

QGP Experimental Program in India - A historical perspective

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1986 : Heavy ions in SPS and AGS

- Theoretical understanding of QCD and quark-gluon plasma had reached a reasonably matured stage, with notable works by Shuryak, Kapusta, Satz, Rappelski and many others.
- Success of heavy ion acceleration and experiments at the Berkeley BEVALAC had laid the foundation for further work with heavy ions at higher energies.
- European groups working at the BEVALAC, notably Hans Gutbrod and Reinhardt Stock pushed CERN authorities to explore heavy ion acceleration at the SPS
- American groups did similar push at the BNL AGS.

^{16}O beam was expected to be available both at the SPS and the AGS towards end of 1986

Sequence of events in India -- 1986

- Bikash Sinha
 - Among Indian theorists Bikash Sinha had taken early lead, publishing a number of papers while still at BARC (He moved to Kolkata only towards end of 1983). Biswarup Banerjee of TIFR (guide of Sourendu) was another person, they had a paper together.
 - In Feb. 1986 he organized a small workshop at VECC on the new branch of physics, with hardly any significant number of workers in the new field, some had just started picking the thread. It was mostly the crowd of traditional nuclear physicists , like Bikash Sinha himself.
 - The inauguration of the meeting was chaired by Prof. M.K. Pal, then Director SINP, who, being a hard core nuclear structure theorist, was critical of this branch, not knowing its future and terming the effort as “jumping the bandwagon”.

Sequence of events in India -- 1986

- Y.P. Viyogi
 - Had been visiting GANIL, France (second visit part of post-doc) during April-June 1986.
 - Scientist were installing the experiments at CERN in preparation for the beam time later in the year.
 - Several scientists had visited GANIL during their stay at CERN and gave talks regarding the future experiments – H.A. Gustaffsson from Lund for WA80, Art Poskanzer from Berkeley for NA35 etc.
 - I was excited about the scale of these experiments and decided to try working with one of them if possible – a wild dream !

Sequence of events in India – 1986

- After my return from GANIL, I proposed to Bikash Sinha that “we should do experiments at CERN”. I had no idea how this could be done, what should be our role etc.
- Bikash Sinha seized upon the idea and started thinking of ways to go about.
- He arranged for a meeting under the chairmanship of P K Iyengar, then Director, BARC in Nov. 1986 to discuss joining the CERN heavy ion experimental program. It was attended by TIFR and BARC/NPD scientists. Only Bikash Sinha and myself gave presentations. I talked about segmented instruments which could be made in parts in India also.
- We all were blissfully unaware of the work of Indian University colleagues from Jaipur, Chandigarh, Jammu who had joined the EMU-01 Collaboration under the leadership of Ingemar Otterlund of Lund University. Possibly Jadavpur also was involved in another experiment, all being emulsion exposures.

The Minutes of the meeting – A truly historical document.

Government of India
Bhabha Atomic Research Centre
V.E.C. Centre

Bidhan Nagar
Calcutta-64.

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Minutes of the meeting to discuss possible participation of BARC/TIFR scientists in the experiments at CERN, Geneva, to study possible signatures of Quark-Gluon Plasma, held on 5.11.86 at the Trombay Council room. Following were present :-

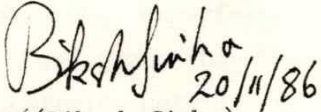
1. P.K. Iyengar, Director, BARC
2. B.V. Sreekantan, Director, TIFR
3. P.K. Malhotra, TIFR
4. A.N. Subramanian, TIFR
5. R.Chidambaram, BARC
6. M.K. Mehta, BARC
7. S.S. Kapoor, BARC
8. V.S. Ramamurthi, BARC
9. M.G. Betigiri, BARC
10. B.K. Jain, BARC
11. S.K. Gupta, BARC
12. M.A. Easwaran, BARC
13. C.L. Bhat, HAL, Srinagar
14. Y.P. Viyogi, VECC, BARC
15. B. Sinha, VECC, BARC

P.K. Malhotra along with A.N. Subramanian indicated modus operandi and the progress they have made in terms of their own experiments using LEP at CERN. P.K. Malhotra along with his group has developed a detector for experiment using LEP at CERN. Certain details of the experiments as well as the theoretical aspects of Quark-Gluon Plasma were discussed by Y.P. Viyogi and B. Sinha. The cosmic ray aspects of Quark-Gluon Plasma were discussed and highlighted by B.V. Sreekantan and C.L. Bhat. It was emphasized that the experimental efforts should be broadly divided into the hardware development in terms of detectors in particular for CERN experiments as well as to continue with the existing efforts at Gulmarg High Altitude Station.

