PANDA Software Trigger

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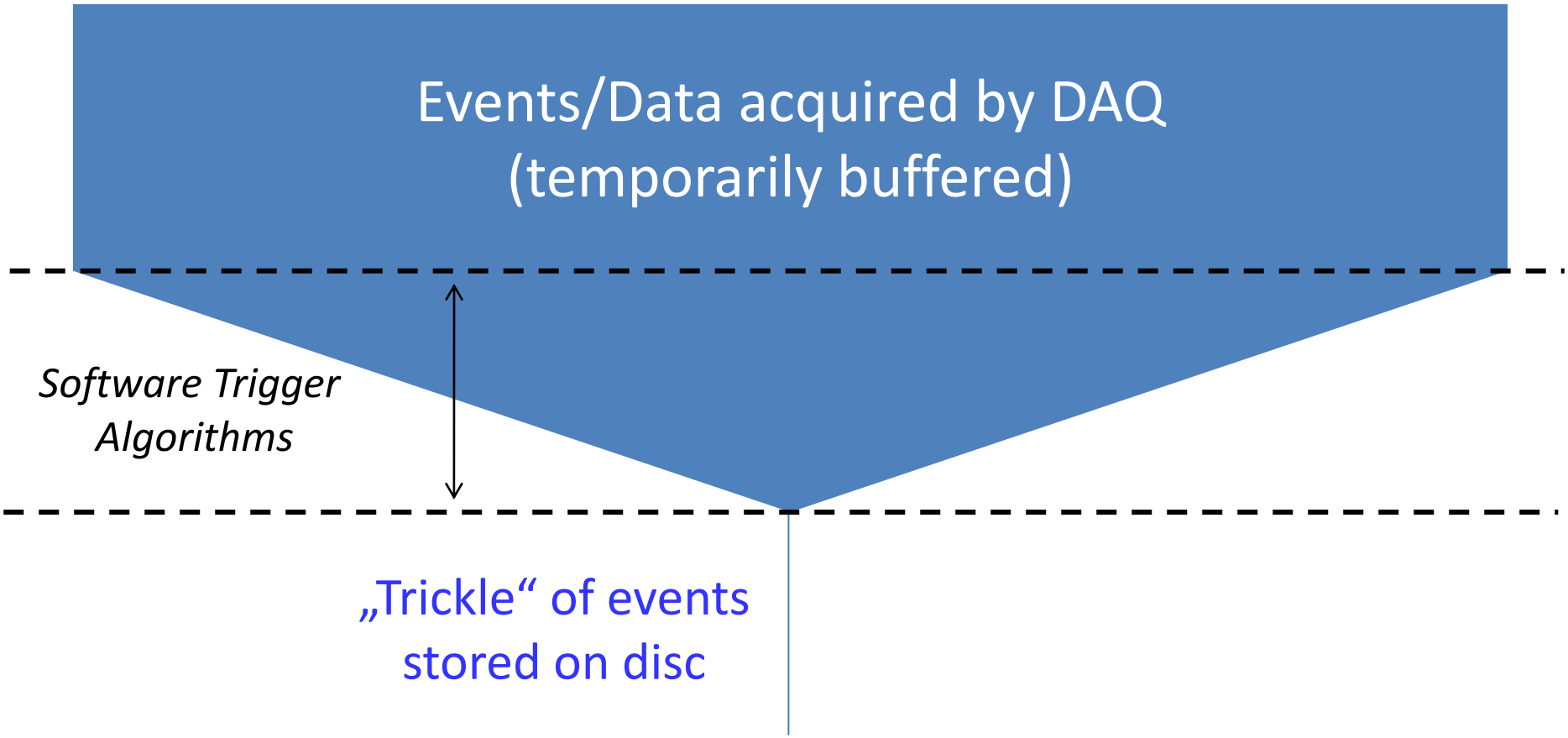
Challenge



- Required reduction factor: ~1/1000 (all triggers in total)
- A lot of physics channel triggers → even higher reduction factor required

Algorithms: Work in progress

- Prerequisites: Tracking, PID, Event building
- For now: Study of algorithms based on
  - Physics Book Channels
  - Charged particles only
  - Combinatorics (inclusive)
  - Invariant masses
  - PID information
- Toy MC and Full MC ⇒ *See Donghee's Talk*
- *Examples with Toy MC from my own studies*

Definition PID Quality

- Asymmetric table, containing
  - selector efficiencies and
  - misID levels; $misID = \frac{\#\ accepted\ wrong\ type\ particles}{\#all\ wrong\ type\ particles}$

Particle Type

Selector	e	mu	pi	K	p
e	eff	misID	misID	misID	misID
mu	misID	eff	misID	misID	misID
pi	misID	misID	eff	misID	misID
K	misID	misID	misID	eff	misID
p	misID	misID	misID	misID	eff

fraction of pions acc. by electron selector

fraction of electrons acc. by pion selector

Definition PID Quality

- Asymmetric table, containing
  - selector efficiencies and
  - misID levels; $misID = \frac{\#\ accepted\ wrong\ type\ particles}{\#all\ wrong\ type\ particles}$

Particle Type

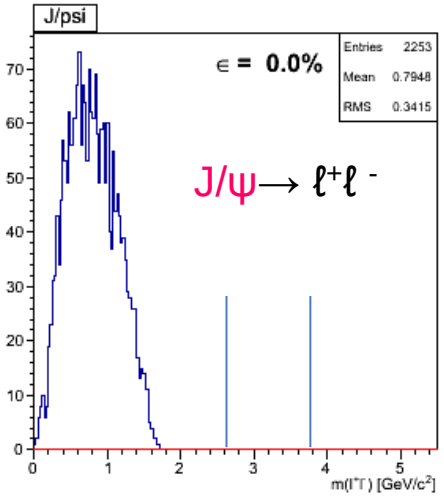
Selector	e	mu	pi	K	p
e	0,95	0,05	0,05	0,05	0,05
mu	0,05	0,95	0,05	0,05	0,05
pi	0,05	0,05	0,95	0,05	0,05
K	0,05	0,05	0,05	0,95	0,05
p	0,05	0,05	0,05	0,05	0,95

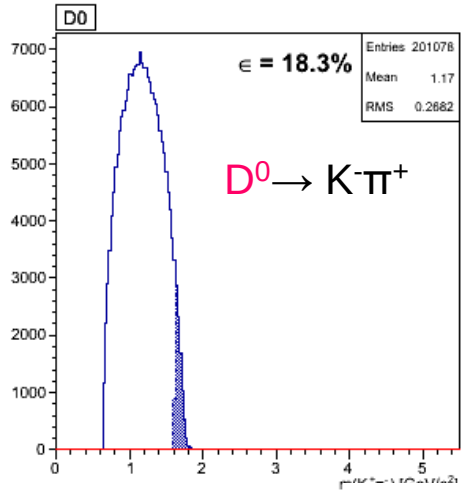
fraction of pions acc. by electron selector

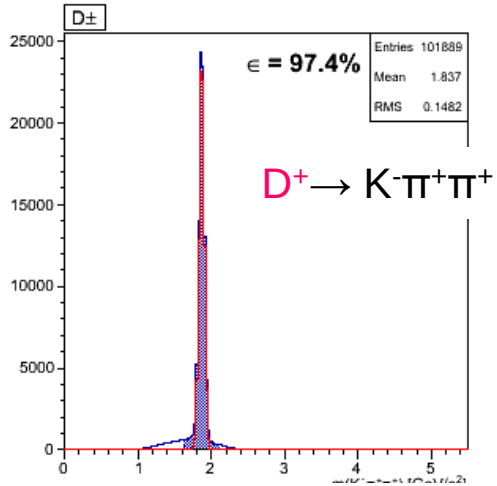
fraction of electrons acc. by pion selector

Simultaneous Tagging Examples (Toy MC)

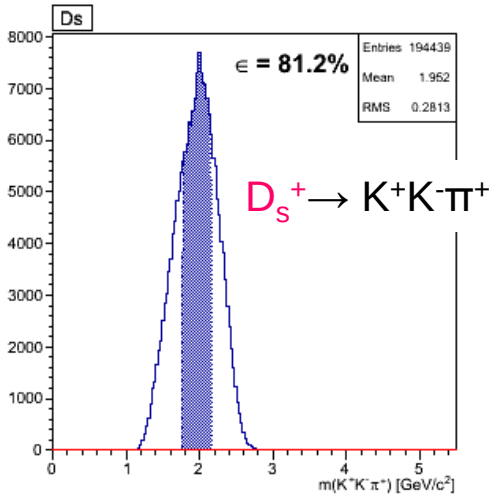
- 6 tagging algo's, **D^+D^-**@3.77 GeV (**$D \rightarrow K\pi\pi$**), good PID (5% misID)

