P349 - Search for polarization effects in the antiproton production process

D. GRZONKA, FORSCHUNGSZENTRUM JÜLICH

D. Alfs, D. Grzonka, F. Hauenstein*, K. Kilian, D. Lersch, J. Ritman, T. Sefzick, H. Xu, Z. Yong	IKP, Forschungszentrum Jülich, 52425 Jülich, Germany
B. Glowacz, P. Moskal, M. Zielinski	IP, Jagiellonian University, ul. Reymonta 4, PL-30 -059 Krakow, Poland
M. Diermaier, V. Kletzl, E. Widmann, J. Zmeskal	SMI für subatomare Physik, Boltzmanngasse 3, 1090 Wien, Austria
W. Oelert	Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany
M. Wolke	Dep. of Physics and Astronomy, Uppsala University, Box 516, 751 20 Uppsala, Sweden
P. Nadel-Turonski	Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606
M. Carmignotto, T. Horn,	PD, The Catholic University of America, 210 Hannan Hall, Washington, DC 20064
H. Mkrtchyan, A. Asaturyan, A. Mkrtchyan, V. Tadevosyan, S. Zhamkochyan	A. I. Alikhanyan Science Laboratory (Yerevan Physics Institute), Yerevan 0036, Armenia
S. Malbrunot-Ettenauer	CERN, Physics department
W. Eyrich, A. Zink	PI, Universität Erlangen, Erwin-Rommel-Strasse 1, 91058 Erlangen, Germany

*Present address: Old Dominion University, Norfolk, Virginia, USA

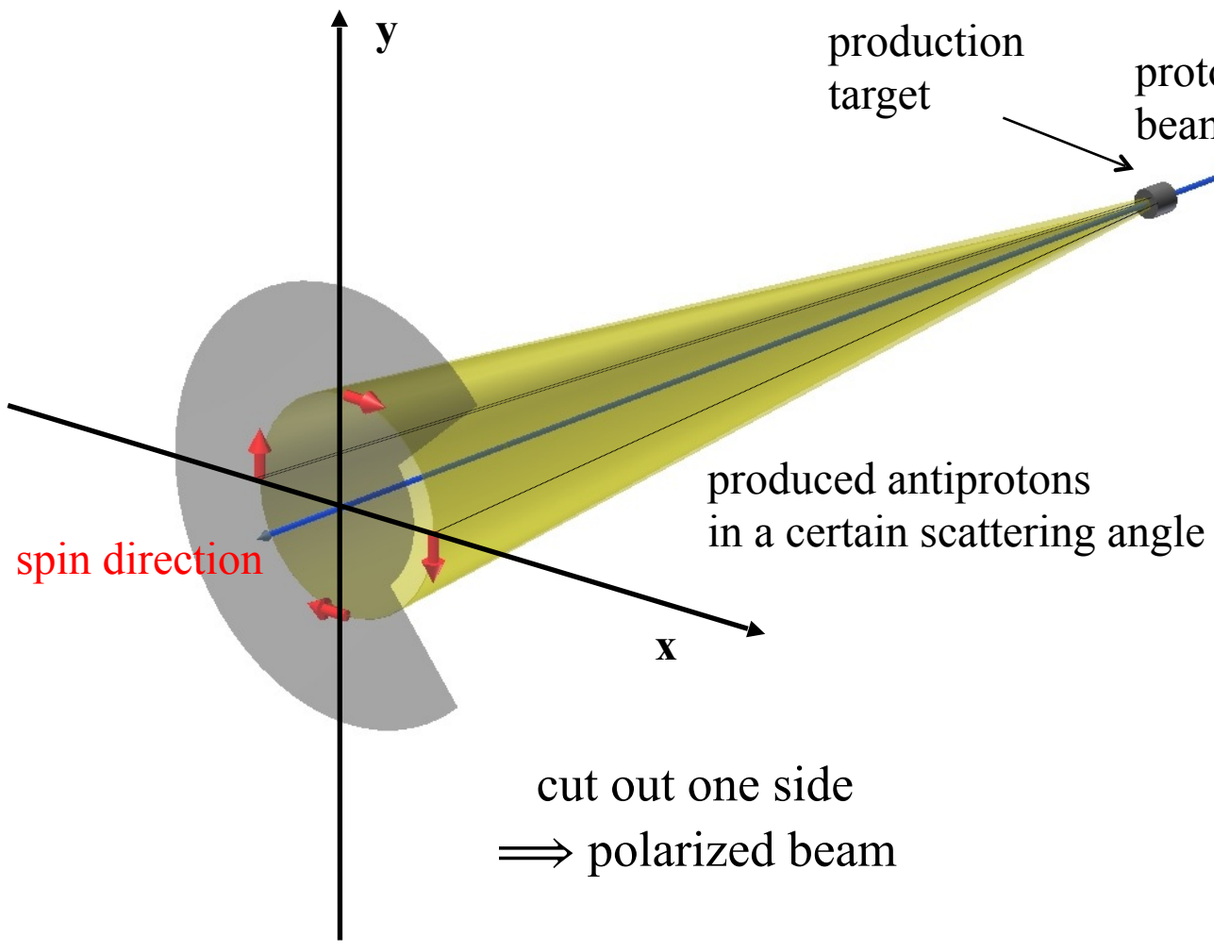
SPSC - 15.10.2019

Motivation

Preparation of a polarized antiproton beam $\Longrightarrow$ requested for specific experiments (e.g. transversity distribution)
allows more detailed analysis

various methods under discussion (e.g. spinfiltering)

simplest method (if production polarized)

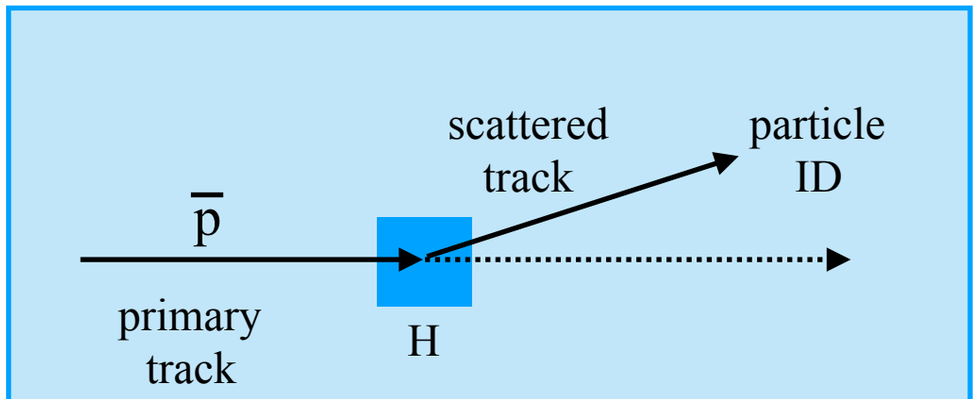


cut out one side
$\Longrightarrow$ polarized beam

experiment:

measurement of the asymmetry
of elastic $\overline{p}$ - p scattering
at known analyzing power

CNI region : Ay = 4.5 %



$d\sigma/(d\theta d\varphi) = d\sigma/d\theta \; (\; 1 + A_y * P * \cos(\varphi) \;)$

