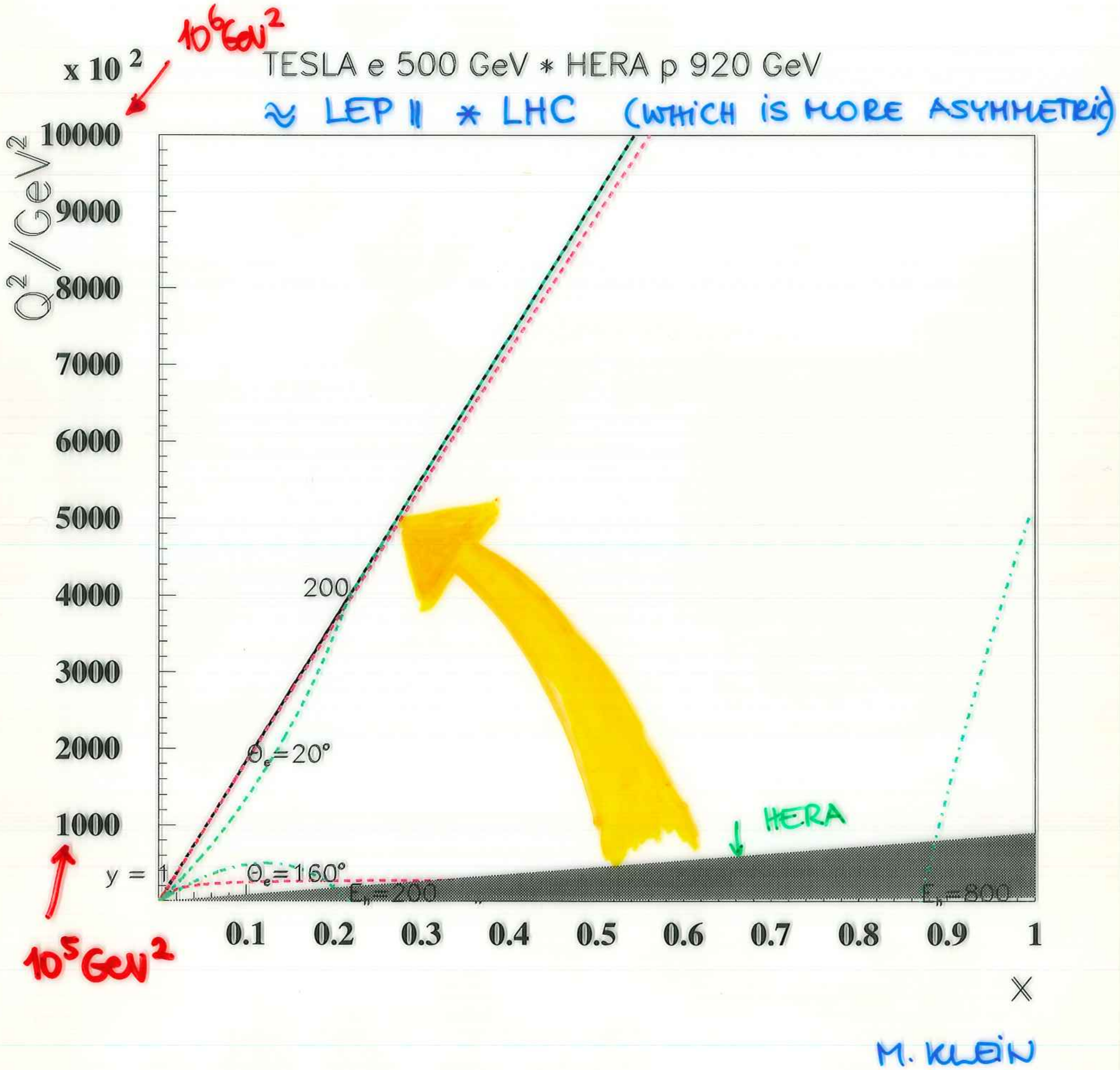
JB, HH
02/2000

DIS AT FUTURE COLLIDERS

A THEORISTS' POINT OF VIEW

J. BLÜMLEIN, DESY

1. STANDARD MEASUREMENTS
2. QCD ANALYSIS
3. LOW x
4. DIFFRACTION
5. POL. e + POL. p
6. THE EXPECTED UNEXPECTED
7. CONCLUSIONS



Q^2 RISES BY x 100 !

