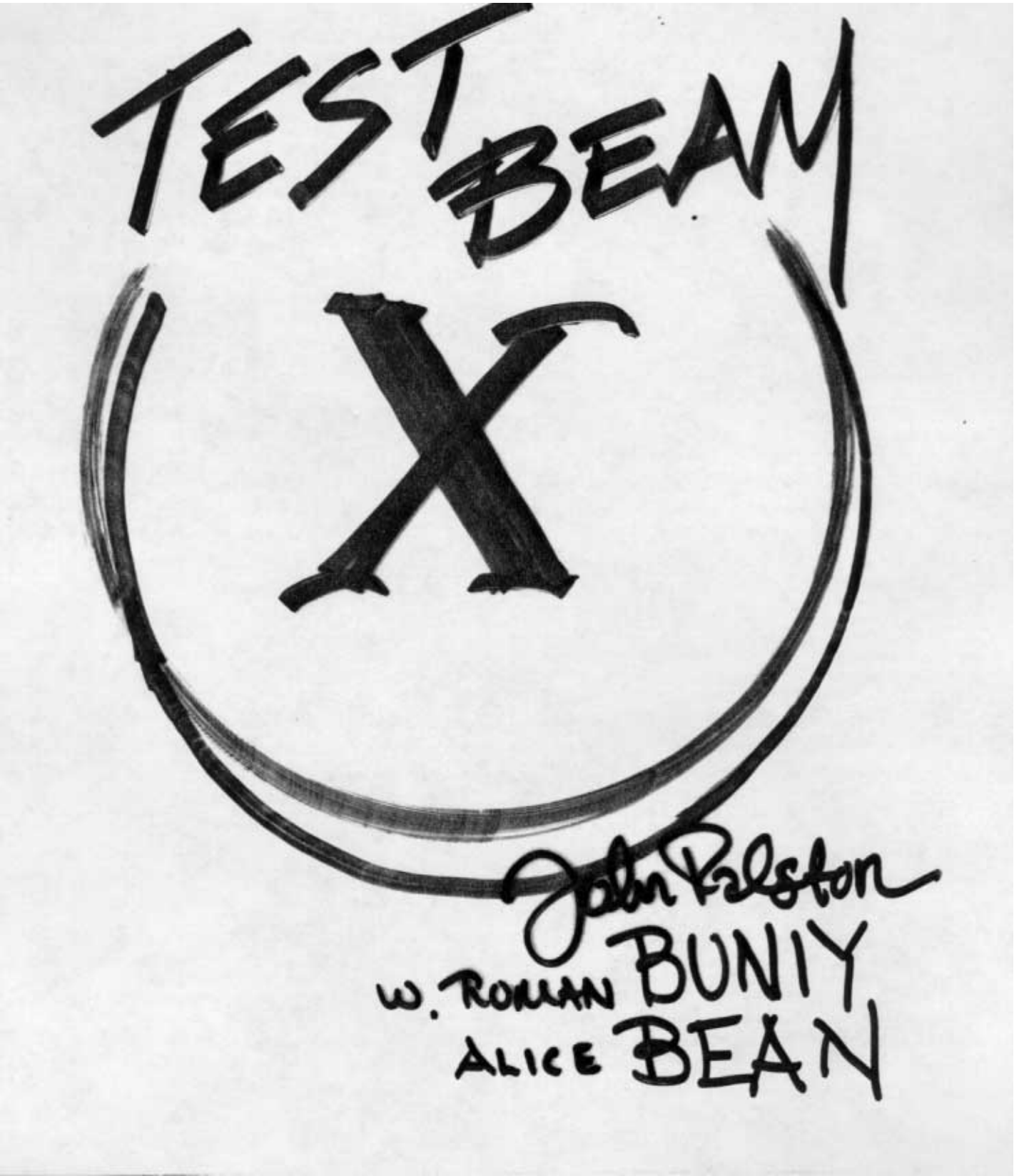

TEST BEAM
X
John Ralston
W. ROMAN BUNIY
ALICE BEAN

hadronic shower test proposal

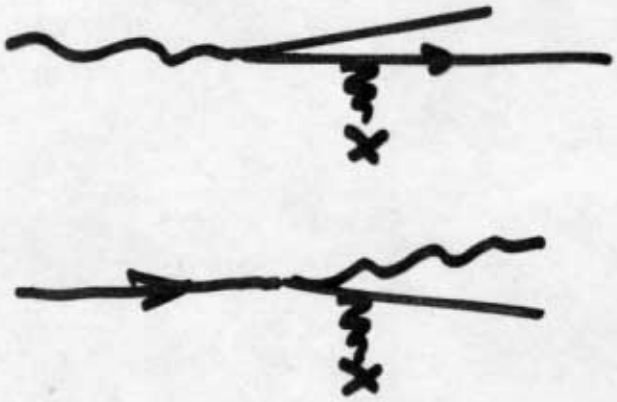
INCORPORATING
WHAT WAS
LEARNED
FROM

c.a. 1995

- A. BEAN, I. KRAVCHENKO (SLAC brems strk)
- D. BESSON (SLAC sand)
- M.A. CUMMINGS (FNAL concrete)
- ANL
- SLAC

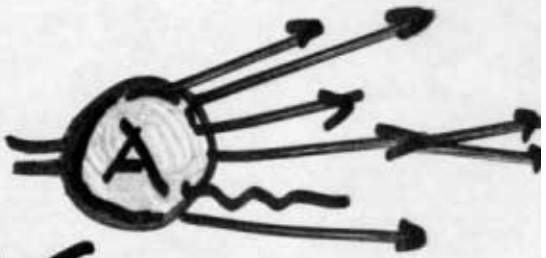
Shoesson, Gorham, Salzburg, Odian et al.

