Conversion Decays of Light Mesons

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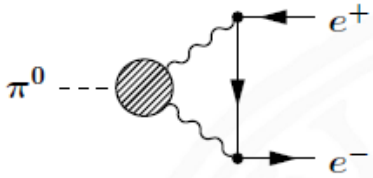
talk at Baryons 2016
May 16-20, 2016, Florida State U

Reactions of hadrons with (virtual) photons

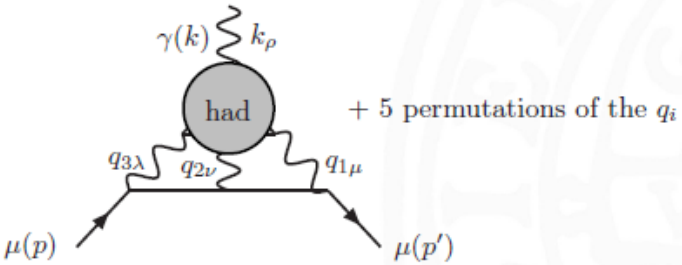
Why is it interesting?

- explore intrinsic structure of hadrons
  - ⇝ form factors
  - ⇝ to which extent does vector meson dominance hold?
- background for physics beyond standard model

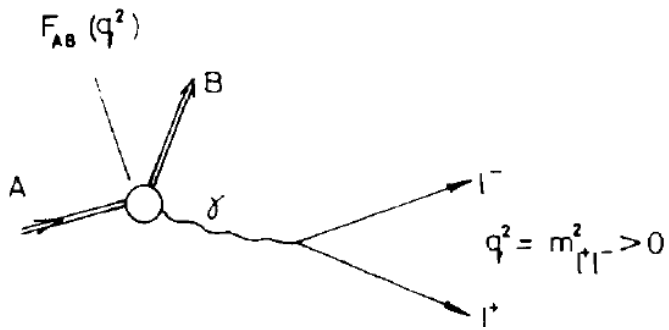
⇝ rare pion decay $\pi^0 \to e^+e^-$



⇝ $g-2$ of muon



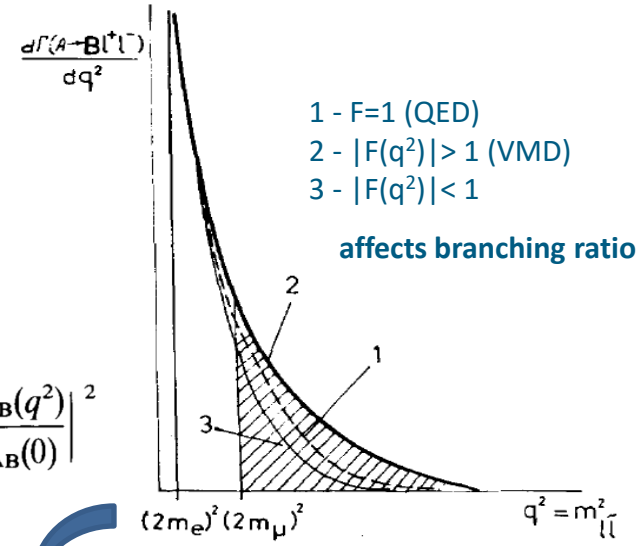
Dalitz (conversion) decays of mesons



$$\frac{d\Gamma(A\to B\ell^+\ell^-)}{dq^2\cdot\Gamma(A\to B\gamma)} = \frac{\alpha}{3\pi}\left[1-\frac{4m_\ell^2}{q^2}\right]^{1/2}\left[1+2\frac{m_\ell^2}{q^2}\right]\frac{1}{q^2}$$

$$\times\left[\left(1+\frac{q^2}{m_A^2-m_B^2}\right)^2-\frac{4m_A^2q^2}{(m_A^2-m_B^2)^2}\right]^{3/2}\left|\frac{f_{AB}(q^2)}{f_{AB}(0)}\right|^2 = [\mathrm{QED}]\cdot\left|\frac{f_{AB}(q^2)}{f_{AB}(0)}\right|^2$$

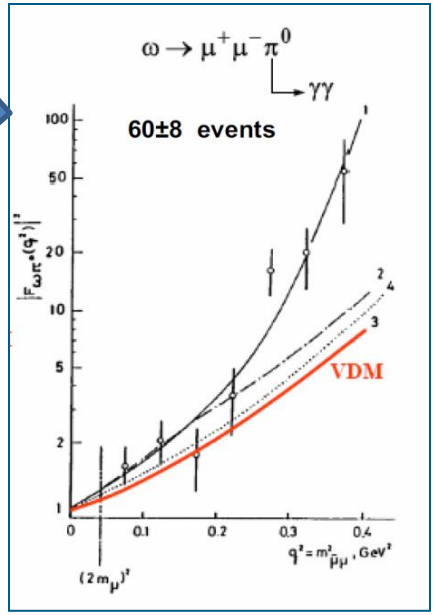
L.G. Landsberg, Electromagnetic decays of light mesons



procedure: divide experimental q^2 distribution by QED

$$F_{AB}(q^2) \simeq 1 + q^2[dF_{AB}/dq^2]|_{q^2\simeq 0} = 1 + q^2 b_{AB} = 1 + \tfrac{1}{6}q^2\langle r^2_{AB}\rangle$$

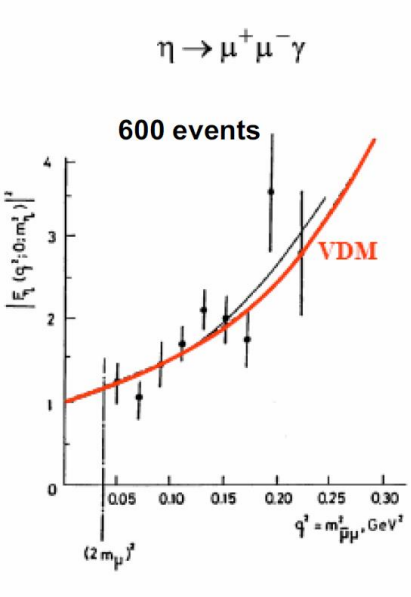
slope parameter
b~ 1/m(rho)
(1.7 GeV^{-2}) 'standard VMD'

