NPS background simulations

(using old code, with B.Wojtsekhowski)

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NP meeting, Mar. 10, 2016

Motivation 1

NPS magnet status:

- 2 versions: vertical field (VF, horizontal bend) and horizontal field (HF, vertical bend).
- Technical issues (unresolved for now) with VF at small angles.
- Design of the HF in advanced stage, construction expected in few months.
- In order to back up the choice of magnet, simulations needed for background estimates and NPS performance for settings/conditions of the NPS experiments.

Simulation codes on hand:

A. Custom made old Fortran code. A greatly simplified model:
   - no background production, pre-calculated spectra from P.Degtyarenko instead;
   - sampling in the angular acceptance of the calorimeter, not in the magnet's acceptance (to be changed);
   - limited angular range, up to 20 deg;
   - uniform magnetic field, single bending at the center of magnet;
   - no magnet acceptance;
   - *Fast*!

Motivation 2

B. Geant4 code under development:
   - based on *Amagnet* code from G.Niculescu;
   - A BERT G4 physics model (can be changed);
   - includes target, scat. chamber, beam pipe, magnet with field, calorimeter;
   - random crashes (may be inherited from *Amagnet*?);
   - slow, porting on a central machine needed.

For prompt, preliminary results decided to go with old code for now.

Calculations (as Bogdan proposed):
- energy spectra of the background in the calorimeter;
- per block energy fluxes in the calorimeter;
- hit maps of the calorimeter;
- reconstructed pi0 mass spectra (pi0 decay + background);
- varied thresholds on the hit energies, distance to calorimeter, field strength (for HF).

NPS configurations

From Bogdan's presentation on July 15 2015 NPS meeting:

SIDIS π^0 (E12-13-007):

θ_γ = 7.93° – 17.23°; Dmag = 1.57 m; Bdl = 0.3 Tm; Dcalo = 1.43 – 3 m.

DVCS (E12-13-10):

θ_γ = 6.3° – 21.7°; Dcalo = 3 -- 6 m; Bdl = 0.3 Tm; Dmag – Calo = 1.43 – 4.43 m.

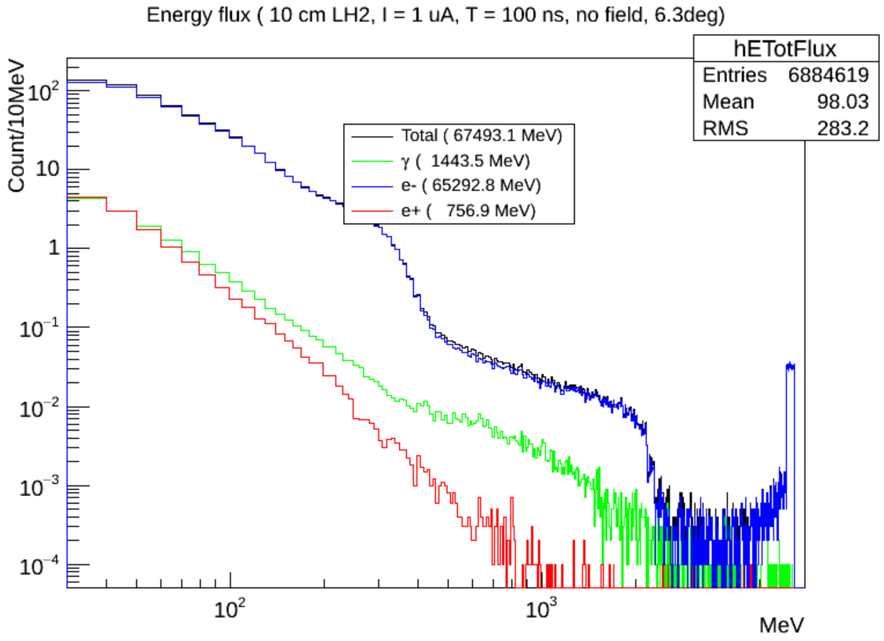
WACS (E12-14-003):

θ_γ = 11° – 34°; Dmag = 1.12– 2.47 m; Bdl = 0.3 – 0.6 Tm; Dmag – Calo = 1.7– 6.15 m.

