Photon veto status

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E949 Analysis Meeting

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Photon veto requirements

- Need $O(10^{12})$ $K_{\pi 2}$ suppression:
  $O(10^6)$ from kinematics
  $O(10^6)$ from photon veto

- Online, offline rejection: $O(10^4)$, $O(10^2)$

- Should also suppress radiative decays

- Should be uncorrelated with $(E, P, R, \cos\theta)$

- Optimal acceptance desirable

- Would like some rejection "in reserve" for candidate event evaluation function, and "outside-the-box" studies

Major elements of photon veto

- Barrel Veto (BV): Pb/scintillator
- Endcaps (EC): CsI crystals + 500 MHz CCD transient digitizers
- Inner upstream ring of EC (EC1)
- Rangestack (RD): scintillator + 500 MHz transient digitizers

Not-so-major elements of photon veto

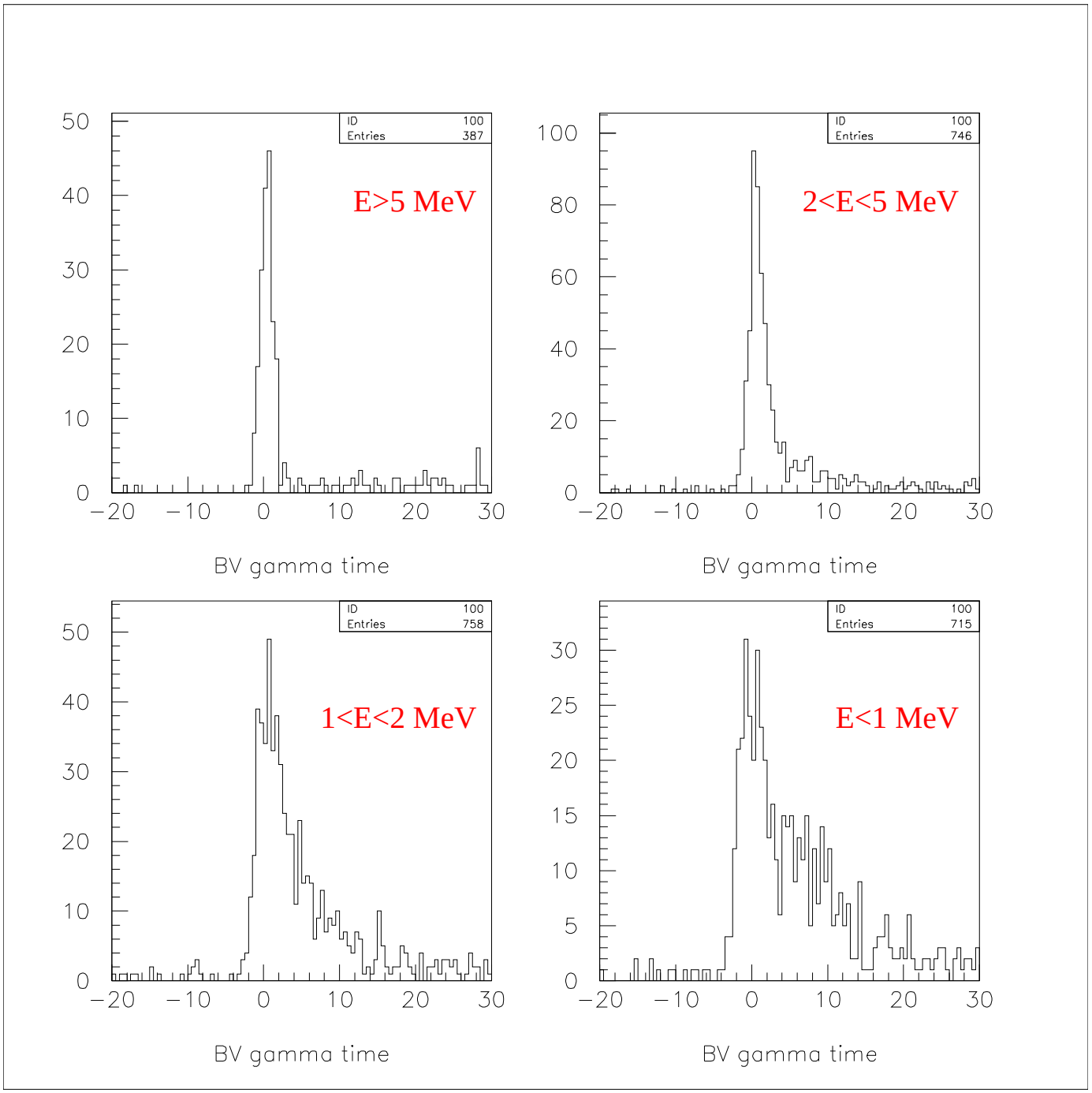
- I-counters/V-counters (IC/VC): scintillator
- Target (TG): scintillating fiber
- Collar (CO): Pb/scintillator
- μ-collar (CM): very small angle; downstream only
- Various "single-ended" hit categories from BV/RD
- EC "second hits" (EC2)

