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ESR10: Real-time calibration of the ALICE Time Projection Chamber and ML traffic predictions

SMARTHEP yearly meeting

Lund 2023
27th November

Lund University

LUND UNIVERSITY

SMARTHEP
REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

MARIE CURIE ACTIONS

SMARTHEP is funded by the European Union's Horizon 2020 research and innovation programme, call H2020-MSCA-ITN-2020, under Grant Agreement n. 956086

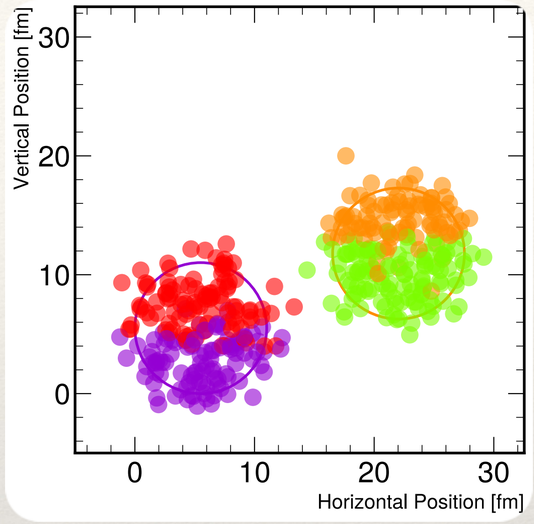
Overview

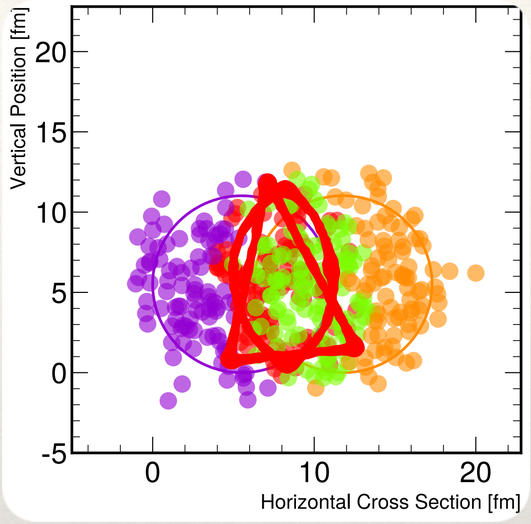
- Past year
  - ALICE
    - Heavy ion physics
    - TPC
  - Ximantis
- Summary

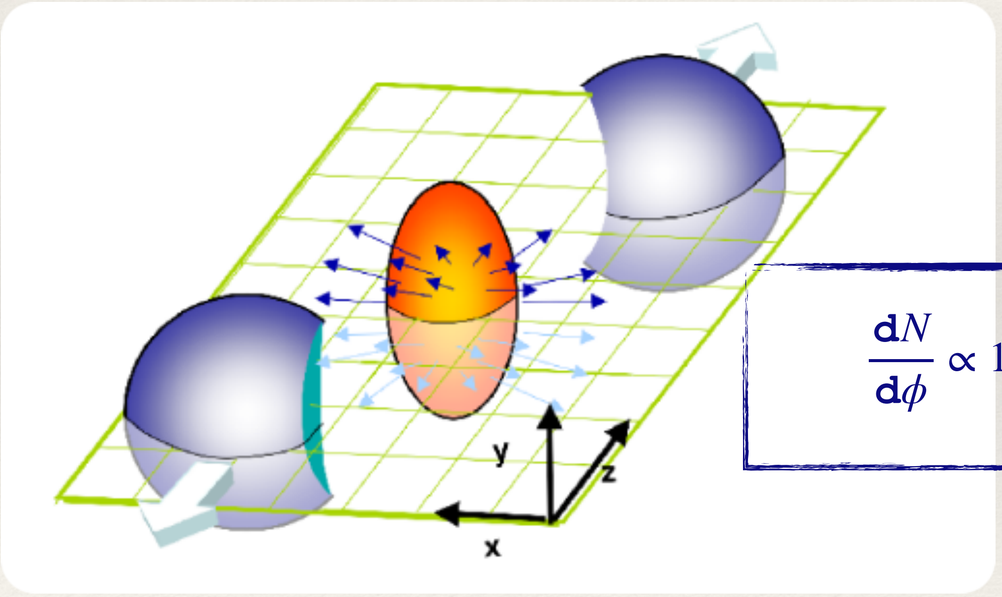
Heavy ion physics

- On a more serious note..
- Much time has gone into heavy-ion physics
  - Trying to analyze properties of the QGP

