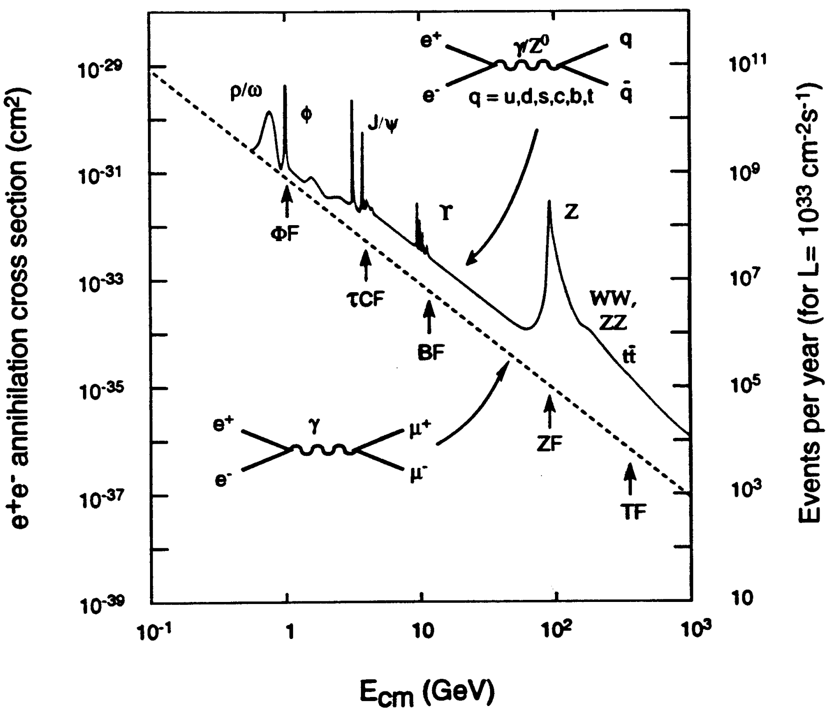
JASPER KIRKBY / CERN
SLAC τc WORKSHOP
9 MAR 99

VIEWS ON THE WORKSHOP AND FUTURE τc PHYSICS

Hadronic cross-section in e+e- annihilation



PRECISION HEAVY QUARK / LEPTON EXPERIMENTAL PROGRAMME

	τ	c	b	t
PREVIOUS / CURRENT MACHINES	BEPC / CLEO / LEP / SLC / TEV			TEV
	↓	↓	↓	↓
NEW MACHINES STARTING UP	BF	BF	BF /TEV (+MI)	TEV (+MI)
	↓	↓	↓	↓
10 YEARS FROM NOW	?	?	LHC	LHC / NLC

- **ARE THE BF's THE END OF THE ROAD FOR τ AND c PHYSICS?**
- **WILL THEY HAVE ANSWERED ALL τ c PHYSICS 10 YR FROM NOW?**

NEW CONCEPT [AT LEAST FOR ME]
FROM THIS WORKSHOP:

THE τCF IS THE
NEXT GENERATION MACHINE
FOR τC PHYSICS AFTER
THE BF'S

- EXPECTED τ-c PHYSICS REACH OF BF'S IS NOW ~'KNOWN' FROM CLEO II (10M $\tau^+\tau^-$)

- CLEAR SIGNS OF SOME LIMITATIONS
  e.g. $M(\nu_\tau)$ LIMIT ~15 MeV
  SYST/BGD-LIMITED MEAS.
  TRIGGER LIMITATIONS
  NEW AT THIS W/S

- CAN THE TCF IMPROVE ON THE BF MEASUREMENTS?
  → DETAILED, CASE-BY-CASE REPLY REQUIRED
  - ONLY GENERAL COMMENTS HERE
  - REQUIRES NEW STUDY