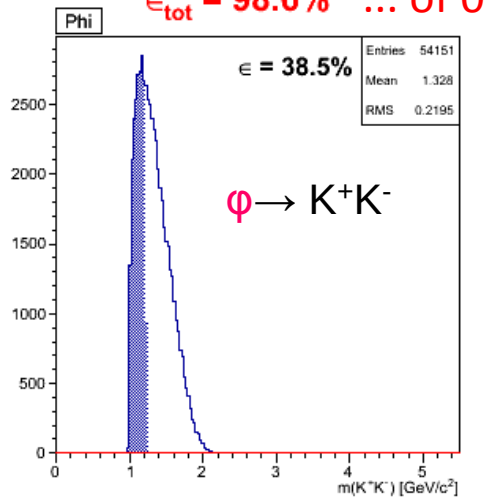


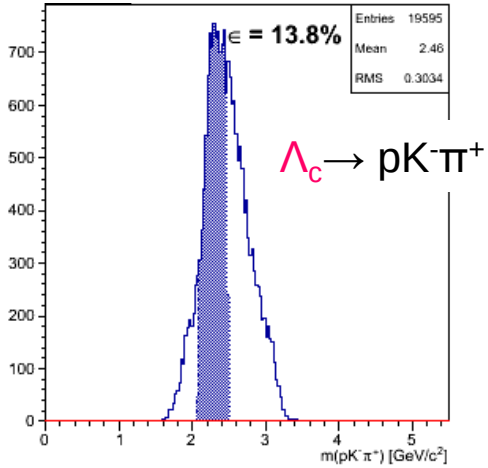




ϵ_{tot} = 98.6% ... of 0.3% of the DD events due to BR^2...

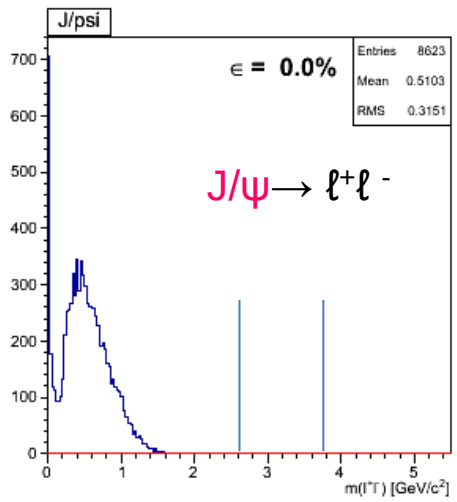


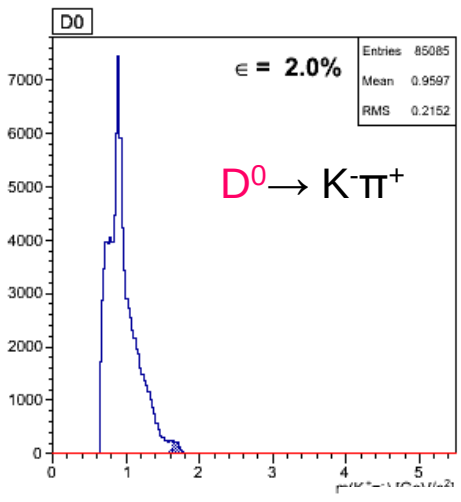


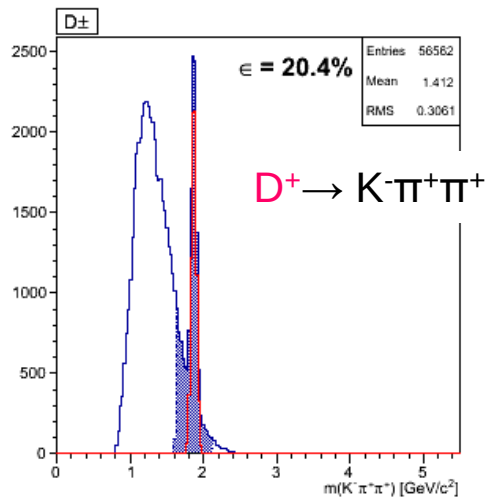


Simultaneous Tagging Examples

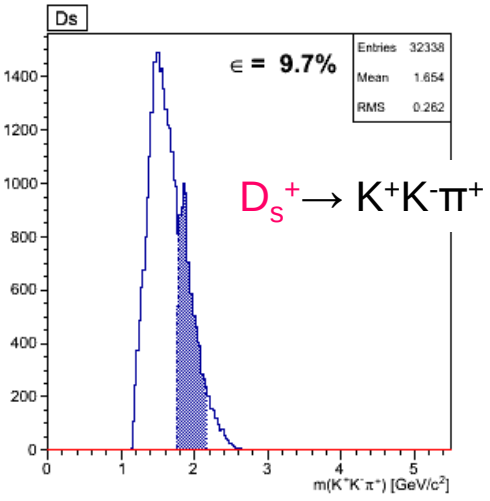
- **D^+D^- ($D \rightarrow$ any)**, good PID (5% misID)

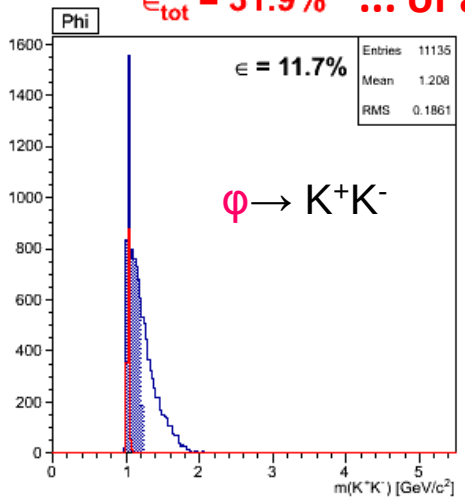


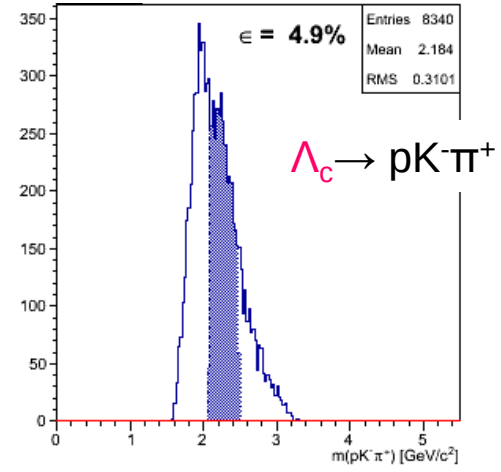




ϵ_{tot} = 31.9% ... of all(!) DD events

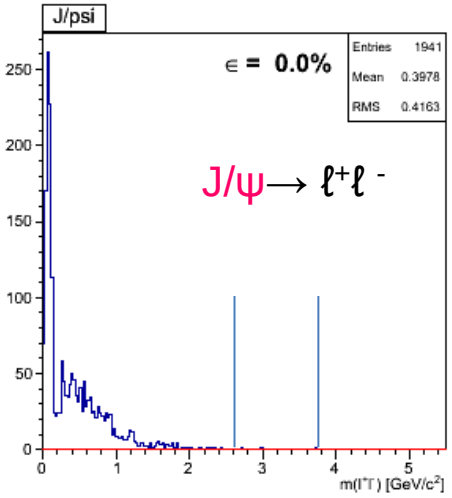


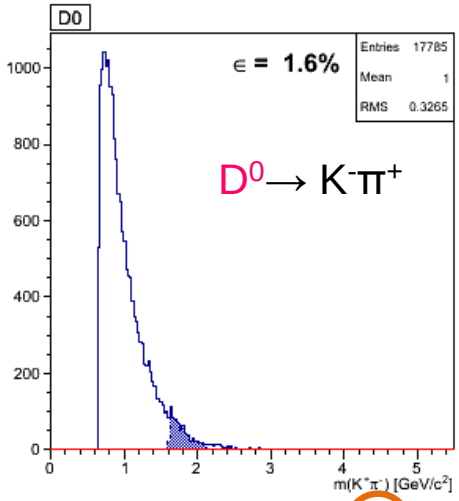


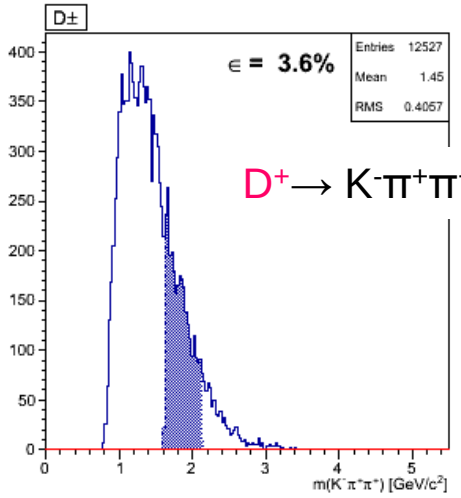


Simultaneous Tagging Examples

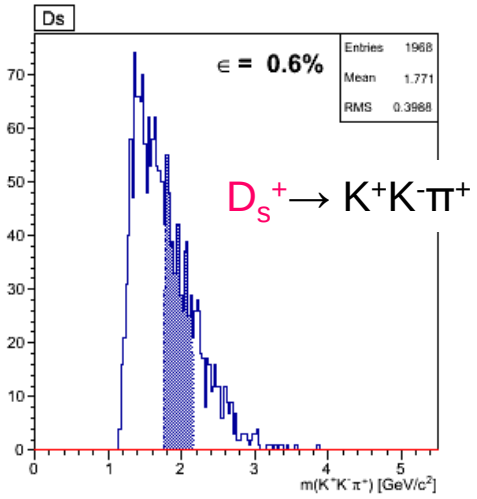
- **DPM**@3.77 GeV, good PID (5% misID)

