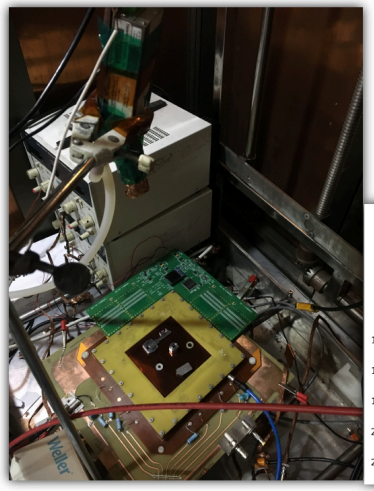
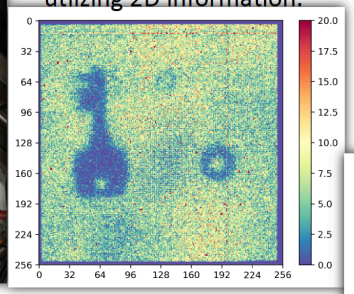
Indian GEM Efforts

- GEM is the new age of the detector for nuclear and particle physics experiments, which was first developed at CERN.
- From that point onwards, only CERN has been the sole provider of the foils which makes it difficult to cope up with increasing demand of the GEM foils. So, there is a need for commercially available GEM foils to help fulfill the surge in demand.
- Along these lines an India based company Micropack Pvt. Ltd. acquired a license from CERN under ToT to produce GEM foils.
- It's a long process to validate the foils delivered by these companies to claim that the GEM detectors made from these foils are compatible with high scientific standards.
- Many Indian institutions and industries are involved in the GEM R&D, application and manufacturing.
- There are groups involved in the GEM detector activity as part of scientific collaborations.
- There is an effort ongoing to utilize GEM technology for the societal applications like medical imaging, cargo imaging, etc.

Medical Imaging with Indian GEMs

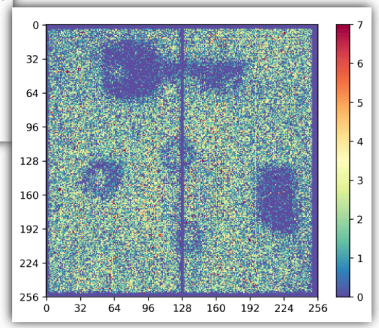


A triple-GEM detector utilizing Micropack foils were assembled and integrated with 2D readout board.
Image was reconstructed utilzing 2D information.



Imaging setup at Delhi University

- GEMROC 64-channel chip manufactured with 350 nm SiGe technology.
- Designed to readout the fast negative pulse (<1 ns).
- Sensitivity to trigger charge pulse of 1fC.
- Power consumption of 1.5 mW/channel.



- The detector used under the operation was built using the Indian made GEM foils
- The detector was operated at a gain of 1000 under Ar/CO2:70/30

Prof. Supratik Mukhopadhyay, Chair of the session on Detectors and Societal Applications said "The mini-review by Prof. Md. Naimuddin was excellent and covered various aspects of the physics and application of GEM-based detectors, including the developments on different readouts. It was extremely encouraging to note that major detector development with GEM detectors were being carried out in India that finally carved out a space in one of the largest accelerator-based experiments on the planet, CMS@LHC. It was also heartening to note that the Indian industry has been significantly involved in the effort."

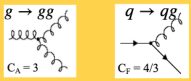
Details: https://www.niser.ac.in/daehep2020/talkposter/Md_Naimuddin_845_780.pdf

Quark/Gluon-jet energy loss in the QGP

γ + jet/Z+jet → initiated by quark jet

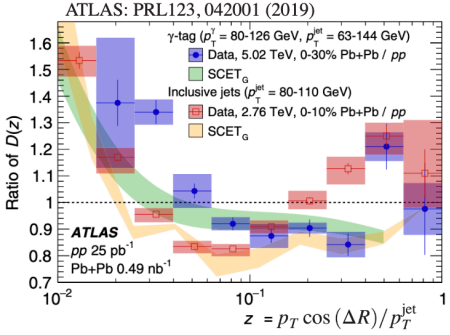
Inclusive jet/h+jet → (mainly) gluon jet

