KAVLI IPMU

BERKELEY CENTER FOR THEORETICAL PHYSICS

Welcome to

KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

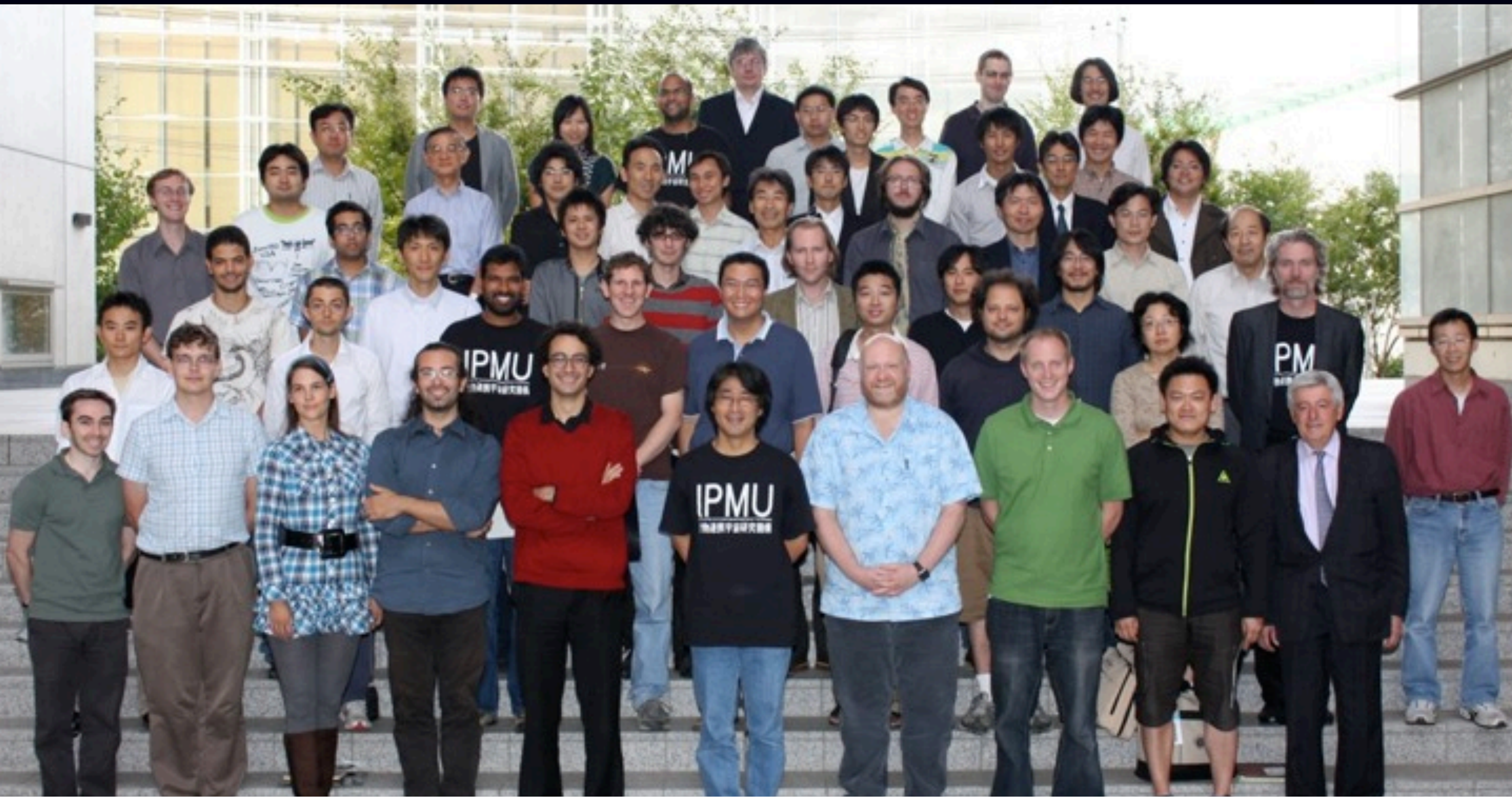
How did the Universe begin?
What is its fate?
What is it made of?
How does it work?
Why do we exist?

interdisciplinary institute of astronomy,
physics and mathematics
10-year program by Japanese
government since 2007

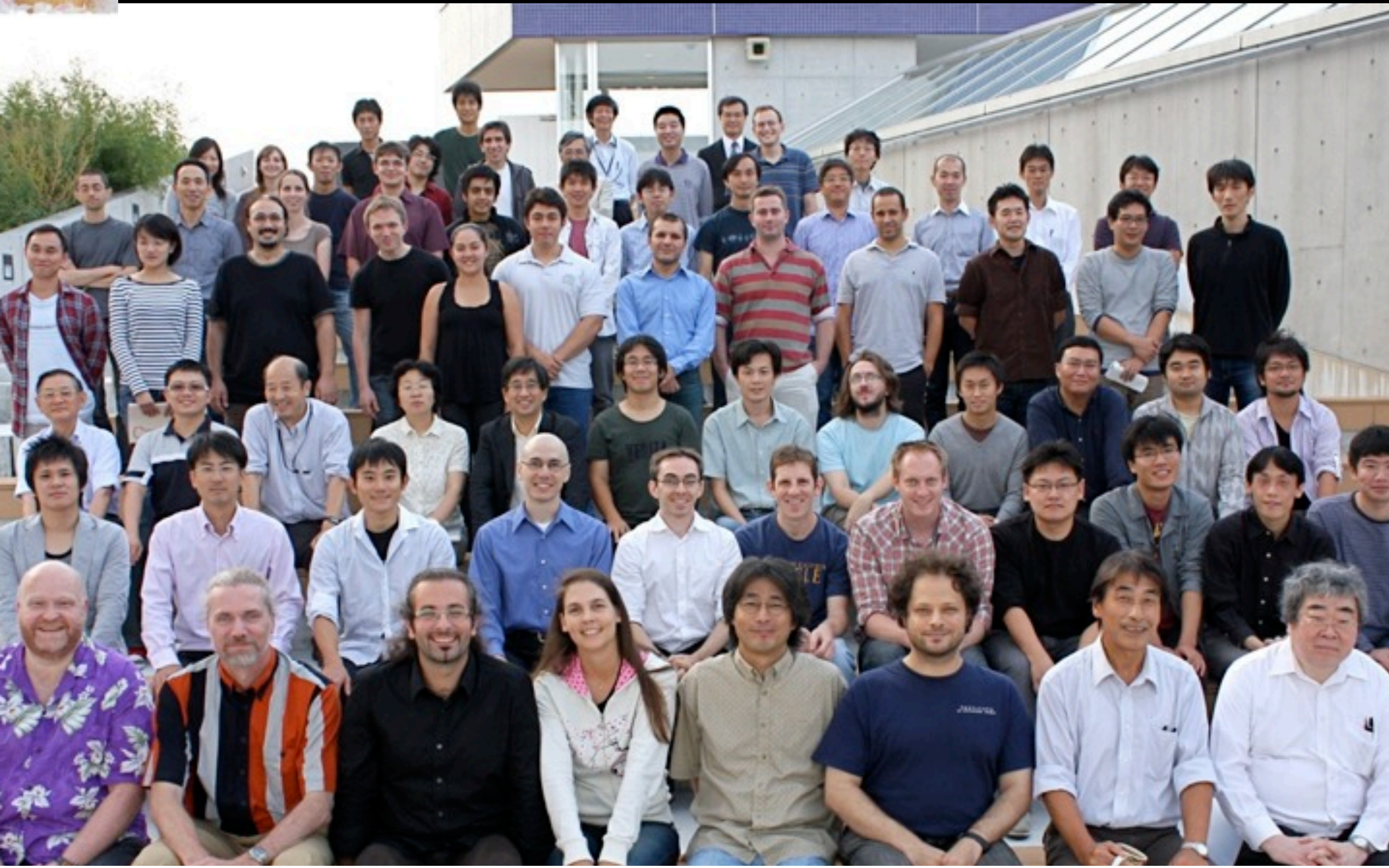
Oct 2007

Oct 2008

Oct 2009



Oct 2010



Oct 2011

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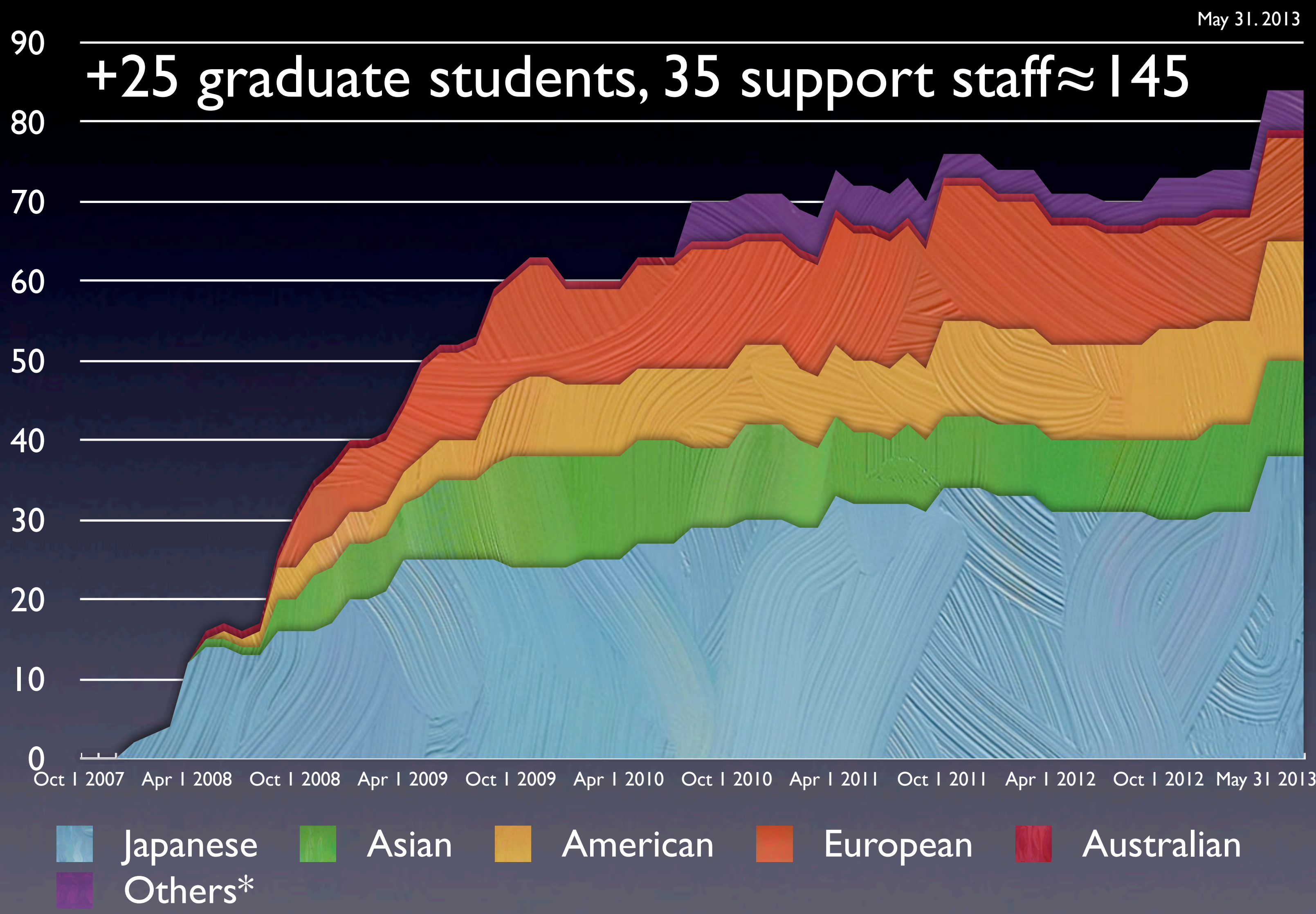
>50% non-Japanese

Full-time Scientists paid by IPMU



*Argentina, Brazil, Canada, Chile


designed specifically for
interdisciplinary research

Introduction to ILC

Hitoshi Murayama (Kavli IPMU & Berkeley)

Kavli IPMU School on the Future of Collider Physics

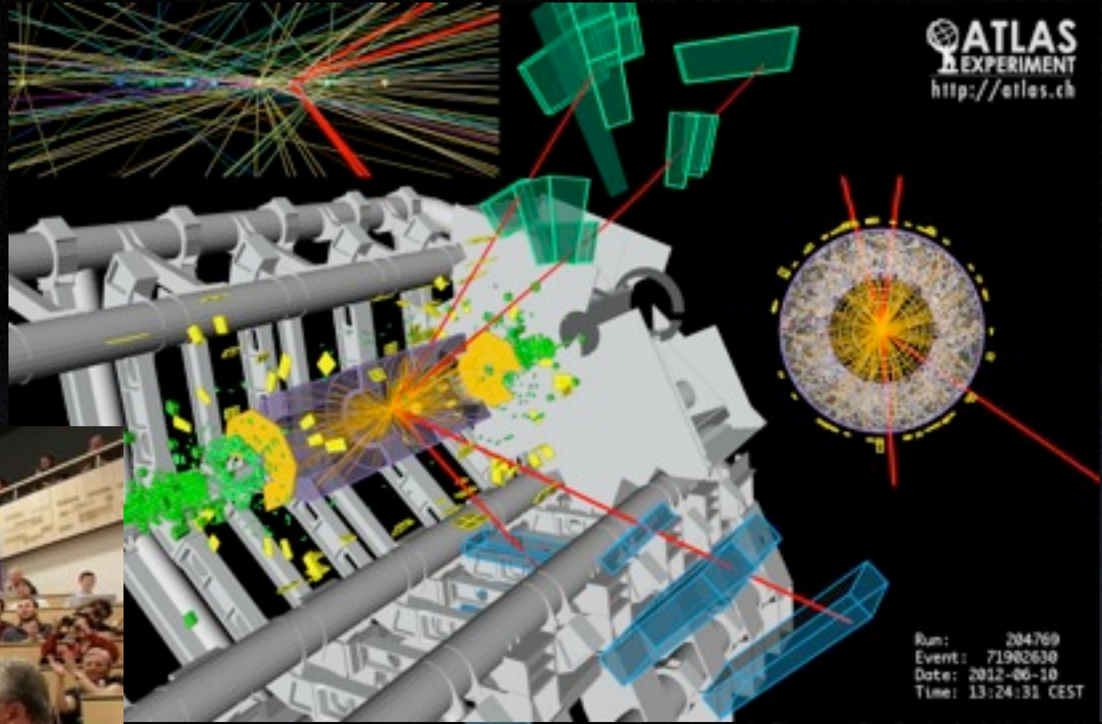
July 16, 2013

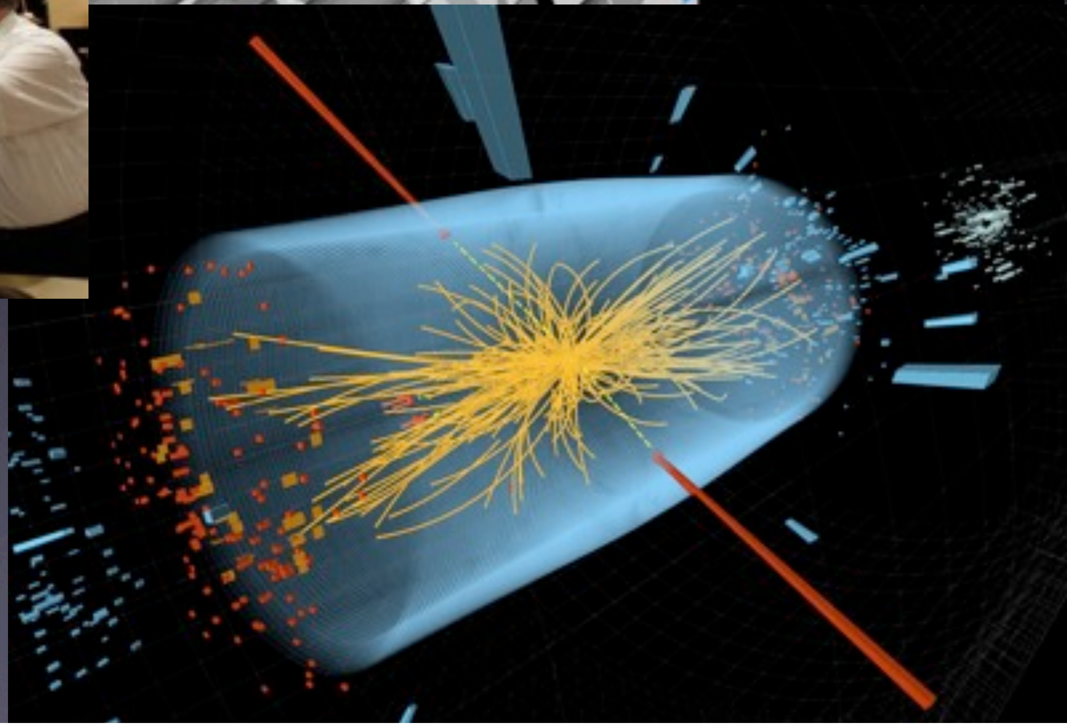
Why ILC?

It's the Higgs, stupid!

2012.7.4

discovery of
Higgs-like boson





theory : 1964

concept : 1984

construction : 1998


webcast watched @
Kavli IPMU
I'm on TV connection
from Berkeley
New Era


Higgsdependence Day

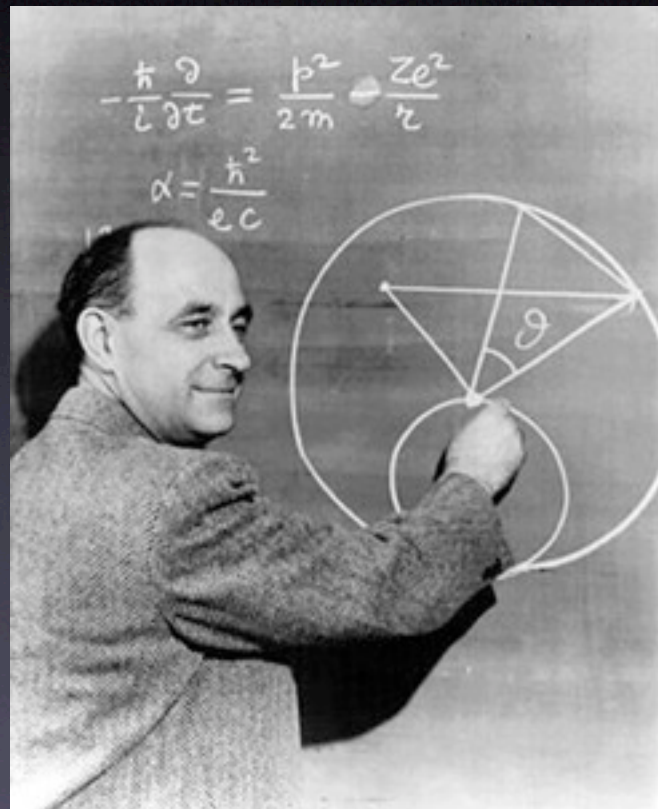
A Higgs boson discovered!
decayed into two photons

Amazing!

pick up tens out of 10^{15}

Fermi scale

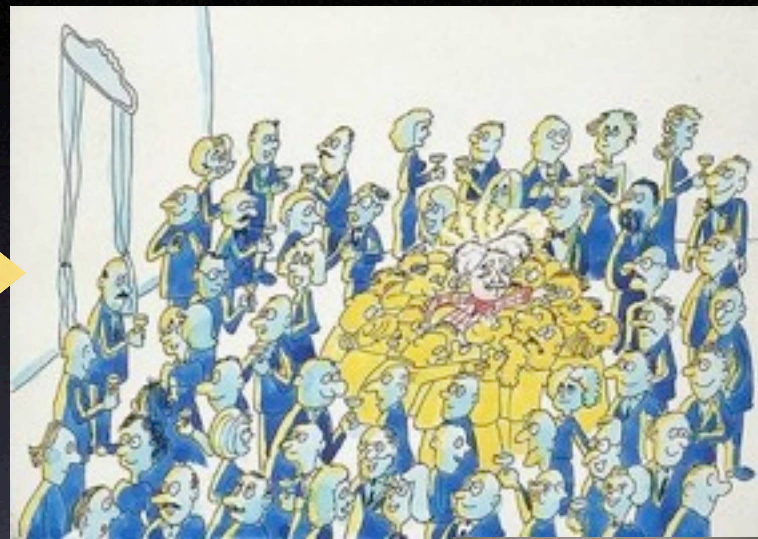
- Fermi told us the energy scale to probe back in 1933
- $G_F^{-1/2} = 300$ GeV
- We finally got there!



New Era

- ~1900 reached atomic scale $10^{-8}\text{cm} \approx 1/(\alpha m_e)$
- ~1970 reached strong scale $10^{-13}\text{cm} \approx M e^{-2\pi/\alpha_s b_0}$
- ~2010 reached weak scale $10^{-17}\text{cm} = \text{TeV}^{-1}$
- known since Fermi (1933), finally there!
- fundamental scale?
  - extra dimensions? TeV string theory?
- a derived scale?
  - from SUSY breaking? composite dynamics?
- rich spectrum of new particles?
- We'll start with Higgs boson(s)

1993 UK competition



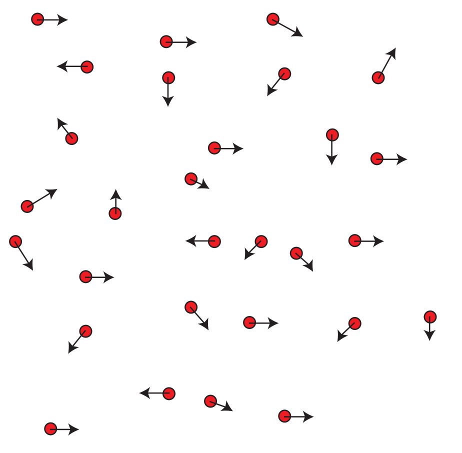
Cosmic Superconductor

- In a superconductor, magnetic field gets repelled (Meissner effect), and penetrates only over the "penetration length"

  ⇒ Magnetic field is short-ranged!

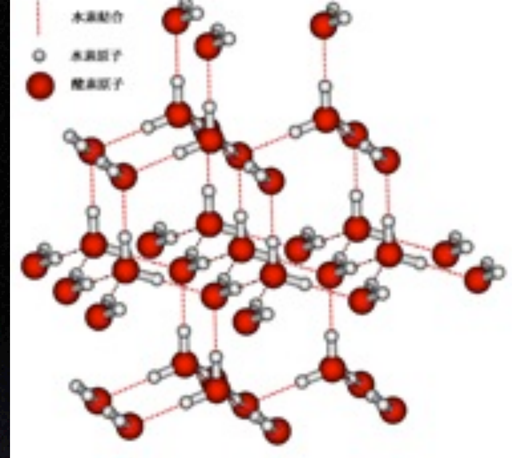
- Imagine a physicist living in a superconductor
- She finally figured:
  - magnetic field must be long-ranged
  - there must be a mysterious charge-two condensate in her "Universe"
  - But doesn't know what the condensate is, nor why it condenses
  - Doesn't have enough energy (gap) to break up Cooper pairs

That's the stage where we are!



Universe has been cooling

4 quadrillion degrees



symmetry breaks spontaneously

disorder ⇒ order


electron
atom
nucleus

uncomfortable

- Higgs boson is the *only spin 0 particle* in the standard model
  - one of its kind, no context
  - but does the most important job
- looks rather artificial
- also superficial, doesn't explain dynamics behind the condensate
- *Higgsless theories*: now dead

Theory for Scalar Bosons?

Supersymmetry

- Higgs just one of *many* scalar bosons
- SUSY loops make m_h^2 negative

composite

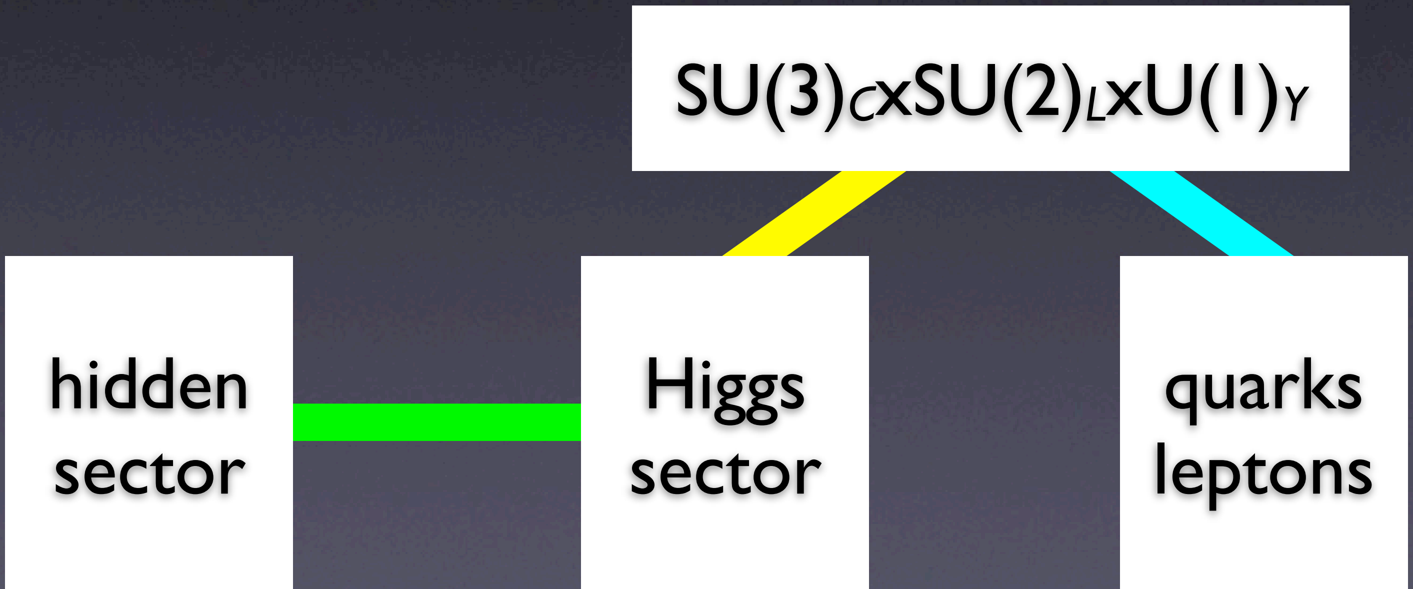
- unitarity solved by KK states or form factors
- condensate by a strong attractive force, holography

Extra dimension

- Higgs spinning in extra dimensions
- new forces from particles running in extra D

Higgs as a portal

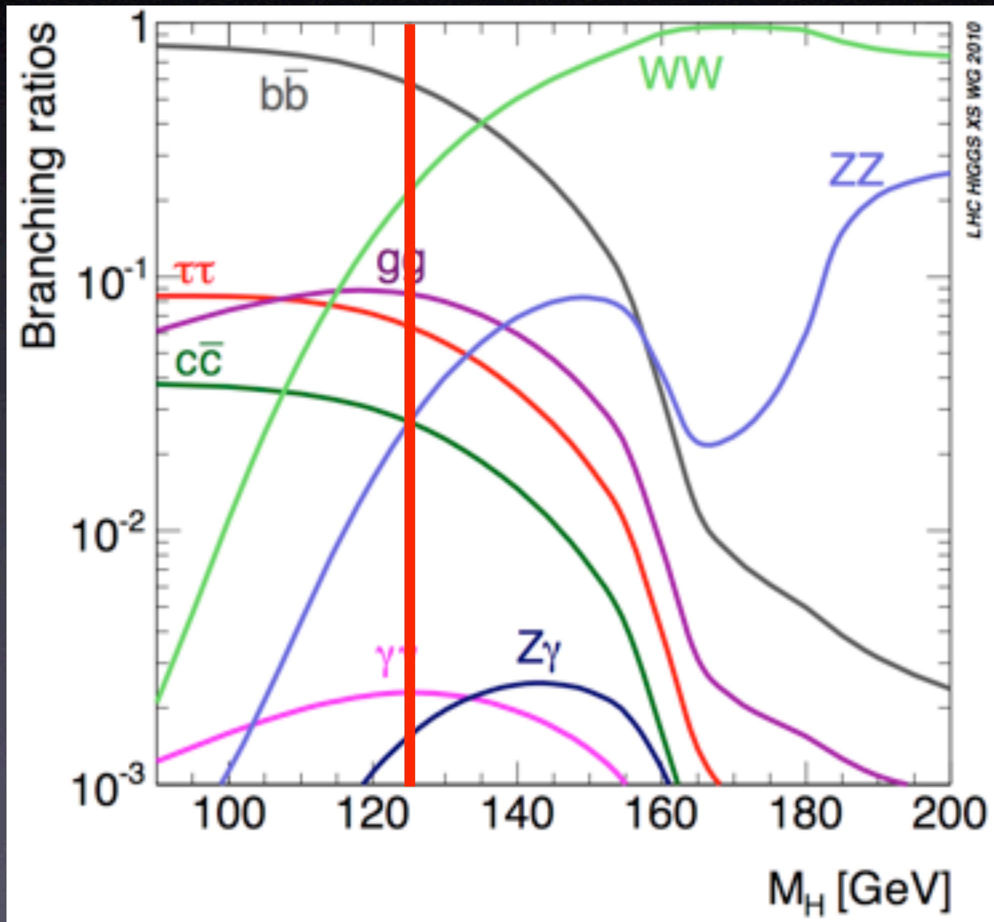
- having discovered *a* Higgs boson
- Higgs boson may connect the Standard Model to other “sectors”, i.e. dark matter



$$\mathcal{L} = \mathcal{O}_{hidden} H^\dagger H$$

28

lucky for experiments



window to new world?