ELECTROMAGNETIC versus HADRONIC showers



DIMENSIONLESS COUPLING α

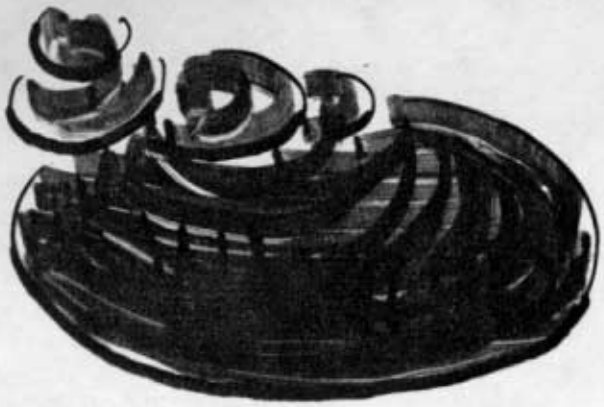
SCALING + ATOMIC



STRONG FORCE DIFFERS @

- MeV
- GeV
- 10 GeV
- 100 GeV
- ⋮

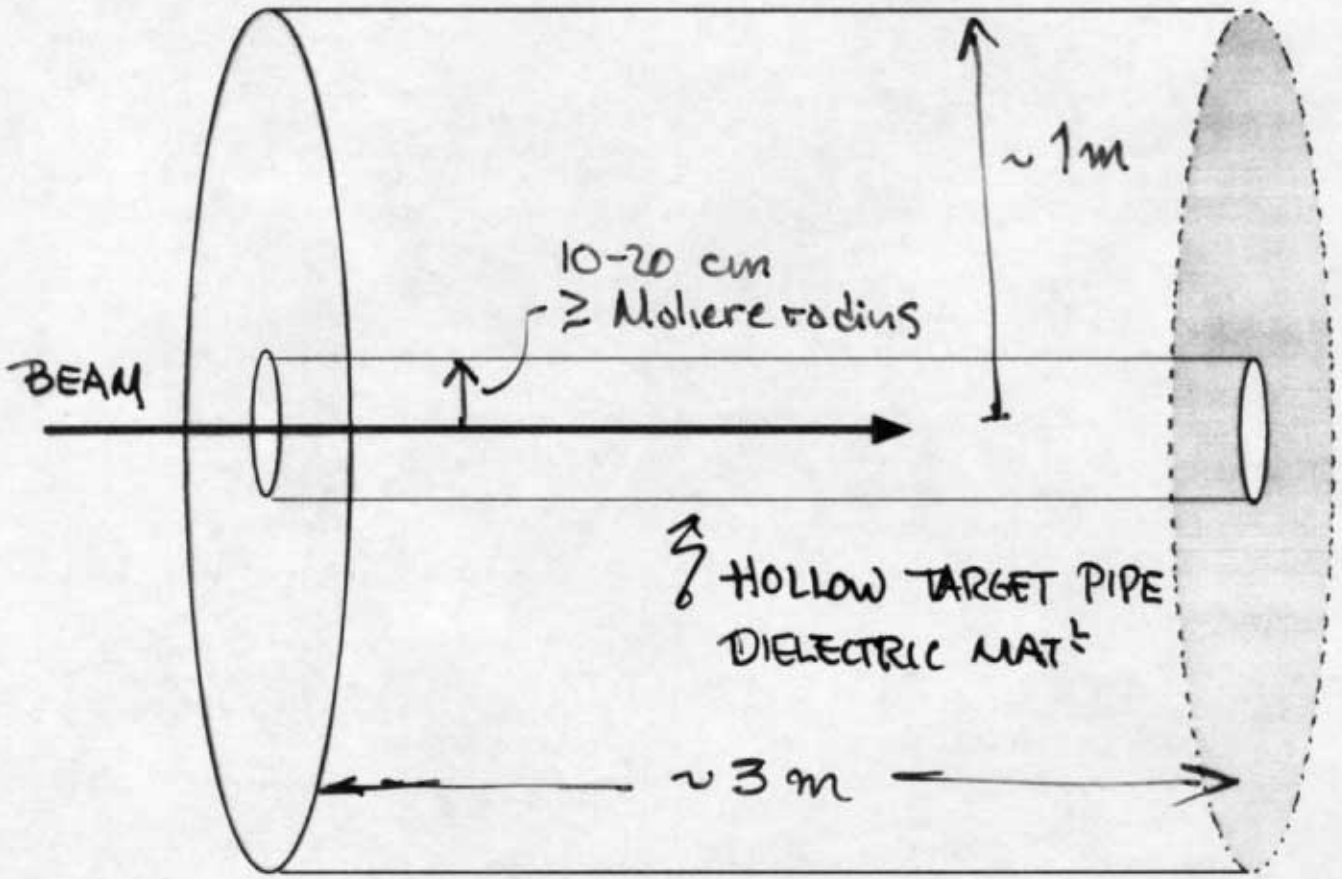
each new energy, new physics



- "exact" electrodynamics
  - HIGH DEGREE OF SYMMETRY
  - CONTROLLED BOUNDARY CONDS.
- over-determined experiment
