

Introduzione

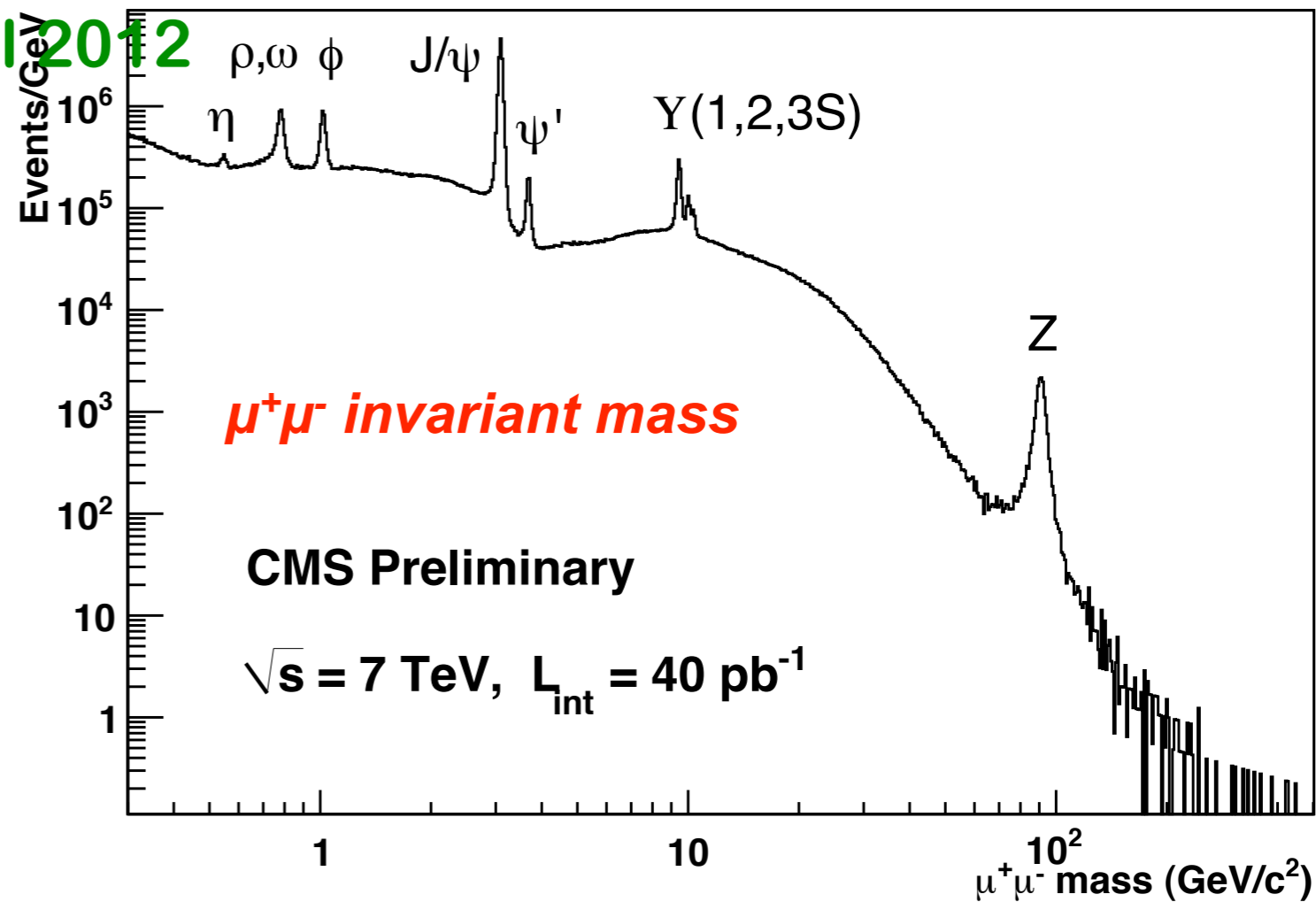
Stato dell'esperimento

- Stato del tracciatore
- Stato del Tier2
- Attività di R&D
- Fisica e prospettive per il 2012

Nuove attività

- Nuovi rivelatori a pixel

Richieste 2012

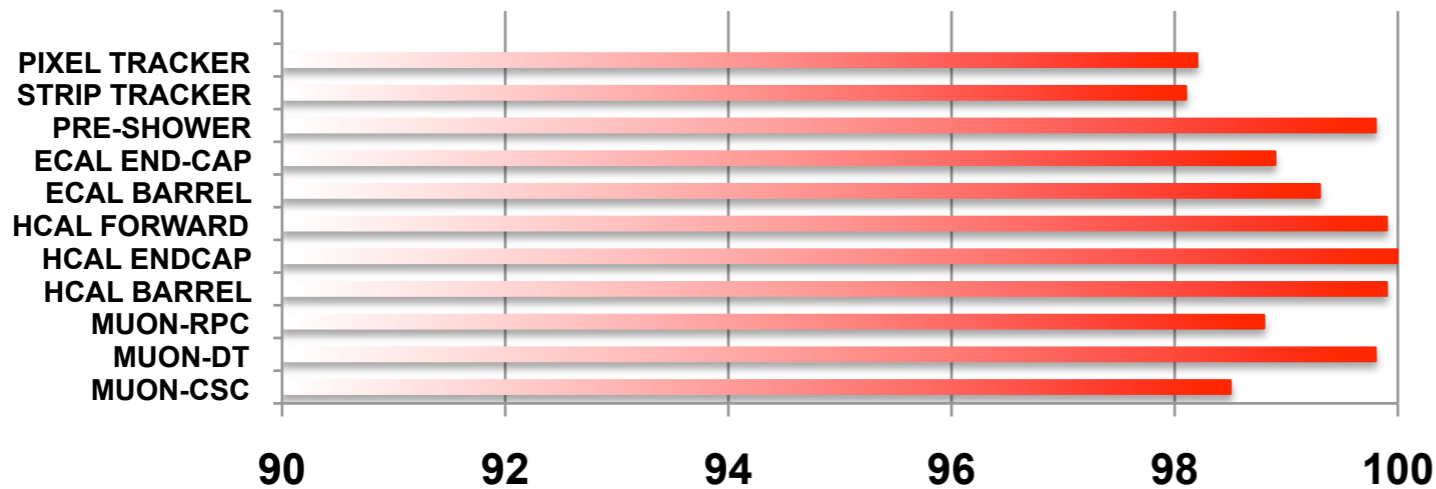




Operazioni nel 2010

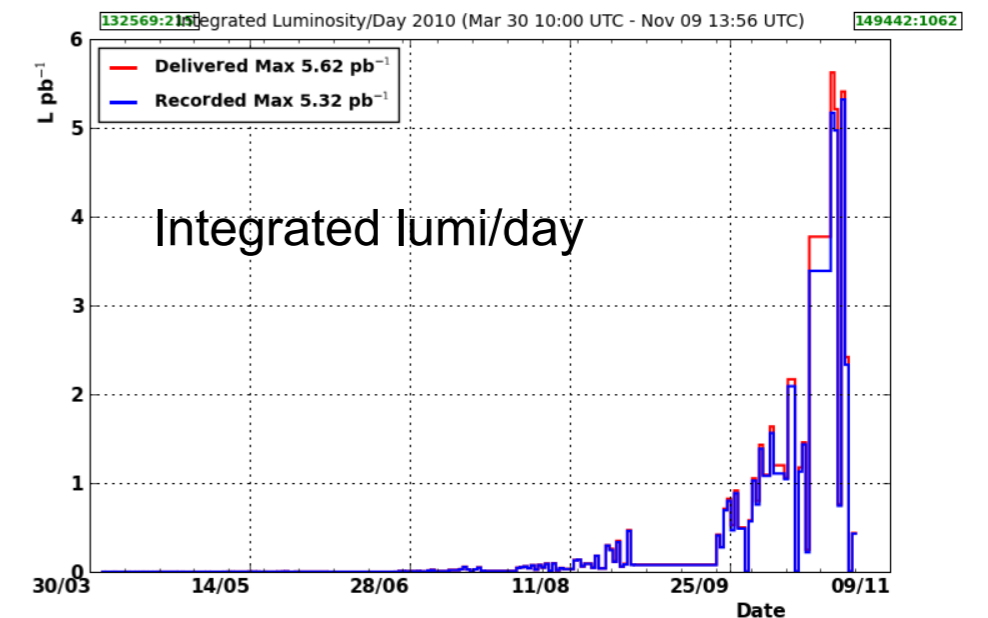
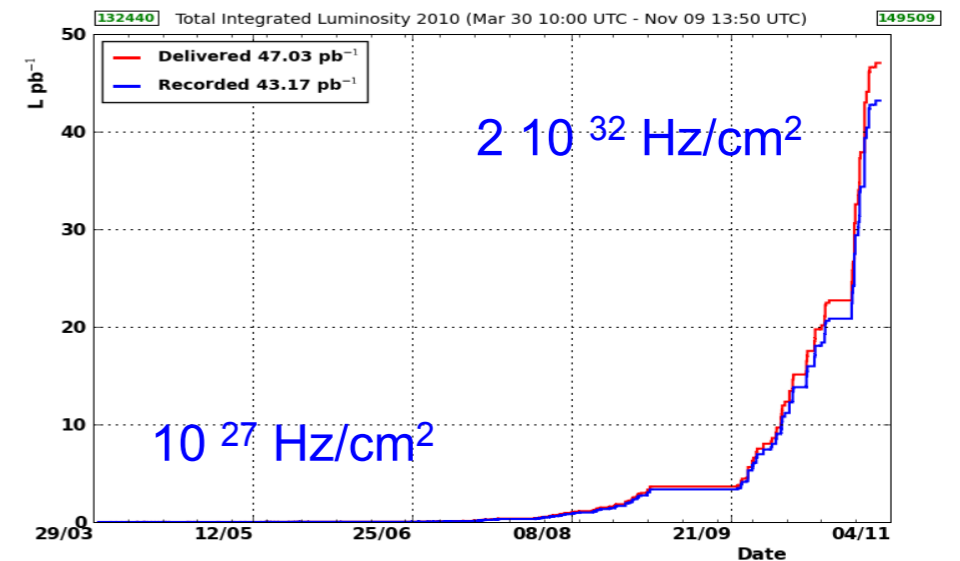


- pp- collisions: 7 TeV from March 2010
 - LHC Delivered 47 pb⁻¹, CMS recorded 43 pb⁻¹.
 - Great flexibility of trigger system.
 - Overall data taking efficiency 92%, ~85% with all subdetectors in perfect conditions



	MUON-CSC	MUON-DT	MUON-RPC	HCAL BARREL	HCAL ENDCAP	HCAL FORWARD	ECAL BARREL	ECAL END-CAP	PRE-SHOWER	STRIP TRACKER	PIXEL TRACKER
Series1	98.5	99.8	98.8	99.9	100	99.9	99.3	98.9	99.8	98.1	98.2

- Heavy Ions: 8th November
 - Delivered ~ 8.4 μb⁻¹, efficiency ~ 93%

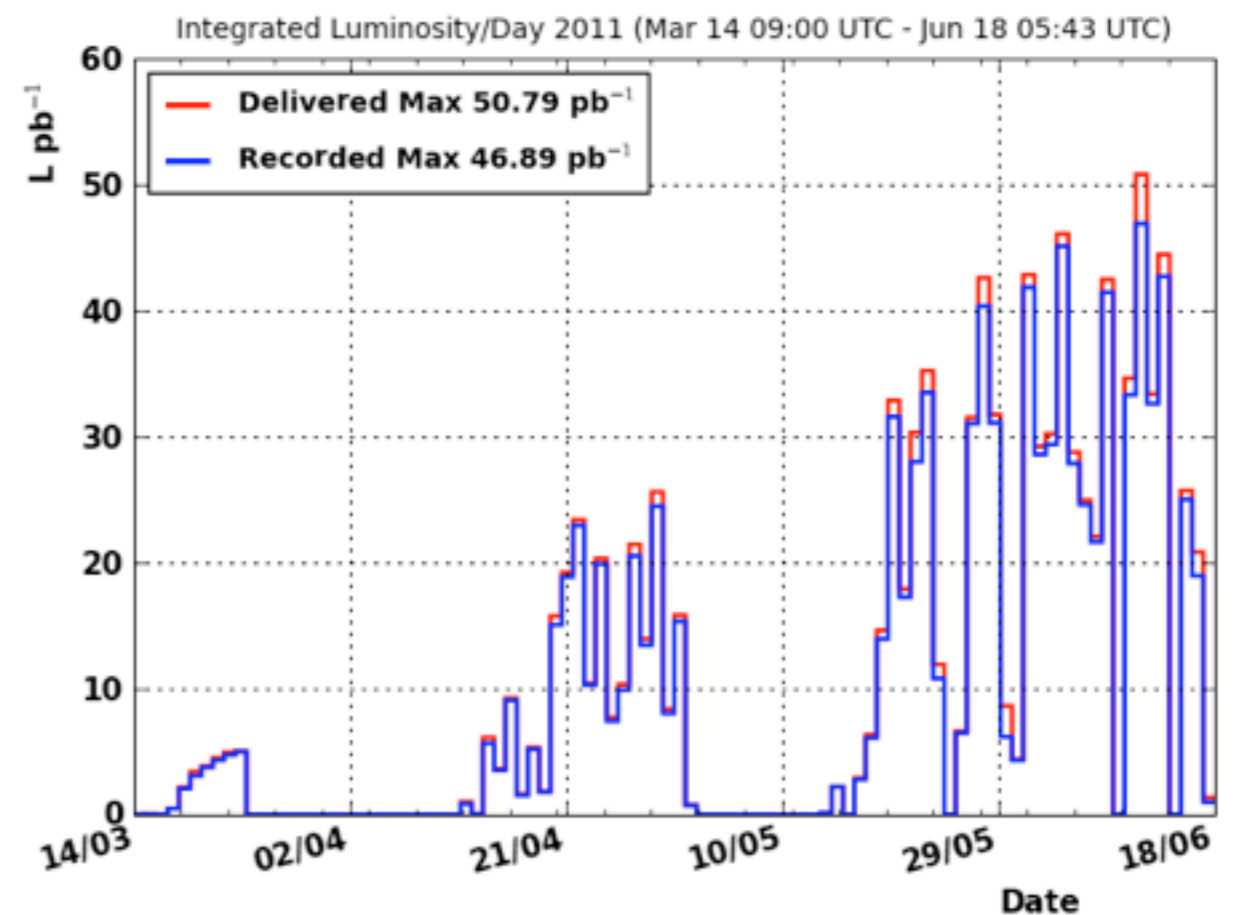
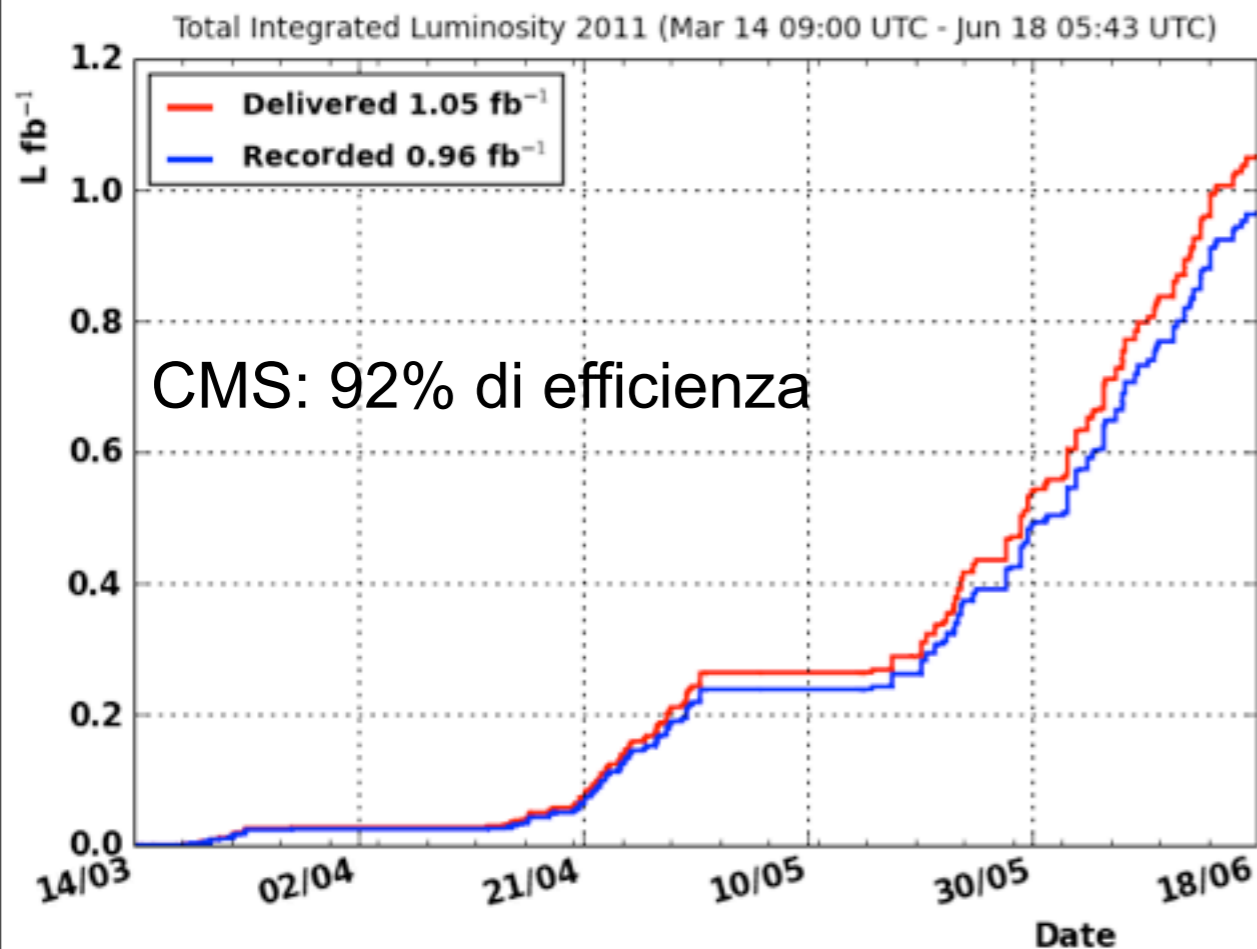




LHC nel 2011

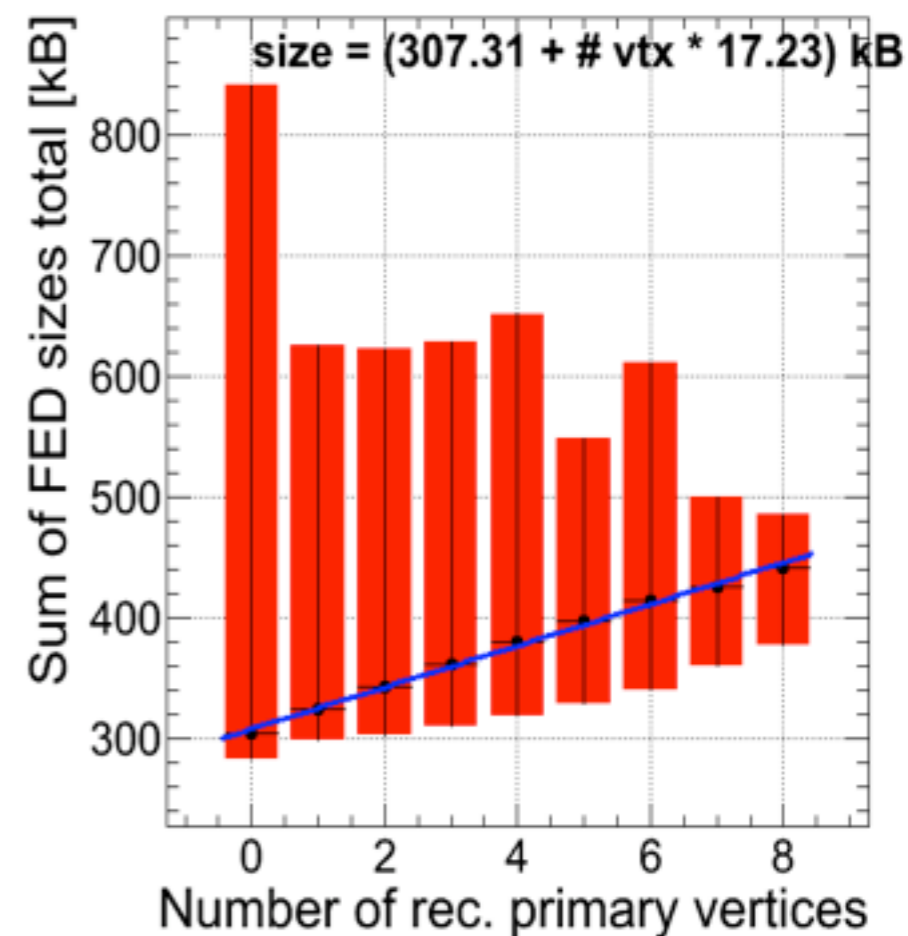
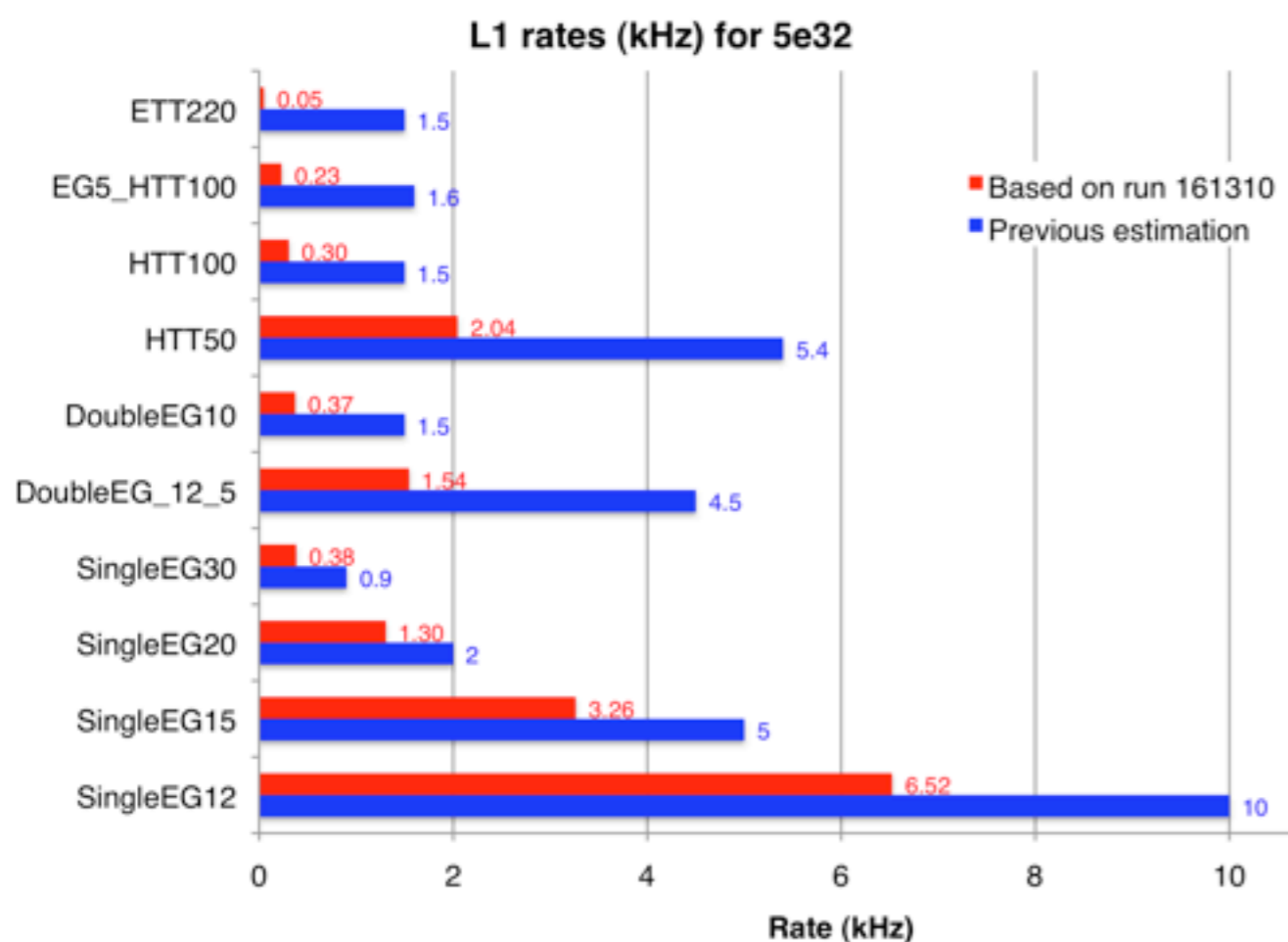


- **LHC estremamente performante**
 - ♦ **1092 bunches in LHC (1042 colliding in CMS); record di luminosità di picco per un collisore adronico: $1.27 \times 10^{33} \text{cm}^{-2}\text{s}^{-1}$.**



- ♦ La luminosità aspettata per il 2011 qualche fb^{-1} , per 2012 si spera di arrivare tra i 10 ed i 20 fb^{-1} .

- L'event-size scala come aspettato con il pileup (media ~10)
- Il menù di trigger riesce a controllare bene il pileup
 - ◆ Rate di L1 ~60 kHz, uso CPU <50%.





The challenge for Computing



Run in 2011: dataset+30%

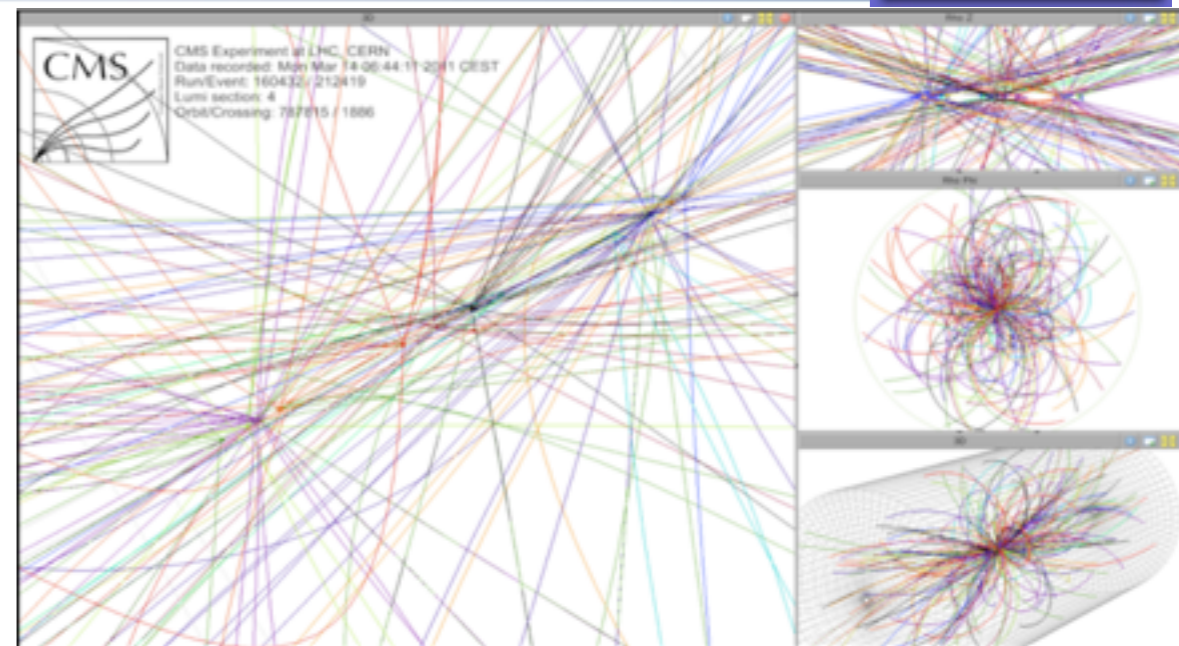
- In 2010 we collected ~1.5B events. Expect more than 2B in 2011.

Events in 2011 are much more complicated

- At 10 interactions per crossing we have factors of 2-3 increase in RECO time. Factor of 2 in RECO size and AOD size

Resources

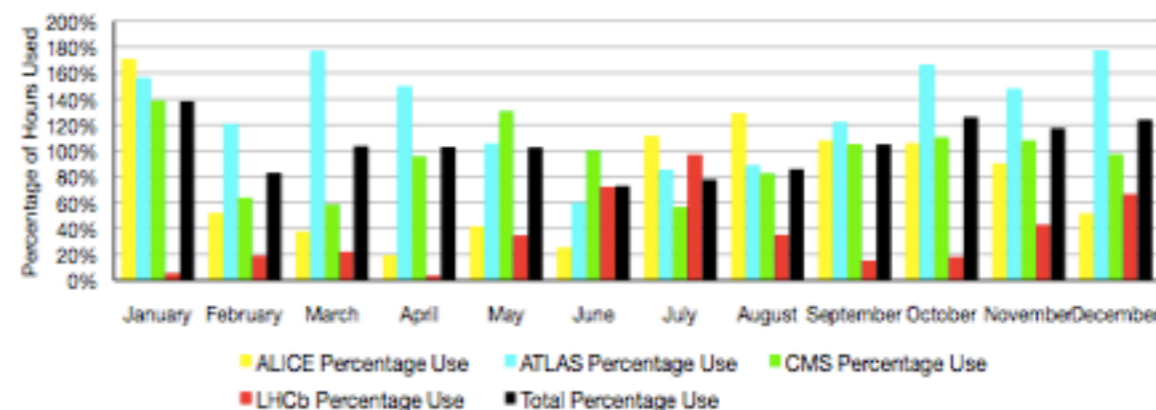
- Resource utilization for analysis was high in 2010 and increasing
- Significant increases in Tier-1 and Tier-2 resources are available for 2011, but even with these we will have to prioritize activities



50% increase on Tier-2 resources for 2011
Larger increase in size and processing time from pile-up

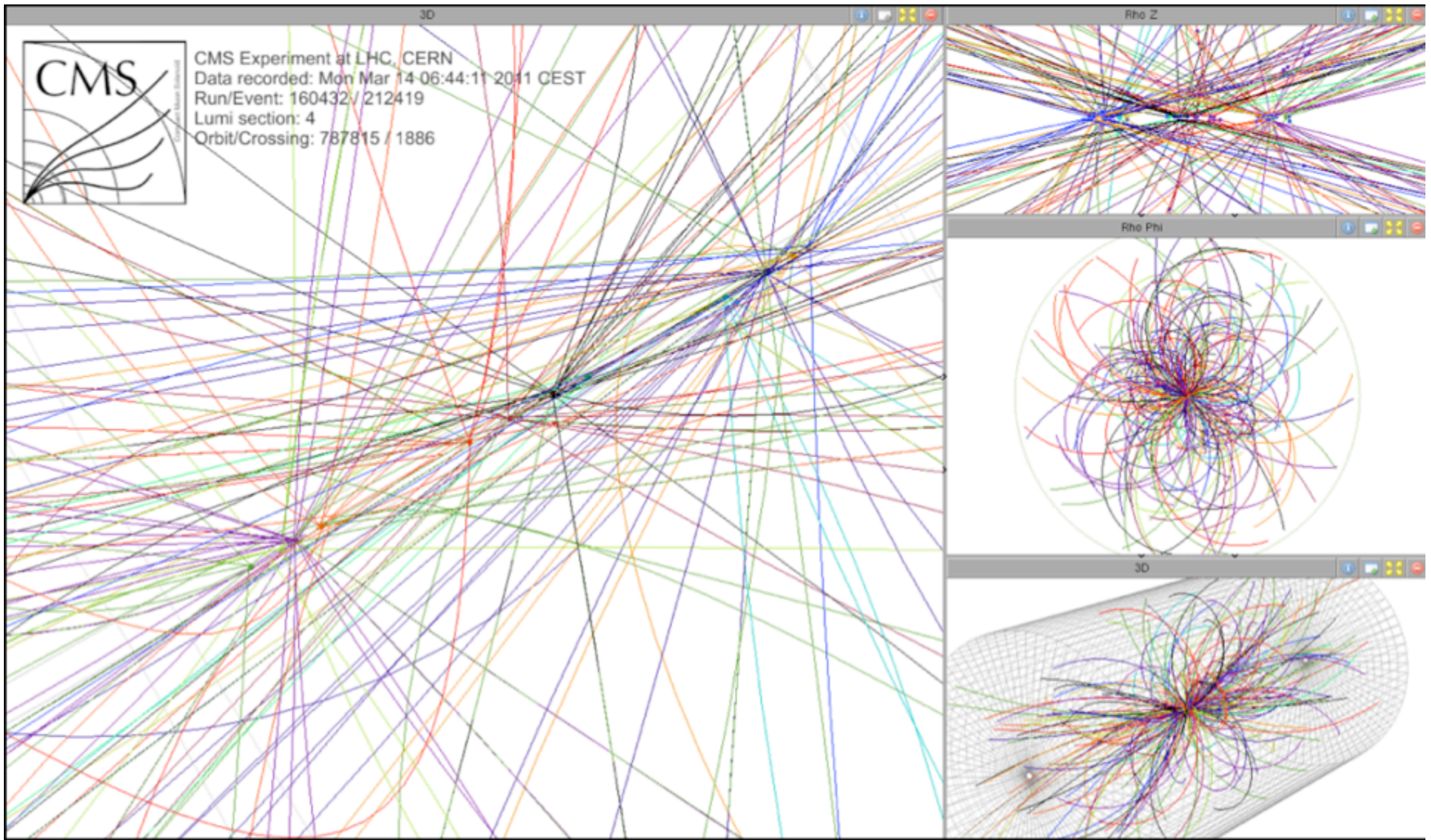
2010 T2 Usage by VO

Total Percentage of Tier-2 Usage





Tracker performance



Too Low signal amplitude (TBM):
1/192 (0.5%)

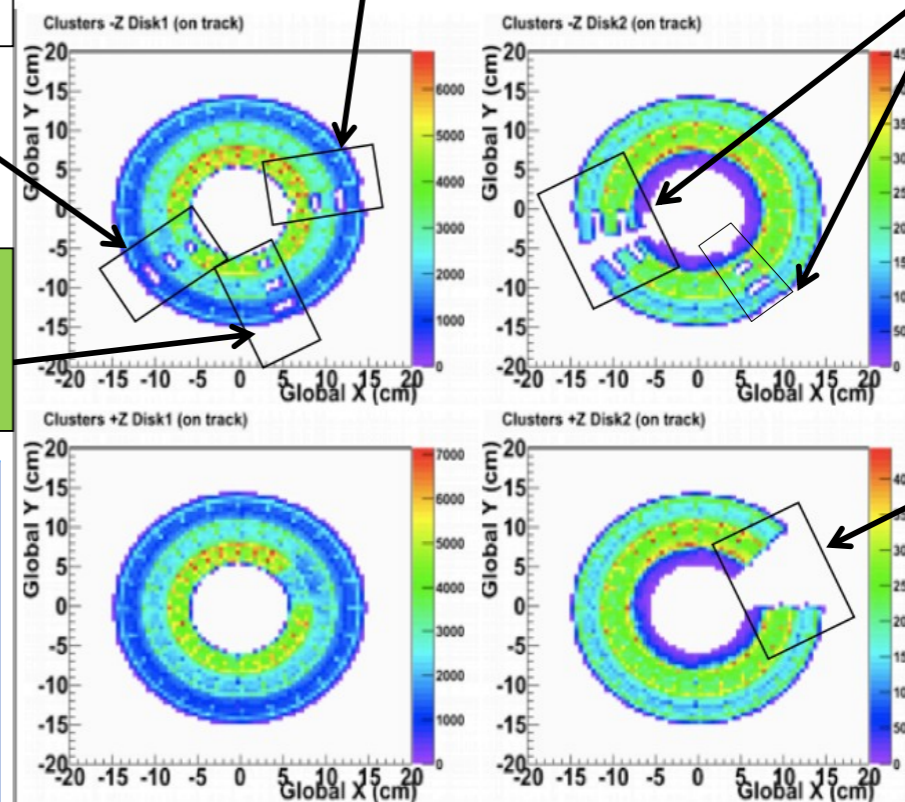
No signal output:
1/192 (0.5%)

Slow panels:
5/192 (2.6%)

One ROC no-signal:
1/192 (0.5%)
Recoverable.