1. ON BASIS OF STATISTICS THERE IS NO DIFFERENCE BETWEEN BF's AND τCF

2. WHAT THE τCF PROVIDES IS A

   UNIQUE EXPTL. ENVIRONMENT

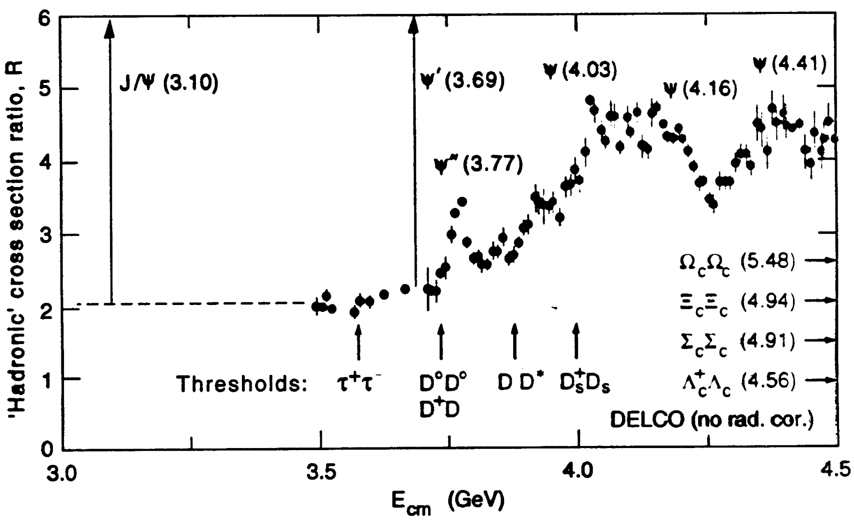
   FOR τ PHYSICS

   FOR c PHYSICS

   AND FOR GLUEBALL SPECTROSCOPY

$\Rightarrow$ τCF SHOULD ACHIEVE SMALLER BACKGROUNDS AND SYSTEMATIC ERRORS THAN BF's / PREVIOUS MACHINES

Tau-charm threshold region



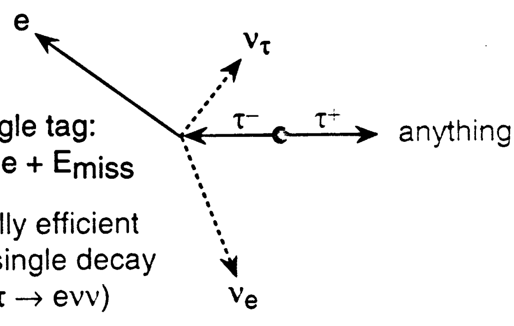
Unique experimental environment at TCF

- Extremely high statistics:
  - 30-50M τ/c /year
  - 10^{10}-10^{11} J/ψ /year
- Lower backgrounds than other machines:
  - τ production below c/b threshold:
    - Single-tagged τ samples
  - Tagged charm hadrons (absolute Br's):
    - D^0, $D^\pm$, $D_s^\pm$, $\Lambda_c^\pm$, Ξ_c, Σ_c, Ω_c
  - Absence of jet fragments / extra particles
- *Experimental* measurement of backgrounds (by operating machine below threshold)
- Favourable kinematics
  - Monochromatic 2-body decays
  - Constraint on single missing ν
  - Low particle overlap / high detection efficiency
  - Clean (low energy) particle i.d.
- High rate detector calibration sources: J/ψ, ψ'
- Special machine features:
  - Longitudinal polarization
  - (Monochromator optics)

• MORE OBSERVABLES
• EASILY REVERSED
→ POWERFUL EXPTL. X-CHECK
• POLN. OF DECAY μ ALSO IN DETECTOR

VERY SUBTLE EFFECTS

Single-tagged τ samples at TCF



single tag:
e + E_{miss}

(fully efficient
on single decay
$\tau \to e\nu\nu$)

- Non-τ backgrounds 10^{-4} - 10^{-3}
  (below charm threshold)

- Typical backgrounds at CESR/LEP ~1%

- At 3.67 GeV:

	ε (qq)	ε(ττ)	#qq/ττ
No cuts	1	1	6
Emiss>0.8 GeV	.005	.95	.03
+Ee>0.4 GeV	10^{-5}	.24	$2x10^{-4}$

Tagged charm samples

- Precision charm experiments require tagged particles.

