SAMURAI-TPC
a detector for multi-fragmentations

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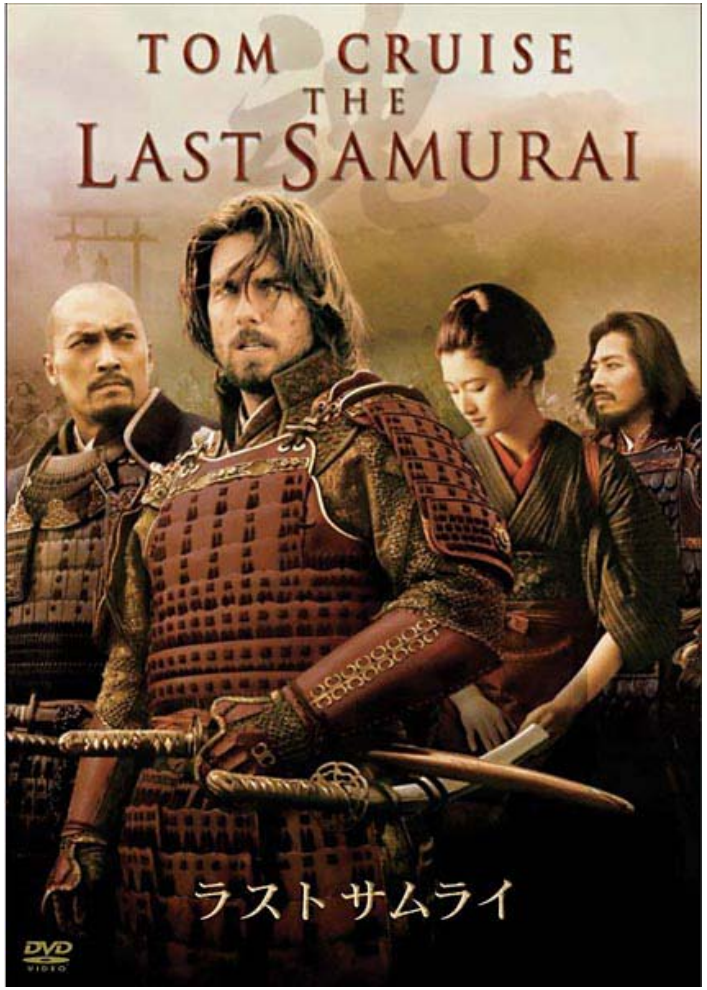
- Summary

- **Samurai** is spectrometer by using superconducting dipole magnet at RIBF.

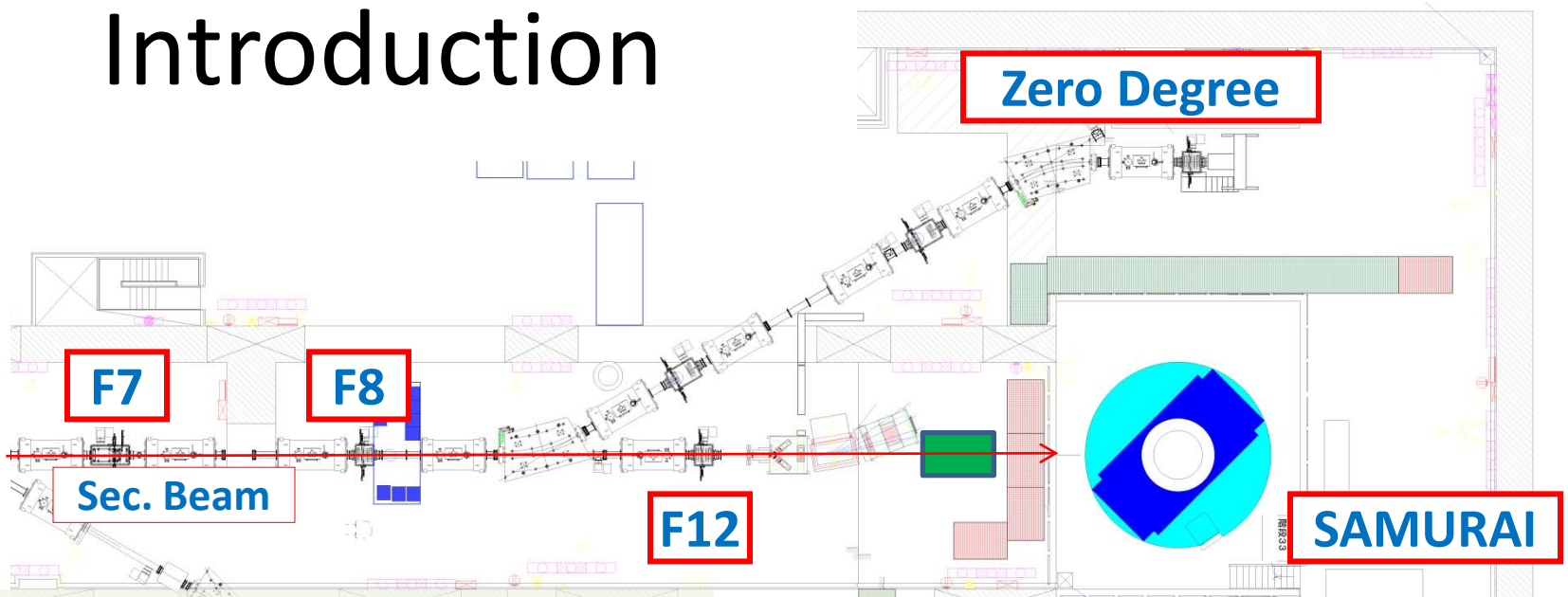
- **Superconducting Analyzer for Multi-particle from Radio Isotope Beams.**

Samurai is the term for the military nobility of pre-industrial Japan.

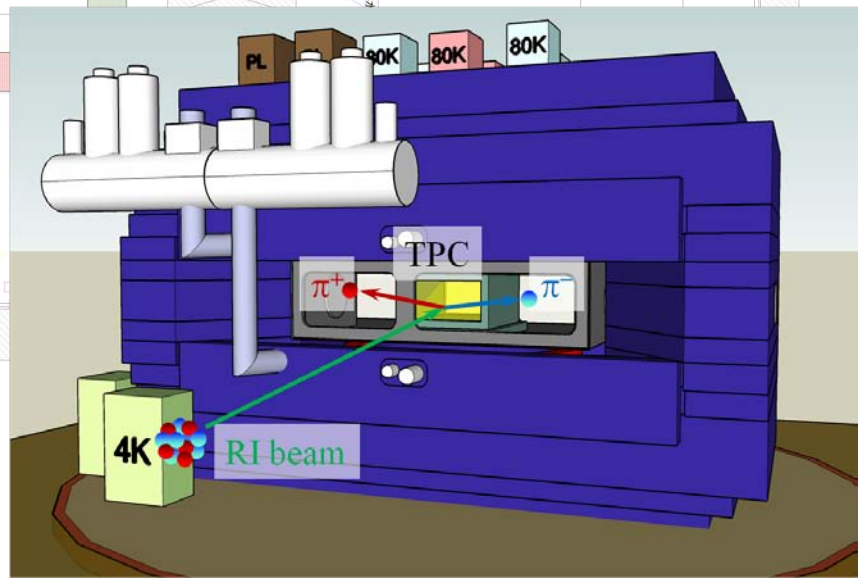
Ref. wikipedia



Introduction



- SAMURAI-TPC is the detector which will be installed inside of the SAMURAI dipole magnet.
- An international collaboration was formed to study the nuclear symmetry energy by using SAMURAI-TPC.



SAMURAI-TPC Collaboration

Determination of the Equation of State of Asymmetric Nuclear Matter

- **The collaboration is formed by 8 Countries, 43 researchers.**
  - **http://groups.nscl.msu.edu/hira/sep.htm**

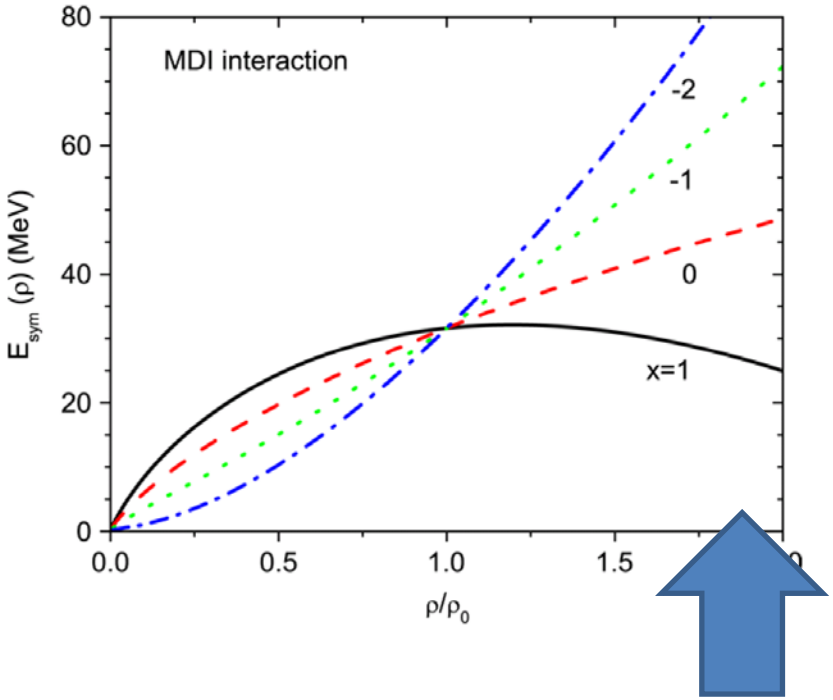
- **NSCL/MSU:** ***M.B. Tsang, W.G. Lynch, Z.Chajecki, G. Westfall, P. Danielewicz, E. Brown, A.Steiner***
- **Texas A&M Univ.:** ***S. Yennello, A. McIntosh***
- **Western Michigan Univ.:** ***Michael Famiano***
- **Univ. Notre Dame:** ***U. Garg***
- **GSI:** ***W. Trautmann, Y. Leifels***
- **Daresbury Lab.:** ***R. Lemmon***
- **INFN/LNS:** ***G. Verde, A. Pagano, P. Russotto, M. di Toro, M. Colonna, A. Bonasera, V. Greco***
- **Univ. Budapest :** ***V. Baran***
- **SUBATECH:** ***C. Hartnack***
- **GANIL:** ***A. Chbihi, J. Frankland, J.-P. Wieleczko***
- **China IAE:** ***Y. Zhang, Z. Li, F. Lu (Peking Univ.), W. Tian (Chinese SAS)***
- **Brazil:** ***S. Souza, R. Donangelo, B. Carlson***
- **RIKEN:** ***H. Sakurai, S.Nishimura, Y. Nakai, A. Taketani, T. Isobe, H. Baba***
- **Rikkyo Univ.:** ***J. Murata, K. Ieki***
- **Tohoku Univ.:** ***A. Ono***
- **Kyoto Univ.:** ***T. Murakami***

Physics motivation for SAMURAI-TPC

- Declaring the symmetry energy is most important aim in terms of the development of SAMURAI-TPC.
- At the energy of RIBF, $\rho \sim 2\rho_0$ is expected to be achieved.
  - Stronger constraint on the symmetry energy.
- Observables which give information on the symmetry energy:
  - π^+ - π^- ratio
  - Proton – neutron ratio
    - Combination with NEBURA
  - Particle flow

Nuclear symmetry energy for different EoS parameters

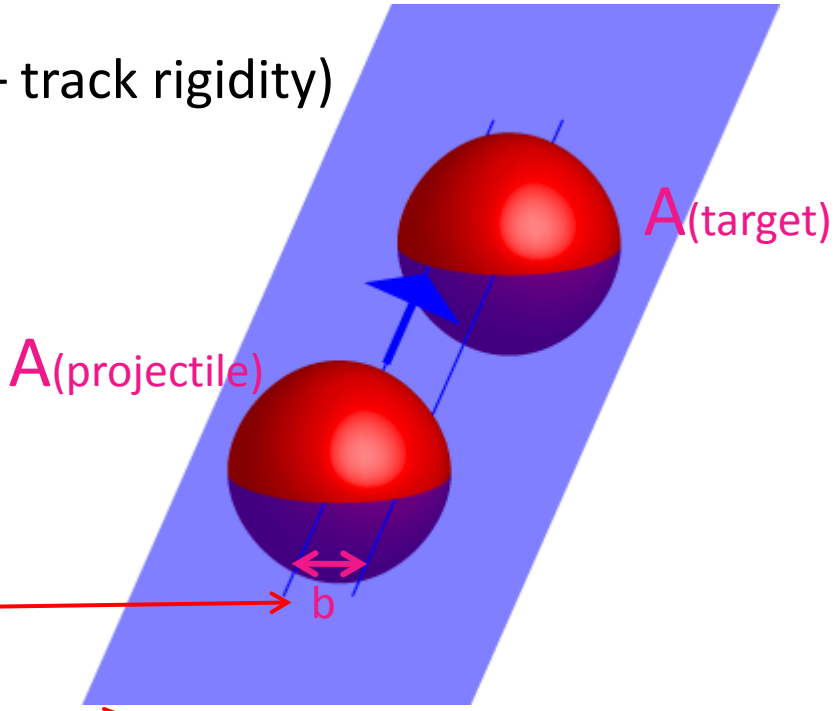
Phys. Rev. Lett. 94 (2005) 032701



RIKEN-RIBF region

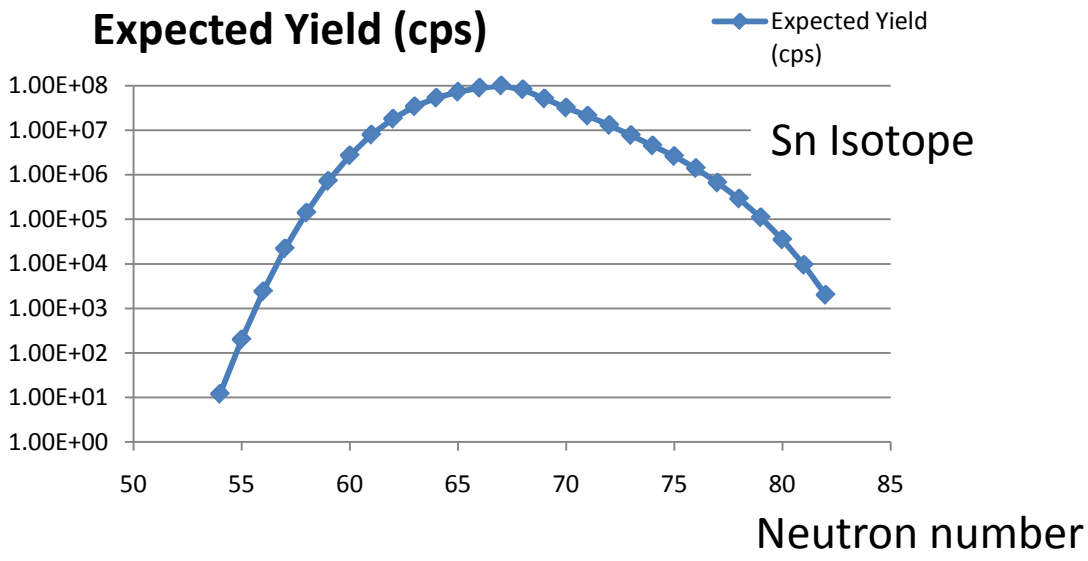
What we have to do with TPC

- Particle measurement.
  - Particle identification (dE/dX – track rigidity)
    - Charged pions
    - Proton
    - Light ions
    - Fragments …
  - momentum measurement
- Event characterization.
  - Collision centrality
    - Impact parameter (b)
    - Central collision: b~0
    - Peripheral collision: b~r(A)
  - Reaction plane
- Multiple particle should be measured.
  - Time projection chamber is suitable detector.



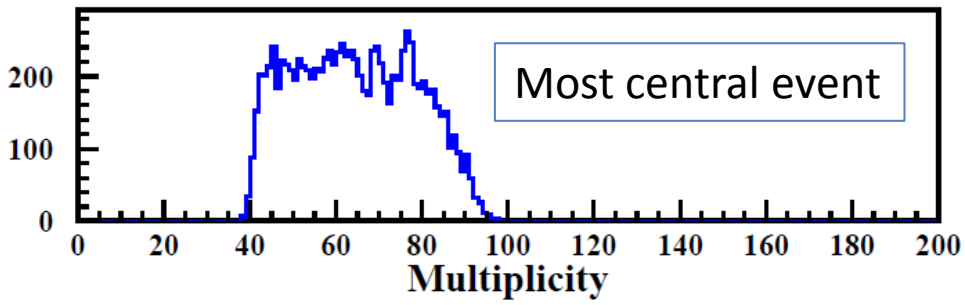
Beam condition

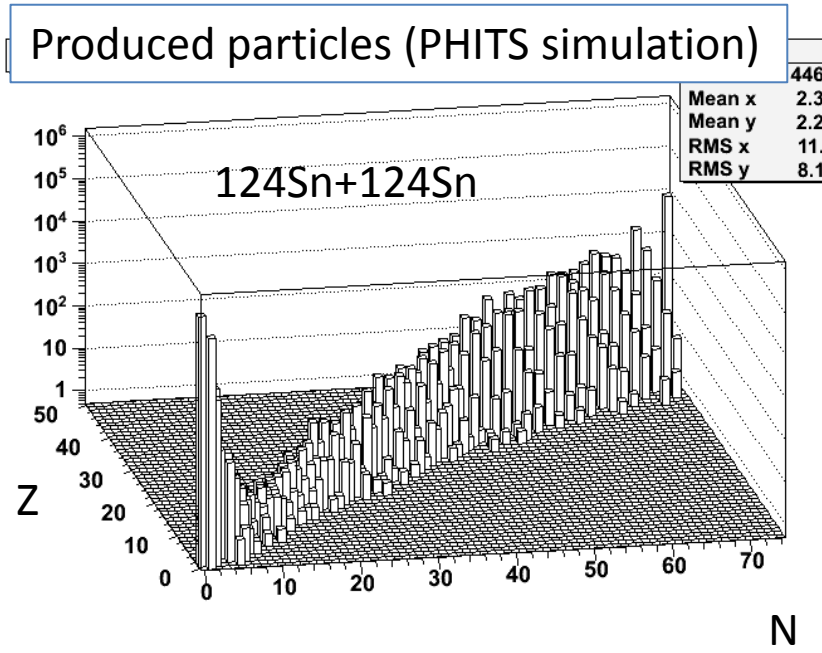
- 136Xe primary beam: 350AMeV 10pnA
- Target secondary beam is neutron rich Sn isotope: ^{132}Sn
- 2kcps ^{132}Sn beam can be expected
  - LISE++ calculation
- 0.1mt ^{124}Sn target: 0.15% event rate (according to PHITS)
  - 3Hz for ^{132}Sn+^{124}Sn, 5000Hz for ^{112}Sn+^{112}Sn



Large number of particles measured by TPC

- Large dynamic range on Z (and N)
  - Most of them are protons
  - Y(π) ~ 0.01 * Y(p)
- High-multiplicity up to ~100

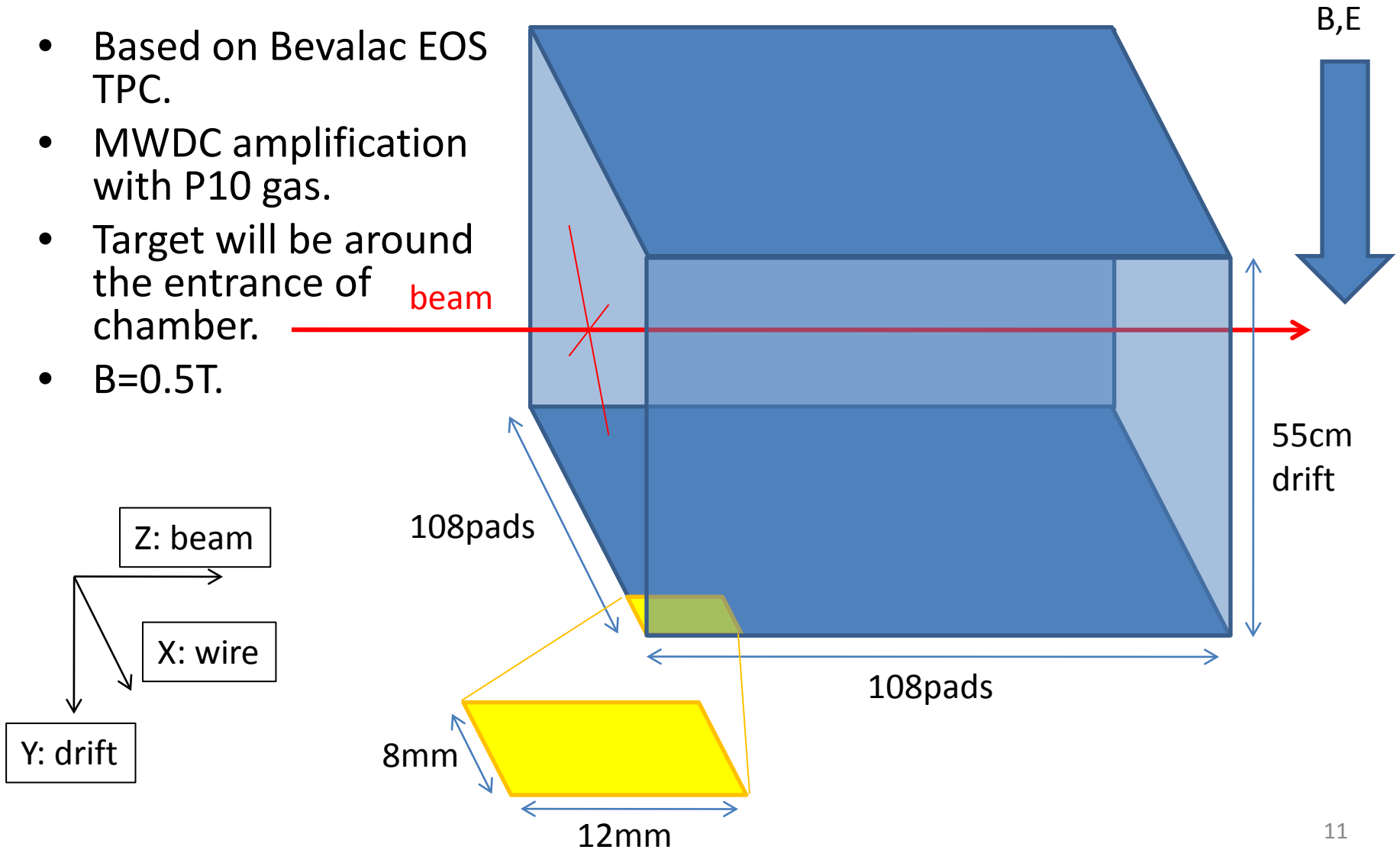




Basic design of chamber (as of today)

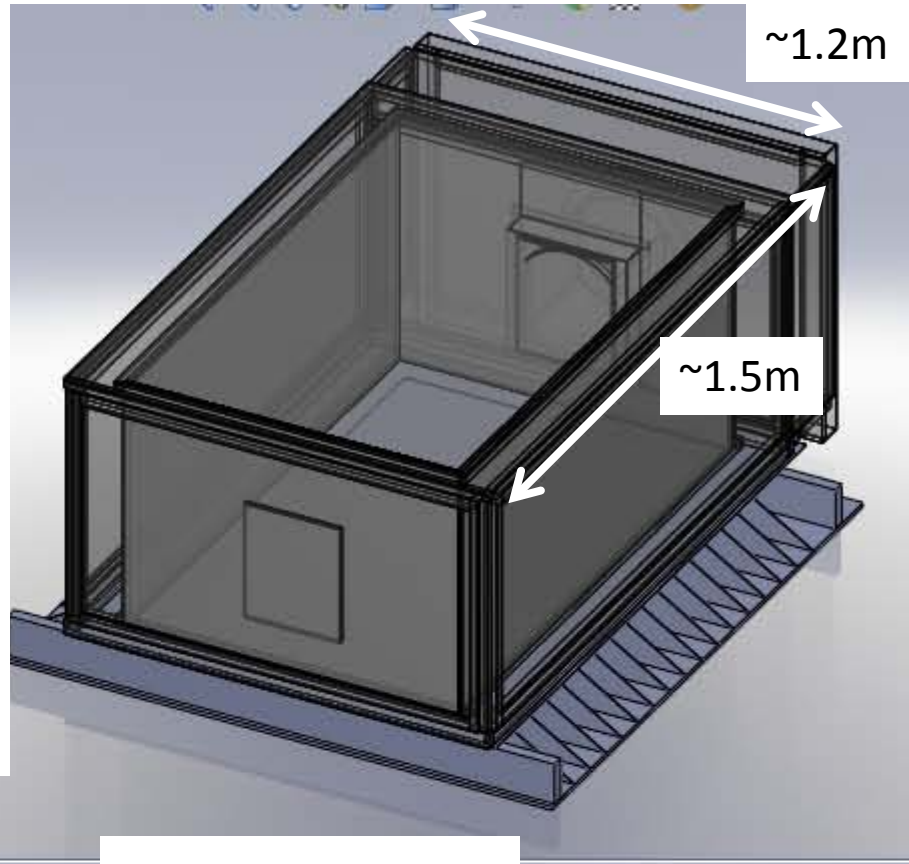
stable operation is most important

- Based on Bevalac EOS TPC.
- MWDC amplification with P10 gas.
- Target will be around the entrance of chamber.
- B=0.5T.



Designing started

- Technical designing mainly by MSU, Texas-A&M.
  - Production is supposed to start at the next physical year.
- Active target mode operation is considered.
  - Surround the all of TPC with SAMURAI vacuum chamber.

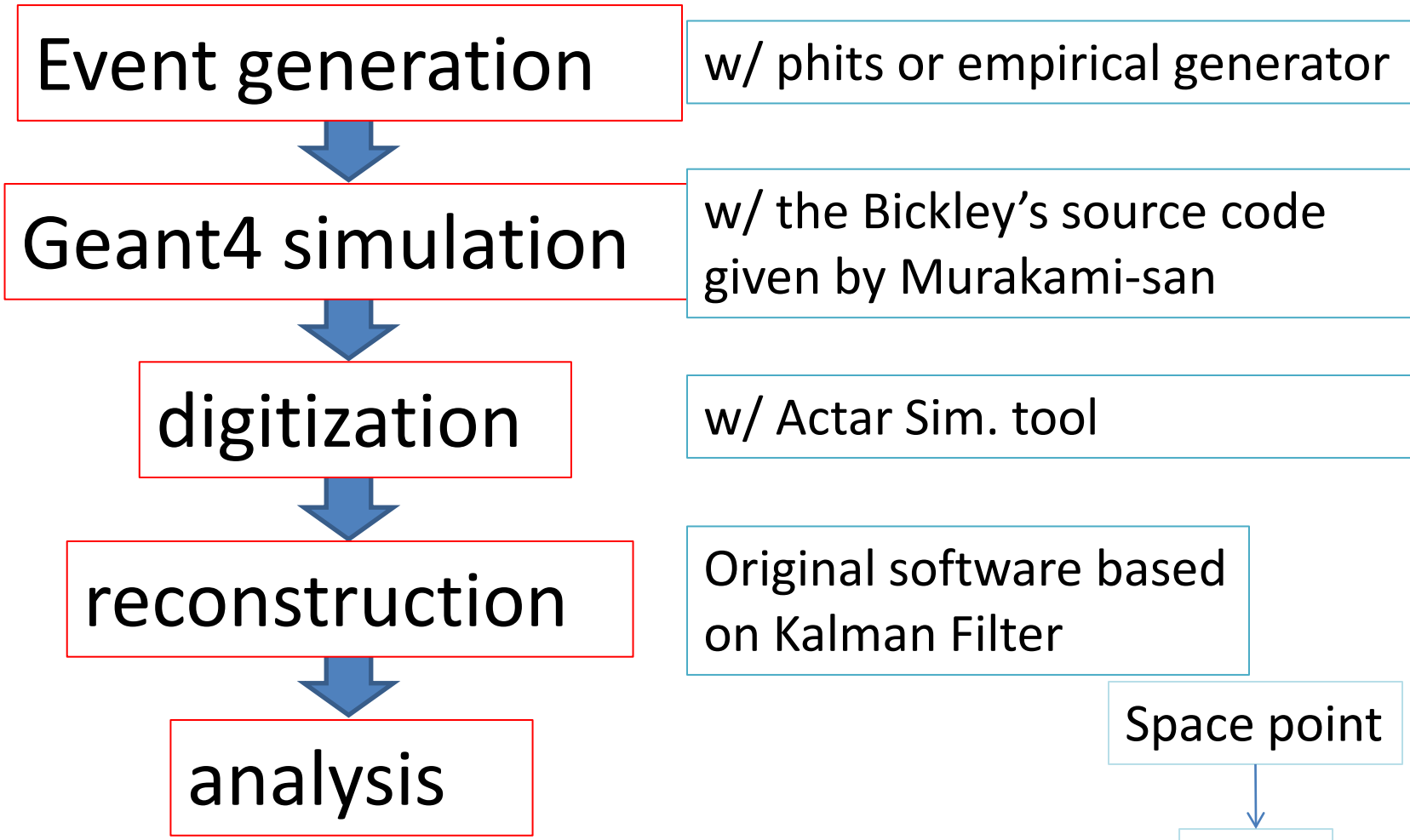


SAMURAI-TPC

(Urgent) Simulation study for designing

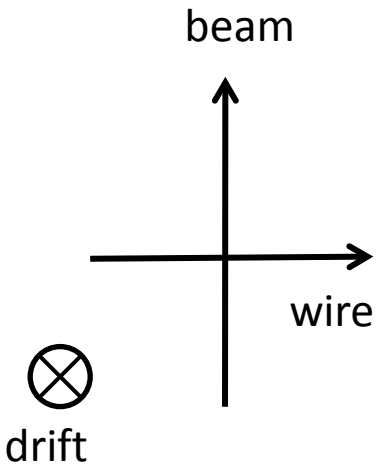
- TPC pad geometry have to be fixed to finalize pad and following electronics design.
  - Mainly based on two track separation.
    - Efficiency of low momentum tracks in central collisions.
  - Also based on energy resolution.
    - PID performance.
- Can we perform the stable TPC operation even under the high intensity heavy ion beam?
  - Most of the projectile pass through the target and deposit many electrons in chamber.
  - We might need a Faraday cage around the beam.

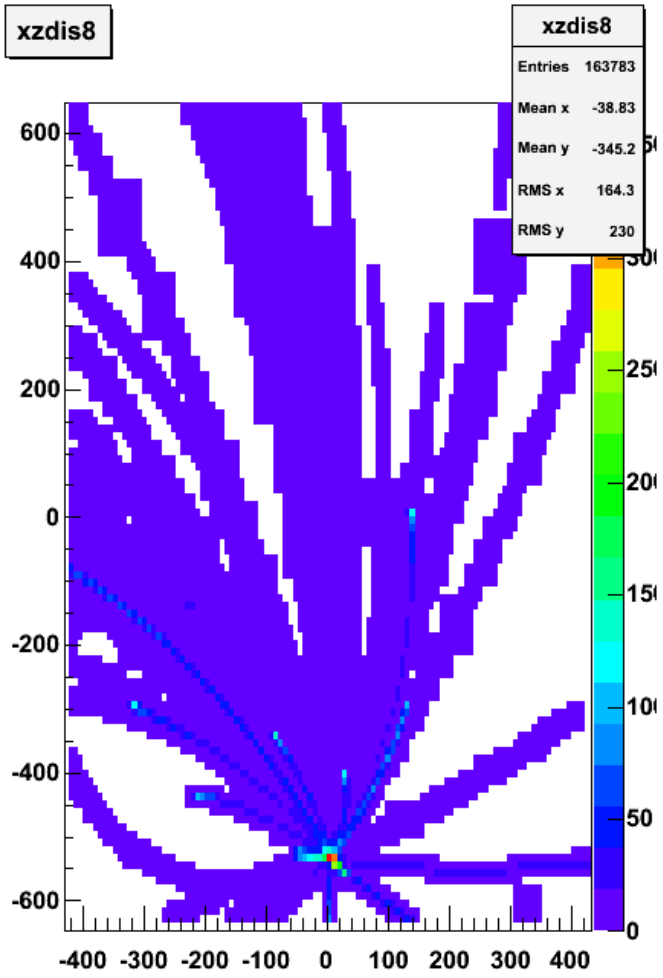
Simulation scheme



Event display

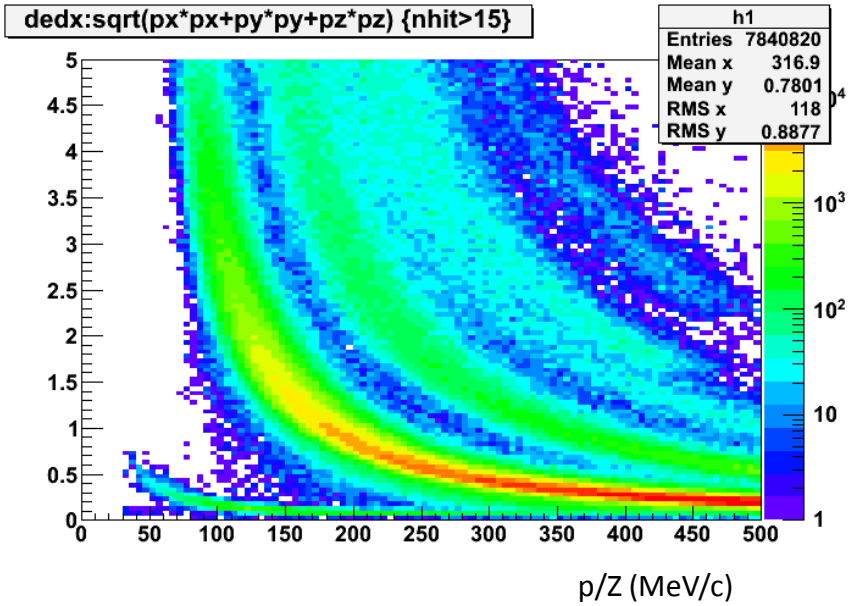
- Deposited energy on each readout pads.
  - 108x108
  - Tracks by light ions can be seen



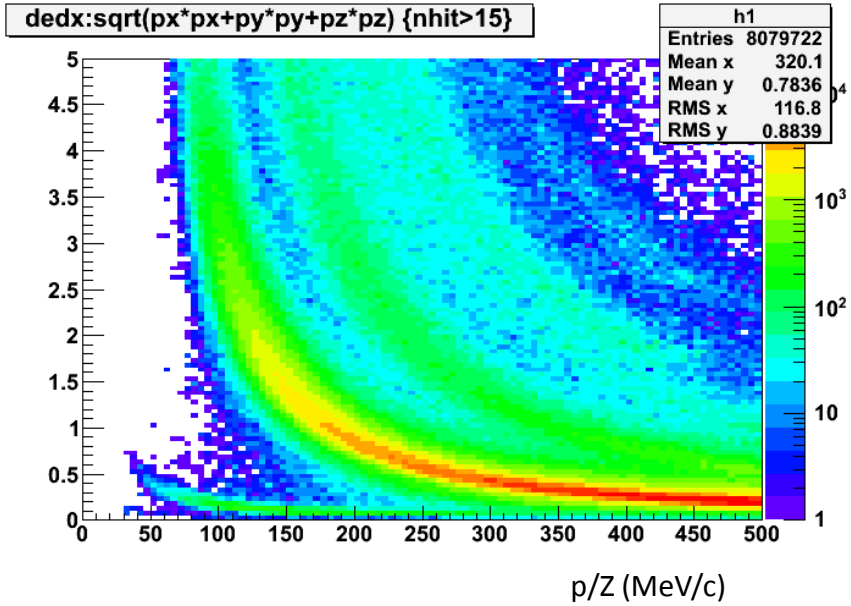


TPC PID performance (8x12mm pad)

Single particle



132Sn+132Sn min. bias

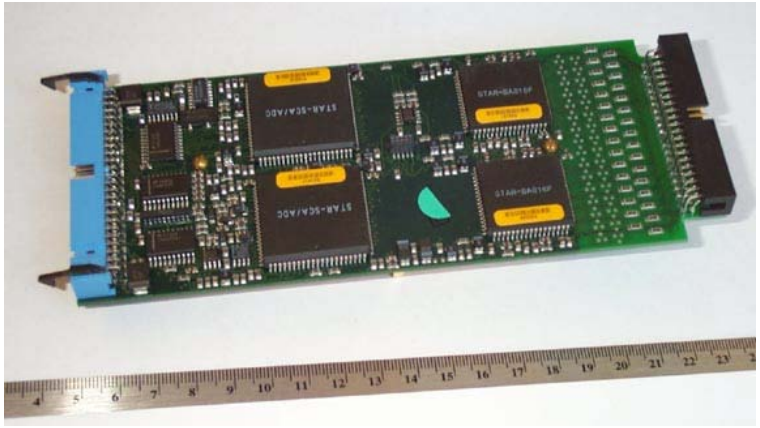


de/dx resolution

pion@140MeV/c	single:13.3%	<->	min. bias: 16%
proton@210MeV/c	single:12.7%	<->	min. bias: 14%

Readout electronics

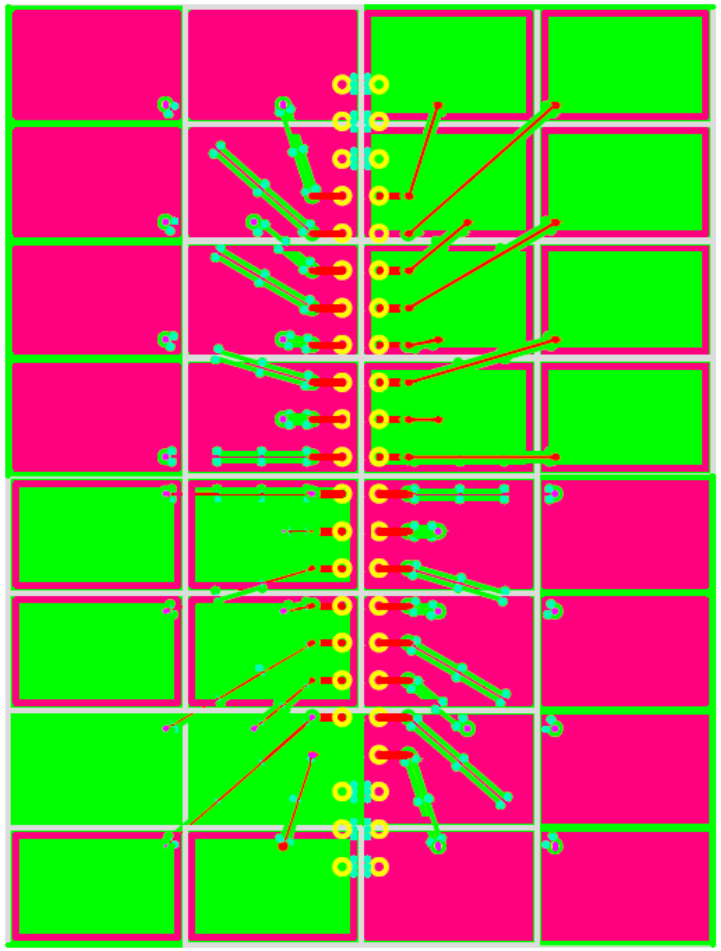
- At the first stage of SAMURAI-TPC experiment, STAR-FEE is planned to be used.
  - Made for 136,608 channel pad readout.
  - 6-12MHz 10-bit FADC, dynamic range of 800:1.
  - Have to learn STAR-DAQ system, and to figure out what we have to modify.



- After GET is ready, we would like to migrate to GET.
  - For that, we have to remain the room to migrate to GET from STAR-FEE.
  - We think to make adopter between FEE and pad plane.

Readout pads

- Started to design the pads adopted to STAR-FEE.
- X-talk from next pad is concerned in terms of tracking small-Z particles.



Data rate estimation

- On the assumption of taking all of the data for drifting electrons.
- 55cm drift, drift velocity is ~5cm/μsec.
- 10MHz, 10-bit digitization.
- 108x108 pads.
- 2% reduction with zero suppression.

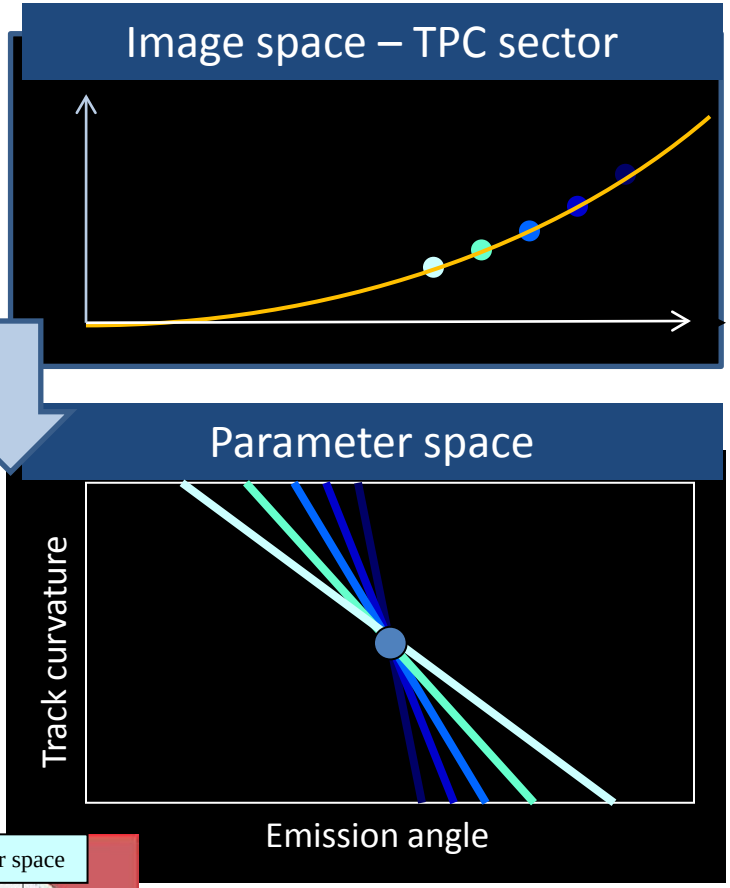
- 50kByte/trigger.

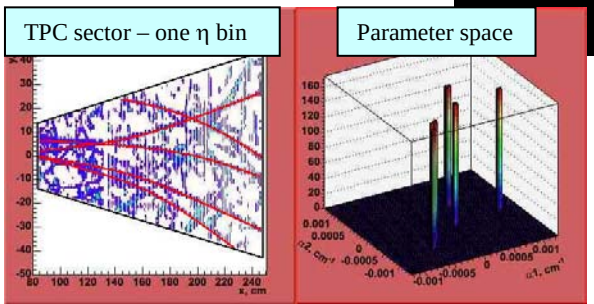
- All of $^{132}Sn+^{132}Sn$ data can be taken.
  - 3Hz trigger rate.
  - 150kByte/sec.
- Part of $^{112}Sn+^{112}Sn$ data can not be taken.
  - 5kHz trigger rate.
  - 250MByte/sec is necessary.

- STAR-DAQ can handle up to 30MByte/sec data rate.
  - Need trigger.

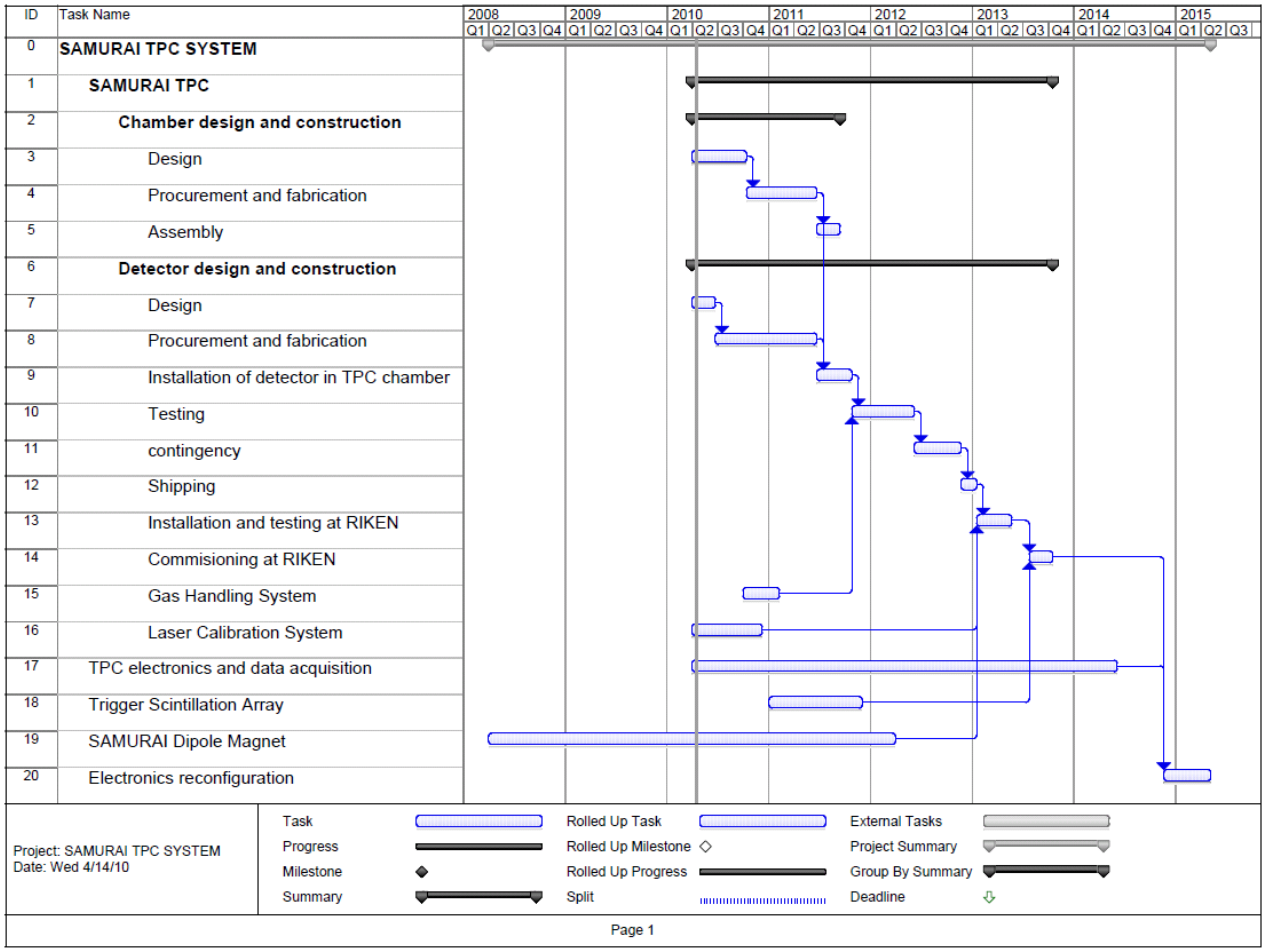
Trigger for Heavy Ion Collision experiment

- STAR-DAQ seems not to have internal trigger mechanism.
  - Need to think external trigger.
- GET can easily realize level2 type trigger.
- It takes ~1minute to reconstruct the tracks in most central collision events.
- Tracking type trigger is not realistic.
- Hough transform might realize tracking base trigger.
  - ALICE





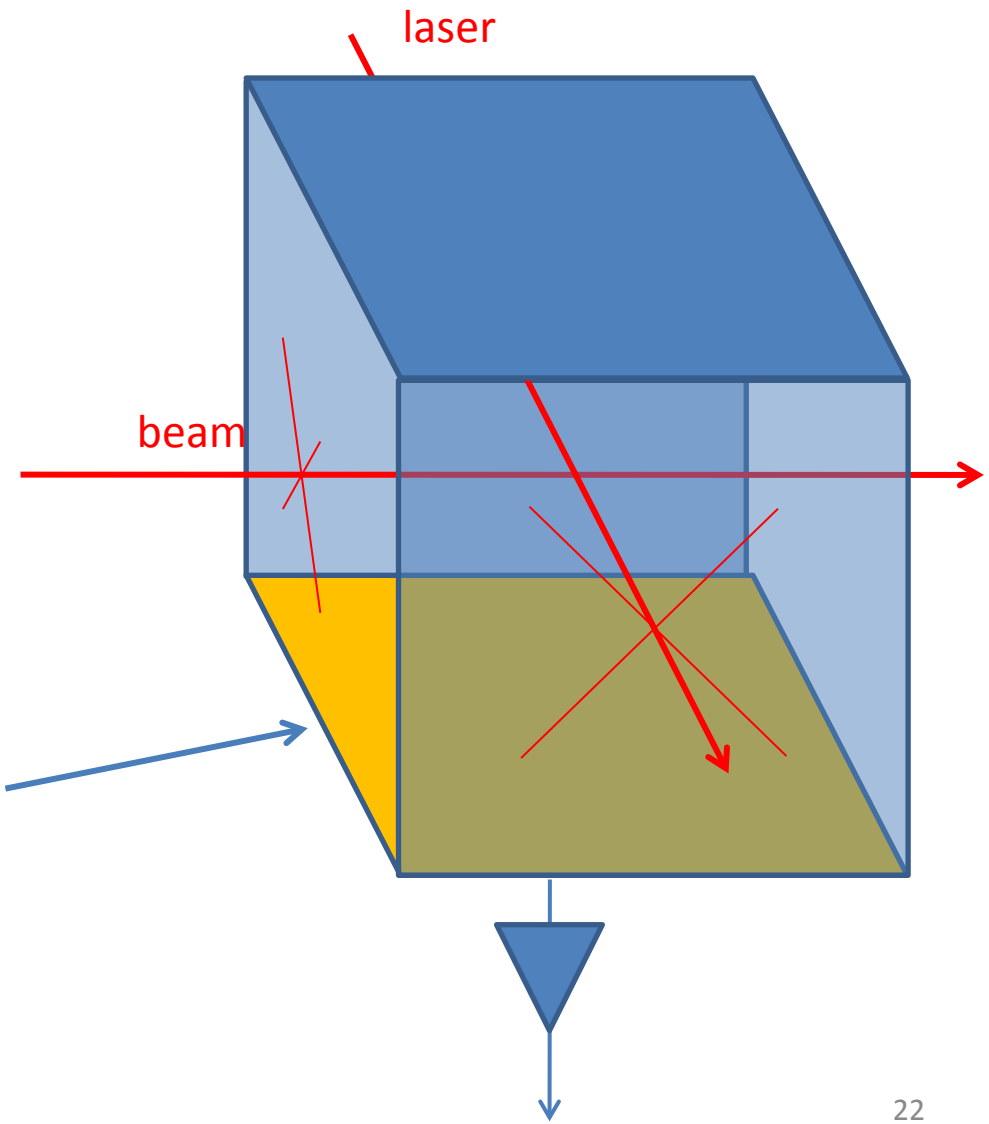
Timescale towards the first experiment



Test chamber

- A development of test chamber is on-going.
- To test FEE for SAMURAI-TPC.
  - Can STAR-FEE sustain heavy ion operation?
- To test laser calibration system.

- Furthermore, supposed to be a tracker for RIBF experiments.
- Wire/MicroMEGAS/GEM amplification.
- Heavy Ion beam test with MPGD type readout.



Summary

- The SAMURAI-TPC development has been started and the designing is on-going.
- The STAR-FEE is planned to be used at the first stage.
  - Migration to GET.
- High data through put from large number of pad is expected, and trigger mechanism should be considered.