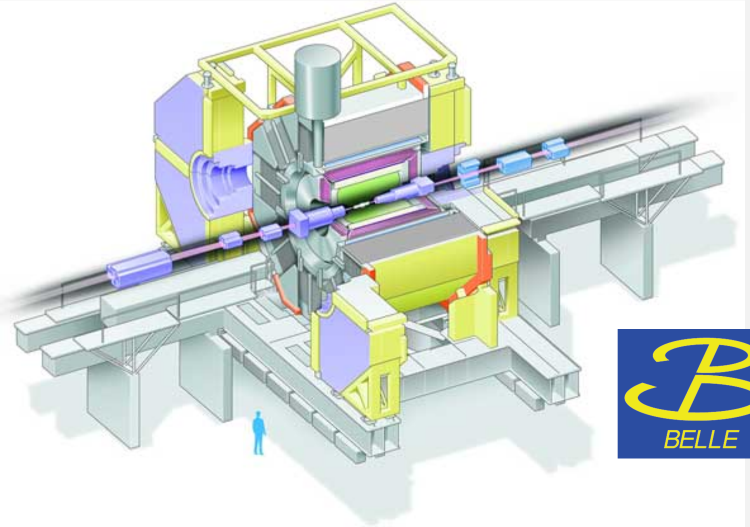
FIRST COLLISIONS AT BELLE II

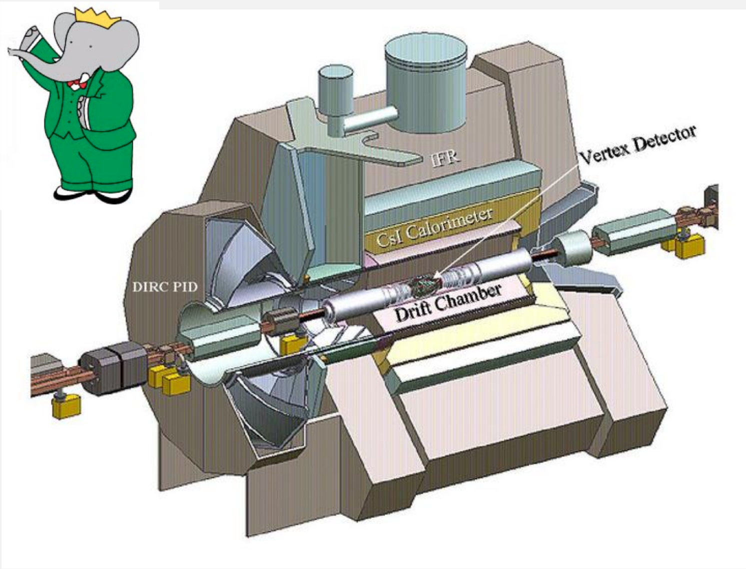
Anselm Vossen

For the Belle II Collaboration

CIPANP 2018

B FACTORIES

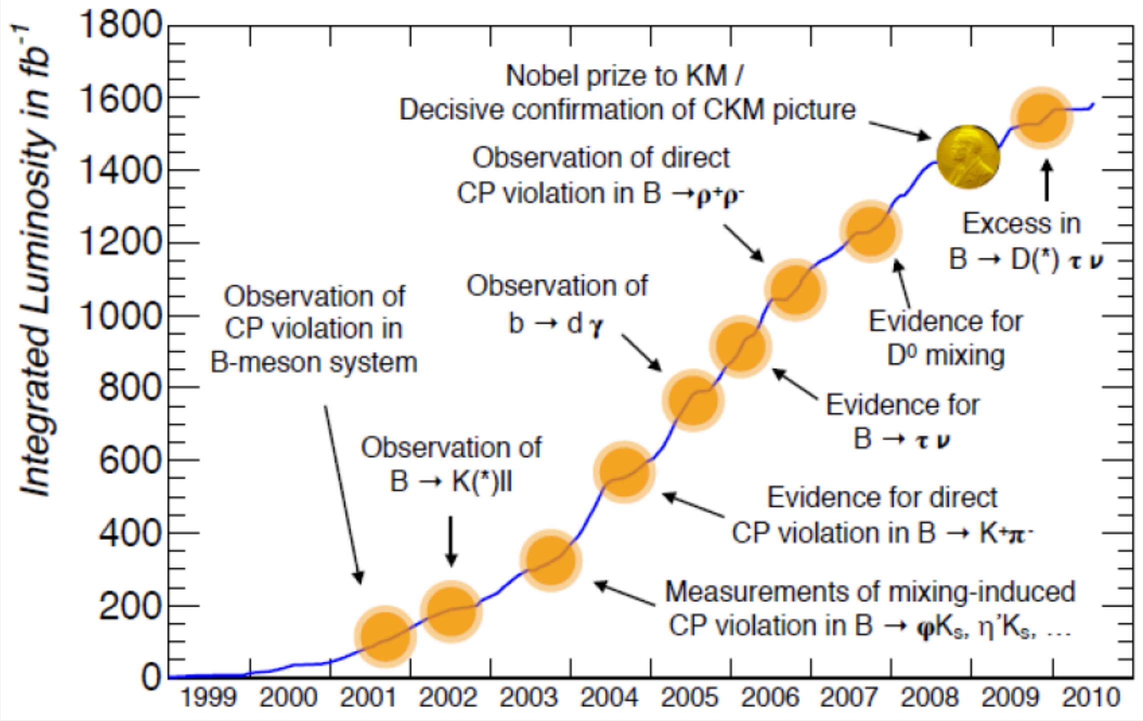




Belle/KEKB (KEK) and BaBar/PEP-II (SLAC)

Very successful physics programs with a total recorded sample over 1.5 ab^{-1} (1.25 x 10^9 $B\overline{B}$)

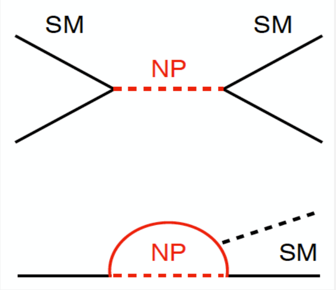
— Experimental confirmation of CKM mechanism as source of CPV in the SM

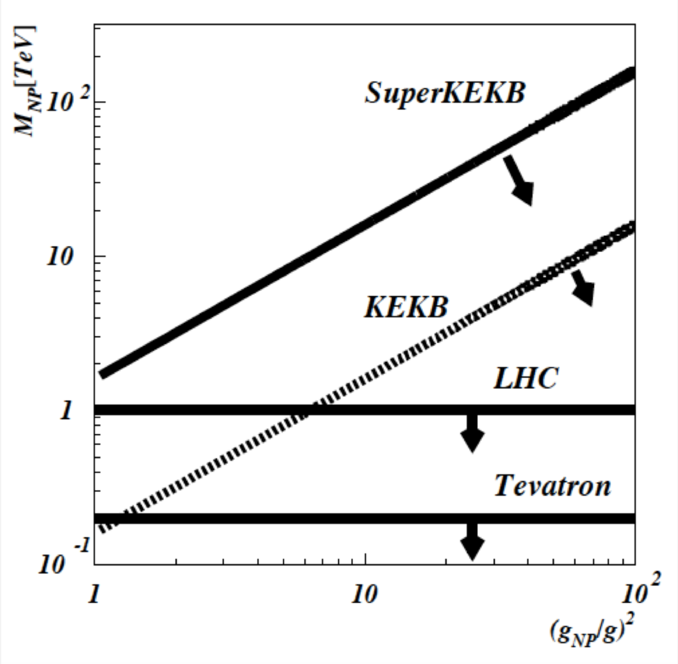


NEW PHYSICS PROSPECTS FOR NEXT GENERATION B-FACTORY

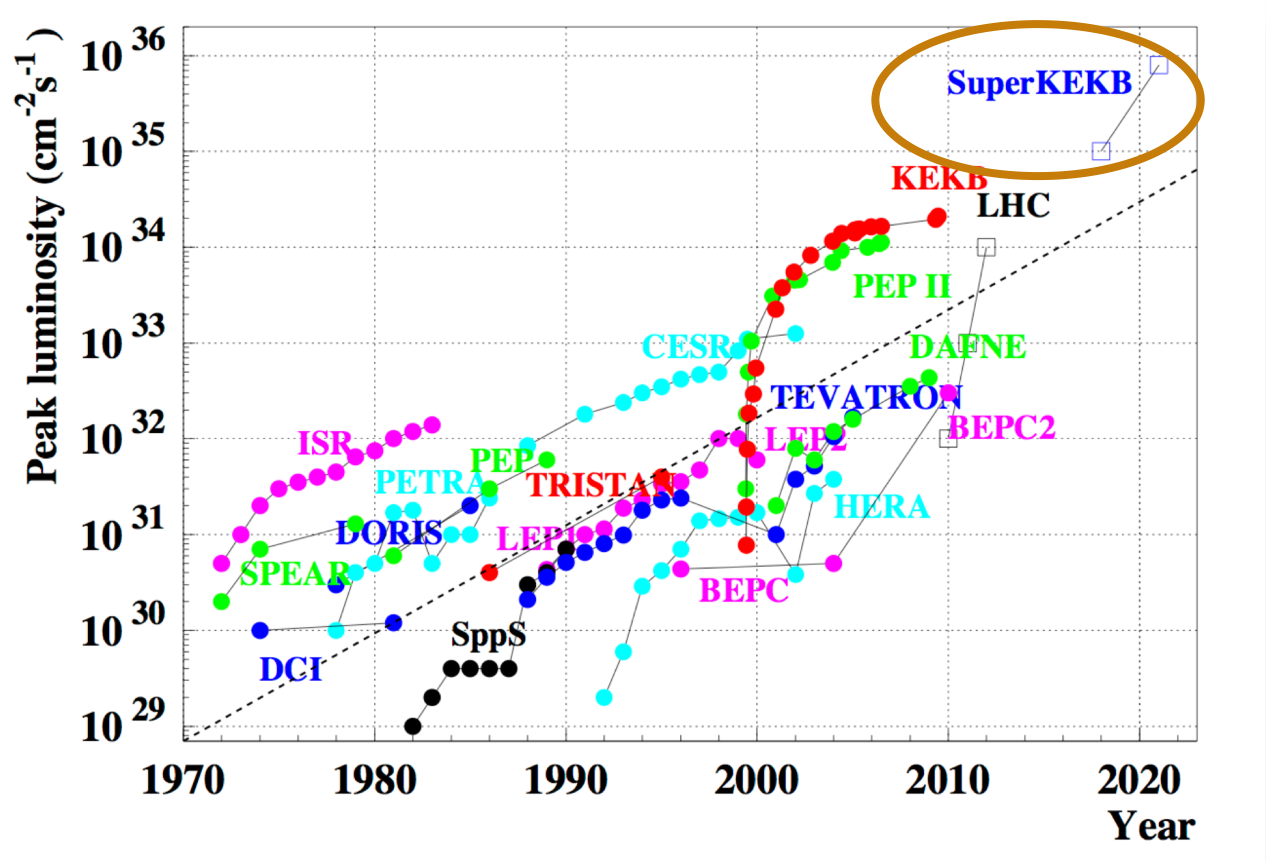
- Search for NP in the flavor sector at the **intensity frontier**
  - Flavor physics as a probe for beyond the TeV scale
- Signatures of new particles or processes observed through measurements of suppressed flavor physics reactions or from deviations from SM predictions
  - An observed discrepancy can be interpreted in terms of NP models
  - Need significantly more data to make this possible
- Large dataset makes exciting physics beyond NP possible
- Advantages of e^+e^-:
  - Clean environment, known intial state, full reconstruction of final states containing one or more ν
- Ultimate goal of Belle II: 50 ab^{-1} data sample

