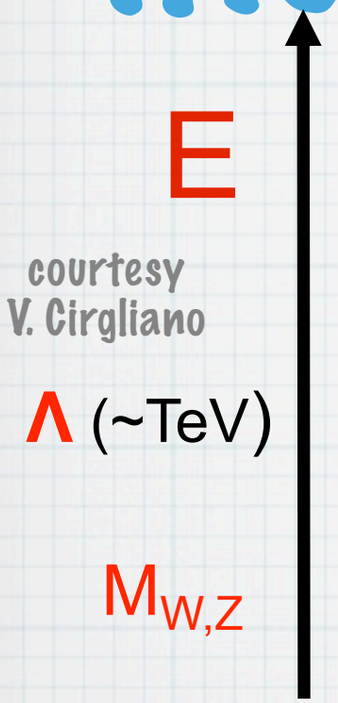
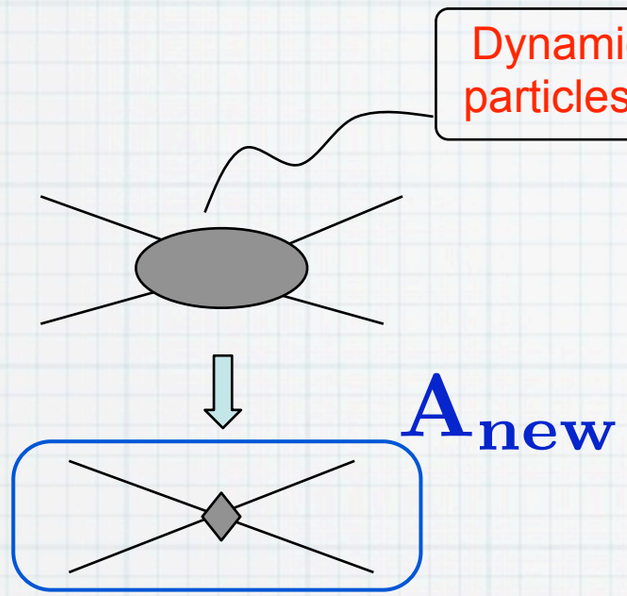
The MOLLER Project:

3 Slides for the PAC

MOLLER Motivation

Many theories predict new particles & interactions that disappeared when the universe cooled





$$\mathcal{L}_{SM+\mathrm{Heavy}}$$

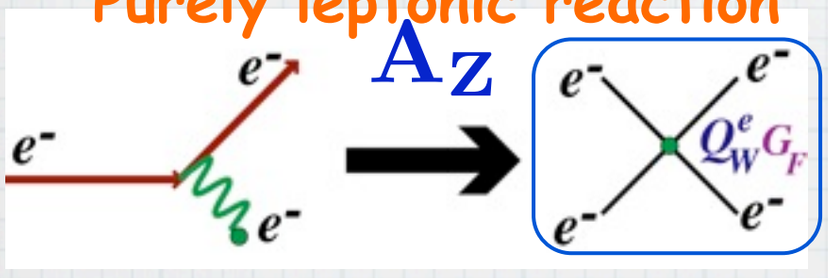
$$\mathcal{L}_{\mathrm{eff}} = \mathcal{L}_{SM} + \sum_{d\geq 5} \frac{c_n^{(d)}}{\Lambda^{d-4}} \hat{O}_n^{(d)}[\phi_{SM}]$$

A comprehensive search for clues requires:

Large Hadron Collider *as well as* **Lower Energy: $Q^2 \ll M_Z^2$**

Parity-violating Møller Scattering $A_{PV} = \dfrac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow}$

Purely leptonic reaction



$$\left|A_\gamma + A_Z + A_{new}\right|^2 \rightarrow A_\gamma^2 \left[1 + 2\left(\frac{A_Z}{A_\gamma}\right) + 2\left(\frac{A_{new}}{A_\gamma}\right)\right]$$

$$A_{PV} \propto \frac{A_Z}{A_\gamma} \propto m_e E_{lab} Q_W^e \propto (1 - 4\sin^2\theta_W)$$

Electromagnetic amplitude interferes with weak amplitude as well as any new physics

$$\frac{\delta(\sin^2\vartheta_W)}{\sin^2\vartheta_W} \cong 0.05 \frac{\delta(A_{PV})}{A_{PV}}$$

