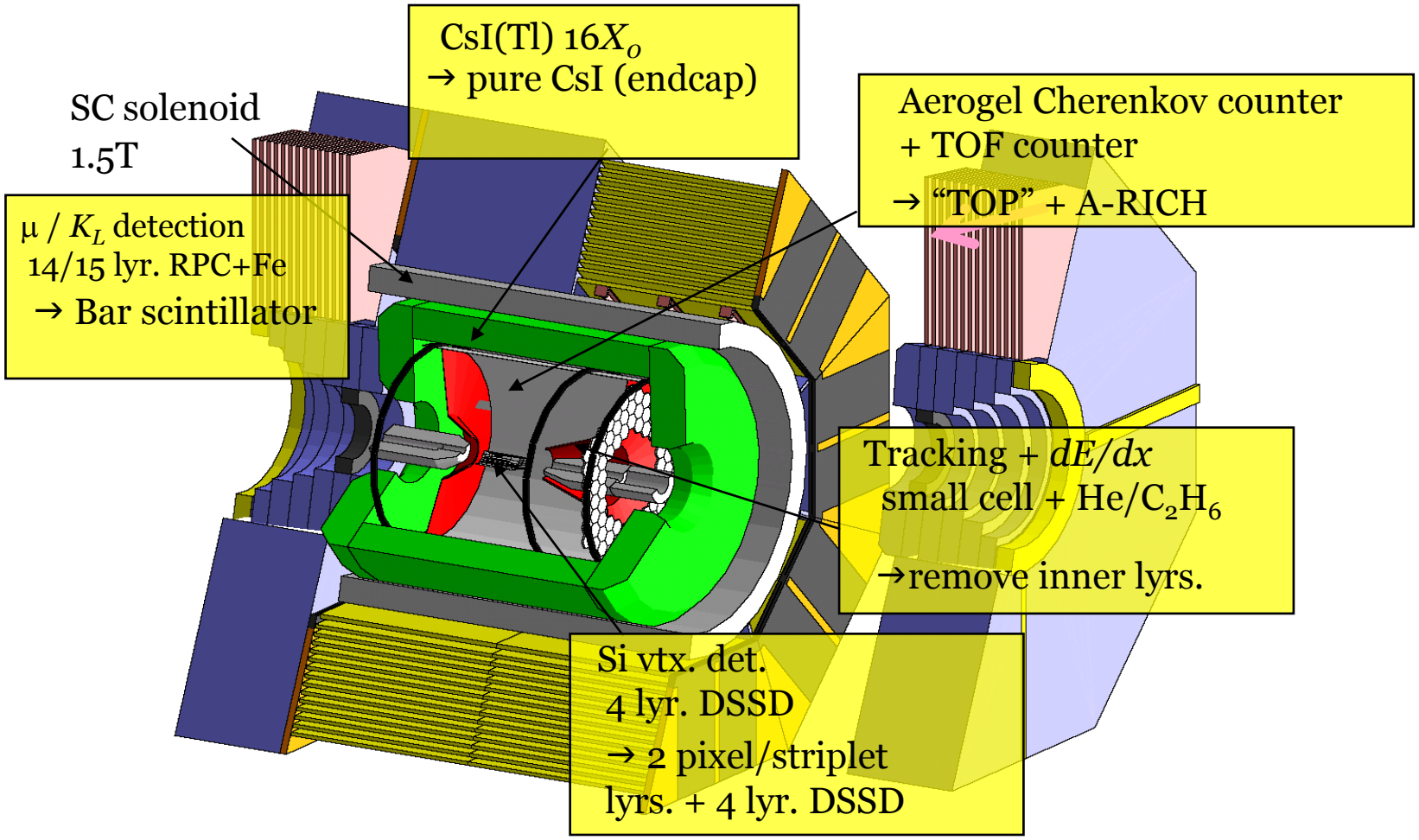
Status of G4superb

Atsuko Kibayashi

March 18, 2008

Open meeting for proto-collaboration

Belle Upgrade



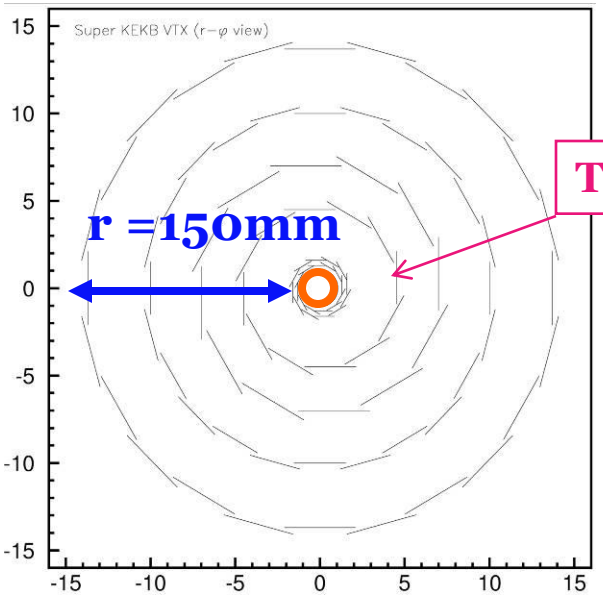
Motivation

- Design decision of SuperBelle detector in March 2009
- Design being confirmed/optimized by
  - Tuned for SuperBelle detector, existing
    - Geant3 based fast simulator
    - Geant3 based full simulator
  - Tools; e.g., TRACKERR
- Needed: full simulator for SuperBelle
  - Geant4