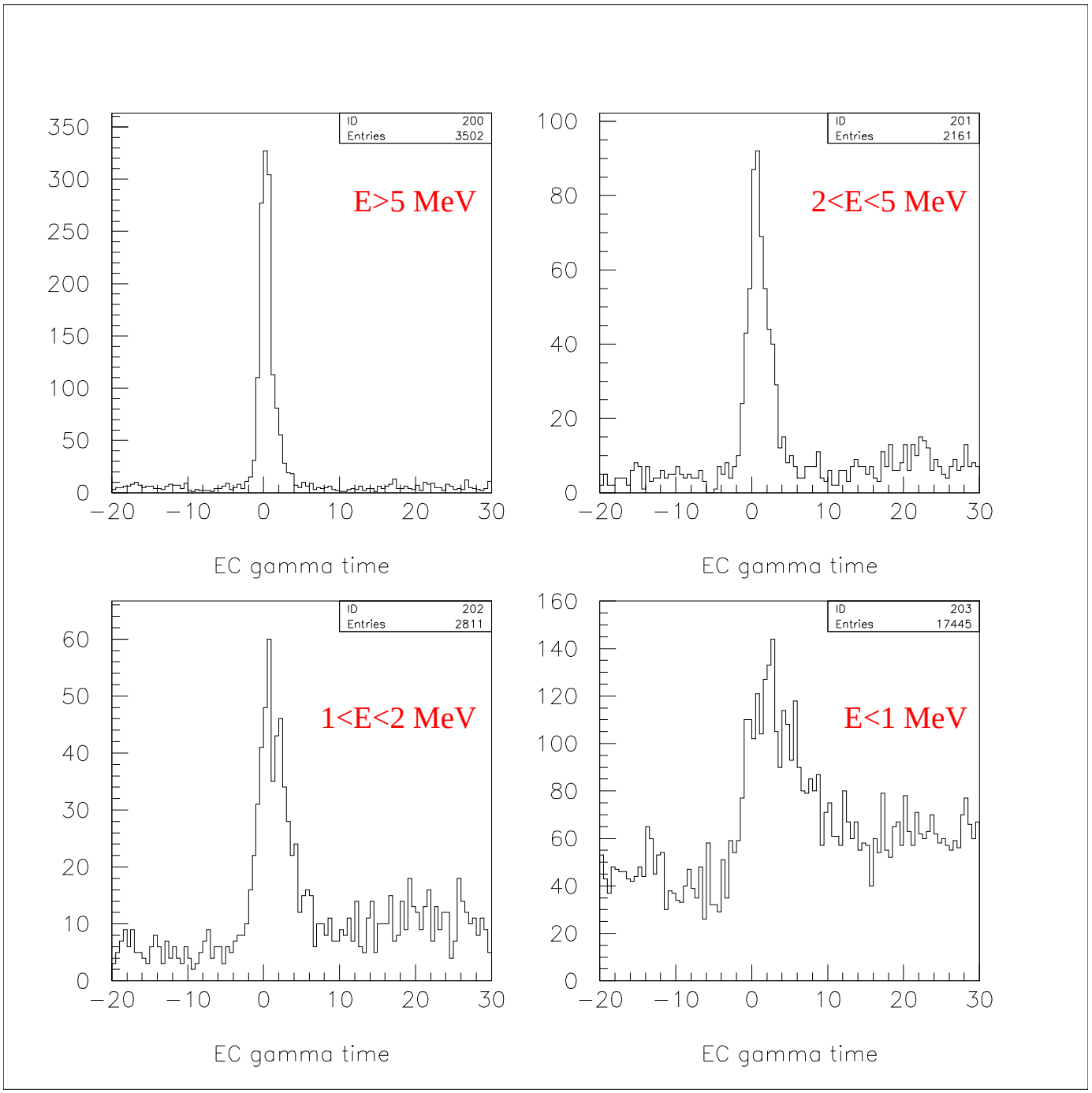
Energy and timing resolution

- Energy resolution is not a primary concern for PV, as $E_{veto} \sim 1\,MeV$

- Timing spectra of accidental hits typically flat, so good timing resolution is important to preserve acceptance; in particular, good *low-energy* timing resolution.

- For BV/RD, photonuclear tails dominate resolution at low energy.


ID 100
Entries 387
E>5 MeV
BV gamma time
ID 100
Entries 746
2<E<5 MeV
BV gamma time
ID 100
Entries 758
1<E<2 MeV
BV gamma time
ID 100
Entries 715
E<1 MeV
BV gamma time


ID 200
Entries 3502
E>5 MeV
EC gamma time
ID 201
Entries 2161
2<E<5 MeV
EC gamma time
ID 202
Entries 2811
1<E<2 MeV
EC gamma time
ID 203
Entries 17445
E<1 MeV
EC gamma time

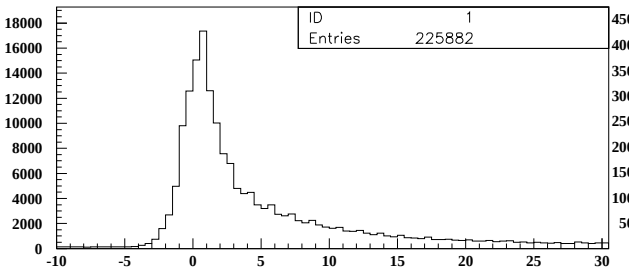
Online photon veto

- BV, EC, RD
- High thresholds ($\sim 10\,MeV$), narrow windows
- Too much rejection **not good**: kinematic background study would run out of statistics!

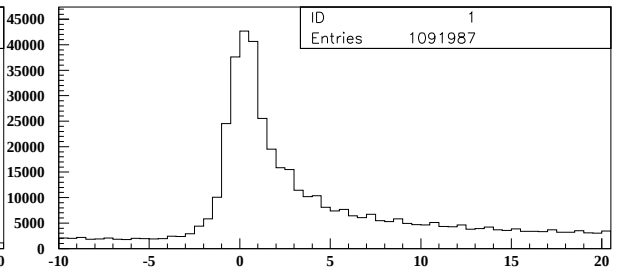
Offline photon veto optimization

- Use $K_{\pi 2}$ (rejection) and $K_{\mu 2}$ (acceptance) events simultaneously to optimize photon veto properties.
- Apply the same "setup" cuts to both samples; ideally, the optimization is done after all other cuts have been applied.
- Optimization starts with a set of 3 plausible parameters for each subdetector: T_{off}, the timing offset; W, window $1/2$-width; E_{min}, the energy threshold.
- Veto is an "OR" of vetoes for different subdetectors, so only "internal" energy/timing calibrations are important.