$\delta(Q_W^e) \sim$ ***2%*** ⇨

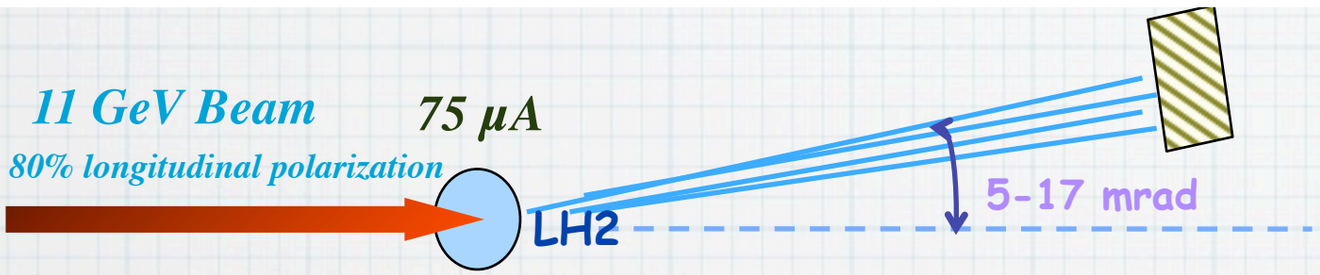
$\delta(\sin^2\theta_W) \sim$ ***0.1%***

MOLLER Reach

Run Period	1kHz Width (ppm)	% Stat. Error	Stat. Error (ppb)	PAC Days (Prod.)	Eff. %	Calendar Weeks (Prod.)	Comm. Weeks	Total Weeks
I	100	11.0	2.88	14	40	5	6	11
II	95	4.04	1.05	95	50	27	3	30
III	90	2.43	0.63	235	60	56	4	60
		2.05	0.53	**344**			**13**	101

Table 4.1: *Summary of the Estimated Beam Time (75 μA, $P_e = 80\%$).*

parameter	value
cross-section	45 μbarn
Rate @ 75 μA	135 GHz
pair stat. width (1 kHz)	83 ppm
$\delta(A_{raw})$ (344 days)	0.53 ppb
$\delta(A_{stat})/A$ (80% pol.)	2.1%
$\delta(\sin^2\theta_W)_{stat+syst}$	0.00029



A_{PV} = 35.6 ppb → 344 days → $\delta(A_{PV})$ = 0.73 ppb

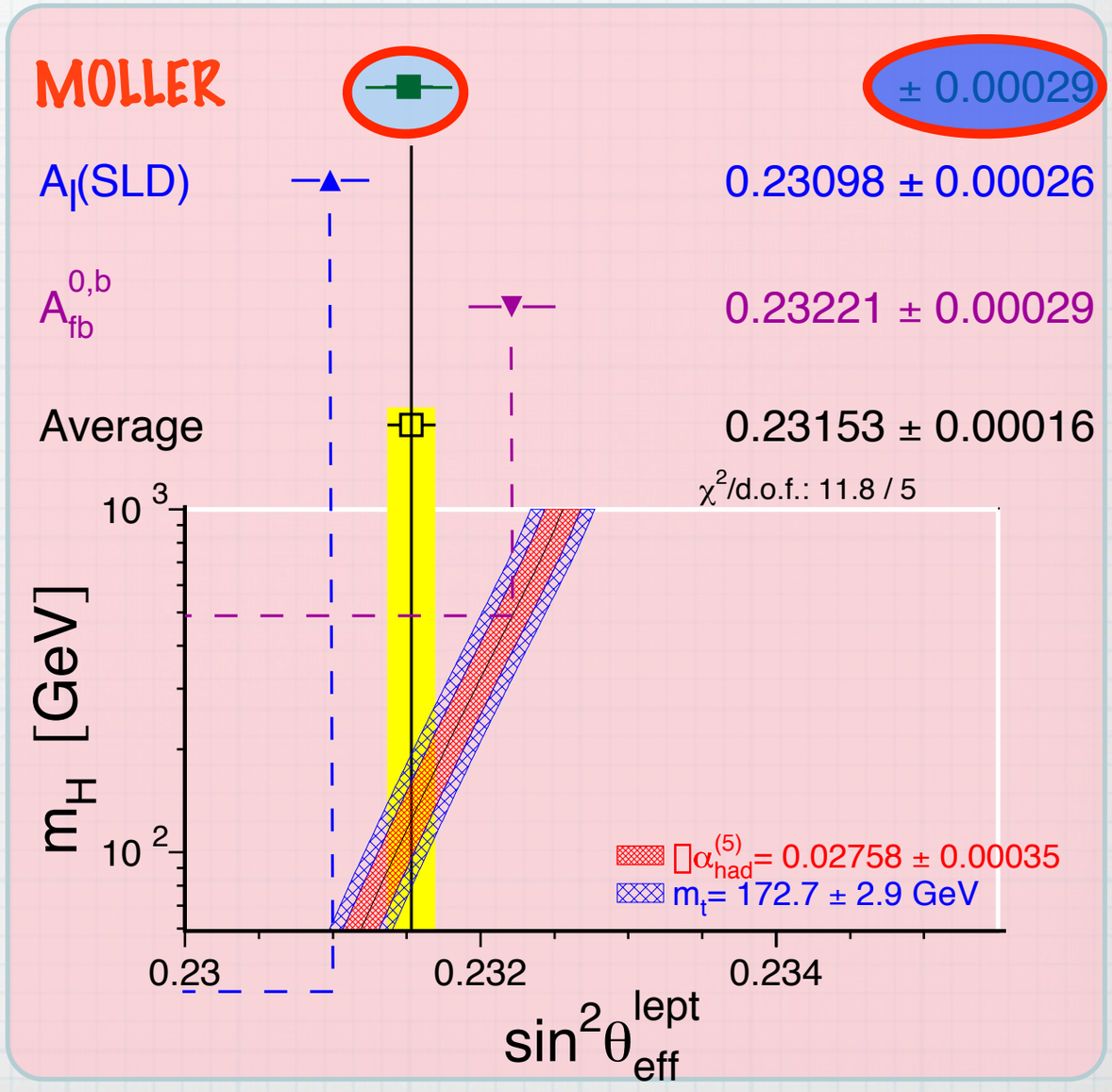
$\delta(Q^e_W)$ = ± 2.1 (stat.) ± 1.0 (syst.) %

