

Identification of ϕ mesons from Be+Be at 150A GeV in the NA61/SHINE

Mateusz Walewski

University of Warsaw

23 April 2016

Outline:

- 1 Introduction
- 2 NA61/SHINE experiment
- 3 Data analysis
- 4 Conclusions

Background

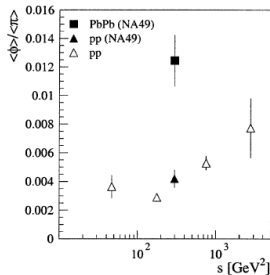
- The enhancement of relative strangeness in $A + A$ with respect to $p + p$ collisions is a well known fact. (results from many experiments at CERN SPS e.g NA49) \rightarrow

The key question:

is the strangeness determined in hadronic or pre-hadronic (e.g QGP) stage of the collision?

\rightarrow ϕ mesons composed of $s\bar{s}$ are good probe in this studies due to its hidden strangeness.

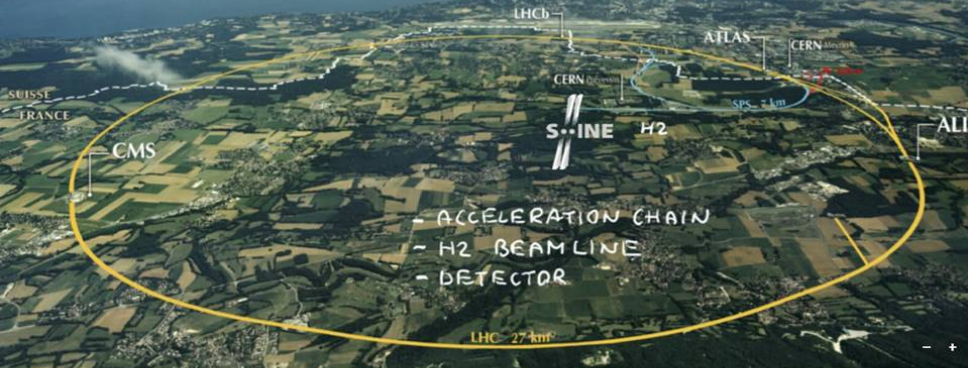
S.V. Afanasiev et al. / Physics Letters B 491 (2000) 59–66



$$\frac{\langle\phi\rangle/\langle\pi\rangle \text{ (Pb + Pb central)}}{\langle\phi\rangle/\langle\pi\rangle \text{ (p + p inelastic)}} = 3.0 \pm 0.7$$

- In hadronic scenario, they are in total strangeness neutral - should be insensitive to strangeness-related phenomena. In partonic scenario, their yield should depend more sensitively than that of singly strange particles e.g kaons (\rightarrow tight constrains on hadron production models)
- NA49 experiment published results on ϕ production at SPS in pp, pPb collisions at 158 GeV as well as PbPb collisions at 20A–158A GeV. Advanced analysis of ϕ production in pp collisions in the NA61/SHINE experiment is in progress.
- The goal is to estimate multiplicities of ϕ in BeBe collisions for several beam energies based on the strategy applied in the analysis of pp in the NA61/SHINE experiment.

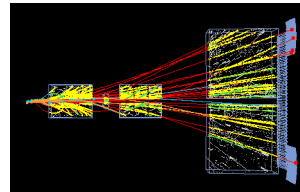
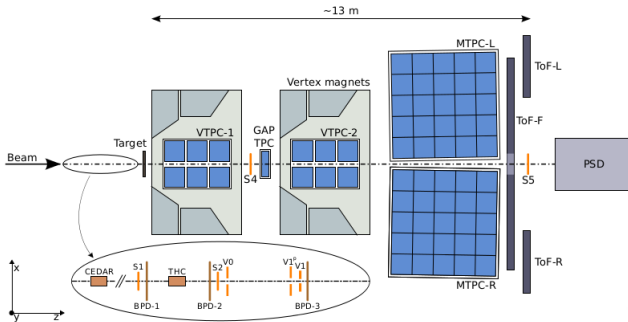
NA61/SHINE - UNIQUE MULTIPURPOSE FACILITY:
HADRON PRODUCTION IN $h+p$, $h+A$, $A+A$
AT 13A - 150A (400) GeV/c



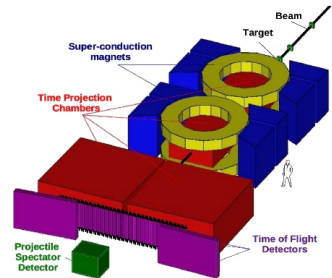
The experimental program of NA61/SHINE includes:

- The study of strong interactions and HG – QGP transition (OD, CP)
- Measurements for neutrino experiments (T2K, Fermilab)
- Measurements for cosmic-ray experiments (Pierre Auger Observatory, KASCADE)

NA61/SHINE spectrometer



- a set of scintillation, Cherenkov counters, BPD's upstream of the target
- the main tracking devices are four large TPCs: 2 VTPCs and 2 MTPCs
- ToF detectors and PSD