To study the color charge dependence of energy loss



Fragmentation Fun.: γ + jet vs inclusive jet

ATLAS: PRL123, 042001 (2019)

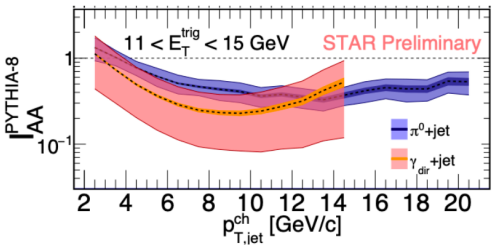


FF of γ + jet modified differently than inclusively selected jets

Geometrical bias needs to be considered (due to path length)

γ + jet vs π^0+jet

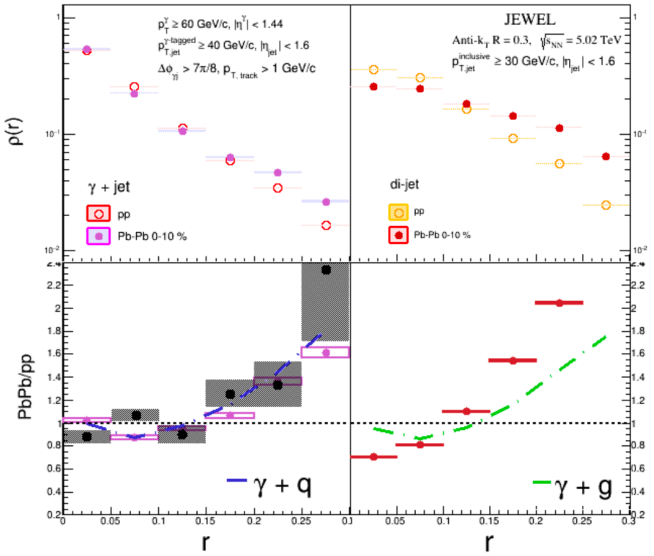
STAR: NRS HP 2020



At RHIC, within uncertainty, both γ + jet vs π^0+jet show similar level of suppression.

