Search for heavy neutrino in leptonic decays of K^+

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on behalf of the OKA collaboration

OKA setup
Selection criteria
Background processes
Upper limit estimate
Comparison with other experiments

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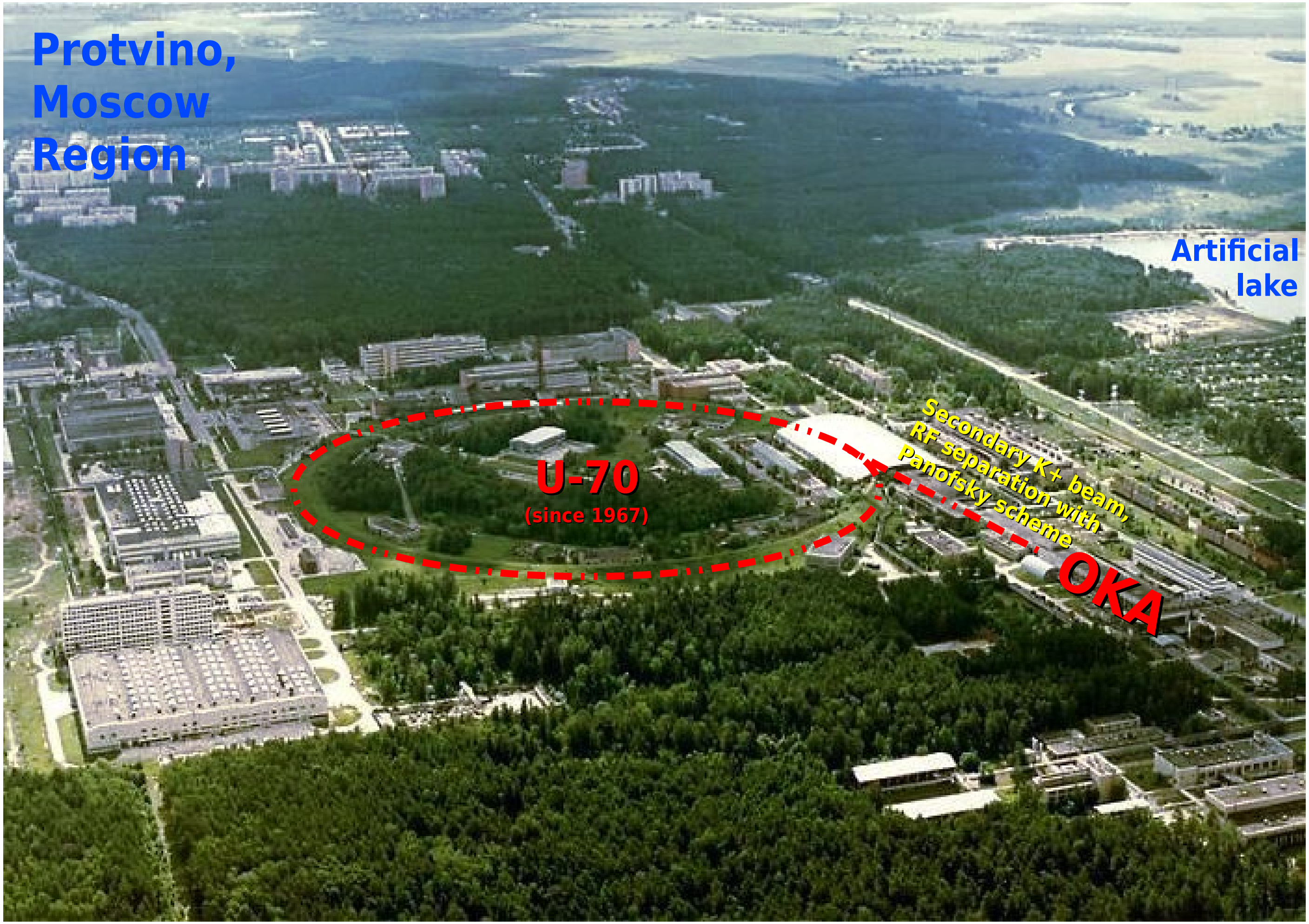
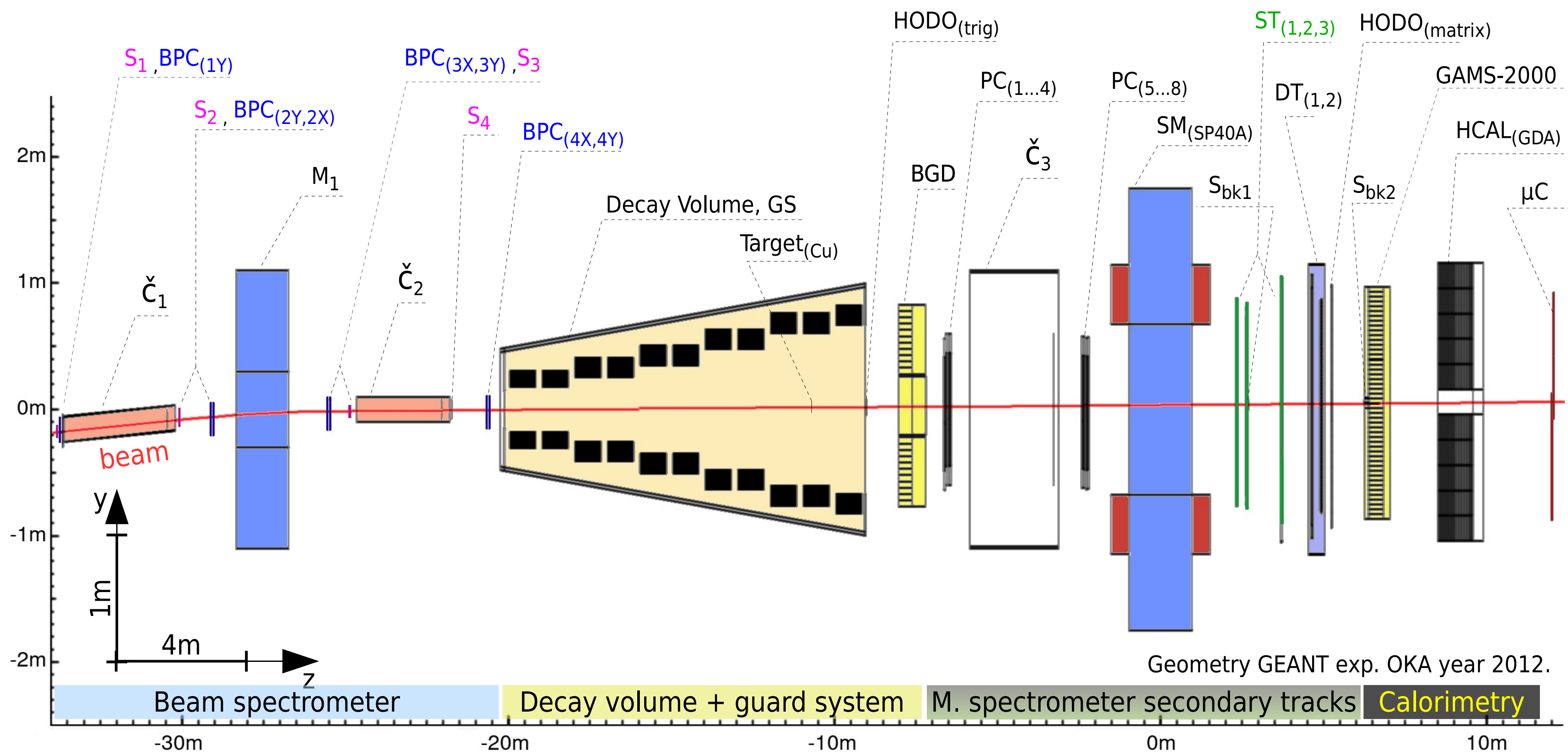
OKA setup at the U-70 accelerator complex NRC "Kurchatov Institute" – IHEP, Protvino