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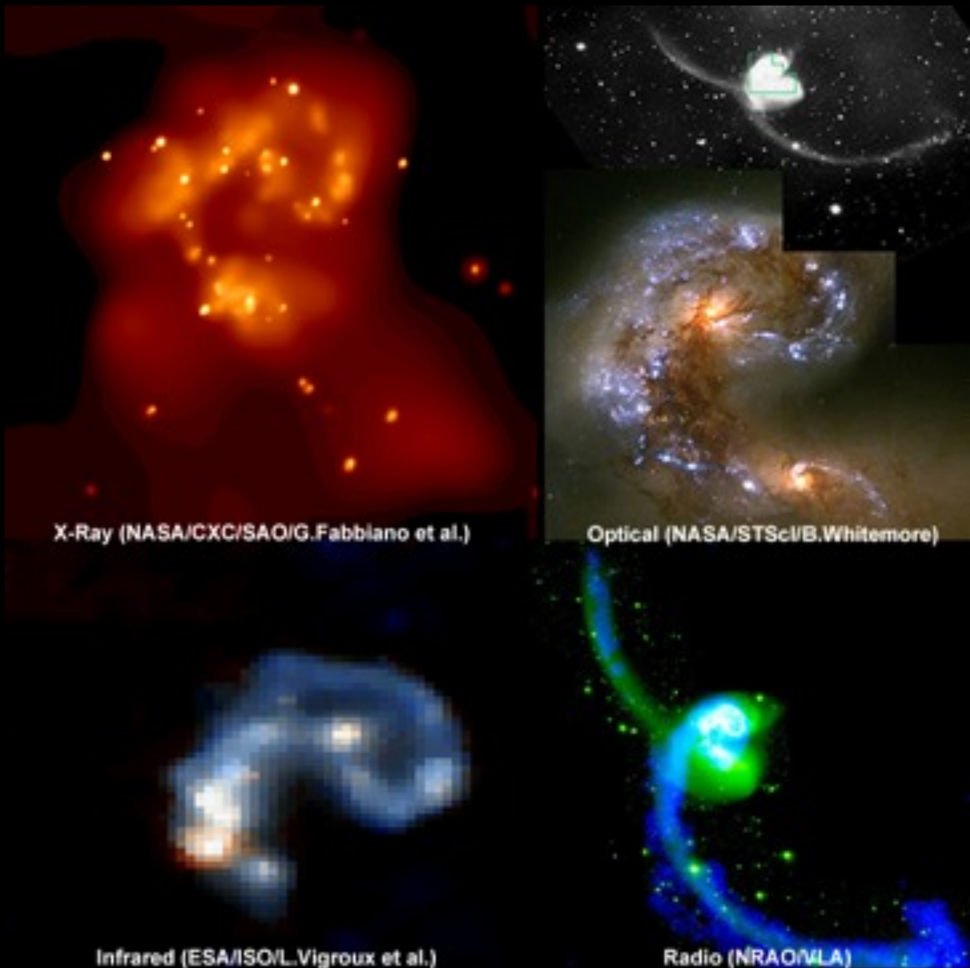
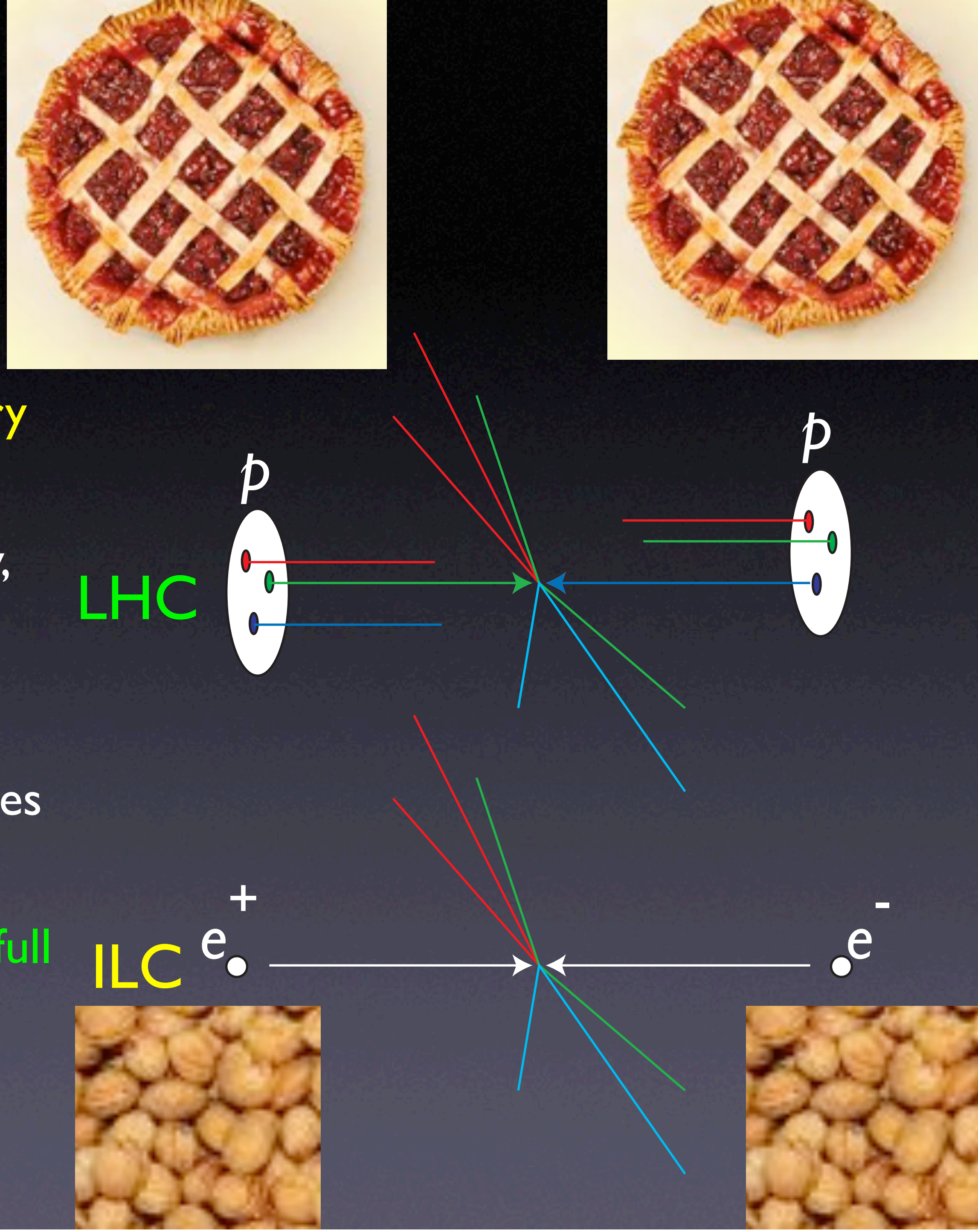
History of Colliders

1. precision measurements with e^- accelerator (*i.e.* polarized $e^- d$) predicted m_W, m_Z
2. UA1/UA2 (*ppbar*) discovered *W*/*Z* particles
3. LEP ($e^- e^+$) *nailed* the gauge sector
1. precision measurements of *W* and *Z* (*i.e.* LEP + Tevatron) predicted m_H
2. LHC (*pp*) discovered *H*-like particle
3. LC ($e^- e^+$) *nails* the Higgs sector?
1. precision *H* measurements at LC predict ???

Need many probes for full understanding

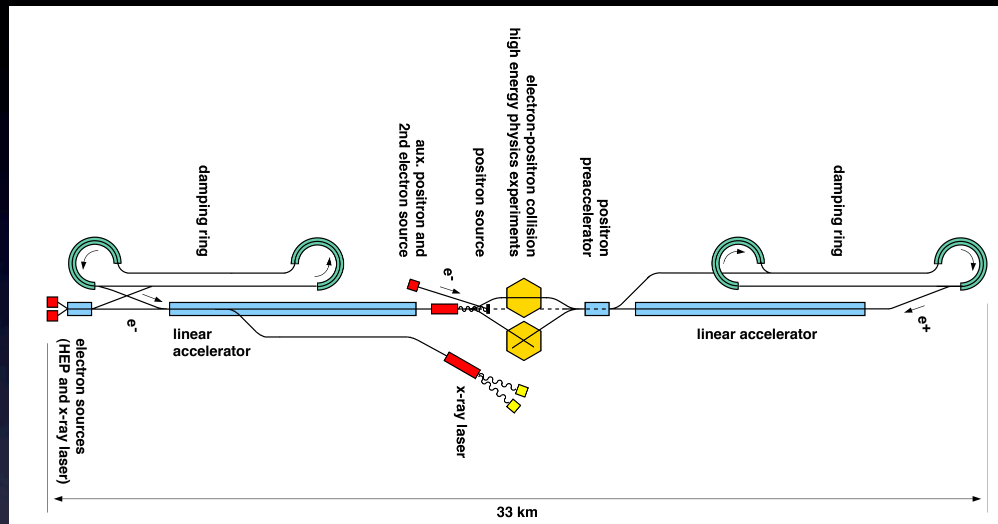


- e^+, e^- are elementary particles
- well-defined energy, angular momentum
- uses its full energy
- can produce particles democratically
- can capture nearly full information



amazing high-tech

- collide electrons and positrons: “cherry pits”
- accelerate beams 15km
- focus beams down to a few nanometers and make sure they meet!
- extendable
- high beam polarization
- superconducting cavities with many possible industrial applications



International Linear Collider (ILC)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LHC vs ILC

(oversimplified)

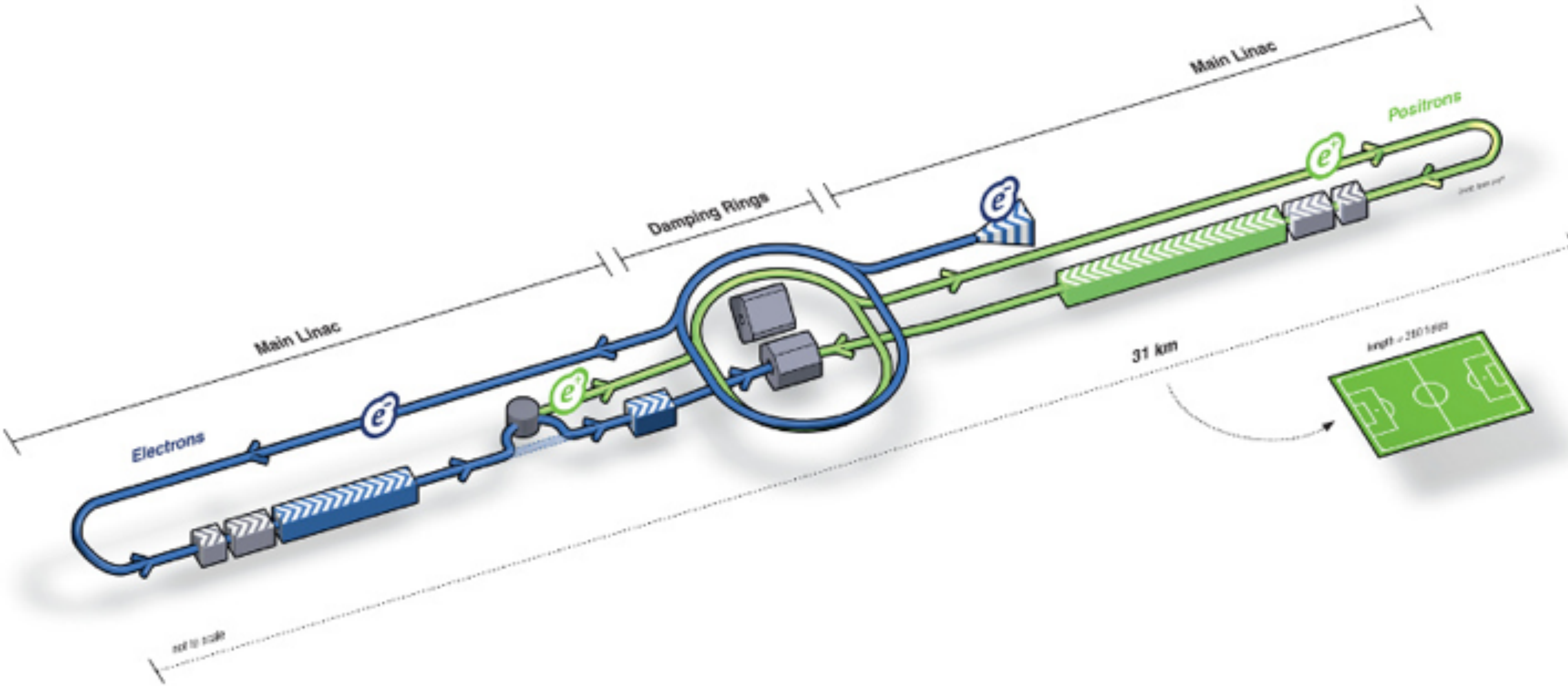
total energy	14TeV	0.5-1 TeV
usable energy	a fraction	full
beam	proton (composite)	electron (point-like)
signal rate	high	low
background rate	very high	low
analysis	easy particles only	nearly all particles
events	lose info along the beams	capture the whole
status	being upgraded	just finished design!

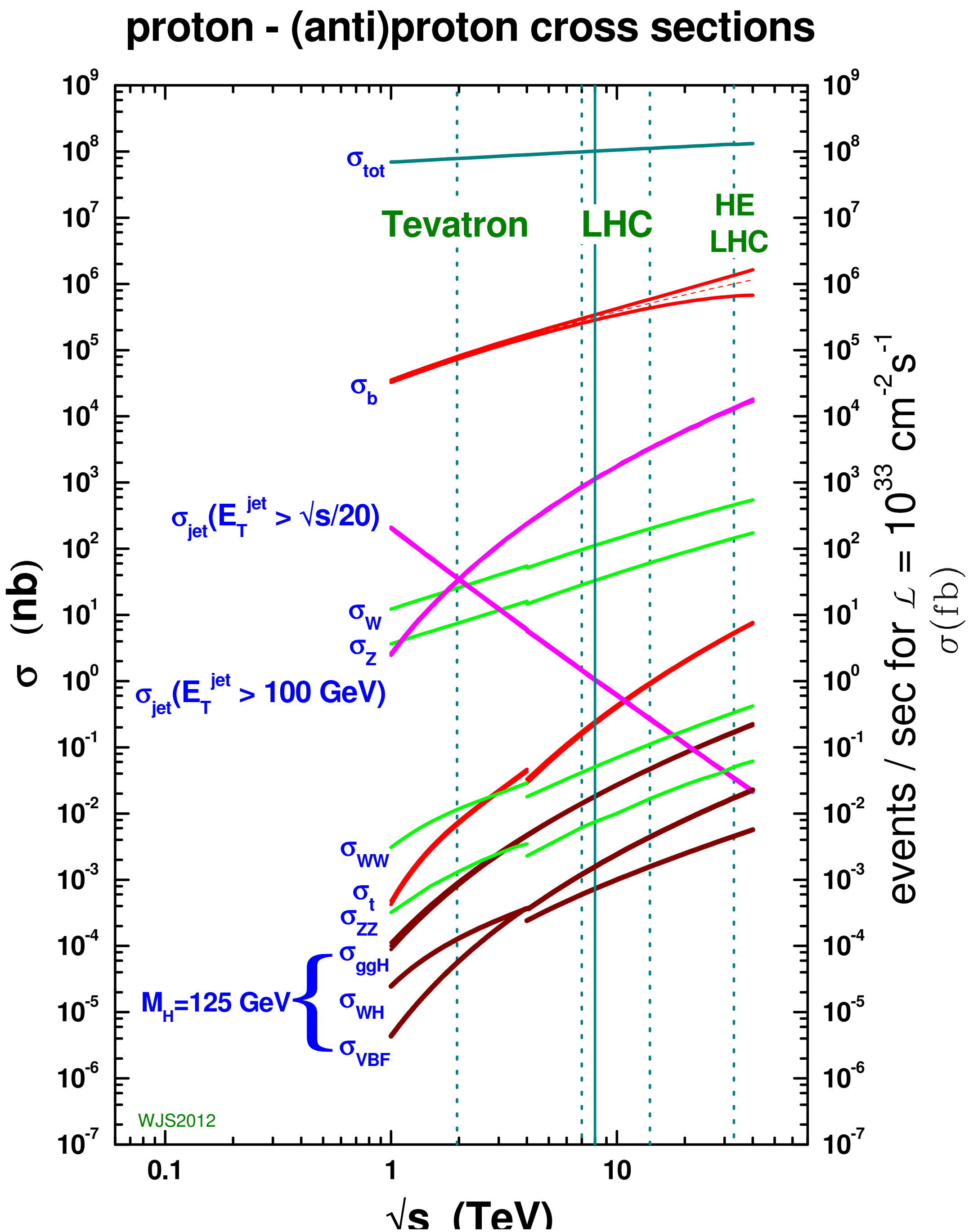
Why linear?

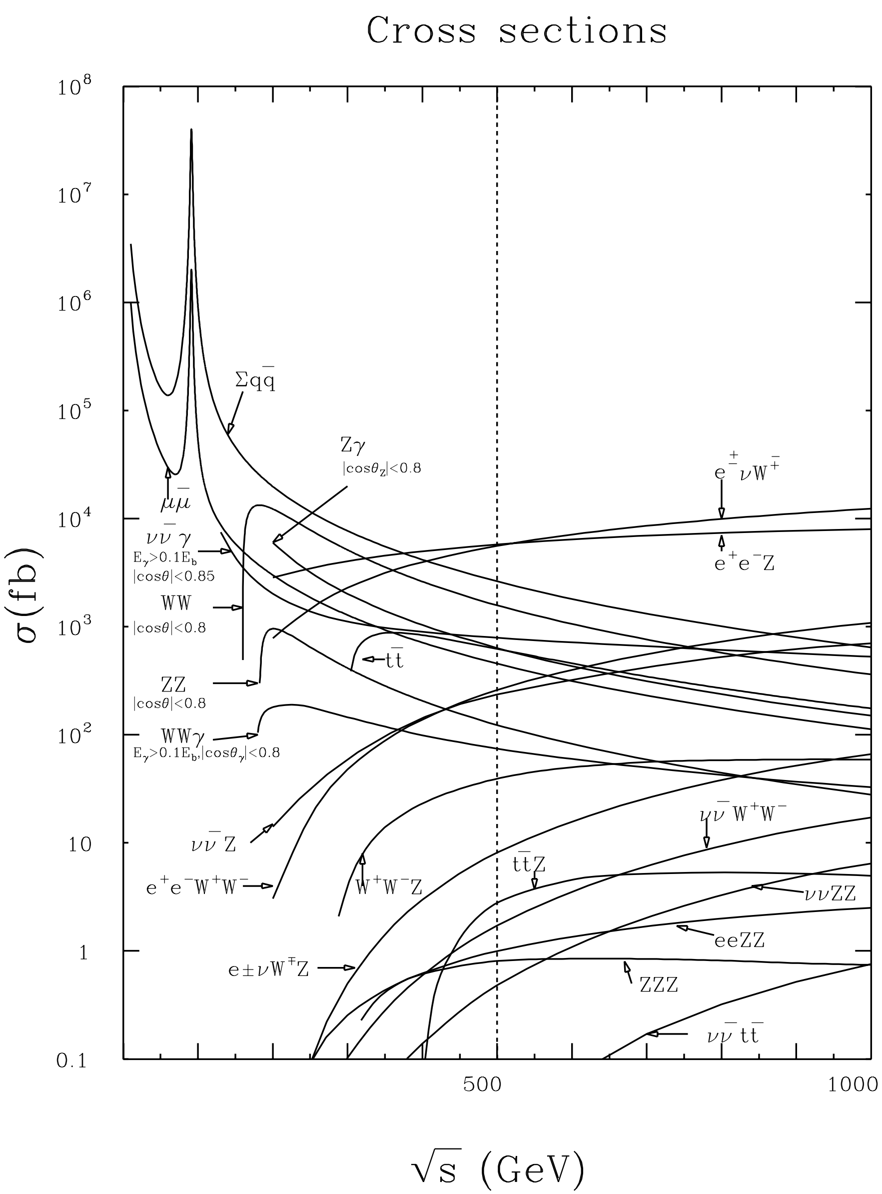
- circular e^+e^- machine suffers from the synchrotron radiation loss
- $P \propto E^4/R$
- If scaled from LEP with the same luminosity and bunch size, 1TeV machine with same power loss would require R=14000km

CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
Lake Superior
MICHIGAN
WISCONSIN
SOUTH DAKOTA
ROCKY MOUNTAINS
IDAHO
OREGON
WYOMING
NEBRASKA
IOWA
ILLINOIS
INDIANA
OHIO
NEW YORK
PENNSYLVANIA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
WEST VIRGINIA
VIRGINIA
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
ARKANSAS
MISSISSIPPI
ALABAMA
GEORGIA
TEXAS
LOUISIANA
FLORIDA
APPALACHIAN MOUNTAINS
PACIFIC OCEAN
ATLA
OCE
MEXICO
Gulf of Mexico
CUBA
THE BAHAMAS
CARIBBEAN SEA
JAMAICA
HAITI
BELIZE
ALASKA
CANADA
Chukchi Sea
Beaufort Sea
Bering Strait
Bering Sea
Gulf of Alaska
Aleutian Islands
PACIFIC OCEAN
HAWAII
Hawaiian Islands
HONOLULU

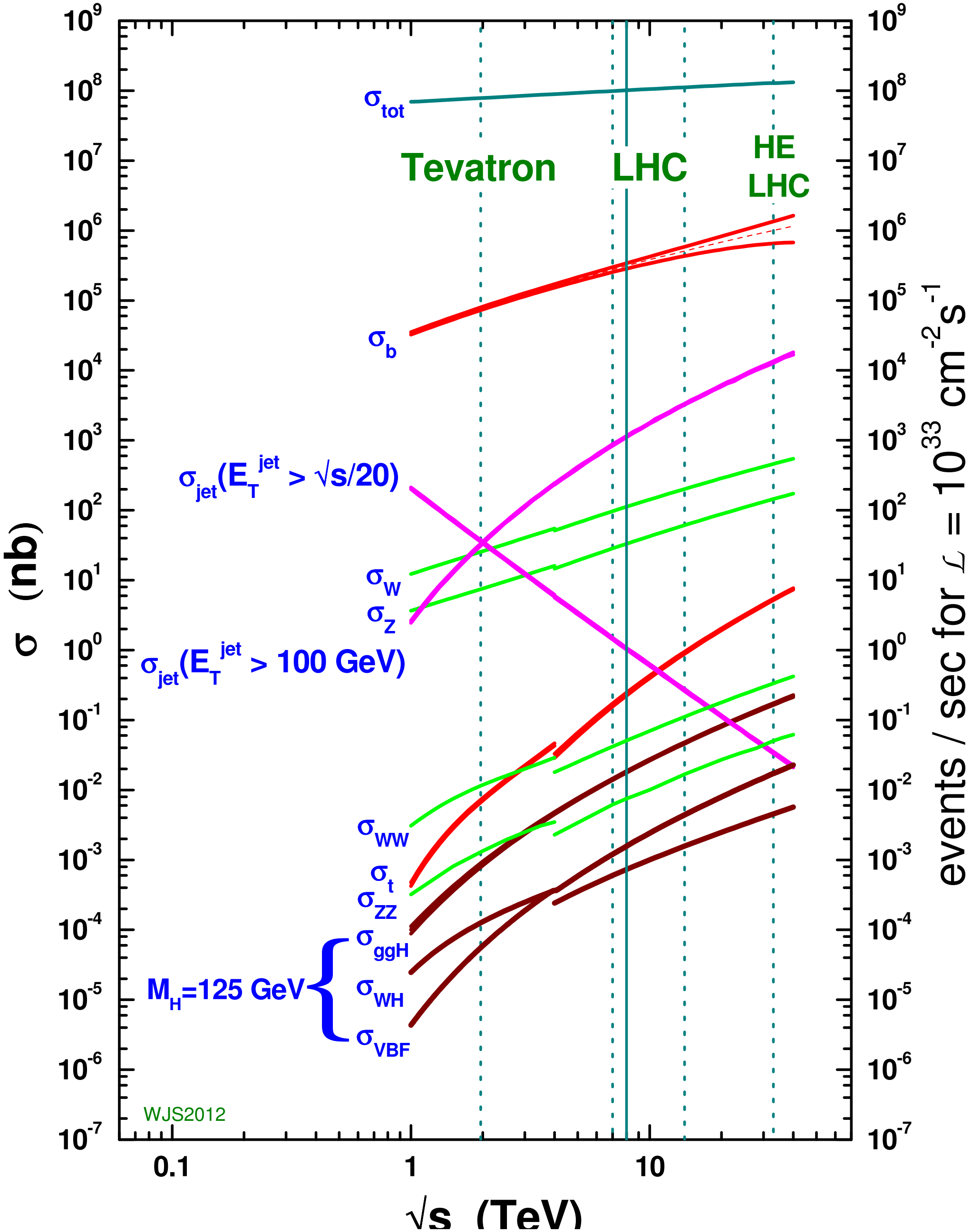
linear = R→∞

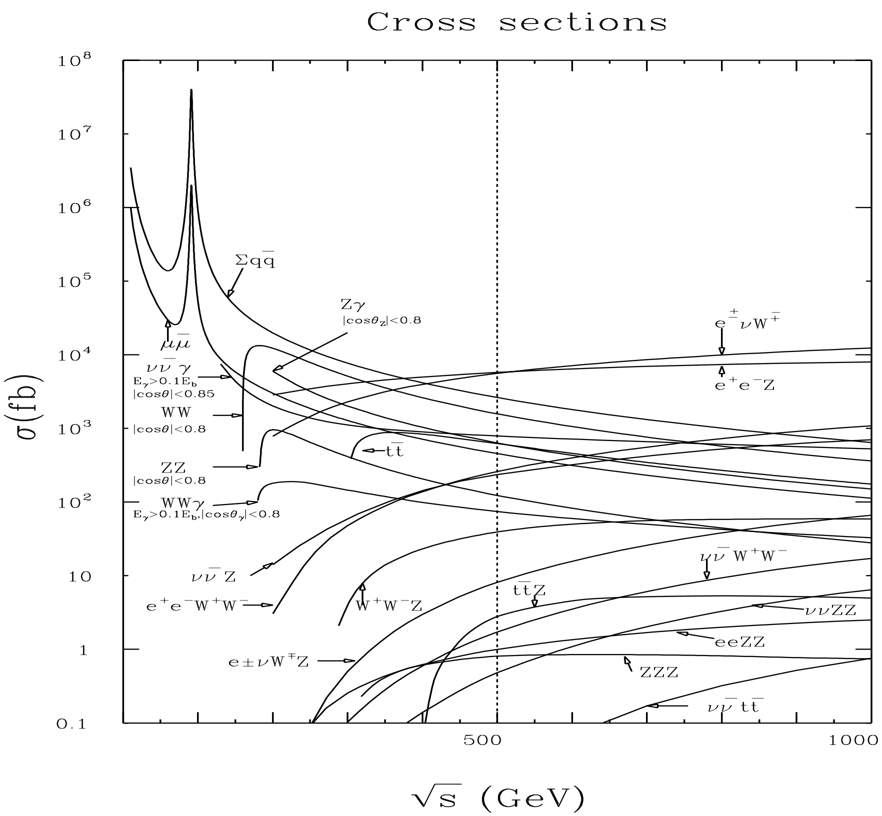

Main Linac
Damping Rings
Main Linac
Positrons
Electrons
31 km
not to scale


proton - (anti)proton cross sections
Tevatron
LHC
HE LHC
σ (nb)
events / sec for ℒ = 10^33 cm^-2 s^-1
√s (TeV)
WJS2012
σtot
σb
σjet(ET jet > √s/20)
σW
σZ
σjet(ET jet > 100 GeV)
σWW
σt
σZZ
σggH
σWH
σVBF
MH=125 GeV


Cross sections
σ(fb)
√s (GeV)
Σqq̄
Zγ
μμ̄
νν̄γ
WW
tt̄
ZZ
WWγ
e+νW-
e+e-Z
νν̄Z
e+e-W+W-
W+W-Z
tt̄Z
νν̄W+W-
ννZZ
eeZZ
ZZZ
e±νW∓Z
νν̄tt̄

proton - (anti)proton cross sections



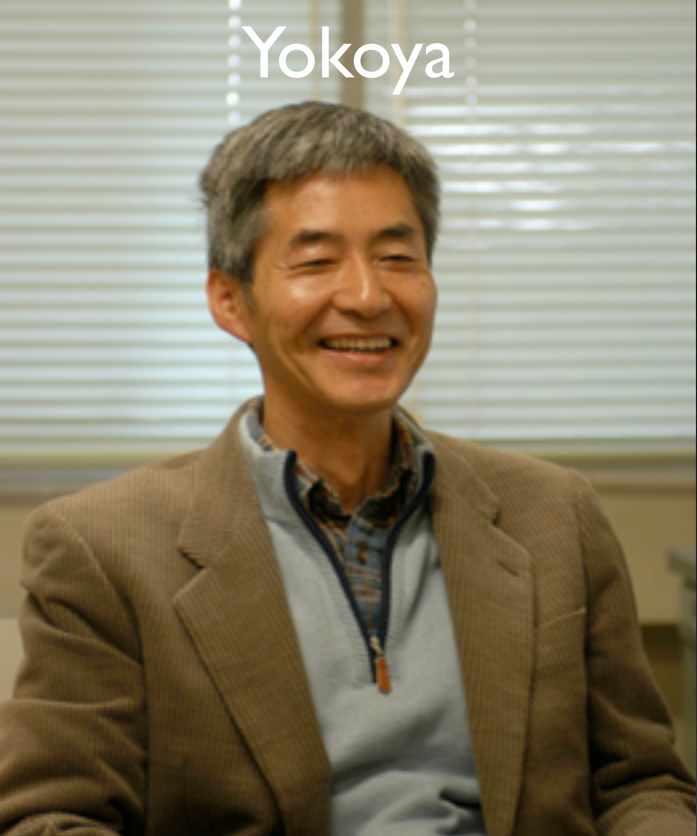


			Baseline 500 GeV Machine		
	E_{CM}	GeV	250	350	500
	f_{rep}	Hz	5	5	5
	f_{linac}	Hz	10	5	5
	n_b		1312	1312	1312
	N	$\times 10^{10}$	2.0	2.0	2.0
	Δt_b	ns	554	554	554
	I_{beam}	mA	5.8	5.8	5.8
	G_a	MV m^{-1}	14.7	21.4	31.5
	P_{beam}	MW	5.9	7.3	10.5
	P_{AC}	MW	122	121	163
	σ_z	mm	0.3	0.3	0.3
	$\Delta p/p$	%	0.190	0.158	0.124
	$\Delta p/p$	%	0.152	0.100	0.070
	P_-	%	80	80	80
	P_+	%	30	30	30
Horizontal emittance	$\gamma\epsilon_x$	µm	10	10	10
Vertical emittance	$\gamma\epsilon_y$	nm	35	35	35
IP horizontal beta function	β_x^*	mm	13.0	16.0	11.0
IP vertical beta function	β_y^*	mm	0.41	0.34	0.48
IP RMS horizontal beam size	σ_x^*	nm	729.0	683.5	474
IP RMS veritcal beam size	σ_y^*	nm	7.7	5.9	5.9
Luminosity	L	$\times 10^{34}$ cm^{-2}s^{-1}	0.75	1.0	1.8
Fraction of luminosity in top 1%	$L_{0.01}/L$		87.1%	77.4%	58.3%
Average energy loss	δ_{BS}		0.97%	1.9%	4.5%
Number of pairs per bunch crossing	N_{pairs}	$\times 10^3$	62.4	93.6	139.0
Total pair energy per bunch crossing	E_{pairs}	TeV	46.5	115.0	344.1

