

Progress on the Kp2 scatter background

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PNN2 Analysis meeting
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Outline

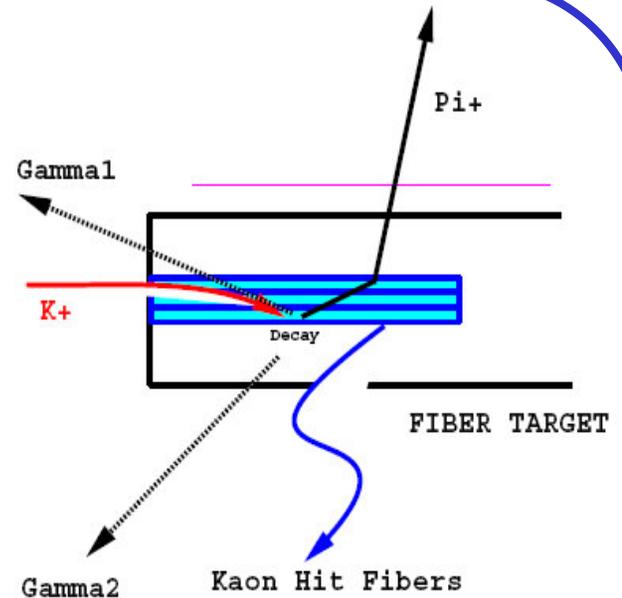
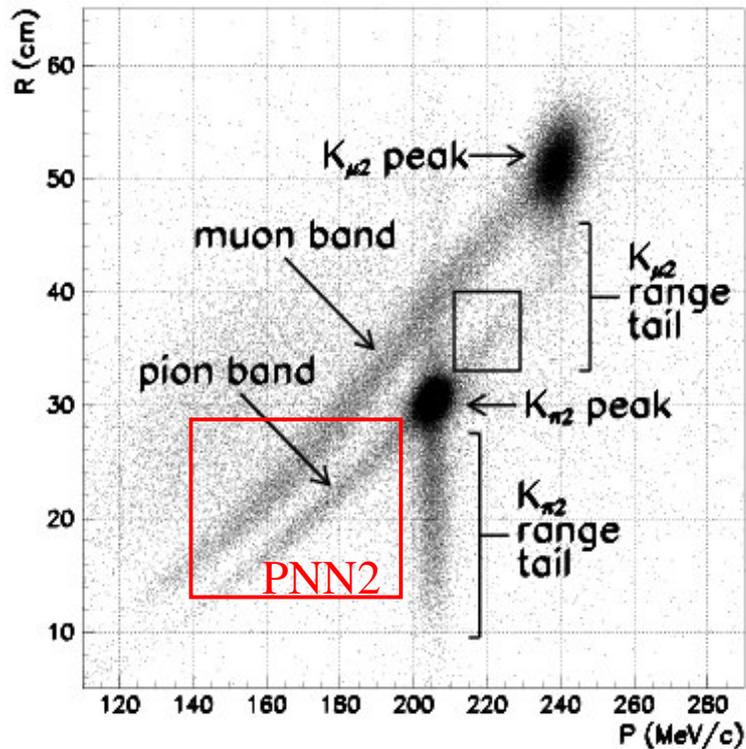
- Kink sample to tune PV on:
 - rej vs acc with new data
- AD:
 - some properties
 - rej & acc
- Classes:
 - intended list
 - introduce new classes: -B4EKZ, pnn2_rpbox kp2_ebox
- To be done

Introduction

Main PNN2 bg mechanism: $K_{\mu 2}$ with π^+ scatter in target

- Simultaneous shift in range, momentum AND energy (through range)
- Photons head near beam direction, the weakest PV region of the detector

Attacked by PV and scattering cuts (xy-pattern & double pulse in the TG fiber)