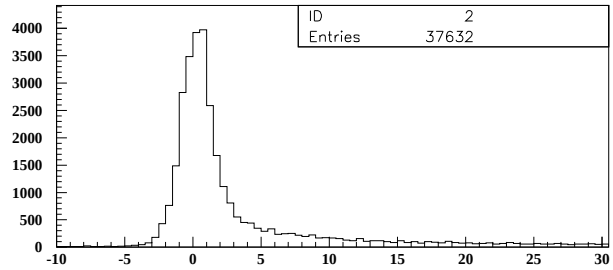
- For each subdetector, examine only those events that are vetoed by no *other* subdetector, as timing and energy properties are correlated.



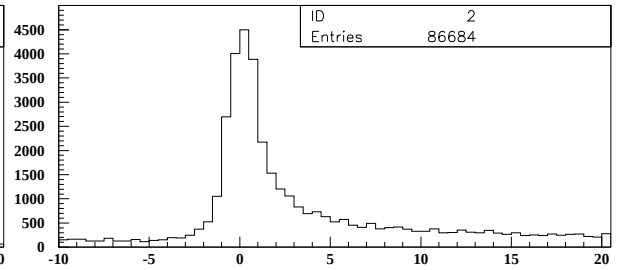
BV time (other veto)



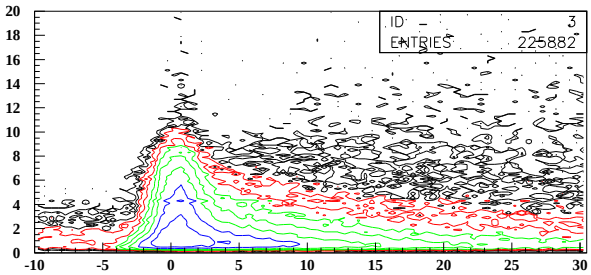
EC time (other veto)



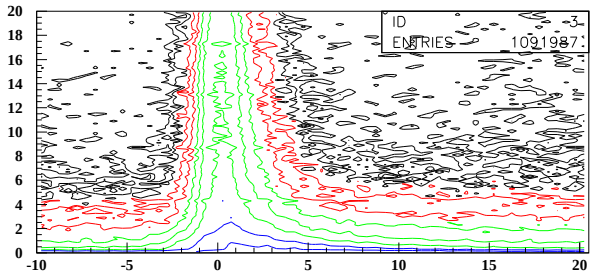
BV time (no other veto)



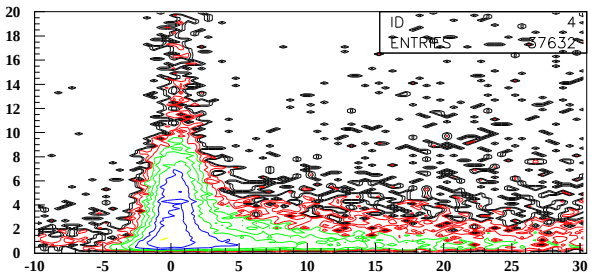
EC time (no other veto)



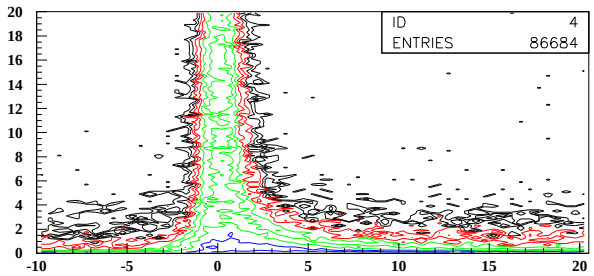
BV energy v. time (other veto)



EC energy v. time (other veto)