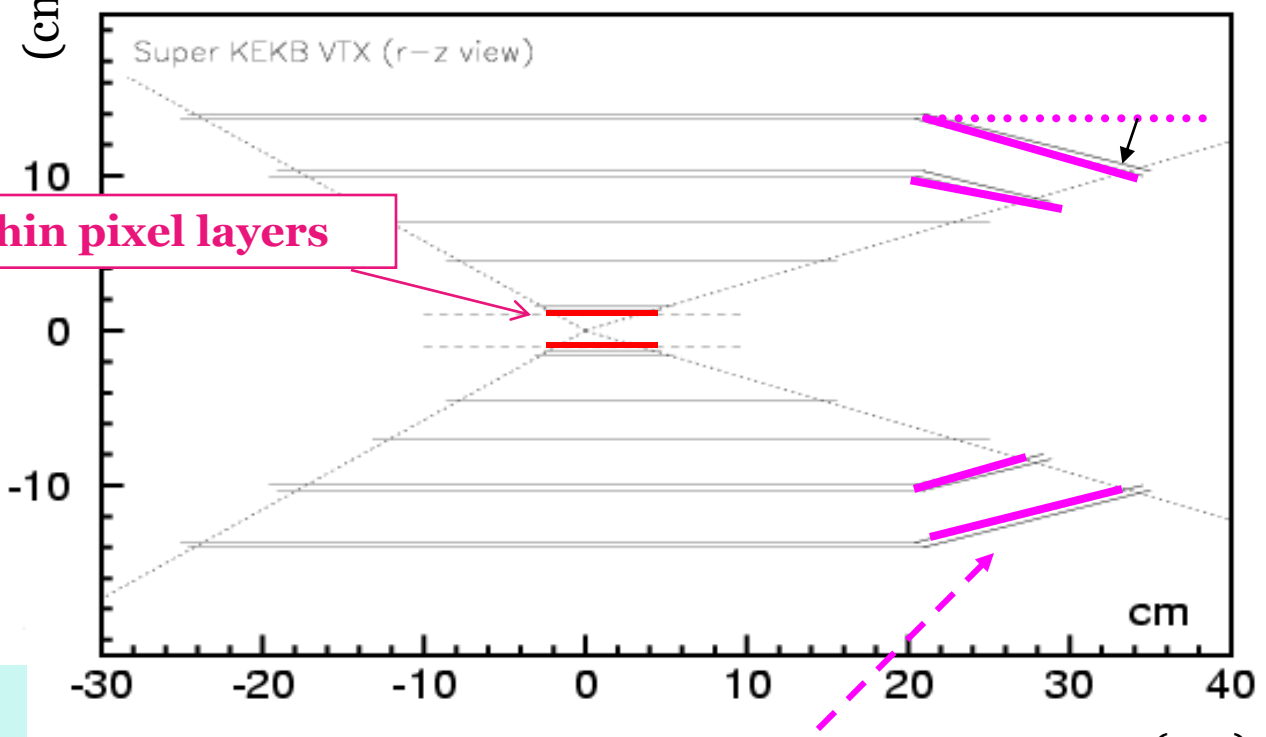
For more info., see individual detector talks…

Vertexing

PXD (pixel detector)
SVD (silicon vertex detector)



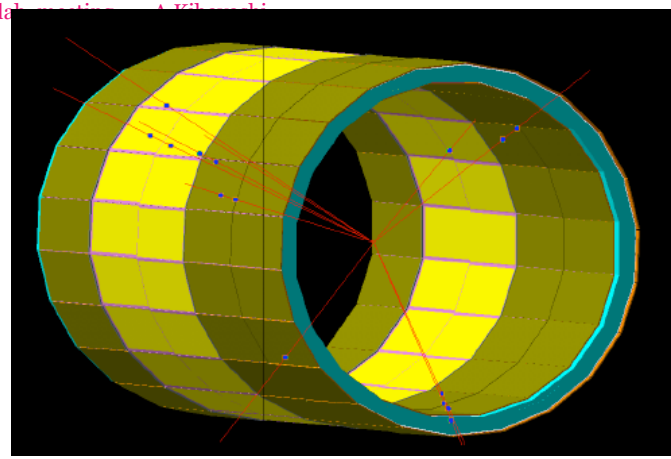
6 sensor layers to make low momentum tracking



Thin pixel layers

Slanted layer to keep acceptance, optimize incident angle and save detector size

Session Geant4.5 (3/18)
PXD (3/19)



PXD

(H. Hoedlmoser)

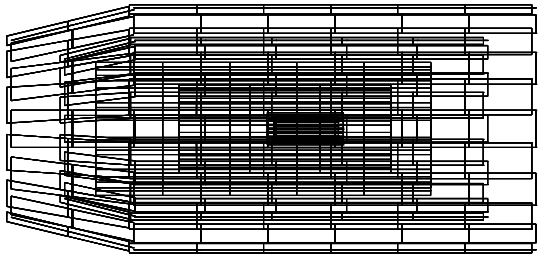
- Standalone almost complete
  - Geometry w/ support structure
  - Hits & digits produced, including
    - Drift time
    - Lateral diffusion
    - Lorentz angle
    - Pixel threshold
    - Channel noise
  - Cluster produced
  - Needs to be integrated into belle library

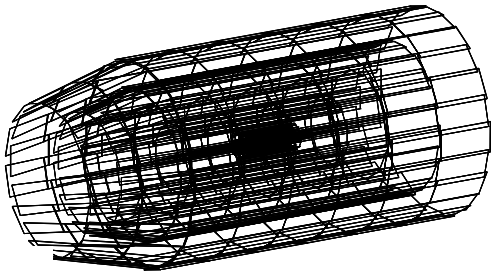
Tracking/vertexing performance (3/20)

