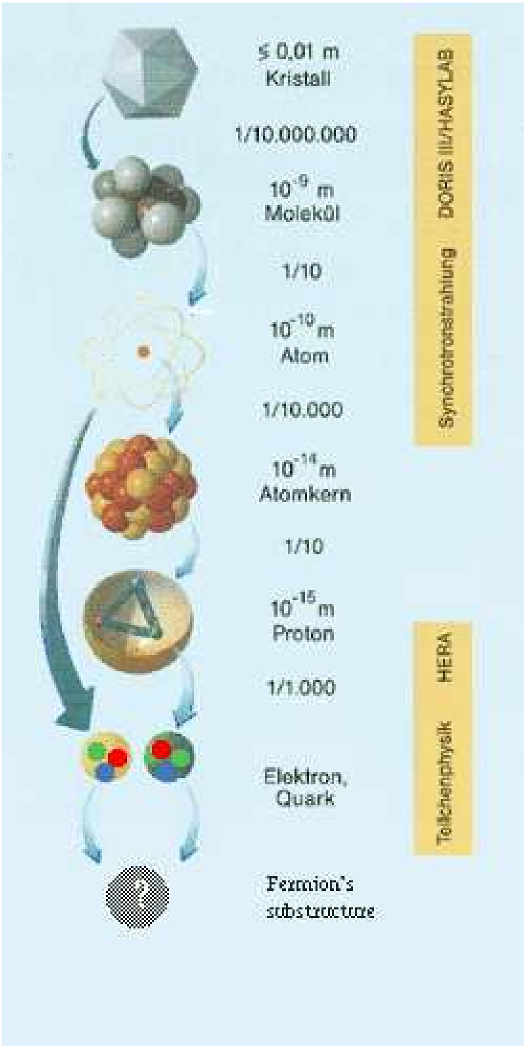
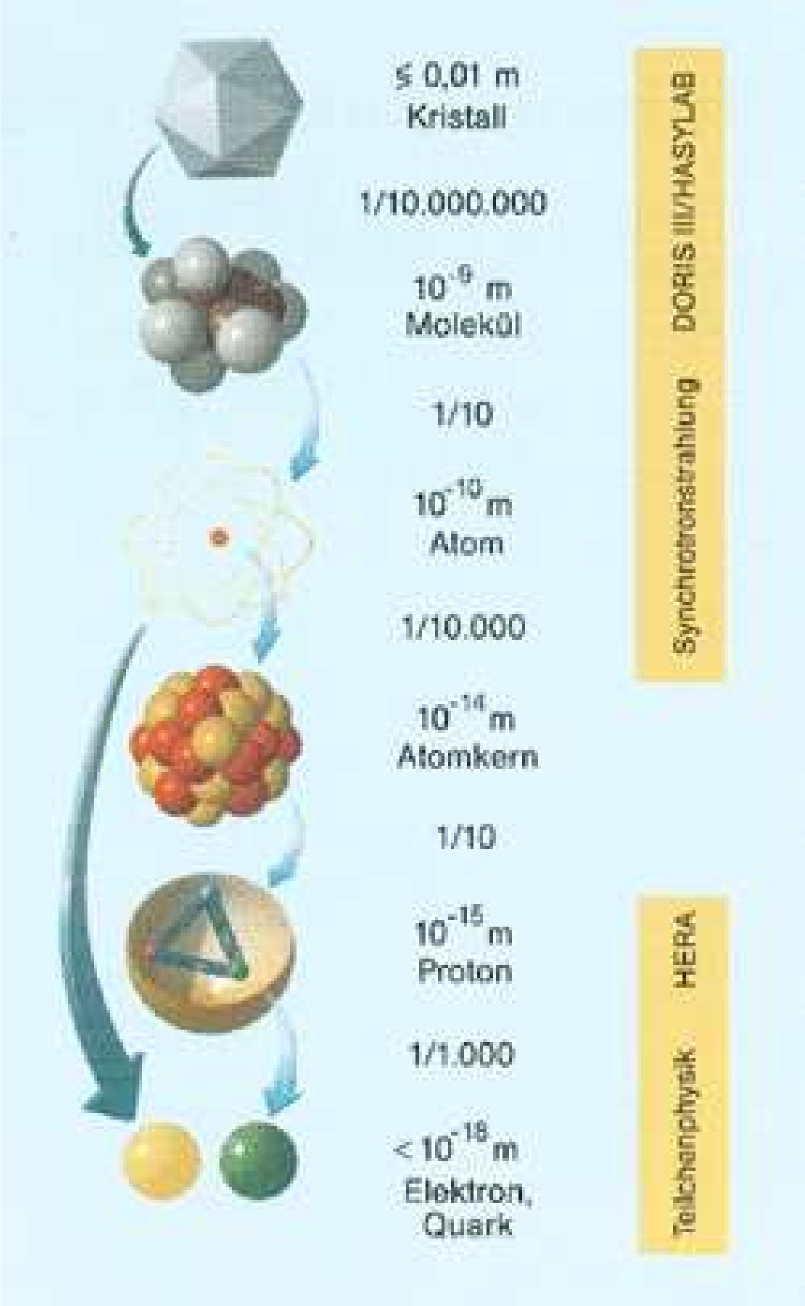
Excited fermions: Do the fermions have a substructure?