Analysis method

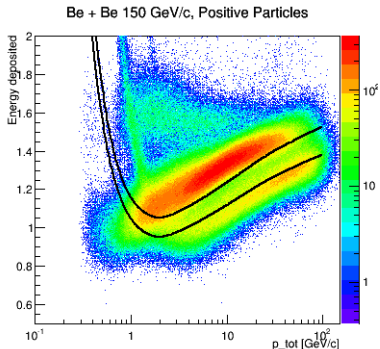
- the goal is to obtain ϕ multiplicities differentially per units of p_T or/and y
- analysis performed in the $\phi \rightarrow K^+K^-$ decay channel using *inv. mass method*
- preselected events and tracks within standard *cuts* of NA61
- PID cut - the most significant to observe ϕ signal \rightarrow

ϕ meson according to PDG 2014

$$m_\phi = 1019.461 \pm 0.019 \text{ [MeV]}$$

$$\Gamma = 4.266 \pm 0.031 \text{ [MeV]}$$

$$\text{BR}(\phi \rightarrow K^+K^-) = (48.9 \pm 0.5)\%$$

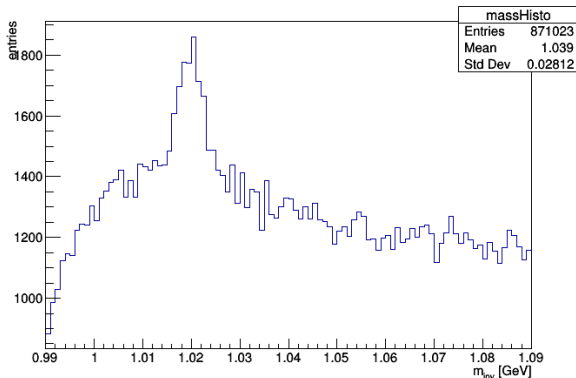


The tracks for which:
 $dE/dx \leq BB_K + 5\%BB_K$
 $dE/dx \geq BB_K - 5\%BB_K$
 were called **K-candidates**

Unbinned invariant mass spectrum

- $p_\phi^\mu = p_{K^+}^\mu + p_{K^-}^\mu$ where $p_{K^\pm}^\mu = (\sqrt{p_\pm^2 + m_K^2}, \vec{p}_\pm)$
- $m_{inv} = \sqrt{p_\phi^\mu p_\mu^\phi} = \sqrt{(p_{K^+}^\mu + p_{K^-}^\mu)(p_\mu^{K^+} + p_\mu^{K^-})}$

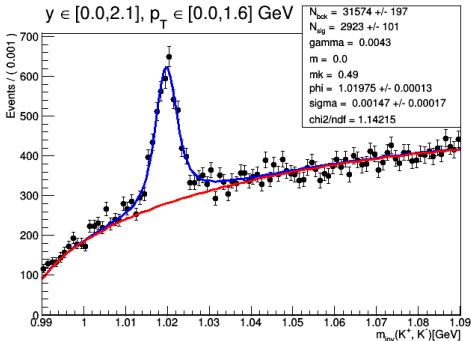
All combinatoric choices of $K^{+/-}$ pairs within an event filled into a histogram:



Fit S+B function to data in broad range of p_T and y

- then ϕ candidates were chosen based on their y and p_T
- fit was performed in the region of high acceptance (based on pp):
 $y \in [0.0, 2.1]$, $p_t \in [0.0, 1.6]$ GeV

$y \in [0.0, 2.1]$, $p_T \in [0.0, 1.6]$ GeV



Signal function:

$$V(x; m_\phi, \sigma, \Gamma) = L \otimes G =$$

$$\int_{-\infty}^{+\infty} G(x'; \sigma) L(x - x'; m_\phi, \Gamma) dx'$$

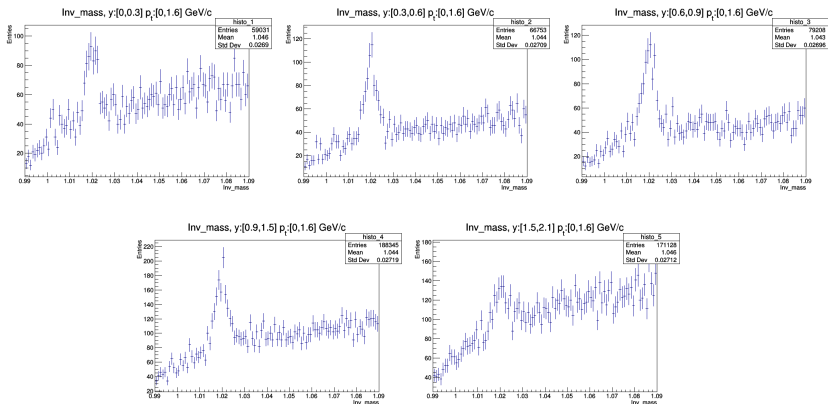
where: L - relativistic Breit-Wigner,
 G - Gauss (q-Gauss)

Background:

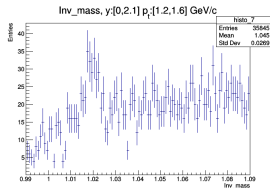
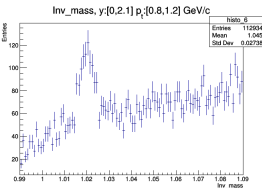
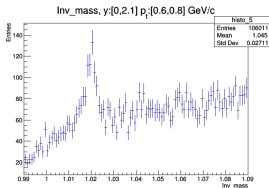
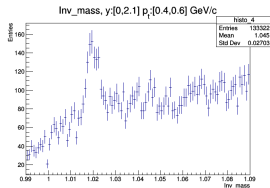
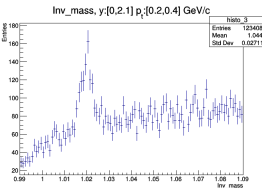
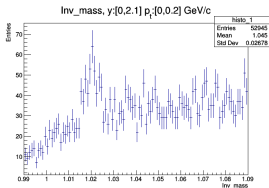
event mixing method.

1D - binning in y ($p_T \in [0.0, 1.6]$ GeV)

- fits will be performed in 1D bins of y and p_T as well as in 2D (y, p_T) bins if statistics permits



1D - binning in p_T ($y \in [0.0, 2.1]$)



Further steps (based on pp analysis in NA61/SHINE)

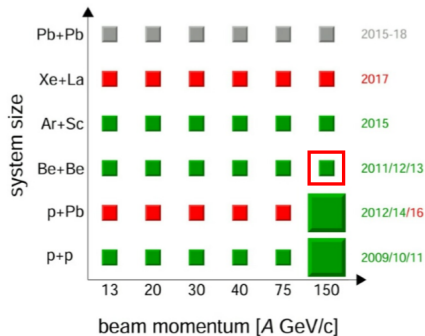
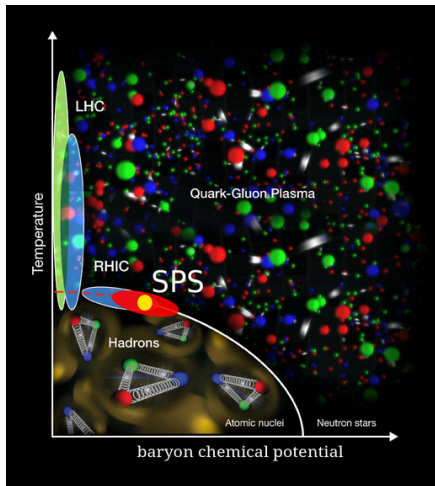
- tag-and-probe method (LHCb, NA61/SHINE)
- corrections and systematic studies, optimizations
- the same analysis for lower energies (75A GeV, 40A GeV ...)
- (...)

Conclusions

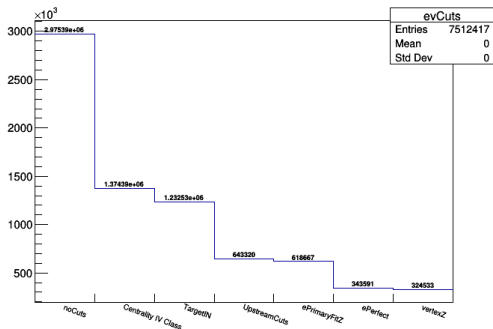
- The clear ϕ signal both in broad y, p_T range and in 1D bins is observed
- Fitted model function well describe data in unbinned region
- Several corrections and systematic studies should be done (support from pp analysis)
- Analysis in progress ...

Thank You!

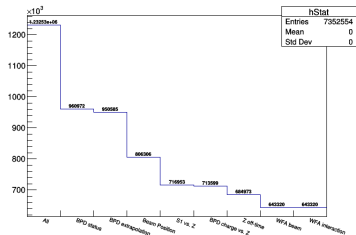
Backup



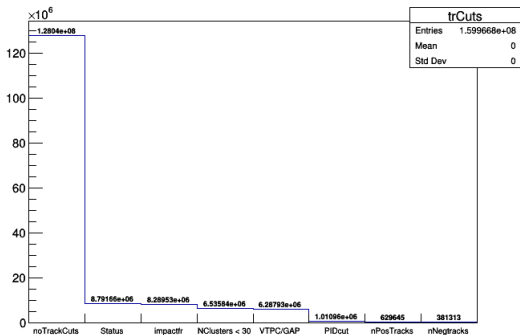
Event cuts



- Centrality IV class (0 - 20 %)
- Target IN
- Upstream Cuts (Emil's function)
- ePrimaryFitZ
- ePerfect
- Vertex $Z \in (-590, -572)$



Track cuts



- Status (= 0)
- $|b_x|, |b_y| < 4$ cm
- $n_{all} > 30$
- $n_{VTPC} > 15$ or $n_{GTPC} > 4$
- PID ± 5 % kaon Bethe-Bloch

Only tracks for which:

$$dE/dx \leq BB_K + 5\%BB_K$$

and

$$dE/dx \geq BB_K - 5\%BB_K$$

passed the cut.