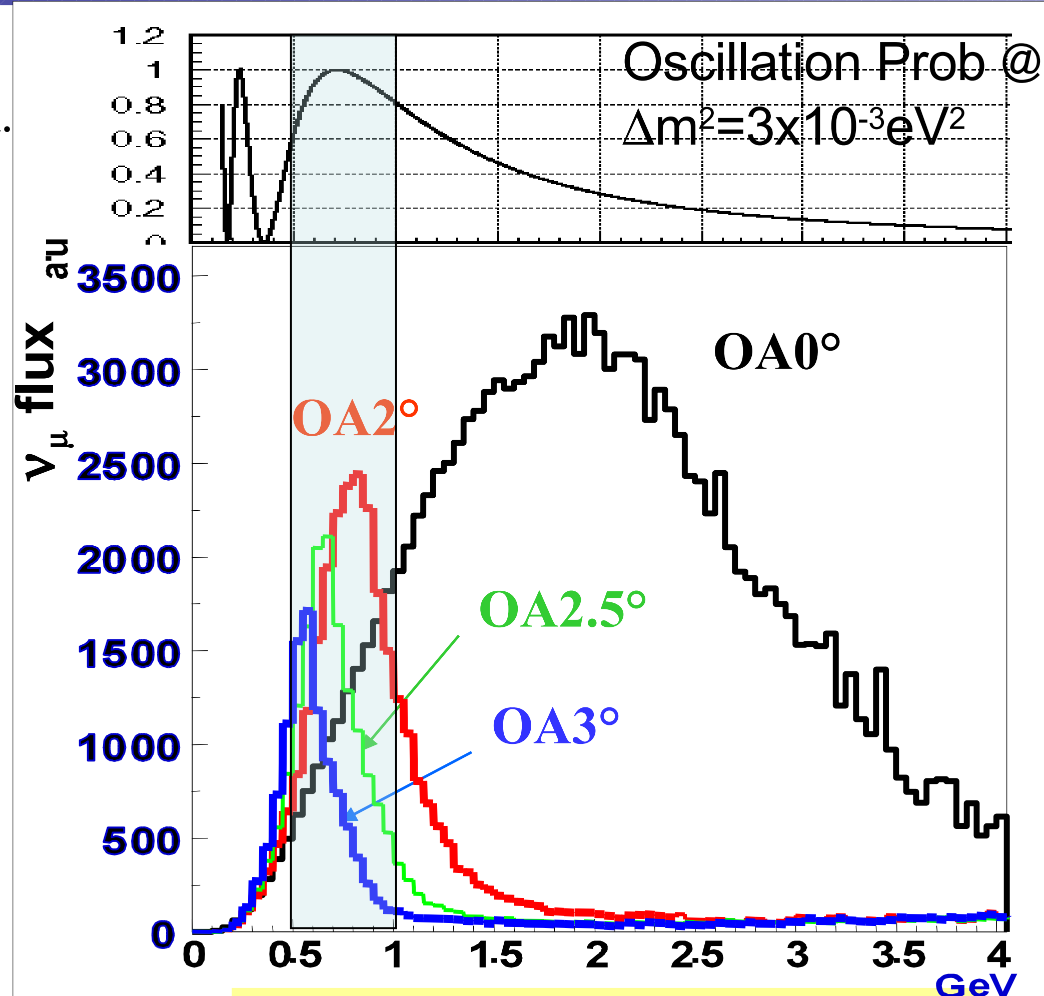


π decay Kinematics





- **Quasi Monochromatic Beam**
- **x 2~3 intense than NBB**
- **Tuned at oscillation maximum**



Statistics at SK

(OAB 2.5 deg, 1 yr, 22.5 kt)

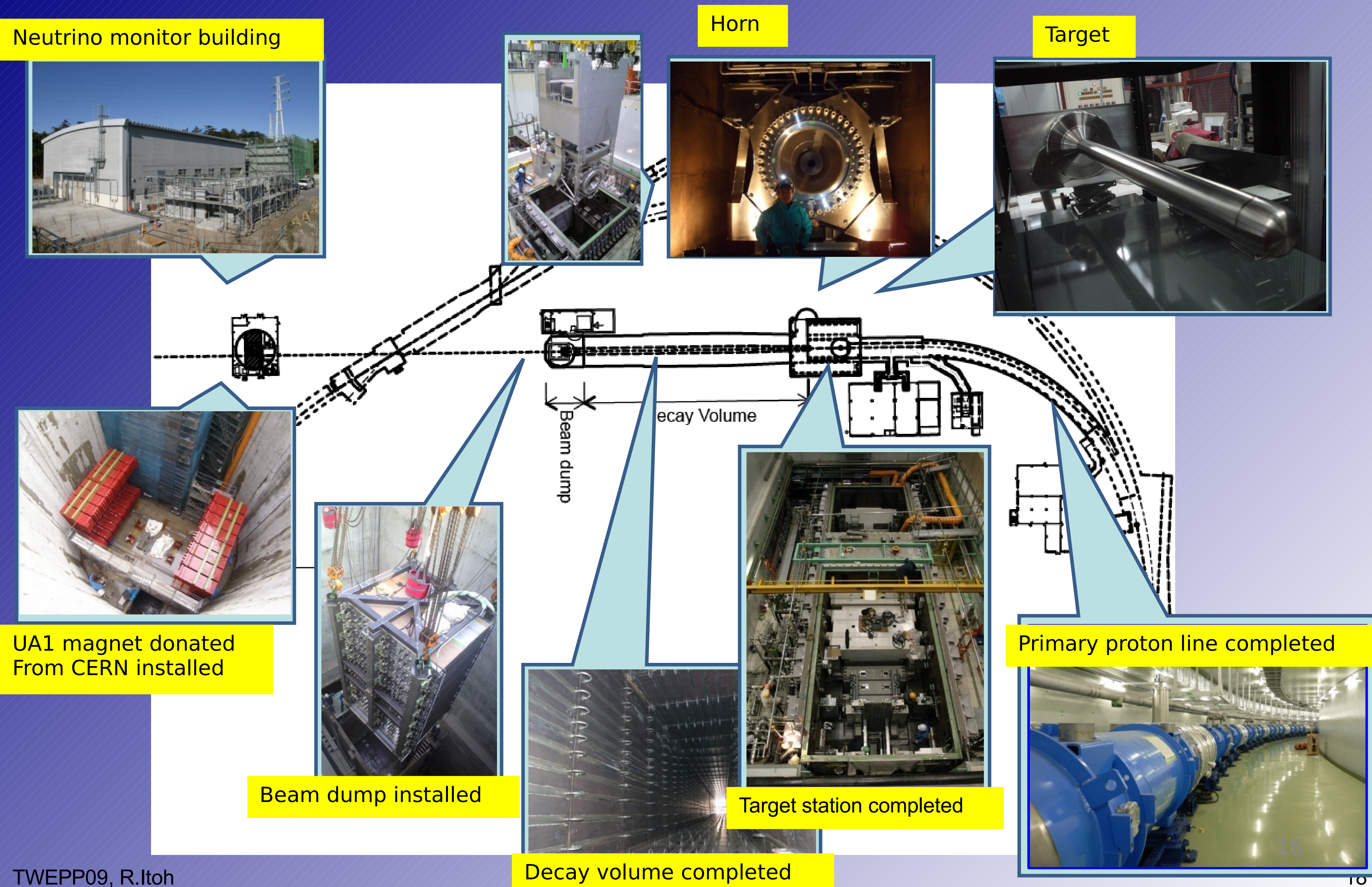
~ 2200 ν_μ tot

~ 1600 ν_μ CC

ν_e ~0.4% at ν_μ peak

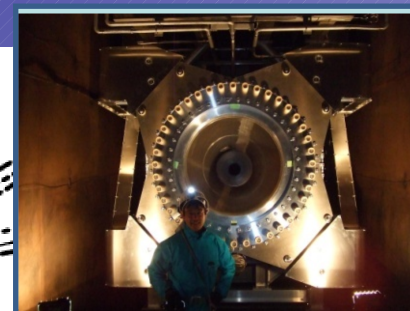
7

Status of neutrino facility construction



Status of neutrino facility construction


Neutrino monitor building


Horn


Target

- 5 year construction 2004~2009
- Construction completed on schedule!
- Start beam commissioning in April 2009!


UA1 magnet donated
From CERN installed

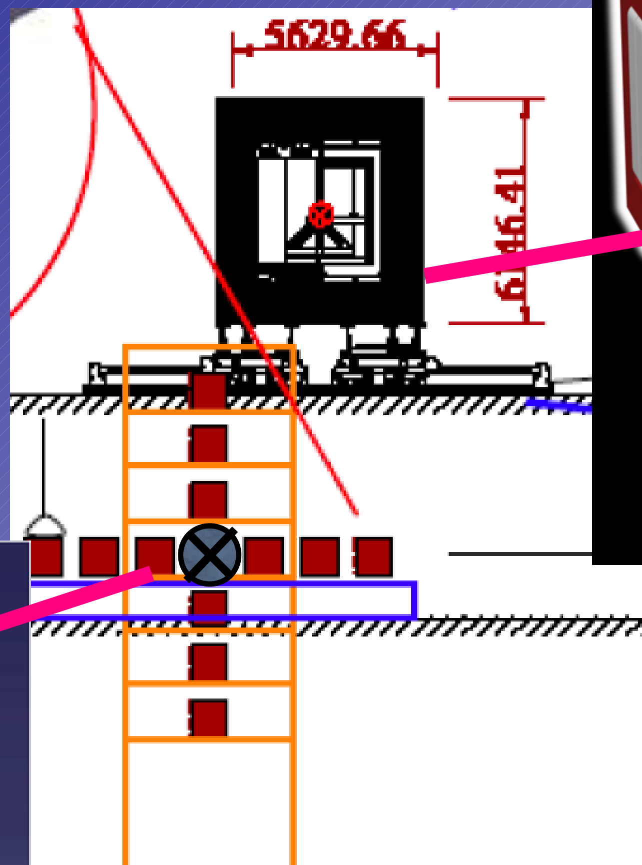

Beam dump installed

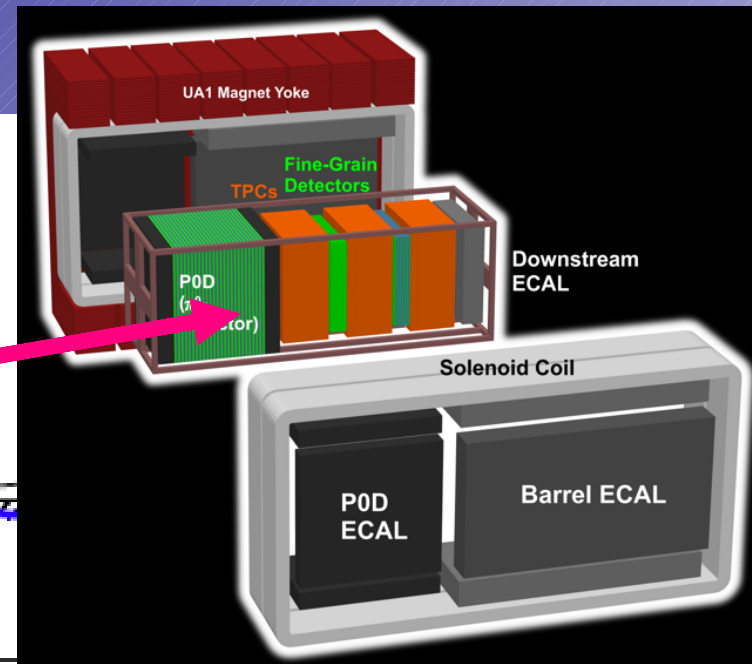

Decay volume completed


Target station completed

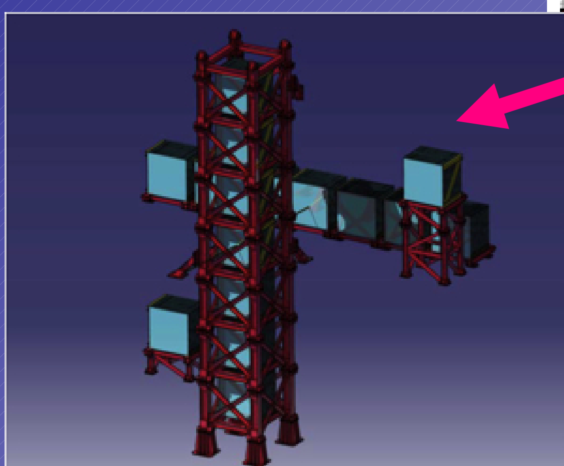

Primary proton line completed

T2K:ND280 detector system





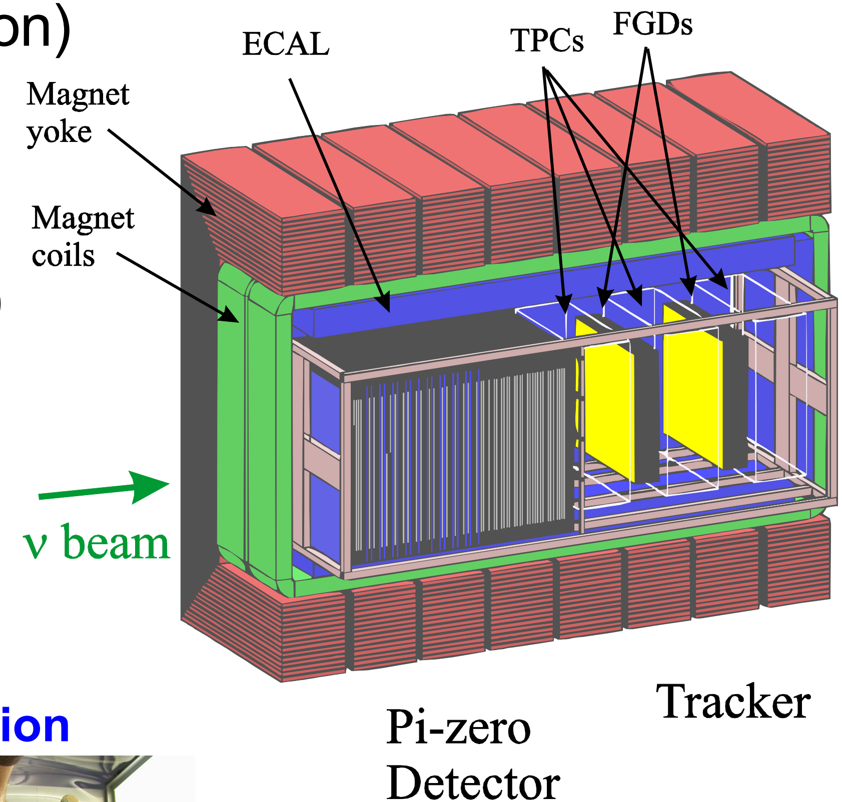
On-axis detector
"INGRID"



Off-axis detectors inside UA1 magnet

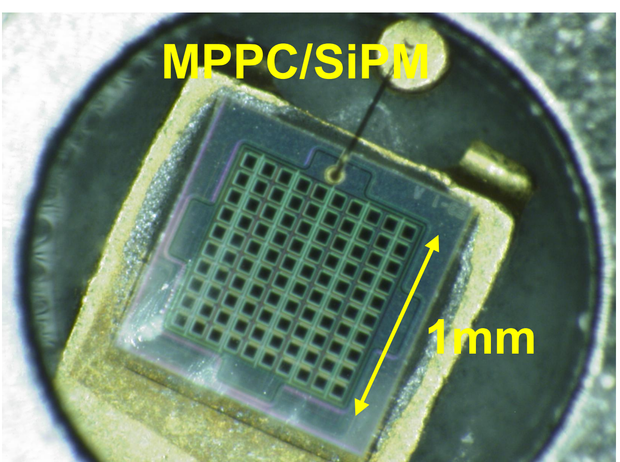
ND280 : Off-axis neutrino detector

- Measurement of ν flux and s in the SK direction.
  - ν_μ , ν_e and anti-ν_μ flux and the energy spectrum.
  - Quasi-Elastic (Signal for E_ν reconstruction)
  - Inelastic $\pi^{\pm,0}$ production (background)
- Detector components.
  - TPC
  - Fine-Grained Scintillator detector (FGD) for CC interaction.
  - Lead/Scintillator tracking detector for π^0
  - Electron Calorimeter
  - Muon Range Detector