Leakage current primo strip layer:
 $\sim 80 \mu\text{A}/\text{fb}^{-1}/\text{group}$

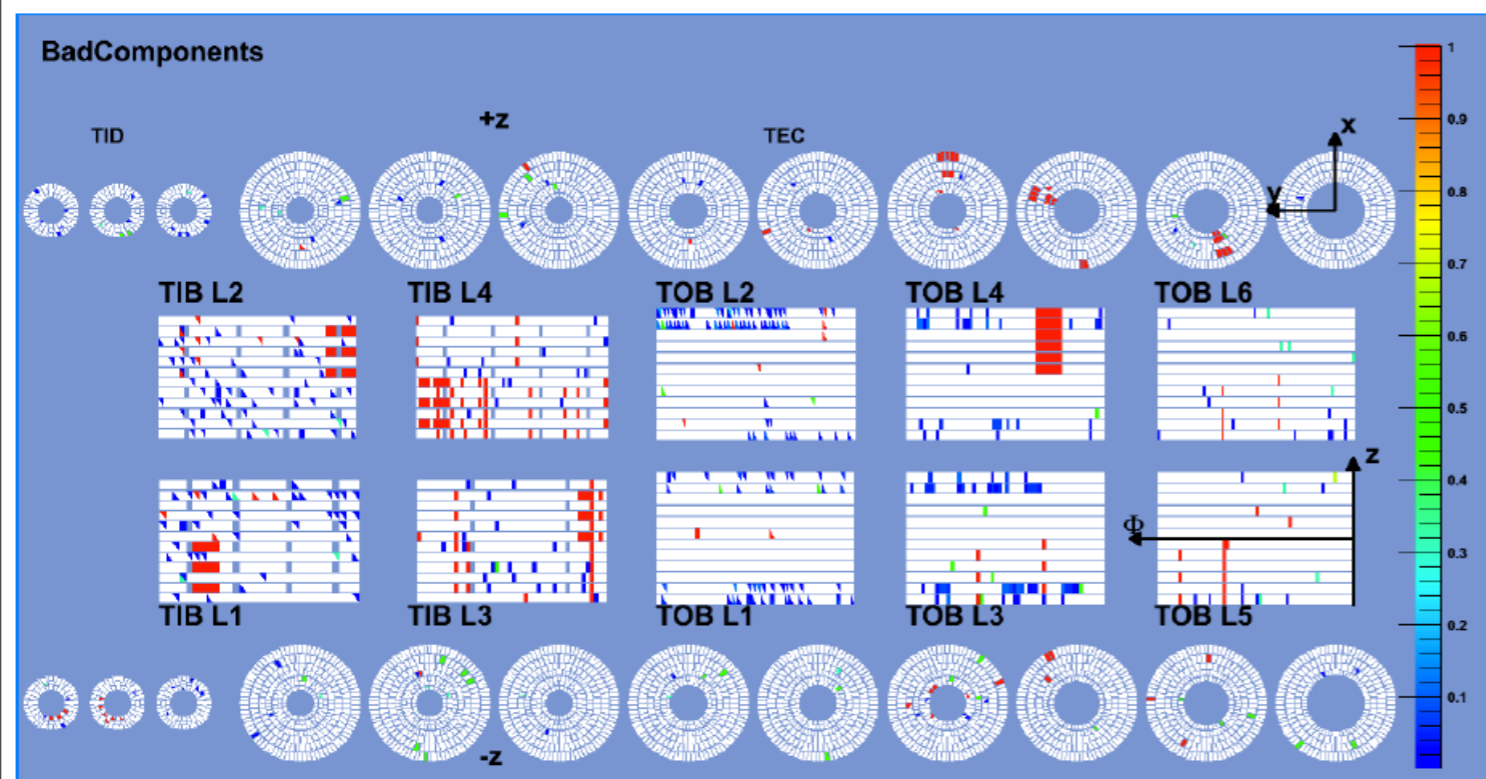
Frazione di strip attive: 97.8%



No I2C communication with AOH:
6/192 (3.1%)

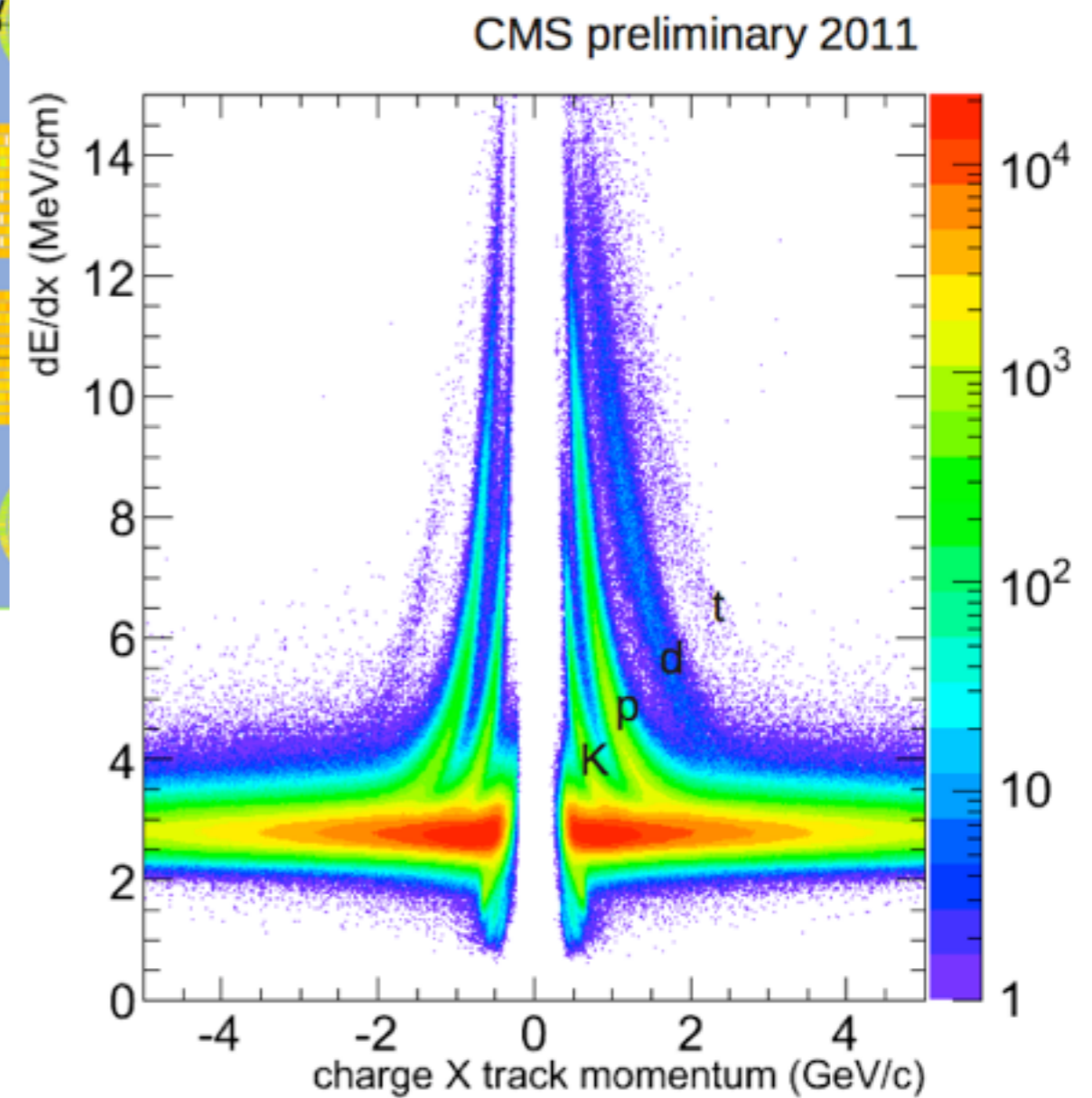
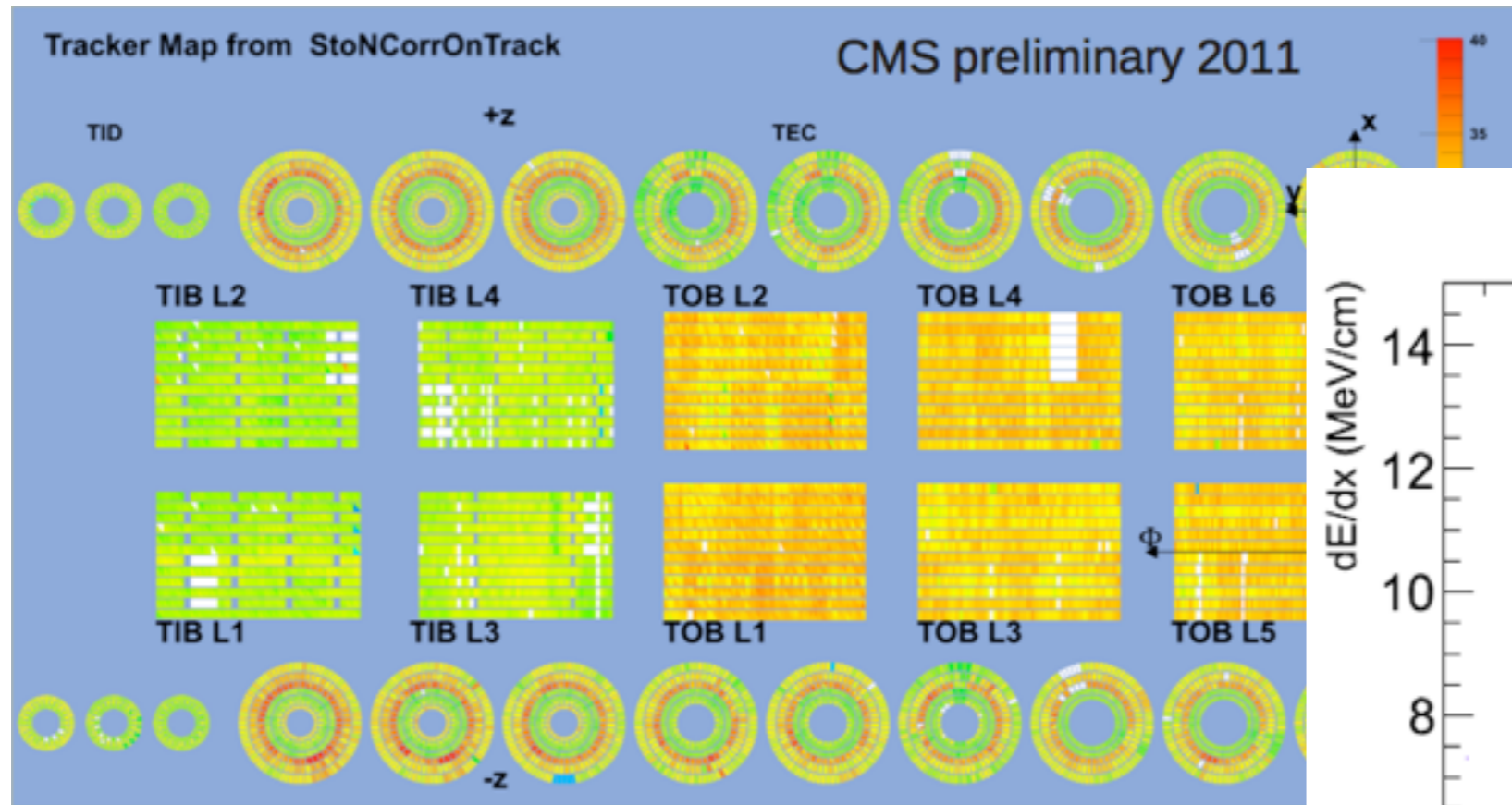
Frazione di pixel attivi: 97.3%

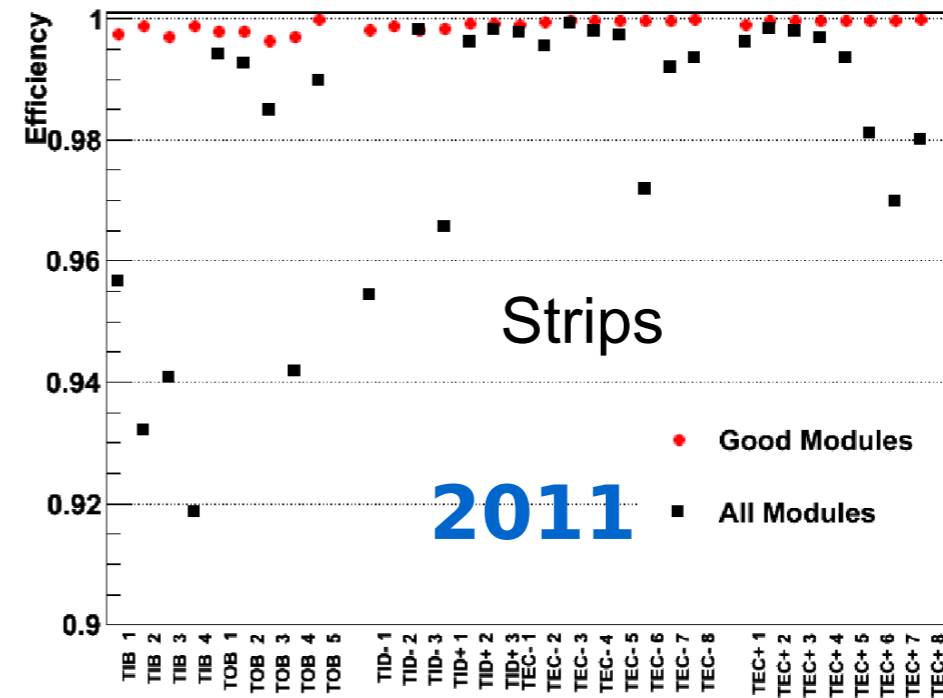
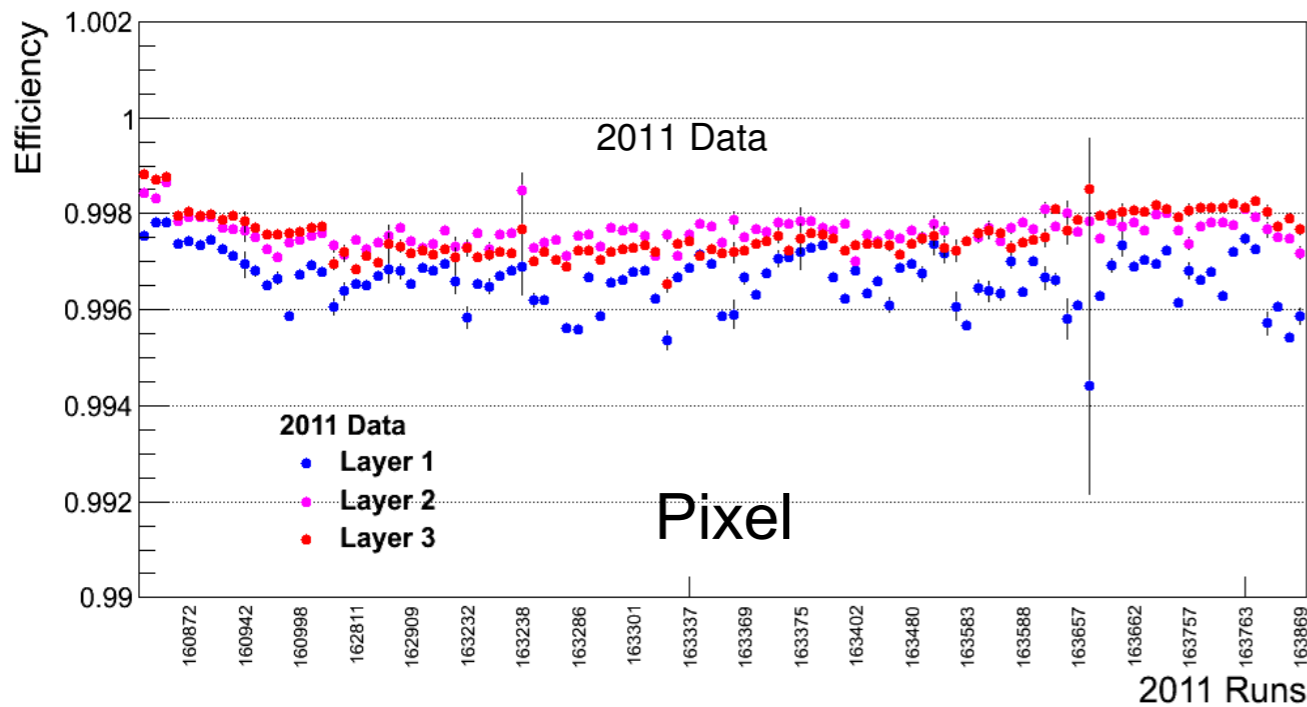
Leakage current primo pixel layer:
 $\sim 200 \mu\text{A}/\text{fb}^{-1}/\text{ladder}$
OK fino a $\sim 12 \text{ fb}^{-1}$



R. Dell'Orso, A. Giassi, A. Messineo, F. Palmonari, A. Venturi, P.G. Verdini

- **S/N TIB (300 μm)~20, TOB (500 μm)~30**





Bin method	Collisions 2010 [μm] $\mathcal{L} = 3.9 \text{ pb}^{-1}$
Degrees 0 - 10	
TIB 12 ($80 \mu\text{m}$)	16.0 ± 3.5
TIB 34 ($120 \mu\text{m}$)	27.5 ± 2.9
TOB 1234 ($183 \mu\text{m}$)	41.3 ± 3.8
TOB 56 ($122 \mu\text{m}$)	24.5 ± 2.7
Degrees 10 - 20	
TIB 12 ($80 \mu\text{m}$)	13.0 ± 3.8
TIB 34 ($120 \mu\text{m}$)	22.5 ± 2.2

PC

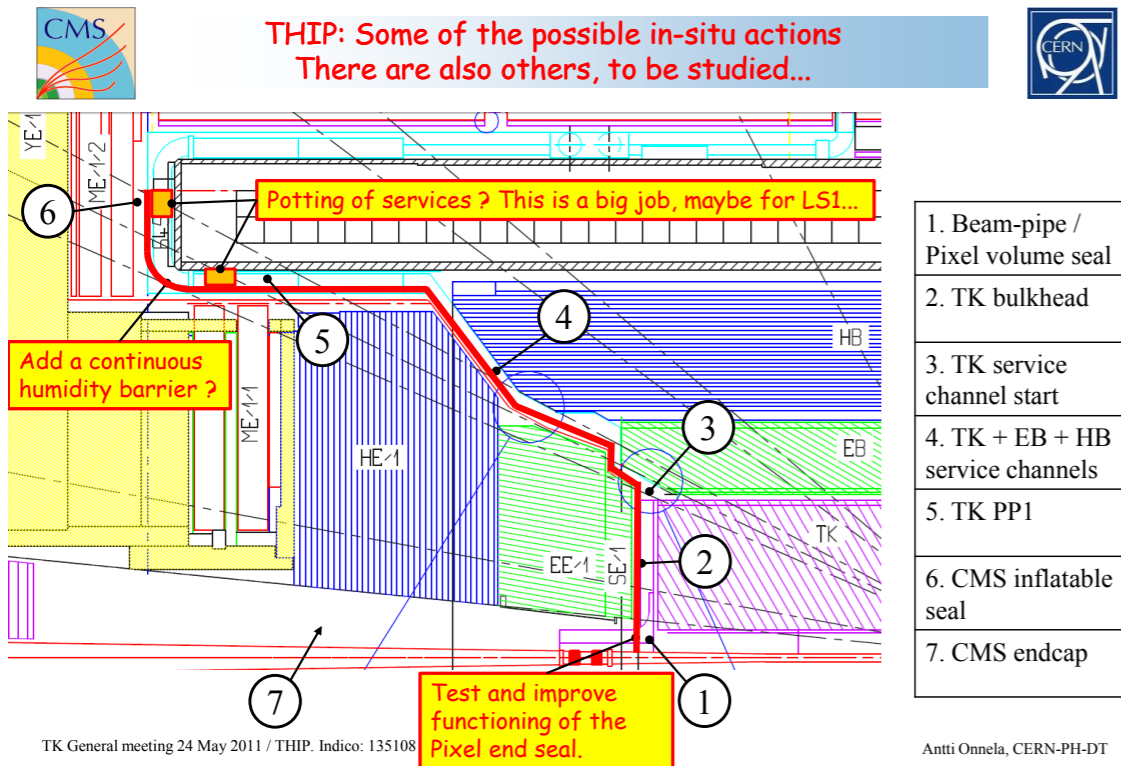
Bin method	Collisions 2011 [μm] $\mathcal{L} = 17.3 \text{ pb}^{-1}$
Degrees 0 - 10	
TIB 12 ($80 \mu\text{m}$)	14.34 ± 4.8
TIB 34 ($120 \mu\text{m}$)	25.2 ± 5.3
TOB 1234 ($183 \mu\text{m}$)	34.1 ± 6.4
TOB 56 ($122 \mu\text{m}$)	20.6 ± 3.6
Degrees 10 - 20	
TIB 12 ($80 \mu\text{m}$)	14.2 ± 2.6



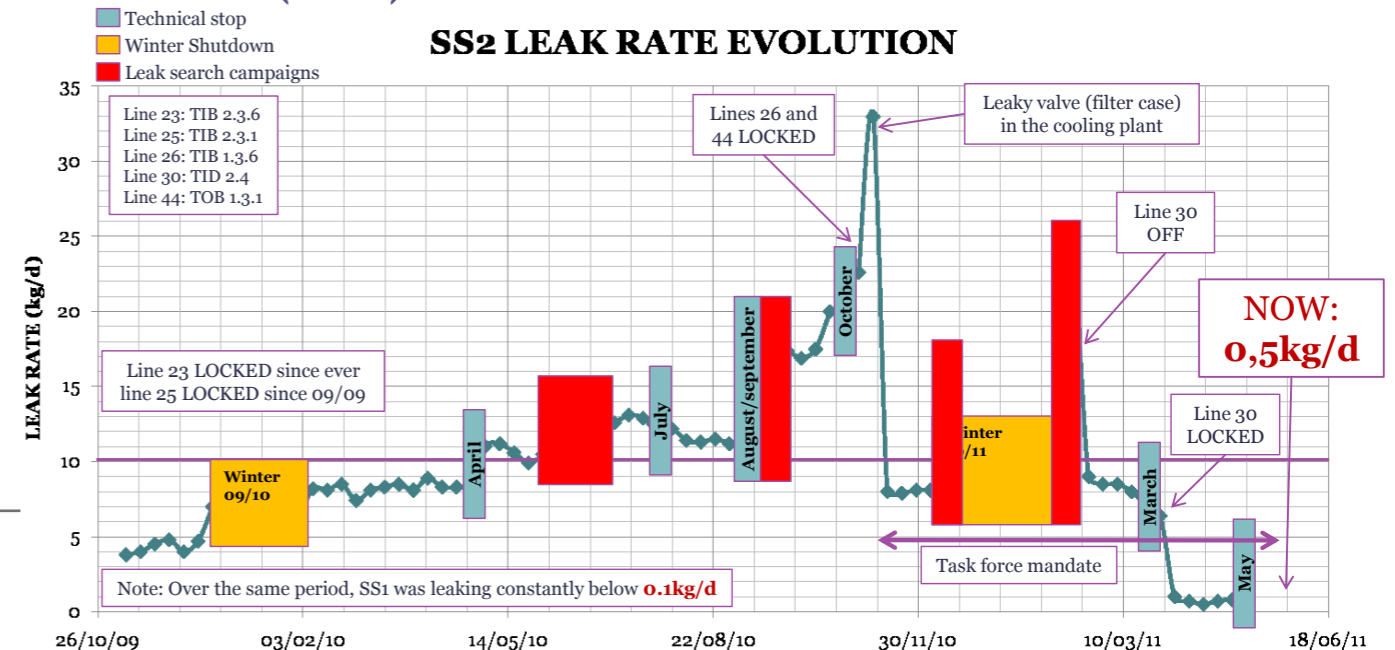
Tracker Cooling



- **Temperatura del coolant in ingresso al detector 4°C**
 - ♦ leak rate adesso 0.5 Kg/giorno
 - ♦ Sniffing system installato nell'estate 2010: (~0.1% C₆F₁₄ misurato nel Tracker)
- **Refill remoto installato per SS2 (A. Moggi, F. Raffaelli, A. Basti, F. Mariani, S. Tolaini)**
- **Dovremmo intervenire per andare ancora più freddi.**
 - ♦ Danneggiamento da radiazione non ancora problema. Pixel potrebbero reggere fino a ~12 fb⁻¹ senza dover andare freddi (ma al limite)
 - ♦ Task force sulla riduzione dell'umidità. Punti problematici rimangono i "cable channels"
 - In discussione: interventi fine 2011, in modo da ripartire "freddi" nel 2012



1) History of the circuits and closed lines (ss2)



Tier 2 di Pisa



Come funziona il T2?

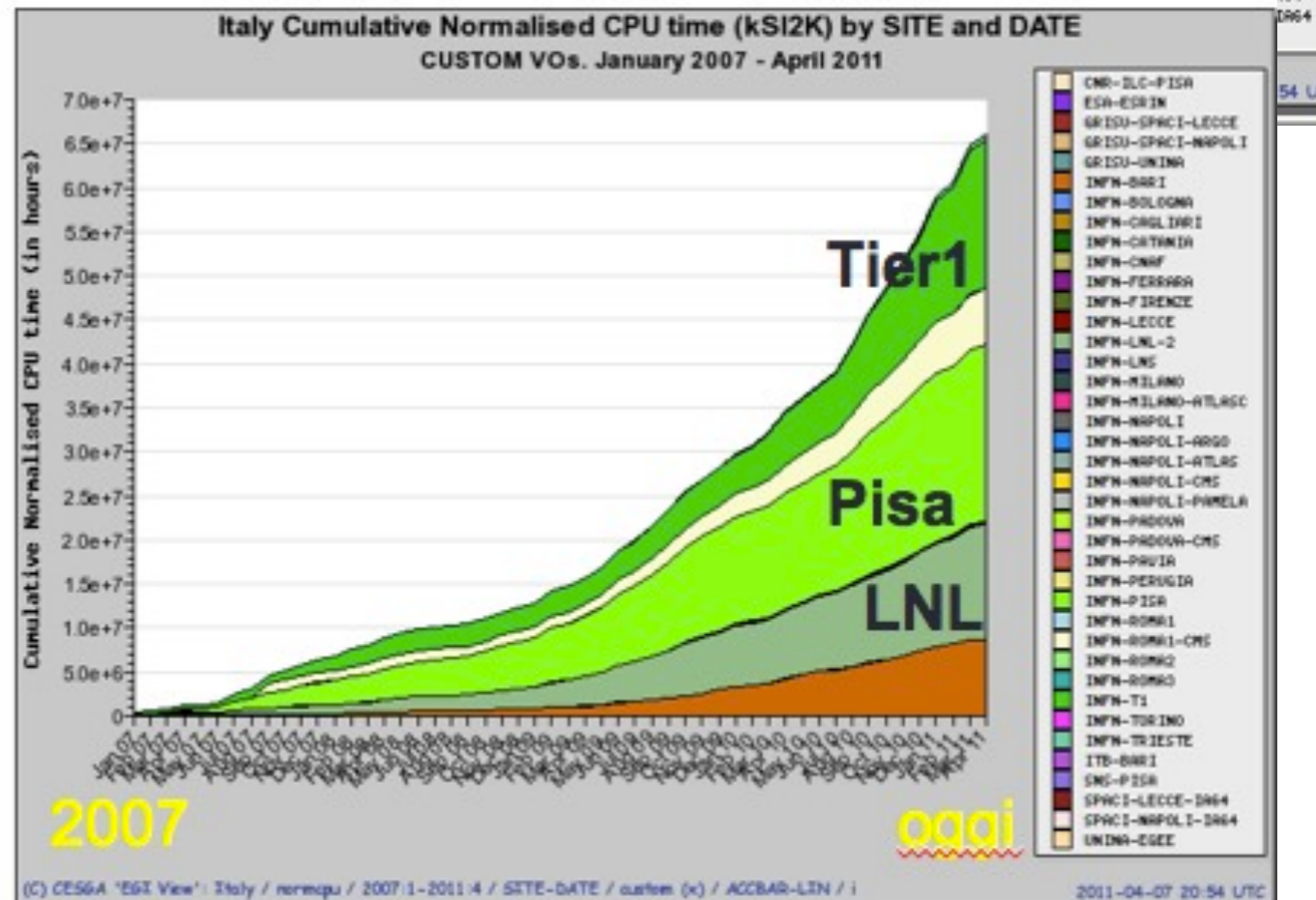
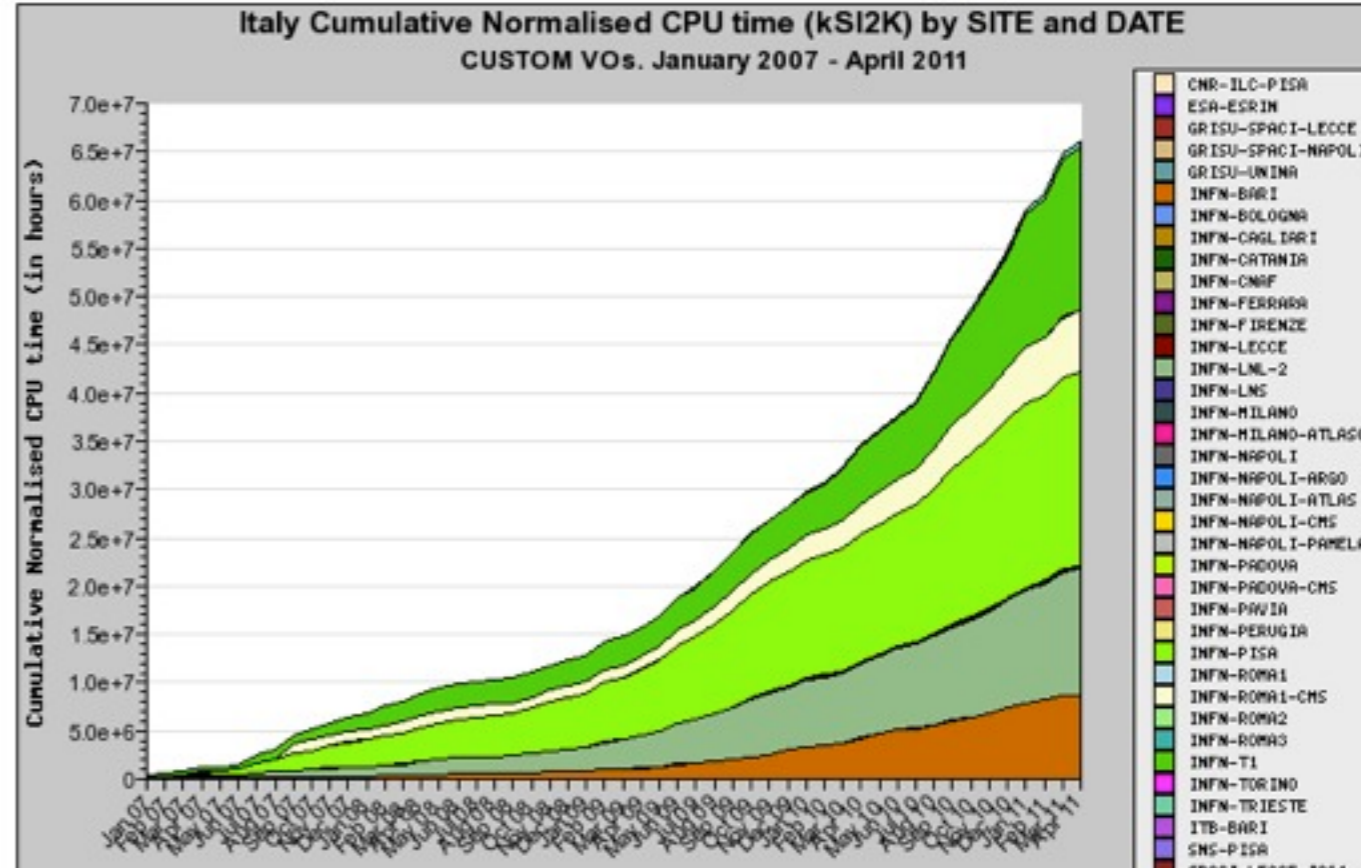
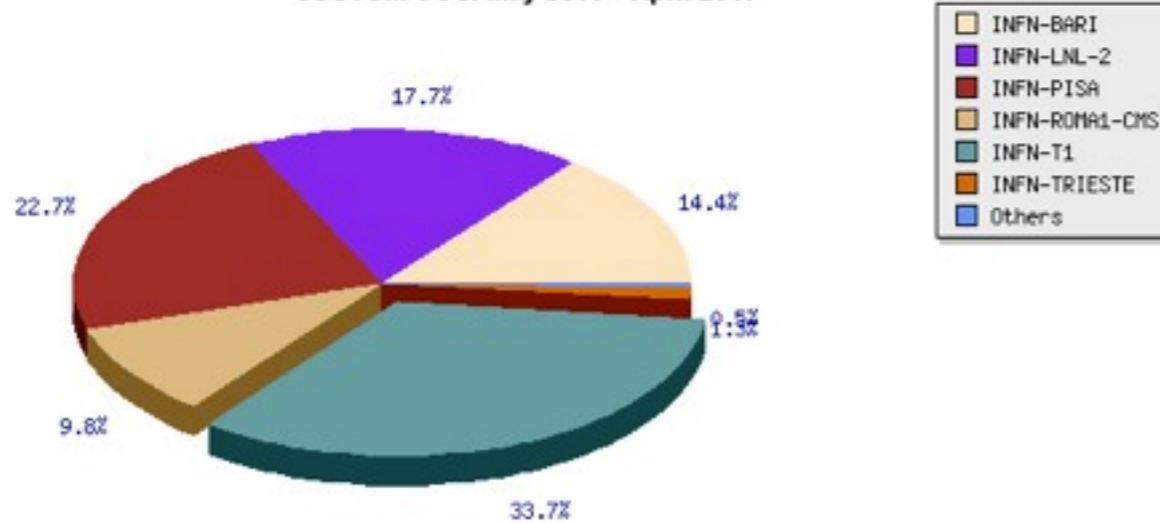


Arezzini, Mazzoni, Ciampa, Calzolari, Taneja
Carboni, Boccali, Bagliesi

Jobs a Pisa:

- 40K/week
- Produzione e Analisi fanno la parte del leone (per fortuna)

ROC Normalised CPU time (kSI2K) per SITE
CUSTOM VOs. May 2010 - April 2011

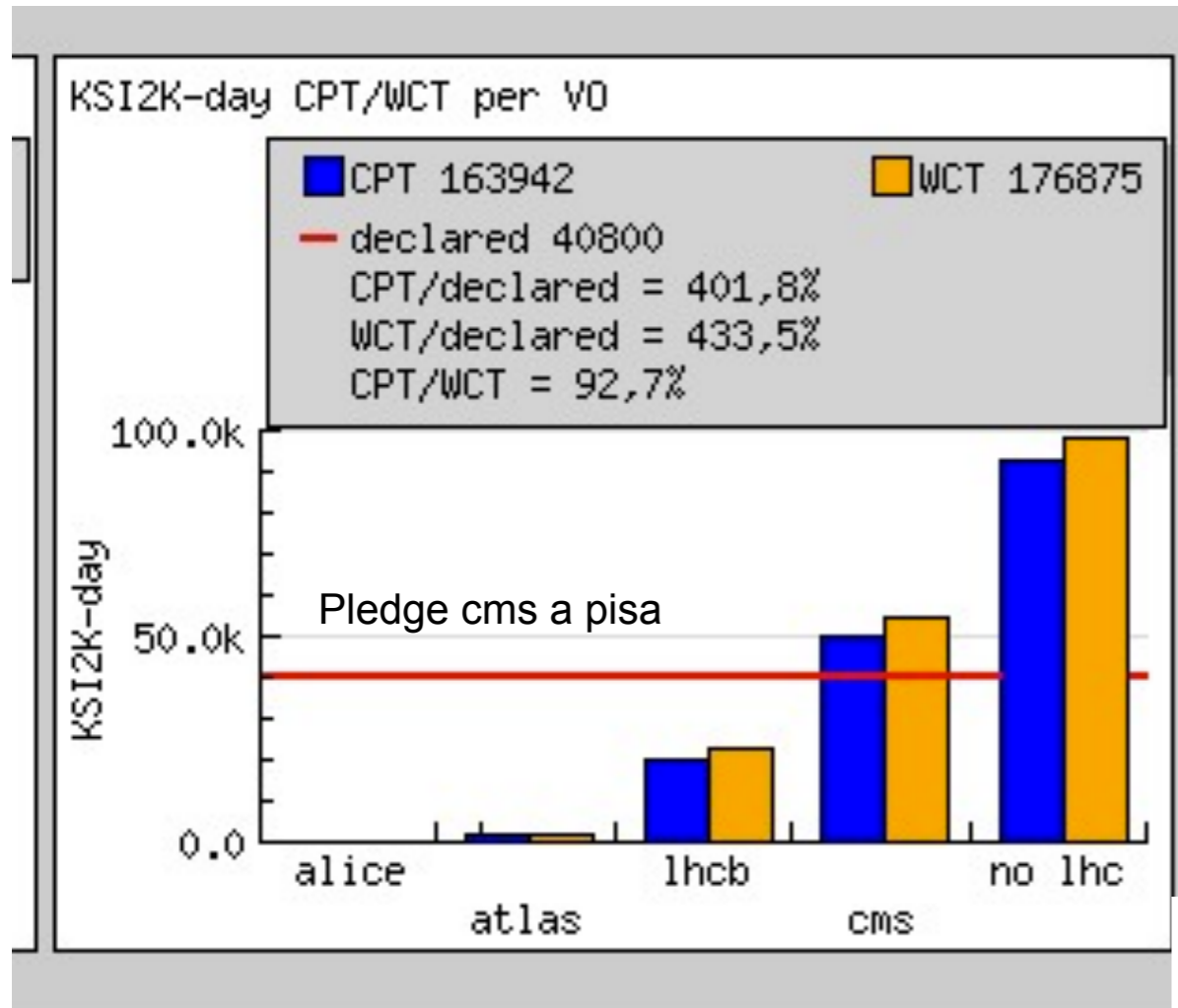


Primo Tier2 italiano come
attivit  ultimo anno, ma
anche meglio negli ultimi 4
anni!

F. Palla INFN Pisa

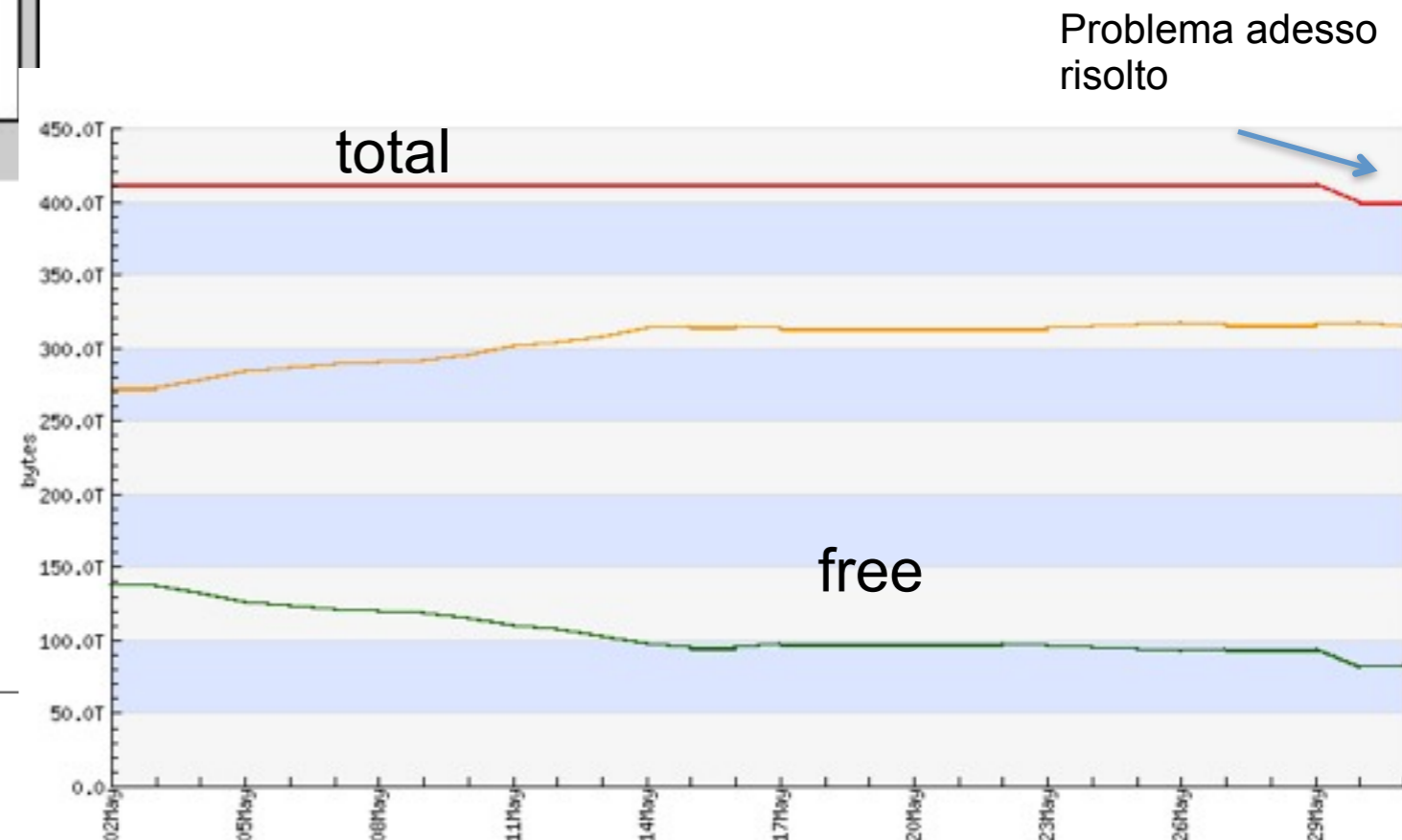


Uso Disco/CPU



CMS usa + del suo pledge (uso opportunistico delle risorse libere)
 CPU efficiency molto alta (netto miglioramento da un paio di anni fa)

Rate di riempimento disco ~ 50 TB/mese adesso
 (Include le cancellazioni)





“fama”



- **Alta considerazione di Pisa in CMS: uno dei 5 siti al mondo (2 in Europa) a ricevere i primi dati di collisioni**

*** Requestor:**

Name: Frank Wuerthwein

Data:

**/MinimumBias/BeamCommissioning09
PromptReco-v2/RECO**

Destination Nodes:

T2_DE_RWTH (Site: RWTH)

T2_IT_Pisa (Site: Pisa)

T2_US_Nebraska (Site: Nebraska)

T2_US_Purdue (Site: Purdue)

T2_US_UCSD (Site: UCSD)

Size:

245 files, 486.9 GB

Comments:

"MinBias PD for central space."



