Recent Progress with the X-Band e^+e^- Linear Collider

C Damerell
1st October 1997

- What we are talking about

  E_{cm} 0.5 TeV → 1.5 TeV

  $\mathcal{L} \geq 0.6\times10^{34}\text{cm}^{-2}\text{s}^{-1} \rightarrow 2.0\times10^{34}\text{cm}^{-2}\text{s}^{-1}$

- Physics Motivation

  (essentially stable since 1995)

- Accelerator Status

- Detector (Tracking)

- Schedule

- Suggested UK Detector R&D Actions (machine-independent)

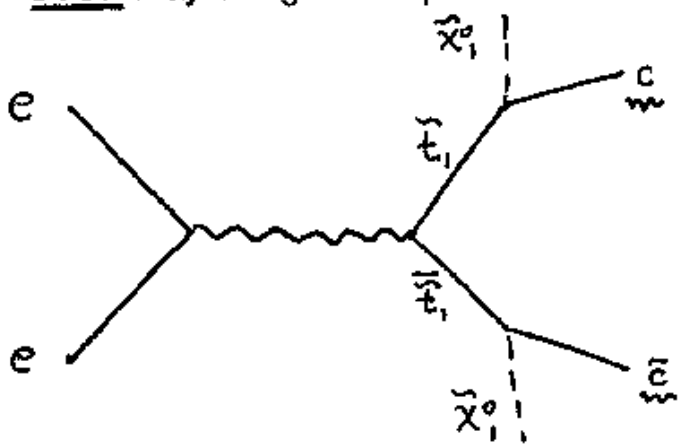
4. **SUSY Higgs**

$e^+e^- \rightarrow HA$

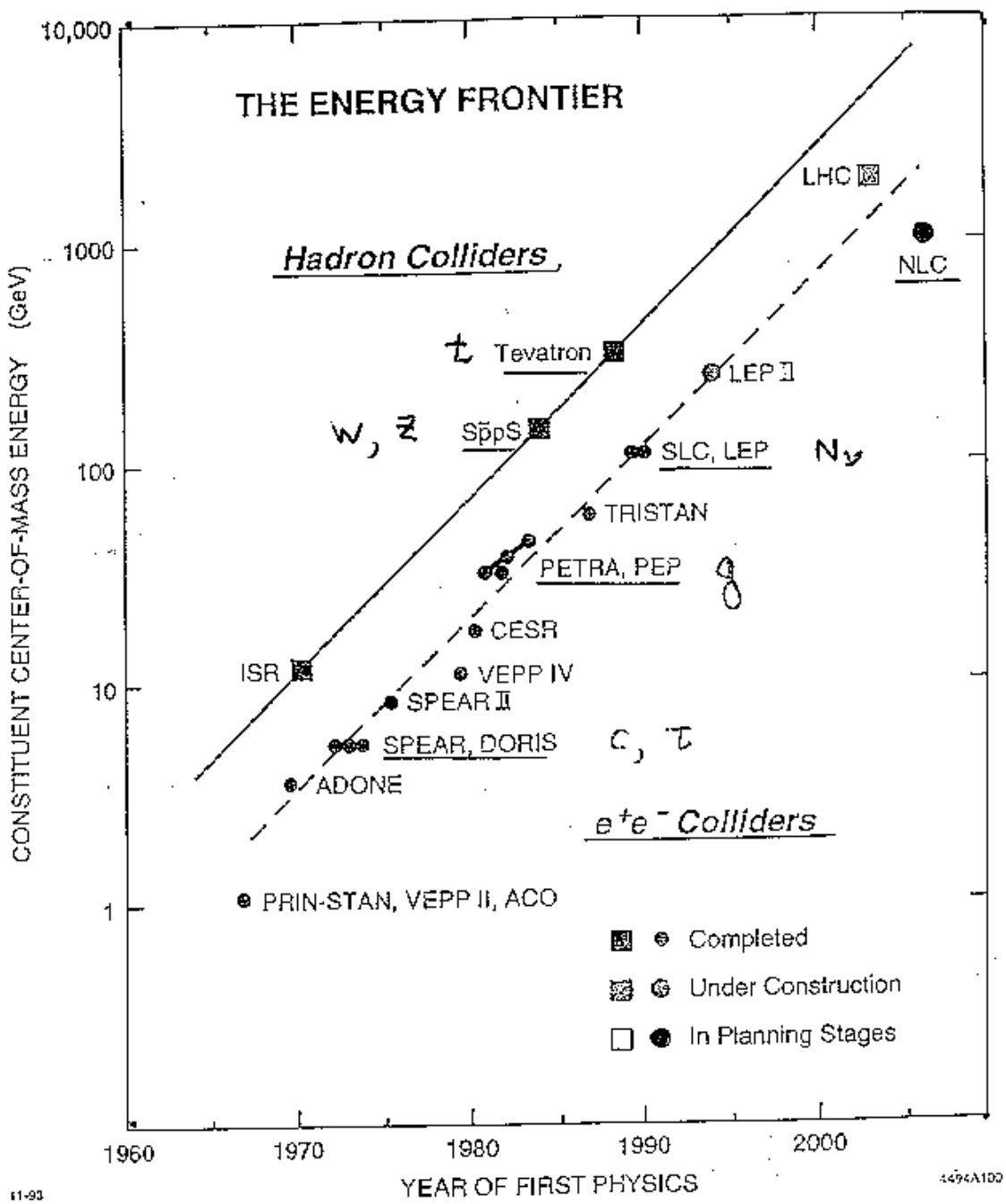
Both H and $A \rightarrow t\bar{t}$ predominently

12 jets, 4 of the *b* flavoured.

5. STOP may be lightest squark



Large background if one lacks a clean charm tag. Small cross-section; *efficiency* is as important as *purity*.



b quark: FIXED TAT EXPERIMENT

- **Accelerator Status**

  - SLC has done its job, in terms of lessons relevant to NLC

    Achieve design luminosity up to
    $N_{e^+} > 2\times10^{10}$
    $N_{e^-} > 3\times10^{10}$
    Stability problems at higher bunch charges

  - Problem solved by multi-bunch operation
    (181 bunches/pulse @ 2.8 ns separation)

  - Why move from S-band to X-band?

  - Final focus $\sigma_x \times \sigma_y$ 294×6.3 nm
    ↓
    360×2.3 nm

  - FFTB gives no surprises with spot sizes down to 60 nm.