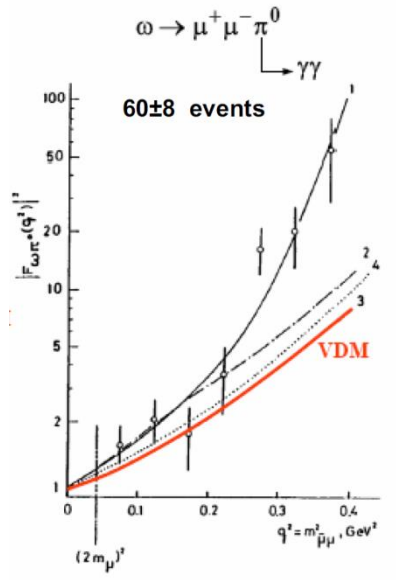


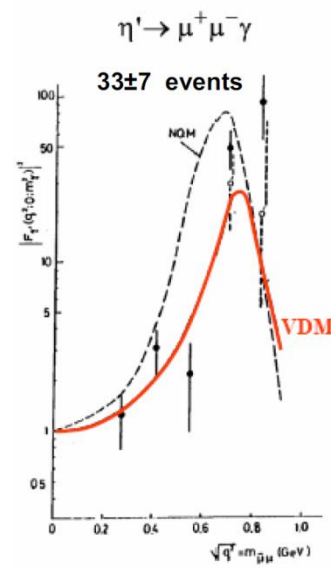
(old) world data set: conversion decays

L.G. Landsberg, Electromagnetic decays of light mesons

IHEP in 1978—1980 on the "Lepton-G" spectrometer







for ω meson, clearly additional mechanisms apart from standard VMD

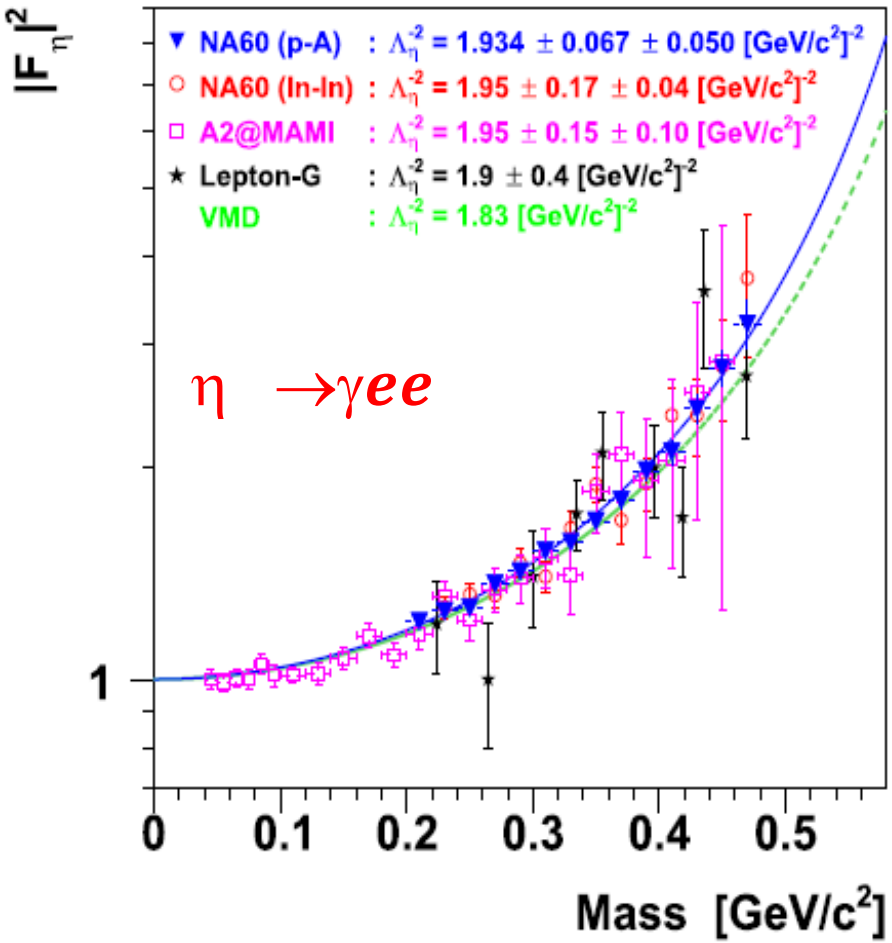
(black curves are fits to the data)

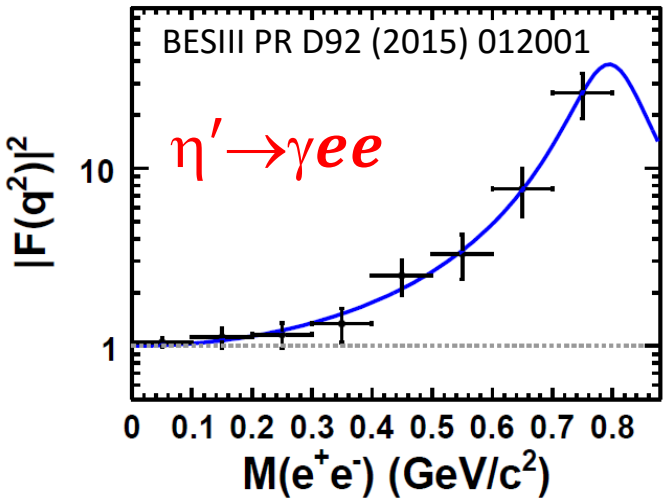
- confirmed by NA60 AA reactions, S. Damjanovic, PLB 677 (2009) 260
- confirmed by NA60 pA reactions, A.Uras, J.Phys. Conf.Ser.270(2011) 012038

