Electromagentic decay of hyperons at FAIR Phase-0

Update and background studies

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Motivation:

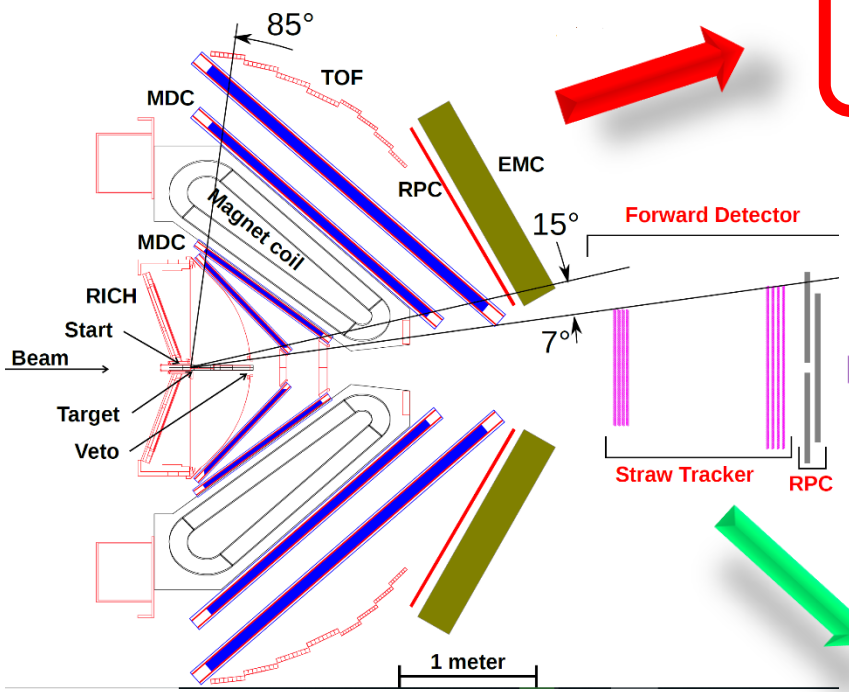
- *The electromagnetic (EM) decay* of bayrons provides a detailed information on their *underlying structure*.
- Clean probe of baryon wave functions.
- Measuring radiative decays provides a means of *discriminating* between *theoretical models*.
- In addition the *hyperon reconstruction* will benefit from the proposed *Forward Detector* that extends HADES acceptance to forward direction.

Model	$\Sigma(1385) \to \Lambda\gamma$	$\Lambda(1405) \to \Lambda\gamma$	$\Lambda(1520) \to \Lambda\gamma$
NRQM	263	200	156
RCQM	267	118	215
MIT Bag	152	60	46
Algebraic model	221	117	85
HBχPT	290-470	-	-
Experiment	$479 \pm 120^{+81}_{-100}$	-	$176 \pm 43^{+26}_{-12}$

Radiative decays of the $\Sigma(1385)$ and $\Lambda(1520)$ hyperons, CLAS Collaboration Phys. Rev. C 2005

HADES Upgrade and the Forward Detector (FD):

FAIR Phase-0 upgrade



Electro Magnetic Calorimeter (EMC). It will provide energy information for leptons and photons

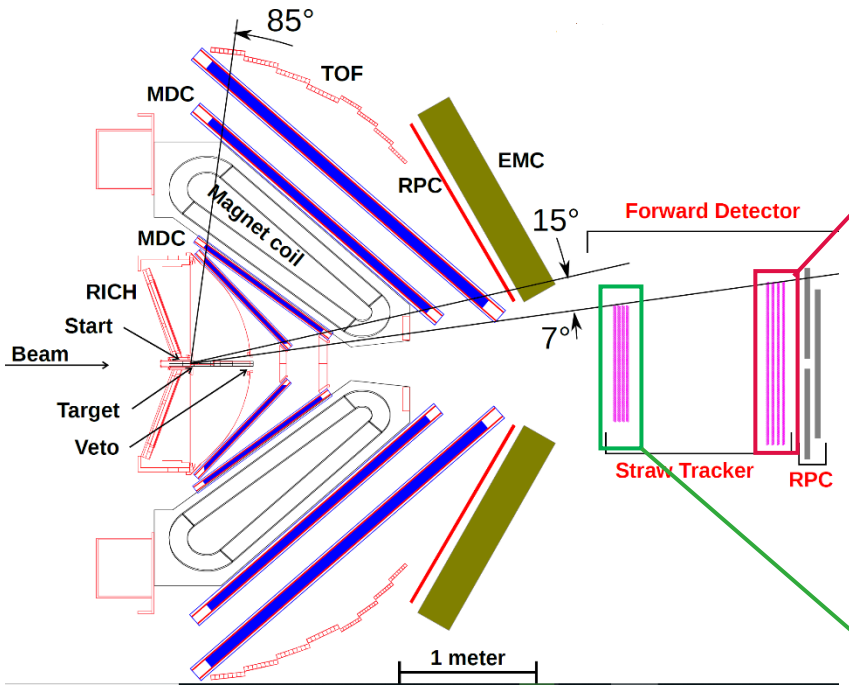
Resistive Plate Chambers (RPC). Provides information on time of flight (TOF)

Straw Tracking Stations. **Based on PANDA straw tubes.**
Eight double layers 90, 0, 0, 90, and 0, 90, +45, -45

In addition:
- **RICH Upgrade (Improve e+e- eff.).**
- **DAQ.**

HADES Upgrade and the Forward Detector (FD):

FAIR Phase-0 upgrade



STS2 Installed in cave

STS1 transport to GSI in April

Event Simulation :

