Measuring the ξ'' Michel Parameter in the Polarized Muon Decay

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contents of the talk

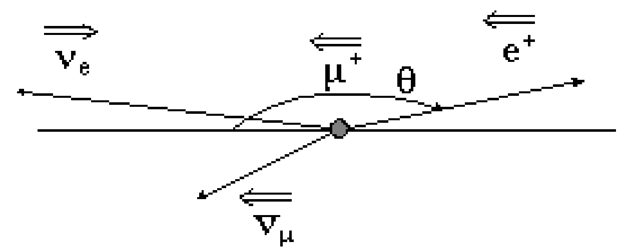
- What are our motivations?
- Which informations do we needed to trust the results?
- How does the setup look like?
- Some very crude results ...
- Conclusion

Why do we study the muon decay?

	PDG value	V-A
ρ	0.7518 ± 0.0026	0.75
δ	0.749 ± 0.004	0.75
η	-0.007 ± 0.013	0
ξ	1.005 ± 0.009	1
ξ'	1.00 ± 0.04	1
ξ''	0.65 ± 0.36	1
η''	0.012 ± 0.016	0
α'/A	-0.0002 ± 0.0043	0
β'/A	-0.0015 ± 0.0063	0

the μ decay:

$\mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu$



The observables are:

- $\vec{k}_e(x)$
- $\vec{P}_\mu(P_\mu, \cos\theta)$
- $\vec{P}_e(P_L, P_{T_1}, P_{T_2})$

The measure of ξ'' comes from $\left(\frac{\xi''}{\xi\xi'} - 1\right) \;=\; -0.35 \pm 0.33$ Burkard & al. Phys. Lett. 150B(1985)242.

The 9 Michel parameters completely describe the observables in the μ decay if the ν's are not observed.

A) Test of the Standard Model

The longitudinal e^+ polarization P_L coming from the μ^+ decay =

$$P_L(x, \cos\theta) = \xi' \left[1 + \frac{P_\mu \xi \cos\theta (2x-1)}{(3-2x) + P_\mu \xi \cos\theta (2x-1)} \left(\frac{\xi''}{\xi\xi'} - 1\right)\right]$$

$$P_\mu = \textit{Muon polarization}$$

$$\theta = \textit{Angle between the muon spin and the positron momentum}$$

$$x = \frac{E_{e^+}}{E_{max}}$$

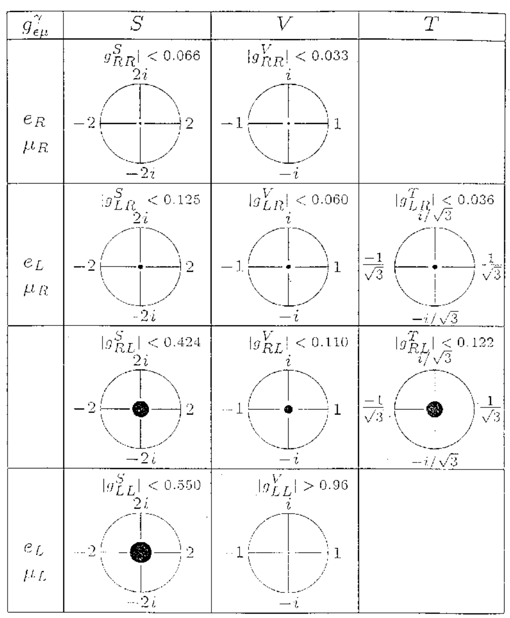
If we want $\left(\frac{\xi''}{\xi\xi'} - 1\right) = 0 \pm 0.005$, then we should measure $P_L(e^+) = 1 \pm 0.03$

$\Longrightarrow$ the Standard Model value is OK .

