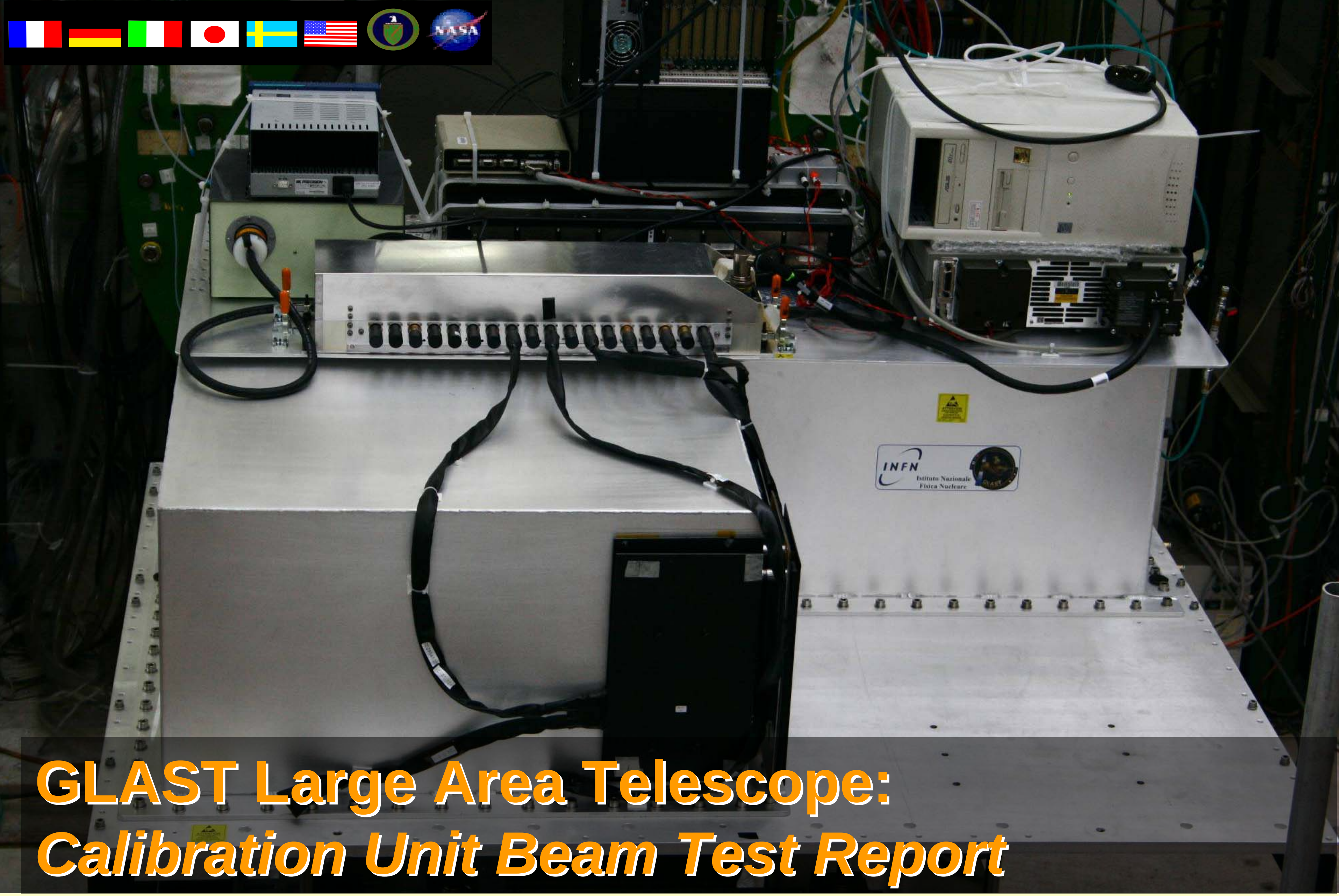
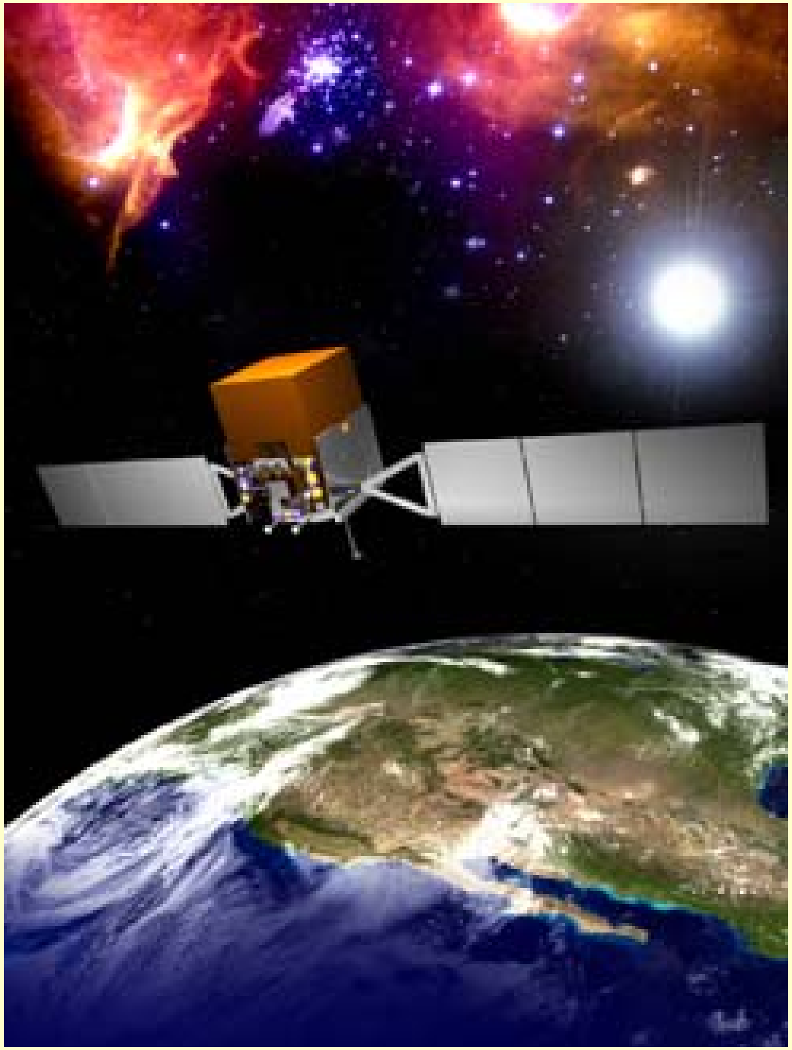


GLAST Large Area Telescope:
Calibration Unit Beam Test Report

Luca Latronico - INFN
on behalf of the beam test team

GLAST Collaboration Meeting
Stockholm 8/29/2006



Talk outline

- Motivations
- Milestones
- The CERN-T9 Run
  - Physics program
  - Data samples and configurations
  - Preliminary analysis
- CERN-SPS Test status
- GSI motivations and status

Calibration Unit Beam test goals

- Calibration Unit beam test at CERN (was SLAC) approved by GLAST 2005 Collaboration Meeting
  - coordinators: R Bellazzini (INFN), E do Couto e Silva (SLAC), B Lott (IN2P3)
  - Beam request submitted to CERN in october 2005
    - Final CERN schedule (delivered 26/6/2006) allocates
      - 4 weeks at PS/T9 area, 26/7-23/8
      - 11 days at SPS/H4 area, 4-15/9
- Goals
  - build a fraction of the LAT using available flight spare modules (Calibration Unit - CU)
  - expose CU to variety of beams
      - tagged photons, electrons, protons, positrons
      - energies from 100MeV to 300GeV
      - many different configurations (angle, impact point)
  - directly measure CU performance
  - validate full LAT Monte-Carlo simulation

Why test the CU at CERN

Why CERN?
- e and hadron beams available
- high energy available
- past experience (INFN-Bari + AGILE γ-tagger at T9, GLAST-CAL at SPS)
- optimization of resources with LAT I&T and ramping up to ISOC only if european GLAST members lead CU beam test

- H4 line - CERN Prevessin (FR)
- Beam extracted from SPS
- e, p, π 10-280GeV
- clean high E beams available
- scheduled 4-15/9

- T9 line - CERN Meyrin (CH)
- Beam extracted from PS
- e-, p, π 0.5-10GeV
- *cocktail* beams
- completed

Motivations for the CU Beam Tests

- A CU Beam Test is part of the LAT Calibration Strategy
  - see LAT-TD-02152 Beam Test Rationale
- Sampling (angle, impact point) phase space on the full flight LAT very demanding in cost and schedule
  - no available beam to irradiate full LAT
- Most events on orbit contained in 2 towers
  - direct calibration with particle beam on a smaller unit is good enough
- MonteCarlo techniques and tools have become extremely sophisticated and reliable
- The LAT calibration, background rejection strategy and performance parameterization heavily rely on our LAT MonteCarlo
  - we need to tune our MonteCarlo description against real data taken with the CU
  - we need to validate the Geant4+Gleam simulation of the relevant physical processes for the LAT

Calibration Unit Description

	Subsystem	Item	Part Number	Serial Number	Status	Notes	Location
➢	TKR	Tracker	LAT-DS-00722	TKRFM8	Flight spare		grid-bay 3
	TKR	Tracker	LAT-DS-00722	TKRFM16	Non-flight	Flight design	grid-bay 2
➢	CAL	Calorimeter	LAT-DS-04536	CALFM101	Flight spare		grid-bay 1
➢	CAL	Calorimeter	LAT-DS-04536	CALFM109	Flight spare		grid-bay 3
	CAL	Calorimeter	LAT-DS-04536	CALFM119	Non-flight	Flight design	grid-bay 2
	ACD	ACD tiles	NA	NA	Non-flight	5 flight design tiles	ISC
	I&T	Mechanical Grid	LAT-DS-01441	NA	Non-flight	Flight-like 1x4 grid	
	ELX	GASU box	LAT-DS-01611	4	Non-flight	Flight design	ISC

Calibration Unit Beam test Milestones

- 10/2005 - coordination group appointed – regular telecons with coordinators to organize activities
  - L Latronico, D Smith, P Bruel, G Godfrey + required experts
- 11/2005 1st VRVS meeting (then bi-weekly on tuesdays), mailing list
- 12/2005: roadmap to CU Integration and Test agreed
  - CU I&T will happen at INFN-Pisa
  - INFN-Pisa will design and build the CU Inner Shipping Container (ISC) for CU operation at CERN and the CU Outer Shipping Container (OSC) for CU/ISC transportation and storage
  - LLR takes full responsibility for providing XYθ scanning table
- 12/2005: transfer of CU hardware to INFN-Pisa initiates
- 1/2006: INFN-Bari offer detectors and DAQ for PID for PS and SPS
- 2/2006: 1x1 tower I&T completed with CU DAQ
  - INFN-Pisa will design and build a new MGSE to integrate CAL into grid from the bottom
  - Online monitoring for CU started at INFN-Pisa

Calibration Unit Beam test Milestones

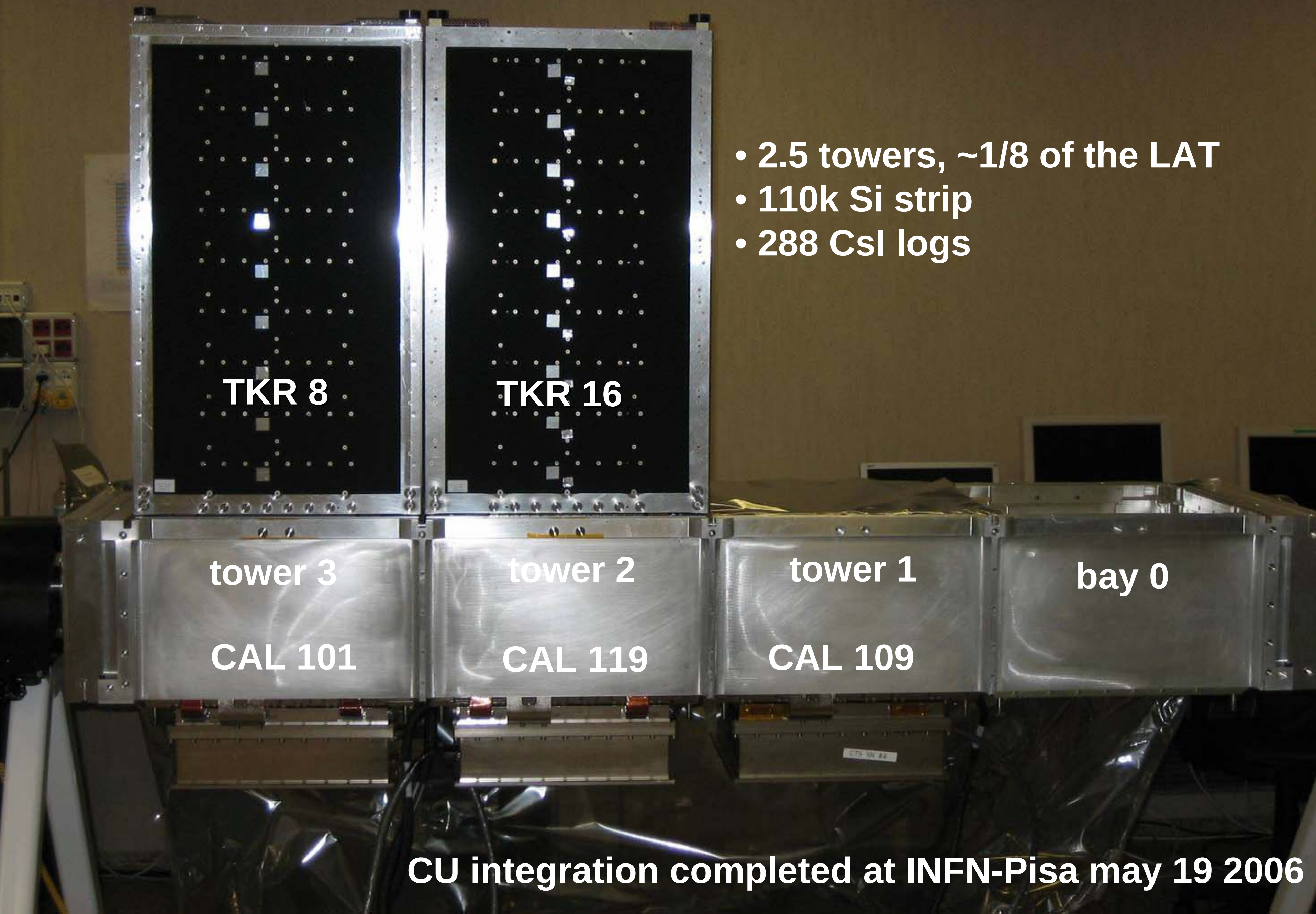
- **3/2006: 1st dedicated CU workshop at INFN-Pisa**
  - ISC, OSC, XYZθ Table design agreed
  - ACD tiles location on ISC agreed
  - γ-tagger silicon detectors from INFN-Trieste
  - Ancillary Detectors (AD) DAQ from INFN-Bari
    - Can read γ-tagger, cerenkov, scintillators
    - 0-suppression on si-tagger for faster readout
  - CU and AD data streams will merge at LDF level online
  - Offline infrastructure from SLAC (calibration DB, recon pipeline, data monitoring tools) – R Dubois
  - 1st MC mass production defined
  - Basic analysis of PSF, Energy Recon, ACD Backsplash presented
- **4/2006: CU Flight Hardware handling Plan (LAT-PS-8131) approved**
  - Flight hardware is shipped to INFN for I&T
- **4/2006: Flight modules received and tested at INFN-Pisa**
- **4/2006: Ancillary Systems at INFN-Pisa for data streams merge**
- **5/2006: CU Integration Procedure and MGSE approved (LAT-PS-8132)**

Calibration Unit Beam test Milestones

- 5/2006: 2nd dedicated CU workshop at INFN-Pisa
  - CU Integration complete
  - PS and SPS experimental setup and basic goals defined
  - First 2 ACD tiles received and tested
- 6/2006: 3rd CU workshop at INFN-Pisa
  - Final DAQ computer network installed
  - CU and AD data streams merged online
  - Online monitor populated with AD plots
  - All ACD tiles calibrated
  - Draft schedule of operations presented
- 7/2006: CU completion
  - ISC and OSC proof test (dry-mount+sealing+OSC-free-fall)
  - CU/ISC Integration and final system test
  - CU/ISC integration with OSC and transportation to CERN
- 7/25/2006: operations start at T9/PS

