Measurements of τ hadronic branching fractions and spectra, and search for 2nd class current τ decays

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For the *BABAR* collaboration

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Contents

- $\tau \rightarrow 3$ prongs + neutrino
  - Branching ratios already published (PRL 100, p011801, 2008)
  - Now present mass distributions (preliminary)
- $\tau \rightarrow$ 3 or 5 prongs + neutrals + neutrino
  - Published as Phys Rev D 86 092010 (2012)
- $\tau \rightarrow 1$ prong + V V + neutrino
  - Published as Phys Rev D - RC 86 092013 (2012)

'prong' means charged track. Pion or kaon

Experimental details

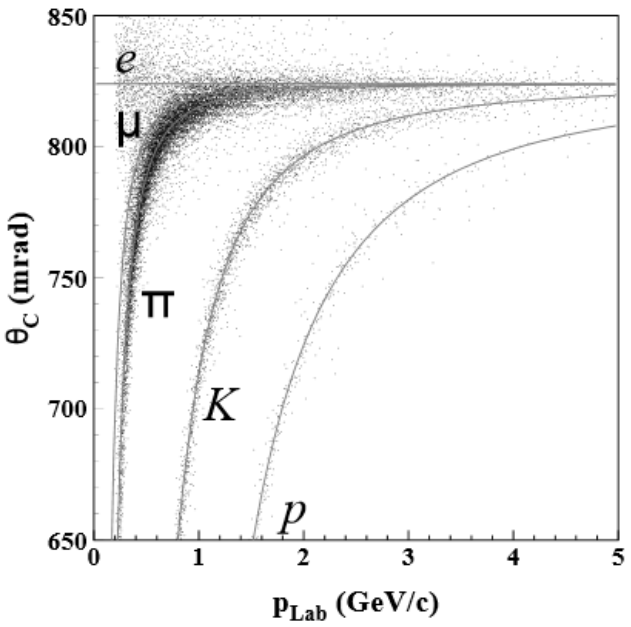
PEP-II is a factory for τ leptons as well as B mesons

Based on full dataset 430M τ pairs

Testbed for models of mesons and QCD

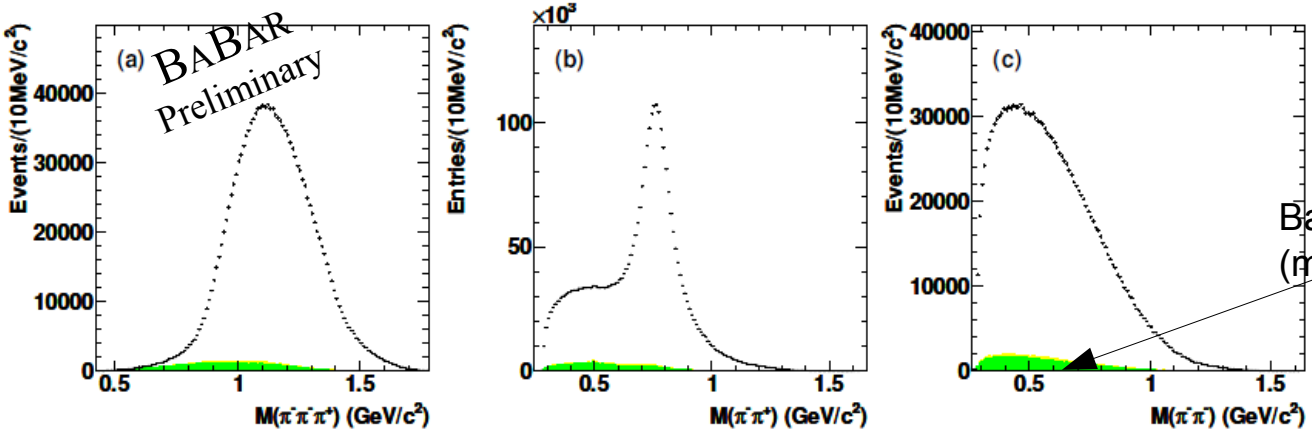
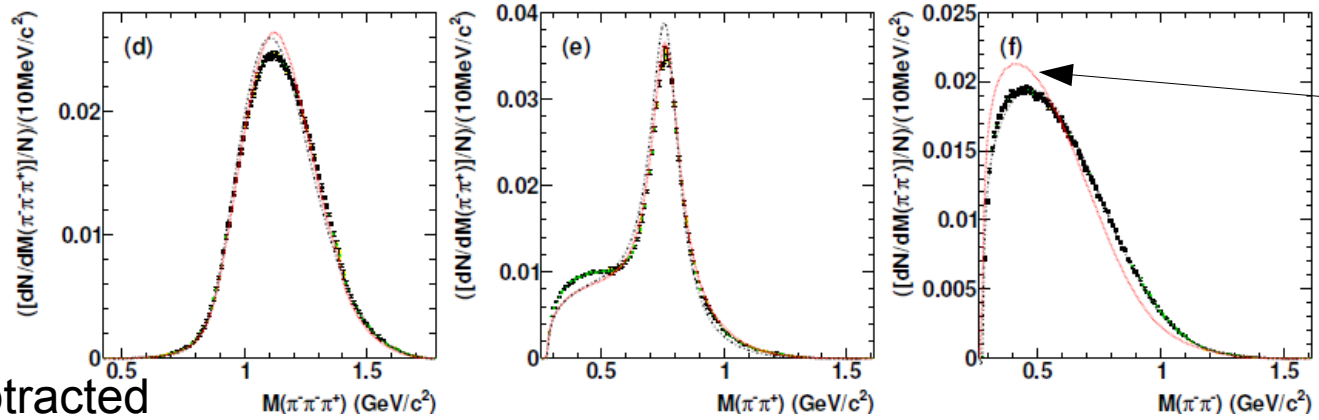
Divide event along thrust axis: 1 track (e or μ, sometimes π) in tagging hemisphere

