30 May　2018

Kimio Niwa

丹羽　　公雄

befor OPERA　after OPERA

PHOTOGRAPHIC EMULSION in the physics research

- 1896 A Becquerel found radioactivity
- by photograpfic plate , naked eye.

- 1910 S Kinoshita 木下季吉 studied
- the darkness by micro scope.
- darkness made by tracks
- “discovery of alpha particle”

S KINOSHITA

1935 Powell developped electron sensitive gel G5 with ilford Co.

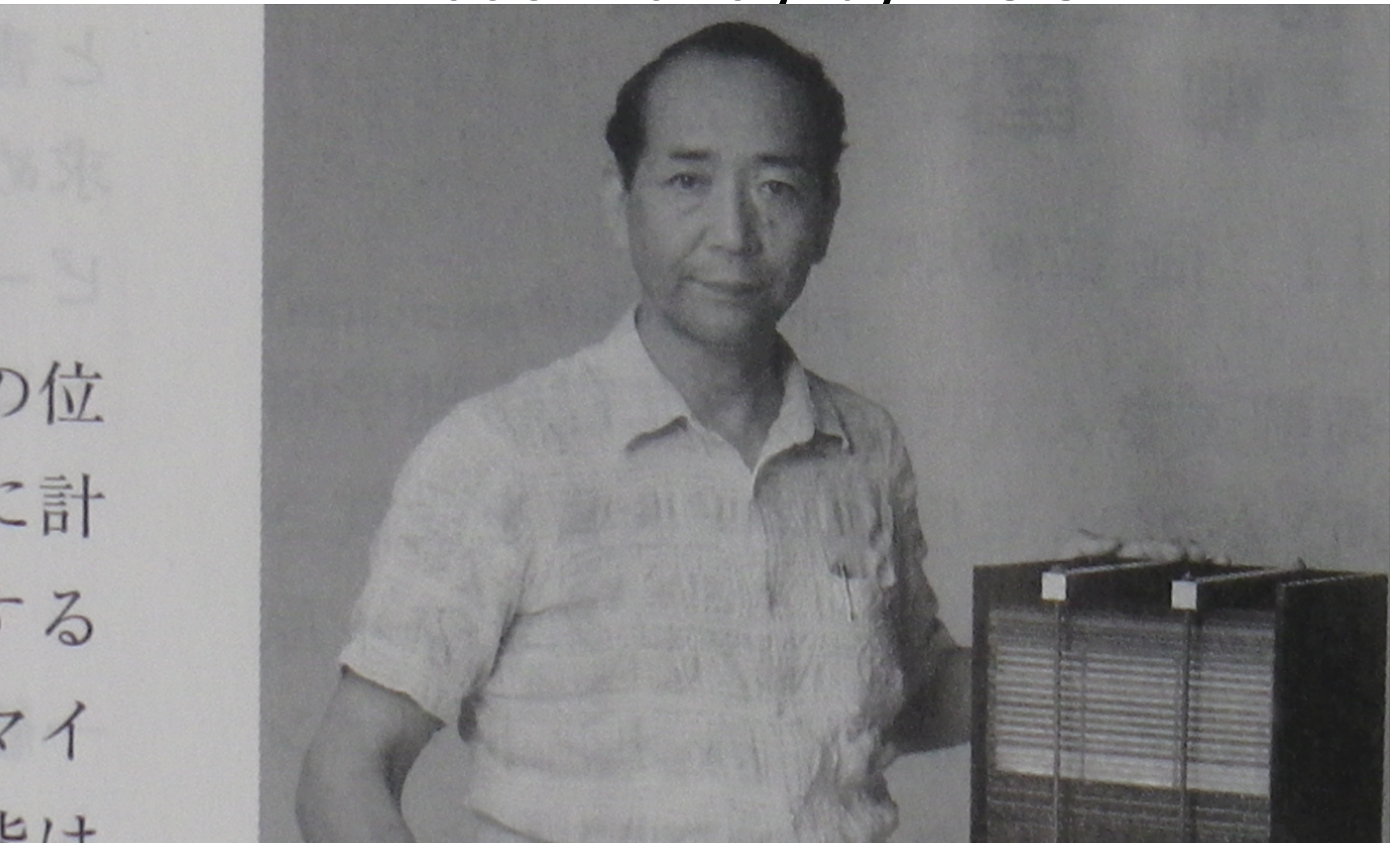
Kodak Co. 1947 pai/ μ/e detected in cosmic ray ,thick gel [pericle]