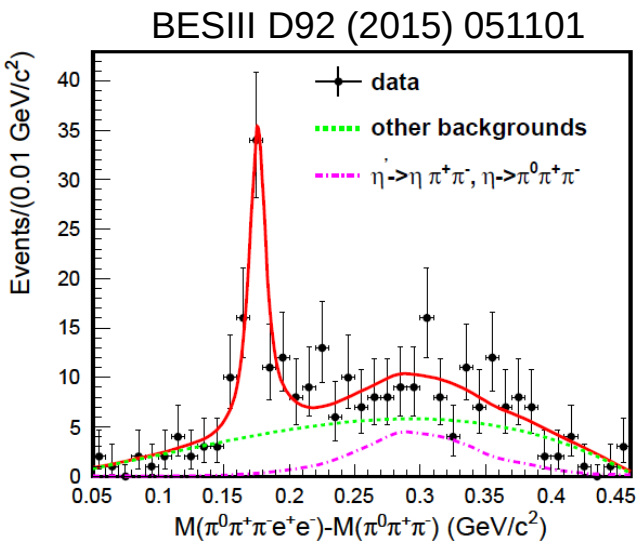
different experimental approach: elementary reactions, using di-electrons

new data sets: η and η‘

A2 Phys.Rev. C89 (2014) 044608
NA60 PLB (2016) in print



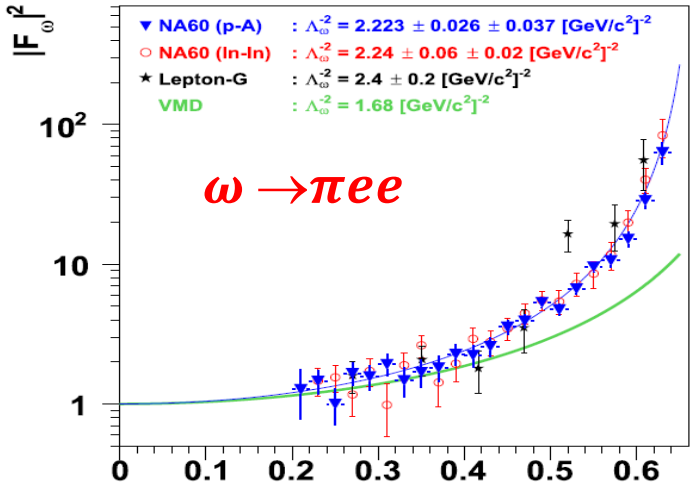


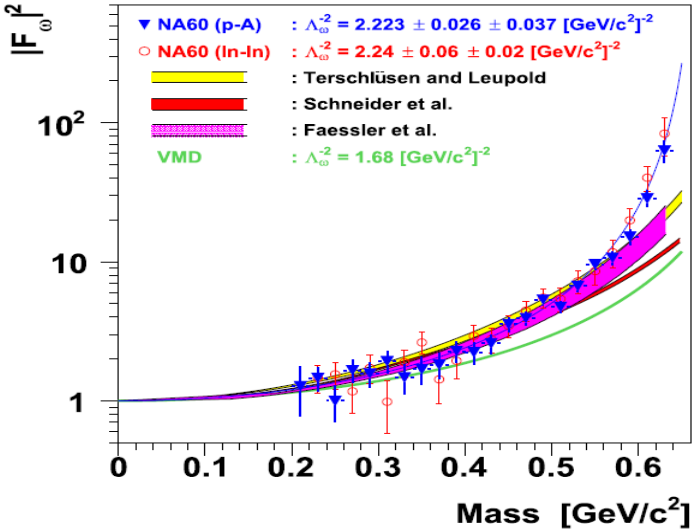


BR($\eta' \to \omega ee$) $(1.97 \pm 0.34(\text{stat}) \pm 0.17(\text{syst})) \times 10^{-4}$

