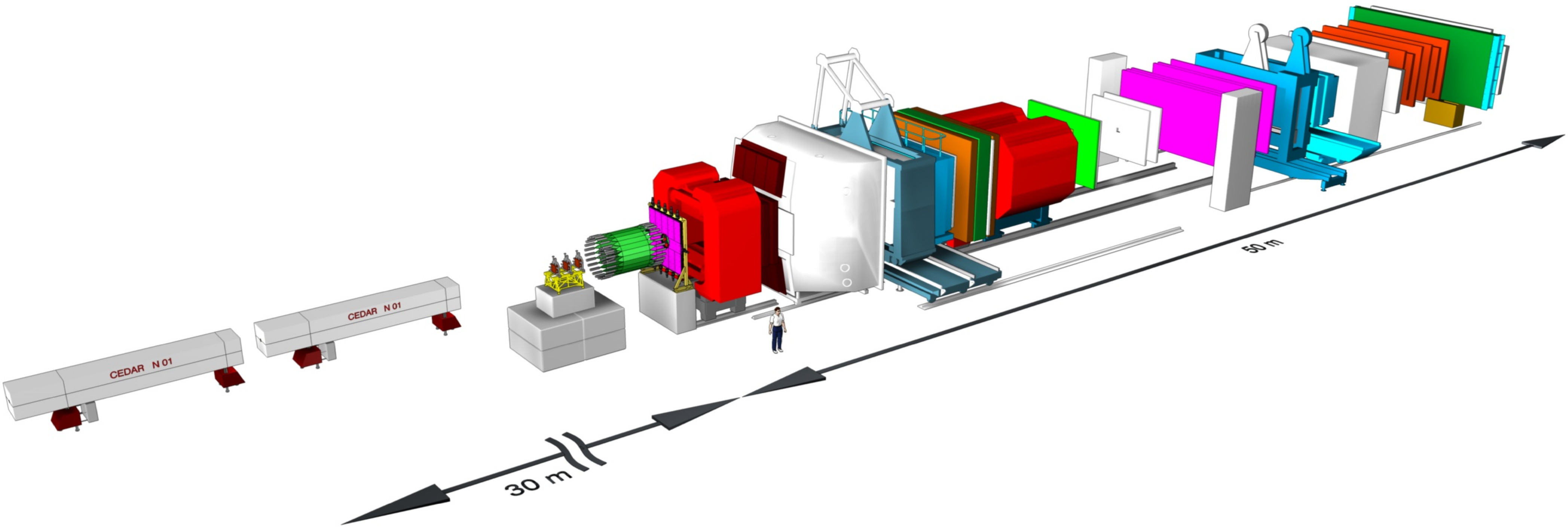
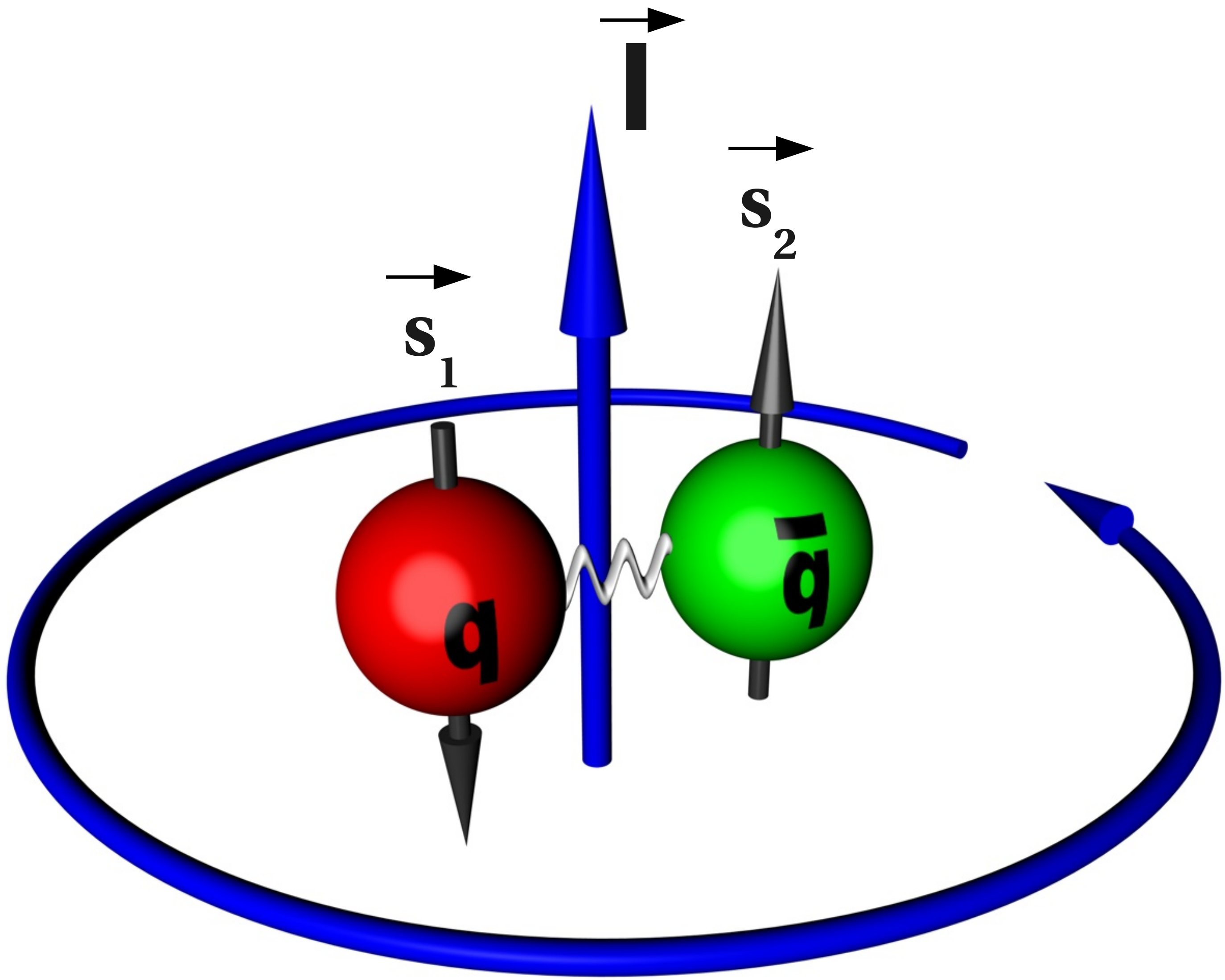
Analysis of diffractively dissociated $K^- \pi^+ \pi^-$ events produced by a 190 GeV/c² hadron beam on a lH_2 target at the COMPASS-experiment



bmb+f - Förderschwerpunkt COMPASS
Großgeräte der physikalischen Grundlagenforschung
COMPASS
JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Prometeusz Jasinski
DPG-Tagung 2011
21.03.2011

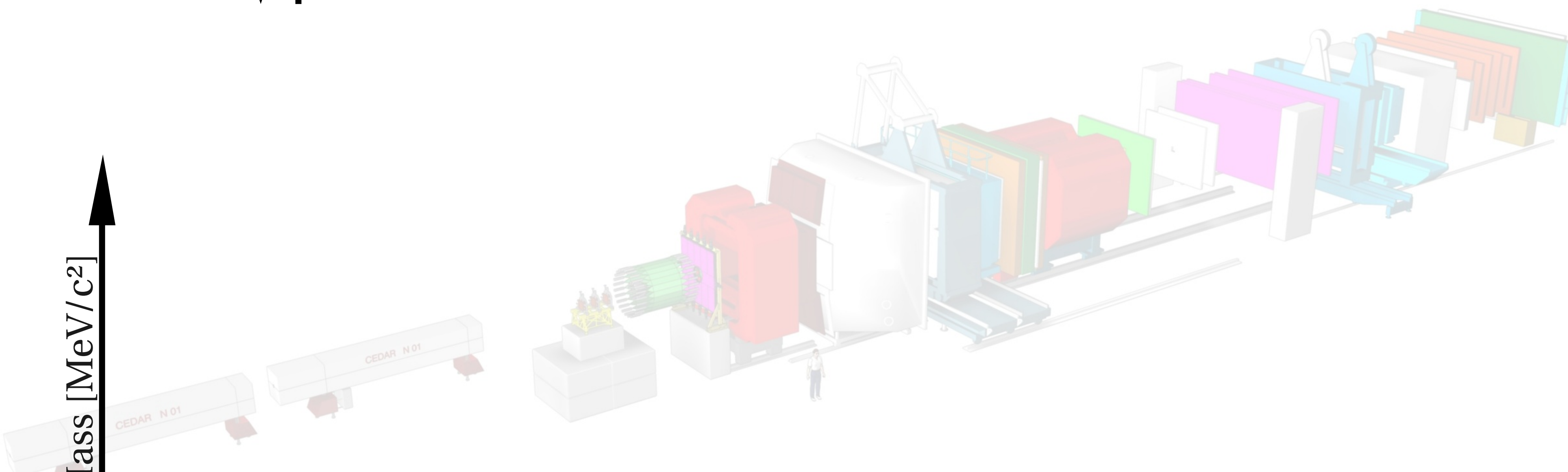
The $q\bar{q}$ model in a potential



Isospin = ½ light meson spectrum

$| u\bar{s} >$ $| d\bar{s} >$ $| \bar{u}s >$ $| \bar{d}s >$

S = 0



Energy = Mass [MeV/c²]

Kaon (494)

Isospin = ½ light meson spectrum

$| u\bar{s} >$ $| d\bar{s} >$ $| \bar{u}s >$ $| \bar{d}s >$

S = 0

S = 1

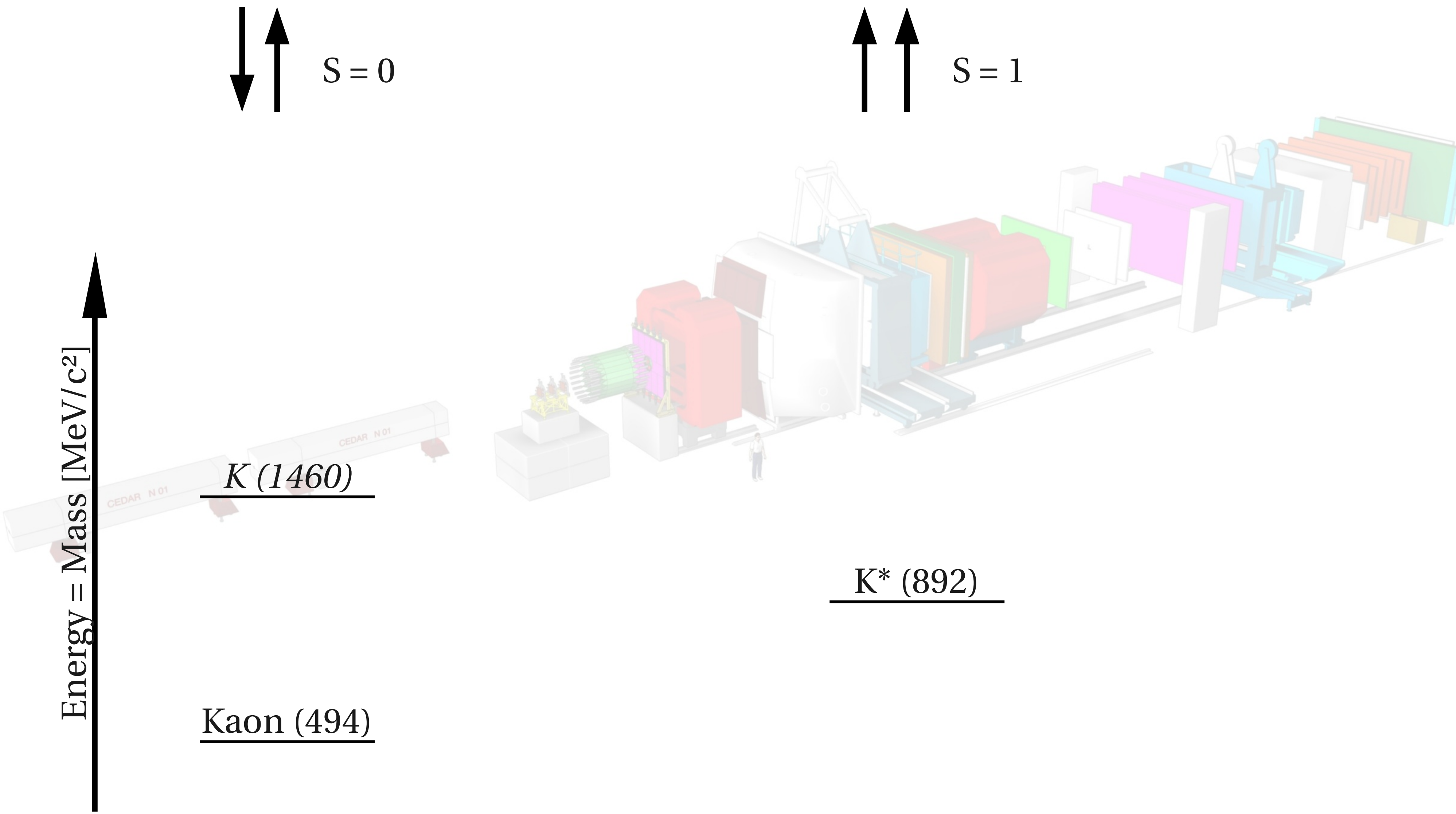
Energy = Mass [MeV/c^2]

K* (892)

Kaon (494)

Isospin = ½ light meson spectrum

$$|\,u\bar{s}\,\rangle \;\; |\,d\bar{s}\,\rangle \;\; |\,\bar{u}s\,\rangle \;\; |\,\bar{d}s\,\rangle$$



Isospin = ½ light meson spectrum

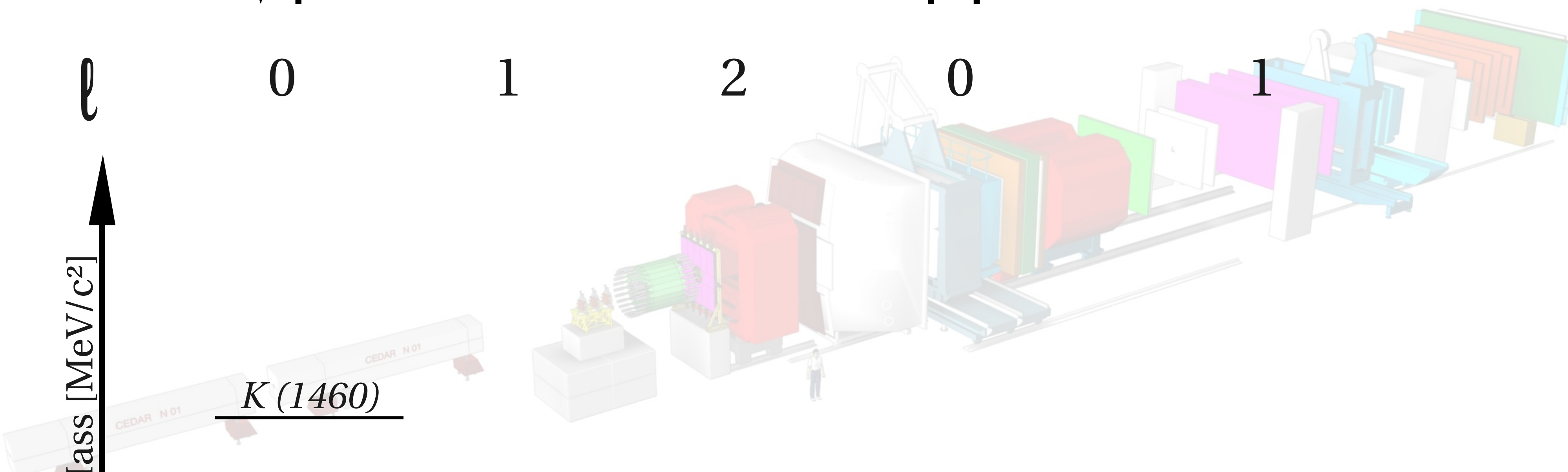
$|u\bar{s}\rangle$ $|d\bar{s}\rangle$ $|\bar{u}s\rangle$ $|\bar{d}s\rangle$

↓↑ S = 0

↑↑ S = 1

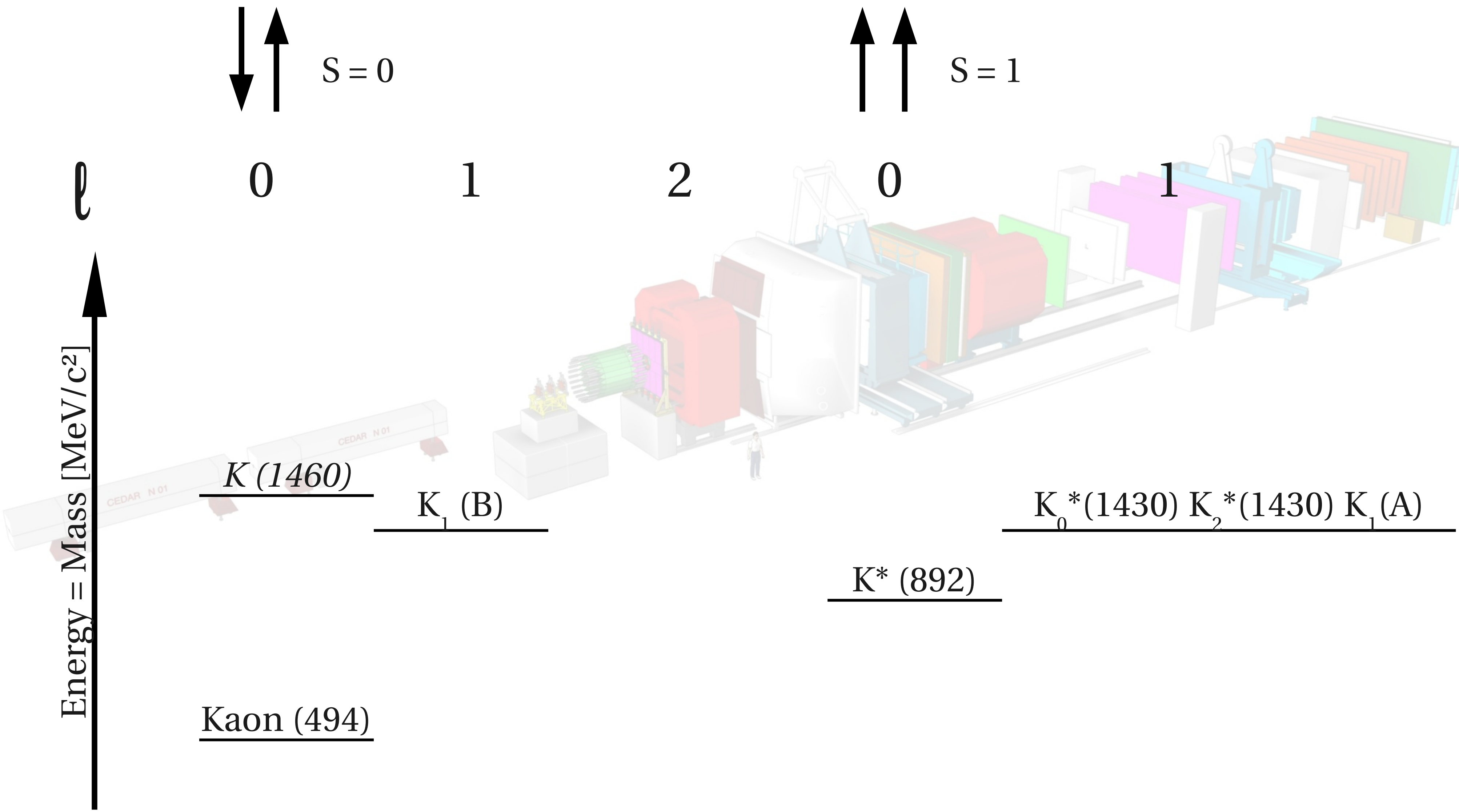
ℓ	0	1	2	0	1
	K (1460)				
				K* (892)	
	Kaon (494)				

Energy = Mass [MeV/c²]