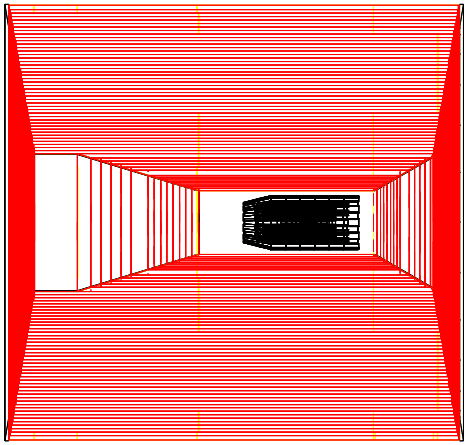
SVD

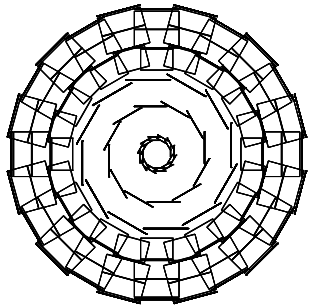
(A.Kibayashi)

- Status
  - Very basic
    - Geometry: Si sensors
    - Digitization: drift time & diffusion
  - Clustering & tracking done
- ToDo
  - Support structure
  - Cooling
  - Digitization
    - Lorentz angle
    - Capacitance
    - …









Vertexing

Issues

w/ Geant4

- Vertex resolution
  - Position of innermost layer (r=15 mm -> 10 mm)
  - Pixel detector
- Vertex efficiency for Ks
  - Larger radial volume
  - Chip-on-sensor?
- Background tolerance
  - Use of APV25

Study the effect of slanted layers, Optimize the slant angles

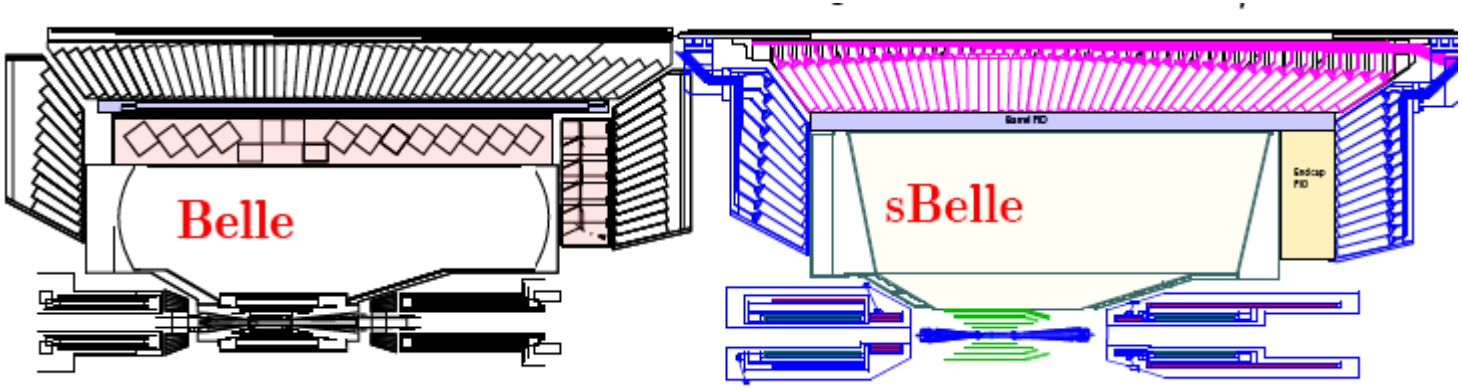
Optimize the pitch sizes

Study the effect of material; chip on sensor + cooling.

Tracking

CDC (central drift chamber)

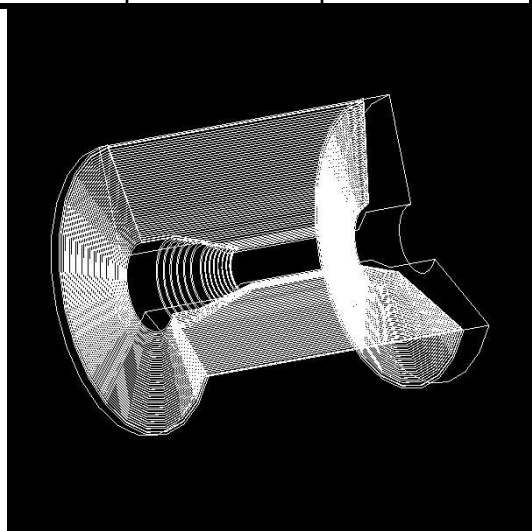
- Pt resolution
  - Longer lever arm to improve momentum resolution
- dE/dx
  - Larger radial volume (752 → 978mm)
- Background tolerance
  - Smaller cell size
    - Innermost 12 mm, 64 cells → 8 mm, 160 cells

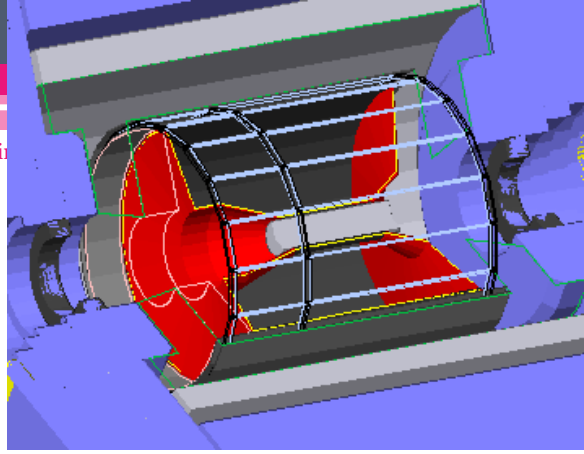


CDC
(H.Ozaki)