  - MULTIPLE CONSISTENCY CHECKS
  - INTERNAL CALIBRATIONS
- pas tros chér

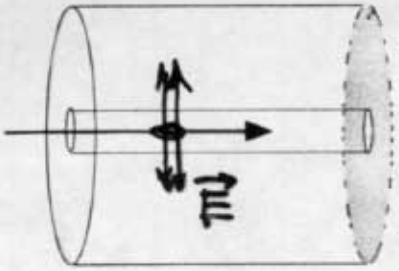
the TANK

CONCEPTUAL OVERVIEW



- Fill target and/or tank w/ dielectric fluid: H_2O

- COMBINATIONS -

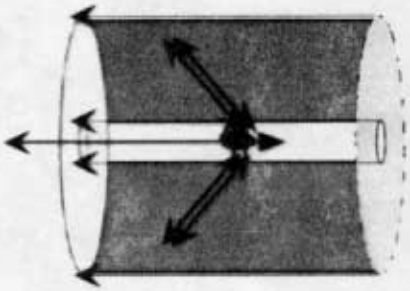


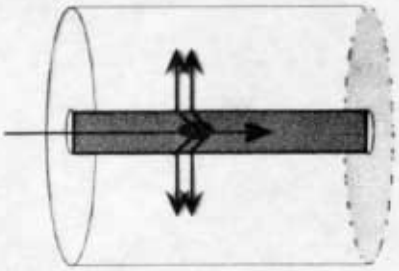
Empty Target : no shower evolution
...Empty Tank