… In reality





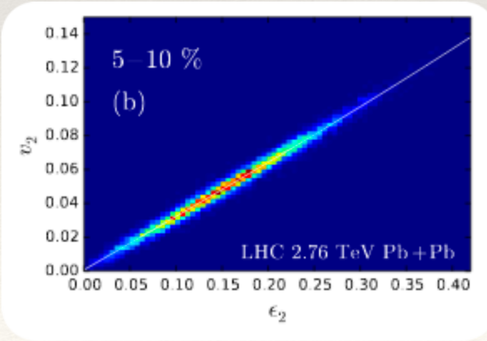


$$\frac{dN}{d\phi} \propto 1 + 2\sum_{n=1}^{\infty} v_n e^{in(\phi - \Psi_n)}$$

$$v_n = \kappa_n \varepsilon_n$$

Final-state observable

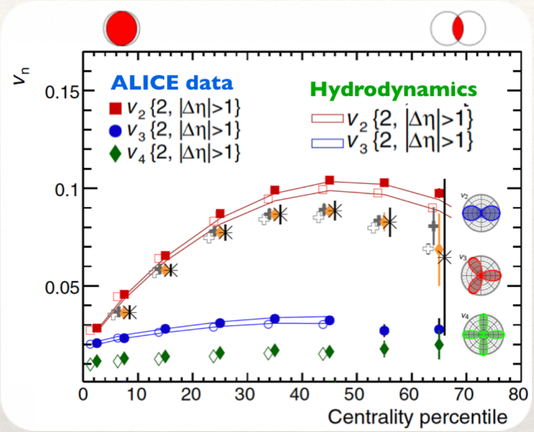
Initial eccentricity



http: //dx.doi.org/10.1088/1751-8113/42/21/214003

10.1103/physrevc.93.014912

My analysis…

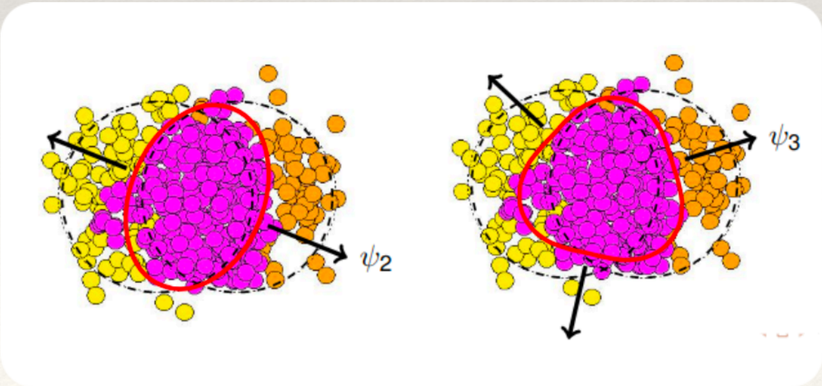


Phys.Rev.Lett.116.132302

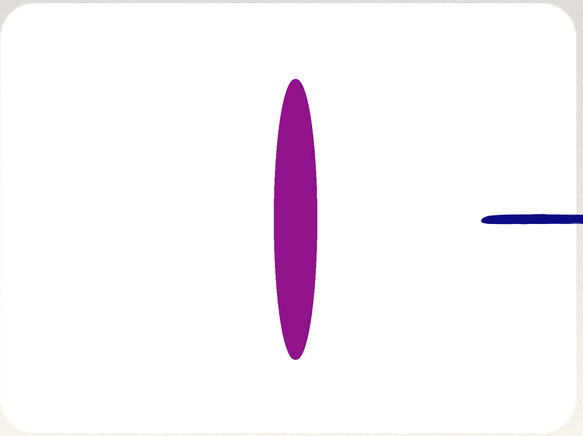
- Manipulate geometry to learn more about the initial conditions

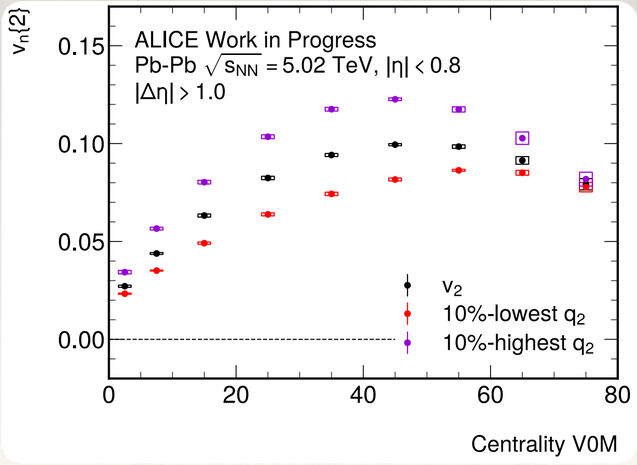
ALICE APPROVAL For Paper

Pb-Pb
Xe-Xe



arXiv: 1205.0579 [hep-ph]





Secondment CERN

- Service task
  - 3 month stay in CERN
- Calibration of TPC

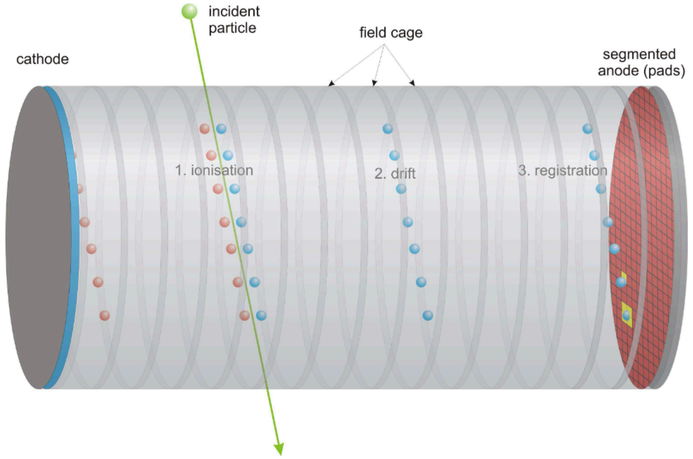
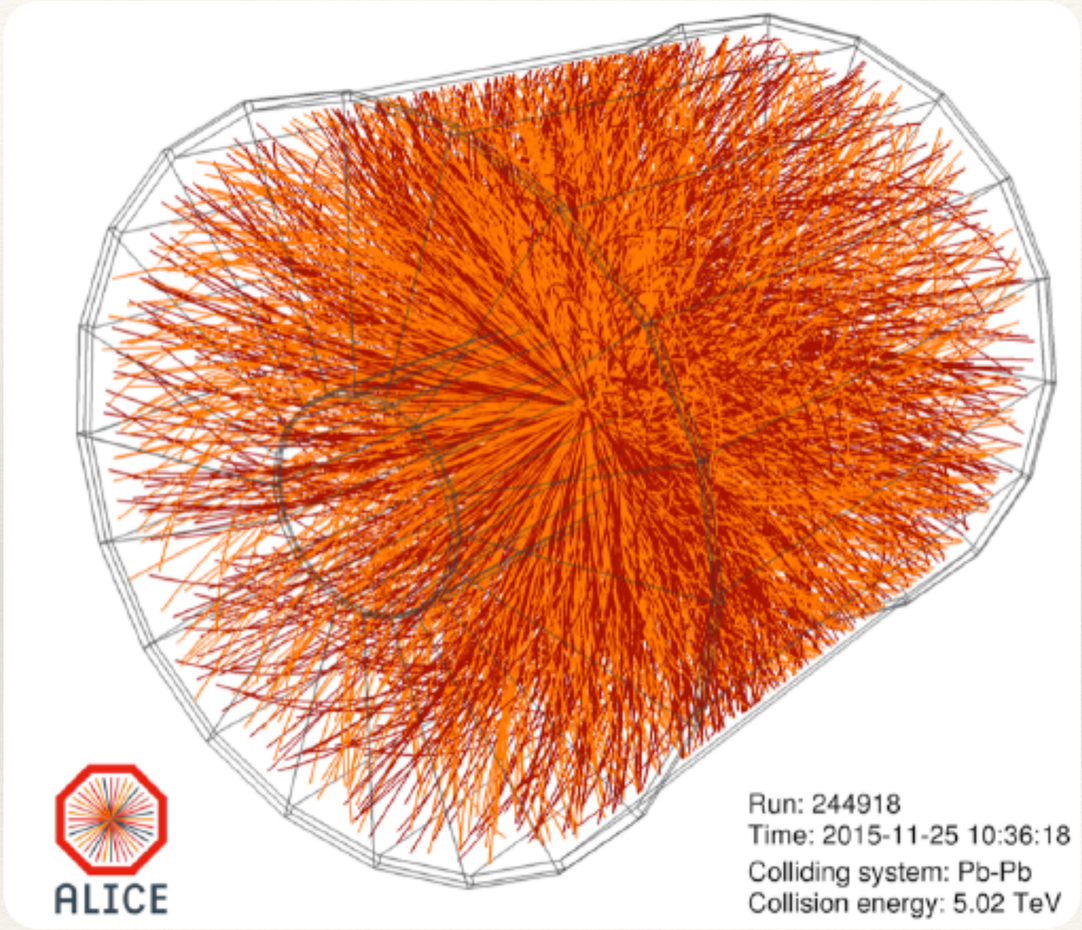