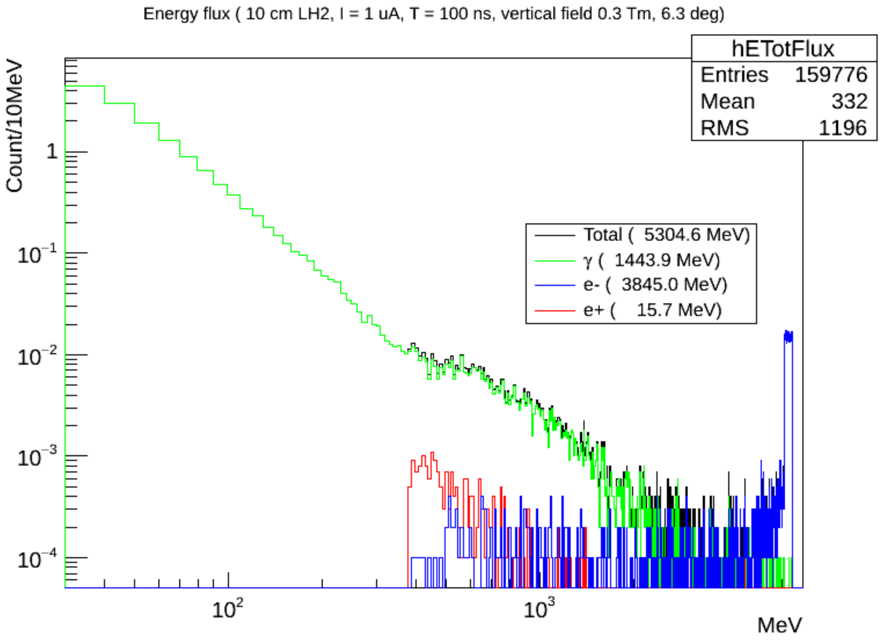
Focused on θ_γ = 6.3°, Dmag = 1.57 m, Bdl = 0.6 Tm (horizontal field), Dcalo = 4m.

Varied Bdl in 0.3 – 0.6 Tm, Dcalo in 3 – 6 m.