PisaTier 2: Potenza installata fine 2011



- **CPU: 12.5kHS06 (1248 cores tutti nuovi, arrivati nel 2011)**
 - ◆ Ci sono anche 5.2kHS06 di macchine dismesse, ma ancora funzionanti – idea e' di usarle per l'interattivo e per l'analisi a-la Tier3
- **Disco: 850 TB netti sotto dCache (> 1 PB di dischi RAW)**
 - ◆ Di questi 230 sono da dismettere nel 2012 per raggiunta eta' (>4 anni) – referees non hanno ancora discusso la richiesta



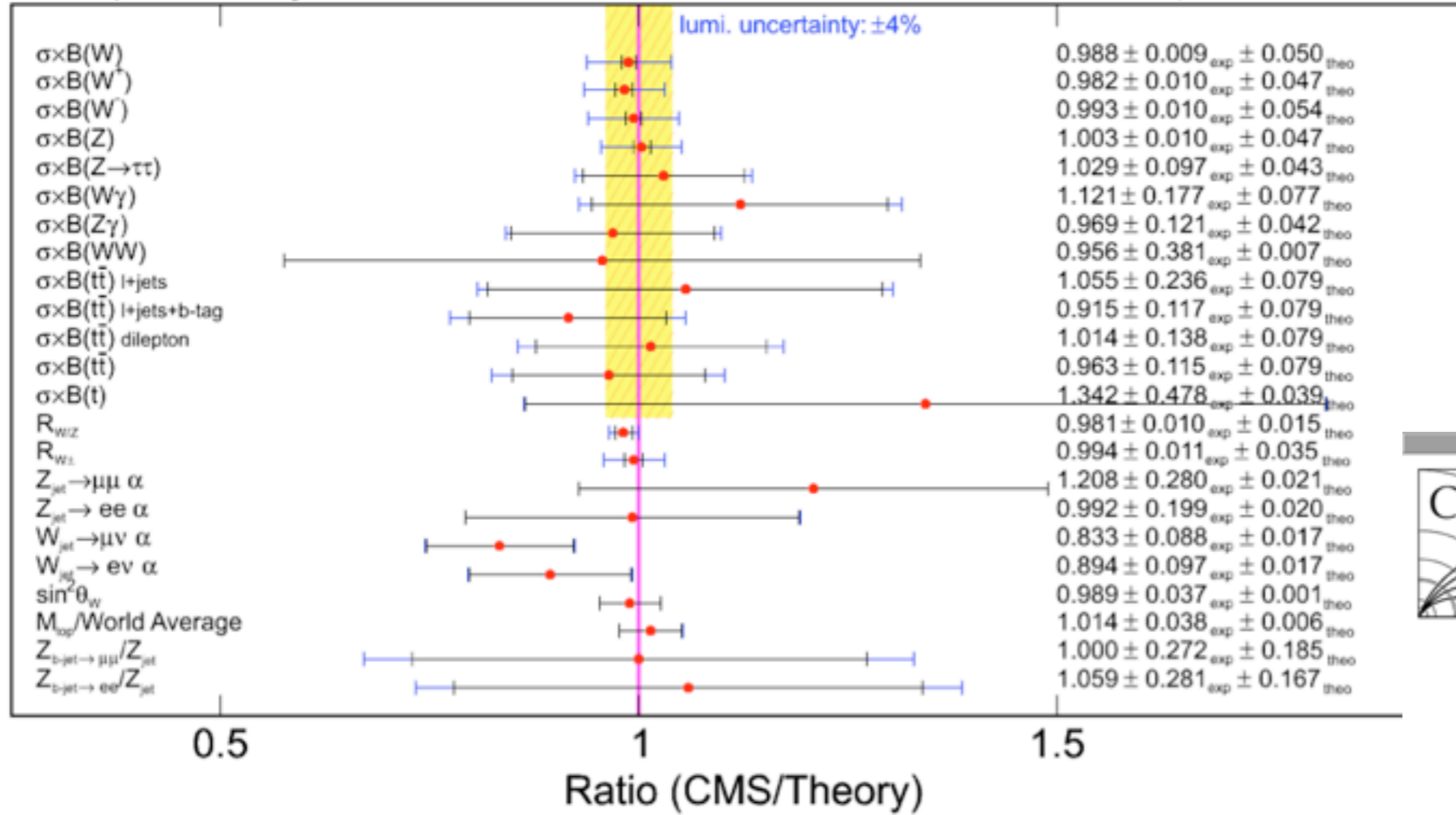
Richieste 2012



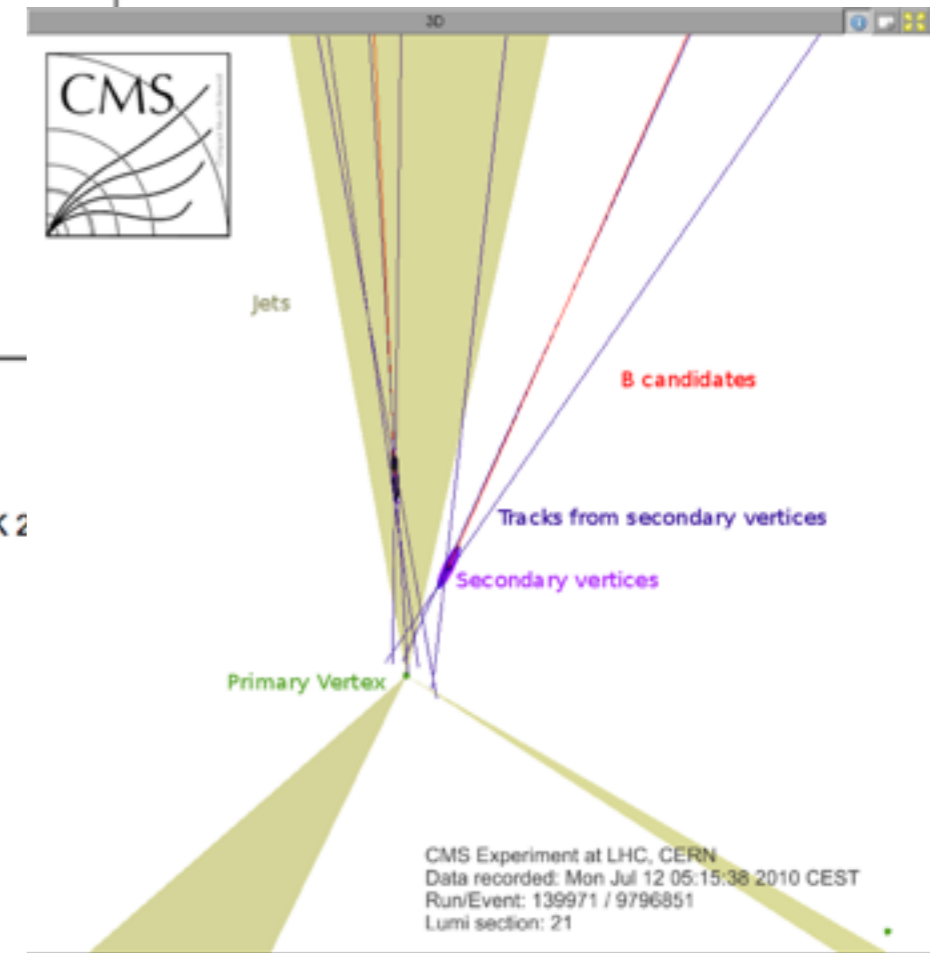
- **Richieste ai referees fatte sulla base dello scrutiny:
+30% disco, +30% CPU (+ le dismissioni)**
 - ♦ +4 kHS06, + 490 TB Netti
- **CPU: proposta dei referees ~ 3 volte + bassa**
- **Disco: non ancora discusso**
 - ♦ (ragione: momento difficile per l'INFN + riassetamento della % di CMS Italia in CMS)

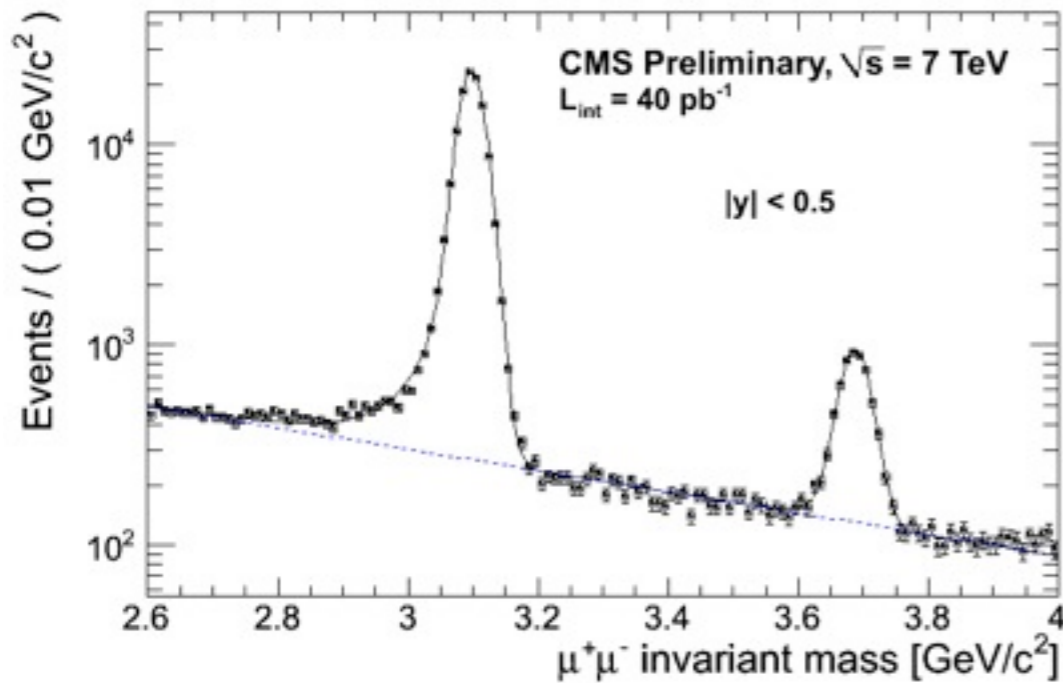
CMS preliminary

36 pb⁻¹ at $\sqrt{s} = 7$ TeV

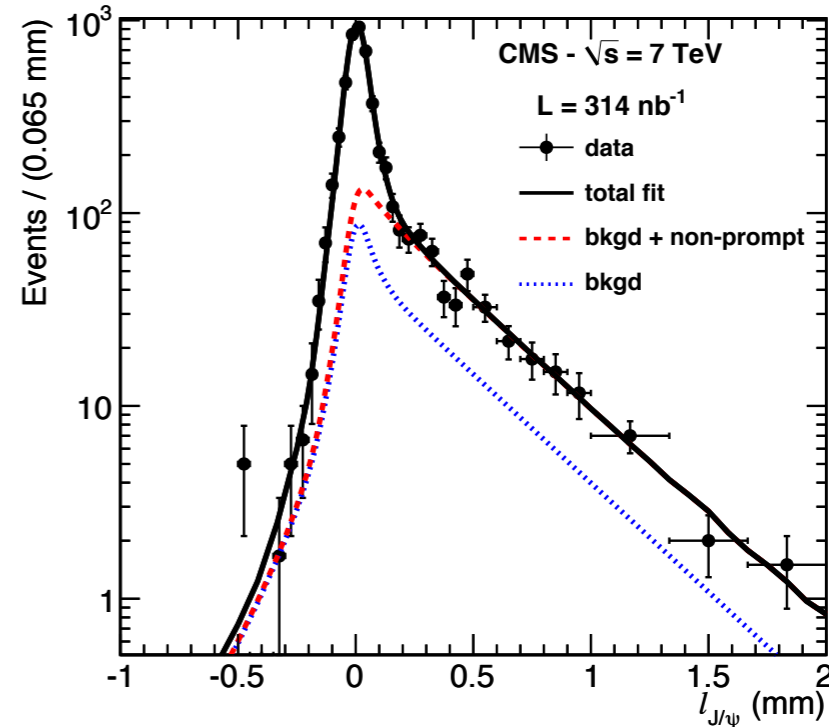


from P.C.Harris, Moriond EWK 2





Eur.Phys.J. C71 (2011) 1575

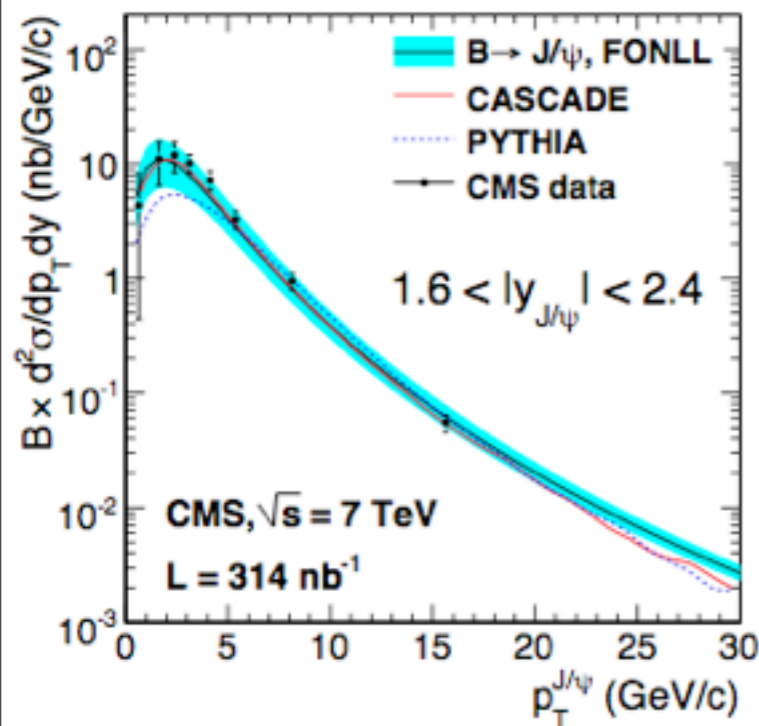


Decay length l_{xy} resolutions depend on the p_T and mildly on the rapidity

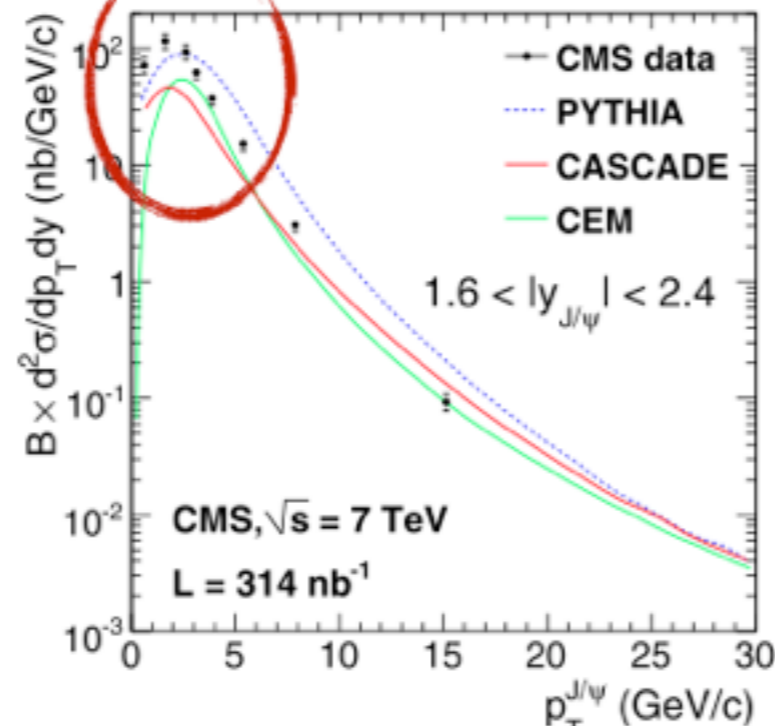
p_T (J/ψ) 0-2 GeV/c $\sim 250 \mu\text{m}$

p_T (J/ψ) 10-30 GeV/c $\sim 35 \mu\text{m}$

$$l_{J/\psi} = L_{xy} \cdot m_{J/\psi} / p_T$$



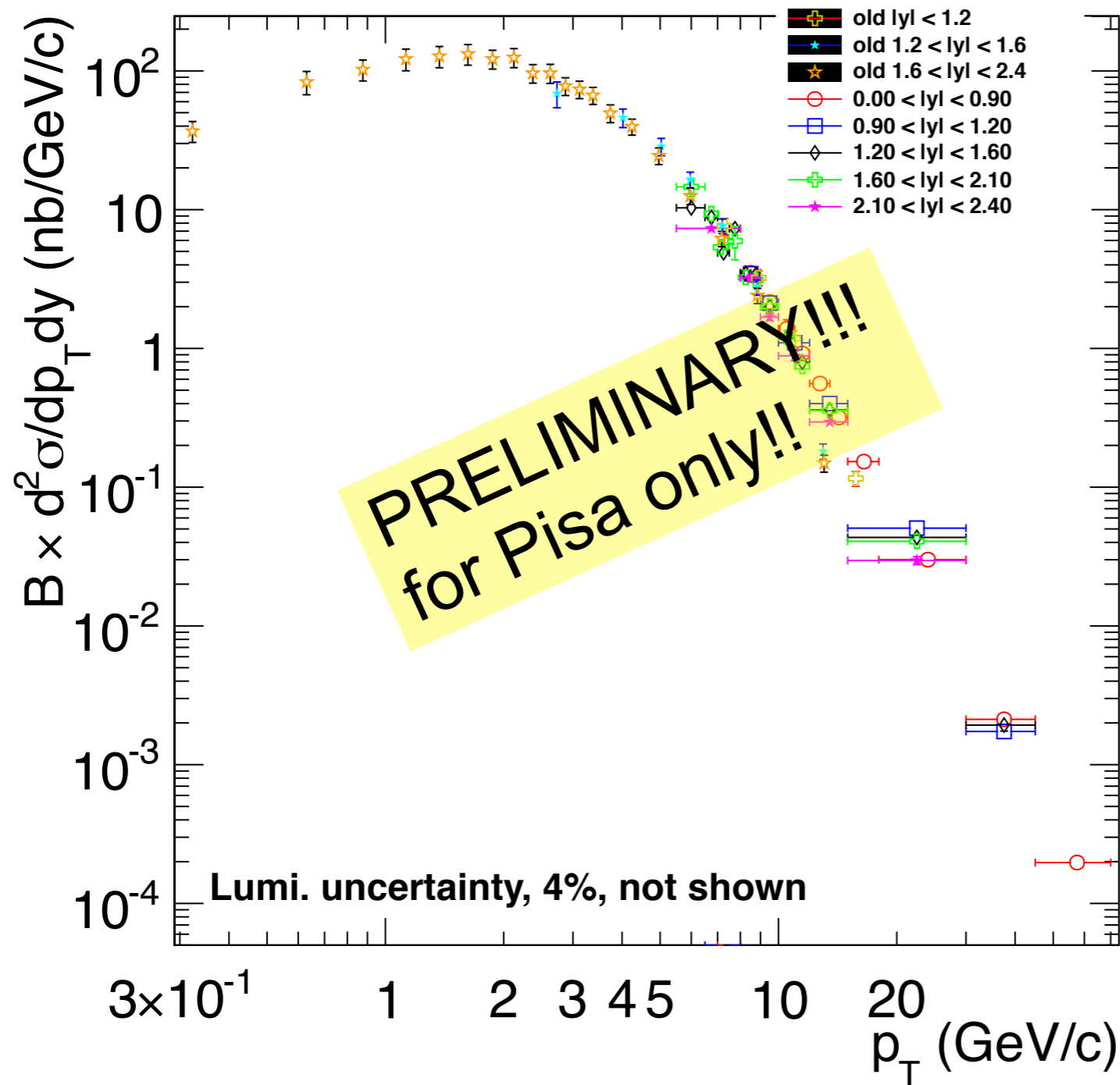
B \rightarrow J/ ψ



Prompt J/ ψ

J. Bernardini, F. Fiori, S. Guo, A. Kraan, F. Ligabue, L. Martini, F. Palla

Prima misura (in corso) della polarizzazione (Tesi di laurea L. Calligaris)



- The mass spectrum is fitted with unbinned log-likelihood
- Mass values are compatible with the PDG values

• CMS fit results:

$$m_{\psi(2S)} = 3685.9 \pm 0.1 \text{ MeV}$$

$$\sigma_{1 \psi(2S)} = 8.1 \pm 0.6 \text{ MeV}$$

$$\sigma_{2 \psi(2S)} = 3.3 \pm 0.3 \text{ MeV}$$

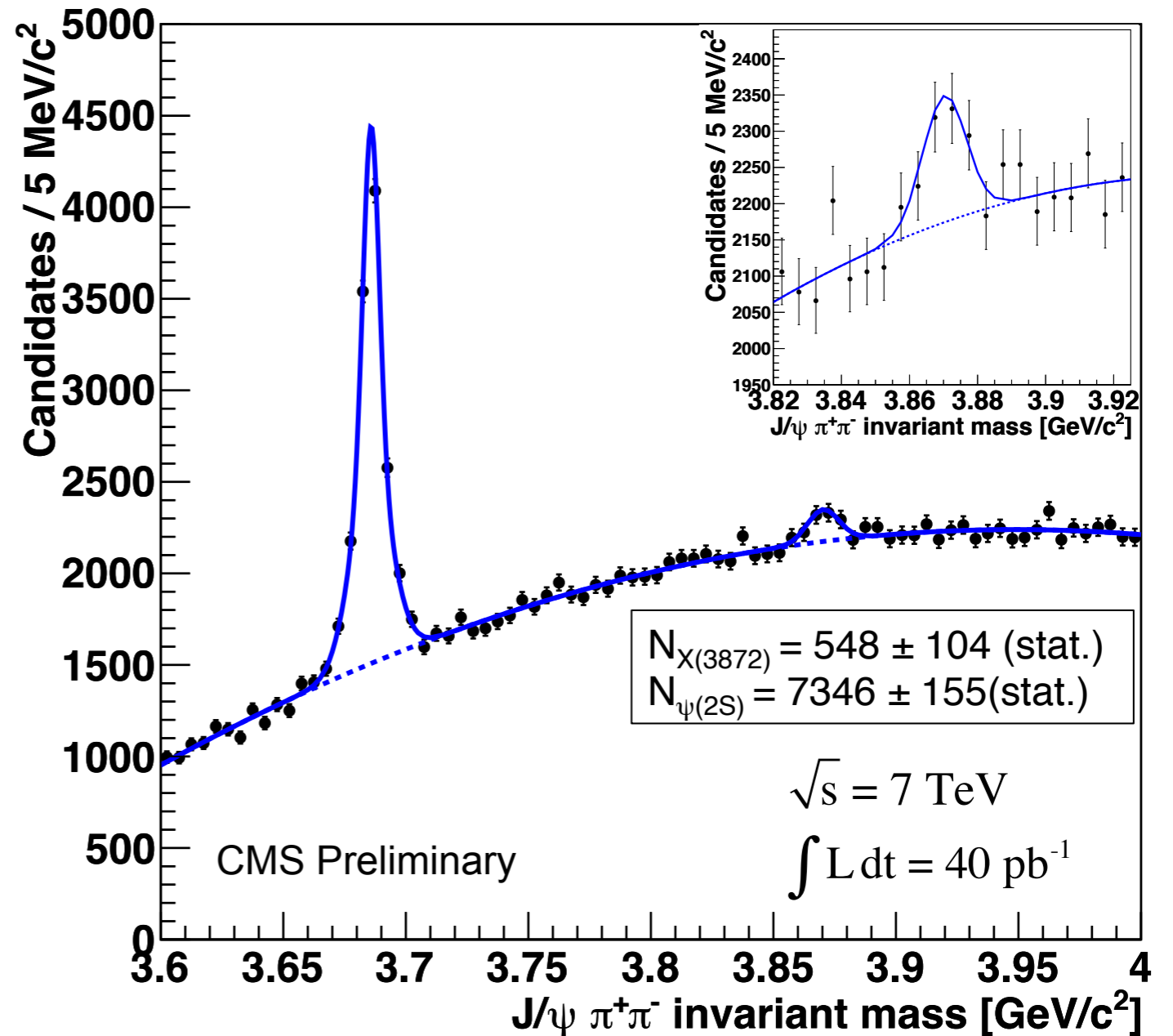
$$m_{X(3872)} = 3870.2 \pm 1.9 \text{ MeV}$$

$$\sigma_{X(3872)} = 6.3 \pm 1.3 \text{ MeV}$$

• PDG values:

$$m_{\psi(2S)} = 3686.09 \pm 0.04 \text{ MeV}$$

$$m_{X(3872)} = 3871.56 \pm 1.9 \text{ MeV}$$



The measurement of the ratio of cross sections

$$R = \frac{\sigma(pp \rightarrow X(3872) + \text{anything}) BR(X(3872) \rightarrow J/\psi \pi^+ \pi^-)}{\sigma(pp \rightarrow \psi(2S) + \text{anything}) BR(\psi(2S) \rightarrow J/\psi \pi^+ \pi^-)}$$

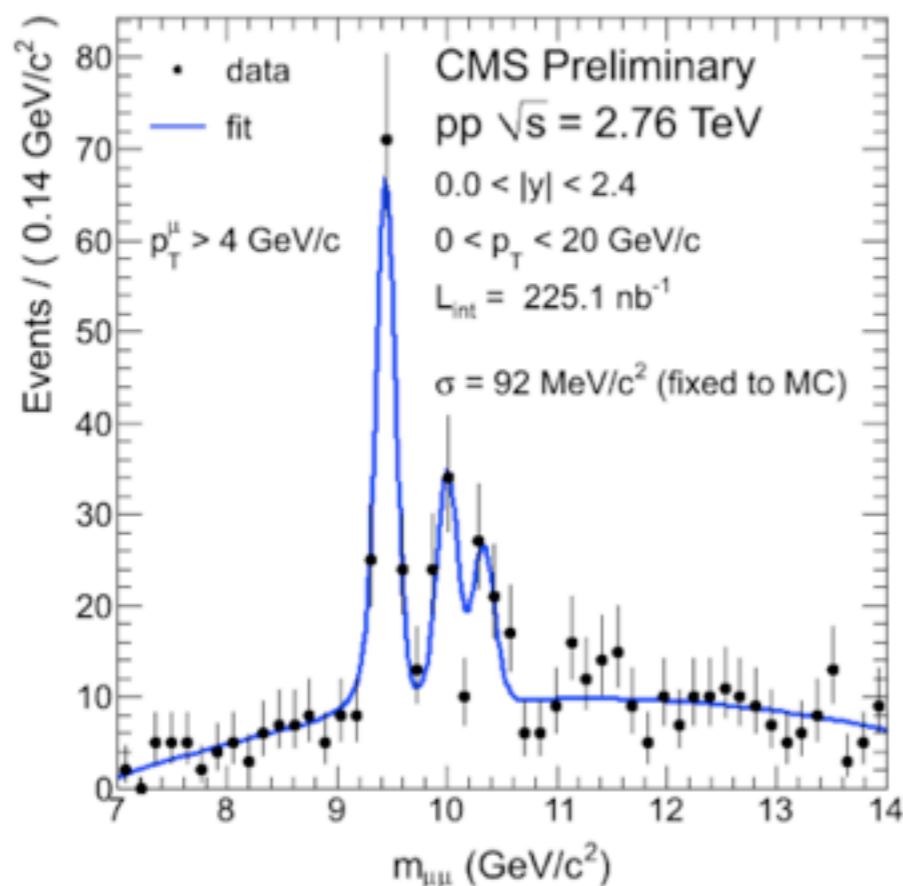
yields:

$$\mathbf{R = 0.087 \pm 0.017 \text{ (stat)} \pm 0.009 \text{ (syst)}}$$

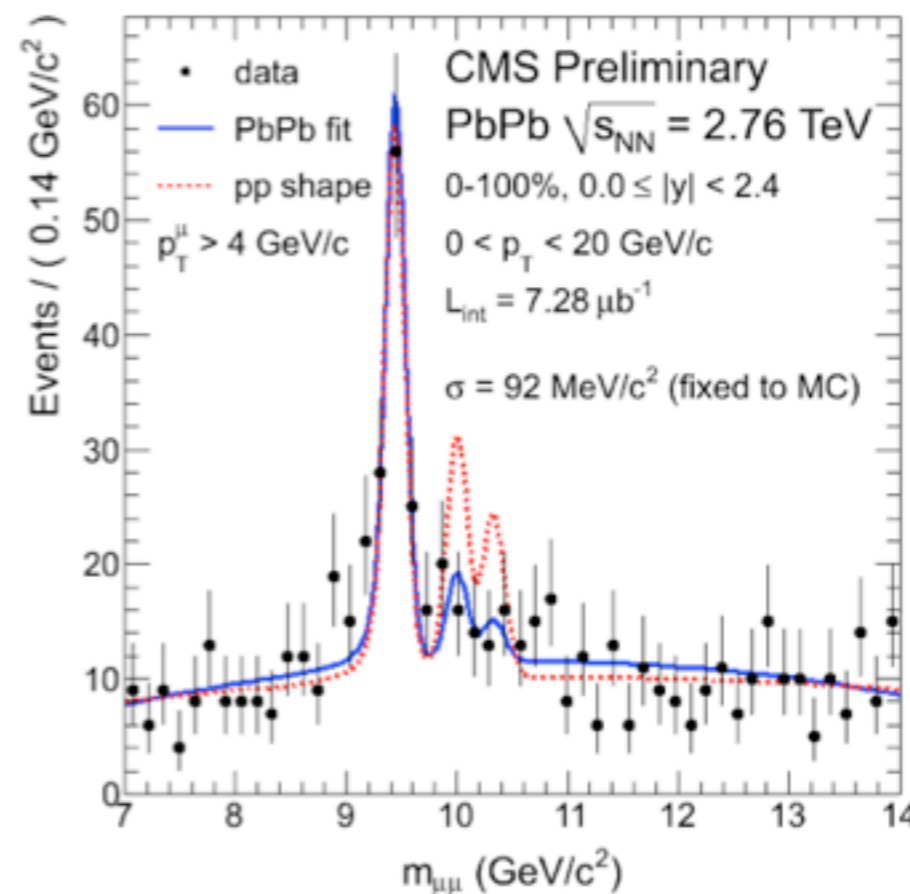
A. Visentini (tesi di laurea), F. Palla

- **Soppressione degli stati eccitati $Y(2S, 3S)$ relativamente alla $Y(1S)$.**
 - ♦ “smoking gun” degli effetti predetti dal Quark-Gluon Plasma

$$R_{23|pp} \equiv \frac{N_{2S} + N_{3S}}{N_{1S}} = 0.78 \pm 0.15 \pm 0.02$$



$$R_{23|PbPb} \equiv \frac{N_{2S} + N_{3S}}{N_{1S}} = 0.24 \pm 0.12 \pm 0.02$$



CERN-PH-EP-2011-074

$$\frac{Y(2S + 3S)/Y(1S)|_{PbPb}}{Y(2S + 3S)/Y(1S)|_{pp}} = 0.31^{+0.19}_{-0.15} \text{ (stat.)} \pm 0.03 \text{ (syst.)}$$

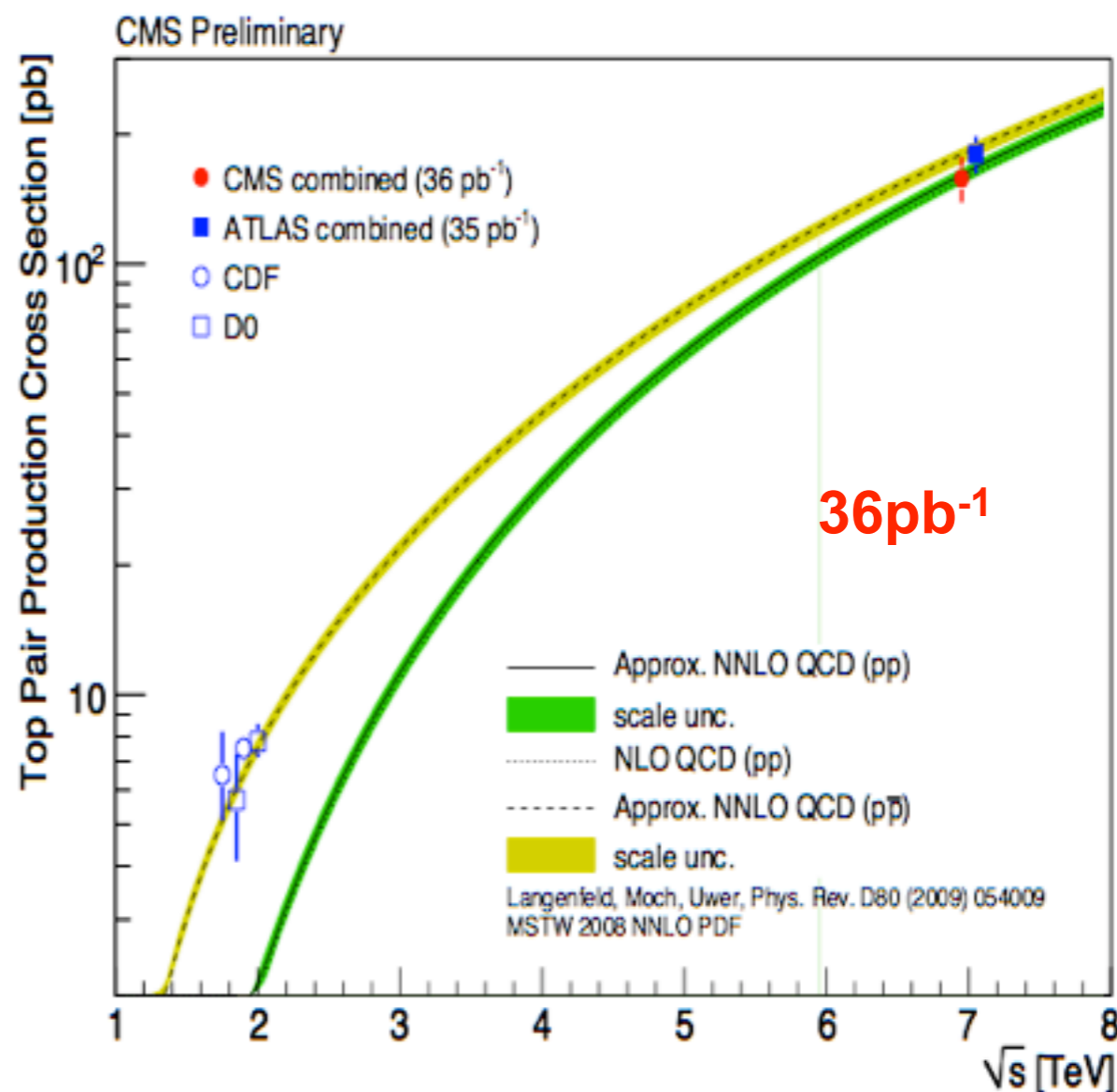
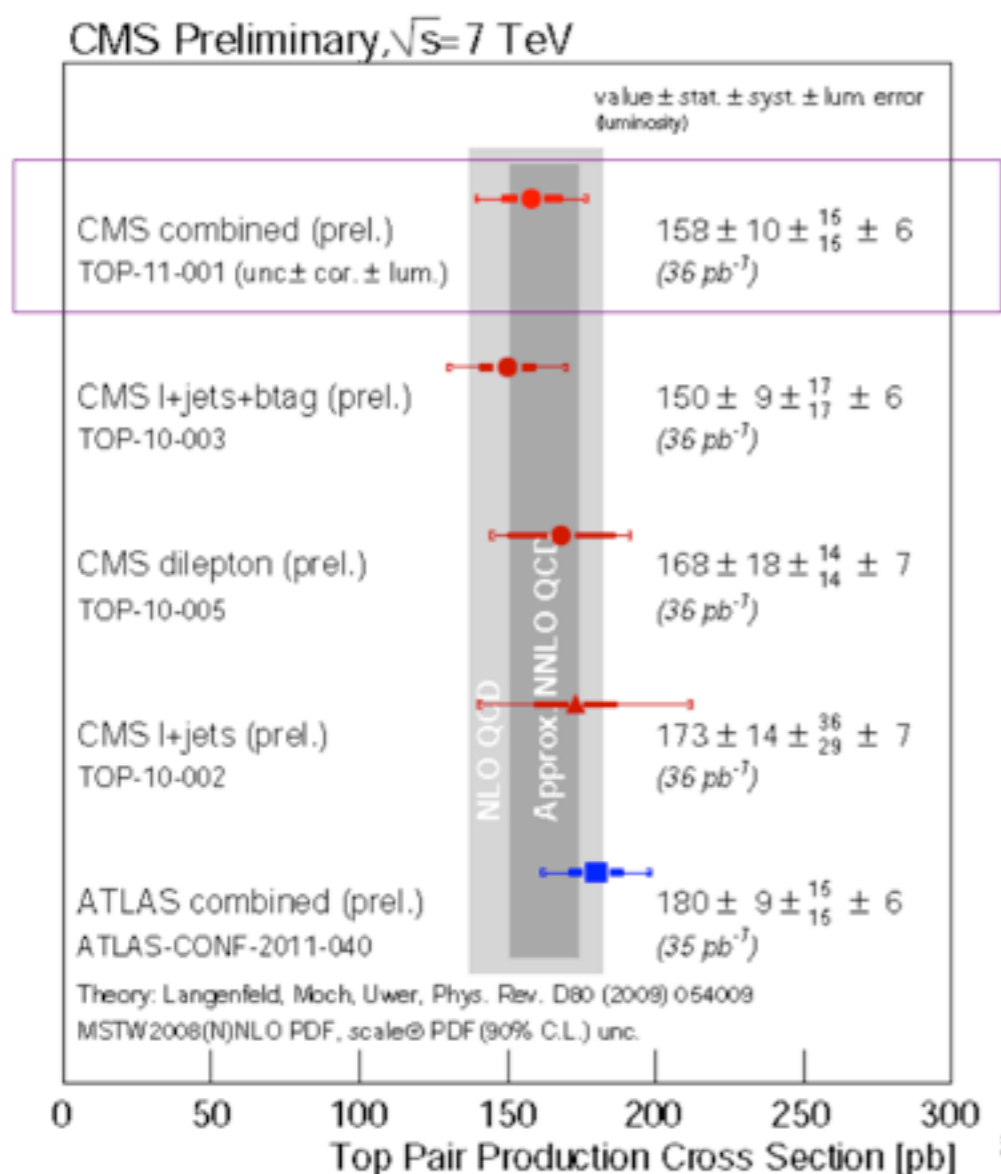


Top cross section combined result



New measurements of the top cross section (leptons+jets with and without btag)

$$\sigma = 158 \pm 10 \pm 16 \pm 6 (\text{lumi}) \text{ pb}$$



CMS-TOP-10-003-001; CERN-PH-EP-2011-085; CMS-TOP-10-002-002; CERN-PH-EP-2011-060
arXiv:1105.5661 ; CMS-TOP-11-002 ; CERN-PH-EP-2011-055

Dilepton channel

$$M_{\text{top}} = 175.5 \pm 4.6 \pm 4.6 \text{ GeV}/c^2$$

Lepton+jets channel

$$M_{\text{top}} = 173.1 \pm 2.1 \pm 2.8 \text{ GeV}/c^2$$

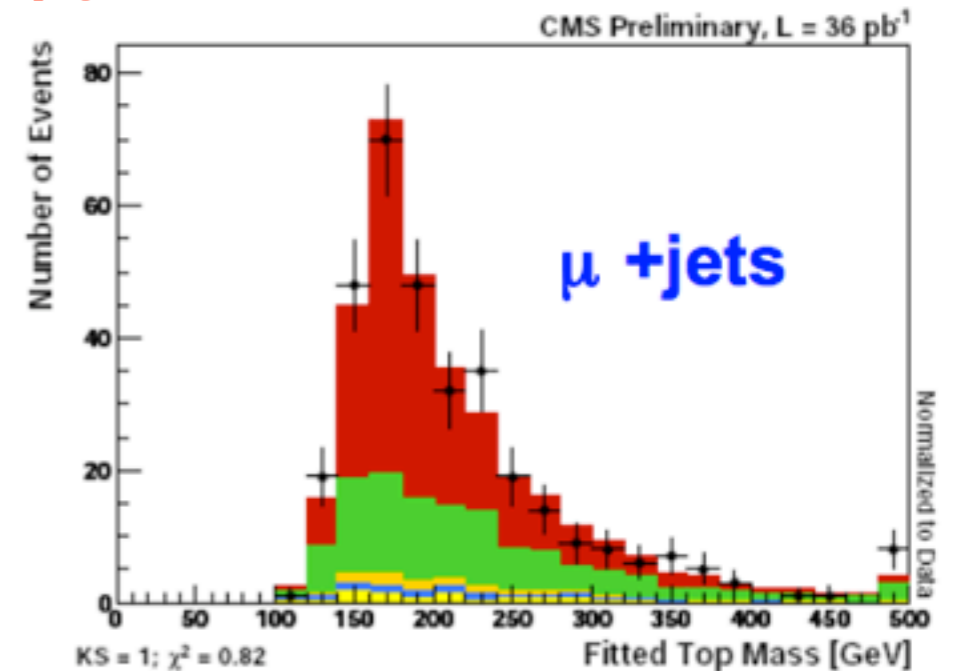
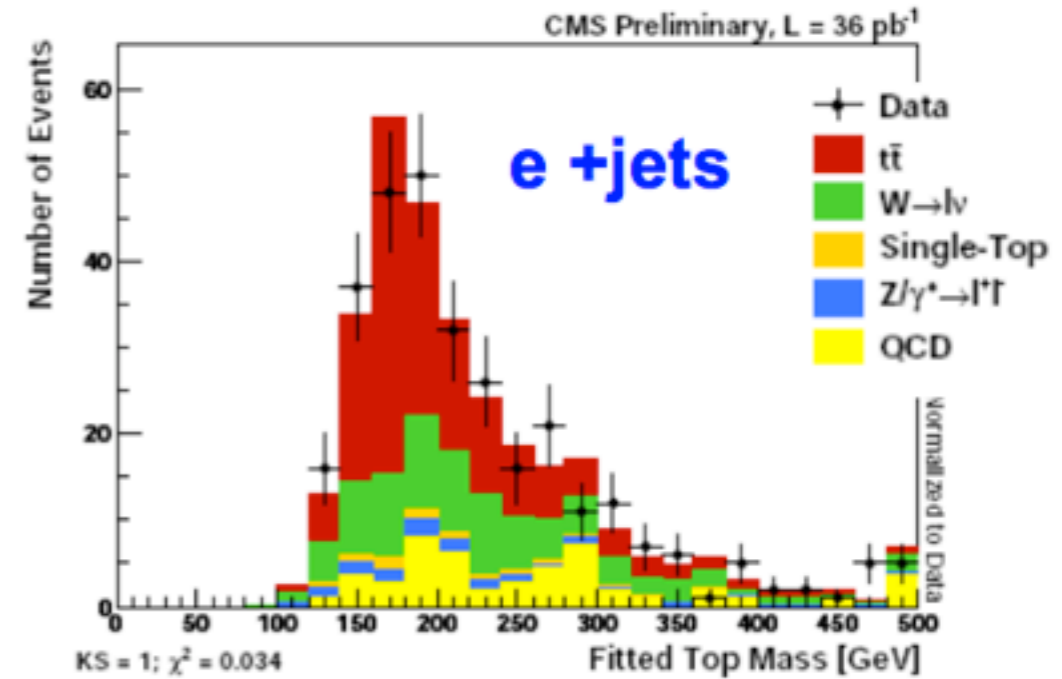
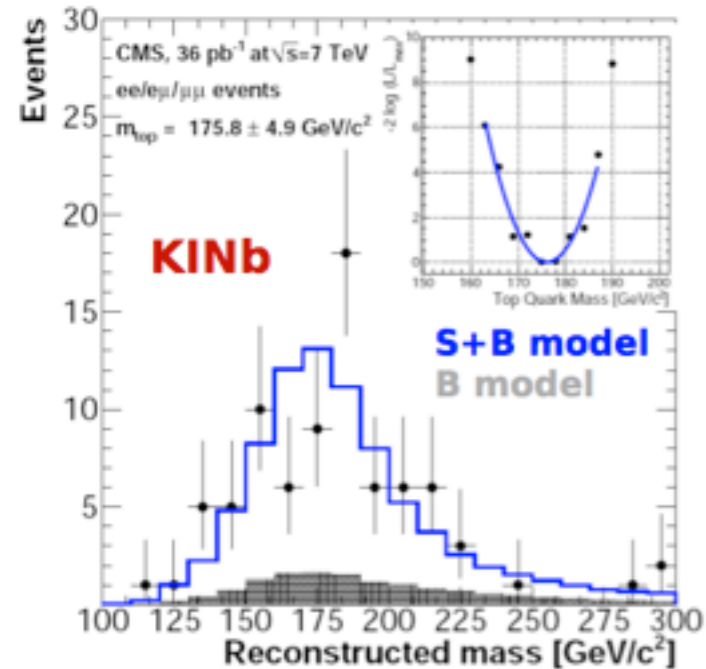
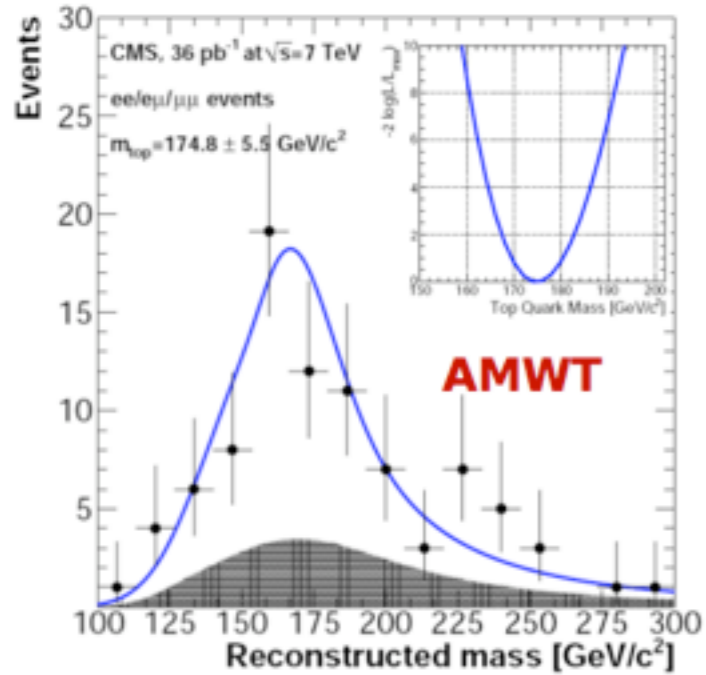
CMS combination

$$M_{\text{top}} = 173.4 \pm 1.9 \pm 2.7 \text{ GeV}/c^2$$

2% precision

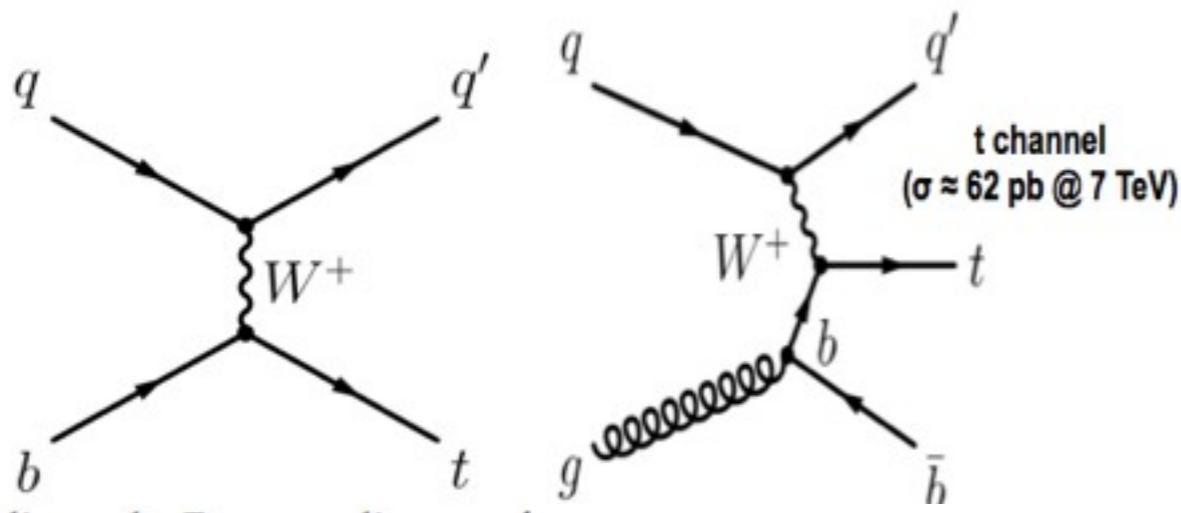
LHC is now a top factory and will allow soon detailed studies of top properties.

