Baryon spectrum

Vincent Drach
LPSC GRENOBLE
ETM Collaboration

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Introduction

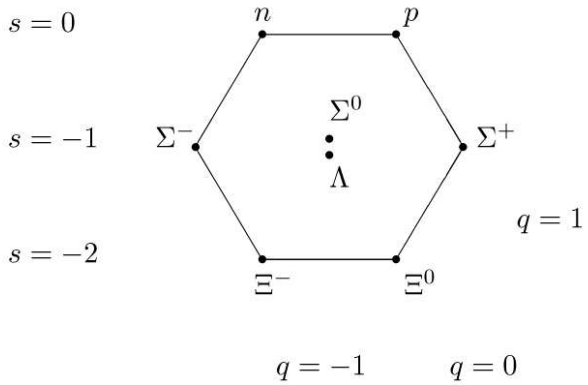
- Lattice Setup
- Octet of strange Baryon
  - ⋆ isospin breaking
  - ⋆ Gell-Mann Okubo
- Decuplet
  - ⋆ isospin breaking
  - ⋆ Dependance in the doublet of strange quark
- Negative parity
- To Do

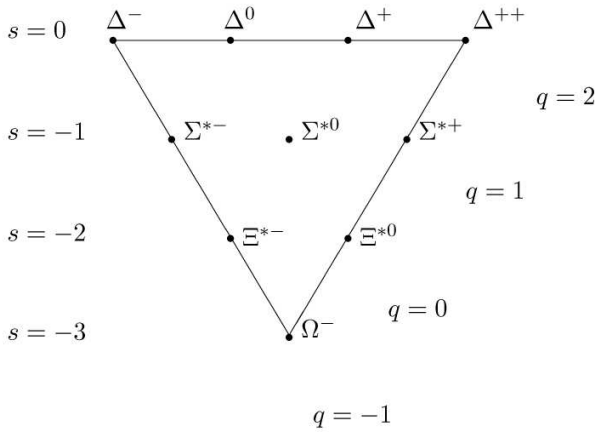
- Smearing : Gaussian + APE
- Source randomly choosen lattice volume
- Partially quenched study : "doublet" of twisted strange quark.
- Bare quark mass of the strange quark (compute by the italian group in the mesonic sector)

-	$\beta = 3.8$	$\beta = 3.9$	$\beta = 4.05$
μ_s^{bare}	0.0208(15)(48)	Our value : 0.0217 new one : 0.0213(8)(22)	0.0166(18)(29)

- Errors on the determination on the strange not take into account
- No Jacknife for fitting the plateau : errors are under estimated

Decuplet and Octet





- General interpolating field for Baryon : $J_{\mu\nu} = \epsilon^{abc} \sum_i \lambda_i \left(\psi^{aT}_{\tilde{A}_i} \Gamma^i_\mu \psi^b_{\tilde{B}_i} \right) \Lambda^i_\nu \psi^c_{\tilde{C}_i}$
- Decuplet interpolating field have a spin 1/2 contribution

Results $\beta = 3.9$ $a = 0.0855$ fm

$a\mu$	Smearing	stat.	am_N	am_Λ	am_{Σ^+/Σ^-}	am_{Σ^0}	am_{Ξ^0/Ξ^-}
$24^3 \times 48$ $\beta = 3.9$ $a = 0.0855$ fm							
0.0040	LL	471	0.535(6)	0.588(5)	0.637(5)	0.611(9)	0.656(4)
0.0040	LS	-	-	-	-	-	-
0.0040	SS	203	0.548(5)	0.594(5)	0.633(4)	0.636(5)	0.670(3)
0.0064	LL	141	0.577(9)	0.625(7)	0.651(10)	0.640(15)	0.679(8)
0.0064	LS	107	0.563(4)	0.612(4)	0.633(4)	0.633(5)	0.669(3)
0.0064	SS	-	-	-	-	-	-
0.0085	LL	155	0.578(7)	0.621(9)	0.648(7)	0.707(8)	0.676(6)
0.0085	LS	162	0.585(2)	0.624(2)	0.651(2)	0.655(3)	0.677(2)
0.0085	SS	-	-	-	-	-	-
0.0100	LL	171	0.622(5)	0.646(6)	0.683(6)	0.687(7)	0.695(5)
0.0100	LS	-	-	-	-	-	-
0.0100	SS	-	-	-	-	-	-
$32^3 \times 64$ $\beta = 3.9$ $a = 0.0855$ fm							
0.0040	LL	-	-	-	-	-	-
0.0040	LS	-	-	-	-	-	-
0.0040	SS	-	-	-	-	-	-