OKA setup (run-14 / 2012)



(§) Trigger (2mm scint.: S_1,S_2,S_4 and 6mm S_3); beam threshold Cherenkov counters (C_1,C_2)

(§) Beam spectrometer: magnet (M1) c 7 BPCs (1mm step, ~1500 chann.)

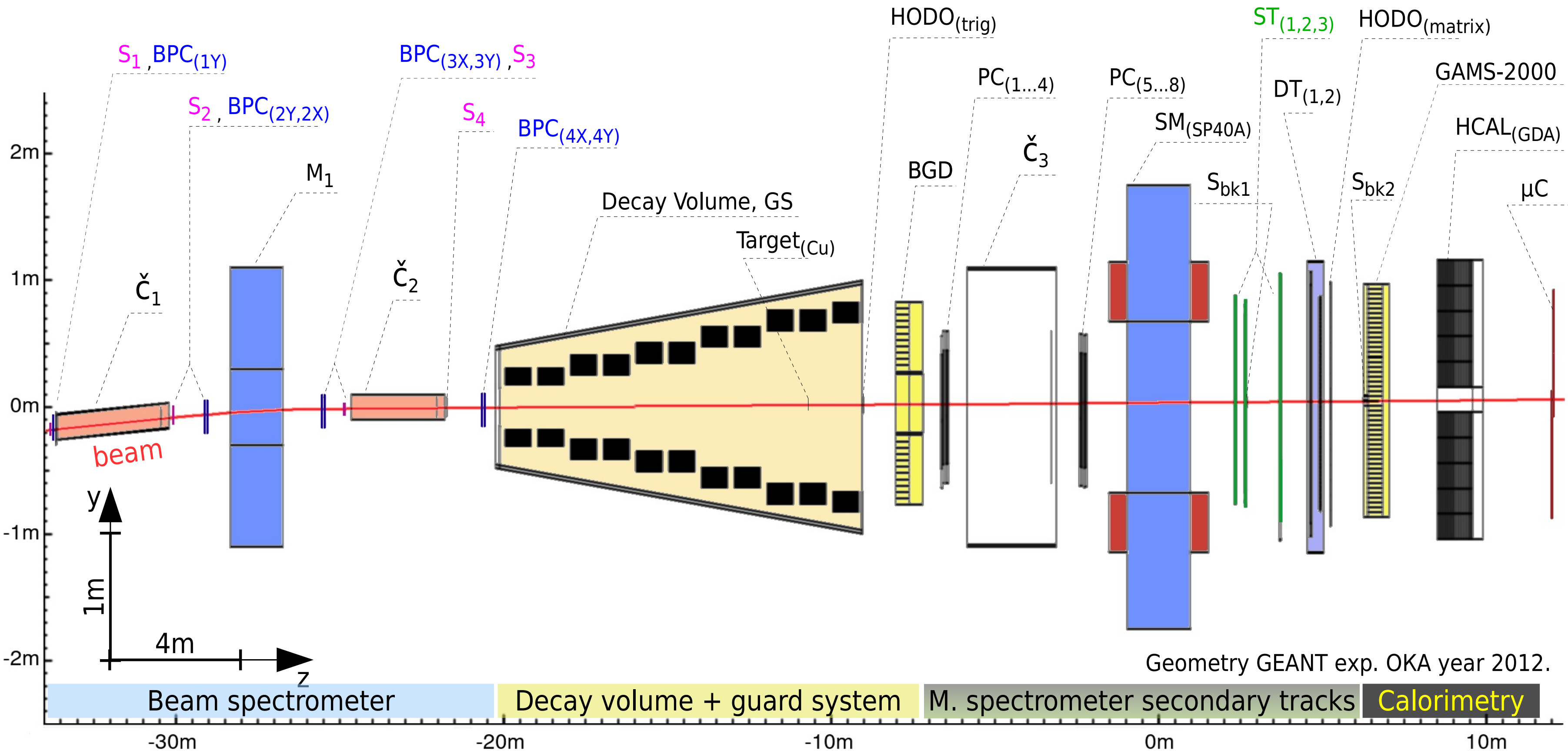
(§) Decay volume (He) with guard system«GS» 670 Pb-Sc (200 chann. ADC)

(§) Magnetic spectromet. for secondary tracks: wide aperture magnet (SP40A) 0.6Tm, 200x140см^2, 8x2mm-PC (5k chann.), 3x10mm-Straw.t.(1k chann.), 2x30mm-DT (300 ch), matrix hodoscope.