Figure 2.1: *Operation principles of a TPC*



Motivation

- Kalm
  - C
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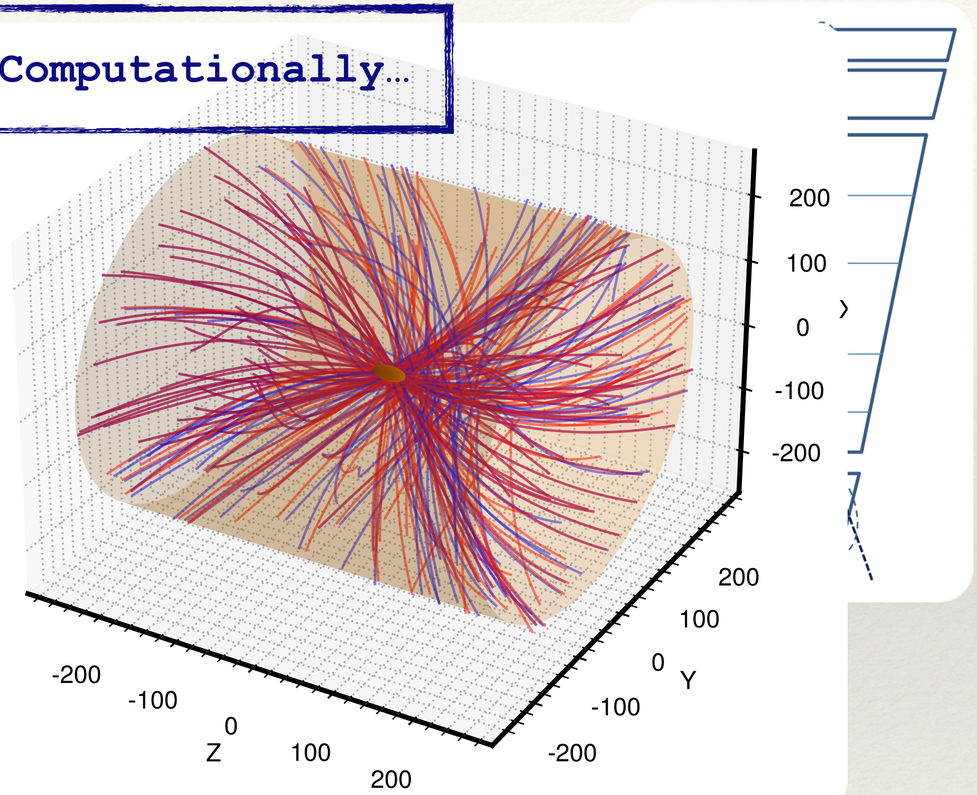
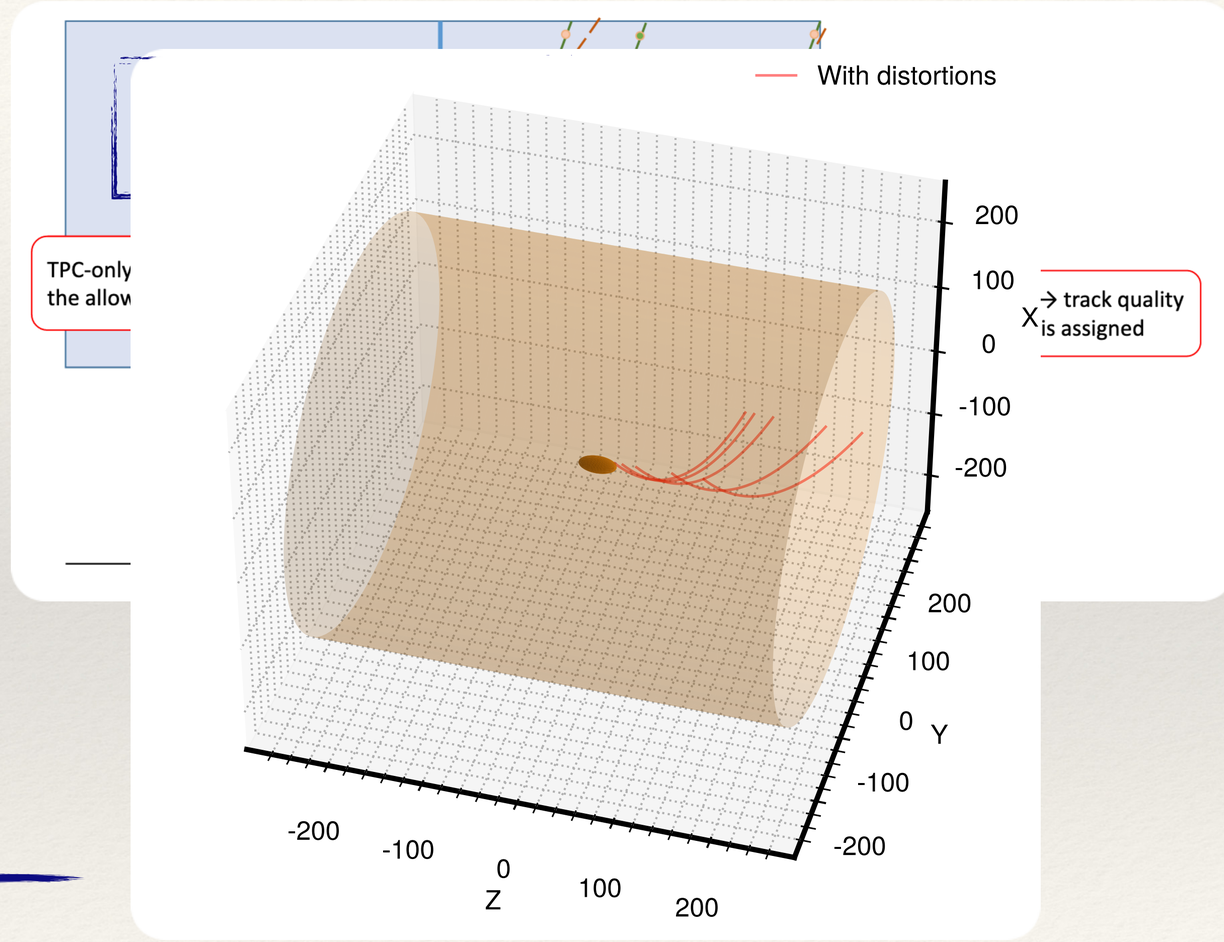
- Para
  Netw
  - (F
    w