Signal Simulation:

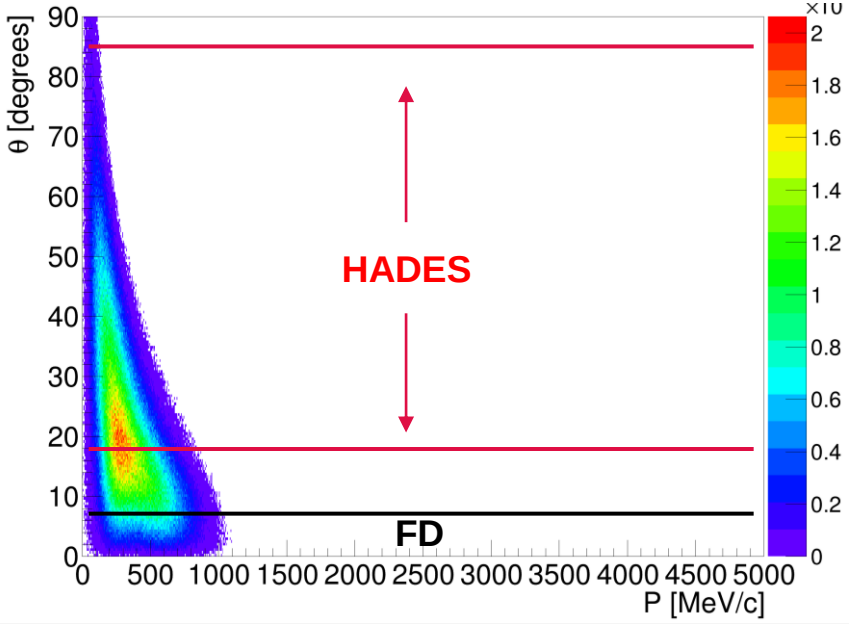
- Production of Y^*, $(\Sigma(1385), \Lambda(1405), \Lambda(1520))$ (Pluto event generator) :

$$p(4.5\text{GeV})p \rightarrow pK^+Y$$

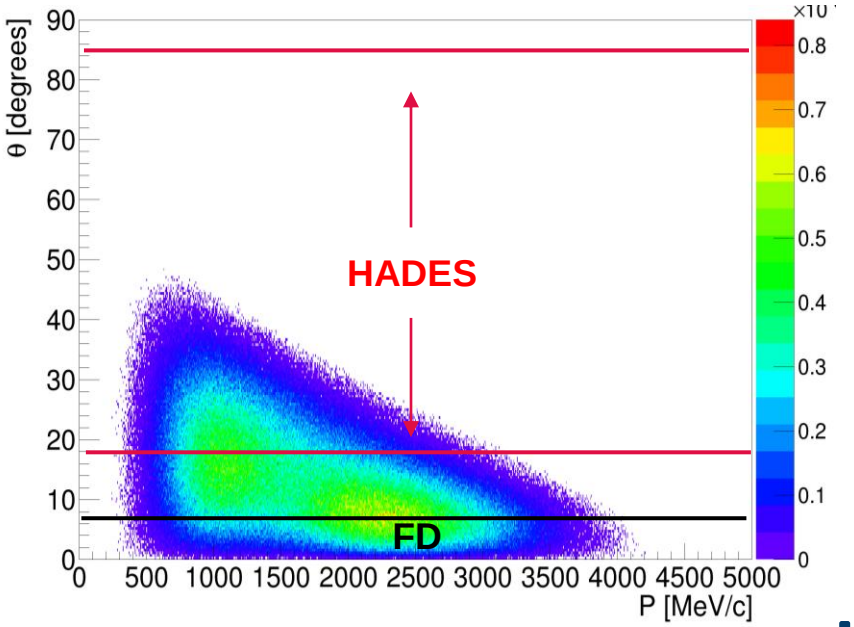
$$Y \rightarrow \gamma\Lambda$$

Γ_1	$p\pi^-$	$(63.9 \pm 0.5)\%$
Γ_2	$n\pi^0$	$(35.8 \pm 0.5)\%$

$\Lambda \rightarrow p\pi^-$



$\Lambda \rightarrow p\pi^-$



Event Simulation :

Background Simulation:

- Thanks to **Rafał Lalik** for background channel simulations**.**
- Cross sections are estimated from literature using a phase space parameterization**.**

- Event weight according to

$$w = \frac{\sigma \mathcal{L}_{integrated}}{N_{MC}}$$

$$\mathcal{L}_{integrated} = \int \mathcal{L}_{ins}\, dt$$

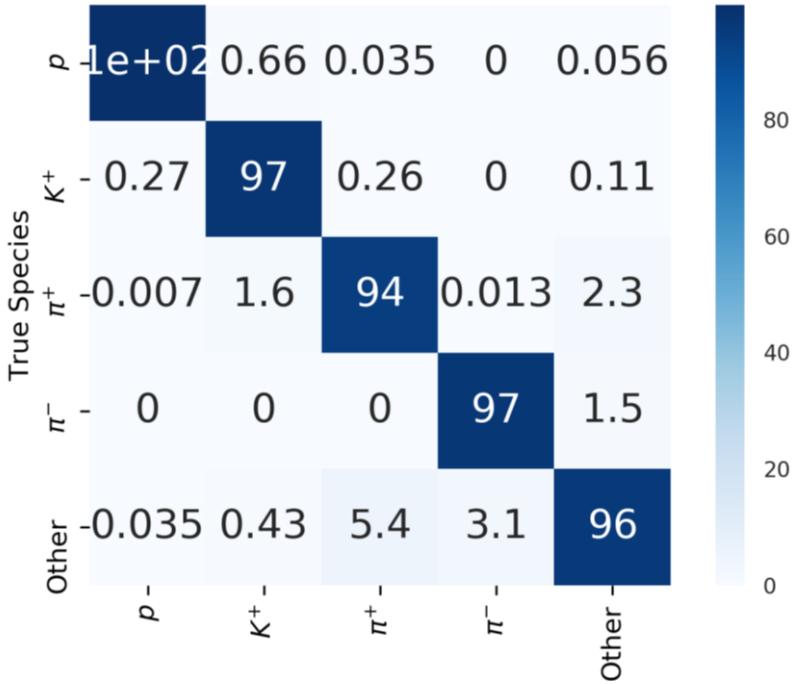
$$\mathcal{L}_{ins} = 0.2\ \mu b^{-1} s^{-1}$$