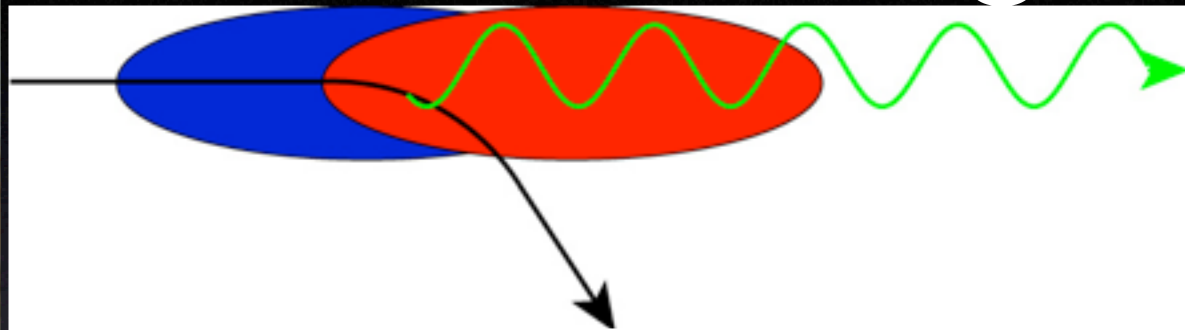
~10^{11}@LHC

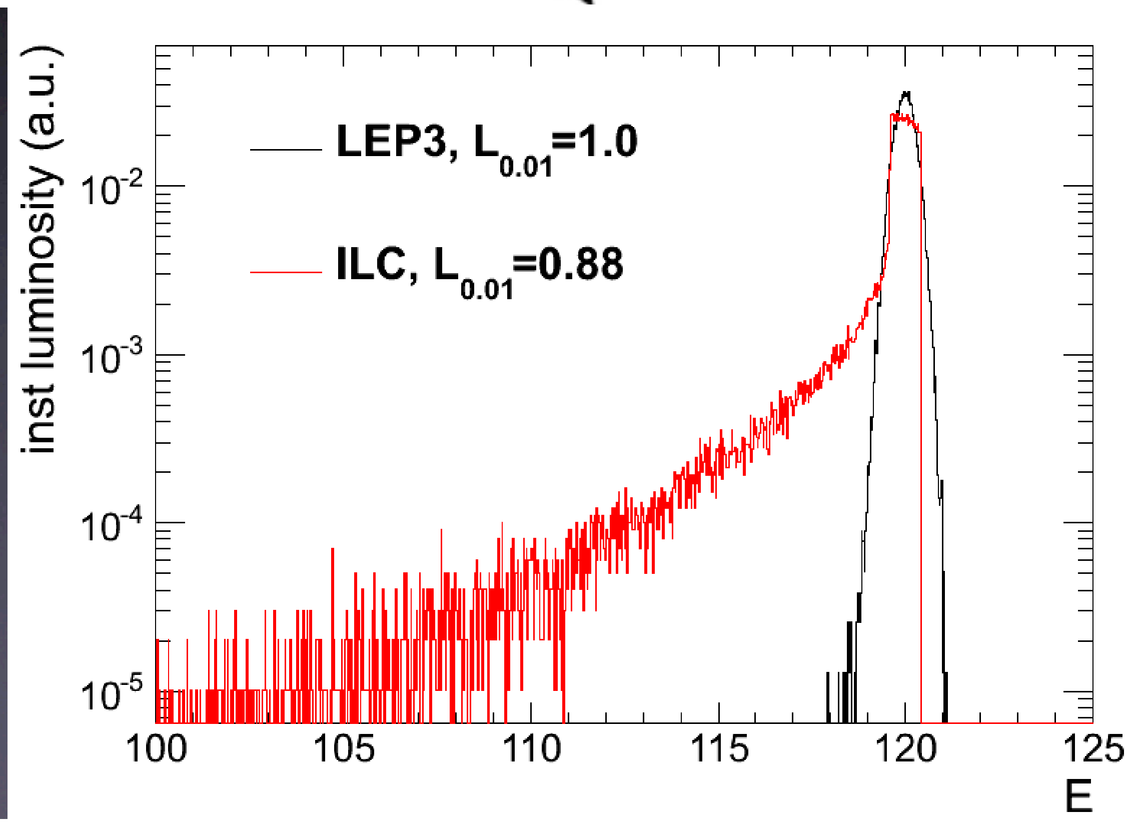
9cm

20µm



beamstrahlung





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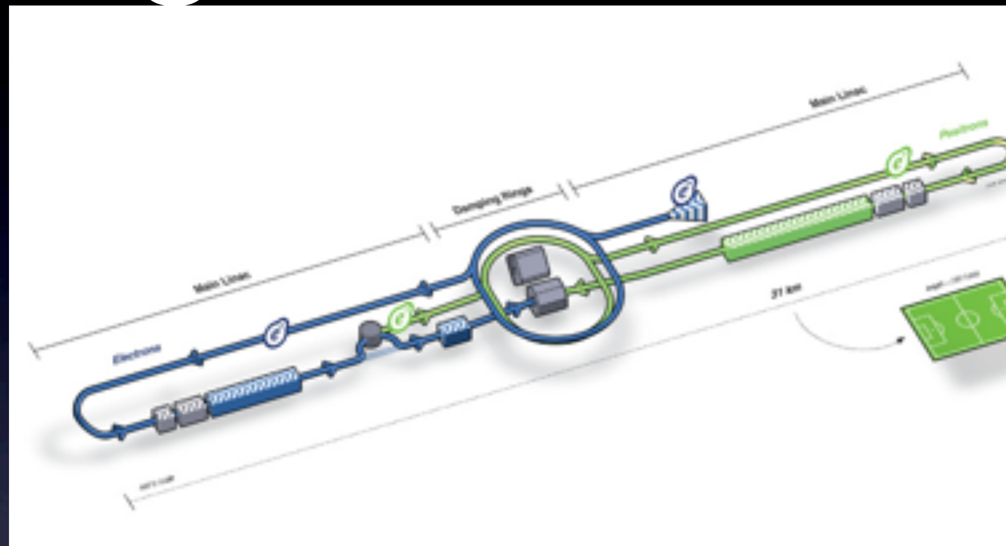


International Linear Collider (ILC)

competing requirements

- luminosity
- beamstrahlung
- power consumption
- need nanobeam!
- still need to achieve a very good efficiency ~6% ⇒ Hayano

$$\mathcal{L} = \frac{1}{4\pi}\frac{N^2 f}{\sigma_x \sigma_y}$$

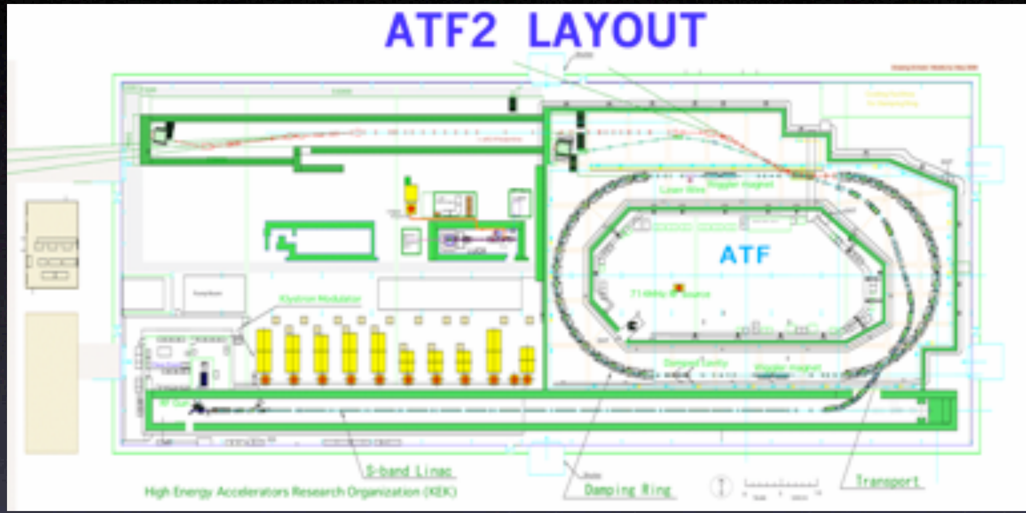
$$n_\gamma = \frac{2\alpha r_e N}{\sigma_x}$$

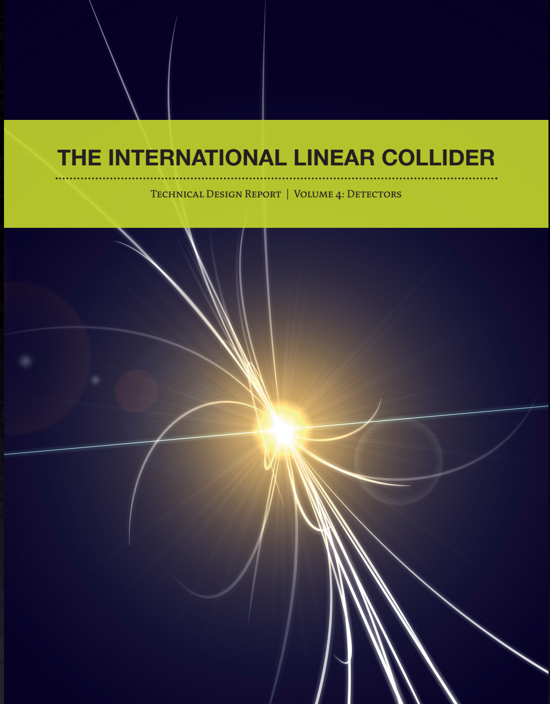
$$P = N f E_e$$

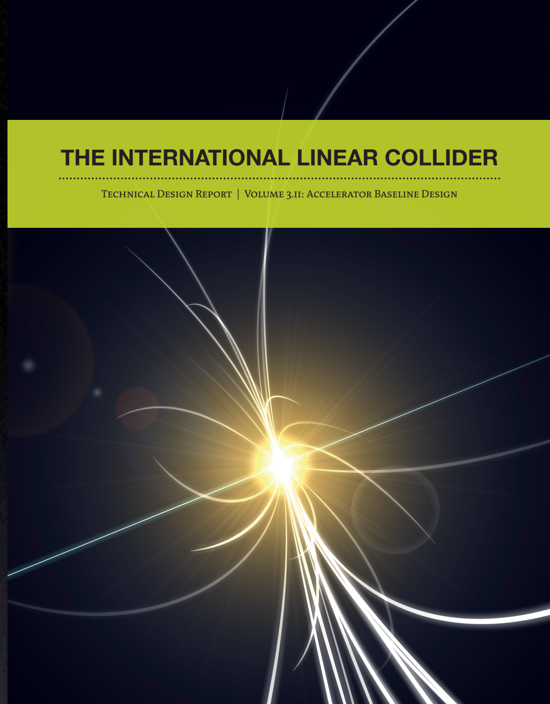
$$\mathcal{L} = \frac{1}{8\pi\alpha r_e E_e}\frac{P n_\gamma}{\sigma_y}$$

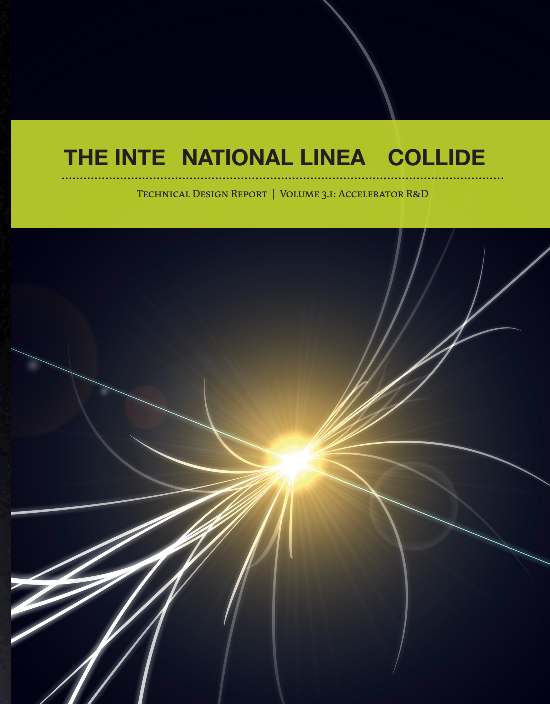
damping ring

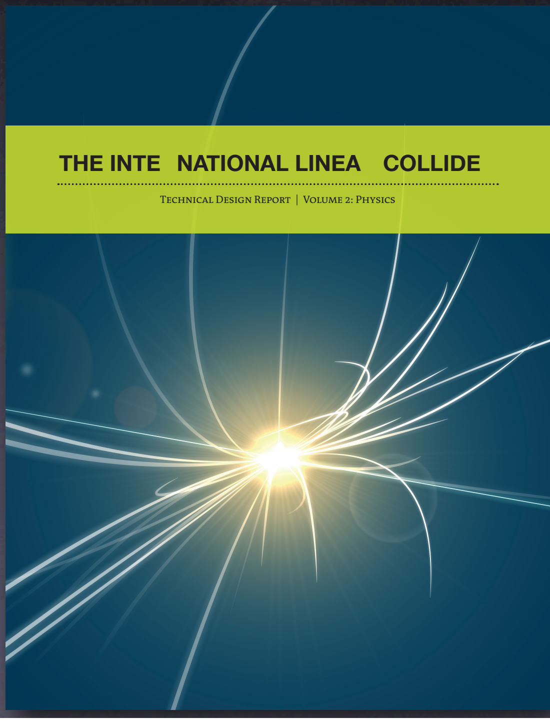
- Liouville's theorem says phase space volume cannot be reduced in a closed system
- need to create a very high quality beam with small Δp and small Δx
- make the curse into a benefit
- use radiation damping
- achieved 72.8nm @ 1.3GeV! on Dec 21, 2012
- needs to go down to 37nm

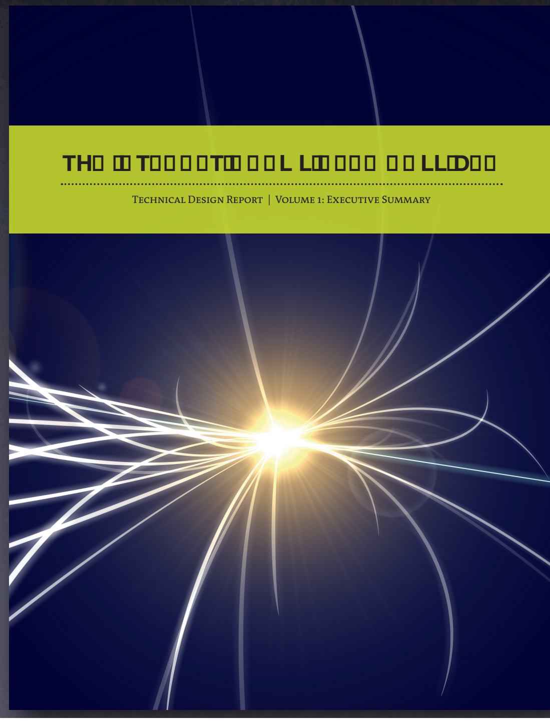



THE INTERNATIONAL LINEAR COLLIDER
Technical Design Report | Volume 4: Detectors

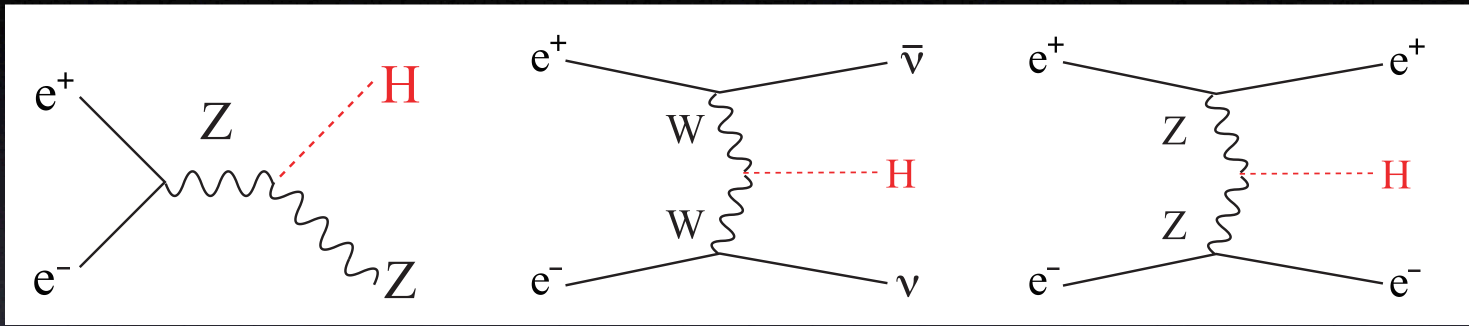

THE INTERNATIONAL LINEAR COLLIDER
Technical Design Report | Volume 3.II: Accelerator Baseline Design

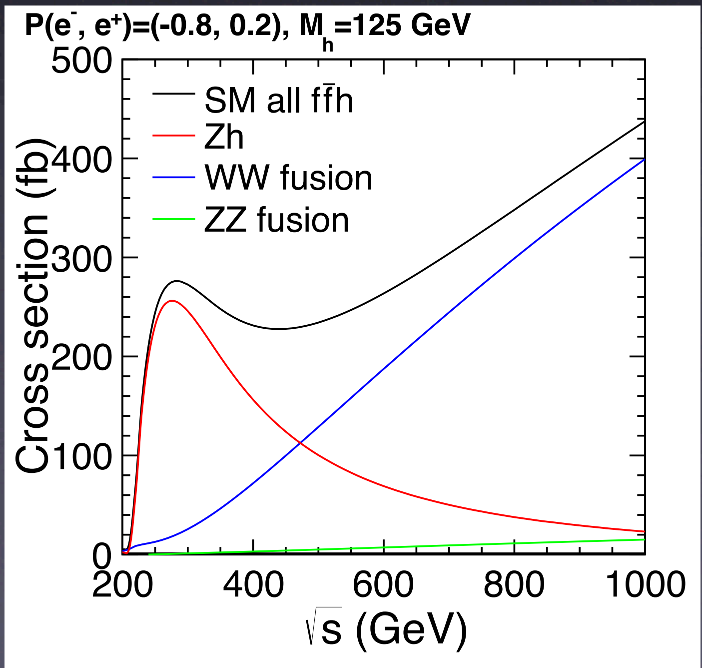

THE INTE NATIONAL LINEA COLLIDE
Technical Design Report | Volume 3.I: Accelerator R&D

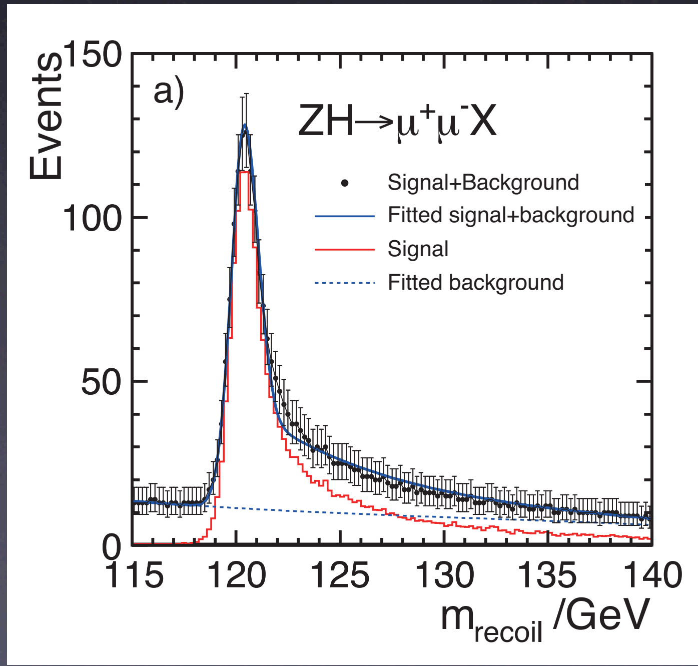

THE INTE NATIONAL LINEA COLLIDE
Technical Design Report | Volume 2: Physics


Technical Design Report | Volume 1: Executive Summary

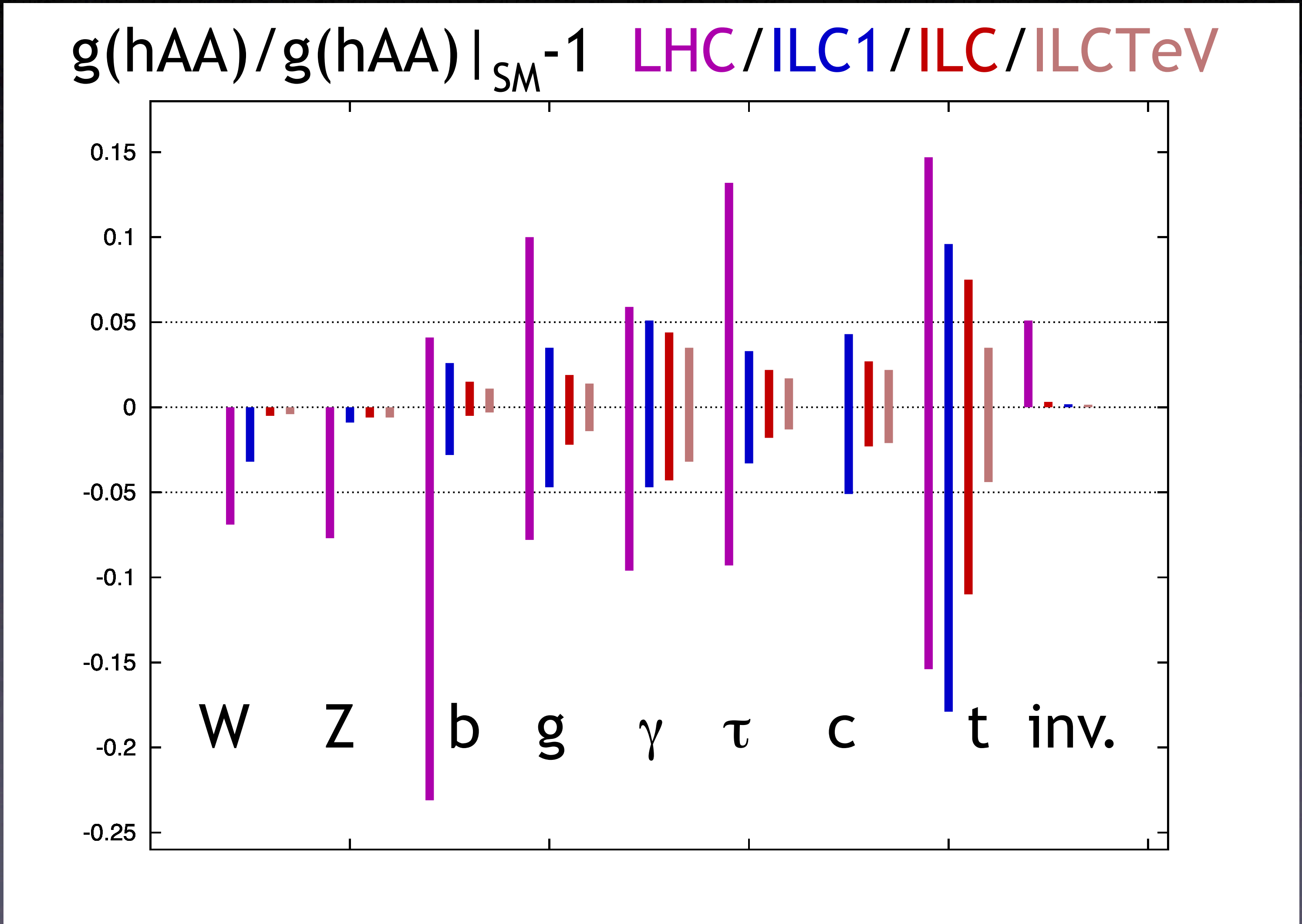
production mechanisms





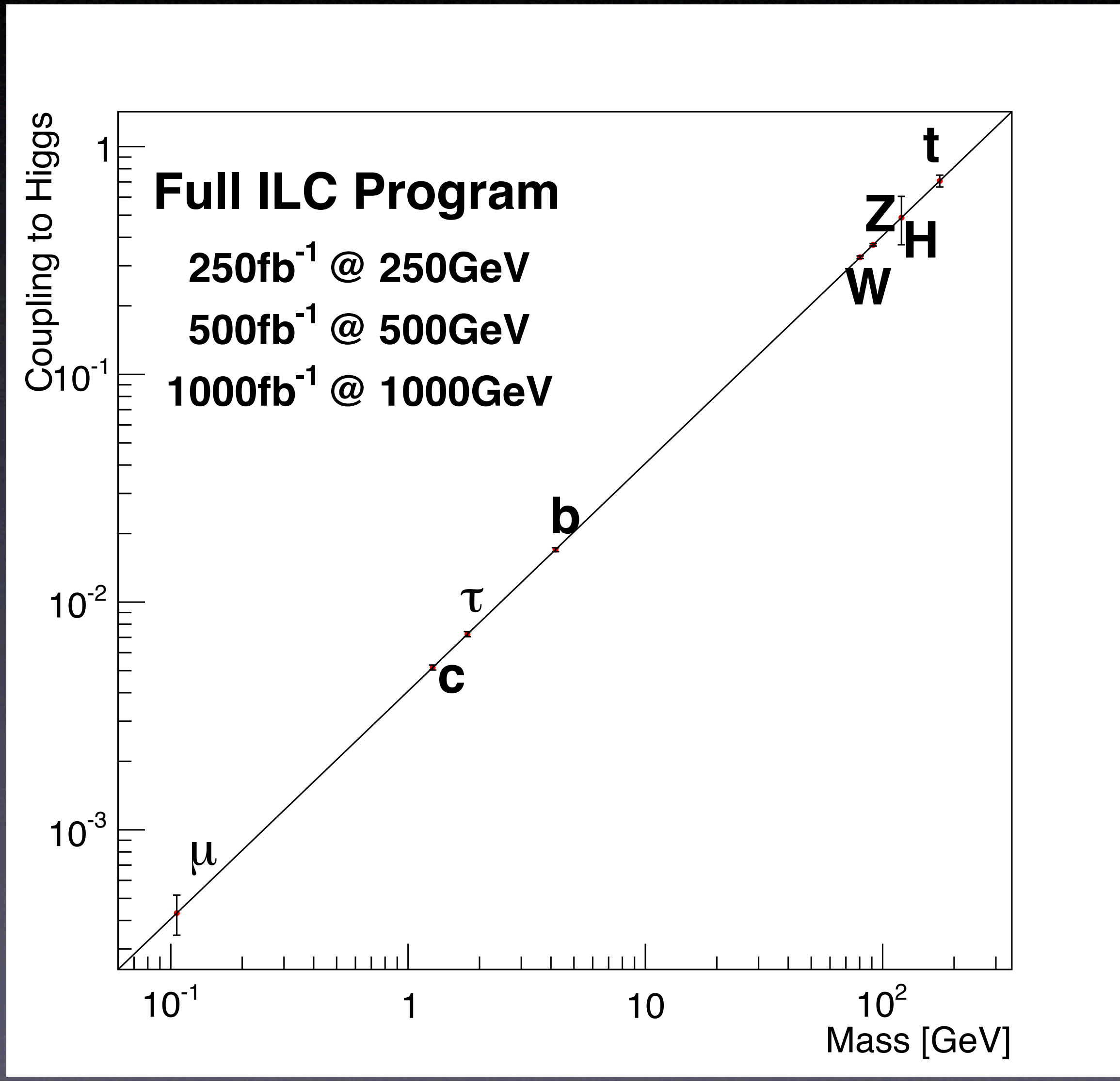


Coupling measurements



Peskin

Coupling measurements



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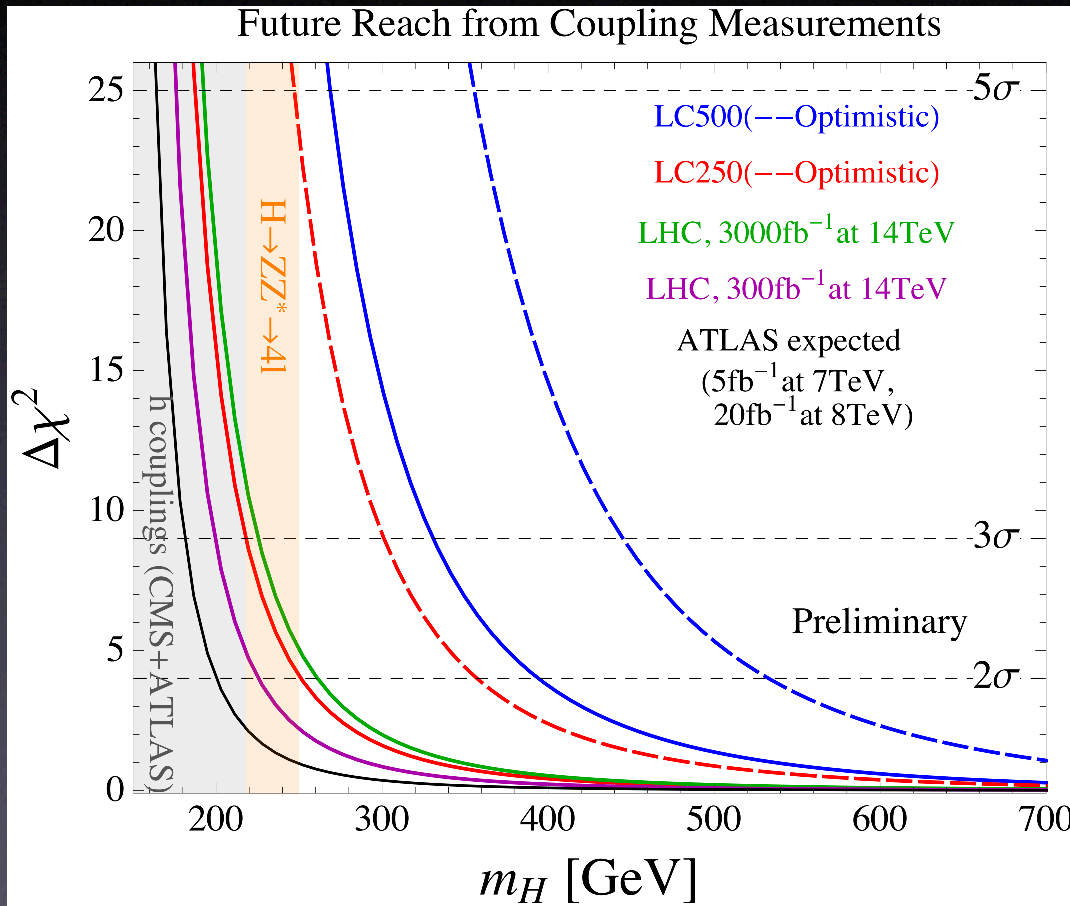
Is Higgs alone?

