Low-scale Gravity Black Holes at LCH

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Quantum gravity and accelerator physics

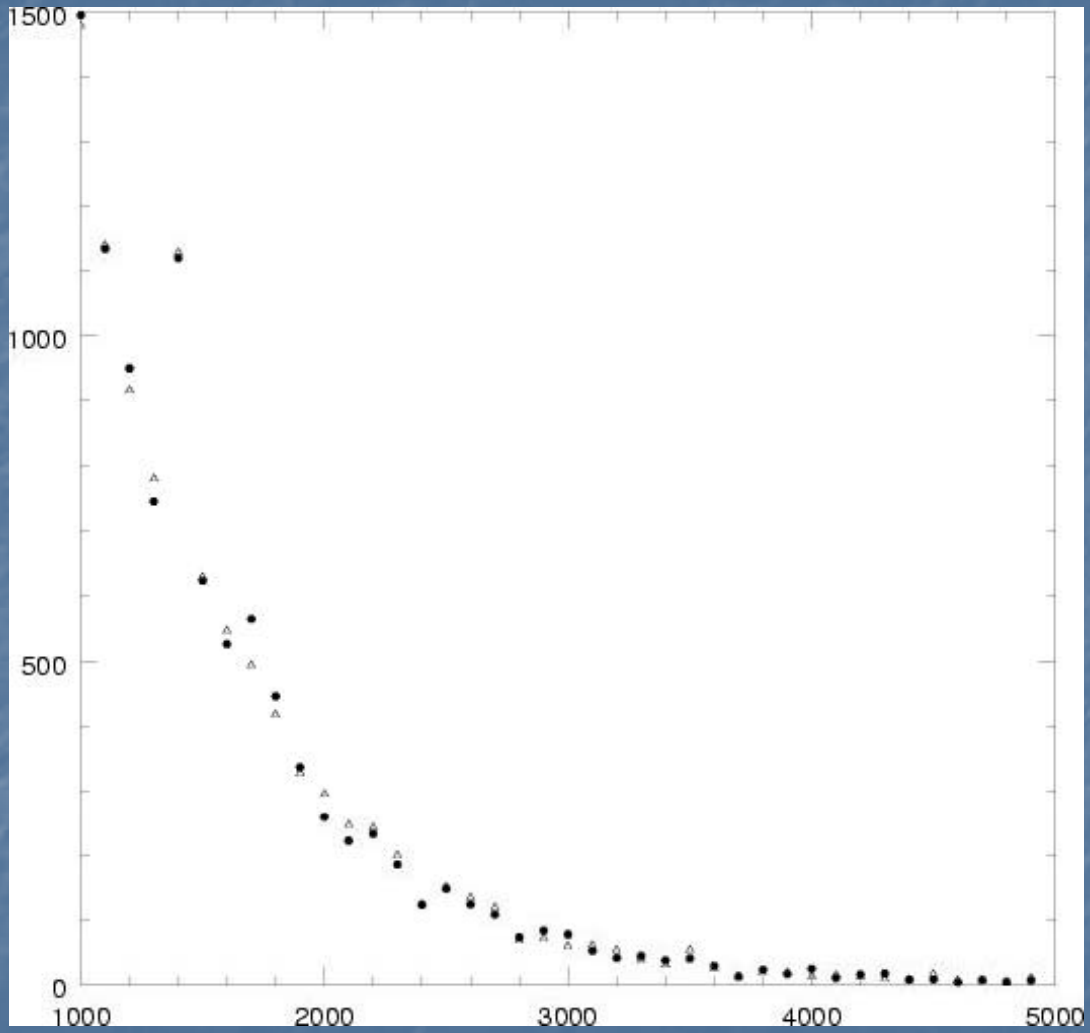
- Obtain limits from collider experiments
- Graviton interference effects at Large Hadron Collider, CERN
- Decay modes of particles with mass in TeV range
- Hadron/lepton scatterings and decays in extra-dimensional models
- Black holes at LHC, CMS
- Limits from cosmology and astrophysics: cosmic rays and supernovae
- Particle astrophysics
  - Dark matter
  - mass of particles, *Ex:* Axions

  Evidence from observations for extra D
  - Quantum black holes: energy spectrum, depend on parameters of space times, strings

Black holes at LHC

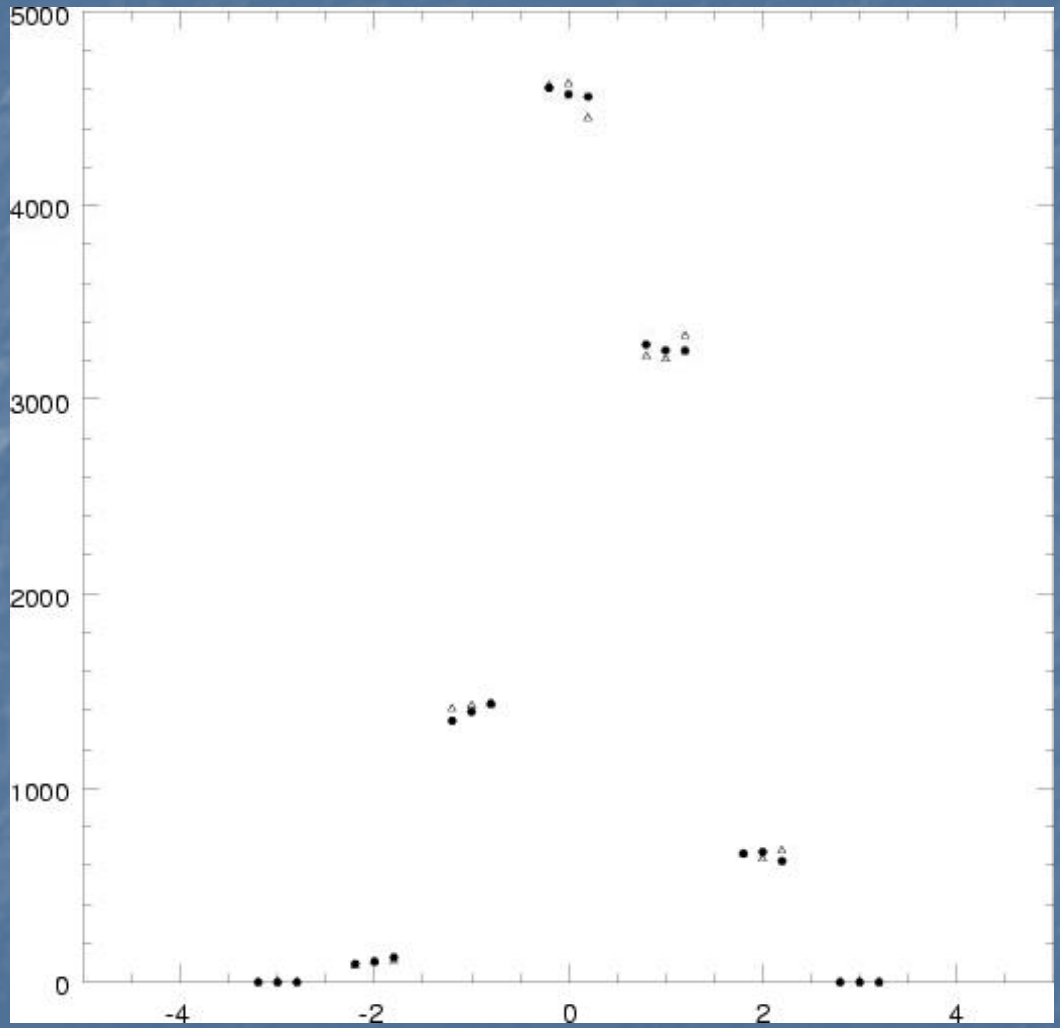
- Event generator for ED BHs : BlackMax
- Rotation, fermion splitting, brane tension
- Experimental signatures, particle decay
- CMSSW analysis
- Further models of Dvali suggest BH detection even more likely