Computationally…





Space charge distortions are non-trivial

Procedure

- Track parametrization:
- Kalman filter fit on the TPC clusters

$$x,\ (y, z, \sin\phi, \tan\lambda, q/p_{\mathrm{T}})$$

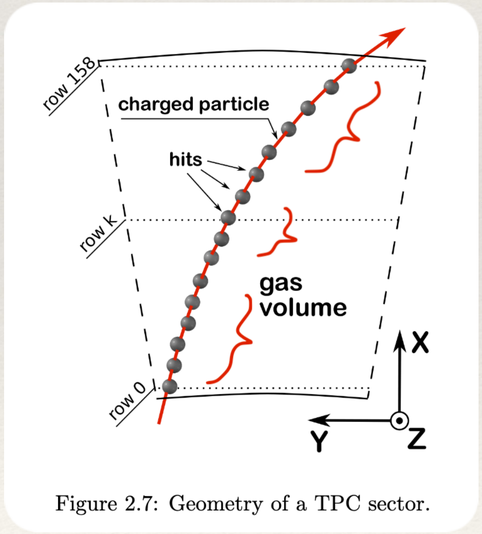
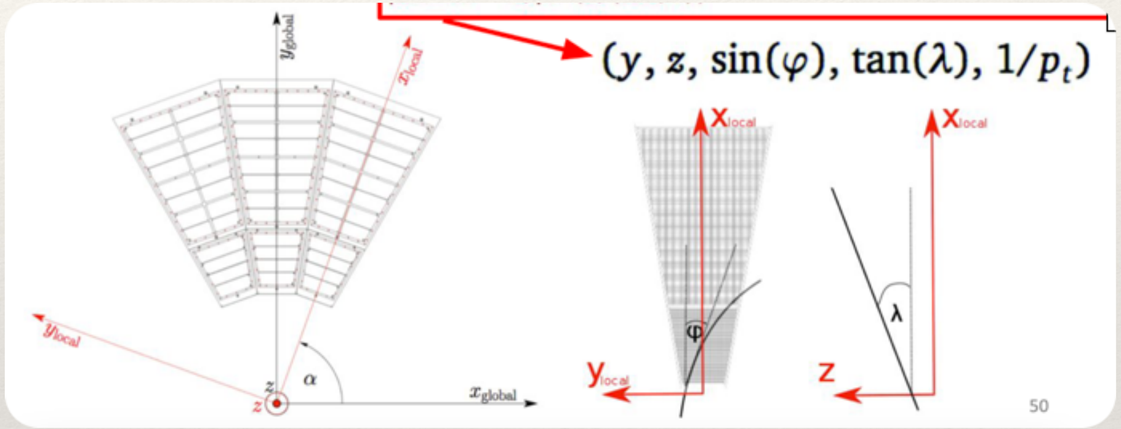
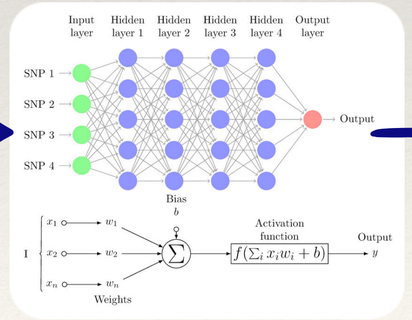


Figure 2.7: Geometry of a TPC sector.



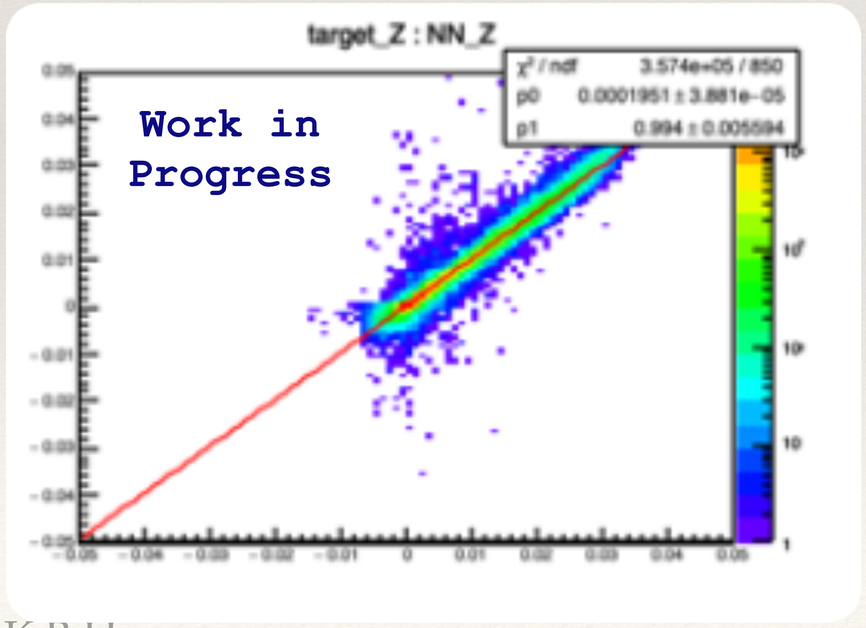
Input:
Initial Kalman fit:
$y, z, \sin\phi, \tan\lambda, q/p_{\mathrm{T}}$
Selected TPC clusters (3)
Z-shift