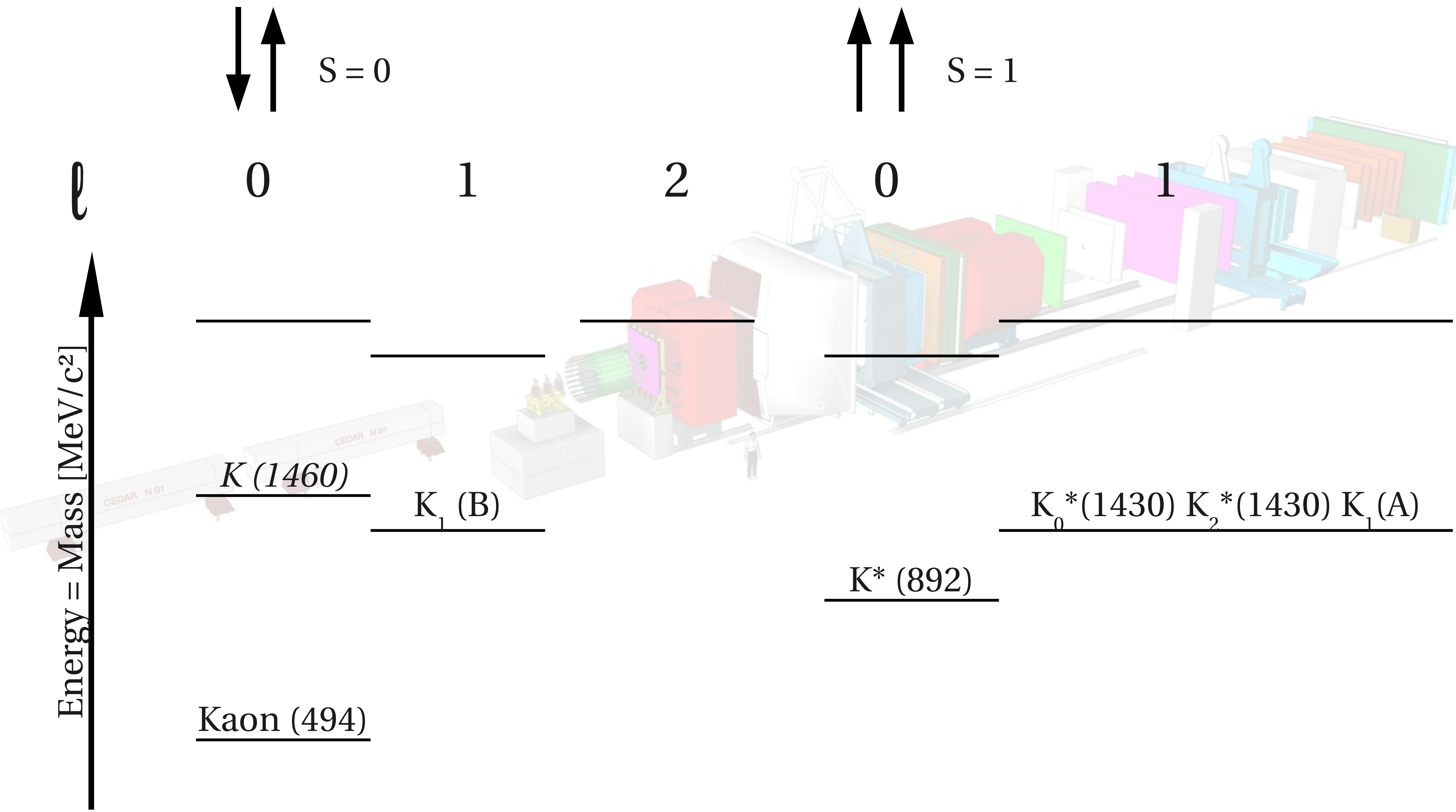
Isospin = ½ light meson spectrum

$| u\bar{s} > \ | d\bar{s} > \ | \bar{u}s > \ | \bar{d}s >$

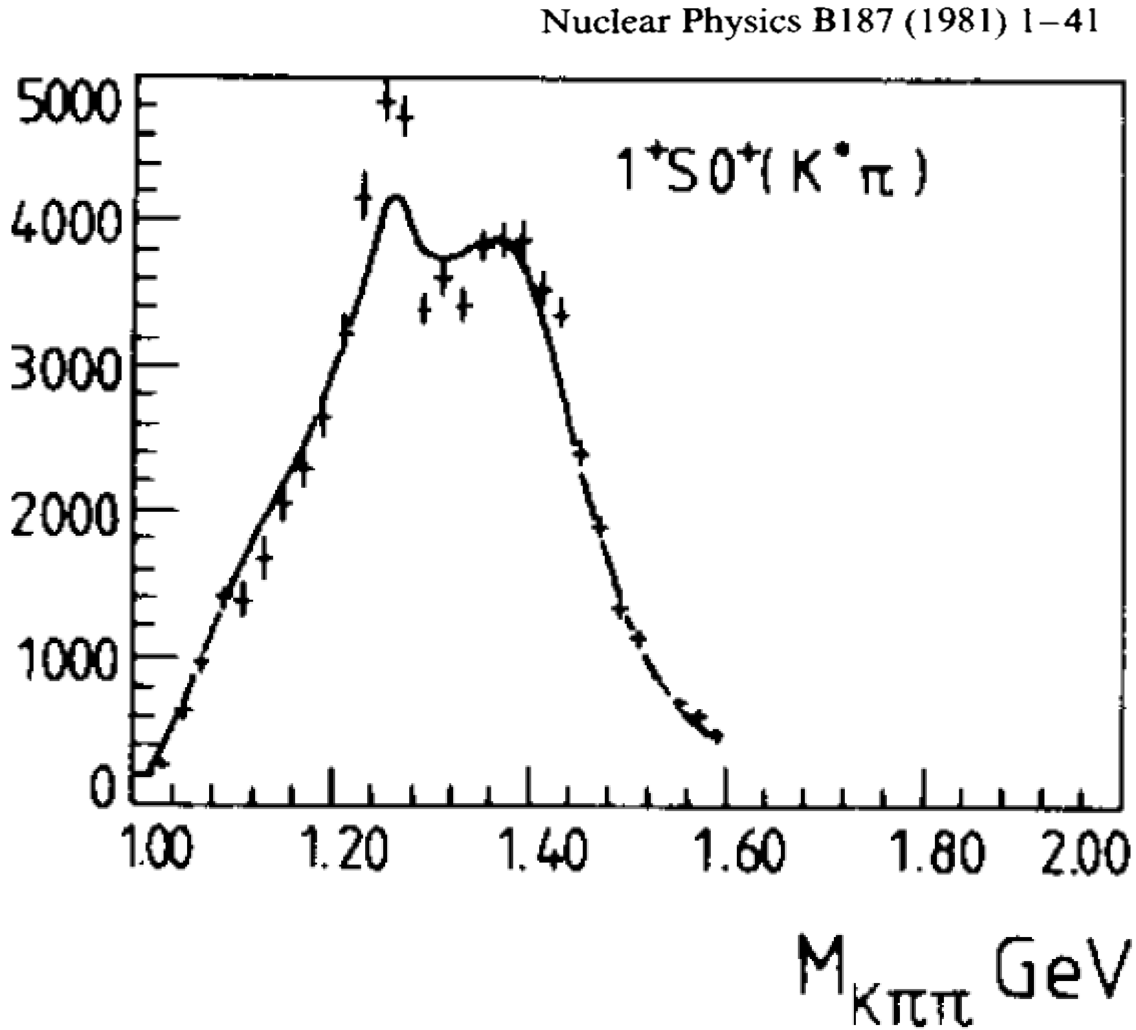


Isospin = ½ light meson spectrum

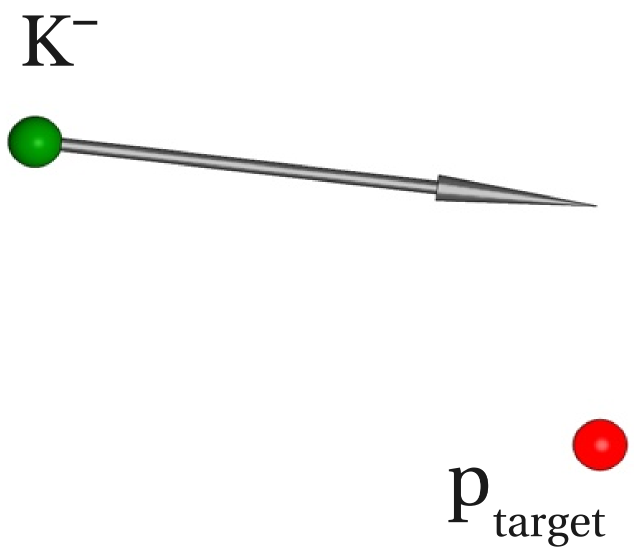
$| u\bar{s} > \ | d\bar{s} > \ | \bar{u}s > \ | \bar{d}s >$



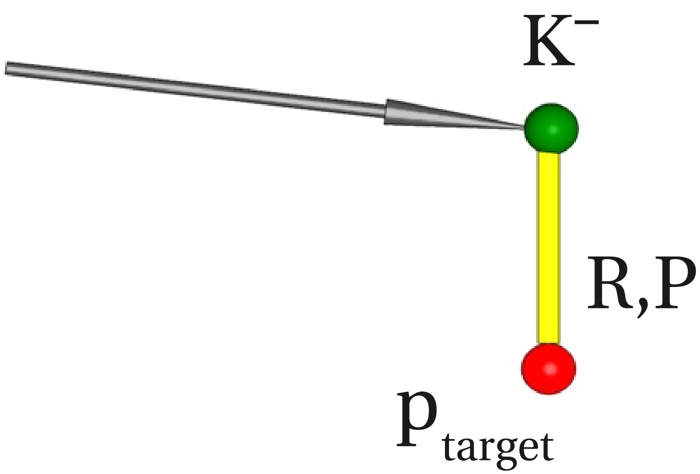
$K_1 \rightarrow K^*(892)\,\pi^-$



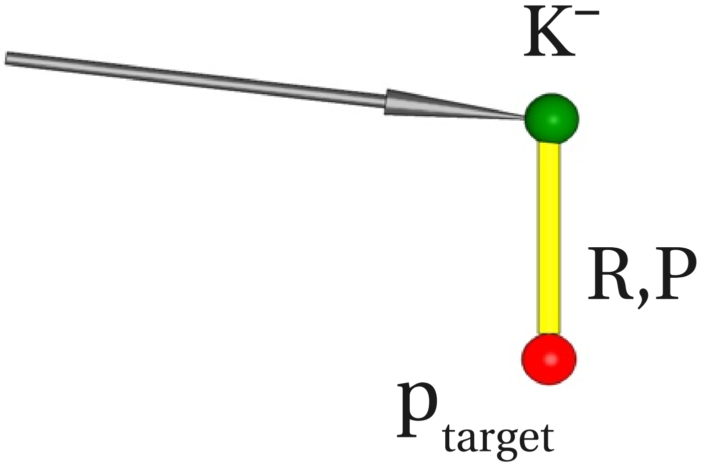
Diffractive dissociation into $K^- \pi^+ \pi^-$



Diffractive dissociation into $K^- \pi^+ \pi^-$



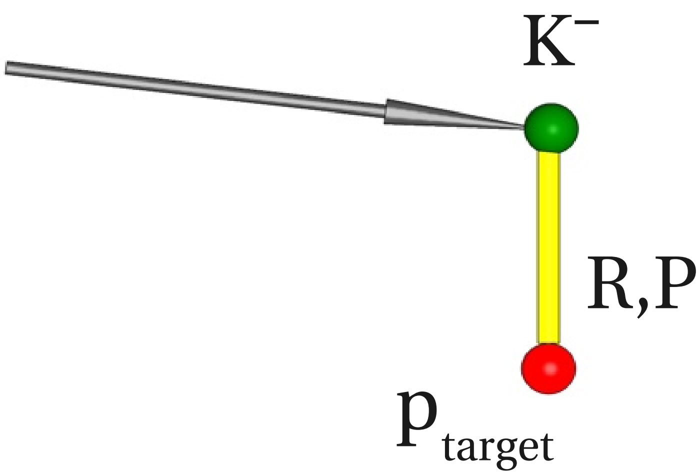
Diffractive dissociation into $K^- \pi^+ \pi^-$



R = Reggeon

"The exchange of a Reggeon is equivalent to the exchange of many particles with different spins"

Diffractive dissociation into $K^- \pi^+ \pi^-$



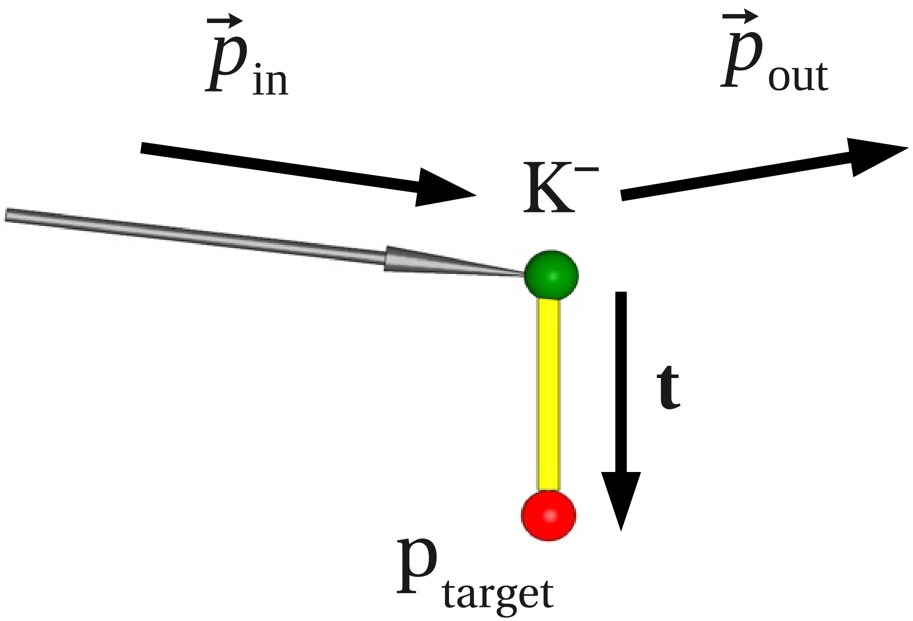
R = Reggeon

"The exchange of a Reggeon is equivalent to the exchange of many particles with different spins"

P = Pomeron

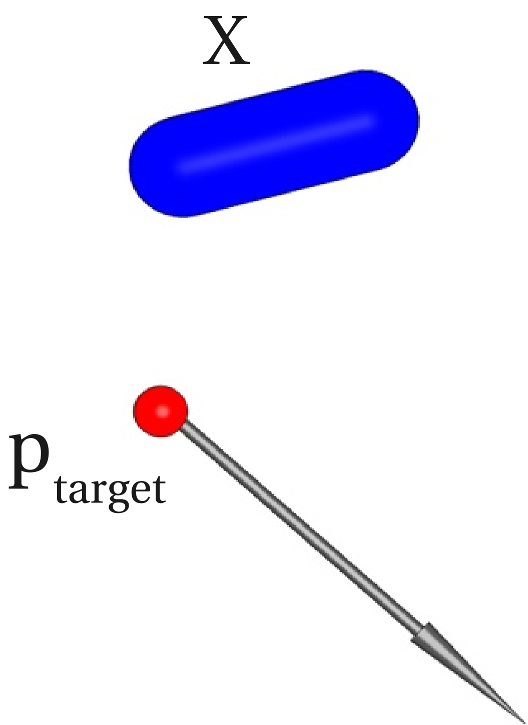
Pomeron is a Reggeon with vacuum quantum numbers $J^{PC} = 0^{++}$ dominating the exchange process at high energies.

Diffractive dissociation into $K^- \pi^+ \pi^-$

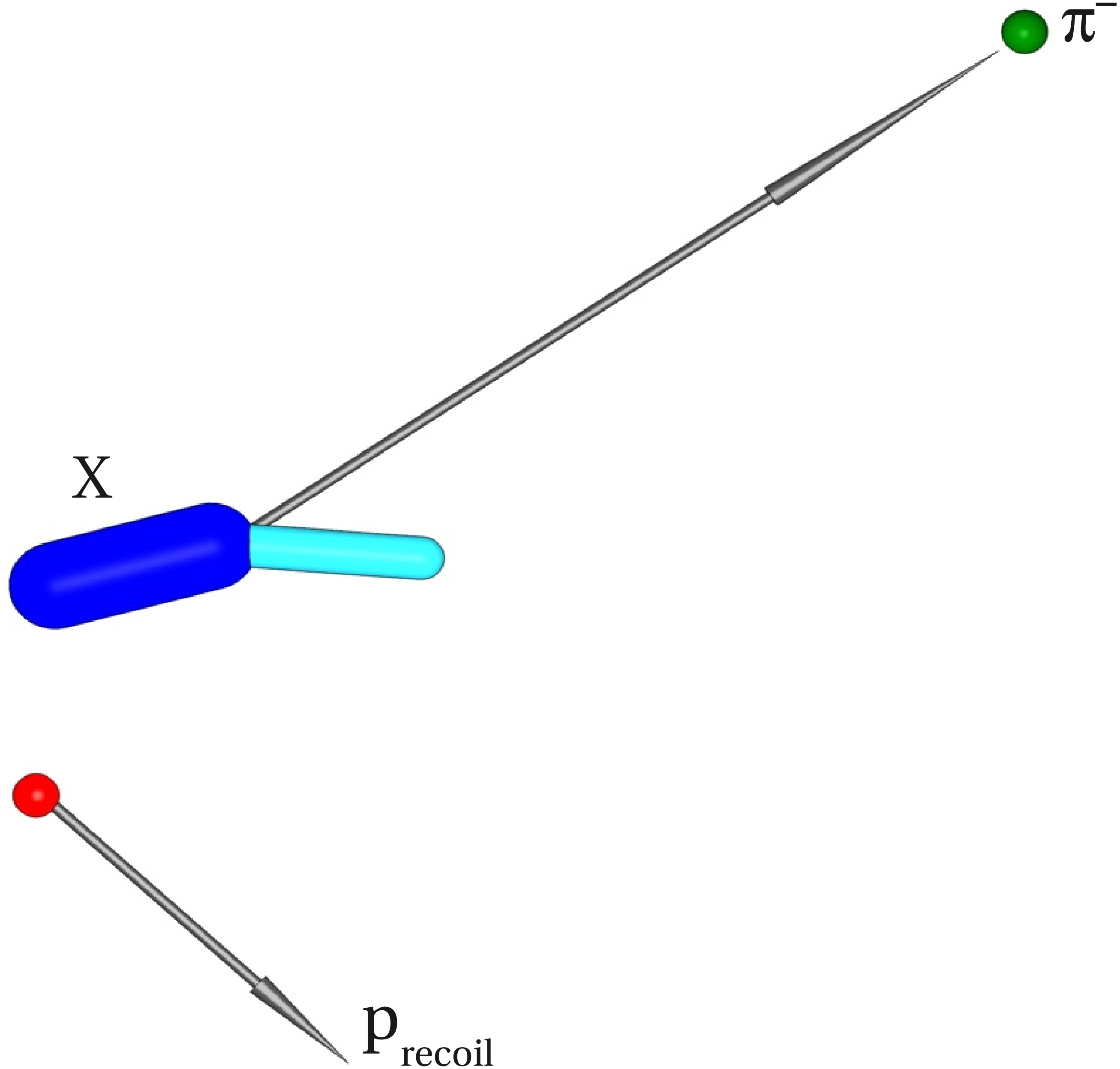


$$\vec{t} = \vec{p}_{in} - \vec{p}_{out}$$

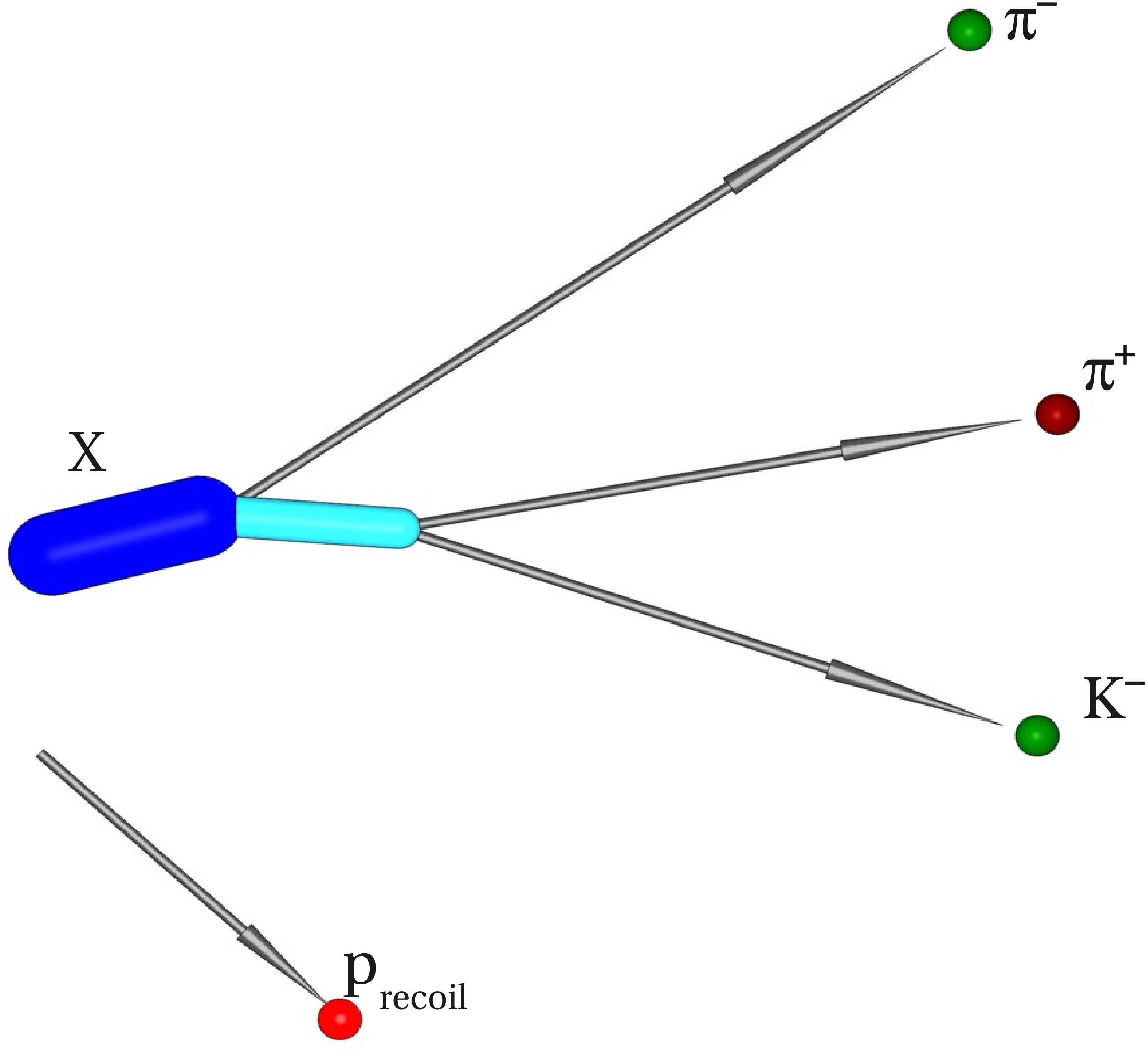
Diffractive dissociation into $K^- \pi^+ \pi^-$