- BB

1970 both side coated emulsion plate introduced by Japanease physisists Niu, Koshiba,Fuji Co.

Both side coated plate is 3D tracking device(x,y,tx,ty and D) with high resolution.

K. 1971 Niu discovered charm ptl. in cosmic ray by ECC



ECC

- Sandwich structure by
- emulsion plate and absorber
- Absorber: iron and or lead etc.
- Emulsion plate: double side gel coated
- Emulsion Cloud Chamber

- Multiple layer of Spark chamber was used in Comic ray study. In 1950-1970 and Ue Uμ identification EXP.

After
J/Ψ discovery 1974

- Beuty particle found
- Tau lepton found
- Interest changed!
- From quark to neutrino

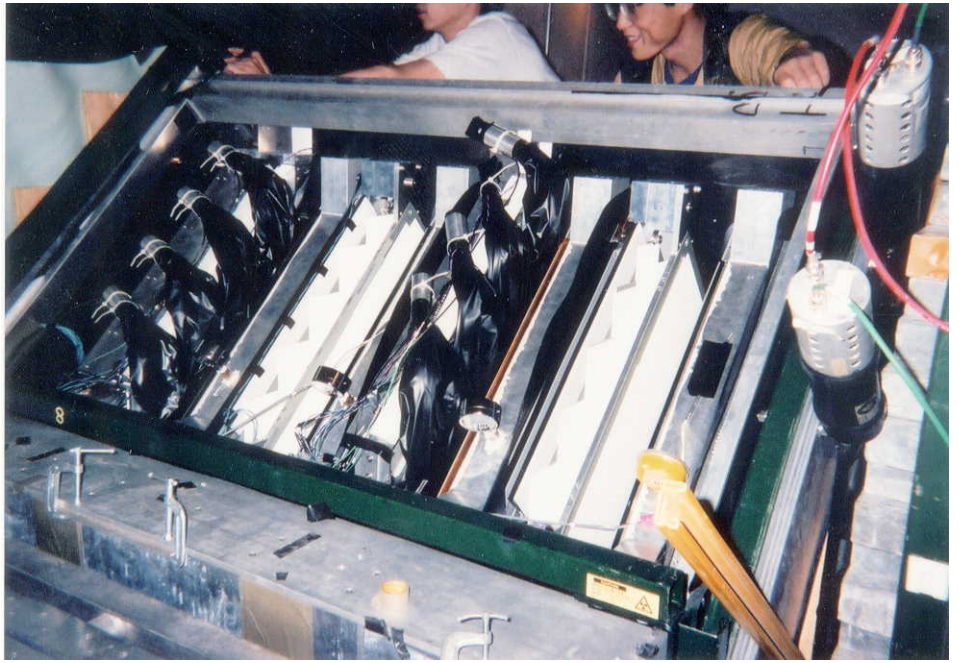
- 1990 KAMIOKANDE obtained atomospheric neutrino. Ue/Uμ separated
- up going neutrino number is missing compare to down going neutrino!
- Neutrino oscillate ? or sterile ?
- Neutrino oscillation was introduced 1962 by NKAGAWA et al.
- If oscillate, Neutrino is not massless !!
- tau neutrino is dark matter!! Harari 1998
- Our interest changed from quark to neutrino world!
- CHORUS 1990 started at CERN
- DONUT at FNAL tau neutrino search

