DETECTOR CONCEPT OF THE SCT FACTORY IN NOVOSIBIRSK

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BINP/NSU

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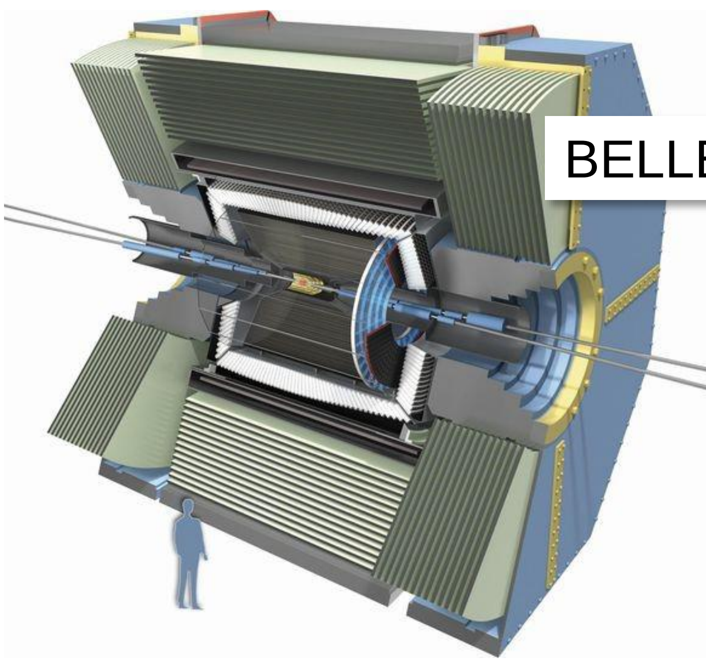
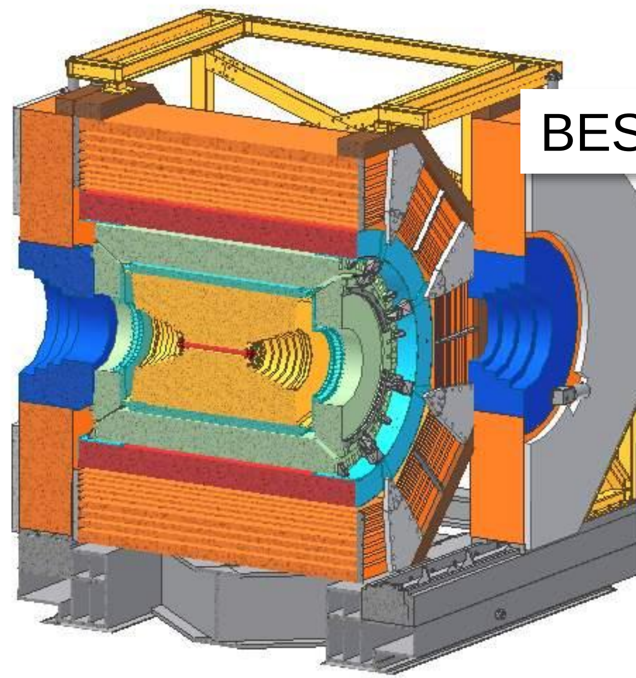
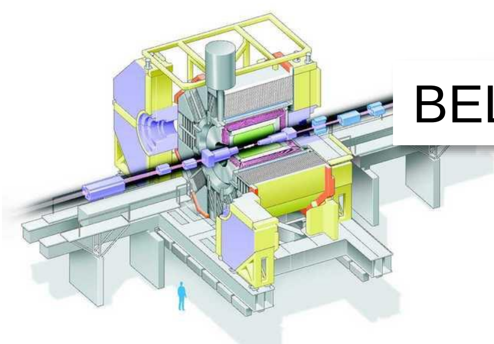
Detector requirements

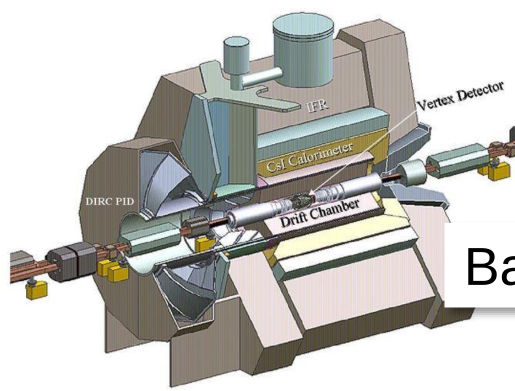
- Good energy and momentum resolution, high efficiency
- High efficiency of soft track detection
  - e.g. in D^* or Λ decays
- Few mm vertexing
  - $c\tau(K_s) = 27$ mm, $c\tau(\Lambda)$ =79 mm
- Very good particle identification: $e/\mu/\pi/K$
  - π/K in the whole energy range, e.g. for $D\bar{D}$ mixing
  - μ/π up to 1.2 GeV, e.g. for $\tau \to \mu\gamma$ search
- Efficient “soft” trigger
- Ability to operate at high luminosity
  - up to 300 kHz at J/ψ