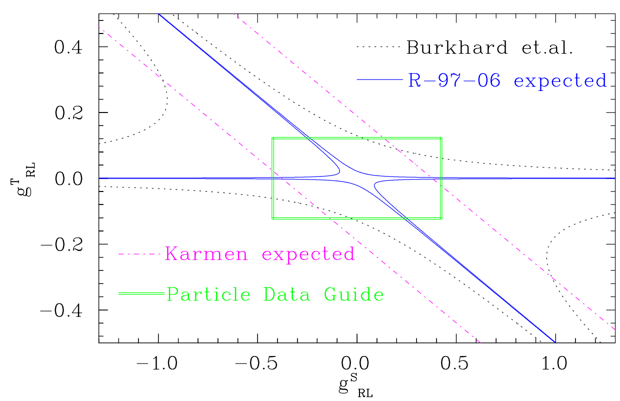
B) Test of models behind the SM

$$\frac{\xi''}{\xi\xi'} - 1 \;=\; 4\left[2\frac{\left|g^V_{RL}\right|^2}{\left|g^V_{LL}\right|^2} + \frac{\left|g^V_{RR}\right|^2}{\left|g^V_{LL}\right|^2} + \frac{1}{4}\frac{\left|g^S_{RR}\right|^2}{\left|g^V_{LL}\right|^2} + 4\frac{\left|g^T_{RL}\right|^2}{\left|g^V_{LL}\right|^2} + 2\mathcal{R}\left(\frac{g^S_{RL}}{g^V_{LL}}\frac{g^{T*}_{RL}}{g^{V*}_{LL}}\right)\right]$$

In V-A electoweak interaction: $g^V_{LL} \;=\; 1$, all others constants $=\; 0$.



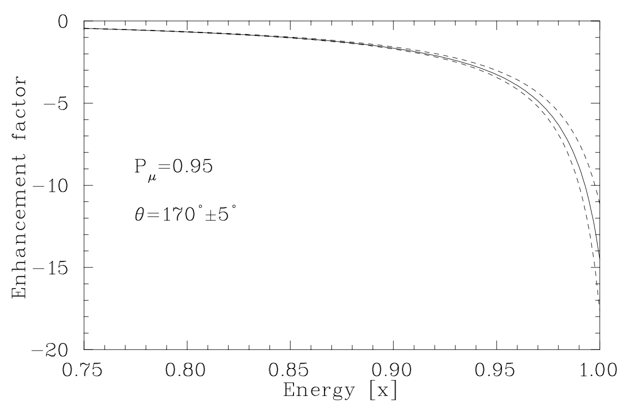
If only $g^{S,T}_{RL}$ remain, we can give new limits:



Why do we trust our results

$$P_L(x, \cos\theta) \;=\; \xi' \left[1 + \frac{P_\mu \xi \cos\theta(2x-1)}{(3-2x)+P_\mu \xi \cos\theta(2x-1)} \left(\frac{\xi''}{\xi\xi'} - 1\right)\right]$$

- Relative measurement: $\frac{P_L(P_\mu=.95)}{P_L(P_\mu=0.12)} \;=\; R \;=\; 1 - \frac{A_{exp}}{1-A_{exp}} \left(\frac{\xi''}{\xi\xi'} - 1\right)$
  with $A_{exp} = e^+$ emission asymmetry
- Energy dependance