1) STANDARD MEASUREMENTS : LARGE Q^2

$\sigma^{e^+p}_{NC}$ $\sigma^{e^+p}_{CC}$ $\sigma^{e^-p}_{NC}$ $\sigma^{e^-p}_{CC}$ (DIS)

WHY ?

→ SHORTDISTANCE BEHAVIOUR & FLAVOURS.

THE UNEXPECTED NEW STRUCTURES MAY BE FLAVOURDEPENDENT

→ NEED $\mathcal{L} = 1 fb^{-1}/yr$ TO HAVE A REASONABLE STATISTICS TO WORK WITH.

YIELD : u_v, d_v, $S = \sum_q (q_s + \bar{q}_s)$

c, $\underline{b}$

↑

2) QCD ANALYSIS : LARGE Q^2

($x \gtrsim 10^{-2}$)

CLEAN α_s MEASUREMENT

$\longleftrightarrow \quad \Delta\alpha_s^{THY}(M_Z) \simeq 0.001$ (3 LOOP)

NEW

NECESSARY TO UNREV. STRUCTURES FROM SM STANDARD EVOLUTION

$\longrightarrow$ BYPRODUCT $G(x, Q^2)$ (HIGH PREC.)

$\longrightarrow$ DIFFERENT OBSERVABLES

$$\left.\begin{array}{l} \dfrac{\partial F_2}{\partial \log Q^2} \\ F_2^{c\bar{c}} \\ F_L \end{array}\right\} \quad G^{\overline{MS}}(x, Q^2)$$

UNIVERSALITY !?

$\longrightarrow$ CLEAN QCD TEST.

L SEVERAL fb^{-1} ! (TO EXPLOIT FULL POTENTIAL)

WHY DO WE NEED TO KNOW α_s ?

@ $\Delta\alpha_s = \pm 0.001$

→ UNIFICATION : GUTS

MSSM, SO_{10}, ... WHICH GUT ?

UNIFICATION AT ALL

HERA WILL PAVE THE WAY.

