Kaon polarisability and neutral pion lifetime

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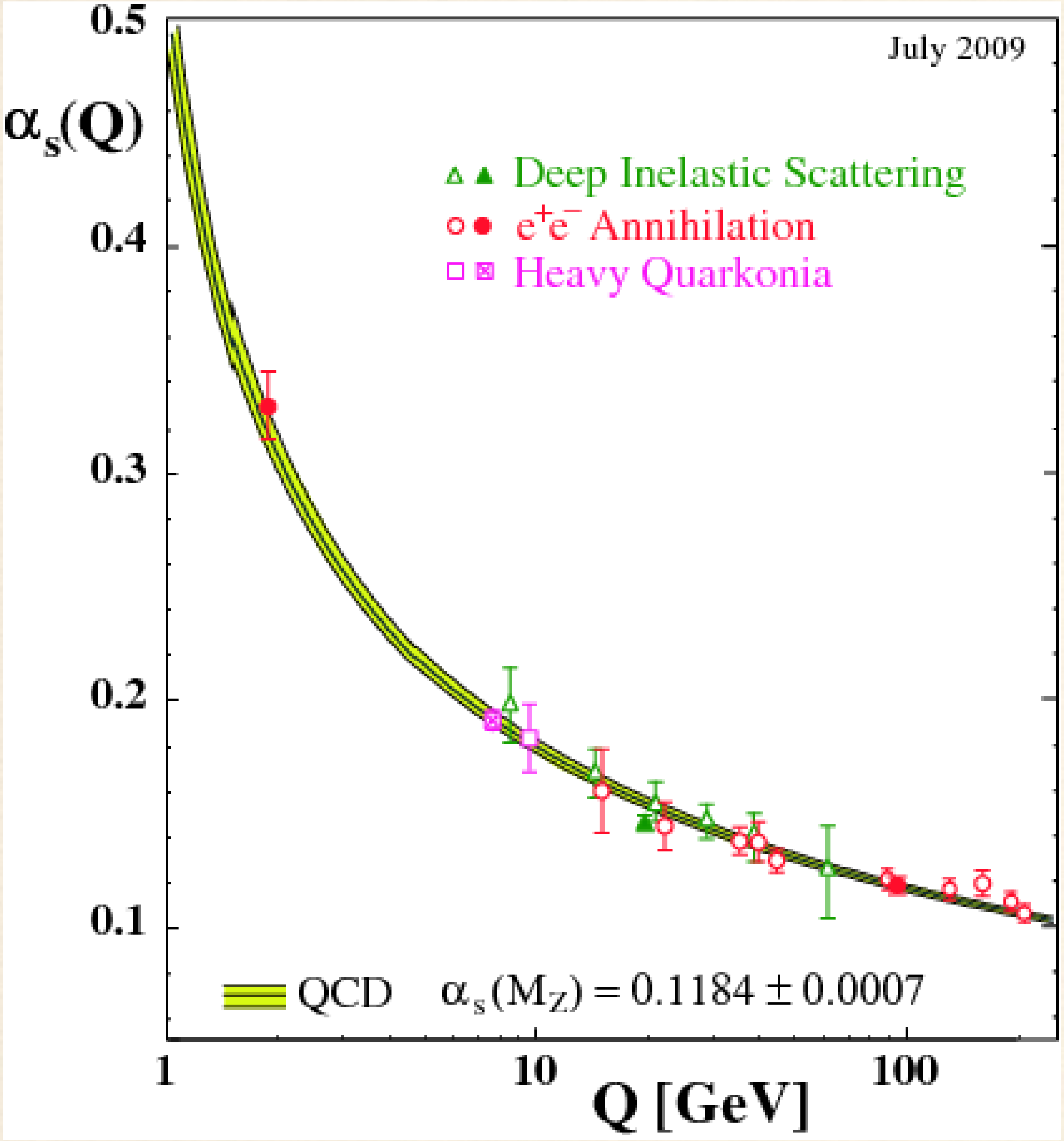
Low-energy QCD