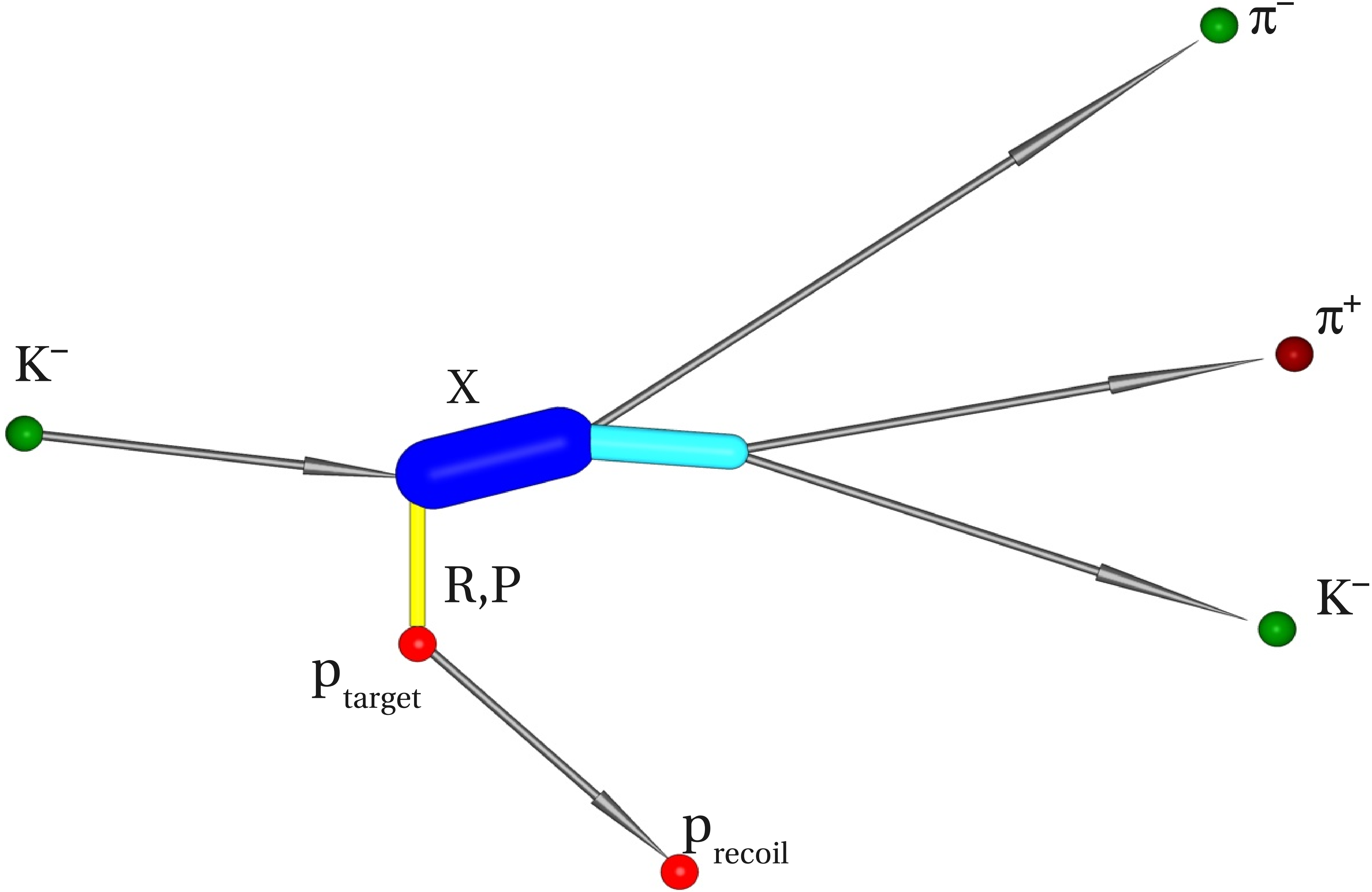
Diffractive dissociation into $K^{-} \pi^{+} \pi^{-}$



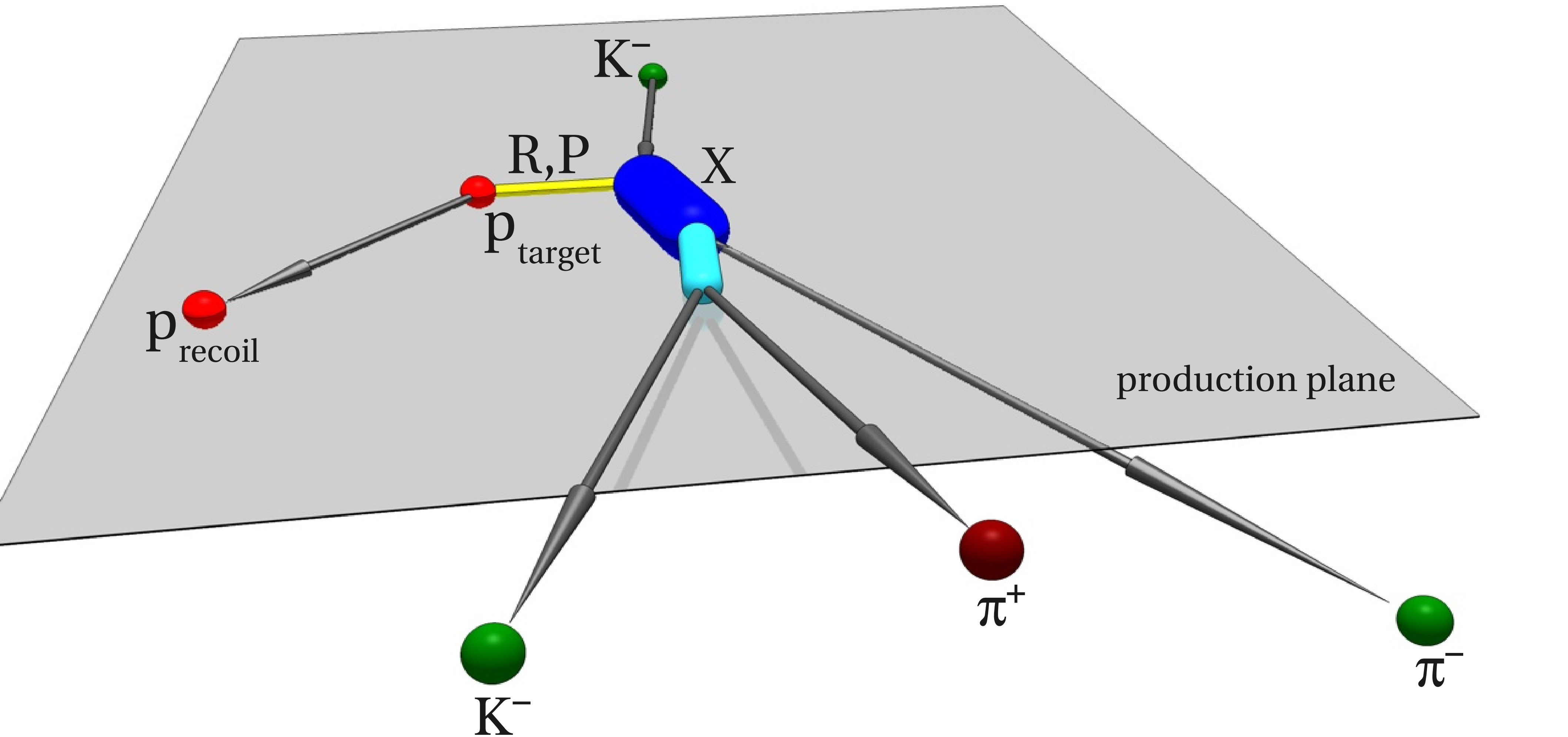
Diffractive dissociation into $K^- \pi^+ \pi^-$



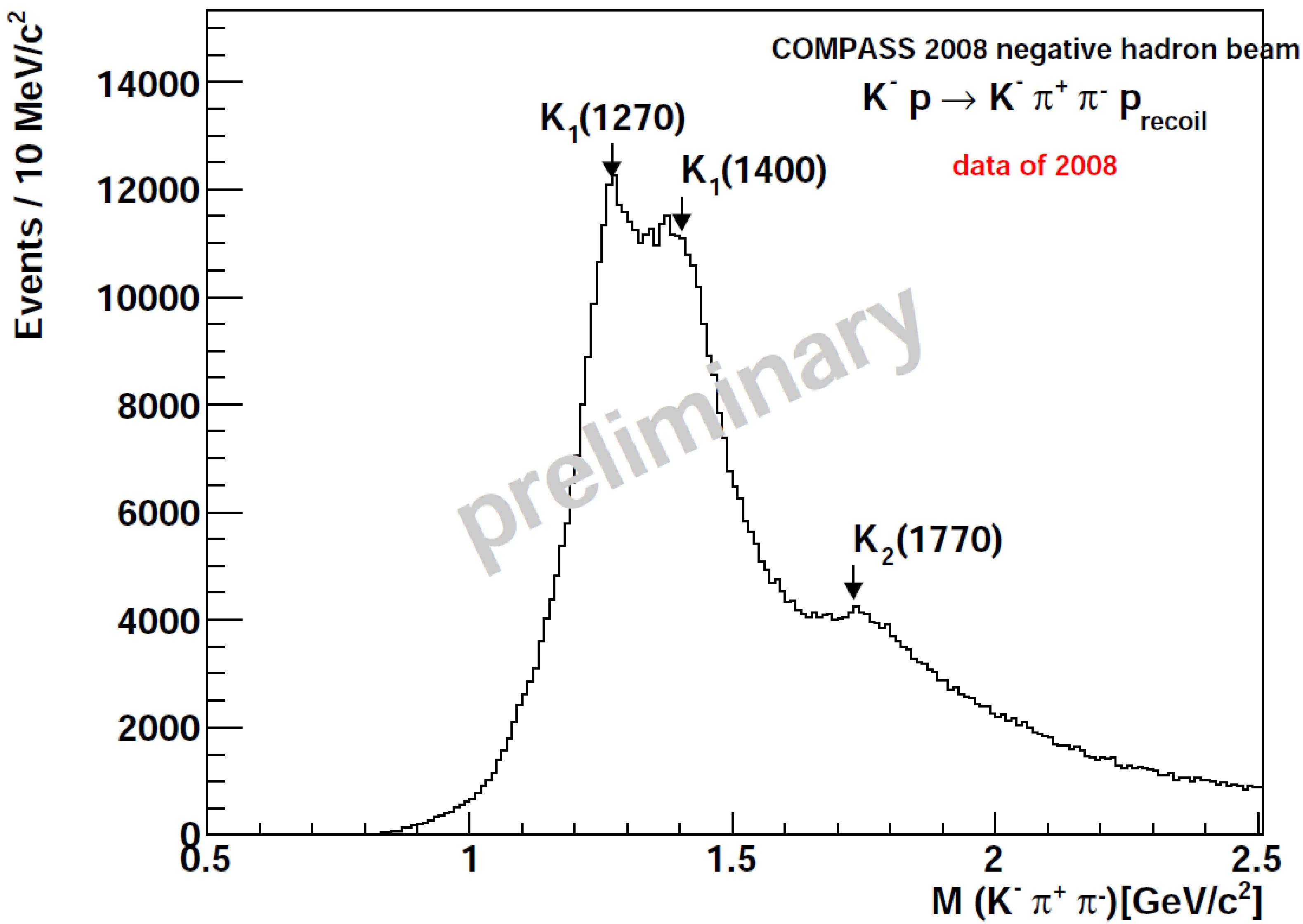
Diffractive dissociation into $K^- \pi^+ \pi^-$



Diffractive dissociation into $K^- \pi^+ \pi^-$

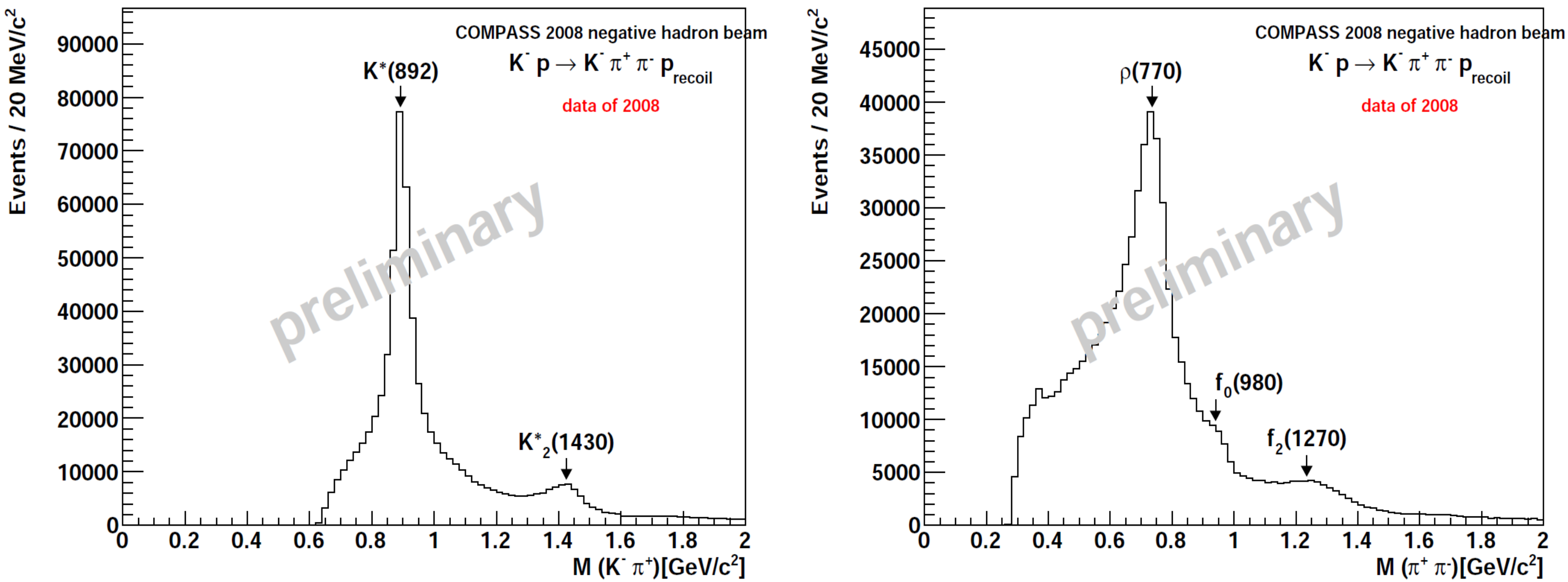


Invariant mass distributions ($K^- \pi^+ \pi^-$)



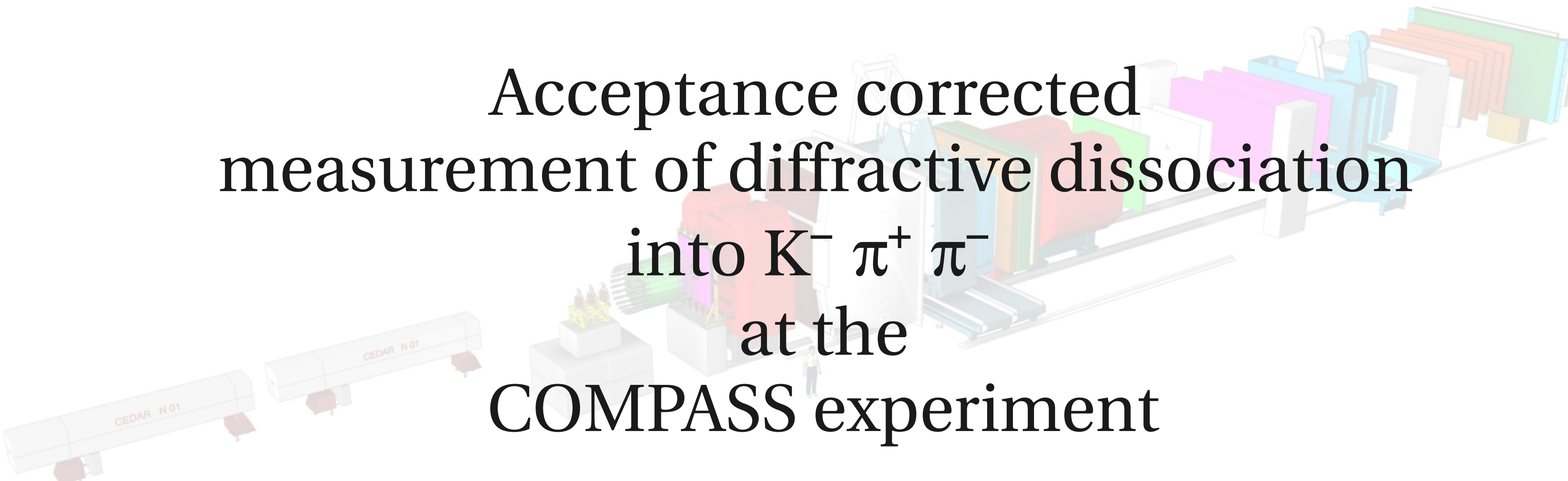
Are those resonances decaying directly into 3 particles? ...

Invariant mass distributions ($K^- \pi^+$) and ($\pi^+ \pi^-$)

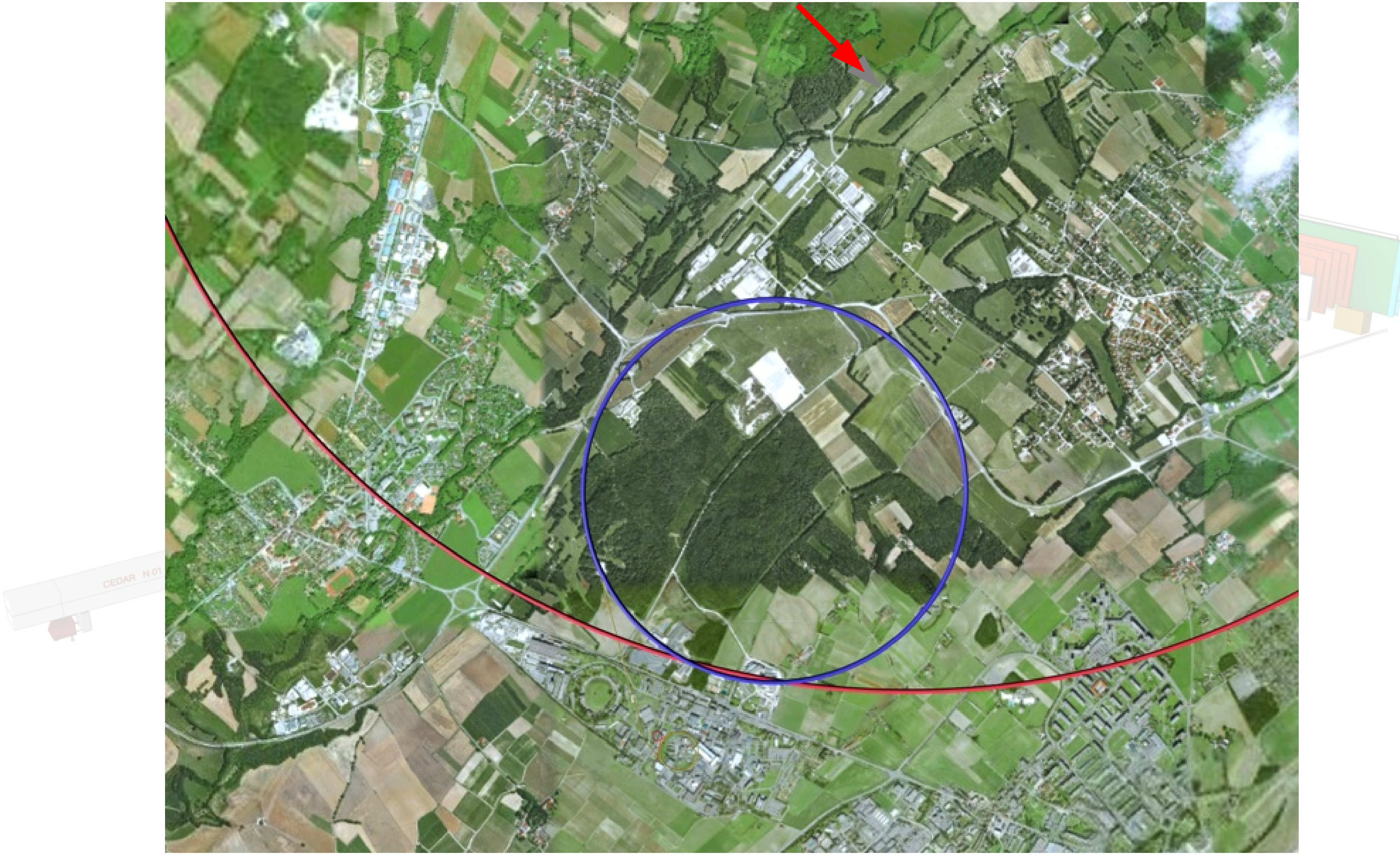


There is structure → Assuming an decay chain...

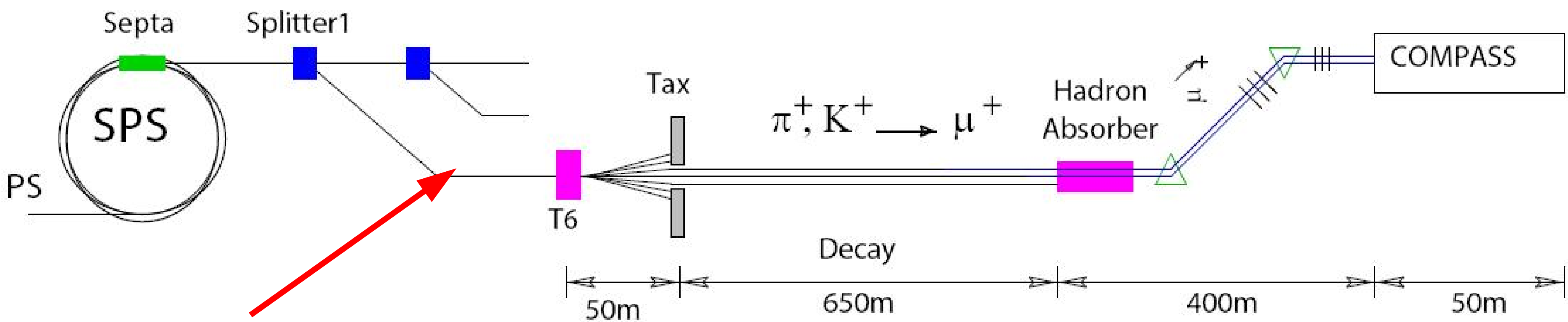
Acceptance corrected measurement of diffractive dissociation into $K^- \pi^+ \pi^-$ at the COMPASS experiment