arXiv:1105.5661 ; CMS-TOP-11-002 ; CERN-PH-EP-2011-055

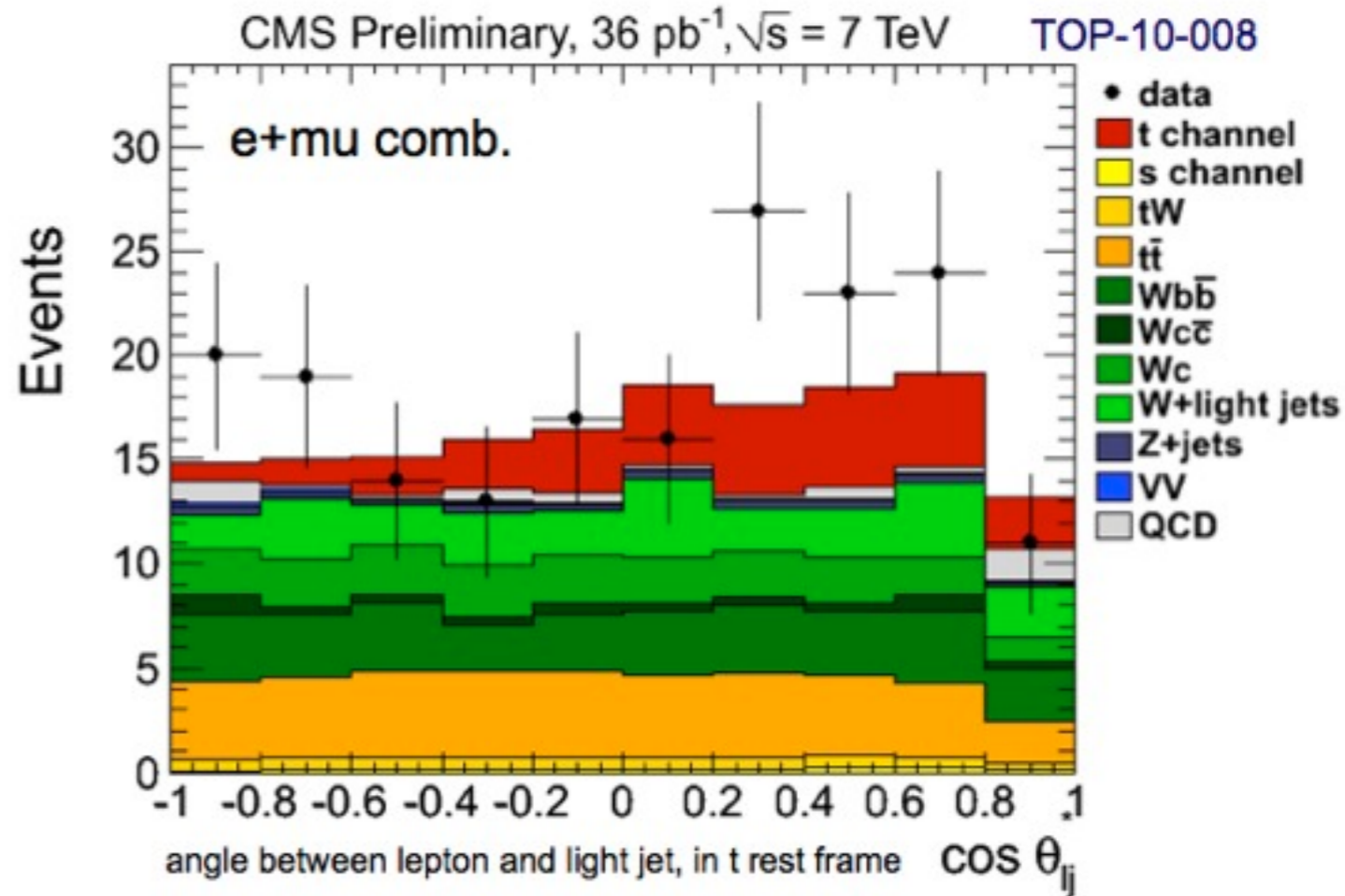
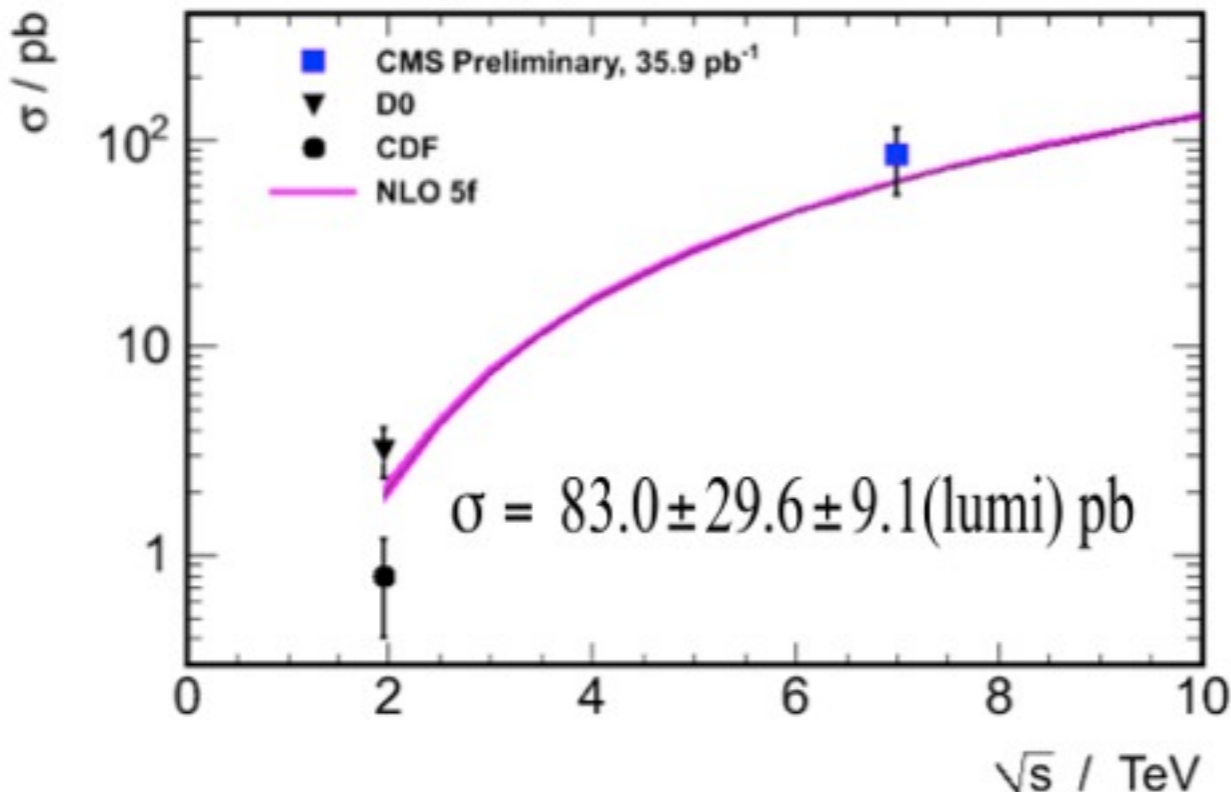


- Two different analysis using leptonic W decays
 - Cut based, using angular info + 1 btagged jet
 - BDT, based on kinematic observables

$$\frac{1}{\Gamma} \frac{d\Gamma}{d \cos \theta_{lj}^*} = \frac{1}{2} (1 + A \cos \theta_{lj}^*)$$

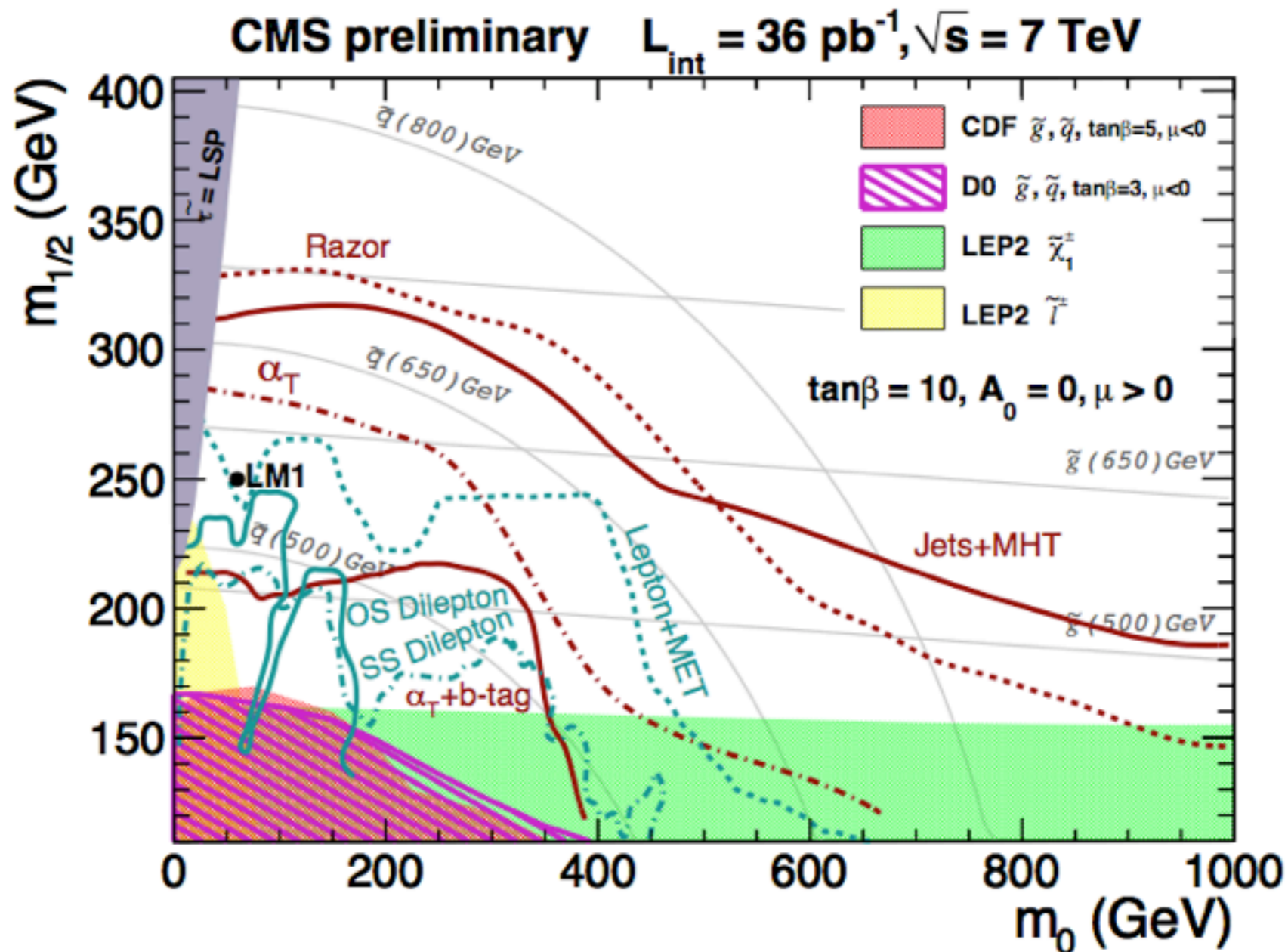


t-channel single top quark production



Single top at 3 sigma level in both analyses

Results on several analyses on SUSY signals (αT with and without b-tag, fully hadronic channels, di-photons, SS/OS dileptons, single leptons +MET, photons and MET, lepton spectrum and multi-leptons etc) have been produced.



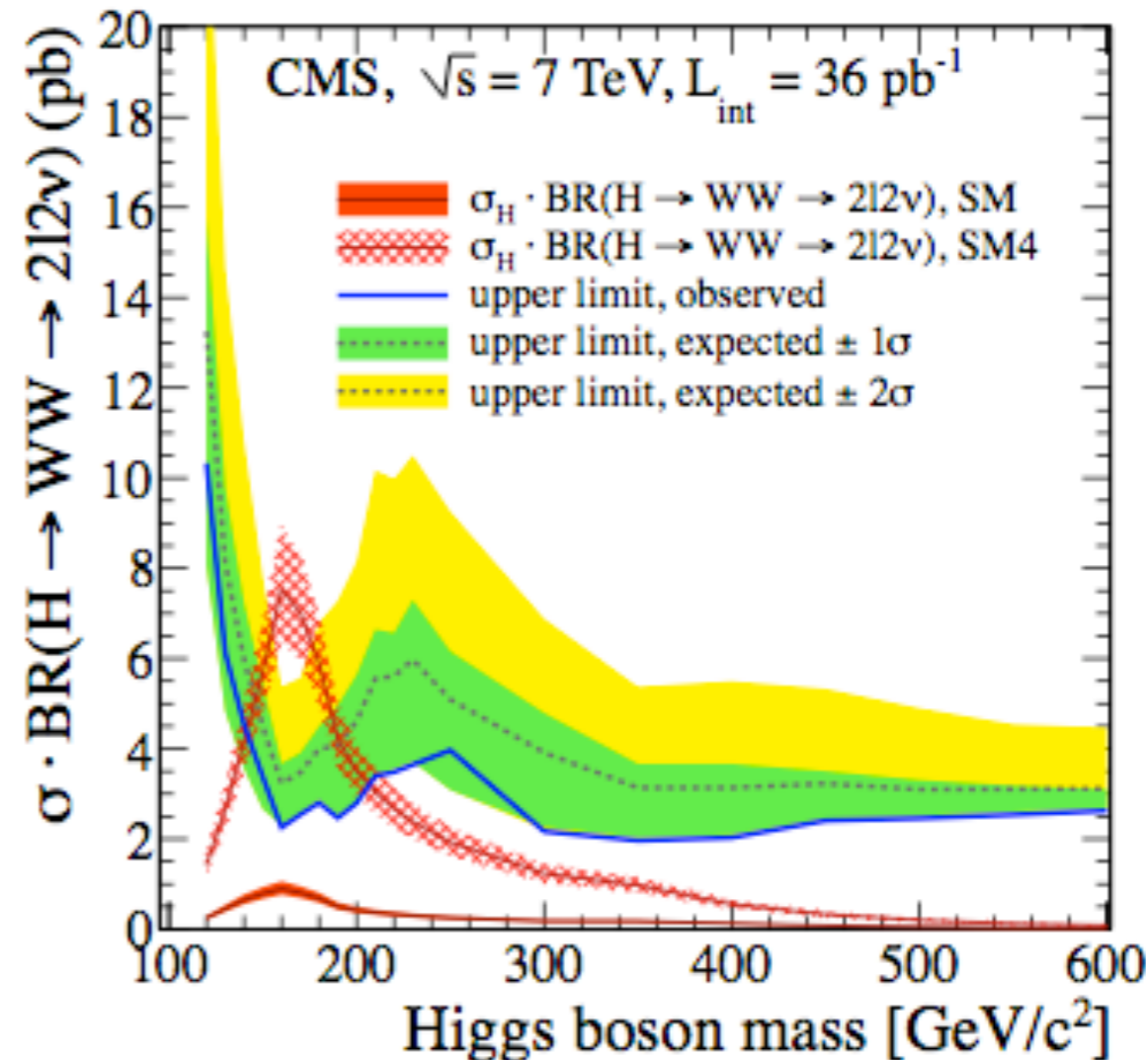
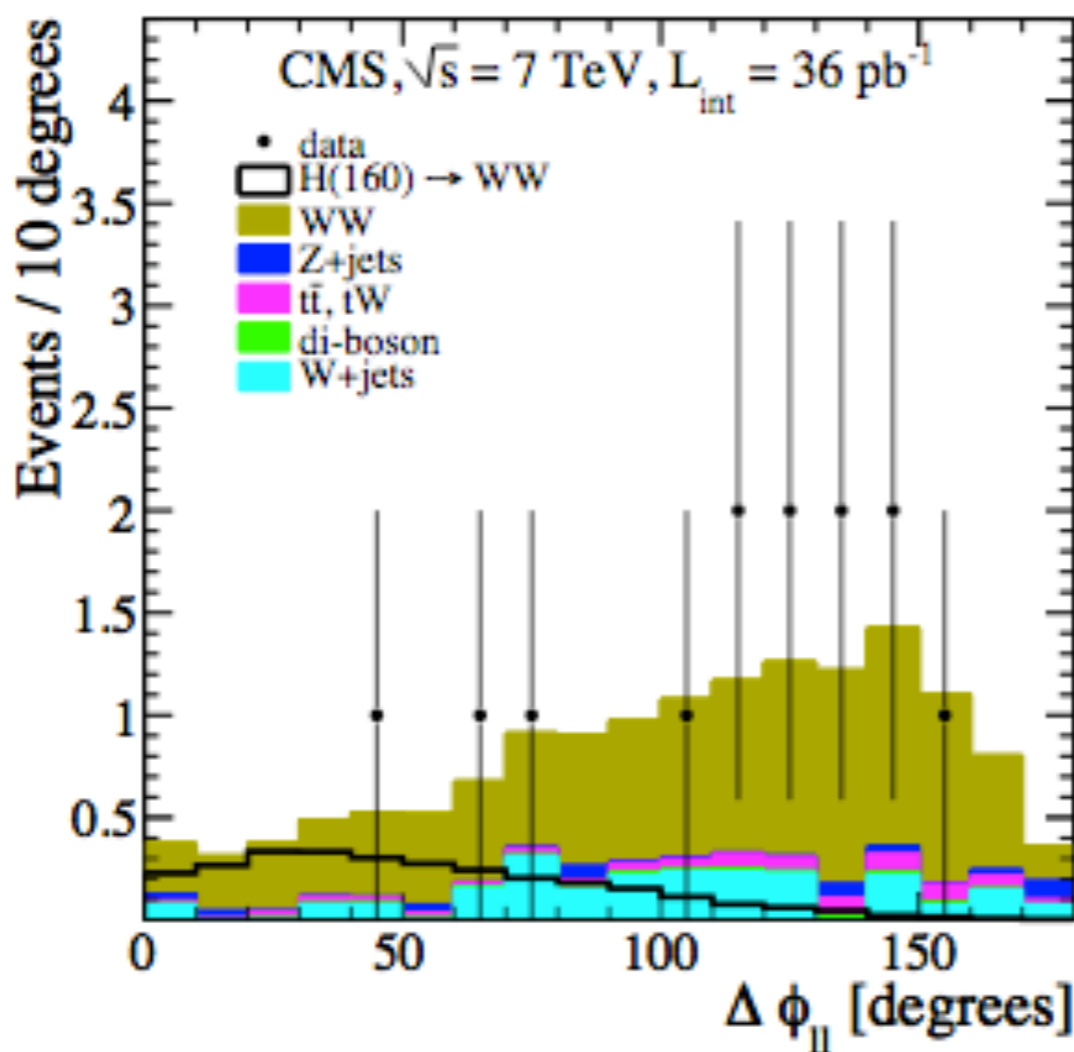
Conservative statistical approach to extract limits adopted by CMS. Prospects for 2011: discover squarks and gluinos (if SUSY is a symmetry of nature) well above 1TeV.



First CMS result on the SM Higgs: $H \rightarrow WW$

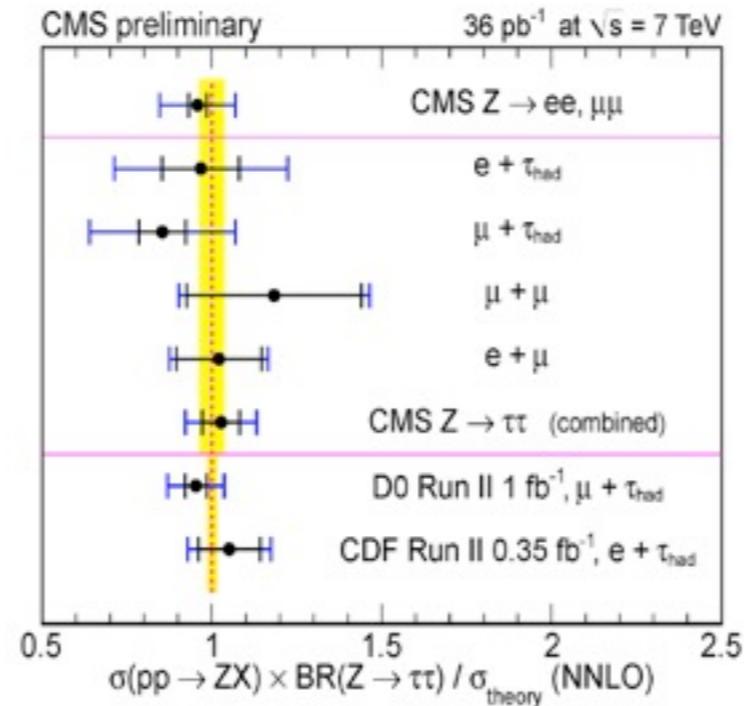
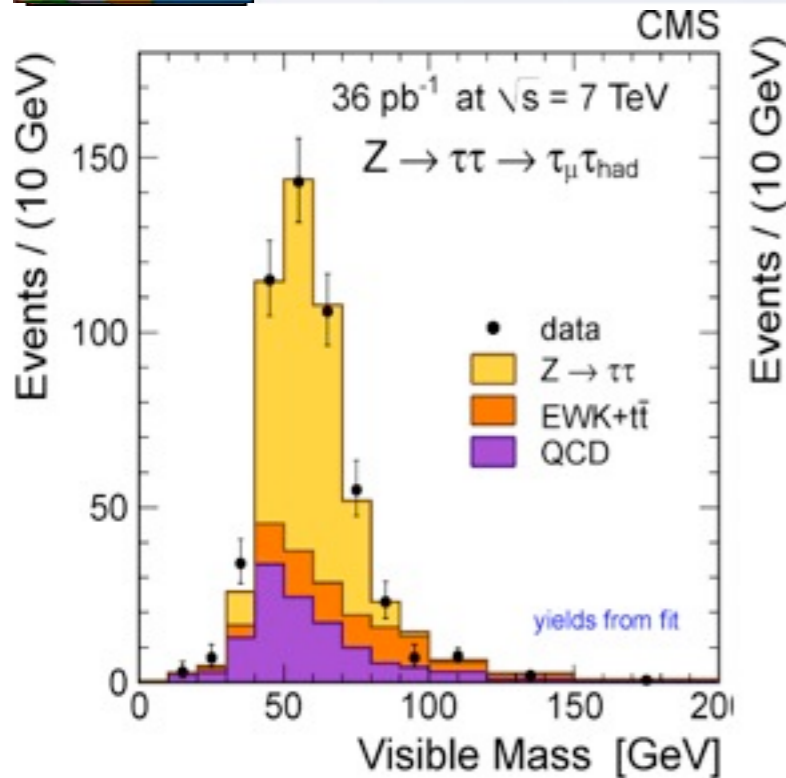


36pb⁻¹



- ☞ 4th-f generation case: excluded region $m_H = [144 - 207] \text{ GeV}$
- ☞ SM case: excluded $\sim \times 3$ SM expectation at $m_H = 160 \text{ GeV}$

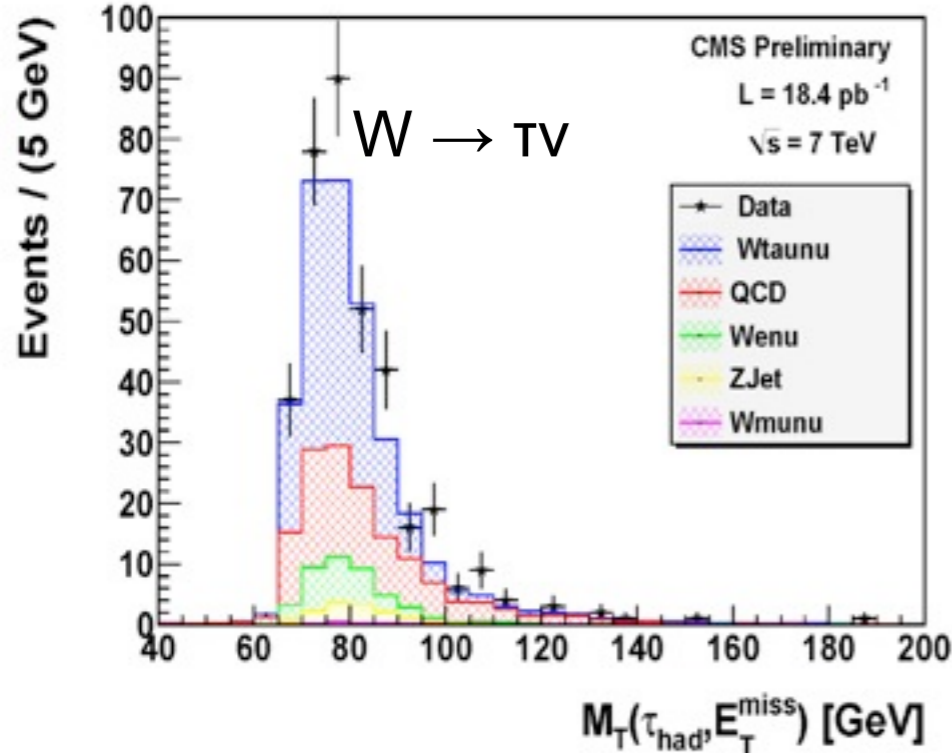
arXiv:1102.5429, *Phys. Lett. B* 699 (2011) 25-47



arXiv:1104.1617

To be published on JHEP

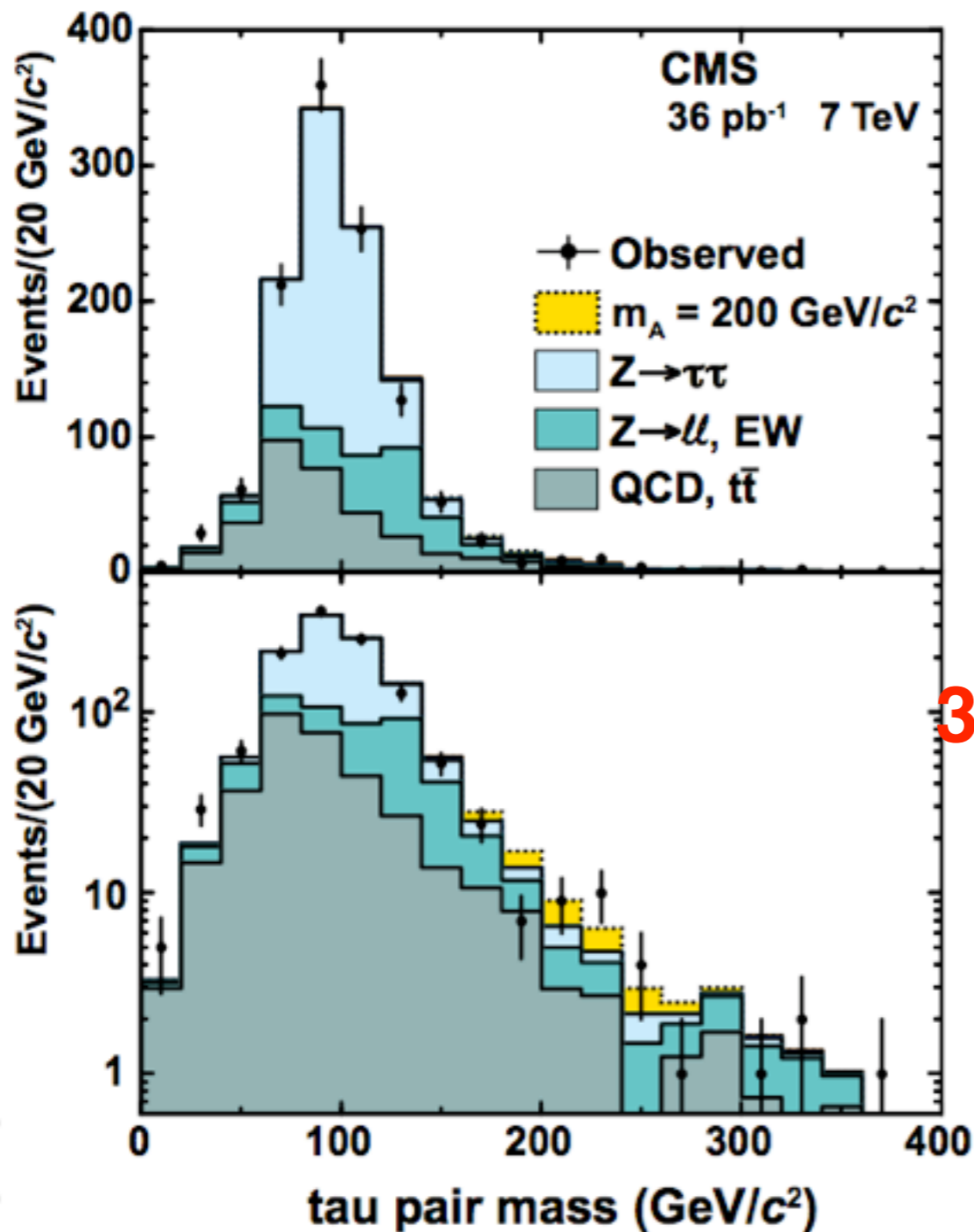
CMS PAS EWK-11-002



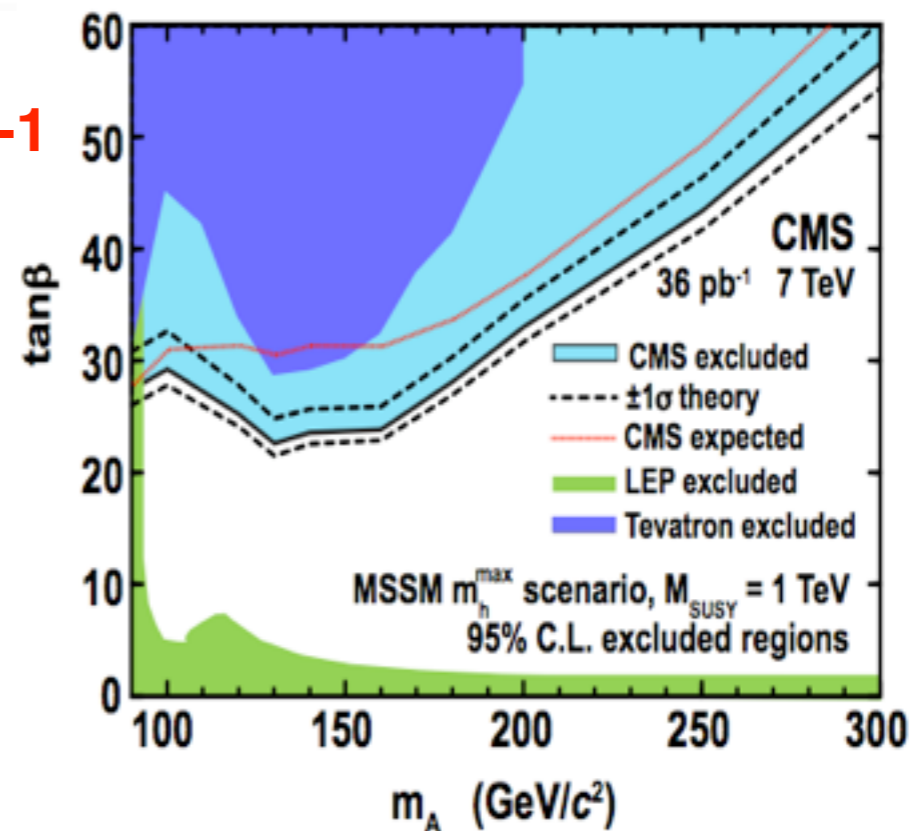
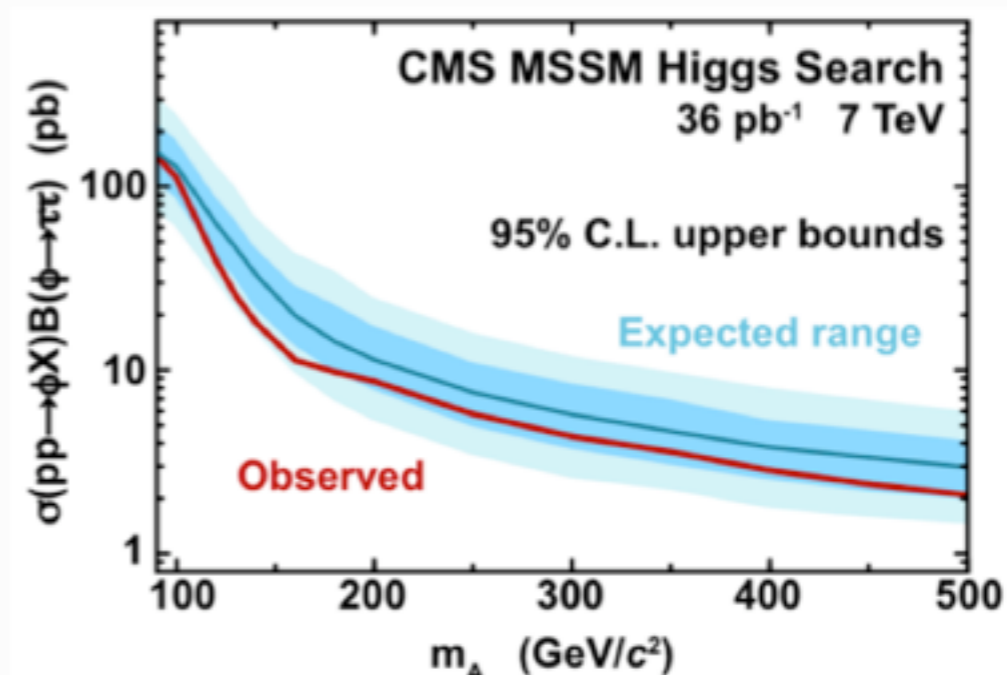
F. Paia INFN PISA

- G. Bagliesi (convener gruppo EWK tau in CMS)
- S. Coscetti ($W \rightarrow \tau \nu$) (laureando)
- F. Gagliardi ($Z \rightarrow \tau \tau$) (laurea breve)

Nel 2011 iniziata attivita' per $H \rightarrow \tau \tau$
 M. Grippo (Laureanda), P. Squillacioti



36pb⁻¹



CMS-HIG-10-002-003. Accettato da Physical Review Letters



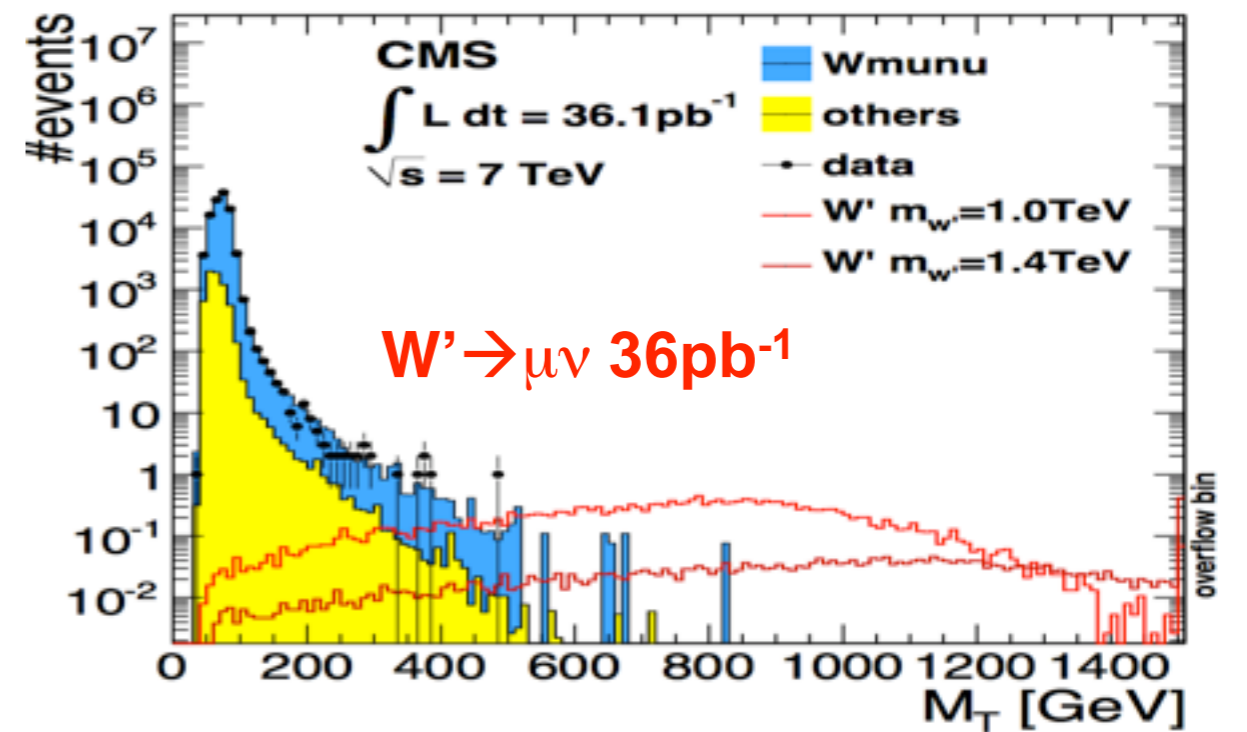
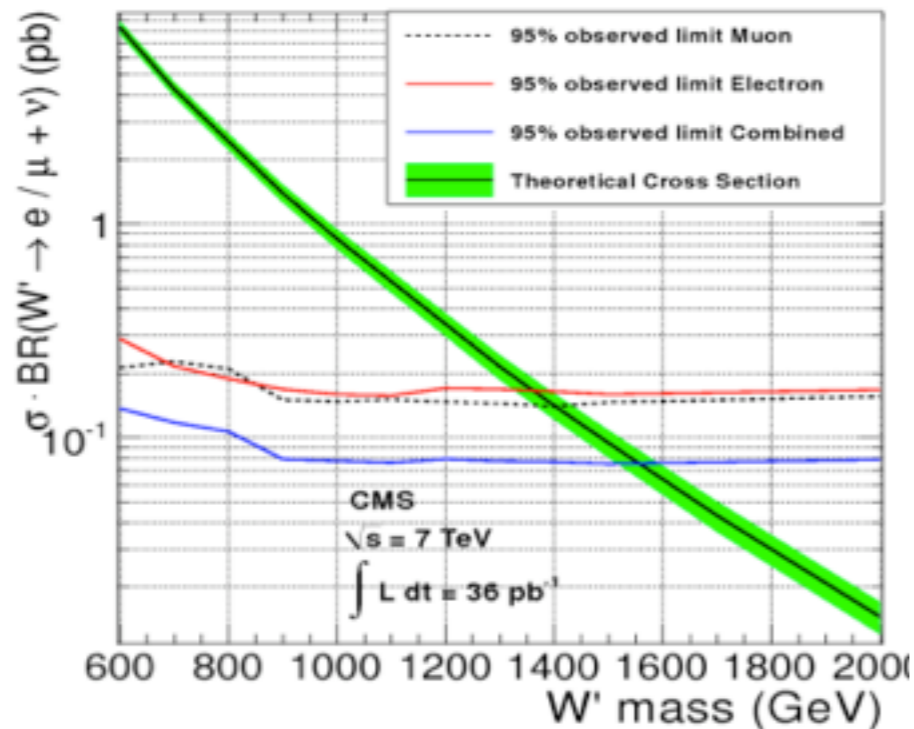
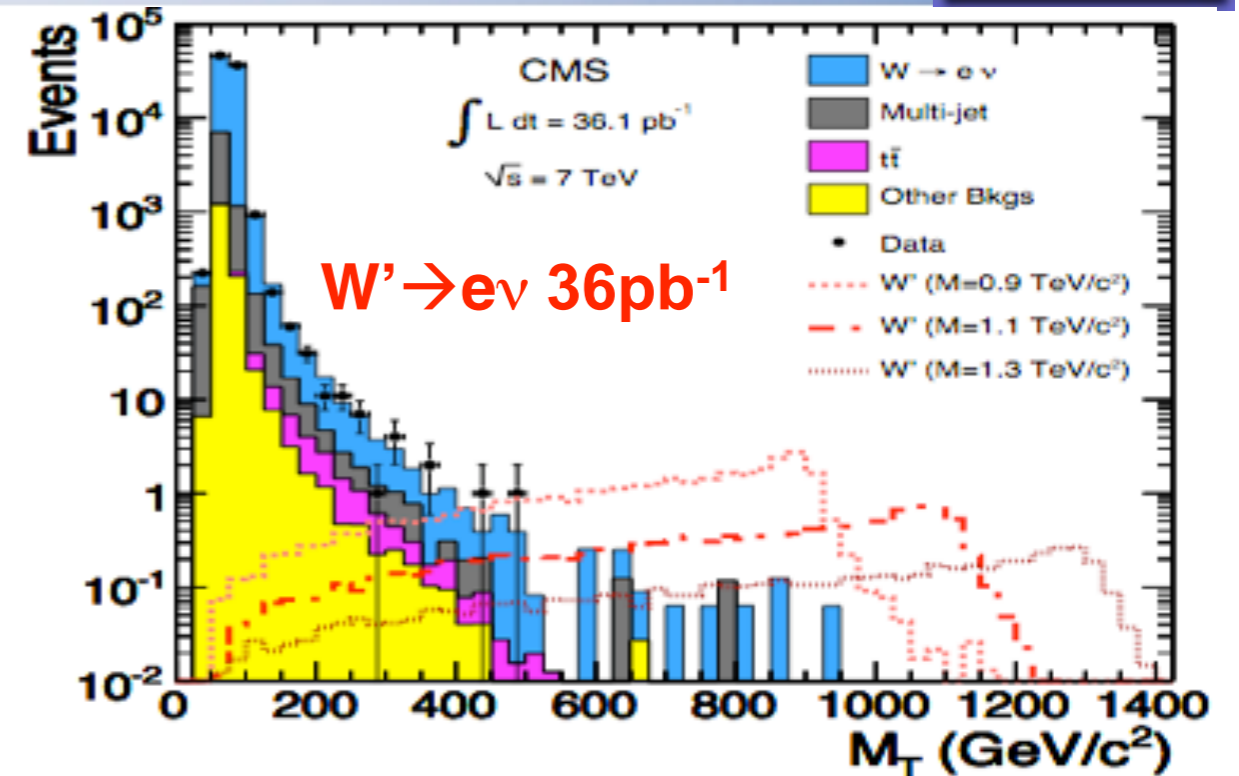
Massive vector bosons search



Evidence of massive extra bosons could possibly hint at new physics models.

