Considerations on the CHOD Rates and Design

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/CERN/

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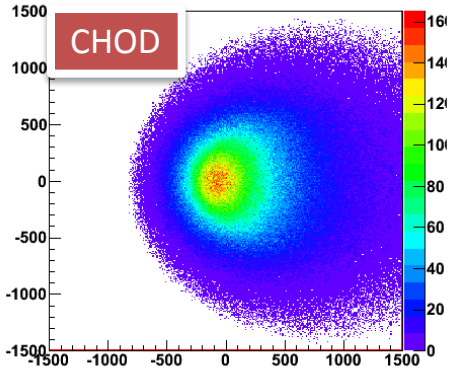
Introduction

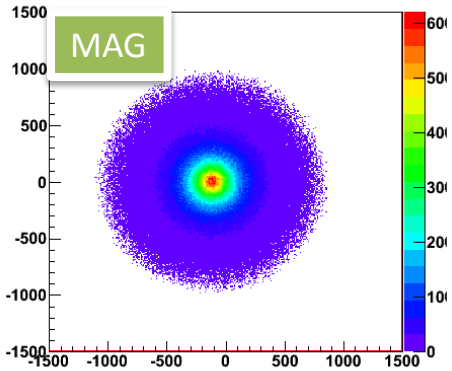
- The CHOD is a **critical** detector in NA62:
  - **as a contribution to L0:**
    - provides complementary signal to RICH in order to define the geometrical acceptance, needed to be covered by MUV3;
    - w/o CHOD the contribution from the muon halo alone is >500 MHz (the total rate being ~1 MHz);
  - **in photon rejection:**
    - CHOD multiplicity is the most powerful tool to detect interacting photons before reaching LKr and SAVs.

- Approach the new CHOD design from the point of view of:
  1. Signal acceptance
  2. Triggering
  3. Photon rejection

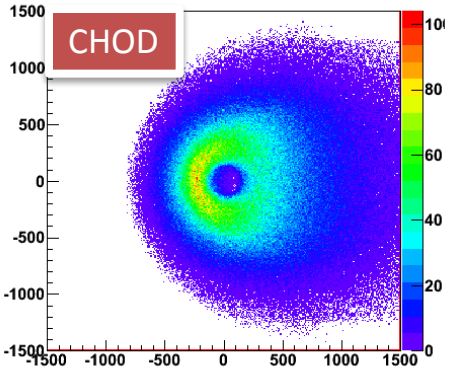
π^+ (from $\pi\nu\nu$) position

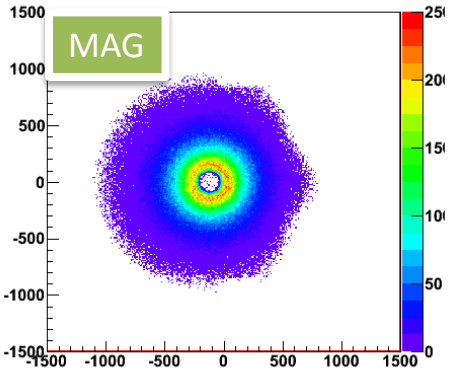
Total



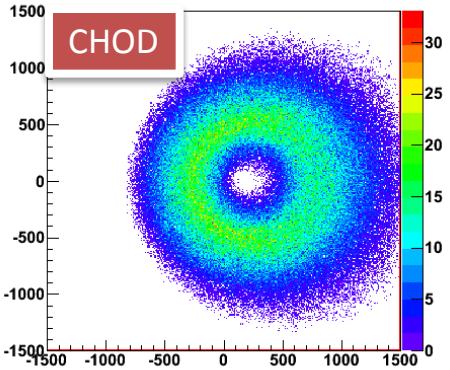


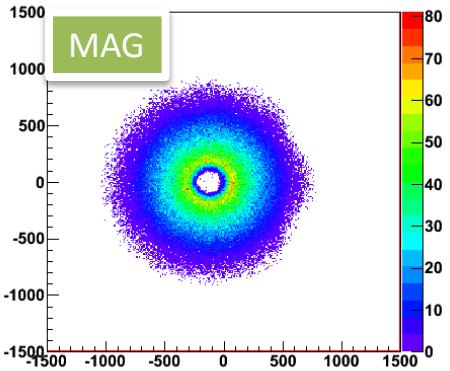
1 trk in STRAWs



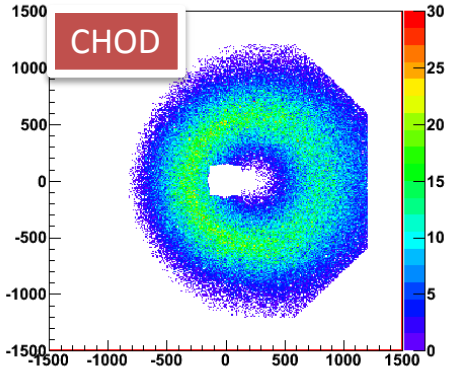


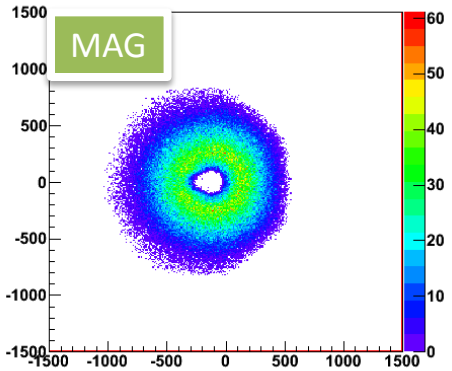
After P cut



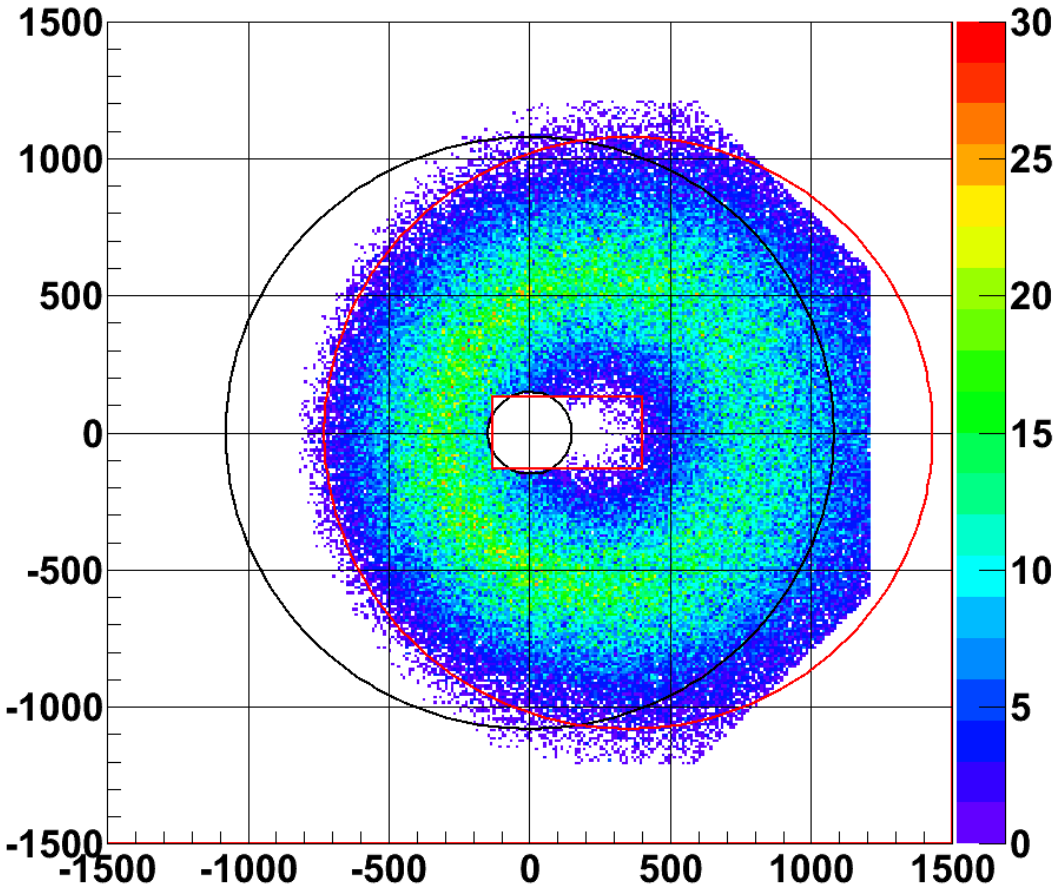


After all cuts



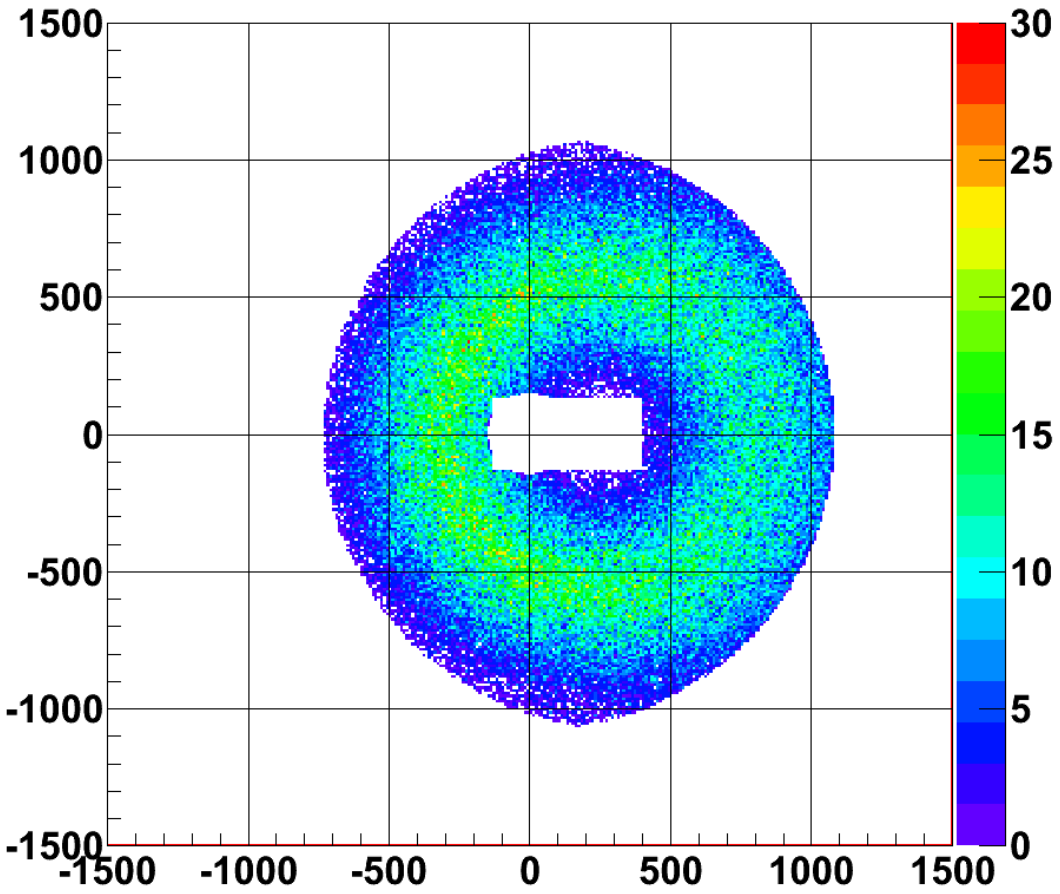


CHOD acceptances



- NA48 CHOD
  Not in |X|,|Y|<130 mm
  |X|,|Y|<1210 mm
  + octragon
- Analysis CHOD
  150 < R < 1080 mm
- Trigger CHOD
  Analysis CHOD
  R(350 mm,0) < 1080 mm
  Not in |Y|<130 mm
  and -130 < X < 400 mmm