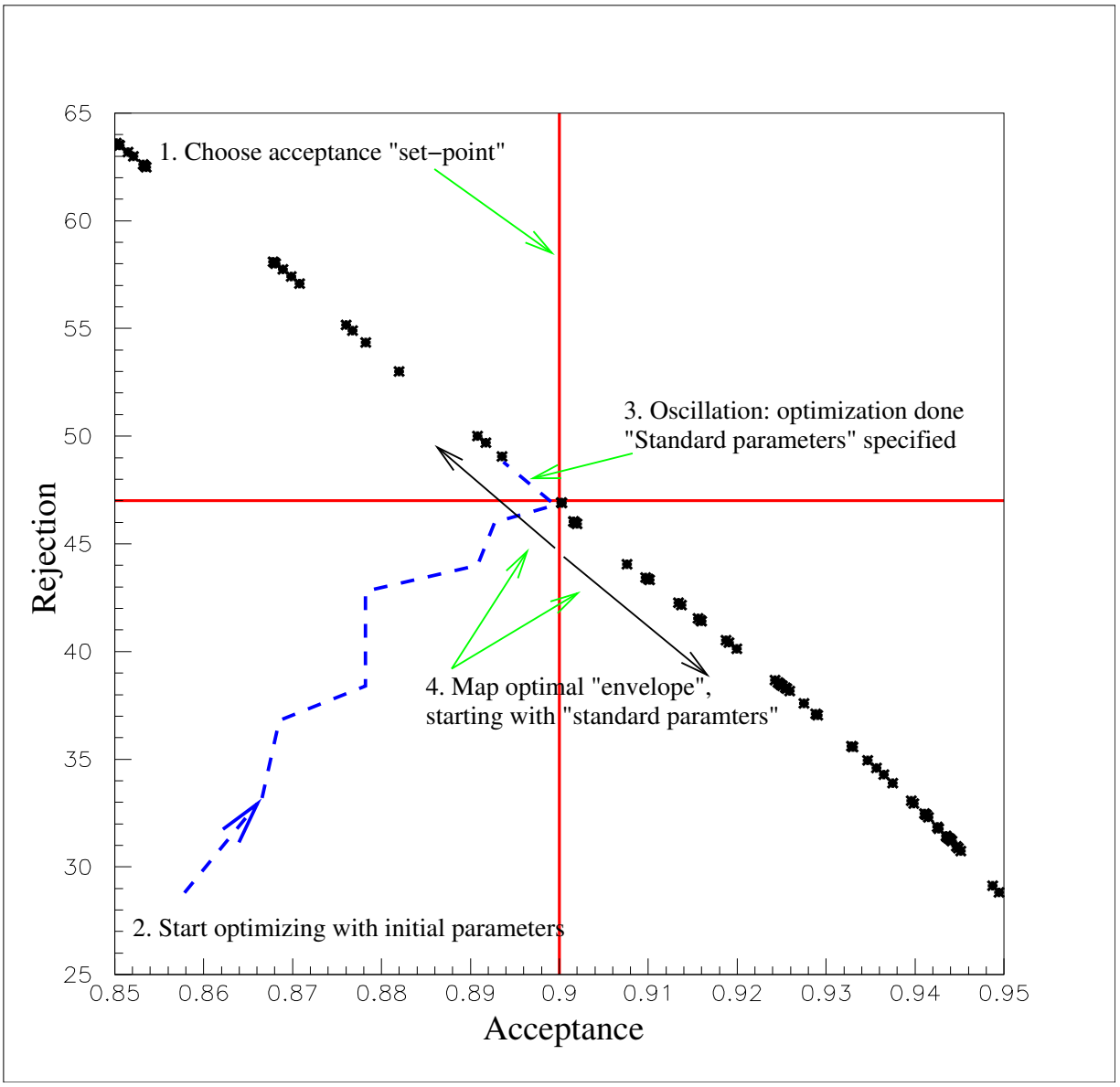
BV energy v. time (no other veto)

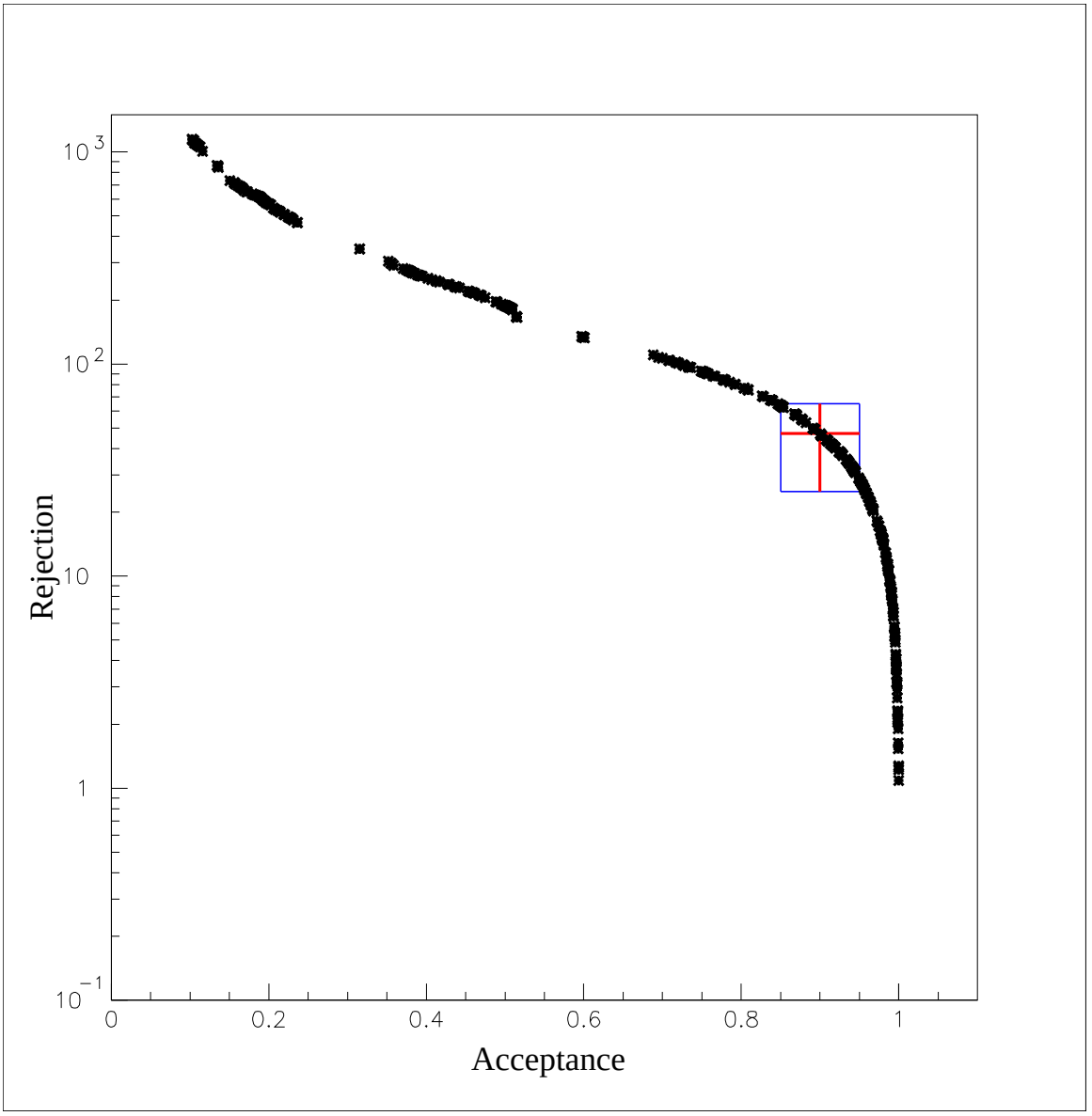


EC energy v. time (no other veto)