Intensity frontier:
indirectly reveal NP virtual particles in loops – probe energy above 10 TeV

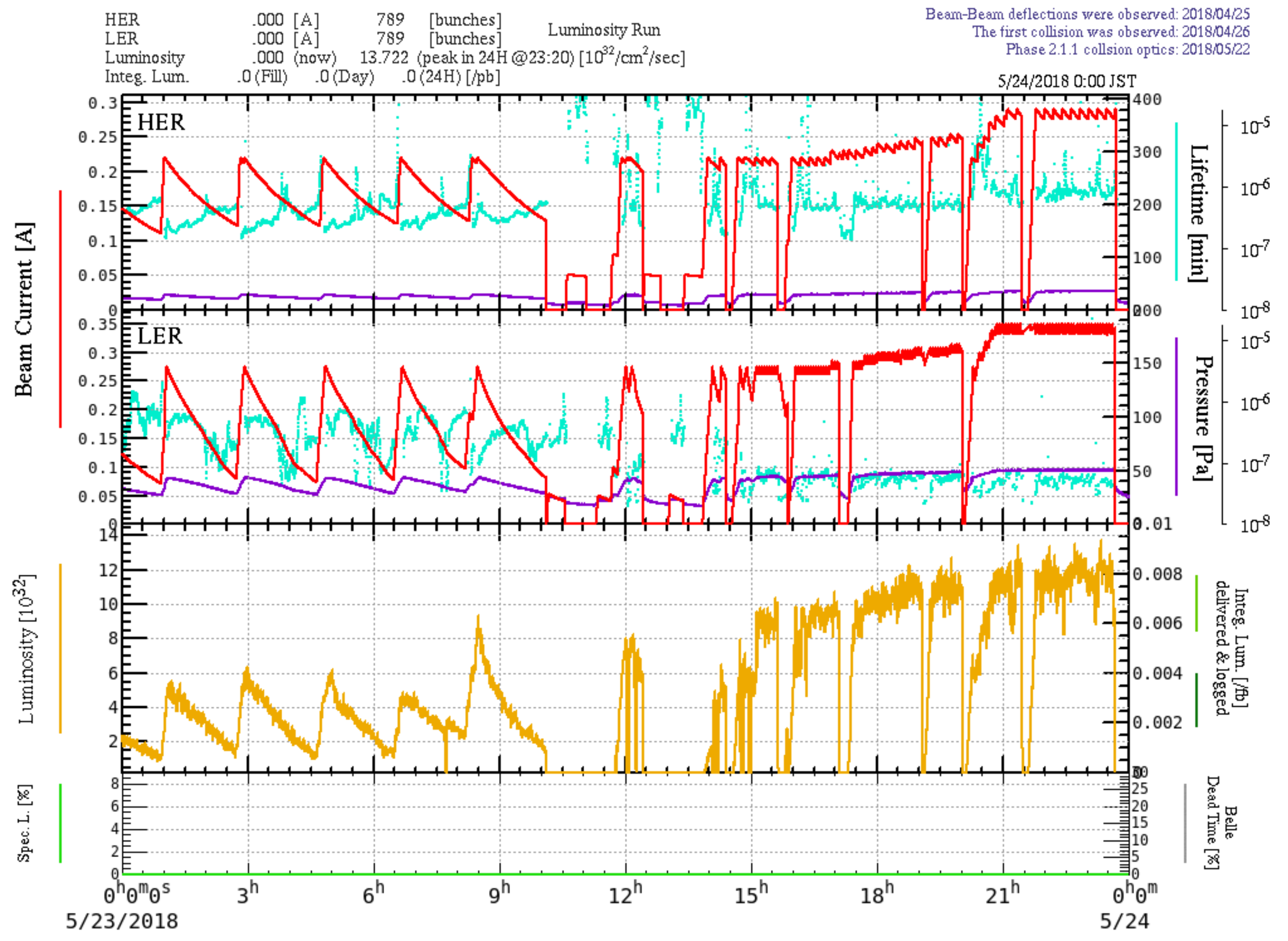




WORLD RECORD LUMINOSITY AT SUPERKEKB



May 23rd: Reached 10^{33} cm^{-2}s^{-1}



ACCELERATOR DESIGN: NANO BEAM SCHEME

Invented by Pantaleo Raimondi for SuperB

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

- Lorentz factor
- Beam current
- Beam-Beam parameter $\xi_y \propto \sqrt{(\beta_y^*/\varepsilon_y)}$
- Geometrical reduction factors (crossing angle, hourglass effect)
- Beam aspect ratio at IP
- Vertical beta function at IP

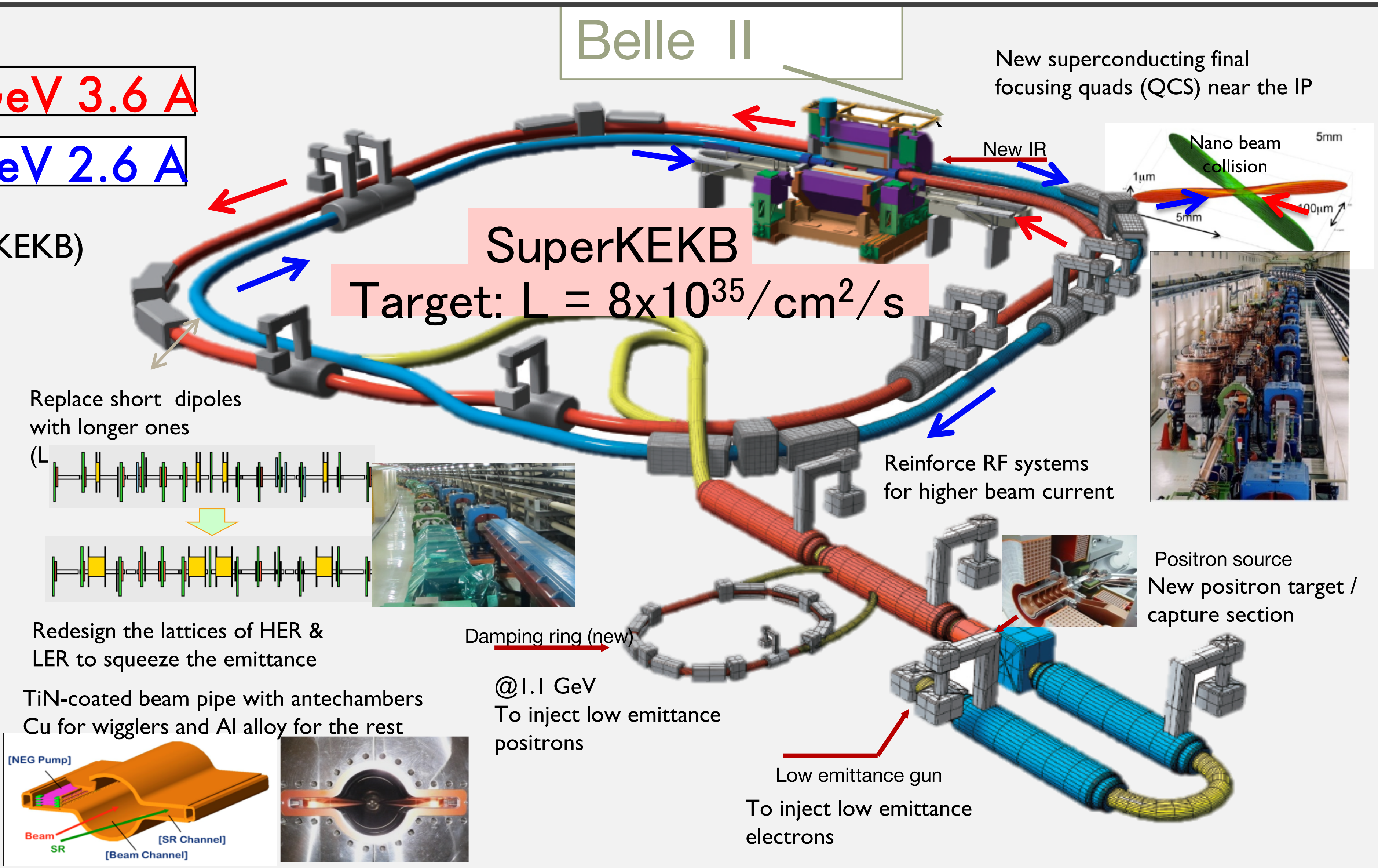
	E (GeV) LER/HER	β^*_y (mm) LER/HER	β^*_x (cm) LER/HER	φ (mrad)	I (A) LER/HER	L ($cm^{-2}s^{-1}$)
KEKB	3.5/8.0	5.9/5.9	120/120	11	1.6/1.2	2.1 x 10^{34}
SuperKEKB	4.0/7.0	0.27/0.30	3.2/2.5	41.5	3.6/2.6	80 x 10^{34}

KEKB →SUPERKEKB: DELIVER INSTANTANEOUS LUMINOSITY X 40

e^+ 4GeV 3.6 A

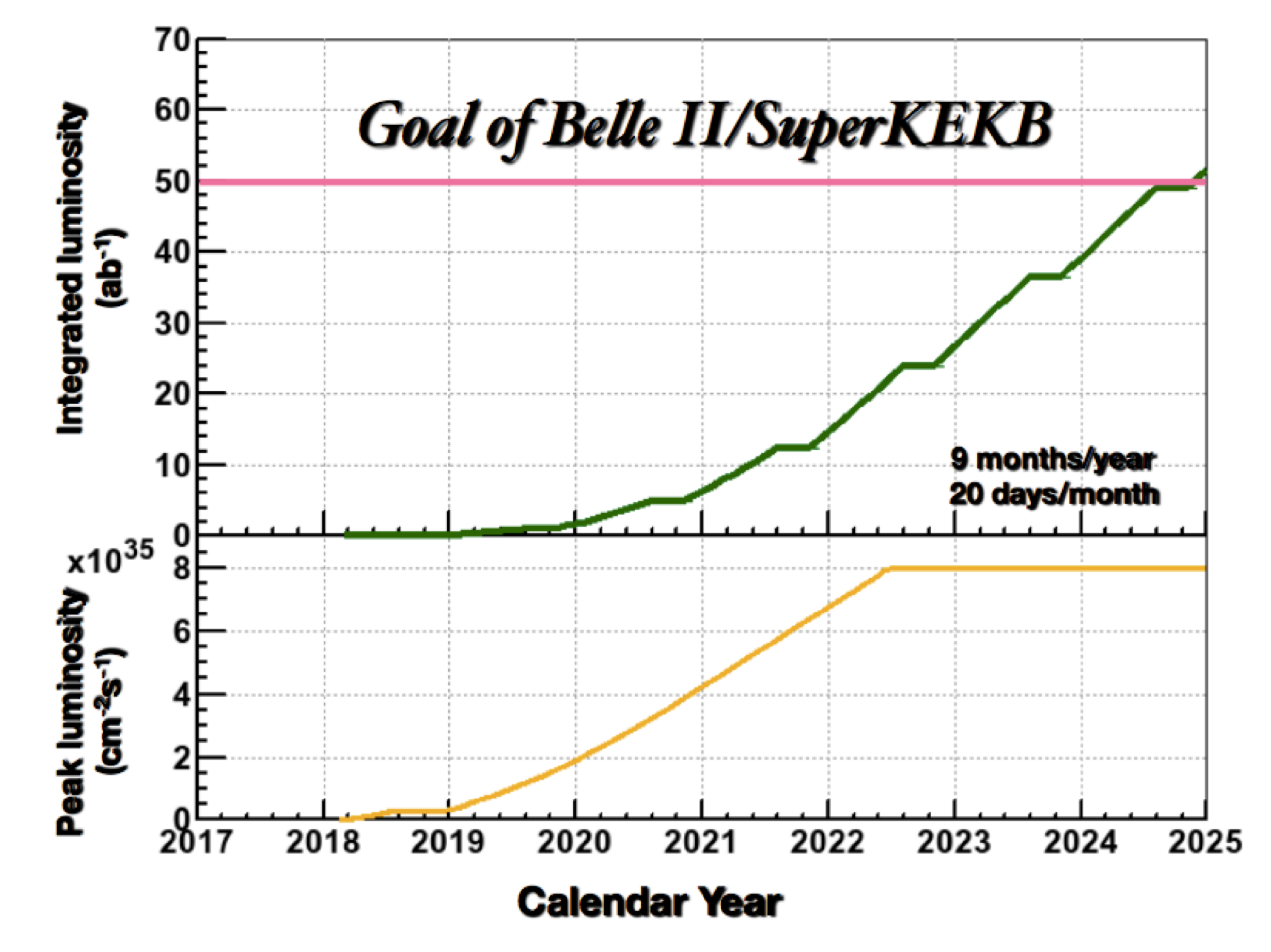
e^- 7GeV 2.6 A

(~2x KEKB)