CHOD acceptances



Statistics in 10^5:

Generated: **9.86**

After reconstruction, Z, P, CDA and NA48 CHOD acceptance cuts: **2.38**

After **analysis** CHOD cut: **2.19**

After **trigger** CHOD cut: **2.17**

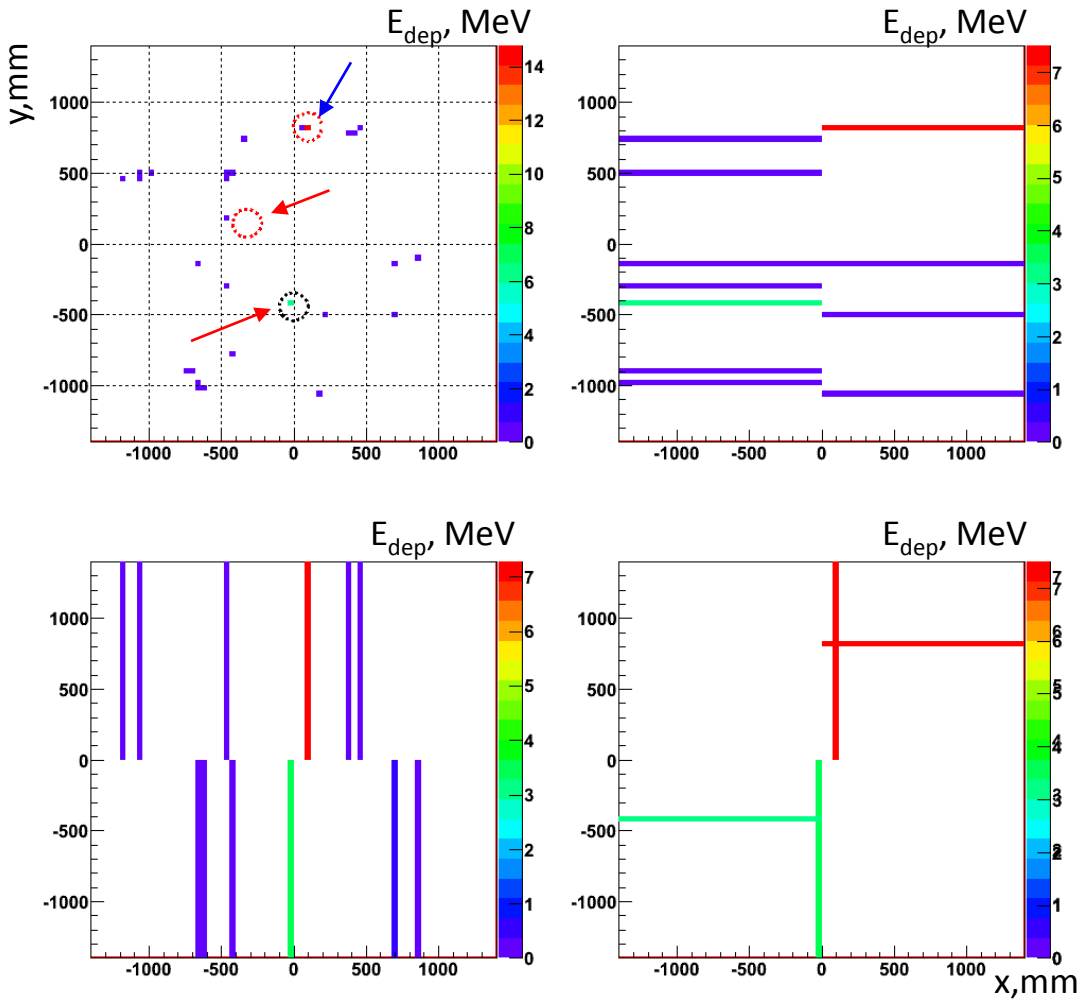
The trigger CHOD cut costs only 0.8% of the signal

CHOD pseudo-digitization

- At the moment, **no digitization** is available in NA62FW for CHOD
- In order to check the rates, we need to define signals
  - **Kinematic signal** → count every charged particle from K+ decay, or halo muon
  - **Realistic signal** → see below

- The **energy deposits** are available for each single hit in NA62MC.
- For CHOD "hit" means single energy deposit in the scintillator. The light yield is not simulated.
- One charged particle can produce many "hits", which are stored separately with their coordinates, energy, time.
- This is useful to study any possible design (given that CHOD consists of two planes with 2 cm thick vinyltoluene)
- **Recipe for realistic signal construction:**
  - add each energy deposit within a single channel;
  - define a signal from this channel if the total energy deposit is E_{tot}>2 MeV.

Example for the NA48 design

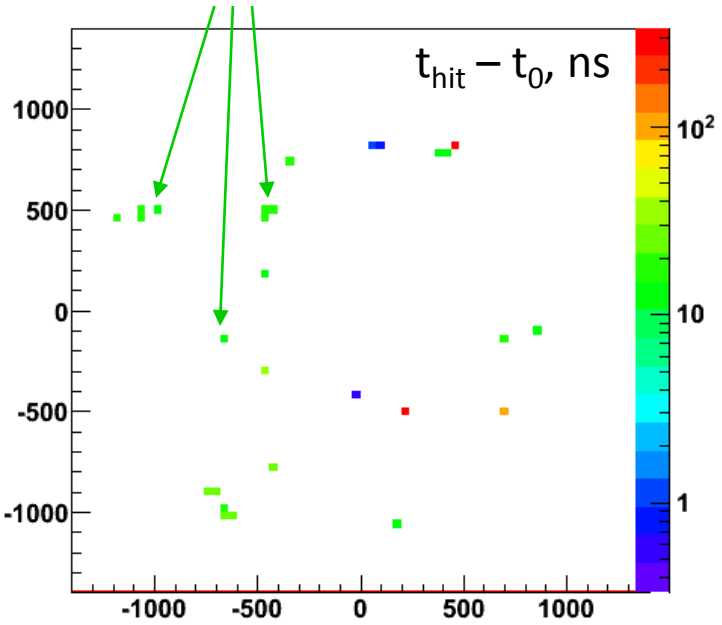


One $\pi\pi^0$ event:

π^+ and one γ reach LKr

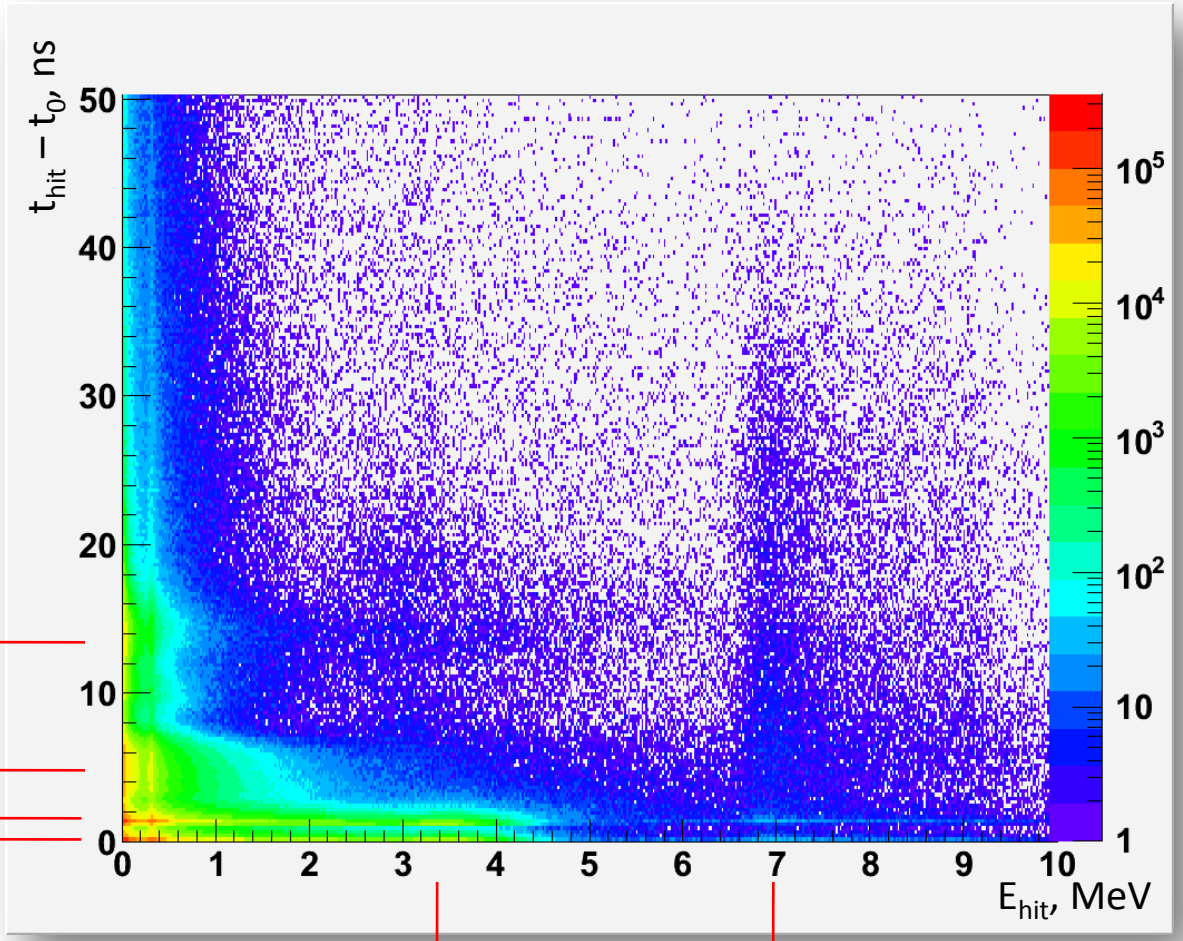
the other γ converts at the end of the RICH

