Proposal of the muon system for the STCF based on scintillator and WLS fiber readout

Timofey Uglov
(LPI RAS)

Outline

- Purposes and challenges for the STCF muon system
- Simulation
- Proposal: Scintillator + WLS + SiPM (Belle II experience)
- Summary

Purposes and challenges

- Muon identification (μ/π separation)
- KL identification
- KL veto

Purposes and challenges

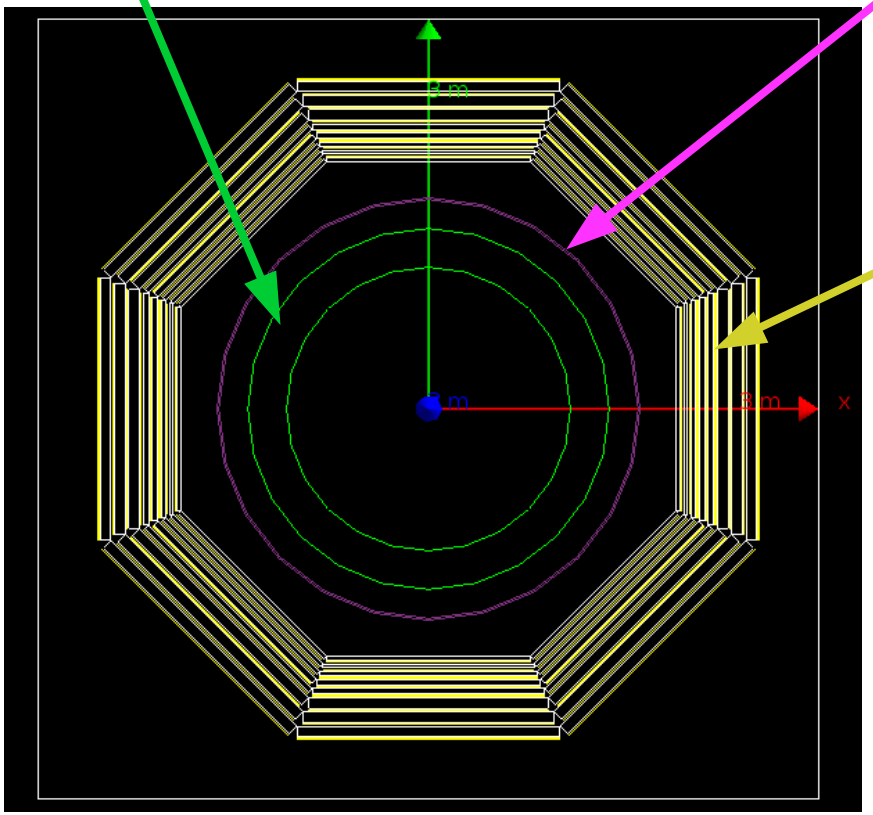
- Muon identification (μ/π separation)
- KL identification
- KL veto

Input from the physics program is demanded!

Simulation (simplified geometry)

Magnet coil (copper)
(radius 1610mm,
thickness 14.4 mm, 1X0)

CsI calorimeter
(inner radius 1090mm,
thickness 297.6 mm, 16 X0)



9 iron absorber layers inner distance 1900mm,
thickness:
30, 30, 30 mm (=1.7 X0),
40, 40 mm(=2.3 X0)
80, 80, 80 mm (=4.5 X0),
The 30 mm gaps between the absorber layers

Do not expect too much from this simulation!

- Pure Geant4
- Simplified construction
- Aim: basic parameters estimation

Simulation (simplified geometry)

Tasks for the 0.1 version of the simulation tools:

- Estimate basic features of the interacting muons (despite of the detector technology choice):
  - Muon smearing due to the multiple scattering (depending of the muon energy, direction and/or specific production process; magnetic field ON/OFF)
  - Desirable thickness of the muon system to reach maximal muon detection efficiency
  - Muon/pion separation: decay point (detector layer) for the muons and pions of the same momentum, feasibility do distinguish processes based on this information
  - Feasibility to distinguish pion kink: distinguish muons originated from the primary vertex and produced in the pion decays.

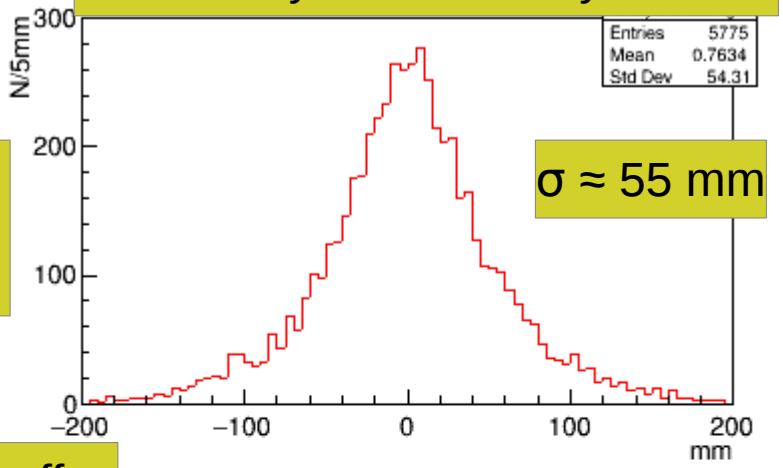
Simulation (multiple scattering)