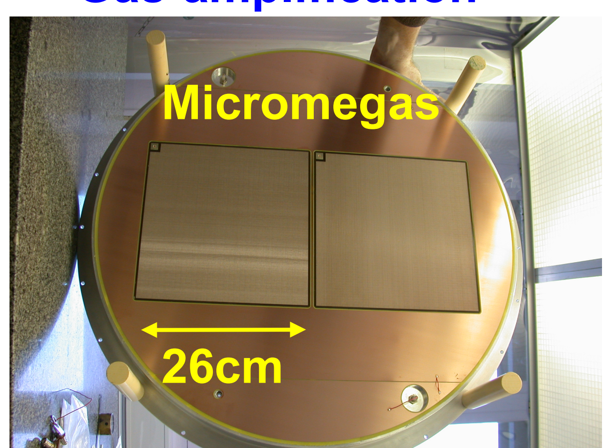


New Technology

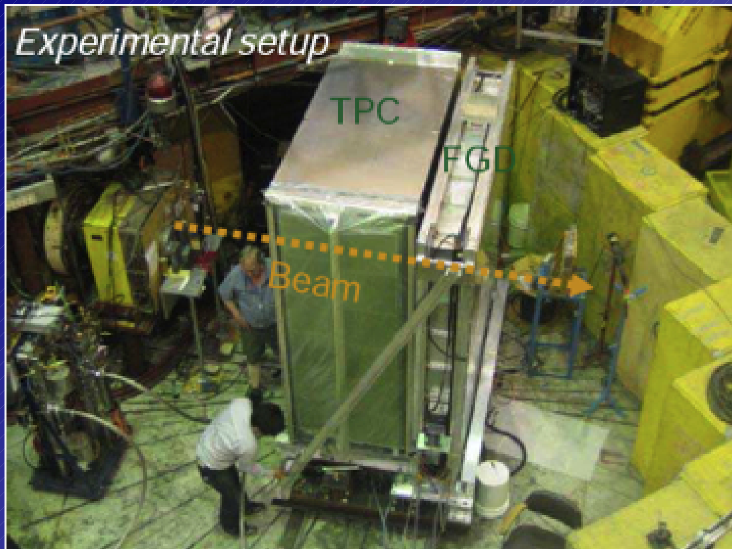
Photo-Sensor



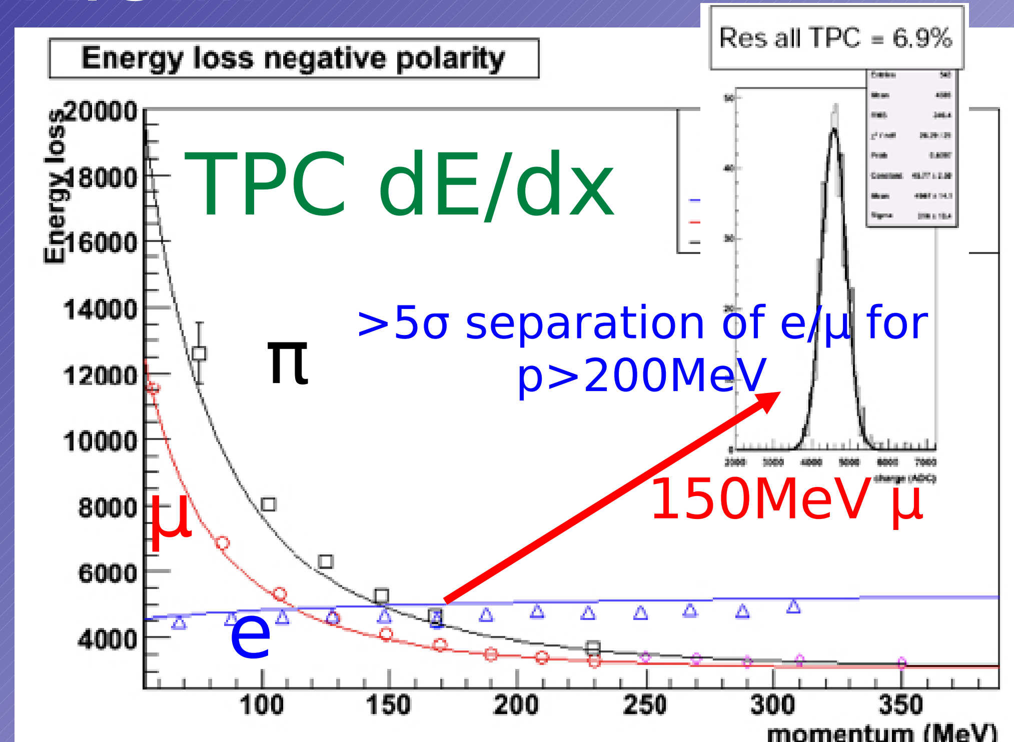
Gas-amplification

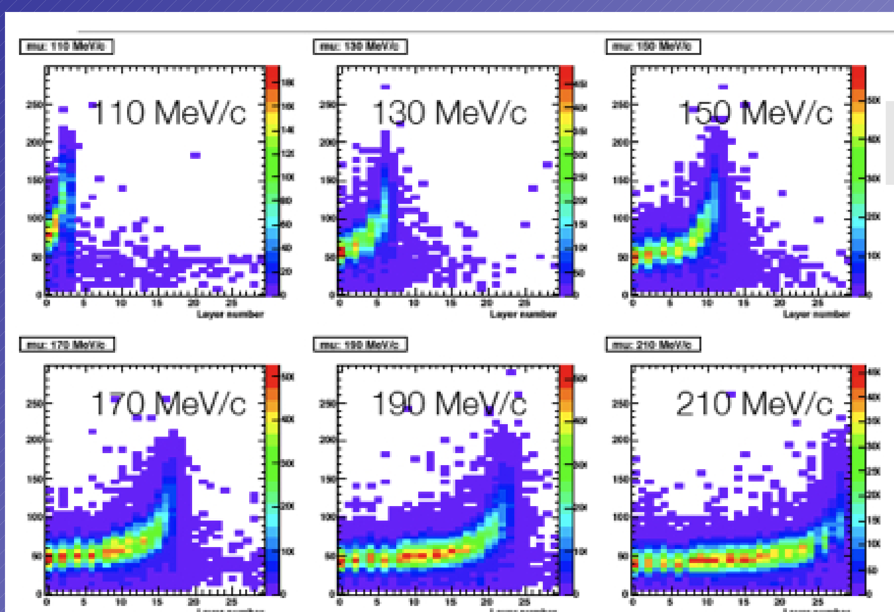


FGD/TPC beam test @ TRIUMF



50-400MeV/c e/μ/π/p

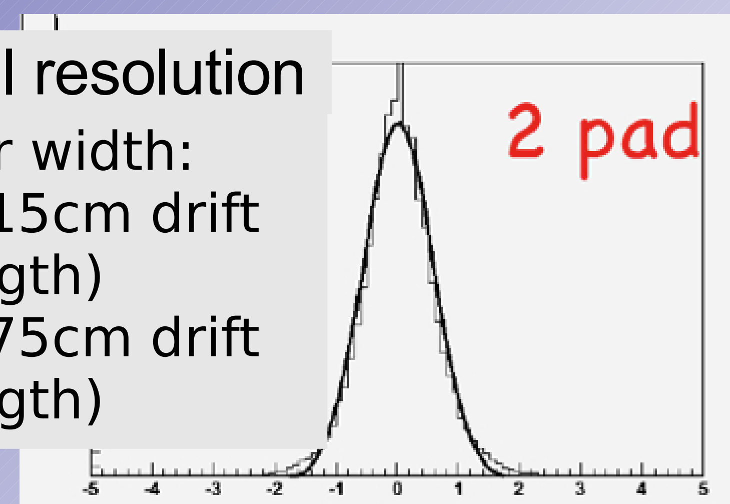




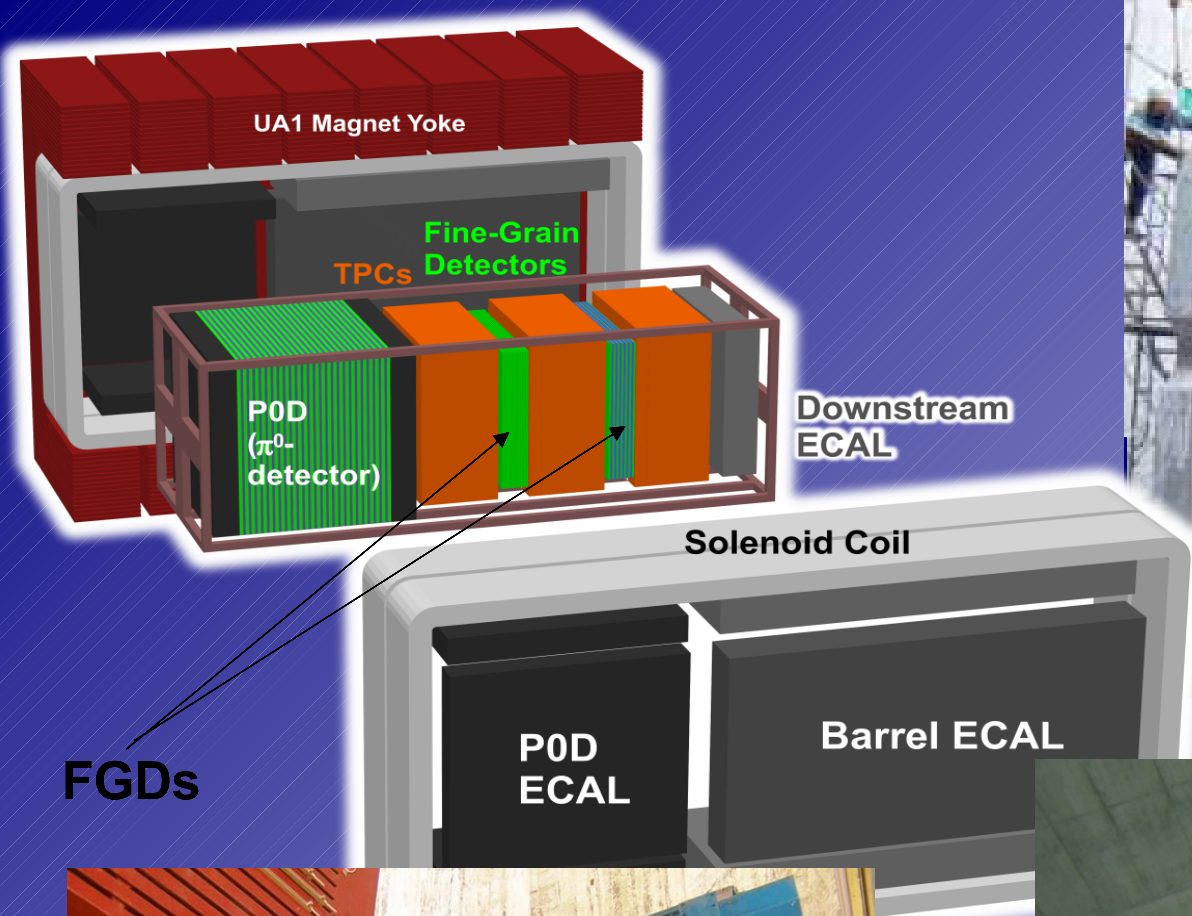
FGD energy deposit vs layer

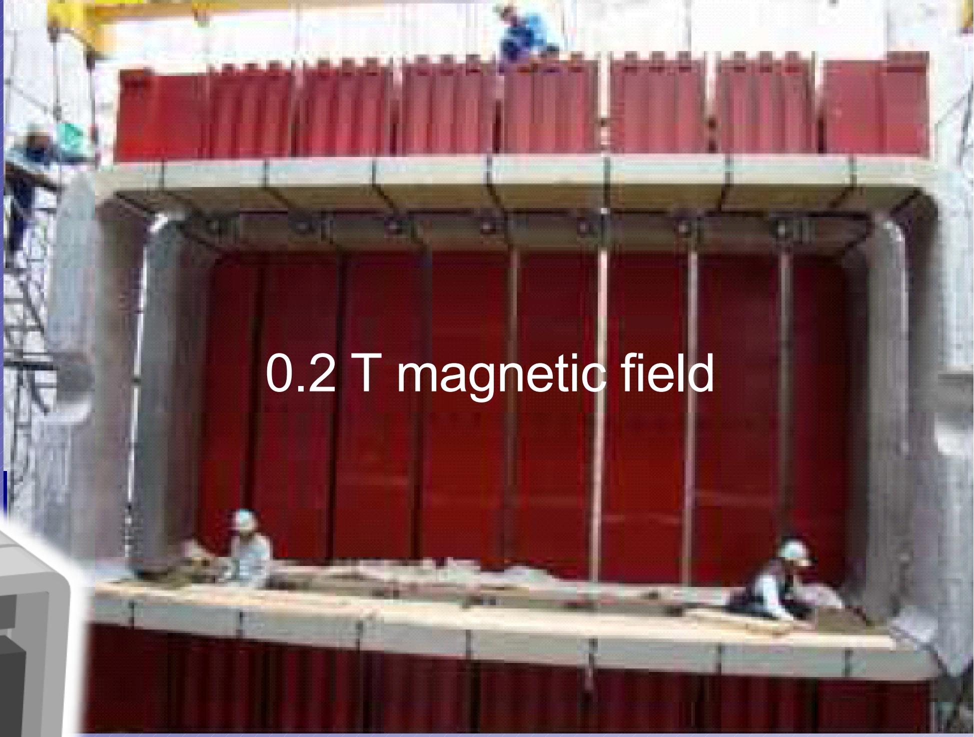
TPC spacial resolution

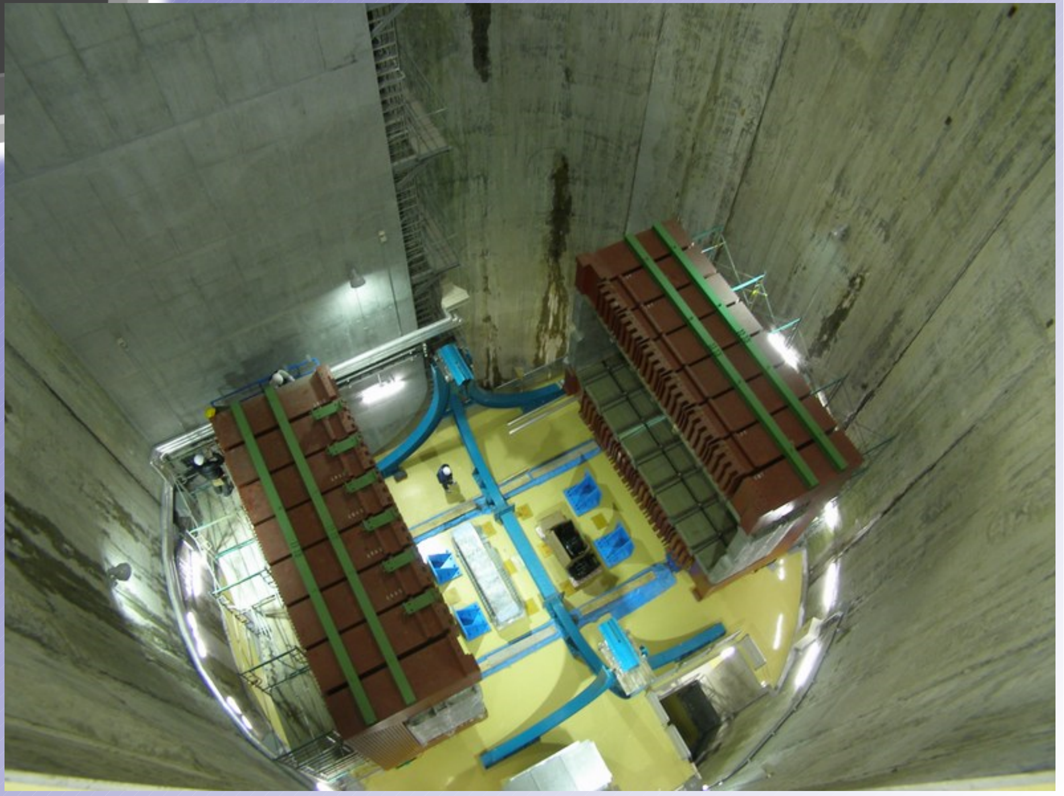
Cluster width:
320um (15cm drift length)
650um (75cm drift length)

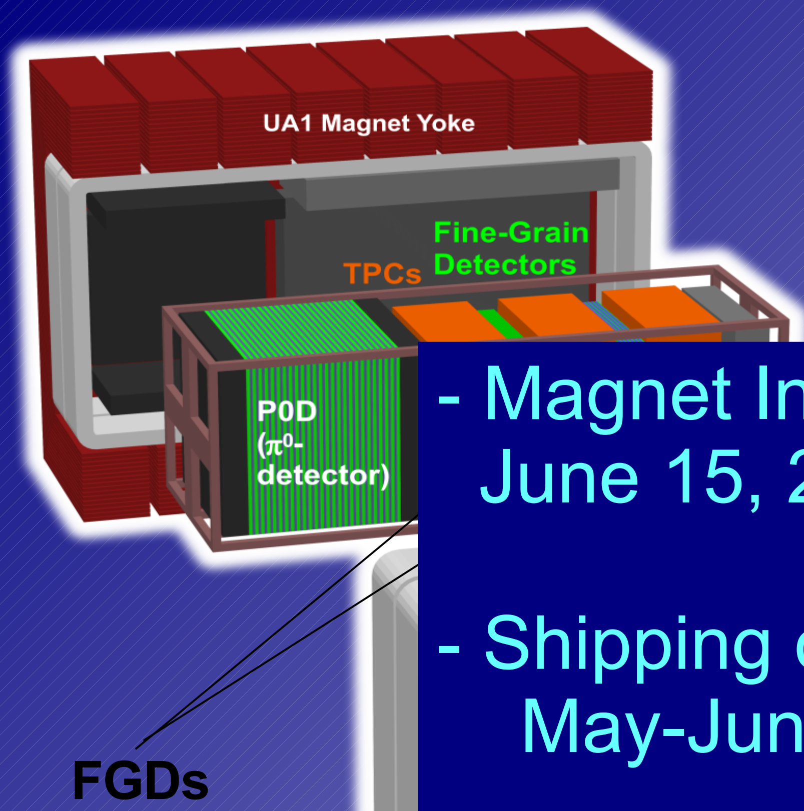


Consistent with expectation, satisfy requireements


UA1 Magnet Yoke
Fine-Grain Detectors
TPCs
P0D
(π^0-
detector)
Downstream ECAL
Solenoid Coil
P0D ECAL
Barrel ECAL
FGDs

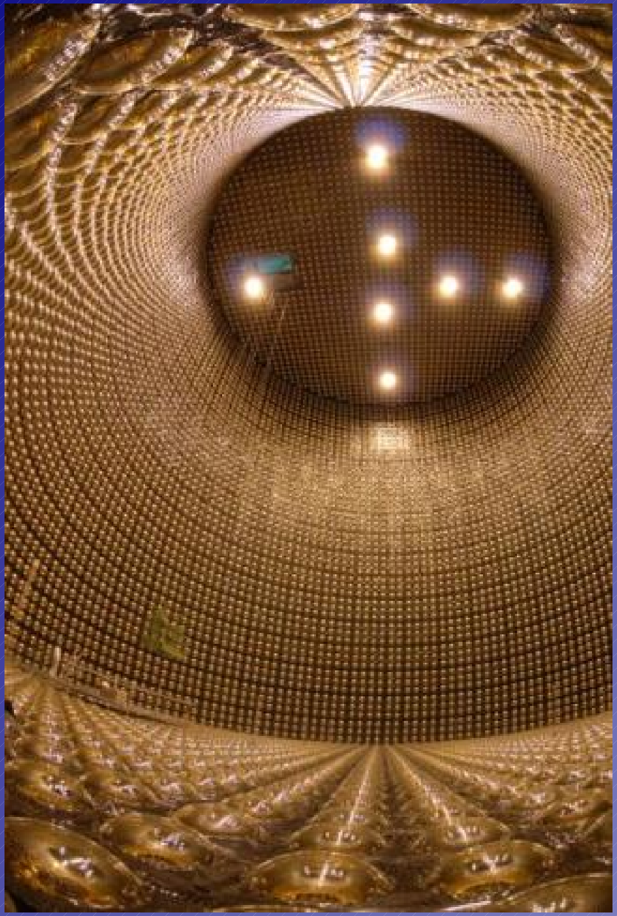

0.2 T magnetic field





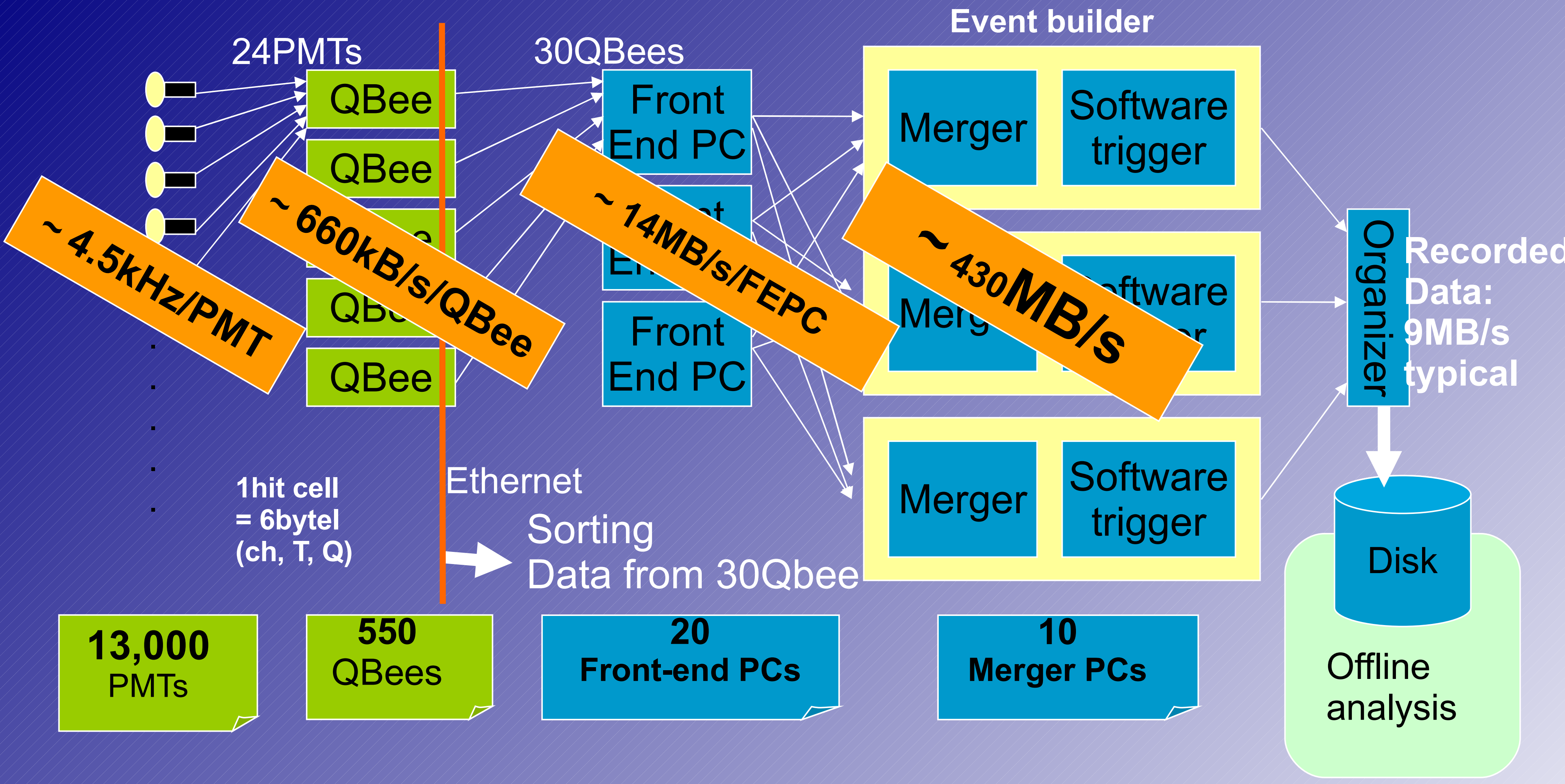
- Magnet Installation Completed June 15, 2008
- Shipping of FGD/TPC to J-PARC May-June, 2009
- Installation of FGD/TPC in Oct.2009
- Commissioning until the end of 2009

Super-K



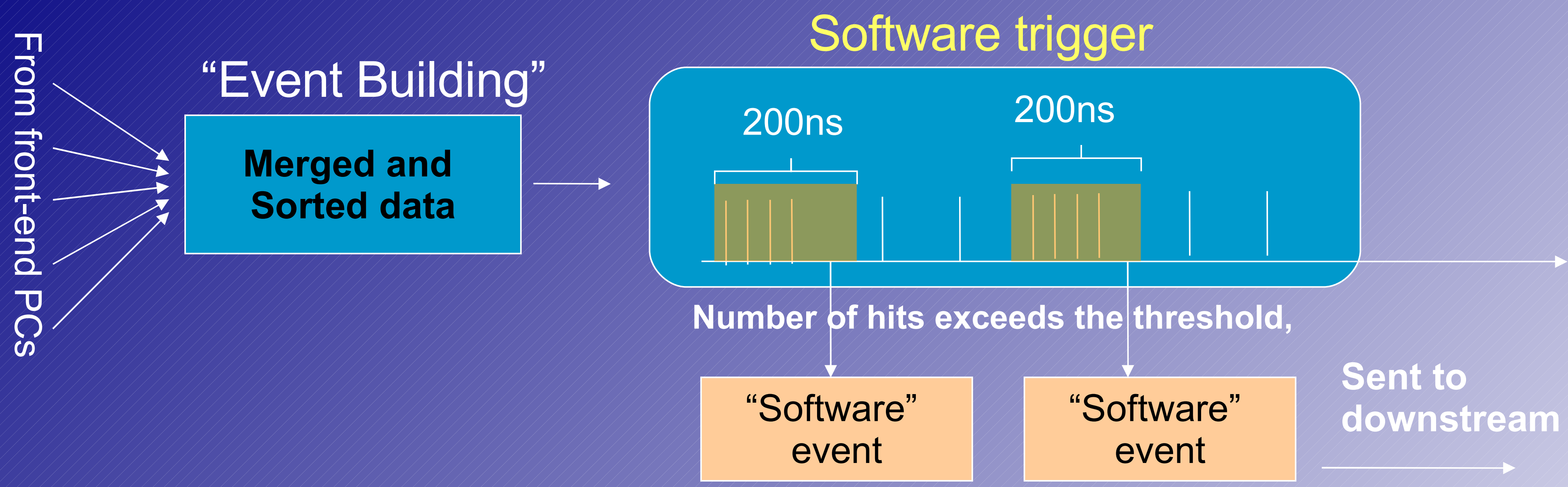
New electronics installed last summer
Ready for commissioning

SK New DAQ system : triggerles DAQ



- Full TCP/IP based data transmission from FE to disk
- "Triggerless" DAQ : No hardware trigger
  * All signal hits from PMT are read.
  * Trigger decision by software after event building.

Software trigger for event building

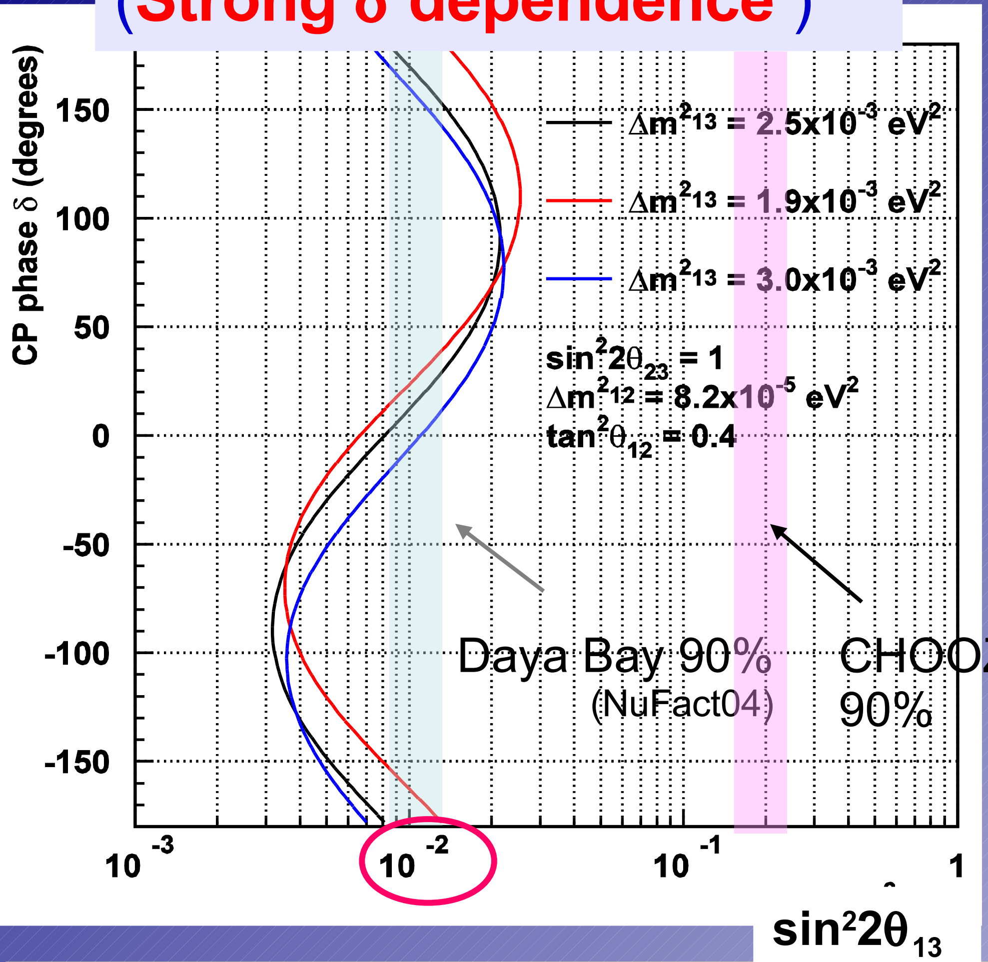


* Sophisticated trigger conditions can be applied
for various event types by varying threshold and gate width
  - Solar neutrino (Low energy trigger)
  - Atmospheric neutrion (Med-High energy trigger)
  - T2K trigger (w/ beam spill info sent from T2K)
  - Calibration trigger (various conditions)

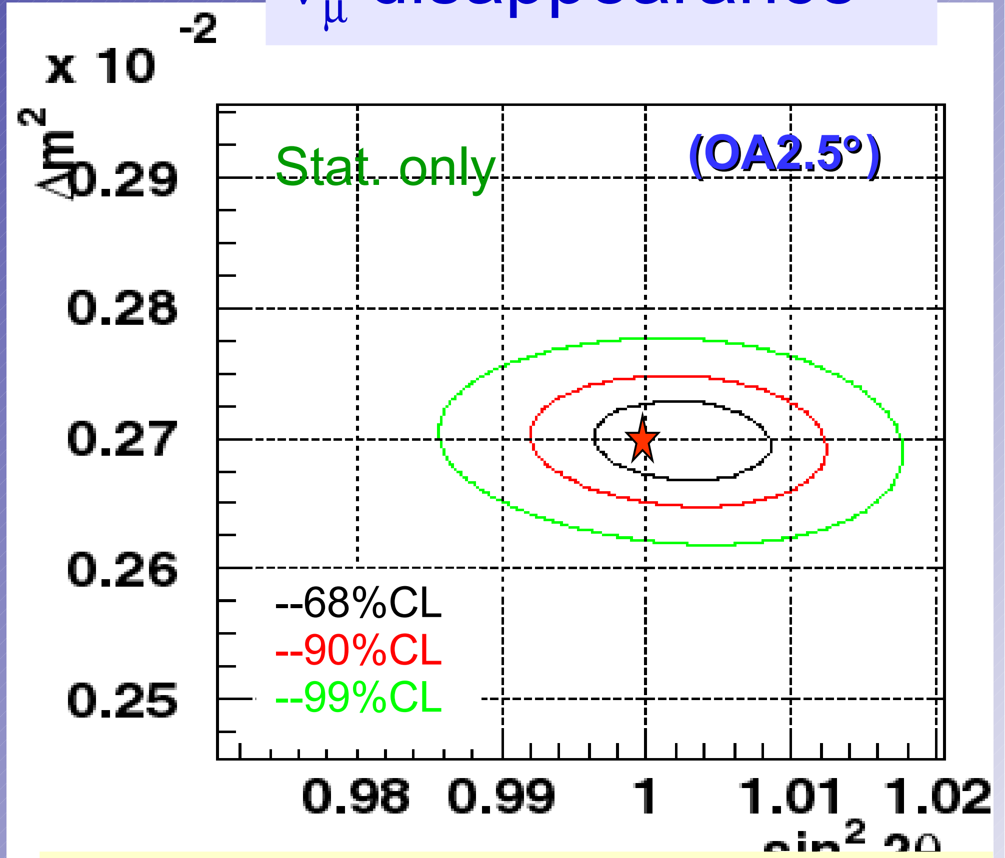
T2K Physics Sensitivity

ν_e appearance

(**Strong δ dependence**)