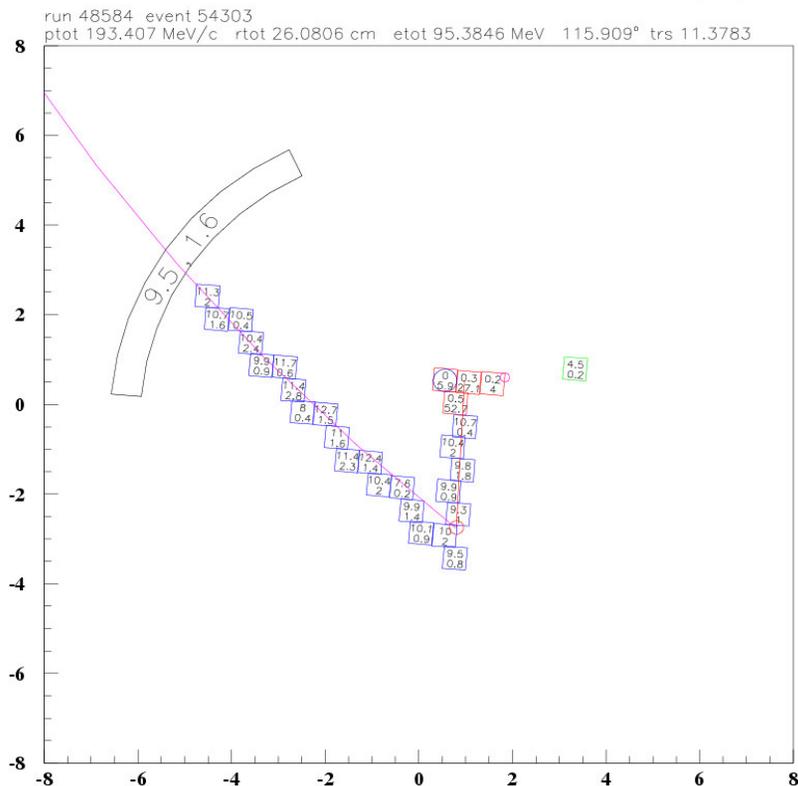


Calculated backgrounds in E787

$K^+ \rightarrow \pi^+ \pi^0$ scatters	1.026 ± 0.227
$K^+ \rightarrow \pi^+ \pi^0 \gamma$	0.033 ± 0.004
$K^+ \rightarrow \mu^+ \pi^0 \nu$ and $\mu^+ \nu \gamma$	0.016 ± 0.011
Beam	0.067 ± 0.043
$K^+ \rightarrow \pi^+ \pi^- e^+ \nu$	0.052 ± 0.037
CEX	0.025 ± 0.018
Total	1.219 ± 0.235
Sg/bg	$\sim 1/10$

Method

Scattering introduces **PV-kinematic correlation**, that was not there for PNN1 \Rightarrow PV rejection has to be measured in the PNN2 kinematic box, unlike in PNN1



Solution:

- Tune PV on *uncorrelated* “kink” sample of xy-scatters in the PNN2 box (“kink finder” thanks to Benji)
- Measure PV rejection on *many different samples* (“classes”) of scattered events, tagged by different “target quality” criteria \Rightarrow get a central value and an estimate of the systematic error.