Need precision measurement

Results: Jet shape

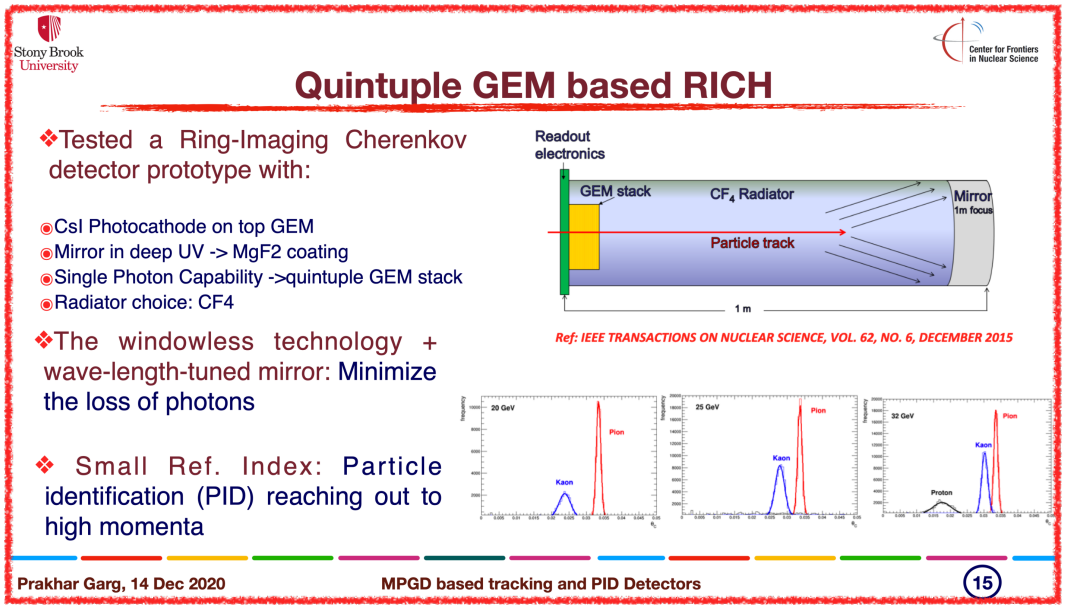


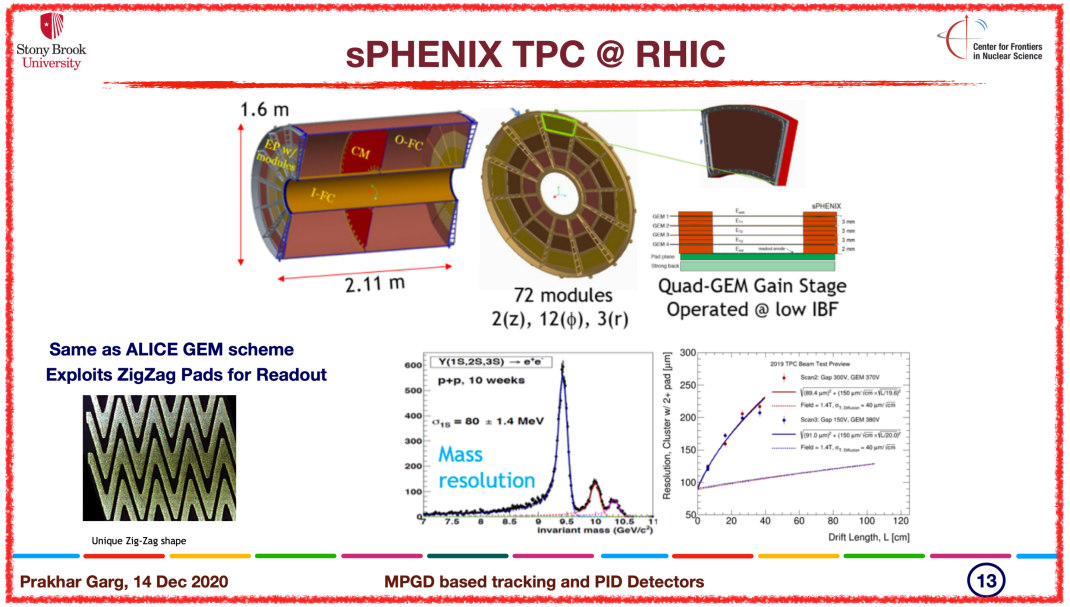
- Large r enhancement is consistent with inclusive jet.
- Unlike data, JEWEL shows depletion at intermediate r. Ratio is consistent with unity.
- γ+q-jet shows same behavior as γ+jet
- Interestingly, γ+g-jet also shows identical behavior as γ+q-jet.

Prof. Sadhana Dash, Chair of the session on Relativistic Heavy-ion collisions and QCD said "In this session dedicated to jet properties and means to quantify them in heavy ion and pp collisions, Dr. Nirhar Ranjan Sahoo and Mr. Rathijit Biswas presented interesting results on Quark/Gluon jet energy loss and Jet shapes, respectively."

https://www.niser.ac.in/daehep2020/talkposter/Nihar_Sahoo__802_783.pdf

https://www.niser.ac.in/daehep2020/talkposter/Rathijit_Biswas_TLK_527_648.pdf





Prof. Bhartendu K Singh, Chair of the session on Detectors and Societal Applications said "The mini-review talk by Dr. Prakhar Garg was excellent and informative. It covered various aspects of Micro pattern Gaseous Detectors. Particularly, one meter short RICH for high momentum particle identification and Zig-Zag pad readout choice for upcoming sPHENIX TPC were interesting to learn."