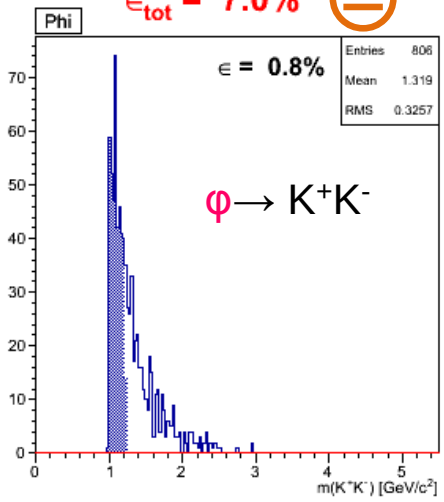


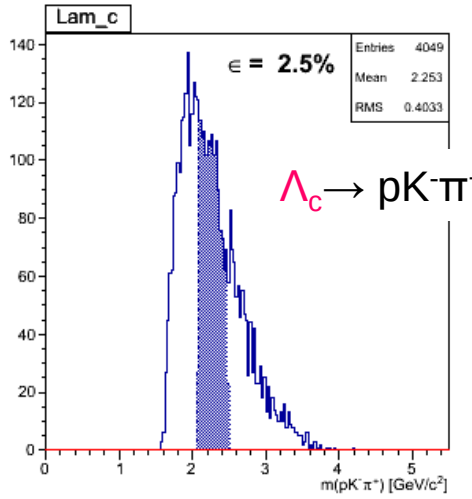




ϵ_{tot} = 7.0%

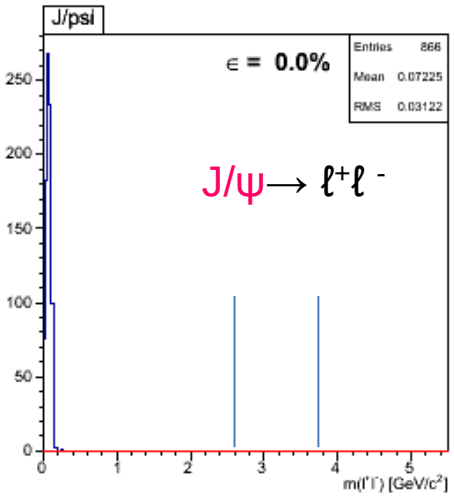


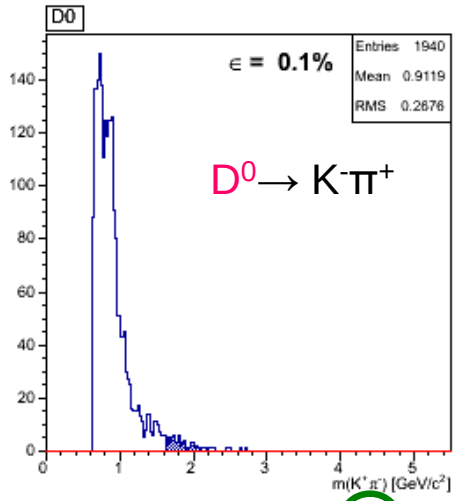


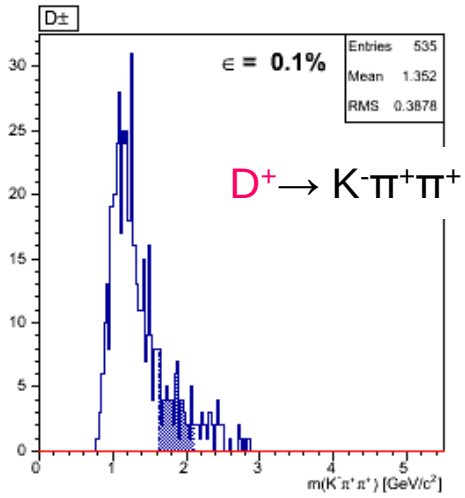


Simultaneous Tagging Examples

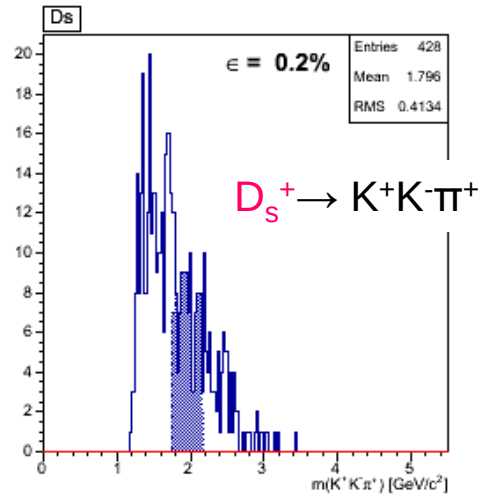
- **DPM**@3.77 GeV, **perfect** PID (0% misID, 100% efficiency)