Kink sample ready: setup cuts

All SKIM8

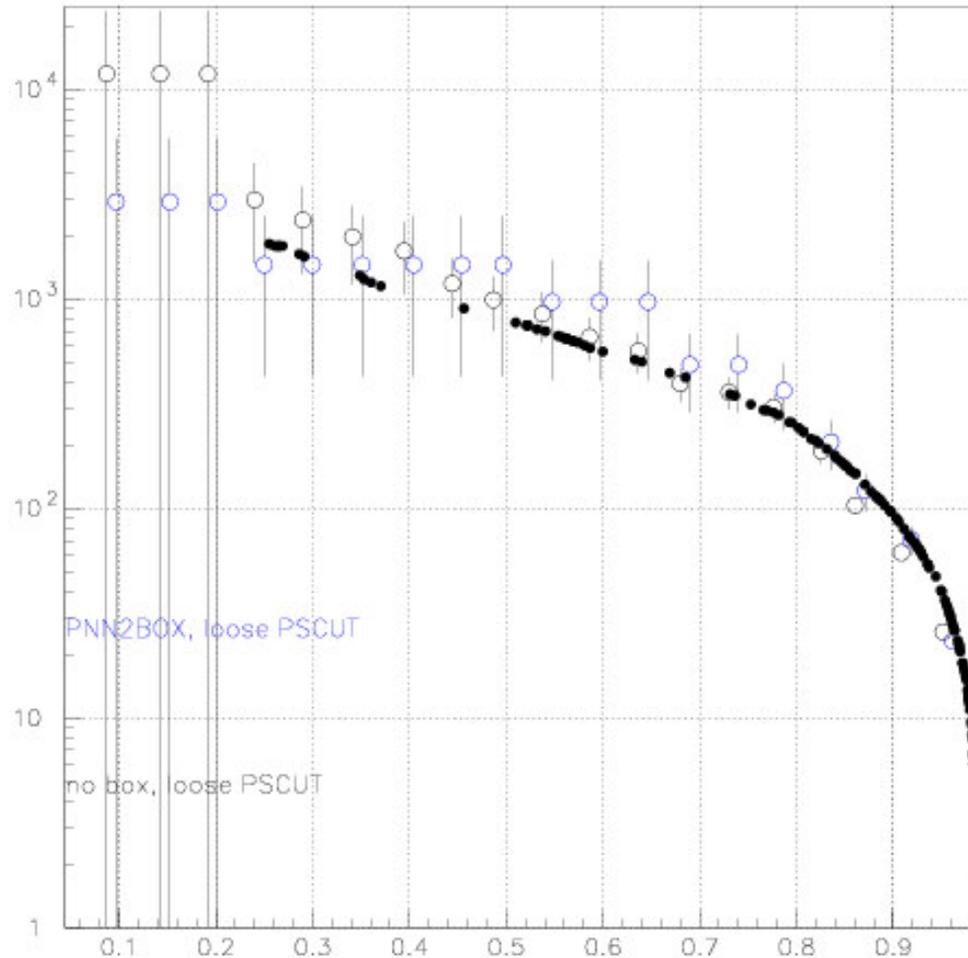
“good” kinks

- Got rid of TDCUT from SKIM1/5 to gain statistics. Muons are cut kinematically.
- Loosened PRRF (in KINCUTS) to take into account that PNN2 pions barely reach the 1st RSSC.
- Loosened RSDedx (in KINCUTS) and UTCQUAL.
- PSCUT02_KINK is a loosened version of PSCUT02, without cuts on the TG pattern, that explicitly eliminate xy kinks.
- Some TGQUAL cuts are skipped (the ones with 0's), because they eliminate kinks.
- The PVCUT applied last uses the loosest PNN1-optimized parameters (at ~95% acceptance)

CUTS	no box, no DELCO	PNN2BOX	DELCO6	links
	1191193	316342	237923	1049880
SKIM1	211185	64383	84754	181110
RECON	199105	58877	77860	170328
KINCUTS	53574	27064	23920	49086
PSCUT02_KINK	23962	11723	18619	20721
PTOT.LT.225	23838	11723	18517	20695
TGPVCUT	22588			20473
B4TIM	0	0	0	0
B4EKZ(IC)	0	0	0	0
TGZFOOL	22585	11610	18311	20470
EPITG	0	0	0	0
EPIMAXK	0	0	0	0
TARGF	22068	11436	17912	20006
DTGTTP	22068	11436	17912	20006
RTDIF	21441	11133	17389	19445
DRP	0	0	0	0
TGKTIM	21252	11025	17305	19274
EIC	20315	10543	16544	18500
TIC	20315	10543	16544	18500
TGEDGE	19564	10068	15937	17858
TGDEDX	0	0	0	0
TGENR	0	0	0	0
PIGAP	19239	9862	15670	17555
TGB4	14089	7335	11431	12873
PHIVTX	0	0	0	0
OPSVETO	13077	6964	10603	11909
TIMKF	13077	6964	10603	11909
TGER	13077	6964	10603	11909
NPITG	13077	6964	10603	11909
TGLIKE	0	0	0	0
ALLKFIT	13037	6941	10568	11872
TPICS	13037	6941	10568	11872
EPIONK	0	0	0	0
DELCO3	12994	6934	10568	11833
KINKCUT	11833	6592	9634	11833
PVCUT	461	294	363	461