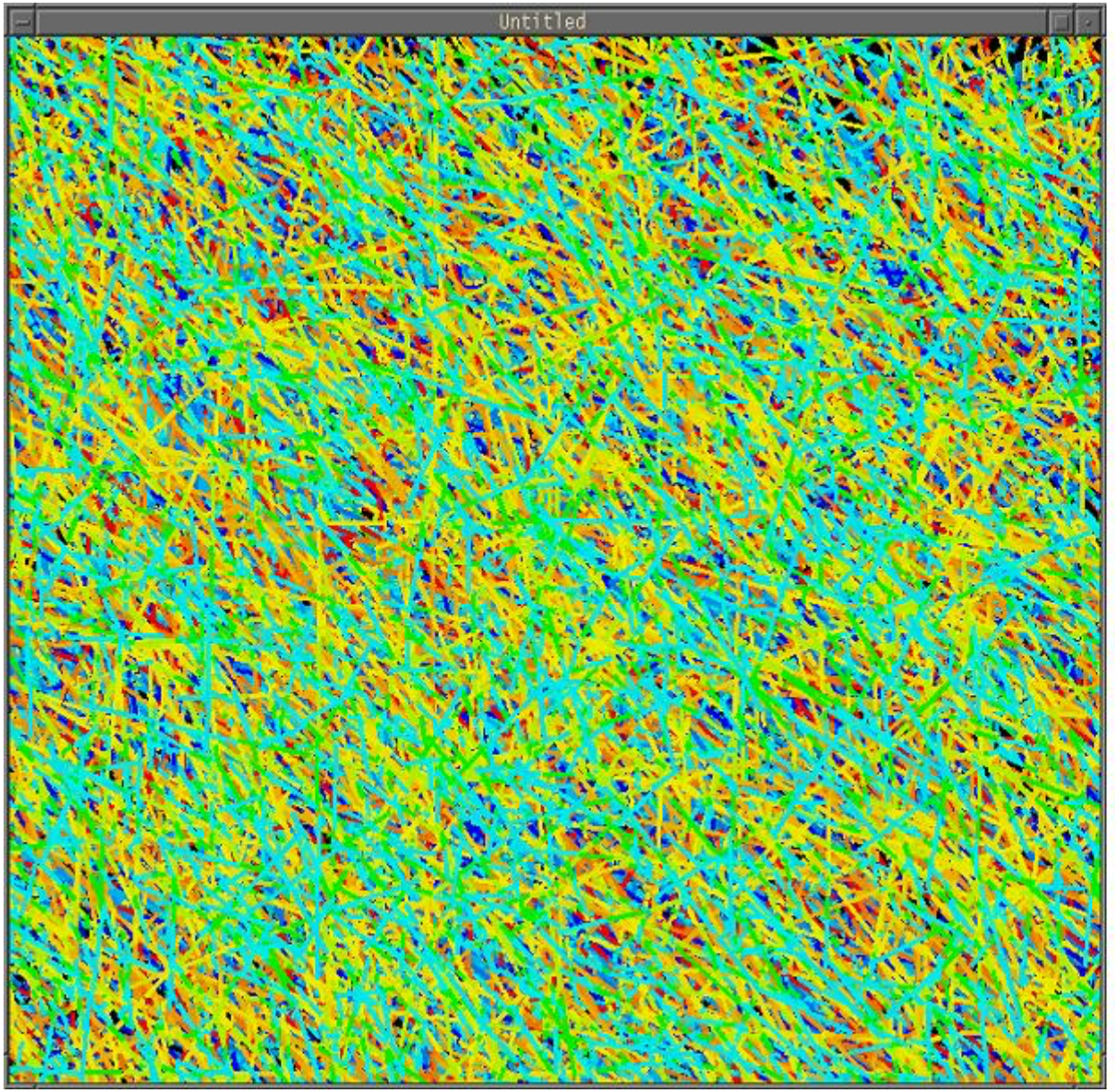
DONUT

- Beam dump of FNAL TEVATRON
- 800GeV proton
- Detecter is ECC+muon spectrometer
- Hand made both side em coated plate
- Absorber is iron with thickness 1mm
- Size 50cm by 50 cm
- Automatic scanning and NET-SCAN was applied
- Track density ~$10^7/cm^2$

