Status report: Reconstruction of the hybrid candidate $\widetilde{\eta}_{c1}$ with PandaRoot

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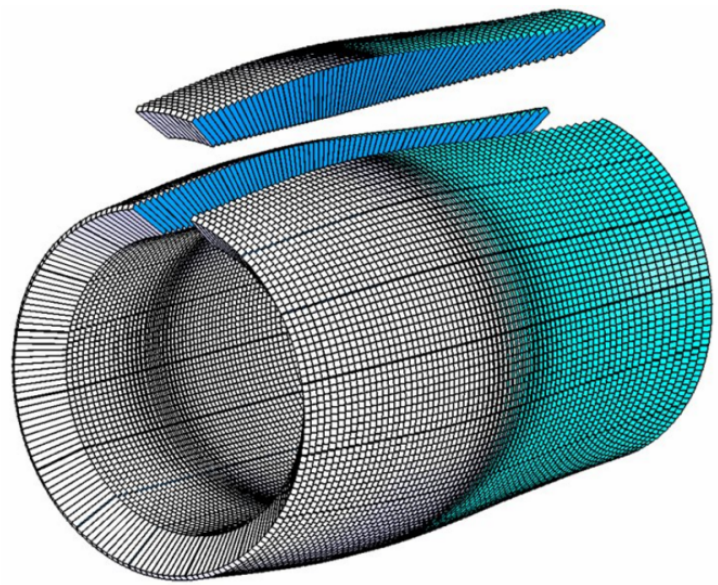
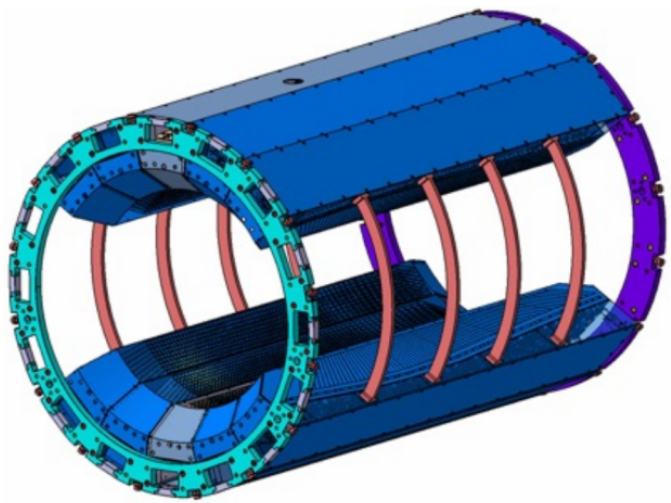
PANDA Collaboration meeting