π/K discrimination by likelihood from DIRC and dE/dx



PID through the DIRC (multihadron sample!)

$\tau^- \to \pi^-\pi^+\pi^-\nu_\tau$

	3π	2π unlike sign	2π like sign
Measured			
Corrected*			

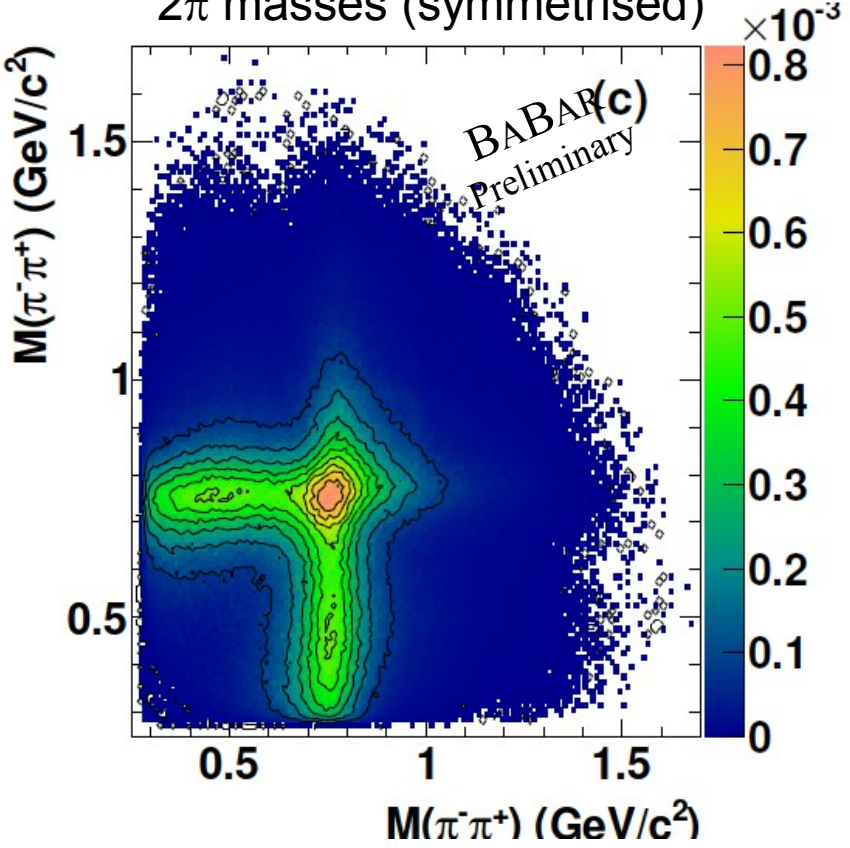
Backgrounds
(mostly other τ decays)

Default MC
Tauola 2.8 tune
Based on CLEO

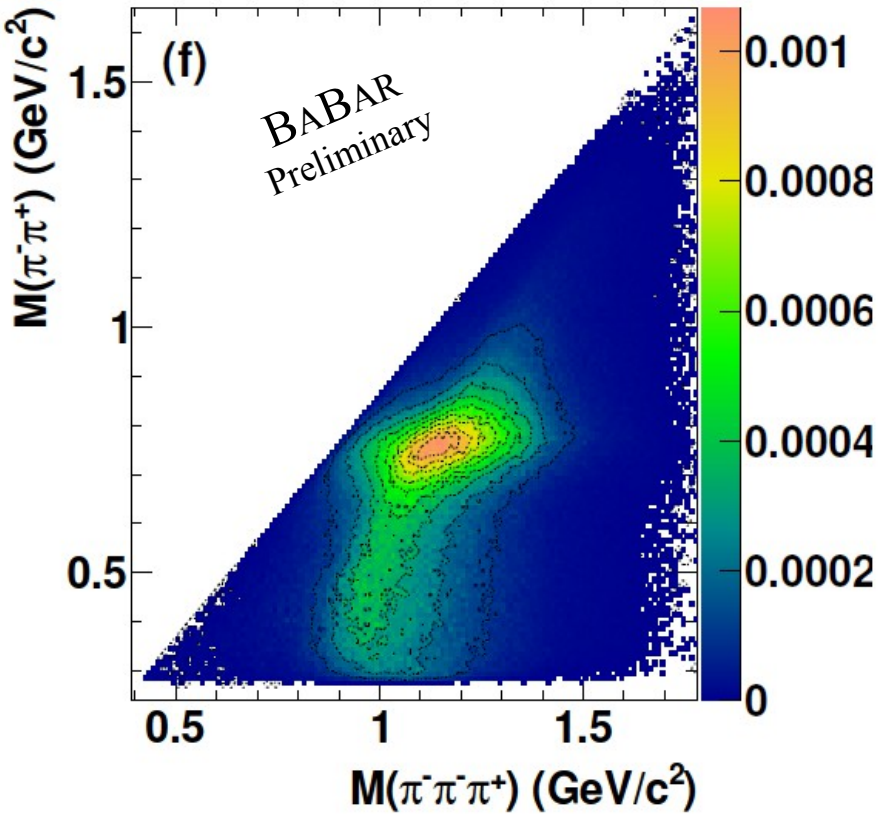
* Background subtracted
Efficiency corrected
Resolution unfolded using Bayesian recipe (d'Agostini)