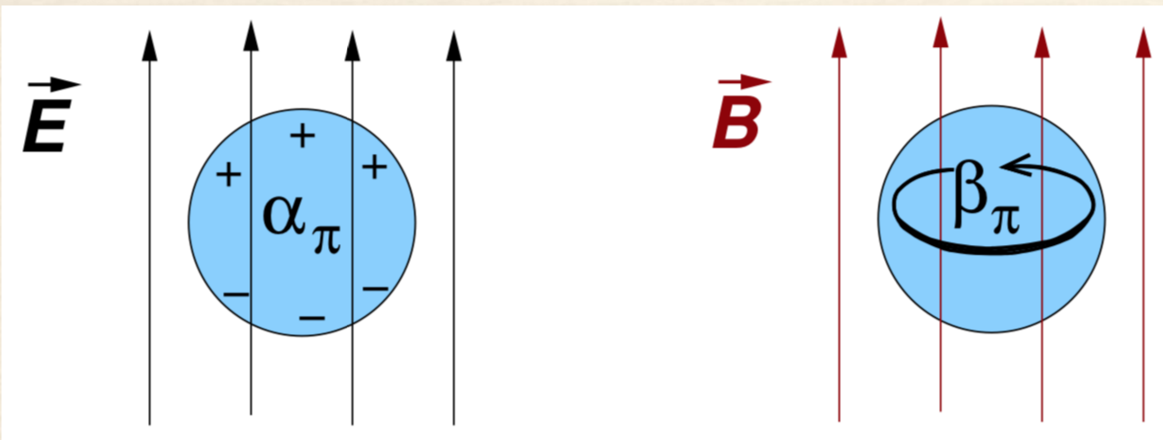


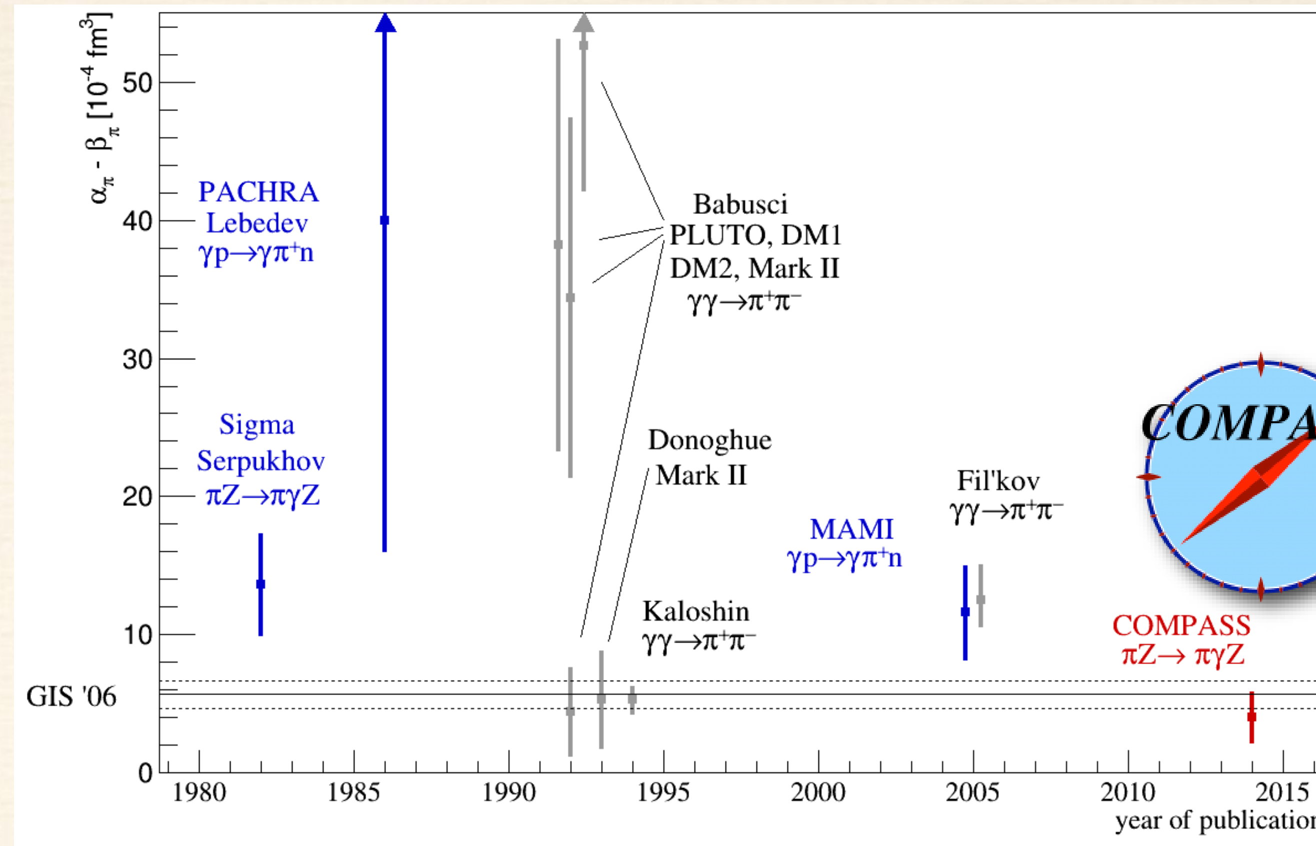
Since the coupling of strong interactions reaches α_S~1 at low energies, perturbative QCD formalism cannot make predictions there.

Effective phenomenological models are used. Chiral theory is one of the most successful of them.

What is their applicability range?