- Do a search (limited range; fixed step size) in the (T_{off}, W, E_{min}) parameter space; measure R and A for each set of parameters.

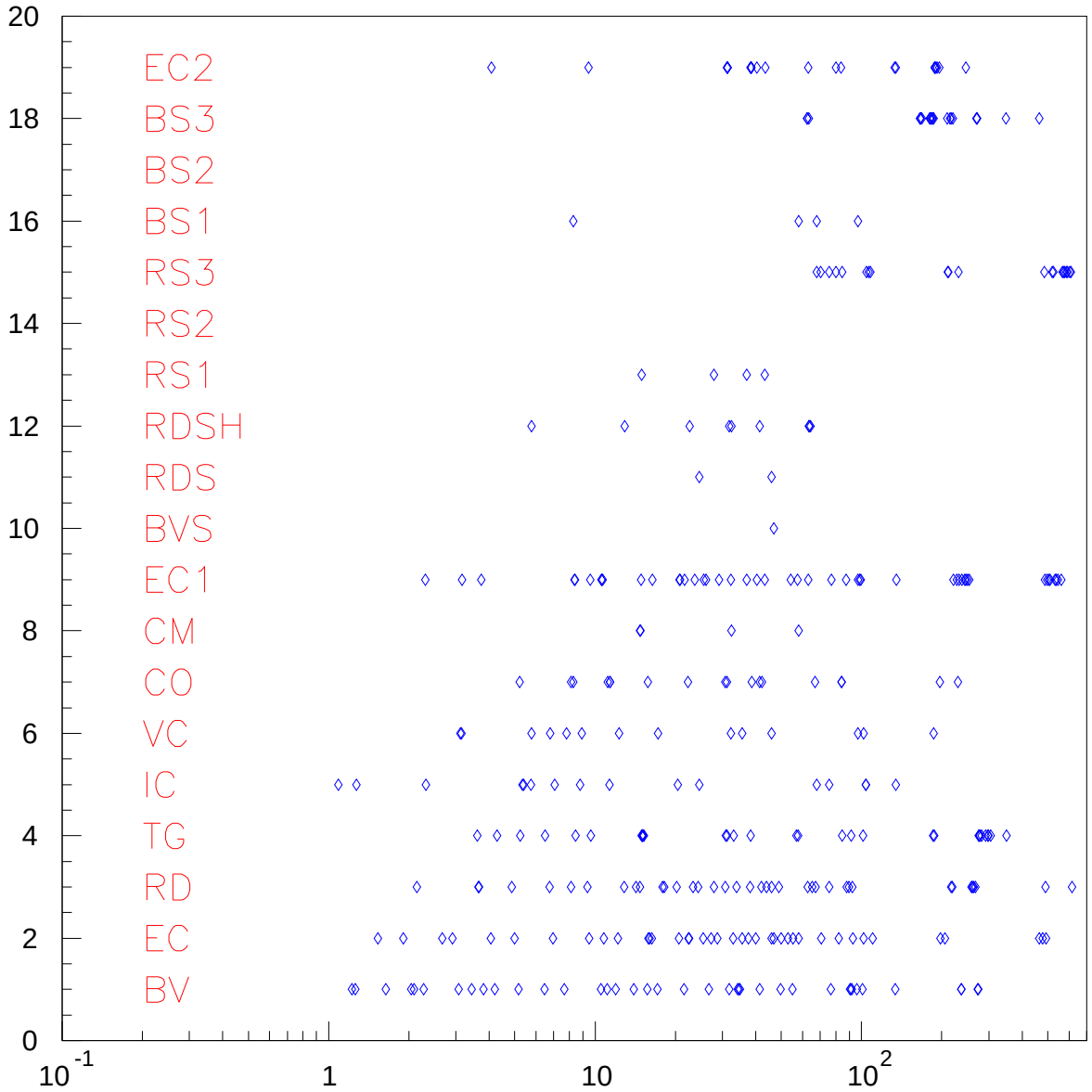
- Choose "best" R:A improvement from amongst all subdetectors