Experiment conditions

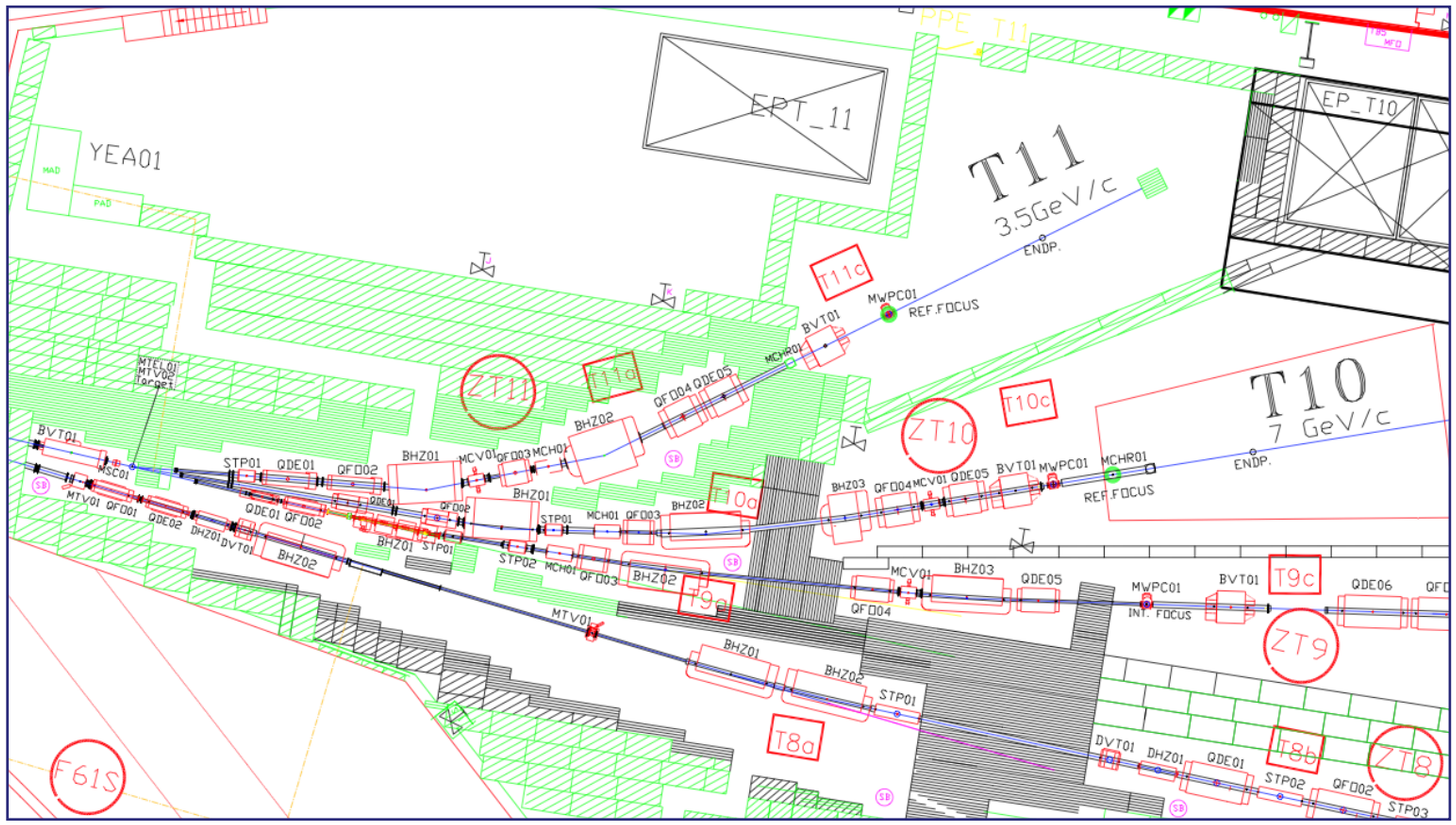
- Production of $\bar{p}$ under useful conditions

$\bar{p}$ momentum ≈ 3.5 GeV/c
($\bar{p}$ production at AD and future FAIR facility)

no s-wave production (θ_{lab} > 56 mrad)

⟹ **<u>T11:</u>** $\bar{p}$ momentum ≦ 3.5 GeV/c (≦ ± 5%)

production angle = 150 mr (±3mrad h, ±10mrad v)

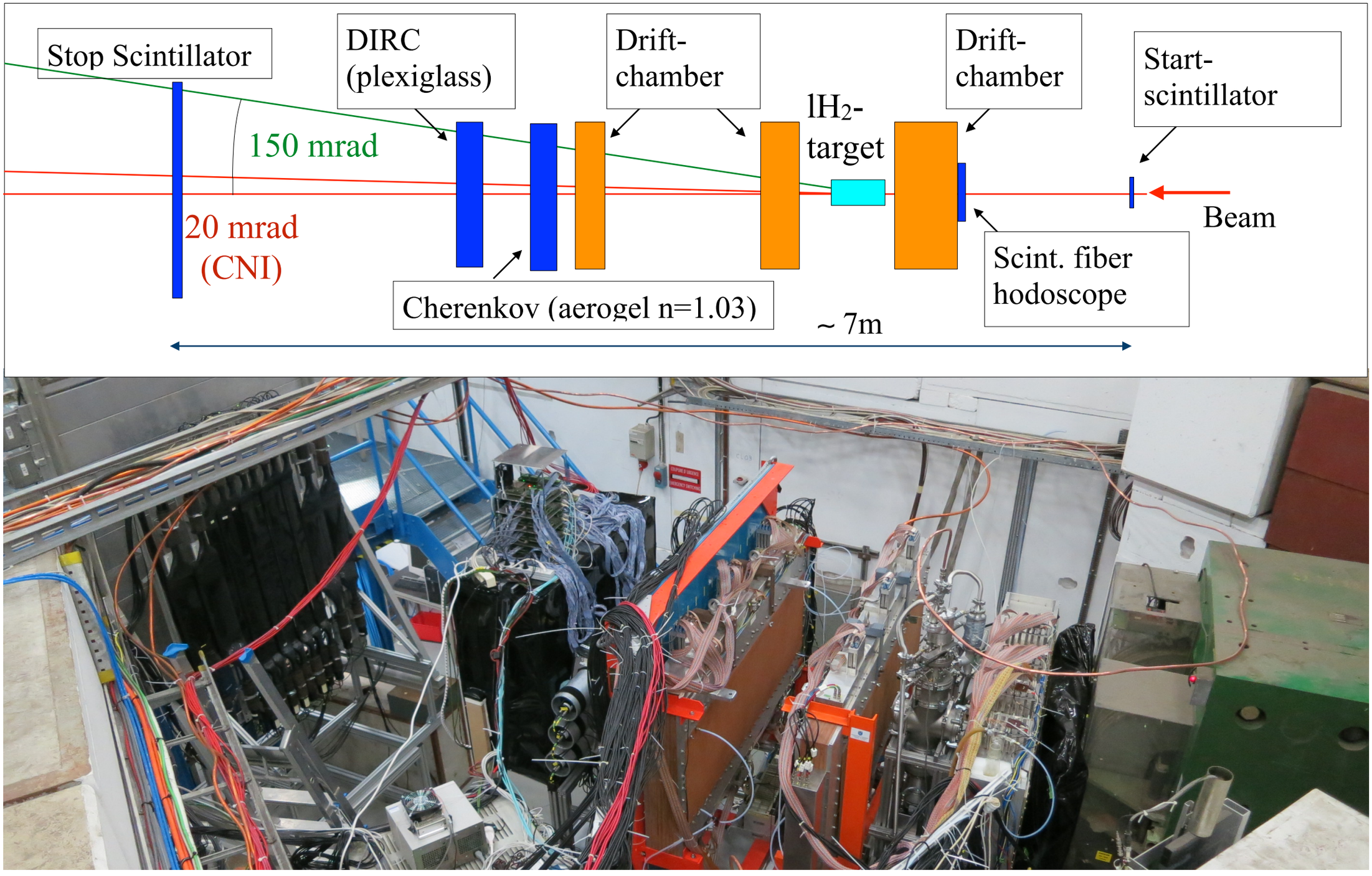


CERN/PS
test beam
east area

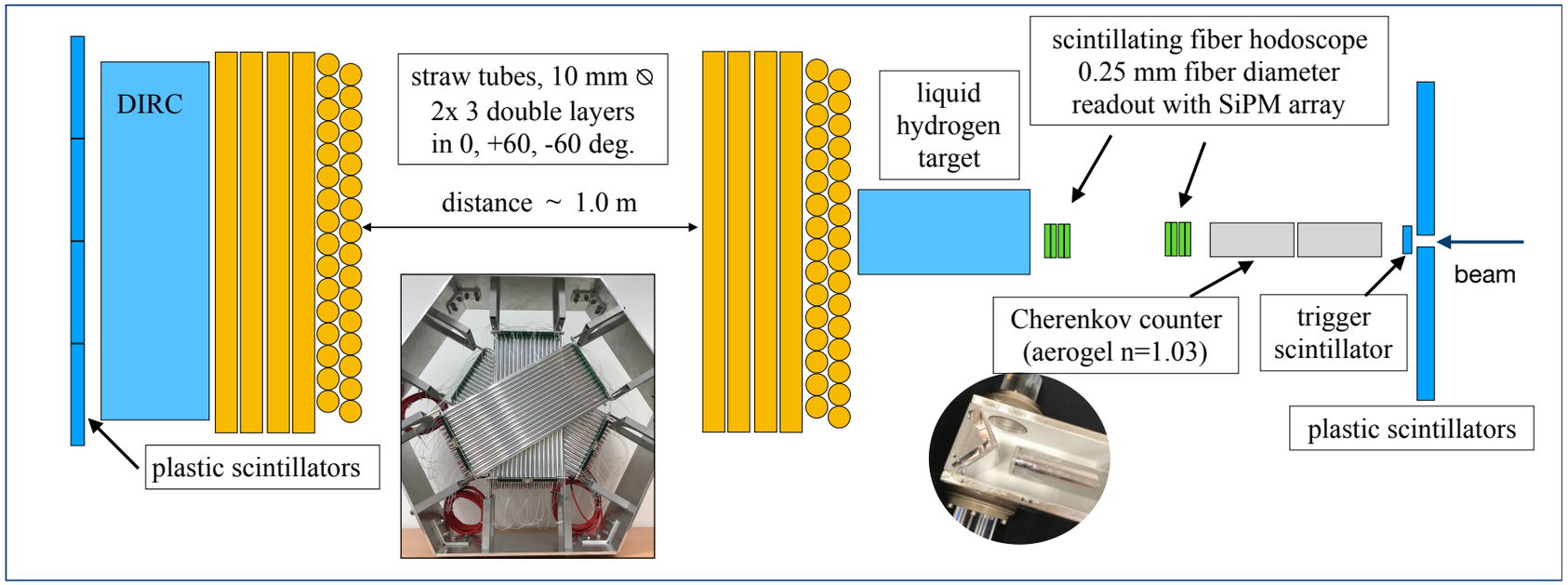
data taking: 7 days 12/2014
14 days 06/2015
5 days 07/2018