  - Ground motion studies and G Bowden's active mounts will ensure mechanical cohesion of final focus spots

  - SLC damping rings now give design emittance (sawtooth instabilities eliminated)

    ATF at KEK should provide confirmation of NLC emittance requirements

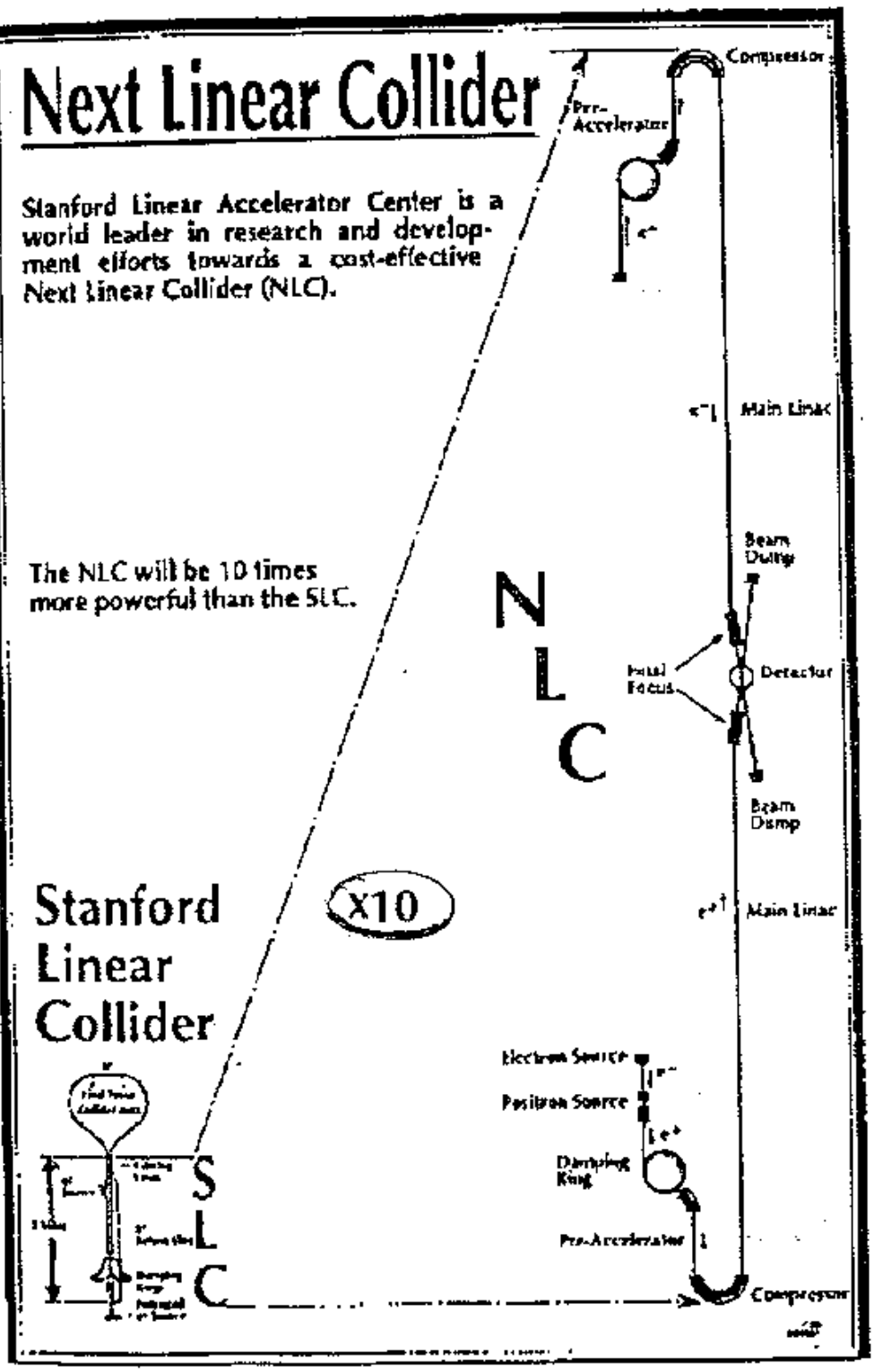
  - Remaining big issue is beam blowup in linac. NLCTA at SLAC (if it can accelerate 80 bunches of $10^{10}e^-$ to 1 GeV without emittance degradation) should prove X-band capability for NLC

  - Accelerating structure has been through DFM process, prototype PPM klystrons are currently in this process.

Next Linear Collider

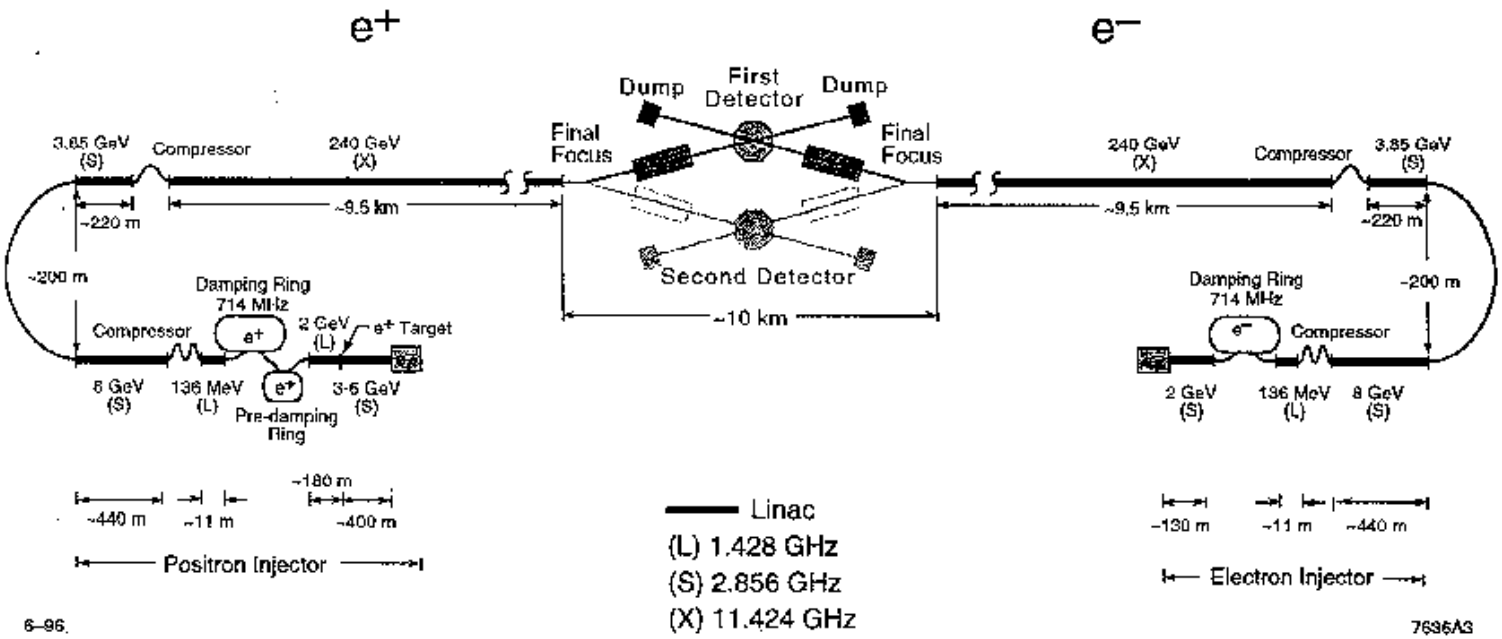
Stanford Linear Accelerator Center is a world leader in research and development efforts towards a cost-effective Next Linear Collider (NLC).