$\tau^- \to \pi^-\pi^+\pi^-\nu_\tau$

2π masses (symmetrised)

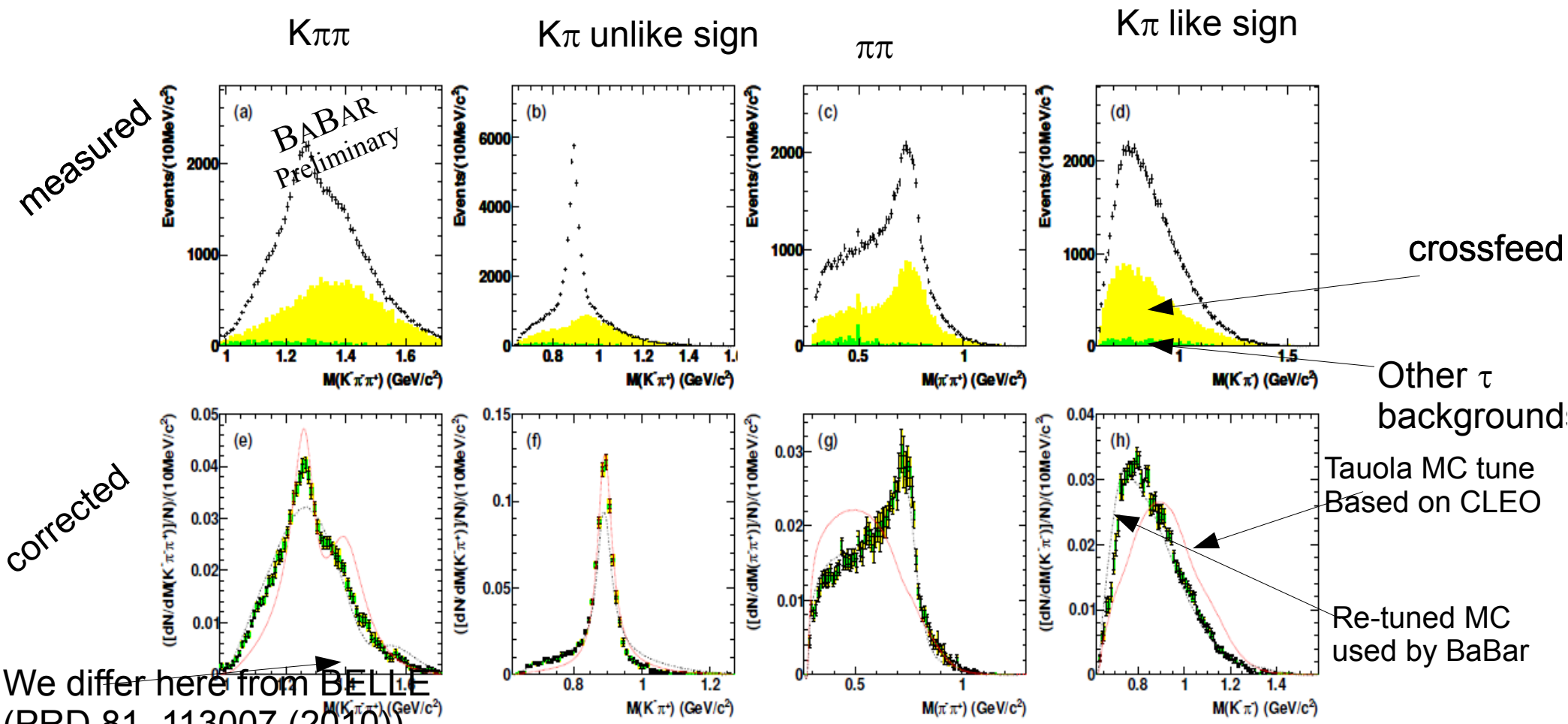


2π and 3π masses



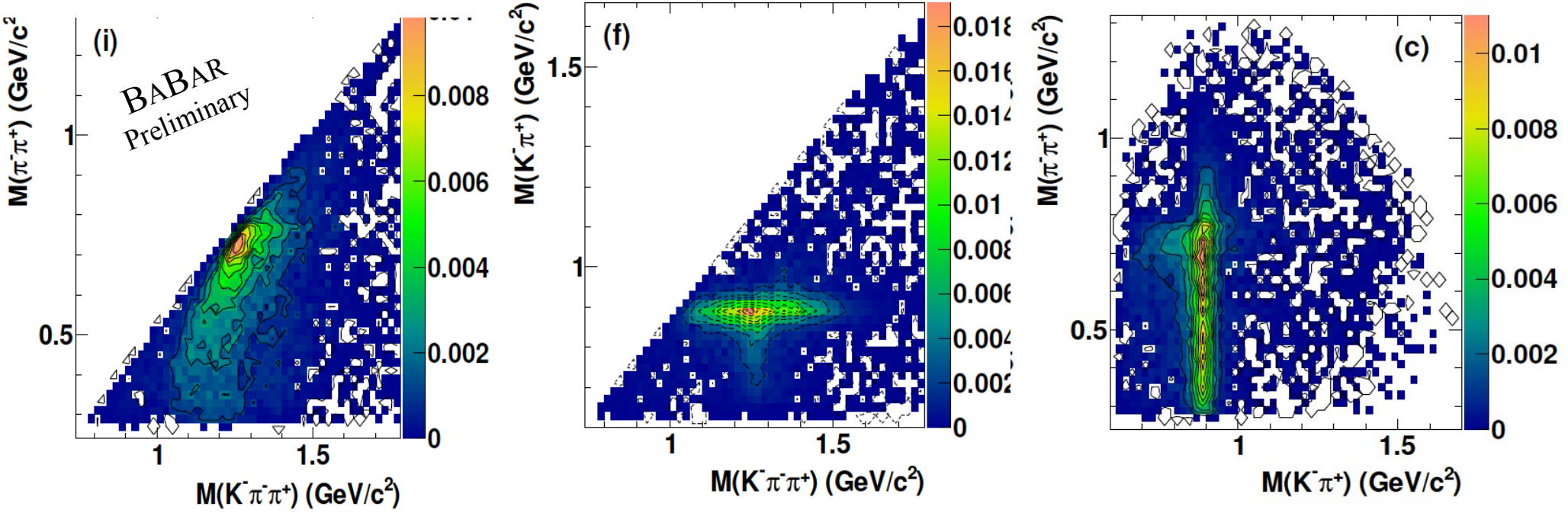