- Many models that try to explain m_h=125GeV require additional Higgs bosons
- precision measurements reveal their existence
- e.g. "Dirac NMSSM"



Lu, HM, Ruderman, Tobioka

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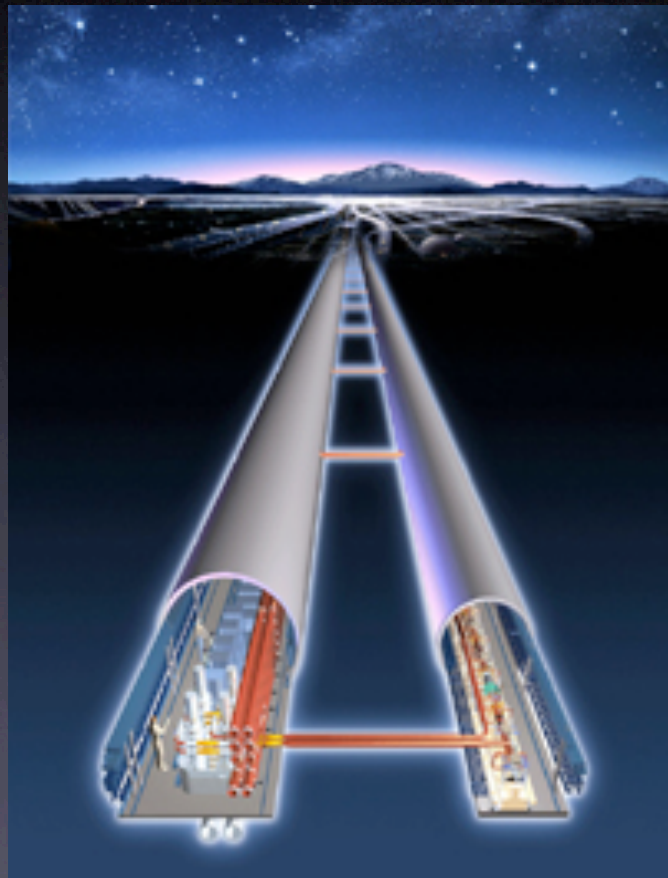
Physics at ILC

- now *guaranteed* at <500 GeV:
  - precision study of *a* Higgs particle
  - window to new physics?
  - top quark threshold
- also possible at higher energies:
  - Higgs self-coupling
  - discovery reach on electroweak particles
  - window to unification?

What about new physics?



What did you find?

- Specify the fields
  - mass
  - spin ⇒ 0, 1/2, 1
  - SU(3)xSU(2)xU(1) quantum numbers
  - mixing of states
- Specify their interactions
  - SU(3)xSU(2)xU(1) quantum numbers determine gauge interactions
  - Yukawa couplings
  - trilinear and quartic scalar couplings

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What did you find?

- Specify the fields
  - mass
  - spin ⇒ 0, 1/2, 1
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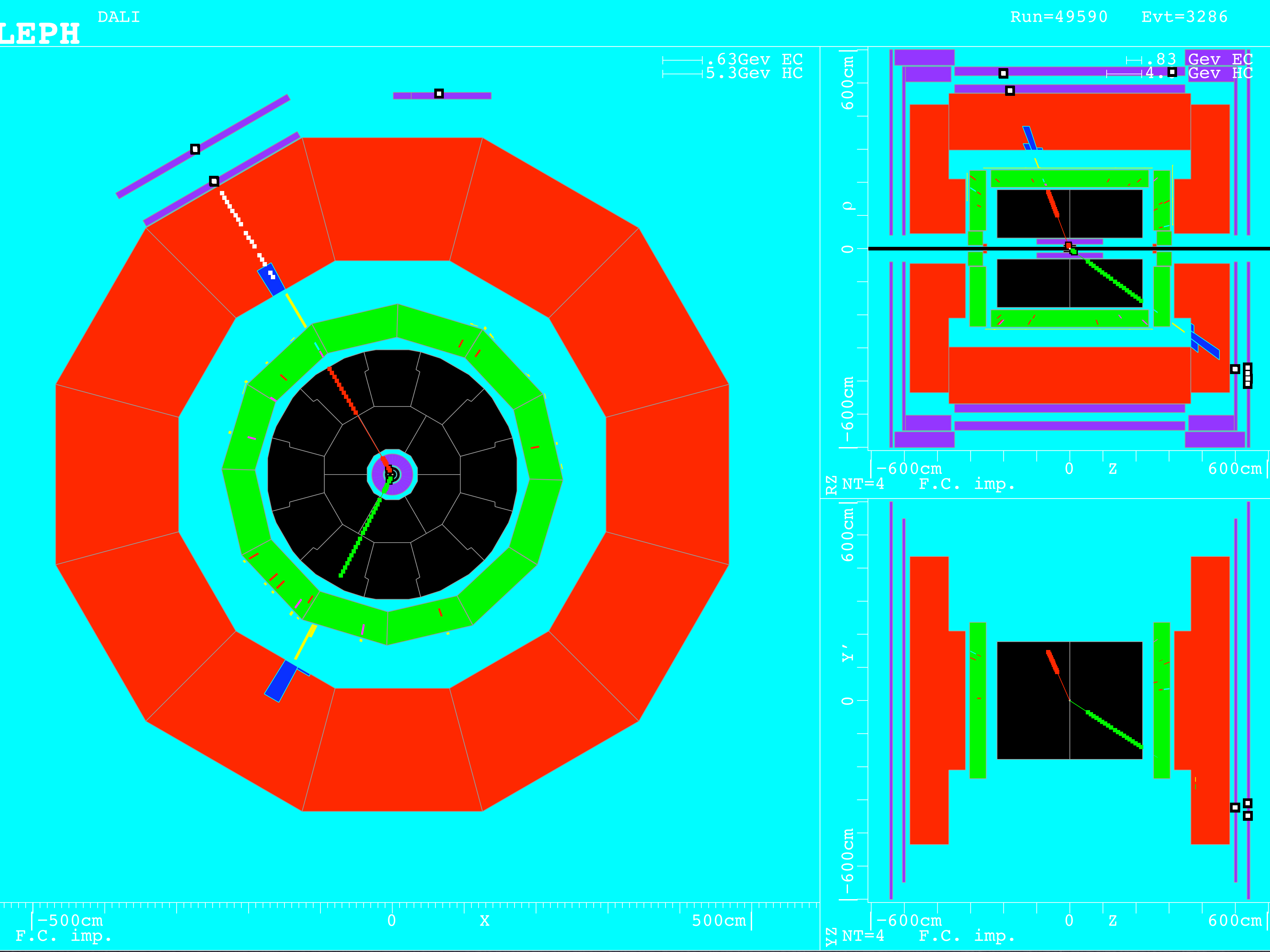
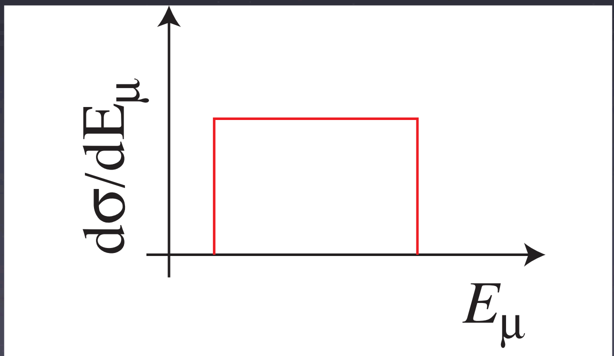
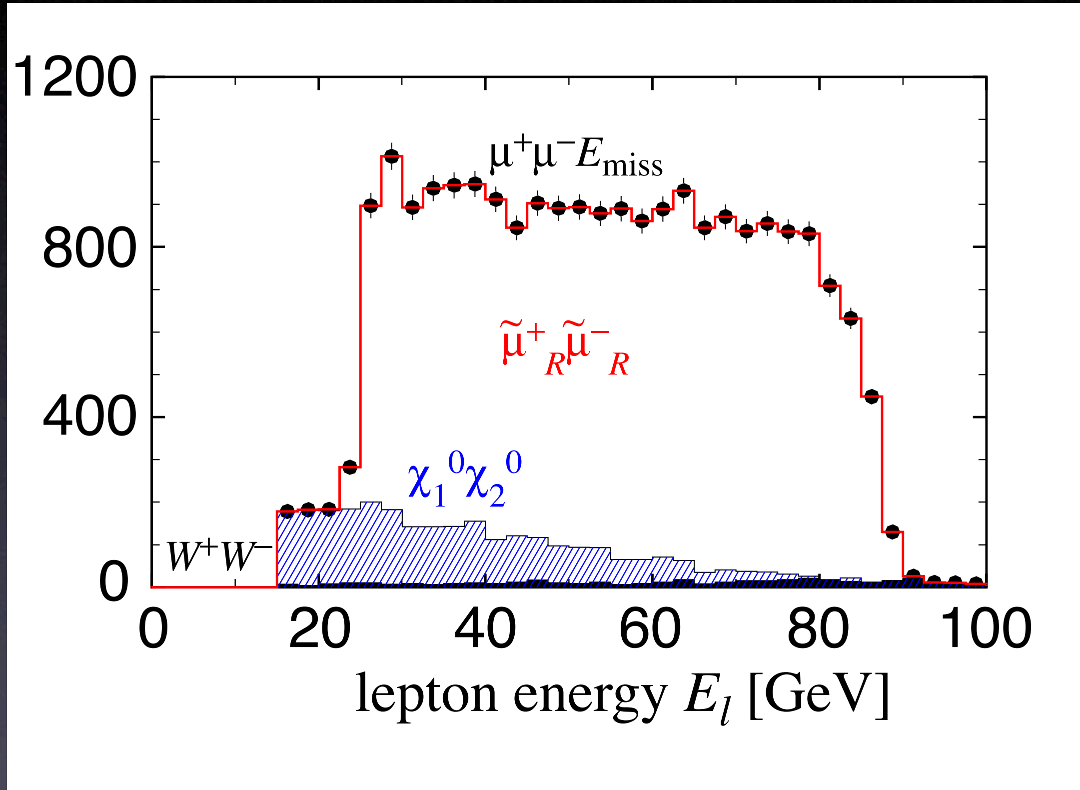

LEPH
DALI
Run=49590 Evt=3286
.63Gev EC
5.3Gev HC
.83 Gev EC
4. Gev HC
600cm
ρ
0
-600cm
-600cm
0
Z
600cm
RZ NT=4 F.C. imp.
600cm
Y'
0
-600cm
-600cm
0
Z
600cm
YZ NT=4 F.C. imp.
-500cm
0
X
500cm
F.C. imp.

$\tilde{\mu} \to \mu\chi^0$

- fit to the kinetic distribution

$m_{\tilde{\mu}} = 132.0 \pm 0.3$ GeV
$m_{\tilde{\chi}^0} = 71.9 \pm 0.1$ GeV





$$\frac{\sqrt{s}}{4}\left(1-\frac{m_{\tilde{\chi}^0}^2}{m_{\tilde{\mu}}^0}\right)(1-\beta_{\tilde{\mu}}) < E_\mu < \frac{\sqrt{s}}{4}\left(1-\frac{m_{\tilde{\chi}^0}^2}{m_{\tilde{\mu}}^0}\right)(1+\beta_{\tilde{\mu}})$$

Two-body kinematics

- In the CM frame of two particles of mass m_1 and m_2

$$E_1 = \frac{\sqrt{s}}{2}\left(1 + \frac{m_1^2}{s} - \frac{m_2^2}{s}\right)$$
$$E_2 = \frac{\sqrt{s}}{2}\left(1 + \frac{m_2^2}{s} - \frac{m_1^2}{s}\right)$$
$$p_1 = p_2 = \frac{\sqrt{s}}{2}\sqrt{1 - \frac{2(m_1^2 + m_2^2)}{s} + \frac{(m_1^2 - m_2^2)^2}{s^2}}$$

$\tilde{\mu} \rightarrow \mu\chi^0$

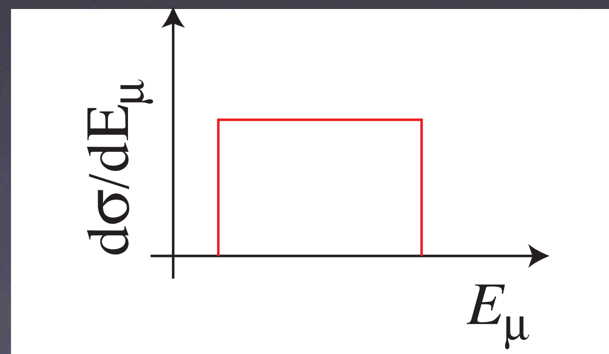
- In the smuon rest frame $\hat{p}_\mu = \frac{m_{\tilde{\mu}}}{2}\left(1 - \frac{m^2_{\tilde{\chi}^0}}{m^2_{\tilde{\mu}}}\right)(1, \sin\hat{\theta}, 0, \cos\hat{\theta})$
- In the lab frame $\gamma_{\tilde{\mu}} = \frac{E_{\tilde{\mu}}}{m_{\tilde{\mu}}} = \frac{\sqrt{s}}{2m_{\tilde{\mu}}}$ $\beta_{\tilde{\mu}} = \sqrt{1 - \frac{4m^2_{\tilde{\mu}}}{s}}$
- muon momentum in the lab frame

$$p_\mu = \frac{m_{\tilde{\mu}}}{2}\left(1 - \frac{m^2_{\tilde{\chi}^0}}{m^0_{\tilde{\mu}}}\right)(\gamma_{\tilde{\mu}} + \gamma_{\tilde{\mu}}\beta_{\tilde{\mu}}\cos\hat{\theta}, \sin\hat{\theta}, 0, \gamma_{\tilde{\mu}}\cos\hat{\theta} + \gamma_{\tilde{\mu}}\beta_{\tilde{\mu}})$$

- Therefore, the muon energy is

$$\frac{\sqrt{s}}{4}\left(1 - \frac{m^2_{\tilde{\chi}^0}}{m^0_{\tilde{\mu}}}\right)(1 - \beta_{\tilde{\mu}}) < E_\mu < \frac{\sqrt{s}}{4}\left(1 - \frac{m^2_{\tilde{\chi}^0}}{m^0_{\tilde{\mu}}}\right)(1 + \beta_{\tilde{\mu}})$$

$$\frac{d\sigma}{dE_\mu} \propto \frac{d\sigma}{d\cos\hat{\theta}} = \text{constant}$$



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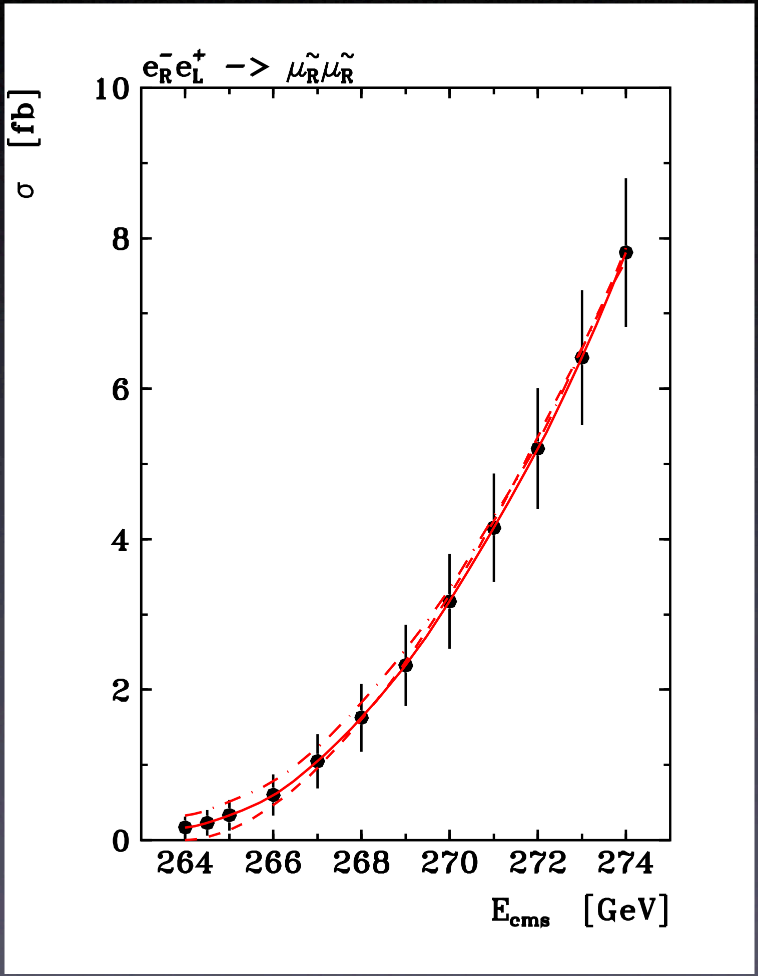
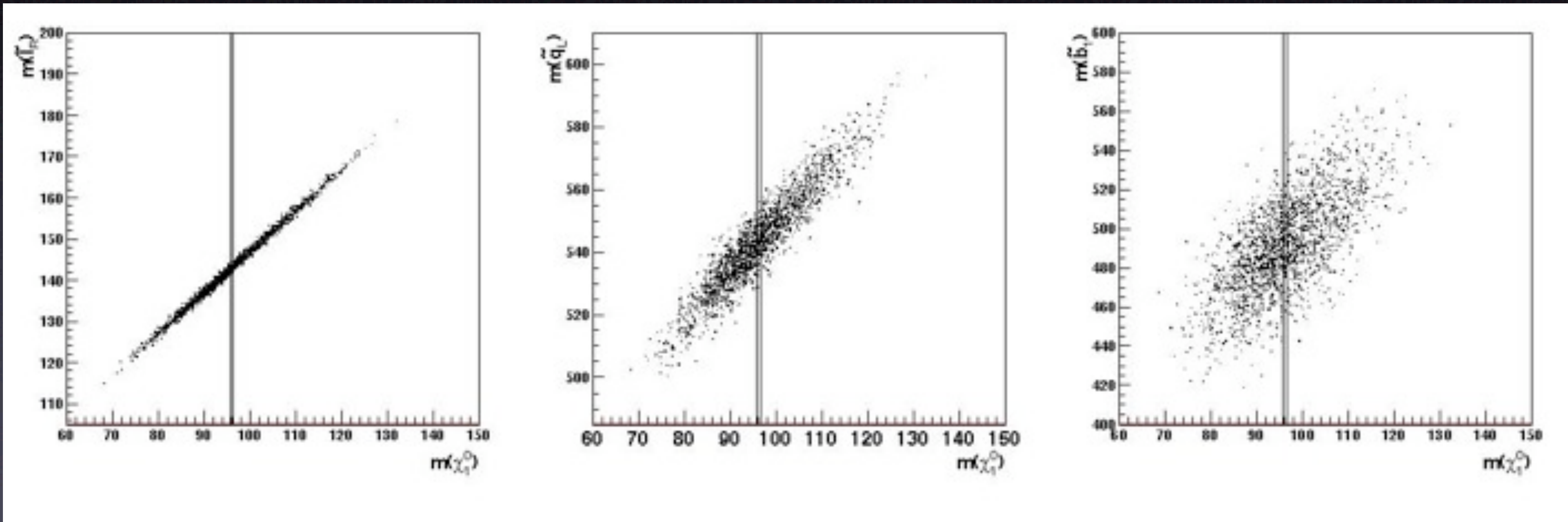
threshold scan



$$m_{\tilde{\mu}} = 132.0 \pm 0.09 \text{ GeV}$$
$$m_{\tilde{\chi}^0} = 71.9 \pm 0.05 \text{ GeV}$$

LHC/LC synergy



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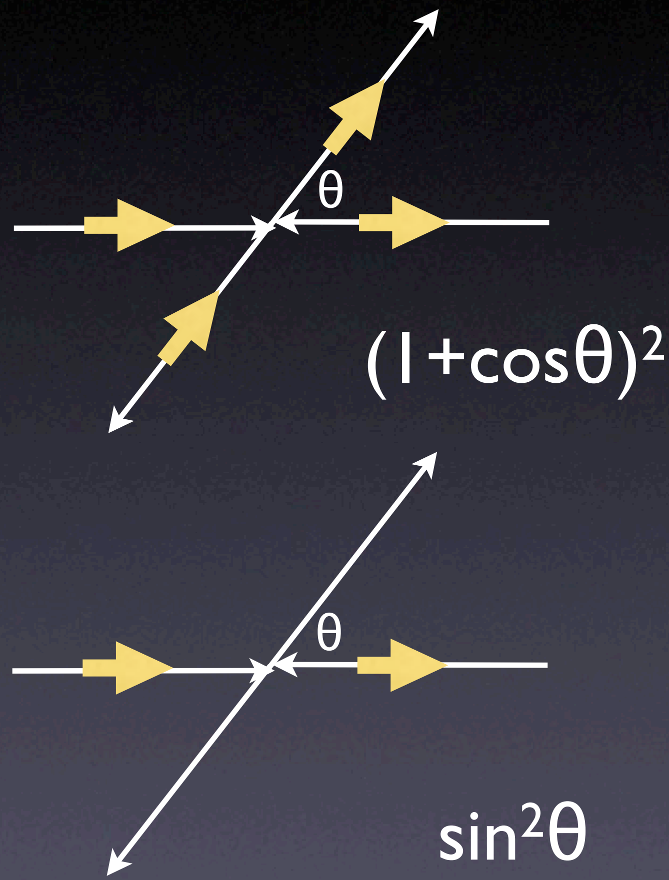
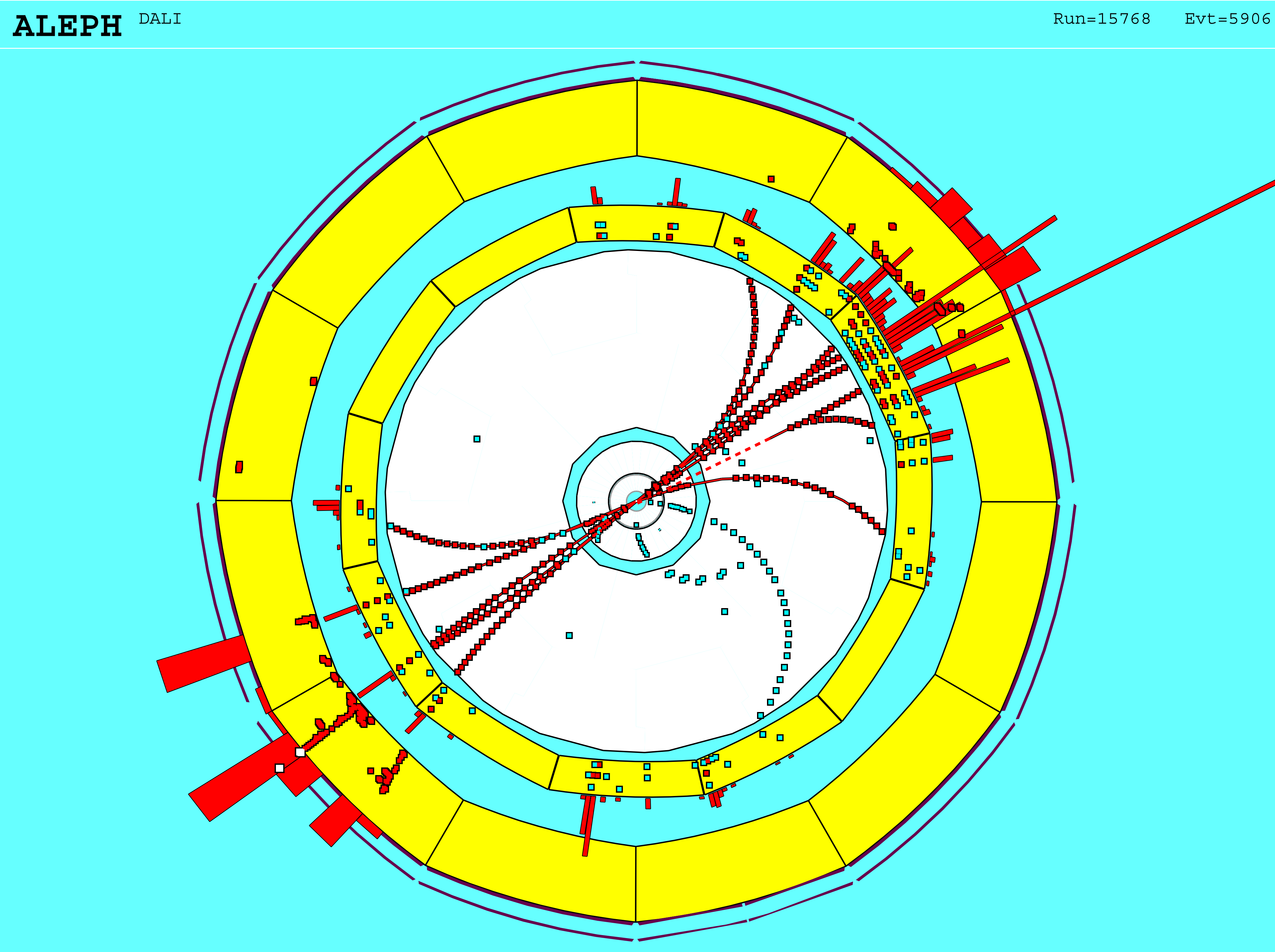
What did you find?