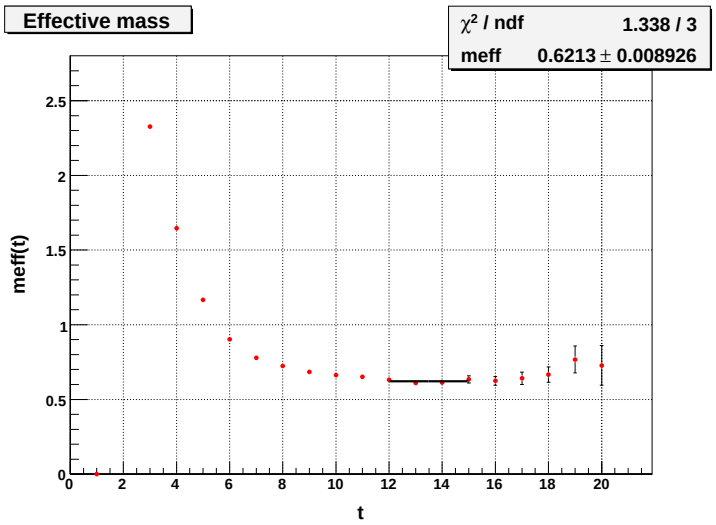
- LL : Local Sink Local Source
- LS : Local Sink Smeared Source
- SS : Smeared Sink Smeared Source

Results $\beta = 3.8$ $a = 0.0995$ fm

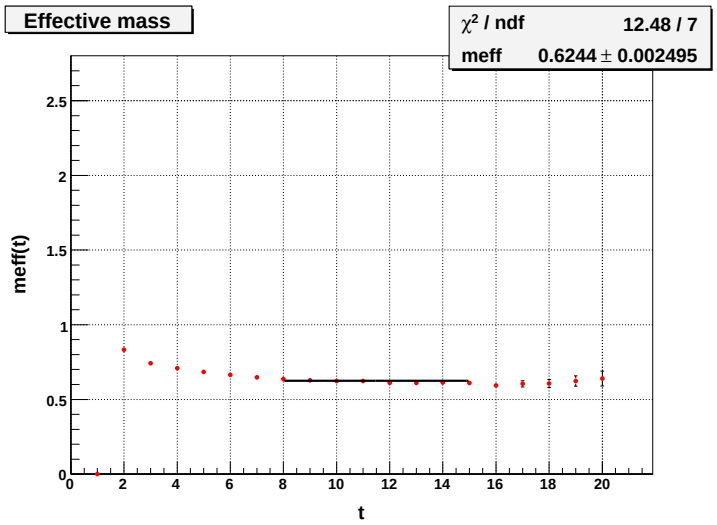
$a\mu$	Smearing	stat.	am_N	am_Λ	am_{Σ^+/Σ^-}	am_{Σ^0}	am_{Ξ^0/Ξ^-}
$24^3 \times 48$ $\beta = 3.8$ $a = 0.0995$ fm							
0.0060	LL	216	0.675(6)	0.723(6)	0.747(6)	0.758(9)	0.775(5)
0.0060	LS	-	-	-	-	-	-
0.0060	SS	-	-	-	-	-	-
0.0080	LL	-	-	-	-	-	-
0.0080	LS	-	-	-	-	-	-
0.0080	SS	-	-	-	-	-	-
0.0011	LL	-	-	-	-	-	-
0.0011	LS	-	-	-	-	-	-
0.0011	SS	-	-	-	-	-	-
0.0165	LL	250	0.760(4)	0.767(6)	0.791(5)	0.781(9)	0.791(5)
0.0165	LS	161	0.769(1)	0.786(2)	0.802(2)	0.810(2)	0.809(2)
0.0165	SS	-	-	-	-	-	-