Older brothers and sisters

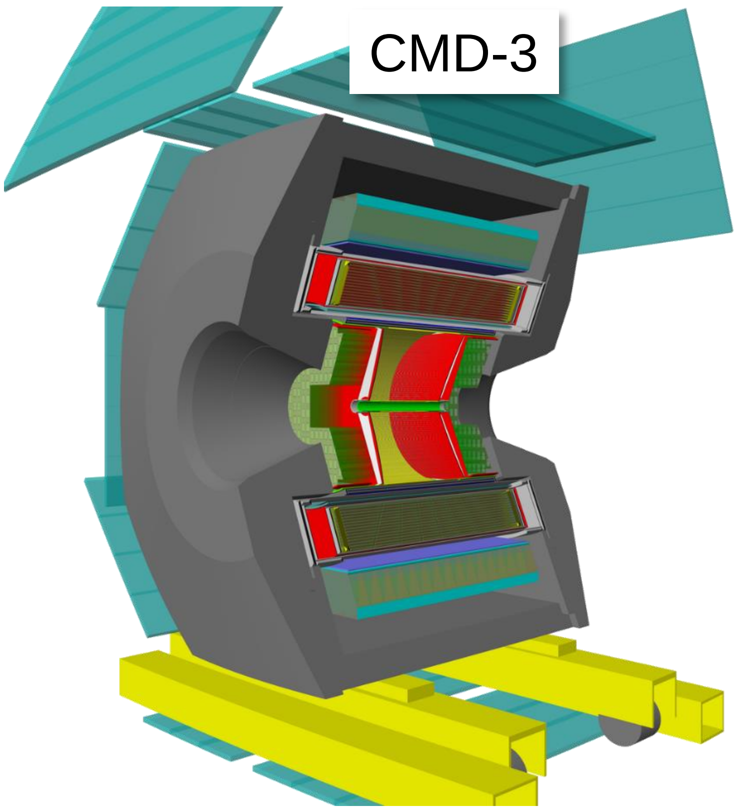


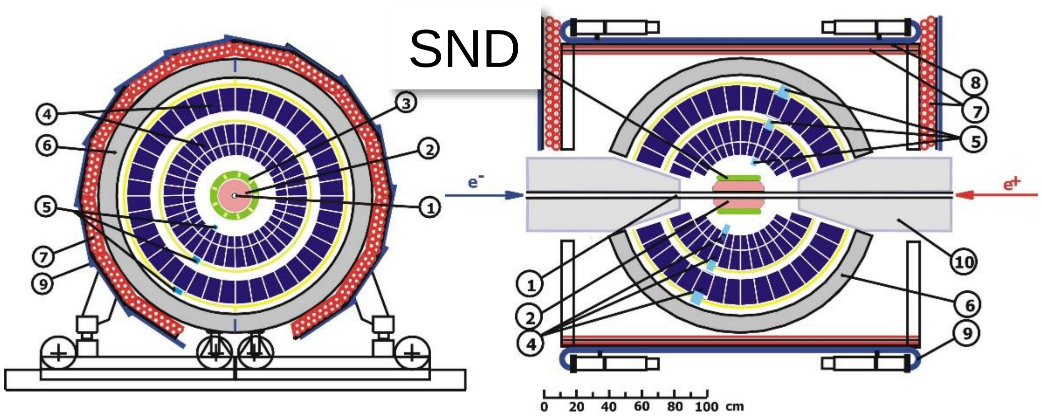


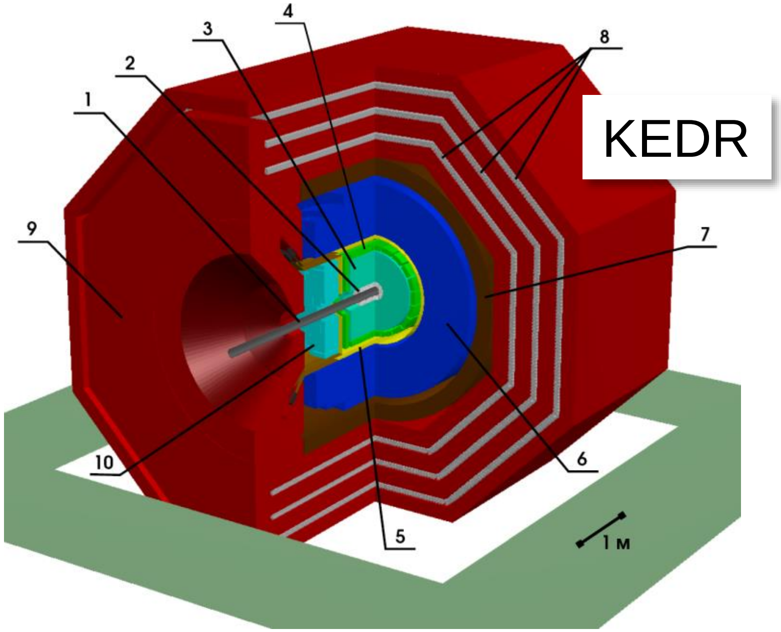




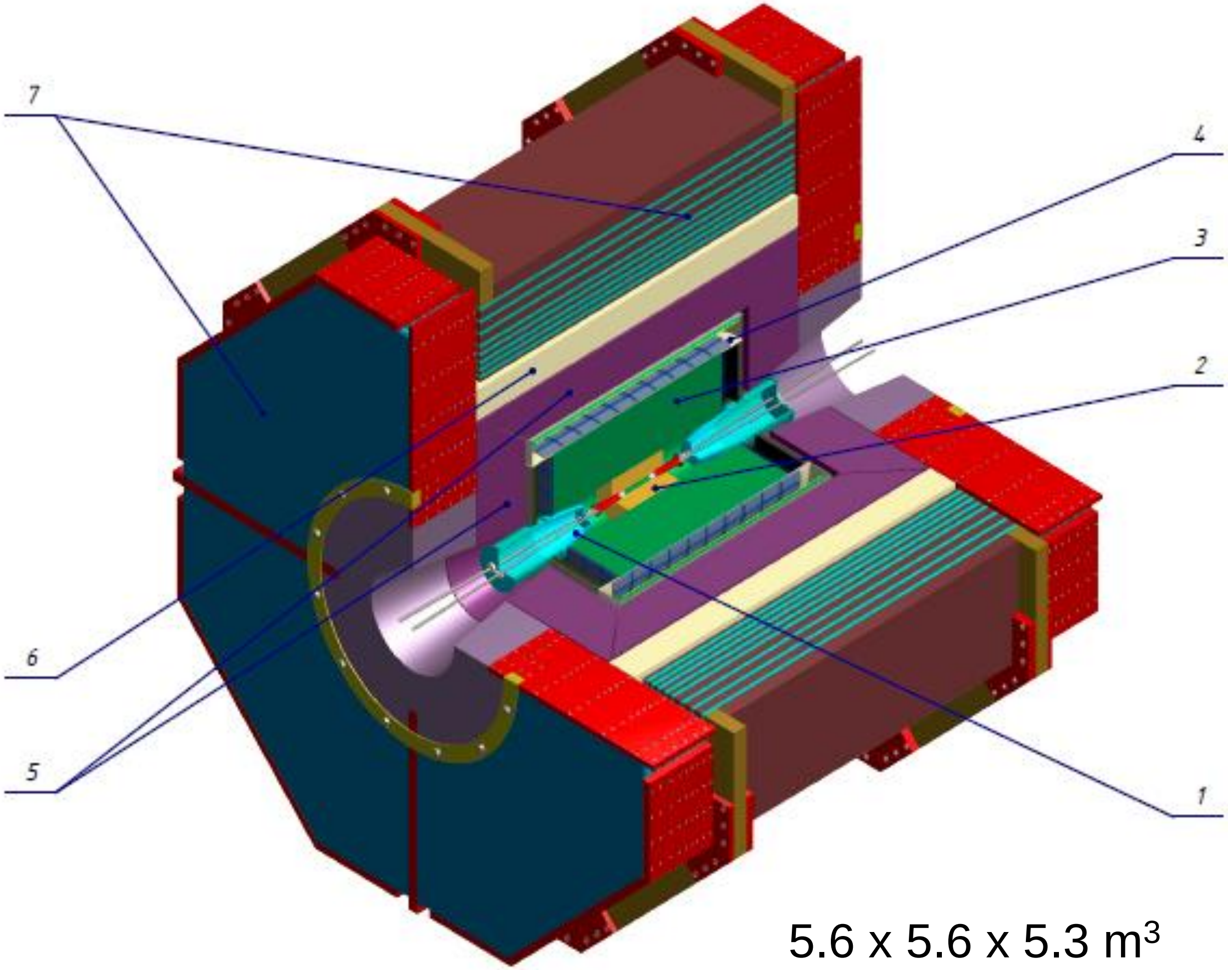
In-house (Novosibirsk) cousins







General layout

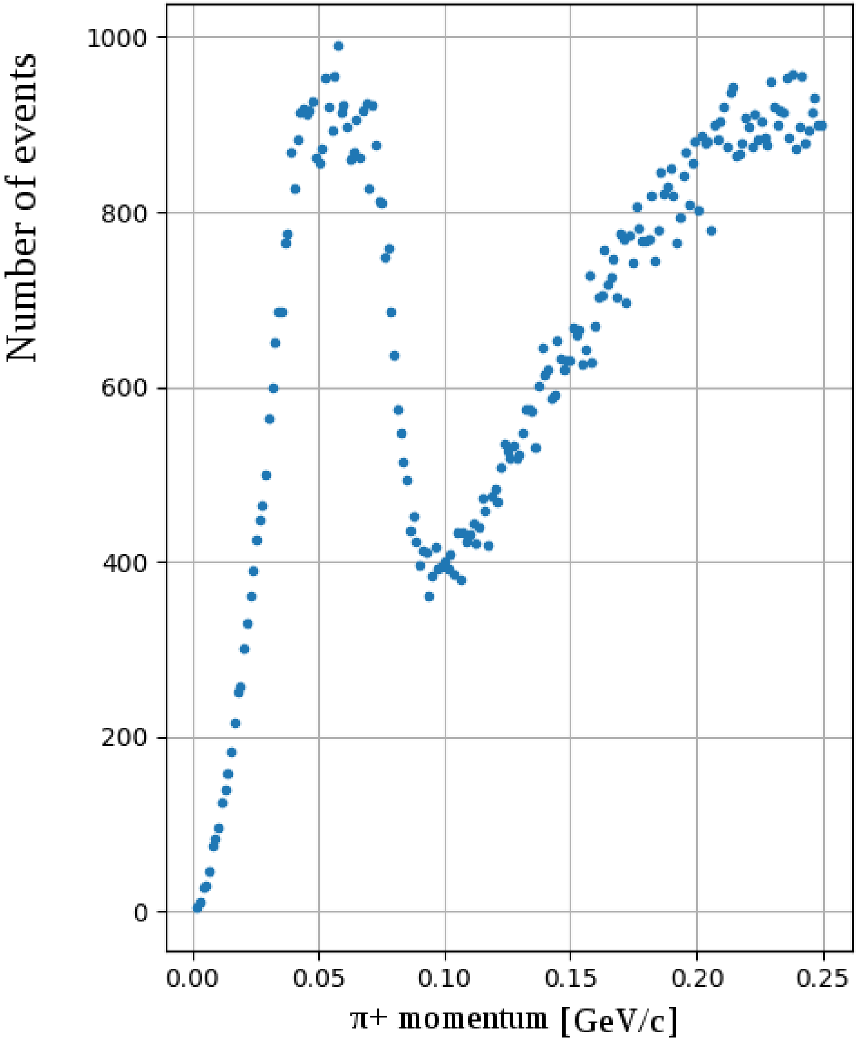


5.6 x 5.6 x 5.3 m^3

1. Vacuum pipe
2. Inner tracker
3. Drift chamber
4. PID
5. Calorimeter
6. SC magnet
7. Muon system

Inner tracker

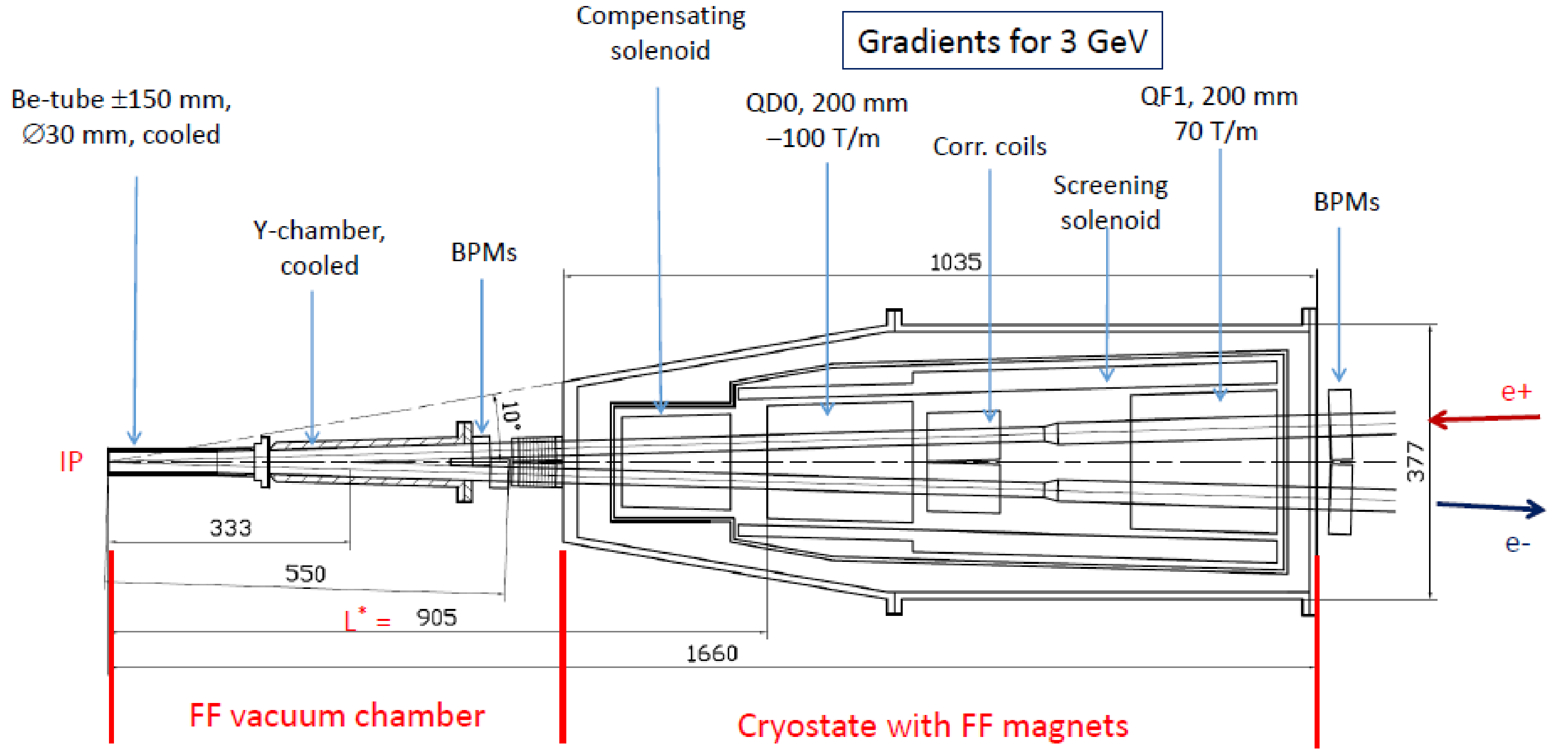
- Resolution similar to drift chamber (~100 μ)
- Sensitive to particles with low momentum (~50 MeV/c)
- Compatible with final focus constraints
- Able to handle high particle flux
