

Fisica dei fotoni prompt

... attivita` di Milano ...

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Motivazioni e attivita`

- Le nostre motivazioni...
 - *Naturale evoluzione della nostra esperienza nel canale $H \rightarrow 2\gamma$...*
 - *Leonardo chairman del sub-group “Standard Model Direct Photon”*
 - *Interesse espresso dai nostri teorici (S. Forte et al.) nello studio di reazioni $pp \rightarrow \text{gamma-jet}$ per sondare la *funzioni-densita` partonica del gluone**
- Principali attivita` attuali del gruppo:
 - *Studio della **purezza** in campioni inclusivi di fotoni (dominati da processi QCD)*
 - *Manutenzione del **software** di analisi (pacchetto **HiggsAnalysisUtils**)*
 - *Studio di MC QCD NLO (diphox, jetphox), effetti dell'isolamento partonico sulla sezione d'urto (Claudio)*
- Possibili sviluppi futuri ...
 - *Sezioni d'urto per canali di fotone singolo e doppio fotone*
 - *Ricerca di nuova fisica nel canale a due fotoni*

Software

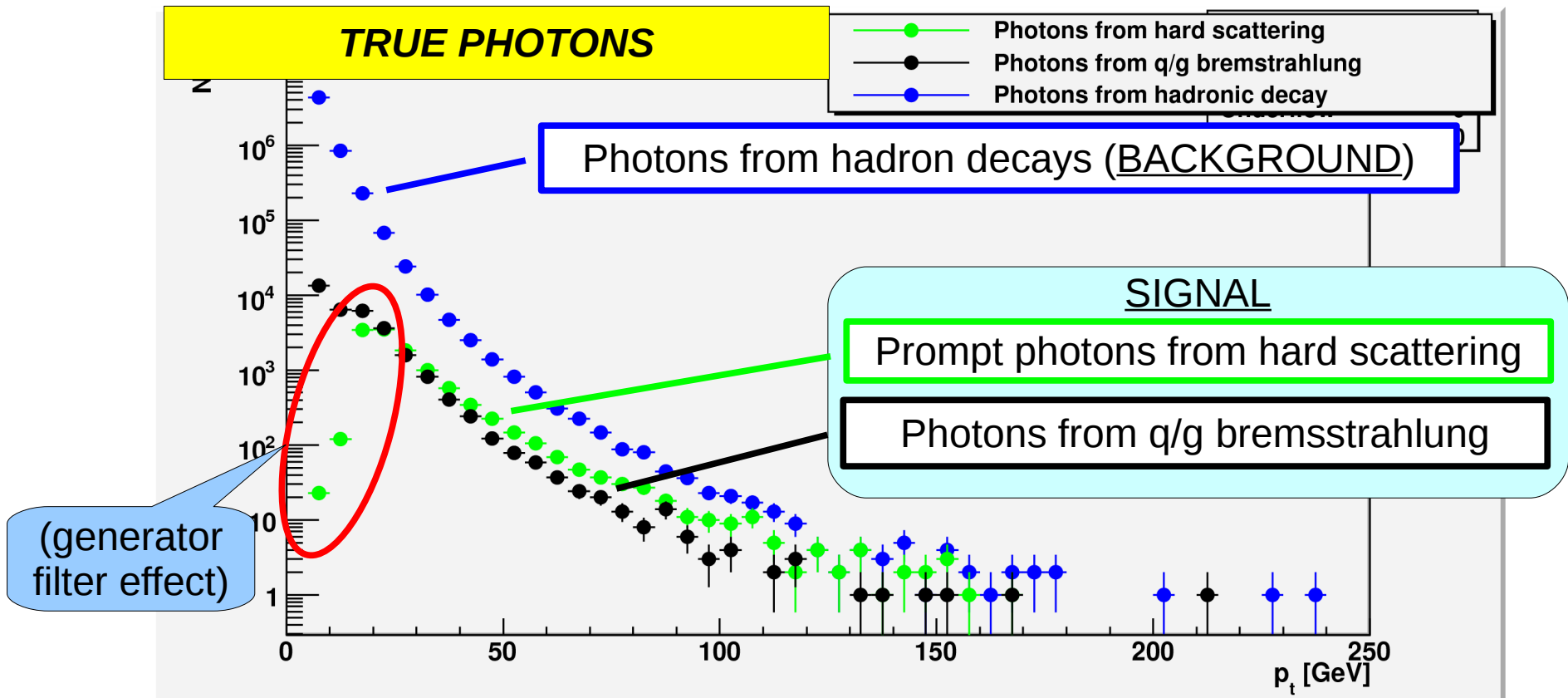
- Pacchetto athena **HiggsAnalysisUtils**, nato nel 2007 per l'analisi del canale **$H \rightarrow 2\gamma$** per la nota CSC...
- Utile anche come **ntuple dumper** (->D3PD) per studi generici sui fotoni:
 - *Fotoni ricostruiti: variabili cinematiche, forma della em shower, isolamento, conversioni*
 - *Jets, elettroni, Pmiss...*
 - *Match reco/truth, classificazione dei fotoni in base alla loro origine (prompt, bremstrahlung, secondari)*
- Al momento e` il pacchetto piu` usato dai gruppi **$H \rightarrow 2\gamma$** e Direct Photon
- Collaborazione con gli sviluppatori del software egamma, integrazione e validazione di tools "standard" di egamma

Evaluation of photon purity

- The problem:
 - Select a sample of photon candidates, using standard criteria (isEM, track isolation)
 - Try to evaluate the purity **P** of the sample
 - ... needed for cross-section evaluation: $\sigma = (N * P) / (\epsilon * \int L dt)$.