ν_μ disappearance



>10 times improvement from CHOOZ

δ, Neutrino ↔ Anti-neutrino, Reactor

Goal

$\delta(\sin^2 2\theta_{23})\sim 0.01$

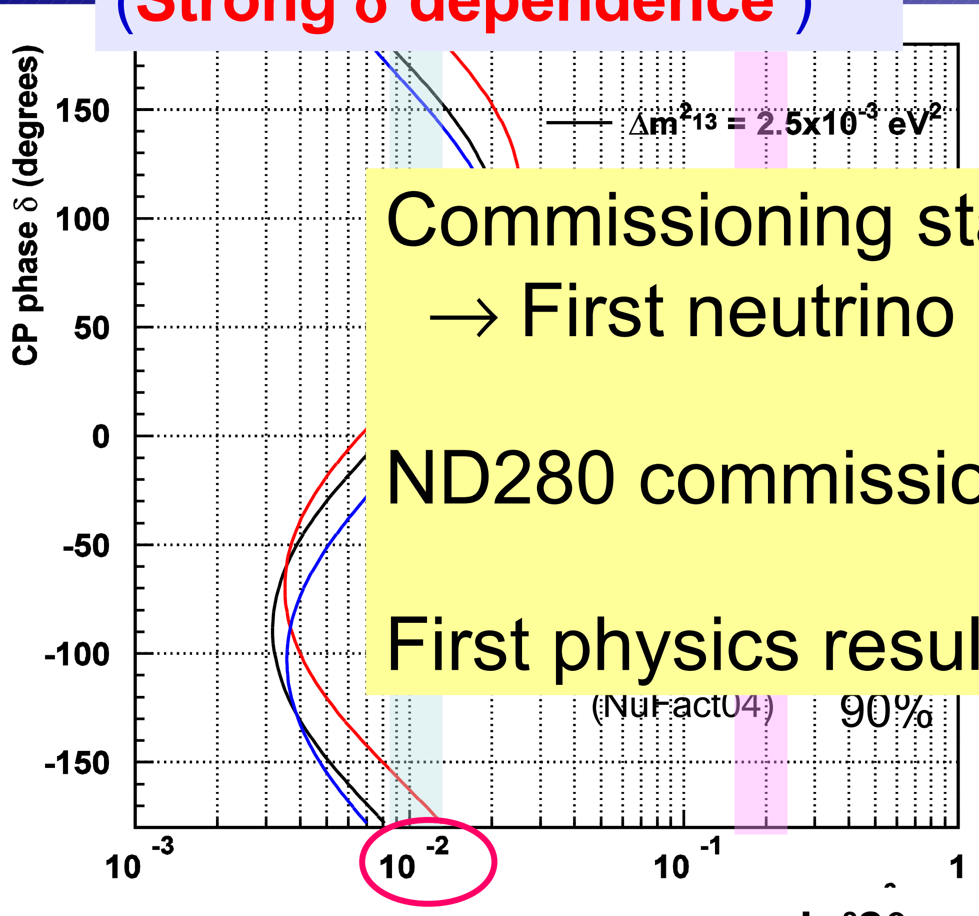
(0.08 MINOS EPS2007)

$\delta(\Delta m_{23}^2)\sim<5\times10^{-5}$ eV^2

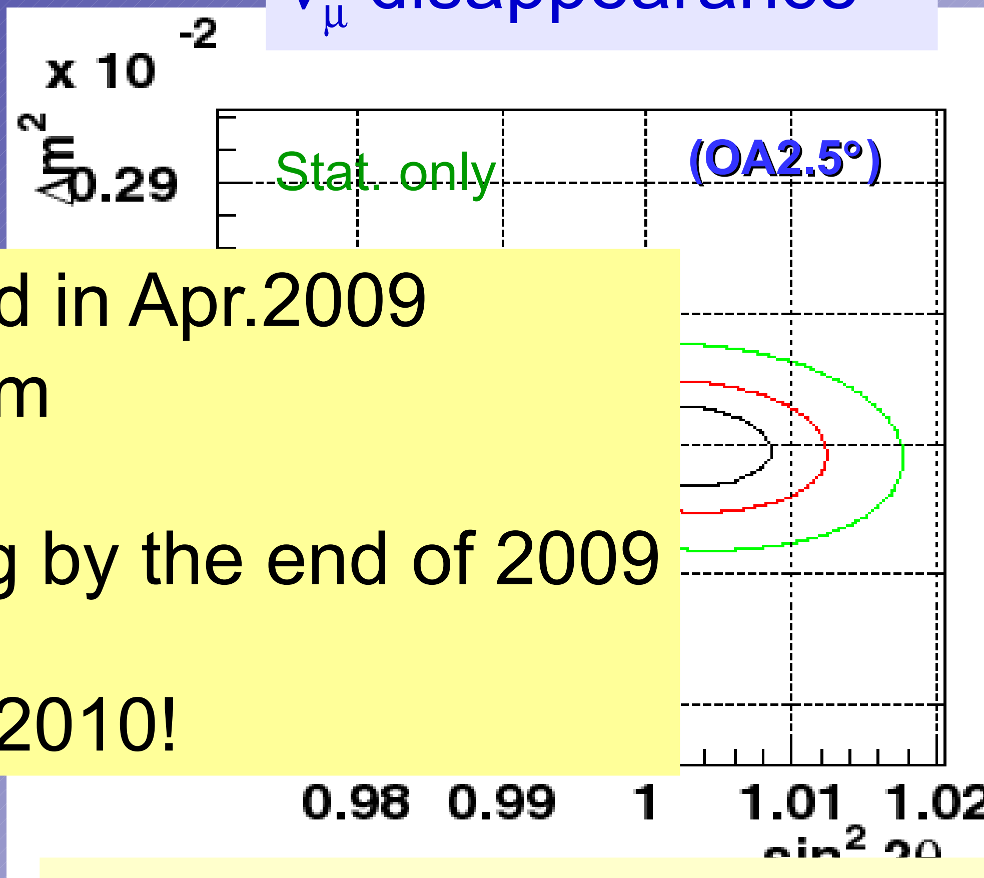
T2K Physics Sensitivity

ν_e appearance

(Strong δ dependence)



ν_μ disappearance



Commissioning started in Apr.2009
→ First neutrino beam

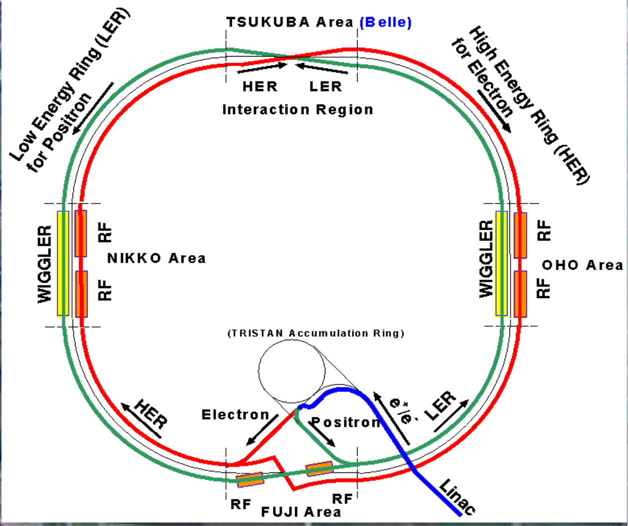
ND280 commissioning by the end of 2009

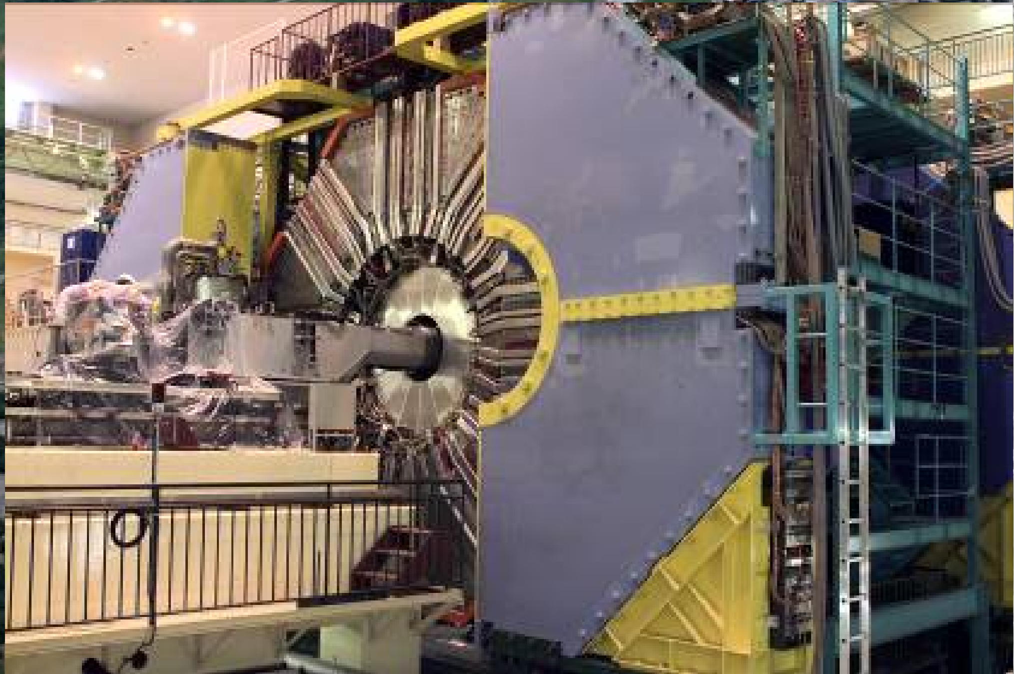
First physics result in 2010!

>10 times improvement from CHOOZ
δ, Neutrino ↔ Anti-neutrino, Reactor

Goal
$\delta(\sin^2 2\theta_{23}) \sim 0.01$
(0.08 MINOS EPS2007)
$\delta(\Delta m_{23}^2) \sim < 5\times10^{-5}$ eV^2

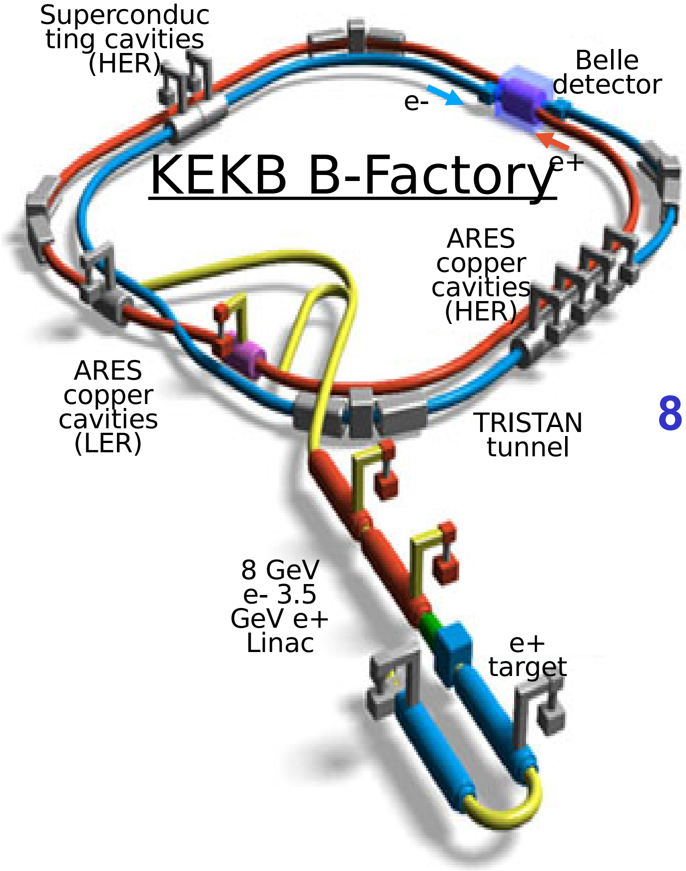
3. KEKB+Belle to SuperKEKB+Belle II



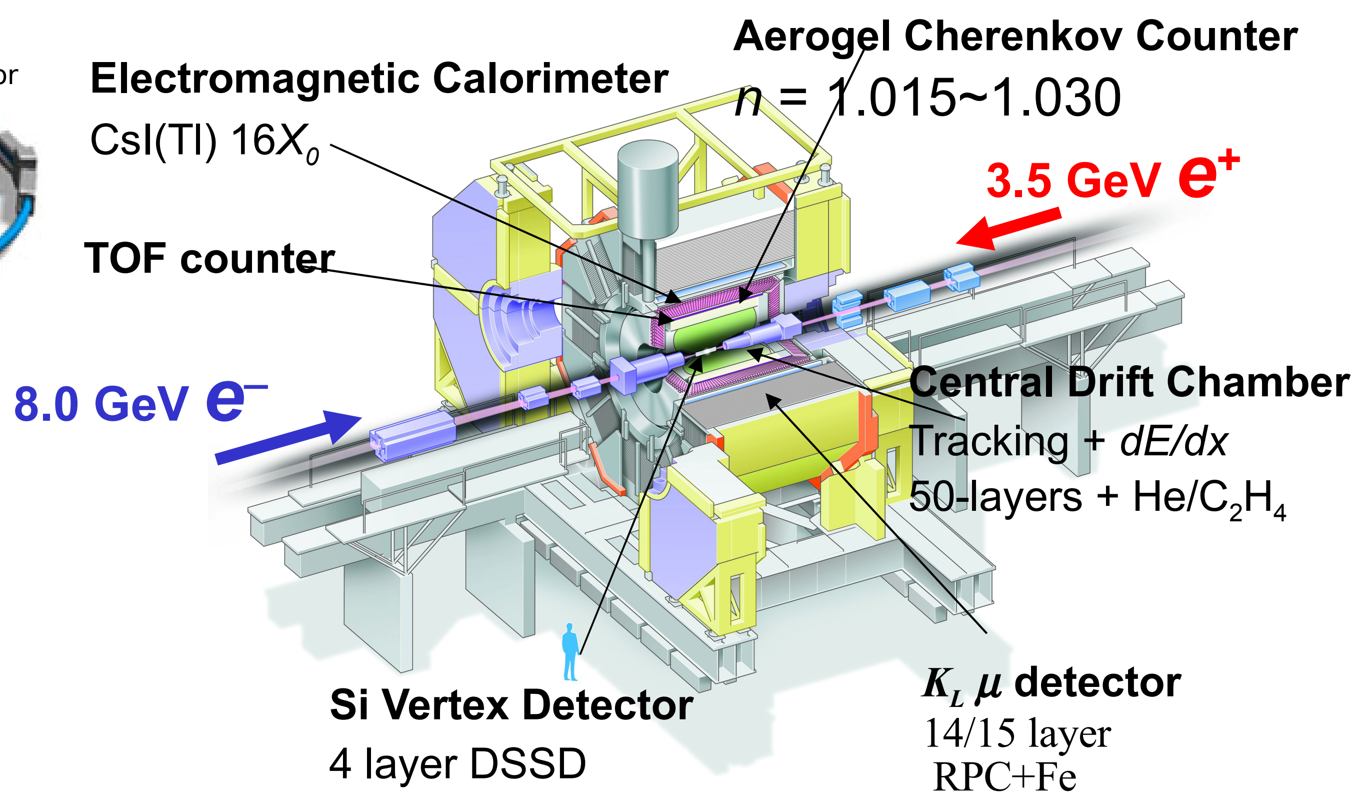


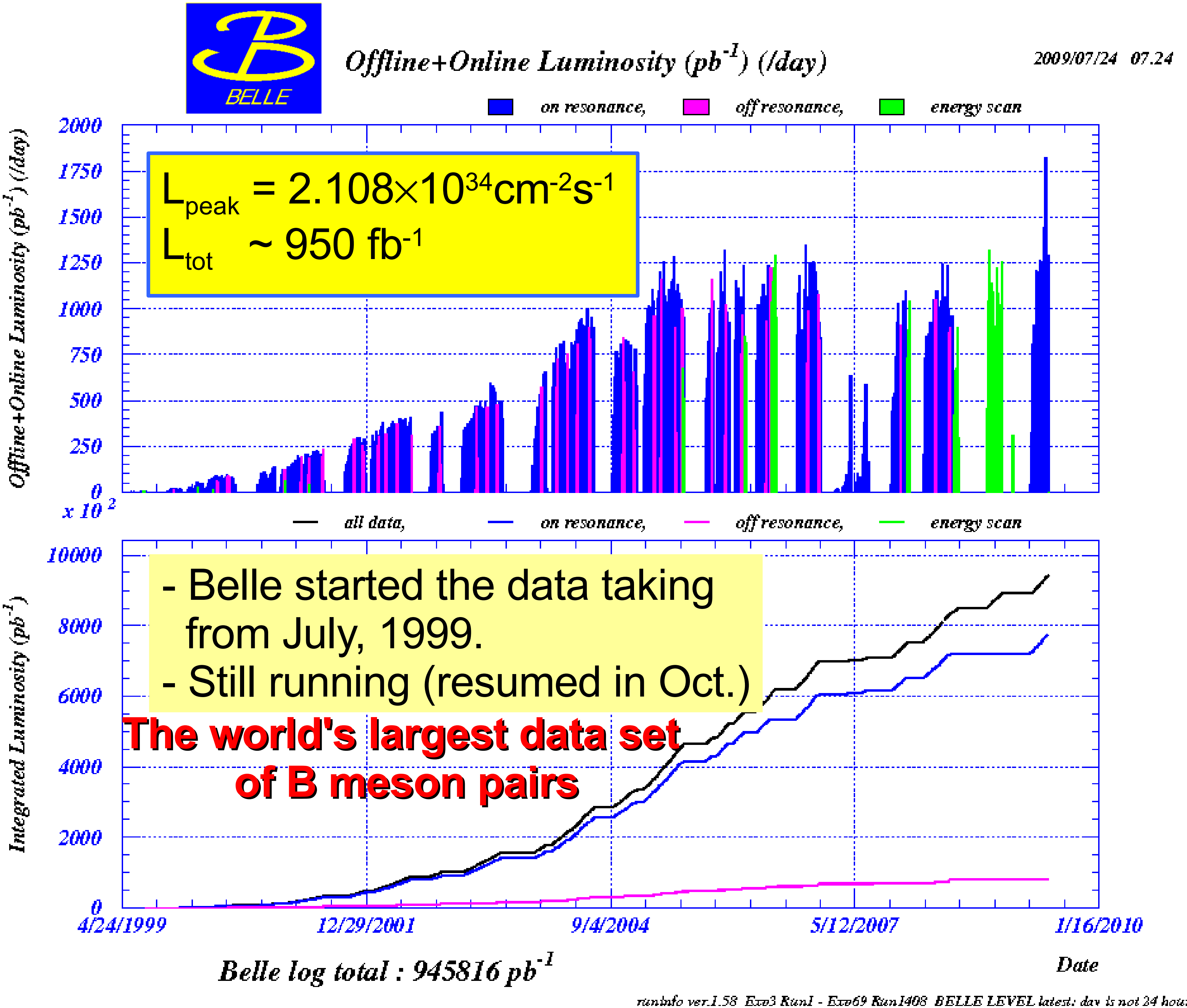
KEKB and Belle

KEKB Accelerator



Belle Detector





L_{peak} = $2.108\times10^{34}cm^{-2}s^{-1}$

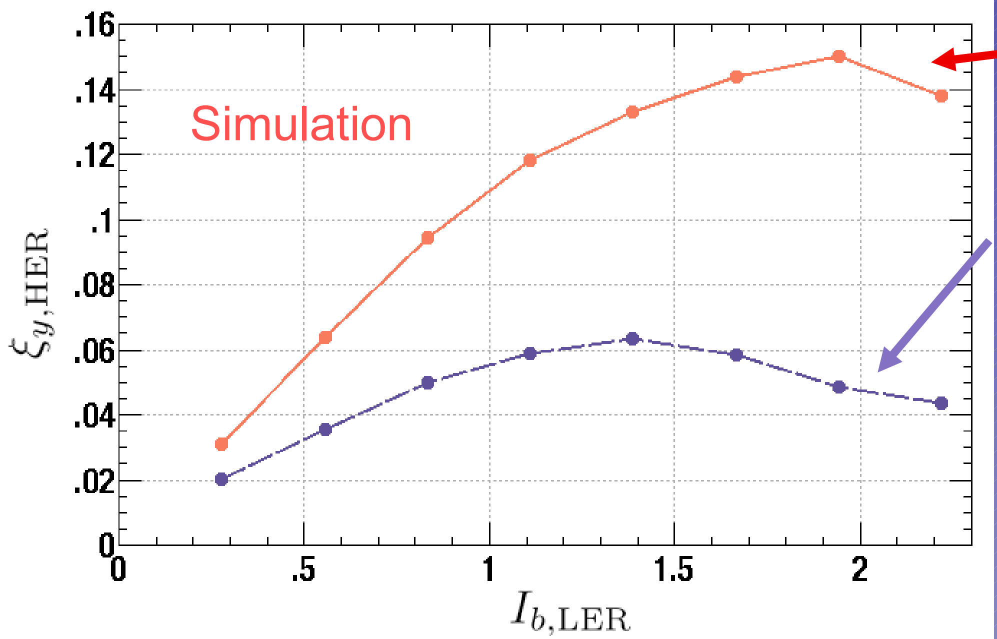
L_{tot} ~ 950 fb^{-1}

- Belle started the data taking from July, 1999.
- Still running (resumed in Oct.)

The world's largest data set of B meson pairs

T

Luminosity improvement by Crab Crossing

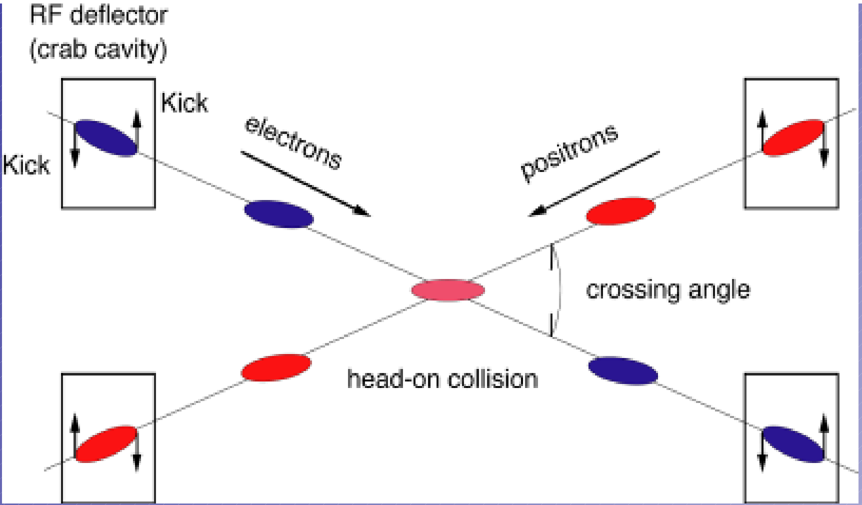


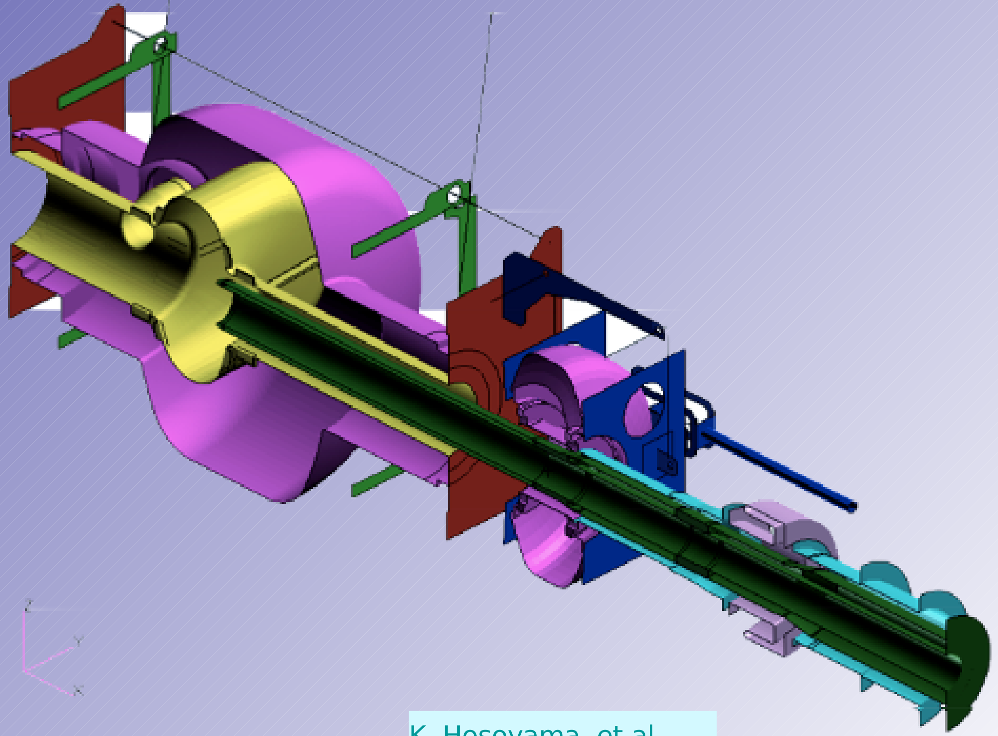
Head-on (crab)

(Strong-strong simulation)

Crossing angle 22 mrad

- Crab cavities were successfully produced and beam study started in Feb. 2007.