Distribution of black hole mass



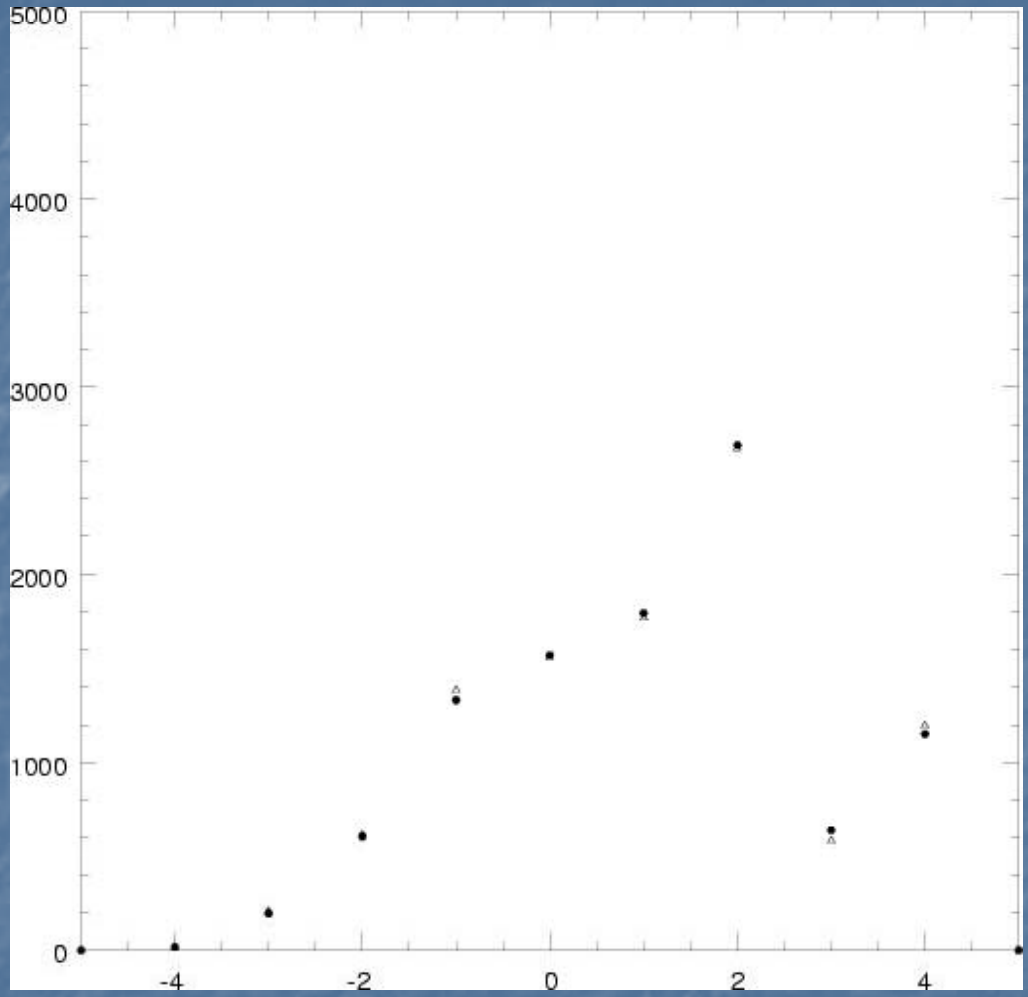
Rotating and non-rotating , 2 ED , 1-5 TeV

Distribution of BH color (red – blue - green)



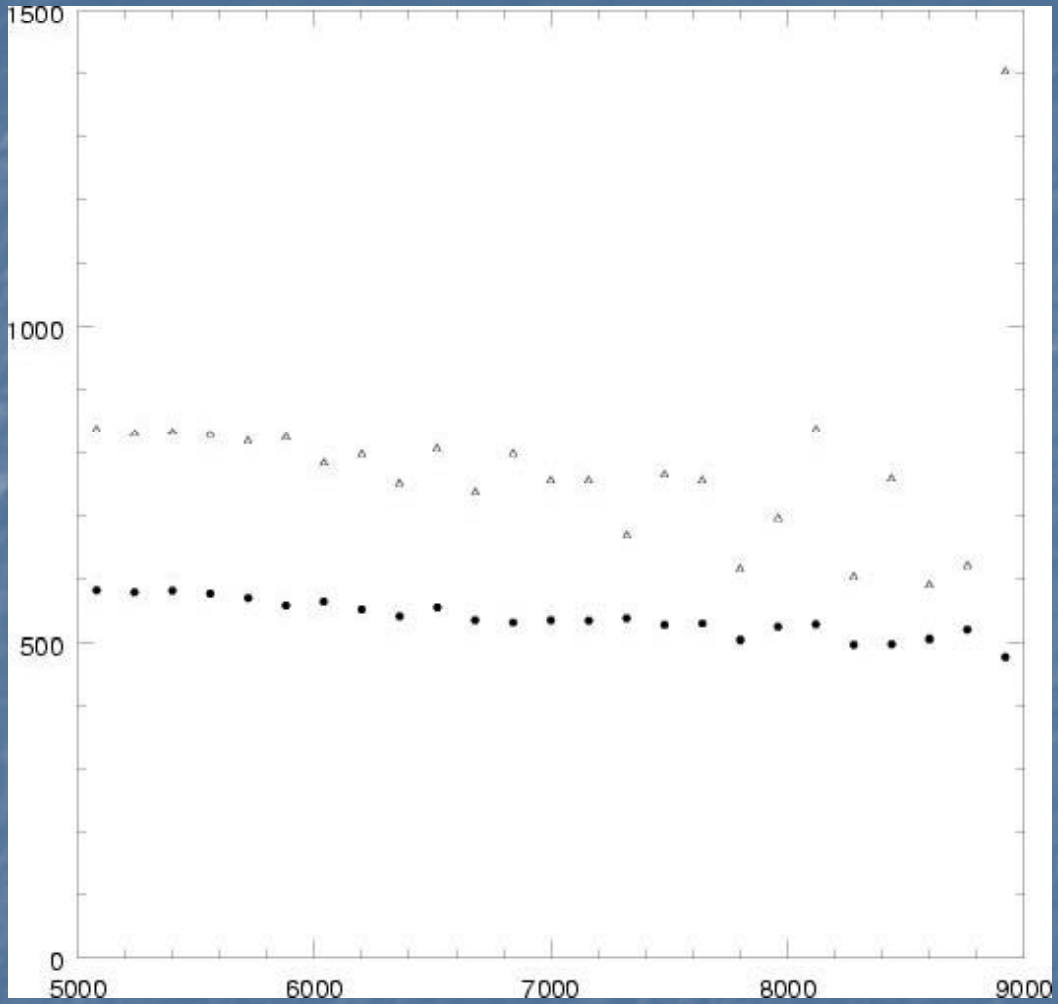
Rotating and non-rotating , 2 ED , 1-5 TeV