The NLC will be 10 times more powerful than the SLC.



NLC Diagram

not to Scale
(500 GeV c.m.)



6-96

7696A3

Why X-Band?

SLC (0.5 TeV)	2.8 GHz	17 MV/m
X-B 0.5-1.5 TeV)	11.4 GHz	64 MV/m
NLC' (5 TeV)	34.0 GHz	190 MV/m

Higher frequency for higher energy

- Shorter λ
- High gradient (shorter machine)
- Smaller structure (lower stored energy)

Disadvantages

- Tighter tolerances ✓
- Dangerous power levels (melting)

- S-Band has been pushed from 10 to 50 GeV
- X-Band believed ~optimal for upgrade to 1.5 TeV

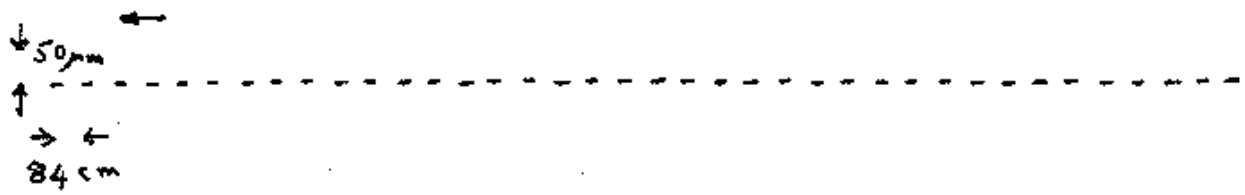
X-Band Vs S-C RF at 1.3 GHz (TESLA)

- Wall Power

X-Band	0.5 - 1.0 - 1.5 TeV	87 - 197 - 295 MW
TESLA	0.5 - 0.8 TeV	99 - 115 MW

- Practical energy limit for TESLA (and high cost) may be the major disadvantages

NLC Bunch Train



Bunch Length (125μm) Not To Scale

No BNS Damping

~5x Reduction In Luminosity

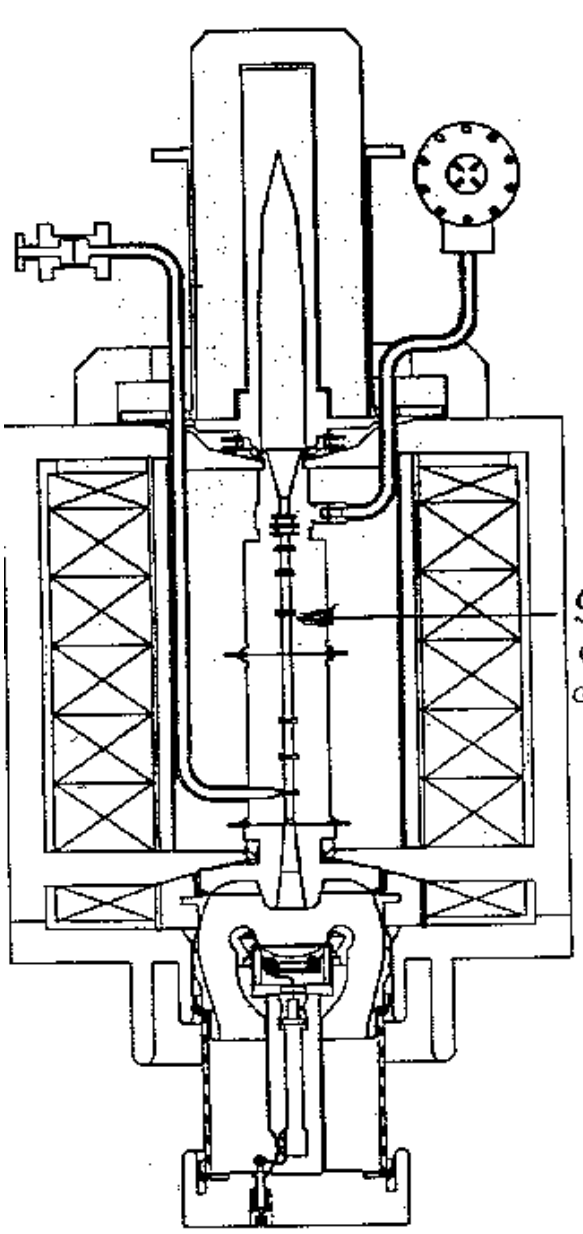
No Damped Cavities
No Detuned Cavities
No Split Tune Lattice

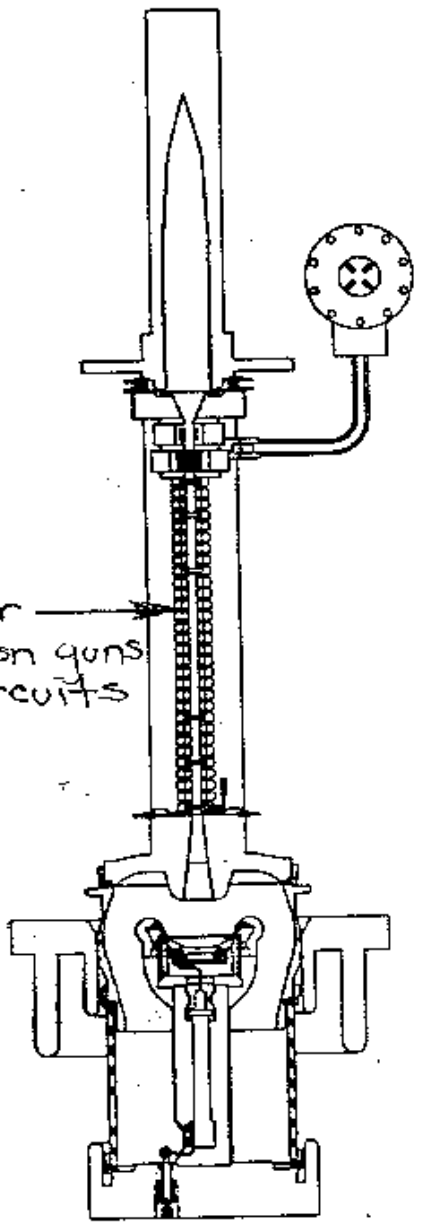
} Any of These → Long Range Transverse Wakefields

~ 10x Reduction In Luminosity

Really Need NLCTA To Confirm The Supercomputer Simulations
(My Opinion)

R. Phillips





Similar electron guns and circuits

XL1

SOLENOID POWER: 24 KW

PPM FOCUSED DESCENDANT

NO FOCUSING POWER

50 MW — 62%

Processing now to long pulse!