Kink sample ready: result

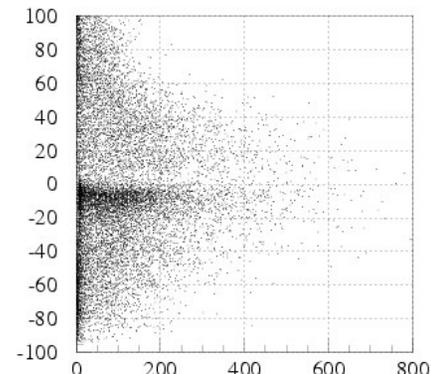
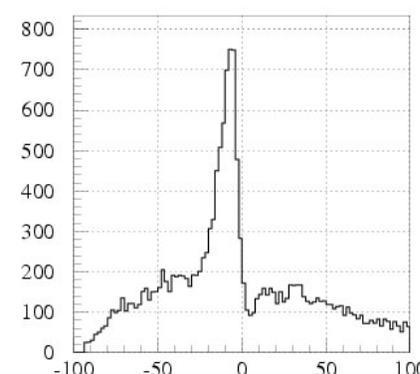
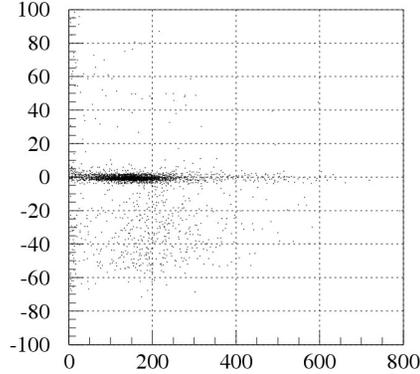
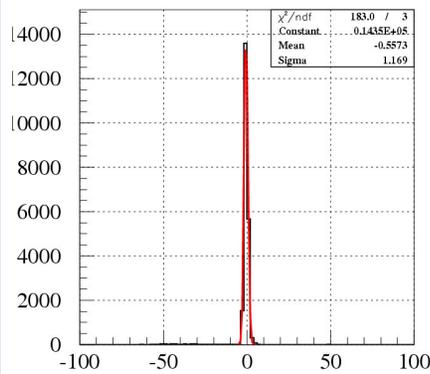
PV offline rejection vs acceptance for kinks: at the same level with the $K^+ \rightarrow \pi^+ \pi^0$ peak (not tuned yet). It includes BV TDs.



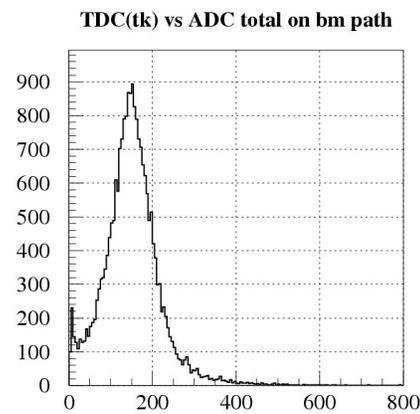
AD: TDC vs ADC

- Adequate PSCUTs, KINCUTs, TGQUAL, DELCO3 and *the loosest PV (at ~95% acceptance)* are applied as setups to all samples (Km21, Kp2 peak, kinks)
- Find which sectors are hit by the incoming K^+ , by extrapolating the path from the BWC and the B4
- Do the same with beam particles at TRS (equivalent to a tighter PSCUT)
- For the K^+ (*wrt tk*), find the hit time closest to the peak and sum the energy in the hit sectors
- For the PV (*wrt trs*), find the hit time closest to the peak and sum the energy in the remaining sectors