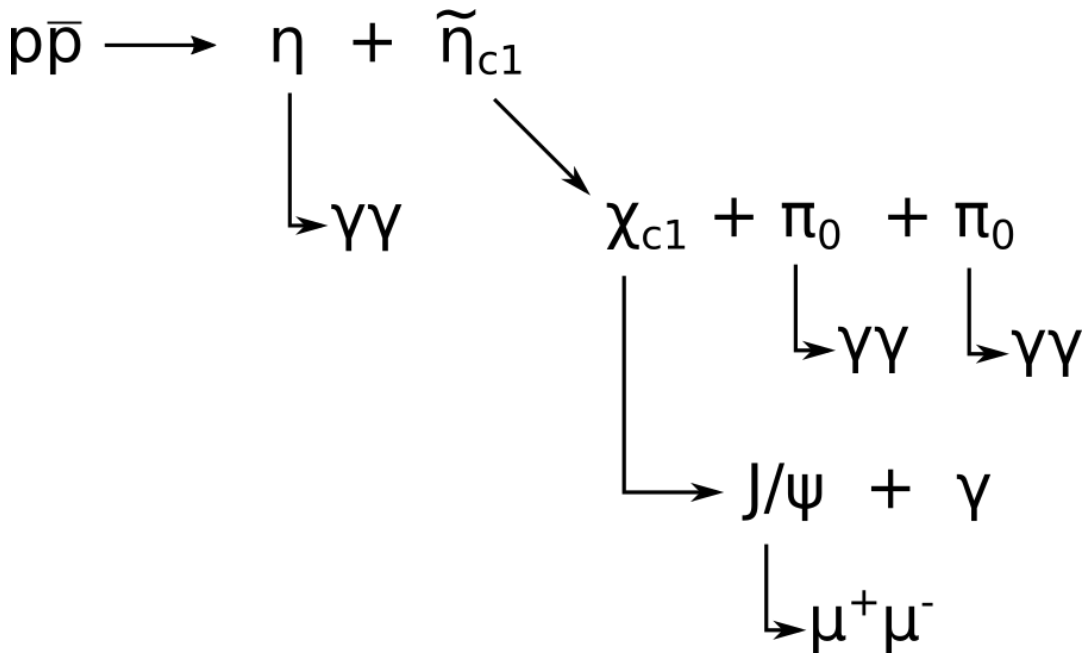
Introduction

- PANDA Phase 0 possibly with reduced EMC
- Which crystals are the least important?





The decay channel

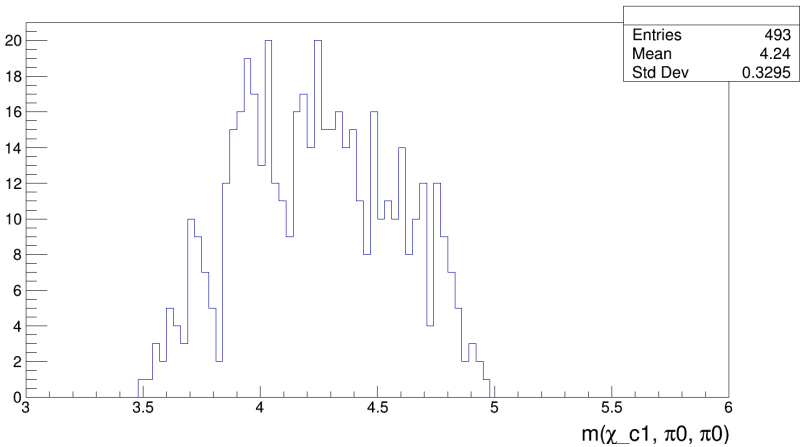


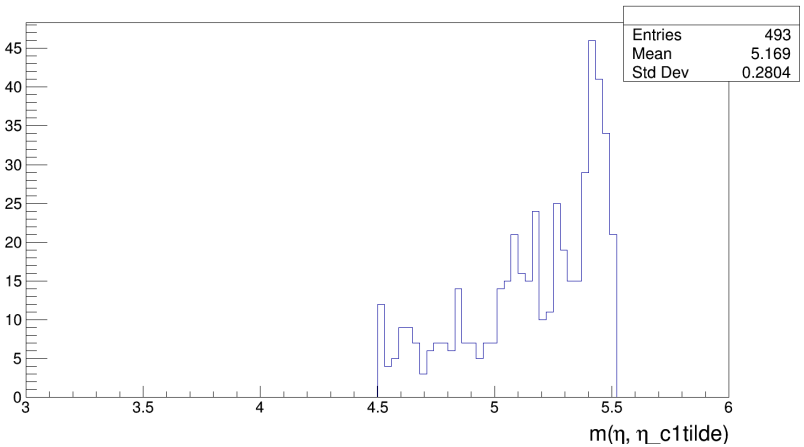
- Proposed measurement in the physics book (sec. 4.2.3.1)
- Predictions: $m = 4.3\,\mathrm{GeV/c^2}$, $J^{PC} = 1^{-+}$, $\sigma = 33\,\mathrm{pb}$

Reconstruction

- Simulate 20k events, phase-space only (except J/ψ, here VLL) at $\sqrt{s} = 5.5\,\text{GeV}$
- Reconstruction works in principle
  - Gamma energy threshold
  - Mass selections (window-cut) for all particles involved
  - Mass constraint fits on π^0, J/ψ, χ_{c1}, η
  - 4 constraint fit on $p\bar{p}$ with masses of fitted particles locked
  - Select best candidate based on χ^2 of 4cf