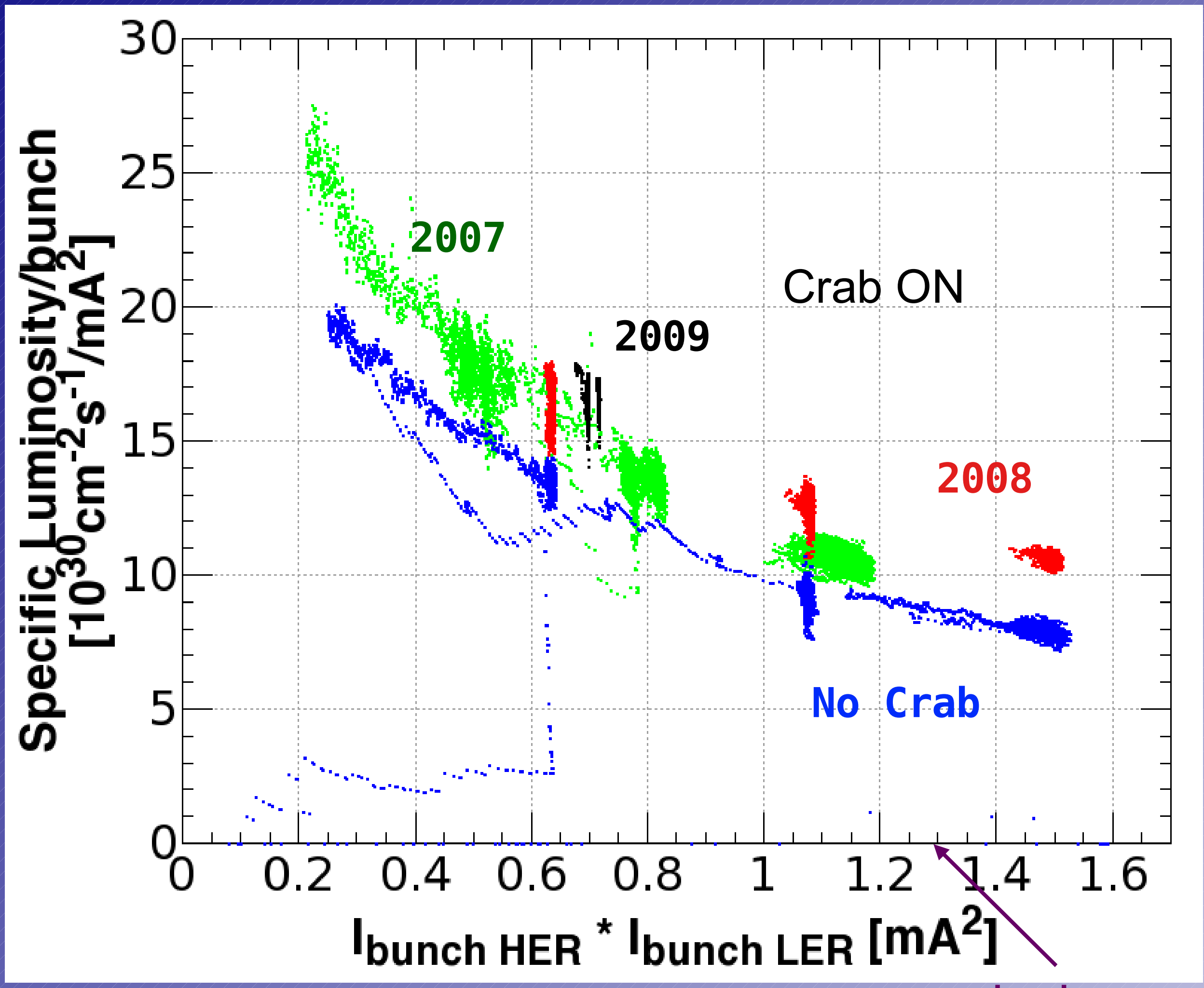




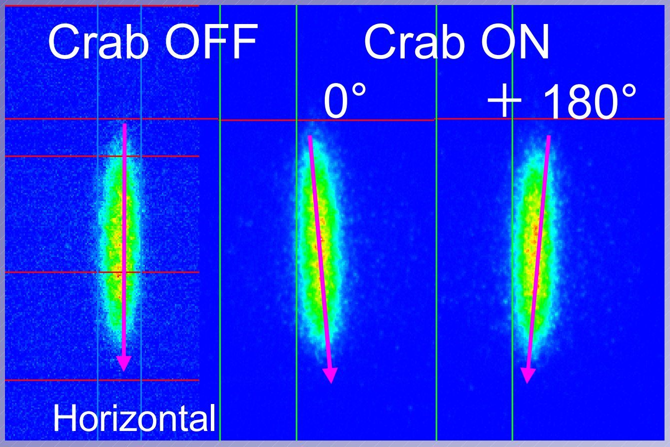
K. Hosoyama, et al

First proposed by R. B. Palmer in 1988 for linear colliders.

Luminosity with Crab Crossing



design



HER(1.43MV)

Crabbing: successful !

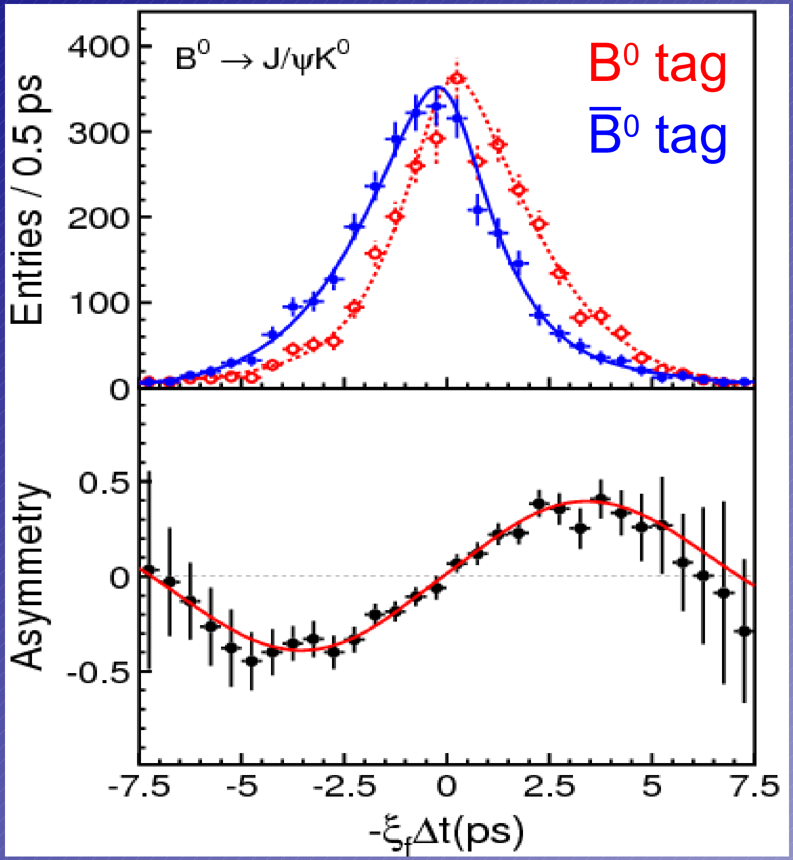
$L = 2.108 \times 10^{34} cm^{-2}s^{-1}$
higher than w/o Crab
(new skew sextupoles)

Specific Lum:
increased ~30%

Still study going on

Physics results from KEKB/Belle

1. Discovery of CP violation in B meson decays



535M BB pairs

$\sin 2\phi_1$ = 0.642 ±0.031 (stat) ±0.017 (syst)
A = 0.018 ±0.021 (stat) ±0.014 (syst)

Physics results from KEKB/Belle

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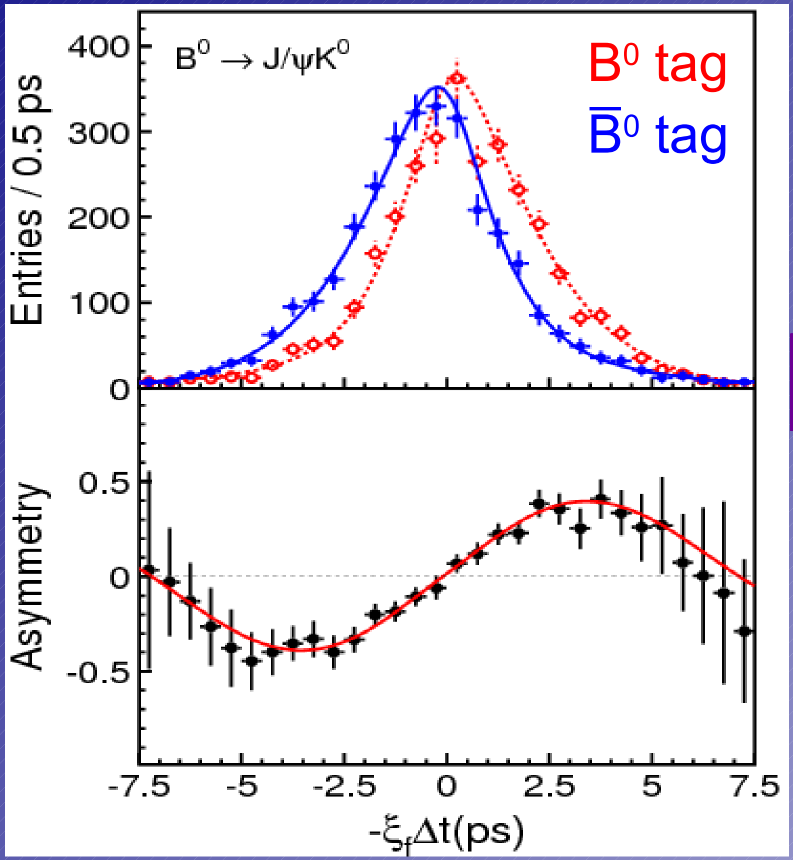

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→ Nobel Prize to Kobayashi and Maskawa

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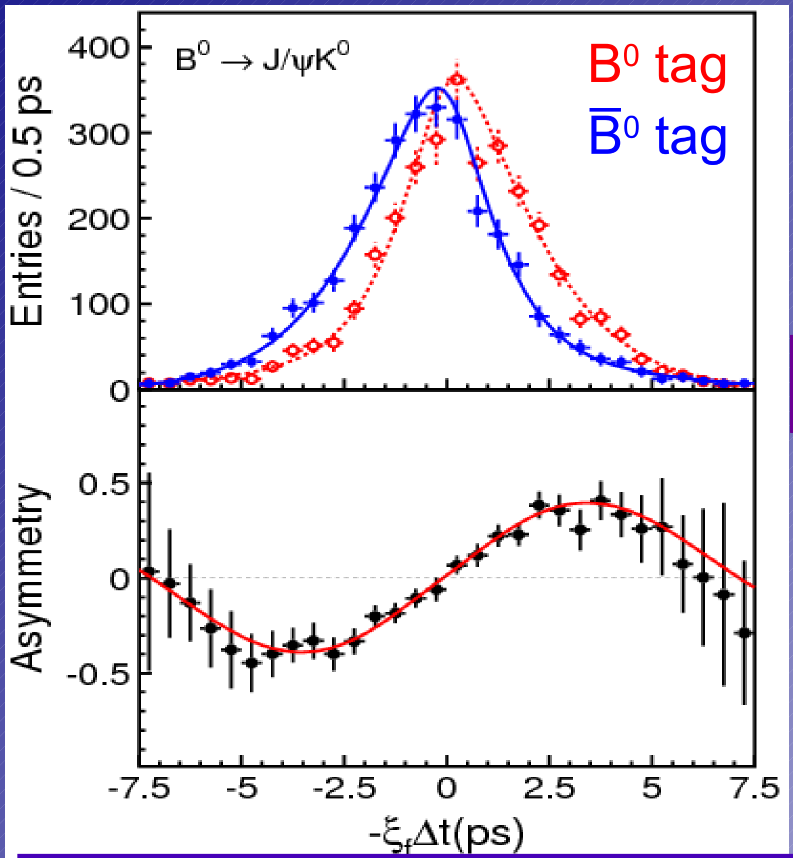

535M BB pairs

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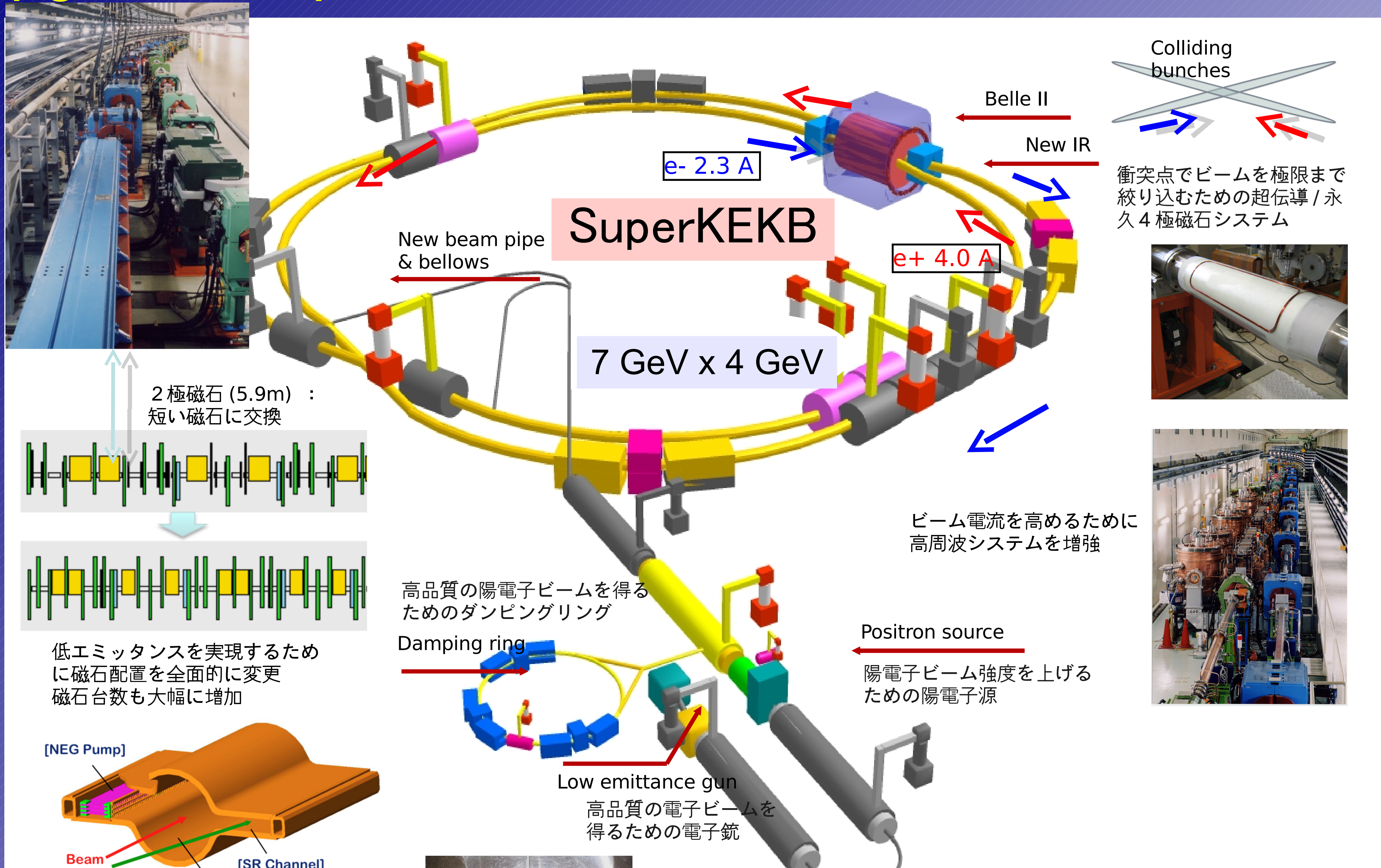
→ Nobel Prize to Kobayashi and Maskawa

2. Discovery of new particles : X(3872), Y(3940), Z(4430)......
→ particles consisting of 4 quarks?
3. Evidence of D^0-D^0bar mixing
.... and much more!

Upgrade: SuperKEKB and Belle II

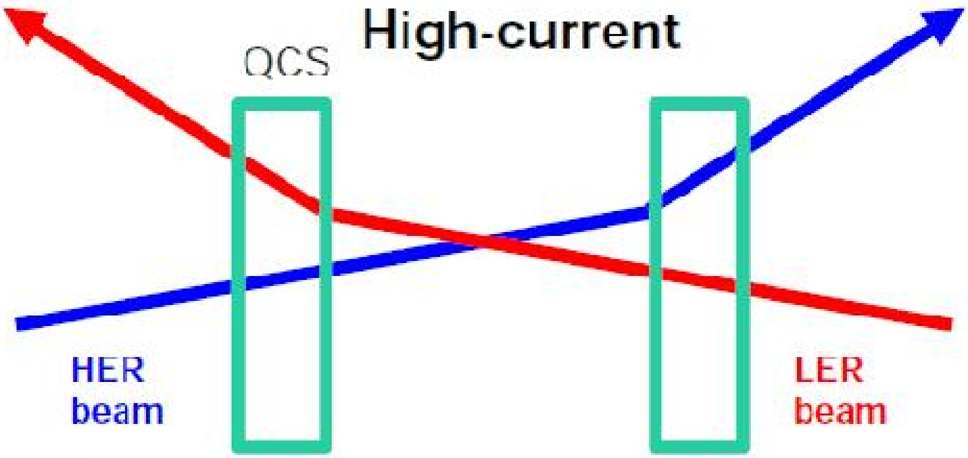


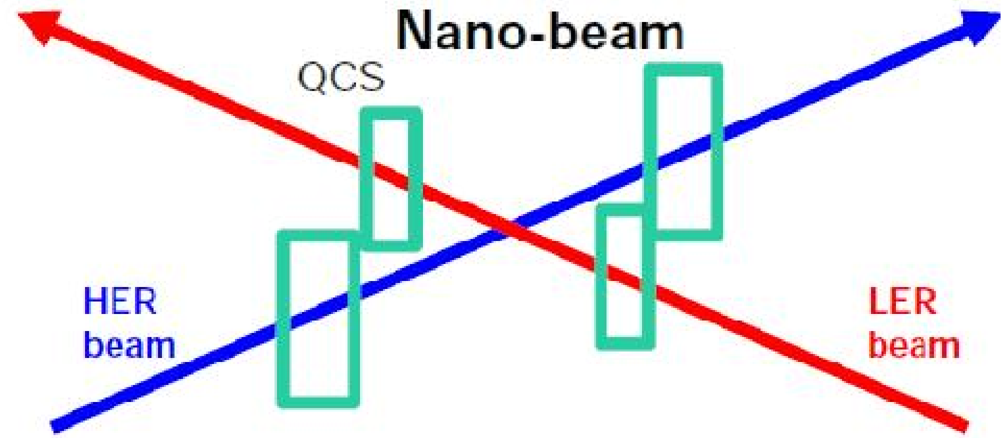
aiming at L ~ 8 x 10^{35} $cm^{-2}s^{-1}$

~ 50 times higher than KEKB!

Two machine options

	High current option (LER/HER)	Nano-beam option (LER/HER)
Beam current I (A)	**High current** : 9.4/4.1	~3/~2
Bunch length σ_z (mm)	**Short bunch length** : 5/3	6/6
Emittance ε_x (nm)	24/18	Low emittance : 1/1
β_y (nm)	3/6	Small β : 0.22/0.22
Beam size σ_y	0.85/0.73 (μm)	Small beam size : 34/44 (nm)
Final Q-magnet layout	- Common QCS for 2 beams - location 40cm (L) / 65cm (R) Little space in L side	Two separate Q-magnets for each 2 beams **Little space in both L/R sides**





High-current option ... Higher SR BG / HOM heating
Nano-beam option ... IR assembly is difficult

Two machine options

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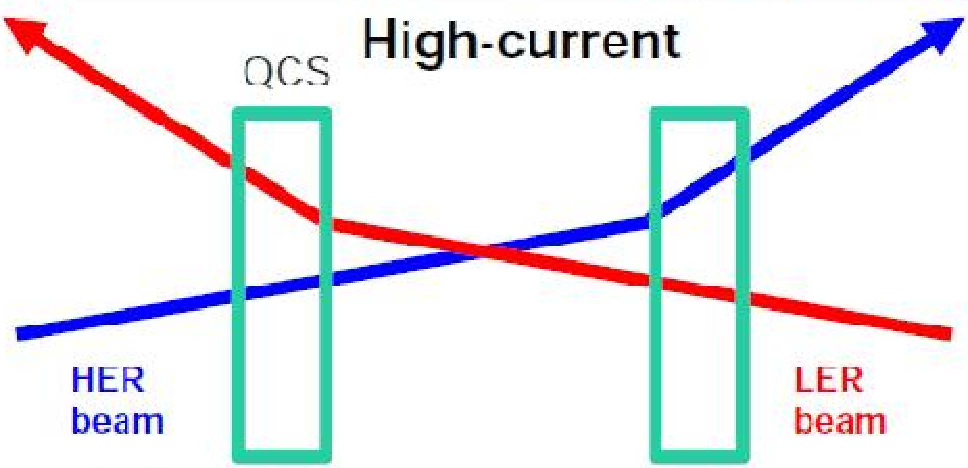
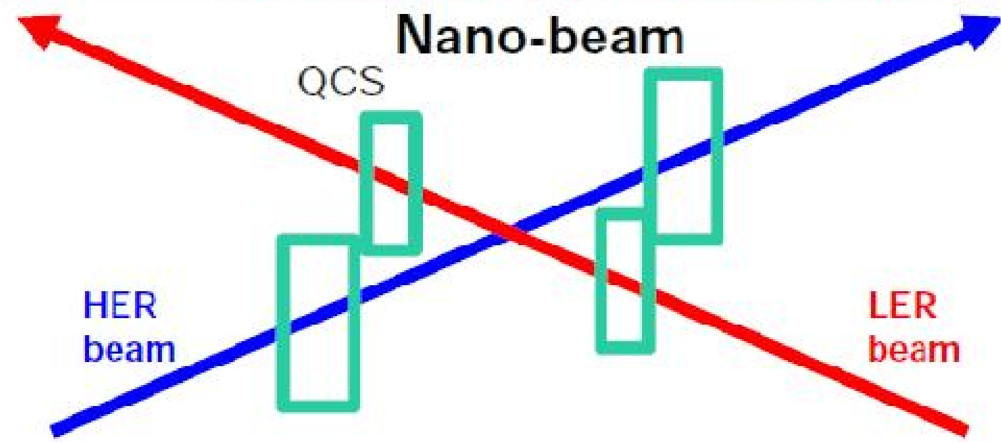
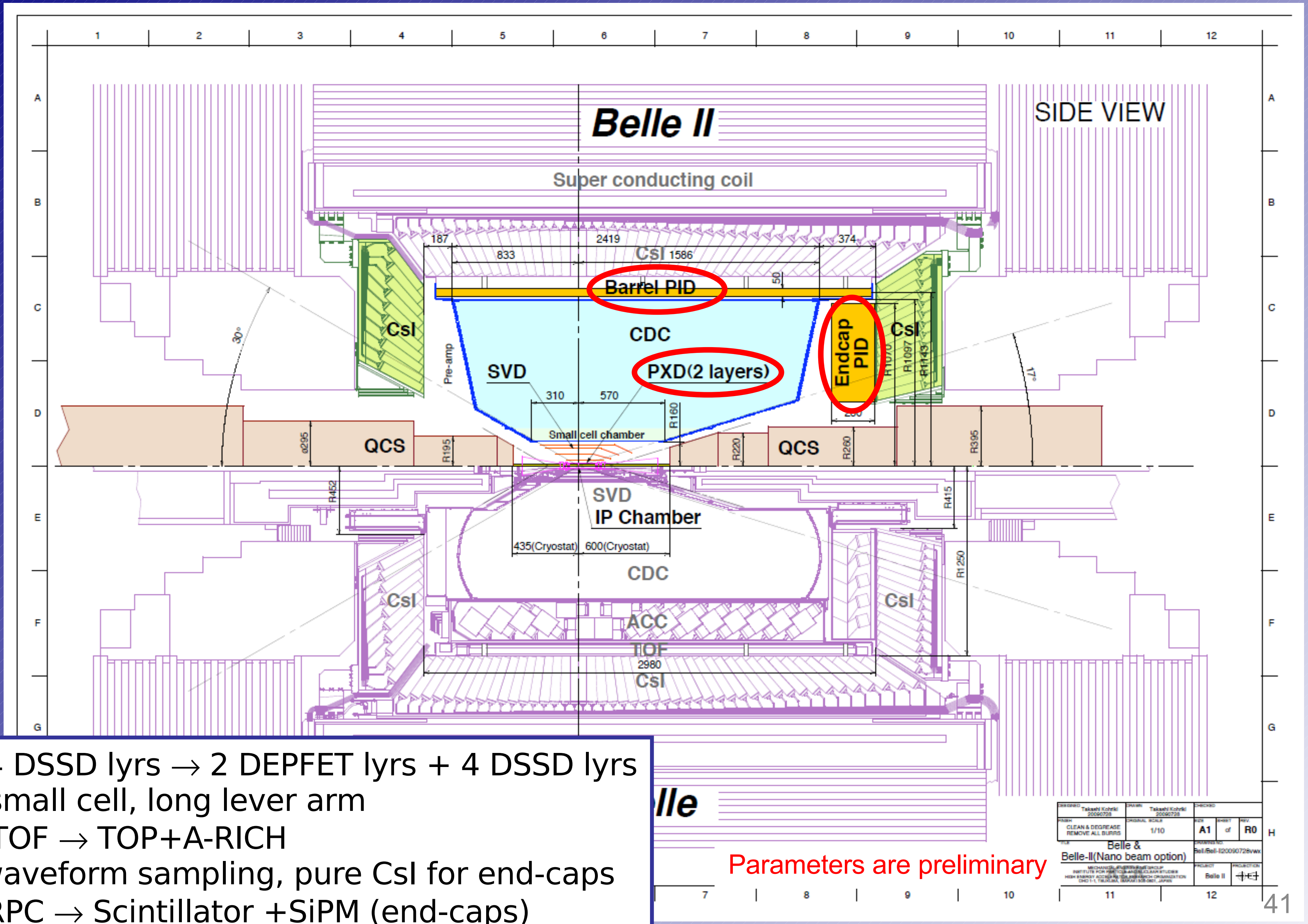