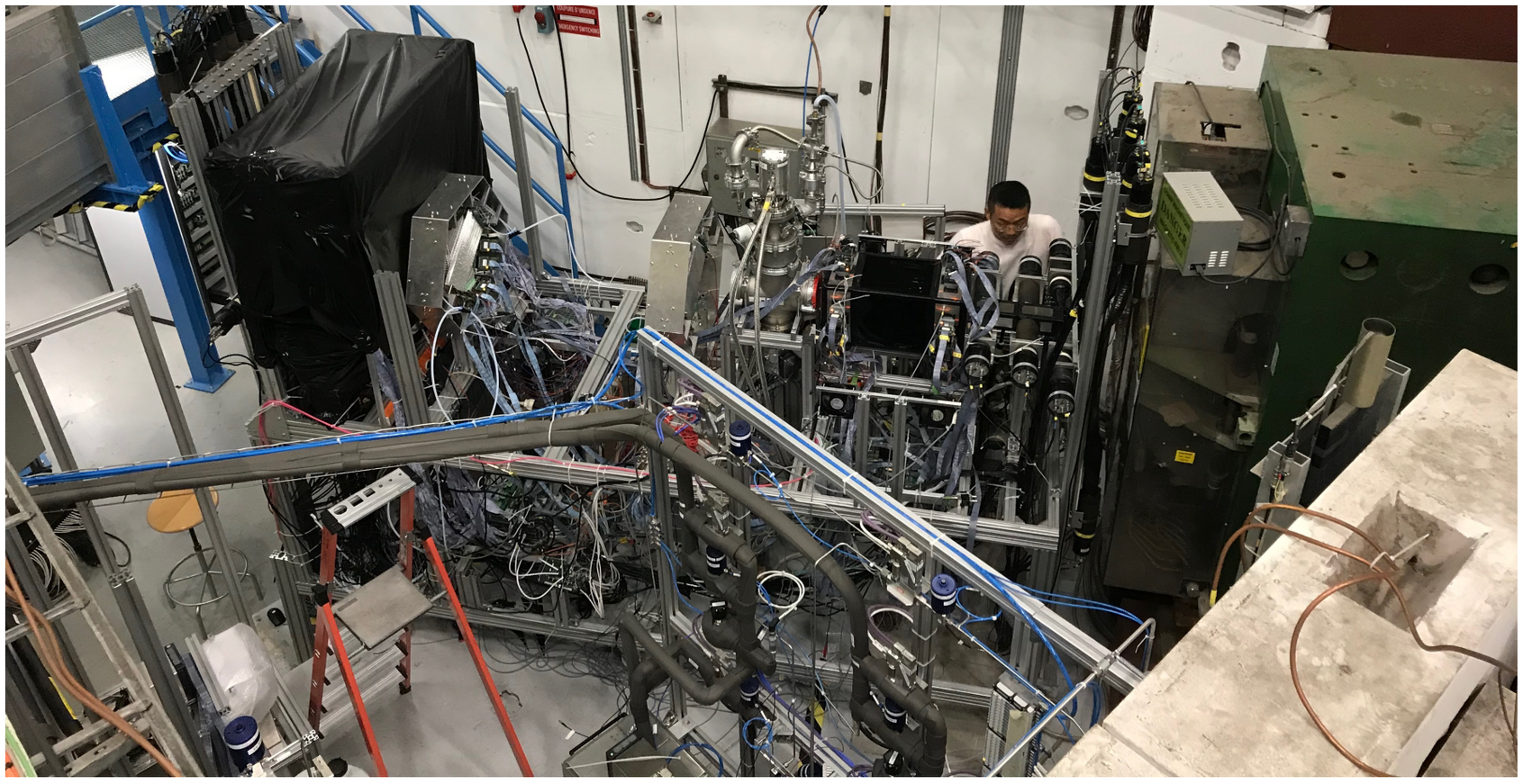
P349 - detection system 2014/2015

Trigger: signal in Startscintillator and Stopscintillator, no signal in Cherenkov (veto)



P349 - detection system July/August 2018



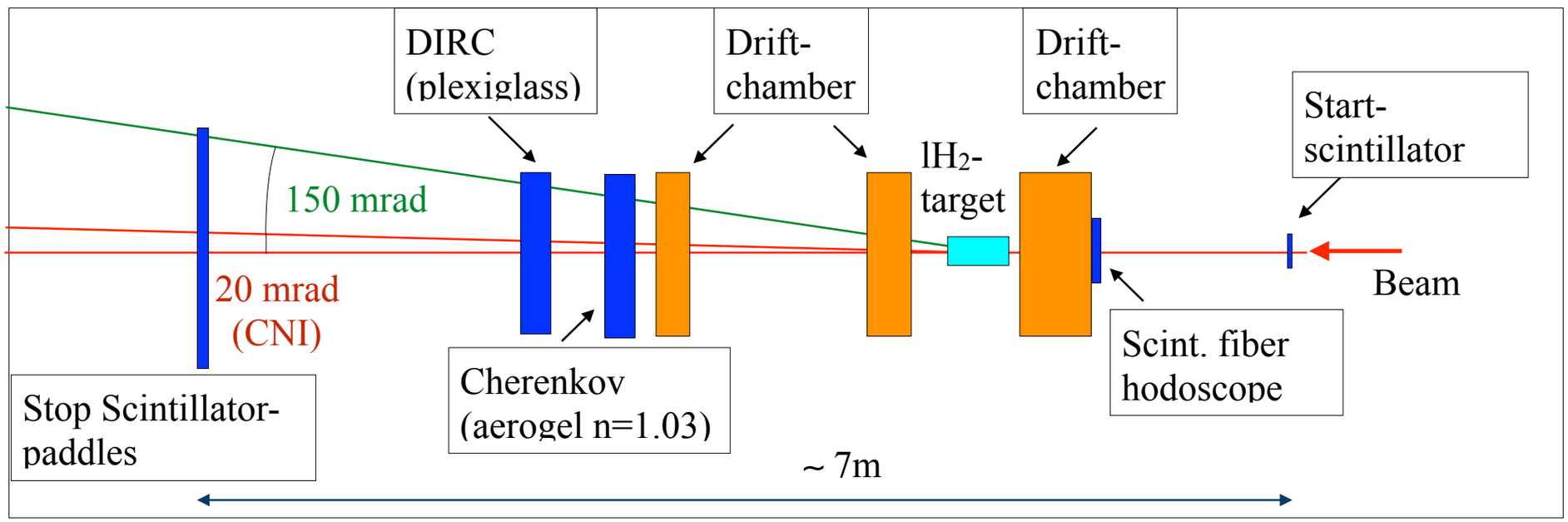


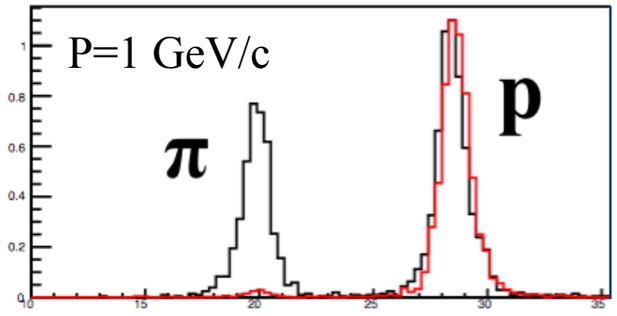
installation at T11

removal of detection system
(all components mounted on one frame)