Clearly as indicated and discussed by P.K. Iyengar that at this stage we have to probably start acquainting ourselves with this very large scale detector system for use in the experiment and get an entry to one of the existing experiments at CERN. The general consensus was -

1. India as a country has no other option but to participate in such an experiment both in CERN as well as in Cosmic-Ray fronts.
2. As suggested by Director, BARC we should have three groups of people looking into (a) the theoretical side, (b) the experimental side and (c) the detector side.
3. A special mention was there about the use of Fibre Optics for detection systems - A.N. Subramaniam who is an expert ~~of~~ of the subject indicated the high precision and efficiency of such systems. The Director, BARC emphasized the utility of such a programme.
4. The Director, TIFR emphasized the tremendous importance of the field of Quark-Gluon Plasma and suggested that all of us take swift action to get into the game of measuring Signatures of the plasma.

It was finally decided that a preliminary meeting in the form of intense discussions should be held in Bombay towards the end of January 1987. The possible participants for that discussion can be decided shortly.


(Bikash Sinha)
Convenor.

Follow-up

- Feb. 1987 : a small meeting was held during the DAE HEP symposium in Calcutta. Prince Malhotra, A N Subramanyam and S. Lokanathan were present. Very rudimentary discussions.
- I visited TIFR for a few days, officially to work with A N Subramanyam's group. This group was working on a calorimeter based on lead and scintillating fibres. Had a first-hand experience of handling plastic scintillating optical fibres.
- Bikash Sinha started preparing for the first ICPA-QGP conference (held in Feb. 1988 at TIFR).
- He was working with Hans Gutbrod (a co-organizer of the conference) during this period and also discussing the possible collaboration work.
- Nothing much happened for me, kept analysing GANIL data

Jaipur School, ICPA-QGP 88 and After

- A week-long QGP school had been organised at Jaipur just preceding the ICPA-QGP at TIFR
- I attended that school which had the talks of H. Satz, Ingmar Otterlund and others.
- Otterlund, being part of WA80 also, gave a presentation where he mentioned about upgrading the experiment by using 10000 lead glass pieces over a time-frame of 3 years.
- This presented a possibility for us to join the collaboration, segmentation of the detector being just perfect for us to contribute and the time frame also.

ICPA-QGP 88 and After

- During the conference at Bombay we briefly discussed the collaboration but the aim was to learn some QGP physics of that time, including the aspects of large experiments.
- Hans Gurbrod had organised an extra day purely for experimental physicists to learn some aspects in detail. There were lectures on tracking, calorimetry, etc. and details of various detectors.
- This conference proved to be the turning point for many theorists also. DKS was converted here. BARC/NPD groups also started thinking positively.

ICPA-QGP 88 and After

- After the conference, two persons, with totally unrelated goals, travelled with us to Calcutta – Hans Gutbrod and Isao Tanihata of RIKEN, Japan.
- Both had come to seek collaboration here in their labs. I got busy with Hans Gutbrod in negotiating the terms for joining the WA80 experiment, Tanihata was taken care of by Alok Chakraborty.
- We worked out modalities for Indian development of SF5-equivalent lead glass (highly transparent flint glass with 55% lead) used in the SAPHIRE calorimeter of WA80. We proposed to contribute 2500 pieces.

Development of lead glass : a disaster

- After the initial euphoria of the conference cooled, we got to business.
- Development of lead glass was started at CGCRI, Calcutta.
- P K Iyengar was always very supportive, almost giving me carte-blanche in matters of expenditure.
- We learnt many tricks about characterizing glass in various labs around the town. Polishing of glass was explored at the National Instruments Ltd., just across the road from CGCRI.
- The progress on glass development was slow, however, because of outdated technology being used and also internal politics of CGCRI.
- After spending almost a year, the project was given up.

1989 – a year of deep depressions

- For the preparation of experiments with sulphur beams expected around 1991-92, WA80 of Hans Gutbrod and NA35 of Rienhardt Stock joined hands and a joint proposal for mega- experiment was submitted to CERN SPSC.
- But Stock pulled out because of differences over photon physics - he did not believe in direct photon measurement, whereas WA80 was insisting on this aspect.
- WA80 later submitted another proposal to SPSC with the provision to have 10000 lead glass pieces as the calorimeter to measure photons.
- This was not approved by the SPSC on the ground that CERN had seen enough of lead glass instrumentation and it was time to seek something novel in calorimetry.