Meson polarisability





For pion:

For kaon:

Quark confinement model:

$$\alpha_K + \beta_K = 1.0 \times 10^{-4} fm^3$$

$$\alpha_K = 2.3 \times 10^{-4} fm^3$$

Theoretical predictions:

χPT prediction O(p⁴):

$$\alpha_K + \beta_K = 0$$

$$\alpha_K = \alpha_\pi \times \frac{m_\pi F_\pi^2}{m_K F_K^2} \approx \frac{\alpha_\pi}{5} \approx 0.6 \times 10^{-4} fm^3$$

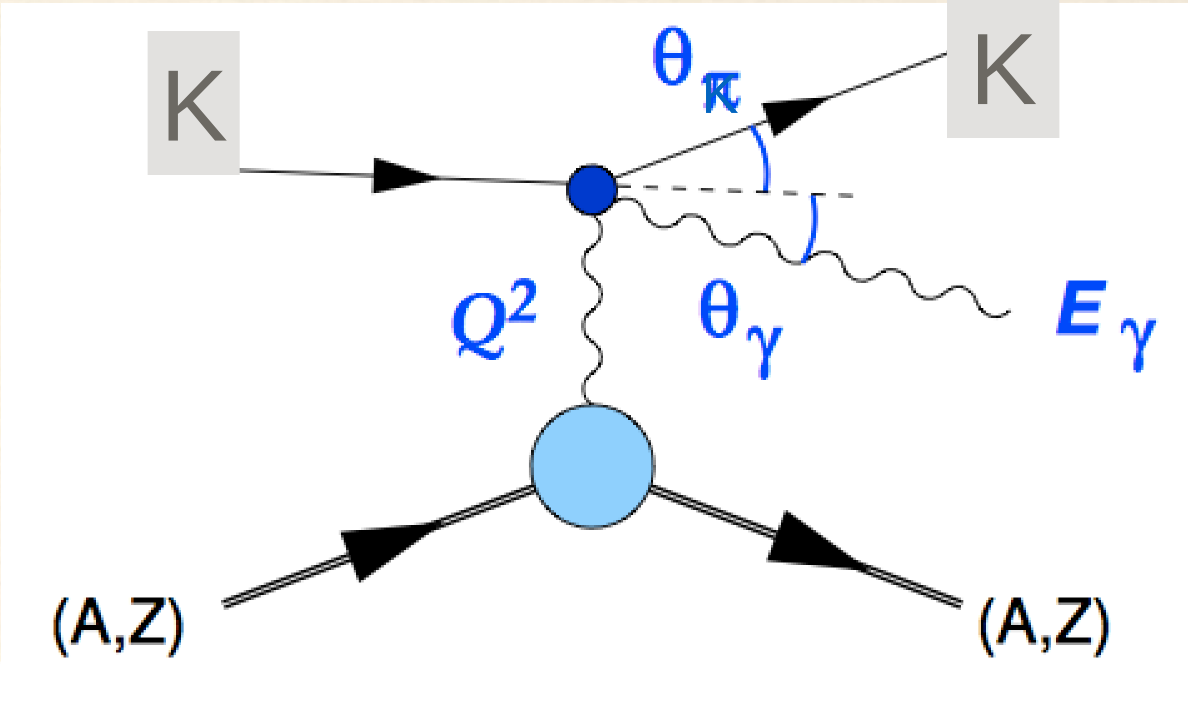
Experimental results:

$\alpha_K < 200 \times 10^{-4}$ fm³ (1973)