The GLAST-LAT Calibration Unit

- 2.5 towers, ~1/8 of the LAT
- 110k Si strip
- 288 CsI logs

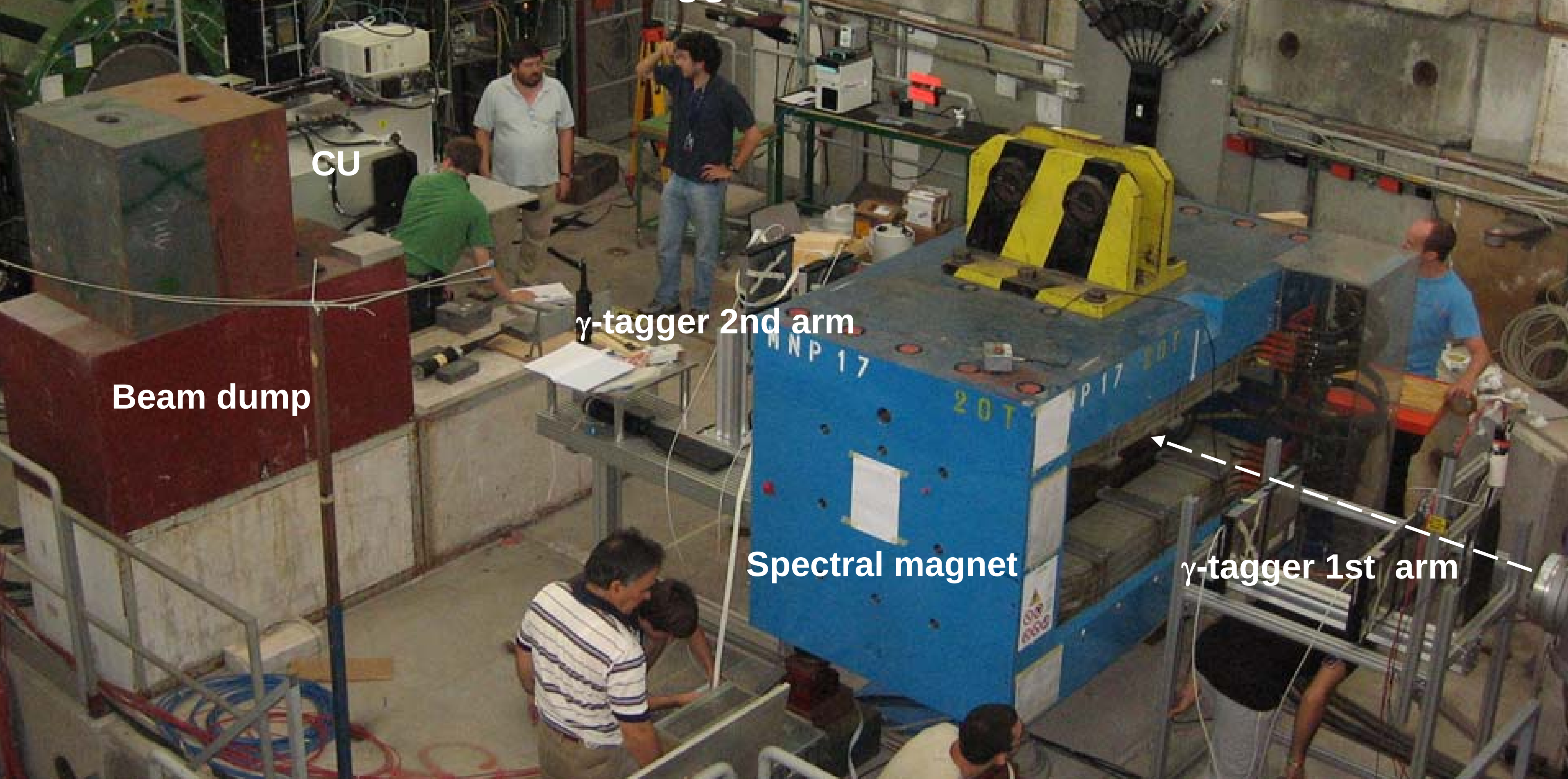


CU integration completed at INFN-Pisa may 19 2006

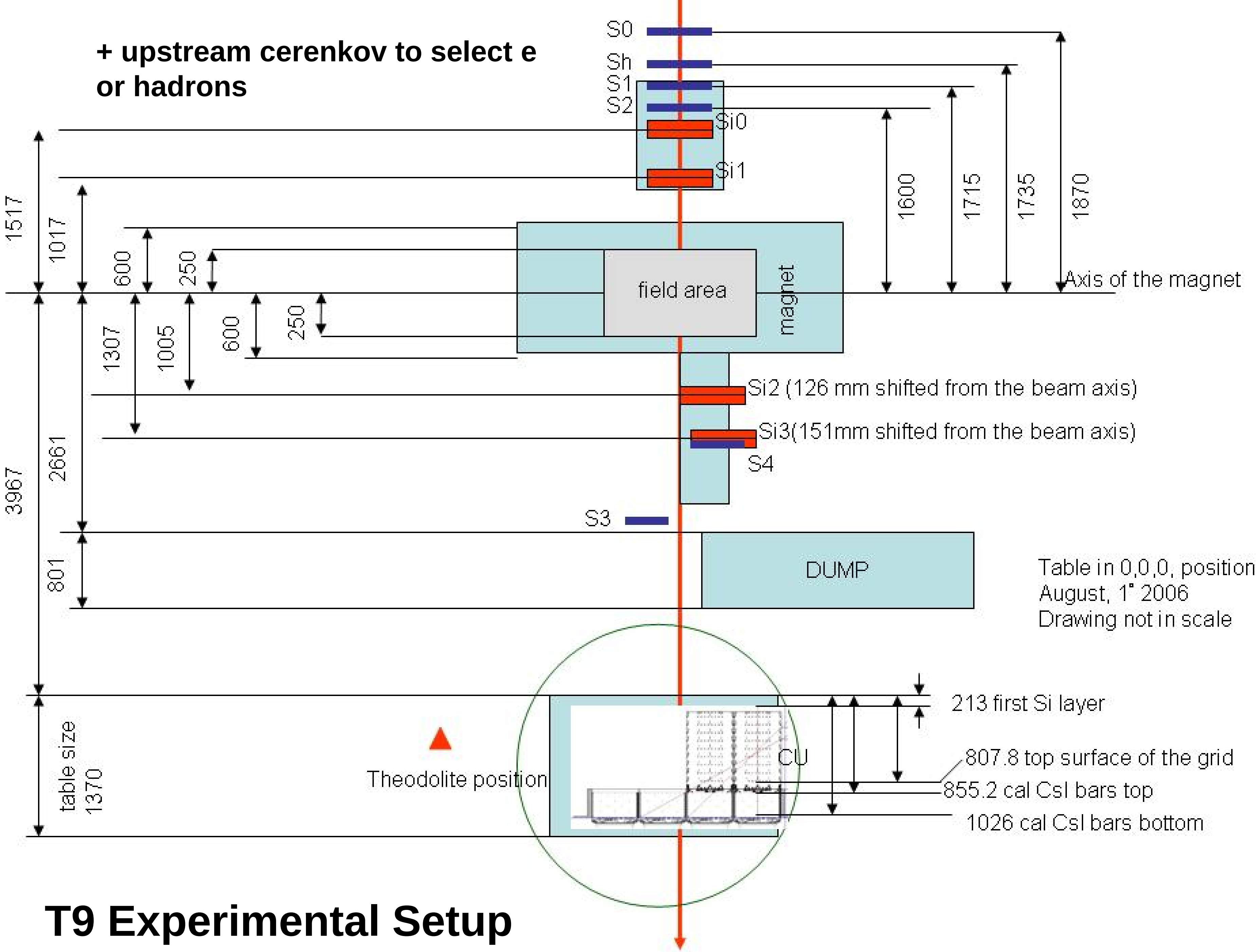
Arrival of hardware to CERN

The CU in the T9 test area

- CU/ISC (750Kg) installation + integration with XYZθ Table completed in 10 hours (from entrance to CERN to final cabling and 1st data)
- CU functional verification (CI test) after transportation immediately cleared
- Test runs with beam in self-trigger within few hours

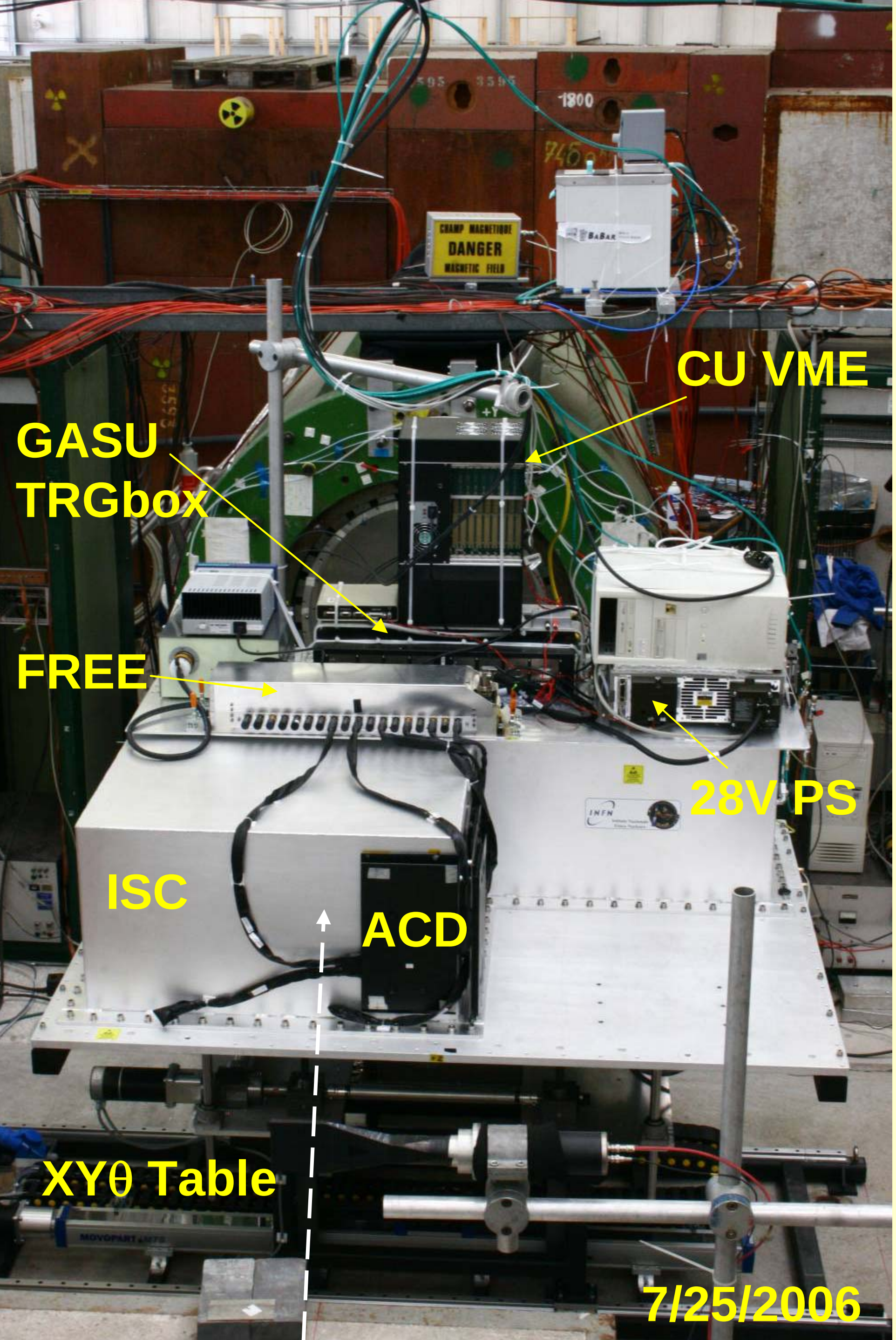


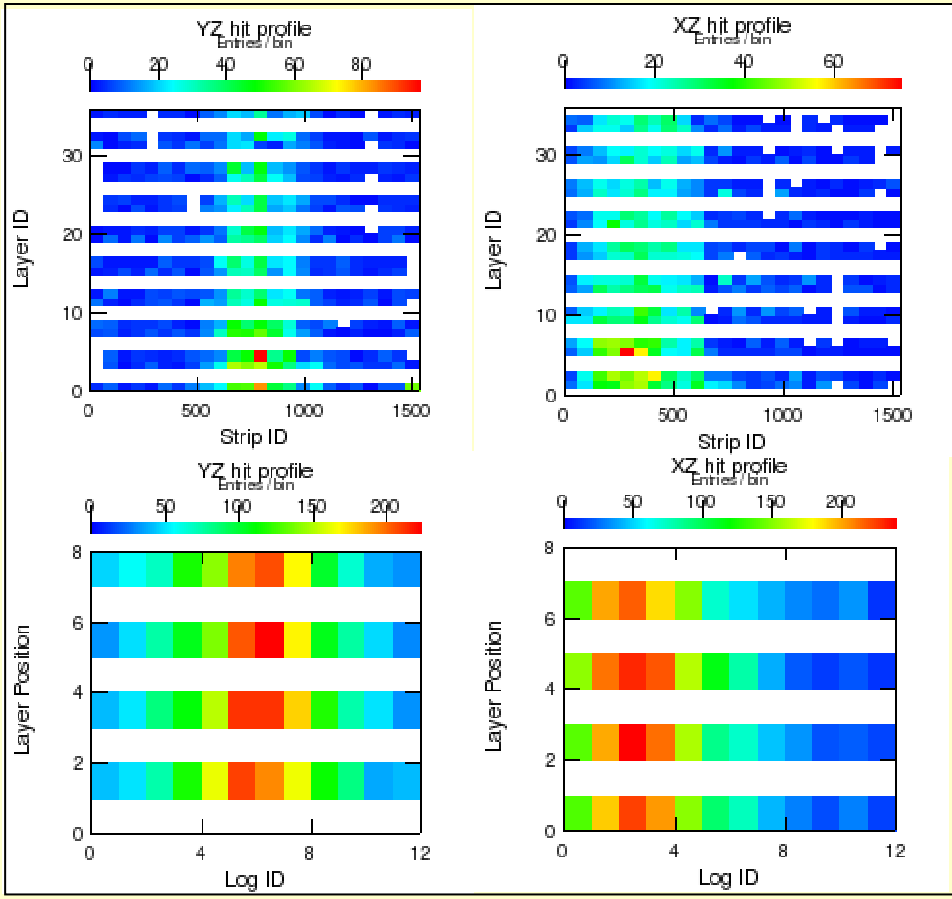
+ upstream cerenkov to select e or hadrons



T9 Experimental Setup

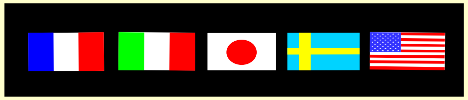
Very first e events from the online





The T9-PS Run

- Collaboration effort for the T9 run
  - 50 worked at T9
    - Very dedicated and excited for a 24/7 experiment
  - All collaboration represented at CERN (IT,FR,US,SW,JP)
  - Support from home institutions during data analysis
  - Valuable experience for ISOC



Run coordinator: L Latronico
CU installation: A Brez
XYZθ Table: P Bruel
CU DAQ: R Claus
Trigger and ancillary detectors: N Mazziotta
Ancillary DAQ: F Gargano
Gamma-Tagger calibration: A Brez, L Baldini

Online and data synchronization: L Baldini
MC simulations: F Longo
Pipeline and recon management: Longo, Kuss, Omodei
Local Offline: L Rochester (Socket Gleam), INFN-PG (offline monitor)
TKR analysis: C Cecchi
CAL analysis: P Bruel
ACD analysis: E Charles