Vertical field sweep



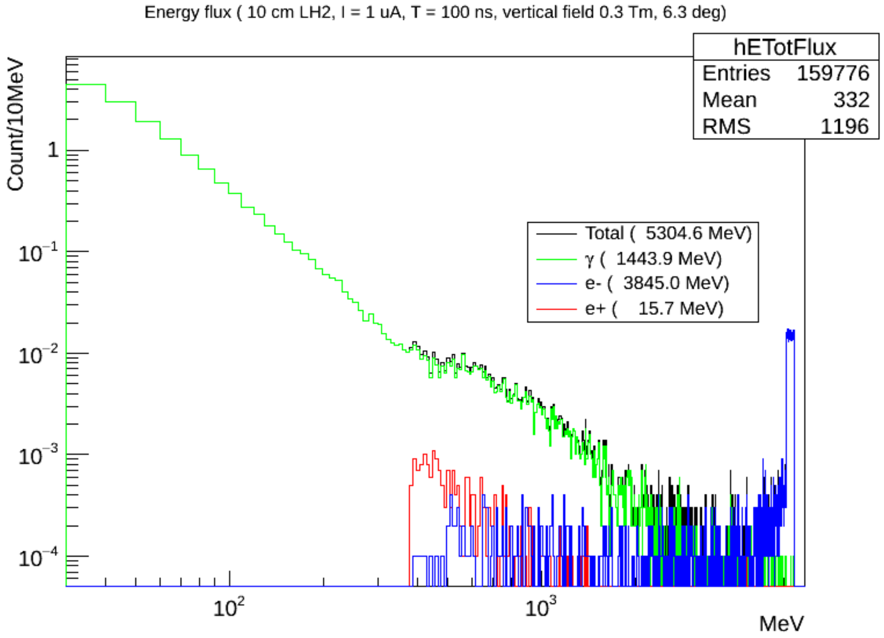
No field



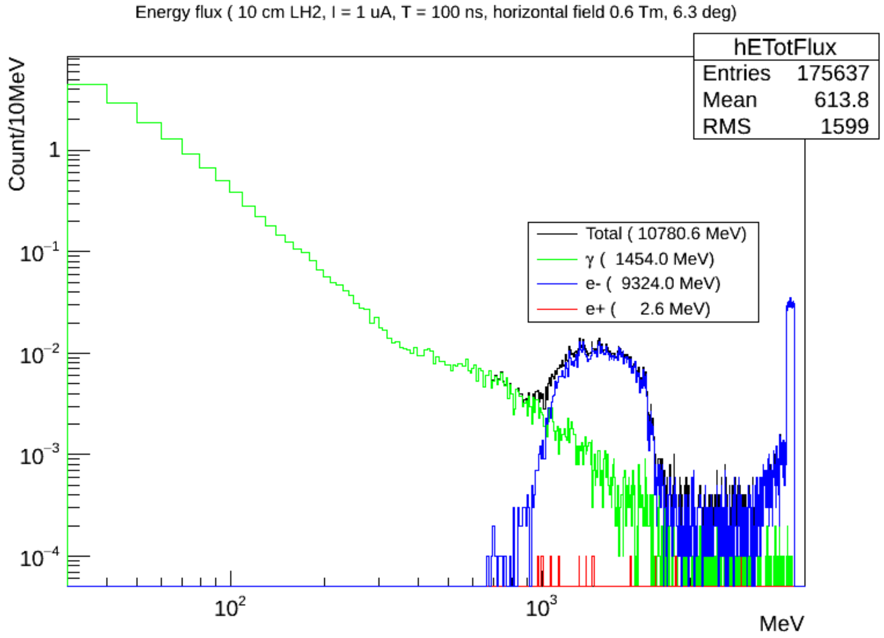
0.3 Tm vertical field

Reduction of background energy ~10 times.

Horizontal filed vs vertical field



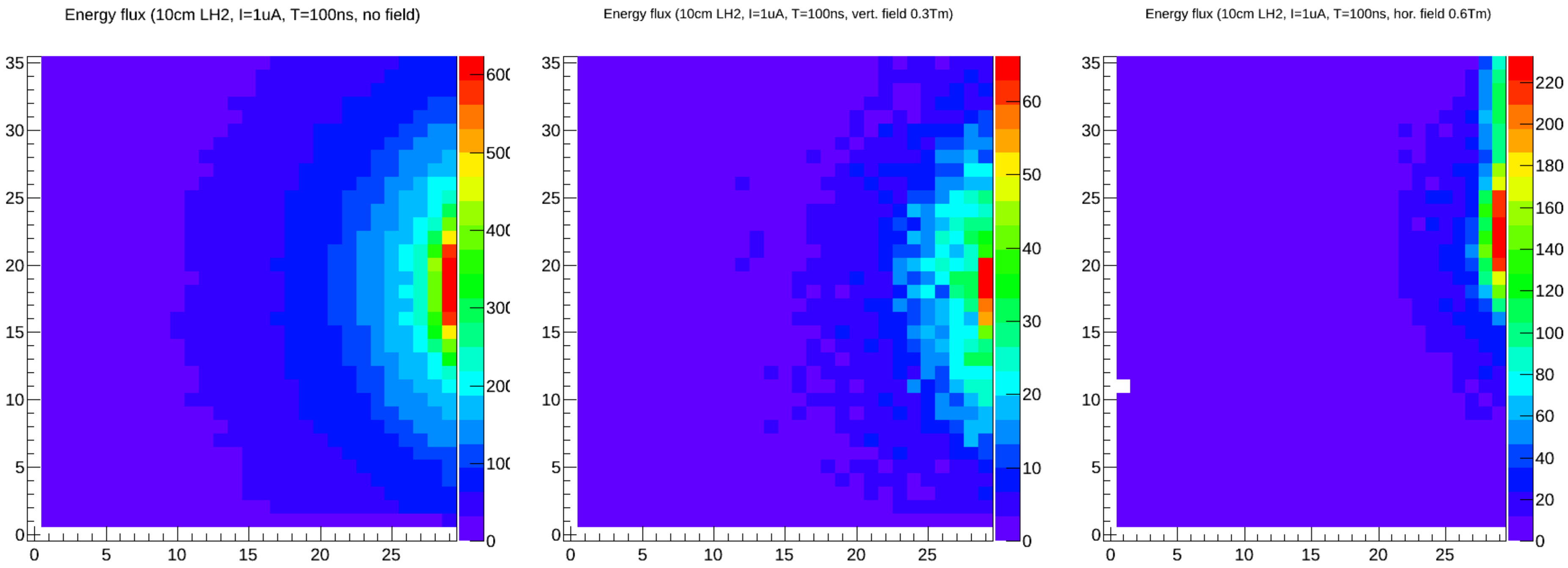
0.3 Tm vertical field



0.6 Tm horizontal field

Vertical field more efficient ~2 times.