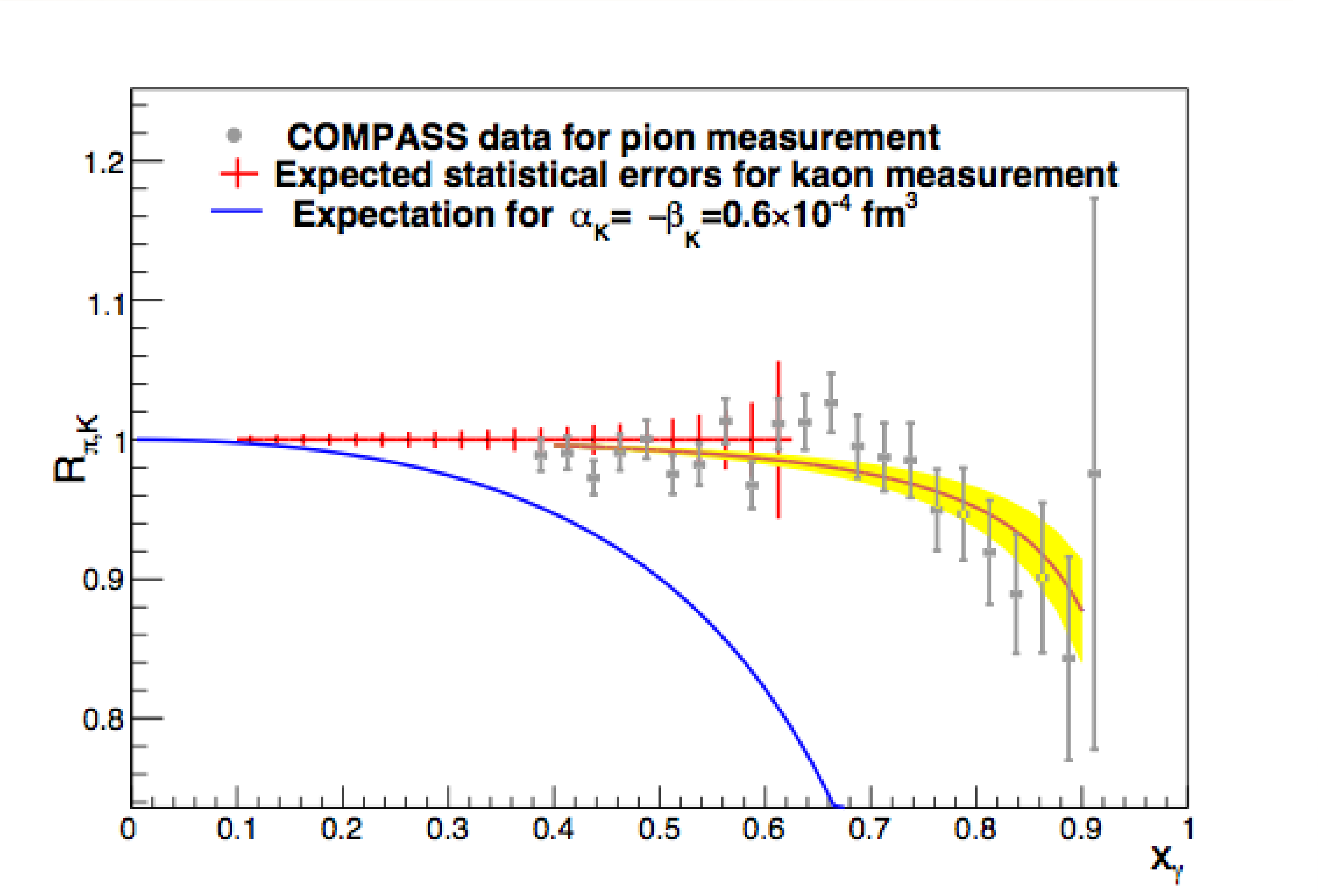
- from kaonic atoms spectra

Kaon polarisability

1 year with $0.3X_0$ Ni target
and 100 GeV kaon beam



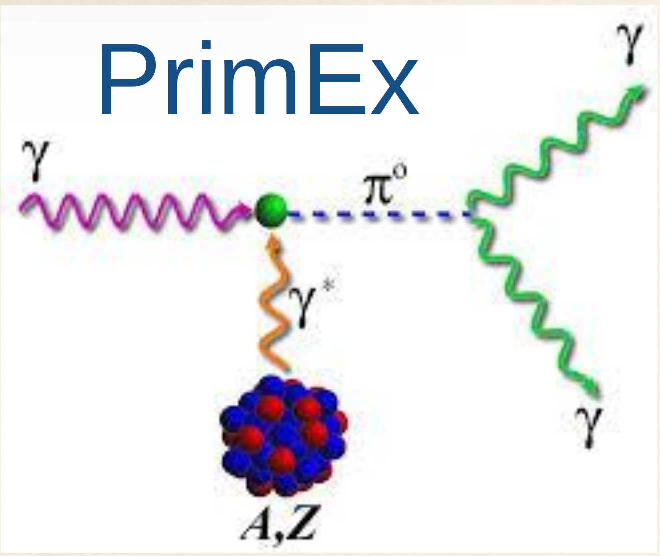
$$R_K \approx \frac{\sigma}{\sigma_{p.l.}} = 1 - \frac{3}{2} \cdot \frac{x_\gamma^2}{1 - x_\gamma} \cdot \frac{m_K^3}{\alpha} \cdot \alpha_K$$