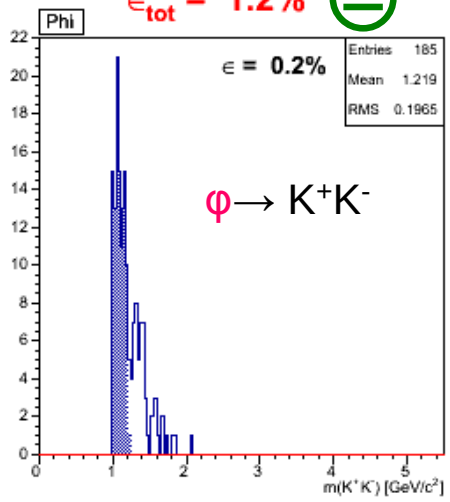


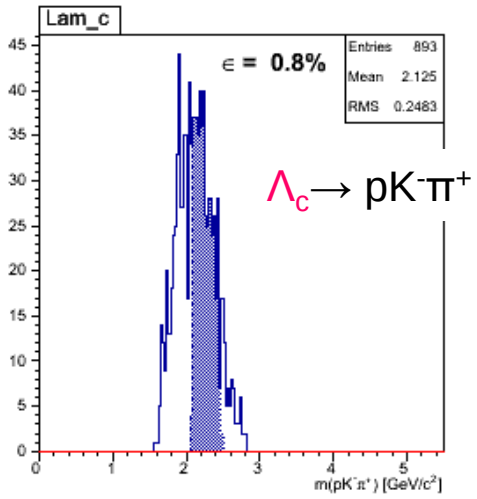




ϵ_{tot} = 1.2%

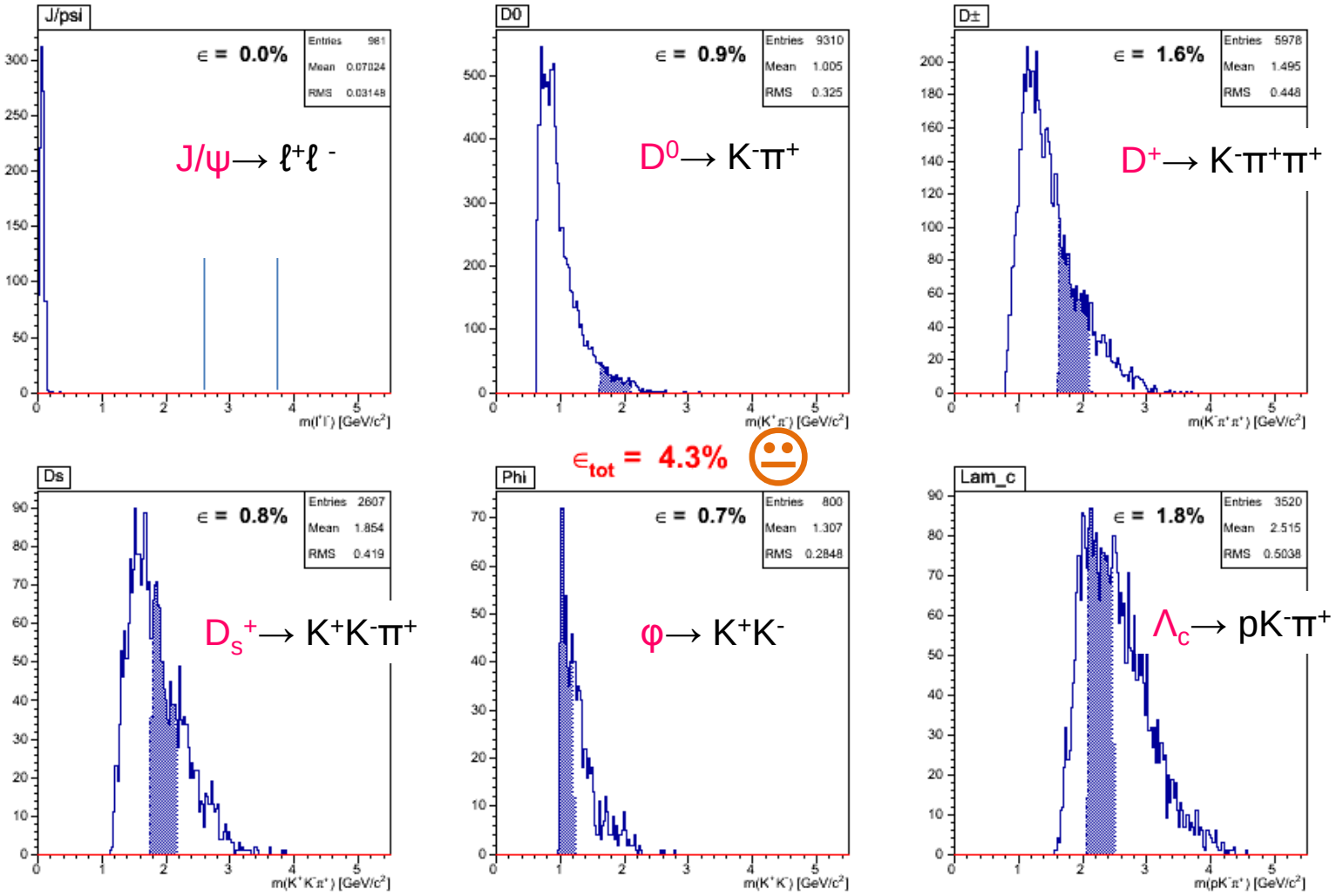




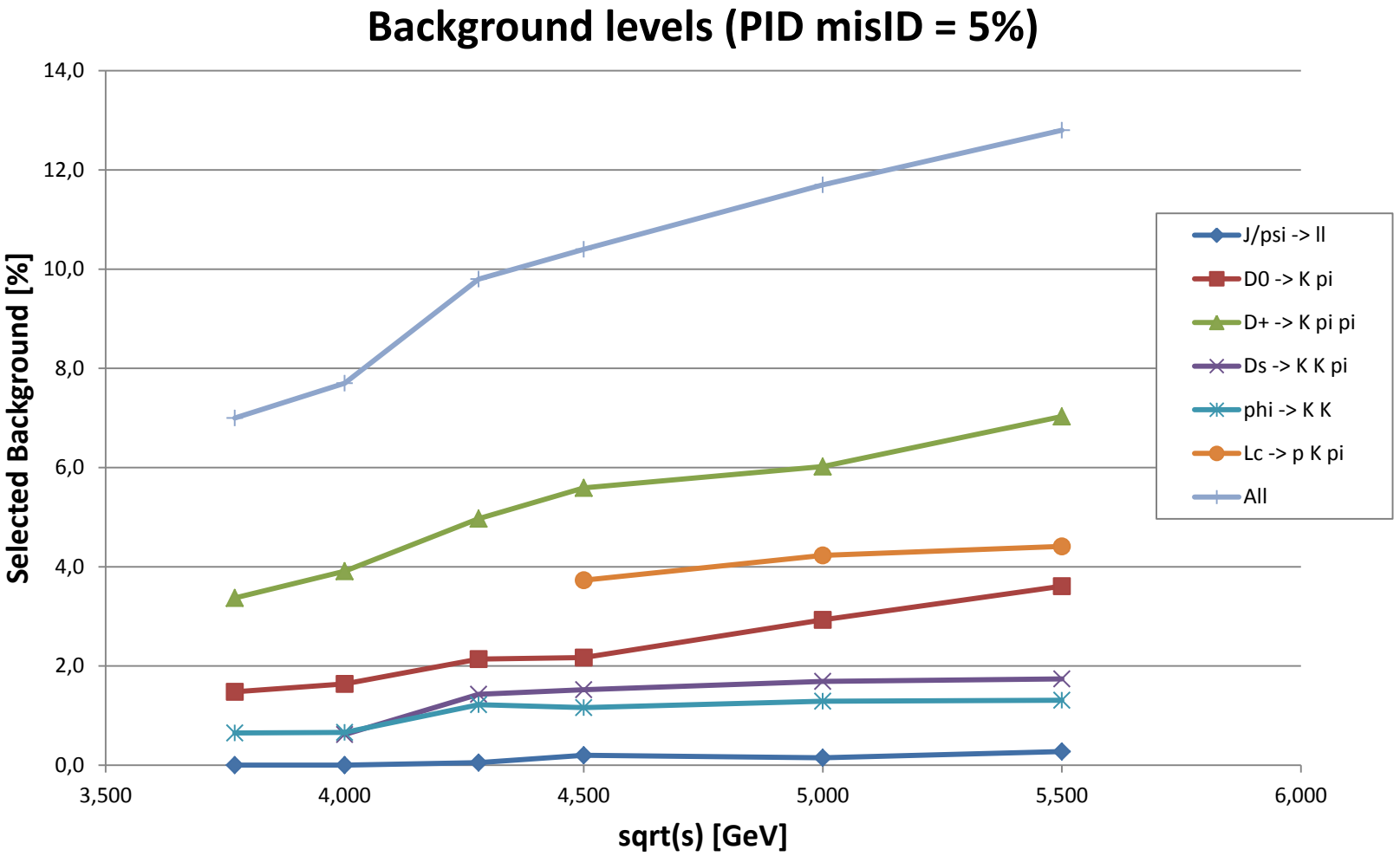


Simultaneous Tagging Examples

- **DPM@5.5** GeV, **perfect** PID (0% misID, 100% efficiency)