Nicolas Delerue



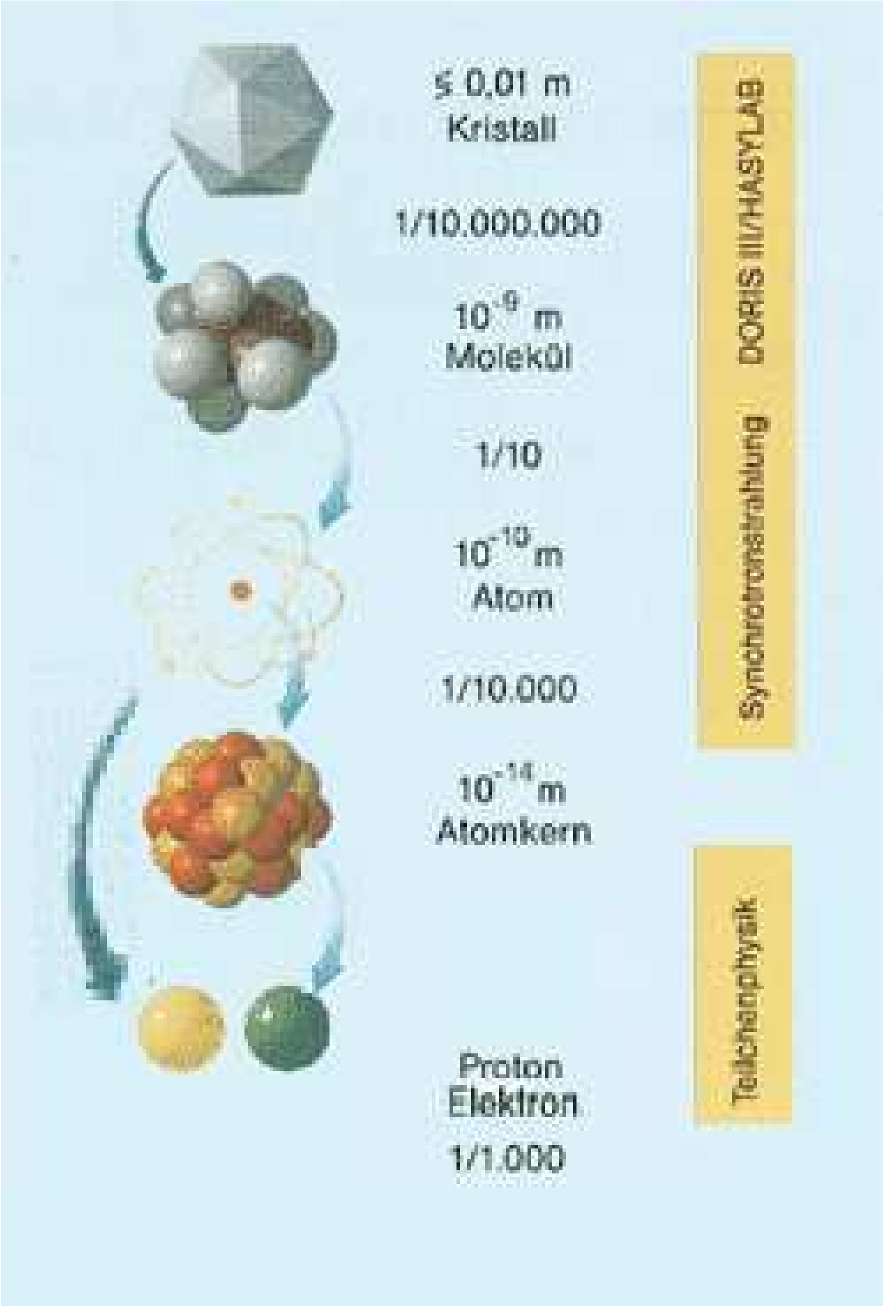
October 2000

DESY's current poster



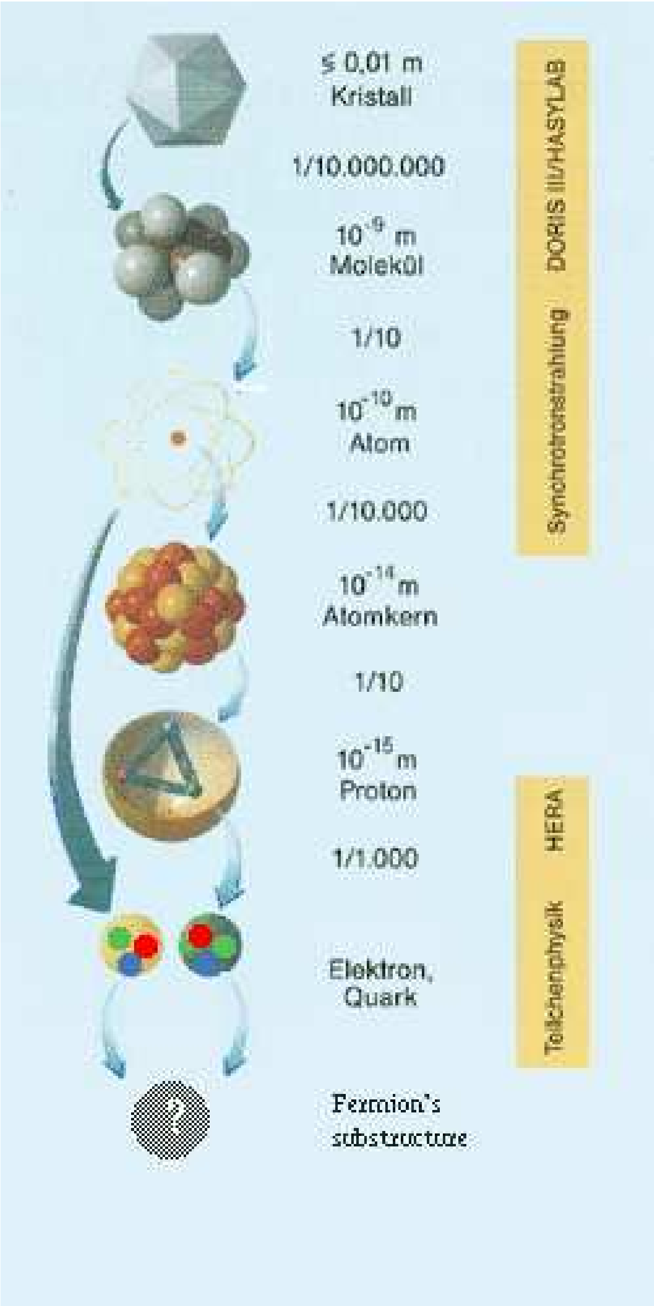
But 50 years ago, before Gell-Mann discovery...

DESY poster 50 years ago.



So, what will be next ?

The futur DESY poster?