With 2010 statistics we have been able to produce limits on W' and Z' exceeding the current limits set by the Tevatron experiments.

Assuming standard-model-like couplings and decay branching fractions we exclude a W' with mass < 1.58 TeV (95%CL)



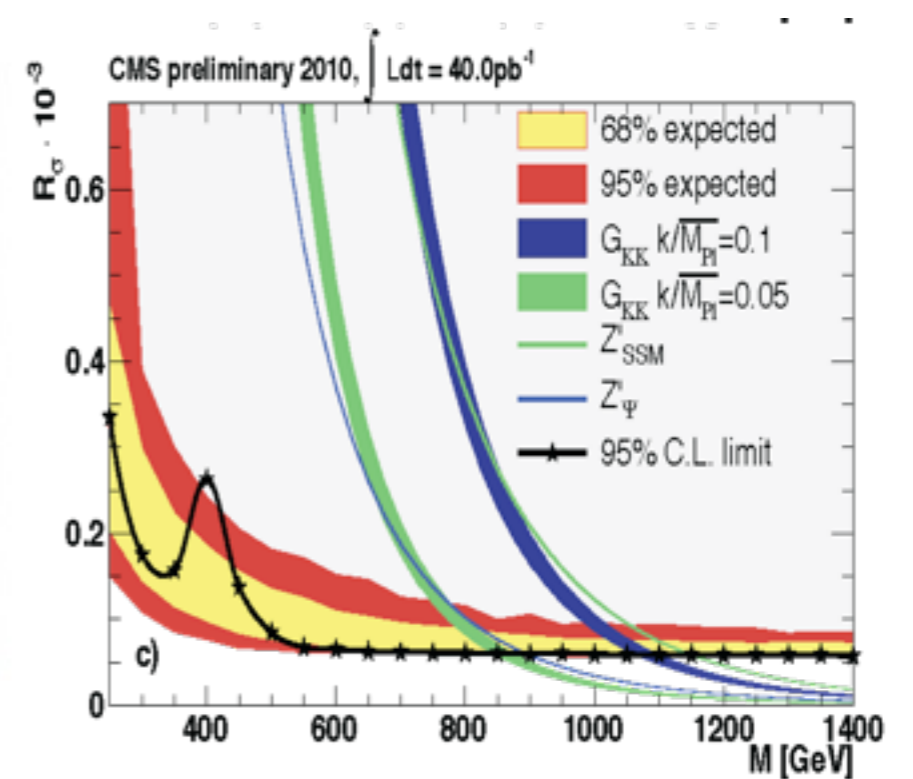
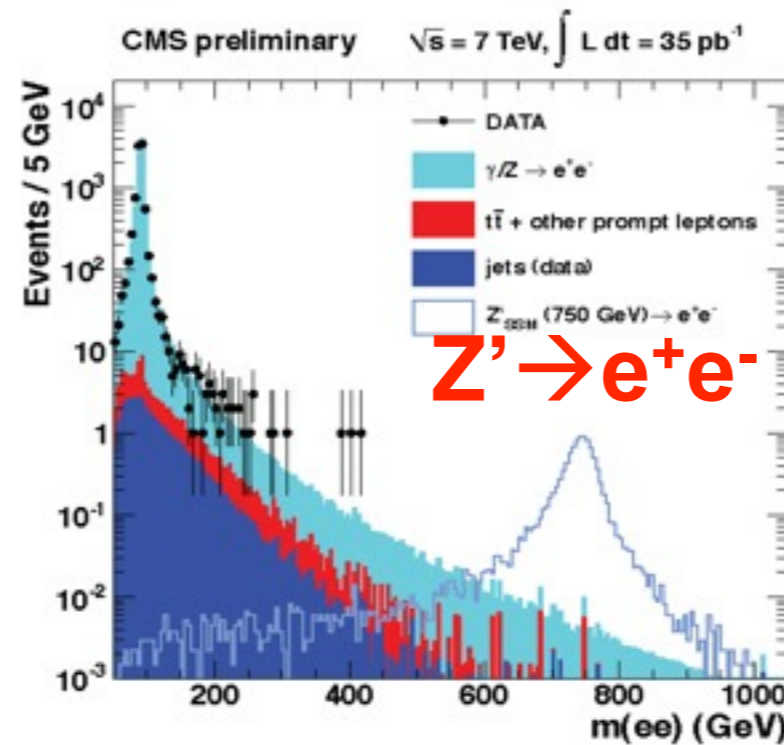
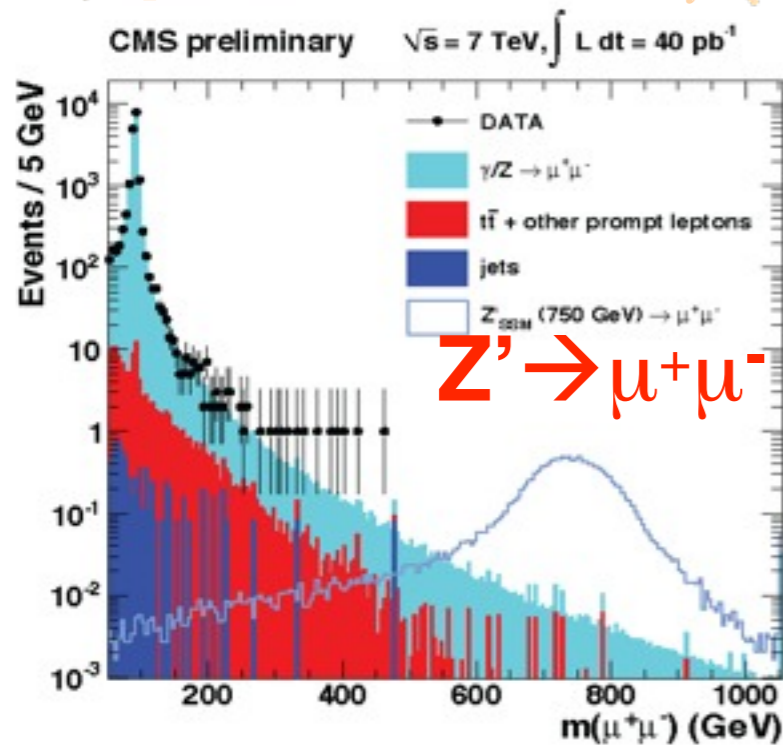
arXiv:1103.0030 Accettati da Physics Letters B.



Search for Z' in dileptons



We study in detail the high mass tail of the Z.
The spectra are consistent with known SM processes.



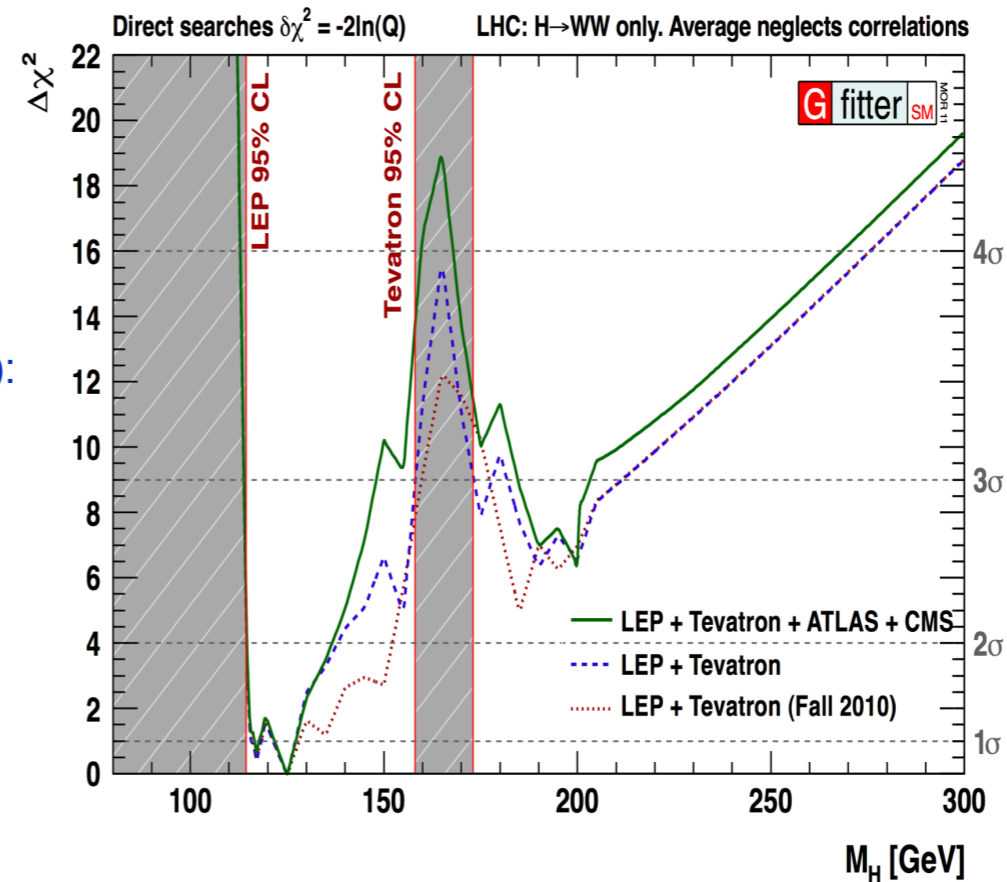
By combining the $\mu^+\mu^-$ and e^+e^- channels, the following 95% C.L. lower limits are obtained: **1140 GeV** for the Sequential Standard Model Z'_{SSM} , **887 GeV** for Super-String inspired models, Z'_ψ . RS Kaluza-Klein Gravitons are excluded below **855-1079 GeV** at 95% C.L. for values of couplings parameters (k/M_{Pl}) 0.05-0.1.

arXiv:1103.0981 ; CMS-EXO-10-013 . Accettati da JHEP **In 2011-12: explore deeply the multi TeV region.**

Global SM Electroweak Fit

- In the assumption of SM Higgs, one should keep into account indirect constraints as well
- **LEP + Tevatron (Fall 2010) :**
 - 2σ interval: [115, 152] GeV
 - $M_H = 120.2^{+17.9}_{-5.2}$ GeV
- **LEP + Tevatron (Moriond 2011):**
 - 2σ interval: [115, 138] GeV
 - $M_H = 120.2^{+12.3}_{-4.7}$ GeV
- **Fit with LEP + Tevatron + LHC (H→WW) searches (Moriond 2011) :**
 - 2σ interval: [115, 137] GeV
 - $M_H = 120.2^{+12.3}_{-4.7}$ GeV

If SM is correct, Higgs mass is determined to <10%



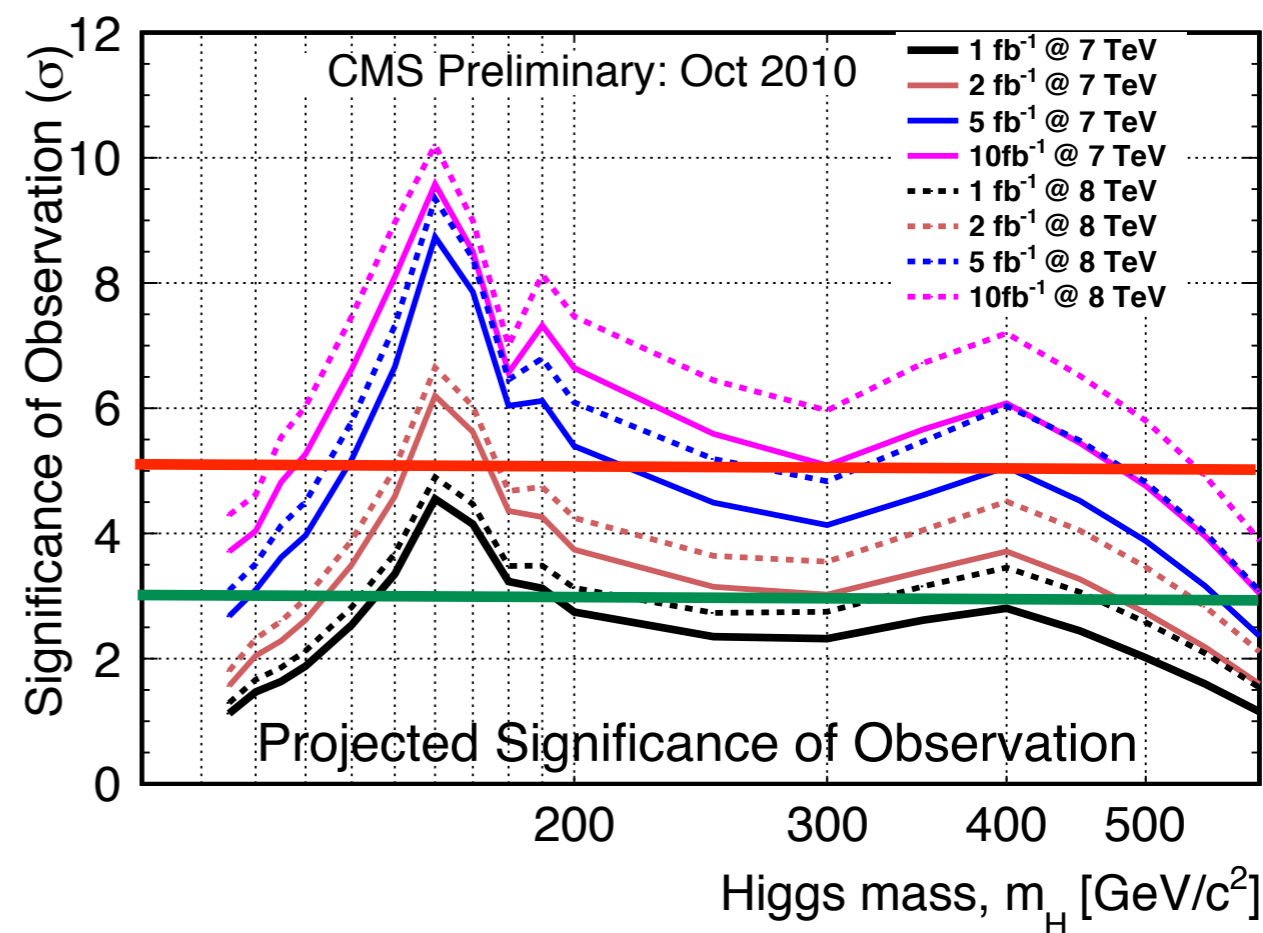
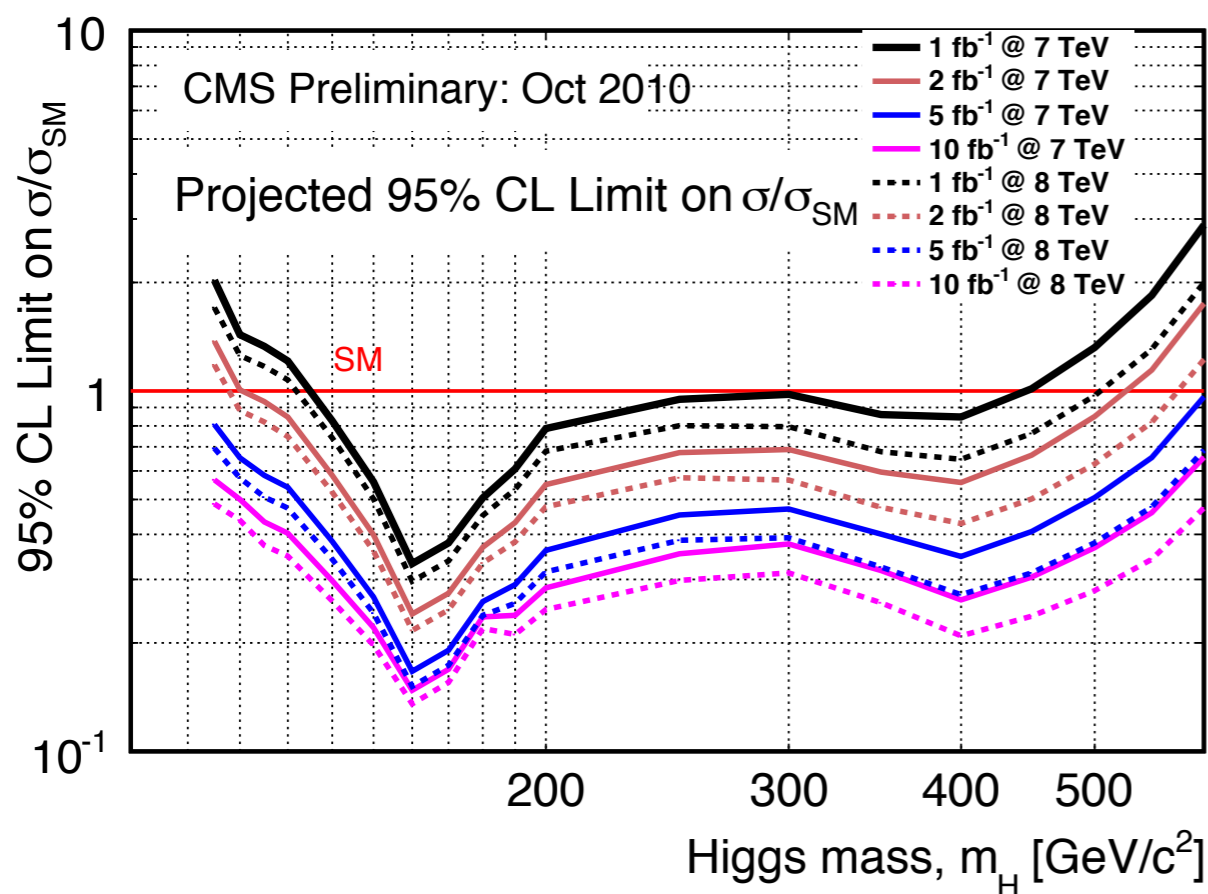
Indirect constraints are going to improve as well - see M. Verzocchi talk

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From G. Punzi, 23th Recontres de Blois, May 30, 2011



CMS Higgs prospects



Luminosità aspettata per il 2012 $>10 \text{ fb}^{-1}$.

È naturale contribuire alla ricerca dell'Higgs nella regione di bassa massa invariante data la grande esperienza del gruppo nel b- e nel tau-tagging.



Analisi a Pisa nel 2012



▪ Gruppi nel 2012:

♦ $B_s \rightarrow \mu\mu$:

- L. Martini (PhD Thesis, Siena), F. Palla

♦ $H \rightarrow \tau\tau$

- G. Bagliesi, S. Coscetti, F. Ligabue, M. Grippo (Laurea, Pisa), P. Squillacioti

♦ $H \rightarrow bb$

- P. Azzurri, J. Bernardini, T. Boccali, R. Dell'Orso, F. Fiori, F. Palla, A. Rizzi, A. Serban, P. Spagnolo, A. Venturi

♦ Top ed eventi multi-top

- R. Tenchini, R. D'Agnolo (PhD Thesis, SNS)



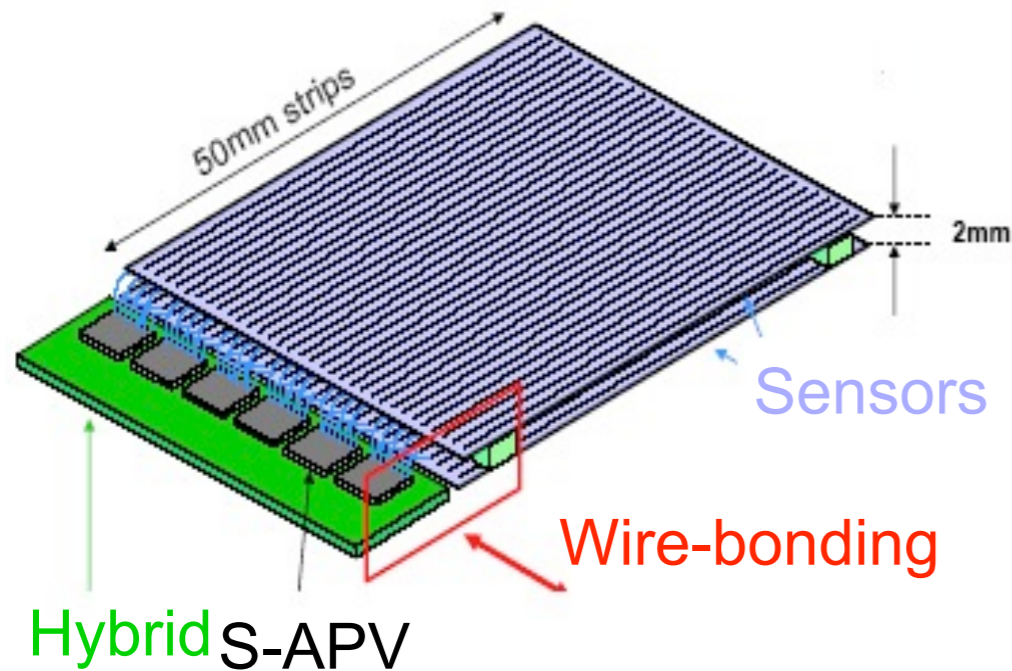
L1 Tracker Trigger



- **Simulazione e Costruzione di rivelatori a micro-strip:**
 - ♦ Per la misura della direzione di volo di particelle cariche
 - ♦ Dedicati a fornire trigger con CW e misura del pT
- **Attività svolta interamente a Pisa con materiale di recupero del tracciatore di CMS**
 - ♦ Attività finanziata con PRIN 2008 e residui delle assegnazioni 2010
 - attività di simulazione: G. Broccolo (Assegnista SNS)
 - attività di validazione con test beam e moduli “stereo” in CMS (dati di collisione!)
 - sinergia con il gruppo di Memorie associative (P. Giannetti, E. Pedreschi)
- **La proposta baseline di CMS, al momento prevede questi moduli come disegno originale**
- **Previsto un Phase2 TP nel 2014. Dovremmo (ri)iniziare a discuterne con l'INFN**

J. Bernardini, F. Bosi, G. Broccolo, R. Dell'Orso, F. Fiori, A. Messineo, F. Palla, E. Pedreschi, A. Profeti, P. G. Verdini

Doppietto di sensori a microstrip



Proposal by R. Horisberger

- The stacked module:
 - two sensors in a stacked module unit are glued one on top of the other
 - Wire micro-bonding connects the stacked unit to a readout hybrid (F.E.)

TIPP 2011
Technology and Instrumentation in Particle Physics
JUNE 17-18, 2011, University of Chicago, Chicago, IL

SS: Sensitivity to CW

TOB Layer 6

→ Tracks CW correlated with reco p_T for various clustering thresholds

- >> CW decreases with p_T , as foreseen from theoretical model
- >> Good p_T sensitivity for higher clustering thresholds ($S/N > 6$)

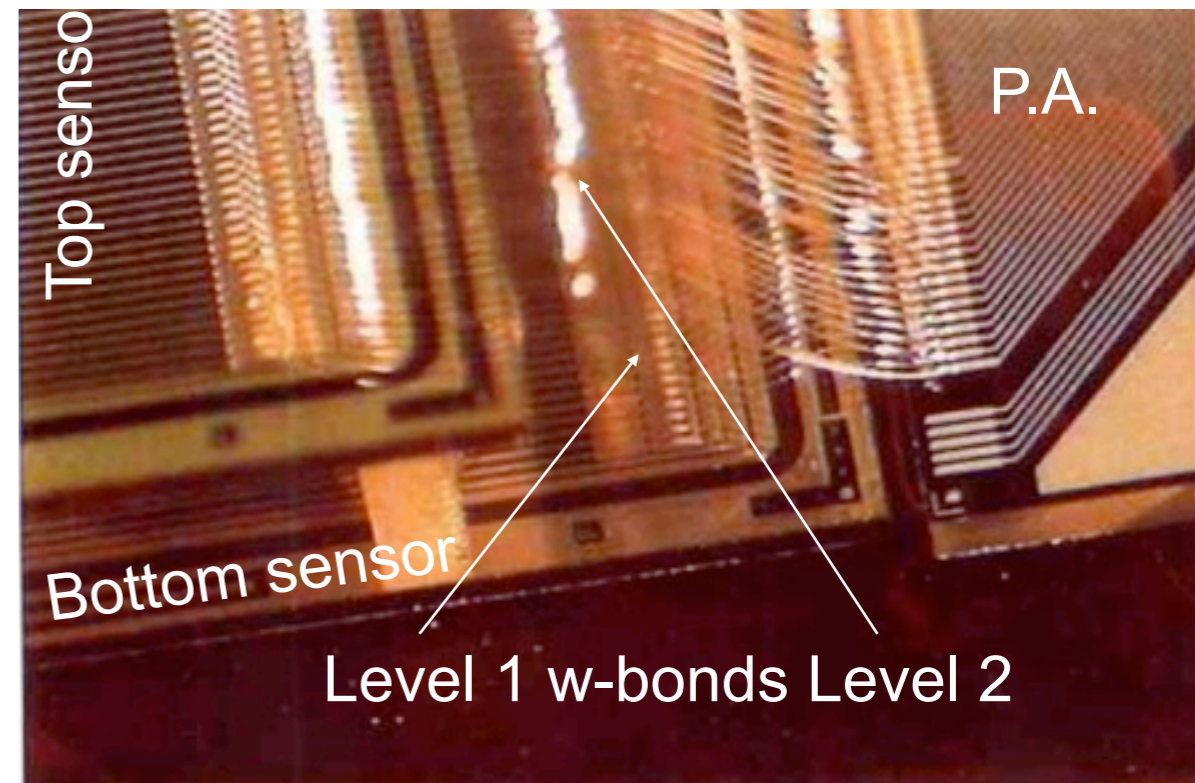
TOB Layer 6

→ Tracks selected with CW < 3

- >> Selection efficiency as a function of p_T superimposed to track p_T distributions
- >> Efficiency > 90% yet from 2 GeV/c

G. Broccolo, "Design & studies of μ -strip stacked module prototypes for tracking @ SLHC", TIPP2011 Chicago, 10/6/11

5





Responsabilità 2012



- **G. Tonelli: Spokesman-Emeritus** (3 mu)
- **R. Tenchini: Membro nel MB** (3 mu)
- **T. Boccali: Deputy computing** (6 mu)
- **F. Palla: Phase 2 Tracker Upgrade Steering Committee** (3 mu)
- **L. Foà: CB emeritus + membro dell'Editorial Board** (3 mu)
- **A. Rizzi: Co-convener gruppo Higgs->bb** (3 mu)
- **A. Venturi: Co-convener del Tracking POG** (3 mu)
- **A. Giassi: Co-convener del DAQ Tracker** (3 mu)
- **P. G. Verdini: Co-convener del TSS** (3 mu)
- **A. Messineo: Convener R&D Trigger Modules Phase 2** (3 mu)
- **G. Bagliesi: Co-Convener Tier2-CMS wide** (3 mu)



Gruppo 2012



Cognome	Nome	Posizione	FTE
Arezzini	Silvia	I Tecnologo INFN	0.30
Azzurri	Paolo	Assegnista SNS	1.00
Bagliesi	Giuseppe	I Ricercatore INFN	1.00
Basti	Andrea	Tecnologo	0.20
Bernardini	Jacopo	Postdoc SNS	
Boccali	Tommaso	Ricercatore INFN	1.00
Braccini	Pierluigi	Professore Ordinario	
Broccolo	Giuseppe	Assegnista SNS	1.00
Busseti	Enzo	Laureando	
Calligaris	Luigi	Laureando	
Calzolari	Federico	Tecnologo SNS	0.40
Castaldi	Rino	Dirigente di Ricerca INFN	1.00
Coscetti	Simone	Laureando	
Carboni	Andrea	Borsa tecnologica (da settembre)	0.50
Ciampa	Alberto	I Tecnologo INFN	0.30
Ciocci	Maria Agnese	Ricercatore Siena	0.40
D'Agnolo	Raffaele Tito	Dottorando SNS	1.00
Dell'Orso	Roberto	I Ricercatore INFN	1.00
Fiori	Francesco	Assegnista Dip	1.00
Foa'	Lorenzo	Professore Ordinario	1.00
Giassi	Alessandro	Ricercatore INFN	1.00
Grippo	Maria Teresa	Laureando	
Kraan	Aafke	Borsista INFN	1.00
Ligabue	Franco	Ricercatore SNS	1.00
Lomtadze	Temuri	I Ricercatore INFN	0.70
Martini	Luca	Dottorando Siena	1.00
Mazzoni	Enrico	Tecnologo	0.30
Messineo	Alberto	Ricercatore Universita' di Pisa	1.00
Moggi	Andrea	Tecnologo	0.20
Palla	Fabrizio	I Ricercatore INFN	1.00
Palmonari	Francesco	Assegnista Siena	0.00
Raffaelli	Fabrizio	Dirigente Tecnologo	0.30
Rolandi	Luigi	Professore SNS a tempo determin:	1.00
Rizzi	Andrea	Ricercatore tempo det. Universita'	1.00
Sanguinetti	Giulio	Senior	0.50
Serban	Alin	Straniero	1.00
Spagnolo	Paolo	Ricercatore INFN	1.00
Squillacioti	Paola	Assegnista Siena	1.00
Taneja	Sonja	Assegnista SNS	0.50
Tenchini	Roberto	Dirigente di Ricerca INFN	1.00
Tonelli	Guido	Professore Ordinario	1.00
Venturi	Andrea	Ricercatore INFN	1.00
Verdini	Piero Giorgio	I Ricercatore INFN	1.00
Vesentini	Alberto	Laureando	
Total FTE			28.60



Richieste 2012



- **Missioni interne:**
 - ♦ Riunioni tracciatore, riunioni CMS Italia, joint-meetings ATLAS-CMS, riunioni con i referees: 1KEuro x 28.6 FTE= 28.6 KEuro
- **Consumi**
 - ♦ Metabolismo (1.5 KEuro x 28.6 FTE)=42.9 KEuro
 - ♦ Affitto camionette al CERN (2x5KEuro) = 10 KEuro
 - ♦ Setup per i pixel = in corso di definizione
 - ♦ Manutenzione T2 = 15KEuro
- **Costruzione apparati (Calcolo!)**
 - ♦ in corso di definizione



Richieste 2012: Missioni Estere



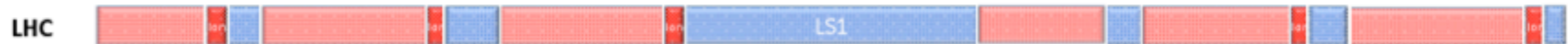
▪ Missioni estere:

- ♦ Servizi per attività al CERN per commissioning e operazione del rivelatore (MoA)
 - a Pisa competono 5 FTE di cui ~l'80% di lavoro al CERN: 4 FTE x 12 mesi = 48 MU
- ♦ Riunioni di collaborazione e metabolismo
 - 1 MU x 28.6 FTE = 28.6 MU
- ♦ Responsabilità (vedi responsabilità dettagliate)
 - 36 MU

- Pixel Upgrade

New Draft 10 year plan

2010					2011					2012					2013					2014					2015					2016																																																	
M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D



- Machine: Splice Consolidation & Collimation in IR3
- ALICE - detector completion
- ATLAS - Consolidation and new forward beam pipes
- CMS - FWD muons upgrade + Consolidation & infrastructure
- LHCb - consolidations
- ?Cryo-collimation point

X-Mas maintenance

X-Mas maintenance

*CERN is revisiting the LHC plan.
A draft is available.
The official revision available in June 2011*



SPS upgrade

? SPS - LINAC4 connection & ? PSB energy upgrade

2016					2017					2018					2019					2020					2021																																		
J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D



- Machine: Collimation & prepare for crab cavities & RF cryo system
- ATLAS: nw pixel detect. - detect. for ultimate luminosity.
- ALICE - inner vertex system
- CMS - New Pixel. New HCAL Photodetectors. Completion of FWD muons upgrade
- LHCb - full trigger upgrade, new vertex detector etc.

X-Mas maintenance

X-mas maintenance

- Machine - maintenance &
- ATLAS - New inner detector
- ALICE - Second vertex detector upgrade
- CMS - New Tracker



SPS - LINAC4 connection & PSB energy upgrade

08/03/2011

Steve Myers SLHC PP

Summary Performance Reach:

Performance Reach of the LHC

-Existing LHC & injectors can reach nominal performance with 25ns and 50ns beams: $L = 1 \cdot 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$

-Small emittance option with 50ns operation can reach: $L = 1.7 \cdot 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$

@ half nominal total beam current for 50ns beam option

-Nominal machine with LINAC4 and 50ns operation can reach: $L = 2.5 \cdot 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$

with approximately nominal total beam current

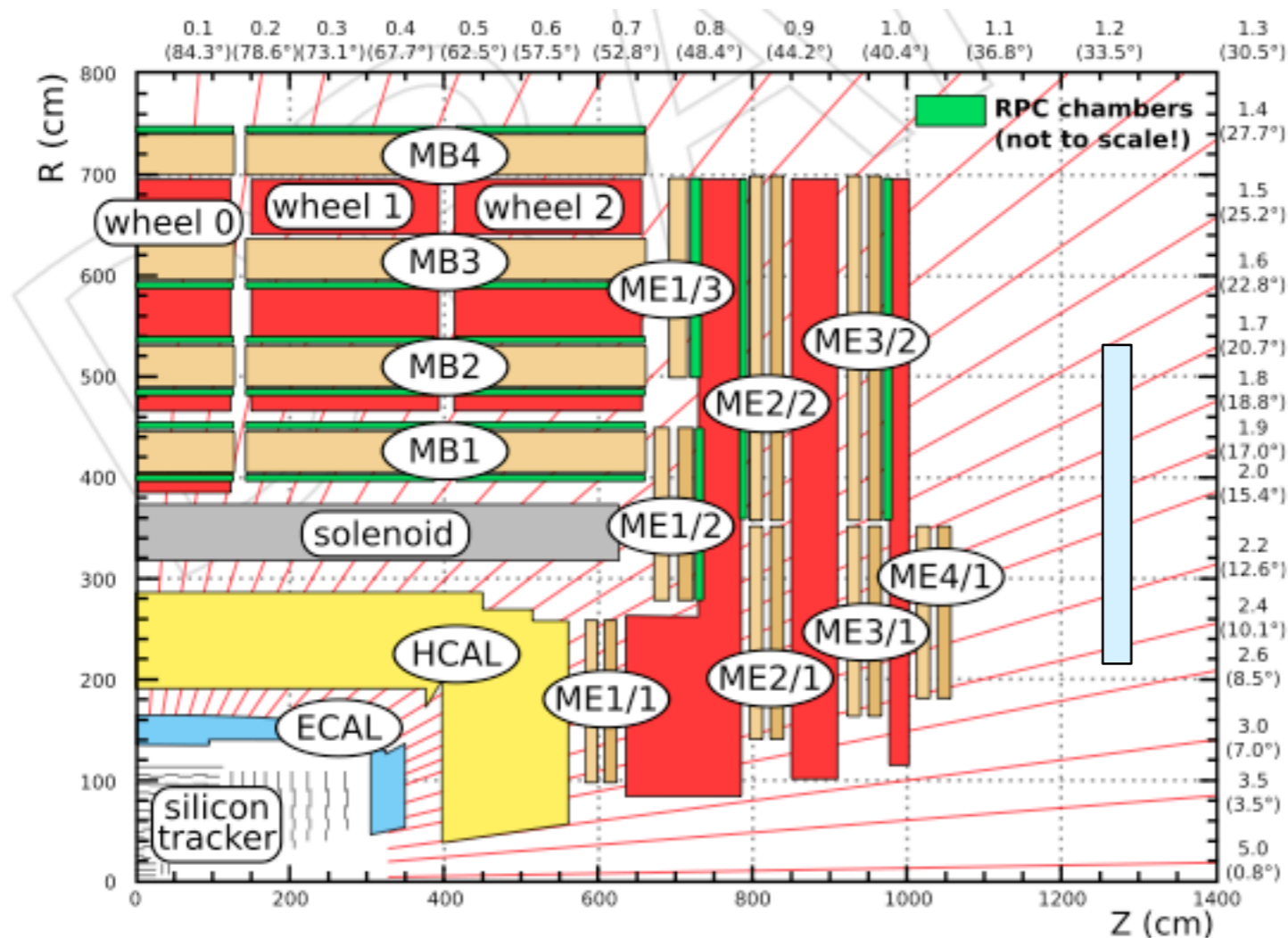
-Full upgrade can reach: $L \geq 5 \cdot 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$

with geometric reduction factor!

→ CC & LRBB wires are ideal tool for leveling!



CMS Upgrade Technical Proposal



DT: rimpiazzo delle TRB
Theta, spostamento e
rifacimento
delle Sector collector board
nella caverna di controllo

RPC: aggiunta di un quarto
layer nell'endcap
R&D per il rimpiazzo dei
rivelatori nel forward

CSC: ME1/1 canali di
lettura individuali Aggiunta
ME4/1 Nuova elettronica di
trigger

HB/HE/HO: rimpiazzo degli HPD con SiPM, segmentazione longitudinale

Calorimetria in avanti: rimpiazzo dei PMT per minore luce Cherenkov generati nel vetro

PIXEL: rifacimento totale

Trigger: passaggio allo standard μ TCA
DAQ: Aumento della banda di un fattore 2-5



Pixel upgrade: le ragioni



- Il rivelatore attuale è molto performante, tuttavia, il suo design permette di sostenere luminosità istantanee fino a $\sim 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$.
- Il piano di LHC è di un aumento di luminosità fino a $2.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ per il 2017
 - ♦ A $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ l'efficienza cala del 4-5% nel primo layer (diventa il 16% se il bunch spacing è di 50 ns)
 - ♦ A $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ si perde il 15% dei dati (50% a 50 ns)
 - ♦ 3 hit coverage $\sim 85\%$ per $|\eta| < 1.5$ degradando la performance nel track-seeding a HLT, compromettendo le capacità di trigger ad alta luminosità.
 - ♦ Fluenza Barrel Layer 1 $\sim 6 \times 10^{14} \text{ cm}^{-2}/\text{anno}$ a $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$, dopo 2 anni la CCE si riduce al 50% e la hit resolution degrada.