DONUT detecter
50kg ECC 4 units total 250kg

- Sandwich structure,emulsion plate and iron plate

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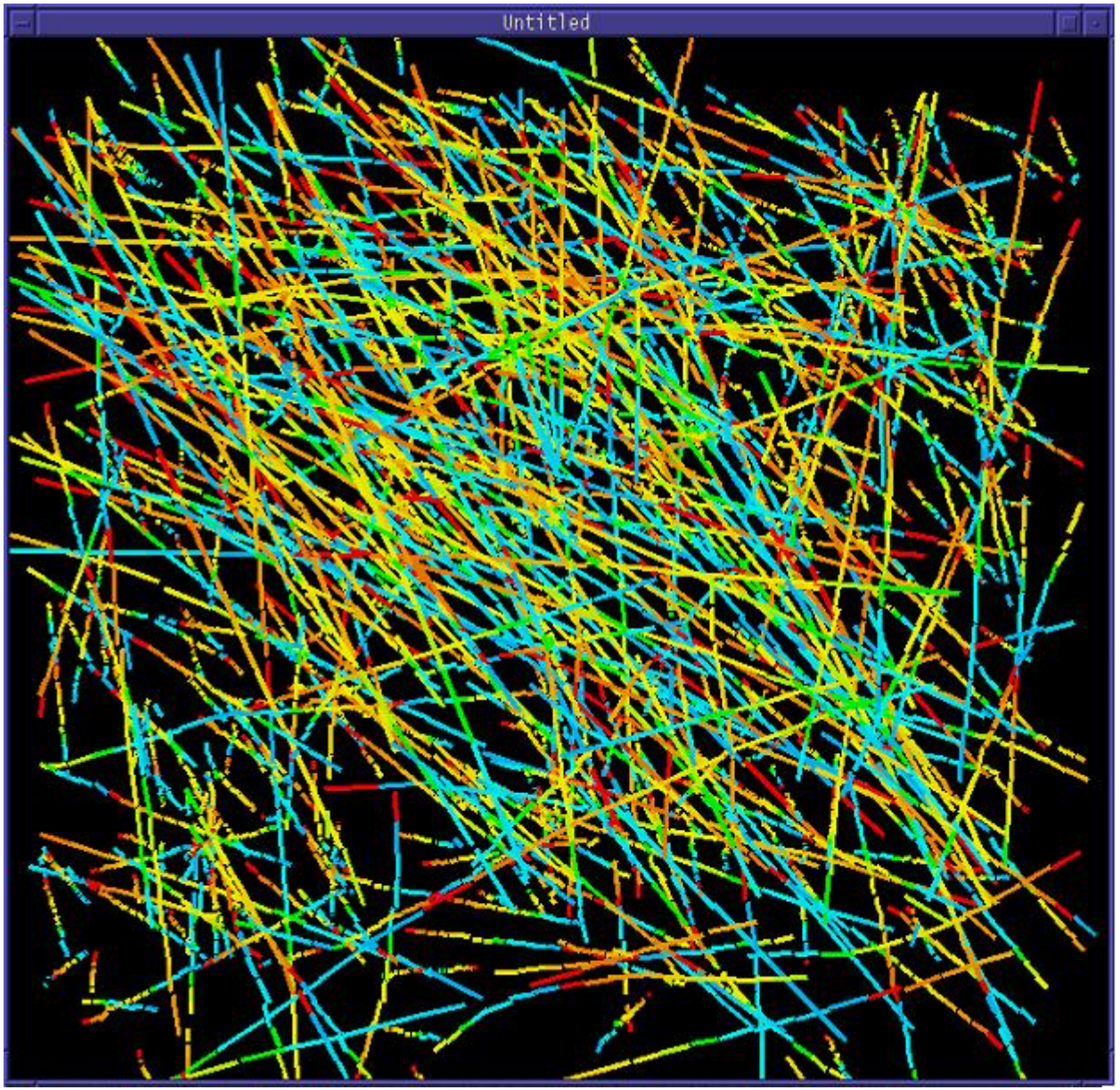
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