- Specify the fields
  - mass
  - spin ⇒ 0, 1/2, 1
  - SU(3)xSU(2)xU(1) quantum numbers
  - mixing of states
- Specify their interactions
  - SU(3)xSU(2)xU(1) quantum numbers determine gauge interactions
  - Yukawa couplings
  - trilinear and quartic scalar couplings

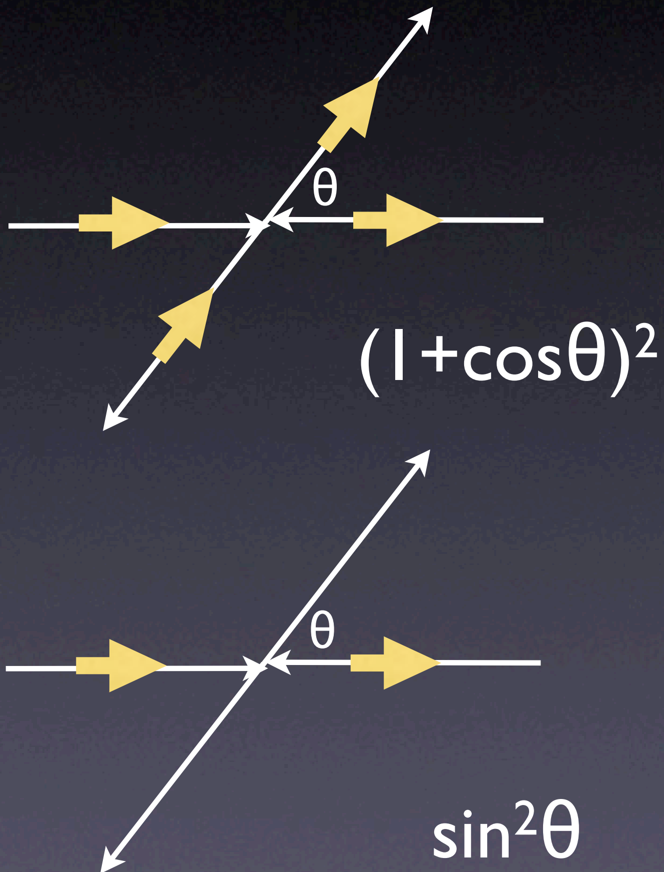
Spin

- production angle distribution well above the threshold:
- spin 1/2
- spin 0

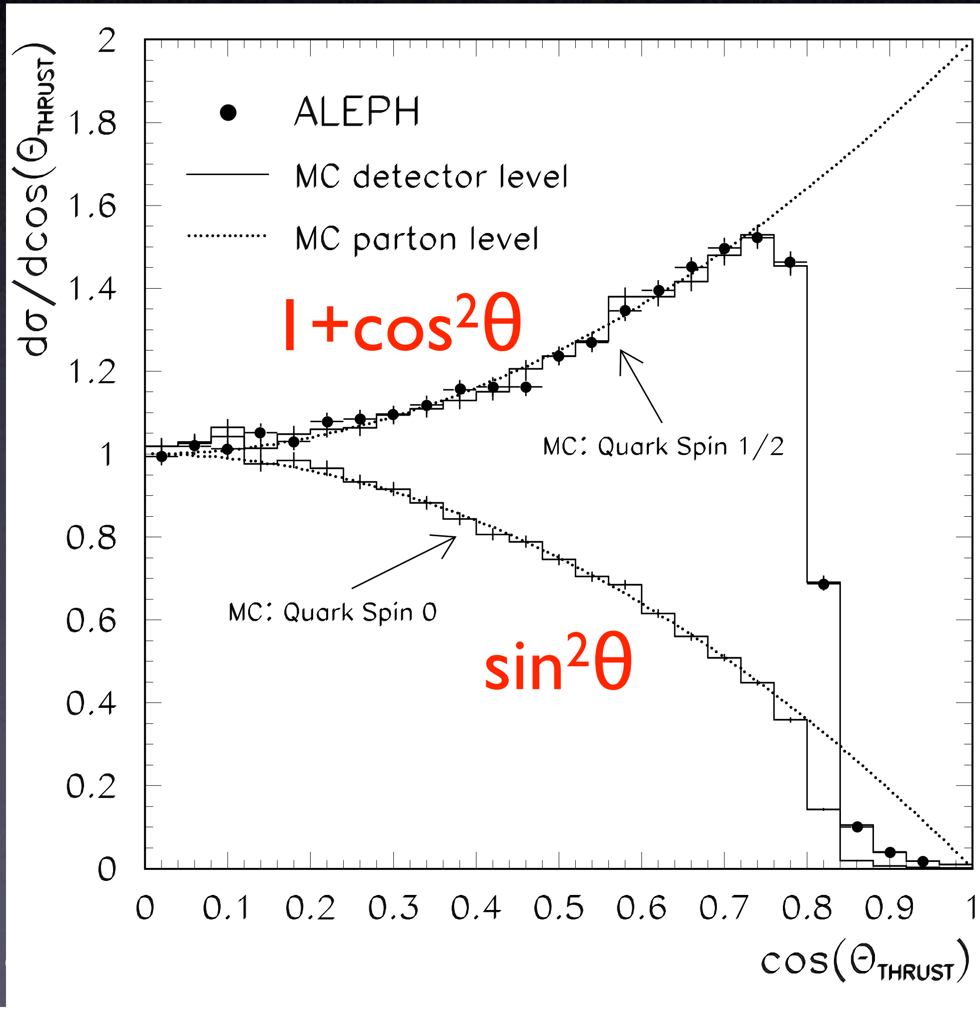


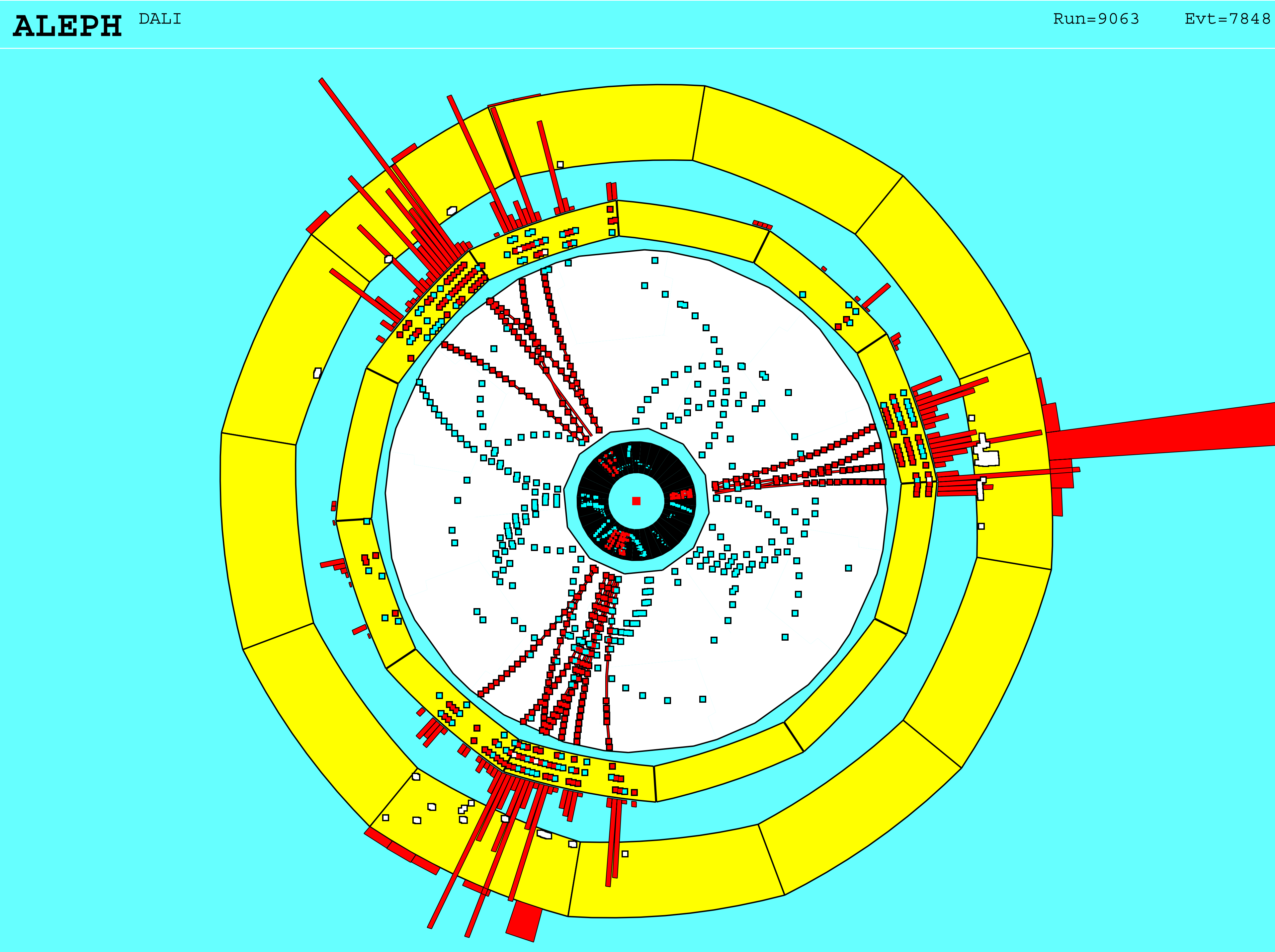

ALEPH
DALI
Run=15768
Evt=5906

"New particle" has spin 1/2



quark





ALEPH
DALI
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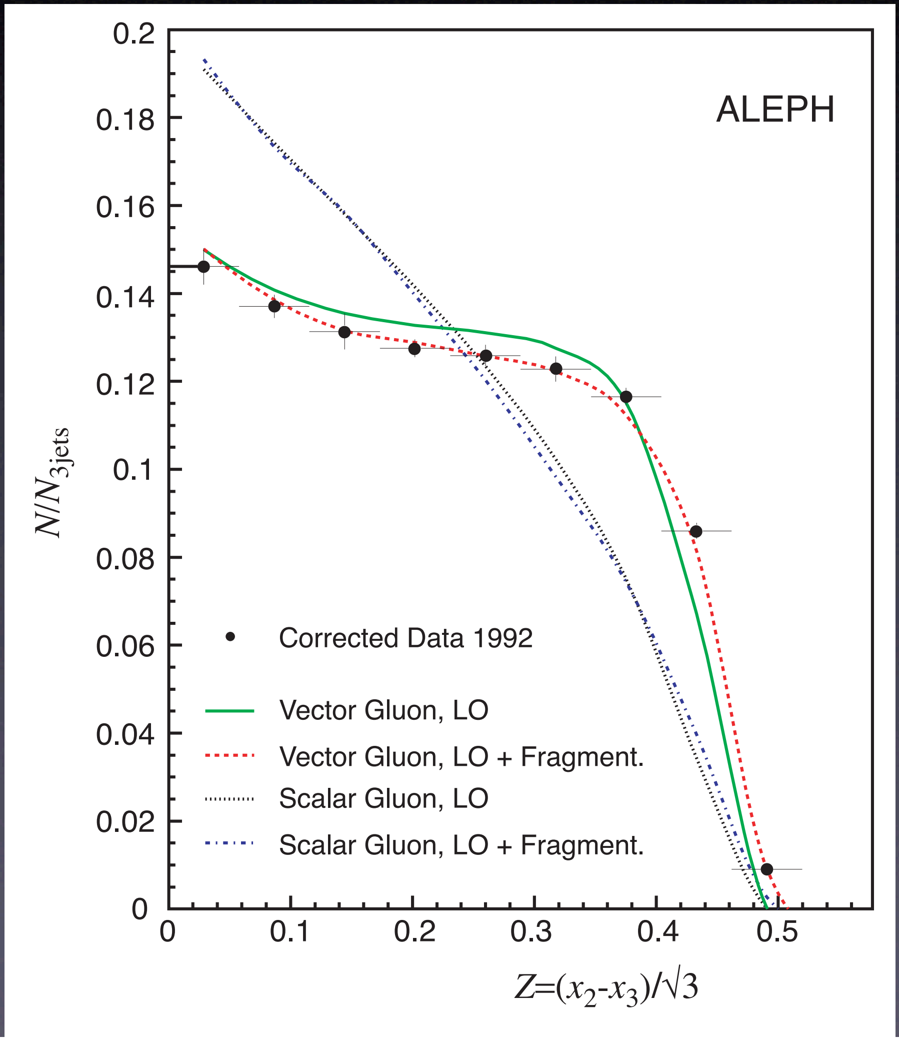
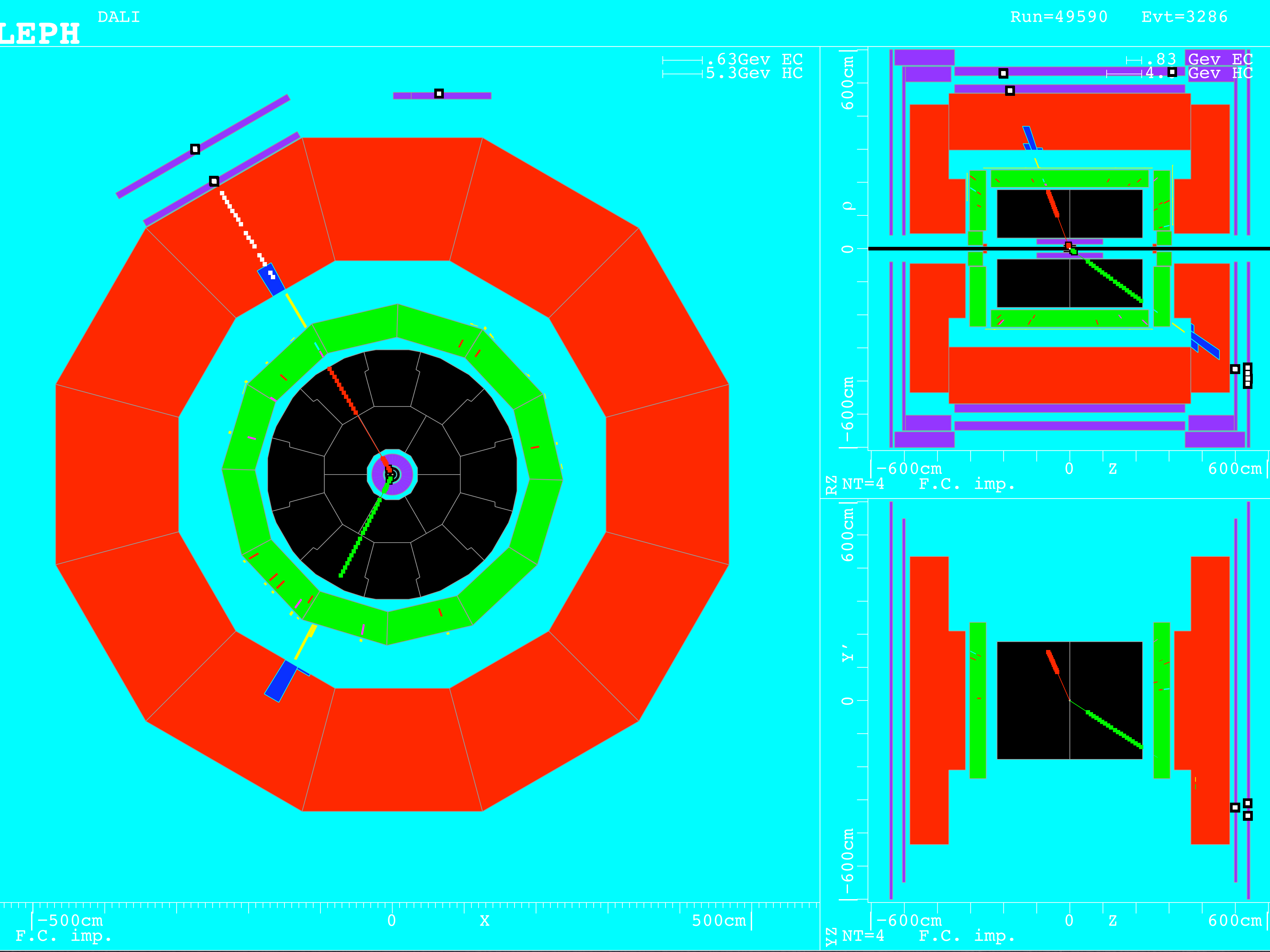
“New particle” has spin 1

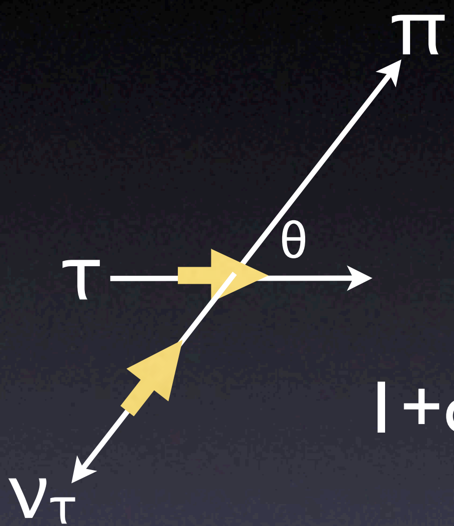
gluon



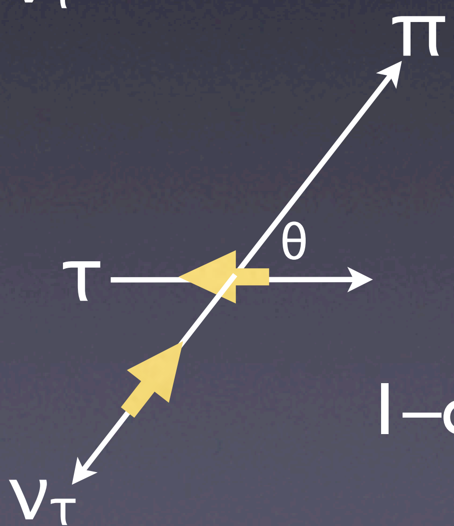

LEPH
DALI
Run=49590 Evt=3286
.63Gev EC
5.3Gev HC
-500cm
0
X
500cm
F.C. imp.
.83 Gev EC
4. Gev HC
600cm
ρ
0
-600cm
-600cm
Z
600cm
RZ NT=4 F.C. imp.
600cm
Y'
0
-600cm
-600cm
Z
600cm
YZ NT=4 F.C. imp.

polarization

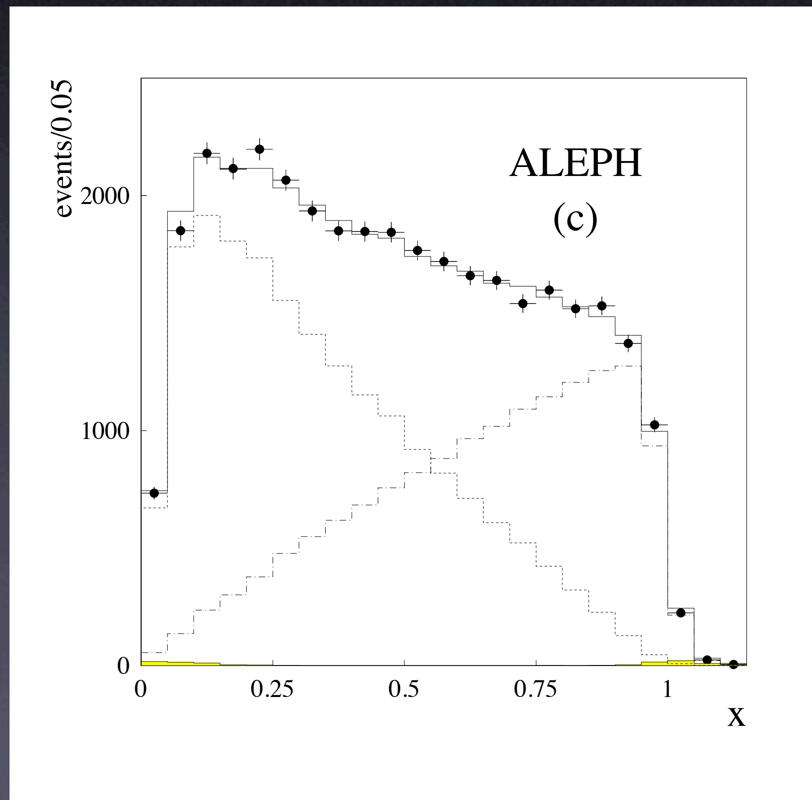
$$\tau^- \to \nu_\tau \pi^-$$



1+cosθ



1−cosθ



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Smuon production

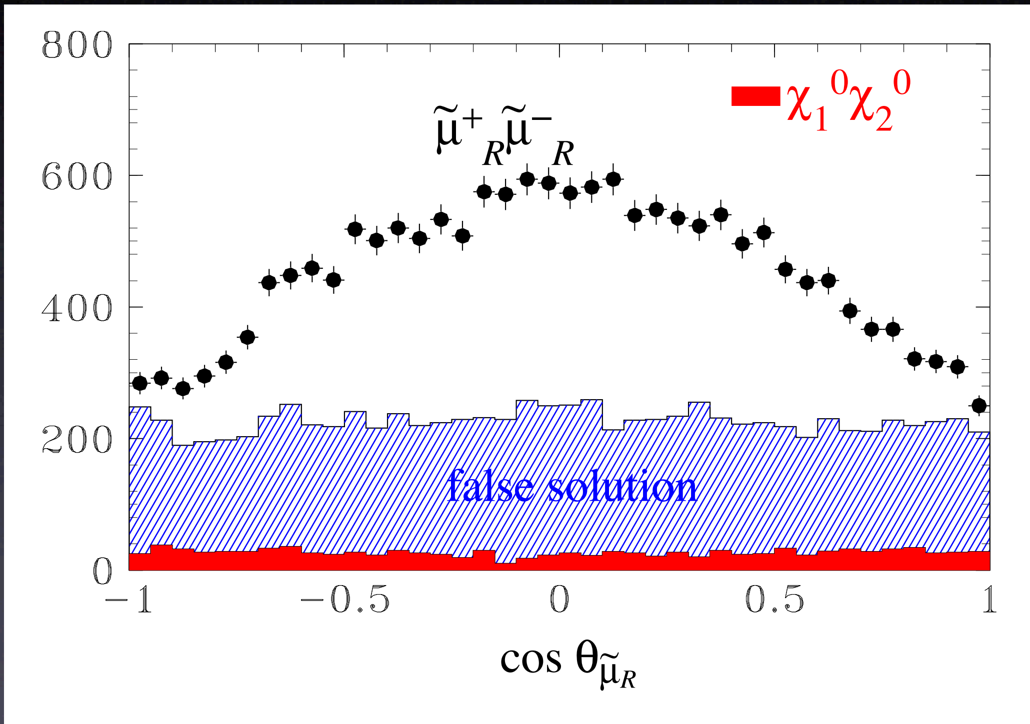
- $e^+e^- \to \tilde{\mu}^+\tilde{\mu}^- \to (\mu^+\tilde{\chi}_1^0)(\mu^-\tilde{\chi}_1^0)$
- once masses known, you can solve kinematics up to a two-fold ambiguity
- muon momenta measured: $p^\mu_{1,2} = (E_{1,2}, \vec{p}_{1,2})$
- neutralino momenta: $q^\mu_{1,2} = \left(\frac{\sqrt{s}}{2} - E_{1,2},\ \vec{q}_{1,2}\right)$
- neutralino mass constraint: $\vec{q}^{\,2}_{1,2} = \left(\frac{\sqrt{s}}{2} - E_{1,2}\right)^2 - m^2_{\tilde{\chi}}$
- smuon mass constraint: $\left(\frac{\sqrt{s}}{2}\right)^2 - (\vec{p}_1 + \vec{q}_1)^2 = m^2_{\tilde{\mu}} \longrightarrow \vec{p}_1 \cdot \vec{q}_1$
- momentum conservation:

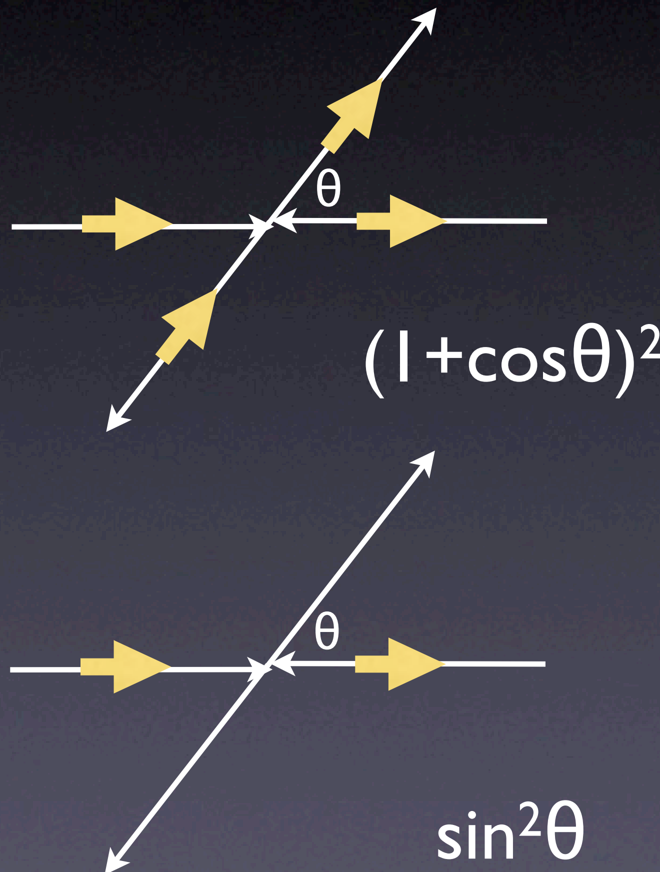
$$\vec{q}^{\,2}_2 = (\vec{p}_1 + \vec{p}_2 + \vec{q}_1)^2 = (\vec{p}_1 + \vec{p}_2)^2 + \vec{q}^{\,2}_1 + 2\vec{p}_1 \cdot \vec{q}_1 + 2\vec{p}_2 \cdot \vec{q}_1 \longrightarrow \vec{p}_2 \cdot \vec{q}_1$$

- Now know $|\vec{q}_1|,\ \vec{p}_1 \cdot \vec{q}_1,\ \vec{p}_2 \cdot \vec{q}_1$
- Know $\vec{q}_1$ up to a two-fold ambiguity

68

Smuon has spin 0

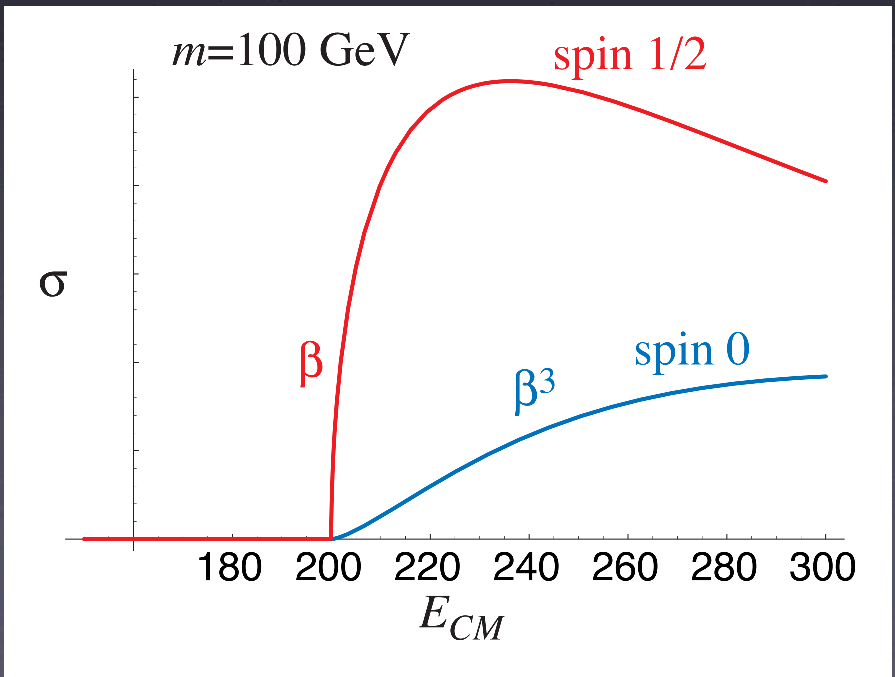


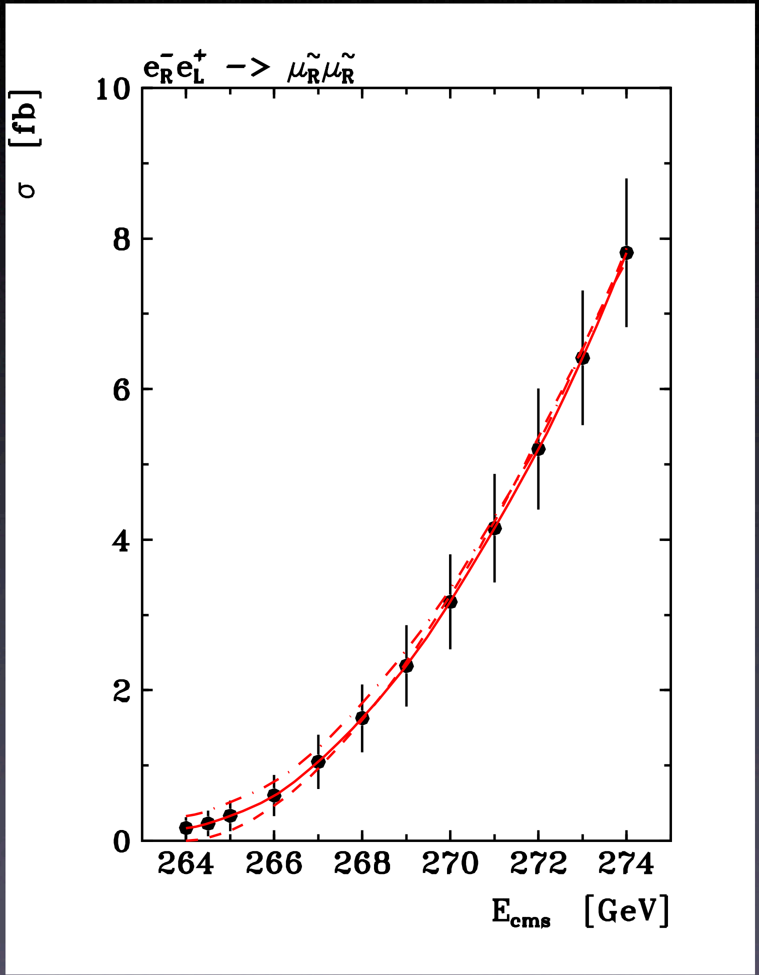


can reconstruct with
a two-fold ambiguity

Spin

- threshold behavior
  non-relativistic limit:
  L, S separately
  conserved





$m_{\tilde{\mu}} = 132.0 \pm 0.09$ GeV
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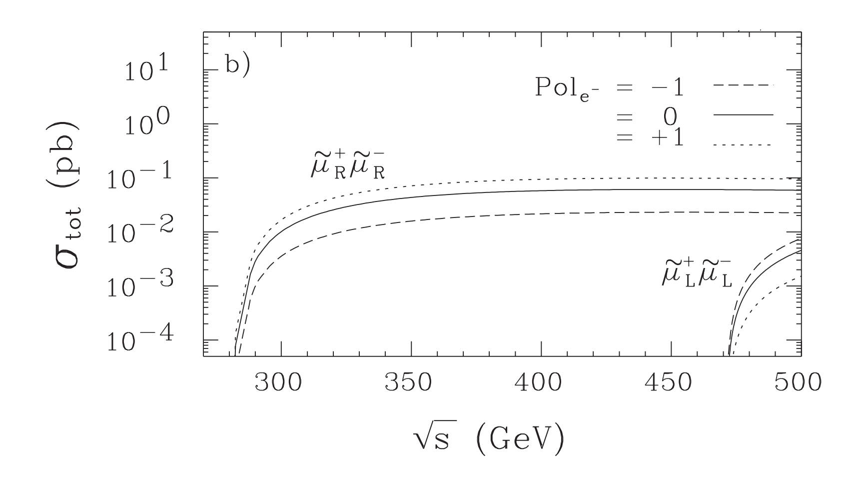
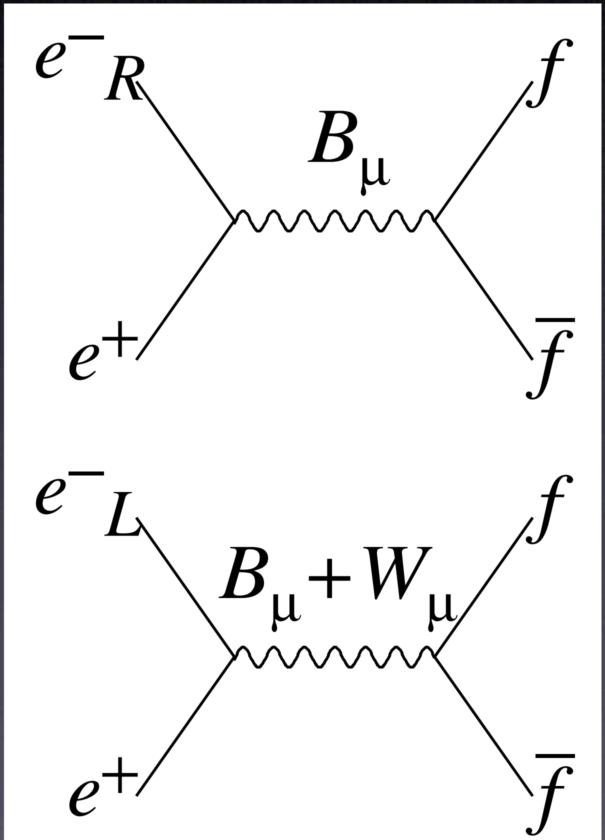
  - trilinear and quartic scalar couplings

polarization

- Use polarized electron beam
- can ignore $m_Z^2 \ll s$
- e_R couples only to B_μ
- e_L couples to $B_\mu + W_\mu^0$

