Status of Belle II and super KEK

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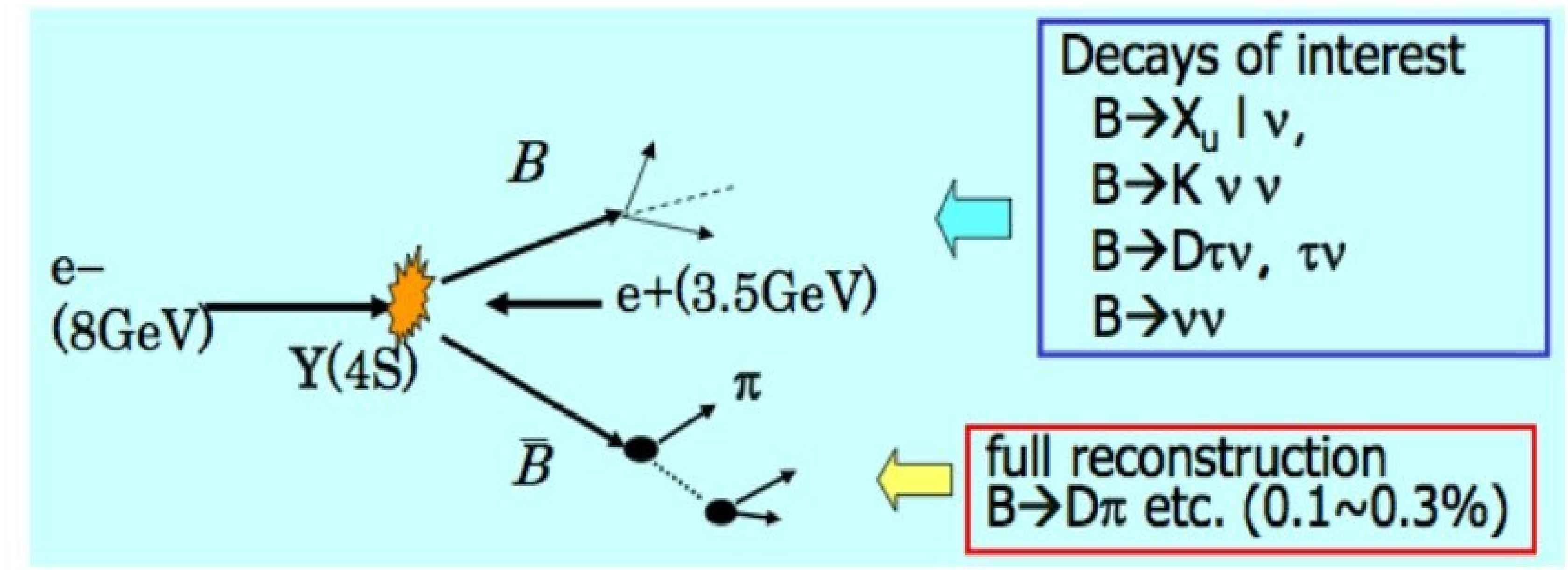
Outline

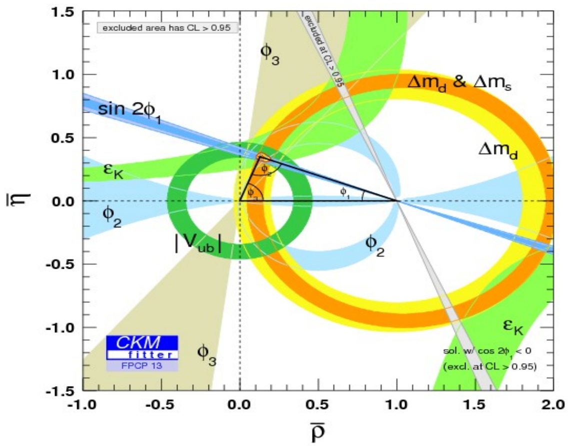
- Physics
- Accelerator status
- Detector Status
- Conclusions

The unique capabilities of e+ e-

- Very low multiplicities
- Full reconstruction
- Allows to detect neutrinos and missing energy !!
- B tagging
- Offline B beam
- Rare Decays



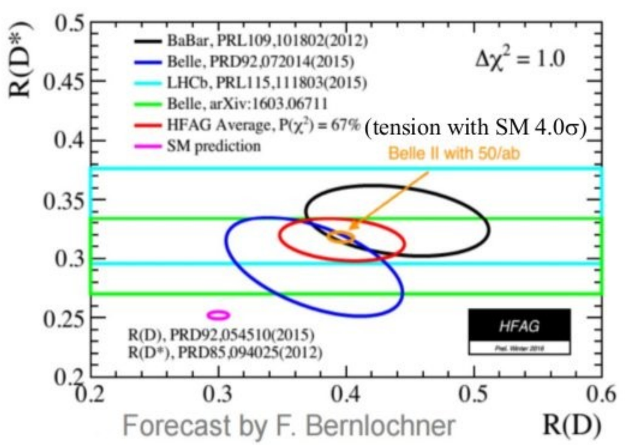
Physics possibilities

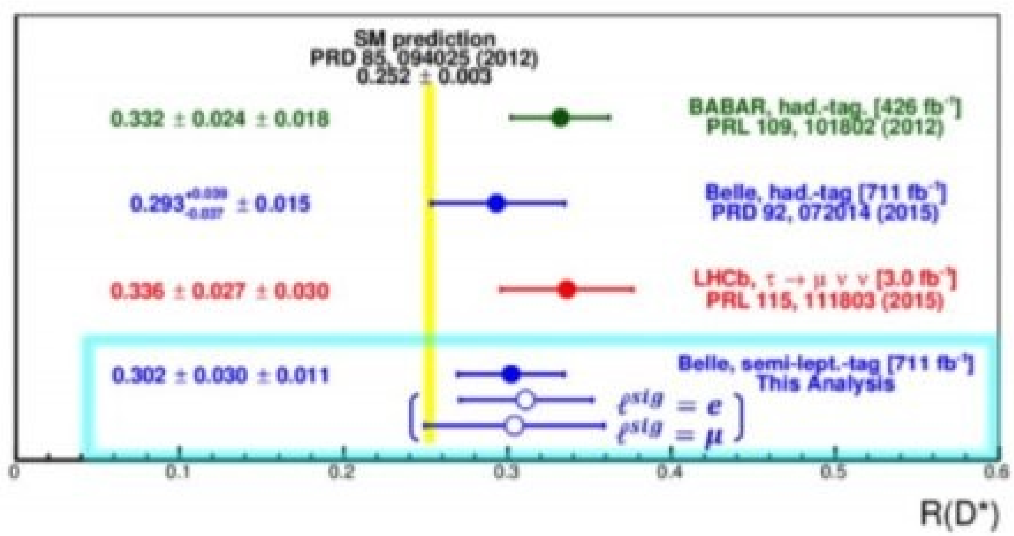


CKM matrix overconstrains

$$R(D^{(*)}) = \frac{\Gamma(B^0 \to D^{(*)} \tau \nu)}{\Gamma(B^0 \to D^{(*)} l \nu)_{l=\mu,e}}$$

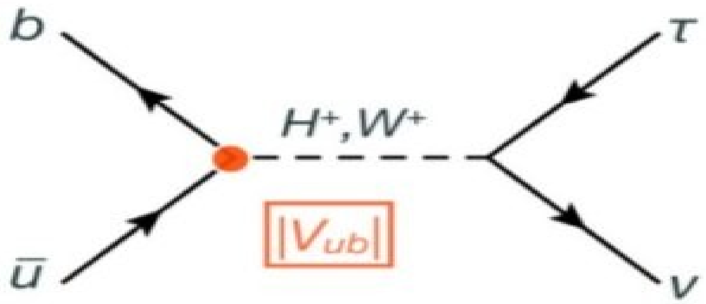
larger BF in the SM (~1%)
smaller theoretical uncertainty of R(D)
discrimination of W and H by differential distribution





Belle II will able to solve the tension

τ & LFV

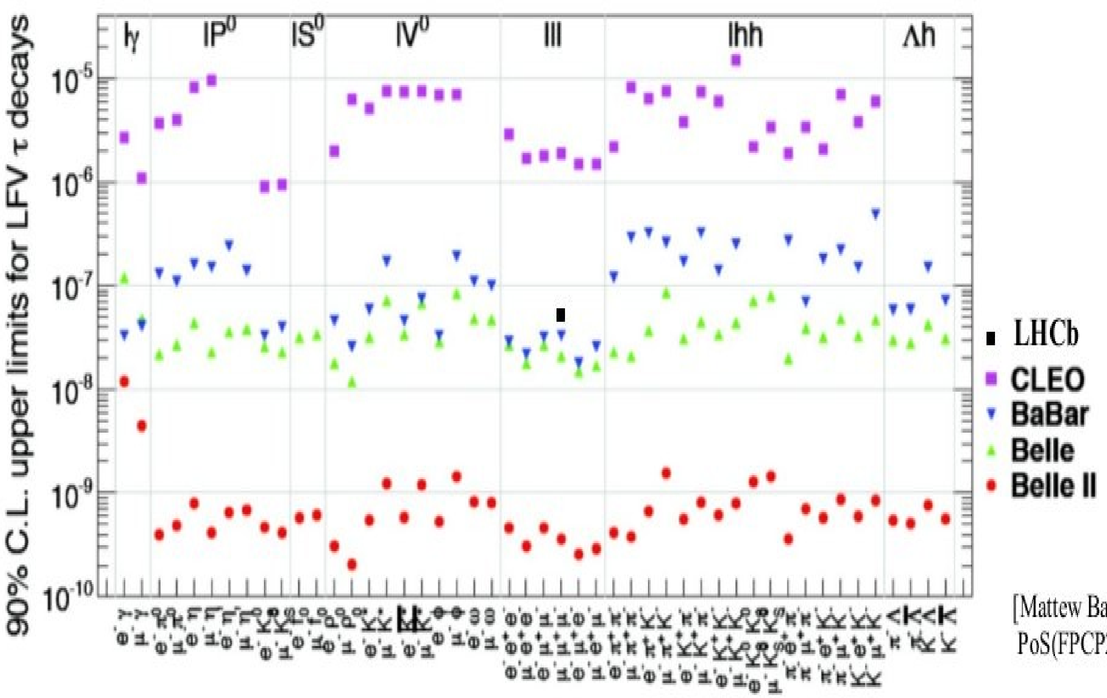


sensitive to existence of
a charged Higgs (H-b-u)

$$BR(B\rightarrow\tau\nu)=BR_{SM}\times\left[1-\left(\frac{m_B^2}{m_H^2}\right)\lambda_H\right]^2$$

$$\lambda_H=\tan^2(\beta)\ \text{for type II 2HDM}$$

$BR_{SM} = 0.75\text{x}10^{-4}$
current measurement $(1.14\pm0.22)\text{x}10^{-4}$



[Mattew Barrett PoS(FPCP2015)049]

Lepton flavor violation
In 2, 3, 4 body decay

One order of
improvement !!!

NP in τ

Belle II physics prospect – tau physics

$\tau \to \mu\gamma$

main background from $ee \to \mu\mu\gamma_{ISR}$

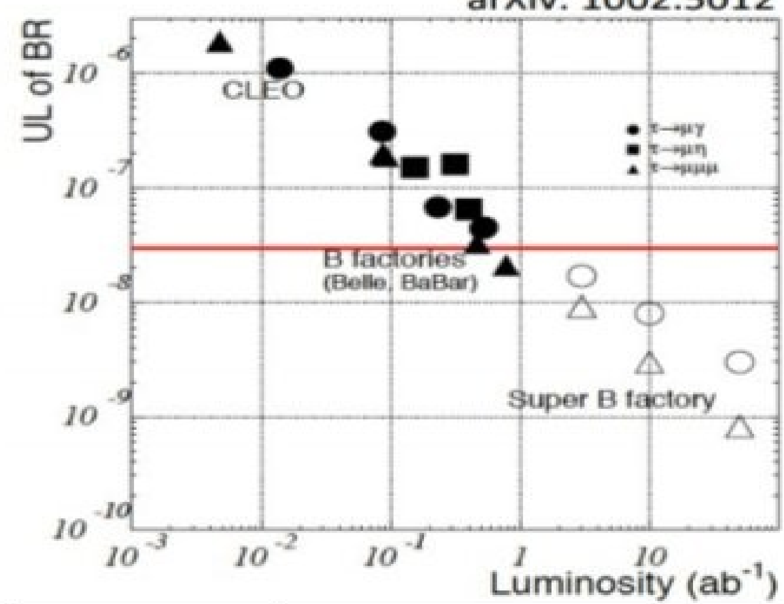
possible to reduce sensitivity by a factor ~7

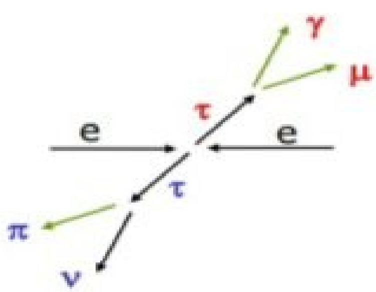
$\tau \to \mu\mu\mu$

very clean mode

possible to reduce sensitivity by a factor of 50

arXiv. 1002.5012

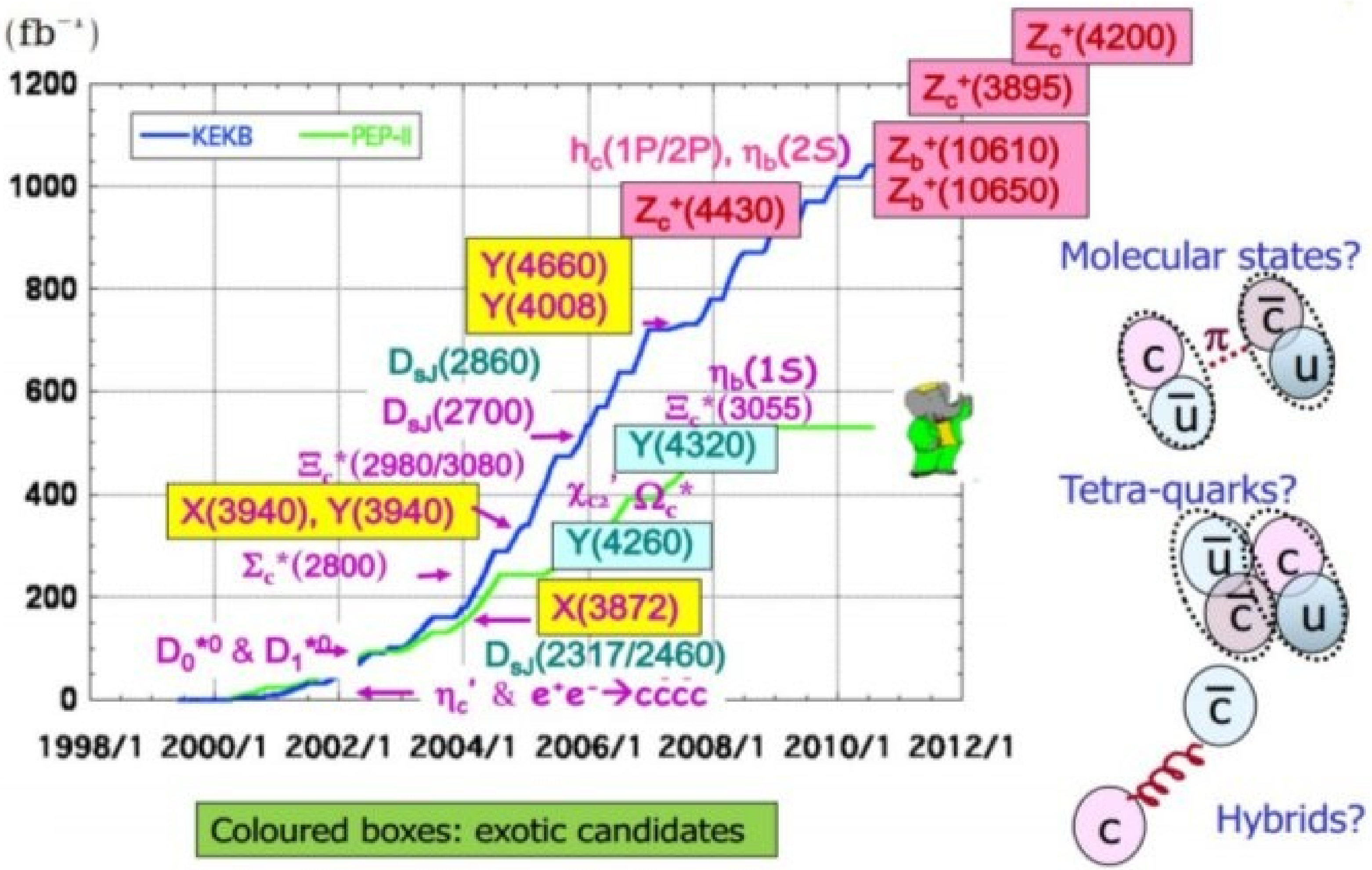




	$\mathcal{B}(\tau \to \mu\gamma)$	$\mathcal{B}(\tau \to \mu\mu\mu)$	
mSUGRA+seesaw	10^{-7}	10^{-9}	PRD 66(2002) 115013
SUSY+SO(10)	10^{-8}	10^{-10}	PRD 68(2003) 033012
SM+seesaw	10^{-9}	10^{-10}	PRD 66(2002) 034008
Non-Universal Z'	10^{-9}	10^{-8}	PLB 547(2002) 252
SUSY+Higgs	10^{-10}	10^{-7}	PLB 566(2003) 217

possible reach by Belle II (50 ab^{-1}) $<10^{-9}$ $<10^{-10}$ $\to$ good to test NP models

