Identification of Central Production in the $\pi^+\pi^-\pi^+\pi^-$ Channel at COMPASS

ASI-Spin-Praha-2009

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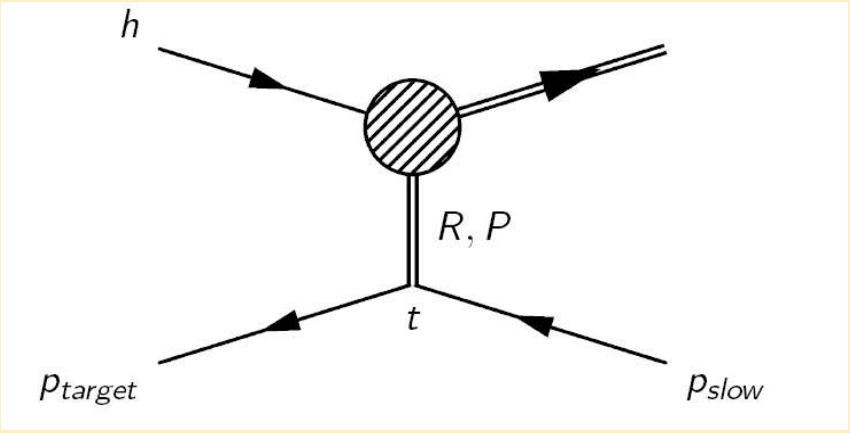
July 28th

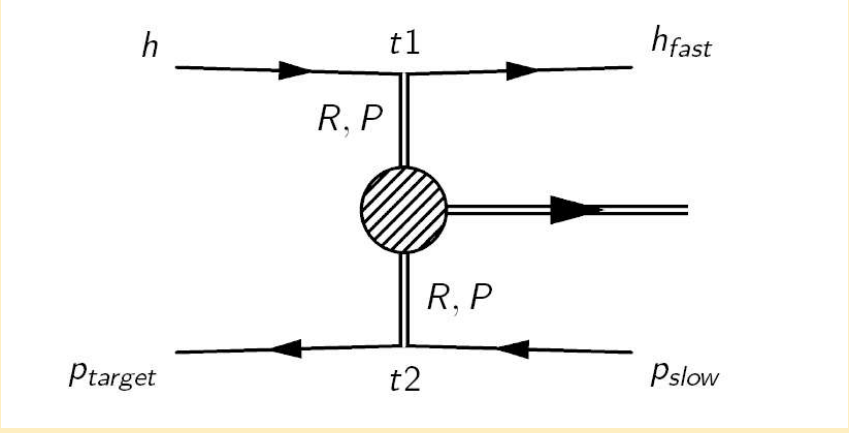
Outline

Introduction

Diffractive Scattering:



Central Production:



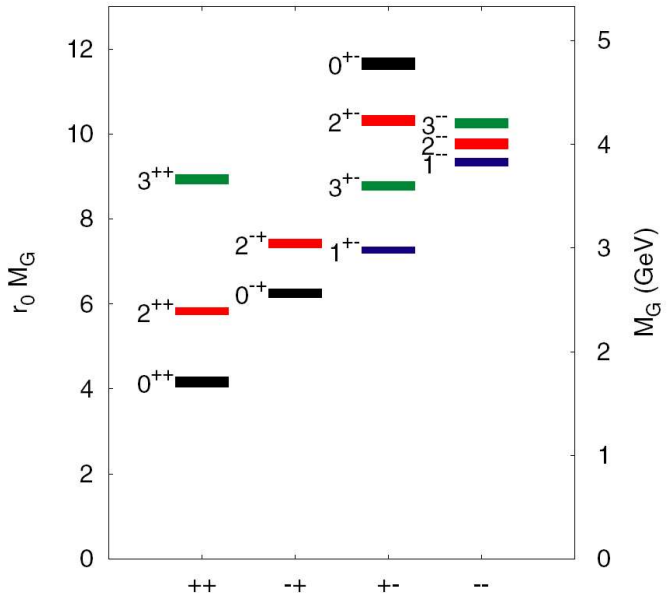
Definition of Central Production

- Original definition, **not only** Double-Pomeron-Exchange
- formation of resonances at central rapidities

CP of $\pi^-\pi^+\pi^-\pi^+$

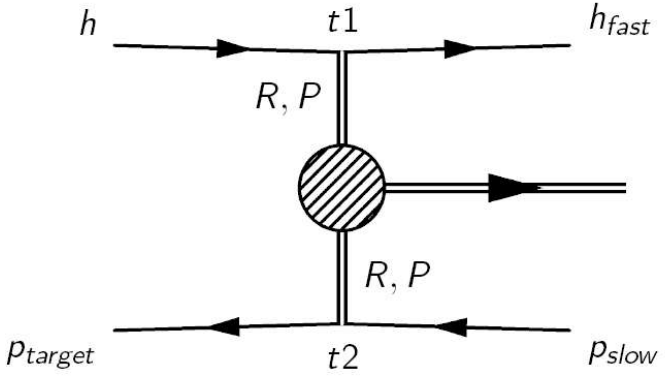
$\longrightarrow$ well suited for the search for scalar and tensor glueballs
f_0 family of resonances most interesting to study

Introduction



Y. Chen et al., Phys. Rev. D 73, 014516 (2006)

Central Production:



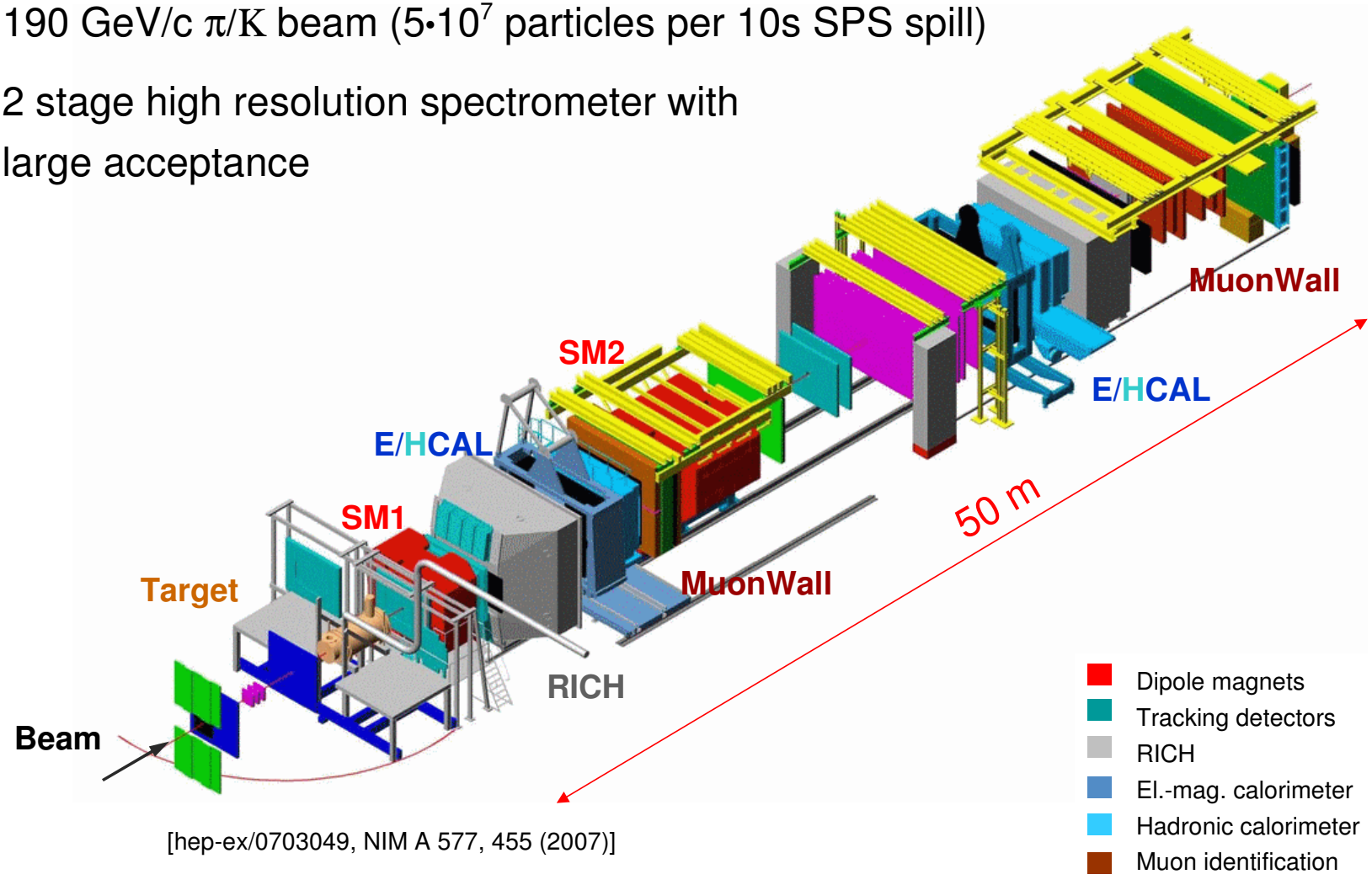
Studies of Central Production with 4π final states

- F. Binon et al. GAMS Collaboration. *Nuovo Cimento*, 78, 1983
- S. Abatzis et al. WA91 Collaboration. Phys.Lett.**B** 324, 1994
- F. Antinori et al. WA102 Collaboration, Phys.Lett.**B** 353, 1995
- C. Amsler et al. Crystal Barrel Collaboration. Phys.Lett.**B** 380, 1996