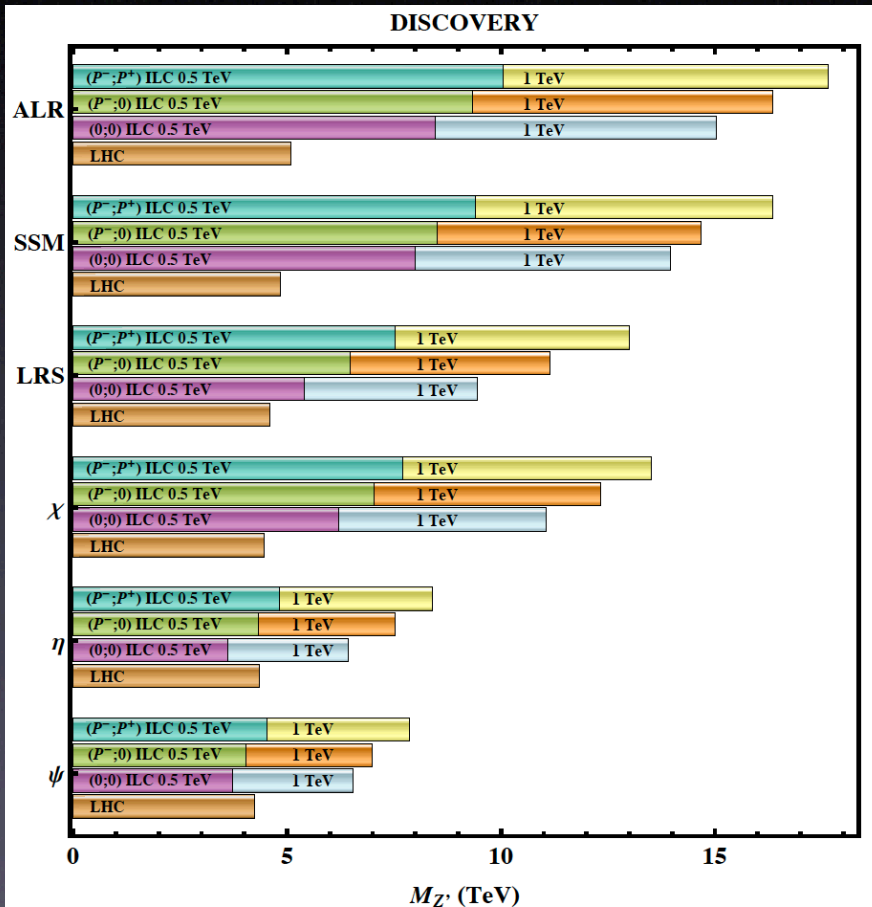


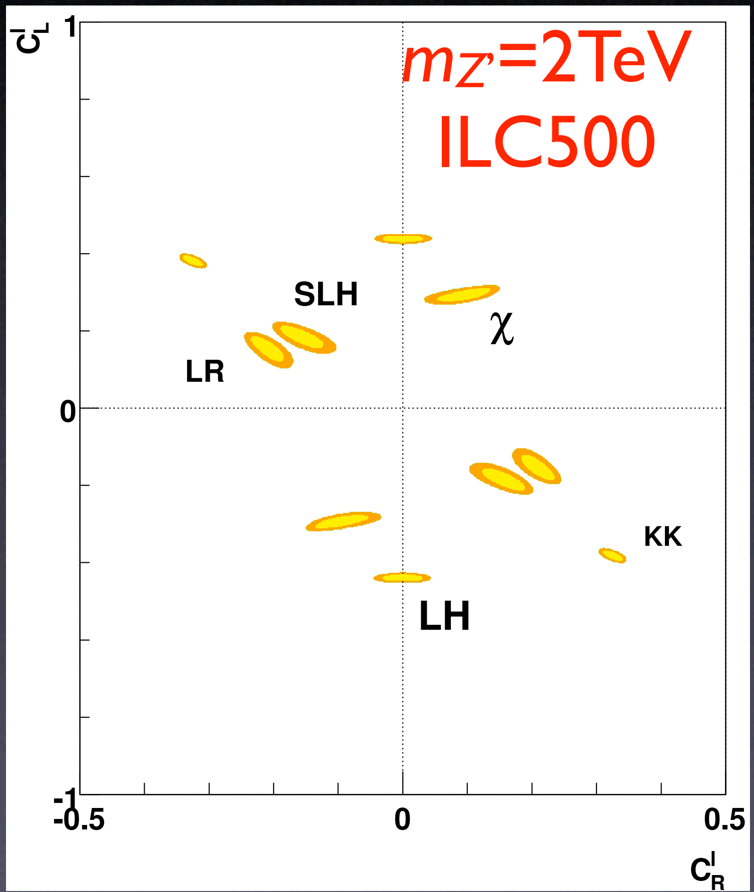


$\propto (g'^2 Y_f)^2$

$\propto (g'^2 Y_f + g^2 I_{3f})^2/4$

a new gauge boson





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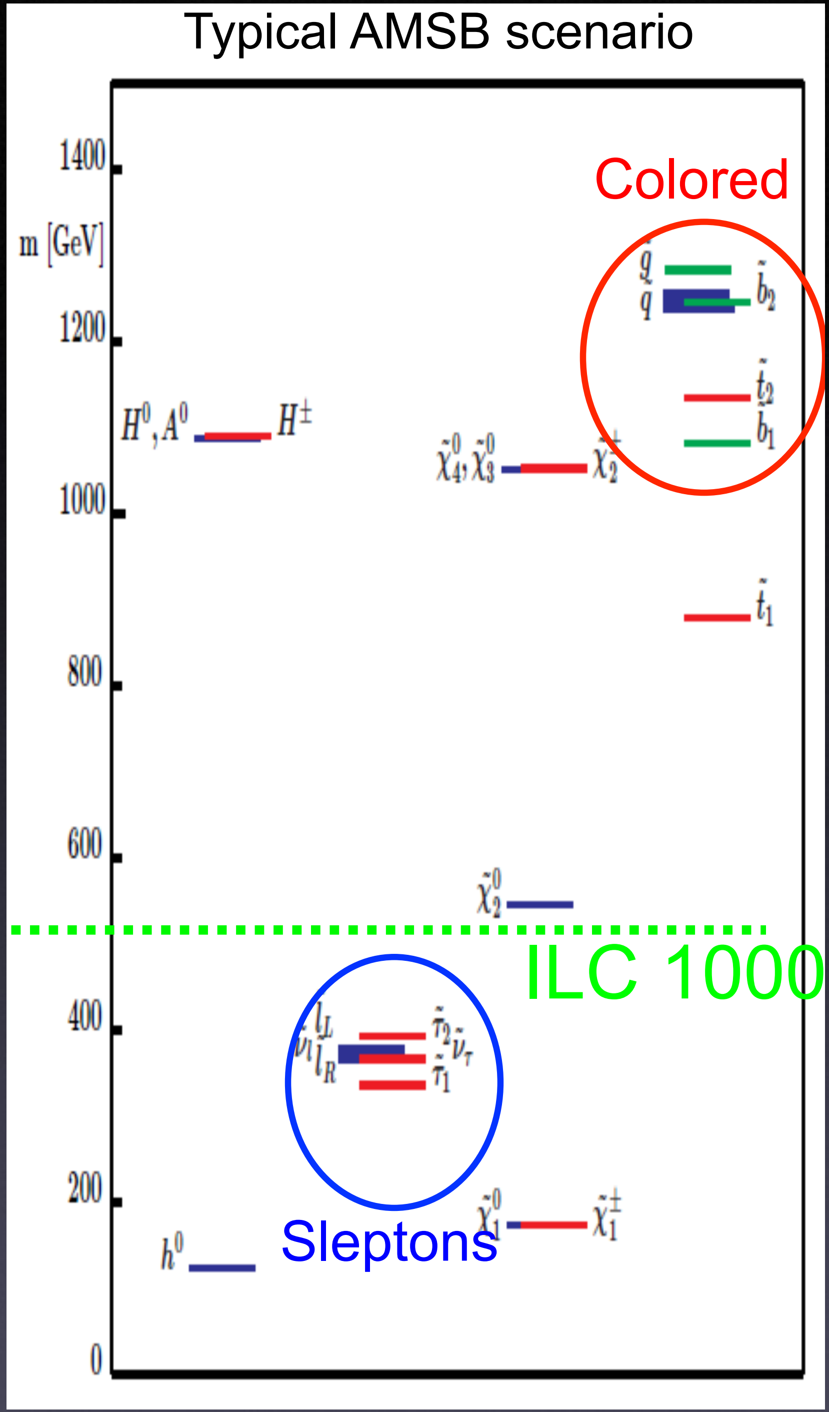
  - trilinear and quartic scalar couplings

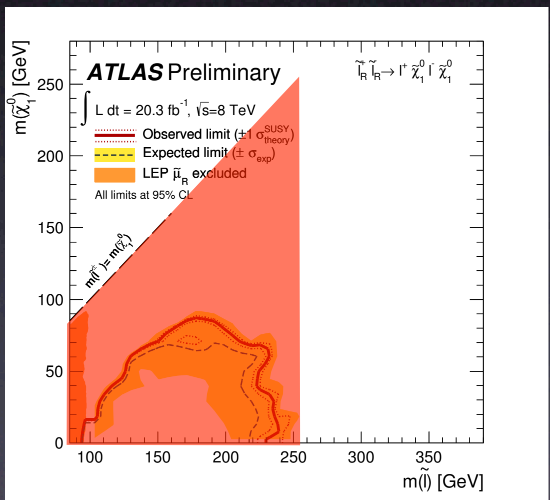
Supersymmetry

- access to color-neutral SUSY particles

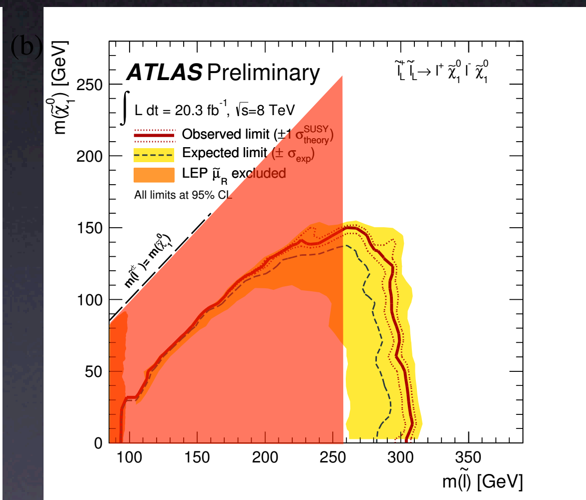


electroweak states

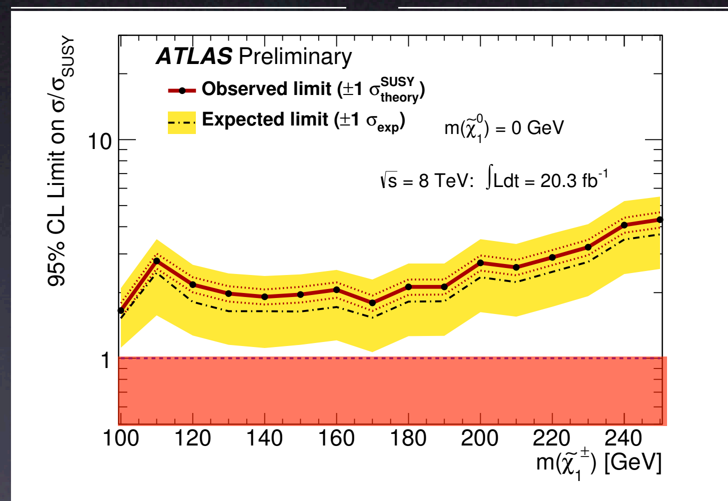
$\tilde{l}_R$



$\tilde{l}_L$



$\tilde{\chi}^{\pm}$



@ILC500

Composite Higgs

- effect of compositeness appears as higher dimension operators
- precision Higgs measurements
- window to high-ener physics beyond TeV

$$
\begin{aligned}
\mathcal{L}_{\rm SILH} = & \frac{c_H}{2f^2}\partial^\mu\left(H^\dagger H\right)\partial_\mu\left(H^\dagger H\right) + \frac{c_T}{2f^2}\left(H^\dagger \overleftrightarrow{D^\mu} H\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) \\
& - \frac{c_6\lambda}{f^2}\left(H^\dagger H\right)^3 + \left(\frac{c_y y_f}{f^2} H^\dagger H \bar{f}_L H f_R + \text{h.c.}\right) \\
& + \frac{ic_W g}{2m_\rho^2}\left(H^\dagger \sigma^i \overleftrightarrow{D^\mu} H\right)(D^\nu W_{\mu\nu})^i + \frac{ic_B g'}{2m_\rho^2}\left(H^\dagger \overleftrightarrow{D^\mu} H\right)(\partial^\nu B_{\mu\nu}) \\
& + \frac{ic_{HW} g}{16\pi^2 f^2}(D^\mu H)^\dagger \sigma^i (D^\nu H) W^i_{\mu\nu} + \frac{ic_{HB} g'}{16\pi^2 f^2}(D^\mu H)^\dagger (D^\nu H) B_{\mu\nu} \\
& + \frac{c_\gamma g'^2}{16\pi^2 f^2}\frac{g^2}{g_\rho^2} H^\dagger H B_{\mu\nu} B^{\mu\nu} + \frac{c_g g_S^2}{16\pi^2 f^2}\frac{y_t^2}{g_\rho^2} H^\dagger H G^a_{\mu\nu} G^{a\mu\nu}.
\end{aligned}
$$

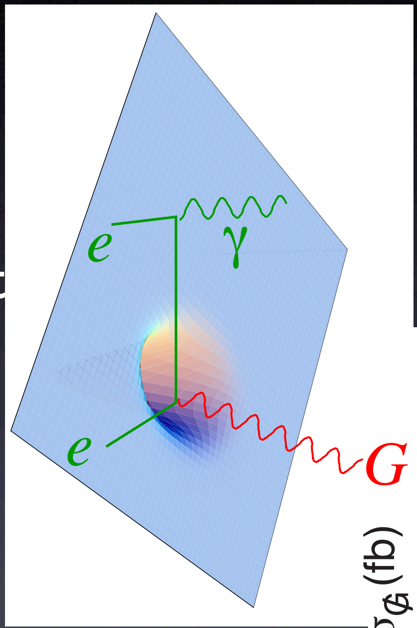
Giudice, Grojean, Pomarol, Rattazzi

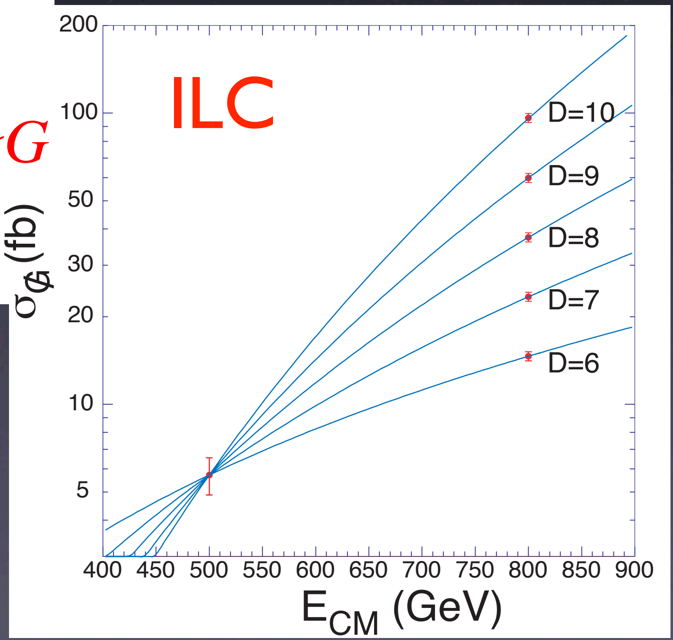
ILC500 ⇒ 4πf~40 TeV

Hidden Dimensions

- Hidden dimensions
- Can emit graviton into the bulk
- Events with apparent energy imbalance

⇒ How many extra dimensions are there?



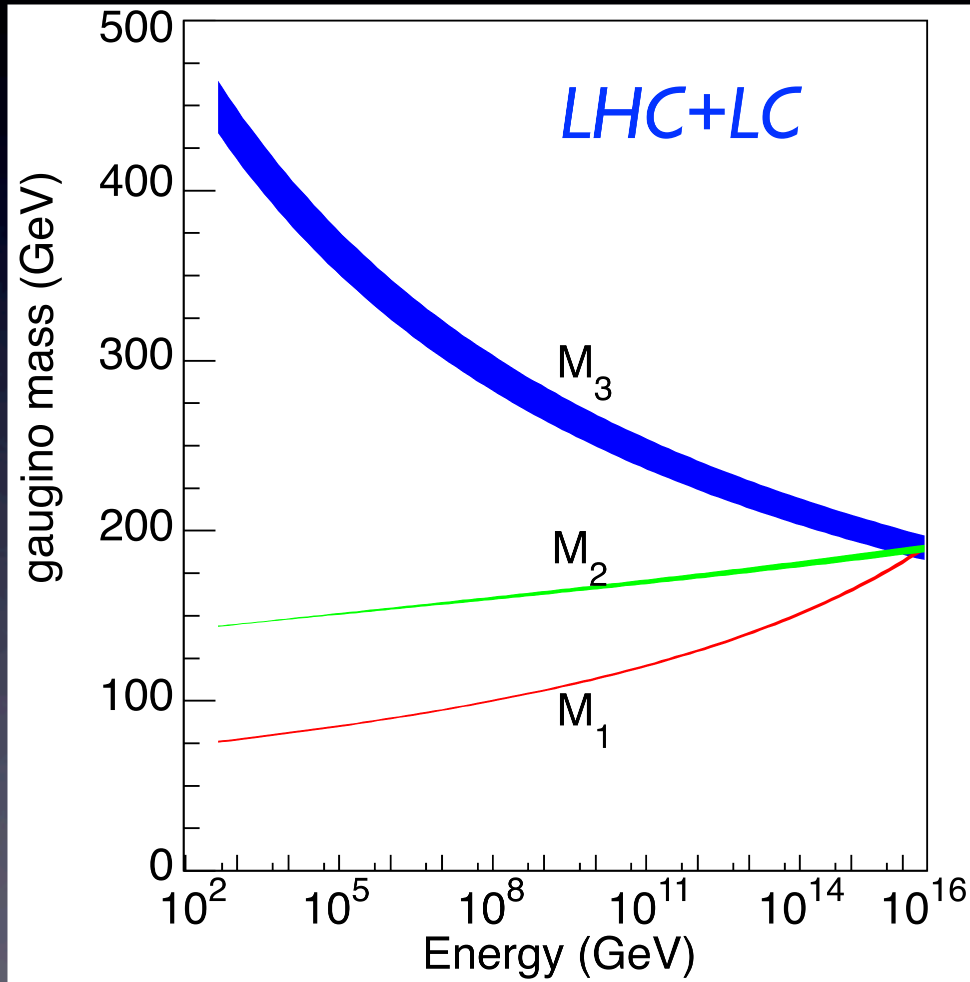


Superpartners as probe

- Most exciting thing about superpartners beyond existence:

They carry information of small-distance physics to something we can measure

"Are forces unified?"



Physics at LCs

- now *guaranteed* at <500 GeV:
  - precision study of the Higgs-like particle
  - window to new physics?
  - top quark threshold
- also possible at higher energies:
  - Higgs self-coupling
  - discovery reach on electroweak particles
  - window to unification?

Sounds great,
but are we going
to have one?

JAHEP statement Oct 2012

In March 2012, the Japan Association of High Energy Physicists (JAHEP) accepted the recommendations of the Subcommittee on Future Projects of High Energy Physics[1] and adopted them as JAHEP's basic strategy for future projects. In July 2012, a new particle consistent with a Higgs Boson was discovered at LHC, while in December 2012 the Technical Design Report of the International Linear Collider (ILC) will be completed by a worldwide collaboration.

On the basis of these developments and following the subcommittee's recommendation on ILC, JAHEP proposes that ILC be constructed in Japan as a global project with the agreement of and participation by the international community in the following scenario:

(1) Physics studies shall start with a precision study of the "Higgs Boson", and then evolve into studies of the top quark, "dark matter" particles, and Higgs self-couplings, by upgrading the accelerator. A more specific scenario is as follows:

(A) A Higgs factory with a center-of-mass energy of approximately 250 GeV shall be constructed as a first phase.

(B) The machine shall be upgraded in stages up to a center-of-mass energy of ~500 GeV, which is the baseline energy of the overall project.

(C) Technical extendability to a 1 TeV region shall be secured.

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Is this a pipe dream?

- There is a lot of momentum in Japan:
  - Community
  - Industry & local regions
  - National Politics
- It crucially depends on international interest & support on its scientific case
- European Strategy supports the proposal for Japan to host an ILC, already helping

European Strategy

There is a strong scientific case for an electron-positron collider, complementary to the LHC, that can study the properties of the Higgs boson and other particles with unprecedented precision and whose energy can be upgraded. The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation. The initiative from the Japanese particle physics community to host the ILC in Japan is most welcome, and European groups are eager to participate. Europe looks forward to a proposal from Japan to discuss a possible participation.

HEPAP Facilities Subpanel: Report on Energy Frontier Facilities

S. Dawson, BNL

March 11, 2013

S. Dav

Need discussions at the diplomatic levels

US Participation in Japanese Hosted ILC

- Science drives the need for e^+e^- collider
  - ILC addresses absolutely central physics questions and is complementary to the LHC
  - Japanese hosted ILC could be under construction before 2024
- Parameters of a potential US contribution are not known and depend on international agreements
  - The US has made substantial contributions to detector and accelerator development through the global effort
  - Should an agreement be reached, the US particle physics community would be eager to participate in both the accelerator and detector construction

Prime Minister Shinzo Abe

- Dec 2012 election
- another one July 2013
- LDP policy documents for both elections mention ILC *twice*

Inaugural Speech by PM Abe

(Japanese version of ‘State of the Union’)
Feb 28, 2013

- *‘Japan is driving global innovation in cutting-edge areas, including among others the world's first production test of marine methane hydrate, a globally unparalleled rocket launch success rate, and our attempts to develop the most advanced accelerator technology in the world.’*

PM Abe at the 83rd session of Diet

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Press conference by the MEXT minister Shimomura

Jan 18, 2013

MEXT
Ministry of
Education
Culture
Sports
Science &
Technology

'(On ILC) We would like to consider the plan for the near future, while as the government actively negotiating with relevant countries in the first half of this year … we are now studying the legal framework.'

Federation of Diet Members for Promotion of ILC

- Established in 2008, expanded to a multi-partisan group
- Re-invigorated after the Higgs discovery: now >150 members!
- New chair: Mr. Kawamura (former MEXT minister)
- Meet *twice a month*

Kickoff Meeting : July 31st, 2008

Lyn Evans meets Prime Minister Mar 27, 2013

I understand ILC is a dream for humankind.
I need to monitor the developments carefully to see what role Japan can play.

Science-Industry Alliance

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- 'Advanced Accelerator Association for promoting science and technology (AAA)'
  - Established in 2008
  - Headed by a former CEO of Mitsubishi Heavy Industries: Mr. Nishioka
  - Hitachi, Toshiba, Mitsubishi, etc.
  - ~90 industries + ~30 universitie

Intensive activities:

- Lecture series, symposiums
- Civil engineering study
- Studies on large projects
- Science-industry cooperation
- …

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Apr 30 Symposium in Washington

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Director DOE/HEP Siegrist

Two Candidate Sites

- Kyushu
  - Sefuri mountains
- Tohoku
  - Kitakami mountains

In order to focus the design efforts:

one of them will be chosen by mid Aug based on:

1. Geology and other technical aspects
2. Infrastructure and economic ripple effects
3. Political aspects

'ILC site evaluation council'

Co-chairs: Kawagoe, Yamamoto

Evaluates 1. and 2. (hopefully that is enough information for decision)


私たちは
国際リニアコライダー
計画を応援しています。
We support the International
Linear Collider Project.
一関商工会議所／岩手県ILC推進協議会

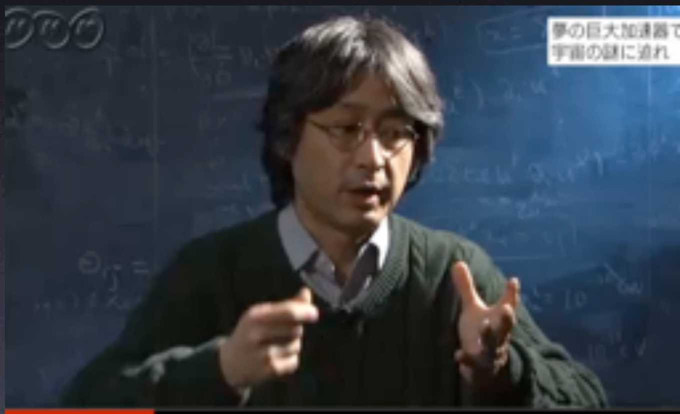
ILC TDR worldwide event June 12

National Coverage of the ILC

- Many TV and newspaper coverages
  - ‘Close-up Today’ Feb 2013

  NHK’s flag-ship news program (30 min)

  ‘Go beyond Higgs – Japan’s Large Accelerator Project’



Anchor: Hirok

This Summer

- Science of Council of Japan was asked by MEXT to evaluate scientific merit of ILC without comparison to other projects
- site selection committee will select one site very soon
- International committee to evaluate viability of the chosen site later this month

Possible Timeline long-term

End 2013

- Japanese government announces its intent to bid

2013~2015

- Inter-governmental negotiations
- Completion of R&Ds, preparation for the ILC lab.

~2015

- Inputs from LHC@14TeV, decision to proceed

2015~16

- Construction begins (incl. bidding)

2026~27

- Commissioning

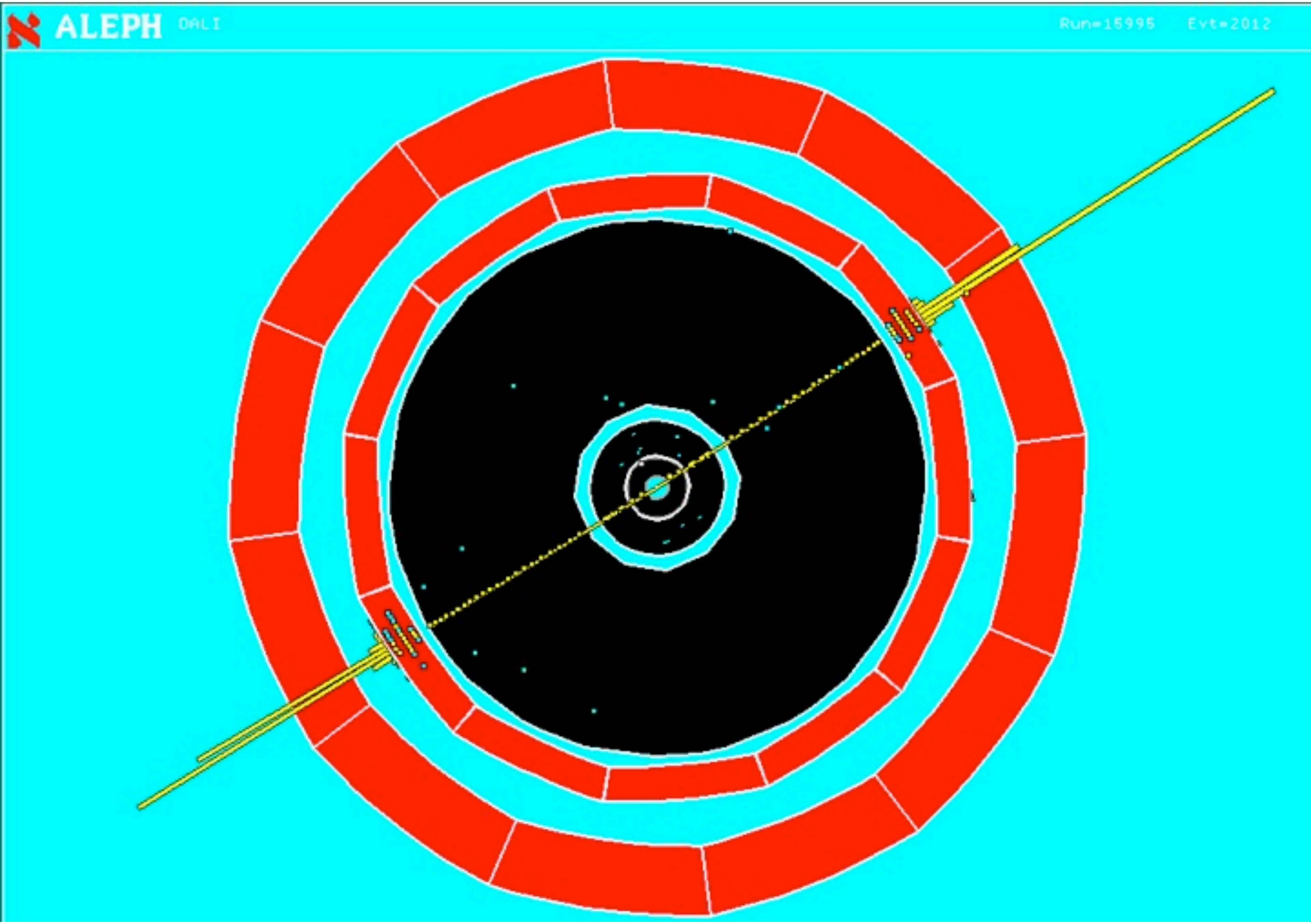
Conclusion

- ILC has a very strong physics case
  - with upgradability, beam polarization
- concrete program with Higgs
  - starting at 250 GeV, up to 1 TeV
- keep our eyes on potential new physics on the way
- a lot of momentum building in Japan

Big Questions

- Is this worth ~$10B?
- If so, how do we convince others?
- If not, what should be the next machine?