Data set

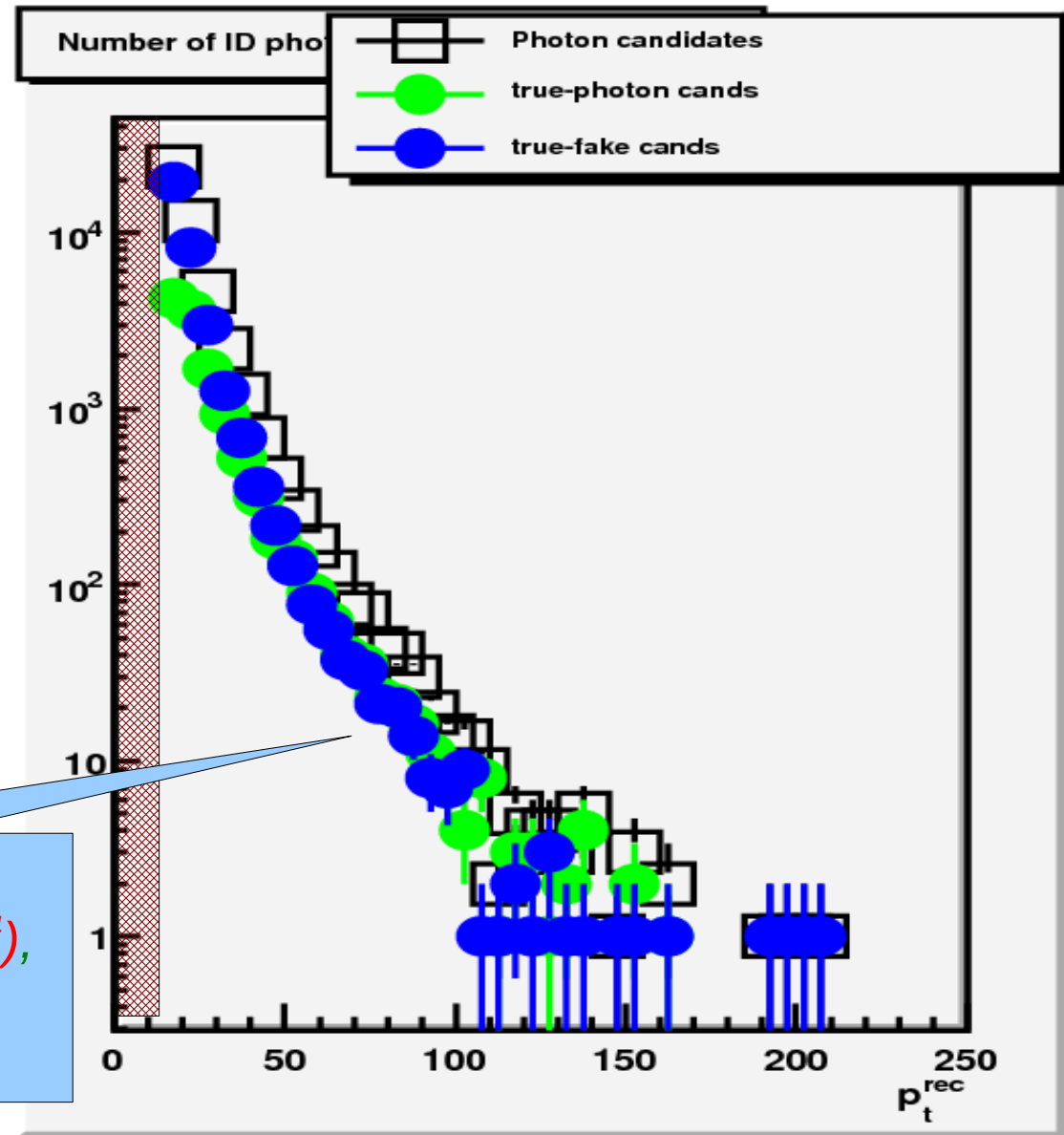
- Data set: **pythia JF17** (mc08.105802...) : ~ 8.5 M events
 - Fully simulated events with **di-jet-like** topology, different processes are balanced according to their cross-sections
 - Mostly di-jets, plus ~11500 gamma-jet, and ~1500 other EW processes
 - Dominating processes at LHC \Rightarrow realistic sample



Photon identification

- Photon ID on EM clusters:
 - IsEM(PhotonTight)
 - Little had leakage
 - Narrow shower width in Middle and Strips
 - No 2nd maximum in strips (γ / π^0 separation)
 - Track isolation
 - $\sum_{\text{tracks}} p_t < 4 \text{ GeV}$ (in cone $dR < 0.3$)

Despite good efficiency (>60%) and high jet rejection ($\approx 10^3 \div 10^4$), signal and background occur in similar amounts...



Purity evaluation (basics)

- Estimate the photon purity P in the candidates' sample:

- Choose a separation variable having pdf's sensibly different for true signal photons and background: $\Pi^\gamma(\xi)$ and $\Pi^{\text{jet}}(\xi)$;

- Get the pdf from observed candidates sample: $\Pi^{\text{cand}}(\xi)$;

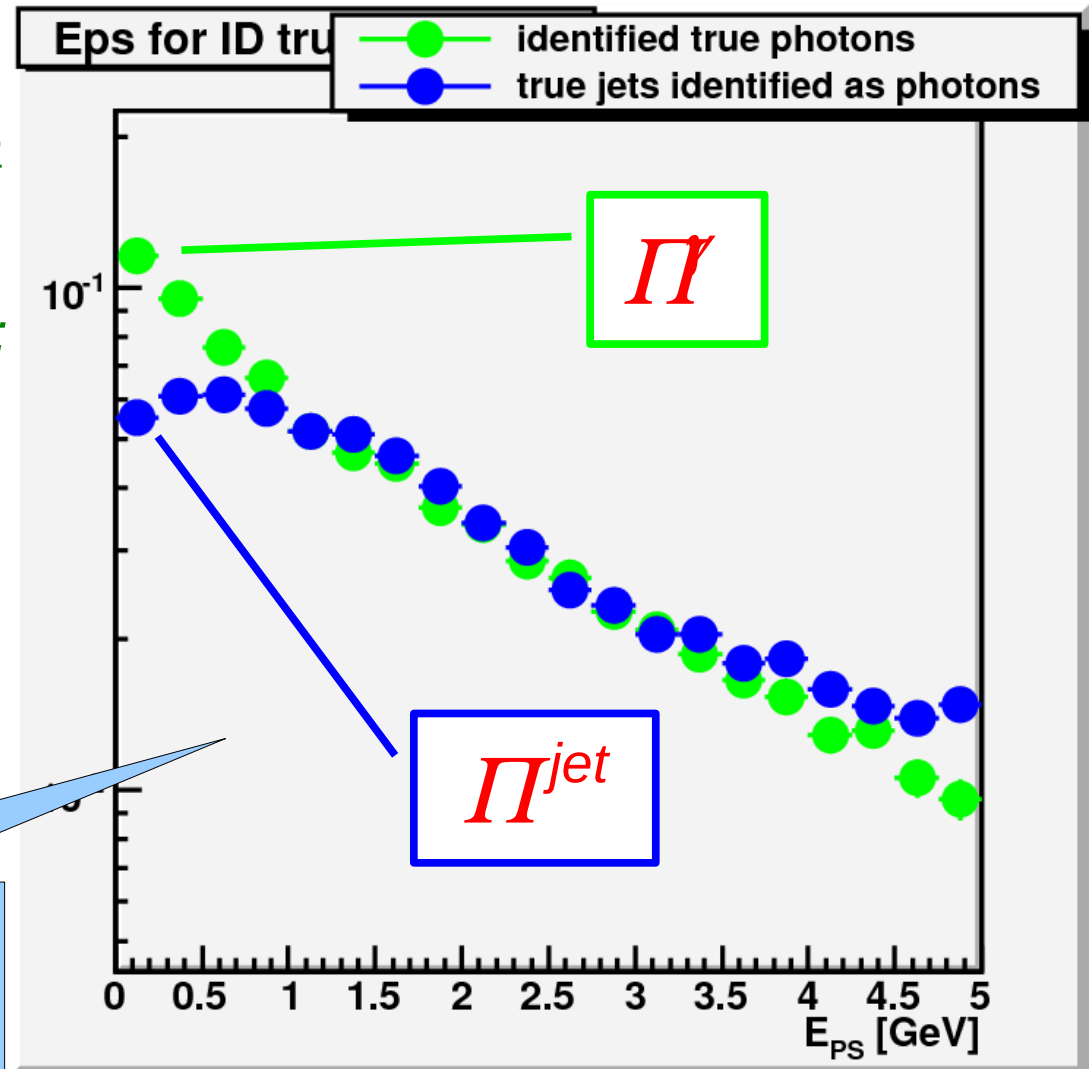
- Find value of P that best fits:

$$\Pi^{\text{cand}}(\xi) = P \Pi^\gamma(\xi) + (1-P) \Pi^{\text{jet}}(\xi).$$

- Choose $\xi \equiv E_{PS}$:

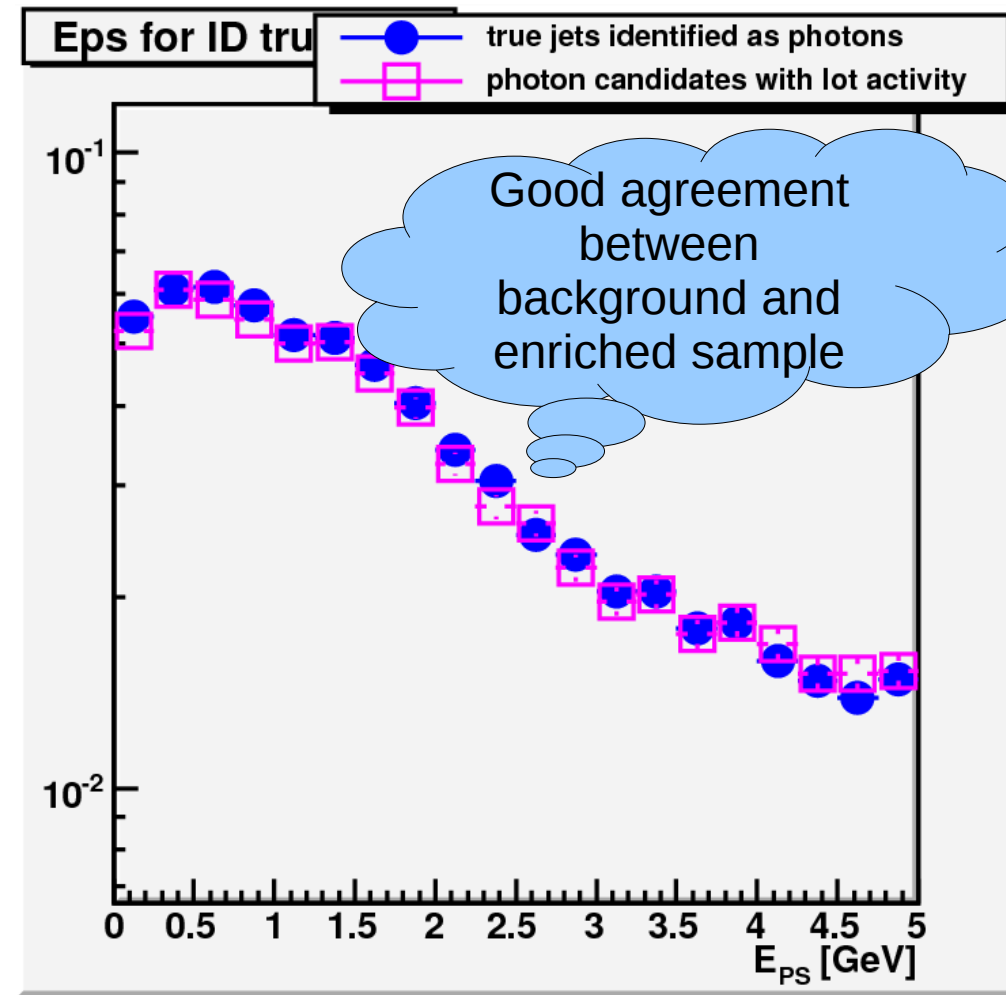
Larger E_{PS} in background:

- in jets (more track activity)
- In $h^0 \rightarrow 2 \gamma$ (more conversions)



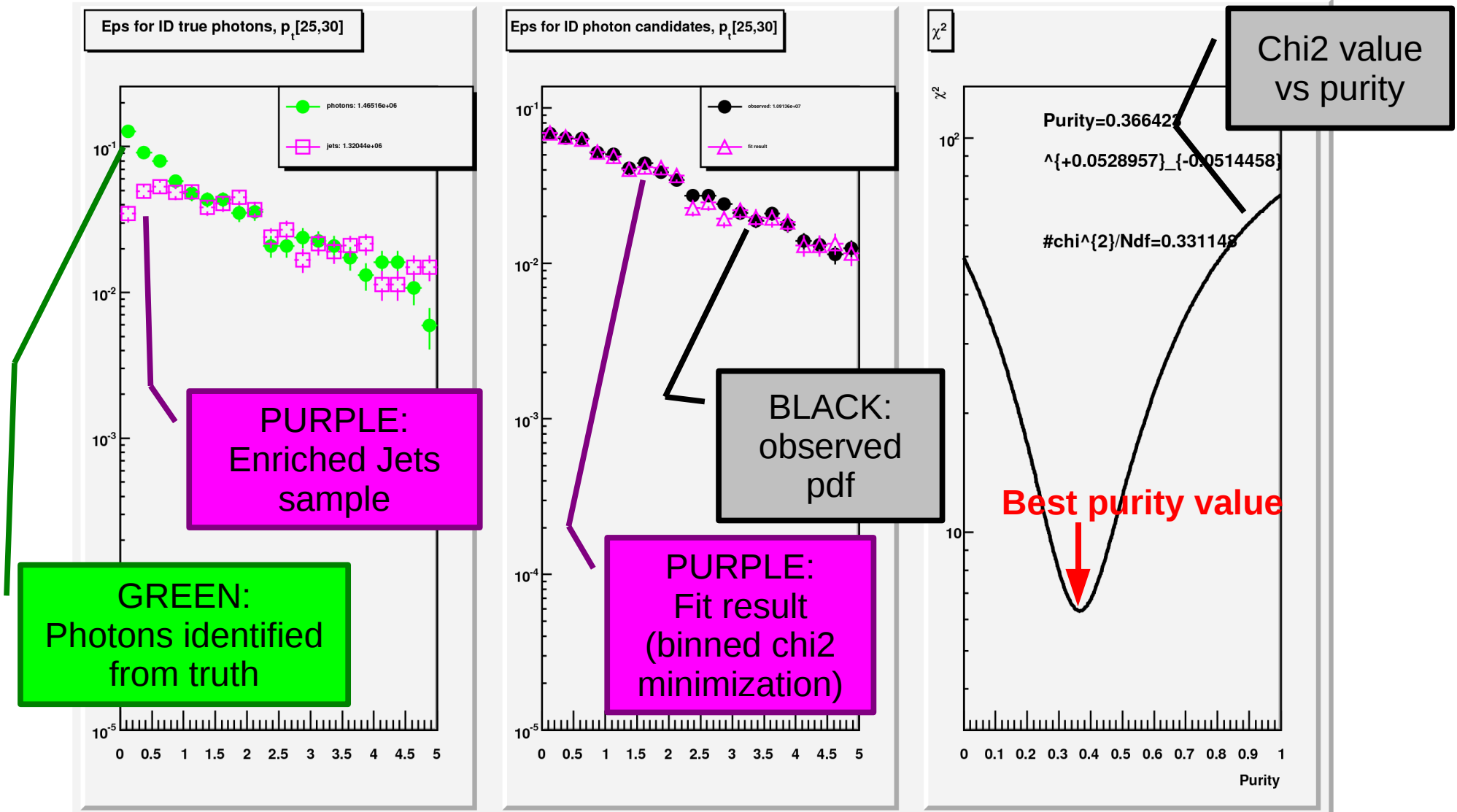
Background pdf from data: “enriched jet” sample

- Pdf of background: do we trust the fragmentation model?
- \Rightarrow try to obtain $\Pi^{\text{jet}}(\xi)$ from data, using “enriched jet” *sample*
 - *Require some track activity around the candidate (“anti-isolation”):*
 - *Reject ~90% signal photons*
 - *Keep ~50% background*
- \Rightarrow enriched jet sample has ~7% photon contamination