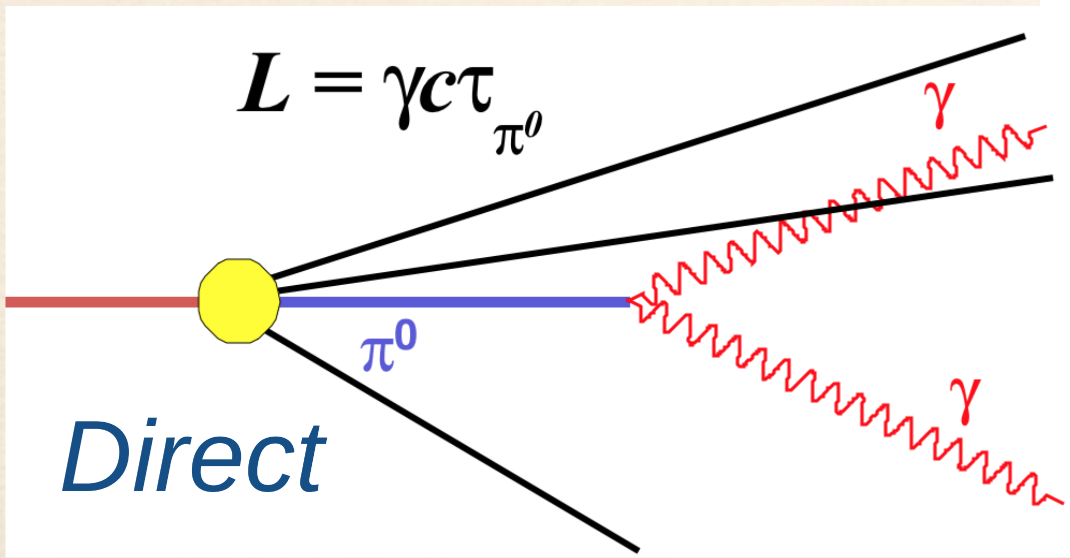


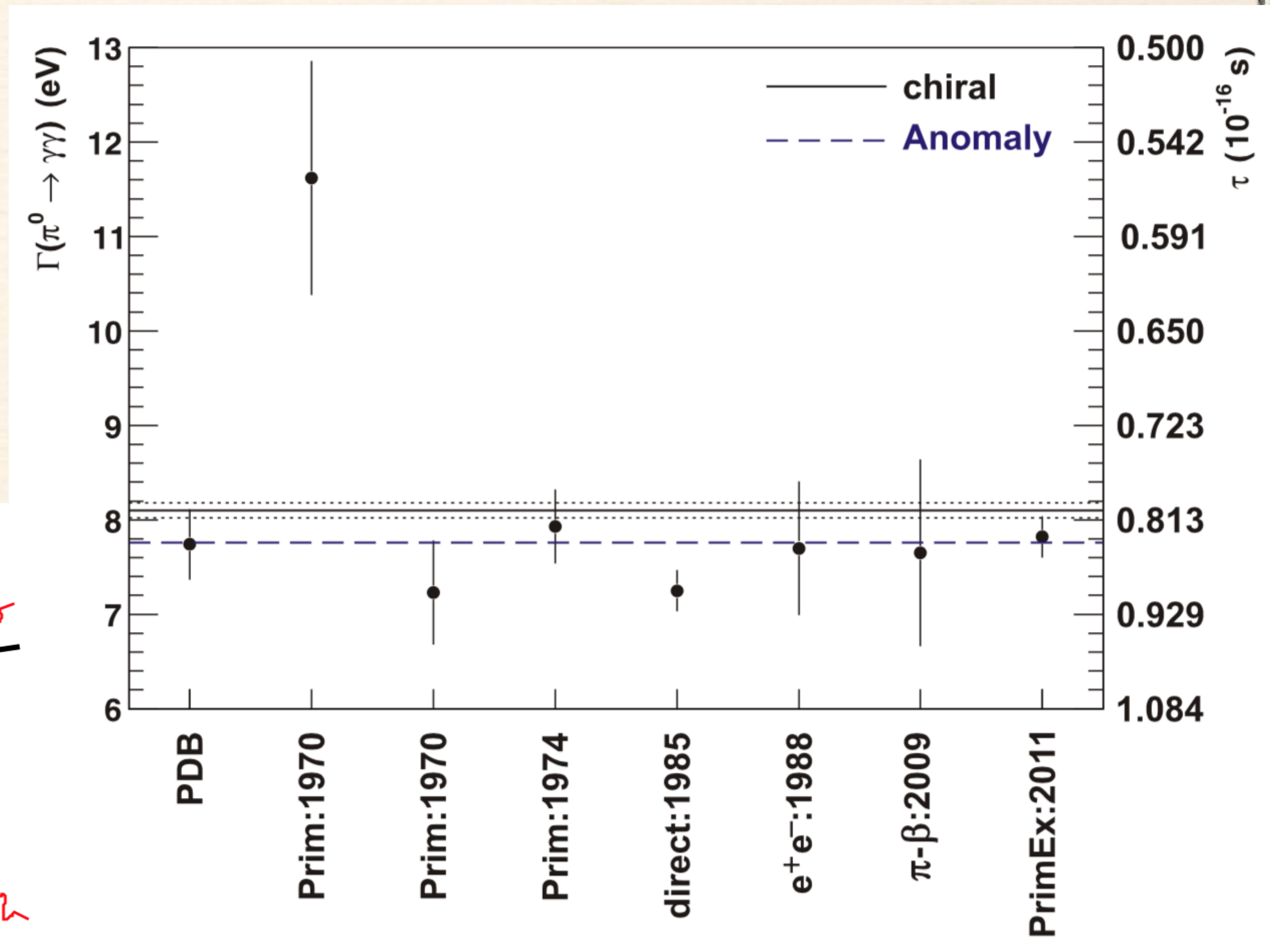
$\sigma_{stat} = 0.03\times10^{-4}$ fm^3