Channel	$\sigma(\mu b)$
$pp \rightarrow pp\,\pi^+\pi^-\pi^0$	1840
$pp \rightarrow p\,K^+\Lambda$	54.4
$pp \rightarrow p\,K^+\Lambda\pi^0$	43
$pp \rightarrow p\,K^+\Sigma^0\pi^0$	35
$pp \rightarrow p\,K^+\Sigma^0$	23.5
$pp \rightarrow p\,K^+\Lambda\pi^+\pi^-$	20
$pp \rightarrow p\,K^+\Sigma^+K_S^0\pi^+\pi^-$	4
$pp \rightarrow p\,K^+\Sigma^0\pi^+\pi^-$	2
…	…

Event Reconstruction:

➢ Charged Particle Identification (PID):

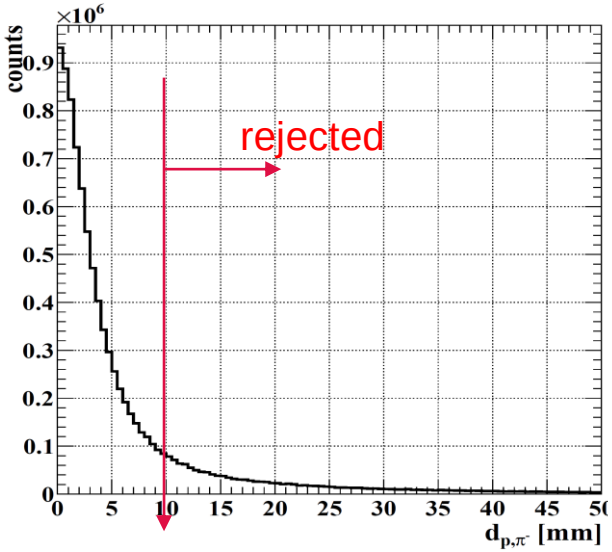
- MVA PID. Neural Network is used to identify particle species
- Input features: momentum, charge, dEdx, velocity
- Output nodes: p, K^+, π^+, π^- and other

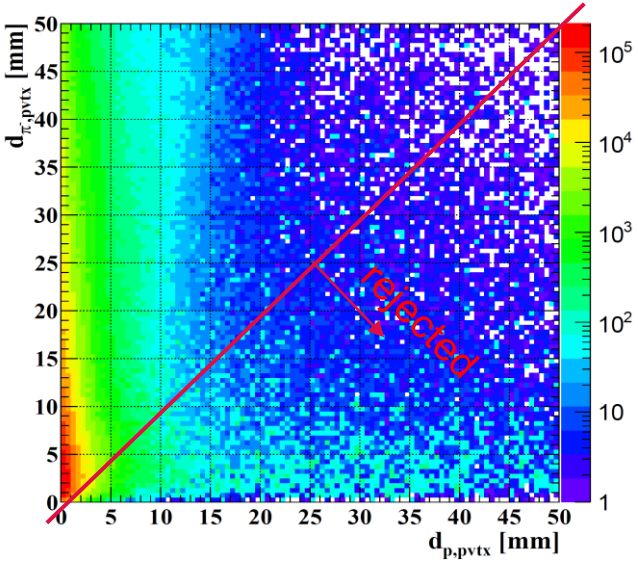


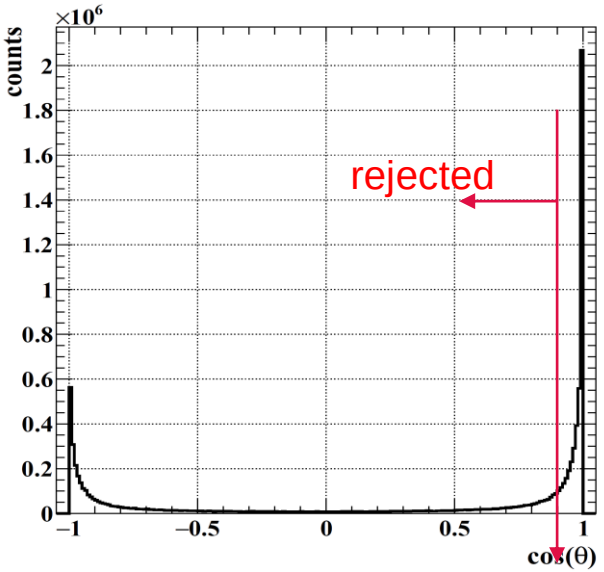
Event Reconstruction:

➢ Lambda Reconstruction at HADES:

At **HADES** Lambdas are reconstructed from daughter particles p and π^-







1. Minimum distance between daughter particles < 10 mm.

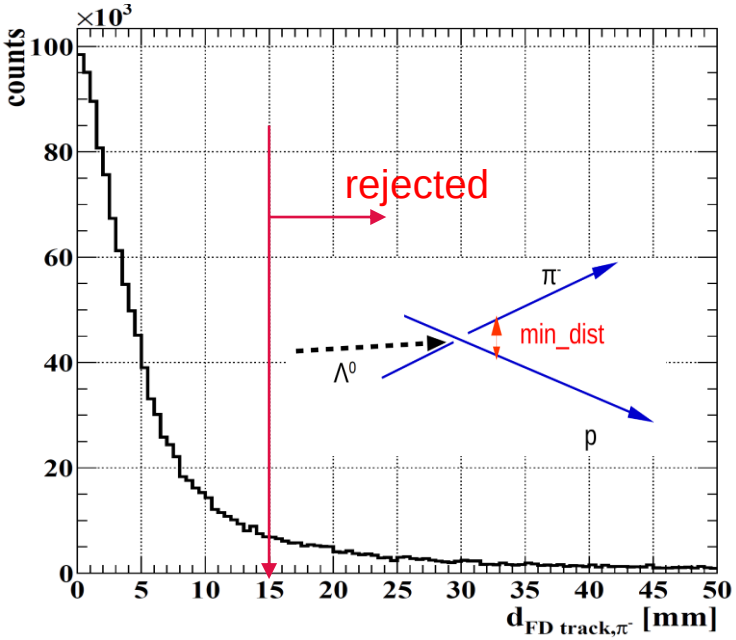
2. distance of proton to the primary vertex < distance of pion to the primary vertex.

3. The angle between the pointing vector and the reconstructed momentum cos(θ)> 0.9.

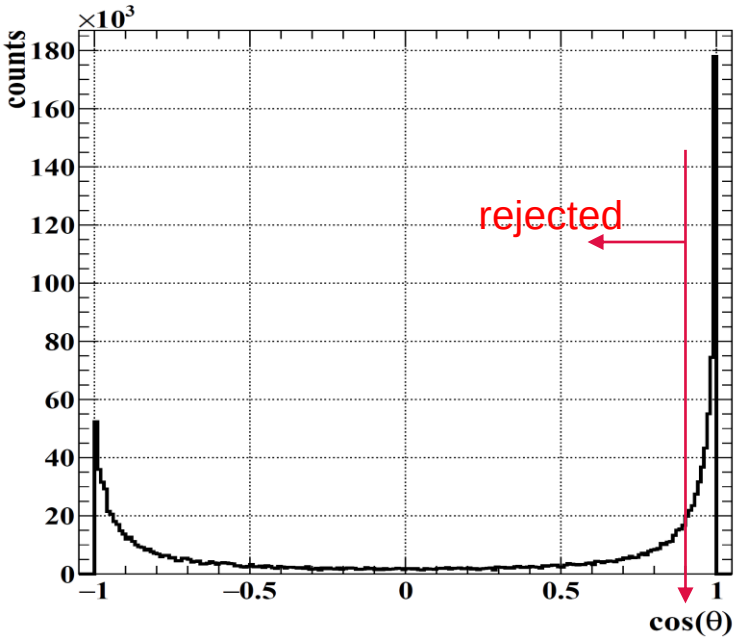
Event Reconstruction:

➢ Lambda Reconstruction at the FD:

- Combine all tracks from the **FD** and π^-candidates from **HADES**.



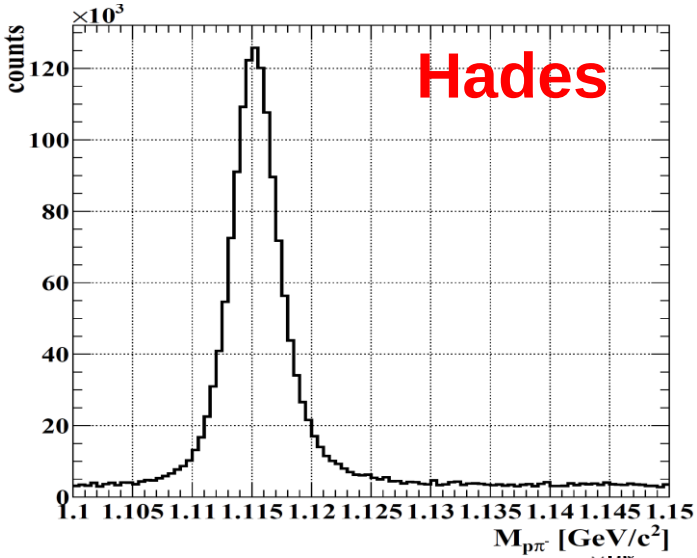
1. Calculate the distance between FD tracks (assumed protons), and π^- from HADES, accept pairs with less than 15 mm.