High-current option ... Higher SR BG / HOM heating
Nano-beam option ... IR assembly is difficult

Belle II in comparison with Belle



SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

Vertex Detector: Pixel + SVD

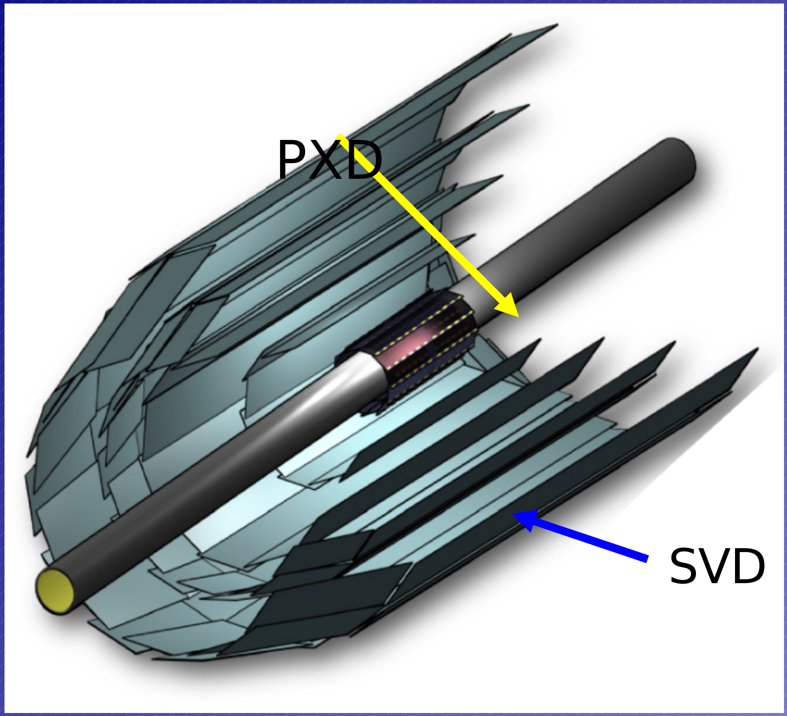
Nano beam option: 1 cm radius of beam pipe

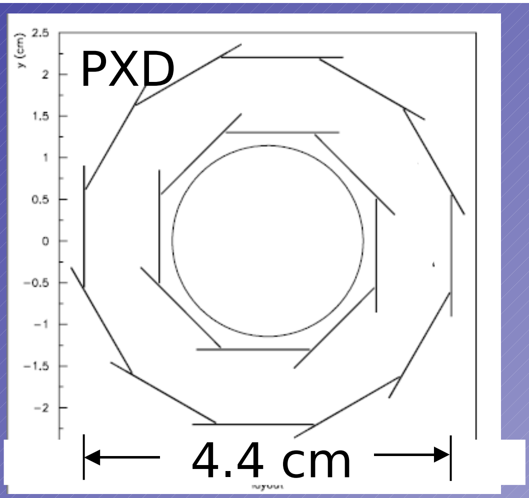
Pixel(PXD)

2 layer Si pixel detector (DEPFET technology)
(R = 1.3, 2.2 cm) monolithic sensor
thickness 50 μm (!), pixel size ~50 x 50 μm²

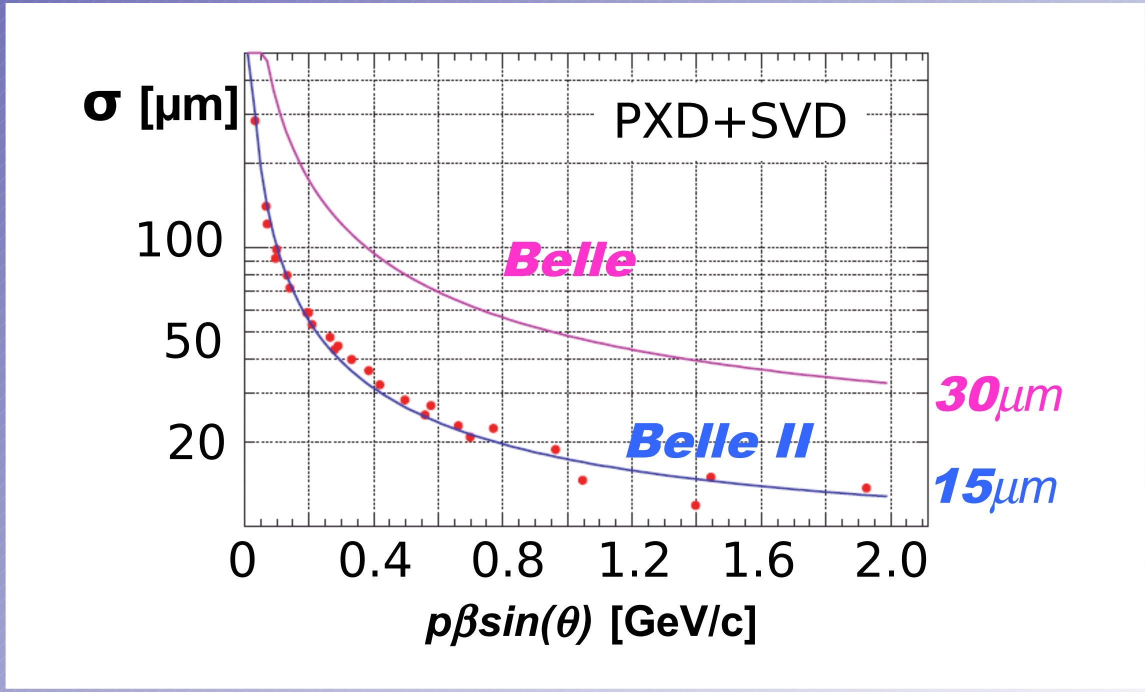
4 layer Si strip detector (DSSD)
(R = 3.8, 8.0, 11.5, 14.0 cm)

SVD

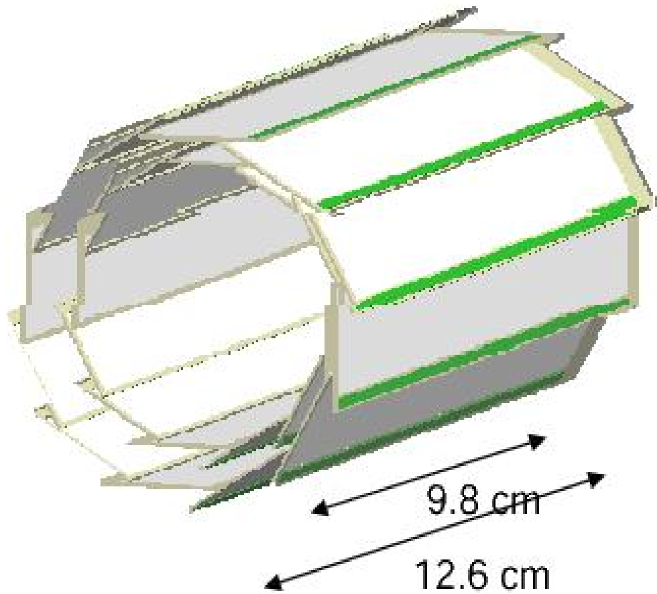




Significant improvement in z-vertex resolution



DEPFET Pixel Detector @ Belle-II

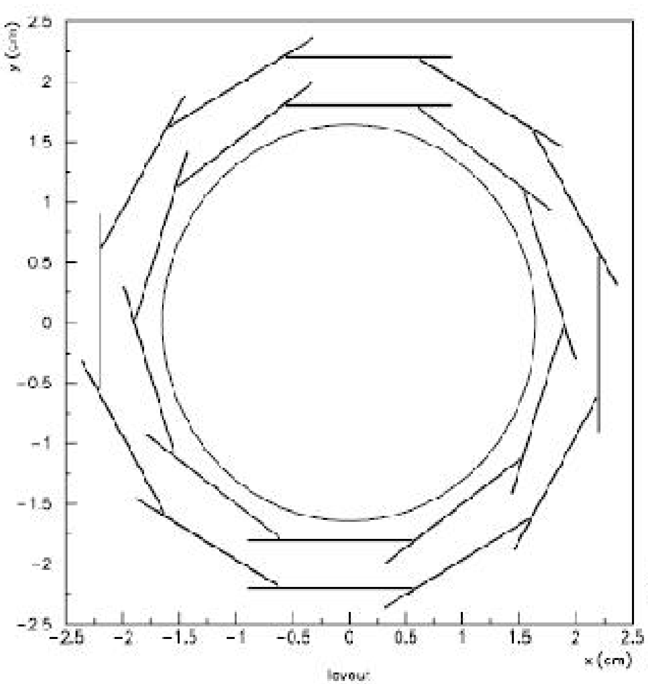


* Originally planned to be used in ILD

Small, thin (50µm) Detector:
2 layers, 20 modules (in total)

Beam pipe radius (presently):
1.0 cm in the nanobeam option (NB)

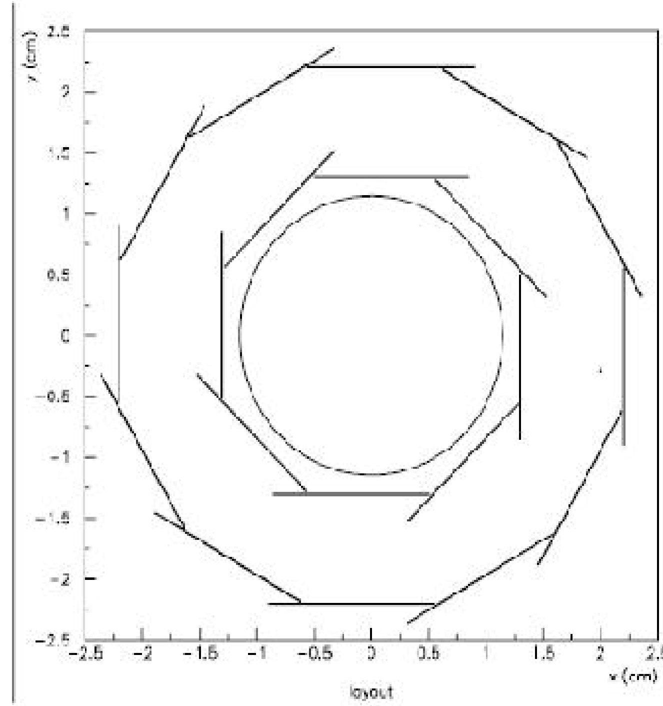
Radii still subject to optimisation:



Likely scenario now:

Layer 1 at 1.3 cm
Layer 2 at 2.2 cm

HC → NB
(high current)

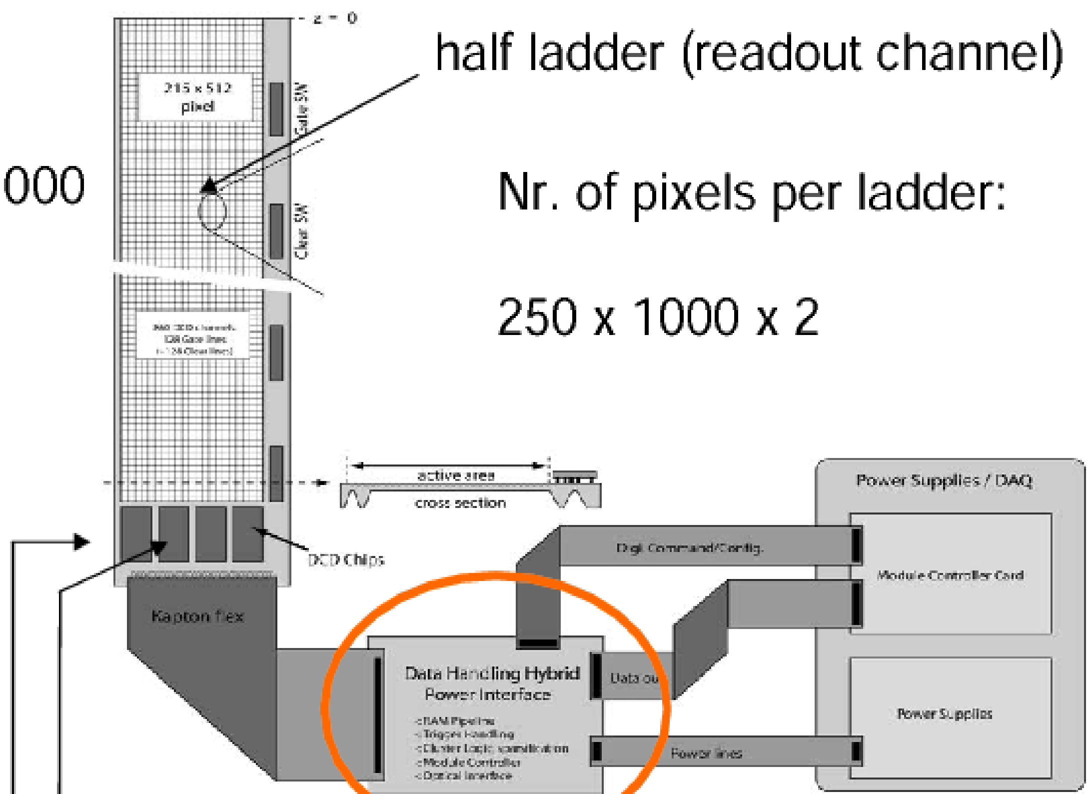


Overview of PXD DAQ Chain

Update: Nano beam option

250

1000



half ladder (readout channel)

Nr. of pixels per ladder:

250 x 1000 x 2

DHP:
zero-suppression
readout buffers (10 MByte)
slow control …

DHH: module controller
data link

Digitzation (DCD)

- 40 half ladders:
  10 Million pixels (px)
- 1-2% occupancy (?)
- 200 kpx on at any time

→ 2×10^5 px in each event

- 4 bytes per px (pos + ADC)
- 800 kB/event

Total evt size: ~ 1 MByte

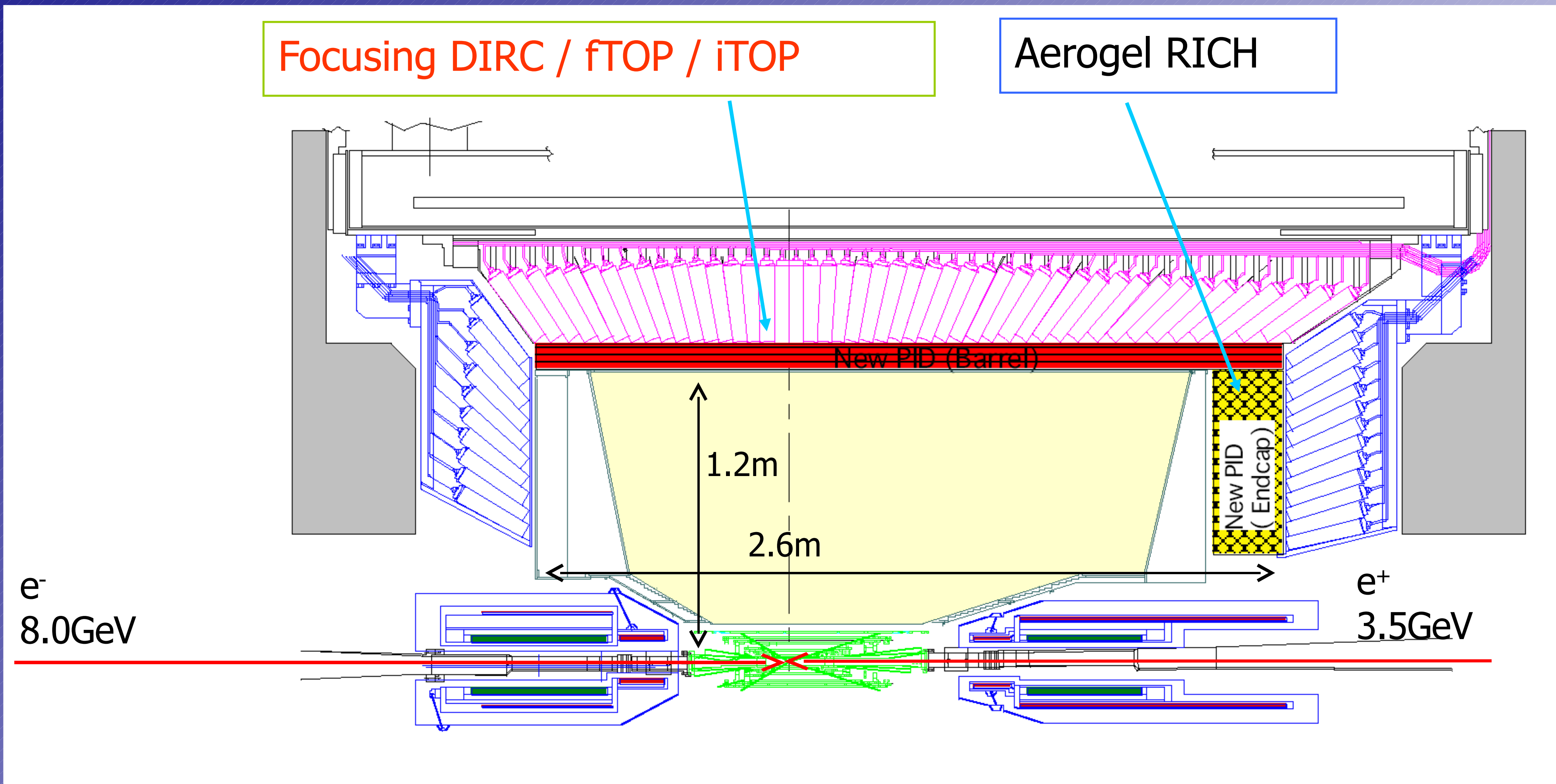
Data Compression (clustering):

→ ½

Particle ID device : upgrade

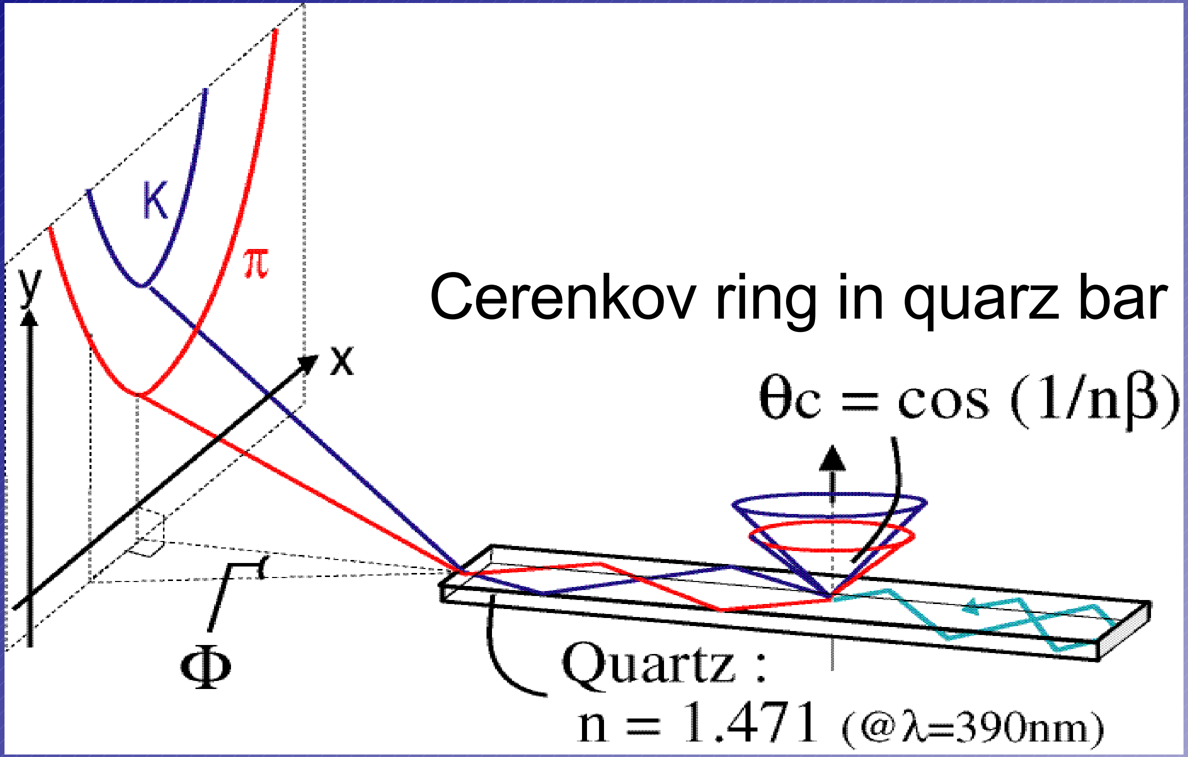
Barrel : 3 candidate = Focusing DIRC, fTOP, iTOP
- Cherenkov ring imaging detectors with quartz
- Locate in the current TOF region

Endcap : Aerogel RICH



Operation principle of Barrel PID device

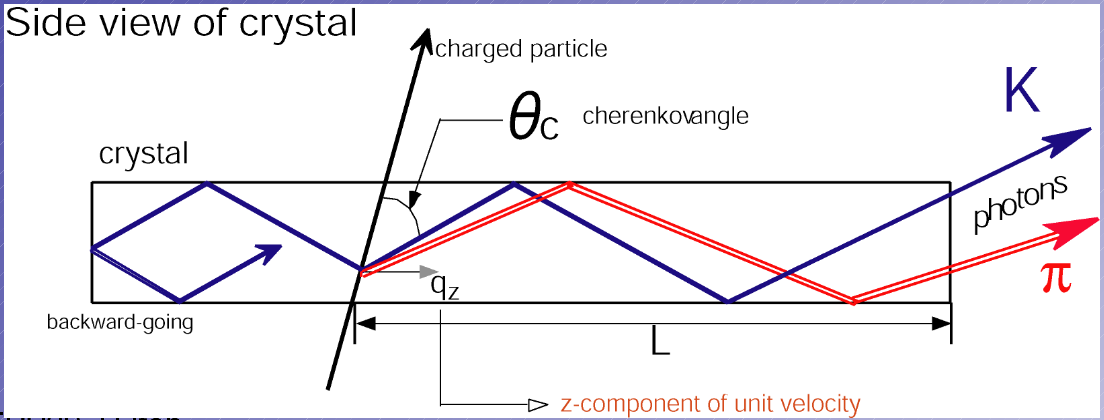
Variant of “DIRC” originally used by BaBar



- Utilize 3D information
  - Arrival position (x,y)
  - Arrival timing (t)

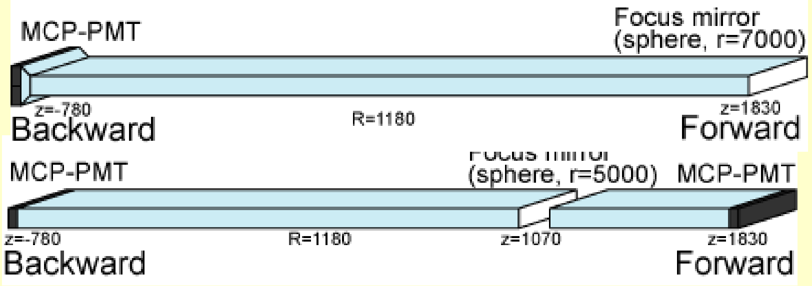
“TOP”

- Difference of propagation time for K/π is ~100ps

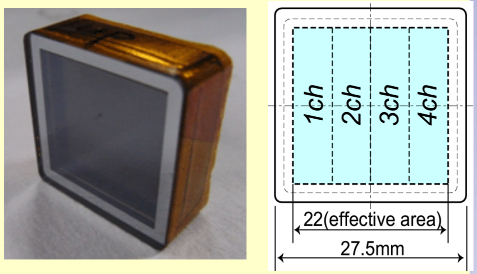


Barrel PID : TOP

- Cherenkov ring imaging detector with precise timing information
  - Quartz radiator
    - 2cm^{T}x~40cm^{W}x~2.5m^L
    - Possible configurations
      - 1-bar or 2-bar
      - Small stand-off box or not

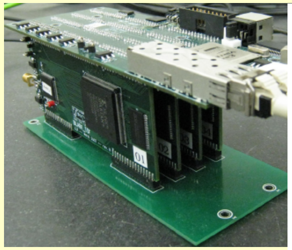


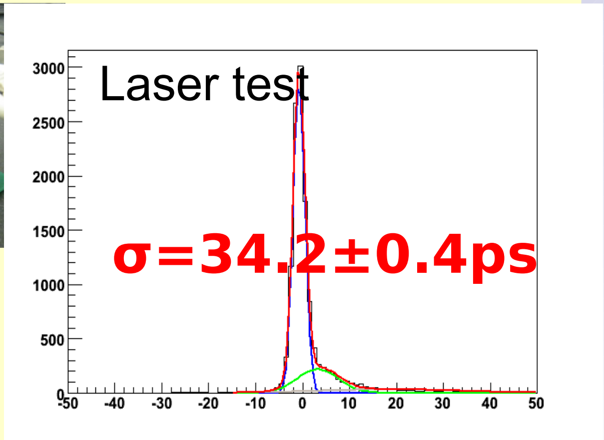
  - MCP-PMT
    - Two candidates
      - Hamamatsu SL10 or Photonis 85015
    - Excellent time resolution (<40ps) required for good K/π separation; confirmed on laser bench