LEP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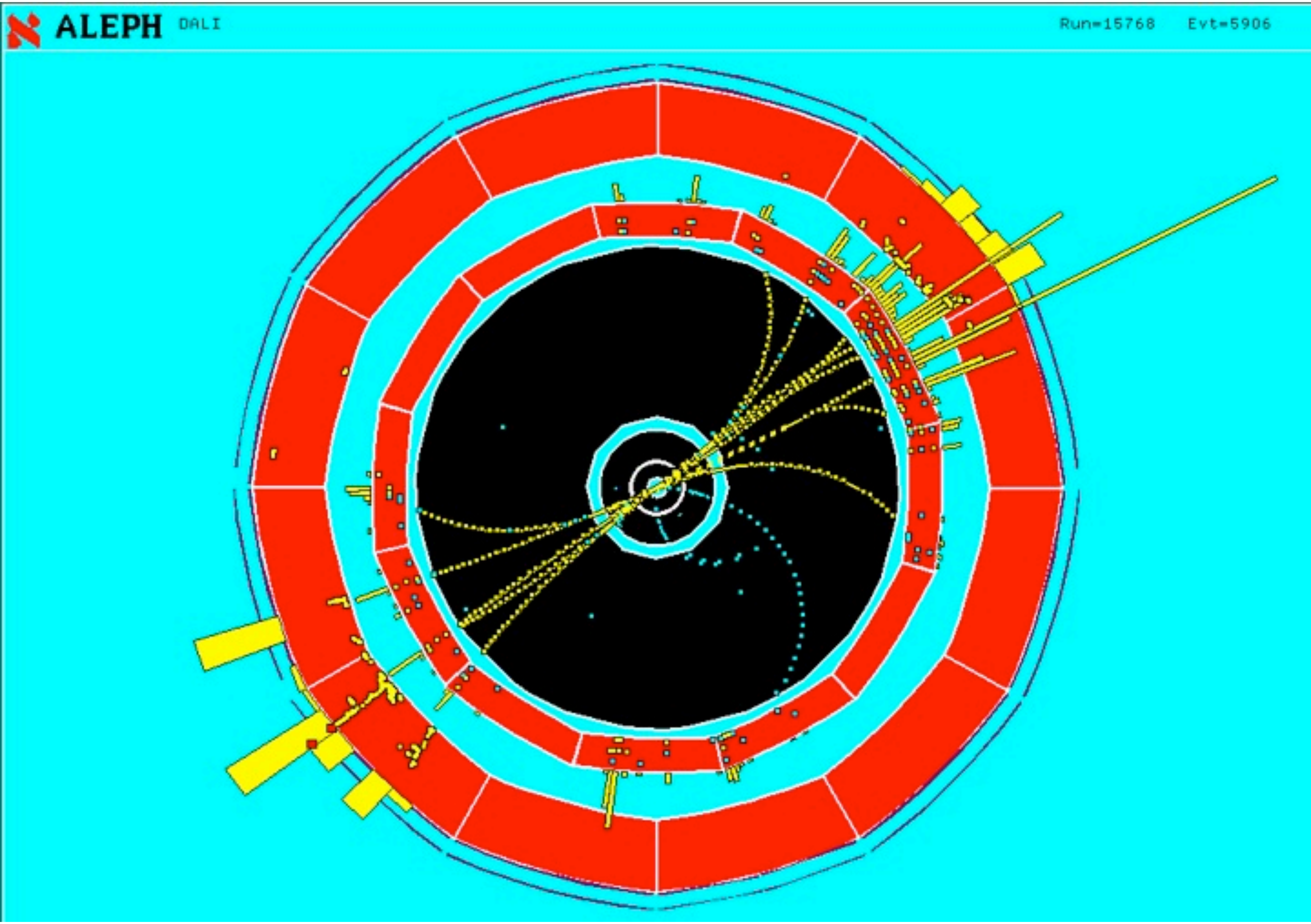
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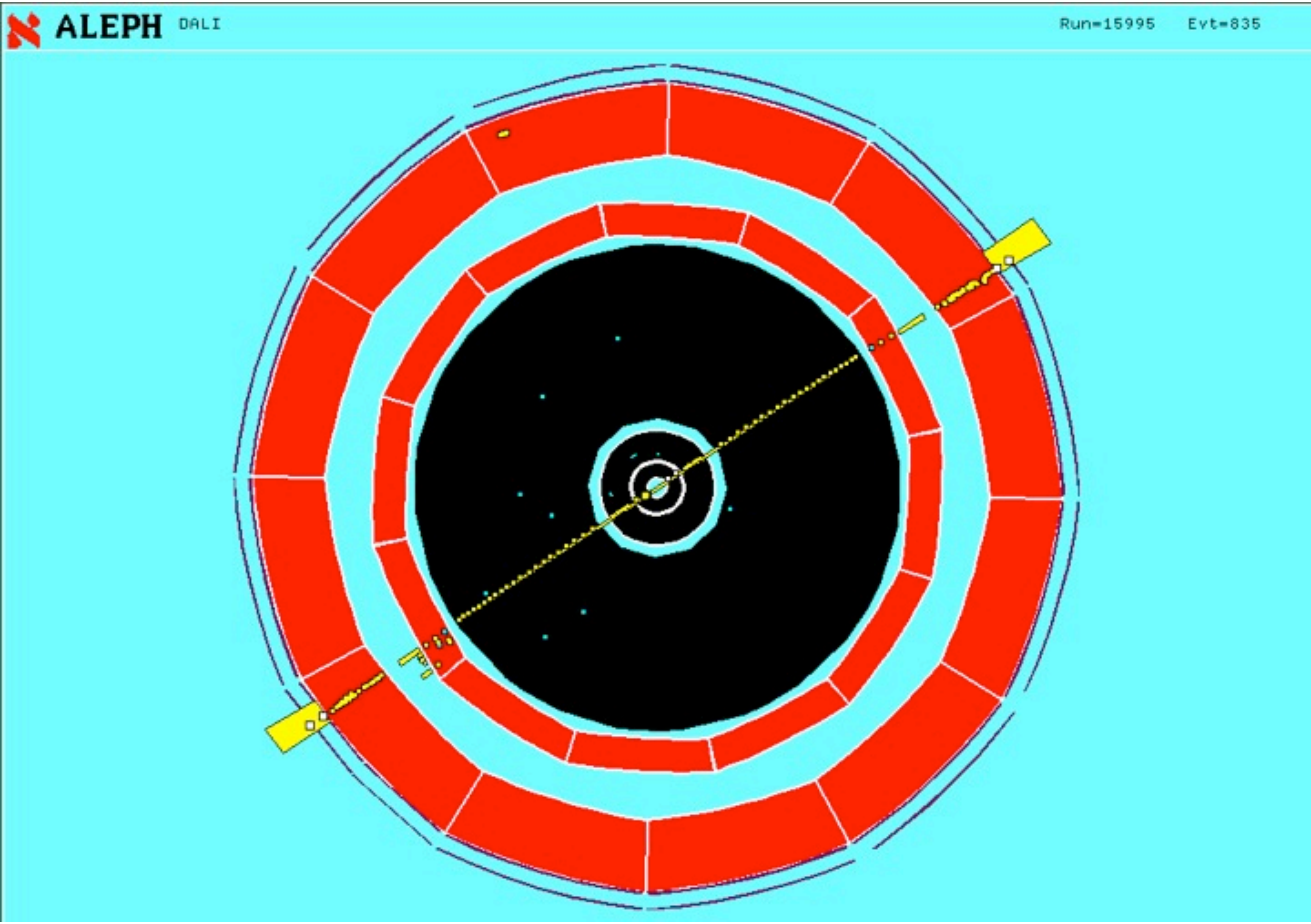
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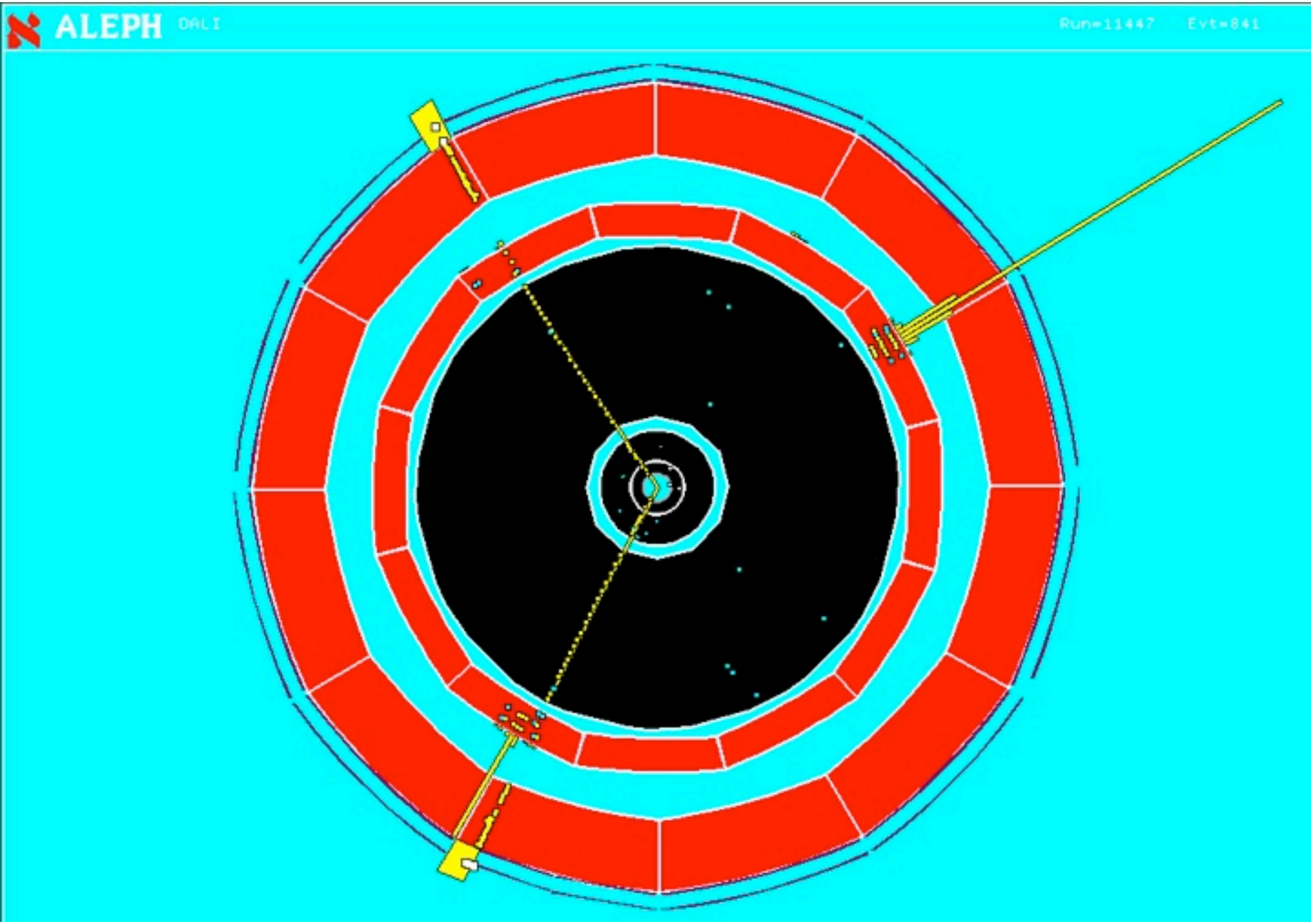
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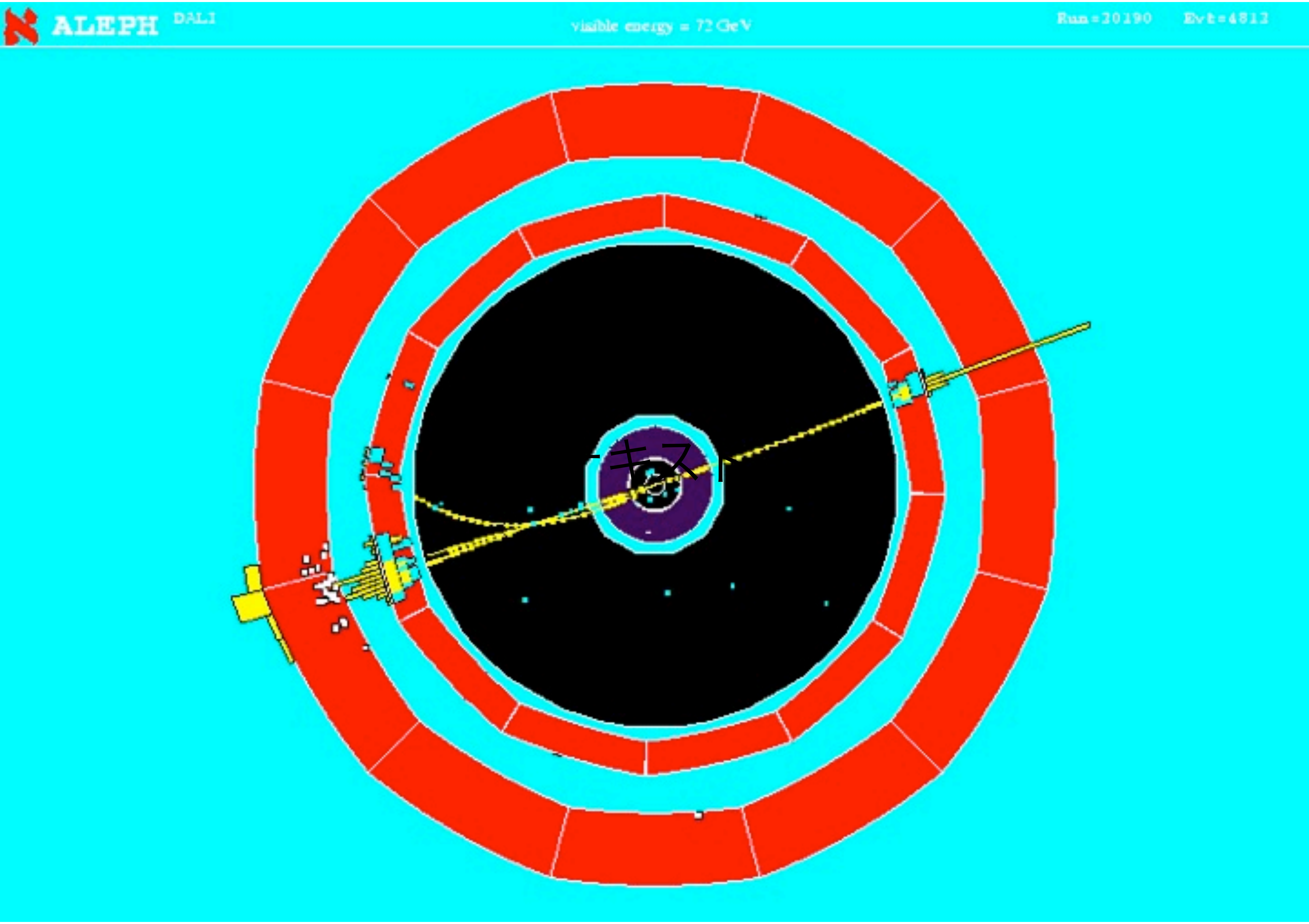
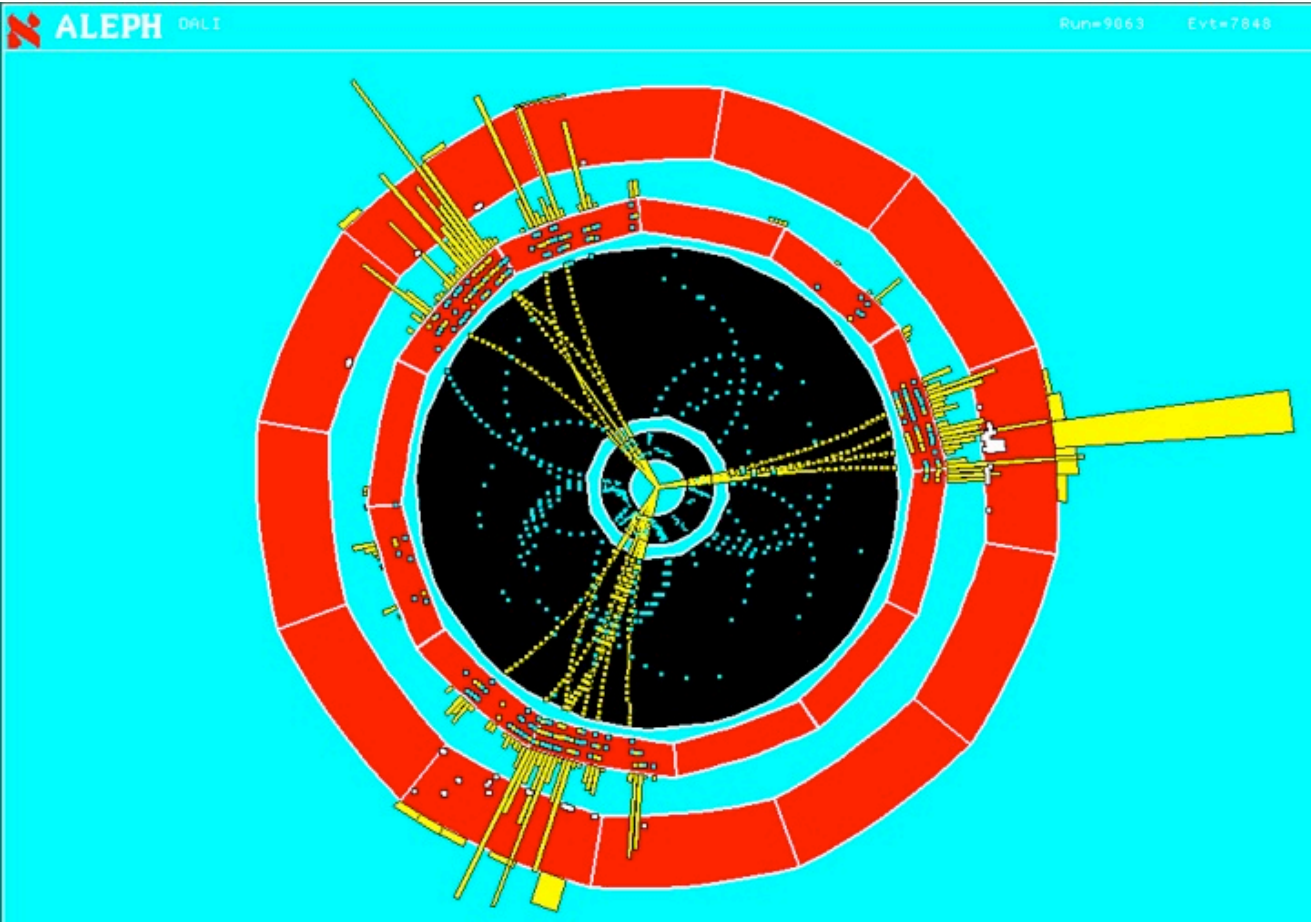
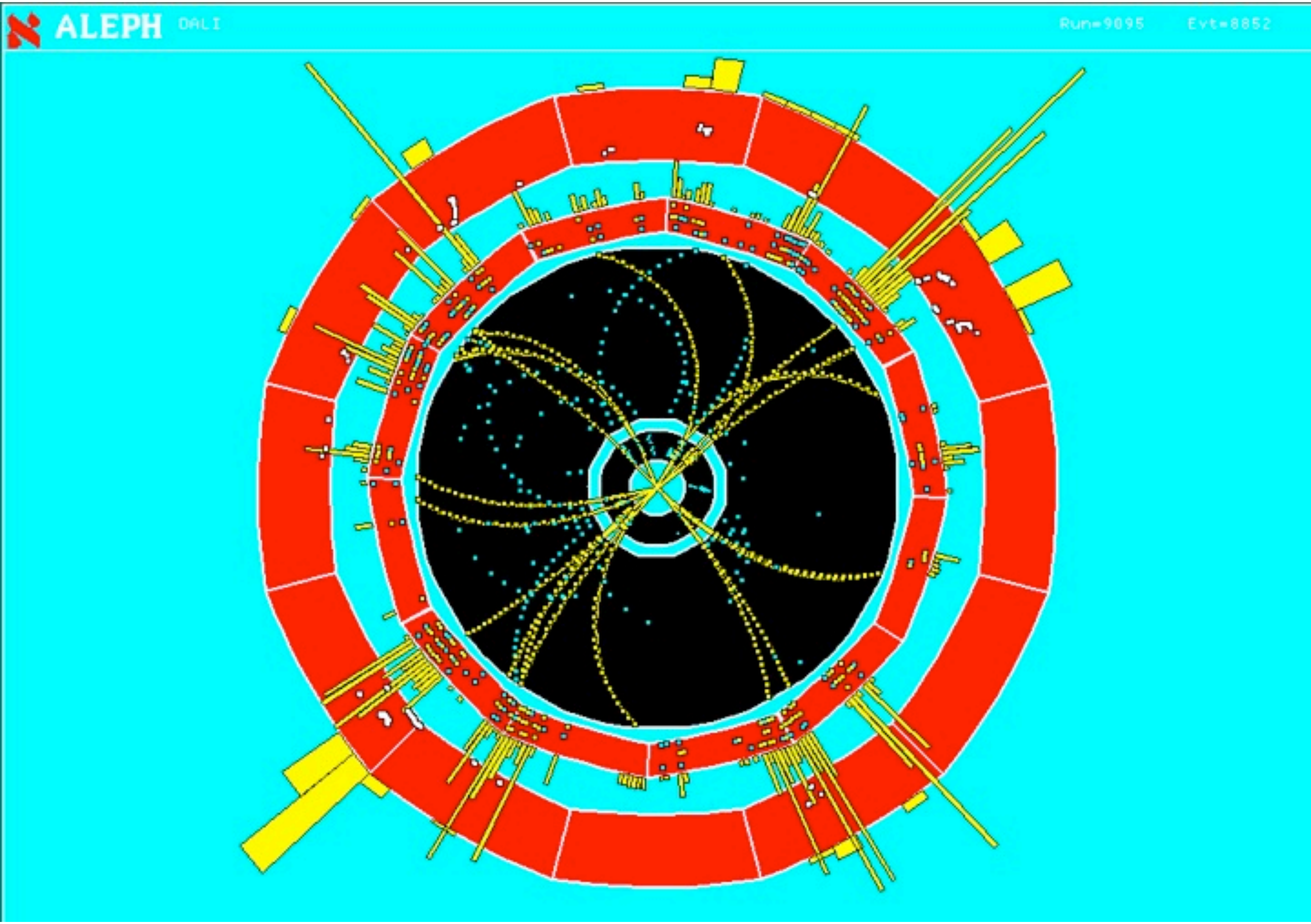
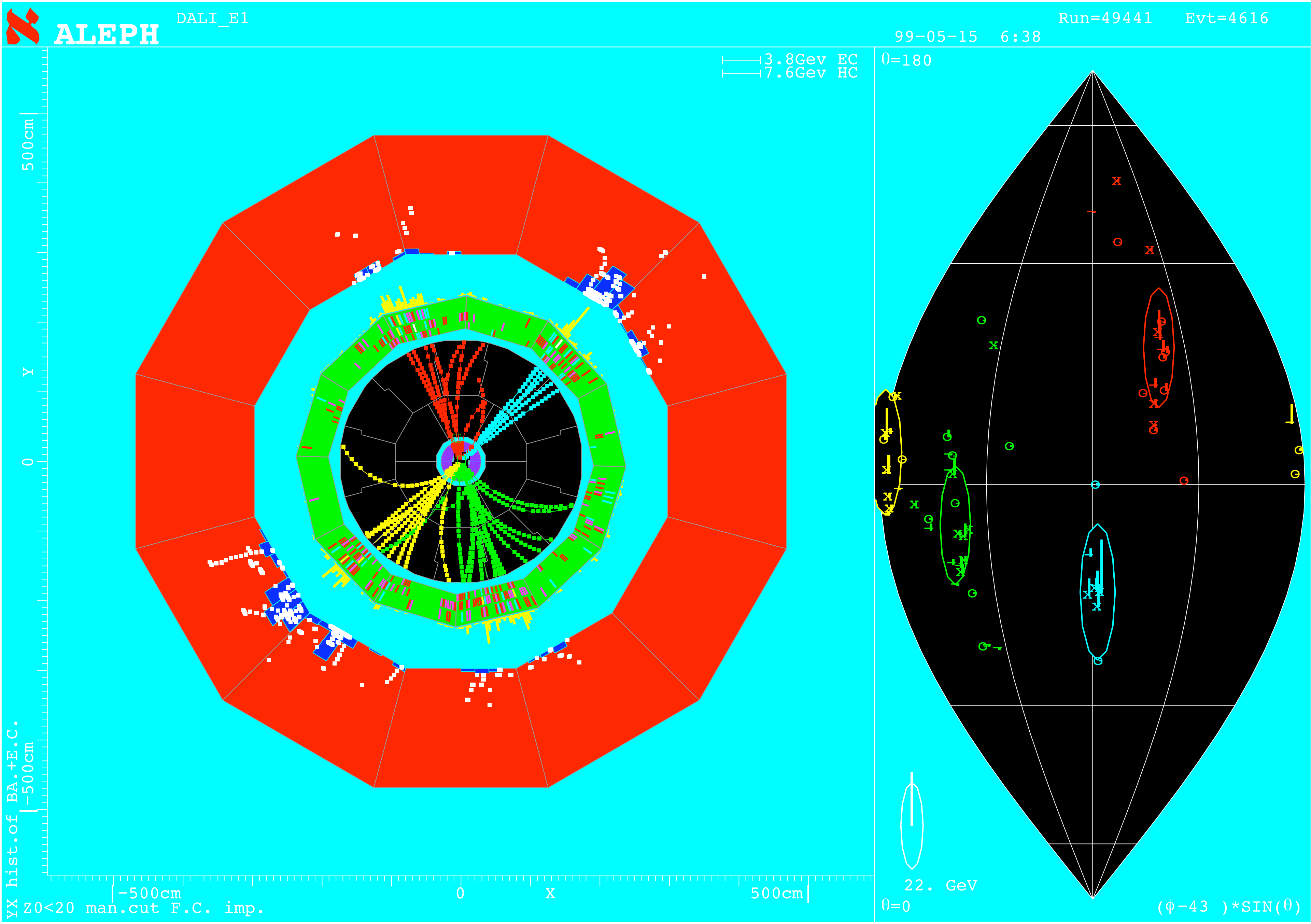
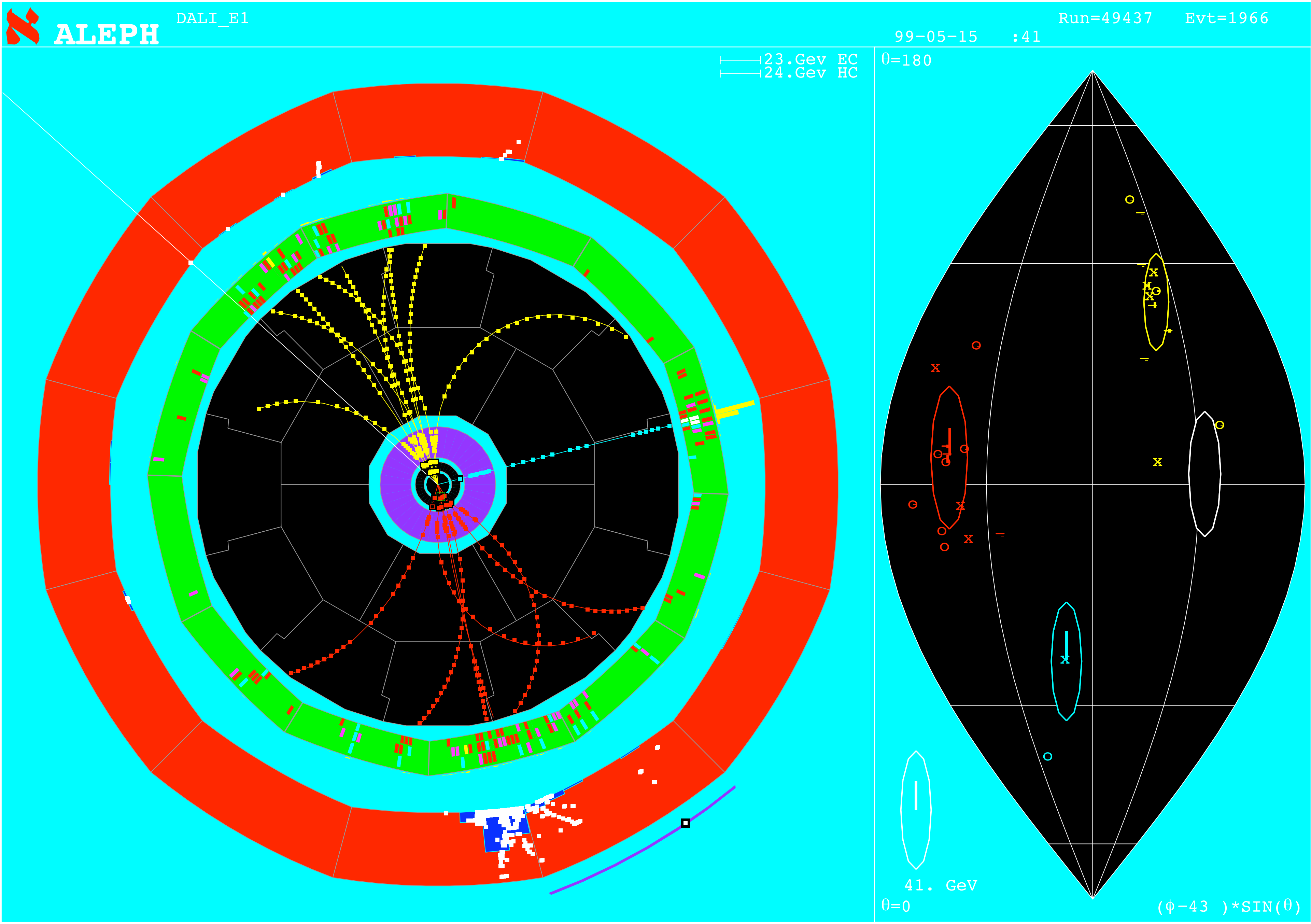