See the backsplashes from LKr:



The backsplashes

Complicated time profile of CHOD hits



Backsplashes from LKr

Backsplashes from IRC

CHOD H and V planes

single charged track

pair

Rates calculation

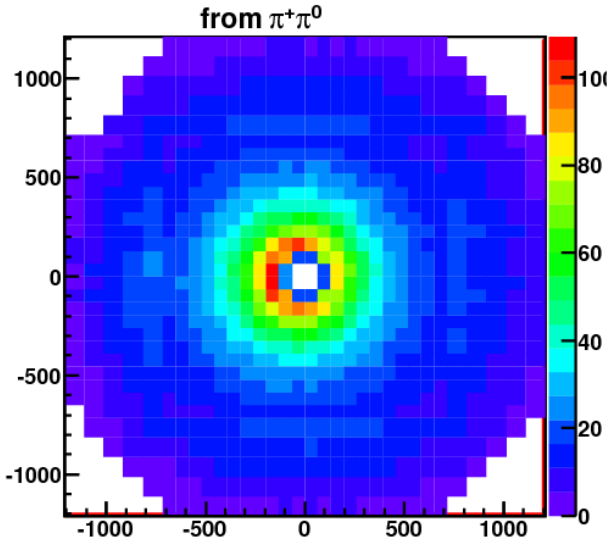
- **Two "extreme" designs studied:**
  - **the NA48 CHOD** with 2 planes of vertical and horizontal slabs (64 + 64) with varying size: 6.5 cm width in the central area and 9.9 cm in the peripheral;
    [MINIMUM SEGMENTATION]
  - **tiles design:** 6.5x6.5 cm^2 in the central area; 6.5x9.9 and 9.9x9.9 cm^2 in the peripheral.
    [MAXIMUM SEGMENTATION]
- **The design, proposed by Italo is a combination of the two.**

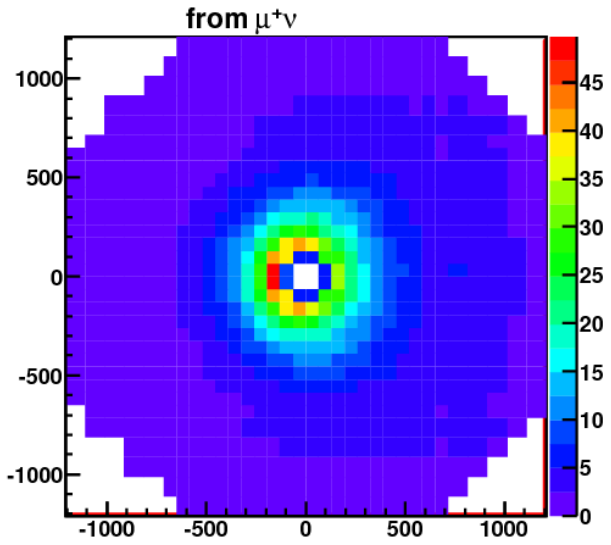
- **Two types of rates studied:**
  - **kinematical rate** (for comparison purposes)
  - **real rate** (taking into account the interactions)

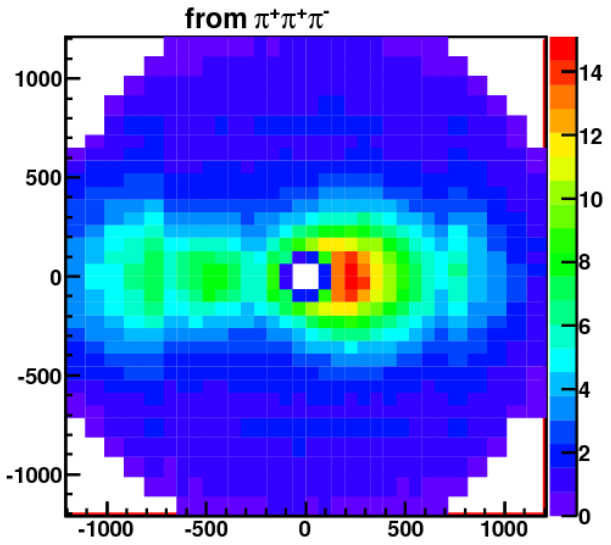
- **All the components simulated:**
  - K^+ decays downstream GTK3 (6 main decay modes)
  - π^+ beam (with $\pi \rightarrow \mu$ decays enabled) after GTK3
  - halo and non-halo muons from $K^\pm$ and $\pi^\pm$ decays upstream GTK3

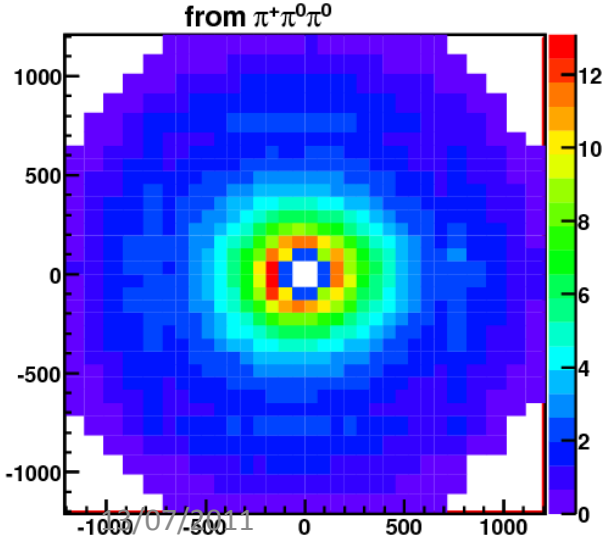
- **All rates in the following slides are in kHz, per element (slab or tile)**

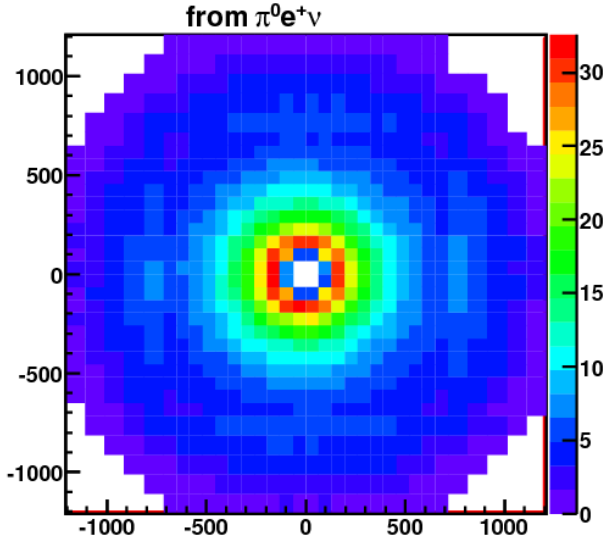
Real signals (box) [1 – K decays]