- Geometry done
  - Inner/outer radius can be adjusted to SVD/PID
- Hits & digits done
- Fine tuning on tracking ongoing
- dE/dx soon to be released

	Present	Future
Radius of inner boundary (mm)	77	160
Radius of outer boundary (mm)	880	1140
Radius of inner most sense wire (mm)	88	172
Radius of outer most sense wire (mm)	863	1120
Number of layers	50	58
Number of total sense wires	8400	15104
Effective radius of dE/dx measurement (mm)	752	978
Gas	He-C_2H_6	He-C_2H_6
Diameter of sense wire (μm)	30	30

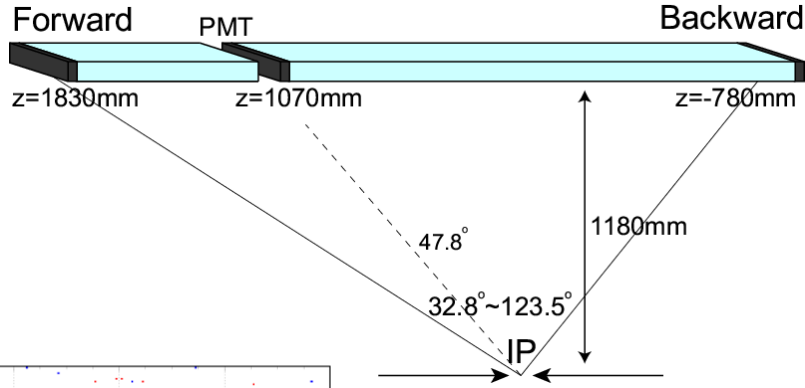


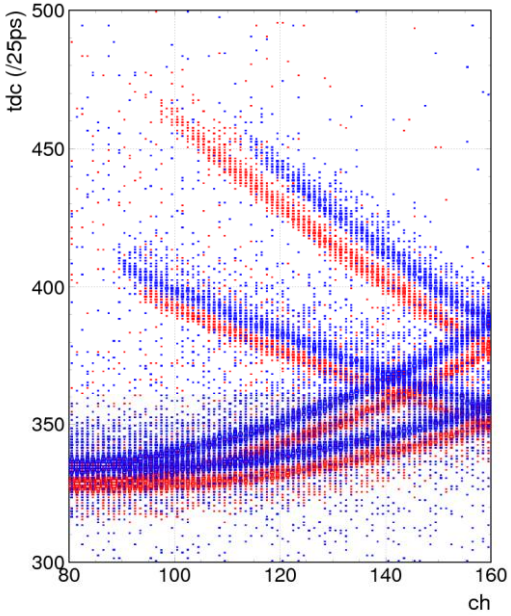


TOP – time of propagation

(K.Inami)

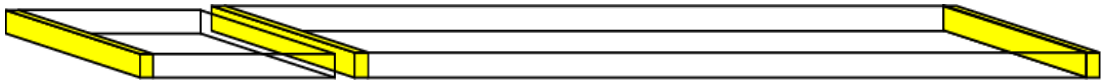
- Three read out type
- Basically working well
  - Correct light propagation and TDC distribution
  - Proper ring image reconstruction
  - Output likelihood as expected
- To Do
  - Check performance for several incident momenta and angles