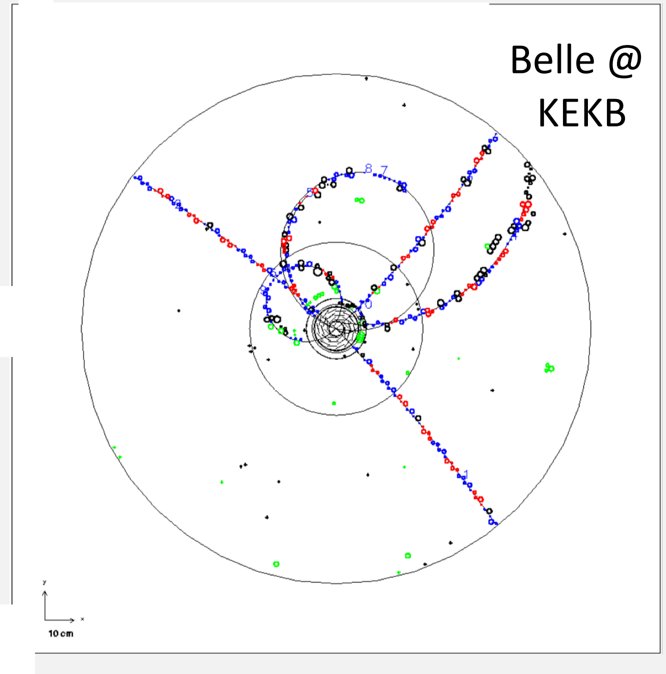


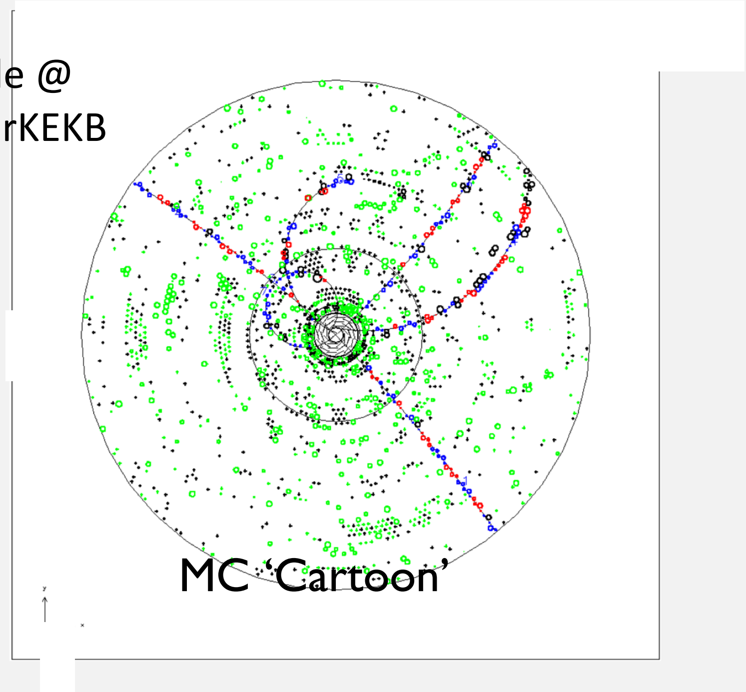
CURRENT STATUS AND SCHEDULE

- Phase 1 (complete)
  - Accelerator commissioning
- Phase 2 (now)
  - First collisions (20±20 fb^{-1})
  - Partial detector
  - Background study
  - Physics possible
- Phase 3 ("Run 1", early 2019)
  - Nominal Belle II start
- **Ultimate goal: 50 ab^{-1}**



BELLE II DETECTOR CHALLENGES





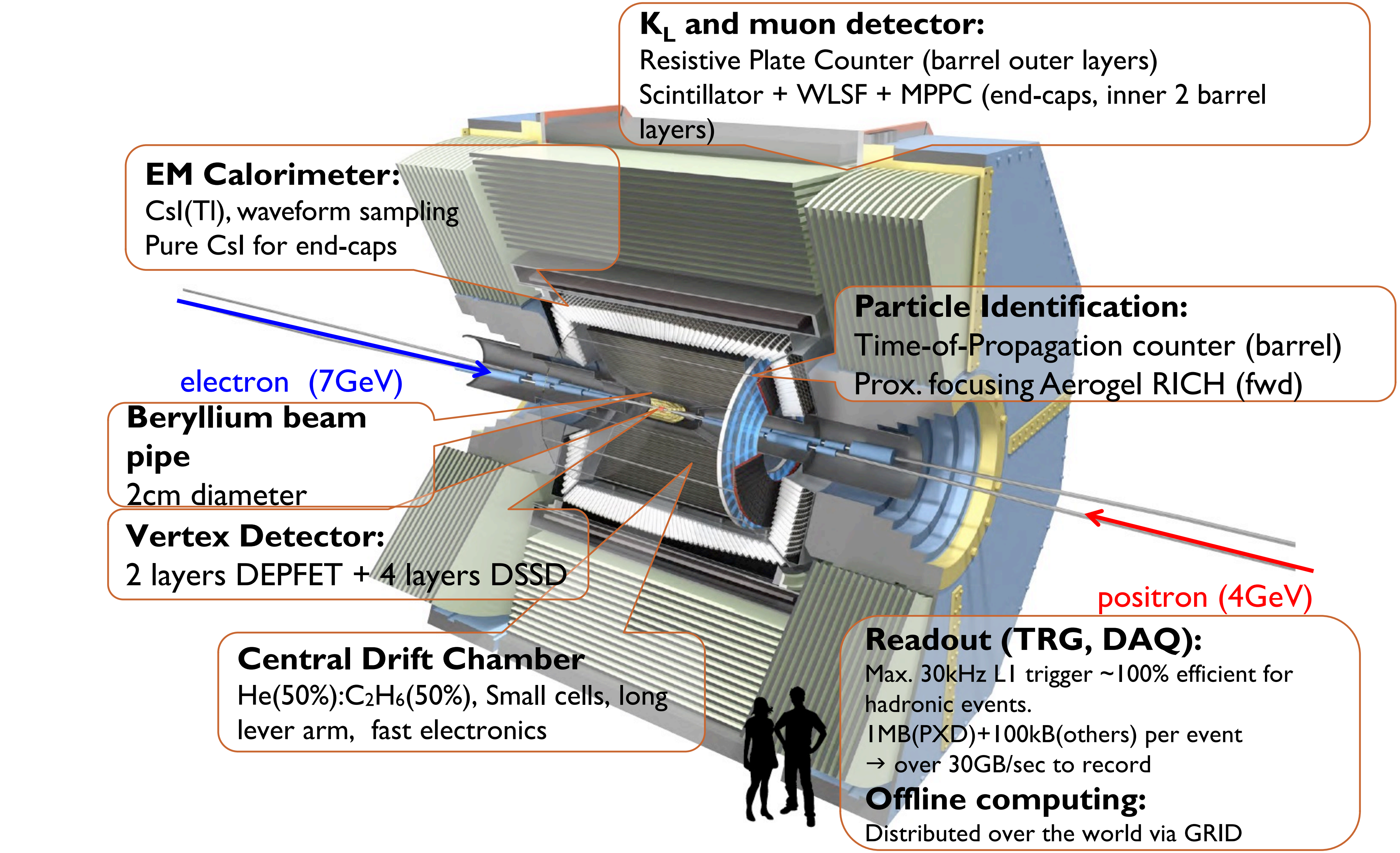
Higher background → radiation damage, occupancy→ VTX (also closer to the beampipe), background in EMC

Higher event rate → trigger, DAQ, computing

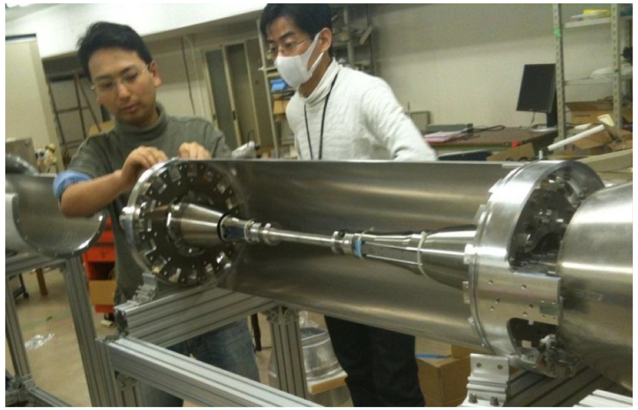
Low momentum particle reconstruction and ID, hermeticity

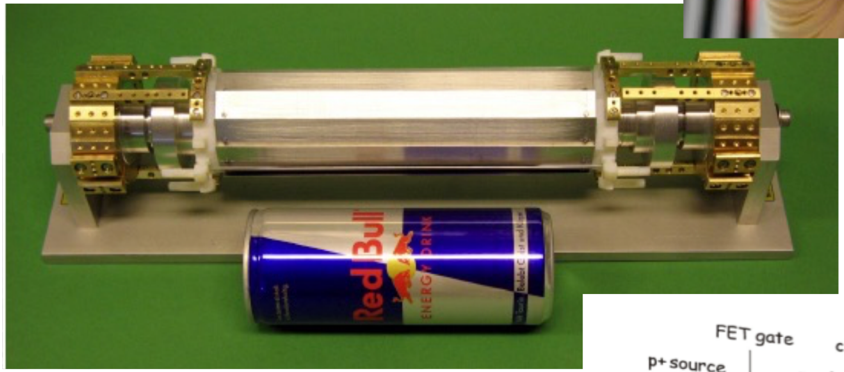
Detector has to be upgraded for SuperKEKB conditions
to achieve equal or better performance than at KEKB

