TOP reconstruction and simulation studies IV

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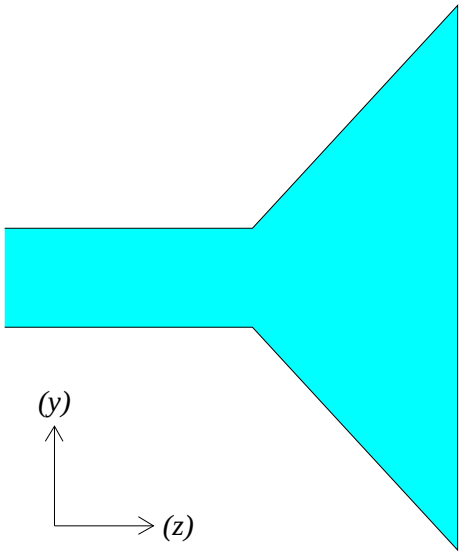
- Reconstruction software (TOPsimrec)
- Comparison: focusing i-TOP vs. f-TOP

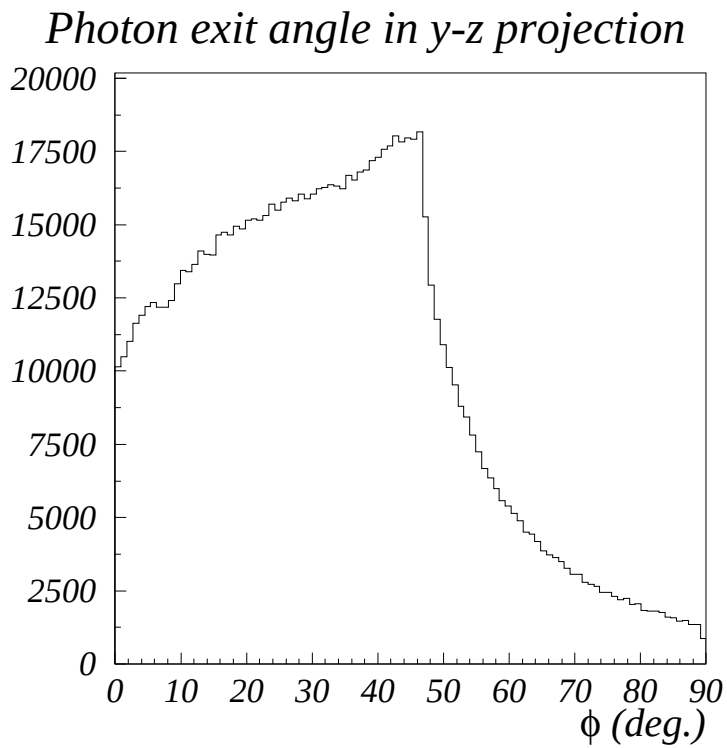
Status of reconstruction code

- First version of TOPsimrec become available from beginning of June
  - based on F77 code
  - C++ user interface provided
  - short write-up on how to use included
- Can be downloaded from http://www-f9.ijs.si/ staric/TOP/
- New version almost ready
  - includes i-TOP simulation/reconstruction
  - will make it available in the next days (same location)

Remark on expansion volume design

From the reconstruction point of view ...