The original Beam Test Plan

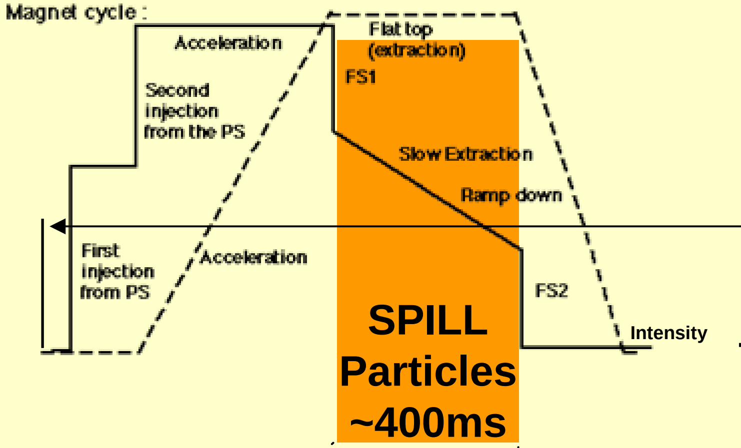
Particle	Energy (GeV)	Angles (deg.)	#Positions per angle	Statistics	Trigger
tagged gamma-rays	0.3,1.,2.5 (incident electrons)	0,5,20,40,60	6	200 k	External
electrons	0.3, 1,5,15	0,5,20,40,60,90,180	6	200k	External
	15	0	60	40k	External
	15	0	1	> 1M	Internal (high rate)
hadrons	0.3, 1,5,15	0,90	2	1 M	External
muons	4	0	6	100 k	Internal+External

- **After beam time reduction due to CERN problems we had to**
  - **Reduce number of angle and impact points**
  - **Add full-brem γ data collection to quickly cover full spectrum (G Godfrey)**
  - **Proceed with caution and first complete all data sets (γ,e,e+,p) with fewer configurations and statistics and only at the end explore phase space more**
- **Eventually it worked very well and managed to cover unforeseen configuration (e.g. Albedo γ)**

The final T9-PS Run Schedule

Week	30 7/24-7/30	31 7/31-8/6	32 8/7-8/13	33 8/14-8/20	34 8/21-8/27
Mo		PS restart		Positrons 1GeV e+ annihilation	Photons Low E tagged γ PS magnet
Tu	CU+table installation Initial debug Test self-trg data	DAQ sync test CU Timing Beam-line cleanup PS magnet glitch	Pile-up inspector Photons Tagger calibration Low E beams test Full brem γ	Protons 6-10 GeV p scan	Special runs FHE scan Random trig Photons VLE tagged γ
We	OK from safety AD installation	PS magnet failure	East Hall magnet failure		Dismantle and transport to H4
Th	Ext Trigger setup Electrons CAL calib 5GeV scan Magnet failure	Reduced noise in Si tagger detectors	4th spill negotiated with CERN	Electrons New 5GeV e scan Photons Tagged-γ Full Brem γ	
Fr	Magnet repair Pions ACD calibration		Photons Tagged-γ Full Brem γ		
Sa	general blackout			Photons	
Su				Positrons New setup	

CERN Beam Structure



SPS SUPER CYCLE 16.8s
3 or 4 SPILL per CYCLE

Working hours cycle

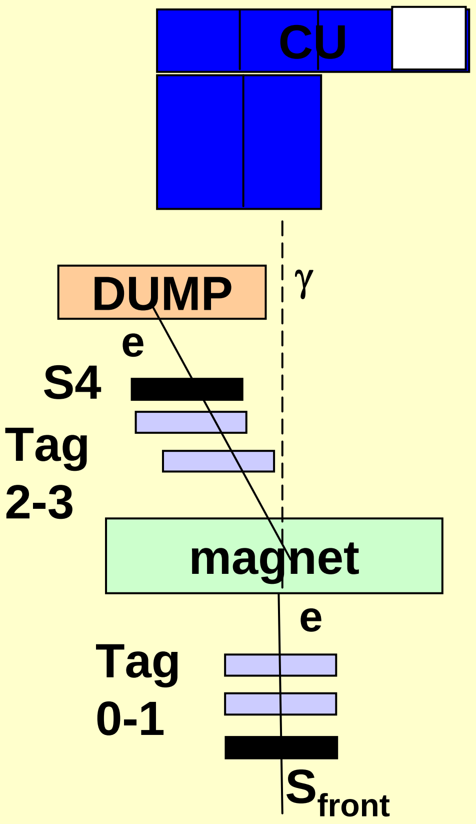
SFTPRO 1	SFTPRO 2	EASTC/AD 3	4	EASTC 5	6	EASTC 7	8	9	CNGS 10	CNGS 11	MDLHC/MD2 12	13	14

Non-Working hours cycle

SFTPRO 1	SFTPRO 2	EASTC/AD 3	4	EASTC 5	6	EASTC 7	8	9	CNGS 10	CNGS 11	EASTC 12	13	14

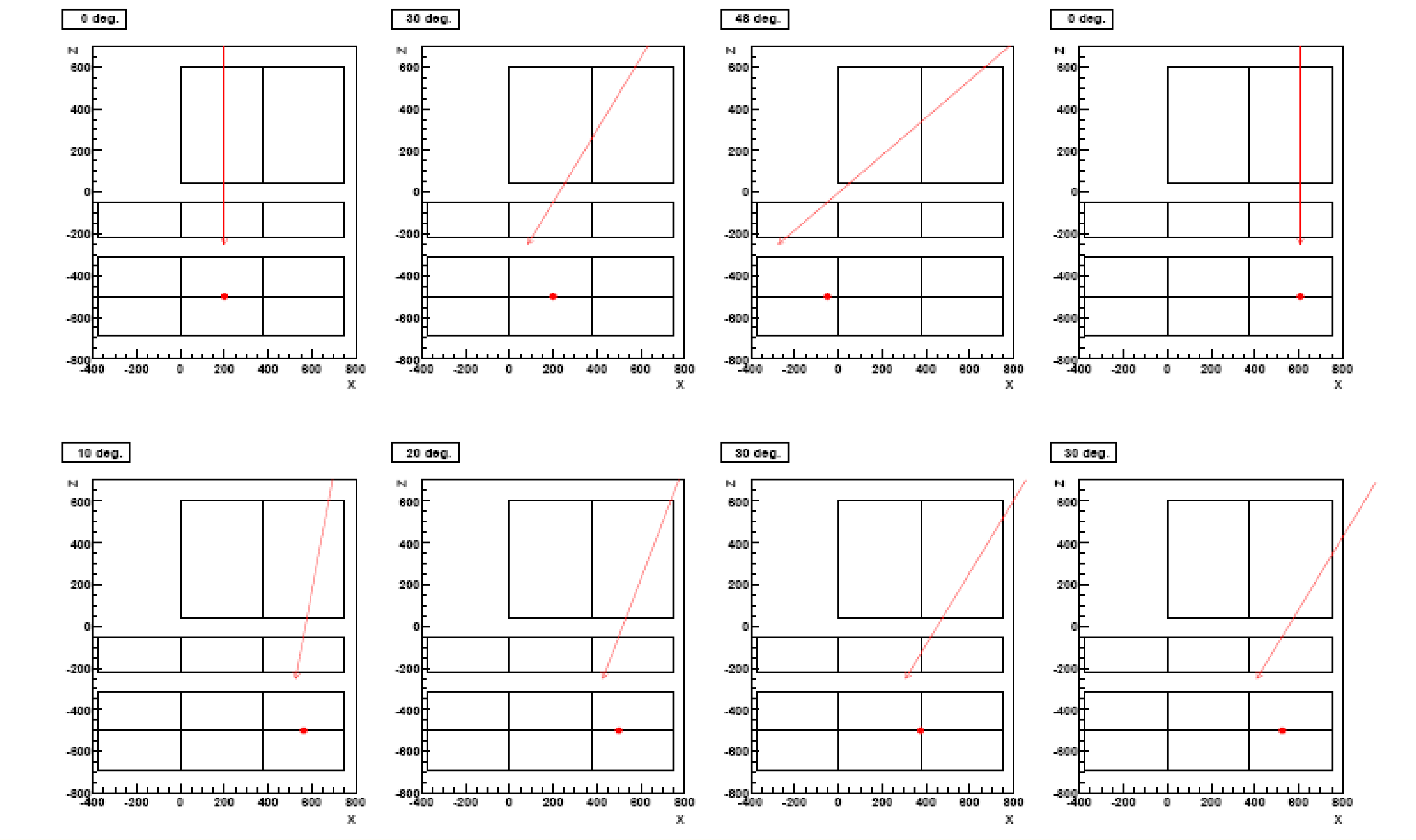
- **We do not have continous beam**
  - **CERN manages many users and accelerators**
- **Large fraction of the cycle w/o particles**
  - **AD data transfer and data merge OFF-spill**
  - **CU DAQ peak rate much higher than average**
  - **4th spill is a 25% duty cycle increase and allowed us to complete the program**

Photon data overview



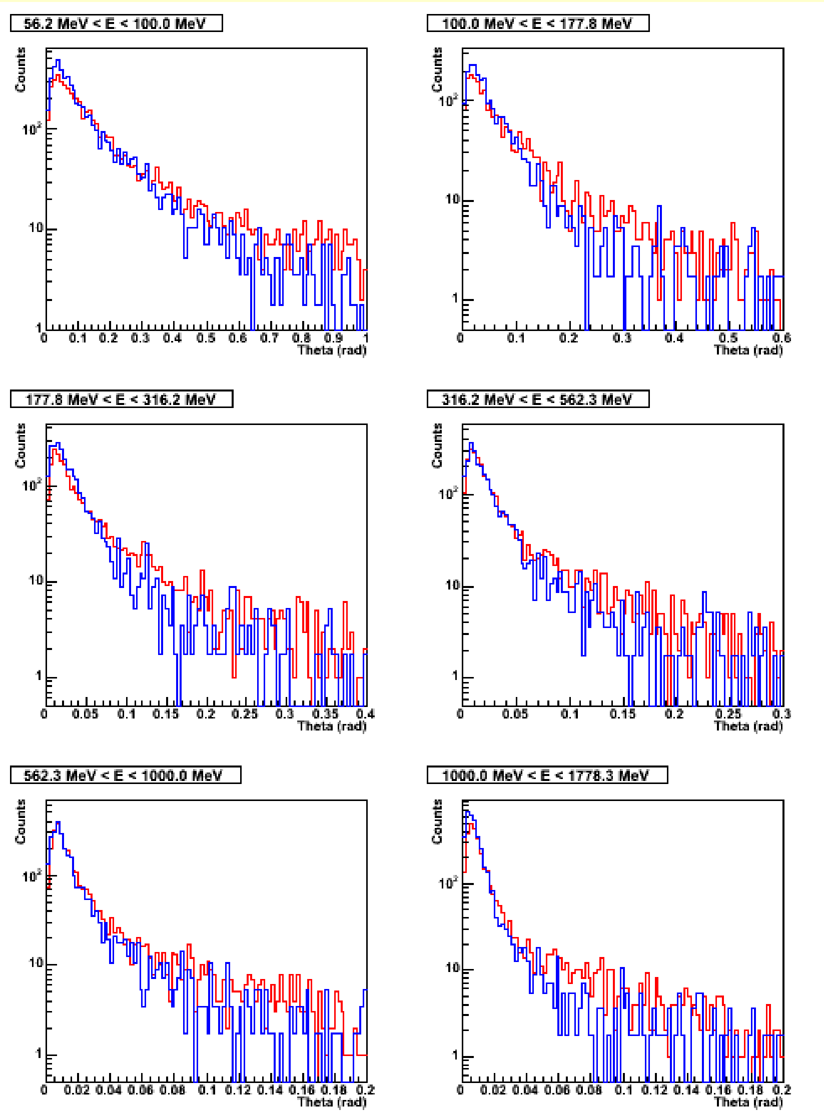
- **Full-bremsstrahlung**
  - **Trigger on S_{front} only (+cerenkov)**
  - **No AD DAQ → KHz readout rate**
  - **Full brem spectrum from 2.5GeV e**
  - **Rely on nominal beam position, G4 bremstrahlung spectrum, estimated radiator material**
- **Tagged photon**
  - **Trigger on S4&S_{front} (+cerenkov)**
  - **Synchronized with AD DAQ → O(100)Hz rate**
  - **Record limited slice of spectrum but provide single γ energy and incoming direction**

Photon data overview - configurations

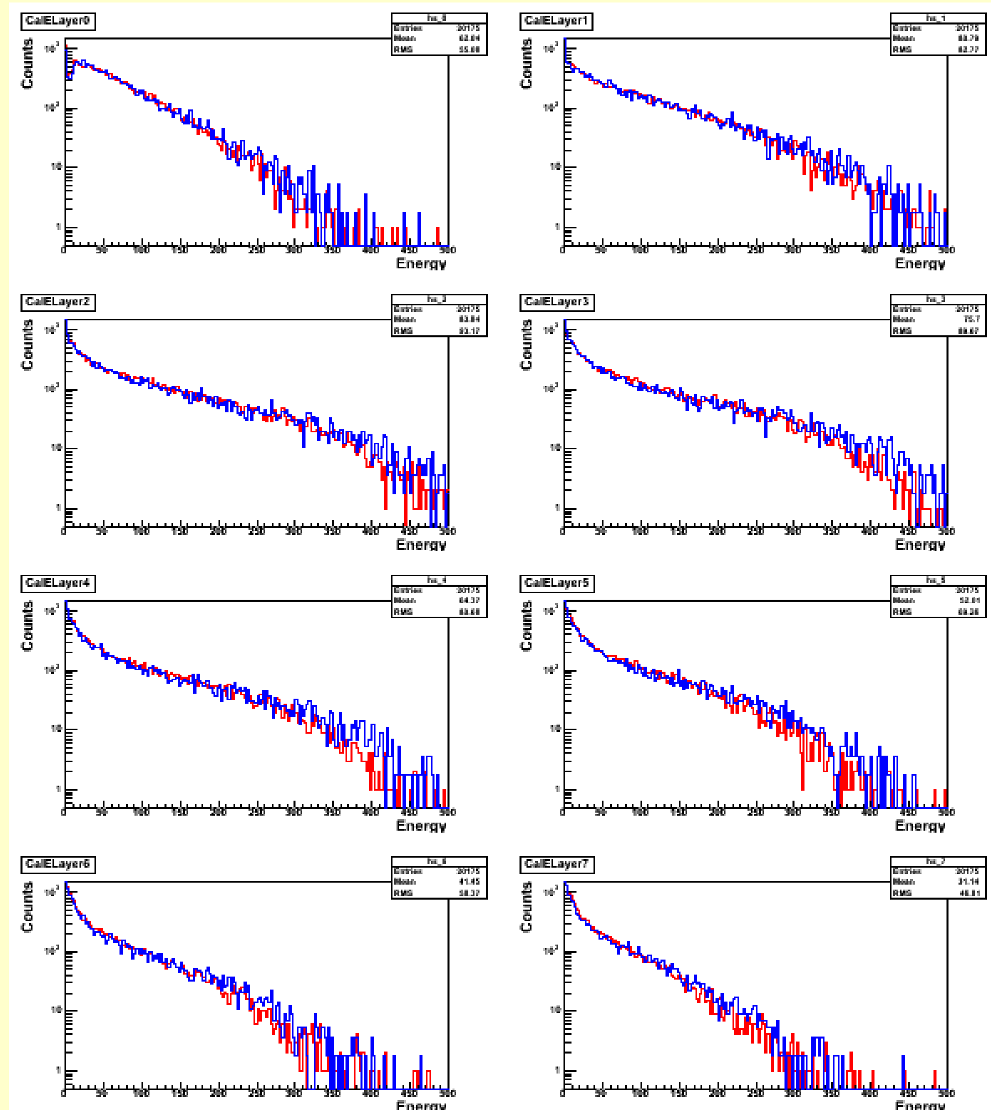


+ 2 *albedo* configurations shooting upwards γ at different angle, position

First comparison of γ data with MC



Full-brem data angular distribution



Full-brem data CAL log E deposit

Lott

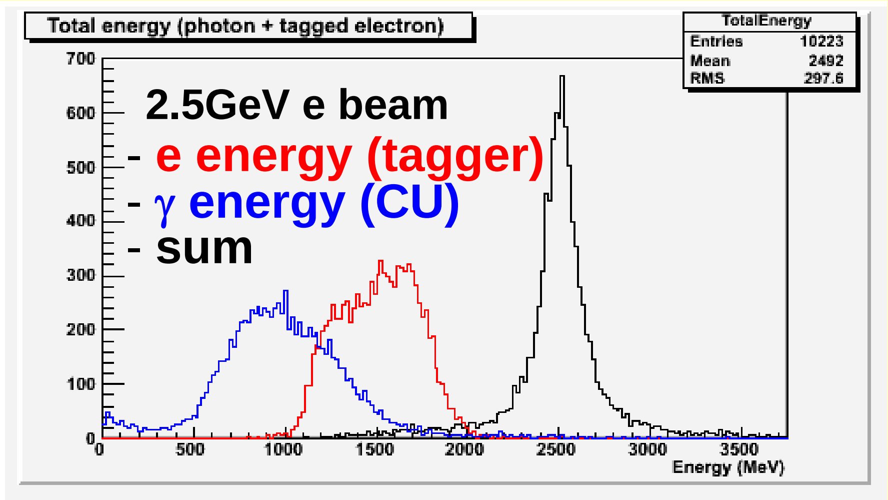
→ within few hours from raw data, thanks to MC, recon, pipeline!