Energy fluxes in the calorimeter



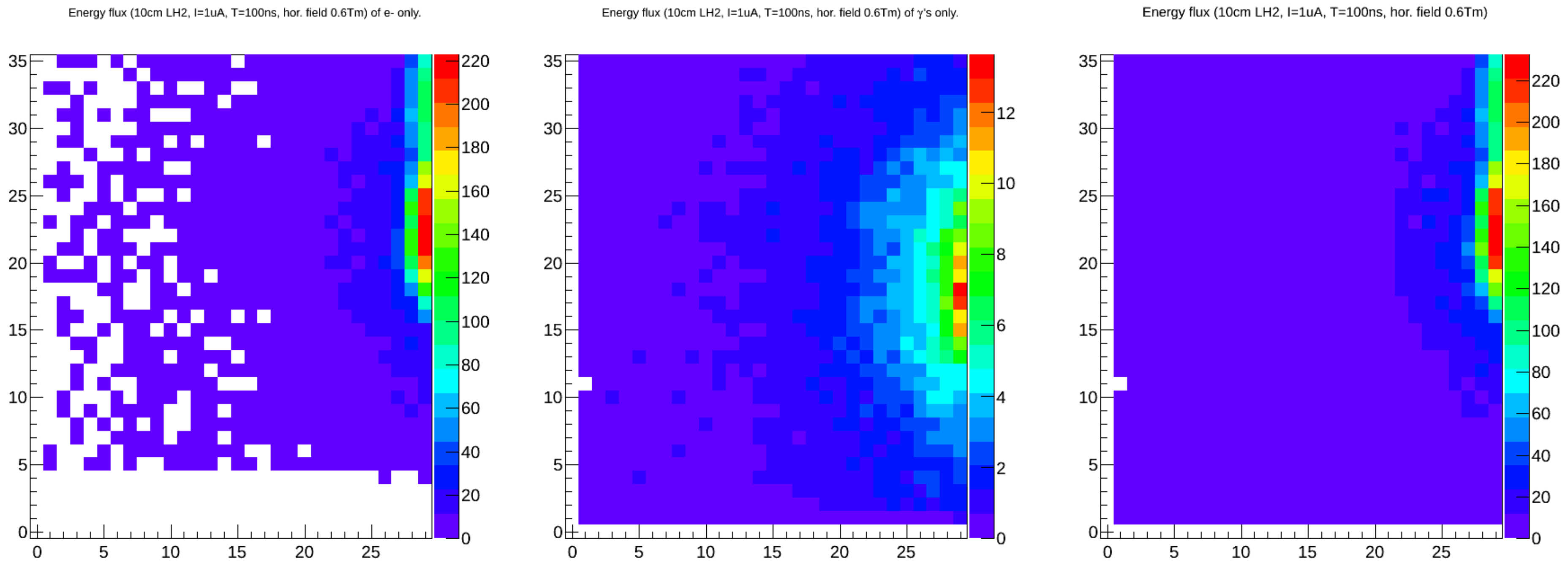
No field

0.3 Tm vertical

0.6 Tm horizontal

Significant background reduction, hot spots at beam side.