$\Longrightarrow$ Energy selection from 48 to 52.8 MeV

$\Longrightarrow$ Angular acceptance from 170° to 190°

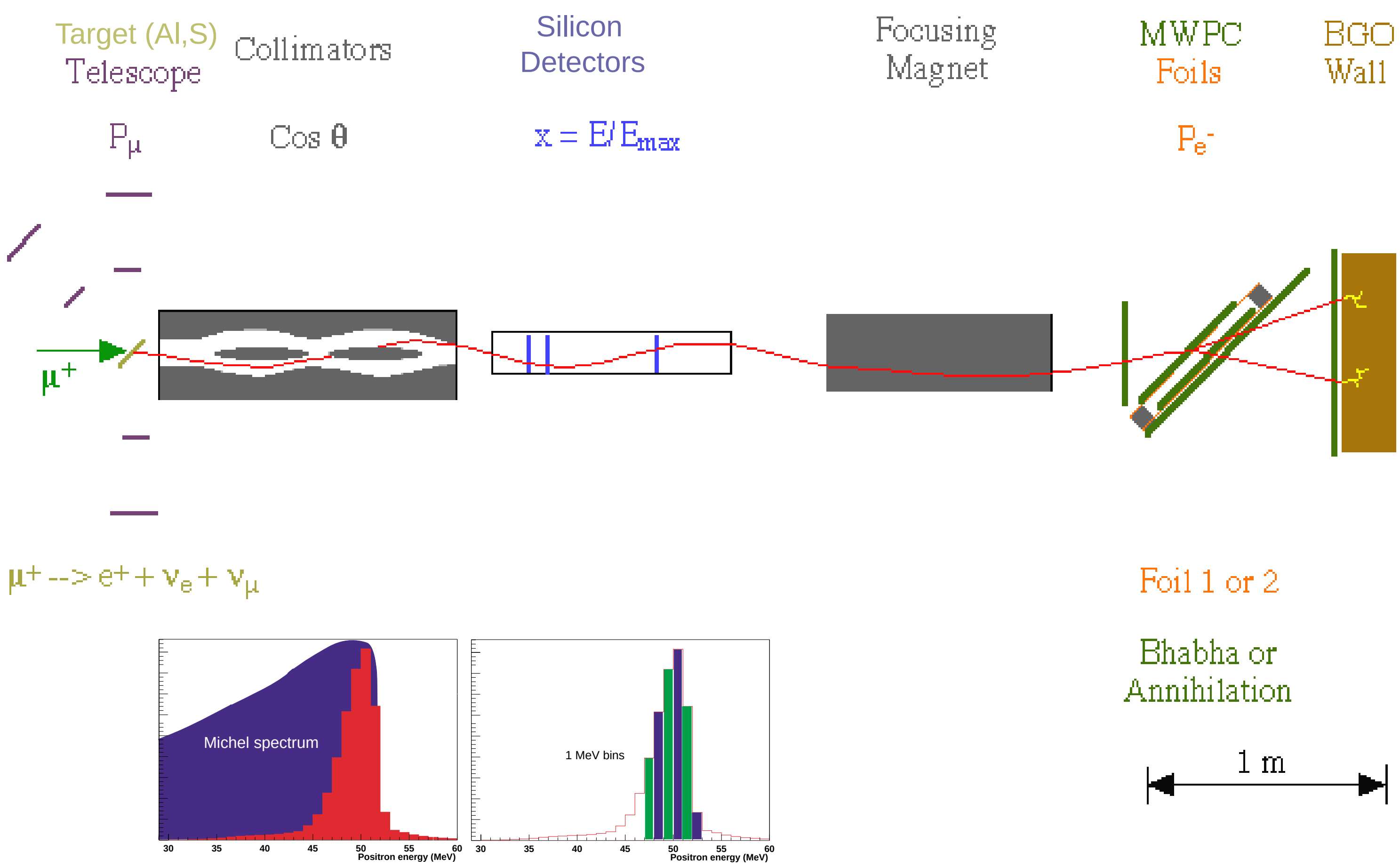
- Analysis with Annihilation and Bhabha events (with opposite analysing powers).

with $A \;=\; \frac{\sigma_{\uparrow\uparrow}-\sigma_{\uparrow\downarrow}}{\sigma_{\uparrow\uparrow}+\sigma_{\uparrow\downarrow}}$ the theoratical analysing power asymmetry

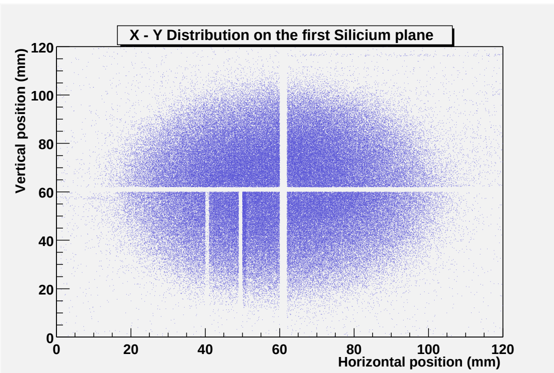
and $a \;=\; \frac{n_{\uparrow\uparrow}-n_{\uparrow\downarrow}}{n_{\uparrow\uparrow}+n_{\uparrow\downarrow}}$ the asymmetry of the measured rates,

