

The μ -Beam for Black Holes Production

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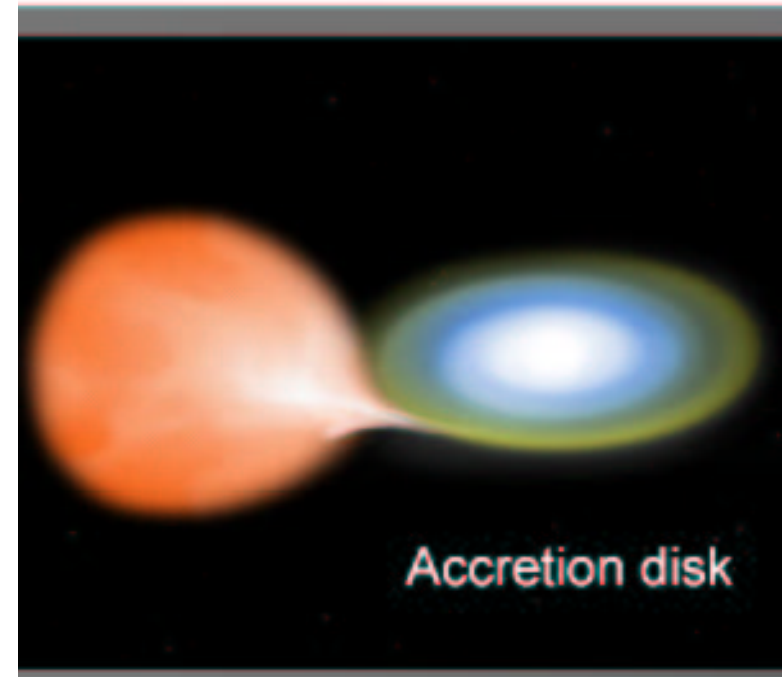
- **Black Holes Overview**
- **Black Holes Production**
- **Black Holes at Accelerators**
- **μ -Beam at 2 TeV Scale**

Black Holes

Astronomical Black Holes

Overview

- There is no doubt that we could find the experimental evidence of the black holes
- We need to rely on indirect evidences to establish the existence of black holes since we cannot see a black hole
- There is an evidence of the astronomical black holes that exist from the nearby star (related to matter accretion)
- We are exploring the possibility of the miniature black holes production in lab



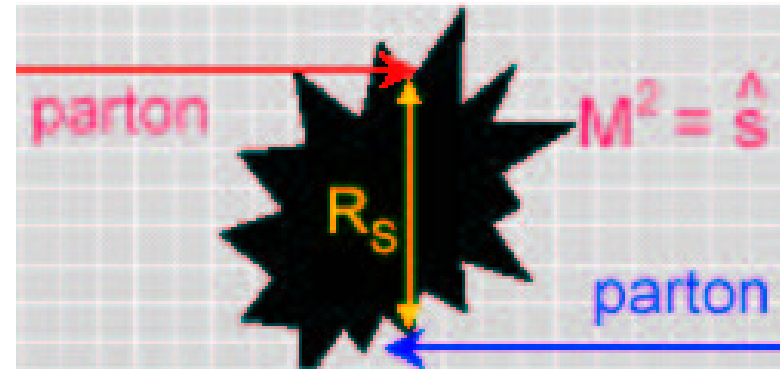
- **Accretion disk is related to a black hole from a nearby star**
- **There are some black hole candidates in the universe!**

Black Holes Production

Black Holes Approach

- **BH's lifetime:** $10^{-25} - 10^{-27}$ s
- Previous studies show the evidence of the black hole production at lab
- **Black hole references :**
 - M. Cavaglià : PLB 569, 7 ('03), Modern Physics A 18, 11 (2003)
 - Dimopoulos & Landsberg : PRL 87, 161602 (2001)
 - Giddings : hep-ph/0106219
 - Banks & Fishler : hep-ph/9906038
 - Argyres *at. al* : hep-ph/9808138
 - Harris *at. al* : hep-ph/0307305