Decay dominated by $a_1(1260)$ decaying to $\pi\rho$.

$\tau^- \to K^- \pi^+ \pi^- \nu_\tau$



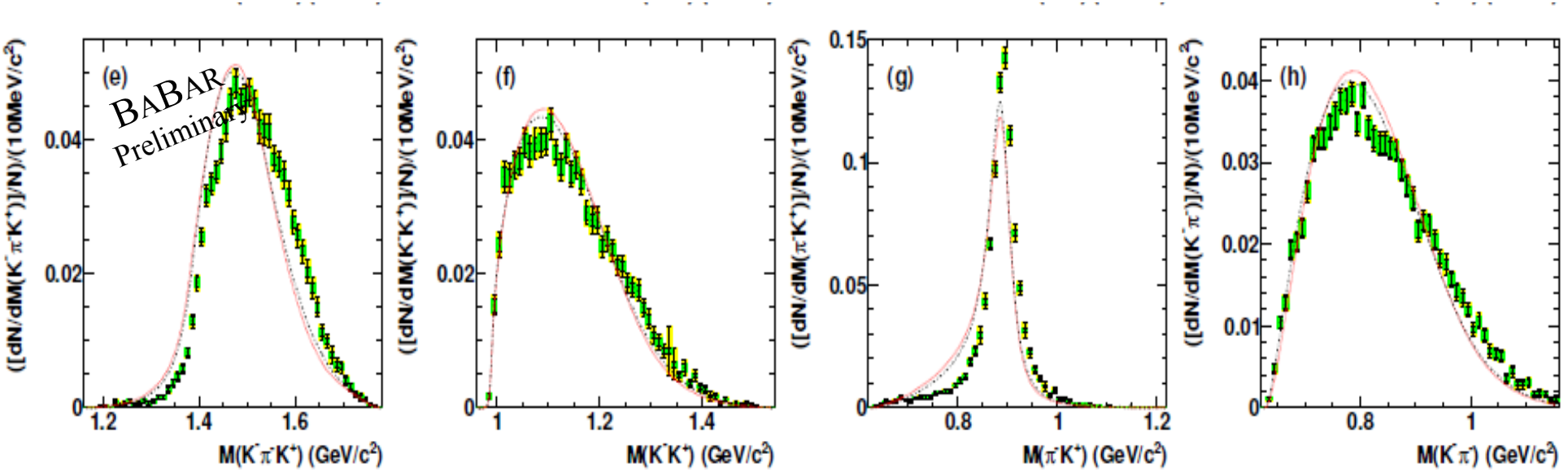
We differ here from BELLE (PRD 81, 113007 (2010))
Large background subtraction