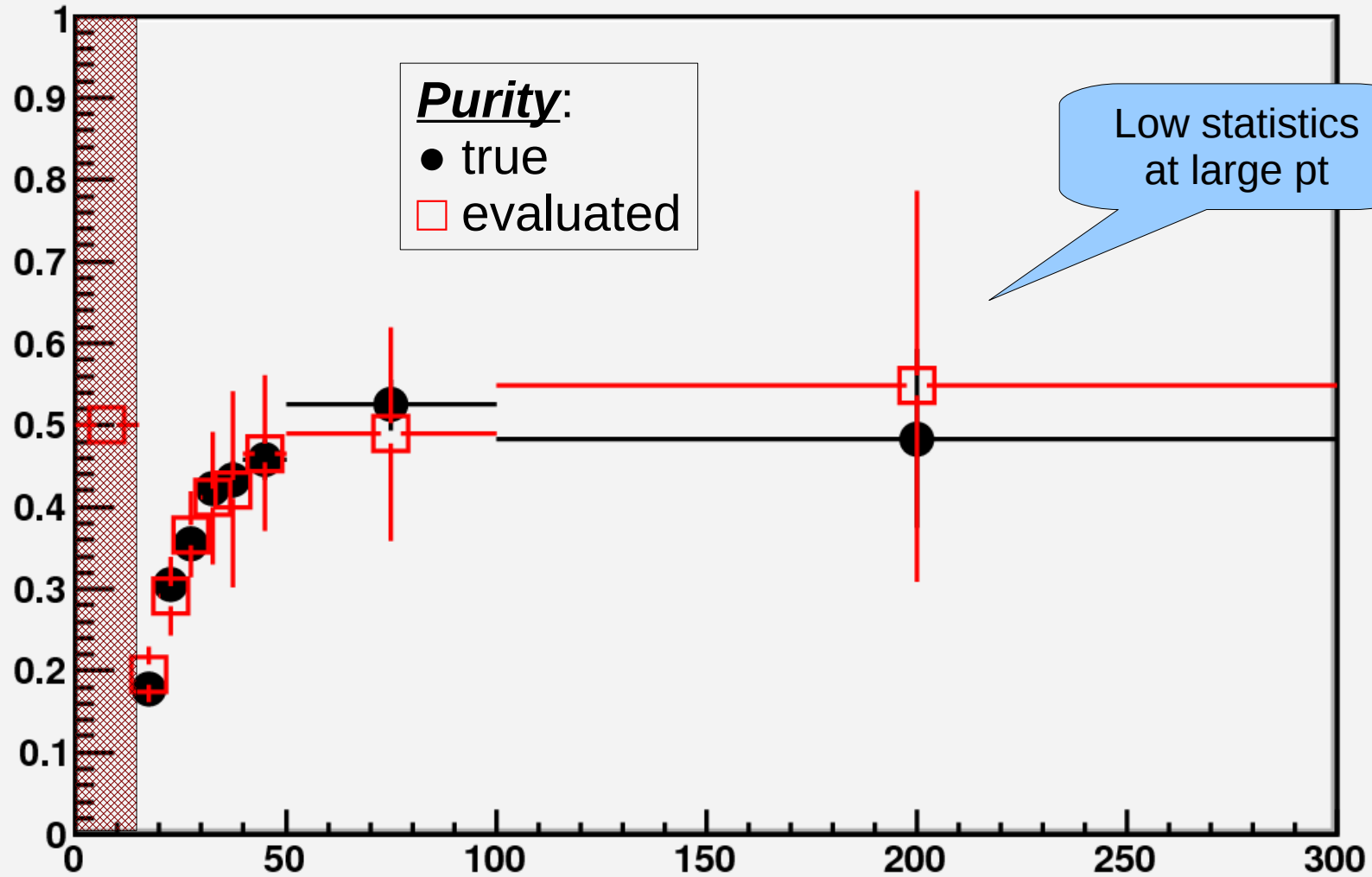


Purity fit ($25 < p_t < 30$)

- Find value of **P** that best fits: $\Pi^{\text{cand}}(\xi) = P \Pi^{\gamma}(\xi) + (1-P) \Pi^{\text{jet}}(\xi)$.



Purity using E_{ps} : result



Conclusions and next steps...


- Purity evaluation based on signal/background pdf's works for pythia JF17.
 - *Performance ok for $pt > 15$ GeV*
 - *Pdf's for background can be derived from data via jet enriched sample, based on track anti-isolation*
- Need to test method on:
 - *unfiltered pythia dijets (105813) : undistorted photon pt spectrum*
 - *Pythia JF35 and JF70 : larger statistics at high pt*
 - *Herwig JF17 (105830) : different fragmentation model*

BACKUP SLIDES

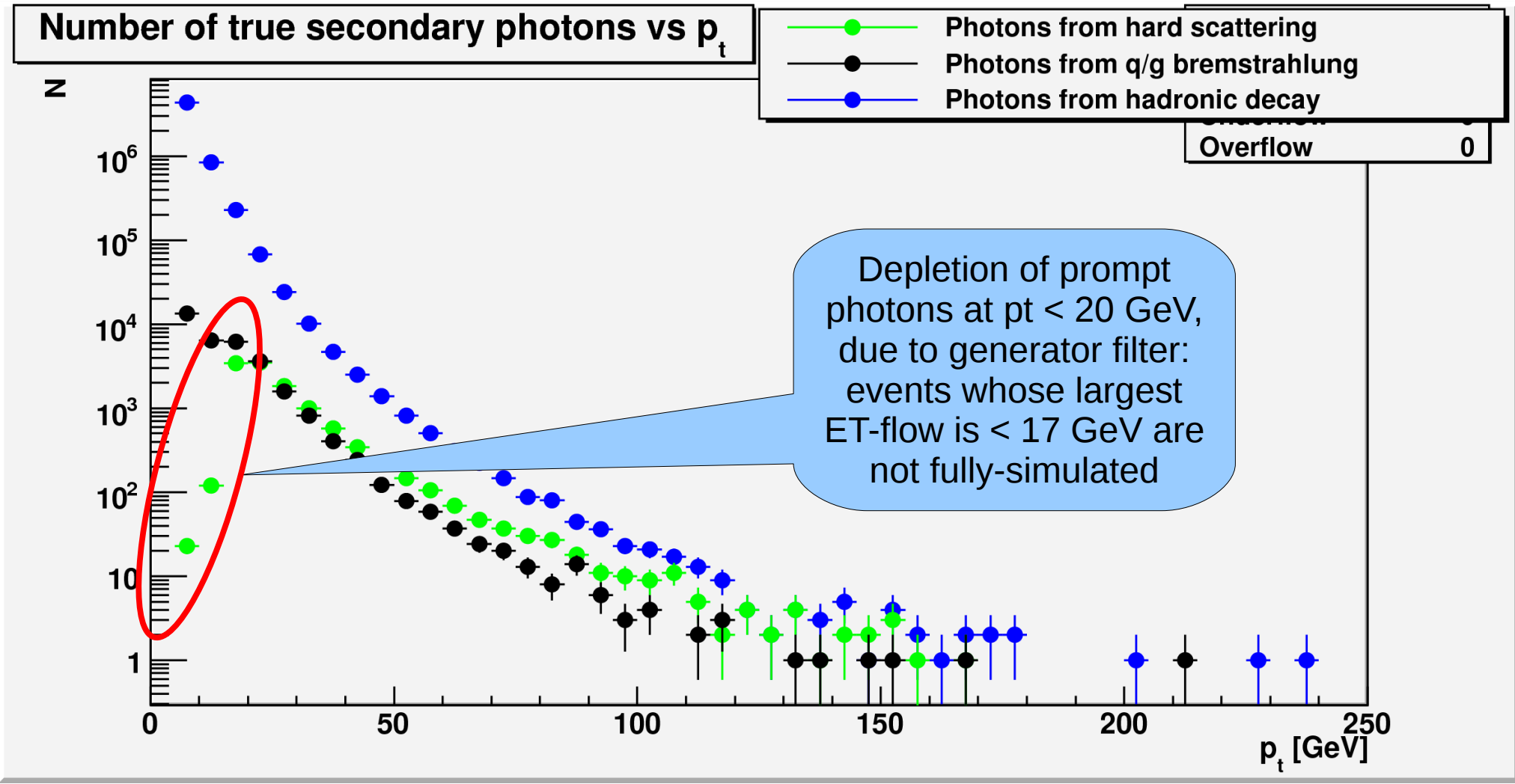
Evaluation of photon purity

- Definitions:
 - **Signal**: photons from hard scattering (“prompt”) and from fragmentation (quark/gluon bremsstrahlung)
 - **Background**: secondary photons from hadron decays and other calorimetric clusters not coming from photons
- The problem:
 - Select a sample of **photon candidates**, using standard criteria (isEM, isolation)
 - Try to evaluate the purity **P** of the sample
 - ... needed for cross-section evaluation: $\sigma = (N * P) / (\epsilon * \int L dt)$.
- Signal/background classification
 - achieved through cone matching (ΔR) between reconstructed candidates and truth particles