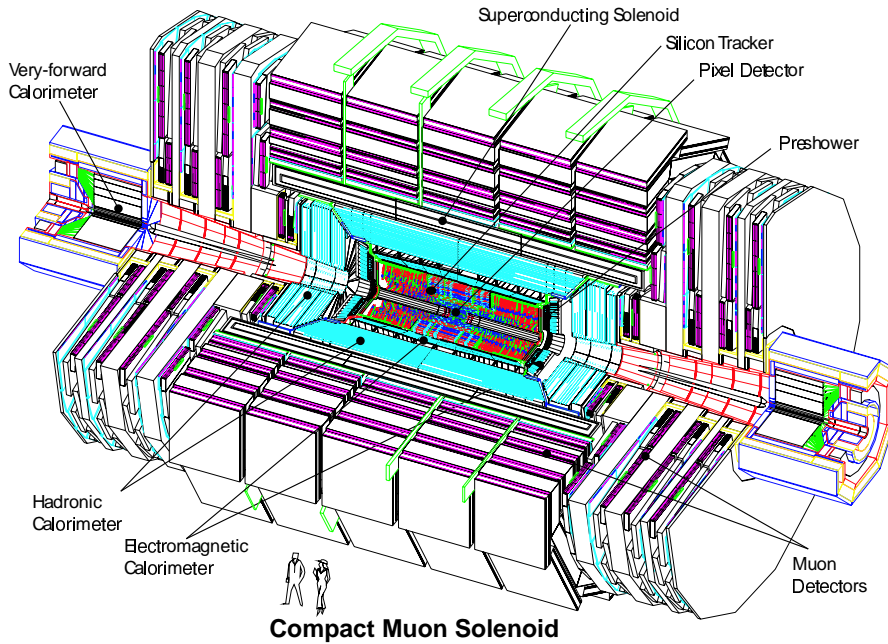
Black Hole Cross Section



- R_s is Schwarzschild's radius
- A black hole is formed when the cms energy approaches the fundamental Planck scale : as low as \sim TeV
- **Parton level cross section :**
$$\sigma(M_{BH}^2) \sim \pi R_s^2 \sim 1 \text{ TeV}^{-2}$$
- **Limitation :** Lack of knowledge of quantum gravity effects

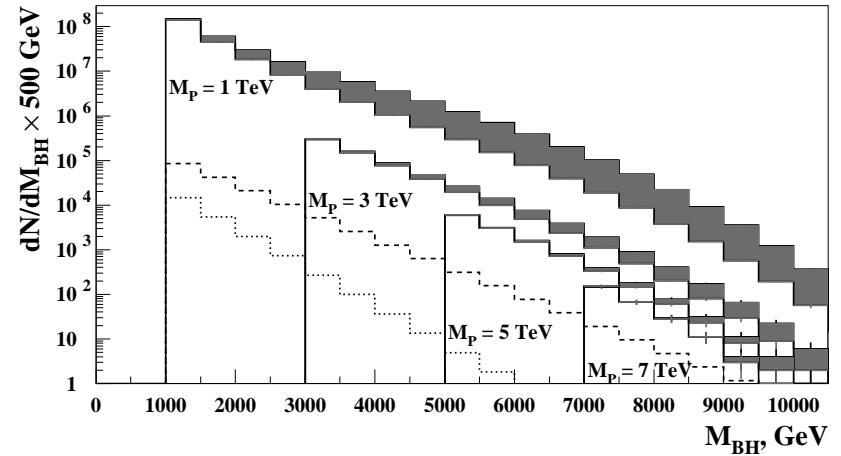
BH at Accelerators

CMS Detector



- We are planning to use a CMS detector simulation to search black holes
- CMS is a suitable detector to study of black holes since it has a good detection of muons and jets