ALEPH
DALI
visible energy = 72 GeV
Run=20190
Evt=4812


ALEPH
DALI
Run=9063
Evt=7848

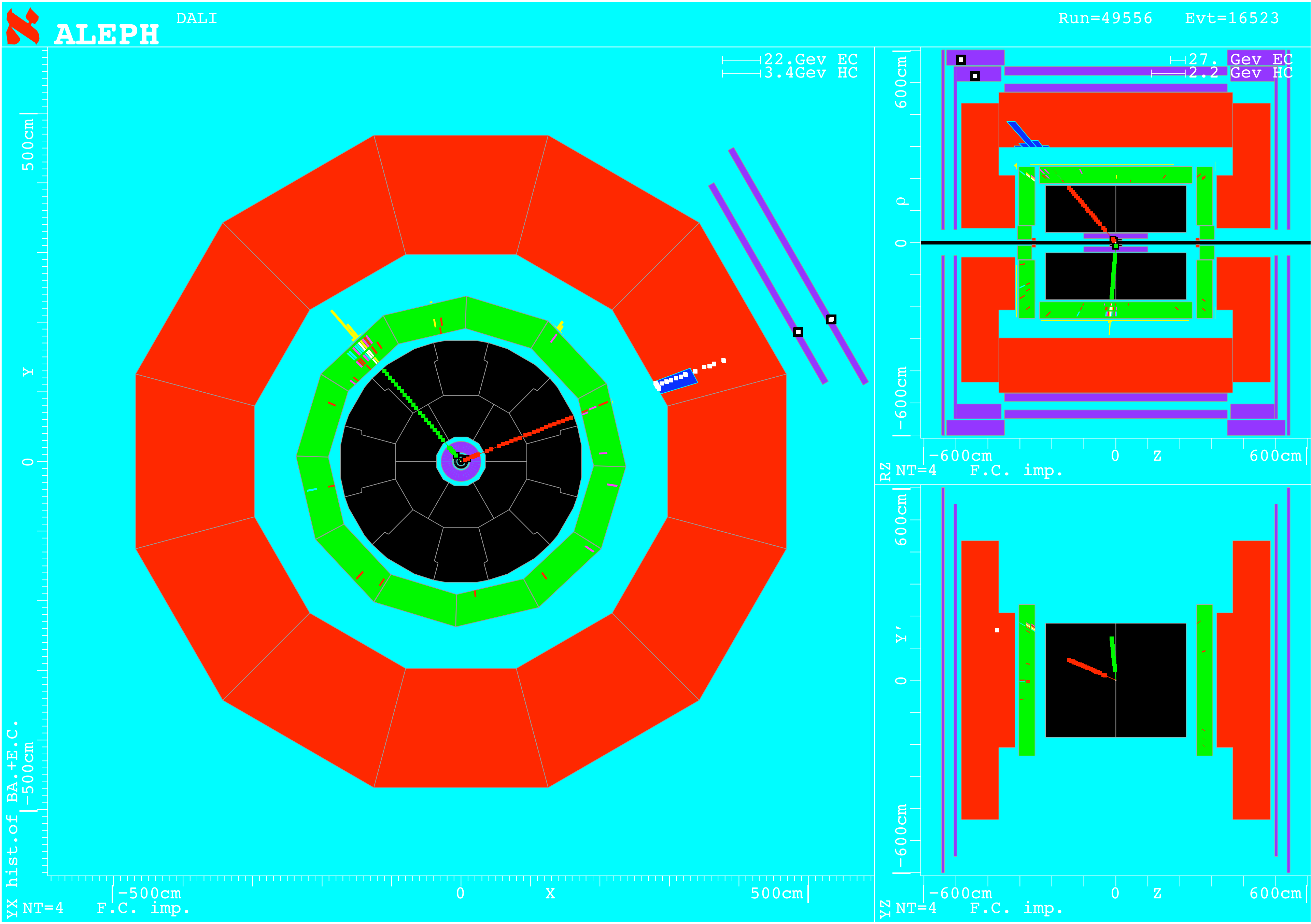

ALEPH
DALI
Run=9095
Evt=8852

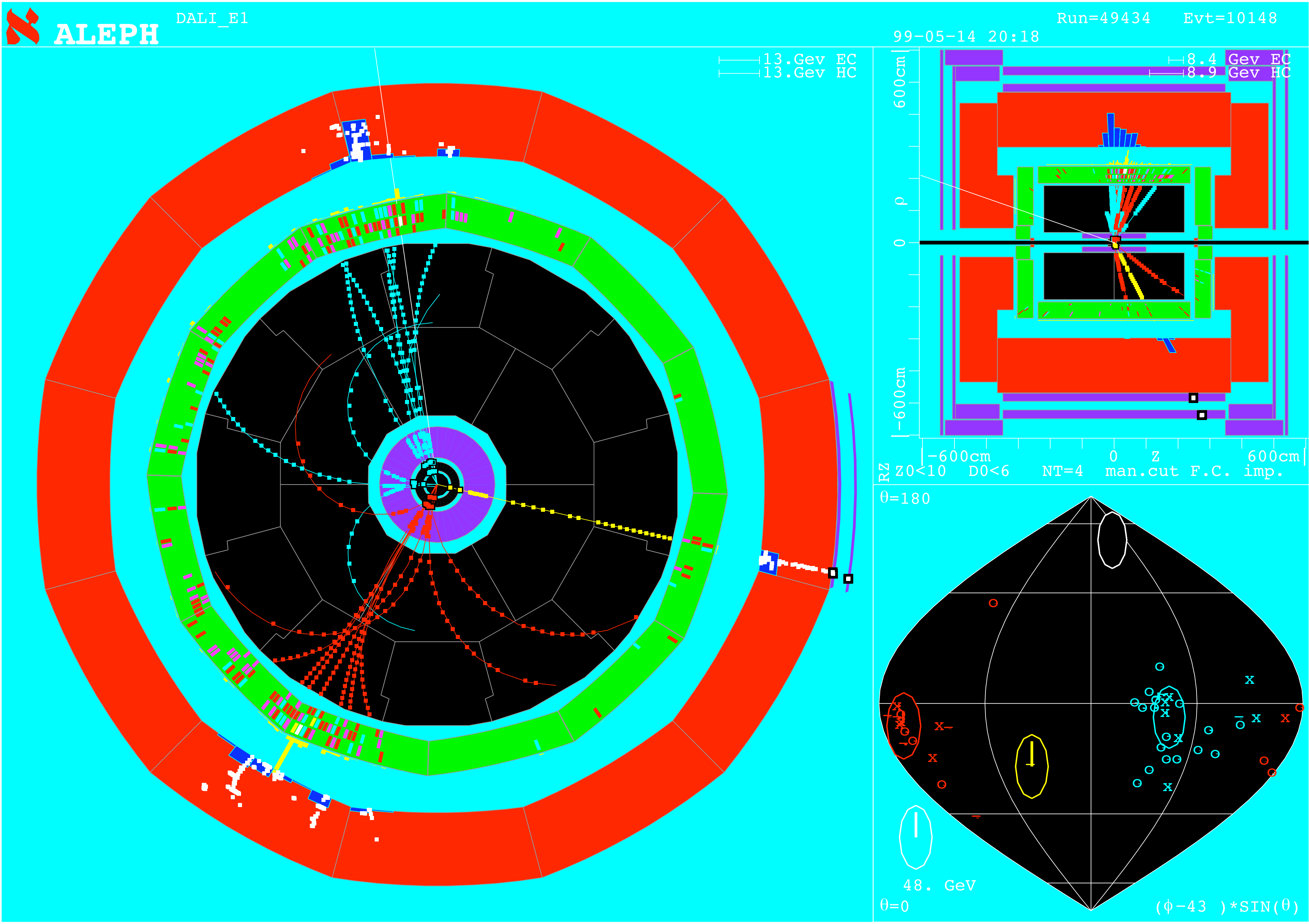
LEP-II

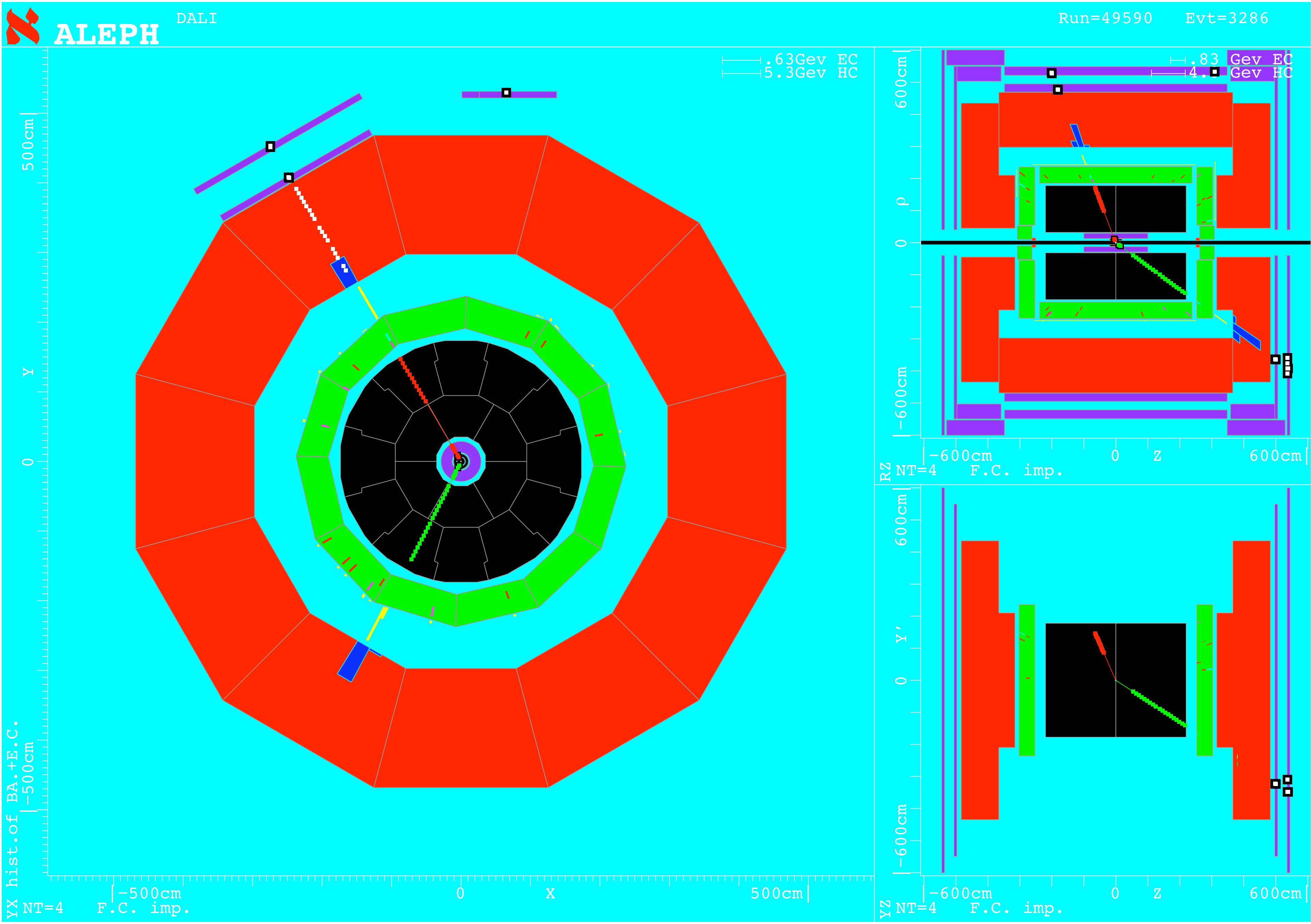

ALEPH
DALI_E1
Run=49441 Evt=4616
99-05-15 6:38
3.8Gev EC
7.6Gev HC
θ=180
500cm
Y
0
-500cm
YX hist.of BA.+E.C.
Z0<20 man.cut F.C. imp.
-500cm
0
X
500cm
22. GeV
θ=0
(ϕ-43)*SIN(θ)

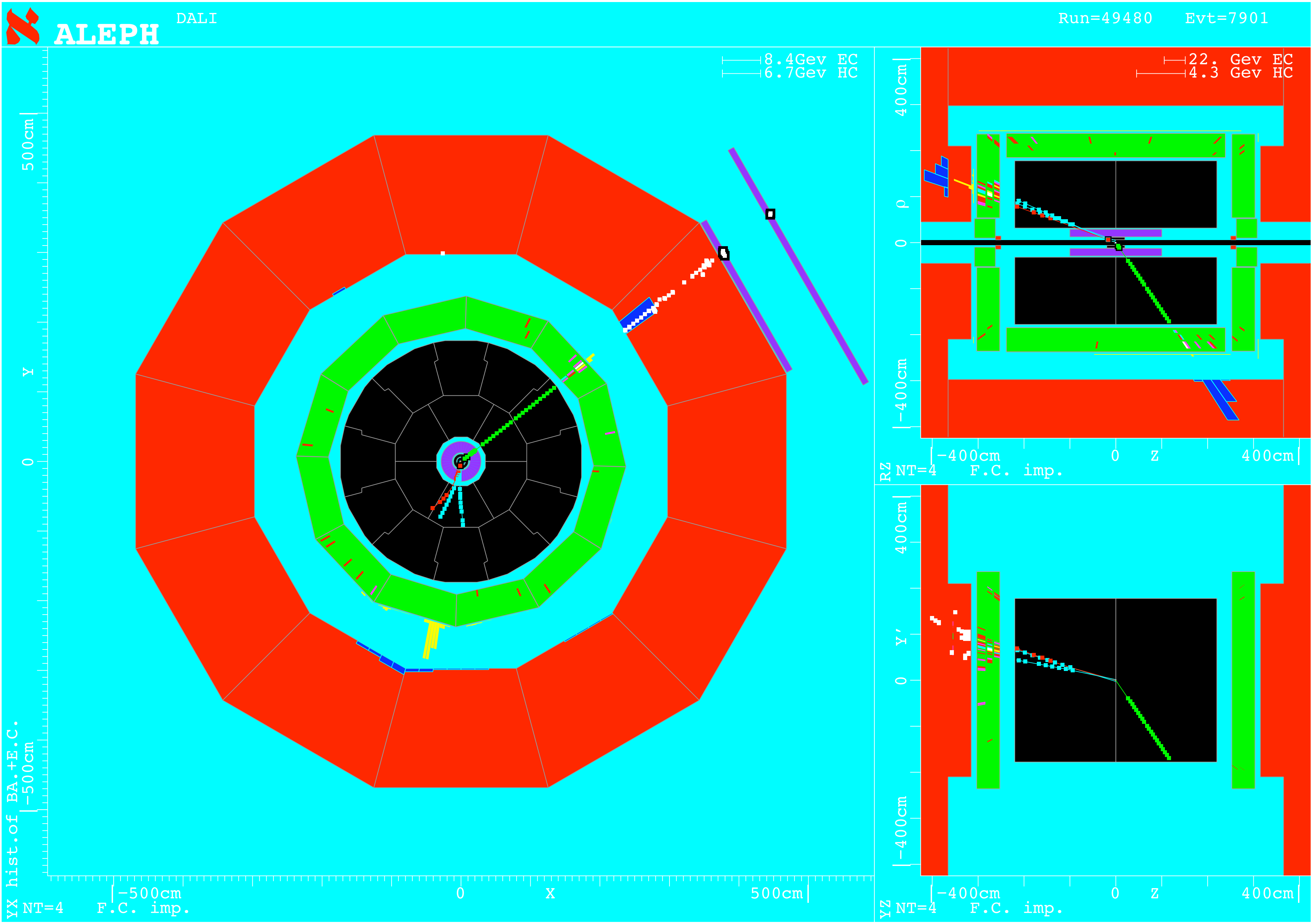


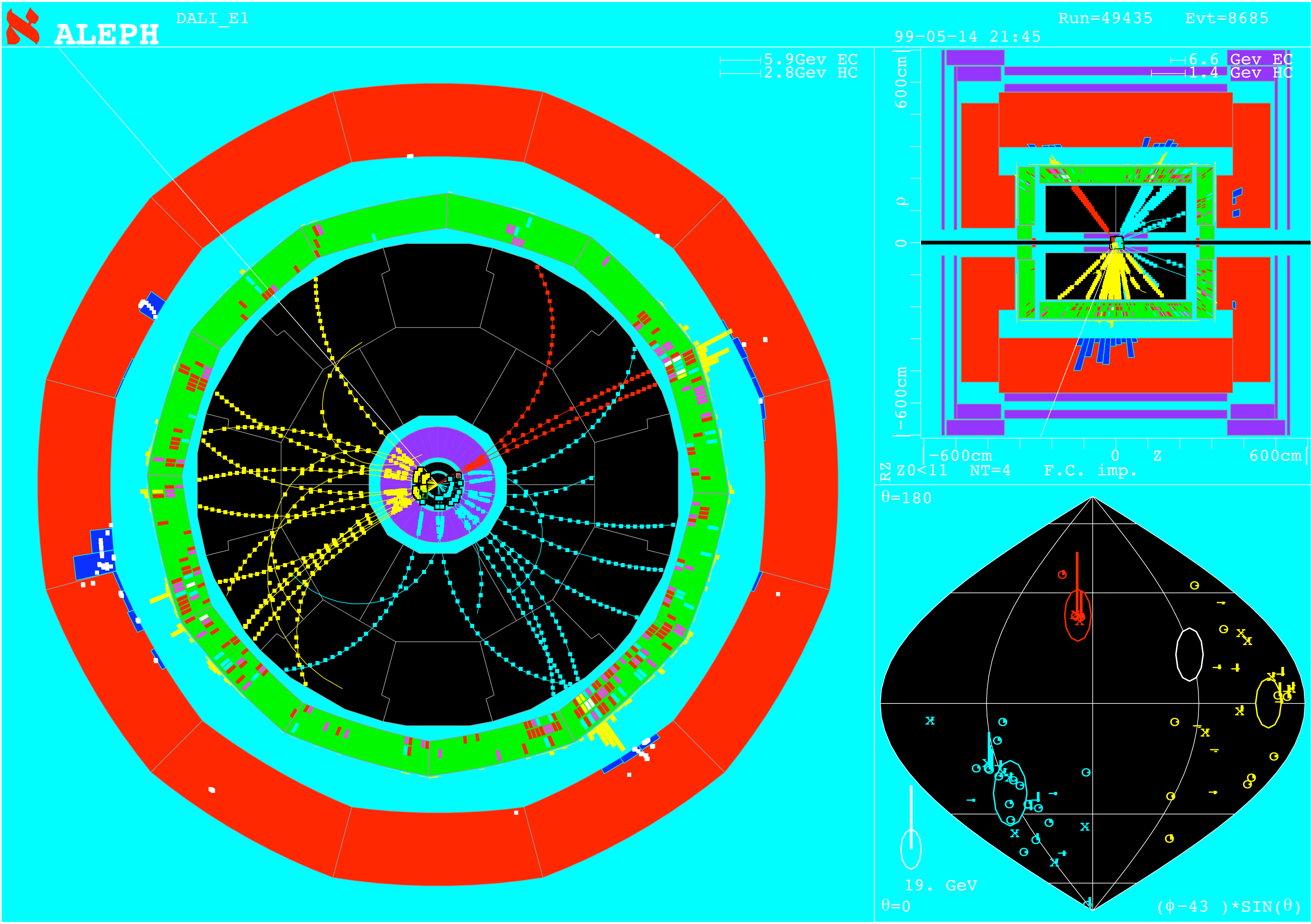
ALEPH
DALI_E1
Run=49437 Evt=1966
99-05-15 :41
23.Gev EC
24.Gev HC
θ=180
41. GeV
θ=0
(φ-43)*SIN(θ)

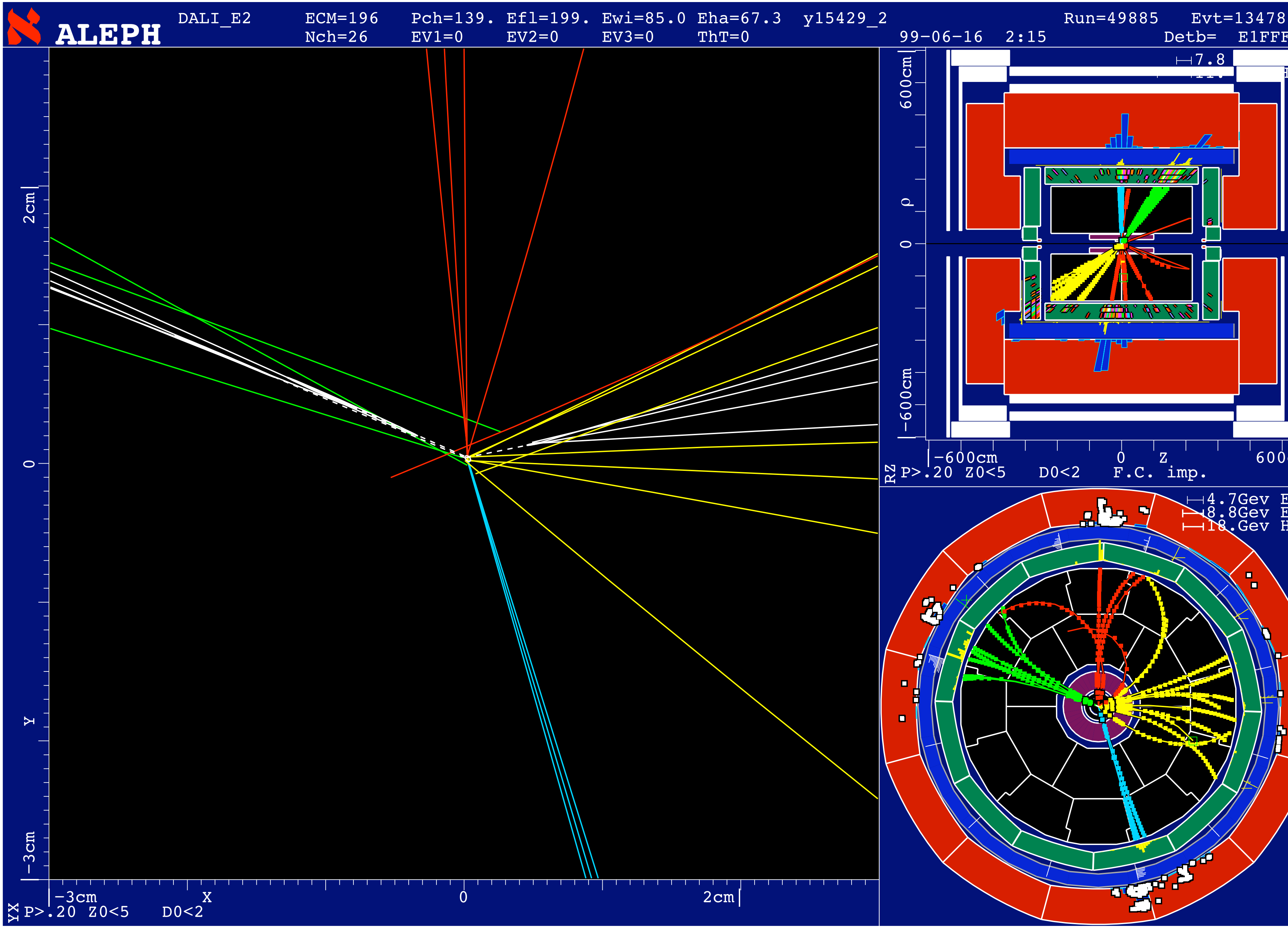

ALEPH
DALI
Run=49556 Evt=16523
22.Gev EC
3.4Gev HC
500cm
Y
0
-500cm
YX NT=4 F.C. imp.
hist.of BA.+E.C.
-500cm
0
X
500cm
27. Gev EC
2.2 Gev HC
600cm
ρ
0
-600cm
-600cm
0
Z
600cm
RZ NT=4 F.C. imp.
600cm
Y'
0
-600cm
-600cm
0
Z
600cm
YZ NT=4 F.C. imp.

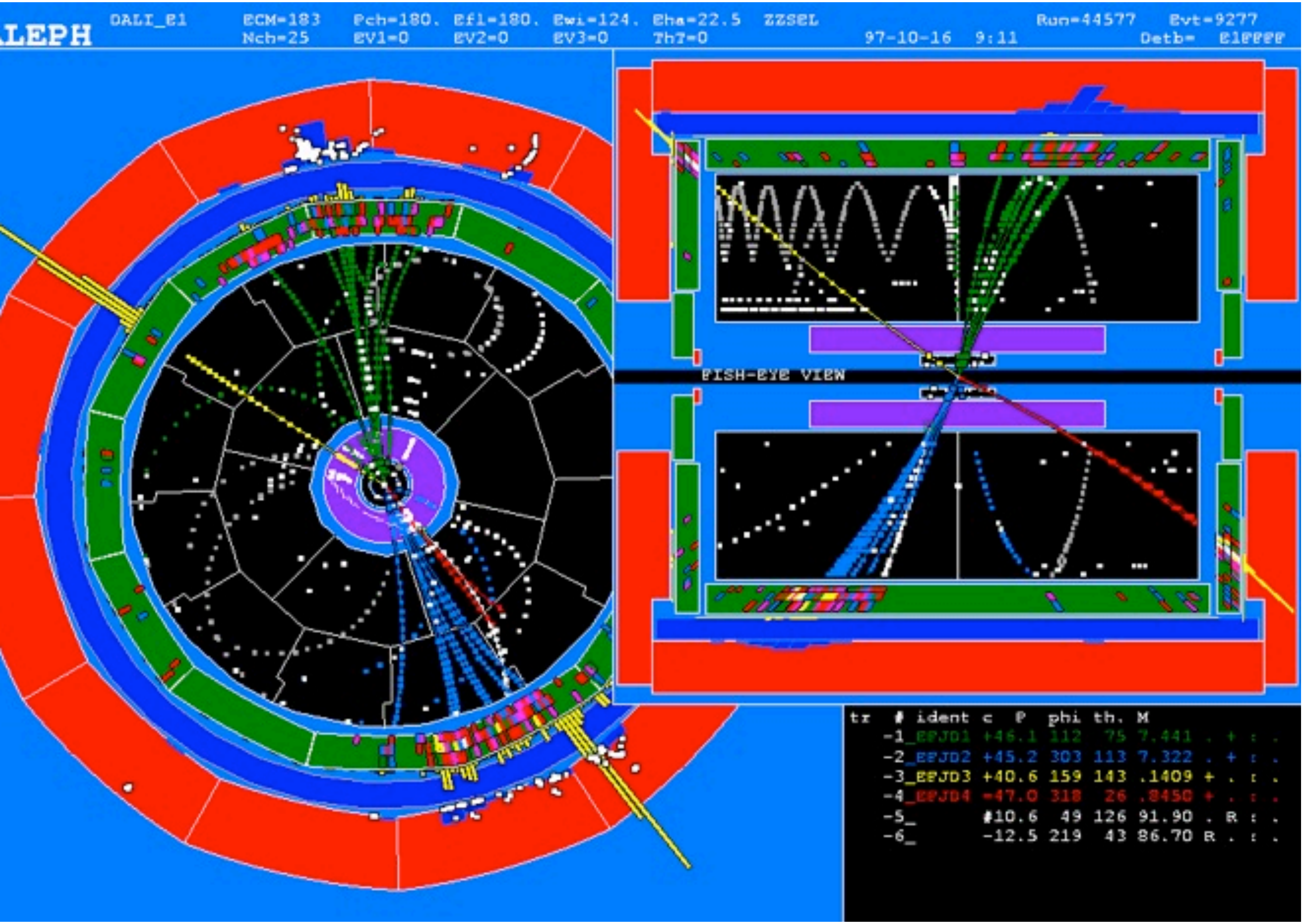

ALEPH
DALI_E1
Run=49434 Evt=10148
99-05-14 20:18
13.Gev EC
13.Gev HC
8.4 Gev EC
8.9 Gev HC
600cm
ρ
0
-600cm
-600cm
0 Z
600cm
RZ Z0<10 D0<6 NT=4 man.cut F.C. imp.
θ=180
48. GeV
θ=0
(φ-43)*SIN(θ)


ALEPH
DALI
Run=49590 Evt=3286
.63Gev EC
5.3Gev HC
500cm
Y
0
-500cm
YX hist.of BA.+E.C.
NT=4 F.C. imp.
-500cm
0
X
500cm
.83 Gev EC
4. Gev HC
600cm
ρ
0
-600cm
RZ NT=4 F.C. imp.
-600cm
0
Z
600cm
600cm
Y'
0
-600cm
YZ NT=4 F.C. imp.
-600cm
0
Z
600cm


ALEPH
DALI
Run=49480 Evt=7901
8.4Gev EC
6.7Gev HC
500cm
Y
0
-500cm
YX hist.of BA.+E.C.
NT=4 F.C. imp.
-500cm
0
X
500cm
22. Gev EC
4.3 Gev HC
400cm
ρ
0
-400cm
-400cm
0
Z
400cm
RZ NT=4 F.C. imp.
400cm
Y'
0
-400cm
-400cm
0
Z
400cm
YZ NT=4 F.C. imp.


ALEPH
DALI_E1
Run=49435 Evt=8685
99-05-14 21:45
5.9Gev EC
2.8Gev HC
6.6 Gev EC
1.4 Gev HC
600cm
ρ
0
-600cm
-600cm
0
Z
600cm
RZ
Z0<11 NT=4 F.C. imp.
θ=180
19. GeV
θ=0
(ϕ-43)*SIN(θ)


ALEPH
DALI_E2
ECM=196
Pch=139.
Efl=199.
Ewi=85.0
Eha=67.3
y15429_2
Run=49885
Evt=13478
Nch=26
EV1=0
EV2=0
EV3=0
ThT=0
99-06-16 2:15
Detb= E1FFF
2cm
0
Y
-3cm
X
YX P>.20 Z0<5 D0<2
600cm
ρ
-600cm
-600cm
Z
RZ P>.20 Z0<5 D0<2 F.C. imp.
7.8
4.7Gev
8.8Gev
18.Gev


ALEPH
DALI_E1
ECM=183 Pch=180. Efl=180. Ewi=124. Eha=22.5 ZZSEL
Nch=25 EV1=0 EV2=0 EV3=0 Th7=0
Run=44577 Evt=9277
97-10-16 9:11
Detb= E1FFFF
FISH-EYE VIEW
tr # ident c P phi th. M
-1_EFJD1 +46.1 112 75 7.441 . + : .
-2_EFJD2 +45.2 303 113 7.322 . + : .
-3_EFJD3 +40.6 159 143 .1409 + . : .
-4_EFJD4 -47.0 318 26 .8450 + . : .
-5_ #10.6 49 126 91.90 . R : .
-6_ -12.5 219 43 86.70 R . : .