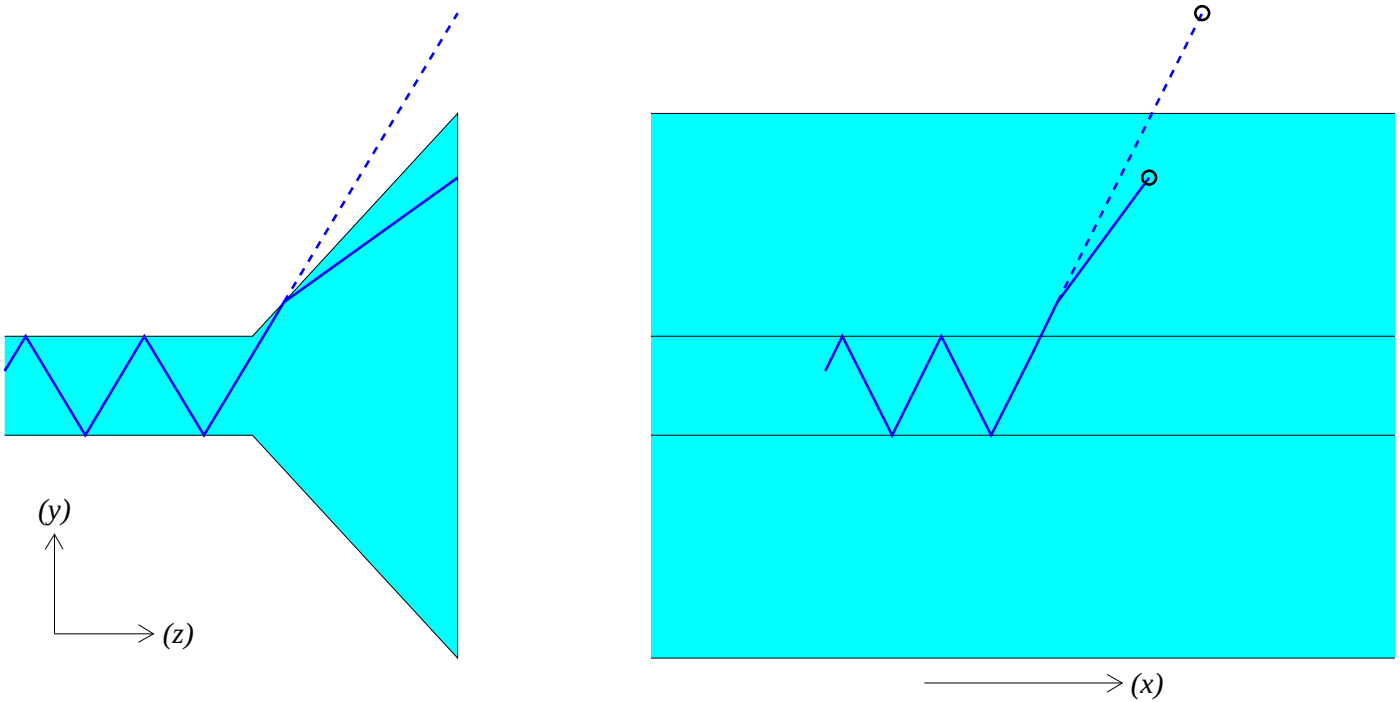




- ▷ a fraction of photons hit the upper/lower sides of expansion volume
- ▷ most of them (all?) are totally reflected into the exit window (e.g. not lost)

Remark on expansion volume design

From the reconstruction point of view ...

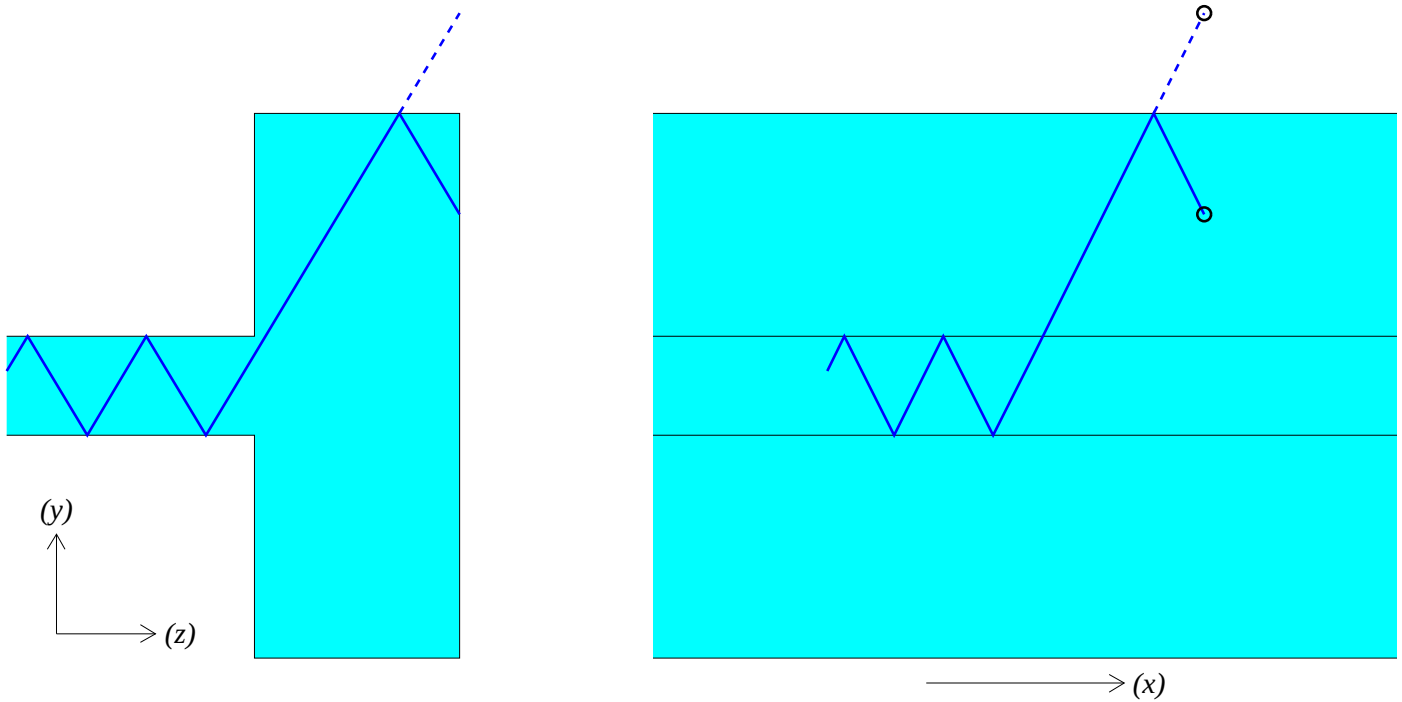


- ▷ at exit window: true hit x position and the extrapolated one are different
- ▷ makes complications for the PDF construction

Reconstruction: not fully implemented (yet)

Remark on expansion volume design

From the reconstruction point of view ...