Finding this substructure of the fermions is the subject of my PhD. thesis

Example of Theoretical models

The Rishons (H.Harari, Physics Letters, 86B(1979)83)

- 2 Rishons “T” and “V”
- Fermions and bosons are made of triplets of Rishons.
- e.g.: $e^- \simeq (\bar{T}\bar{T}\bar{T})_{1,1}$

The Haplons (H.Fritzsch and G.Mandelbaum, Physics Letters, 105B(1981)319)

- Fondamental particles are:
  - the photon and the gluons
  - $n^2 - 1$ hypergluons
  - 2 fermions (α and β)
  - 2 scalars (x and y)
- Fermions and bosons are made by pairs of these 2 fermions and scalars.
- e.g.: $e^- \simeq (\bar{\beta}\bar{y})_1$

But isn't it too early to follow a given theoretical model ?

Phenomenology

- Fermion's substructure would allow excited states.
- These excited states would be short-lived wrt H1's size.
- But we can search their decay products in the data.
- $\Rightarrow$ need a phenomelogical model for the decay of an f^*.
- No clue in favor of a given model $\Rightarrow$ most general lagragian
- This Lagrangien describes magnetic transition between f^* and f.
- Hagiwara, Komamiya and Zeppenfeld, Z.Phys C29(1995)115

The excited fermion effective lagrangian

$$\mathcal{L}_{int} = \frac{1}{2\Lambda} F_R^* \sigma^{\mu\nu} \left[g f \frac{\tau^a}{2} W_{\mu\nu}^a + g' f' \frac{Y}{2} B_{\mu\nu} + g_s f_s \frac{\lambda^a}{2} G_{\mu\nu}^a \right] F_L + h.c$$

where $W_{\mu\nu}^a$, $B_{\mu\nu}$ and $G_{\mu\nu}^a$ are the field-strength tensors of the $SU(\mathbf{2})$, $U(\mathbf{1})$ and $SU(\mathbf{3})_C$ gauge fields, $\mathbf{\Lambda}$ is the compositeness scale and f, f' and f_s are form factors associated to the three gauge groups.

Using this Lagrangian we generate f^*-like events and compute cross-sections for given parameters...

Then the hunt can start...

The main decay modes of excited fermions

	ν^*	e^*	q^*
γ decay	$\nu^* \to \nu\gamma$	$e^* \to e\gamma$	$q^* \to q\gamma$
W decay	$\nu^* \to eqq$	$e^* \to \nu qq$	$q^* \to qqq$
Z decay	$\nu^* \to \nu qq$	$e^* \to eqq$	$q^* \to qqq$

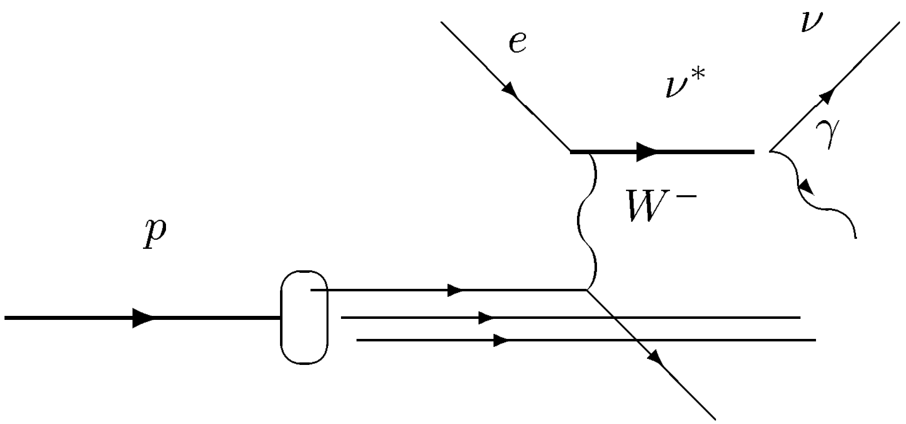
All these decay modes were covered for e^+p 820 GeV data

For e^-p: ν^* decays modes are under study, 2 are already stamped preliminary.

Analysis started with ν^* channels as the discovery potential was bigger there.