- Techniques:
  - TCF: Opposite particle: $D^0\bar{D}^0$, D^+D^-, $D_s^+D_s^-$, $\Lambda_c^+\Lambda_c^-$..
  - BF: "D* trick": $D^{*+}\rightarrow D^0\pi^+$, $D_s^{*+}\rightarrow D_s^+\gamma$ (not low p_T).
    $D^{*+}\rightarrow D^+\pi^0$ (but, $D^{*0}\rightarrow D^0\pi^0$ also!)
  - Fixed target: Secondary vertex

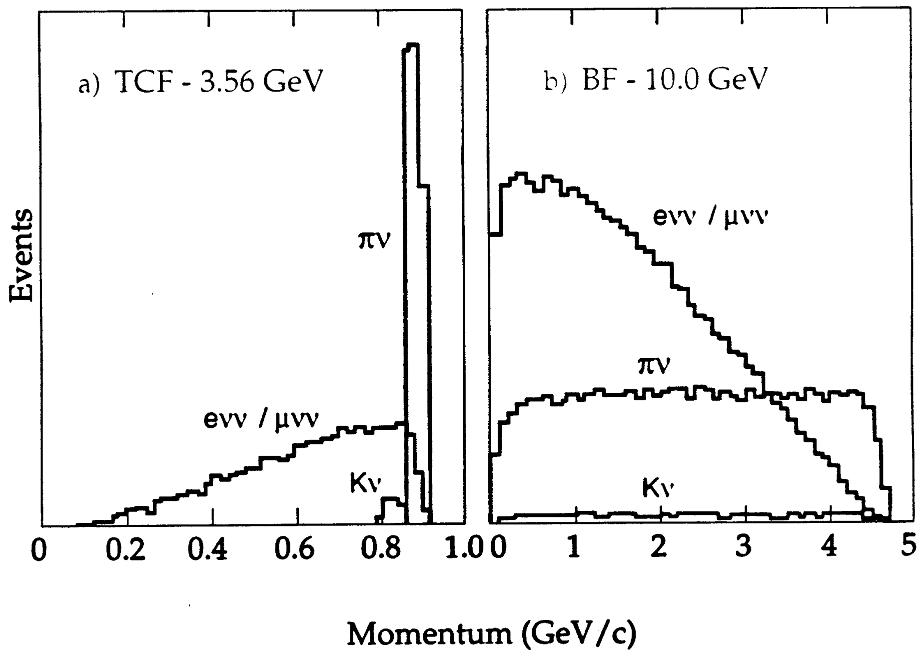
- All work well for easy channels like $D^0\rightarrow K^-\pi^+$

- But for more difficult decays, like semi-leptonics and pure leptonics, there are big differences in backgrounds:
  - eg. $D^0\rightarrow K^-l^+\nu$

eg. $D^0\rightarrow K^-l^+\nu$	Mark III (TCF)	1% bgd.
	Fixed target	30%
	CLEO (BF)	30%

- Also, TCF can tag *all* charm states: D^0, $D^\pm$, $D_s^\pm$, D^{*0}, $\Lambda_c^\pm$..