- ▷ at exit window: true hit x position and the extrapolated one are the same
- ▷ much easier to implement

Reconstruction: ready

TOPsimrec: a short tutorial

Directory structure:

docu	documentation
examples	examples and makefile
hbo	place for the output hbook file(s) from top_simu.cc
include	C++ include files (user interface)
obj	place for compiled (object) files
paw	paw macros to analyze output from top_simu.cc
src	C++ source code
srcF77	F77 source code

Include:

RandomParticle.h	
TOPconfig.h	TOP counter configuration functions
TOPf77fun.h	
TOPhbook.h	
TOPreco.h	interface class to reconstruction
TOPsimu.h	interface class to simulation
TOPutil.h	data conversion utilities (for debugging etc.)

Example I: 2-readout f-TOP

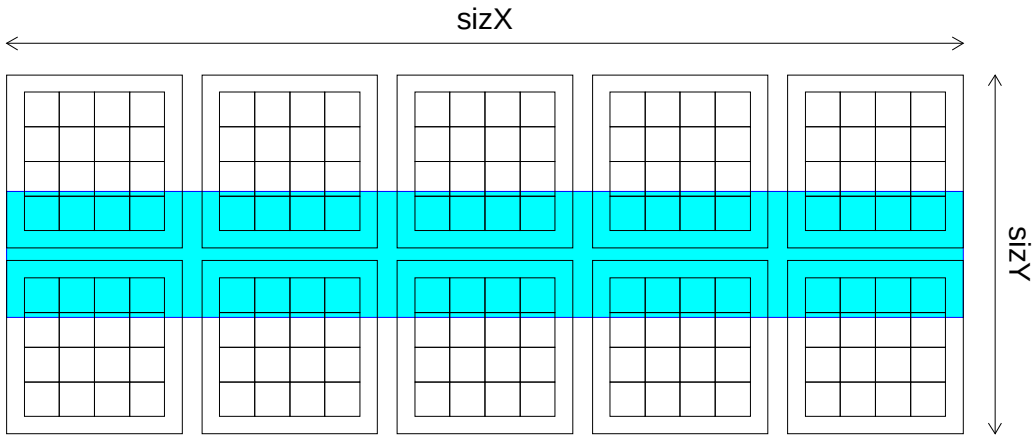
```
#include "TOPconfig.h"

void TOPconfigure(){
  TOPvolume(115, 125, -80, 190);
  setBfield(1.5);
  setPMT(2.75, 2.75, 2.2, 2.2, 1, 4);
  double frac[3]={0.5815, 0.2870, 0.1315};
  double mean[3]={-13.59e-3, 29.03e-3, 273.0e-3};
  double sigma[3]={31.97e-3, 53.39e-3, 340.2e-3};
  setTTS(3, frac, mean, sigma);
  setQE("qe_GaAsP400nm.dat", 0.35);
  setTDC(10, 50.E-3);

  int n=18;
  double Dphi=2*Pi/n; double Phi=0; int id;
  for(int i=0; i<n; i++){
    id=setQbar(40, 2, -78, 107, 118, 0, Phi, PMT, SphericM);
    setMirrorRadius(id, 500);
    id=setQbar(40, 2, 108, 183, 118, 0, Phi, None, PMT);
    Phi+=Dphi;}
  TOPfinalize();
}
```

Example II: focusing i-TOP

```
int n=16;
double Dphi=2*Pi/n; double Phi=0; int id;
for(int i=0; i<n; i++){
  id=setQbar(44, 2, -80, 190, 115.8, 0, Phi, PMT, SphericM);
  setMirrorRadius(id, 720);
  addExpansionVolume(id, Left, Box, 4.14, 11.0);
  Phi+=Dphi;}
```

- PMT's are arranged automatically on the exit window
- can be re-arranged with:

```
arrangePMT(int QbarID, double sizX, double sizY)
```

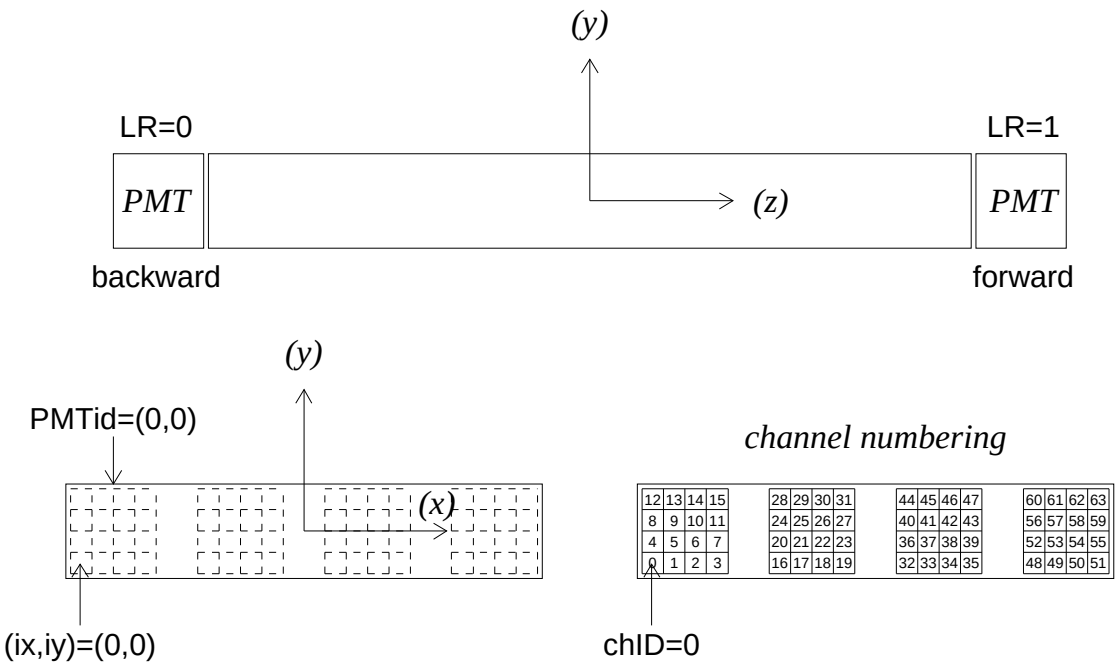


Example III: reconstruction

```
#include "TOPreco.h"

double Masses[3]={.13957, .49368, .93827}; int Nhyp=3;
double Bkg=1.5; // expect this number of background hits for ex.

void RecEvent(){
  TOPreco reco(Nhyp, Masses, Bkg);
  reco.Clear();
  for(...){ //loop over your digitized data (all bars)
    ...
    reco.AddData(QbarID, chID, TDC);
  }
  for(...){ //loop over tracks
    ...
    reco.Reconstruct(x,y,z,t,px,py,pz,q);
    if(reco.Flag() == 1) {
      double LogL[Nhyp], ExpPhot[Nhyp]; int Nphot;
      reco.GetLogL(Nhyp, LogL, ExpPhot, Nphot);
      ...
    }
  }
}
```

Channel numbering

```
reco.AddData(QbarID, chID, TDC)
```



- If backward equipped (LR=0)
  `chID=ix+Nx*(iy+Ny*(PMTidX+NumPMTx(LR,QbarID)*PMTidY))`
- If forward equipped (LR=1)
  `chID=NumCh(LR=0)+`
  `ix+Nx*(iy+Ny*(PMTidX+NumPMTx(LR,QbarID)*PMTidY))`
- To x-check use functions defined in include/TOPutil.h

CPU and memory consumption

Jobs run on B computers:

- Simulation and reconstruction of 500 000 single-track events per job
- Tracks (half pions half kaons) uniformly over 4π, uniformly in $0 < p < 5$ GeV/c
- 65% tracks in the acceptance, π and K mass hypotheses used

SL-10, 1×4

configuration	CPU (rec/tot)	Max memory
2-readout f-TOP	22 min. (38%)	11 MB
focusing i-TOP	50 min. (73%)	14 MB

SL-10, 4×4

configuration	CPU (rec/tot)	Max memory
2-readout f-TOP	45 min. (67%)	14 MB
focusing i-TOP	150 min. (91%)	27 MB

- CPU time for recon. per track (in acceptance) per mass hypothesis:

configuration	SL-10, 1×4	SL-10, 4×4
2-readout f-TOP	0.8 ms	2.8 ms
focusing i-TOP	3.4 ms	12.6 ms

Detector configurations

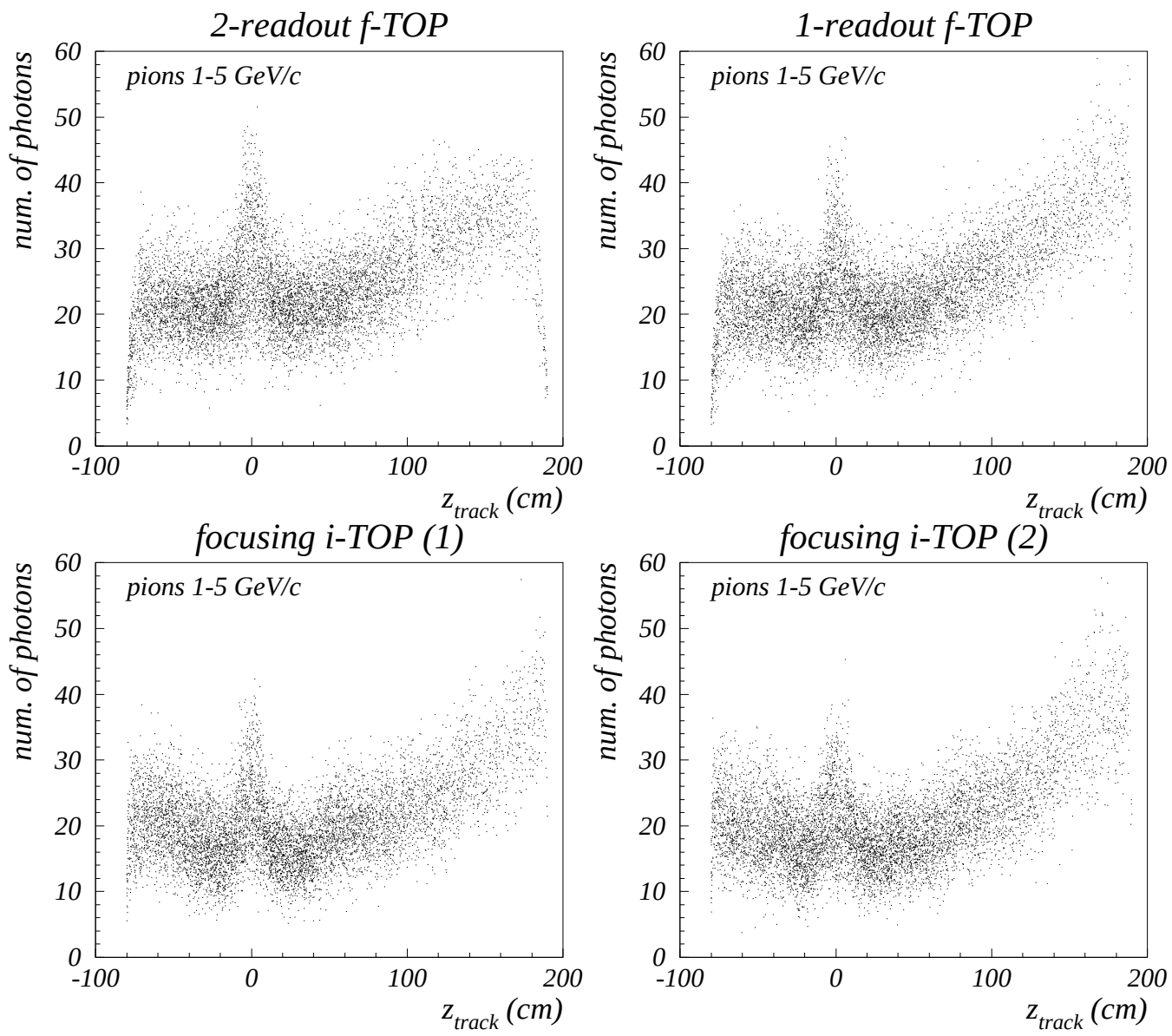
- PMT: Hamamatsu SL-10 with 1×4 or 4×4 channels
- TTS: 3-gaussian (fitted Inami-san's distribution)
- QE: GaAsP with 400nm filter (sharp cutof), 35% CE
- CFD: 500ps delay, 5ns pileup time
- TDC: 10 bit, 50ps/ch, multihit (>5ns)
- 16 detector segments in ϕ at $R = 115.8$ cm
- Q-bars: 44×2 cm^2
- Focusing with spherical mirror
- i-TOP expansion volume: $\Delta z = 4.14(8.28)$ cm, 11 cm high, box-shaped

configuration	z_1	z_2	R_{mirror}	num.PMT	Δz
2-readout f-TOP	-80 cm	107 cm	500 cm	16	
	108 cm	190 cm		16	
1-readout f-TOP	-80 cm	190 cm	720 cm	16	
focusing i-TOP (1)	-80 cm	190 cm	720 cm	4×16	4.14 cm
focusing i-TOP (2)	-80 cm	190 cm	720 cm	4×16	8.28 cm

Simulation

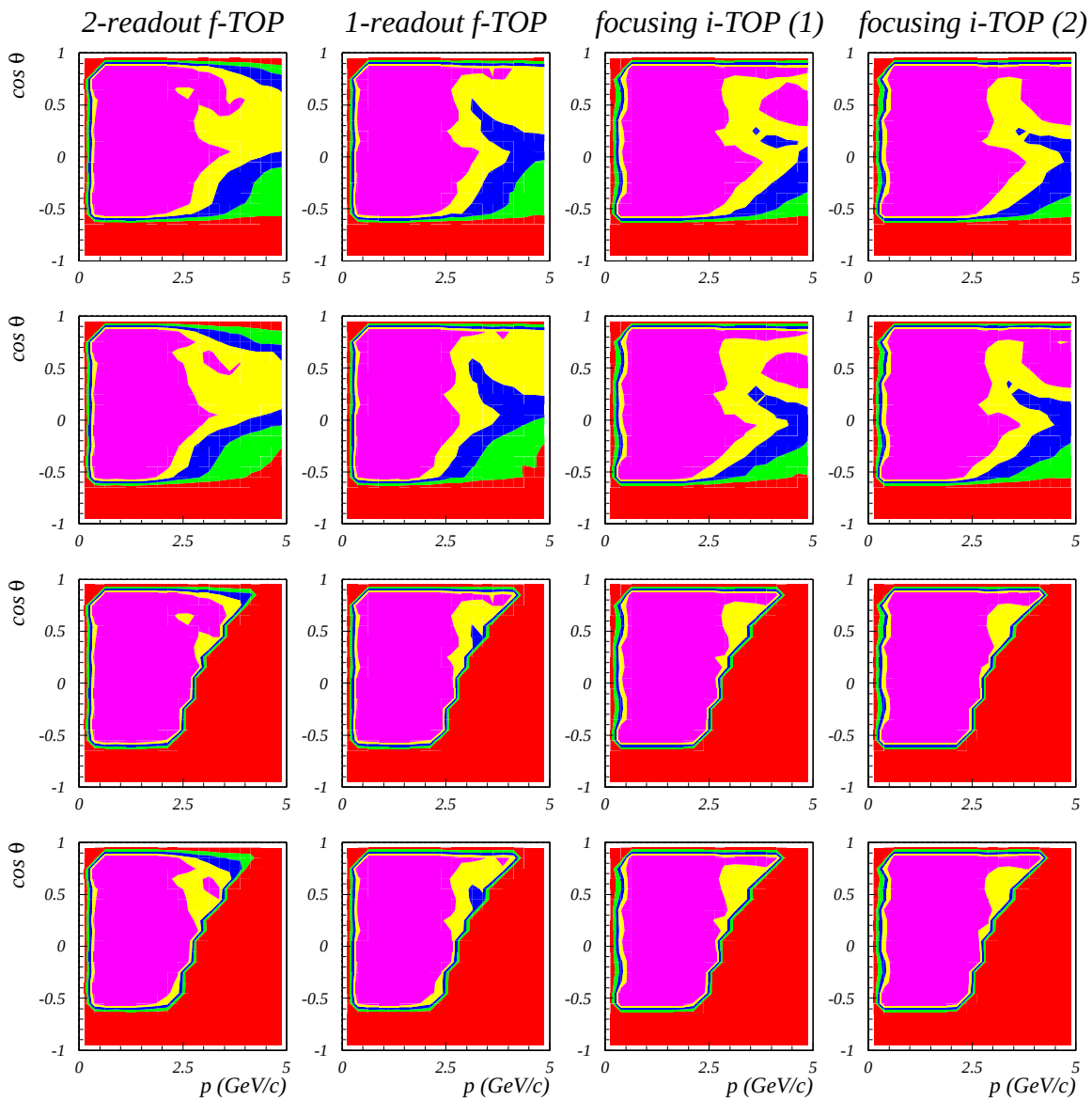
- Pions and kaons (half-half) of both charges distributed uniformly over 4π with momenta distributed uniformly between 0 and 5 GeV/c
- 500 000 tracks/job
- Magnetic field B=1.5 T
- Background/bar/50ns: 20 hits uniformly distributed
- T_0 jitter: 10 ps (rms) or 25 ps (rms)

Results: number of photons



Results: separation power

SL-10, 1×4



$\sigma_{T_0} = 10$ps

$\sigma_{T_0} = 25$ps

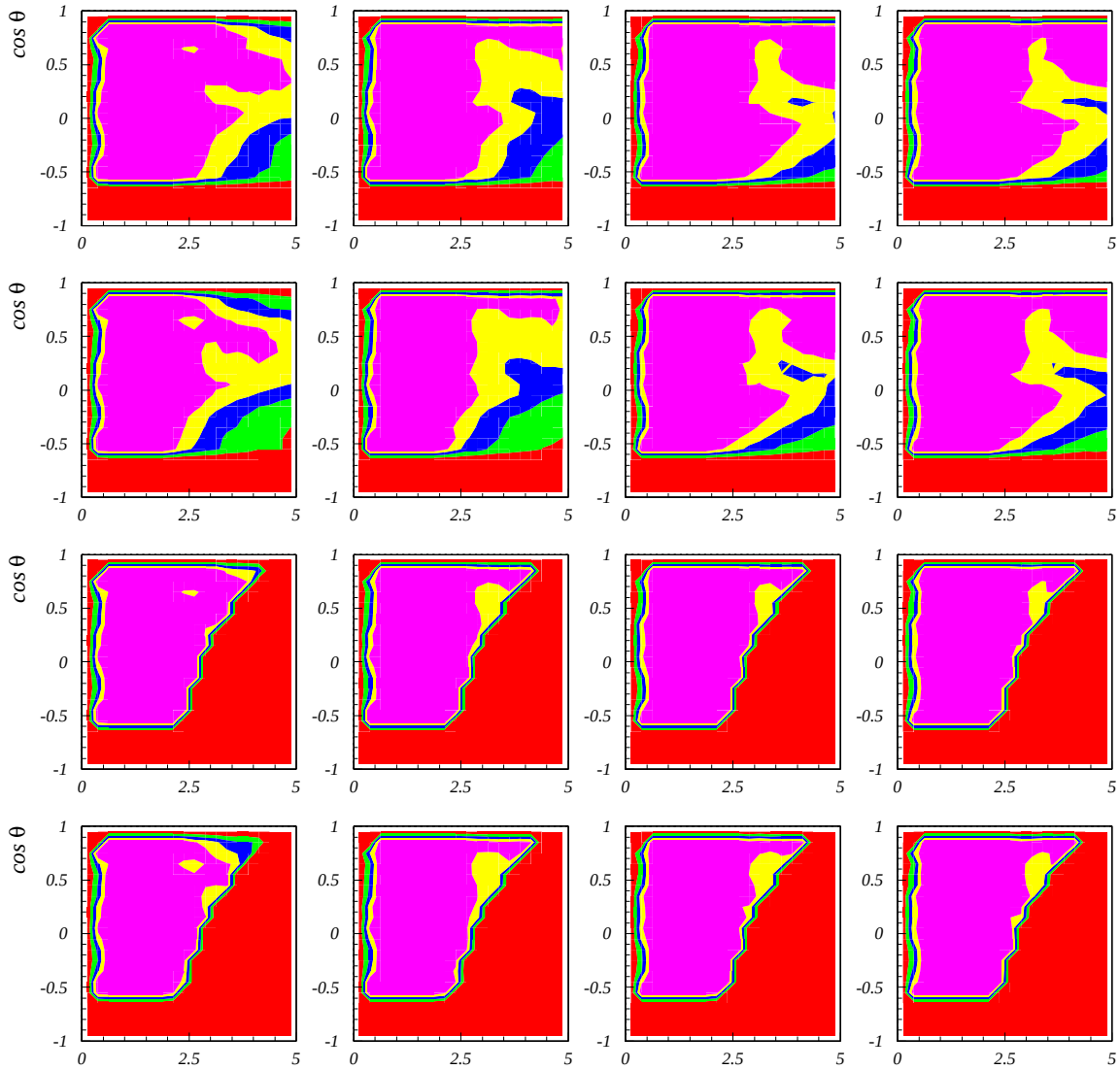
$\sigma_{T_0} = 10$ps

$\sigma_{T_0} = 25$ps

- $> 4\sigma$
- $> 3\sigma$
- $> 2\sigma$
- $> 1\sigma$

Results: separation power

SL-10, 4×4



$\sigma_{T_0} = 10$ps

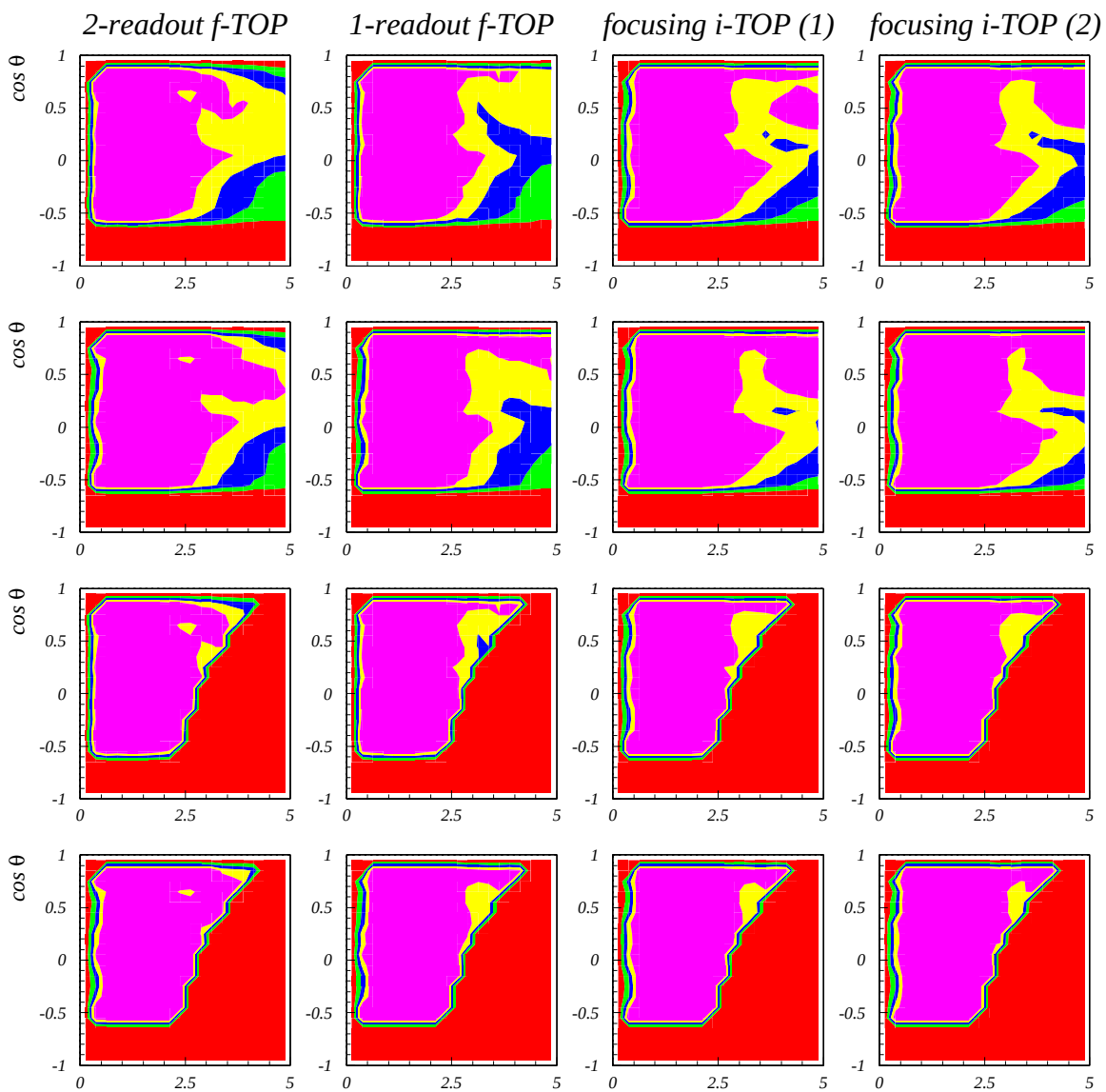
$\sigma_{T_0} = 25$ps

$\sigma_{T_0} = 10$ps

$\sigma_{T_0} = 25$ps

- $> 4\sigma$
- $> 3\sigma$
- $> 2\sigma$
- $> 1\sigma$

Results: separation power



$\sigma_{T_0} = 10$ps

SL-10, 1×4

SL-10, 4×4

SL-10, 1×4

SL-10, 4×4

$> 4\sigma$

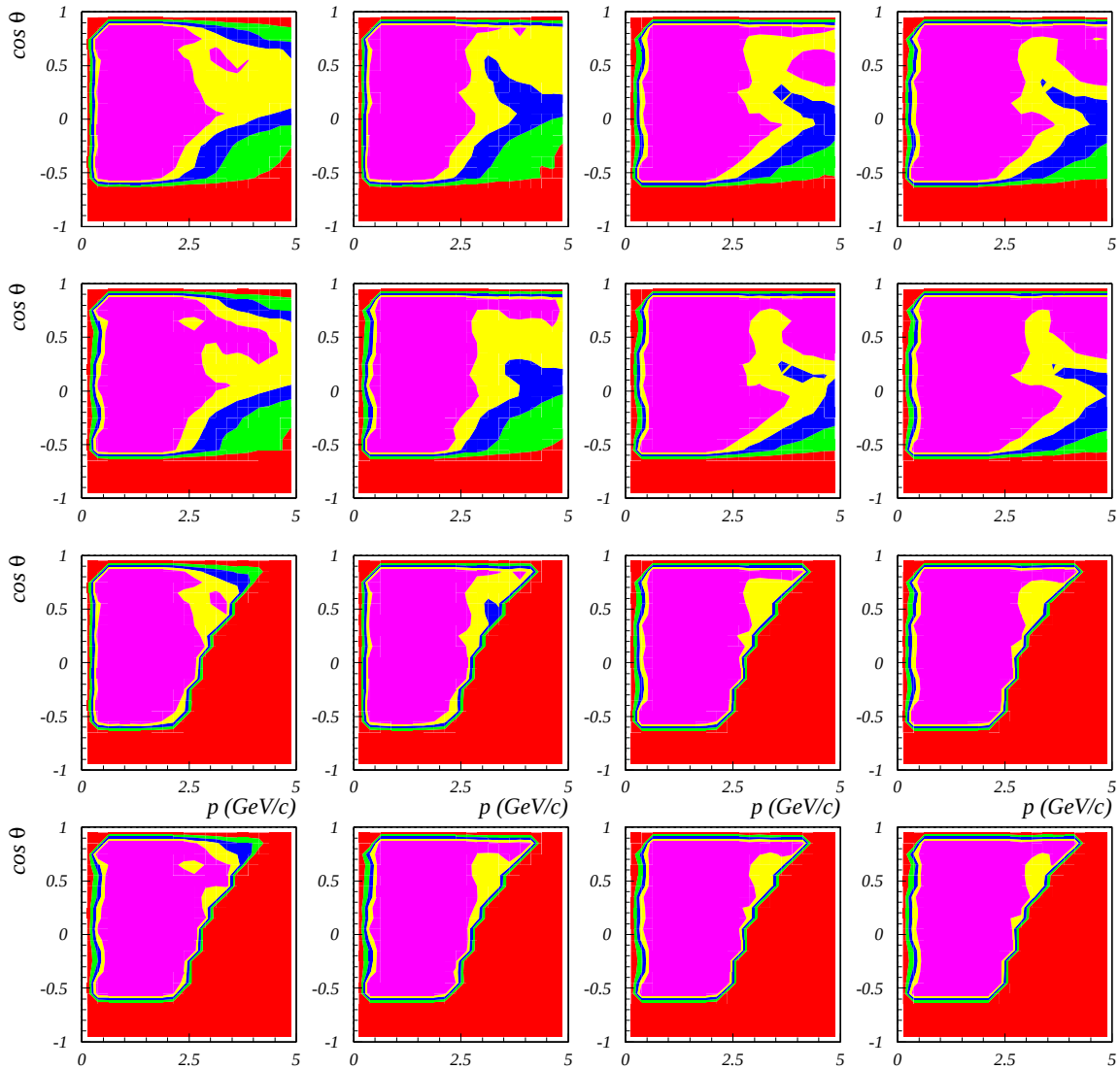
$> 3\sigma$

$> 2\sigma$

$> 1\sigma$

Results: separation power

$\sigma_{T_0} = 25$ps



SL-10, 1×4

SL-10, 4×4

SL-10, 1×4

SL-10, 4×4

$> 4\sigma$

$> 3\sigma$

$> 2\sigma$

$> 1\sigma$