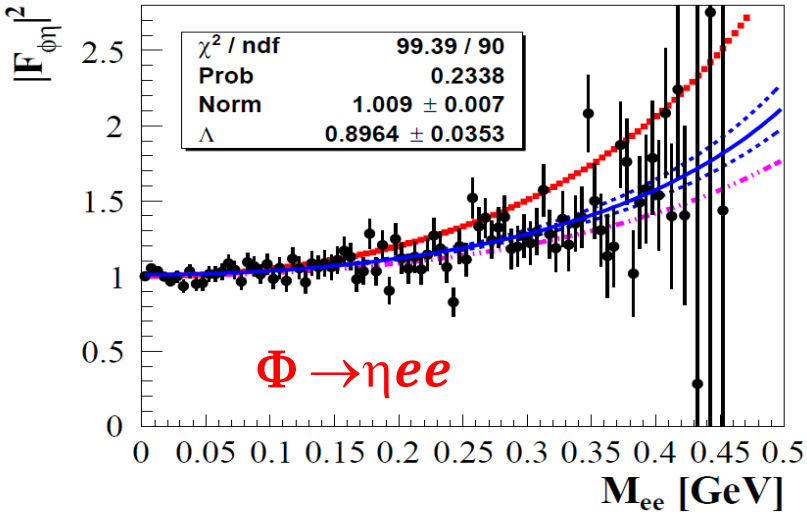
new data sets: ω and Φ

NA60 PLB (2016) in print

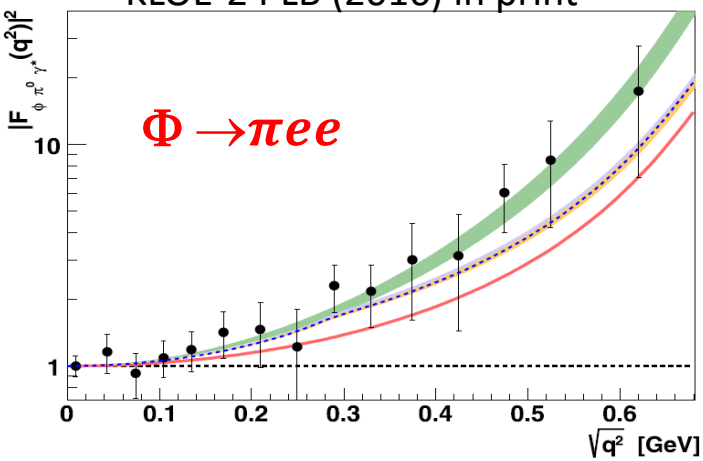




KLOE2 PLB742 (2015) 1

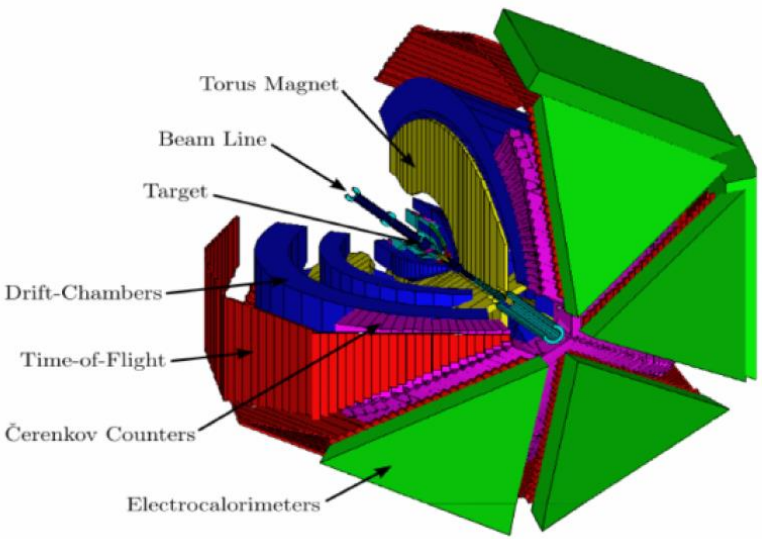


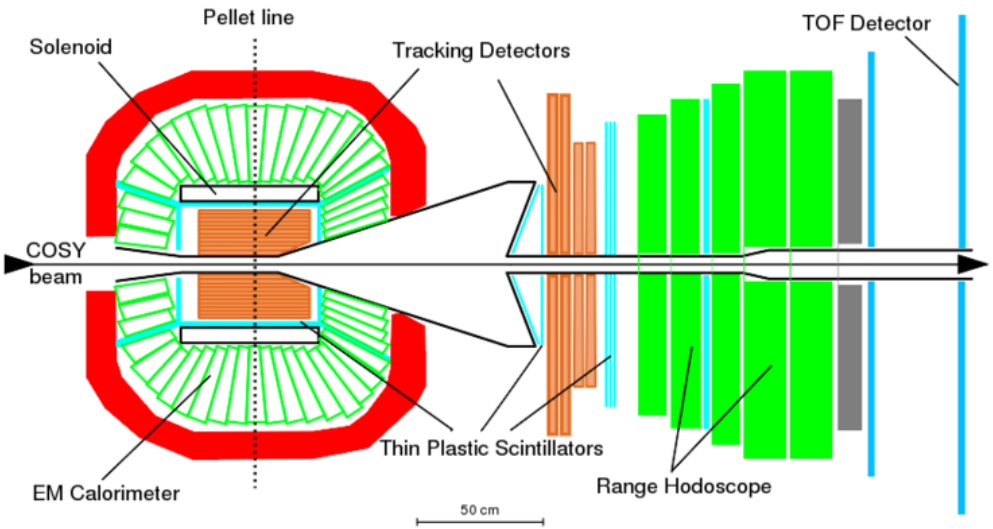
KLOE-2 PLB (2016) in print



puzzle not solved yet

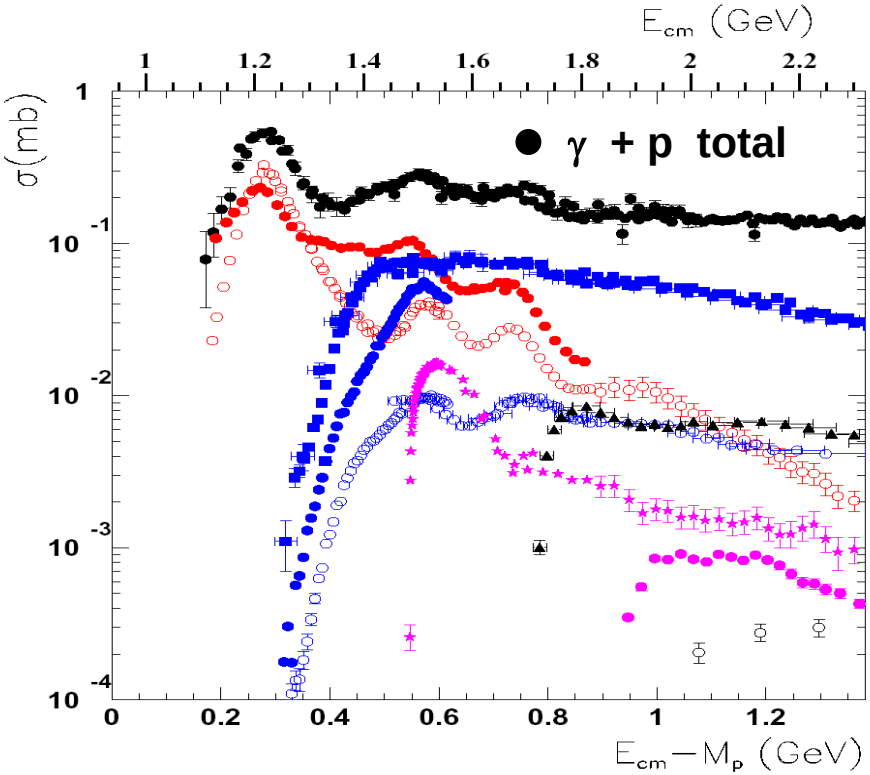
a tale of two experiments

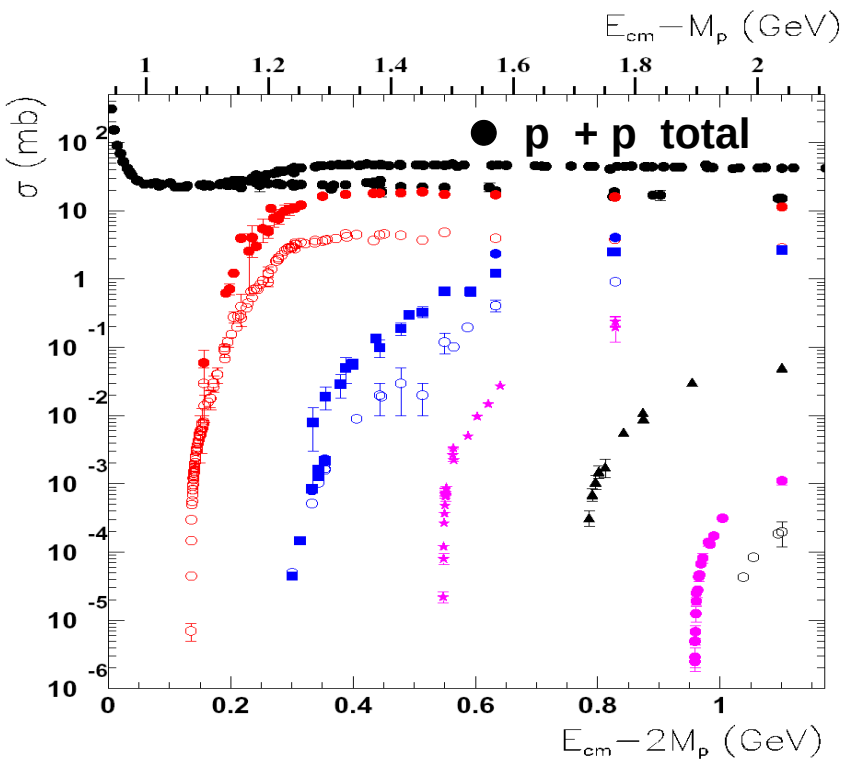




CLAS Jefferson Lab	experimental issue	WASA COSY-Jülich
$\gamma + p$ (g12 experiment)	• cross section • multipion background	$p + p$ (2010)
LH_2 target	external γ conversion	pellet target + beam pipe