e+e- → μ+μ-
√s=3.096 GeV

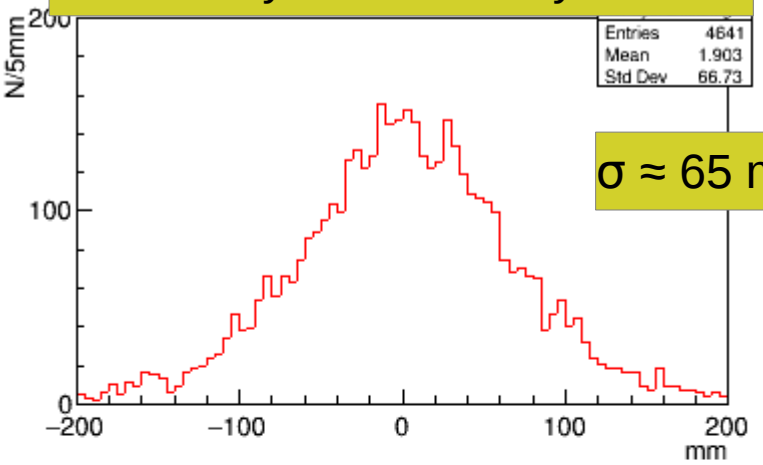
Magnetic field off

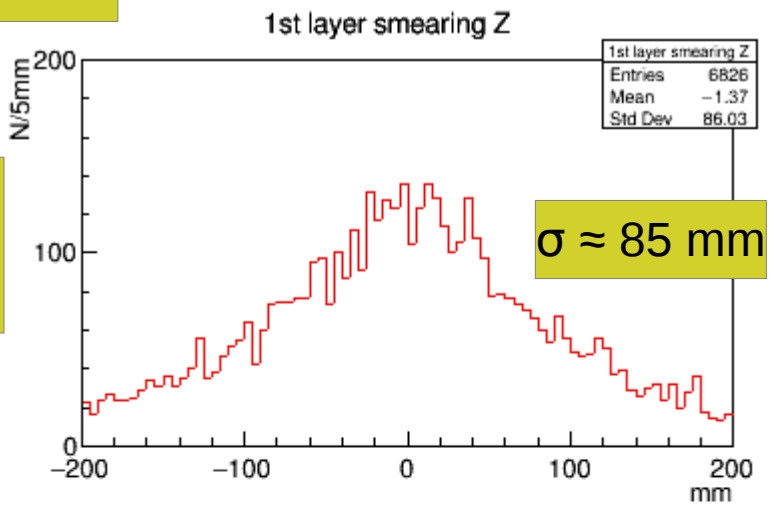
e+e- → τ+τ-
τ → μ + X
√s=3.096 GeV

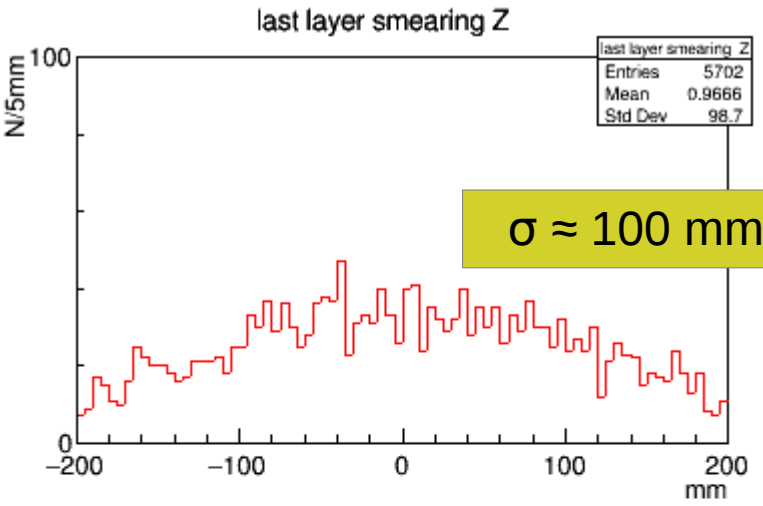
First layer of muon system



Last layer of muon system







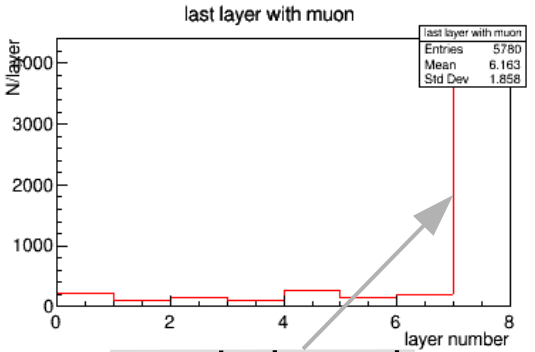
Simulation (layer based μ/π separation)

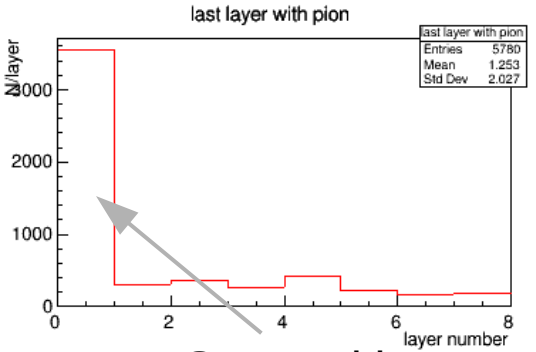
Last layer with muon

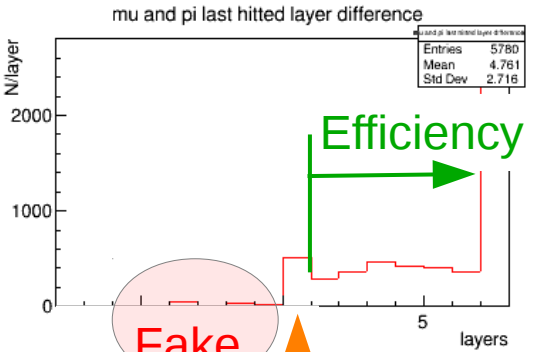
Last layer with pion

Last layer difference

e+e- → μ+μ-
√s=3.096 GeV







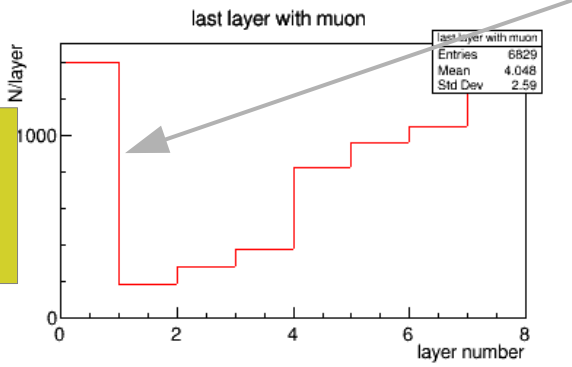
Punch through

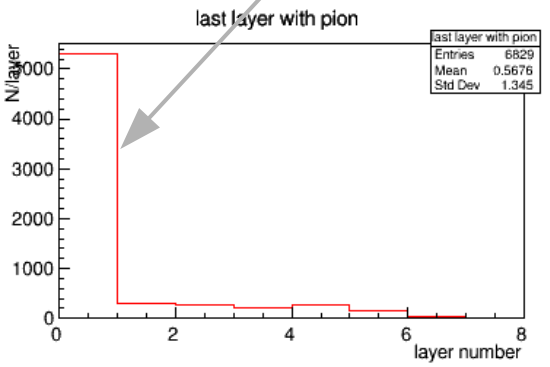
Stopped in Calorimeter/magnet

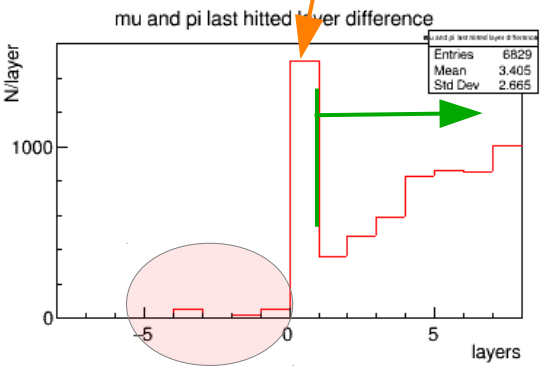
Inefficiency

Magnetic field off

e+e- → τ+τ-
τ → μ + X
√s=3.096 GeV

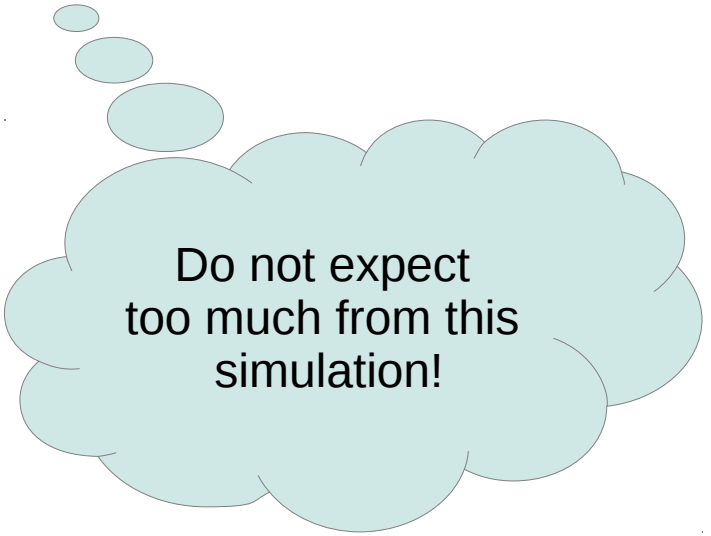






Simulation summary

- Smearing due to the multiple scattering limits space resolution of the muon system to ≥ 5 cm
- Muon system is capable to separate pion and muons even with a few layers
- KL identification capabilities are to be estimated