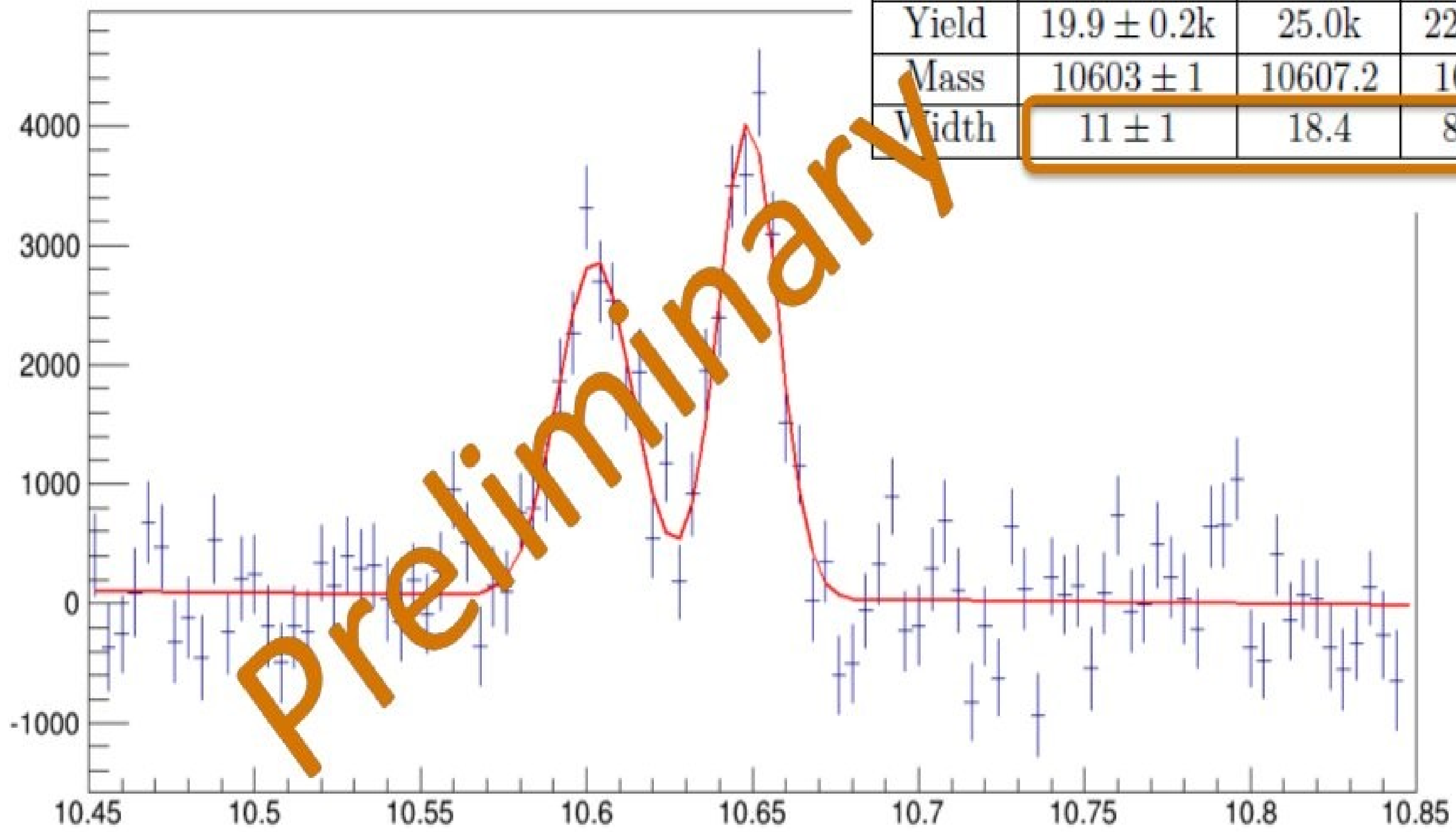
Spectroscopy, maybe new creatures



We require 20 fb-1 to perform this analysis, more to come

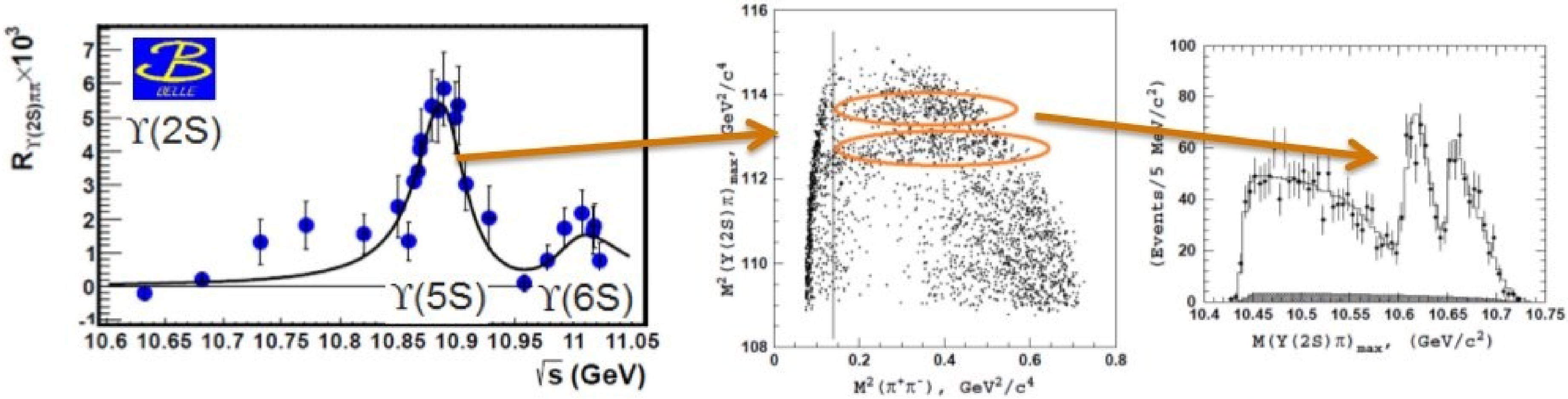
- $\Upsilon(6S)\to\pi^{\mp}Z_b^{\pm}(10610/50)\to\pi^{\pm}h_b(1P)$
  - Fitted width better than generated?!
  - Minor concern about yield/efficiency

	10610		10650	
	Fit	Gen	Fit	Gen
Yield	19.9 ± 0.2k	25.0k	22.3 ± 0.2k	25.0k
Mass	10603 ± 1	10607.2	10649 ± 1	10652.2
Width	11 ± 1	18.4	8.9 ± 0.5	11.5

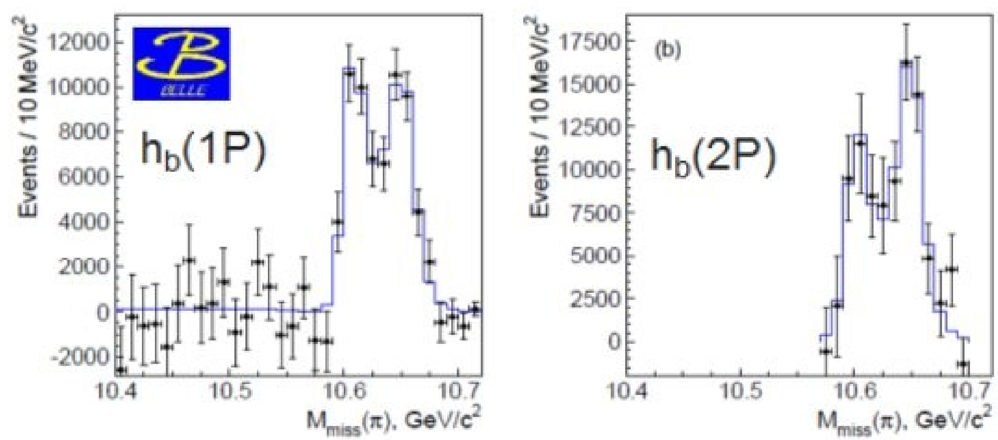


First physics one example

- Anomalous $\Upsilon(5S)\to\pi\pi\Upsilon(pS)$ transitions led to discovery of $Z_b^{\pm}(106XX)$



- Similar for $\Upsilon(5S)\to\pi\pi h_b(nP)$



- What is the situation at $\Upsilon(6S)$?

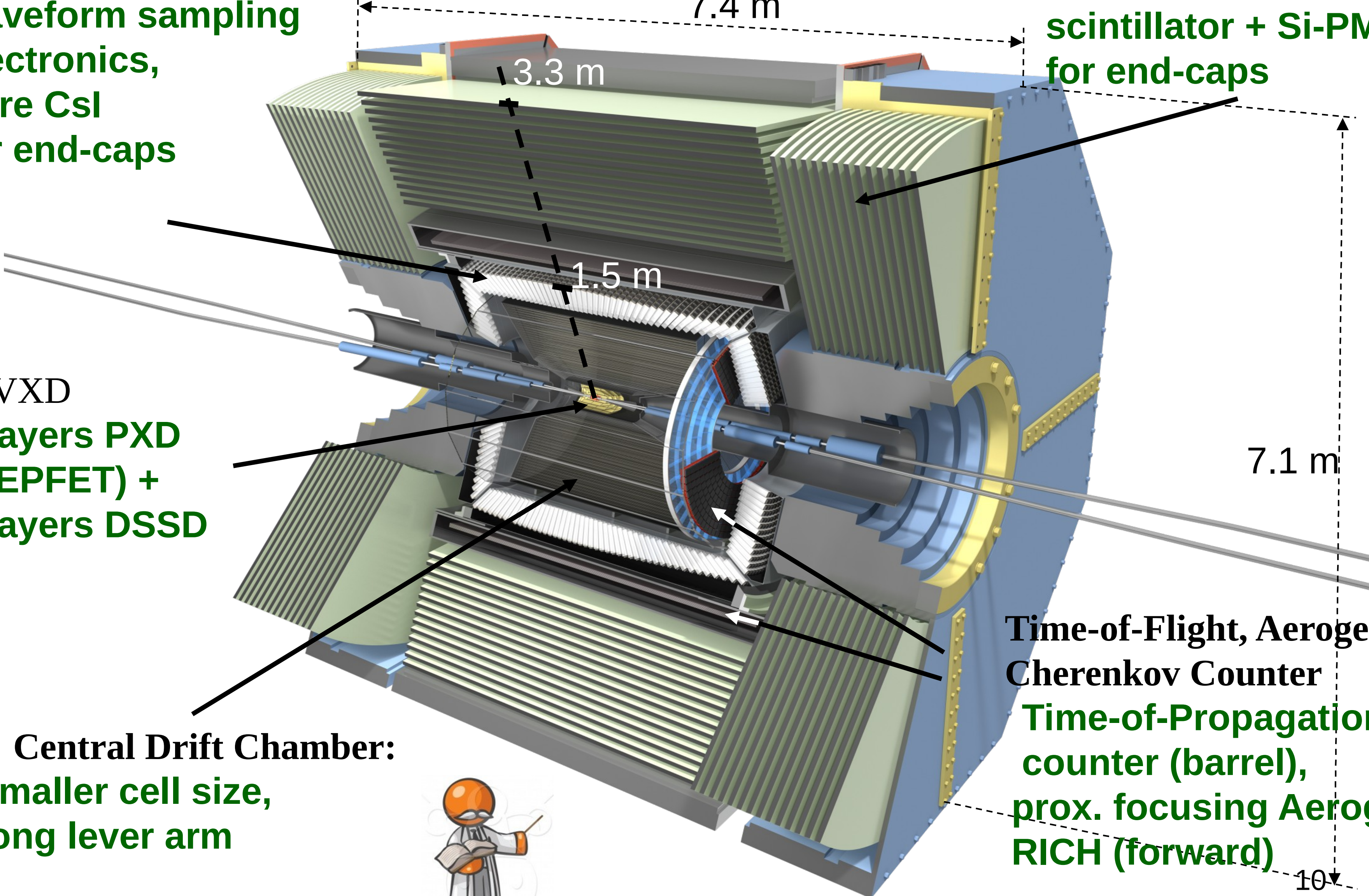
Belle II detector upgrade

Belle II

waveform sampling electronics, pure CsI for end-caps

RPC & K_L counter:

scintillator + Si-PM for end-caps



VXD

2 layers PXD (DEPFET) + 4 layers DSSD

Time-of-Flight, Aerogel Cherenkov Counter

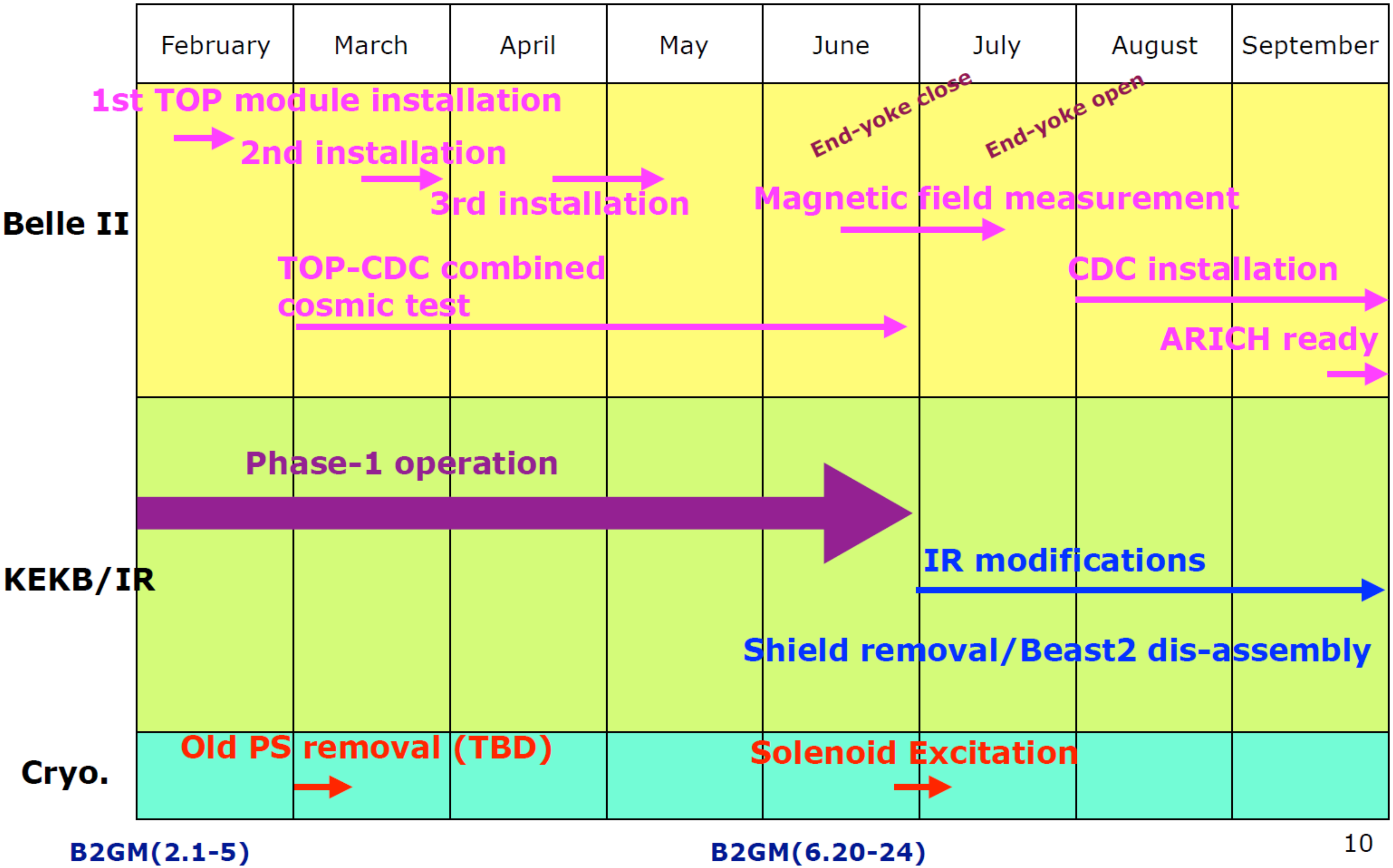
Time-of-Propagation counter (barrel), prox. focusing Aerogel RICH (forward)