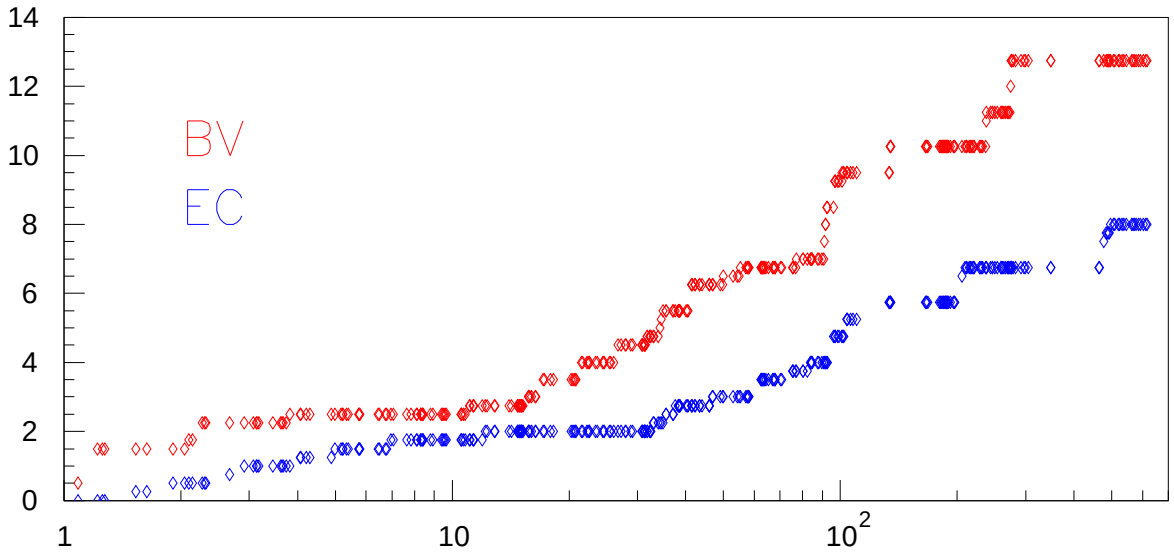

Rejection
Acceptance
10^3
10^2
10
1
10^{-1}
0
0.2
0.4
0.6
0.8
1

Optimization properties

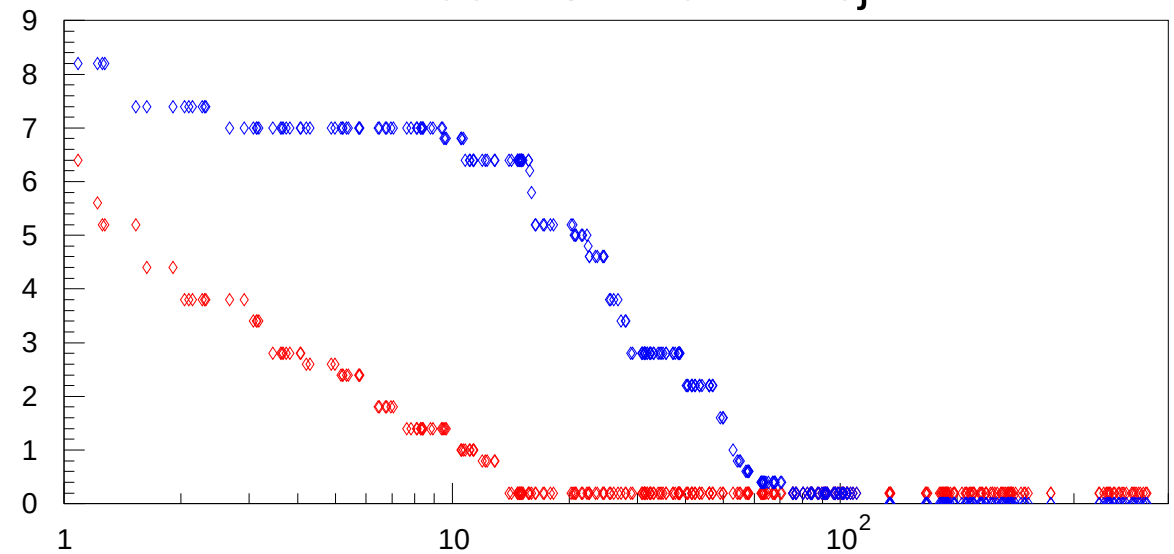
Det.	Timing (ns)	E_{min} (MeV)	Rej.	Acc.
BV	3.75 ± 6.25	0.2	5.61	0.981
EC	0.50 ± 3.00	2.2	3.35	0.981
RD	2.50 ± 4.25	0.8	2.30	0.967
EC1	0.50 ± 2.75	0.4	1.34	0.986
IC	-1.00 ± 2.50	0.4	1.21	0.997
CO	2.00 ± 3.50	0.4	1.13	0.997
TG	-0.50 ± 2.25	3.8	1.12	0.998
RDSH	0.00 ± 3.50	2.4	1.10	1.000
VC	-1.25 ± 3.50	0.4	1.08	0.998
EC2	0.50 ± 1.50	6.8	1.03	0.998
CM	-0.50 ± 1.50	2.0	1.01	1.000
RS1	0.50 ± 2.50	0.4	1.01	1.000
RSS	-7.50 ± 2.50	3.6	1.00	1.000
BVS	-8.00 ± 2.50	0.0	1.00	1.000
RS2	-3.00 ± 5.00	0.4	1.00	1.000
BV1	8.00 ± 5.50	2.0	1.00	1.000
RS3	-3.50 ± 0.00	1.6	1.00	1.000
BV2	3.00 ± 1.00	0.0	1.00	1.000
BV3	-6.50 ± 0.00	3.6	1.00	1.000