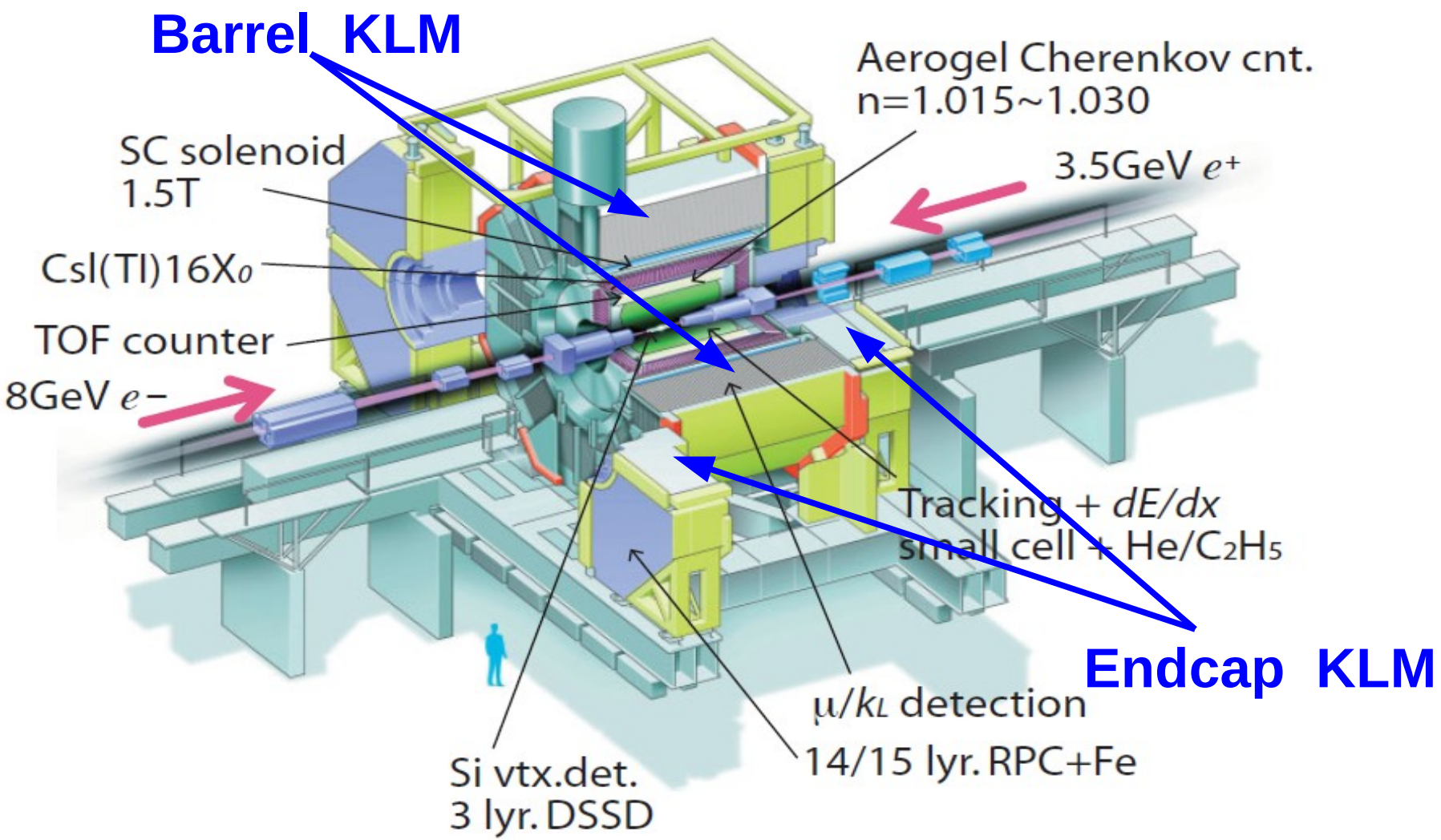


Scintillator option for the muon system of the Super τ-charm Factory

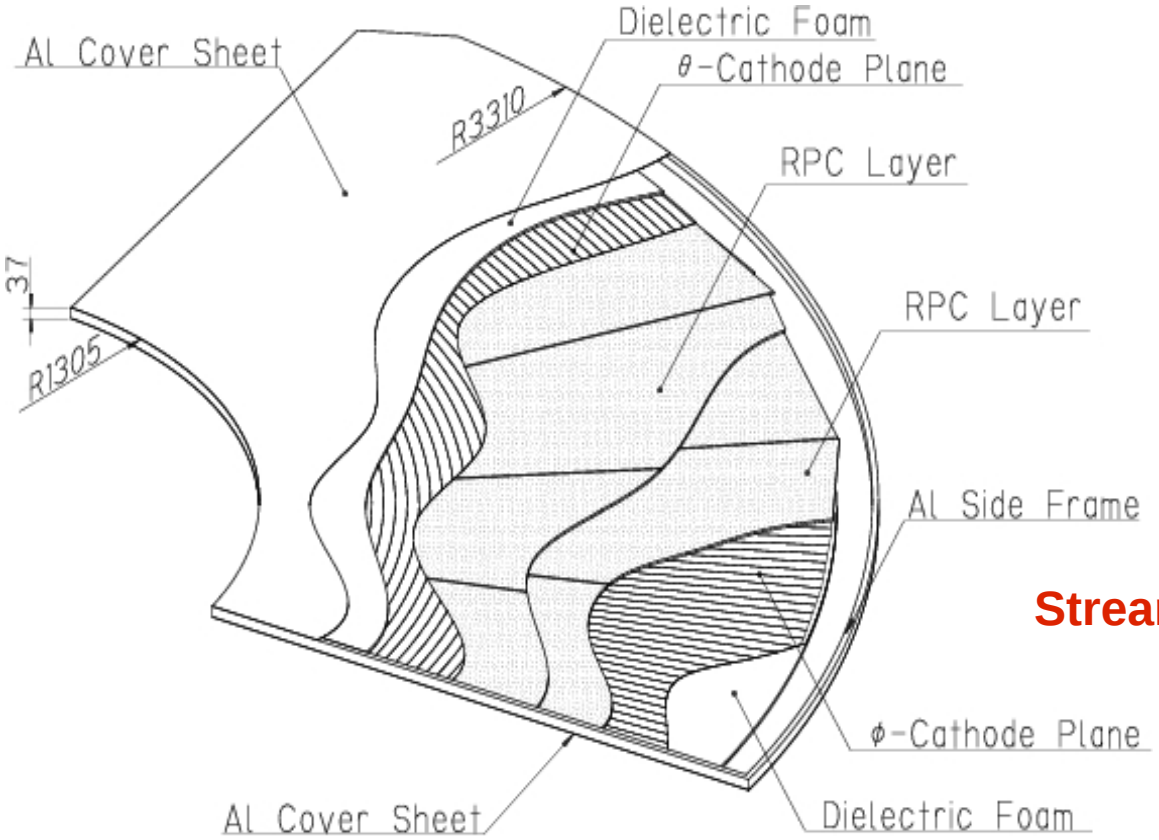
(based on Belle/Belle II experience)