$$\mathcal{L}_{e_1e_2} = \sum_{i,j=L,R} \frac{g_{ij}^2}{2\Lambda^2} \bar{e}_i \gamma_\mu e_i \bar{e}_j \gamma^\mu e_j$$

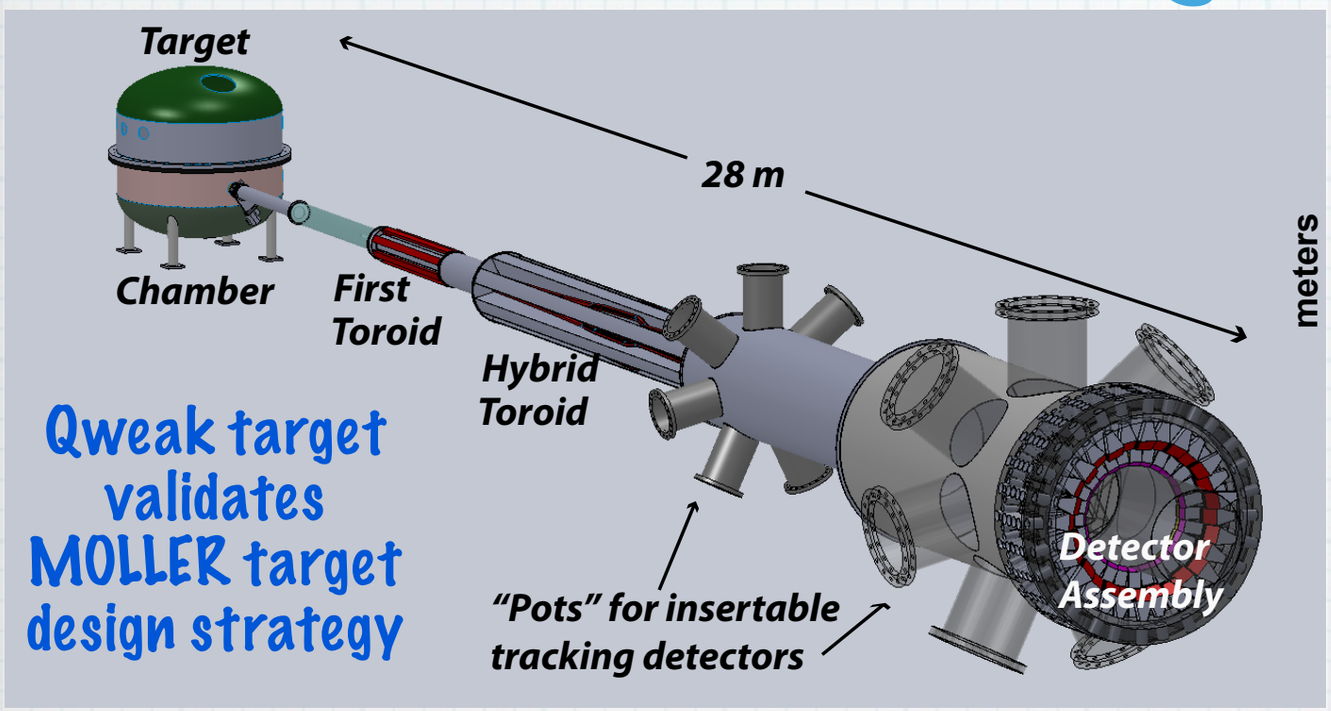
$$\Rightarrow \quad \frac{\Lambda}{\sqrt{|g_{RR}^2 - g_{LL}^2|}} = 7.5 \text{ TeV}$$