The COMPASS Spectrometer @ SPS

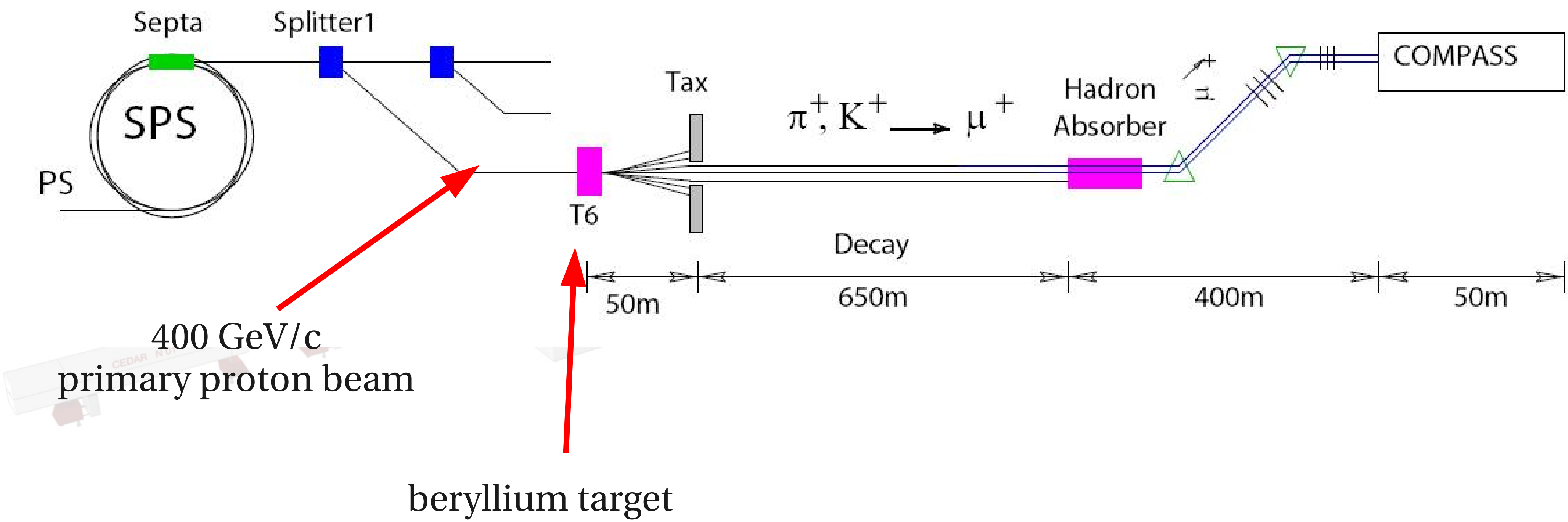


The M2 secondary beam line for COMPASS



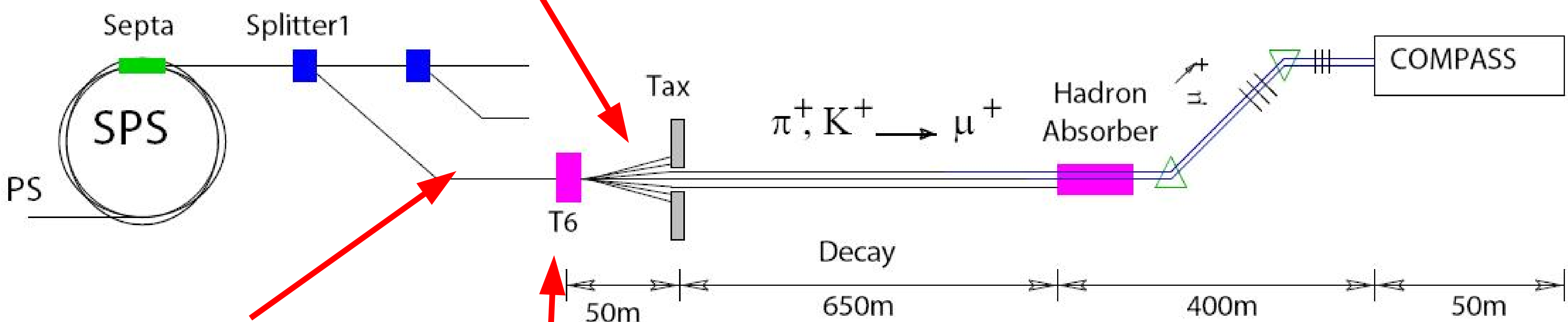
400 GeV/c
primary proton beam

The M2 secondary beam line for COMPASS



The M2 secondary beam line for COMPASS

seconday beam consists
mainly of
(anti)protons,
pions and kaons



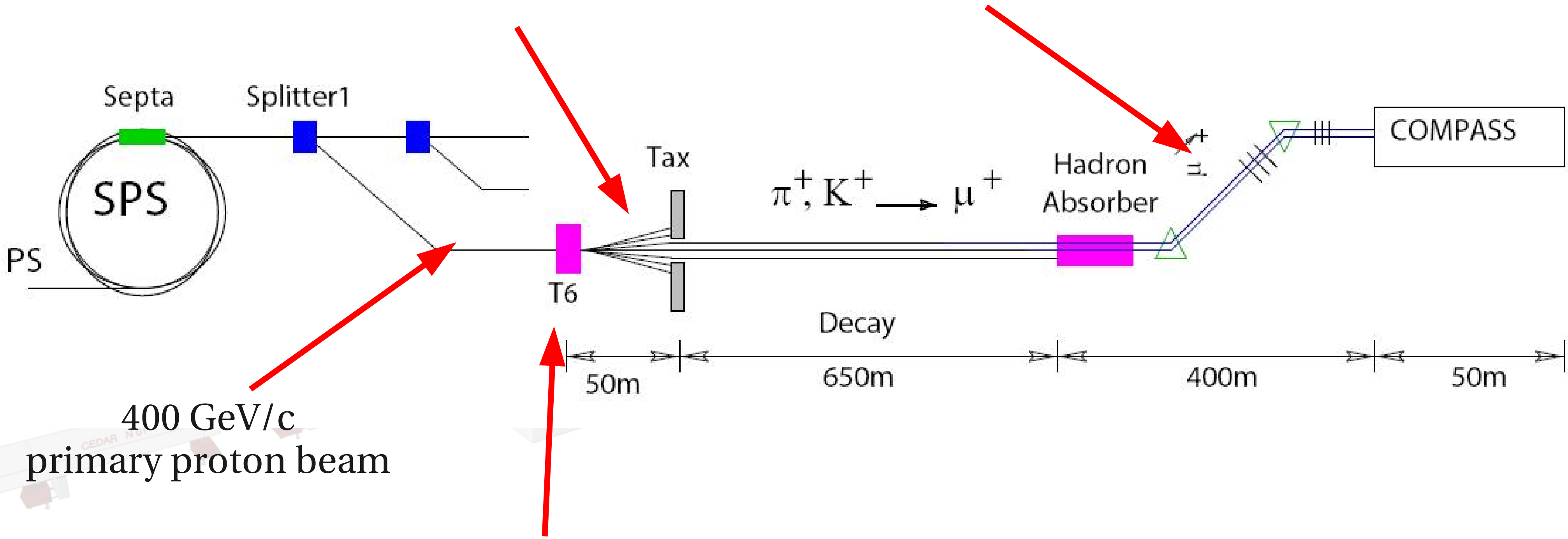
400 GeV/c
primary proton beam

beryllium target

The M2 secondary beam line for COMPASS

seconday beam consists
mainly of
(anti)protons,
pions and kaons

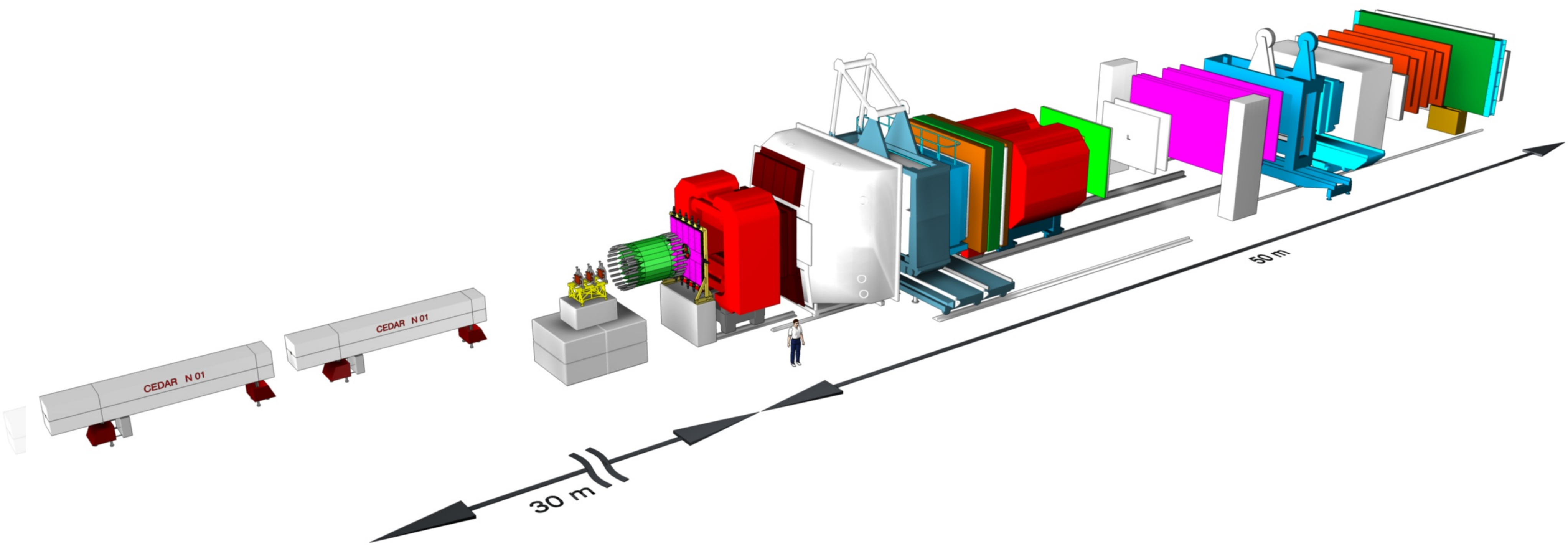
momentum separation



400 GeV/c
primary proton beam

beryllium target

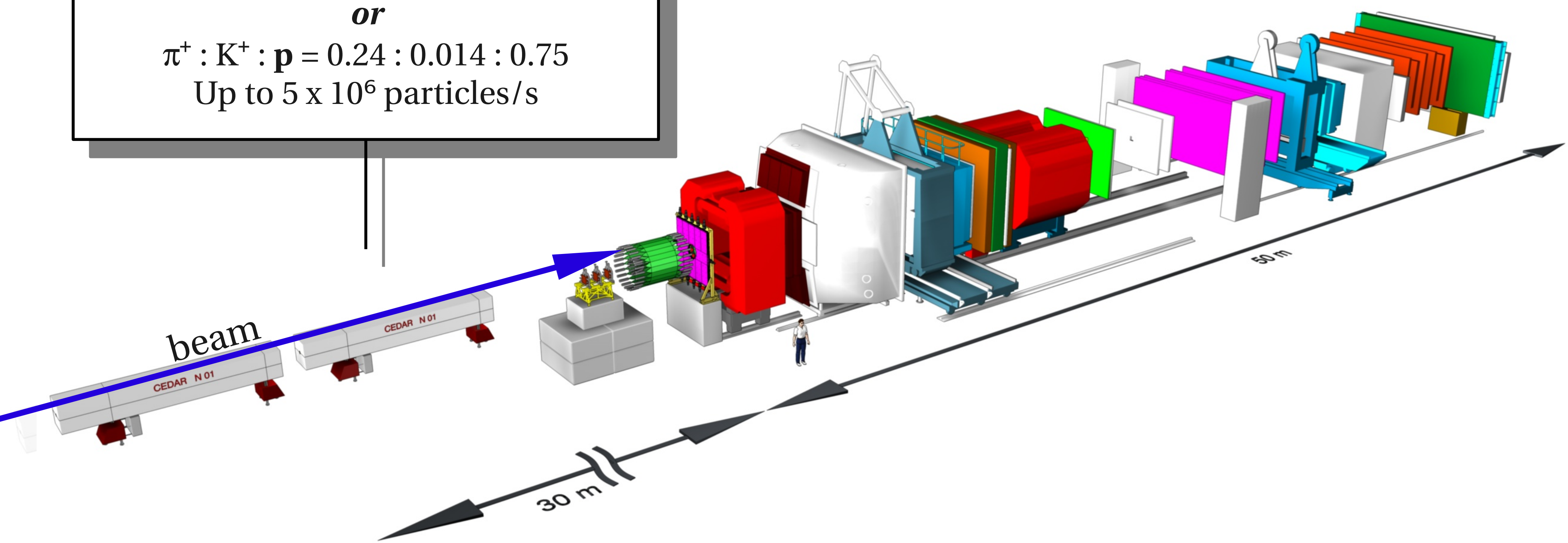
The COMPASS Spectrometer 2008/2009



The COMPASS Spectrometer 2008/2009

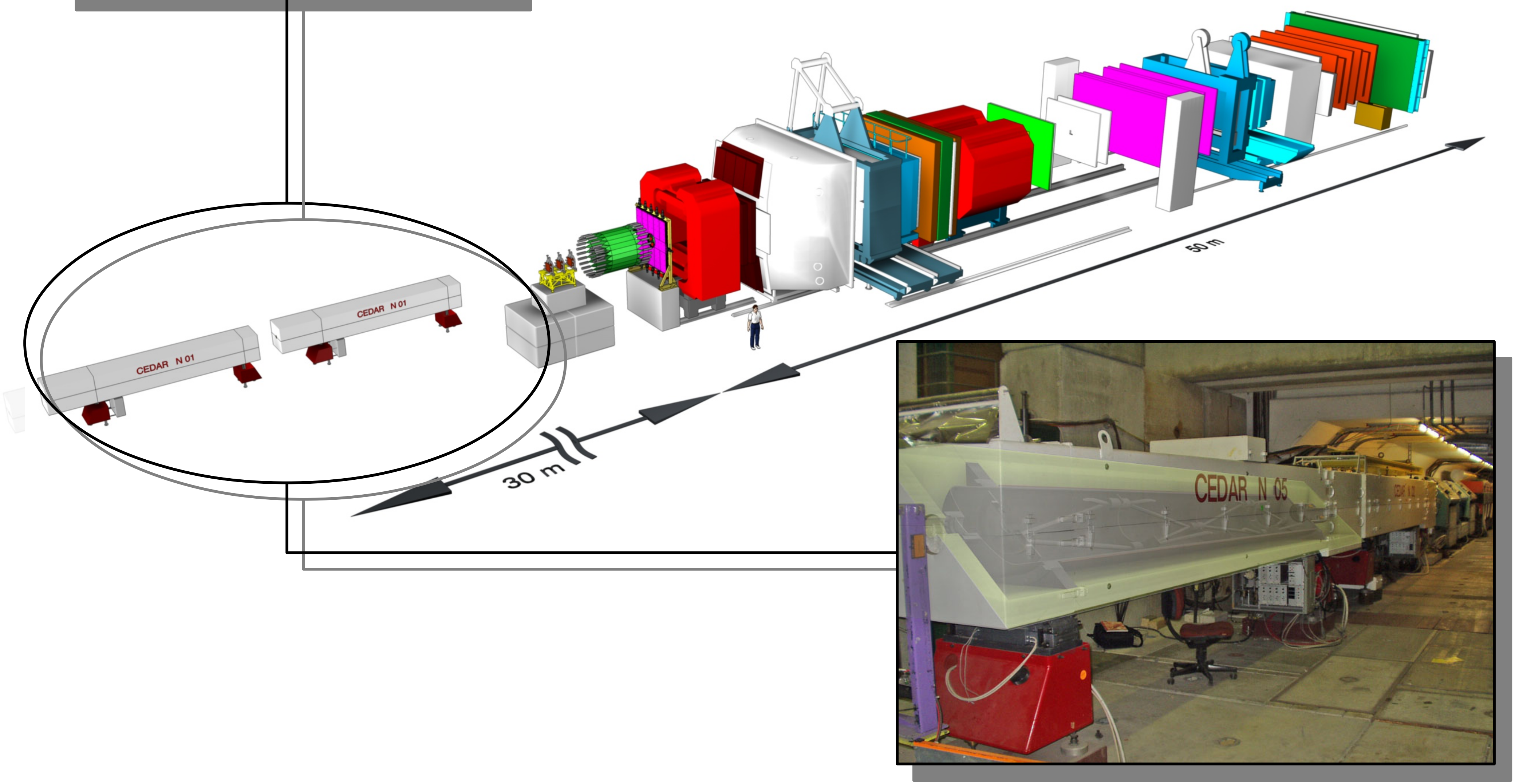
Beam properties

Beam momentum 190 GeV/c
Beam composition:
$\pi^- : K^- : \bar{p} = 0.97 : 0.024 : 0.008$
or
$\pi^+ : K^+ : p = 0.24 : 0.014 : 0.75$
Up to 5×10^6 particles/s

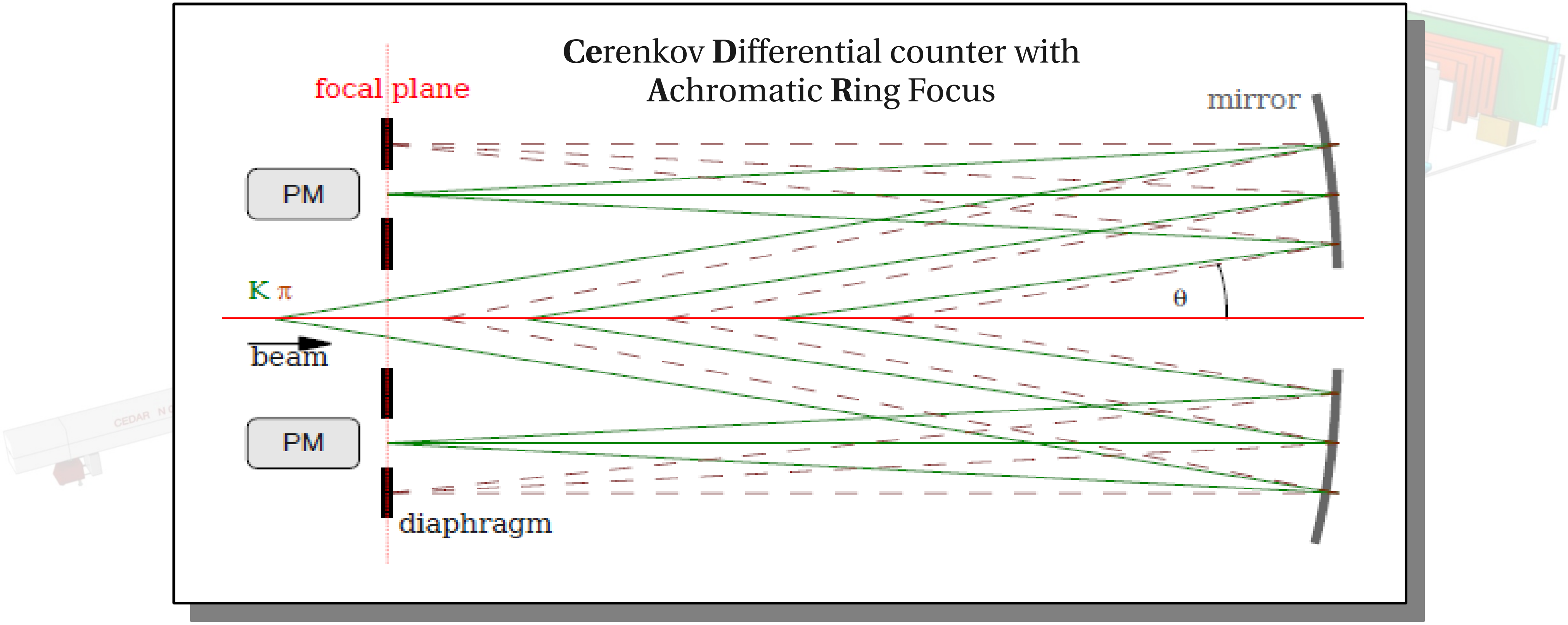


The COMPASS Spectrometer 2008/2009

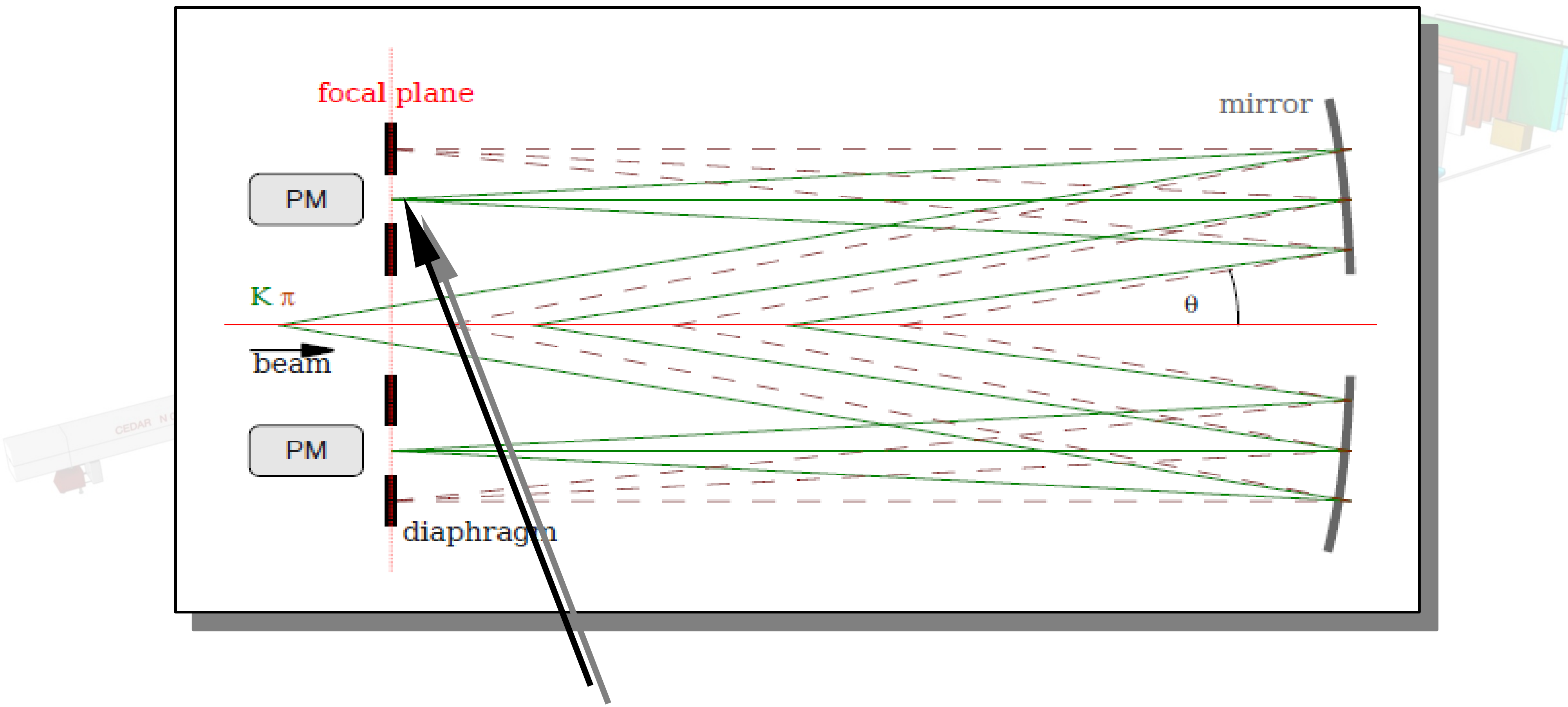
CEDAR detectors for
beam particle identification