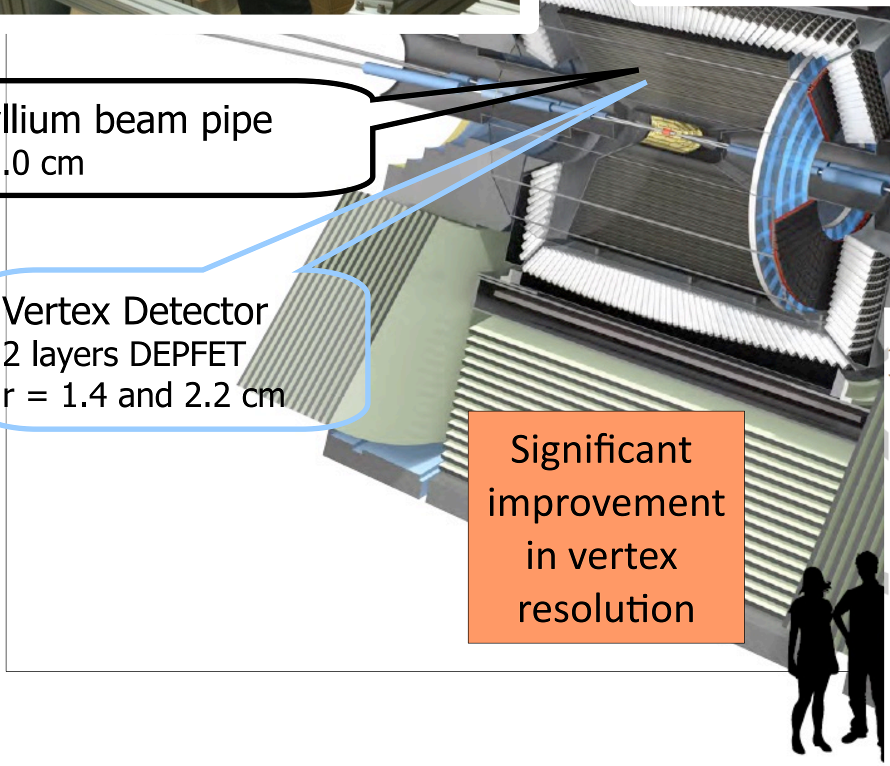
CUT VIEW OF BELLE II DETECTOR



BEAM PIPE AND PIXEL DETECTOR



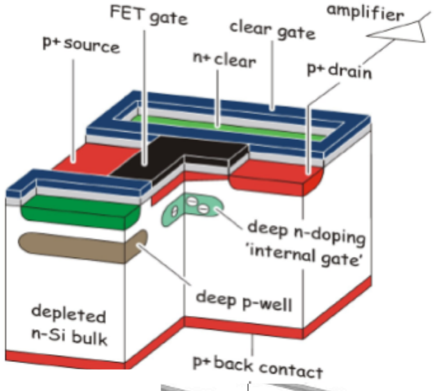


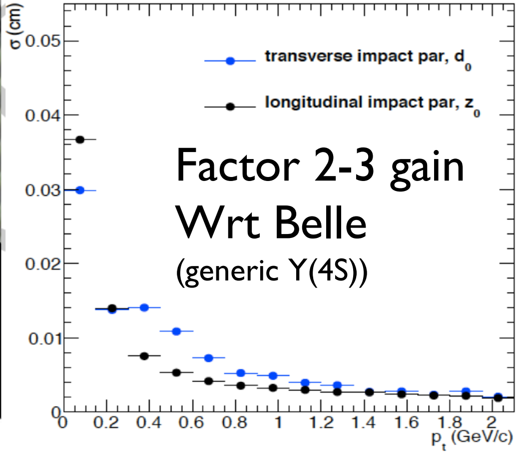


Beryllium beam pipe
r = 1.0 cm

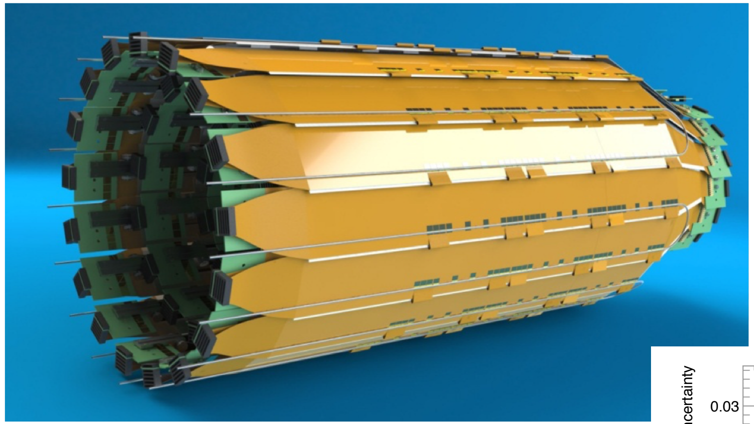
Vertex Detector
2 layers DEPFET
r = 1.4 and 2.2 cm