Reconstruction

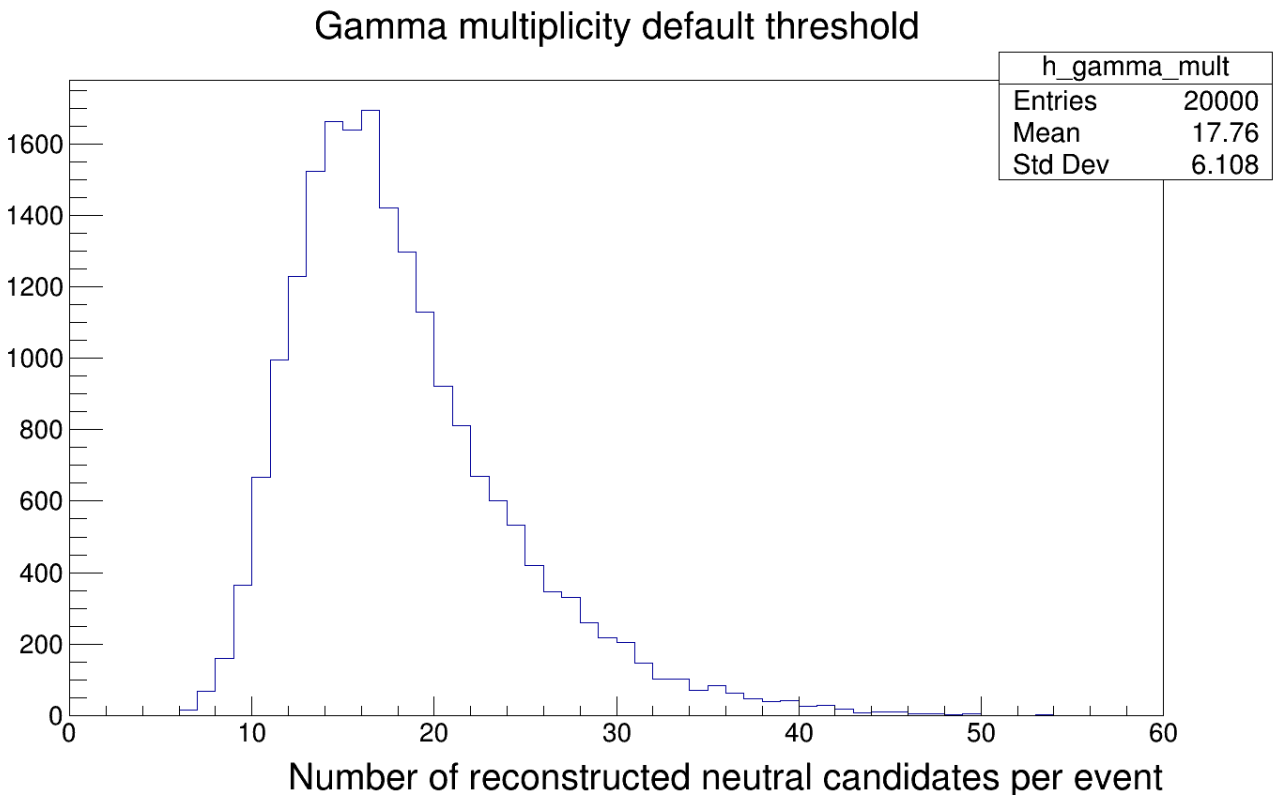




- Number of reconstructed particles and peak shapes vary strongly with applied cuts
- Without best candidate selection: Huge multiplicity within one event