CEDAR particle identification

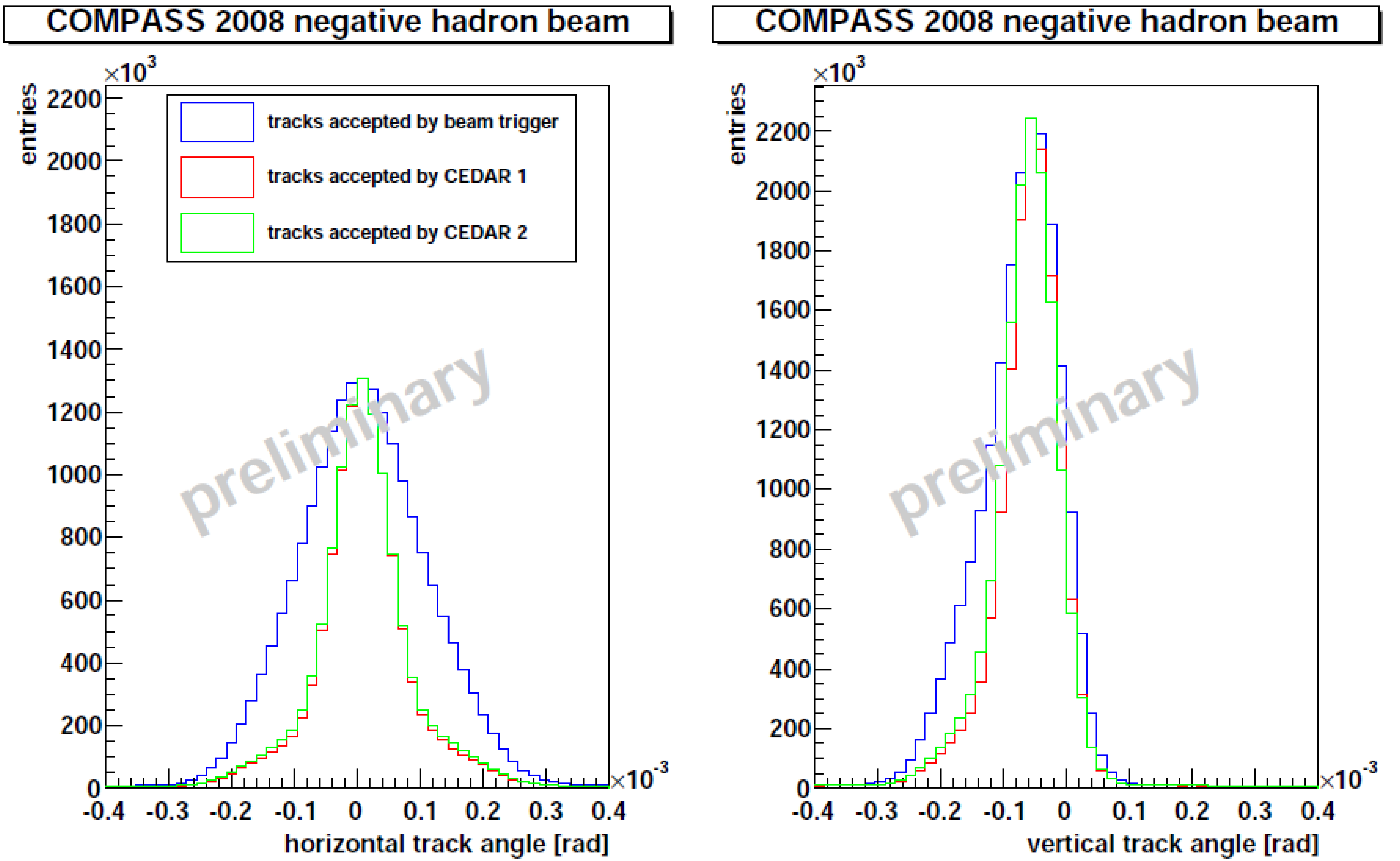


CEDAR particle identification



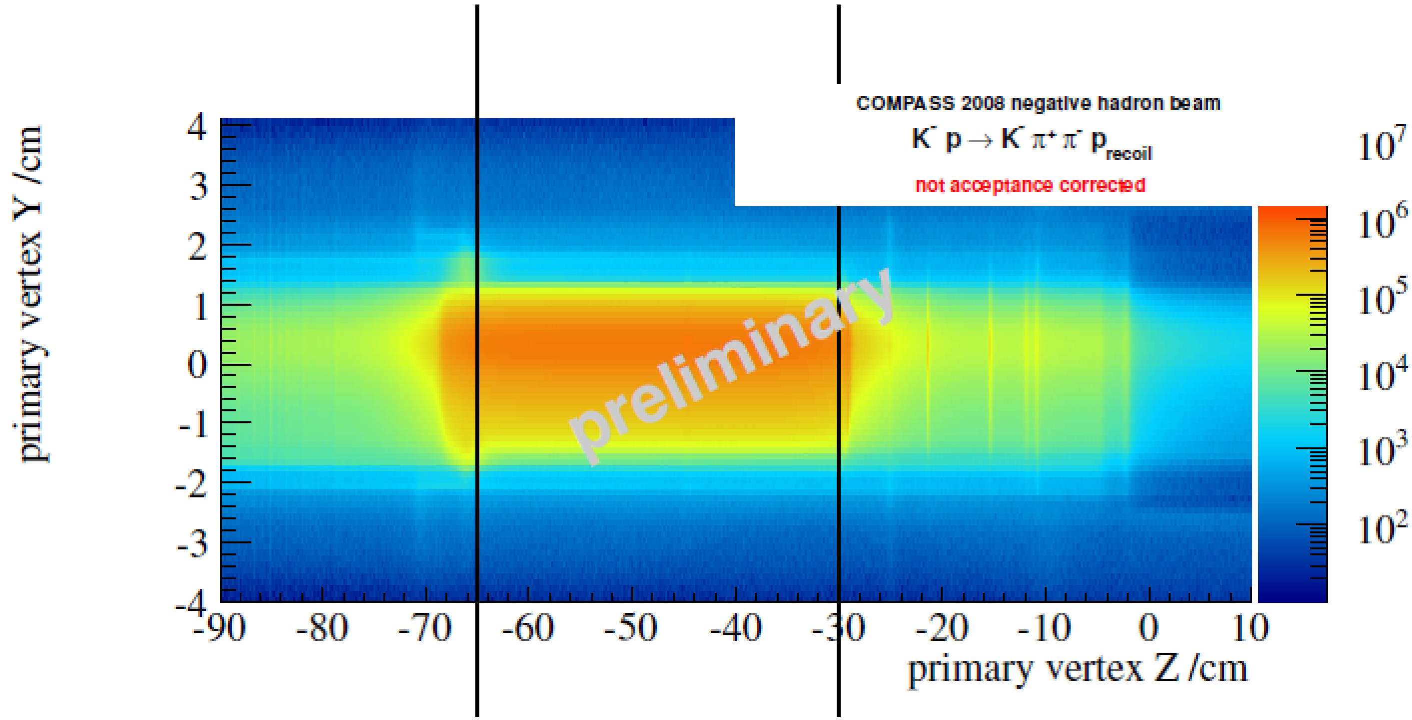
Difference of the cherenkov ring radii of a pion and a kaon is below 0.1 mm at 190 GeV/c beam momentum !

Beam divergence lowering the performance

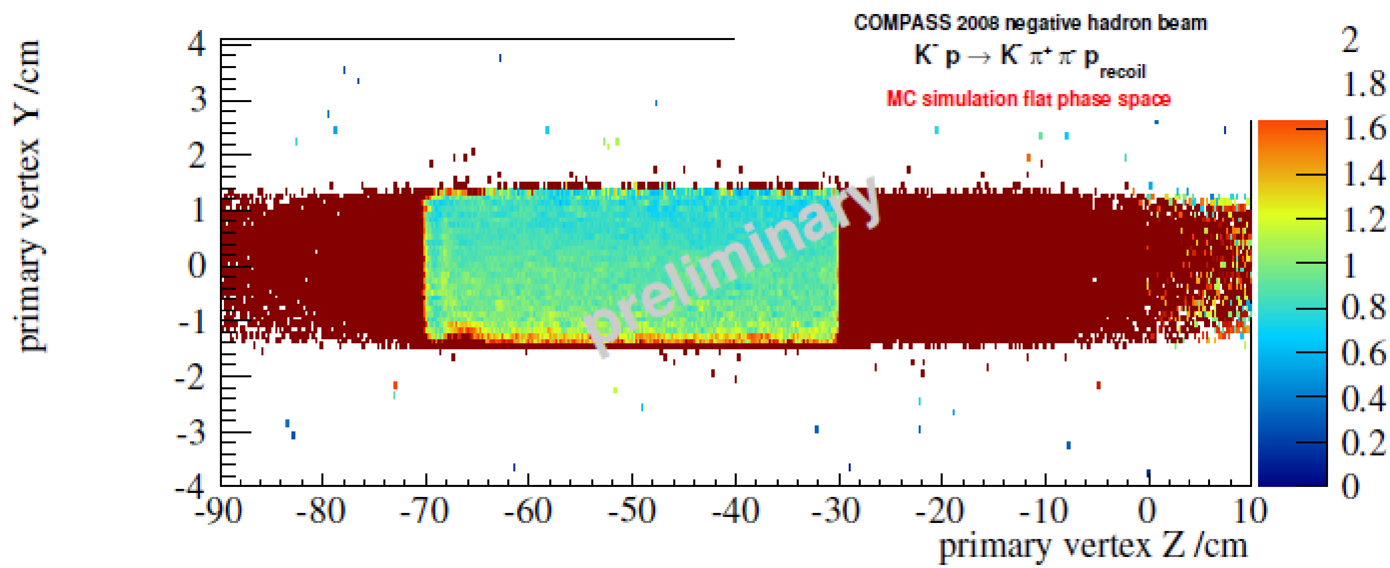


Measured beam properties

data



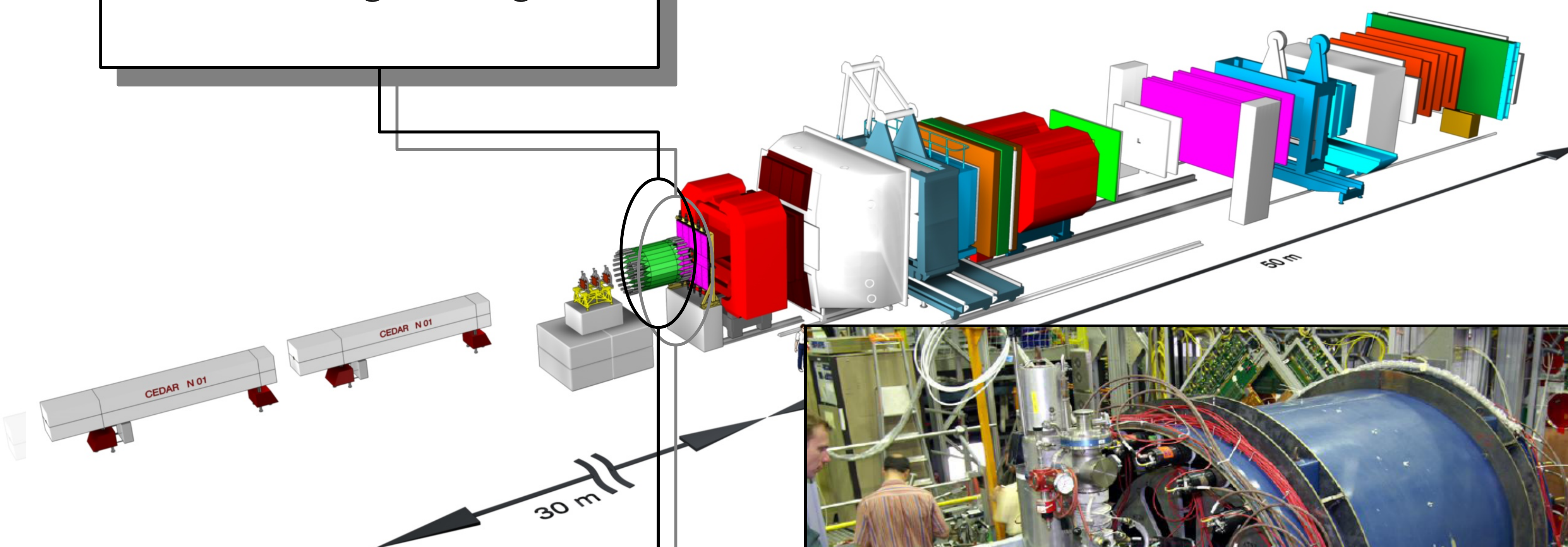
MC



ratio: data/MC

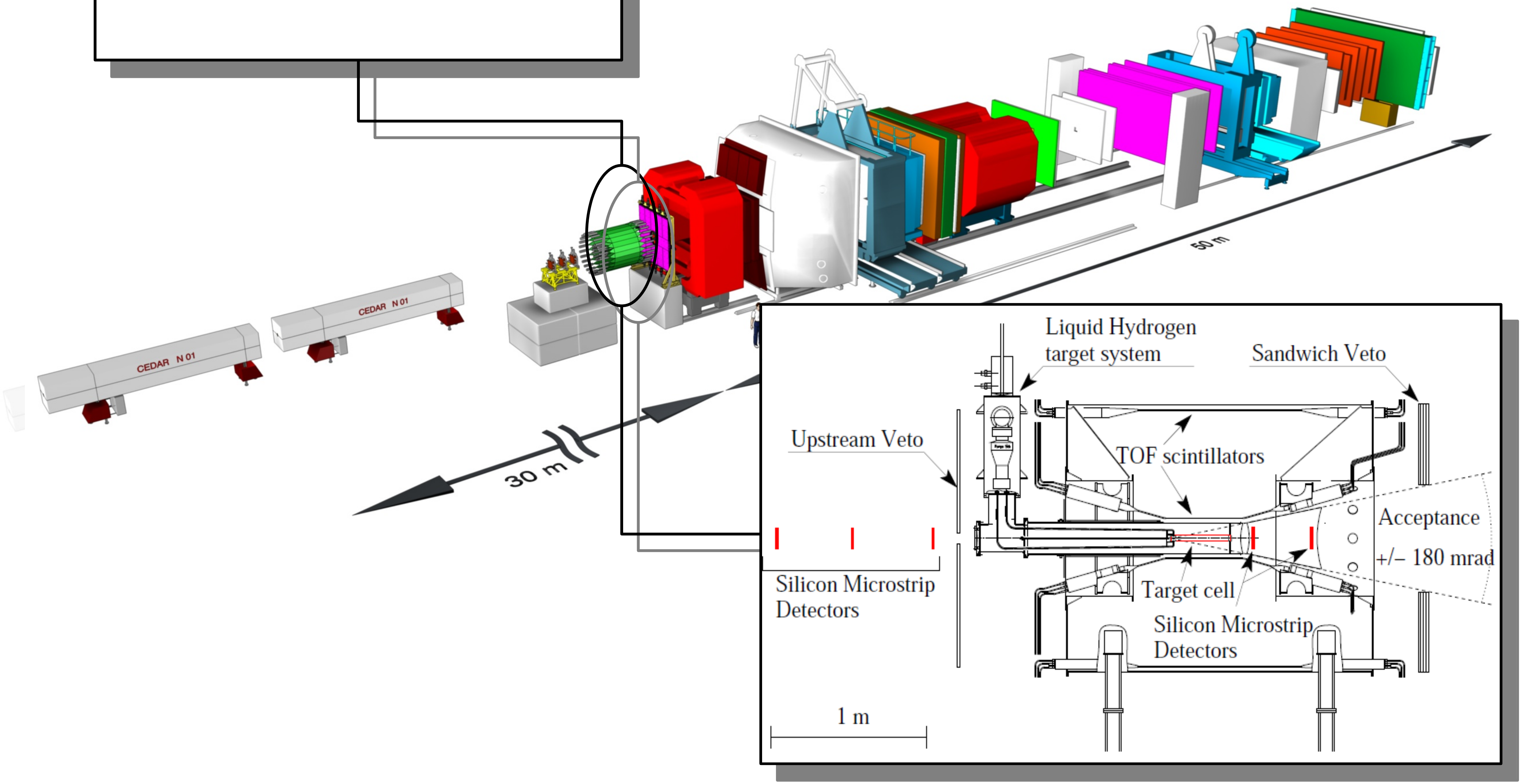
The COMPASS Spectrometer 2008/2009

Recoil proton detector
around
40 cm long lH2 target

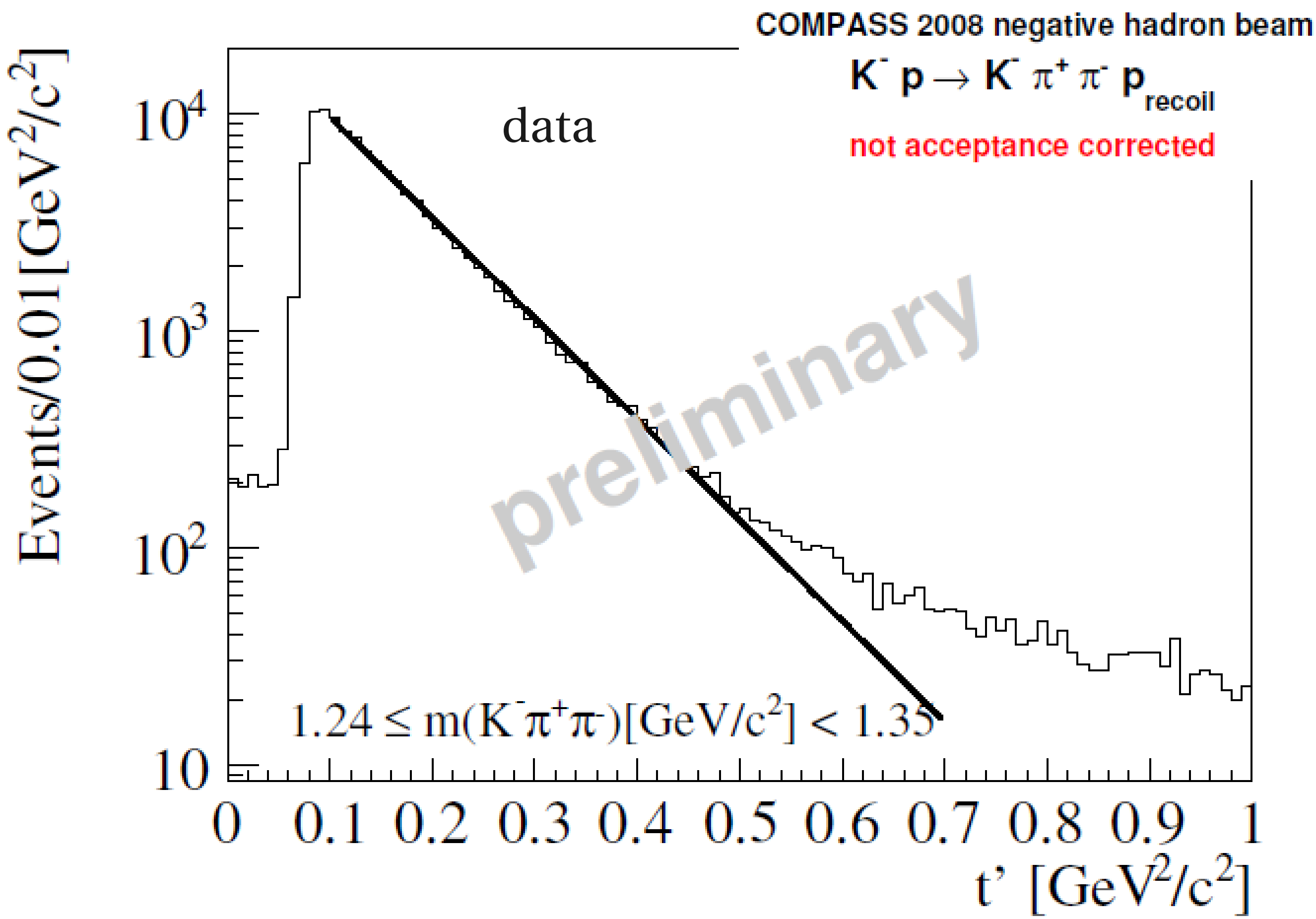


The COMPASS Spectrometer 2008/2009

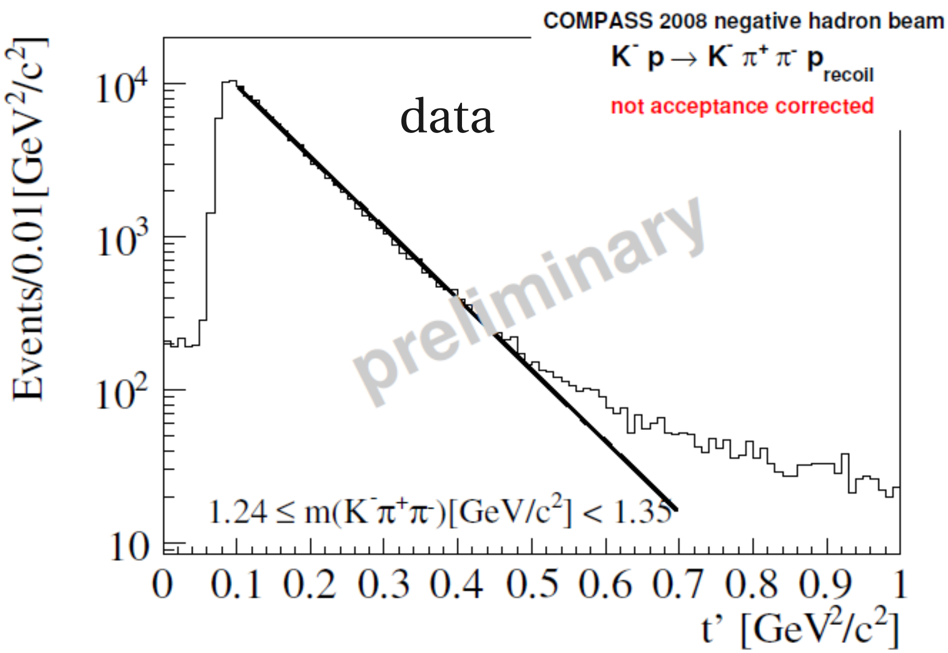
Recoil proton detector
around
40 cm long lH2 target