Distribution of BH charge / 3q /



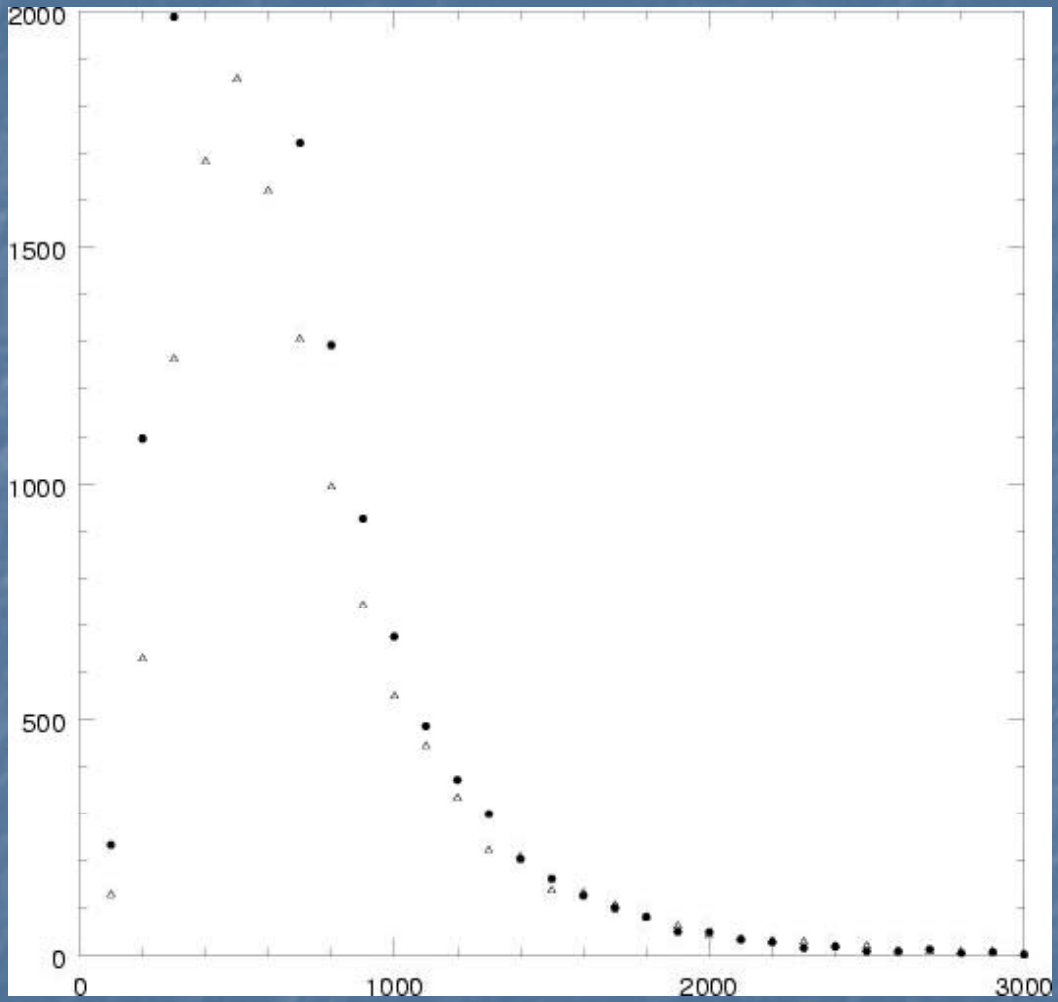
Rotating and non-rotating, 2 ED, 1-5 TeV