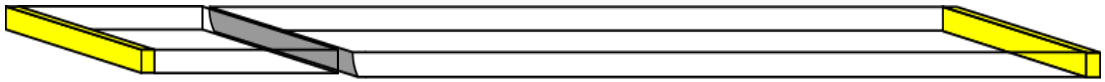


TOP for Barrel PID
possible options

3 readout type



Focusing type



Focus Mirror

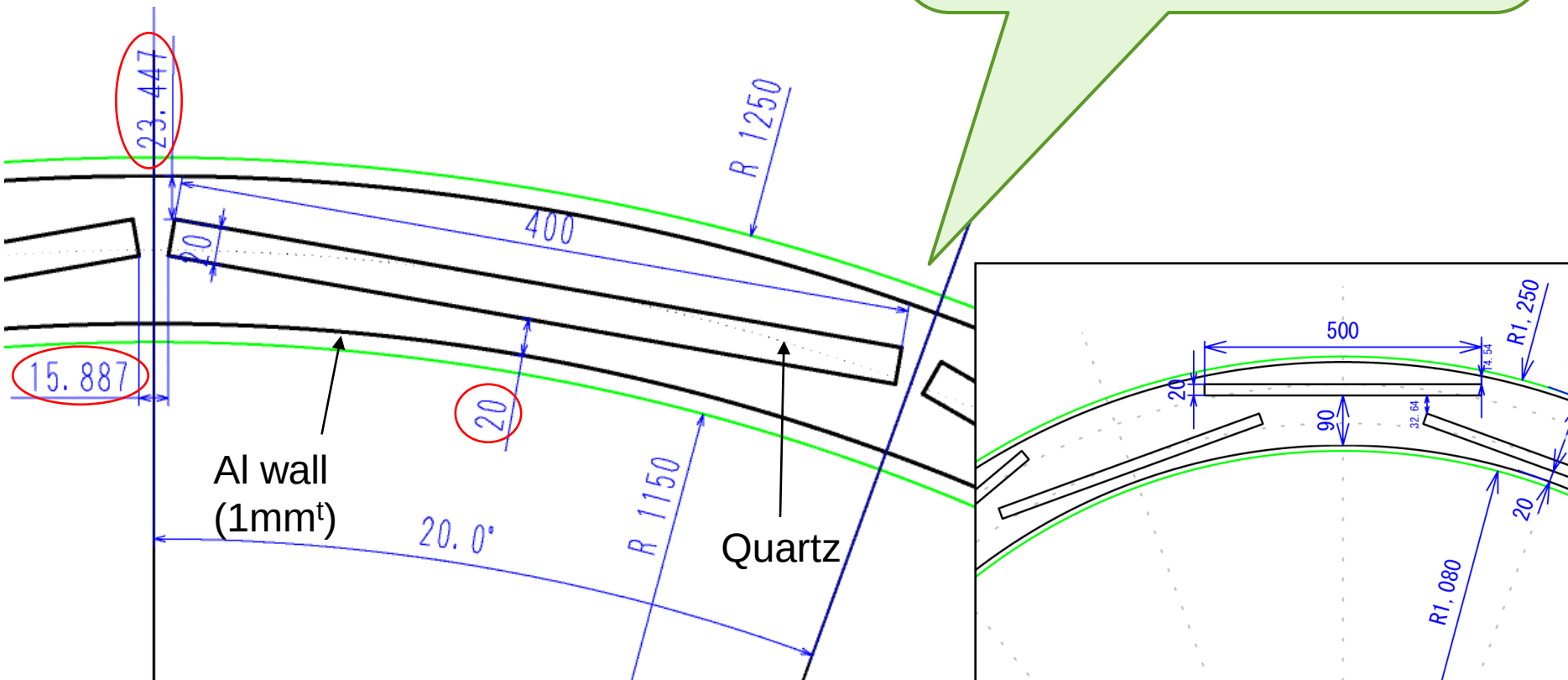
Study w/ Geant3

	Option 0 **3 readout** **+ multi-alkali MCP-PMT**	**Option 1** **Focusing** **+ multi-alkali MCP-PMT**	**Option 2** **Focusing** **+ GaAsP MCP-PMT**
4GeV K/π	2.8σ	2.5σ → 4.0σ	4.2σ
comment	Principle established	Correction Eff. to be improved	GaAsP under development

For options 1 & 2, Geant4 needs:
Focusing mirrors included, new reconstruction method needed for complicated ring image

TOP

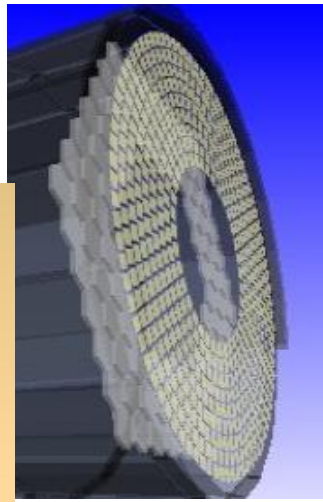
w/ Geant4
Study the effect of
-10% dead space
- overlapping option

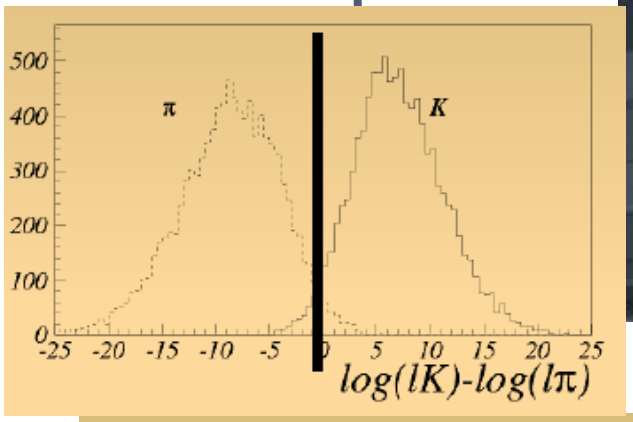


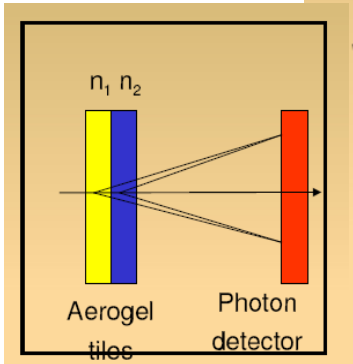
Session Geant4.1 (3/18)
A-RICH (3/20)

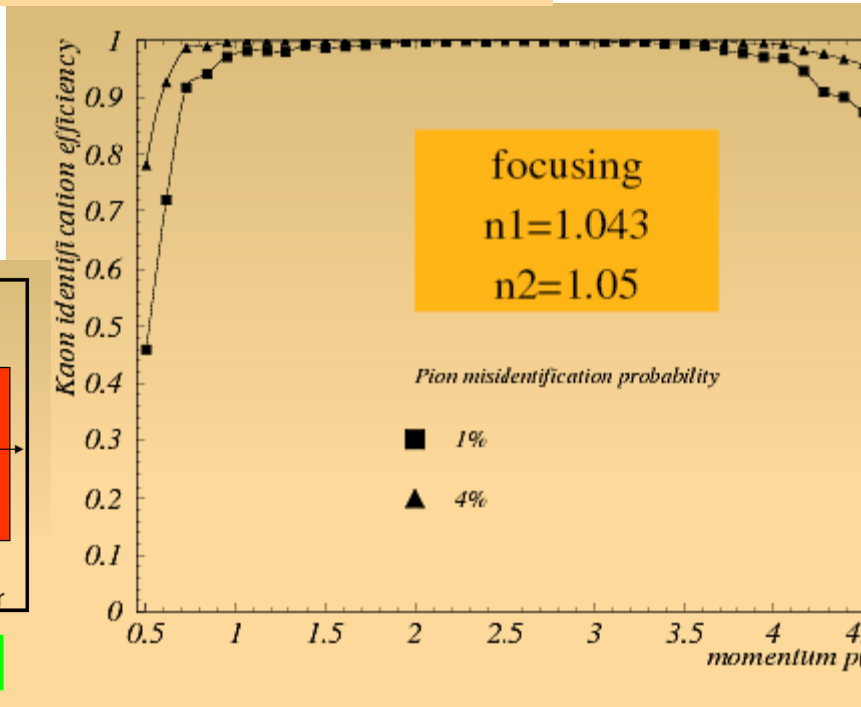
RICH – aerogel RICH for endcap PID (R.Petotnik)