Hamamatsu SL10

  - Electronics
    - Fast waveform sampling
      - New ASIC chip ready soon

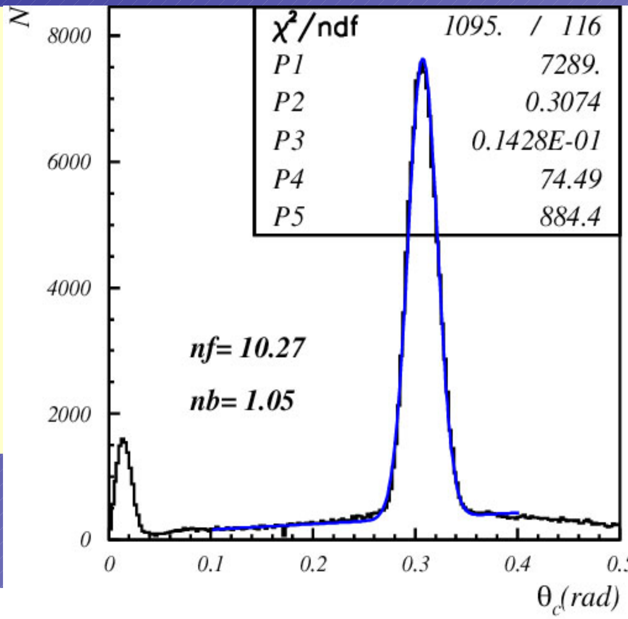


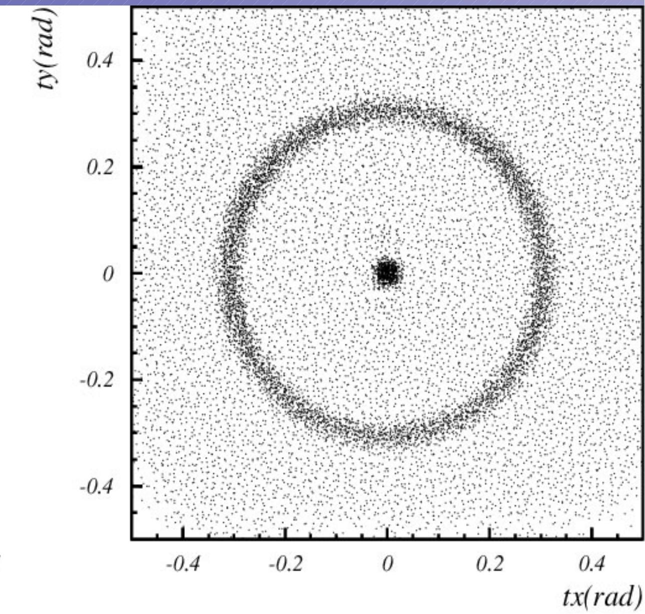


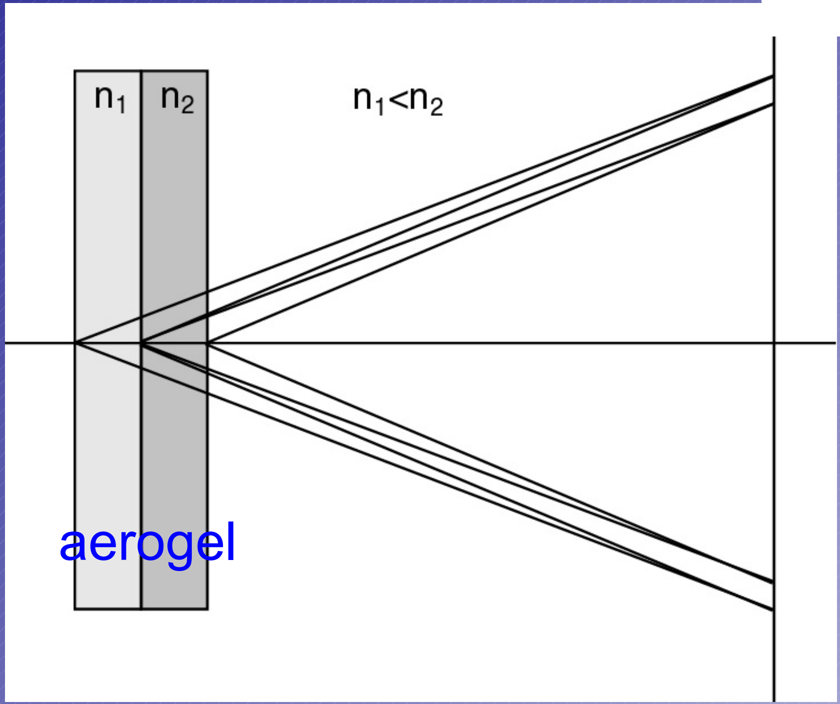
Endcap PID: Aerogel RICH (proximity focusing RICH)

Requirements and constraints:

- ~ 5 σ K/π separation @ 1-4 GeV/c
- operation in magnetic field 1.5T
- limited available space ~250 mm





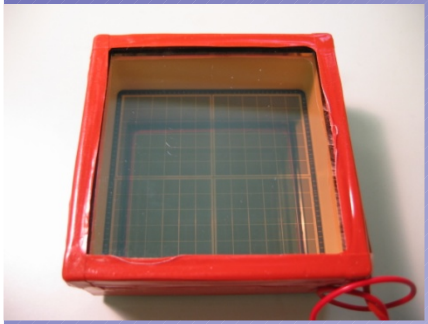


- n = 1.05
- $\theta_c(\pi)$ ~ 308 mrad @ 4 GeV/c
- $\theta_c(\pi)$– $\theta_c(K)$ ~ 23 mrad
- pion threshold 0.44 GeV/c,
- kaon threshold 1.54 GeV/c

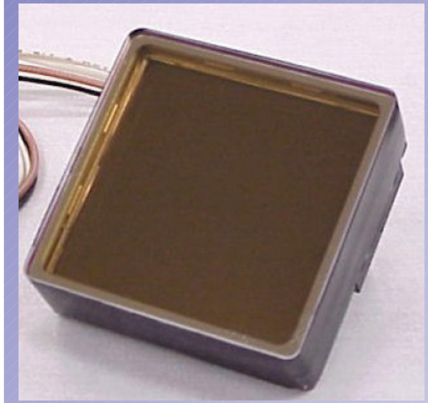
- time-of-flight difference (2m):
  t(K) - t(π)
  = 180 ps @ 2 GeV/c
  = 45 ps @ 4 GeV/c

Photon sensor options

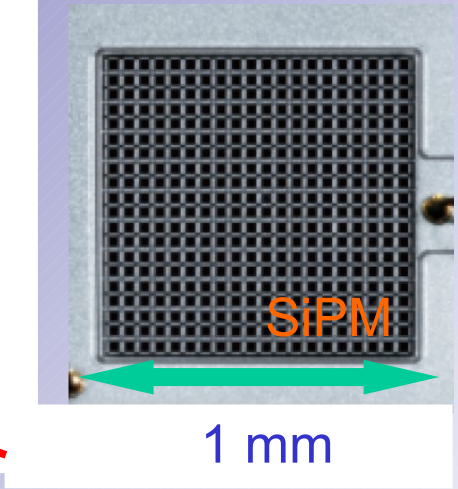
- HAPD
  - Tested on the bench and in the beam
  - Stability, radiation hardness? Need more production R&D



- MCP-PMT
  - Excellent beam and bench performance
  - Good TTS for TOF information
    - ~35ps TOF resolution (low momentum PID)
  - Need lifetime estimation



- ~~SiPM (GAPD)~~
  - ~~Large number of photons, good stability, enough gain and reasonable TTS~~
  - ~~Light guides tested to increase the active area fraction~~
  - ~~Radiation hardness: most probably a show-stopper~~



Requirements to Belle II DAQ

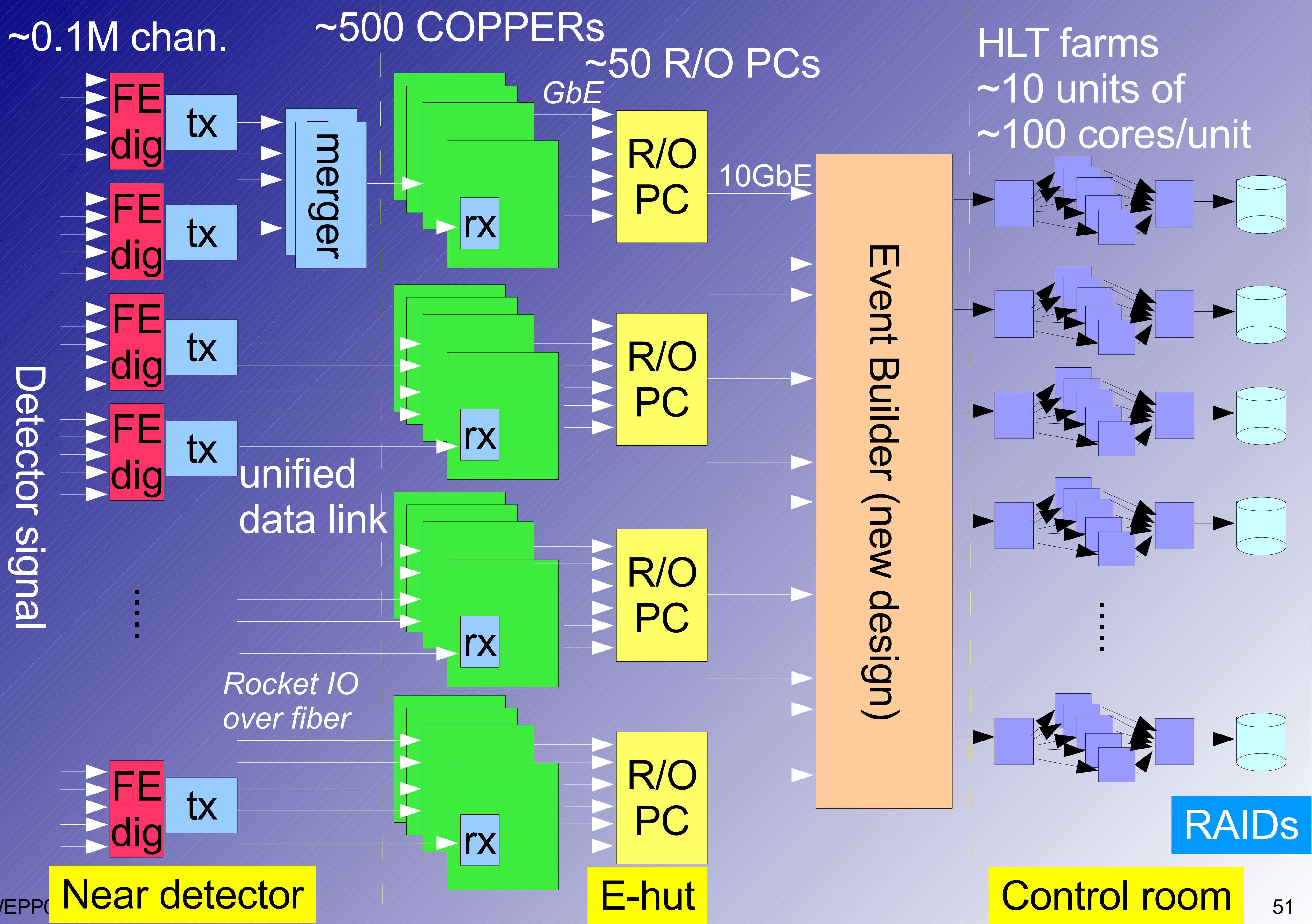
- Keep the same L1 trigger policy as that of Belle

	Current Belle	Upgraded KEKB
Typical L1 rate	0.5kHz	20kHz
(Maximum L1 rate	~1kHz	~40kHz)
L1 data size(in)	40kB/ev	300kB/ev
flow rate(in)	20MB/sec	6GB/sec
reduction	1	1/3
data size(out)	40kB/ev	100kB/ev
flow rate(out)	20MB/sec	2GB/sec
L3+HLT reduction	1/2	~1/10
Storage badwidth	20MB/sec	400MB/sec
	(including	HLT recon. data)

- Event size estimation does NOT include PXD!

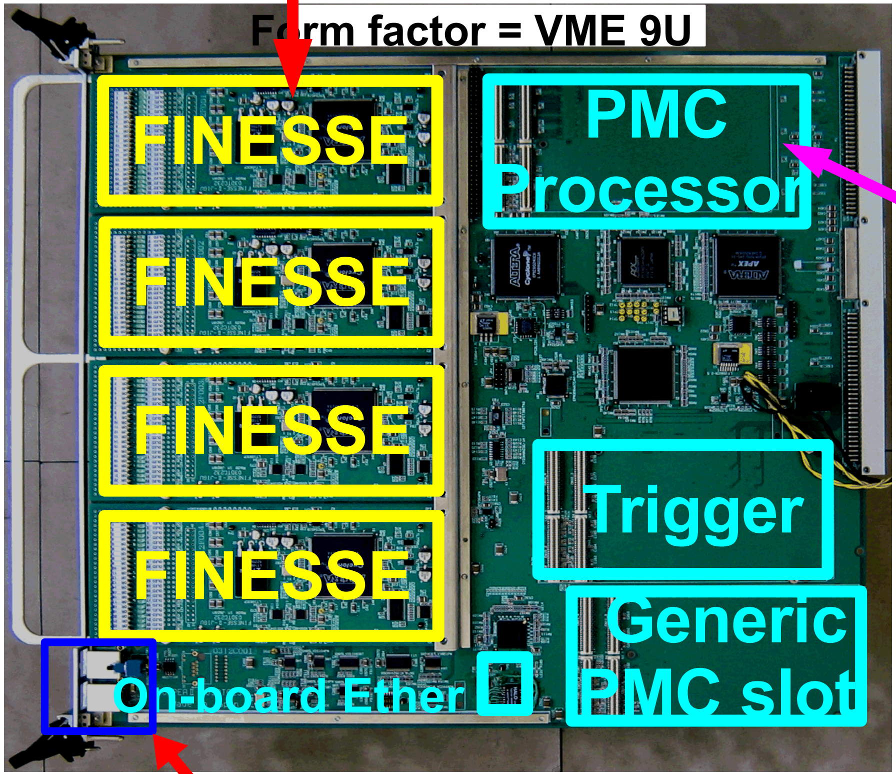
Belle II DAQ Design

* Timing dist. scheme is not included in this figure.



COPPER: Unified Readout Module

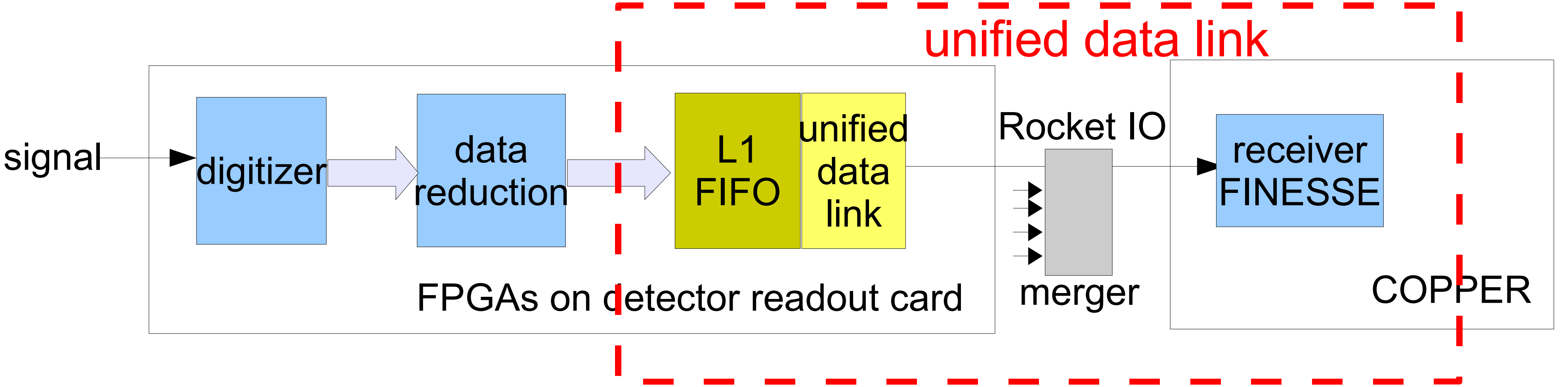
digitizers are mounted as daughter cards



Linux operated

Data transmission thru. TCP/IP

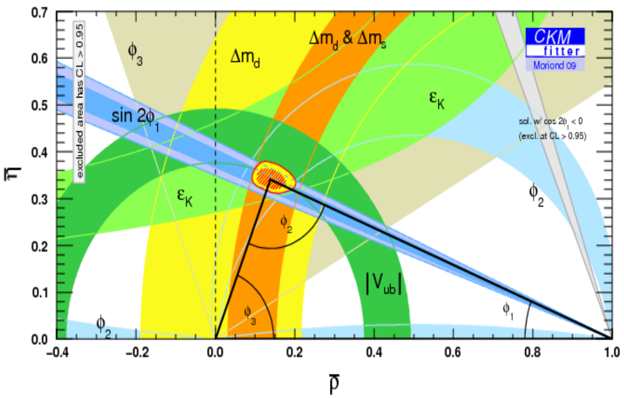
- Unified pipeline readout platform developed at KEK
- Used already in Belle for readout upgrade.
- Recycled in Belle II by replacing digitizer cards with unified data link.



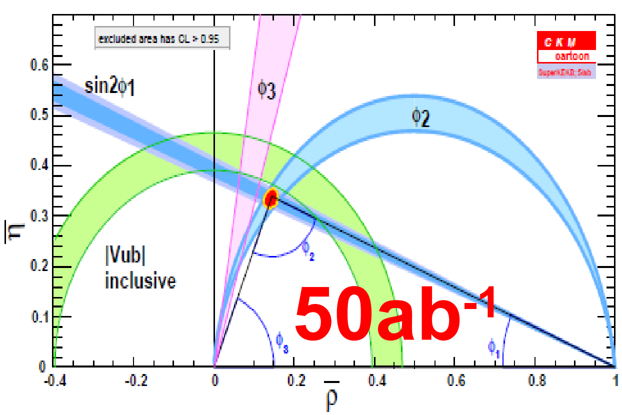
Physics Sensitivity

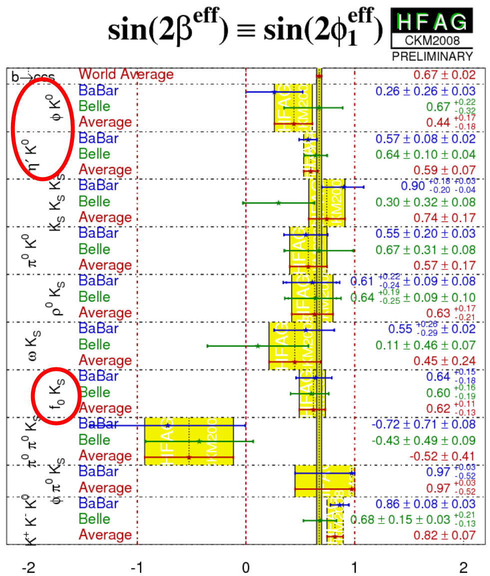
CKM UT triangle

Now

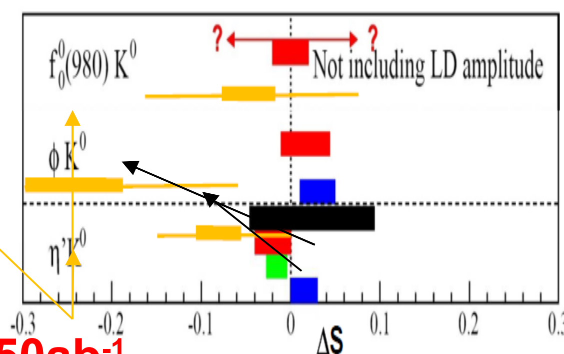


NP effect





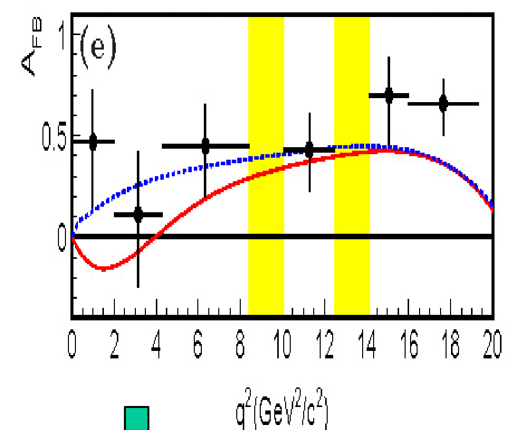
New CP phase



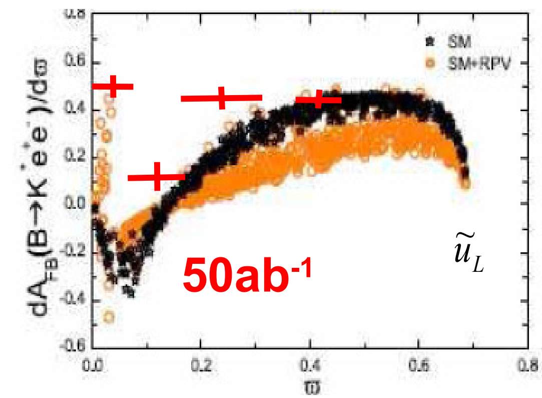
$50ab^{-1}$

Theory errors

$B \to K^* l^+ l^-$: A_{FB}



NP on $C_{7,9,10}$



Physics Sensitivity

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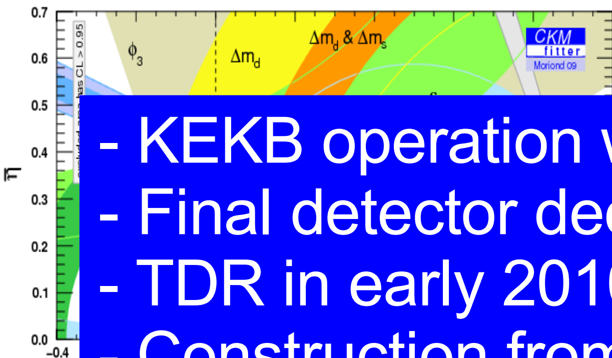
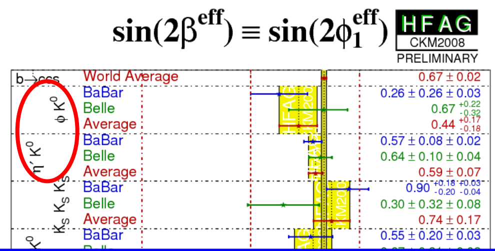
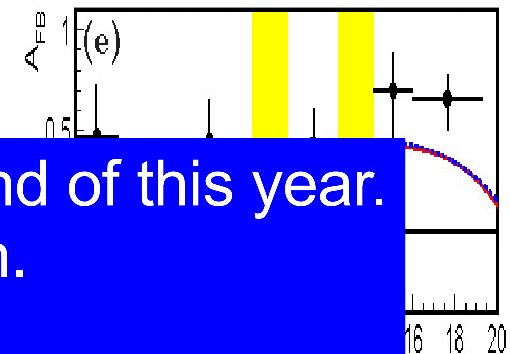


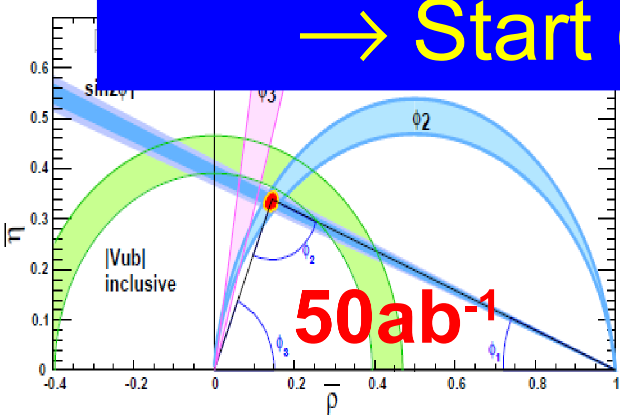


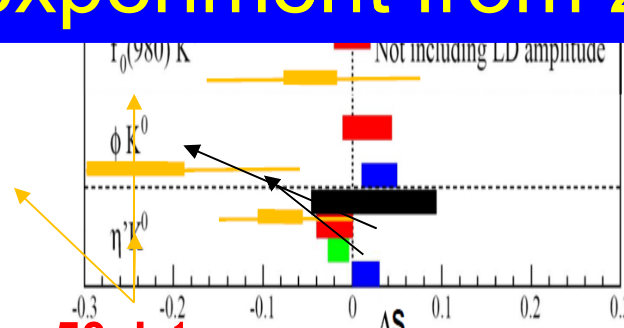
$B \to K^* l^+ l^-$: A_{FB}



- KEKB operation will be stopped by the end of this year.
- Final detector decision for Belle II by then.
- TDR in early 2010
- Construction from 2010 spring to 2013 summer