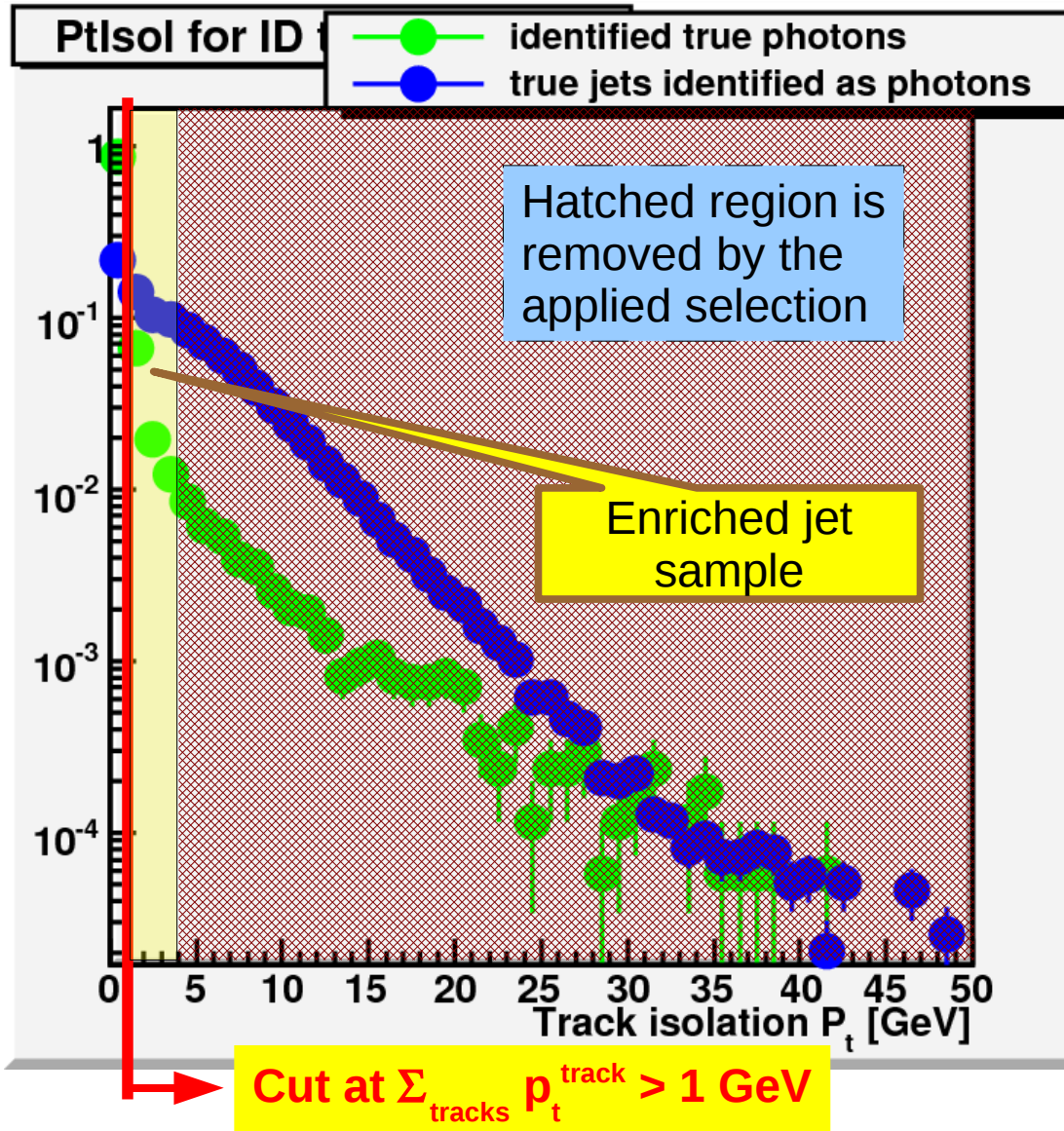
Data set

- Data set: **pythia JF17** (mc08.105802...)
 - Full simulation of events with **di-jet-like** topology, different processes are balanced according to their cross-sections
 - Dominating processes at LHC \Rightarrow realistic sample
 - ~ 8.5 M events of which:
 - 11583 QCD gamma-jet
 - 1553 other processes
 - The rest are true QCD jet-jet
 - True photon counting:
 - 11583 prompt (from hard scattering)
 - 33176 bremsstrahlung from quark/gluon
 - 5.5 M from hadron decays
- 