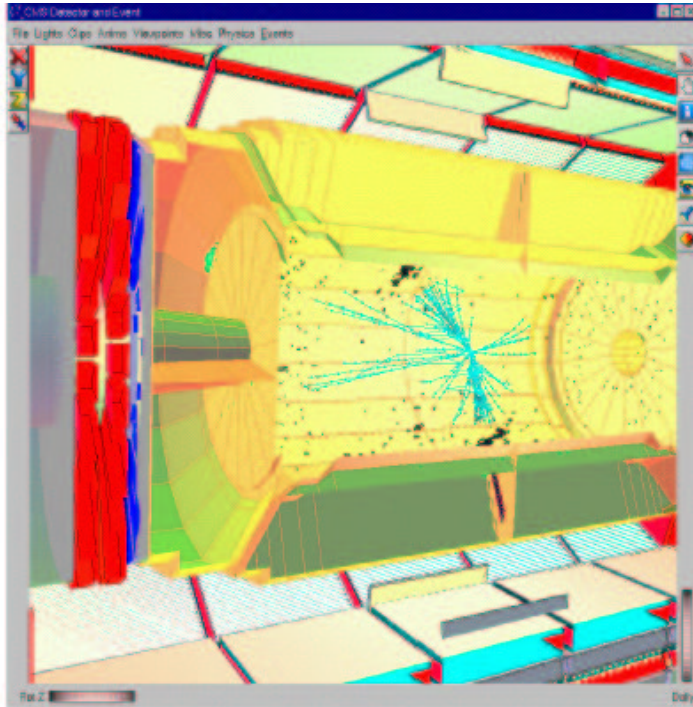
Black Hole Factory



- Spectrum of BH produced at LHC
- Number of BH as a function of M_{BH}
- Shaded region is number of events
- Dashed line is the total background
- Final states tagged with e or γ (PRL 87, 161602 (2001))

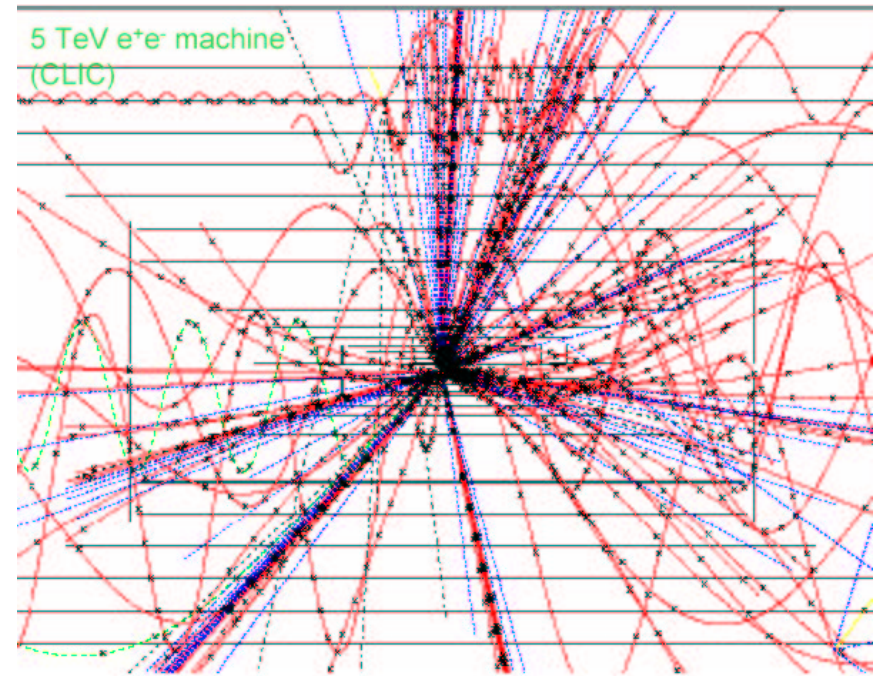
BH at Accelerators

Black Hole at CMS



- A black hole event with $M_{BH} \sim 8 \text{ TeV}$
- BH decays immediately by Hawking radiation (democratic evaporation): large multiplicity, small missing energy, and ratio jets/leptons ~ 5