1989 – a year of deep depressions

- Jan. 1989 – I visited CERN for the first time, to attend the WA80 collaboration meeting there and then to go to Muenster for learning lead glass calorimeter data analysis
- Also went to DESY Hamburg where the Muenster group was testing a piece of spaghetti calorimeter (a mixture of lead and scintillating fibre, similar to what I had seen in TIFR)
- It was easy to pickup the calorimeter analysis with my experience in invariant mass construction of GANIL hodoscope data (Tapan had also worked with that for his PhD)
- After my return from CERN, the whole world was consumed by the fire of cold fusion and we also were drown to that fire for several months.

1989 – a year of deep depressions

- Hans Gutbrod wanted to push the spaghetti calorimeter for photon measurement.
- He proposed to us to make the light guides.
- This was not such an attractive proposal, a small work of not much quality and standing, but we accepted to start the collaboration. So far we had not been part of the collaboration.
- In August 1989 I visited Jaipur to invite university colleagues to join the collaboration for on-line experiments. The Jaipur-Chandigarh-Jammu group joined together, with the small exception that in Jammu only Prof. N K Rao and Badyal were taken.
- A proposal was submitted to DST to fund the universities.

1989 – a year of deep depressions

- Towards end of 1989, we were still struggling to get into the WA80 collaboration.
- At Puri school there came a proposal to join the NA38 experiment, but the terms were not spoken of. It had been put forth by Sibaji Raha for his friend Romana of Saclay, France.

1990 – a bright sunshine

- Early in the year came the proposal for a photon multiplicity measurement to study Disoriented Chiral Condensates.
- The technique to be used should be based on plastic scintillator pads and wavelength shifting optical fibres.
- There had been a similar system made by Kevin Wolf of Texas A&M Univ for one of the AGS experiments at BNL.

1990 – a bright sunshine

- Hans visited Calcutta in March, just one week before DST had scheduled the review of our light guide proposal.
- We discussed the detector fabrication. A quick simulation suggested about 15000 pads for the available phase space in the WA80 setup.
- None of us had any experience of making such large number of detector pieces with so many steps involved.
- Myself and Murthy quickly sat and worked out a flowchart. We still had no knowledge of how to handle the fibres – cutting, polishing, gluing etc. Just seen a piece from TIFR.
- Help came from Dr. Bishnu Pal of IIT Delhi's photon Laboratory.
- A new proposal modifying the WA80 experiment, adding the new PMD from India and a set of new tracking chambers from the University of Geneva group was submitted to the SPSC by Hans Gutbrod for the sulphur beam experiment.

DST Review – a bombshell

- The DST had setup a special committee to review our proposal of making certain (large) number of light guides for the spaghetti calorimeter. – Experts were CVK Baba, VS Ramamurthy.
- When we went there, Bikash Sinha started presenting the case for photon signal and bla-bla.
- My presentation was also completely contrary to the committee's expectation. – There was a completely new proposal on the table – a large segmented PMD with 15000 pads, to be fabricated in one year's time. The light guides had vanished.
- There was big hue and cry, with some core PAC members suggesting abandoning the review, fresh submission of the new proposal and a new date etc. But some others at least favoured listening to what we had to say.

DST Review- one vs 15000

- The main concern of the reviewers was : when one traditionally takes more than a year to perfect a single plastic detector in the lab, how could we make 15000 of them within a year ?
- I explained through a nice flow-chart each step of fabrication, the approach being a factory assembly line, both in fabrication and quality control.
- This was the first time they were listening to such a concept. Even though at TIFR Prince Malhotra's group had made some proportional counters for the L3 experiment in a similar manner, it was all supposed to be continuously supervised by the Germans and hence no one ever bothered to ask any question, leave alone go near and find out what was being done.

Next steps

- DST sanctioned some money to the universities – not to make the detectors but to visit GSI to learn making such detectors – typical bureaucratic approach, not even trying to understand that what we had proposed was not being made in GSI but was to be done within India alone.
- At VECC we started work on a new lab – with reasonably clean environment.
- Director BARC sanctioned two posts of fixed term Scientific Assistants for the project. Tarun Ghosh and Arun Das joined. Although they were PhD scholars, they were treated differently by the administration. The concept of PhD scholars was almost unheard of in the BARC setup around that time.