$\tau \rightarrow$ 1-prong spectra



Indirect ν_τ Mass Measurement

- A heavy ν_τ (≥100eV) must be unstable, eg:

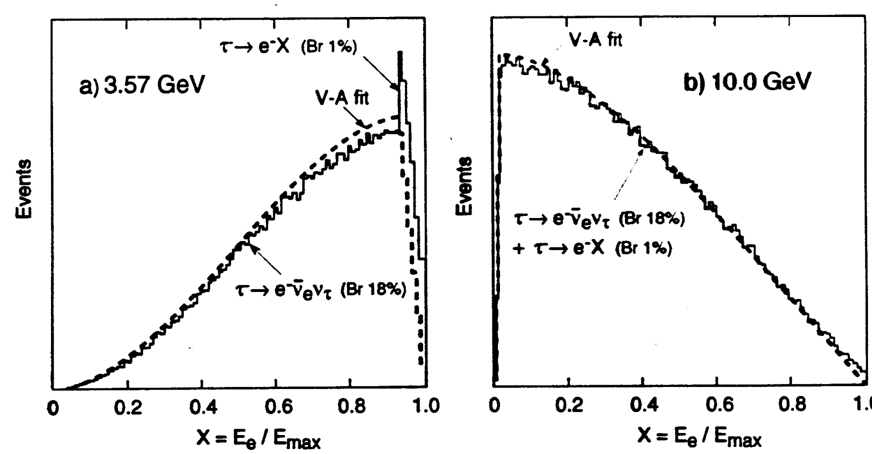
  - $\nu_\tau \to \nu_e/\nu_\mu X$, where X is a weak, massless, spin 0 Goldstone boson (majoron, flavon, etc.)

  => τ will decay via same process:
  $\tau \to e/\mu X$ (<3×10^{-3} at 95%CL - ARGUS)

  and estimated Br's may be ~10^{-5}-10^{-6} (Valle).

  => Indirect access to 100 eV < $m(\nu_\tau)$ < 1 MeV

- TCF sensitivity is < 10^{-5} for $\tau \to e X$

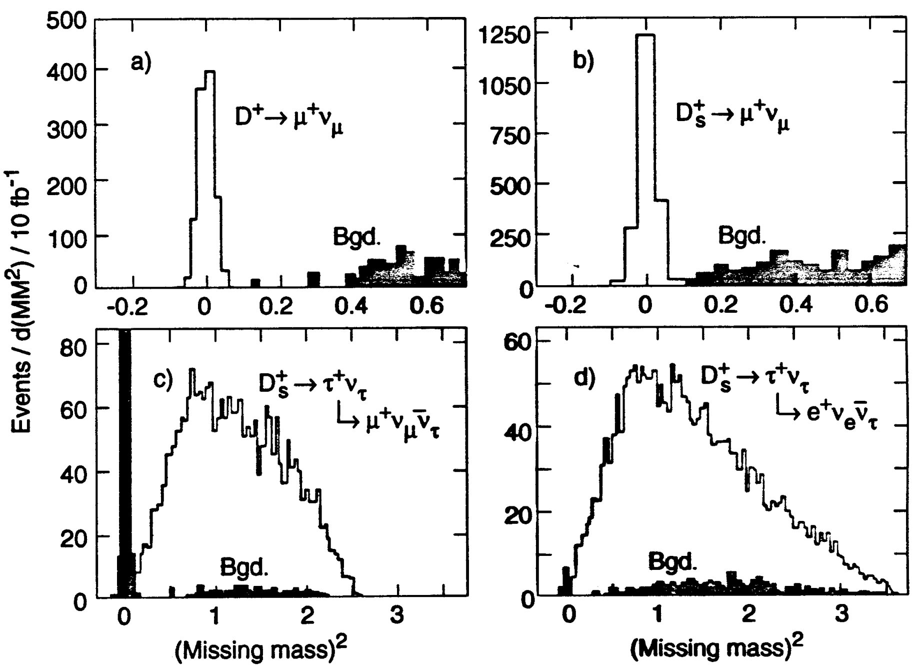


Pure leptonic D decays

- Present experimental errors are large, eg.

$$f_{D_s} = 344 \pm 37 \pm 52 \pm 42 \quad \text{CLEO II}$$

The TCF precision is 1% for f_D and f_{D_s} /1-year's data:



- The best way to determine f_B precisely is to measure f_D and use lattice QCD to extrapolate from the D to the B region. [Br($B^+ \to \tau^+\nu_\tau$) $\sim 7 \times 10^{-5}$, and $| V_{bu} |$ is poorly known.]