Background levels from DPM events

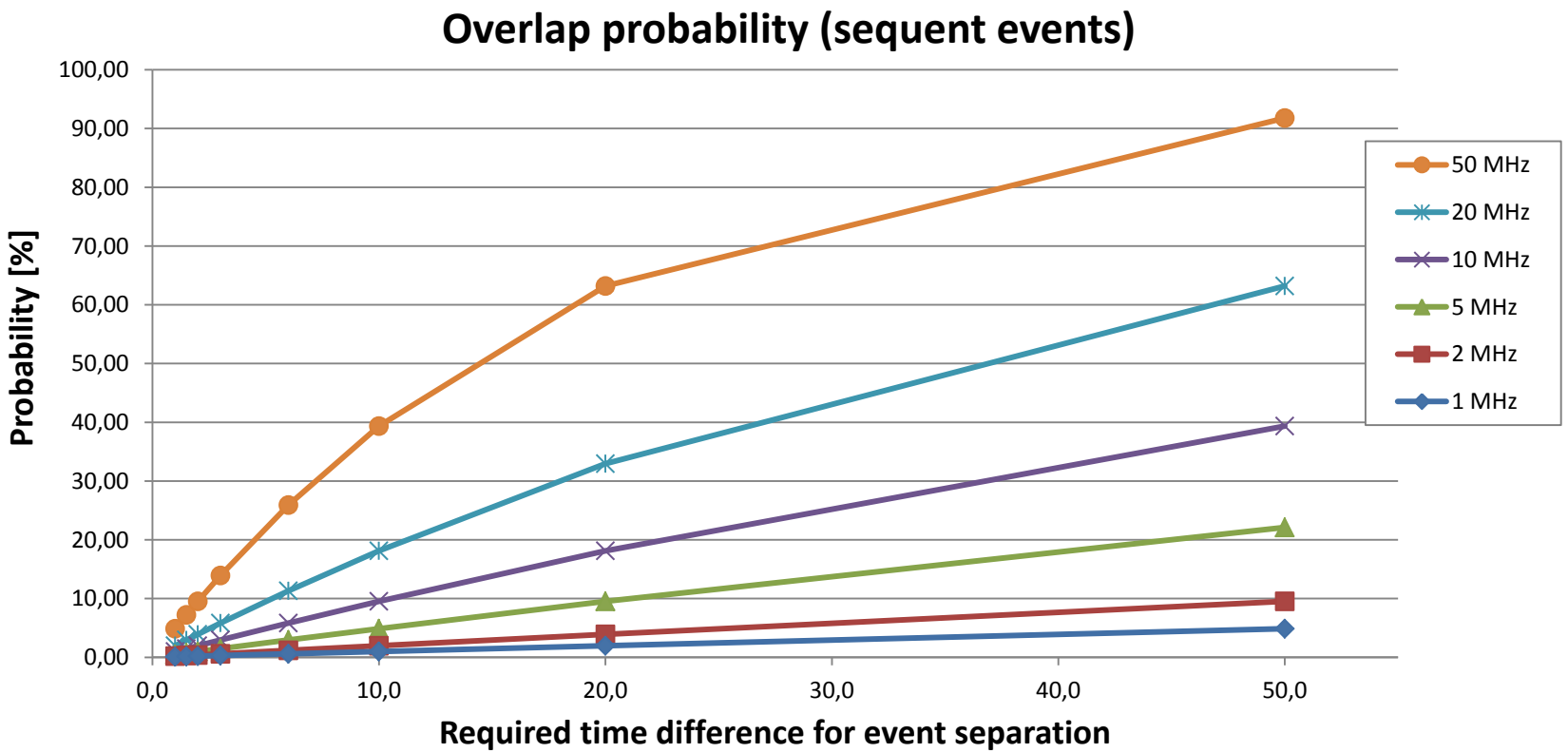


Open Issues for ST

- Need full list of all interesting channels! (What‘s gone is gone!)
- Selection of D, D_s, Λ_c, ...
  - Invariant mass cuts seem insufficient to reduce background
  - Displaced vertices *online* for $c\tau \approx 50\text{-}200\mu m$ w/o precise IP?
- Performance studied with generic background events from DPM
  - What if DPM is not realistic?
- How treat channels, which are indistinguishable from background?
- Environment for testing
  - Toy MC, Full MC, *Online Reco Algorithms*?
- PID performance, neutrals quality, event builing quality online
- Effect of event mixing/merging (higher combinatorics) on selection performance?

Event mixing and performance

- When do events mix in online scenario?
- Assumption: Minimum time between events required for separation



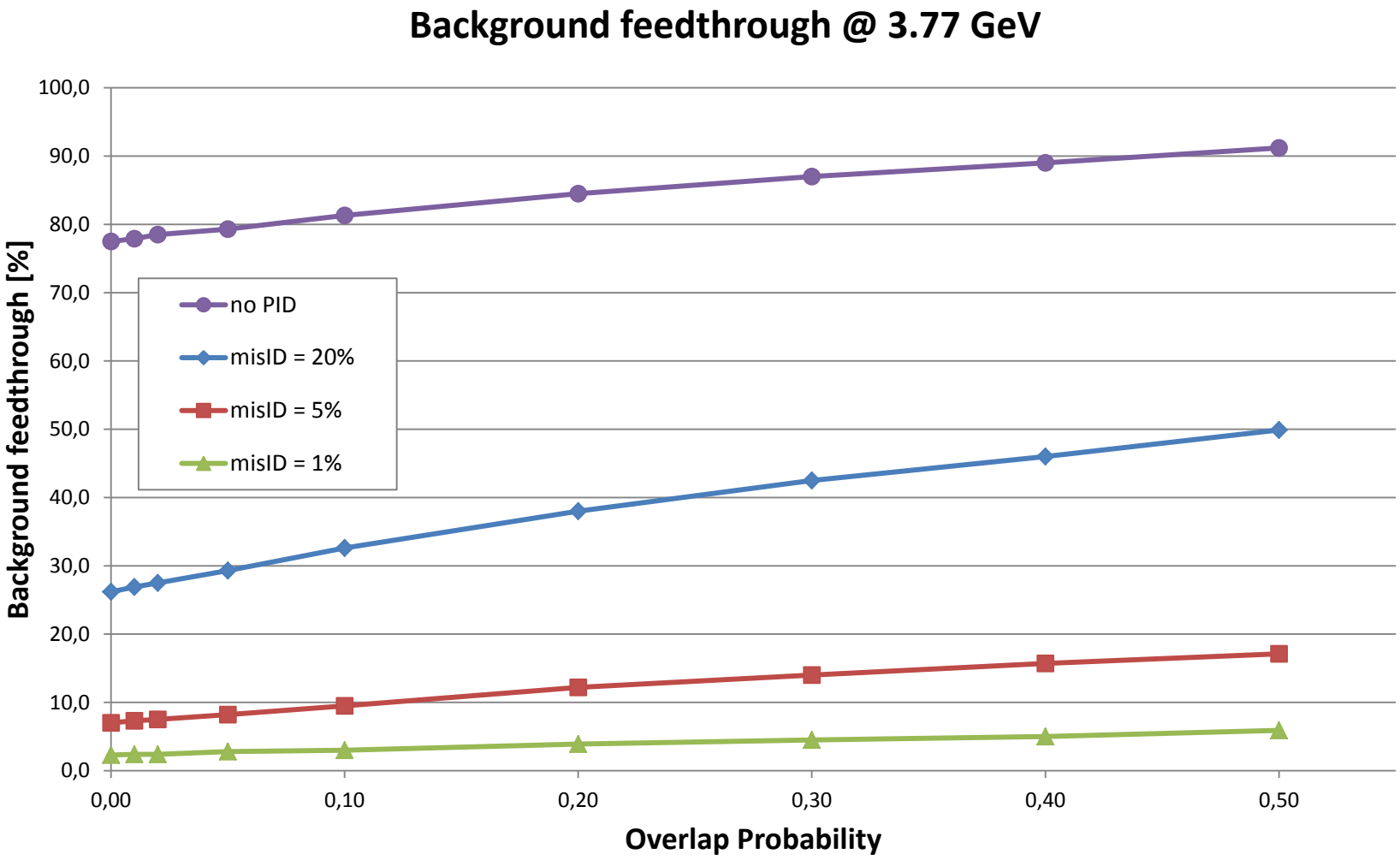
- What is performance loss due to more combinatoric?

Event mixing and performance

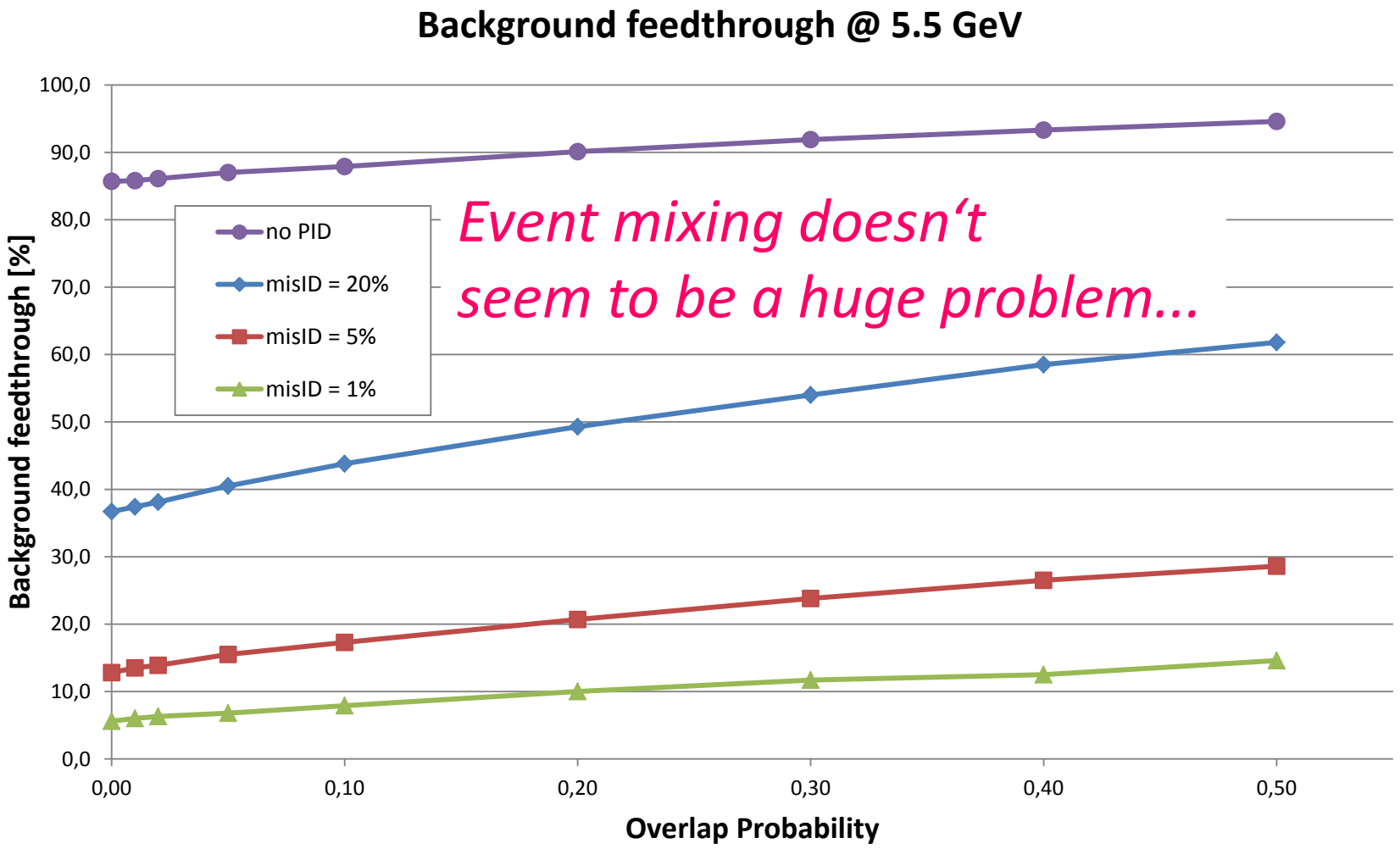
- Determine effect of higher combinatorics due to event merging