May 1990 – CERN visit

- During the QM90 conference in France in May 1990, Bikash Sinha and Hans Gutbrod decided that I should attend the SPSC presentation later in the month. This was important as for the first time India groups would appear as part of the collaboration, that too with a promise to supply a new equipment. SPSC might like to know something from an Indian face, quite reasonable.
- Bikash Sinha called me from France that I should somehow reach CERN on such and such date. Hans told me that he would organise the letter of invitation for visa purposes. Neither Hans would come to CERN for signing the letter nor Bikash Sinha would be in India to sign the deputation proposal.

Under such circumstances a government official to take a foreign trip ??

How ? Smuggling in ??

May 1990 – CERN visit

- I somehow reached CERN and attended the SPSC meeting also. No questions asked. The new experiment was christened as WA93.
- During that visit I managed to get a plastic scintillator pad (although differently made and had a thru hole) and a piece of WLS fibre from Michele Martin, took some mineral oil, assembled the detector with PMT and tested there in Hans's lab with a radioactive source.
- First time experience with such a detector.
- It was a success – I could see the signal clearly.

May 1990 – CERN visit

- I was invited to lunch by Kluberg, spokesperson for NA38 experiment (the proposal initiated by Sibaji had not died yet).
- We discussed some options for joining NA38, although I categorically told them that now we were firmly with WA80.
- Kluberg wanted India to contribute some beryllium for the NA38 muon absorber. Beryllium is a critical material for atomic energy program.
- After returning to India, when I mentioned this to P K Iyengar, he scoffed at the very idea, telling me that they had tons of beryllium at Saclay. Why don't they just take some from there ? I had no idea. Anyway it was not to be and it fizzled out.

PMD fabrication during 1990-91

- New lab was made in a record time and work started for the detector fabrication.
- The entire collaboration was energized beyond any description. Although money offered to the universities were little, it at least provided for travel of students and technicians to VECC.
- Several students from Jaipur and Chandigarh and technicians came to VECC, contributed a lot in the detector fabrication, learnt the tricks of the trade, which was employed later in setting up facilities for the next generation WA98 experiment in those labs.
- Subhasis went to CERN around March 1991 to learn the data acquisition and analysis trade.
- Hans wanted a quadrant of the detector sent to CERN by May 1991 for beam tests in July. We sent the entire detector before time.
- After the tests, we installed the detector in the experiment and took data with sulphur beam in the November beam time of 1991.

Indian PMD effort appears in CERN Courier

Taste of success and after...

- After the success of the first PMD, IOP Bhubaneswar joined the collaboration and became part of the WA98 experiment with lead beam.
- Flow analysis of WA93 PMD was a landmark in our contribution to physics – the word ‘elliptic flow’ did not exist in literature before our paper was published. Our paper also did not have that word.
- Detector fabrication was carried out at all the collaborating institutions for WA98. This led to a strong team effort and a good name for us in the country.
- DCC work with WA98 became another landmark, with several papers and a Physics Report article, as you all know today.

Entry to STAR

- During Quark Matter 93 Conf. at Borlange in Sweden we started discussing the possibility of shifting the WA98 PMD to one of the RHIC experiments. WA98 was scheduled to be shut down by end of 1996 in preparation for LHC. Lead glass was already earmarked for PHENIX.
- PHENIX had no real estate available for our detector. STAR just had an opening in the forward region.
- We started negotiations with STAR. Visited BNL in 1995 and 1996 during their collaboration meetings and presented the scheme. Submitted a proposal in 1997 with old detector. But the 1998 Bomb event stalled all the efforts.
- In a sense it was blessing in disguise. The development of honeycomb proportional counter was going on for the ALICE experiment. This was completed by 1999 and approved by the LHCC.
- Once things started going easy by the end of 1999 for USA visit, we submitted a revised proposal to STAR.

Rest of the history you all know.

Some tips and lessons for the youngsters

- Failure is a key to success.
- Negotiation is the key to strong presence in a collaboration.
- Always attempt to give less and take more. Never be overboard in dealing with rich collaborators.
- Novelty of ideas, whether in Physics or in instrumentation, is very important for your strong footing in any collaboration.
- You should always try to make yourself indispensable but don't tighten the string too much.