Cerenkov Counters	dilepton identification	
EM calorimeter	photon detection	CsI EM Colrimeter

meson production from the proton





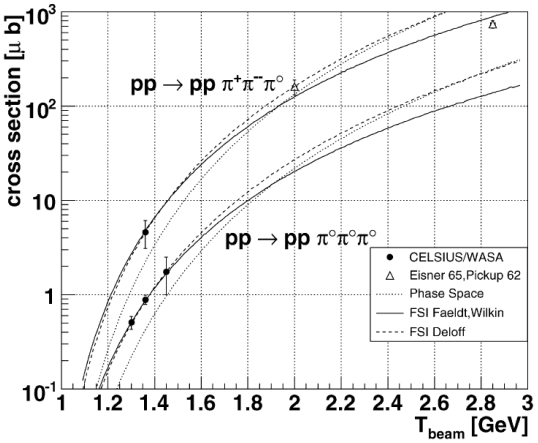
● π + ○ π ° ● π + π ° ○ π ° π ° ★η ● η' ▲ ω ○ ϕ

γp reactions:

- in second resonance region, $\sigma(\eta) > \sigma(\pi^0\pi^0)$

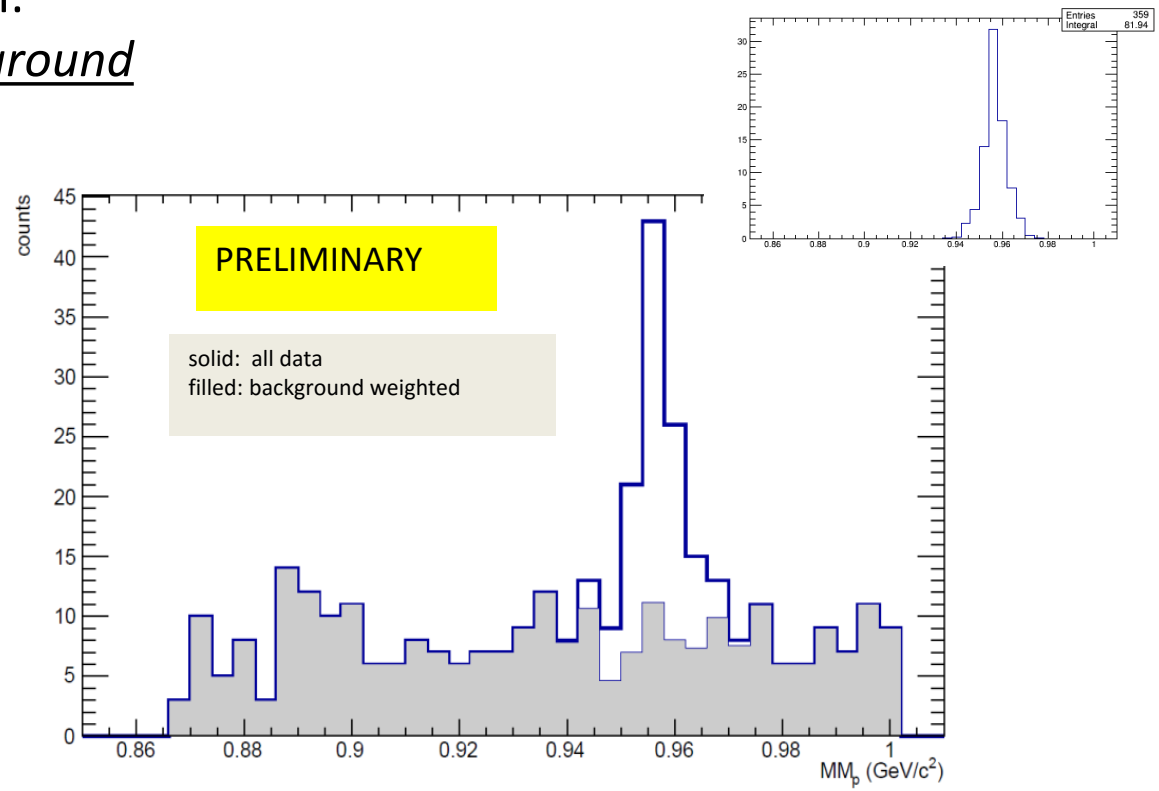
pp reactions:

- either or both protons can be excited
- multi pion background



$\eta' \to \gamma ee$: cut-based analysis

- CLAS g12 experiment
- data analysis: g12 procedures
- q-factor signal extraction:
  evaluate <u>smooth background</u>
  event-by-event

