PHY397K - NUCLEAR PHYSICS - 9

PHY397K - NUCLEAR PHYSICS
Spring 2015, Unique numbers: 57115
RLM 5.116, TTH 12:30 - 2:00 pm

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Homework for Tuesday next week

https://web2.ph.utexas.edu/~cmarkert/home/Teaching.html

1.)Install root software on your computer
https://root.cern.ch/drupal/

2.) Calculate mass of mother particle from decay daughters
Units for momentum in GeV/c

decay particle 1 = Pion , decay particle 2 = Pion
px part1 -0.645309 px part2 -1.43542
py part1 1.03136 py part2 3.51513
pz part1 4.29267 pz part2 13.8416

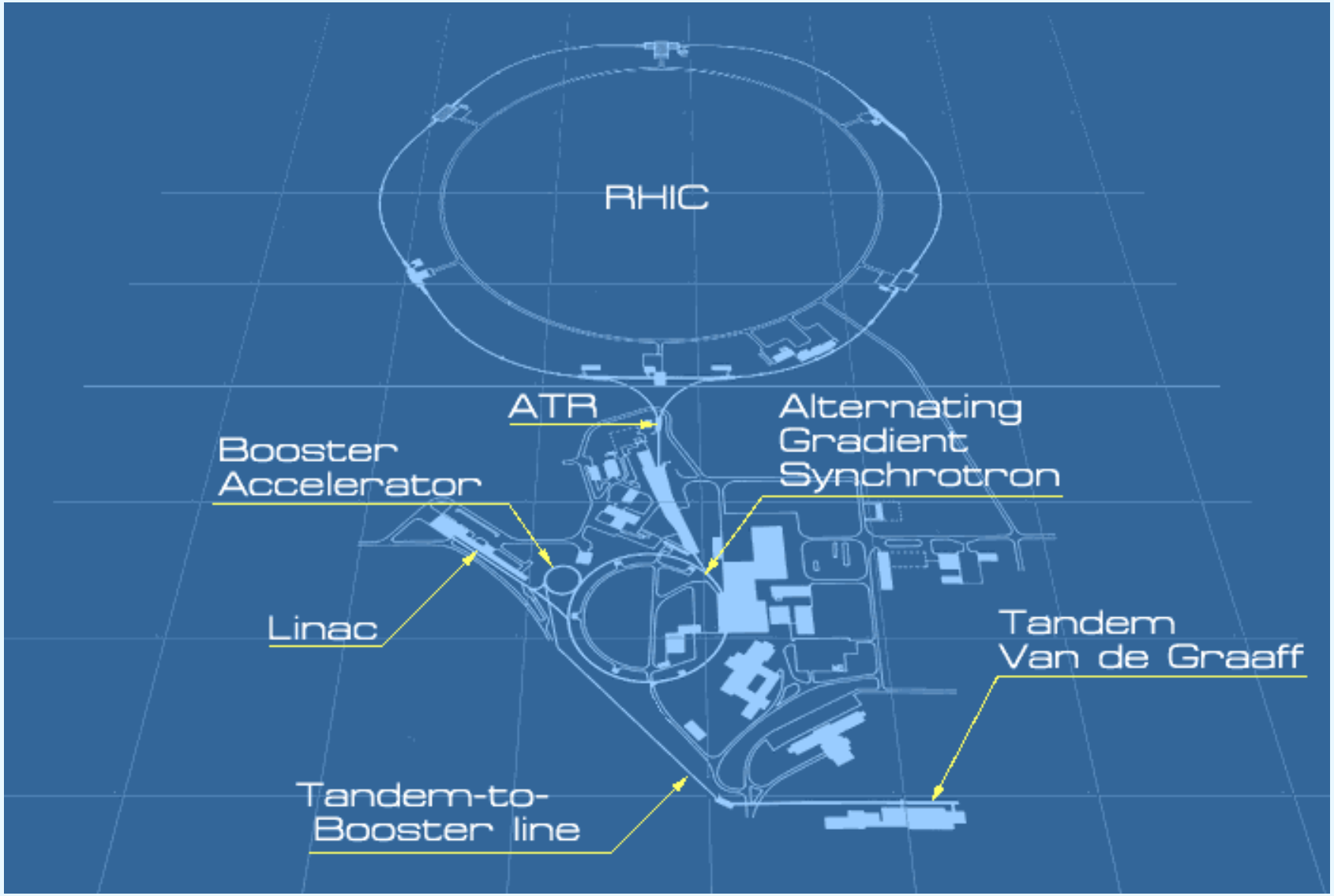
decay particle 1 = Proton , decay particle 2 = Pion
px part1 -1.76698 px part2 -0.313754
py part1 3.64028 py part2 0.906203
pz part1 4.77863 pz part2 1.09737

3.) http://pdg.lbl.gov/ (particle physics booklet)