Pion lifetime: present status

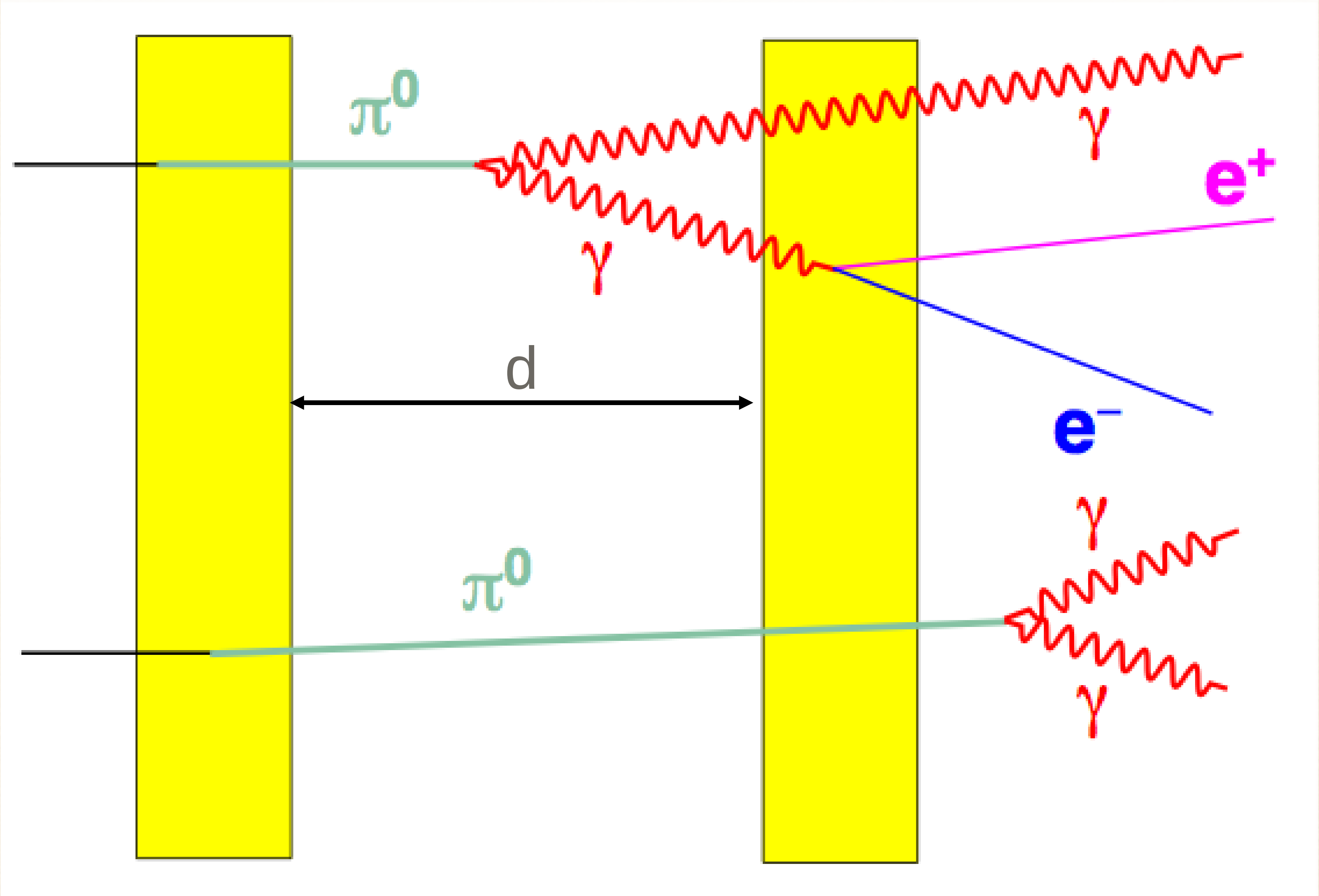
VALUE (10^{-17} s)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*	
8.52±0.18 OUR AVERAGE		Error includes scale factor of 1.2.			2.1%
8.32±0.15±0.18		[1] LARIN 11	PRMX	Primakoff effect	2.8%
8.5 ±1.1		[2] BYCHKOV 09	PIBE	$\pi^+ \to e^+ \nu \gamma$ at rest	
8.4 ±0.5 ±0.5	1182	[3] WILLIAMS 88	CBAL	$e^+ e^- \to e^+ e^- \pi^0$	
8.97±0.22±0.17		ATHERTON 85	CNTR	Direct measurement	3.1%
8.2 ±0.4		[4] BROWMAN 74	CNTR	Primakoff effect	