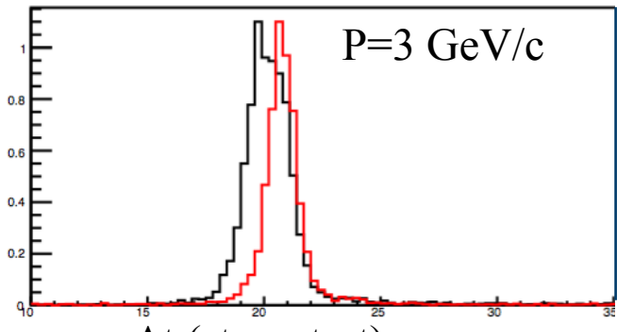
P349 Experiment and analysis

determination of pion reduction





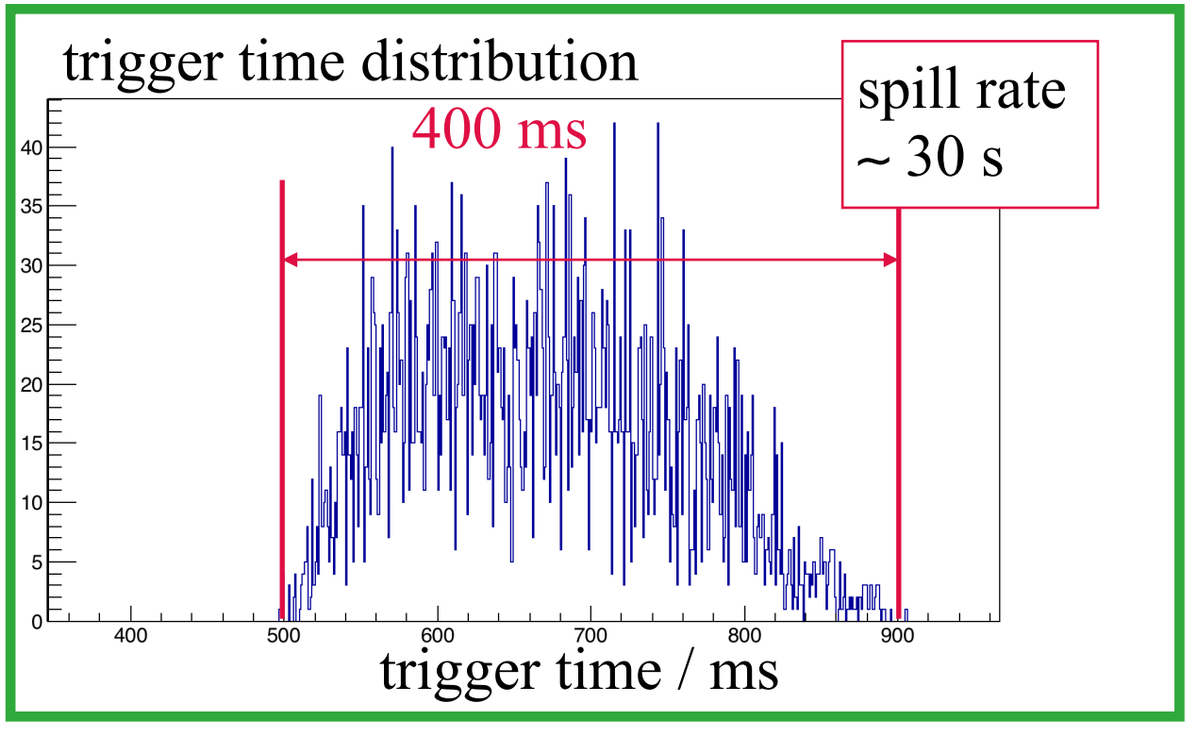
separate datasets:
black: data no Cherenkov veto
red: Cherenkov veto on



Δt (stop-start)

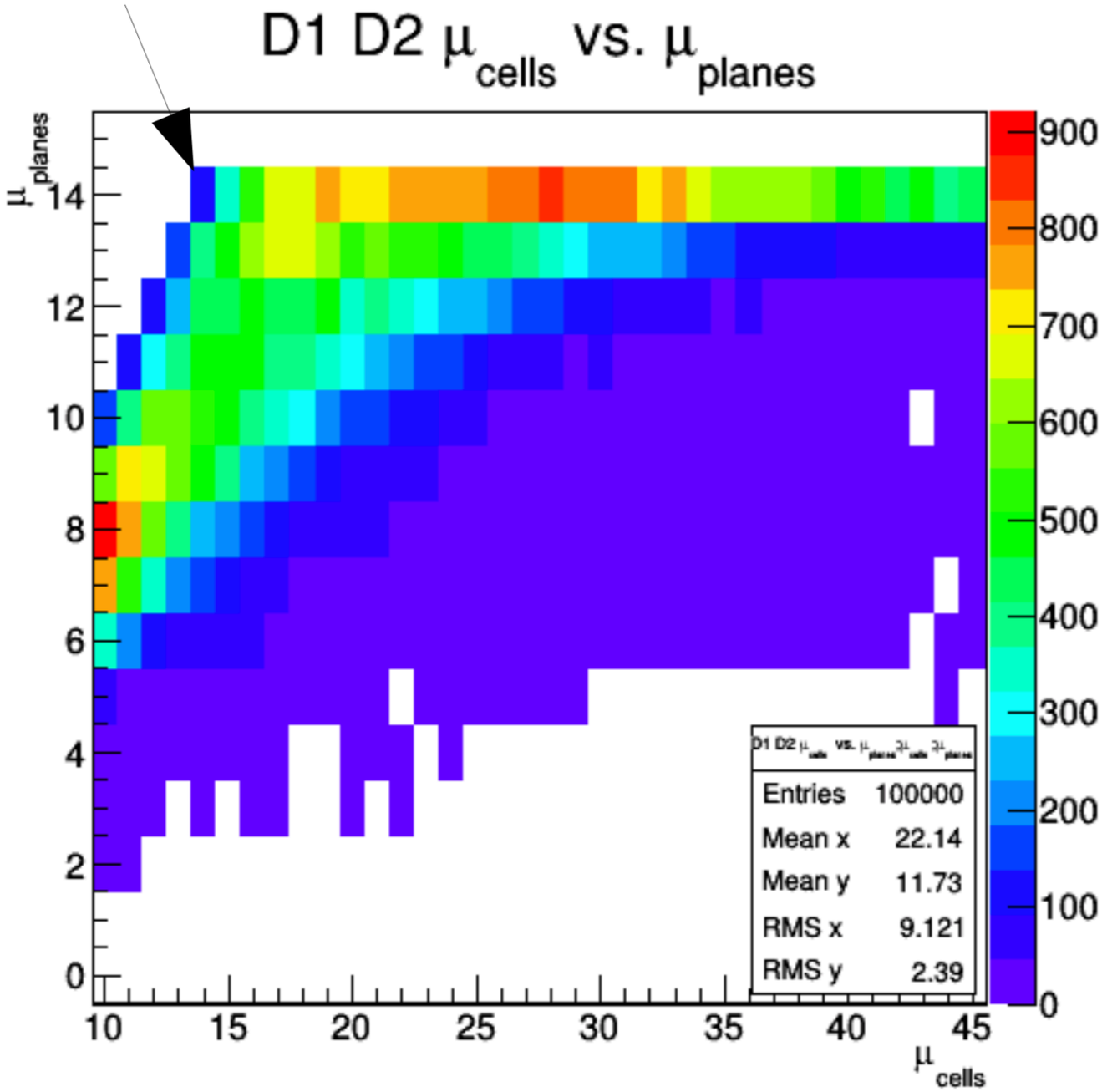
check of Cherenkov veto with p/π+

→ suppression of pions ~ 1/30



Calibration and positioning of drift chambers

$\Longrightarrow$ selection of perfect tracks,
i.e. one hit in each dc-plane (14 cells, 14 planes)



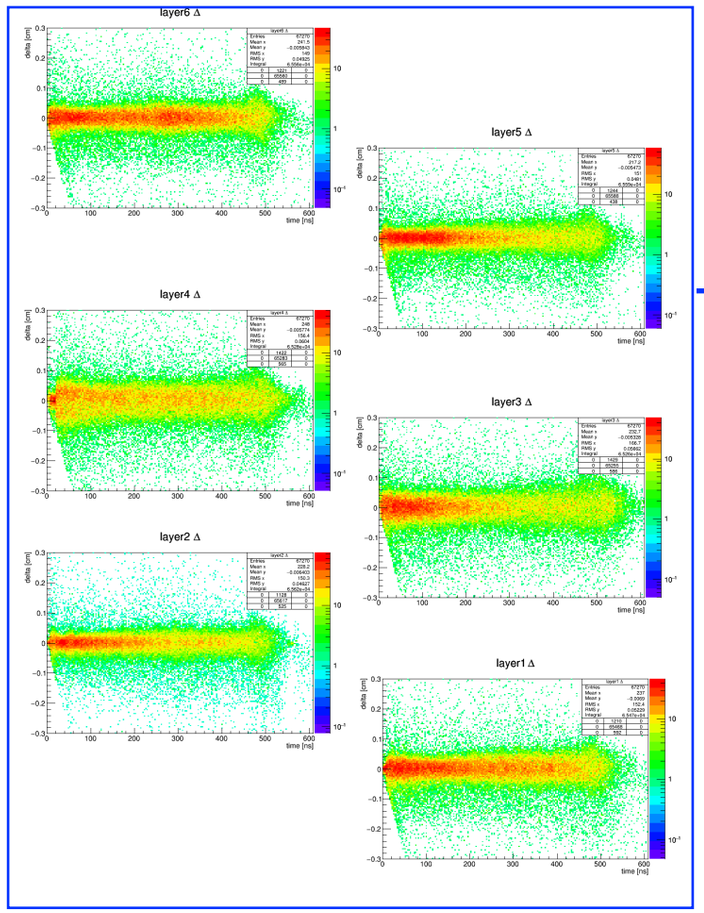
Multiplicity distribution of drift chamber signals