Example of Plateaux : Lambda Baryon

Local-Local

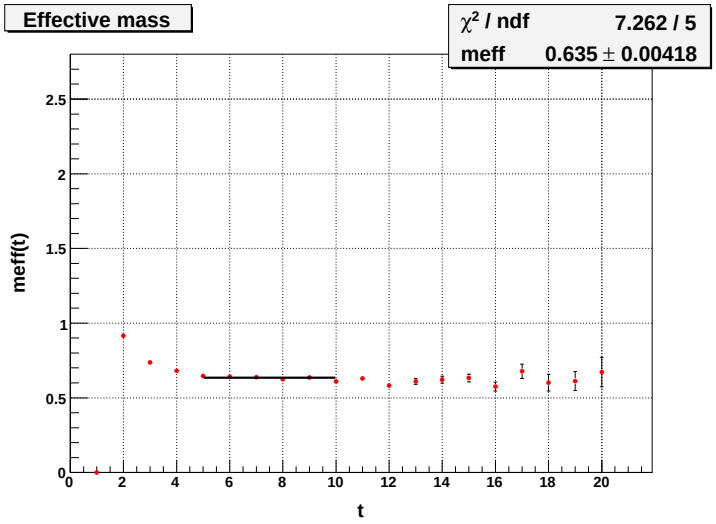


Local-Smeared



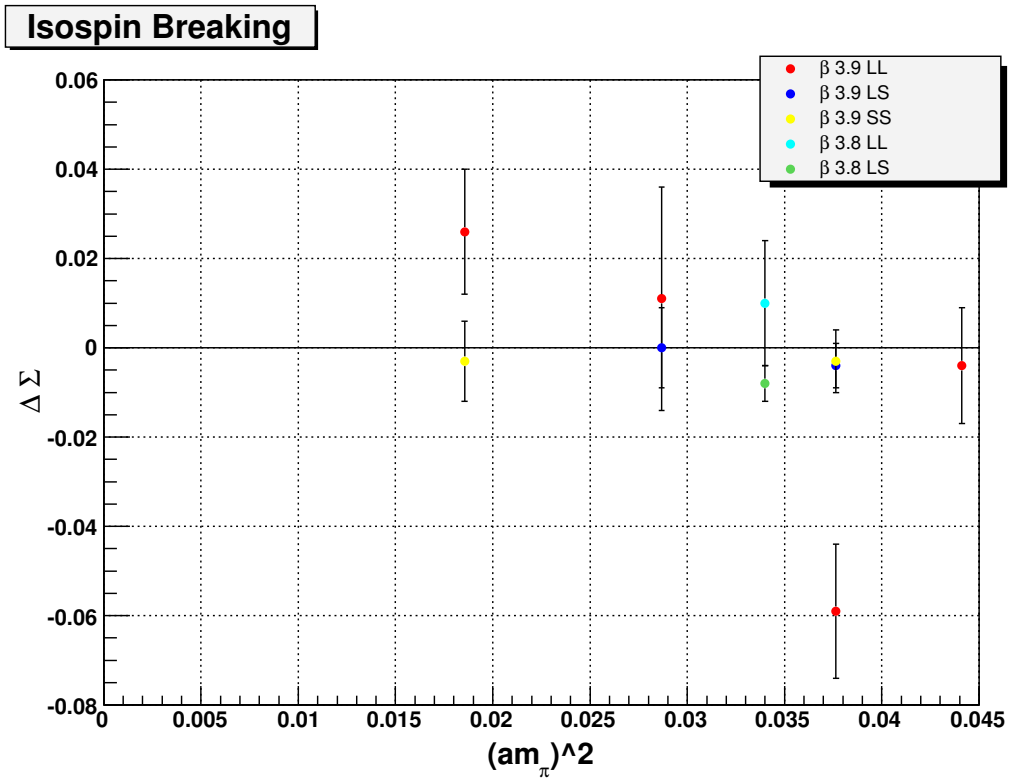
Smeared-Smeared

$\beta = 3.9\ \mu = 0.0085$



Isospin Breaking

- Test of isospin breaking in the Σ sector
- Close from 0 for smeared results

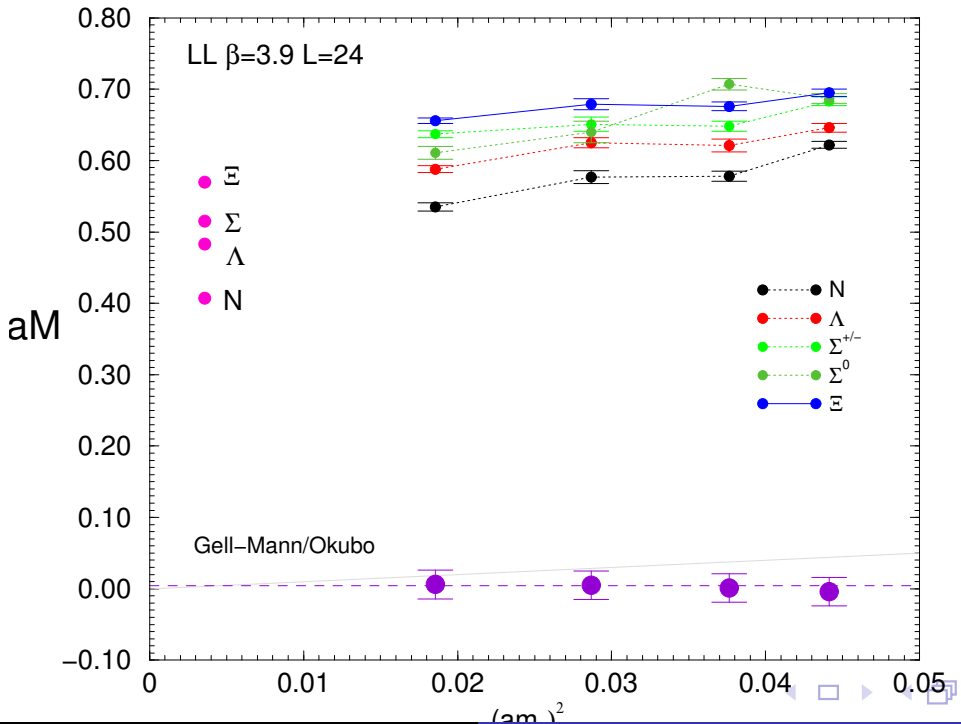


Gell Mann Okubo formula

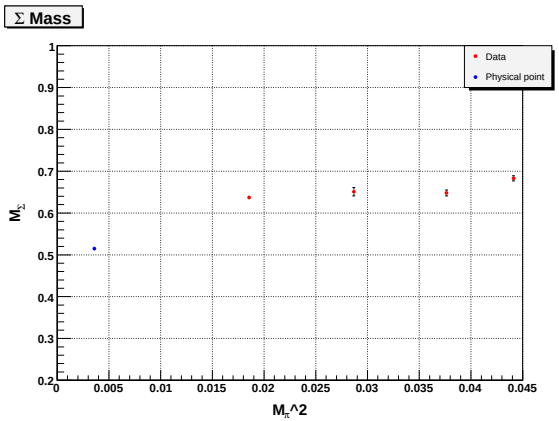
- Gell Mann Okubo formula : $T = M_\Lambda + \frac{1}{3} M_\Sigma - \frac{2}{3} M_N - \frac{2}{3} M_\Xi = 0$