< Energy > of emitted particles vs. BH mass



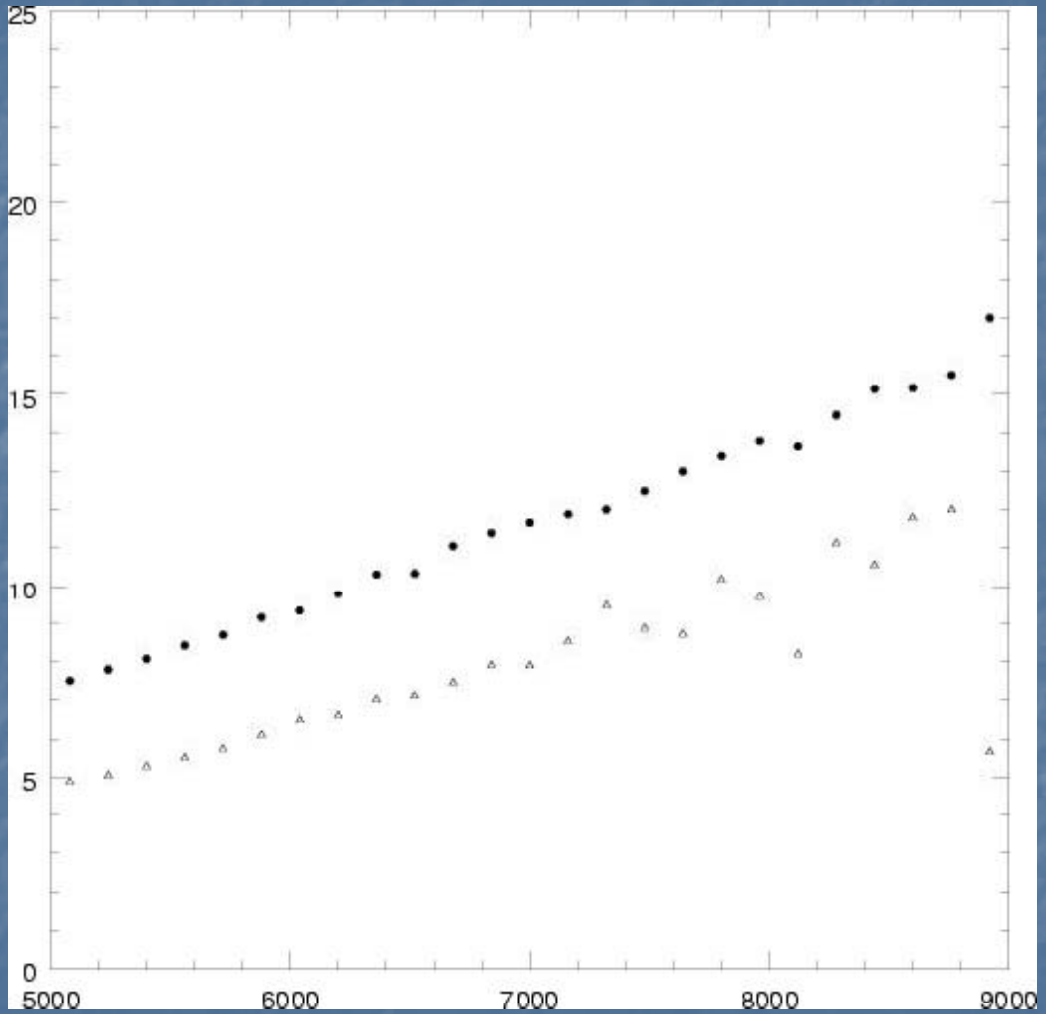
Rotating and non-rotating, 2 ED, 5-14 TeV

Energy spectrum of emitted particles



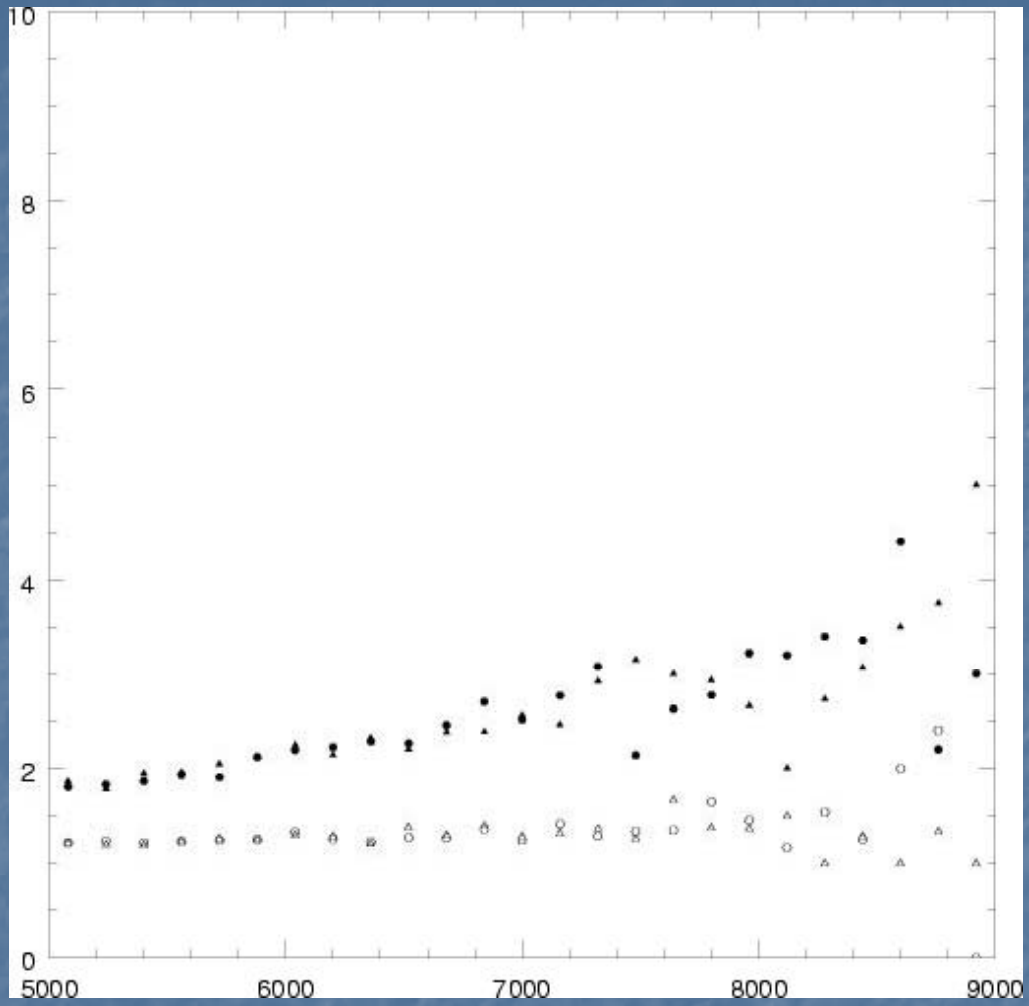
Rotating and non-rotating , 2 ED, 1-5 TeV

Number of emitted particles vs. BH mass during Hawking phase



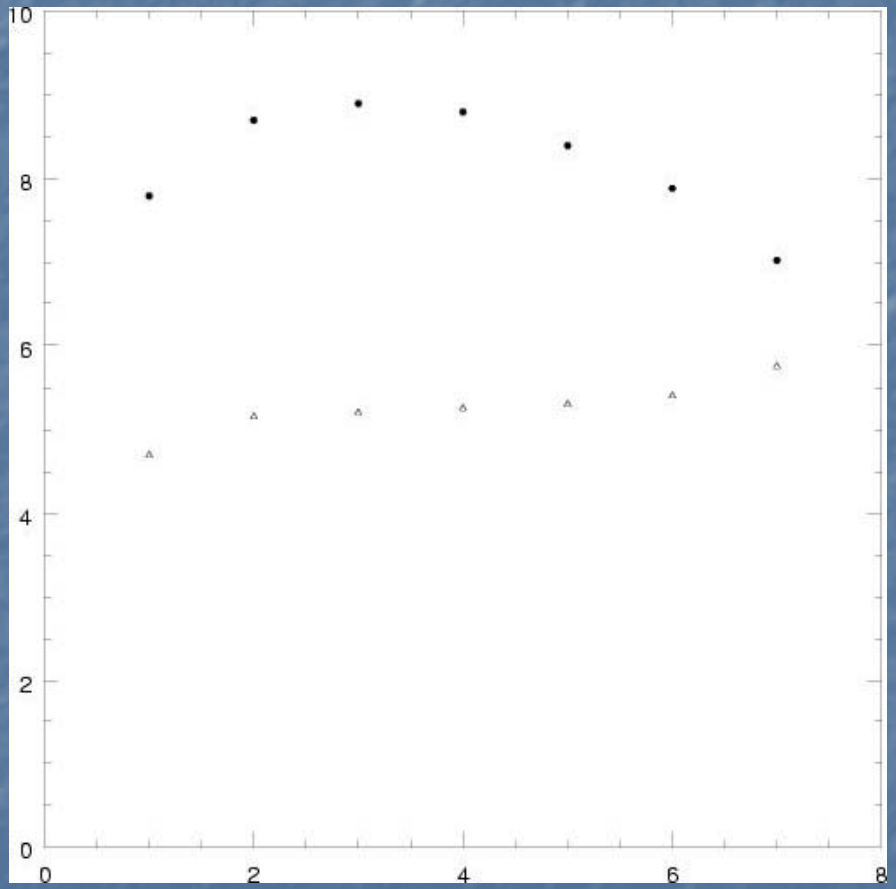
Rotating and non-rotating, 2 ED, 5-14 TeV