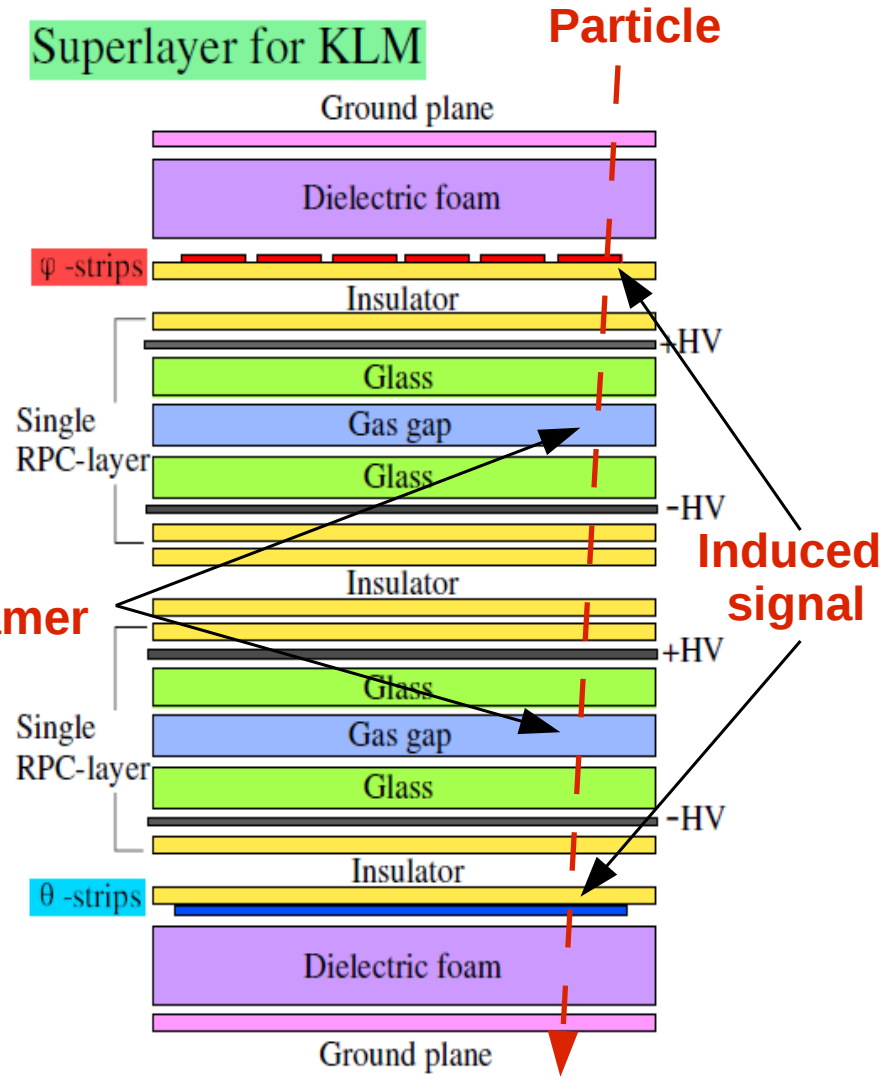
NIM **A 789**, 134–142 (2015)

The Belle detector



Belle: Resistive Plate Chambers





Gas: Ar/C_4H_{10}/HFC-134a = 30/8/62 (%)
Voltage≈7kV

RPC efficiency for Belle2

Moderate → Higher luminosity → Higher background → Larger dead time → Lower efficiency

Belle2 TDR

Layer	Barrel		Endcap forward		Endcap backward	
	KEKB	SuperKEKB	KEKB	SuperKEKB	KEKB	SuperKEKB
0	0.91	0.70	0.91	0.0	0.90	0.0
1	0.94	0.81	0.93	0.0	0.90	0.0
2	0.96	0.87	0.94	0.0	0.90	0.0
3	0.98	0.91	0.94	0.0	0.90	0.0
4	0.98	0.94	0.94	0.0	0.89	0.0
5	0.99	0.95	0.92	0.0	0.88	0.0
6	0.99	0.95	0.93	0.0	0.89	0.0
7	0.99	0.96	0.92	0.0	0.87	0.0
8	0.99	0.94	0.92	0.0	0.86	0.0
9	0.99	0.96	0.90	0.0	0.85	0.0
10	0.99	0.98	0.87	0.0	0.82	0.0
11	0.99	0.97	0.82	0.0	0.80	0.0
12	0.99	0.96	0.78	0.0	0.81	0.0
13	0.99	0.97	0.77	0.0	0.76	0.0
14	0.99	0.96	N/A	N/A	N/A	N/A

Acceptable

Inacceptable

RPC efficiency measured in KEKB and extrapolated to SuperKEKB.

Scintillator option for KLM

Requirements for a muon system:

- Low dead time
- Large geometrical acceptance
- High detection efficiency
- Low background

Solution

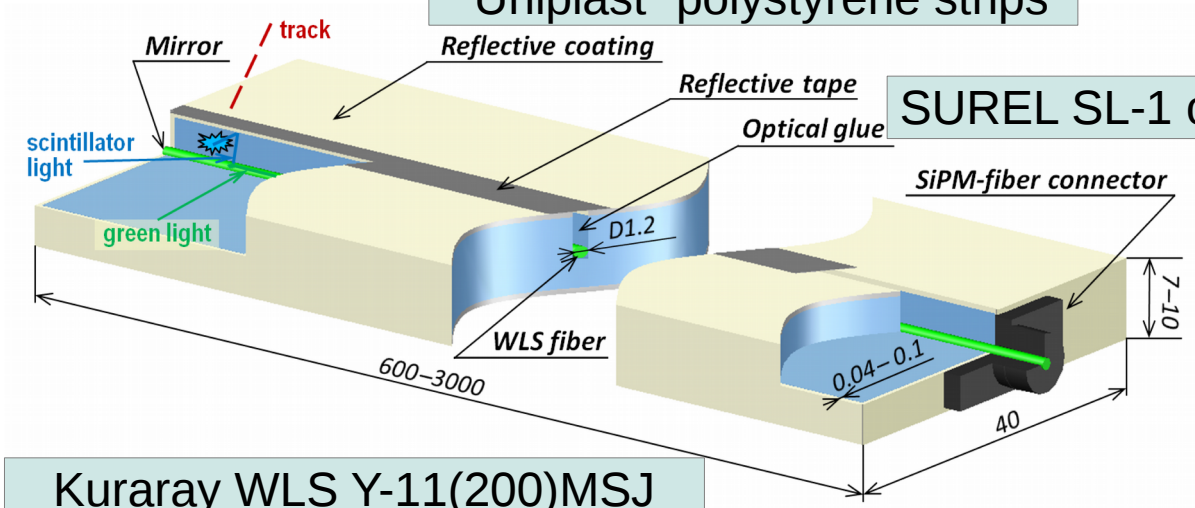
- Scintillator based detector with WLS readout
- Fast photodector: Si photo diode in Geiger mode
- Independent operation of x-y layers