Lienard-Weichert Calibration

Empty Target : no shower evolution
....Full Tank

Cherenkov Propagation with Known Q



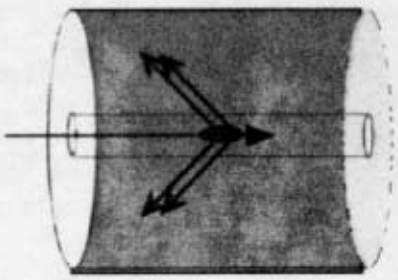


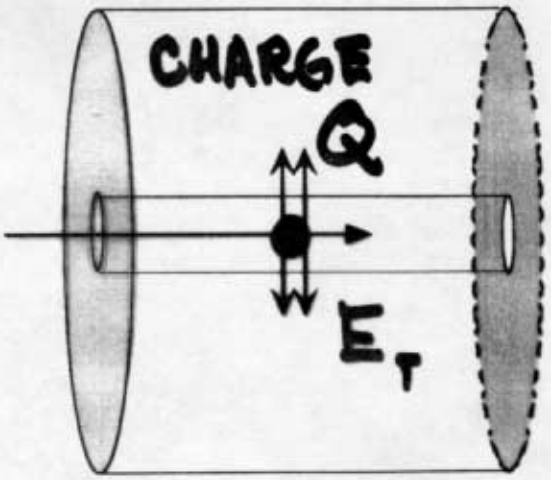
Full Target : shower evolution
Empty Tank

Lienard-Weichert Propagation with shower-evolved Q

Full Target : shower evolution
...Full Tank

Cherenkov Propagation with shower-evolved Q





Empty Target : no shower evolu
...Empty Tank

Lienard-Weichert Calibration

Gauss - the fundamentals:

$$\oint \vec{E} \cdot d\vec{S} = 4\pi Q_{enc}$$

$$\downarrow$$

$$\int 2\pi |X_T| E_T \, dz$$

$$\hookrightarrow \int \frac{dz}{\sqrt{2\pi}} E_T = v \int \frac{dt}{\sqrt{2\pi}} E_T = E_T(\omega = 0$$

$$E_T(\omega \to 0) = \sqrt{\frac{2}{\pi}} \frac{Q}{v|X_T|} \qquad \omega \lesssim \frac{v\gamma}{|X_T|}$$

IN MORE DETAIL,
FREE SPACE,

$$E_T(x,\omega) = \frac{Q\omega}{v^2\gamma}\sqrt{\frac{2}{\pi}}\,K_1\left(\frac{\omega|x_T|}{v\gamma}\right)$$

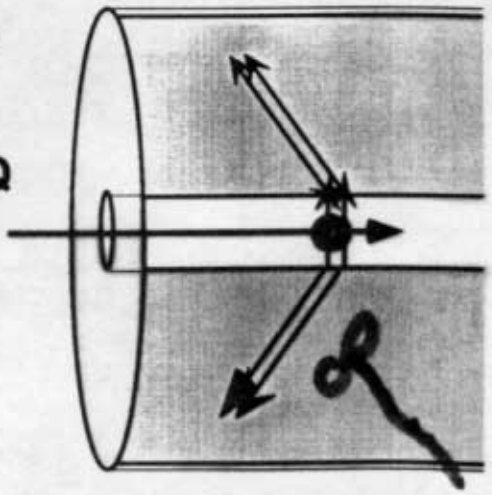
$$E_z(x,\omega) = -\frac{iQ\omega}{v^2\gamma}\sqrt{\frac{2}{\pi}}\,K_0\left(\frac{\omega|x_T|}{v\gamma}\right)$$

EXACT - LORENTZ CONSEQUENCE

"EQUIVALENT PHOTONS"

$$\frac{\omega}{m\gamma} = x_{Feynman}$$

Empty Target : no shower evolution
...Full Tank
Cherenkov Propagation with Known Q



in pipe:

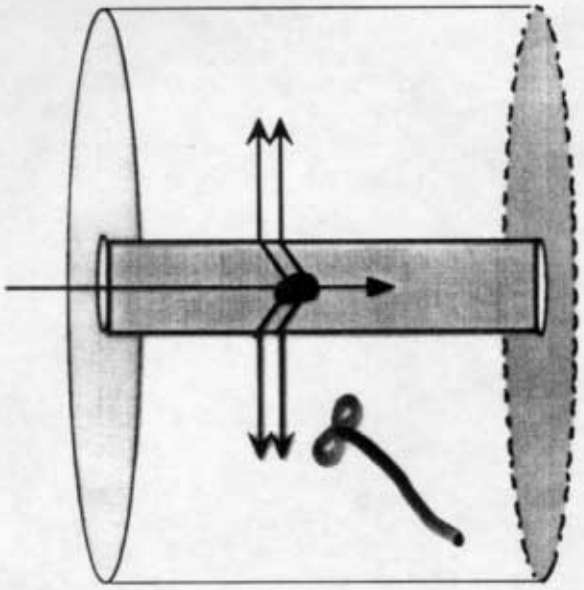
$$Q\left[\alpha K_0\left(\frac{\omega |x_T'|}{v\gamma}\right) + \beta I_0\left(\frac{\omega |x_T'|}{v\gamma}\right)\right.$$

in medium:

$$J_0\left(\frac{\omega |x_T'|}{v\gamma_m}\right) ; N_0\left(\frac{\omega |x_T'|}{v\gamma_m}\right)$$

$$-i\gamma_m = \frac{1}{\sqrt{1 - v^2/c_m^2}} \qquad v > c_m$$

EXACT and OVERDETERMINED



Full Target : shower evolution
...Empty Tank

Lienard-Weichert Propagation wi
shower-evolved Q

MEASURE Q $E = E\left(\frac{\omega |x_T|}{v\gamma}\right)$

$\gamma(100\,\text{GeV}\,p) \sim 100$

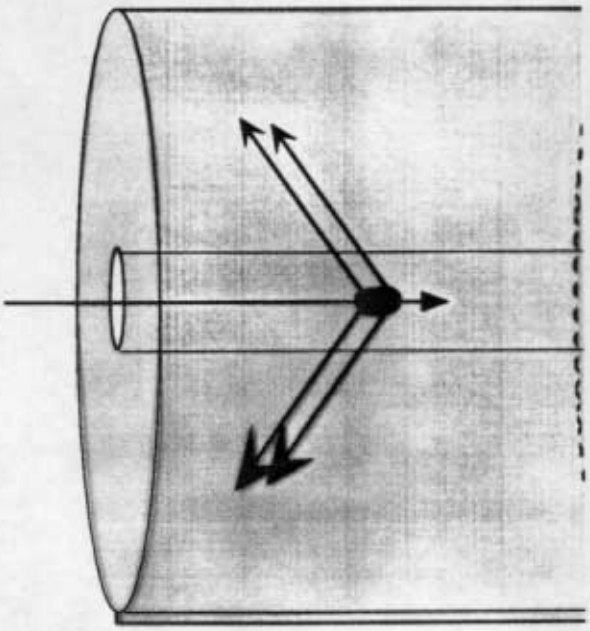
Gauss' $\omega \lesssim |x_T|/v\gamma$

"FREE SPACE"