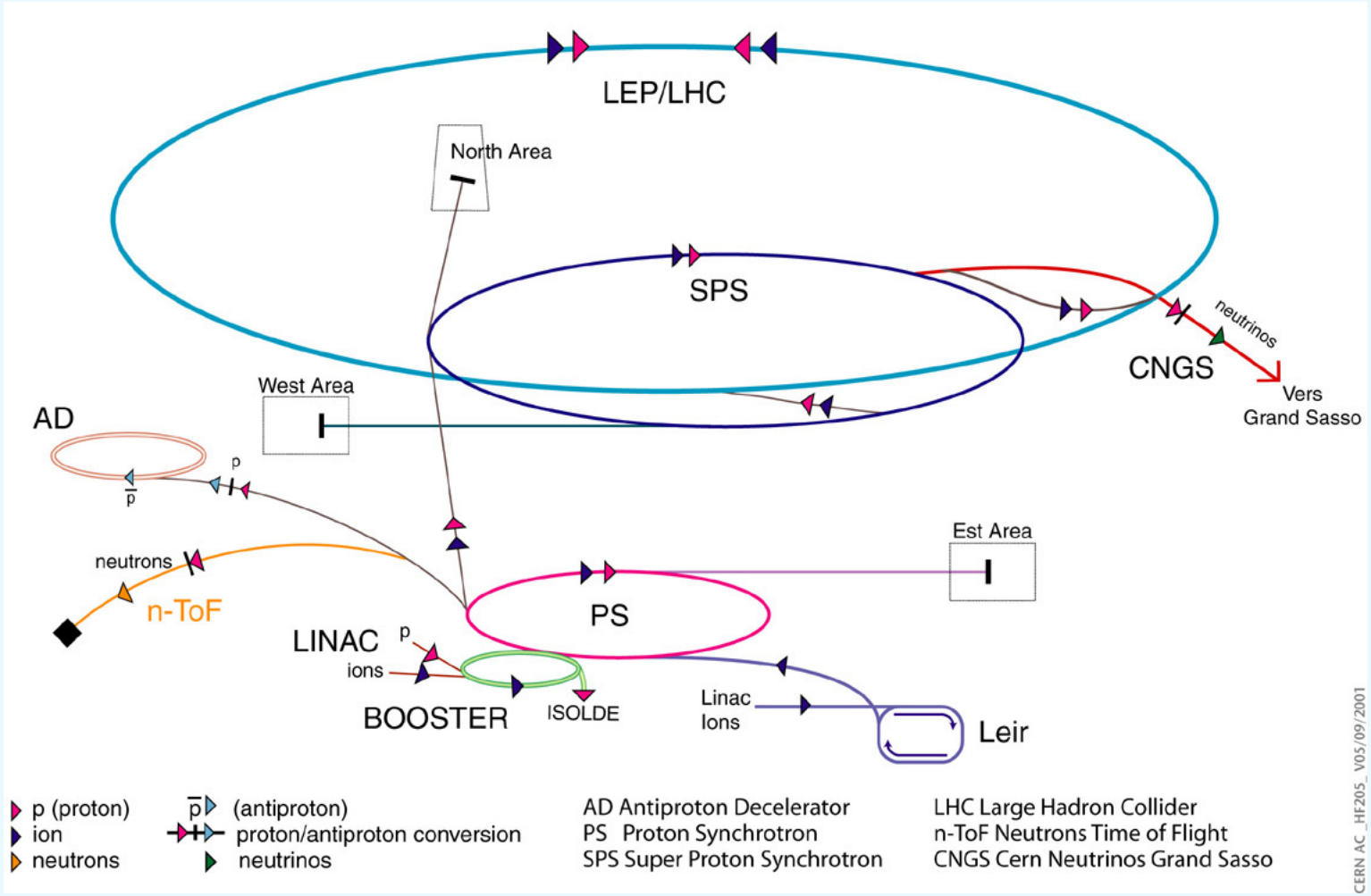
Accelerators: Relativistic heavy ion collisions

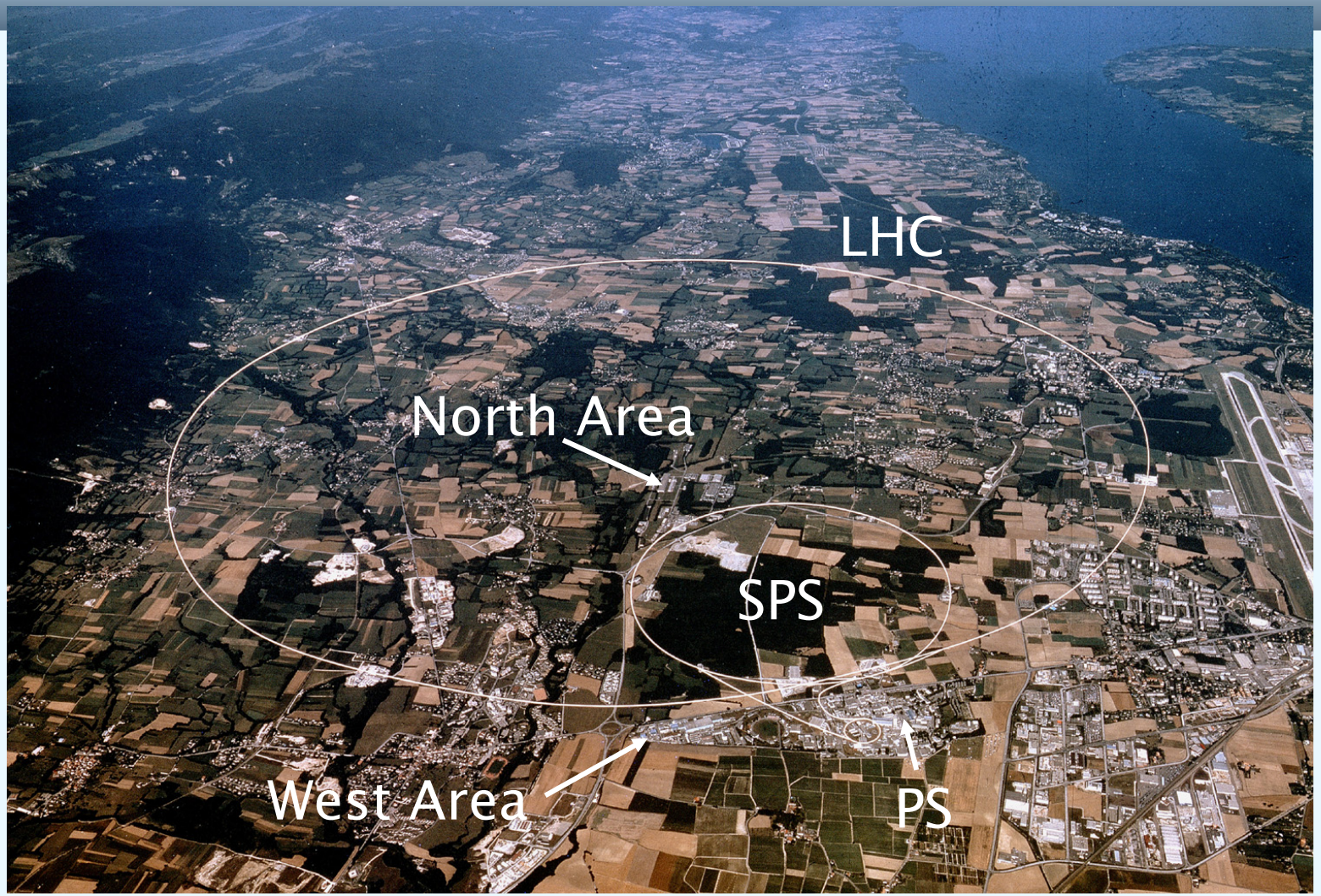
Beschleuniger	Ort	HI-Perioden	Max. Energie	Projektile	Experimente
Bevalac	LBNL, Berkeley	1984 - 1993	< 2 *A*GeV	C, Ca, Nb, Ni, Au, ...	Plastic Ball, Streamer Chamber, EOS, DLS
Synchro-Phasotron	JINR, Dubna	1974 - 1985	> 100 *A*MeV		
AGS	BNL, Brookhaven	1986 - 1994	14.5/11.5 *A*GeV	Si, Au	E802, ..., E917
SPS	CERN, Geneva	1986 →	200/158 *A*GeV	O, S, In, Pb	NA34,... , WA80,...
SIS	GSI, Darmstadt	1992 →	2 *A*GeV	Kr, Au	FOPI, KAOS, HADES
RHIC	BNL, Brookhaven	2000 →	$\sqrt{s_{NN}}$ = 200 GeV	Cu,Au	STAR, PHENIX, BRAHMS, PHOBOS
LHC	CERN, Geneva	2009 →	$\sqrt{s_{NN}}$ = 5.5 TeV	O, Ar, Pb	ALICE, CMS, ATLAS
SIS100/300	GSI, Darmstadt	2019 →	30/45 *A*GeV	Au	HADES, CBM
Nuklotron	JINR, Dubna	2017 →	6 *A*GeV	Au	
NICA	JINR, Dubna	2017 →	$\sqrt{s_{NN}}$ = 4 – 11 GeV	Au	MPD