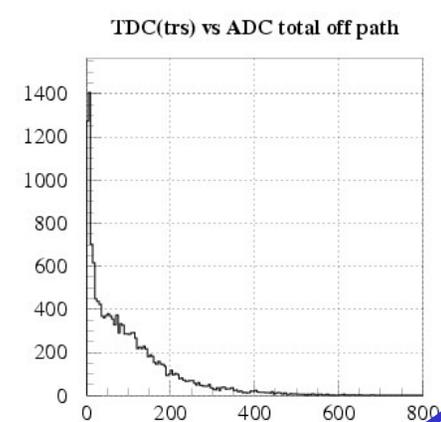
Acceptance sample: Km21 monitors



Time wrt tk

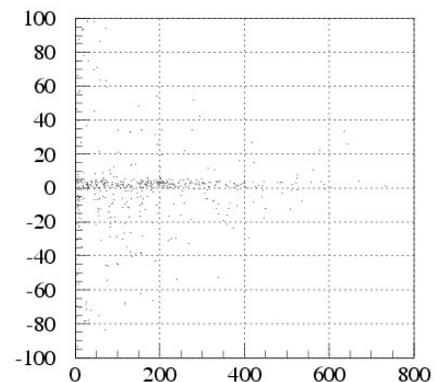
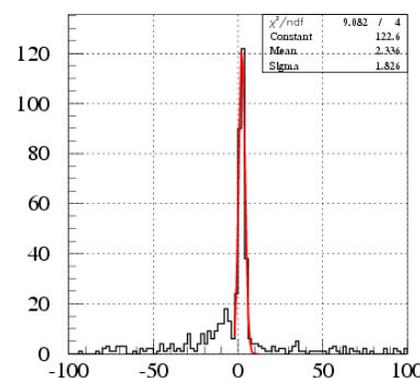
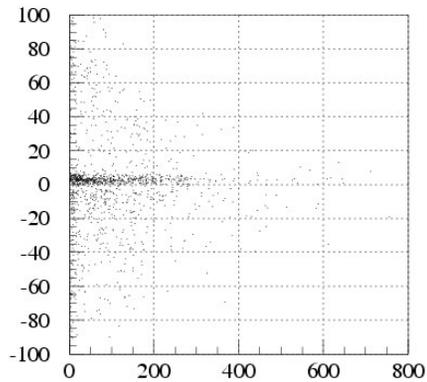
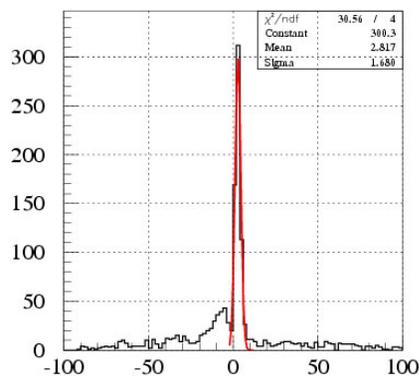


Time wrt trs

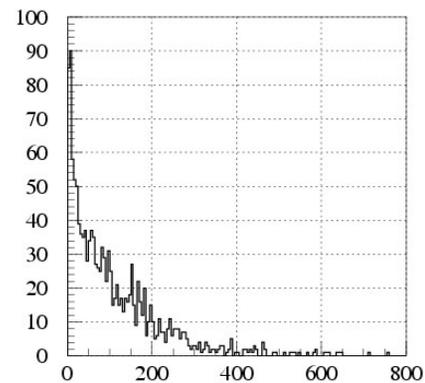
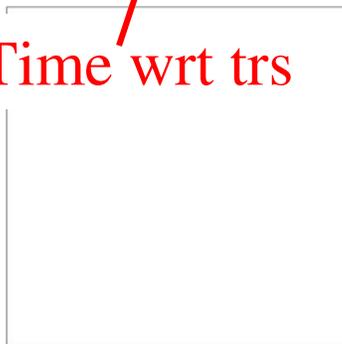