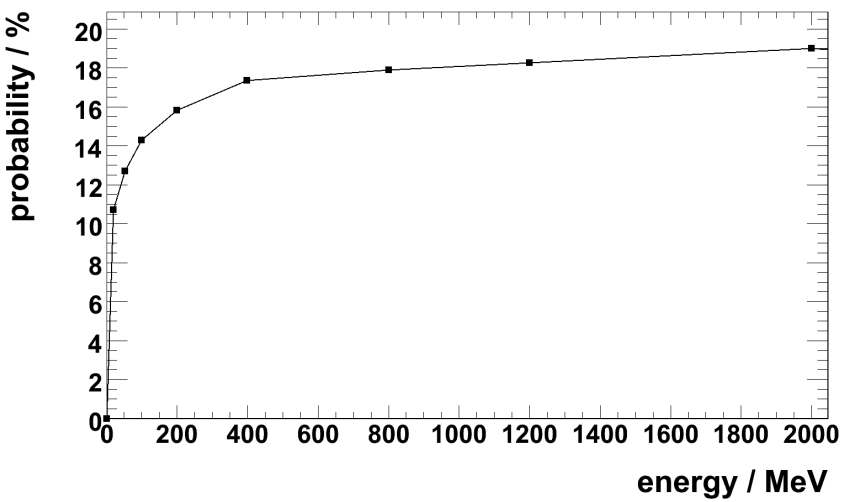
Neutral candidate multiplicity

- Origin of huge multiplicity: Number of reconstructed neutral candidates way higher than seven



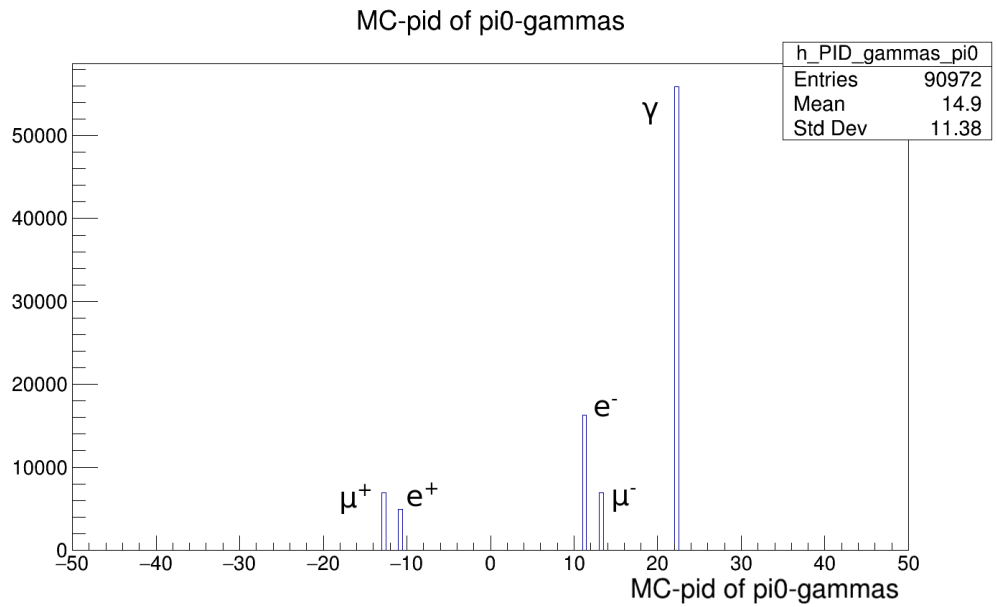
Multiplicity of neutral candidates

- High multiplicity stems from split-off and conversion
- E.g. GEANT simulated conversion in DIRC: probability for no pair production $0.8^7 = 21\%$