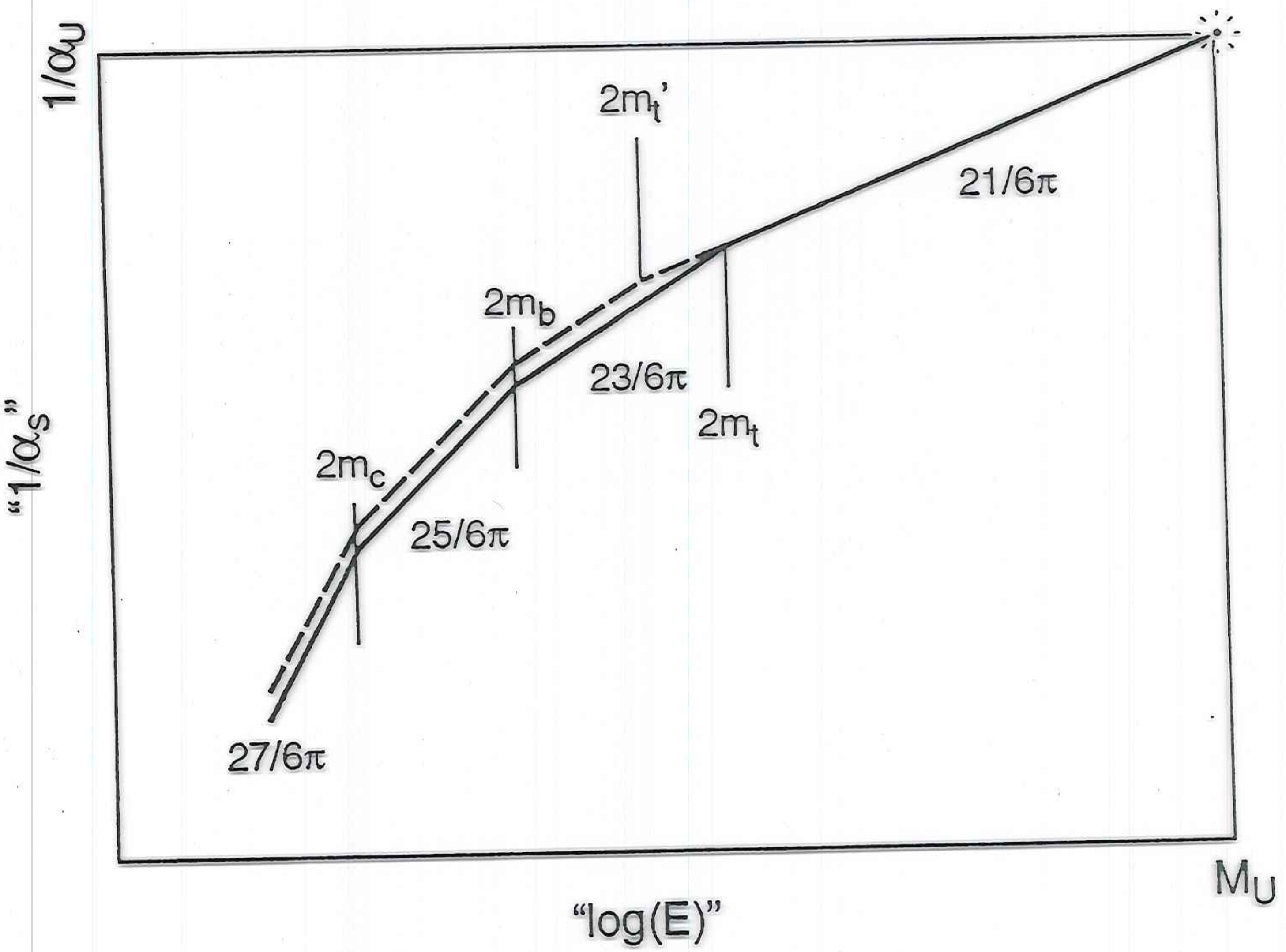
→ MIGHT TURN OUT THAT

$$\alpha_s^{\text{non DIS}} \neq \alpha_s^{\text{DIS}}$$

↓

FINAL STATE EFFECTS ? (DIFFICULT)

WHAT IS α_s ? → α_s^{DIS} .



C.QUIGG 2/8/00

URE 10. Two evolutions of the strong coupling constant α_s. A smaller value of the

3.) LOW x

DOMAIN FOR MEASUREMENT.

$\Delta F_2^{exp}(x, Q^2) \lesssim 1\%$ WANTED.

⟶ SEARCH FOR STRUCTURES.

- SCREENING

NO THEORY YET. ⟶ SYSTEMATIC HIGHER TWIST CALCULATIONS

QUANTUM FIELD THEORY NEEDED (QCD)

SOMETHING LIKE FANS, BUT NOT NAIVELY.

⟶ IT IS LIKELY THAT ONE WILL NEED A GRADUAL UNDERSTANDING OF TWIST BY TWIST.

THIS IS NOT A SMALL x (OR $s \to \infty$) APPROACH ONLY

LOW x ⟷ MEDIUM x

HARD THEORETICAL PROBLEM.

'BFKL' & STRUCTURE FUNCTIONS.

→ THE 3-LOOP COMPLETE RESULTS
WILL YIELD A FRESH LOOK!

TWIST 2 IS NOT SO MUCH DIFFERENT
FOR SMALL x IF COMP. TO MEDIUM x.

MORE CALCULATIONS NEEDED,
LESS OPINIONS ON KNOWN CALCULATIONS.

- MORE STABLE RESULTS CAN ONLY BE ACHIEVED BY WORKING OUT MORE.

4) DIFFRACTIVE STRUCTURE FUNCTIONS

"F_2^D" (HARD SCATTERING)

→ MEASURE IT TO HIGH PRECISION

↔ QFT TREATMENT POSSIBLE.

→ INTERESTING LEADING TWIST RESULTS WITHOUT TO MUCH MODELLING.

→ NOT ONLY INTERESTING AT SMALL x BUT AT ALL x.

- MAY DEVELOP INTO A VERY STABLE TEST AREA FOR PT. QCD

MANY MORE THINGS TO STUDY.

5. POLARIZED e- POLARIZED p SCATTERING

1ST HIGHER TWIST IN VIVO

- LOWER Q^2: TWIST 3

$\longrightarrow$ g_2^{III} NEW INTEGRAL RELATIONS.