I:/dgn/xlseries/xl1/gclb.dgn Jul. 18, 1994 11:12:12

- **Detector (Tracking)**

  - Primary background is e^+e^- pair production from beam-beam interaction

  - To reach R_{inner}= 10 mm for vertex detector, require solenoid field of 4T

  - Proposed in Hawaii Workshop (1993), now generally accepted

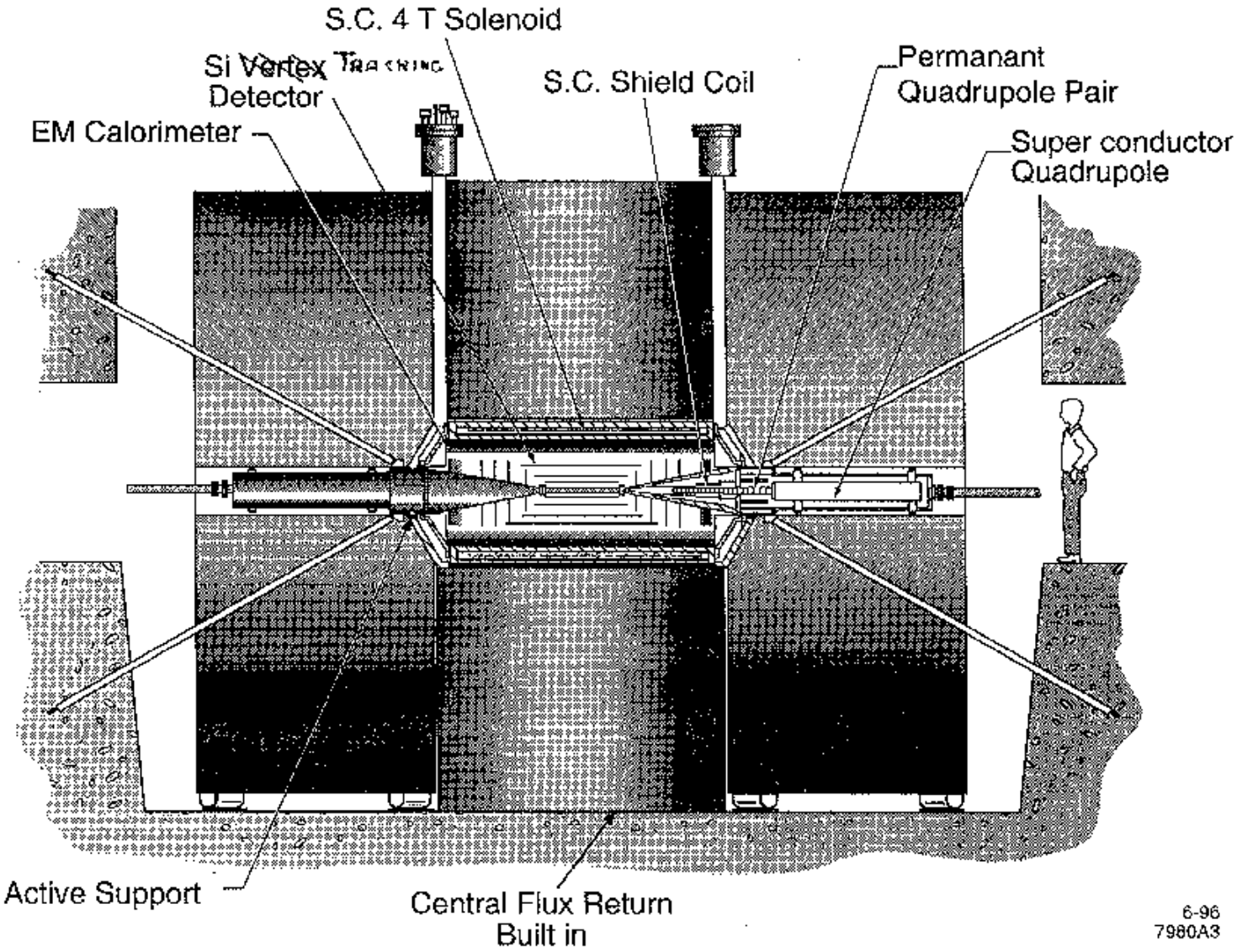
  - Plan to avoid support tube external to vertex detector; push out to magnet vacuum vessel

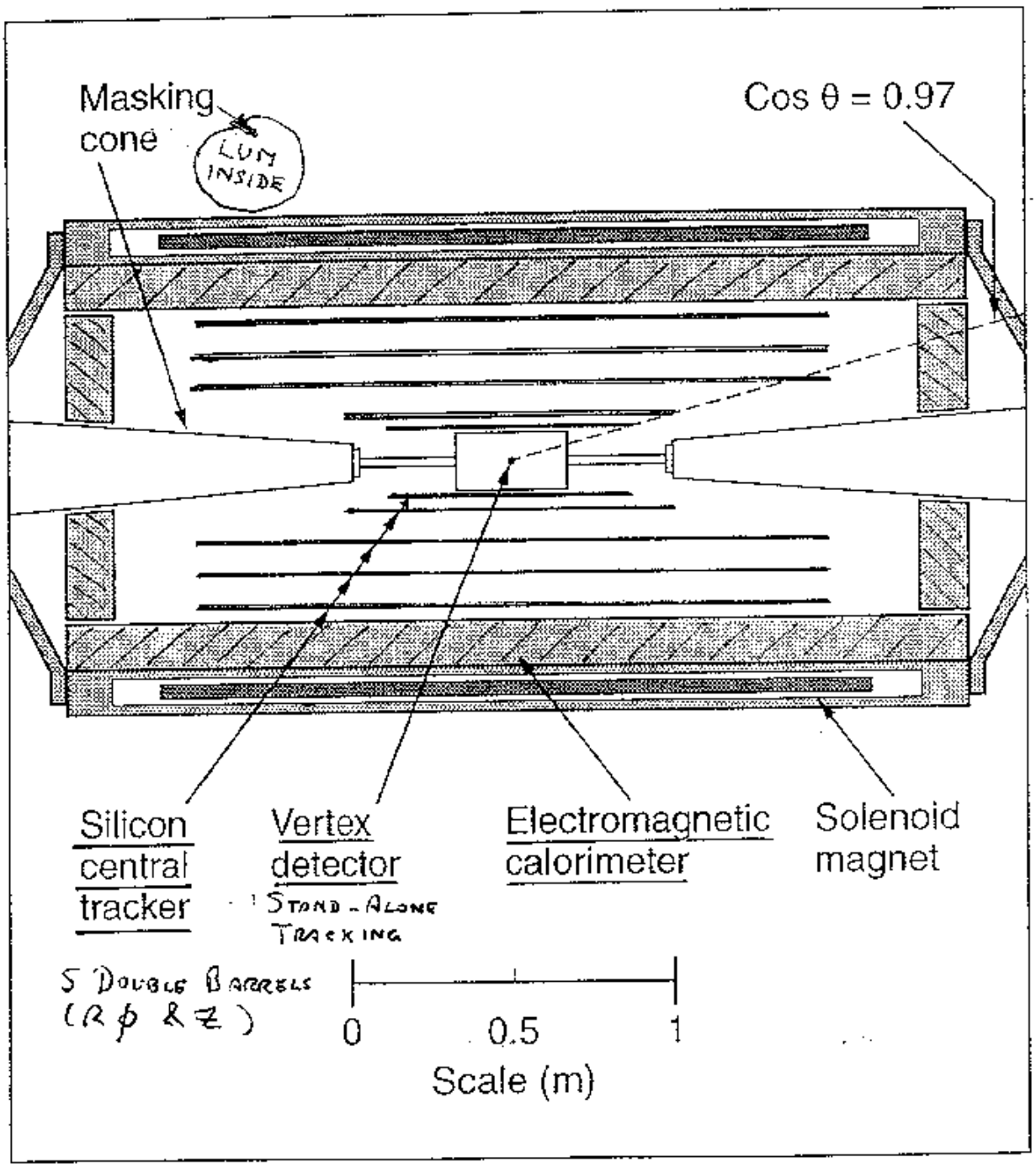
  - Tracking probably silicon based, given anticipated background and SLC experience (problems) with gaseous detectors