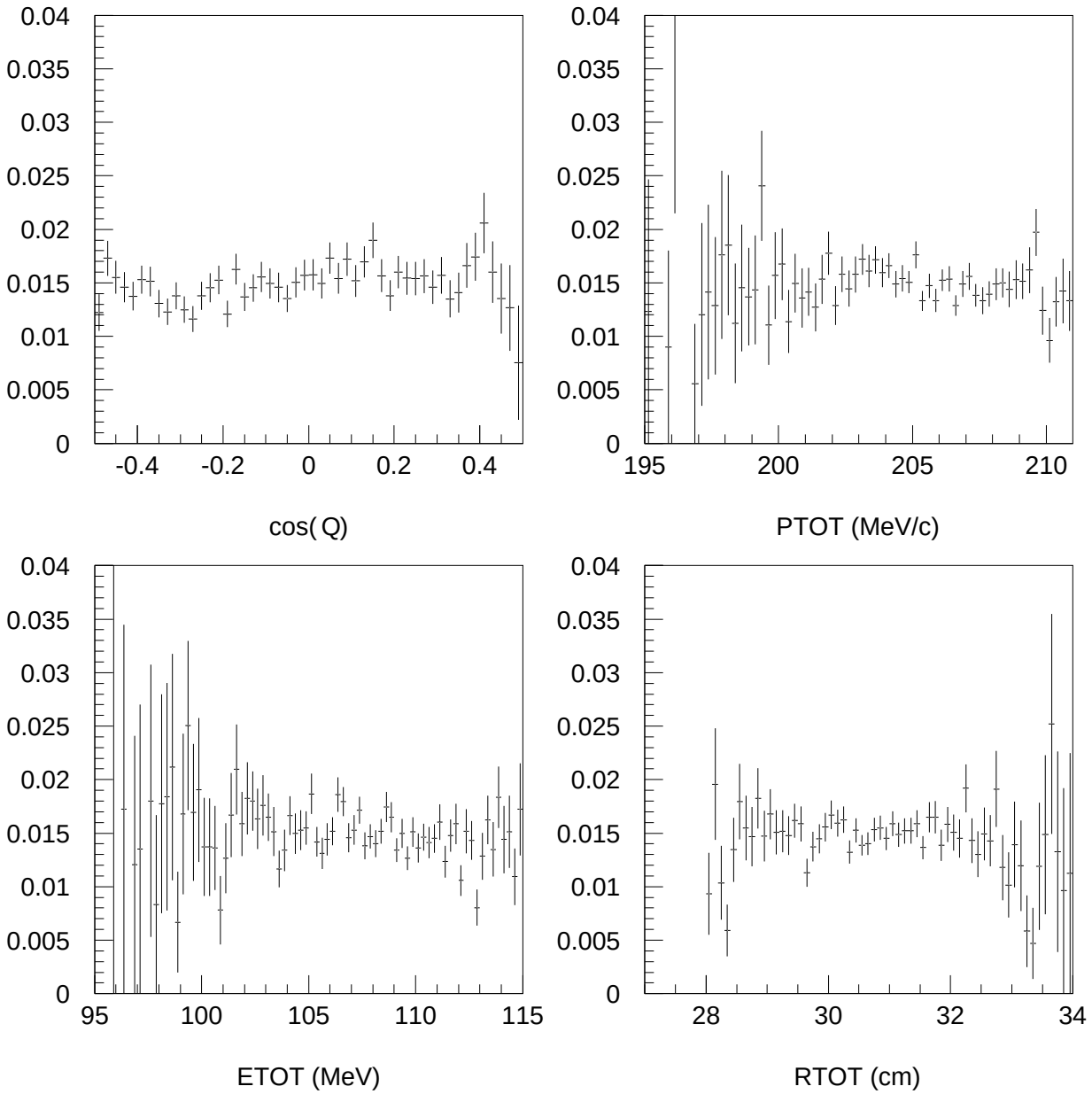
Subdetector v. rej.



Window 1/2-width v. rej.



Energy threshold v. rej.


0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.4
-0.2
0
0.2
0.4
cos(Q)
195
200
205
210
PTOT (MeV/c)
95
100
105
110
115
ETOT (MeV)
28
30
32
34
RTOT (cm)

2002 Phveto status

- Questions:

  1. Does the BVL work as advertised?
  2. What will the new small angle devices do for us?

- To answer 1. we need to measure *absolute* π^0 rejection.
  - Measure offline rejection from pnn(1) $K_{\pi 2}$ peak events (online PV already applied).
  - Measure online rejection using kp2(1) monitors with exactly the same cuts (except for online PV, of course. . .); use run-dependent prescale factors.
  - To measure acceptance, we must "blank out" the portions of BV/BVL in the vicinity of where km2(1) events leave RS; we then correct the acceptance for the blanked-out segments of the detectors. (N.b. don't yet know how to measure online BV/BVL acceptance loss)
  - Try to make R/A measurements at a standard value of acceptance. Traditionally, we've used 80% *total* acceptance.
  - Best to try to optimize R v. A