Detector calibration at TCF

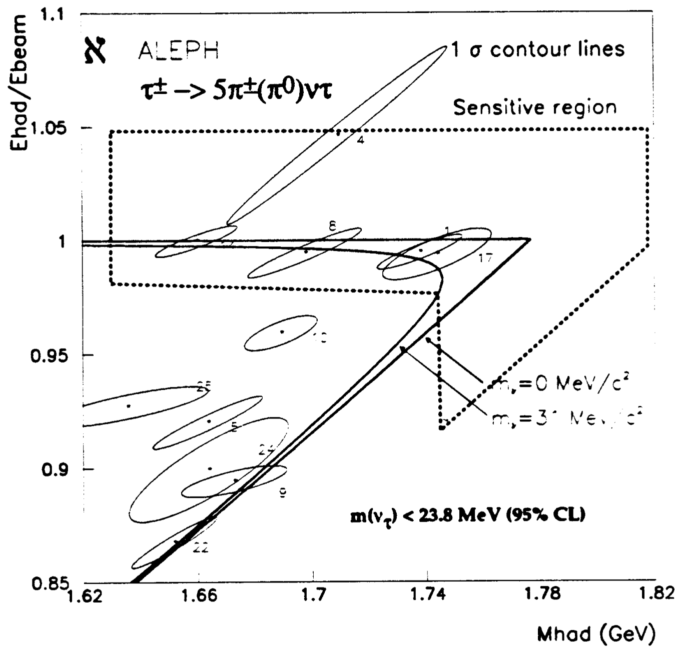
- Example of some calibration channels at the J/ψ (1.3kHz total rate):

Particle	Final states	Rate (/day)
$\pi^\pm, \pi^0$	$\rho\pi$	2M
$K^\pm$	K^*K	0.7M
p	$pp, pp\pi^0, pp\pi^\pm$	1.5M
γ	$\rho\pi, \gamma 4\pi^\pm, \gamma ee$	2M
K^0_L	$K^0_L K^0_S$	10k
n	$np\pi$	0.3M
e	$ee, \gamma ee$	8M
μ	$\mu\mu, \gamma\mu\mu$	8M

Direct ν_τ Mass Limit

$m(\nu_\tau) < 18.2$ MeV (95% CL)

ALEPH (3π/5π-2D, TAU96)



- Expected TCF improvement relative to ALEPH:
  - Per year, x100 statistics above
  - σ_m ~2 MeV $5\pi^\pm$ mass resolution (1/10 x ALEPH)
  - Background fraction $<10^{-4}$

- ν mass limit $\propto \sigma_m / \sqrt{N}$

  => TCF will reach $m(\nu_\tau) = 1$ MeV sensitivity

Interest in charm physics

1. Precision quantitative tests of QCD in a unique regime (perturbative/non-perturbative interface)
   - Charm tightly constrained in SM
   - D is accessible to precise predictions of lattice QCD
   - Fundamental charm parameters poorly measured:
     - $V_{cd} = 0.224 \pm 0.016$ (unitarity: 0.2210 ± 0.0030)
       $V_{cs} = 1.010 \pm 0.180$ (0.9743 ± 0.0007)

2. Input for precision physics at higher energies:
   - Poor charm data (Br, s.l. spectra,...) limits precision of *present* B, Z measurements
   - Test and calibrate theoretical tools, eg:
     - V_{td}/V_{ts} from $B \rightarrow \gamma\rho$, $\gamma\omega$, γK^{*0} needs $D^0 \rightarrow \gamma K^{*0}$ etc.
     - f_B determination needs f_D, f_{Ds} in $D_{(s)} \rightarrow l\nu$