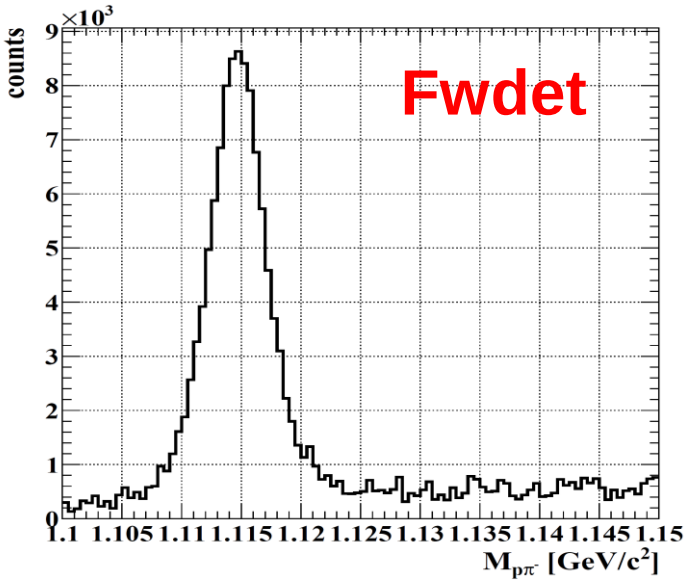


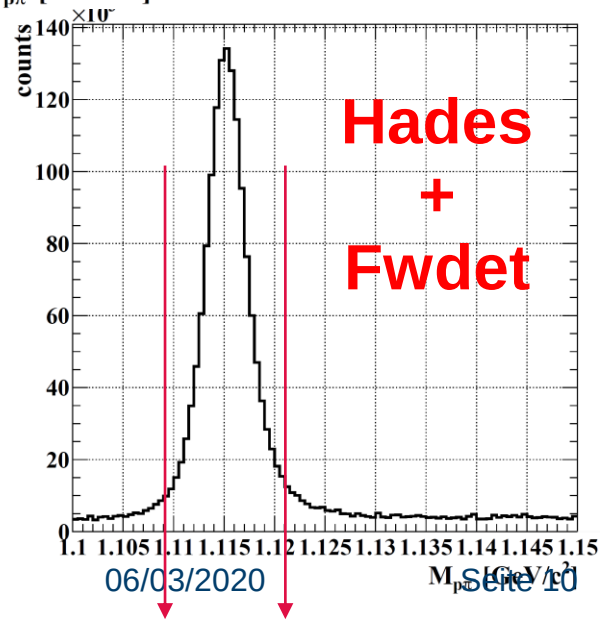
2. The angle between the pointing vector and the reconstructed momentum cos(θ)> 0.9.

Event Reconstruction:

- **Lambdas from HADES and the Fwdet :**

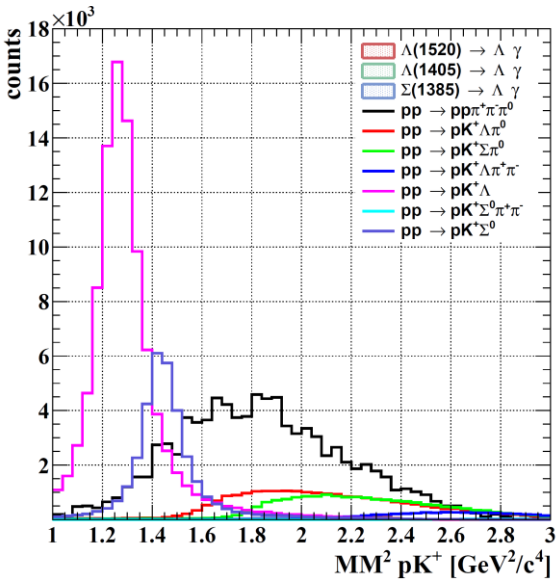


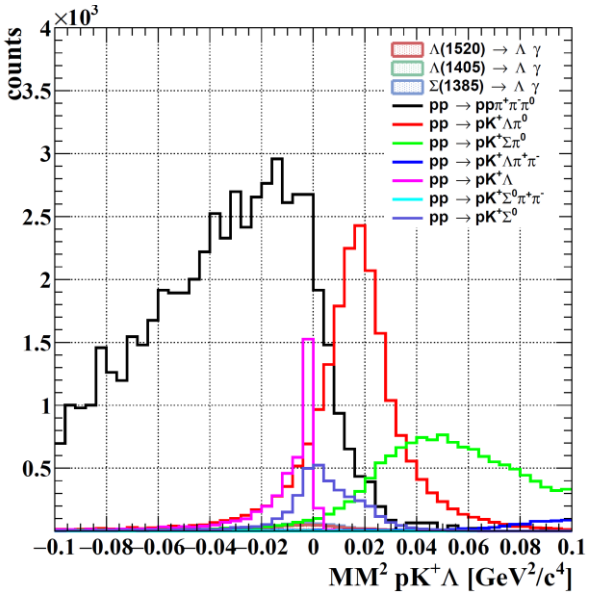


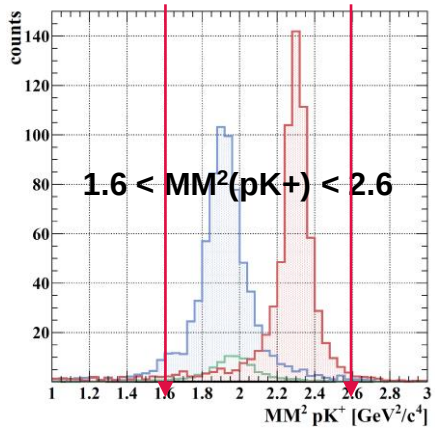


Event Reconstruction:

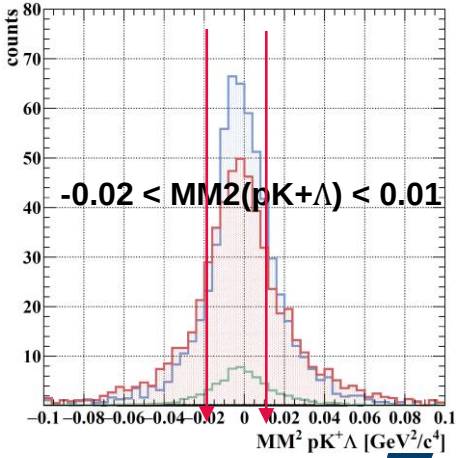
➢ Background Rejection:







ZOOM

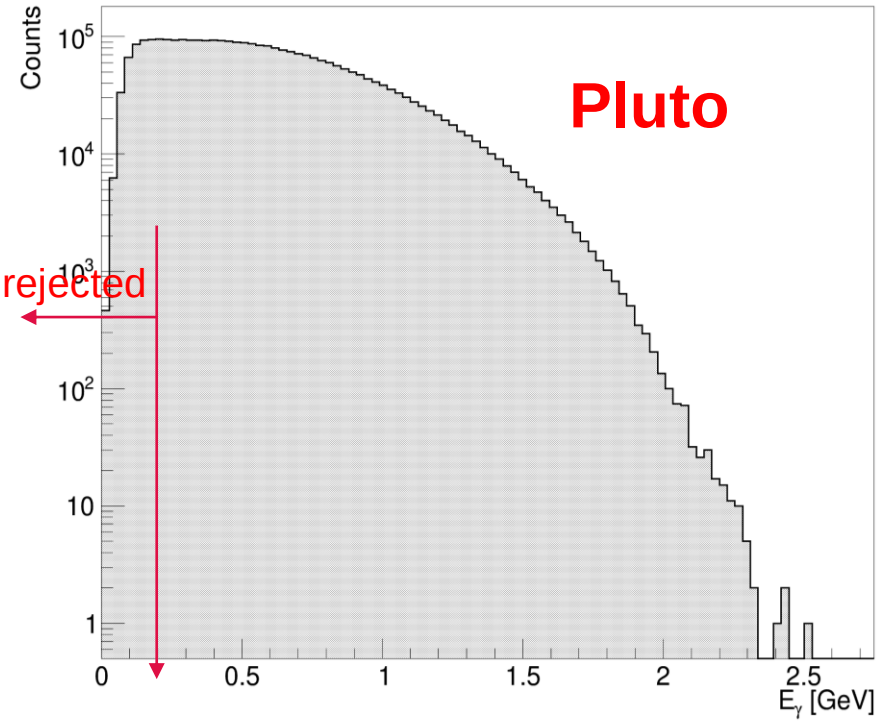


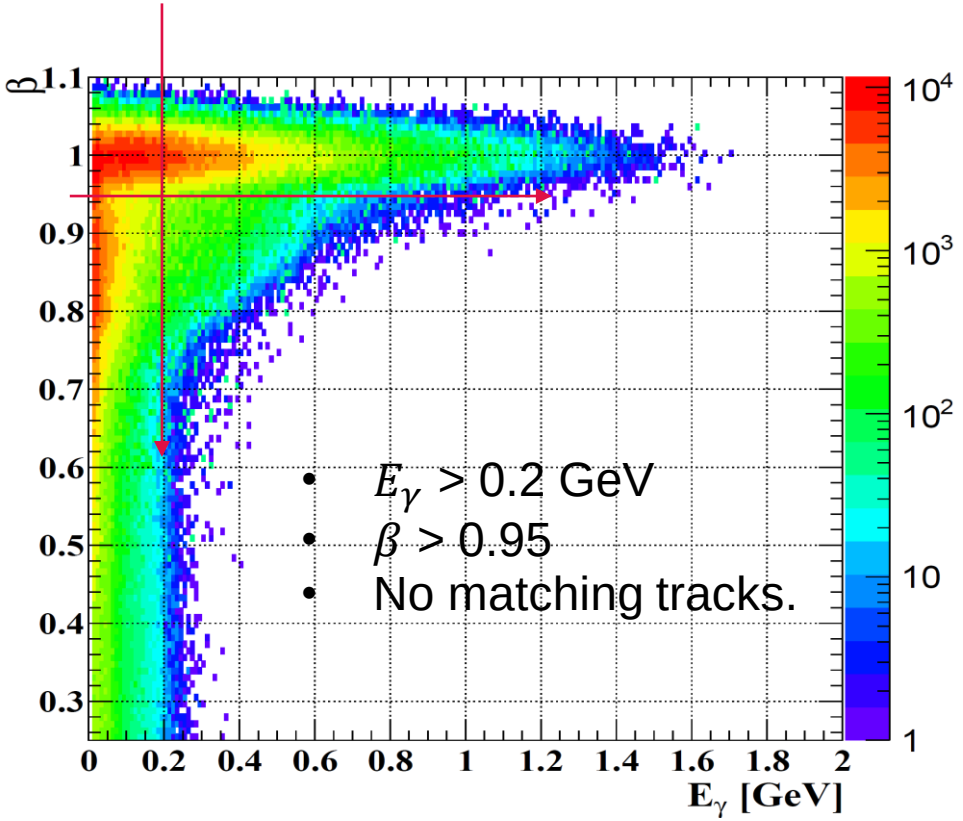
ZOOM

Event Reconstruction:

➢ Photon Identification:

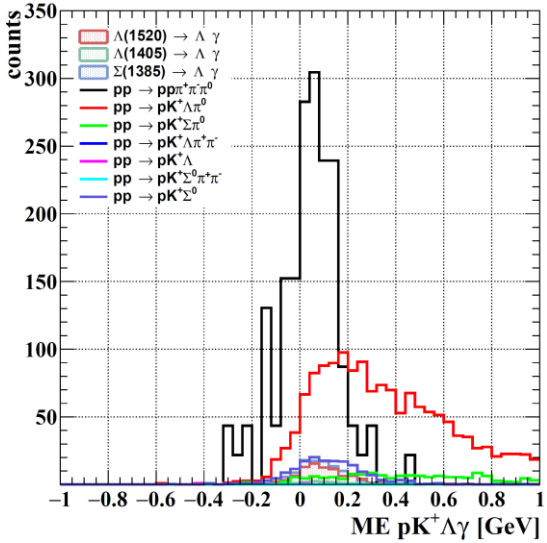
- Photons are identified as energy cluster in the **EMC** with no tracks associated and β close to 1.