after perfect calibration and positioning

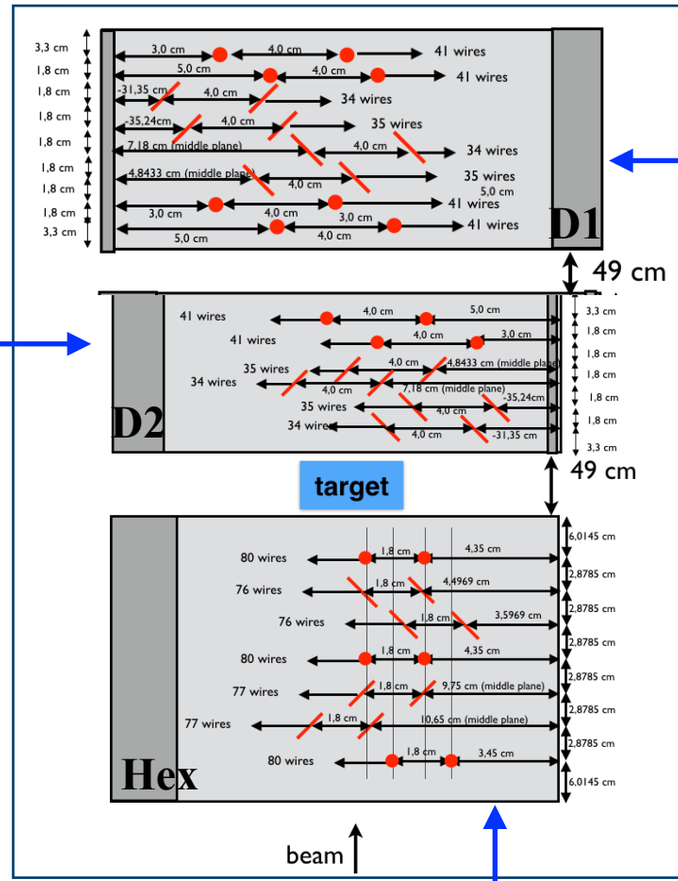
removal of background signals

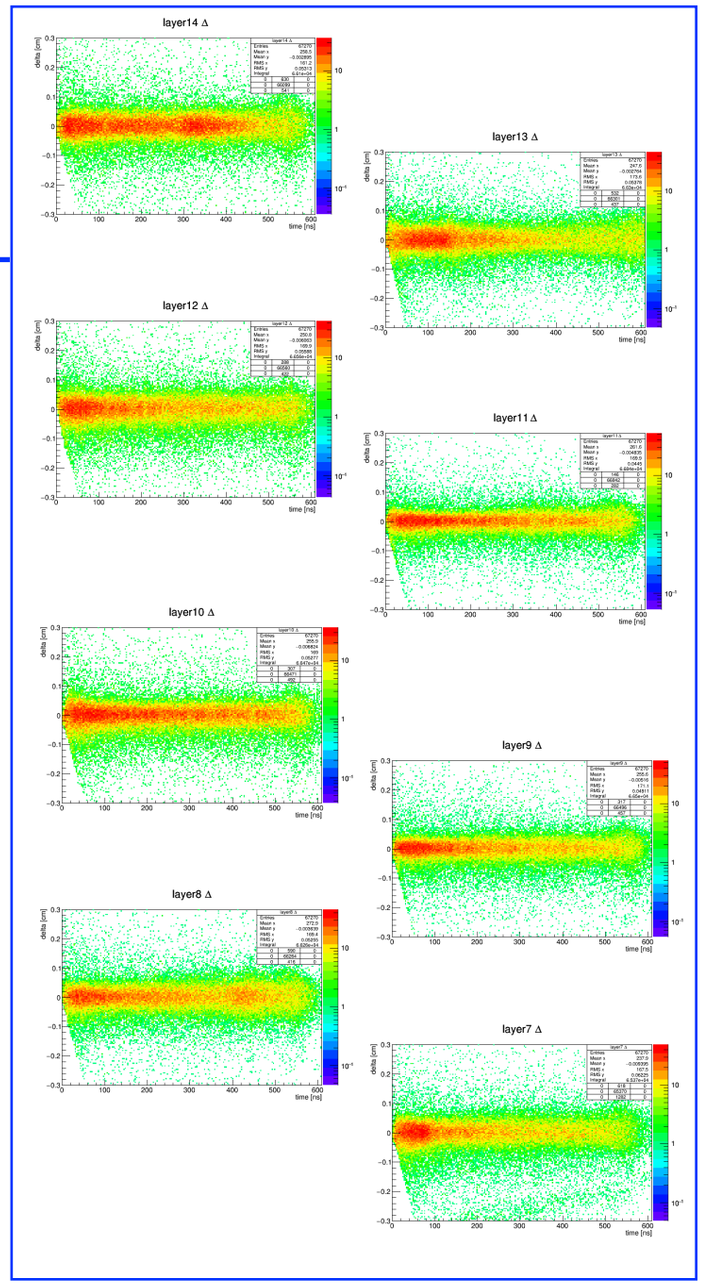
track reconstruction of all events with at least
1 vertical and 1 inclined wire signal in D1 and D2

Drift chamber Calibration



residuals of separate dc-planes



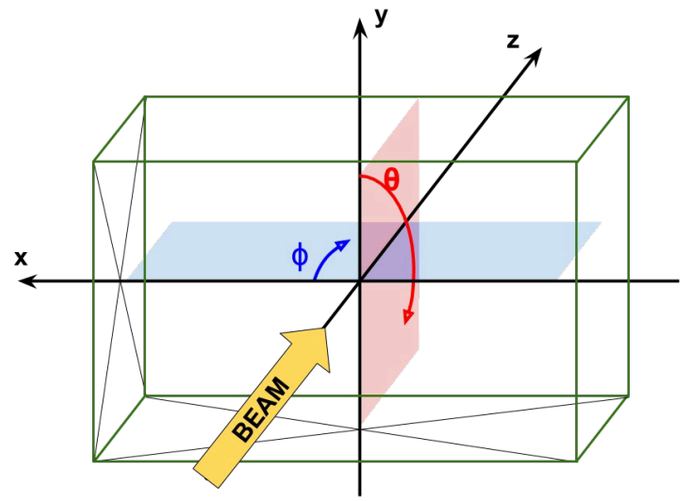


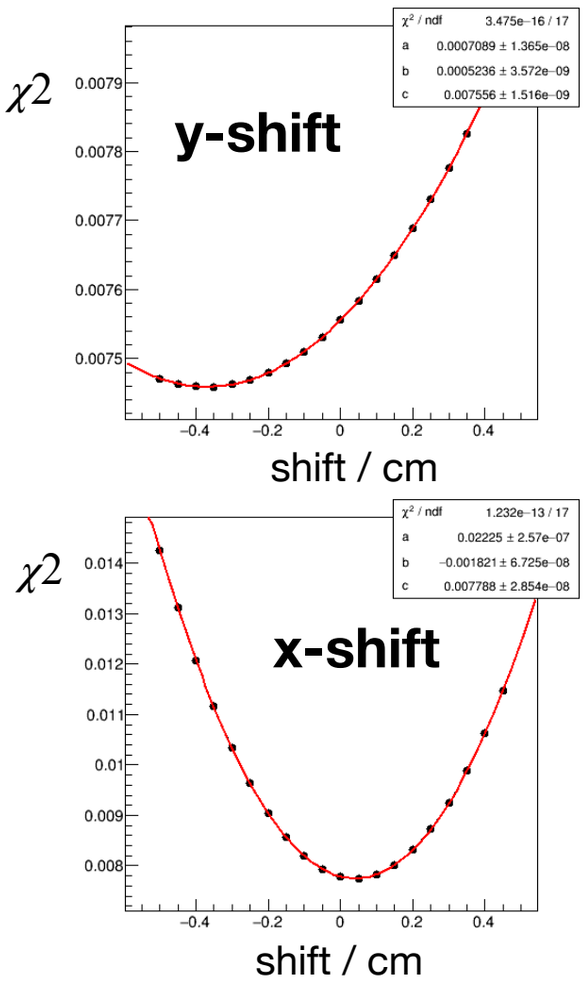
Position resolution (σ): 150 - 300 **µ**m