3. New physics discovery potential:
   - CP violation, $D^0\bar{D}^0$ mixing, rare decays...
   - Rich variety of weak decays (CA,CS,DCS, leptonic, semi-leptonic, 2nd-order weak)
   - Sole window for +2/3 heavy flavour physics

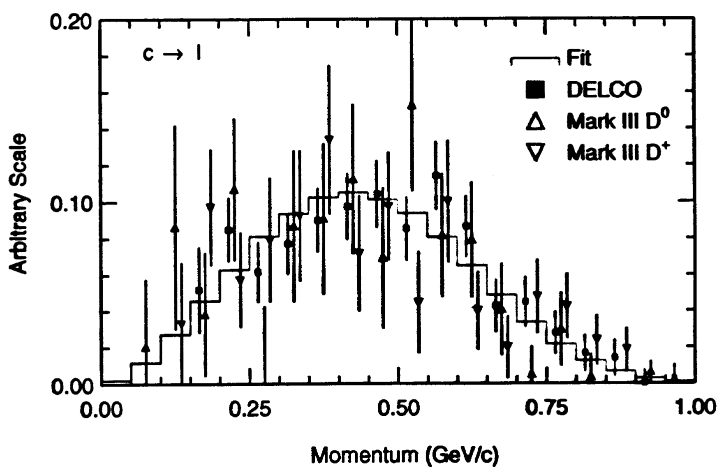
Experimental status of charm decays

- Experimental precision of charm Br's is poor:
  - D^0 / $D^\pm$ $\gtrsim$10%
  - $D_s^\pm$ $\gtrsim$20% (no absolute measurement yet)
  - $\Lambda_c^\pm$ $\gtrsim$20%
  - Ξ_c / Ω_c Br's are unknown

  ... and 20-50% of decays not yet seen. Stark contrast with τ decays!

- The TCF will measure absolute Br's with precisions:
  - D^0 / $D^\pm$ / $D_s^\pm$ 0.1-0.3% /1-year's data
  - $\Lambda_c^\pm$ 1% /y
  - Σ_c / Ξ_c / Ω_c 3-10% /y

- Present experimental status of c →l spectrum:



τcF PHYSICS

1. SURE THING

- ALMOST ANY τc PHYSICS TOPIC YOU THINK OF INVOLVES AN ENORMOUS PROGRAMME OF IMPORTANT MEASUREMENTS
  (eg AW TALK ON QCD PHYSICS IN τ DECAYS)

  ⇒ "LEP-STYLE" PRECISION PHYSICS PROGRAM IS GUARANTEED

2. NO GUARANTEE

- REVOLUTIONARY DISCOVER[IES]
- BUT POTENTIAL EXISTS
  $m(\nu_\tau)$, $\tau \to \mu\gamma$, $D^0\bar{D}^0$ mix ...
- IS τcF THE SPEAR AFTER ADONE?
  OR THE PEP/PETRA/TRISTAN/LEP AFTER SPEAR?

IMPORTANT τc PHYSICS EXPTS.

[PERSONAL CHOICE]

τ:

- $m(\nu_\tau)$
- MICHEL PARAMETERS
- RARE DECAYS:
  - ALLOWED $\tau \to \mu\nu\bar{\nu}\gamma$ ...
  - FORBIDDEN $\tau \to \mu\gamma$ ...
- CP

c:

- D^0–$\bar{D}^0$ MIXING
- PURE LEPTONICS $D^{\pm}_{(s)} \to \mu\nu,\ \tau\nu$
- RARE DECAYS
- CP

EW:

- R_{HAD}

QCD:

- GLUEBALL/HYBRID SPECTROSCOPY
  - ↳ "DREAM MACHINE"

TOPICS REQUIRING MORE STUDY IN TCF

- RHAD
- $M(\nu_\tau)$ [ALL CHANNELS]
- τ MICHEL PARAMETERS (INC μ POL.)
- $\not{CP}$ IN τ DECAY
- $D^0\bar{D}^0$ MIXING
- $\tau\bar{\tau}$ TAGGING AT 3.67 GeV
- L3TC DETECTOR
- SPLITOFFS IN ECAL
- MACHINE BGDS INC:
  - TOUSCHEK
  - ECAL NOISE HITS