Target*:
Final Kalman fit:
$y, z, \sin\phi, \tan\lambda, q/p_{\mathrm{T}}$

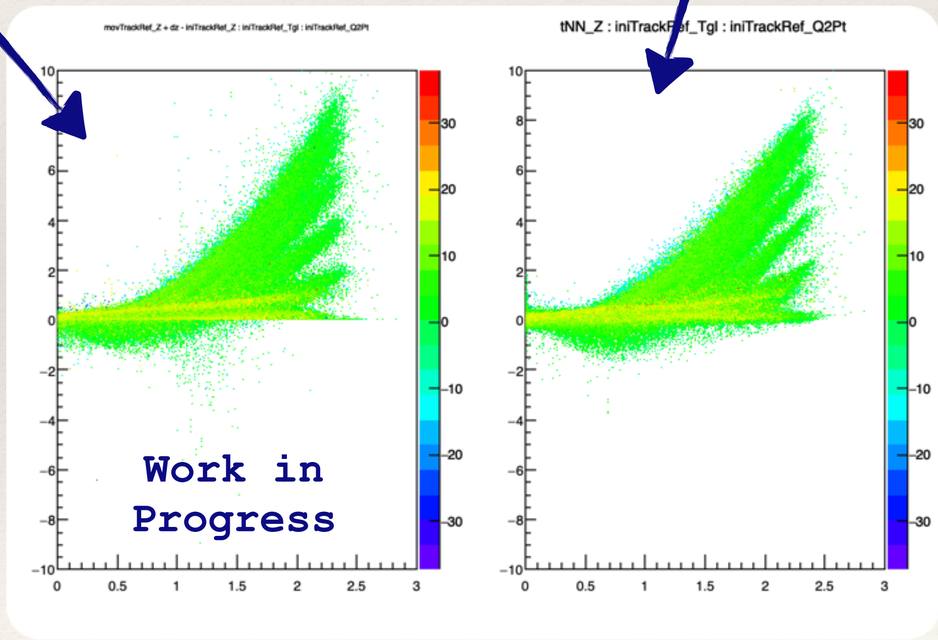
Results

- We have had issues with compatibility between online/offline reconstruction
- Initially issues catching the correlation between the track parameters