Central Drift Chamber:

smaller cell size, long lever arm

Slide take from kurtis Nishimura talk

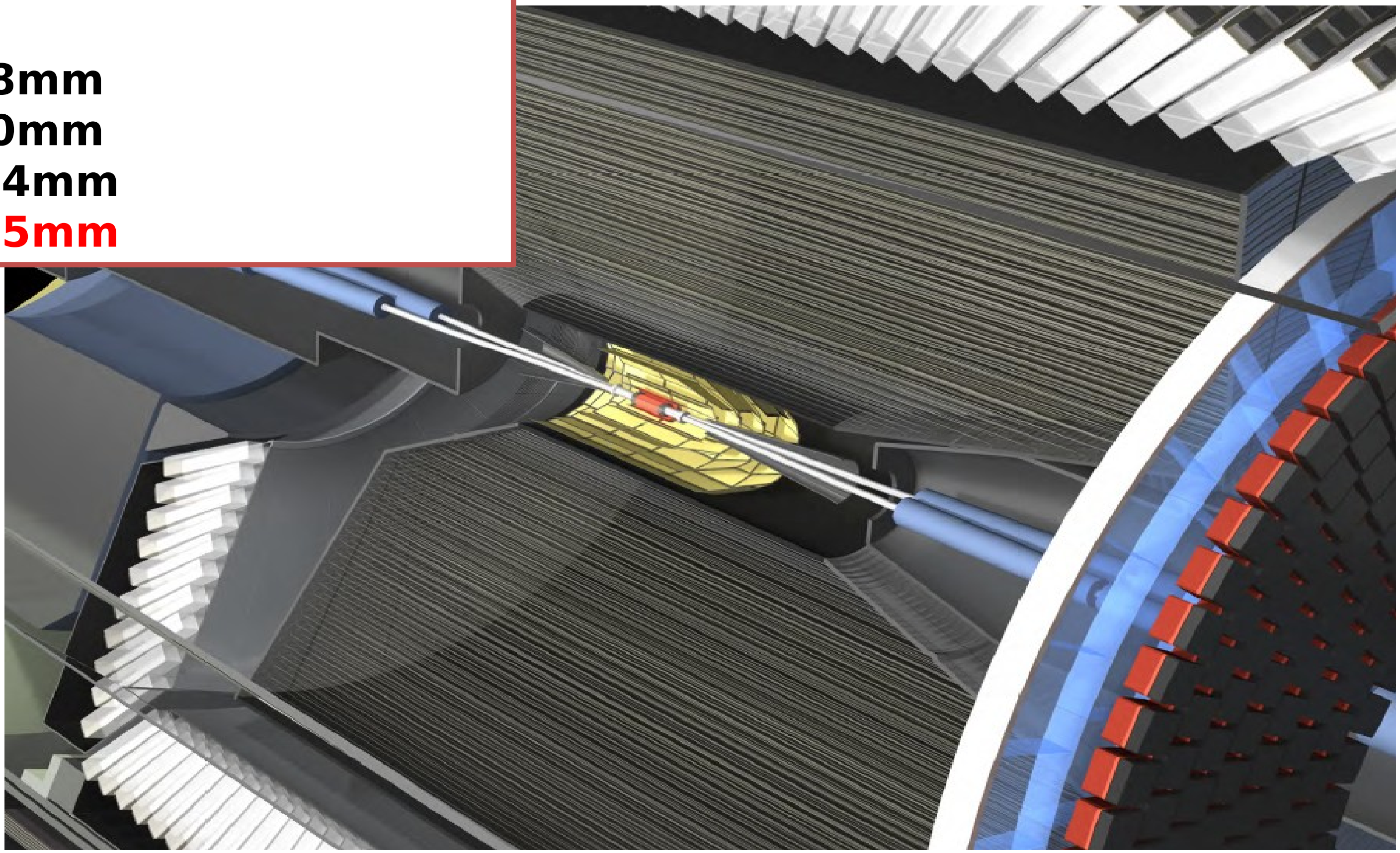
2016 Schedule



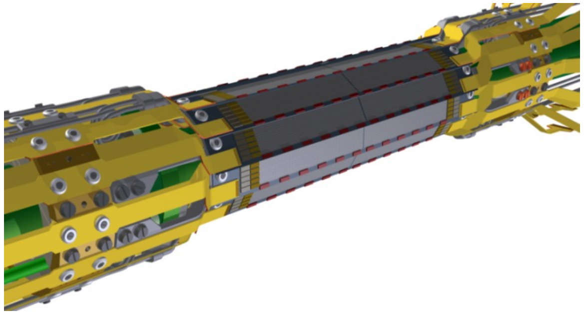
Belle II Detector – vertex region

VXD

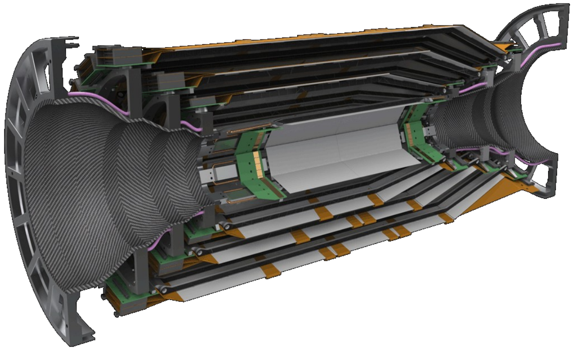
Beam Pipe r = 10mm
DEPFET (PXD)
Layer 1 r = 14mm
Layer 2 r = 22mm
DSSD (SVD)
Layer 3 r = 38mm
Layer 4 r = 80mm
Layer 5 r = 104mm
Layer 6 r = 135mm

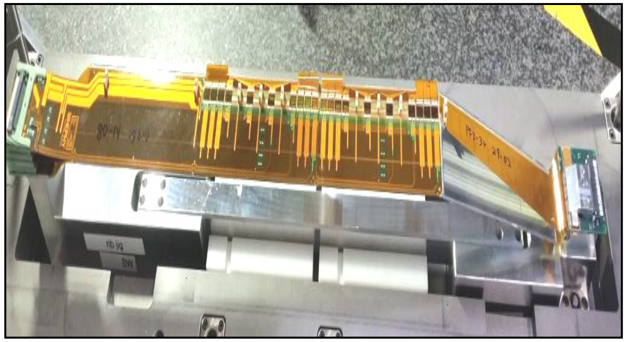


VXD



PXD two layer simple barrel
DEPFET
Layer 1 r = 14mm
Layer 2 r = 22mm



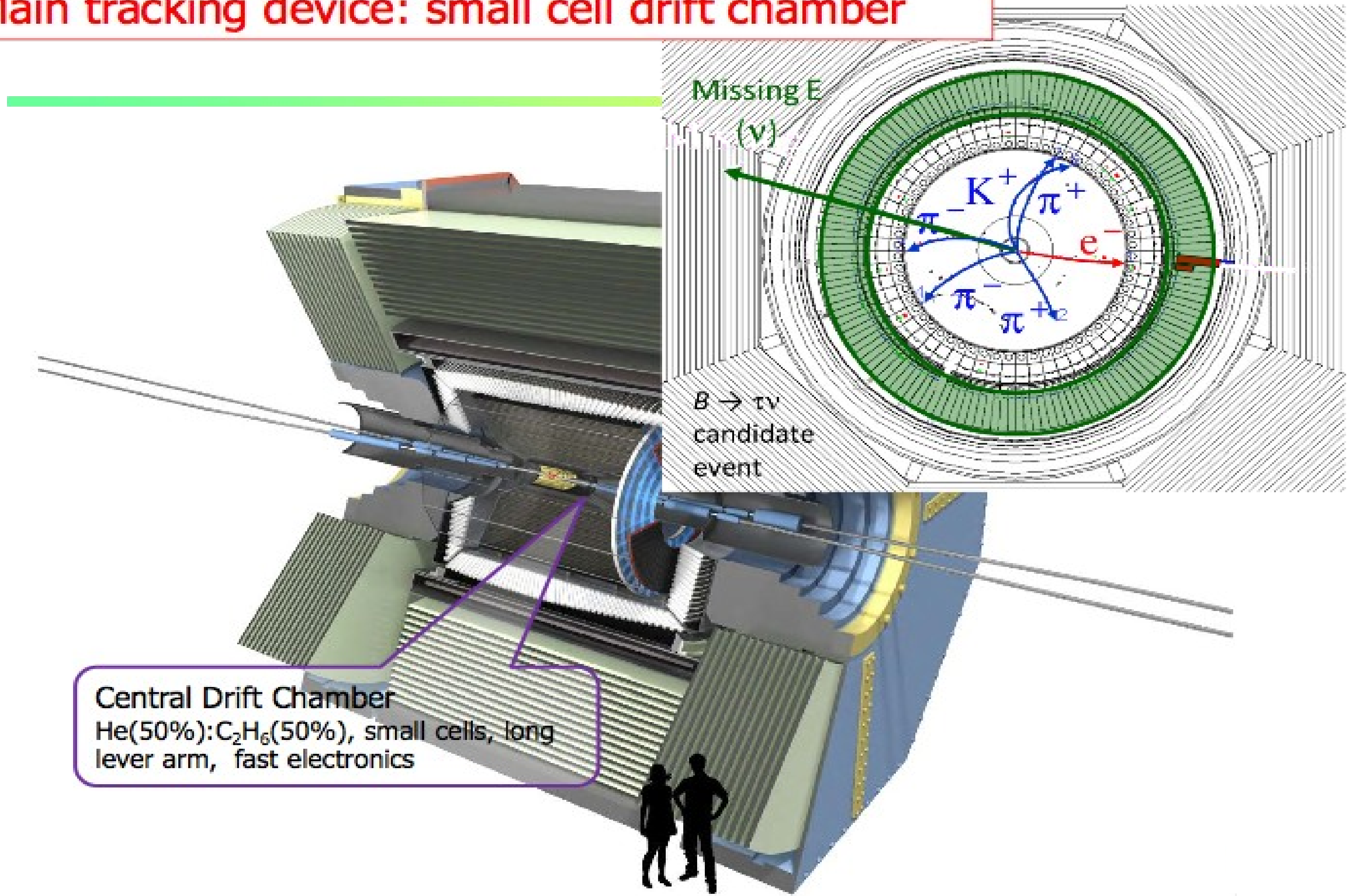


SVD
DSSD
Layer 3 r = 38mm
Layer 4 r = 80mm
Layer 5 r = 104mm
Layer 6 r = 135mm

	2014			**2015**												**2016**						
Site	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Pisa	**CCQ**							**CBQ**									**CAM**					
Melbourne							**PCCQ**				**CCQ**			**CBQ**			**CCQ**		CAM			
TIFR					**PCCQ**			**CCQ**								**CCQ**	CBQ	**CAM**				
Hephy				**PCCQ**							**CBQ**							**CAM**				
IPMU	**PCCQ**									**CCQ**						**CCQ**		CBQ	**CAM**			
																	TODAY					

- Development
- Class C production (mechanical)
- Class B production (electrical)
- Class A production

Main tracking device: small cell drift chamber



CDC status

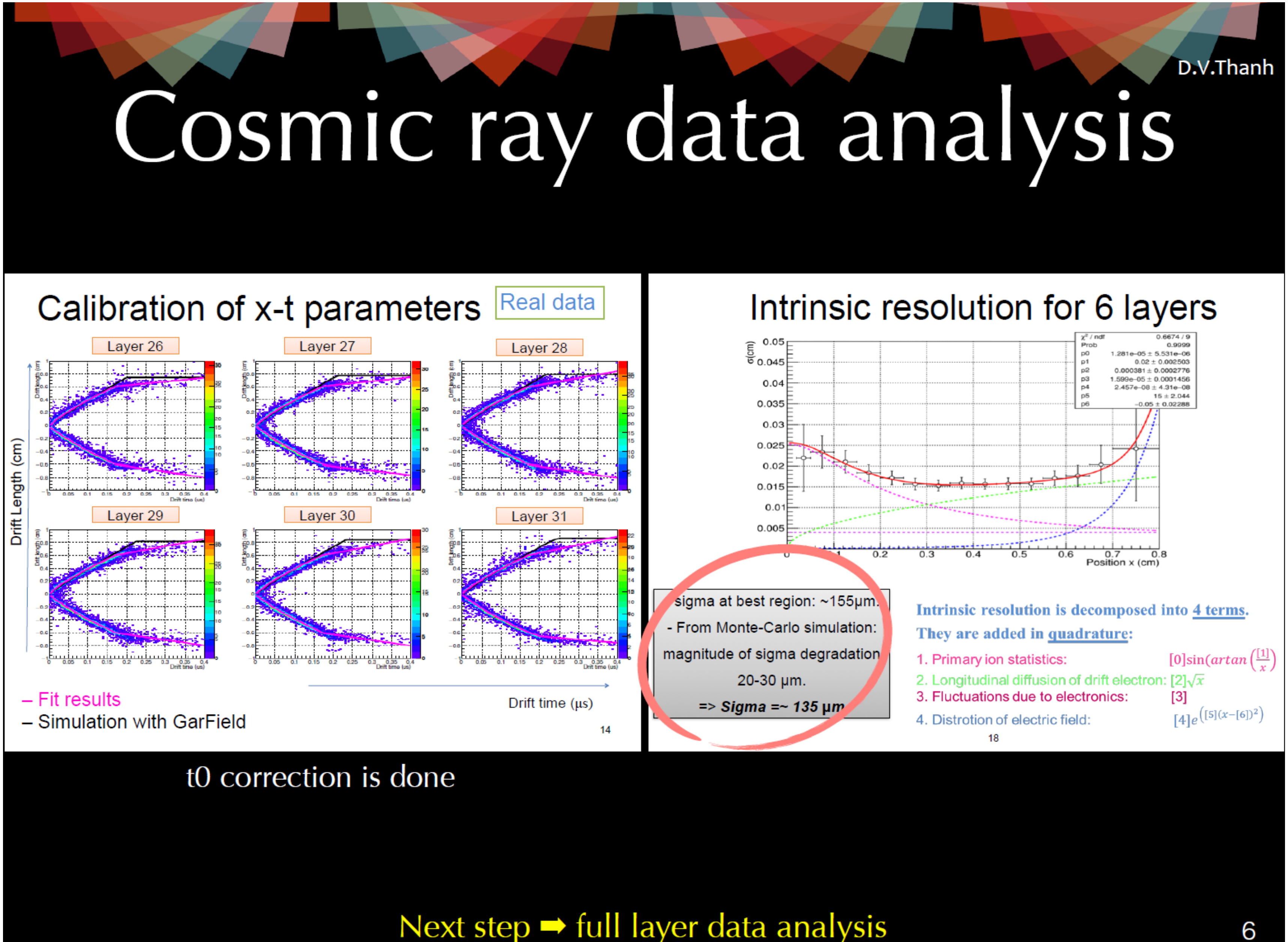
- 14336 drifts cell with sense wires
Spacial resolution 100 um

- Smaller cell in innermost layer

- Fully constructed

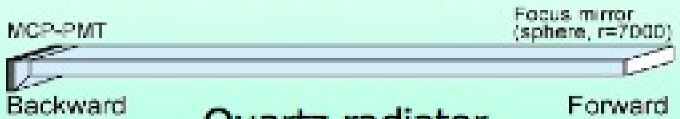
- Cosmic data validation

CDC: cosmic ray tests



Particle Identification

Barrel PID: Time of Propagation Counter (TOP)



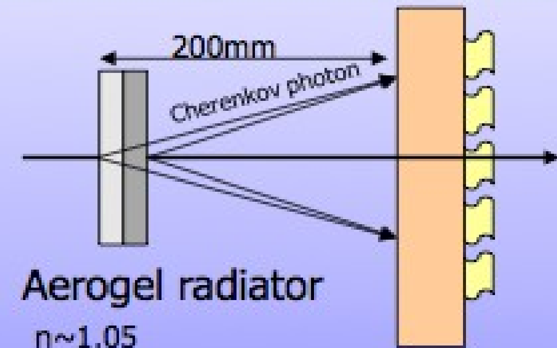
Quartz radiator

Focusing mirror

Small expansion block

Hamamatsu MCP-PMT (measure t, x and y)