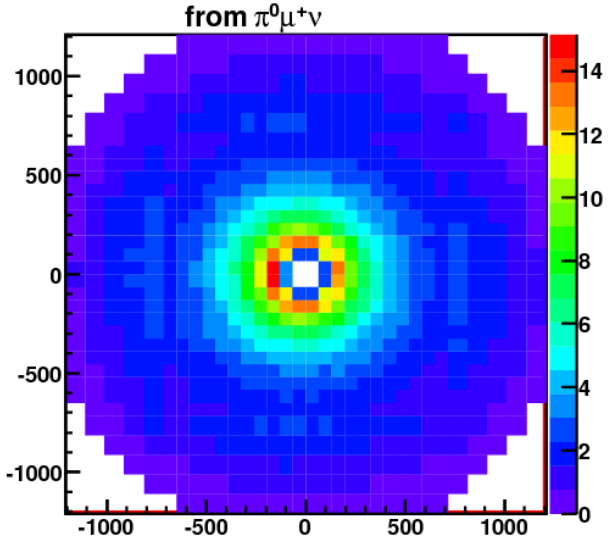




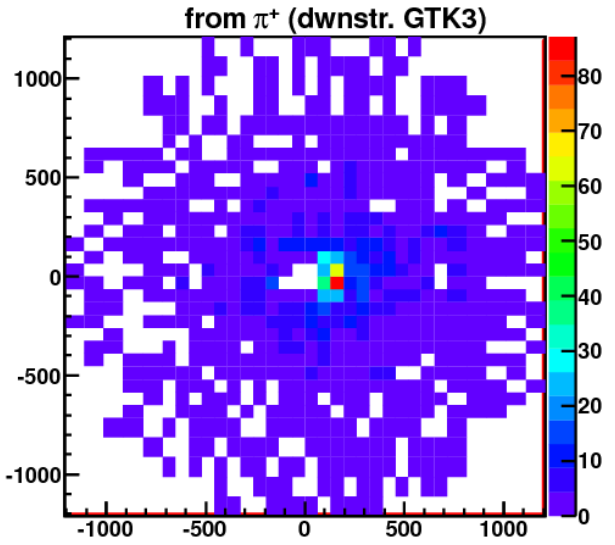


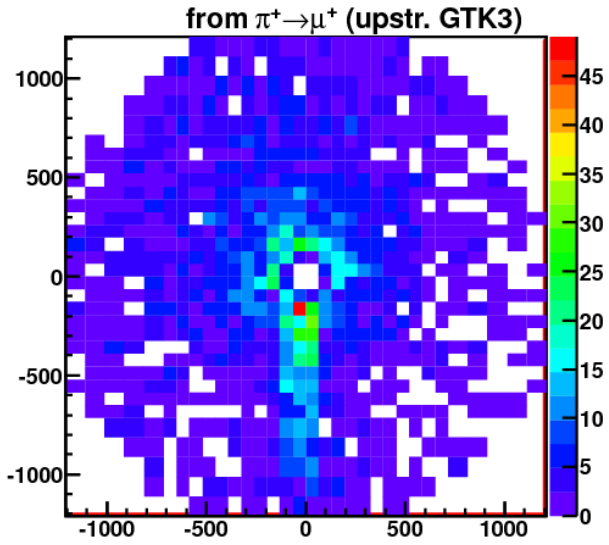


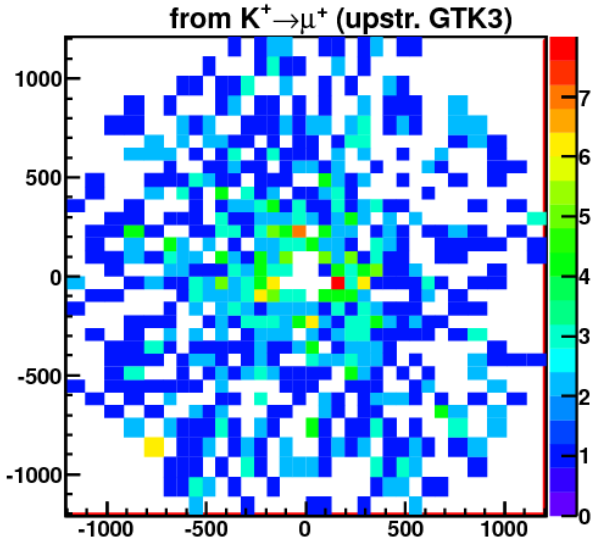


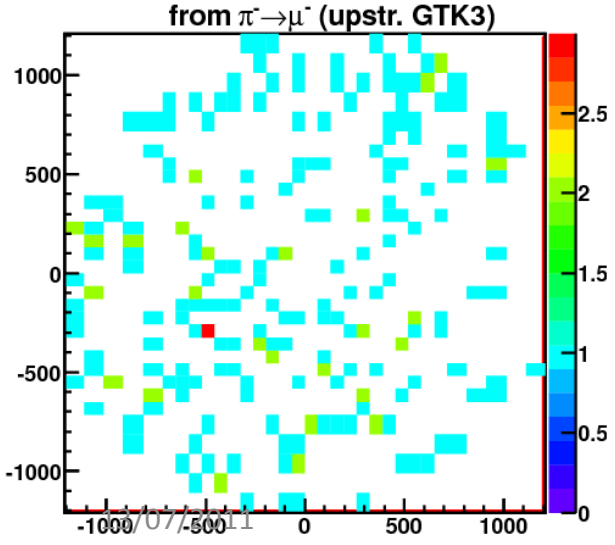


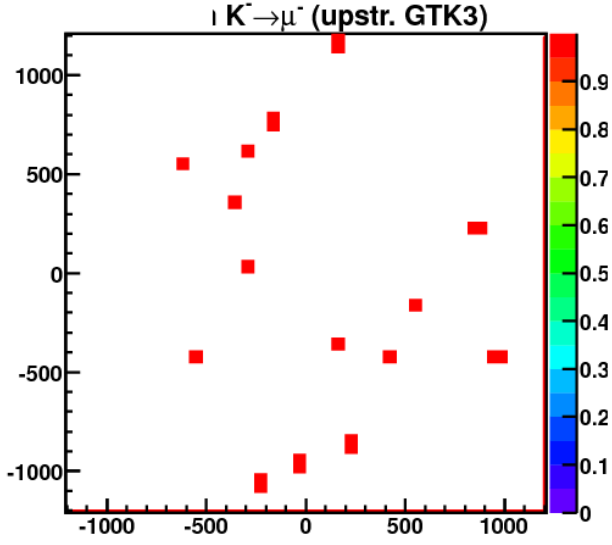
Real signals (box) [2 – HALO]

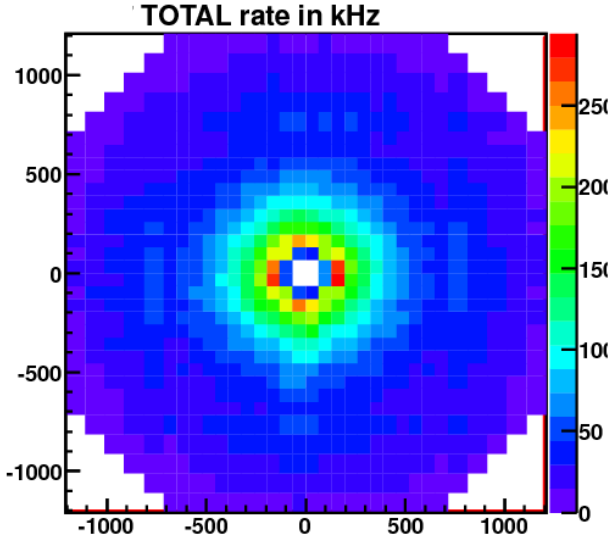




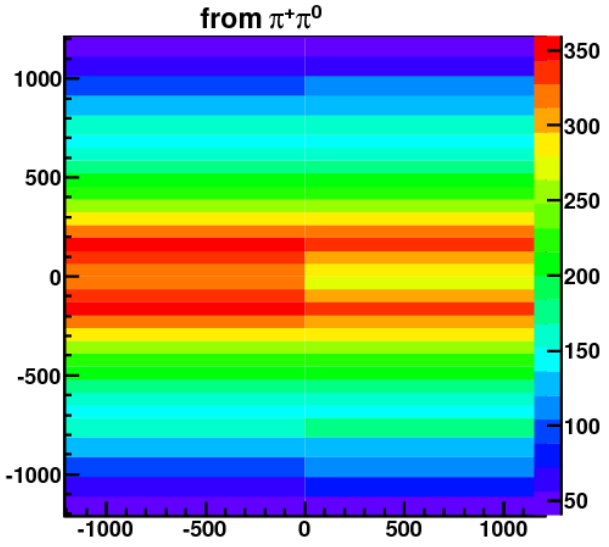


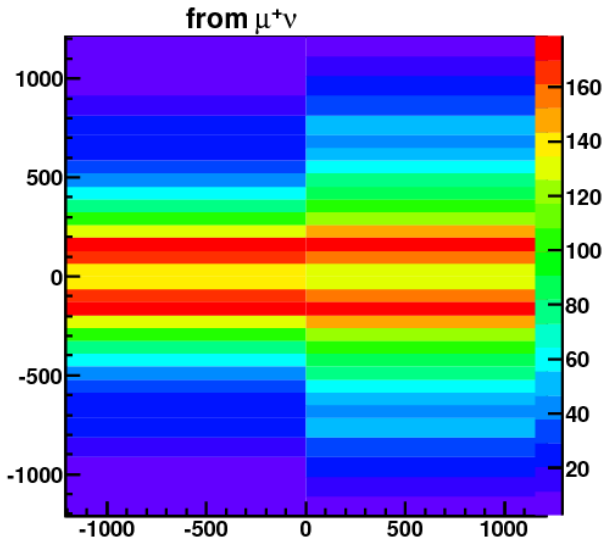


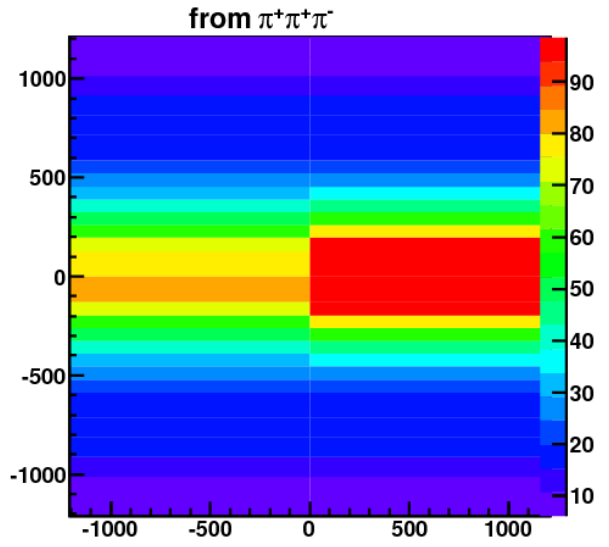


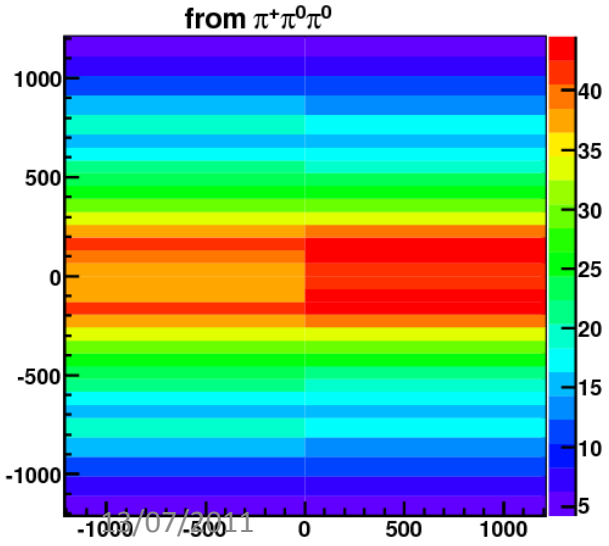


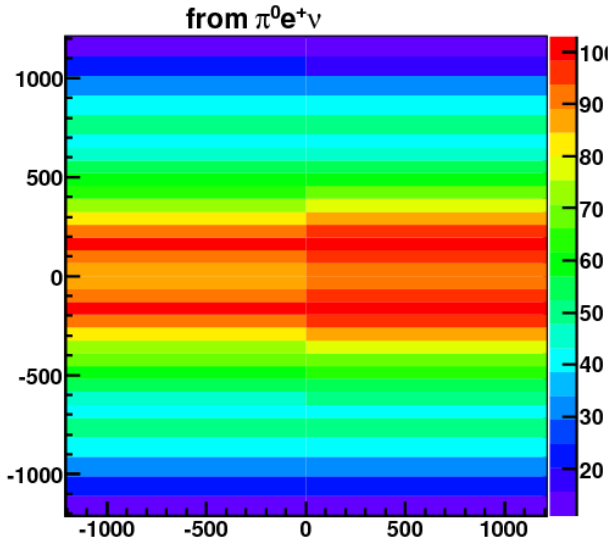
Real signals (slab) [1 – K decays]