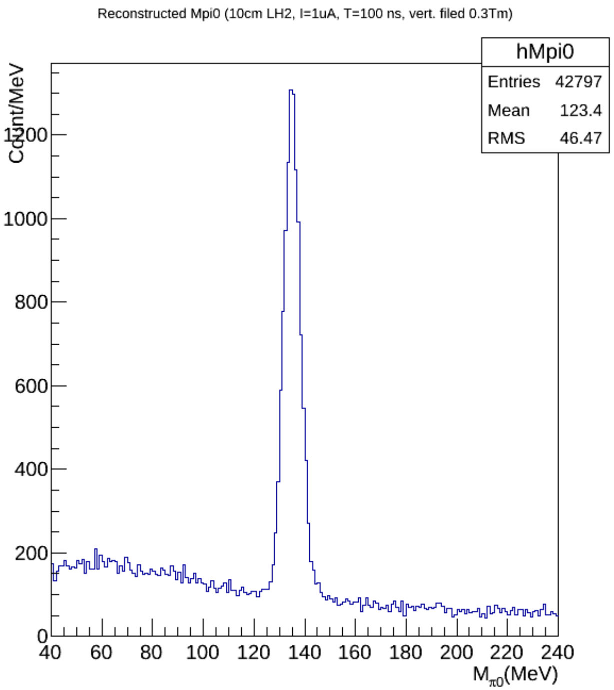
Energy fluxes from photons and e-



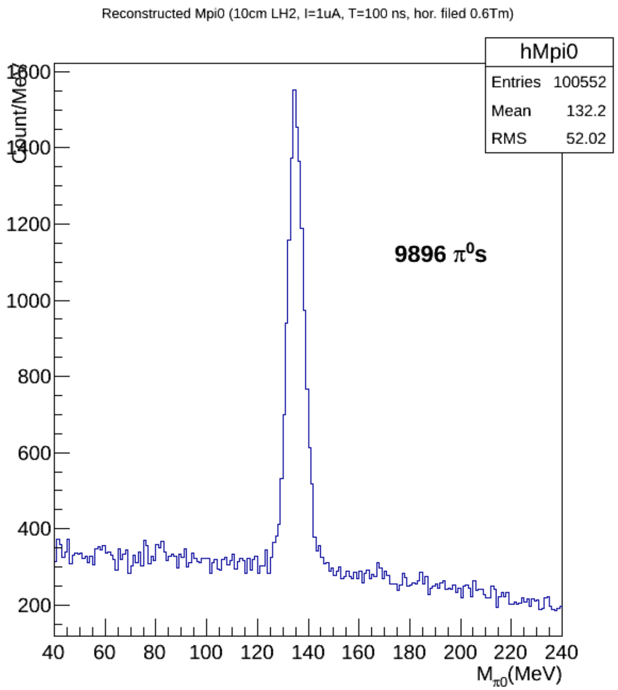
electrons photons total

Electrons displaced, dominant. Photons more spread.