(§) EM-calorimeters: «GAMS-2000» (~2300 chann. 4X4cm^2), «BGD» (~1050 chann. 5X5cm^2)

(§) Muon stations: HCAL «GDA» (120 20x20cm^2 Fe-Sc) complemented by 4 Sc plates 1x1m^2 (μC)

OKA setup (run-14 / 2012)



Kaons/spill at OKA setup~ $250 \cdot 10^3$

Main trigger: $(S_1 \bullet S_2 \bullet S_3 \bullet S_4 \bullet C_1 \bullet \overline{C}_2 \bullet \overline{S}_{bk1} \bullet \overline{S}_{bk2} \bullet [\Sigma_{GAMS} > Mip])$ ~$2.3 \cdot 10^9$ triggers written for 17.7GeV/c

½ time dedicated to Cu target (2mm in the end of decay volume).

Two prescaled triggers used

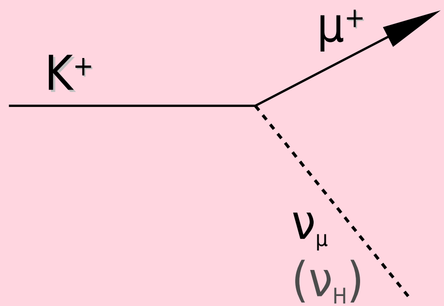
$\{1/10\}(S_1 \bullet S_2 \bullet S_3 \bullet S_4 \bullet C_1 \bullet \overline{C}_2 \bullet \overline{S}_{bk1} \bullet \overline{S}_{bk2})$ – kaon decay, additionally with,

$\{1/4\}(S_1 \bullet S_2 \bullet S_3 \bullet S_4 \bullet C_1 \bullet \overline{C}_2 \bullet \overline{S}_{bk1} \bullet \overline{S}_{bk2} \bullet \mu C)$ – kaon decay with muon in μC

≈43% from 504 mln reconstructed single track events

Topology for K → μν and background processes

K → μν decay selection



(at high m_{miss})

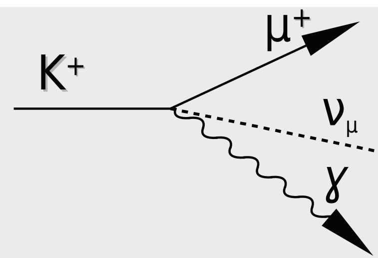
1) – Selections:

- Kaon momentum ≃ 17.7 GeV/c
- single track events
- secondary track – muon
- angle (μ^K) >3 mrad
- p(μ) clearly below p(beam)
- no hits in GS+BGD
- good track quality

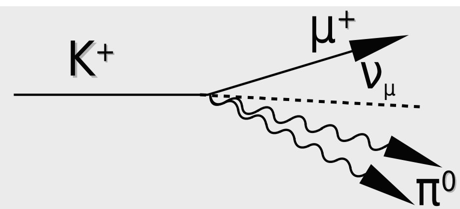
2) – Simulation of all pronounced decay channels to allow for subsequent background subtr. from the experim.-data spectrum

Background Processes

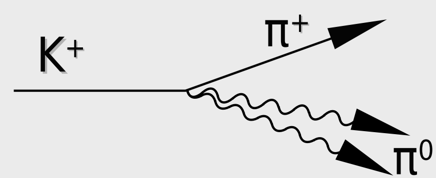
K → μνγ



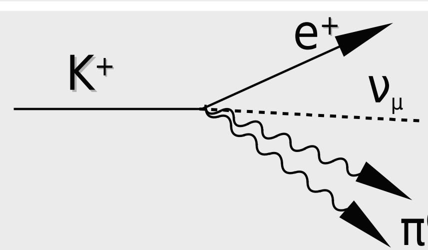
K → μνπ⁰



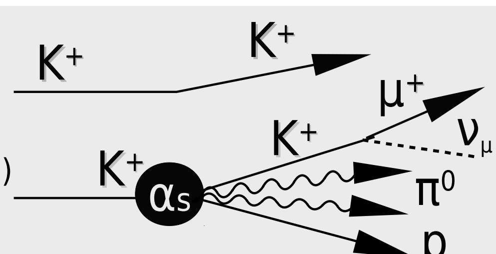
K → π⁺π⁰



K → eνπ⁰

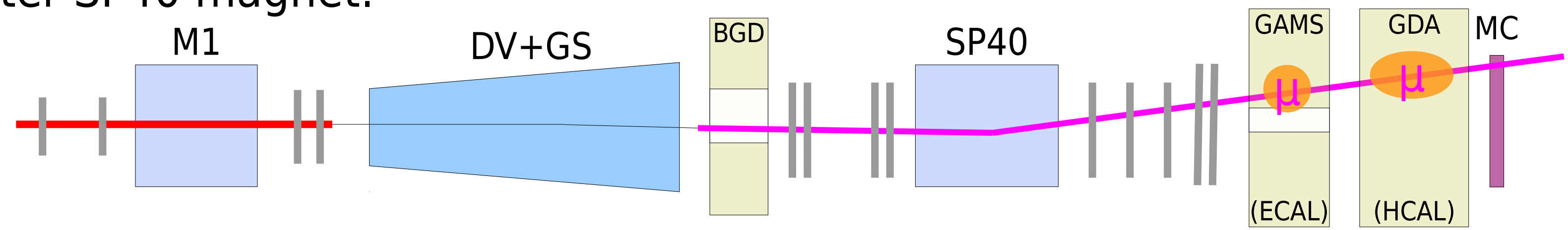


Undecayed (scatt., interact.)