- Approximate size: Ø (40-400) x 600 mm



Simulation of π^+ momentum distribution in $e^+e^- \longrightarrow DD^*$ (V. Vorobyev)

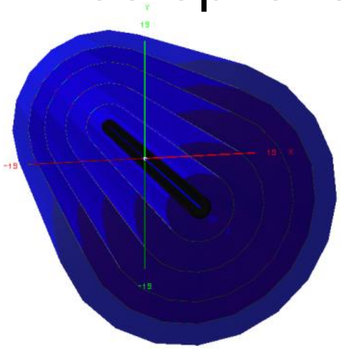
Inner tracker and the final focus

Inner tracker have to be interfaced with the final focus magnets

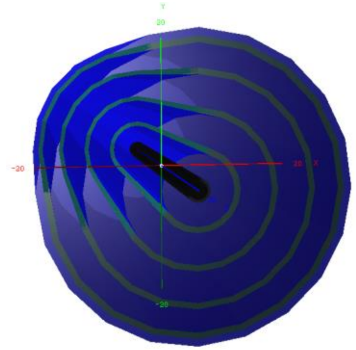


Inner tracker technologies

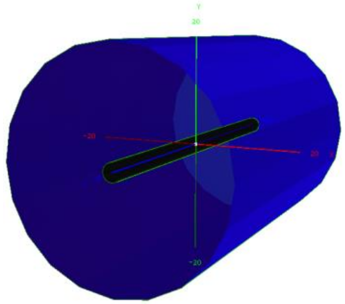
- Three options are being considered



4-layer Si-strip



4-layer CGEM (cylindrical GEM)



Time Projection Chamber (TPC)

Dedicated talk "Full simulation of Inner Tracker, choice of options" by T.Maltsev

- Other interesting technology - μRWELL

Dedicated talk "Update on micro-rwell technology: recent results from the beam test at PSI and final analysis on the micro-TPC mode" by G.Bencivenni

Building endcap coordinate plates and cylindrical Z-chamber for CMD-3 detector using this technology

Drift chamber

Measurement of momentum and dE/dx (PID)

- Spatial resolution ~100 μ
- Small cell
- Minimal material (reduce MS)
- Approximate size: Ø (400-1600) x 1800 mm

“Traditional” option	**“Beyond-traditional” option**
Babar, BES-3, Belle-2	KLOE, MEG-2, IDEA
Axial and stereo superlayers	Full stereo
Traditional dE/dx	dE/dx by cluster counting
Feed-through wiring	Feed-through-less wiring