Piano di rimpiazzo dei pixel



- **Nuovo layout con 4 barrel layers e 3 dischi per parte**
 - ♦ **Riduzione dell'inefficienza di readout**
 - **Nuovi chip di lettura con inefficienze <5% nel primo layer per $L = 2 \cdot 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$**
 - ♦ **Riduzione del material budget del 50%**
 - **Diminuzione dello scattering multiplo, conversioni di fotoni e interazioni nucleari**
 - **miglior precisione nel parametro d'impatto e maggiore efficienza di ricostruzione**
 - ♦ **Inserzione di un nuovo layer (raggio 160 mm) più vicino al TIB Layer1**
 - **Aumento dell'efficienza di track seeding e l'ermeticità**
 - **Tracciatura più efficiente, anche a HLT**
 - **Aumento della ridondanza e robustezza della pattern recognition**
 - **Migliore tracciatura per jet di alte energie**
 - **Eventuale "copertura" dei possibili rischi nell'inner layer del TIB.**
 - ♦ **Riduzione del raggio interno del primo layer da ~44 mm a ~39 mm (possibilmente 30 mm) con una nuova beampipe di 25 mm di raggio (22.5 mm in discussione)**
 - **Migliore b-tagging**
 - **Riduzione della dipendenza del charge sharing e mantenimento della risoluzione con più radiazione**



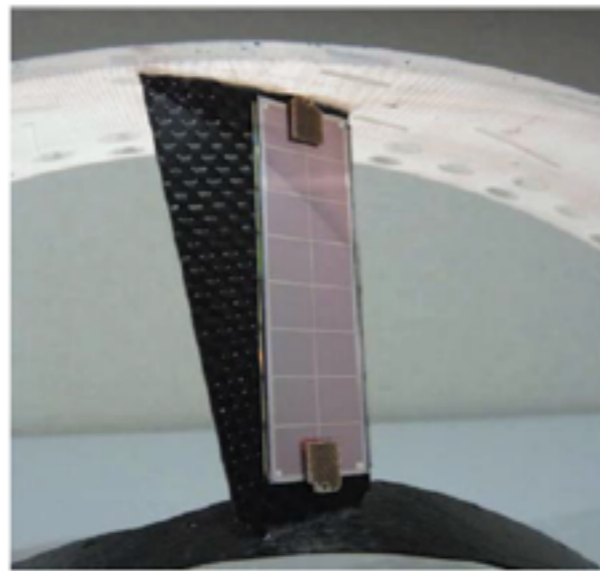
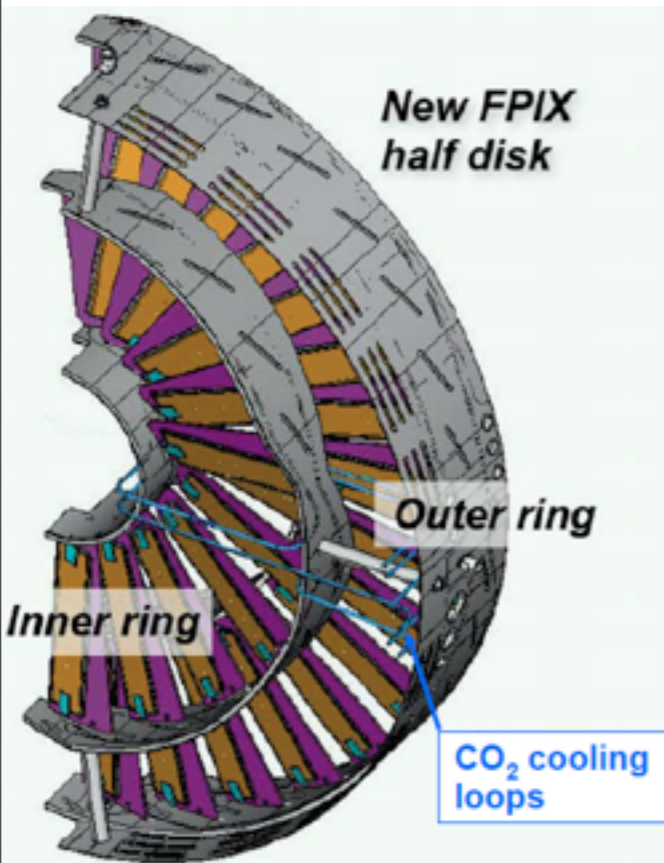
Broad brush description Pixel Upgrade - Systems



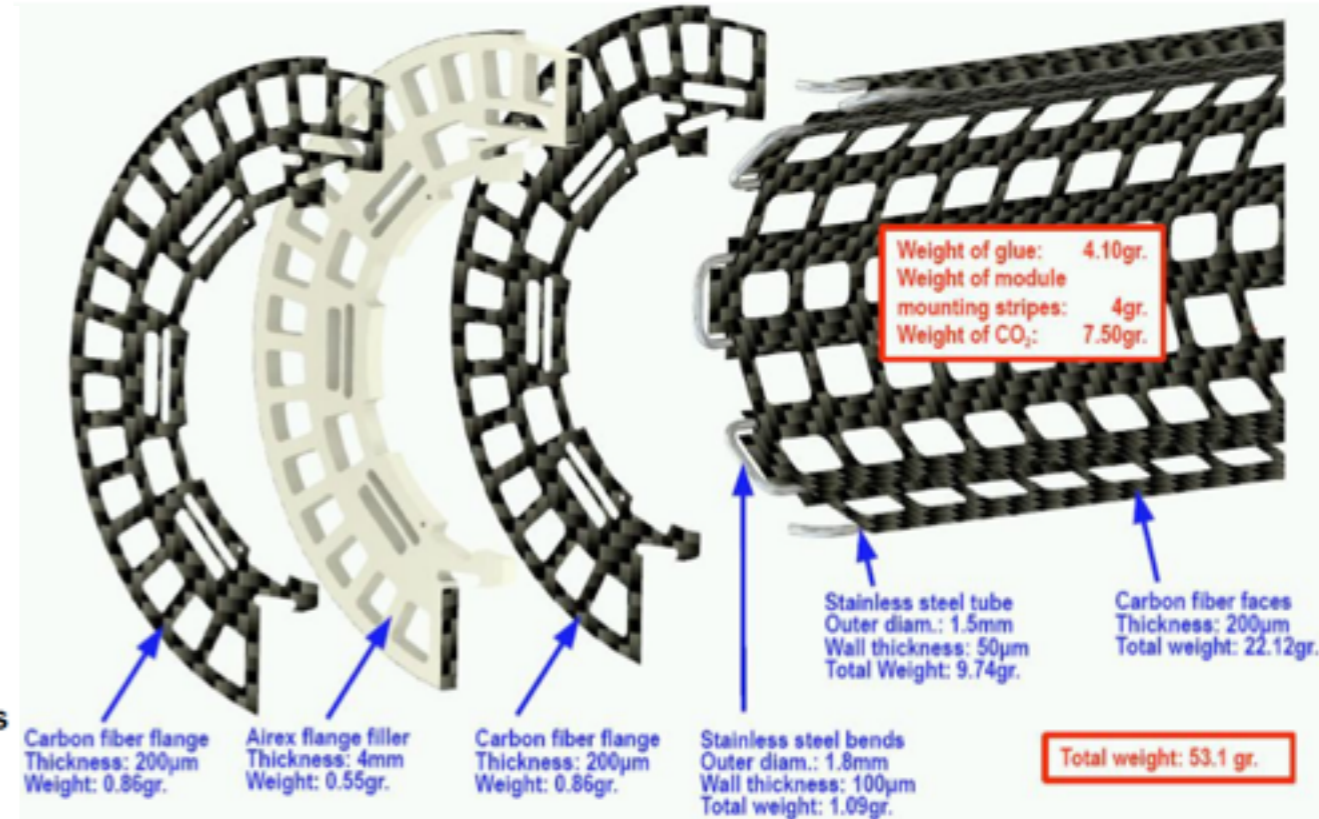
- **New PSI46dig ROC:**
 - Reduce data losses at high luminosity
 - Robust digital readout link for higher data rate transmission
 - Protection mechanism against large clusters induced by beam background (**observed in present Pixel**)
- **New Cooling System: CO₂ Cooling**
 - Higher refrigeration capability, smaller pipes, lower mass fluid, reduce contribution to MB etc.
- **New Power System: DC-DC conversion Power System**
 - Lower currents, lighter internal cables, reduce contribution MB
- **New Optical Readout link System: 320 MHz digital optical link**
 - Replace obsolete analog link with more robust digital link, with new lasers, new opto-hybrids and new opto-receivers
- **Modified DAQ and Control Systems**
 - Preserve present TTC, Px FEC
 - Modify Px FED to adapt to digital 320 MHz Readout
 - Fall forward Inner Layers option compatible with these read-out and controls systems

Forward Pixel Mechanics

Barrel Pixel Mechanics

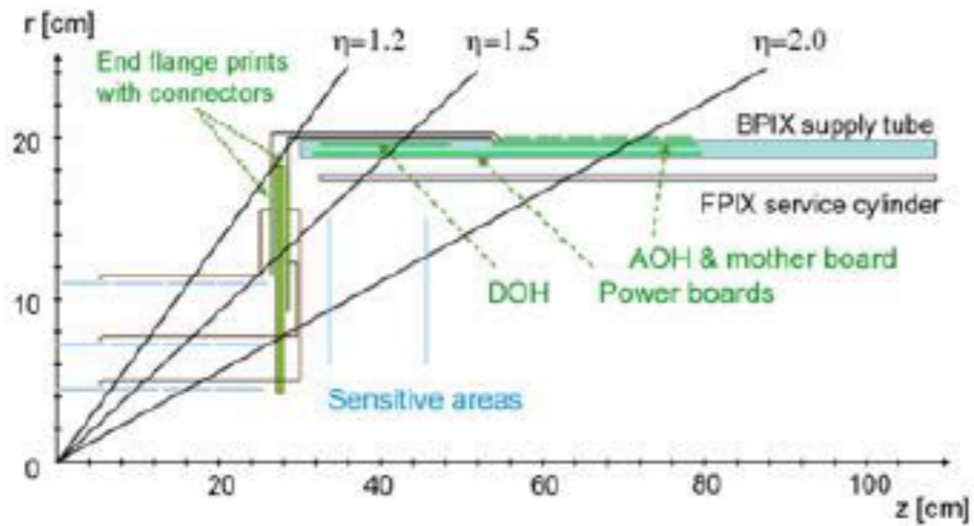


- inner & outer ring for easier replacement
 - 6 disk of 112 sensors each → 672 modules
 - one module size with 2x8 ROC / module
- 10'752 ROC's ~ **44M pixel** (2.5 x old FPIX)



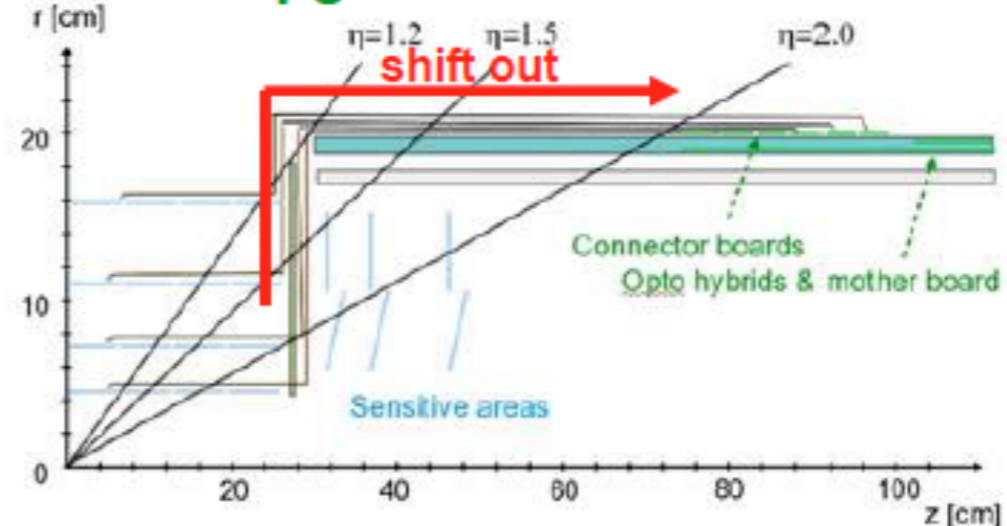
- 4 Barrel layers with 1.216 modules
- One module 2x8 ROCs
- 19.456 ROC's ~ **80M pixel**

Current BPIX Services

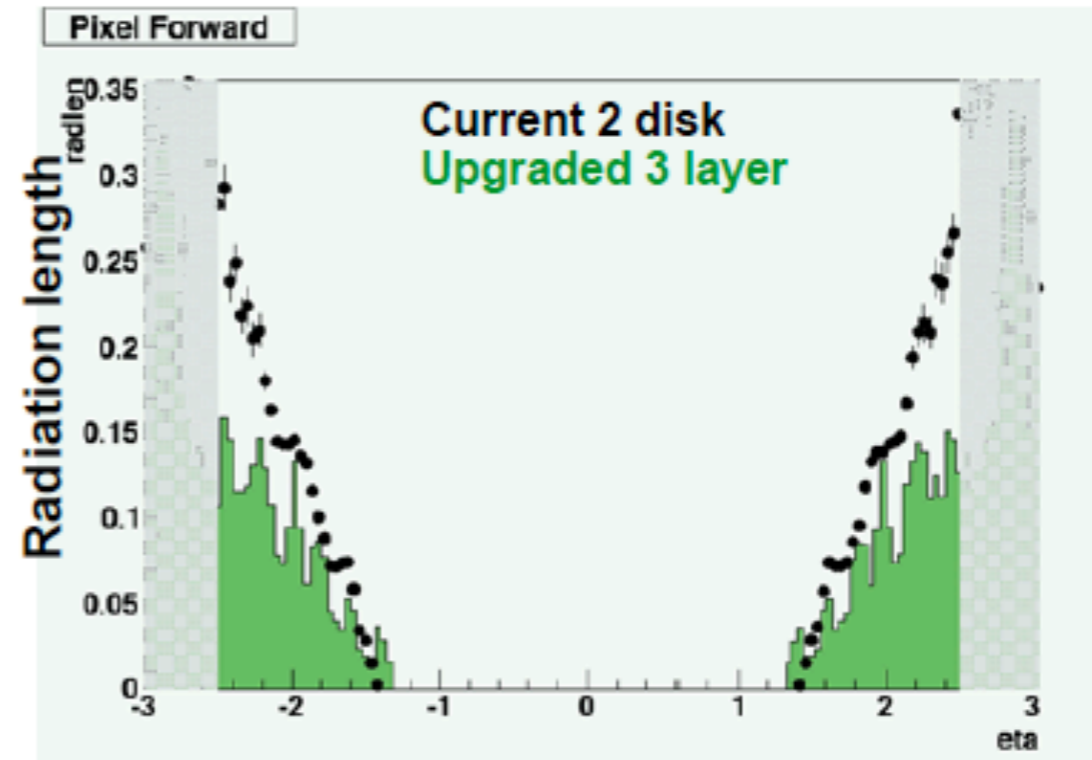
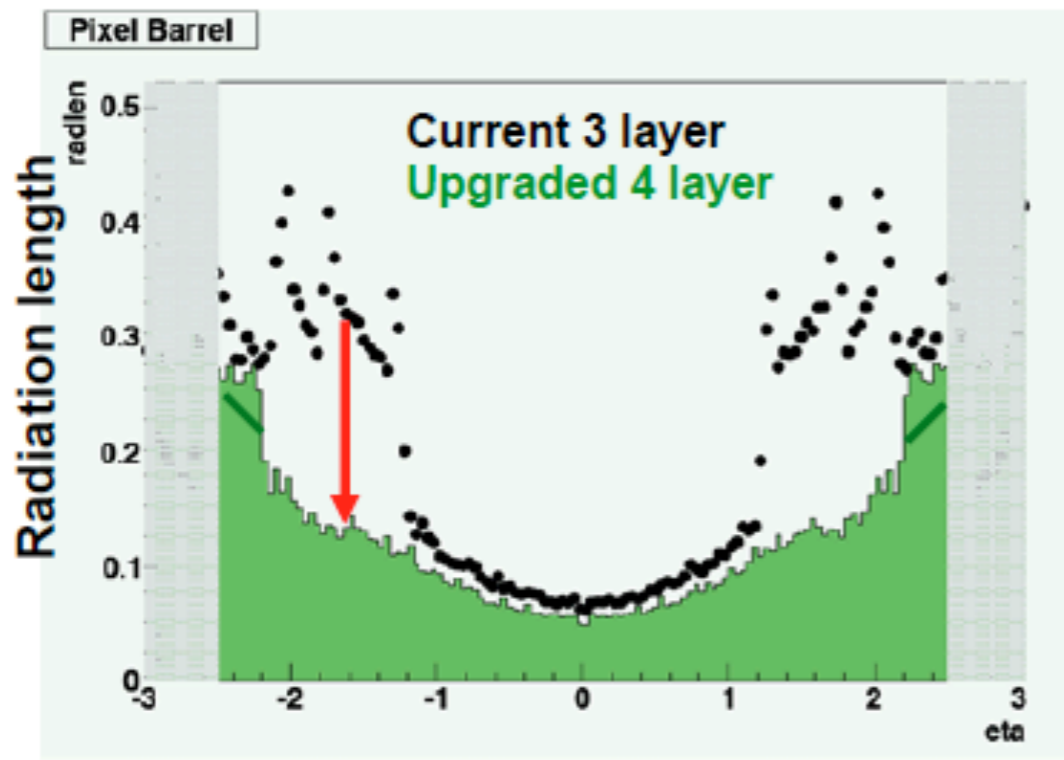


$\eta < 2.2$: weight = 16.9 Kg (3 layer)

Upgraded BPIX Services



$\eta < 2.2$: weight = 6.5 Kg (4 layer)



Major reduction (~ 50-60%) of Material Budget



Tracking efficiency at $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$

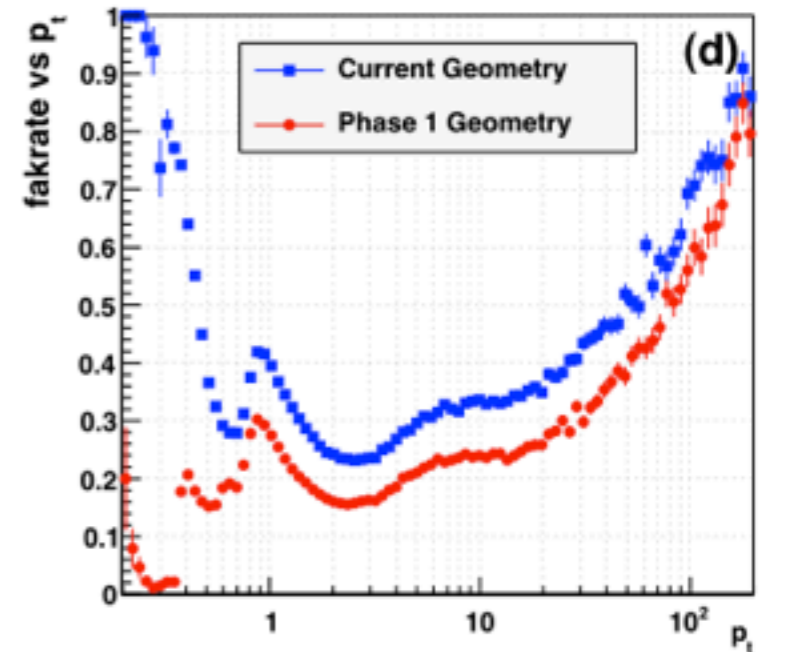
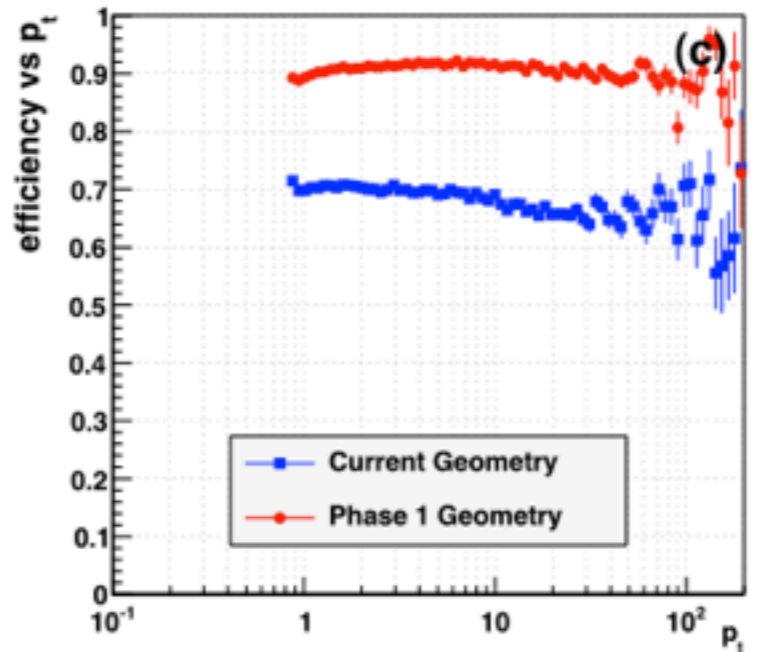
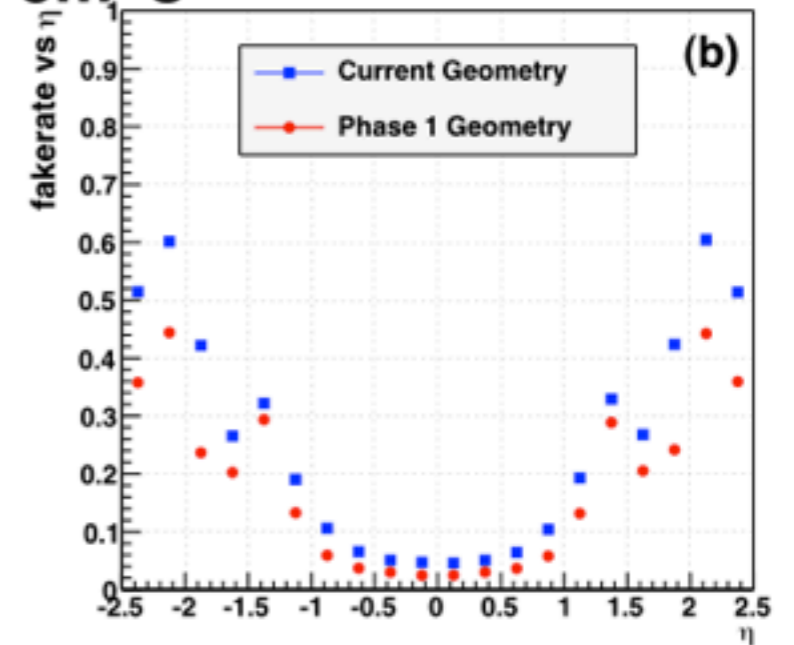
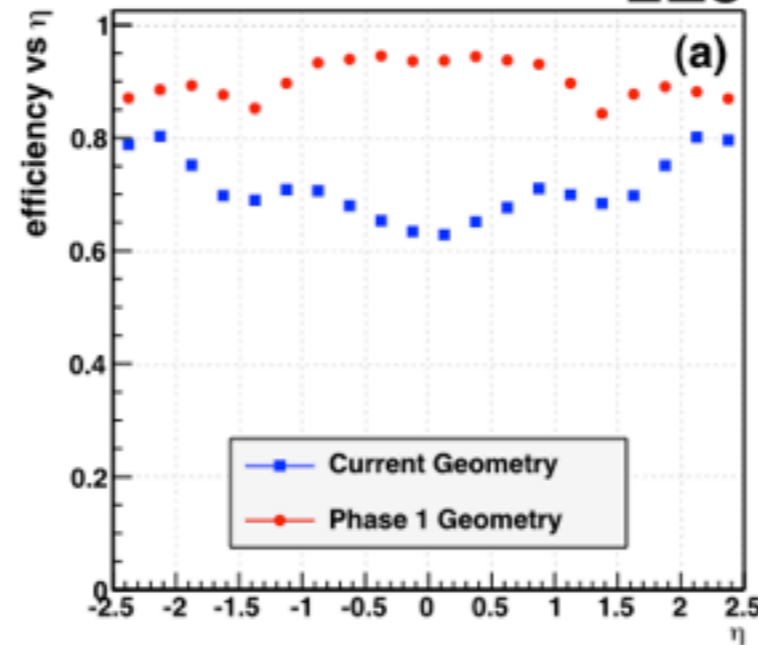


$2E34 \text{ cm}^{-2} \text{ s}^{-1}$ ttbar sample

- Phase 1 with data loss
- Std Geometry with data loss

Present Detector	Radius (cm)	% Data loss at 2×10^{34}
BPIX1	4.4	16
BPIX2	7.3	5.8
BPIX3	10.2	3.0
FPIX1&2		3.0

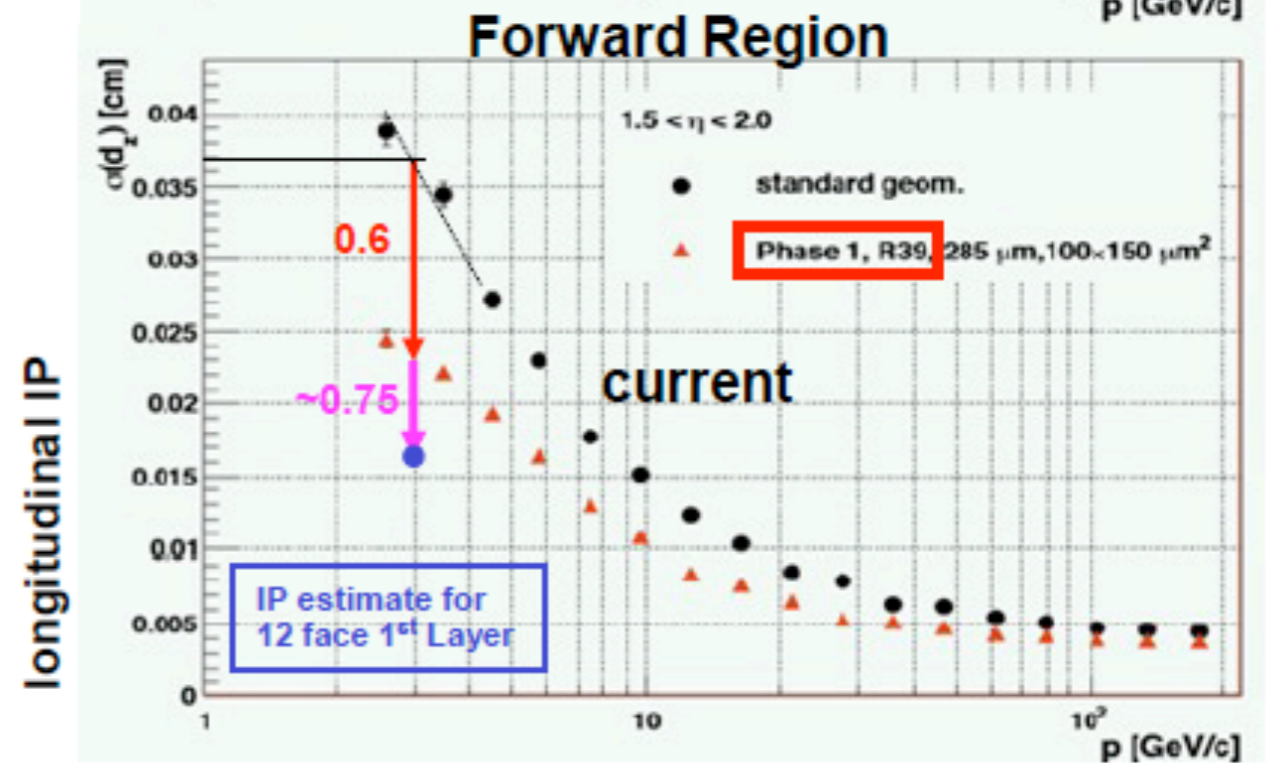
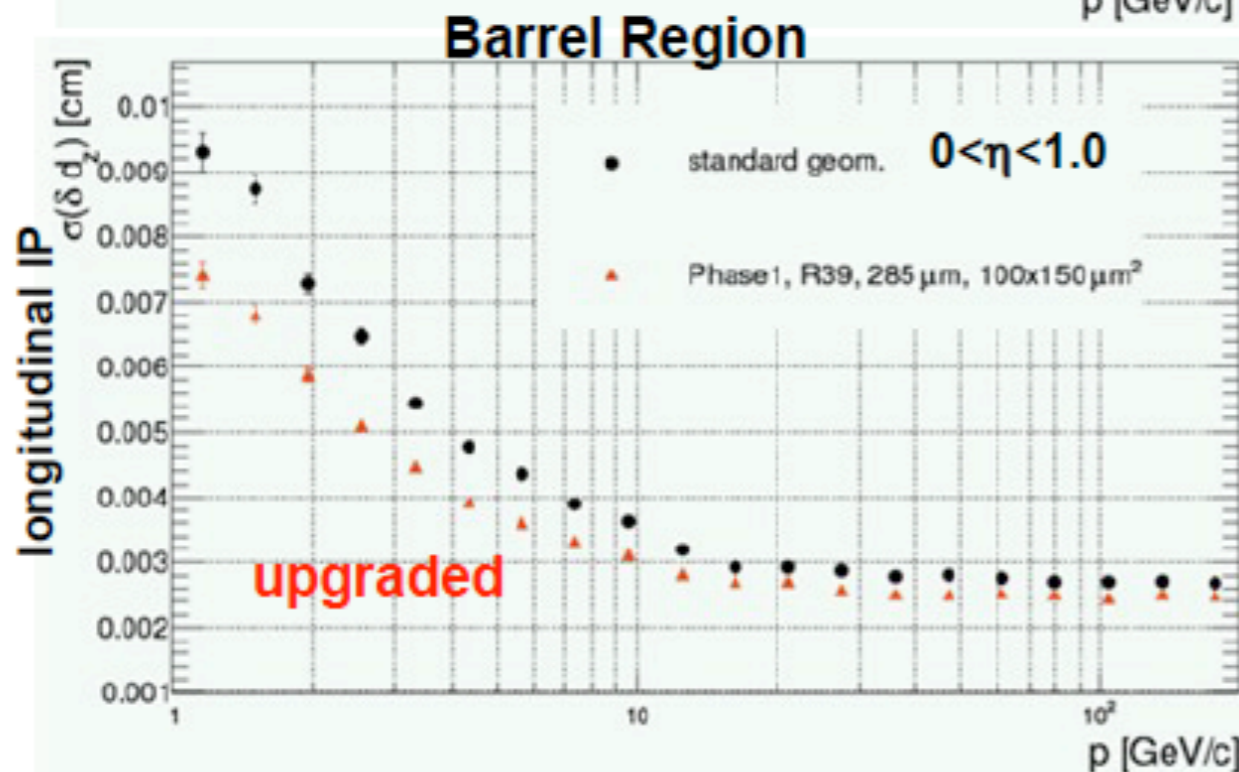
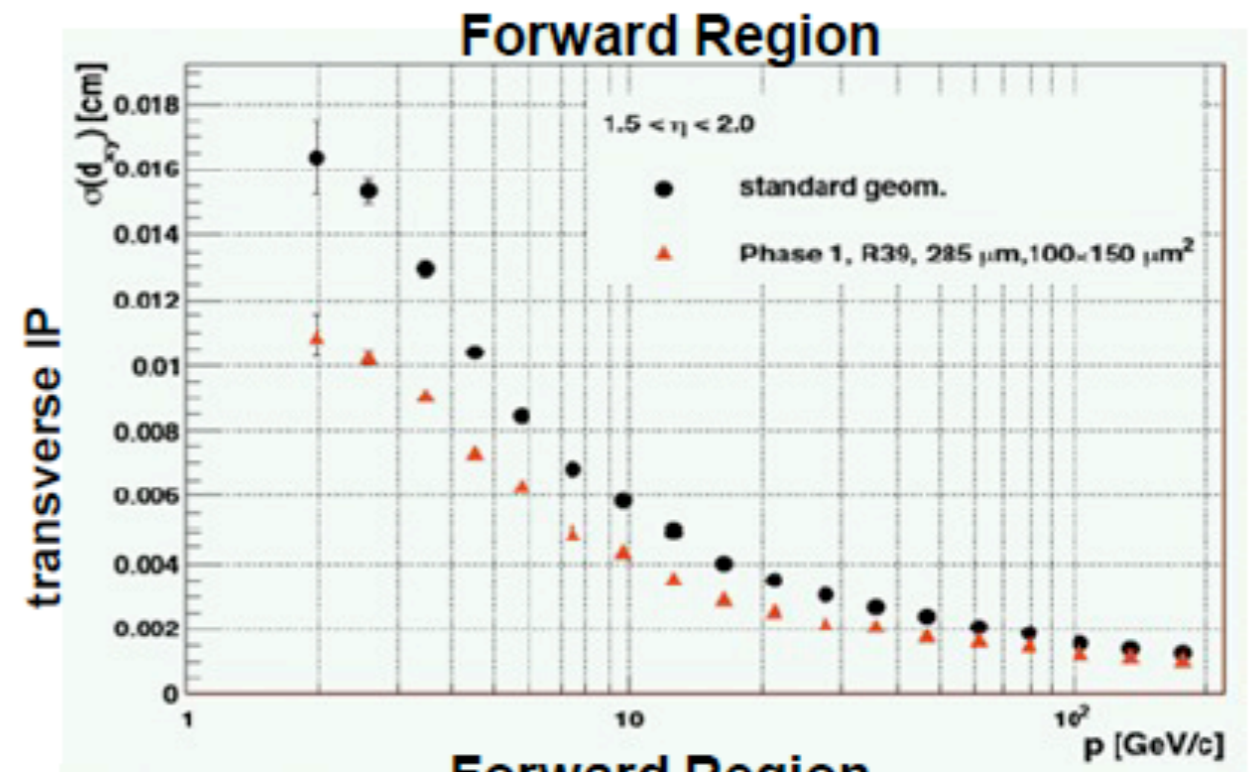
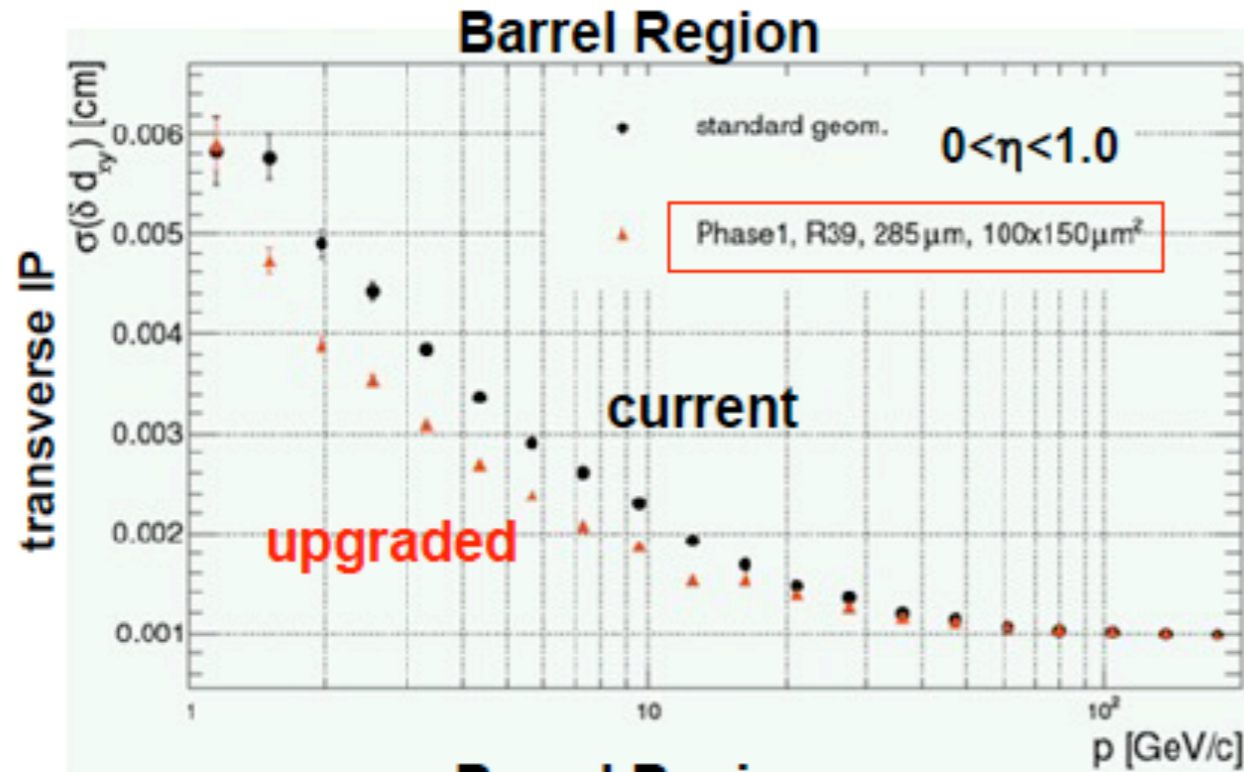
Phase 1 Detector	Radius (cm)	% Data loss at 2×10^{34}
BPIX1	3.9	4.7
BPIX2	6.8	1.5
BPIX3	10.9	0.6
BPIX4	16.0	0.28
FPIX1&2		0.6



Tracking efficiency = #sim trks assoc. to reco trk / #sim trks

Tracking fake rate = #reco trks not assoc. to sim trk / #reco trks

25-40% improvement in impact parameter resolution in both directions



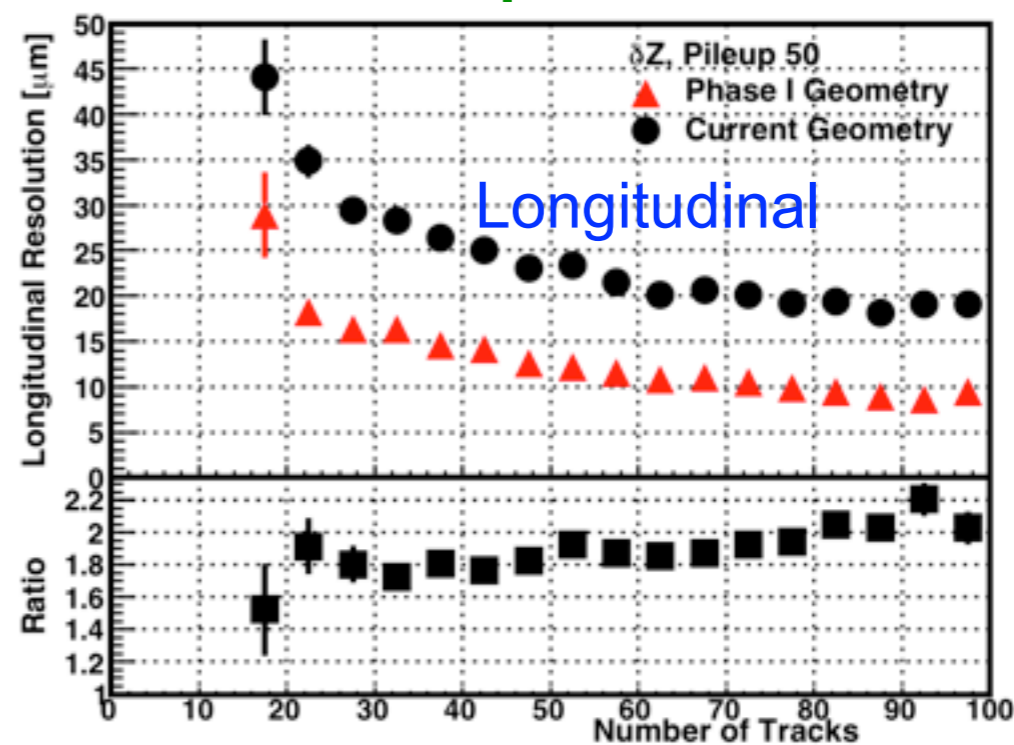
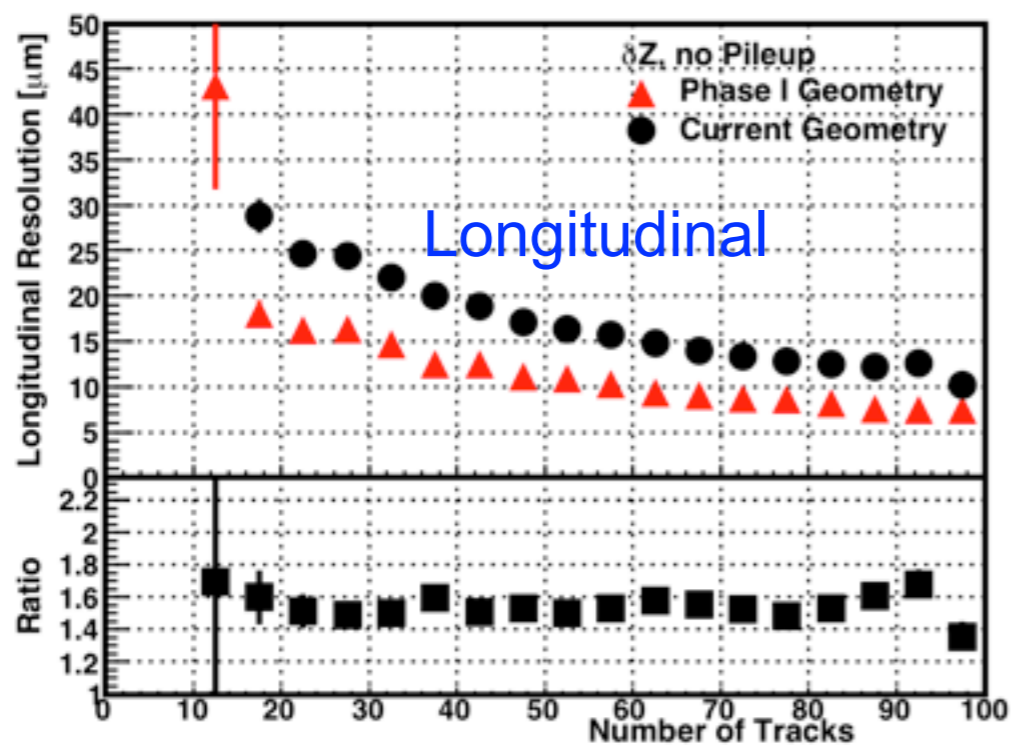
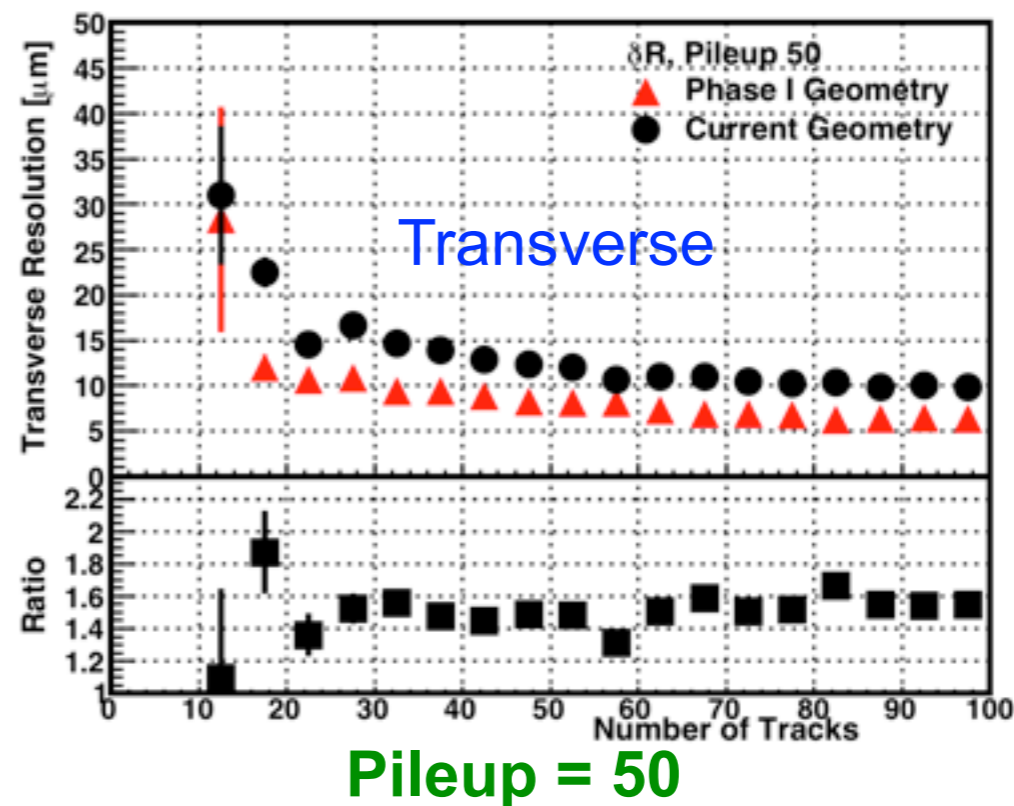
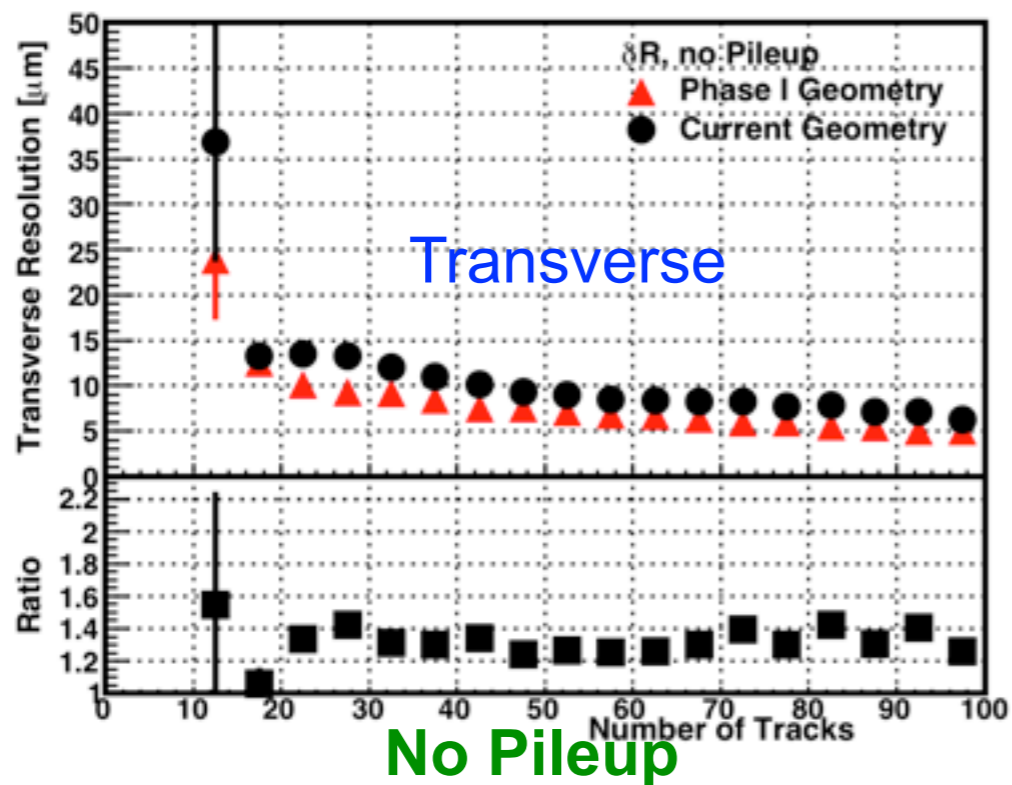
Direct impact to *b*-tagging both at HLT and offline!