- Basic geometry done
  - Aerogel
  - Photon detector: HAPD
  - Support structure not yet
- Hits & digits done
  - Processes included
    - Cherenkov photon generation
    - Rayleigh scattering in aerogel
    - Optical photon transport
- Reconstruction
  - Standalone working well
  - Integrate into belle lib









ECL – electromagnetic calorimeter

(P.Krokovny)

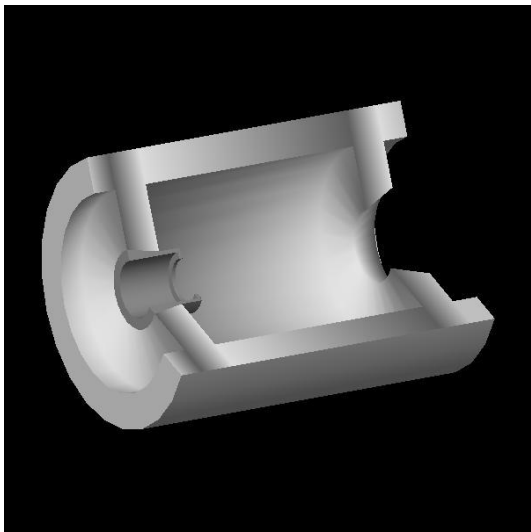
issues

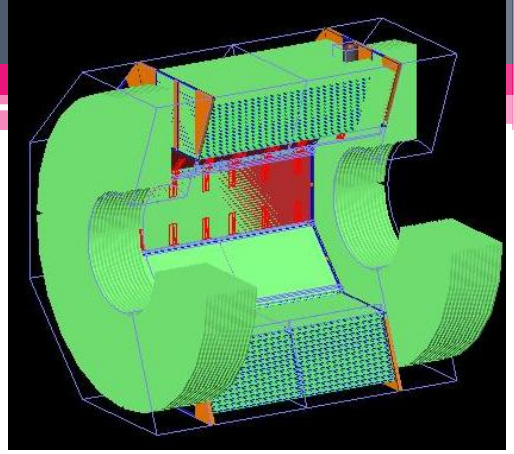
- Endcap
  - Background
  - Faster crystal: CsI(Tl) τ~1μs → pure CsI τ~30ns
  - Small light yield UV
  - PMT
- Barrel
  - Background, not as bad as endcaps
  - Waveform sampling & fitting
- Smaller material inside ECL

G4 status

- Rough geometry done
- Reconstruction OK
  - Clusters
- Study being done w/ backgrounds

w/ Geant4
Study the effect of pure/partial CsI





KLM

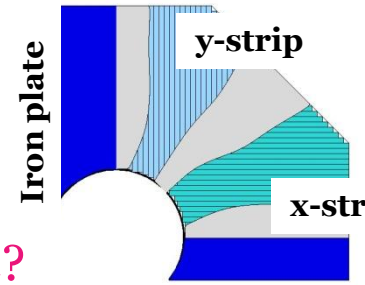
(L.Piilonen)

- Resistive plate counter (RPC) option in Barrel & Endcap
  - Detailed geometry already in
- Geant4 output
  - Raw data: hit strip info
  - Recon: k long id info. ready
- ToDo
  - Muid (software complications)
  - Include the tabulated RPC detection efficiencies in generating the RPC hits

From Geant3 based optimization study…

Layer	Barrel(F)	E-cap(F)	E-cap(B)
0	3.6	2.4	3.4
1	2.3	2.4	2.9
2	1.6	2.4	2.8
3	1.1	2.0	2.8
4	0.7	2.2	2.8
5	0.6	2.7	2.9
6	0.6	2.7	1.5
7	0.4	3.3	2.6
8	0.7	3.1	3.0
9	0.5	3.9	2.8
10	0.3	4.7	3.5
11	0.4	5.3	3.0
12	0.4		
13	0.4		
14	0.5		

- Endcaps
  - Killed by high rate of background
  - Scintillator + GAPD (SiPM)
    - T recover = 1s →500ns
  - Radiation hardness, OK for >5 years
- Barrel
  - background will be OK
  - PRC in avalanche mode?



$L=5\times10^{35}/cm^2/s$

w/ present RPC Background in Hz/cm²
1sec to recover,
ε = 50% @ 1Hz/cm²
ε = 0% @ 2Hz/cm²

For more study w/ Geant4,
Add Scintillator +GAPD option in the Endcap

Session Geant4.3 (3/18)

G4EXT – track extrapolation

(L.Piilonen)

- Charged track propagation from the end point of CDC
- Store position, momentum, and covariance matrix at the entrance/ext of selected volumes
- Basically done
  - A few problems: conflicts w/ g4 simulation module
    - Two separate jobs required currently, before/after g4ext
- Outer detectors can now use track info.