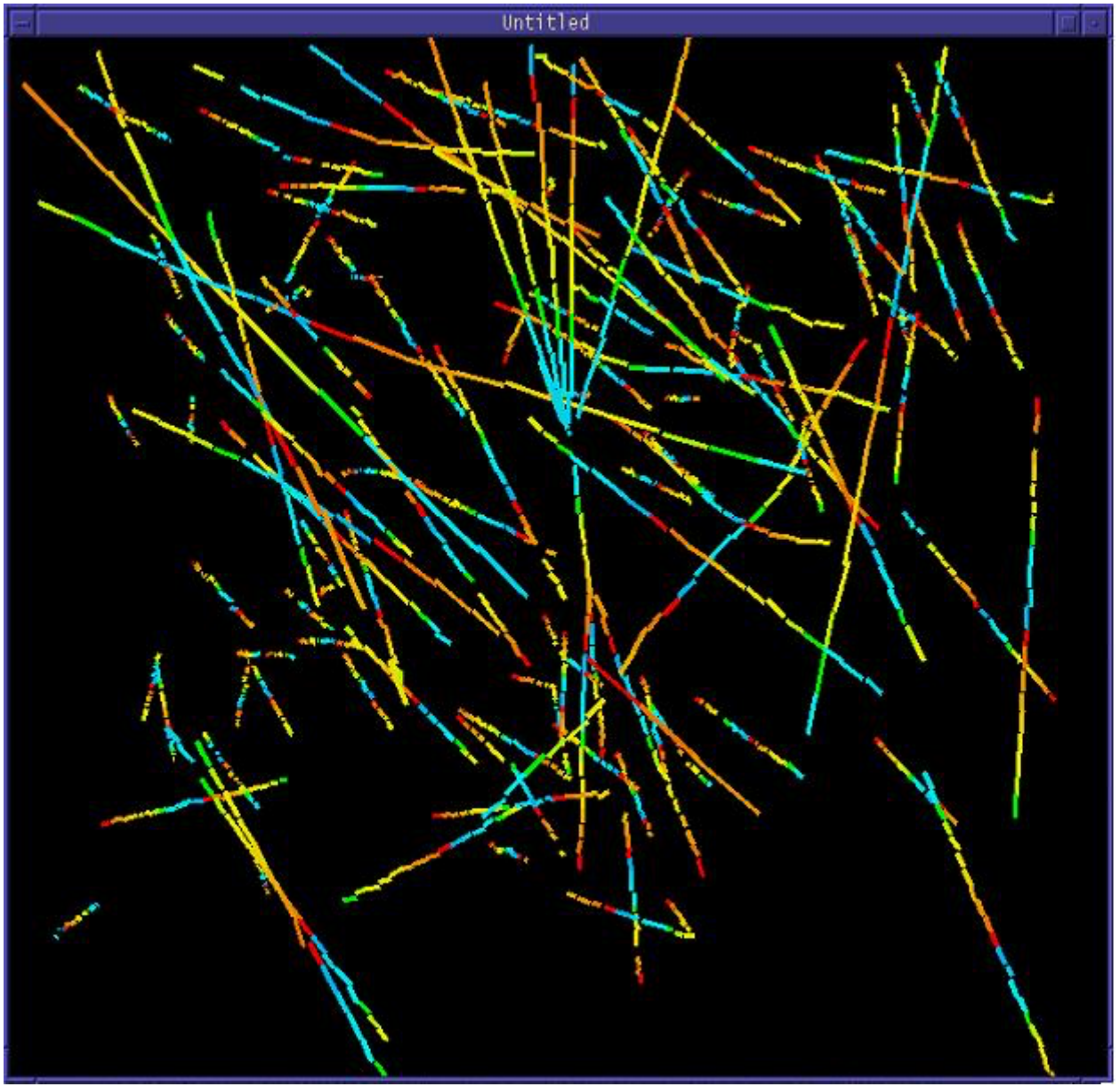
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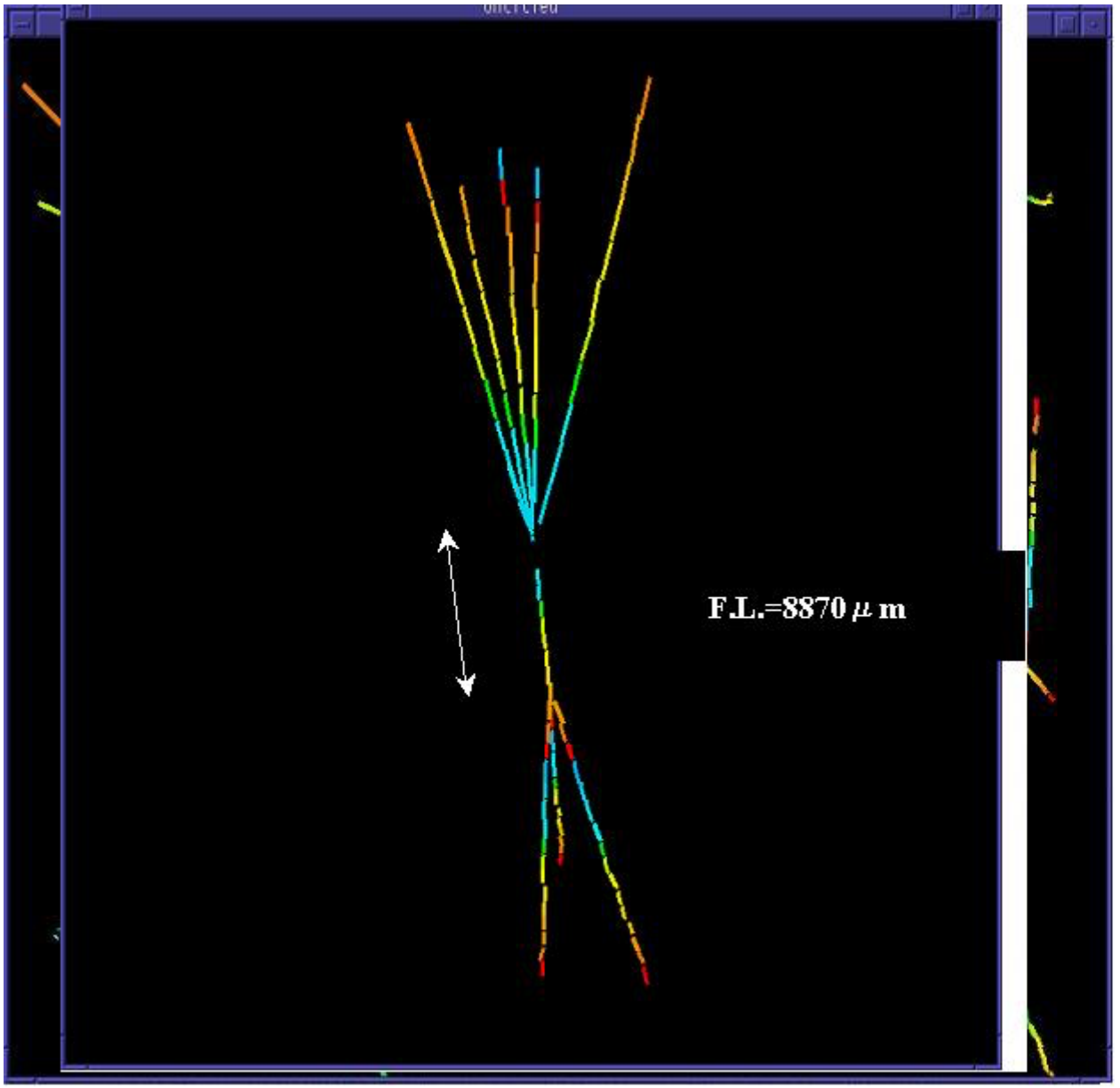
F.L.=8870 μ m