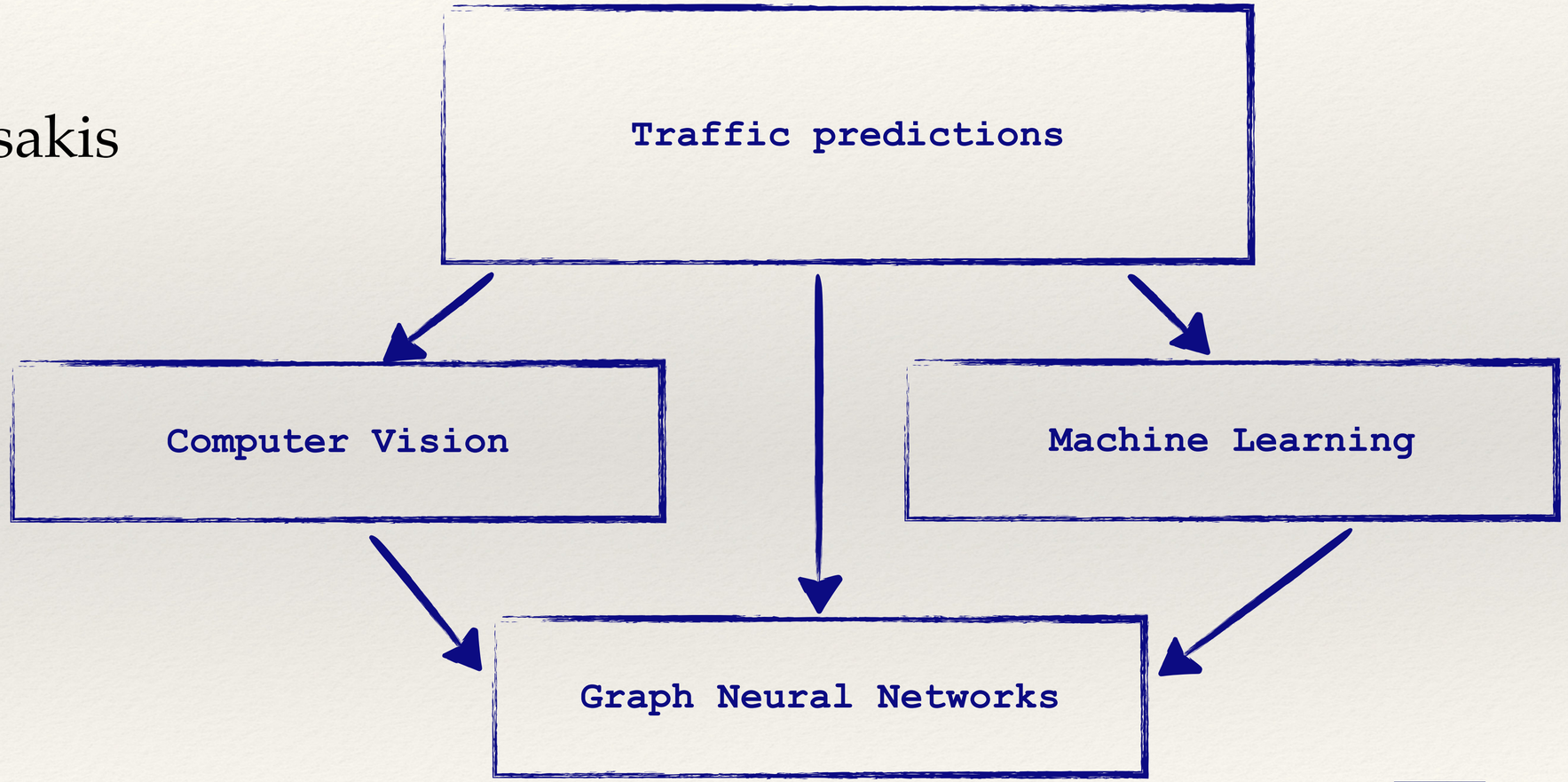
Input-target correlation

Input-NN correlation



Ximantis

- Collaborating with:
  - Alexandros Sopasakis
  - Donglin Liu



Input data

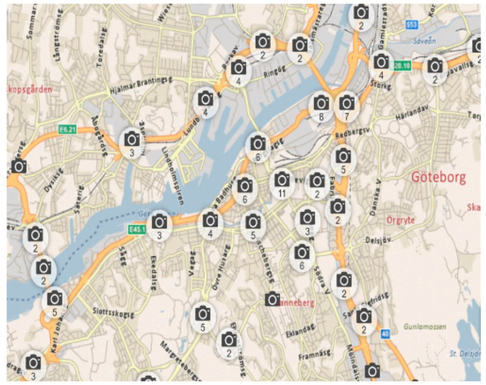
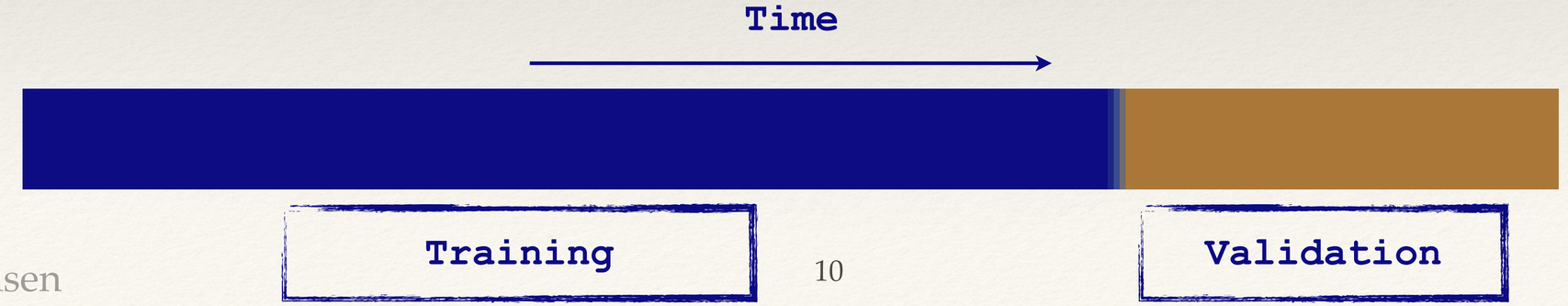


Fig. 1. A section of the Goteborg traffic network with multiple cameras indicated along each road each collecting images every minute. Data provided by the Swedish traffic authoridy: Trafikverket.

Sopasakis, A. (2019)

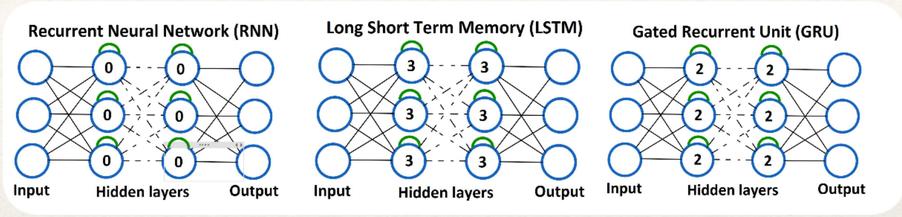
Fig. 2. Original image with superimposed mask on the region of interest.

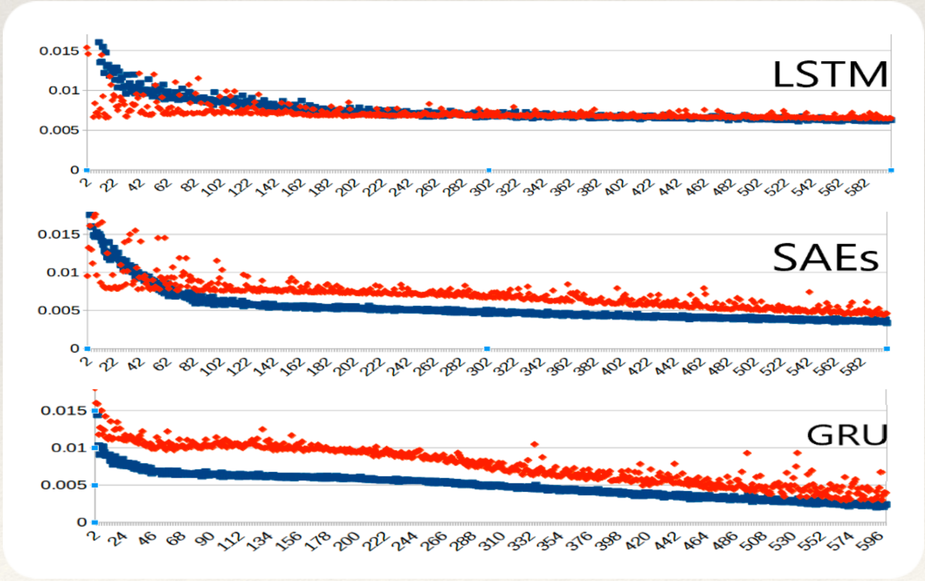
- The input data of our Network
- Will be done for every camera available