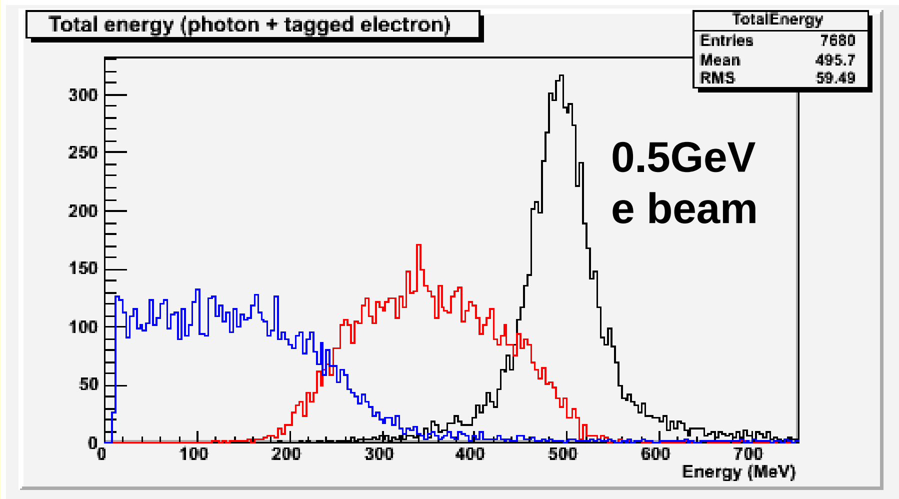
Gamma tagger operation and calibration

- Tagger operation
  - Keep geometry fixed to avoid recalibration
  - Scan γ spectrum using several combinations of beam and bending power (constant E/BL)
  - Geometry only modified at the end of the test to improve resolution for low energy γ
    - Lowest E, max BL

- Tagger calibration – performed in 6 hours
  - Alignment
    - First tagger arm aligned with direct beam
    - Second arm with direct beam and magnet ON
  - Bending power (BL)
    - calibrated scanning spectral magnet current vs beam deflection measured from first tagger arm to CU
  - Multiple Scattering (MS)
    - From tracks opening in non-bending plane
  - Beam momentum dispersion $\Delta p/p$
    - calculated deconvolving MS from overall tagger resolution

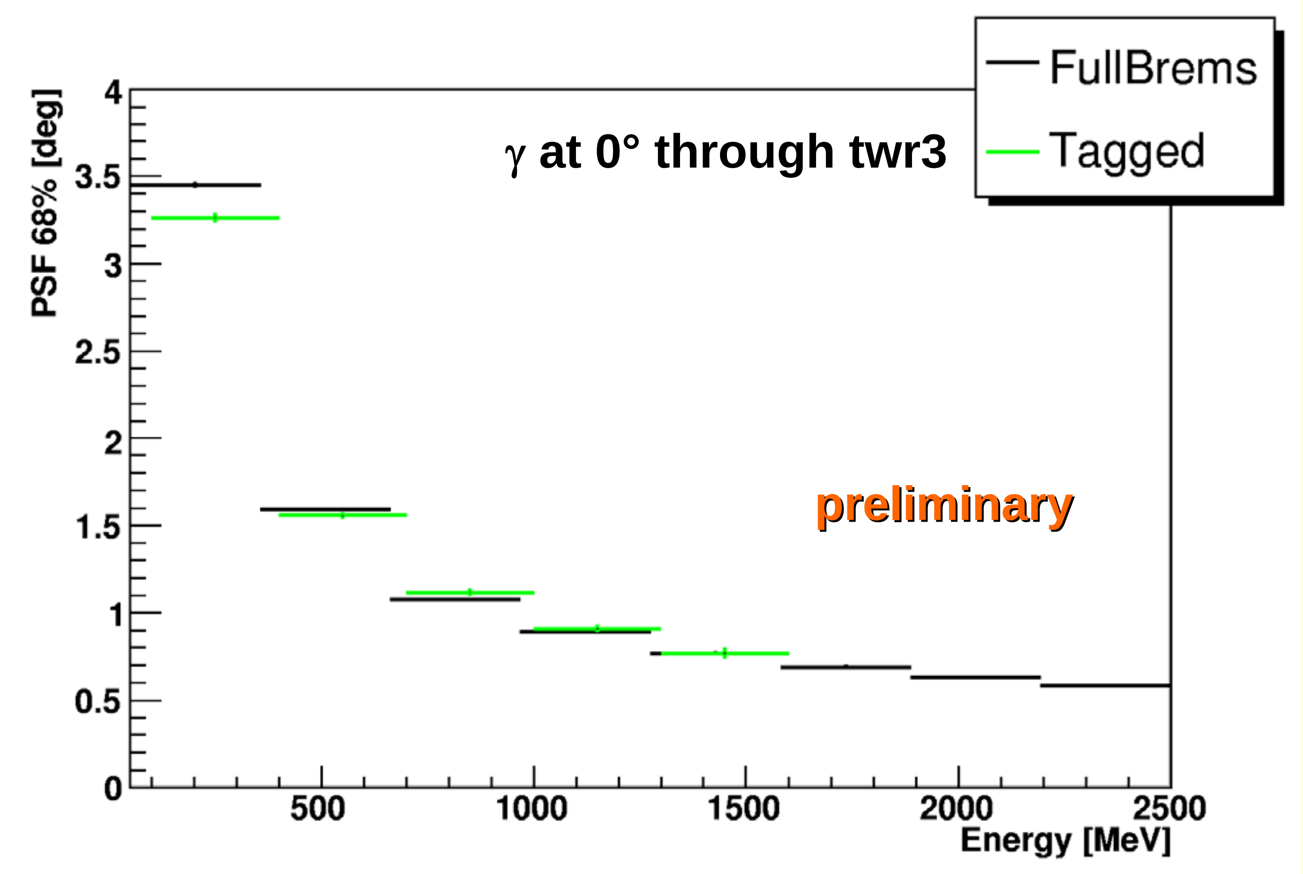
Tagger: standard configuration





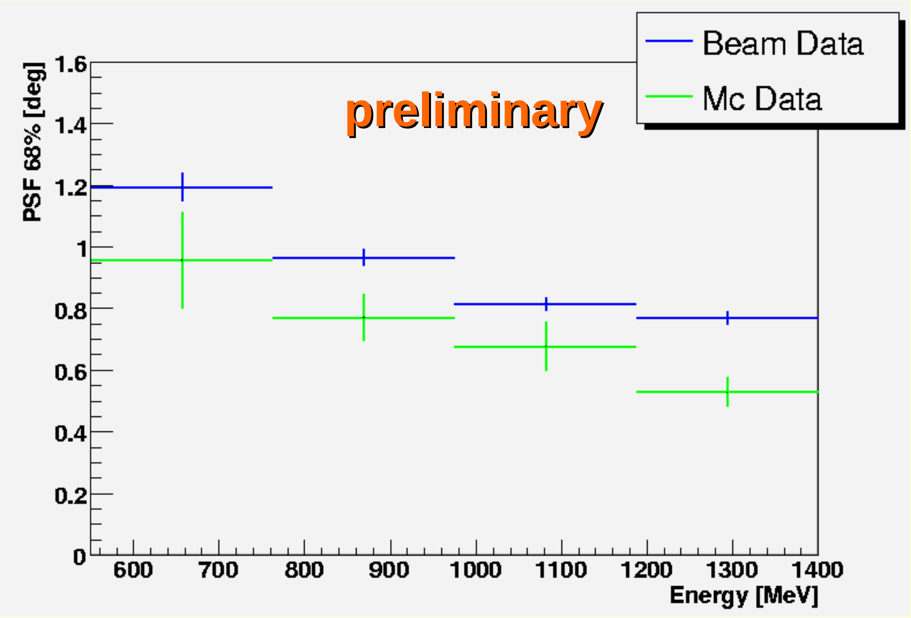
- **Tagger resolution worse at lower E**
  - **Scales as 1/BL (we scaled magnet to preserve geometry)**
    - **~1.4 % @ 0.7 T*m (max bending power)**
  - **Larger beam divergence and momentum spread**
  - **Larger MS**
- **For 500MeV the acceptance cut into unradiated beam**
  - **Some empty events in the CU (no γ)**
  - **More statistics required**

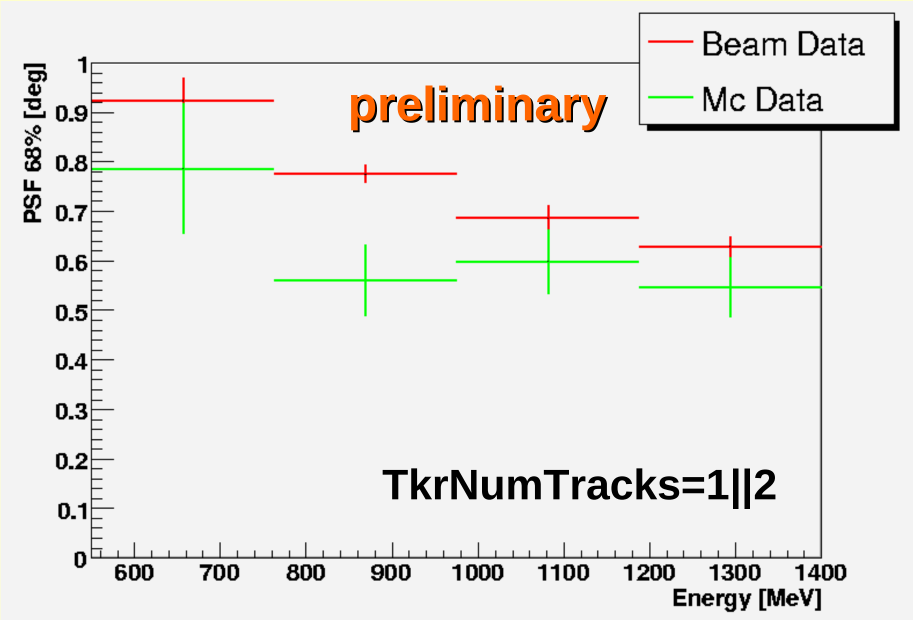
Comparison with tagger data



- Tagged γ analysis: incoming γ direction from tagger and error from resolution
- Full-brem γ analysis: average beam line and dispersion assumed
- Can benefit from large statisics and acceptance of full-brem data

Point Spread Function with tagged γ



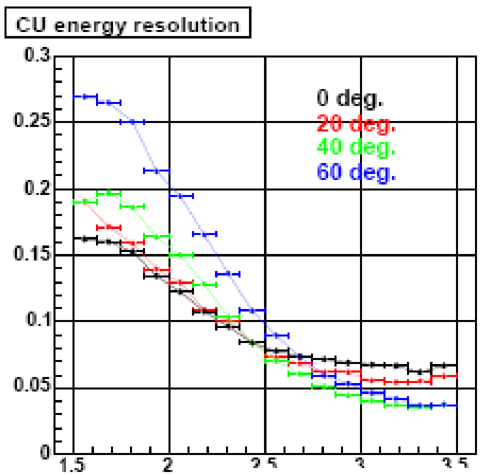


- **Performance and systematic effects of the beam and tagger must be fully understood and transferred to analysis**
  - **Beam dispersion**
  - **Double photons from extra material**
- **MC data must be tuned and above effects included or controlled with proper cuts**

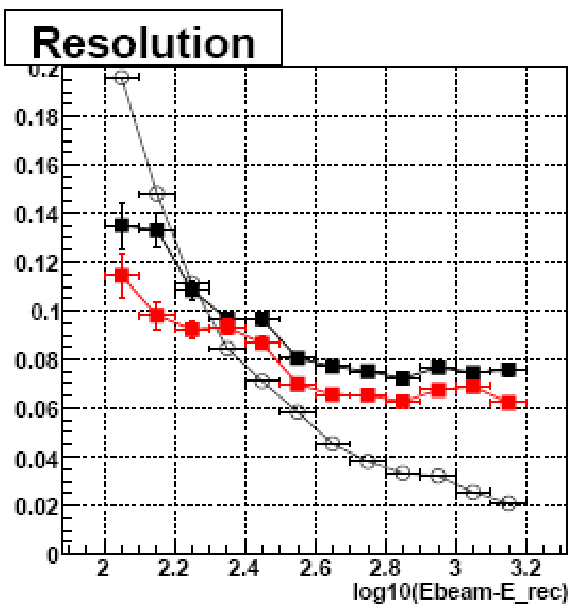
Energy Resolution

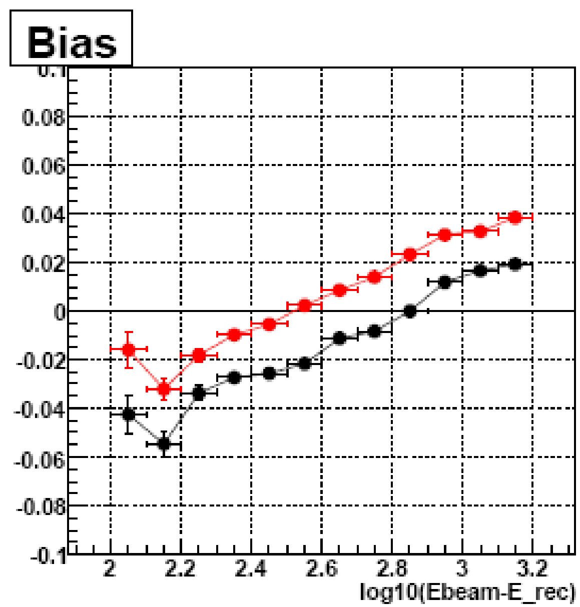
CU resolution 0 deg

preliminary



- empty circles : (beam+tagger) resolution
- black squares : EvtEnergyCorr corrected resolution
- red squares : CalLkHdEnergy corrected resolution