PROPAGATION

Full Target : shower evolution
Full Tank

Cherenkov Propagation with shower-evolved Q

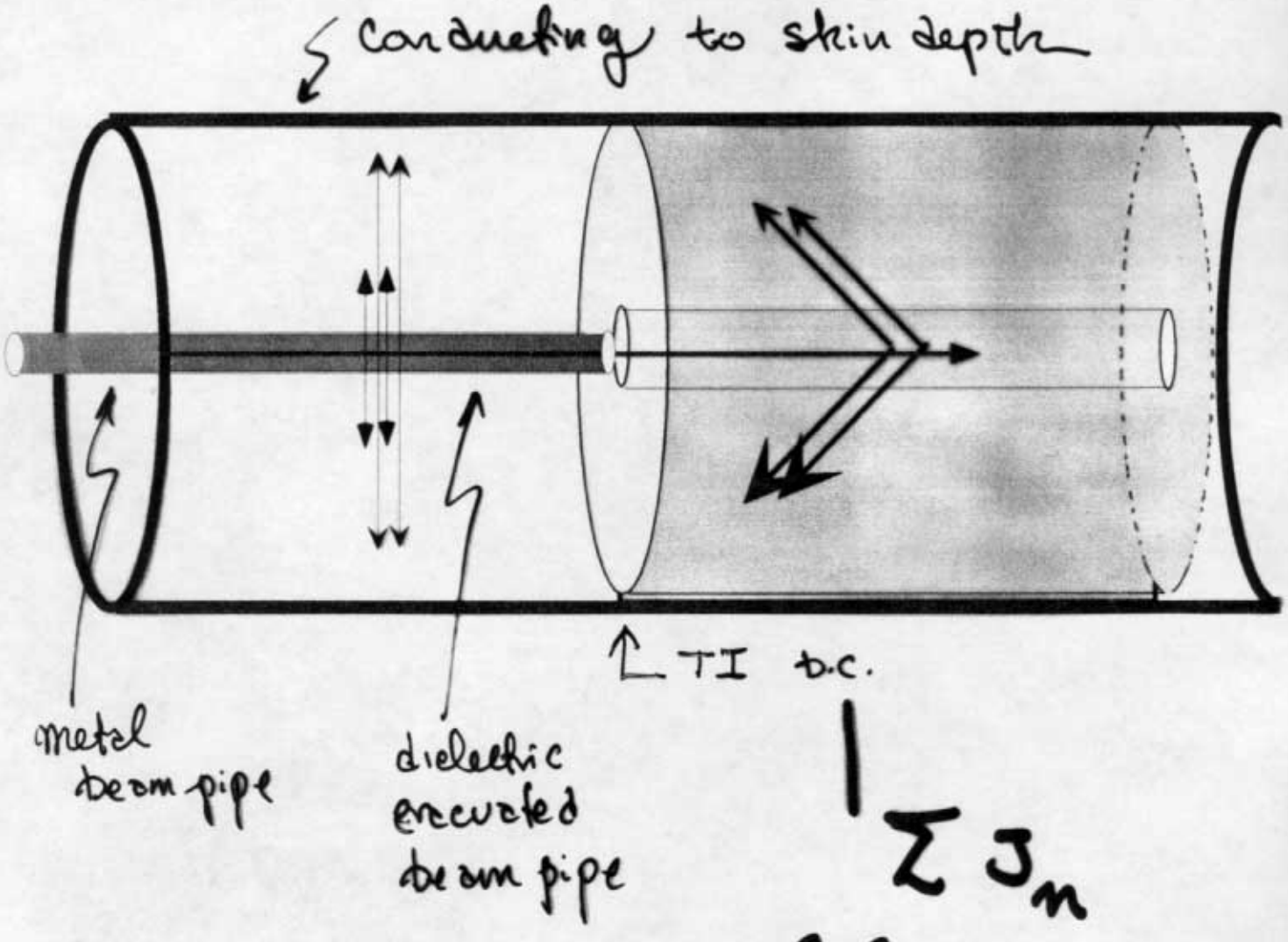


- HOMOGENEOUS
- OVERDETERMINED, 2x, GIVEN PREVIOUS
- TIMING DIRECTLY RESOLVES Č CONE

... CAUSALITY a GREAT HELP

RECOUNT

..."THIS (ELECTION) IS NOT ABOUT ISSUES...
...IT'S NOT ABOUT 'CHARACTER'...
.....IT'S ALL ABOUT CHOOSING THE
PROPER BOUNDARY CONDITIONS..."



K_o, N_o, J_o, I_o ... all solved ...