Current best measurements

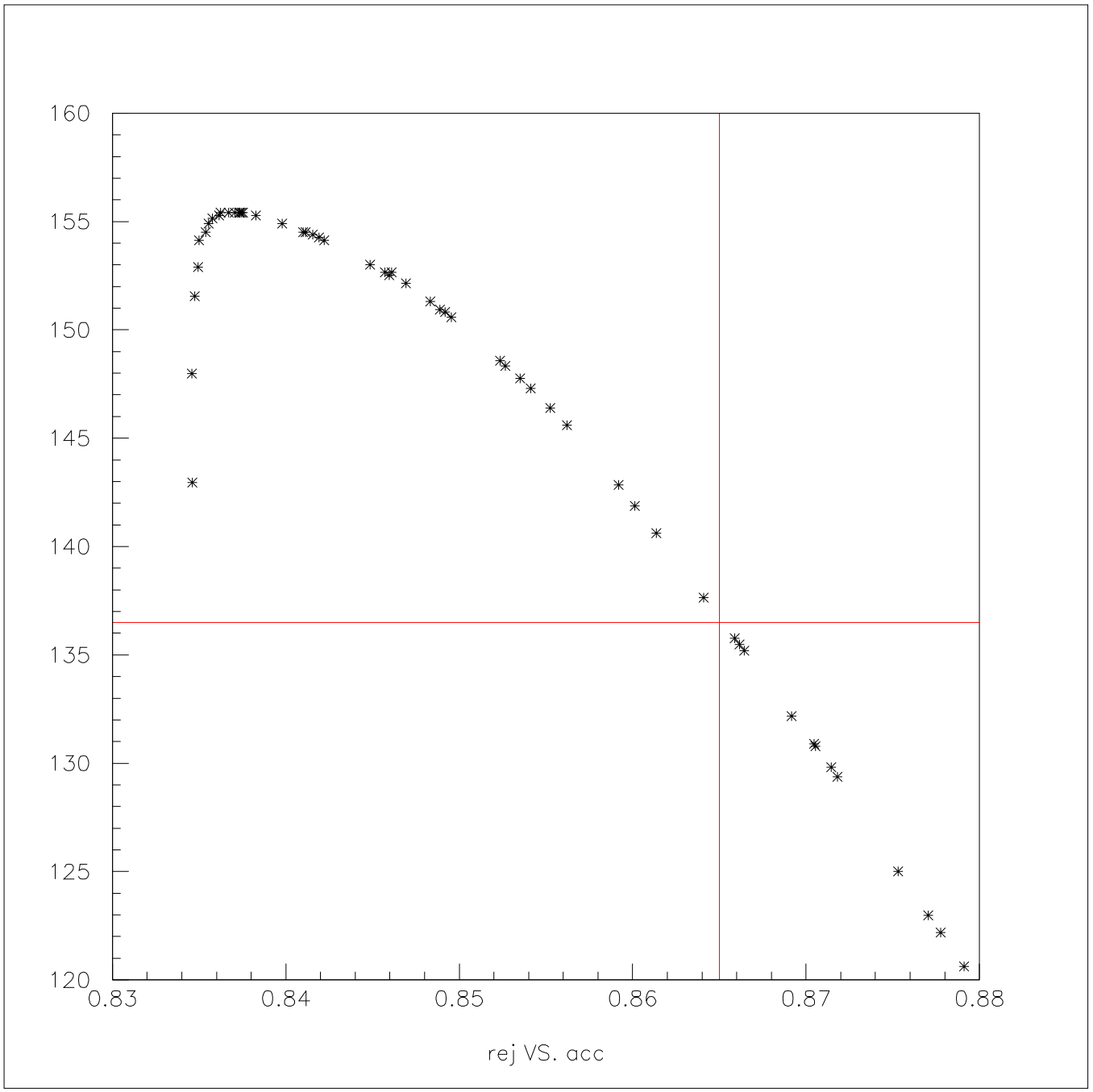
- $A_{online} = 46494/50337 = 0.9237$ (LHEX +EC only)
- Assume that BV/BVL online acceptance losses will be absorbed into the offline measurements, since these cuts are tighter. Probably a good approximation, at least.
- $R_{off} = 164937/1670 = 98.76$ $(A_{off} = 0.90)$
- $R_{HEX} = 5.499 \times 10^9/1.911 \times 10^9 = 2.878$
- $R_{total} = 5.499 \times 10^9/1670 = 3.293 \times 10^6$ (*cf* 1.7×10^6 for previous "best".)
- Above value is for higher-than-normal total acceptance; remeasure R_{total} for $A_{offline} = 0.80/0.9237 = 0.865$; get this information from the optimization code.

```
 ITERATIONS :  42
 RREF / AREF :   137.648468  0.864095807 1374 71686
 RMAX / AMAX :   135.770996  0.865912378 1393 71835
 SUBSYSTEM : EC2  0.00154131453
                OLD            NEW
    TOFF :  -1.5 -2.5
    WIND :   1.5  0.5
    EMIN :   14.  14.

-0.899999976

 ***** NO constraints on parameter changes *****


   Optimizing for acceptance of   0.899999976
   Photon veto cut parameters
  ******************************************
    DET.   TOFF    DPR   EMIN  TSTEP  ESTEP
   ----------------------------------------
    BV     0.75   5.25   0.60   0.25   0.20     4   4   4
    EC     1.00   2.75   2.00   0.25   0.20     4   4   4
    RD    -0.25   2.25   0.00   0.25   0.20     4   4   1
    TG     0.25   2.00   5.20   0.25   0.20     4   4   4
    IC     0.75   3.25   1.60   0.50   0.40     4   4   4
    VC    -1.25   2.50   1.20   0.50   0.40     4   4   4
    CO     3.25   1.75   0.80   0.50   0.40     4   4   3
    CM    -1.00   1.50   2.80   0.50   0.40     4   3   4
    EC1    0.75   3.00   0.60   0.25   0.20     4   4   4
    BVS   -8.50   4.00   0.80   0.50   0.40     4   4   3
    RDS   -7.50   2.50   3.60   0.50   0.40     4   4   4
    RDB   -0.50   1.00   2.20   0.50   0.40     4   2   4
    RS1    1.00   1.00   0.00   0.50   0.40     4   2   1
    RS2   -3.00   5.00   0.40   0.50   0.40     4   4   2
    RS3   -3.50   0.00   1.60   0.50   0.40     4   0   4
    BS1    3.50   0.50   0.80   0.50   0.40     4   1   3
    BS2    1.50   0.00   2.80   0.50   0.40     4   0   4
    BS3   -6.50   0.00   3.60   0.50   0.40     4   0   4
    EC2   -2.50   0.50  14.00   0.50   0.40     4   1   4
    BL     1.00   2.00   0.20   0.25   0.20     4   4   2
```



- Re-measure R_{off}; scale R_{total}:

$$R_{total} = 3.293 \times 10^6 \times (136.5/98.76) = 4.55 \times 10^6$$