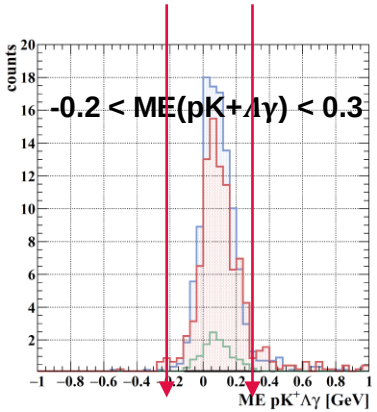




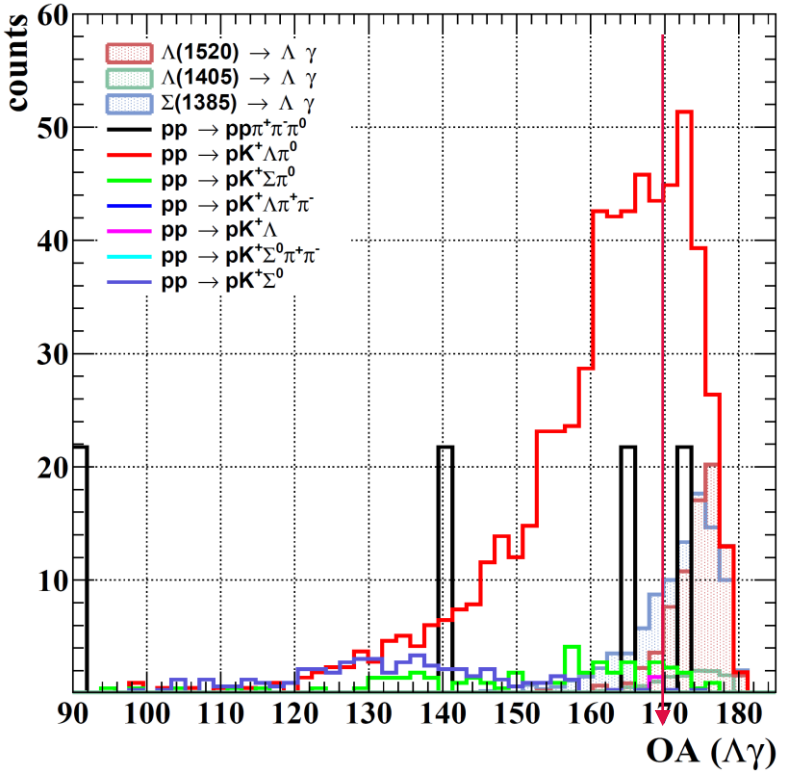
Event Reconstruction:

➢ Background Rejection:





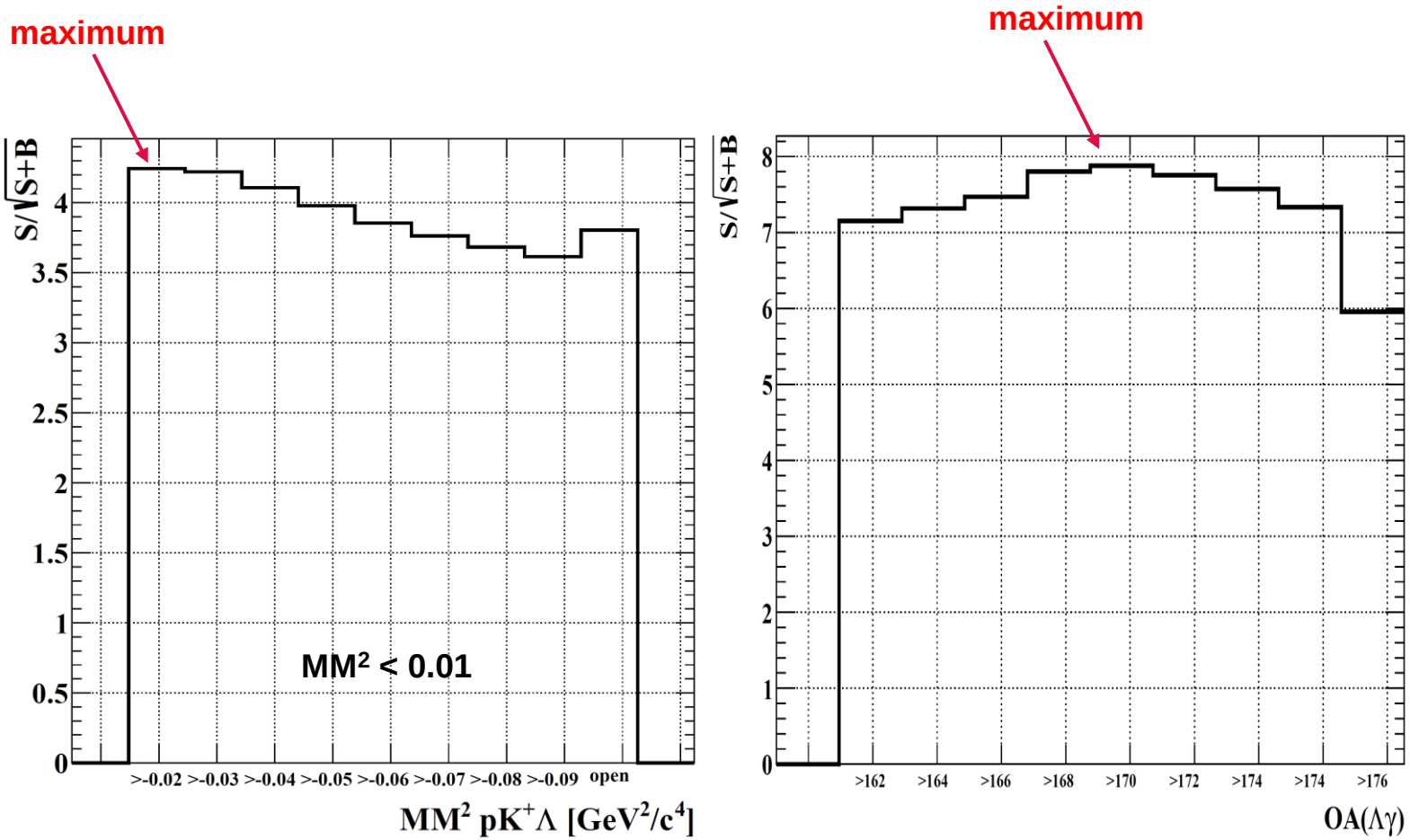
The **Opening Angle** between the **Λ** hyperon and the **γ** in the **pK+ missing particle rest frame**.