BNL Accelerators facility



CERN Accelerator Facility




LHC
North Area
SPS
West Area
PS

The Maschine: LHC

Large Hadron Collider

Circumference: 27 km

1232 Magnets

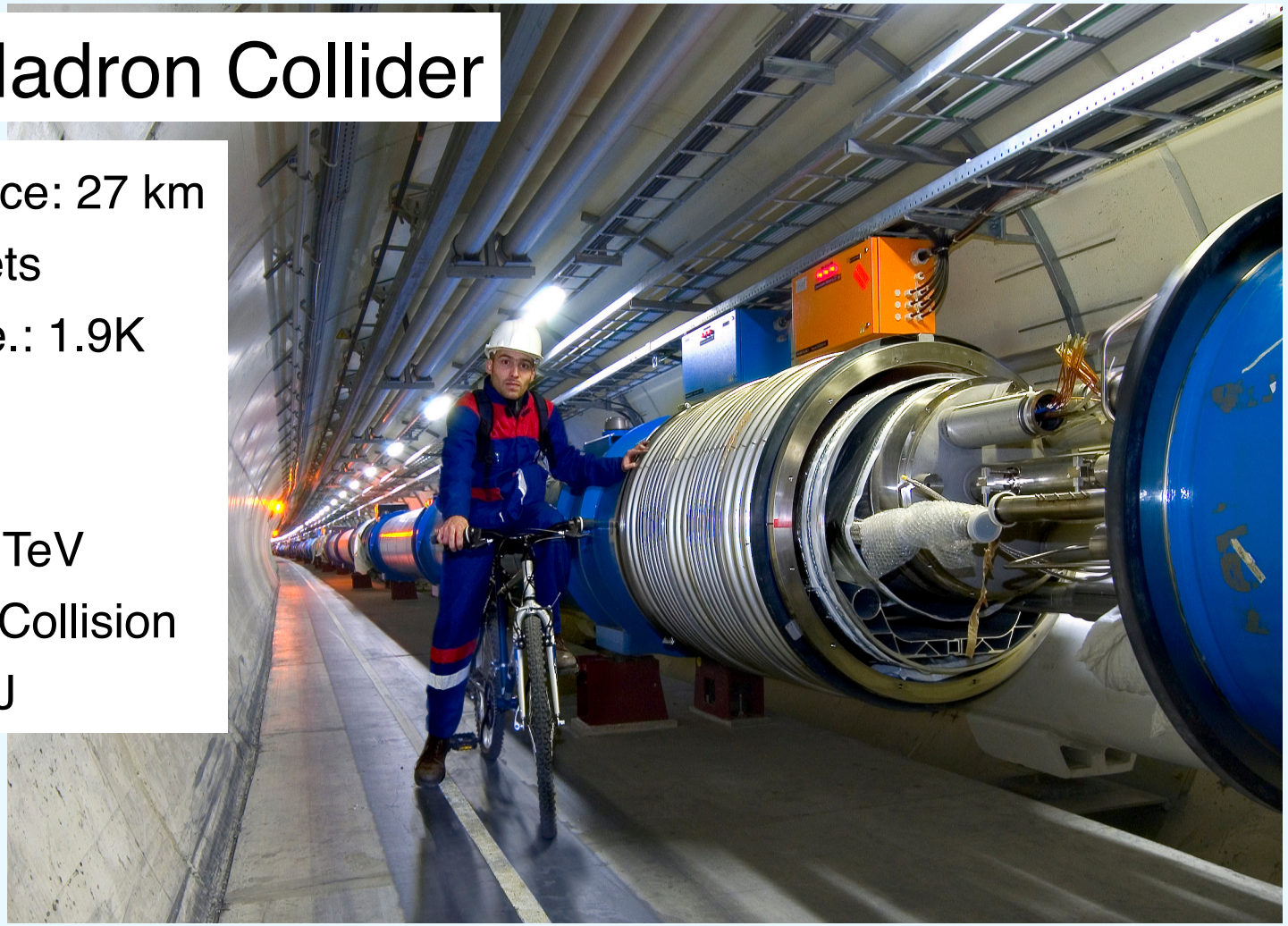
Temperature.: 1.9K

Energies

Pb+Pb: 5.5 TeV

→ 1 Pb+Pb Collision

= 0.36 mJ



Particle Detectors

Interaction of particles with detector material,
energy loss of particles in matter:
(usually electromagnetic interactions)