Offline selections: K → μν

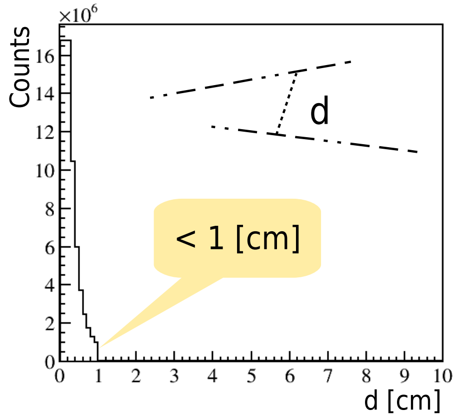
1) Events with single track before DV of proper momentum 17.7 GeV/c and single track after DV with p<16.4 GeV/c and w/o additional track segments after SP40 magnet.

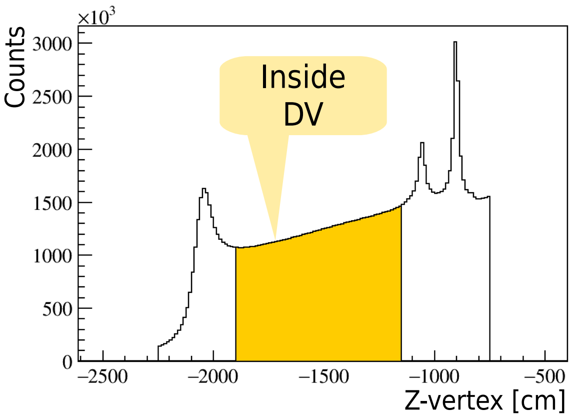


2) Secondary track matches to muon-type cluster in GAMS and GDA

3) Good vertex reconstruction

4) Z-vertex 2σ away from the DV entrance window and from the Cu-target

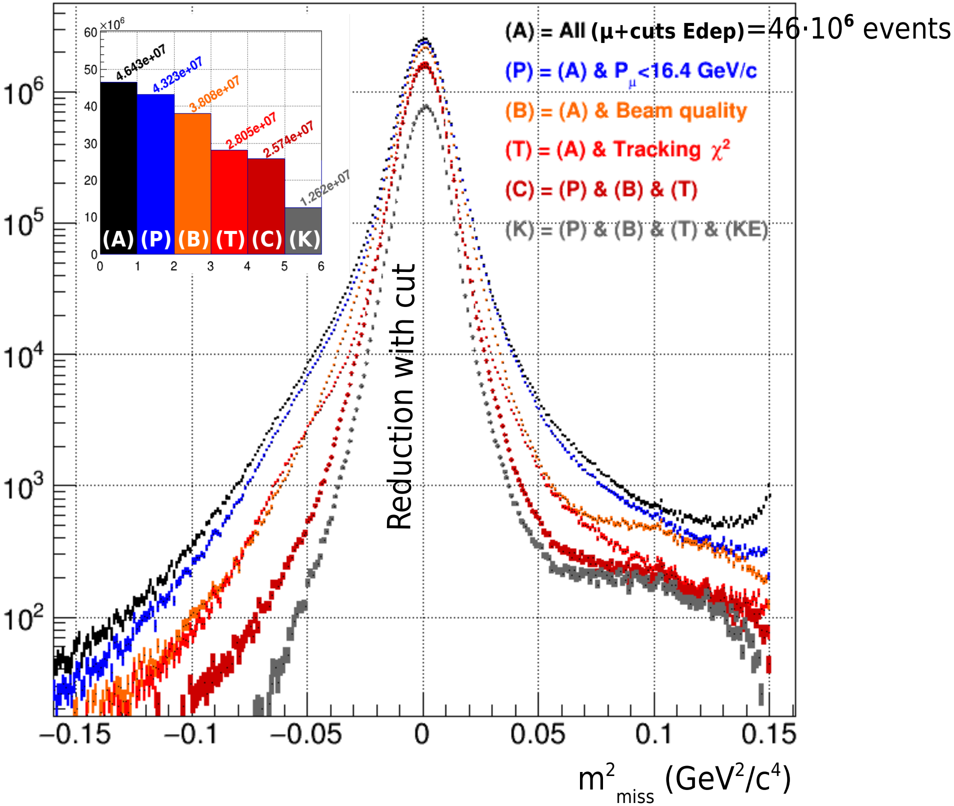




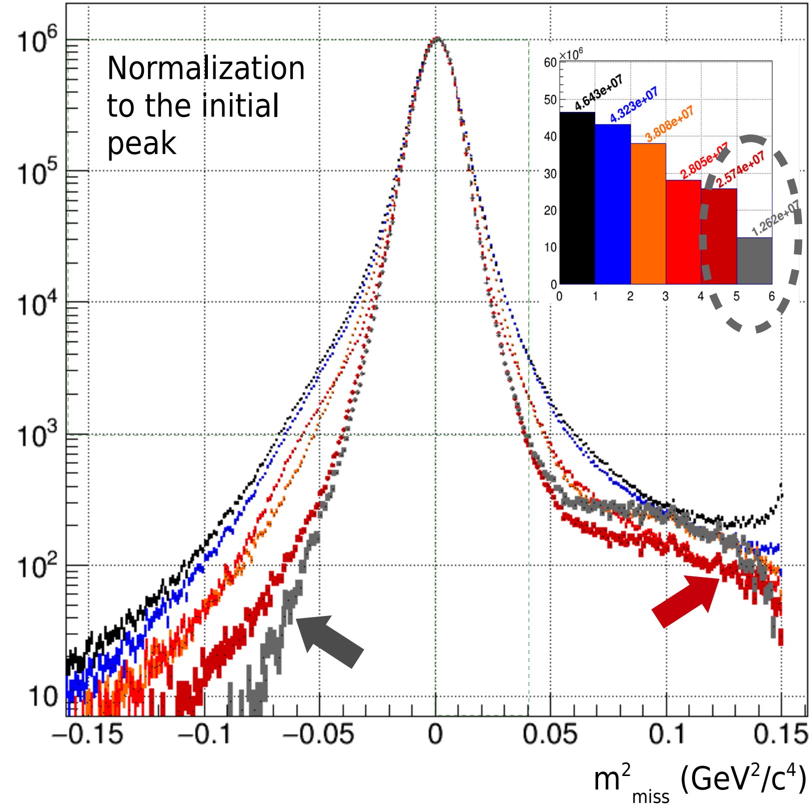
5) Guard system + BGD hermetic cuts (no tracks nor gammas allowed)