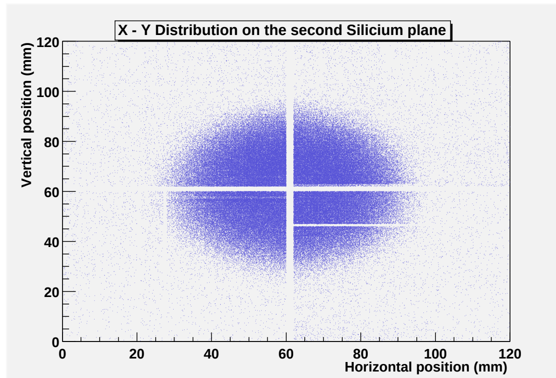
we have: $P_L \;=\; \frac{a}{AP_{e^-}}$

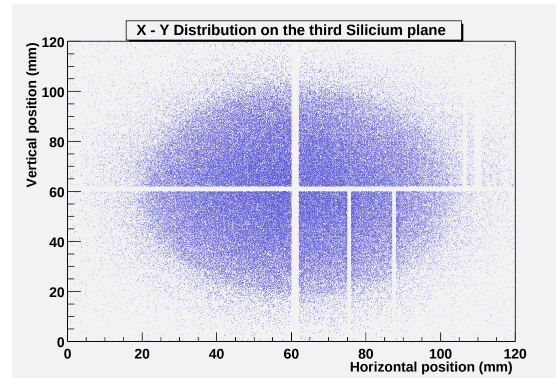
The experimental setup

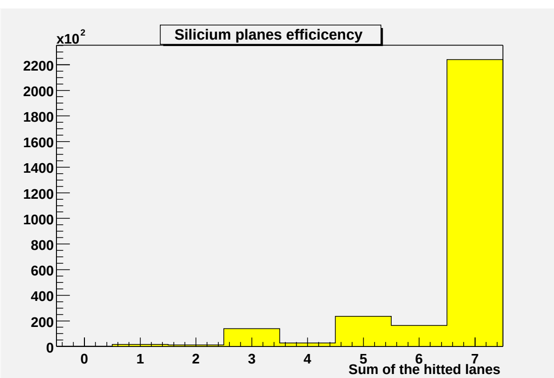


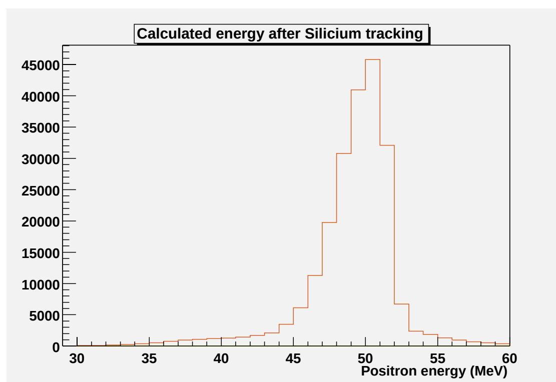
The Silicium tracker









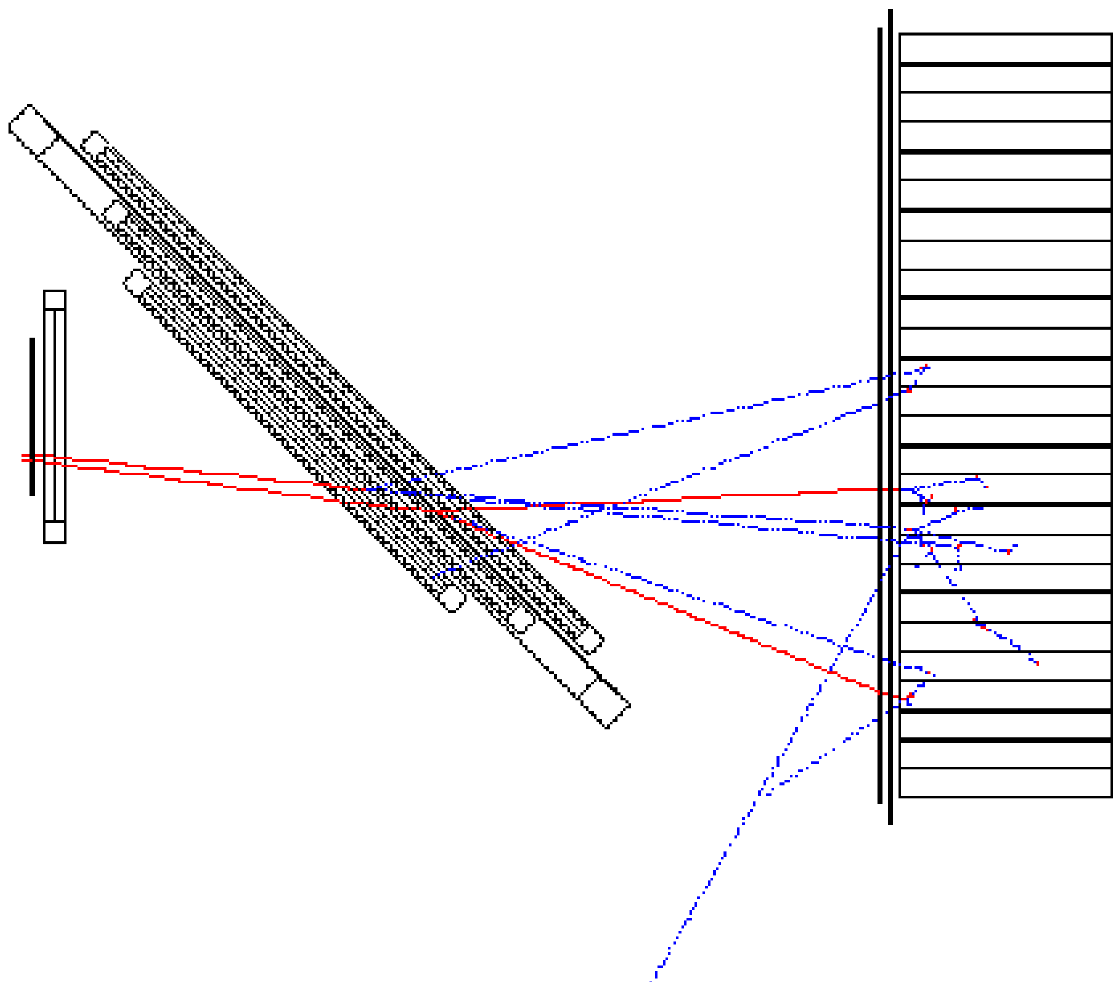