AD: TDC vs ADC

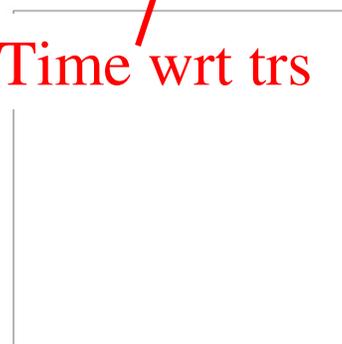
Rejection samples: Kp2 peak from pnn1or2 data & kinks



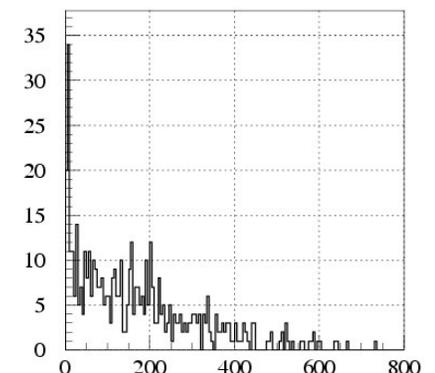
Time wrt trs



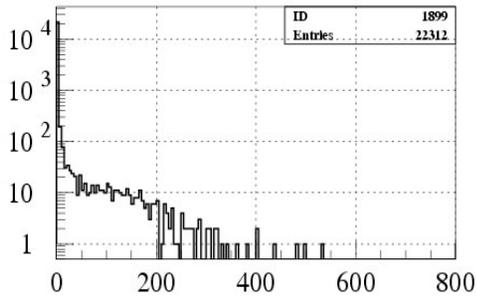
Time wrt trs



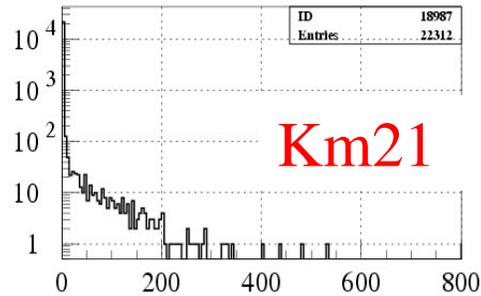
TDC(trs) vs ADC total off path



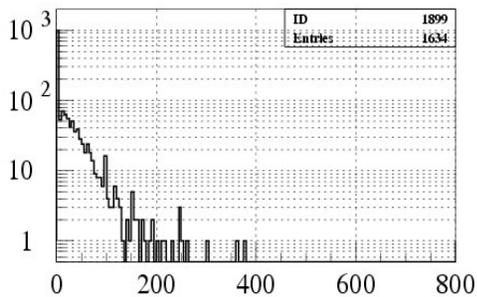
AD: rejection & acceptance



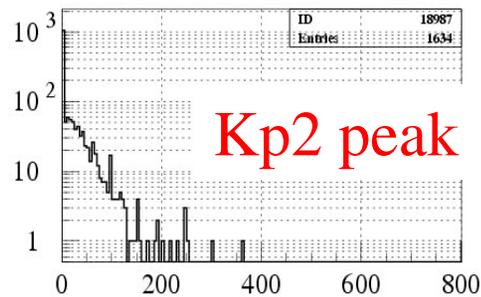
Total ADC at trs only



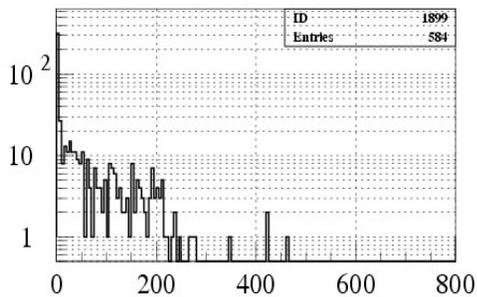
Total ADC off path, at trs only



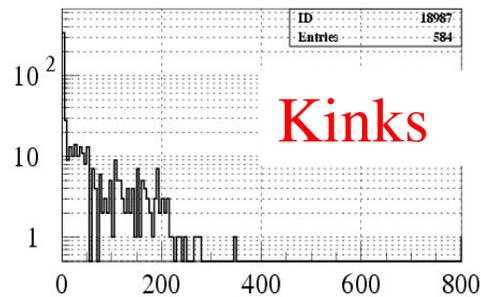
Total ADC at trs only



Total ADC off path, at trs only



Total ADC at trs only



Total ADC off path, at trs only

- Left column: sum the energy of sectors with hits at (0ns,10ns) wrt trs, but no hits at (-5ns,5ns) of tk
- Right column: same as above, but exclude sectors on any beam particle path (K⁺ near tk and/or anything at trs)