Summary

- 1st set of simulation data soon to be released
  - Very basic version
- Still needs
  - Fine geometry including support structure, cooling, readout electronics…
  - Materials under R&D
  - Fine tuning of the reconstruction software
- Studies
  - Space optimization between sub-detectors
  - Fine tuning/optimization of each sub-detector
  - Backgrounds
  - Hermiticity
  - …
- Join us!

backups

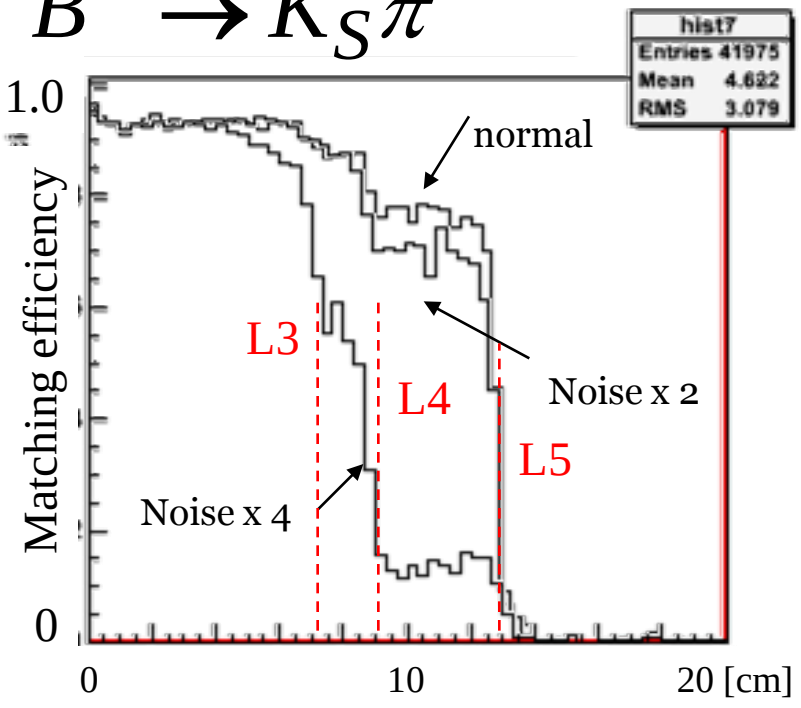
Sample scripts

- /belle/belle/b20080316_1250/docsrc/examples/g4superb

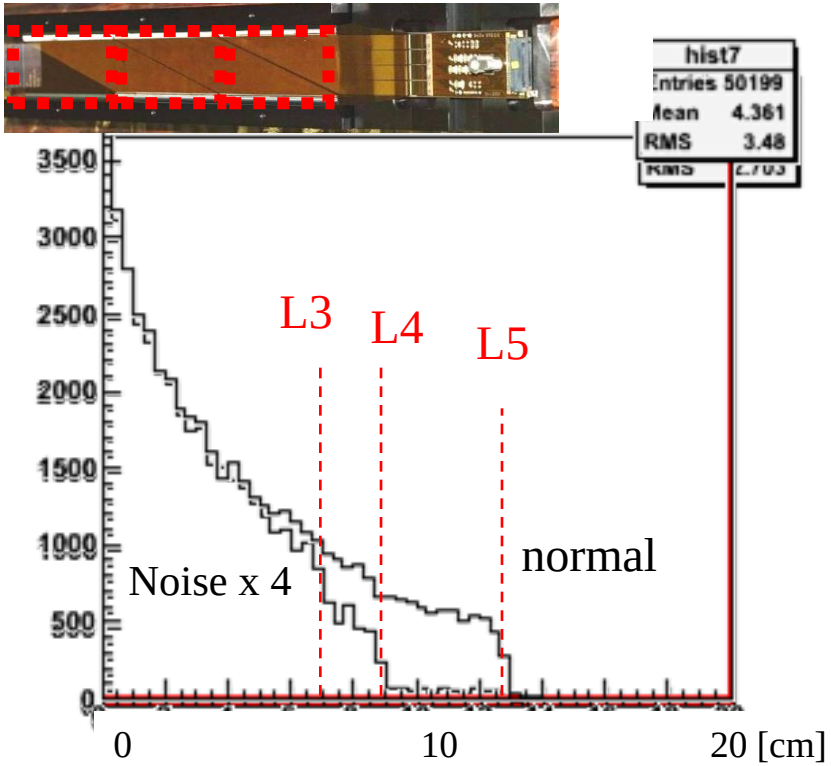
SVD : Matching efficiency for Ks

Geant3 full simulation

$B^+ \to K_S \pi^+$



r of Ks decay vertex



r of Ks decay vertex

Ks daughter affected by S/N degradation
Lose 20% events with 4 times worse S/N

Noise due to
- sensor leakage current
- detector capacitance

Chip on sensor?
- check material effect

SVD - Material Effect on Vertex Resolutions Study done by Geant3 (T.Hara)

	$\pi^+\pi^-$ (31mm)	$J/\psi K_S$ (36mm)	D^+D^- (43mm)	$K^*(K_S\pi^0)\gamma$ (128mm)
2×ρ for SVD,CDC	6%	11%	19%	
2×ρ for SVD	6%	11%	21%	
2×ρ for SVD lyr1,2	6%	11%	19%	
2×ρ for SVD lyr3,4	0%	0%	0%	
2×ρ for SVD lyr3,4 + cooling tube	0%	0%	0%	7%