Significant improvement in vertex resolution

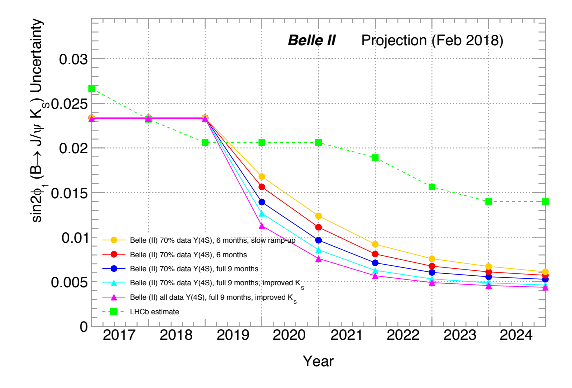


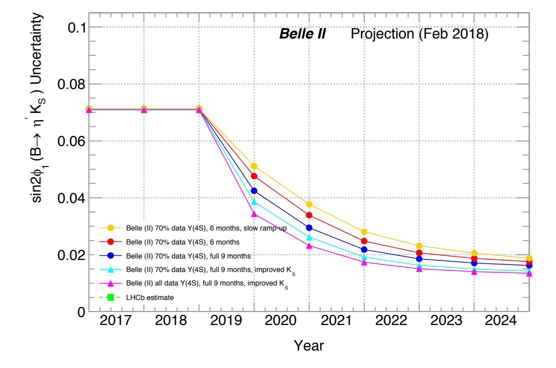


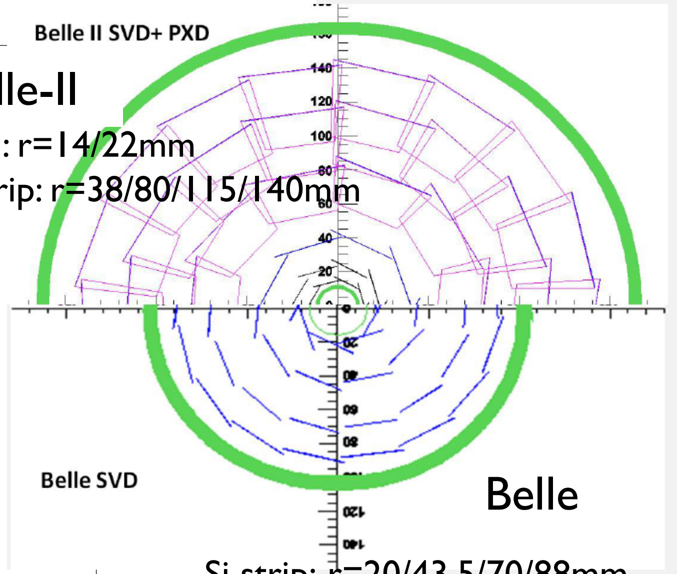
SILICON STRIP DETECTOR



Vertex Detector
4 layers DSSD
r = 3.8 – 14.0 cm







Belle-II

Pixel: r=14/22mm

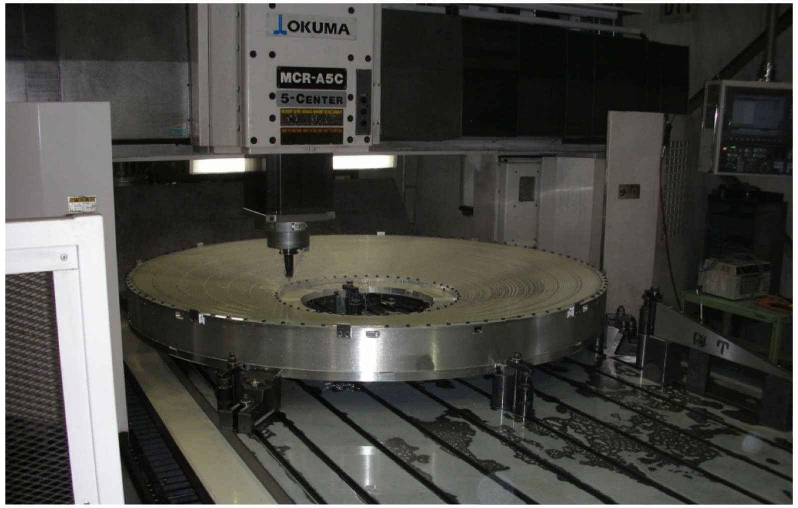
Si strip: r=38/80/115/140mm

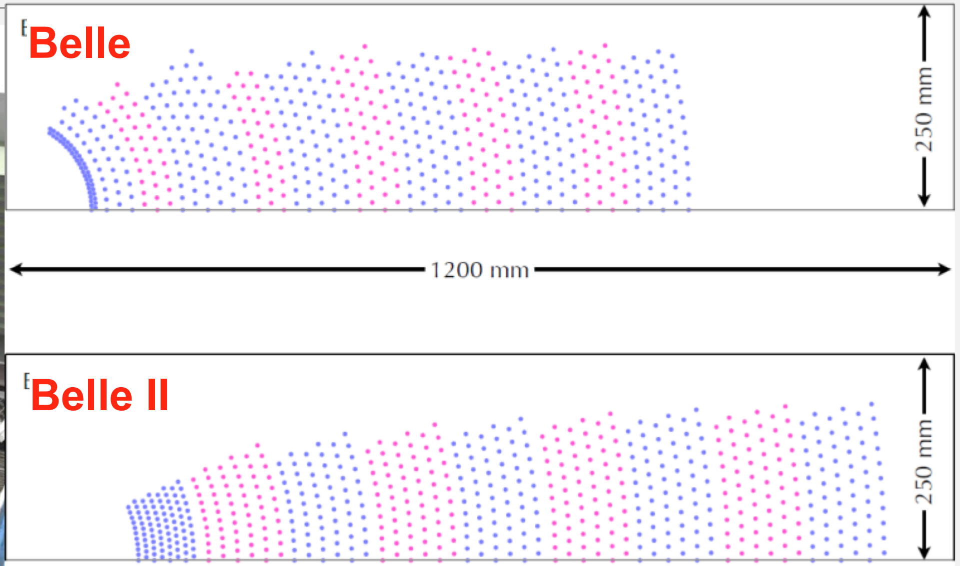
Belle

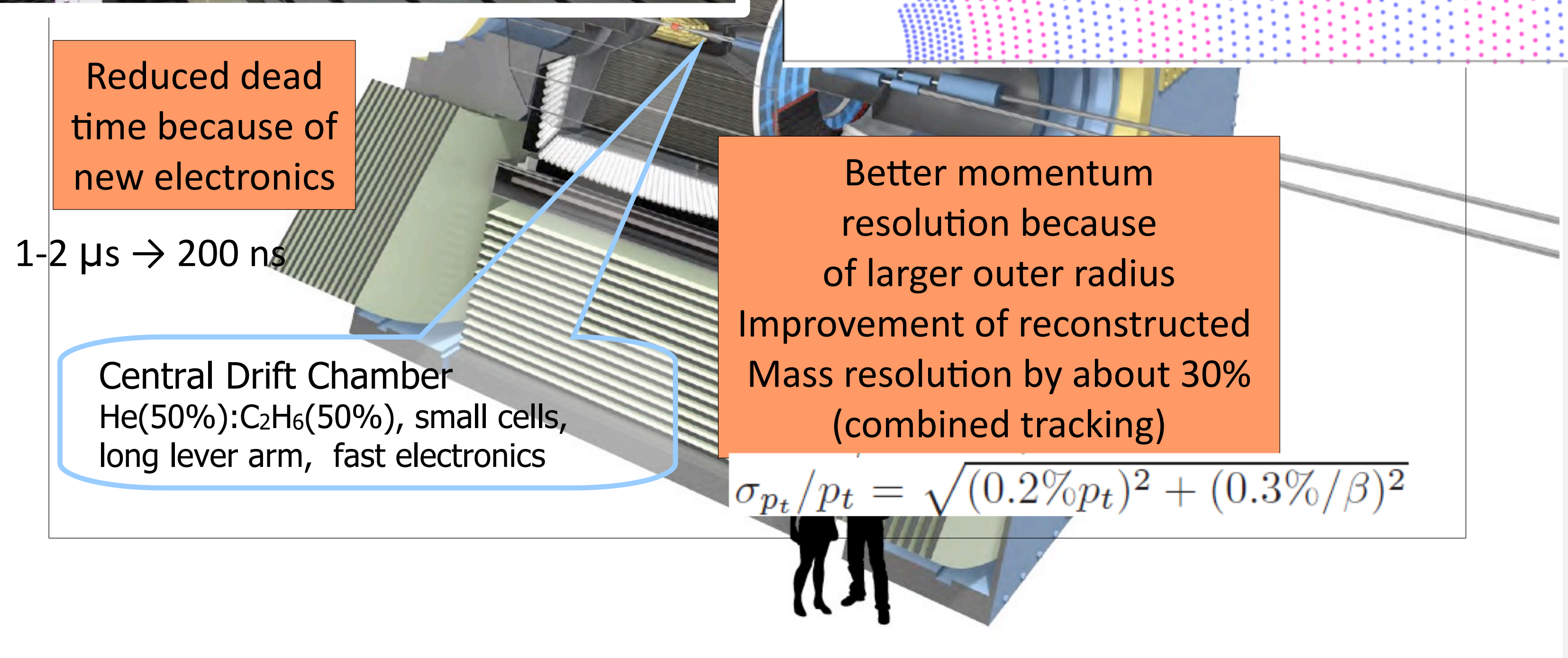
Si strip: r=20/43.5/70/88mm

Improvement in $\delta S(K_S\pi^0\gamma)$ (diff to $\sin2\phi_1(J/\Psi K_S)$ because of larger K_S vtx acceptance (by ~30%)

DRIFT CHAMBER







Reduced dead time because of new electronics

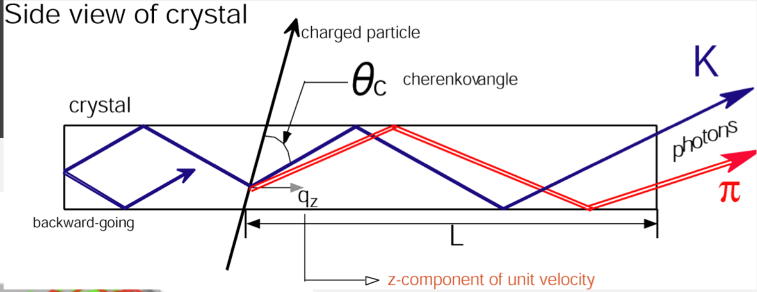
1-2 μs → 200 ns

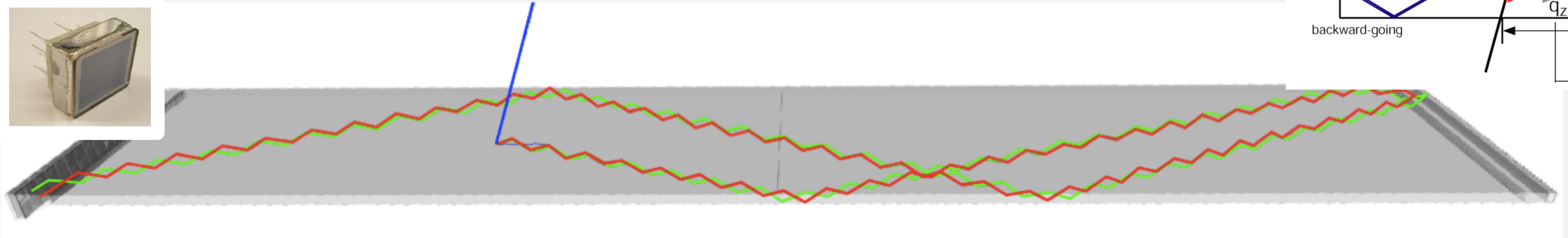
Central Drift Chamber
He(50%):C_2H_6(50%), small cells, long lever arm, fast electronics

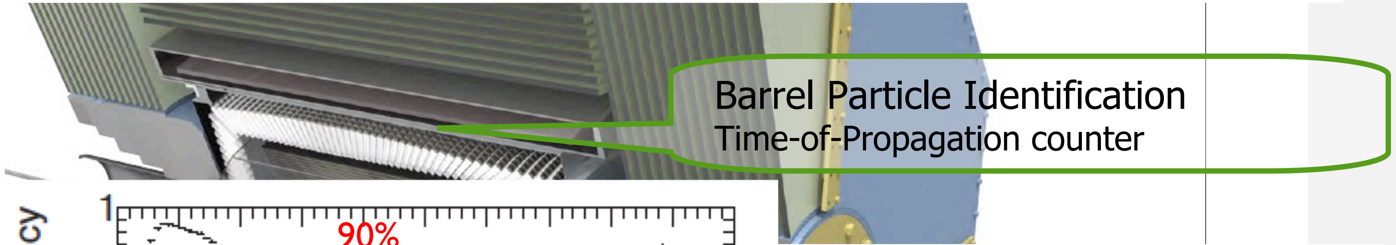
Better momentum resolution because of larger outer radius
Improvement of reconstructed Mass resolution by about 30% (combined tracking)

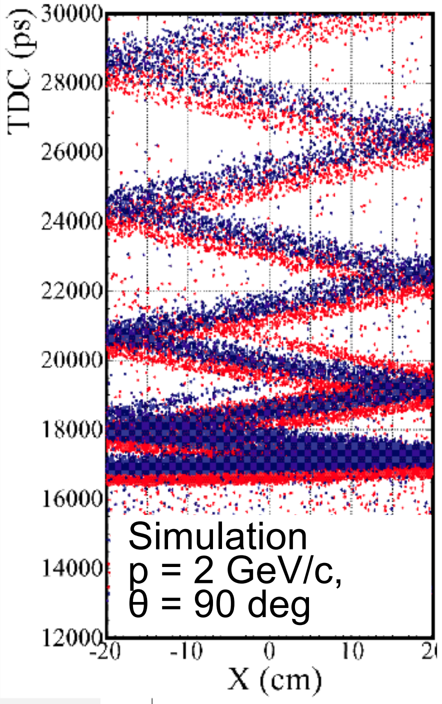
$$\sigma_{p_t}/p_t = \sqrt{(0.2\% p_t)^2 + (0.3\%/\beta)^2}$$