The COMPASS spectrometer

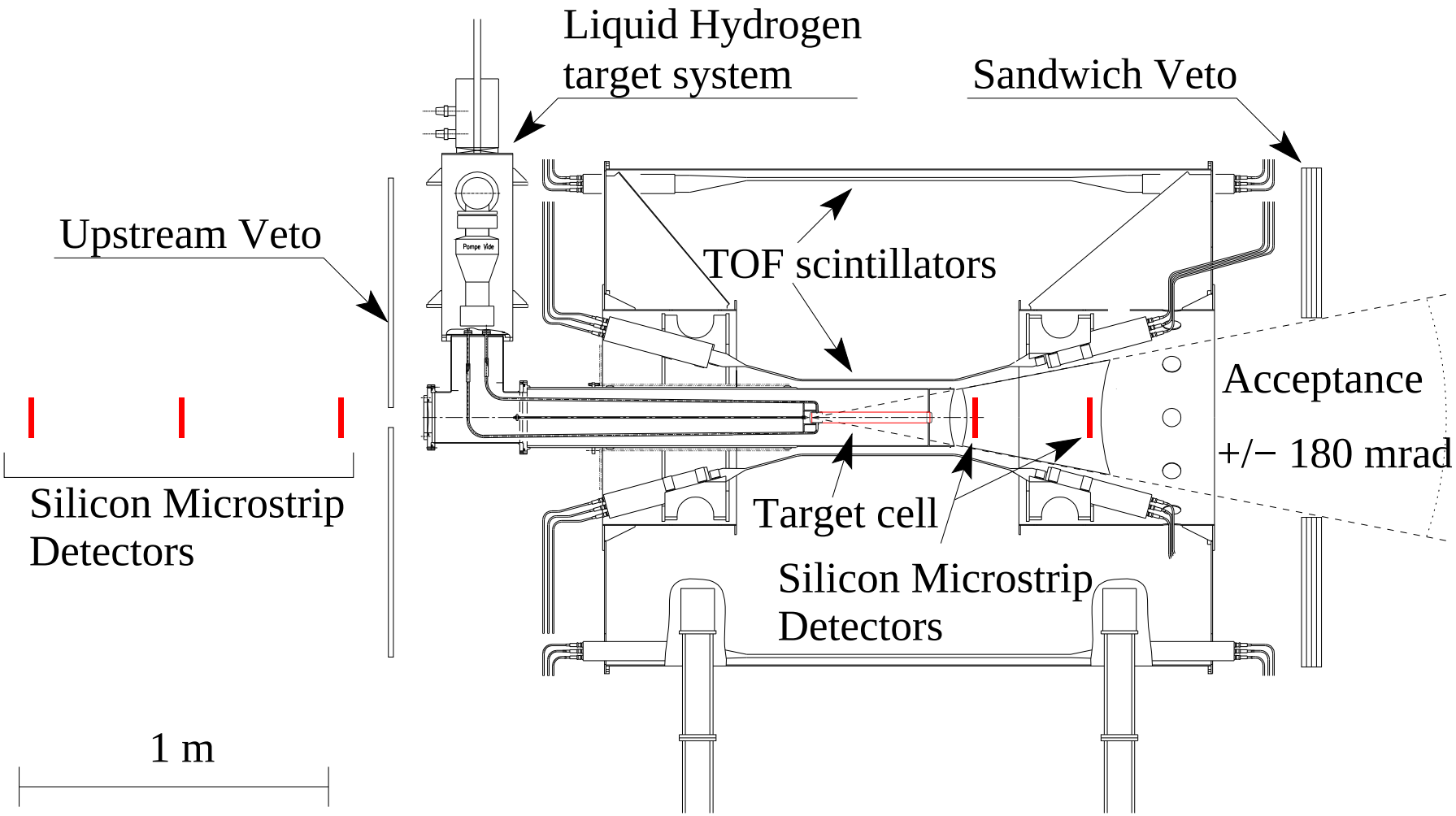
190 GeV/c π/K beam ($5 \cdot 10^7$ particles per 10s SPS spill)

2 stage high resolution spectrometer with large acceptance



[hep-ex/0703049, NIM A 577, 455 (2007)]

Target Zone

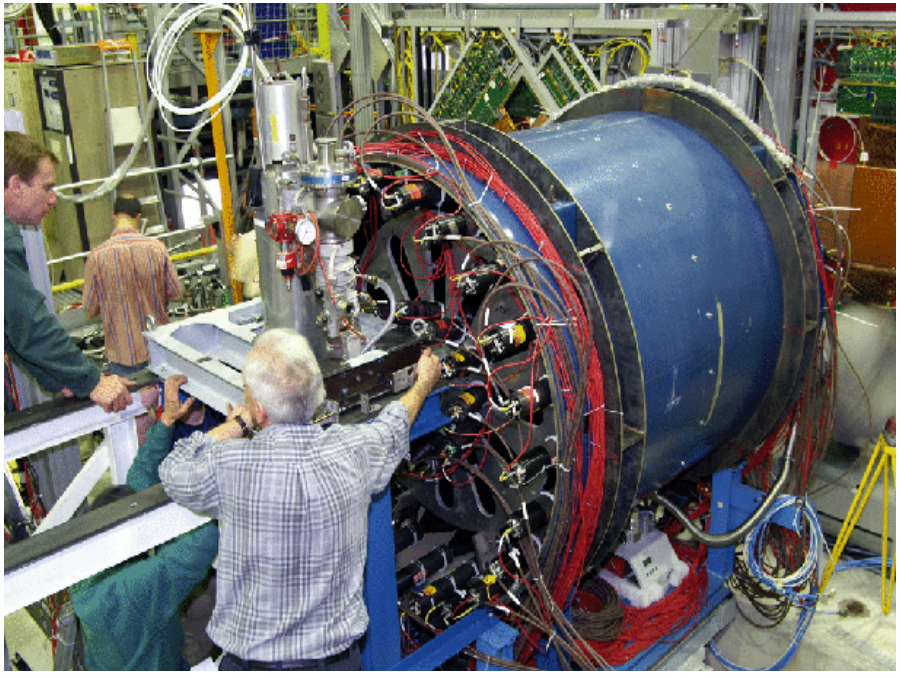


- 40cm lH_2 target
- luminosity $0.15 pb^{-1}$/day

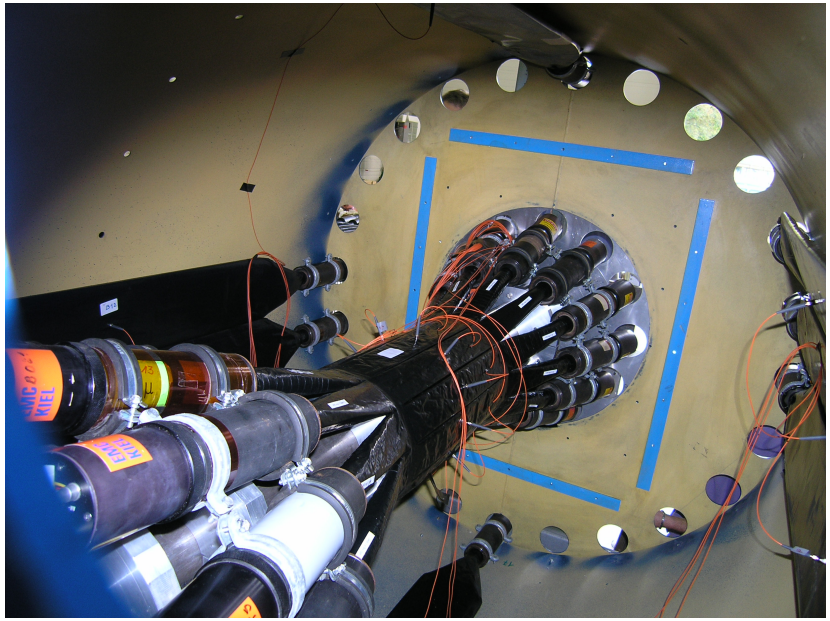
Recoil Proton Detector

Function:

1. fast **trigger** on recoil proton
2. Proton **PID** via TOF and dE/dx measurement



Recoil Proton Detector



RPD during its assembly

- small e^- and π^- background
- time resolution $\sigma < 350\,\text{ps}$

- layout: 2 cylindrical layers of scintillators ($r_1 = 120\,\text{mm}$ and $r_2 = 775\,\text{mm}$ surrounding the target)
- inner ring w/ 12 scintillator slabs (5 mm x 500 mm BC404, U Mainz)
- outer ring w/ 24 scintillator slabs (10 mm x 1080 mm, IHEP Protvino)
- large dynamical range of the signals due to small attenuation length ($\lambda_{eff} \approx 70\,\text{cm}$)

Calibration I

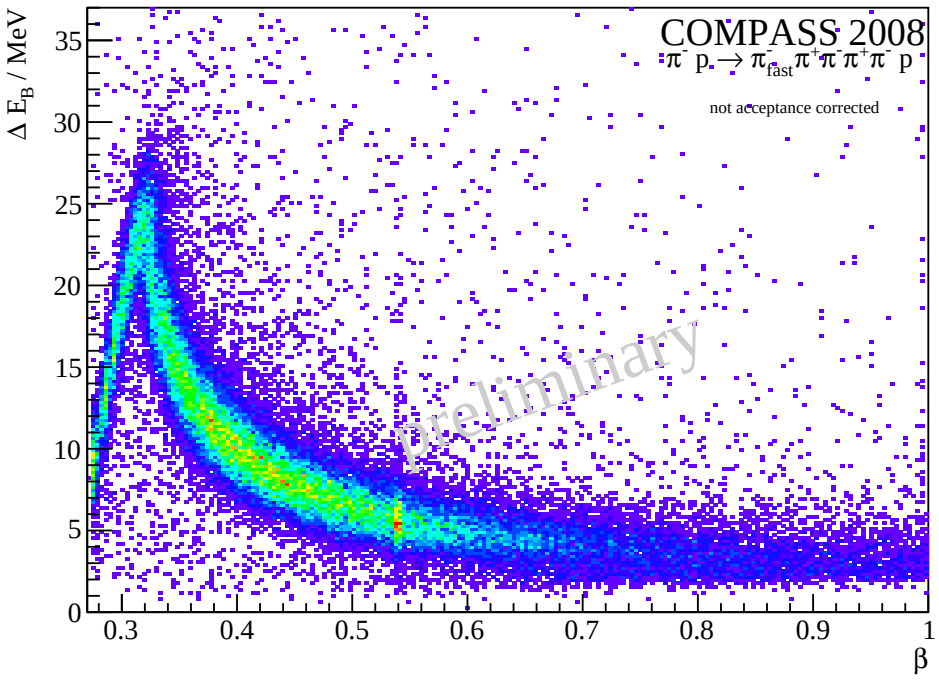
How to come to proton tracks?