Scintillator - WLS - SiPM

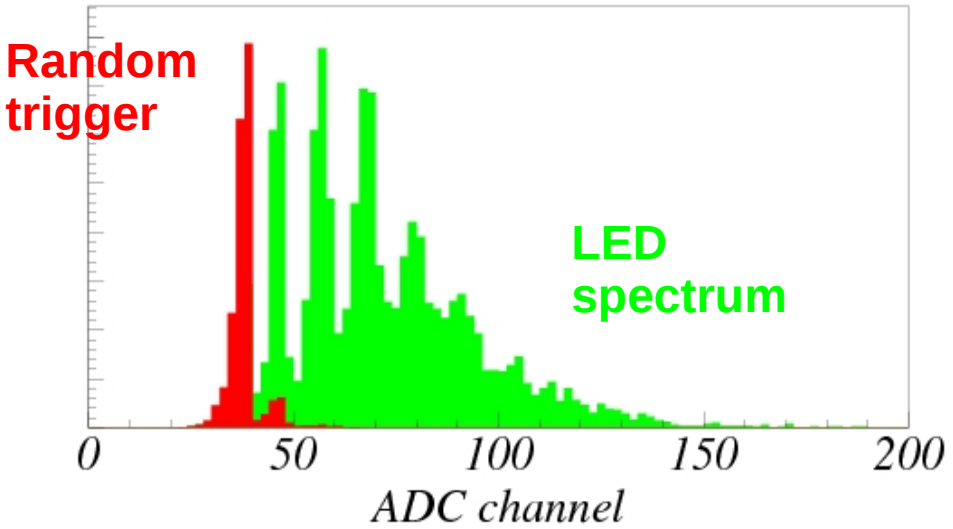
"Uniplast" polystyrene strips

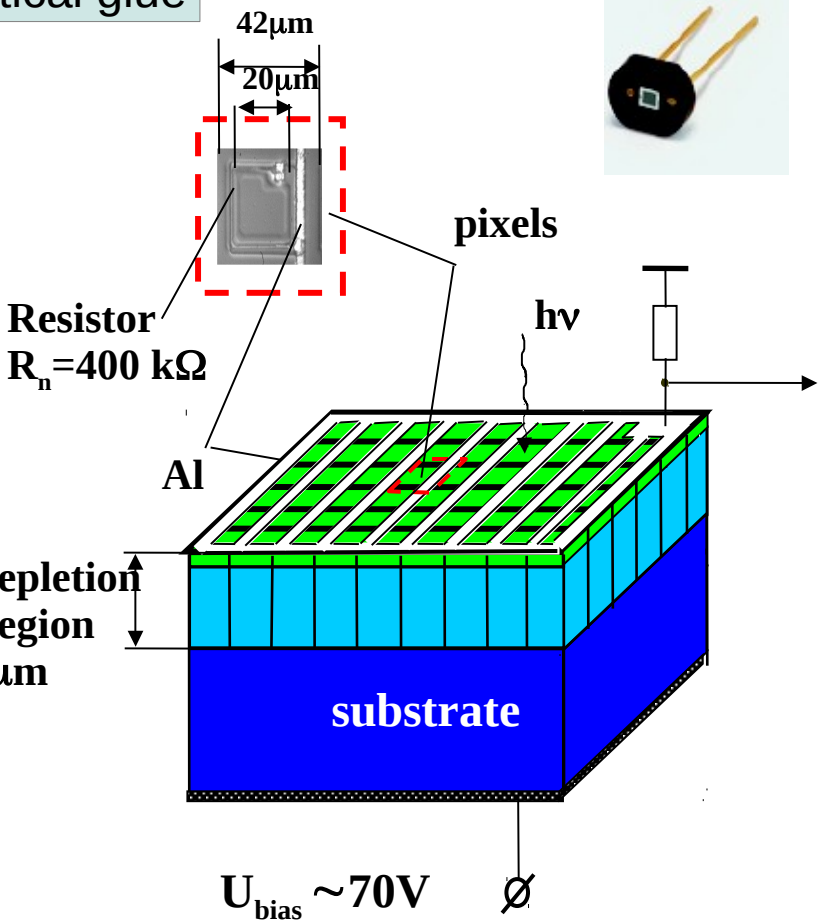
Hamamtsu MPPC S10362-13-050

SUREL SL-1 optical glue



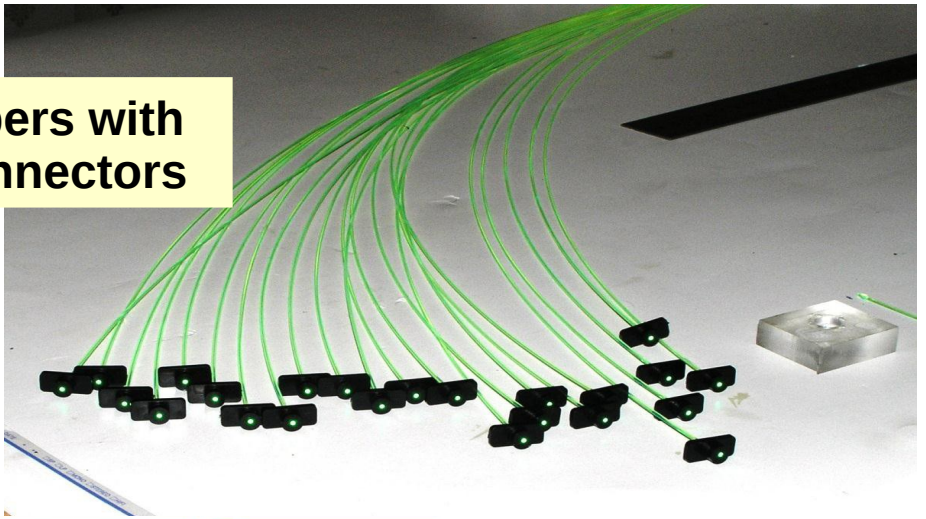
Kuraray WLS Y-11(200)MSJ

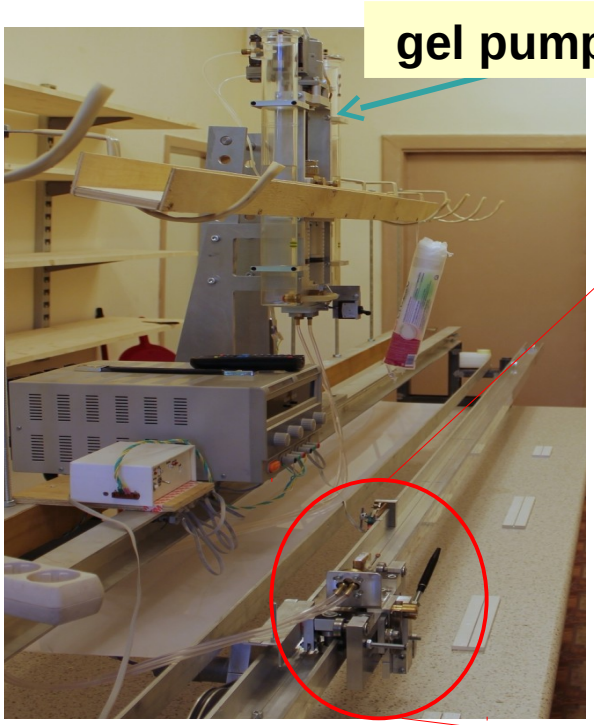


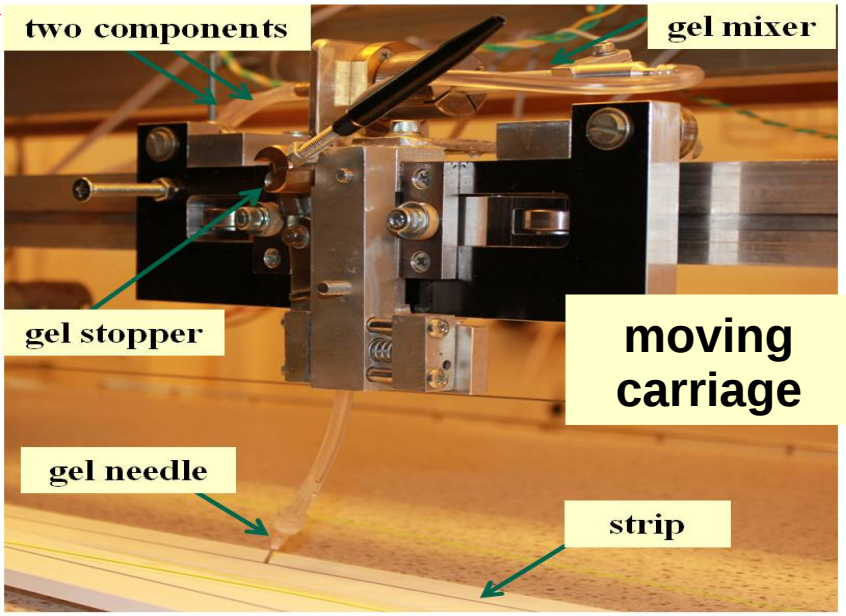


Scintillator strip production

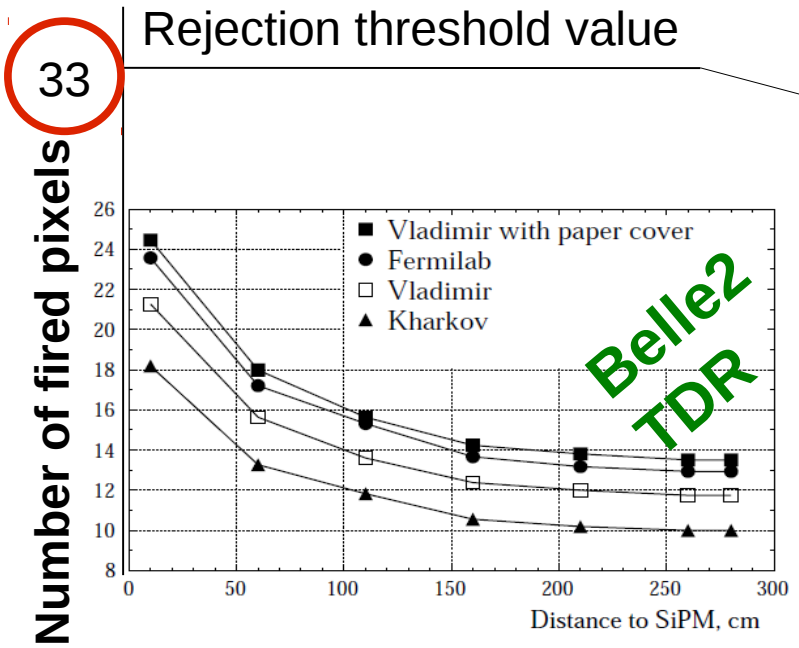
filling the strip groove with optical gel from the top with moving carriage