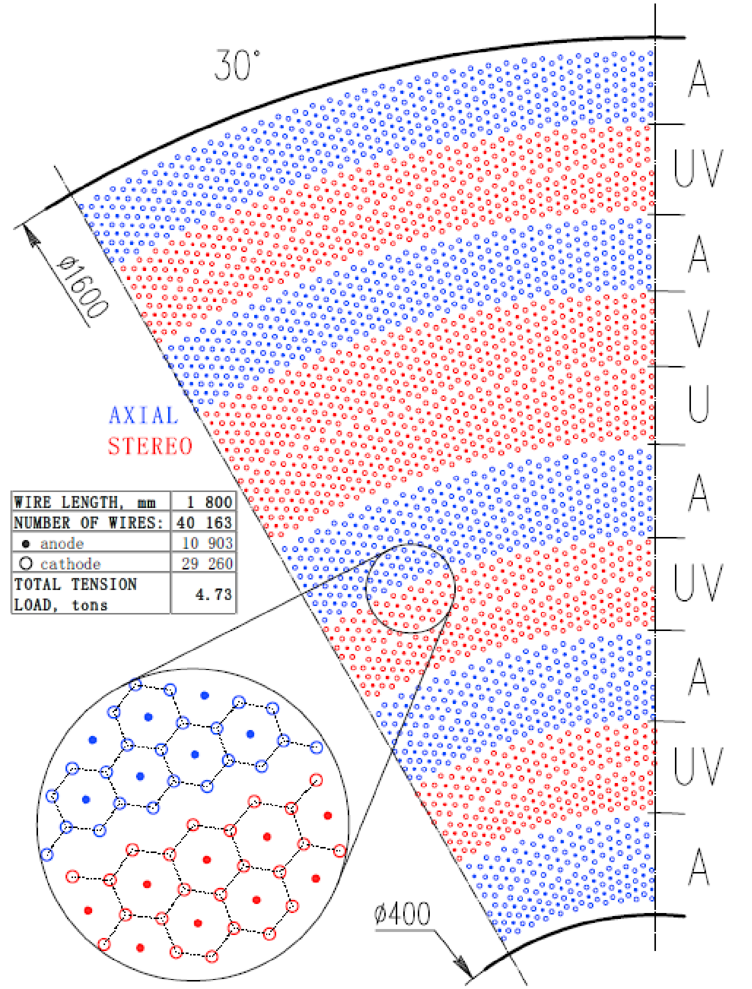
Drift chamber: traditional option

- ~40000 wires
  - 11k sensitive, W-Rh(Au)
  - 29k field, Al(Au)
- Hexagonal cell, 6.3-7.5 mm
- 41 layers
- 60% He + 40% C_3H_8
- 330 ns drift time (1.5 T)

$$\frac{\sigma_{p_t}}{p_t} \approx \sqrt{0.21\%^2 p_t^2 + 0.31\%^2}$$

≈0.4% at 1 GeV

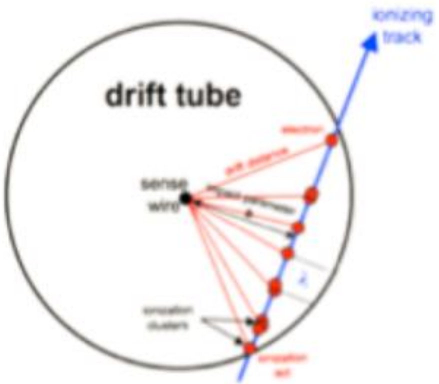
$$\frac{\sigma_{dE/dx}}{dE/dx} \approx 6.9\%$$



Dedicated talk and poster “Drift chamber design proposal for SCTF” by K.Todyshev

Drift chamber: beyond traditional option

- ~141000 wires
  - 23k sensitive, W
  - 117k field, Al
- Square cell, 7.2-9.1 mm
- 64 layers
- 90% He + 10% iC_4H_{10}



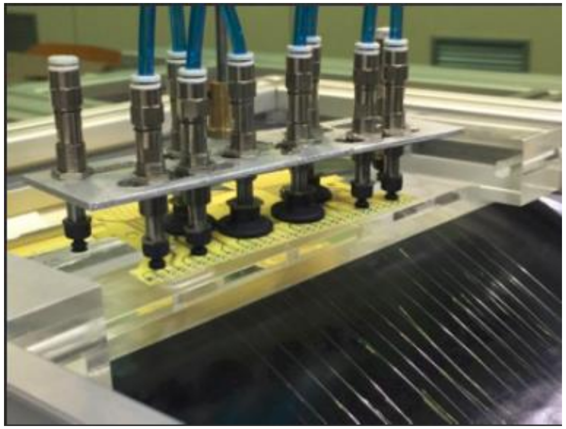
Measurement of individual clusters improves time and dE/dx resolution

$$\frac{\sigma_{p_t}}{p_t} \approx \sqrt{0.078\%^2 p_t^2 + 0.18\%^2}$$

$\approx$0.2% at 1 GeV

$$\frac{\sigma_{dE/dx}}{dE/dx} \approx 3.6\%$$

With room for improvement!



Robotic wiring

Dedicated talk "A tracking detector with particle identification capabilities" by F.Grancagnolo

Particle identification

Requirements for PID system

- π/K separation $> 4\sigma$ up to 2.5-3.0 GeV/c

  TOF (BES-3): 3σ at 0.9 GeV/c, DIRC (BaBar): 4σ at 2.5 GeV/c

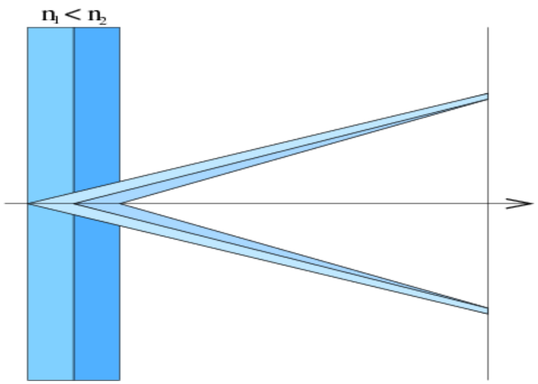
  ASHIPH (KEDR): 4σ at 1.5 GeV/c
- μ/π suppression ~1/40 for to 0.5-1.2 GeV/c
- good μ/π separation at low momentum