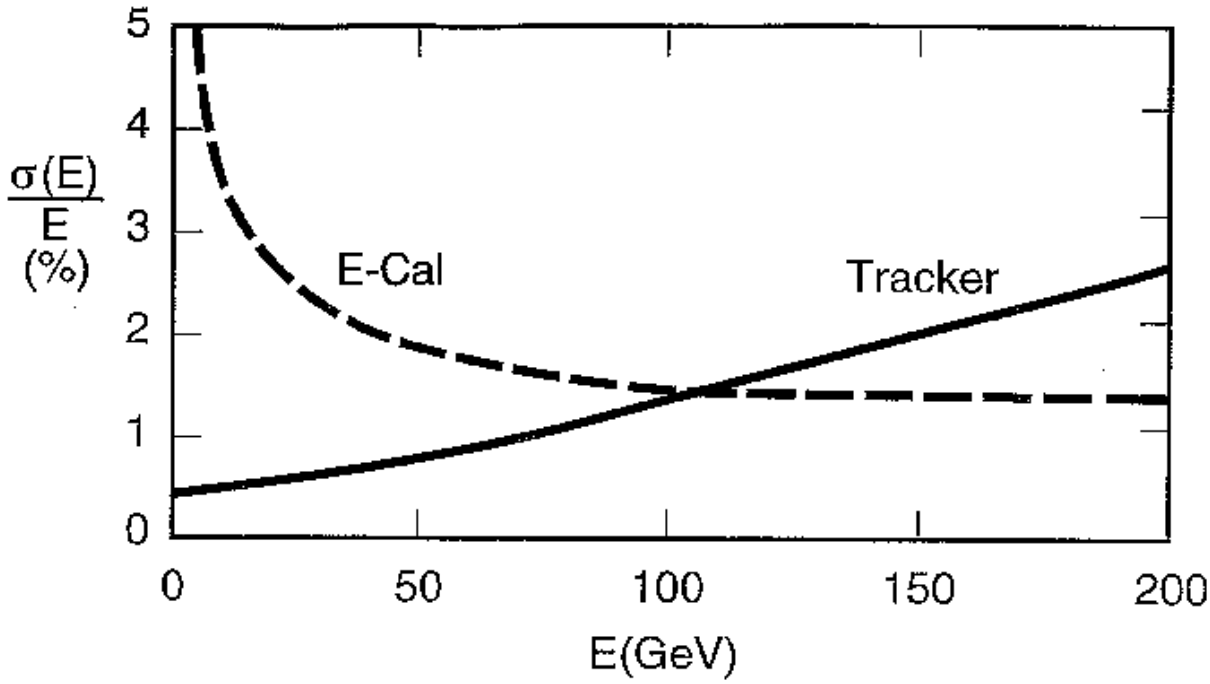
  - Plan to reduce layer thickness well below LHC SCT; highly multiplexed readout

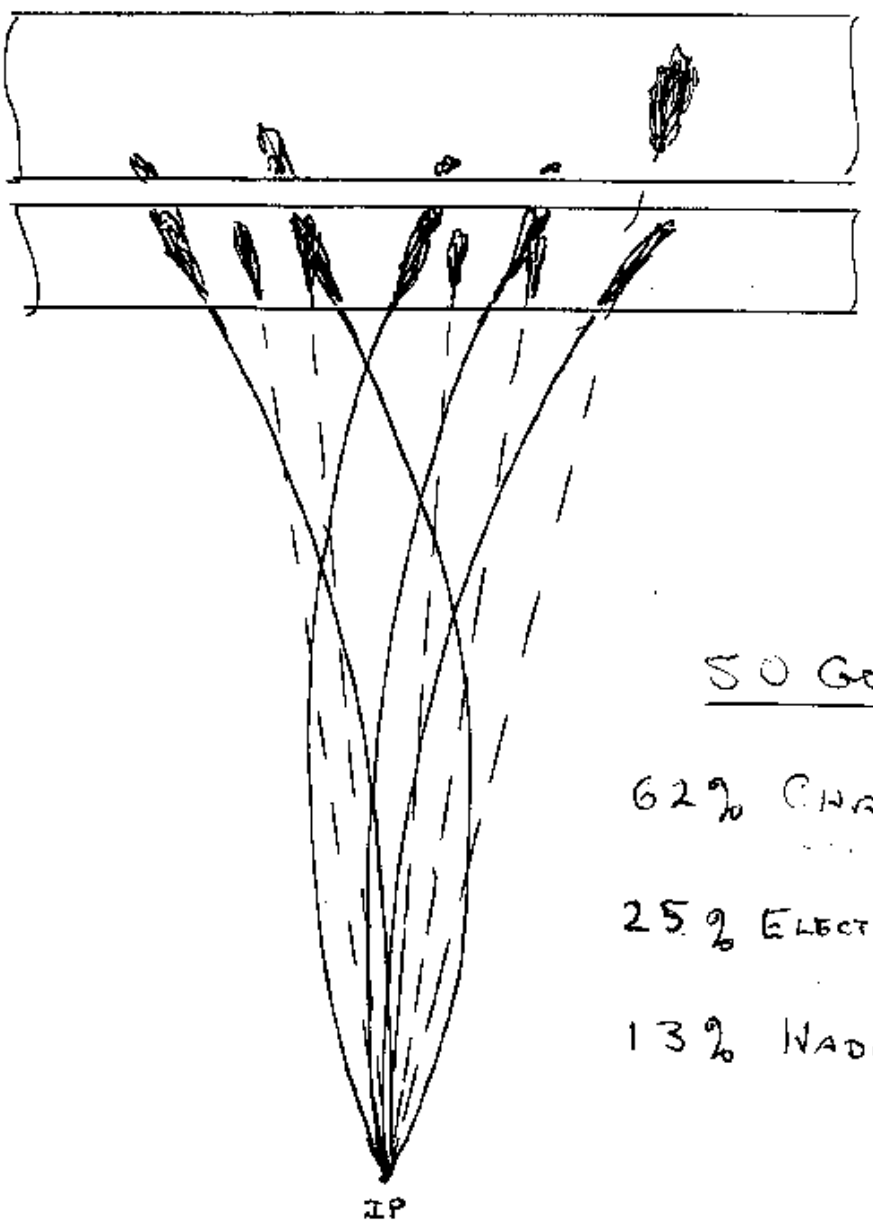
- Main feature of tracking system (new at Snowmass) is the huge improvement in quality of flavour ID, compared with any other existing or proposed experiments