Particle types:

1.) Charged particles:
ionize atoms -> release of electrons

2.) Neutral particles:
transfer energy onto nucleus and atomic electrons

Charged Particles

Charged Hadrons: pions, protons, kaons, electrons,

Collisions with electrons of atom.
Massive charged particle -> Rutherford-like scattering

Ionization energy (loss)
- dE/dx = n_ion * I
n_ion = number of electron pairs found per unit length
I = average energy needed to ionize an atom in the medium.

Bethe-Bloch: $$-\frac{dE}{dx} = K \cdot z^2 \cdot \frac{Z}{A} \cdot \frac{1}{\beta^2} \cdot \left[\frac{1}{2} \ln \frac{2m_e c^2 \beta^2 \gamma^2 T_{\max}}{I^2} - \beta^2 - \delta/2\right]$$

$\delta(\beta\gamma)$ Density effect correction to ionization energy loss

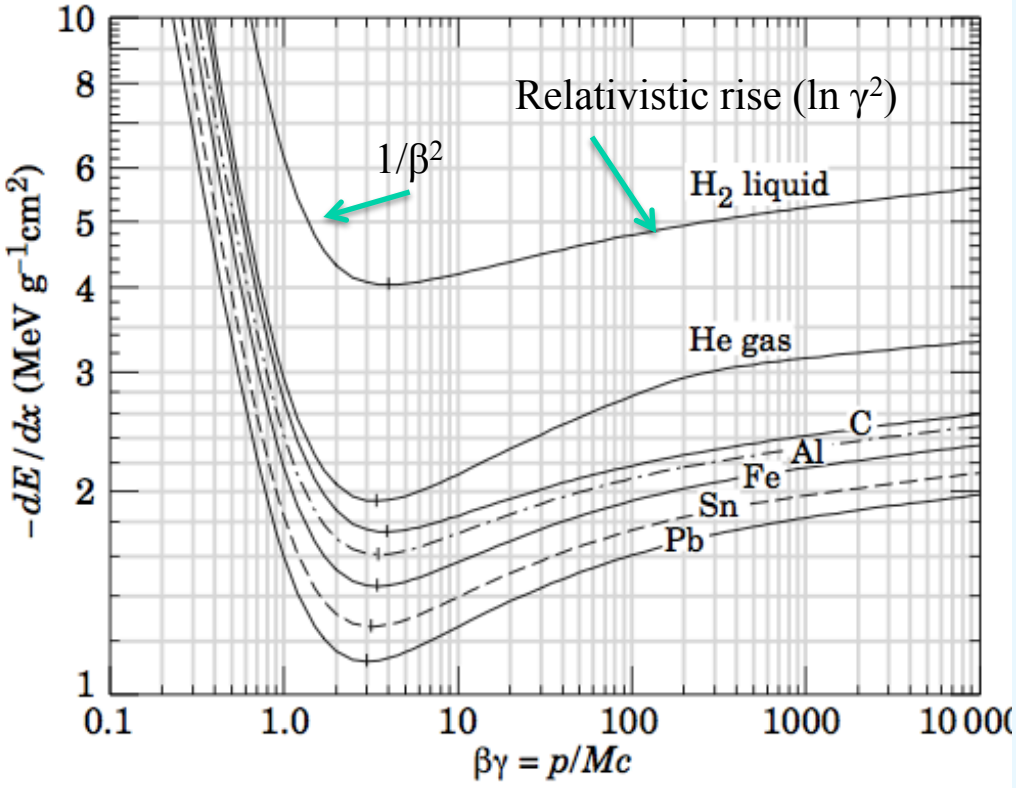
ze	Charge of incident particle
Z	Atomic number of absorber
A	Atomic mass of absorber
K/A	$4\pi N_A r_e^2 m_e c^2/A$