best contact interaction reach at low Q^2

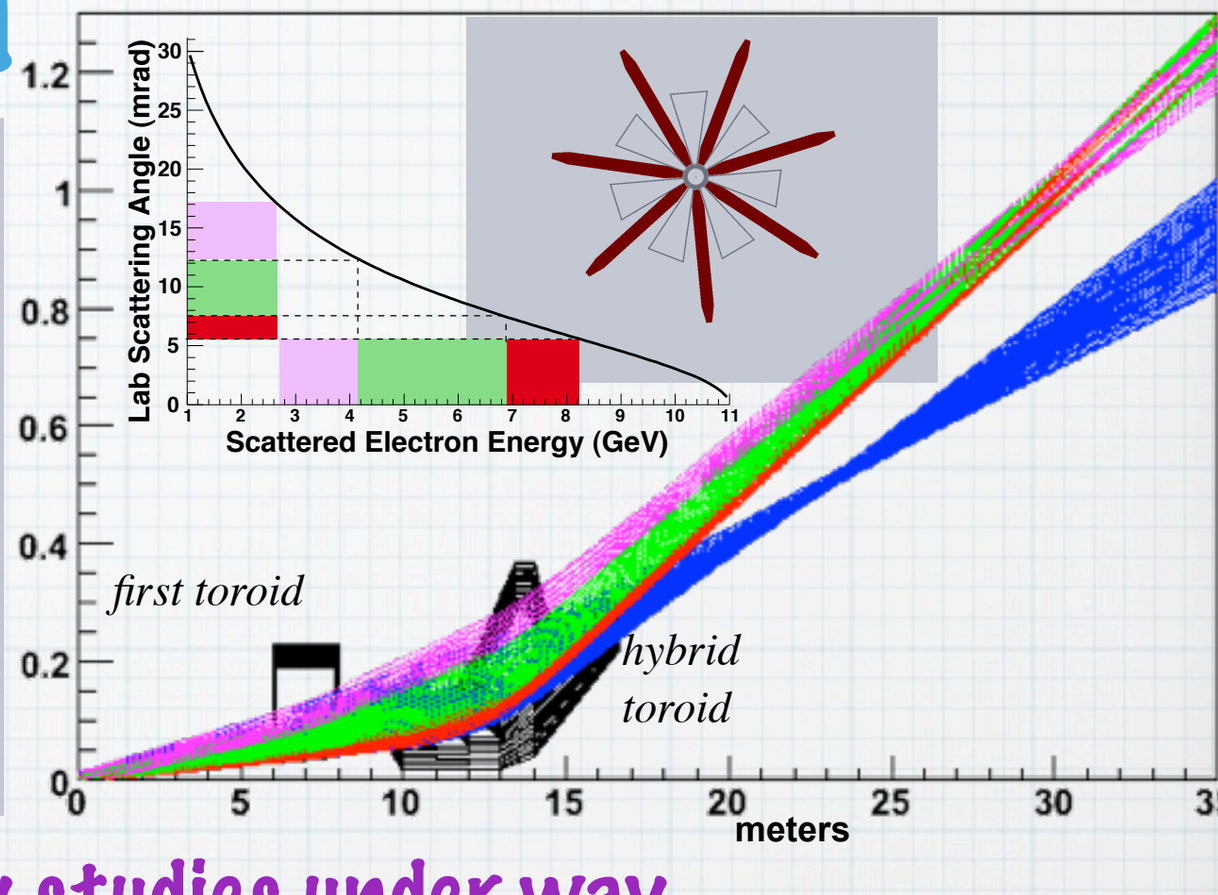
Critical input to interpret LHC anomalies



