

NA61/SHINE facility beams and detector system

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NA61/SHINE Physics Programme

SHINE — SPS Heavy Ion and Neutrino Experiment

The physics programme of the NA61/SHINE:

- Strong interaction:
 - Study of the onset of deconfinement
 - Search for the critical point
- Neutrino:
 - Precise particle spectra measurements for neutrino flux estimation
- Cosmic Rays:
 - Measurements for corrections of cosmic ray showers simulations

Beams, targets and data taking

Possible beams:

- Hadrons:
 - Primary protons at 400 GeV/c
 - Secondary (π , K, p) at 13–350 GeV/c
- Ions:
 - Primary: Ar, Xe, Pb at 13A–150A GeV/c
 - Secondary from Pb fragmentation (e.g. Be) at 13A–150A GeV/c

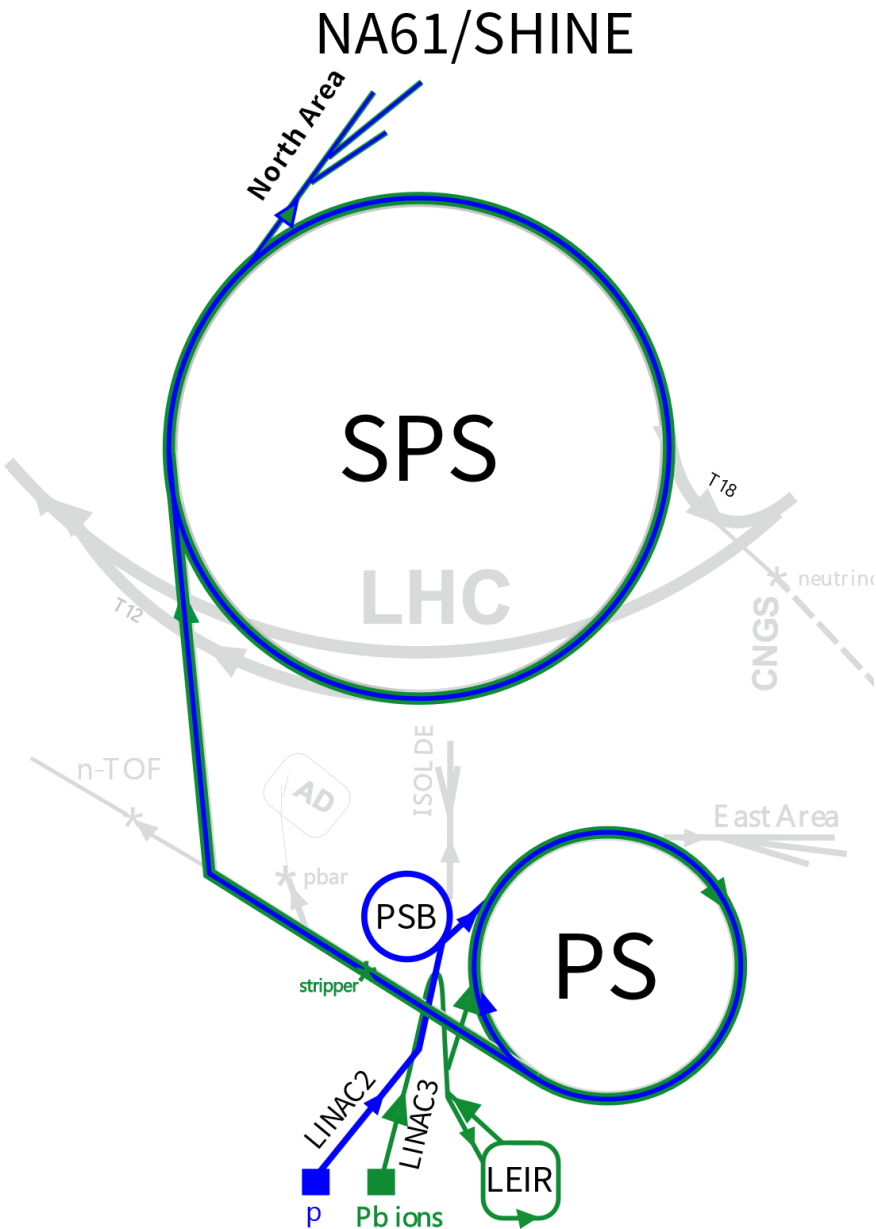
Targets:

- Almost any solid state (from 500 μm to 1 m)
- Liquid hydrogen (20 cm)

Data taking speed:

- More than 500 000 events per day

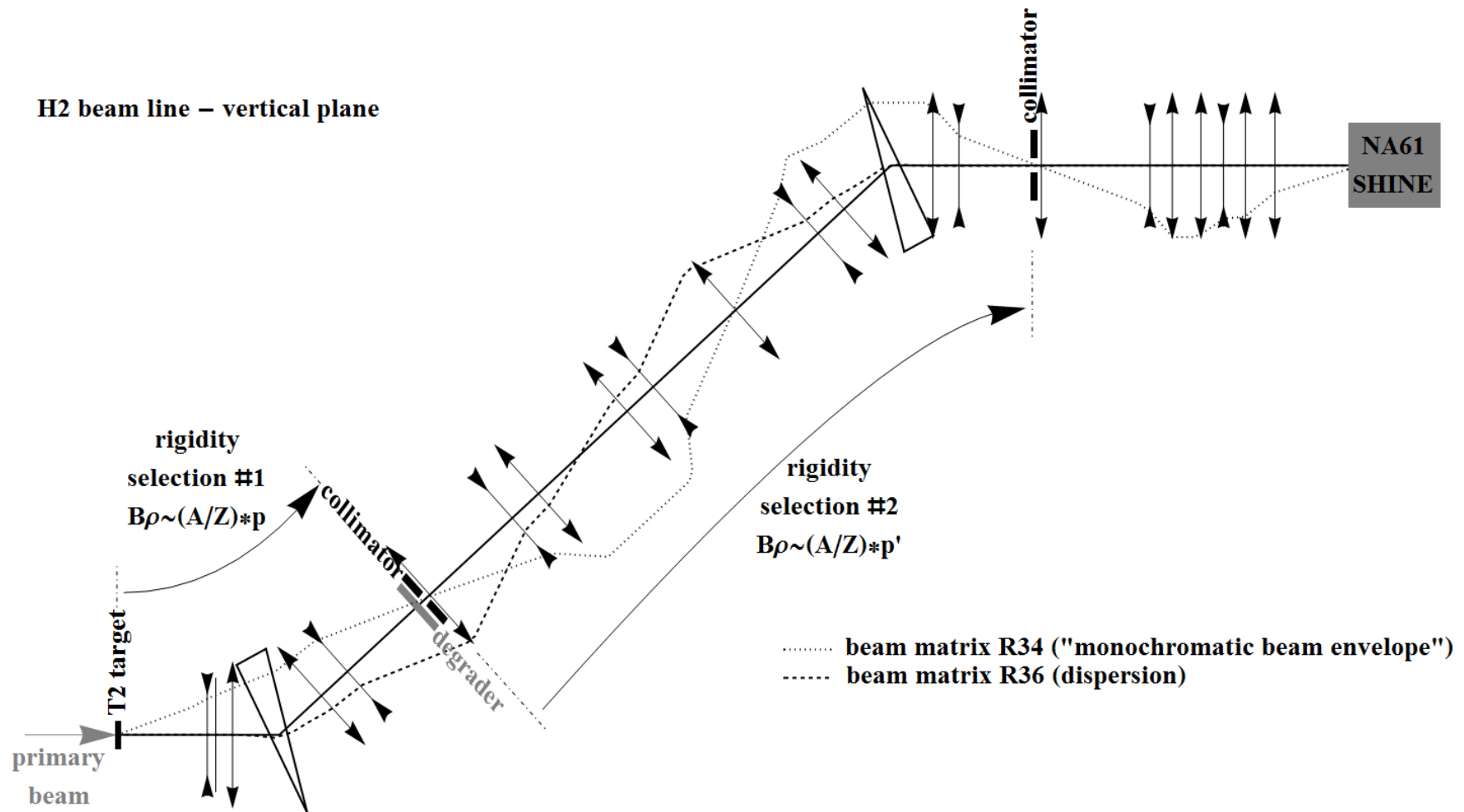
CERN Accelerator Chain



Multi-stage accelerator chain:

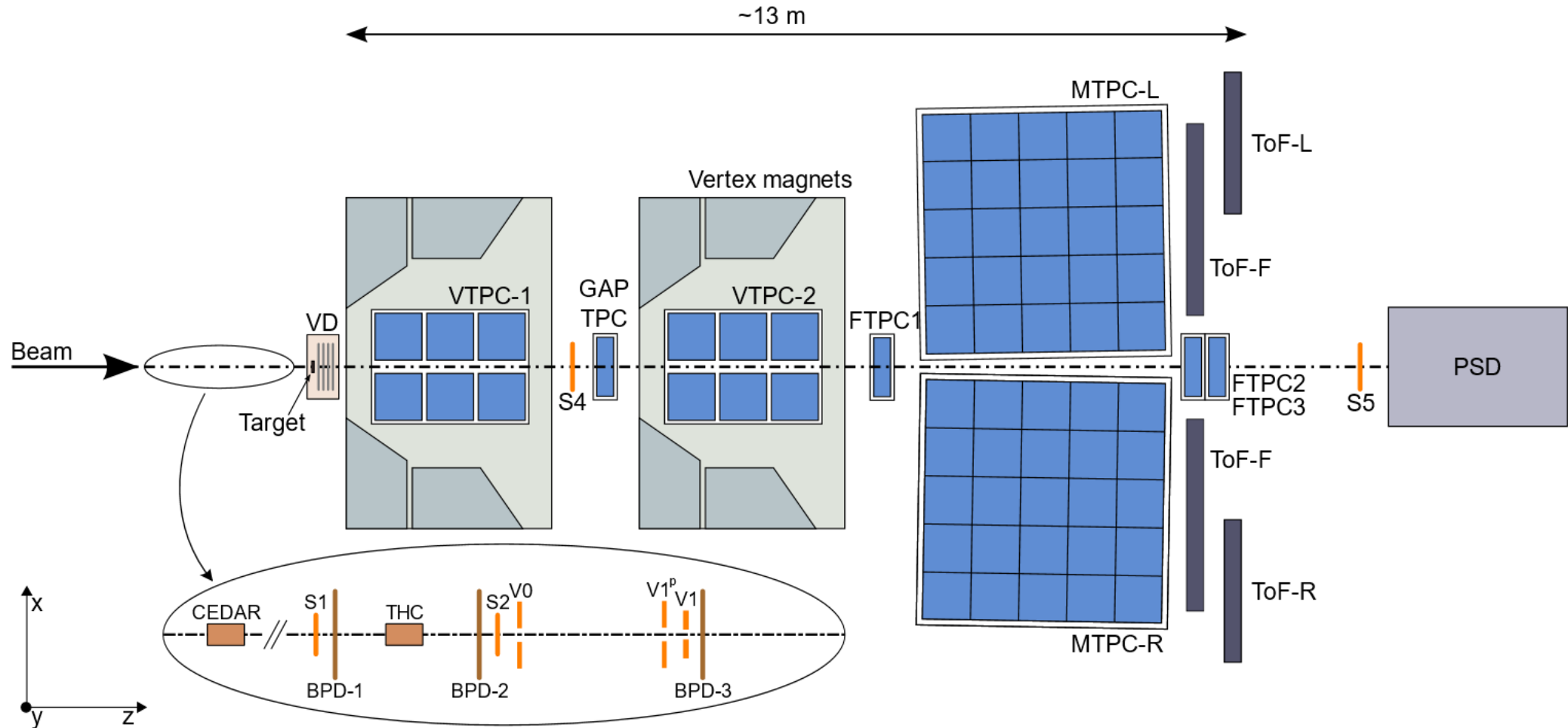
- Protons:
 - LINAC2 to 50 MeV
 - PS Booster to 1.4 GeV
 - PS to 14 GeV/c
 - SPS to 400 GeV/c
- Ions (Pb):
 - LINAC3 to 4.2A MeV
 - LEIR to 72A MeV
 - PS to 5.9A GeV
 - SPS to 160A GeV
- 5–10 s extraction to the North Area

H2 Beamline

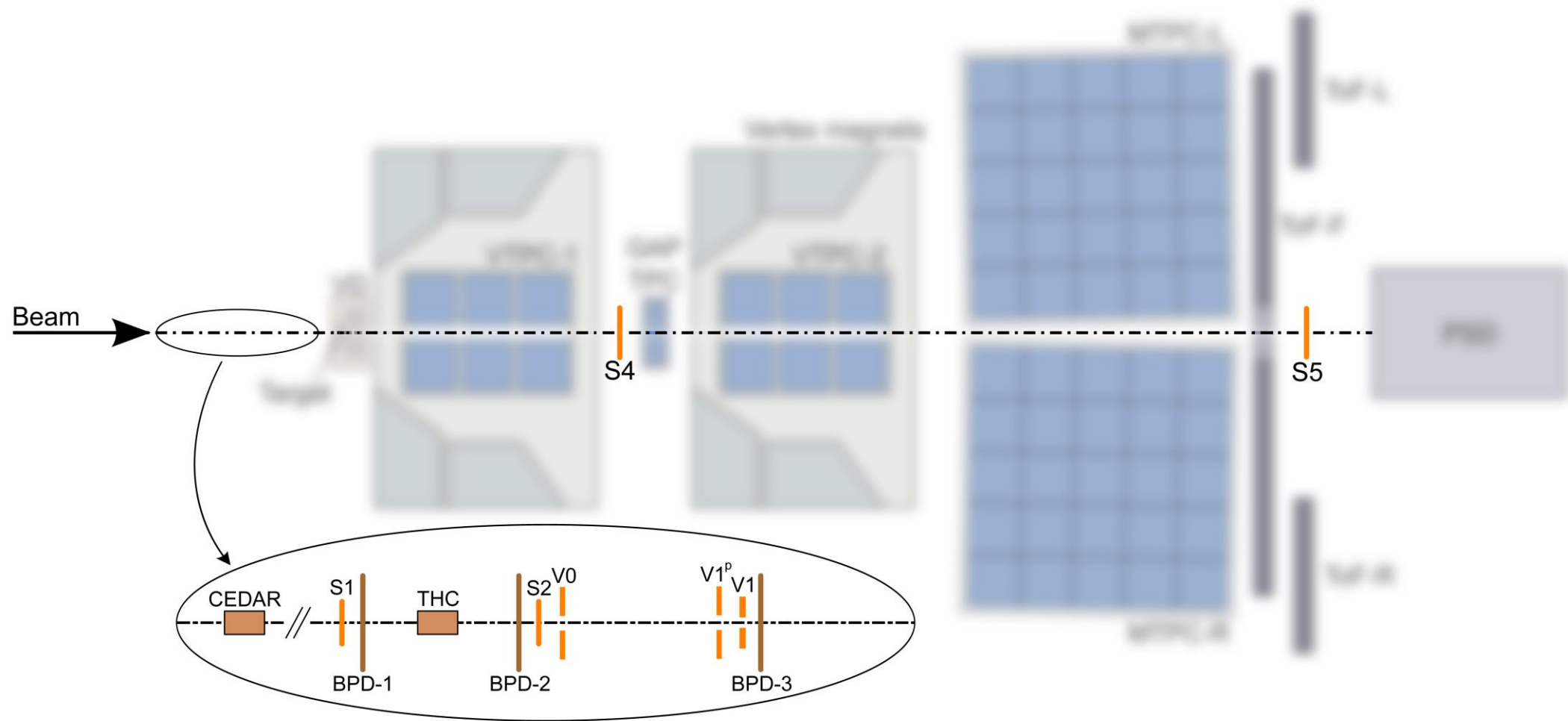


The beamline is used for momentum and charge selection as well as nuclear fragments separation