- Experimental value $T^{exp} = 0.009$ GeV

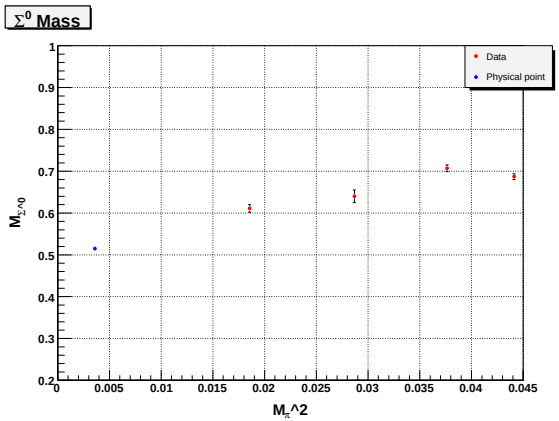
μ	aT
0.0040	0.006
0.0064	0.005
0.0085	0.001
0.0100	-0.004

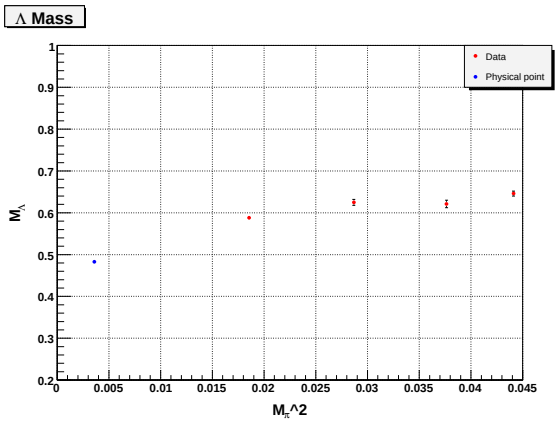
μ	aT
0.006	0.005
0.008	-
0.011	-
0.0165	-0.003

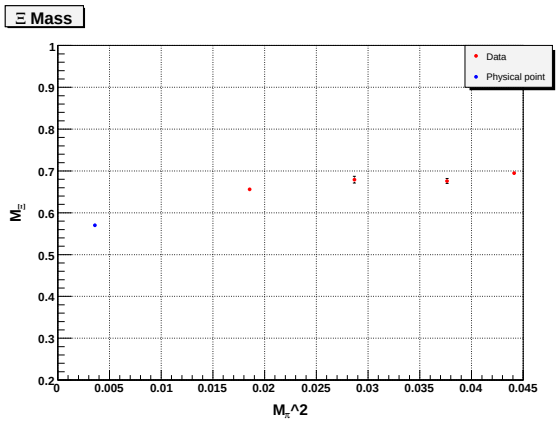


Chiral extrapolation









- Local results for the whole Octet at $\beta = 3.9$
- Physical point in blue
- Linear fit in m_π globally better ...