Details: https://www.niser.ac.in/daehep2020/talkposter/Prakhar_Garg__700_784.pdf

What is soft graviton theorem?

Take a general coordinate invariant quantum theory of gravity coupled to matter fields

Consider an S-matrix element involving

– arbitrary number N of external particles of finite momentum $p_1, \cdots p_N$

– M external gravitons carrying small momentum $k_1, \cdots k_M$.

Soft graviton theorem: Expansion of this amplitude in power series in $k_1, \cdots k_M$ in terms of the amplitude without the low energy (soft) gravitons.

Similar results exist for soft photons as well.

4

1. Soft theorems relate quantum amplitudes with low energy photons / gravitons to quantum amplitudes without such photons / gravitons.

2. However it is connected to several other apparently unrelated topics, e.g.

– asymptotic symmetries

– low frequency gravitational and / or electromagnetic radiation during classical scattering processes.

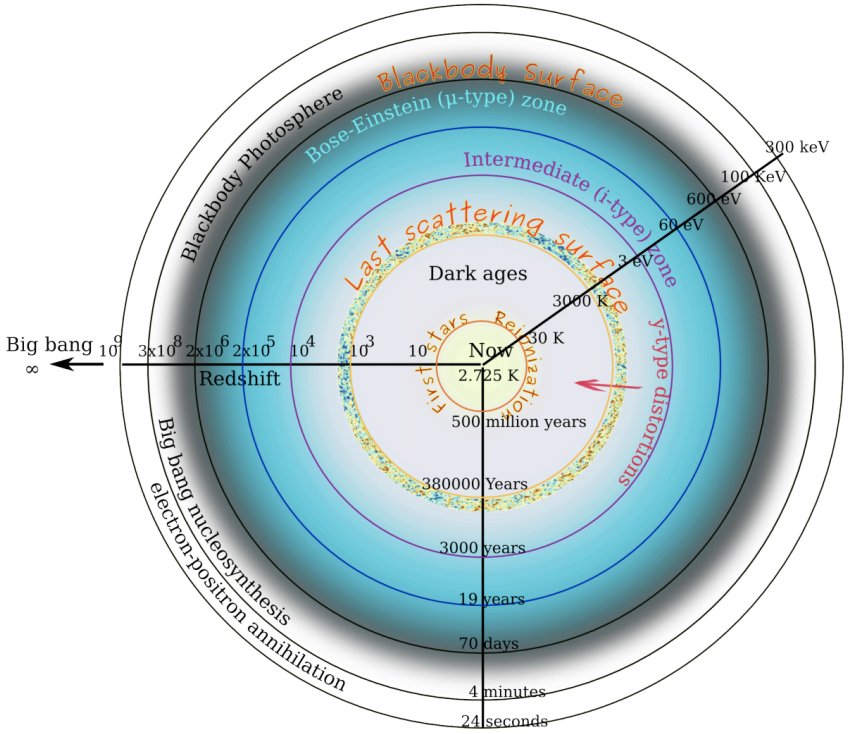
3. As a result, soft theorem can be used to compute low frequency classical radiation during scattering / explosion in terms of incoming and outgoing particle momenta.

26

Prof. Anshuman Maharana, Chair of the session on Formal Theory said "Prof. Ashoke Sen gave a talk which had a concise introduction to soft theorems. Classical soft theorems were discussed. Finally, applications and connections to asymptotics were discussed."