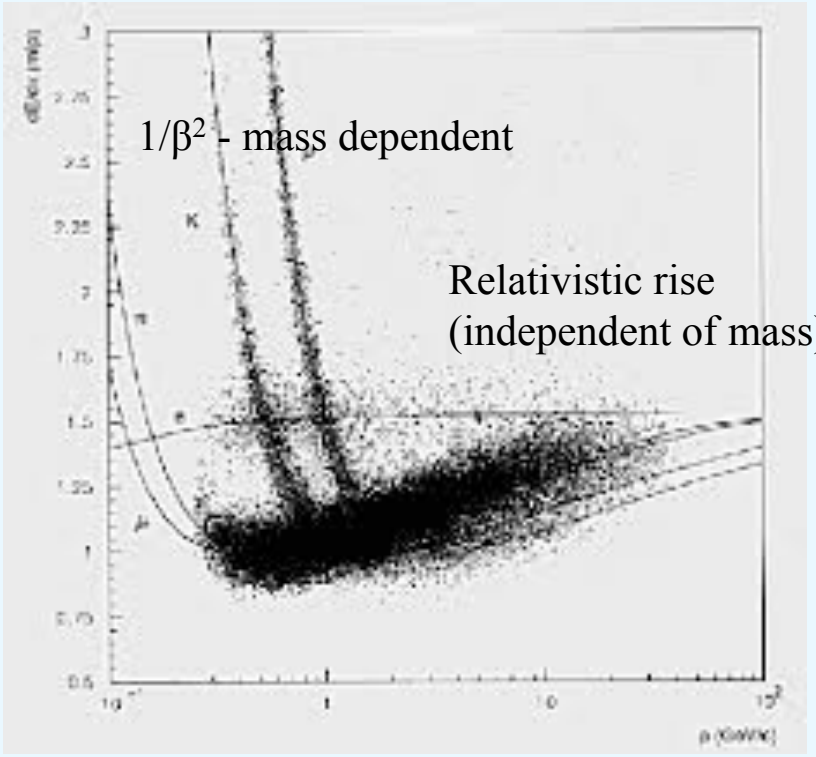
T_max : maximum of kinetic energy

- dE/dx $\approx 1/\beta^2 = M^2 c^2 \gamma^2 / p^2 \rightarrow \gamma\beta = p/Mc$
($1/v^2 = M^2 \gamma^2 / p^2$) velocity dependence

($p = \gamma M v$, $\beta = v/c$)

Charged Particles





$\beta\gamma = 3$ (v = 0.96c (minimum)

- $dE/dx \approx 1/\beta^2 = M^2 c^2 \gamma^2 / p^2 \rightarrow \gamma\beta = p/Mc$
  ($1/v^2 = M^2 \gamma^2 / p^2$) velocity dependence

$p = \gamma M v$, $\beta = v/c$

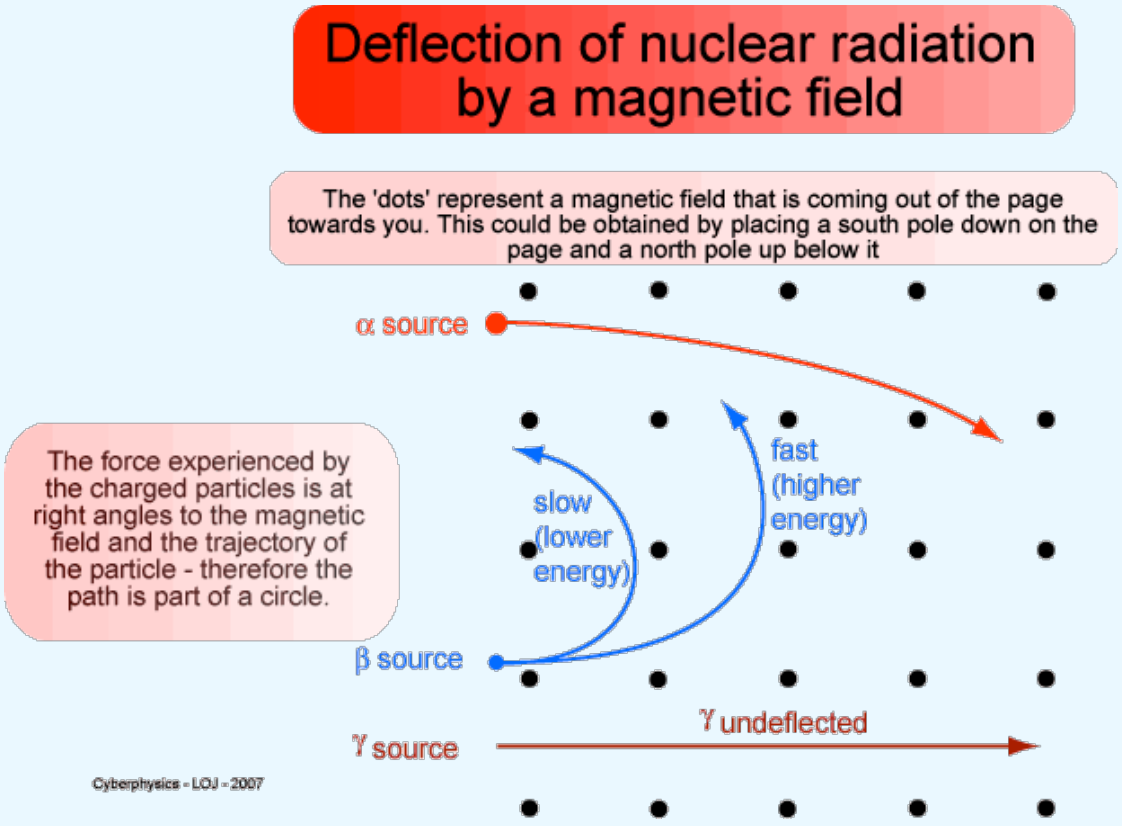
Charged Particles

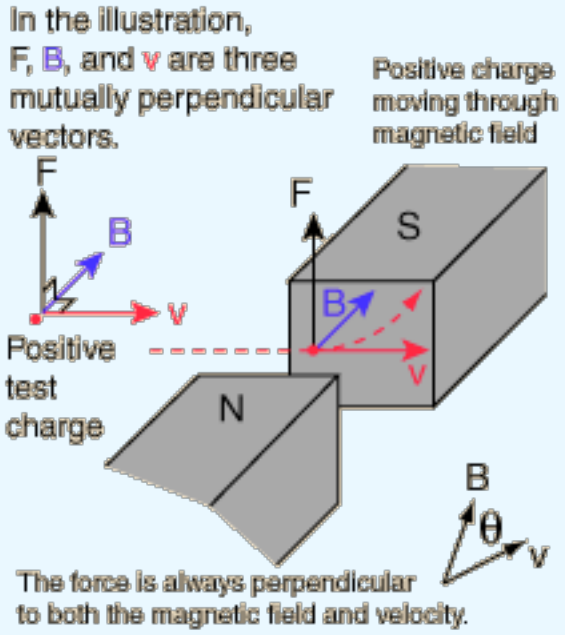
Charged hadrons: pions, protons, anti-protons, kaons, electrons, positrons, …..
Time Projection Chamber (TPC)