Summary

- Right hierarchy of mass for the octet
- Question of the chiral extrapolation still open ...
- Gell-Mann Okubo relation satisfied at any pion mass
- Isospin breaking seem to be small if we trust Smeared correlators
- Analysis has to be done carefully to obtain results in agreement between local and smeared correlators

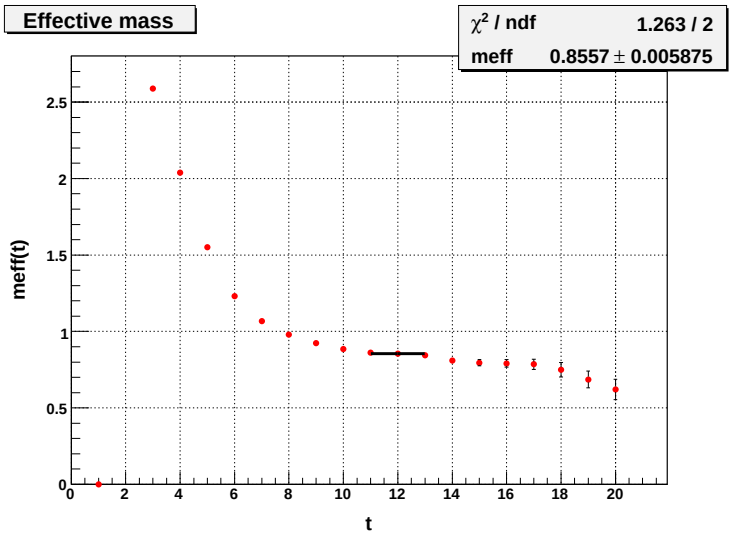
Results $\beta = 3.9$ $a = 0.0855$ fm

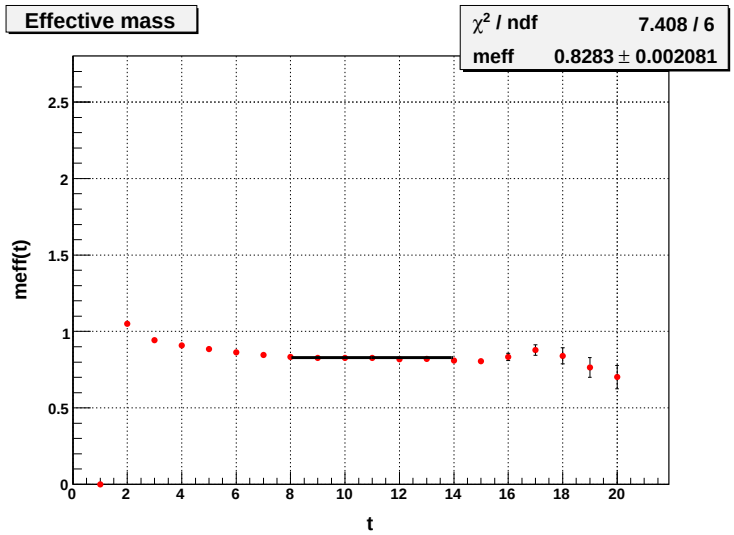
$a\mu$	Smearing	stat.	$am_{\Delta^{++,-}}$	$am_{\Delta^{+,0}}$	$am_{\Sigma^{*+,-}}$	$am_{\Sigma^{*0}}$	$am_{\Xi^{*0,-}}$	am_{Ω}
			$24^3 \times 48$ $\beta = 3.9$ $a = 0.0855$ fm					
0.0040	LL	471	-	-	0.783(6)	0.774(10)	0.725(4)	0.840(3)
0.0040	LS		-	-	-	-	-	
0.0040	SS	203	0.720(5)	0.748(3)	0.766(4)	0.770(5)	0.779(3)	0.837(3)
0.0064	LL	141	-	-	0.727(15)	0.819(16)	0.759(7)	0.851(5)
0.0064	LS	107	0.704(7)	0.715(4)	0.741(4)	0.744(5)	0.743(3)	0.816(3)
0.0064	SS		-	-	-	-	-	-
0.0085	LL		-	-	0.797(10)	0.829(15)	0.706(10)	0.856(6)
0.0085	LS	162	-	-	0.772(3)	0.774(4)	0.759(2)	0.828(2)
0.0085	SS	-	-	-	-	-	-	-
0.0100	LL	171	-	-	0.814(7)	0.794(12)	0.761(6)	0.849(7)
0.0100	LS	-	-	-	-	-	-	-
0.0100	SS	-	-	-	-	-	-	-
			$24^3 \times 48$ $\beta = 3.9$ $a = 0.0855$ fm					
0.0040	LL	-	-	-	-	-	-	
0.0040	LS	-	-	-	-	-	-	
0.0040	SS	-	-	-	-	-	-	

Results $\beta = 3.8$ $a = 0.0995$ fm

$a\mu$	Smearing	stat.	$am_{\Delta^{++,-}}$	$am_{\Delta^{+,0}}$	$am_{\Sigma^{*+,-}}$	$am_{\Sigma^{*0}}$	$am_{\Xi^{*0,-}}$	am_{Ω}
$24^3 \times 48$ $\beta = 3.8$ $a = 0.0995$ fm								
0.0060	LL	216	0.771(21)	0.795(25)	0.843(17)	0.859(15)	0.842(6)	0.943(6)
0.0060	LS		-	-	-	-	-	
0.0060	SS		-	-	-	-	-	
0.0080	LL		-	-	-	-	-	
0.0080	LS		-	-	-	-	-	-
0.0080	SS		-	-	-	-	-	-
0.0011	LL		-	-	-	-	-	
0.0011	LS		-	-	-	-	-	
0.0011	SS	-	-	-	-	-	-	-
0.0165	LL	250	0.950(6)	0.928(11)	0.932(14)	0.950(7)	0.885(5)	0.978(7)
0.0165	LS	161	0.921(2)	0.931(2)	0.936(2)	0.942(2) -	0.865(5)	0.955(2)
0.0165	SS	-	-	-	-	-	-	-