AD: rejection & acceptance

At 95% PV (setup w/o AD) acceptance		Km21 (acc)	Kp2 peak (rej)	Kinks (rej)
ADC/TDC	<i>At TRS only</i>	0.96 ± 0.001	1.64 ± 0.03	1.81 ± 0.07
	<i>At TRS only & out of path</i>	0.98 ± 0.001	1.54 ± 0.03	1.73 ± 0.05
CCD	<i>At TRS only</i>	0.94 ± 0.002	1.79 ± 0.04	1.95 ± 0.08
	<i>At TRS only & out of path</i>	0.97 ± 0.001	1.59 ± 0.03	1.80 ± 0.07

At 53% PV (setup w/o AD) acceptance		Km21 (acc)	Kp2 peak (rej)	Kinks (rej)
ADC/TDC	<i>At TRS only</i>	0.97 ± 0.002	1.76 ± 0.11	1.28 ± 0.14
	<i>At TRS only & out of path</i>	0.98 ± 0.001	1.61 ± 0.09	1.28 ± 0.14
CCD	<i>At TRS only</i>	0.95 ± 0.002	1.95 ± 0.14	1.28 ± 0.14
	<i>At TRS only & out of path</i>	0.98 ± 0.001	1.68 ± 0.10	1.28 ± 0.14

⇒ No PV-tightness dependent optimization needed for the AD

AD: open issues

- Time calibration of sectors relative to each other – there are small fluctuations.
- Time slewing: the time of the K^+ and photon peaks depend on the energy. Since photons deposit less energy in the AD, this effect partly accounts for the $\sim 3\text{ns}$ shift between the peaks.
- Remaining of shift: different calibration of TG and RS quantities \Rightarrow see time distributions wrt tpi (instead of trs).
- Measure AD rejection on other “classes” – see following slides.

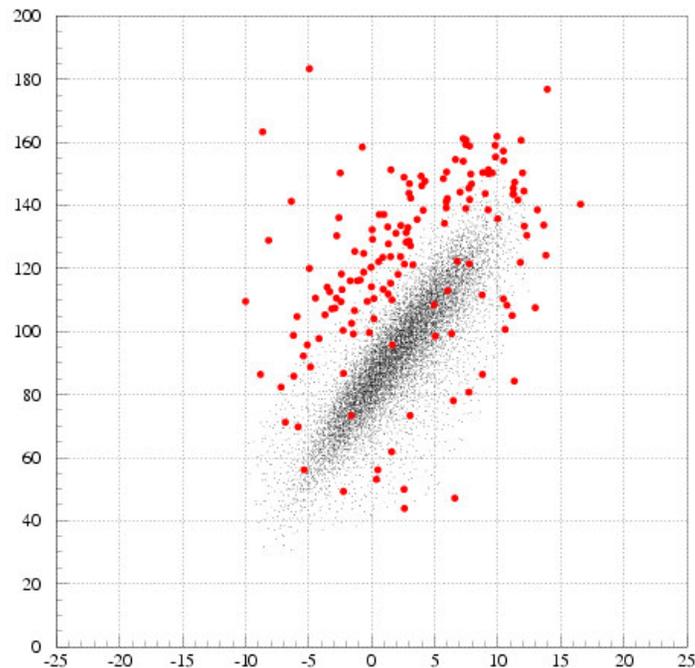
Classes of events (for rej measurement)

- Setup cuts (almost) the same as in kink sample: SKIM5 w/o TDCUT, RECON (BAD_BFIELD, STLAY, LAYV4), loosened KINCUT, whole PSCUT02, DELCO3
- Most likely will get rid of B4TIM (it was used in E787 because the double pulse fitter couldn't handle late Kaons)
- Every class has 3 “subclasses”: KP2BOX, PNN2BOX, PNN2RP-KP2E BOX
- The classes tagged with CCDPUL are meaningless for the moment.