6) Energy deposition corresponds to single muon hit in both GAMS and GDA

Reduction in statistics (experiment)



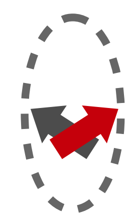
Resolution also improves



Tracking:
Number of points and χ^2/ndf

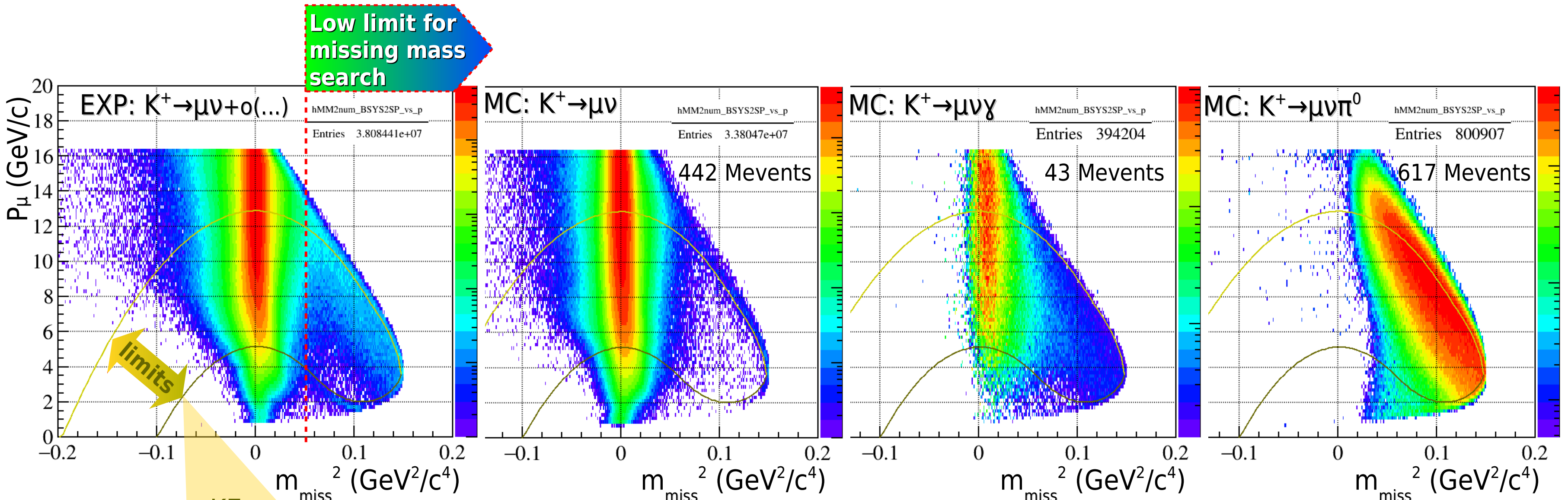
beam track: N>6, $\chi^2/ndf \leq 6$
secondary track: N>15, $\chi^2/ndf \leq 4$

