The HADES experiment @GSI

- Motivation
- Detector description
- Performance
- outlook

Collaboration:
18 Inst. 125 members

Motivation

✓ **Properties of hadrons in strong int. matter: M, Γ vs ρ, m_B, T, V**

Vector meson ρ, ω, φ spectral functions measurements

✓ **Hadron's structure: VDM, Form factors, vector meson-nucleon inter.**

Dalitz and two-body decays, πN, ρN reactions

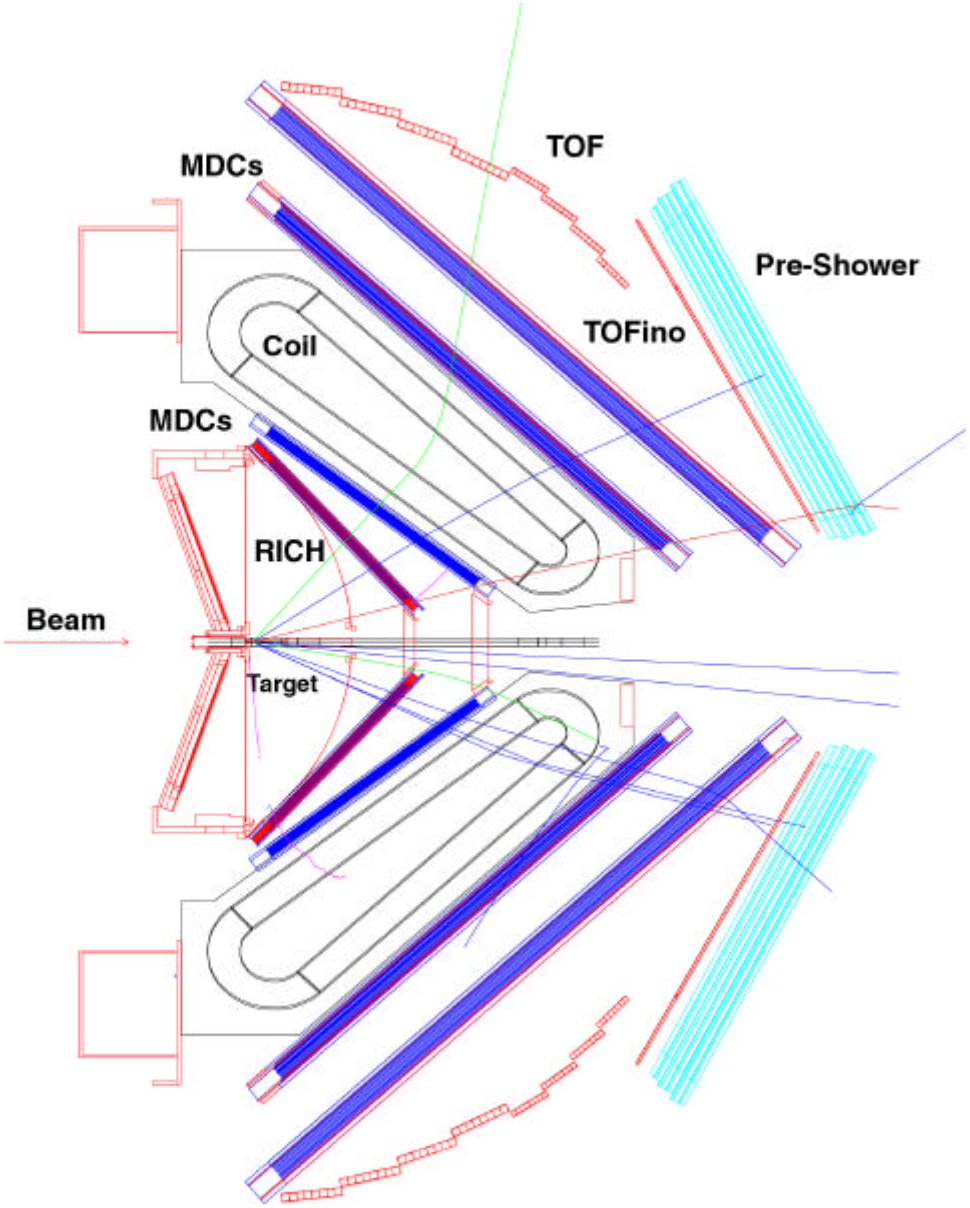
SIS / GSI : heavy ion, proton,pion beams

$0 \leq \rho \leq 3\,\rho_0 \quad 0 \leq T \leq 80$ MeV

HADES: systematic dielpton spectroscopy

- meson prod. in πp / pp : $\rho = 0$, T = 0 MeV
- meson prod. in πA / pA : $\rho = \rho_0$, T = 0 MeV
- meson prod. in AA : $\rho = 1\text{–}3\rho_0$, T = 80 MeV

High Acceptance DiElectron Spectrometer



Magnet

SC. toroid (6 coils)

2π in ϕ $\quad 18^{o} < \vartheta < 85^{o}$

Lepton Identification

RICH C_4F_{10} + gas Phot. Det.
CsI - cathode

META TOF scintillator wall +
Pre-Shower detector

p/p identification

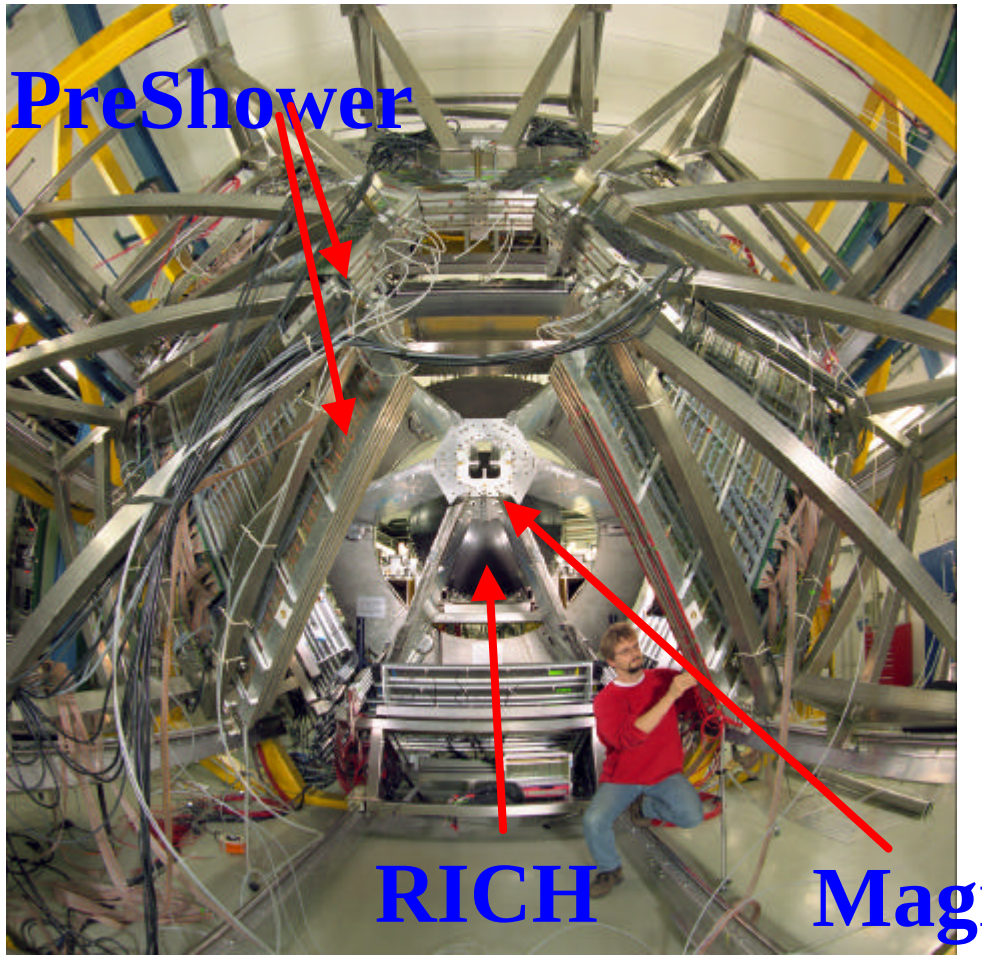
META and tracking

Tracking

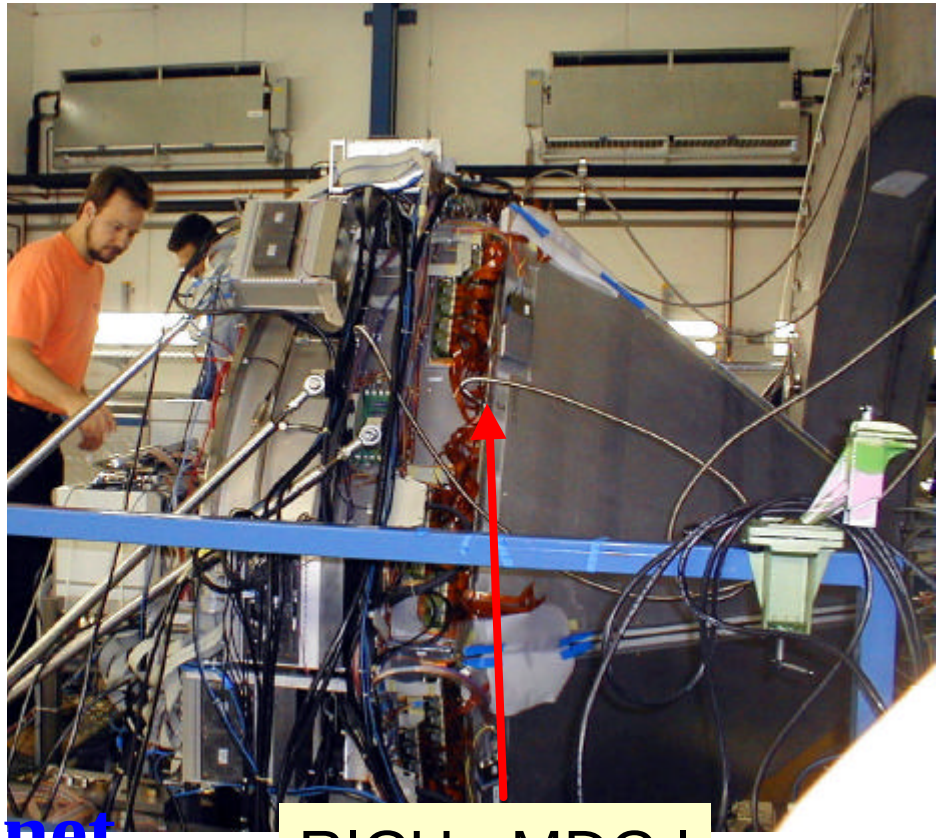
p – measurement, vertex reconstruction

MDC Drift chambers d**x ~ 80 m**m **(**s**)**

HADES @GSI



Back view



RICH +MDC I

HADES S.C. Magnet ILSE

➔ **SC Toroid**

I_{max} = 3465 A

↳ B^{coil}_{max} = 3.7 T

↳ B^{air}_{max} = 0.7 T

Δp (θ=25°) = 103 MeV/c

Δp (θ=80°) = 60 MeV/c

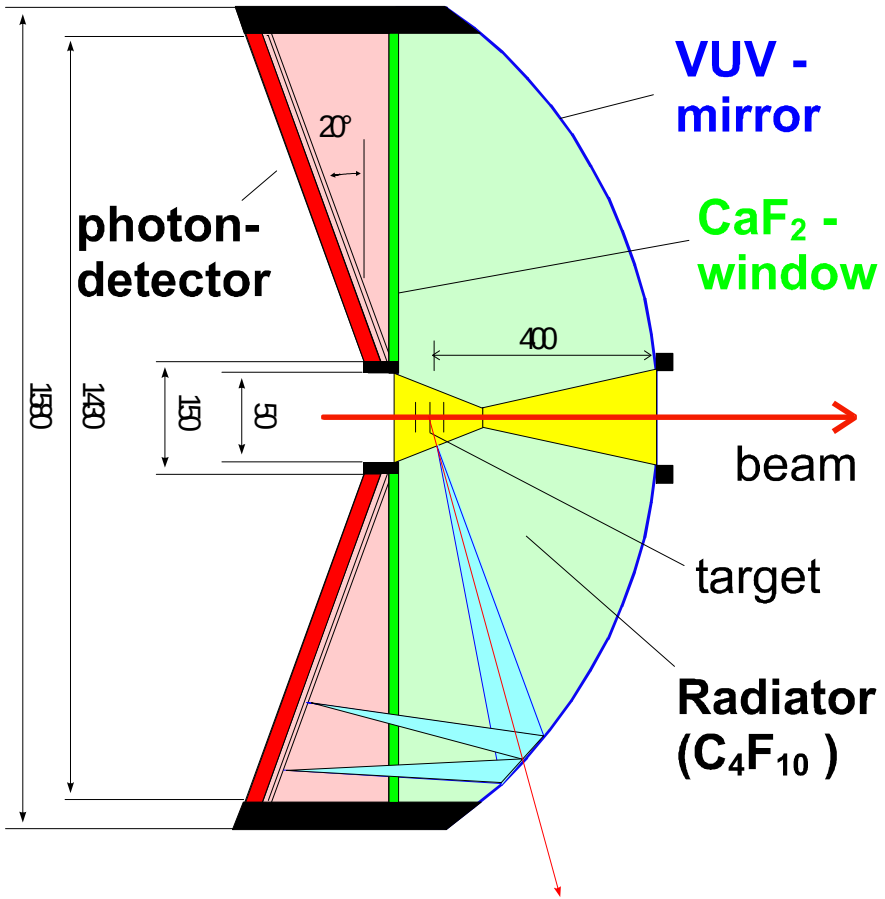
➔ **Beam operation**

↳ I = 2500 A

Δp (25°) = 74 MeV/c

Ring Imaging CHerenkov Detector

e^+e^- - *identification*



- **Cherenkov light**

  $\cos \theta_c = 1/\beta \cdot n(\lambda)$

  $N = N_0 \cdot l_{rad} \cdot 1/\sin^2\theta_t$ (l_{rad} = 40 cm)

  ↳ N_0 **det. characteristics**

- **Radiator** (hadron blind!)