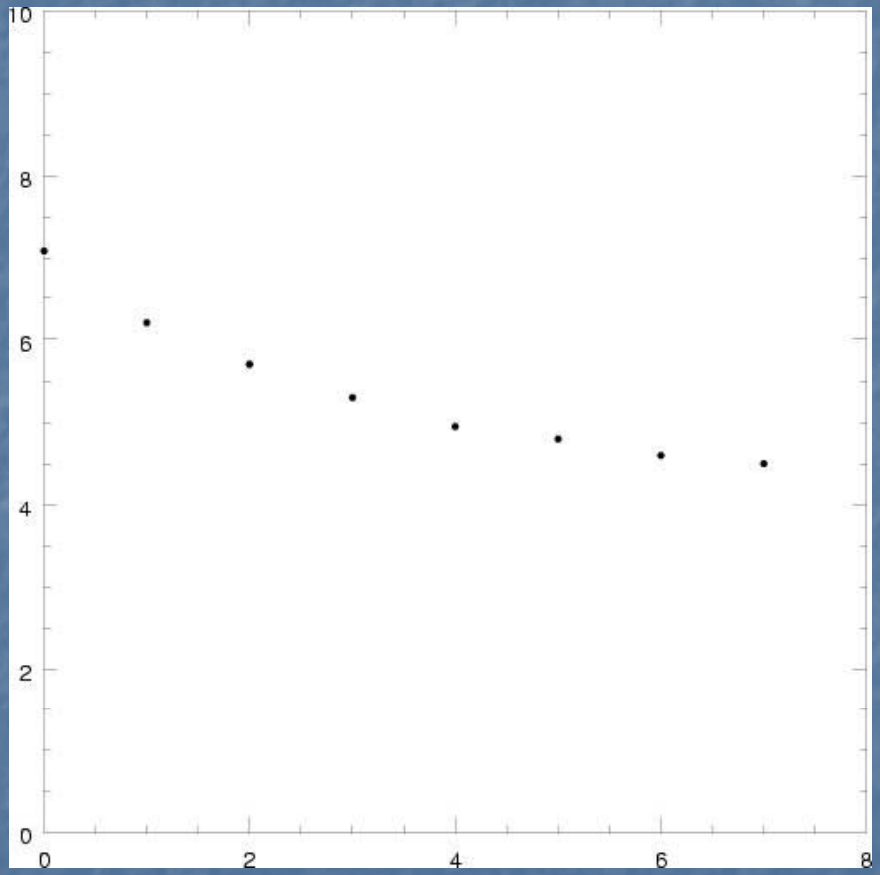
Multiplicity of various species (Hawking)



Rotating and non-rotating, 2 ED, 5-14 TeV , quarks, anti-quarks, leptons, anti-leptons

Number of emitted particles vs. # extra dimensions and # fermion splitting dimensions

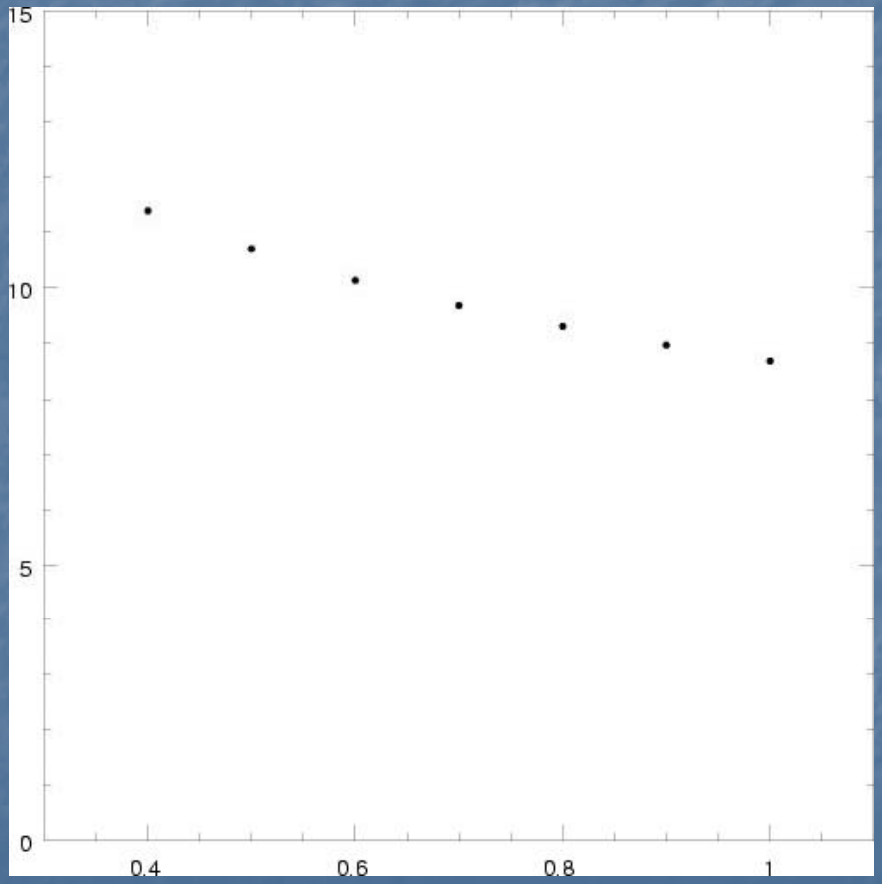




rotating and non-rotating

ED = 7

Number of emitted particles / BH vs. brane tension B



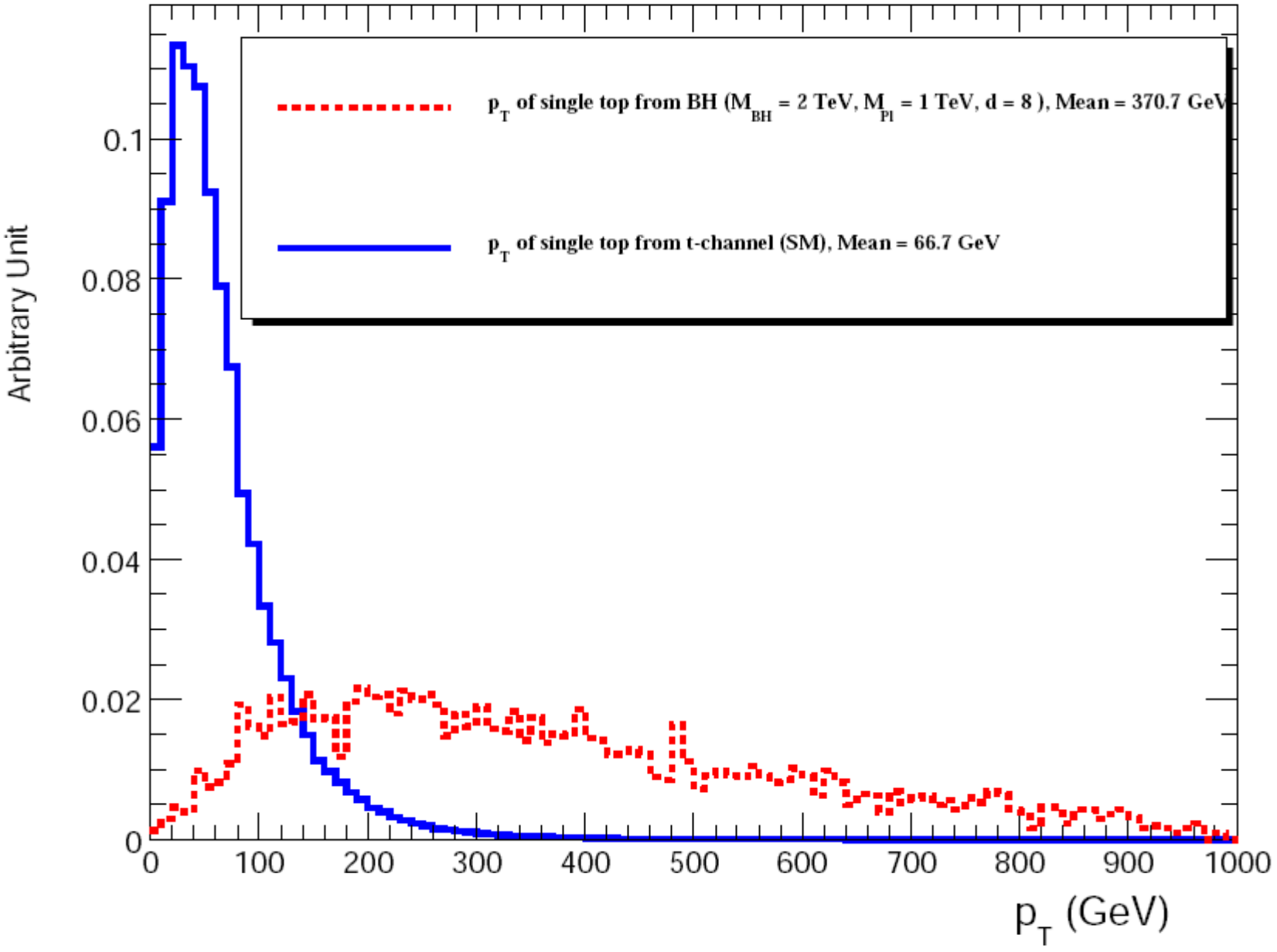
non-rotating

ED = 2

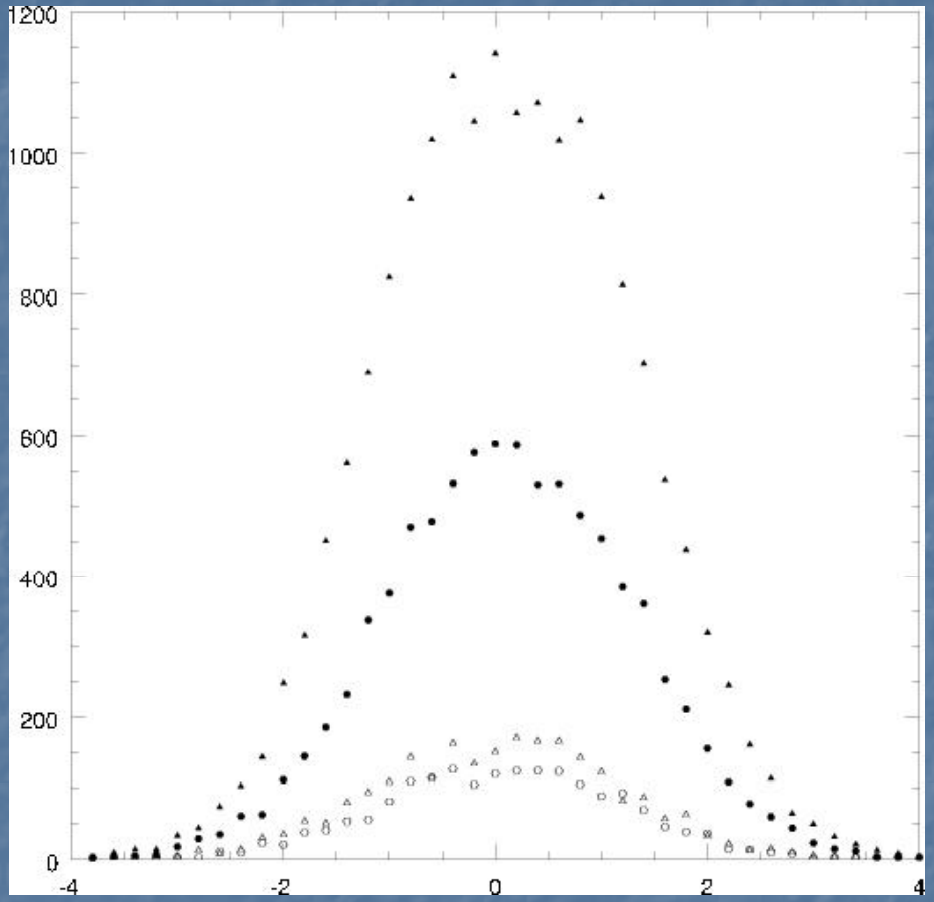
5-14 TeV

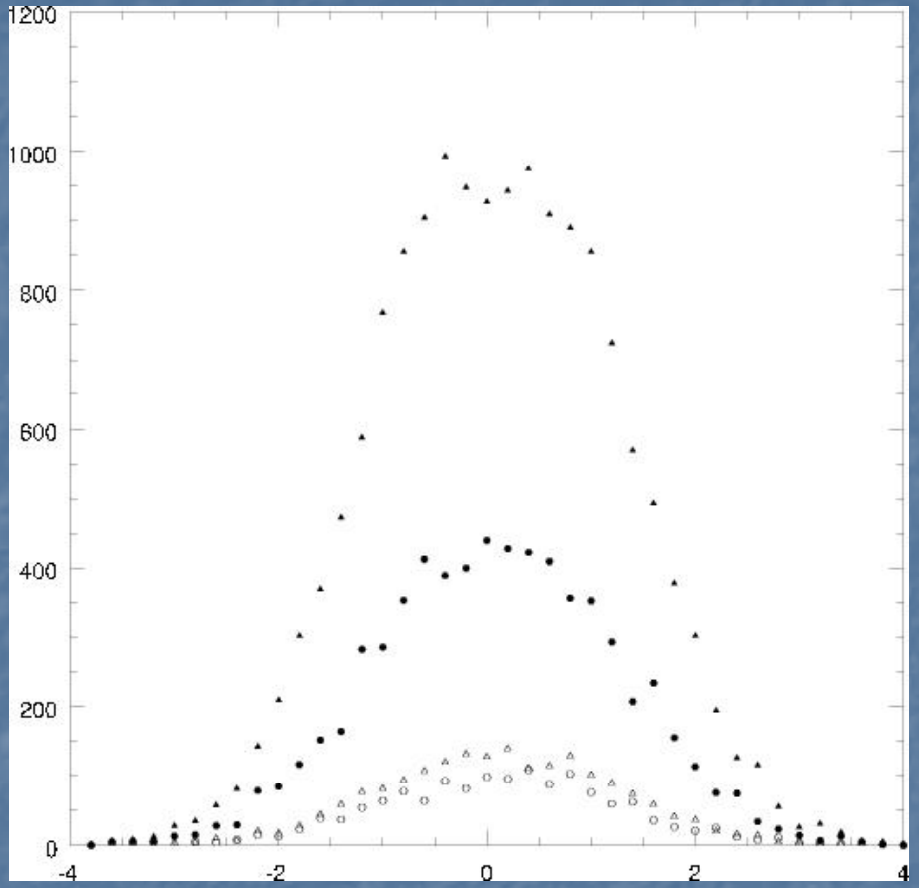
Hawking phase

M_Pl = 1 TeV


p_T of single top from BH (M_{BH} = 2 TeV, M_{Pl} = 1 TeV, d = 8), Mean = 370.7 GeV
p_T of single top from t-channel (SM), Mean = 66.7 GeV
Arbitrary Unit
0
0.02
0.04
0.06
0.08
0.1
0
100
200
300
400
500
600
700
800
900
1000
p_T (GeV)

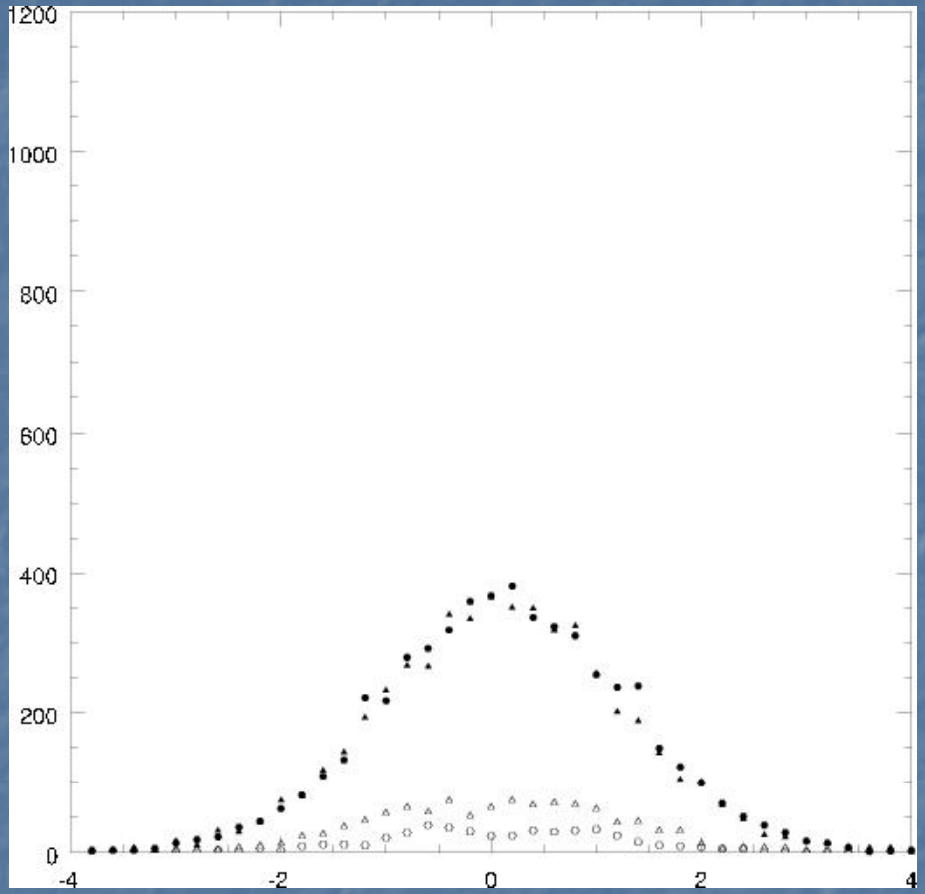
Pseudorapidity with final burst

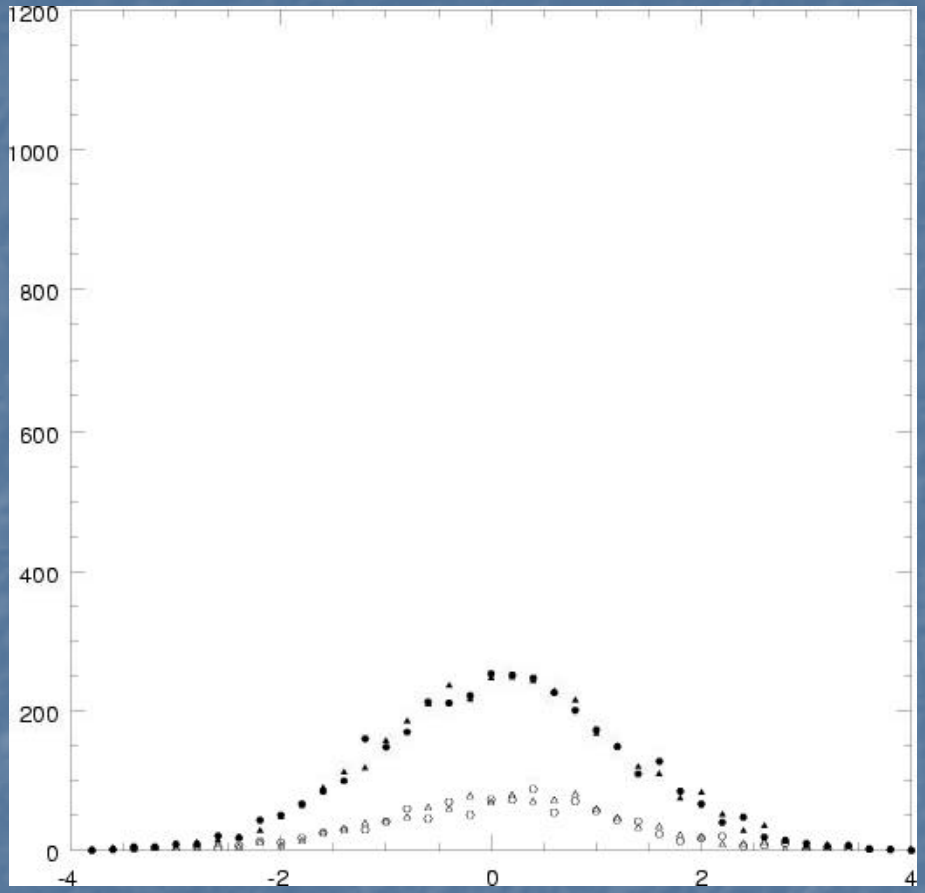




Non-rotating and rotating , 2 ED , 1-5 TeV , quarks, anti-quarks, leptons, anti-leptons

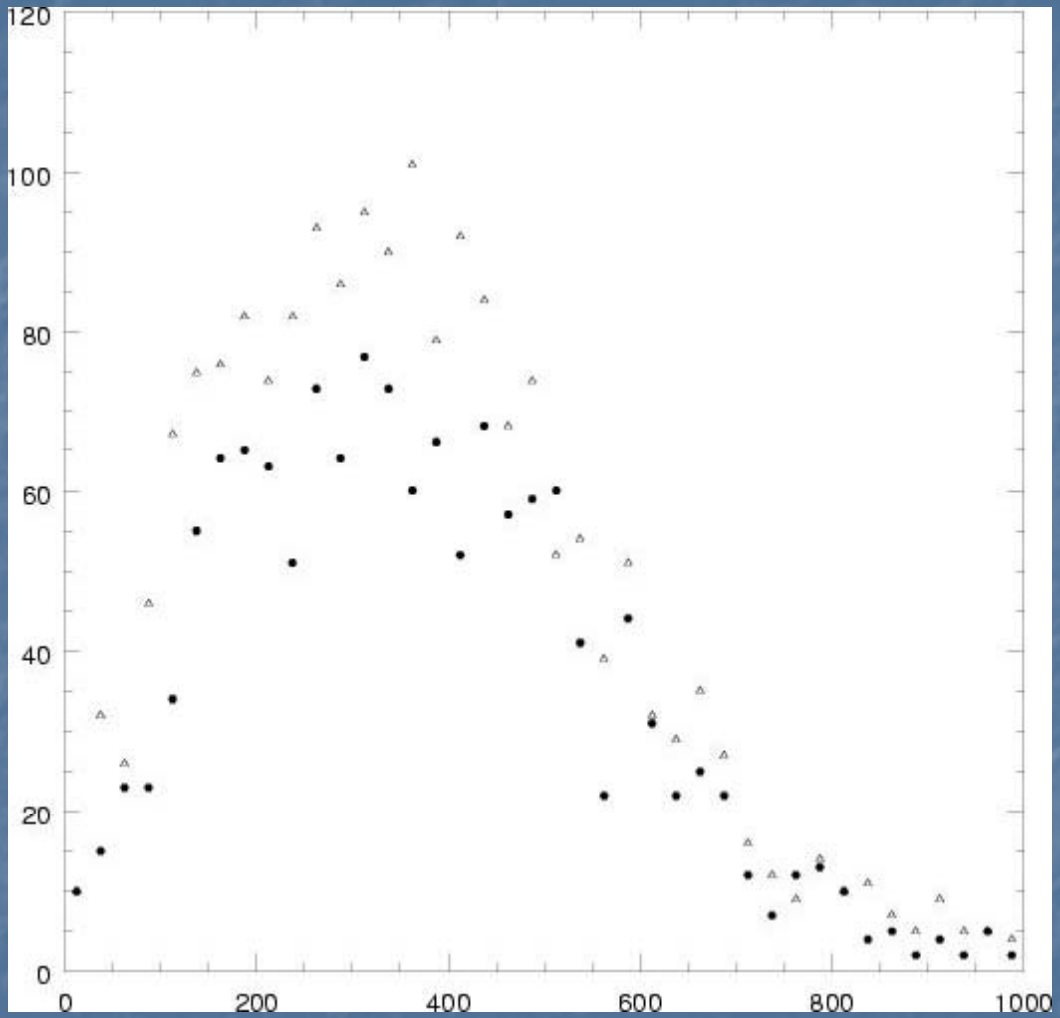
Pseudorapidity without final burst





Non-rotating and rotating , 2 ED , 1-5 TeV , quarks, anti-quarks, leptons-, anti-leptons+

Distribution of lepton transverse momentum



Leptons & anti-leptons, rotating, 2 ED, 1-5 TeV

Analysis at CMS

- Rate : ϱ * L_t * event : (same for rot & non-rot)
- Total ET, missing ET
- Missing: G + v : model dependent
- Peak (most likely) or mean for lepton & jet distributions : ratio different from Standard Model
- Jet finder for CMS
- Hardest lepton transverse momentum : lepton easy to identify, cuts off for SM

  Combined cuts : ṅ , p_T distribution

Model settings for detector which have different signature

Angular acceptance cut for detector acceptance

- ή_lepton < 2.5 Jets, q, W, Z < 5
- t, b
- Implementation of generator in CMSSW
- Interface BlackMax
- CMSSW : signal and SM background
- Fast simulation
- Triggering
- Comparison w Charybdis : consistent
- missing ET possible difference

Further models to test at CMS

- BHs in model for SM copies :

  BH -> SM particle rates different,

  difference in particle decay

  distribution of p_T, MET

  Even more likely for BHs w ADD & finding them

Thank you for your attention !