All other channels will be studied together with e^+p 920 GeV data

The $\nu^* \to \nu + \gamma$ channel



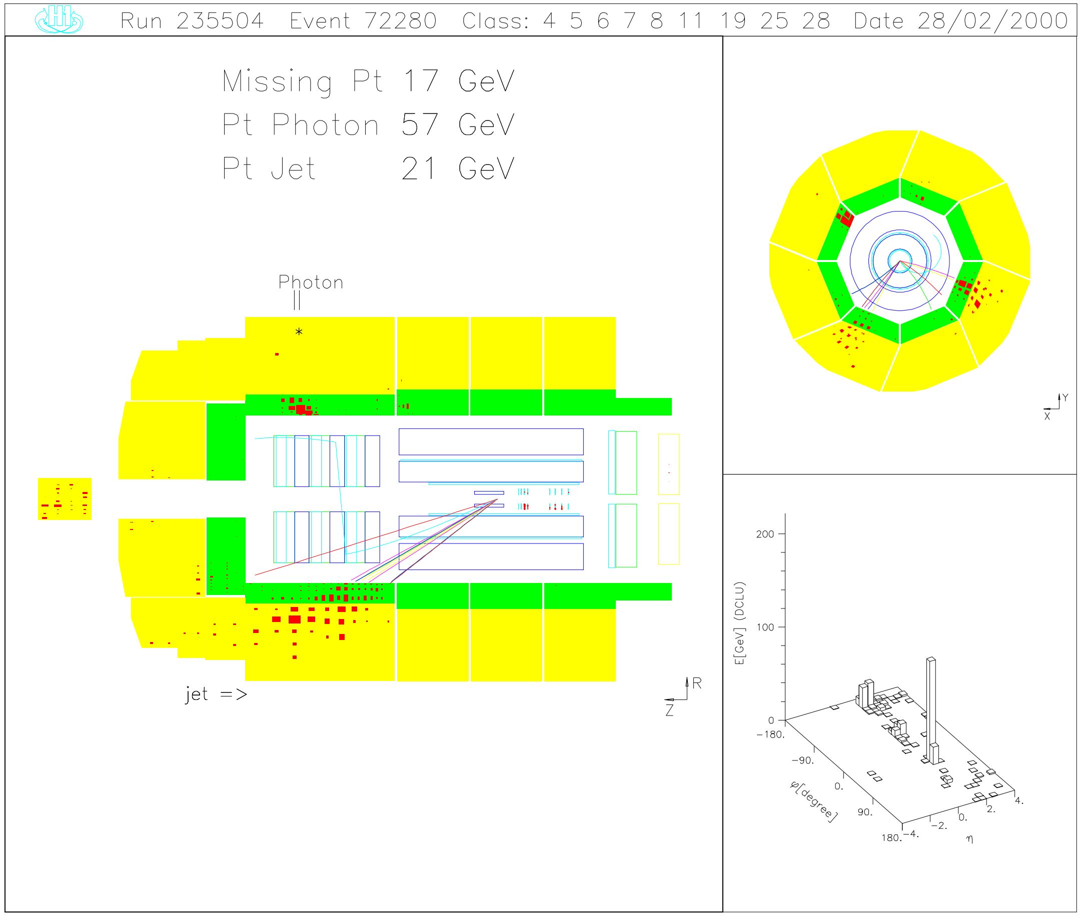
One photon and $\not{P}_t$ $\Rightarrow$ not enough to trigger $\Rightarrow$ require recoil jet.

Danger: Photons close from the jet are badly modelized!!!

Main background: Radiative CC

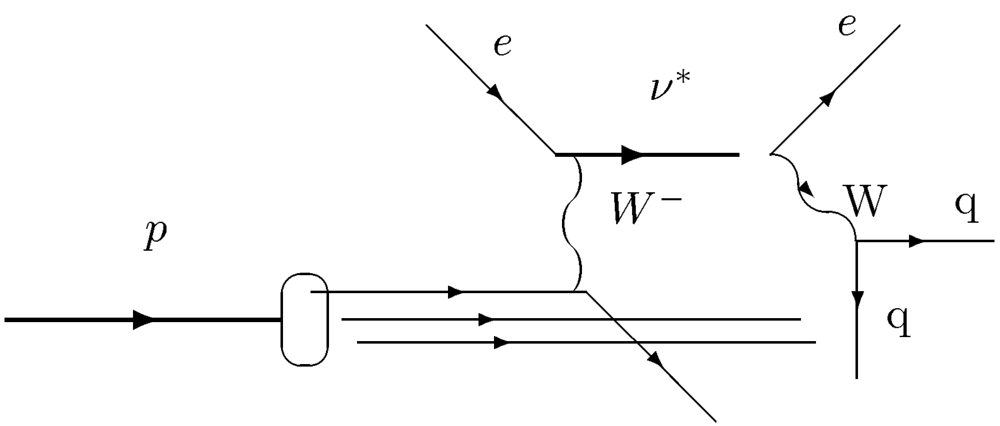
Result: 2 candidates in the data, 2.56 ± 1.20 background events expected...