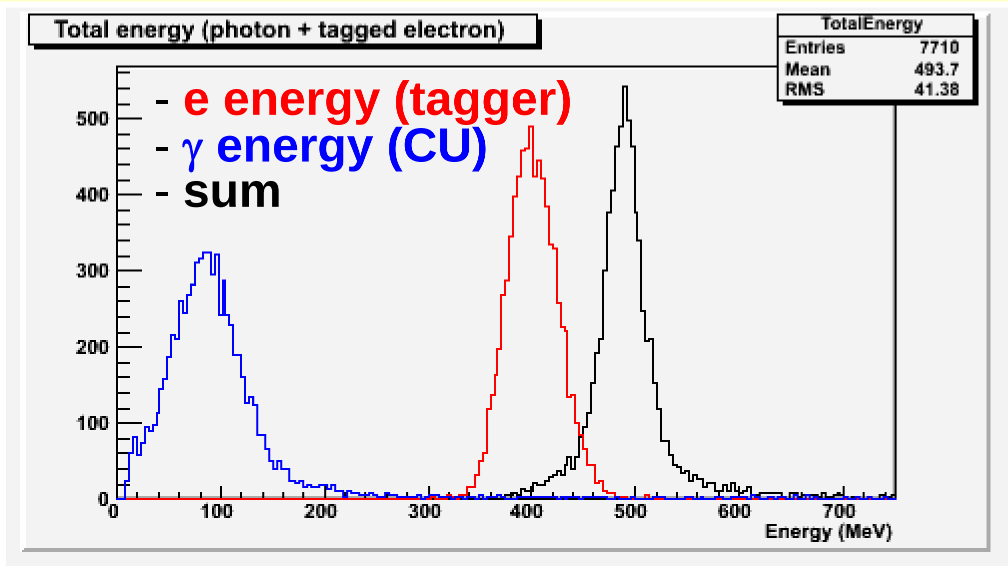
– p.10/13

Energy Resolution analysis

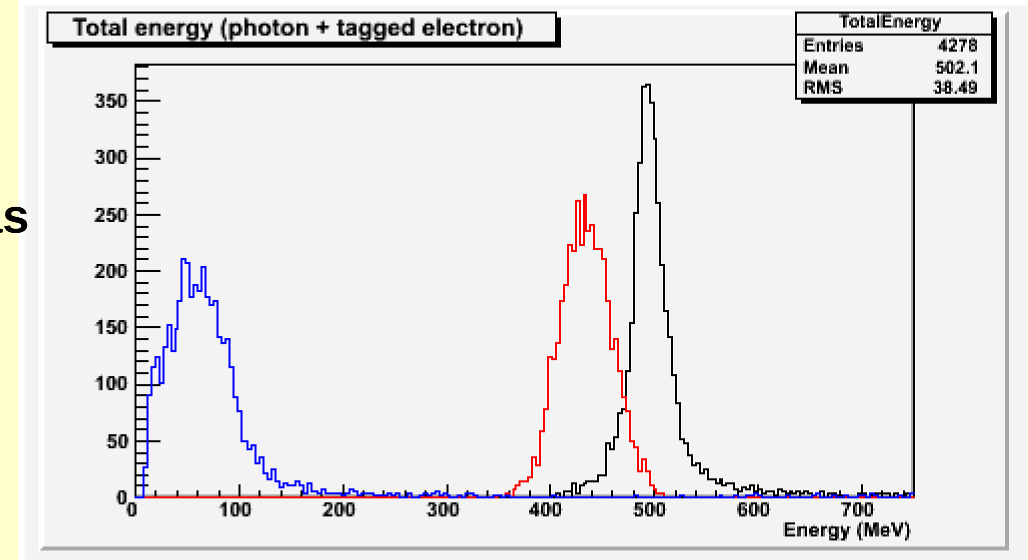
- at 100 MeV : huge correction due to tagger+beam resolution
  $\Rightarrow$ use the runs taken with the optimized tagger configuration
- some strange behaviours (i.e 48 deg. resolution at 1 GeV worse than at 30 deg.)
- very preliminary :
  - check the beam energy dispersions, the analysis cuts
  - the comparison with the realistic simulation will come soon
- other data available : the 5 GeV electron runs (many configurations and especially around the cracks)

– p.13/13

Tagger: low energy setup



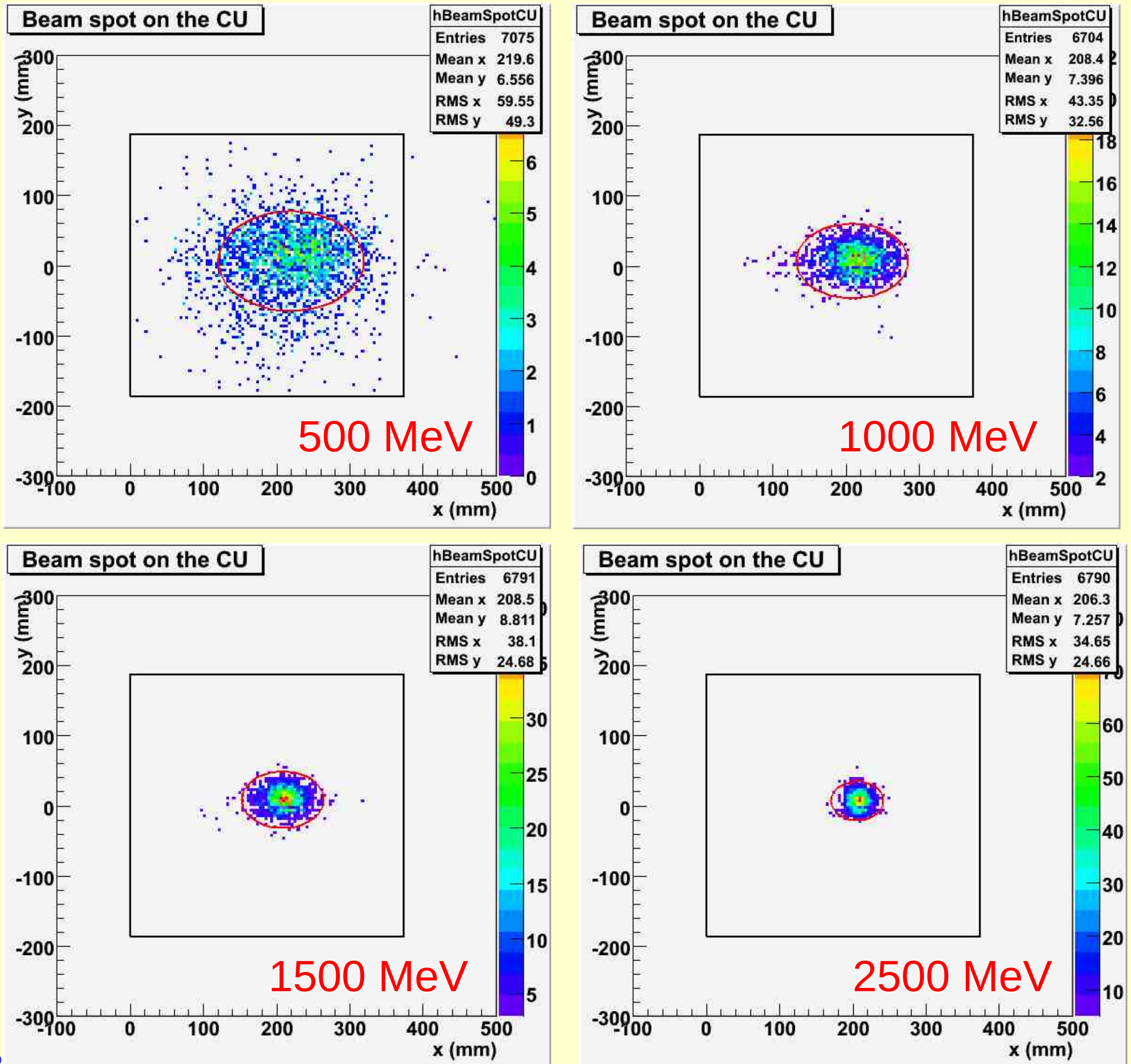
- Geometry optimized for Low E
  - 500 MeV beam, 480 A -> ~100 MeV γ
- Geometry optimized for Very Low E
  - 500 MeV beam, 525 A -> ~ 80 MeV γ



- Higher energy resolution available for low energy gammas
- Calibration runs analysis only preliminary (larger MS)
- Crucial for CU studies at low energy

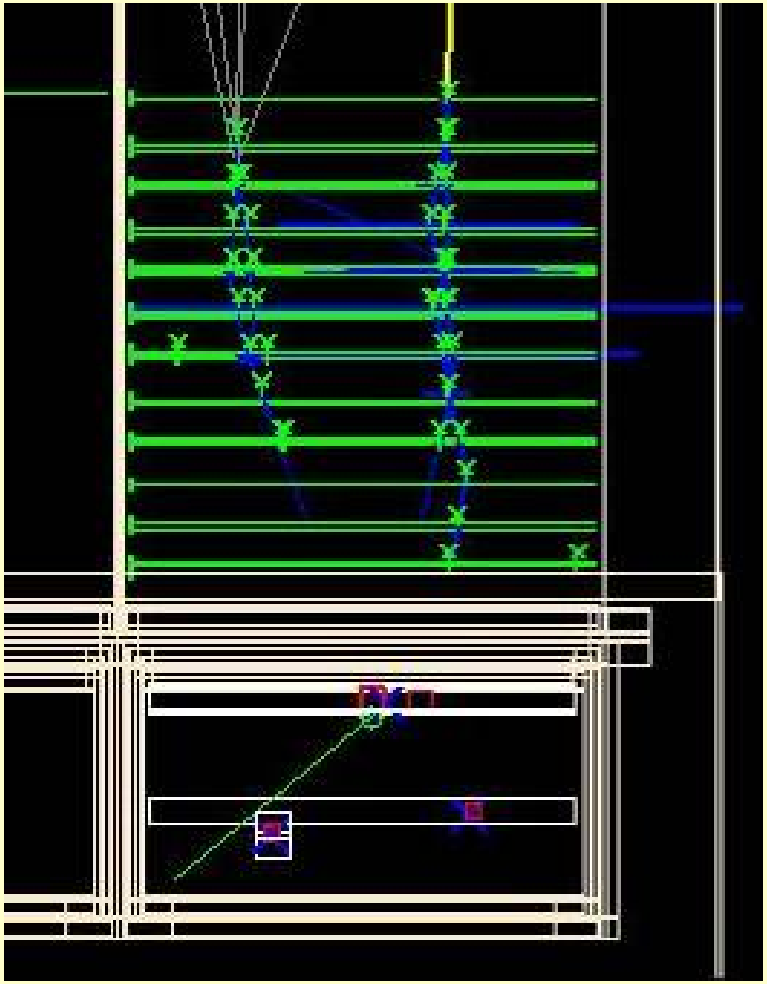
Brez, Baldini, Sgro, Bregeon

Photon beam dispersion

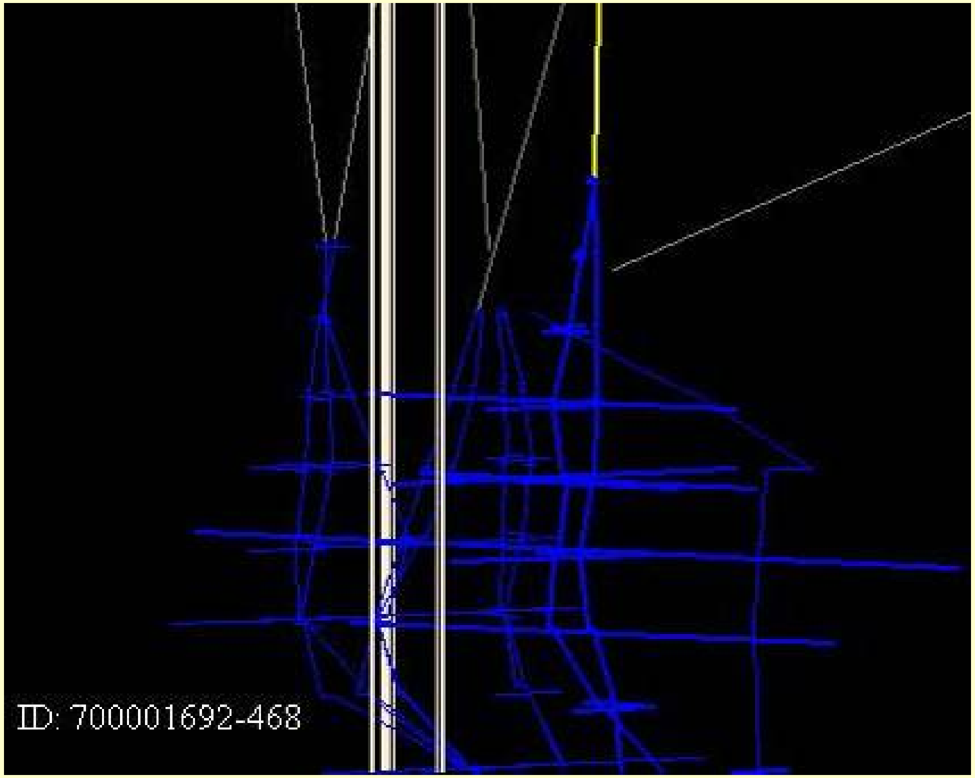


- Circular beam spot (1 cm radius) selected on the first layer of the tagger
- Red ellipse is the beam spot projected to the CU, taking into account the e beam divergence in the two directions (as measured by the tagger)
- Data points are γ vertex positions
- Experimentally seen as beam dump was cutting γ beam when working at 500MeV e
- Must take this into account for analysis