True photons populations

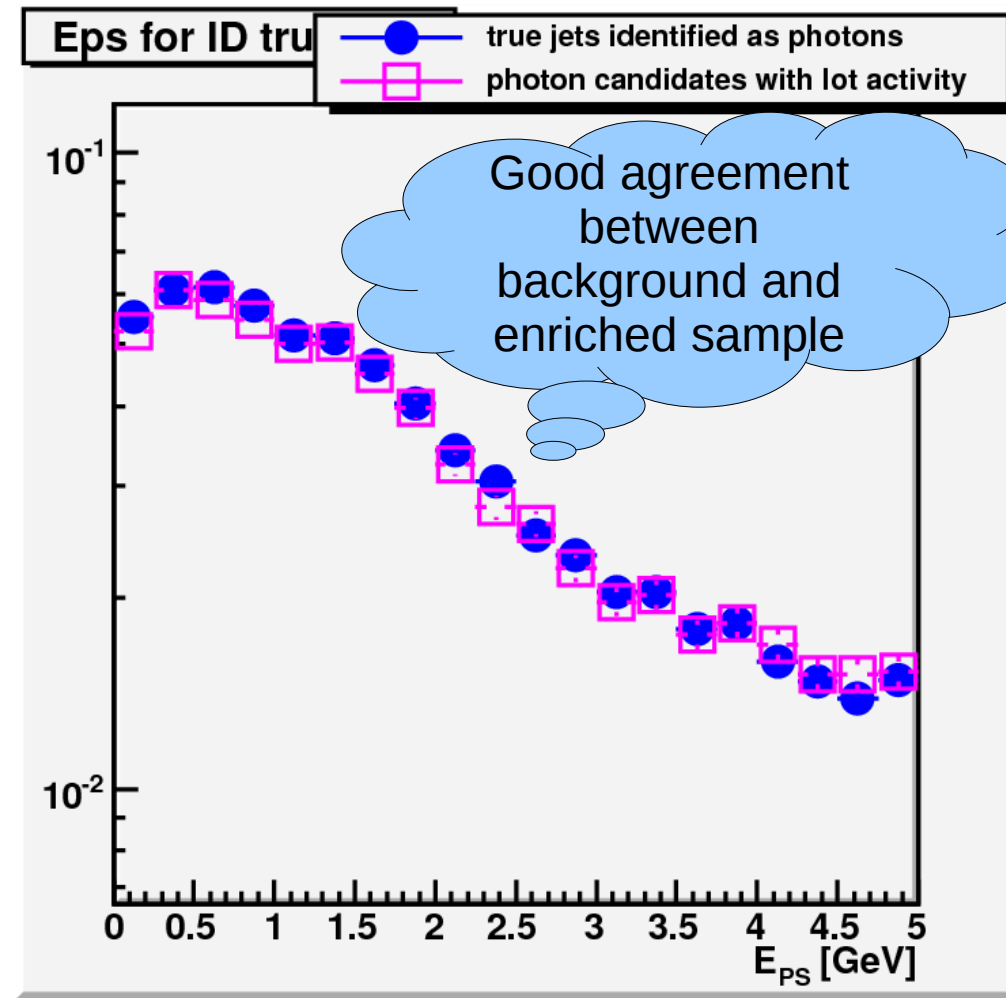
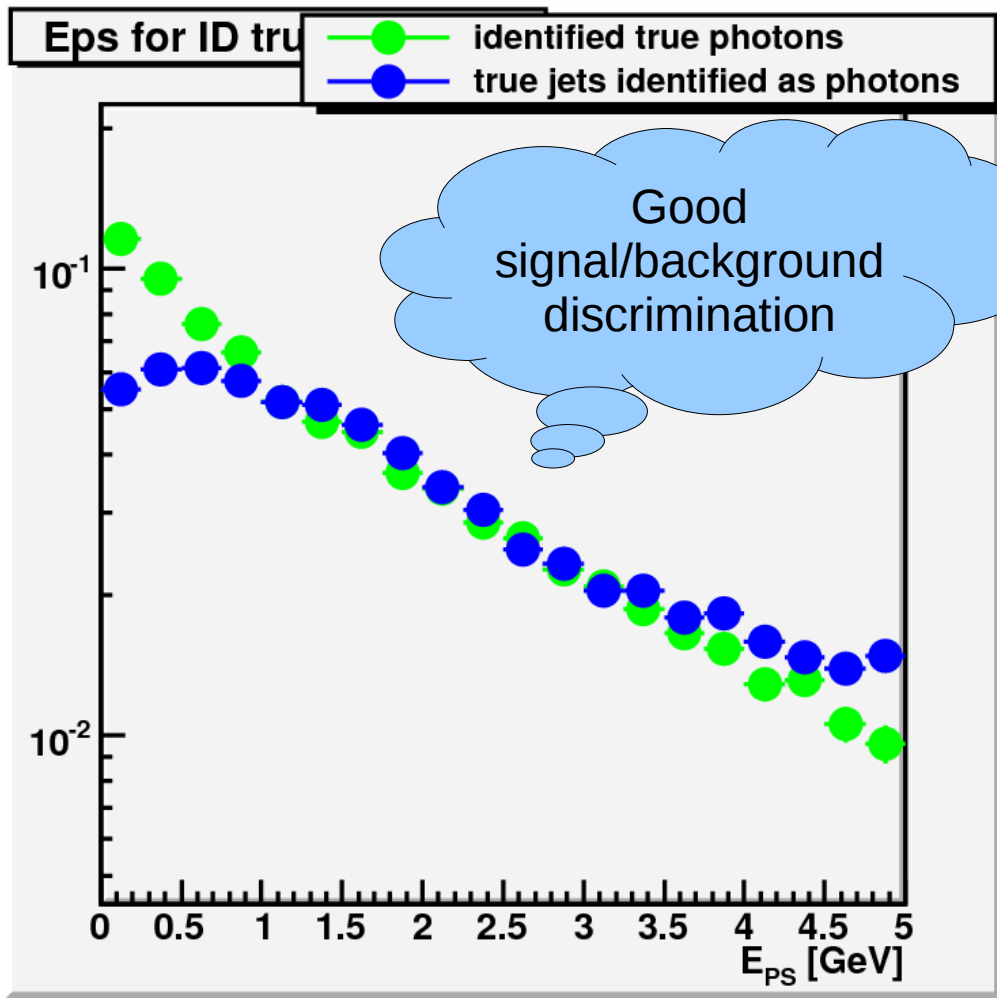


Obtaining “enriched jet” sample



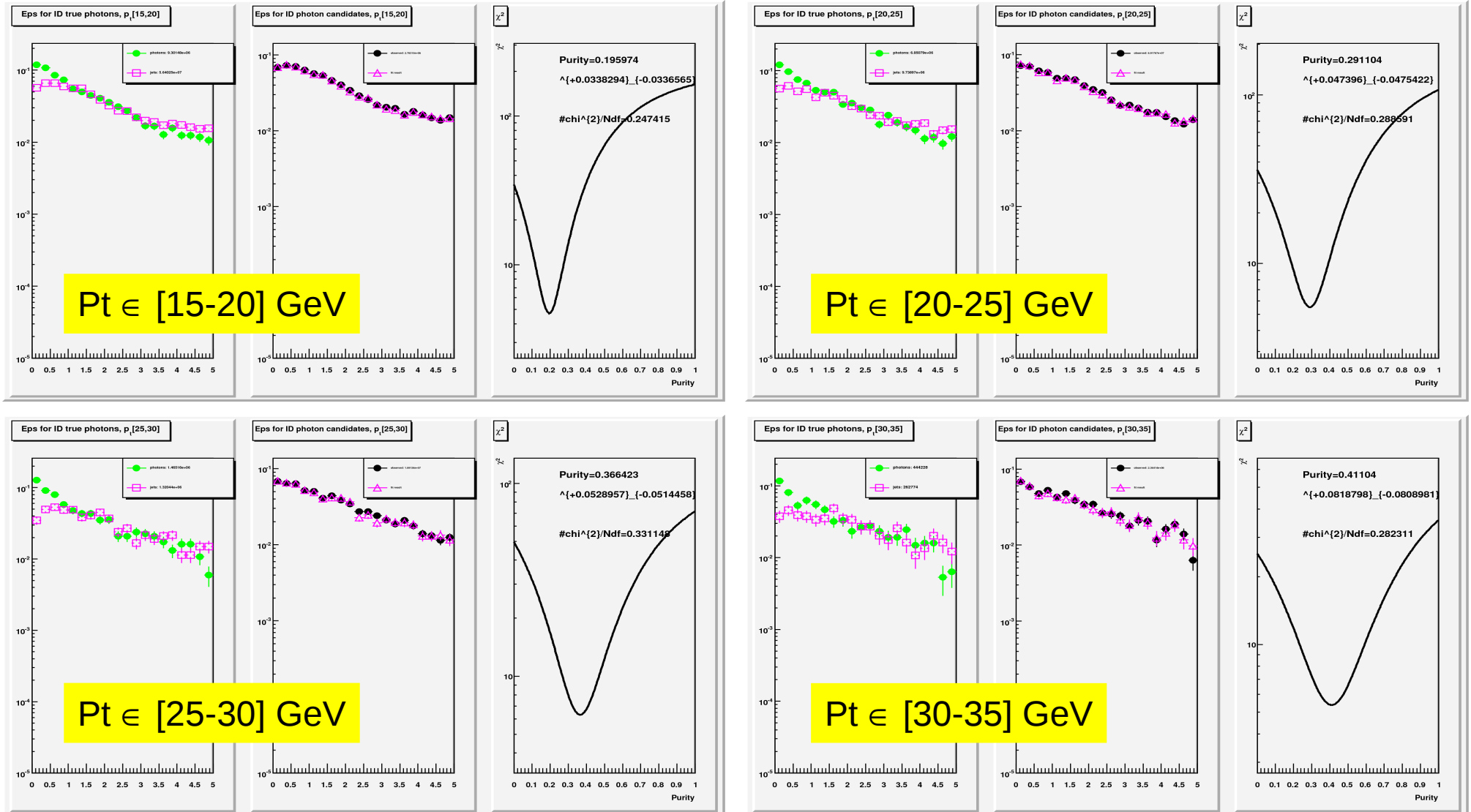
- Pdf of background: do we trust the fragmentation model?
 - \Rightarrow try to estimate $\Pi^{\text{jet}}(\xi)$ from data, using “enriched jet” sample
- Require some track activity:
 - $\Sigma_{\text{tracks}} p_t > 1 \text{ GeV}$; (cone 0.3)
 - Reject $\sim 90\%$ signal photons
 - ~ 1200 photons survive
 - Keep $\sim 50\%$ background
 - $\sim 17\,000$ fakes survive
 - $\Rightarrow \sim 7\%$ photon contamination in enriched jet sample