Silicium resolution:

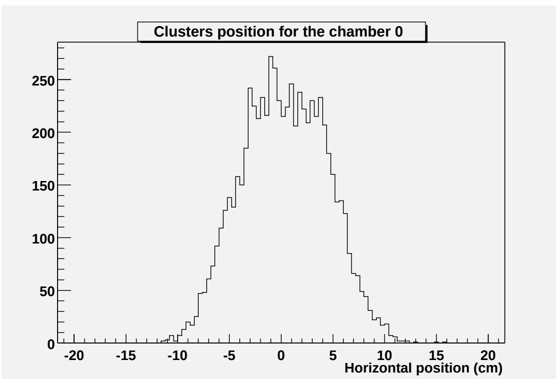
$1.12\ MeV$ for $P_\mu = 0.12\%$

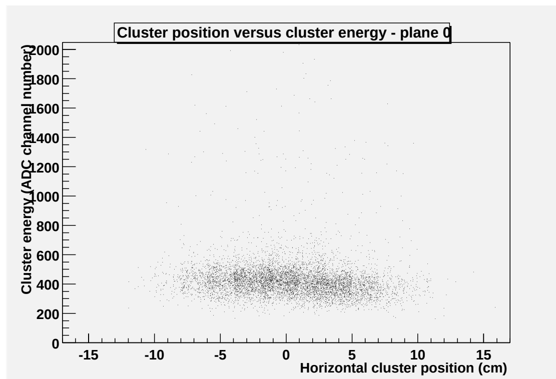
$1.19\ MeV$ for $P_\mu = 0.95\%$

The Polarimeter



The Multi Proportional Wire Chambers





Efficiency of the chambers:

chamber 0: $\sim$ 100%

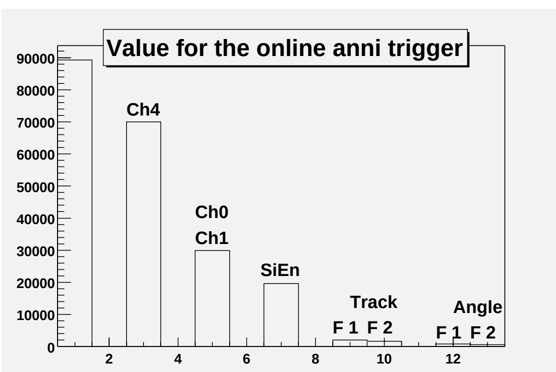
chamber 1: $\sim$ 99.8%

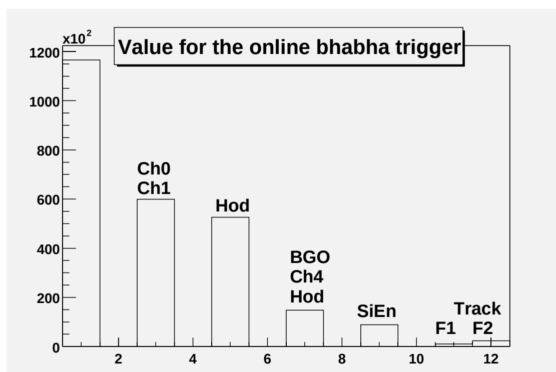
chamber 2: $\sim$ 97%

chamber 3: $\sim$ 96%

chamber 4: $\sim$ 98.5%

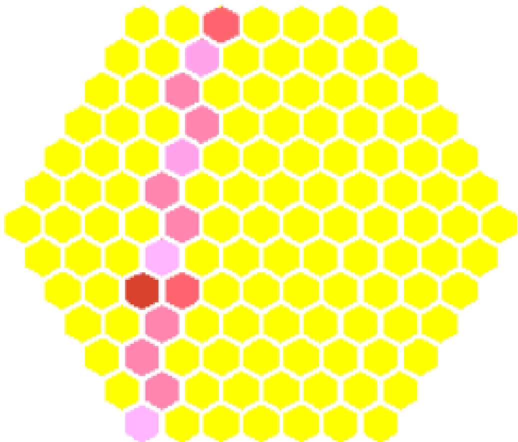
Total: $\sim$ 91.5%

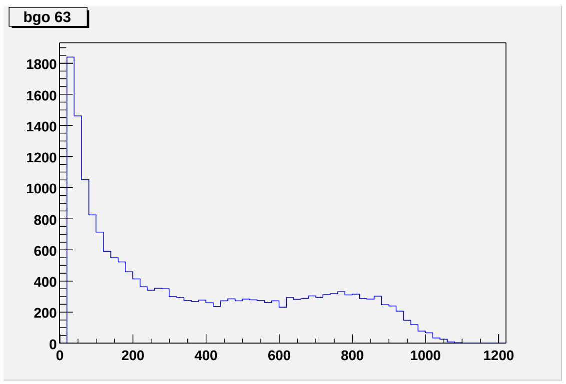




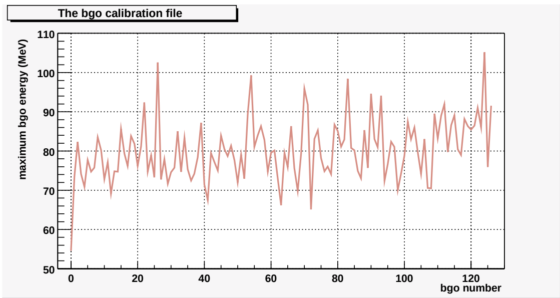
$\Longrightarrow$ Asymmetry calculations are possible

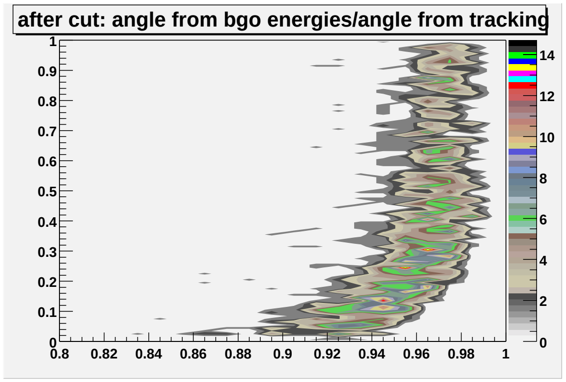
The BGO's wall





Signal stability:
peaks are stable within 1% on a period of two days.