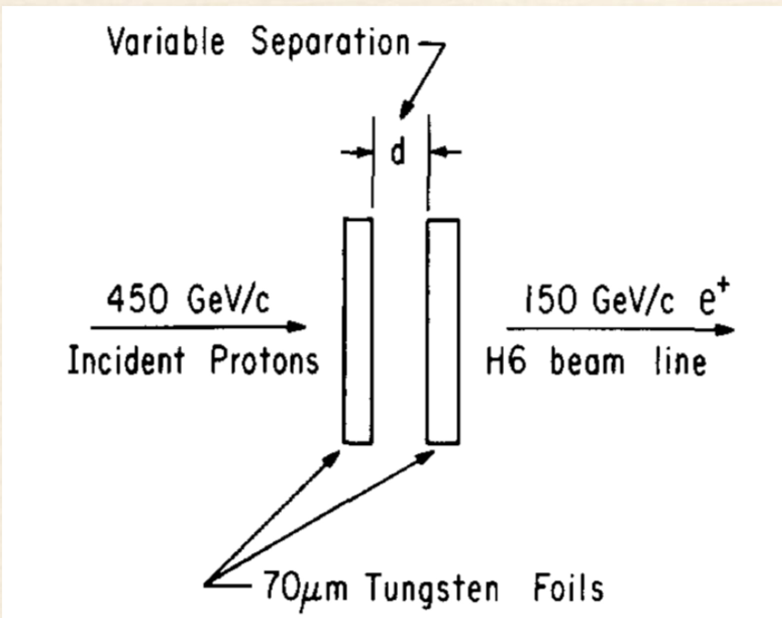
Pion lifetime: general idea of direct measurement



Pion lifetime: direct measurement at CERN (1982)

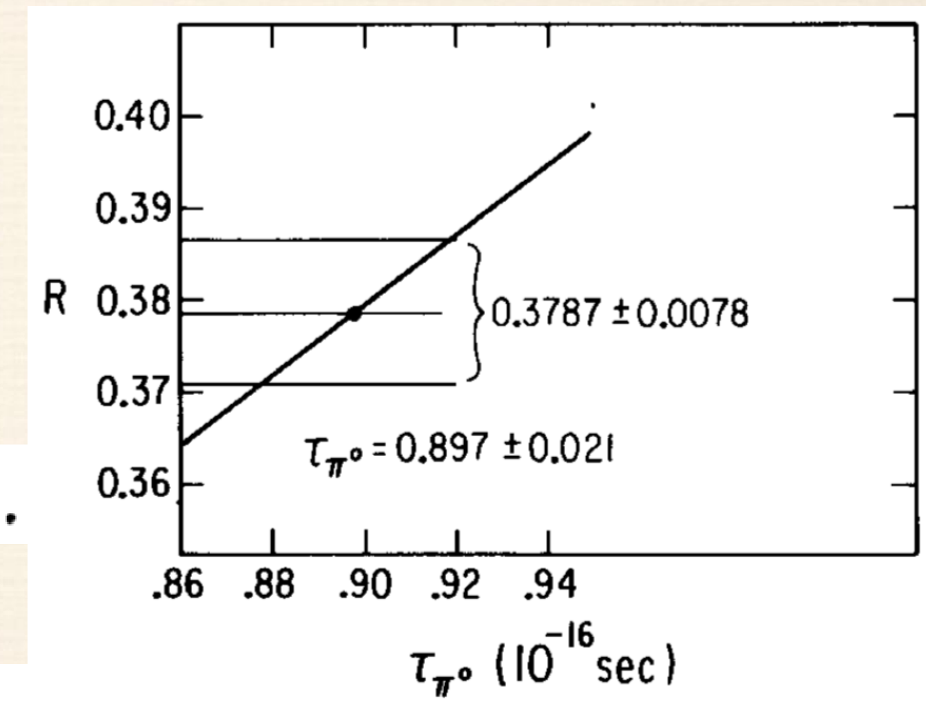
$$Y(d) = N\{A + B[1 - \exp(-d/\lambda)]\}$$

$\lambda = \lambda(E)$



π^0 spectrum $S_{\pi 0}(E)$ was not measured directly.
It was assumed that $S_{\pi 0}(E)=(S_{\pi +}(E)+S_{\pi -}(E))/2$.
It was the main contribution to systematics