$\tau^- \to K^- \pi^+ \pi^- \nu_\tau$



Decay to $K_1(1270)$ and $K_1(1400)$, then ρ and $K^*(892)$

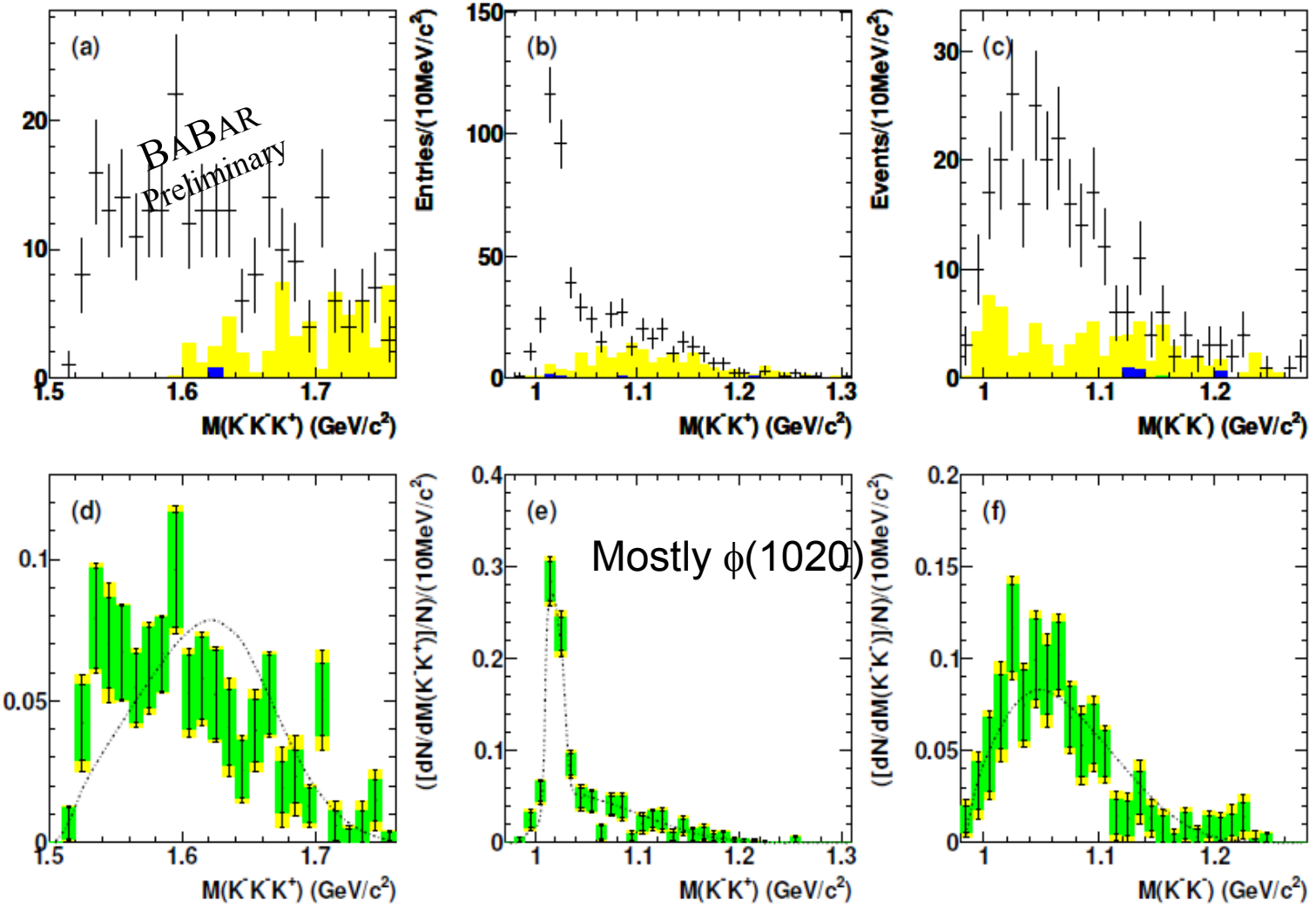
$\tau^- \to K^- K^+ \pi^- \nu_\tau$



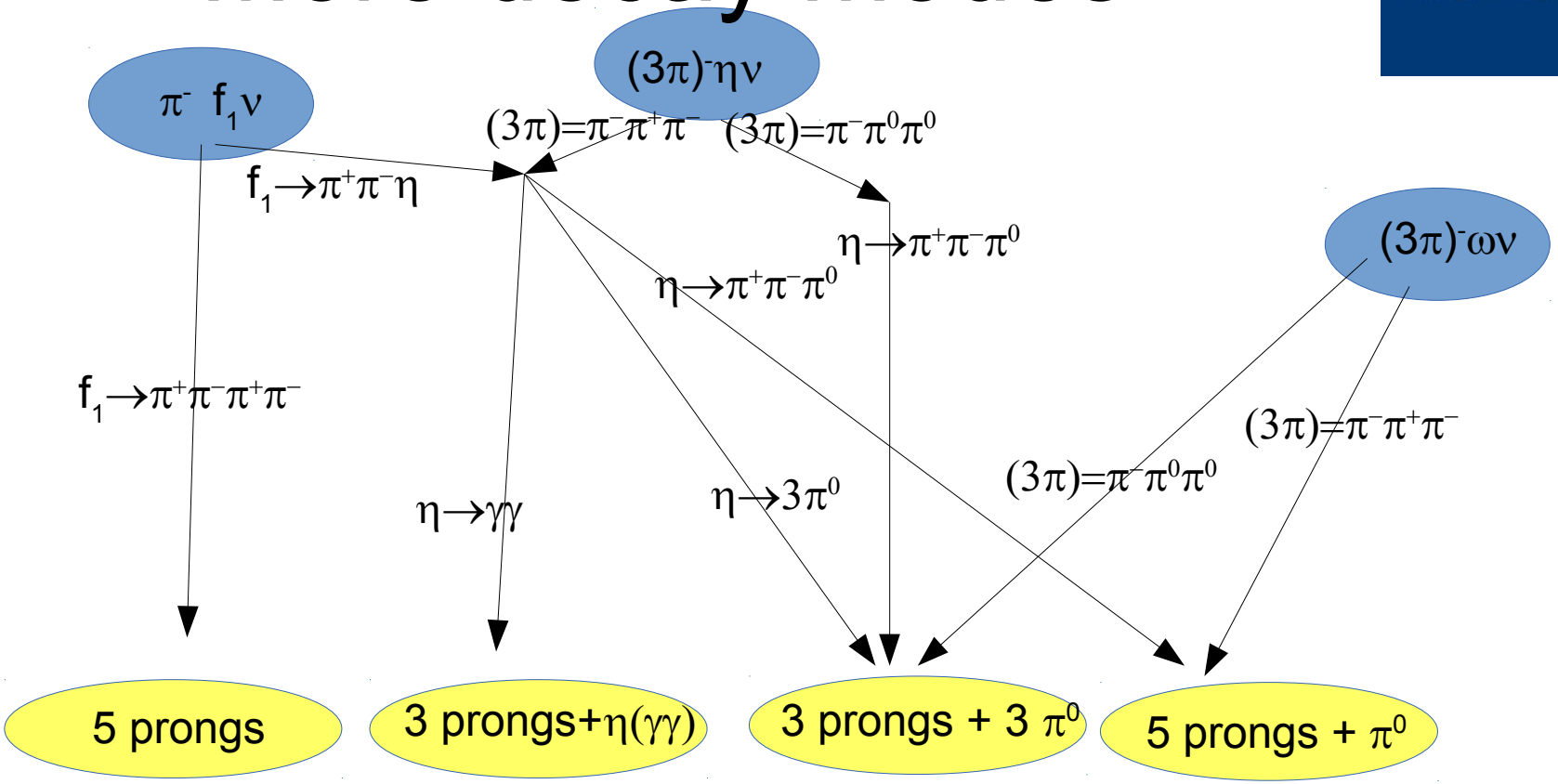