From Quark to neutrino

- 1996 KAMIOKANDE new data mean
- atomospheric neutrino is misterius !!
- Looks like, neutrino is oscillating...
- Mixing angle is big, mass difference is small
-

1995 at FNAL I(Niwa) introduced the idea of

long base line ν_μ-ν_τ appearance EXP by

DONUT like100tonECC.start of opera

assumed mixing angle 10^{-2}

using KAMIOKANDE(before SK)data

Neutrino mass may be not heavy,

ν_t dose not a candidate of darkmatter.

ν_μ-ν_t dose not osc. in short distance.

CHRUS should be no solution! Long base line shold be done with big target mass

Summary 1947 to 2005

- 1947 C.F.Powell Π/μ/e [emulsion thickgel: pericle]
- electron sensitive gel G5
-
- 1971 K Niu Charm ptl by ECC Emulsion cloud chamber
- both side coated film : track position(x,y) and angle(tx,ty)
- manually scanning

- 1998(200) DONUT tau neutrino by ECC
- handmade emulsionfilm
- automatic scanning

1995 I(丹羽)introduced the idea of long base line

ν_μ-ν_τ appearance EXP at FNAL by

- DONUT like100tonECC 700km fromFNAL.
- assumed mixing angle 10^{-2}
- using KAMIOKANDE before SK
-

- Neutrino shold not be heavy,
- U_t dose not a candidate of darkmatter.
- myu-neutrino dose not osc. in short distance.
- CHRUS should be no solution!
- Long base line should be done!!

Who intersted to Niwa talk ?

- FNAL adam para
- MINOS leader S.Wojiki?
- ECC 100 ton ! Emulsion ?
- At CERN：discussed with chorus p
- K.Winter, Dore, Roberta
- Next suporter!
- L.Fore, Antonio , P strolin
- Seminar at rome univ. etc.
-

まとめ From chorus to opera proposal

- 1998 TAKAYAMA neutrino conference.
- SK group (Totsuka and Kajita) presented
- the beutiful result on atmospheric neutrinos
- Up going neutrino missing compare to down
- going neutrino. Mu neutrino disappeared !
- Strongly sugestted neutrino oscillation
- Sterile?
- DONUT presented one neutau event detected
- In ECC.

LOI : ANTONIO E assembled !

[Appearans] is indispensable to confirm the neutrino oscillation.

- Tau neurino detection is possible by ECC
- Big ECC detector construction is possible !
- Fuji Co. can make big volume emulsion film.
- Scanning is possible! $20cm^2/h/sys$

- 1999 OPERA proposed
- DG Maiani suported
- 2000 approved at CERN
- 1.5kton ECC sensitive to $3 \cdot 10^{-3}$ mixing
- Maiani pushed OPERA

- Machine made emulsion film by FUJI Co.
- BAM, Lead plate,packing, Target tracker,
- Muon spectrometer, 1.5kton mounting.
- Brick handring(exchange) system,
- Automatic develop, CS, CS to Brick, etc.
-
- By international collaboration work.

-

Opera progress after approval

- 2007 OPERA detector constructed at Grnsasso
- CNGS(neutrino beam from CERN)constructed
- Neutrino exposure 2008-2014
- 2008/5 The first event (first light) detected in ECC
- under microscop
- 20010 the first tau neutrino candidate
- 20012 clear tau neutrino (leptonic tau) detected
- 20015 5 tau neutrino events
- 20018 final analysis 6 sigma

Opera summary

- 1995 idea at fnal (DONUT meeting)
- OPERA detecter constructed in Gransasso.
- OPERA/CNGS construction 2000-2007
- Exposure 2008-2014
- 2008 dec. first neutrino event is located.
- Nμ-Nt 5 events 6-sigma
- Technological out put, useful for future
- Big volume emulsion film handling
- High speed scanning machine with $1m^2/h$

教訓

- Thanks INFN for monay short of “japan”
- to organize international collabolation
- Trouble: over light velocity
- Good lesson to scientist

- It is important to open OPERA data
- Big data handling, application soft.
- for out side researcher and education .