- Procedure:
  - Toy MC (DPM; generator level) background events
  - Merge fraction of sequent events corresponding to P_{mix}
  - Apply algorithm and determine amount of background feedthrough
  - Vary PID mis-ID levels (flat)
  - Vary center-of-mass energy

Background levels @ 3.77 GeV



Background levels @ 5.5 GeV



Status

- **Work being done**
  - Toy MC studies; performance of simultaneous algo‘s
  - Toy/Full MC studies (→ *Donghee*)
  - Influence of PID on background suppression (→ *Donghee*)
  - Event source simulation (→ *Mohammad*)
  - Online Track reco (→ *Yutie, Marius, Sean*)

- **To do**
  - Compile full list of signatures & develop algorithms
  - Study neutral particles/channels
  - Open charm/baryon selection with displace vertices
  - Alternative background generation

BACKUP

Why Software Trigger at all?

- Many benchmark channels (no ‚golden' channel)
- Channels consist purely/predominantly of hadrons
- Signal and background events look quite similar in terms of
  - Multiplicity tracks/neutrals
  - kinematic distributions
  - event shape, ...
- *Many, many, many* more background reactions ($\times 10^6$)
- No ‚simple' hardware trigger can cope with that situation
- Need sophisticated algorithms with high selectivity
- Only possible with online reco + a lot computing power

Online Reco ↔ Software Trigger

Distinguish between:

- Development of the selection/trigger algorithms
  - Selection algorithms based on information available online

  → Task of Software Trigger

- Online reconstruction/event building
  - Time ordering / Tracking / Clustering / Track-Cluster-PID-Matching / Event building

  → Should mainly be addressed by Detector/FEE/DAQ people

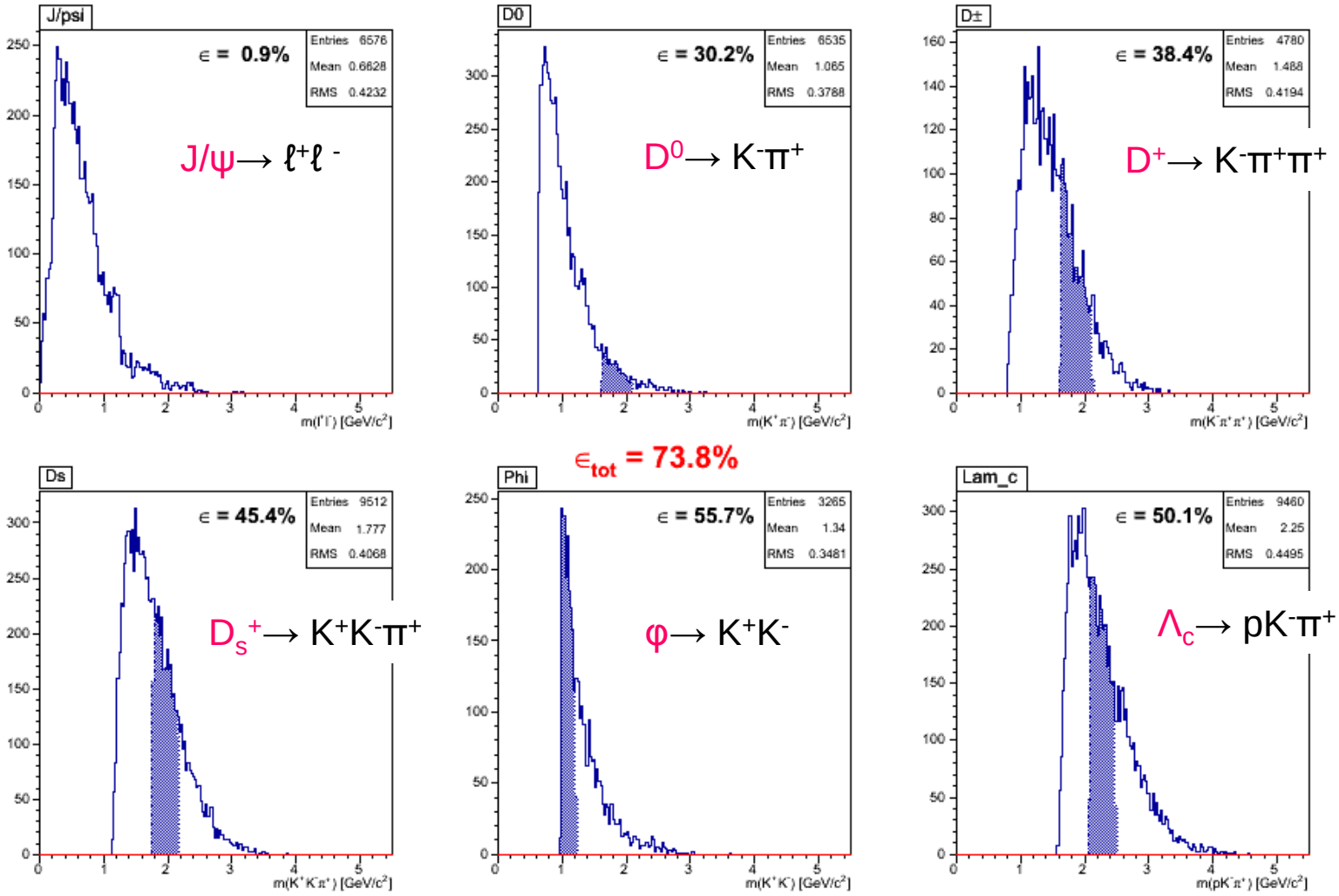
  → Will be addressed both in this session

Assignment of tasks (till now)

- Identification of various selection criteria for relevant PANDA physics channel
  (cut on momenta, cut on masses, PID, fitting, etc...)
  → **Klaus; DONE**
- Determination of their selection power of different criteria
  (ideally in terms of signal efficiency/background suppression).
  → not assigned; addressed partially in algorithm development
- Determination of their dependence from detection quality
  (efficiency, momentum resolution, energy resolution, partial PID informtation
  → **Donghee's; work in progress**
- Identification of/search for new selection criteria using more basic information
  → **Donghee + Klaus; work in progress**
- Evaluation to what extent online event building is a requirement
  (incl. ↔ excl. triggers), implementation when necessary. Depends on level of event mixing.
  → **Klaus; work in progress**
- Full implementation of time base simulation for all detectors
  (in particular pattern recognition and reconstruction based on a time sequential digi stream)
  → **done for some detectors** → is up to the detector subgroups.
- Implementation of identified algorithms on trigger hardware (FPGA, GPU)
  → TBD
- Test of this hardware with simulated PANDA DAQ input.
  Use time based simulated detector digis to feed into hardware to test function and performance.
  → **Mohammad**

