DETECTOR CONCEPT OF THE SCT FACTORY IN NOVOSIBIRSK

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Detector requirements

- Good energy and momentum resolution, high efficiency
- High efficiency of soft track detection
  - e.g. in $D^*$ or $\Lambda$ decays
- Few mm vertexing
  - $c\tau(K_S) = 27$ mm, $c\tau(\Lambda) = 79$ mm
- Very good particle identification: $e/\mu/\pi/K$
  - $\pi/K$ in the whole energy range, e.g. for $D\bar{D}$ mixing
  - $\mu/\pi$ 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 $J/\psi$
Older brothers and sisters
In-house (Novosibirsk) cousins

CMD-3

SND

KEDR
General layout

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

5.6 x 5.6 x 5.3 m³
Inner tracker

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

Simulation of $\pi^+$ momentum distribution in $e^+e^- \rightarrow DD^*$ (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 - $\mu$RWELL

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

<table>
<thead>
<tr>
<th>“Traditional” option</th>
<th>“Beyond-traditional” option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babar, BES-3, Belle-2</td>
<td>KLOE, MEG-2, IDEA</td>
</tr>
<tr>
<td>Axial and stereo superlayers</td>
<td>Full stereo</td>
</tr>
<tr>
<td>Traditional dE/dx</td>
<td>dE/dx by cluster counting</td>
</tr>
<tr>
<td>Feed-through wiring</td>
<td>Feed-through-less wiring</td>
</tr>
</tbody>
</table>
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% C₃H₈
- 330 ns drift time (1.5 T)

\[
\frac{\sigma p_t}{p_t} \approx \sqrt{0.21\%^2 p_t^2 + 0.31\%^2}
\]

\[
\approx 0.4\% \text{ at } 1 \text{ GeV}
\]

\[
\frac{\sigma dE/dx}{dE/dx} \approx 6.9\%
\]

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\textsubscript{4}H\textsubscript{10}

\[
\frac{\sigma_{p_t}}{p_t} \approx \sqrt{0.078\%^2 p_t^2 + 0.18\%^2} \\
\approx 0.2\% \text{ at 1 GeV}
\]

\[
\frac{\sigma_{dE/dx}}{dE/dx} \approx 3.6\%
\]

Measurement of individual clusters improves time and dE/dx resolution.

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

Robotic wiring
Particle identification

Requirements for PID system

• $\pi/K$ separation $> 4\sigma$ up to 2.5-3.0 GeV/c
  - TOF (BES-3): $3\sigma$ at 0.9 GeV/c, DIRC (BaBar): $4\sigma$ at 2.5 GeV/c
  - ASHIPH (KEDR): $4\sigma$ at 1.5 GeV/c

• $\mu/\pi$ suppression $\sim 1/40$ for to 0.5-1.2 GeV/c

• Good $\mu/\pi$ 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:
\[ \pi/K: 7.6\sigma \text{ at } 4 \text{ GeV/c} \]
\[ \mu/\pi: 5.3\sigma \text{ at } 1 \text{ GeV/c} \]

ASHIPH: threshold Cherenkov counter with WLS+PMT readout
Two n values
Low cost:
30000 readout channels
\[ \pi/K \text{ from 0.5 to 2 GeV/c} \]
\[ \mu/\pi \text{ from 0.4 to 0.9 GeV/c} \]
dE/dx + TOF for lower momenta, muon system for higher momenta

TOF (TOP) counters, \( \sigma_t \approx 30 \text{ ps} \):
\[ \pi/K \text{ up to } 2.5 \text{ GeV/c} \]
\[ \mu/\pi \text{ from 0.25 to 0.5 GeV/c} \]
Calorimeter

Baseline:
BELLE/BELLE-2-like electromagnetic crystal calorimeter

Scintillator:
CsI(Tl) has large light yield, “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+Csl(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

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

This option is being prototyped and optimized.
Magnet

Two options considered:

- 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 $O(1cm)$
- $\mu/\pi$ separation
- $K_L$ detection

Baseline option:
- scintillator strips + WLS fiber + SiPM
- (BELLE-2, CMD-3)
- 8-9 layers inside iron yoke
- $\sim1500$ m²

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

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

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

**Online**

- **Output buffer**
- **DAQ components**
- **Event Builder**
- **HLT**
- **FLT**
- **Detector**
- **Information system (DB)**

**Offline**

- **Buffer**
- **Disk storage**
- **Virtualized computing center**
- **Simulation, Reconstruction, Data analysis**
- **Long-term storage (tapes)**

**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!