- RPD measures **times** and **hits**
- with effective speed of light: **times** $\rightarrow$ **hit postions**
- combine measurements of TOF and positions to calculate angles and $\beta = \frac{v}{c}$
- no magnetic field around the target $\rightarrow$ no direct p measurement
- combine with dE/dx measurement to obtain p
- calibration of energy and TOF necessary

Calibration II

Strategy of calibration:

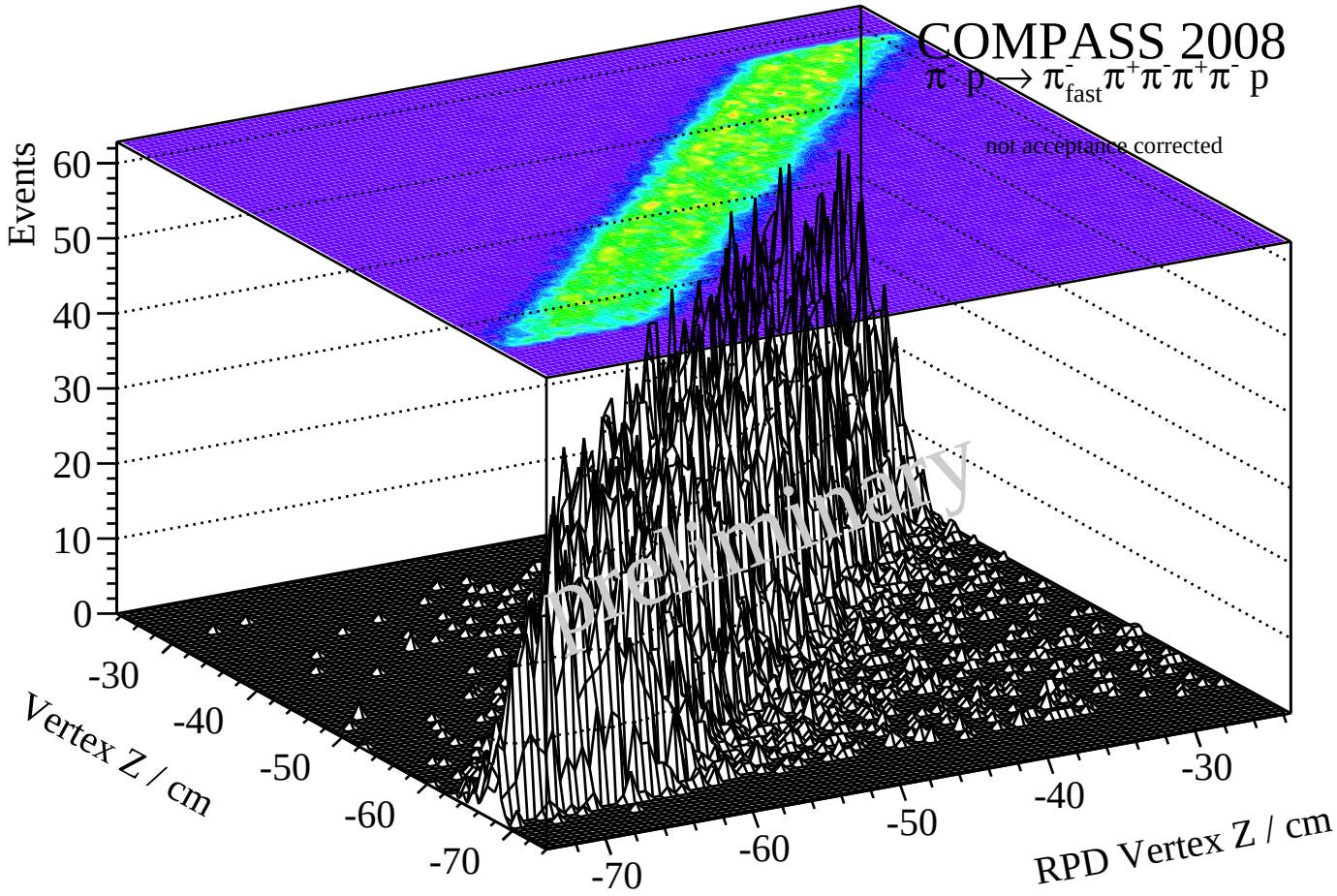
- test measurements with cosmics, μ- and e^- beam to determine eff. speed of light and MIP pulse spectra (HV settings), also energy calibration
- online calibration with hadron/μ on recoil proton signal to set β in the correct range
- offline calibration with elastic and diffractive events for final tuning



recoil proton signal

Calibration III

Finally correct for small effects, like energy loss in the target, finite beam spot size (RMS of 1 cm), ...



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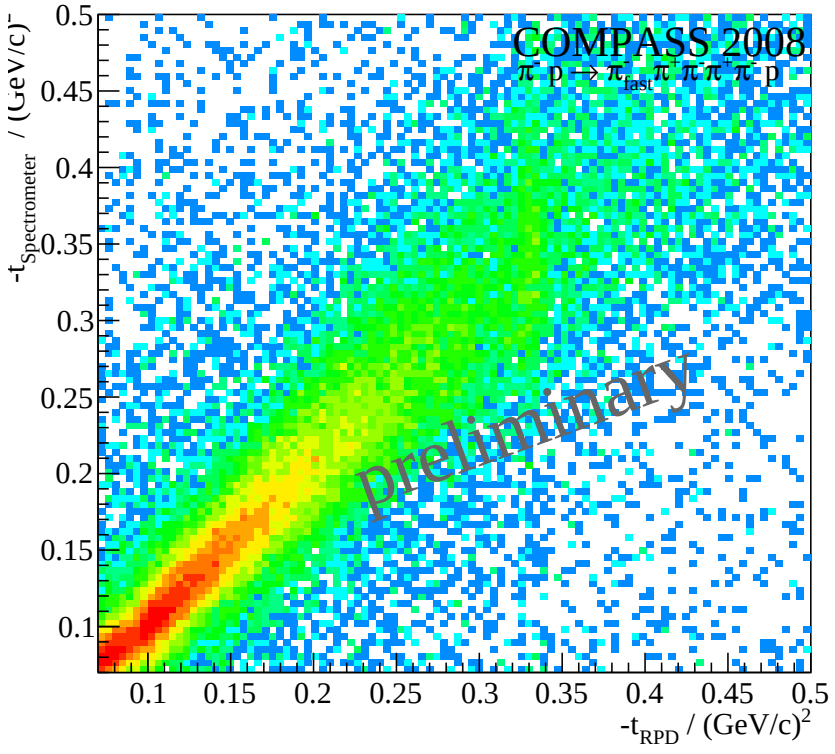
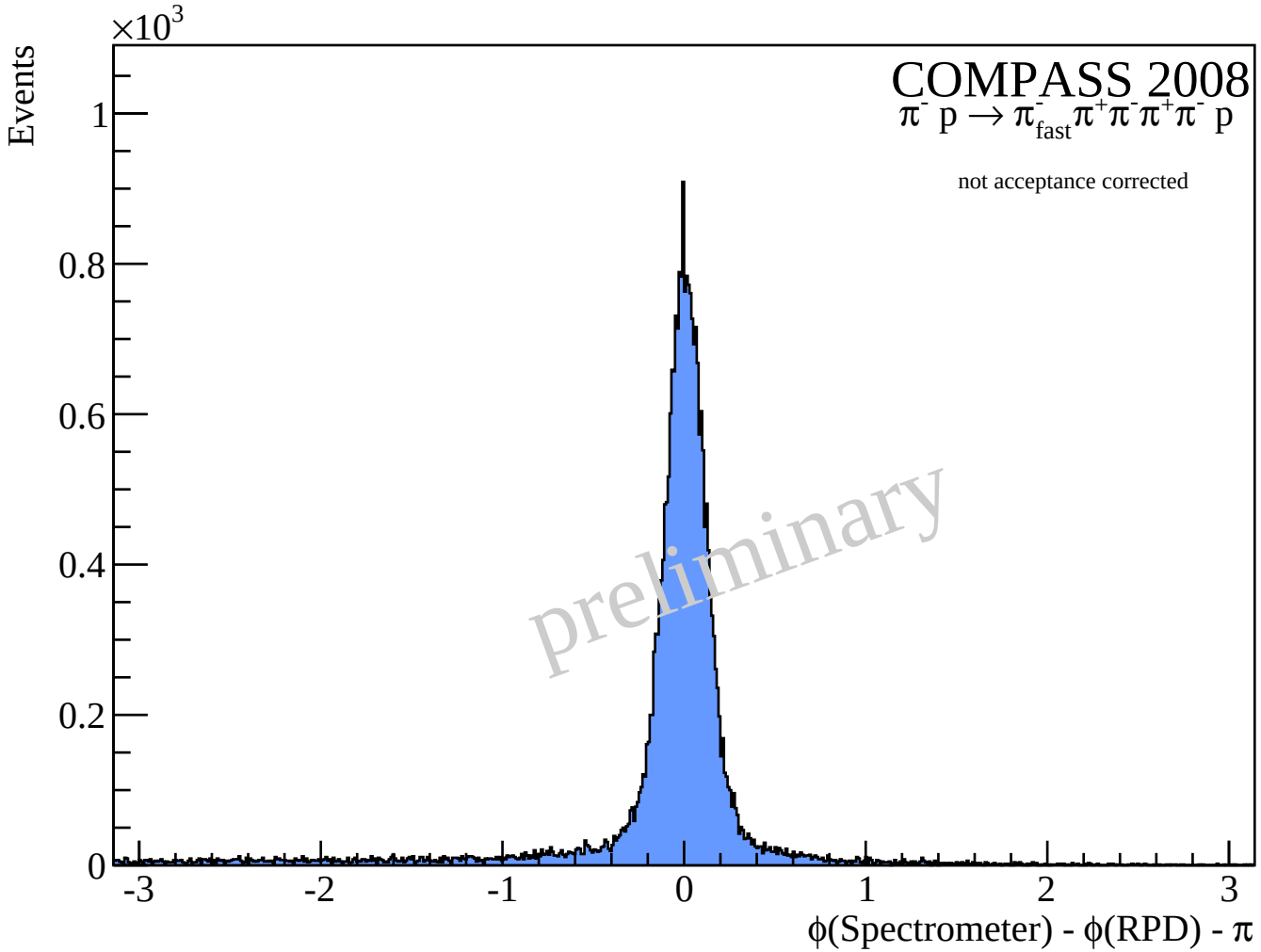