(FIXED TARGET)

- HIGH Q^2: $\Delta\Sigma$, ΔG, Δs ...

$\longrightarrow$ WATCH OUT FOR NOVEL HIGH Q^2 STRUCTURES.
DUE TO NUCLEON POLARISATION

- DIFFRACTION: NEW TESTS OF QCD
g_1^D, g_2^D TWIST 2.

(FIXED TARGET)

6. WHY DO WE WANT TO MICROSCOPE THE NUCLEON ANYFURTHER ?

WE WOULD LIKE TO SEE, WHETHER QUARKS & GLUONS HAVE PIECES.

THEY ARE TOO MANY NOT TO HAVE PIECES.

TO SEE THE PIECES OF A WHOLE ONE HAS TO USE MICROSCOPES.

NOTE: LIGHT PARTONS WERE NOT FOUND WITH HADRON COLLIDERS. PREONS MAY BE HEAVY ... BUT HOW DO WE KNOW ?

IS IT THE HIGGS WHO GIVES THE MASS TO THE TOP QUARK - OR IS THIS A PREON MECHANISM ?

CAN HADRON COLLIDERS ESTABLISH PREONS UNAMBIGOUSLY ?

SPACELIKE & TIMELIKE RESOLUTION IS NOT THE SAME.

THE MISSING LINK IN THE SM IS NOT ONLY THE HIGGS.

ONE WANTS TO UNDERSTAND THE ROOTS FOR 3 QUARK & 3 LEPTON TYPES ! BEING OTHERWISE EQUAL (UP TO THEIR MASS).

ONE POSSIBILITY: PREONS

PREONS SHOULD DECONFINE.

Quark–Compositeness

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- Example: purely electromagnetic interactions

- $Q^2 \ll \Lambda^2_{\rm Preon}$: elastic lepton–quark scattering with a point–like coupling

$$J_\mu^{em} = e_q^2 \overline{u}_q(p')\gamma_\mu u_q(p)$$

- $Q^2 \lesssim \Lambda^2_{\rm Preon}$: quasi–elastic lepton–quark scattering

$$J_\mu^{em} \rightarrow e_q^2 \overline{u}_q(p')\Gamma_\mu(q^2) u_q(p)$$

$$\Gamma_\mu(q^2) = F_1(q^2)\gamma_\mu + \frac{F_2(q^2)}{2M} i\sigma_{\mu\nu}q^\nu$$

$$\begin{aligned} G_E(Q^2) &= F_1(Q^2) - \frac{Q^2}{4\Lambda^2}F_2(Q^2) \\ G_M(Q^2) &= F_1(Q^2) + F_2(Q^2) \end{aligned}$$