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Trouble : Neutrino velocity

Money short

friends passed away

G Romano

Giacomelli

Tolun(ankara)

Niu(japan)

Kanazawa Fuji co.

Guy Vanbeek(burussel)

合掌

HTS scanning speed 1m2/h

- HTS の写真

After opera [future]

- We maneged big volume emulsion film
- by low cost $1m^2$ 100 ER(big volume only)
- Other device are more expensive.
- We have big scanning power
- $1m^2/h$ or more ~$10m^2/h$ in future

Emulsion future

- Emulsion is the long life detecter in physics
- Start 1896 ,
- Used in research and business..
- Very good interaction with industrial technology.

- Emulsion is not behind the times,
- rather ahead of the times.
-

-

OPERA else

- Gamma ray star AOKI
- balloon , 1m^2, 10 m^2 Eγ>10MeV,,,1GeV
- Monopol, antiproton ,quark,
- Under ground ,airple,balloon,
- μon radiography
- blast furnace / pyramid /etc
- check the status without distroy
- WIMPS search ?, super fine AgBr crystal
- Double hyper nuclus analyzed ΛΛ force, important for neutron star study NAKAZAWA

Nuclear reacter

F.Reines ν_e

detecter:liquid scintillater+PMTs

BNL 14/28 GeV beam dump

Lederman ν_μ

detecter:multilayer spark chambers

FNAL 800GeV beam dump

DONUT ν_t

detecter:ECC

4^{th} Neutrino

e μ τ X_4 ?

ν_e ν_μ ν_τ ν_4 ?

rejected Mass (v4) ≤ 50GeV LRP exp
Mass () ≤ 100GeV LHC

try mass 100GeV≤ .. ≤ 7TeV

- Search for very heavy neutrino V4
- One of dark matter WIMP candidate

- LEP killed leight neutrino U_4 mass<50GeV
-
- LHC no signal on heavy mass neutrino
- DAMA result is not killed
- mass~50GeV??

LHC

7TeV X 7TeV

- On the ground above CMS/ATLAS
- Collision point to the surface≈ 100m

- Detecter area 100m X 100m

- Detect the muon position and impact parameter and momentum

LHC　ポンチ絵

Beam dump emulsion exp

name	Target mass	physics	date year
DONUT FNAL tevatron	100kg	ν_τ discover	2000
.OPERA . SPS	1000 ton	$\nu_\mu \rightarrow \nu_\tau$ appearance	2017
.New . LHC	1 Mega ton	ν_4	?

Experiment	Numbr of proton int	Target mass	Energy cross section
DONUT tau neutrino	10^{18}	250kg	20Gev (800GeV)
LHC V_4 search	100MHz · $3 \cdot 10^7$s=$3 \cdot 10^{15}$int/y	1M ton	14TeV (10^8 GeV)

present situation LHC is wonderfull !

LHC beam colliding position is under ground depth 100m

Put the detecter on the ground

above ATLAS and/or CMS

detecter size 100m*100m

ECC muon detecter

- Posion and angle of muon
- impact parameter analysis
- Momentum measurement
- multiple scattering

- Iron plate and emulsion film ~50 layers
- muon momentum (Tev muon)
- iron plate thickness ~0.5cm 40kg
- Unit ECC weightis ~2 ton

possible ? SCANNING

	Opera	new
unit size	10*cm*10cm*0.6cm	100*100*50 layer
	mag spectrometer +scat.	Scatterng only
• Unit number	100000 units	10000 units
•scanning power	100cm^2/h	10000cm^2/h
•	Only selected	all

コスト how mach??

- Ecc 10000 units cost
- Ecc cost film 2万/m^2 100万円10^4 euro/unit
- Total detecter cost　10^8 euro　　100億円

- 仲間　　中国？
- 　　(HP Kamioka::　korea　chaina)

- 宇宙線研究　高エネルギーμフラックス