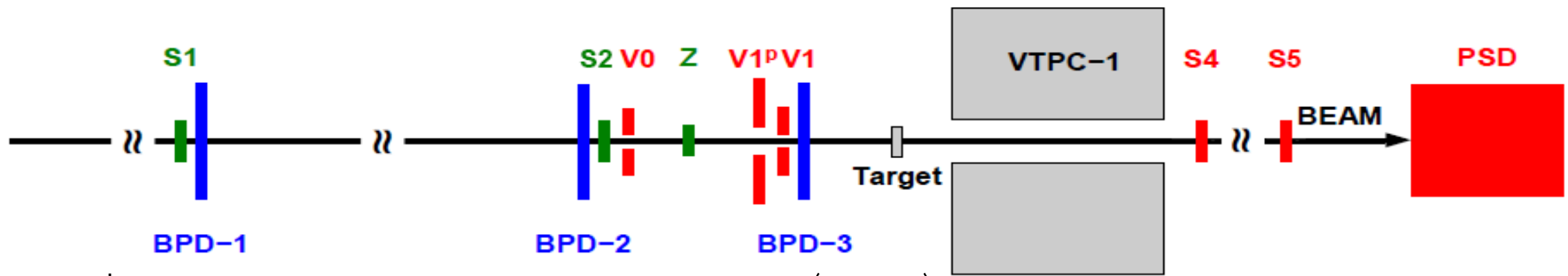
NA61/SHINE Detector



NA61/SHINE — Beam and Trigger Detectors

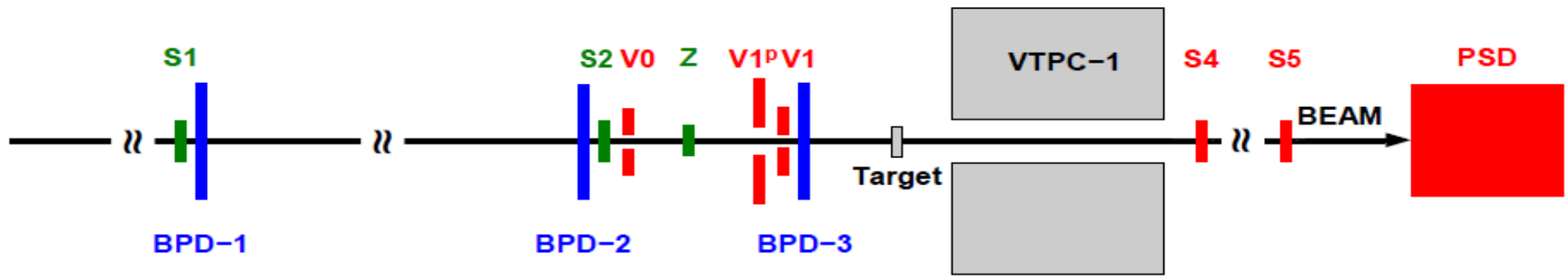


NA61/SHINE — Beam and Trigger Detectors



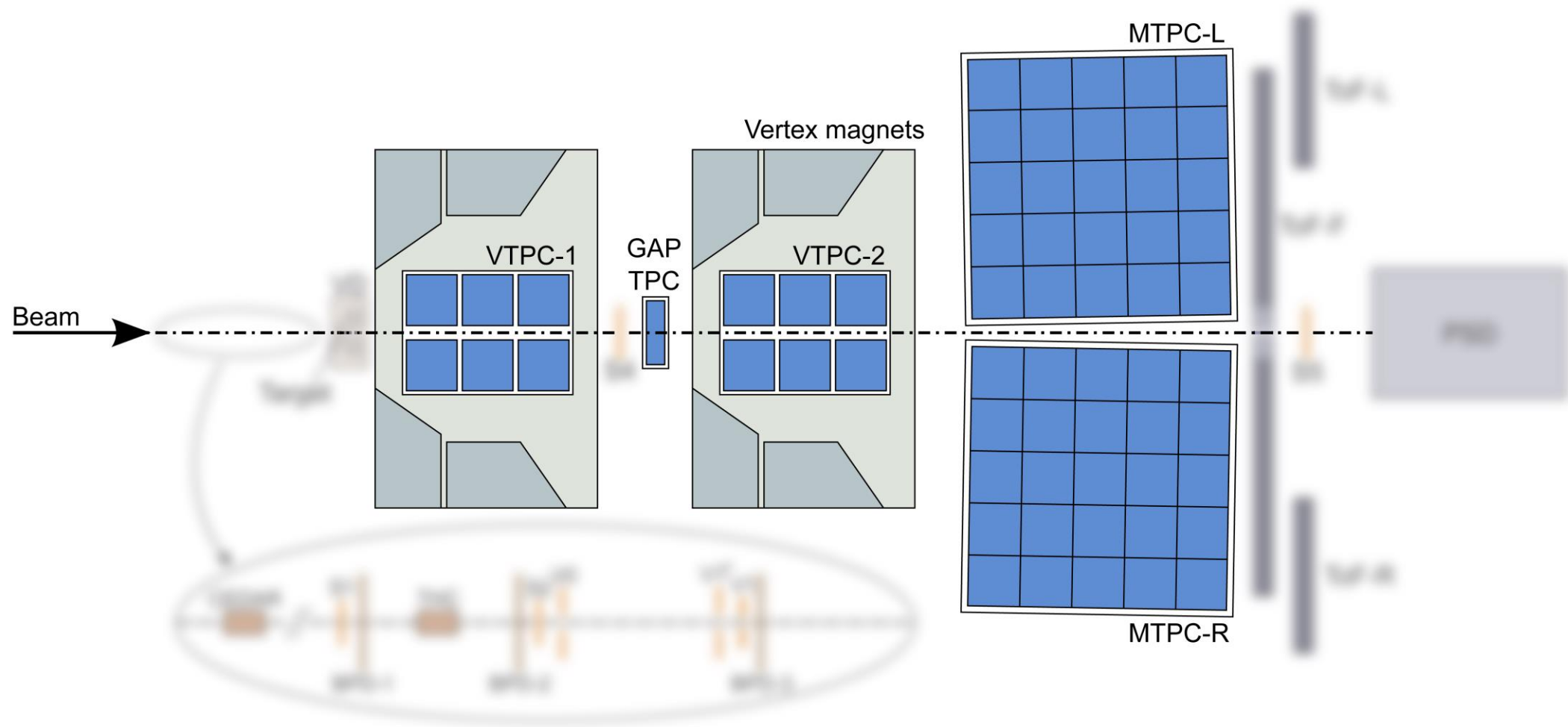
- Three Beam Position Detectors (BPD)
 - Multiwire Proportional Chambers
 - 250 μm tracking resolution
- Positive counters:
 - S1 — Scintillator with 4 PMTs, 30 ps time resolution
 - S2, Z — Check for beam presence, measure charge
- Veto counters:
 - V0, V1, V1p — Define beam envelope
- Interaction counters:
 - S4, S5 — Lack of signal indicate interaction

NA61/SHINE — Trigger Configuration



- Up to four independent triggers, usual configuration (for Ar):
 - T1 — beam: $S1 \times S2 \times \overline{V0} \times \overline{V1}$
 - T2 — central interaction: $T1 \times \overline{S5} \times \overline{PSD}$
 - T3 — not used
 - T4 — minimum bias interaction: $T1 \times \overline{S5}$
- Possibility to select ratios of triggers saved to disk, e.g.:
 - T1: 10% — for study of cross section and trigger biases
 - T2: 60% — as a main physics trigger
 - T4: 30% — for flow studies