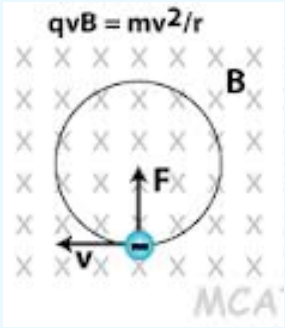
Neutral short lived hadrons:
reconstruction via changed decay particles in TPC

TPC – measurements:
1.) Momentum, change
2.) Energy loss (dE/dx) PID (particle identification)

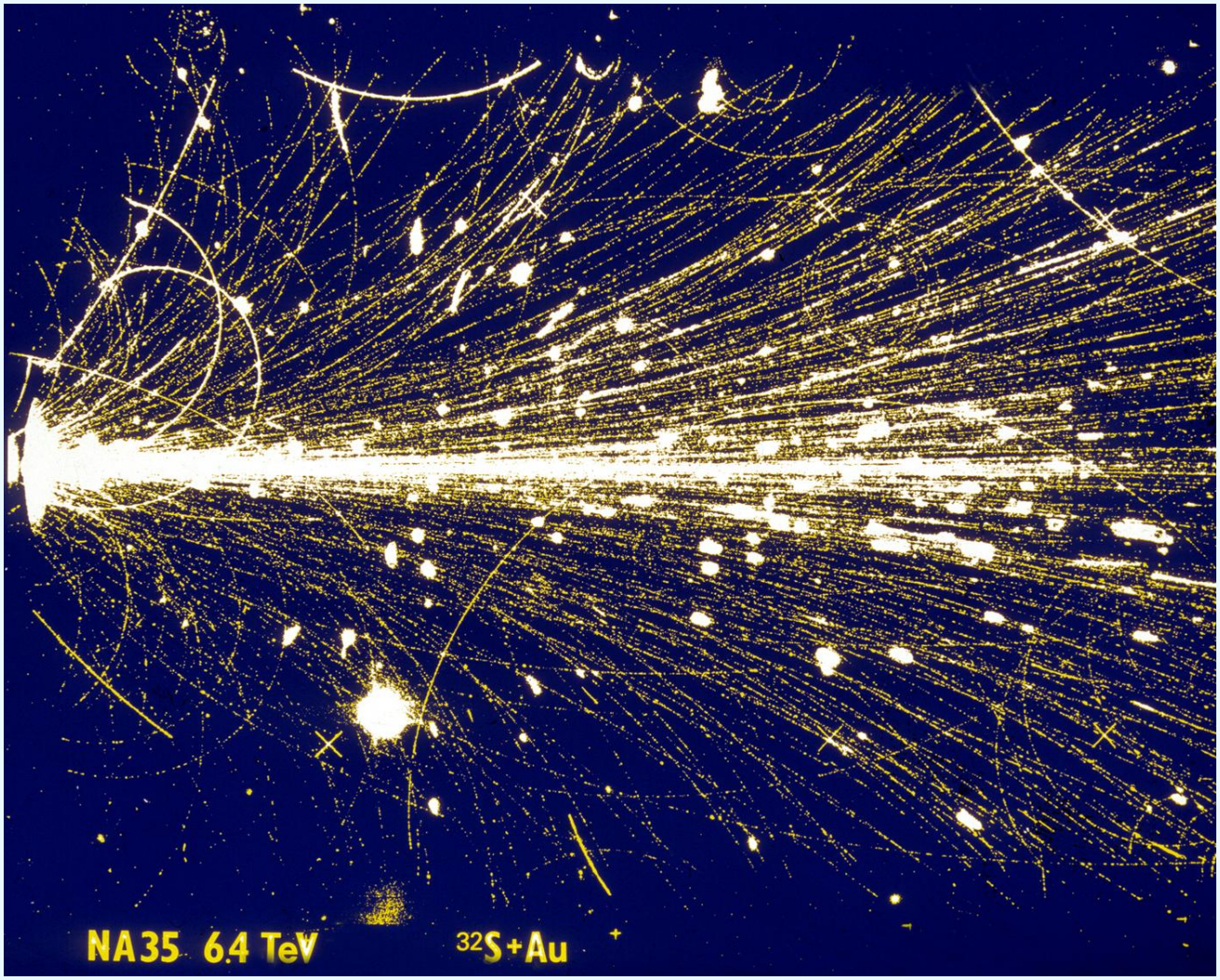
Momentum and change