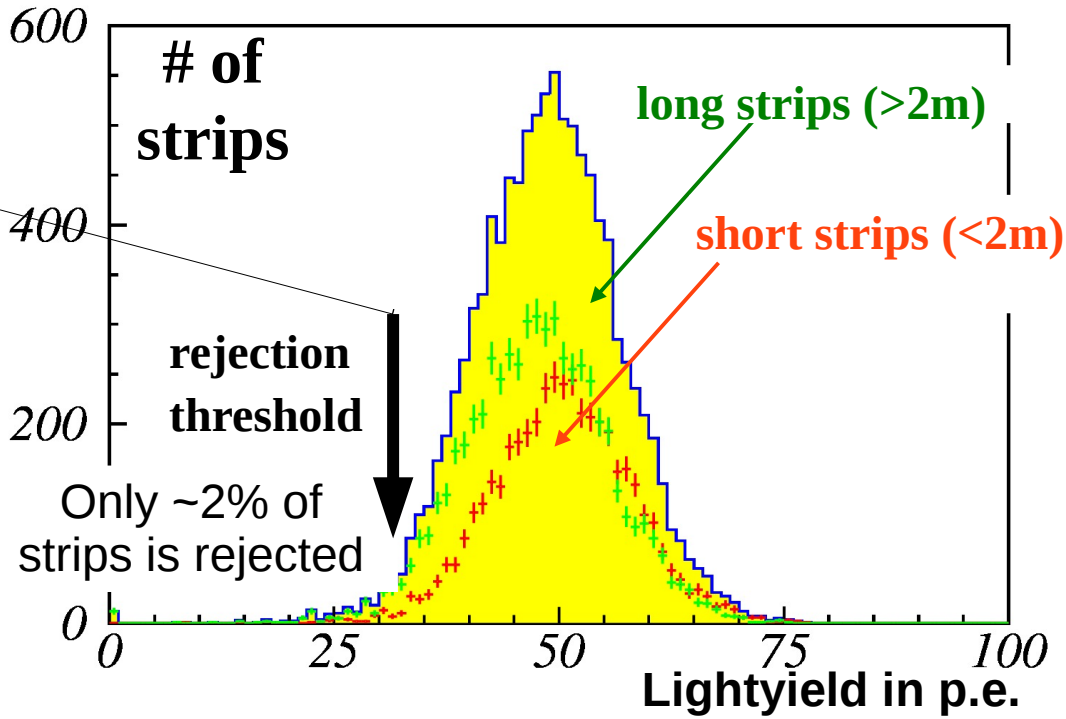


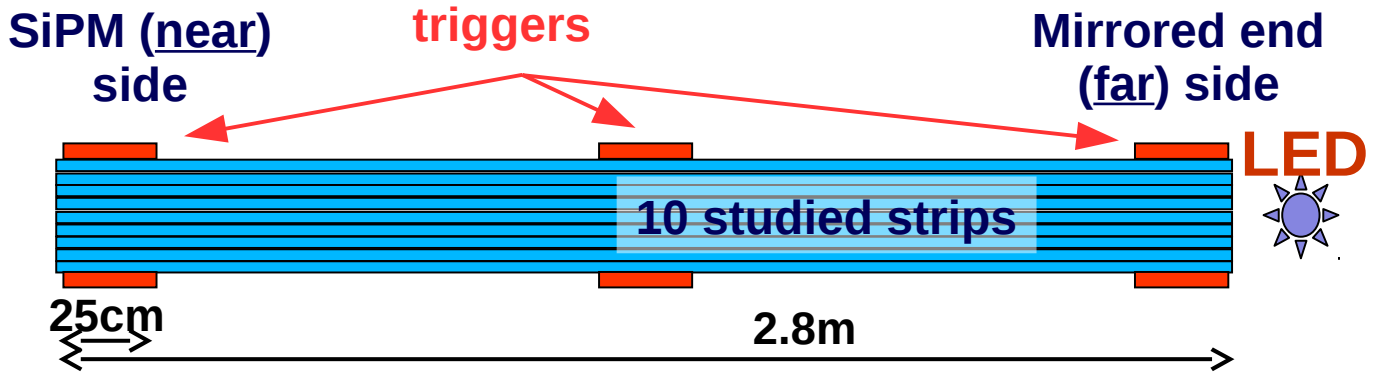




Scintillator strip lightyield

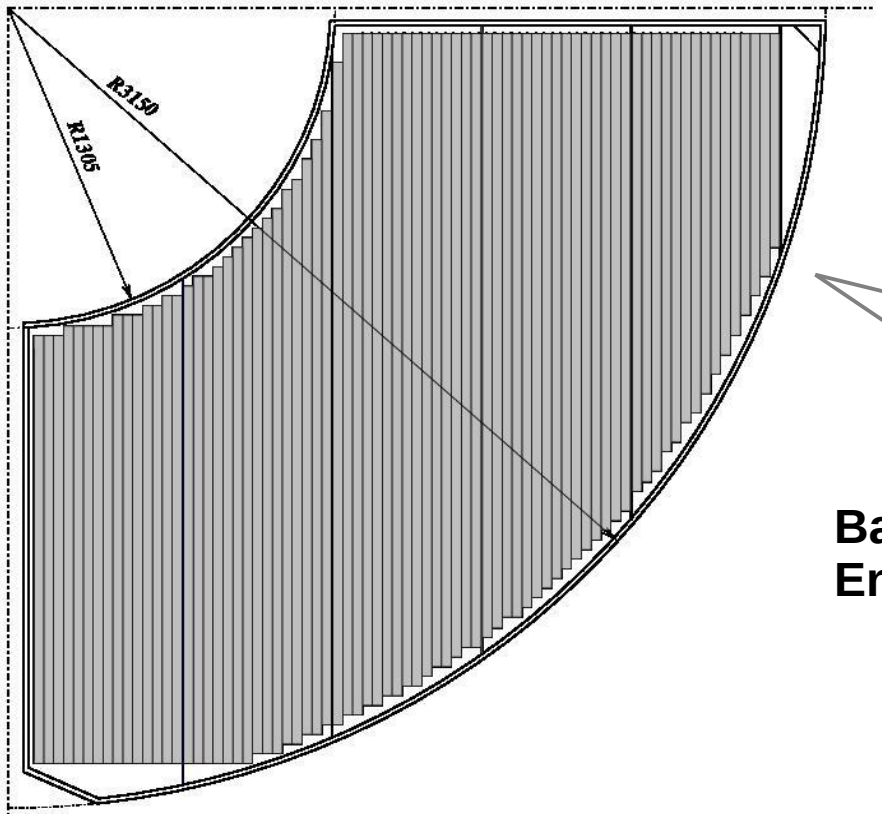




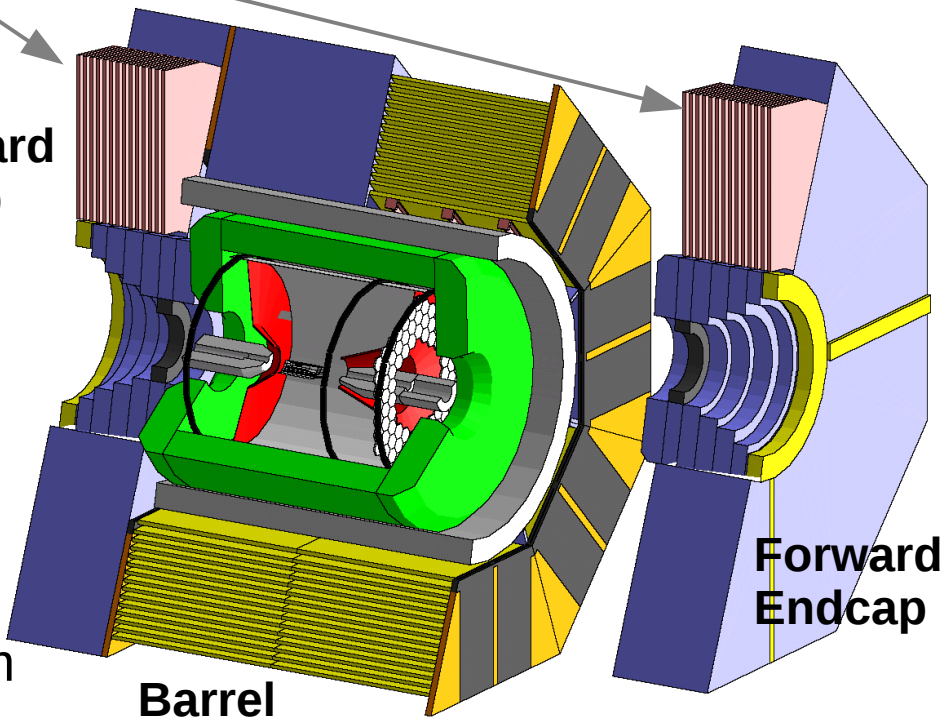


Good Gaussian distribution with a small RMS and perfect (almost twice larger than at TDR) mean value

Endcap sector layer



- WLS fiber in each strip