$\Rightarrow$ No signal found, let's continue the hunt...



$\theta_\gamma = 25^o \qquad \varphi_\gamma = 38^o$

The $\nu^* \to e + W_{\hookrightarrow qq}$ channel



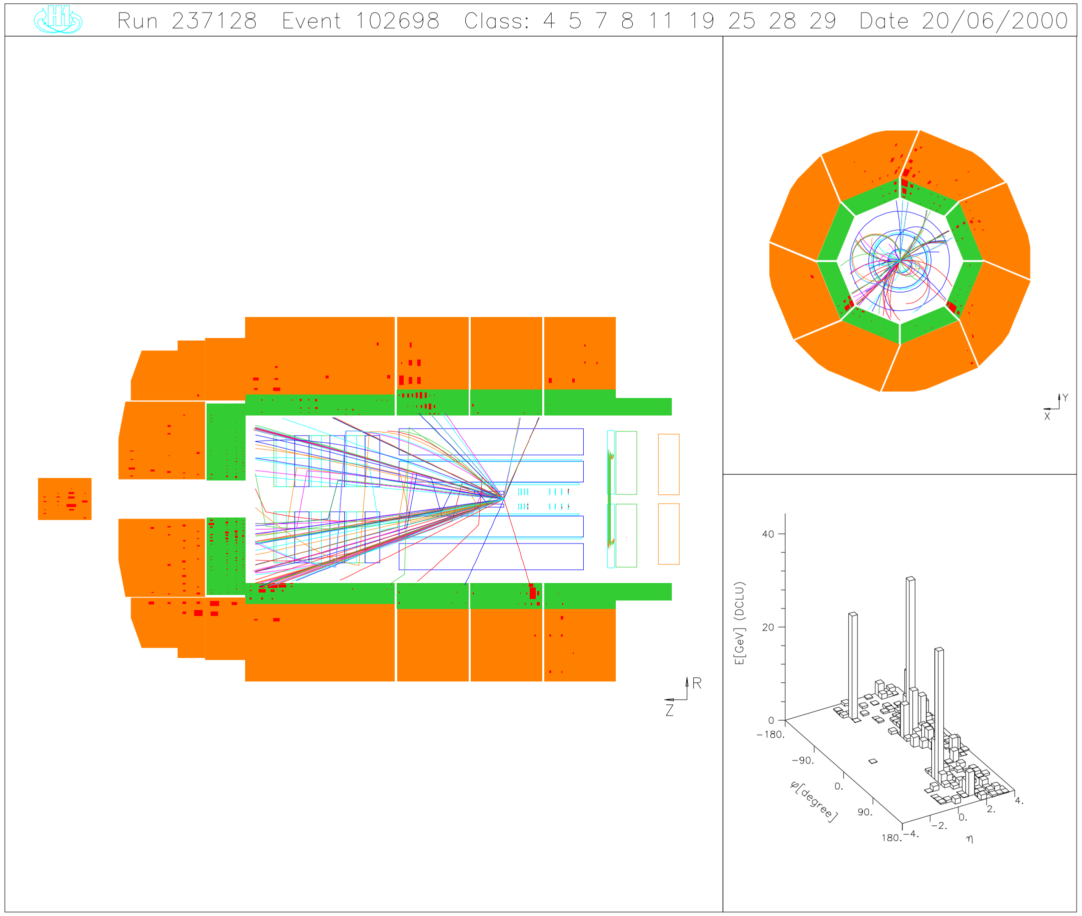
One electron and 2 jets (+ sometimes the recoil jet)

Main background: NC (all backgrounds become negligeable at high p_t^e)

$\Rightarrow$ anti-NC cuts at low p_t^e, relaxed at high p_t^e.

Result: 4 candidates in the data, 7.74 ± 1.38 background events expected...