Double gammas in the CU



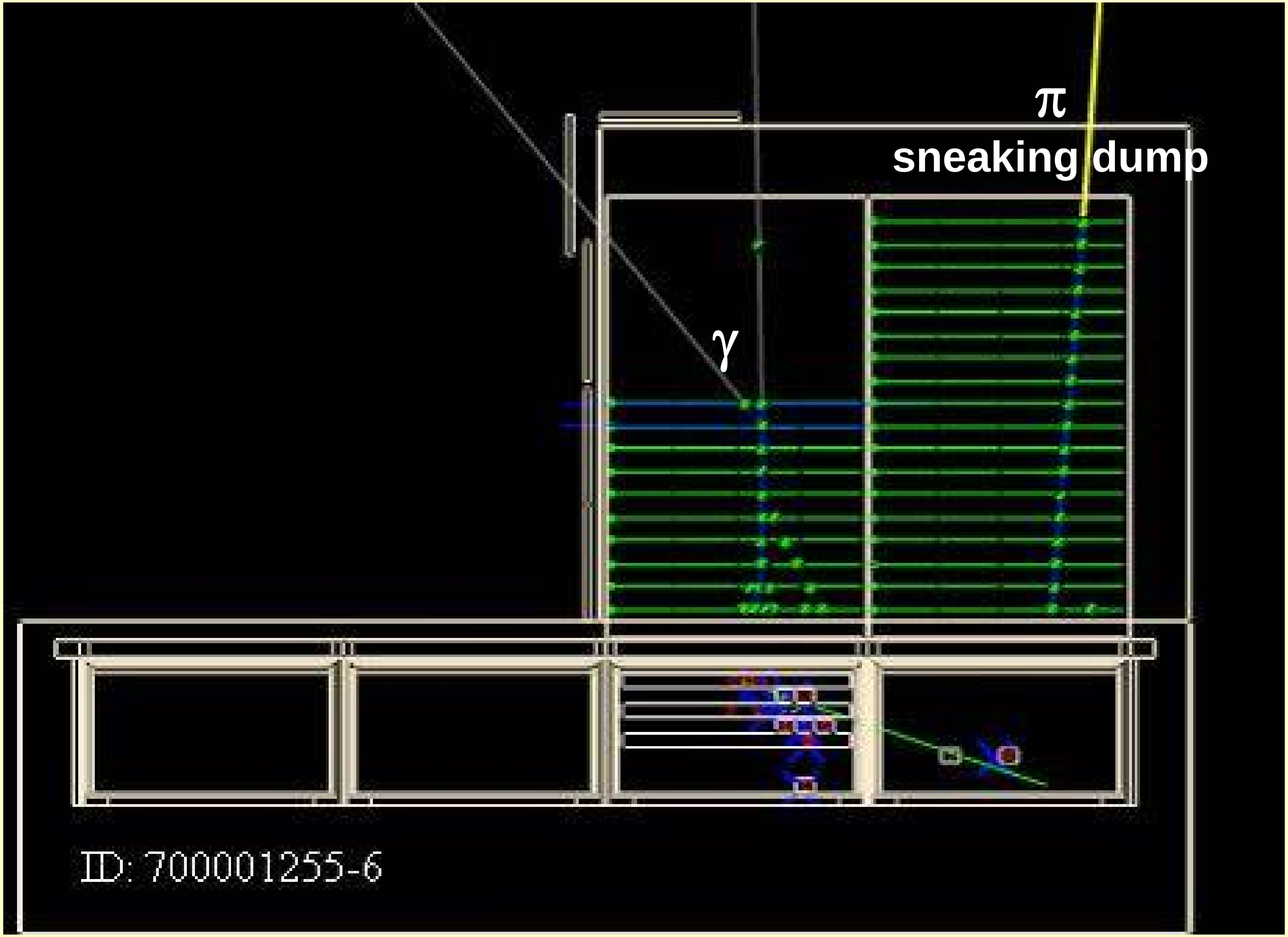
From VLE tagged-γ



Could see these in real-time using Socket-Gleam

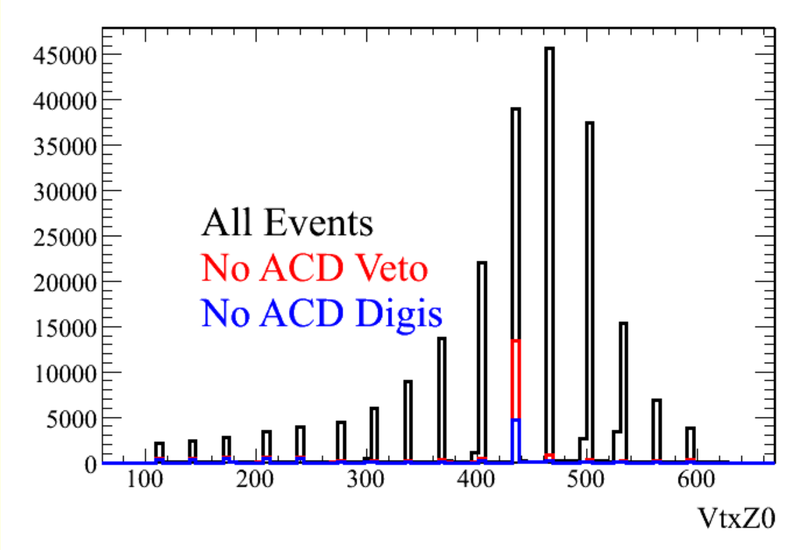
More photons

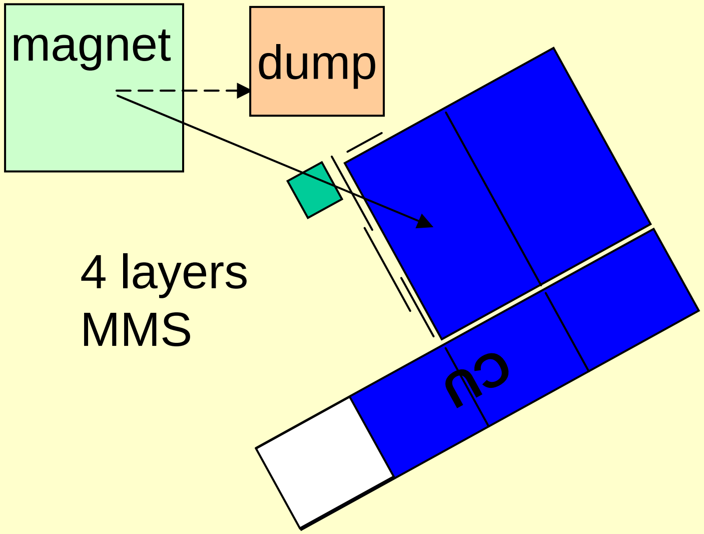
More photons



Positron runs – setup I

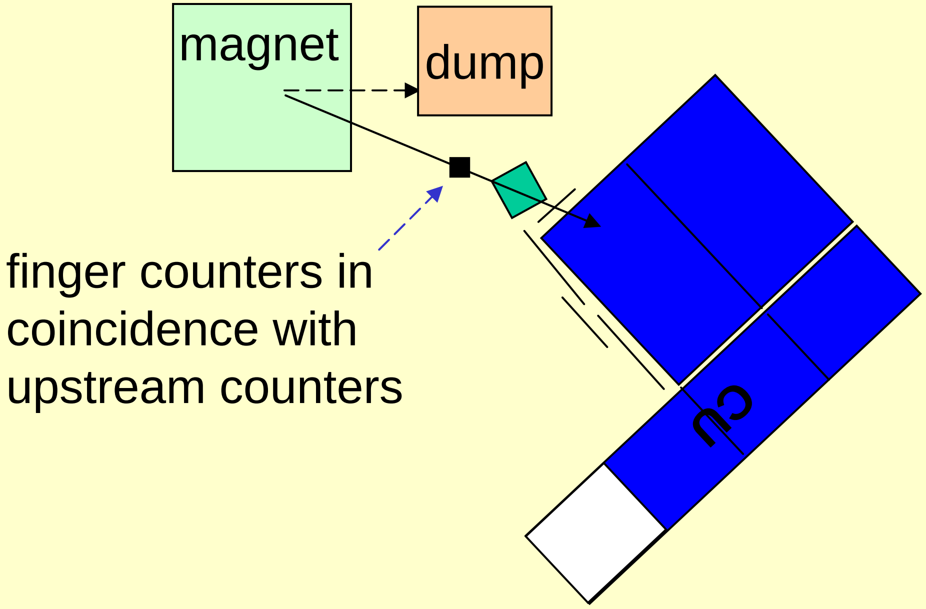
- first set of data with simplified setup
  - Magnet ON and extended dump to stop brem γ from e+
  - Just shoot 1M e^+ through MMS placed in front of ACD side top tile (to increase path length in tracker)
  - Also shoot 1M e for comparison
  - Rely on ACD side veto power
  - Require tracking to
    - Identify exact MMS target position
    - Identify ACD cracks (see plot)
    - Find double photon events from annihilation





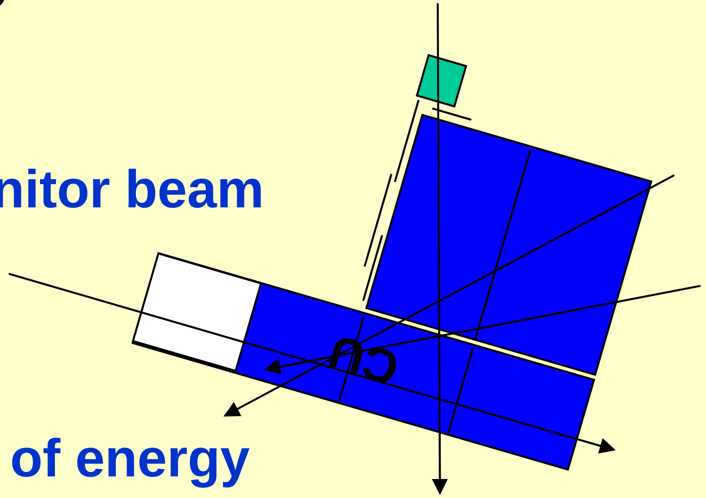
Positron runs – setup II

- **second set of data with modified setup**
  - **Magnet ON and extended dump to stop brem g from e+**
  - **Finger counters in front of CU to trigger on fiducial volume centerd on annihilator**
  - **Collect 1M e^+ and 1M e**
  - **Rely on ACD top tile veto power**
  - **Ongoing analysis and MC simulations (Mizuno, Funk)**

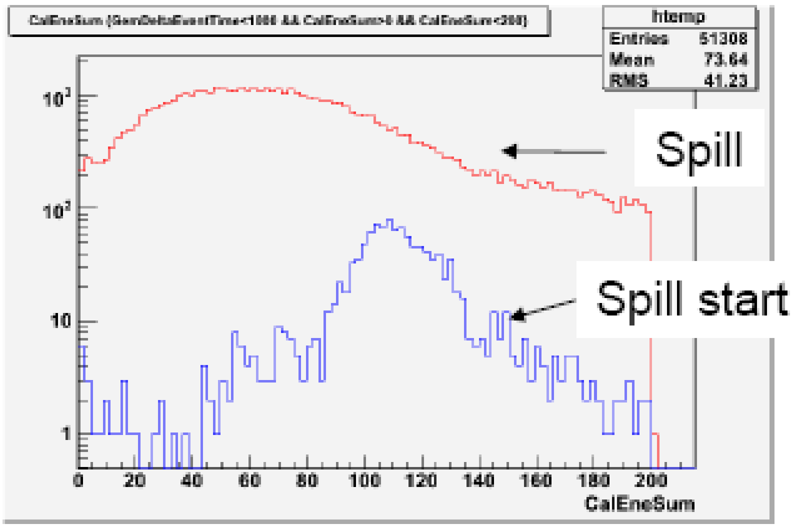


Proton runs

- **Collected 5M protons at 10, 6 GeV, several angle**
  - **Small angle and through MMS target**
  - **30°, 60° and 90° for background study and hadronic interactions modeling in the CAL**
  - **Have to live with few % K contamination, while π are rejected by veto on cerenkov**
- **Collected high rate data, external trigger**
  - **LATTE peak rate over 4KHz**
  - **Pipeline test too**
  - **Running ancillary in parallel to monitor beam stability**
- **Issues**
  - **Some runs taken with ACD OFF**
  - **CAL pedestal drift due to high rate of energy deposition in logs**

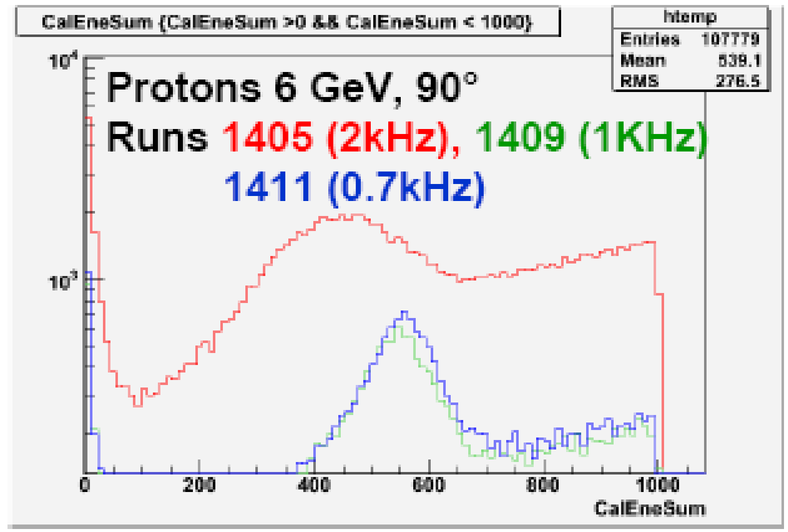


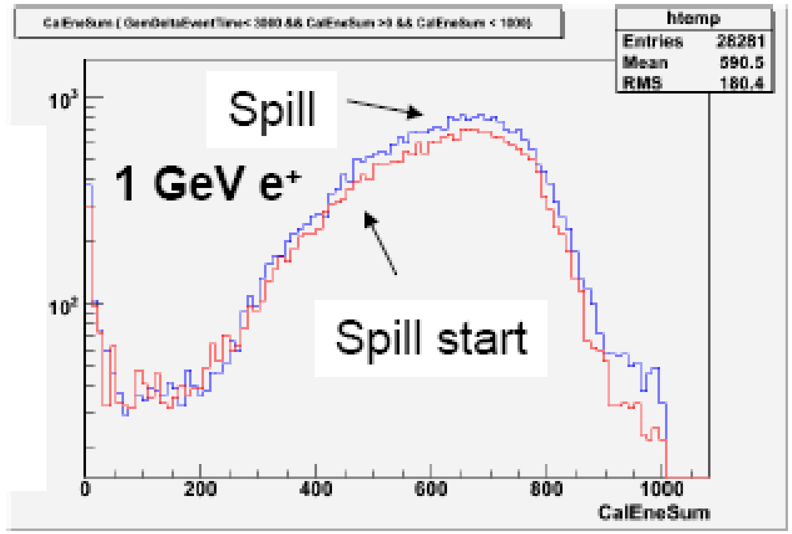
Proton Runs



Protons 10 GeV at 30°
Run 1370

- **Analysis must take this effect into account**
  - **reduce statistics cutting on start of spill**
  - **correct offline based on Δt and deposited E (Berrie)**





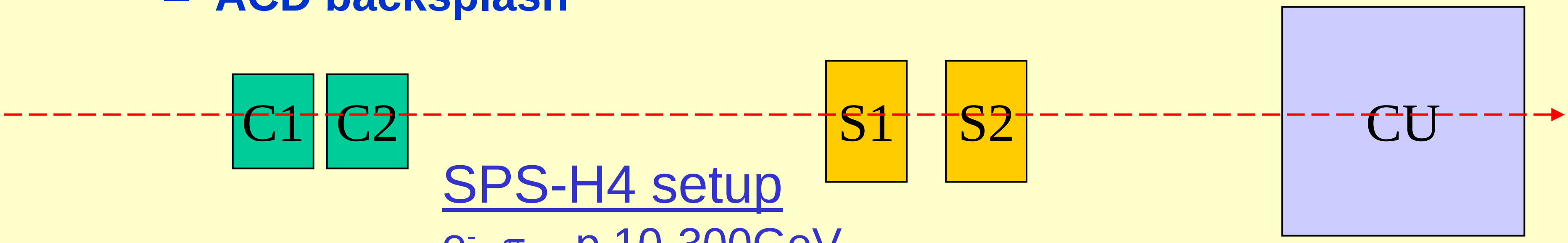
Benoit Lott 4

DAQ: Beam Test Data-taking Experiences

- Standard data-taking with external trigger
- Sporadic CU DAQ crash experienced
  - malformed TKR phasing error contribution (R Claus + E. Siskind)
  - LDF parser (v06-02-01) modified to not parse pathological contributions
  - No crashes after modification
- Sporadic loss of synchronization between CU and AD DAQ
  - Mainly due to operator mistakes or hardware instabilities (AD timestamp cable)
  - Catched in real-time by Online monitor and runs immediately stopped
- High rate (KHz) standalone CU with internal trigger + high occupancy
- More than the usual rate of TKR FIFO Full errors wrt LAT experience
  - Set point at which GTCC Data FIFO Almost Full condition comes on from 75% to 52% (E. Siskind): Rate is now acceptable
  - May need to revisit this, along with the GTRC buffer sizes, for SPS running where higher TKR occupancy is expected
- High rate of "Packet errors" (truncation errors)
  - mismatch between flight model EBM (GASU) and EM TEMs: Not an issue for flight
  - Such contributions are ignored by analyses since as are not decodable

H4-SPS Test status

- CU and electronics already in H4 since end of T9 run
- Installation starting next Monday 9/4 – everything ready
- 9 days for data taking until 9/15 (2 days MD)
- Clean high energy beams promised
  - Simple setup
  - No ancillary detectors other than trigger plastics and cerenkov for hadron beam (p/π discrimination)
- Same crew with Benoit Lott run coordinator
- Focus on
  - High energy EM shower
  - High occupancy in TKR
  - ACD backsplash



SPS-H4 setup

e^-, π , p 10-300GeV

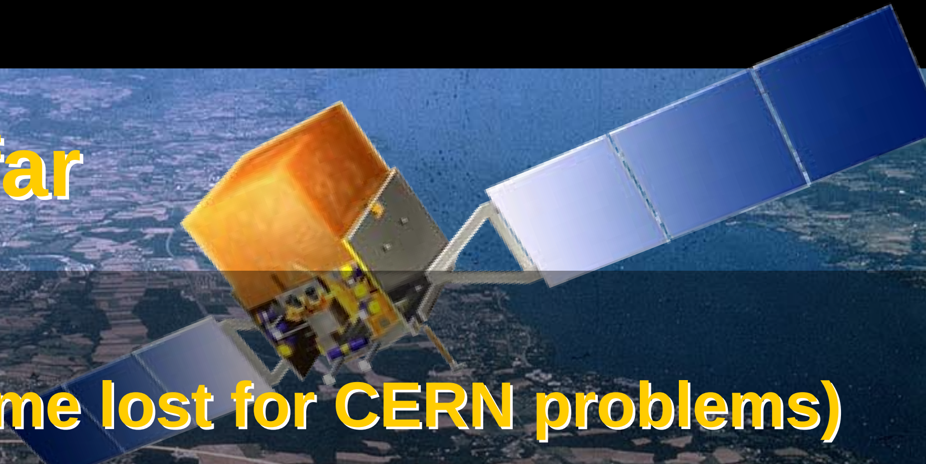
CU Beam Test at GSI - Motivations

- **Motivations**
  - **TKR response to relativistic heavy ions**
    - **TKR never tested with heavy ions**
    - **Spice simulations (R. Johnson) show that a heavy ion signal can saturate a strip amplifier, thus making the strip and few neighboring inactive for ms, and the layer trigger OR inactive for more than 100μs**
  - **CAL response to relativistic heavy ions**
    - **verification of the publihsed CAL GSI beam test results with a flight unit**
  - **Verify CNO operation for CAL on-orbit calibration**
    - **ACD CNO triggering**
    - **TKR to track ion path to CAL**
    - **CAL calibration**

CU Beam Test at GSI - Status

- Requirements – minimal from now
  - No integration work on the CU
  - No need for ancillary detectors
    - primary pure ion beam (C), well defined in energy and spot
  - No further DAQ development
  - No further offline infrastructure required
  - External trigger plastic scintillators
  - Estimated resources - 12FTE for 7 days
    - core team of experts for installation, 2 days of run, dismantling
- Status – ready to commit
  - CU test already in the GSI schedule for mid November
    - good relationship with lab from previous run, crucial to guarantee success in a 2 days run
    - INFN plan to visit GSI in october to verify installation of CU, scanning table and trigger detectors in the cave
  - CU will travel back to INFN-Pisa after SPS
    - same people responsible for storage and test