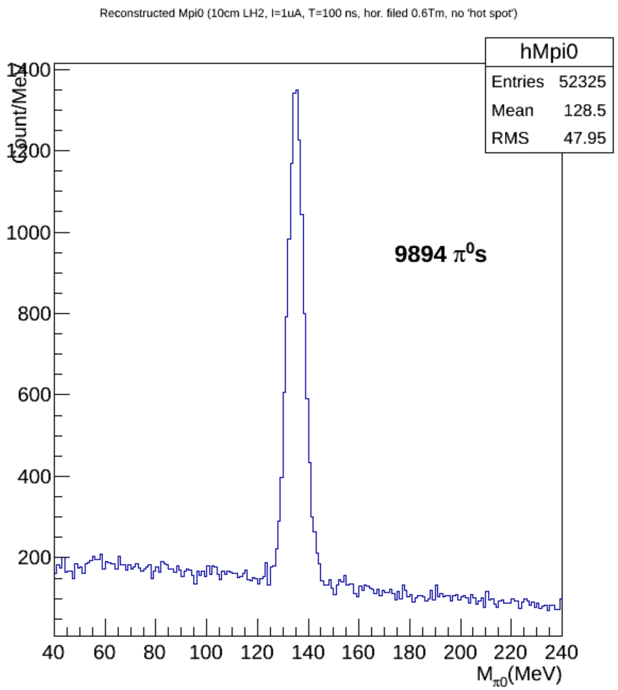
$M_{\pi 0}$ reconstruction



0.3 Tm vertical



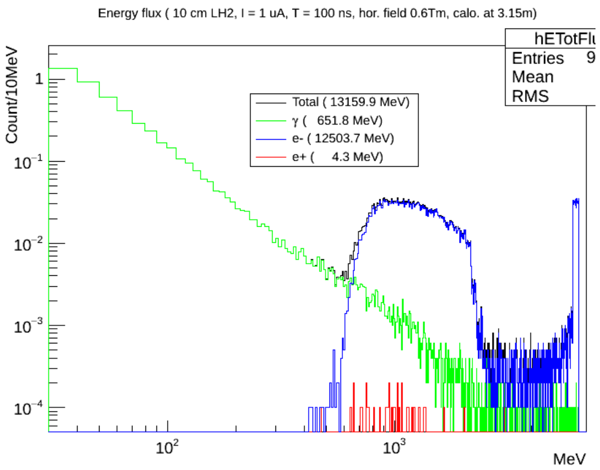
0.6 Tm horizontal



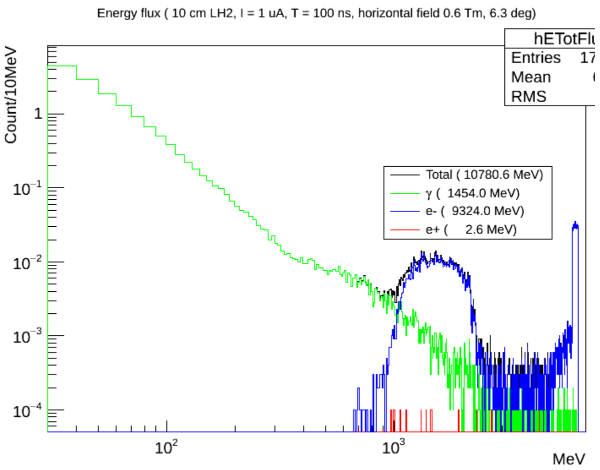
0.6 Tm horizontal,
hot spot removed

Hot spot removal : noticeable reduction in background, negligible efficiency reduction.

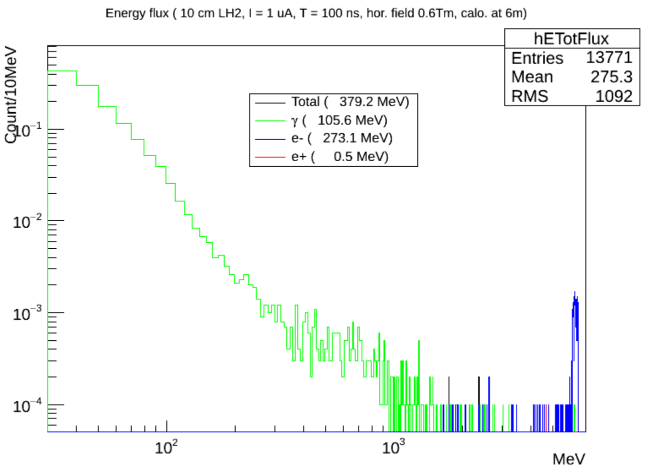
Calorimeter at different distances



3.15 m



4 m



6 m

Background reduces with distance.

Conclusions:

- reasonable results from old code, ensures confidence;
- 0.3 Tm VF is most efficient in sweeping charged background;
- 0.6 Tm HF performance is also good, a reasonably low background levels can be achieved;
- $M\pi^0$ background can be lowered by sacrifice of small part of acceptance (at beam pipe side), without compromising π^0 detection efficiency;
- detailed calculations with G4 code are needed to check these results.

Status of the G4 code:

- got new blueprints of scattering chamber from B.Metzger;
- added magnetic field;
- Slow on a laptop (not a surprise);
- Random crashes (will debug).

Backup slides

Kinematics of SI pion (E12-13-007)

#	θ_γ	θ_e	D_{mag}, m	Bdl, Tm	D_{mag}-Calo, m	angle range, degree
A	10.57	10.27	1.57	0.3	3-1.57	
B	16.20	11.70	1.57	0.3		
C	12.44	15.38	1.57	0.3		
D	7.93	24.15	1.57	0.3	1.43	4.7-11.1
E	16.57	15.65	1.57	0.3	1.43	
F	17.23	17.84	1.57	0.3	1.43	

Kinematics of DVCS (E12-13-10)