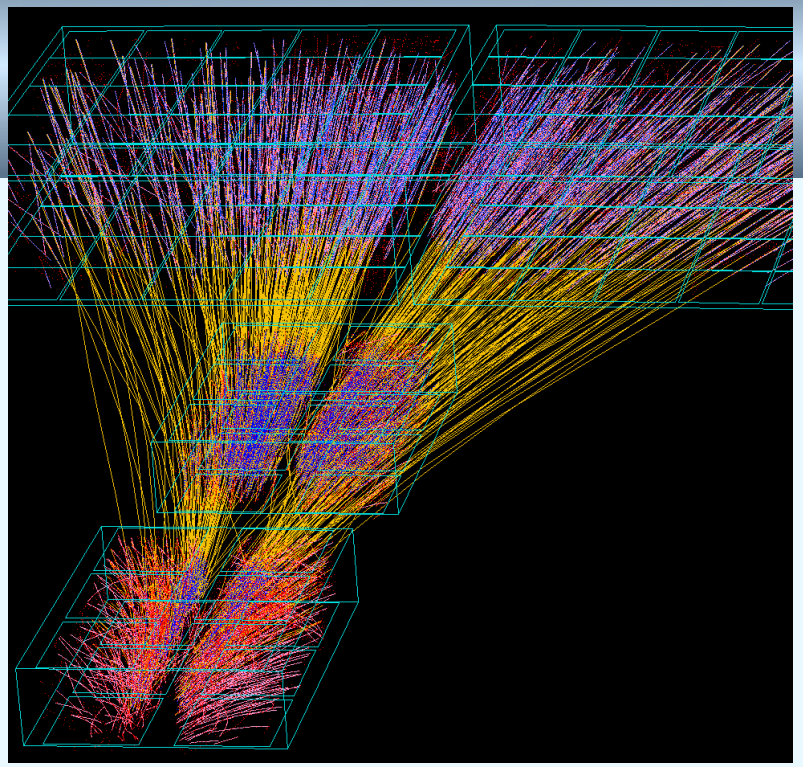


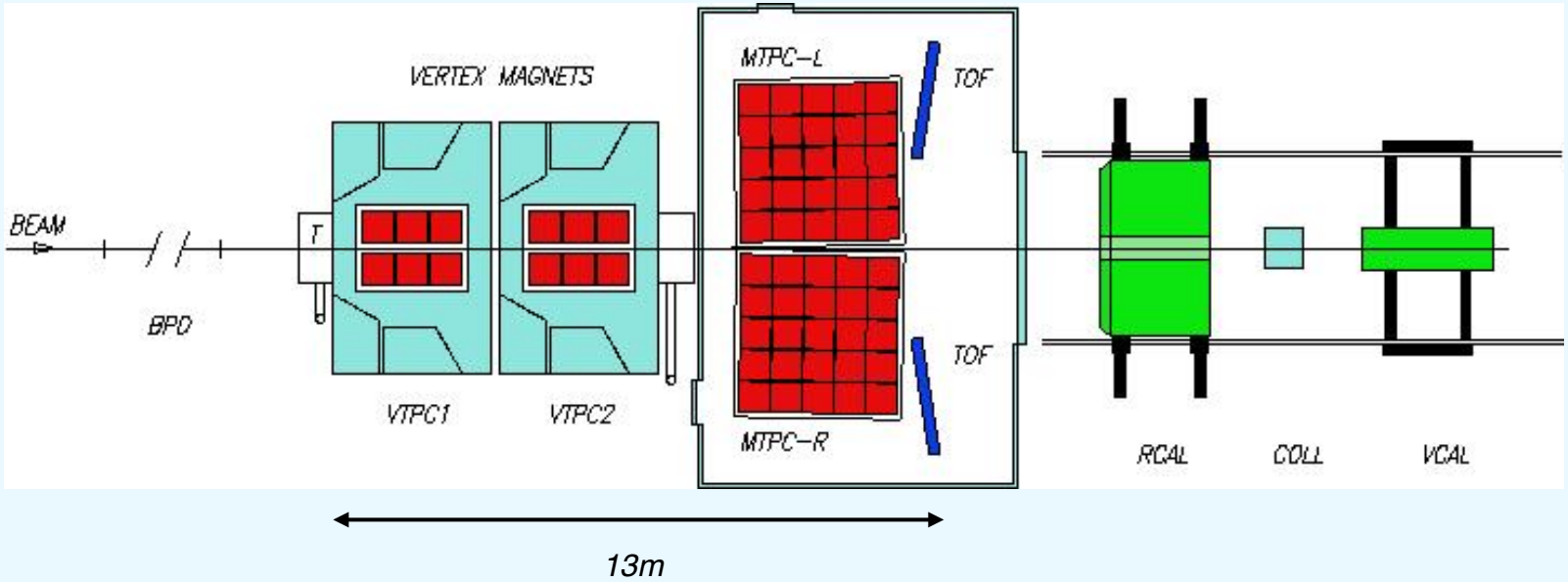


NA35 am SPS: S+Au, 200*A* GeV

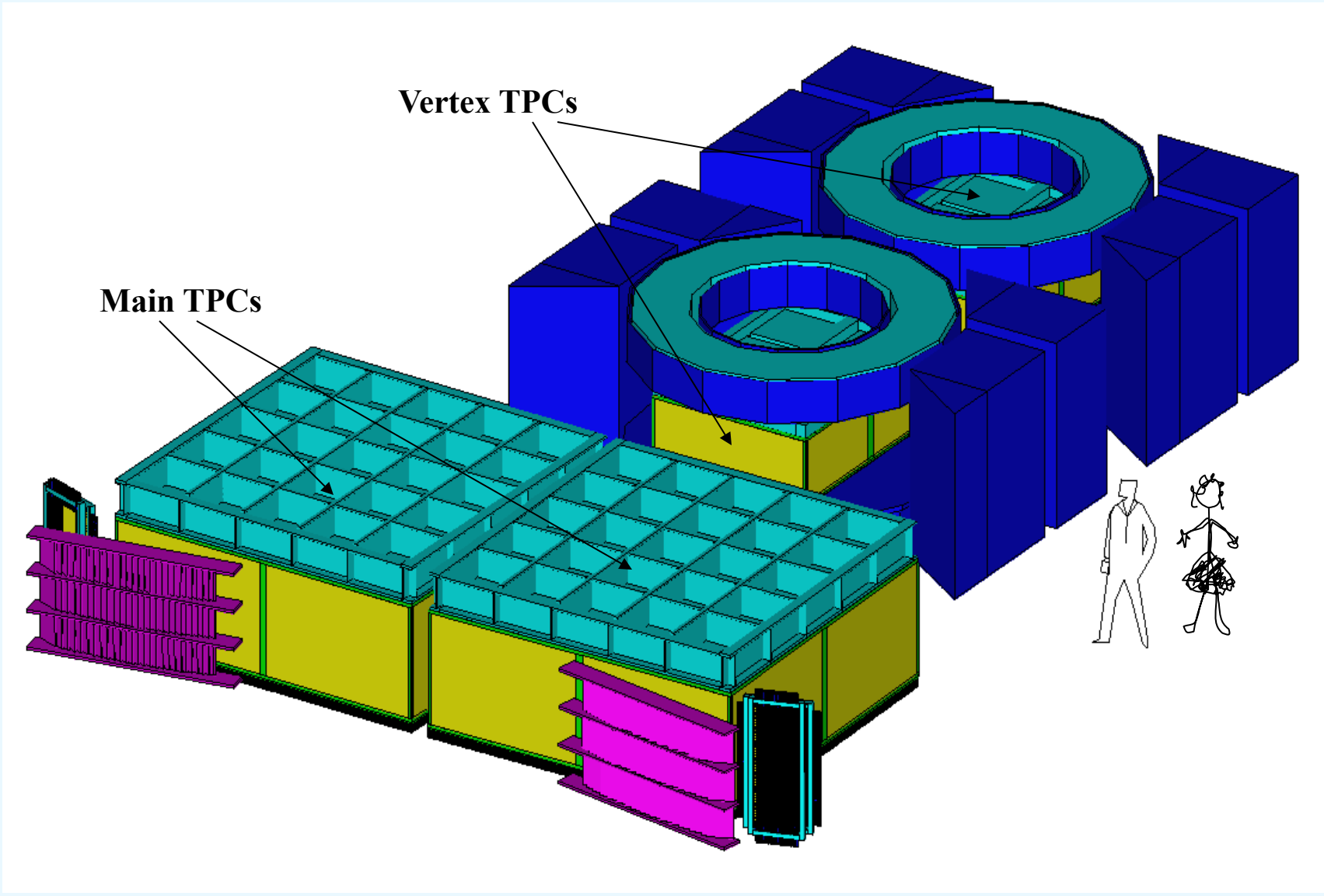


NA49 at CERN SPS: Pb+Pb, 158*A* GeV



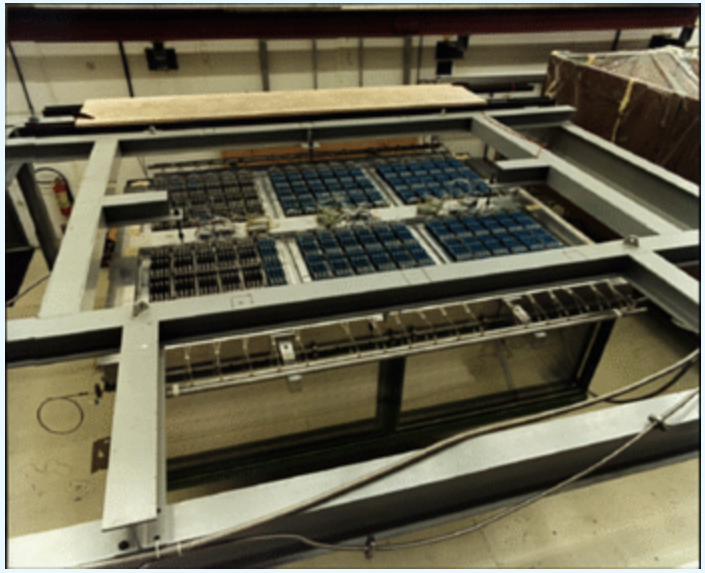