- SiPM at one fiber end
- mirrored far fiber end



75 strips (4 cm width)/sector

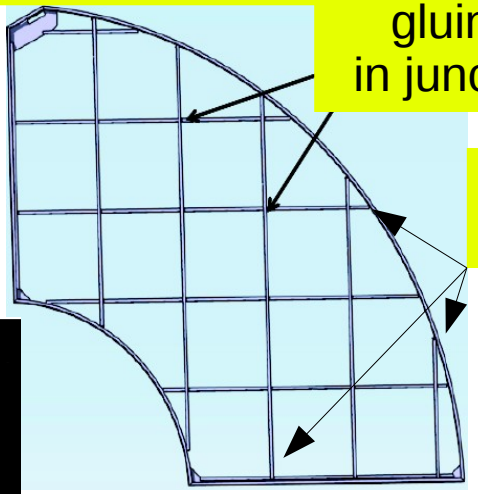
16800 strips for F&B Endcap KLM

the longest strip 2.8 m; the shortest 0.6 m

Layer assemble

15 strips are glued to polystyrene substrate (1.5mm, both sides)

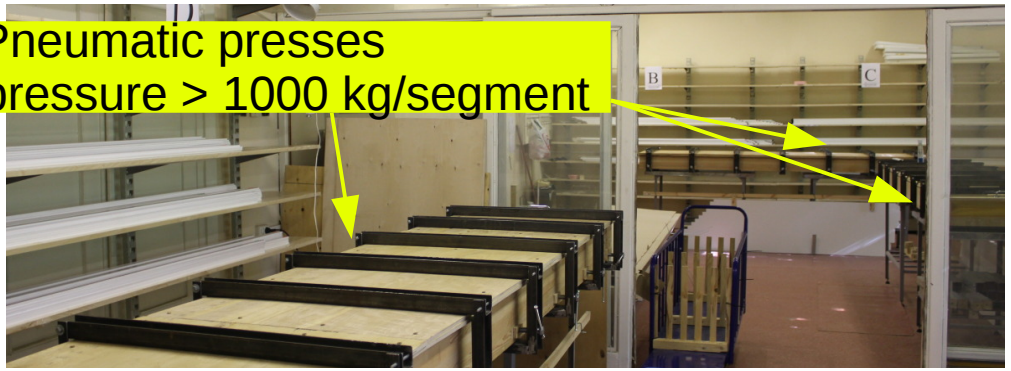
Support structure made of I-beam profiles

