



**KoALICE**



# **PNU-KOALICE REPORT 2022-01**

**IN-KWON YOO**

**PUSAN NATIONAL UNIVERSITY**

# PNU-KoALICE Team (WHO)



KoALICE

# PNU-KoALICE Team (WHO)



KoALICE

\* 2Profs. + 2PhD + 1PhD Stud + 7MAStud + (1+5) UG = 12 (+6)

# PNU-KoALICE Team (WHO)



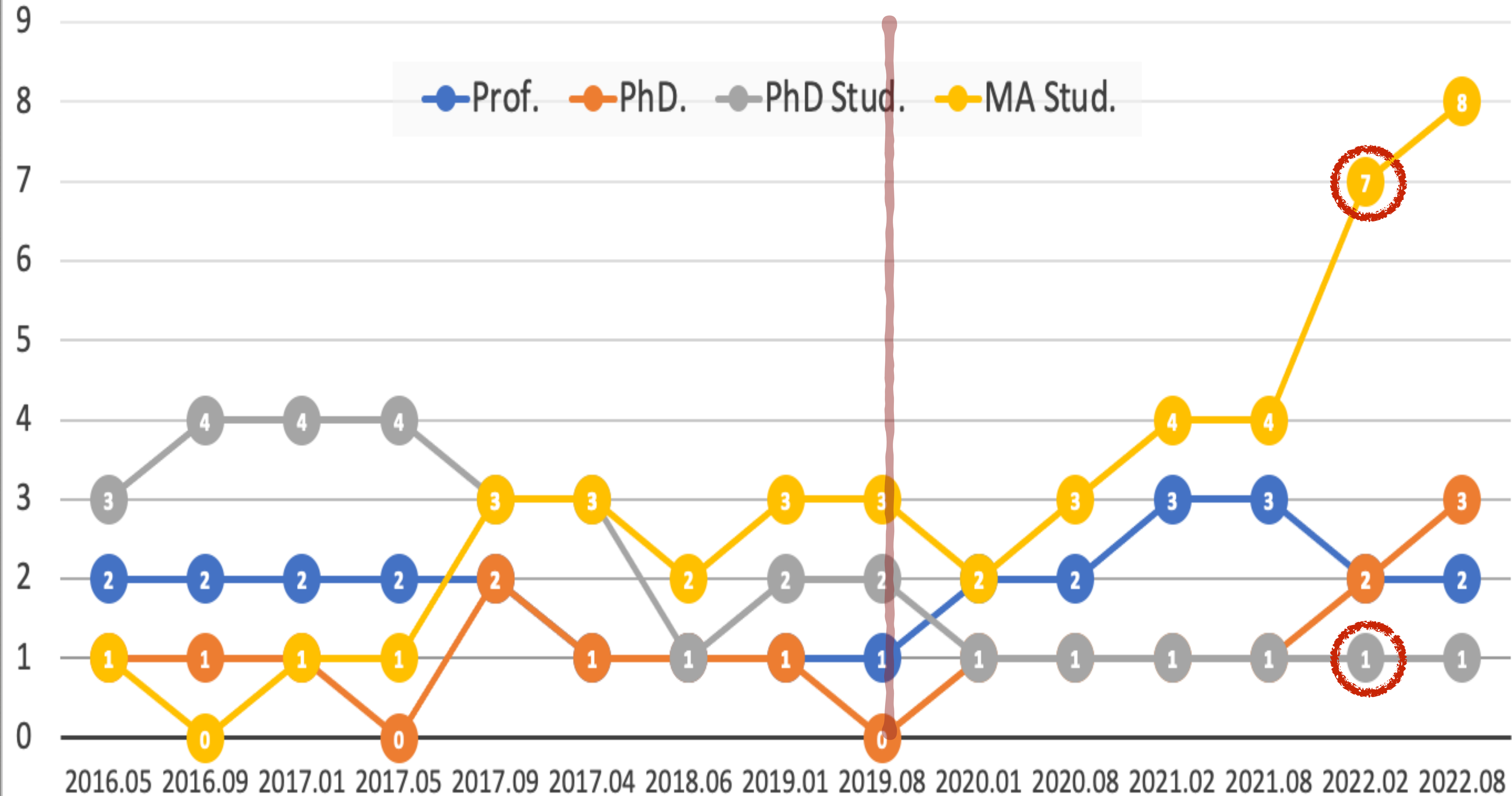
- \* 2Profs. + 2PhD + 1PhD Stud + 7MAStud + (1+5) UG = 12 (+6)
- \* 2021.03 - 2021.08 - 2022.02 (IKY)
  - \* 1PhD Stud. (BHLim PhD '22.02)
  - \* -JHKim, +JHJeong, +SWChoi in 2021.09
  - \* MJKwon MS '22.02 → PhD Stud. '22.03 - (Military Service 3Y) -
  - \* GTPark, YJChoi, SWPark UG intern

# PNU-KoALICE Team (WHO)



- \* 2Profs. + 2PhD + 1PhD Stud + 7MAStud + (1+5) UG = 12 (+6)
- \* 2021.03 - 2021.08 - 2022.02 (IKY)
  - \* 1PhD Stud. (BHLim PhD '22.02)
  - \* -JHKim, +JHJeong, +SWChoi in 2021.09
  - \* MJKwon MS '22.02 → PhD Stud. '22.03 - (Military Service 3Y) -
  - \* GTPark, YJChoi, SWPark UG intern
- \* 2021.03 - 2021.08 - 2022.02 (SHLim)
  - \* 1Prof. (BKKim) → SKKU Faculty (new KoALICE) in 2021.09
  - \* ChKim + JHSong in 2021.12
  - \* MAStud: JHRyu, SJJi, JHOh (MA) + YJKim in '21.09
  - \* HGJang, HJLim, YHHong, GBPark, MJKim UG Internship

# KoALICE - PNU



12-15

5-6

3-4

2-3

2

# PNU-KoALICE Team Working Frame



# PNU-KoALICE Team Working Frame



- Goal: Expertise (Education) + Contribution (Research)



# PNU-KoALICE Team Working Frame



- Goal: Expertise (Education) + Contribution (Research)
- Timeline: 2009 - 2022 - 2025 - 2028 - 2031 (Silicon!)

# PNU-KoALICE Team Working Frame



- Goal: Expertise (Education) + Contribution (Research)
- Timeline: 2009 - 2022 - 2025 - 2028 - 2031 (Silicon!)
- Strategy
  - ▶ Hardware (DET): ~~ITS~~ ~~MCT~~ + ~~HIC~~ + R&D (ALPIDE..) + A NEW Exp. (Trillision)
  - ▶ Software (DA): LF (Resonance) / HF (Pr.fLim) / xT-scaling (new)

# PNU-KoALICE Team Working Frame



- Goal: Expertise (Education) + Contribution (Research)
- Timeline: 2009 - 2022 - 2025 - **2028** - 2031 (**Silicon!**)
- Strategy
  - ▶ Hardware (DET): ~~ITS~~ ~~MCT~~ + ~~HIC~~ + R&D (ALPIDE..) + A NEW Exp. (Trillision)
  - ▶ Software (DA): LF (Resonance) / HF (Pr.fLim) / **xT-scaling (new)**
- PNU (311-206/207:125 m<sup>2</sup> + **201:35 m<sup>2</sup>**) / CERN (587-R-24: 15m<sup>2</sup> / ITS Lab.)
  - ▶ PhD Stud.: PNU - CERN (2-3Y) - PNU for Physics Analysis
  - ▶ MA Stud./UG: PNU - CERN (<0.5Y total) for DET R&D + **KOMAC**
  - ▶ MA Stud./UG: Simulation / Data Analysis
  - ▶ PhD: CERN/PNU for ALL (Prof. Lim's supervision)

# PNU-KoALICE Team Working Frame



- Goal: Expertise (Education) + Contribution (Research)
- Timeline: 2009 - 2022 - 2025 - **2028** - 2031 (**Silicon!**)
- Strategy
  - ▶ Hardware (DET): ~~ITS MCT + HIC~~ + R&D (ALPIDE..) + A NEW Exp. (Trillision)
  - ▶ Software (DA): LF (Resonance) / HF (Pr.fLim) / **xT-scaling (new)**
- PNU (311-206/207:125 m<sup>2</sup> + **201:35 m<sup>2</sup>**) / CERN (587-R-24: 15m<sup>2</sup> / ITS Lab.)
  - ▶ PhD Stud.: PNU - CERN (2-3Y) - PNU for Physics Analysis
  - ▶ MA Stud./UG: PNU - CERN (<0.5Y total) for DET R&D + **KOMAC**
  - ▶ MA Stud./UG: Simulation / Data Analysis
  - ▶ PhD: CERN/PNU for ALL (Prof. Lim's supervision)
- Budget: Personnel / Subsistence / Travel / Infra. / R&D / Construction **KoALICE** + ~~A basic budget (50M/y) in 2019 - 2022~~

# PNU-KoALICE Team Working Frame



- Goal: Expertise (Education) + Contribution (Research)
- Timeline: 2009 - 2022 - 2025 - **2028** - 2031 (**Silicon!**)
- Strategy
  - ▶ Hardware (DET): ~~ITS MCT + HIC~~ + R&D (ALPIDE..) + A NEW Exp. (Trillion)
  - ▶ Software (DA): LF (Resonance) / HF (Pr.fLim) / **xT-scaling (new)**
- PNU (311-206/207:125 m<sup>2</sup> + **201:35 m<sup>2</sup>**) / CERN (587-R-24: 15m<sup>2</sup> / ITS Lab.)
  - ▶ PhD Stud.: PNU - CERN (2-3Y) - PNU for Physics Analysis
  - ▶ MA Stud./UG: PNU - CERN (<0.5Y total) for DET R&D + **KOMAC**
  - ▶ MA Stud./UG: Simulation / Data Analysis
  - ▶ PhD: CERN/PNU for ALL (Prof. Lim's supervision)
- Budget: Personnel / Subsistence / Travel / Infra. / R&D / Construction **KoALICE** + ~~A basic budget (50M/y) in 2019 - 2022~~
- Working Group - using Google disk, Notion, Public Web. (Google)
  - ▶ **Webserver problem! No secretary!** -> <https://hipex.pusan.ac.kr>
  - ▶ Lab.Meeting (1 wk): report + discussion
  - ▶ LF PWG / ~~MCT / HIC / PNU-Inha Vidyo Meeting /~~ **SQM2022**
  - ▶ Lim's NPL: <https://npl.pusan.ac.kr/npl/index.do>

# Working Chronology



KoALICE

# Working Chronology



- IKY (PNU): Administration (2003 -
  - ▶ Heavy Ion > LF / Exotic > Matter@LHC > Phase Transition in high  $\mu$
  - ▶ Scintillator > RICH + Silicon > Silicon > Charmed Baryons ... (2021 - )
  - ▶ A new idea on trillisions (2019 - 2030)

# Working Chronology



- IKY (PNU): Administration (2003 -
  - ▶ Heavy Ion > LF / Exotic > Matter@LHC > Phase Transition in high  $\mu$
  - ▶ Scintillator > RICH + Silicon > Silicon > Charmed Baryons ... (2021 - )
  - ▶ A new idea on trillisions (2019 - 2030)
- SHLim (PNU): A new faculty (2019.09 - )
  - ▶ Particle Correlations (Jet, HF)
  - ▶ PHENIX > sPHENIX ITS (ALPIDE)
  - ▶ ALICE, RAON



# Working Chronology



- IKY (PNU): Administration (2003 -
  - ▶ Heavy Ion > LF / Exotic > Matter@LHC > Phase Transition in high  $\mu$
  - ▶ Scintillator > RICH + Silicon > Silicon > Charmed Baryons ... (2021 - )
  - ▶ A new idea on trillisions (2019 - 2030)
- SHLim (PNU): A new faculty (2019.09 - )
  - ▶ Particle Correlations (Jet, HF)
  - ▶ PHENIX > sPHENIX ITS (ALPIDE)
  - ▶ ALICE, RAON

# Working Chronology



## ■ IKY (PNU): Administration (2003 -

- ▶ Heavy Ion > LF / Exotic > Matter@LHC > Phase Transition in high  $\mu$
- ▶ Scintillator > RICH + Silicon > Silicon > Charmed Baryons ... (2021 - )
- ▶ A new idea on trillisions (2019 - 2030)

## ■ SHLim (PNU): A new faculty (2019.09 - )

- ▶ Particle Correlations (Jet, HF)
- ▶ PHENIX > sPHENIX ITS (ALPIDE)
- ▶ ALICE, RAON

## ■ SUChung (CERN-Guest) (2009 - 2018)

- ▶ Glueball/Exotics/ Diffractive Physics/ PWA / Spin / Mathematics > [Paper](#)

# Working Chronology



## ■ IKY (PNU): Administration (2003 -

- ▶ Heavy Ion > LF / Exotic > Matter@LHC > Phase Transition in high  $\mu$
- ▶ Scintillator > RICH + Silicon > Silicon > Charmed Baryons ... (2021 - )
- ▶ A new idea on trillisions (2019 - 2030)

## ■ SHLim (PNU): A new faculty (2019.09 - )

- ▶ Particle Correlations (Jet, HF)
- ▶ PHENIX > sPHENIX ITS (ALPIDE)
- ▶ ALICE, RAON

## ■ SUChung (CERN-Guest) (2009 - 2018)

- ▶ Glueball/Exotics/ Diffractive Physics/ PWA / Spin / Mathematics > Paper

## ■ HOesler (DA) (2016) Great regret!!

- ▶ Resonance / THERMUS / 1 short - 1 long paper on THERMUS > Pending

# Working Chronology



## ■ IKY (PNU): Administration (2003 -

- ▶ Heavy Ion > LF / Exotic > Matter@LHC > Phase Transition in high  $\mu$
- ▶ Scintillator > RICH + Silicon > Silicon > Charmed Baryons ... (2021 - )
- ▶ A new idea on trillisions (2019 - 2030)

## ■ SHLim (PNU): A new faculty (2019.09 - )

- ▶ Particle Correlations (Jet, HF)
- ▶ PHENIX > sPHENIX ITS (ALPIDE)
- ▶ ALICE, RAON

## ■ SUChung (CERN-Guest) (2009 - 2018)

- ▶ Glueball/Exotics/ Diffractive Physics/ PWA / Spin / Mathematics > Paper

## ■ HOesler (DA) (2016) Great regret!!

- ▶ Resonance / THERMUS / 1 short - 1 long paper on THERMUS > Pending

## ■ JHSong (CERN/PNU) (2018), ABorrisov (~2016)

- ▶ LF,  $\Sigma$ ,  $\Sigma^*$ ,  $\Xi^*$  Resonances > ' $\Xi^*$  in PbPb' paper in 2018  
> delayed due to  $\Xi$  correction
- ▶ ' $\Sigma^0$  in pp' paper: soon submitted to the 1st round with IRC → now in 2nd round

# Working Themes for Stud.



KoALICE

# Working Themes for Stud.



## ■ BHLim (CERN 2018.05 - )

- ▶ HIC Assembly System (Soldering) > Mass Chip Test Infrastructure 2016
- ▶ ITS Coordinator 2017, ITS Commissioning during LS2 (2019-2021)
- ▶ Physics Analysis (LF) from 2018- ( $\Xi^*$ ,  $\Sigma^*$  in hi-mul pp@13TeV)
- ▶ PhD Thesis + JHEP paper (IRC2)
- ▶ Post-Doctor / SQM2022 documentary staff

# Working Themes for Stud.



## ■ BHLim (CERN 2018.05 - )

- ▶ HIC Assembly System (Soldering) > Mass Chip Test Infrastructure 2016
- ▶ ITS Coordinator 2017, ITS Commissioning during LS2 (2019-2021)
- ▶ Physics Analysis (LF) from 2018- ( $\Xi^*$ ,  $\Sigma^*$  in hi-mul pp@13TeV)
- ▶ PhD Thesis + JHEP paper (IRC2)
- ▶ Post-Doctor / SQM2022 documentary staff

## ■ MJKwon (Lab. 2016.12 - ): Internship UG > MA Stud. since 2018.12

- ▶ Mass Chip Test 2017.07 - 2018.06, HIC Electrical Tests incl. Setup (2017.10 - 2018.06 - 2019)
- ▶ MA Stud. in 2019 + ITS Commissioning during LS2 (temp.stay at CERN)
- ▶ Trillision (Beam-Beam) simulation + Experiment
- ▶ MS Thesis + NPSM paper submitted
- ▶ PhD Stud.: ITS3 + ALICE3 / SQM2022 technical Staff

# Working Themes for Stud.





# Working Themes for Stud.



## ■ JHJeong (Lab. 2017.08 - )

- ▶ Mass Chip Test 2017.10 - 2018.06
- ▶ ITS Commissioning during LS2 (temp.stay at CERN)
- ▶ (~~MVD vs. ALPIDE chip study for CBM~~) → Garfield simulation for further chips at CERN par. to Commissioning
- ▶ Intermission ('20.03 - '21.08) - Rejoin ('21.09)
- ▶ Simulation study on ALPIDE Charge Collection Time + Radiation Hardness (alpha@5MeV)

# Working Themes for Stud.



## ■ JHJeong (Lab. 2017.08 - )

- ▶ Mass Chip Test 2017.10 - 2018.06
- ▶ ITS Commissioning during LS2 (temp.stay at CERN)
- ▶ (~~MVD vs. ALPIDE chip study for CBM~~) → Garfield simulation for further chips at CERN par. to Commissioning
- ▶ Intermission ('20.03 - '21.08) - Rejoin ('21.09)
- ▶ Simulation study on ALPIDE Charge Collection Time + Radiation Hardness (alpha@5MeV)

## ■ SWChoi (Lab. 2021.03 - ): Internship UG > BS-MA Stud. '21.09

- ▶ re-operate ALICIA (Win10 upgrade)+ Chip-characterization
- ▶ Study in ITS3 WP3
- ▶ CERN visit '22.01 (ITS3-project coordination): MLR? (curved ALPIDE?) ITS3 Radiation Hardness at KOMAC (TR102) - within 6 months '22
- ▶ ALPIDE chip carrier board production in MEMSPEC (on-going)

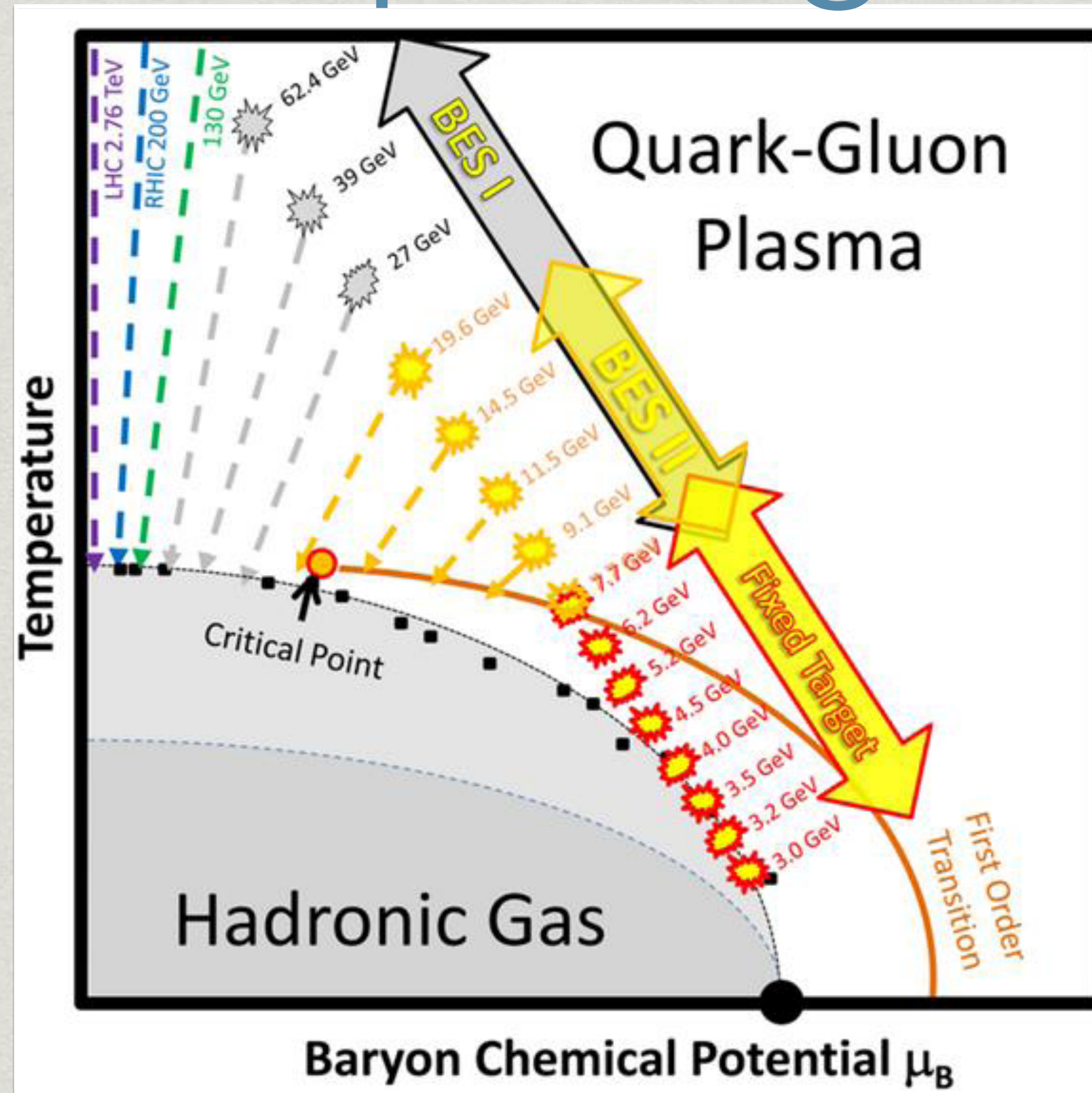
# A New Proposal beyond LHC

- ❑ Exploring a new area in QCD Phase diagram
- ❑ A totally new concept of 'Co'-llision > 'Tri'-llision  
> 'Quad'-llision
- ❑ Technical challenge
- ❑ beam-beam interaction  $\otimes$  beam-beam interaction

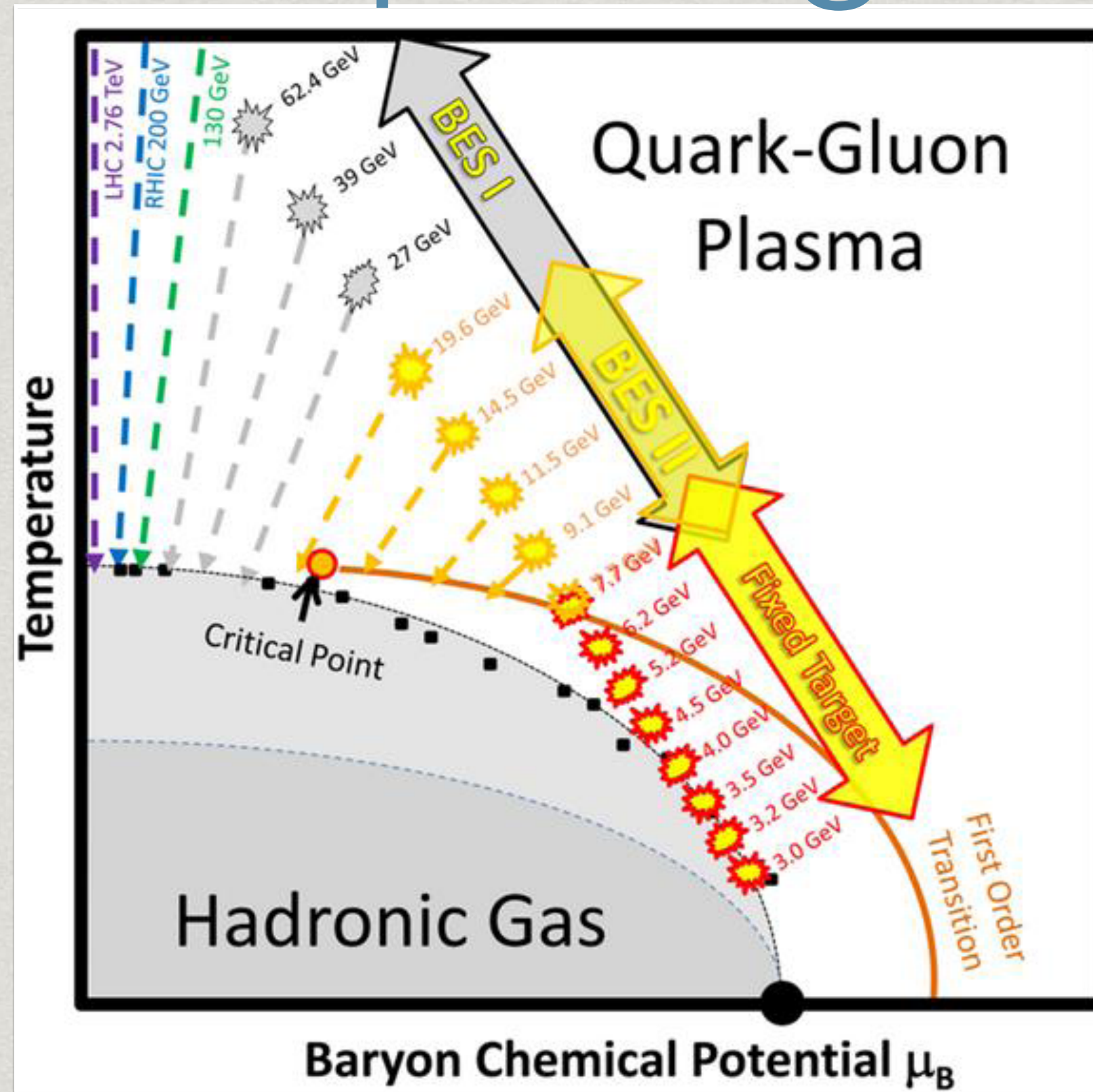
# Exploring QGP phase



KoALICE

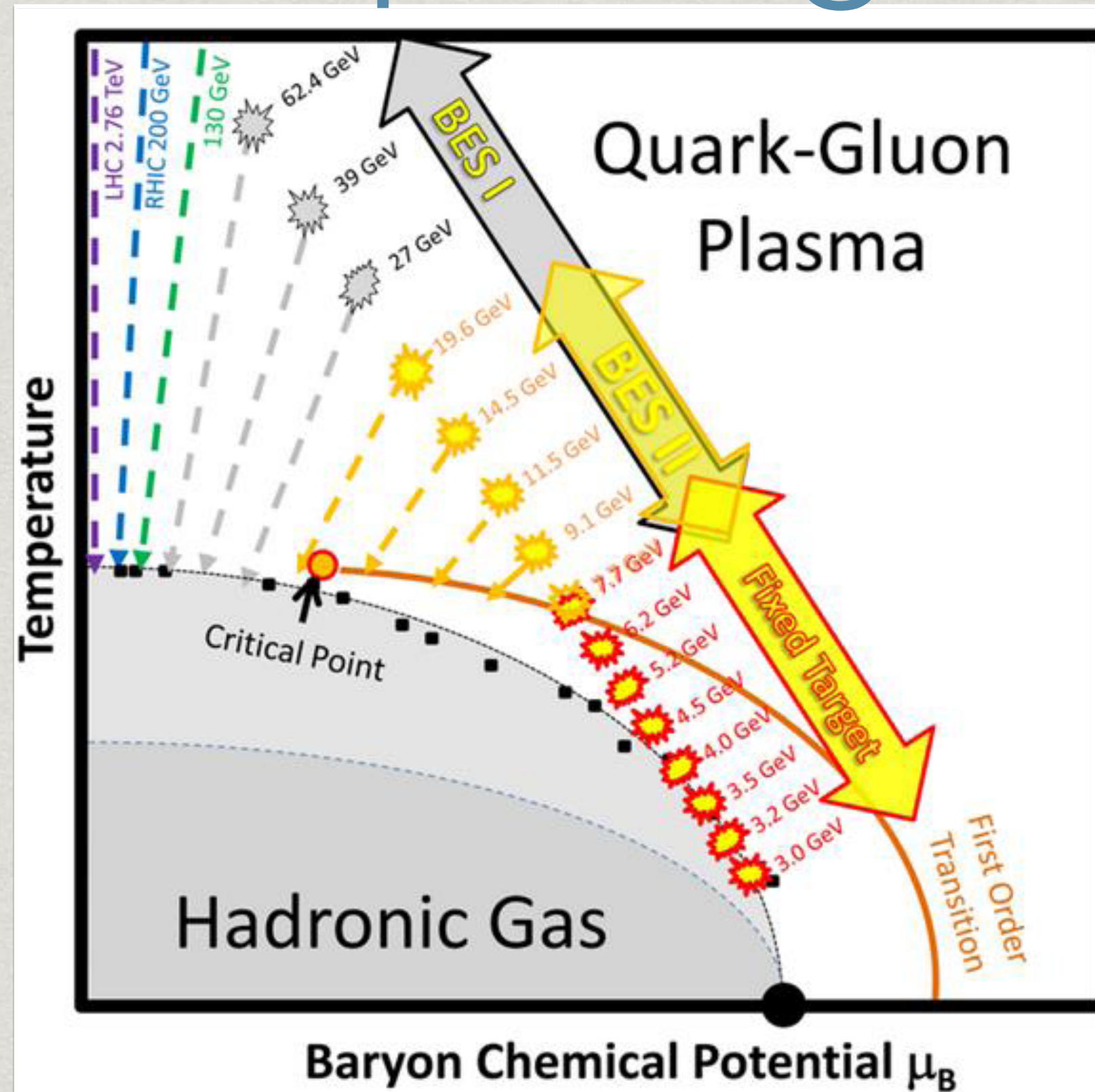


# Exploring QGP phase



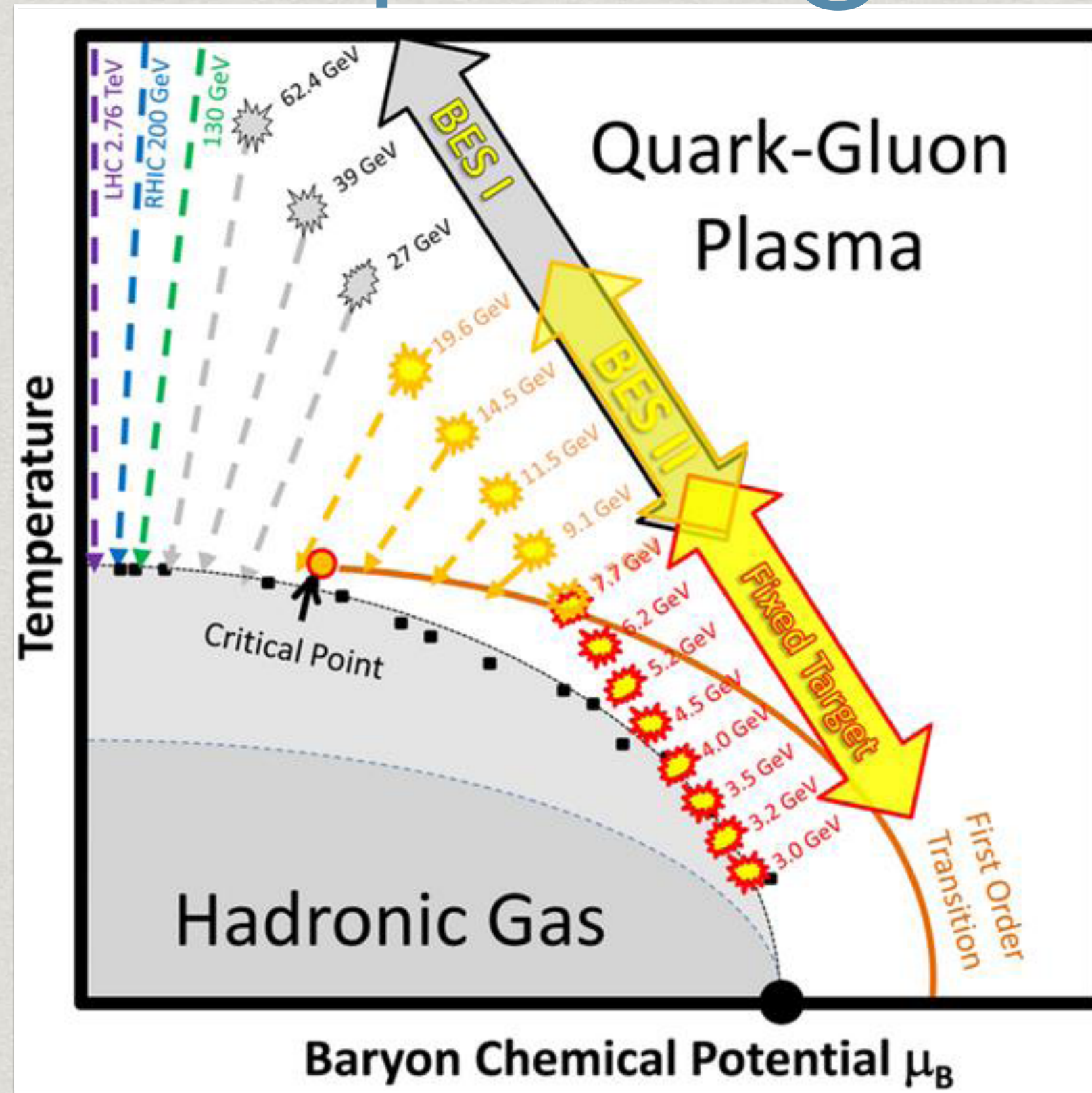
- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition

# Exploring QGP phase

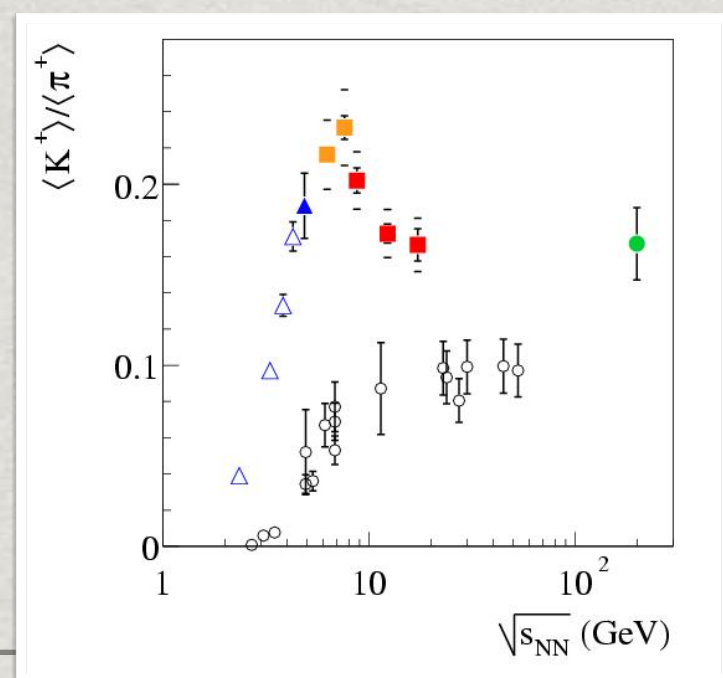


- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}}$  ~ boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

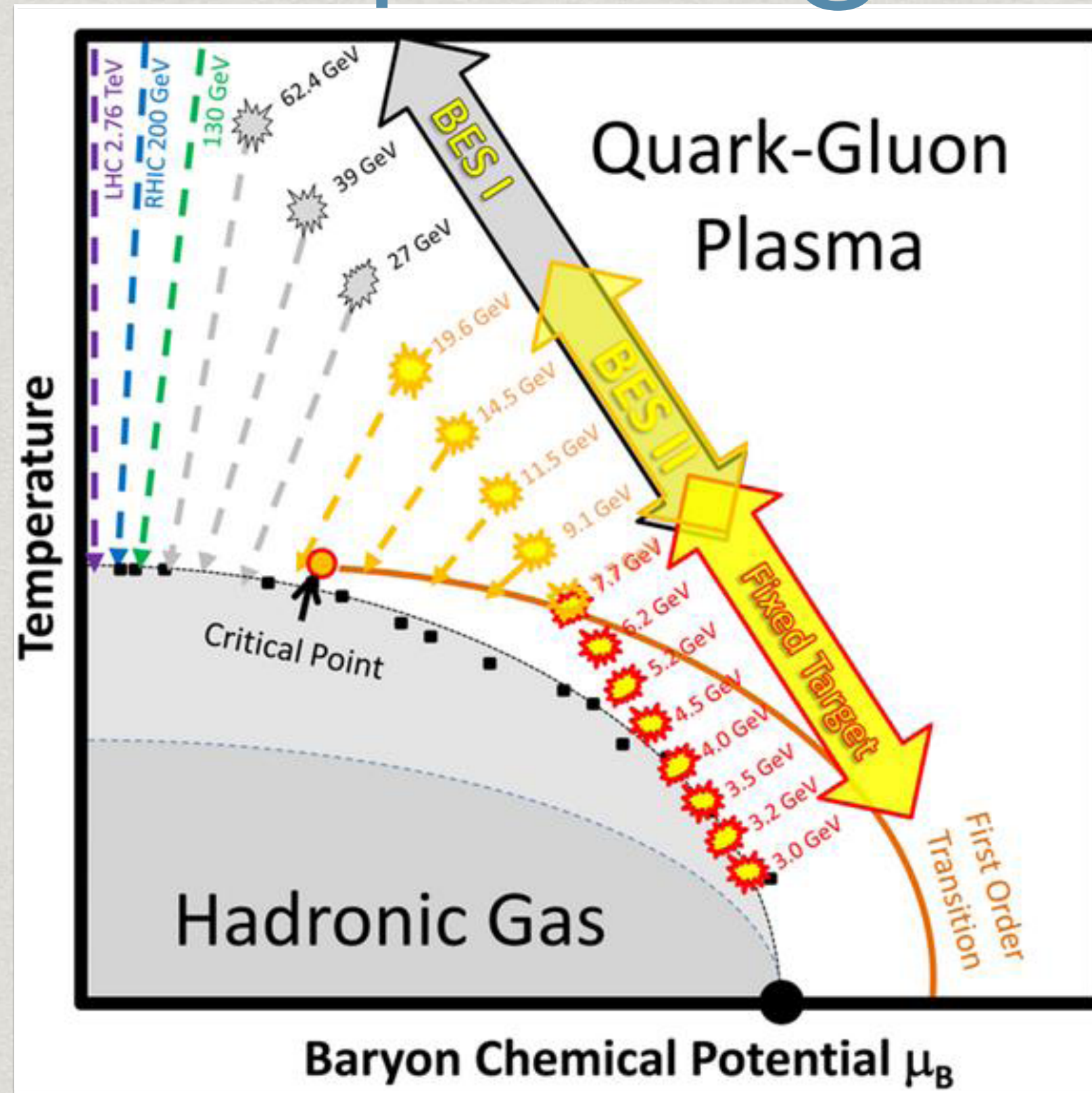
# Exploring QGP phase



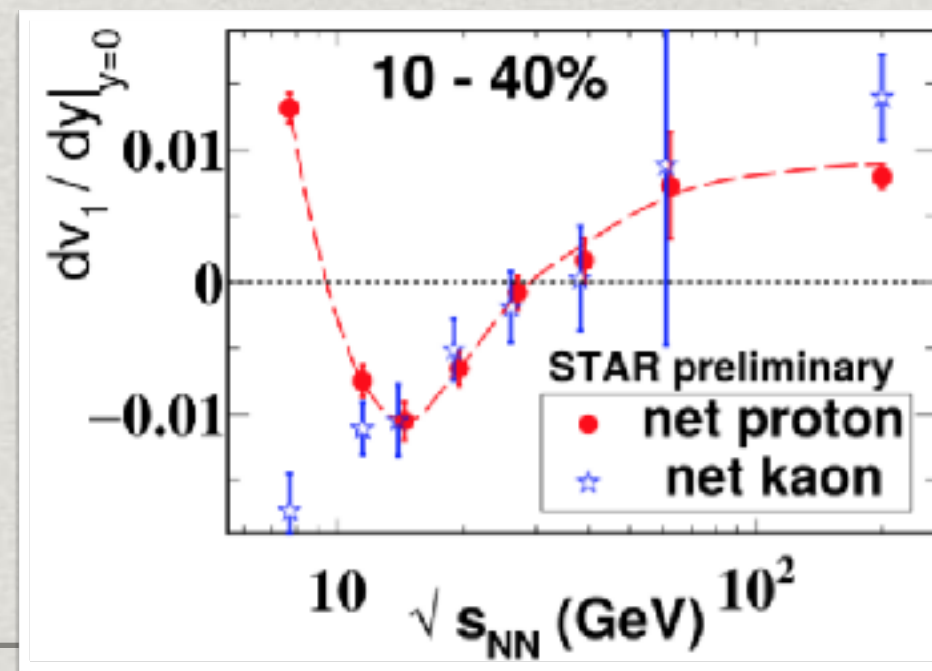
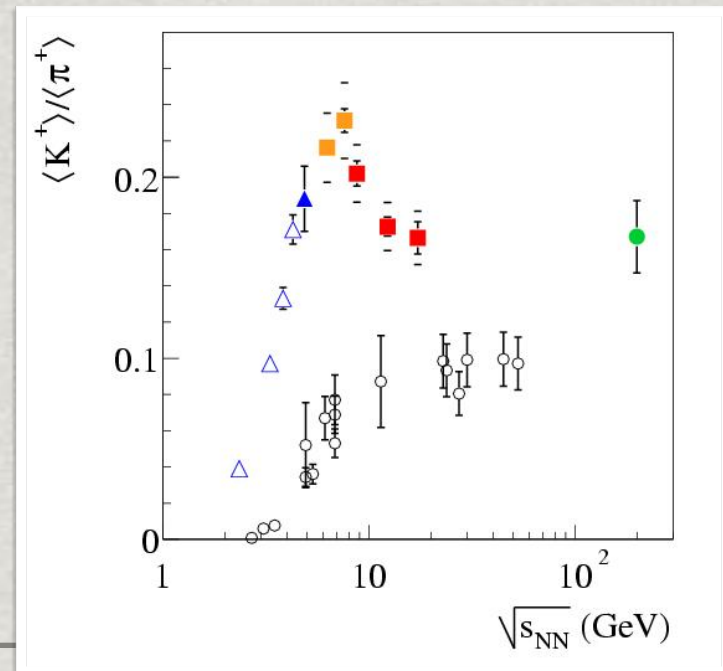
- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}}$  ~ boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?



# Exploring QGP phase

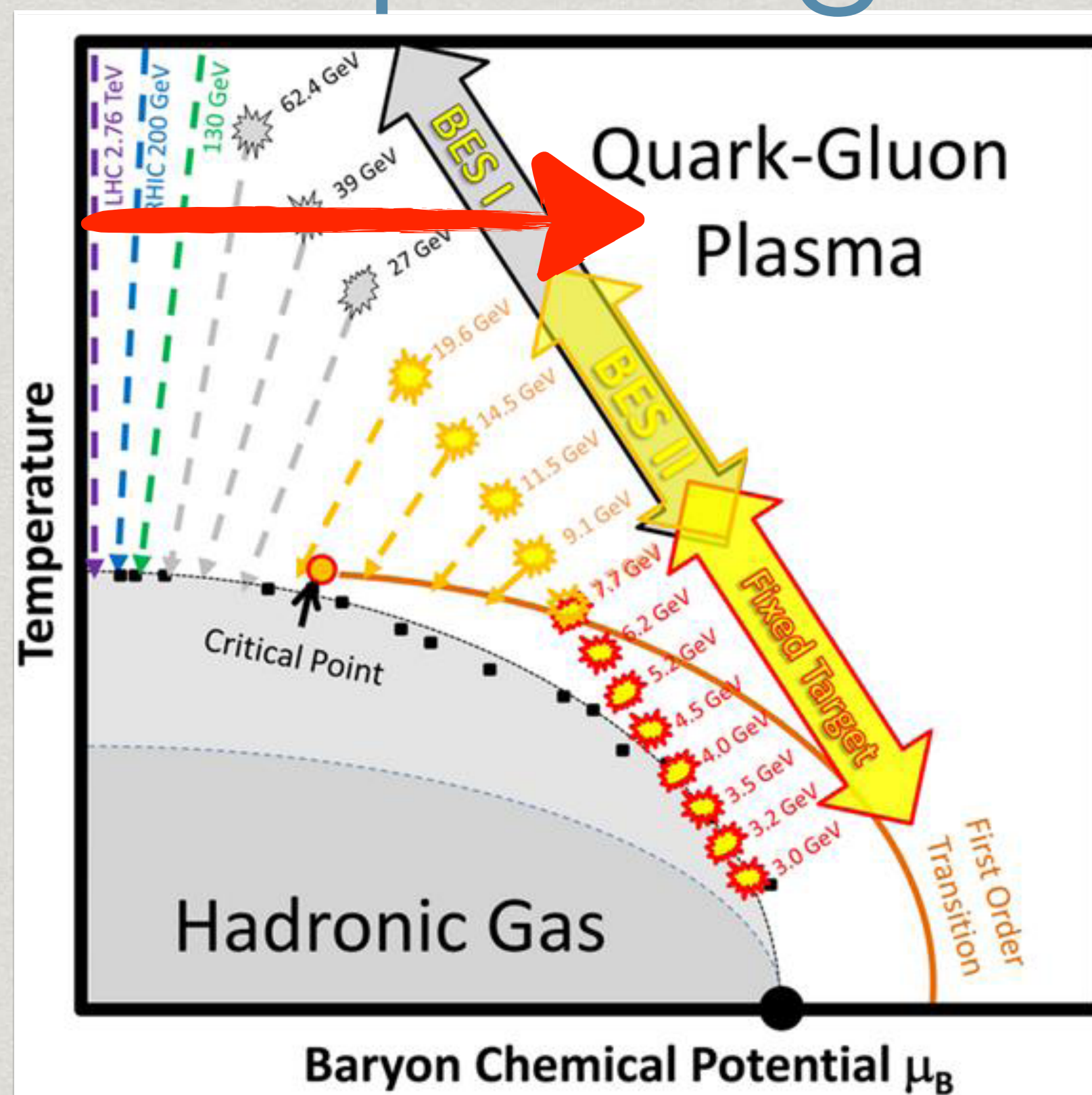


- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}}$  ~ boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

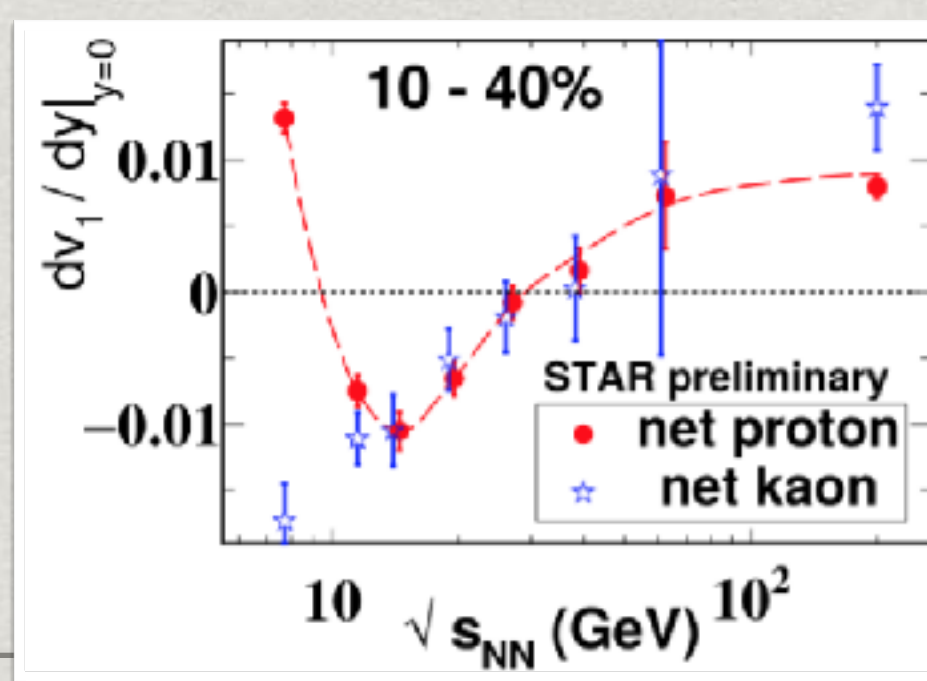
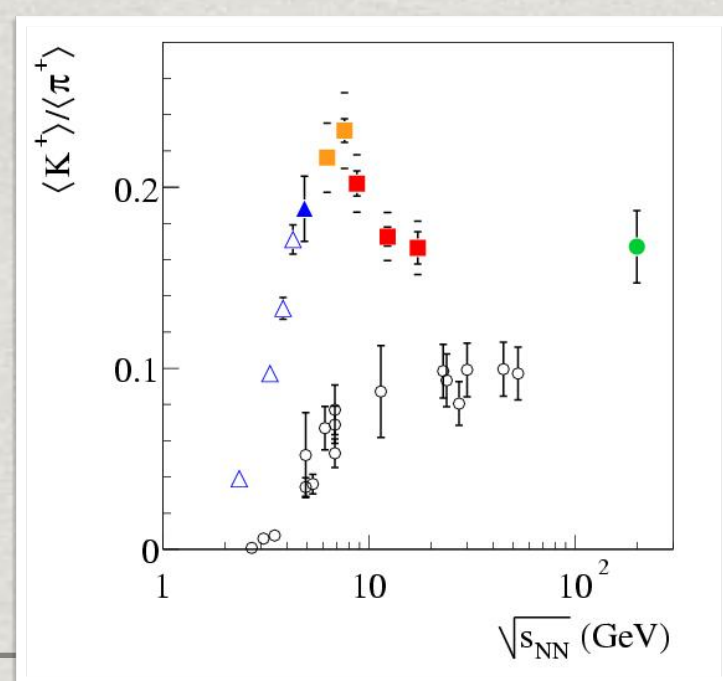




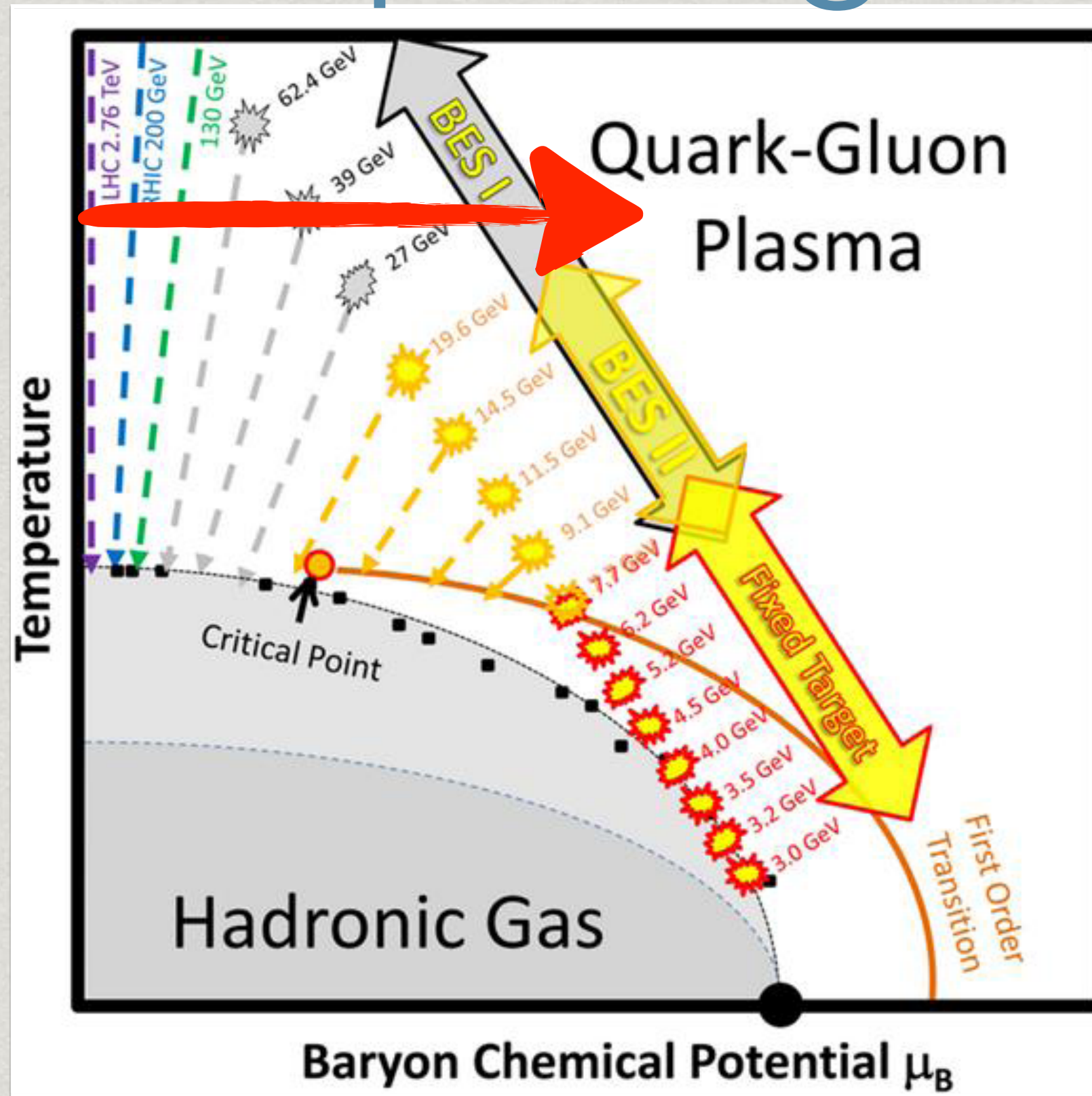
# Exploring QGP phase



- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}}$  ~ boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

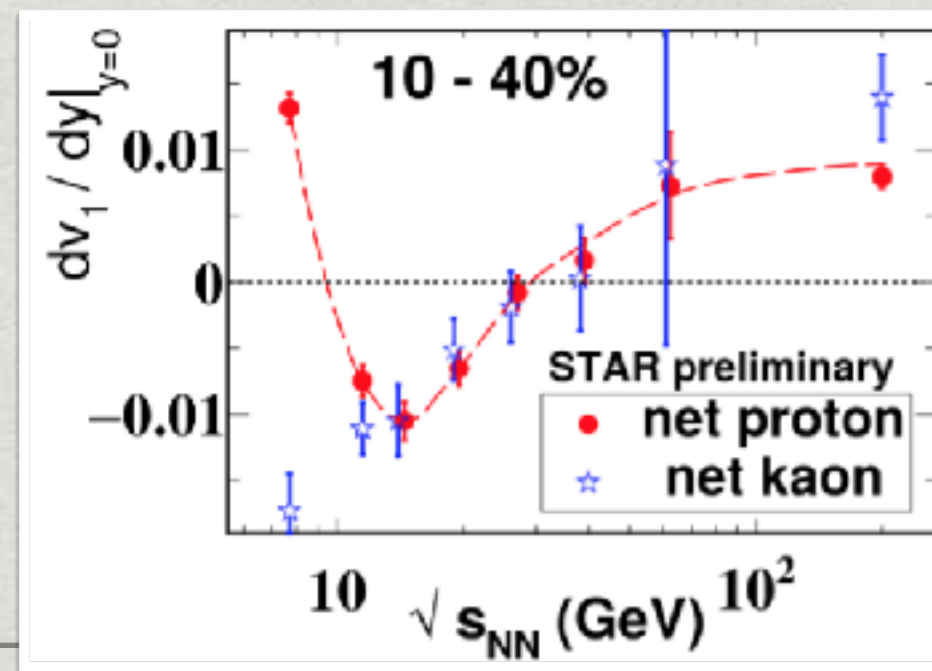
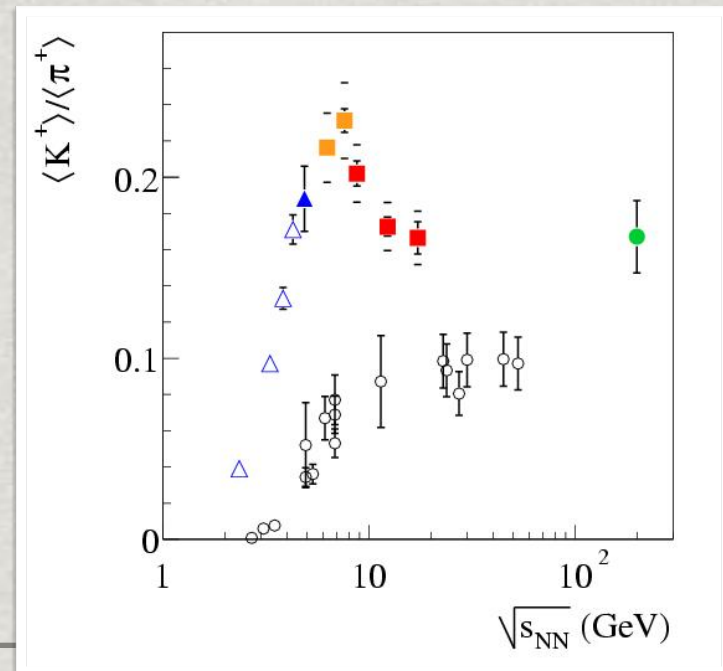
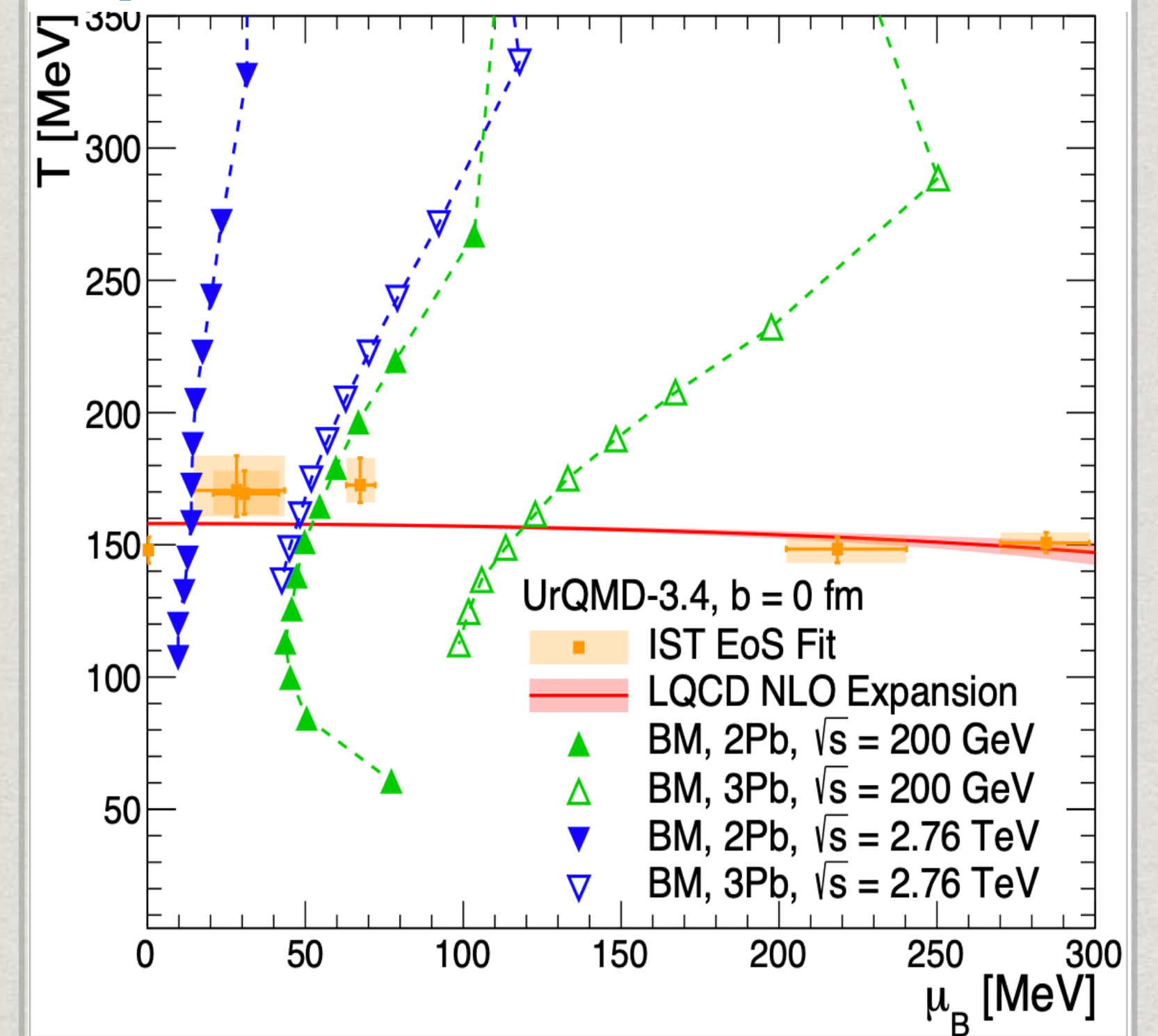


# Exploring QGP phase



- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}} \sim$  boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

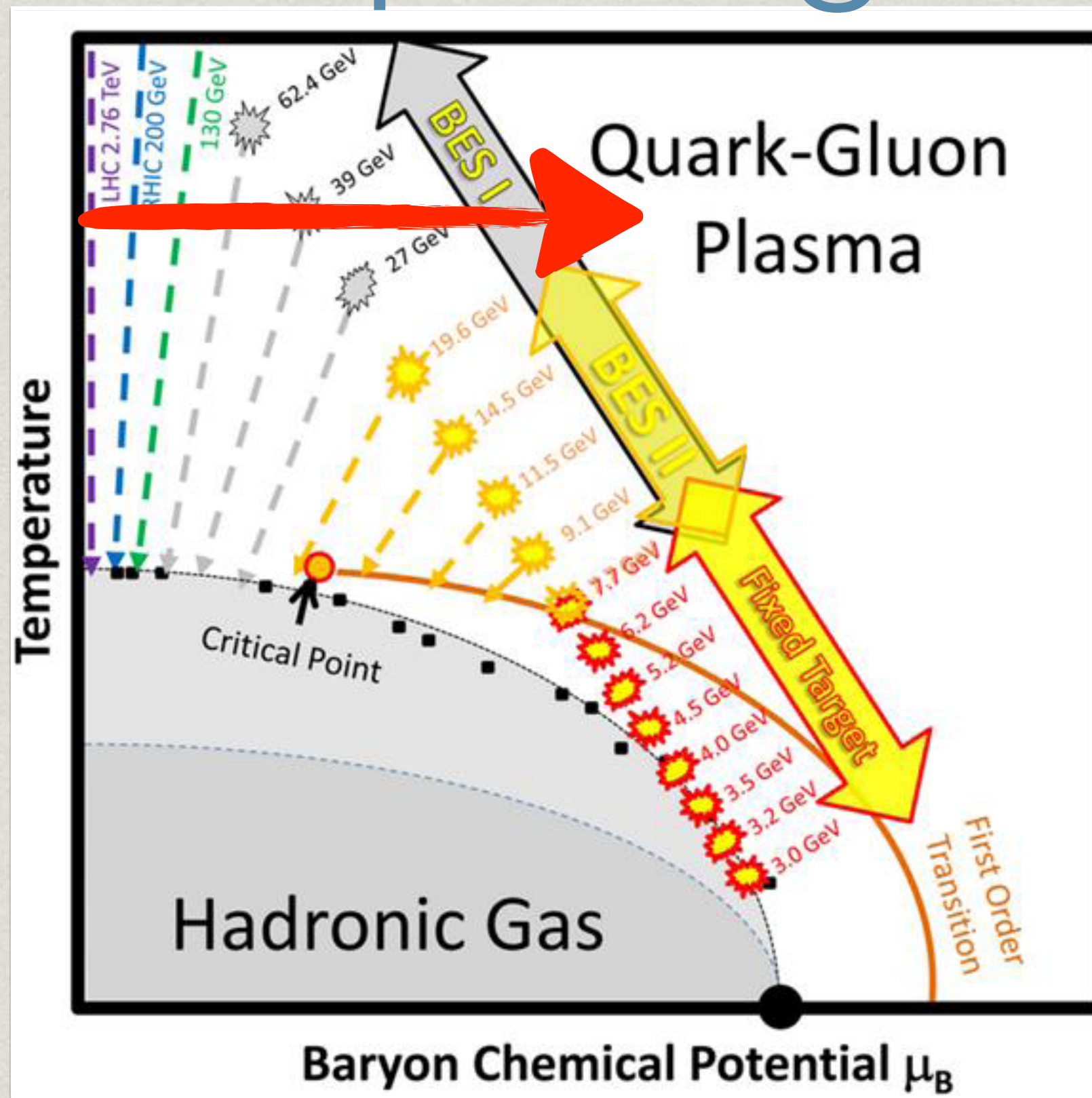
## SQM2021, K. Bugaev, O. Vitiuk, Triple Nuclear Collision



# Exploring QGP phase

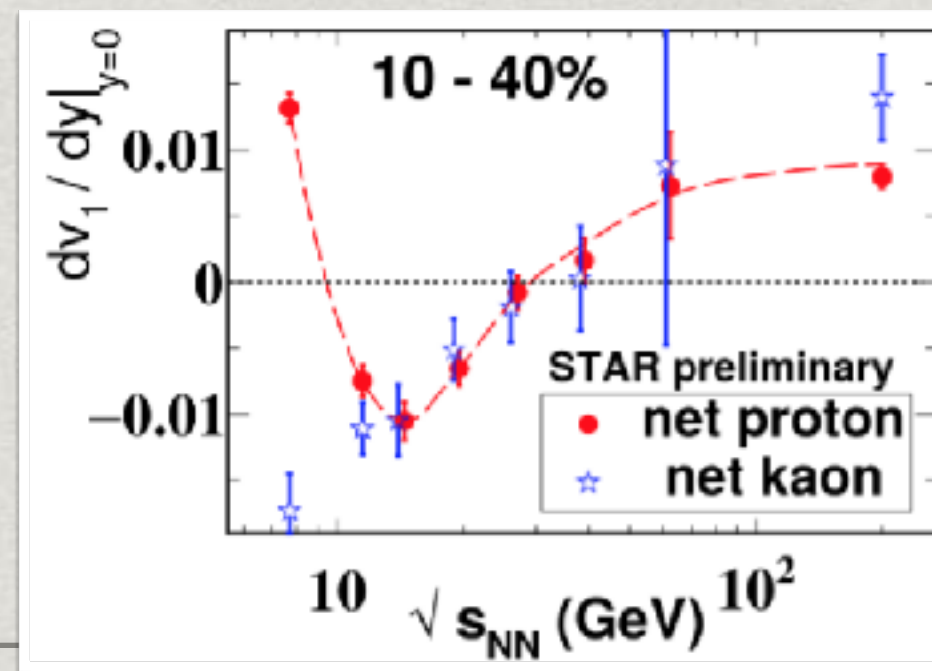
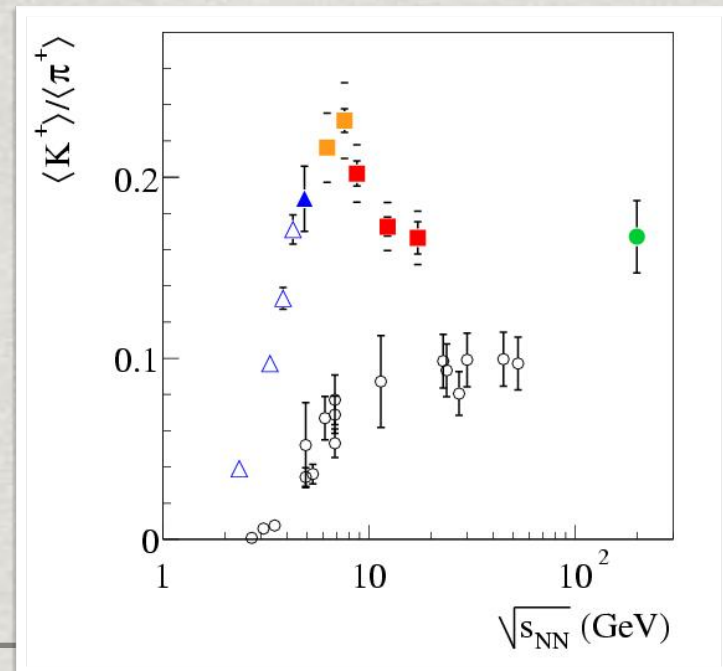
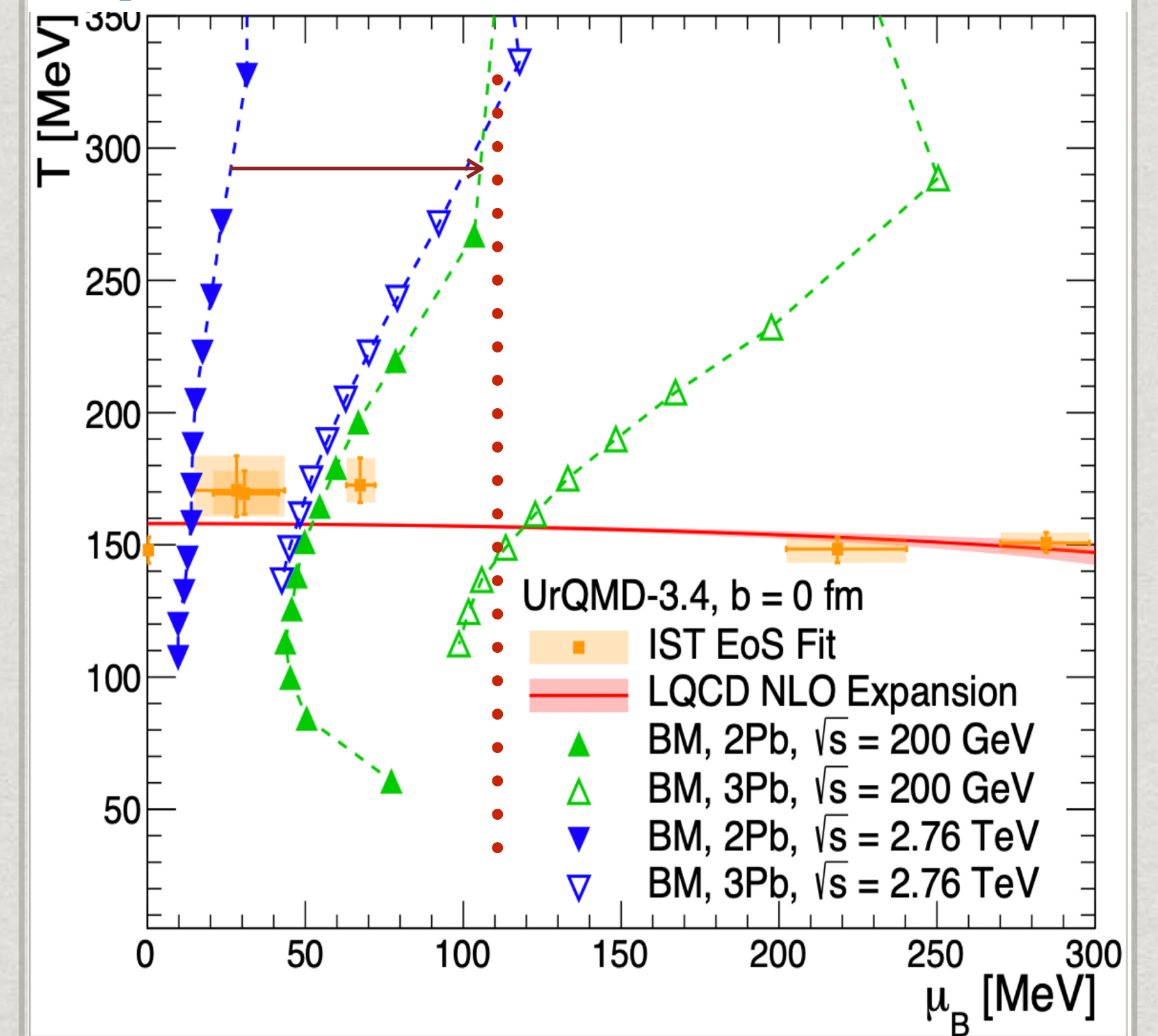


KoALICE



- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}} \sim$  boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

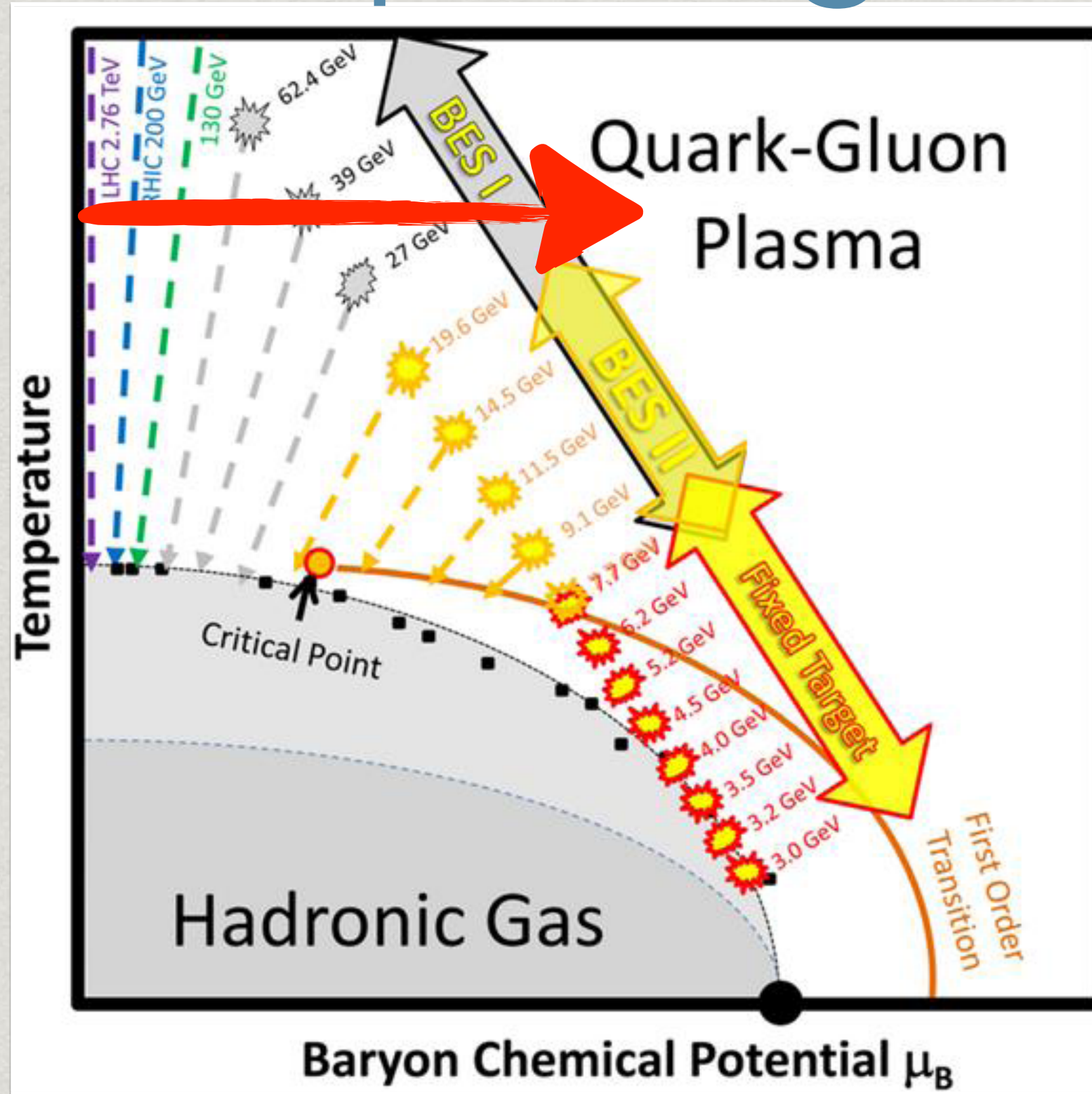
## SQM2021, K. Bugaev, O. Vitiuk, Triple Nuclear Collision



# Exploring QGP phase

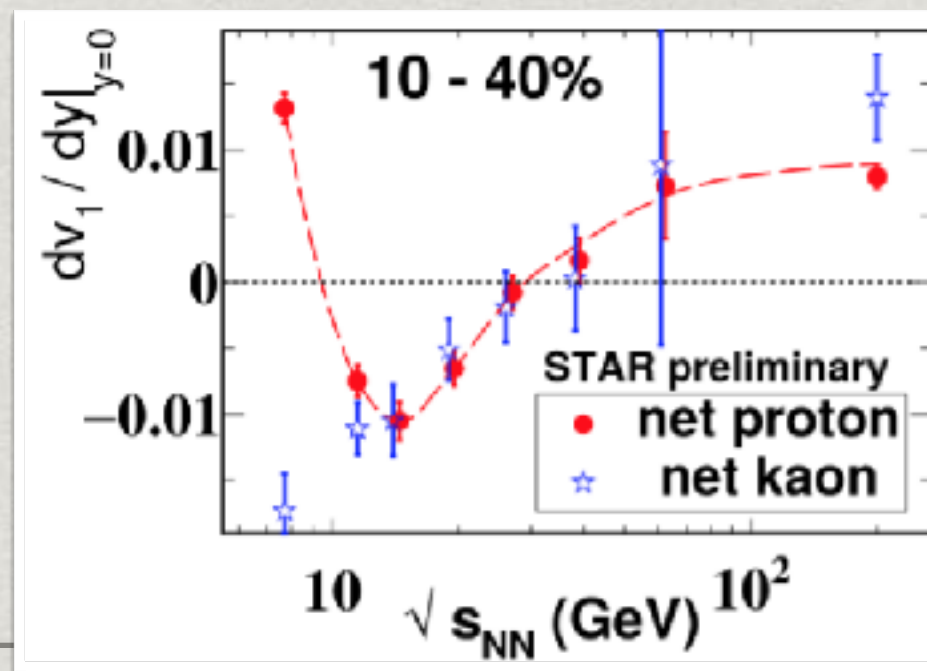
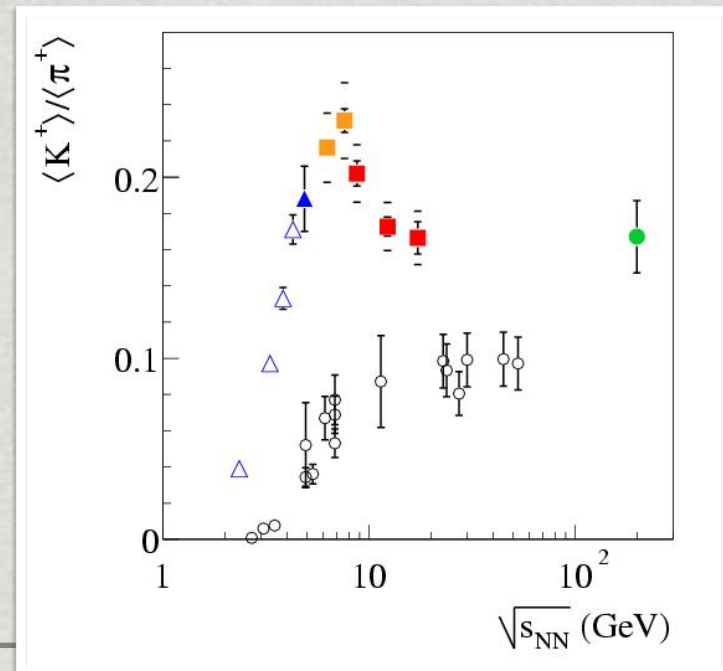
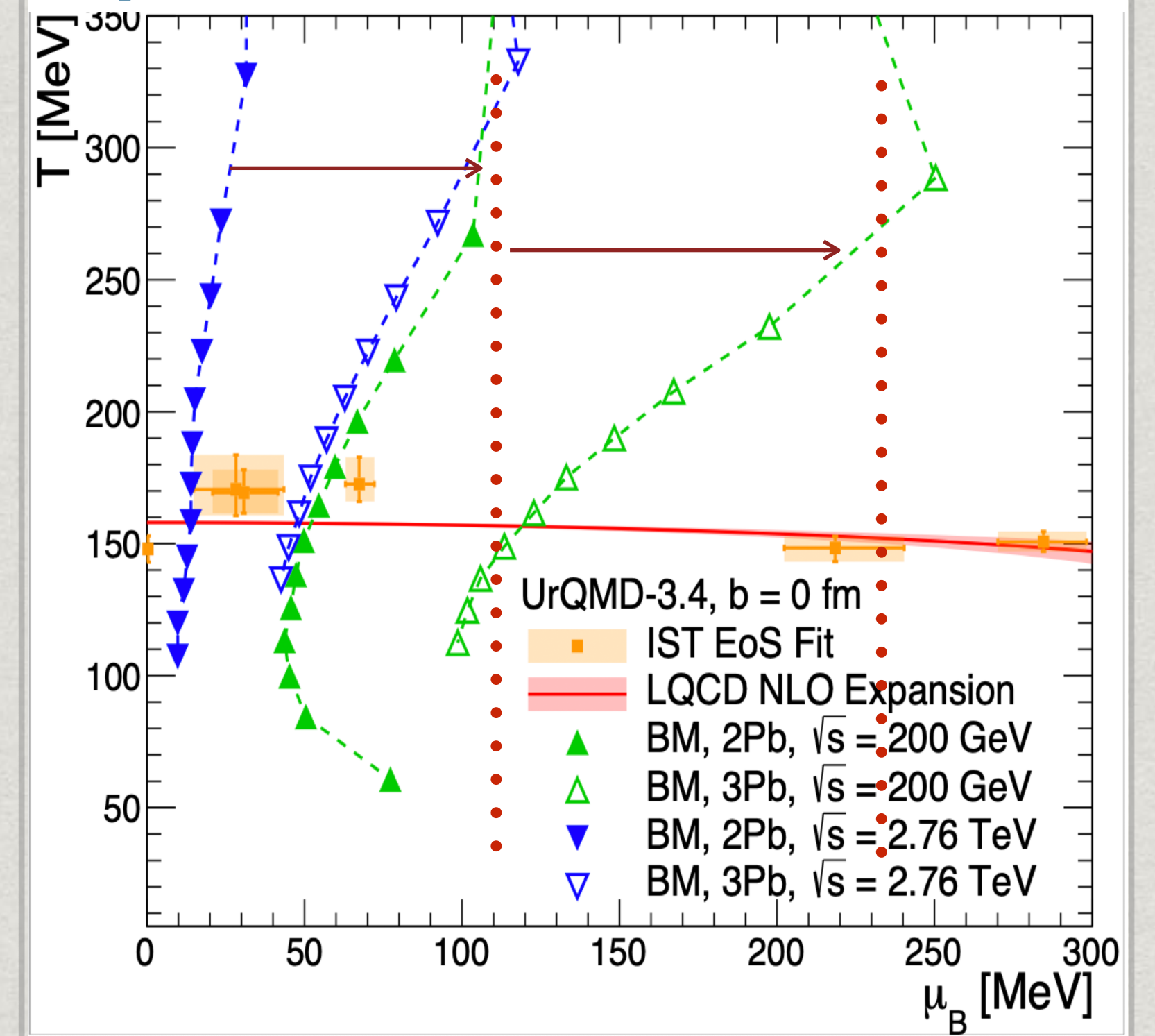


KoALICE



- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}} \sim$  boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

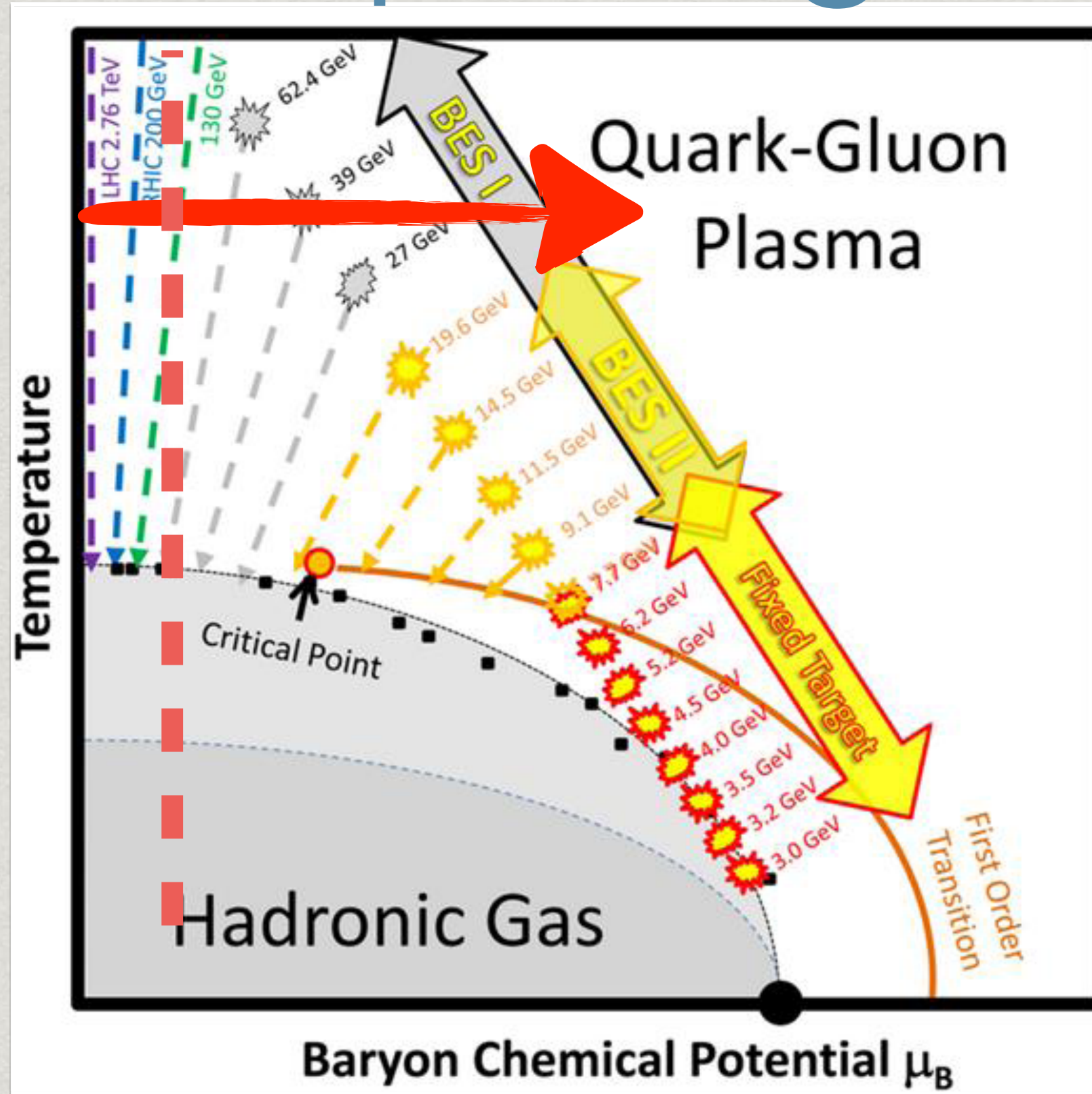
## SQM2021, K. Bugaev, O. Vitiuk, Triple Nuclear Collision



# Exploring QGP phase

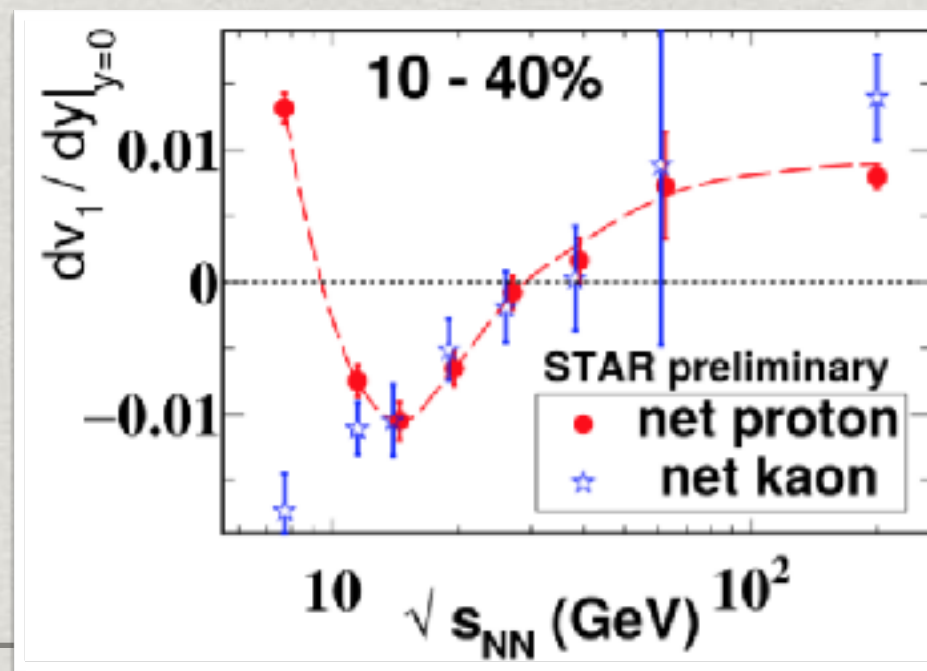
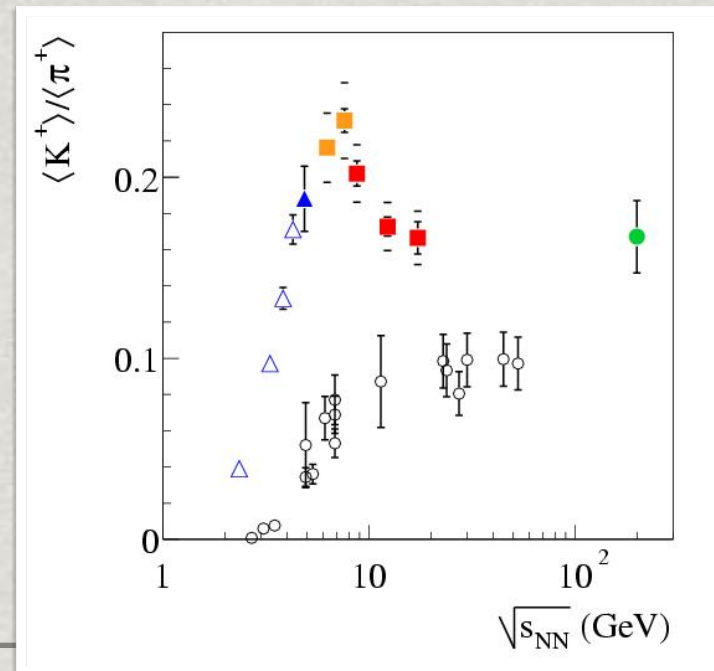
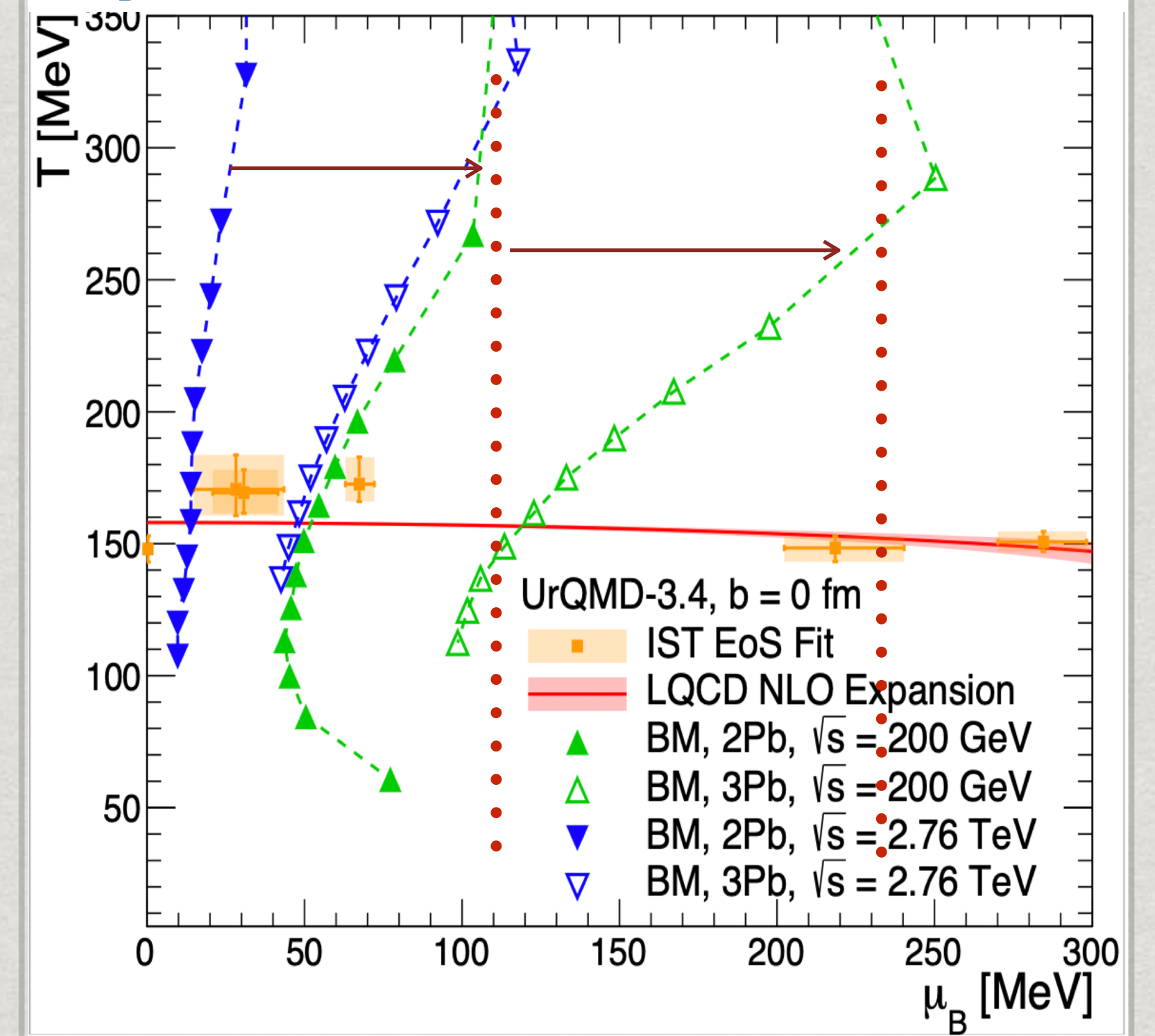


KoALICE

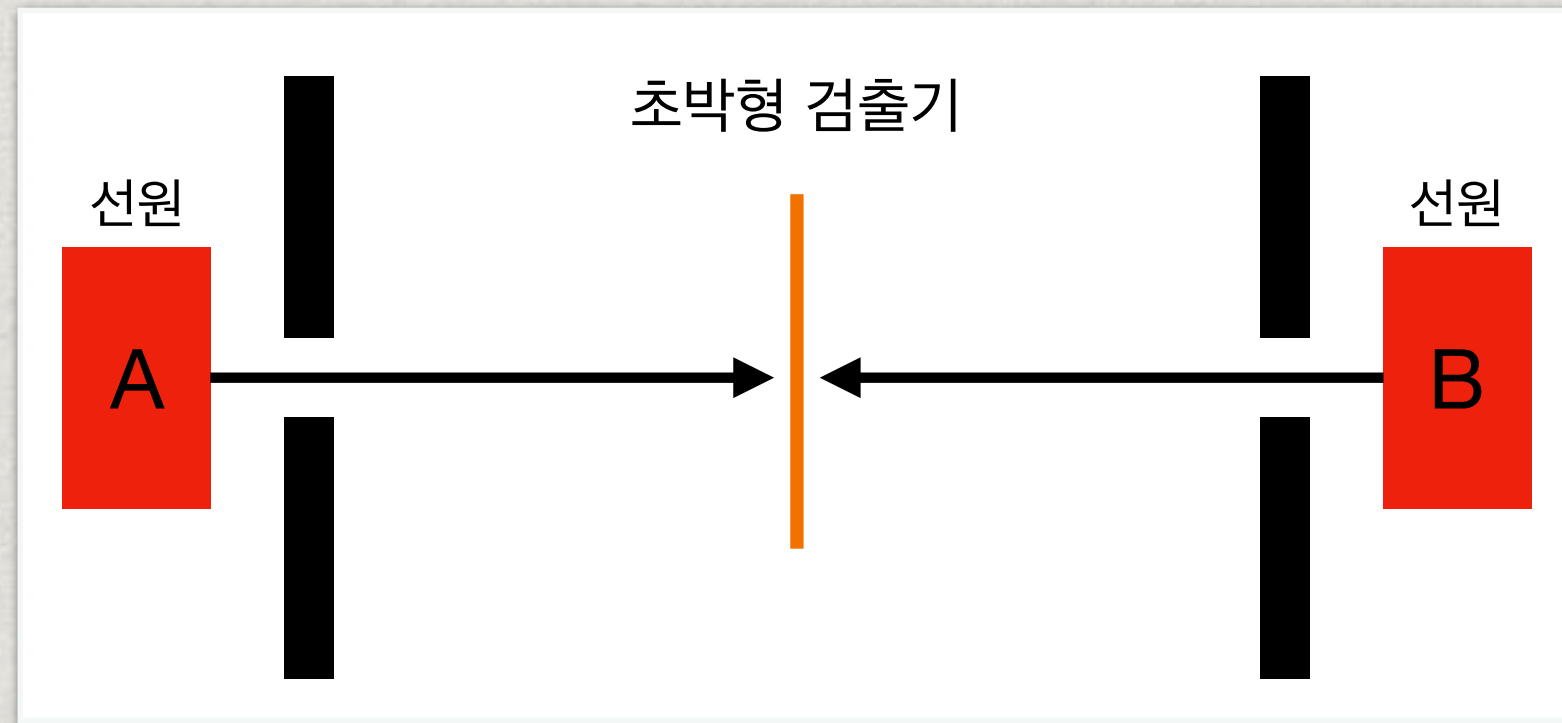


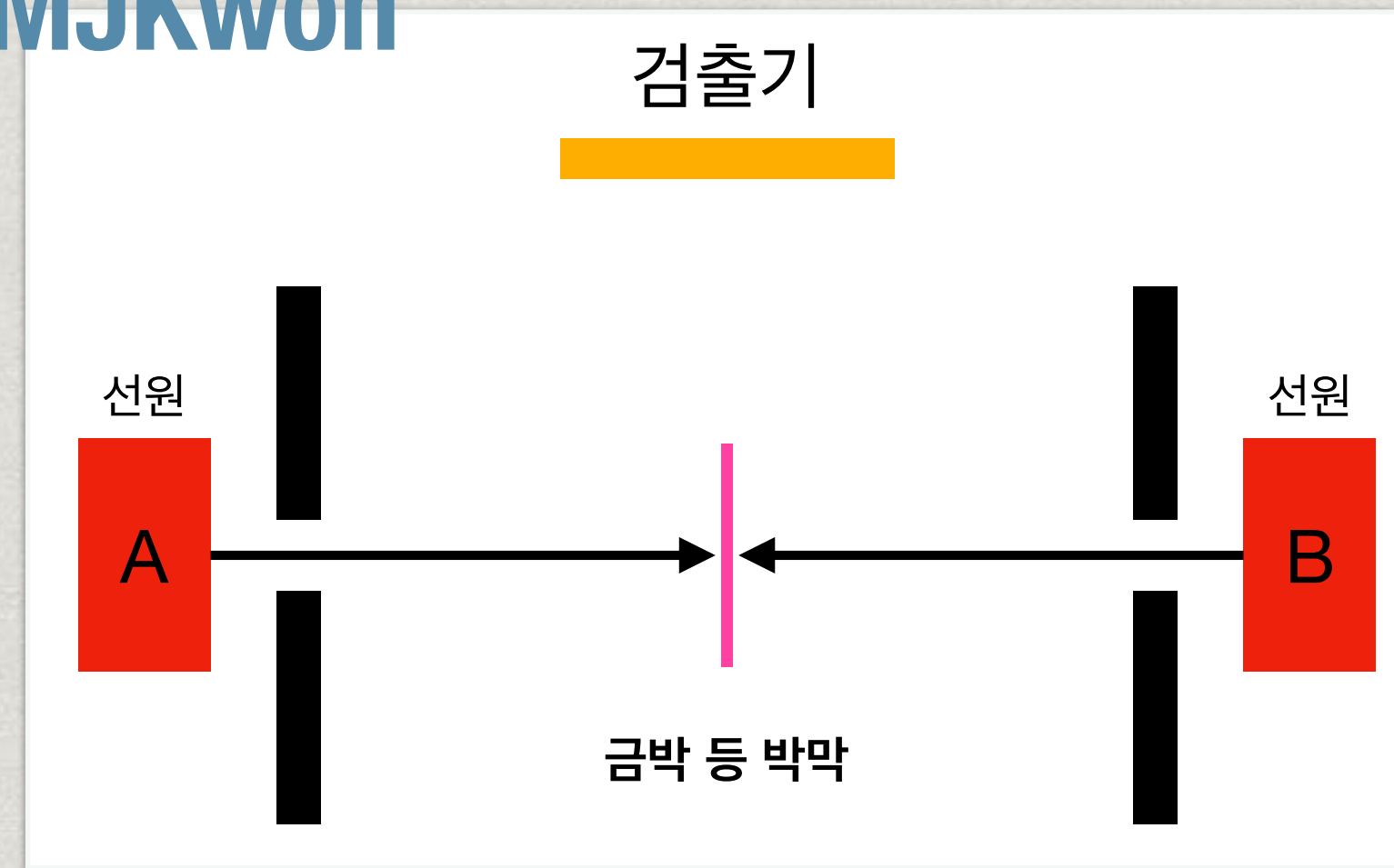
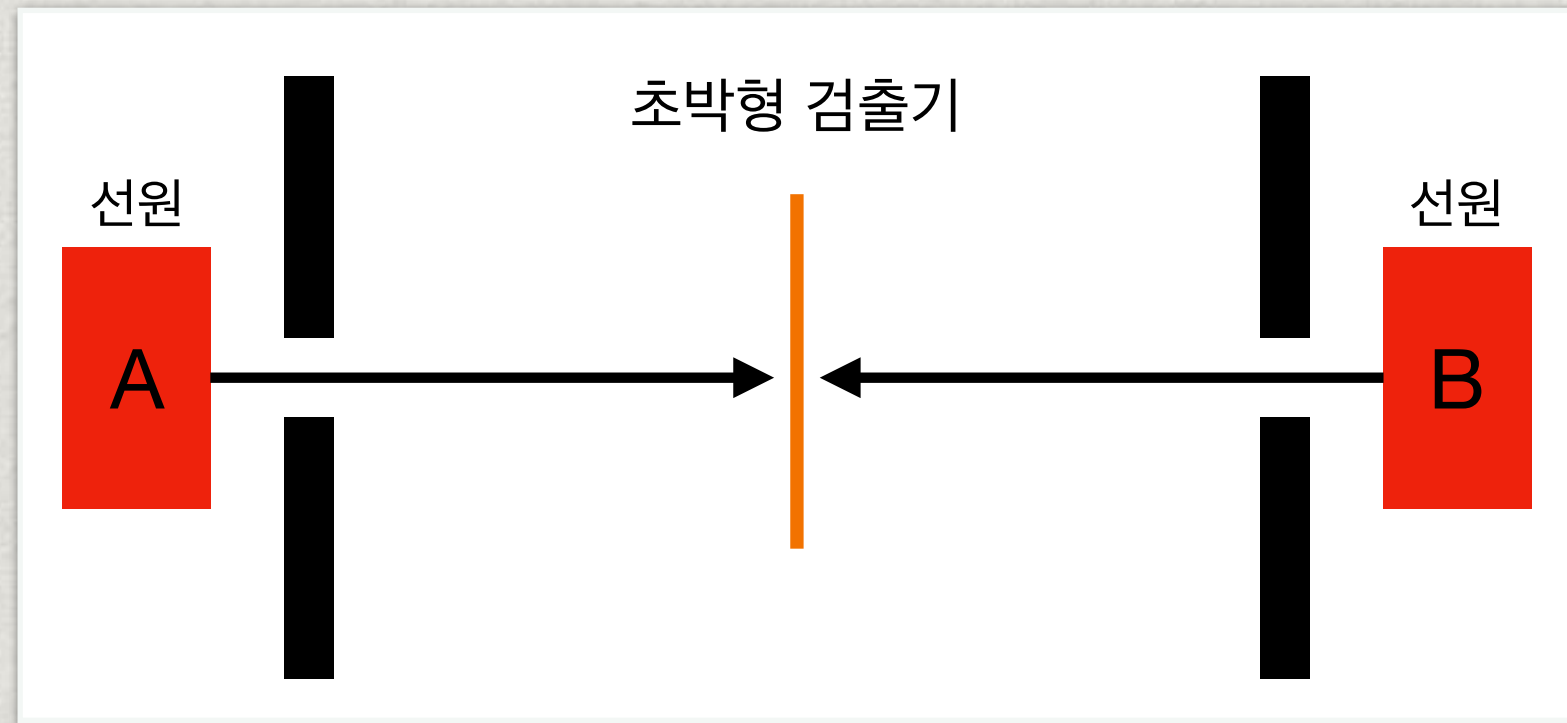
- ☑ Cross-over via URHIC @ LHC
  - Can. ensemble in AA
  - semi-can. ensemble in pA & even in pp (high-mul events)
  - QGP(? or any?) property study
  - no 1st-order Phase Transition
- High  $\mu_B$  region
  - CP Search (QGP? !!)
  - 1st Phase Transition (QGP? !)
  - BESII (STAR) (lower  $\sqrt{s_{NN}} \sim$  boost of  $\mu_B$ )
  - even higher  $\mu_B$ ?

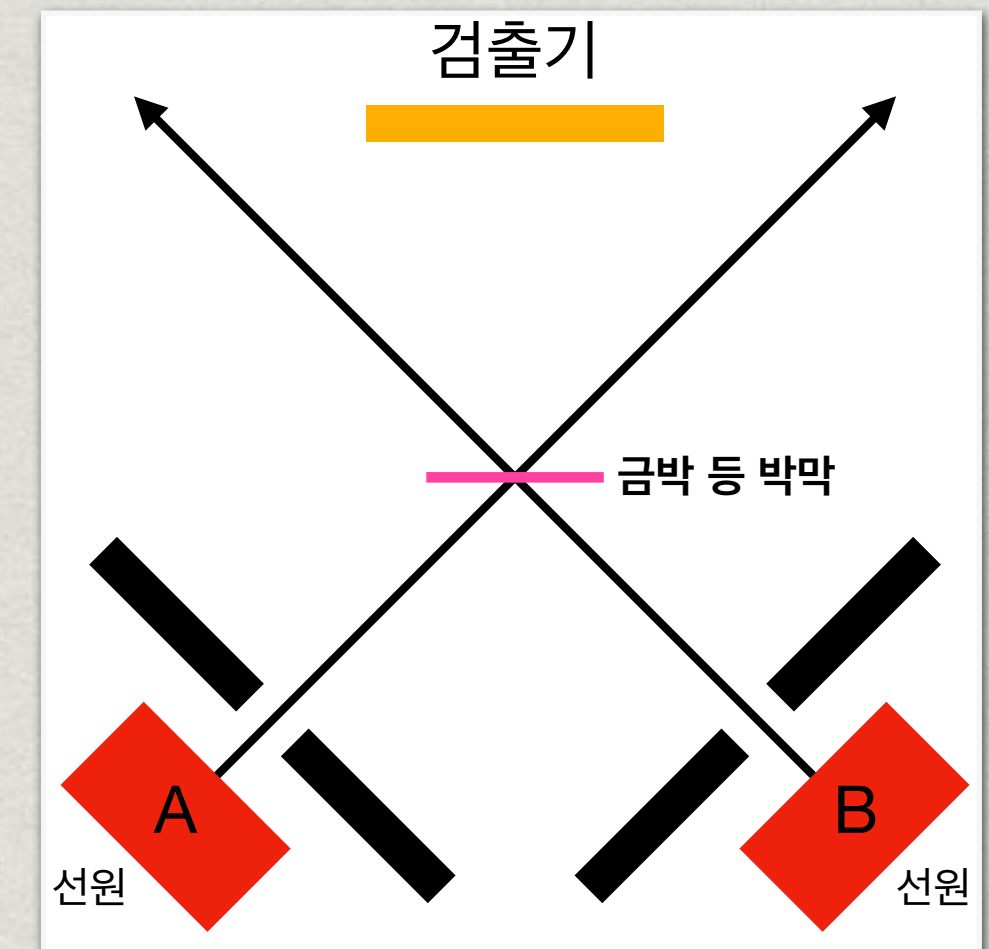
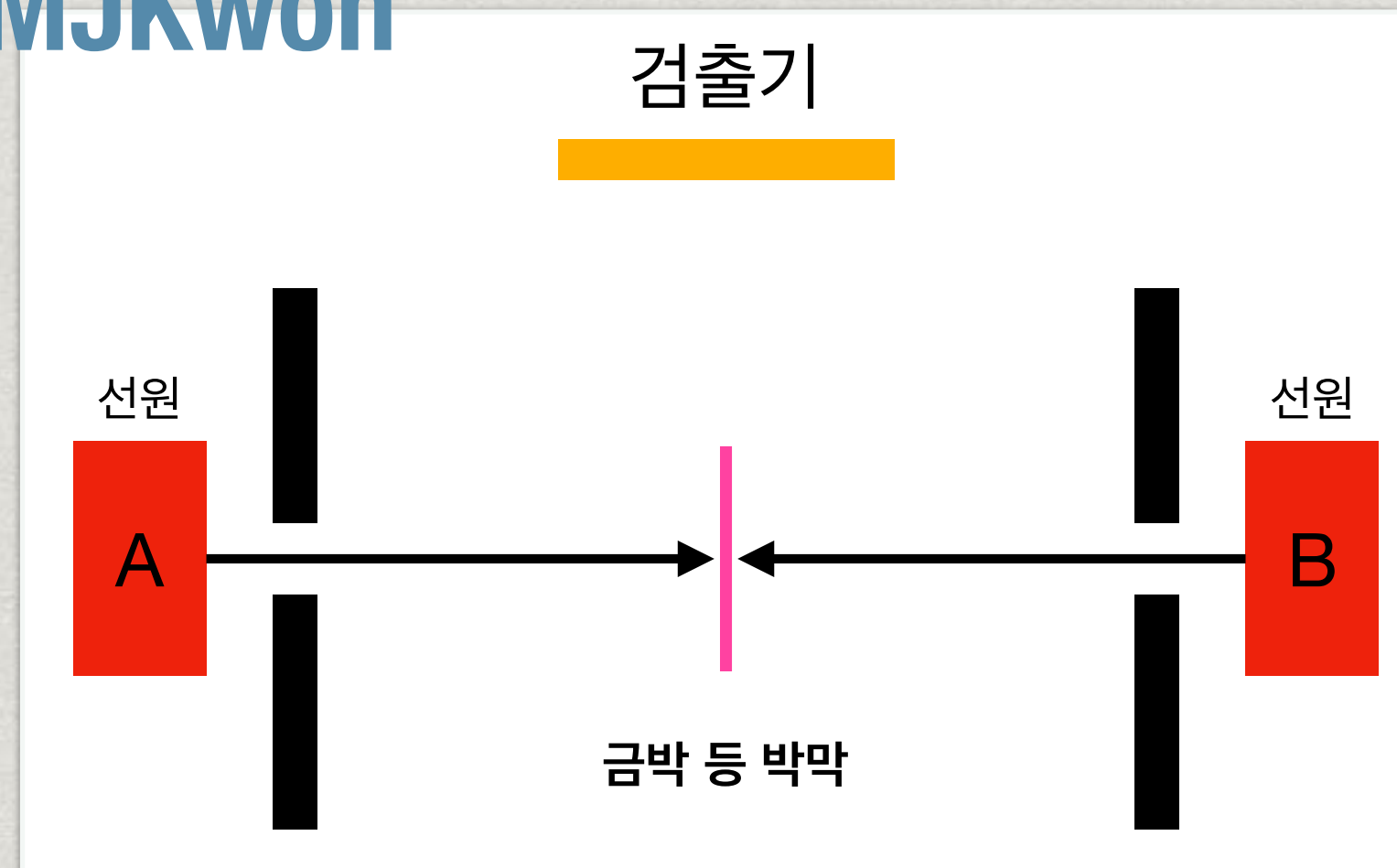
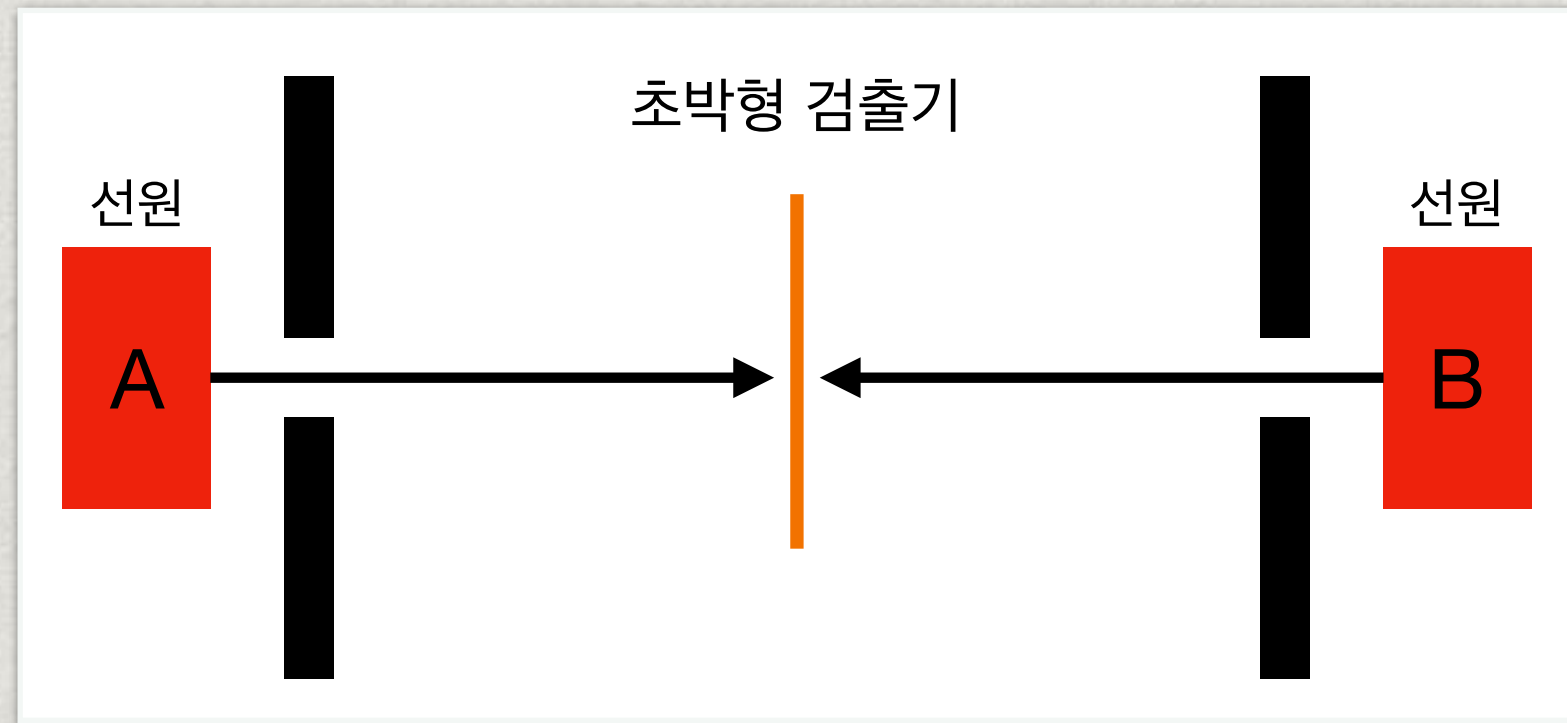
## SQM2021, K. Bugaev, O. Vitiuk, Triple Nuclear Collision



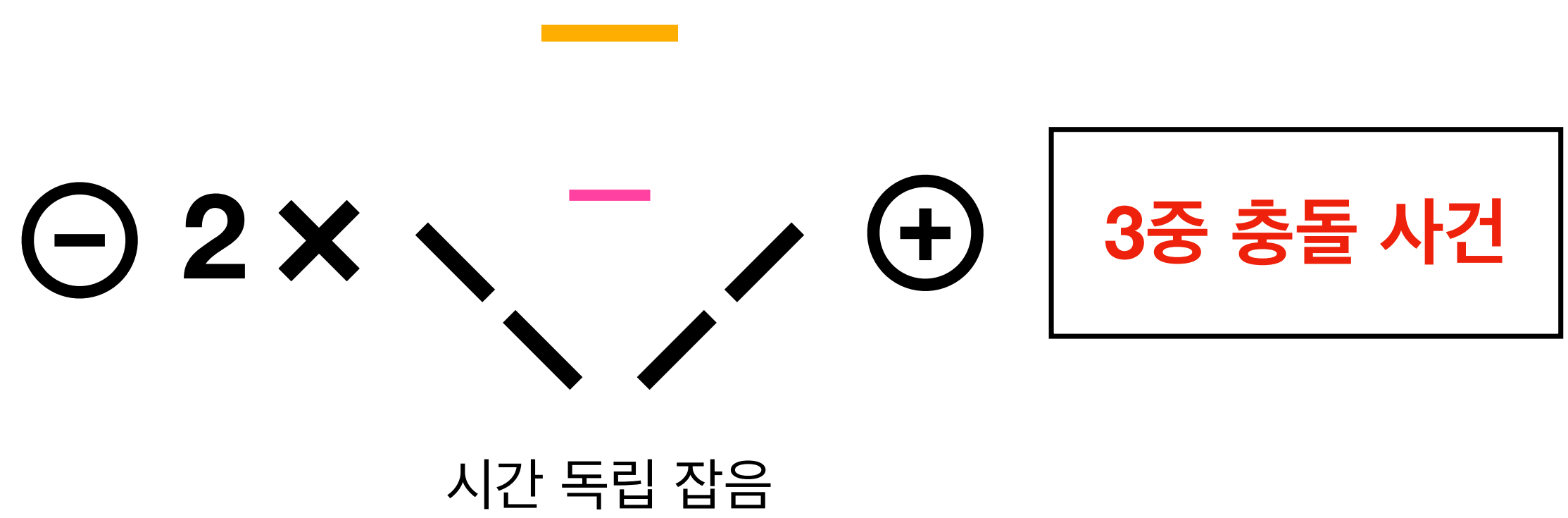
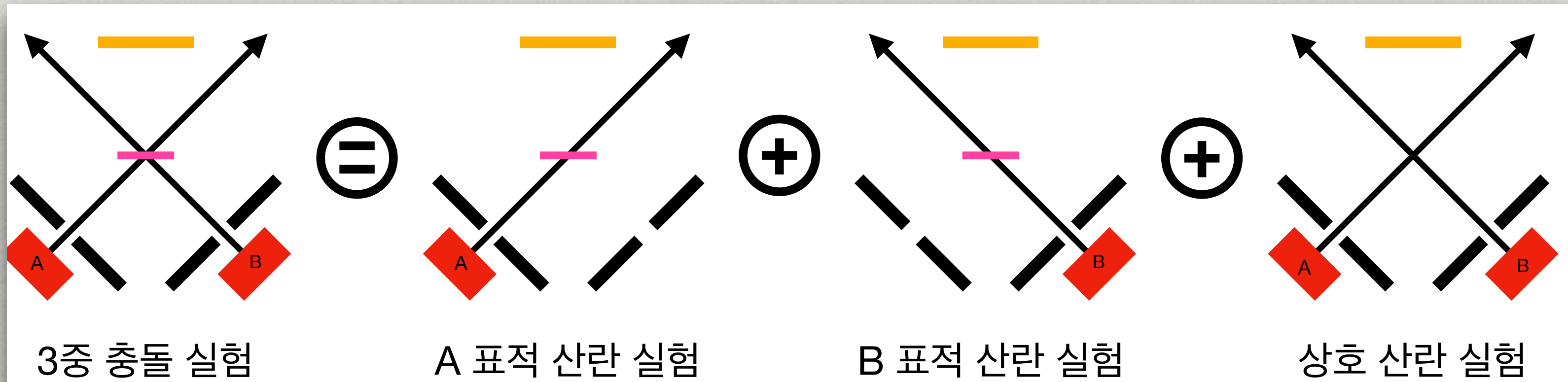
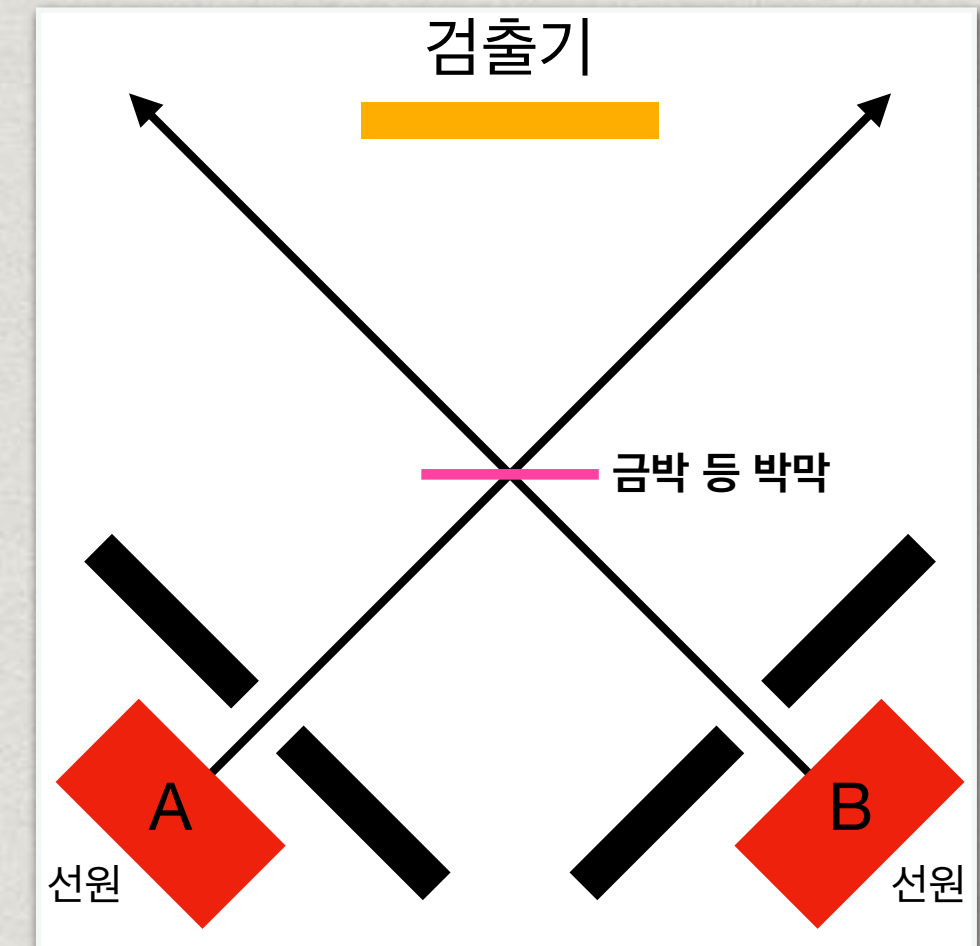
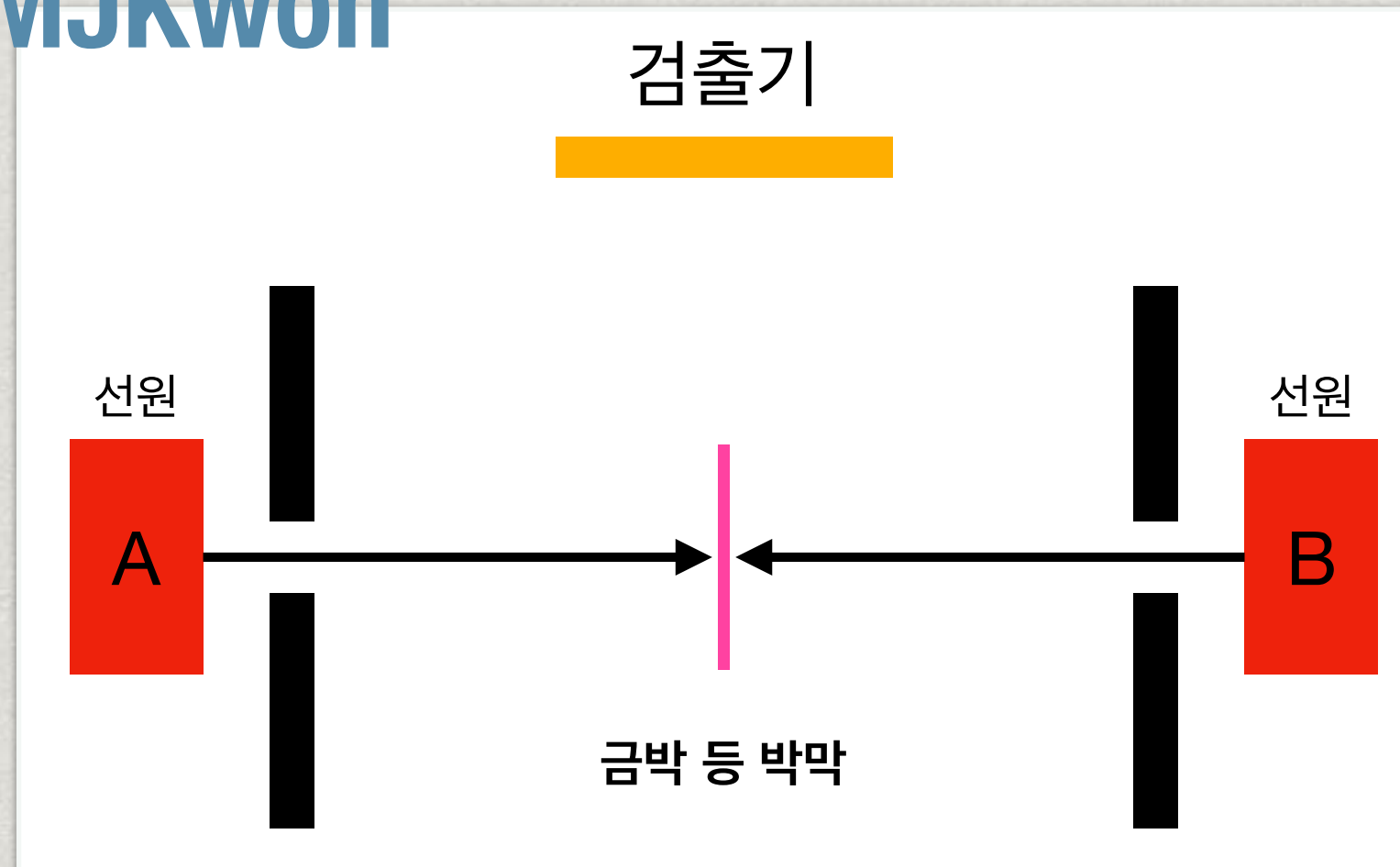
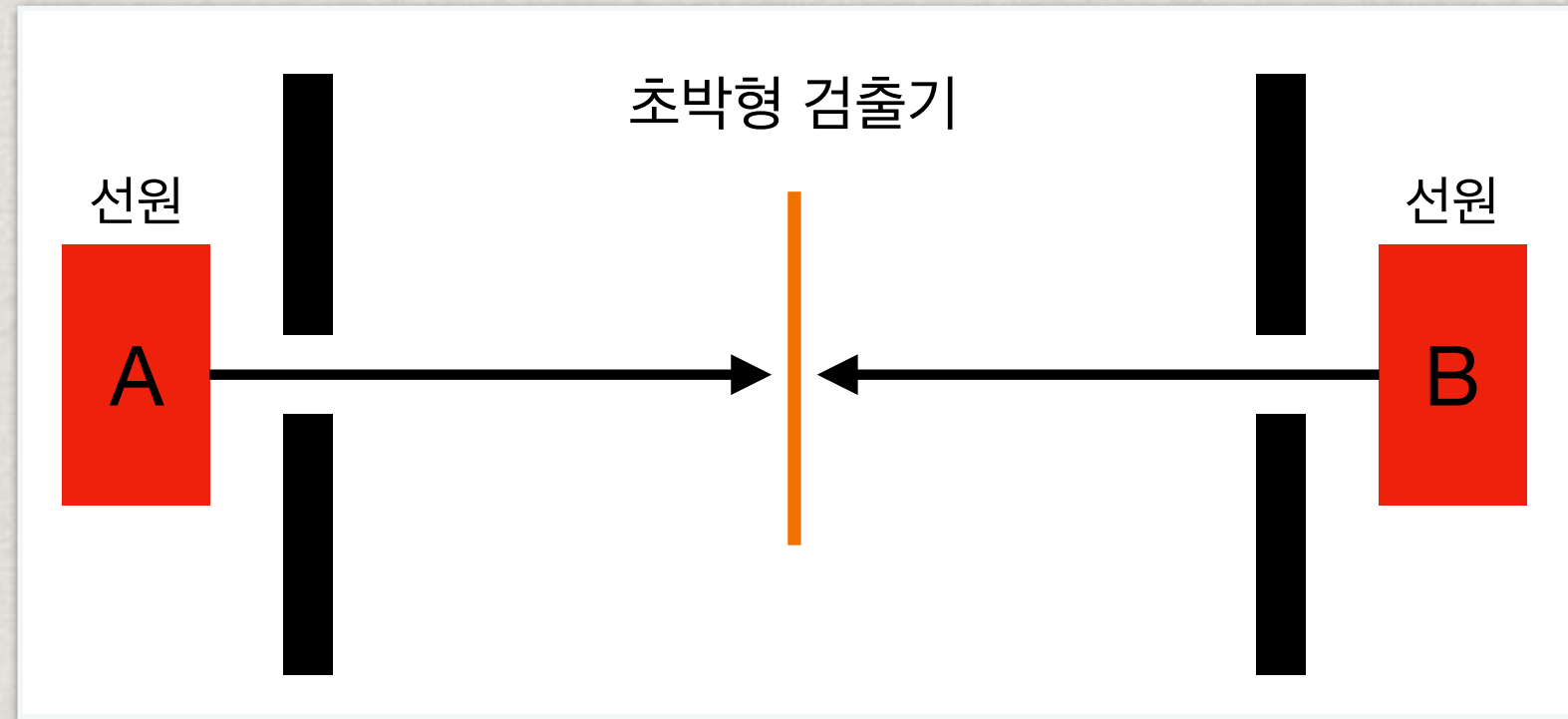
# MJKwon's study on-going © MJKwon

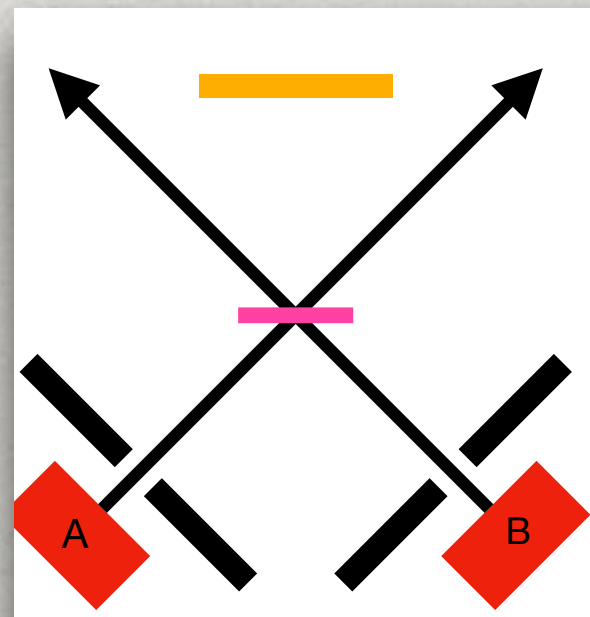
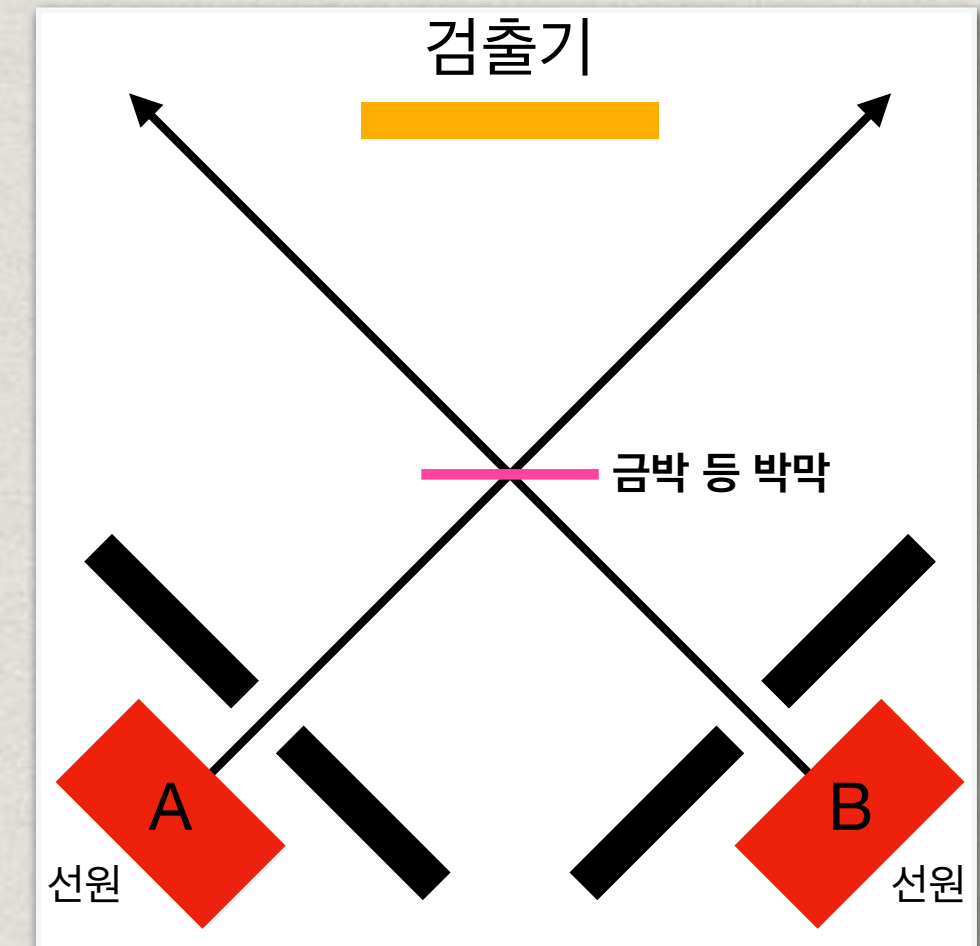
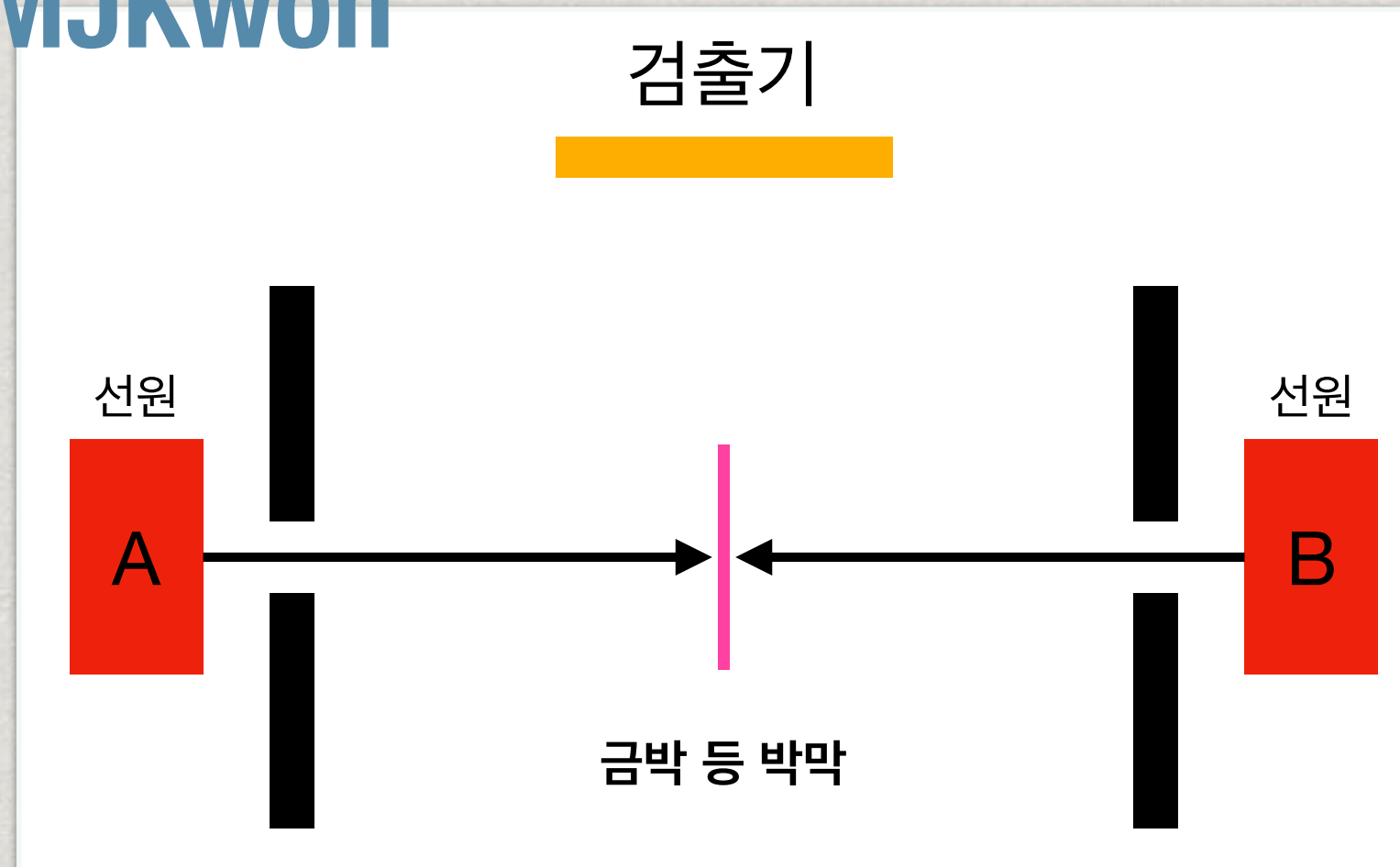
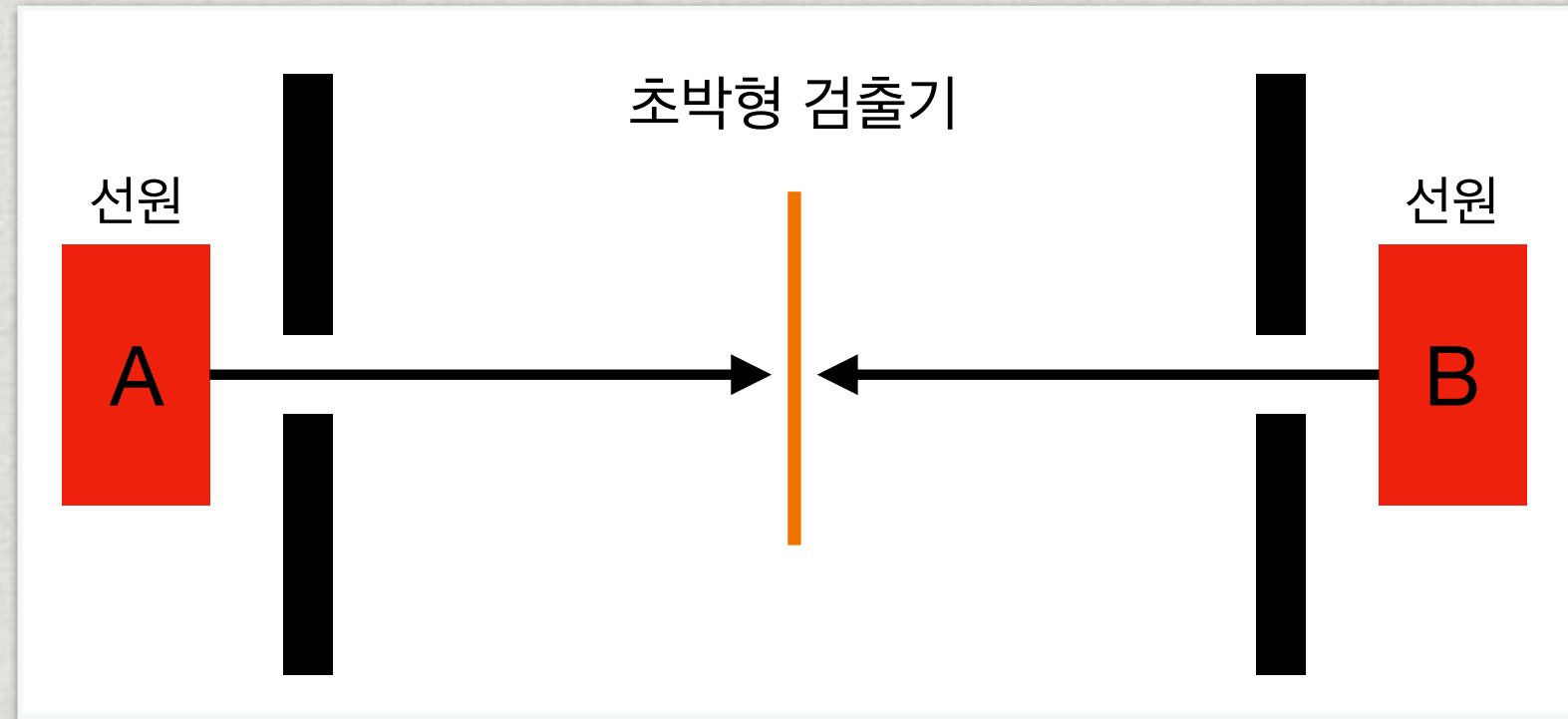




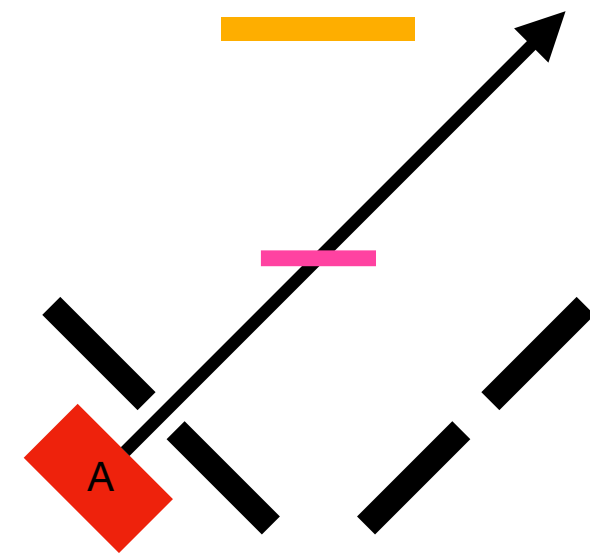




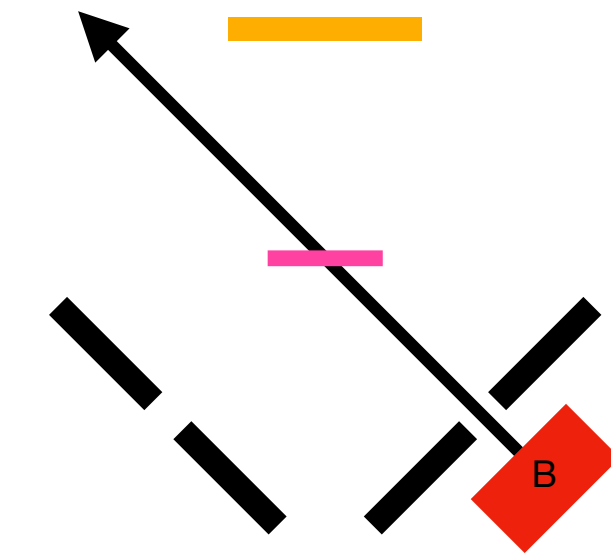




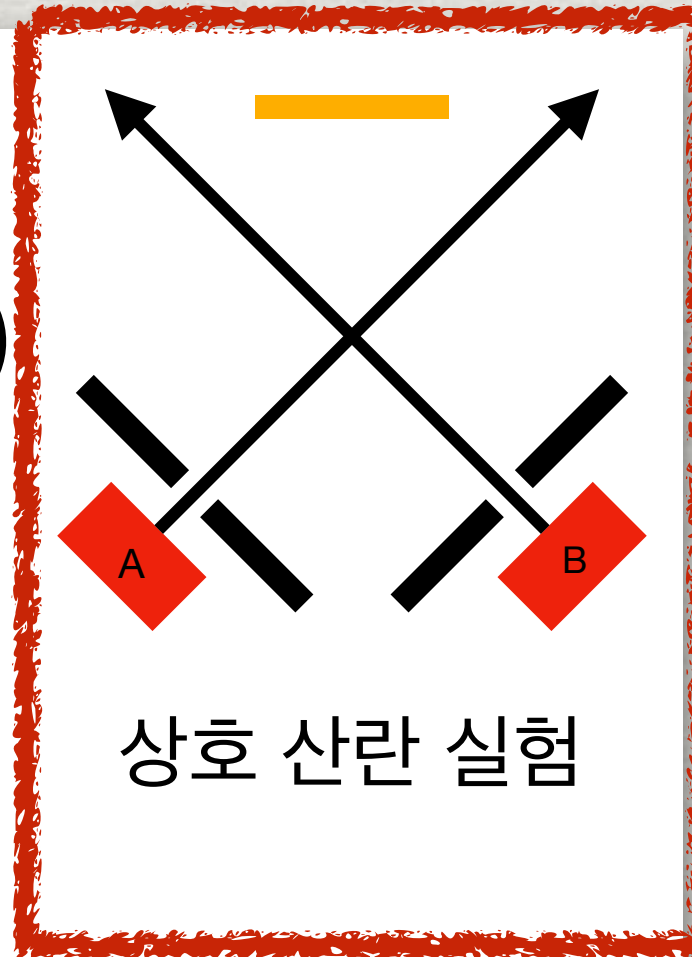
⊖



⊕

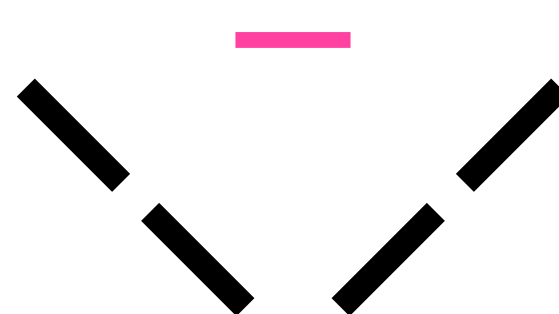


⊕



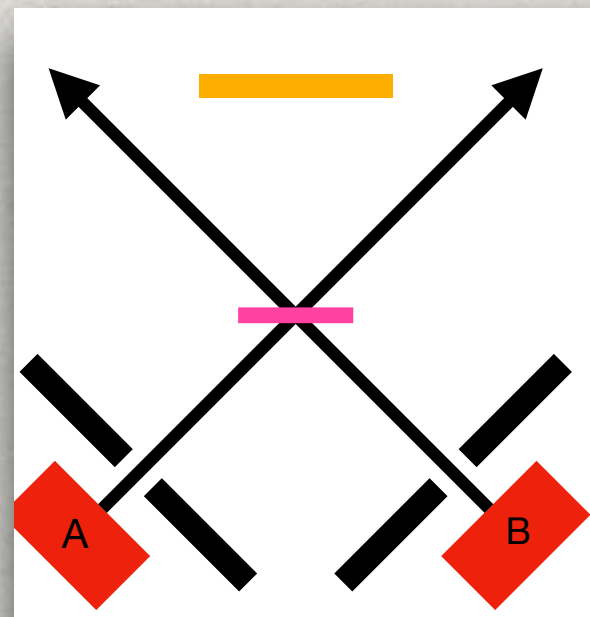
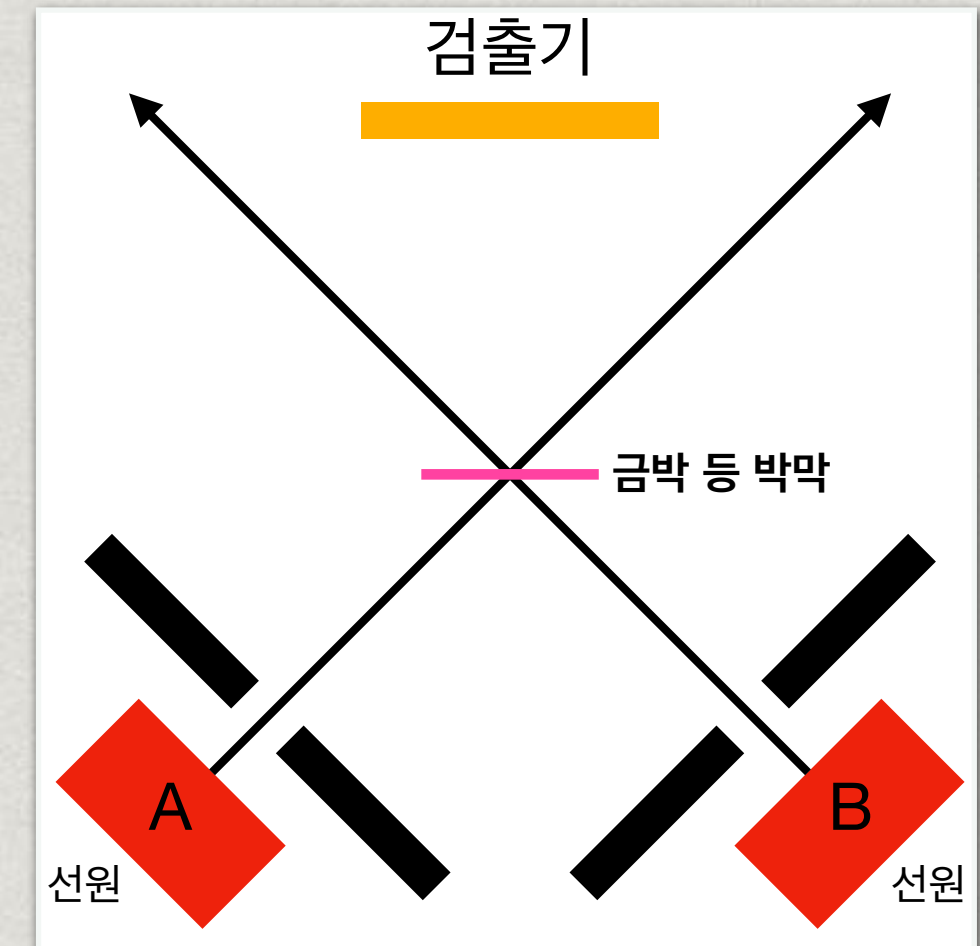
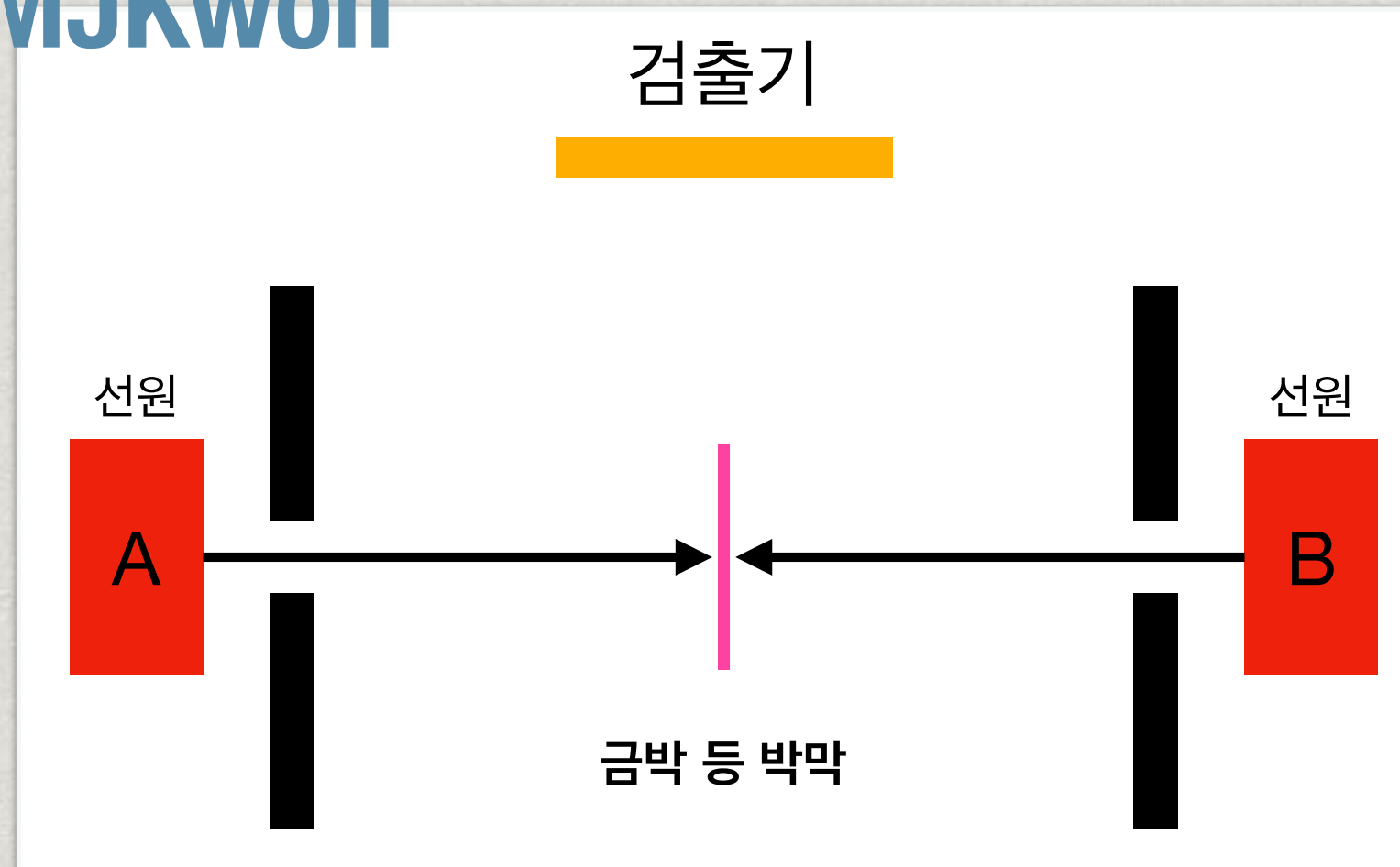
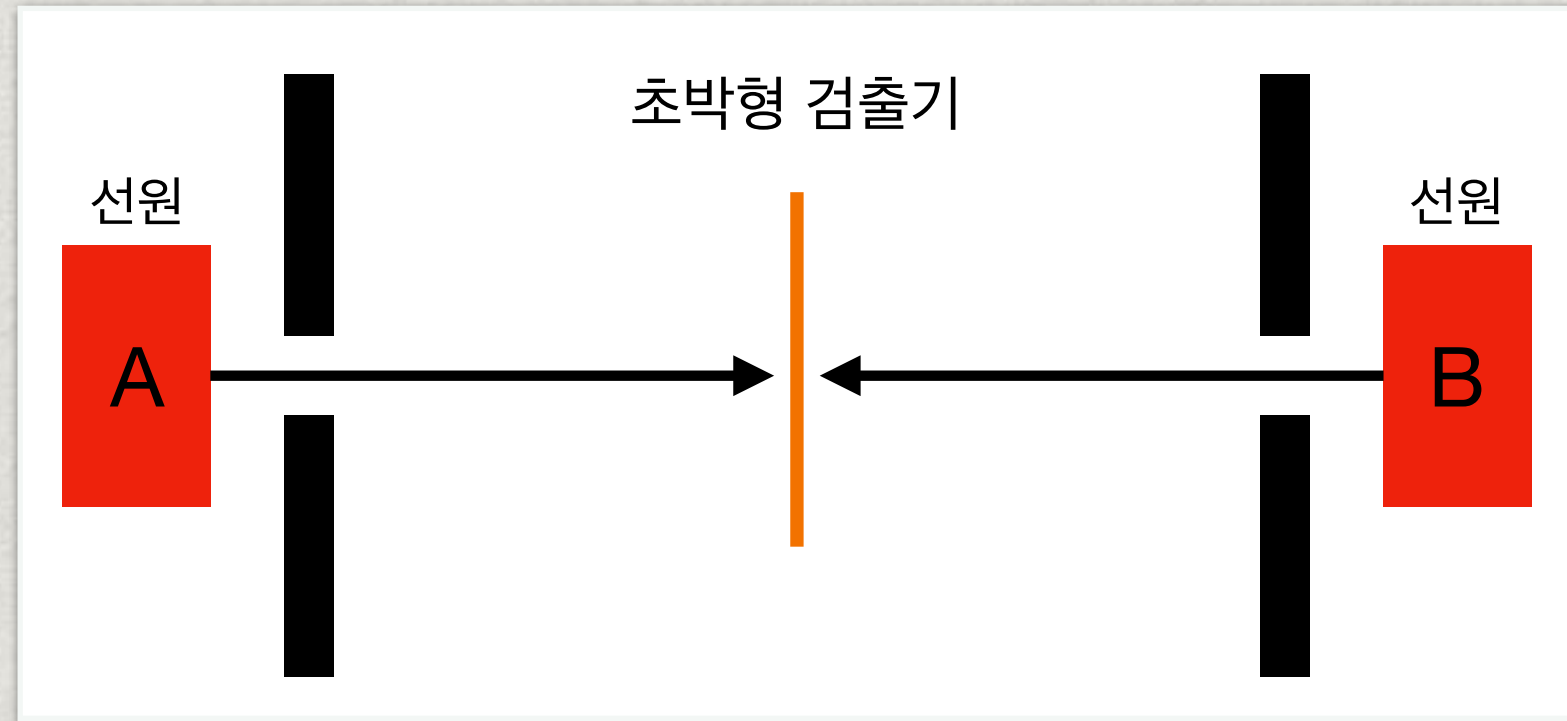
⊖

2x



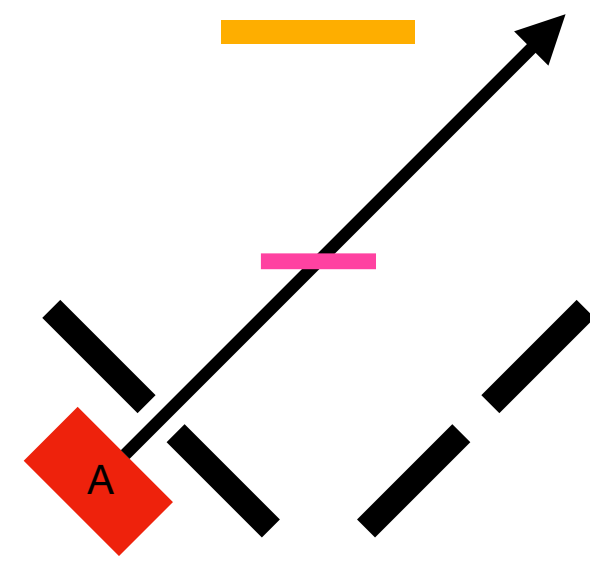
⊕

3중 충돌 사건



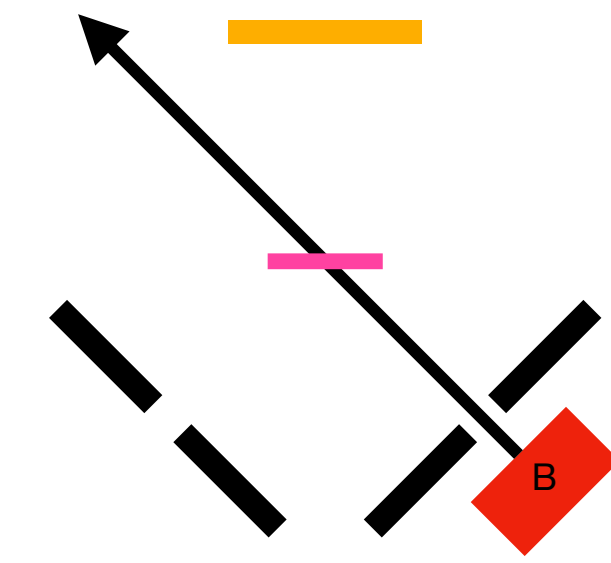
3중 충돌 실험

⊖



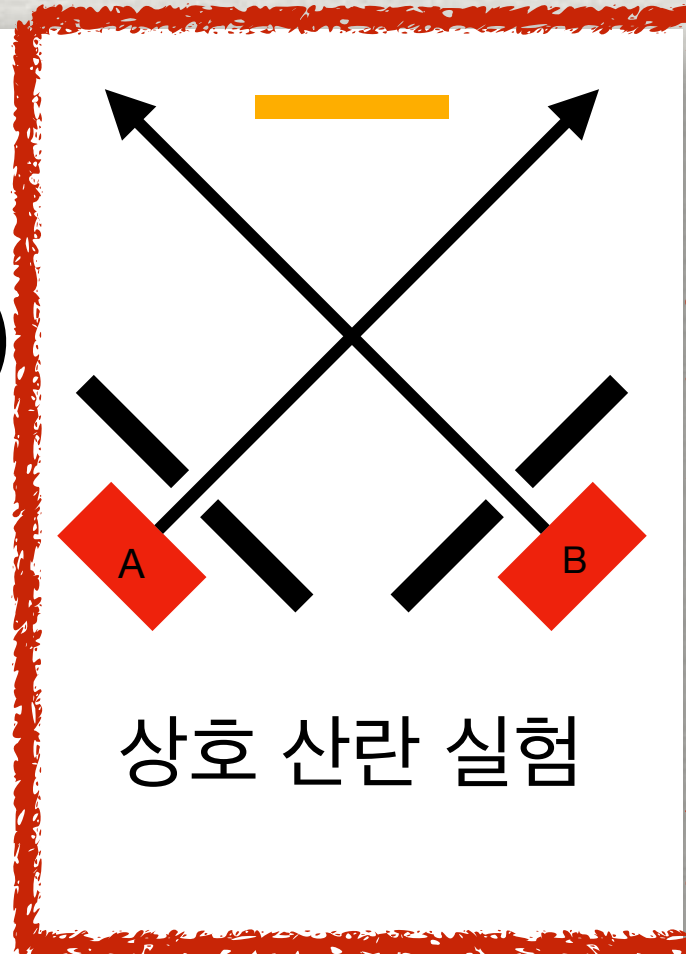
A 표적 산란 실험

⊕



B 표적 산란 실험

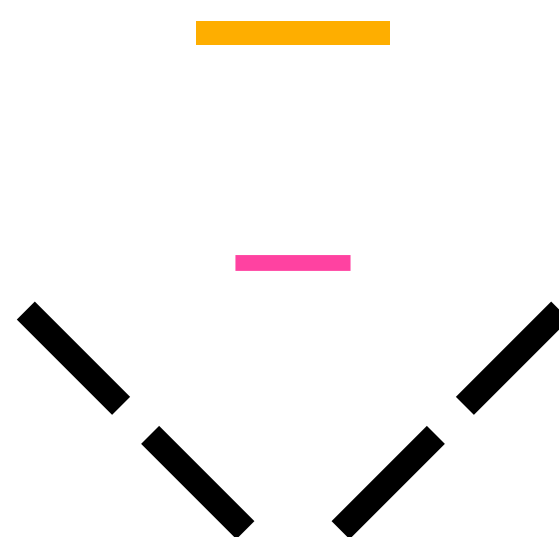
⊕



상호 산란 실험

⊖

2x



시간 독립 잡음

⊕

3중 충돌 사건

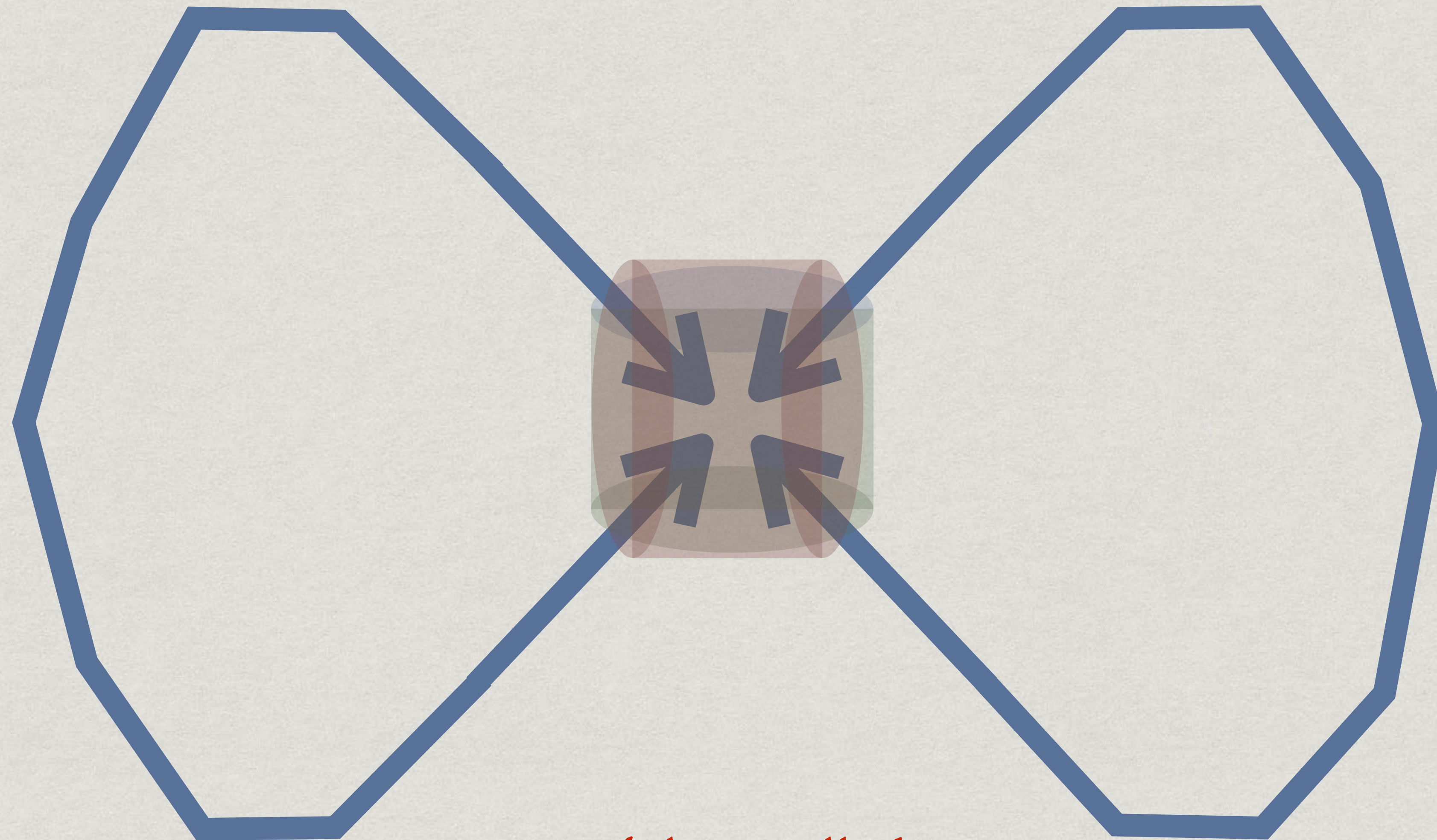
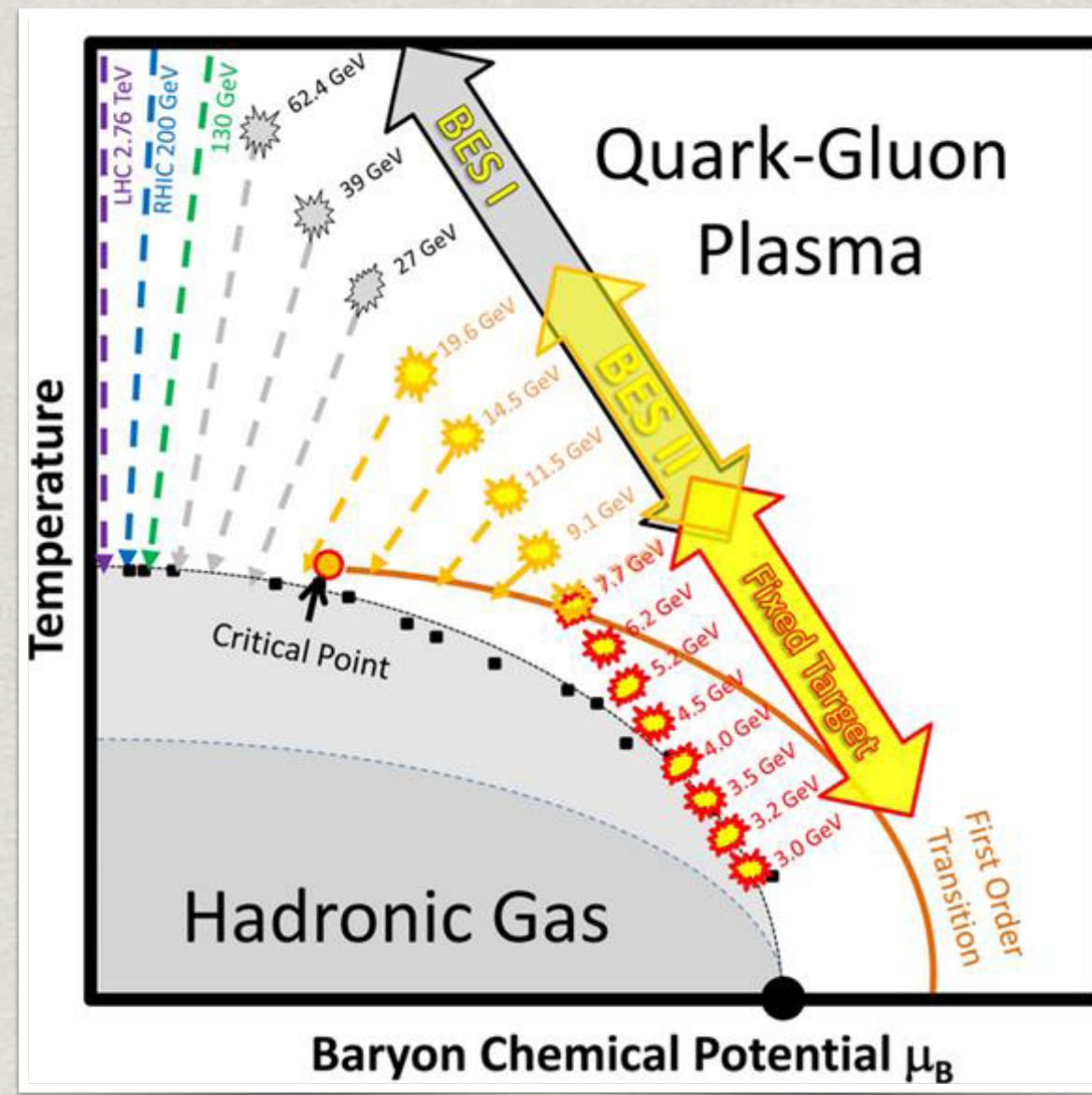
1. Technically:

- ① acceptance problem at mid-rapidity
- ② Unfeasible in the current Collider

2. Physics:

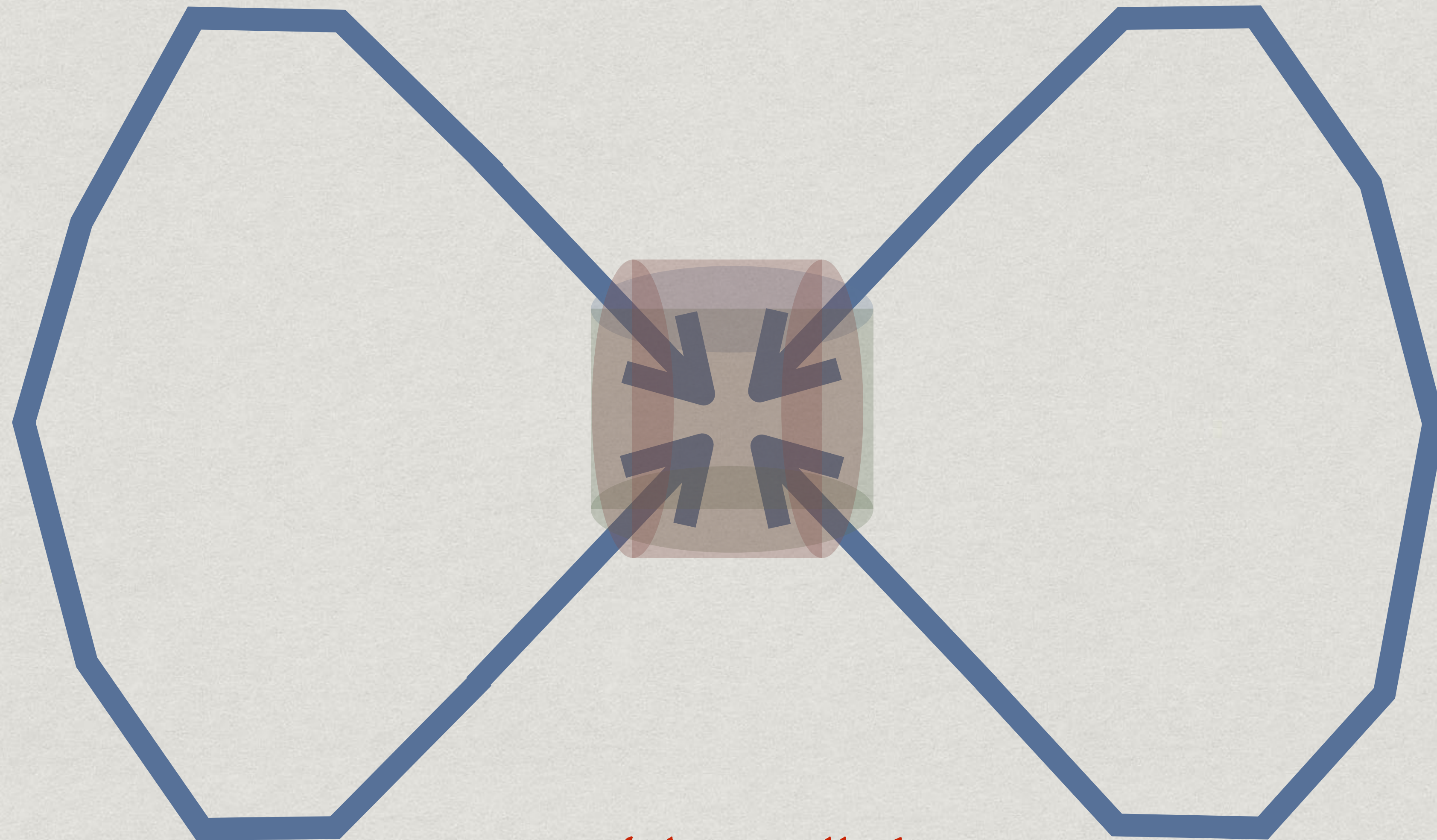
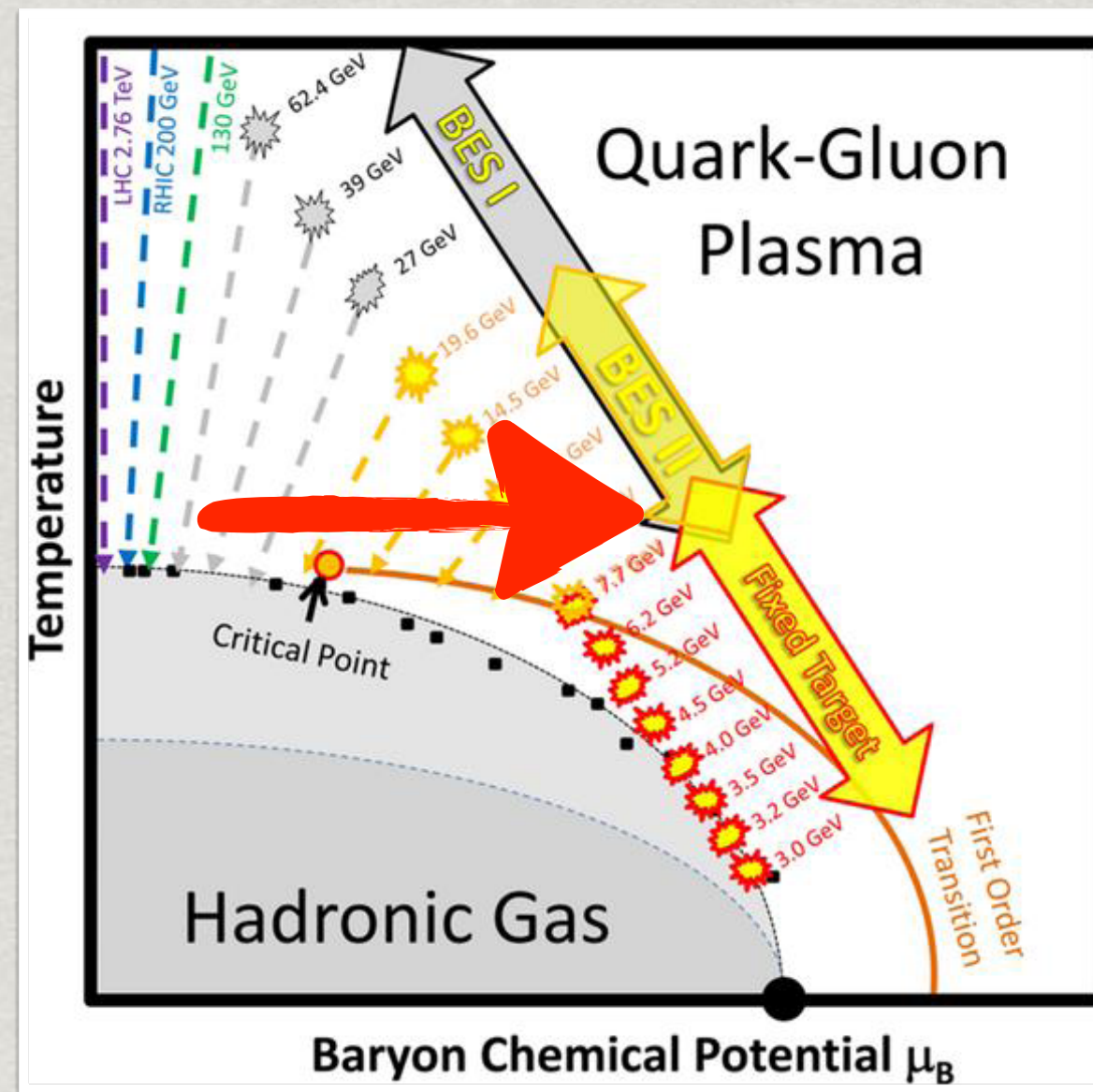
Not enough high  $\mu$

# 'Quad'-llision@ $\sqrt{s_{NN}} = 50-100\text{ GeV}$



Double Collider

# 'Quad'-llision@ $\sqrt{s_{NN}} = 50-100\text{ GeV}$



Double Collider