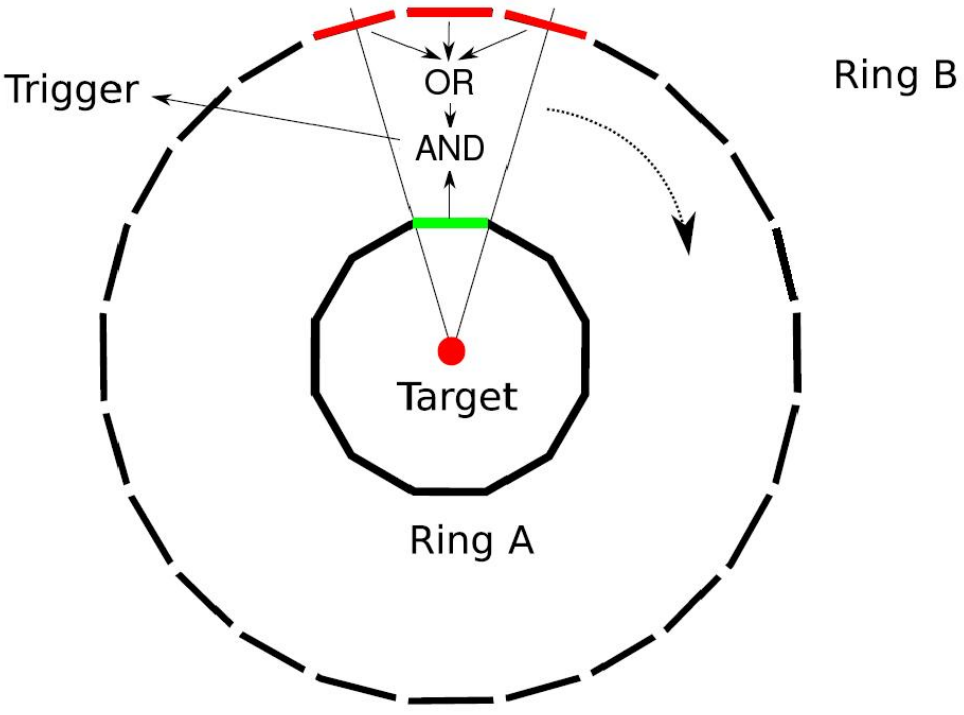
Momentum transfer t after momentum correction (offline)

Calibration III

Finally correct for small effects, like energy loss in the target, finite beam spot size (RMS of 1 cm), ...

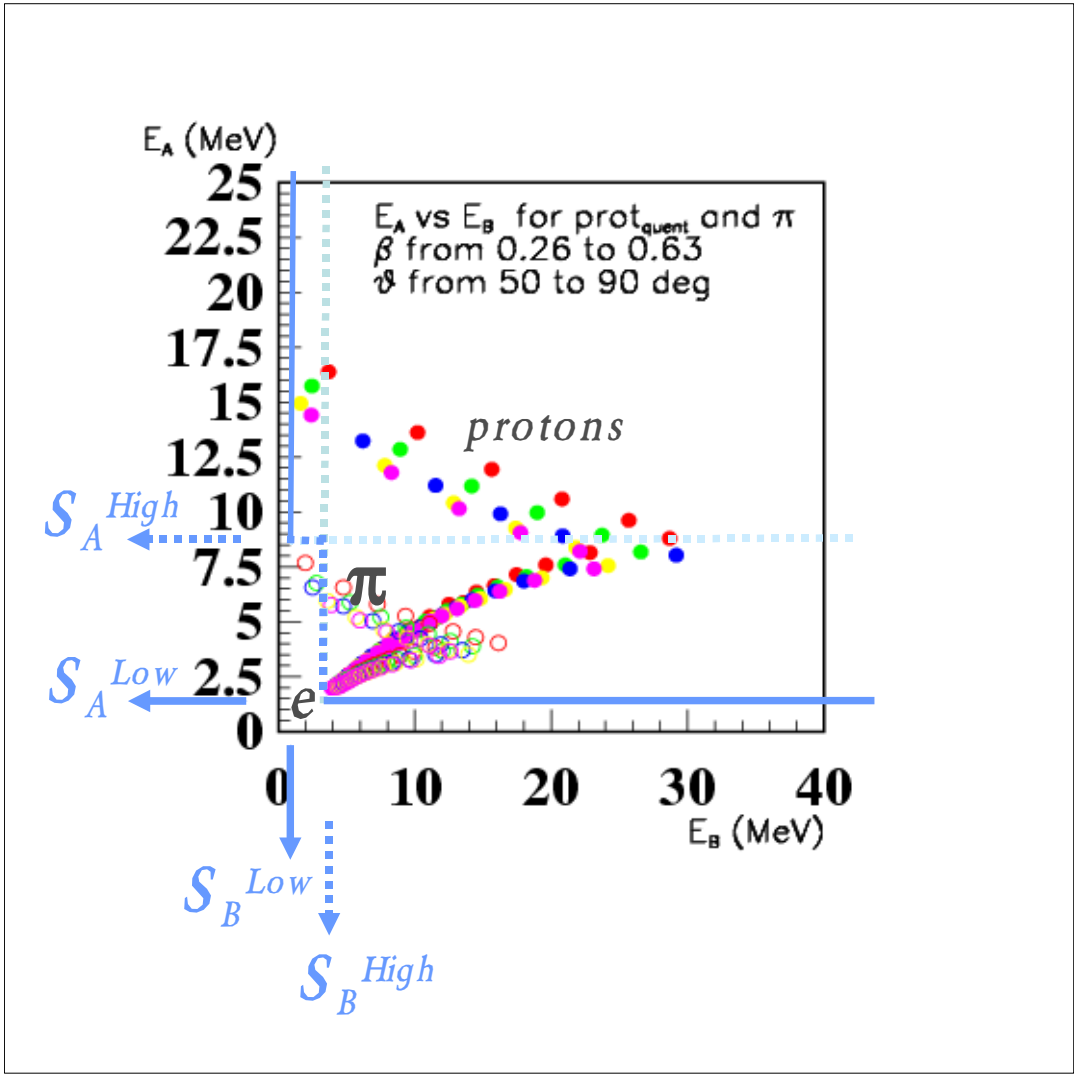


Proton Trigger



- no 2nd level trigger, so *fast*, *efficient* and *pure* trigger necessary
- trigger on slow recoil proton with RPD
- coincidence of one ring A element and one out of three possible ring B elements

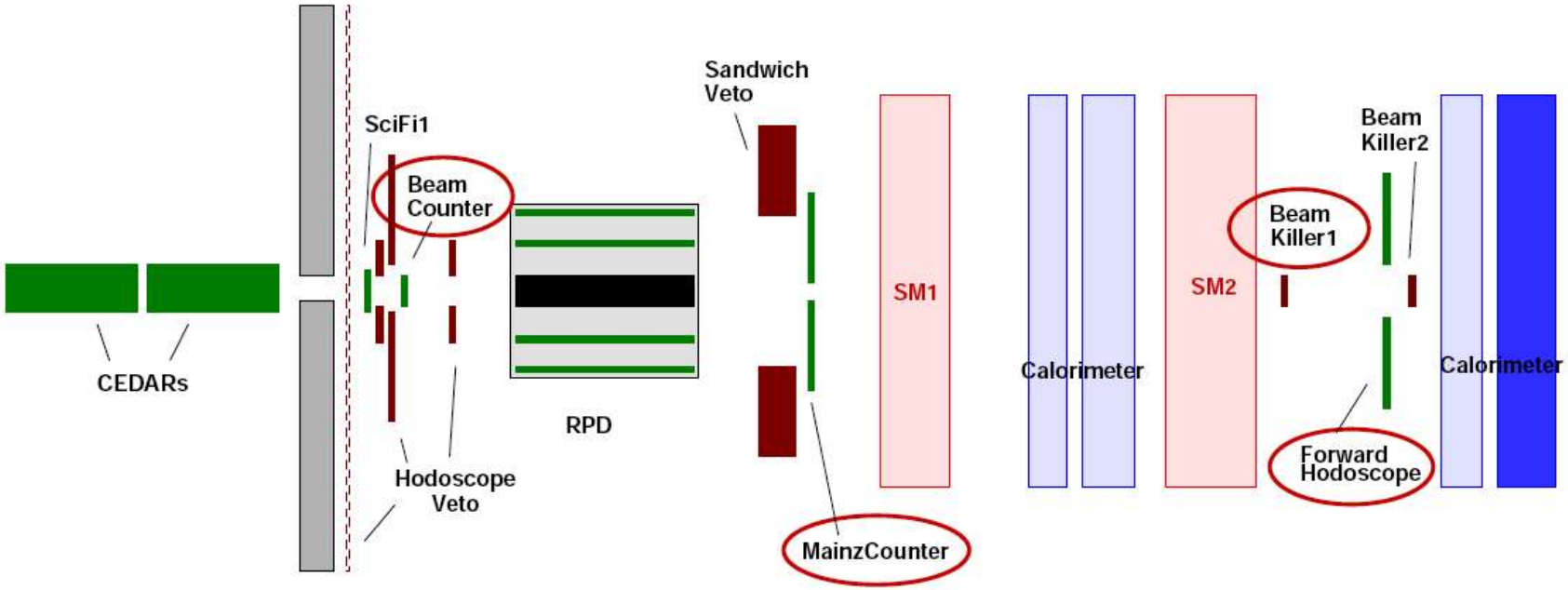
Proton Trigger



calculated energy losses in both rings for different incident angles and particles

- identify proton by TOF and dE/dx meas. (with thresholds to cut out e^- and $\pi^\pm$)