Enriched jet sample (cont'd)

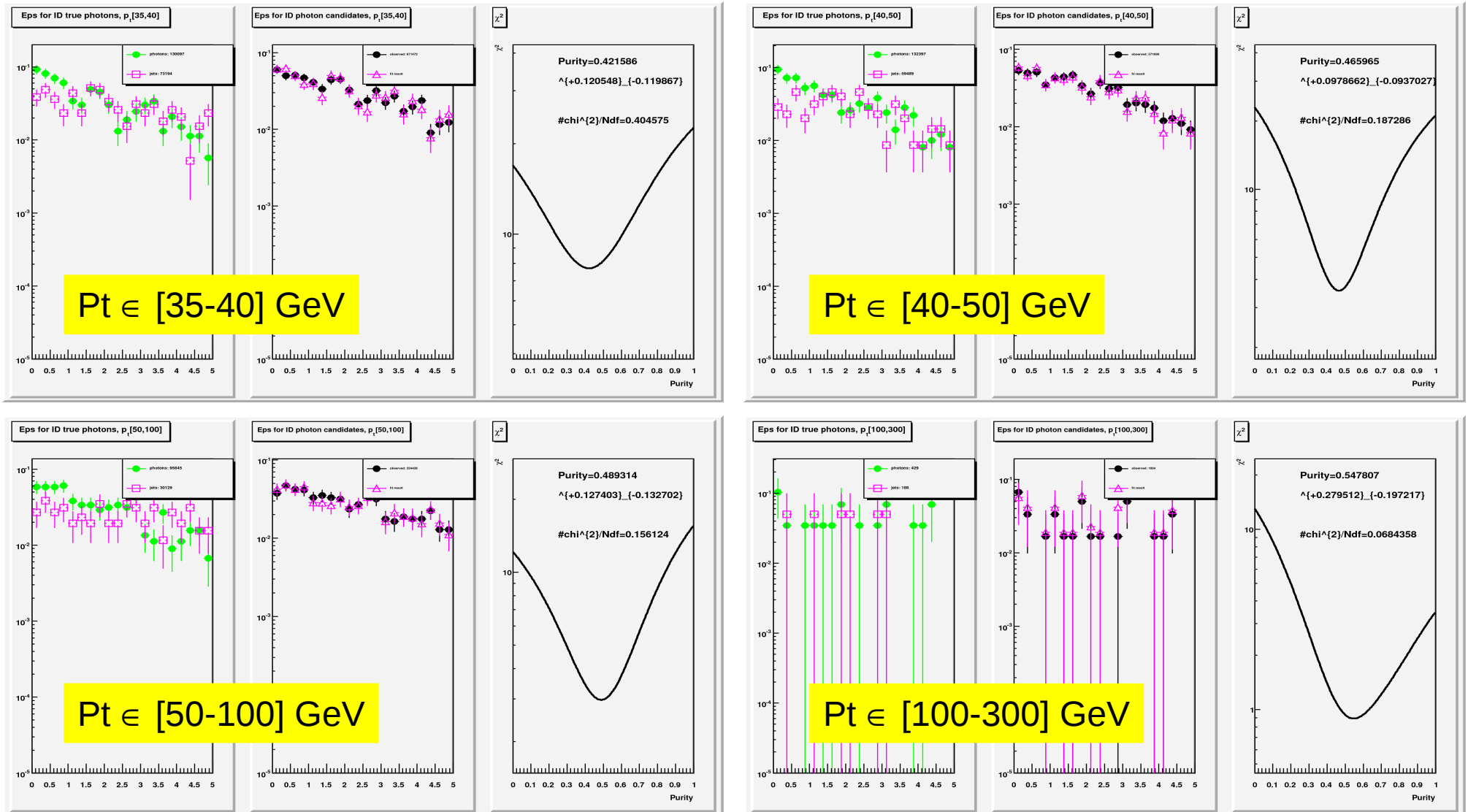


- This is inclusive, but purity and pdf's change with η and p_t :
need binning, depending on available statistics

Example: purity fit (several pt bins)



Example: purity fit (several pt bins)



Using detected conversion

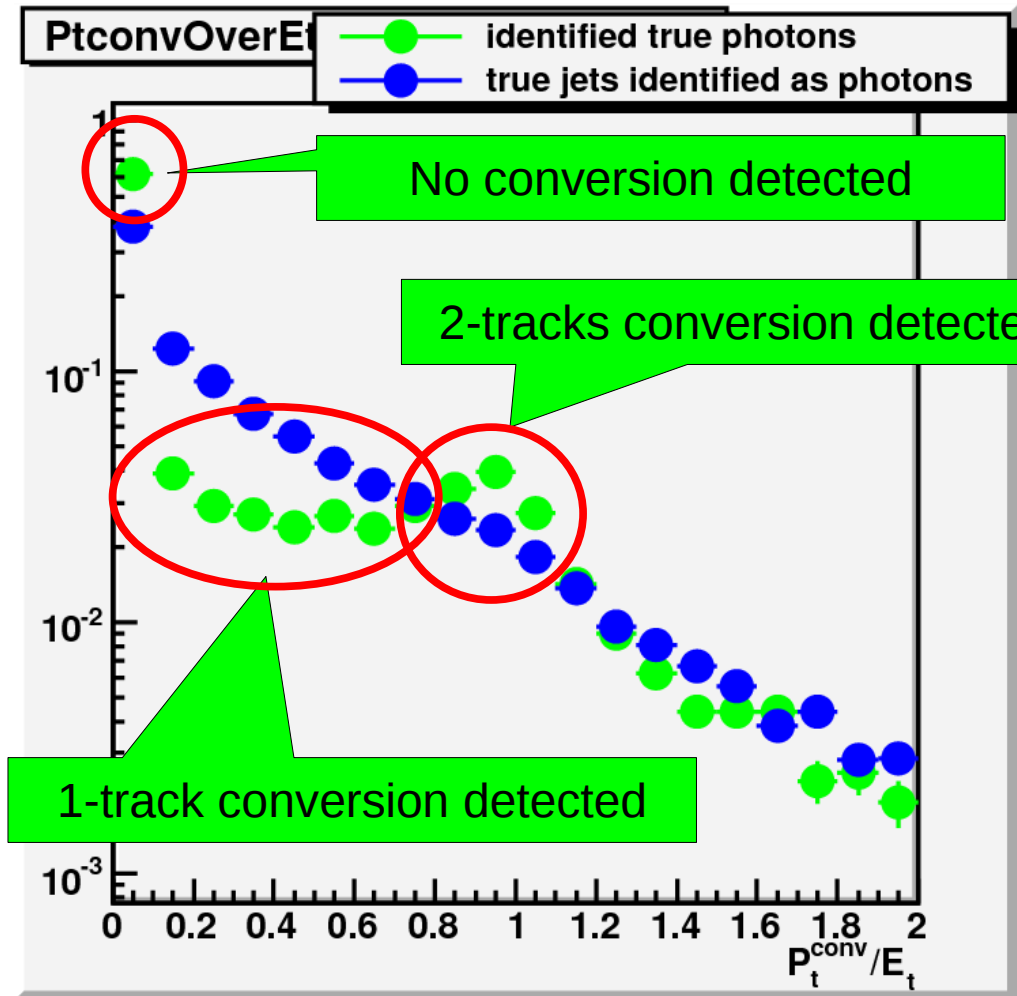
- Detected photon conversions:

- **2-tracks conversion:** 2-tracks vertex, displaced from primary vertex, with at least a track pointing to em cluster
- **1-track conversion:** em cluster with an associated track, without hits in B-layer

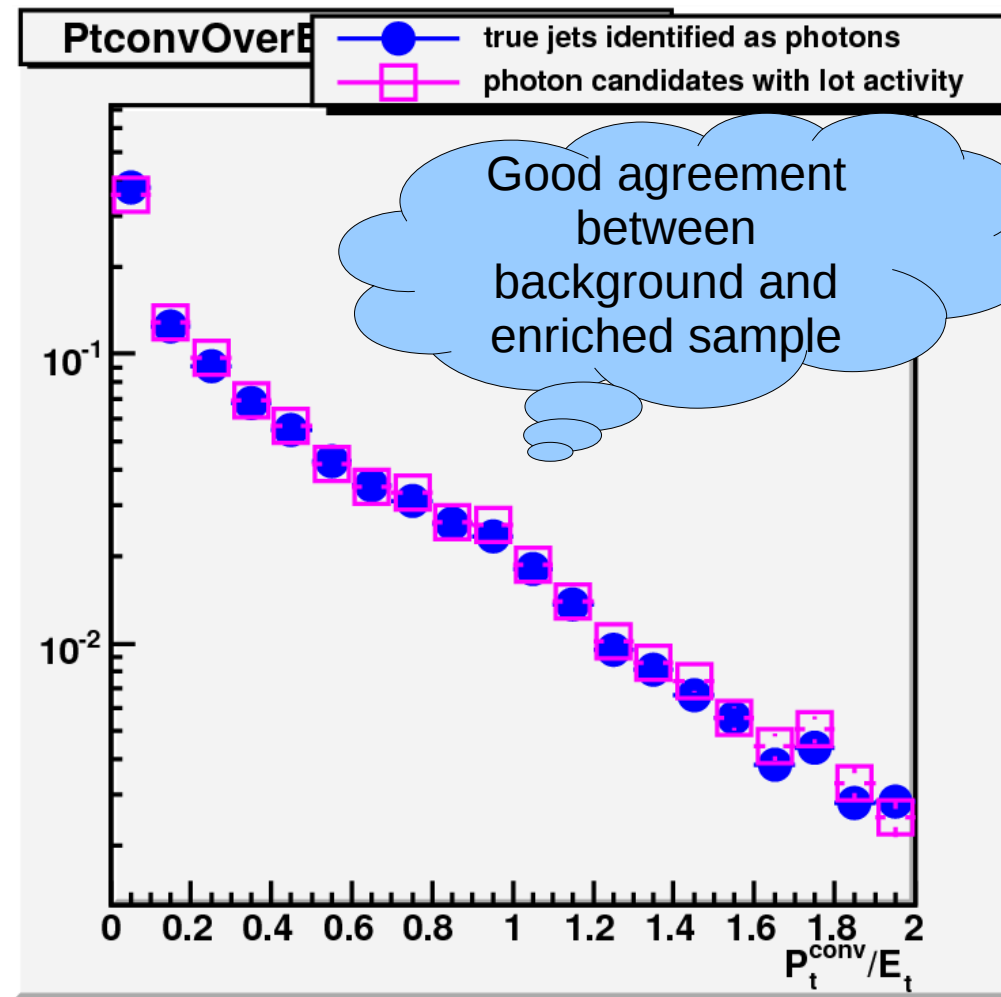
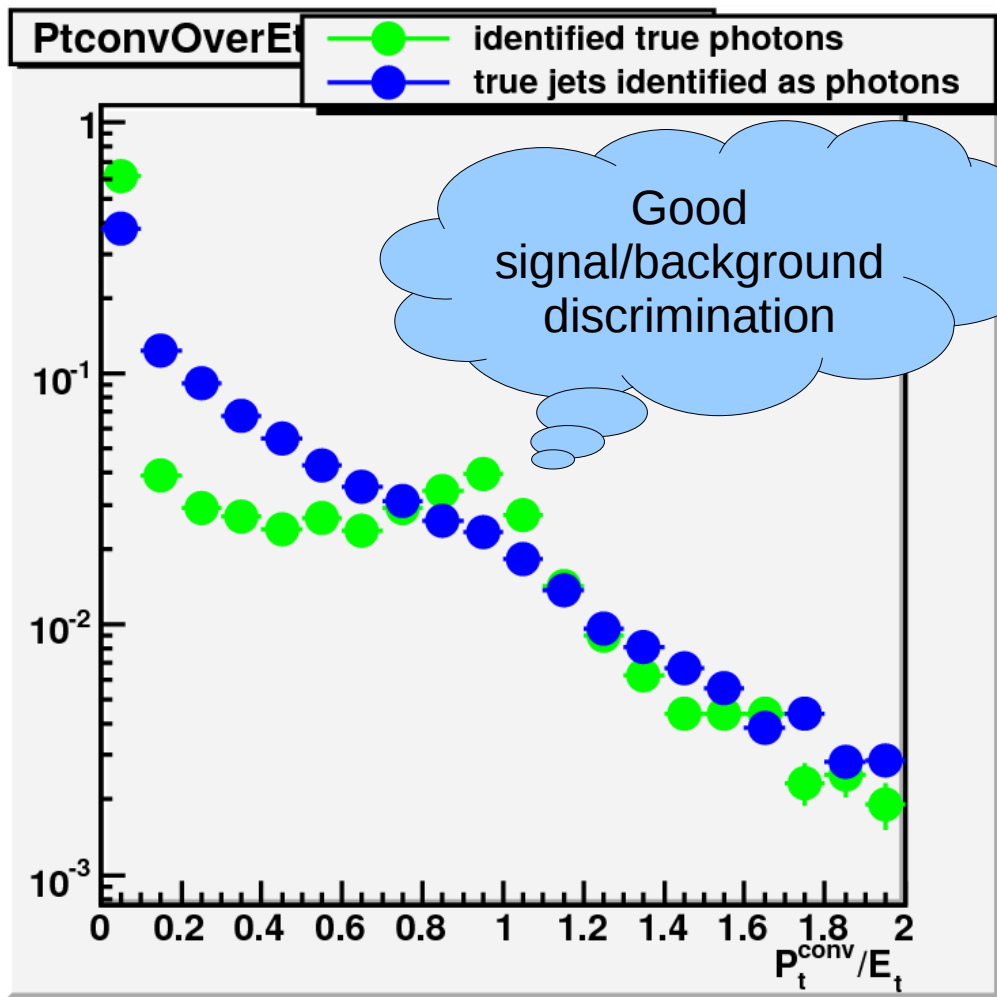
- Define P_t^{conv} as:

- $P_t^{track1} + P_t^{track2}$ for 2-tracks conv
- P_t^{track1} for 1-track conv

- Use $\xi \equiv P_t^{conv} / E_T$.



Using detected conversion (cont'd)



Purity using p_t^{conv}/E_t : result