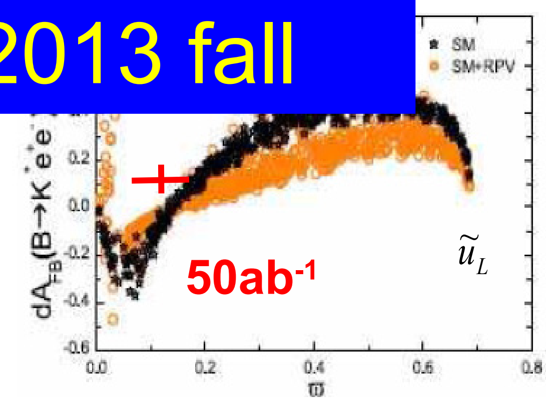
→ Start experiment from 2013 fall



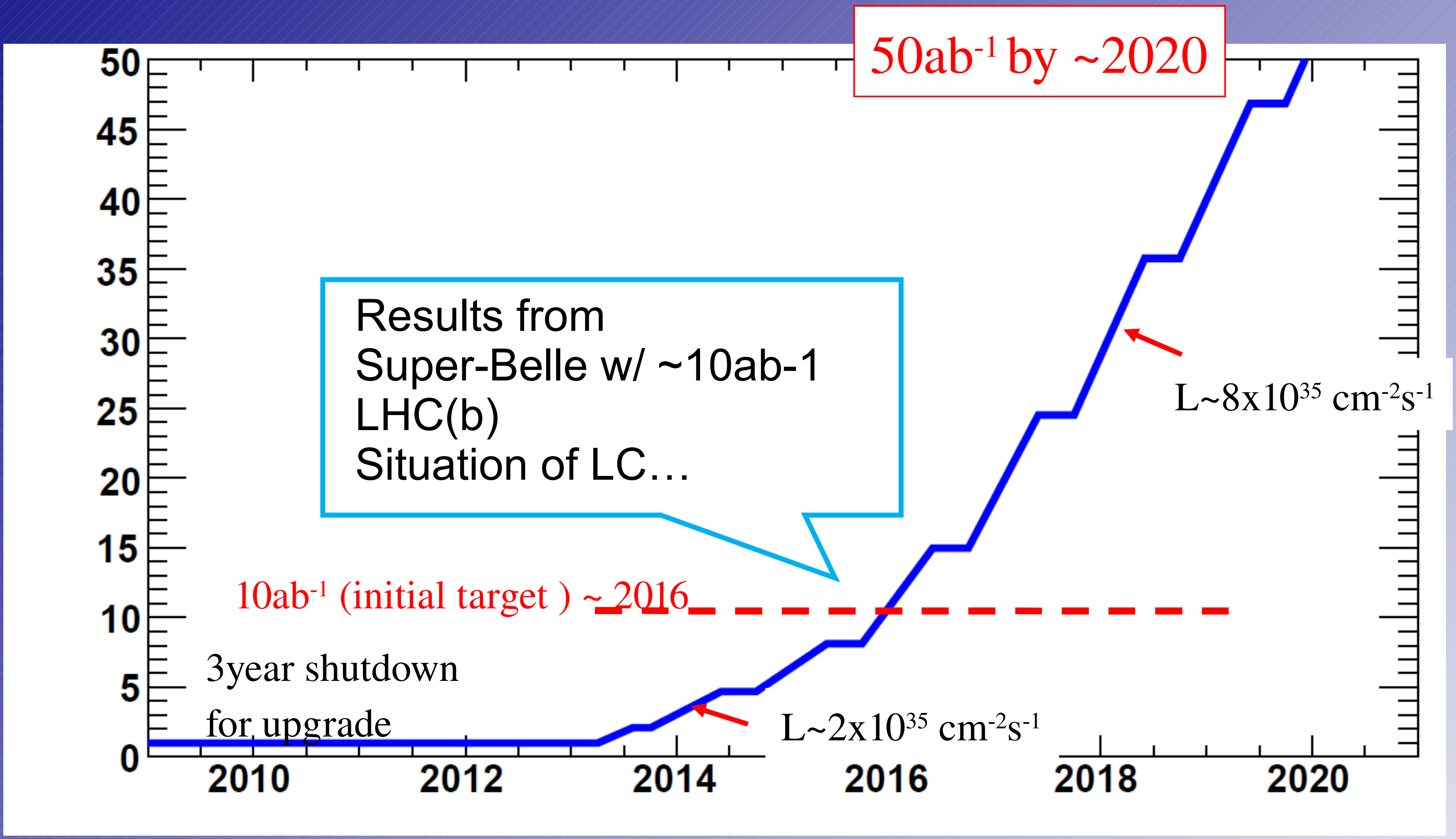


50ab^{-1}

Theory errors



Plan of Luminosity Accumulation



4. Summary

- Japan has a long tradition of accelerator-based HEP experiments.

- New proton facility called J-PARC started operation and T2K is now at the commissioning stage.

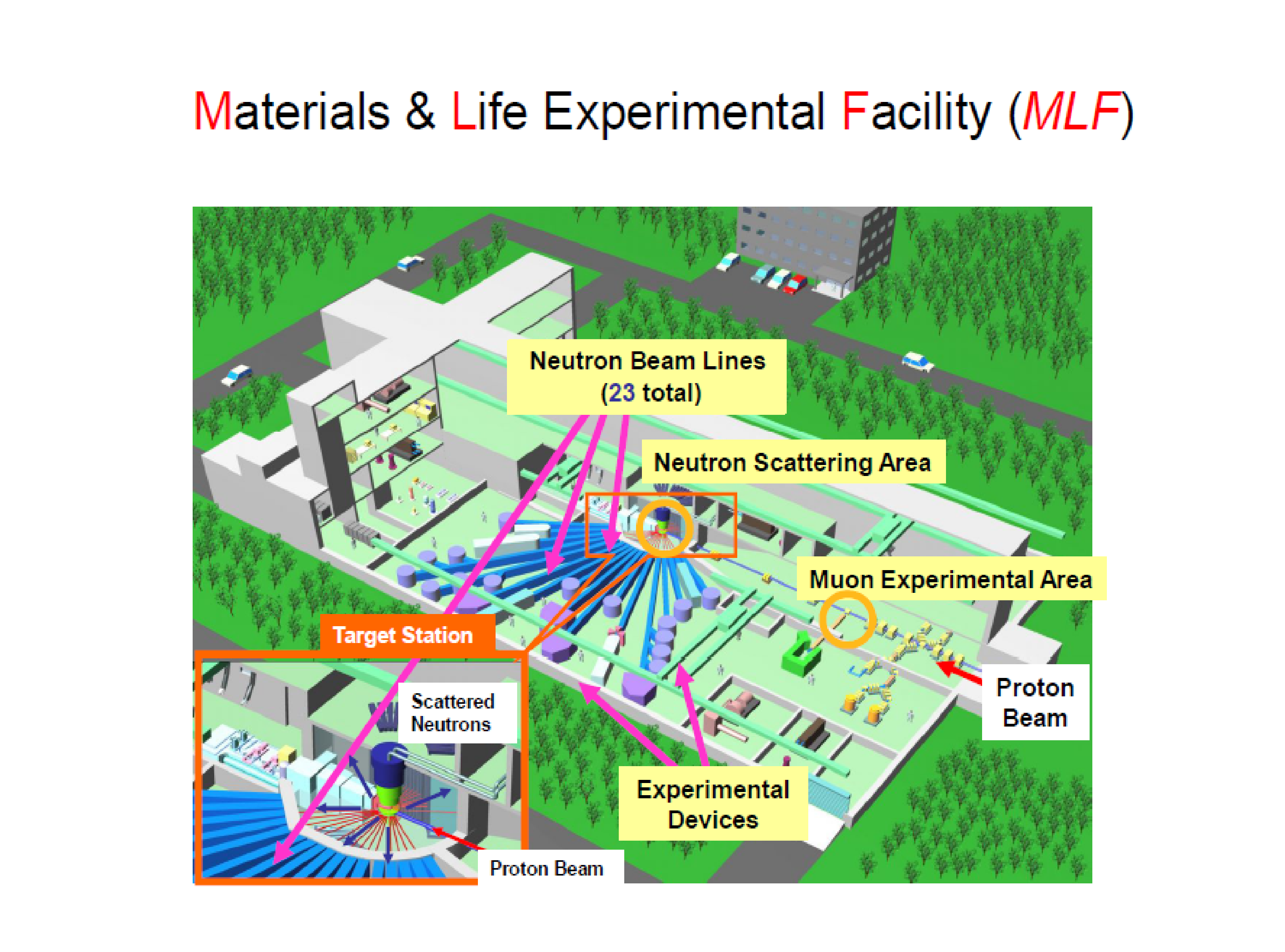
- KEKB/Belle has been running for more than 10 years and already produced many physics results.

- The upgrade to SuperKEKB/Belle II is about to start soon aiming at >50 times higher luminosity.

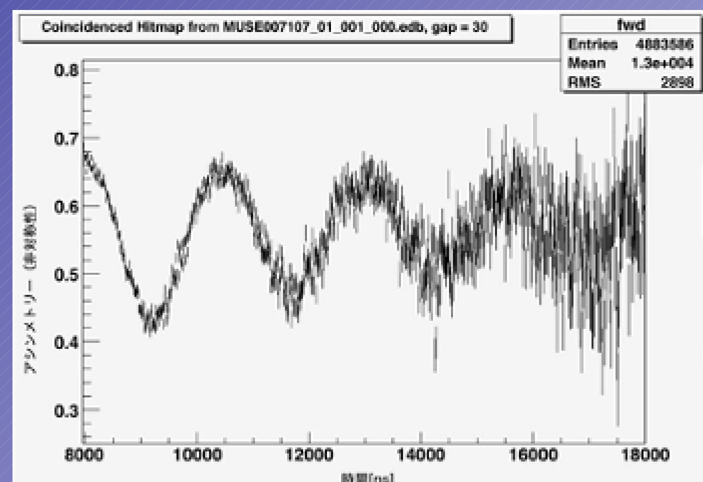
- Both T2K and SuperKEKB/Belle II will be the flagship HEP experiments in Japan for the coming decade.

Backup Slides

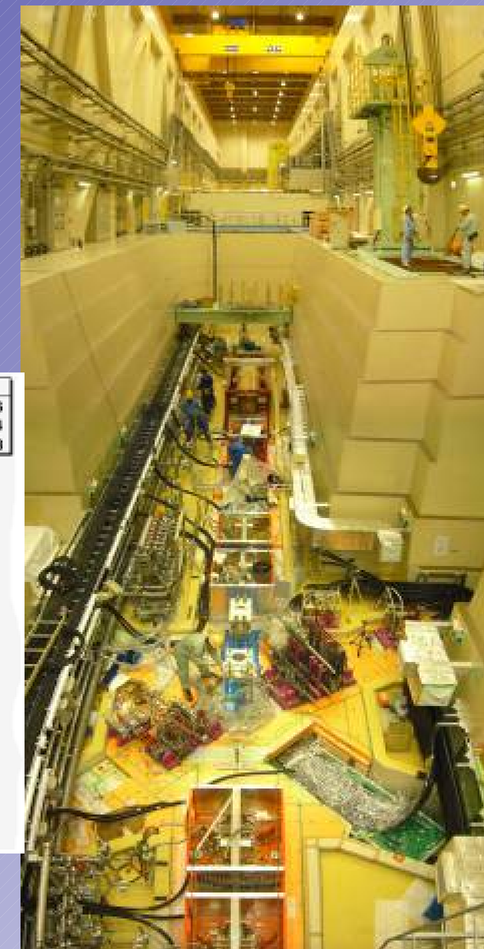
3GeV proton beam from RCS



First muon beam
on September, 28nd, 2008



Firstly observed μ-SR oscillation
at J-PARC



Proton beam transfer line
with muon target

J-PARC problems

Beam commissioning has been accomplished on schedule,
BUT with low intensity.
Real challenge toward the power frontier machine just started.

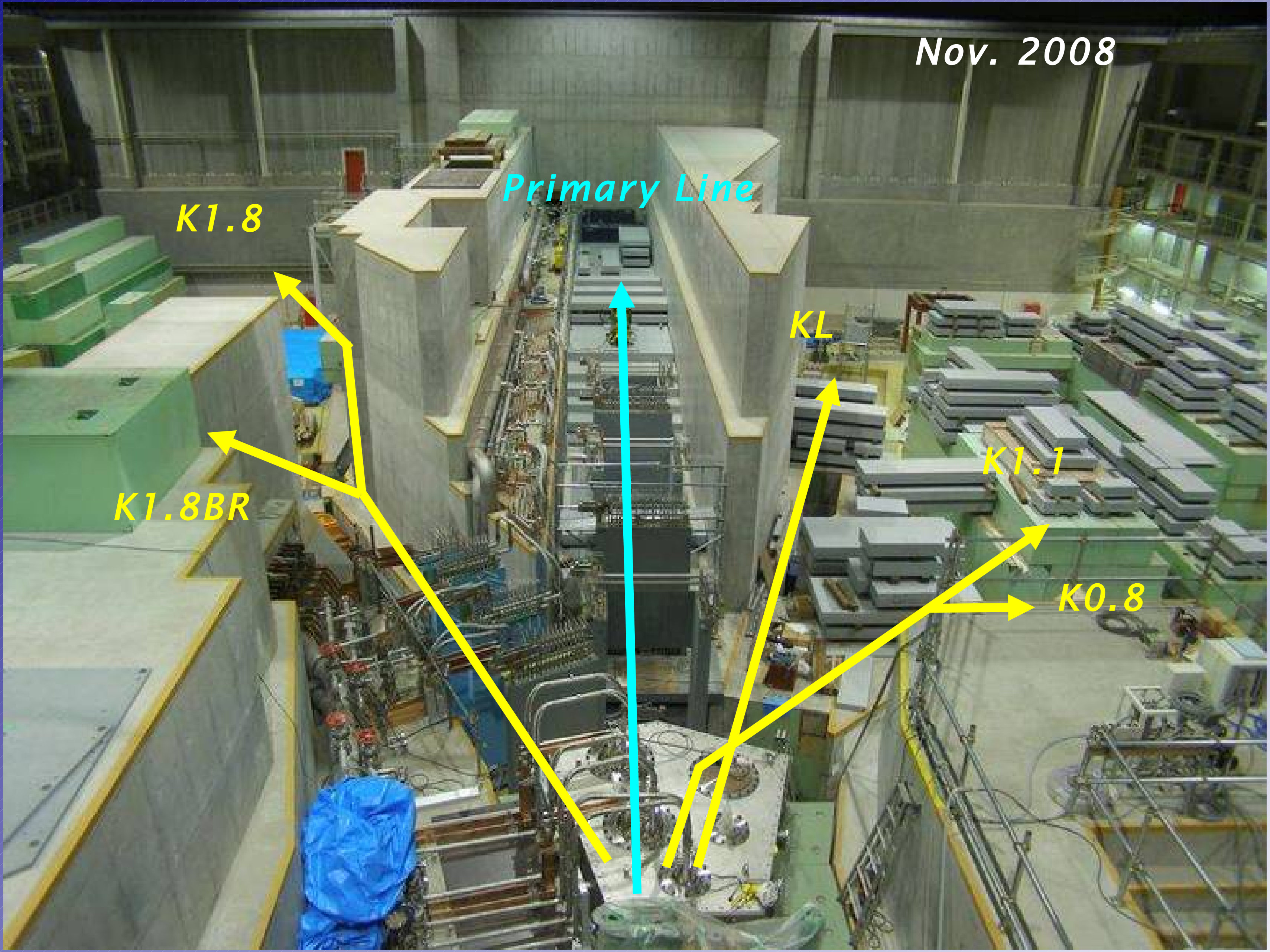
1. Many issues (unreliable components, design etc.) to be solved
2. Beam must be provided to the users
1. Power upgrade should be also accomplished steadily.

- RFQ discharge problem:
- RF core long term stability problem:
- Stability of MR power supply and beam loss
    - No problem for fast extraction with a level of 100kW operation
    - Need more stability for slow extraction
    - Clearly need major improvement for MW operation

J-PARC: Mid-term Schedule

- April-May, 2009
  - First beam commissioning with target/horn1 system
  - Mid. May: Pass governmental inspection
- June~Sept, 2009 (during scheduled shutdown)
  - Horn 2 and 3 installation and operation test
- Fall~Winter, 2009
  - Beam/Detector commissioning with full configuration
    - Target/horn1,2,3
    - Full 280m detector configuration
- Winter JFY2009 ~ Summer 2010
  - As soon as ~100kW stable acc operation achieved,
  - Physics run at ~100kW x10^7s by Summer 2010
  - First physics results in 2010
  - → Exceed sensitivity of present world record result from Chooz experiment
- After Summer 2010 (after RFQ replacement)
  - Physics data taking with > a few 100kW
  - Next milestone: 1~2MW.yr = ~300kWx3~6yr= ~500kWx2~4yr
  - Final goal: 3.75MW.yr (approved by PAC)

Experiments at Hadron Hall



SuperKEKB: Design Options

	KEKB Design	KEKB Achieved (): with crab	SuperKEKB High-Current Option	SuperKEKB Nano-Beam Option
β_y^* (mm) (LER/HER)	10/10	6.5/5.9 (5.9/5.9)	3/6	0.22/0.22
ε_x (nm)	18/18	18(15)/24	24/18	1/1
σ_y(μm)	1.9	1.1	0.85/0.73	0.034/0.044
ξ_y	0.052	0.108/0.056 (0.101/0.096)	0.3/0.51	0.07/0.07
σ_z (mm)	4	~ 7	5(LER)/3(HER)	6
I_{beam} (A)	2.6/1.1	1.8/1.45 (1.6/1.1)	9.4/4.1	2.96/1.70
$N_{bunches}$	5000	~1500	5000	2500
Luminosity (10^{34} cm^{-2} s^{-1})	1	1.76 (1.96)	53	80

High Current Option includes crab crossing and travelling focus.
Nano-Beam Option does not include crab waist.

Strategies for Increasing Luminosity

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

Lorentz factor

Beam current

Beam-beam parameter

Classical electron radius

Beam size ratio@IP
1 ~ 2 % (flat beam)

Vertical beta function@IP

Lumi. reduction factor (crossing angle)&
Tune shift reduction factor (hour glass effect)
0.8 ~ 1
(short bunch)

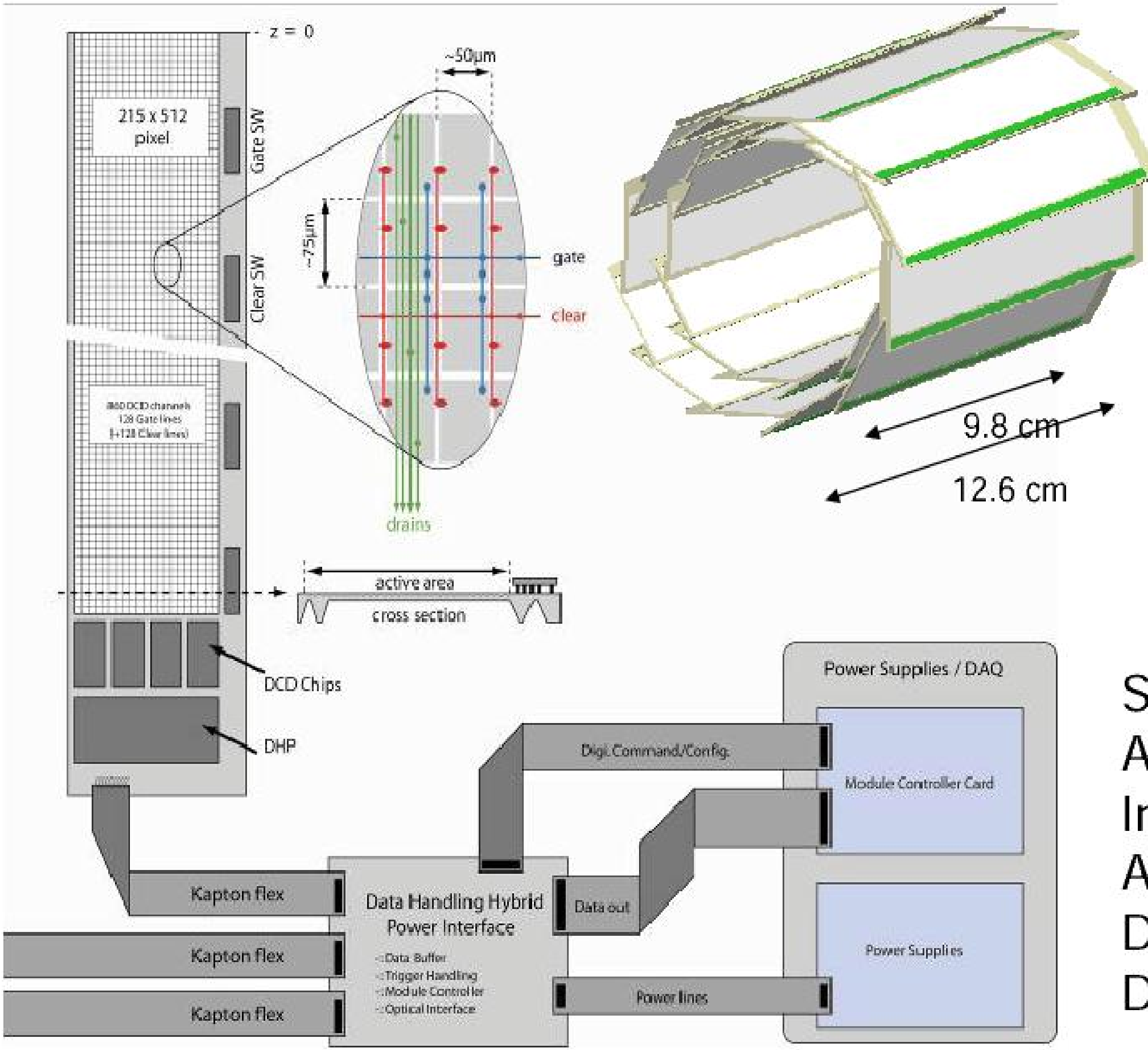
High-Current Option

(1) Smaller β_y^* ← Nano-Beam Option

(2) Increase beam currents

(3) Increase ξ_y

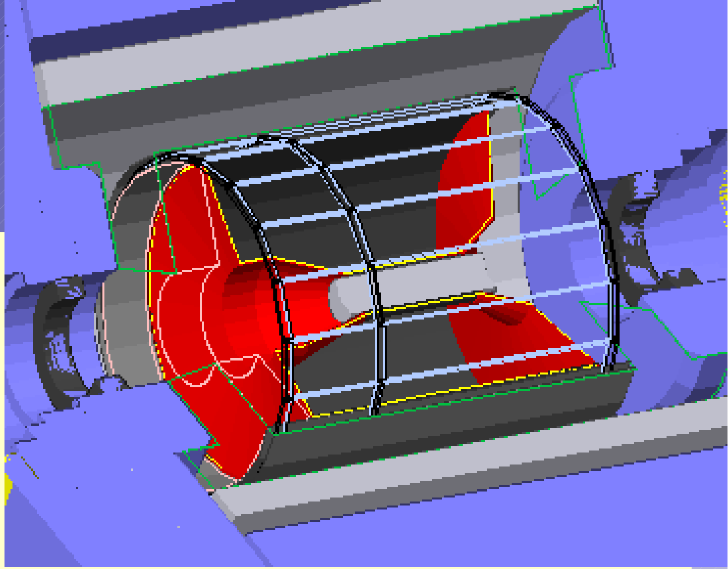
Main Components of the PXD



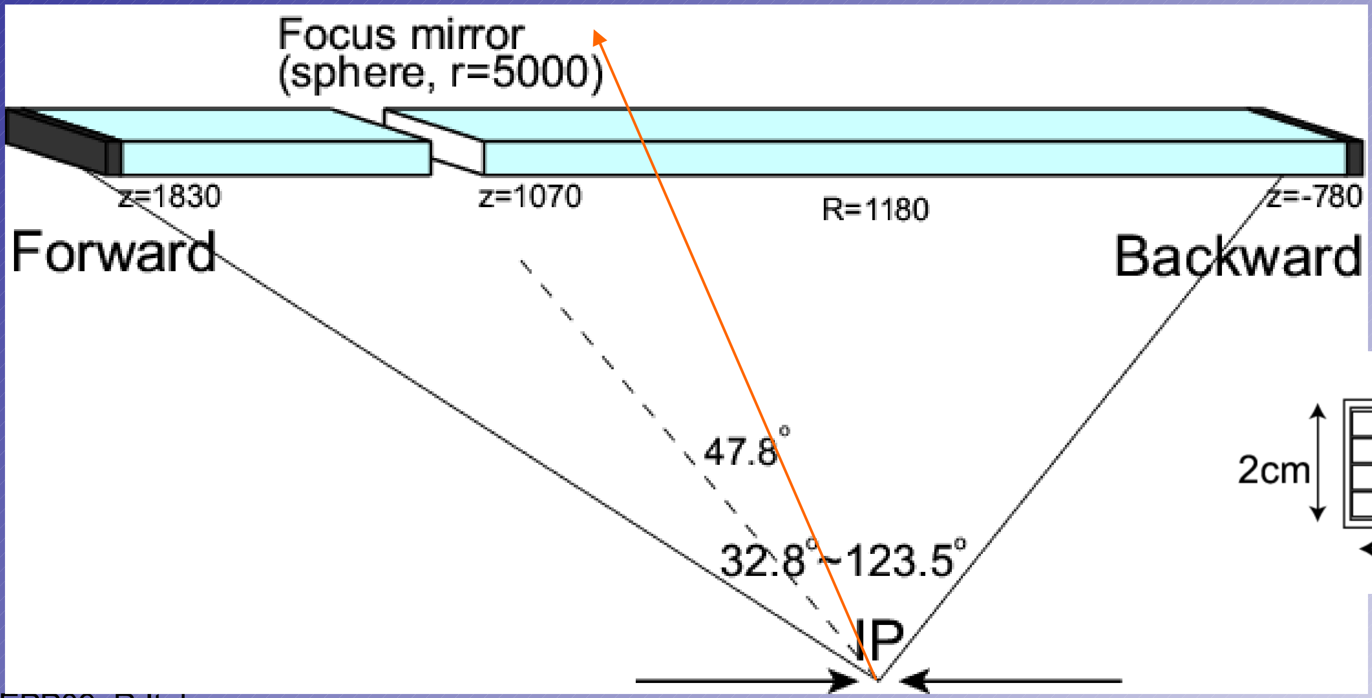
Mechanics
Power
Services
Cooling
Assembly
Control …

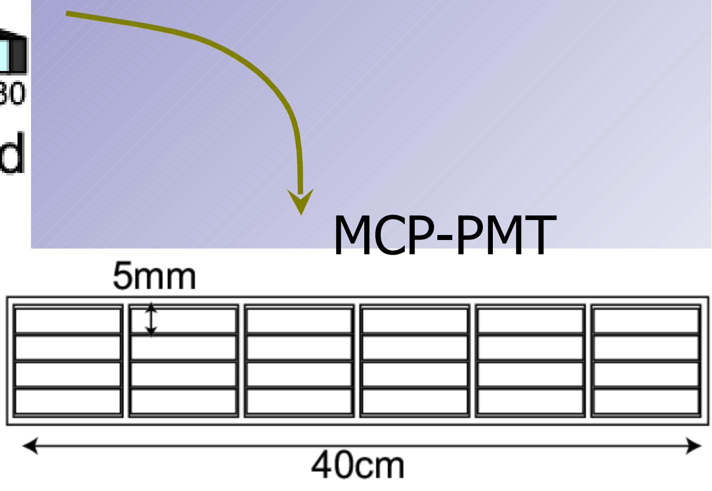
Sensors
ASICs
Interconnections
Assembly
Data links
DAQ

TOP



- Quartz: 255cm^L x 40cm^W x 2cm^T
  - Focus mirror at 47.8deg.
    to reduce chromatic dispersion
- Multi-anode (GaAsP) MCP-PMT
  - Linear array (5mm pitch), Good time resolution (<~40ps)
  - → Measure Cherenkov ring image with timing info.





