Update on feasibility study of the detection of $D^0$ mesons in the NA61/SHINE experiment

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Outline

1. New Vertex detector setup

3. Particle fluxes in Pb+Pb at 158 AGeV

4. Particle density in central Pb+Pb

5. Tentative detector project

6. Some results for $D^0 \rightarrow K^- \pi^+$

7. Testing influence of other decay channels
NA61/SHINE detector – top view

Vertex Detector (VD)

- Planned main detector upgrades
- Finished upgrades
Vertex detector in geant4
Vertex detector in geant4 – zoom in

Pb target
Charged Particle Fluxes

Sources of particles hitting VD:

   - during spill the anticipated beam intensity is $10^5$ Pb ions per second.
   - for 200 $\mu$m Pb target interaction probability is 0.5% which leads to 500 Hz interaction rate
   - used AMPT to generate 100k min. bias Pb+Pb at 158 AGeV

2. Delta electrons produced mostly in target
   - study 10k Pb ions passing through the lead target
   - soft particles – surrounding material might be important
   - production threshold cut in geant4: minimum distance that produced particle will travel in a given material $\rightarrow$ translates to cut on energy
     - If the distance is (too) small $\rightarrow$ a lot of soft particles is produced (CPU consumption)
     - If the distance is (too) large $\rightarrow$ important component might not be described

$\rightarrow$ the influence of the production threshold cut has to be studied
AMPT Event: Pb+Pb at 158GeV
Charged particles produced in Pb+Pb interactions
Charged particles produced in Pb+Pb interactions
Charged particles produced in Pb+Pb interactions
Charged particles produced in Pb+Pb interactions

![Graph showing charged particle distribution in Pb+Pb interactions with VSD4 hits/mm²/event.]
Pb electromagnetic interaction
Pb electromagnetic interaction – zoom in
Delta electrons: results (averaged over 10k Pb events)
Delta electrons: results II

**Hadronic interactions:**

\[
\text{flux} = (10^5 \times 0.005) \text{ event/s} \times 1.6 \text{ particles/mm}^2/\text{event} = 800 \text{ particles/mm}^2/\text{s} = 800 \text{ Hz/mm}^2
\]

**Electromagnetic interactions (δ-electrons):**

\[
\text{flux} = 10^5 \text{ event/s} \times 0.04 \text{ particles/mm}^2/\text{event} = 4000 \text{ Hz/mm}^2
\]

**ABSTRACT:** New Micromegas (*Micro-mesh gaseous detectors*) are being developed in view of the future physics projects planned by the COMPASS collaboration at CERN. Several major upgrades compared to present detectors are being studied: detectors standing five times higher luminosity with hadron beams, detection of beam particles (flux up to a few hundred of kHz/mm², 10 times larger than for the present Micromegas detectors) with pixelized read-out in the central part, light and integrated electronics, and improved robustness. Two solutions for a
Charged particles produced in Pb+Pb 0-10% central interactions
Charged particles produced in Pb+Pb 0-10% central interactions
Preliminary drawing of the 1-st station

1. Pixels cover area where hits/mm² > 0.5
2. Some overlap between pixels and MicroMegas
3. Inner (pixel) structure is composed of detectors equipped with a single Timepix chip - active dimension 14x14 mm²
D⁰→K⁺π⁻, 200k 0-10% cent. Pb+Pb at 158 AGeV

\[ \sigma_{x,y} = 10 \mu m \]
beam hole ± 2.5mm

S/B=13
For 50M events:
SNR = 193
40k D⁰+D⁰bar

\[ \sigma_{x,y} = 10 \mu m \]
beam hole ± 3.0 mm

S/B=15
For 50M events:
SNR = 178
34k D⁰+D⁰bar

\[ \sigma_{x,y} = 15 \mu m \]
beam hole ± 2.5 mm

S/B=6.6
For 50M events:
SNR = 163
31k D⁰+D⁰bar

\[ \sigma_{x,y} = 15 \mu m \]
beam hole ± 3.0 mm

S/B=9.6
For 50M events:
SNR = 155
26k D⁰+D⁰bar
Influence of other decay channels

\[ D^0 \rightarrow K\pi^+\pi^0 \text{ (BR=13.9%)} \]

\[ D^0 \rightarrow K2\pi^+\pi^- \text{ (BR=8.1%)} \]

\[ (D^0 \rightarrow K\pi^+ \text{ (BR=3.87%))} \]
$D^0 \rightarrow K\pi^+$, BR in geant is 100%

0-10 central Au+Au at 158AGeV

Suppression by factor 3, final yield: 143 $D^0$s
$D^0 \rightarrow K\pi^+, \rightarrow K\pi^+\pi^0, \rightarrow K2\pi^+\pi^-$, sum of BRs in geant normalized to 100%

Suppression by factors $2.1/257$  final yield: 24 $D^0$s  (expected ~21)
$D^0 \rightarrow K\pi^+\pi^0$, $\rightarrow K2\pi^+\pi^-$, sum of BRs in geant normalized to 100%

Suppression by factor 220
Backup Slides
Delta electrons: study effect of production threshold cuts

Electrons hitting VSD1 (Pb@157)

counts

10^4

10^3

10^2

0 0.002 0.004 0.006 0.008 0.01 0.012 0.014 0.016 0.018

energy [GeV]

25 μm  577k

100 μm  551k

200 μm  527k

500 μm  448k

1 cm    76k
Delta electrons: study effect of production threshold cuts

Electrons hitting VSD2 (Pb@157)

- 25 μm: 216k
- 100 μm: 213k
- 200 μm: 230k
- 500 μm: 219k
- 1 cm: 73k

counts

$10^2$ $10^3$

energy [GeV]

0.002 0.004 0.006 0.008 0.01 0.012 0.014 0.016 0.018