Mostly K*(892)

$\tau^- \to K^- K^+ K^- \nu_\tau$

All 3 | unlike sign KK | like sign KK



More decay modes



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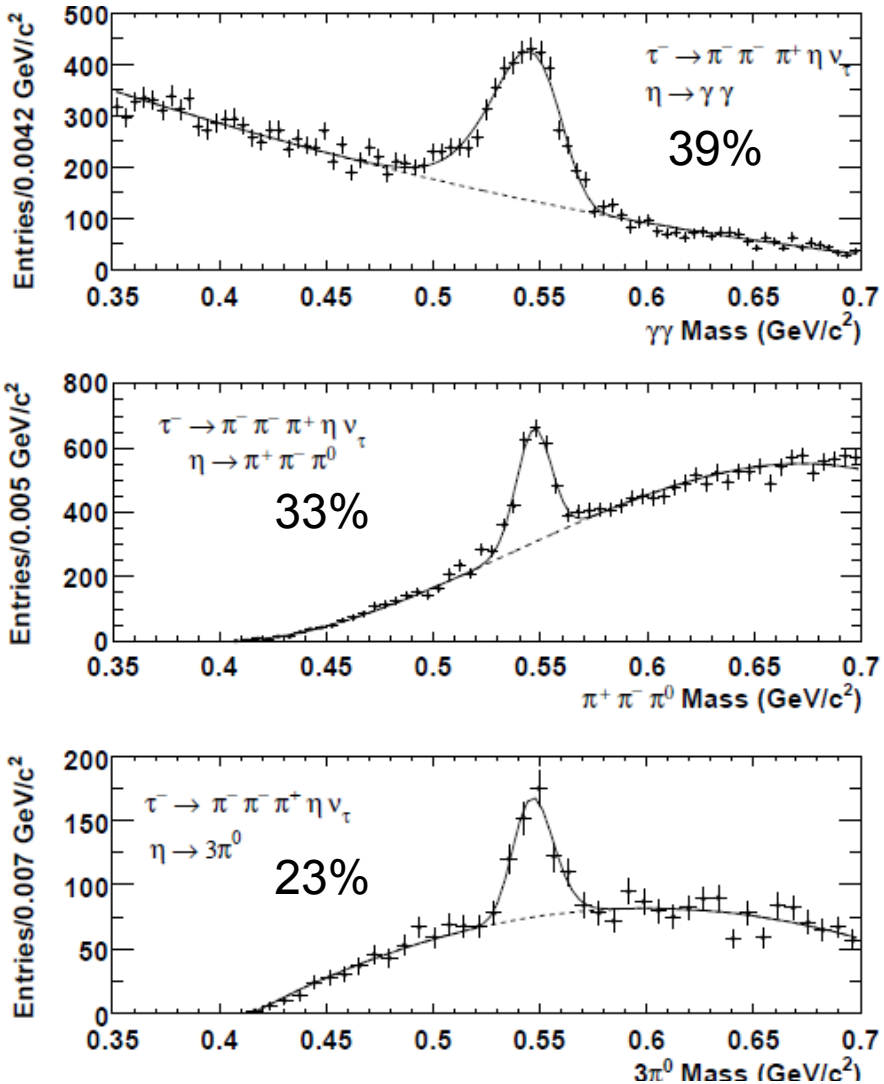
3 different η decay modes