No signal found! $\Rightarrow$ do ν^* really exist ???


Run 237128 Event 102698 Class: 4 5 7 8 11 19 25 28 29 Date 20/06/2000
R
Z
Y
X
E[GeV] (DCLU)
40
20
0
-180.
-90.
0.
90.
180.
φ[degree]
-4.
-2.
0.
2.
4.
η

No signal was found !!!

What can we learn from that?

Does that mean that the ν^* doesn't exist?

It may be hidden elsewhere...

$\Rightarrow$ Exclusion limits

How to set an exclusion limit?

Limit: comparison between observed events and the predicted cross section.

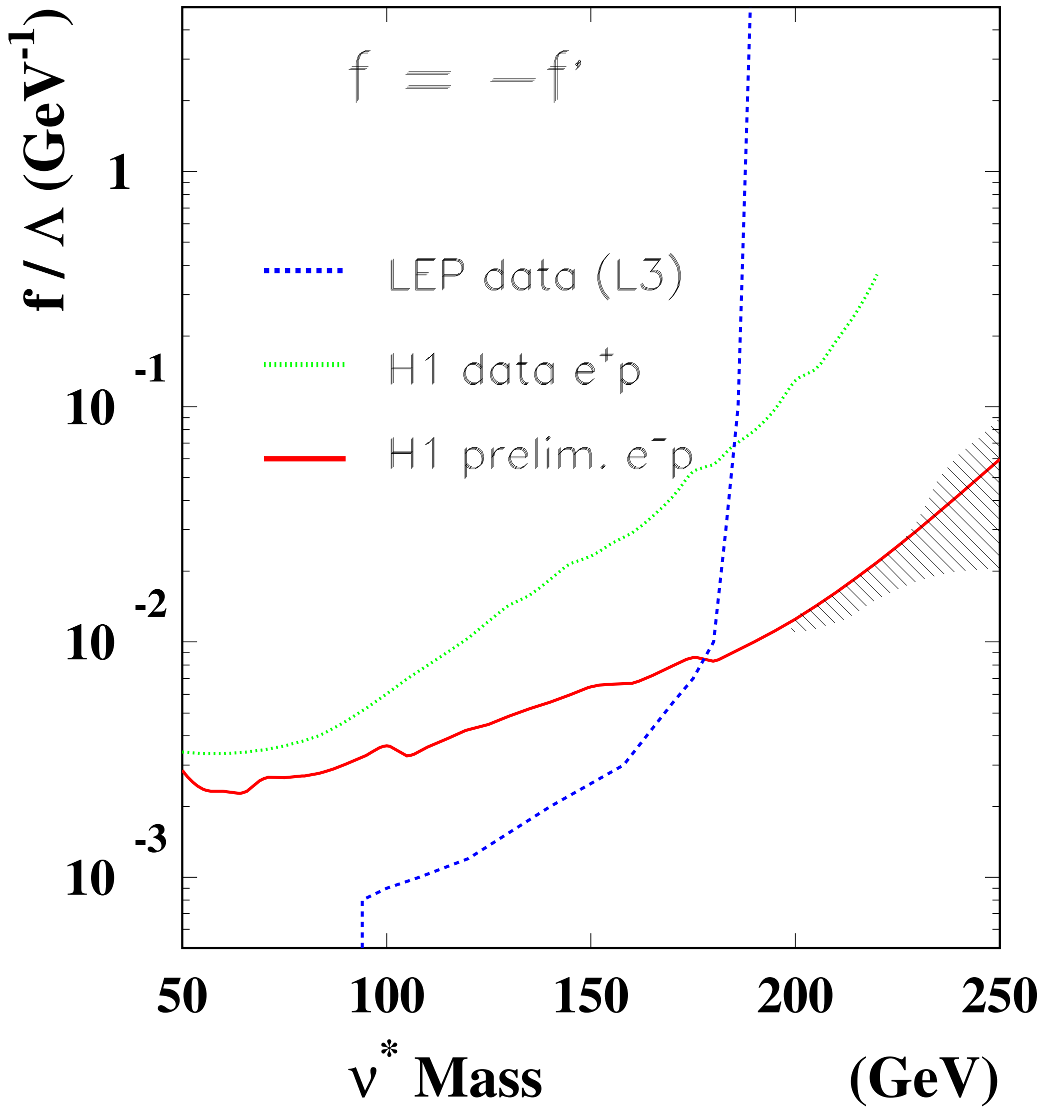
Observation is compared to cross-section prediction for each point of the parameter space (M_{ν^*} and $\frac{f}{\Lambda}$).