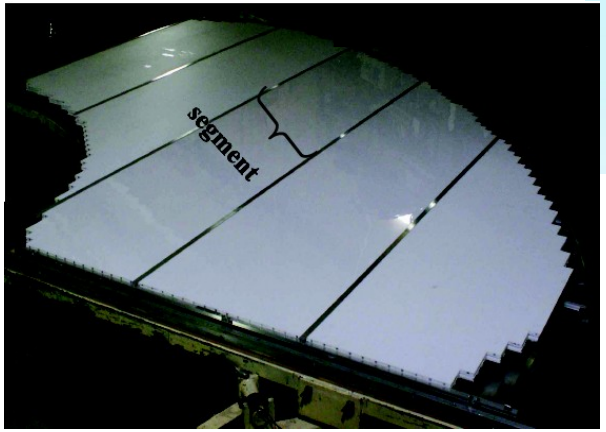


gluing in junction

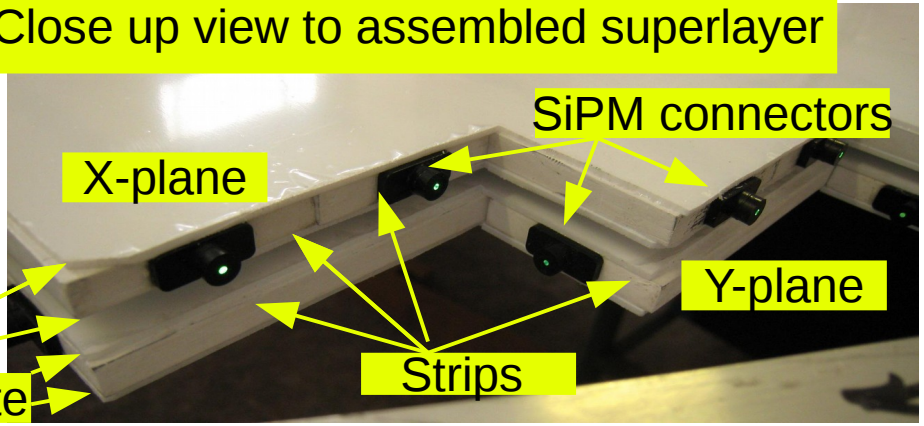
screwing to the net

Pneumatic presses providing pressure > 1000 kg/segment





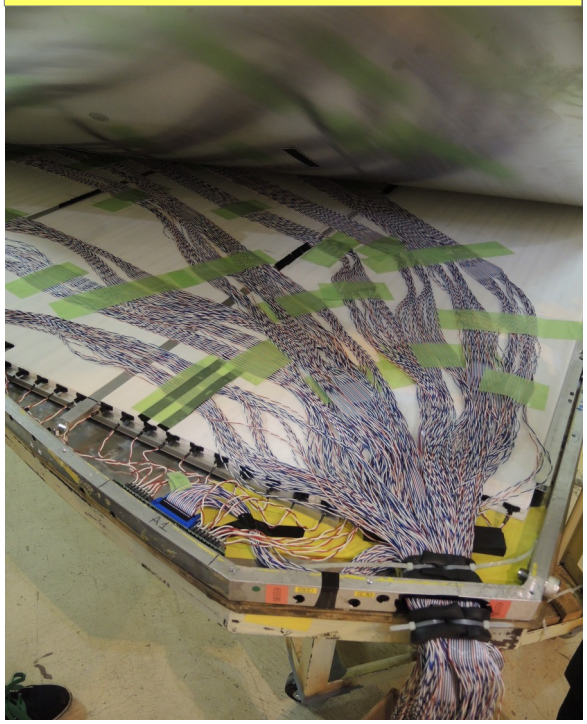
Close up view to assembled superlayer



Modules assemble and installation

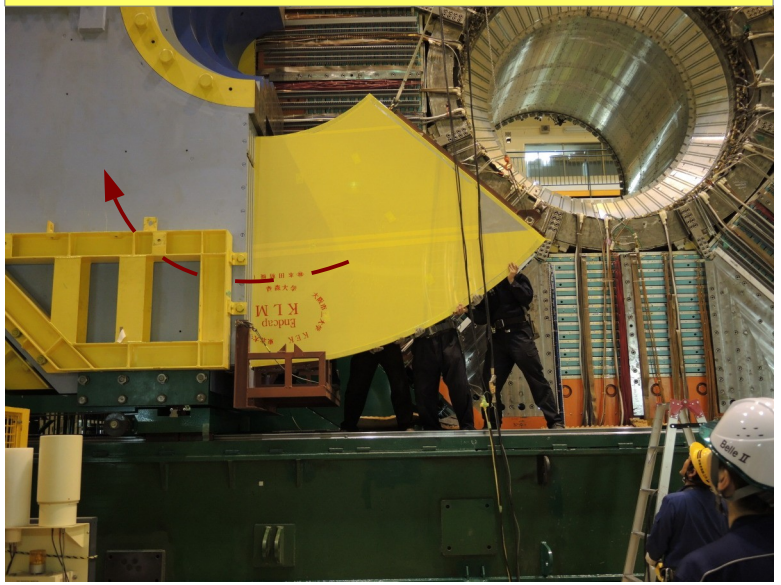
NIM **A 789**, 134–142 (2015)

Assembled module before closing the cover

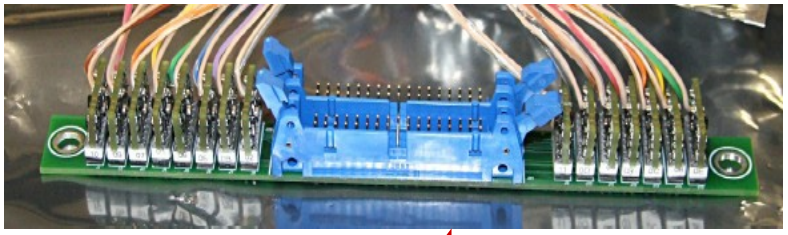


Installation gaps in the magnet flux return

Module installation



Electronics



Belle 2 DAQ

KLM Readout
(150 channels)

10 × 2 × 34-cond
Ribbon cables

Subdetector Readout Module
ASICs
FPGA
or ADCs
On or in Detector

Giga-bit Fiber
Transceiver Links

COPPER
FINESSE
Global Decision Logic
Clock/Event Timing Distribution

SiPMs

HV

preamplifier
board (15 ch)
Inside the detector

readout board
(one per layer)
outside the detector

Conclusion

- Muon system is an essential part of the Super tau-charm factory detector
- A system based on the mixed technique: (scintillator+WLS+SiPM) is proposed.
- Have experience with Belle2 KLM system with similar parameters
- Parameters of the muon system depends highly on the whole detector construction which is not clear yet.

Input from the physics program is demanded!

- Standalone MC seems to be feasible to rough estimate required parameters.