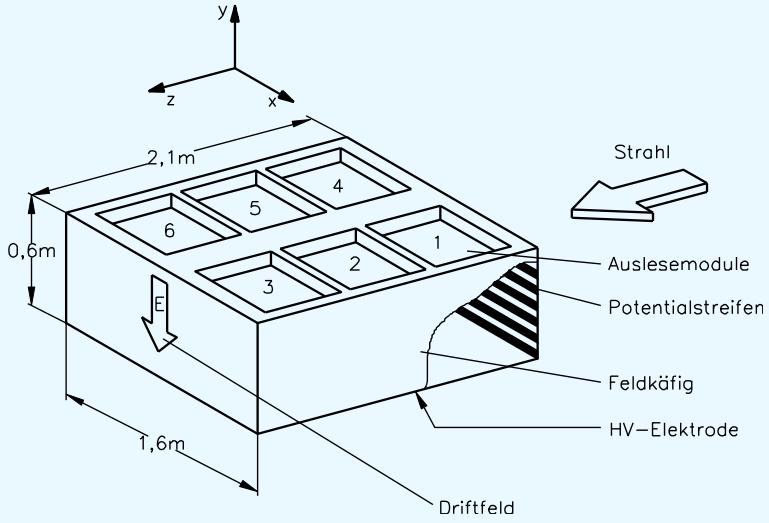
NA49 Experiment



NA49 Vertex and Main TPC

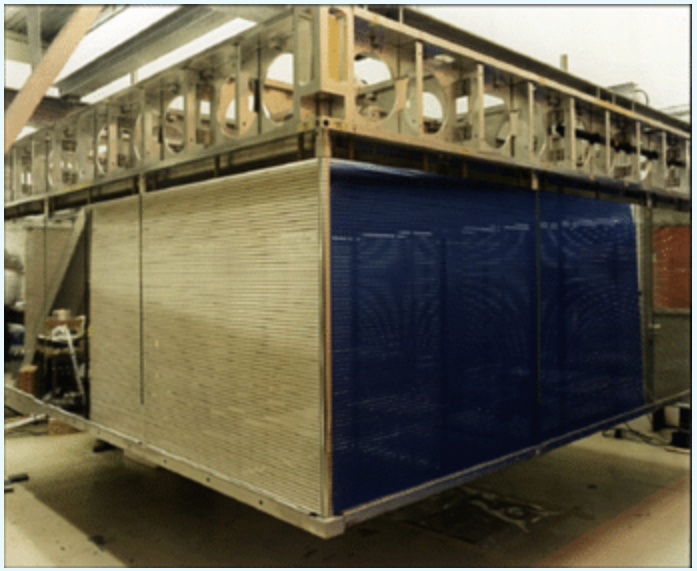
Vertex TPC





More about the TPC:
http://na49info.cern.ch/Public/detector/?276,211

Main TPC



NA49 Vertex TPC
(sorry this labels are in German on this plots !!!)