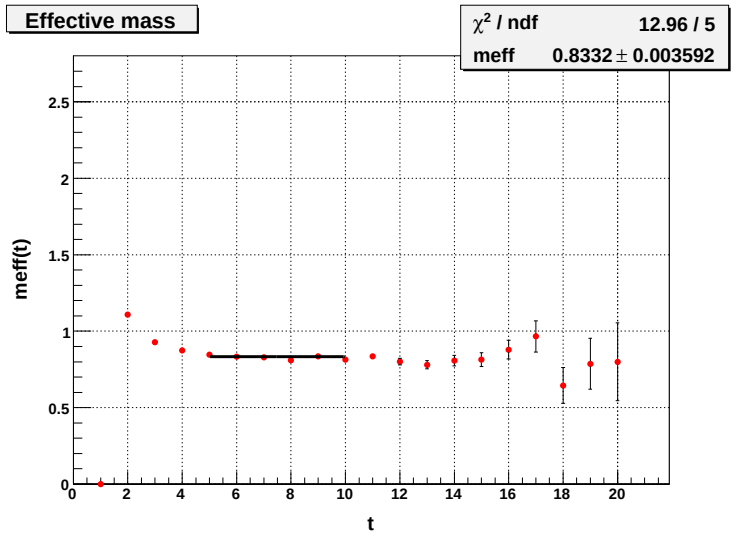
Example of Plateaux : Ω Baryon





Smeared-Smeared

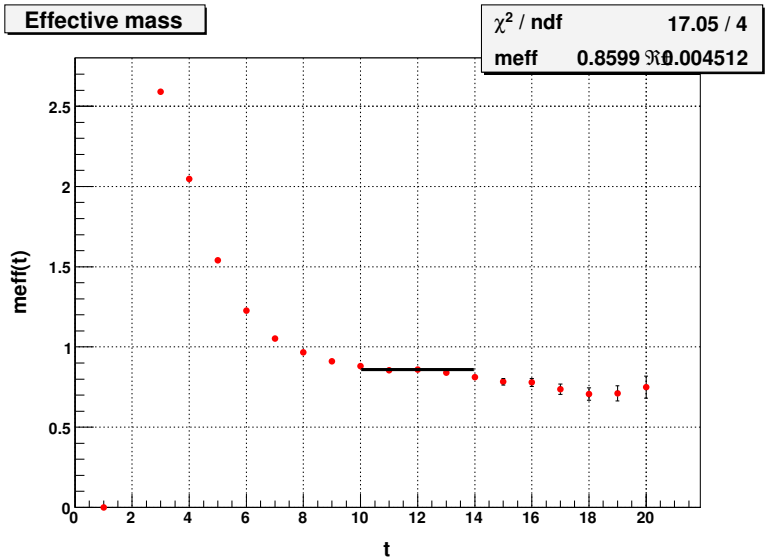
$\beta = 3.9\ \mu = 0.0085$



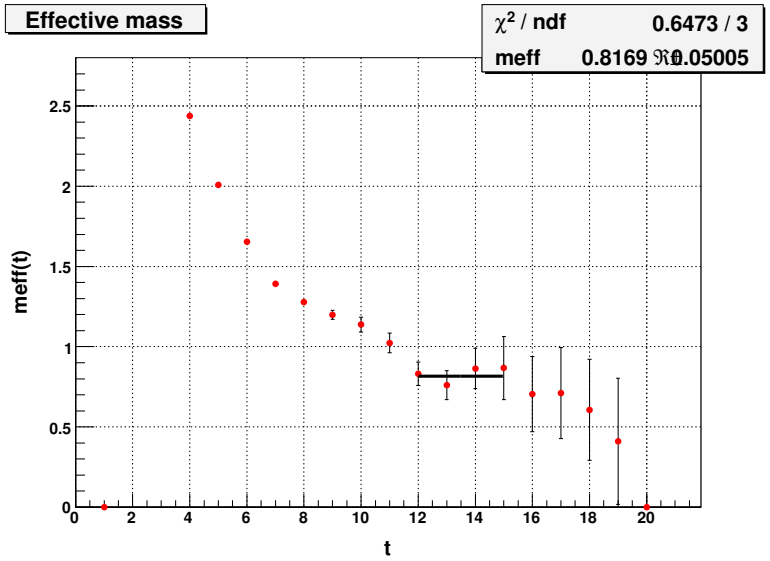
Ω Mass

- 2 s quark : s_{up} and s_{down}
- Computation of the Ω mass (sss) with different s quark
- If we want to keep the structure of contraction we have to change all s_{up} in s_{down}