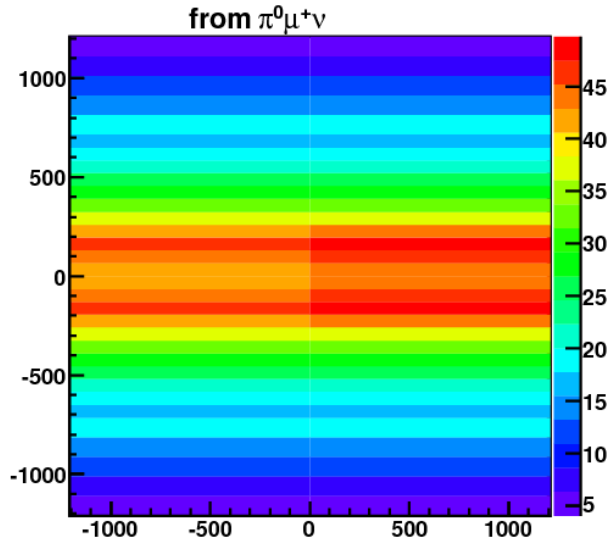




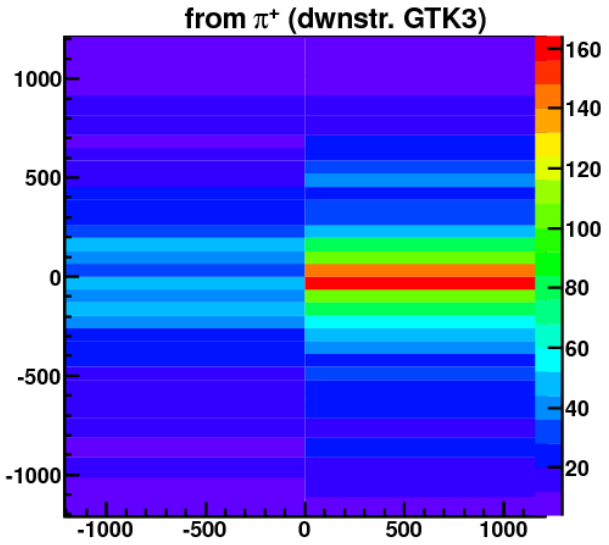


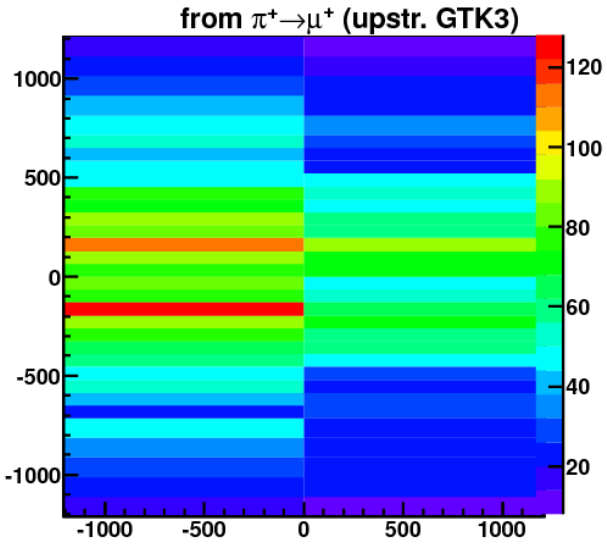


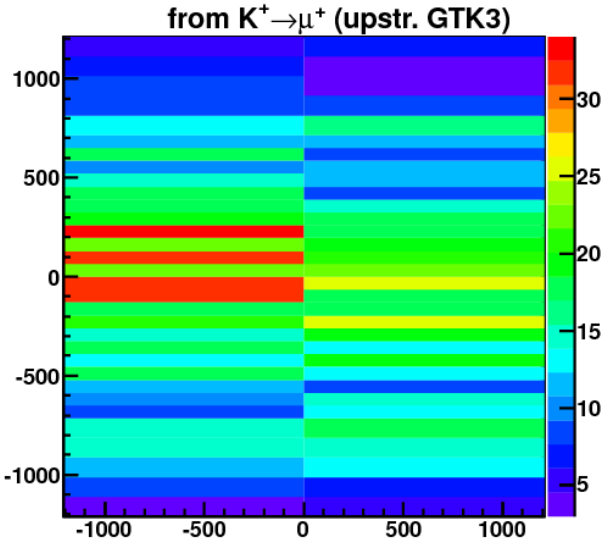


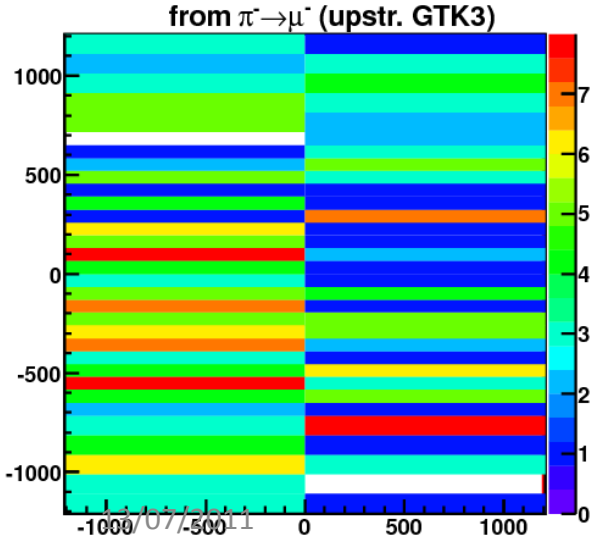


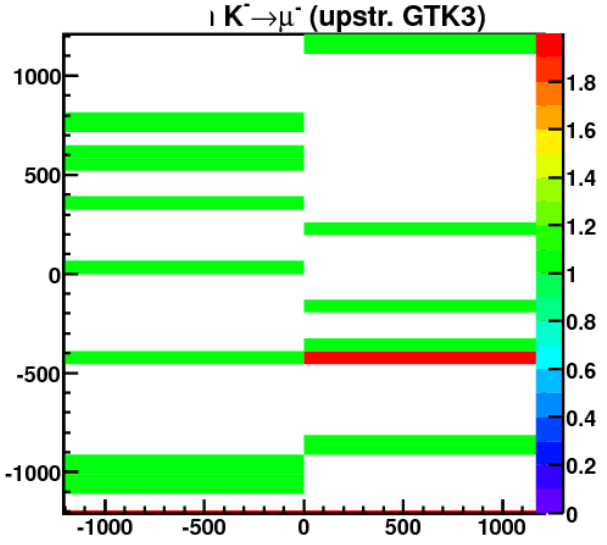
Real signals (slab) [2 – HALO]