  $3 \sim \gamma_{had} < \gamma_t < \gamma_{lep}$

  C_4F_{10} : γ_t = **18.3**

  $p_p > 3$ **GeV/c**

- **VUV - Mirror**

  Poly-C substr. (2 mm) **x/X < 2%**

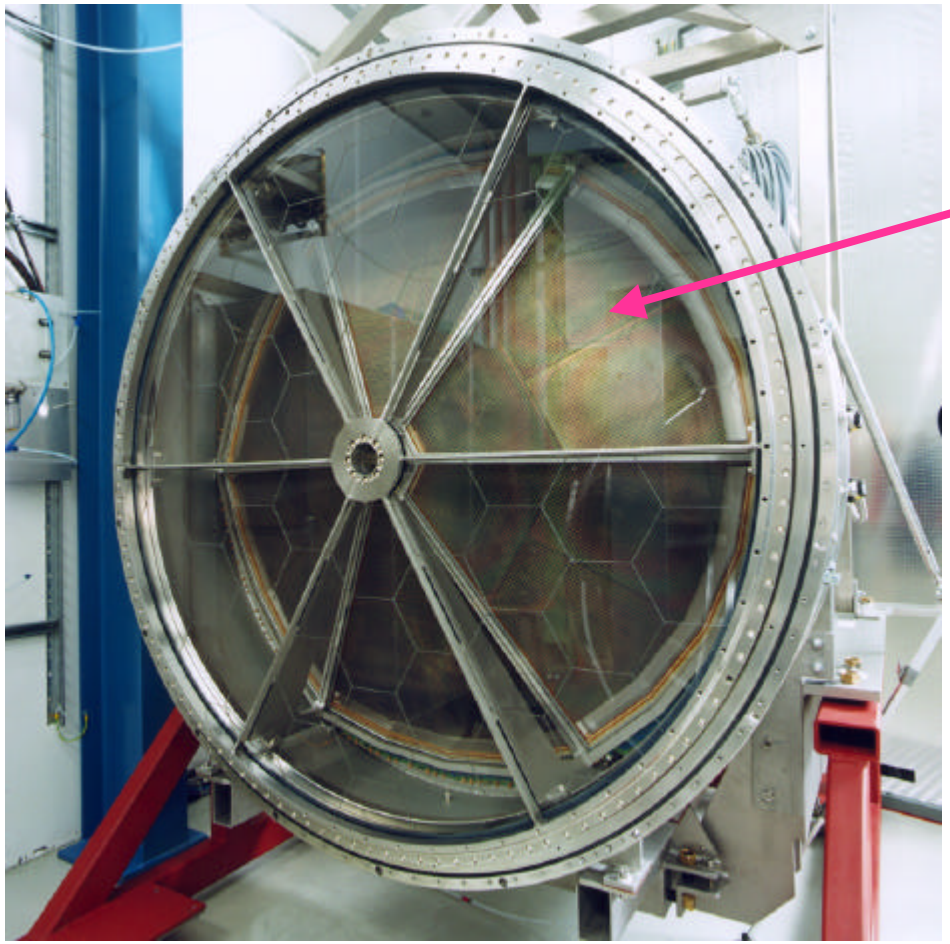
  Al + MgF_2 coating **R > 80%**

- **Photon detector** (MWPC)

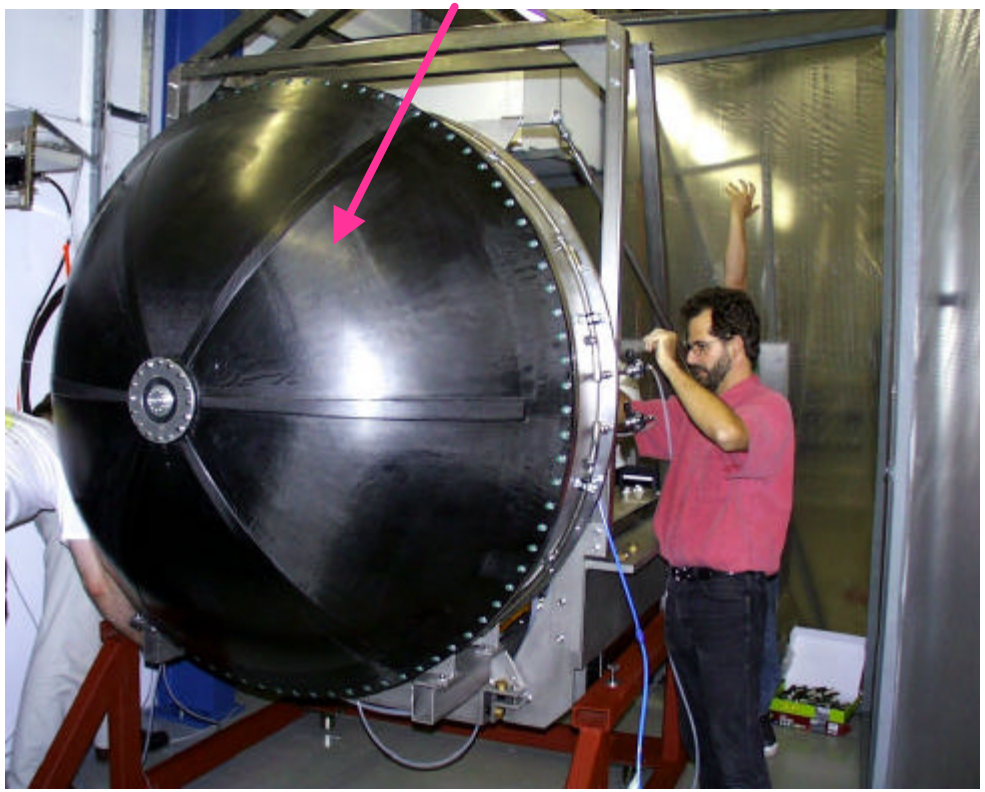
  CsI - cath.

  CaF_2 window

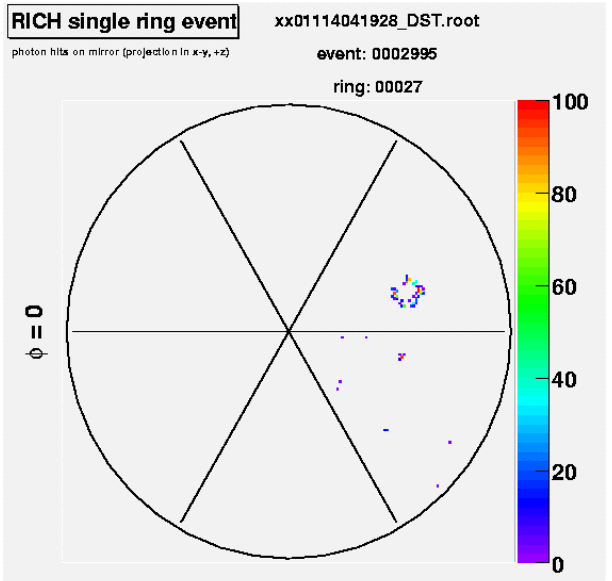
RICH in parts

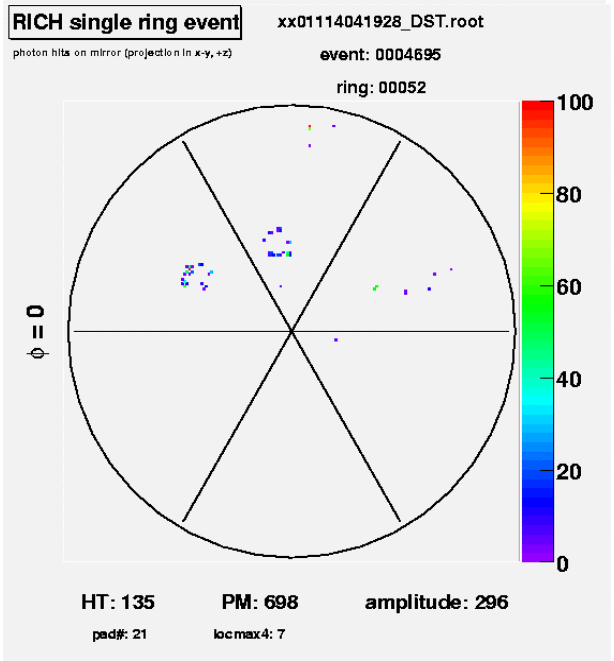


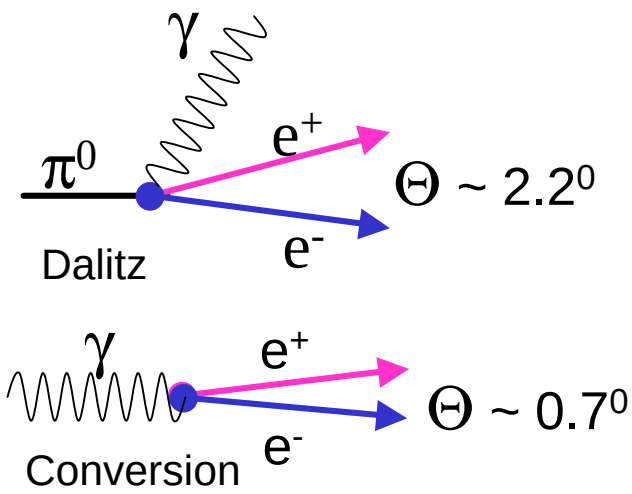
Photon detector with
CaF2 window
&
CFK radiator shell



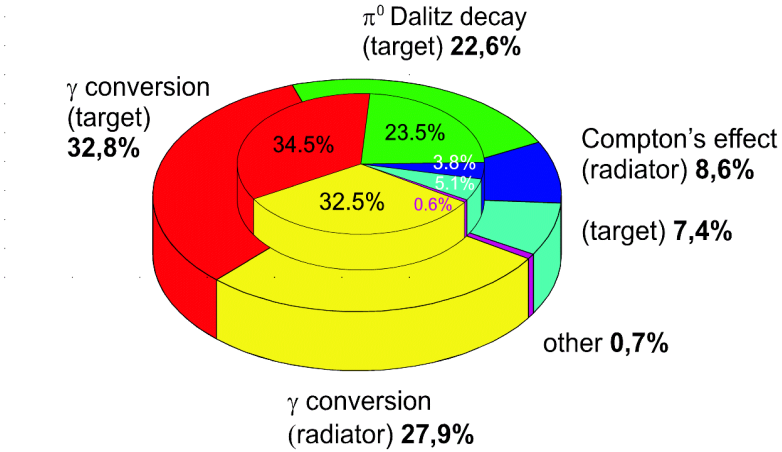
RICH rings







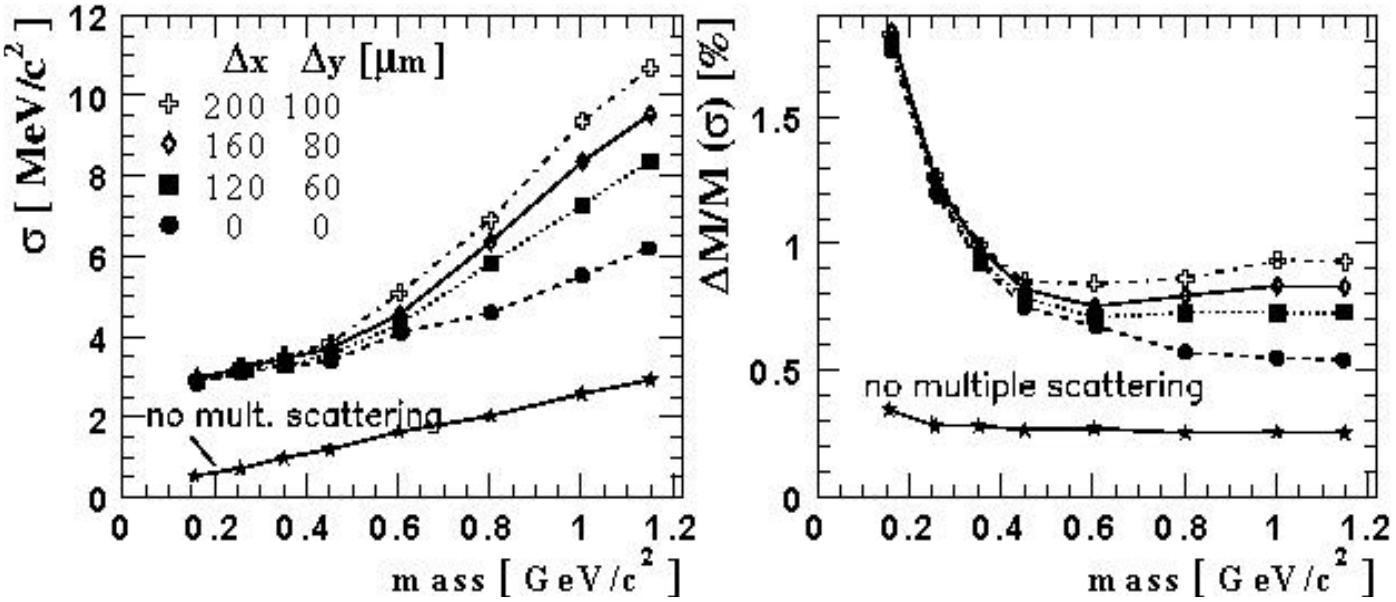
Strong sources lead to large *comb. backgr.!!!*