$$G_M(Q^2) = \frac{\mu}{\left(1+\frac{Q^2}{\Lambda^2}\right)^2}$$

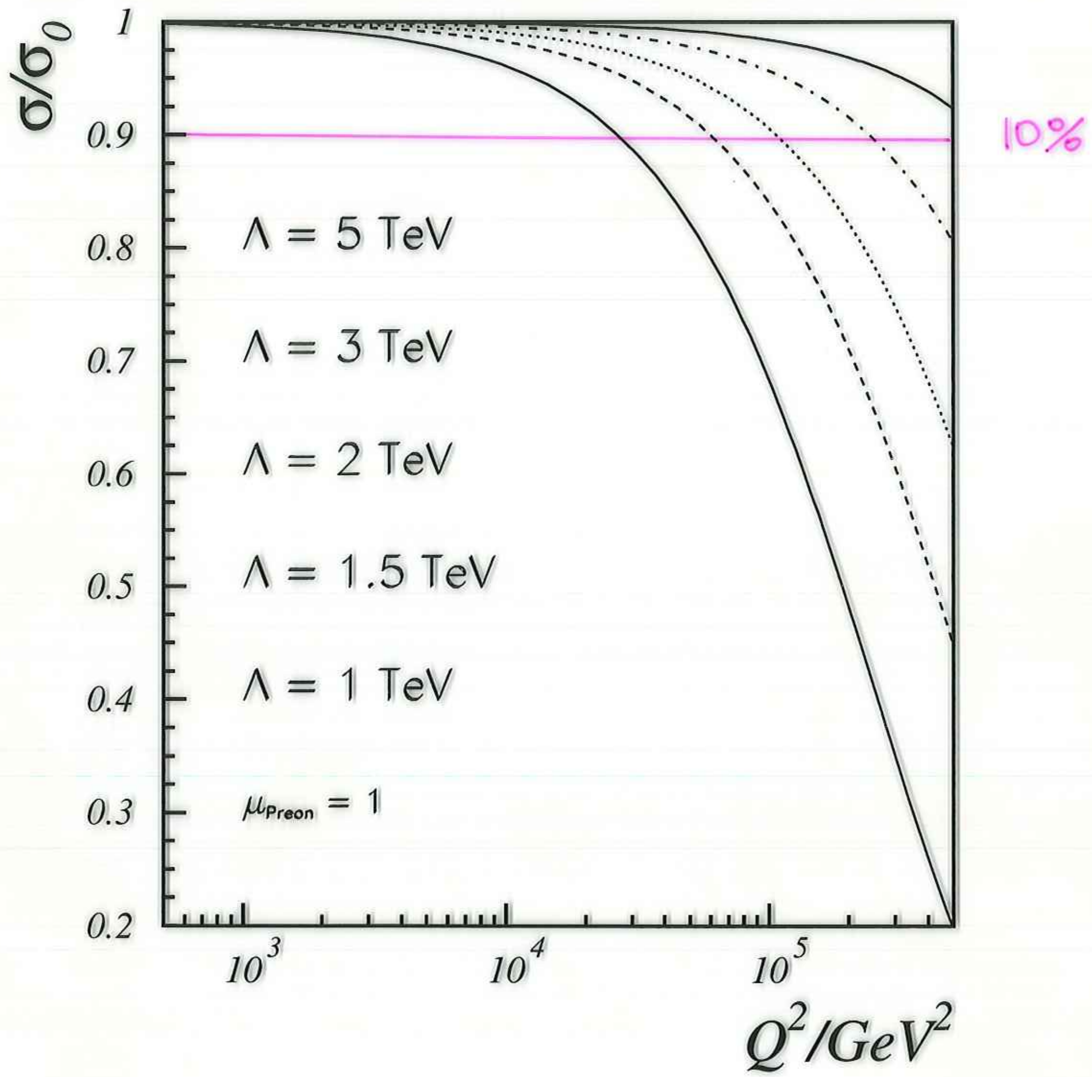
- assume $\mu = 1$ and $G_M = G_E$

$$\frac{d^2\sigma}{dxdQ^2} = \frac{d^2\sigma_0}{dxdQ^2} \times \frac{\Lambda^8}{(\Lambda^2+Q^2)^4}$$

with

$$\frac{d^2\sigma_0}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[1+(1-y)^2\right] F_2^{em}(x,Q^2)\Big|_{\rm partonic}$$

HERA×TESLA, LEP×LHC : $\sqrt{s} \sim 1.8\,\mathrm{TeV}$; $Q^2_{\mathrm{max}} \approx 5 \times 10^5\,\mathrm{GeV}^2$.



Still higher scales :

- $Q^2 \gtrsim \Lambda^2_{\mathrm{Preon}}$: one may expect also resonant contributions depending on the yet unknown binding force
- $Q^2 \gg \Lambda^2_{\mathrm{Preon}}$: New Scaling: elastic lepton–preon scattering, if both the leptons and the photon remain pointlike

7 CONCLUSIONS

1667 R. HOOK USED THE MICROSCOPE AND FOUND THE CELL.

1969 SLAC-MIT FOUND THE PARTON USING A MICROSCOPE TOO.

⋮

ONE SHOULD SEARCH FOR DEEPER STRUCTURES AS AT THE MOMENT TOO MANY "EQUAL" ANIMALS ARE FLOATING IN FRONT OF THE LENSE.

⟹ BETTER MICROSCOPE(S) NEEDED.

⟹ WELL EQUIPPED WITH ENOUGH LIGHT ! SEVERAL fb^{-1}.

→ WILL BE A CHALLENGE FOR TESLA * HERA.

(NOT CLEAR WHETHER IT CAN BE SOLVED.)

STANDARD PROGRAMME : RICH

MAIN GOAL : SUBSTRUCTURE !
FROM THE BEGINNING.