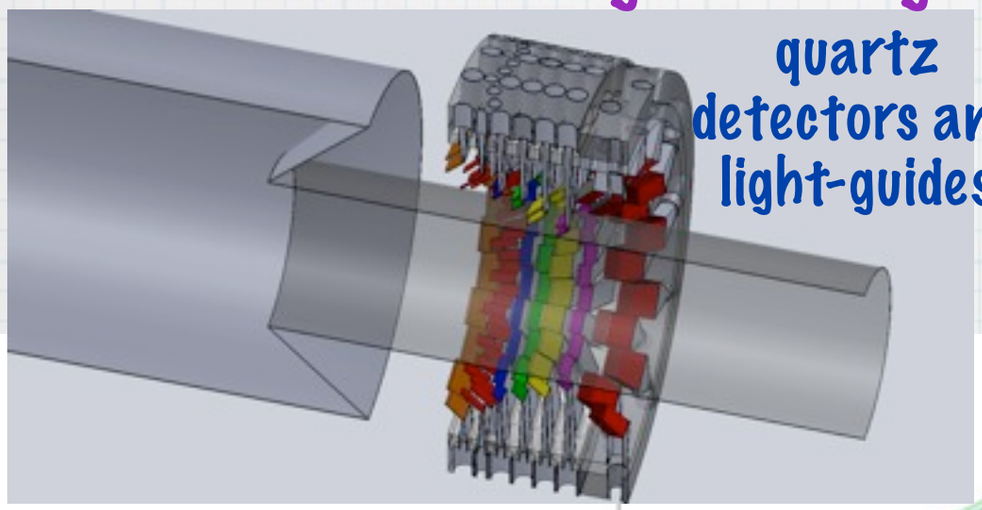
MOLLER Design

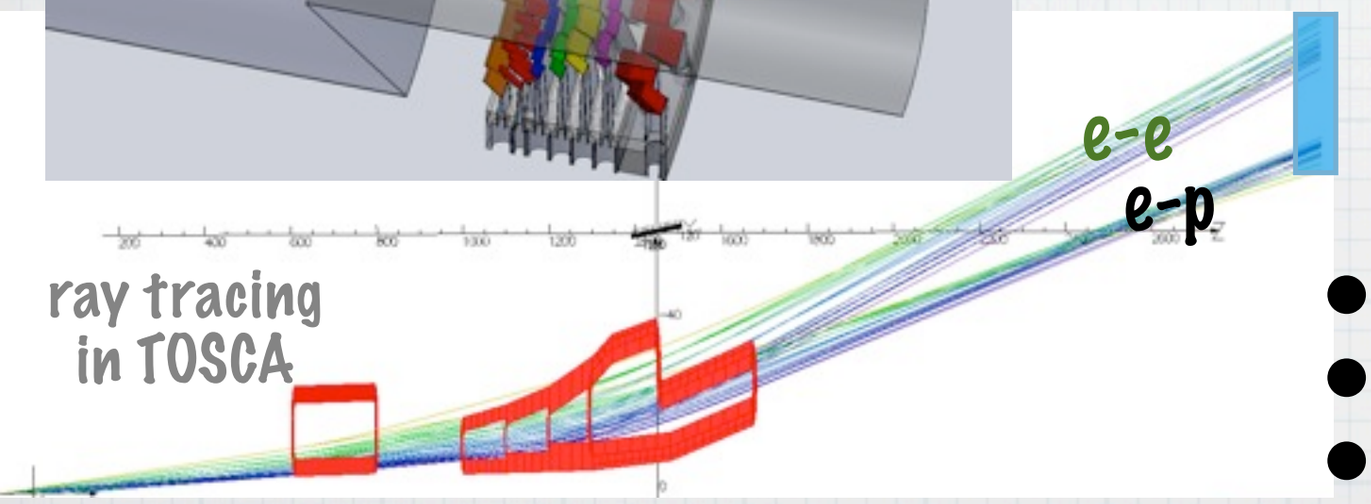


Qweak target validates MOLLER target design strategy



Engineering feasibility studies under way





A buildable coil configuration (shown) has yielded the proposal field map

- Strong Collaboration (approx. 100)
- Experience (E158/HAPPEX/GO/Qweak)
- Eager to get funding launched!