  → could be a vital window on new physics


S.C. 4 T Solenoid
Si Vertex Tracking Detector
EM Calorimeter
S.C. Shield Coil
Permanant Quadrupole Pair
Super conductor Quadrupole
Active Support
Central Flux Return Built in
6-96
7980A3


Masking cone
LUM INSIDE
Cos θ = 0.97
Silicon central tracker
Vertex detector
STAND-ALONE TRACKING
Electromagnetic calorimeter
Solenoid magnet
5 DOUBLE BARRELS (R φ & Z)
0
0.5
1
Scale (m)


σ(E)
E
(%)
5
4
3
2
1
0
E-Cal
Tracker
0
50
100
150
200
E(GeV)



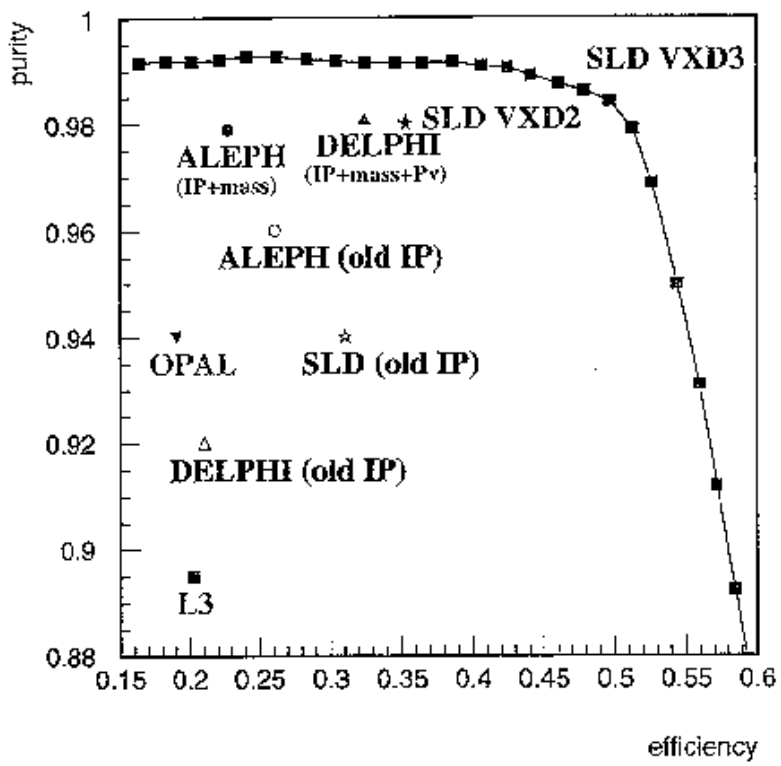
50 GeV JET

62% CHARGED ENERGY

25% ELECTROMAGNETIC ENERGY

13% HADRONIC ENERGY

Hemisphere b-tag Performance



- Impact parameter precision at IP

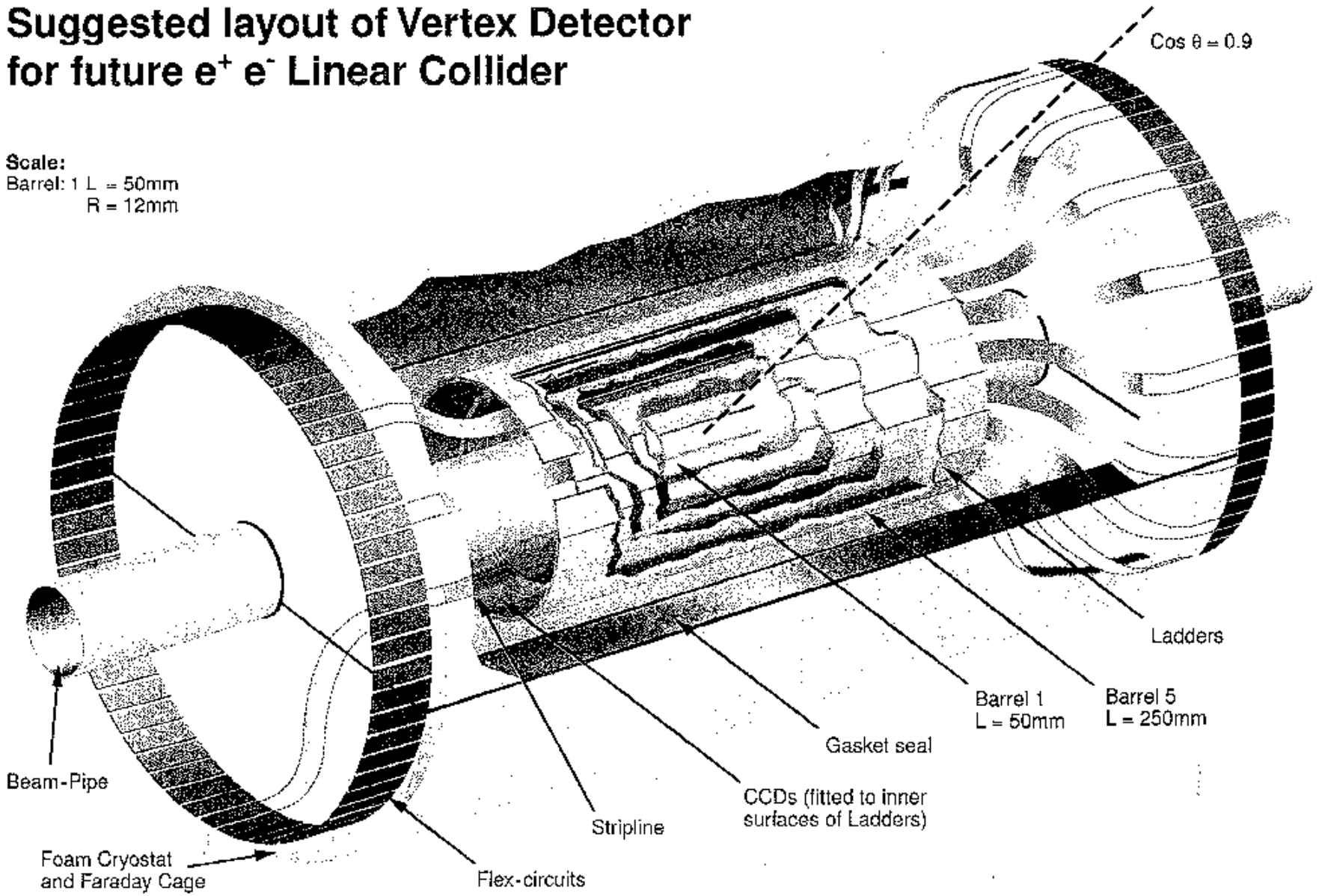
$$\sigma_{xy} \approx 5.5\ \mu\text{m} \oplus \frac{5.5\ \mu\text{m}}{p \sin^{3/2}\theta}$$