NB: last two selection samples are subjects for further analysis



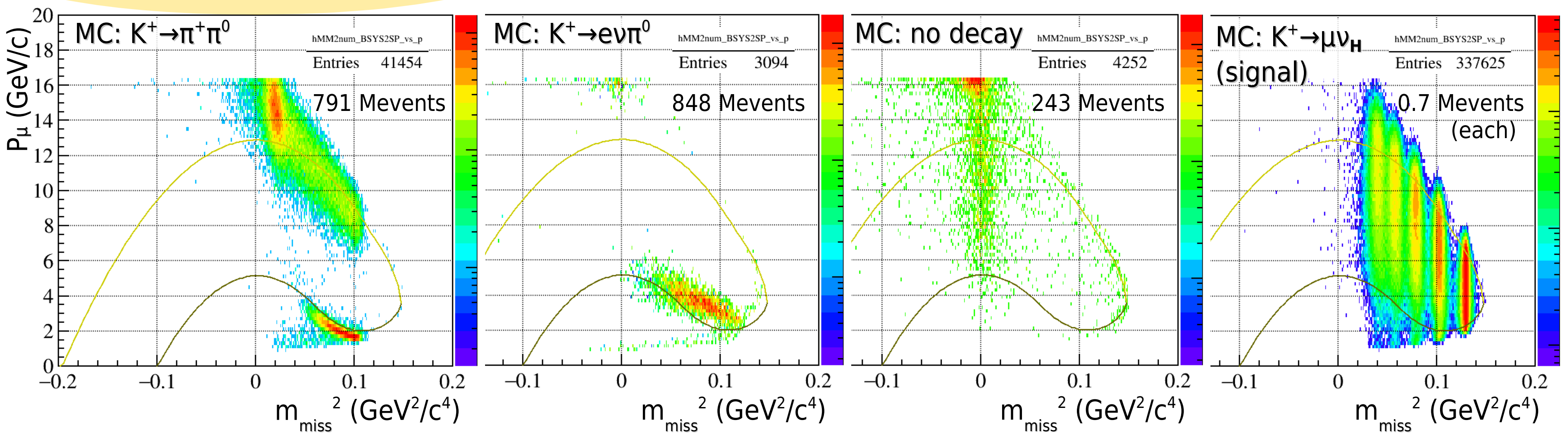
EXP vs. MC comparison

+ motivation to introduce kinematic limits



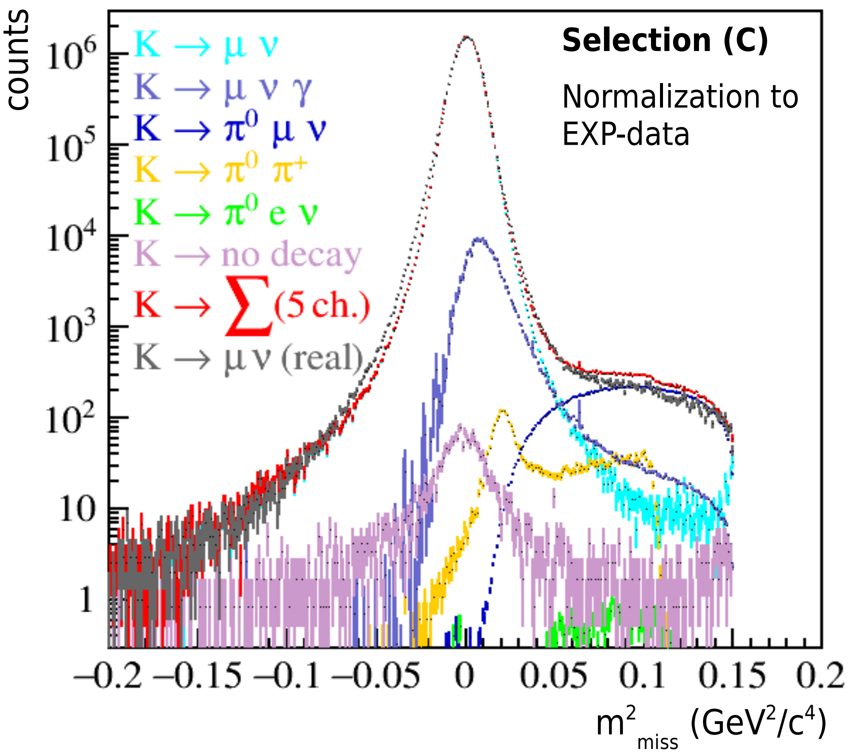
«KE»
Partially suppr. background processes and also improves the resolution.

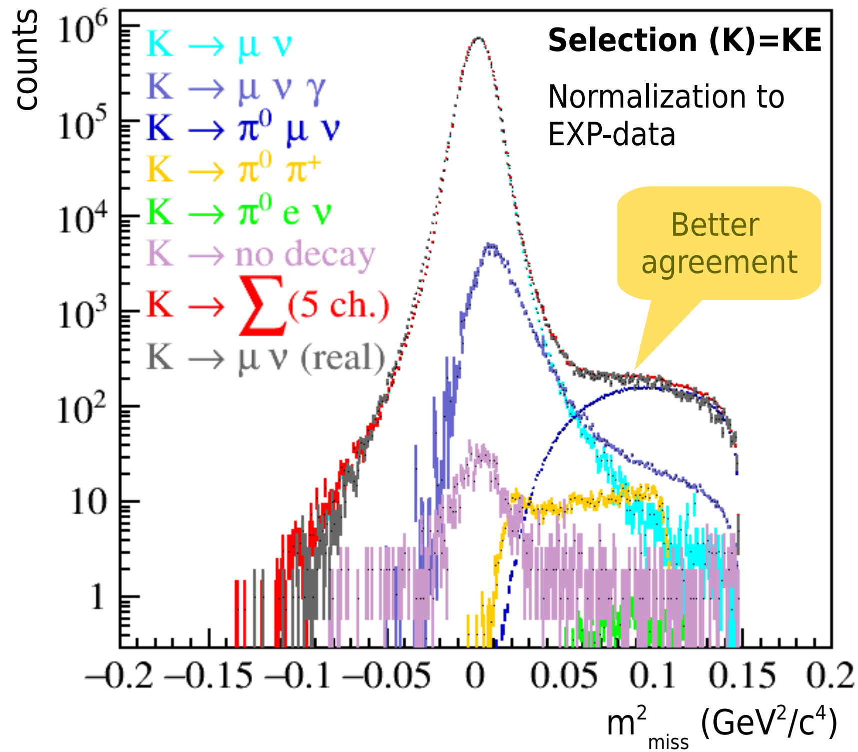
NB: only bi-plots (w/o relative normalization yet)



EXP data and MC comparison – selections (C) and (K)

Each MC-channel is normalized to the main one K → μν (known branchings are used).

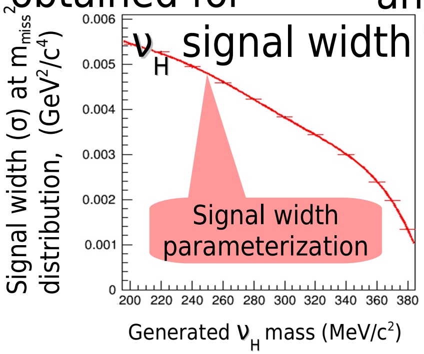


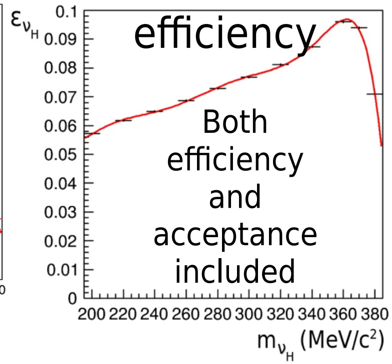


Squared missing mass distribution for all pronounced channels obtained with Monte-Carlo and their sum (red) superimposed with EXP data (gray). Normalization is done to EXP data.

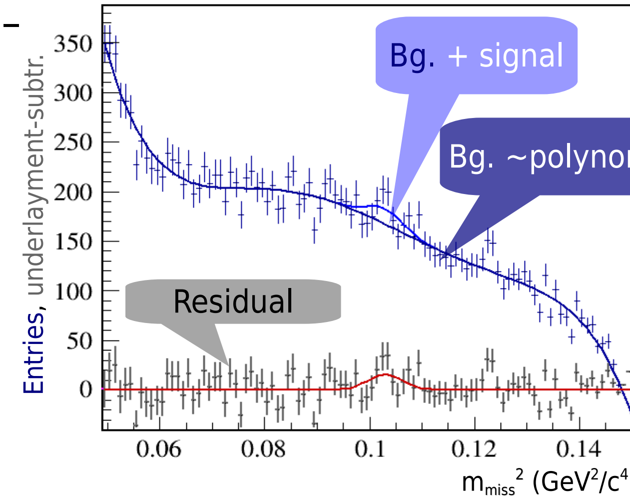
Three approaches for signal extraction

A set masses for ν_H generated in MC and reconstructed. Parameterization obtained for and for