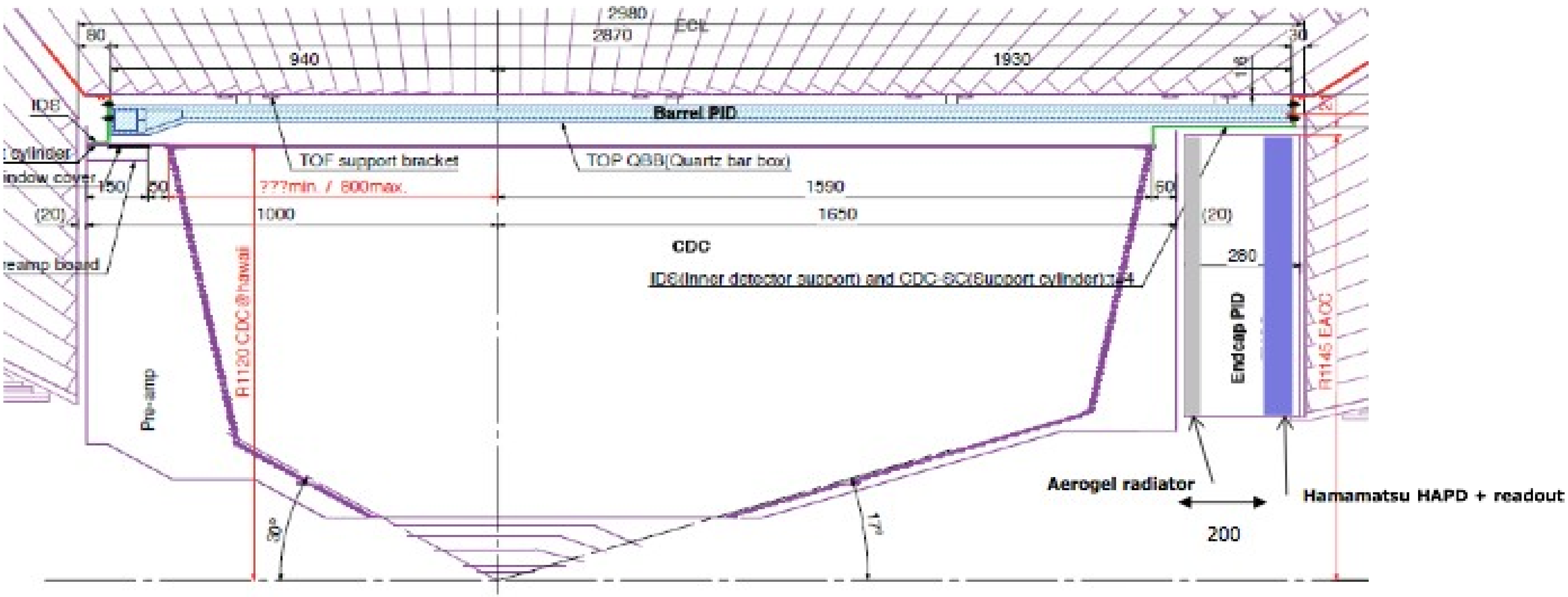
Endcap PID: Aerogel RICH (ARICH)



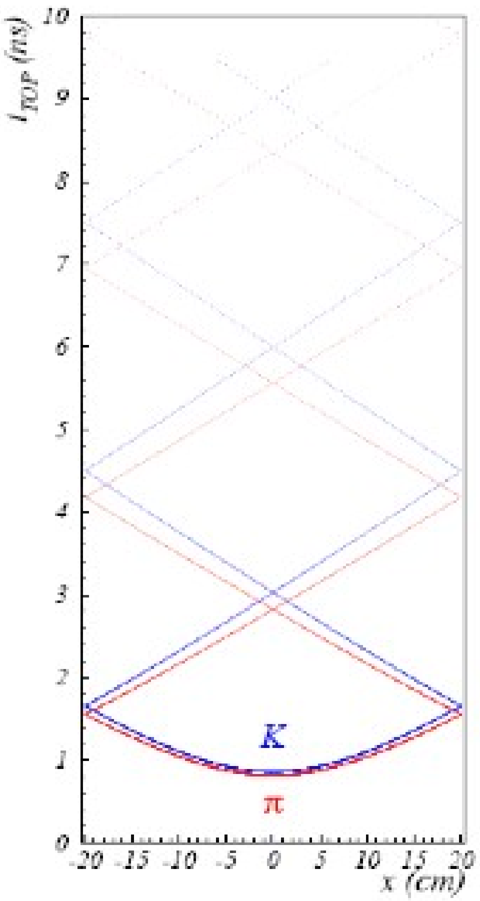
Aerogel radiator

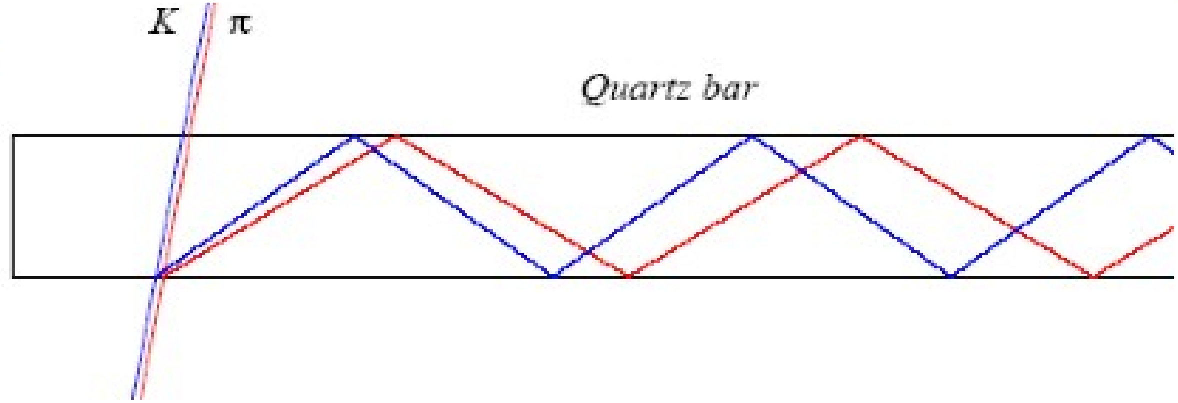
n~1.05

Hamamatsu HAPD
+ new ASIC



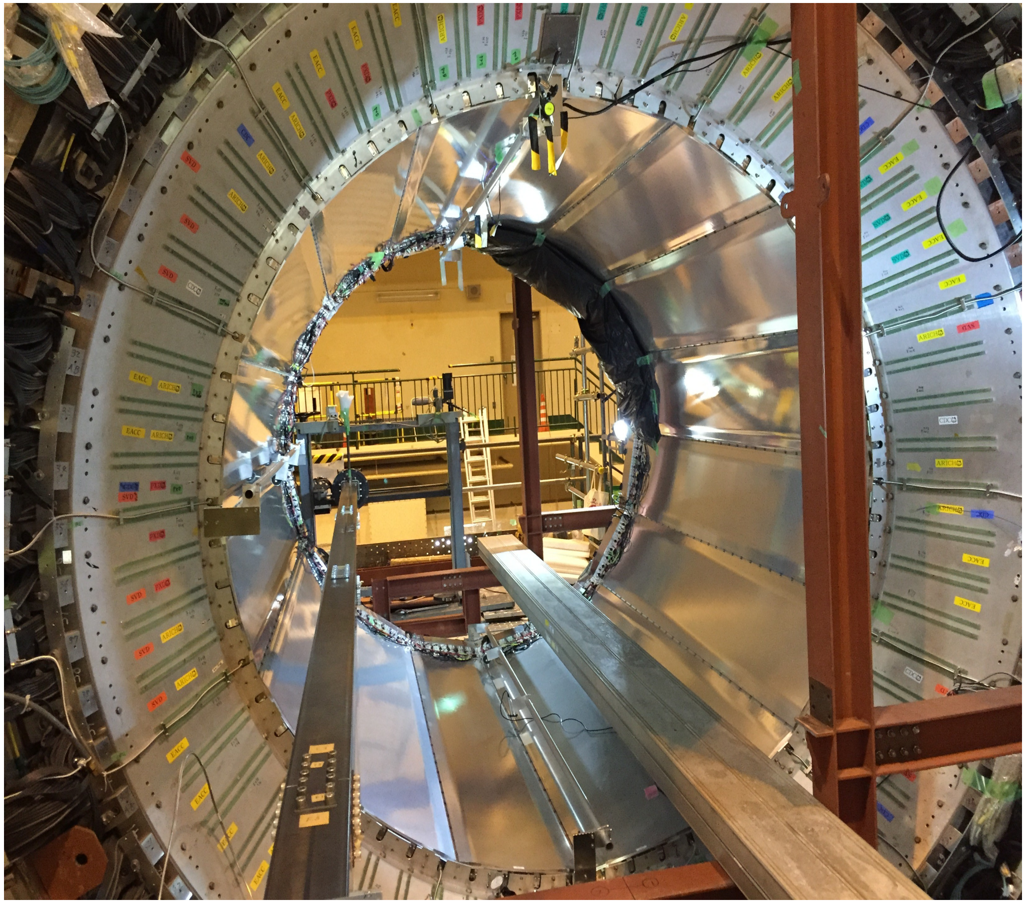
Barrel PID, Time of propagation counter (TOF)





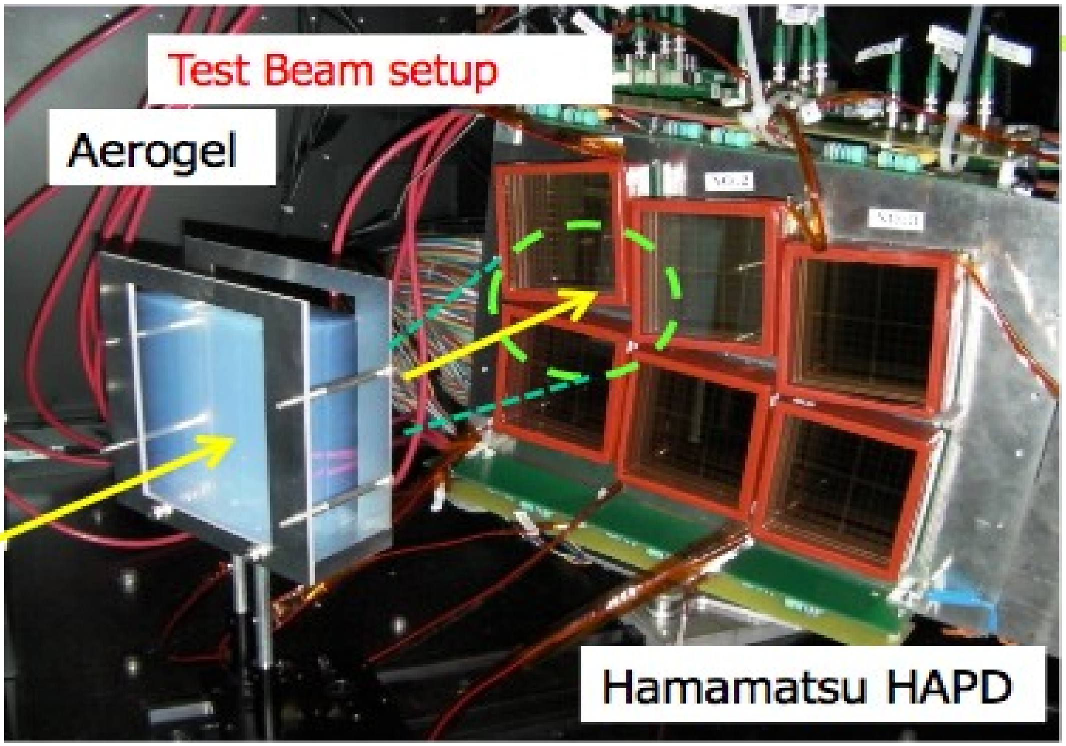
- Cherenkov ring imaging with precise time measurement.
- Device uses internal reflection of Cerenkov ring images from quartz like the BaBar DIRC
- Reconstruct Cherenkov angle from two hit coordinates and the time of propagation of the photon
  - Quartz radiator (2cm)
  - Photon detector (MCP-PMT)
    - Good time resolution ~ 40 ps
    - Single photon sensitivity in 1.5 T field
    - Hamamatsu SL10

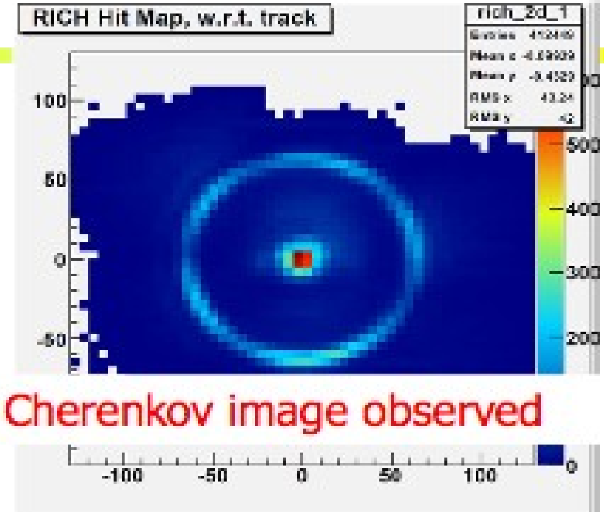
TOP status



- Installation completed on may 12th
- It is being prepared to be tested with cosmic runs
- Check stability under fast removal performance going well

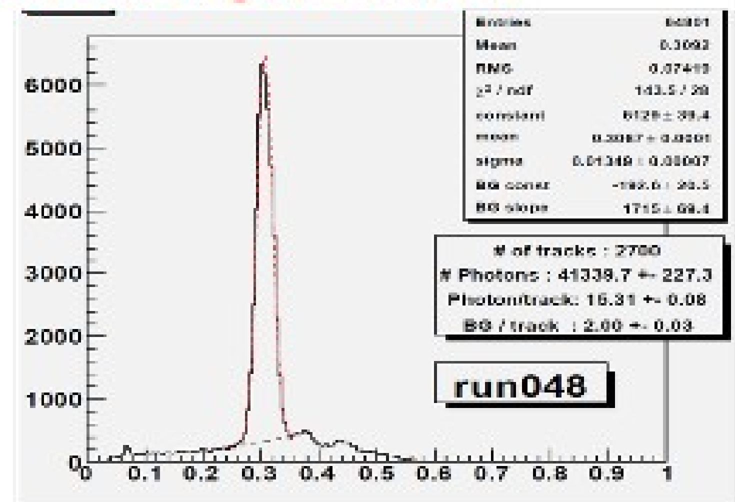
AEROGEL RICH (end cap PID)





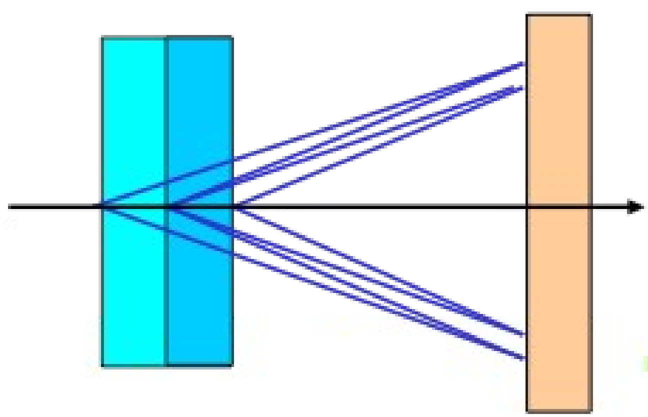
Clear Cherenkov image observed

Cherenkov angle distribution



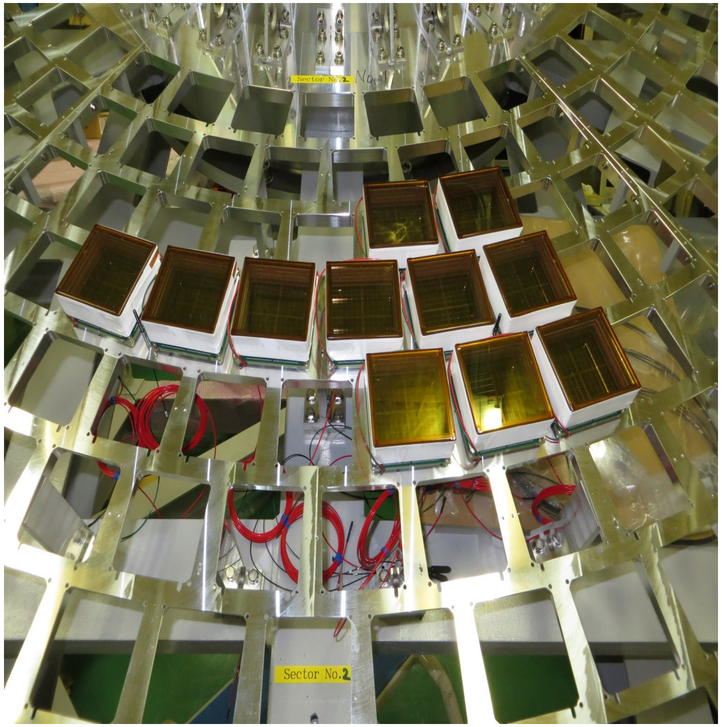
RICH with a novel "focusing" radiator – a two layer radiator