- Contrast multiple scattering term of

  ~ 70 μm (original SLD detector and typical LEP detector)

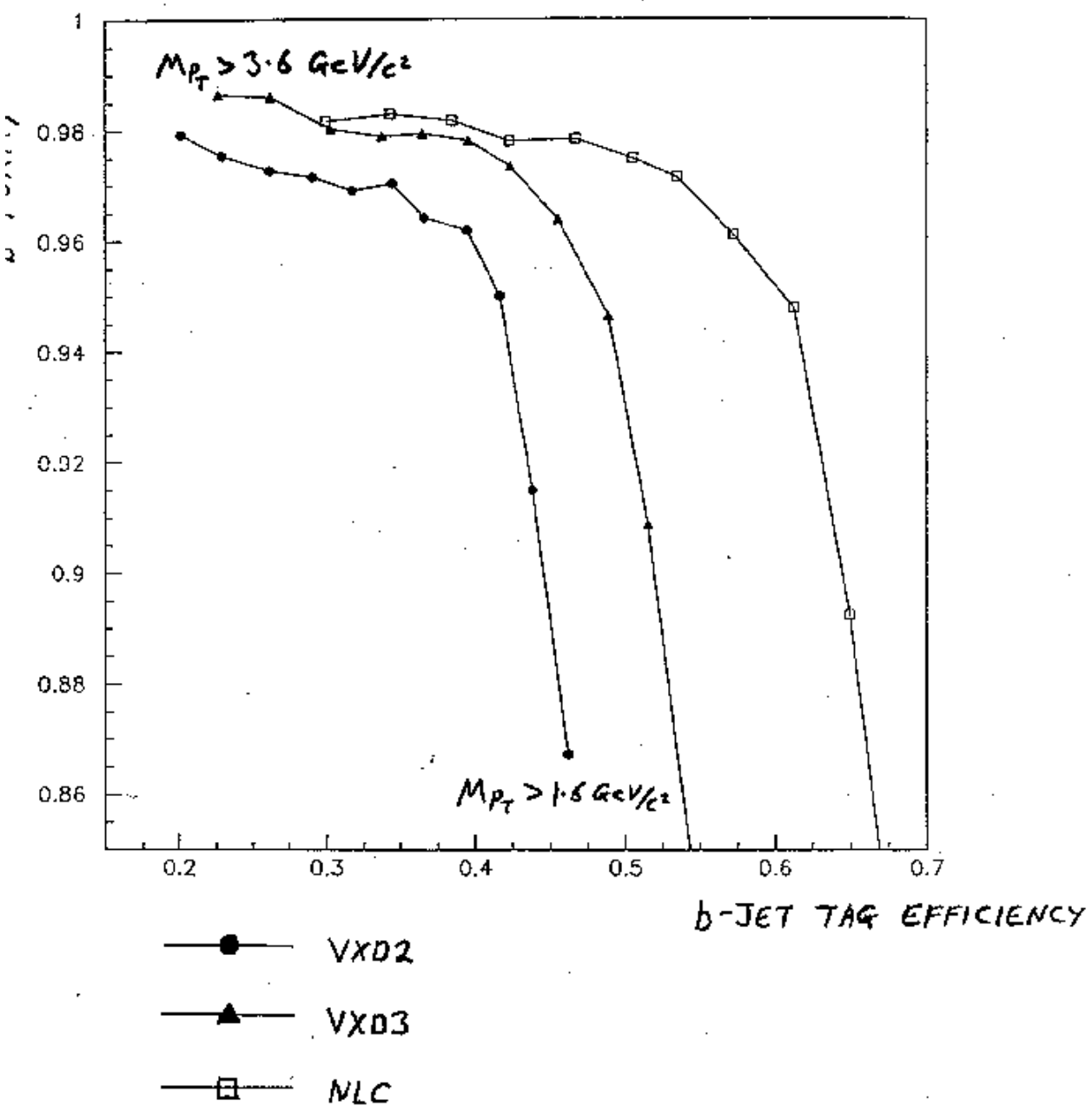
  ~ 29 μm (SLD upgrade detector)