$\Omega = s_{up}s_{up}s_{up}$



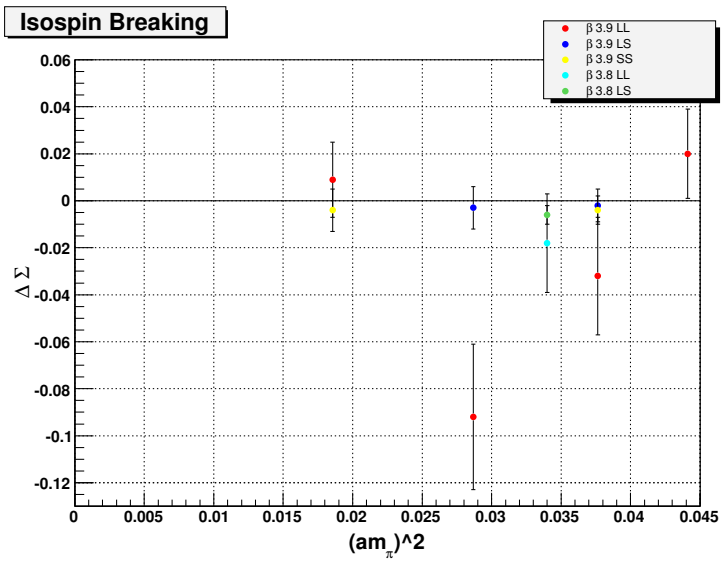
$\Omega = s_{down}s_{down}s_{down}$



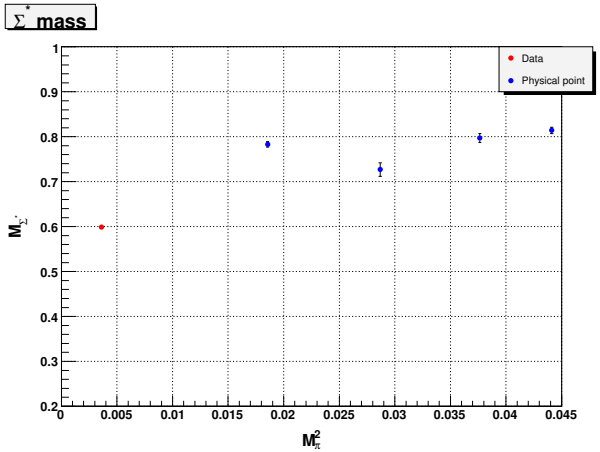
- Local analysis $\beta = 3.9$ with only 114 configuration
- Effective mass obtained with the interpolating field $s_{down}s_{down}s_{down}$ is not clean at all

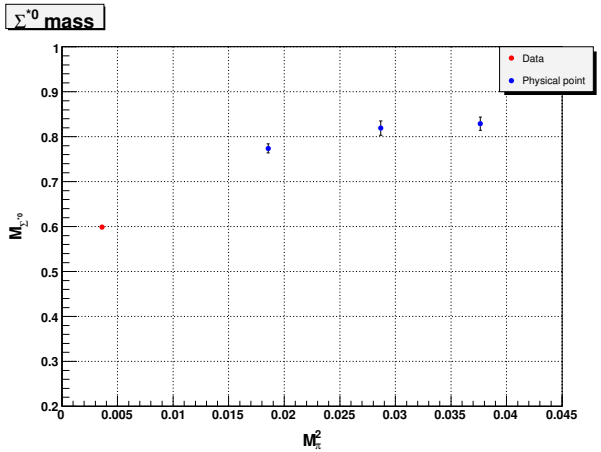
Isospin Breaking

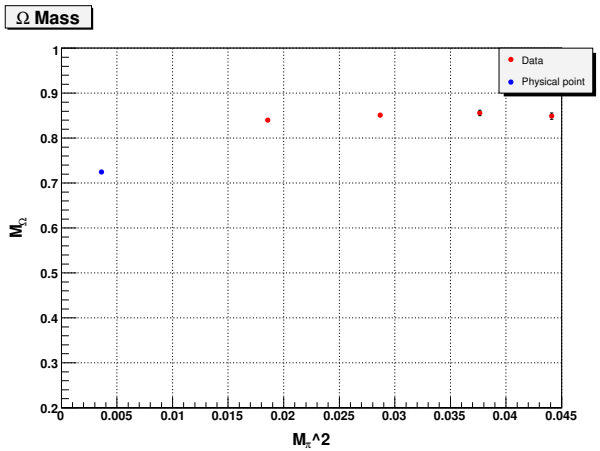
- Test of isospin breaking in the Σ^* sector
- Close from 0 for smeared results