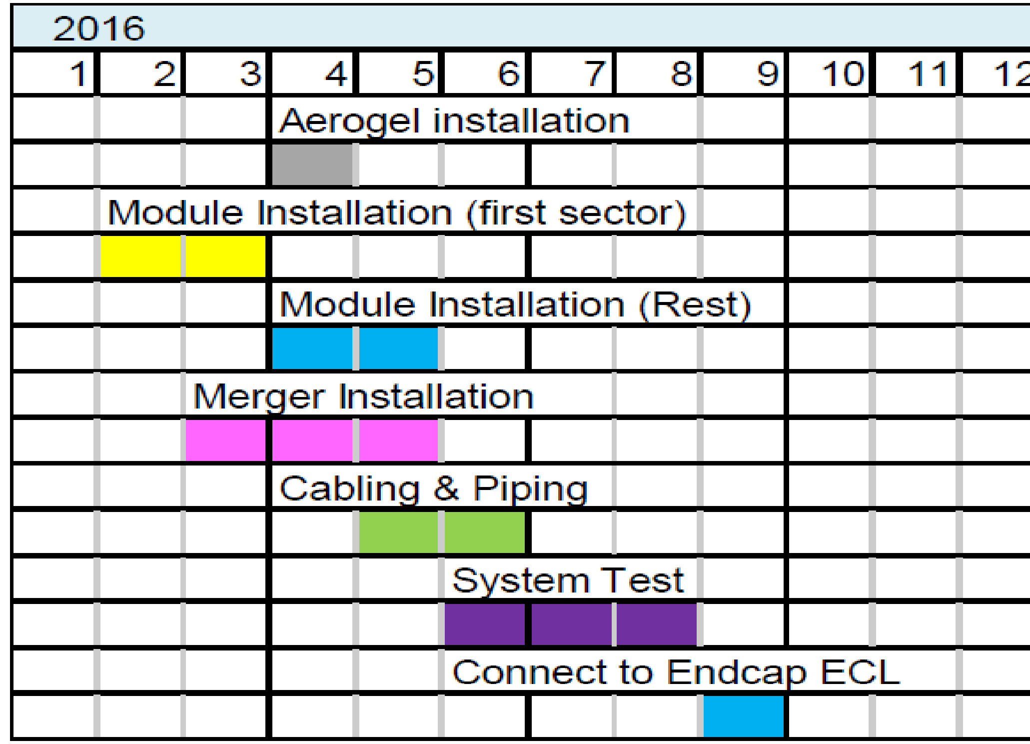
Employ multiple layers with different refractive indices→ Cherenkov images from individual layers overlap on the photon detector.



6.6 σ π/K at 4GeV/c !

ARICH

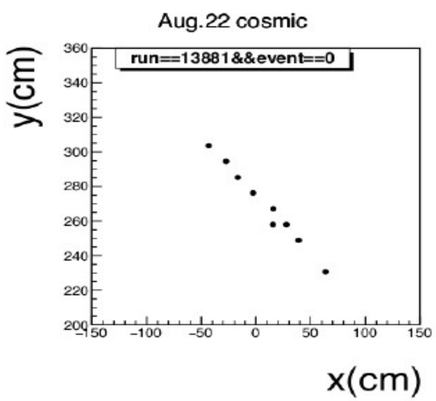


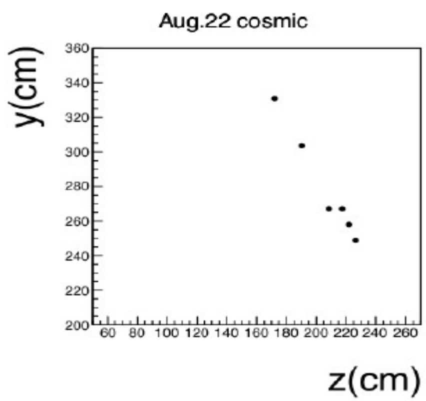


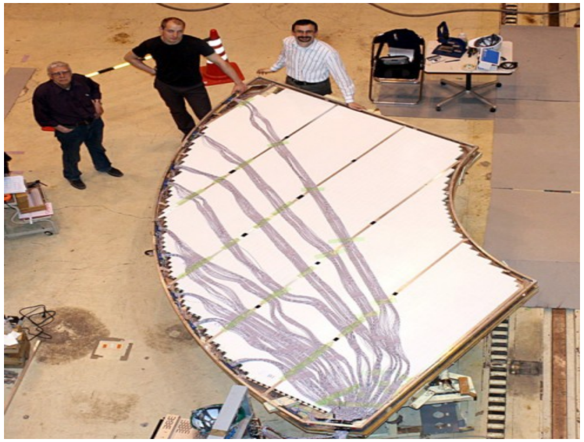
- Tests with a partially equipped detector + cosmics

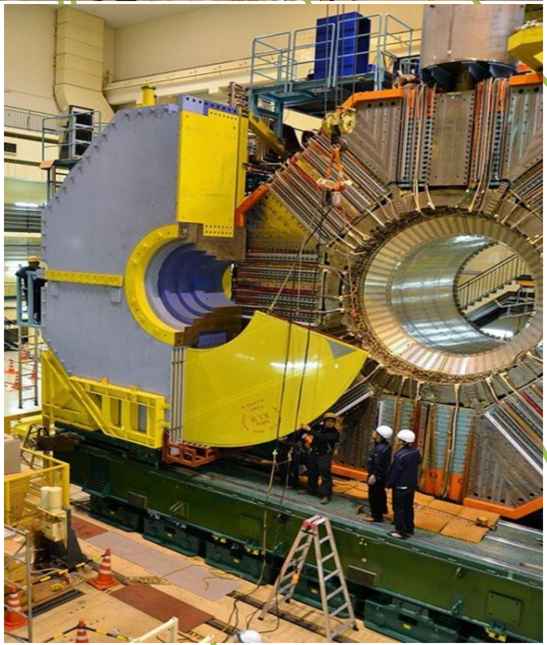
KLM status

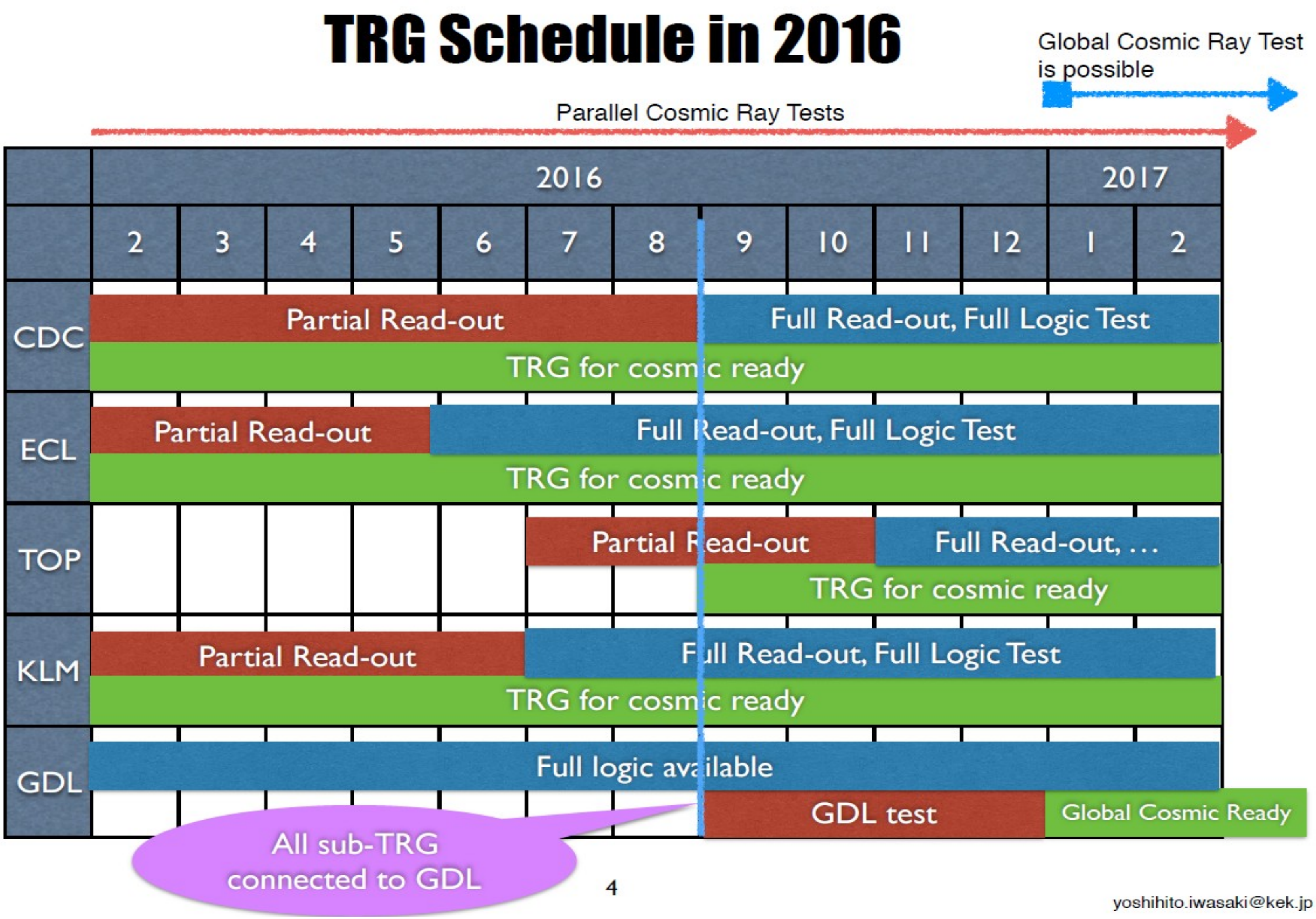
KLM
- Hardware and DAQ is in place an installed
- Taking cosmic data
- Implementing trigger with TOP





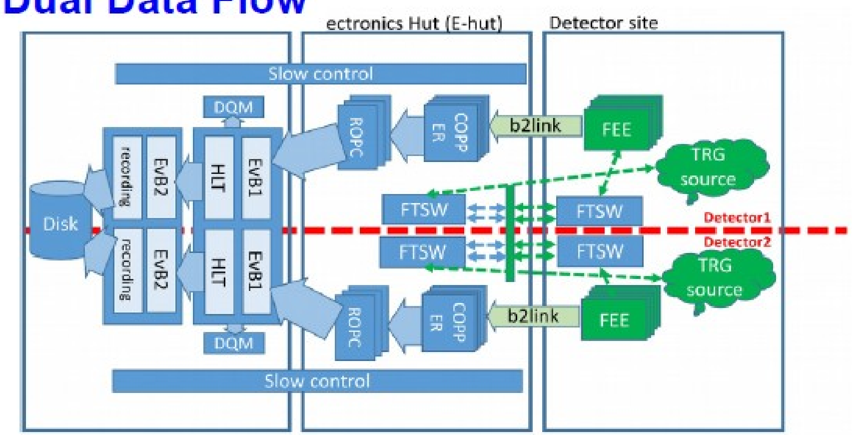




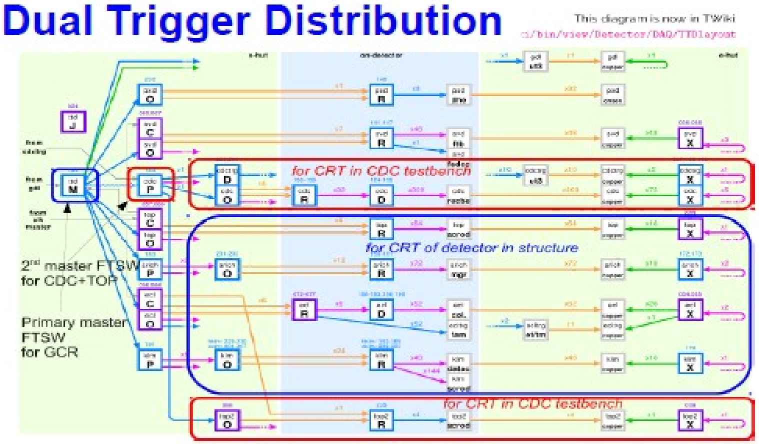

TRG Schedule in 2016
Global Cosmic Ray Test is possible
Parallel Cosmic Ray Tests
2016
2017
2 3 4 5 6 7 8 9 10 11 12 1 2
CDC
Partial Read-out
Full Read-out, Full Logic Test
TRG for cosmic ready
ECL
Partial Read-out
Full Read-out, Full Logic Test
TRG for cosmic ready
TOP
Partial Read-out
Full Read-out, ...
TRG for cosmic ready
KLM
Partial Read-out
Full Read-out, Full Logic Test
TRG for cosmic ready
GDL
Full logic available
GDL test
Global Cosmic Ready
All sub-TRG connected to GDL
4
yoshihito.iwasaki@kek.jp

We are ready for multi-ring CRT circus + DESY TB!!

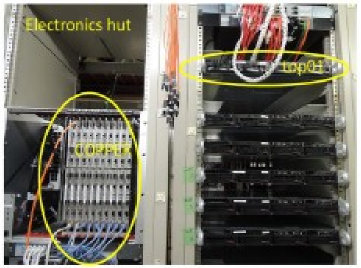
Dual Data Flow



Dual Trigger Distribution



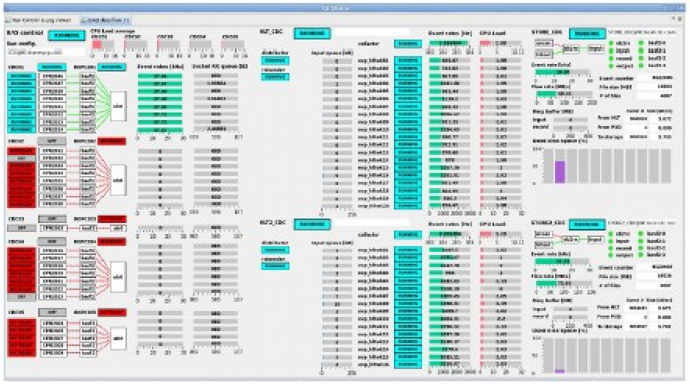
TOP COPPERs



CDC COPPERs

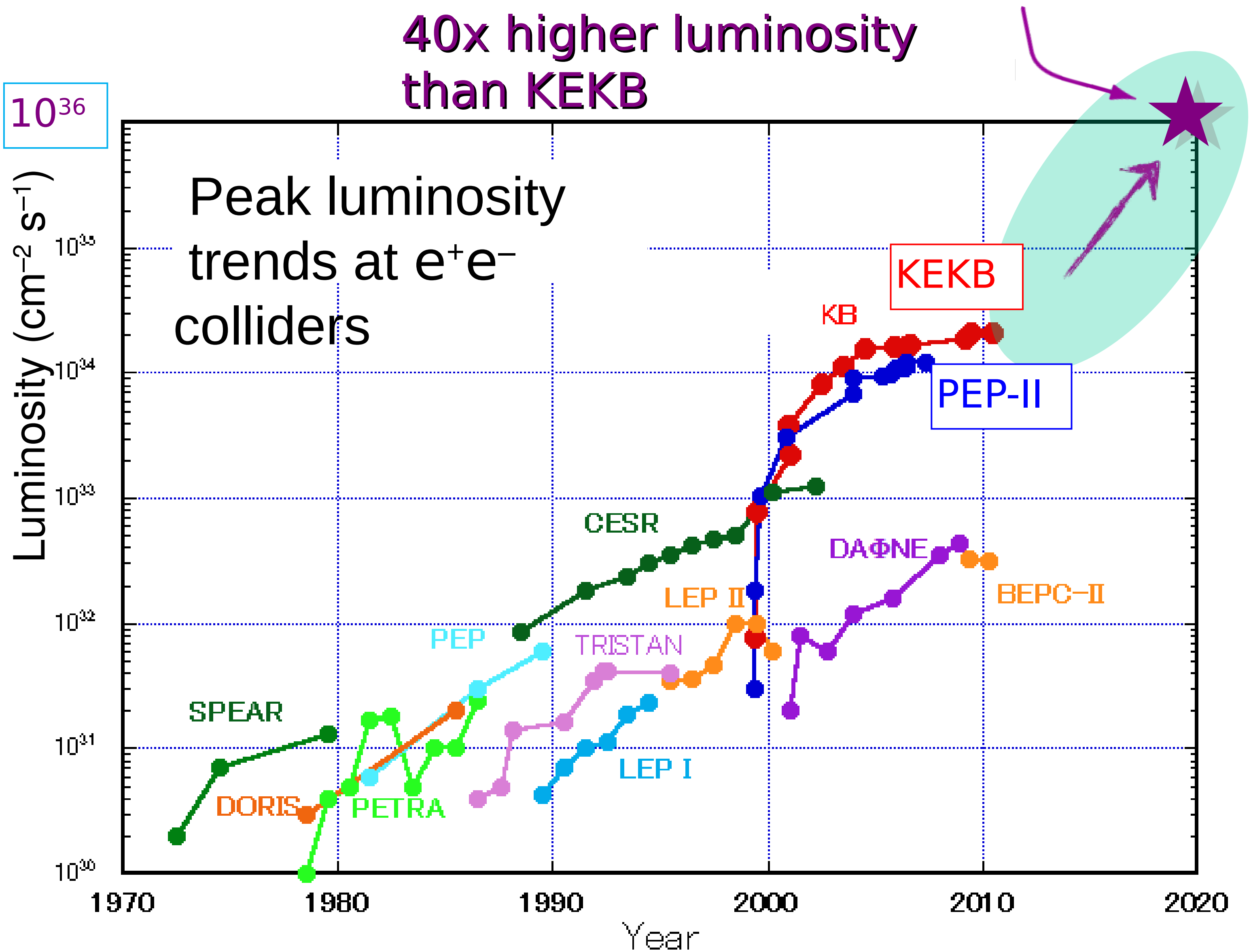
2 HLT+ Storage

Control GUI (data flow panel)