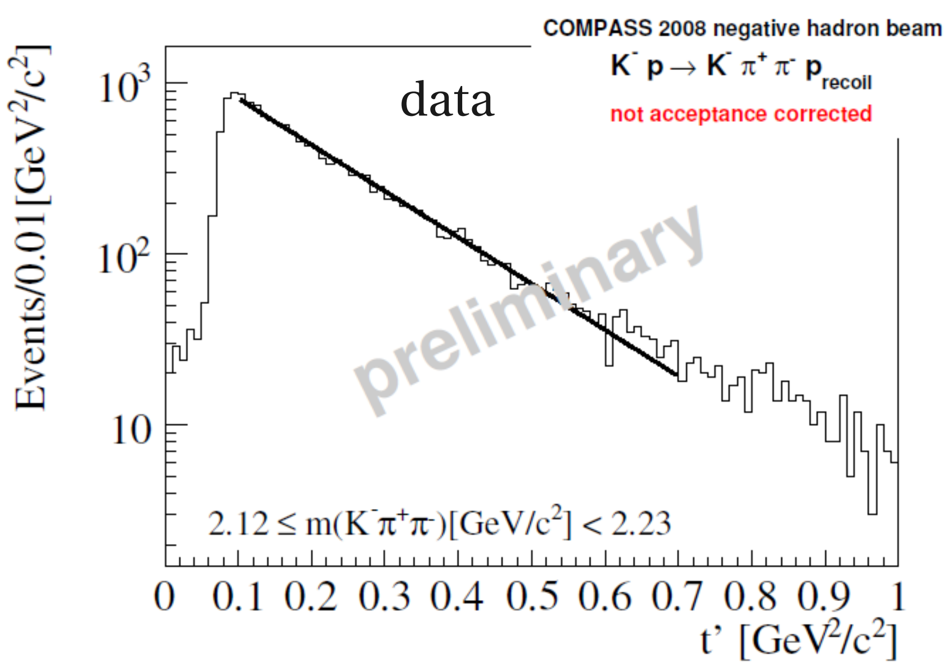


RPD: determination of t' acceptance

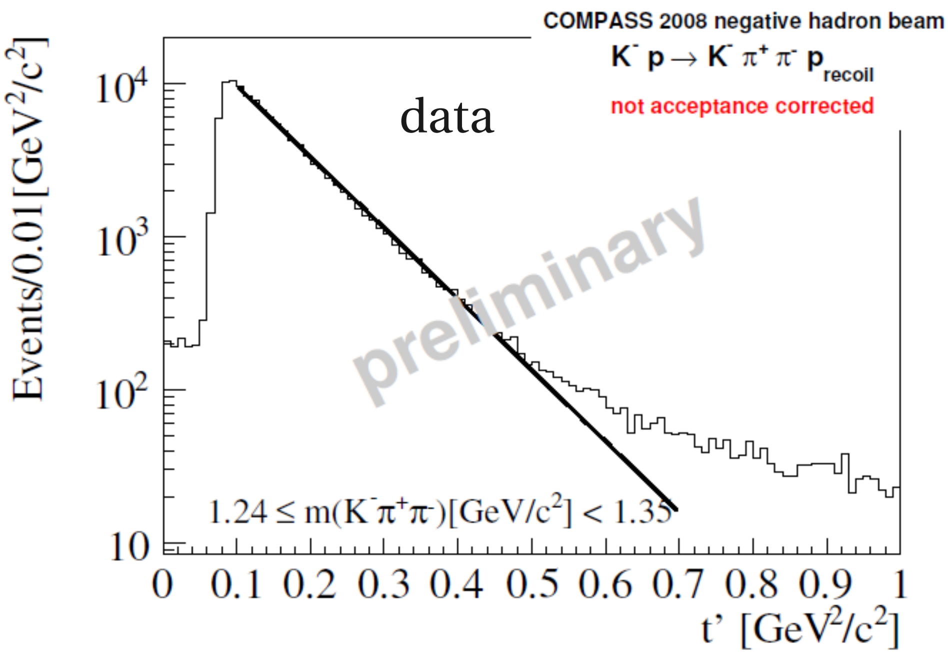


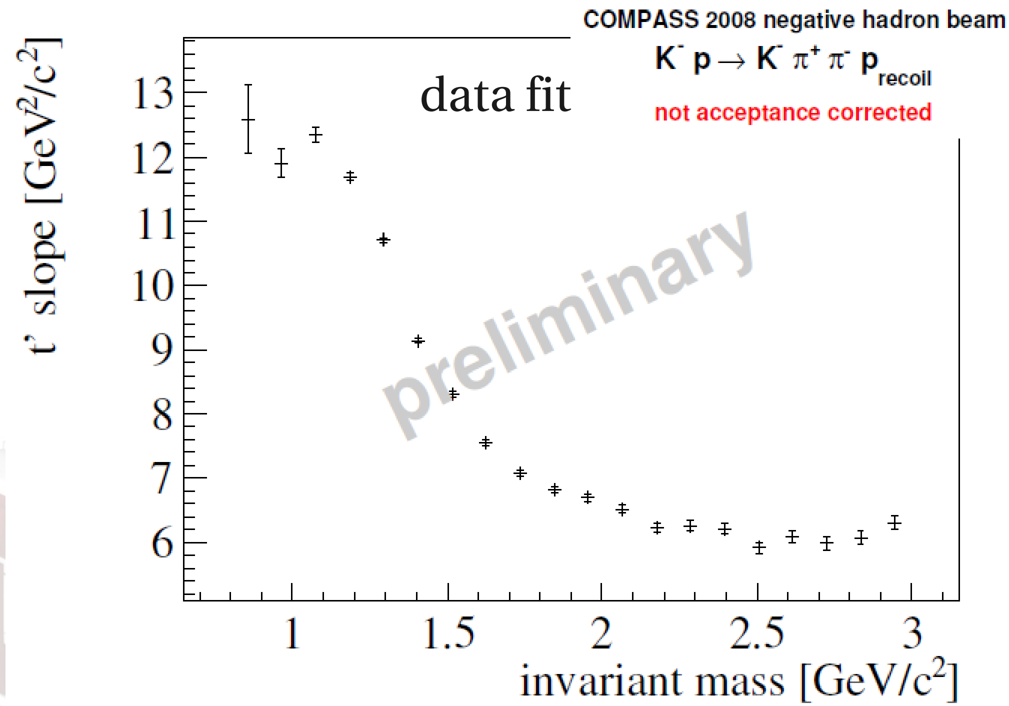
RPD: determination of t' acceptance

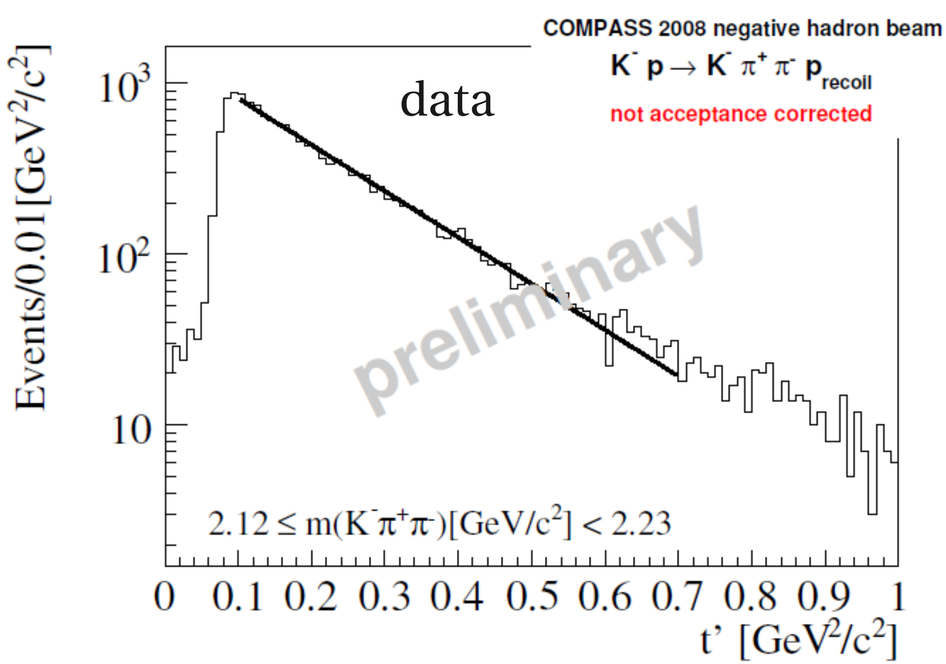




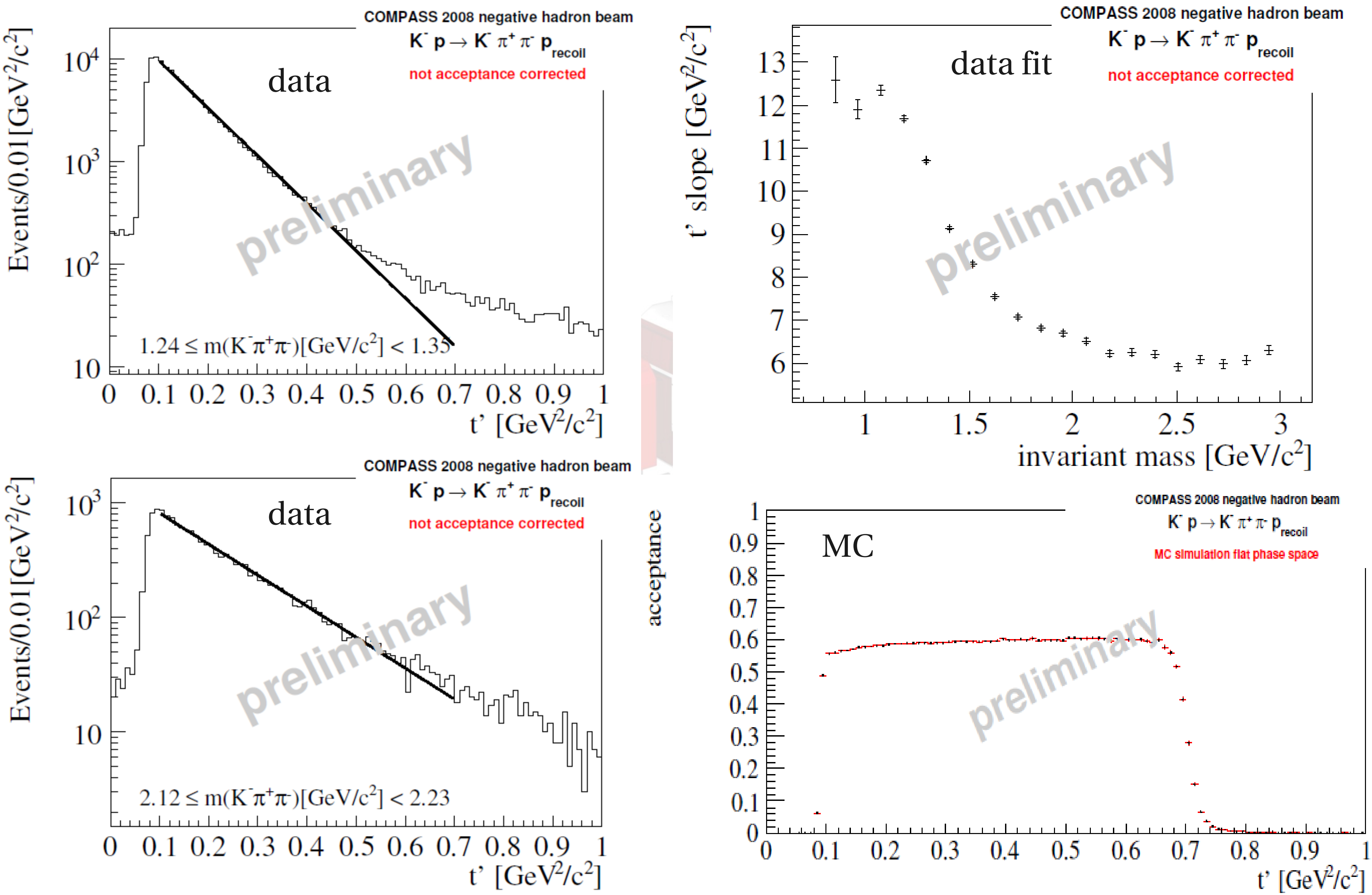
RPD: determination of t' acceptance





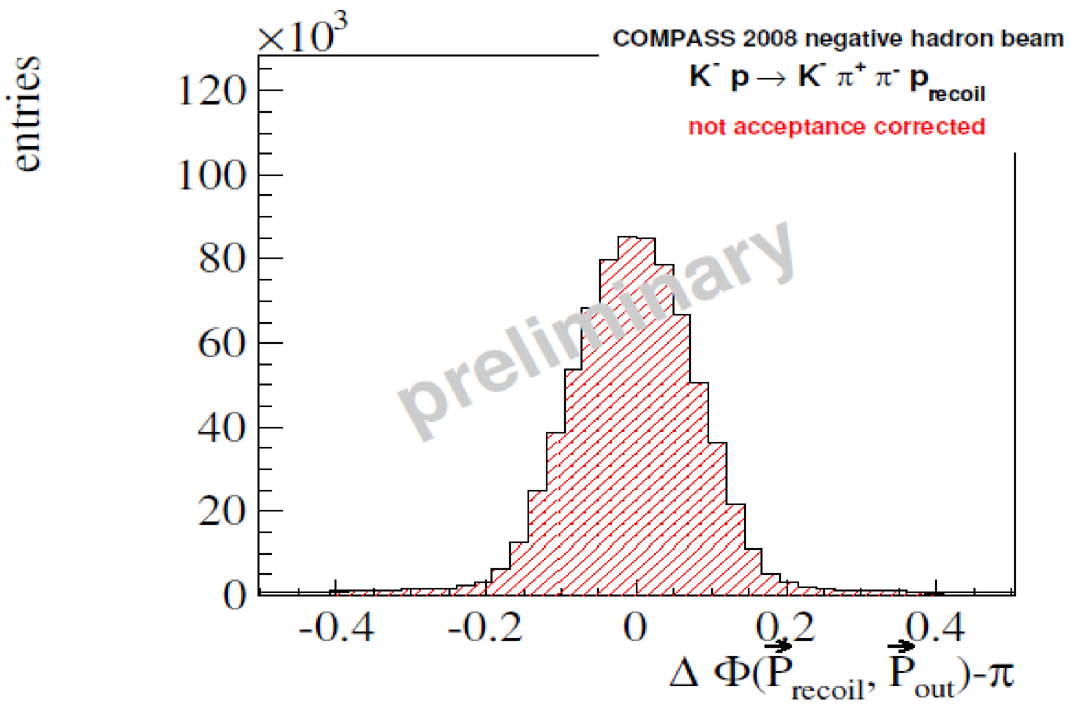


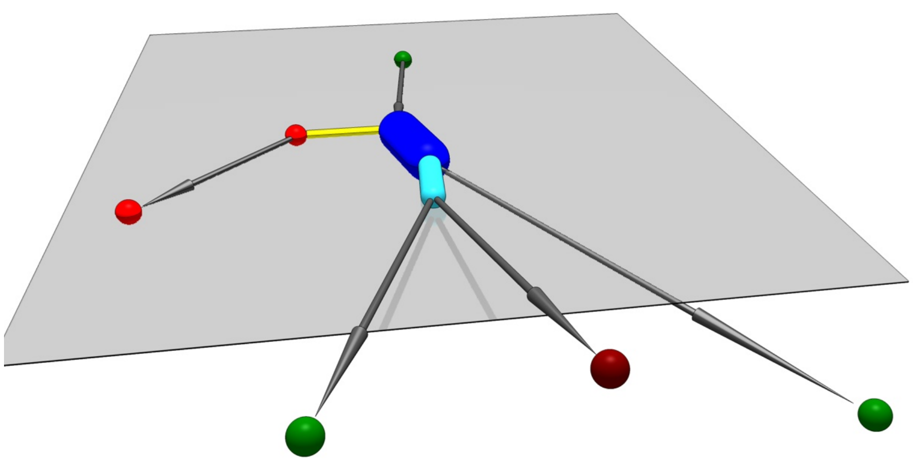
RPD: determination of t' acceptance



RPD: measurement of coplanarity

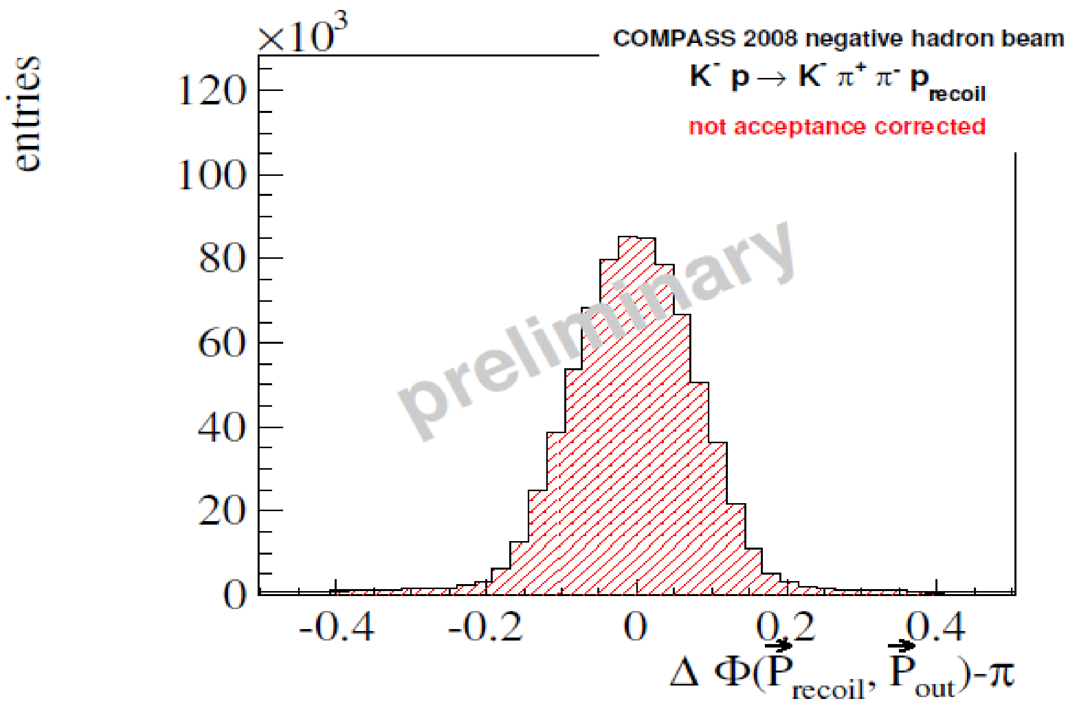
data



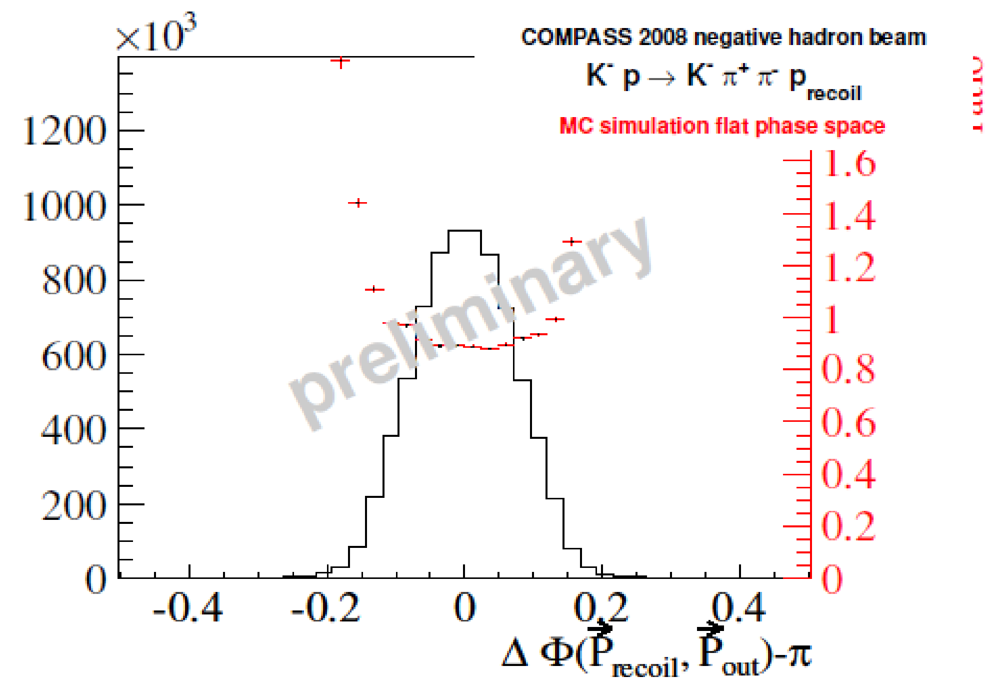


RPD: measurement of coplanarity

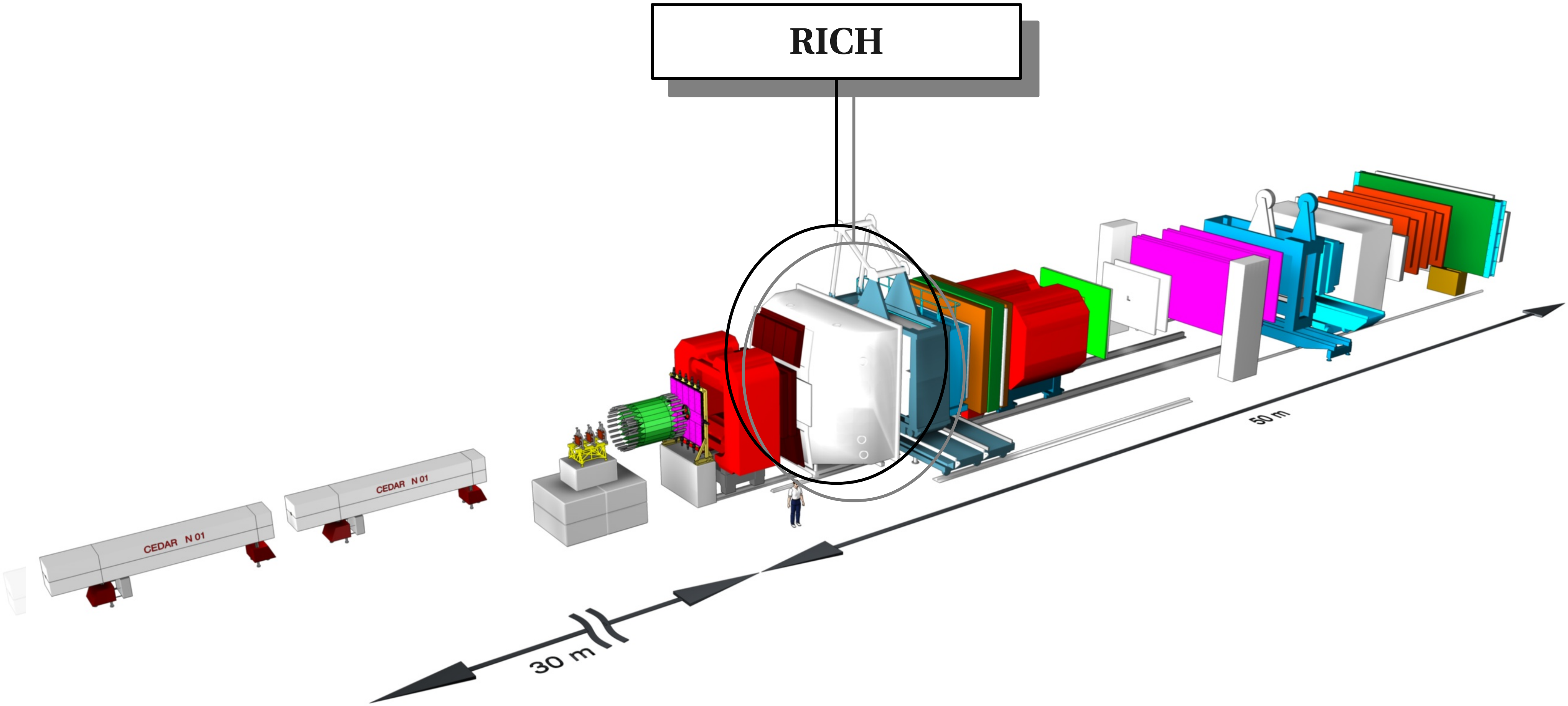