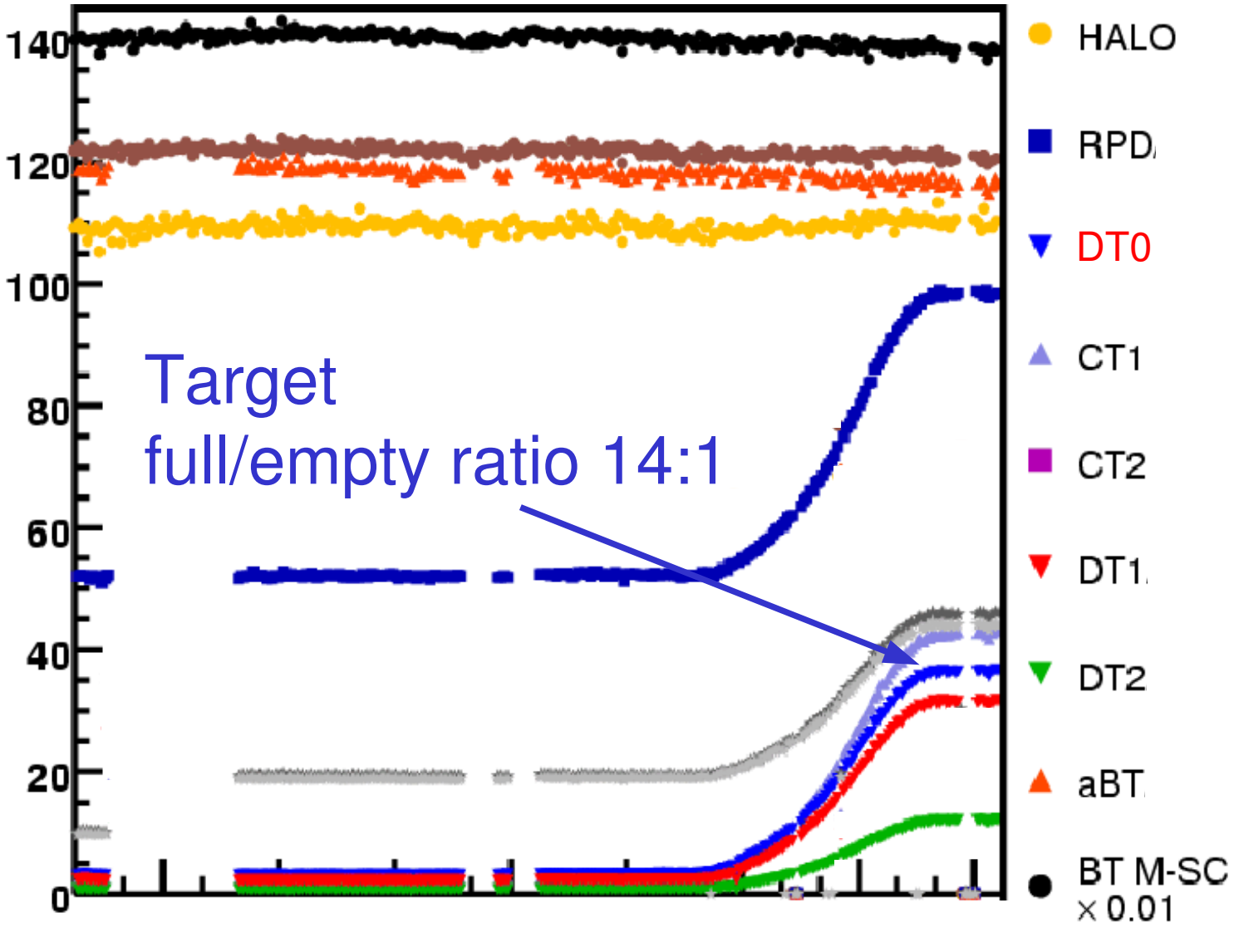
DT0 Physics Trigger



1. **Beam Definition:** aBT = SciFi01X $\wedge$ Beamcounter
2. **Target Pointing:** RPD = Recoil Proton Detector
3. **Veto System:** Veto = SandwichVeto $\vee$ Hodoscope Vetos $\vee$ Beamkiller

Physics Trigger DT0 = aBT $\wedge$ RPD $\wedge$!(Veto)

DT0 Physics Trigger - Empty/Full Target Effect



Event Selection

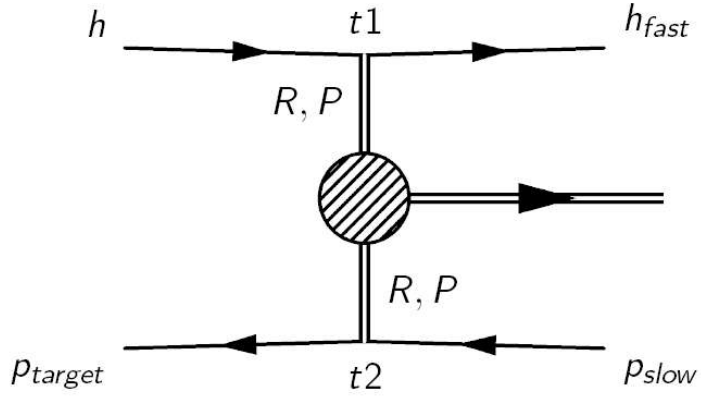
Compass 2008 Run (shown here: 13% of 2008 data)

$\pi^- p \longrightarrow \pi^-_{fast}(\pi^+\pi^-\pi^+\pi^-)p_{recoil}$

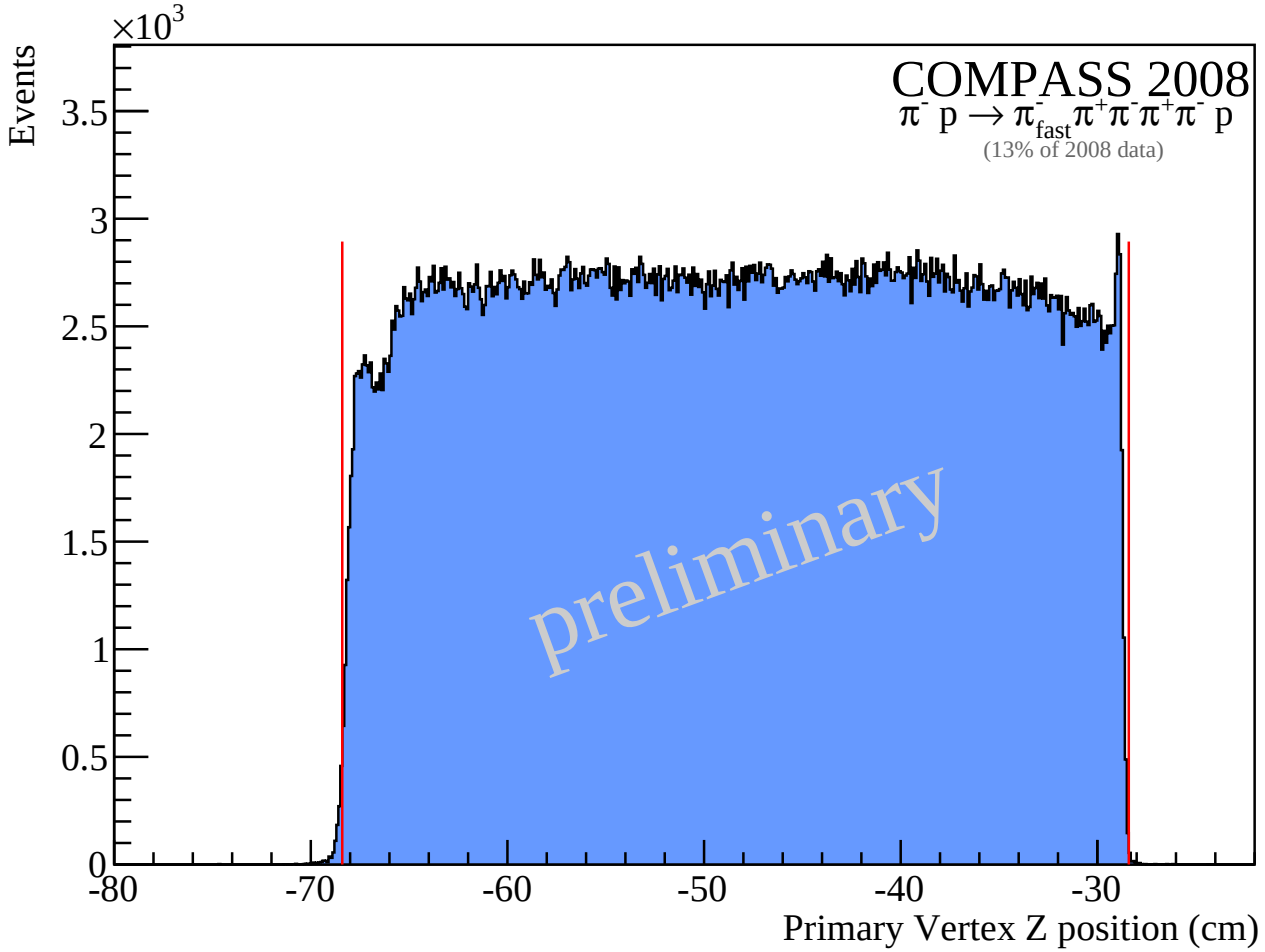
Cuts:

Cut	%
-no-	100
1 Primary Vertex	67.9
DT0 Trigger	58.4
5 Outgoing Charged Tracks	3.52
PV in Target	3.51
CEDAR Kaon Veto	3.46
Charge Conservation $\Sigma Q = -1$	2.52
Exclusivity (190 ± 5) GeV	0.27
$Q_{fast} = -1$	0.18

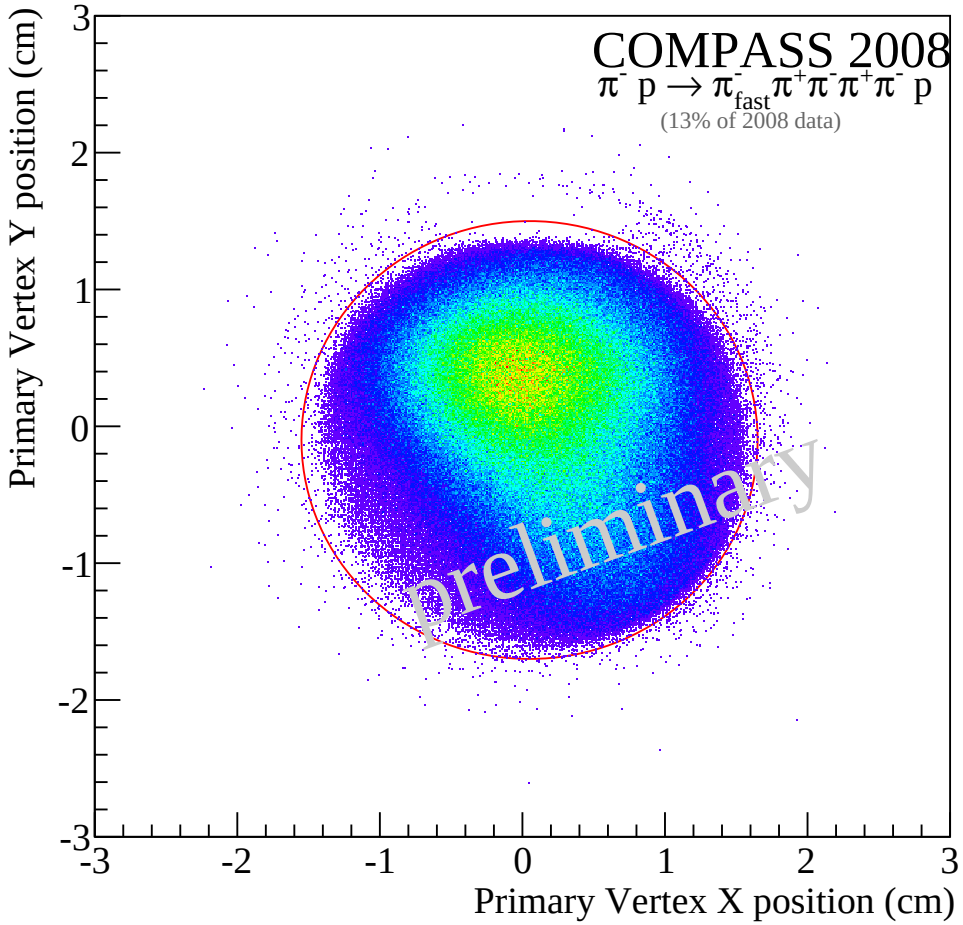
Central Production:



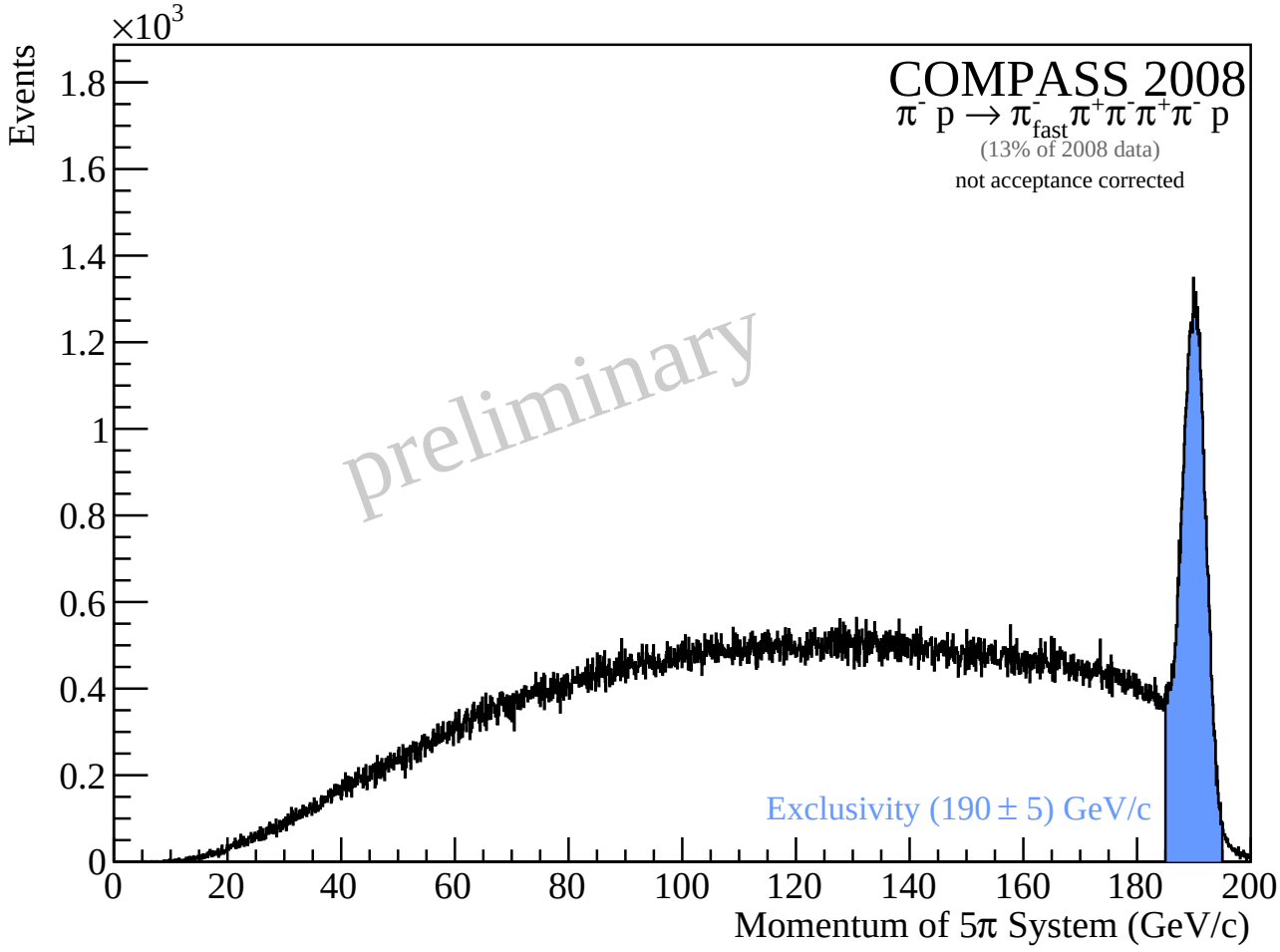
Vertex Distribution in Z (beam) direction