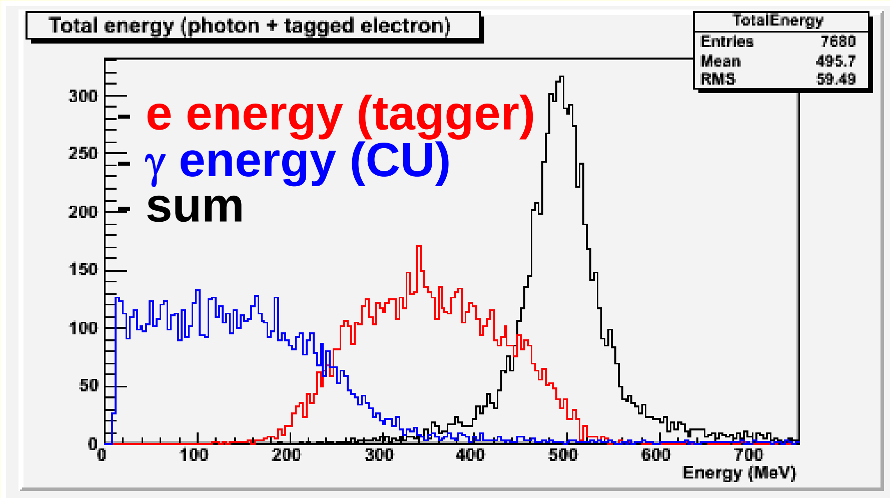
Conclusions .... so far



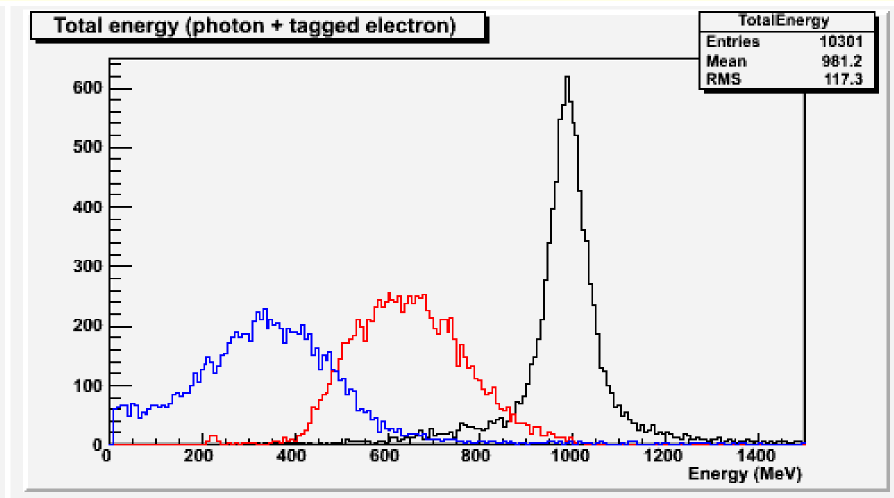
- First beam test completed
- Program completed (despite time lost for CERN problems)
- High quality and high statistics data
  - γ in 100MeV-2.5GeV range (tagged+untagged)
  - e at 1,2.5, 5GeV
  - e+ at 1GeV
  - p at 6,10GeV
  - many CU configurations
- High energy e and p next week – setup and people ready
- Preliminary analysis show very good agreement between data and MC and measured performances in agreement with the specs
- Plan to be busy with analysis for 6-12 months

BACKUP

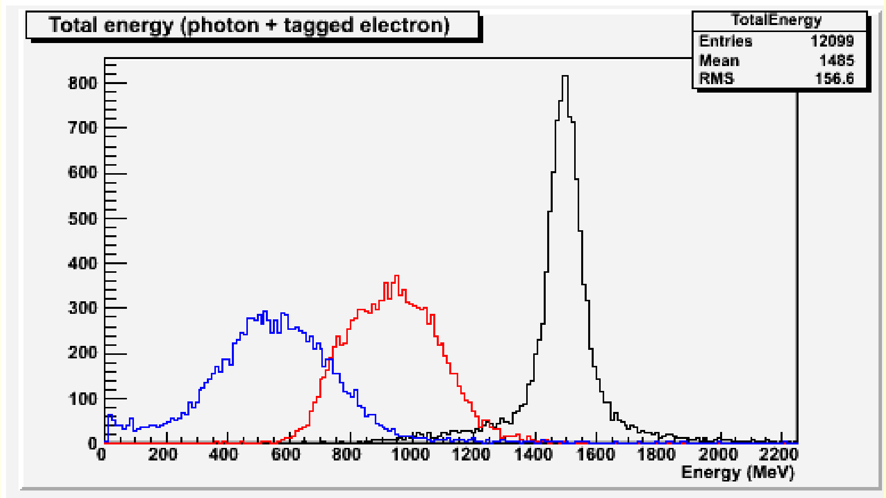
Tagger: standard configuration



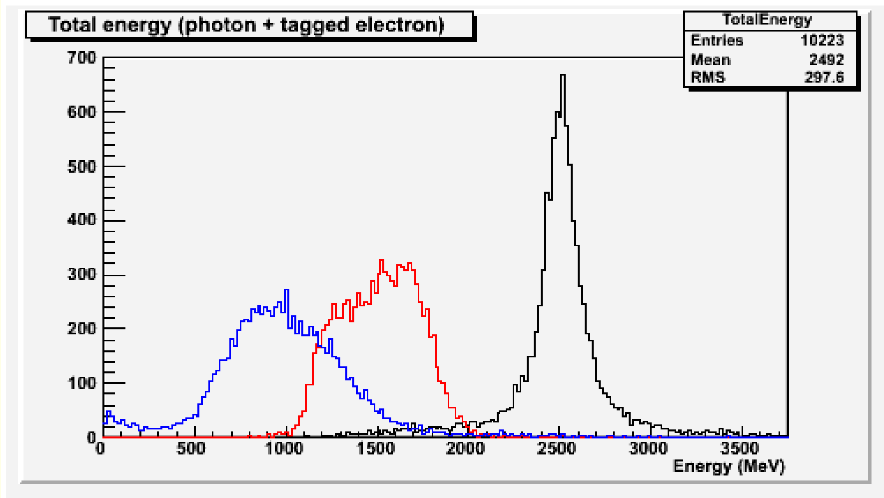
0.5GeV primary e beam



1GeV



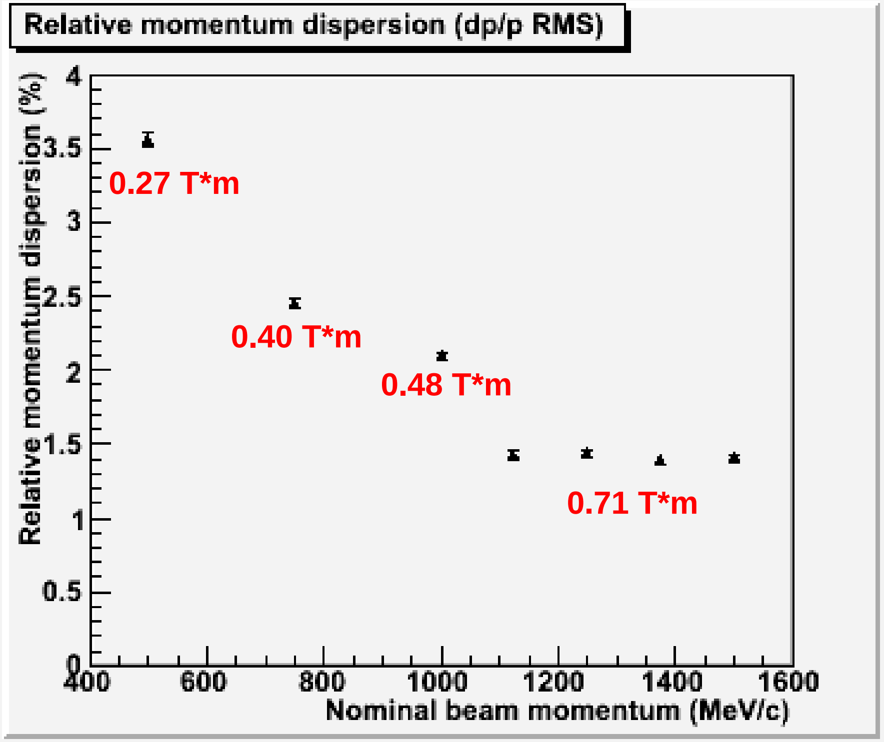
1.5GeV

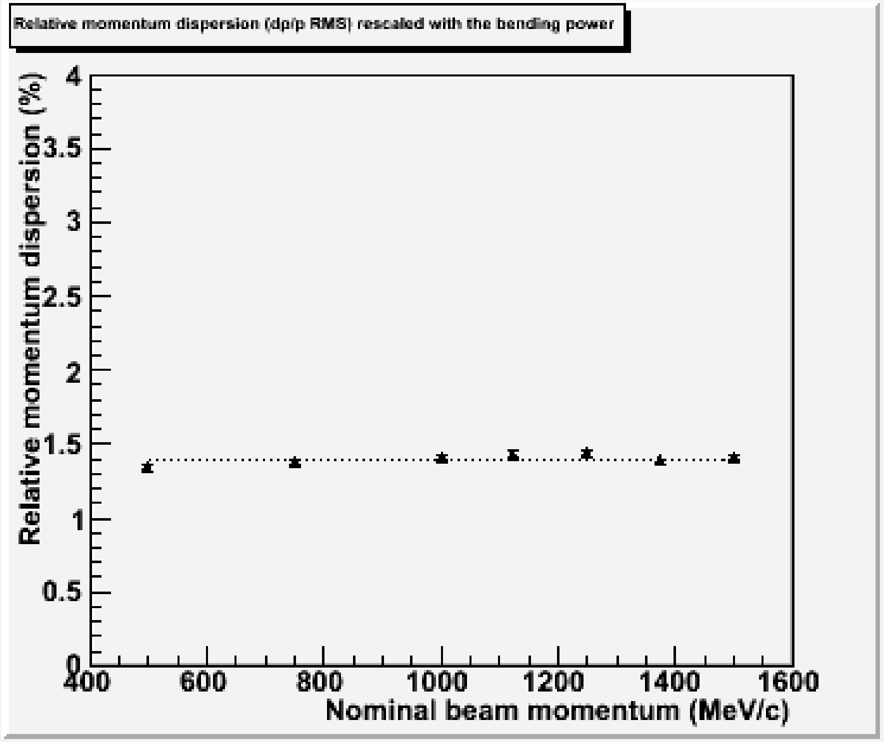


2.5GeV

Brez, Baldini, Sgro, Bregeon

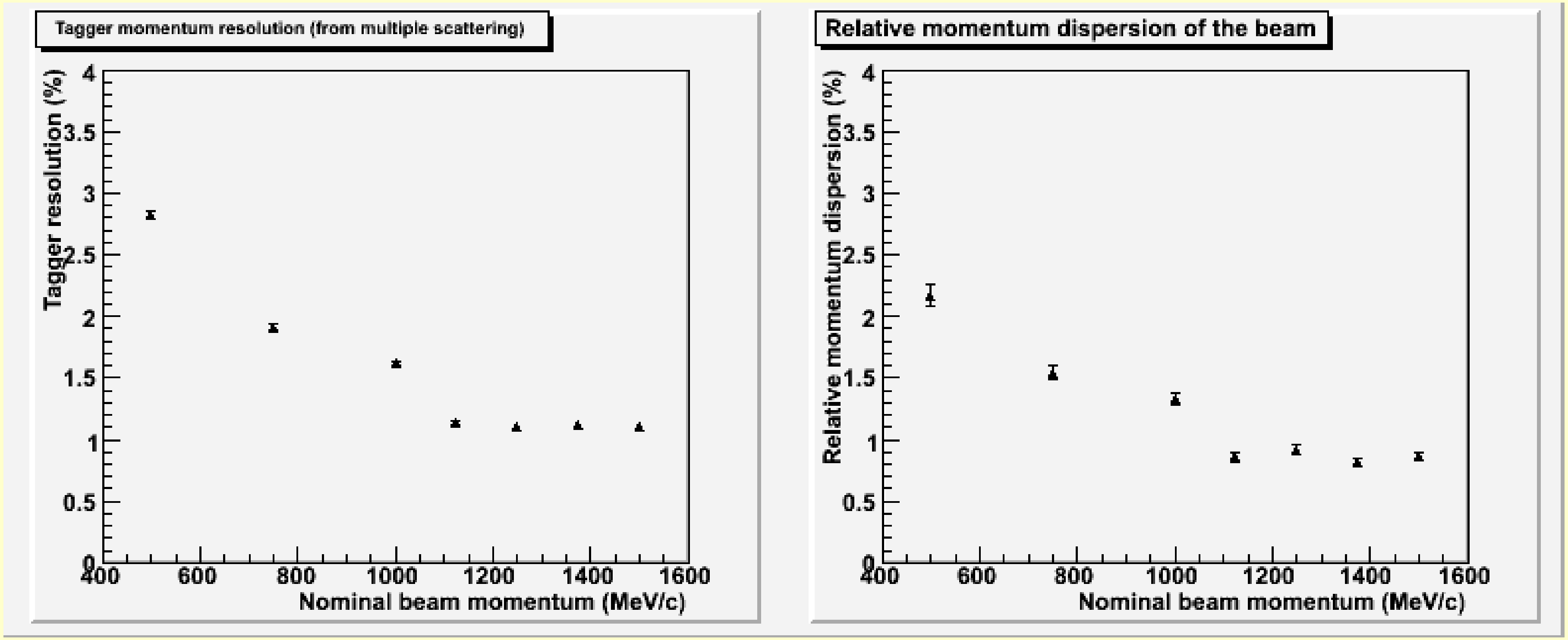
Tagger (+ beam) resolution





- **Electron energy resolution fixed for fixed bending power (bending angle and multiple scattering have the same dependence on energy) ~1.4 % @ 0.7 T*m including the beam dispersion.**
- **For fixed geometry, the energy resolution scales as expected with the bending power.**

Tagger calibration



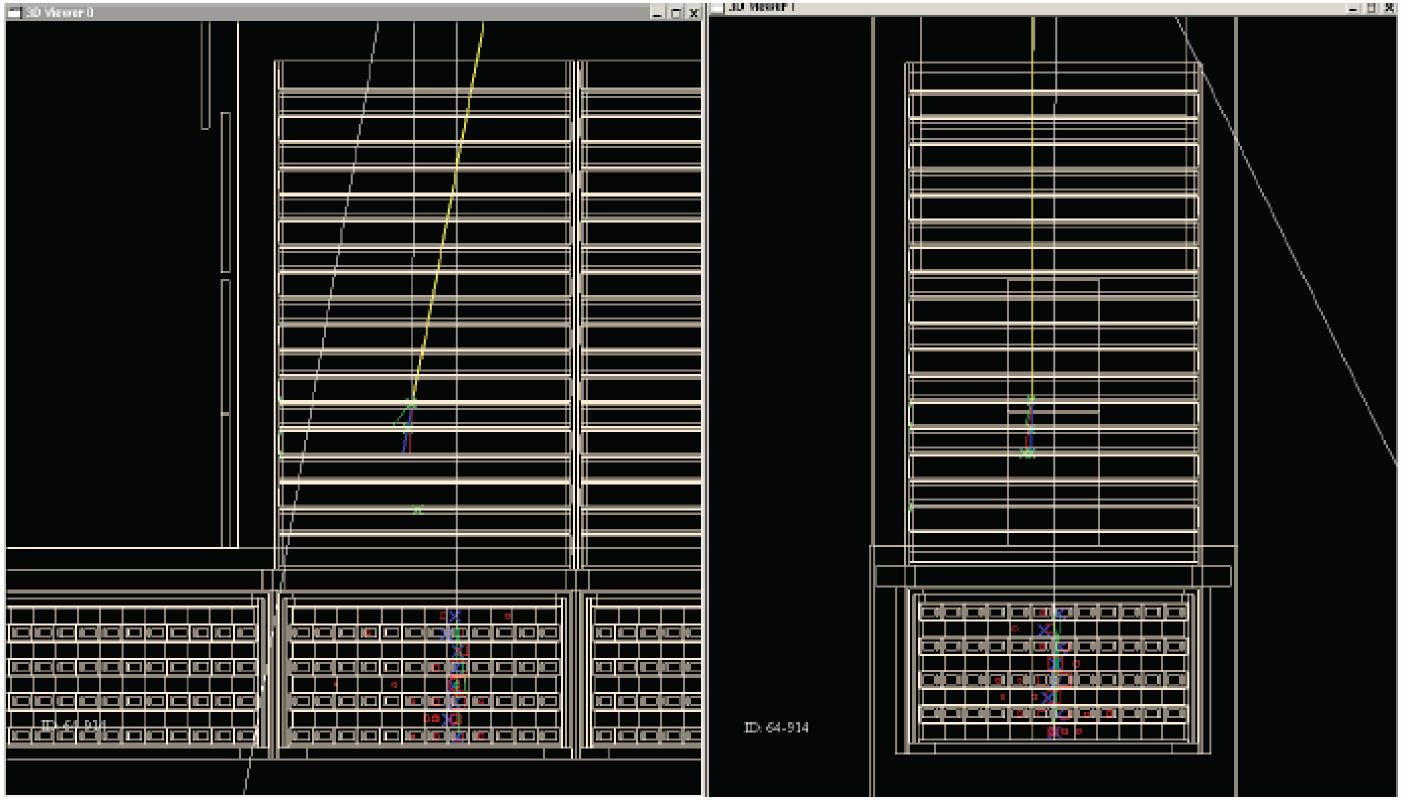
• The multiple scattering measurement (from tracks angle in non-bending plane) allow to decouple the tagger resolution from the beam dispersion.