data



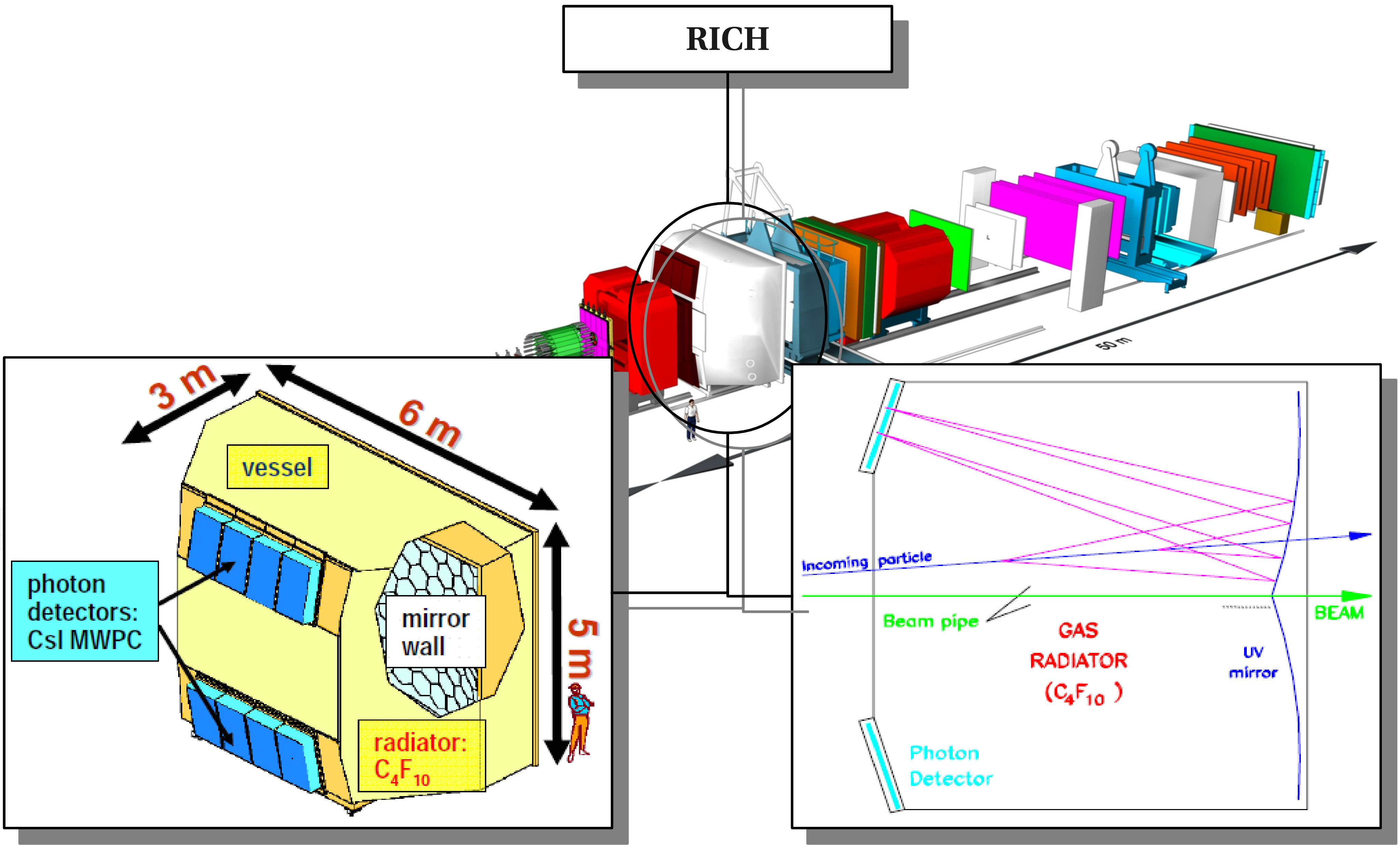
MC



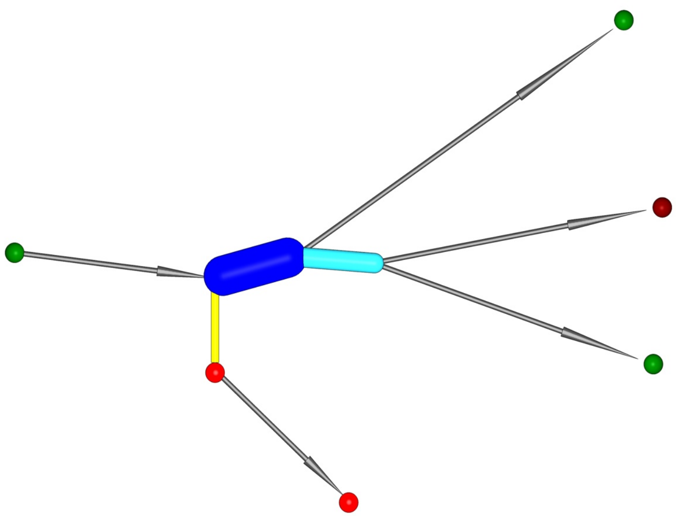
The COMPASS Spectrometer 2008/2009



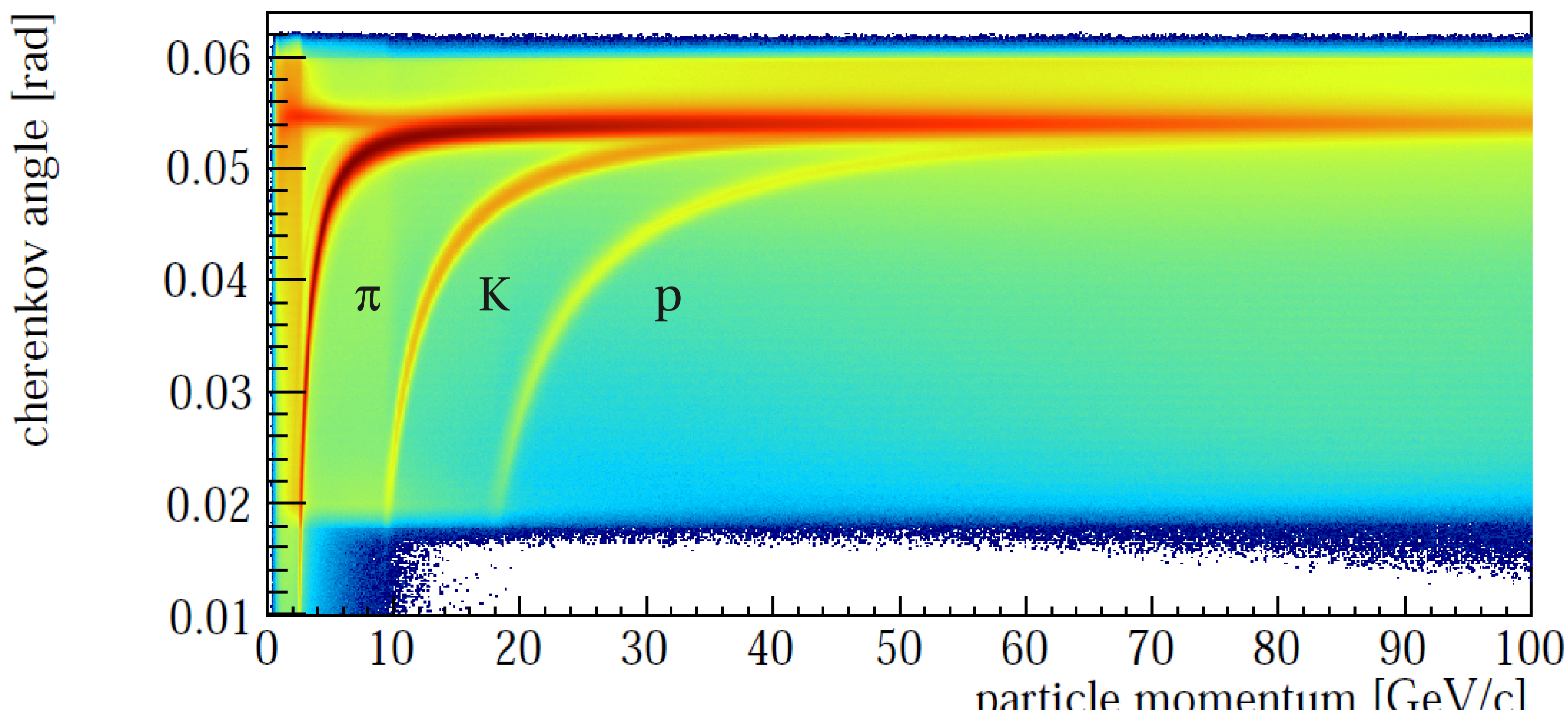
The COMPASS Spectrometer 2008/2009



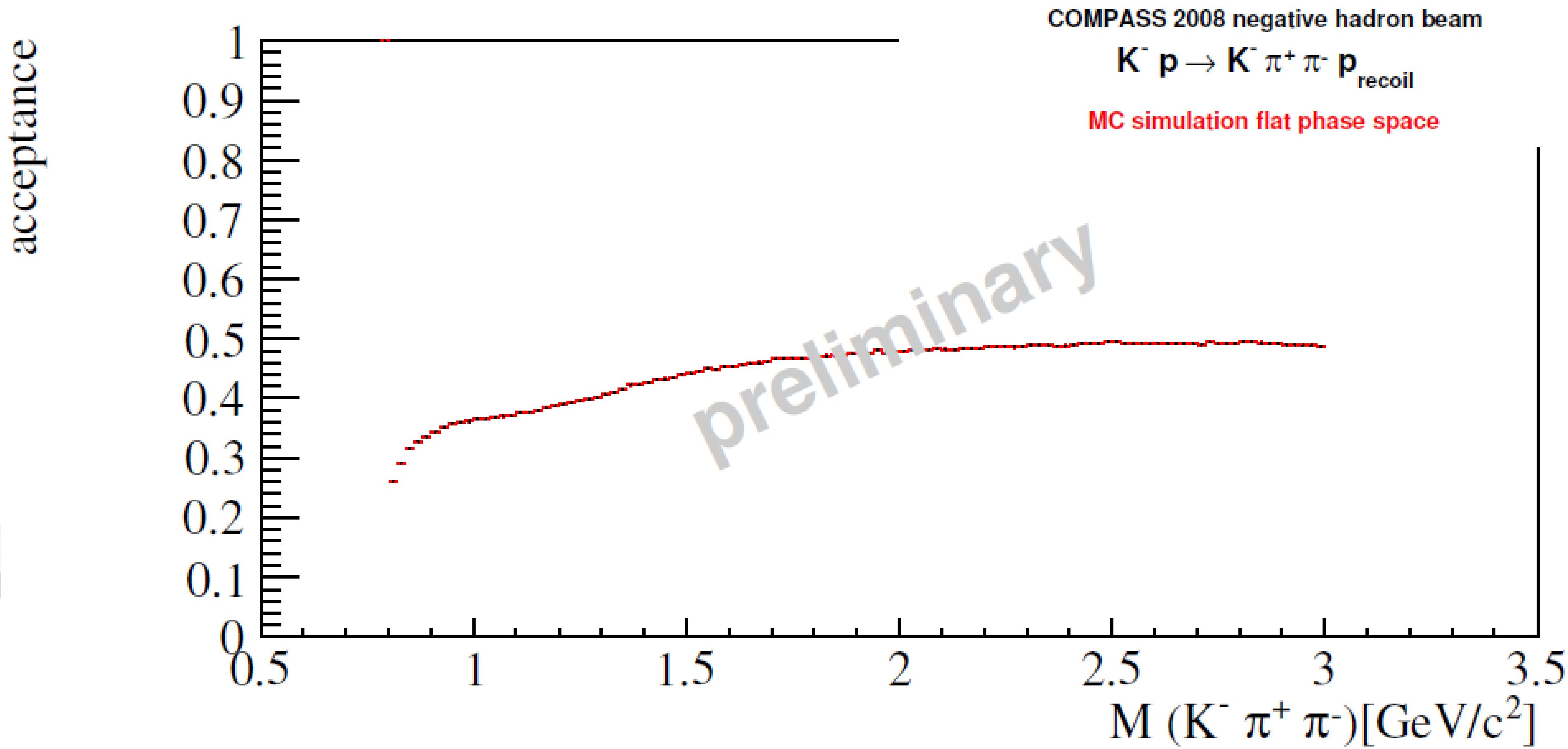
RICH final state PID



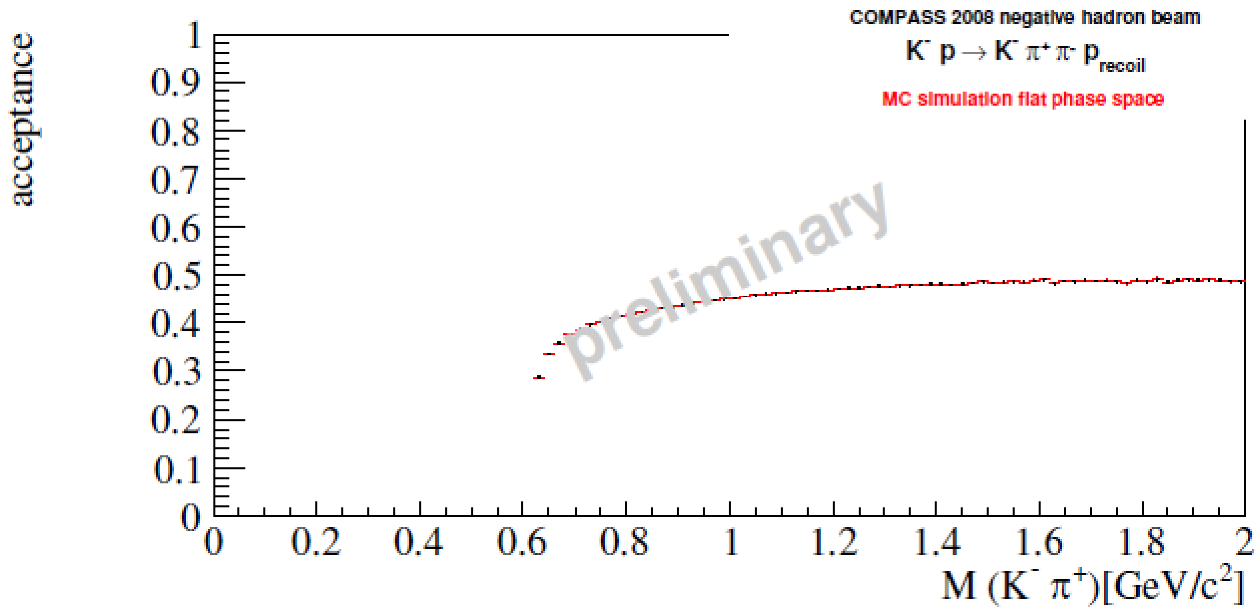
Two negatively charged tracks →
Two possibilities to adapt K^- and π^- masses

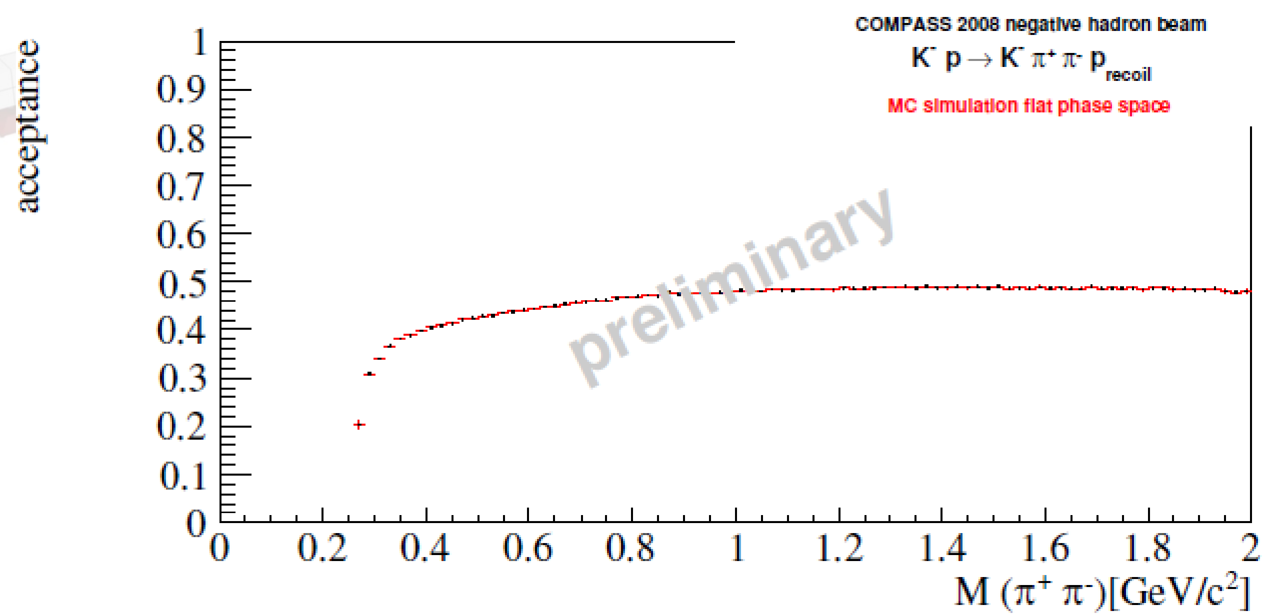


Acceptance in the $K^- \pi^+ \pi^-$ invariant mass

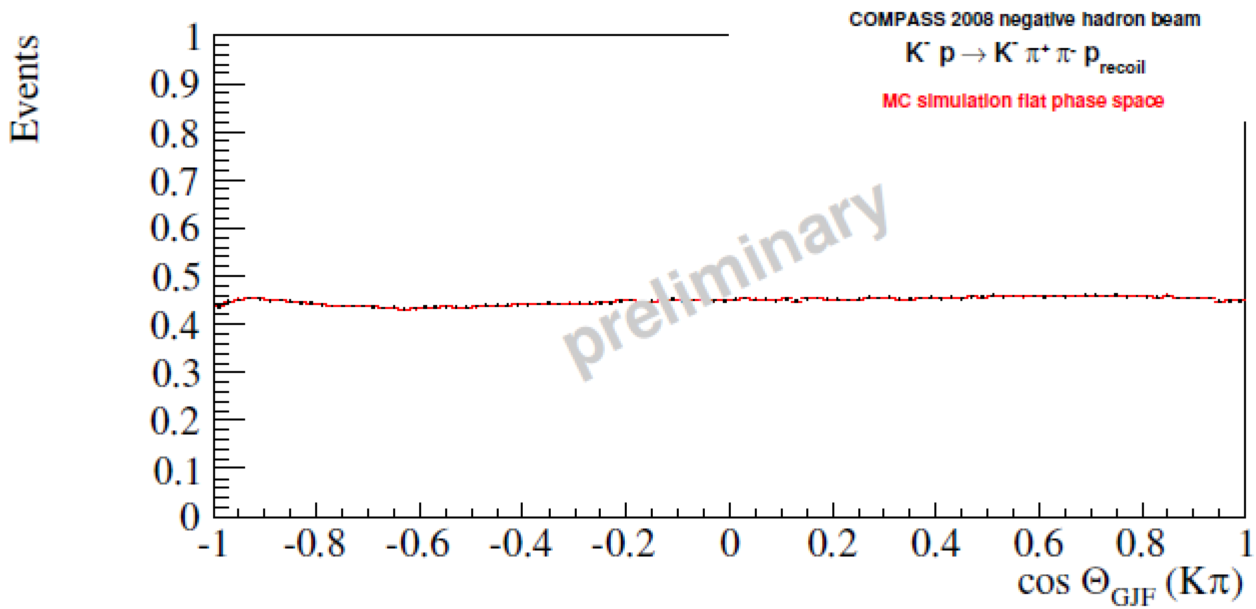


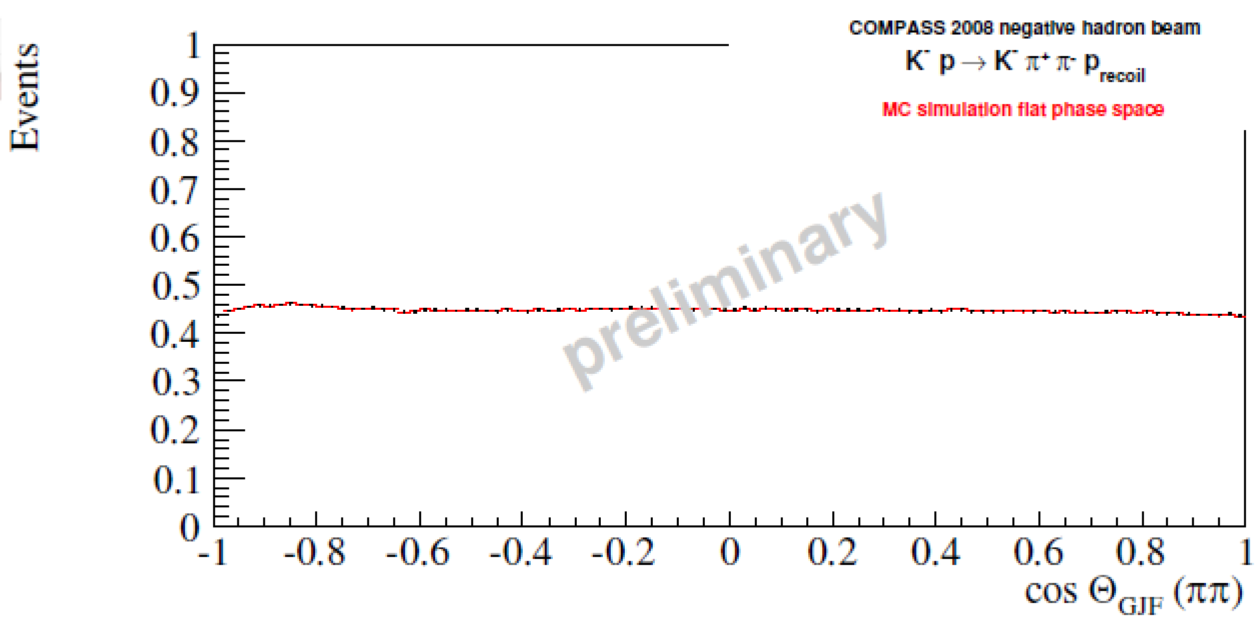
Acceptance in the $K^-\pi^+$ and $\pi^+\pi^-$ invariant mass