Primary Vertex Resolution

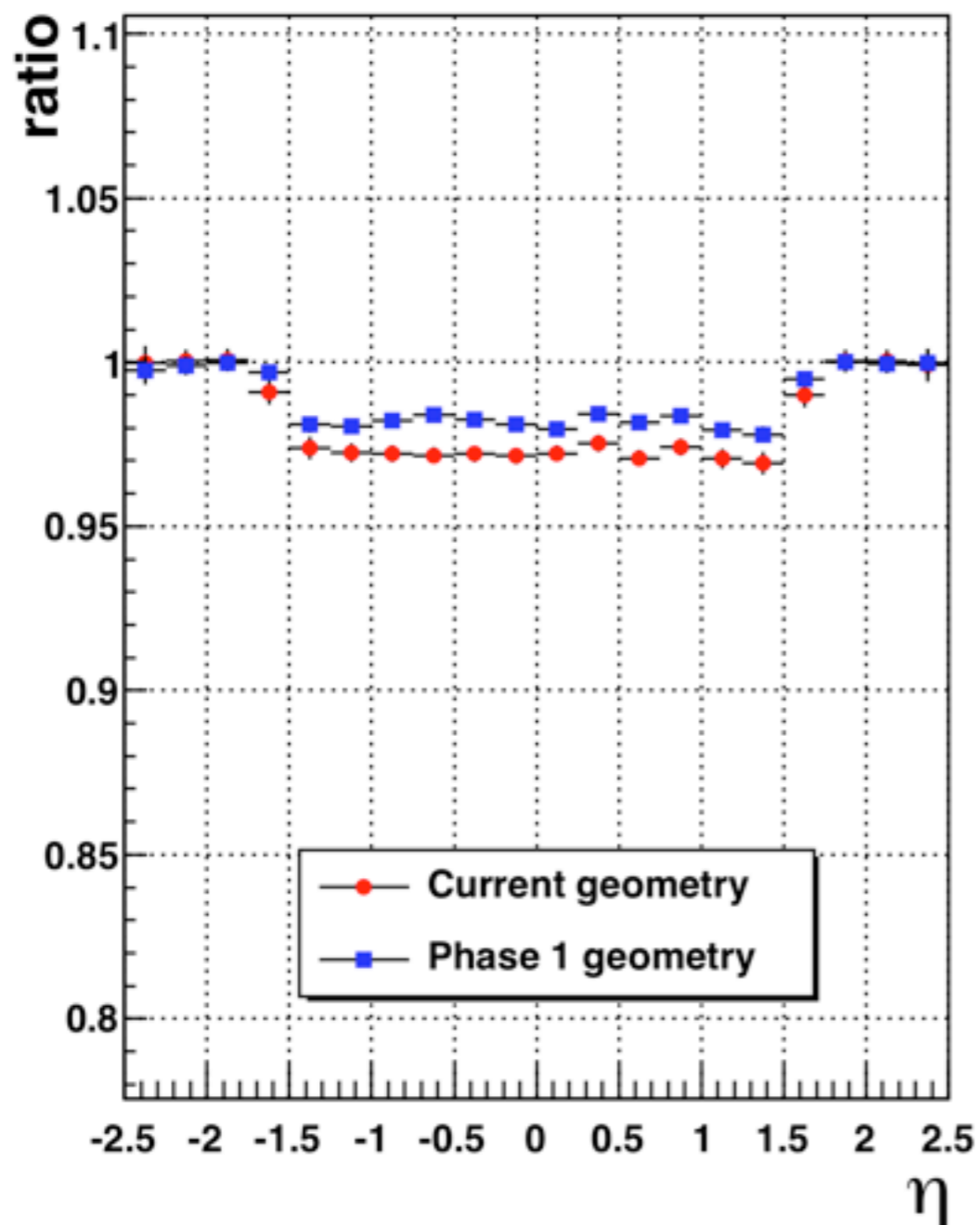


Ratio Resolution (μm)

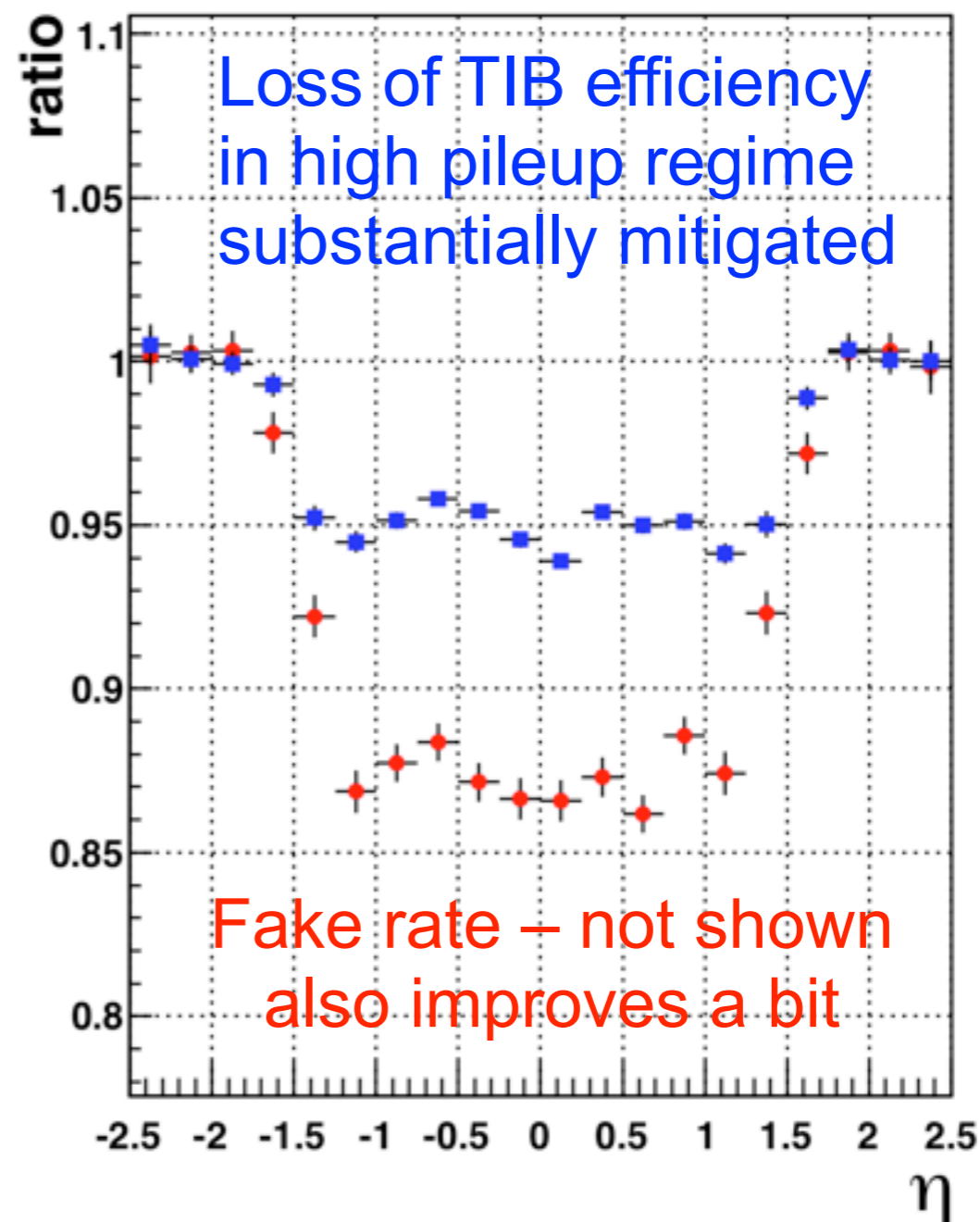


F. Palla INFN Pisa

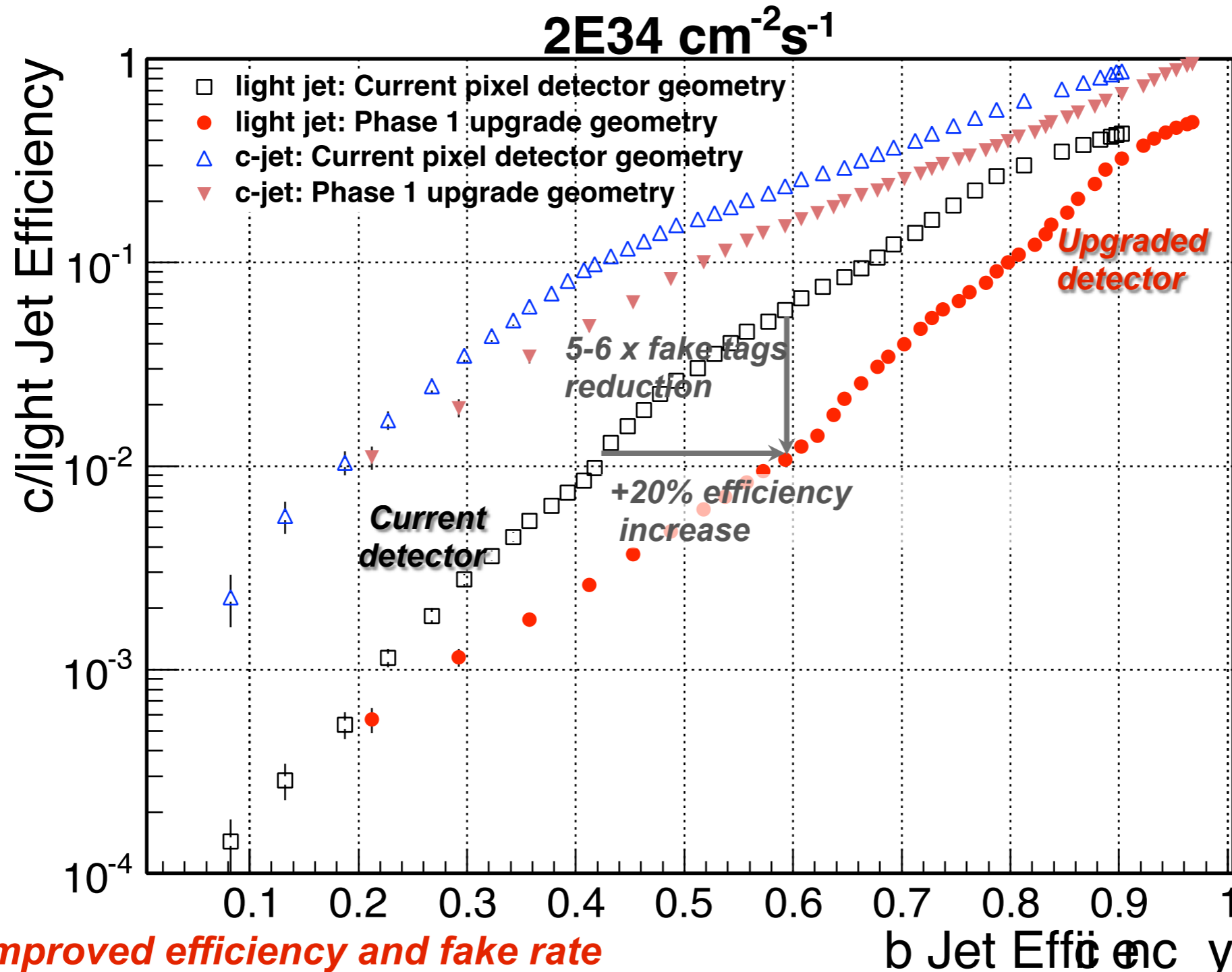
Ratio of efficiency with $\epsilon(\text{TIB1,2})=80\%$ to efficiency with $\epsilon(\text{TIB1,2})=100\%$ $\langle\text{PU}\rangle=0$



Ratio of efficiency with $\epsilon(\text{TIB1,2})=80\%$ to efficiency with $\epsilon(\text{TIB1,2})=100\%$ $\langle\text{PU}\rangle=50$



If Tracker Inner Barrel layers degrade prematurely, pixel upgrade recover losses



Improved efficiency and fake rate contributing exponentially with the number of b-tagged jets (e.g. Top, Susy, etc.)

QCD $80 < p_t < 120 \text{ GeV}$
 Combined Secondary Vertex tagger



Preliminary - Area of Interests per Country



V1		Preliminary Areas of Interests for the Pixel Upgrade										
Deliverables		A	D	I	CERN	CH	GB	TW	USA	F	B	FI
1	Silicon Pixel Sensors qualification		X	X	X	X			X			
2	Read Out Chip (ROC)					X						
3	ROC qualification		X	X		X		X	X			
4	Token Bit Manager (TBM) chip								X			
5	High Density Interconnection (HDI) circuit					X			X			
6	Module production and test		X	X		X		X	X			
7	Test Beams and System Qualification		X	X	X	X	X	X	X			X
8	Detector Mechanics and Supply tubes					X			X			
9	DAQ and Control Systems	X				X	X		X	X		
10	Optical Link System				X				X			
11	Control, Safety and environmental Systems				X				X			
12	Power System		X		X				X			
13	CO2 Cooling System				X				X	X		
14	Module Integration and Tests		X	X	X	X			X			
15	Services, Mechanical Integration and tests				X					X		
16	System long term test at TIF	X	X	X	X	X			X	X		
17	Installation and Engineering				X	X			X			
18	Commissioning in CMS	X	X	X	X	X	X	X	X			

Preliminary Draft

Pixel upgrade cost evaluated to be ~ 17.3 MCHF. Sharing among agencies is under discussion

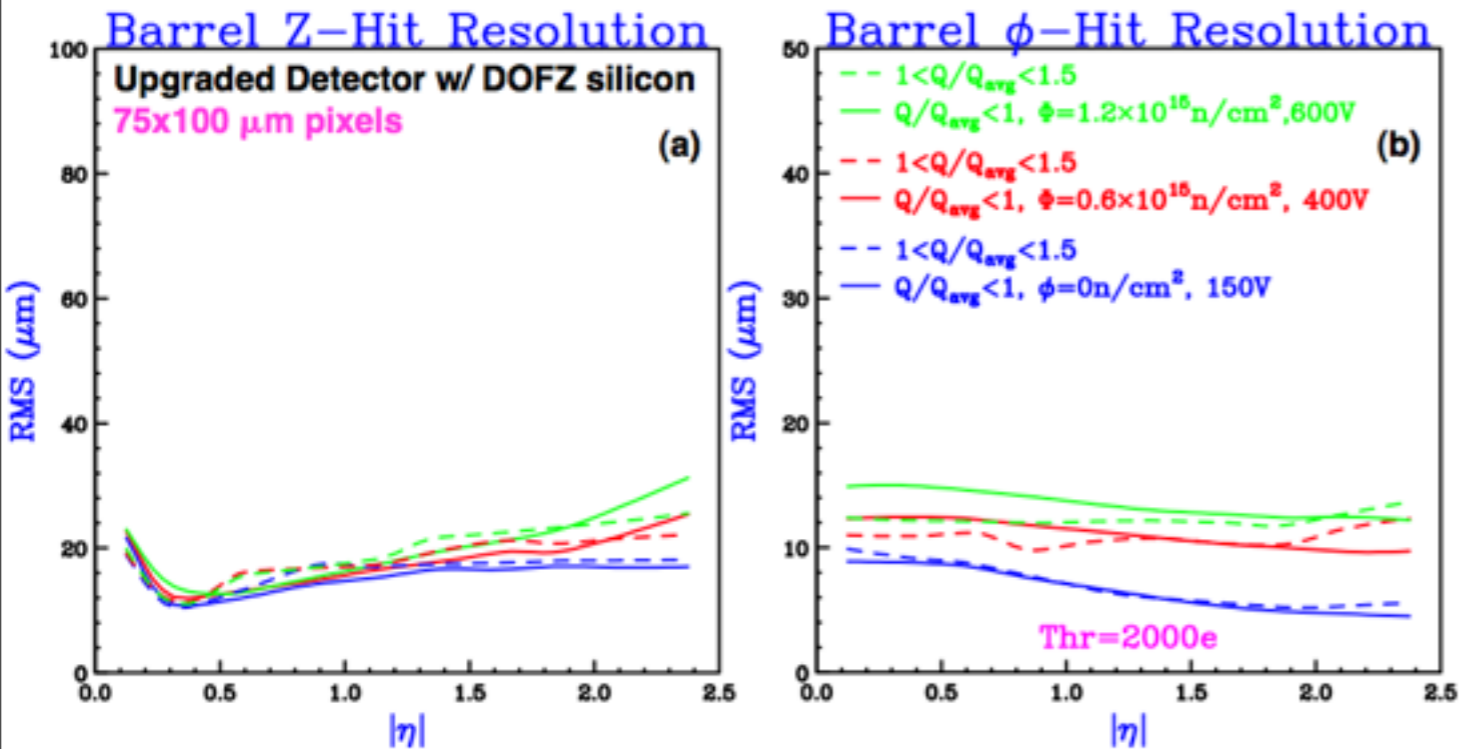
F. Palla INFN Pisa



Fall forward option Pixel Upgrade: Inner Layers



- LHC is planning to deliver $\sim 300 \text{ fb}^{-1}$ by the end of Phase 1.
- The inner layer will have to be replaced once due to radiation damage.
- This replacement presents a further opportunity to improve detector performance and test newer technologies for later stage (in view of HL LHC era).
- Evaluating Performance, Physics gains in increasing the hit resolution in the inner layer – ring (reducing the pixel pitch and sensors thickness)
 - **Sensors design: n-on-n with reduced thickness and 50% pixel area.**
 - Fall forward option: Develop thinner n-on-n sensors ($\sim 220 \mu\text{m}$ thick), $\sim 50\%$ smaller pixel area ($\sim 75 \times 100 \mu\text{m}^2$) and evaluate possible alternatives (diamond).
Improving single hit resolution (gain in term of radiation tolerance and reduction of material)
 - **Evolved Readout Chip: ROC chip design optimized for lower thresholds and 50% pixel area.**
 - Fall forward option: evolved ROC chip, compatible with DAQ and controls.
 - Optimized design for lower operational thresholds to ‘extend’ lifetime of the inner layers.
 - Reduce readout cell size ($\sim 75 \times 100 \mu\text{m}^2$) to match reduced pixel area.
This can be reached thanks to 130 nm (or lower) technologies and to a careful optimization of the chip layout design.
 - Possibly able to digest higher rate with reduced dead time

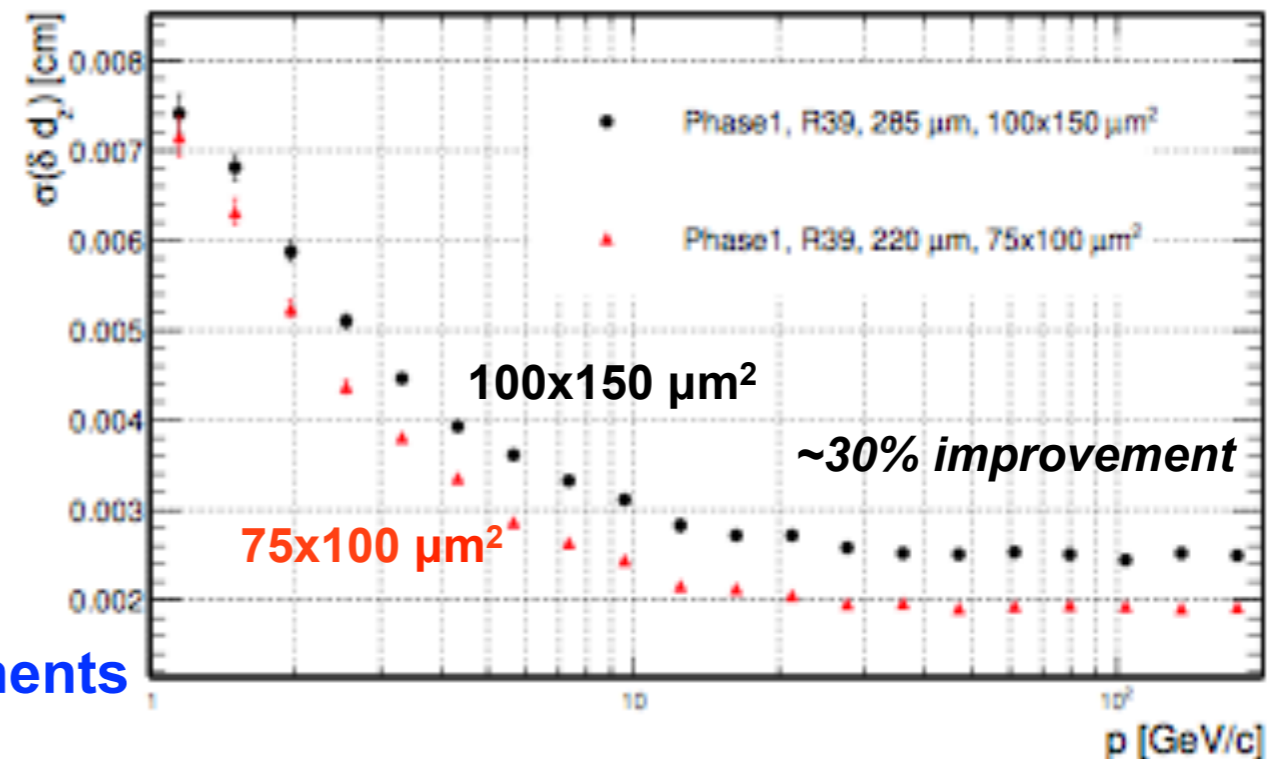


Replacement of layer 1 opens door for attractive opportunities

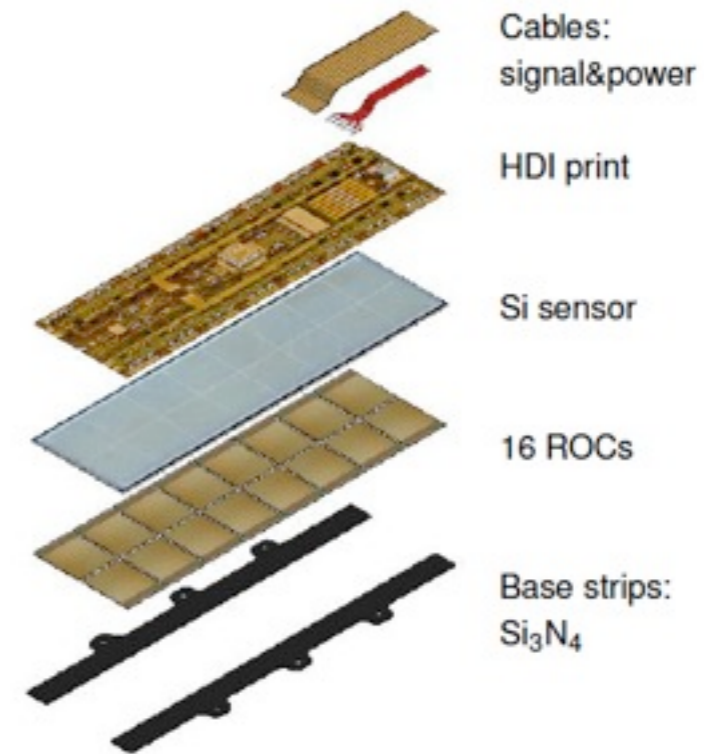
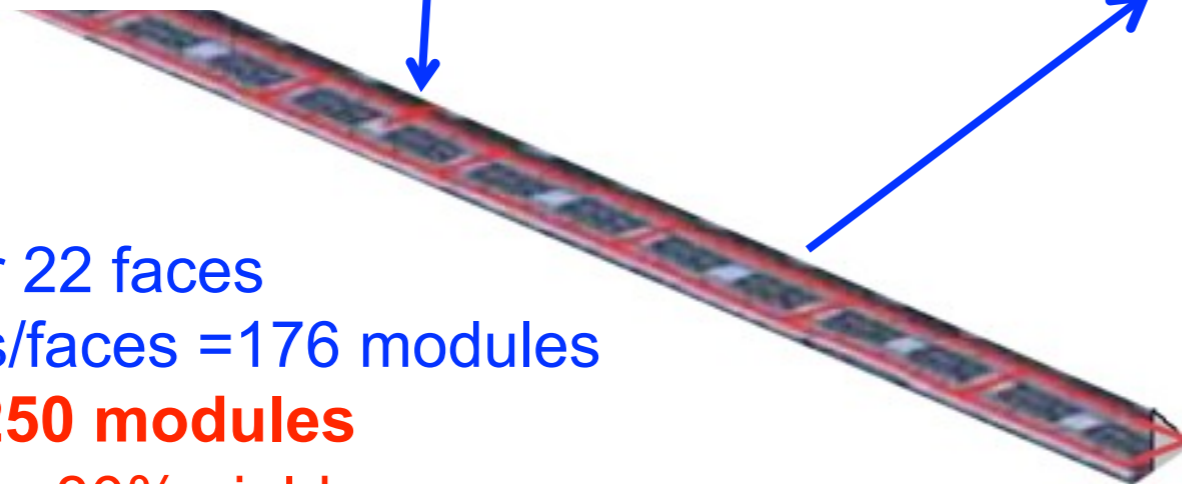
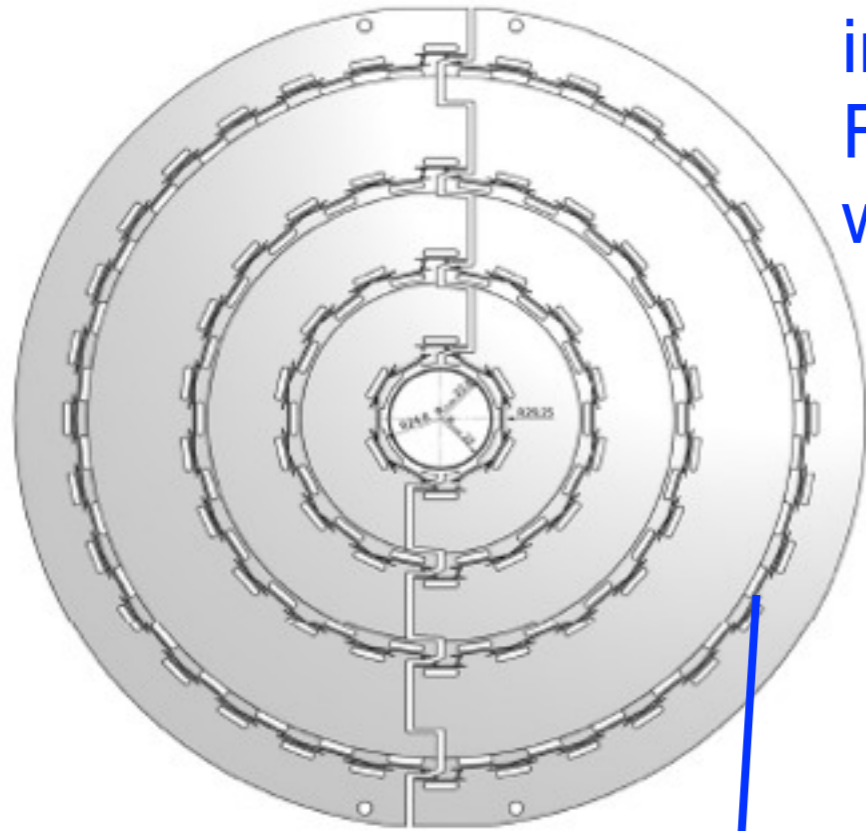
- New chip based on 130nm or smaller CMOS technology
- Can implement smaller pixel cells
- Aim at lower readout threshold

Longitudinal IP resolution

- Smaller pixels with lower readout thresholds can better preserve **position resolution** after irradiation.
- Improve **impact parameter** resolution.
- Add resolving power for **high pt jets** and boosted objects (b, tau, top).
- Better **vertex resolution** in a high pile-up environment and improved **lifetime measurements**

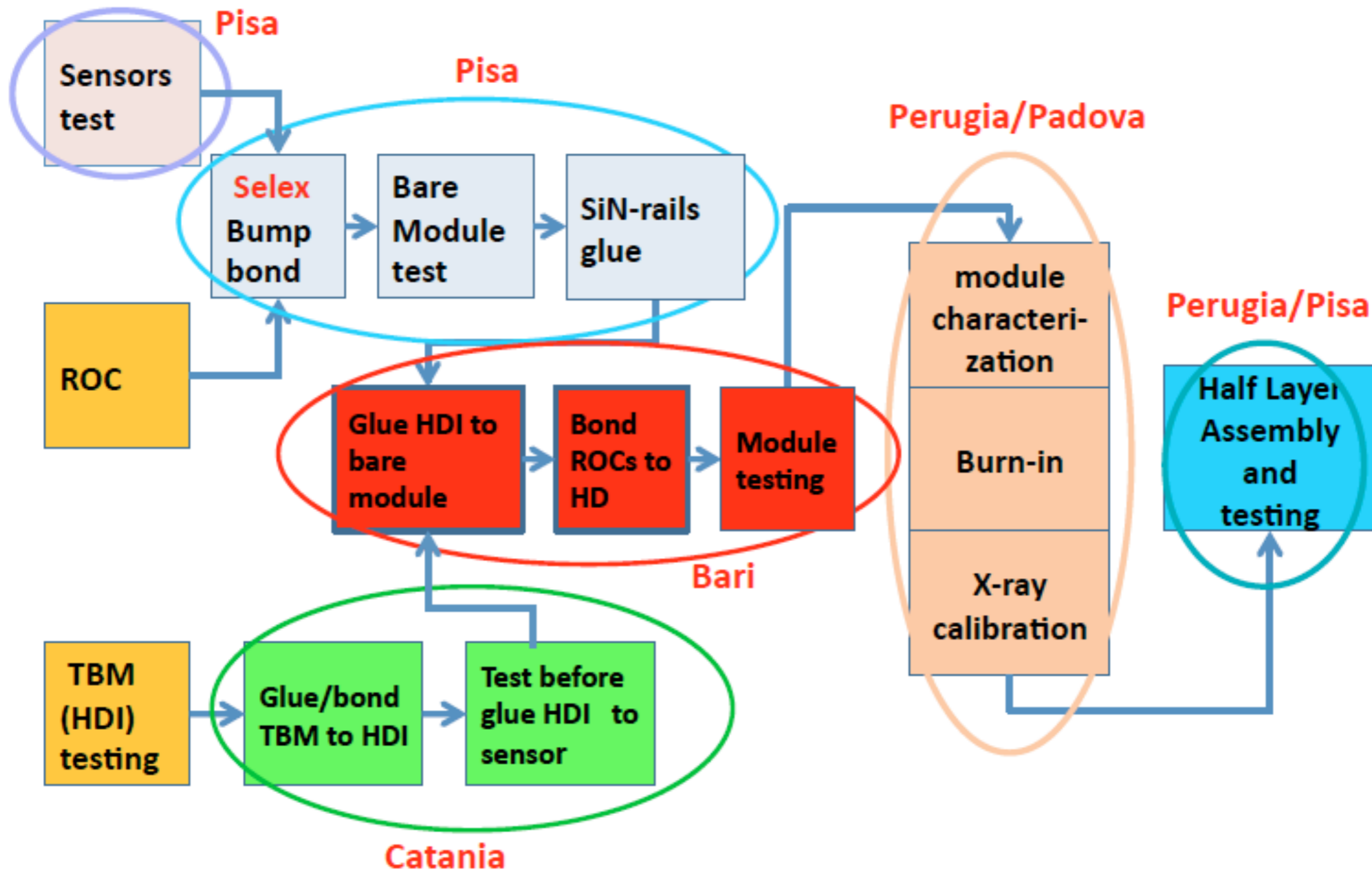


Expressed to the Tracker community our interest to contribute with a part of BPix layer 3. Final sharing among countries in discussion and will be available at the time of TDR



Half Layer 22 faces
 8 modules/faces = 176 modules
Needs ~ 250 modules
 allowing for 80% yield
 and 15% spares

Preliminary sharing for Pixel Module Construction

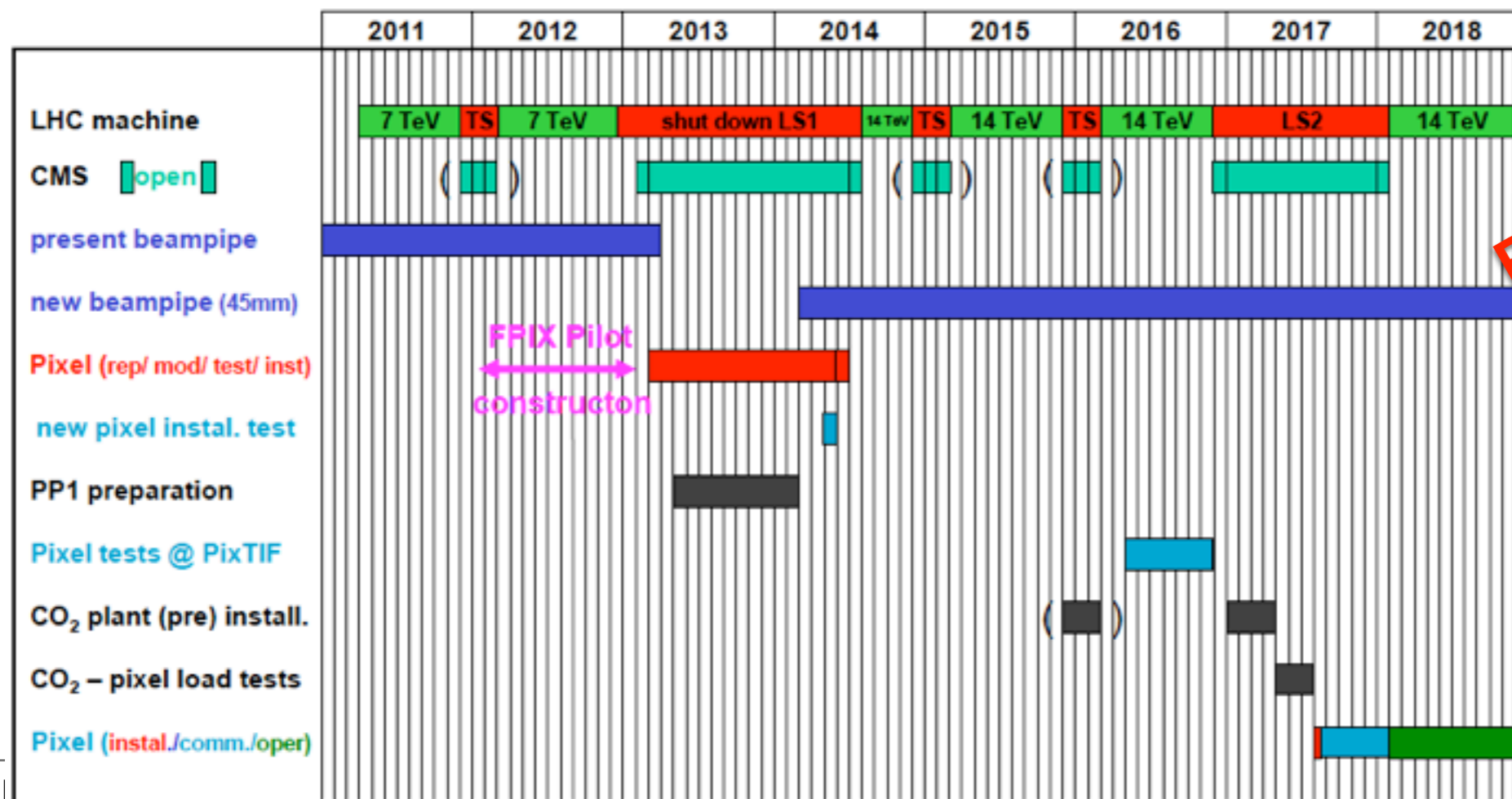




Draft timeline of INFN activities



Develop and produce assembly tools	start 2011	
Develop assembly and testing procedures	start 2011-12	
Participate to qualification of ROC chip and TBM	2012	
Bump bonding tests and qualification of Selex	2012	
Assembly and test procedures established	2012	
Full qualification of pre-production modules	2012-13	
Module assembly and calibration (~ 12 months construction)	2013-14	
Participate to integration at CERN	2015	
Participate to commissioning, full system test at CERN		2016
Ready for installation in CMS	mid 2017	



**Piano in discussione.
TDR aspettato per
la fine del 2011**

Il piano dipende dalla produzione del nuovo ROC. Module production potrebbe slittare al 2014-15



Fall Forward Option development



Design of new readout chip in 130 nm CMOS technology with objectives:

1) Readout architecture able to sustain very high data flow:

concept: keep data inside the matrix until a request arrives.

“**Regional**” approach (**size 2x2, 2x4..**), pixels share memory buffers, logic block and possibly an ADC. Experience exists (ViPix, SuperB..).

2) Pixel size reduction:

improvement in impact parameter resolution, occupancy reduction and sensitivity to radiation damage (sensor leakage current).

Pixel size of **100x75 μm^2 or even smaller** appears feasible.

Experience exists for smaller pixels (ViPix, SuperB..).

3) Increase of clock frequency and output data bit rate:

In 130 nm experience exists (ViPix) with logic blocks operated @~1GHz.

Good safety margin for a digital design at frequencies of **few hundreds MHz**.

Dead time reduction and readout efficiency optimization.

Logic blocks inside the pixel matrix can operate at lower frequencies.

■ Project structured in 3 stages (~12-16 months each) total time 4-5 years.

- ◆ Design, submission of Test structures (FE, ADC, pixel-level logic), 1 or more chips (estimate cost 250 KCHF)
- ◆ Design, submission and test of a small scale version of readout chip (~ 150 KCHF)
- ◆ Design, submission and test of a full scale version of the readout chip (~250 KCHF)
- ◆ Production run (~ 400 CHF)

■ Funding: possible sharing 50-50 INFN - USA (~ 500KCHF each)

CMS: pixels $\frac{1}{2}$ L3

❖ Richieste:

- Materials, sensors and bonding 850 kCHF → 650 k€
- Setup: 150 kCHF → 120 k€
- Totali: 1000 kCHF → 770 k€

❖ Proposta referees:

- Si autorizza CMS ad impegnarsi fino 750 k€
- Si prevedono inoltre 150 k€ di contingenza che la CSN1 puo' assegnare, anche parzialmente, a fronte di motivate richieste
- Massima assegnazione multiennale per questo progetto:
 - 900 k€
- Assegnazione 2011:
 - 50 k€ per iniziare setup laboratori (a scalare dai 900)

CMS: pixel – chip

❖ Richieste:

- 600 kCHF → 460 k€
 - Di cui 200 kCHF (160 k€) per il run di produzione

❖ Proposta referees:

- S'incoraggia l'attività che però non ha ancora trovato una sua chiara definizione. I partecipanti sono invitati a creare un piano che coinvolga un'importante contributo italiano alla progettazione del nuovo chip.
- L'approvazione del finanziamento si articola in due stadi:
 - fino a 50 kE per le prime produzioni e test di parti del circuito, dopo verifica della definizione del programma di lavoro e di collaborazione
 - fino a 150 kE per successive produzioni di prototipi e test, dopo verifica dello stato del progetto dopo il completamento del punto precedente.
 - NON si finanzia il costo di produzione. Eventuali contributi vanno presi dalla contingenza residua sulla costruzione del Layer 3.



Cosa vorrebbe fare Pisa?



- **Attività preliminari e parallele alla produzione:**
 - ♦ Setup degli apparati di laboratorio per test dei pixel, acquisizione dei componenti HW e SW
 - ♦ partecipazione ai test beam di qualifica e pre-produzioni
- **Ricezione e test dei ROC per il bump-bonding**
- **Test dei sensori finali**
- **Bump-bonding**
 - ♦ Pre-qualifica delle procedure di bump-bonding con l'industria
 - ♦ Qualifica e controllo del "bare module" dopo il bump-bonding
- **Assemblaggio e test sulla struttura meccanica (prodotta al PSI) - in fase di discussione con Perugia**
- **Commissioning della struttura al CERN**
- **Partecipazione al design del ROC per la fase "fall-forward"**



Ricezione e test dei ROC



- I ROC vengono ricevuti dopo che la compagnia ha fatto la UBM, In bump, affinamento e il dicing

- **Cosa serve per il test:**
 - ♦ **Attrezzatura:**
 - Probe station con SW Windows
 - Chuck adapter per il test simultaneo di 16 ROC
 - Probe card per test individuale dei ROC
 - Test board per il module test
 - PC con SW del PSI
 - ♦ **Manpower**
 - È necessario un tecnico elettronico, auspicabile che almeno nella prima fase sia presente anche un tecnologo con esperienza VHDL.