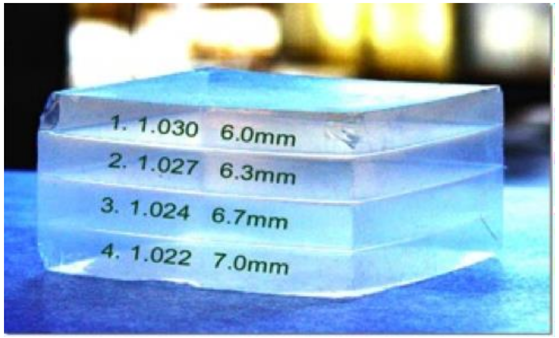
Several option are being considered: FARICH, ASHIPH, TOF

Dedicated talk “Review of PID system options for STC factory project” by A.Barnyakov

Poster “PID system for STC factory project based on threshold aerogel Cherenkov detectors” by E.Kravchenko

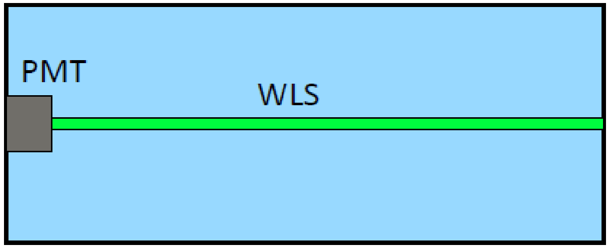
PID options





FARICH: focusing aerogel

O(10^6) readout channels!
Test beam:
π/K: 7.6σ at 4 GeV/c
μ/π: 5.3σ at 1 GeV/c



ASHIPH: threshold Cherenkov counter with WLS+PMT readout

Two n values
Low cost:
30000 readout channels
π/K from 0.5 to 2 GeV/c
μ/π from 0.4 to 0.9 GeV/c

dE/dx + TOF for lower momenta, muon system for higher momenta

TOF (TOP) counters, $\sigma_t \approx 30$ ps:
π/K up to 2.5 GeV/c
μ/π from 0.25 to 0.5 GeV/c

Calorimeter

Baseline:

BELLE/BELLE-2-like electromagnetic crystal calorimeter

Scintillator:

CsI(Tl) has large light yeild, “cheap”, very popular – but slow

LSO, LYSO, etc. – have large LY, very fast – but very expensive (x10)

pure CsI – good compromise: reasonable LY, 30 ns component, reasonable price

Other options being considered:

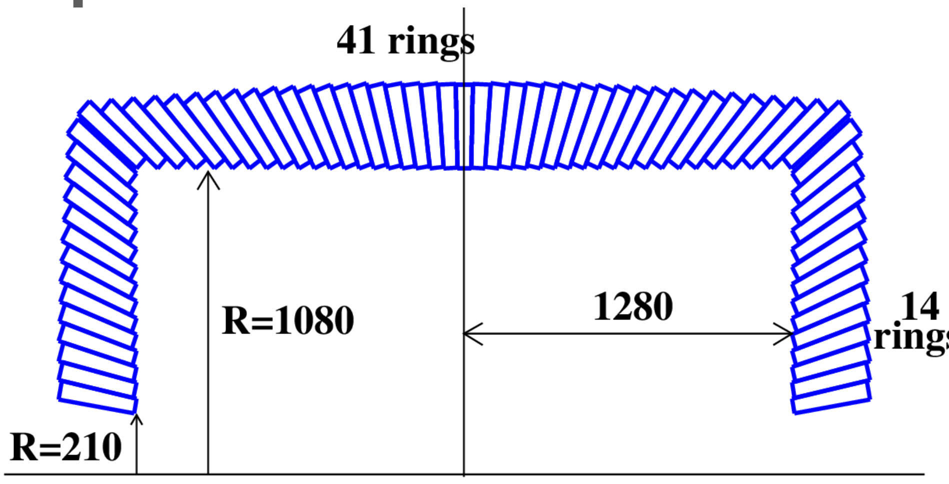
LXe calorimeter, combined LXe + pCsI calorimeter (CMD-3: LXe+CsI(Tl))

Dedicated talk “Status of the pCsI crystal calorimeter prototyping for STC factory” by A.Kuzmin

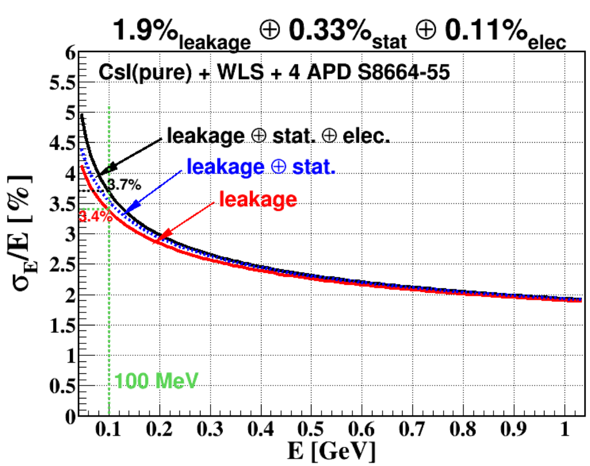
Poster “Status of calorimeter simulation for Novosibirsk STC factory project” by V.Ivanov