$\Box A^\mu = -4\pi J^\mu$

$A^\mu = -4\pi J^\mu \cdot \frac{1}{\Box}$ — GEANT PART

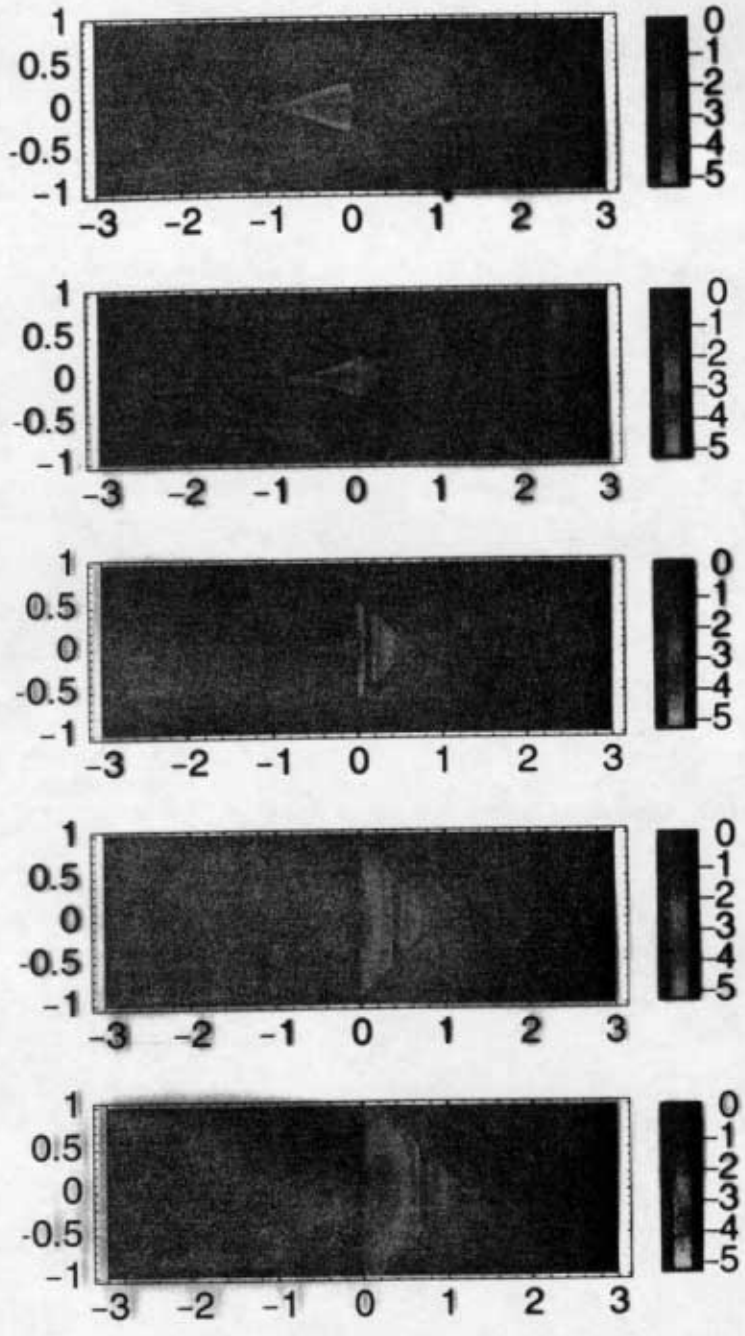
$\frac{1}{\Box}$ — bc's w/ cylindrical symmetry

R. BUNIY

real-space, real time GREEN FUNCTIONS

"movies"