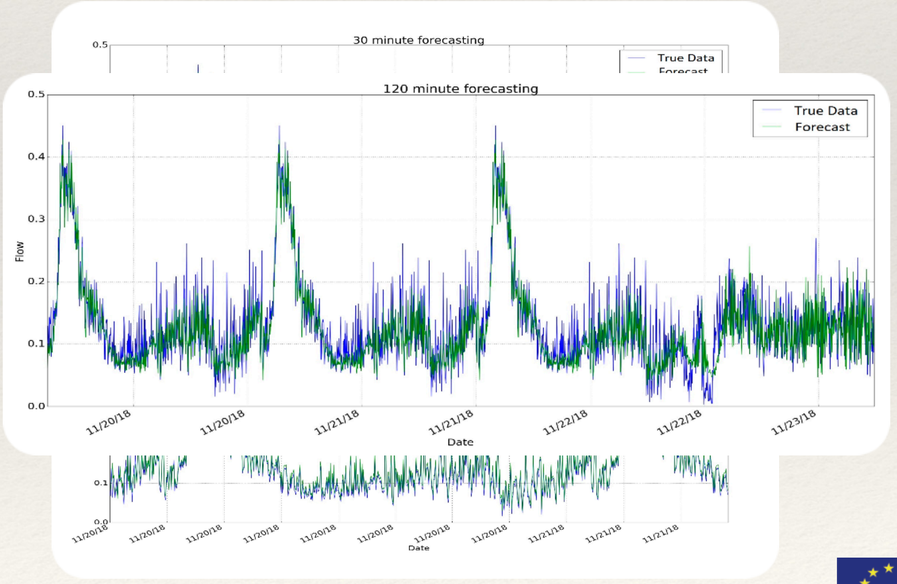


Previous work

- Traffic forecasting using different approaches…
- Works well, **but** can be improved



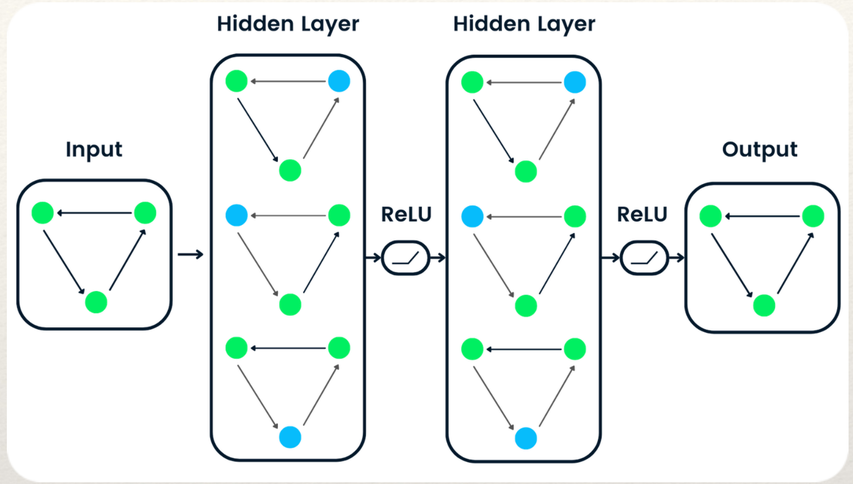




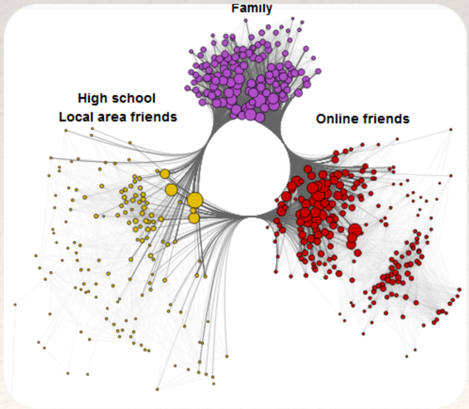
Graph Neural Network (GNN)

- Real world data does not (always) live on a **grid**
- $G = (V, E)$
  - V: Set of Vertices (or nodes)
  - E: Set of Edges (links)
    - Directional (non-directional)

Examples



source



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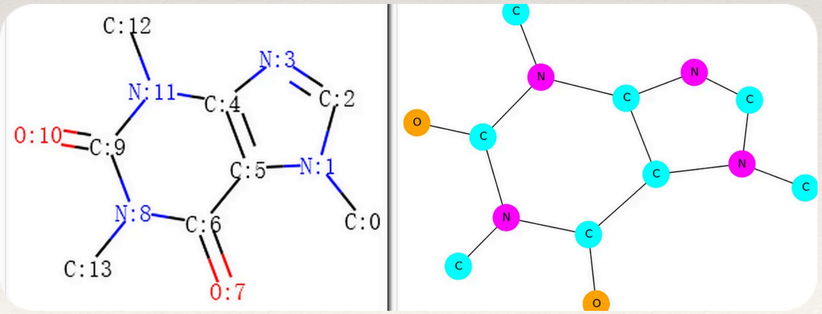
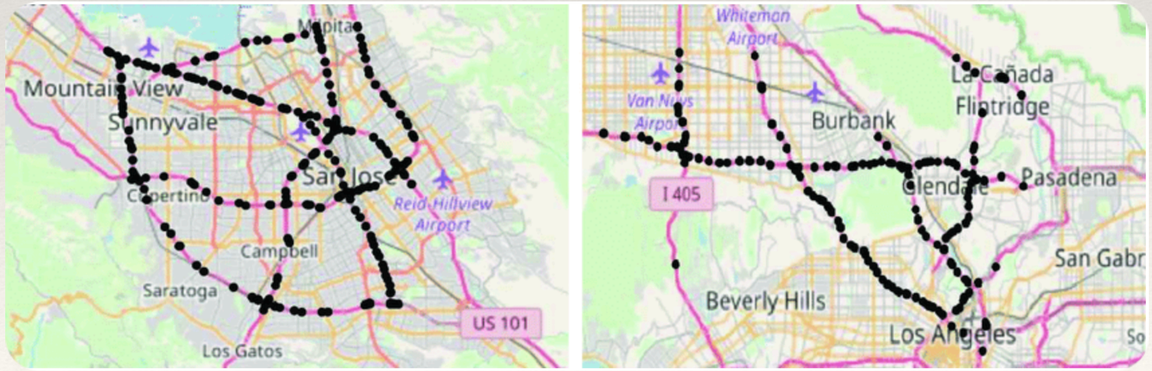


source

Graphs in Traffic

- Roads and intersections provides a “graph” structure itself
  - In our case
    - Camera + GPS
  - Caltrans Performance Measurement System
    - PeMSD8 (San Bernardino) Highway data