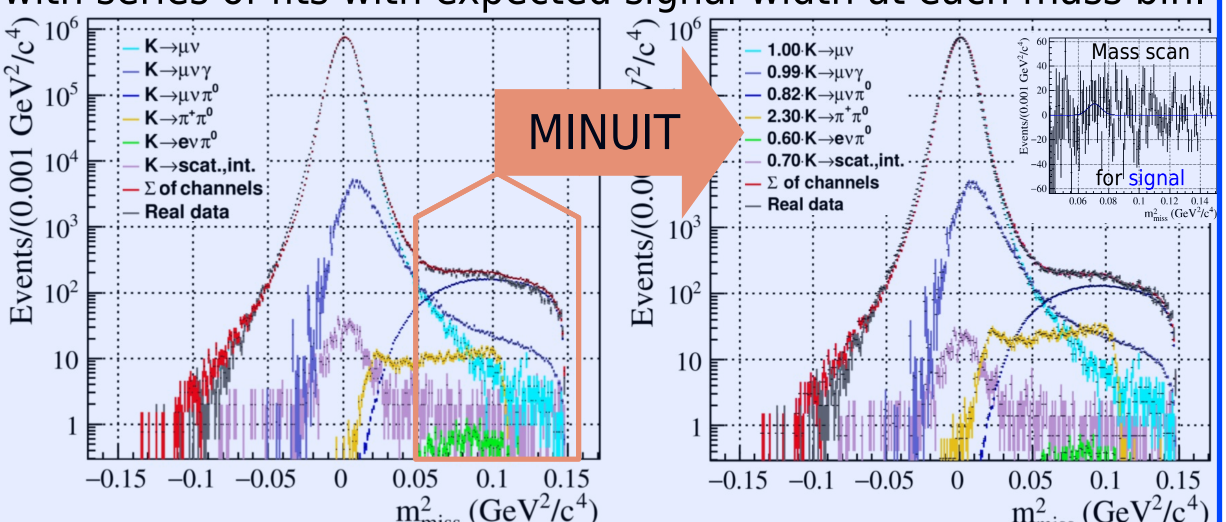




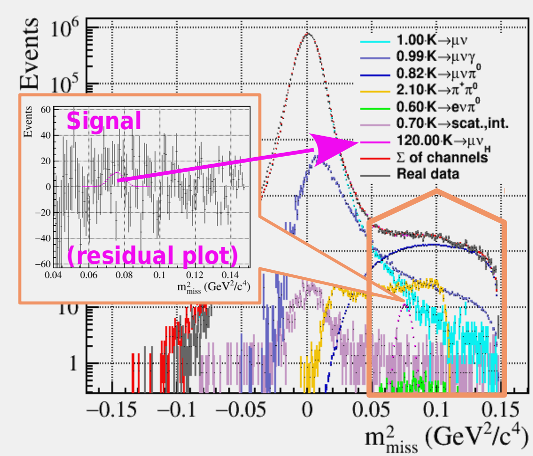
1-st approach – at each mass step refit with polynomial model for bg. and Gaussian for ν_H signal



2-nd approach – efficiency for MC each background process at the mass window of interest is tuned (once); bg. subtraction; procedure with series of fits with expected signal width at each mass bin.

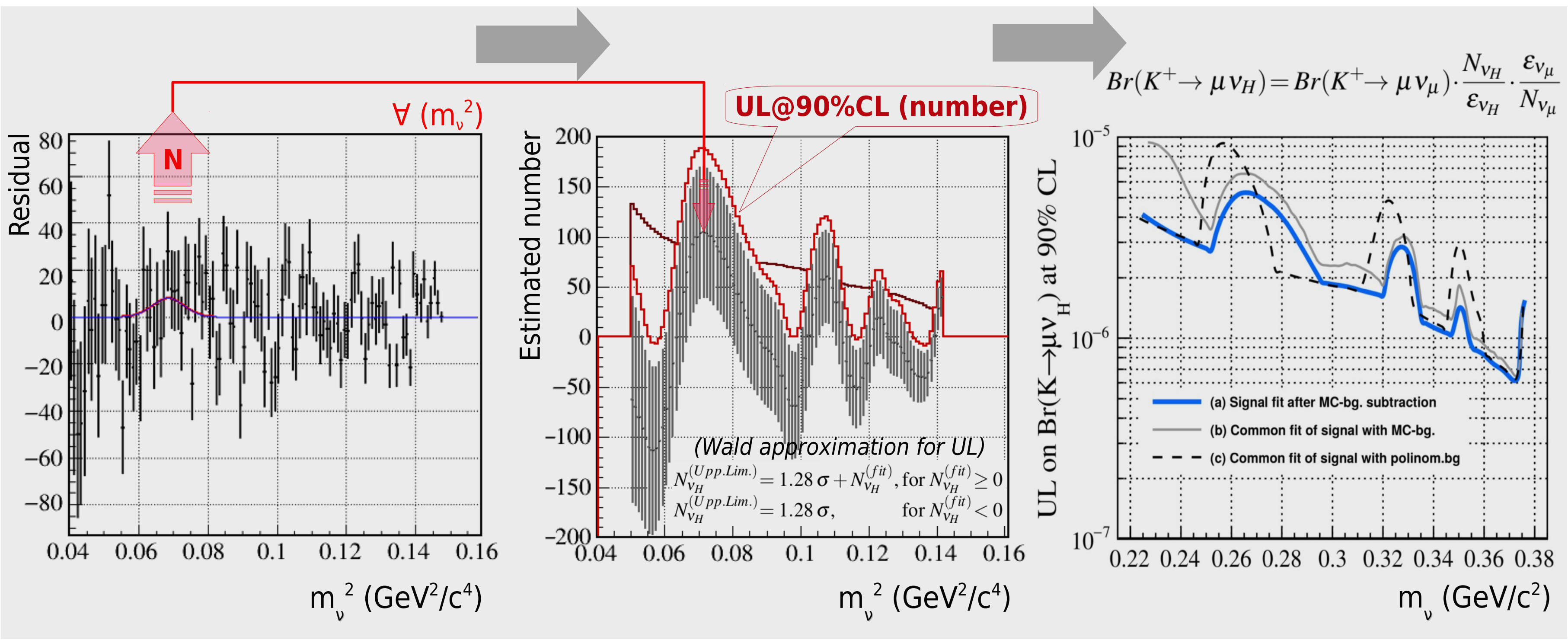


3-rd approach = 2-nd, but MC bg. processes are adjusted together with signal at each mass fit