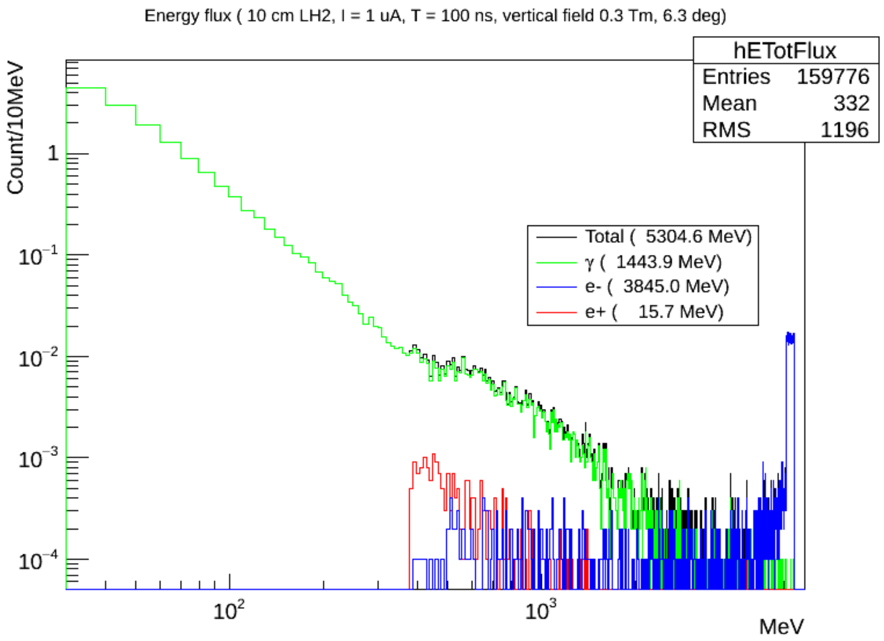
#	θ_γ	θ_e	D_{calo},m	Bdl, Tm	D_{mag}-Calo, m	angle range, degree
3	16.2	11.7	3	0.3	1.43	
5	12.4	15.3	3	0.3	1.43	
7	21.7	11.7	3	0.3	1.43	
8	16.6	15.6	3	0.3	1.43	
13	6.3	27.9	6	0.3	4.43	3.1 - 9.6
16	6.3	17.3	6	0.3	4.43	

range of angles: 68 cm / 300 => 12.8 degrees
range of angles: 68 cm / 600 => 6.5 degrees

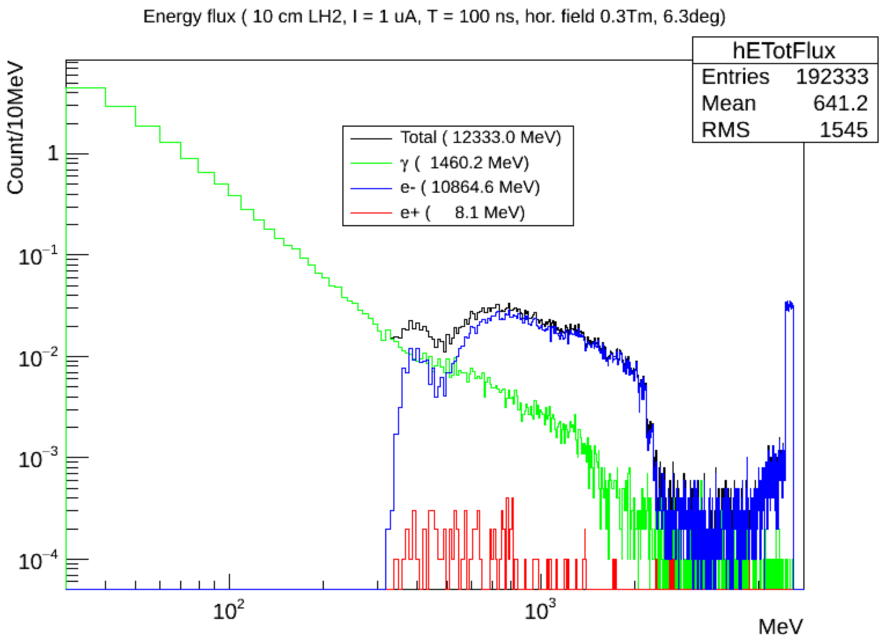
Kinematics of WACS (E12-14-003) /Pion

#	θ_γ	θ_p	D_{mag} ,m	Bdl, Tm	D_{det}, m	D_{magr}-Calo, m	Bdl,Tm / D_{mag}-Calo, m
4A	14.2	40.1	2.45+0.2	0.3	9.0	6.15	0.3 / (9-1.57)
4B	17.9	33.7	1.65+0.2	0.4	7.0		
4C	22.5	27.8	1.65+0.2	0.5	5.0		
4D	26.9	23.7	1.10+0.2	0.6	3.5		
4E	34.0	18.9	1.10+0.2	0.6	3.0	1.7	0.61 Tm / 1.68
5A	11.0	41.7	2.45+0.2	0.25	11.0		9.3-12.7 deg
5B	13.8	35.3	2.45+0.2	0.35	9.0		
5C	16.9	30.0	1.65+0.2	0.4	7.5		
5D	19.7	26.3	1.65+0.2	0.5	6.0		
5E	29.9	17.8	1.10+0.2	0.6	3.25	1.95	0.70 Tm / 1.68

Horizontal filed vs vertical field



0.3 Tm vertical field



0.3 Tm horizontal field

Vertical field more efficient, ~2 times.