⋮

MACHINE & DETECTOR

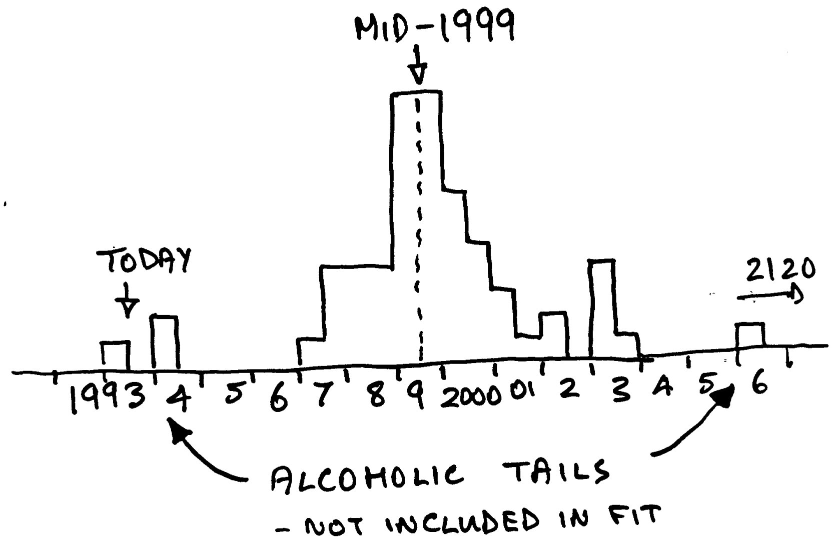
- THE LATENESS OF τcF SHOULD BE CHANGED INTO AN ADVANTAGE BY UTILIZING ALL THE
  - MACHINE RESULTS FROM DAΦNE / CESR / PEP II / KEKB
  - DETECTOR ADVANCES FROM BABAR / BELLE / LHC DETE. etc.

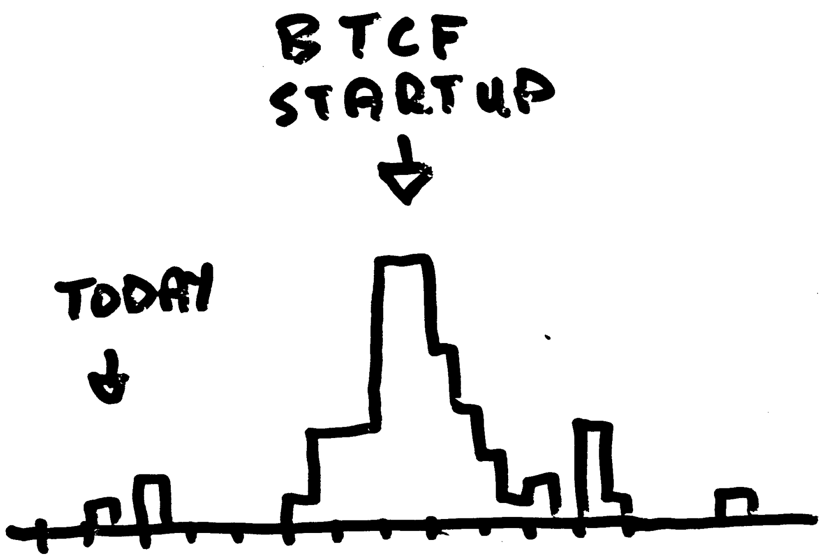
"GROUNDS-UP-REVIEW" OF MACH + DET. DESIGNS

MARBELLA TCF WORKSHOP BANQUET (3 JUNE 1993)

TCF BANQUET :

1st TCF COLLISIONS EXPECTED IN . . .




BTCF
START UP
TODAY