"SCENES from "CHERENKOV",
COHEN BROS., 20th CENTURY

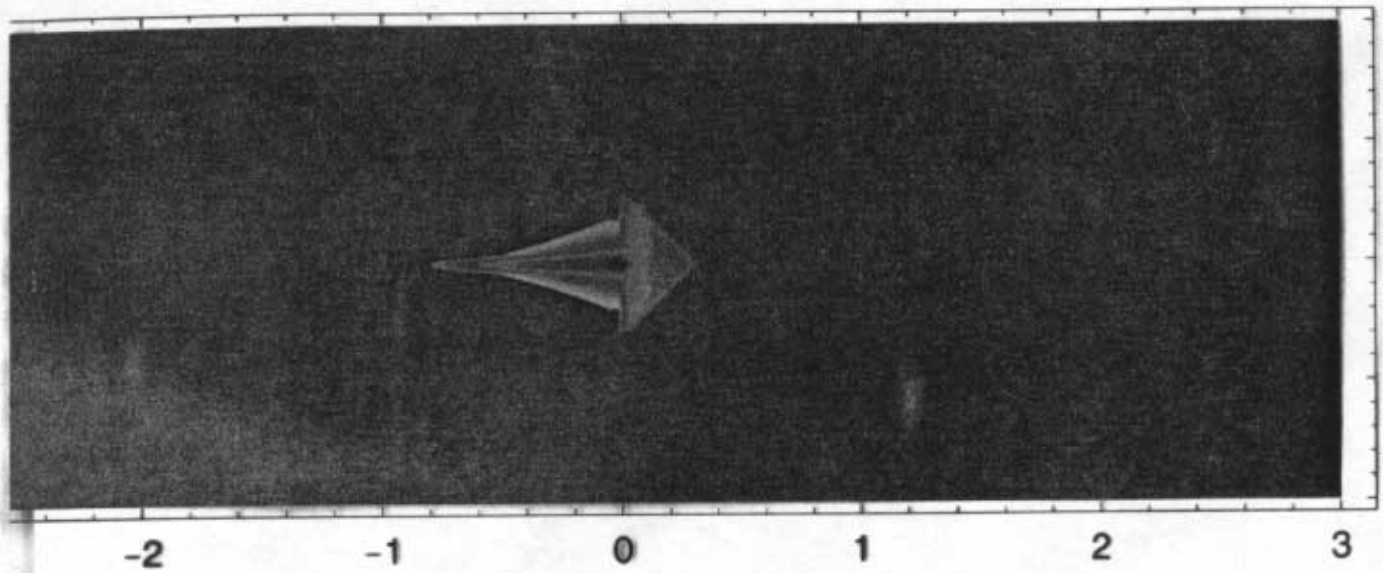


← log scale

time

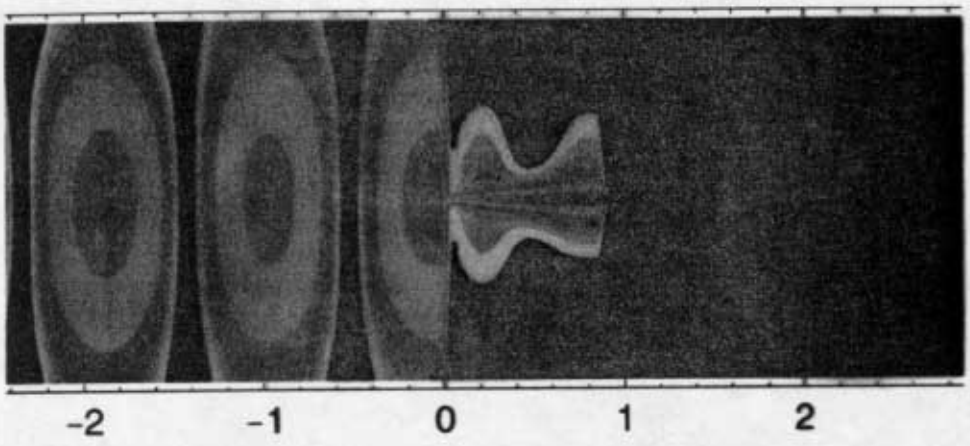
R. BUNNY, DIRECTOR & CINEMATOGRAPHY

... grand entrance,
with Arrow of Time...



CAUSALITY!

exit with flourish into free space



$|\leftrightarrow|$

$L \quad \Delta t \sim O\left(\frac{R}{\cos\theta_c}\frac{\Sigma z}{c_m}\right)$ "CAVITY RING"

as in ANL Wakefield

W. Gai, P. Schoessow, et al.

- H_2O has $n = 9$ flat

  $\nu \lesssim 100$ MHz

  ★ VERY LONG RING TIME A PLUS

- STRONGLY ATTENUATING

but

| Orders of Magnitude
| $\int \vec{E}$ avail
| @ FNAL

this is first test beam

with symmetry & planning

to zap near, far, fresnel,

b.c. & all ELECTRODYNAMIC troubles

small task group of Beau, Bunin, Ralston

still in EARLY PLANNING STAGES

of EXPERIMENTAL IMPLEMENTATION,

for FNAL PROPOSAL 4/01

Collaboration

Welcome!