ACCELERATOR

SuperKEKB is the intensity frontier



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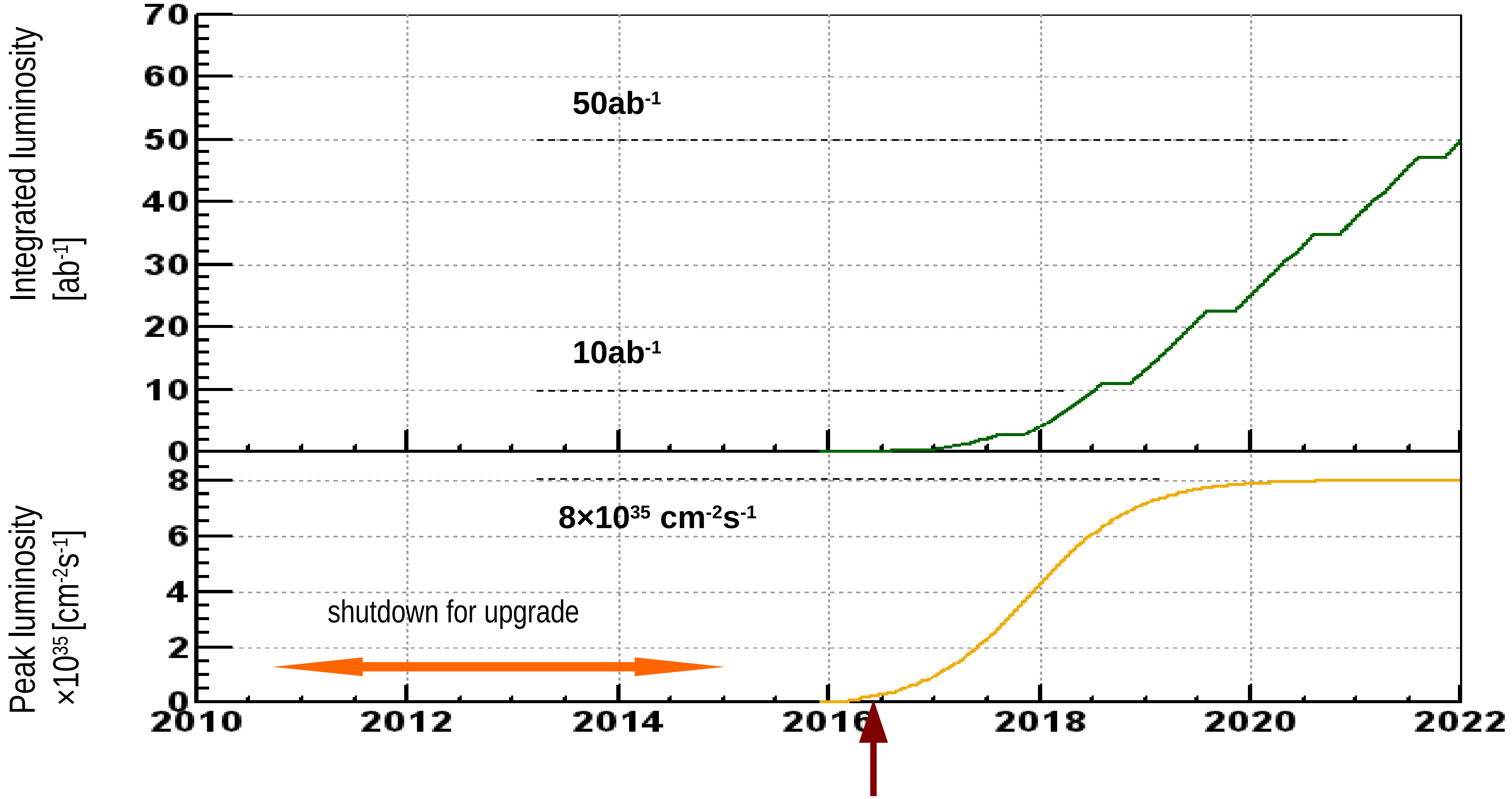
Luminosity prospects at SuperKEKB

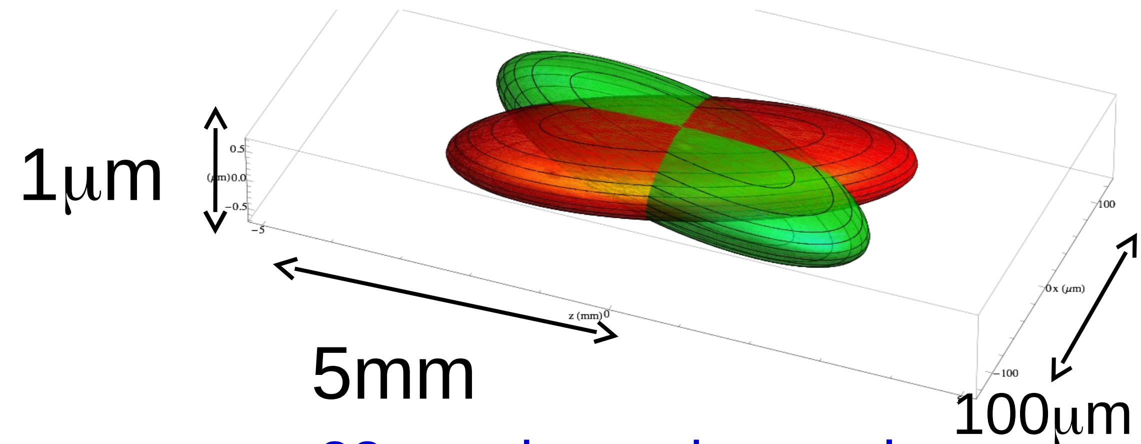


We are here,here, already data taking, physics runs around the corner

(without crab)

Nano-Beam implies quite a challenge in monitor and control of beam parameters

KEKB

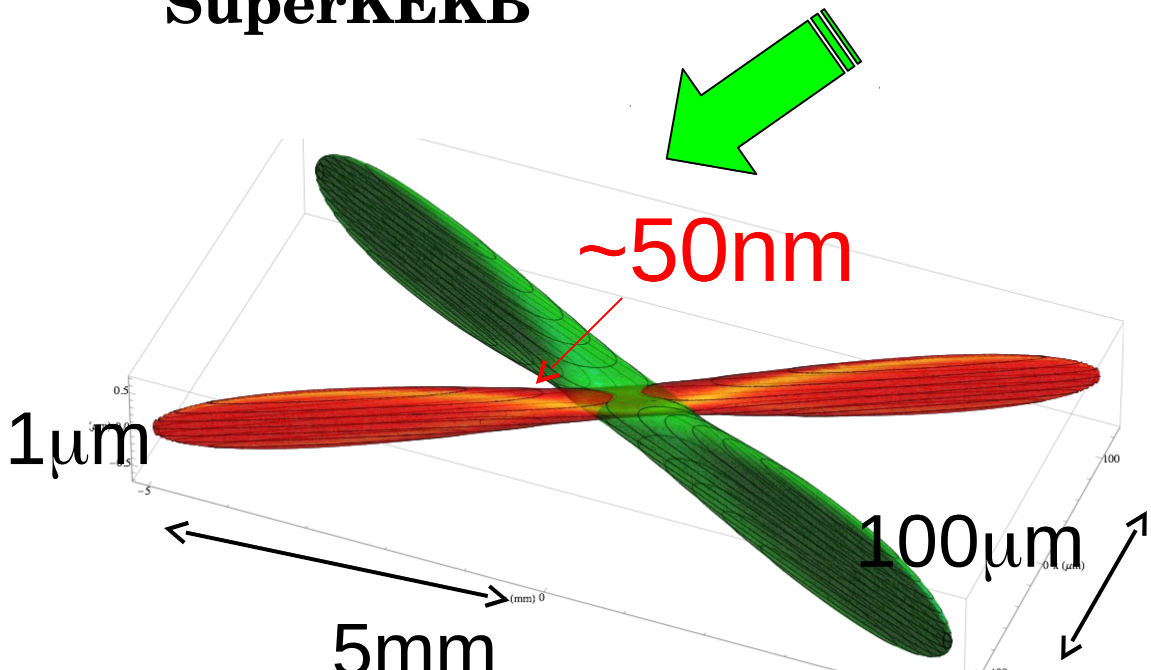


22 mrad crossing angle

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

$$L = \frac{N_+ N_- f}{4\pi\sigma_x^*\sigma_y^*} R_L$$

SuperKEKB



83 mrad crossing angle

Machine design parameters

parameters		KEKB LER	KEKB HER	SuperKEKB LER	SuperKEKB HER	units
Beam energy	E_b	3.5	8	4	7	GeV
Half crossing angle	φ	11		41.5		mrad
Horizontal emittance	ε_x	18	24	3.2	4.6	nm
Emittance ratio	κ	0.88	0.66	0.37	0.40	%
Beta functions at IP	β_x^*/β_y^*	1200/5.9		32/0.27	25/0.30	mm
Beam currents	I_b	1.64	1.19	3.60	2.60	A
beam-beam parameter	ξ_y	0.129	0.090	0.0881	0.0807	
Luminosity	**L**	**2.1×10^{34}**		**8×10^{35}**		**$cm^{-2}s^{-1}$**

- **Nano-beams and a factor of two more beam current** to increase luminosity
- **Large crossing angle**
- **Change beam energies** to solve the problem of short lifetime for the LER

SuperKEKB and Belle II x40 Higher luminosity!!

Belle II

New superconducting /permanent final focusing quads near the IP

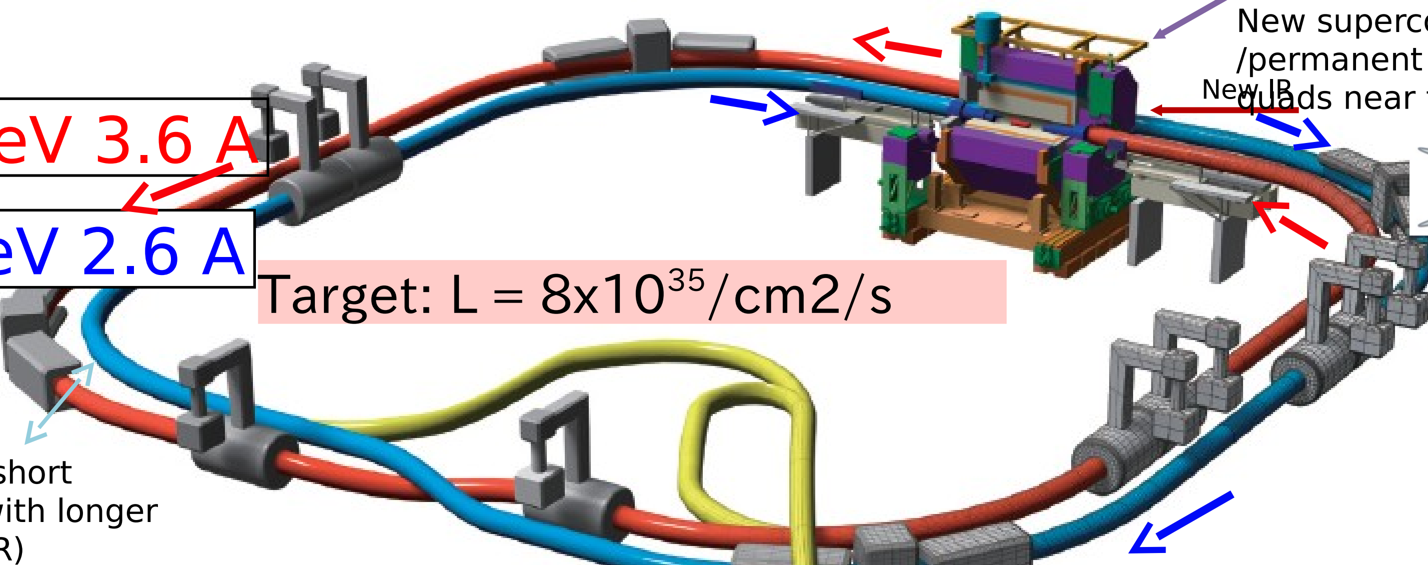
New IP

Colliding bunches

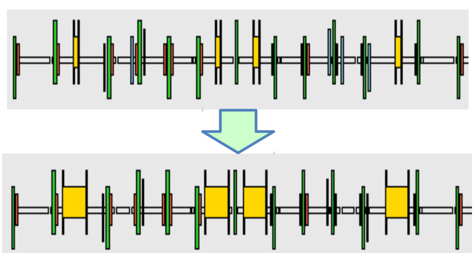
e+ 4GeV 3.6 A

e- 7GeV 2.6 A

Target: $L = 8x10^{35}/cm2/s$



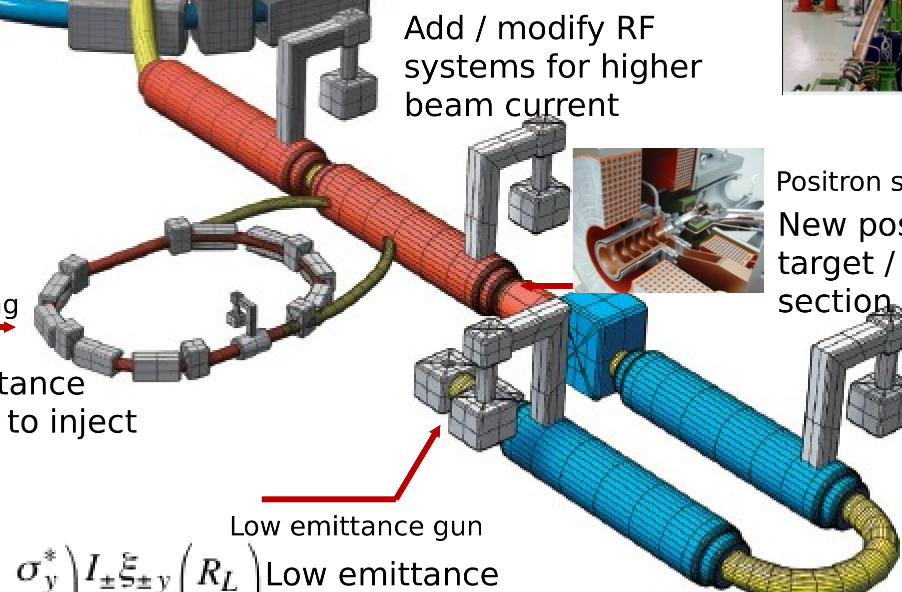
Replace short dipoles with longer ones (LER)