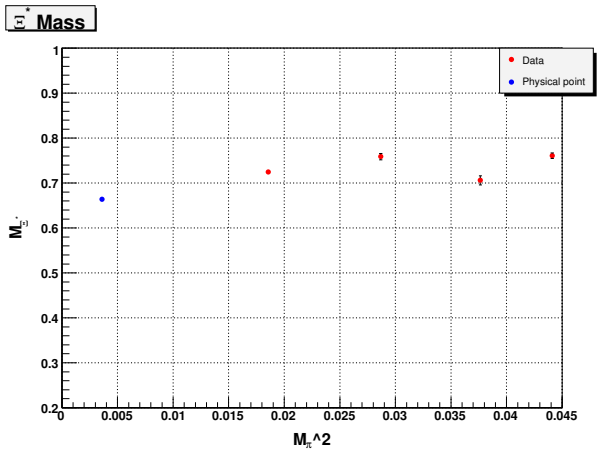


Chiral extrapolation









- Local results for the whole Decuplet at $\beta = 3.9$
- Physical point in blue
- Linear fit in m_π globally better ...

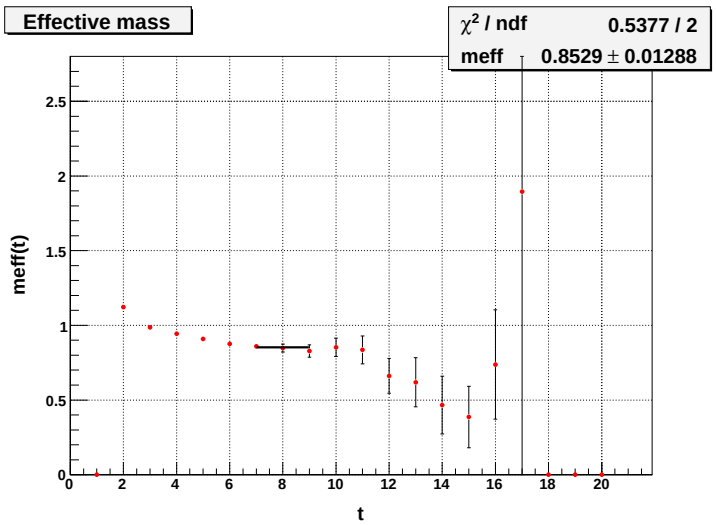
Summary

- Inversion of the state Ξ^* and Σ^* at $\beta = 3.9$
- Situation even worst at $\beta = 3.8$
- Ω have very small dependance in the pion mass BUT is too heavy. ($\sim$ 1.9 GeV)
- Is there some strong lattice artefact ? don't forget that : $M_\Omega^{latt} \sim 2$ GeV $\sim a^{-1}$ at $\beta = 3.9$
- Study of lattice spacing dependance very important to do
- Question of the chiral extrapolation still open ...
- Isospin breaking seem to be small if we trust Smeared correlators
- Analysis has to be done carefully to obtain results in agreement between local and smeared correlators

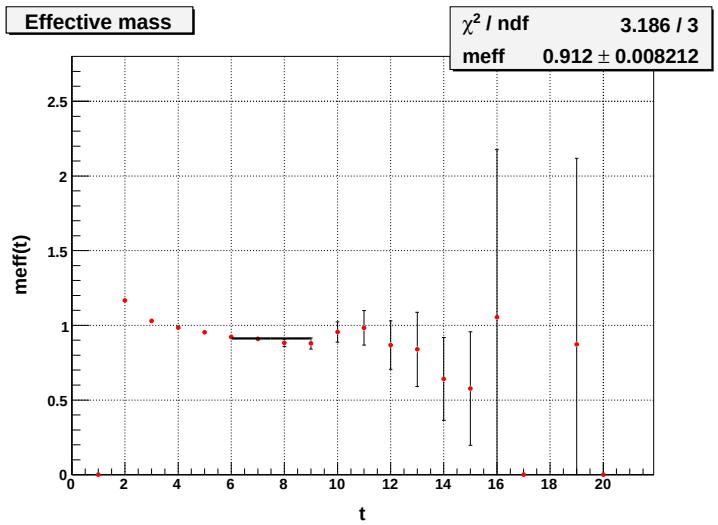
Negative parity state

$\beta = 3.9$ $\mu = 0.0085$ LS correlators projection on negative parity state

Nucleon partner



Lambda partner



- $\left(\frac{M_N^+}{M_N^-}\right)^{exp} \sim 0,611$ and $\left(\frac{M_N^+}{M_N^-}\right)^{lat} \sim 0,678$

To do ...

- Compute the mass of the octet and of the decuplet at $\beta = 4.05$
- Compare result obtain by other colaboration
- Problem of the chiral extrapolation
- Define a strategy for the analysis
- Excited states ? negative parity states ?