Suggested layout of Vertex Detector for future $e^+ e^-$ Linear Collider



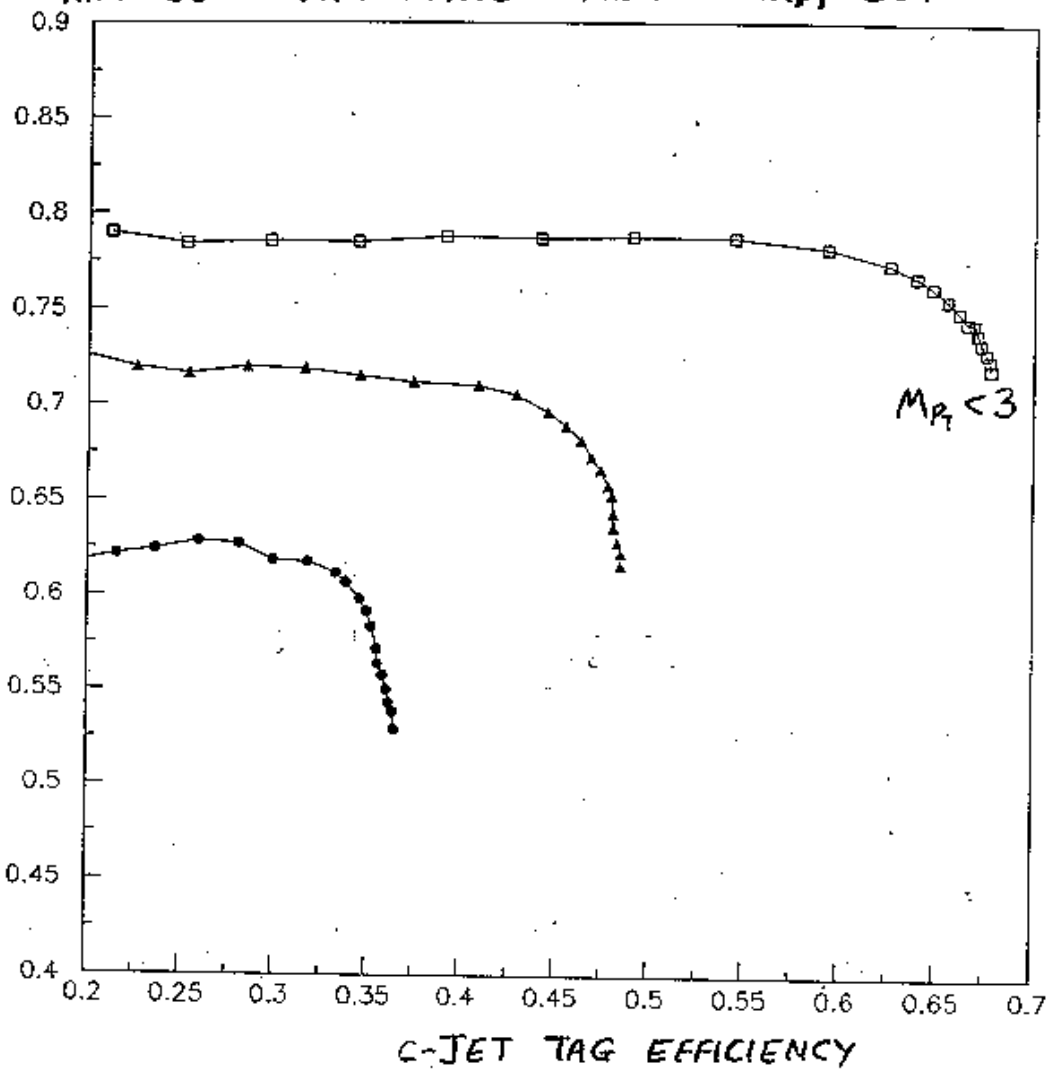
PURITY v. EFFICIENCY OF b-TAG

AS A FUNCTION OF CUT ON P_T ADDED MASS



PURITY v EFFICIENCY OF c-TAG

INCLUDE JETS WITH PRIMARY + 1 ISOLATED TRACK ONLY
AND JETS WITH VERTEX PASSING M_{P_T} CUT



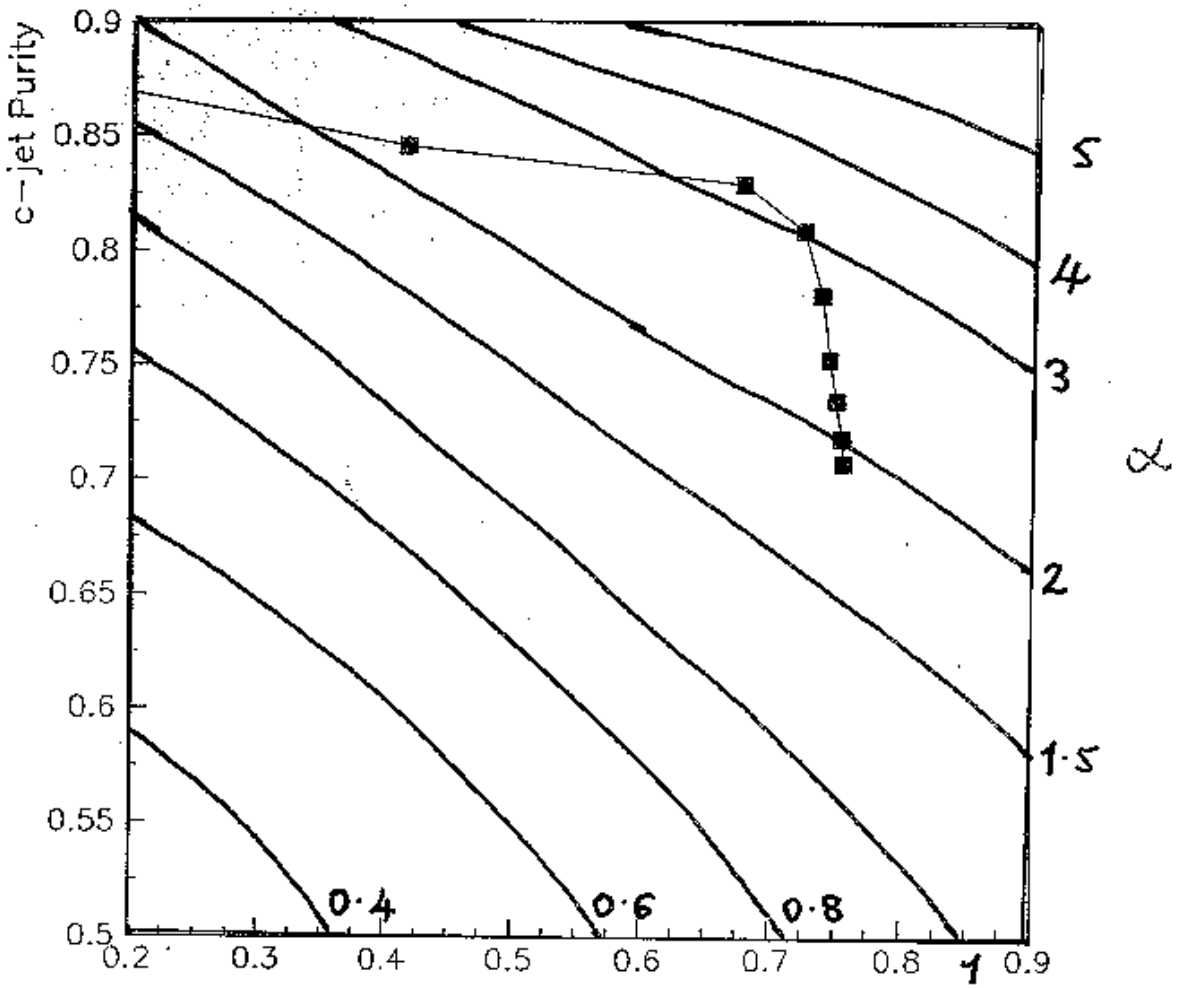
VX02

VX03

NLC

RUNNING TIME ENHANCEMENT α

SINGLE C - TAG



N-JET TAG $\Rightarrow$ FACTOR α

CCD

$R_{bp} = 10$ mm

- **Schedule**

  - ATF and NLCTA now operating. Studies to level required for full design will be completed early '98

  - HEPAP Sub-Panel on Planning for the Future of U.S. High Energy Physics (the 'Gilman panel') is preparing its report, due February 27, 1998

  - Japanese community decided August 29 to collaborate with U.S. on a single LC project. Formal signing of the bi-national agreement expected in a few weeks

  - We expect an international physics and detector R&D programme to be initiated within the next few months

  - Conceptual Design phase (for U.S. project) to be supported from FY99 (October '98) if all above are in place. Standard conditions for 'Control Decison 1':

    (Site)
    (Management Plan)
    Reasonably optimised design (>ZDR)
    Cost estimate (to ± $0.5 B)
    Congressional agreement

  - This will provide funding of ~$25M/yr for the machine, and ~$1+1M/yr for detector R&D. Similar sums expected from Japan

  - CDR to be completed Spring 2001, then seek approval for construction (*early* in next U.S. administration)

  - Project completion by 2007 + whatever delays for project approval.

- **Suggested UK Detector R&D**

  - Assume all activities will be as part of internationally coordinated groups

  - Modest UK support will permit active collaboration with colleagues funded by

    US (DOE)
    Japan (Monbusho)
    Germany (DESY)

  - Current areas of active UK participation at level of paper studies are

    Vertex detectors
    Tracking detectors (gaseous and silicon)
    Small angle calorimetry

  - These (and maybe new) studies will evolve into a coherent R&D proposal to the PPESP on timescale of ~ Summer '98

  - Further participants in these studies will be welcomed

  - Scale envisaged is modest relative to LHC detectors (both in UK and globally);
    ~ 6 UK universities at present