If less than 5% of the data agree with a prediction $\Rightarrow$ excluded

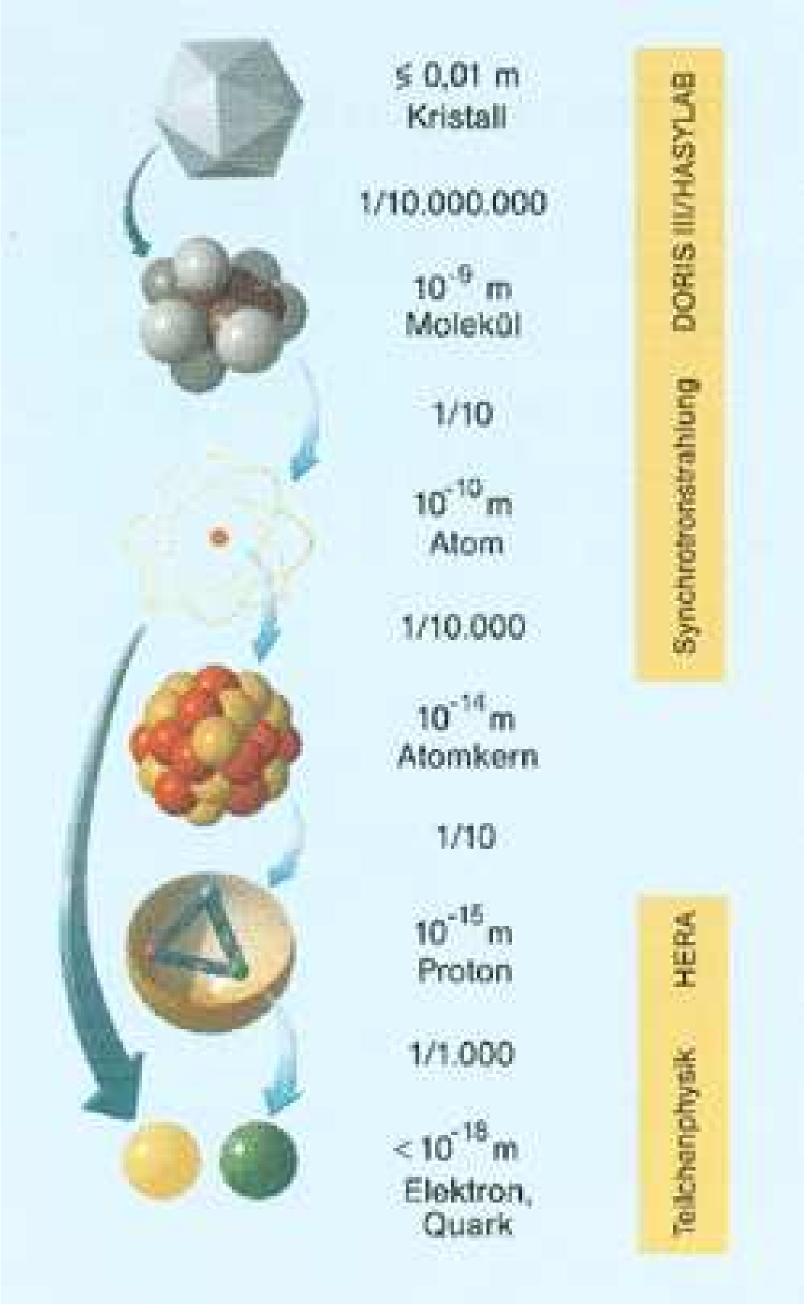
$\Rightarrow$ To set the limits we need the cross-sections of ν^*.

But at high mass the ν^* is more a resonance $\Rightarrow$ uncertainty band.

H1's Osaka limits on ν^*



Conclusion



DESY can keep its posters for a few more years...