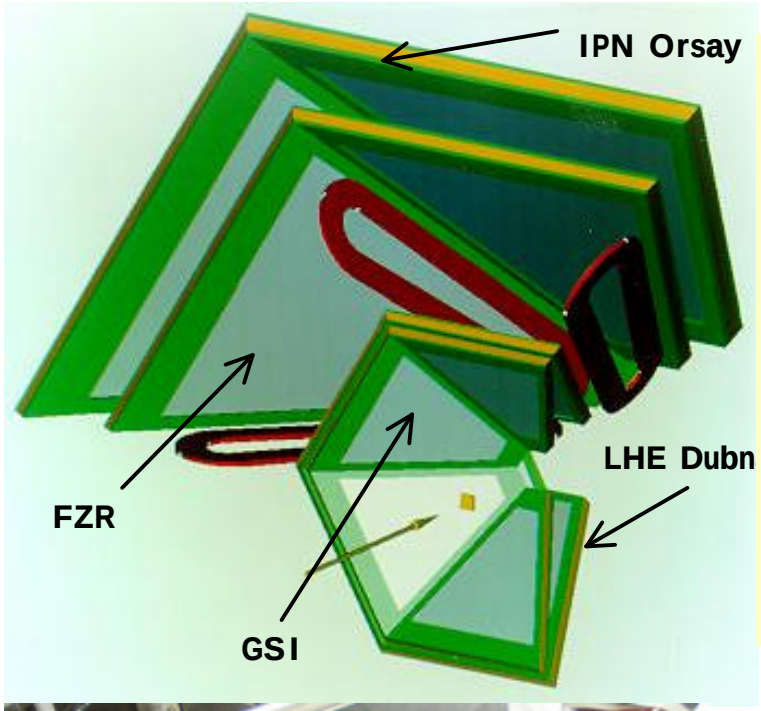
electrons

Multiwire Drift Chambers

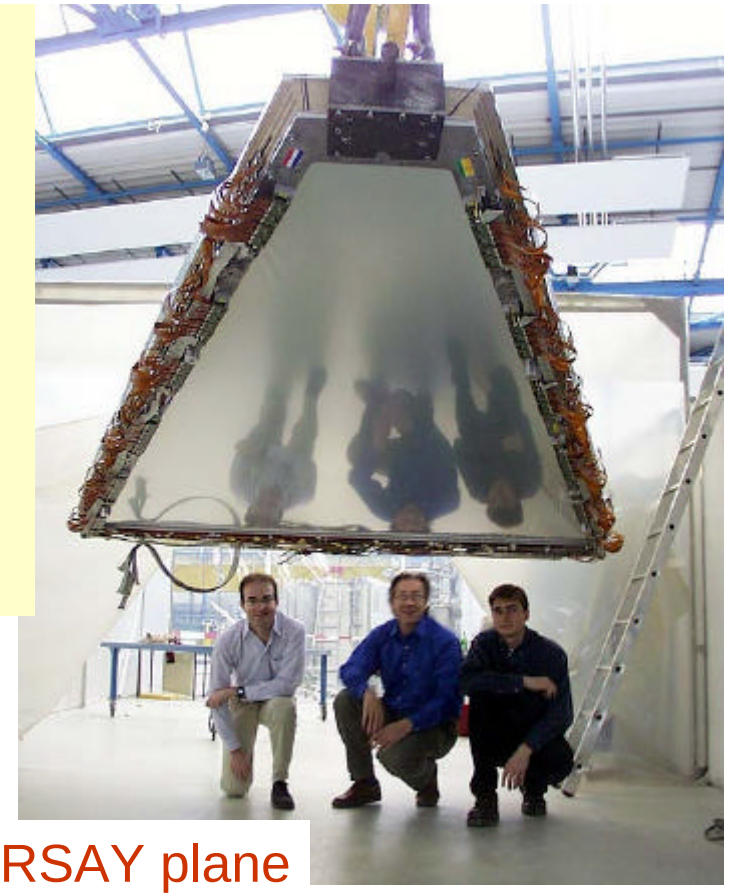
- 0.7 % mass resolution in the ρ/ω - region
- Combinatorial background reduction – e+,e- close pair rejection



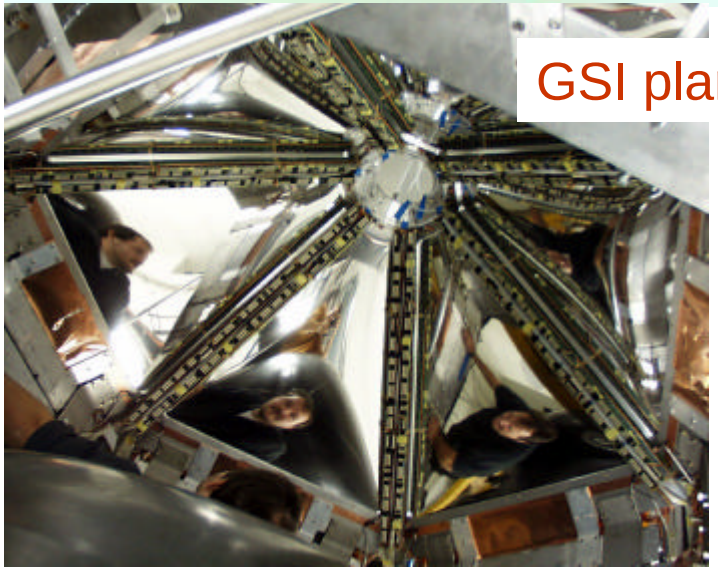
Multiwire Drift Chambers HADES MDC



- ✓ **4 layer/sector.**
- ✓ **total 33 m^3 active area, 27000 cells**
- ✓ **Dy<100 mm plane resolution**
- ✓ **He-iC_4H_{10} [60-40] gas mixture and low Z material**



ORSAY plane



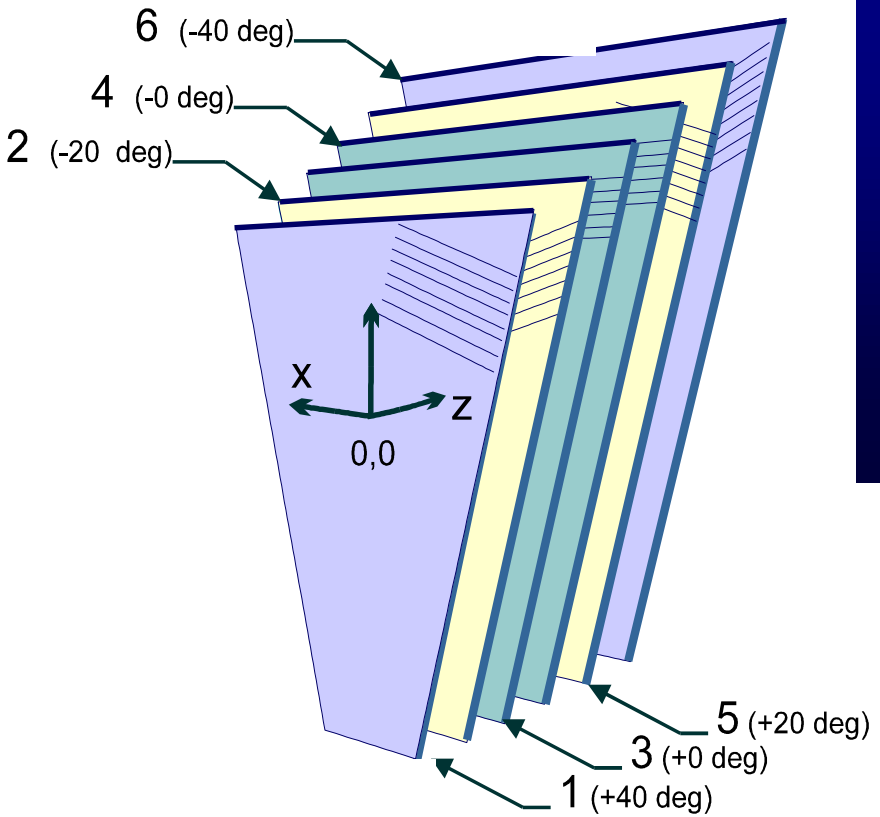
GSI plane

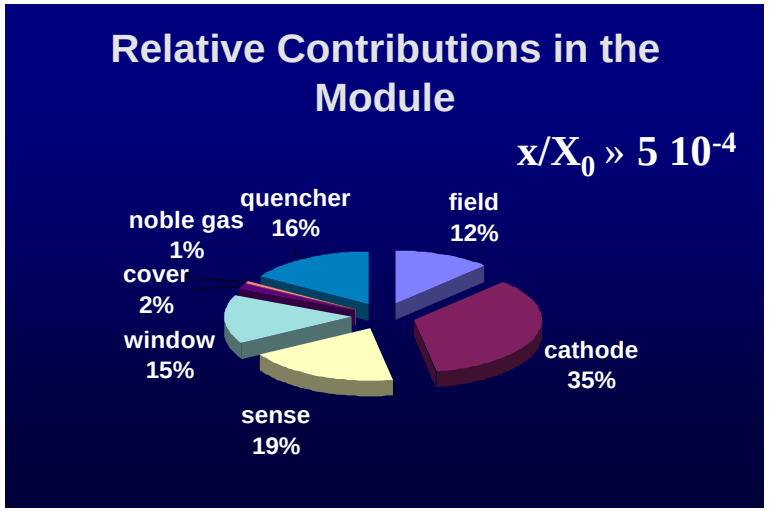
MDC: participating Institutions:

I: GSI,
II: LHE/JINR Dubna,
III: FZ Rossendorf,
IV: IPN Orsay

MDC module

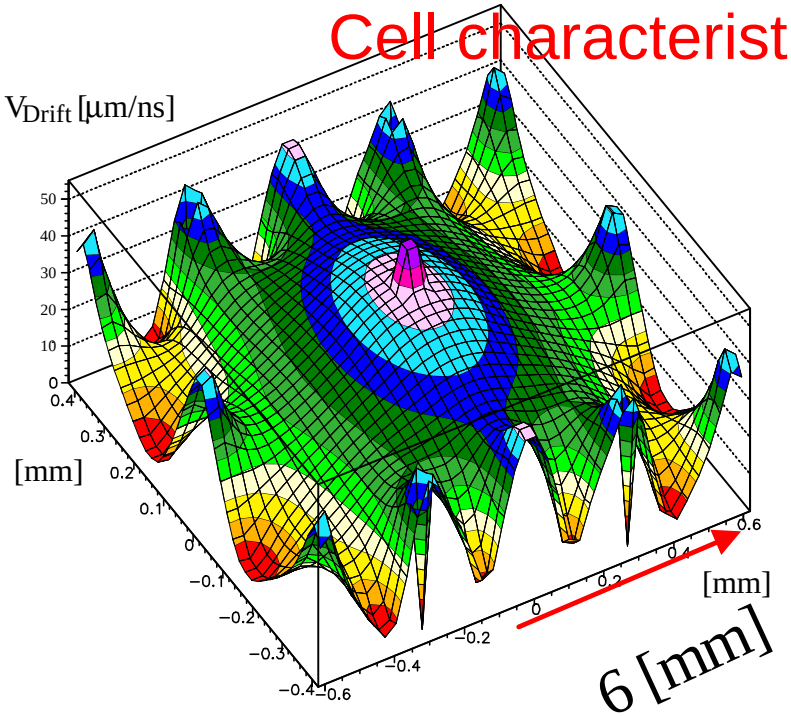
HADES MDC





Layer	Width/m	Height	Area[m^2]
I	76,7	75,5	0,34
II	90,5	88,3	0,49
III	180,5	178,0	1,88
IV	222,4	219,9	2,83

Cell characteristic

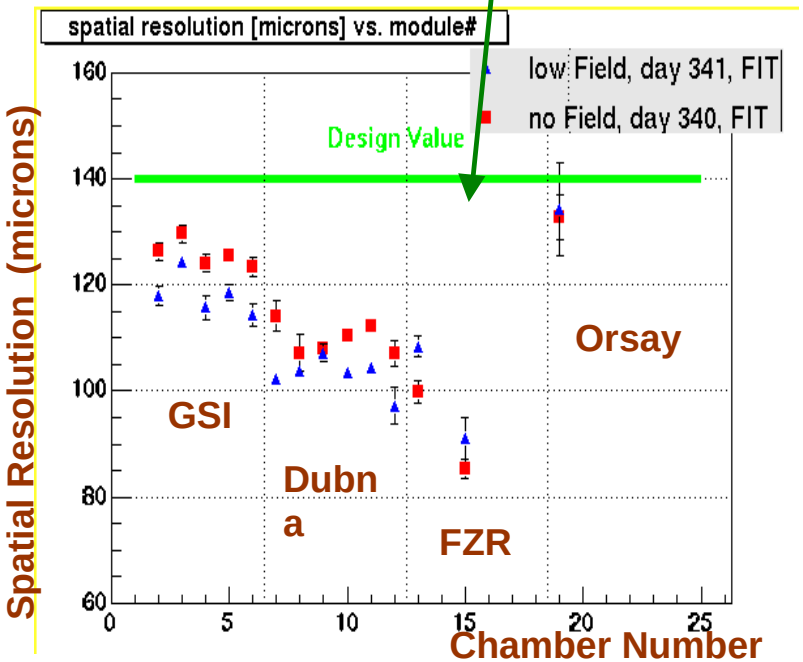


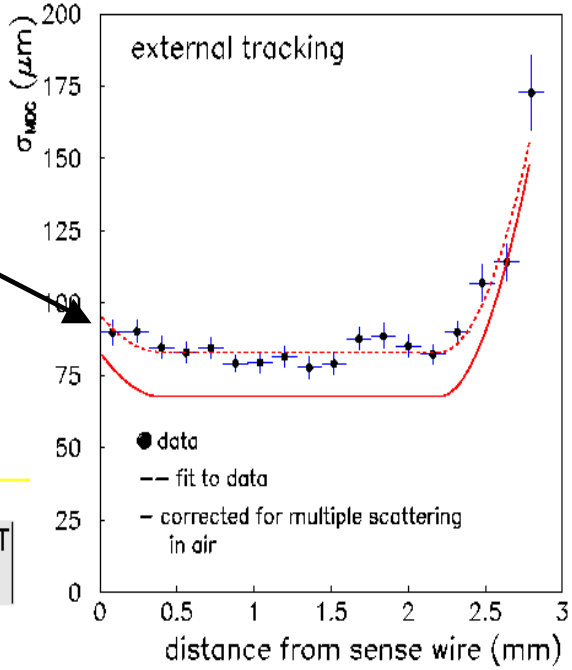
Performance of MDC

HADES MDC

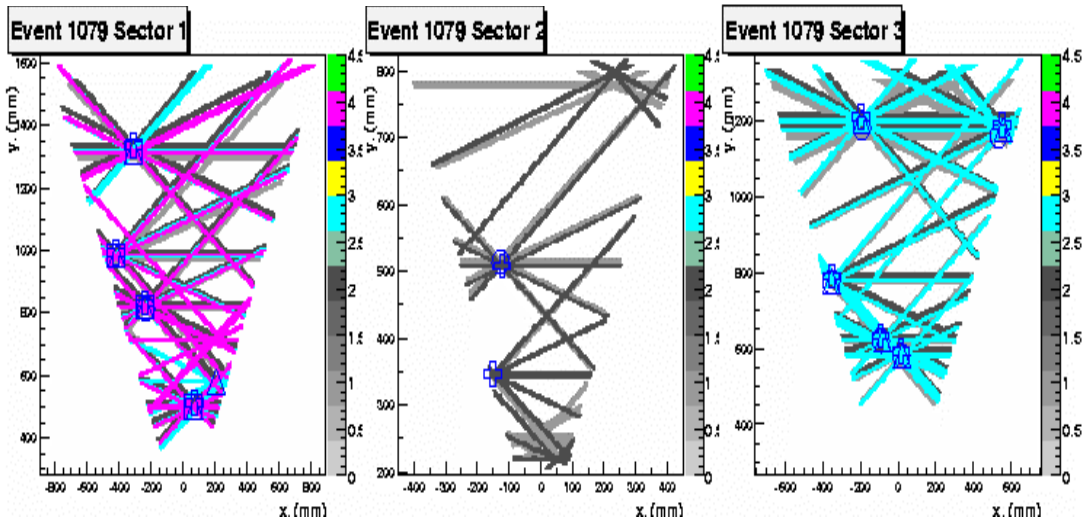
Intrinsic spatial resolution:
Proton beam, silicon tracker