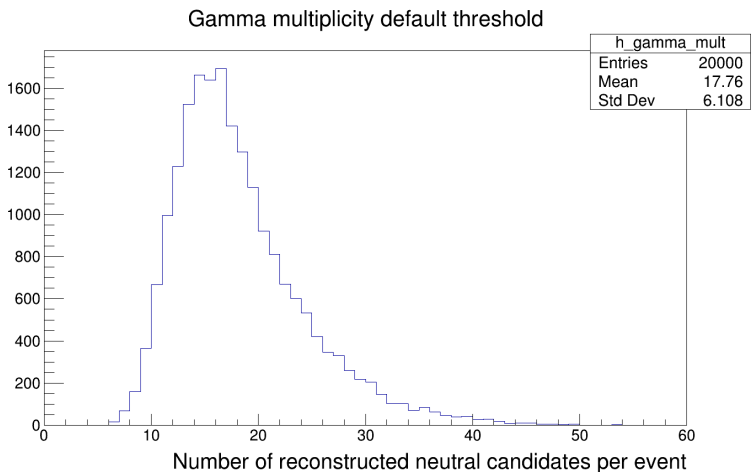
Multiplicity of neutral candidates

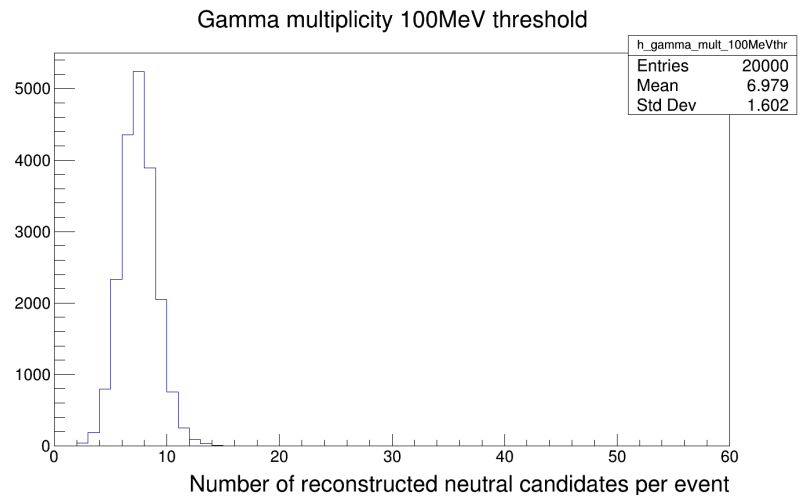
- Check the ID of the reconstructed neutral candidates (Monte Carlo numbering scheme)
  → Electrons from conversion
  → Muons falsely identified as gammas?



Multiplicity of neutral candidates

- Gamma multiplicity can be somewhat controlled by setting an energy threshold (default: 3 MeV)
- Loss in efficiency?





MC-truth matching

- Reconstruction efficiency hard to quantify since simple Monte-Carlo truth matching is not possible
- Reconstruction efficiency for a true muon pair: 44%
- 'Base efficiency' = exactly seven true gammas and at least one true muon pair: 1.6%

Optimization of parameters

- Possible parameters to change during analysis: Gamma energy threshold, mass selection (window-cuts), χ^2-cut after fits, ...
- Aim is to maximize the statistical significance
- Rough estimator for signal s and background b: $\frac{s}{\sqrt{s+b}}$
- Optimization problem: Maximize the significance which is a function of many parameters
  $\rightarrow$ Genetic algorithm

Genetic algorithm

- Idea is to use evolution as analogy: Mutation and selection
- A certain generation G has a certain number of individuals I
- Each individual represents a set of parameters with corresponding fitness (here significance)
- New individuals are created by mixing parameters from individuals of the old generation
- Additionally establish a certain probability for a parameter to change (mutation)
- Best individuals survive, worst individuals are killed

$\rightarrow$ Eventually the best set of parameters is found

Genetic algorithm

Advantages:

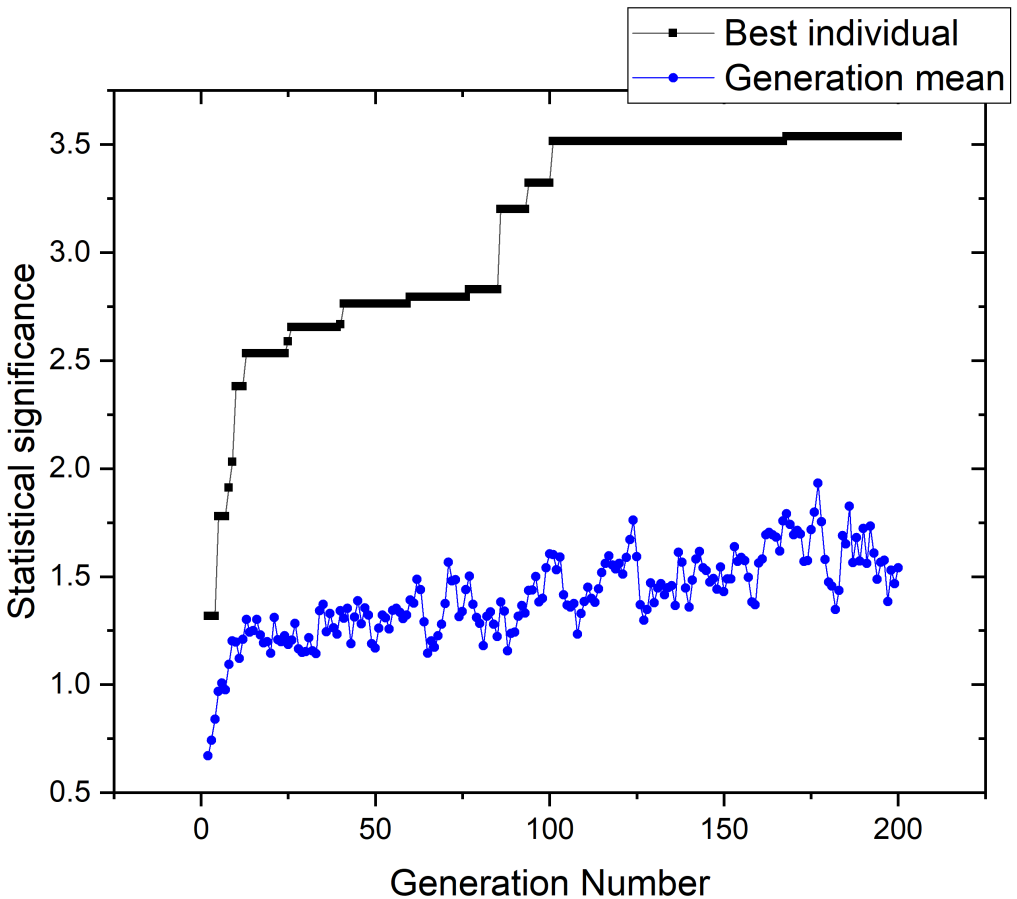
- No gradient needed
- Data type of parameters can be anything
- With extinction of the weakest not prone to run into local maxima

Disadvantages:

- Rather slow
- Performance depends on parameters of the algorithm itself

Genetic algorithm

- Use combinatorical background as toymodel: The first $p\bar{p}$ is interpreted as signal, every additional one as background



Background channels

- Light hadronic background:

$\pi^+\pi^+\pi^-\pi^-\pi^0\pi^0\pi^0\pi^0$	880 µb
$\pi^+\pi^+\pi^-\pi^-\pi^0\pi^0\pi^0\pi^0\pi^0$	287 µb
$\pi^+\pi^-\pi^0\pi^0\pi^0\pi^0\pi^0$	327 µb
	$\Sigma = 1.5$ mb

- Reminder: Estimate of $\sigma = 33$ pb!
- Other channels with charm will follow (from physics book):

$\chi_{c0}\,\pi^0\,\pi^0\,\eta$, $\chi_{c1}\,\pi^0\,\eta\,\eta$, $\chi_{c1}\,\pi^0\,\pi^0\,\pi^0\,\eta$, $J/\psi\,\pi^0\,\pi^0\,\pi^0\,\eta$

Outlook

- Currently: Collecting background data for the light hadronic channels
- Divide reconstruction into two distinct steps:
  1) Make the decision if the event was an $\widetilde{\eta}_{c1}$ as good as possible with respect to α- and β-error
  2) Reconstruct proper peak shapes
- In parallel shower algorithm is being reworked by Áron Kripkó

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Thank you for your attention!
Questions, comments, suggestions, ... ?

Details genetic algorithm

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- One generation = 40 individuals
- Mutation rate: 1/3 in negative direction, 1/3 in positive direction, 1/3 no mutation
- Mutation change: According to γ-distribution with $\alpha = 3.0$, $\beta = 3.0$