Photon data configurations

- CU positions
  - Twr2: 0, 30, 50 deg
  - Twr3: 0, 10, 20, 30 , 50 deg
    - Full-brem: 800k γ 0-2.5GeV
    - Tagged: 100K γ 0-1.5GeV
  - Albedo 145 degrees deep in CAL
    - ACD tile moved on twr 3 side to simulate LAT response to such photons
    - Full-brem: 800k γ 0-2.5GeV
    - Tagged: 100k γ 500-800MeV, 25k 100-300MeV
  - Albedo 215 degrees above CAL
    - Full-brem: 800k γ 0-2.5GeV

Double gammas in the CU

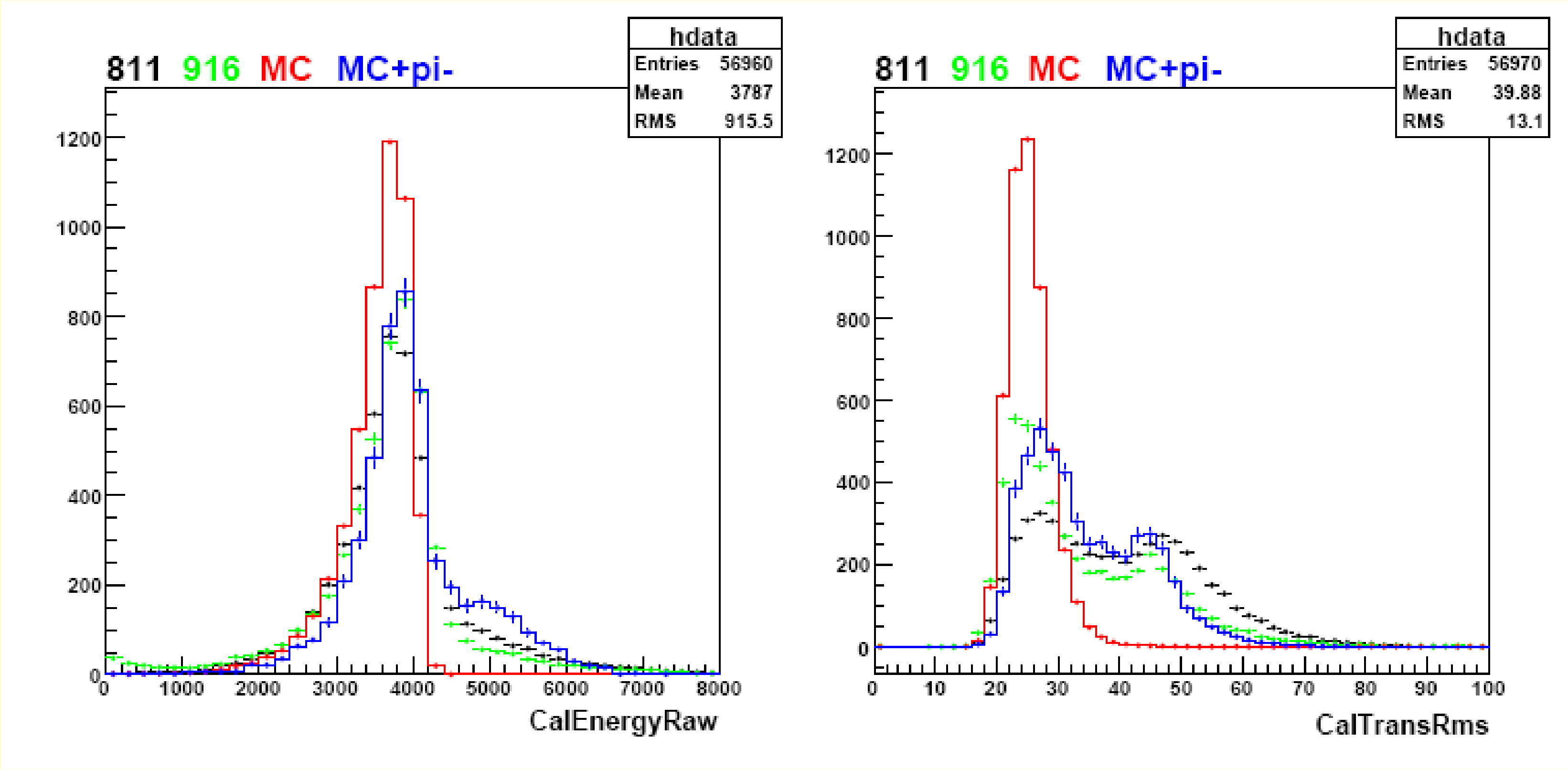
Two photon events in which the low energy photon (28 MeV in this case) scatters an electron (Compton) or produces a pair electron-positron, while the high energy electron (1.6 GeV in this case) gets converted in the Cal



MC data

Electron runs

- First 5GeV scan affected by π pileup
- Second 5GeV scan has more positions, minimized pileup, correct CU timing, new CAL calibration constant and better beam definition – analysis in progress (Bruel)



Special Runs

- **CAL FHE scan**
  - **5GeV e at 0 and 60 degrees with FHE thresholds from 500MeV to 2000MeV**
- **Random trigger for direct pileup measurement in full-brem mode**
  - **CU configurations as in full-brem runs**

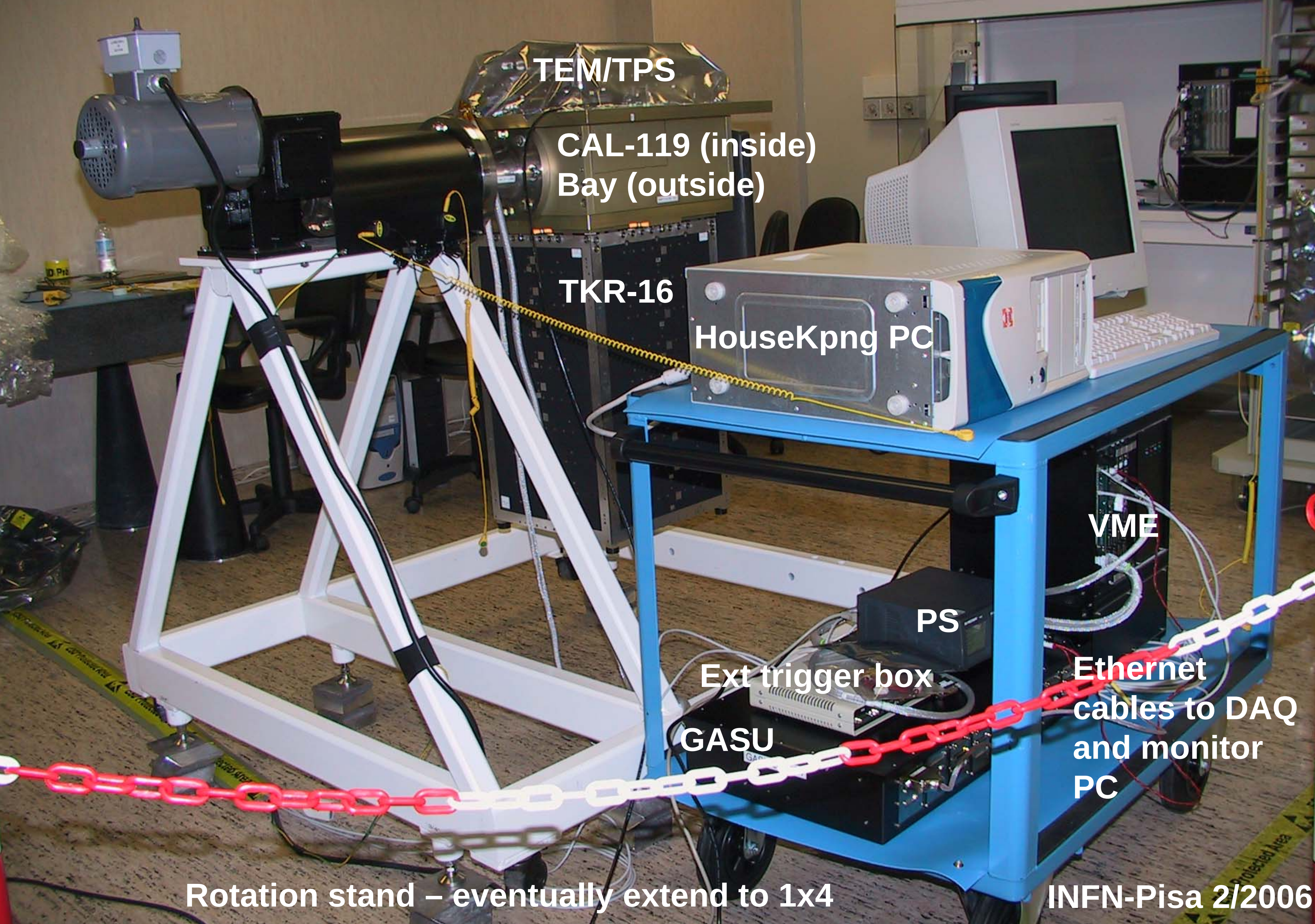
DAQ: Beam Test Data-taking Experiences

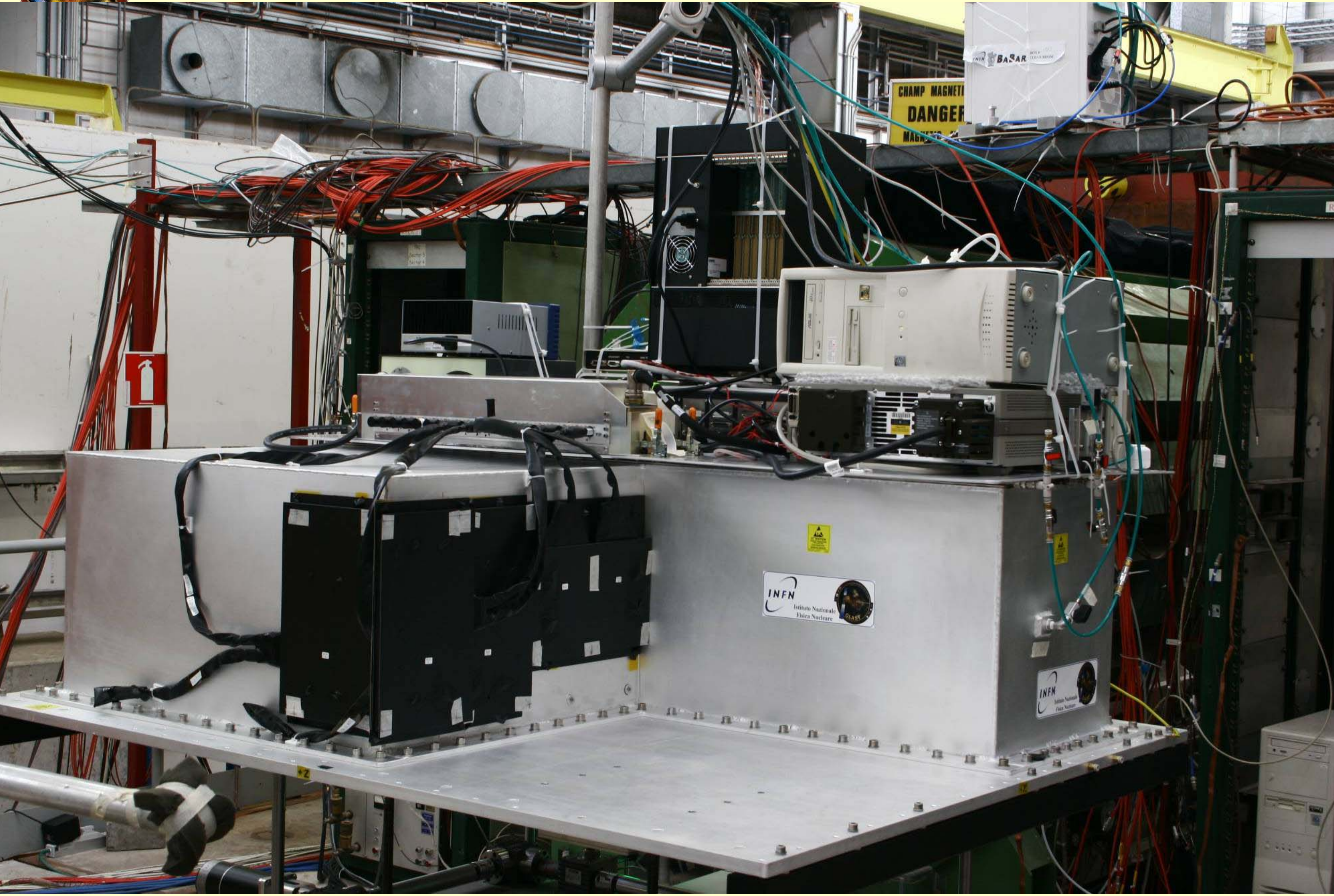
- High rate standalone CU with internal trigger (KHz trigger rates, high occupancy)
- One run with all events having cable phasing errors (700000611)
  - Unexplained issue seen only once (despite initial reports)
  - Appears to be a start-up problem: possibly power on sequence wasn't properly followed or it was the consequence of the previous run's crash (see below)
- More than the usual rate of TKR FIFO Full errors wrt LAT experience
  - Set point at which GTCC Data FIFO Almost Full condition comes on from 75% to 52% (E. Siskind): Rate is now acceptable
  - ➢ May need to revisit this, along with the GTRC buffer sizes, for SPS running where higher TKR occupancy is expected
- High rate of "Packet errors" (truncation errors)
  - Due to flow control model mismatch between flight model EBM (GASU) and EM TEMs: Not an issue for flight
  - ➢ Contributions with these errors are ignored by analyses since they are not decodable

DAQ: Beam Test Data-taking Experiences (cont.)

- **Data-taking sometimes crashed**
  - **Problem turned out to be corrupted data coming from the CU**
    - **Affected all users of LDF: Online scripts, Online monitor, Offline (pipeline)**
  - **Analysis revealed malformed TKR phasing error contribution (E. Siskind)**
  - **Further investigation of TEM VHDL firmware code found three problems:**
    1) **"TEM bug" (NCR 458 found with the LAT and exists in both flight and EM TEMs): results in reporting of many errors**
       - **TKR data from that tower is not trustable**
    2) **For a subset of "TEM bug" instances, the TKR phasing error contribution becomes malformed (exists in both flight and EM TEMs)**
       - **Have to "grin and bear it"**
       - **LDF parser (v06-02-01) modified to not parse these**
    3) **EM TEMs (only) can fail to inform the EBM they're truncating their contribution => packet error "truncated" bit not set**
       - **This type of error has not obviously been seen**
       - **Would lead to segmentation faults**
       - **Difficult to trap (no indication that a portion of the event is missing)**
  - ➢ **No crashes have been seen Online since LDF v06-02-01 was installed**
    - **A large amount of data has passed through updated software**

The 1x1 tower – our lab for CU I&T

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