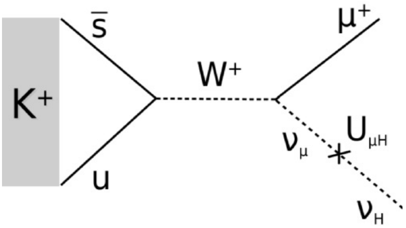


Upper limit estimates

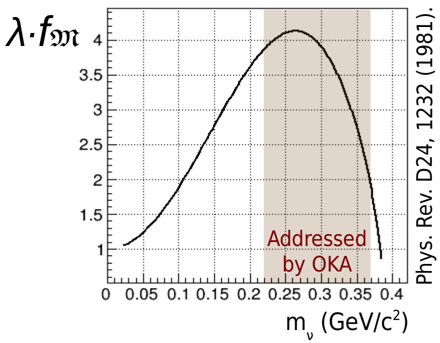
Best fit MC to EXP data →
→ Obtained residual = for signal search →
→ For each bin at m_ν^2 distribution (in the window of interest) →
→ Obtained number of events (with error) →
→ Upper limit on number of events @ CL90% →
→ Using efficiency (from MC) & full number of Km2 (from EXP)→
→ Upper limit on Br. @CL90%

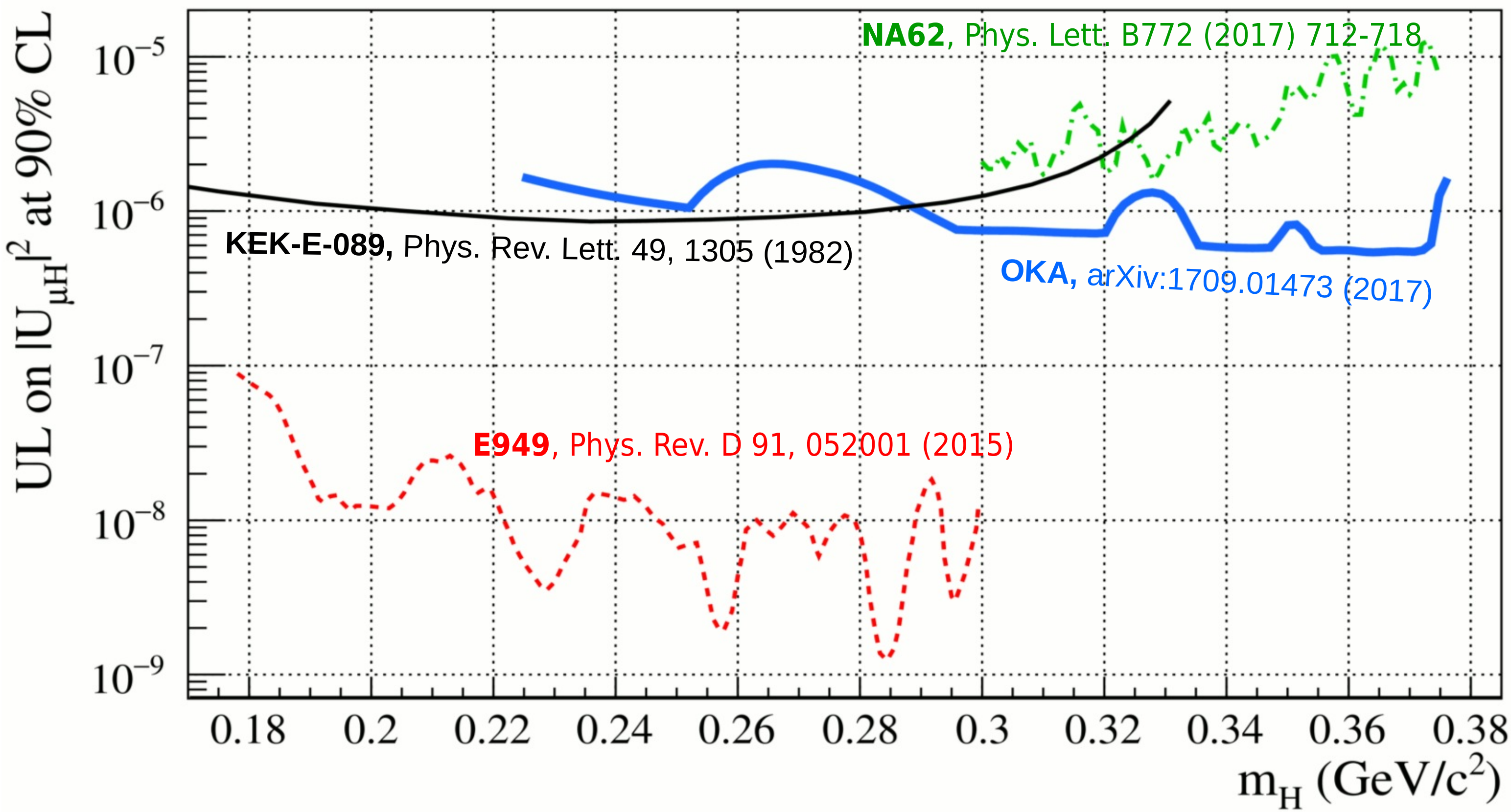


Results on coupling strength



$$\frac{Br(K \to \mu \nu_H)}{Br(K \to \mu \nu_\mu)} = |U_{\mu H}|^2 \cdot \lambda \cdot f_{\mathfrak{M}}$$





Thank you for your attention