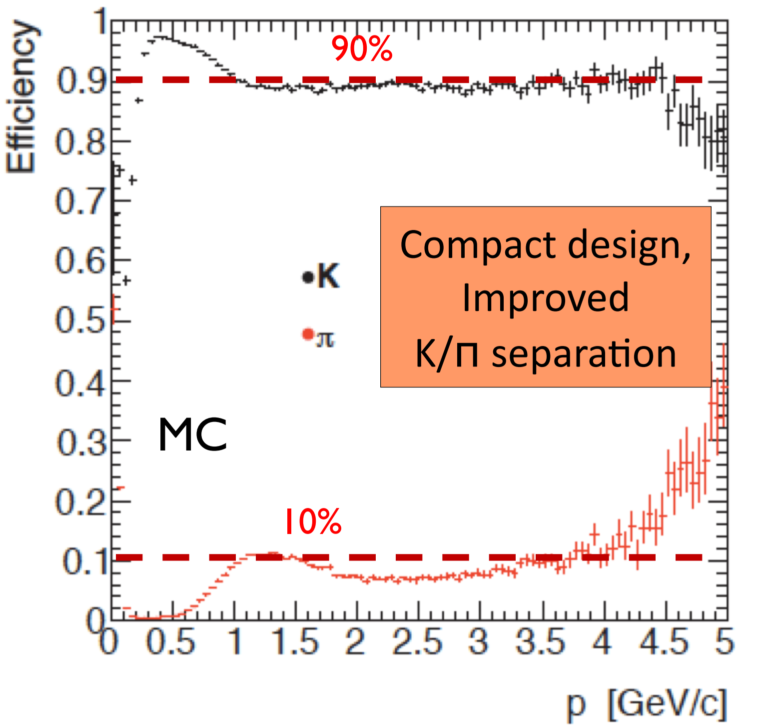
BARREL PARTICLE ID



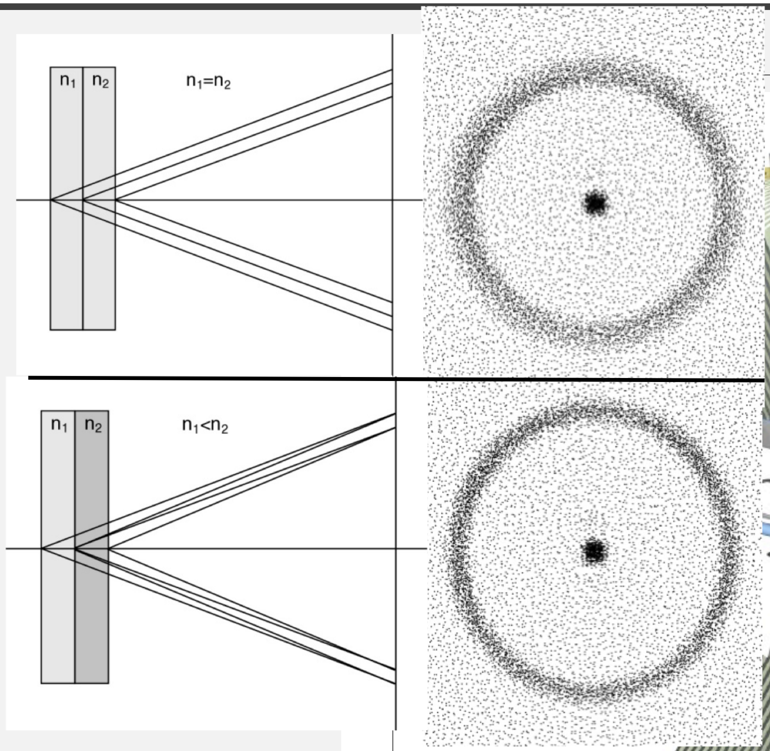


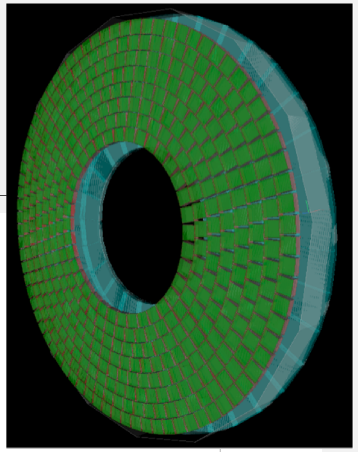


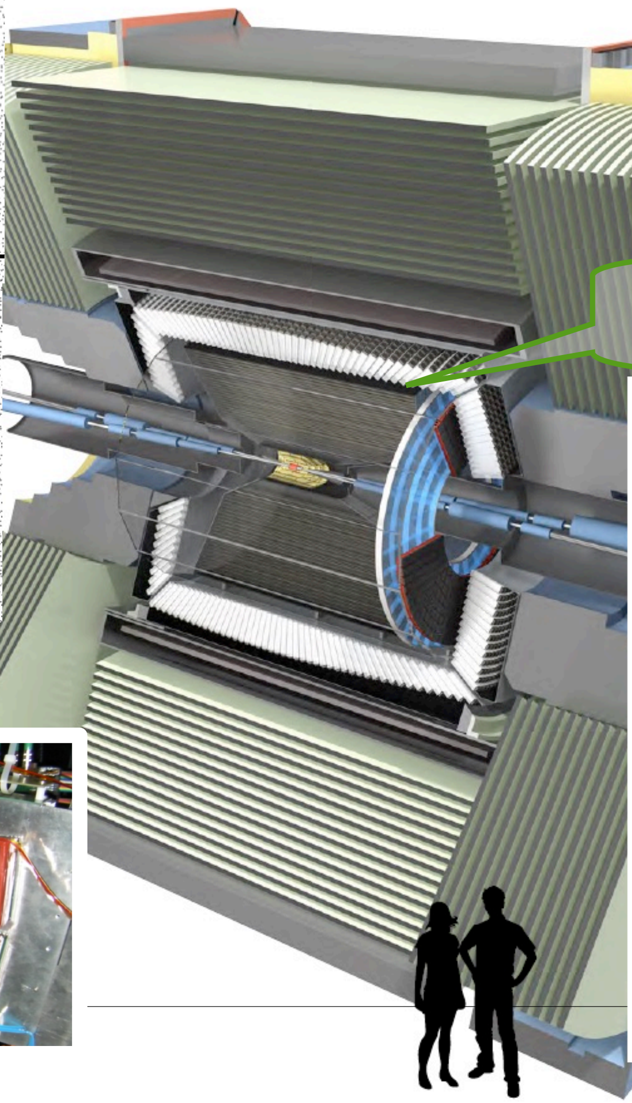


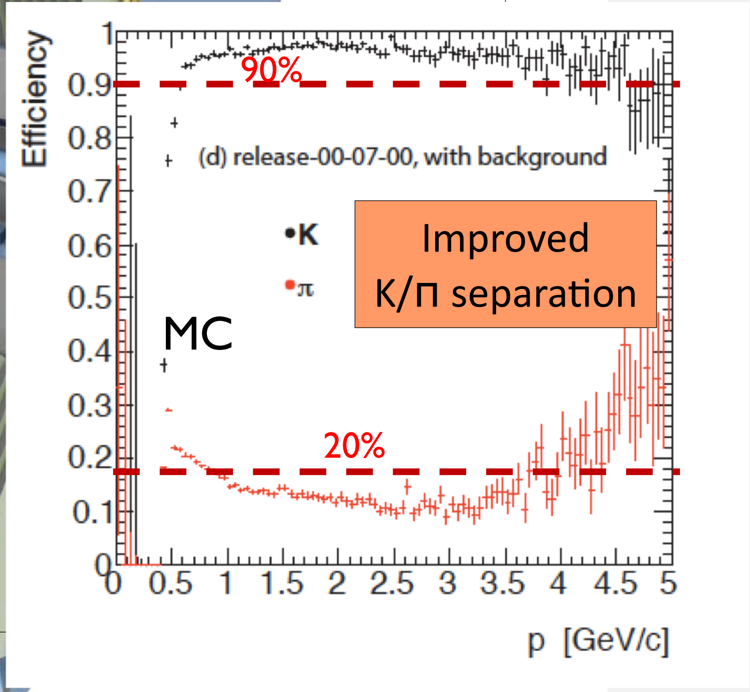


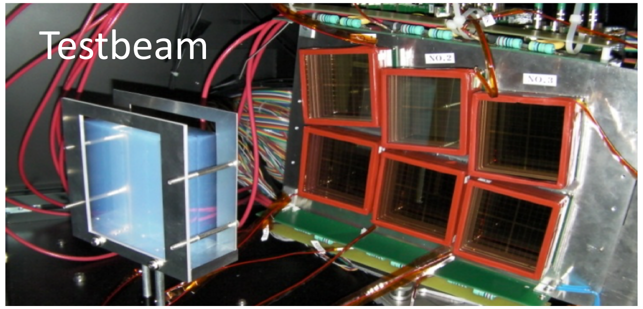
ENDCAP PARTICLE IDENTIFICATION







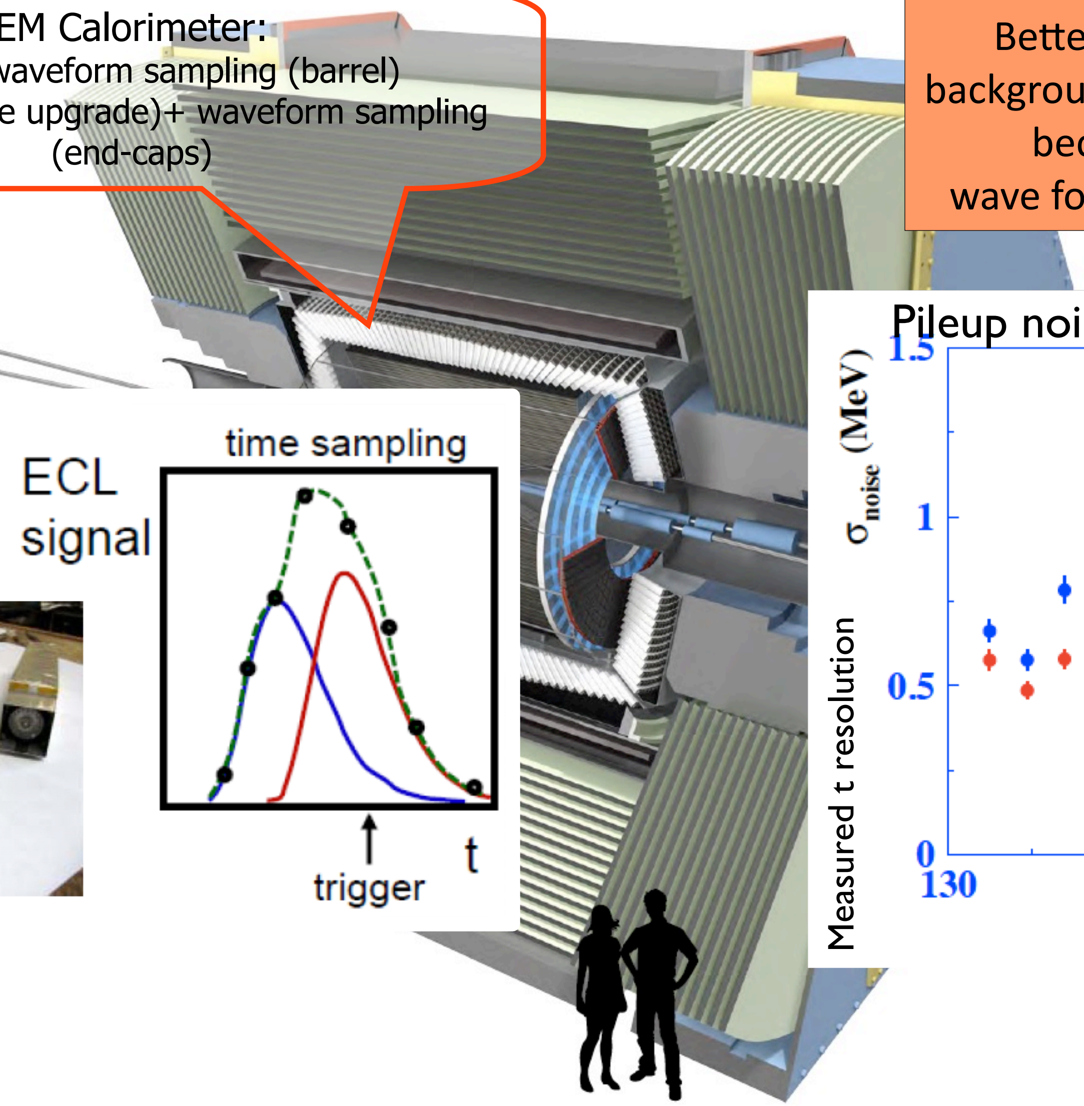


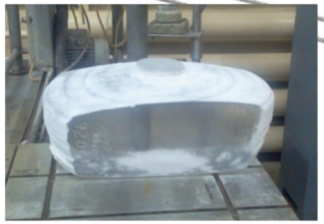


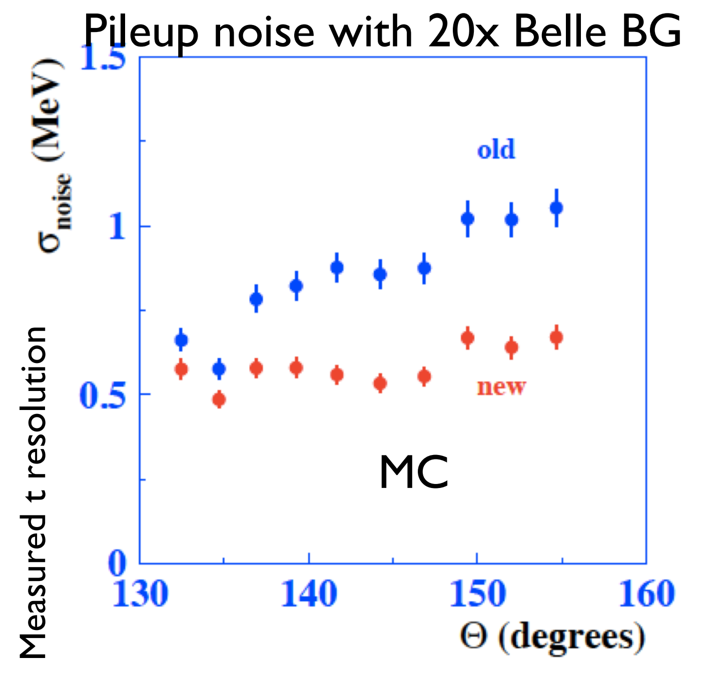
EM CALORIMETER

EM Calorimeter:
CsI(Tl), waveform sampling (barrel)
Pure CsI (future upgrade)+ waveform sampling (end-caps)