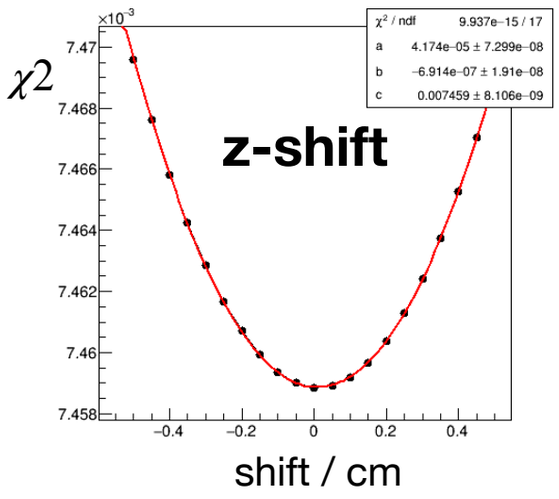
⇨ expected track resolution: < 1 mrad

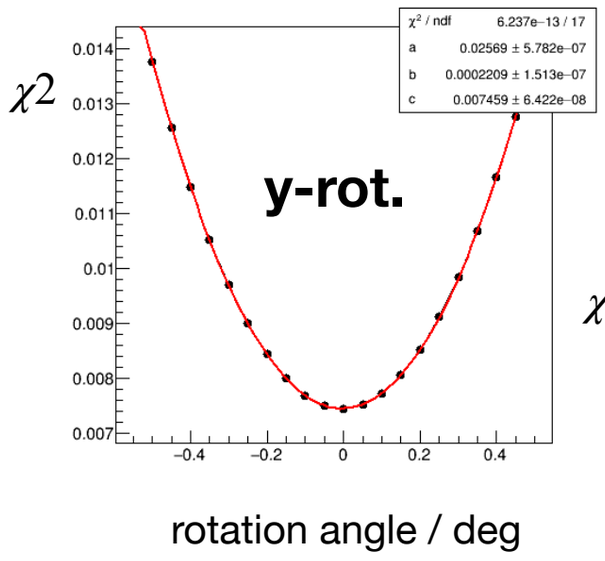
DC Positioning

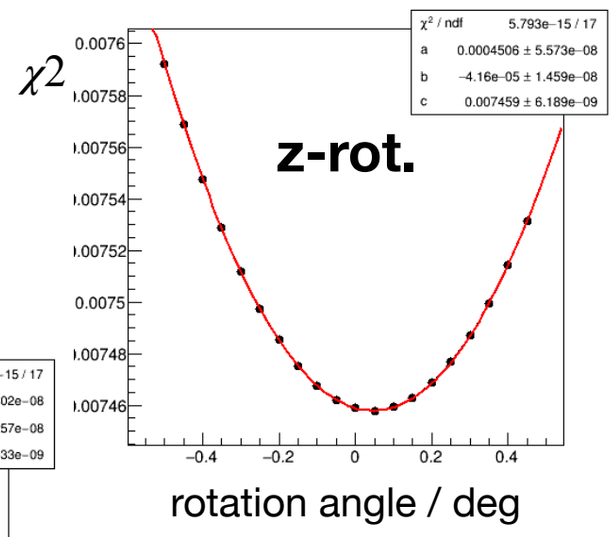
D2 is shifted/rotated relative to D1
determine mean $\chi 2$ for track fit
as a function of shift

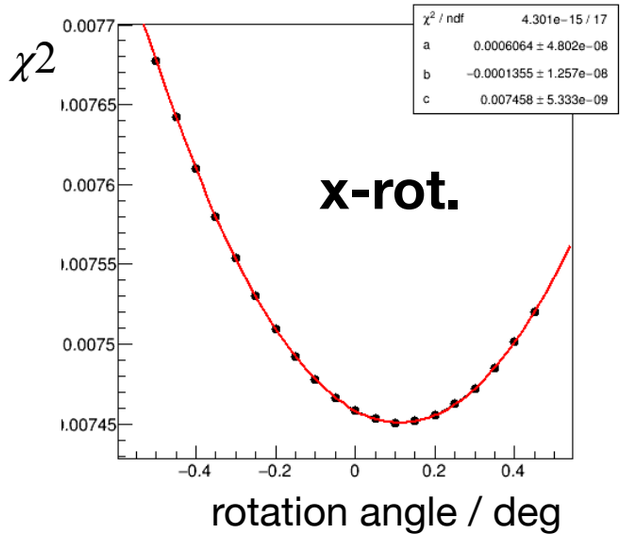








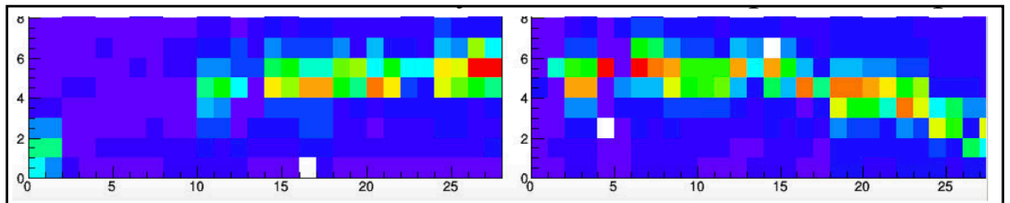




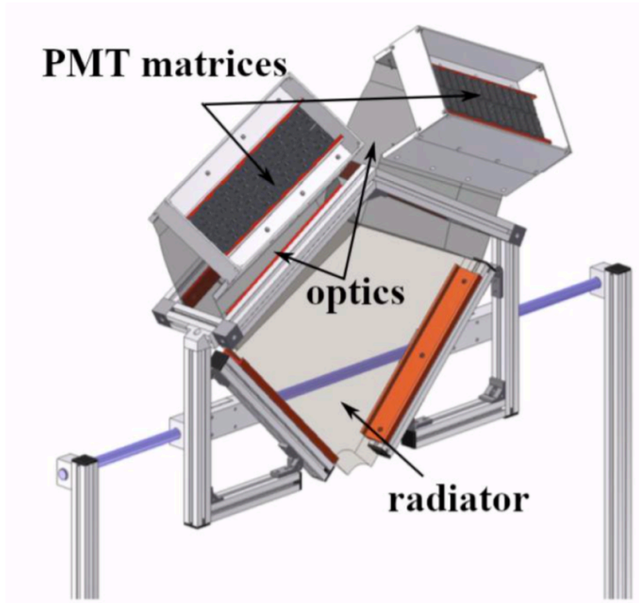
track reconstruction precision
sufficient for positioning

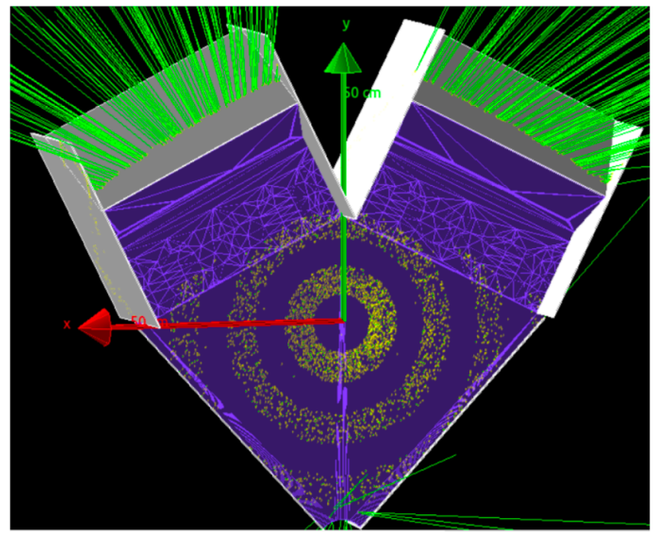
Particle ID

distribution of Cherenkov photons in DIRC



hit pattern of an event sample of one spill

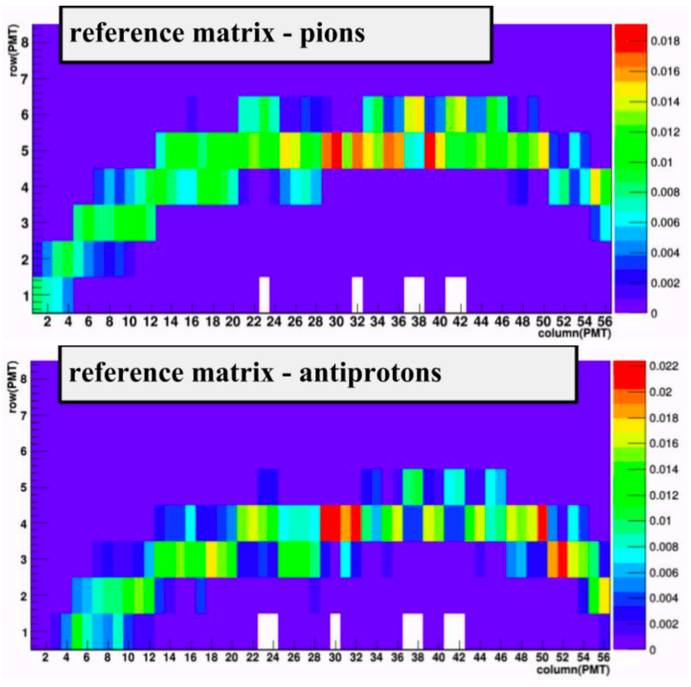




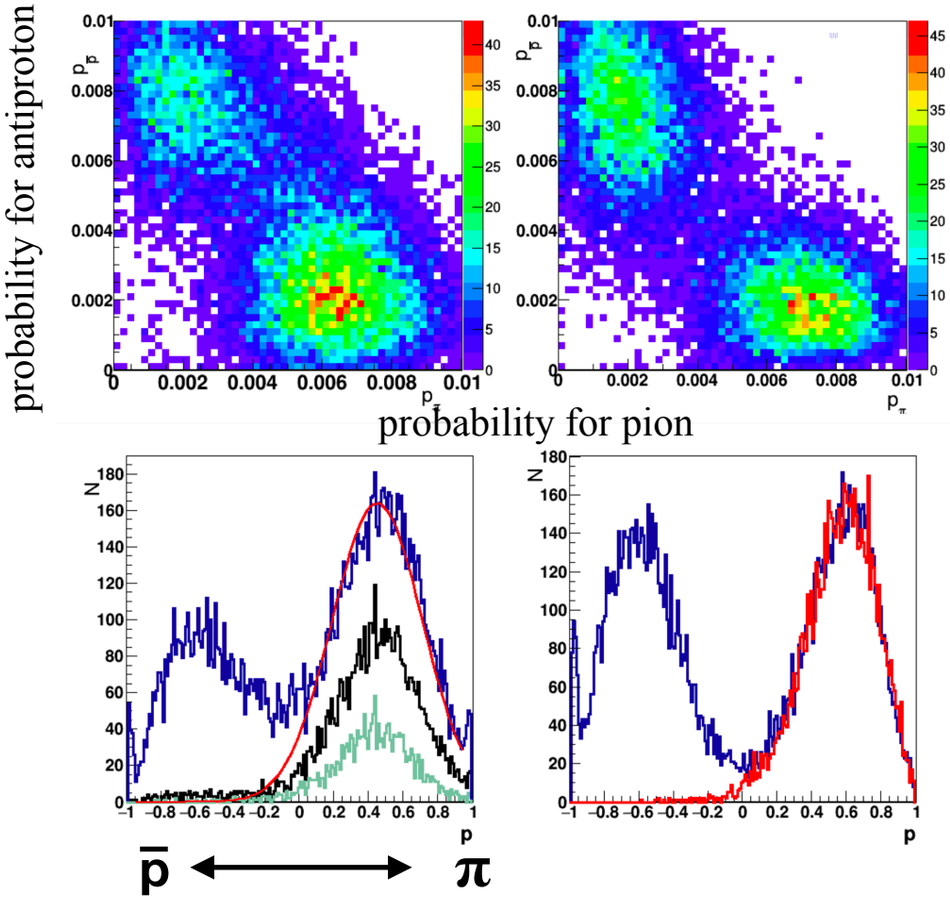
$\overline{p}$-selection: position and angular dependent
Cherenkov arc reconstruction (MC supported)

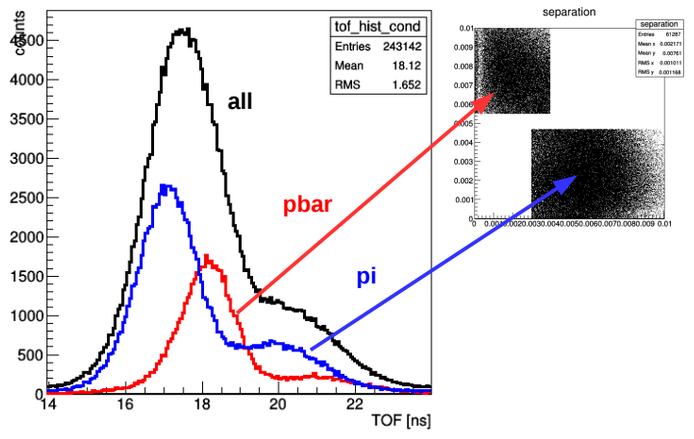
---

generation of reference matrices
for pion and antiproton (GEANT4)



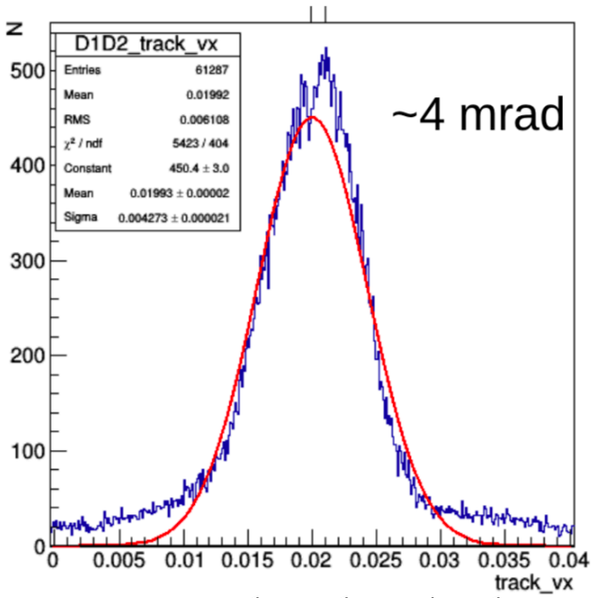
Data **MC**



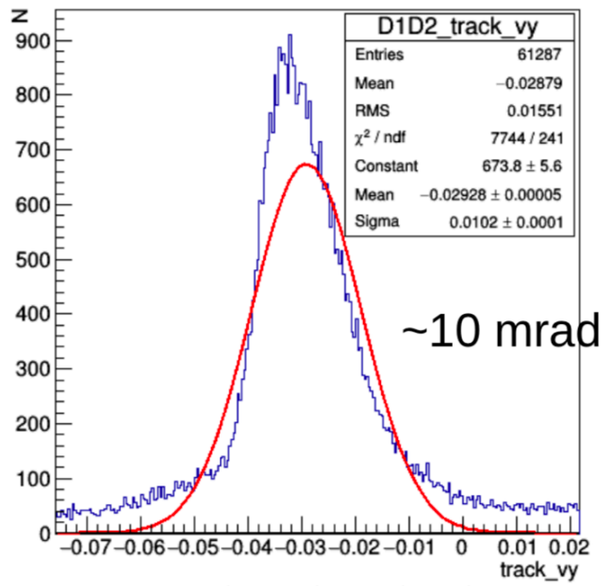


Δt(start-stop)

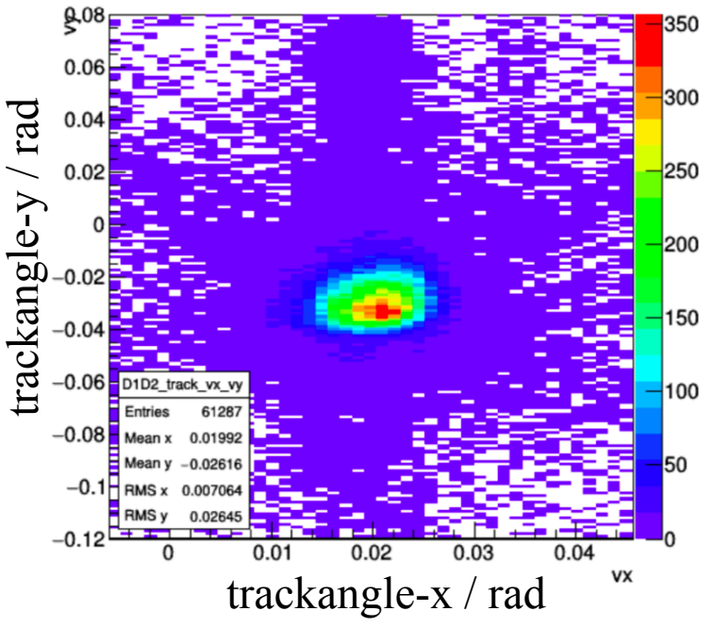
$\overline{P}$ - tracks from D1/D2



trackangle-x / rad



trackangle-y / rad



consistent with T11 beam parameters: $\sigma_{x'} = 3.89$ mrad, $\sigma_{y'} = 8.43$ mrad

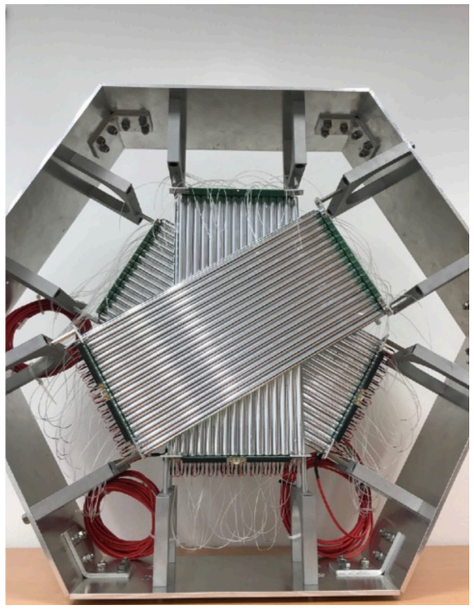
---

in general all components work but:

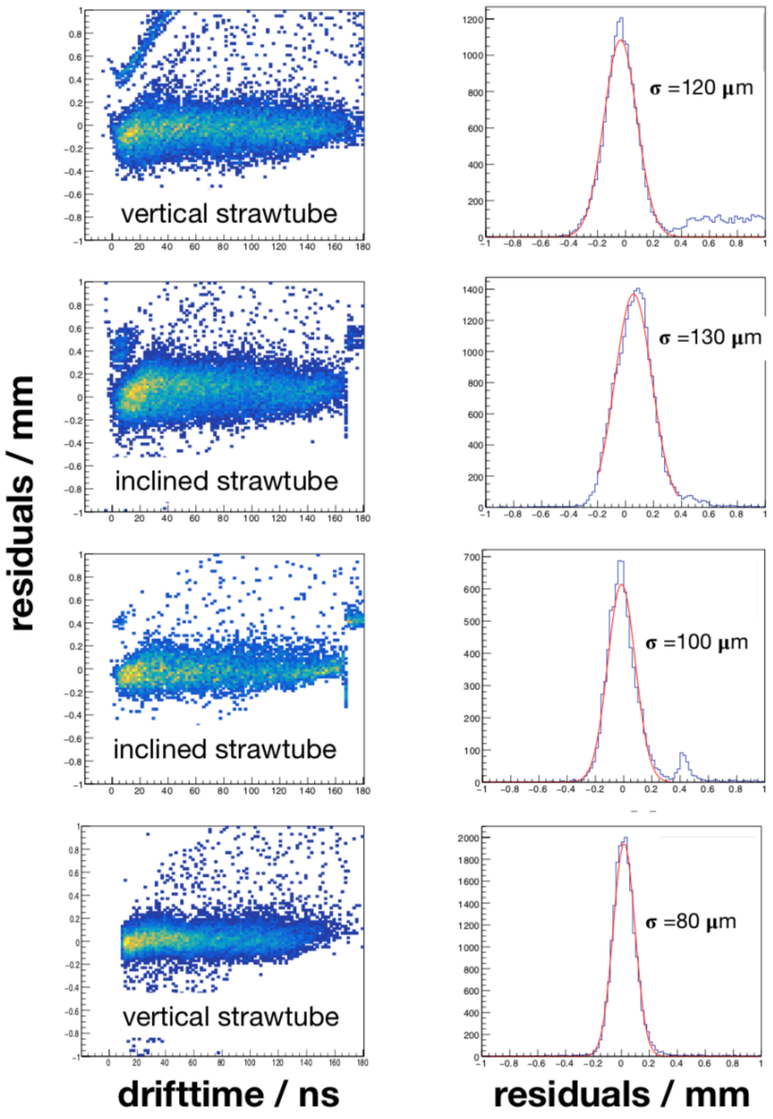
high background (multiple particles, additional sources due to scattered particles,…),
beam condition changes,
change of detector positioning,
low efficiency,
…

Data from 2018

Straw-tubes for tracking



position resolution:
$\sigma = 100 - 150\ \mu m$



many problems
during beam time with:
data acquisition and
detector components

$\Longrightarrow$ effectively ~ 5 days data taking

tracking with straw-tubes worked
very good,
but fiber detector shows low efficiency

achieved statistics

assumed (proposal): at T11 (p = 3.5 GeV/c): $5 \cdot 10^5$ particles/spill, 4000 $\bar{p}$/spill
4000 spills/day (spill every 22 s)
21 days beam time

$\Longrightarrow$ 4.2 · 10^{10} particles , 3.3 · 10^8 $\bar{p}$

estimate event sample (data):
3 days: $5.5 \cdot 10^7$ particles (triggered events), $6 \cdot 10^4$ $\bar{p}$
21 days (2014/2015): $3.8 \cdot 10^8$ x 30 (pion reduction) = $1.2 \cdot 10^{10}$ particles
5 days (2018): $2.4 \cdot 10^8$ x 30 (assumed pion reduction) = $7 \cdot 10^9$ particles

$\Longrightarrow$ 1.9 · 10^{10} particles statistics: 50% of required events

estimate reconstructed $\bar{p}$:
3 days: $6 \cdot 10^4$ $\bar{p}$
26 days (2014/2015/2018): **$5.2 \cdot 10^5$ $\bar{p}$**

antiproton numbers drastically too low

improvement still possible

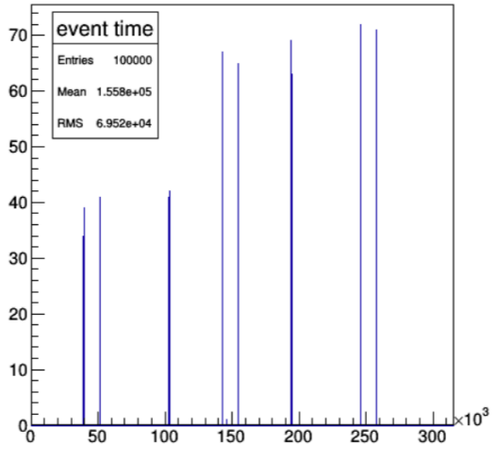
<u>event reduction due to applied cuts:</u>

triggered events	:	100 000	all particles
start & stop signal	:	> 20 000	single hit start&stop
DIRC signals		>2 500	antiprotons
track reconstruction	:	>300	antiproton tracks

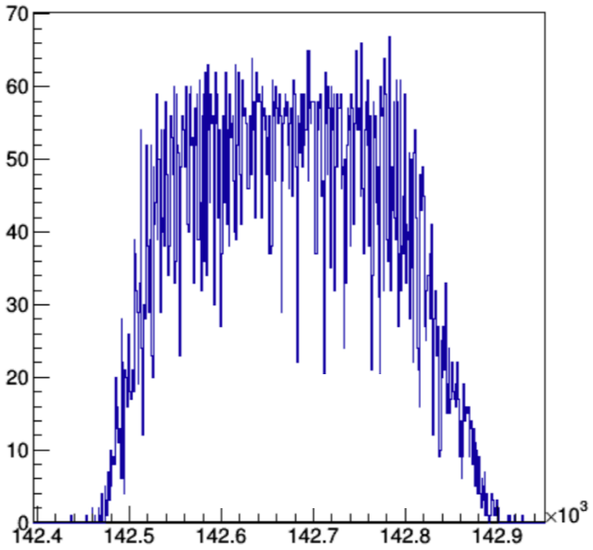
achieved statistics

drastic reduction not obvious in the beginning:

sample of 100 000 triggered events

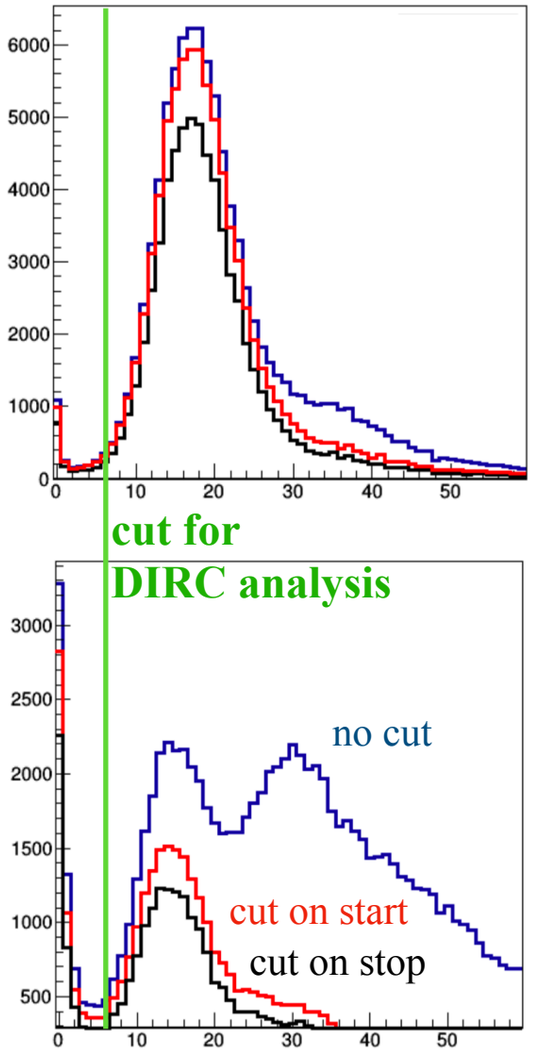


8 spills
$\Longrightarrow$ 12 500 events/spill
with reduction factor 30
due to Cherenkov veto
375 000 particles
roughly consistent with
assumed rate



homogeneous event
distribution in spill

$\Longrightarrow$ event rate
10^6 events/s
close to limit



DIRC PM signals

multiplicity
distribution
of DIRC
PM-signals
for different
beam conditions

with cut at >=6
high efficiency

extraction of tracks and antiproton events
requires final analysis

next steps:

complete analysis of all data

new measurement?

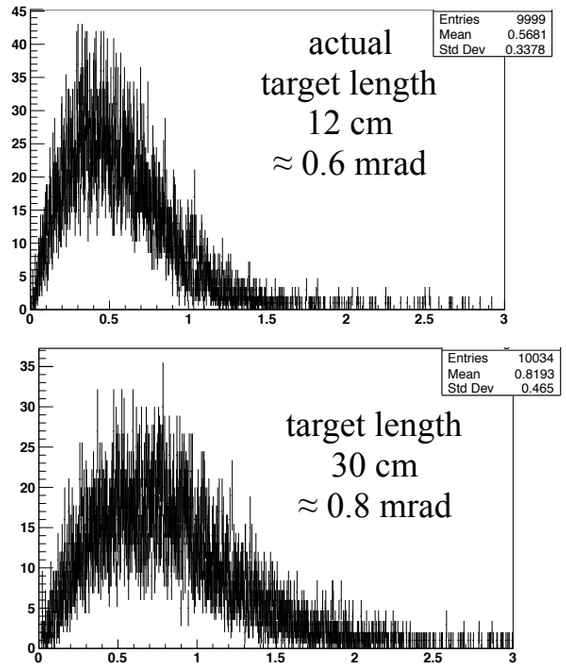
if antiproton rate can be significantly increased

$\Longrightarrow$ increase target volume
increase pion reduction factor
increase efficiency of all detector components to 100%

possible procedure:

improve detection system
test with proton beam at COSY
if requested statistics can be achieved
(based on knowledge from data analysis)
beam time request at T11

straggling increase
due to increased
target length



straggling angle at target exit