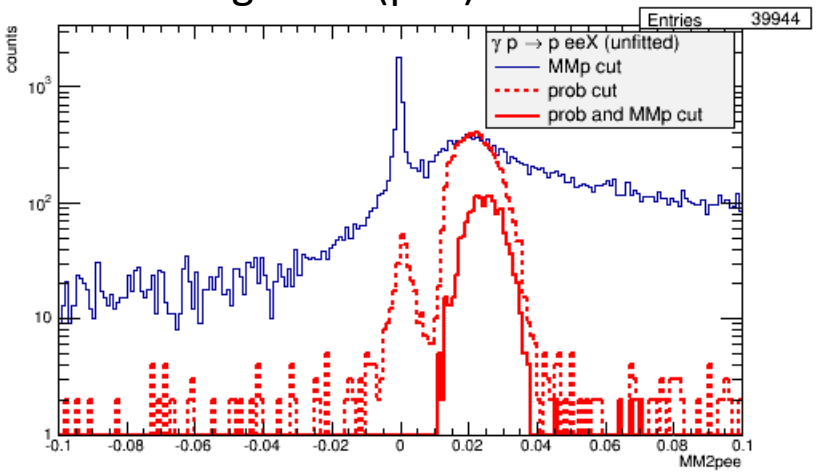


- ➢ 359 event candidates
- ➢ **82 events (signal weight)**

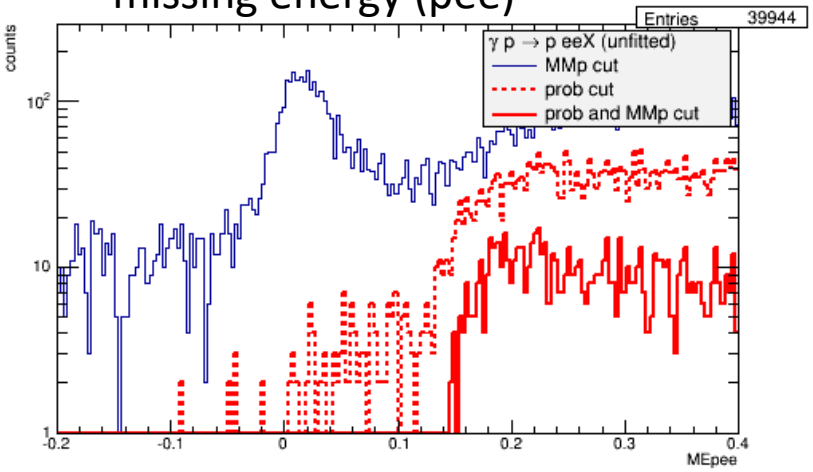
not competitive
more statistics with CLAS12 experiments

towards the ω-π transition form factor

missing mass (pee)



missing energy (pee)



kinematic fit for CLAS g12 dileptons

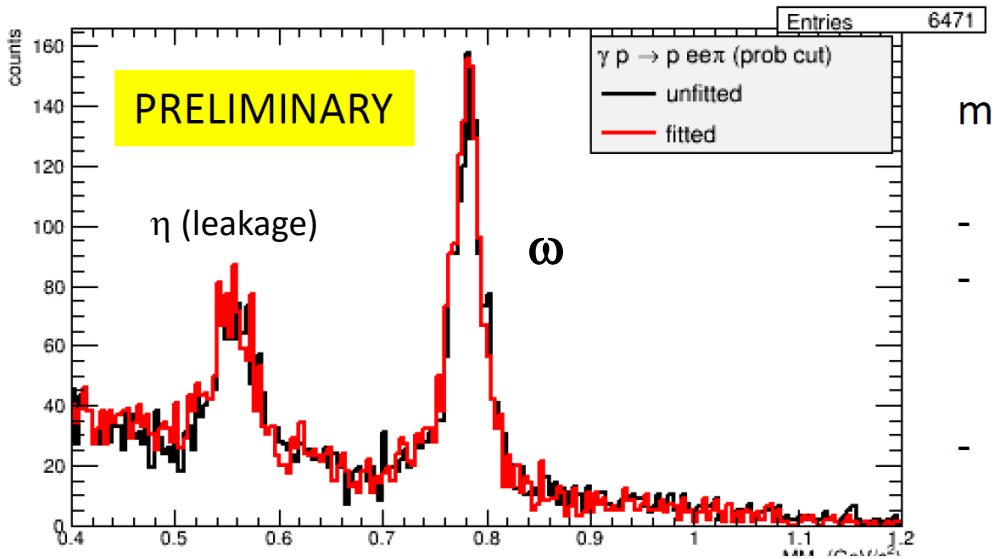
analysis strategy:
e+e- detection
and missing particle

missing pion: **ω→πee**
- missing mass is pion mass
- missing energy

missing photon: **η(´)→γee**
- missing mass zero
- missing energy

missing nothing: **ρ/ω→ee**
- missing mass and nergy zero

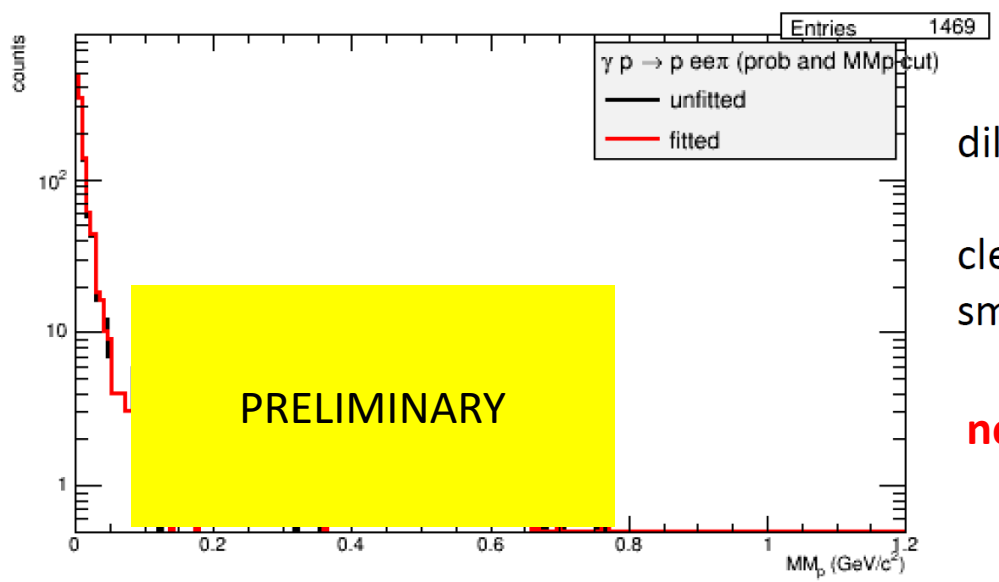
towards the ω-π transition form factor



missing mass (p)