Redesign the lattices of HER & LER to squeeze the emittance

Add / modify RF systems for higher beam current

Positron source

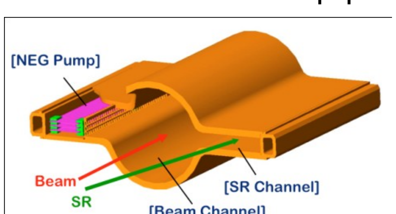


New positron target / capture section

Damping ring

Low emittance positrons to inject

TiN-coated beam pipe with antechambers



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

Low emittance gun

Low emittance electrons to inject

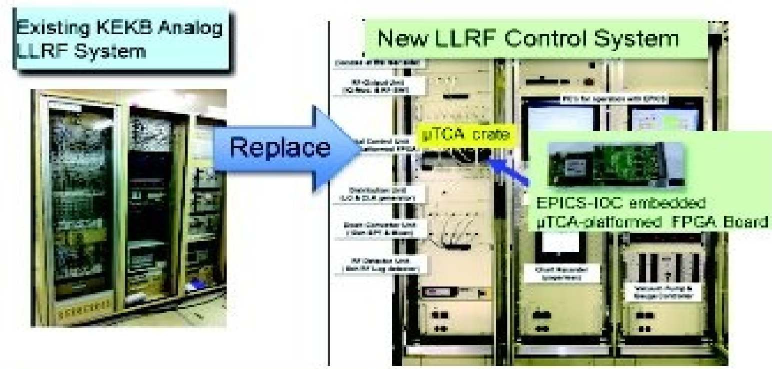
30

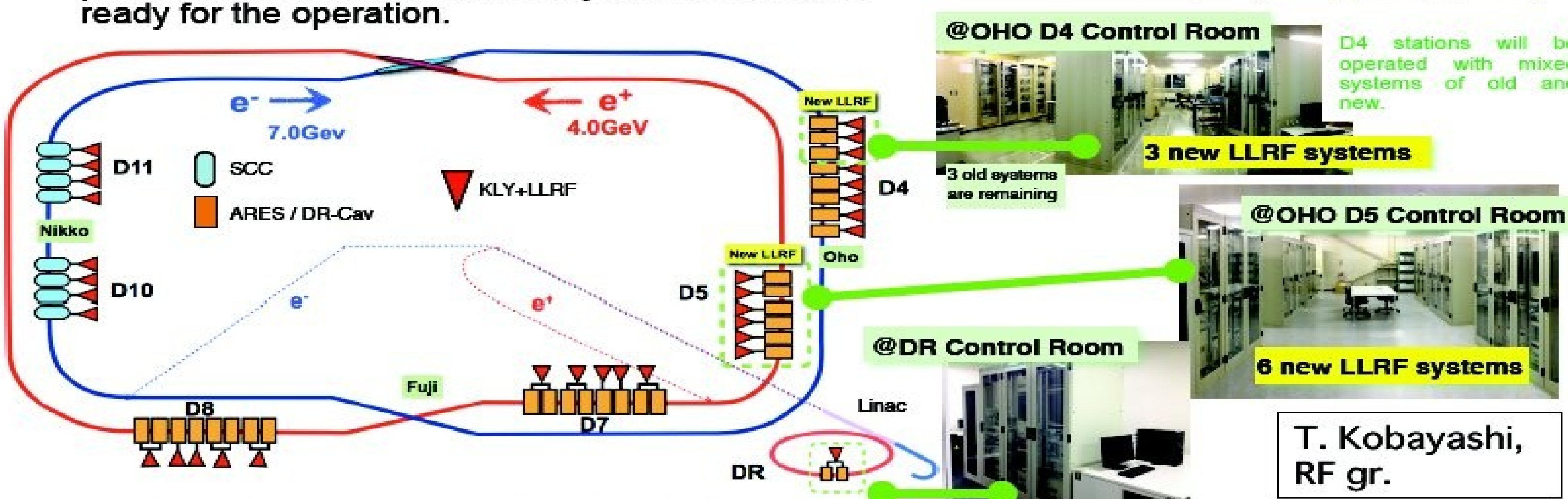
Task before first injection

- Alignment for beam pipes and beam transport lines
- Beam collimator
- Hardware ; pumps , gate valves , temperature sensors, flows sensors, compress air lines, etc.
- Safety check: Control and monitor software, operation check, beam abort signals and beams stoppers
- MR magnet system
- RF system: adding klystrons, power suplies, cavity conditioning

LLRF Status

- LLRF Control System was updated to a digital system.
- The new system consists of μTCA-platformed FPGA board (AMC), PLC and EPICS-IOC embeded with Linux-OS in each of them.
- Nine new systems were installed at Oho D4 and D5, and the DR-LLRF control system was also fabricated and installed.
- Performance of existing systems was also proofed. All MR-LLRF control systems are almost ready for the operation.

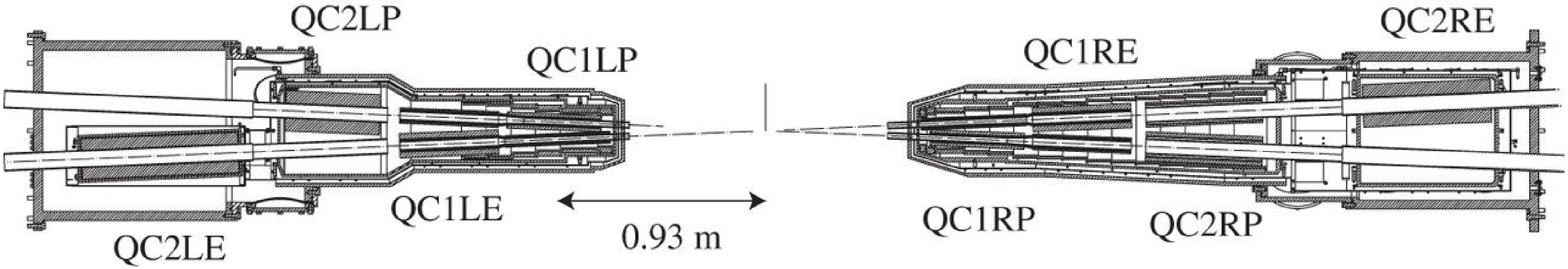




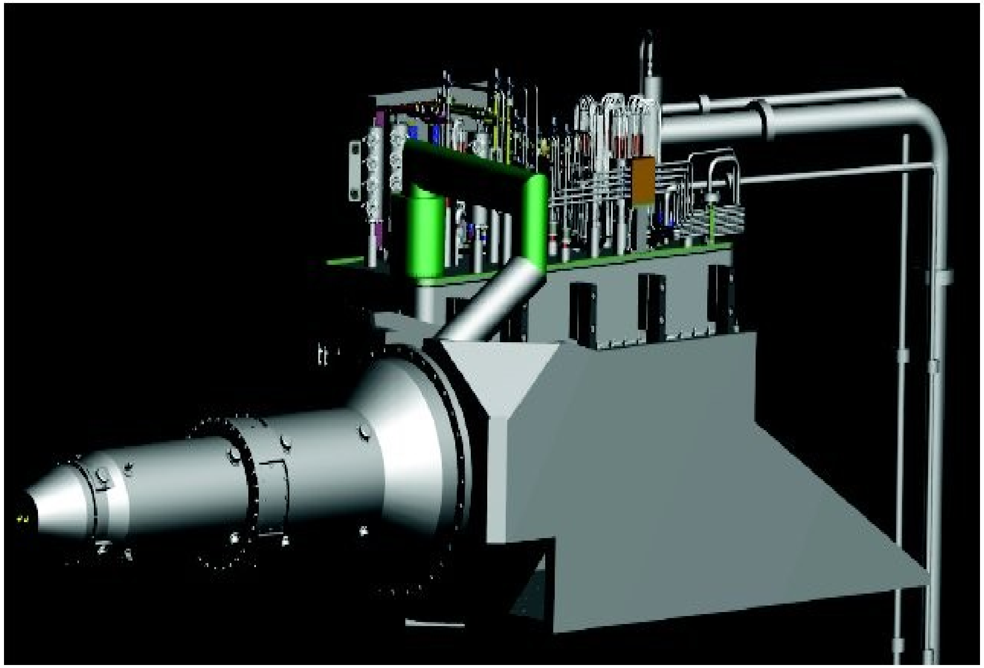
T. Kobayashi, RF gr.

K. AKAI, SuperKEKB status, schedule and plans, Feb. 1, 2016 @B2GM 11

Final focusing magnets (QCS)



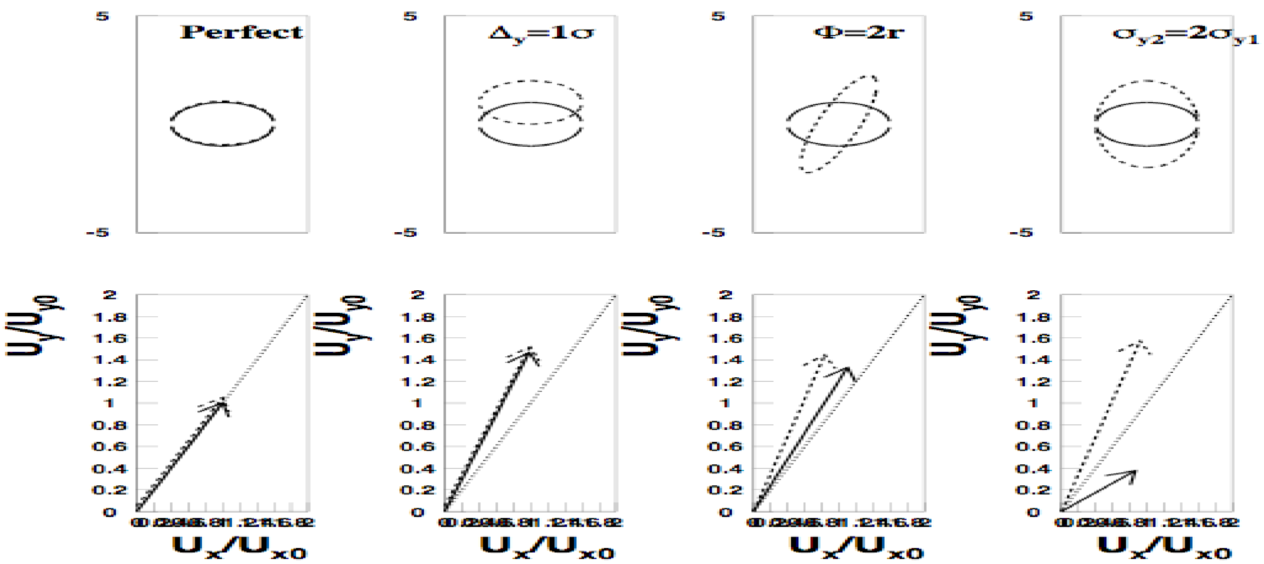
QCSL already being tested



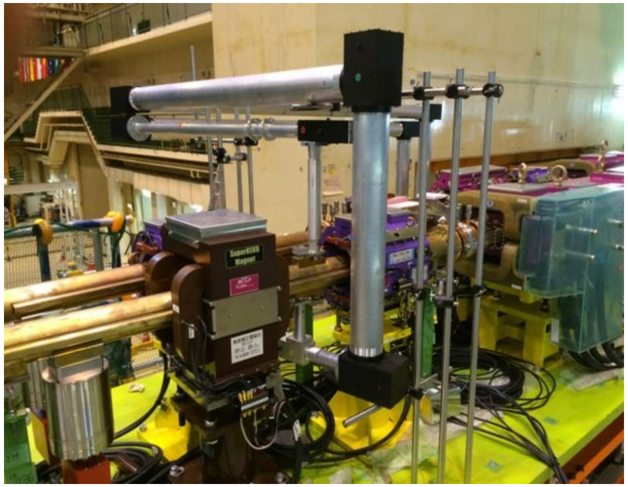
QCSR final design, september 2016 to be delivered

LABM

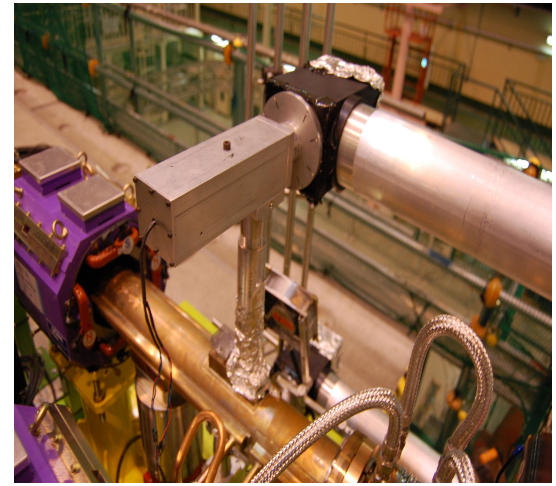
Some examples of Large Angle BMST pattern recognition (collinear beams case)
3 asymmetries are defined (4 are possible)