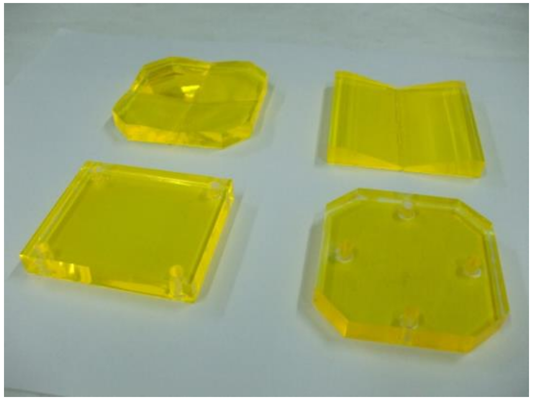
Calorimeter: pCsI option

- 7424 crystals
  - 5248 in barrel
  - 2176 in endcap
- 5.5 x 5.5 x 30(34) cm
- pCsI+WLS+4 APD



$$\frac{\sigma_E}{E} \approx \frac{1.9\%}{\sqrt[4]{E(GeV)}} \oplus \frac{0.33\%}{\sqrt{E}} \oplus \frac{0.11\%}{E}$$

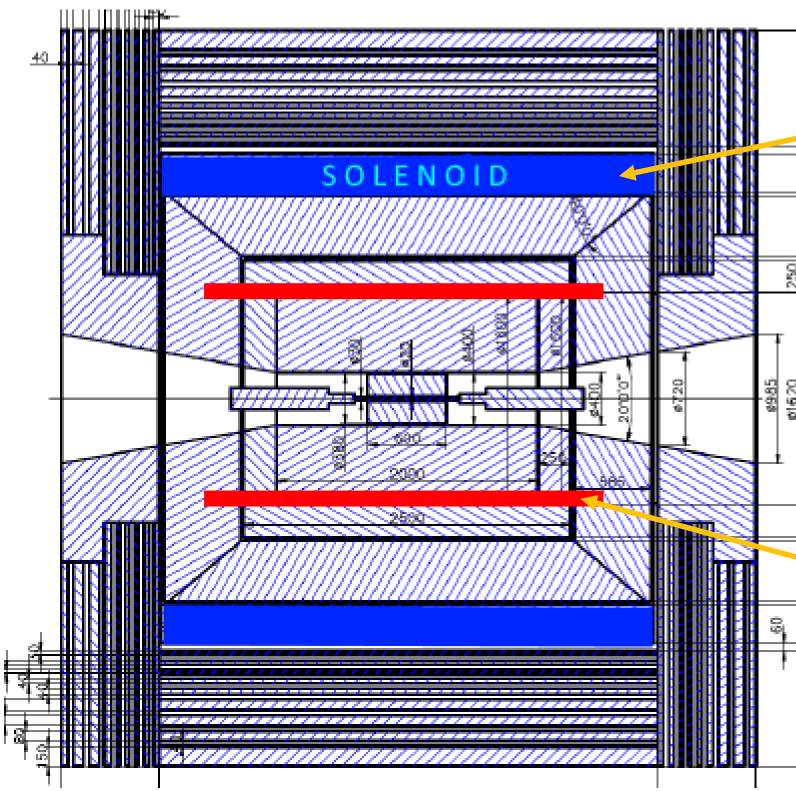




This option is being prototyped and optimized

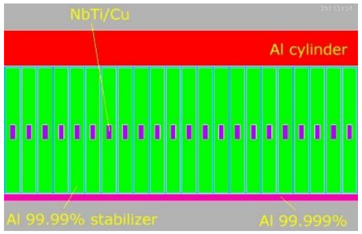
Magnet

Two options considered:

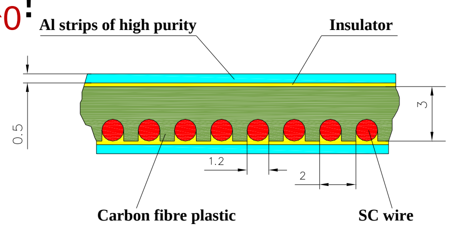


1.0 or 1.5 T

- Outside calorimeter
  - “thick” design
  - Al-stabilized coil, established technology
  - Similar to PANDA magnet
  - Baseline option



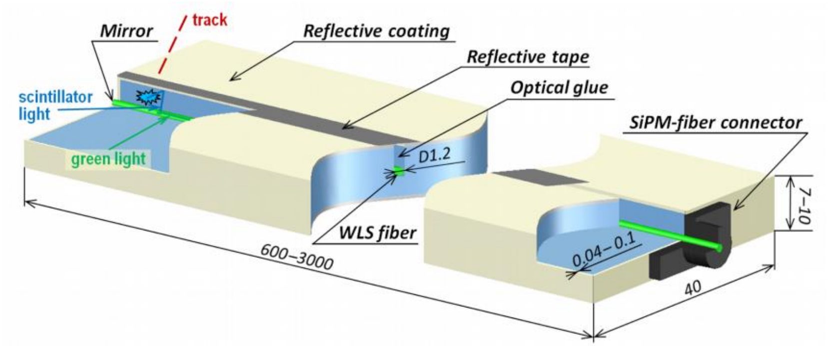
- Just outside drift chamber
  - “thin” design, 0.1 X_0!
  - CMD-3 and KEDR experience

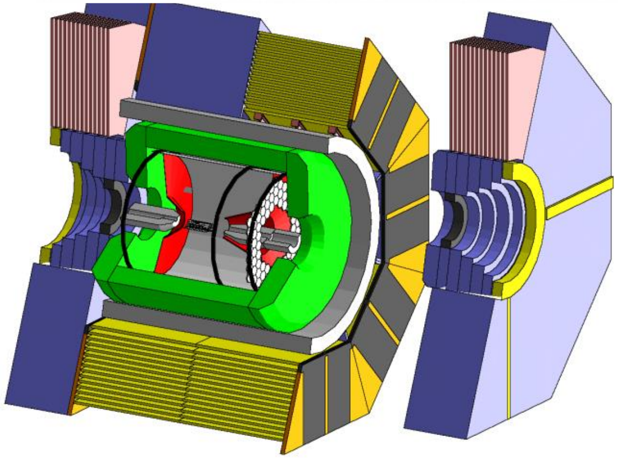


Dedicated talk “The comparison of the thin solenoid and traditional magnetic system option” by A.Bragin

Muon system

- detect muons
  - mult.scat. of O(1cm)
- μ/π separation
- K_L detection





BELLE-2

Baseline option:

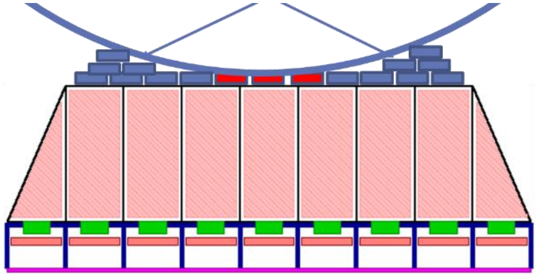
scintillator strips + WLS fiber + SiPM

(BELLE-2, CMD-3)

8-9 layers inside iron yoke

~1500 m^2

CMD-3



Dedicated talk “Proposal of muon system based on scintillator and WLS fiber readout: status of the simulation and prototyping” by T.Uglov

Electronics

We are still at the very early stage of electronics/DAQ design

Detector	N ch	Rate of digitization	Time precision
Inner tracker	5-100k	from 20 MHz to 80 MHz	1 ns
DC	12-30 k	50 MHz (ordinary mode) 1-2 GHz (cluster mode)	1 ns
FARICH	1-2 M	TDC	200 ps
Calorimeter	7.5 k	40 – 50 MHz	1 ns
Mu	4-44 k	TDC	60 ps

Some considerations:

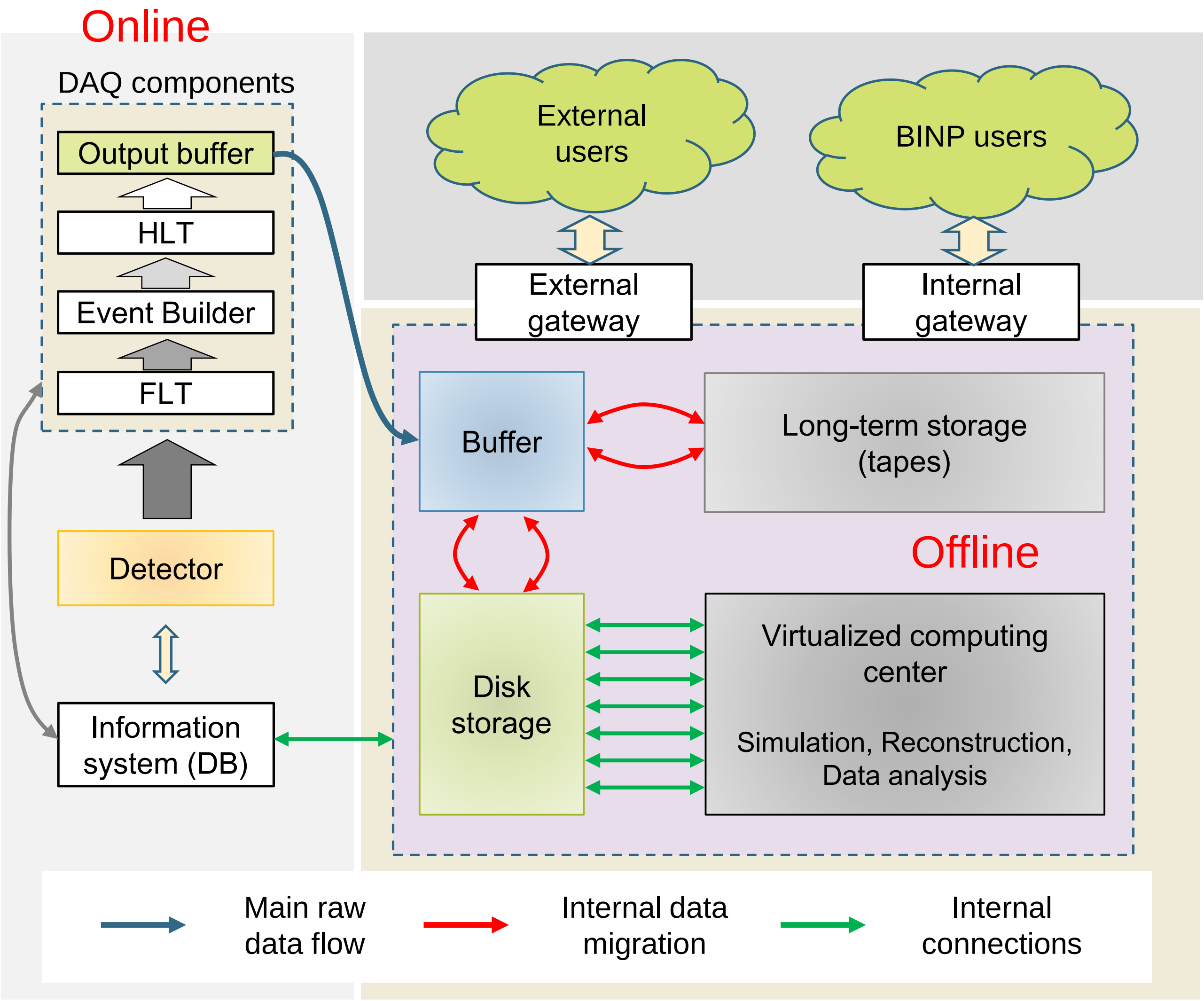
- digitization inside/close to detector, optical links out
- ASICs are required
- water-cooled electronics
- trigger is required (triggerless mode is discussed but not feasible yet)

Event size 30-50 kB

Rate up to 300 kHz

Up to 10 GB/s

DAQ and data analysis/storage



Requirements

Maximum input data rate:
10 GB/s

Total storage system capacitance
~300 Pbytes

Computing power
~1 Pflops

Can be realized with commercial solutions

Conclusion

- We need detector with excellent performance to realize SCTF potential
- The detector can be constructed on the base of existing detector technologies, taking into account experience of BES-3, Belle-2 and other detectors
- A lot of R&D, from simulation to prototyping, is required to make the choice of technology and to optimize the subsystems parameters
- There are working groups for most (all) subsystems

Perfect opportunity for collaboration!