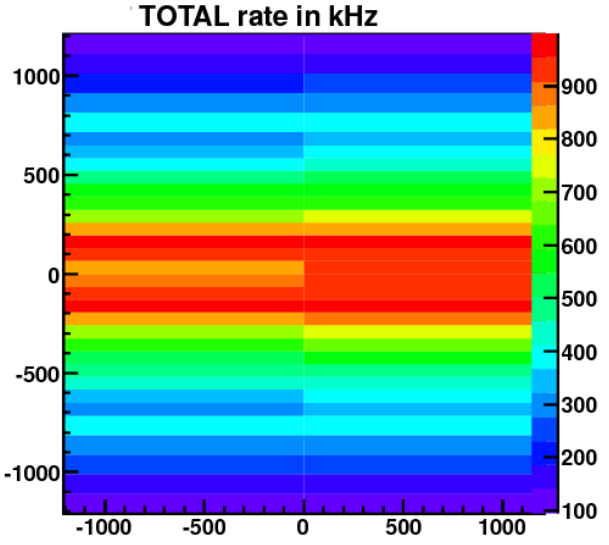






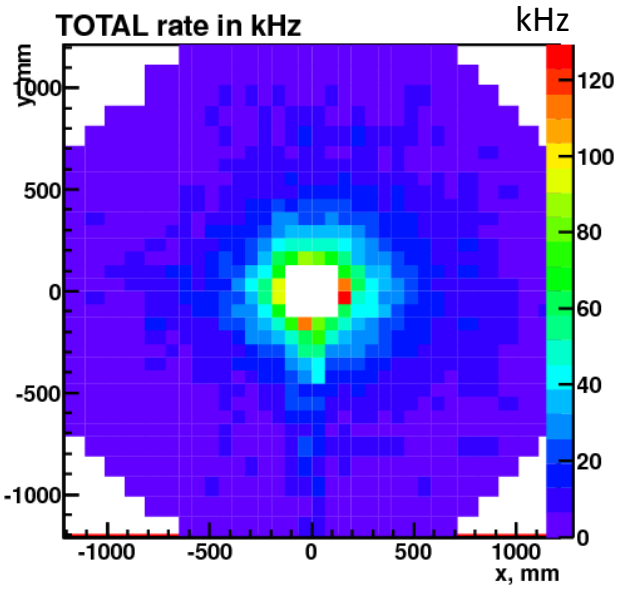


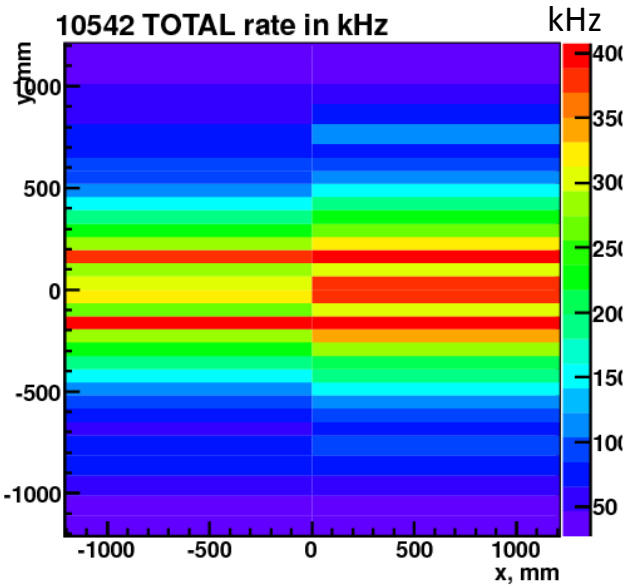




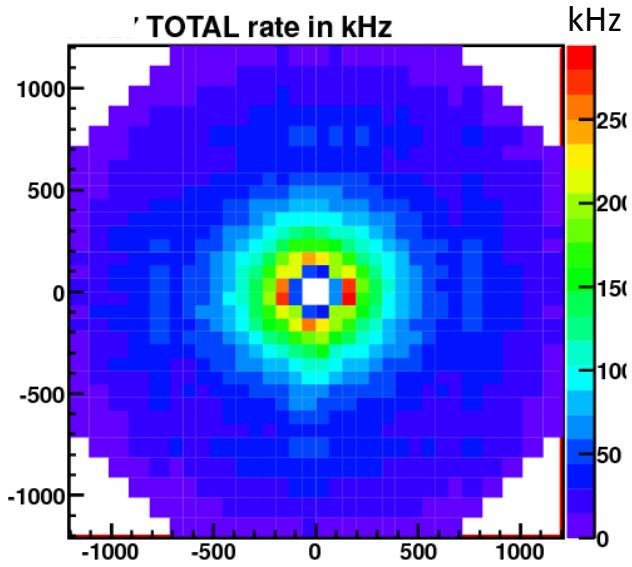
Rates - Summary

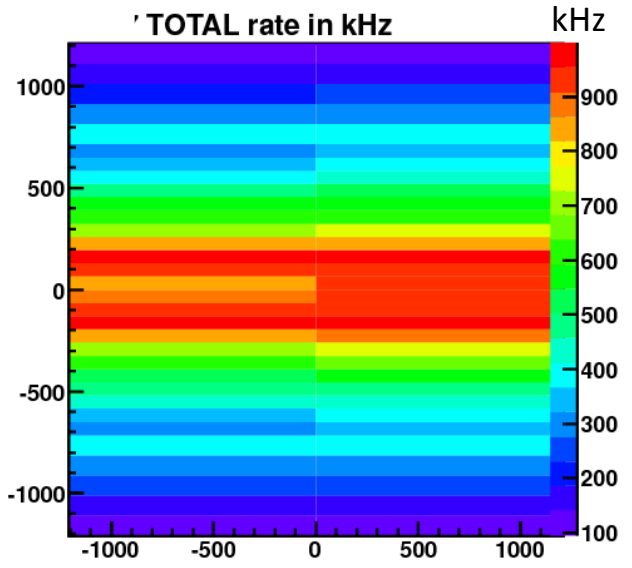
Kinematics signals



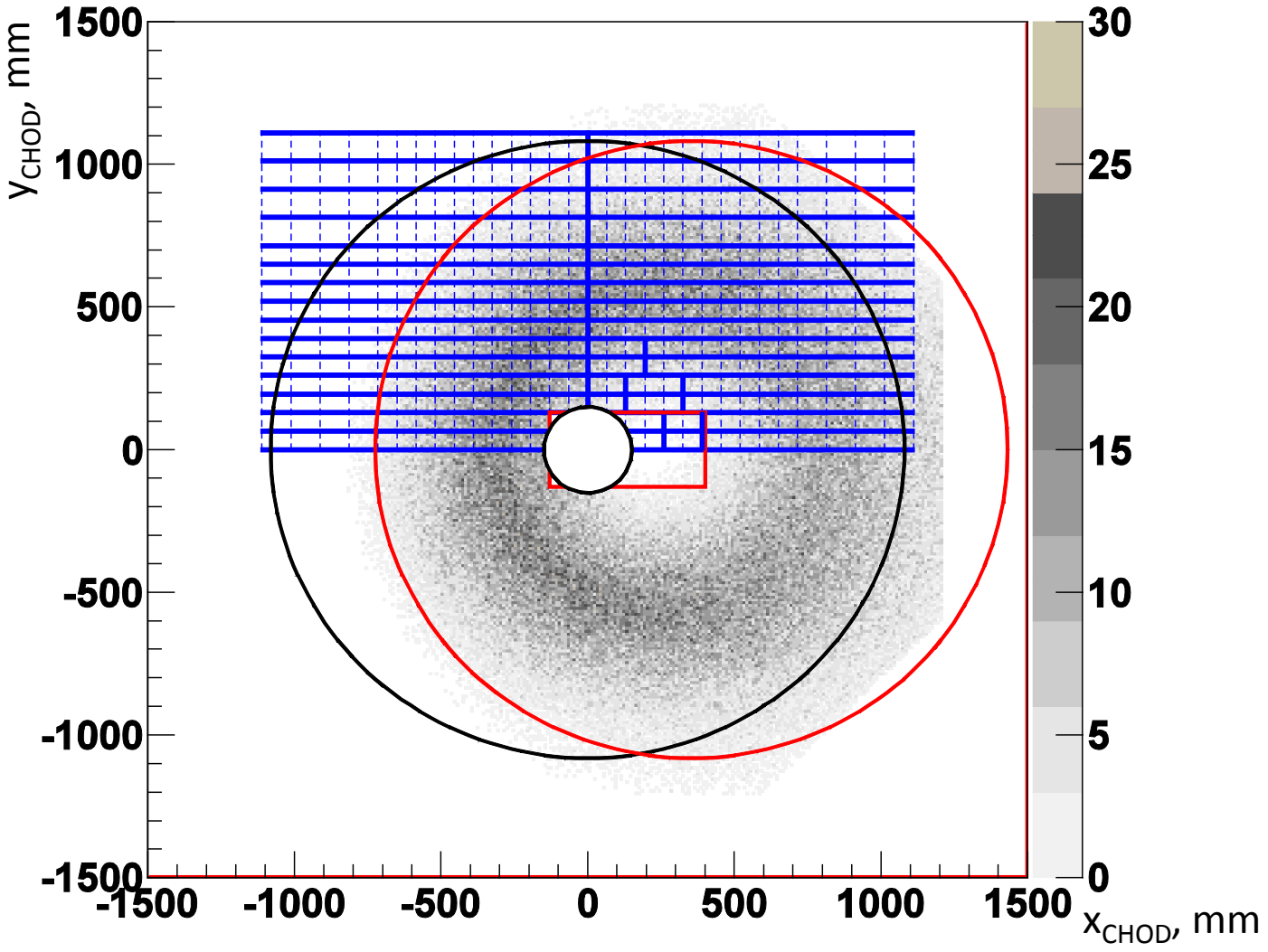


Real signals

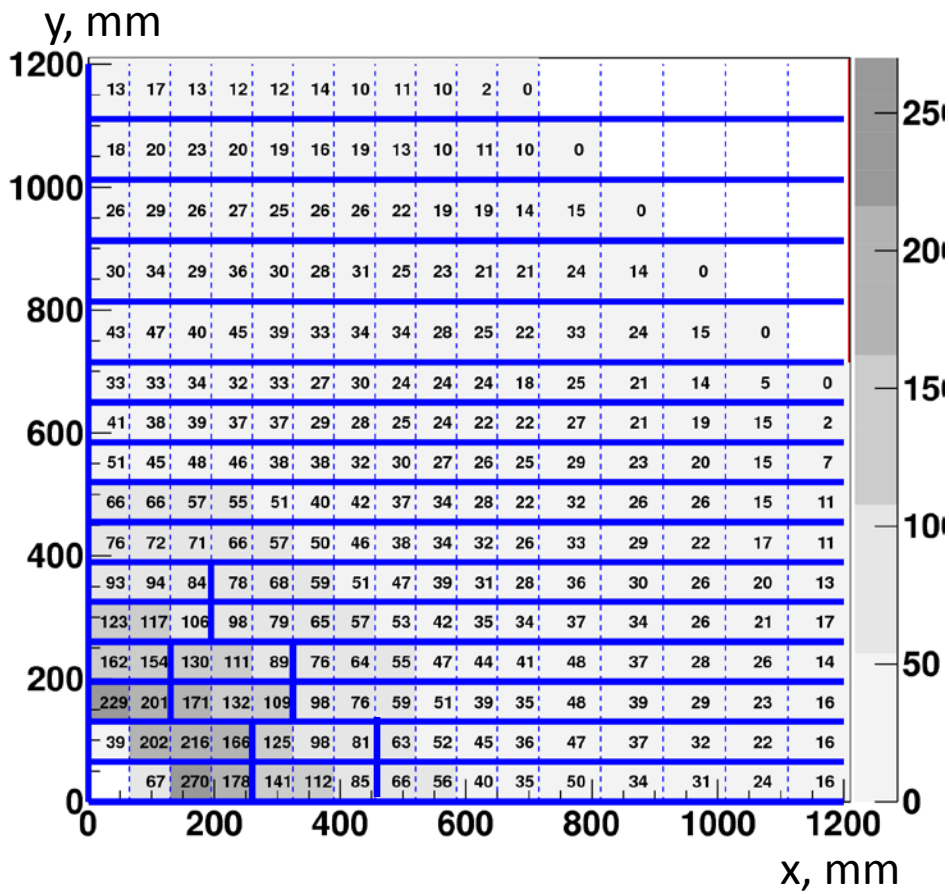


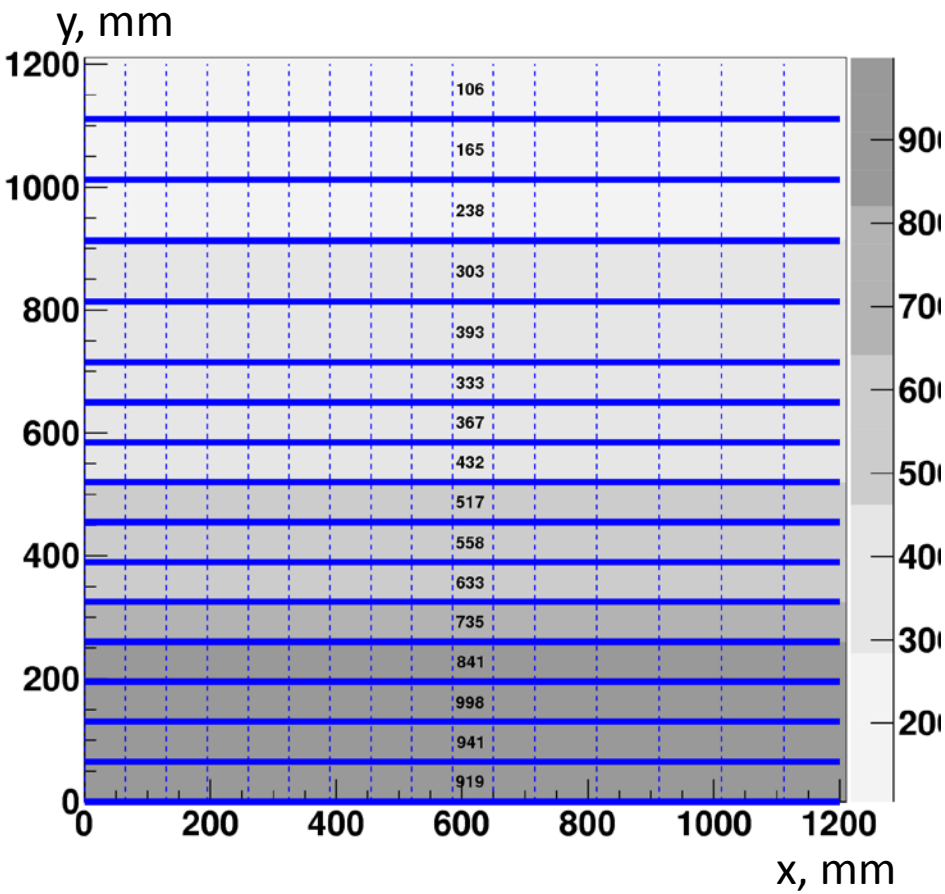


CHOD optimal design



Rates [kHz] per channel





Total rates for CHOD signals

	CHOD signal	Rate of signal [kHz]
Ideal	**CHOD_ACC_0**	9916
	CHOD_ACC_TR_0	7928
Real NA48 acc.	**CHOD_Q0**	**11580**
	CHOD_Q1	9309
	CHOD_Q0 * !CHOD_QX	9909
Real trigger acc.	**CHOD_TR_Q0**	9493
	CHOD_TR_Q1	7692
	CHOD_TR_Q0 * !CHOD_TR_QX	8212
Multiplicity	**CHOD_X14**	**10018**

0 → at least 1 quadrant; 1 → exactly one quadrant; X → two opposite quadrants
X14 → number of crossing points between 1 and 4
For signal loss: all cuts applied for the normalization