- smooth background
- in-peak background:
  competing decays
  photon external conversion
- peaking background?

not background subtracted
not acceptance corrected



dilepton mass

clearly dominated by background
small masses: external conversion

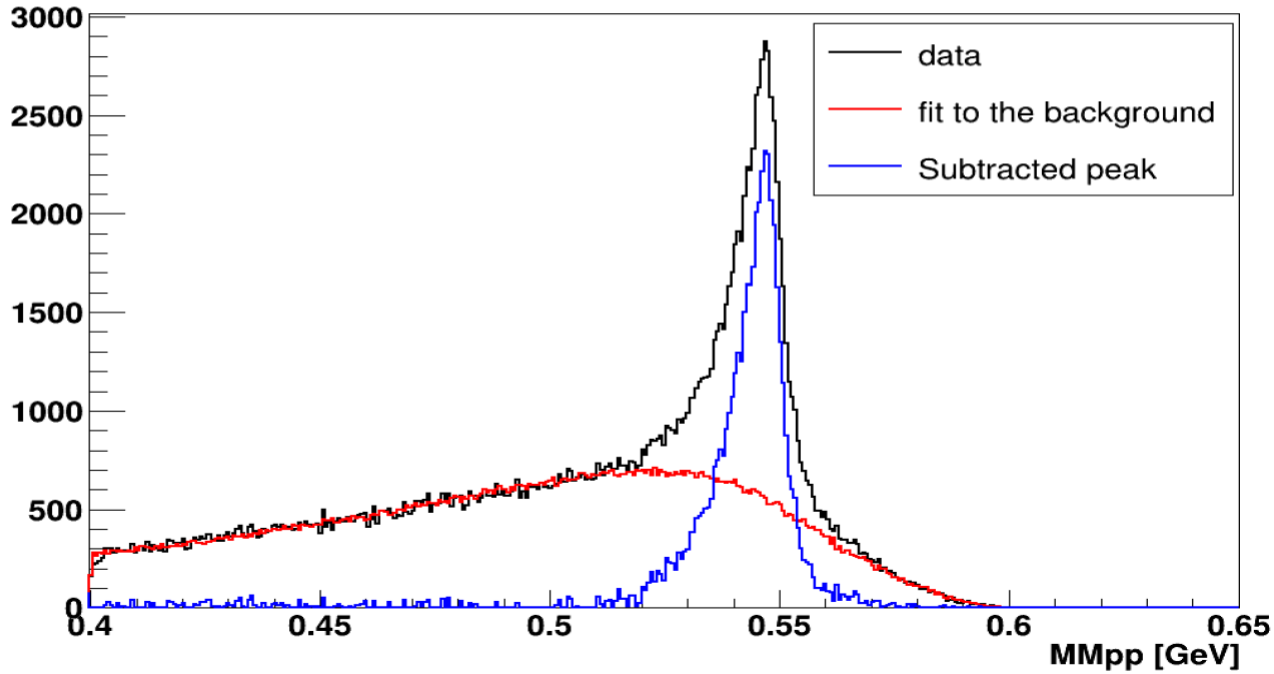
next step: background study

cut-based analysis: $\eta \rightarrow \gamma ee$

- **Number of $\eta \rightarrow \gamma e^+e^-$: 43946.8±281.194** **preliminary, from this fit**

WASA-at-COSY 2010 1.4 GeV pp run

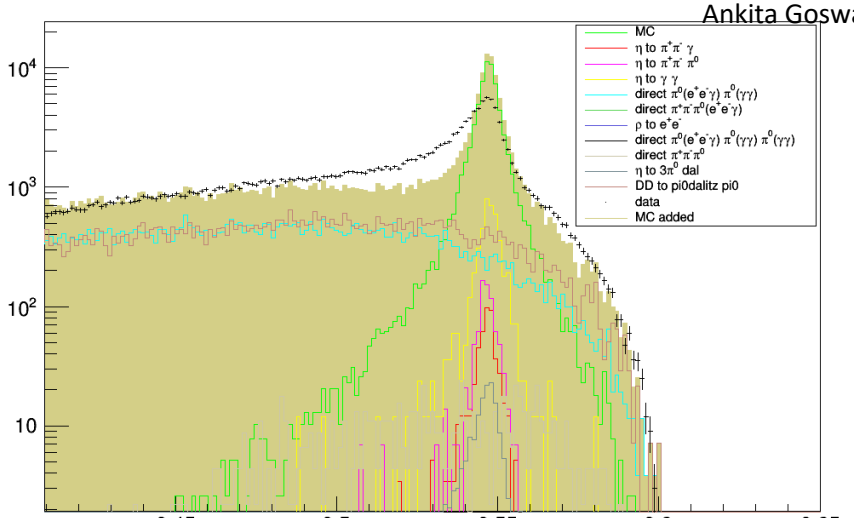
Ankita Goswami



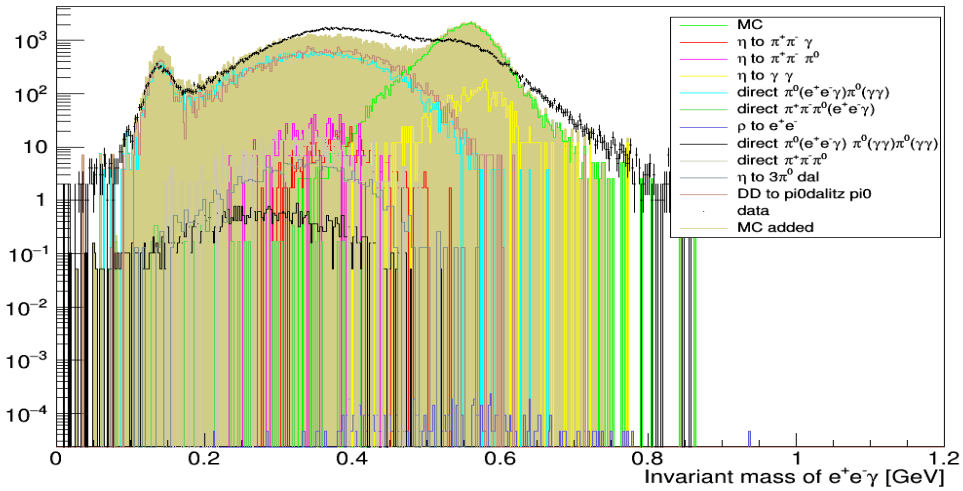
- usual method: multipion phase space * polynomial fit to background (excluding peak)
- **background subtraction method good for dilepton analysis?**