Details: https://www.niser.ac.in/daehep2020/talkposter/Ashoke_Sen__806_777.pdf

CMB is directly affected by new physics at $z \lesssim 2 \times 10$



Discovery Space for the next CMB mission

Discovery	Precision measurement (of things already discovered)
Primordial B-modes (Gravitons)	Lensing B-modes Spectral Distortions E-modes

Discovery

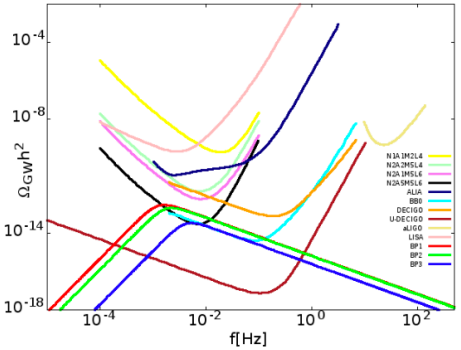
17 e-folds of inflation, Nature of Dark Sector, Primodial Black Holes, Topological Defects, New interactions, particles

Prof. Tuhin Ghosh, Chair of the session on Cosmology and Particle Astrophysics said " In this session dedicated to cosmic microwave background (CMB) physics, new improved component separation techniques, parity violation and statistical isotropy tests of CMB temperature and polarization anisotropies and looking beyond the standard inflation paradigm. Prof. Rishi Khatri gave an excellent overview of CMB physics and its spectral distortions. He mentioned about proposed CMB-Bharat (ISRO) mission and its capabilities to probe fundamental physics".

Slides: https://www.niser.ac.in/daehep2020/talkposter/Rishi_Khatri__799_788.pdf

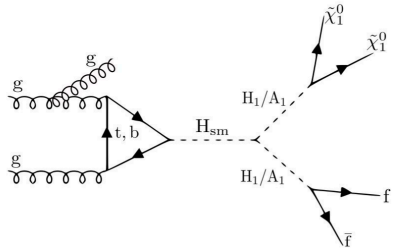
Calculations and Results

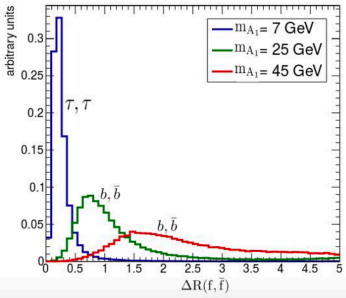
BP	v_n in GeV	v_c in GeV	T_c in GeV	$\frac{v_c}{T_c}$	T_n in GeV	α	$\frac{\beta}{H}$
1	226.89	220.44	135.68	1.62	119.86	0.24	317.86
2	191.03	180.67	146.89	1.23	132.14	0.25	402.89
3	209.95	205.69	170.92	1.20	158.24	0.19	783.65



How to search at the LHC

- Singlino DM **indirectly** produced via production of **light singlet Higgs bosons**
- **Light singlet Higgs bosons** act as **portal** between visible and dark sector
- Features of the **fermions** and the **extra jet** helps to characterise the MET as coming from DM





$$\Delta R(f, \bar{f}) \simeq \frac{m_{A_1/H_1}}{z(z-1)p_T}$$

- $m_{H_1/A_1} \leq 10$ GeV **(Low mass region)**
- $10 \text{ GeV} \leq m_{H_1/A_1} \leq 30$ GeV **(Moderate mass region)**
- $30 \text{ GeV} \leq m_{H_1/A_1} \leq 60$ GeV **(High mass region)**

Prof Kirtiman Ghosh, Chair of the session on Standard Model and Beyond said: "In the session dedicated to the phenomenology of Dark Matter (DM) models, one of the highlights was the talk by Avik Paul (Saha Inst.) on the possible production and detection of Gravitational Wave from the first-order phase transition of the early universe in the framework of nan Extended Inert Doublet DM Model. Arnab Roy (TIFR) has presented an interesting strategy to search for the light singlino DM at the LHC. The direct production of singlino DM in the framework of Next-to-Minimal Supersymmetric Standard Model (NMSSM) is suppressed. Arnab's strategy relies on the indirect production of singlino DM from the decay of a singlet Higgs boson."

Slides: https://www.niser.ac.in/daehep2020/talkposter/AVIK_PAUL_TLK_384_196.pdf
and https://www.niser.ac.in/daehep2020/talkposter/Arnab_Roy_TLK_297_100.pdf