Better signal to background separation because of wave form sampling

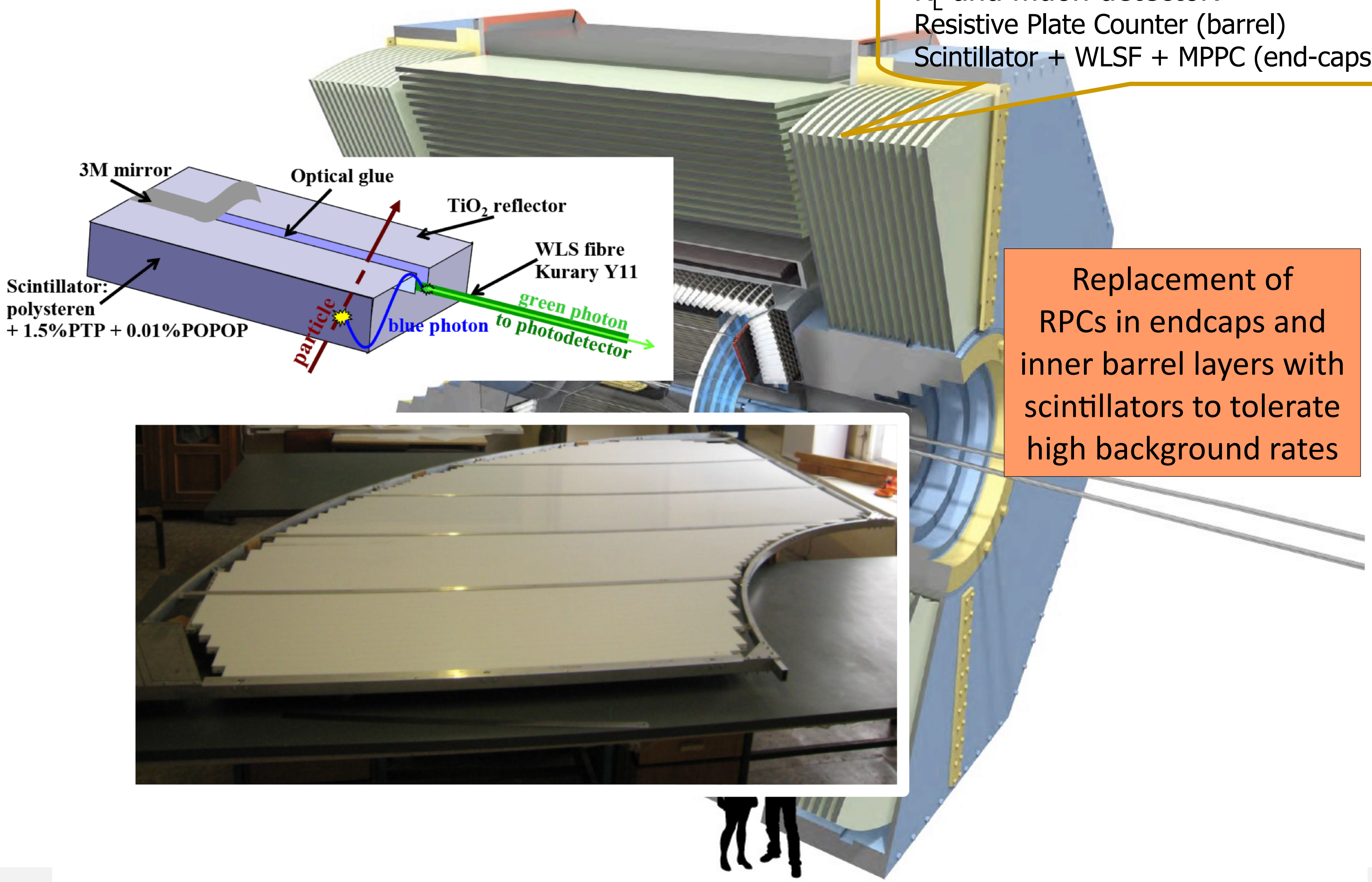






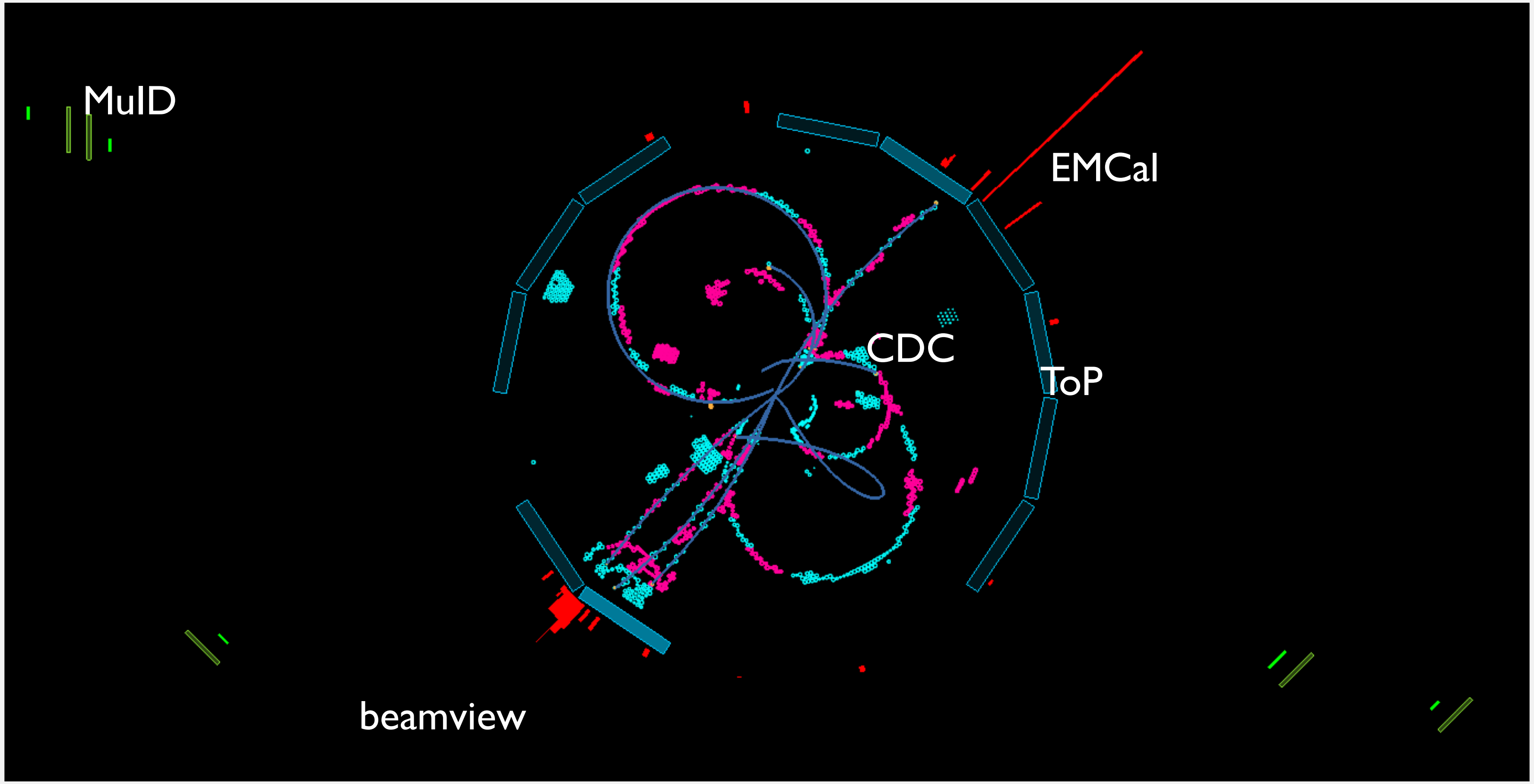
K_L AND MUON DETECTOR

K_L and muon detector:
Resistive Plate Counter (barrel)
Scintillator + WLSF + MPPC (end-caps)

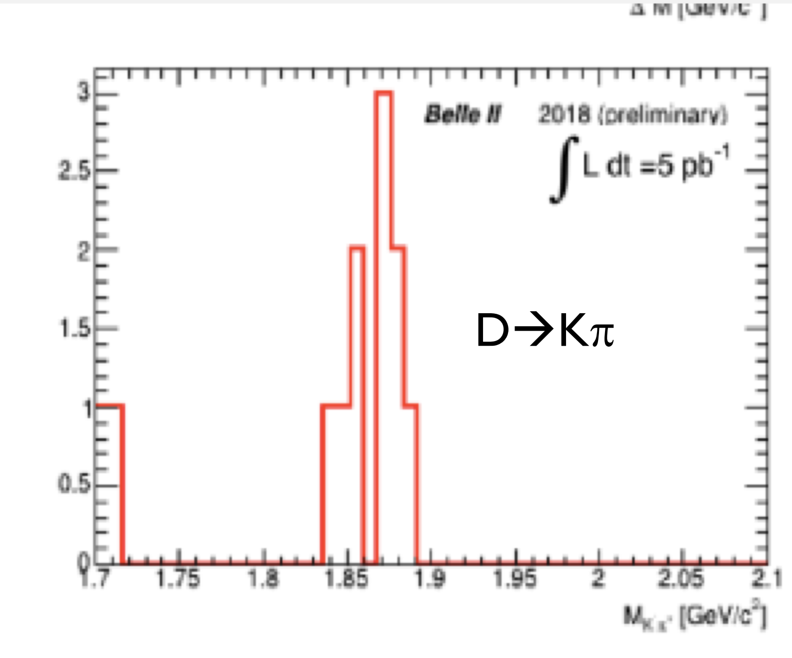


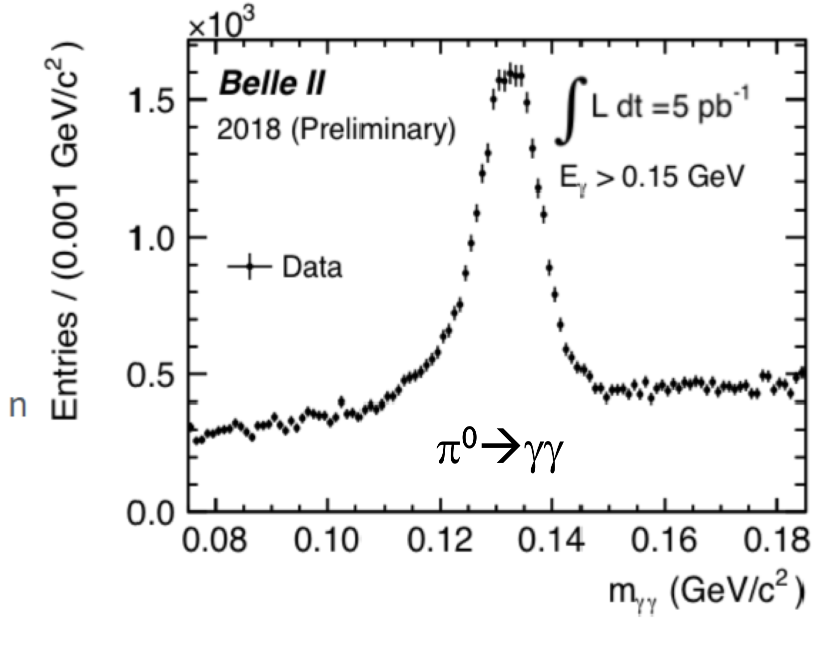
Replacement of RPCs in endcaps and inner barrel layers with scintillators to tolerate high background rates

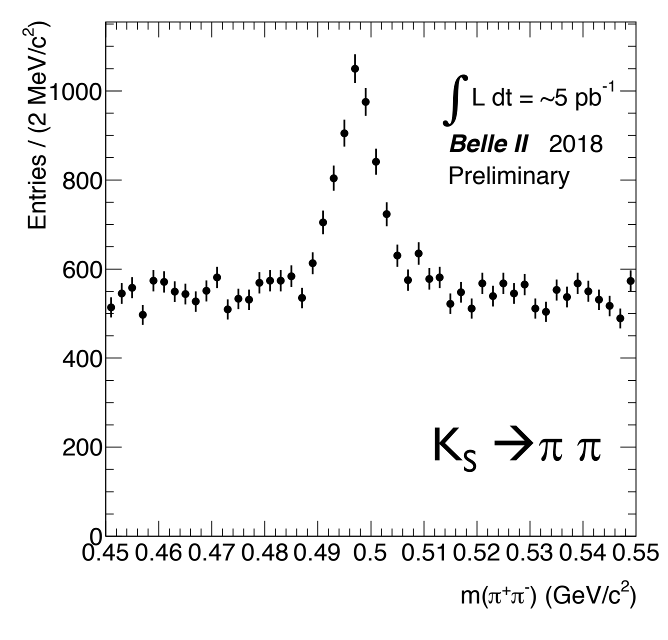
26 APRIL 2018 00:38 GMT+09:00: FIRST COLLISIONS