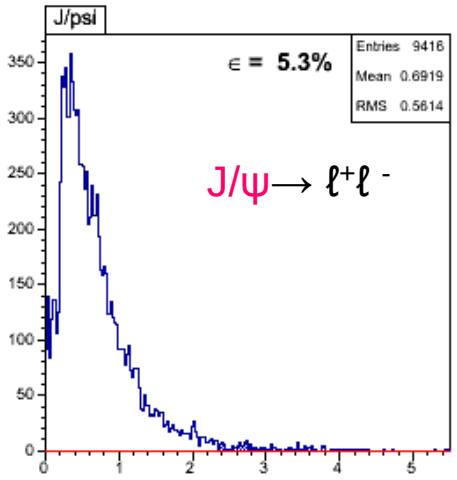
Quick Compare Toy and Full MC

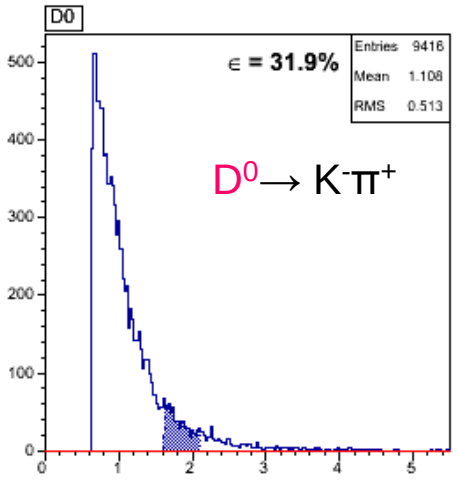
- DPM@3.77 GeV, **Toy MC,** no PID

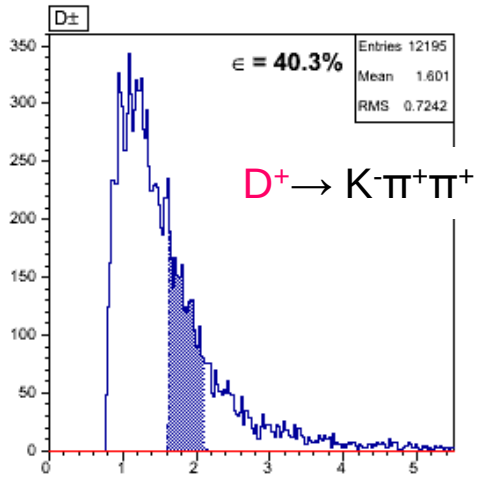


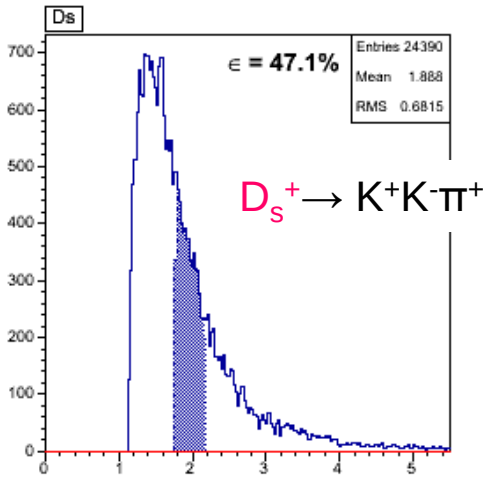
Quick Compare Toy and Full MC

- DPM@3.77 GeV, **Full MC,** no PID

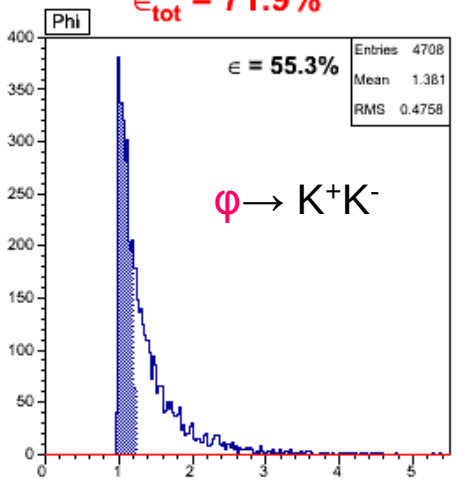


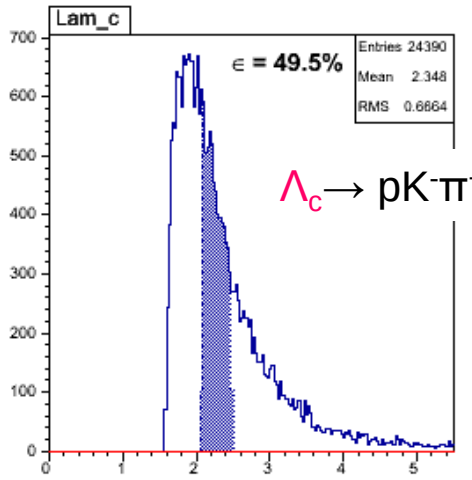






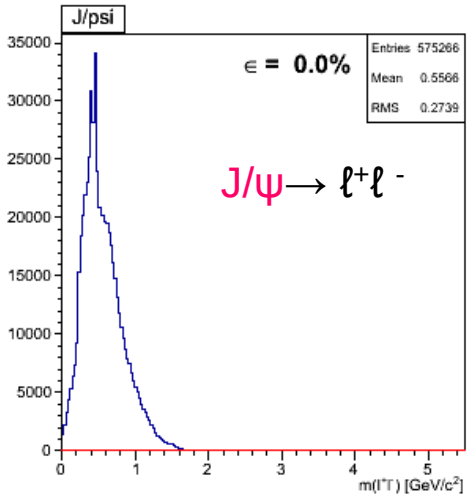
ϵ_{tot} = 71.9%

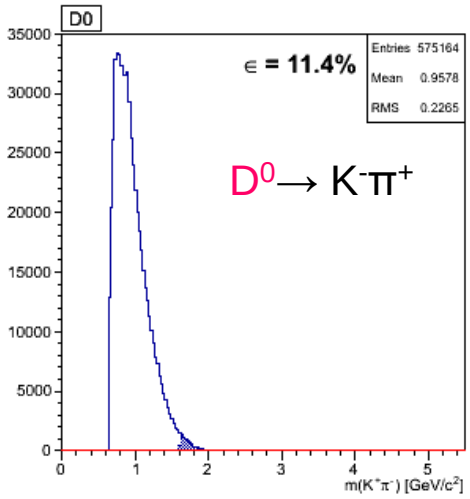


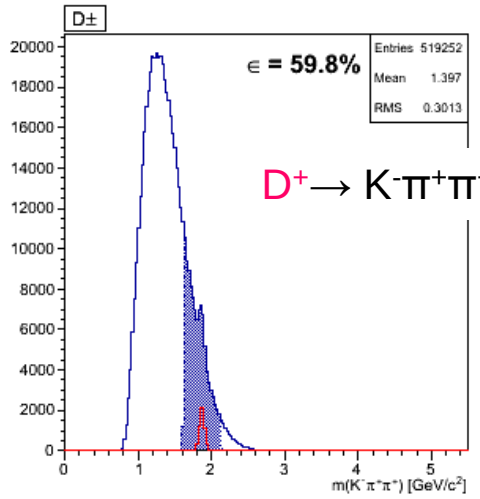


Simultaneous Tagging Examples

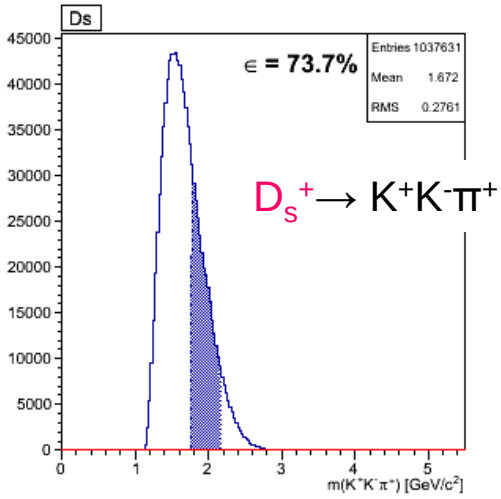
- D^+D^- (**D → any**), no PID

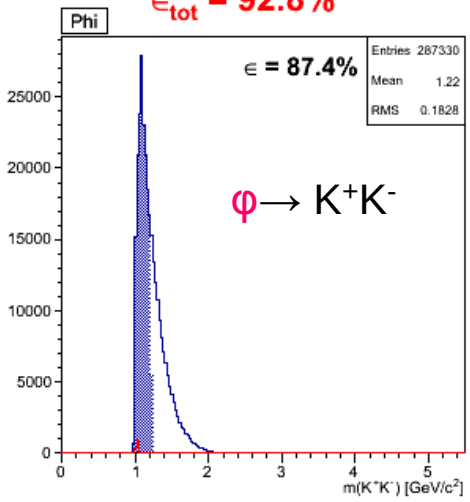


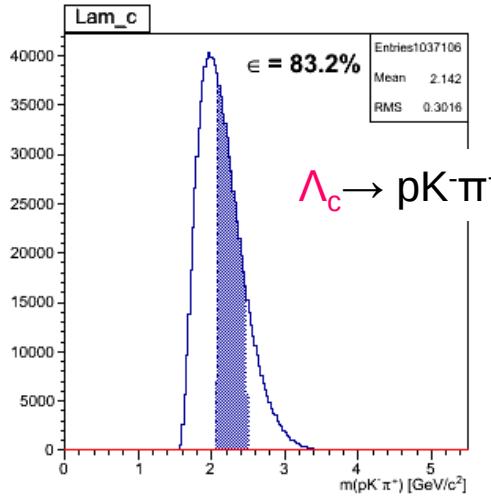