Degradation in resolutions, **No change**

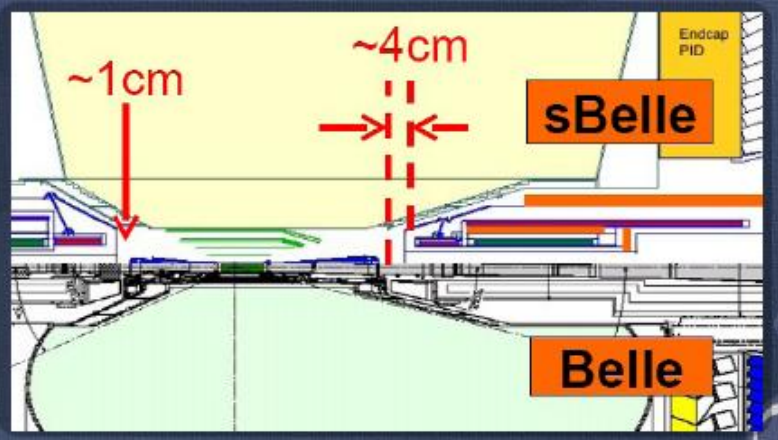
- **No problem to increase the material in outer layers for 'normal' vertex reconstruction**
- **Dilutes the merit to have larger volume for K_S**

SFD

(K.F.Chen)

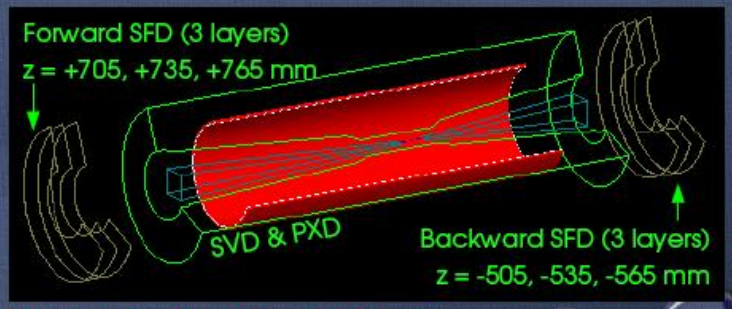
Super Forward Detector

- Minimum hypothesis & target:
  A SFD for improving detector acceptance.
  (No direct contribution to main analysis, but as a veto detector)
- Reject the prompt tracks from IP for the sBelle full-recon. analysis.
- However, we are actually out of space:



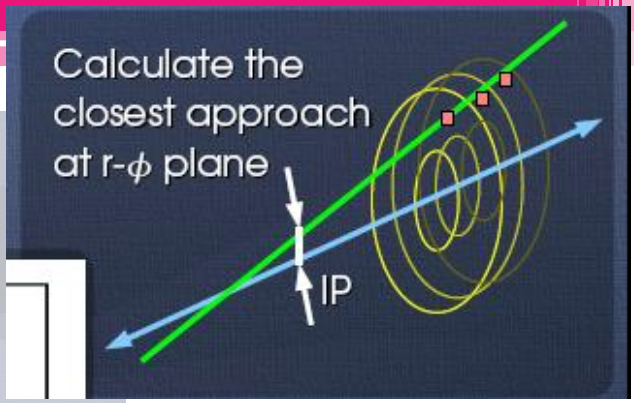
Geant4 Module

- Regardless of the space, we prepared a g4superb-sfd module.
  (as a copy of g4superb-pxd...)
- Assuming silicon pixel detector with large cells: 2mm x 2mm.
- Preliminary geometry (sensors only at this moment...):



- Coverage: FW (5.3°–11.1°), BW(165.1°–172.7°)
- Produce two panther tables: DATSFD_TRUEHIT, DATSFD_CELL

BNM2008

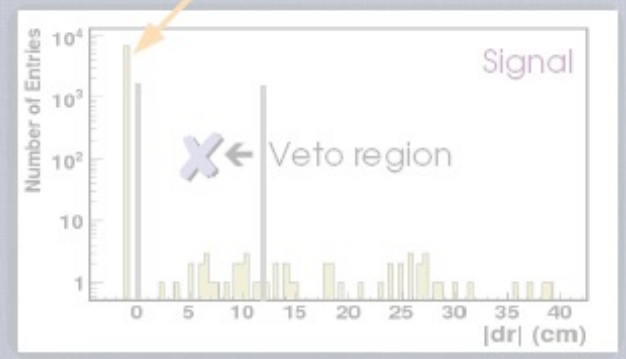


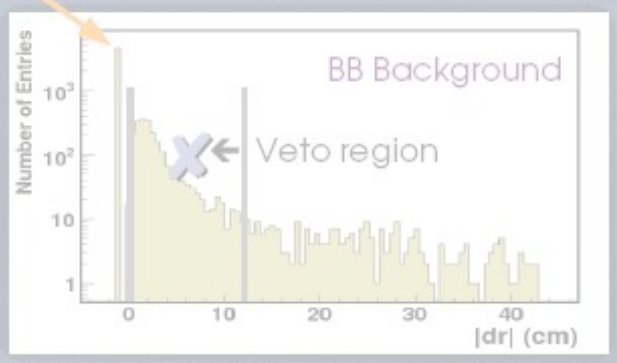
Sraight line track finding

Preliminary Effects on $B \to K^{(*)} \nu\nu$

- Veto the events with one or more track(s) reconstructed:

No track(s) reconstructed





Signal efficiency: 99.7%

Background reduction: 31.5%

➔ *More studies are required to have a conclusive result:*
e.g. material in front of the detector,
supporting structure, shielding, etc.

page. 17

~30% of backgrounds from B decays removed by rejecting the charged tracks pointing From the IP