NA61/SHINE — Time Projection Chambers



NA61/SHINE — Tracking in TPCs

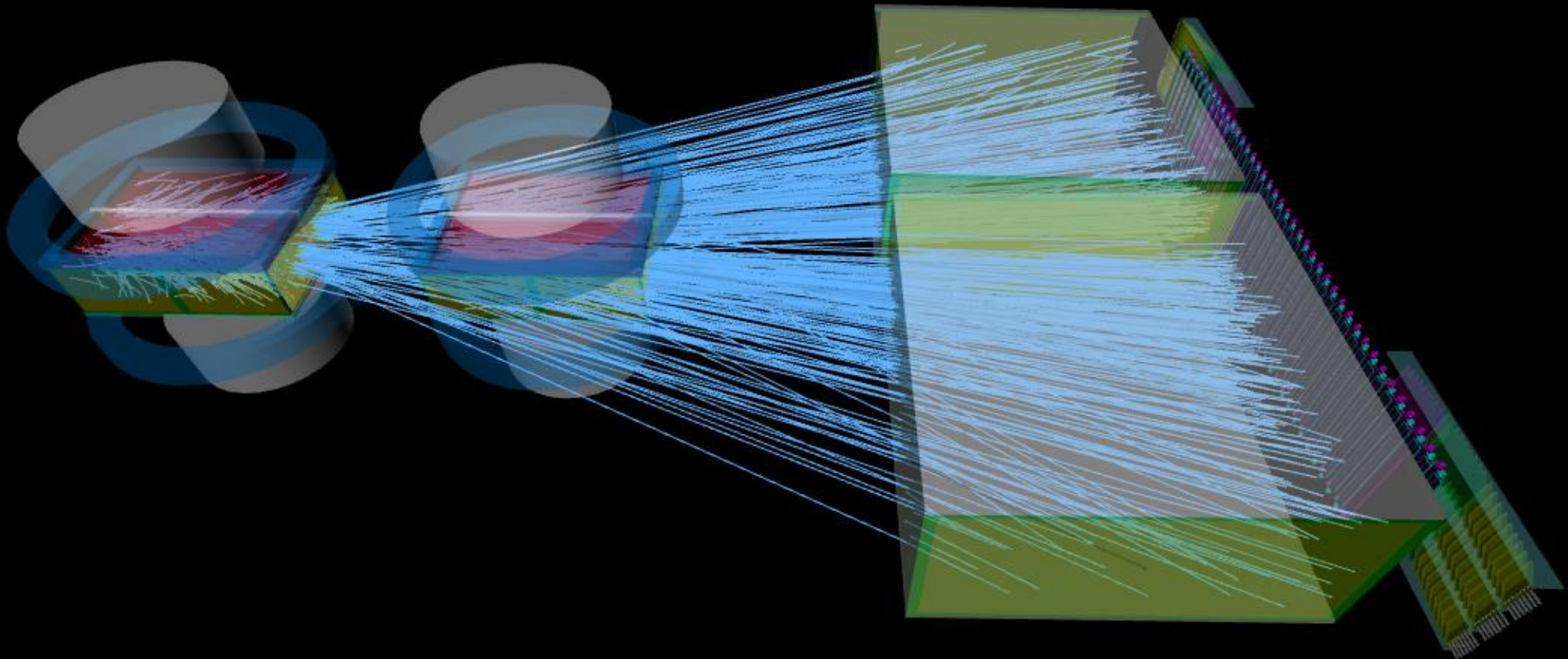
RUN INFORMATION

ID: 841

RUN NUMBER: 27286

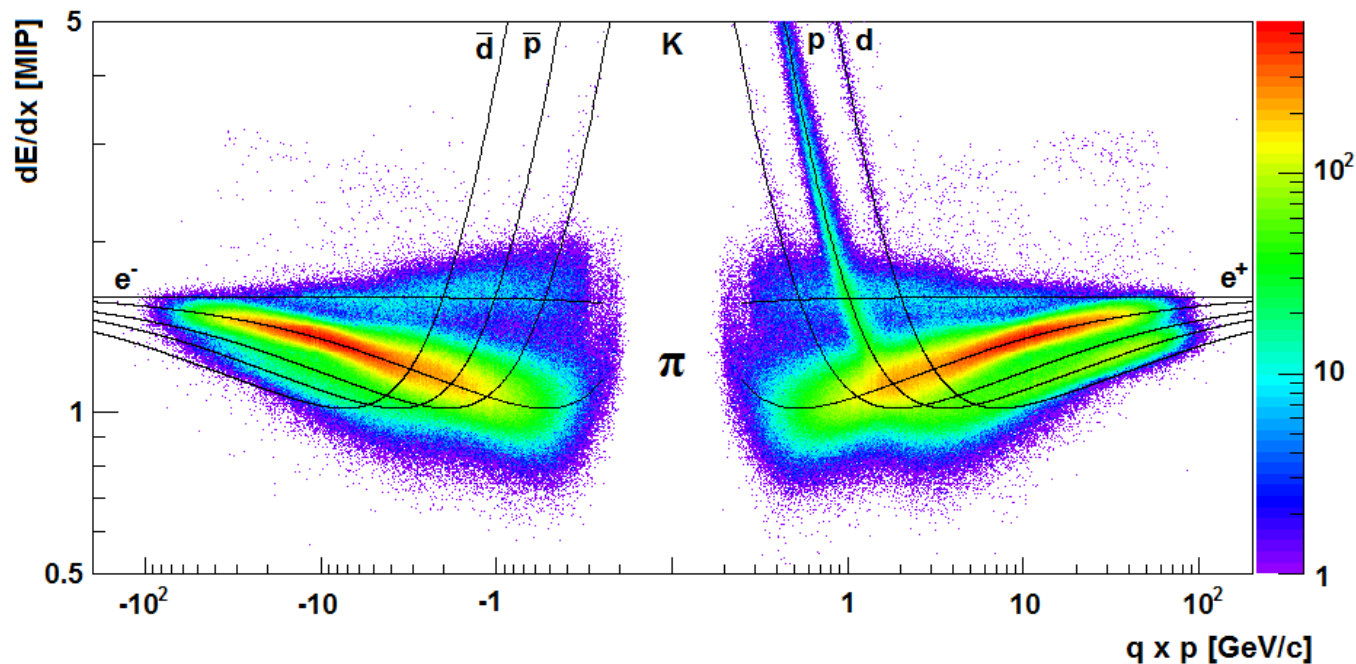
TIME: 2016-12-09T14:52:58Z (UTC)

TAPE NUMBER: 1165330395 (GPS)



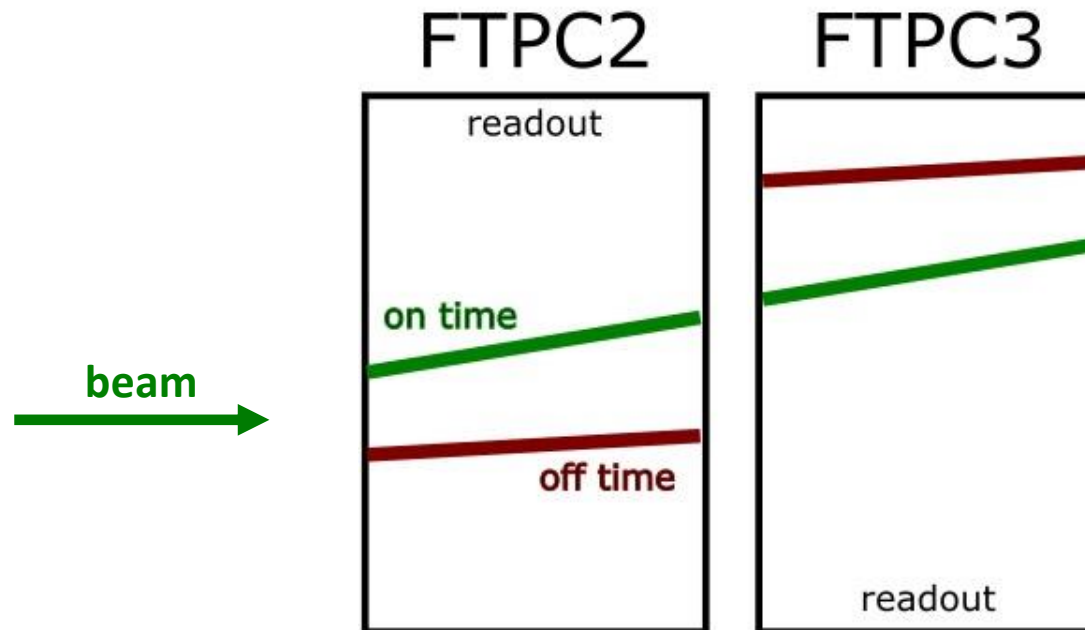
NA61/SHINE — TPCs

- VTPC1 and VTPC2 placed in superconducting magnets:
 - 1.5 T maximum magnetic field
 - 9 T·m bending power
 - Momentum resolution: $\frac{\sigma(p)}{p^2} \approx 10^{-4} \text{ (GeV/c)}^{-1}$
- Particle identification via specific energy loss