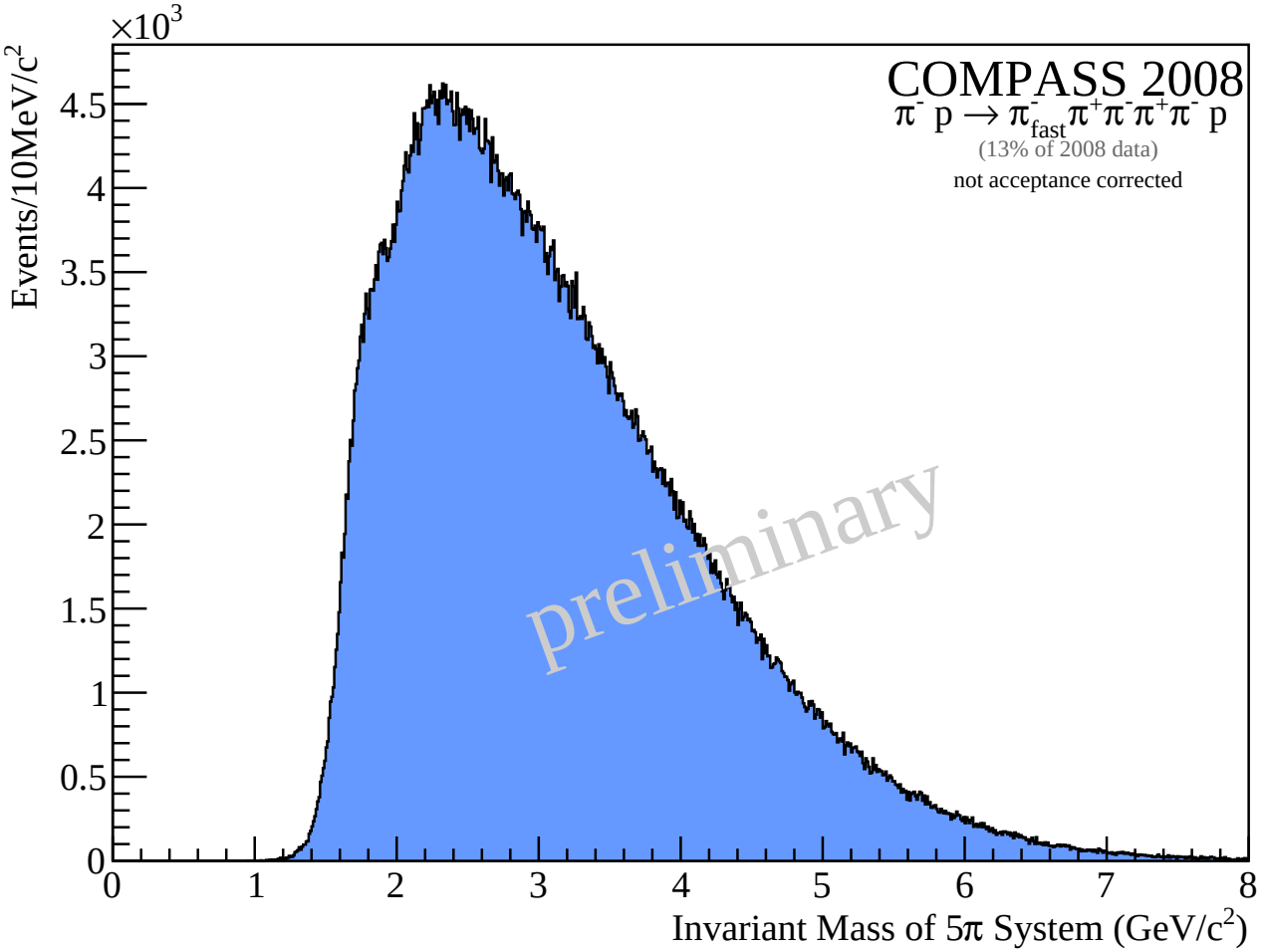
Vertex Distribution in XY-Plane



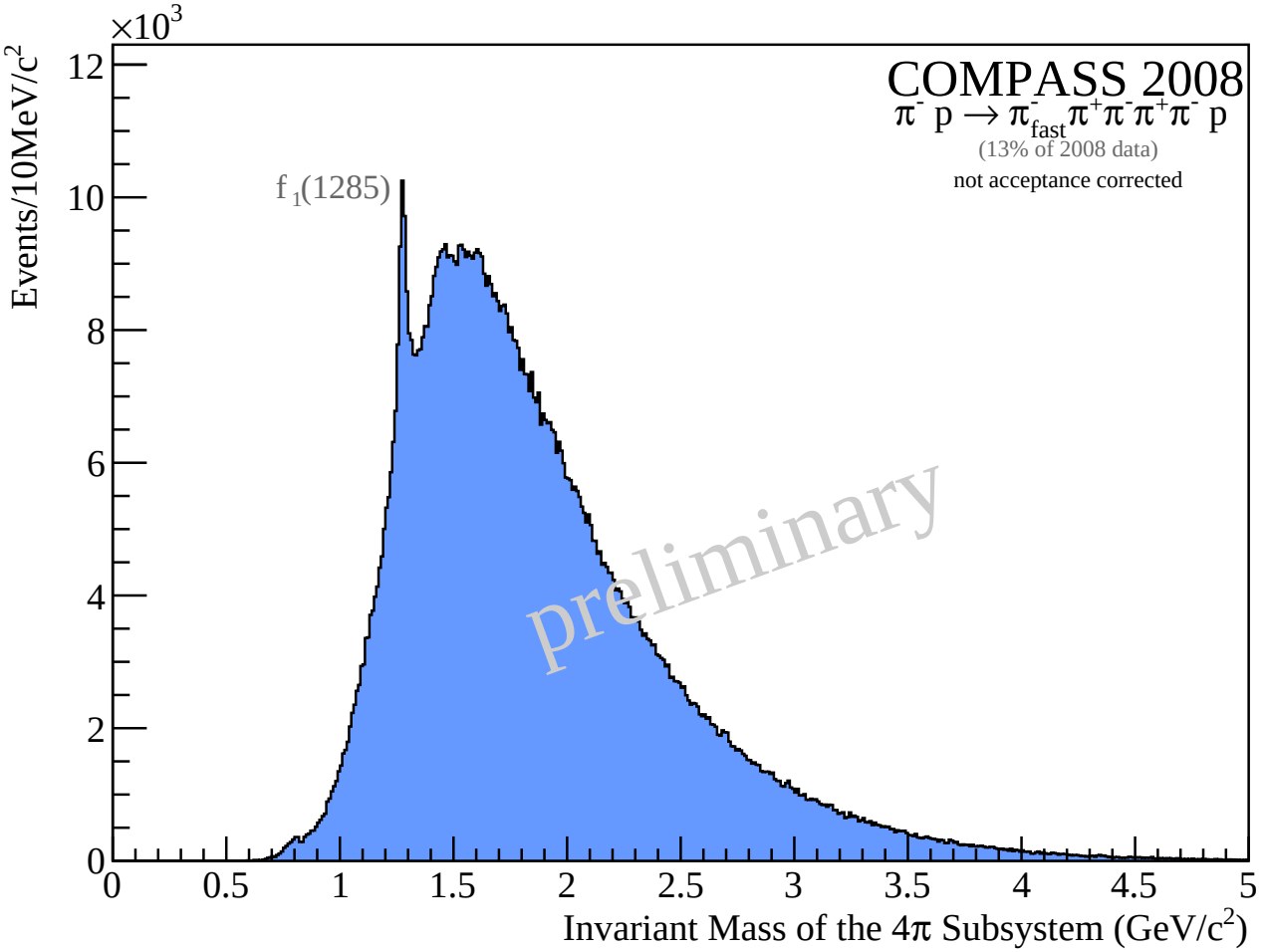
Exclusivity



Invariant Mass Distribution (5π)



Invariant Mass of 4π System

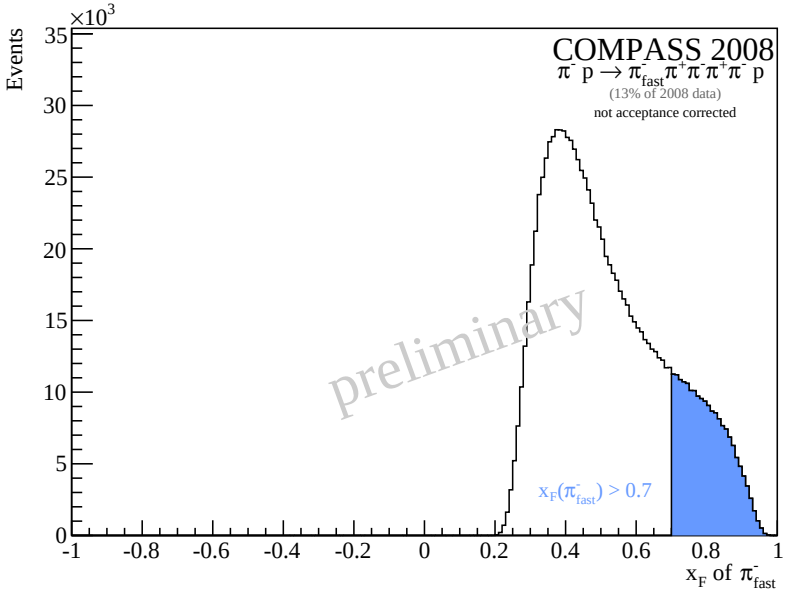


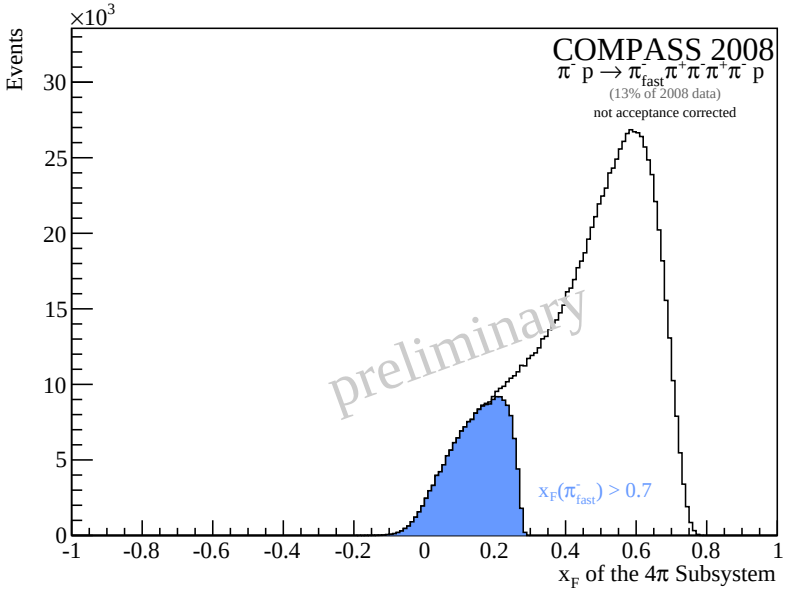
Enhancement of CP events: xF

One Approach to Select CP: Feynman x_F

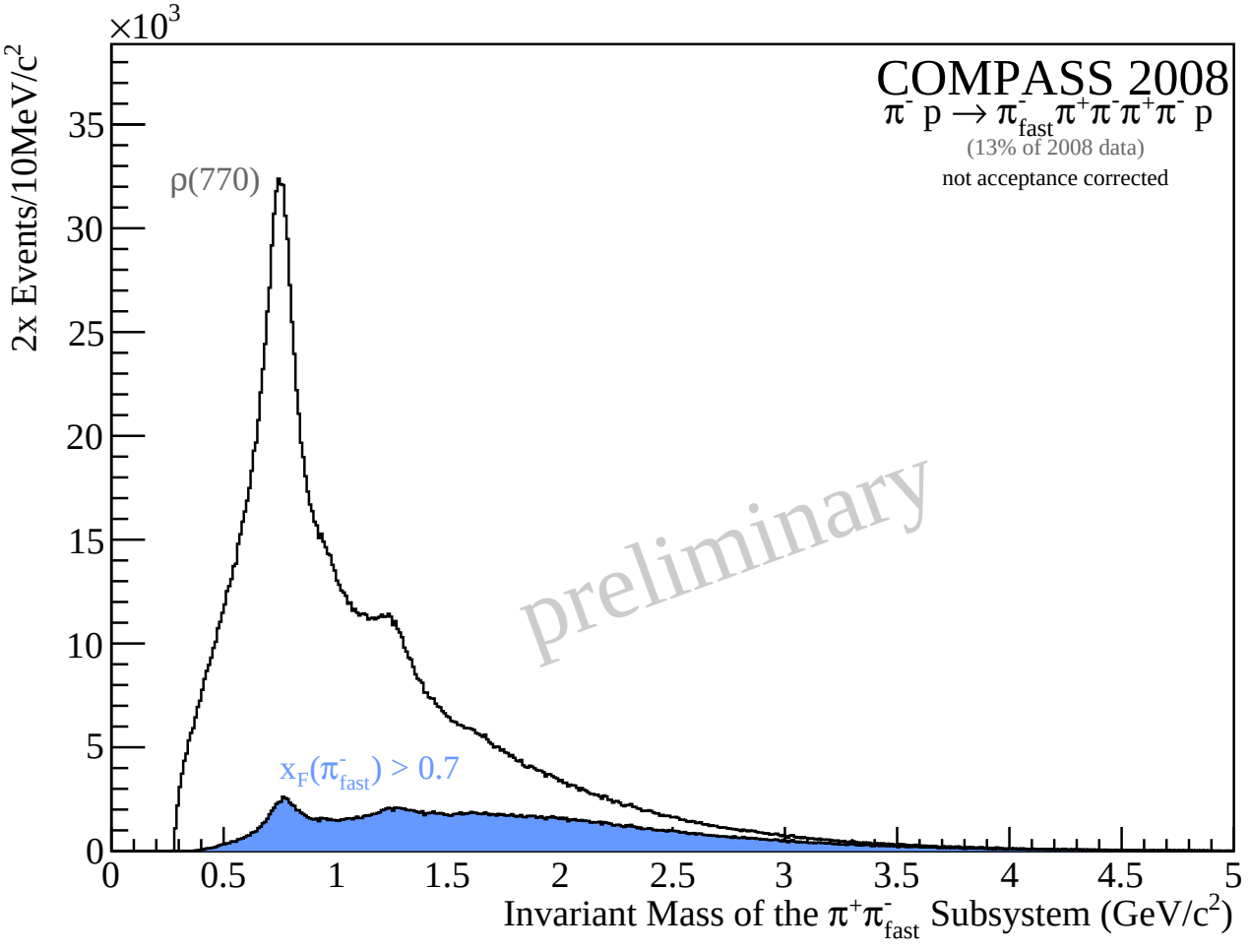
$$x_F = \frac{|\vec{p}_l|}{|\vec{p}_l^{\,max}|} = \frac{2\,|\vec{p}_l|}{\sqrt{s}},$$

- $|\vec{p}_l|$: longitudinal momentum
- $\sqrt{s}$: total center-of-mass energy of the interaction
- $|\vec{p}_l^{\,max}|$: the maximum allowed longitudinal momentum