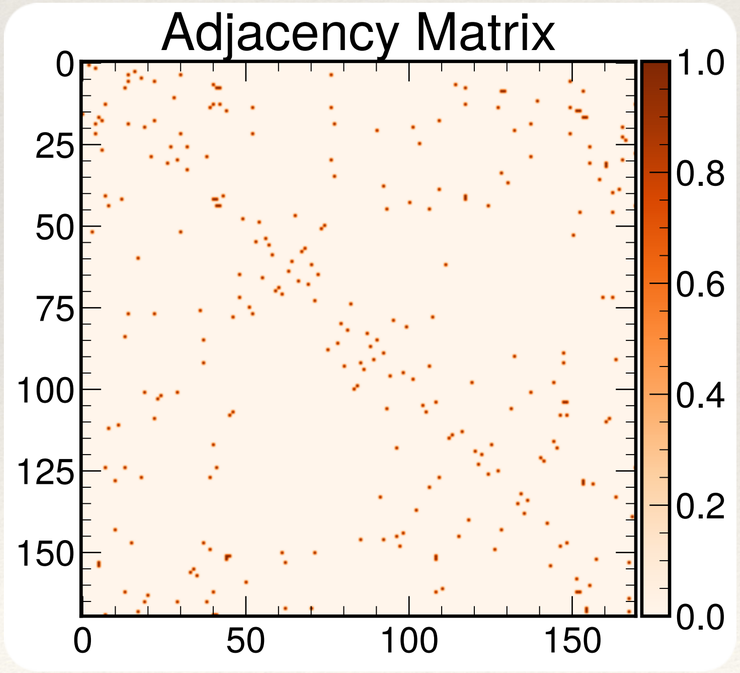
source



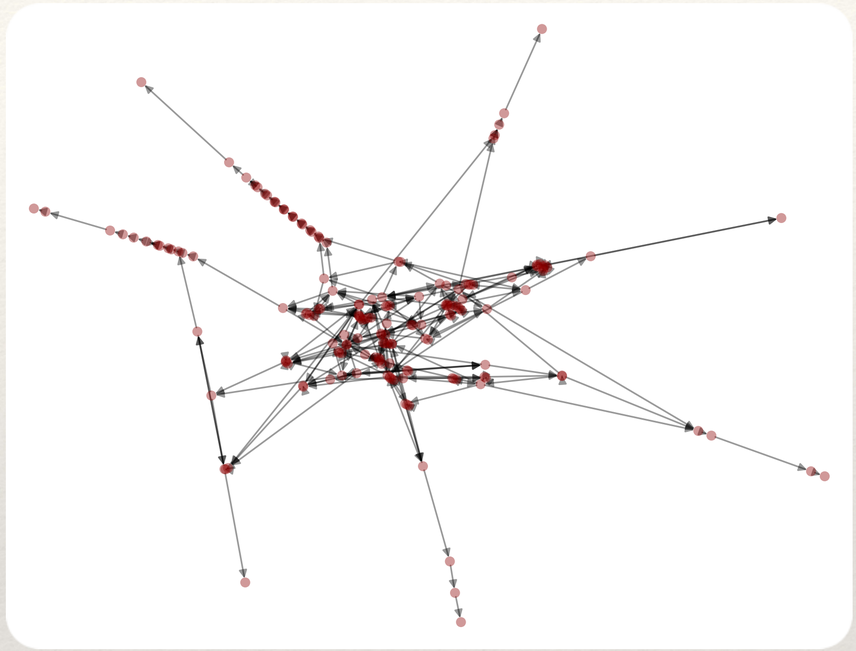
source

Adjacency Matrix

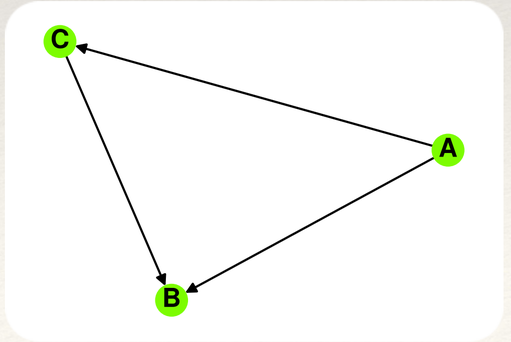
- Plenty Detectors (1979)
  - Most removed so left with 170 (5.6 km limit between V)
- Describes the direction between the different vertices



Connections between nodes



	A	B	C
A	0	1	1
B	0	0	0
C	0	1	0



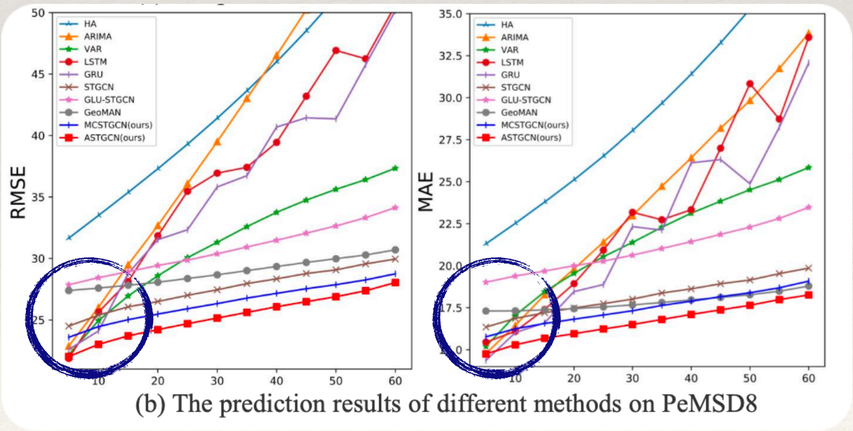
Our work so far

- Training state-of-the-art models
- Model: e.g. ASTGCN → **Attention Based Spatial-Temporal**
- Data: PEMS

We have reproduced SOTA

Table 1

Model	MAE	MAPE	RMSE
GWNE	15.9980	0.1043	24.8106
H_GCN_wh	17.6598	0.1151	26.6680
ASTGCN_Recent	19.3278	0.1270	28.6746
GRCN	20.4614	0.1338	32.4759



(b) The prediction results of different methods on PeMSD8

https://doi.org/10.1609/aaai.v33i01.3301922

Next steps

- Adapt to Göteborg in the current workflow
  - Expand our architecture → Higher precision
  - We have GPS coordinates of cameras → To build our graph
  - We have a traffic “flow” measurable → Our input & target

Summary

- Physics Analysis ✔
- TPC calibration ✔
- Ximantis ✔