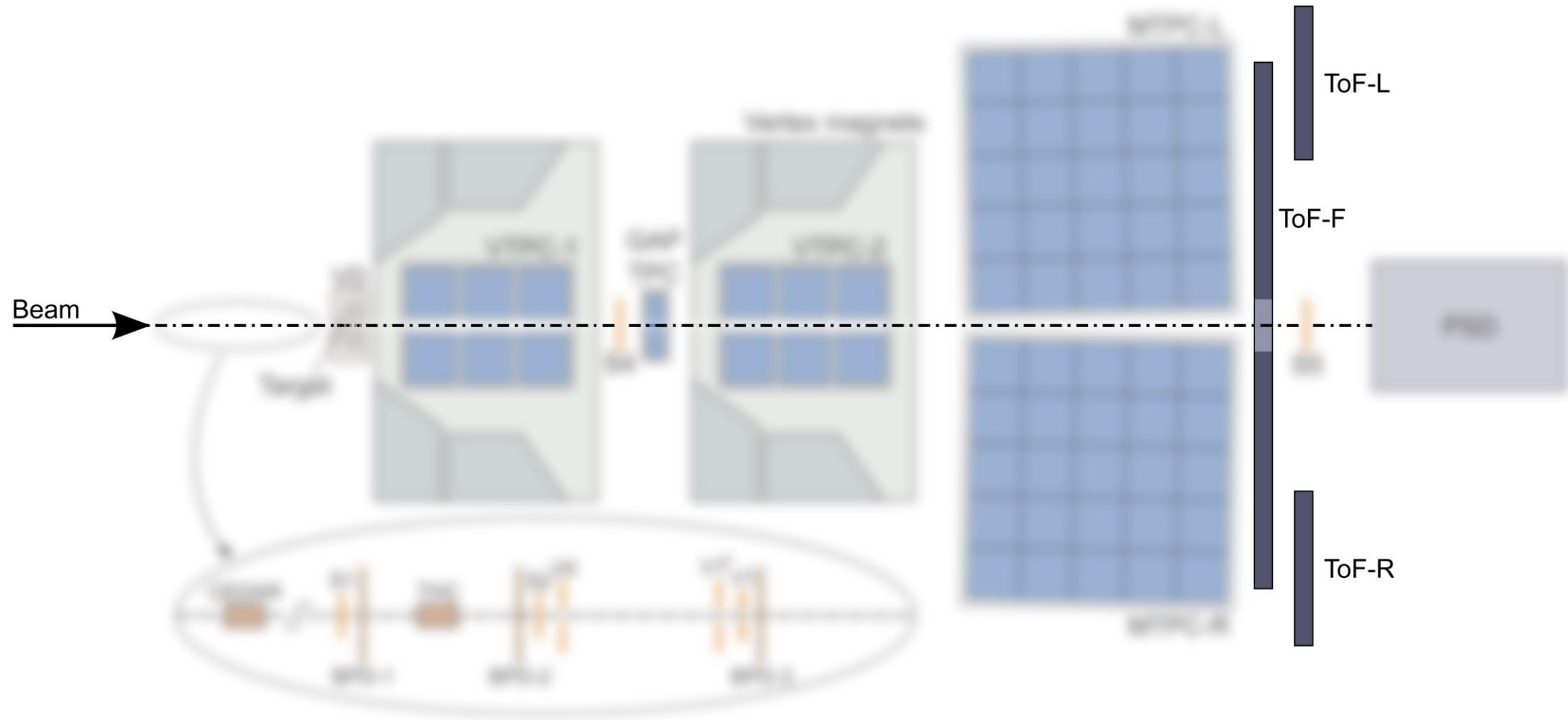


NA61/SHINE — FTPCs, Tandem TPC

- New detectors installed and tested this summer
- Increase acceptance in the large momentum region
- Important for the neutrino physics programme
- Tandem TPC for off-time particle rejection
 - Electrons drift in opposite directions
 - Off-time tracks do not match between FTPC2 and FTPC3

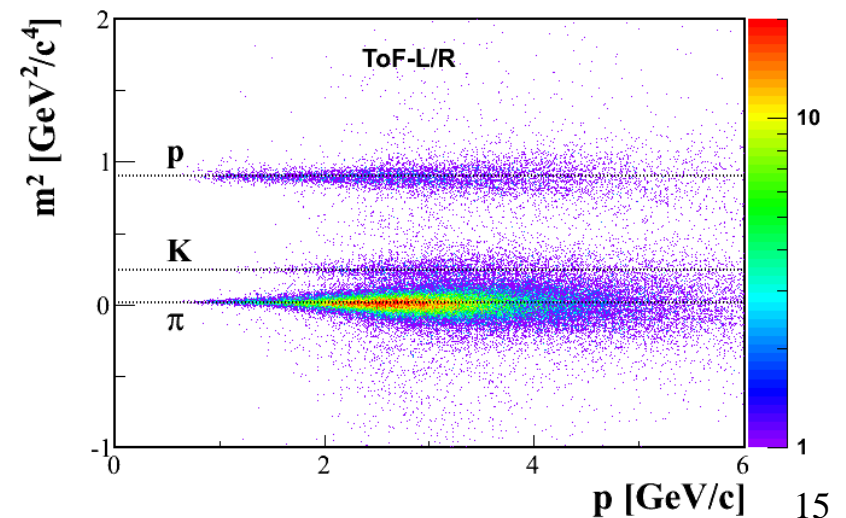
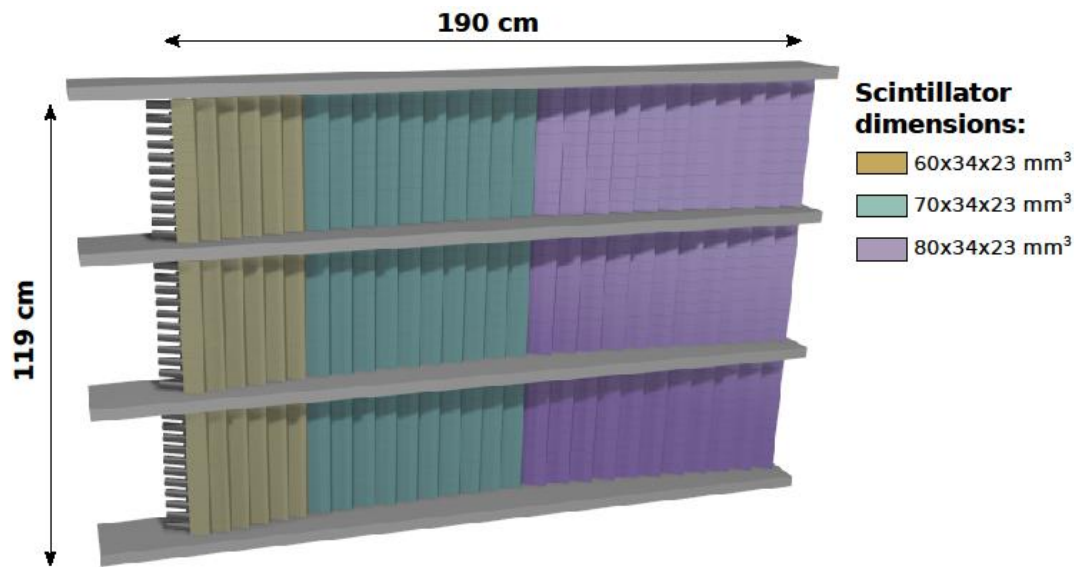


NA61/SHINE — Time-of-Flight



NA61/SHINE — Time-of-Flight

- Three Time-of-Flight walls:
 - ToF-L and ToF-R — pixel scintillators and PMTs, optimized for identification of Kaons at midrapidity
 - ToF-F — scintillator bars with PMTs, used for low multiplicity systems, optimized for low momentum particle identification
- Time resolution of the ToF walls: ~ 100 ps



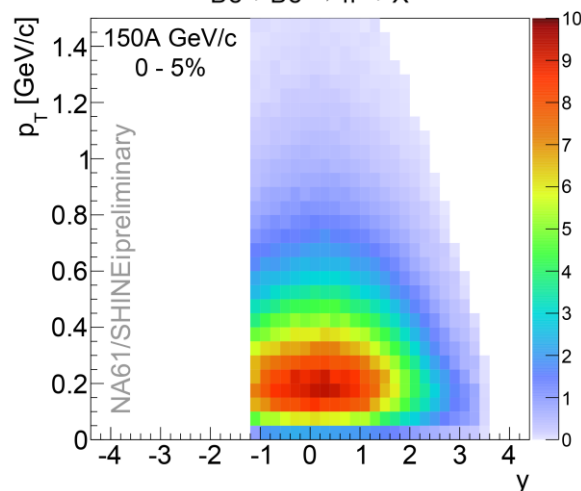
NA61/SHINE — Particle Identification

- Particle identification methods
 - dE/dx — based on TPCs energy loss measurements
 - ToF- dE/dx — based on combined TPCs and ToFs measurements
 - h^- — used for π^- identification based on Monte-Carlo models
 - $V0, \Xi, \Omega, D^0$ — based on decay topology
- Example phase space coverage of various identification methods:

π^- from h^- method

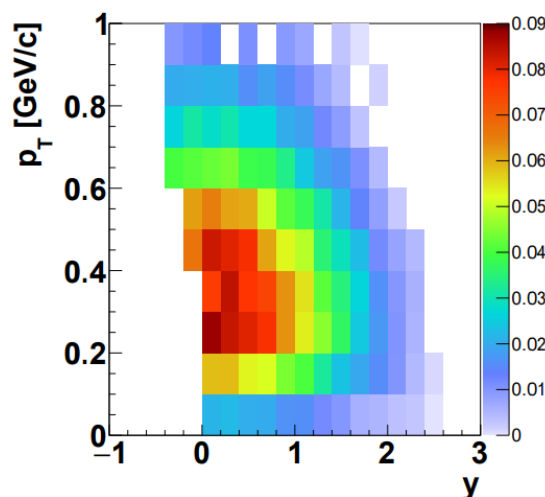
Be + Be

Be + Be $\rightarrow \pi^- + X$



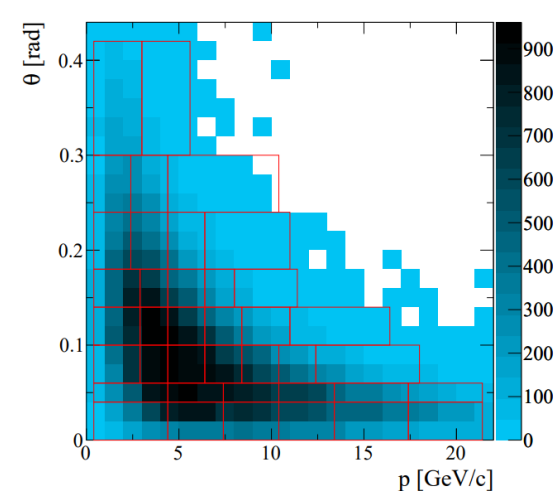
K^- from ToF- dE/dx

p + p

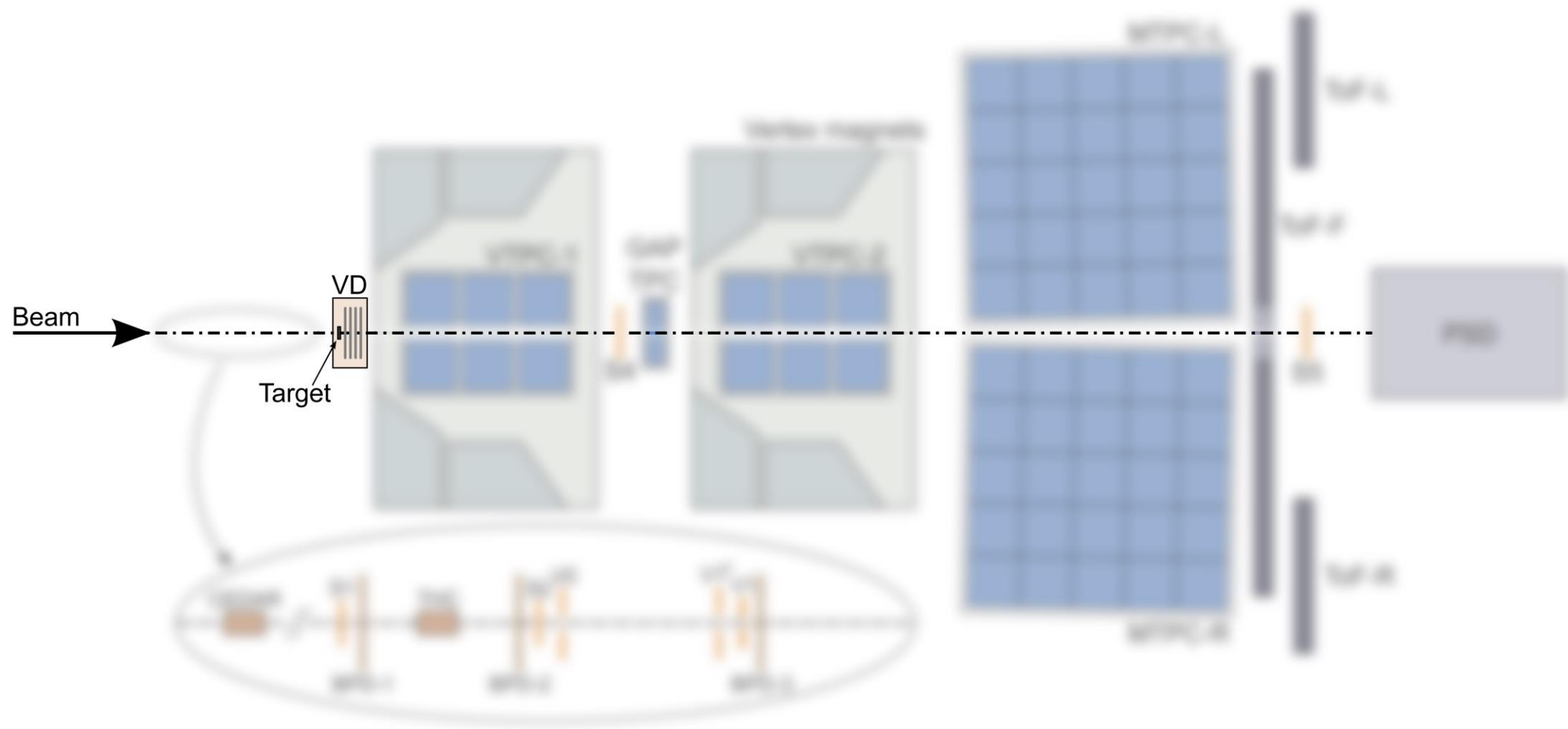


Λ from V0

p + C

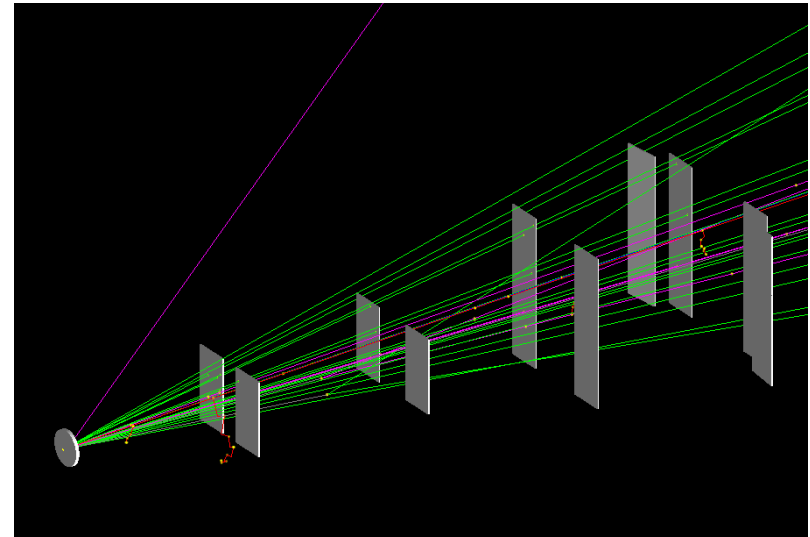
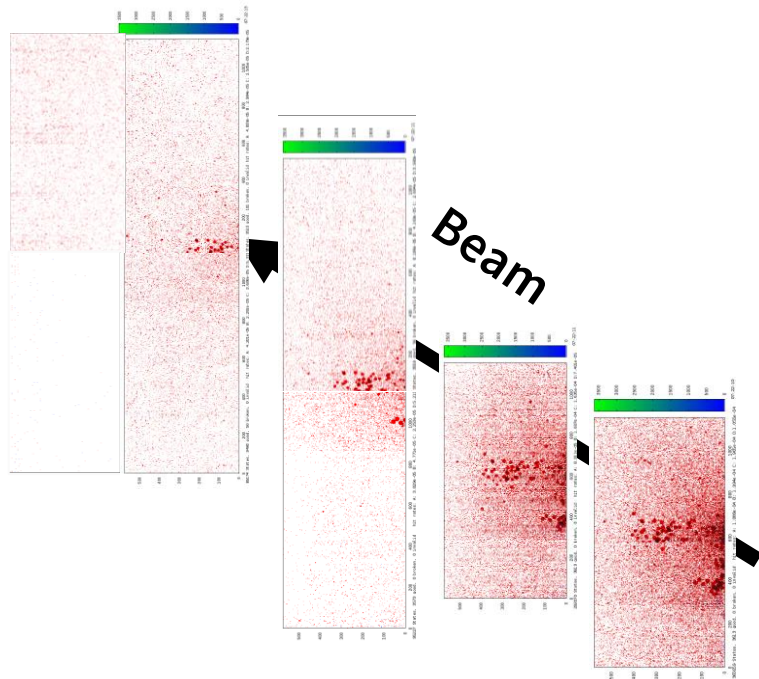


NA61/SHINE — Vertex Detector



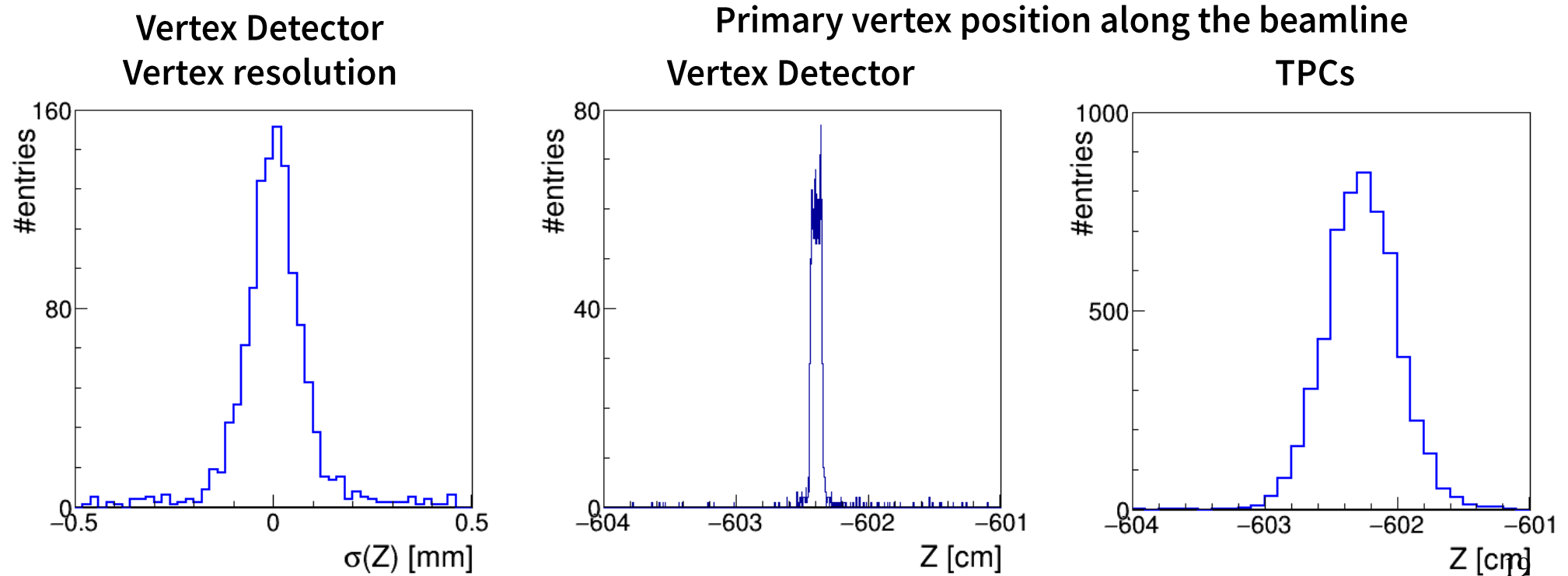
NA61/SHINE — Vertex Detector

- Build for open charm measurements
- Based on Mimosa26 sensors
- Small Acceptance VD:
 - Four station, 16 sensors
- 5 μm tracking resolution

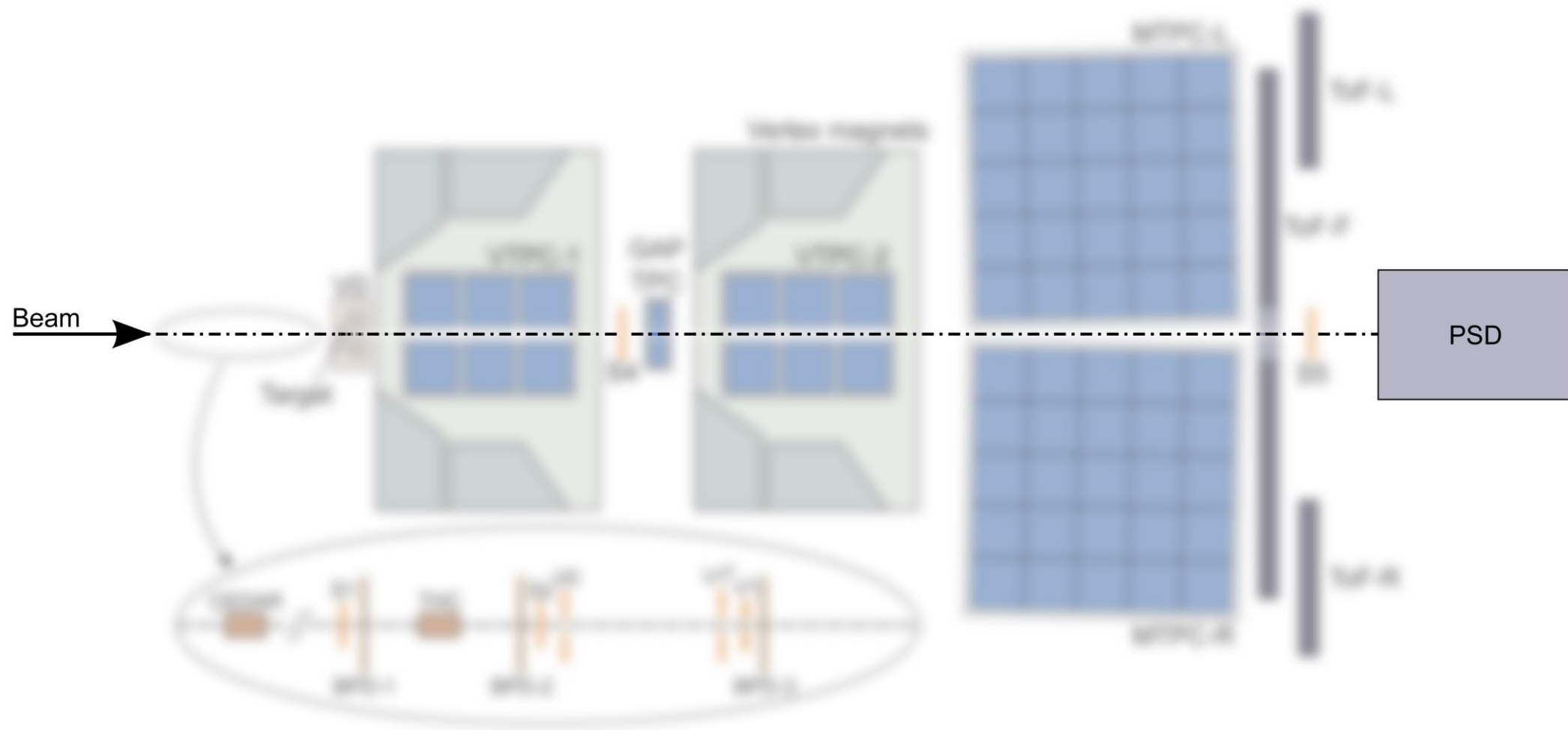


NA61/SHINE — Vertex Detector

- Vertex detector was commissioned in December 2016
- Pb + Pb at 150A GeV/c data taking with 1 mm target
- Vertex resolution: 30 μm — possible to distinguish D^0 decays

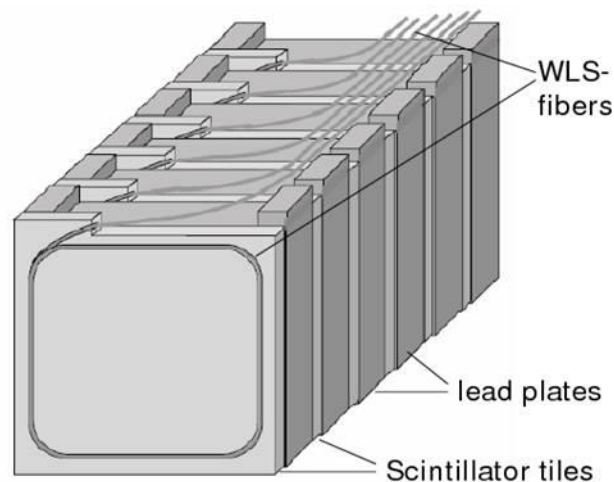
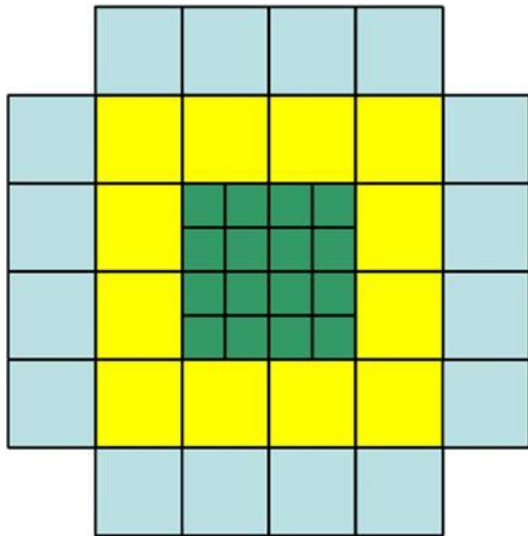


NA61/SHINE — Projectile Spectator Detector



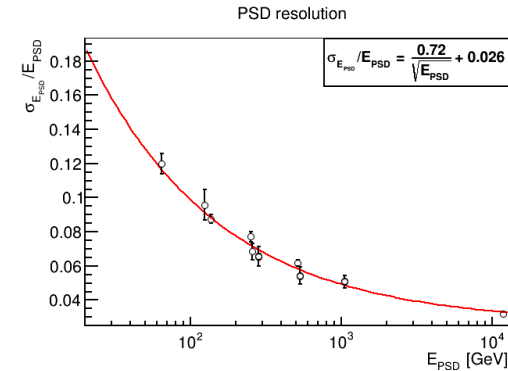
NA61/SHINE — PSD

- PSD is a modular zero-degree calorimeter used for:
 - Centrality selection
 - Reaction plane determination
- PSD consists of:
 - 44 transverse modules (16 small, 28 large)
 - 10 longitudinal sections
 - 440 measurements of deposited energy

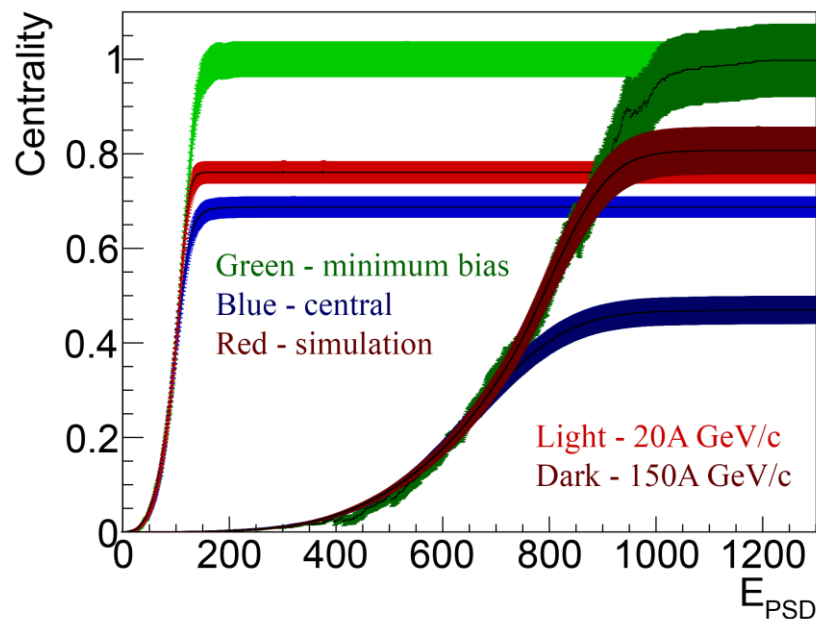


NA61/SHINE — PSD

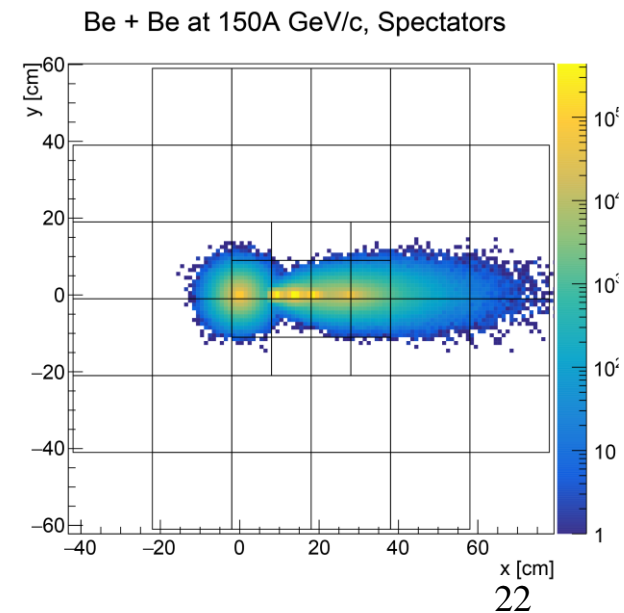
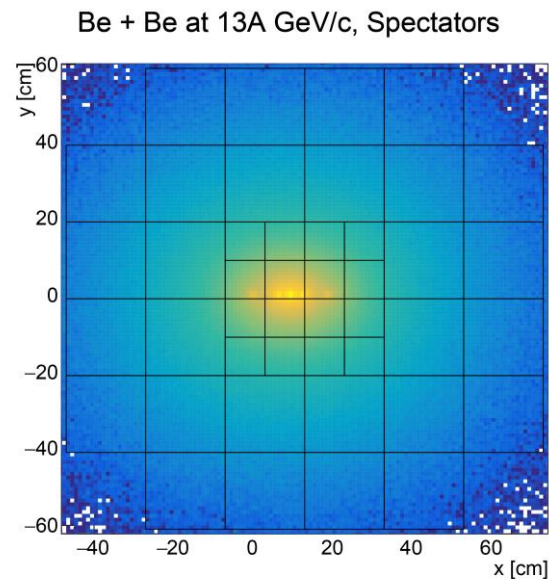
- Modularity of the PSD allows to select optimal set of modules for centrality determination
- Very good energy resolution



Centrality determination
Be + Be



Distribution of spectators on the front face of the PSD
for lowest and highest beam momentum



NA61/SHINE 2020

NA61/SHINE plans following upgrades:

- Increase readout rate to 1 kHz:
 - New TPC readout electronics (from ALICE)
 - New Data Acquisition System
- Upgrade detectors:
 - New ToF walls based on mRPC technology
 - New BPDs based on scintillating fibres
 - Large Acceptance Vertex Detector based on ALPIDE sensors
 - Upgrade of the PSD to handle large beam intensities

More information about proposed upgrades will be given in following days

Summary

Current status:

- NA61/SHINE is a unique facility for particle production study
- Broad physics programme, from strong interaction study to neutrino physics and cosmic rays
- Large acceptance detectors
- Good particle identification
- Each year new detectors are added to extend physics possibilities

Future:

- More than 10-fold increase in data taking rate!
- Large Acceptance Vertex Detectors for precise open charm study
- PSD capable of handling large beam intensity
- Many more ideas will be discussed during this workshop

Thank you for your
attention