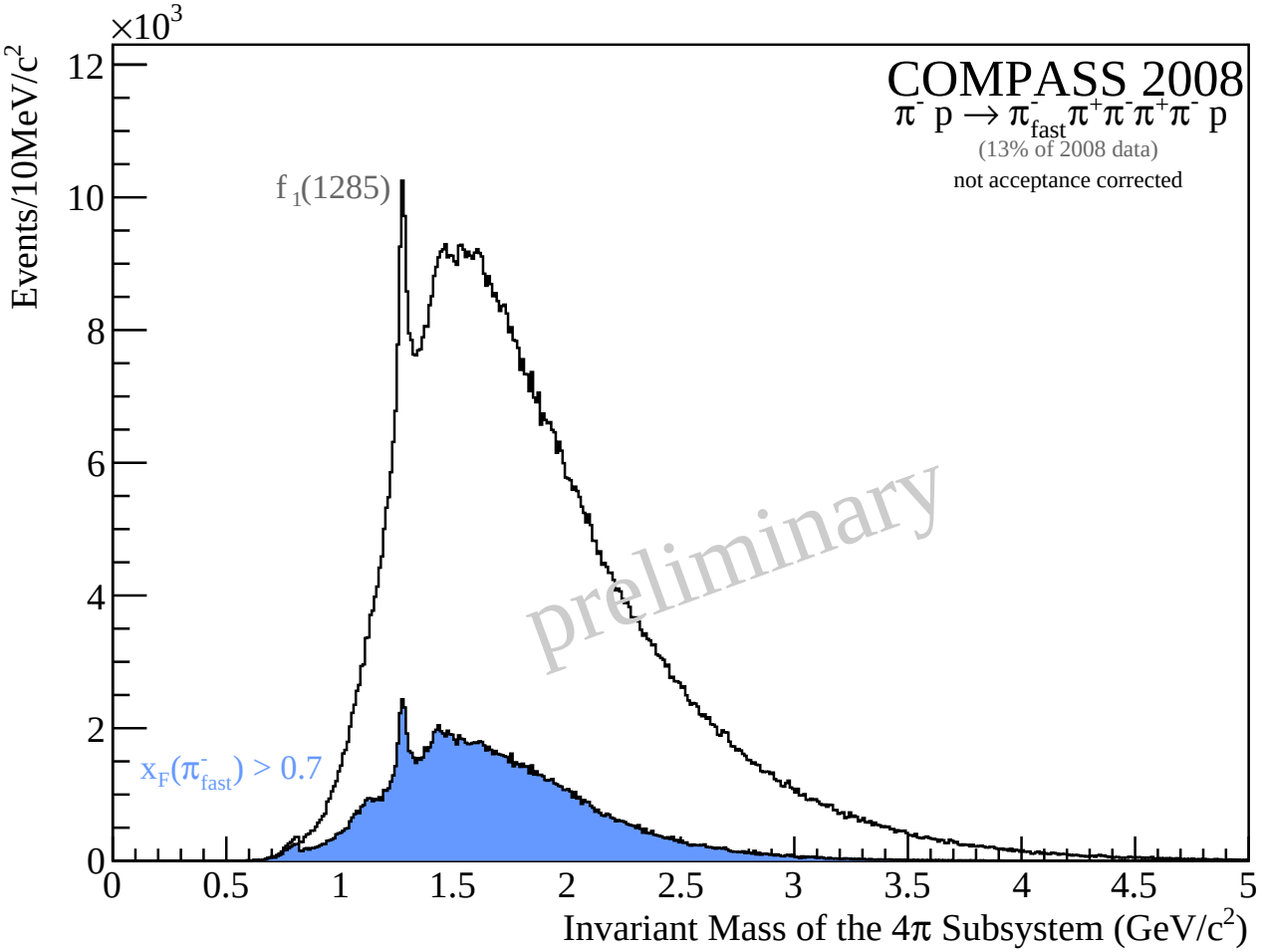




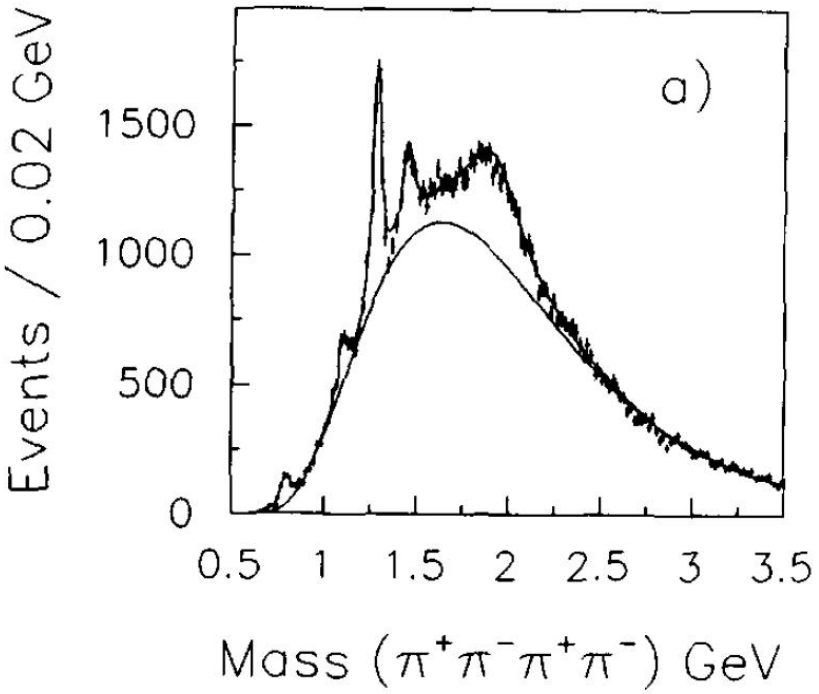
Invariant Mass of 2π System with π^-_{fast}



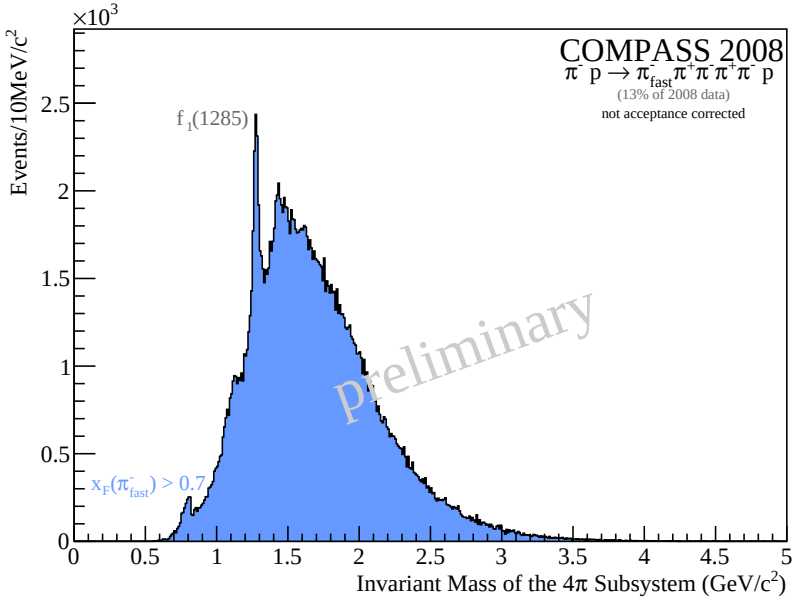
Invariant Mass of 4π System



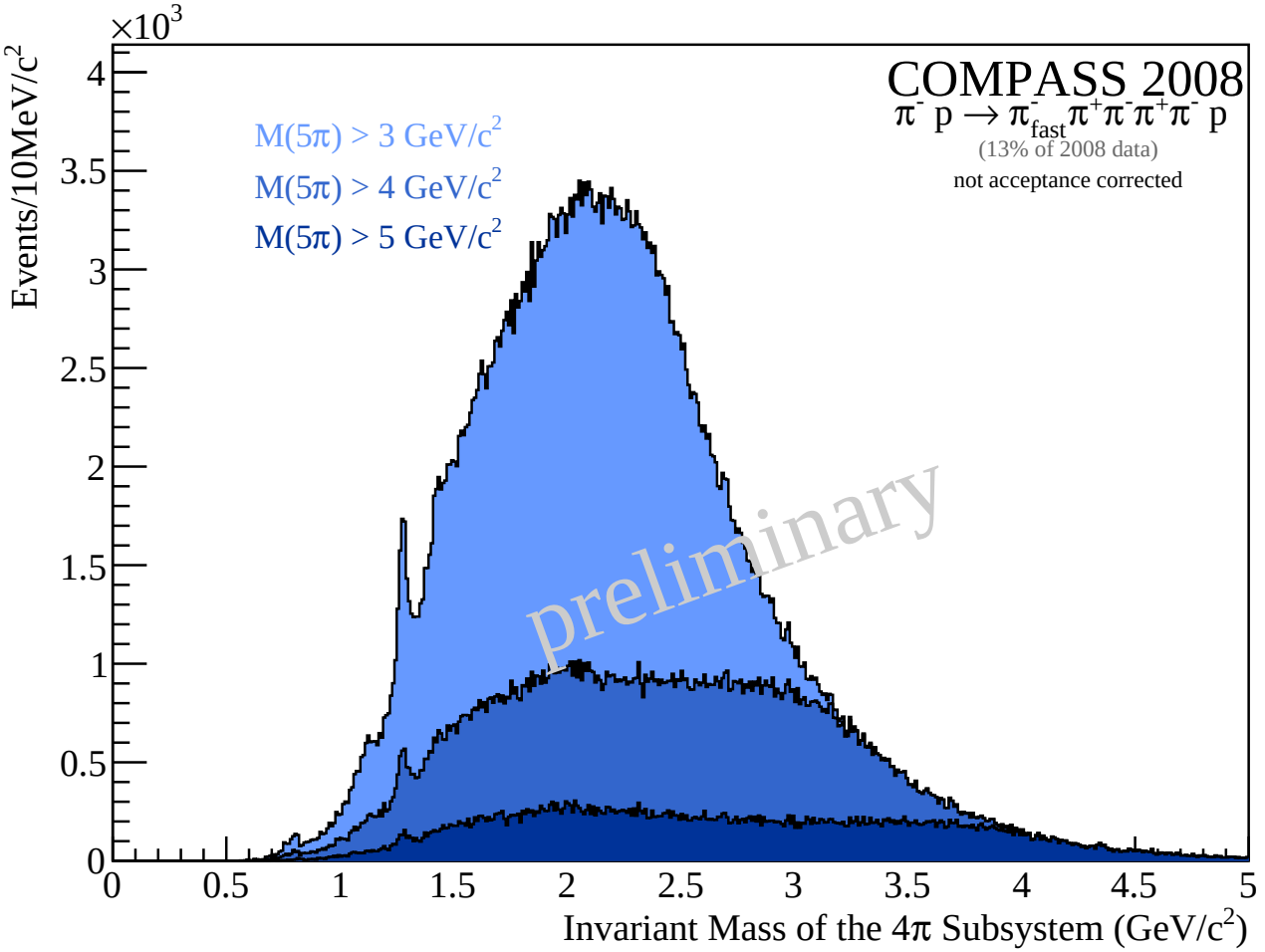
Invariant Mass of 4π System



WA91 4π analysis



Different Approach: Cut on M(5π)



Summary and Outlook

- COMPASS 2008 Hadron Trigger and Recoil Proton Detector were presented alongside a first glance at potentially interesting centrally produced events
- both trigger and RPD show excellent performances
- ideas for central production cuts under investigation
- mass spectra compared to former experiments
- only few days of 2008 data taking used in this analysis, 2009 data also to be included

Next steps:

1. include RPD and RICH information in the analysis
2. acceptance correction
3. study possibility of kinematic fitting with RPD
4. investigate further cuts for central production
5. perform Partial Wave Analysis