Event Reconstruction:

➢ Cut Optimization:

- An example:

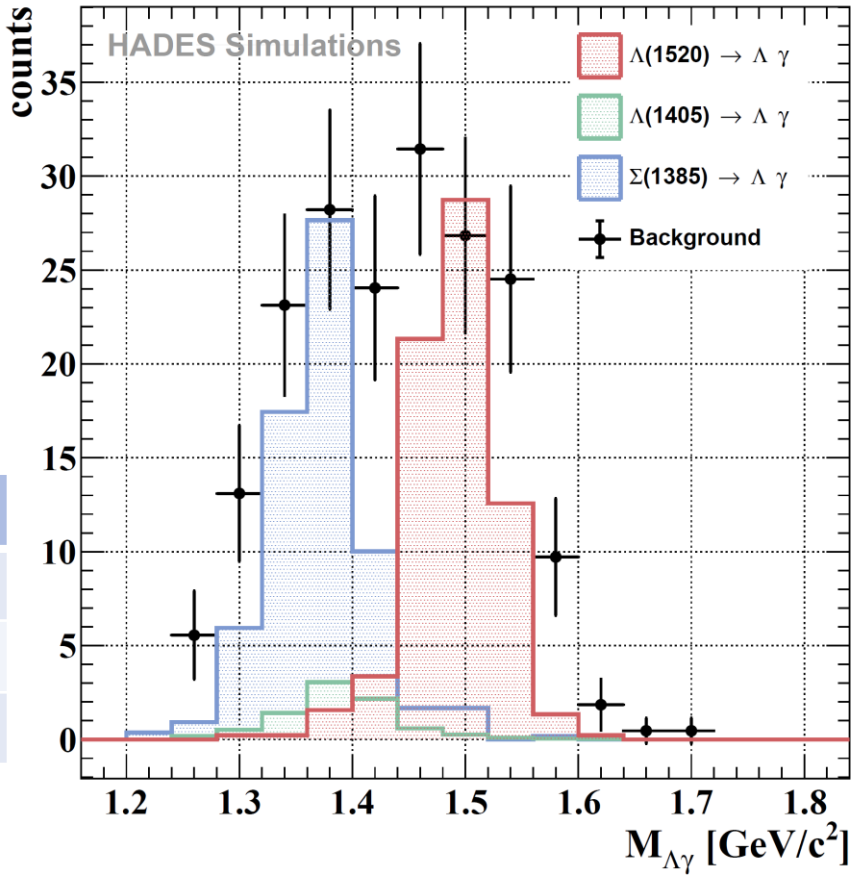


Event Reconstruction:

➢ Y* Reconstruction:

- An estimation of the number of reconstructed hyperons for p(4.5GeV)p, of 28 days of beam time and luminosity $\mathcal{L} = 2 \times 10^{31} cm^2 s^{-1}$ is:

channel	$S/\sqrt{S+B}$	Total events
$pp \rightarrow pK^+\Sigma(1385)$	4.2	4640
$pp \rightarrow pK^+\Lambda(1405)$	0.6	585
$pp \rightarrow pK^+\Lambda(1520)$	4.4	5500



Signal σ estimation: **Feasibility studies of production and electromagnetic decay studies of hyperons for HADES.** *Krzysztof Nowakowski and Joanna Kubos*.

Conclusion and Outlook:

- Physics case study of radiative decays at FAIR Phase-0
- The FD significantly improves the hyperon reconstruction
- Reconstruction efficiency for real γ decay of excited hyperons is very small, however doable
- Background $pK^+\Lambda\pi^o$ is very hard to suppress
- Photon can be identified as missing mass, but the background contribution is irreducible.

- Waiting for new data.

Thank You

Back Up

TRAINING SAMPLES:

- $pp \rightarrow p\ p\ \pi^+\pi^-\pi^0$
- $pp \rightarrow p\ K^+\ \Sigma^0$
- $pp \rightarrow p\ K^+\ \Lambda\ \pi^0$

  ~ 11.000.000 events.

Photon Energy Resolution: