Beam transport: Checks in PLUTO

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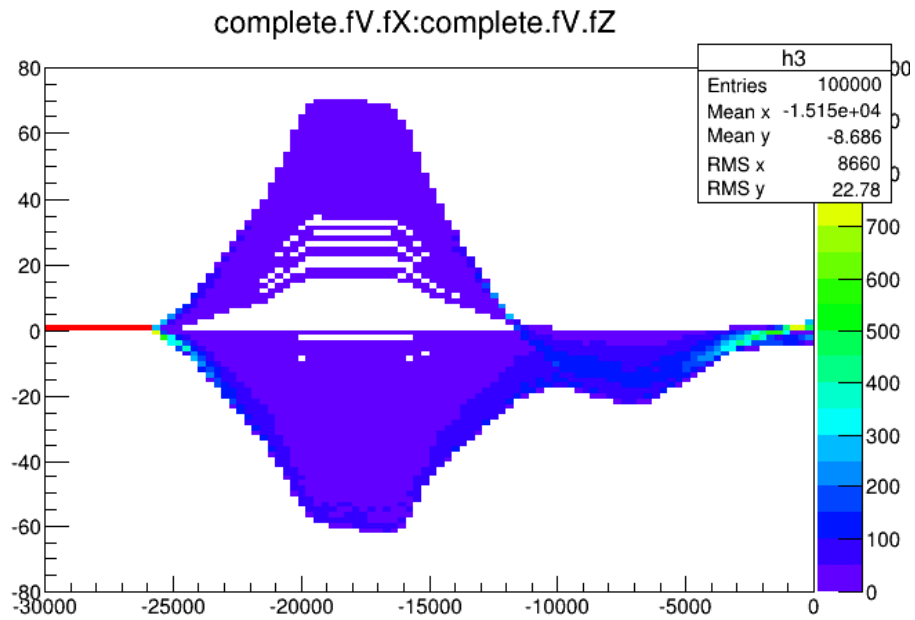
Element positions along the beam line

step number	length of element (meters)	integrated length from production target (meters)	integrated length from HADES target (mm, counted backward)	step name
0	0	0	-33645,24	production target
1	0,9	0,9	-32745,24	in Q1
2	1	1,9	-31745,24	out Q1
3	1	2,9	-30745,24	in Q2
4	1	3,9	-29745,24	out Q2
5	0,6	4,5	-29145,24	in FOPI
6	0	4,5	-29145,24	FOPI
7	1	5,5	-28145,24	FOPI
8	0,5	6	-27645,24	FOPI
9	0	6	-27645,24	out FOPI
10	1,58	7,58	-26065,24	in dipole 1
11	1,47262	9,05262	-24592,62	out dipole1
12	3	12,05262	-21592,62	in Q3
13	0,6	12,65262	-20992,62	out Q3
14	0,8	13,45262	-20192,62	in Q4
15	0,6	14,05262	-19592,62	out Q4
16	1,5	15,55262	-18092,62	nominal interm. focus
17	1	16,55262	-17092,62	detector 1
18	0,5	17,05262	-16592,62	in Q5
19	0,6	17,65262	-15992,62	out Q5
20	0,8	18,45262	-15192,62	in Q6
21	0,6	19,05262	-14592,62	out Q6
22	3	22,05262	-11592,62	in dipole 2
23	1,47262	23,52524	-10120	out dipole2
24	2,81	26,33524	-7310	in Q7
25	1	27,33524	-6310	out Q7 (Q7 length = 1m)
26	0,91	28,24524	-5400	detector 2
27	1,9	30,14524	-3500	in Q8
28	1	31,14524	-2500	out Q8 (Q8 length = 1 m)
29	0,6	31,74524	-1900	in Q9
30	0,4	32,14524	-1500	out Q9 (Q9 length = 0.4 m)
31	0,5	32,64524	-1000	interm. Point
32	1	33,64524	0	HADES target
33	0	33,64524	0	HADES target

This excell table gives positions in mm going from target backward

Effect of Dp/p =+-8%

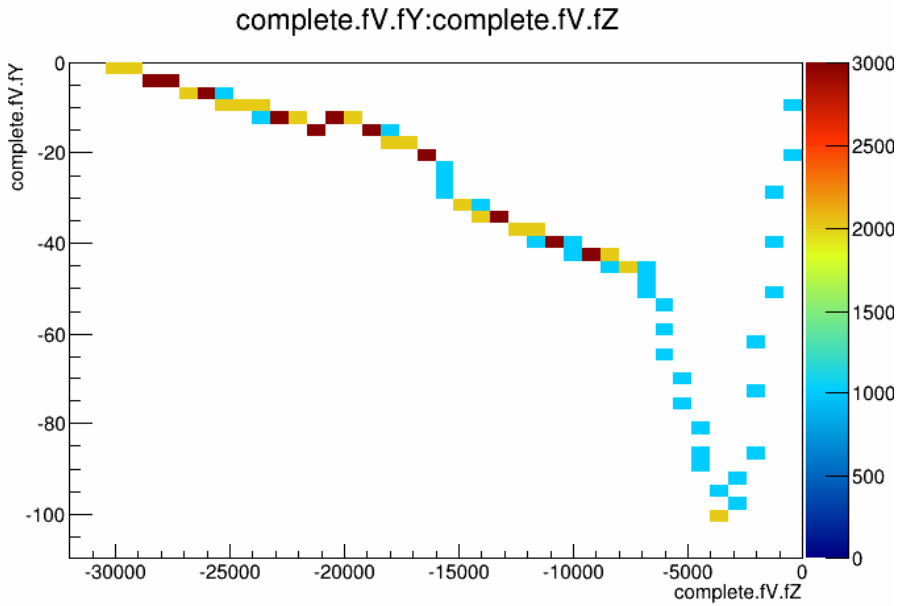
```
//Init the reaction for c.m. sampling:
PBeamLineSimulation *sim = new PBeamLineSimulation("beam", "Beam line simulation");
sim->SetReaction("p + p");
//Read the data file
sim->InitBeamLine("pibeam_set6.data");
//Place (virtual) detector along the beam line. Units are in mm:
sim->AddDetector("det1", -3000.0);
sim->AddDetector("det2", -6000.0);


for (double dist = -30000; dist<0; dist+=300)
        sim->AddDetector("complete", dist);
//open the ROOT file and type:
//data.Draw("complete.fV.fX:complete.fV.fZ >>h3(100,-30000,0,100,-80,80)","","colz");


//Choose which module should be the target:
sim->TargetIsElement(33);
//Select the global momentum:
sim->SetGlobalMomentum(3.0);

//Beam profile at the production target
//position in mm:
sim->Do("_beam_x = 0;  _beam_y = 0;");
//divergence in px/pz and py/pz:
//sim->Do("_beam_px = 0; _beam_py = 0.05;");
sim->Do("_beam_px = 0; _beam_py = 0;");
//momentum spread:
sim->Do("_beam_dp = 0.16*sampleFlat() - 0.08; "); //+- 8%
//sim->Do("_beam_dp = -0.08; ");

//Add and enable module:
makeDistributionManager()->Add(sim);

PReaction my_reaction("_T1 = 2.2","p","p","p p eta [dilepton [e+ e-] g]", "beam_line");
//PReaction my_reaction("_T1 = 2.2","p","p","p p", "beam_line");

my_reaction.Print();   //The "Print()" statement is optional
my_reaction.Loop(1000);
```

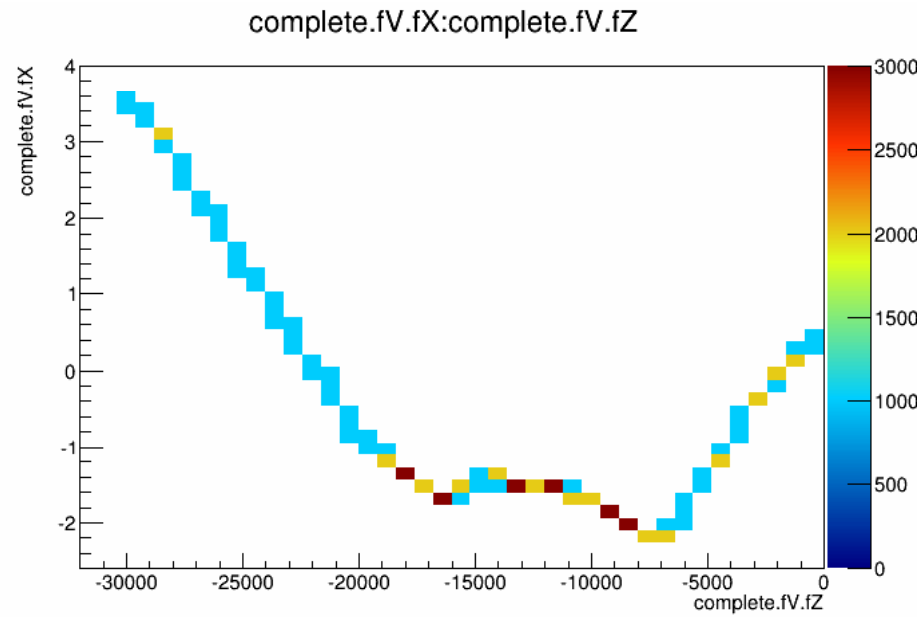


units in Z and X are in mm

Pion production point: X:1mm, Y:1 mm

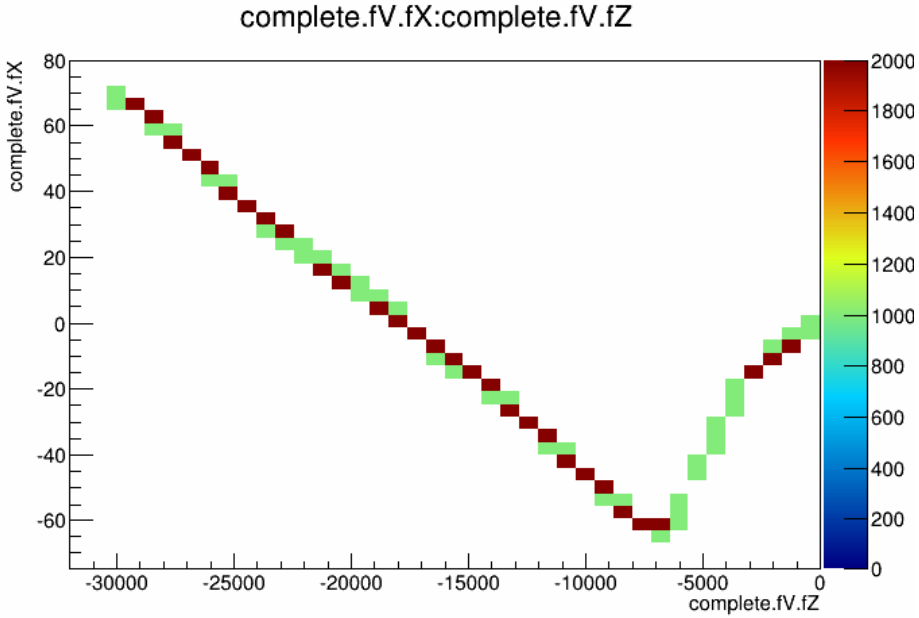
```
 //Beam profile at the production target    //position in mm:
sim->Do("_beam_x = 1.;  _beam_y = 1. ;
//divergence in px/pz and py/pz:
//sim->Do("_beam_px = 0; _beam_py = 0.05;");
sim->Do("_beam_px = 0; _beam_py = 0;");
//momentum spread:
//sim->Do("_beam_dp = 0.16*sampleFlat() - 0.08; "); //+- 8%
sim->Do("_beam_dp = 0.00;
```

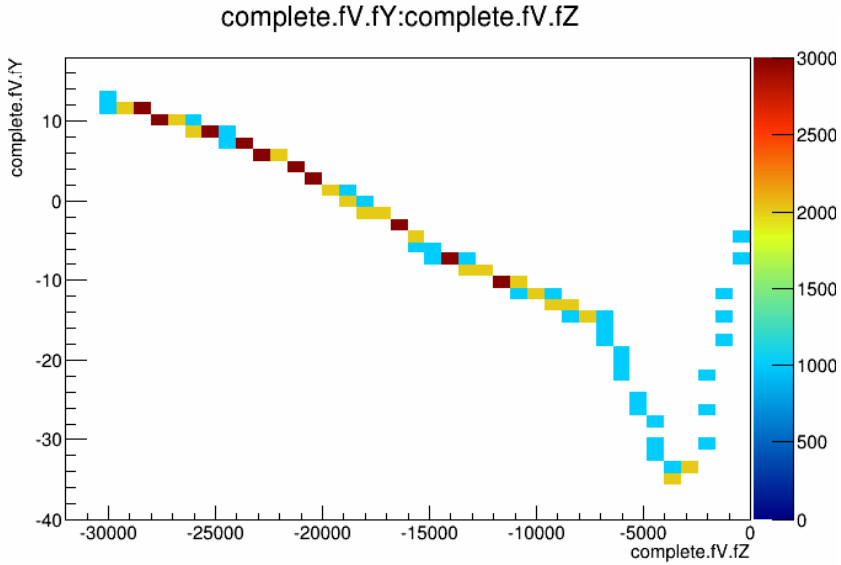




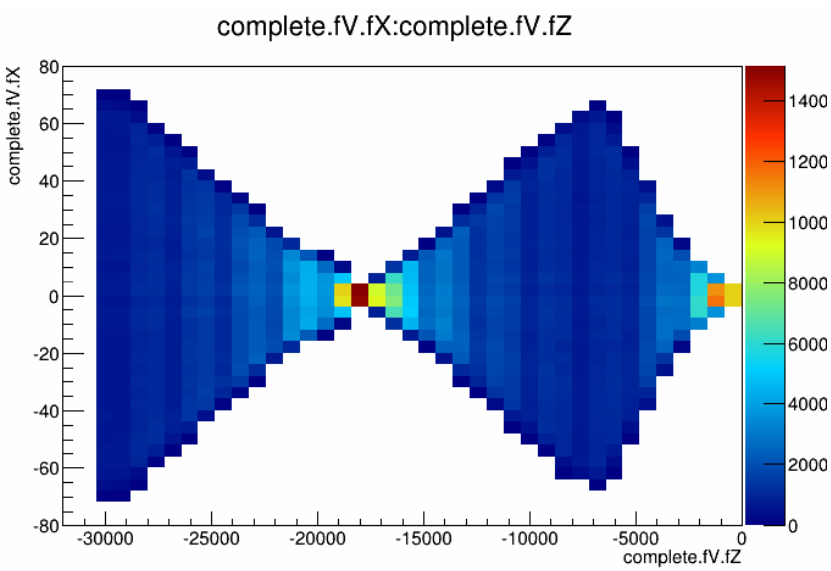
Pion emission angles: $\Delta\Theta$=10, $\Delta\phi$=20 mrad

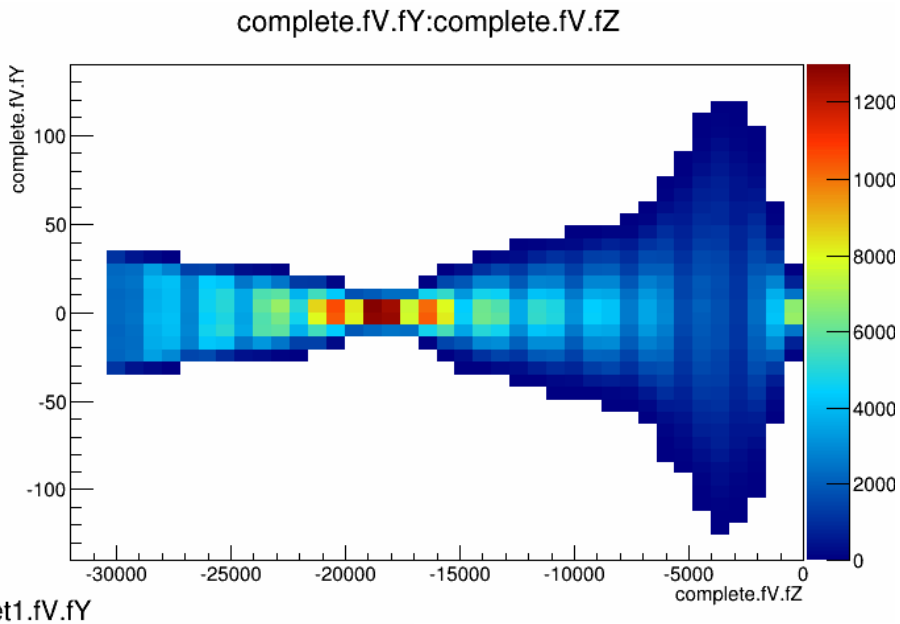
```
//Beam profile at the production target    //position in mm:
sim->Do("_beam_x = 0..;  _beam_y = 0. ;
//divergence in px/pz and py/pz:
//sim->Do("_beam_px = 0; _beam_py = 0.05;");
sim->Do("_beam_px = 10; _beam_py = 20;");  // mrad  !!
//momentum spread:
//sim->Do("_beam_dp = 0.16*sampleFlat() - 0.08; "); //+- 8%
sim->Do("_beam_dp = 0.00;
```

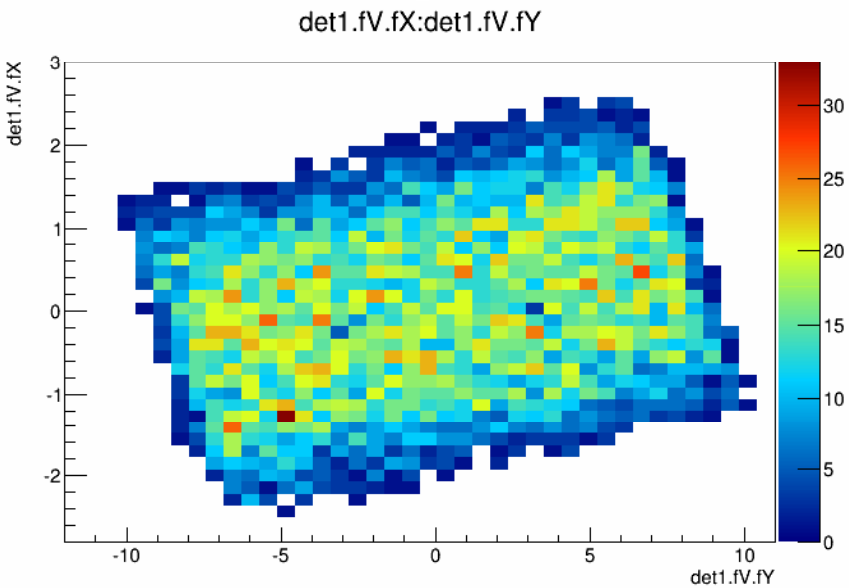




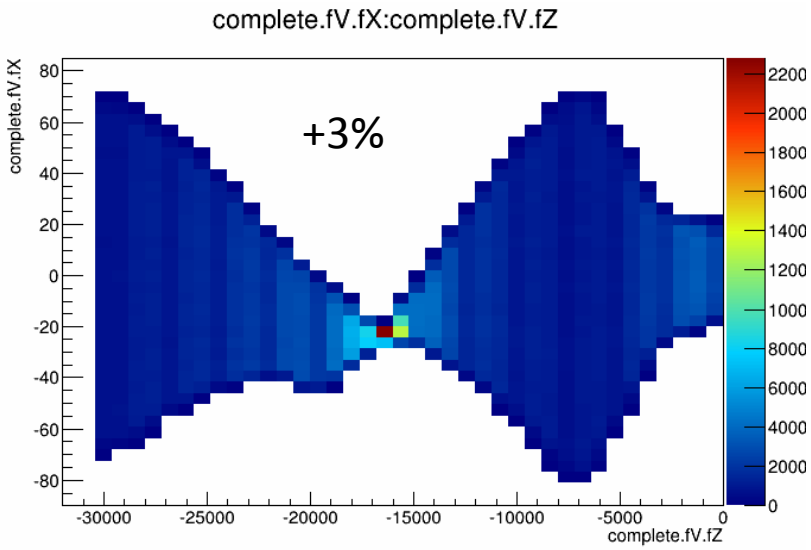
Dp=0.0, Full smearing $\Delta\Theta,\phi$ and $\Delta X_0 Y_0$

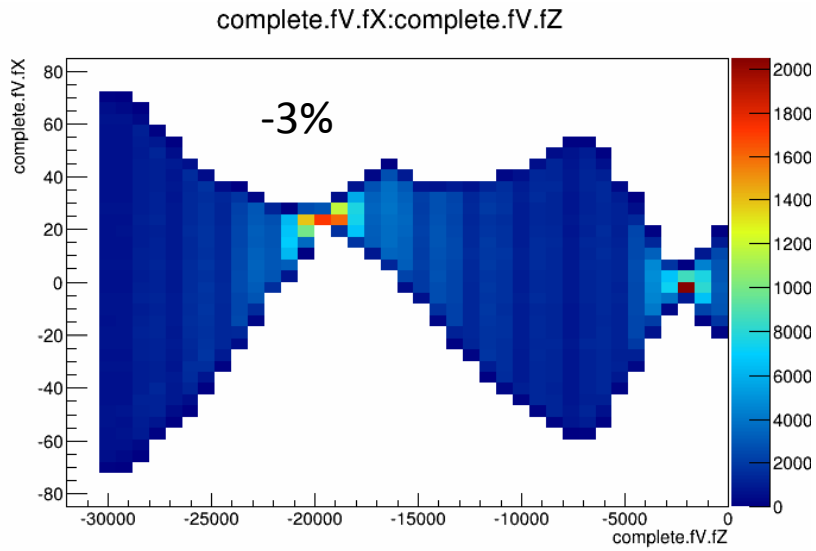


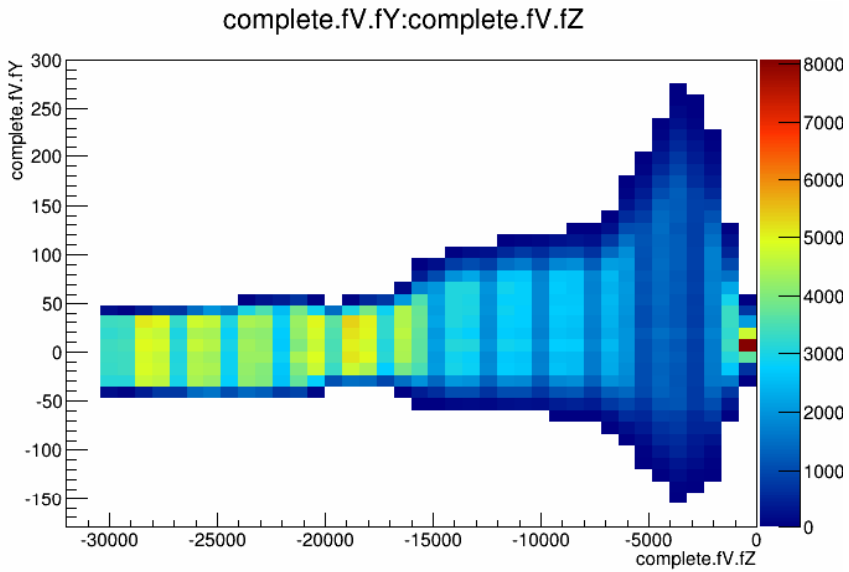


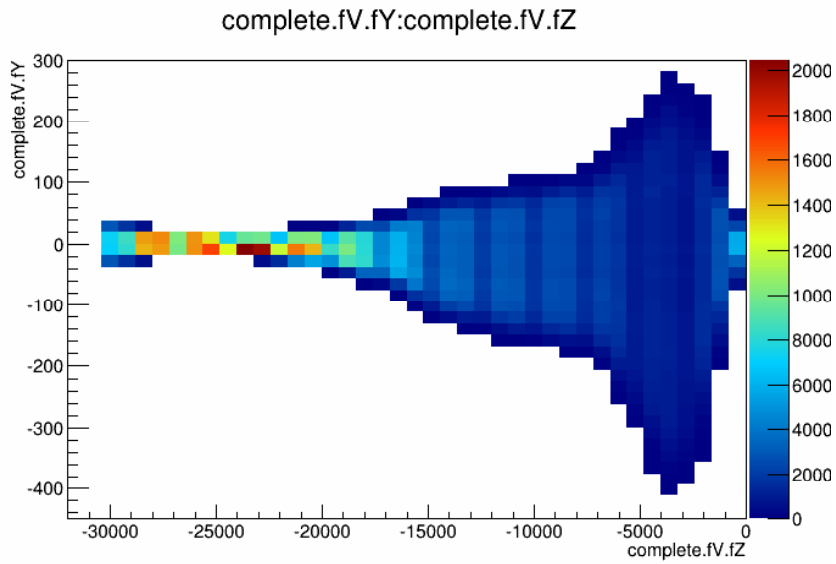


Dp=±3%, Full smearing $\Delta\Theta$, $\Delta\phi$ and $\Delta X_0, Y_0$



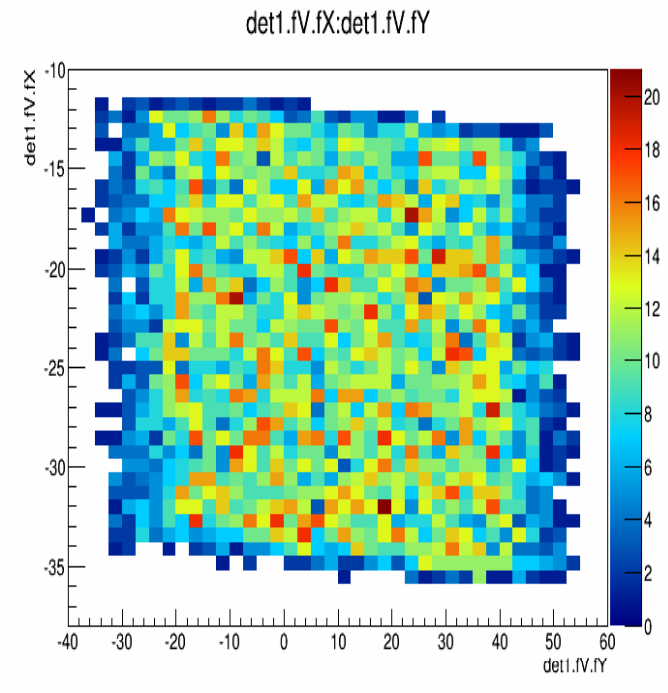




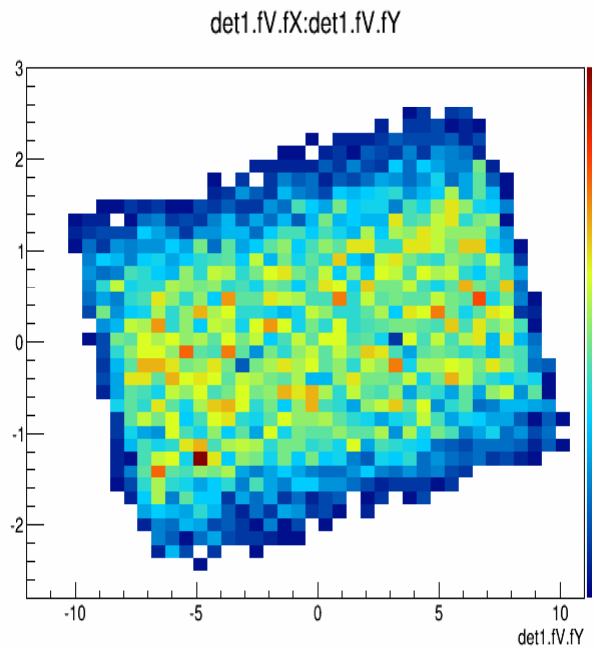


Dp=0%,±3%, Full smearing $\Delta\Theta,\phi$ and $\Delta X_0 Y_0$

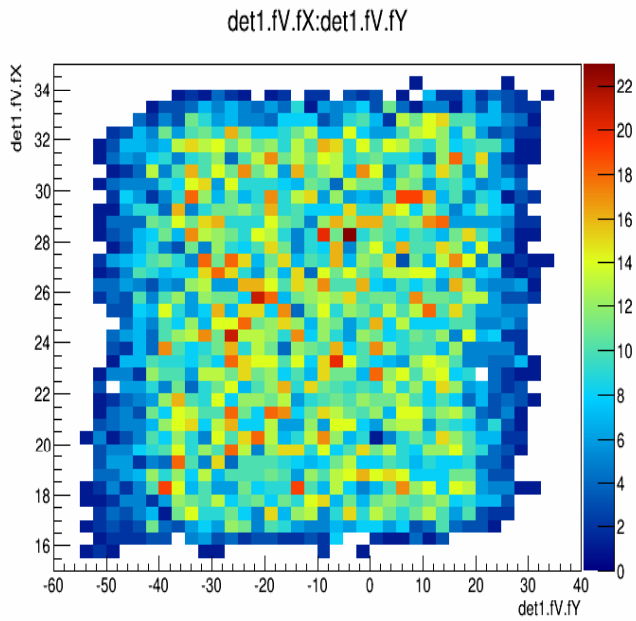
+3%



0%

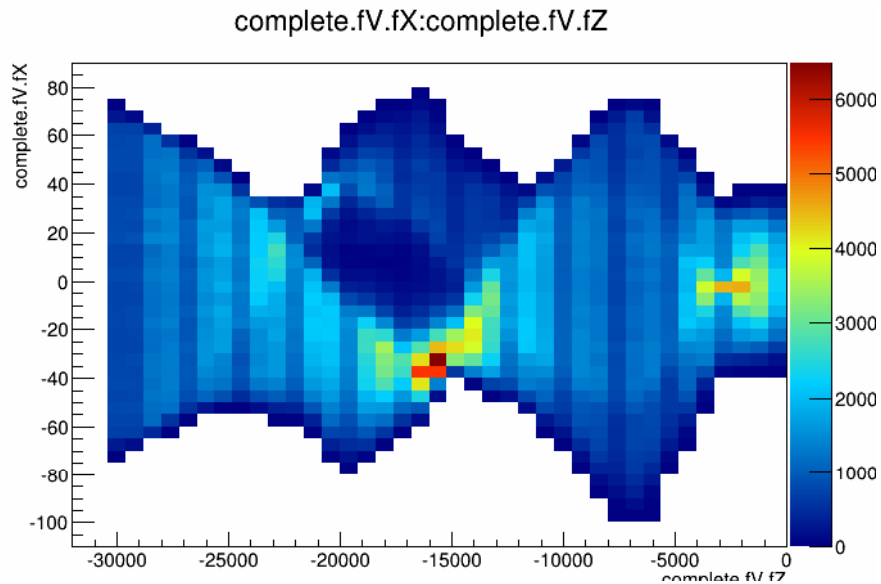


-3%

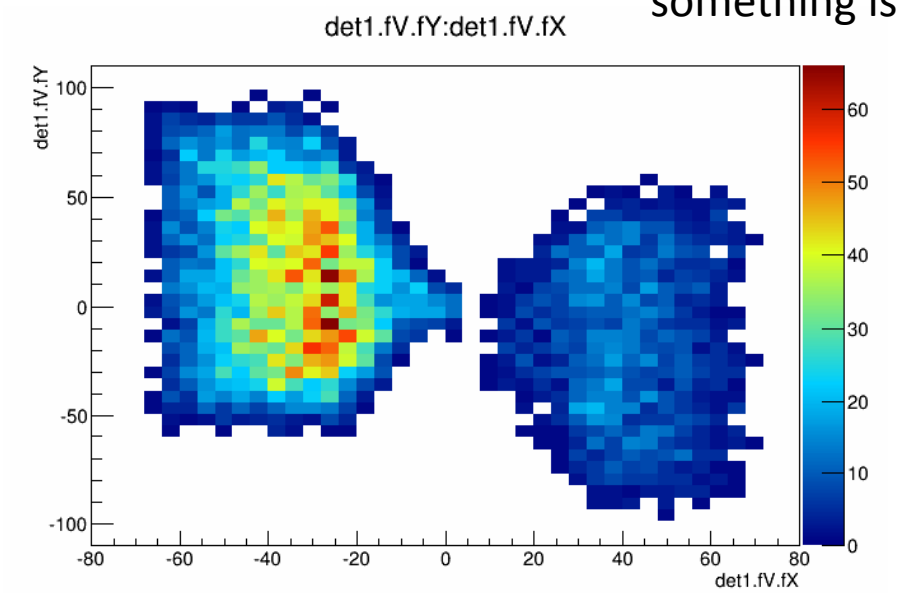


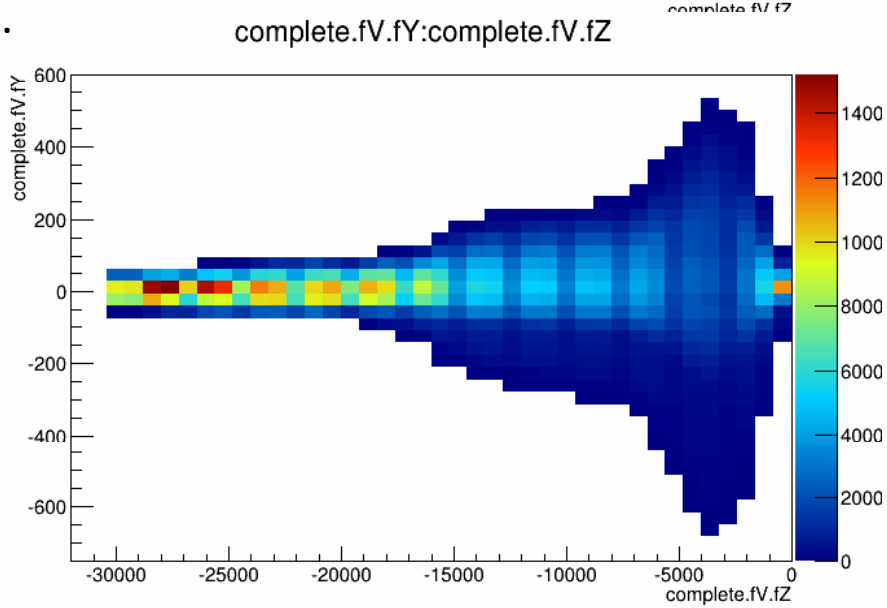
Full smearing Dp, $\Delta(\Theta,\phi)$ and $\Delta(X_0Y_0)$

```
 //Place (virtual) detector along the beam line. Units are in mm:
sim->AddDetector("det1", -18092.6);
sim->AddDetector("det2", -6310.0);
for (double dist = -30000; dist<0; dist+=300)
sim->AddDetector("complete", dist);
//Choose which module should be the target:
sim->TargetIsElement(33);
 //Select the global momentum:
 sim->SetGlobalMomentum(3.0);
//Beam profile at the production target    //position in mm:
sim->Do("_beam_x = 1.*sampleFlat()-0.5;  _beam_y = 1.0*sampleFlat()-0.5;"); //+- 1mm
//divergence in px/pz and py/pz:
sim->Do("_beam_px = 20.*sampleFlat()-10.; _beam_py = 100.*sampleFlat()-50.;");
//momentum spread:
 sim->Do("_beam_dp = 0.12*sampleFlat() - 0.06; "); //+- 6%
```

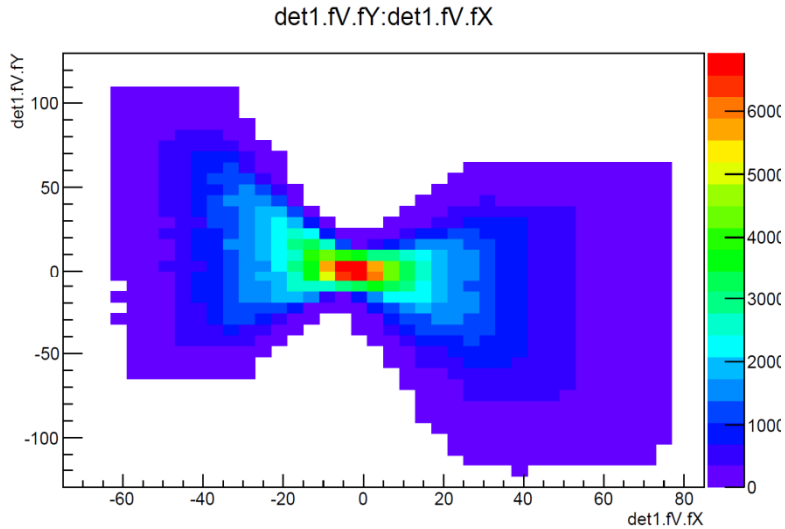


something is wrong..





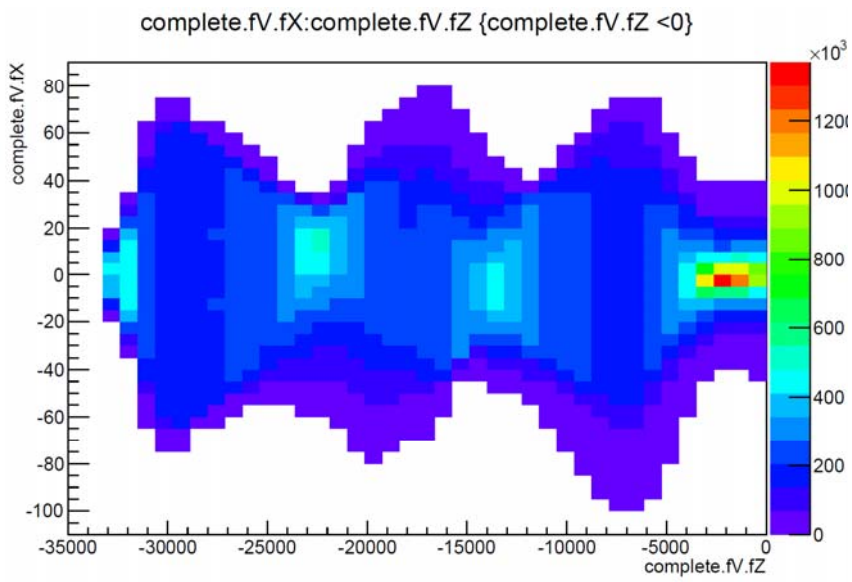
Full smearing Dp, $\Delta\Theta,\phi$ and $\Delta X_0 Y_0$

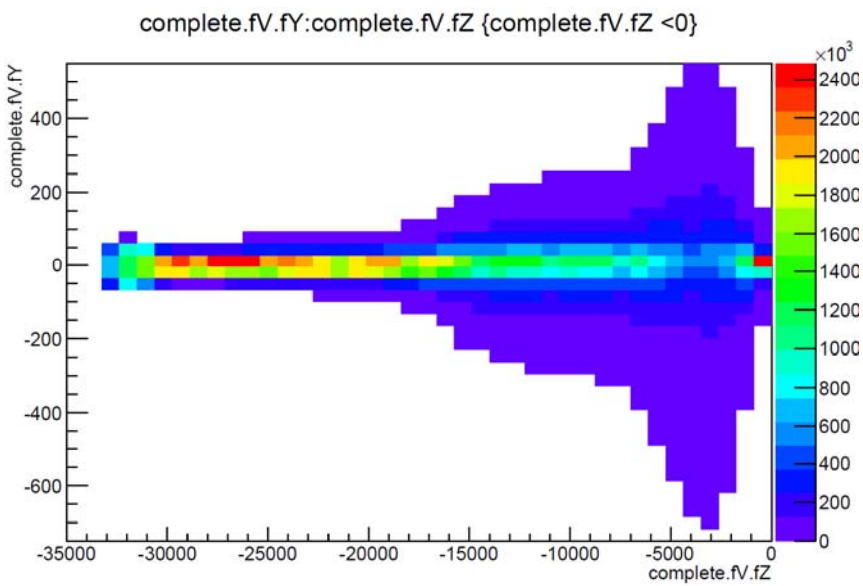


problem with momentum sampling found and removed

calculation of the output momentum from dp to p was not correct

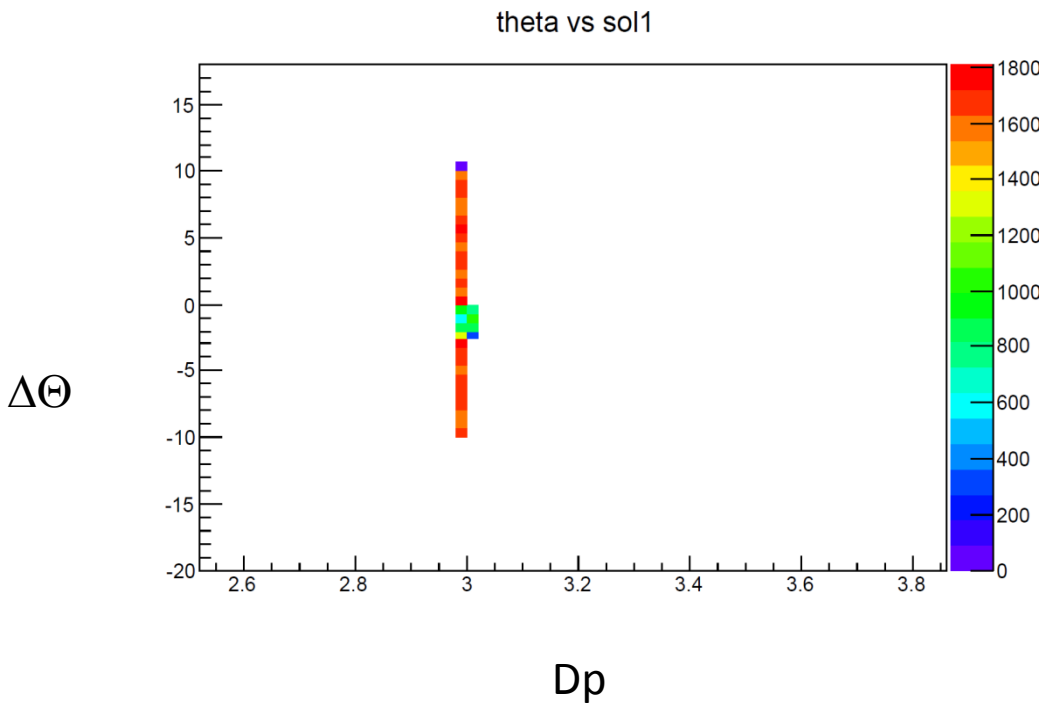
Now all looks fine !





Test of mementum reconstruction

- delta(p)/p = 3 % emission angles $\Delta\Theta$ uniform between -10 mrad and + 10 mrad i.e. px/pz -0.01 to 0.01 , no x and Y smearing

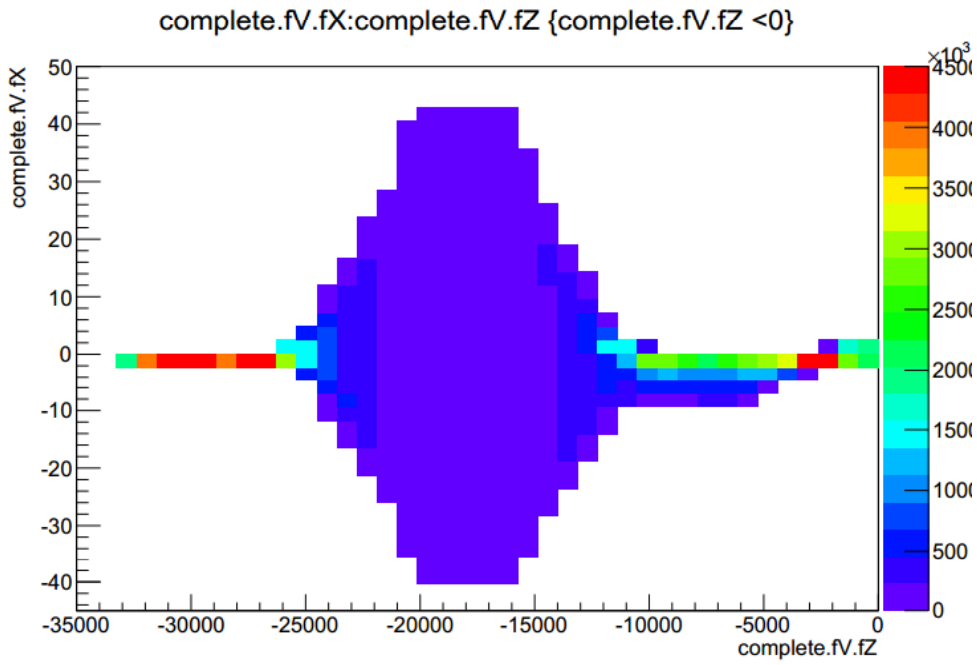


New Simulation

```
{
    //Init the reaction for c.m. sampling:

    PBeamLineSimulation *sim = new PBeamLineSimulation("beam", "Beam line simulation");
    sim->SetReaction("pi- + p");
    //Read the data file
    sim->InitBeamLine("pibeam_set6_mod.data");
    //Place (virtual) detector along the beam line. Units are in mm:

    sim->AddDetector("det1", -17092.6);

    sim->AddDetector("det2", -5400.0);

    sim->AddDetector("det3",-300);

    sim->AddDetector("det4",-10);

    for (double dist = -36000; dist<0; dist+=100)

            sim->AddDetector("complete", dist);

    //open the ROOT file and type:

    //Choose which module should be the target:

    sim->TargetIsElement(33);

    //Select the global momentum:

    sim->SetGlobalMomentum(3.0);

    sim->Do("_beam_y = 1.0*sampleFlat()-0.5;"); //+- 1mm
    sim->Do("_beam_x = 1.0*sampleFlat()-0.5;"); //+- 1mm

    //divergence in px/pz and py/pz:

    sim->Do("_beam_px = 0.02*PUtils::sampleFlat() - 0.01;");

    sim->Do("_beam_py = 0.1*PUtils::sampleFlat() - 0.05;");

    //momentum spread:
    sim->Do("_beam_dp = 0.12*sampleFlat() - 0.06;"); //+- 6%

    //Beam profile at the production target
    //position in mm:

    //Add and enable module:

    makeDistributionManager()->Add(sim);

PReaction my_reaction("_T1 = 1.3","pi-","p","n w [e+ e-]","pi_p_n_rho0");

    my_reaction.Print();   //The "Print()" statement is optional

    my_reaction.Loop(500000);
```

Results

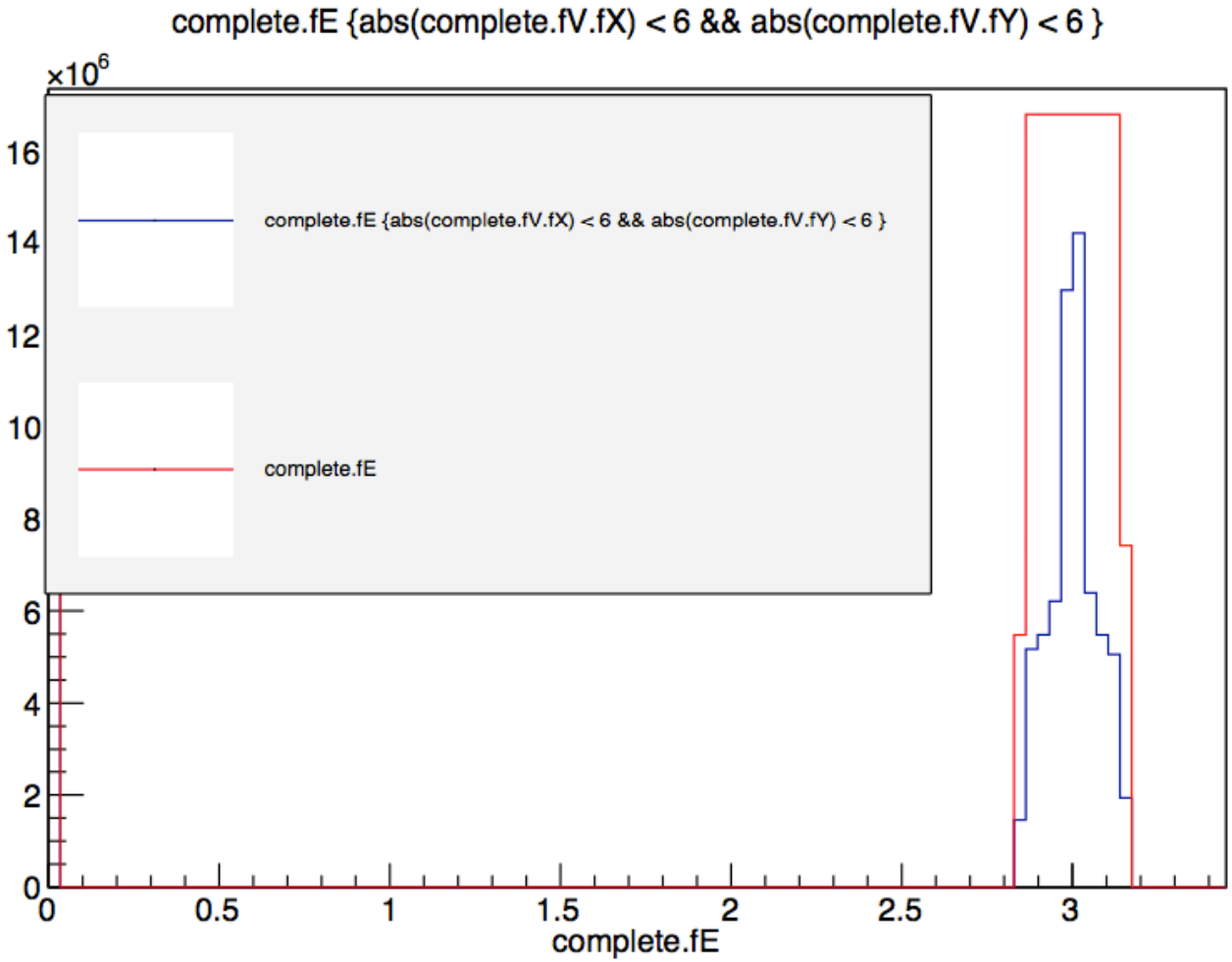
- Remark to syntax in PLUTO macro : settings of x, y /px ,py need to be set in separate lines
- Results for beam profile are as expected



Momentum reconstruction at HADES target

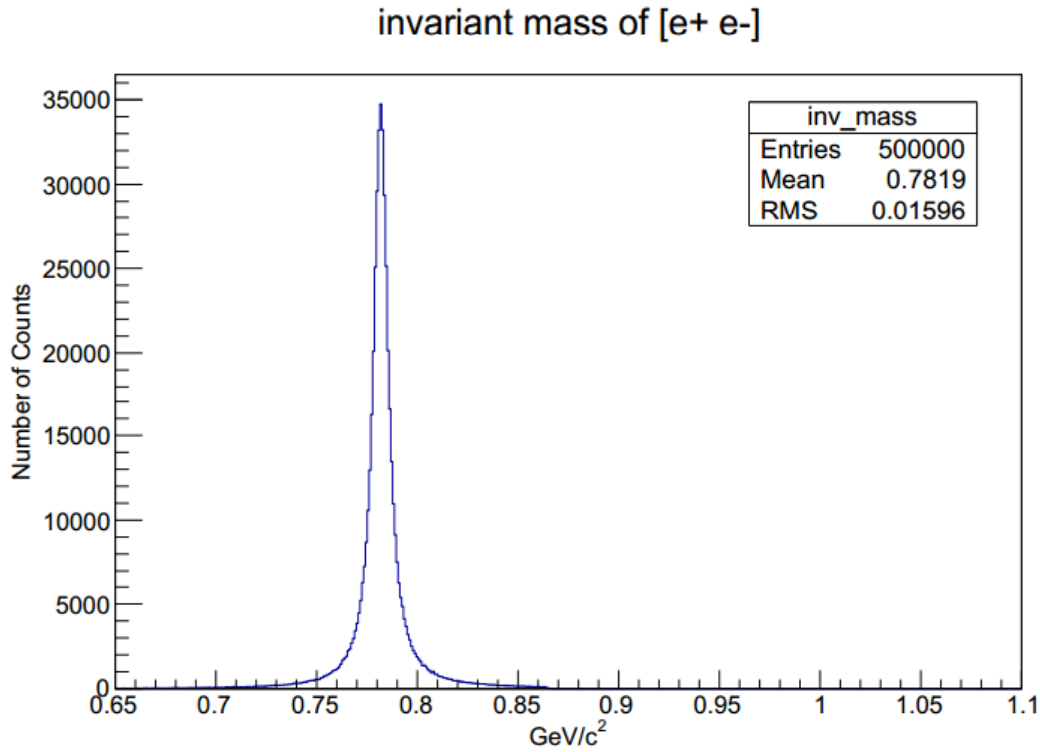
- A reconstruction of p_x, p_y ,p_z was preformed
- To check the reconstructed values of momentum a so called target detector was implemented on the beam line simulation (1 cm before the target)
- To simulate the acceptance of the beam line, a condition was introduced ($x < 6$ & $y < 6$)
- A start detector was also added to the beam line (a hit from the start detector says that this was a valid event)
- Simulated reaction: $\pi\uparrow- + p \rightarrow n\ \omega \rightarrow n\ e\uparrow+\ e\uparrow-$
- Calculations of the mass of neutron was preformed for three situations (fixed momentum = 1.3, momentum form target detector, momentum coming from reconstruction)

Acceptance cut

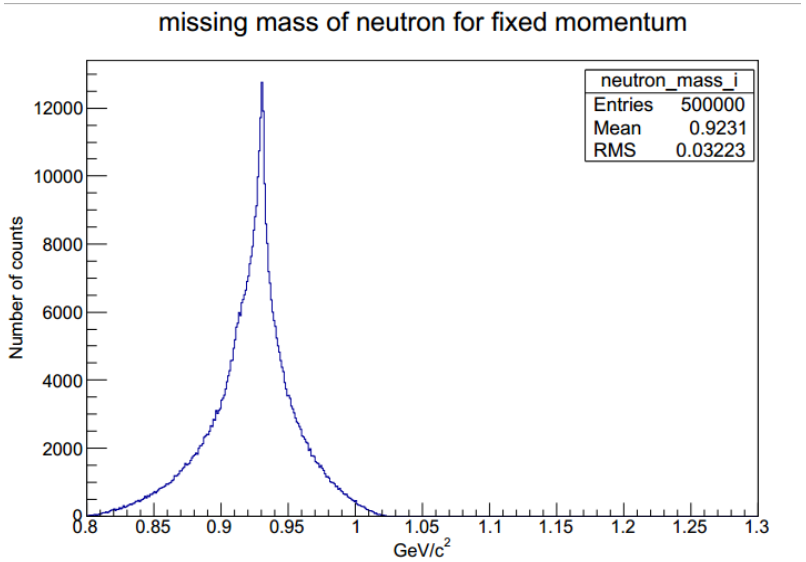


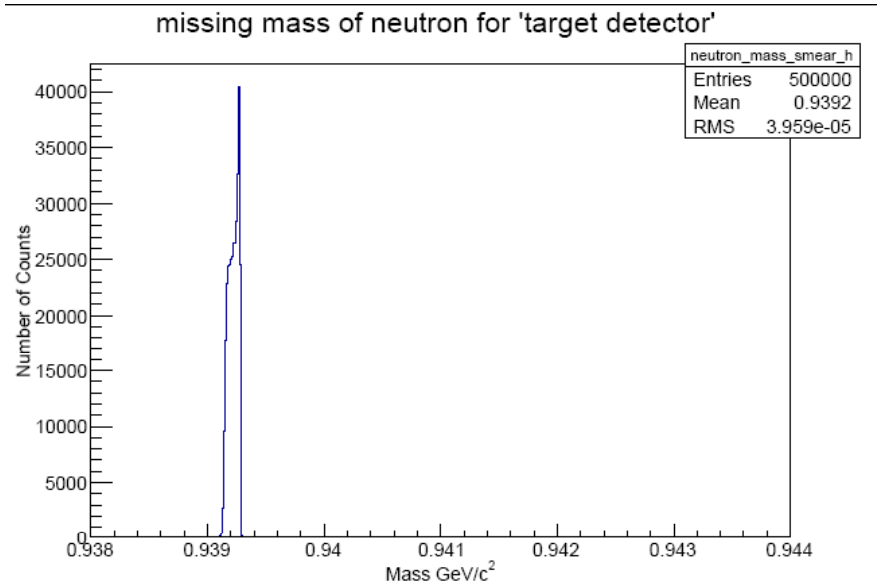
Results

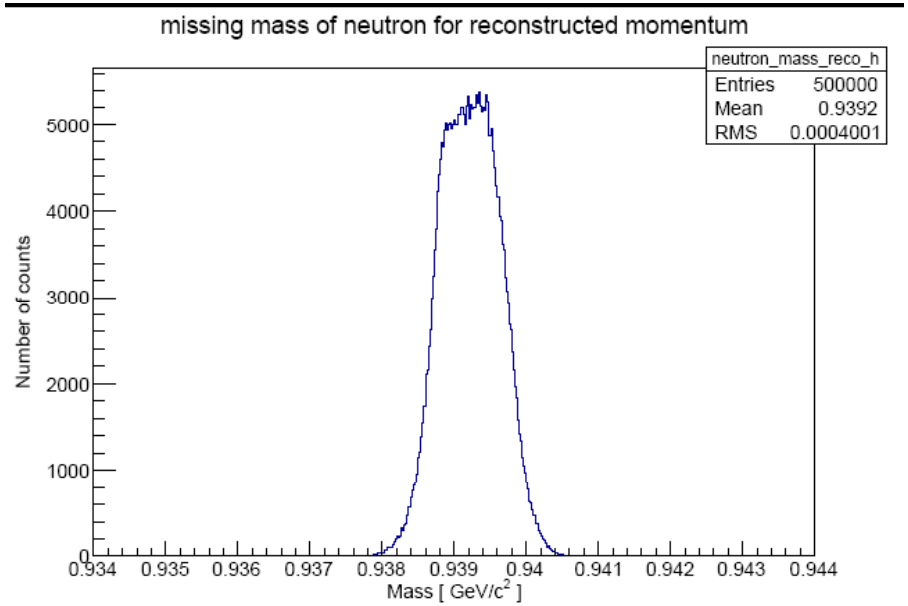
- Invariant mass of e+ e-



Neutron mass calculations

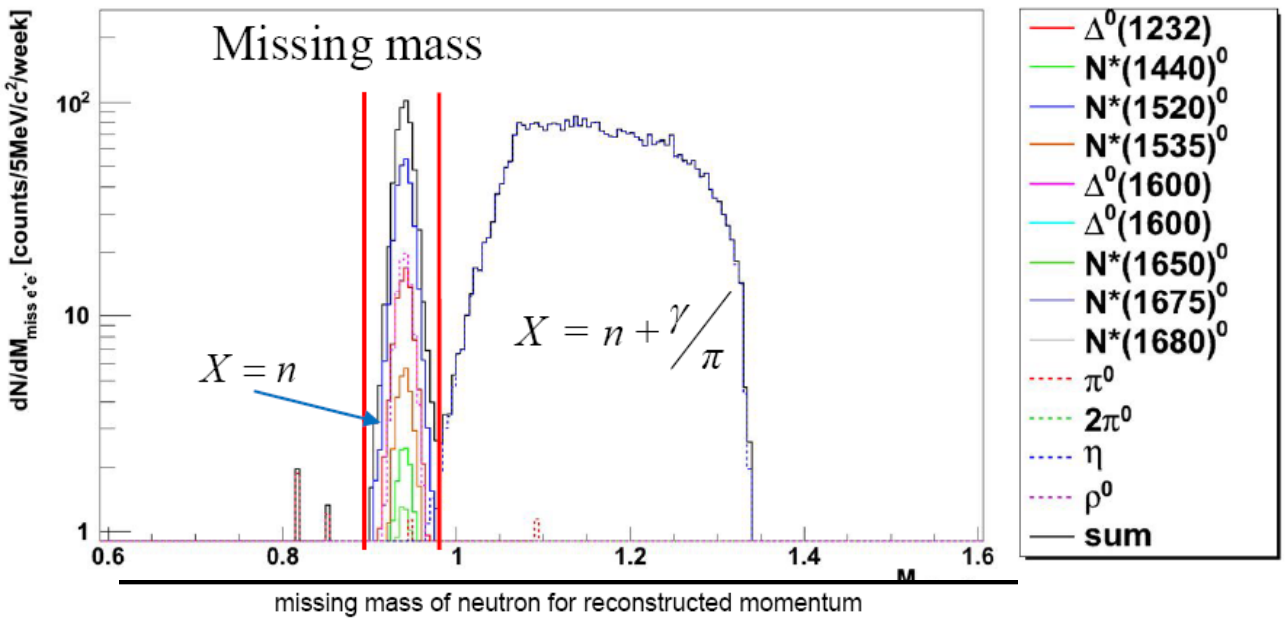




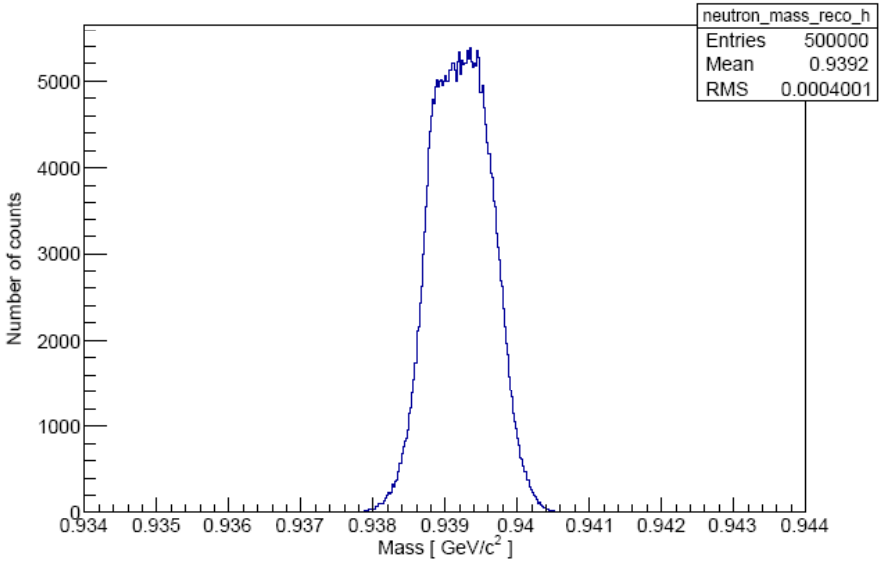


- pion beam acceptance included
- hits on start detector required (30 cm in front of the target 16x16 mm^2 active area)

Comparison of missing mass resolutiuon from HADES and pion beam reconstruction procedure



HADES resolution ;
beam momentum fixed



no HADES resolution;
beam momentum
reconstructed from hits
on tracker

Conclusions

- The issue of missing momentum in the simulation is fixed;
- Calculations of neutron missing mass show that the algorithm works as it should (same results coming from reconstruction and target detector)