FIRST BUMPS

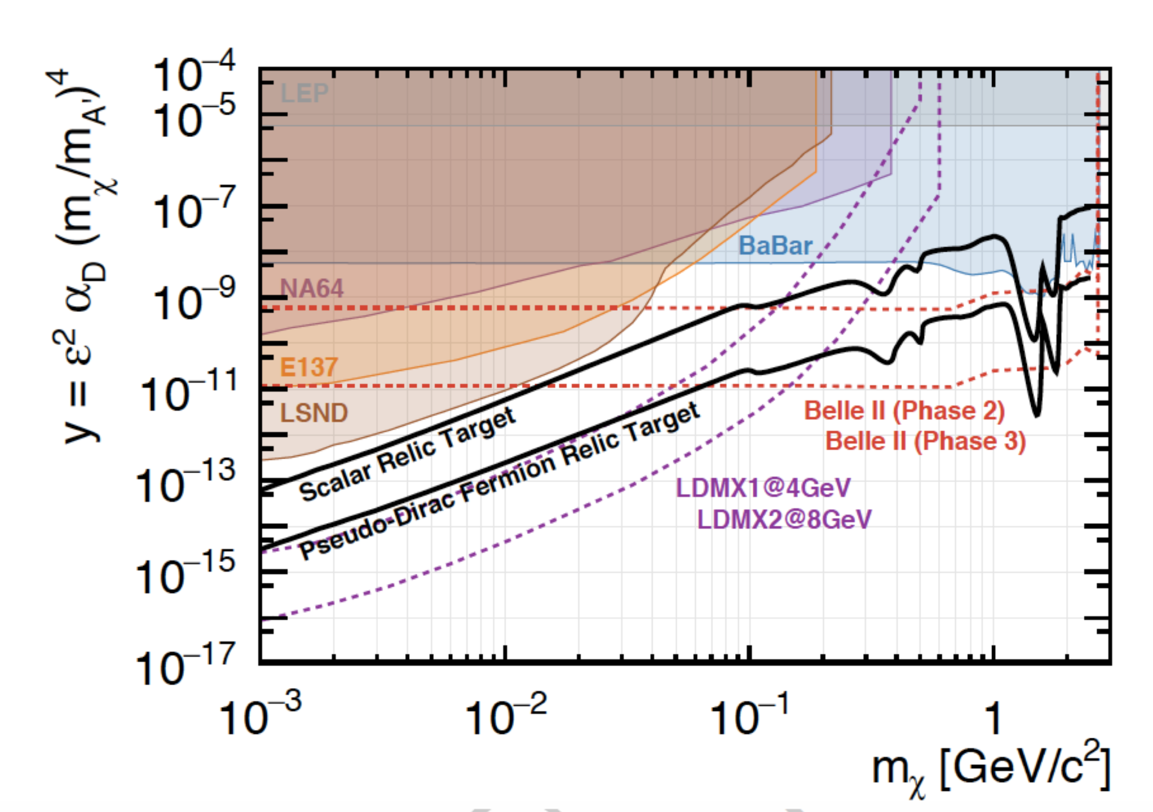

Belle II 2018 (preliminary)
∫L dt =5 pb⁻¹
D→Kπ
1.7 1.75 1.8 1.85 1.9 1.95 2 2.05 2.1

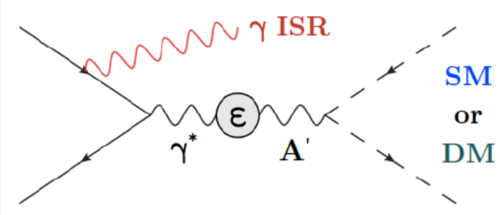

Belle II
2018 (Preliminary)
∫L dt =5 pb⁻¹
E_γ > 0.15 GeV
Data
π⁰→γγ
Entries / (0.001 GeV/c²)
m_γγ (GeV/c²)


∫L dt = ~5 pb⁻¹
Belle II 2018
Preliminary
K_S →π π
Entries / (2 MeV/c²)
m(π⁺π⁻) (GeV/c²)

FIRST PHYSICS HIGHLIGHTS

- **New physics: Dark photon searches**



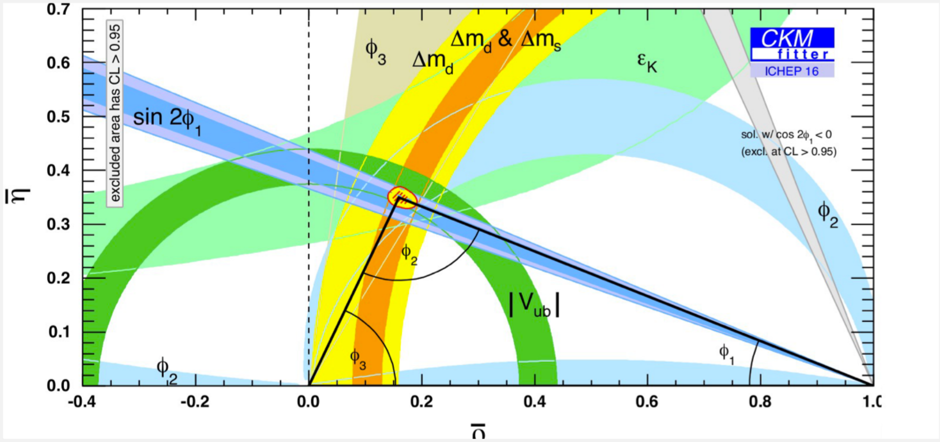


J. Alexander et al. (2016), arXiv:1608.08632

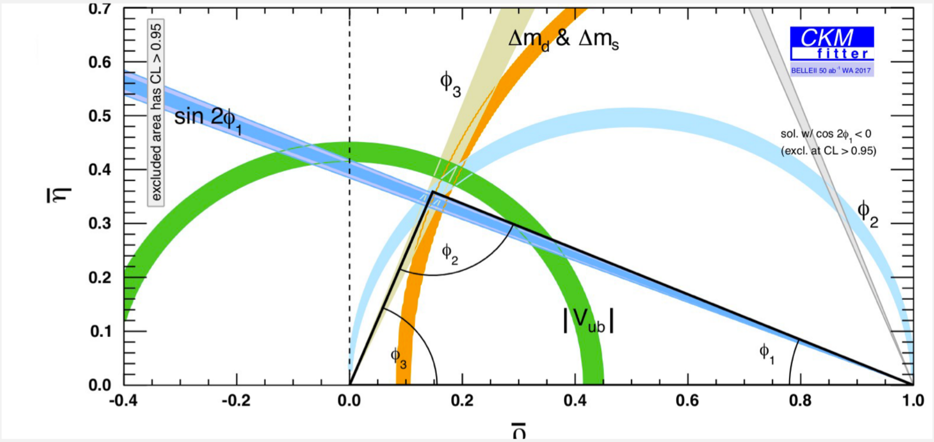
FIRST PHYSICS HIGHLIGHTS

- New physics: Dark photon searches
- **Precision CPV, CKM studies**
- **Example: Impact on unitarity triangle**

State of the art 2016

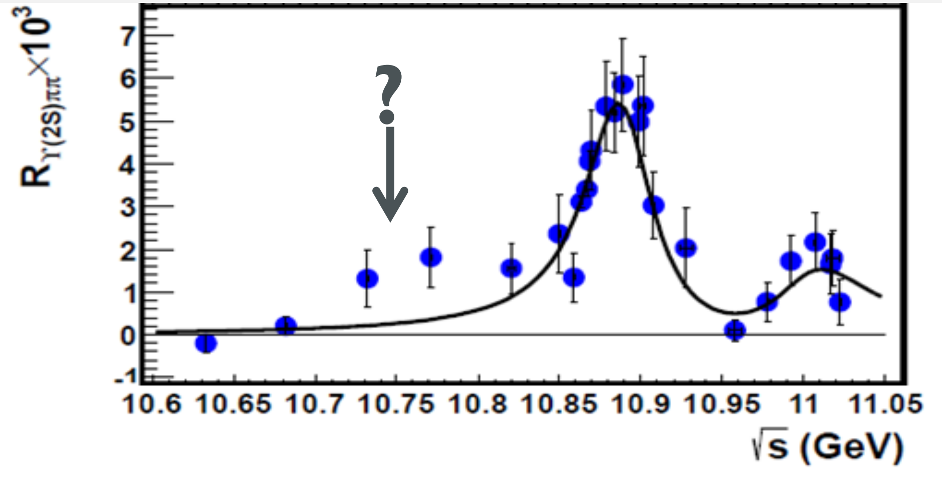


Belle II 50 ab^{-1}



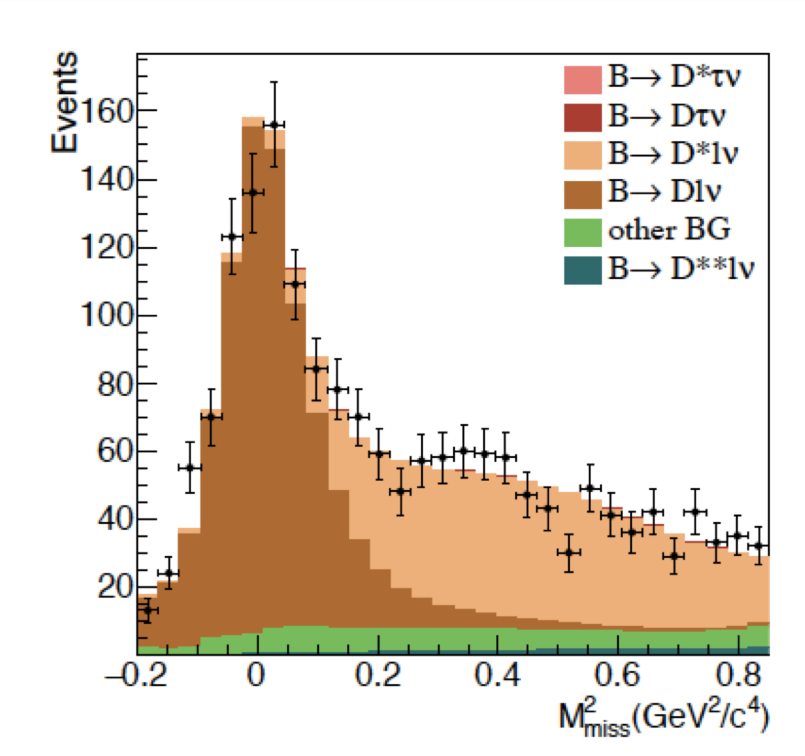
FIRST PHYSICS HIGHLIGHTS

- New physics: Dark photon searches
- Precision CPV, CKM studies
- **Quarkonium-like physics, exotics > Y(4s)**



Phys.Rev.Lett.102:012001,2009, (Babar)
PRD 82, 091106 (2010). 0810.3829. (Belle)

FIRST PHYSICS HIGHLIGHTS



- New physics: Dark photon searches
- Precision CPV, CKM studies
- Quarkonium-like physics, excoticss > Y(4s)
- Tau factory
- **B→D(*) τ ν precision goes from 16.5 (7.4)% (D/D*) to 7.1 (3.9) % with 5ab^{-1} (3(2) % with full dataset)**

FIRST PHYSICS HIGHLIGHTS

- New physics: Dark photon searches
- Precision CPV, CKM studies
- Quarkonium-like physics, excoticss > Y(4s)
- Tau factory
- $B \rightarrow D^{(*)} \tau \nu$ precision goes from 16.5 (7.4)% (D/D*) to 7.1 (3.9) % with 5ab^{-1} (3(2) % with full dataset)
- **Detailed writeup in forthcoming B2TIP document (PTEP**)

PTEP Prog. T

The Belle II Physics Book

BACKUP