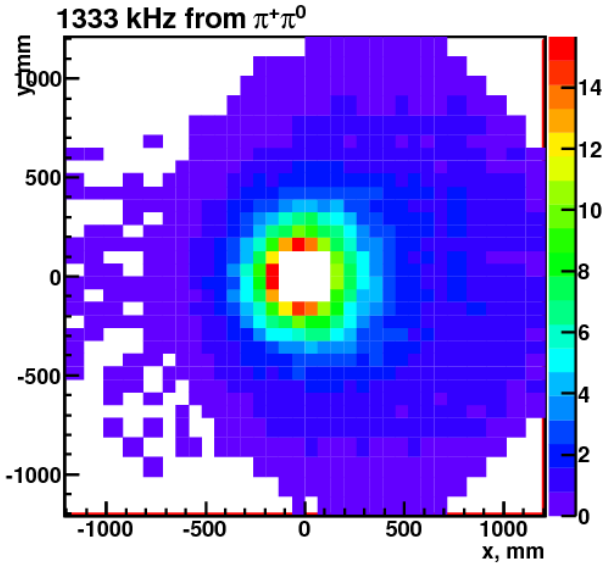
Summary

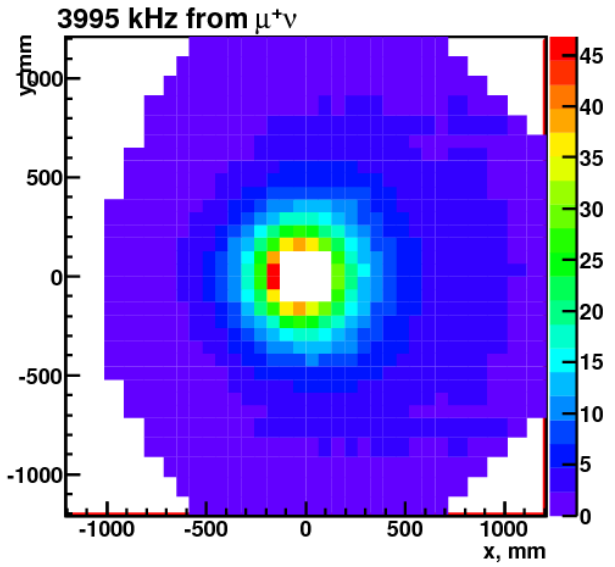
- The rates map of the CHOD is obtained:
  - for the NA48 design the rate per slab is between 100 and 900 kHz
  - in the tiles design the rate per single channel will be ~200-400 kHz

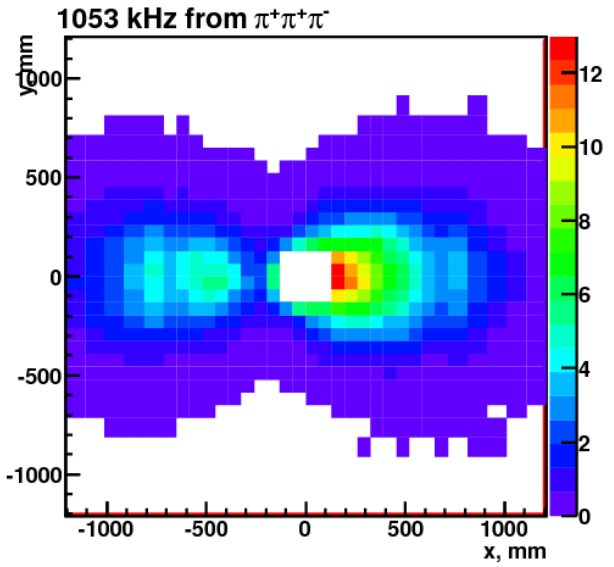
- Finer segmentation around the beam will be beneficial:
  - decrease the rate load per channel;
  - part of the CHOD can be excluded from the trigger depending on the intensity;
  - more freedom in construction efficient CHOD signals [see my presentation for TDAQ WG meeting];
  - no dramatic benefit in photon rejection [see my presentation for Physics Sensitivity WG meeting].

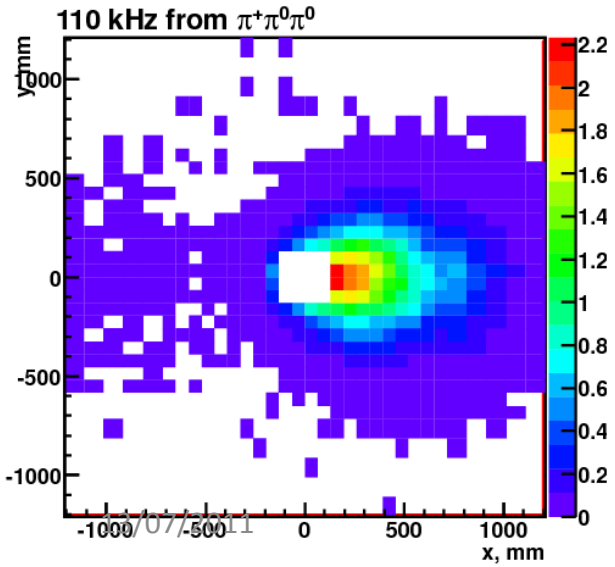
SPARES

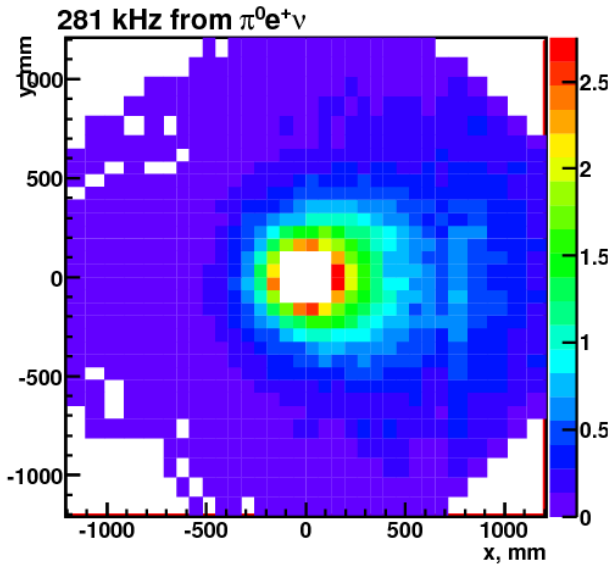
Kinematics (box) [1 – K decays]