cut-based analysis: η→γee

Ankita Goswami



preliminary and not acceptance corrected



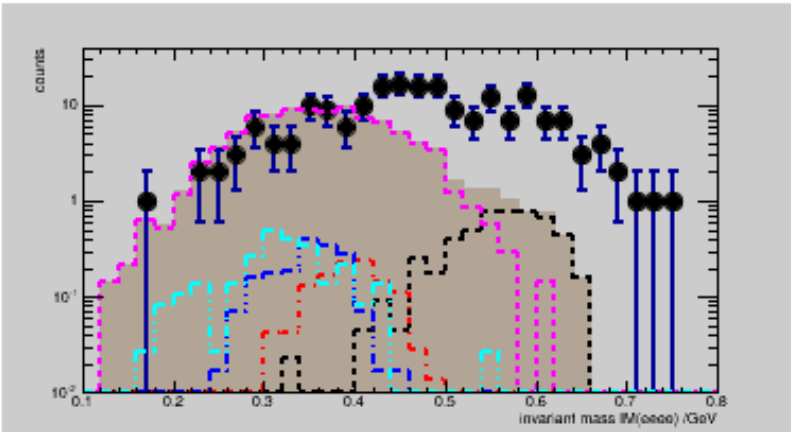
background study

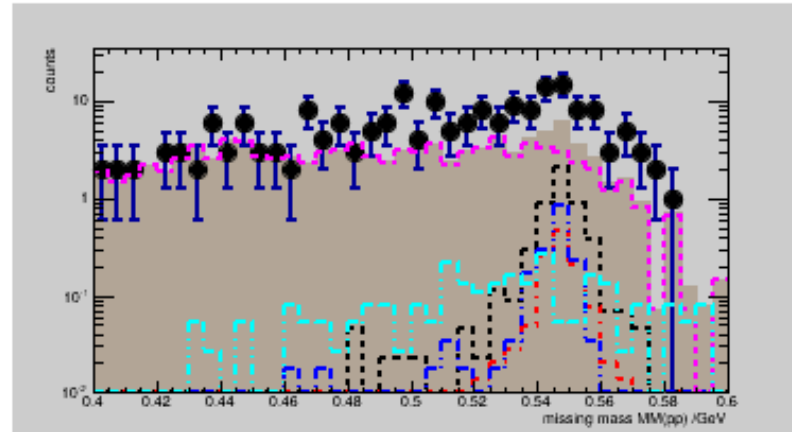
- direct (not from ηdecays)
- competing decays
- mostly phase space simulations (for now)
- for WASA, has to include charged pion pairs
- seen even better in invariant mass of decay particles
- needs improvement
- helps with sys errors

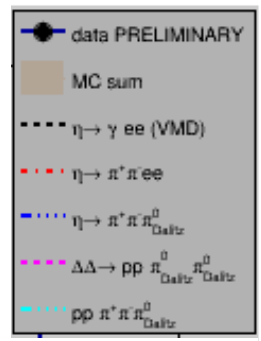
very promising and high statsitics

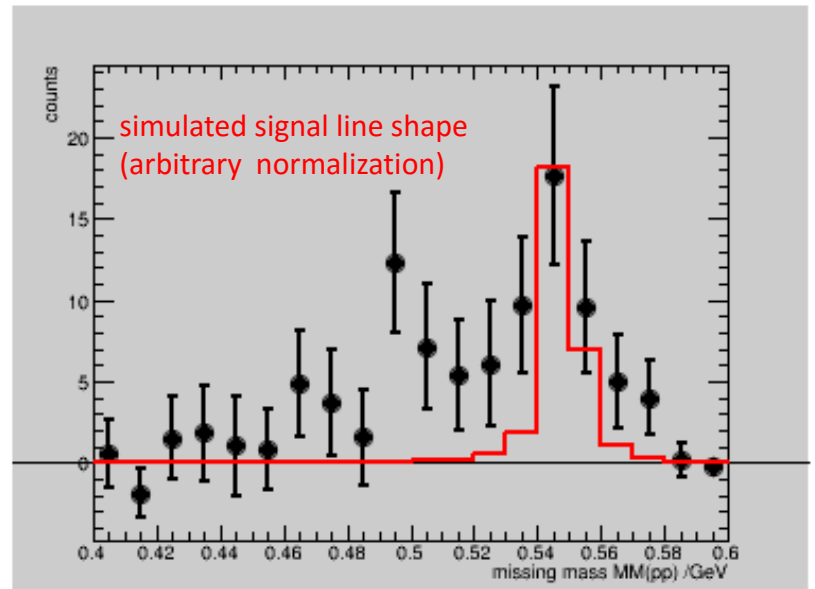
reaching for the double Dalitz decay

ppη 2010 | $\eta \to e^+e^-e^+e^-$ | cut-based analysis: background study









- WASA-at-COSY standard analysis
- preliminary and not acceptance corrected.
- **consistency-check :** yield consistent with our preliminary single Dalitz decay analysis

goal: evaluate branching ratio

latest WASA result: nucl-ex/1509.06588
BR = $(3.2 \pm 0.9_{stat} \pm 0.5_{sys}) \times 10^{-5}$

Summary

chasing conversion decays of light mesons

- WASA-at-COSY:
  - η meson decays
- CLAS g12 experiment
  - η and ω decays
- CLAS12 campaigns:
  - η' and Φ decays?

tough competition

physics landscape needs the results