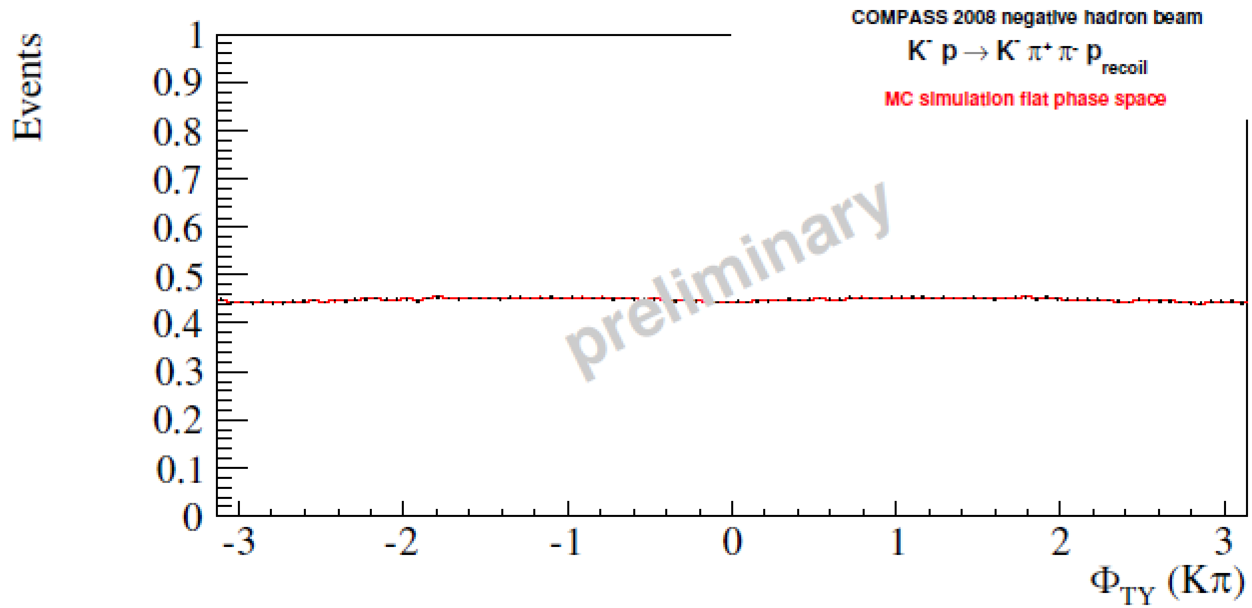


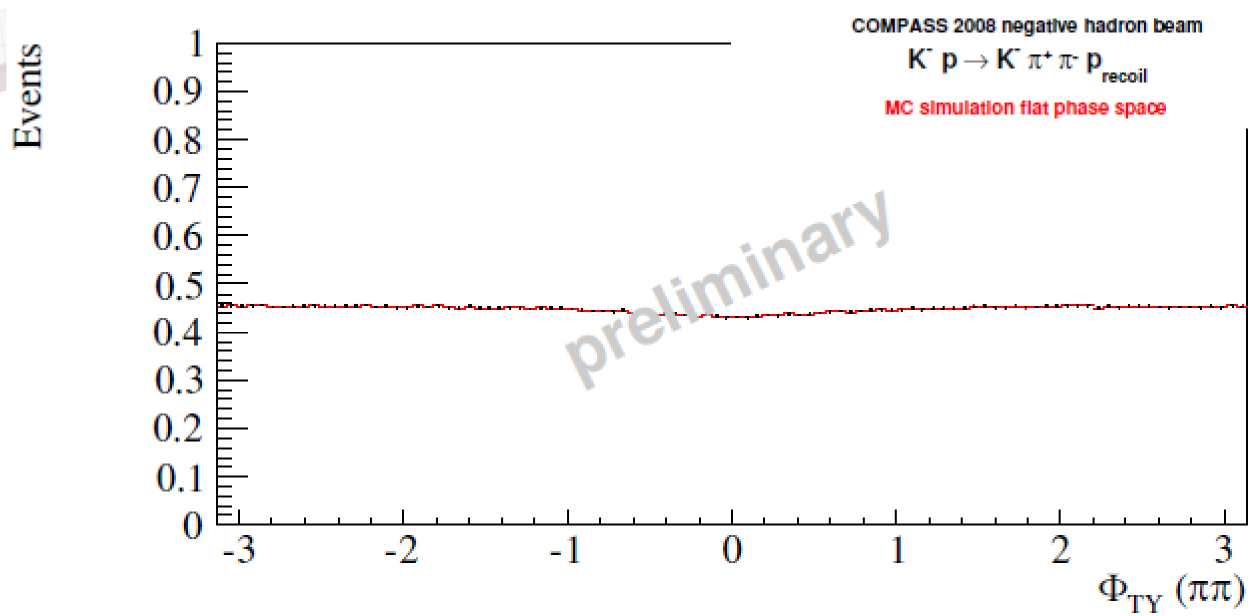
Acceptance in the Gottfried Jackson frame





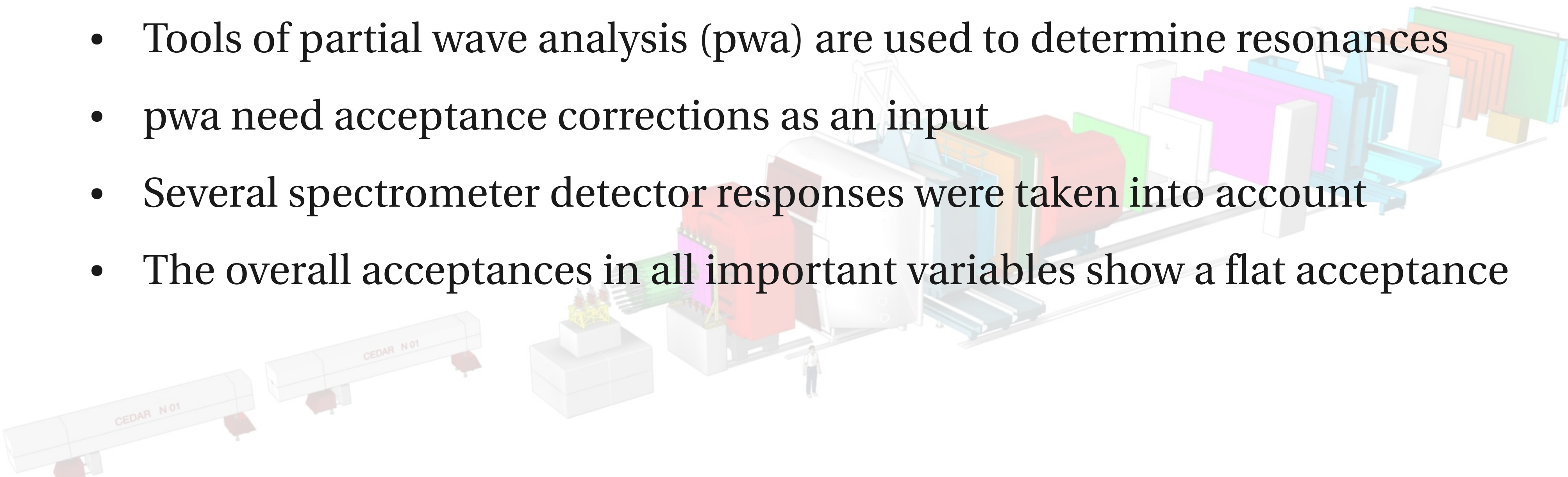
Acceptance in the Gottfried Jackson frame





Conclusions

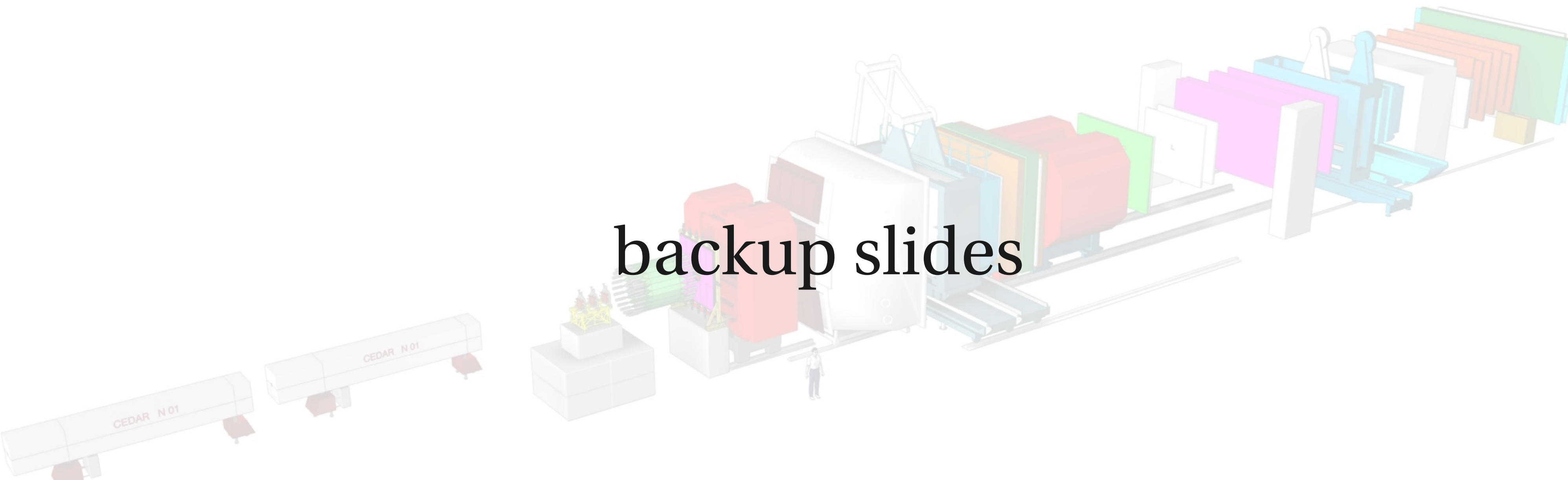
- Open strangeness single diffractive mechanisms show resonant behavior
- Those states are understood to be $q\bar{q}$ bar states with isospin ½
- The $K^- \pi^+ \pi^-$ final state is shown to decay via substates
- Tools of partial wave analysis (pwa) are used to determine resonances
- pwa need acceptance corrections as an input
- Several spectrometer detector responses were taken into account
- The overall acceptances in all important variables show a flat acceptance



For final results concerning pwa I refer to my PhD thesis, available soon.

Thank you!

backup slides



Measured strange meson level scheme

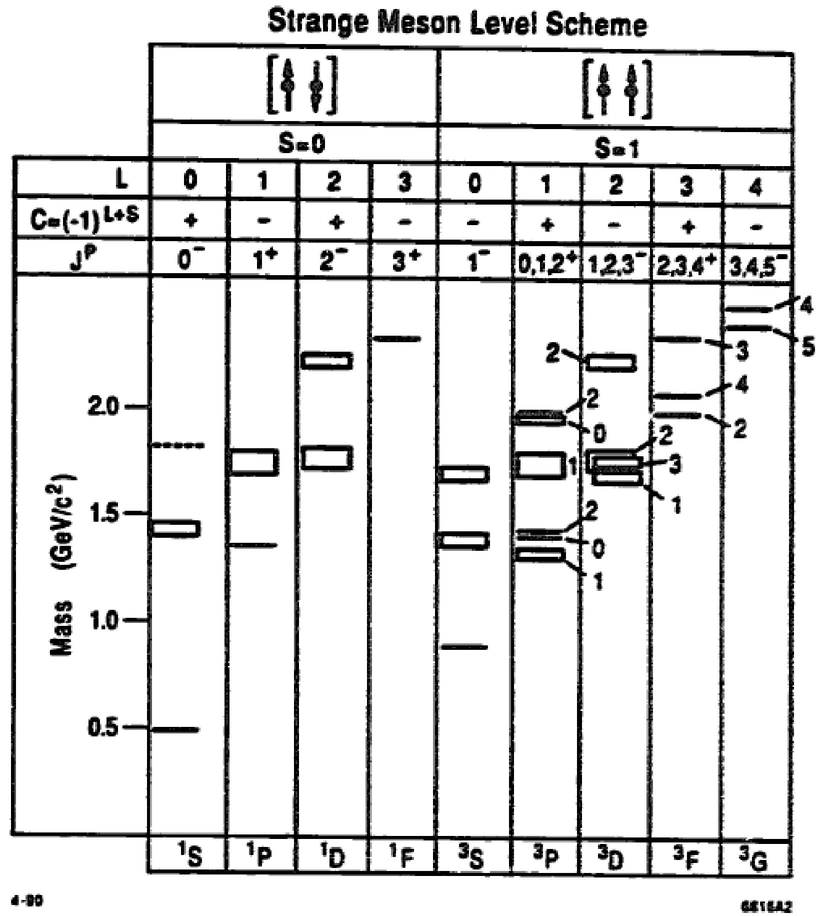


FIGURE 2

The quark model level diagram summarizing the status of strange meson spectroscopy; the C parity is that of the neutral, non-strange members of the relevant SU(3) multiplet.

resonances fitting the $q\bar{q}$ model

$n\,^{2s+1}\ell_J$	J^{PC}	$I=1$ $u\bar{d},\ \bar{u}d,\ \frac{1}{\sqrt{2}}(d\bar{d}-u\bar{u})$	$I=\frac{1}{2}$ $u\bar{s},\ d\bar{s};\ \bar{d}s,\ -\bar{u}s$	$I=0$ f'	$I=0$ f	θ_{quad} [°]	θ_{lin} [°]
$1\,^1S_0$	0^{-+}	π	K	η	$\eta'(958)$	−11.5	−24.6
$1\,^3S_1$	1^{--}	$\rho(770)$	$K^*(892)$	$\phi(1020)$	$\omega(782)$	38.7	36.0
$1\,^1P_1$	1^{+-}	$b_1(1235)$	$K_{1B}{}^\dagger$	$h_1(1380)$	$h_1(1170)$		
$1\,^3P_0$	0^{++}	$a_0(1450)$	$K_0^*(1430)$	$f_0(1710)$	$f_0(1370)$		
$1\,^3P_1$	1^{++}	$a_1(1260)$	$K_{1A}{}^\dagger$	$f_1(1420)$	$f_1(1285)$		
$1\,^3P_2$	2^{++}	$a_2(1320)$	$K_2^*(1430)$	$f_2'(1525)$	$f_2(1270)$	29.6	28.0
$1\,^1D_2$	2^{-+}	$\pi_2(1670)$	$K_2(1770)^\dagger$	$\eta_2(1870)$	$\eta_2(1645)$		
$1\,^3D_1$	1^{--}	$\rho(1700)$	$K^*(1680)$		$\omega(1650)$		
$1\,^3D_2$	2^{--}		$K_2(1820)$				
$1\,^3D_3$	3^{--}	$\rho_3(1690)$	$K_3^*(1780)$	$\phi_3(1850)$	$\omega_3(1670)$	32.0	31.0
$1\,^3F_4$	4^{++}	$a_4(2040)$	$K_4^*(2045)$		$f_4(2050)$		
$1\,^3G_5$	5^{--}	$\rho_5(2350)$					
$1\,^3H_6$	6^{++}	$a_6(2450)$			$f_6(2510)$		
$2\,^1S_0$	0^{-+}	$\pi(1300)$	$K(1460)$	$\eta(1475)$	$\eta(1295)$		
$2\,^3S_1$	1^{--}	$\rho(1450)$	$K^*(1410)$	$\phi(1680)$	$\omega(1420)$		

$$f' = \psi_8\,\cos\theta - \psi_1\,\sin\theta$$

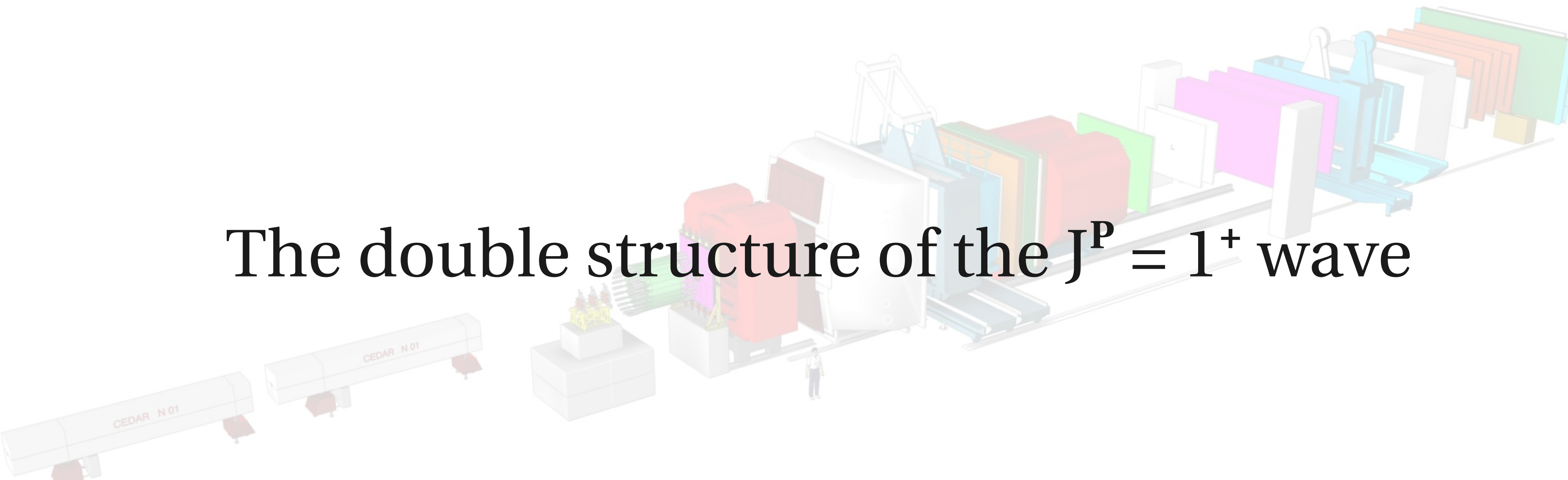
$$f = \psi_8\,\sin\theta + \psi_1\,\cos\theta$$

$$\psi_8 = \frac{1}{\sqrt{6}}(u\bar{u} + d\bar{d} - 2s\bar{s})$$

$$\psi_1 = \frac{1}{\sqrt{3}}(u\bar{u} + d\bar{d} + s\bar{s})$$

† The $1^{+\pm}$ and $2^{-\pm}$ isospin $\frac{1}{2}$ states mix. In particular, the K_{1A} and K_{1B} are nearly equal (45°) mixtures of the $K_1(1270)$ and $K_1(1400)$. The physical vector mesons listed under 1^3D_1 and 2^3S_1 may be mixtures of 1^3D_1 and 2^3S_1, or even have hybrid components.

The double structure of the $J^P = 1^+$ wave



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Clues for the existence of two $K_1(1270)$ resonances

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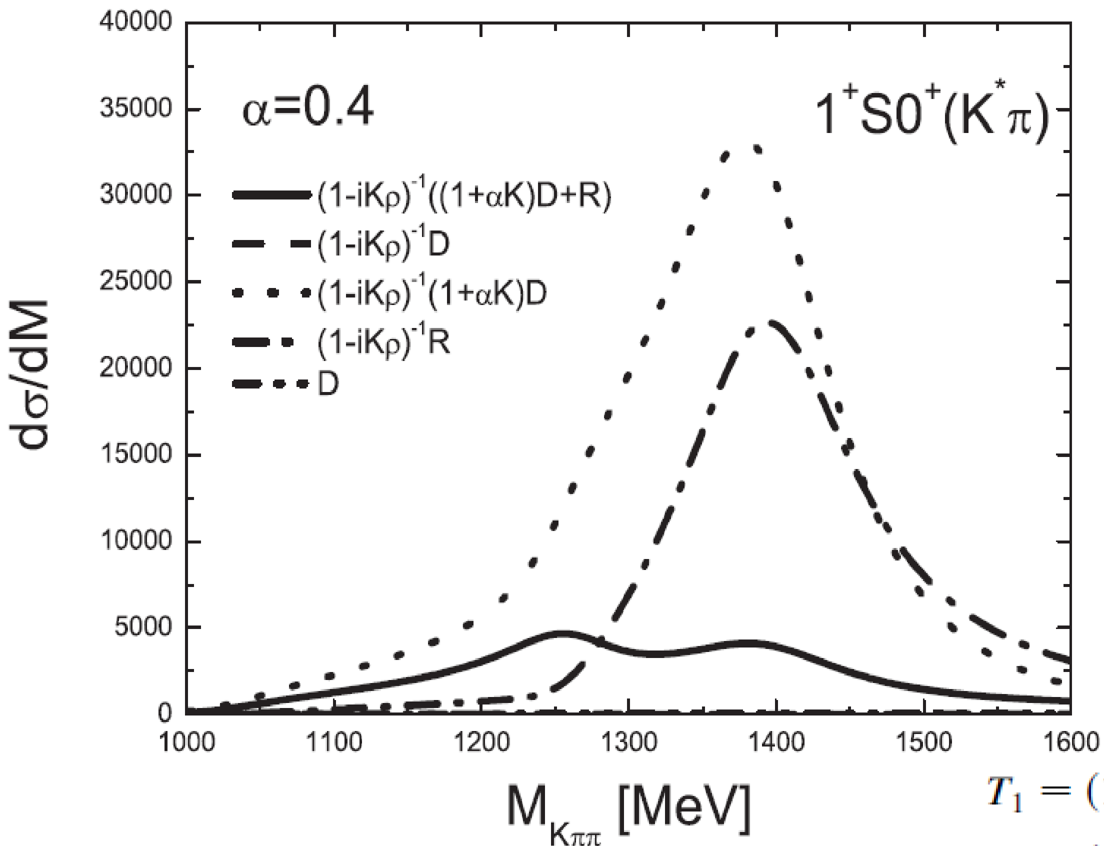

$T_1 = (1 - iK\rho)^{-1}((1 + \alpha K)D + R)$ the full amplitude

$T_2 = (1 - iK\rho)^{-1}D$ the unitarized Deck background

$T_3 = (1 - iK\rho)^{-1}(1 + \alpha K)D$ the full background

$T_4 = (1 - iK\rho)^{-1}R$ the direct production amplitude

$T_5 = D$ the pure Deck background