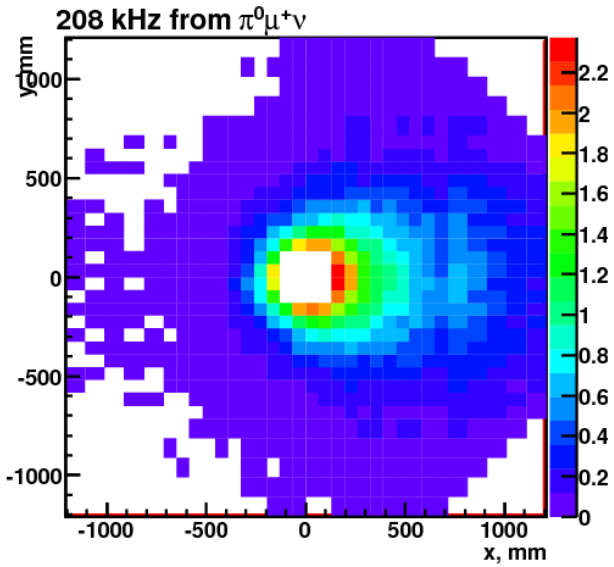




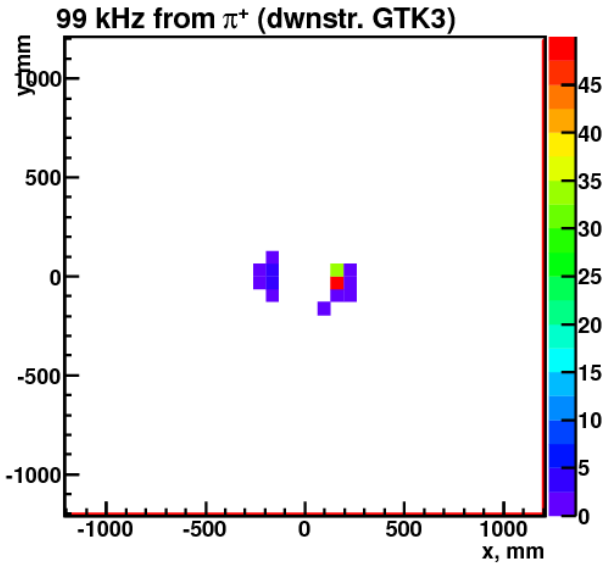


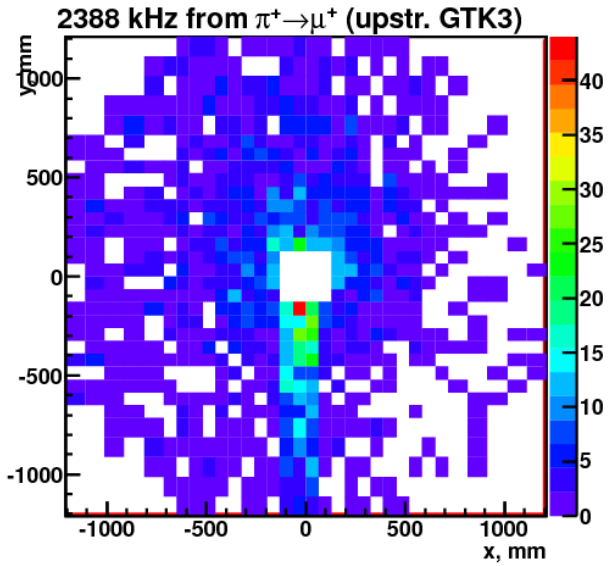


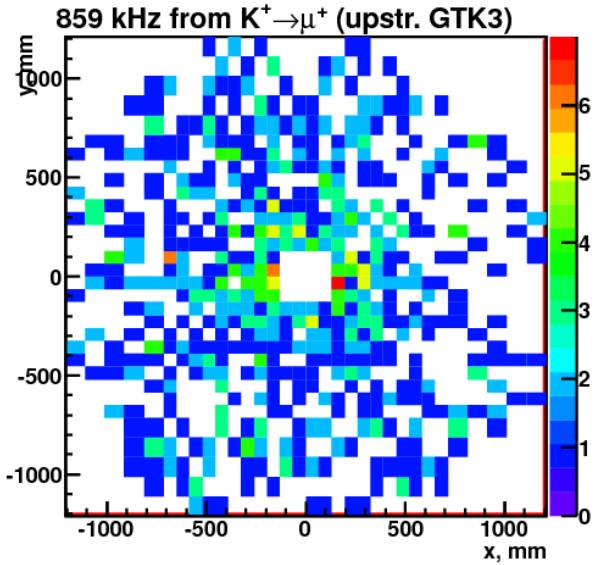


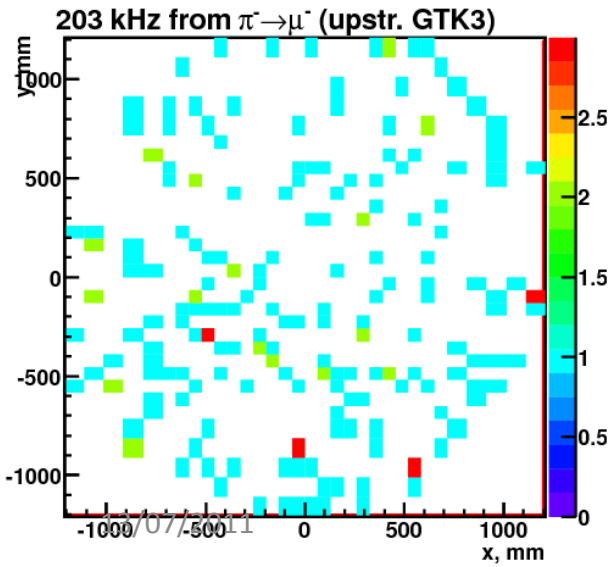


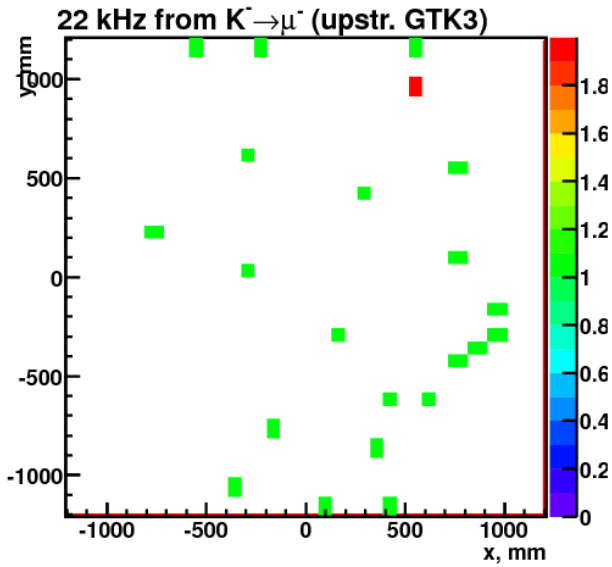
Kinematics (slab) [2 – HALO]

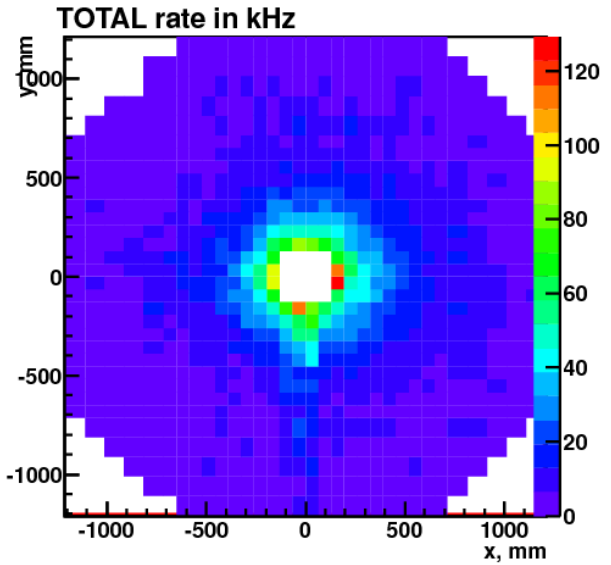




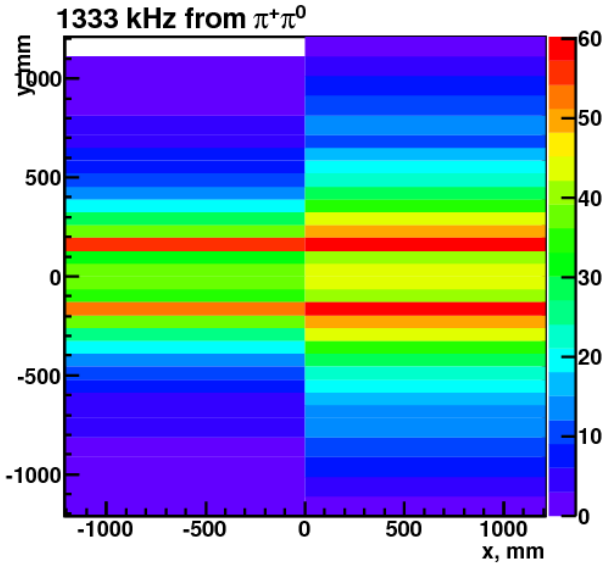


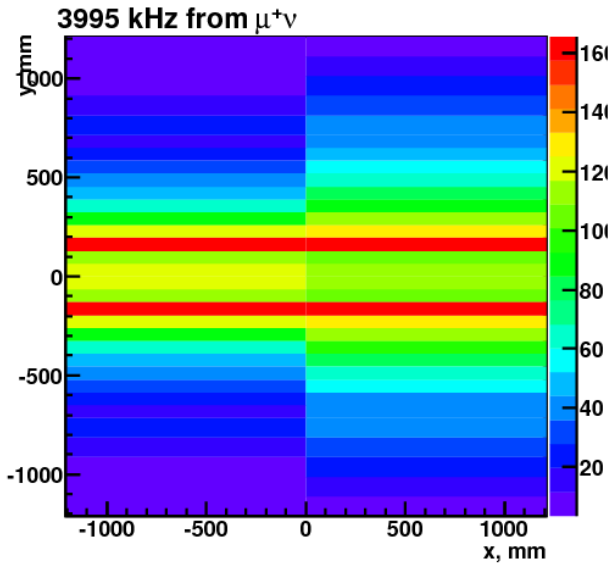


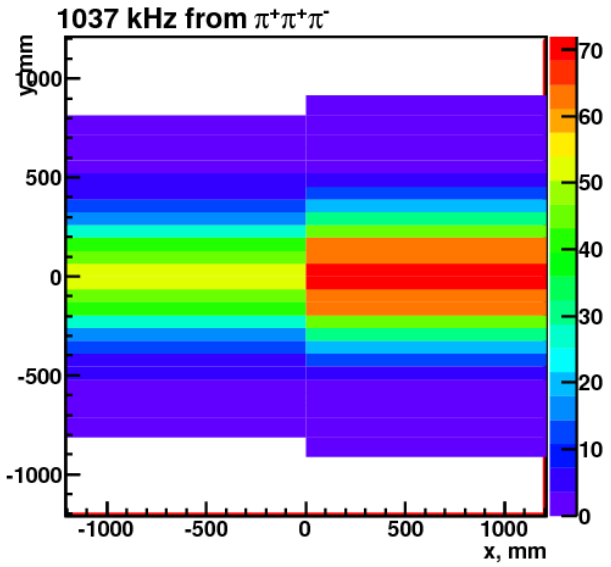


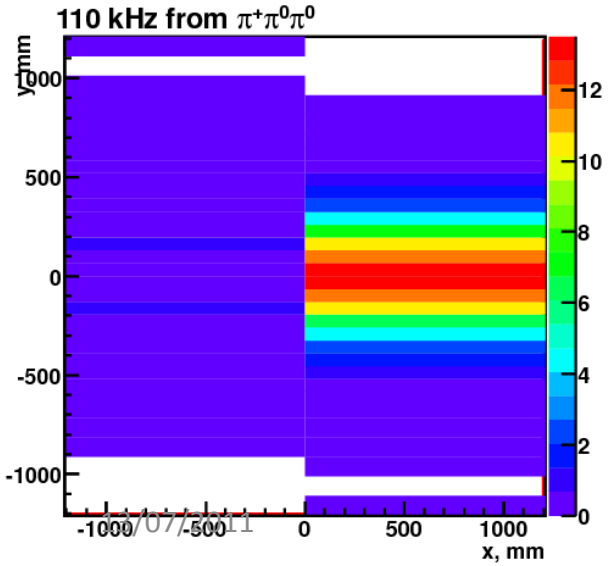


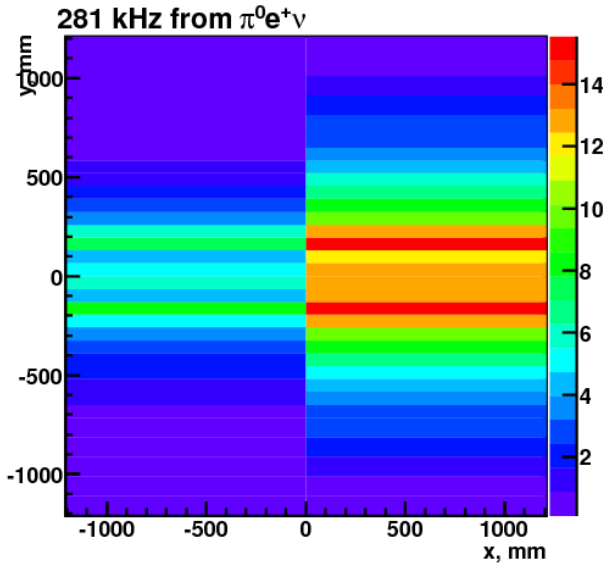
Kinematics (slab) [1 – K decays]

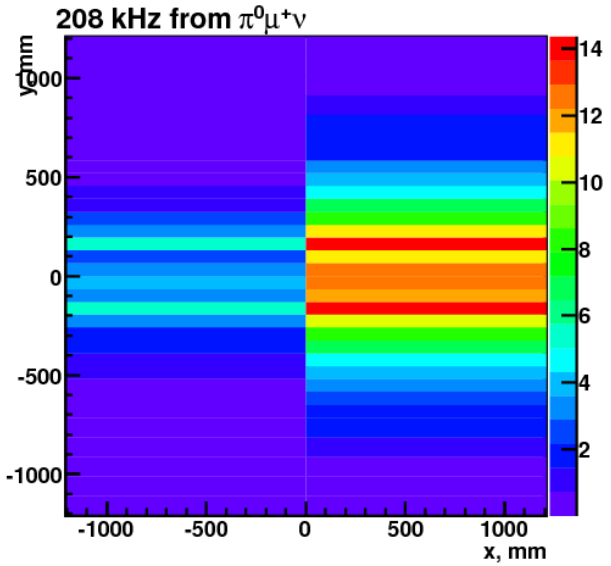












Kinematics (slab) [2 – HALO]