Barrel PID options

focusing TOP (Nagoya)

Originally:

Bar cut into two pieces, forward piece used TOF

Separate readout plane for forward piece, i.e., two readout planes per phi segment

Now (a la Staric):

Single bar used with single readout plane (?)

focusing DIRC (Cincinnati)

Originally:

mirror was external to bar, standoff region between mirror and bar needed

Conceived with narrow (Babar-like) bars

Now:

Mirror now part of bar, may be tilted (off axis)

Wide bar now used, ambiguities reduced

imaging TOP (iTOP) (Hawaii)

Originally:

No focusing

Ultra-fine readout granularity

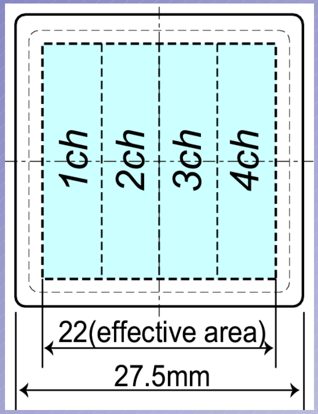
Now:

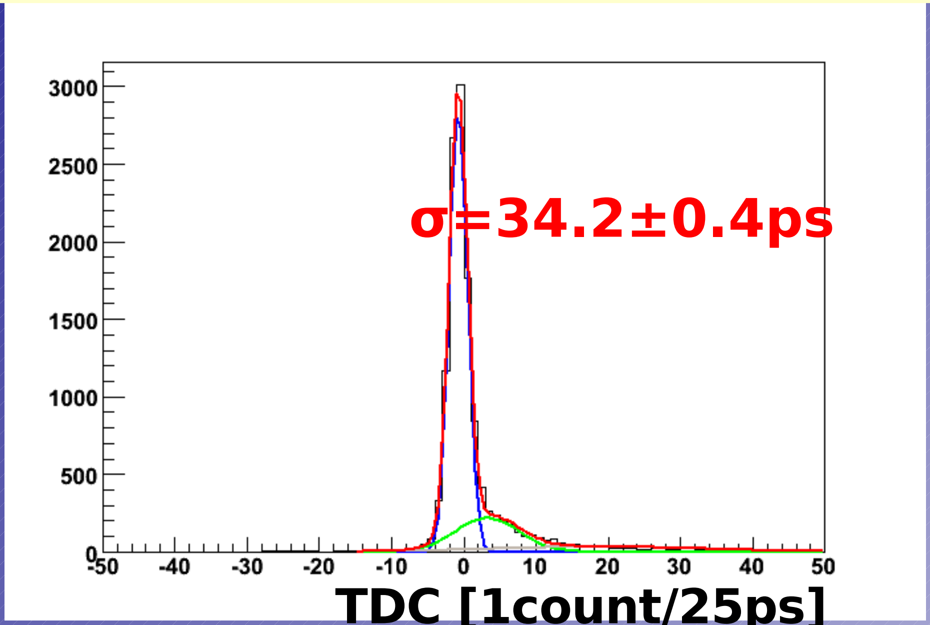
Focusing mirror added

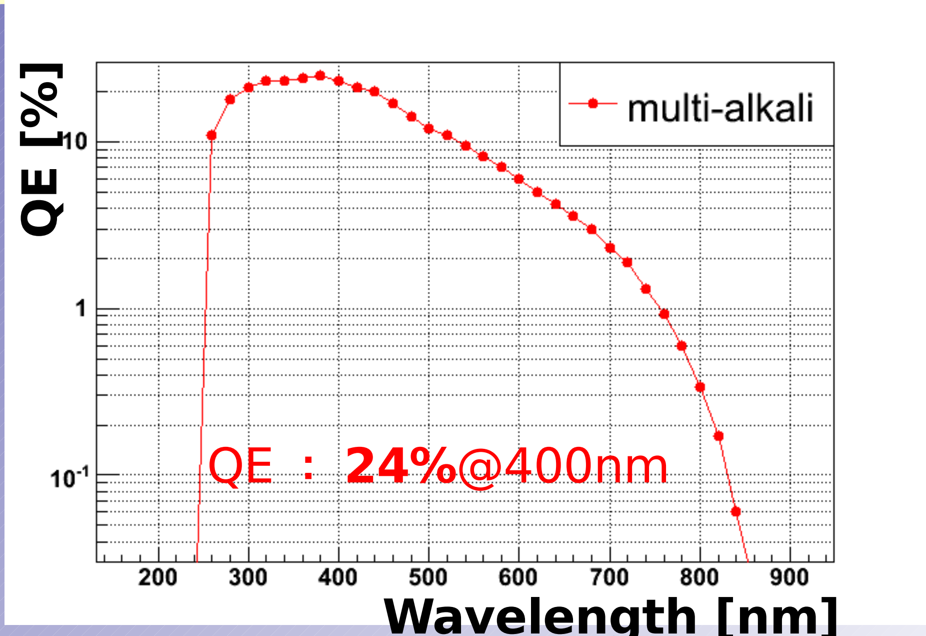
Other photo-detectors possible

MCP-PMT status (Nagoya)

- Square-shape multi-anode MCP-PMT
  - Multi-alkali photo-cathode
    - Gain=1.5x10^6 @B=1.5T
  - Transit Time Spread (TTS): ~35ps @B=1.5T (single photon)
    - Position resolution: <5mm
- Semi-mass-production (14 PMTs)







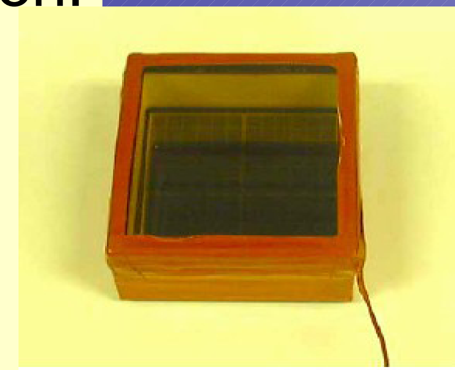
TTS＜40ps for all channels

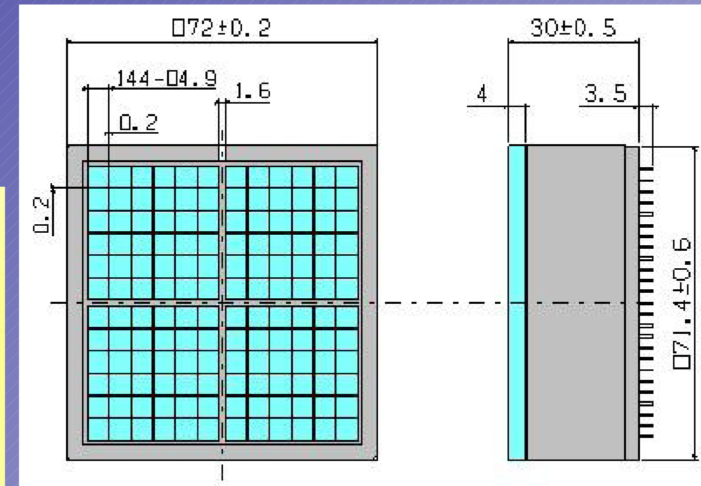
Ave. QE ： **17%**@400nm

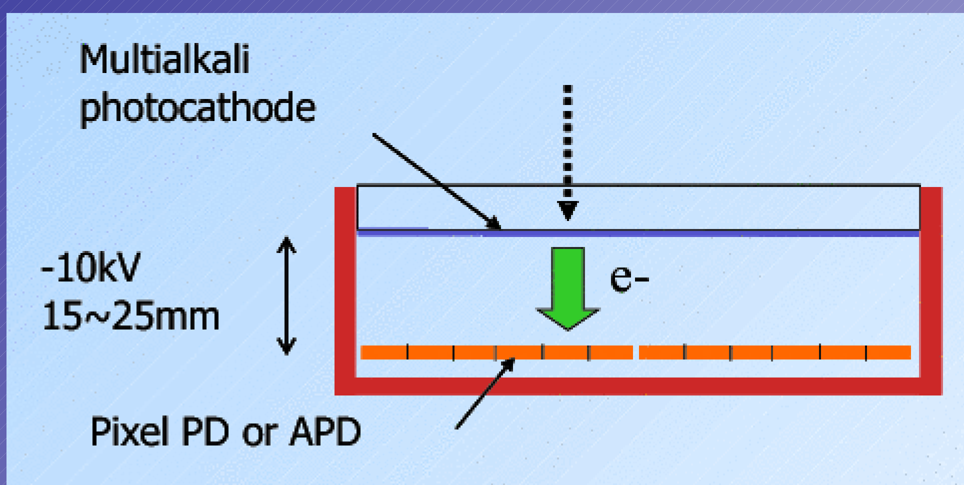
HAPD status

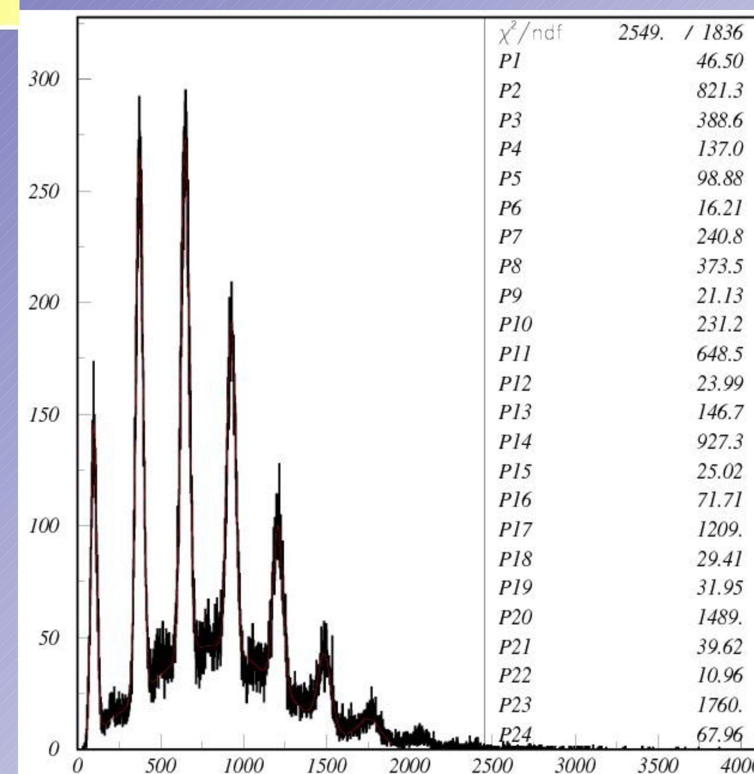
Hybrid avalanche photo diode - proximity focusing configuration:

- 12x12 channels (~5x5 mm2)
- size ~ 74mm x 74mm
- ~ 65% effective area
- total gain ~ 104 - 105
- detector capacitance ~ 80pF
- peak QE ~ 25%
- works in mag. field perpendicular to the entrance window



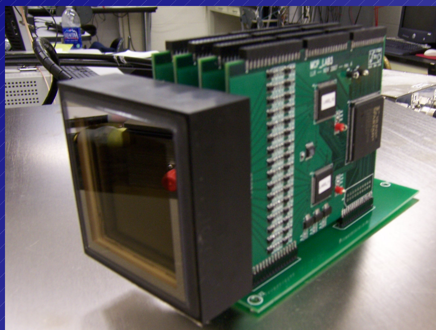


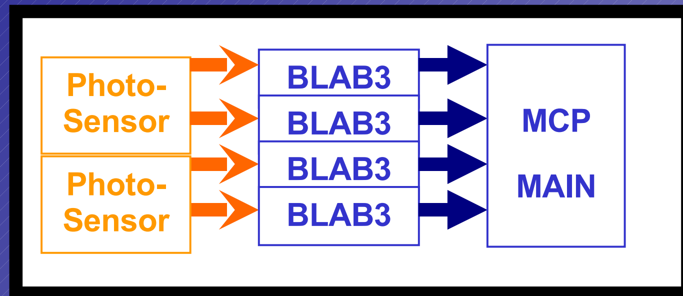


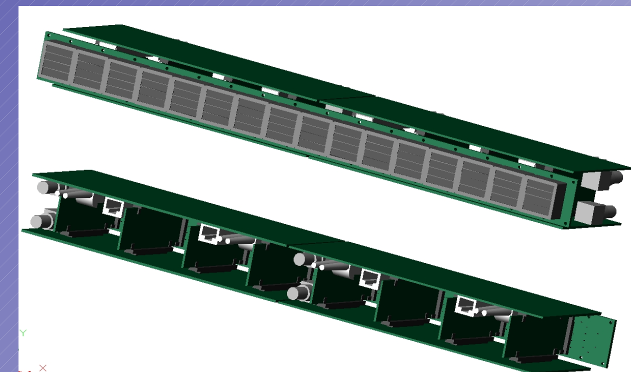


Front-End Electronics for Photon Detectors

a) MCP-PMT : BLAB3 readout for HPK SL10 (Hawaii)

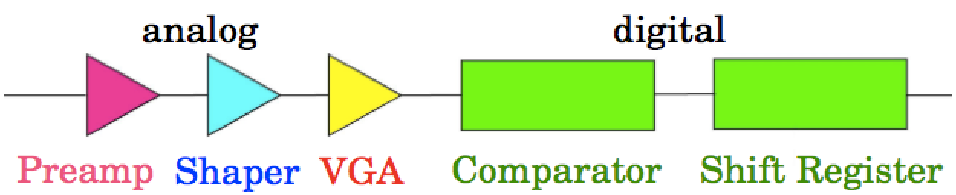


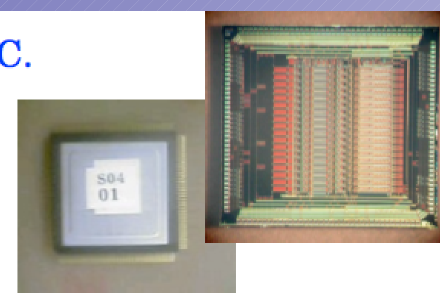




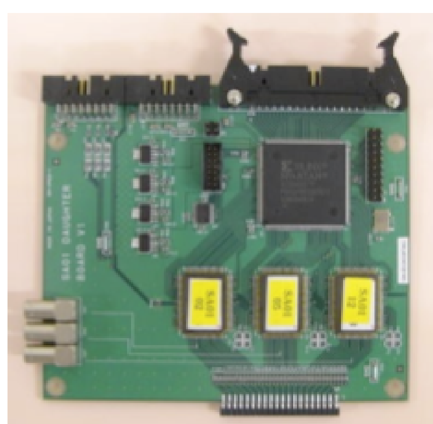
b) HAPD : Custom ASIC (KEK+Nagoya)

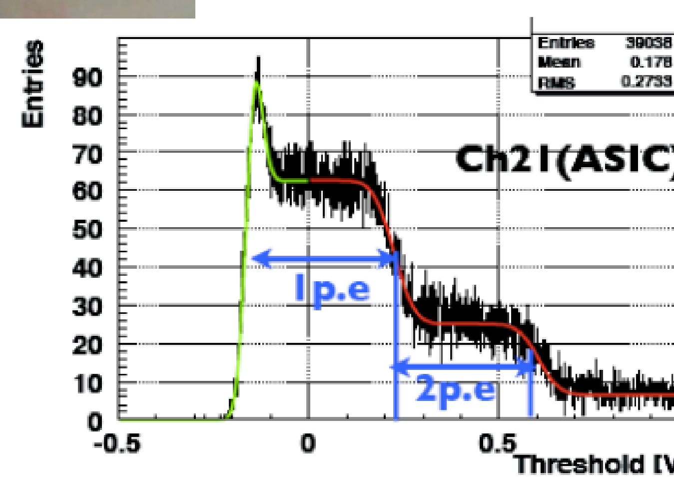
4 trial productions of prototype ASICs (S01-S04) at VDEC.





- New board with 1 FPGA + 3 SA01 is developed.
- Now all the 36ch from 1 APD chip can be read.
- Very clean threshold scan: good S/N (the reason is not clear).

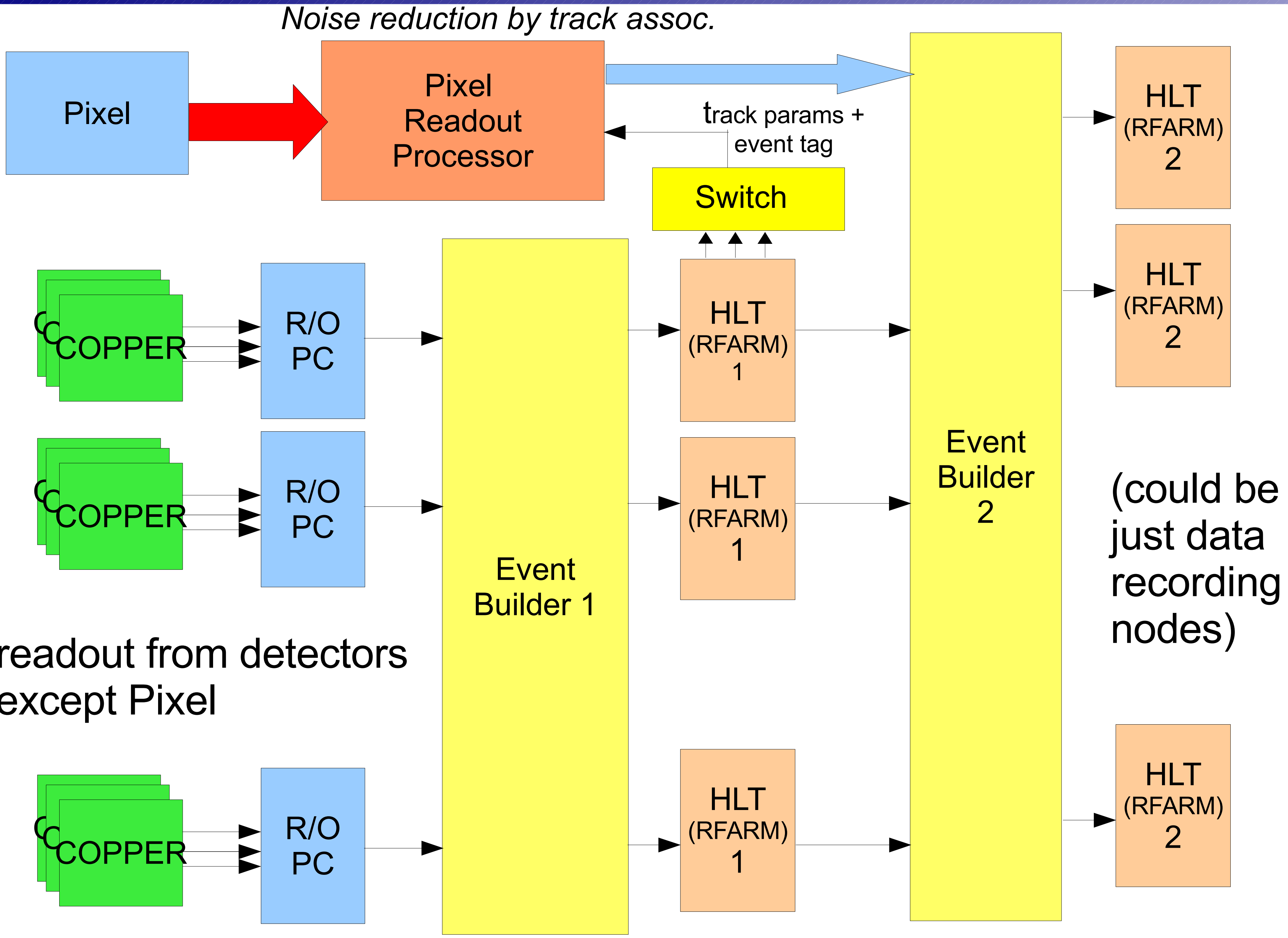




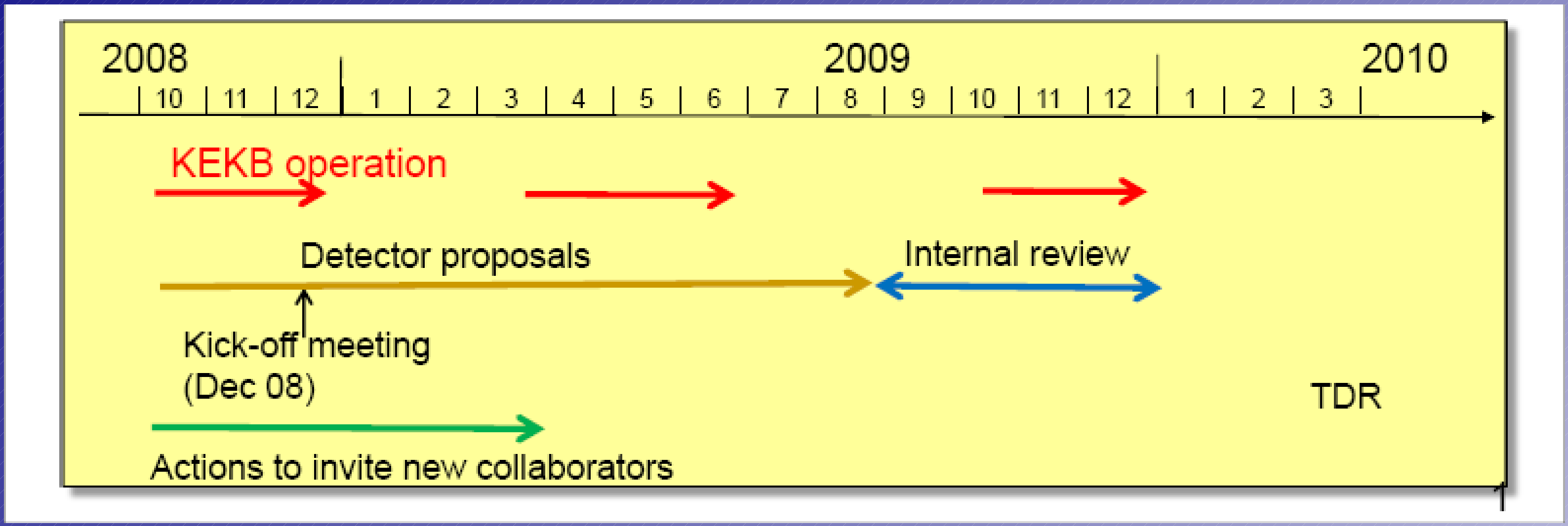
Comparison of Photon Detectors

	HAPD	MCP-PMT	MPPC
N_{ph}	8(+1) (→16)	10 (→15)	30
σ_{ϑ}	14	15	14
B = 1.5T	OK (improved perf.)	OK (improved perf.)	OK
long term stab. (aging)	OK (HV stability?)	OK?	OK
neutron damage	leakage current? → signal / noise	OK(?)	X
production	2.5 y	2 y	?
pieces	< 600	< 1000	< 500000
cost / piece	< 7000 €	< 4000 €	< 20 €
electronics	ASIC	WFS	WFS
channels	~ 75k	~ 60k	~ 120k

PXD integration with Belle II DAQ (one idea)



Near term schedule



- KEKB operation will be stopped by the end of this year.
- Detector decision by the same time.
- TDR in 2010
- Construction between 2010 spring and 2013 summer

-> Start experiment from 2013 fall

Summary of KEK Roadmap