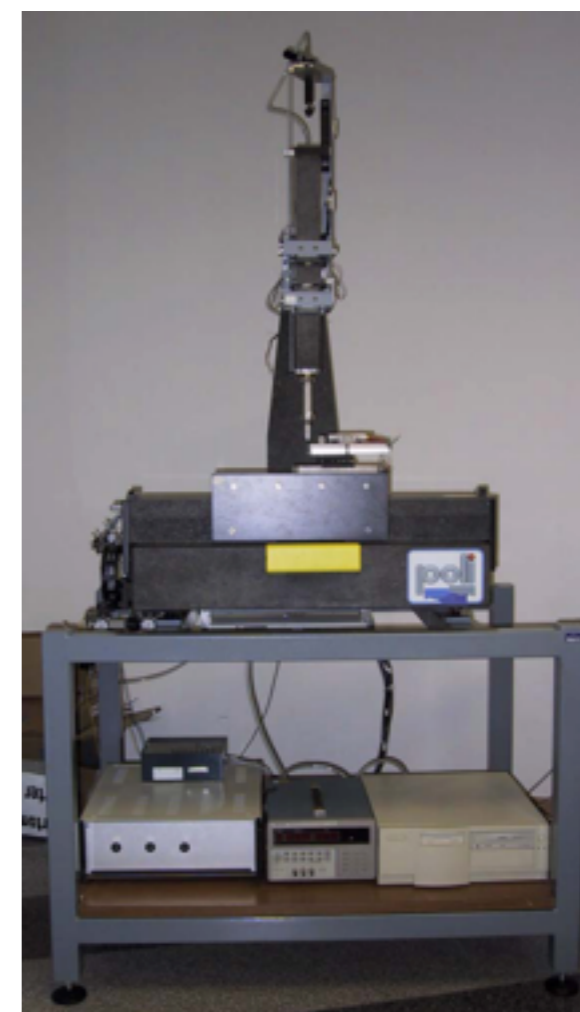


Test dei sensori



- **I sensori vengono ricevuti dopo che la compagnia ha fatto la UBM, In bump ed il dicing**
- **Cosa serve**
 - ◆ **Attrezzatura**
 - **Probe station**
 - **Chuck adapter per i sensori DS**
 - **Probe card**
 - **Labview Windows SW**
 - **Setup per la qualifica dei Si**
 - ◆ **Personale**
 - **Alte tecnologie**

- **Lavorazione fatta in ditta (Selex?)**
- **Ispezione ottica**
 - ♦ misura della planarità e posizione dei ROC secondo specifiche
- **Test Meccanici**
 - ♦ Pull test
- **Cosa serve**
 - ♦ **Attrezzatura**
 - CMM contactless (pattern recognition)
 - Pull tester
 - PC + SW
 - Reworking machine ? (TBD)
 - ♦ **Personale**
 - Alte tecnologie
 - Disegnatori meccanici
 - Servizio elettronica



- **Test IV, ROC current consumption, I2C, token passage, set analogue current, scan dei DACs, Bump yield test**

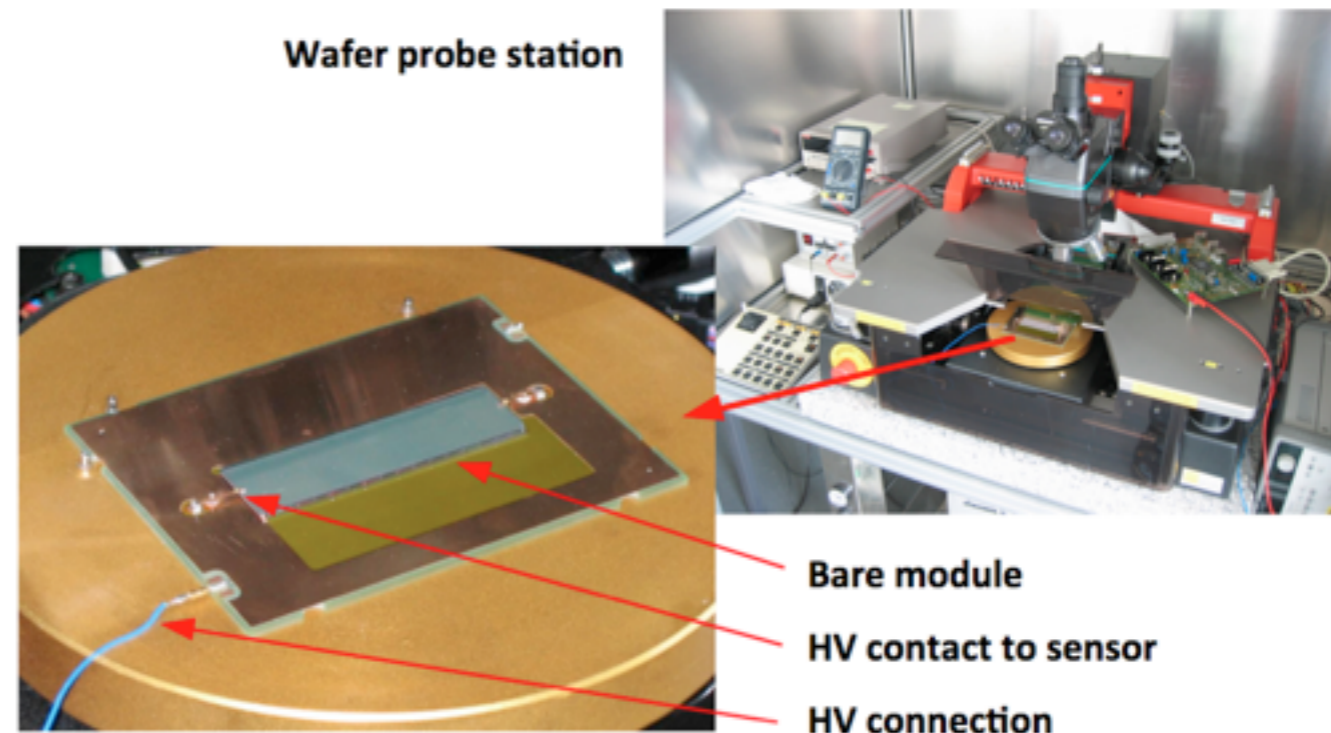
- **Cosa serve**

- ♦ **Attrezzatura**

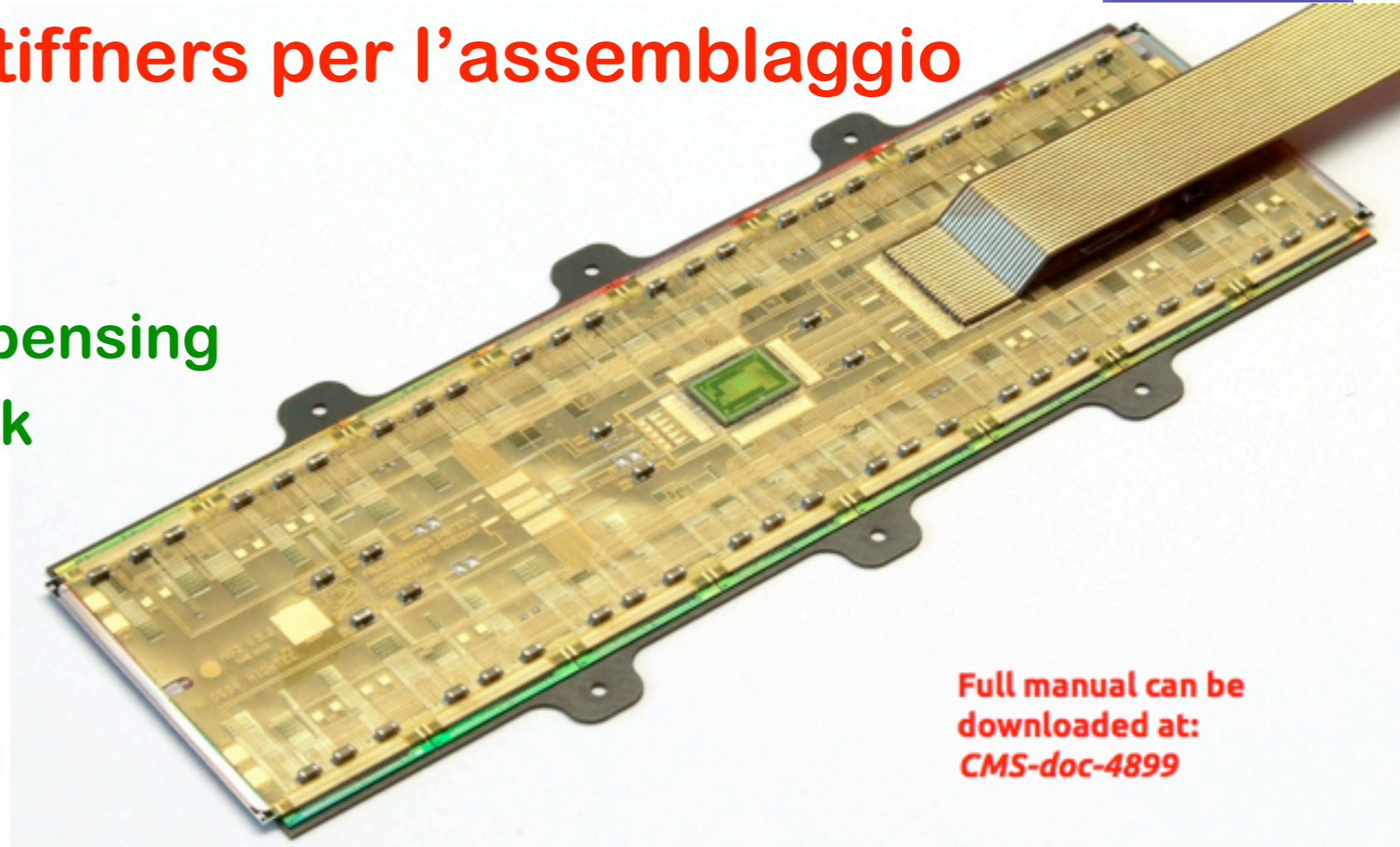
- Probe station
 - Chuck adapter
 - Probe card
 - Test board
 - PC + SW

- ♦ **Personale**

- Alte tecnologie
 - Disegnatori meccanici
 - Servizio elettronica



- Incollaggio Si₃N₄ stiffners per l'assemblaggio
- Cosa serve
 - ◆ Equipaggiamento
 - Robot per glue-dispensing
 - Gluing/curing chuck
 - ◆ Personale
 -



Full manual can be
downloaded at:
[CMS-doc-4899](#)

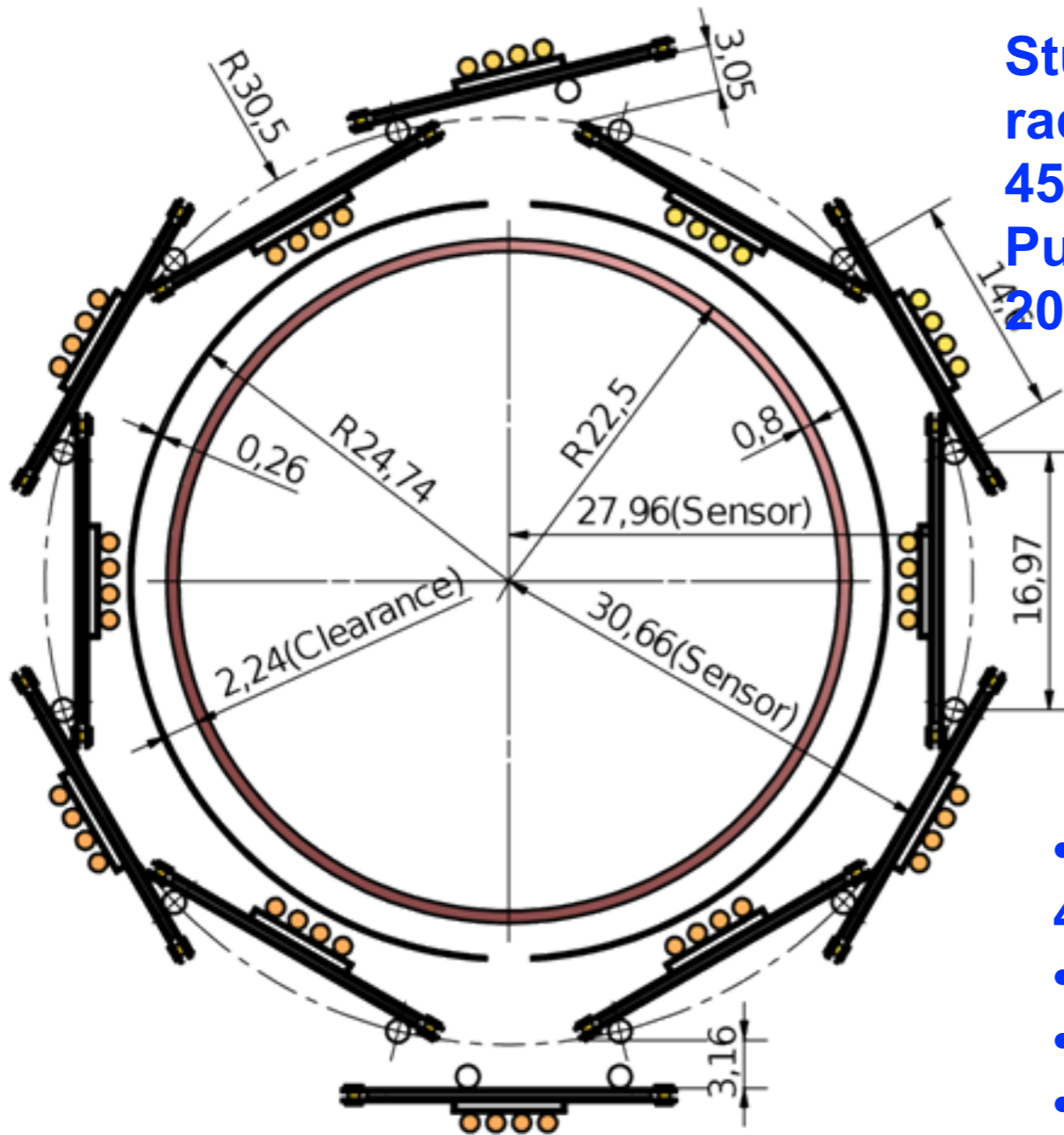
Attività/Anno	2011-12	2012-13	2013-14	2015-16	Tot
Tecnici					
0 (attività preliminari e test beam)	0.5 AT 0.5 Mec	0.5 AT 0.5 Mec 0.5 Elet	0.5 Mec 0.5 Elet		1.0 AT 1.5 Mec 1.0 Elet
1 (Test dei sensori)		0.5 AT	0.5 AT		1 AT
2 (Bump bonding e bare module test)		0.5 AT 0.5 Mec 0.5 Elet	0.5 AT 0.5 Mec 0.5 Elet		1 AT 1 Mec 1 Elet
3 (Assemblaggio finale e test)			0.5 AT 0.5 Mec 0.25 Elet	1.5 AT 0.5 Mec 0.25 Elet	2.0 AT 1.0 Mec 0.5 Elet
Totale per anno per servizio	0.5 AT 0.5 Mec	1.25 AT 0.75 Mec 0.75 Elet	1.5 AT 1.5 Mec 1.25 Elet	1.5 AT 0.5 Mec 0.25 Elet	
Progettisti e disegnatori					
0	0.1 dis. mec	0.3 dis. mec			
1					
2	0.2 Bosi 0.1 dis. Mec 0.2 Elet	0.5 Bosi 0.7 dis. Mec 0.2 Elet	0.3 Elet	0.2 Elet	
3			0.3 Bosi 0.3 dis. mec		

Tecnologo Elettronico
 espressione di interesse
 R. Beccherle

Tabella soggetta a variazioni dovuta alla qualifica
 del nuovo ROC.

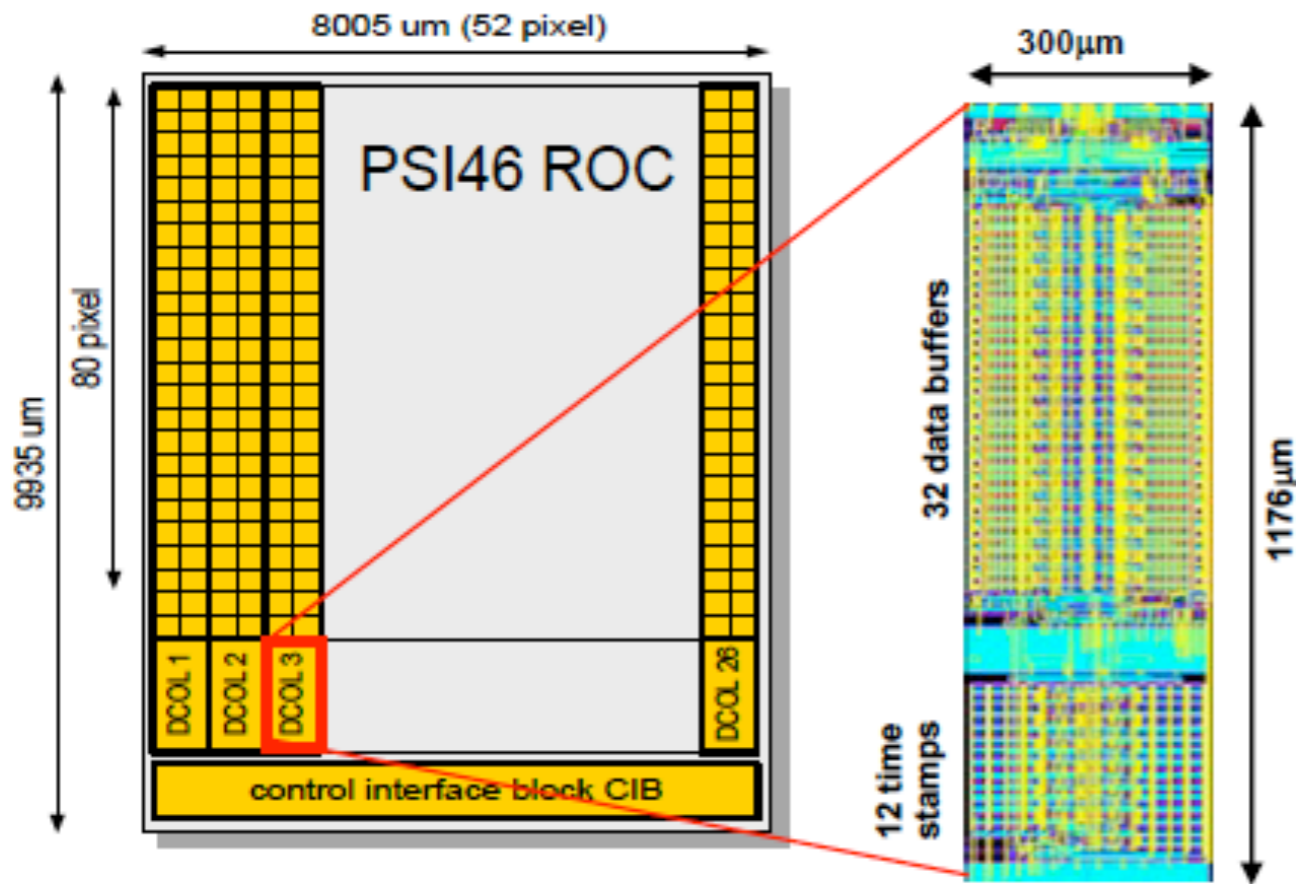


Back up slides



Studies are ongoing to assess safe beam pipe radius.
 45 mm diameter seems doable.
 Pushing for Beam Pipe installation in LS1
 2013

- mean 1st layer Si- radius = 29.8 mm from 44
- need 2 mm clearance to beam pipe
- need adjustable closing mechanism
- Beam pipe diameter 45 mm from 58



Present ROC for 1st Layer:

<u>Luminosity</u> <u>Loss</u>	<u>bx-spacing</u>	<u>Data</u>
$1 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$	25nsec 50nsec	4% 16%
$2 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$	25nsec 50nsec	15% ~50%

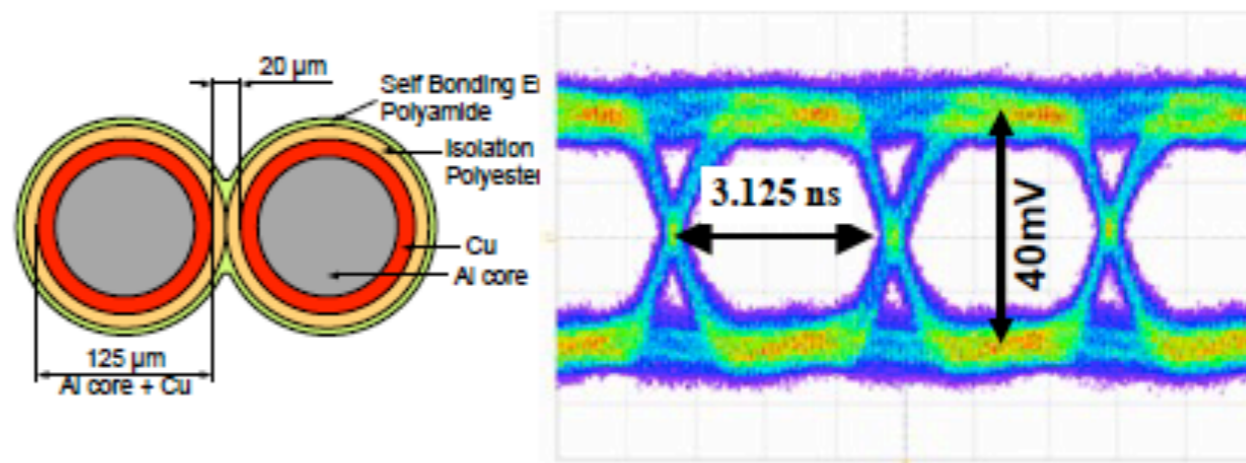
50nsec operation of LHC was not planned in original ROC architecture in 1998.

Data losses removed by ROC changes:

- | | |
|---------------------------------------|---------------|
| 1) increase depth of | <u>Status</u> |
| - data buffer 32 → 80 | done |
| - timestamps 12 → 24 | done |
| 2) add readout buffer | done |
| 3) 160Mbit/sec serial binary data out | now |
| 4) deal with PKAM events → DAQ resync | |

μ-twisted CCA pair (Copper-Cladded Aluminum)

- 1m long low mass link at 320MHz, chips done!



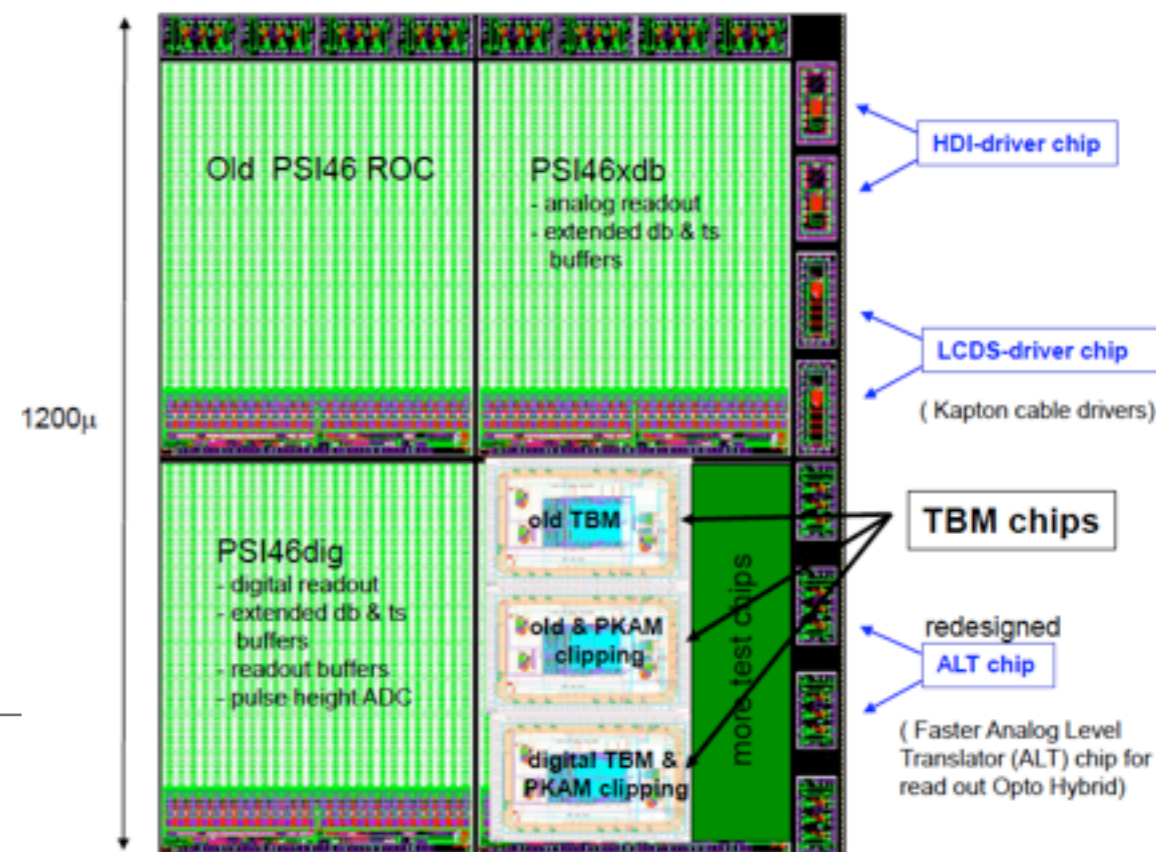


Upgraded PSI ROC Chip

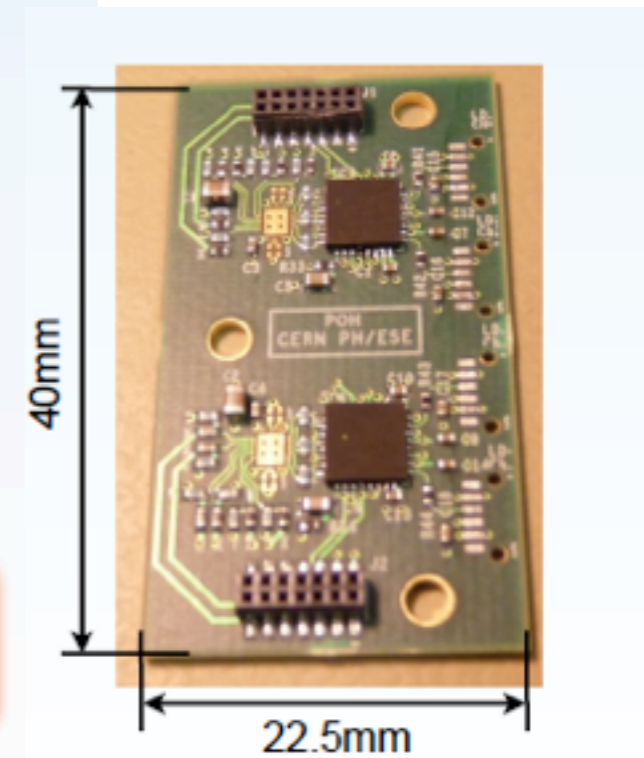
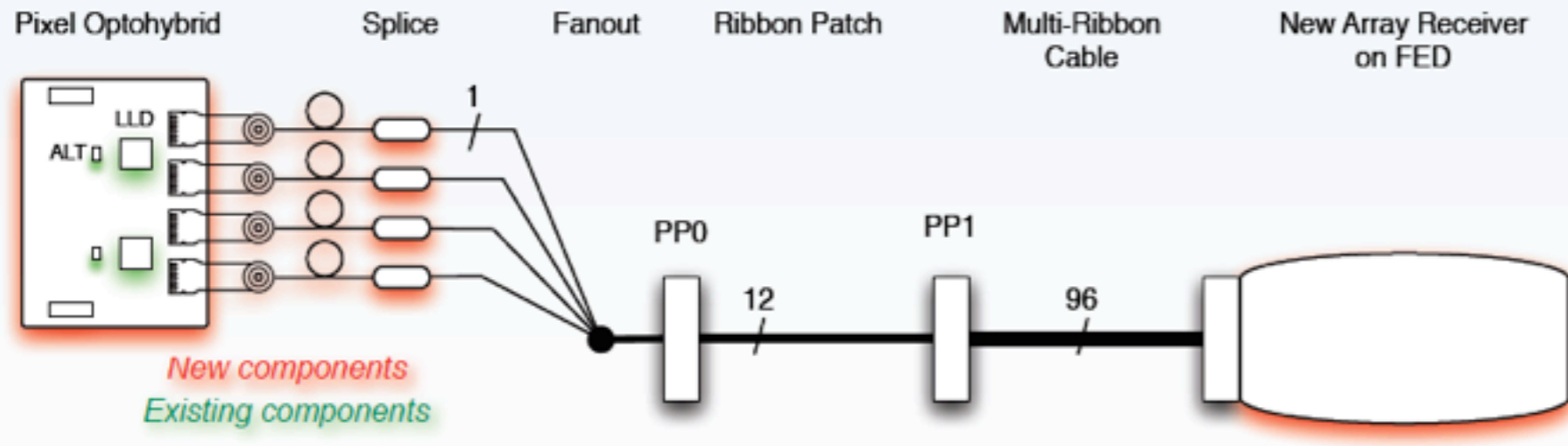
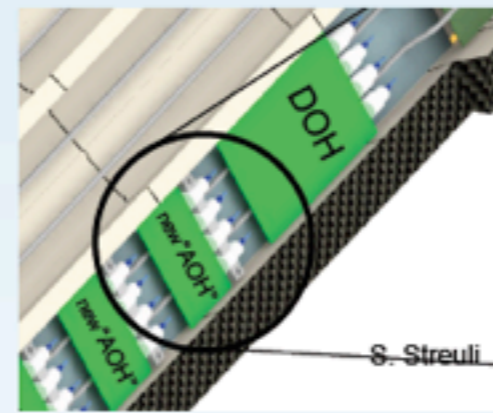


- The current ROC was designed for $1E34 \text{ cm}^{-2} \text{ s}^{-1}$
- There is a $\sim 4\%$ dynamic data loss in the innermost BPIX layer at this lumi (readout-related losses 3%, column-drain time 0.8%)
- This increases gradually to $\sim 16\%$ for $2E34 \text{ cm}^{-2} \text{ s}^{-1}$
- For 50 ns bunch spacing at $2E34 \text{ cm}^{-2} \text{ s}^{-1}$, the data loss would be $\sim 50\%$
- Current ROC needs to be replaced for running above $1E34 \text{ cm}^{-2} \text{ s}^{-1}$
- Double buffer space to reduce readout-related dead time
- All digital readout clocked out at 160 MHz from ROC to new digital Token Bit Manager (TBM). Multiplex multiple rings with TBM at 320 MHz. Allows reduction in number of cables and therefore mass and power.

Submission foreseen for Sep. 2011



- New pixel system aims at reducing material within the CMS detector acceptance
 - New supply tube
 - Electronics re-design with digital readout at 320 Mb/s
- Basic concept for the link is to keep the installed fibre system and replace the front-end and back-end components with ones compatible with 320 Mb/s digital operation



Activity advancing well at CERN. First Pixel Opto Hybrid (POH) prototypes with new laser available for evaluation



CO₂ Cooling System



Current cooling system for Tracker uses C₆F₁₄, which has density of 1.7 x water

- Biphase CO₂ successfully used in HEP, e.g. LHCb “Velo”
- Small channel (~2mm ID) biphase CO₂ system would have good thermodynamic properties (low dT/dP, low mass, low viscosity, high latent heat, high heat transfer coefficient). Also rad hard
- Factor of ~2 lower density in liquid phase compared to C₆F₁₄
- High heat transfer means smaller area of thermal contact.
High latent heat means more heat load per channel.
Smaller pipes, less manifolding and less material.

R&D ongoing since ~ 2 years and well advanced at CERN/USA



DC - DC Power Supply System



- Assume that we will reuse same cable plant (very difficult to change)
- New pixel detector has factor of ~ 2 more readout chips.
- Will need more power To limit resistive losses, propose to bring in high V along long cables (50m) and use DC-DC switched mode converter (“buck”) near the detector
- Needs to be rad hard and magnetically tolerant
- R&D ongoing in Germany/CERN since ~ 3 years. Prototypes underway

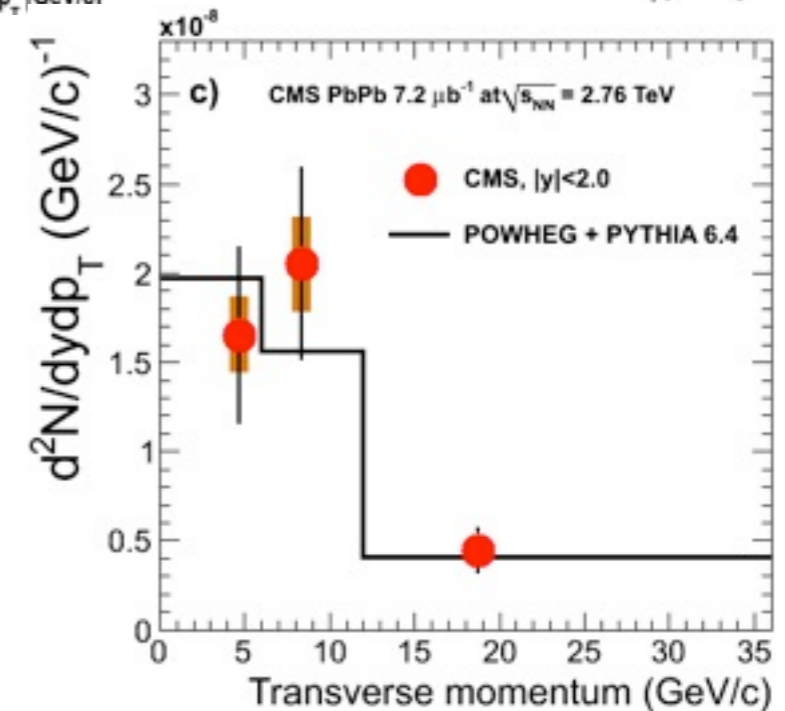
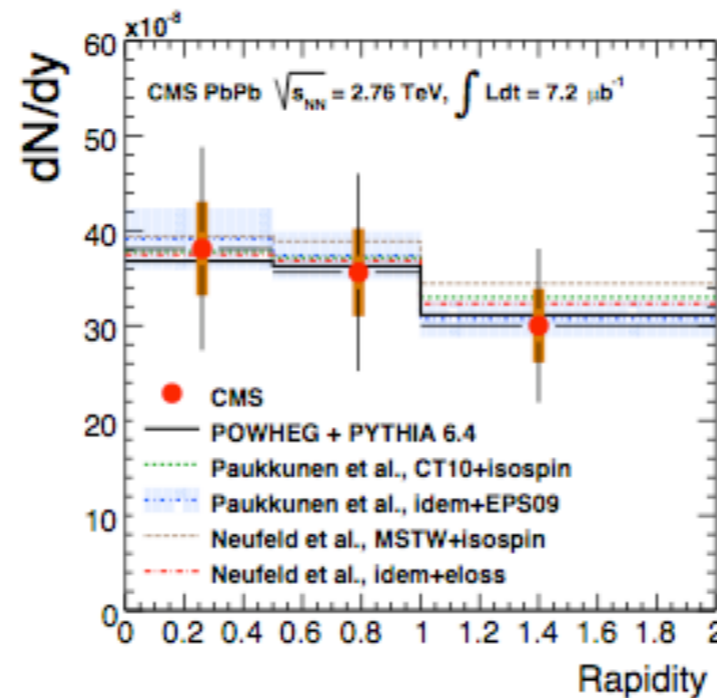
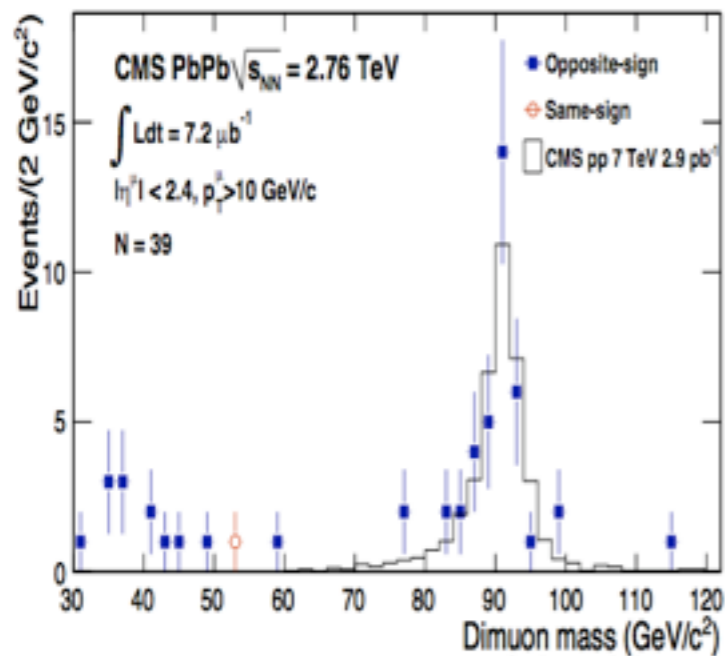
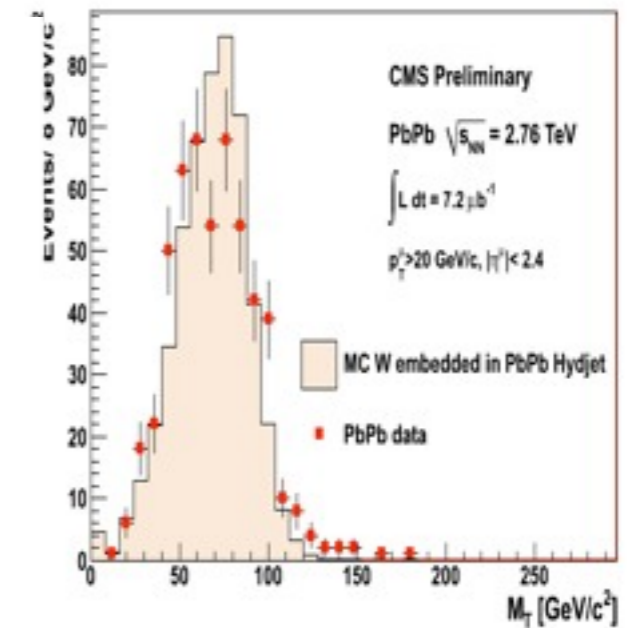
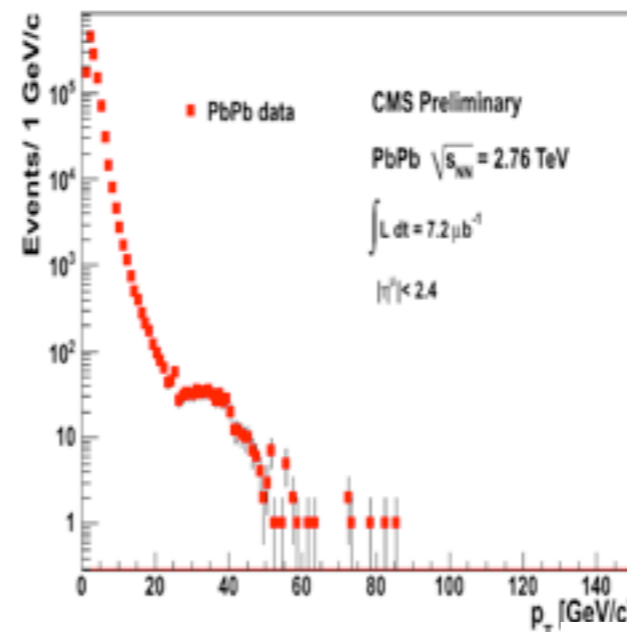
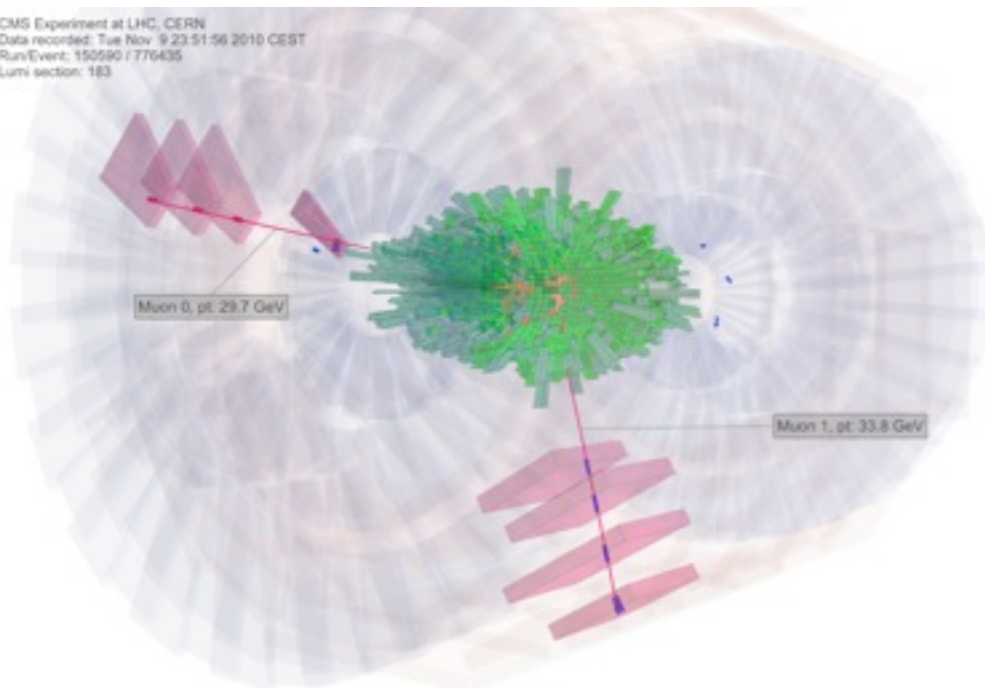
Observation of Z and W produced in HI collisions

collisions

For the first time Electroweak probes accessible in HI collisions.



CMS Experiment at LHC, CERN
Data recorded: Tue Nov 9 23:51:56 2010 CEST
Run/Event: 150590 / 776435
Lumi section: 183



arXiv:1102.5435; PRL 106, 212301 (2011)