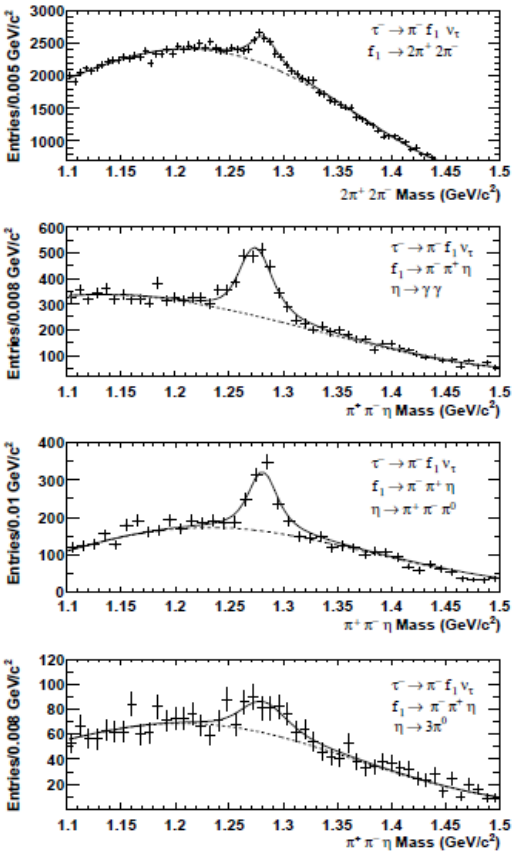


Background mostly from q-qbar
Calculated from data

Results

Channel	Branching Ratio
$\pi^-\pi^+\pi^-\eta\nu$	$(2.25 \pm 0.07 \pm 0.12) \times 10^{-4}$
$\pi^-\pi^0\pi^0\eta\nu$	$(2.01 \pm 0.34 \pm 0.22) \times 10^{-4}$
$\pi^- f_1\nu$, $f_1 \to \pi^+\pi^+\pi^-\pi^-$	$(5.20 \pm 0.31 \pm 0.37) \times 10^{-5}$
$\pi^- f_1\nu$, $f_1 \to \pi^+\pi^+\eta$	$(1.26 \pm 0.06 \pm 0.06) \times 10^{-4}$
$\pi^-\pi^+\pi^-\omega\nu$	$(8.4 \pm 0.4 \pm 0.6) \times 10^{-5}$
$\pi^-\pi^0\pi^0\omega\nu$	$(7.3 \pm 1.2 \pm 1.2) \times 10^{-5}$
$\pi^-\pi^+\pi^-\pi^+\pi^-\nu$ nonresonant	$(7.68 \pm 0.04 \pm 0.40) \times 10^{-4}$
$\pi^-\pi^+\pi^-\pi^+\pi^-\pi^0\nu$ nonresonant	$(3.6 \pm 0.3 \pm 0.9) \times 10^{-5}$
$\pi^-\pi^+\pi^-\pi^0\pi^0\pi^0\nu$ nonresonant	$< 5.8 \times 10^{-5}$ @ 90% CL