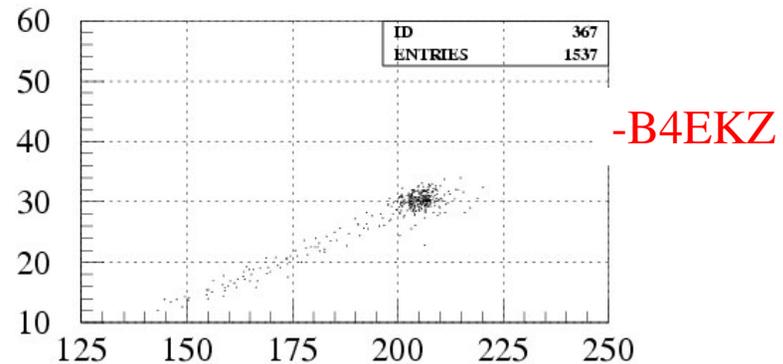
CLASS	TGCUTS
1	All cuts but B4TIM
2	All cuts
3	\overline{CCDPUL}
4	\overline{CCDPUL} , all others but B4TIM
5	\overline{CCDPUL} , all others
6	CCDPUL, TGZFOOL, EIC, OPSVETO, \overline{OTHERS}
7	CCDPUL, B4TIM, TGZFOOL, EIC, OPSVETO, \overline{OTHERS}
8	$\overline{CCDPUL, CHI567, VERRNG}$
9	$\overline{CCDPUL, CHI567, VERRNG}$, all others but B4TIM
10	$\overline{CCDPUL, CHI567, VERRNG}$, all others
11	$\overline{CHI567, VERRNG}$
12	$\overline{CHI567, VERRNG}$, all others but B4TIM
13	$\overline{CHI567, VERRNG}$, all others
14	$\overline{CCDPUL, CHI567, VERRNG, KIC, PIGAP, TARGF, TPICS}$
15	$\overline{B4EKZ}$
16	$\overline{B4EKZ}$, all others but B4TIM
17	$\overline{B4EKZ}$, all others

New classes

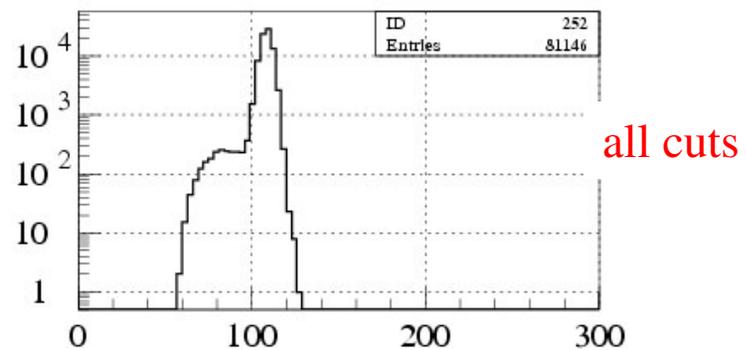
- B4EKZ cuts on a likelihood built from the B4 energy, ek and UTC-extrapolated tgz. Disagreement between them means a wrong decay z – a z kink!
- Kp2 events with the correct etot but ptot and rtot in the PNN2BOX are also good candidates for z scatters, as the momentum is mismeasured and the range depends on it.
- We can use these 2 classes for another way to tag z scatters, besides CCDPUL.



ek vs tg, KP2BOX (all cuts) &
PNN2BOX (-B4EKZ)



rtot vs ptot CLASS 17



etot CLASS2

Future

- Finalize PV cut: re-optimize on the Kp2 peak, then tune by eye on the kink sample.
- DPV has shown little promise. Revisit?
- As soon as CCDPUL is ready, can calculate the Kp2-scatter background.