The bgo's energy sum has to be bigger than 60% of the given Silicium energy

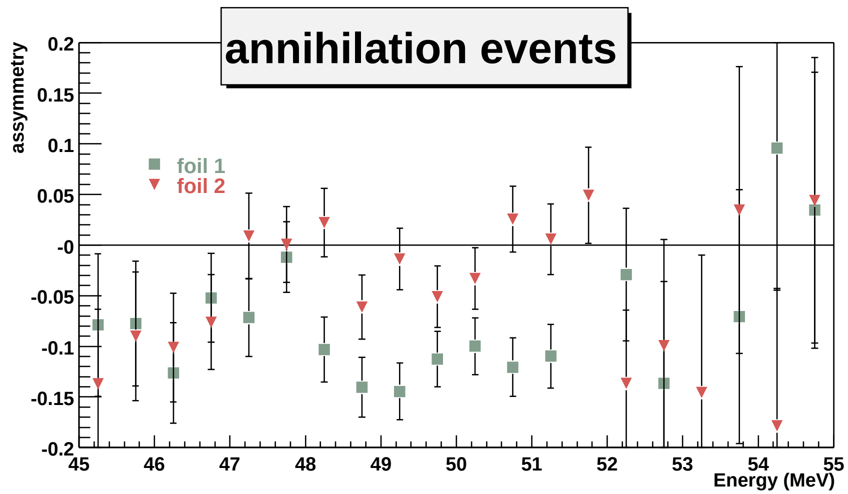
Data from the last run

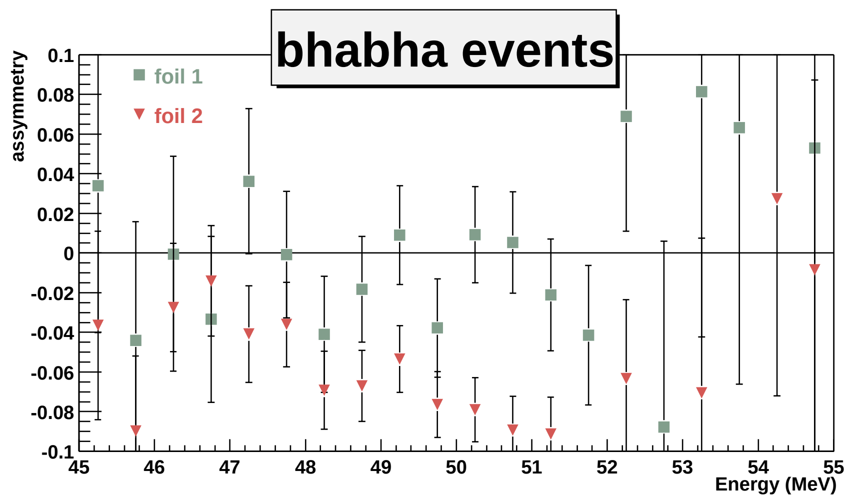
Number of analysed triggers: 20309346.

$\Longrightarrow$ We have 100 times more statistics!!!

Statistics of the last run:

		Number of triggers	
Pos.	target	$I_{foils} < 0A$	$I_{foils} > 0A$
$+45°$	S	449997312	451675008
	Al	433657408	443233792
$-45°$	S	462856256	465895712
	Al	459272000	436142688





Conclusion

During the last run, we obtained:

- enough statistics,
- a good energy selection (the enhancement factor depends on the energy),
- data with different geometries and e^- polarization (systematics).

To get the final results, we will:

- check the stability of the whole apparatus,
- check the background and understand it (compare it with Monte Carlo),
- check the systematics for the different energies and geometries.

My personal conclusion: I'm quite optimistic for the future...