Decays of the f_1

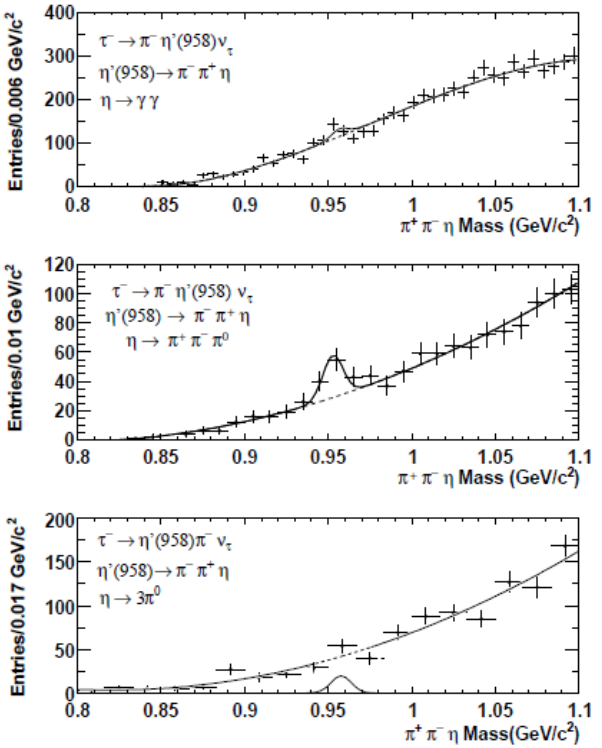


Mass of f_1 = 1.28116 ± 0.00039 ± 0.00045 GeV/c²

More limits

Channel	Branching Ratio
$\pi^-\eta'\nu$	$< 4.0 \times 10^{-6}$
$\pi^-\pi^0\eta'\nu$	$< 1.2 \times 10^{-5}$
$K^-\eta'\nu$	$< 2.4 \times 10^{-6}$
$K^-\pi^-\pi^-\pi^+\pi^+\nu$	$< 2.4 \times 10^{-6}$
$K^+\pi^-\pi^-\pi^-\pi^+\nu$	$< 5.0 \times 10^{-6}$
$K^-K^+\pi^-\pi^-\pi^+\nu$	$< 4.5 \times 10^{-7}$
$K^-\pi^-\pi^-\pi^+\pi^+\pi^0\nu$	$< 1.9 \times 10^{-6}$
$K^+\pi^-\pi^-\pi^-\pi^+\pi^0\nu$	$< 8 \times 10^{-7}$

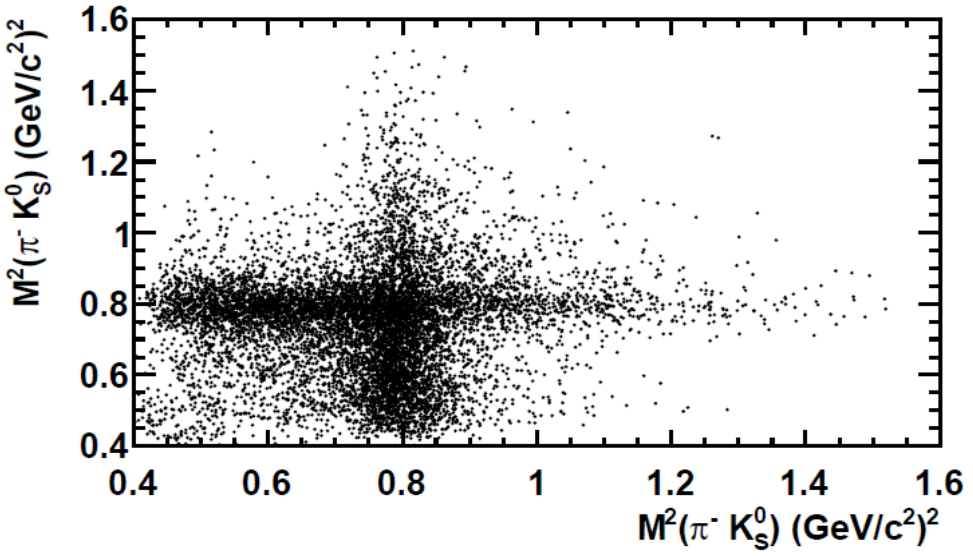
2nd class current



η' is seen in sample,
but comes from background
from q-qbar

Decays with $K^0_s K^0_s$

Channel	Branching Ratio
$\pi^- K^0_s K^0_s \nu$	$(2.31 \pm 0.04 \pm 0.08) \times 10^{-4}$
$\pi^- K^0_s K^0_s \pi^0 \nu$	$(1.60 \pm 0.20 \pm 0.22) \times 10^{-5}$
$K^- K^0_s K^0_s \nu$	$< 6.3 \times 10^{-7}$
$K^- K^0_s K^0_s \pi^0 \nu$	$< 4 \times 10^{-7}$



Current knowledge of branching ratios is poor. Interesting in their own right – and because of forming a background to $\tau^- \to \pi^- K^0_s \nu$

Which is/will be an important CP violation measurement

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Conclusions: results on

$\tau^- \rightarrow$

$\pi^-\pi^+\pi^-\nu$, $a_1\nu$

$K^-\pi^+\pi^-\nu$, $K^{*0}\pi^-\nu$, $K^-\rho^0\nu$

$K^-K^+\pi^-\nu$, $K^{*0}K^-\nu$

$K^-K^+K^-\nu$, $\phi K^-\nu$

$\pi^- f_1\nu$

$\pi^-\pi^+\pi^-\eta\nu$

$\pi^-\pi^0\pi^0\eta\nu$

$\pi^-\pi^+\pi^-\omega\nu$

$\pi^-\pi^0\pi^0\omega\nu$

$\pi^-\pi^+\pi^-\pi^+\pi^-\nu$

$\pi^-\pi^+\pi^-\pi^+\pi^-\pi^0\nu$

$\pi^-\pi^+\pi^-\pi^0\pi^0\pi^0\nu$

$\pi^-\eta'\nu$

$\pi^-\pi^0\eta'\nu$

$K^-\eta'\nu$

$K^-\pi^+\pi^-\pi^+\pi^-\nu$

$K^+\pi^-\pi^-\pi^+\pi^-\nu$

$K^+K^-\pi^-\pi^+\pi^-\nu$

$K^-\pi^+\pi^-\pi^+\pi^-\pi^0\nu$

$K^+\pi^-\pi^-\pi^+\pi^-\pi^0\nu$

$\pi^- K^0_s K^0_s\nu$

$\pi^- K^0_s K^0_s\pi^0\nu$

$K^- K^0_s K^0_s\nu$

$K^- K^0_s K^0_s\pi^0\nu$

… and more to come!

There is still a lot of tau physics to be extracted from the BaBar dataset