Black Hole at CLIC

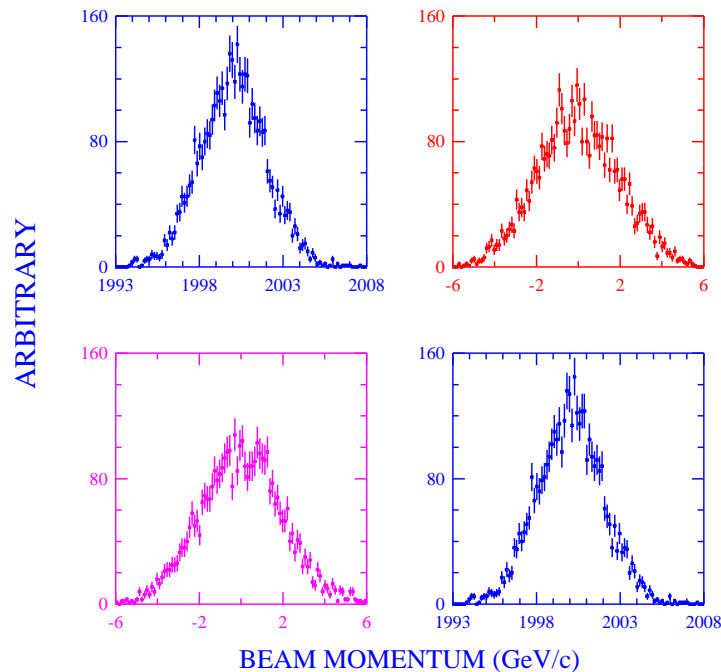


- BH event display at CLIC at 5 TeV (simulated by A. De Roeck)
- This event has a large final state multiplicity as a typical BH event

μ -Beam Generated

File: stdmake_2tev_4000.pt

ID	IDB	Symb	Date/Time	Area	Mean	R.M.S.
21	0	-31	040302/0952	3999.	2000.	1.980
22	0	-31	040302/0952	3981.	-1.7287E-02	1.951
23	0	-31	040302/0952	3992.	1.2535E-02	1.963
24	0	-31	040302/0952	3999.	2000.	1.979



- We generate 2 TeV μ -beam with a Gaussian distribution

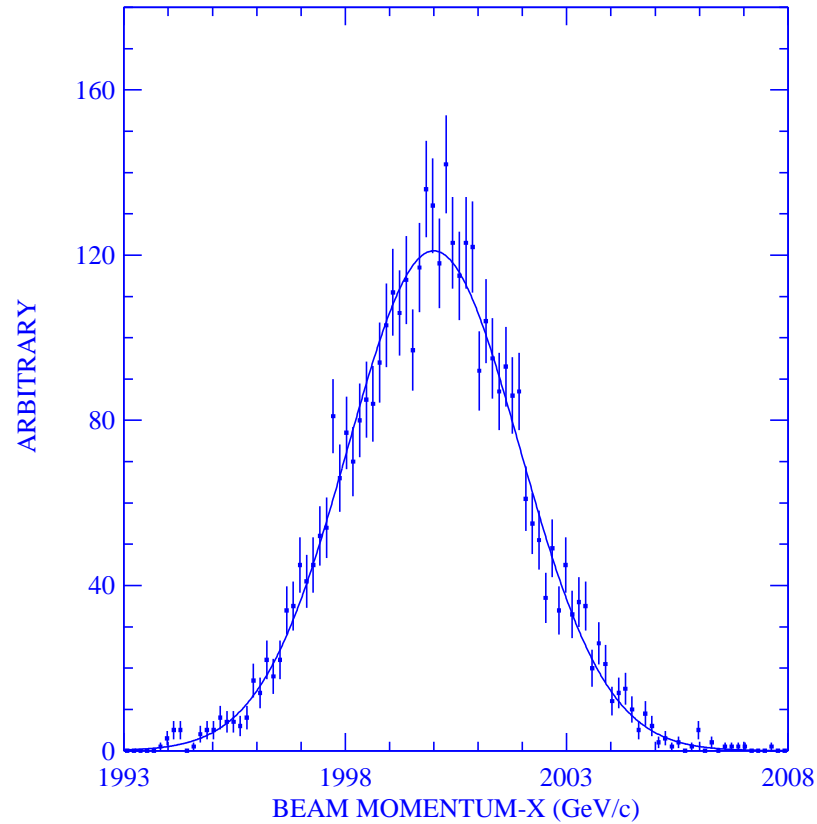
μ -Beam Parameters:

- 4000 particles of μ -beam'
- Beam's energy is 2 TeV
- σ_E is ~ 2 GeV
- σ_z is ~ 0.25 - 0.12 cm
- Note that the beam's parameters are as an output of the second rapid cycling synchrotrons (RCS2)
- Based on PRST-AB 6, 081001 (2003) for 4 TeV muon collider

μ -Beam for Black Holes

MINUIT χ^2 Fit to Plot 21&0

File: stdmake_2tev_4000.plt 2-MAR-2004 10:43
Plot Area Total/Fit 3999.0 / 3999.0 Fit Status 3
Func Area Total/Fit 3925.0 / 3925.0 E.D.M. 3.835E-16
 $\chi^2 = 81.3$ for 100 - 3 d.o.f., C.L. = 87.4%
Errors Parabolic Minos
Function 1: Gaussian (sigma)
AREA 3925.6 ± 62.72 - 0.000 + 0.000
MEAN 2000.0 $\pm 3.1305E-02$ - 0.000 + 0.000
SIGMA 1.9407 $\pm 2.3219E-02$ - 0.000 + 0.000

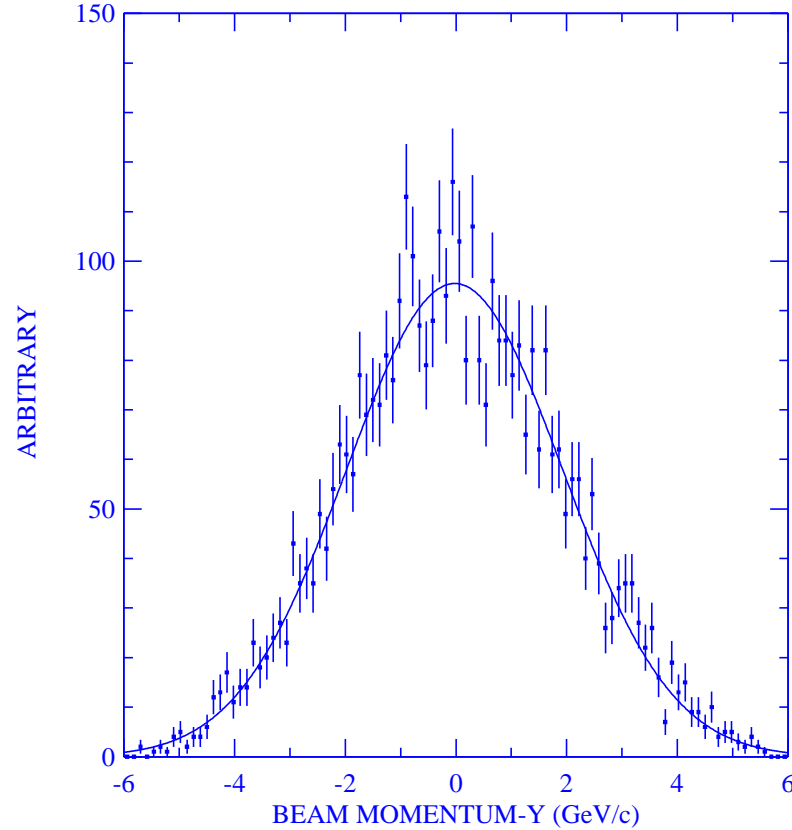


- Fitting the μ -Beam X-momentum

μ -Beam for Black Hole

MINUIT χ^2 Fit to Plot 22&0

File: stdmake_2tev_4000.plt 2-MAR-2004 10:43
Plot Area Total/Fit 3981.0 / 3981.0 Fit Status 3
Func Area Total/Fit 3888.9 / 3888.9 E.D.M. 2.172E-16
 $\chi^2 = 99.2$ for 100 - 3 d.o.f., C.L. = 41.9%
Errors Parabolic Minos
Function 1: Gaussian (sigma)
AREA 3897.2 ± 62.57 - 0.000 + 0.000
MEAN -2.47612E-02 $\pm 3.2071E-02$ - 0.000 + 0.000
SIGMA 1.9537 $\pm 2.3538E-02$ - 0.000 + 0.000



- Fitting the μ -Beam Y-momentum