LABM installation

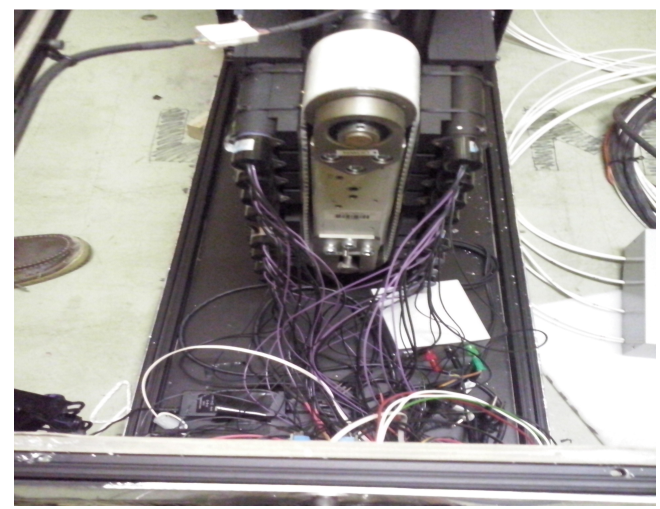


Installation before shielding



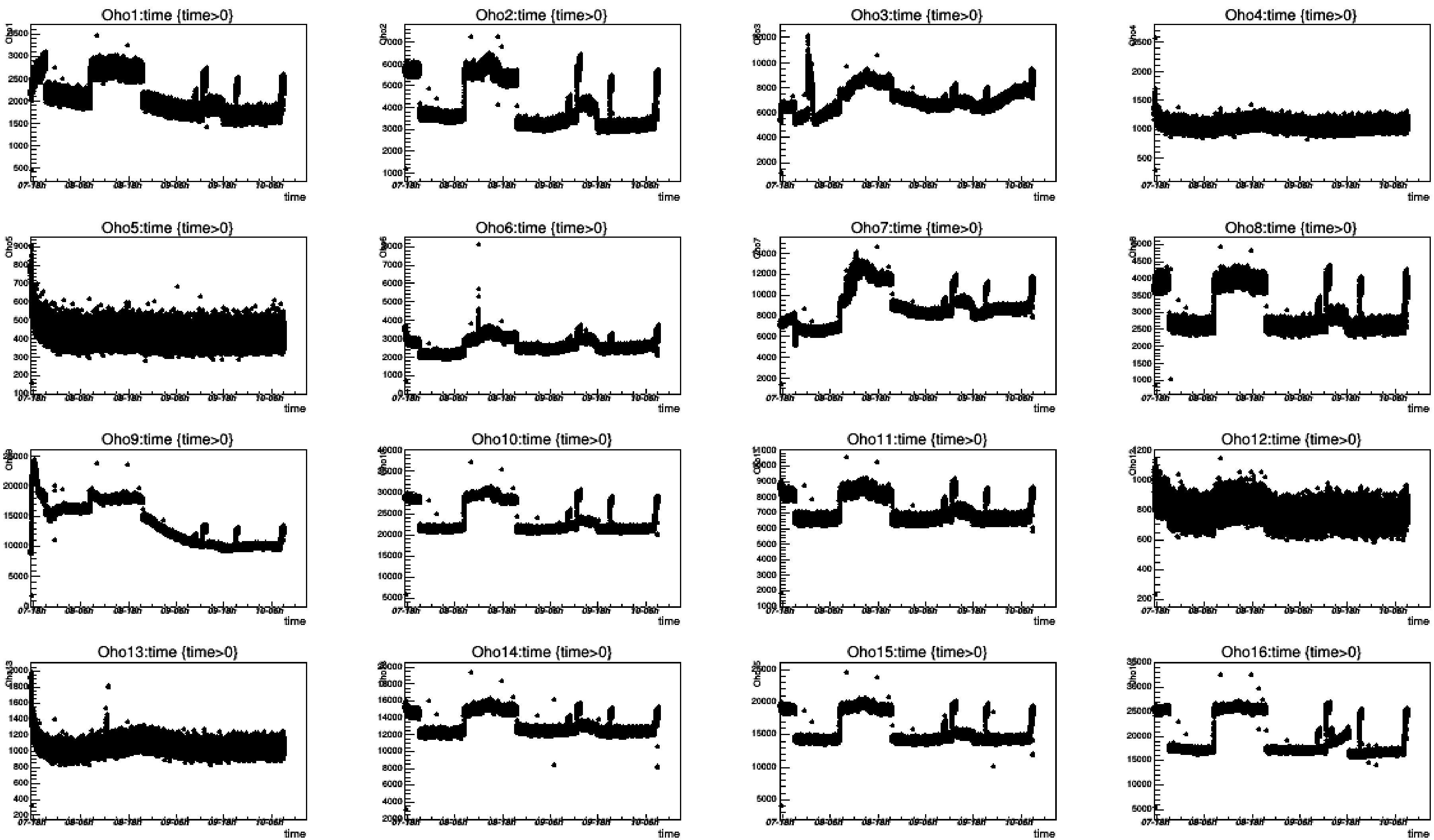
Primary mirror slow control

VME electronics and HV



Conveyor belt control, HV, light shielded

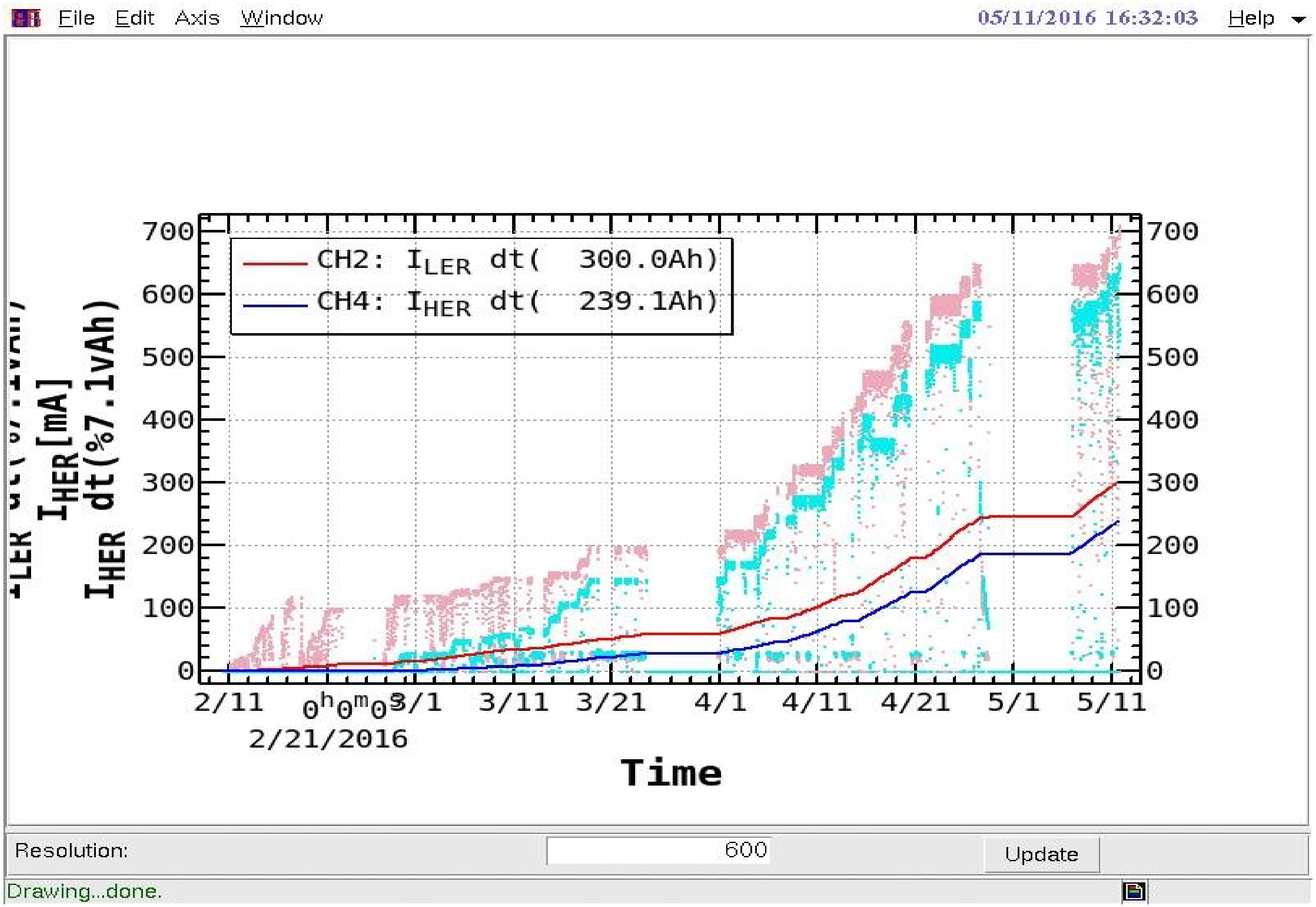
Rate monitoring



LABM plans

- We are taking data from February to June
- We got very good results
- As soon as they are approved, a note and a paper is expected
- Upgrade for phase 2, replace PMTs for SiPM

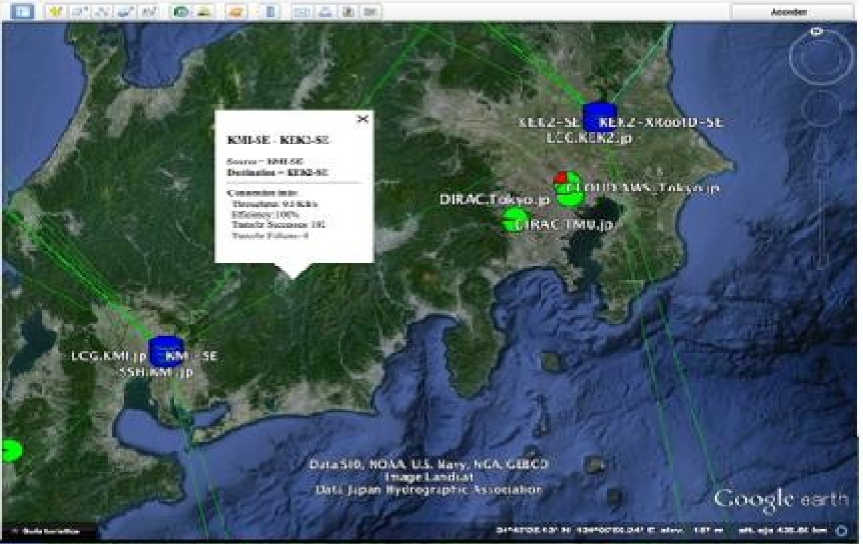
Great milestones 300 mA reached for LER (positrons) and 239 por HER(electrons)

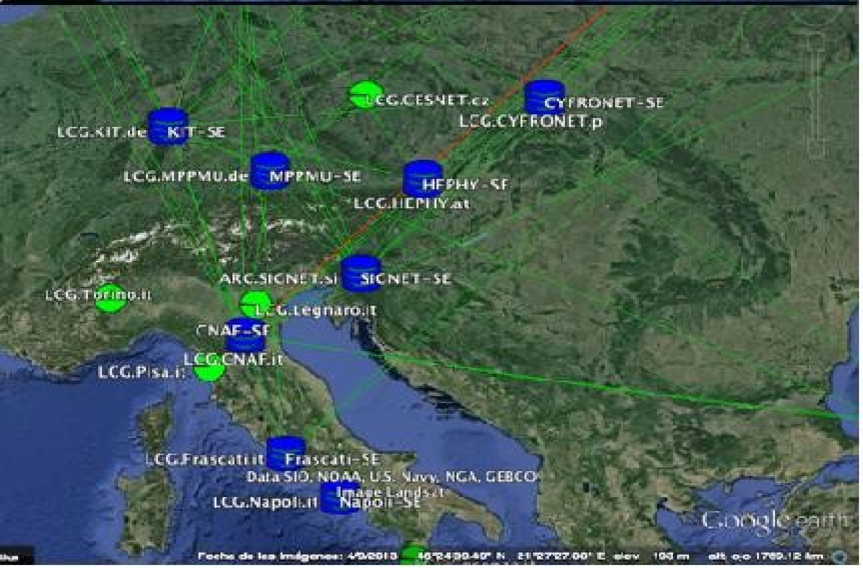


Computing and software

- Basf2 the computing framework is advanced to detector relates issues, geometry from DB, alignment, calibration, trigger simulation, beam background overlay,
- Last tunning of MC tools.
- GRID sites already developed, 17 countries, 20 K jobs, two sites in Mexico, CINVESTAV and UAS.
- Data transfer rehearsal successful (100 Gps Japan-US, 20 Gps Japan-EU).
- KekCC the main computer center in japan, upgraded form 4k to 10k cpus, from 24 to 84 Pb data.

Visualization of the Network connection





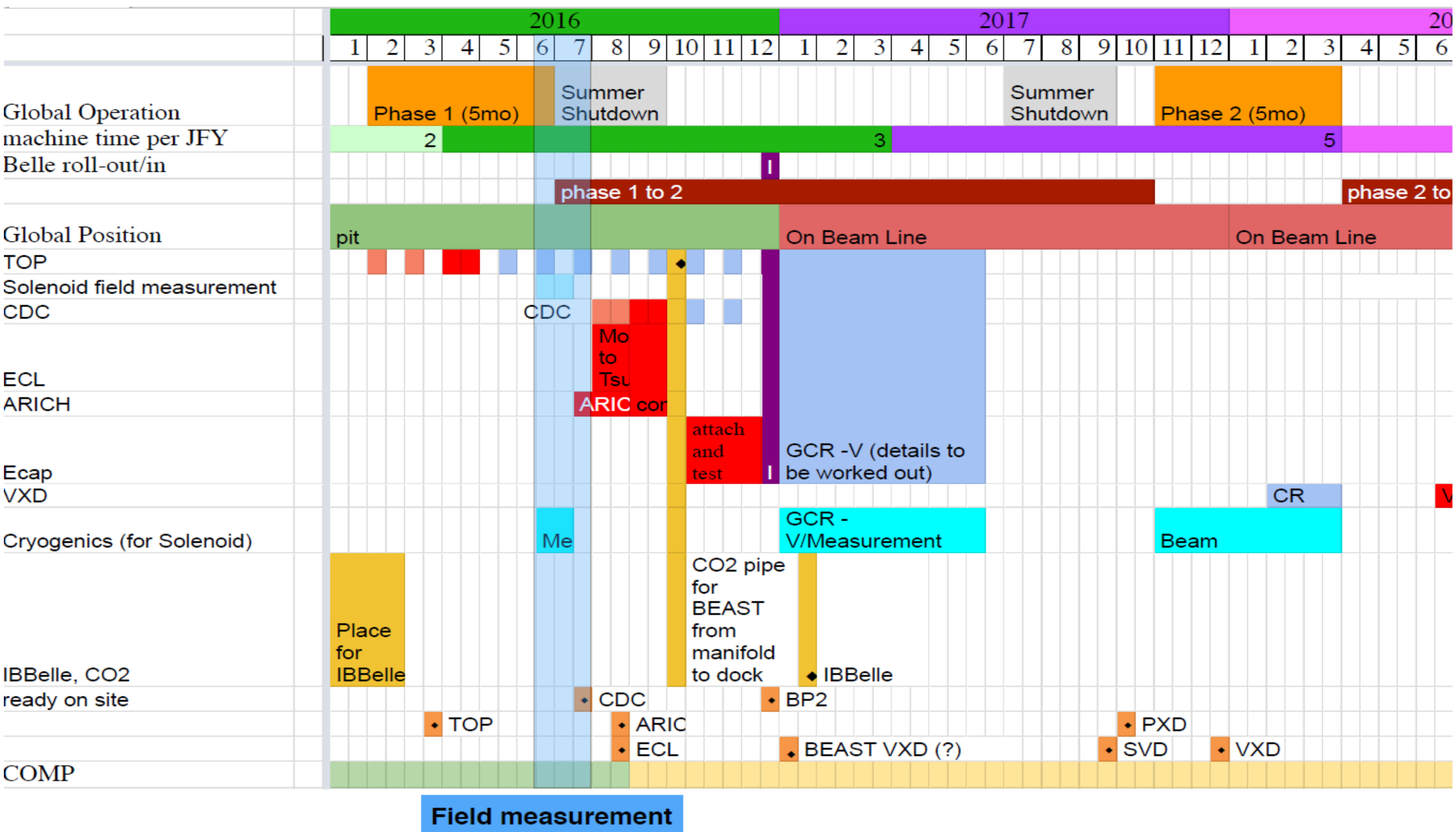
We have several network monitors

FTS3, PerfSONAR, MaDDash, etc.

Now, we have a nice visualization tool

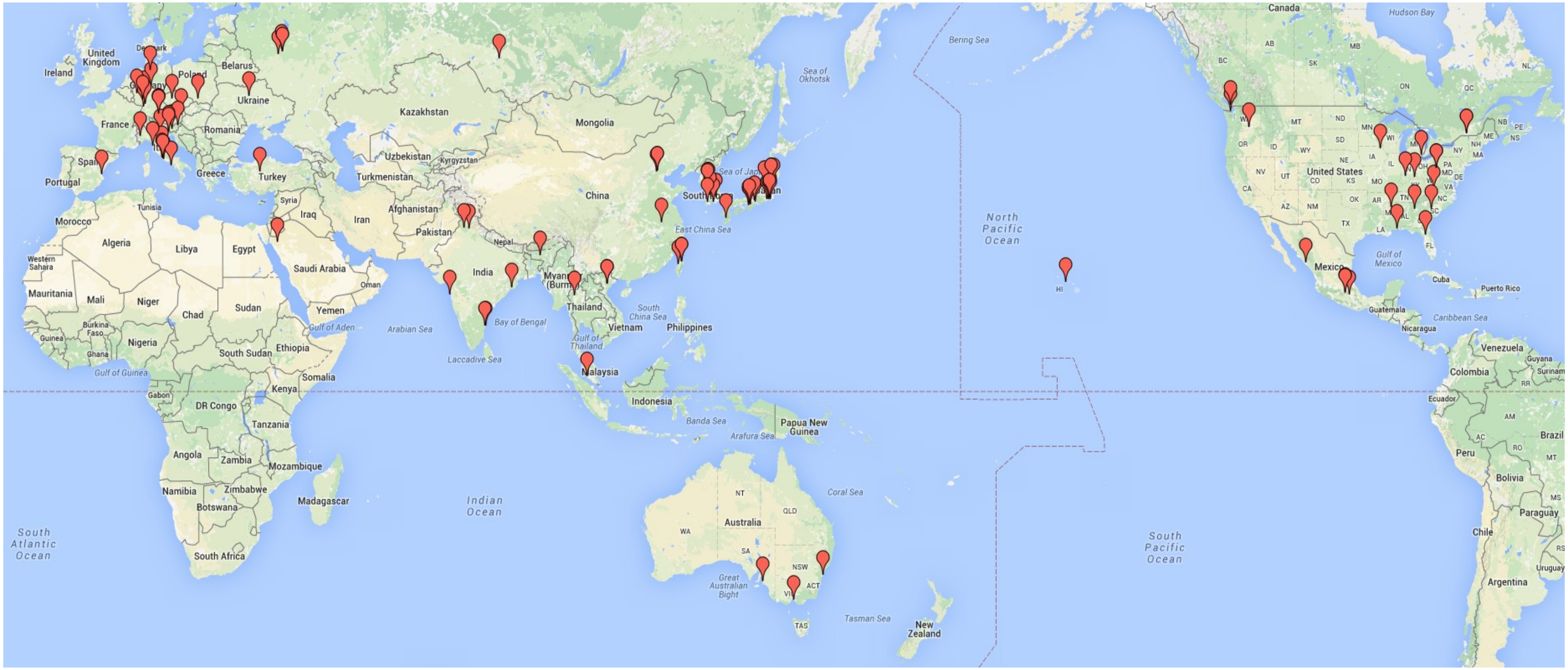
to watch the present network connection

Updated Installation Schedule



04.02.16: B2GM TB **B-Field Measurement** 13 carsten.niebuhr@desy.de

Belle II Collaboration



23 countries/regions, 98 institutions, 638 collaborators

Conclusions

- Physics goals are very well established, still opportunity for new ideas, BTIP is the perfect forum
- The accelerator is working very well ar phase 1.
- Sub detectors are started to go in full installation, no major trouble.
- Mexican participation is going as planned.
- Very exciting times, new results to come.