"In-beam" (C+C 1.8 AGeV)



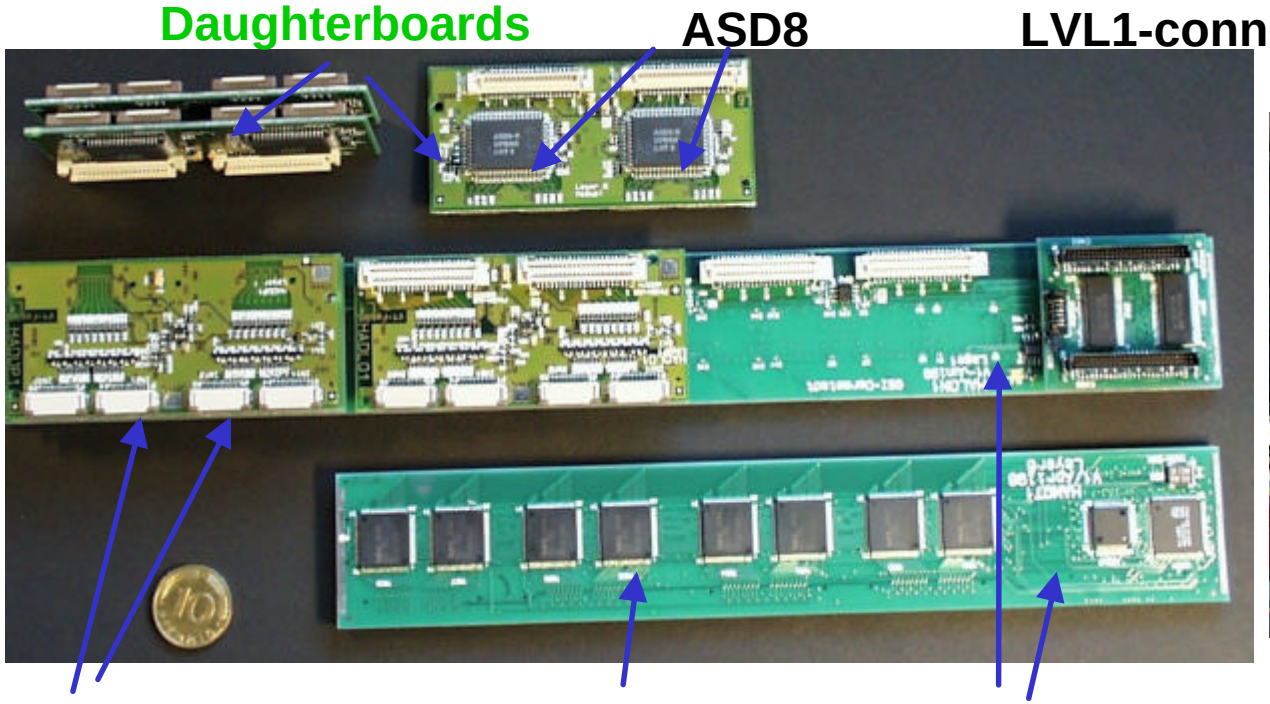


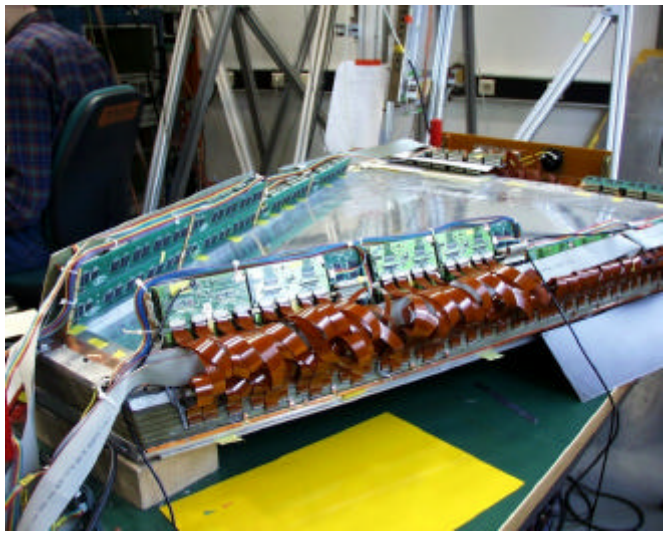
Layer efficiency:
> 98%



MDC Read-out

HADES MDC





Analog Read-out:

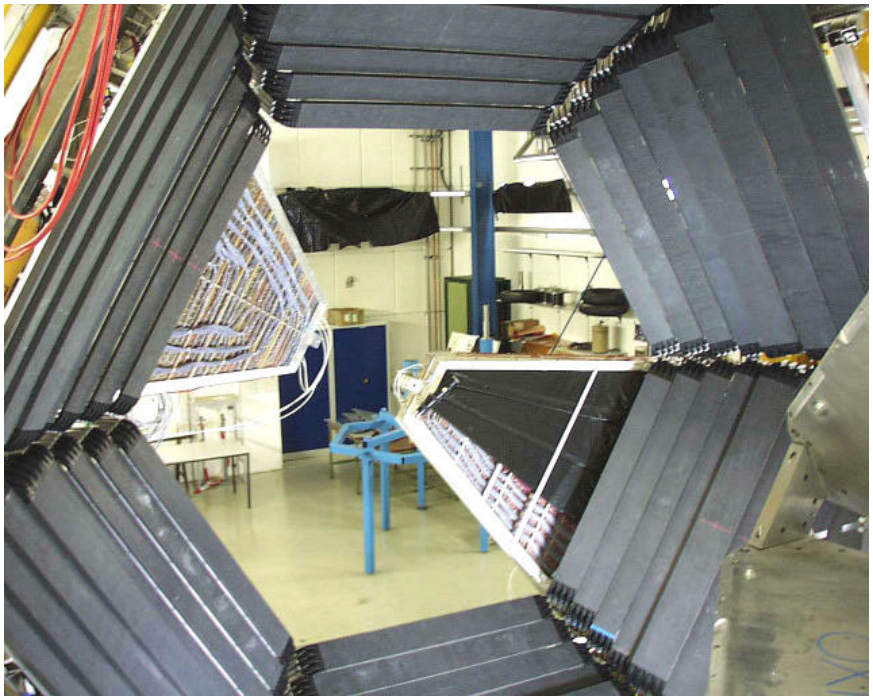
- ✓ Differential amplifier, ASD8 chip, 8 channels,
- ✓1 fC intr. Noise, 30 mW/channel
- ✓ adjustable threshold (one for 16 channels)

TDC Features: (8 channels per chip)

- 8 channels per chip
- 250/500 ps/channel
- "2 times (t1, t2) – **multi-hit capable**
- Zero & spike (t1-t2 < 20ns) suppression
- Calibration Mode (…mixed trigger
- "Time above threshold" (…signal shape, charge):

Efficient Offline noise suppression!

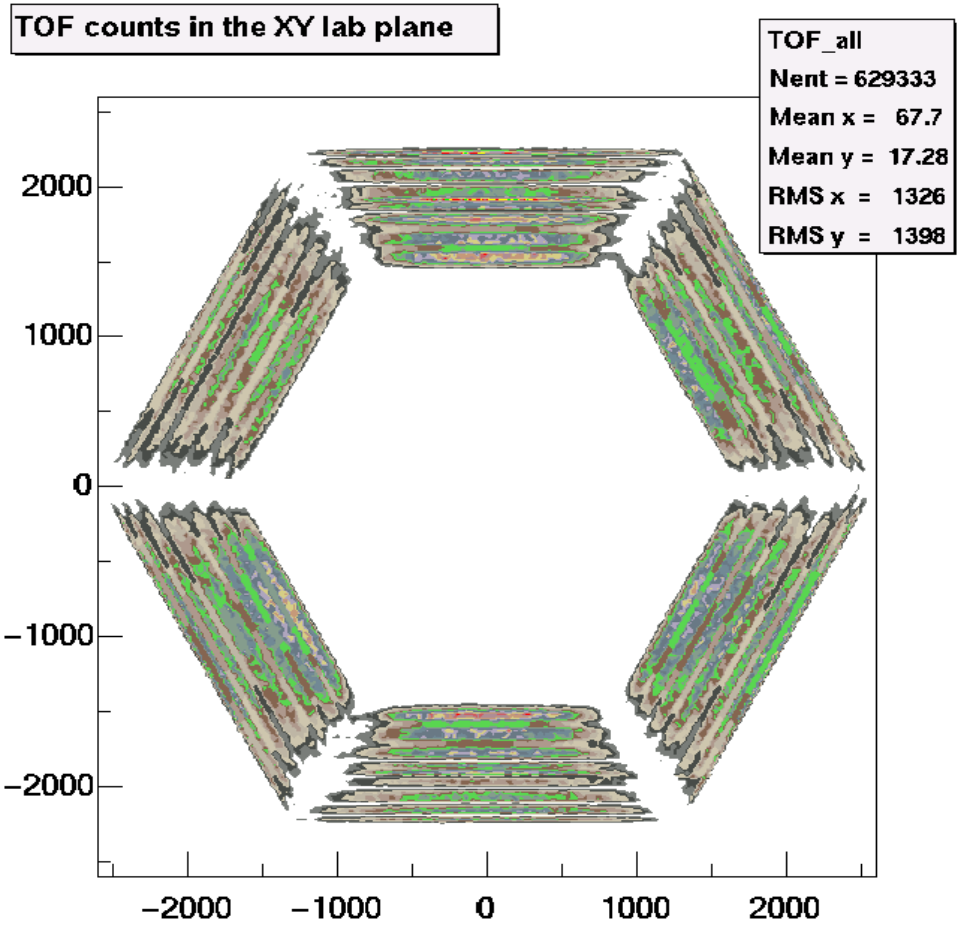
TOF Q>45^0



Outer TOF wall Q>45^0:

- ✓ 6 * 64 scint. Installed.
- ✓ T line fully operational
  δt : 90 – 140 ps
- ✓ dE/dx measurement
- ✓tracking

Ch. p. distribution for
C+C @ 1.5 AGeV

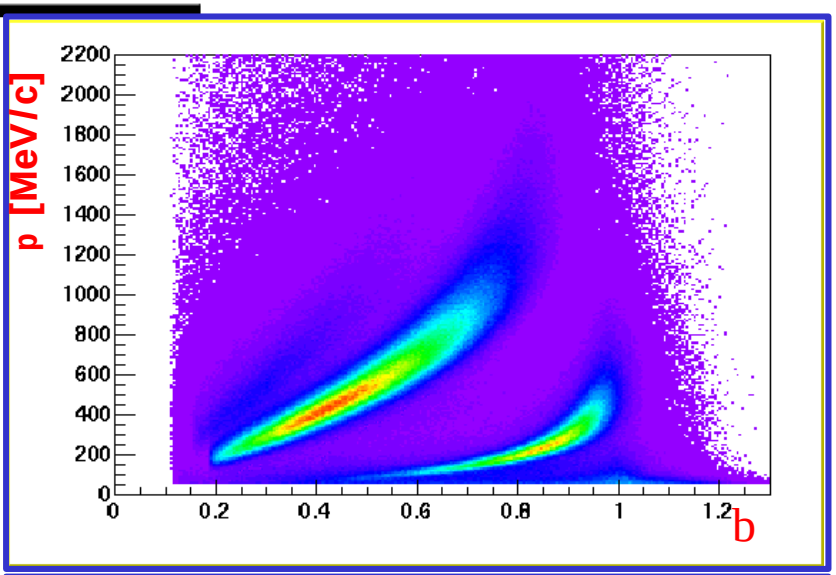


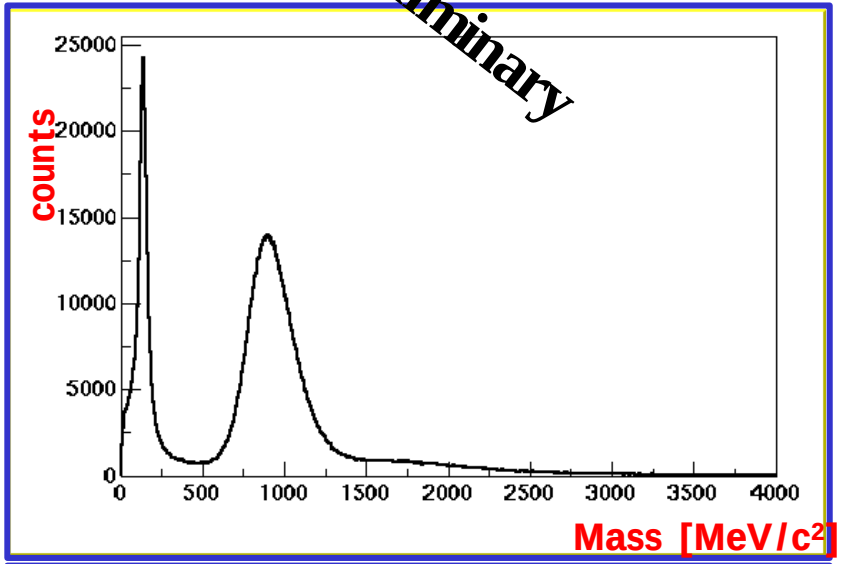
TOF-hadron identification

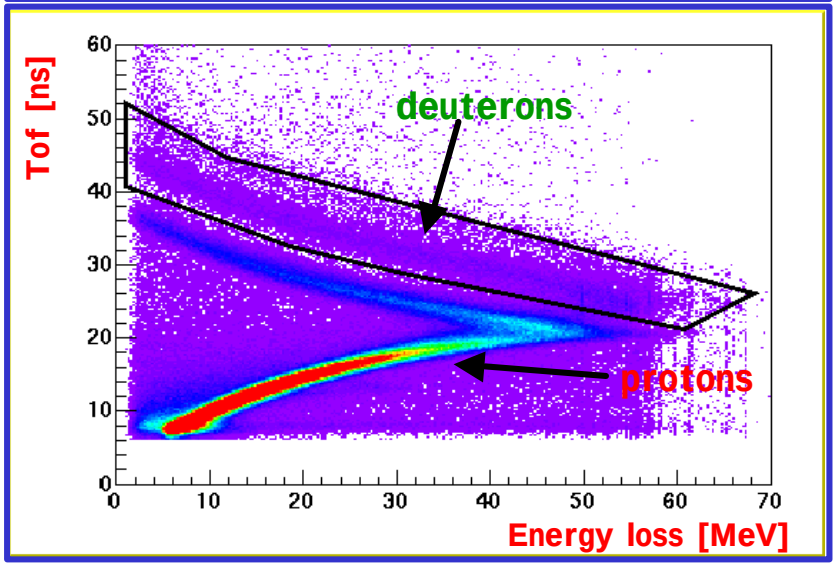
HADES

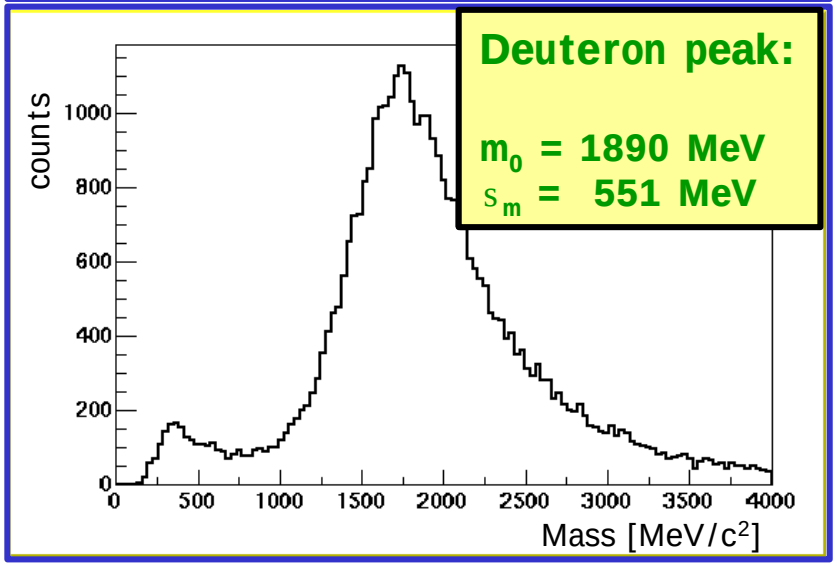
TOF

Preliminary









Deuteron peak:

m_0 = 1890 MeV

σ_m = 551 MeV

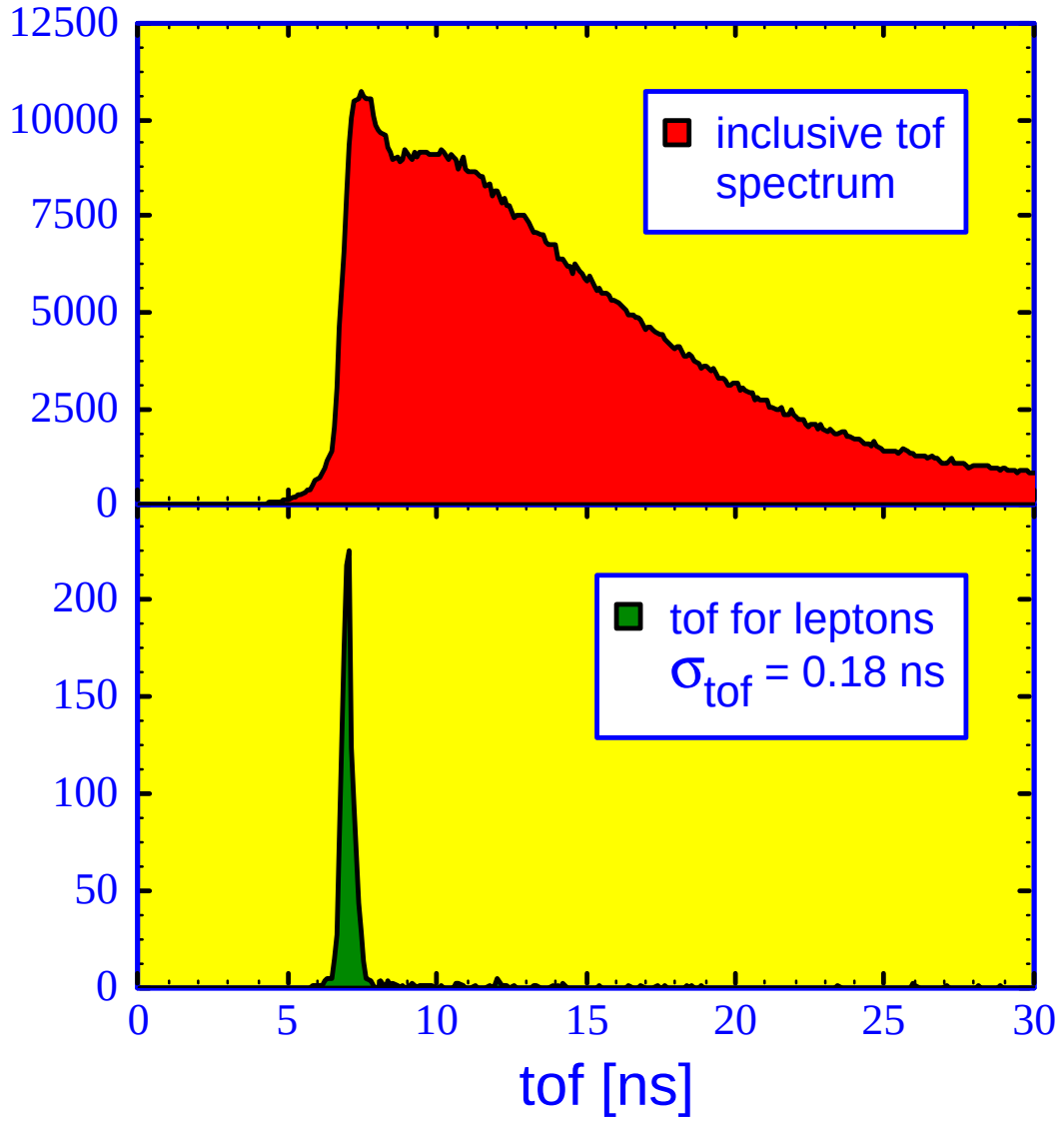
TOF-RICH lepton identification

TOF

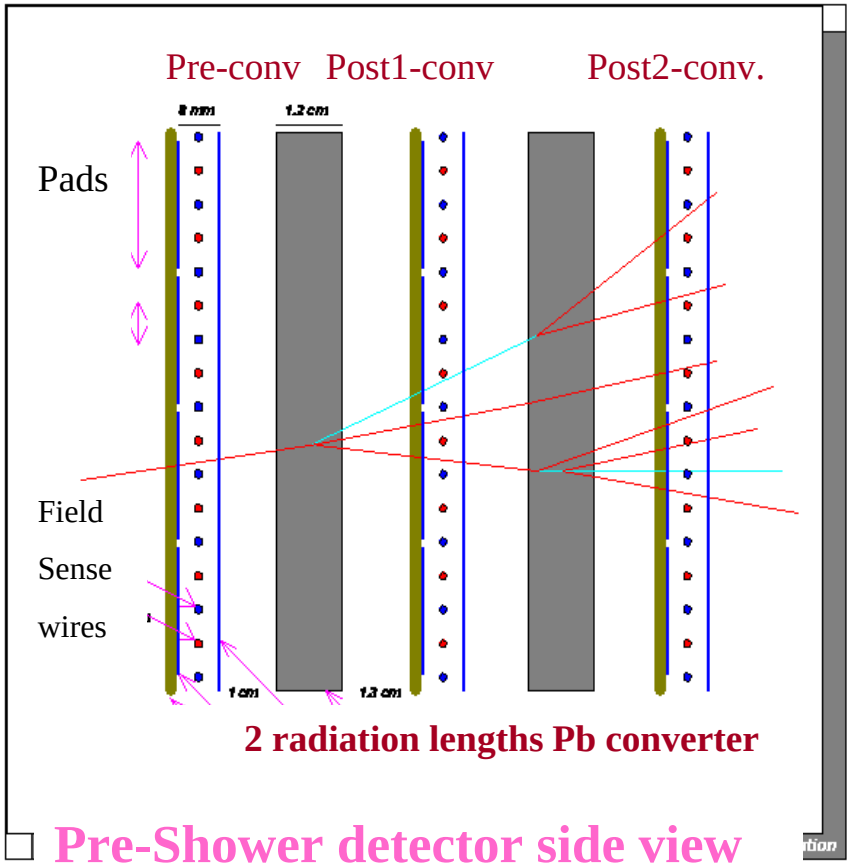
Start-Stop

tof resolution

Exclusive tof spectrum for particles producing a signal on the RICH in the TOF-RICH coincidence angular window $|\Delta\theta|<2°$ and $|\Delta\phi|<1°$.



Pre-Shower/TOF system Q<45^0



Pre-Shower detector side view

✓3 pad chambers (20000 pads)

✓em. showers in Pb converters

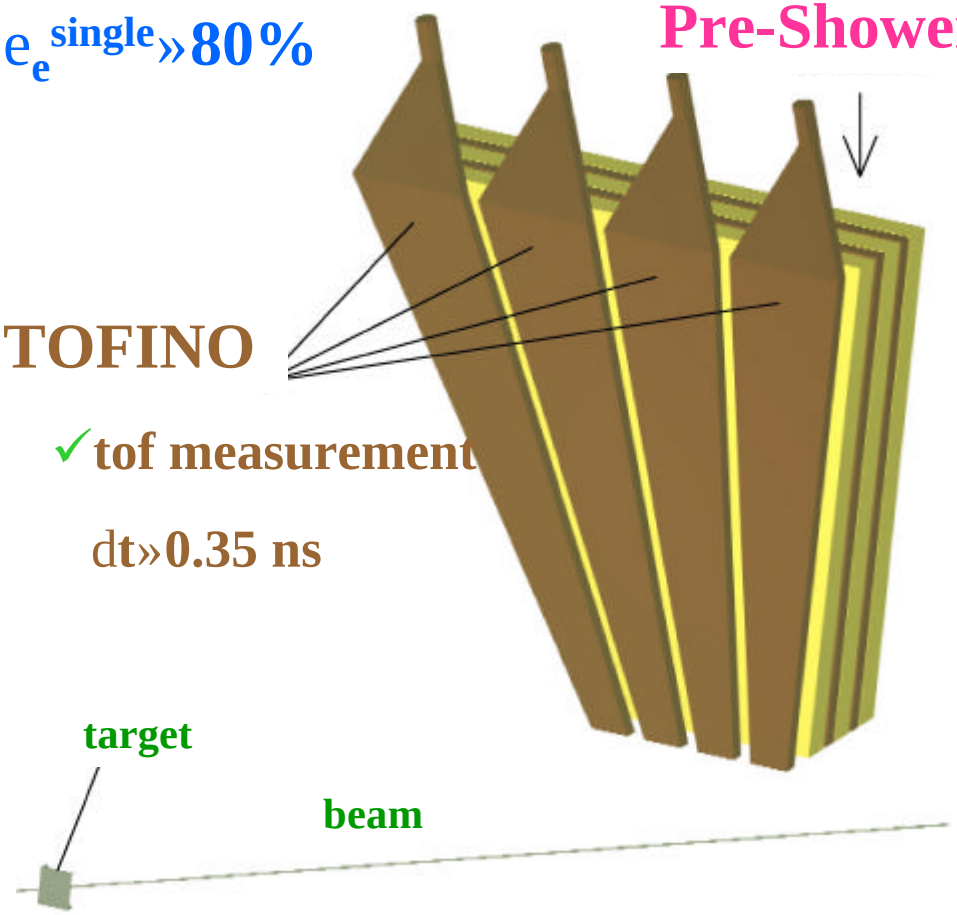
e_e^{single}»80%

Pre-Shower

TOFINO

✓tof measurement

dt»0.35 ns

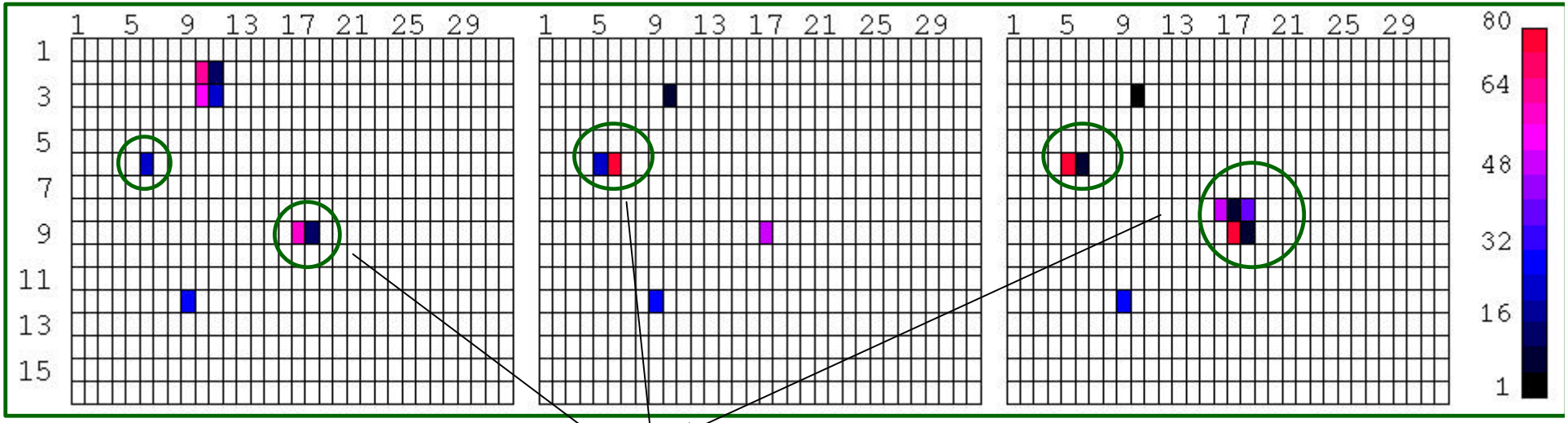


One event: detector response

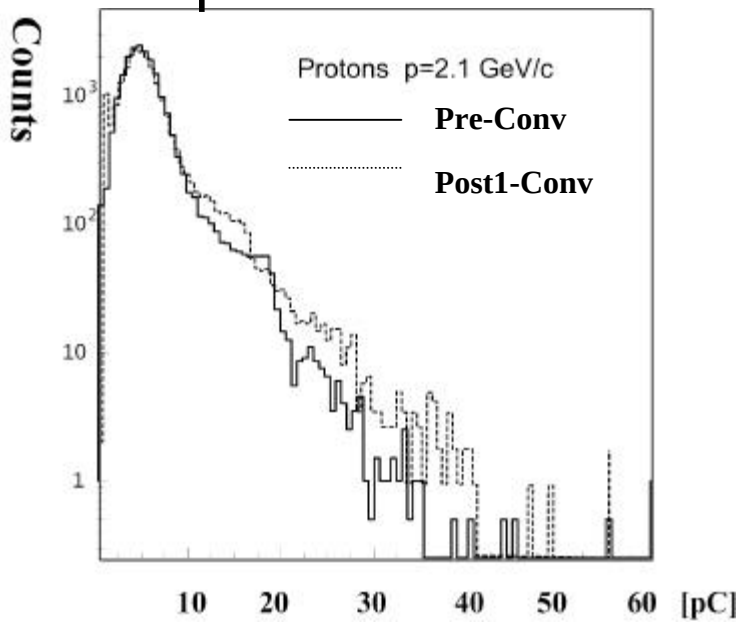
C+C 1.5 AGeV

HADES

Pre-converter **Post1-converter** **Post2-Converter**

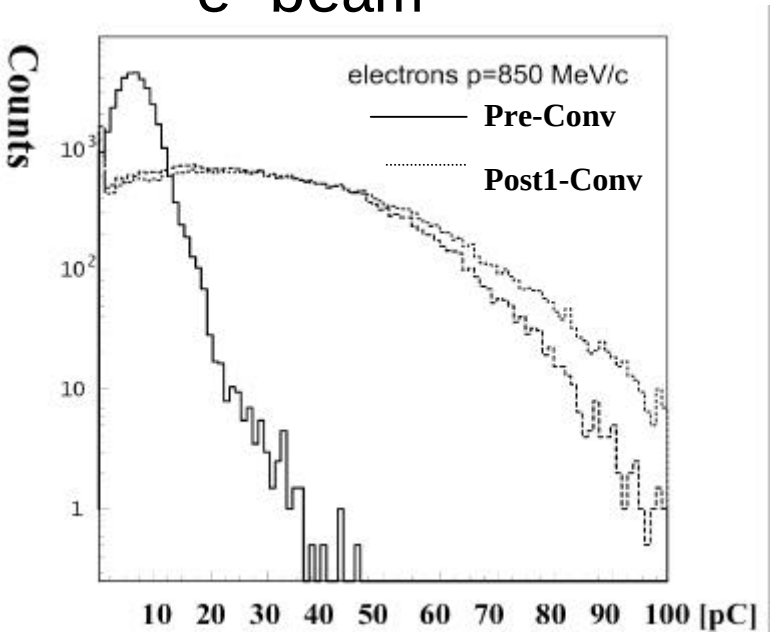


p beam



Shower candidate

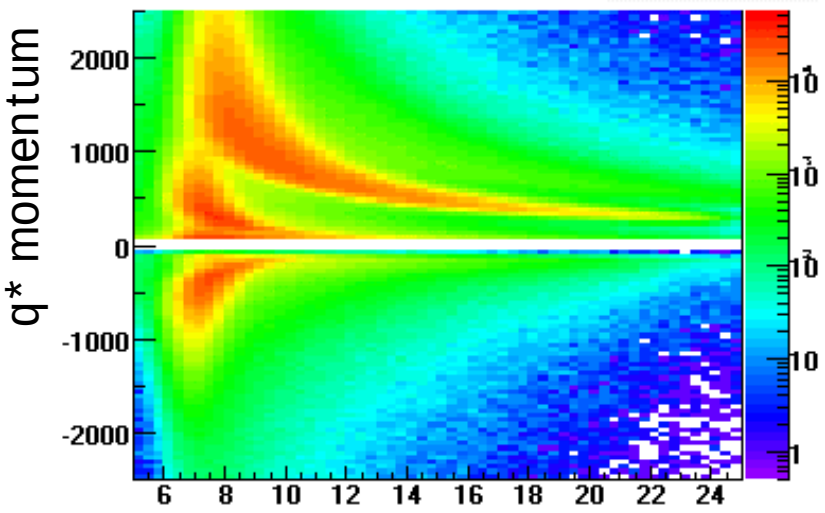
e^- beam

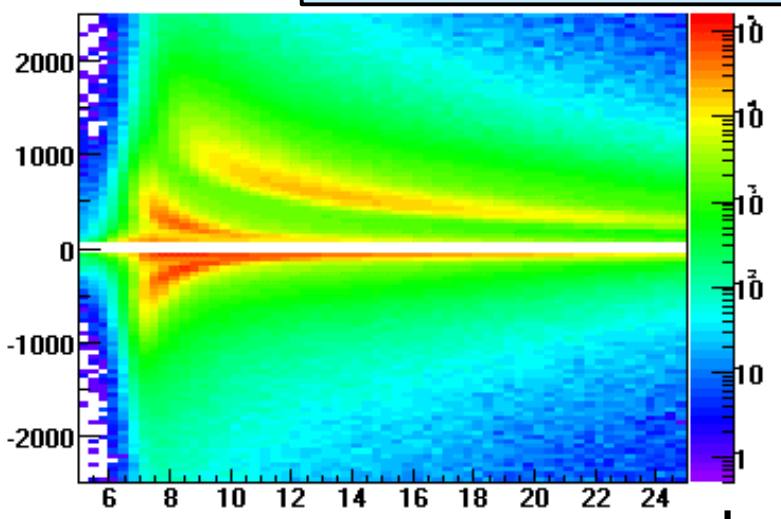


RICH-MDC-META lepton identification

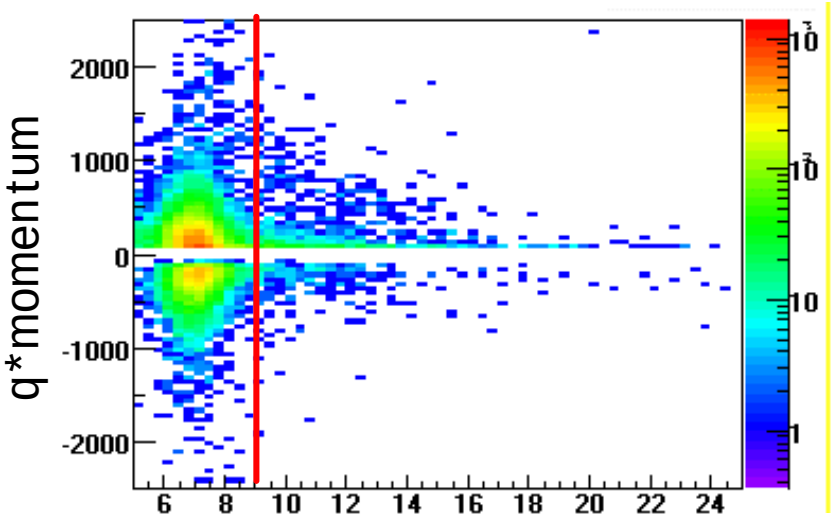
preliminary

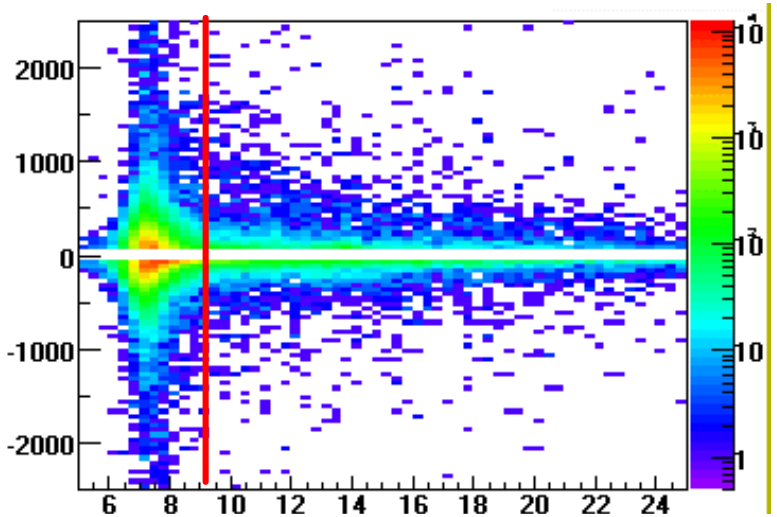
Data: Nov01
C-C 2.0 AGeV magnetic field





Log z!

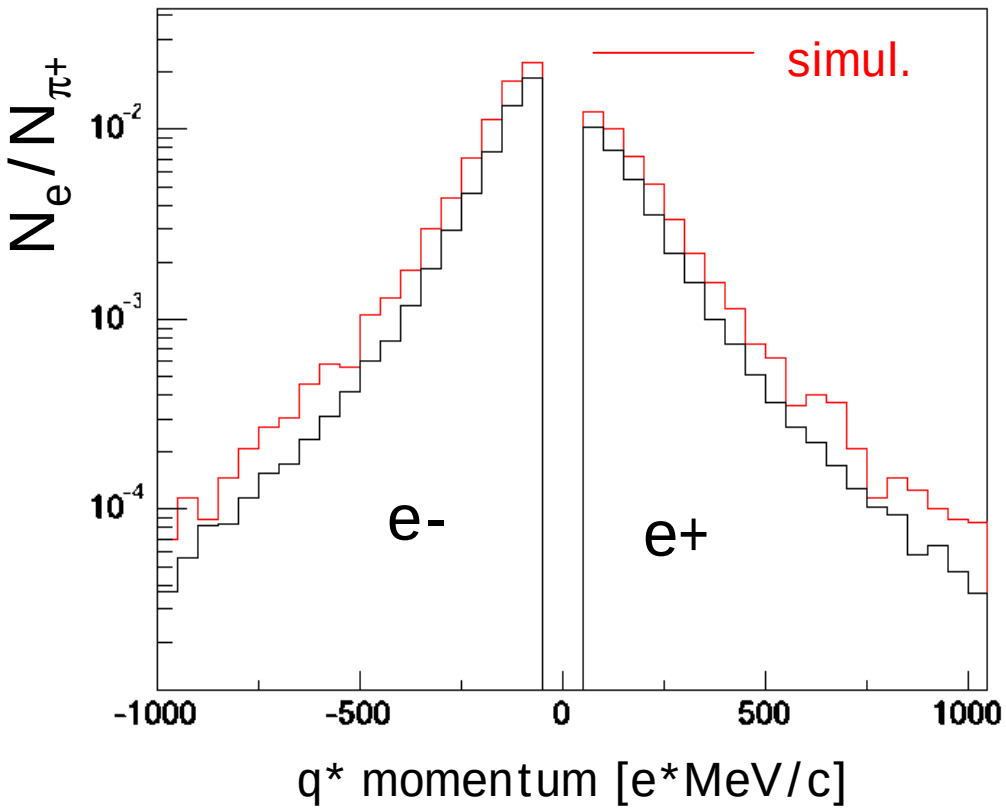




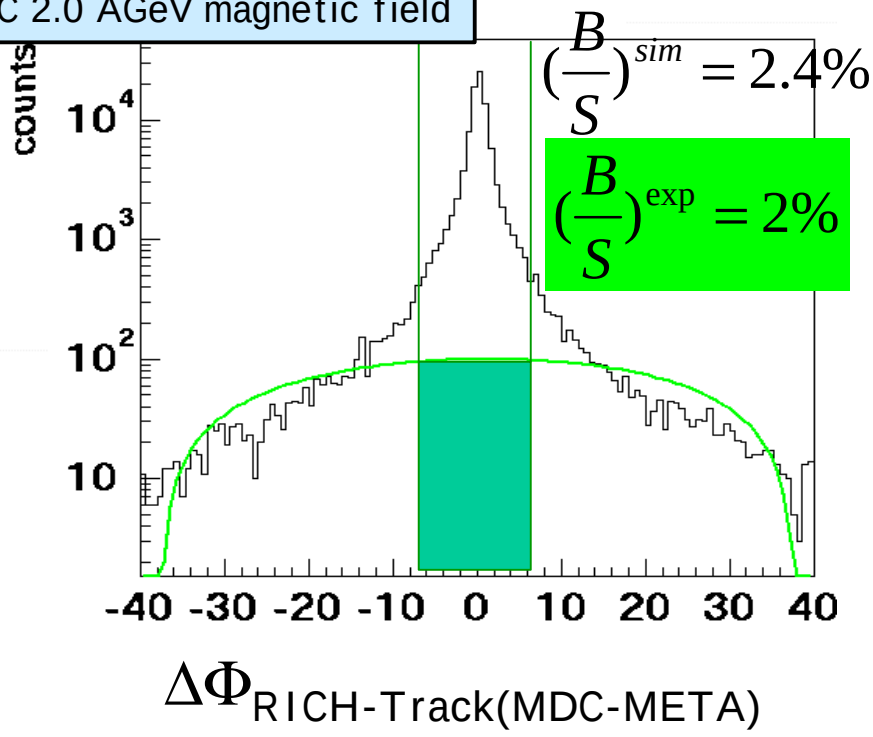
RICH-MDC-META lepton identification

preliminary

- Full HADES simulation and data analysis
- RQMD ev.generator



Data: Nov01
C-C 2.0 AGeV magnetic field

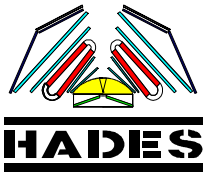


$(\frac{B}{S})^{sim} = 2.4\%$

$(\frac{B}{S})^{exp} = 2\%$

- ✓ RICH & fast tof &shower
- ✓ MDC I/II (inner)

HADES Trigger System



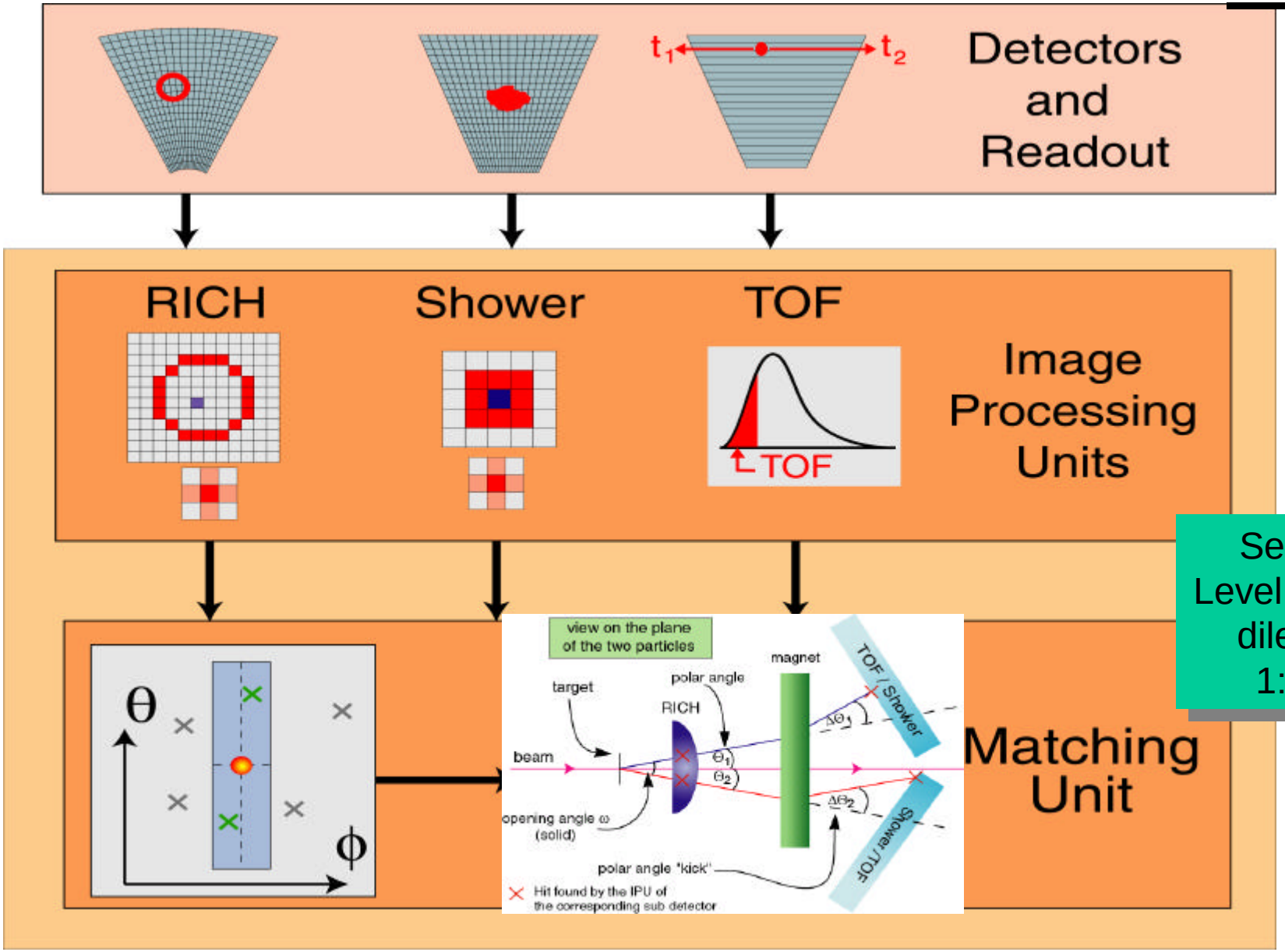
- 10^{7-} 10^{8} paricles/s
- 10^{5-6} interactions/s (1% target)
- Level 1 Trigger:
  - Multiplicity in TOF
  - 10^{4}–10^{5} central events/s
- Large data rate
  3 GByte/s

- Needs level 2 trigger:
  - Ring recognition in RICH
  - Hit finding and tof calculation in TOF
  - El. Shower search in Pre-Shower

  RICH and META candidate matching via azimuthal correlations
  - Selection of $e^{+}e^{-}$-pairs (momentum and invariant mass analysis)
  - High rates (10^{5} Hz)
  - 10μs max. LVL2 trigger decision time)

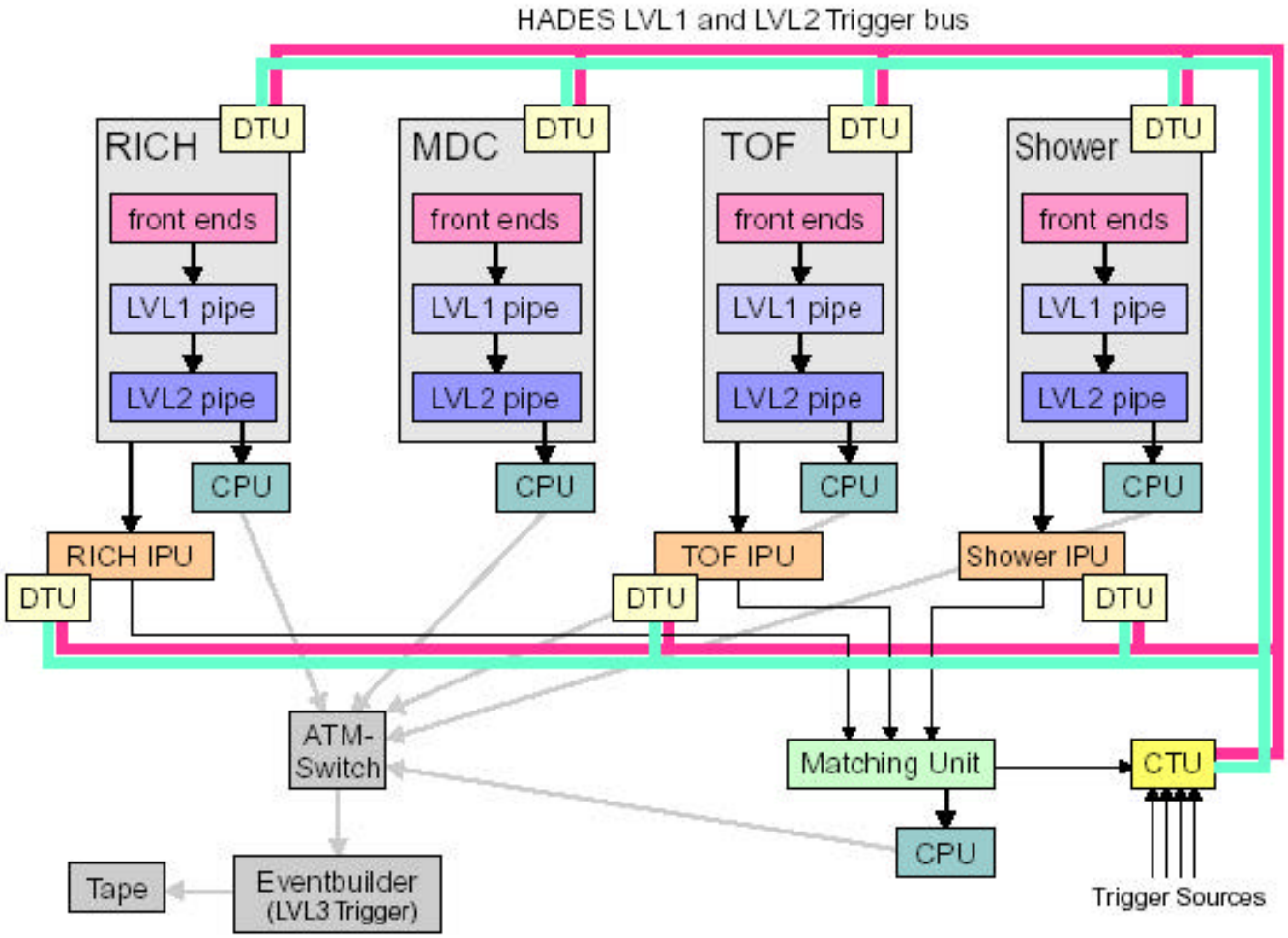
  ⇩
  - Parallel- und Pipeline architecture
    FPGAs, CPLDs and DSPs

Second Level trigger flow



Second Level Trigger dilepton 1:100

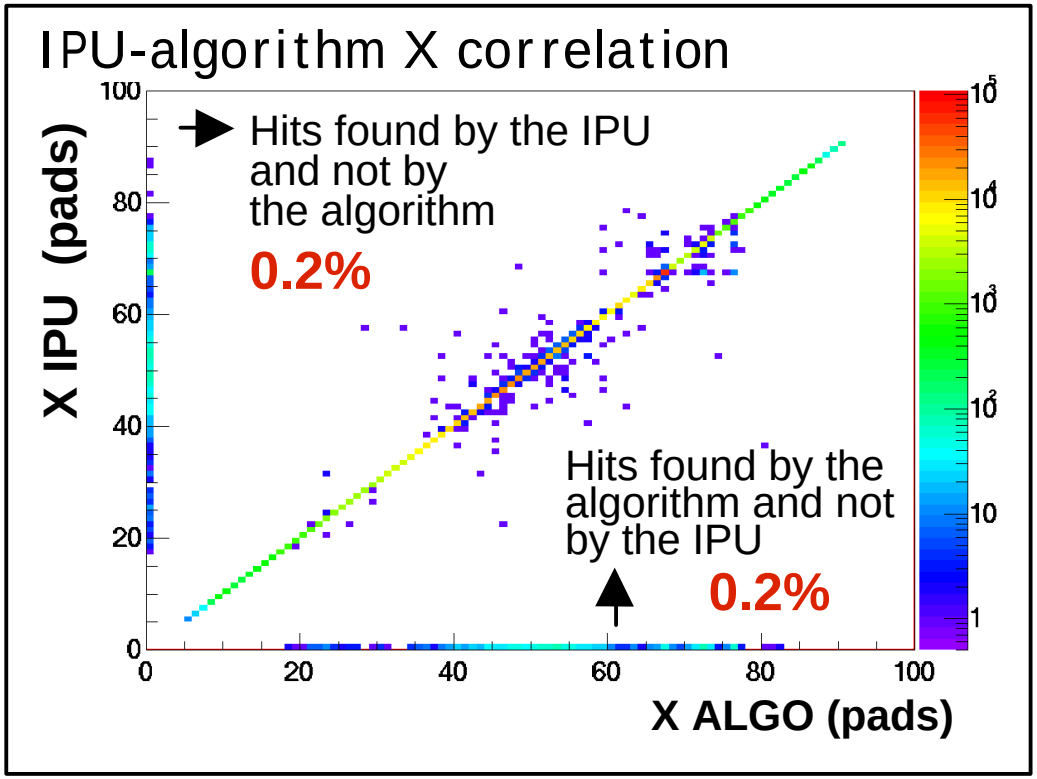
Trigger distribution system



- Trigger distribution: LVL1 (TOF Mult.) and LVL2 (MU) via CTU
- DAQ synchronized via event number distribution
- Total: 50 VME-Modules

RICH IPU

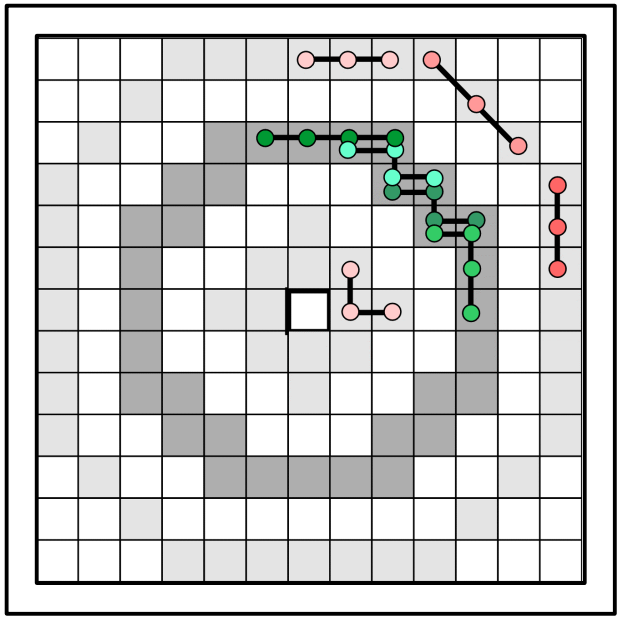
- Pattern reconstruction (96x96 pad plane)
- Ring recognition
  - fixed 80 pads mask (● ring/● veto region)
  - local maximum search



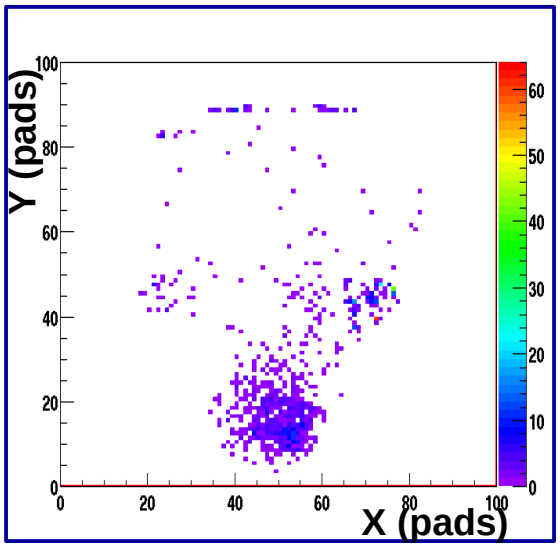
- Discrepancy: 0.4%

Data: Nov01
C-C 1.5 AGeV full field

1 ring search mask (13x13 pads)



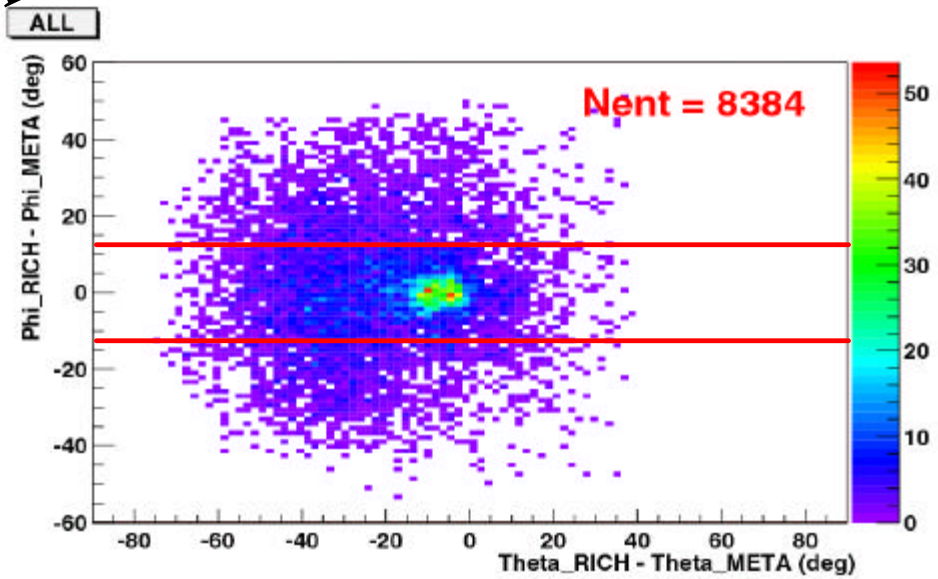
uncorrelated emulation rings



Preliminary

Matching Unit

Data: Nov01
C-C 1.5 AGeV magnetic field



Reference System: offline analysis leptons

LVL2 conditions in the MU:

- 1 hit in RICH
- 1 hit in TOF
- $\Delta\phi < 15°$

} lepton

Trigger condition	% evts
evt >= 1 ring	10.5%
evt >= 1 lepton	2.9%
evt >= 2 rings	4.6%
evt >= 2 leptons	1.7%
evt >= 1 dilepton	0.3%

Efficiency

	RICH IPU	LVL2
integrated eff	85.3%	84.7%
event eff	87.3%	86.6%
N. fakes ele/evt	0.24	0.19

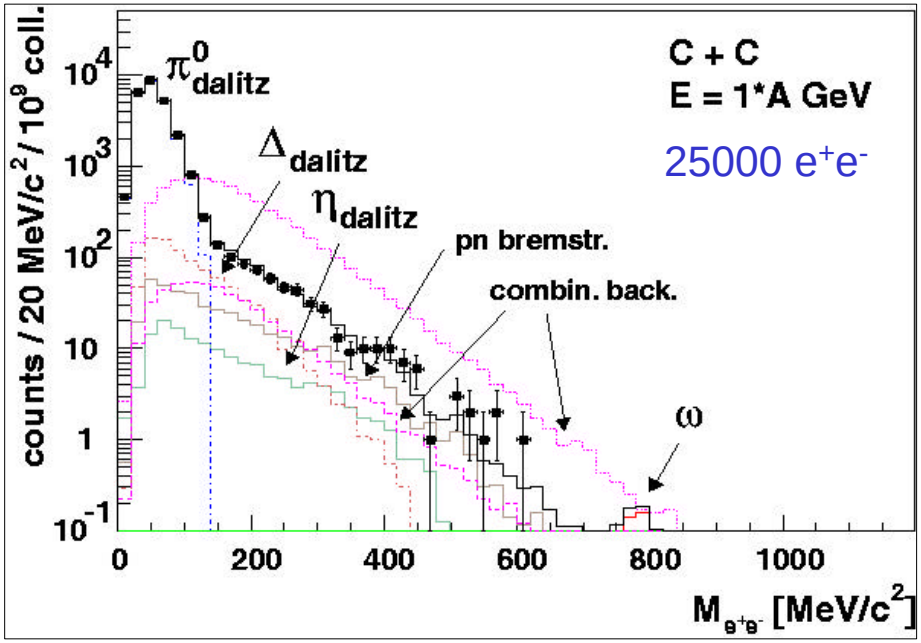
Outlook

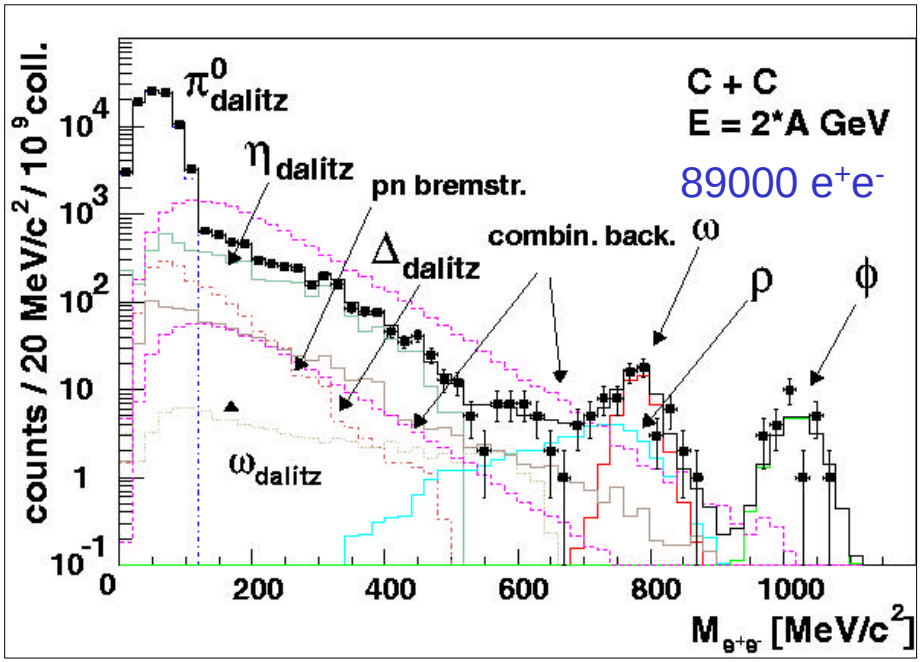
- HADES comes into operation(e/π/p sep., LVL2 trig., tracking)
- 3 MDC layer will be completed this summer (δp≈3% for ρ/ω)
- DAQ and LVL2 trigger commisioning

Phase I (2002 – 2003) : (acc. proposals S200 ,S262)

- Continuum below $M_{inv} < 600$ MeV/c^2 ; π^0 Dalitz in C+C
- High statistics e^+,e^- production in HI reactions C+ C @ 1 – 2 AGeV (compare to DLS)
- e^+e^- production in π^- p π^- p @ 0.8 – 1.3 GeV/c (below and above threshold for r/w
- e^+e^- pair acceptances $pp \rightarrow pp\ h \rightarrow pp\ e^+e^-$

e^+e^- pairs in C + C collisions





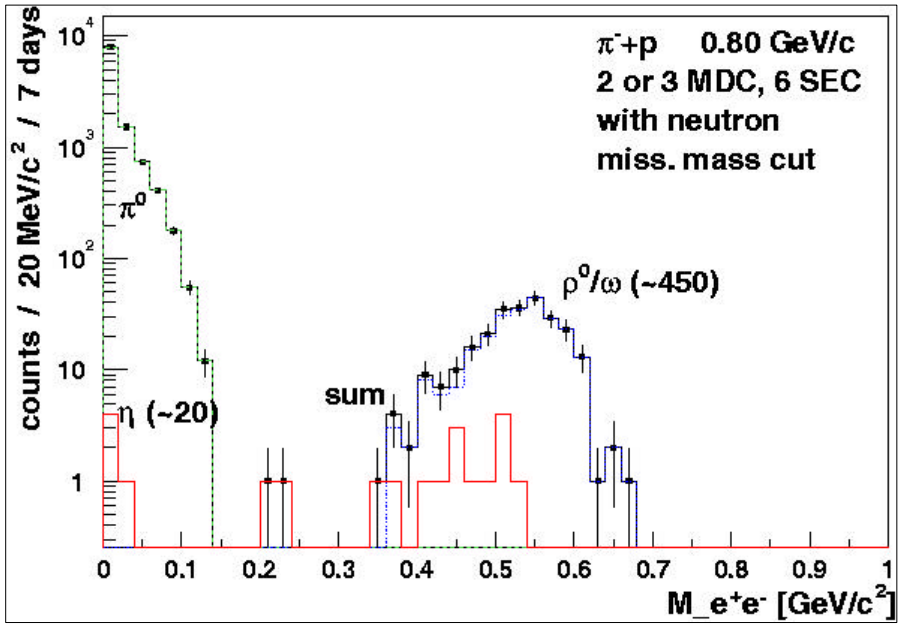
E_{beam} = 1A GeV/c

Simulation for 3 MDC setup :

needs
2 * 10^9 events
~ 5 days

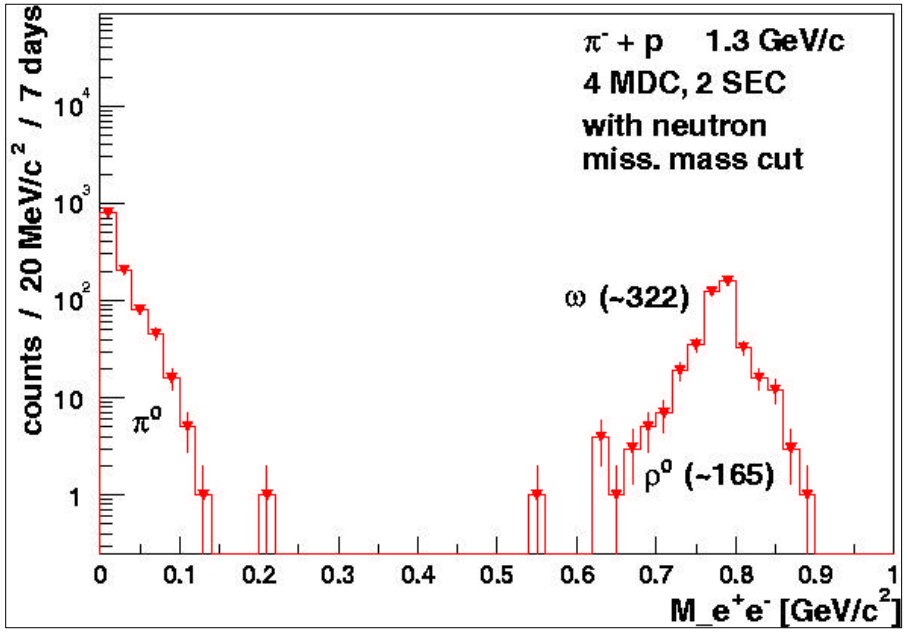
E_{beam} = 2A GeV/c

e^+e^- pairs in p^-+p reactions



P_{beam} = 0.8 GeV/c

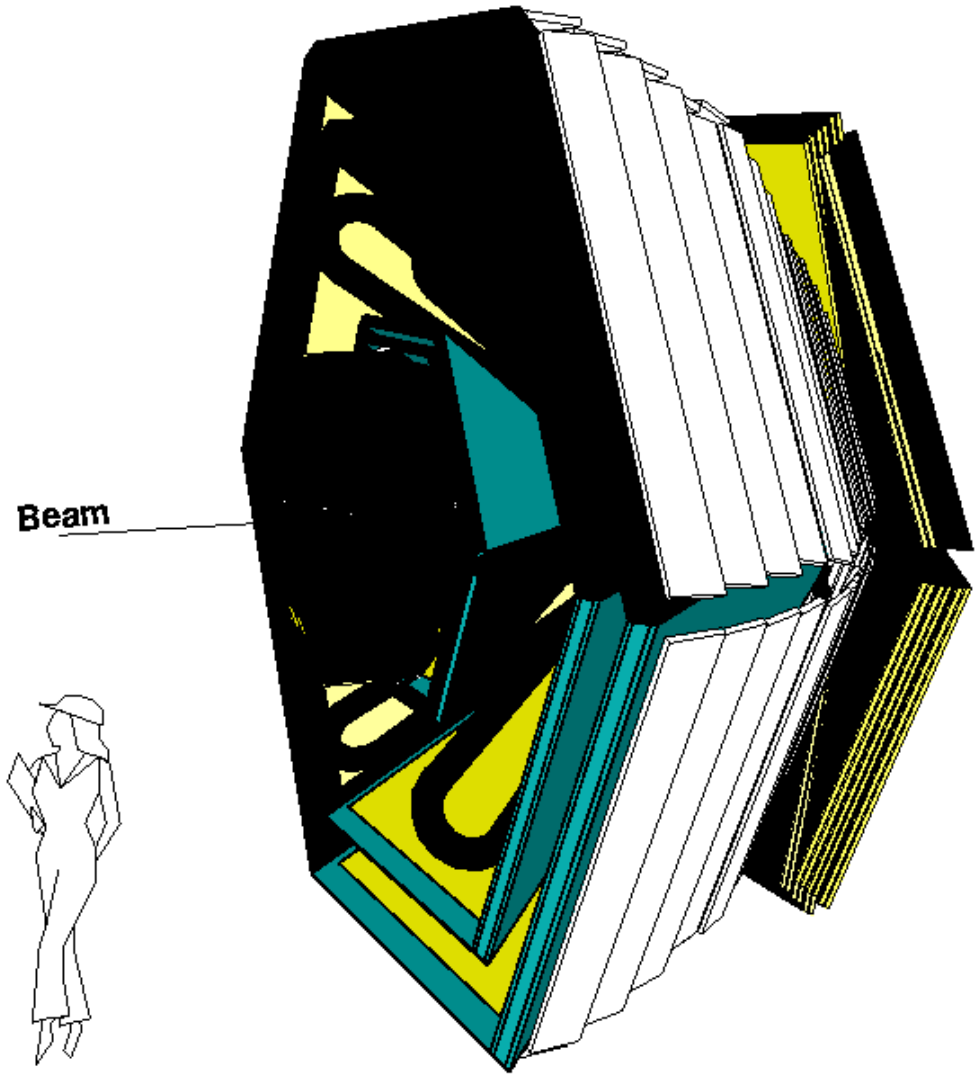
Simulation for 3 MDC setup :



7 days of π^- beam @ $1 * 10^6\ s^{-1}$!!

P_{beam} = 1.3 GeV/c

Collaboration



- **Bratislava (SAS, PI)**
- **Catania (INFN - LNS)**
- **Clermont-Ferrand (Univ.)**
- **Cracow (Univ.)**
- **Darmstadt (GSI)**
- **Dresden (FZR)**
- **Dubna (JINR)**
- **Frankfurt (Univ.)**
- **Giessen (Univ.)**
- **Milano (INFN, Univ.)**
- **Moscow (ITEP, MEPhI, RAS)**
- **Munich (Tech. Univ.)**
- **Nicosia (Univ.)**
- **Orsay (IPN)**
- **Rez (CAS, NPI)**
- **Sant. de Compostela (Univ.)**
- **Valencia (Univ.)**