ϵ_{tot} = 92.8%

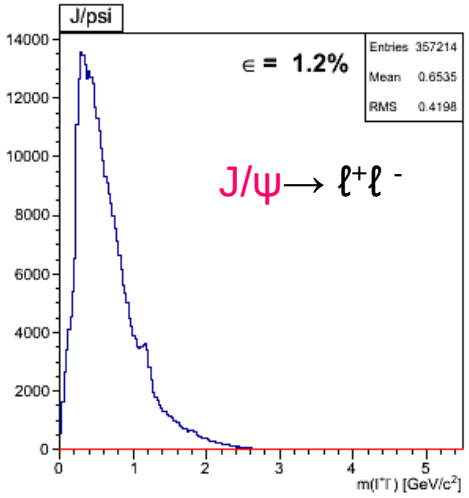


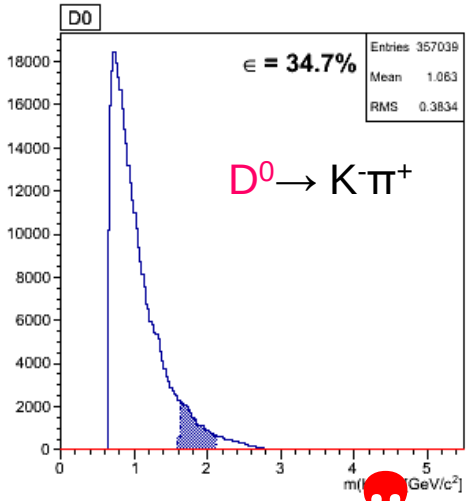


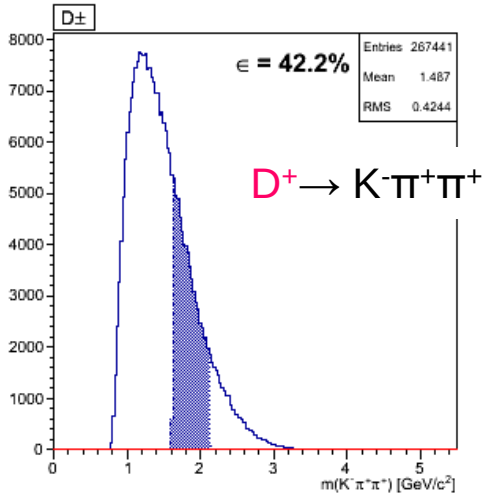


Simultaneous Tagging Examples

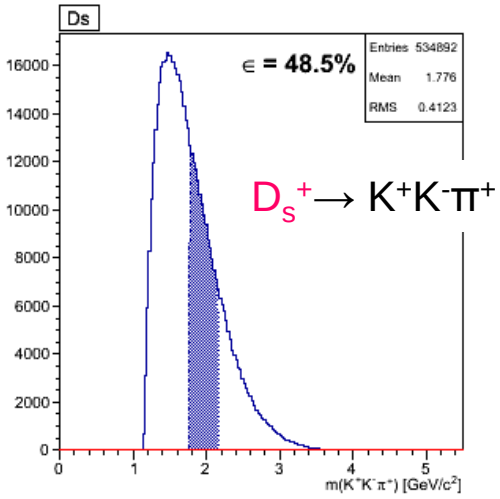
- **DPM**@3.77 GeV, no PID

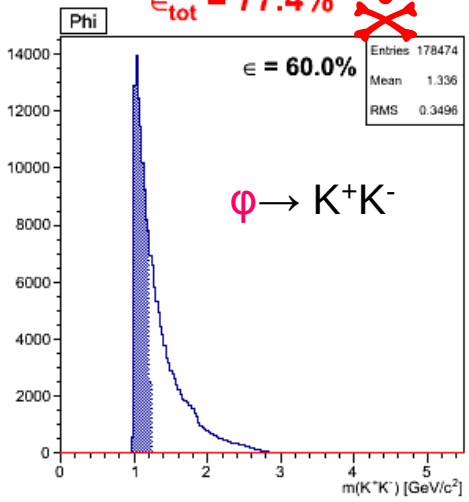


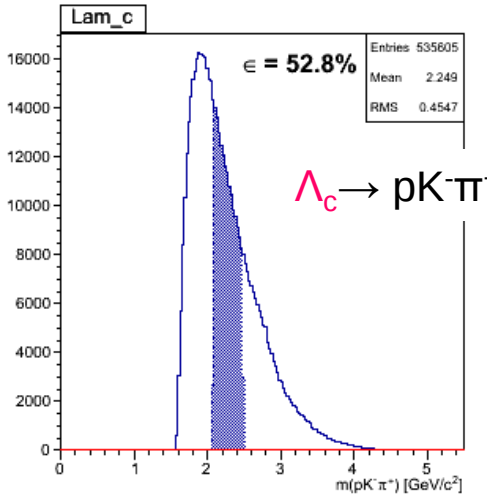




ϵ_{tot} = 77.4%

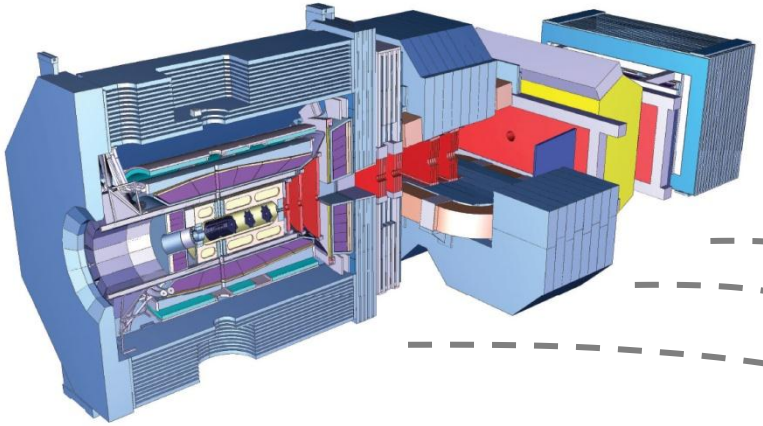




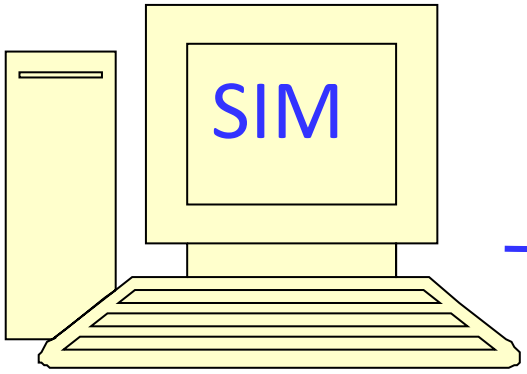


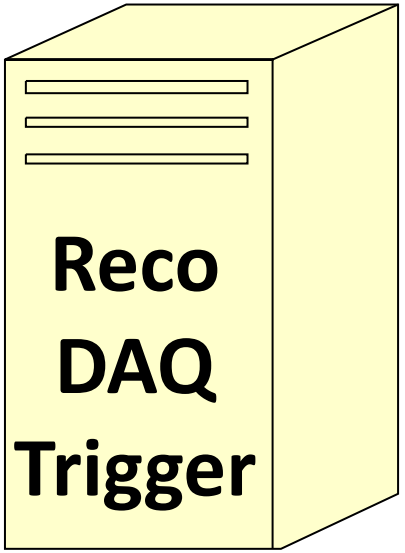
Interface to online reco/hardware

- When algorithms are implemented on hardware
  → need a realistic test scenario
- **Idea:**
  Do time ordered simulation + simulate hardware digi stream



For testing this …





See Mohammads talk