$$R = [Y(250) - Y(45)]/[Y(250) - Y(0)] = 0.3787 \pm 0.0078.$$



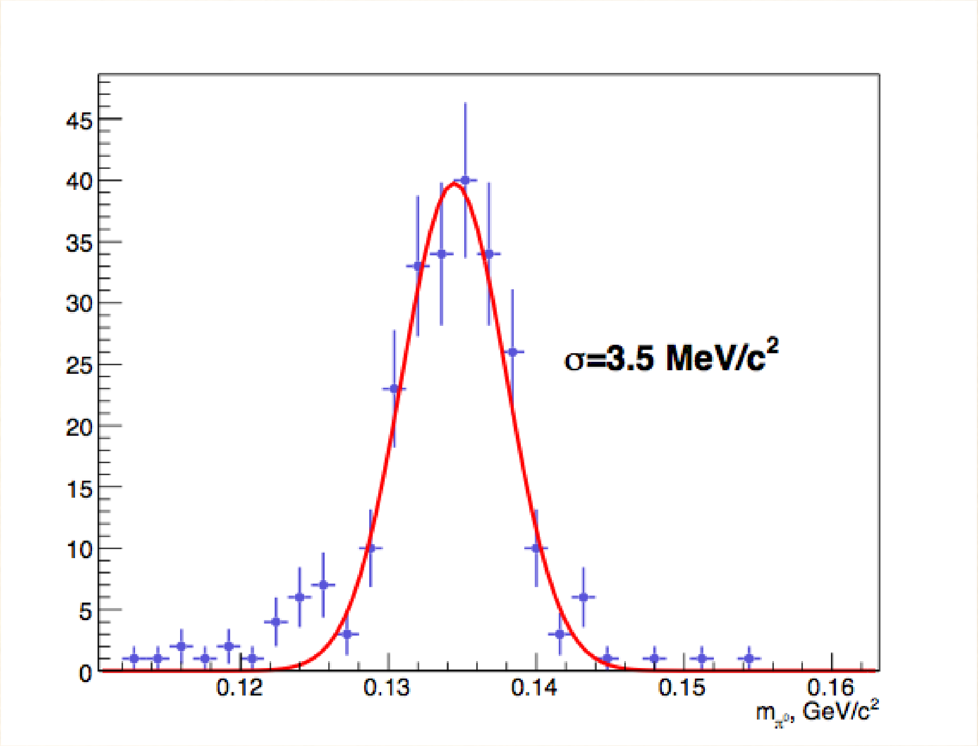
Positron rate as a function of foil separation.

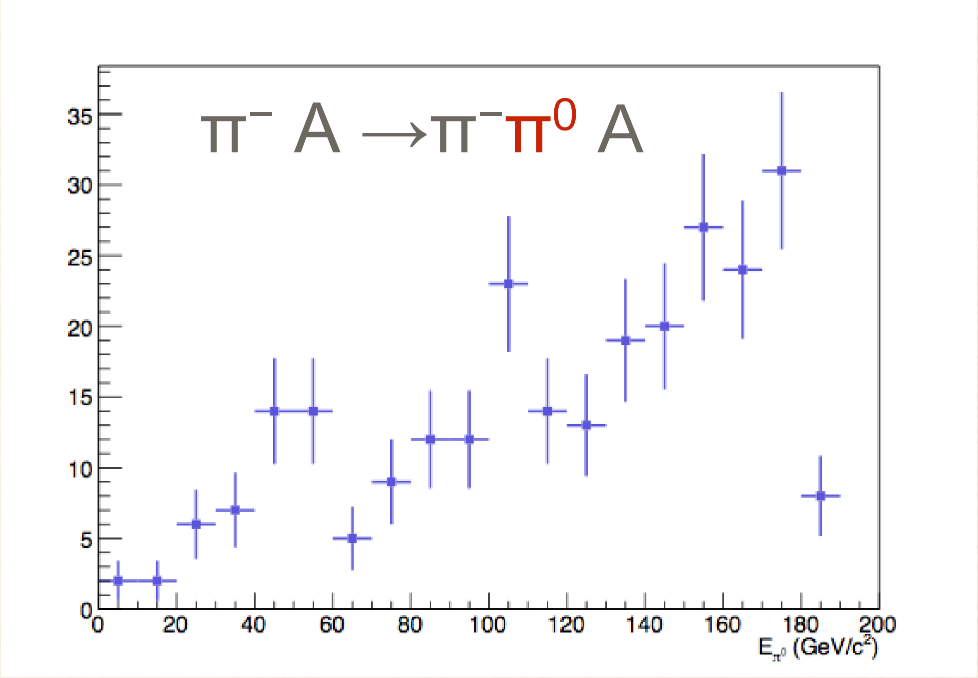
Foil separation (μm)	$\frac{\text{Positrons}}{\text{incident proton}} \times 10^{11}$ a)	Number of positrons detected
d_{min}	19.2346 ± 0.0125	2.49×10^6
d_{min} + 44.80 ± 0.25	20.0738 ± 0.0075	7.79×10^6
d_{min} + 250 ± 0.50	20.5852 ± 0.0091	5.32×10^6

Pion lifetime: our possibilities with kaon beam

Strong points:

1) We can detect both electrons and positrons from γ conversion in the wide momentum range.
2) We can directly measure the spectrum of produced π^0 via reconstruction of γγ decay;
3) To control systematics we have the known π^0 spectrum from beam kaons decay as a reference.





It would be nice to have the momentum of hadron beam as high as possible

Summary

The COMPASS experiment already performed significant contributions to test low-energy QCD models.

- The first measurement of the kaon polarizability and
- precise determination of the neutral pion lifetime

represent appealing next important steps to take.